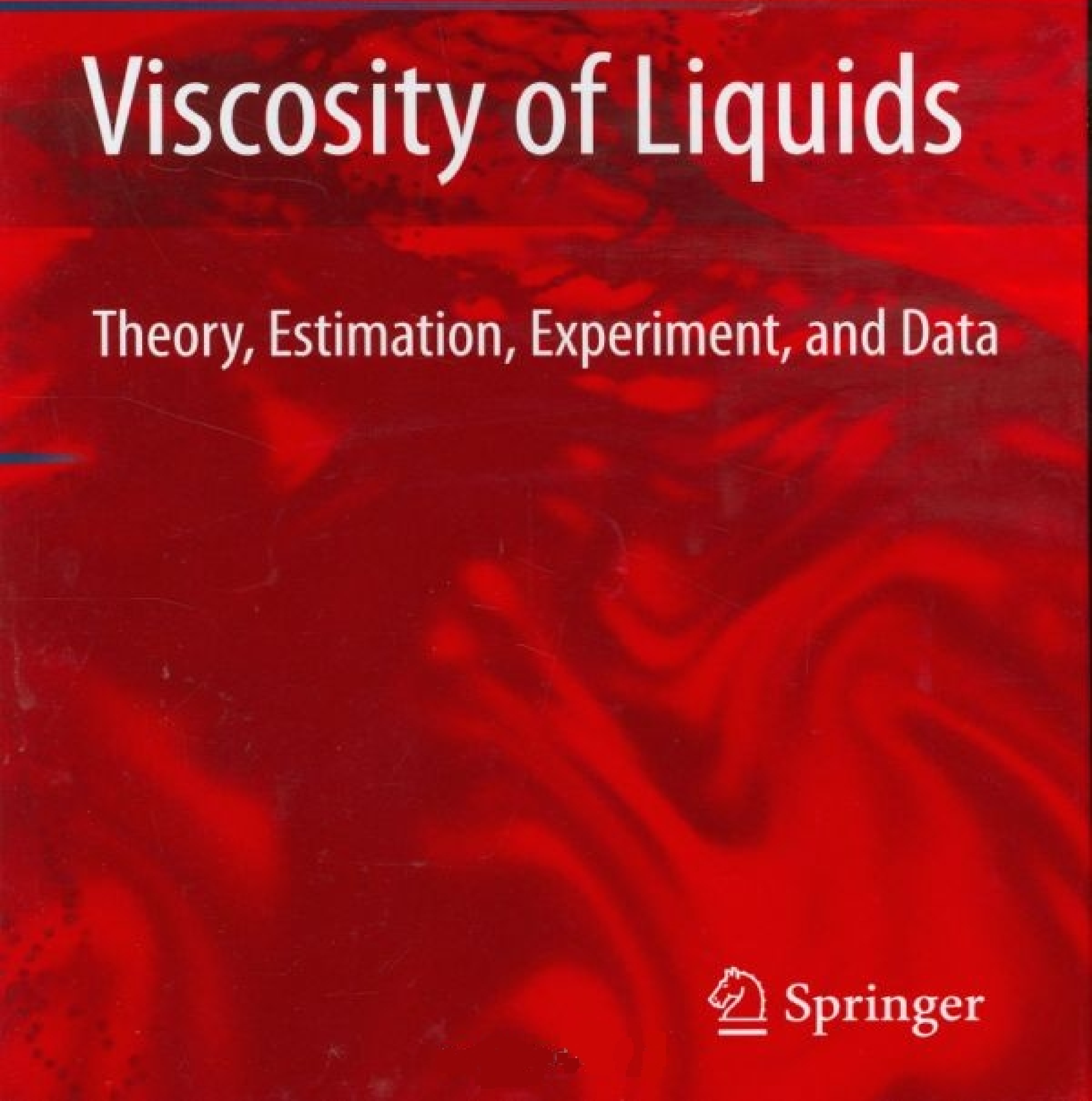
Dabir S. Viswanath
Tushar K. Ghosh
Dasika. H. L. Prasad
Nidamarty V. K. Dutt
Kalipatnapu Y. Rani

Viscosity of Liquids

Theory, Estimation, Experiment, and Data



Springer

VISCOSITY OF LIQUIDS

Viscosity of Liquids

Theory, Estimation, Experiment, and Data

by

DABIR S. VISWANATH
University of Missouri, Columbia, MO, U.S.A.

TUSHAR K. GHOSH
University of Missouri, Columbia, MO, U.S.A.

DASIKA H. L. PRASAD
Indian Institute of Chemical Technology, Hyderabad, India

NIDAMARTY V. K. DUTT
Indian Institute of Chemical Technology, Hyderabad, India

and

KALIPATNAPU Y. RANI
Indian Institute of Chemical Technology, Hyderabad, India

Springer

A C.I.P. Catalogue record for this book is available from the Library of Congress.

ISBN-10 1-4020-5481-5 (HB)
ISBN-13 978-1-4020-5481-5 (HB)
ISBN-10 1-4020-5482-3 (e-book)
ISBN-13 978-1-4020-5482-2 (e-book)

Published by Springer,
P.O. Box 17, 3300 AA Dordrecht, The Netherlands.

www.springer.com

Printed on acid-free paper

Contents

Preface

The need for properties is ever increasing to make processes more economical. A good survey of the viscosity data, its critical evaluation and correlation would help design engineers, scientists and technologists in their areas of interest. This type of work assumes more importance as the amount of experimental work in collection and correlation of properties such as viscosity, thermal conductivity, heat capacities, etc has reduced drastically both at the industry, universities, and national laboratories.

One of the co-authors, Professor Viswanath, co-authored a book jointly with Dr. Natarajan "Data Book on the Viscosity of Liquids" in 1989 which mainly presented collected and evaluated liquid viscosity data from the literature. Although it is one of its kinds in the field, Prof. Viswanath recognized that the design engineers, scientists and technologists should have a better understanding of theories, experimental procedures, and operational aspects of viscometers. Also, rarely the data are readily available at the conditions that are necessary for design of the equipment or for other calculations. Therefore, the data must be interpolated or extrapolated using the existing literature data and using appropriate correlations or models. We have tried to address these issues in this book.

Although Prof. Viswanath had a vision of writing a book addressing the above issues, he never got to a point when he could sit for long hours, days, and months to undertake this challenge. During one of his visits to India, a former student and colleague, Dr. D. H. L. Prasad expressed his desire to work with Prof. Viswanath to bring this book to reality. Thus the journey began and started adding more collaborators to this effort.

Dr. Prasad was instrumental in putting together the framework for this book. His efforts were further supported by Dr. Dutt, Dr. Rani and Professor Ghosh.

Dabir S. Viswanath
Tushar K. Ghosh
Dasika H. L. Prasad
Nidamarty V. K. Dutt
Kalipatnapu Y. Rani

Acknowledgments

Dabir Viswanath takes great pleasure in thanking his family, colleagues, and friends who helped him in this task. With out their patience and understanding he could not have ventured on this journey. I sincerely thank Dr. Prasad for starting this journey and Professor Ghosh in bringing this journey to a successful completion by spending countless hours on this book.

Tushar Ghosh thanks his wife Mahua for her patience and understanding during writing this book. He also thanks his son Atreyo and daughter Rochita for their understanding, patience and help in their own capacity during writing and proof reading the manuscript.

Prasad is grateful to Dr. K.V. Raghavan and Dr. J.S. Yadav who headed the Indian Institute of Chemical Technology at the time of carrying out this activity for their encouragement and support, other friends and colleagues, wife Vijaya, daughter Jayadeepti and son Ravinath for their role.

Dutt wishes to place on record the encouragement and support received from his wife Anuradha and friends.

Yamuna Rani would like to thank Dr. D.H.L. Prasad for incorporating her participation into this venture, and also thanks Dr. M. Ramakrishna and Dr. K.V. Raghavan for permitting it. She also thanks the other co-authors for bearing with her and her family and friends for support.

The authors would like to thank their graduate student Mr. Rajesh Gutti for his help in formatting the manuscript.

Chapter 1

INTRODUCTION

1.1 GENERAL INFORMATION

Viscosity is a fundamental characteristic property of all liquids. When a liquid flows, it has an internal resistance to flow. Viscosity is a measure of this resistance to flow or shear. Viscosity can also be termed as a drag force and is a measure of the frictional properties of the fluid. Viscosity is a function of temperature and pressure. Although the viscosities of both liquids and gases change with temperature and pressure, they affect the viscosity in a different manner. In this book, we will deal primarily with viscosity of liquids and its change as a function of temperature.

Viscosity is expressed in two distinct forms:

a. Absolute or dynamic viscosity
b. Kinematic viscosity

Dynamic viscosity is the tangential force per unit area required to slide one layer (*A*) against another layer (*B*) as shown in Figure 1.1 when the two layers are maintained at a unit distance. In Figure 1.1, force *F* causes layers *A* and *B* to slide at velocities v_1 and v_2, respectively.

Since the viscosity of a fluid is defined as the measure of how resistive the fluid is to flow, in mathematical form, it can be described as:

Shear stress = η (Strain or shear rate)

where η is the dynamic viscosity.

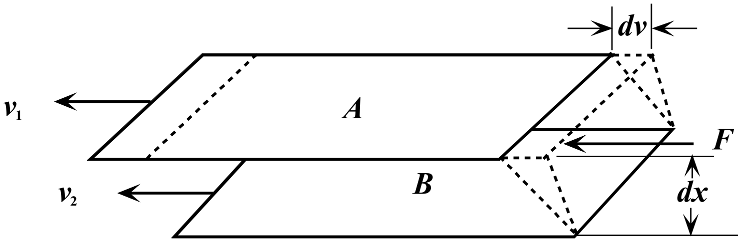


Figure 1.1. Simple shear of a liquid film.

If σ is shear stress and $\dot{e}$ is strain rate, then the expression becomes:

$$\sigma = \eta \dot{e} \tag{1.1}$$

The strain rate is generally expressed as

$$\dot{e} = \frac{1}{x}\frac{dx}{dt} = \frac{v}{x} \tag{1.2}$$

where x is the length, t is the time, and dx/dt is the velocity v. Therefore, the dynamic viscosity can be written as

$$\eta = \sigma \frac{x}{v} \tag{1.3}$$

Kinematic viscosity requires knowledge of density of the liquid (ρ) at that temperature and pressure and is defined as

$$\upsilon = \frac{\eta}{\rho}. \tag{1.4}$$

1.2 VISCOSITY UNITS AND CONVERSION

Common units for viscosity are poise (P), Stokes (St), Saybolt Universal Seconds (SSU) and degree Engler.

Centipoise (cP) is the most convenient unit to report absolute viscosity of liquids. It is 1/100 of a Poise. (The viscosity unit Poiseuille, in short Poise was named after French physician, Jean Louis Poiseuille (1799 - 1869)).

In the SI System (*Système International d'Unités*) the dynamic viscosity units are N·s/m^2, Pa·s or kg/m·s where N is Newton and Pa is Pascal, and, 1 Pa·s = 1 N·s/m^2 = 1 kg/m·s

The dynamic viscosity is often expressed in the metric system of units called CGS (centimeter-gram-second) system as g/cm·s, dyne·s/cm^2 or poise (P) where,

1 poise = dyne·s/cm^2 = g/cm·s = 1/10 Pa·s

In British system of units, the dynamic viscosity is expressed in lb/ft·s or lbf·s/ft^2. The conversion factors between various dynamic viscosity units are given in Table 1.1 and that for kinematic viscosity units are listed in Table 1.2.

For the SI system, kinematic viscosity is reported using Stokes (St) or Saybolt Second Universal (SSU) units. The kinematic viscosity is expressed as m^2/s or Stokes (St), where 1 St = 10^{-4} m^2/s. Stokes is a large unit, and it is usually divided by 100 to give the unit called **Centistokes** *(cSt)*.

1 St = 100 cSt.

1 cSt = 10^{-6} m^2/s

The specific gravity of water at 20.2°C (68.4°F) is one, and therefore the kinematic viscosity of water at 20.2°C is 1.0 cSt.

Saybolt Universal Seconds (SUS) is defined as the efflux time in Saybolt Universal Seconds (SUS) required for 60 milliliters of a petroleum product to flow through the calibrated orifice of a Saybolt Universal viscometer, under a fixed temperature, as prescribed by test method ASTM D 88[1]. This is also called the SSU number (Seconds Saybolt Universal) or SSF number (Saybolt Seconds Furol).

Degree Engler is used in Great Britain for measuring kinematic viscosity. The Engler scale is based on comparing a flow of a fluid being tested to the flow of another fluid, mainly water. Viscosity in Engler degrees is the ratio of the time of flow of 200 cm^3 of the fluid whose viscosity is being measured to the time of flow of 200 cm^3 of water at the same temperature (usually 20°C but sometimes 50°C or 100°C) in a standardized Engler viscosity meter.

Table 1.1. Conversion factors between various dynamic viscosity units.

Multiply by	To						
From	Poiseuille (Pa.s)	Poise (dyne.s/cm^2 = g/cm.s)	centipoise	kg/m.h	lb$_f$.s/ft^2	lb/ft.s	lb/ft.h
Poiseuille (Pa.s)	1	10	10^3	3.63×10^3	2.09×10^{-2}	0.672	$2.42\ 10^3$
Poise (dyne.s/cm^2 = g/cm.s)	0.1	1	100	360	2.09×10^{-3}	6.72×10^{-2}	242
centipoise	0.001	0.01	1	3.6	2.9×10^{-5}	6.72×10^{-4}	2.42
kg/m.h	2.78×10^{-4}	2.78×10^{-3}	2.78×10^{-1}	1	5.8×10^{-6}	1.87×10^{-4}	0.672
lb$_f$.s/ft^2	47.9	479	4.79×10^4	1.72×10^5	1	32.2	1.16×10^5
lb/ft.s	1.49	14.9	1.49×10^3	5.36×10^3	3.11×10^{-2}	1	3.6×10^3
lb/ft.h	4.13×10^{-4}	4.13×10^{-3}	0.413	1.49	6.62×10^{-6}	2.78×10^{-4}	1

Table 1.2. Conversion factors between various kinematic viscosity units.

Multiply by	To					
From	Stokes	CentiStokes	m^2/s	m^2/h	ft^2/s	ft^2/h
Stokes	1	100	1.00×10^{-4}	3.60×10^{-1}	1.076×10^{-3}	3.875969
CentiStokes	0.01	1	1.00×10^{-6}	3.60×10^{-3}	1.08×10^{-5}	0.03876
m^2/s	1.00×10^{4}	1.00×10^{6}	1	3.60×10^{3}	1.08×10^{1}	3.88×10^{4}
m^2/h	2.78	2.78×10^{2}	2.78×10^{-4}	1	2.99×10^{-3}	1.08×10^{1}
ft^2/s	929.0	9.29×10^{4}	9.29×10^{-2}	3.34×10^{2}	1	3.60×10^{3}
ft^2/h	0.258	25.8	2.58×10^{-5}	9.28×10^{-2}	2.78×10^{-4}	1

1.3 FLUID FLOW AND VISCOSITY

Liquid viscosities are needed by process engineers for quality control, while design engineers need the property for fixing the optimum conditions for the chemical processes and operations as well as for the determination of the important dimensionless groups like the Reynolds number and Prandtl number. Liquid viscosity is also important in the calculation of the power requirements for the unit operations such as mixing, pipeline design, pump characteristics, atomization (liquid droplets), storage, injection, and transportation.

The flow characteristics of liquids are mainly dependent on the viscosity and are broadly divided into three categories:

a) Newtonian
b) Time independent Non-Newtonian, and
c) Time dependent Non-Newtonian.

When the viscosity of a liquid remains constant and is independent of the applied shear stress, such a liquid is termed a Newtonian liquid.

In the case of the non-Newtonian liquids, viscosity depends on the applied shear force and time. For time independent non-Newtonian fluid, when the shear rate is varied, the shear stress does not vary proportionally and is shown in Figure 1.2. The most common types of time independent non-Newtonian liquids include psuedoplastic (This type of fluid displays a decreasing viscosity with an increasing shear rate and sometimes called shear-thinning), dilatant (This type of fluid display increasing viscosity with an increase in shear rate and is also called shear-thickening), and Bingham plastic (A certain amount of force must be applied to the fluid before any flow is induced). Bingham plastic is somewhat idealized representation of many real materials, for which the rate of shear is zero if the shearing stress is less than or equal to a yield stress e_o. Otherwise, it is directly proportional to the shearing stress in excess of the yield stress.

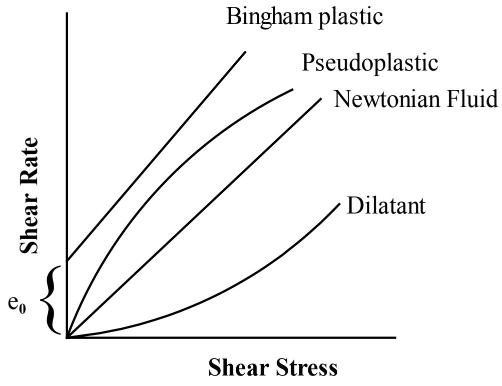
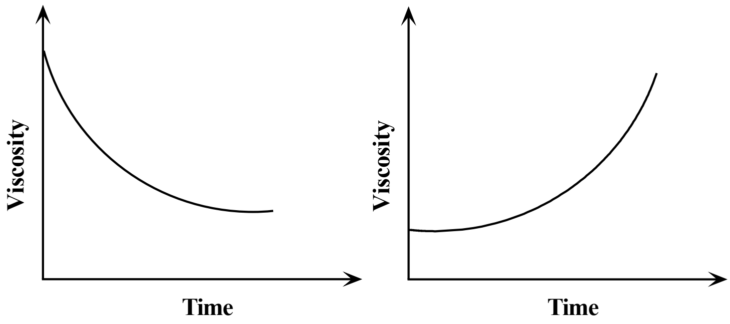


Figure 1.2. Various types of fluids based on viscosity.

Time dependent non-Newtonian fluids display a change in viscosity with time under conditions of constant shear rate. One type of fluid called Thixotropic undergoes a decrease in viscosity with time as shown in Figure 1.3a. The other type of time dependent non Newtonian fluid is called Rheopectic. The viscosity of rheopexic fluids increases with the time as it is sheared at a constant rate (See Figure 1.3b).



a) Thixotropic fluid

b) Rheopectic fluid

Figure 1.3. Change in Viscosity of time-dependent non-Newtonian fluids.

These as well as several other considerations, including attempts to understand interactions among different molecules, have resulted in a very large number of experimental, theoretical and analytical investigations in the areas related to viscosity. In this book, we will discuss both theory for estimation of viscosity and various measurement techniques.

A brief description of the material dealt in each chapter is given below.

Chapter 2 describes the general methodology of the experimentation and the techniques commonly used to measure viscosity with the essential details.

Chapter 3 is devoted to the description of the development of the theories of liquid viscosity.

Chapter 4 gives an account of the commonly used methods for the correlation and estimation of pure liquid viscosity.

Chapter 5 mentions the commonly used methods for the correlation and estimation of the viscosity of solutions and mixtures.

Chapter 6 provides the viscosity-temperature data for more than 1,000 liquids collected from literature sources. The data were evaluated by the authors and are provided in tabular form. The data have been correlated to three equations, and the goodness of fit is discussed.

REFERENCE

1. ASTM (American Society for Testing and Materials) D 88, *Standard Test Method for Saybolt Viscosity*.

Chapter 2

VISCOMETERS

The measurement of viscosity is of significant importance in both industry and academia. Accurate knowledge of viscosity is necessary for various industrial processes. Various theories that are developed for prediction or estimation of viscosity must be verified using experimental data. Instruments used to measure the viscosity of liquids can be broadly classified into seven categories:

1. Capillary viscometers
2. Orifice viscometers
3. High temperature high shear rate viscometers
4. Rotational viscometers
5. Falling ball viscometers
6. Vibrational viscometers
7. Ultrasonic viscometers

A number of viscometers are also available that combine features of two or three types of viscometers noted above, such as Friction tube, Norcross, Brookfield, Viscosity sensitive rotameter, and Continuous consistency viscometers. A number of instruments are also automated for continuous measurement of viscosity and for process control. Several apparatus named after pioneers in the subject as well manufactured by popular instrument manufacturers are available for each of the classes.

2.1 CAPILLARY VISCOMETERS

Capillary viscometers are most widely used for measuring viscosity of Newtonian liquids. They are simple in operation; require a small volume of sample liquid, temperature control is simple, and inexpensive. In capillary viscometers, the volumetric flow rate of the liquid flowing through a fine bore (capillary) is measured, usually by noting the time required for a known volume of liquid to pass through two graduation marks. The liquid may flow through the capillary tube either under the influence of gravity (Gravity Type Viscometer) or an external force. In the instruments where an external force is applied, the liquid is forced through the capillary at a predetermined rate and the pressure drop across the capillary is measured. Capillary viscometers are capable of providing direct calculation of viscosity from the rate of flow, pressure and various dimensions of the instruments. However, most of the capillary viscometers must be first calibrated with one or more liquids of known viscosity to obtain "constants" for that particular viscometer.

The essential components of a capillary viscometer are

1. a liquid reservoir,
2. a capillary of known dimensions,
3. a provision for measuring and controlling the applied pressure,
4. a means of measuring the flow rate, and
5. a thermostat to maintain the required temperature.

Several types of capillary viscometers have been designed through variation of above components, and commercially available capillary viscometers can be classified into the following three categories based on their design.

1. Modified Ostwald viscometers,
2. Suspended-level viscometers, and
3. Reverse-flow viscometers.

Glass capillary viscometers are most convenient for the determination of the viscosity of Newtonian liquids. Often the driving force is the hydrostatic head of the test liquid itself. Kinematic viscosity is generally measured using these viscometers. The same principles can also be applied to measure the viscosity of Non-Newtonian liquids, however an external pressure will be necessary to make the Non-Newtonian liquid flow through the capillary. Glass capillary viscometers are low shear-stress instruments. Usually the shear stress ranges between 10 and 150 dyn/cm^2 if operated by gravity only and 10 to 500 dyn/cm^2 if an additional pressure is applied. The rate of shear in glass capillary viscometers ranges from 1 to 20,000 s^{-1} (based on 200 to 800 s efflux time).

2.1.1 THEORY

The calculation of viscosity from the data measured using glass capillary viscometers is based on Poiseuille's equation. In this section, first the derivation of Poiseuille's equation is discussed and then various corrections made to this equation are explained.

Consider a cylindrical capillary of diameter a and length l, as shown in Fig. 2.1, with a pressure difference ΔP between the ends. P_1 and P_2 are pressures at two ends and the fluid is subjected to a force F.

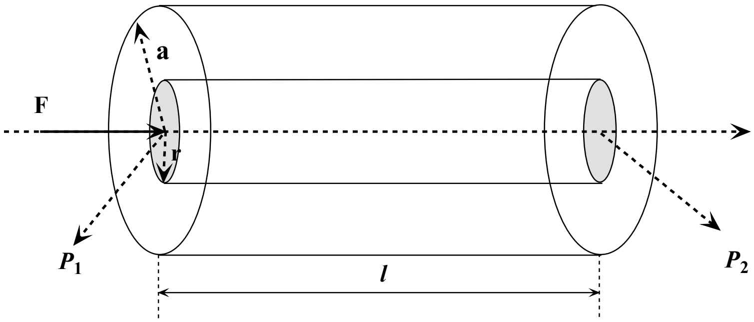


Figure 2.1. Derivation of Poiseuille's equation.

The following assumptions are made to derive Poiseuille's equation.

1. The flow is parallel to the axis of the tube everywhere, i.e., streamline flow is followed.
2. The flow is steady and there is no acceleration of the liquid at any point within the tube.
3. There is no slip at the wall, i.e., the liquid is stationary at the capillary wall.
4. The liquid is a Newtonian liquid.

Since the liquid is Newtonian, the following relationship holds.

$$\sigma = \eta \dot{e} = \eta \frac{dv}{dr} \tag{2.1}$$

In Eq. 2.1,

σ is shear stress,

$\dot{e}$ is strain rate,
η is dynamic viscosity,
v is the velocity, and
r is any distance from the center of the capillary.

A force balance on the cylindrical element of length l and radius r coaxial with the capillary provides the following expression.

$$\sigma \times 2\pi r l = \Delta P \times \pi r^2 \tag{2.2}$$

Substitution of Eq. (2.1) into Eq. (2.2) yields

$$\frac{dv}{dr} = \frac{\Delta P}{2\eta l} r \tag{2.3}$$

Integration of Eq. (2.3), using the boundary condition that at the wall of the capillary $v(a) = 0$, gives

$$v = \frac{\Delta P\left(a^2 - r^2\right)}{4\eta l} \tag{2.4}$$

It may be noted from Eq. (2.4) that the velocity distribution across the capillary is parabolic. The volumetric flow rate through the capillary can be calculated by noting that in unit time between radii r and $r+dr$ the volume of liquid flowing is given by $2\pi r v\, dr$. The overall flow rate (Q cm^3/s) can be obtained by integrating the following expression.

$$Q = \int_0^a 2\pi r v\, dr \tag{2.5}$$

Substitution of Eq. 2.4 into Eq. 2.5 yields

$$Q = \int_0^a \frac{2\pi \Delta P}{4\eta l} r\left(a^2 - r^2\right) dr = \frac{2\pi \Delta P}{4\eta l} \int_0^a r\left(a^2 - r^2\right) dr \tag{2.6}$$

or,

$$Q = \frac{\pi \Delta P a^4}{8\eta l} \tag{2.7}$$

This is known as Poiseuille's equation and is used for calculation of viscosity when using a capillary viscometer. For vertical tube arrangement which is the case for most of the capillary viscometer, the hydrostatic pressure, ρgh, depends on the height, *h*, of the liquid. Therefore, the pressure difference, Δp, in terms of hydrostatic pressure is given by

$$\Delta P = \rho gh \tag{2.8}$$

It should be noted that *h* is a function of time. Substitution of Eq. 2.8 into Eq. 2.7 and further rearrangement provides the expression for viscosity (η).

$$\eta = \frac{\pi\, g\, h\, a^4}{8 l V} \rho t \tag{2.9}$$

where,

> $Q = {}^{V}\!/_{t}$ (*V* is the defined volume of the liquid dispensed during the experiment and *t* is the time required for this volume of liquid to flow between two graduation marks in a viscometer).

For a particular viscometer, Eq. 2.9 can be rewritten as

$$\eta = K \rho t \tag{2.10}$$

where *K* is a constant for a viscometer and is given by

$$K = \frac{\pi\, g\, h\, a^4}{8 l V} \tag{2.11}$$

Equation 2.10 can be used to obtain the kinematic viscosity

$$\upsilon = K\, t \tag{2.12}$$

where

$$\upsilon = \frac{\eta}{\rho} \tag{2.13}$$

A number of viscometers are designed based on Eq. 2.12. The equipment is calibrated for the value of *K*, which is obtained by using a liquid of known viscosity and density. Once the value of *K* is known, the viscosity of test liquid can be obtained by measuring the time required for a known volume of sample to flow between two graduation marks.

2.1.1.1 Kinetic Energy Corrections

A number of factors can influence the experiment and introduce errors in the measurements. To improve the accuracy of the measurement, various corrections are made to the experimentally determined data. Among these corrections, kinetic energy and end effect corrections are most significant. In most types of viscometers, a portion of the applied force is converted to kinetic energy that sets the liquid into motion. However, as Poiseuille's equation is strictly for flow of fluid with parabolic velocity profile, a correction to Poiseuille's equation is necessary to account for the pressure used in overcoming viscous resistance.

The work done due to the kinetic energy transferred to the liquid per unit time may be expressed as

$$W_{KE} = \int_0^a \frac{1}{2} v^2 \, 2\pi r \rho v \, dr \tag{2.14}$$

Substitution of Eq. 2.4 into Eq. 2.14 yields

$$W_{KE} = \int_0^a \pi \rho \frac{\Delta P^3}{4^3 \eta^3 l^3} \left(a^2 - r^2\right)^3 r \, dr \tag{2.15}$$

Integration of Eq. 2.15 and subsequent substitution of Eq. 2.8 provides

$$W_{KE} = \frac{\rho Q^3}{\pi^2 a^4} \tag{2.16}$$

Therefore, the work done against the viscous force is given by

$$W_{vis} = PQ - \frac{\rho Q^3}{\pi^2 a^4} \tag{2.17}$$

The effective pressure difference, then, can be written as

$$\Delta P_{eff} = P - \frac{\rho Q^2}{\pi^2 a^4} \tag{2.18}$$

Several viscometers make this correction for kinetic energy by connecting a reservoir to both ends of the capillary. However, several researchers noted that still some correction is necessary. As noted by Dinsdale and Moore[1], the correction term takes the form:

$$\Delta P_{eff} = P - m\frac{\rho Q^2}{\pi^2 a^4} \tag{2.19}$$

where *m* is a constant which is determined experimentally.

2.1.1.2 End Corrections

The converging and diverging streamlines at the entrance and exit of the capillary must be taken into consideration for accurate estimation of viscosity from capillary viscometers. Couette first suggested increasing the capillary length *l* by *na* to take into account the end effects. The Poiseuille's equation after correcting for kinetic energy and end effects can be written as

$$\eta = \frac{\pi a^4 P}{8Q(l + na)} - \frac{m\rho Q}{8\pi(l + na)} \tag{2.20}$$

The values of *n* varied between 0 and 1.2. Equation 2.20 can be written in terms of time as follows:

$$\eta = \frac{\pi a^4 Pt}{8V(l + na)} - \frac{m\rho V}{8\pi t(l + na)} \tag{2.21}$$

Equation 2.21 for relative viscometers may be written as

$$\eta = \alpha Pt - \beta \rho t \tag{2.22}$$

The constants α and β are determined from the experimental data using three or four liquids of known viscosity.

Equation 2.21 for gravity flow type viscometers becomes

$$\upsilon = A t - \frac{B}{t} \tag{2.23}$$

The constants A and B are also determined from the experimental data using three or four liquids of known viscosity.

Descriptions of various capillary viscometers along with the experimental procedures are described below.

2.1.2 OSTWALD VISCOMETER

The most common design of gravity type viscometer is the U-tube type and best known as the Ostwald viscometer. It consists of two reservoir bulbs and a capillary tube as shown in Fig. 2.2.

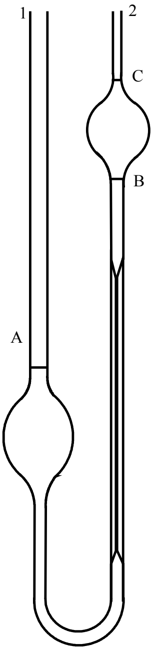


Figure 2.2. An Ostwald viscometer.

The efflux time (t) of a fixed volume of liquid under an exactly reproducible mean hydrostatic head is measured. The viscometer is filled with the liquid until the liquid level reaches the mark A. Usually a pipette is used to accurately measure the volume of liquid added to the viscometer. The viscometer is then placed inside a constant temperature bath to equilibrate the temperature of the test liquid with the bath temperature. The liquid is drawn through the side 2 of the U-tube using a suction and then the flow is timed between marks C and B. The viscosity is calculated using Eq. 2.12. The constant K is determined from the measurement of reference liquid such as water.

Ostwald type viscometers can cause significant error in the measurement if the viscometer is not vertical in alignment. If the distance between the two sides (1 and 2) of the viscometer is s, a tilt of θ from the vertical position can introduce a relative error in the hydrostatic head h by

$$\Delta h_{error} = 1 - \cos\theta \pm \left(\frac{s}{h}\right)\sin\theta \qquad (2.24)$$

It follows from Eq. 2.24 that if s is $0.6h$, 1° deviation from vertical axis will introduce 1% error in the head.

Another source of error in Ostwald viscometer is the requirement to use exact volume of liquid for the reference liquid and the test liquid. This requirement becomes further problematic if the measurements are made at different temperatures. The accurate knowledge of density is necessary to adjust the volume at different test temperatures.

2.1.3 MODIFIED OSTWALD VISCOMETERS

Several modifications to the original design of Ostwald viscometer was made to address these issues and are discussed below. Modified Ostwald viscometers can be divided into two categories.

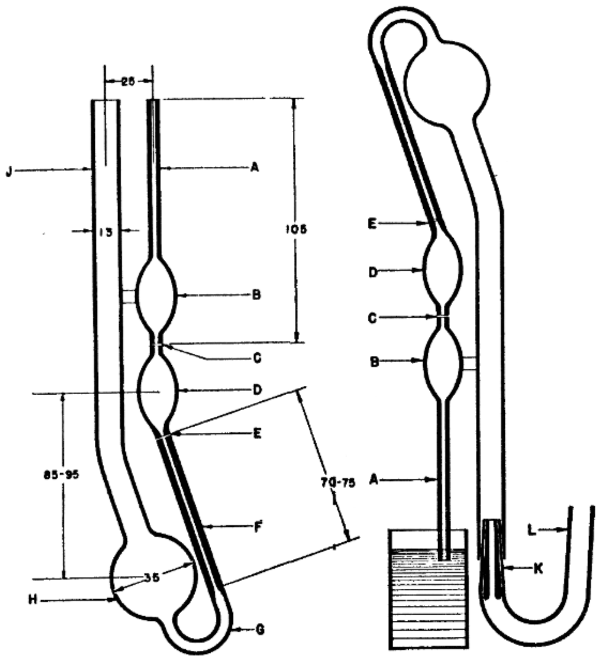
a. Constant volume viscometer at filling temperature
    a. Cannon-Fenske routine viscometer
    b. Cannon Manning semi-micro viscometer
    c. Pinkevitch viscometer
b. Constant volume at the test temperatre
    a. Zeitfuchs viscometer
    b. SIL viscometer
    c. BS/U-tube viscometer
    d. BS/U-tube miniature viscometer

2.1.3.1 Cannon-Fenske Routine Viscometer

Ostwald viscometer is modified by Cannon and Fenske[2,3] in such a manner that the upper bulb (Bulb *B*) and lower bulb (Bulb *D*) lie in the same vertical axis in order to reduce the error in the mean head caused by the deviation of the viscometer from the vertical position. A schematic drawing of a Cannon-Fenske Routine viscometer of Size 25 is shown in Fig. 2.3. The Cannon-Fenske routine viscometers are designed for measuring the kinematic viscosity of transparent Newtonian liquids in the range of 0.5 to 20,000 cSt (mm^2/s). The Cannon-Fenske viscometers can also be used to measure shear stress versus shear rate relations that is useful to the study of non-Newtonian liquids, wax crystallization, and oil flow characteristics at low temperatures.

Cannon-Fenske Routine viscometer that is used to measure viscosity of transparent liquids is based on standard ASTM D-445 and D-446 and ISO 3104 and 3105 methods. The general procedure for using a Cannon-Fenske Viscometer is discussed below. Before any measurement, the viscometer must be cleaned using a suitable solvent or solvents. Although it is desirable to dry the viscometer by passing clean, dry, filtered air through the instrument to remove the final traces of solvents, filtered air may not be readily available in laboratories. In that case, the viscometer may be given a final rinse with acetone and then dried in an oven. The viscometer should be periodically cleaned with acid to remove trace deposits that might occur due to repeated use. One of the best acids for cleaning glasses is chromic acid. It is also advisable to filter the liquid sample to remove solid suspensions before filling the viscometer.

The viscometer shown in Figs. 2.3a and 2.3b depicts the arrangement convenient for filling the apparatus. The sample is drawn into the apparatus by inserting the tube *A* in the inverted position into the liquid (free from air bubbles) kept in a beaker and liquid is drawn applying suction to the arm as shown in Fig. 2.3a, through bulbs *B* and *D* up to the etched mark *E*. The viscometer is turned to its normal position, wiped carefully, inserted into a holder and placed in a thermostat. The viscometer is aligned vertically in the bath by means of a small plumb bob in tube *G*, if a self-aligning holder is not used. After reaching the equilibrium conditions at the required temperature, suction is applied to tube *A*, to bring the sample in to bulb *D* and allowed to reach a point slightly above mark *C*. The time required for the liquid meniscus to pass from the mark at *C* to mark *E* is recorded. The measurement should be repeated several times and the average time of all the runs should be used in the calculation of kinematic viscosity, which is obtained by multiplying the efflux time in seconds by the viscometer constant. If the efflux time observed is less than 200s, the observation should be repeated with another viscometer with a smaller capillary.



(a) Dimensional sketch of size 25 (b) Method of filling

Figure 2.3. Cannon-Fenske Routine viscometer of Size 25 shown with the dimensions in millimeters and its filling procedure.

A single viscometer is not capable of measuring the viscosity over the entire range. The main limitation is the size of the capillary *F*. Table 2.1 lists the range for measuring viscosity using various size Cannon-Fenske Routine viscometers.

2.1.3.2 Cannon-Manning Semi-micro Viscometer

The Cannon-Manning Semi-Micro viscometer is a modified Ostwald type model requiring approximately 1 mL of the sample and is capable of measuring the kinematic viscosity of transparent Newtonian liquids in the same range of 0.4 to 20,000 cSt as that of Cannon-Fenske Routine viscometer[4]. The apparatus is shown in Fig. 2.4.

Table 2.1. Kinematic viscosity range of various size Cannon-Fenske Routine viscometers.

Viscometer Size	***Kinematic Viscosity Range, mm^2/s***	***Diameter of Capillary Tube, F, mm* (±2%)**
25	0.5 – 2 *	0.30
50	0.8 – 4	0.44
75	1.6 – 8	0.54
100	3 – 15	0.63
150	7 – 35	0.78
200	20 – 100	1.01
300	50 – 250	1.27
350	100 – 500	1.52
400	240 – 1,200	1.92
450	500 – 2,500	2.35
500	1,600 – 8,000	3.20
600	4,000 – 20,000	4.20

*: Minimum flow time is 250 s. Minimum Flow time for other size viscometers is 200 s.

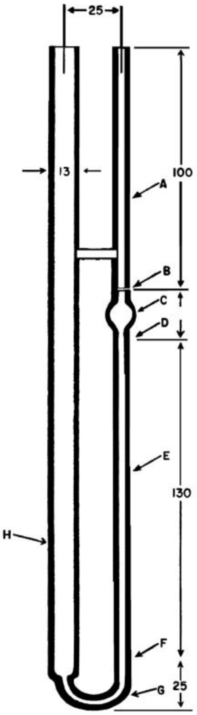


Figure 2.4. A Cannon-Manning Semi-Micro viscometer of size 25 for measuring viscosity of transparent liquid (Modified from ASTM D446-04, American Society for Testing and Materials International, West Conshohocken, PA, USA).

Cannon-Manning Semi-Micro viscometer may be modified by including another timing bulb on the top for measuring viscosity for opaque liquids. The apparatus is charged with the liquid by inverting the instrument and applying suction to tube *H*, immersing tube *A* in the liquid. The liquid is drawn to the filling mark *F*. The apparatus is wiped and placed in the thermostat, in the vertical position. After the apparatus reaches equilibrium, suction is applied to tube *A* (pressure to tube *H*) and the liquid is drawn to a position slightly above the timing mark *B*. The suction is released and the efflux time is recorded. Cannon-Manning Semi-Micro viscometer is also available in different sizes based on the viscosity range. The size-number and the viscosity range are same as that given in Table 2.1 for Cannon-Fenske Routine viscometer.

2.1.3.3 Pinkevich Viscometer

The Pinkevich viscometer[5] is a modified form of Ostwald type viscometer used for the determination of the kinematic viscosity of transparent Newtonian liquids in the range of 0.6 to 17,000 cSt. A sketch of Pinkevich viscometer is presented in Fig. 2.5. The viscometer is made of transparent colorless heat resistant glass. The capillary should be straight without any bends, and unevenness and should have a constant internal diameter over its entire length. The joint between the capillary and the tubing should be such as to give a smooth transition without abrupt changes in the direction. The internal diameter of the neck between bulbs *B* and *D* should not be smaller than the capillary diameter. The ring marks should be clearly visible and in a plane perpendicular to the capillary. Ring mark *E* should be 3 mm below the conical end of the bulb *D*. Each viscometer must be etched with the diameter of the capillary and a serial number. Breakage of the lower U-shaped tube between the cylindrical and capillary tubes can be eliminated by the use of an elastic oil resistant hose connection between the tubes at the bottom and a clamping tube at the top. The capillary diameters are in the ranges from 0.4 mm (for 1 to 1.5 cSt) to 4 mm (for 2000 to 15,000 cSt). Minimum efflux time is to be 120 s.

A rubber tube is attached to the side outlet *H*. The top arm *G* is covered with a finger, the viscometer is inverted and arm *A* is inserted into the sample. The sample is sucked up to the ring mark *E*, using a suction bulb, water pump or any other means of creating vacuum. Care is taken to avoid air bubbles, separations, or films in arm *A* or bulbs *B* and *D*. When the sample reaches the ring mark *E*, the viscometer is removed from the sample and quickly inverted to the normal position. The rubber tube is removed and the viscometer is wiped carefully. The viscometer is placed in the thermostat and allowed to reach the required temperature. The rubber tube is connected to the top of the arm *A* and the sample is sucked up to a level slightly above the ring mark *C*. The suction is released and the time required by the liquid to pass between the marks *C* and *E* is noted. Pinkevich viscometers are also designated as their size number referring to various viscosity ranges. The size-number and the corresponding viscosity ranges are given in Table 2.2.

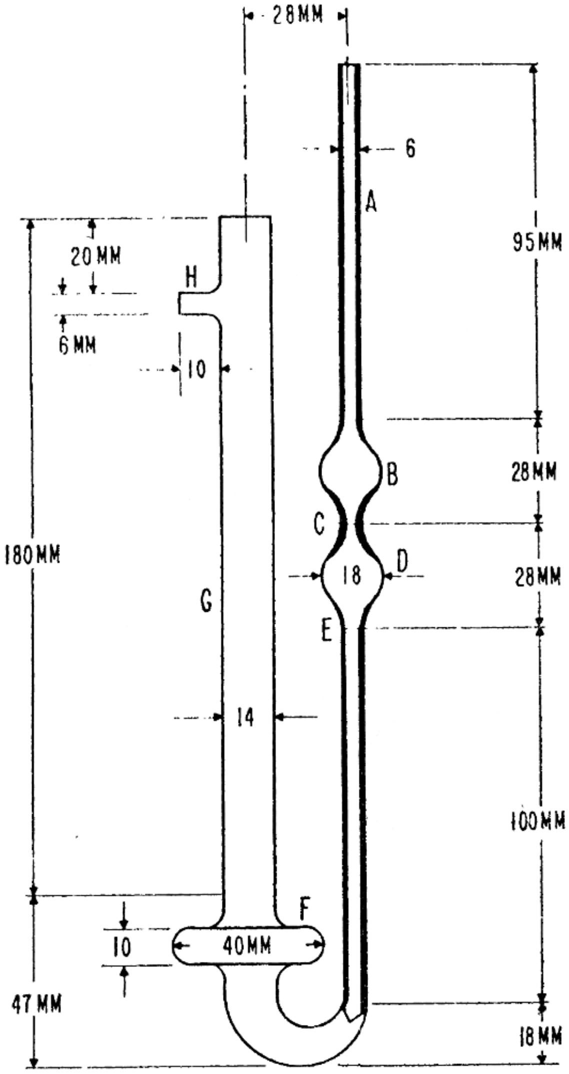


Figure 2.5. Pinkevich viscometer for transparent liquids. (Modified from ASTM D446-04, American Society for Testing and Materials International, West Conshohocken, PA, USA).

Table 2.2. The size-number and corresponding viscosity ranges of Pinkevich viscometers.

Size No	***Kinematic Viscosity Range, mm^2/s (cSt)***	***Diameter of the Capillary, mm***
0	0.6 – 1.7	0.40
1	1.7 – 8.5	0.60
2	5.4 – 27	0.80
3	13 – 65	1.00
4	28 – 140	1.20
5	70 – 350	1.50
6	200 – 1,000	2.00
7	520 – 2,600	2.50
8	1,060 – 5,300	3.00
9	1.980 – 9,900	3.50
10	3,400 – 17,000	4.00

2.1.3.4 Zeitfuchs Viscometer

Zeitfuchs viscometer[6-8] is normally used to measure the kinematic viscosity of Newtonian oils in the range of 0.6 to 3,000 cSt at temperatures between 50 and 250 ^{0}C. The constructional features shown in Fig. 2.6, enable cleaning, filling and measurement of the efflux time without removing the viscometer from the thermostat.

The apparatus is charged by pouring the test liquid into the filling tube 1, approximately to the filling line *D*. A screened funnel can be used to filter the sample before pouring into the viscometer. After the apparatus attains the desired temperature, the sample is drawn into the measuring bulb by partially opening the stop cock located over flow tube 2 that is under vacuum, and partially closing the vent to the atmosphere at the top of the capillary tube 3 with a finger. The excess liquid is allowed to flow into the over flow trap and thus to the trap provided in the vacuum line. When the liquid in the filling tube reaches a point 2 to 5 mm above the reference mark *C*, it is held at that level by alternately closing and opening the vent to the atmosphere. Finally, the working volume is adjusted by drawing the meniscus in the filling tube exactly to the mark *C*, making sure that the liquid completely fills the viscometer between the mark and the tip of the over flow. After the final adjustment of the working volume, the connection to the vacuum source is removed and the vent tube 3 is opened to the atmosphere to allow the flow of the liquid to the measuring bulb. The efflux time is carefully measured.

Zeitfuchs viscometer is available in seven sizes. The viscosity range is mainly determined by the size of the capillary of the tube. The viscosity range for different size viscometers is given in Table 2.3.

Table 2.3. Size number and viscosity range of Zeitfuchs viscometers.

Size No.	***Kinematic Viscosity Range, mm^2/s (cSt)***	***Diameter of the Capillary, mm (± 2%)***
1	0.6 – 3	0.42
2	2 – 10	0.59
3	6 – 30	0.78
4	20 – 100	1.16
5	60 – 300	1.54
6	200 – 1000	2.08
7	600 – 3000	2.76

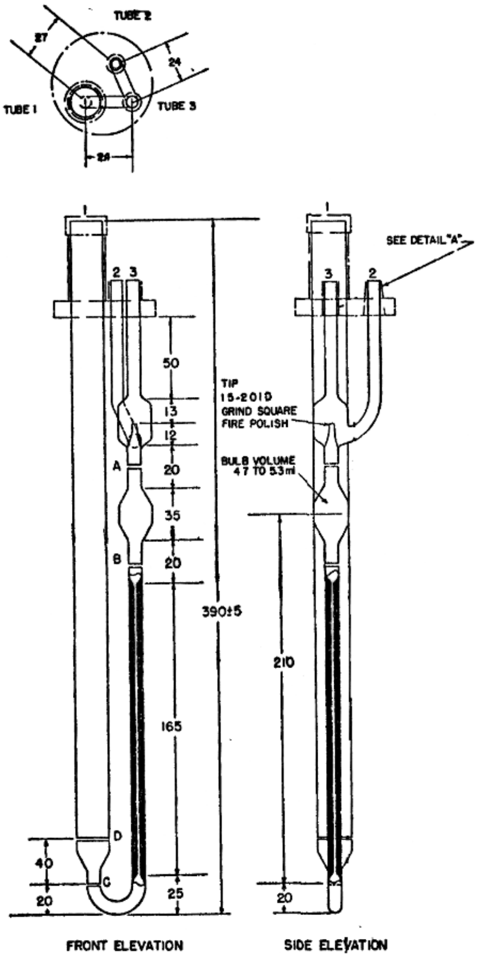


Figure 2.6. Zeitfuchs viscometer for measuring viscosity of transparent liquids.

2.1.3.5 SIL Viscometer

SIL viscometer[9] is useful for the determination of the kinematic viscosity of transparent Newtonian liquids in the range of 0.6 to 10,000 cSt. The special features include capability to minimize the effects of surface tension and better precision in terms of volume determination. Fig. 2.7 gives a schematic representation of the apparatus. The volume of the bulb changes with the range of viscosity to be studied and is: 3 mL for the range of 0.6 to 3 cSt, 4 mL for the range of 2 to 30 cSt, and 5 mL for the range of 20 to 20, 000 cSt. Generally, SIL viscometers are available in 8 sizes and their number and the corresponding viscosity range are given in Table 2.4.

The viscometer is charged by tilting it by about 30° from the vertical, with bulb *A* below the capillary. Enough sample is introduced into tube 1 to fill bulb *A* completely and for slight overflow into the gallery. The quantity of sample introduced should provide a level of liquid between 6 and 12 mm above the opening *D*, after the viscometer reaches the required temperature. The excess liquid from the gallery is removed by applying suction through tube 3. Time is allowed to ensure complete drainage of the liquid from the lower end of the capillary. A slight suction is applied to tube 2, until its upper meniscus reaches the middle of the bulb *C*. The suction is removed and the efflux time for the flow of liquid is noted.

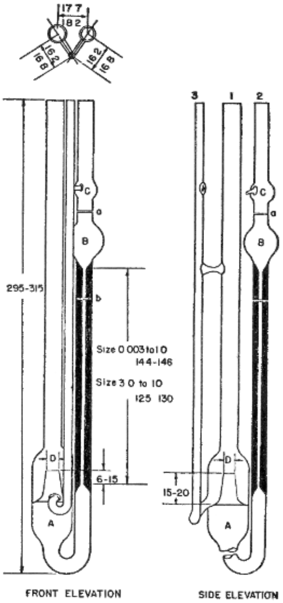


Figure 2.7. A SIL viscometer.

Table 2.4. Size number and viscosity range of SIL viscometers.

Size No.	***Kinematic Viscosity Range, mm^2/s (cSt)***	***Diameter of the Capillary, mm***
0C	0.6 – 3	0.41
1	2 – 10	0.61
1C	6 – 30	0.73
2	20 – 100	1.14
2C	60 – 300	1.50
3	200 – 1,000	2.03
3C	600 – 3,000	2.68
4	2,000 – 10,000	3.61

2.1.3.6 BSU-tube Viscometer

The BSU-tube viscometer is generally used when IP Method 71 is required[10]. The viscometer is useful for the determination of the kinematic viscosity in the range of 0.9 to 10,000 cSt. Fig. 2.8 presents the essential features of the apparatus.

The cleaned viscometer is placed in the thermostat, taking care to ensure that the capillary arm is vertical, as a deviation of 1^o from the vertical will introduce an error of approximately 0.2% in the measurement. The viscometer is charged with a slight excess of the filtered sample, by means of a long pipette to minimize the wetting of the tube above the filling mark *G*. The apparatus is allowed to attain the required temperature and the volume is adjusted to bring the liquid level to within 0.2 mL of the filling mark by applying suction. Once the desired temperature is attained, suction or pressure is applied to bring the liquid level up to a point about 1 cm above the timing mark *E*. The suction or pressure is removed and time required for the liquid to pass from the top edge of the mark *E* to the top edge of the mark *F* is noted. BSU viscometer is available in 8 sizes and their sizes are designated using letters and are given in Table 2.5.

Table 2-5. Size number and viscosity range of BSU-Tube viscometers.

Size No.	***Kinematic Viscosity Range, mm^2/s (cSt)***	***Capillary Diameter, mm (± 2%)***
A	0.9 – 3	0.50
B	2 – 10	0.71
C	6 – 30	0.88
D	20 – 100	1.40
E	60 – 300	2.00
F	200 – 1,000	2.50
G	600 – 3,000	4.00
H	2,000 – 10,000	6.10

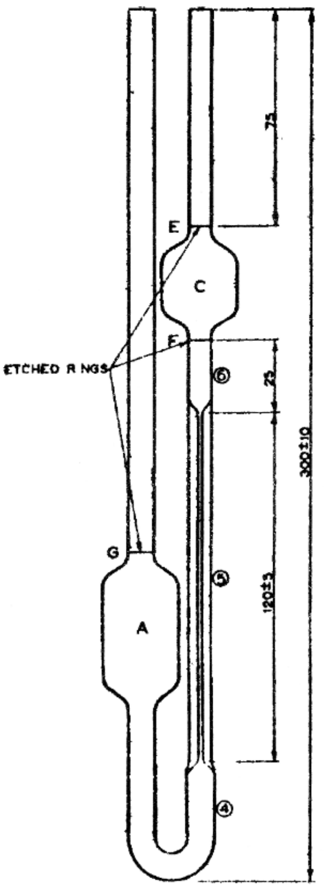


Figure 2.8. BSU-Tube viscometer for measuring viscosity of transparent liquid (Modified from ASTM D446-04, American Society for Testing and Materials International, West Conshohocken, PA, USA).

2.1.3.7 BSU-Miniature Viscometer

BSU-Miniature viscometer is designed to measure the kinematic viscosity in the range of 0.2 to 100 cSt. The basic design of the viscometer is same as that of the BSU viscometer shown in Fig 2.8. The diameter of the capillary tube ranges from 0.2 to 0.65 mm and the volume of the sample reservoir is fixed at 0.50 (± 5%) mL. BSU-Miniature viscometer is available in five sizes. Table 2.6 provides the kinematic viscosity range corresponding to the size number.

Table 2.6. Size number and viscosity range of BSU-Miniature Tube viscometers.

Size Number	***Kinematic Viscosity Range,*** ***mm^2/s (cSt)***	***Diameter of Capillary Tube,*** ***mm*** **(± 2%)**
M1	0.2 – 1	0.20
M2	1 – 5	0.30
M3	3 – 15	0.40
M4	8 – 40	0.50
M5	20 – 100	0.65

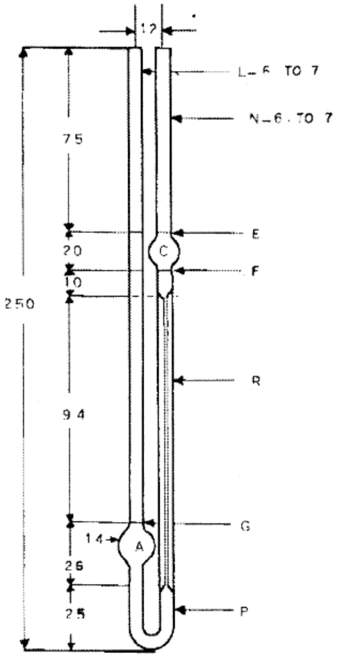


Figure 2.9. A BSU-Miniature Tube viscometer (Reproduced from ASTM D446-04 with permission of American Society for Testing and Materials International, West Conshohocken, PA, USA).

2.1.4 SUSPENDED LEVEL VISCOMETERS FOR TRANSPARENT LIQUID

In suspended level viscometers the test liquid is suspended in the capillary so that it becomes completely filled. The advantage of suspended level viscometers is that they ensure a uniform driving head of liquid independent of the quantity of sample charged into the viscometer. As a result, viscometer constant becomes independent of temperature. The effect of surface tension is greatly reduced by making the diameter of the lower meniscus approximately equal to the average diameter of the upper meniscus. The suspended level viscometers include the following types.

a. Ubbelohde
b. FitzSimons
c. Atlantic
d. Cannon-Ubbelohde
e. Cannon-Ubbelhode semi-micro
f. BS/IP/SL
g. BS/IP/SL(S)
h. BS/IP/MSL

2.1.4.1 Ubbelohde Viscometer

Ubbelohde suspended level viscometer[11,12], shown schematically in Fig. 2.10, is useful for the determination of the kinematic viscosity of transparent Newtonian liquids in the range of 0.3 to 100,000 cSt. A Ubbelohde viscometer possesses the same viscometer constant at all temperatures. This property is advantageous when measurements are to be made at a number of different temperatures. The liquid is induced to flow only down the walls of the bulb below the capillary, thus forming a suspended level, ensuring that the lower liquid level is automatically fixed and coincides with the lower end of the capillary, avoiding the need to fill the viscometer with a definite volume of the liquid and application of corrections for the expansion of glass due to changes in temperature.

The viscometer is charged by tilting the instrument by about 30°C from the vertical, with the bulb *A* below the capillary, by introducing the liquid into tube 1 up to the lower filling line. Care should be taken to see that the liquid does not go above the upper filling line when the viscometer is brought to the vertical position. The U–tube must be filled completely at the bottom and should be free from air bubbles and particulate matter. The viscometer is positioned in a thermostat maintained at the required temperature. After desired temperature is attained, a plug is placed over tube 3 and suction is applied to tube 2, until the liquid reaches the center of the bulb *C*. The suction is disconnected from tube 2, the plug is removed from tube 3 and is immediately placed over tube 2 until sample drops away from the lower end of the capillary. The plug is removed and the efflux time is noted.

The advantages of Ubbelohde type viscometers are speed, accuracy (within $\pm 0.1\%$), small sample size (about 11 mL is sufficient), low susceptibility to errors (due to drainage, and alignment), and cost effectiveness (the equipment is cheaper than the other models providing the same type of accuracy). The main concern with this viscometer is the prospect of clogging (specially, in small capillaries).

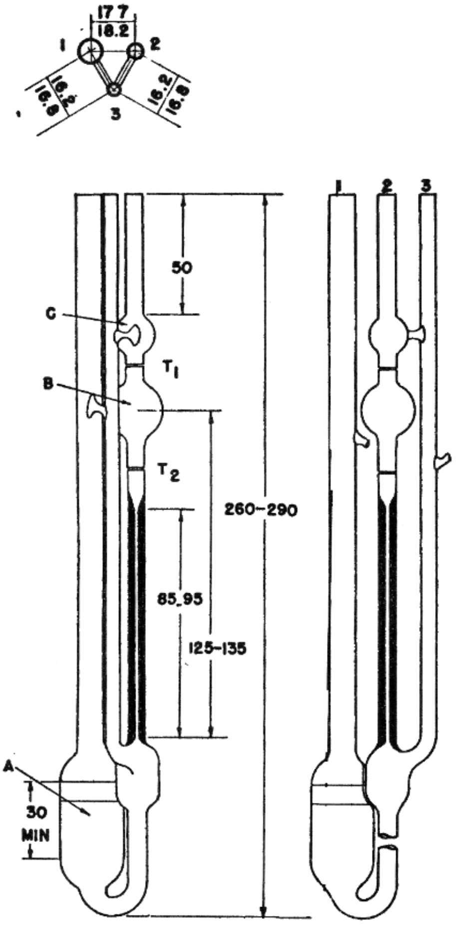


Figure 2.10. Ubbelohde suspended level viscometer for measuring viscosity of transparent liquids (Modified from ASTM D446-04, American Society for Testing and Materials International, West Conshohocken, PA, USA).

There are 16 types of Ubbelohde viscometers covering the kinematic viscosity in the range of 0.3 to 100,000 cSt. In Table 2.7 is lists the size number of Ubbelohde viscometers and corresponding kinematic viscosity range.

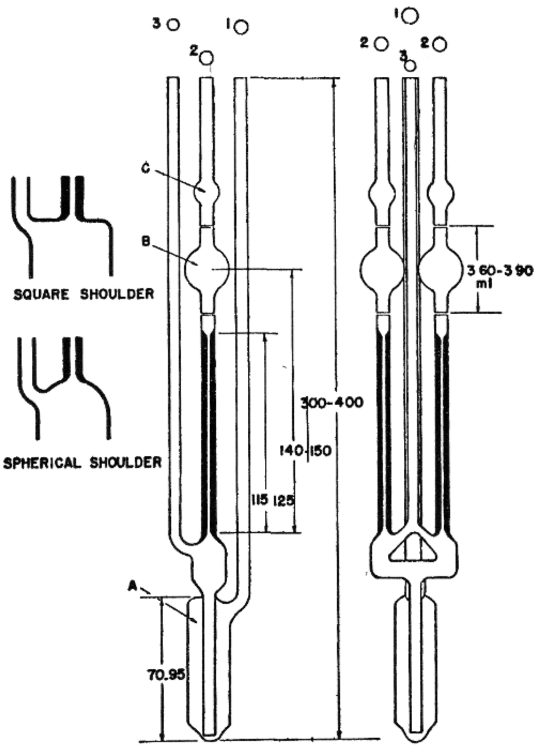
Table 2.7. Size number and corresponding viscosity range of Ubbelohde viscometers.

Size No.	***Kinematic Viscosity Range, mm^2/s (cSt)***	***Capillary Diameter, mm* (± 2%)**
0	03 – 1	0.24
0C	0.6 – 3	0.36
0B	1 – 5	0.46
1	2 – 10	0.58
1C	6 – 30	0.78
1B	10 – 50	0.88
2	20 – 100	1.03
2C	60 – 300	1.36
2B	100 – 500	1.55
3	200 – 1,000	1.83
3C	600 – 3,000	2.43
3B	1,000 – 5,000	2.75
4	2,000 – 10,000	3.27
4C	6,000 – 30,000	4.32
4B	10,000 – 50,000	5.20
5	20,000 – 100,000	6.25

2.1.4.2 FitzSimons Viscometer

FitzSimons viscometer[13], useful for the determination of the kinematic viscosity of transparent Newtonian liquids, has a range of 0.6 to 1200 cSt. A schematic diagram of the apparatus is shown in Fig. 2.11. This model permits sample filling, observation of efflux time and cleaning of the apparatus without removing the viscometer from the thermostat. FitzSimons viscometer, which is available both with one capillary and two capillaries, is shown in Fig. 2.11a and 2.11b, respectively. Being a viscometer with a spherical shouldered outlet tube, liquids with different surface tensions do not produce different mean effective heads and no correction for surface tension is required.

About 10 mL of the sample is filtered into the viscometer through tube 1 and sufficient time is allowed to enable the sample attain the required temperature. A finger is placed over tube 3, and the liquid is drawn in by applying suction to tube 2 to a level above the upper mark but below the center of the smaller bulb *C*. This operation is to be carried out slowly and cautiously to avoid formation of air bubbles in the sample. When a double capillary model is being used, tube 2 when not in use should be kept closed by means of a flexible tube when not in use. The suction on tube 2 is released and the finger is removed from tube 3. The efflux time for the free flow of sample through the capillary is measured. Prior to the actual experiment, the viscometer should be thoroughly cleaned by means of a solvent, such as petroleum ether or benzol. FitzSimons viscometer is available in six sizes that cover from 0.6 to 1,200 cSt (Table 2.8).



(a) One capillary (b) Two capillaries

Figure 2.11. FitzSimons suspended level viscometer for measuring viscosity of transparent liquid (Reproduced from ASTM D446-04 with permission of American Society for Testing and Materials International, West Conshohocken, PA, USA).

Table 2.8. Size number and corresponding viscosity range of FitzSimons viscometers.

Size No.	*Kinematic Viscosity Range, mm²/s (cSt)*	*Capillary Diameter, mm* (± 2%)
1	0.6 – 3.0	0.43
2	2 – 10	0.60
3	7 – 35	0.81
4	20 – 100	1.05
5	50 – 250	1.32
6	240 – 1,200	1.96

2.1.4.3 Atlantic Viscometer

Atlantic viscometers[14] are available in eleven sizes that cover the kinematic viscosity of transparent Newtonian liquids in the range of 0.7 to 5,000 cSt and are given in Table 2.9. The temperature range is from the dew point to 100 ^{0}C.

This apparatus does not have a U-tube type arrangement in contrast to the other models, but it is well suited for routine use with applied air pressure. Provision for filling, measuring efflux time and cleaning without removing from the thermostat are some attractive features of this type. Fig. 2.12 presents the apparatus schematically. The volume of the efflux bulb is $3.2 \pm 5\%$ mL. The capillary diameter is between 0.41 and 2.69 mm and the length is 100 mm. The three-way stopcock has a curved outlet for connection to a vacuum manifold, making the charging of the viscometer a simple operation. The capillary is connected to a large diameter tube so that the liquid can flow along the wall to form a suspended level without the need for an air vent, simplifying the constructional features considerably.

The viscometer is mounted vertically in the constant temperature bath with the enlargement *B*, resting on the top split collar and the lower end of the capillary *E*, 20 mm below the bottom of the bath. A number of viscometers can be accommodated in a thermostat. The filtered sample is poured into a carefully cleaned 50 mL beaker. The viscometer is charged by positioning the beaker containing the sample under the lower opening of the viscometer and keeping the opening immersed in the liquid. A small vacuum is applied by means of the provision through the three-way stopcock *A*. The sample is drawn into the apparatus until the upper bulb *C* is approximately half filled. The stopcock *A* is closed. After the required temperature is achieved, the stopcock is turned to the vent position to allow the flow of the liquid. The efflux time is measured.

Table 2.9. Size number of various Atlantic viscometers.

Size No.	***Kinematic Viscosity Range, mm^2/s (cSt)***	***Capillary Diameter, mm* ($\pm$ 2%)**
0C	0.7 – 3	0.42
0B	1 – 5	0.46
1	2 – 10	0.56
1C	6 – 30	0.74
1B	10 – 50	0.83
2	20 – 100	1.00
2C	60 – 300	1.31
2B	100 – 500	1.48
3	200 – 1,000	1.77
3C	600 – 3,000	2.33
3B	1,000 – 5,000	2.64

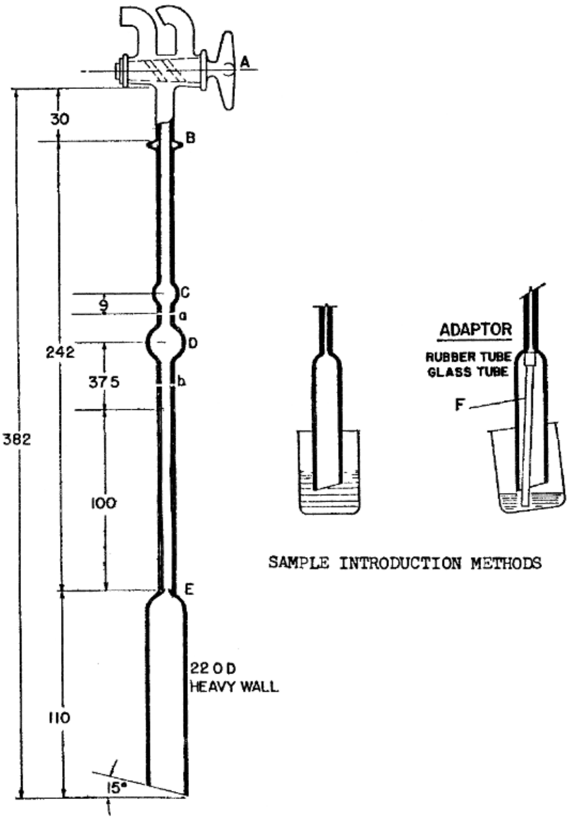
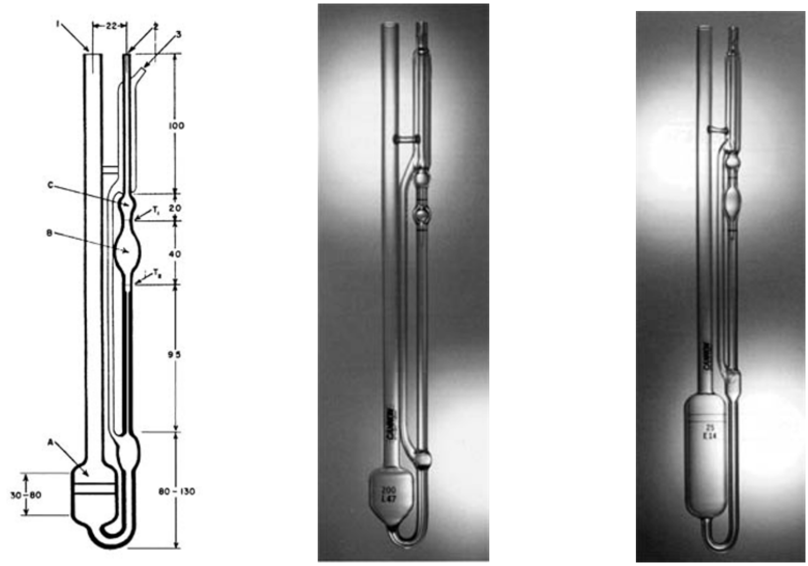


Figure 2.12. Atlantic viscometer for measuring viscosity of transparent liquid (Reproduced from ASTM D446-04 with permission of American Society for Testing and Materials International, West Conshohocken, PA, USA).

2.1.4.4 Cannon - Ubbelohde Dilution Viscometer

The Cannon-Ubbelohde, Cannon-Ubbelohde Dilution, Cannon-Ubbelohde Semi-Micro, and Cannon-Ubbelodhe Semi-Micro Dilution suspended level viscometers are normally used for the determination of the kinematic viscosity of transparent Newtonian liquids in the range of 0.4 to 100,000 cSt. The size number for various viscosity ranges is shown in Table 2.10. Fig. 2.13 shows a Cannon-Ubbelohde and Cannon-Ubbelohde Dilution Viscometer for transparent liquids. The volume of the bulb *B* of the Cannon-Ubbelohde viscometer for Size No. 25 which has a kinematic viscosity range of 0.5 to 2 cSt is 1.5 mL and it is 3 mL for the rest of the size numbers. The capillary diameters are in the range of 0.31 ± 0.02 mm to 5.6 ± 0.1 mm. For Cannon-Ubbelohde Semi-Micro-Dilution viscometer, the volume of the bulb *B* is 0.3 mL, bulb *A* is 30 mm long and the capillary diameters are in the range of 0.22 ± 0.1 mm to 3.70 ± 0.05 mm. Eight to twelve mililiters of the sample is charged into tube 1 (approximately 1 mL for the Semi-Micro size). The viscometer is placed vertically in the thermostat. After thermal equilibrium is established, a finger is placed over tube 3, and suction is applied to tube 2 until the liquid reaches the center of tube 2 until the sample drops away from the lower end of the capillary. The finger over tube 2 is removed and efflux time is measured. A Cannon-Ubbelohde semi micro dilution viscometer is shown in Fig. 2.14.

The Cannon-Ubbelohde Dilution viscometer is useful for measuring viscosity of polymers. Molecular size and shape of large polymer molecules can be related to their kinematic viscosity measured using dilute solutions of the polymers. The Cannon-Ubbelohde Dilution viscometer has an extra-large reservoir which allows polymer solutions to be diluted several times. Dilute polymer solutions frequently appear to exhibit changes in kinematic viscosity when the shear rate is changed. Cannon-Ubbelohde Dilution viscometer allows up to five fold dilution of the sample. The Semi-Micro Dilution Viscometer requires only 1 mL sample and provides up to twenty fold dilution.

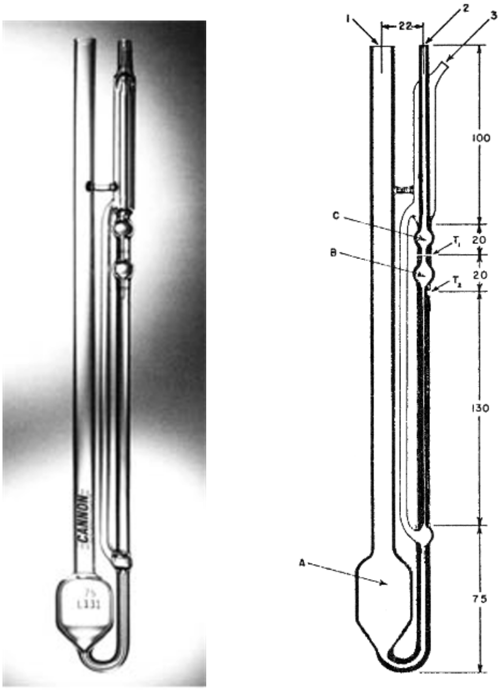


(a) (b) (c)

Figure 2.13. Cannon-Ubbelohde and Cannon-Ubbelohde Dilution viscometers. (a) Line diagram of a Cannon-Ubbelohde viscometer (b) Picture of Cannon-Ubbelohde viscometer (c) Picture of Cannon-Ubbelohde dilution viscometer (Courtesy of Cannon Instrument Co., State College, PA, USA).

Table 2.10. Size number and corresponding viscosity range of Cannon-Ubbelohde, Cannon-Ubbelohde Dilution, Cannon-Ubbelohde Semi-Micro, and Cannon-Ubbelodhe Semi-Micro Dilution suspended level viscometers.

Size No.	***Kinematic Viscosity Range, mm^2/s (cSt)***	***Diameter of Capillary, mm*** **($\pm$ 2%)**
Cannon-Ubbelhode and Cannon-Ubbelohde Dilution viscometers		
25	0.5 – 2	0.31
50	0.8 – 4.0	0.44
75	1.6 – 8.0	0.54
100	3 – 15	0.63
150	7 – 35	0.78
200	20 – 100	1.01
300	50 – 250	1.26
350	100 – 500	1.48
400	240 – 1,200	1.88
450	500 – 2,500	2.25
500	1,600 – 8,000	3.00
600	4,000 – 20,000	3.75
650	9,000 – 45,000	4.60
700	20,000 – 100,000	5.60
Cannon-Ubbelohde Semi-Micro and Cannon-Ubbelodhe Semi-Micro Dilution viscometers		
25	04 – 1.0	0.22
50	0.8 – 4	0.25
75	1.6 – 8	0.30
100	3 – 15	0.36
150	7 – 35	0.47
200	20 – 100	0.61
300	50 – 250	0.76
350	100 – 500	0.90
400	240 – 1,200	1.13
450	500 – 2,500	1.40
500	1,600 – 8,000	1.85
600	4,000 – 20,000	2.35



(a) (b)

Figure 2.14. Cannon-Ubbelodhe Semi-Micro and Cannon-Ubbelodhe Semi-Micro Dilution suspended level viscometers. (a) Picture of Cannon-Ubbelodhe Semi-Micro viscometer (Courtesy of Cannon Instrument Co., State College, PA, USA) (b) Line diagram of Cannon-Ubbelodhe Semi-Micro dilution viscometer.

2.1.4.5 BS/IP/SL, BS/IP/SL(S), BS/IP/MSL Viscometers

BS/IP/SL, BS/IP/SL(S), BS/IP/MSL (Figs. 2.15a and 2.15b) viscometers are charged through tube *L* with sufficient sample so that bulb *A* is completely filled and not bulb *B* (see Fig. 2.15b). Following charging of the sample, viscometer is mounted vertically in a constant temperature bath. Once the constant temperature is attained which may take about 30 minutes, tube *M* is closed with the finger and vacuum is applied to tube *N* (or pressure to tube *L*, if the sample contains volatile constituents) to draw the sample slowly through bulb *C* to about 8 mm above the upper timing mark *E*. Vacuum from tube *N* is released and the finger from tube *M* is immediately switched to tube *N*. The meniscus above timing mark *E* should be maintained until the lower meniscus has dropped below the end of capillary *R* in bulb *B*. The finger is lifted slowly to allow the sample to flow through capillary, and the time is noted. The size number and corresponding kinematic viscosity range is given in Table 2.11.

Table 2.11. Various sizes of BS/IP/SL, BS/IP/SL(S), BS/IP/MSL viscometers.

Size No.	***Kinematic Viscosity Range, mm^2/s (cSt)***	***Capillary Diameter, mm (± 2%)***
	BS/IP/SL	
1	3.5 – 10	
1A	6 – 30	
2	20 – 100	
2A	60 – 300	
3	200 – 1,000	
3A	600 – 3,000	
4	2,000 – 10,000	
4A	6,000 – 30,000	
5	20,000 – 100,000	
	BS/IP/SL(S)	
1	1.05 minimum	0.36
2	2.1 – 3	0.49
3	3.8 – 10	0.66
4	6 – 30	0.87
5	20 – 100	1.18
6	60 – 300	1.55
7	200 – 1,000	2.10
8	600 – 3,000	2.76
9	2,000 – 10,000	3.80
	BS/IP/MSL(S)	
1	0.6 – 3	0.36
2	2 – 10	0.45
3	6 – 30	0.62
4	20 – 100	0.81
5	60 – 300	1.10
6	200 – 1,000	1.45
7	600 – 3,000	1.98

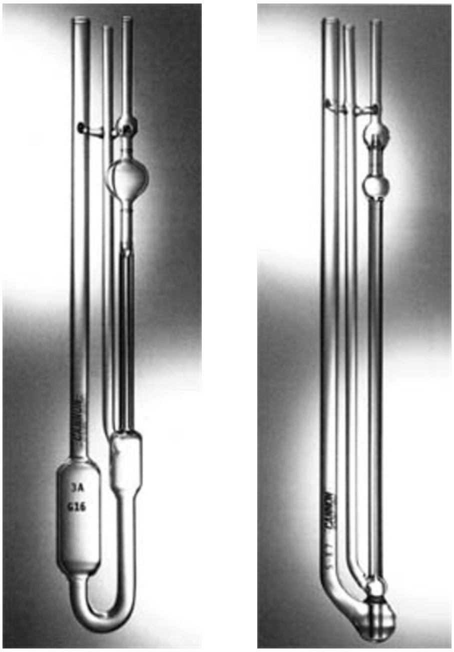


Figure 2.15a. BS/IP/SL, BS/IP/MSL viscometers for measuring viscosity of transparent liquids (Courtesy of Cannon Instrument Co., State College, PA, USA.)

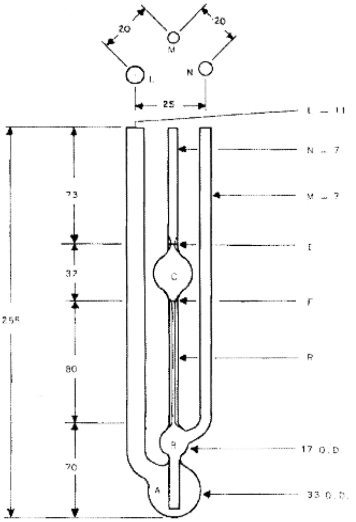


Figure 2.15b. BS/IP/SL(S) viscometer for measuring viscosity of transparent liquids (Reproduced from ASTM D446-04 with permission of American Society for Testing and Materials International, West Conshohocken, PA, USA).

2.1.5 REVERSE FLOW VISCOMETERS

Special arrangement is necessary when measuring viscosity of opaque liquids. Viscometers used for this purpose are generally known as Reverse Flow Viscometer. They can be used for both transparent and opaque liquids, specially for measurement of kinematic viscosity of dark Newtonian liquids according to ASTM D 445 and ISO 3104. These reverse flow type viscometers wet the timing section of the viscometer capillary only during the actual measurement. The liquid sample flows into a timing bulb not previously wetted by sample, thus allowing the timing of liquids whose thin films are opaque. Reverse flow viscometers must be cleaned, dried, and refilled prior to each measurement. By contrast, other viscometer types commonly used to measure transparent liquids allow the same sample to be repeatedly drawn up into the capillary, permitting multiple measurements for verification. The reverse flow viscometers for transparent and opaque liquid include the following types:

a. Cannon-Fenske Opaque
b. Zeitfuchs cross-arm
c. Lantz-Zeitfuchs
d. BS/IP/RF

2.1.5.1 Cannon-Fenske Opaque Viscometer

The most common type of reverse flow viscometer is a Cannon-Fenske Opaque Viscometer[15]. A schematic diagram of the apparatus is shown in Fig. 2.16. The sample is drawn in the same manner as described for the transparent liquids through bulb *B*, up to the mark *C*. The viscometer is turned to the normal position, wiped and cleaned. When the meniscus travels through *D* and fills the bulb *E* up to its half, a small rubber tube connected to a pinch cock is used to close the limb *A* to stop the flow of the liquid. The viscometer is placed in a thermostat by means of a proper holder and is allowed to attain the required temperature. Subsequently the pinch-cock is removed and the efflux time for the liquid to pass through the bulbs *G* and *J*, is recorded by measuring the time required by the liquid to pass between the markings *F*, *H* and *K*. The viscosities calculated from the efflux times for the two bulbs are compared. It should be noted that any reverse flow viscometers must be cleaned, dried, and refilled before a repeat measurement can be made. By contrast, Cannon-Fenske Opaque Viscometer or similar types commonly used to measure transparent liquids allow the same sample to be repeatedly drawn up into the capillary, permitting multiple measurements for verification. Cannon-Fenske Opaque viscometers are available in 12 sizes covering the kinematic viscosity range from 0.4 to 20,000 cSt and are given in Table 2.12.

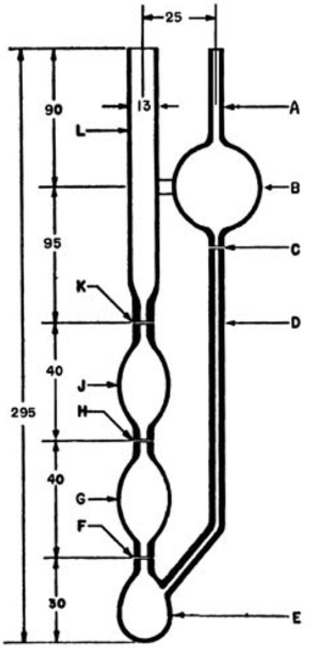


Figure 2.16. Cannon-Fenske opaque reverse flow viscometer for both transparent and opaque liquids (Reproduced from ASTM D446-04 with permission of American Society for Testing and Materials International, West Conshohocken, PA, USA).

Table 2.12. Various size Cannon-Fenske opaque reverse flow viscometer.

Size No.	***Kinematic Viscosity Range, mm^2/s (cSt)***	***Capillary Diameter, mm (± 2%)***
25	0.4 - 2	0.31
50	0.8 - 4	0.42
75	1.6 - 8	0.54
100	3-15	0.63
150	7-35	0.78
200	20-100	1.02
300	50-200	1.26
350	100-500	1.48
400	240-1,200	1.88
450	500-2,500	2.20
500	1,600-8,000	3.10
600	4,000-20,000	4.00

2.1.5.2 Zeitfuchs Cross-Arm Viscometer

The Zeitfuchs Cross-arm viscometer[16] is useful for the determination of the kinematic viscosity in the range of 0.3 to 10,000 cSt for both transparent and opaque liquids. Fig. 2.17 is a schematic drawing of the apparatus. Two positions of the bulb are shown. Position *A* requires a larger capillary for a fixed volume of the bulb and the diameter thereby increases. Position *A* is normally used for viscometer constants of 24 or less, because an increase in diameter is desirable for relatively small bore capillaries to avoid clogging by foreign matter and provides a free passage for cleaning. Position *B* for the larger constants makes it possible to use a smaller capillary and a bulb. Capillary diameters range from 0.28 mm (for 0.6 to 3.0 cSt) to 3.06 mm (for 20,000 to 100,000 cSt) and the length of the capillary tube is either 210 or 165 mm. The lower bulb volume is 0.3 or 0.35 mL and the horizontal tube diameter is 3.8 or 4.3 mm.

The viscometer is mounted in the vertical position in a thermostat by means of a metal holder. The sample is introduced into the clean dry viscometer through the filling tube 1. The sample flows into the horizontal cross arm 6, until the meniscus stands at the line 5, on the siphon 4. The sample is allowed to reach equilibrium temperature. Suction is applied to start the flow of the sample through the siphon and into the capillary 11. The efflux time is measured. Advantages[17] include – small sample size, high length/diameter ratio, and application to both opaque and transparent liquids and wide range. Table 2.13 provides the size number and the corresponding viscosity range of Zeitfuchs Cross-arm viscometer.

Table 2.13. Size number and viscosity range of Zeitfuchs Cross-arm viscometer.

Size No.	***Kinematic Viscosity Range, mm^2/s (cSt)***	***Capillary Diameter, mm* (± 2%)**
1	0.6-3	0.27
2	2-10	0.35
3	6-30	0.46
4	20-100	0.64
5	60-300	0.84
6	200-1,000	1.15
7	600-3,000	1.42
8	2,000-10,000	1.93
9	6,000-30,000	2.52
10	20,000 -100,000	3.06

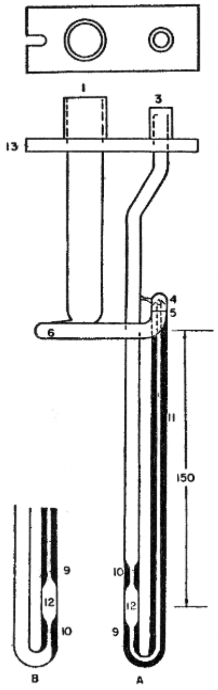


Figure 2.17. A Zeitfuchs Cross-arm viscometer (Adopted from J. F. Johnson, R. L. LeTourneua, and R. Matteson, All-purpose capillary viscometer, *Anal. Chem.* **24**(9), 1505-1508, 1952).

2.1.5.3 Lantz-Zeitfuchs Reverse Flow Viscometer

The kinematic viscosity of opaque Newtonian liquids in the range of 60 to 120,000 cSt, at temperatures between 50 to 250°C can be measured conveniently by Lantz-Zeitfuchs reverse flow viscometer, shown schematically in Fig. 2.18. The capillary diameters vary in the range of 1.62 ± 0.03 mm (for 60 to 360 cSt) to 5.60 ± 0.08 mm (for 20.000 to 120,000 cSt). The siphon diameters are in the range of 3.00 ± 0.03mm to 5.60 ± 0.08 mm and the bulb volumes range from 5.0 ± 0.4 mL to 0.9 ± 0.06 mL. The lengths of the capillary range between 200 and 490 mm. Various sizes of commercial units are listed in Table 2.14.

The sample is charged into the apparatus through a filter screen into the filling tube 1 until the sample overflows the weir into the trap. Sufficient time is allowed to bring the sample to the required temperature. The sample flow is started by applying a slight vacuum at the vent 3 or if the application of vacuum is undesirable (due to the presence of volatile matter in the sample) the flow may be started by the application of slight pressure to the filling tube until the sample flows over the siphon to a point opposite to the timing mark *A*. The sample is allowed to flow under its own head around the bend in the capillary and the efflux time is measured.

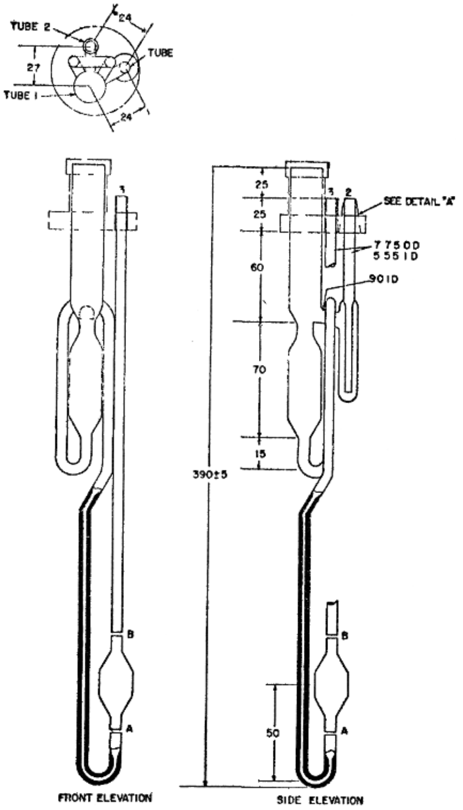


Figure 2.18. Lantz-Zeitfuchs reverse flow viscometer for opaque liquids (Reproduced from ASTM D446-04 with permission of American Society for Testing and Materials International, West Conshohocken, PA, USA).

Table 2.14. Various commercially available Lantz-Zeitfuchs reverse flow viscometers.

Size No.	***Kinematic Viscosity Range, mm²/s (cSt)***	***Capillary Diameter, mm* (± 2%)**
5	60-300	1.65
6	200-1,000	2.25
7	600-3,000	3.00
8	2,000-10,000	4.10
9	6,000-30,000	5.20
10	20,000-100,000	5.20

2.1.5.4 BS/IP/RF U - Tube Reverse Flow

BS/IP/RF U-Tube reverse flow viscometer is useful for opaque liquids for the determination of kinematic viscosity in the range of 2.0 to 10,000 cSt. The viscometer is made of clear borosilicate glass or other heat resistant glass free of visible defects. The apparatus shown in Fig. 2.19, typically has a capillary diameter from 0.51 ± 0.02 mm (1.7 cSt) to 10 ± 0.3 mm (60,000 cSt). Inside diameters at the marks *B*, *C* and *D* range from 3 to 10 mm. The lengths of the capillaries are between 185 ± 2 and 210 ± 2 mm. A viscometer giving at least 200 s efflux time is selected. Filtered sample is introduced into the viscometer. The viscometer is placed in the thermostat in such a manner that the upper filling mark is about 3 cm below the surface of the bath liquid and the capillary is vertical. After temperature equilibrium is reached, the liquid is allowed to flow freely through the capillary, taking care that the liquid column remains unbroken until it reaches a position about 5 mm below the lower filling mark. The flow is arrested by closing the timing tube with a cork or rubber bung. If necessary, more liquid can be added. The viscometer should be allowed to attain the desired temperature. Adjustments are made to coincide the top of the upper meniscus of the liquid to the upper filling mark. The stopper is removed and the time required for the liquid to flow from the top mark to the bottom mark is recorded.

Table 2.15. Specifications for BS/IP/RF-U tube Reverse flow viscometers.

Size	*Approximate Instrument Constant, mm²/s² (cSt/s)*	*Viscosity Range, mm²/s (cSt)*
1	0.003	0.6 – 3
2	0.01	2 – 10
3	0.03	6 – 30
4	0.1	20 – 100
5	0.3	60 – 300
6	1.0	200 – 1000
7	3.0	600 – 3000
8	10	2000 – 10000
9	30	6000 – 30000
10	100	20000 – 100000
11	300	60000 – 300000

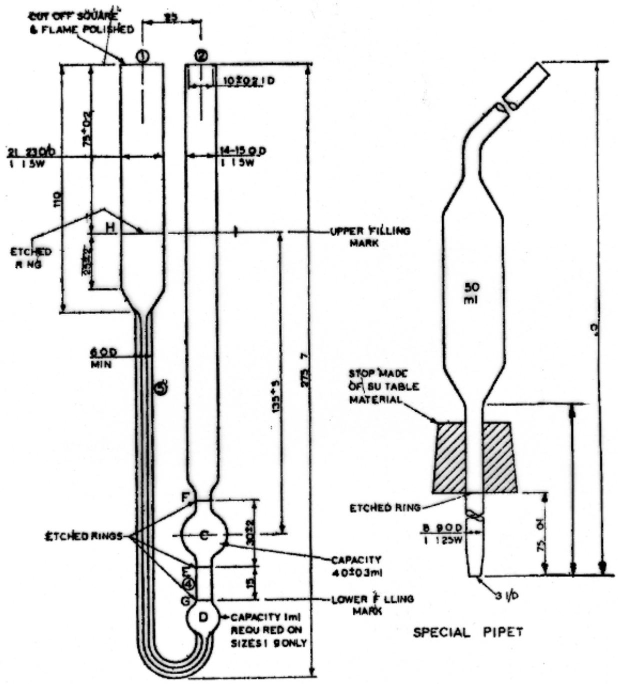


Figure 2.19. BS/IP/RF U-Tube reverse flow viscometer (Modified from ASTM D446-04, American Society for Testing and Materials International, West Conshohocken, PA, USA).

2.2 ORIFICE VISCOMETERS

Orifice viscometers are mainly adopted by the oil industry due to their simplicity and easy operation. They are also known as efflux type viscometers. Orifice viscometers essentially consist of a reservoir, an orifice and a receiver. The orifice length does not exceed 10 times the diameter of the orifice. Although the original design concept of these viscometers was based on the Hagen-Poiseuille Law which states that the efflux of a fixed volume of liquid through a capillary is proportional to the viscosity of the fluid, the actual design of the instrument failed to meet the requirement of the Hagen-Poiseuille Law. The friction loss at the orifice entrance was found to be a function of cross sectional area ratio of cup to orifice, velocity of fluid, and the shape of the orifice entrance. Also the varying hydrostatic head during an experimental run needs to be considered when calculating the viscosity. Because of these reasons, the efflux time no longer remains proportional to the viscosity. Time is measured for the flow of a fixed volume of sample through an orifice and efflux time is taken as an arbitrary measure of viscosity. Conversion formulas or tables must be used for comparing results which are generally not very accurate. Absolute measurements cannot be carried out using this type of equipment and also the viscosity of non-Newtonian fluid cannot be determined.

The general method of operation of most of the orifice viscometers is basically the same. The sample liquid is poured into a cup which is maintained at a constant temperature by a water or oil bath. The level of the liquid in the cup is adjusted to a definite height, and the liquid is allowed to attain the temperature of the bath. Once the desired temperature is reached, a valve at the base of the cup is opened and the time required for a specific volume of liquid to discharge through the orifice is measured.

The efflux time measured in seconds is a totally arbitrary expression of the viscosity and is usually designated as *viscometer seconds* corresponding to the type of viscometer used. The viscosity is calculated using an empirical expression that is specific to each instrument and has the general form as follows.

$$\upsilon=\frac{\eta}{\rho}=kt-\frac{K}{t} \tag{2.25}$$

where t is the viscometer second (such as Redwood seconds, Saybolt seconds, or Engler degrees), and k and K are instrument specific constants and must be determined for each instrument.

Most common orifice viscometers used by oil industry are listed below. A brief description of these instruments is given below.

1. Redwood viscometer
2. Engler viscometer
3. Saybolt viscometer
4. Ford viscosity cup viscometer
5. Shell viscosity cup viscometer
6. Zahn cup viscometer

2.2.1 REDWOOD VISCOMETER

The Redwood viscometer may be considered as the first orifice meter designed and described by Redwood[18] in his address before the Society of the Chemical Industry in 1886. The Redwood viscometer was primarily developed for the determination of the viscosity of petroleum products which follow Newton’s law exhibiting a linear relationship between shearing stress and the rate of shear under the test conditions. Redwood viscometer is mainly used in the United Kingdom and follows the British Standard IP 70/62. The method measures the viscosity of oil as a time of flow in seconds. The apparatus is illustrated in Fig. 2.20. The important components of the viscometer are–oil cup, jet, heating bath, stirrer, valve, thermometer support, oil cup cover and screen.

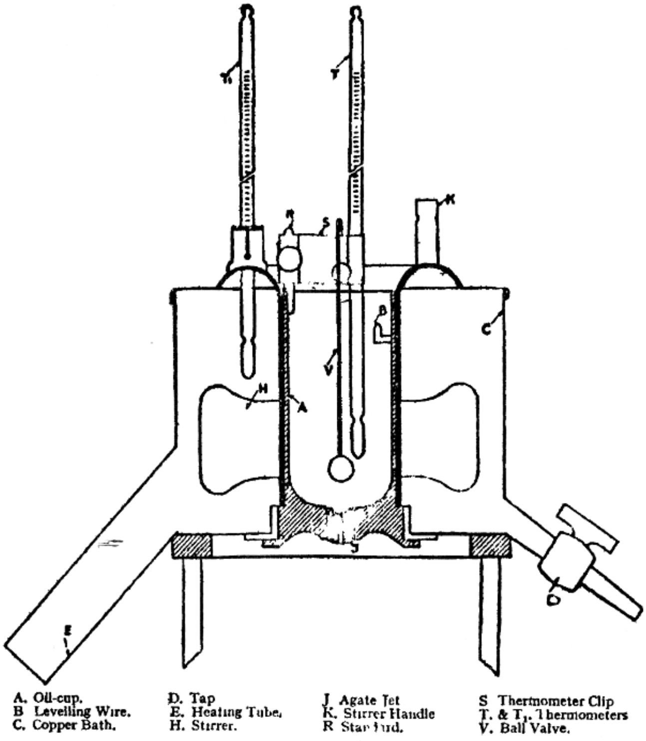
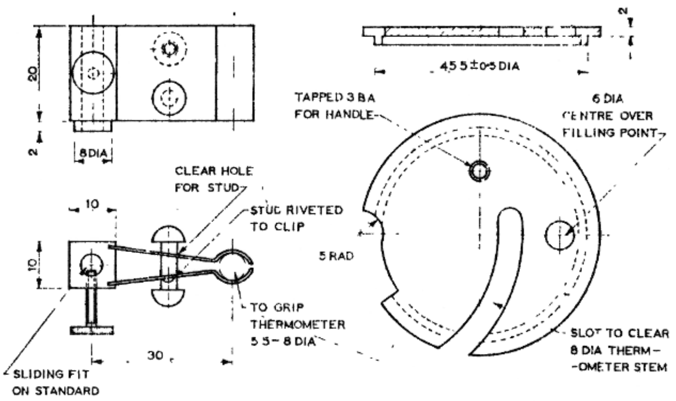


Figure 2.20. Redwood viscometer (Adapted from A. W. Nash and A. R. Bowen, *The Principles and Practice of Lubrication*, Chapman and Hall, London, 1929).

A cylindrical brass vessel *A* of 3 mm wall thickness and a base for the cup are provided with a tapering and a central hole into which the jet is fitted and cemented with its bore along the axis of the cup. The level (to which the oil is to be filled) is indicated by a stout wire *B*. This wire is turned upwards at right angles and tapered to a sharp point at the precise level for the oil surface. The point is at 7 ± 1 mm from the inner wall of the cup. The oil cup is internally silver plated to reduce corrosion. The internal diameter of the oil cup is 46.5 ± 0.5 mm. The vertical distance from the rim is 46 ± 1 mm, the height of the cylindrical portion of the oil cup is 86 ± 1 mm, and the height of the filling point above the bore is 82.5 ± 2 mm. The jet is constructed of agate and the central hole is drilled and polished to the maximum possible precision.

The upper end of the jet is provided with a concave depression, into which a ball valve for starting and stopping the flow of the oil is fitted. The standard specifications are: internal length of the jet: 10 ± 0.05 mm, minimum internal diameter of the jet: 1.62 mm. The heating bath is of 4 cm diameter and is 9.5 cm deep and spun from a sheet of copper that surrounds the oil cup and is provided with a tap for emptying. The bath is externally heated by means of a suitable electrical resistance wire. Stirring of the oil is provided by means of a cylinder with four wanes surrounding the oil cup.

The valve *V*, for starting and stopping of the flow of the liquid from the oil cup consists of a metal ball approximately 11 mm diameter, carried on a stiff wire (1.63 mm diameter). The wire and the ball are both heavily silver plated. The fit of the ball valve in the socket is such that, when the cup is filled with an oil of viscosity 300 to 400 seconds, the leakage is not more than 2 drops per minute. A spring clamp, approximately 20 mm in width is provided to support the oil cup thermometer *T*, as illustrated in Fig. 2.21. The instrument is provided with a brass cover, fitted with an insulated handle as illustrated in Fig. 2.21. A suitable screen is attached to the stand to prevent undue cooling of the lower side of the instrument. With this instrument, the flow time should be more than 30 seconds. Measurements for flow times above 2000 seconds should be carried out in the instrument illustrated in Fig. 2.22. The filtered sample is filled in the oil cup up to the level mark and is brought to the desired temperature. The efflux time for 50 mL of the sample flow out of the viscometer is noted. Redwood viscometer is available in two sizes; Redwood viscometer 1 or Redwood viscometer 2. Redwood viscometer 1 is used when the time of flow of the oil at the desired temperature is less than 2000 seconds. The difference between the two viscometers is the diameter of the orifice. The capillary diameter of Redwood viscometer 1 is 1.62 mm and its length is 10.0 mm, whereas that of Redwood viscometer 2 is 3.5 mm and 5.0 mm, respectively.



THERMOMETER CLIP **OIL CUP COVER**

Figure 2.21. Details of the Redwood viscometers (Adapted from A. W. Nash and A. R. Bowen, *The Principles and Practice of Lubrication*, Chapman and Hall, London, 1929).

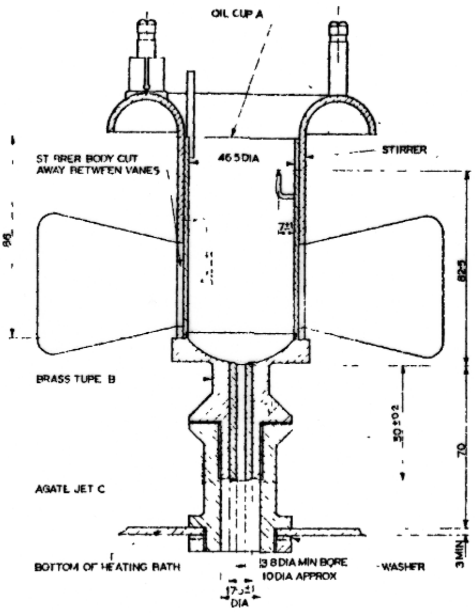


Figure 2.22. Details of the Redwood viscometer 2 used for measuring flow times greater than 2000 s (Adapted from A. W. Nash and A. R. Bowen, *The Principles and Practice of Lubrication*, Chapman and Hall, London, 1929).

2.2.2 ENGLER VISCOMETER

Engler viscometer is mainly used in former Eastern Europe for measuring viscosities of lubricating oils. Engler recommended that all viscosities be compared with water. By comparison with standards, lubricating oils may be rated as to its viscosity thus giving one of the values required for a lubricant. A full description of the instrument is given by Stillman[19]. It is also used for determination of specific viscosity of tars and their fluid products according to ASTM D1665-98 standard. The constructional features of the viscometer are shown in Fig. 2.23. The principle of operation is similar to that of Redwood viscometer. The jet is made of platinum instead of agate. The oil cup of this type of viscometer is made in such a manner that the time for the out flow of 200 mL of water at 20°C is 52 s. However for standardization and calibration of viscometer, the efflux time for 200 mL of distilled water at 20°C is first determined and then the factor representing the efflux time for 50 mL of water at 25°C. The oil container is surrounded by a thermostat and is closed with a lid through which a thermometer, a valve plug and a hand stirrer are introduced. The height of the oil is noted by means of three inverted point gauges (which also indicate the level of the apparatus). The measuring flask is graduated at 100 mL and 200 mL for checking purposes. Engler specific viscosity which is usually expressed as Engler degrees is defined as the ratio of the time of outflow of 50 mL of sample at the selected temperature to the time of out flow of the same volume of water at 25°C.

2.2.3 SAYBOLT VISCOMETER

Saybolt viscometer was used as a standard viscometer by the chemists of the Standard Oil Co. in the USA for determining viscosity of oil. A detailed description of the instrument was first described by Gill[20]. Saybolt viscometer is available in two types: Saybolt universal viscometer and Saybolt–Furol viscometer. The viscosity of lubricating oils is generally measured by means of a Saybolt universal viscometer while the viscosity of fuel oils is often measured by means of a Saybolt–Furol viscometer. Standard test methods using Saybolt viscometer is described in ASTM D88-94 standard. Saybolt universal viscometer should not be used for the liquids whose outflow time is less than 32 s. The apparatus is shown in Fig. 2.24. It consists of an oil tube fitted at the top with an over flow cup, the tube is surrounded by a bath. The outflow capillary tube is fitted to the bottom of

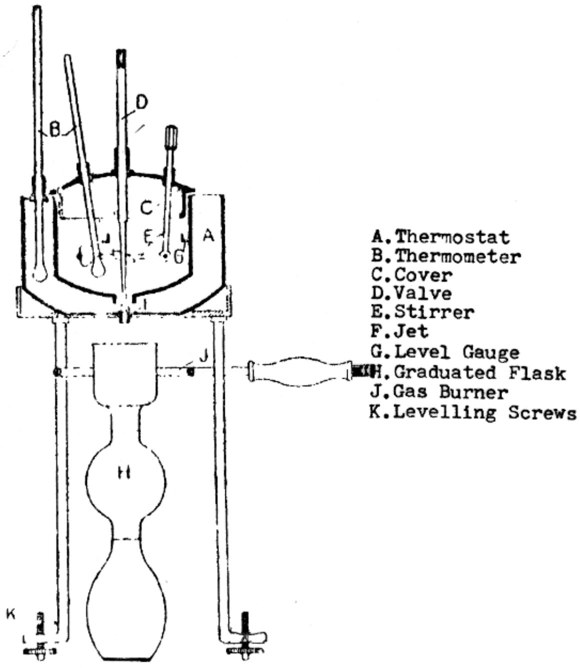


Figure 2.23. Engler viscometer (Adapted from A. W. Nash and A. R. Bowen, *The Principles and Practice of Lubrication*, Chapman and Hall, London, 1929).

the oil tube and is made of stainless steel or of hard and corrosion resistant materials. The receiving flask is marked to hold 60 mL (± 0.15 mL) at 20°C.

The lower end of the outflow tube is enclosed by a larger tube, sealed by means of a cork, which acts as a closed air chamber and prevents the flow of oil until the cork is removed. The use of a looped string to withdraw this cork is recommended. Two thermometers are installed to measure the temperature of the oil as well of the bath. The bath is heated to the required temperature using a electrical heater. Oil used in this instrument should first be strained through a 100-mesh sieve and the excess oil over flow at the top should be removed by means of a suitable pipette. The outflow time is recorded by making use of a stop-watch. The results are normally expressed as Saybolt universal seconds.

There are several precautions to be observed in connection with this instrument. The level of the bath liquid must be above the over flow rim of the oil tube and any oil used for test or cleaning should be strained before its use. The oil is heated to the required temperature and some of it poured through the clean tube. The cork is inserted tightly enough to prevent air leakage but not to reach the outflow tube. The oil under test is heated outside the viscometer to a temperature about 1.5°C or 3°F above the temperature of the test and is poured into the oil tube until it ceases to over flow into the over flow cup. Stirring of the oil in the container and also of the bath should be constant during the entire time of the test. Adequate stirring and control should be provided for the bath so that the temperature of a test sample in the viscometer will not vary more than ± 0.03°C (± 0.05°F). After the bath and the oil in the container have reached the required temperature, the oil tube thermometer is withdrawn, the excess oil in the over flow cup is pipetted out, so that the level of the oil in the over flow cup is below the level of the oil in the tube. The cork is then dexterously withdrawn and the time of flow of 60 mL of the oil is recorded. The liquid in the surrounding bath is kept under constant stirring during the entire test.

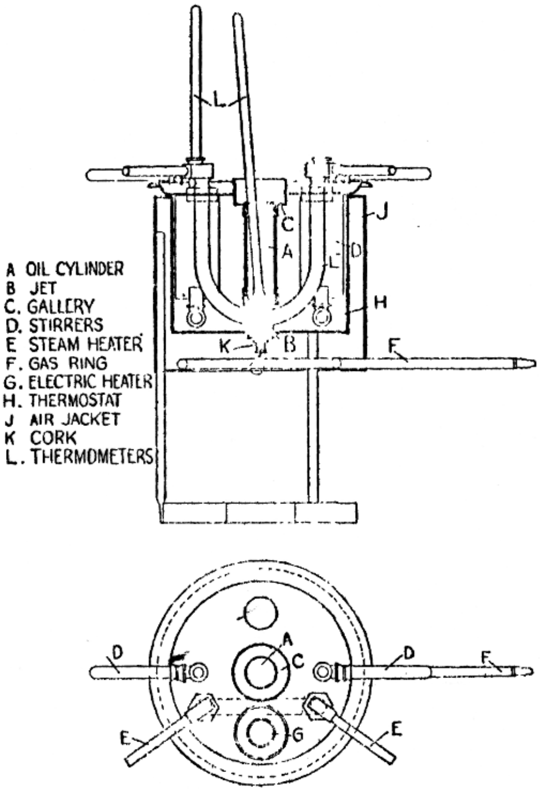


Figure 2.24. Saybolt viscometer (Adapted from A. W. Nash and A. R. Bowen, *The Principles and Practice of Lubrication*, Chapman and Hall, London, 1929).

2.2.4 FORD VISCOSITY CUP VISCOMETER

Ford viscosity cup is generally used for determination of viscosity of Newtonian paints, varnishes, lacquers, and related liquids. The protocols for the test methods are provided in ASTM D 1200-94. If the material is non-Newtonian, Ford viscosity cup may be used according to Test method ASTM D 2196. The Ford viscosity cup shown in Fig. 2.25 is filled with the liquid under test up to the top level and the time for the liquid to flow through one of the five standard orifices is measured. Based on the orifice size, five Ford viscosity cup viscometers are available: Nos. 1, 2, 3, 4, and 5. Measurement of viscosity is carried out at 25 ± 0.2^{o}C (77 ± 0.4^{o}F). The choice of cup depends on the efflux time and Fig. 2.26 may be used as a preliminary guide for this choice. However, all the cups should be calibrated using the procedure described in Test Method ASTM D 1200-94. Certified kinematic viscosity standards available from various companies should be used for the calibration of cups. Viscosity standards that can be used from Cannon Instrument Co., P.O. Box 16, State College, PA, 16801 for calibration of Ford viscosity cups are given in Table 2.16. The general formula to convert the time of flow in seconds, t, to kinematic viscosity, υ is

$$\upsilon_i = At - B \tag{2.26}$$

where i refers to the number of the cup and A and B are constants to be determined from the standard oil.

Table 2-16. Standard oils for calibration of Ford viscosity cups.

Cup Number	***Approximate Cup Viscosity Range, cSt***	***Standard Oil Designation for Calibration***	***Approximate Viscosity Designated at $25^{o}C$, cSt***
1	10 – 35	S-10	20
2	25 – 120	S-20	35
3	49 – 220	S-60	120
4	70 – 370	S-60	120
5	200 – 1200	S-200	460

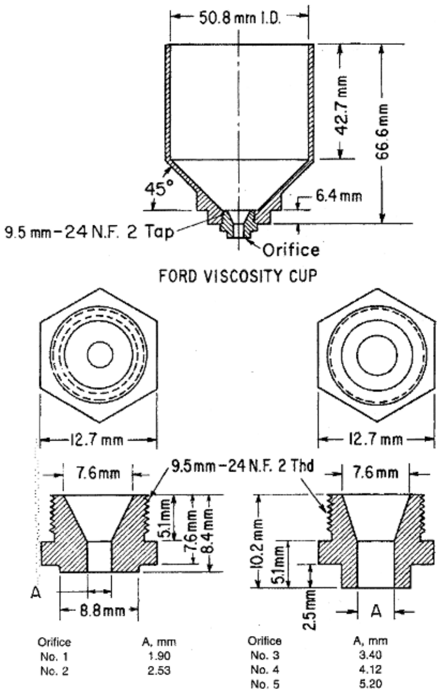


Figure 2.25. Ford viscosity cup viscometer (Reproduced from ASTM D1200-94 with permission of American Society for Testing and Materials International, West Conshohocken, PA, USA).

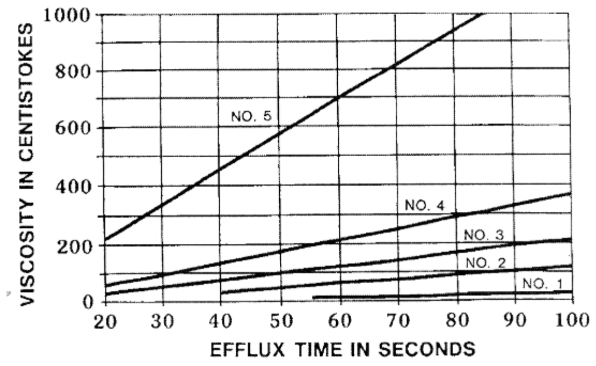


Figure 2.26. Selection of Ford viscosity cups (Reproduced from ASTM D1200-94 with permission of American Society for Testing and Materials International, West Conshohocken, PA, USA).

2.2.5 ZAHN VISCOSITY CUP

The General Electric (or "Zahn") viscometer consists of a bullet-shaped steel cup with a small orifice in the bottom[21]. Zahn viscosity cup is also known as Dip-Type viscosity cup because of the manner in which viscosity of a test sample is determined. It can be used to determine the viscosity of Newtonian paints, varnishes, lacquers, ink, and related liquids. For measuring viscosity, the cup is completely immersed in the liquid, withdrawn (that is why it is called Dip-Type), and the time for the flow time through the orifice at the bottom of the cup is measured. Although, this type of cups can be used to measure viscosity directly in tanks or containers, the measurement is still approximate. Zahn viscosity cups are available in 5 sizes that can measure the oil viscosity in the range of 20 to 1600 cSt. The cups are made of corrosion and solvent resistance materials. The volume of a cup can vary from 43 to 49 mL depending on the manufacturer. The design features of Zahn cup are shown in Fig. 2.27 and cup orifice diameters are listed in Table 2.17.

Viscosity measurement using Zahn viscosity cups is generally made at 25^0C. For viscosity determination at other temperature, a temperature correction curve or factor needs to be determined for each liquid. The choice of cup for measuring viscosity depends on the efflux time which should be between 20 to 80 s. The container holding the test liquid should be stirred well to provide a uniform temperature and density. The cup is immersed in the container and is kept there for 1 to 5 minutes to allow thermal equilibration. The cup is lifted vertically from the container in a quick steady motion. As the top edge of the cup breaks the surface, the timer is started and the cup is held about 6 in (15.2 cm) above the level of the liquid. When the liquid stream breaks at the base of the cup, the timer is stopped and the efflux time in seconds is noted. The efflux time in seconds is converted to kinematic viscosity using the following expression:

$$\upsilon = At - B \tag{2.27}$$

Zahn viscosity cup should be calibrated periodically according to Test Method ASTM 4212-99 using standard fluids. However, it should be noted that the temperature control of Zahn viscosity cups is extremely difficult and this introduces errors in the calibration.

Table 2.17. Zahn viscosity cup orifice diameter.

Cup Number	***Nominal Orifice Diameter, (mm)***	***Approximate Viscosity Range, (cSt)***	***Approximate Oil Viscosity at 25°C, (cSt)***
1	2.0	5 – 60	20
2	2.7	20 – 250	120
3	3.8	100 – 800	480
4	4.3	200 – 1,200	480
5	5.3	400 – 1,800	900, 1600

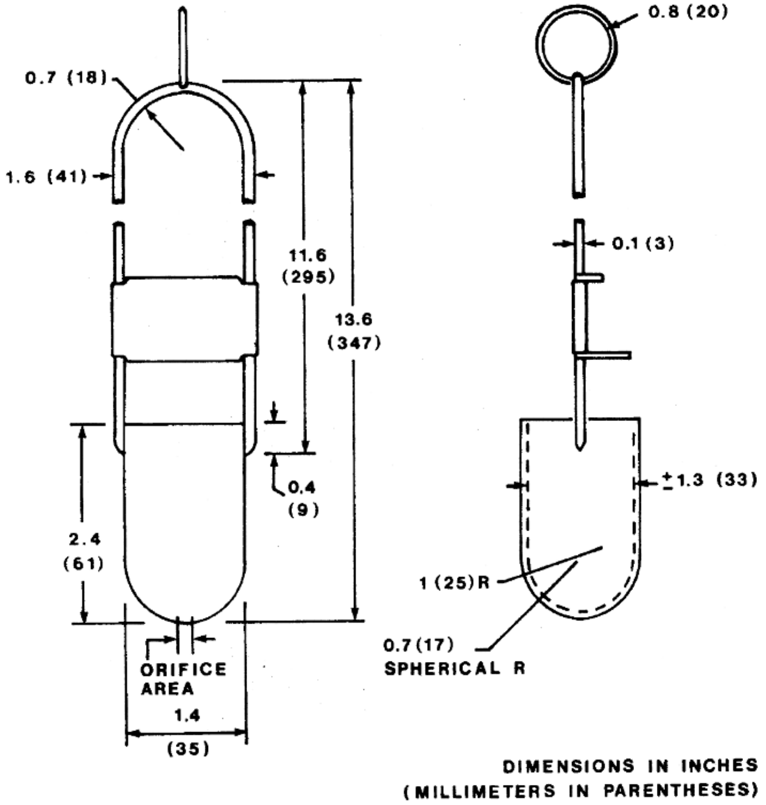


Figure 2.27. Zahn viscosity cup (Reproduced from ASTM D4212-99 with permission of American Society for Testing and Materials International, West Conshohocken, PA, USA).

2.2.6 SHELL VISCOSITY CUP

Shell viscosity cups are also Dip-Type viscosity cups and are available in 8 sizes. They are made of stainless steel with a capacity of 23 mL and a 25 mm long capillary in the bottom. Typical design of a Shell Viscosity cup is shown in Fig. 2.28. The orifice size and the recommended use for various viscosity ranges are given in Table 2.18. The operational procedure and calibration method is same as that of Zahn viscosity cups.

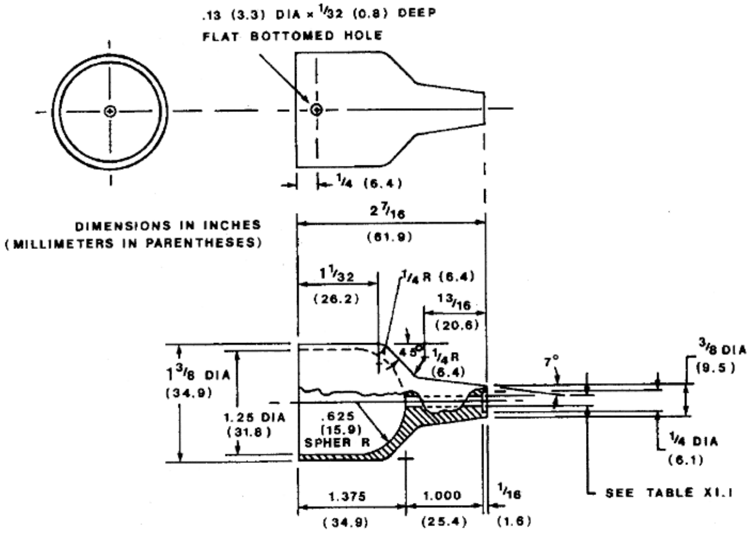


Figure 2.28. Shell viscosity cup (Reproduced from ASTM D4212-99 with permission of American Society for Testing and Materials International, West Conshohocken, PA, USA).

Table 2.18. Orifice size of Shell cup viscometer.

Cup Number	*Nominal Orifice Diameter, (mm)*	*Approximate Viscosity Range, (cSt)*	*Approximate Oil Viscosity at 25°C, (cSt)*
1	1.8	2 – 20	9
2	2.4	10 – 50	9, 20
2 1/2	2.7	20 – 80	35
3	3.1	30 – 120	35, 120
3 1/2	3.5	40 – 170	120
4	3.8	70 – 270	120
5	4.6	125 – 520	120, 480
6	5.8	320 – 1300	480

A number of other viscometers have been designed whose principle of operation is similar to Redwood viscometer. Various aspects of these viscometers are summarized in Table 2.19.

2.3 HIGH TEMPERATURE, HIGH SHEAR RATE VISCOMETERS

Viscosities up to 1000 poise are conveniently measured using suspended-level capillary viscometers. For measuring higher viscosity, Cylinder-piston type viscometers are preferable. Cylinder-piston type viscometers are often referred to as variable pressure capillary viscometers. In the cylinder-piston type viscometers, the instrument has a cylinder as the liquid reservoir, and the fluid is displaced by a mechanically driven piston or plunger. The mechanism that activates the piston can be - a dead weight, a pneumatic device, and hydraulic pressure or mechanical devices. The equipment is well suited for the viscous non-Newtonian fluids. Several instruments in the past were designed based on cylinder-piston mechanism. These include MCER high shear rate capillary viscometer, Standard oil high pressure capillary viscometer, Plunger viscometer, and Erica-Glynn and Grunberg Viscometer. All of these viscometers were available commercially. One of the major issues with these viscometers was the temperature control of the instrument that generally led to less accurate measurement. As a consequence, most of these viscometers are now obsolete.

Several new viscometers in recent years have been developed to address the temperature control of the instrument and also the accuracy. Different configurations of capillary viscometers are available for measuring viscosity of engine oil at a single temperature and single shear rate that can provide greater uniformity and improved precision. Klaus et al.[22] developed a single-pass capillary viscometer that consisted of a long capillary which was necessary to meet the specifications for measuring the viscosity of oil according to the requirements of the Society of Automotive Engineers, Washington D.C., USA. However, the instrument requires a long time to run a measurement and also significant corrections to the data are necessary. Further work by Rein and Alexander[23] and Graham et al.[24] noted that the capillary approach for measuring viscosity of oil under high temperature, high shear conditions is feasible. Manning and Lloyd[25] designed a multicell high temperature high shear capillary viscometer that was later commercialized by the Cannon Instrument Co. PO Box 16, State College, PA, USA.

This multicell viscometer is capable of measuring viscosity of engine oil at 150°C. In this method, applied gas pressure forces a fixed volume of fluid through a small-diameter glass capillary. The rate of shear can be varied up to 10^6 s^{-1}. This technique is commonly used to simulate the viscosity of motor oils in operating crankshaft bearings. This viscosity is called high-temperature high-shear (HTHS) viscosity and is measured at 150°C and 10^6 s^{-1}. A schematic diagram of the viscosity cell is shown in Fig. 2.29.

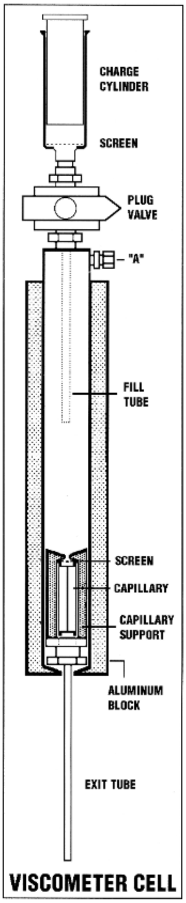


Figure 2.29. High Temperature High Shear rate viscometer (Courtesy of Cannon Instrument Co., State College, PA, USA).

2.4 ROTATIONAL VISCOMETERS

Rotational viscometer operates on the principle of measuring the rate of rotation of a solid shape in a viscous medium upon application of a known force or torque required to rotate the solid shape at a definite angular velocity. Although rotational viscometers are more elaborate than the capillary type during operation and often less accurate for Newtonian liquids, they have several advantages that make them attractive particularly to study the flow properties of non Newtonian materials. Some of the advantages are: measurements under steady state conditions, multiple measurements with the same sample at different shear rates, continuous measurement on materials whose properties may be function of temperature, and small or no variation in the rate of shear within the sample during a measurement.

A number of rotational viscometers with different designs are available commercially. These viscometers can be classified into three general categories based on their design configuration.

1. Coaxial-Cylinder Viscometer
2. Cone and Plate Viscometer
3. Coni-Cylinder Viscometr

2.4.1 COAXIAL-CYLINDER VISCOMETER

The basic design of a coaxial-cylinder viscometer is shown in Fig. 2.30. It consists of an inner cylinder (which is also called a bob) of radius R_1 and height h, and an outer cylinder or cup of radius R_2. The inner cylinder is stationary. The outer cylinder that contains the test sample is rotated at a constant speed (Ω rad/sec). The resultant torque (T dyne cm) is measured by the angular deflection of the inner cylinder that is suspended by a fine wire. The velocity of the outer cylinder can be varied to obtain the data on the change in viscosity of the fluid with the shear rate. The dynamic viscosity of Newtonian fluid may be obtained from the following expression.

$$T = \frac{4\pi R_1^2 R_2^2 h \eta \Omega}{R_2^2 - R_1^2} = C \eta \Omega \tag{2.28}$$

where C is a constant specific to the instrument. Equation (2.28) actually provides the torque exerted by the liquid on the curved surface of the inner cylinder and suggests that the viscosity is directly proportional to the ratio of torque to angular velocity. However, the equation fails to account for the forces on the ends of the cylinder introducing errors in the measurement.

The end effects are generally accounted for by adjusting the instrument constant *C* during the calibration process using experimental data of one or more liquids of known viscosity. A general description and operating procedure of a coaxial cylinder viscometer is given below.

The ranges of operation depend on the dimensions and design of the cylinders. The outer cylinder could be about 3 in. in diameter, made of forged steel, bored to the required size of about 0.5 in. diameter, grounded and hardened. The inner cylinder is made of mild steel with a radius of about 50 microns less than that of the bore in the outer cylinder. This small clearance enables to shear the film of the same thickness as a normal paint film. The instrument functions well when housed in a constant temperature room, but in other situations the outer cylinder holds the constant temperature long enough to complete the experiment isothermally. The outer cylinder is fixed coaxially on the spindle of a motor for convenient rotation. The lower edge of the outer cylinder is cut away so that the inevitable drips of test sample fall on the flat top of the motor housing and do not run down into the apparatus. Using three springs of different gauge wire and an ordinary motor, the instrument is capable of determining the viscosities over the range of 0.2 to 100 poise.

The instrument is adjusted so that the pointer gives a zero reading on the circular scale with the motor running. The cylinder and the sample are then adjusted to the right temperature. The outer cylinder is placed in the correct position and filled with the test sample and the inner cylinder inserted. For thin fluids, the inner cylinder is just pushed in and displaces some of the sample which can be removed from the top by means of palette knife. For thicker or highly thixotropic materials, it is better to use the plug provided for the purpose of removing the excess sample from the bottom of the cylinder. This method ensures the maintenance of continuous and uniform film between the two cylinders. The motor is in a wound up condition. On commencing the experiment, the outer cylinder is rotated at a constant predetermined speed and the scale reading observed.

The inner cylinder is now displaced manually from its position and a further reading is taken with the motor in the running condition. The procedure is repeated several times and the minimum reading recorded as the correct one. If the inner cylinder is out of center, readings higher than the true value are obtained. With temperature remaining constant and the film remaining unbroken the minimum reading results. For samples containing volatile liquids, it is better to have the top of the inner cylinder about a millimeter below that of the outer cylinder and keep this small place filled with the sample. If the top of the outer cylinder is flat, the height of the inner cylinder can be adjusted by a simple gauge, resting on the top of the outer cylinder. The experiment can be repeated to ensure consistency.

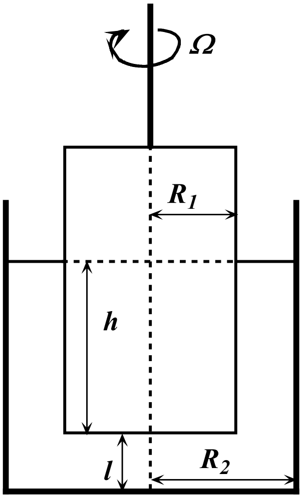


Figure 2.30. Basic structure of a coaxial cylinder viscometer.

The instrument can be calibrated for determining the torque equivalent per unit scale reading by comparison with weights operated over pulleys. Such measurements are subject to inaccuracies due to friction in the pulleys and particularly in this instrument by the fact that the cylinder radii must be determined with very great accuracy. In practice it is simpler to assemble the apparatus and calibrate the spring using a series of liquids with known Newtonian behavior. However it should be noted that the equipment is not suitable for greases and solid substances like bitumen.

The main concern with the coaxial cylinder viscometer is the end effects. Couette[26] and Hatschek[27] modified the design to eliminate end effects by the use of guard rings. Mallock[28] suggested that the inner cylinder can have a concave base in which a bubble of air could be trapped to reduce the drag on the base. However, the difficulty of trapping the same volume of air during each measurement prevented its wide range use. Lindsley and Fisher[29] found that the end effect is negligible in the range of 1 to 150 poise, but the viscosity must be corrected when it is below 1 poise. They also noted that the viscous drag on the bottom of the inner cylinder was about the same whether the bottom was open or closed. Lindsley and Fisher[29] and Highgate and Whorlow[30] suggested that modification of the design may not be adequate to account for the end effects. Therefore experimental measurements and theoretical analysis were proposed by a number of researchers to correct the viscosity for end effects. Kobayashi et al.[31] provided end corrections for several combinations of bobs and cup design. For rotating bob viscometer system, the end correction appears to increase for Reynolds numbers above 10, even for low viscosity and Newtonian liquids. A conical end of the bob and a wide gap between the bob and cup give a larger end correction. According to Wein and Tovchigrechko[32], liquids display both a general shear thinning behavior and an apparent slip at solid wall. They suggested a new way of correcting the viscosity data for several configurations of coaxial cylinder viscometers with different gap widths. Other concerns related to coaxial cylinder viscometer include viscous heating[33], calibration procedures[34], and measurement on non-Newtonian fluids[35-37].

For measuring viscosity for materials of higher viscosity or at a low temperature, it is more convenient to rotate the inner cylinder keeping the outer cylinder stationary. This method is often called Cold Cranking Simulator (CCS) and follows the Test Method ASTM D2602. A schematic diagram of a CCS is given in Fig. 2.31. It should be noted that Equation 2.28 is equally applicable when the inner cylinder is rotated at angular velocity Ω rad/sec. It also holds when torque is applied externally and the resultant speed of rotation is measured.

Figure 2.31. Cold crank simulator (Courtesy of Cannon Instrument Co., State College, PA, USA).

2.4.2 CONE AND PLATE VISCOMETERS

Cone and plate viscometers are probably the most popular rotational viscometers for studying rheological properties of non-Newtonian fluid. As shown in Fig. 2.32, the sample is contained in the space between a cone of large apical angle and a flat surface normal to its axis. If the angle between the cone and plate is small, less than 0.05 rad (3^o), the rate of shear is essentially uniform throughout the sample. The same is also true for non-Newtonian fluids making cone and plate viscometers useful for both Newtonian and non-Newtonian fluids.

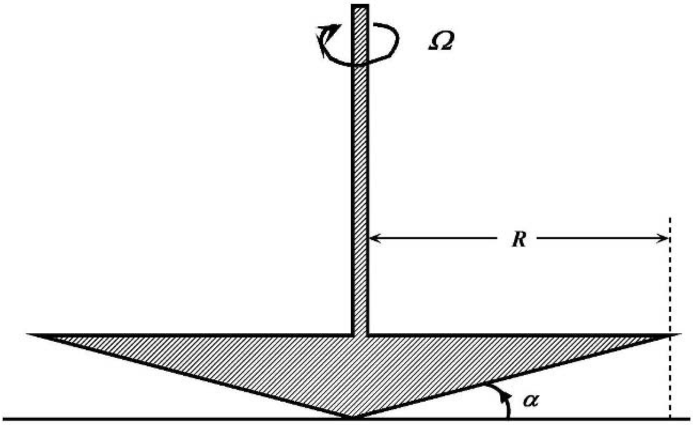


Figure 2.32. Cone and Plate viscometer.

The rate of shear D at a distance r from the axis can be written as

$$D = \frac{r\,\Omega}{r\,\alpha} = \frac{\Omega}{\alpha} \tag{2.29}$$

where, α is the angle between the cone and plate in radian, Ω is the relative angular velocity in rad/sec. Since D is independent of r, the shearing stress should be independent of r too and the total torque T can be expressed as

$$T = \int_0^R F\,r\left(2\pi r\right)dr = \frac{2\,\pi\,R^3\,F}{3} \tag{2.30}$$

Therefore for a Newtonian liquid the viscosity may be obtained from

$$\eta D = F \tag{2.31}$$

or,

$$\eta = \frac{3T\alpha}{2\pi R^3 \Omega} = \frac{CT}{\Omega} \tag{2.32}$$

where, C is the instrument constant and is typically provided by the manufacturer. A number of possible errors associated with cone and plate viscometers have been suggested, however in normal operations these problems appear to be minimal with a well constructed and calibrated viscometer. Adams and Lodge[38] noted that the error in using Equation 2.32 for shear rate at the plate is less than 0.7% at 0.1 rad and 2% at 0.18 rad. A number of researchers have studied the effect of inertia and secondary flow[39-42]. In cone and plate viscometers, inertia forces tend to pull the plates together and generates a secondary flow that increases the torque. Turian[43] suggested that Equation 2.32 may be modified to take into account this extra torque as follows.

$$\frac{T}{T_0} = 1 + 6.1 \times 10^{-4}\, Re^2 \text{, where } Re = \frac{\rho \Omega \alpha^2 R^2}{\eta_0} \tag{2.33}$$

Other factors that can introduce errors include edge effects and shear heating. Miller and Christiansen[40] found that the edge effects for a 4° cone and plate viscometer were negligible. However, other researchers[44-46] discussed the edge problems and proposed modifications to Equation 2.32 to account them during calculations. Viscous heating in cone and plate viscometers was studied by a number of researchers[47-51]. However, in recent designs, the temperature of the sample is controlled during tests. This is achieved by circulating a coolant through the plate of the viscometer. Other corrections for cone and plate viscometers include secondary flow[52,53], tangential stress[54], non-linear flow[55], migration of particles[30,56], non-Newtonian fluids[57, 58], and slip caused by wall effects[59].

Mooney and Ewart[60] appear to have been the first to design a cone and plate viscometer for viscosity measurements. A double cone and plate viscometer was described by Piper and Scott[61] in which rubber sample was subjected to increased hydrostatic pressure during viscosity measurements. Higginbotham[62], and Higginbotham and Benbow[63] described detailed construction features of three cone and plate viscometers for which the cone angle was only 0.009 rad (0.5°). Markovitz et al.[64] first described a cone and plate viscometer in which cones of angle 0.5, 1 and 2° could be interchanged. Jobling and Roberts[65] and Lammiman and Roberts[66] described the development of Weissenberg Rheogoniometer. The Ferranti Shirley viscometer was designed based on the work by Russell[67] who used the cone and plate geometry to measure normal stress[68]. Today both manual and automatic cone and plate viscometers are available commercially. A list of the manufacturers and the special features of these instruments are given in Table 2.19. Among various rotational viscometers, Rotovisco-Haake, Agfa Rotational, Brookfield, Ferranti-Shirley, Stormer, and Rheogoniometer are considered as classic one, since most of the modern viscometers are improvements of these classic ones. These viscometers are briefly described below.

2.4.2.1 Haake Rotovisco

The Rotovisco originally manufactured by Gebruder-Haake in Berlin, Germany is considered one of the most versatile viscometers. It measures the viscosity in the range of $5x10^{-3}$ to $4x10^{7}$ poise. The range of apparent rate of shear is 10^{-2} to 10^{4} s^{-1}, and the range of shear stress is 10 to 10^{6} dyn.cm^{-2}. The results are generally accurate within $\pm 1\%$. The apparatus consists of a fixed outer cup and an inner rotor. Several combinations of cups and rotors of different dimensions are available. The rotor is driven through torque dynamometer. The basic speeds ranging from 3.6 to 582 rpm, can be produced by means of gears. Rotors are some times ribbed to prevent slippage. Plastic rotors are provided for use with high temperature studies. The various torsion heads and speed reducers are interchangeable. These types are often provided with coaxial cylinder as well as plate and cone viscometers. The main disadvantage with this model is the high moment of inertia resulting in difficulties in determining the yield value.

2.4.2.2 Agfa Rotational Viscometer

Viscosities in the range of 10^{-1} to 10^{5} poise with shearing rates 0.4 to 450 s^{-1} and shear stresses in the range of 10 to 10^{5} dyn.cm^{-2} are the normal ranges for the use of Agfa rotational viscometers. The temperatures studied are generally –30 to 70^{o}C. The basic unit has an inner cylinder of 1.7 cm radius and 5.5 cm height, while the outer cylinder is of 1.82 cm radius. The torsion rod has a length of 6 cm and a diameter of 0.5 cm and a torsional spring constant of $1.48x10^{7}$ dyn.cm.(deg of deflection)$^{-1}$. The cup which is immersed in a constant temperature bath is rotated by means of a continuous variable speed drive operating in the range of 0.08 to 250 rpm. The high natural frequency of the torque sensing system produces accurate readings in intervals as short as 0.01s.

2.4.2.3 Rheogoniometer

Rheogoniometers are capable of measuring the normal forces and their distribution as a function of the distance and tangential stress. The range of measurable viscosities is from 10^{-3} to 10^{10} poise and multi point flow curves can be obtained for fluids ranging from 10^{-2} to 10^{9} poise. Normal stresses can be measured over the range of 1.3 to $6.3\text{x}10^{4}$ dyn. cm^{-2}. In this instrument the cone is rigidly fixed while the flat lower plate rotates. The selection of the cone angles and plate diameters can be made according to the requirements. The torsion imparted on the cone due to the rotation of the flat plate is measured. Two synchronous motors drive a sixty speed gear box. Requirement of a very small amount of the sample is the main advantage. In oscillatory tests, the plate oscillates about its axis and the oscillating motion is transmitted to the cone through the sample. The special features include – uniform shear rate throughout the sample, applicability to non-Newtonian flow. Oscillatory shear can be applied to determine the elastic and viscous components.

2.4.2.4 Ferranti-Shirley Cone-Plate Viscometer

The range of this instrument is from zero to 32,000 poise. It has a stationary flat plate and rotating conical disk driven by a variable speed motor through a gear train and torque spring. The torsion due to viscous drag is measured by a potentiometer on the spring which sends the signal to the recorder. This instrument is one of the most versatile types available for the study of the rheological properties of non-Newtonian fluids, especially of the pseudo-plastic type. The viscometer has an essentially constant rate of shear through out the gap. The ranges are wide in terms of – viscosity, shear stress and shear rate. These features enable the measurement of the brush-ability of paints, etc. The temperature rise in the gap is often of the order of one degree.

2.4.2.5 Stormer Viscometers

The distinguishing feature of this instrument is that the shear rate is held constant and shear stress is measured. It consists of a stationary outer cup and inner rotor driven by weights and pulley. Stress is varied by applying different weights. The time for 10 revolutions is noted. In this model, the end and edge effects are eliminated. The model is not suitable for measuring the fast time dependant phenomena accurately and precisely.

2.4.3 CONI-CYLINDER VISCOMETER

The coni-cylinder viscometer is a modification of the coaxial cylinder viscometer to eliminate the end effect as much as possible. Mooney and Ewart[60] suggested conical extension of both inner and outer cylinders. Fig. 2.33 shows a schematic of a coni-cylinder viscometer. The advantage of coni-cylinder viscometer is that the mean rate of shear in the cylindrical annulus and in the conical portion is about the same.

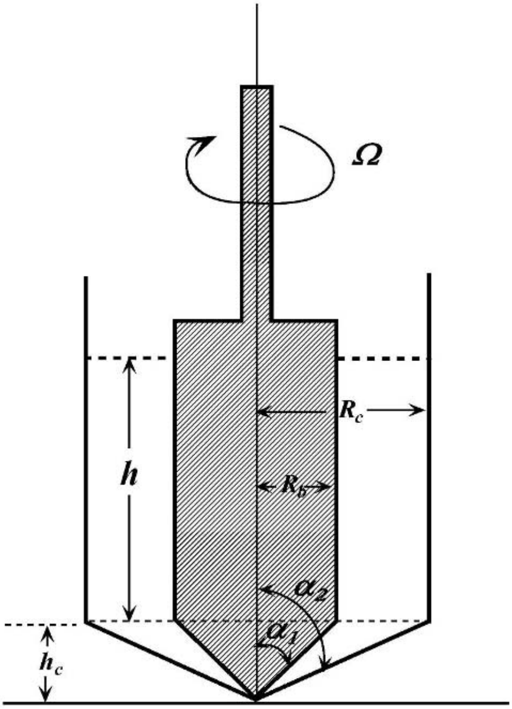


Figure 2.33. Coni-Cylinder viscometer.

The viscosity may be calculated from the following relationship.

$$\frac{T}{\Omega}=\frac{4\pi h\eta}{\left(\frac{1}{R_b^2}-\frac{1}{R_c^2}\right)}\left(1+\frac{\Delta h}{h}\right) \tag{2.34}$$

where Δh is given by

$$\Delta h = \frac{h_c}{6\cos^2\alpha_2}\left(\frac{1}{\tan^2\alpha_1} - \frac{1}{\tan^2\alpha_2}\right)\left(\int_{\alpha_1}^{\alpha_2}\frac{d\alpha}{\sin^3\alpha}\right)^{-1} \tag{2.35}$$

and,
T is the torque,
Ω is the angular velocity,
h is the length of the cylindrical portion as shown in Fig. 2.33,
h_c is the length of the conical portion as shown in Fig. 2.33,
R_b is the radius of the inner cylinder, and
R_c is the radius of the outer cylinder.

The coni-cylinder geometry is found to be most convenient for measuring viscosity and shear rate of slurries. Chang et al.[69] measured viscosity of Al_2O_3 slurry using coni-cylinder geometry containing 0.10 volume fraction Al_2O_3. Wang et al.[70] also used a similar geometry for measuring viscosity of silicon nitride slurry containing up to 0.515 volume fractions solid.

2.4.4 ROTATING/PARALLEL DISK VISCOMETERS

The rotating disk or the parallel disk geometry suggested by Mooney[71] consists of a disk rotating inside a cylindrical cavity formed by two dies maintained at specified conditions of temperature and die closure force. It is used extensively for measuring viscosity of rubber. Several modifications to the original design of Mooney[71] led to current commercial rotating disk viscometers[72-75]. The detailed construction features of a rotating disk viscometer, better known as the Mooney viscometer, are described in Test method ASTM D 1646. A number of Mooney viscometers are available commercially and are listed in Table 2.19. The Mooney viscometer is capable of measuring the effect of temperature and time on the viscosity of rubbers. If the stress relaxation test is to be performed, the rotation of the disk is stopped and the relaxation of stress versus time is measured. The dies and die holders forming the cavity are fabricated from a nondeforming steel, that has an unplated finish. The surfaces of the die cavity are either serrated or contain V-grooves to minimize slippage of the sample. The test procedure is given in ASTM D 3346. The viscosity of rubber is expressed as Mooney viscosity, which is an arbitrary measure of the viscosity of a rubber determined in a Mooney shearing disk viscometer, indicated by the torque required to rotate the disk embedded in a rubber specimen and enclosed in the die cavity under specified conditions.

The theory for calculating viscosity and shear stress using a rotating disk viscometer along with various correction factors has been described by a number of researchers. Goodrich and Chatterjee[76] analyzed numerically the fluid flow in the neighborhood of a rotating disk inserted into a liquid interface. They concluded that the rotating disk viscometer may not be the best instrument for determination of low surface viscosity.

Cross and Kaye[77] obtained rubber viscosity/shear rate data (*R*) with a parallel disk viscometer from measurements of viscous torque as a function of disk separation and angular velocity using a modified procedure via an equation which related the rim shear stress to the torque and the disk radius. The data appeared to be satisfactory

Perry et al.[78] designed a parallel-disk viscometer which can be fitted directly onto a reaction-injection molding machine and provided the criteria for isothermal operation, taking into account both conduction to the viscometer and the rapid exothermic reaction typical of reaction-injection molding polymer solutions.

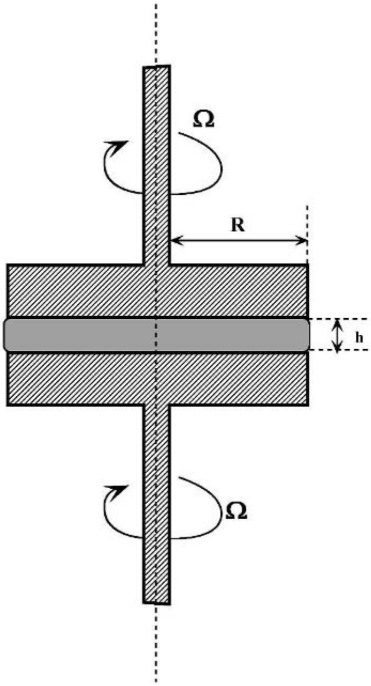


Figure 2.34. Schematic of a parallel disk viscometer (Mooney viscometer).

Other issues that were addressed by various researchers include viscometric flow under apparent wall slip[79], operation for high Reynolds number[73] and instability of a viscoelastic fluid[80].

2.5 FALLING BALL VISCOMETERS

In falling ball viscometers, a solid body is allowed to fall under gravity through a viscous medium. After a period of initial acceleration, the solid body attains a uniform terminal velocity when the gravitational force is balanced by the viscous resistance of the fluid. By measuring the terminal velocity of the falling body, the viscosity can be determined. Although a solid body of any shape and size can be used, a spherical geometry is preferable due to the simplicity involved in deriving the theory. Consider the system shown in Fig. 2.35 in which a sphere is falling through a homogeneous fluid. If the motion of the sphere is sufficiently slow, the inertia terms become negligible. Under this condition and assuming that the fluid medium has an infinite extension, the viscous resistance to the motion of the sphere moving with a velocity *v* is equal to the driving force due to the difference in density between the sphere and the fluid. This is known as the Stokes' law and is given by

$$6\pi r \eta v = \frac{4}{3}\pi r^3 (\sigma - \rho) g \tag{2.36}$$

where,
η is viscosity of fluid,
ρ is density of fluid
σ is density of sphere
r is radius of sphere, and
g is acceleration due to gravity.

Equation 2.36 can be rewritten as follows to obtain the viscosity

$$\eta = \frac{2 g r^2 (\sigma - \rho)}{9 v \pi} \tag{2.37}$$

For a given system, r, σ, and ρ are fixed. Therefore, viscosity can be obtained by measuring the velocity of the sphere through the fluid. Equation 2.37 is for ideal situation and is corrected for practical viscometers by a number of researchers. The main error is due to the wall effect. For a sphere falling in a cylinder of finite length, Ladenburg showed that the viscosity calculated from the Stokes law (Eq. 2.37) should be corrected as follows:

$$\eta_{true} = \frac{\eta_{measured}}{\left(1 + 2.4\frac{r}{R}\right)\left(1 + 3.3\frac{r}{h}\right)} \tag{2.38}$$

where r is the radius of the sphere, R is the radius of the cylinder containing fluid and h is the height of cylinder containing fluid. The first term in the denominator is a correction for the wall effect, where as the second term corrects for the finite depth of the fluid.

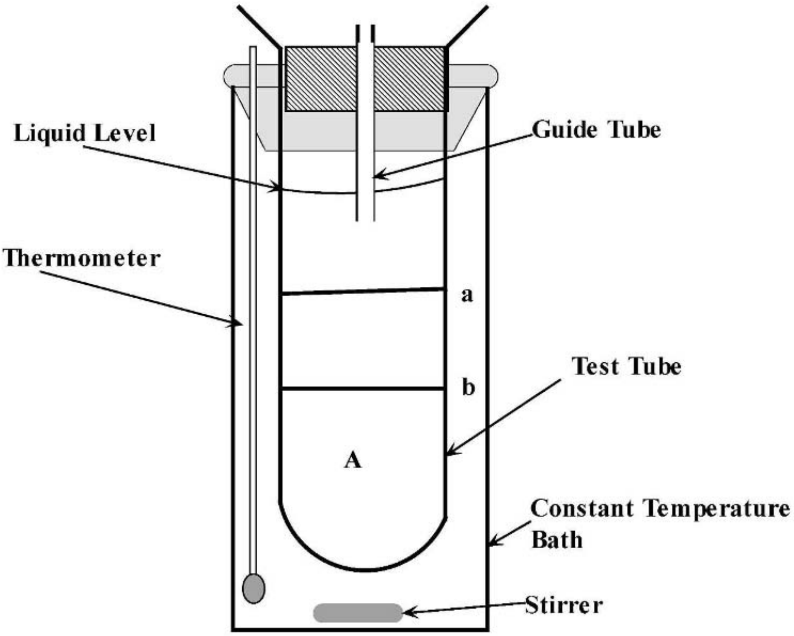


Figure 2.35. Falling ball viscometer.

Although a number of correction factors have been suggested, the Faxen expression appears to provide the best result. The Faxen correction factor is given as

$$\eta_{true} = \eta_{measured}\left[1 - 2.104\frac{r}{R} + 2.09\left(\frac{r}{R}\right)^3 - 0.95\left(\frac{r}{R}\right)^5\right] \tag{2.39}$$

The basic experimental system is shown in Fig. 2.35. The tube A, closed at the bottom, is filled with the sample to be tested. The tube A is placed inside a constant temperature bath that could be maintained within $\pm 0.1^{\circ}$C. The arrangement should exist to align the tube vertically inside the constant temperature bath. The tube is kept in the bath for about an hour until the test sample is at a uniform temperature and free from bubbles. Once the desired temperature is attained, the sphere is introduced into the tube along the axis by means of a guide tube. It is advisable to clean the sphere and bring it to the temperature of the test liquid by an external means before dropping into the liquid. The position of the sphere is followed and the time at which it passes the reference marks *a* and *b* is noted. Various systems including telescope, optical device, or magnetic sensors are used to follow the sphere movement and to accurately determine the time to travel between marks *a* and *b*. The density of both the liquid and the sphere at the test temperature should be determined as accurately as possible. If the same sphere and fall tube are used, the expression for calculating viscosity may be written as

$$\eta = K\,t(\sigma - \rho) \tag{2.40}$$

where t is the time to fall between the reference marks a and b, K is a constant specific to the instrument, σ is density of sphere, and ρ is density of fluid. In Table 2.19 is listed various manufacturers of falling ball viscometers and their sensing mechanism.

A number of researchers have studied various aspects of falling ball viscometers because of its simplicity and ease of operations. Cho[81] measured the viscosity of non-Newtonian flows using a falling ball viscometer. Later Cho et al.[82] studied the wall effect for viscoelastic fluids. They noted that with increasing elasticity, the magnitude of correction needed became smaller. The wall, inertial, and end effects in a falling ball viscometer are an interesting area of research, and several researchers in the past have addressed these issues[83-86]. Feng et al.[87] addressed these effects by obtaining both experimental data and numerically, which according to them will lead to both accuracy and reproducibility of the data. Attempts have also been made to design high precision viscometer[88], computer interfaced system[89], viscometer for refrigerants and mixtures[90] and for samples less that 1 mL[91].

2.5.1 FALLING SPHERE VISCOMETER FOR OPAQUE LIQUIDS

Falling ball viscometers may be used to measure viscosity of opaque liquids. Since the direct observation of the sphere using an optical device is not possible, other methods such as electric and magnetic methods and x-ray photograph have been used.

2.5.2 ROLLING BALL VISCOMETERS

Similar to falling ball viscometers, the viscosity can also be measured using a sphere rolling down an inclined cylindrical tube filled with the test liquid. A schematic diagram of the system is shown in Fig. 2.36. Hubbard and Brown[92] carried out a detailed analysis of the rolling ball viscometers for Newtonian fluid. However, for a specific instrument, for the same sphere and tube, Equation 2.40 can be used to calculate viscosity. Rolling ball viscometers offer several advantages over fall balling viscometers including (1) only a small amount of sample is required, (2) visual observation in glass apparatus is possible even with opaque liquids since the ball is in contact with the glass tube making it possible for use of optical sensing system, and (3) a number of parameters such as tube diameter, angle of inclination, and rolling distance can be varied. Flowers[93] first suggested the use of a rolling ball system for measuring viscosity. Hersey[94] developed the correlation of the variables involved in the measurement. Sage[95] used the system for measuring viscosity of hydrocarbons. The work of Hoeppler[96] led to the development of a commercial instrument which is currently known as Hoeppler Viscometer. Hoeppler used the eccentric fall of large spheres in a tube inclined at an angle of 80° for his measurements. A classical Hoeppler Viscometer is shown in Fig. 2.36. The modern day Hoeppler Viscometer is designed in the same manner. The precision bore tube is made of heat resistant, chemically inert glass and is about 16 mm in diameter and 200 mm long. The length of the measuring distance is generally 100 mm in both running direction. The working angle is generally 10% vertical, but it can be extended up to 50° in some of the models. The tube is jacketed and using a constant temperature circulating bath, the test temperature can be controlled in the range of -60°C to +150°C.

The tube is filled with about 30 to 40 mL test liquid, and after the proper ball has been enclosed, it is sealed by means of a special capillary plug. This allows inversion of the tube without introducing air bubble into the system. The measurement is made by timing the passage of the ball between two marks in the glass tube using an optical device. The viscosity is calculated from Eq. (2.40) with an accuracy of 0.5 to 2% depending on the ball used. The instrument is supplied with a set of six balls. Generally two balls are made of borosilicate glass, two from nickel-iron alloy, and the other two from stainless steel.

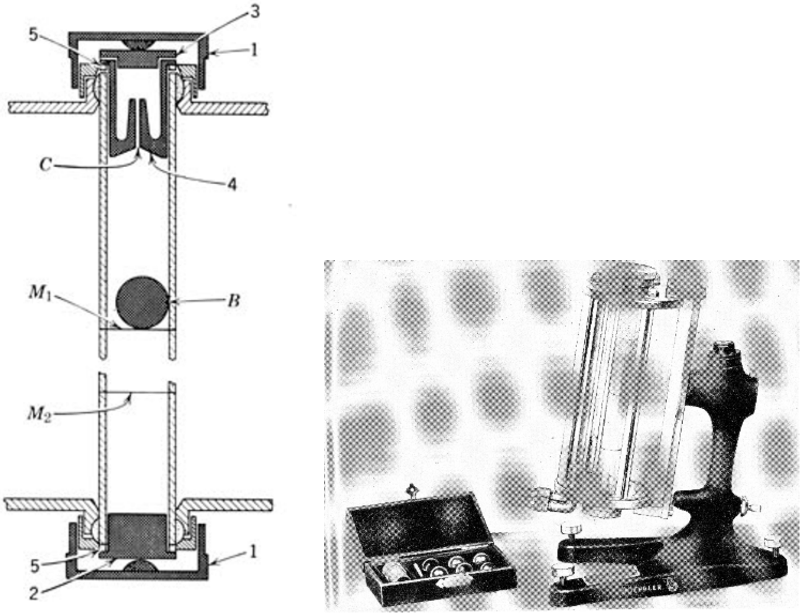


Figure 2.36. Rolling ball viscometer (Adopted from J. R. Van Wazer, J. W. Lyons, K. Y. Kim, and R. E. Colwell, *Viscosity and Flow Measurement A Laboratory Handbook of Rheology*, Interscience Publishers, New York, 1963).

Most of the current rolling ball viscometers are designed for high pressure operations[97-101]. A number of investigators have also addressed the theory for the improvement of the understanding of the operation particularly for non-Newtonian fluids and accuracy of the measurements[102-106].

2.5.3 FALLING CYLINDER VISCOMETERS

Although the use of a sphere in falling ball viscometers simplifies the analysis and the calculation of viscosity, other geometry has also been explored to improve the accuracy of the measurement. Both cylinders and needles have been used by various researchers to measure the viscosity. Instruments are also available commercially using these types of geometry.

The working principle of the falling cylinder viscometer is basically the same as that of a falling ball viscometer and it can be used for both Newtonian and non-Newtonian fluids. The measuring system consists of a cylinder or a piston in a measuring tube. The measuring element is installed in a tank or in a liquid filled line. The measuring tube is completely immersed in the liquid. The piston assembly is raised by an air lifting or other mechanisms such as magnetic lift, drawing a sample of the liquid to be measured down through the clearance between the piston and the inside of the cylinder into the space which is formed below the piston as it raised. The operation is shown in Fig. 2.37. The piston is then allowed to fall by gravity discharging the sample out through the same annulus. The time of fall is noted. The current instruments display the viscosity directly after making necessary corrections. A flow diagram of an automated a falling cylinder viscometer system using magnetic sensor is shown in Fig. 2.38.

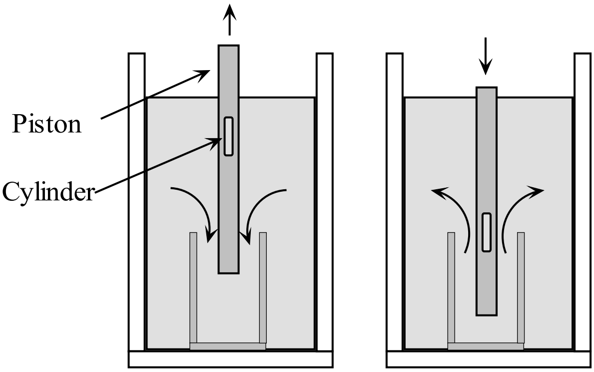


Figure 2-37. The operating principle of a falling cylinder viscometer.

Since the early work of Bridgman[107], most of the work on falling cylinder viscometers concentrated on development of an accurate high pressure system[108,109], studying the end effects[110-116], and development of theoretical model and mathematical analysis of the system[117-119].

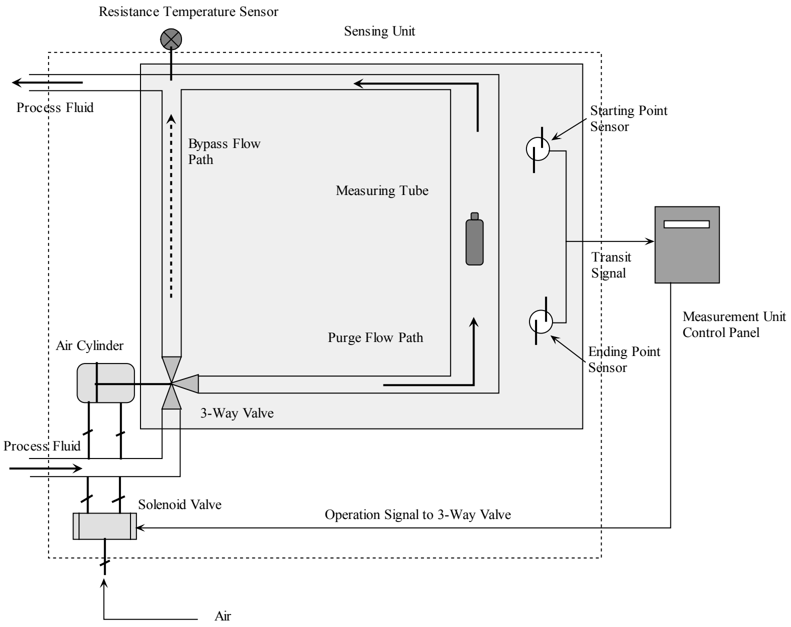


Figure 2.38. Flow diagram of a commercially available falling cylinder viscometer (Adopted from Toki Sangyo Co., Ltd. www.tokisangyo.com, Tokyo, Japan).

2.5.4 FALLING NEEDLE VISCOMETER

Falling needle viscometers offer several advantages over falling cylinder or piston viscometers and was first suggested by Park and Irvine[120]. It can measure absolute viscosity without instrument calibration with an accuracy of better than 1%. Also the viscosity range for falling needle viscometer is 0.1 to 10^8 cP. Another advantage is that it can measure density and viscosity of the test fluid simultaneously at the test temperature. A schematic diagram of the falling needle viscometer is shown in Fig. 2.39. A slender hollow cylinder, or called the needle, with hemispherical ends falls under gravity through the test liquid. The longitudinal axes of the needle and the measuring cylinder should be vertical or parallel to the gravity vector. Once the needle reaches its terminal velocity, which is generally attained after traveling a short distance, it is measured either visually or electronically. For a Newtonian fluid, the expression for calculating the dynamic viscosity for the geometry shown in Fig. 2.39 is as follows.

$$\eta = \left(\frac{g\, d^2 (\rho_s - \rho)}{8\, v_{true}} \right) \left[-\left(1 + \ell n\, k\right) \right] \tag{2.41}$$

where g is acceleration due to gravity
d is diameter of the needle
ρ_s is density of solid (needle)
ρ is density of fluid, and
V_{true} is terminal velocity of needle.

Equation 2.41 is obtained assuming that the flow field around an infinitely long needle and is valid for $k<0.033$, where $k = d/D$. D is the diameter of the cylinder. The terminal velocity must be corrected for end effects. A number of expressions have been developed for determining end correction factor. Park and Irvine[121] suggested following correction factor to Equation 2.41.

$$\frac{v_{measured}}{v_{true}} = 1 + \frac{2}{3L^+}\left[1 + \frac{3}{2C_w L^+}\left(\frac{k^2(1-\ell n\, k)-(1+\ell n\, k)}{1+k^2}\right)\right]^{-1} \qquad (2.42)$$

where

$C_w = 1 - 2.04k + 2.09k^3 - 0.95k^5$, and $L^+ = L/d$.

L is the length of the needle minus one diameter. Park and coworkers[122-127] studied in detail various aspects of falling needle viscometers and extended its applications to a variety of systems.

The ASTM test method D5478-98 provides the standardized protocol for measuring viscosity using a falling needle viscometer. Several improvements to the falling needle viscometer were suggested to overcome the shortcomings of the conventional instrument. Thiessen and Krantz[128] studied the behavior of terminal velocity of a falling needle and provided a rationale for using only small terminal velocity. Sha[129] suggested a new design of the needle structure, collector, and launcher and used Hall magnetic sensors and single-board computer in the system, which made the measurement automatic. Davis and Brenner[130] calculated drag coefficients in the presence of the tube wall for shapes varying from spheroidal toward cylindrical and suggested an alternative means of calibration. Later Davis[131] pointed out some of the limitations on the use of the Stokes law when applied to falling needle.

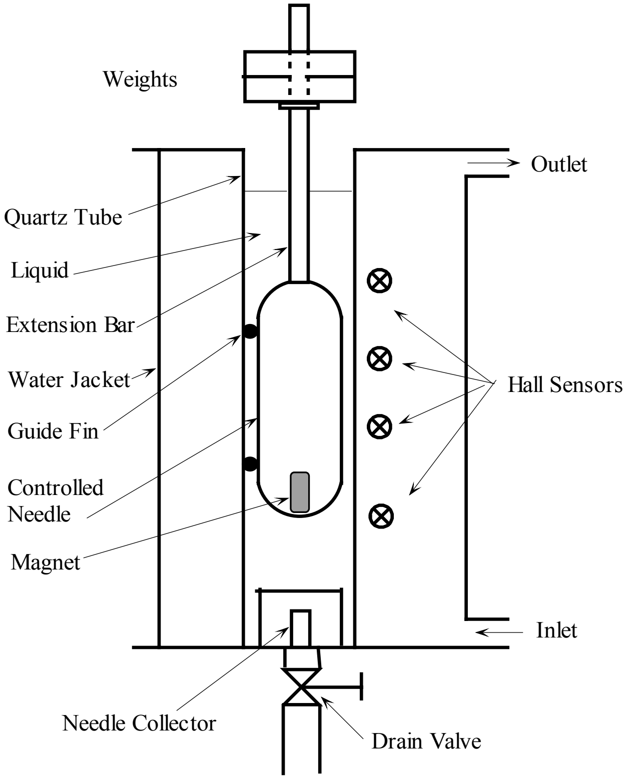


Figure 2.39. Falling needle viscometer. (Adopted from N. A. Park and T. F. Irvine, The falling needle viscometer-A new technique for viscosity measurement, *Warme Stoff.* **18**, 201-206, 1984).

2.6 VIBRATIONAL VISCOMETERS

In the petrochemical industry, on-line measurement of viscosity is a critical measurement parameter for maintaining the quality of the product. Vibrational viscometers are best suited for this purpose. The important features of vibrational viscometers are small sample volume requirement, high sensitivity, ease of operation, continuous readings, wide range, optional internal reference, flow through of the test liquid and consequent easy clean out and prospect of construction with easily available materials.

Vibrational viscometers measures the damping of an oscillating electromechanical resonator immersed in the test liquid. The resonator may be a cantilever beam, oscillating sphere or tuning fork which oscillates in torsion or transversely in the liquid. The resonator's damping is measured by several methods:

1. The power required to maintain the oscillator vibrating at constant, precise amplitude is measured. The higher the viscosity, the more power is needed to maintain the amplitude of oscillation. The vibrating probe accelerates the fluid and power input is proportional to product of viscosity and density.
2. The vibration of the resonator is stopped and the decay time of the oscillation is measured. The higher the viscosity, the faster the signal decays.
3. The frequency of the resonator as a function of phase angle between excitation and response waveforms is measured. The higher the viscosity, the larger the frequency change for a given phase change.

2.6.1 TUNING FORK TECHNOLOGY

Vibrational viscometers designed based on tuning fork technology is capable of measuring simultaneously both the fluid viscosity and density accurately and independently. Designed specifically for hydrocarbons, continuous on line measurement is performed by determining the bandwidth and frequency of the vibrating fork resonance; the bandwidth giving the viscosity measurement whilst the frequency giving the liquid density (Fig 2.40). A temperature sensor can be easily accommodated in the instrument for temperature measurement. In addition to this, other parameters such as viscosity gravity gradients and ignition indices for fuel oils can be calculated.

2.6.2 OSCILLATING SPHERE

A stainless steel sphere oscillates about its polar axis with precisely controlled amplitude (Fig. 2.41). The viscosity is calculated from the power required to maintain this predetermined amplitude of oscillation. While it is very simple in design, the oscillating sphere viscometer provides viscosity that is density dependent. Therefore, density of the test fluid should be determined independently if kinematic viscosity is required for process control.

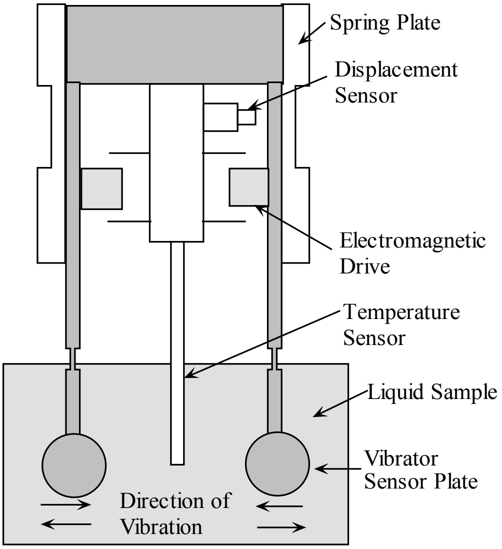


Figure. 2.40. A schematic diagram of the viscometer designed based on tuning fork technology (http://www.gardco.com/pages/viscosity/viscometers/sv_10_100.html).

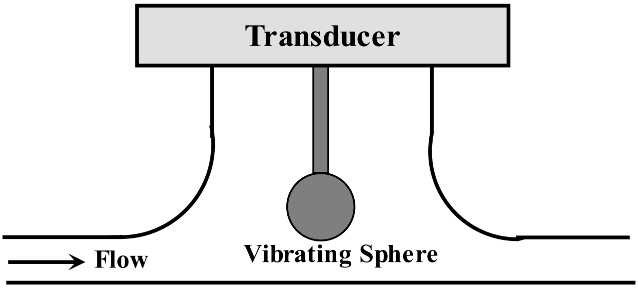


Figure. 2.41. An oscillating sphere system for creating controlled amplitude in liquid (Adopted from J. F. Steffe, *Rheological Methods in Food Process Engineering*, 2nd Ed., Freeman Press, Michigan, 1996).

2.6.3 VIBRATING ROD

These viscometers determine the dynamic viscosity by measuring the damping of a resonator that is excited at its natural frequency in a torsional (or twisting) vibration (Fig 2.42). A constant power source vibrates the rod, and the amplitude variations are measured to determine the viscosity. Like the oscillating sphere, the vibrating rod cannot measure kinematic viscosity.

Sieben[133] designed a vibrational viscometer using an oscillating capillary tube. However, recent designs employ various geometries. The solid stainless steel sensor element can be submerged in the fluid and made to twist back and forth microscopically at a high frequency. As the surface of the sensor shears through the liquid, energy is lost to the fluid because of its viscosity. Dissipated energy is accurately measured by microprocessor-controlled electronics and then equated back to viscosity (Hydramotion Ltd, York, England).

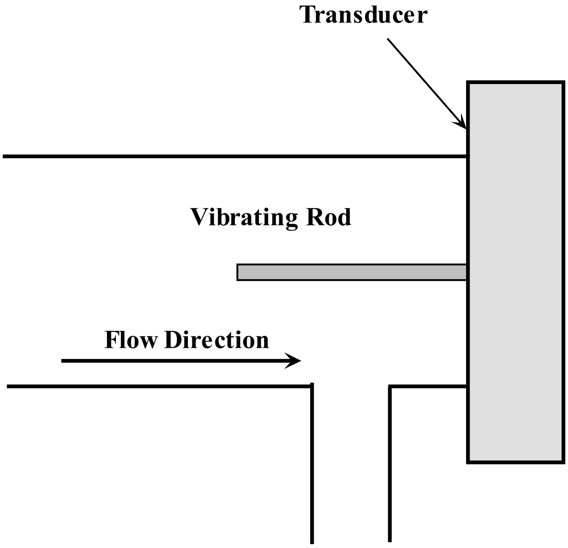


Figure. 2.42. Vibrating rod system for measuring dynamic viscosity (Adopted from J. F. Steffe, *Rheological Methods in Food Process Engineering*, 2nd Ed., Freeman Press, Michigan, 1996).

2.7 ULTRASONIC VISCOMETERS

Ultrasonic viscometers provide instantaneous and continuous measurement of viscosity by means of ultra high frequency sound waves. The first ultrasonic viscometer, called "Ultra-Viscoson" was developed by Rich-Roth Laboratories, Hartford, Connecticut, USA.[134]. The basic characteristics of an ultrasonic viscometer is shown schematically in Fig. 2.43. It consists of a small sensing element or probe which is immersed in the liquid being tested. The instrument can operate over a temperature range of – 93 to 315°C as well as in vacuum. This instrument has high utility in connection with refinery vacuum distillation systems.

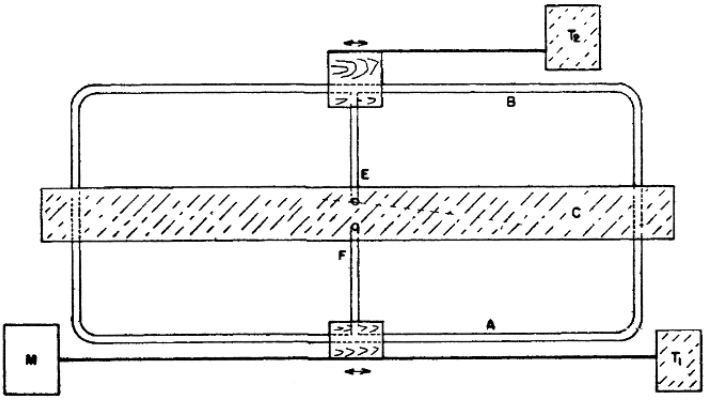


Figure 2.43. A schematic diagram of an ultrasonic viscometer.

The oscillatory motion of a sphere in a viscous liquid is utilized to measure the viscosity. The device consists of two electro dynamic transformers, placed along a common axis. The coils of both the transformers are suspended in permanent electric fields and attached to each other by means of a rod. When measurements are carried out on liquids, a sphere is attached to the rod, while the viscoelastic materials are directly fixed to the end of the rod. The emf is induced in the coil of the measuring transformer with magnitude proportional to the velocity and phase displacement. The emf is measured by means of an oscilloscope. The viscosity of the liquids over wide ranges can be determined within a few percent accuracy, applying frequencies of oscillation in the range of 0.05 to 0.07 kilocycles. Vibration is realized by switching the driving transformer.

The damping of transverse vibrations of a fine wire stretched between two rigid supports is shown to be a measure of the viscosity of liquids. The simplicity of the hydrodynamic problem and the low nuisance damping of the wire make the method attractive, particularly for the measurement of small viscosities. A number of researchers have designed and studied various types of ultrasonic viscometers[135-139]. Recently, Sheen et al.[140] of Argon National Laboratory, Il, USA designed and employed an ultrasonic viscometer for remote measurement of viscosity of radioactive liquids. Greenwood and coworkers[141-144] at the Pacific Northwest national Labortory, Richland, VA, US, developed an on-line sensor capable of measuring viscosity continuously. Their system is shown in Figure 2.44.

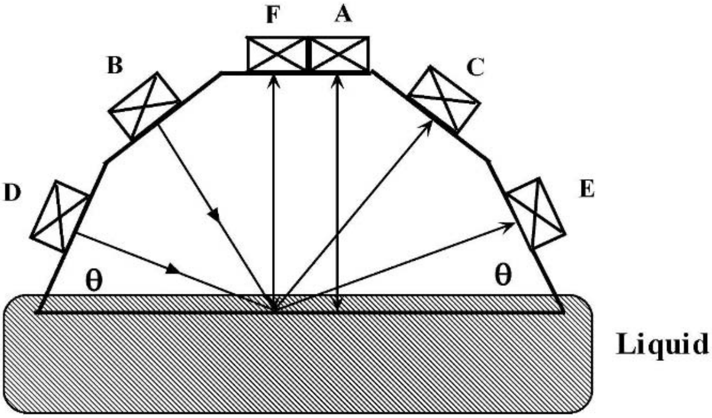


Figure 2.44. Ultrasonic wedge immersed in fluid for measuring viscosity and other properties (Adopted from M. S. Greenwood and J. A Bamberger, Ultrasonic sensor to measure the density of a liquid or slurry during pipeline transport, *Ultrasonics*, **40**(1), 413-417, 2002).

Greenwood and Bamberger[141] described the working principle of the sensor as follows: The sensor consists of longitudinal (*B*, *C*, *D*, *E*, and *F*) and shear wave (*A*) transducers mounted upon a Rexolite ™ wedge. The transducers have a center frequency of 2.25 MHz. When ultrasound from transducer *F* (operating in pulse-echo mode) strikes the wedge-liquid interface, part of it is reflected back toward *F* and the rest is transmitted into the liquid. Similarly, when ultrasound from transducer *D* (or *B*) (operating in pitch-catch mode) strikes the interface, some of it is reflected toward transducer *E* (or *C*), some mode converts to a shear wave in the wedge, and part is transmitted into the liquid. The reflection coefficient, that describes the amount of ultrasound reflected to the receive transducer, is dependent upon the densities and speed of sound in the liquid and the wedge material. The reflection coefficient is measured by comparing the voltage on the receive transducer when the base is immersed in the liquid with that when the base is immersed in a reference liquid, usually water. The experimental measurements are described in detail in Greenwood and Lail[142], Greenwood and Harris[143], and Greenwood et al.[144].

2.8 SUMMARY

The viscosity data is necessary for the design of process equipment and maintenance of product quality, where continuous on-line viscosity data is necessary. During processing, particularly in plastic industry, viscosity changes significantly altering both the rheological behavior and flow pattern of the liquid. Therefore no single instrument should be chosen without careful consideration of the range of measurement needed and the type of flow of the material. The change of viscosity with temperature necessitates the use of several different instruments for full characterization of the materials. Choice of measuring instruments also depends on the type of flow or if the liquid is Newtonian or non-Newtonian. Other issues that should be considered in selecting viscometers are: calibration of the instrument, ease of operation, method of accurately measuring and recording shear and shear rate variables, temperature control, and sample size. A quick guide for selecting a viscometer is given in Table 2.19.

Table 2.19 .Selection guide for viscometers, their viscosity measurement ranges and manufacturers.

Instrument	*Viscosity Range*	*Applications*	*Standard*	*Manufacturers/Suppliers*
Glass Capillary Viscometers				
Ostwald	0.3 – 10 cSt	Control testing.	ASTM D445, D446.	Cannon Instrument Co., State College, PA, USA.
Cannon-Fenske Routine	0.5 – 100 000 cSt	Petroleum products, Lubricants, Fuels, Cut back asphalt, Road oil.	ASTM D445, D446; ISO 3104, 3105.	Cole-Parmer Instrument Co., Vernon Hills, IL, USA.
Zeitfuchs Transparent	0.6 – 100 000 cSt	Newtonian liquids, Control testing.		Ertco Precision, Dubuque, IA, USA.
BS/U Tube	0.9 – 10 000 cSt	Newtonian liquids, Control testing.	ASTM D445, D446; ISO 3104, 3105; IP 71.	Rheotek -Poulten Selfe Ltd, Essex, UK. Brinkmann Instruments Inc, Westbry, NY, USA
Suspended Level Viscometer				
Ubbelohde	0.3 – 100 000 cSt		ASTM D 445, D446; ISO 3104, 3105.	Schott Instruments GmbH, Mainz, Germany Ace Glass Inc., Vineland, NJ, USA.
Cannon-Ubbelohde	0.5 – 100 000 cSt	Low temperature applications, Lubricants, Fuels.		DC Scientific Glass, Pasadena, CA, USA. Humboldt Mfg. Co., Norridge, IL, USA (for Zeitfuchs Cross-Arm)
BS/IP/SL	3.5 – 100 000 cSt	Transparent Newtonian liquids.		
BS/IP/SL(S)	1.05 – 10 000 cSt	Transparent Newtonian liquids.		
BS/IP/MSL	0.6 – 3 000 cSt	Transparent Newtonian liquids.		

Instrument	***Viscosity Range***	***Applications***	***Standard***	***Manufacturers/Suppliers***
Reverse Flow Viscometer				
Zeitfuchs Cross-Arm	0.6 – 100 000 cSt	Lubricants, Fuels, Paints.	ASTM D 445, D446; ISO 3104, 3105.	
Cannon-Fenske Opaque	0.4 – 20 000 cSt	Lubricants, Fuels, Paints.	ASTM D 2170 and BS 188.	
BS/IP/RF-U Tube	0.6 – 300 000 cSt	Opaque Newtonian liquids.	ASTM D 445, D446; ISO 3104, 3105.	
Small Volume Viscometer				
Cannon Manning Semi Micro	0.5 – 100 000 cSt	Transparent Newtonian liquids, Blood and plasma, Petroleum products, Lubricants.	ASTM D 445, D446; ISO 3104, 3105.	
Cannon-Ubbelohde Semi Micro	0.3 – 100 000 cSt	Blood and plasma.		
Cannon Manning Semi Micro Extra Low Charge	0.3 – 100 000 cSt	Blood and plasma.		
Dilution Viscometer				
Cannon-Ubbelohde Dilution	0.5 – 100 000 cSt	Polymer solution.	ASTM D 445, D446; ISO 3104, 3105.	
Cannon-Ubbelohde Four Bulb Shear Dilution	0.5 – 100 000 cSt	Polymer.		

Instrument	Viscosity Range	Applications	Standard	Manufacturers/Suppliers
Vacuum Viscometer				
Asphalt Institute Vacuum	42 – 5 800 000 P	Asphalts.	ASTM D2171.	
Cannon Manning Vacuum	0.036 – 80 000 P	Asphalts.		
Modified Koppers Vacuum	42 – 200 000 P	Asphalts.		
Efflux Type Viscometers				
Saybolt	10^{-1} – 10 P		ASTM D88, D244.	Koehler Instrument Co., Inc., Bohemia, NY, USA.
Redwood	10^{-1} – 10 P			
Engler	10^{-1} – 10 P			
Ford Cup	10 – 1 400 cSt		ASTM D 333, D 365, and D 1200.	Cole-Parmer Instrument Co., Vernon Hills, IL, USA. BYK-Gardner GmbH Lausitzer Strasse 8 D-82538, Geretsried Germany. Elcometer Instruments Ltd., Manchester, UK. Cannon Instrument Co. State College, PA, USA Paul N. Gardner Company, Inc., Pompano Beach, FL, USA.

Instrument	*Viscosity Range*	*Applications*	*Standard*	*Manufacturers/Suppliers*
Zahn Cup	20 – 1 200 cps	Thin oil, Mixed paints, Lacquers.		Weschler Instruments Cleveland, OH, USA BYK-Gardner GmbH Lausitzer Strasse 8 D-82538 Geretsried Germany Cannon Instrument Co. State College, PA, USA Paul N. Gardner Company, Inc. Pompano Beach, FL, USA.
Shell Cup	1 – 7 000 cP			Norcross Corporation Newton, MA, USA. Cannon Instrument Co., State College, PA, USA.
Marsh Funnel				Fann Instrument Company, Houston, TX, USA.
EZ (Equivalent Zahn) Viscosity Cup	10 – 1 401 cSt		ASTM D 816, D 1084, and D 4212.	Cole-Parmer Instrument Co., Vernon Hills, IL, USA. BYK-Gardner GmbH Lausitzer Strasse 8 D-82538 Geretsried Germany
Gardco/Din Cup	38 – 545 cSt		DIN 53211	
Iso Cup	4.6 – 2 611 cSt		ISO 2431; ASTM D5125.	
Parlin Cup	7 – 15 000 cSt		ASTM D 1084A.	
Fisher Cup	11 – 1 125 cSt		ANSI/NCSL Z540-l.	

Instrument	*Viscosity Range*	*Applications*	*Standard*	*Manufacturers/Suppliers*
Rotational Viscometers				
Stabinger Viscometer SVM 3000	0.2-20 000 (mPa .s) < 1 up to 10 000 mm^2/s	Diesel fuel, Engine oil, Lubricants, Asphalt and bitumen, Wax; Paraffin, Vaseline	ASTM D 7042.	Anton Paar GmbH, Graz, Austria.
Cannon Rotary Viscometer, Model 2020	1 – 13 000 000 cP			Canon Instrument Co. State College, PA, USA
Brookfield Viscometer	15 – 104 000 000 cP	Oils, Solvents, Paints, and coatings, Sauces, Adhesives, Creams, and varnishes, Epoxies, Gels, and Tars.		
Cone and Plate				
HAAKE ViscoTester 550	1– 1 000 000 (mPa s)	Highly viscous liquids and pastes.	ISO 3219.	Thermo Electron Corporation, Waltham, MA, USA.
Brookfield Viscometer				BYK-Gardner GmbH, Lausitzer Strasse 8 D-82538 Geretsried, Germany
Ferranti Portable Viscometer			ASTM D 3245.	Ravenfield Designs Limited, Heywood Lanes, UK
Elcometer Digital Viscometer	150 – 4 000 cP		ASTM D 562, D 856, D 1131; FTMS 141 M 4281.	Elcometer Instruments, Ltd., Manchester, UK
Toki Sangyo	0.6 – 512 000 cP			Toki Sangyo Co. Ltd., Tokyo, Japan
Brookfield CAP 1000+ Viscometer	Shear Rate: 10 s^{-1} to 13 300 s^{-1}		ASTM D4287; ISO 2884; BS 3900.	5. Paul N. Gardner Company, Inc., Pompano Beach, FL, USA.

Instrument	*Viscosity Range*	*Applications*	*Standard*	*Manufacturers/Suppliers*
Coaxial Cylinder				
Visco 88 Viscometer	$5 - 10^7$ mPa. s	Paints and coatings, Inks, Surfactants and polymer solutions, Foods, Pharmaceuticals and cosmetics, Biochemical and medical, Plastics and polymers, Adhesives and sealants, Petrochemicals, Drilling Fluids	DIN 53019.	Malvern Instruments Ltd., Worcestershire, UK.
Direct Reading Viscometer	Shear Rate: 0.17 to 1022 s^{-1}	Drilling fluids, Cement slurries, Fracturing fluids, and Production fluids.	API Spec 10, API RP-13B and API RP-39.	Chandler Engineering Co., Tulsa, OK, USA
Schott Viscoeasy Rotational Viscometers	2 – 1 060 000 000 cP		ASTM D 115-96, D 789-94, D 1076-88, D 1084-88, D 1470-90, D 1439-94, D 1824-95, D 2364-89, D 2393-86, D 2556-93a, D 2669-87, D 2983-87, D 2994-77, D 3236-88, D 3716-83, D 4016-93, ISO 2555, 1652.	Schott Instruments GmbH, Mainz, Germany.

Instrument	*Viscosity Range*	*Applications*	*Standard*	*Manufacturers/Suppliers*
HAAKE VT550	1– 1 000 000 (mPa s)	Newtonian liquids.	DIN 53019; ISO 3219.	Thermo Electron Corporation, Waltham, MA, USA.
Visco Star Plus	2 – 13 000 000 cP		ISO 2555 and ISO 1652.	Geneq Inc. Montreal, Canada
Viscometers RC01 / RC02	3 – 13 000 000 mPa s		ISO 2555.	RheoTec Messtechnik GmbH, Ottendorf-Okrilla, Germany
Visco Elite	3.2 – 1 060 000 P		ISO 2555 and ISO 1652.	GR Scientific Ltd, Bedfordshire, UK
Falling Ball Viscometer				
HAAKE Falling Ball Viscometer C	0.6 – 75 000 mPa s	Transparent Newtonian liquids and gases.	DIN 53015; ISO 12058.	Thermo Electron Corporation, Waltham, MA, USA.
Gilmont Falling Ball	0.2 – 2 000 cP		ASTM D 1343-93.	Cole-Parmer Instrument Co., Vernon Hills, IL, USA.
Falling Ball Viscometer KF 10	0.5 – 7 10^4 mPa s	Newtonian Fluid, Fuels, Paper emulsions, Polymer solutions, Paints, Varnishes, Detergents, Food industry.	DIN 53015.	RheoTec Messtechnik GmbH, Ottendorf-Okrilla, Germany.
Minivis Micro Viscometer	0.2 to 1 500 mPa s (cSt)	Used oil, Heavy-oil, Black ink and blood.	ISO 12058; DIN 53015.	Grabner Instruments GmbH, Vienna, Austria.
Rolling Ball Viscometers				
Rolling Ball Viscometer		Oil reservoir fluid.		Chandler Engineering Co., Tulsa, OK, USA

Instrument	*Viscosity Range*	*Applications*	*Standard*	*Manufacturers/Suppliers*
Falling Needle Viscometers				
FNV-200	0.5 to 2.4 x 1 0^6 cP	Adhesives, Automobile fluids, Fuels, Paints, Petroleum, Polymers, Solutions, Surfactants, Suspensions, Varnish.	ASTM 5478-98.	Stony Brook Scienrific, Ltd., Norristown, PA, USA
CNV-100	0.1 to 10^6 cP			
PDV-100	5 to 10^5 cP			APT Instruments, Farmersville, PA, USA
Falling Cylinder Viscometers				.
Toki Sangyo Viscometer	1 – 120 000 000 cP			Toki Sangyo Co. Ltd., Tokyo, Japan.
Ultrasonic Viscometers				
XL7 Viscometer	0 to 1 000 000 000 cP	Polymer melt.		Hydramotion Ltd., York, England
SV-10 Vibro Viscometer	0.3 to 10 000 mPa.s			Malvern Instruments Ltd., Worcestershire, UK.
	0.3 to 10 000 cps	Newtonian, Non-Newtonian.		A&D Weighing, Milpitas, CA, USA.
Dynatrol Viscosity System	1 to 10 0000 cps	Newtonian, Non-Newtonian.		Automation Products, Inc., Houston, TX, USA.
Tuning Fork Vibration Viscometer	0.3 – 100 000 cP	Ink, Paint, Food, Pharmaceutical, Chemical processing, Rubber, Oil, Paper.		Cole-Parmer Instrument Co., Vernon Hills, IL, USA.

Instrument	*Viscosity Range*	*Applications*	*Standard*	*Manufacturers/Suppliers*
High Temperature High Shear Viscometers				
Ravenfield HTHS Viscometers	Shear Rate: 100 000 to 1 500 000 s^{-1}		ASTM D 4741; CEC L 36-A-90 and IP 370.	Ravenfield Designs Limited, Heywood, Lancs., UK
Cannon HTHS	Shear Rate: $10^6 s^{-1}$	Engine oil at 150°C.	ASTM D5481; SAE J300.	
Cold Cranking Simulator				
CS-2 Cranking Simulator			ASTM D 5293.	Ravenfield Designs Limited, Heywood, Lancs., UK
Cannon, CCS-2050	1500 – 27 000 cP	Oil (-35°C to -5°C).	ASTM D5293; SAE J300.	Cannon Instrument Co., State College, PA, USA
On-Line Viscometers				
SPC/L372J Flow - Through Viscometer	0.2 – 20 000 cP			Cambridge Applied Systems, Inc., Medford, MA, USA
High Temperature, High Pressure	0-300 cP at 300 rpm			Fann Instrument Co., Houston, TX, USA.
Bubble Viscometer				
Cole-Parmer Bubble Viscometer	0.005 – 1 066 St		AOC method Ka 6-63, ASTM D 1131, D 1545, D 1725, and FTMS 141-a method 4271.	Cole-Parmer Instrument Co., Vernon Hills, IL, USA.
PRA Bubble Viscometer	0.7 – 225 St		ISO 3104 and 3105.	PRA Coatings Technology Center, Middlesex, UK.

REFERENCES

1. A. Dinsdale and F. Moore, *Viscosity and its measurement*, Chapman and Hall, London (1962).
2. M. R. Cannon and M. R. Fenske, Viscosity measurement, *Ind. Eng. Chem. Analytical Edition.* **10**(6), 297-301 (1938).
3. M. R. Cannon and M. R Fenske, Viscosity measurement, *Ind. Eng. Chem. Analytical Edition*. **13(**5), 299-300 (1938).
4. M. R Cannon, R. E Manning, and J. D. Bell, Viscosity measurement, the kinetic-energy correction and a new viscometer, *Anal. Chem*. **32**, 355-358 (1960).
5. Y. A. Pinkevich, New viscometer for the determination of the viscosity of petroleum products at low temperatures, *Petroleum* (London), **8**, 214-215 (1945).
6. E. H. Zeitfuchs, An accurate kinematic viscometer for refinery-control laboratories, *Proc. Am. Petroleum Inst 9th Mid-Year Meeting*, Sect. III, **20**, 104-114 (1939a).
7. E. H. Zeitfuchs, Modified Ostwald viscometer for routine control tests [at petroleum refineries], *National Petroleum News*, **31**(24), 262-3 (1939b).
8. E. H. Zeitfuchs, Speeds viscosity measurement in capillary-type viscometer, *National Petroleum News*, **33**(16), R-121-124 (1941).
9. E. L. Ruh, R. W. Walker, and E. W Dean, The S.I.L. viscometer, *Ind. Eng. Chem. Anal. Ed*. **13**(5), 346-349 (1941).
10. IPT (Institution of Petroleum technologists, London), *Standard Methods for Testing Petroleum and Its Products*, 3rd ed 171-177 (1935).
11. L. Ubbelohde, The suspended-level viscometer, *J. Inst. Petro*. **22**, 32-41 (1936).
12. L. Ubbelohde, The viscometer with suspended level. (The elimination of the influence of the surface tension by the suspended spheric level.), *J. Inst. Petro.* **23**, 427-51 (1937).
13. O. Fitzsimons, A rapid precision viscometer, *Ing. Eng. Chem Anal. Ed*. **7**, 345-347 (1935).
14. J. J. Watt and C. E. Headington, New viscometer solves old problems, *Petroleum Refiner*, **33**(10), 121-125 (1954).
15. M. R. Cannon and M. R. Fenske, Viscosity measurement, *Ind. Eng. Chem. Anal. Ed*., 13, 299-300 (1941).
16. E. H. Zeitfuchs, Kinematic viscometer for opaque and very viscous liquids, *Oil and Gas J*. **44**(36), 99-102 (1946).
17. J. F. Johnson, R. L. LeTourneau, and R. Matteson, All-Purpose Capillary Viscometer, **24**(9), 1505-1508 (1952).
18. A. W. Nash and A. R. Bowen, *The principles and Practice of Lubrication*, Chapman and Hall, London (1929).
19. T. B. Stillman, *The Examination of Lubrication Oils*, The Chemical Publishing Co., Easton, PA, USA (1914).
20. A. H. Gill, *Oil Analysis*, J.B. Lippicott Company, PA, USA (1927).

21. E. A. Zahn, New viscometer measures viscosity quickly and accurately, *Chem Industries,* **51**(2), 220 (1942).
22. E. E. Klaus, F. M. Angeloni, and M. R. Fenske, *Development and Application of the PRL Single Pass Capillary Viscometer*, ASTM STP NO. 299 (1962).
23. S. W. Rein and D. L. Alexander, Development of a high shear rate capillary viscometer, *SAE Paper* No. 800363 (1980).
24. E. E. Graham, E. E. Klaus, and R. S. Badgley, Determination of the viscosity shear behavior of polymer containing fluids using a single pass, high shear capillary viscometer, *SAE Paper* No. 841391 (1984).
25. R. E. Manning and W. A. Lloyd, Multicell high temperature high shear capillary viscometer, *SAE Paper* No. 861562 (1986).
26. M. Couette, Études sur le frottement des liquids, *Ann. Chim.* (Phys), **21**,433-510 (1890).
27. E. Hatschek, The General Theory of the Viscosity of Two-phase Systems. *Trans. Faraday Sco*. **9**, 80-93 (1913).
28. A. Mallock, Determination of the viscosity of water, *Proc. Roy. Soc.* **45**, 126-132 (1888).
29. C. H. Lindsley and E. K. Fisher, End-effect in rotational viscometers, *J. Appl. Phys*. **18**, 988-996 (1947).
30. D. J. Highgate and R. W. Whorlow, Migration of particles in a polymer solution during cone and plate viscometry, *Polym. Syst Proc. Annu. Conf. Brit. Soc. Rheol*. Ed, Wetton, R. E. Macmillan, London, UK, 251-261 (1968). D. J. Highgate and R. W Whorlow, End effects and particle migration effects in concentric cylinder rheometry, *Rheologica Acta*, **8**(2), 142-151 (1969).
31. H. Kobayashi, T. Nashima, Y. Okamoto, and F. Kaminaga, End effect in a coaxial cylindrical viscometer, *Rev. Sci. Instrum*. **62**(11), 2748-2750 (1991).
32. O. Wein and V. V. Tovchigrechko, Rotational viscometry under presence of apparent wall slip, *J. Rheology*, **36**(5), 821-844 (1992).
33. G. Palma, G. Pezzin, and L. Busulini, Viscous heating in coaxial cylinder viscometers, *Rheologica Acta*, **6**(3), 259-264 (1967).
34. D. C. H. Cheng,, The calibration of coaxial cylinder viscometers for Newtonian and non-Newtonian viscosity measurement, *Theor. Appl. Rheol. Proc. Int. Congr. Rheol.* 11th , **2**, 902-903 (1992).
35. J. C. Harper, Coaxial cylinder viscometer for non-Newtonian fluids, *Rev. Sci. Instrum*. **32**, 425-428 (1961).
36. E. W. Merrill, Coaxial-cylinder viscometer for non-Newtonian fluids, *ISA J.* **3**, 124-128 (1956).
37. T. Nagy and K. Koczo, Correction of data measured with a rotational viscometer in the case of non-Newtonian liquids, **31**(4), 221-231 (1987).
38. N. Adams, and A. S. Lodge, Rheological properties of concentrated polymer solutions II. A cone-and-plate and parallel-plate pressure distribution apparatus for determining normal stress differences in steady shear flow, *Phil. Trans. Royal Soc. (London). Series A, Mathematical and Physical Sciences*, **256**(1068), 149-184 (1964).

39. K. Walters, *Rheometry*, Chapman and Hall, London (1975).

40. M. J. Miller and E. B. Christiansen, The stress state of elastic fluids in viscometric flow, *AIChE J.* **18**(3), 600-608 (1972).

41. W. M. Kulicke, G. Kiss, and R. S. Porter, Inertial normal-force corrections in rotational rheometry, *Rheologica Acta*, **16**(5), 568-572 (1977).

42. P. J. Whitcomb and C. W. Macosko, Rheology of xanthan gum, *J. Rheology*, **22**(5), 493-505 (1978).

43. R. M. Turian, Perturbation solution of the steady Newtonian flow in the cone and plate and parallel plate systems, *Ind. Eng. Chem. Fundam.* **11**(3), 361-368 (1972).

44. J. S. Vrentas, P. C. Venerus, and C. M. Vrentas, An exact analysis of reservoir effects for rotational viscometers, *Chem. Eng. Sci.* **46**(1), 33-37 (1991).

45. R. I. Tanner, *Trans. Soc. Rheol.* **14**, 483-507 (1970).

46. O. Olabisi and M. C. Williams, Secondary and primary normal stresses, hole error, and reservoir edge effects in cone-and-plate flow of polymer solutions, *Trans. Soc. Rheol.* **16**(4), 727-769 (1972).

47. R. B. Bird and R. M. Turian, Viscous heating effects in a cone-and-plate viscometer, *Chem. Eng. Sci.* **17**, 331-334 (1962).

48. R. M. Turian and R. B. Bird, Viscous heating in the cone-and-plate viscometer. II. Newtonian fluids with temperature-dependent viscosity and thermal conductivity, *Chem. Eng. Sci.* **18** 689-896 (1963).

49. R. M. Turian, Viscous heating in the cone-and-plate viscometer. Non-Newtonian fluids with temperature-dependent viscosity and thermal conductivity, *Chem. Eng. Sci.* **20**, 771-781 (1965).

50. T. C Ho, Viscous heating effects of a torsional flow between two circular plates, *J. Chinese Inst. Chem. Eng.* **2**(1), 75-77 (1971).

51. F. Rieger, Viscous heating effect in a cone and plate viscometer, *Chem. Eng. Sci.* **25**(1), 219-220 (1970).

52. B. Liu, *Secondary Flow and Misalignment in Cone-and-Plate Rheometry*, Ph.D. Dissertation, Diss. Abstr. Int B 2003, **64**(3), 1371 (2003).

53. D. C. H. Cheng, Effect of secondary flow of the viscosity measurement using the cone-and-plate-viscometer, *Chem. Eng. Sci.* **23**(8), 895-899 (1968).

54. K. R Sharma, Tangential stress corrections to the cone and plate viscometer calculations, Abstracts of Papers, 223rd ACS National Meeting, April 7-11, 2002, Orlando, FL, USA (2002).

55. H. Shankaran and S. Neelamegham, Nonlinear flow affects hydrodynamic forces and neutrophil adhesion rates in cone-plate viscometers, *Biophysical J.* **80**(6), 2631-2648 (2001).

56. D. J. Highgate, Particle migration in cone-plate viscometry of suspensions, *Nature*, **211**(5056), 1390-1391 (1966).

57. S. Oka, Theory of a cone-plate viscometer for non-Newtonian liquids, *Jap J. Appl. Phys.* **6**(2), 258-262 (1967).

58. E. O. Forster and H. H. Horowitz, Application of the cone-plate viscometer to non-Newtonian systems, *Am. Soc. Testing Mater*. Spec. Tech. Publ. No. 299, 85-95 (1962).
59. R. J. Brungraber, T. E. Stelson, and H. G. Wenzel, Modification of cone-plate viscometer to eliminate slip caused by wall effects, *Rev. Sci. Instr*. **37**(5), 669-570 (1966).
60. M. Mooney and R. H Ewart, The conicylindrical viscometer, *Physica* (The Hague), **D5**, 350-354 (1934).
61. G. H. Piper and J. R. Scott, Rubber plastometer with uniform rate of shear - shearing-cone plastometer, *J. Sci. Instrum*. **22**, 206-210 (1945).
62. R. S. Higginbotham, A cone and plate viscometer, *J. Sci. Instrum*. **27**, 139-141 (1950).
63. R. S. Higginbotham and J. J. Benbow, Two viscometers for rapid measurements at definite shearing stresses, *J. Sci. Instrum*. **29**, 221-224 (1952).
64. H. Markovitz, L. J. Elyash, F. J. Padden, and T. W. deWitt, A cone-and-plate viscometer, *J. Collid. Sci*. **10**, 165-173 (1955).
65. A. Jobling and J. E. Roberts, An investigation, with the Weissenberg Rheogoniometer, of the stress distribution in flowing polyisobutylene solutions at various concentrations and molecular weights, *J. Polym. Sci*. **36**, 433-441 (1959).
66. K. A. Lammiman and J. E Roberts, Notes on the measurements of viscoelasticity in materials of high viscosity, *Lab. Pract.* **10**, 816-824 (1961).
67. R. J. Russell, Ph.D. Dissertation, London University (1946).
68. R McKennell, Versatile cone and plate viscometer with automatic flow curve recording, *Proceedings of the Second International Congress on Rheology*; Ed. V. G. W. Harrison, Butterworths, London, 350-358 (1954).
69. J. C Chang, F. F. Lange, and D. S Pearson, Viscosity and yield stress of alumina slurries containing large concentrations of electrolyte, *J. Am. Ceram. Soc*. **77**(1), 19-26 (1994).
70. L. Wang, W. Sigmund, and F. Aldinger, Systematic approach for dispersion of silicon nitride powder in organic media, ii, dispersion of the powder, *J. Am. Ceram. Soc*. **83**(4), 697-702 (2000).
71. M. Mooney, A shearing disk plastometer for unvulcanized rubber, *Ind. Eng. Chem. Analy. Ed*. **6**(2), 147-151 (1934).
72. D. M. Ball, *Rotational Viscosity Measurement Apparatus*, US Patent No. 5987970 (1999).
73. J. P. Dickerson, L. M. Flesher, and R. D Hester, A high Reynolds number rotating disk rheometer, *J. Appl. Poly. Sci*. **53**(2), 151-159 (1994).
74. A. F. Borghesani and M. Santini, Magnetic rotating disk viscometer, *Inter. J. Thermophys*. **10**(5), 917-27 (1989).
75. L. Bruschi, M. Santini, G. Torzo, Rotating disk viscometer, *J. Physics E, Scientific Instruments* **17**(4), 312-16 (1984).
76. F. C. Goodrich and A. K. Chatterjee, Theory of absolute surface shear viscosity. II. Rotating disk problem, *J. Coll. Inter. Sci*. **34**(1), 36-42 (1970).

77. M. M. Cross and A. Kaye, Simple procedures for obtaining viscosity/shear rate data from a parallel disc viscometer, *Polymer*, **28**(3), 435-340 (1987).
78. S. J. Perry, J. M. Castro, and C. W. Macosko, A viscometer for fast polymerizing systems, *J. of Rheology*, **29**(1), 19-36 (1985).
79. O. Wein, Viscometric flow under apparent wall slip in parallel-plate geometry, *J. Non-Newtonian Fluid Mechanics*, **126**(2-3), 105-114 (2005).
80. A. Oztekin and R. A. Brown, Instability of a viscoelastic fluid between rotating parallel disk. Analysis for the Oldroyd-B fluid, *J. Fluid Mech*. **255**, 473-502 (1993).
81. Y. I. Cho, *The study of non-Newtonian flows in the falling ball viscometer*, Ph. D. Dissertation, University of Illinois, Chicago, IL, USA. *Diss. Abstr. Int. B*, **41**(1), 304-305 (1980).
82. Y. I. Cho, J. P Hartnett, and E. Y. Kwack, A study of wall effect for viscoelastic fluids in the falling ball viscometer, *Chem. Eng. Comm*. **6**(1-3), 141-149 (1980).
83. H. Faxen, Die bewegung einer starren kugel langs der achse eines mit zaherer fussigkeit gefullten rohres, *Arkiv. Mat. Astronom. Fys*. **17**(1), 45-46 (1923).
84. T. Bohlin, On the drag on a rigid sphere moving in a viscous liquid inside a cylindrical tube, *Trans. R. Inst. Tech.* (Stockholm), **155**, 1-63 (1960).
85. W. L. Haberman and R. M. Sayre, *David Taylor Model Basin*, Report No. 1143, U.S. Navy Department, Washington DC. (1958).
86. H. Brenner, and H. Happel, Slow viscous flow past a sphere in a cylindrical tube, *J. Fluid Mech*. **4**, 195-213 (1958).
87. S. Feng, A. L. Graham, P. T. Reardon, J. Abbot, and L. Mondy, Improving Falling Ball Tests for Viscosity Determination, *J. Fluids Eng*. **128**(1), 157-163 (2006).
88. M. Brizard, M. Megharfi, E. Mahe, and C. Verdier, Design of a high precision falling-ball viscometer, *Rev. Sci. Instr*. **76**(2), 1-6 (2005).
89. J. Wang, F. Reitz, T. Donaldson, and L. Pagliaro, A computer-interfaced falling ball viscometer, *J. Biochem. Biophys. Methods*, **28**(4), 251-261 (1994).
90. S. Sicars, U. Hesse, and W. K. Snelson, A new falling ball viscometer for measurement of the viscosity of refrigerants and mixtures, *Actes Congr. Int. Froid*, 18th, **2**, 418-422.
91. C. B. Lindemann and R. Rikmenspoel, Simple viscometer for samples less than 1 ml, *J. Physics E, Scientific Instruments*, **5**(2), 178-179 (1972).
92. R. M. Hubbard and G. G. Brown, The rolling ball viscometer, *Ind. Eng. Chem. Anal. Ed.* 15, 212-218 (1943).
93. A. E. Flowers, Viscosity measurement and a new viscosimeter, *Proc. Am. Soc. Testing Materials*, **14**(II), 565-616 (1914).
94. M. D. Hersey, The theory of the torsion and rolling-ball viscosimeters, and their use in measuring the effect of pressure on viscosity, *J. Wash. Acad. Sci*. **6**, 525-530 (1916).
95. B. H. Sage, Measurement of Viscosities of Liquids Saturated with Gases at High Pressures, *Ind. Eng. Chem. Anal. Ed.* **5**, 261-263 (1933).
96. F. Hoeppler, The eccentric fall of spheres through liquids or gases in cylinders, *Z. Tech. Physik*, **14**, 165-169 (1933).

97. S. Sawamura, N. Takeuchi, K. Kitamura, and Y. Taniguchi, High pressure rolling-ball viscometer of a corrosion-resistant type, *Rev. Sci. Instrum.* **61**(2), 871-873 (1990).
98. M. Izuchi and K. Nishibata, A high pressure rolling-ball viscometer up to 1 GPa, *Jap. J. Appl. Phys. Part 1*, *Regular Papers, Short Notes & Review Papers*, **25**(7), 1091-1096 (1986).
99. K. Nishibata and M. Izuchi, A rolling ball viscometer for high pressure use, *Physica B+C, Physics of Condensed Matter + Atomic, Molecular and Plasma Physics, Optics* (Amsterdam), **139-140**(1-3), 903-906 (1986).
100. E. M. Stanley and R. C. Batten, Rolling-ball viscometer for measuring viscosity of fluids at high pressures and moderate temperatures, *Anal. Chem.* **40**(11), 1751-1753 (1968).
101. D. E. Harrison and R. B. Gosser, Rolling ball viscometer for use at temperatures to 400 K under pressures to 5 kilobar, *Rev Sci. Instru.* **36**(12), 1840-1843 (1965).
102. R. B. Bird and R. M. Turian, Non-Newtonian flow in a rolling-ball viscometer, *Ind. Eng. Chem. Fundm.* **3**(1), 87 (1964).
103. M. Carreira and E. Becerro, Theory of inclined-tube and rolling-ball viscometers. I. Hydrodynamic treatment, *Anales de Quimica*. **64**(3), 263-274 (1968a).
104. Carreira, M and Becerro, E , Theory of inclined-tube and rolling-ball viscometers. II. Dimensional análisis, *Anales de Quimica*, 64(3), 275-282 (1968b).
105. M. A. Hasan, Calibration of rolling ball viscometer in the intermediate Reynolds number region, *Can. J. Chem. Eng.* **61**(4), 607-611 (1983).
106. B. J. Briscoe, P. F. Luckham, S. R. Ren, An assessment of a rolling-ball viscometer for studying non-Newtonian fluids, *Colloids and Surfaces*, **62**(1-2), 153-162 (1992).
107. P. W. Bridgman, Effect of pressure on the viscosity of 43 pure liquids, *Proc. Am. Acad. Arts Sci.* **61**, 57-99 (1926).
108. R. K. Y. Chan and D. A Jackson, An automated falling-cylinder high pressure laser-Doppler viscometer, *J. Physics E: Scientific Instruments*. **18**(6), 510-515 (1985).
109. A. G. Ovcharenko and L. N. Glemba, Falling cylinder viscosimeter for studying viscosity of liquids for a wide range of conditions, in *Teplofiz. Svoistva Uglevodorodov Nefteprod*, Ed. G. I. Cherednichenko, 115-121 (1983).
110. N. A. Park and T. F. Irvine, Jr., Falling cylinder viscometer end correction factor, *Rev. Sci. Instrum.* **66**(7), 3982-3984 (1995).
111. E. G. Wehbeh, T. J. Ui, and R. G. Hussey, End effects for the falling cylinder viscometer, *Phys. Fluids A, Fluid Dynamics*, **5**(1), 25-33 (1993).
112. M. C. S Chen and G. W. Swift, Analysis of entrance and exit effects in a falling cylinder viscometer, *AIChE J.* **18**(1), 146-149 (1972).
113. J. A. Lescarboura and G. W. Swift, Effect of eccentricity on the terminal velocity of the cylinder in a falling cylinder viscometer. Experimental verification for Newtonian fluids, *AIChE J.* **14**(4), 651-652 (1968).
114. M. C. S. Chen, J. A Lescarboura, and G. W. Swift, Effect of eccentricity on the terminal velocity of the cylinder in a falling-cylinder viscometer, *AIChE J.* **14**(1), 123-127 (1968).

115. F. J. Eichstadt and G. W. Swift, Theoretical analysis of the falling-cylinder viscometer for power law and Bingham plastic fluids, *AIChE J.* **12**(6), 1179-1183 (1966).
116. E. Ashare, B. R. Bird, and J. A. Lescarboura, Falling cylinder viscometer for non-Newtonian fluids, *AIChE J.* **11**(5), 910-916 (1965).
117. V. B. Borisov, The equation for a falling-cylinder viscometer, *High Temperature* (Translation of Teplofizika Vysokikh Temperatur), **36**(2), 293-298 (1998).
118. F. Gui and T. F. Irvine, Jr Theoretical and experimental study of the falling cylinder viscometer, *Inter. J. Heat and Mass Transfer*, **37**(1), 41-50 (1994).
119. J. Lohrenz, *Experimentally Verified Theoretical Analysis of the Falling-Cylinder Viscometer*, Ph.D. Dissertation, University of Kansas, Lawrence, KS, USA, Dissertation Abstract, **21**, 2650 (1961).
120. N. A. Park and T. F. Irvine, Jr., The falling needle viscometer - A new technique for viscosity measurements, *Warme und Stoffubertragung*, **18**, 201-206 (1984).
121. N. A. Park and T. F. Irvine, Jr., Measurement of rheological fluid properties with the falling needle viscometer, *Rev. Sci. Instrum*. **59**(9), 2051-2058 (1988a).
122. N. A. Park and T. F. Irvine, Jr., The falling needle viscometer - A new technique for viscosity measurements, *American Laboratory*, **20**(11), 57-60, 62-63 (1988b).
123. N. A. Park and T. F. Irvine, Jr., A multipurpose falling needle viscometer to measure thermophysical properties of Newtonian and non-Newtonian fluids, *American Laboratory*, **21**(12-A), 8-9 (1989).
124. N. A. Park Y. I. Cho, and T. F. Irvine, Jr., Steady shear viscosity measurements of viscoelastic fluids with the falling needle viscometer, *J. Non-Newtonian Fluid Mechanics*, **34**(3), 351-357 (1990).
125. N. A. Park and T. F. Irvine, Jr., Multifunctional falling needle viscometer to measure thermophysical properties of Newtonian and non-Newtonian fluids, Applications in Surface Phenomena and Additives in Water-Based Coatings and Printing Technology, Ed. M. K. Sharma, Plenum Press, New York, 241-253 (1991).
126. T. F. Irvine, Jr N. A. Park, F. L. Gui, and S. S. Park, A high pressure falling needle viscometer, in *Theor. Appl. Rheol Proc. Int. Congr. Rheol* 11th, Editor(s), Moldenaers, P. and Keunings, R Elsevier, Amsterdam, Netherlands, **2**, 985-987 (1992).
127. I. Kim, T. F. Irvine, Jr., and N. A. Park, Experimental study of the velocity field around a falling needle viscometer, *Rev. Sci. Instrum*. **65**(1), 224-228 (1994).
128. D. B. Thiessen and W. B. Krantz, Bimodal terminal velocities using the falling needle viscometer, *Rev. Sci. Instrum*. **63**(9), 4200-4204 (1992).
129. Z. S. Sha, The improvement on the falling needle viscometer, *Rev. Sci. Instrum*. **68**(4), 1809-1811 (1997).
130. A. M. J. Davis and H. Brenner, The falling-needle viscometer, *Physics of Fluids*, **13**(10), 3086-3088 (2001).
131. A. M. J. Davis, Limitation on the use of slender-body theory in Stokes flow, Falling needle viscometer, *Physics of Fluids*, **16**(11), 4204-4205 (2004).
132. J. F. Steffe, *Rheological Methods in Food Process Engineering*, Freeman Press, East Lansing, MI, USA (1996).

133. A. Sieben, A recording bridge viscometer, *Anal. Biochem*. **63**(1), 220-230 (1975).
134. W. Roth and S. R. Rich, A new method for continuous viscosity measurement. General theory of the ultra-viscoson, *J. Appl. Phys*., **24**, 940-950 (1953).
135. I. N. Kogan, L. I. Menes, and N. Y. Parlashkevich, Continuous viscosity measurement with an ultrasonic viscometer, *Veshchestva*, **10**, 33-45 (1960).
136. N. Y. Parlashkevich and I. N. Kogan, Determining the viscosity of concentrated polymer solutions with an ultrasonic viscometer, *Plasticheskie Massy*, **1**, 49-52 (1965).
137. S. G. R. Ruttle and M. I. Stephenson, A high-pressure ultrasonic viscometer, in Ultrason. Int. Conf. Proc. Ed. L. J. Browne, I, 224-227, IPC Sci. Technol. Press, Guildford, England (1975).
138. K. Burdova and M. Porubska, New method for measuring the viscosities of dilute solutions using an ultrasonic viscometer, *Makrotest*, 67-69 (1980).
139. V. N. Bindal, M. Chandra, and J. N. Som, An ultrasonic viscometer for the measurement of dynamic shear viscosity of liquids, *Indian J. Pure and Appl. Phys.*, **21**(3), 176-179 (1983).
140. S. H. Sheen, H. T. Chien, and A. C. Raptis, An ultrasonic instrument for measuring density and viscosity of tank waste, in Science and Technology for Disposal of Radioactive Tank Wastes, *Proceedings of the American Chemical Society Symposium on Science and Technology for Disposal of Radioactive Tank Wastes*, Ed. W. W. Schulz and N. J. Lombardo, 439-447, Plenum, New York, N. Y. (1998).
141. M. S. Greenwood and J. A Bamberger, Ultrasonic sensor to measure the density of a liquid or slurry during pipeline transport, *Ultrasonics*, **40**(1), 413-417 (2002).
142. M. S. Greenwood and J.C. Lail, *Ultrasonic Fluid Densitometry and Densitometer*, US Patent 5,708,191 (1998).
143. M. S. Greenwood and R.V Harris, *Pitch-catch Only Ultrasonic Fluid Densitometer*, US Patent 5,886,250 (1999).
144. M. S. Greenwood, J. R. Skorpik, J. A. Bamberger, and R. V. Harris, On-line ultrasonic density sensor for process control of liquids and slurries, *Ultrasonics*, **37**, 159-171 (1999).
145. D. J. Highgate and R. W Whorlow, End effects and particle migration effects in concentric cylinder rheometry, *Rheologica Acta*, **8**(2), 142-151 (1969).

Listing of Standards

American Society for Testing and Materials International, West Conshohocken, PA, USA

ASTM D88, Standard Test Method for Saybolt Viscosity-AASHTO No.: T72, 09/15/1994 (R 2005).

ASTM D 115-96, Standard Test Methods for Testing Solvent Containing Varnishes Used for Electrical Insulation, 09/10/2002.

ASTM D244, Standard Test Methods and Practices for Emulsified Asphalts-AASHTO No.: T59, 12/01/2004.

ASTM D 333, Standard Guide for Clear and Pigmented Lacquers, 05/10/2001.

ASTM D 365, Standard Guide for Soluble Nitrocellulose Base Solutions, 05/10/2001 (R 2005).

ASTM D445, Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)-IP Designation: 71/1/97; British Standard 2000: Part 71:1990, Doc. Date, 05/01/2004 (E 2004) (E 2005).

ASTM D446, Standard Specifications and Operating Instructions for Glass Capillary Kinematic Viscometers-IP Designation: 71/2/95, Doc. Date, 04/21/2004.

ASTM D 562 , Standard Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using a Stormer-Type Viscometer, 02/10/2001 (R 2005).

ASTM D 789-94, Standard Test Method for Determination of Relative Viscosity of Polyamide (PA), 03/15/2006.

ASTM D 816, Standard Test Methods for Rubber Cements, 05/01/2006.

ASTM D 1076-88, Standard Specification for Rubber - Concentrated, Ammonia Preserved, Creamed, and Centrifuged Natural Latex, 06/01/2006.

ASTM D 1084 , Standard Test Methods for Viscosity of Adhesives, 03/10/1997 (R 2005).

ASTM D 1200, Standard Test Method for Viscosity by Ford Viscosity Cup, 08/15/1994 (R 2005).

ASTM D 1343-93., Standard Test Method for Viscosity of Cellulose Derivatives by Ball-Drop Method, 11/10/1995 (R 2006).

ASTM D 1439-94, Standard Test Methods for Sodium Carboxymethylcellulose, 12/01/2003.

ASTM D 1545, Standard Test Method for Viscosity of Transparent Liquids by Bubble Time Method, 10/10/1998.

ASTM D 1725, Standard Test Method for Viscosity of Resin Solutions, 03/01/2004.

ASTM D 1824-95, Standard Test Method for Apparent Viscosity of Plastisols and Organosols at Low Shear Rates, 03/15/1995 (R 2002).

ASTM D 2170, Standard Test Method for Kinematic Viscosity of Asphalts (Bitumens)-IP Designation: 319/84 (89), Doc. Date, 12/10/2001.

ASTM D2171, Standard Test Method for Viscosity of Asphalts by Vacuum Capillary Viscometer-IP Designation: 222/84 (89), 08/10/2001.

ASTM D 2364-89, Standard Test Methods for Hydroxyethylcellulose, 06/10/2001.

ASTM D 2556-93a, Standard Test Method for Apparent Viscosity of Adhesives Having Shear-Rate-Dependent Flow Properties, 12/15/1993 (R 2005).

ASTM D 2669-87, Standard Test Method for Apparent Viscosity of Petroleum Waxes Compounded with Additives (Hot Melts)-No Replacement, 08/30/1987 (R 1999).

ASTM D 2983-87, Standard Test Method for Low-Temperature Viscosity of Lubricants Measured by Brookfield Viscometer, 05/01/2004.

ASTM D 3236-88, Standard Test Method for Apparent Viscosity of Hot Melt Adhesives and Coating Materials, 10/31/1988 (R 2004).

ASTM D 3245, Standard Test Method for Pumpability of Industrial Fuel Oils, 03/10/2003.

ASTM D 3716-83, Standard Test Methods for Use of Emulsion Polymers in Floor Polishes, 09/10/1999 (R 2006).

ASTM D 4016-93, Standard Test Method for Viscosity of Chemical Grouts by Brookfield Viscometer (Laboratory Method), 11/10/2002.

ASTM D 4212, Standard Test Method for Viscosity by Dip-Type Viscosity Cups, 05/10/1999 (R 2005).

ASTM D4287, Standard Test Method for High-Shear Viscosity Using a Cone/Plate Viscometer, 11/10/2000 (R 2005).

ASTM D 4741; Standard Test Method for Measuring Viscosity at High Temperature and High Shear Rate by Tapered-Plug Viscometer, 05/01/2006.

ASTM D5125, Standard Test Method for Viscosity of Paints and Related Materials by ISO Flow Cups, 03/10/1997 (R 2005).

ASTM D5293; Standard Test Method for Apparent Viscosity of Engine Oils Between -5 and -35 Degrees C Using the Cold-Cranking Simulator, 05/01/2004.

ASTM 5478-98. Standard Test Methods for Viscosity of Materials by a Falling Needle Viscometer, 06/10/1998 (R 2003).

ASTM D5481; Standard Test Method for Measuring Apparent Viscosity at High-Temperature and High-Shear Rate by Multicell Capillary Viscometer, 05/01/2004.

ASTM D 7042, Standard Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity), 07/01/2004.

International Organization for Standardization (ISO is the short name), Geneva, Switzerland.

ISO 1652. Rubber latex -- Determination of apparent viscosity by the Brookfield test method, 2004.

ISO 2431, Paints and varnishes -- Determination of flow time by use of flow cups, 1993.

ISO 2555, Plastics -- Resins in the liquid state or as emulsions or dispersions -- Determination of apparent viscosity by the Brookfield Test method, 1989.

ISO 2884, Paints and varnishes -- Determination of viscosity using rotary viscometers -- Part 1: Cone-and-plate viscometer operated at a high rate of shear, 1999; Paints and varnishes -- Determination of viscosity using rotary viscometers -- Part 2: Disc or ball viscometer operated at a specified speed, 2003.

ISO 3104, Petroleum products -- Transparent and opaque liquids -- Determination of kinematic viscosity and calculation of dynamic viscosity, 1994.

ISO 3105, Glass capillary kinematic viscometers -- Specifications and operating instructions, 1994.

ISO 3219, Plastics -- Polymers/resins in the liquid state or as emulsions or dispersions -- Determination of viscosity using a rotational viscometer with defined shear rate, 1993.

ISO 3219, Plastics -- Polymers/resins in the liquid state or as emulsions or dispersions -- Determination of viscosity using a rotational viscometer with defined shear rate, 1993.

ISO 12058, Plastics -- Determination of viscosity using a falling-ball viscometer -- Part 1: Inclined-tube method, 1997.

Deutsches Institut für Normung (DIN), Germany.

DIN 53015, Viscometry - Measurement of viscosity using the Hoeppler falling-ball viscometer (FOREIGN STANDARD).
DIN 53019-1, Viscometry; Determination of viscosities and flow curves using standard design rotary viscometers with a standard geometry measuring system.
DIN 53019-2, Viscosimetry - Determination of viscosity and flow curves with rotational viscosimeters - Part 2: Viscosimeter calibration and determination of the uncertainty of measurement.

Association des Constructeurs Européens d'Automobiles/ European Automobile Manufacturers Association.

CEC L 36-A-90, Viscosity at High-Temperature and High-Shear Rate Test.

Institute of Petroleum (IP Test Methods)

IP 71, Kinematic Viscosity
IP 370 is technically identical to ASTM D 4741 and CEC L-36 A-90.

The British Standards Institution

BS 188, Methods for determination of the viscosity of liquids, 31/12/76.
BS 3900, Methods of test for paints. General introduction, 28/02/89.

American National Standard Institute

ANSI/NCSL Z540-l, ANSI/NCSL Z540-1-1994: Calibration Laboratories and Measuring and Test Equipment - General Requirements.

American Petroleum Institute

API-RP-13B, Recommended practice for field testing oil-based drilling fluids.
API-RP-39, Measuring the viscous properties of a cross-linked water-based fracturing fluid.

The Society of Automotive Engineers

SAE J300, Engine Oil Viscosity Classification, May 2004.

Federal Test Method Standard (FTMS)

FTMS 141-a method 4271, Viscosity
FTMS 141 M 4281, Determining consistency (viscosity).

Chapter 3

THEORIES OF VISCOSITY

Among the theories of viscosity (a measure of internal friction) of fluids, those related to gases are well developed compared to the situation of liquids. In a gas, momentum transfer occurs due to collisions between the molecules, while forces between the closely packed molecules cause the momentum transfer in liquids. Because of the complexities involved in the liquid momentum transfer mechanisms - including those due to dispersive and electrostatic forces - there has been no simple basis for the estimation of liquid viscosities. The simplicity of approach adopted in the kinetic theory applied to gas viscosity, which is of natural interest to the development of the theories on liquid viscosity will be dealt first in our discussion. This will be followed by the theories on the viscosities of dense gases and liquids. An account of the treatment carried out on the lean and dense gases as well as the liquid phase taken together will also be given. For a clear understanding of the theories of pure fluid and mixture viscosities, it is helpful to refer to the critical reviews like those by: Brush[1], Touloukian[2], Stephan and Lucas[3], Viswanath and Natarajan[4], Monnery *et al.*[5], Poling *et al.*[6] and Mehrotra *et al.*[7]

3.1 THEORIES OF GAS VISCOSITY

The case of lean gases involving momentum transfer through translatory motion with fewer collisions is described by the kinetic theory of gases. From the application of the kinetic theory of gases based on the mean free path for colliding gas molecules (as hard spheres), Maxwell deduced that the gas viscosity is independent of density and proportional to the square root of the absolute temperature. This is seen from the expression derived for the gas viscosity:

$$\eta \propto \frac{(MT)^{(1/2)}}{\sigma^2} \tag{3.1}$$

In Eq. (3.1), the terms M, T and σ respectively denote the molecular mass, absolute temperature in K and hard-sphere diameter (Å). Maxwell tested his theory with data on air. Hirschfelder *et al.*[8] have assigned a value of 26.69 for the proportionality constant in Eq. (3.1). Expressing the viscosity coefficient in terms of the velocity distribution function and the inter-atomic force law, Maxwell developed a more general theory. In the special case of the inverse fifth power repulsive force, the viscosity coefficient was shown to be proportional to the absolute temperature. A dimensional analysis by Rayleigh showed that, for atoms repelling with an nth power force law, viscosity varies as the [(n+3)/(2n-2)]th power of temperature. In the case of colliding molecules, a correction factor known as the collision integral, Ω_V, could be introduced into Eq. (3.1). The values of collision integral are reported by Chapman and Cowling[9]. For non-attracting molecules, Ω_V becomes unity. Using Hirschfelder's assignment[8] of 26.69 to the proportionality constant and introducing the term Ω_v, Eq. (3.1) can be modified as:

$$\eta_{CE} = 26.69 \frac{(MT)^{(1/2)}}{\sigma^2 \Omega_v} \tag{3.2}$$

Equation (3.2) is applicable to spherical monatomic gases only. Neufeld *et al.*[10] reported an empirical expression for the estimation of Ω_v in terms of the dimensionless temperature T^* (= kT/ϵ), where k is the Boltzmann constant and ϵ is the minimum pair-potential energy. Of the several potential energy functions proposed for the estimation of the collision integral, the Lennard-Jones (12-6) model[11] given by Eq. (3.3) is widely used[8].

$$\psi(r) = 4\varepsilon\left[(\sigma/r)^{12} - (\sigma/r)^6\right] \tag{3.3}$$

In Eq. (3.3), σ denotes the value of the separation distance r at which $\psi(r)$ becomes zero. For dependable calculation of gas viscosity from Eqs. (3.2) and (3.3), the parameters σ and (ϵ/k) should be taken together from the same data compilation. Chung *et al.*[12] extended the applicability of Eq. (3.2) to polyatomic, polar and dilute gases with hydrogen bonding for the calculation of viscosity (η) by multiplying η_{CE} with a correction factor, CF, defined by:

$$CF = 1 - 0.2756\,\omega - 0.0509035\,\mu_R - k' \tag{3.4}$$

where, ω, μ_R, and k' are the acentric factor, reduced dipole moment and association parameter (accounting for the shape, polarity and the hydrogen bonding effects), respectively. The potential parameters σ and $(\in/k)$ are determined from the critical volume and critical temperature, respectively. Using the method of Neufeld *et al.*[10] for the estimation of Ω_v and the value of k' from the regressed data on alcohols, Chung *et al.*[12] obtained viscosity estimates close to the experimental values.

Monnery *et al.*[5] and Poling *et al.*[6] described various empirical methods of estimating lean gas viscosities. These methods used the critical properties and the reduced dipole moment, μ_R as the inputs for viscosity estimations. Poling *et al.*[6] also listed the group contributions needed for the application of Reichenberg method[13] in addition to the critical temperature (T_C, K), critical pressure (P_C, bar) and dipole moment (μ, Debyes) for various substances. Reduced dipole moment is defined by:

$$\mu_R = 52.46\,\frac{\mu^2 P_C}{T_C^2} \tag{3.5}$$

and is to be used in calculating the correction factor (CF) by applying Eq. (3.4). This method is not applicable to the hydrogen bonding gases. Stiel and Thodos[14] reported empirical equations for non-polar gas viscosities as functions of reduced temperature (T_R) and a parameter (ξ) defined by:

$$\xi = \frac{T_C^{(1/6)}}{M^{(1/2)} P_C^{(2/3)}} \tag{3.6}$$

Later the authors extended the method to polar and hydrogen bonding gases[15] by introducing the critical compressibility factor (Z_C). Okeson and Rowley[16] developed a method for the estimation of non-polar gas viscosities by using the Lee-Kesler[17] approach for compressibility factor. Based on the data for 80 non-polar gases, the size/shape factor (α) was correlated by them in terms of the radius of gyration (r_g) resulting in the following equation:

$$\alpha = 7.7706 \times 10^{-4} + 0.033\,r_g + 0.01506\,r_g^{\,2} - 9.997 \times 10^{-4}\,r_g^{\,3} \tag{3.7}$$

An empirical equation for reduced viscosity of polar and quantum mechanical gases at low pressure, which is also applicable at atmospheric pressure, was proposed by Lucas[18] that included polar and quantum correction factors F_p and F_q, respectively. The equation in terms of T_R is:

$$\eta\xi = \begin{bmatrix} 0.807\ T_R^{-0.618} - 0.357\ exp(-0.449\ T_R) \\ + 0.34\ exp(-4.058\ T_R) + 0.018 \end{bmatrix} F_P.F_q \tag{3.8}$$

This equation is reported to yield deviations within a few percent from the experimental values. F_p and F_q have been expressed in terms of Z_C and T_R. The method described is not applicable to hydrogen bonding gases. Tham and Gubbins[19], from their study on dilute gas and liquid viscosities, reported that the corresponding states principle was obeyed by both the monatomic and polyatomic dilute gases.

Millat *et al.*[20] have provided explanations of the molecular theory of gas viscosity based on the kinetic theory of gases and statistical mechanics. Shan *et al.*[21] have applied a generalized correlation based on a modified Eyring's reaction rate theory for the estimation of the gas viscosities of pure oxygen, nitrogen, and argon as well as their mixtures. The same authors[22] applied Eyring's theory to trifluoromethane (R-23) for the calculation of viscosity and thermal conductivity of dilute gas and saturated vapor in addition to the supercritical and saturated liquid regions. Over the temperature range of 153-570 K, the estimated accuracy for the viscosity is 1%.

Mandal and Thakur[23] obtained reasonably good results from a modified version of a model developed by them earlier for neon, argon and helium. The modification including the effect of intermolecular forces and molecular size on the molar density can be helpful in determining the potential energy and collision diameter as well as their variation with temperature. Monnery *et al.*[5] presented a critical review of the predictive and correlative methods for pure component and mixture viscosities of dilute and dense gases as well as liquids. The chosen well-known, accepted and promising methods have been divided into the theoretical, semi-theoretical and empirical categories. The review also included the discussion on the limitations and reliability of the methods along with recommendations.

Several semi-empirical theories of gas viscosities have been reported by Partington[24]. Among the later ones, an approach is based on the method of partition functions known as the Fluctuation-Dissipation theory, using auto-correlation functions of dynamic variables. In the case of dilute gases, the auto-correlation formula was shown to reduce to Chapman-Enskog results for binary diffusion by Mori[25]. The Fluctuation-Dissipation theory is based on the concept of the tendency of an irreversible process to return to the state of equilibrium. Some of the theories developed (using mathematical techniques) subsequent to the kinetic theory of gases were reported by Massignon[26].

3.2 THEORIES OF DENSE-GAS VISCOSITY

For dilute gases, the density (at lower pressures) does not change appreciably with pressure (at lower pressures) and the gas viscosity increases with temperature only. However, at higher pressures, there will be a rapid change in the gas density resulting in a large increase in viscosity. The behavior of viscosity at high pressures is influenced by pressure, giving rise to the dense-gas situation. An account of such studies on the viscosity of dense gas, valid for hard spheres is presented here. Jager[27] proposed a correlation for the dense gas viscosity situation by taking into account the molecular finite size and represented viscosity by the formula

$$\eta = \eta_0 \left(\frac{1}{Y} + A + B\,Y \right) \tag{3.9}$$

with Y denoting the collision rate correction factor. η and η_0 are the dense gas and dilute gas viscosities. Y is determined from the equation of state:

$$(PV/RT) = 1 + (4b/V)\,Y \tag{3.10}$$

where b is the volume occupied by spheres. A and B of Eq. (3.9) are given as $(8b/V)$ and $(16b^2/V^2)$. Enskog[28] modified Eq. (3.9) by using $A = (16b/5V)$ and $B = 0.7614\ (16b^2/V^2)$. The modified form was based on the concept that, for colliding spheres, the change in collision rate is accompanied by the momentum transfer across the finite distances. Theoretical calculations of Y over the entire range of density with reasonable accuracies are reported by Alder and Wainwright[29-31]. The viscosities of dense fluids of hard spheres given by Eq. (3.9) have been extended to a more generalized form by Davis *et al.*[32]. Livingston and Curtiss[33] modified Enskog's dense gas theory through the determination of a more accurate non-equilibrium function. Henderson[34] obtained good agreement with the experimental values of both the dense gas and liquid viscosities, by modifying the hole theory in the light of significant structures concept. The method assumed the free volume to be a linear function of the neighboring holes. In the case of dense gas hard spheres, Alder and Dymond[35] and Alder[36] assumed a faster rate of occurrence of events because of higher collision rates. Taking this increase in collision rate to be proportional to a radial distribution factor, the equation for the dense gas viscosity becomes:

$$\eta = \eta_0\,\rho b_0 \left[0.8 + \frac{1}{Z-1} + 0.761(Z-1) \right] \tag{3.11}$$

This equation could be derived in terms of the excluded volume (b_0), gas density (ρ), and compressibility factor (Z). The excluded volume, b_0, is calculated from the hard sphere diameter, σ (in Å), using the relation;

$$b_0 = (2/3)\pi N\sigma^3 \tag{3.12}$$

where N is the Avogadro number. A molecular dynamics simulation approach used by Dymond and Alder[37] predicted viscosities within 1% at densities up to 2.5 times the critical value. Further attempts by Dymond and Assael[38] and Assael *et al.*[39] yielded an expression for reduced viscosity (η_R) as a function of reduced volume ($V_R = V/V_0$), V_0 being the close-packed volume. η_R is expressed in terms of temperature (T, K), molar volume (V, cm^3/mol), molecular mass (M, g/mole) and a parameter (R_η) which accounts for deviations from smooth hard spheres. The values of R_η and close-packed volume (V_0) for 16 fluids are listed by Poling *et al.*[6]. Alle and Pomeau[40] used the Enskog and virial expansions approach to the theory of dense gases. They have computed the coefficient of the Green-Kubo integrand by means of the first Enskog approximation in the case of collisions between three particles. Their study revealed a breakdown of the Enskog expansion just beyond the Navier-Stokes range. A molecular dynamic simulation work on dense gases was carried out by Chen and Rahman[41] using a system of 500 Lennard-Jones particles. The results obtained by using the equilibrium correlation function calculated without considering the attractive part were found to be in good agreement with the hard sphere Enskog theory of dense gases at low densities. At high densities, the agreement between the simulation study and Enskog theory was not good. Collings and Evans[42] reported the calculated values of viscosity of argon ranging between (1/3) and (2/3) of the experimental data, from their study of the application of Kirkwood's molecular theory of momentum in a simple dense gas[43]. The theory, applicable to both the dense gases and liquids can be classified as a distribution function theory, wherein the momentum flux is expressed in terms of velocity distribution function. Kirkwood *et al.*[44] deriving an expression for viscosity in terms of a friction coefficient, calculated the viscosity of argon at 89 K as 0.127 mpa.s, compared to the experimental value of 0.239 mpa.s. Applying the distribution function theory, Kirkwood and Boggs[45] derived an integral equation for the pair distribution function for a hard sphere fluid. Frezzotti[46] used a molecular dynamics approach to the study of one-dimensional problems in the kinetic theory of dense hard sphere gases. The results obtained from this method were comparable to the Enskog theory of solutions. Some of the reviews on the theories based on non-equilibrium distribution functions are by Green[47], Bondi[48], and Rice and

Frisch[49]. Cummings and Evans[50] reviewed both the non-equilibrium and equilibrium molecular dynamic simulation approaches.

3.3 GAS AND LIQUID VISCOSITY THEORIES

Equation (3.11) applied to the hard spheres considers only the repulsions. To extend the applicability to real fluids, a term has to be included in the equation to account for the attraction between the molecules. By introducing a 'thermal pressure' term, Enskog modified Eq. (3.11) for application to real fluids. Applying the modified form to three non-polar substances (oxygen, hydrogen and argon) at temperatures below T_C, Hanley *et al.*[51] reported good agreement between the calculated and experimental viscosities (within 10-15%). Davis et al.[32] derived an expression for the viscosity of hard sphere dense fluids using a square-well intermolecular potential. Sather and Dahler[52] also reported expressions for viscosity of dense fluids of rough spheres. The square-well model developed by Davis *et al.*[32] was used by Collings and McLaughlin[53] for viscosity calculations of 14 polar and non-polar fluids. The results showed wide deviations ranging between 2 and 70%. Chung *et al.*[54] in an attempt to extend their earlier work[12] on dilute gases to dense fluids, introduced empirically correlated density and temperature-dependent functions. The extended model, tested with 37 non-polar, polar and hydrogen bonded fluids yielded average absolute deviations below 4%. Using the Enskog theory to correlate the dense fluid viscosity of argon, nitrogen and oxygen, Cohen and Sandler[55] used the equation developed by Sandler and Fizdon[63].

$$\eta = \eta_0 \rho b \left[0.8 + \frac{1}{y} + 0.761 y \right] \tag{3.13}$$

where y denotes the hard sphere diameter and is defined as

$$y = b \, \rho \, g(\sigma) \tag{3.14}$$

g(σ) of Eq. (3.14) is the hard sphere radial distribution function at contact. A model developed by Abdelazim[56] by multiplying the right hand side of Eq. (3.13) with an empirically determined correction factor showed good agreement with experimental data for both the dense gas and liquid phases. Application of an empirically modified square-well theory of Davis *et al.*[32] by Du and Guo[57] to 26 non-polar fluids including hydrocarbons, oxygen and nitrogen yielded an overall deviation of about 9%.

Viscosity correlations of several investigators covering the entire phase range of dilute gas through the liquid stage are described next. Based on the observation that the residual viscosity defined as the difference between the dense fluid and dilute gas viscosities (η-η_o) is nearly independent of temperature, Jossi *et al.*[58] obtained the empirical expression for 11 non- polar fluids in the form:

$$(\eta - \eta_0)\xi = f(\rho_R) \tag{3.15}$$

where $f(\rho_R)$ is a function of the reduced density, ρ_R, valid for the range $0.1 < \rho_R < 3$. The reduced viscosity parameter (ξ) is defined by Eq. (3.6). Using a similar approach, Stiel and Thodos[59] developed the residual viscosity equations for 14 polar substances. For argon, neon, krypton and xenon, Tham and Gubbins[19] proposed a generalized corresponding states relationship;

$$\eta^*(T^*, V^*) = \frac{\eta\sigma^2}{(M\varepsilon)^{(1/2)}} \tag{3.16}$$

where $$T^* = (kT/\varepsilon), \tag{3.17}$$

$$V^* = (V/N\sigma^3), \tag{3.18}$$

in which k is the Boltzman constant, T is the absolute temperature, ε is the minimum potential energy, V is the molar volume, N is the Avogadro's number, and σ is the distance of separation between the molecules. They obtained good agreement with 6% average absolute deviation.

To extend the applicability of their approach to polyatomic fluids, Tham and Gubbins[19] modified Eq. (3.16) by multiplying the product $M\varepsilon$ with an empirically adjusting factor, α. T^* was taken as equivalent to ($kT/\varepsilon\alpha$). The modified approach, when applied to 25 non-polar substances including hydrocarbons showed errors ranging between 6% and 10%. Introducing the corrections for molecular attractions and chaos into the Enskog theory and using the values of the close-packed volumes determined from his previous work[60] , Dymond[61] correlated the viscosity data on krypton, xenon and argon within 2-5% over the entire density range, from dilute gas to liquid. A similar approach applied to C_2 - C_5 hydrocarbons[62] also yielded deviations within 2-5%, except for a few data points in the case of C_2, n-C_4 and n-C_5.

Combining a procedure of obtaining the hard sphere diameter y of the Enskog equation, Sandler and Fiszdon[63] developed the following equation.

$$\frac{\eta}{\eta_0 \rho b} = \left[0.8 + \frac{1}{y} + 0.761\, y \right] \tag{3.19}$$

with the determination of the excluded volume (b_0) from the minimum of the plot of ($\eta/\eta_o b$) vs. density (ρ), Cohen and Sandler[55] suggested a method of calculating the dense fluid viscosity, η, from the dilute gas viscosity, η_0. The method fitted the data on methane with an average deviation of 2.4%.

Lucas[64] presented a generalized viscosity phase diagram for non-polar fluids. The product of viscosity (η) and reducing factor for viscosity (ξ) defined by Eq. (3.6) is plotted as a function of the reduced temperatures (T_R), at various reduced pressures (P_R). The dilute gas state is indicated by the lower limit of the P_R-curves on the diagram. The liquid phase is simulated at higher pressures. A method developed by Ely and Hanley[65] incorporating an empirical correction to the reference fluid (methane) viscosity correlation of Hanley *et al.*[66], when tested on the data of 35 non-polar fluids, showed an *Average Absolute Deviation* (AAD) of 8.4%. However, large errors were found in the case of iso-alkanes and naphthalenes.

Modifying the Ely and Hanley model by changing the reference fluid from methane to propane, Ely[67] could bring down the AAD to 2.4%. A corresponding states approach by Pedersen *et al.*[68] for estimating the viscosity of crude oil fractions yielded an AAD of 5.0 %. The method, based on the approach of Tham and Gubbins[19], when applied to 15 non-polar fluids including carbon dioxide and hydrocarbons showed an overall deviation of 8.1%.

Modifying Ely and Hanley approach[65] using a viscosity acentric factor (ω_η) and an association parameter (k) along with the coefficients of the shape factors of Leach[69], Hwang and Whiting[70] could improve on the results obtained by Ely and Hanley[65]. For the 38 polar, hydrogen bonding and non-polar substances studied, their method showed an AAD of 5.3% compared to 17.6% of the Ely and Hanley method.

Lawal[71] developed a viscosity model similar to a cubic equation of state with four constants calculated from critical properties and two temperature-dependent functions that were evaluated from the experimental data. Tested with the data on 24 non-polar fluids at about 6700 points, the method showed an overall deviation of 5.9%.

Heyes et al.[72] fitted the expressions of Dymond *et al.*[60] to the data on shear viscosity, thermal conductivity and self-diffusion coefficient of Lennard-Jones fluid over the entire phase diagram at densities below the solid-fluid co-existence line. A modified form of the Enskog theory is given by:

$$b_0\,\rho\rho\,(\sigma)=\left[\frac{V}{R}\left(\frac{dP}{dT}\right)_V\right]-1=T\left(\frac{dZ}{dT}\right)_V+Z-1 \tag{3.20}$$

Equation 3.20 when combined with an equation of state like Peng and Robinson[73], can be used to obtain the hard sphere radial distribution function *g(σ)*. Equation (3.20) can further be utilized to obtain the excluded volume (b_0) by taking its limit as ρ and $g(\sigma)$ approach zero and unity, respectively. Using such a procedure to obtain b_0 and $g(\sigma)$ and replacing the constant 0.8 of Eq. (3.19) by an adjustable parameter (whose value is regressed), Sheng and Lu[74] calculated the viscosities for the whole phase range of five non-polar fluids with a maximum AAD of 3.7%.

Using an equation of the form

$$log(\eta^*/C)=\sum\alpha_i(V/V_0)^i \tag{3.21}$$

with the constants α_i determined from the approach of Dymond[75] and generalizing the values of C as function of carbon number and V_0 as a function of temperature and carbon number, Assael *et al.*[76-77] obtained AADs of 2.8% for 16 non-polar fluids and less than 3% for 7 aromatic hydrocarbons. Using the same method, the authors[78] have calculated the viscosities of 6 polar and non-polar compounds with AADs ranging between 1.9 % and 4.1 %.

Hildwein and Stephan[79] developed a semi-theoretical significant structures model expressing viscosity as a function of several variables:

$$\eta=f(T,V,\varepsilon,r_0,d,\sigma,S,n1,a,b) \tag{3.22}$$

r_0 and d in Eq. (3.22) denote the radius of Kihara potential minimum and Kihara potential hard core diameter, S is the Sutherland constant and *nl*, *a* and *b* are adjustable parameters regressed from the experimental data. For 3 polar and 14 non-polar fluids, Eq. (3.22) fitted the data with the AAD ranges of 0.2 to 1.6% for dilute gases, and 2.0 to 4.7% and 1.6 to 6.9% for saturated liquids and saturated vapors, respectively.

Introducing a cross over function between the low-pressure and high-pressure limits into Eq. (3.19), Xiang *et al.*[80] have extended its applicability to the entire fluid range. The scheme, tested with the data on 18 fluids fitted the low-pressure viscosities within 4% and high-pressure viscosities mostly within 10%.

A generalized correlation based on Eyring's significant structures theory covering the entire fluid range of the components of air and its mixtures was developed by Shan *et al.*[21]. The wide-ranging formulation explicit in viscosity and thermal conductivity as functions of temperature and density yielded satisfactory results.

Meir *et al.*[81] obtained self-diffusion coefficients and viscosities of a Lennard-Jones fluid through molecular dynamic simulations employing the Einstein plots covering the entire fluid range. The uncertainties for self-diffusion, liquid region and low-density viscosities have been 0.5%, 2.0% and 15%, respectively.

3.4 PURE-LIQUID VISCOSITY THEORIES

There has been no comprehensive theory on the viscosity of liquids so far because of its complex nature. Theoretical methods of calculating liquid viscosities like those proposed by Kirkwood *et al.*[44] and the molecular dynamic approaches reported by Cummings and Evans[50] are useful in providing valuable insights into the theory even though they result in large deviations from the measured viscosity data. In contrast, semi-empirical and empirical methods provide reasonable results but lack generality of approach. At temperatures below the normal boiling point, the logarithm of liquid viscosity varies linearly with the reciprocal of the absolute temperature as described by the model;

$$ln(\eta) = A + (B/T) \quad or \quad \eta = Aexp(B/T) \tag{3.23}$$

with the constants A and B determined empirically. At temperatures above the normal boiling point, the $ln\ \eta$ versus $(1/T)$ relationship becomes non-linear and is described by a number of semi-empirical methods including those based on the principle of corresponding states. Among the important compilations providing liquid viscosity data are Kestin and Shankland[82], Viswanath and Natarajan[4], Daubert *et al.*[83], Perry and Green[84] , Lide[85] and Dean[86]. As our primary concern in this book is liquid viscosity, in the following sections, we present the theories proposed, semi-theoretical and empirical models, for estimating liquid viscosity. More elaborate discussions about the semi-theoretical and empirical methods are presented in Chapter 4 (devoted to the correlation and estimation methods).

3.4.1 THEORIES PROPOSED

The observed fact that the liquid property values like those of density and viscosity are between those of solids and gases, led to the formulation of several theories based on gas-like, and/or, solid-like structures.

Of these, the distribution function theories favor the gas-like concept of liquids. These theories introduce a short-range pair distribution function in a disordered state of the fluid. Among the various distribution function theories applied to viscosity calculations, those by Kirkwood and associates[43-45] are already discussed in section 3.3. An expression for liquid viscosity was obtained by Born and Green[87, 88] using Kirkwood-Bogg integral[45]. Rice and Kirkwood[89] obtained an expression for viscosity coefficient of argon in terms of equilibrium properties.

The theories on liquids with solid-like structure assume the molecules to be confined within small spaces and each molecule interacts with only a few neighbors. Brush[1] referred to four types of such theories as hole, vibration, phonon (sound wave) and relaxation theories.

In hole theories, the liquid is considered as a lattice of densely populated molecules with a few holes. Jumping of molecules within the holes under the influence of a shearing stress causes the viscous flow.

Vibration theories assume that the vibration of molecules around equilibrium positions causes momentum transfer within the liquid.

Phonon theories assume that the momentum transfer within the liquid occurs due to the vibration of the lattice as a whole.

In relaxation theories, viscous flow is considered to be similar to the deformation of elastic solids. The need for sufficient data at molecular level limits their application.

The best example of the hole theory is the reaction rate theory of Eyring and co-workers[90-92], in which the viscous flow is considered as a reaction causing the molecule to acquire the activation energy, while crossing over a potential barrier. Applying Eyring's theory[90], Glasstone *et al.*[92] derived the following liquid viscosity equation in terms of the molar free energy of activation of flow (ΔF^*) and molar volume (V):

$$\eta = \frac{Nh}{V}\, exp\left(\Delta F^* / RT\right) \tag{3.24}$$

where N is the Avogadro's number, h is the Planck's constant and R is the universal gas constant. Eq. (3.24) suggests the flow to be Newtonian in the sense that viscosity is independent of the applied force. Kincaid *et al.*[93] related ΔF^* to the energy of vaporization, ΔE_{Vap}. Plotting ΔF^* (calculated from Eq. (3.24)) as a function of ΔE_{Vap} (expressed in terms of the enthalpy of vaporization, ΔH_{Vap}) by the equation:

$$\Delta E_{Vap} = \Delta H_{Vap} - RT_B \tag{3.25}$$

where T_B is the normal boiling point in Kelvin, Kincaid *et al.*[93] obtained a straight line (passing through the origin) with a slope of (1/2.45) from the data of 93 organic and inorganic liquids. Their theory, based on Eq. (3.25), over-predicts experimental viscosities by 2 to 3 times[93, 94]. A brief discussion on the enthalpy of activation of several systems is given by Hirschfelder *et al.*[95].

In an extension of Eyring's theory to hydrocarbons, Moore *et al.*[96] found that the flow is largely translational at low temperatures and becomes rocking at intermediate temperatures. At high temperatures, the molecules freely rotate about their long axes. Collins[97] proposed an alternate form of Eyring's theory, making use of a constant volume temperature coefficient of viscosity instead of the isobaric temperature coefficient (employed by Ewell and Eyring) for the determination of the activation energy. The theory was reported to be in moderate agreement with the experimental viscosities of simple liquids.

Macedo and Litovitz[98] reformulated Eyring's rate theory using an expression for the probability of finding a vacant site and assessed the relative roles of the activation energy and free volume. Application of the equation developed by them to various liquids including argon, fused SiO_2, polyatomic van der Waals and H-bonded compounds provided consistent fits to both the temperature and pressure dependence of viscosity.

Shakhparonov[99] discussed the mechanism of viscous flow in monohydric alcohols and gave the reasons for the differences between the viscosity-temperature relationships of carbon disulfide, carbon tetrachloride, benzene, alcohols and normal alkanes. The solid-like and gas-like aspects of the liquid behavior, wherein a molecule vibrates about an equilibrium lattice before jumping into a neighboring vacant site are combined in the significant structures theory of Eyring *et al.* proposed in 1958[100]. The liquid viscosity (η_L) considered as the sum of contributions due to the solid-like and liquid-like behaviors can be expressed in terms of the volume fractions occupied by the solid and liquid portions as:

$$\eta_L = (V_S/V)\eta_S + [1 - (V_S/V)]\eta_G \tag{3.26}$$

where V_S is the volume occupied by the solid portion and V is the sum of the volumes of the solid and gas portions. Application of the significant structures theory[100] by Eyring and Ree[101] to argon showed deviations from experimental viscosities ranging up to 60%. Egelstaff[102], in a review on the structure of simple liquids, presented calculation procedures on viscosity, diffusion, and viscosity coefficients in addition to a discussion of static and dynamic structure factors.

The peculiar phenomenon of super fluidity of helium near absolute zero was attributed to the phonon excitations by Landau[103, 104]. Using density and velocity as quantum operators for describing the collective phonon excitations, Landau could predict the phenomenon of second sound (thermal waves), which was reported to have been confirmed experimentally by Peshkov in 1944 as quoted by Brush[1]. For calculating the viscosity coefficient of helium at low temperatures, Landau and Khalatnikov[105-108] introduced the concept of considering the phonon and proton excitations as quasi-particles of an ideal gas and applied the kinetic theory to compute the momentum transport.

The Landau-Khalatnikov (L-K) theory attributed the negative temperature viscosity coefficient of helium below 1.6 K to the strong temperature dependence of the phonon-phonon scattering. Further details on the application of the L-K theory can be found in Brush's review[1].

3.4.2 SEMI-THEORETICAL MODELS

In general, semi-theoretical models provide satisfactory results. Most of the theoretical models discussed involve large errors in their estimates of liquid viscosities. On the other hand, semi-theoretical methods combine theoretical principles with models based on the trends in experimental data. Semi-theoretical models generally involve coupling of a viscosity model with the density or volume prediction method. Most of these methods utilize corresponding states approaches and/or the models based on statistical mechanics like hard sphere and significant structures theory.

According to the corresponding states theory, the dimensionless property of a compound should be equal to that of a reference compound at the same reduced conditions. To calculate the viscosity of a compound, these methods need the correlations on viscosity and density of a reference liquid along with the critical properties and parameters like acentric factor and shape factors. A brief discussion of the predictive and correlative methods based on semi-theoretical approach is presented in the following section while more details particularly on applied aspects are presented in Chapter 4.

Using the square-well intermolecular potential developed by Davis *et al.*[32], Davis and Luks[109] calculated the viscosity of liquid argon. The equation for calculating liquid viscosity can be expressed as a function of the density (ρ), molar mass (M), the repulsion diameter (σ_l), intermolecular potential attractive energy (ε), ratio of attraction diameter to repulsion diameter (R) and the radial distribution functions at repulsion diameter ($g(\sigma_1)$) and at attraction diameter ($g(\sigma_2)$) as:

$$\eta = f\left(\sigma_2, \varepsilon, R, g(\sigma_1), g(\sigma_2), \rho, M\right) \tag{3.27}$$

Obtaining the parameters: σ_1, $\in$ and R from the virial coefficient data and $g(\sigma_1)$ and $g(\sigma_2)$ by using Percus-Yevick equation along with the perturbation theory of Lowry *et al.*[110], Davis and Luks[109] predicted argon viscosities with an AAD of 6%. Letsou and Stiel[111] correlated the viscosity data for 13 liquids including hydrocarbons with an overall deviation of 3% by means of an equation of the type:

$$\eta\xi = f^{(0)}(T_R) + f^{(1)}(T_R) \tag{3.28}$$

with the parameter ξ defined by Eq. (3.6). $f^{(0)}(T_R)$ and $f^{(1)}(T_R)$ are quadratic functions in T_R, valid for the range $0.70 < T_R < 0.92$.

Fischer[112] developed an equation of state for a variety of materials including UO_2, using Eyring's significant structures theory[100]. He included a defect term in the solid-like partition function to determine the O/U ratio. The gas-like partition functions were adjusted to obtain agreement with the experimental data at the melting point. Eyring's significant structures theory[100] was also applied by Gillan[113] for deriving thermodynamic properties from the consideration of molecular structure of liquids. Liquid thermodynamic partition function is expressed as an average of the solid and gas partition functions. The three parameters contained by the liquid function are then determined from experimental data. The calculated thermodynamic properties showed good agreement with experimental data in the case of alkali metal halides and UO_2. The approach appears promising for liquid viscosity as well.

Heckenberger and Stephan[114] proposed a viscosity equation of state based on the conclusion from their earlier work[115] that a residual transport property (ΔTP) surface P-ΔTP-T corresponded better than the thermal P-ρ-T surface. Regressing the seven model parameters with experimental data, the method showed an AAD of 4.7 %. At reduced temperatures below 0.6, the deviations increased rapidly up to about 33%. The constants of Eq. (3.23) are expressed by Allan and Teja[116] in terms of carbon numbers for pure alkanes, from ethane to eicosane. Using the method, they obtained an AAD of 3% for 19 compounds. Regressing the effective carbon numbers (ECN) with an experimental value of viscosity of each compound, they could correlate the data on 50 hydrocarbons with an AAD of 2.3%. A Walther type of equation,

$$log(log\,\eta + 0.8) = b_1 + b_2\,log\,T \tag{3.29}$$

was fitted by Mehrotra[117] to the API Project 42[118] data on 273 heavy hydrocarbons with AADs ranging between 0.8 % (for n-paraffins and olefins) and 1.4% for non-fused aromatics. It this equation b_1 and b_2 are constants. Developing an empirical equation of the type given below:

$$log(log\,\eta + 0.8) = 100(0.01T)^b \tag{3.30}$$

where b is equivalent to the constant b_2 of Eq. (3.29), the optimum values of b were regressed for each compound. The method yielded an overall AAD range of 2.3 % (for branched alkanes and olefins) to 10.6 % (for fused ring naphthenes). Mehrotra[119] also correlated the data on 89 light and medium hydrocarbons by regressing the constants b_1 and b_2 of Walther equation in good agreement with experimental viscosities. Regressing the parameter b of Eq. (3.30) resulted in the AADs ranging between 6.6 % for aromatics and 12.5 % for n-alkyl cyclopentanes.

Aasberg-Petersen *et al.*[120] developed a method using the Teja-Rice[121] type of model for estimating liquid viscosities. The equation is given by:

$$ln(\eta\xi) = ln(\eta\xi)^{R1} + \frac{\left(\omega - \omega^{R1}\right)}{\left(\omega^{R2} - \omega^{R1}\right)}\left[ln(\eta\xi)^{R2} - ln(\eta\xi)^{R1}\right] \tag{3.31}$$

where *R1* and *R2* refer to the two chosen reference fluids and ξ is defined by Eq. (3.6). Aasberg-Petersen employed molecular mass (*M*) instead of the acentric factor (ω) as the characteristic property. Testing of Eq. (3.31) for 6 aromatics and 12 alkanes at pressures up to 70 MPa, yielded deviations ranging between 5% and 39%.

Cao *et al.*[122] developed a viscosity model for pure liquids and mixtures on the basis of Eyring's absolute rate theory, statistical thermodynamics and local compositions. The model, used to describe the viscosity-temperature relationship of 314 pure liquids showed a mean relative standard deviation (MRSD) of 1.1%. All the four parameters were regressed for the calculation of viscosities. The liquids studied include hydrocarbons, alcohols, ethers, acetates, amines, aldehydes, ketones and water. Mehrotra[123] proposed a method that predicted viscosities of 70 liquid hydrocarbons with an AAD of 5% by employing Eq. (3.30) along with the expression for b in the equivalent carbon number, *ECN*

$$b = -5.745 - (40.468 / ECN) + 0.616\ ln(ECN) \tag{3.32}$$

Other methods include those of Mehrotra[123], Monnery et al.[5], Sauder and Orbey[124], and Lei et al.[125]. Monnery *et al.*[5] presented a review on theoretical, semi-theoretical and empirical categories of methods for dilute and dense gases, liquids and mixtures and included many references. They have also discussed the limitations and reliability of various methods. The gaps in viscosity prediction/correlation methods were also identified. Sandler and Orbey[124] reviewed the methods of prediction and correlation of the viscosity of liquid hydrocarbons and their mixtures with regard to the changes in pressure, temperature and composition. Mehrotra[7] reviewed semi-theoretical and empirical methods used for prediction or correlation of pure liquid hydrocarbons, petroleum fractions and their mixtures. The review also summarized the results obtained from various calculation methods for the selected set of compounds and their mixtures mentioned earlier. Lei *et al.*[125] presented a two-parameter model based on Eyring's absolute rate theory for the calculation of pure liquid viscosities over a wide temperature range. The model parameters were determined using the viscosity data and from knowledge of the vapor pressure, saturated liquid volume and heat of vaporization. The overall average deviation was reported as 1.5% for 106 compounds (including non-polar, polar, organic and inorganic liquids) for 1473 data points.

3.4.3 EMPIRICAL METHODS

Finding relationships between viscosity and other properties, by means of mathematical expressions that provide the best fit of the experimental data, is a common practice among investigators. Partington[24] presented some of the empirical methods proposed and tested on several liquids by various experimenters in addition to providing a state of the art assessment of the literature. The models included two, three and multi-constant equations. A number of such equations involve temperature, pressure, molecular mass and properties like surface tension, vapor pressure, heat of vaporization, normal boiling point and refractive-index. Some of the important and commonly used correlation and estimation methods including those dependent on group contributions are discussed in detail in Chapter 4.

3.5 SUMMARY

Well understood theories of liquid viscosity have not been developed, probably because liquid state is an intermediate state of matter between gas and solid, and not easy to represent in terms of different characteristic properties of substances. Often attempts have been made to describe liquid as having solid-like and/or liquid-like structure. Therefore an attempt has been made to describe theories of dilute gas viscosity and dense gas viscosity in the first two sections of this chapter. The next two sections describe the theories for the understanding gas and liquid viscosity and liquid viscosity (exclusively). The discussion under pure liquid viscosity is sub-divided into theories proposed, semi-theoretical models and empirical methods.

In all the sections, an attempt has been made to present a review of the salient features, application aspects like requirements of input data, average absolute deviation in applying the theory/method, etc., to the extent possible. It is expected that the information provided will be useful in developing relations for liquid viscosity based on the theoretical concepts/ideas presented, to the situation of one's interest and type of accuracies required.

REFERENCES

1. S. G. Brush, Theories of liquid viscosity, *Chem.Rev.* **62**, 513-548 (1962).
2. Y. S. Touloukian, S. C. Saxena, and P. Hestermaus, *Thermophysical Properties of Matter*-PRS Data Series, Vol. II, Viscosity, Purdue Research Foundation (1975).
3. K. Stephan and K. D. Lucas, *Viscosity of Dense Fluids*, Plenum, New York (1979).
4. D. S. Viswanath and G. Natarajan, *Data Book on the Viscosity of Liquids*, Hemisphere, New York (1989).
5. W. D. Monnery, W. Y. Svrcek, and A. K. Mehrotra, Viscosity: a critical review of practical predictive and correlative methods, *Can. J. Chem. Eng.* **73**(11), 3-40 (1995).
6. B. E. Poling, J. M. Prausnitz, and J. P. O'Connell, *The Properties of Gases and Liquids*, McGraw Hill, New York (2001).
7. A. K. Mehrotra, W. D. Monnery, and W. Y. Svrcek, A review of practical calculation methods for the viscosity of liquid hydrocarbons and their mixtures, *Fl. Phase Equilib.* **117**(1), 344-355 (1996).
8. J. O. Hirschfelder, C. F. Curtiss, and R. B. Bird, *Molecular Theory of Gases and Liquids*, John Wiley, New York (1954).
9. S. Chapman and T. Cowling, *The Mathematical Theory of Non-Uniform Gases*, Cambridge Univ. Press (1939).
10. P. D. Neufeld, A. R. Janzen and R. A. Aziz, Empirical equations to calculate 16 of the transport collision integrals $\Omega^{(l,s)*}$ for the Lennard-Jones (12–6) potential, *J. Chem. Phys.* **57**, 1100-1102 (1972).
11. J. E. Lennard-Jones, Determination of molecular fields (I) from the variation of viscosity of a gas with temperature, *Proc. Royal Soc.* (London) **A106**, 441 (1924).
12. T. H. Chung, L. L. Lee, and K. E. Starling, Applications of kinetic gas theories and multiparameter correlation for prediction of dilute gas viscosity and thermal conductivity, *Ind. Eng. Chem. Fundam.* **23**, 8-13 (1984).

13. D. Reichenberg, *DCS Report 11*, National Physical Laboratory, Teddington, England (1971).
14. L. I. Stiel and G. Thodos, Viscosity of nonpolar gases at normal pressures, *AIChE J.* **7**, 611-615 (1961).
15. L. I. Stiel and G. Thodos, The normal boiling points and critical constants of saturated aliphatic hydrocarbons, *AIChE J.* **8**, 527-529 (1962).
16. K. J. Okeson and R. L. Rowley, A four-parameter corresponding-states method for prediction of Newtonian, pure-component viscosity, *Int. J. Thermophys*. **12**(1), 119-136 (1991).
17. B. I. Lee and M. G. Kesler, Generalized thermodynamic correlation based on three-parameter corresponding states, *AIChE J.* **21**(3), 510-527 (1975).
18. K. Lucas, *Review of Present Status of Transport Properties Predictions, Phase Equilibria and Fluid Properties in the Chemical Industry*, DECHEMA, Frankfurt (1980).
19. M. J. Tham and K. E. Gubbins, Correspondence principle for transport properties of dense fluids. Nonpolar polyatomic fluids, *Ind. Eng. Chem. Fundam*. **9**(1), 63-70 (1970).
20. J. V. Millat, J. H. Dymond, and C. A. Nieto Castro, *Transport Properties of Fluids, Their Correlation, Prediction and Estimation*, Cambridge Univ. Press, Cambridge (1996).
21. Z. Shan, R. T. Jacobsen, and S. G. Penoncello, A generalized model for the transport properties of air components and mixtures, *Adv. Cryog. Eng*. **45**(Pt. B), 1229-1236 (2000).
22. Z. Shan, S. G. Penoncello, and R. T. Jacobsen, A Generalized model for viscosity and thermal conductivity of trifluoromethane (R-23), *ASHRAE Trans*. **106**(1), 757-767 (2000).
23. J. N. Mandal and M. L. Thakur, Modified formula for the coefficient of viscosity of gases, *Indian J. Pure & Appl. Phys*. **36**(9), 516-518 (1998).
24. J. R. Partington, *An Advanced Treatise on Physical Chemistry, Vol. 2, Properties of Liquids*, Longmans Green, London (1951).
25. H. Mori, Time-correlation functions in the statistical mechanics of transport processes, *Phys. Rev.* **111**, 694-706 (1958).
26. D. Massignon, *Mecanique Statique des Fluids: Fluctuations et Properties Locales*, Dunod, Paris (1957).
27. G. Jager, *Sitzber .kgl. Acad. Wiss., Physik-math. Kl.* **109**(2A), 74 (1900) [as quoted in Reference 1].
28. D. Enskog, Kinetic theory of heat conductivity, viscosity and diffusion in certain condensed gases and liquids, *Kgl. Svenska Vetenskapsakad. Handl.* **63**(4), 44 (1922).
29. B. J. Alder and T. E. Wainwright, Molecular motions, *Sci. American*. **202**(4), 113-126 (1959).
30. B. J. Alder and T. E. Wainwright, Studies in molecular dynamics. I. General method, *J. Chem. Phys*. **31**, 459-466 (1959)

31. B. J. Alder and T .E. Wainwright, Molecular dynamics. II. Behavior of a small number of elastic spheres, *J. Chem. Phys*. **33**, 1439-1452 (1960).
32. H. T. Davis, S. A. Rice, and J. V. Sengers, The kinetic theory of dense fluids. IX. The fluid of rigid spheres with a square-well attraction, *J. Chem. Phys*. **35**, 2210-2233 (1961).
33. P. M. Livingston and C. F. Curtiss, Kinetic theory of moderately dense, rigid-sphere gases, *Phys. Fluids*. **4**(7), 816-833 (1961).
34. D. Henderson Jr., Hole theory of of liquids and dense gases.I. Equation of state *J. Phys. Chem*. **37**, 631-635 (1962).
35. B. J. Alder and J. H. Dymond, *van der Waals Theory of Transport in Dense Fluids*, UCRL 14891-T, Univ. of California, Berkeley (1966).
36. B. J. Alder, *Prediction of Transport Processes of Dense Gases and Liquids*, UCRL 14870-T, Univ. of California, Berkeley(1966).
37. J. H. Dymond and B. J. Alder, Van der Waals theory of transport in dense fluids, *J. Chem. Phys*. **45**(6), 2061-2068 (1966).
38. J. H. Dymond and M. J. Assael, in *Transport Properties of Fluids, their Correlation, Prediction, and Estimation*. (Ed. J. Millat, J. H. Dymond, and C. A. Nieto de Castro). IUPAC, Cambridge (1996).
39. M. J. Assael, J. P. M. Trusler, and T. F. Tsolakis, *Thermophysical Properties of Fluids: An Introduction to their Prediction*. Imperial College Press, London (1996).
40. C. Alle and Y. Pomeau, Enskog and virial expansions in the theory of dense gases, *Physica* (Amsterdam), **66**(1), 145-165 (1973).
41. S. H. Chen and A. Rahman, Molecular dynamic simulation of dense gases I. Test particle motion, *Mol. Phys*. **34** (5), 1247-1262 (1977).
42. A. F. Collings and D. J. Evans, On the Kirkwood theory of shear viscosity in a simple dense fluid, *Aust. J. Phys*. **39**(6), 881-890 (1986).
43. J. G. Kirkwood, The stastical mechanical theory of irreversible processes, *Nuovo Cimento Suppl*. **6**(2), 233-236 (1949).
44. J. G. Kirkwood, F. P. Buff, and M. S. Green, The statistical mechanical theory of transport processes. III. The coefficients of shear and bulk viscosity of liquids, *J. Chem. Phys*. **17**(10), 988-994 (1949).
45. J. G. Kirkwood and E. M. Boggs, The radial distribution function in liquids, *J. Chem. Phys*. **10**, 394 (1942).
46. A. Frezzotti, Molecular dynamics and Enskog theory calculation of one dimensional problems in the dynamics of dense gases, *Physica A: Statistical Mechanics and its Applications*. **240** (1-2), 202-211 (1997).
47. H. S. Green, *The Molecular Theory of Fluids*. North Holland Publishing Co., Amsterdam (1952).
48. A. Bondi, *Rheology: Theory and Application*. Vol. I, Chap. 9. Academic Press, New York (1956).
49. S. A. Rice and H. L. Frisch, Some Aspects of the Statistical Theory of Transport, *Ann. Rev. Phys. Chem*. **11**, 187-272 (1960).

50. P. T. Cummings and D. J. Evans, Nonequilibrium molecular dynamics approaches to transport properties and non-Newtonian fluid, *Ind. Eng. Chem. Res*. **31**, 1237-1252 (1992).
51. H. J. M. Hanley, R. D. McCarty, and E. G. D. Cohen, Analysis of the transport coefficients for simple dense fluids. Application of the modified Enskog theory, *Physica* (Amsterdam), **60**(2), 322-356 (1972).
52. N. F. Sather and J. S. Dahler, Approximate theory of viscosity and thermal conductivity in dense polyatomic fluids, *Phys. Fluids*. **5**, 754-768 (1962).
53. A. F. Collings and I. L. McLaughlin, The transport coefficients for polyatomic liquids, *J. Chem. Phys*. **73**(7), 3390-3395 (1980).
54. T. H. Chung, L. L. Lee, M. Ajlan, and K. E. Starling, Generalized multiparameter correlation for nonpolar and polar fluid transport properties, *Ind. Eng. Chem. Res*. **27**(4), 671-679 (1988).
55. Y. Cohen and S. I. Sandler, The viscosity and thermal conductivity of simple dense gases, *Ind. Eng. Chem. Fundam*. **19**(2), 186-188 (1980).
56. M. S. Abdelazim, Viscosity and thermal conductivity of simple fluids at high pressures, *High.Temp.-High Press*. **22**(2), 193-205 (1990).
57. L. G. Du and T. M. Guo, A semi-theoretical viscosity model for non-polar liquids, *Chem. Eng. J.* **47**(3), 163-167 (1991).
58. J. A. Jossi, L. I. Stiel, and G. Thodos, The viscosity of pure substances in the dense gaseous and liquid phases, *AIChE J.* **8**(1), 59-63 (1962).
59. L.I. Stiel and G. Thodos, The viscosity of polar substances in the dense gaseous and liquid regions, *AIChE J.* **10**(2), 275-277 (1964).
60. J. H. Dymond, The interpretation of transport coefficients on the basis of the van der Waals model: I. Dense fluids, *Physica* **75**, 100-114 (1974).
61. J. H. Dymond, Interpretation of transport coefficients on the basis of the Van der Waals model. II. Extension to dilute gases, *Physica A: Statistical Mechanics and Its Applications* (Amsterdam, Netherlands), **79A**(1), 65-74 (1975).
62. J. S. Rowkinson, The transport properties of non-polar gases, *J. Chem. Phys*. **17**, 101 (1949).
63. S. I. Sandler and J. K. Fiszdon, On the viscosity and thermal conductivity of dense gases, *Physica A* **95**(3), 602-608 (1979).
64. K. Lucas, Die druckabhangigkeit der viskositat von flussigkeiten – ein eeinfache abschatzung(Pressure dependence of viscosity of liquids-a simple estimate), *Chem. Ing. Tech*. **53**, 959 (1981).
65. J. F. Ely and H .J. M. Hanley, Prediction of transport properties. 1. Viscosity of fluids and mixtures, *Ind Eng. Chem. Fundam*. **20**(4), 323-332 (1981).
66. H. J. M. Hanley, R. D. McCarty, and W. M. Haynes, Equations for the viscosity and thermal conductivity coefficients of methane, *Cryogenics*, **15**(7), 413-417 (1975).
67. J. F. Ely, Prediction of dense fluid viscosities in hydrocarbon mixtures, *GPA Proc. 61st Ann. Conv*. 9 (1982).

68. K. S. Pedersen, A. Fredenslund, P. L. Christiansen, and P. Thomassen, Viscosity of crude oils, *Chem. Eng. Sci.* **39**(6), 1011-1016 (1984).
69. J. W. Leach, *Molecular Structure Corrections for the Application of the Theory of Corresponding States to Non-Spherical Pure Fluids and Mixtures*, Ph.D Thesis, Rice Univ. Houston, Texas (1967).
70. M. J. Hwang and W. B. Whiting, A corresponding-states treatment for the viscosity of polar fluids, *Ind. Eng. Chem. Res.* **26**(9), 1758-1766 (1987).
71. A. S. Lawal, Prediction of vapor and liquid viscosities from the Lawal-Lake-Silberg equation of state. *SPE/DOE paper* 14926 (1986).
72. D. M. Heyes, Simple expressions for self diffusion coefficient, shear viscosity and thermal conductivity of Lennard-Jones fluids, *Chem. Phys. Lett.* **153**, 319-321 (1988).
73. D. Y. Peng and B. D. Robinson, A new two-constant equation of state, *Ind. Eng. Chem. Fundam.* **15**(1), 59-64 (1976).
74. W. Sheng and B. C. Y. Lu, Calculation of shear viscosity of mixtures by means of an equation of state, *Adv. Cryo. Eng.* **35**(B), 1533-1540 (1990).
75. J. H. Dymond, Corrections to the Enskog theory for viscosity and thermal conductivity, *Physica B and C: Physics of Condensed Matter and Atomic, Molecular and Plasma Physics, Optics* (Amsterdam), **144**(3), 267-276 (1987).
76. M. J. Assael, J. H. Dymond, M. Papadaki, and P. M. Patterson, Correlation and prediction of dense fluid transport coefficients. I. n-Alkanes, *Int. J. Thermophys.* **13**(2), 269-281 (1992).
77. M. J. Assael, J. H. Dymond, M. Papadaki, and P. M. Patterson, Correlation and prediction of dense fluid transport coefficients. III. n-Alkane mixtures, *Int. J. Thermophys.* **13**(4), 659-684 (1992).
78. M. J. Assael, J. H. Dymond, M. Papadaki, and P. M. Patterson, Correlation and prediction of dense fluid transport coefficients. II. Simple molecular fluids, *Fl. Ph. Equilib.* **75**, 245-255 (1992).
79. H. Hildwein and K. Stephan, Equation of state and equations for viscosity and thermal conductivity of non-polar and polar pure fluids based on the significant-liquid-structure theory, *Chem. Eng. Sci.* **48**(11), 2005-2023 (1993).
80. H. W. Xiang, Y. V. Duan, and M. S. Zhu, A new three-parameter viscosity-temperature equation for saturated liquids from the triple point to the critical point, *Fl. Phase Equilib.* **135**(2), 279-286 (1997)
81. K. Meir, A. Laesecke and S. A. Kabelac, A molecular dynamics simulation study of the self-diffusion coefficient and viscosity of the Lennard-Jones fluid, *Int. J. Thermophys.* **22**(1), 161-173 (2001).
82. J. Kestin, I.R. Shankland, and J.V. Sengers, Empirical correlation and prediction schemes for the viscosity of multicomponent electrolyte solutions, *Proc. 8th Symposium on Thermophysical Properties*, Vol. II, pp.352-356, ASME, New York (1981).
83. T. E. Daubert, R. P. Danner, H. M. Sibel, and C. C. Stebbins: *Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation*. Taylor & Francis, Washington DC (1997).

84. R. H. Perry and D. W. Green (Eds). *Chemical Engineers' Handbook*. McGraw Hill, New York (1997).
85. D. R. Lide (Ed.). *Handbook of Chemistry and Physics*, 80th Edn. CRC Press, Boca Raton (1999).
86. J. A. Dean, *Lange's Handbook of Chemistry*, 15th Edn. McGraw Hill, New York (1999).
87. M. Born and H. S. Green, *A General Kinetic Theory of Liquids*. Cambridge Univ. Press, London (1949).
88. M. Born and H. S. Green, A kinetic theory of liquids, *Nature*, **159**, 251-254 (1947).
89. S. A. Rice and J. G. Kirkwood, On an approximate theory of transport in dense media, *J. Chem. Phys*. **31**(4), 901-908 (1959).
90. H. Eyring, Viscosity, plasticity, and diffusion as examples of absolute reaction rates, *J. Chem. Phys*. **4**(4), 283-291 (1936).
91. H. Eyring and J. O. Hirschfelder, The theory of the liquid state, *J. Phys. Chem*. **41**, 249-257 (1937).
92. S. Glasstone, K. J. Laidler and H. Eyring: *The Theory of Rate Processes*, McGraw Hill, New York (1941).
93. J. F. Kincaid, H. Eyring and A. E. Stearn, The theory of absolute reaction rates and its application to viscosity and diffusion in the liquid state, *Chem. Rev*. **28**, 301-365 (1941).
94. R. H. Ewell, The temperature, pressure and volume coefficients of the viscosity of fluids, *J. Chem. Phys*. **5**(7), 571-576 (1937).
95. J. O. Hirschfelder, C. F. Curtiss, and R. B. Bird, *Molecular Theory of Gases and Liquids*, John Wiley, New York (1964).
96. R. J. Moore, P. Gibbs, and H. Eyring, Structure of the liquid state and viscosity of hydrocarbons, *J. Phys. Chem*. **57**, 172-178 (1953).
97. F. C. Collins, Activation energy of the Eyring theory of liquid viscosity and diffusion. *J. Chem. Phys*. **26**(2), 398-400 (1957).
98. P. B. Macedo and T. A. Litovitz, On the relative roles of free volume and activation energy in the viscosity of liquids, *J. Chem. Phys*. **42**(1), 245-256 (1965).
99. M. I. Shakhparonov, Theory of the viscosity of liquids.IV: Benzene, Alcohols. Eyring theory, *Zhur. Fiz. Khim*. USSR. **54**, 582-584 (1980).
100. H. Eyring, T. Ree and N. Hirai, Significant structures in the liquid state. I, *Proc. Natl. Acad. Sci*. (USA). **44**(7), 683-688 (1958).
101. H. Eyring and T. Ree, Significant liquid structure. VI. The vacancy theory of liquids, *Proc. Natl. Acad. Sci*. (USA). **47**, 526-537 (1961).
102. P. A. Egelstaff, The structure simple liquids, *Ann. Rev. Phys. Chem*. **24**, 159-187 (1973).
103. L. D. Landau, Theory of superfluidity of helium II, *Zhur. Eksptl. i. Theoret. Fiz*. **11**, 592-614 (1941).
104. L. D. Landau, Theory of the superfluidity of helium II, *Phys. Rev*. **60**, 356-358 (1941).

105. L. D. Landau and I. M. Khalatnikov, *Zhur. Eksptl. i. Theoret. Fiz*. **19**, 637 (1949) [as quoted in Reference 1].
106. L. D. Landau and I. M. Khalatnikov, *Abhandl. Sowjetischen Physik* **1**, 151 (1951) [as quoted in Reference 1].
107. L. D. Landau and I. M. Khalatnikov, *Zhur. Eksptl. i. Theor. Fiz*. **19**, 708 (1949) [as quoted in Reference 1].
108. L. D. Landau and I. M. Khalatnikov, *Abhandl. Sowjetischen Physik* **1**, 168 (1951) [as quoted in Reference 1].
109. H. T. Davis and K. D. Luks, Transport properties of a dense fluid of molecules interacting with a square well potential, *J. Phys. Chem*. **69**(3), 869-880 (1965).
110. B. A. Lowry, H. T. Davis, and S. A. Rice, Perturbation calculation of mixed pair correlation functions, *Phys. Fluids,* **7**(3), 402-406 (1964).
111. A. Letsou A and L. I. Stiel, Viscosity of saturated nonpolar liquids at elevated pressures, *AIChE J*. **19**(2), 409-411 (1973).
112. E. A. Fischer, Equation of state for substoichiometric urania using significant structures theory, *Proc. Intl. Symp. Thermodyn. Nucl. Mater,* **1**, 115-128 (1980).
113. M. J. Gillan, Derivation of an equation of state for liquid uranium dioxide using the theory of significant structures, *Proc. Symp. Thermodyn. Nucl. Mater*, **1**, 269-285 (1975).
114. T. Heckenberger and K. Stephan, Cubic equations of state for transport properties, *Intl. J. Thermophys*. **12**(2), 333-356 (1991).
115. T. Heckenberger and K. Stephan, Cubic equations of state for transport properties. An equation for the thermal conductivity of oxygen, *Intl. J. Thermophys*. **11**(6), 1011-1023 (1990).
116. J. M. Allan and A. S. Teja, Correlation and prediction of the viscosity of defined and undefined hydrocarbon liquids, *Can. J. Chem. Eng*. **69**(4), 986-991 (1991).
117. A. K. Mehrotra, A generalized viscosity equation for pure heavy hydrocarbons, *Ind. Eng. Chem. Res*. **30**(2), 420-427 (1991).
118. API. Properties of Hydrocarbons of High Molecular Weight. API Research Project 42, American Petroleum Institute, Washington D.C. (1966).
119. A. K. Mehrotra, Generalized one-parameter viscosity equation for light and medium liquid hydrocarbons, *Ind. Eng. Chem. Res*. **30**(6), 1367-1372 (1991).
120. K. Aasberg-Petersen, K. Knudsen, and A. Fredenslund, Prediction of viscosities of hydrocarbon mixtures, *Fl. Ph. Equilib*. **70**(2-3), 293-308 (1991).
121. A. S. Teja and P. Rice, Generalized corresponding states method for the viscosities of liquid mixtures, *Ind. Eng. Chem. Fundam*. **20**(1), 77-81 (1981).
122. W. Cao, A. Fredenslund, and P. Rasmussen, Statistical thermodynamic model for viscosity of pure liquids and liquid mixtures, *Ind. Eng. Chem. Res*. **31**(11), 2603-2619 (1992).
123. A. K. Mehrotra, Correlation and prediction of the viscosity of pure hydrocarbons, *Can. J. Chem. Eng*. **72**(3), 554-557 (1994).

124. S. I. Sandler and H. Orbey, *Multi-phase Reactor and Polymerization System Hydrodynamics*. (Ed. N.P. Cheremisinoff), 1-23, Gulf Publishing Co., Houston (1996).
125. Q. F. Lei, Y. C. Hou, and R. S. Lin, Correlation of viscosities of pure liquids in a wide temperature range, *Fl. Ph. Euilib*. **140**(1-2), 221-231 (1997).

Chapter 4

CORRELATIONS AND ESTIMATION OF PURE LIQUID VISCOSITY

Available experimental data reveal that the viscosity of liquids generally decreases with temperature in a rapid and non-linear fashion and is not significantly dependent on pressures up to several atmospheres. However, liquid viscosity for organic liquids[1] at high pressures changes as shown in Fig 4.1.

For practical purposes, it is often sufficient to know the viscosity of liquids at atmospheric pressure as a function of temperature. In view of the preference of industrial activities near atmospheric pressures and lack of sufficient data on the viscosity for a large number of liquids as a function of pressure, we will confine our discussions primarily to the variation of liquid viscosity with temperature, after first mentioning a few estimation methods for the variation of viscosity with pressure and methods for estimation of liquid viscosity at characteristic conditions like critical point and normal boiling point are discussed. Liquid viscosity correlation methods based on density, surface tension and other physical and molecular properties are mentioned. We have also included group contribution and corresponding states methods in subsequent sections.

4.1 EFFECT OF PRESSURE ON VISCOSITY OF LIQUIDS

Viscosity of a number of fluids has been experimentally measured, but a compilation and correlation of data (particularly as a function of pressure) appears to be scarce. The book of Stefan and Lucas[2] is probably the first monograph to list the variation of liquid viscosity as a function of both temperature and pressure for 50 fluids. We will mention the most important correlations here.

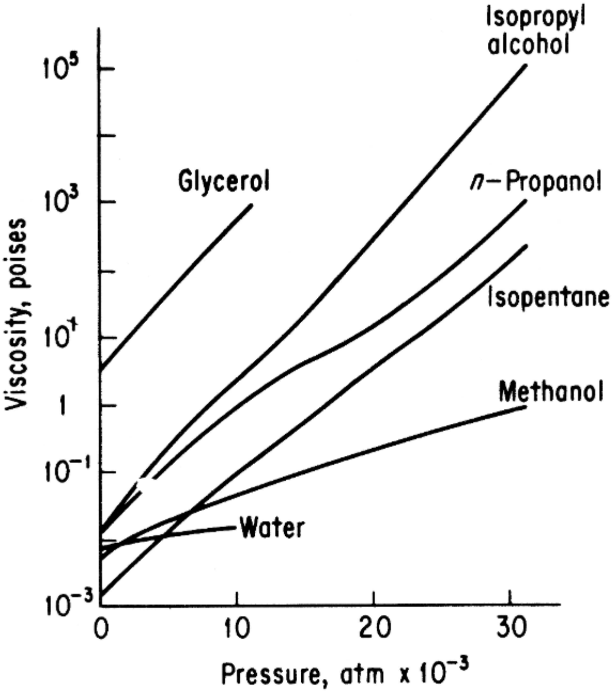


Figure 4.1. Variation of the liquid viscosity of some organic liquids with pressure at room temperature. (Adopted from R. C. Reid, J. M. Prausnitz, and T. K. Sherwood, *The Properties of Gases and Liquids*, McGraw-Hill, New York, 3rd Ed. 1977).

4.1.1 LUCAS METHOD FOR THE EFFECT OF PRESSURE

Lucas[3] proposed the following equation for the effect of pressure on liquid viscosity.

$$\frac{\eta}{\eta_{SL}} = \frac{1 + D(\Delta P_R / 2.118)A}{1 + C\omega \Delta P_R} \tag{4.1}$$

where, η is the liquid viscosity at the pressure of interest P,

η_{SL} is the viscosity of the saturated liquid at the temperature of interest T,

ΔP_R is $[(P - P_{VP}) / P_C]$,

P_{VP}	is the saturated vapor pressure at the temperature of interest T,
P_C	is the critical pressure,
ω	is the acentric factor,
A	is $0.9991 – [4.674 \text{ x } 10^{-4} / (1.0523\, T_R – 0.3877 – 1.0513)]$,
D	is $[0.3257 / (1.0039 – T_R^{2.573})^{0.2906}] – 0.2086$,
C	is $– 0.07921 + 2.1616\, T_R – 13.4040\, T_R^2 + 44.1706\, T_R^3 – 84.8291\, T_R^4 + 96.1209\, T_R^5 – 59.8127\, T_R^6 + 15.6719\, T_R^7$, and
T_R	is the reduced temperature (= T/T_C).

The estimated values of liquid viscosity using Lucas method are generally within 10 % of their experimental values.

4.1.2 NEURAL NETWORK APPROACHES FOR THE EFFECT OF PRESSURE

In recent years, neural network theory has been applied to correlate the pressure and temperature dependence of viscosity. One such method is due to Scalabrin and coworkers[4-6]. The authors initially used two approaches: the first through multilayer feedforward neural network and the other based on corresponding states approach with a scaling parameter. The corresponding states approach follows the method outlined by Teja and Thurner[7]. This method predicted the viscosity of certain hydrocarbons and refrigerants with a deviation of 5%. The authors have extended this method to mixtures. The corresponding states approach has been applied to very few compounds.

4.2 VISCOSITY AT SELECTED REFERENCE POINTS

4.2.1 LIQUID VISCOSITY AT THE CRITICAL POINT

Kim and Chair[8] discuss a method of calculating the viscosity of fluids at the critical point. Based on a three-parameter equation of state, the authors suggested the following equation.

$$\eta_C = 78.84(n-1)(MT_C)^{0.5}\,\frac{0.5 + Z_C/(n-1)}{\sigma^2} \tag{4.2}$$

where,	η_C	is viscosity at the critical point in micropoise,
	n	is the characteristic parameter in the equation of state,
	M	is molecular mass in grams,
	σ	is collision diameter in Å,
	T_C	is the critical temperature in K, and

Z_C is the critical compressibility factor.

4.2.2 LIQUID VISCOSITY AT THE NORMAL BOILING POINT

Smith *et al.*[9] compared three correlations (available in the literature at that time) to evaluate liquid viscosities at the normal boiling point, and support the view that a relation of the type;

$$\eta_B = C\rho_B^{0.5} \tag{4.3}$$

where, ρ_B is the density at the normal boiling point and C is a characteristic constant for a class of compounds, can be used to predict the viscosity at the normal boiling point with reasonable accuracy. Such relations in conjunction with a relation of the type

$$\eta = \eta_B P_S^{-n} \tag{4.4}$$

where, P_S is the saturated vapor pressure and n is a constant characteristic of each series of liquid hydrocarbons[10,10a], can be used to predict viscosity of saturated liquids.

Grain[11] recommends that, in the absence of a measured value for the liquid viscosity at the normal boiling pont (η_B), the value indicated by the class of the substance from the following table can be used in Eq. (4.4).

Table 4.1. Liquid viscosity at normal boiling point for different classes of substances.

Class of the Substance	η_B
Alcohols (Aliphatic & Aromatic)[a]	0.45
Primary Amines (Aliphatic & Aromatic)	0.45
All Other Organic Liquids[b]	0.20

[a] Not Applicable to Thiols

[b] Exceptions are Benzene ($\eta_B = 0.30$) and Cyclohexane ($\eta_B = 0.40$)

4.3 EFFECT OF TEMPERATURE

Simple as well as complex expressions have been proposed for the representation of liquid viscosity as a function of temperature with the main objective of representing the available experimental data and for interpolation purposes. We will mention the different forms of temperature dependence of viscosity proposed under correlation methods. Several methods have been proposed for the estimation of liquid viscosity from a variety of input information. We will discuss such methods under estimation methods. For most of the methods, we have tabulated the constants for the viscosity relation, to facilitate the reader in using the relation to predict viscosities for liquids of interest.

4.3.1 CORRELATION METHODS

Correlation methods in use some times have a theoretical basis but are often based on the observed behavior and optimally evolved representation. We mention below several correlation methods proposed and tested in the order of their complexity of form under the categories of: two-constant, three-constant and multi-constant equations.

4.3.1.1 Two-Constant Equations

Among several proposed relations, the simplest form of representation of liquid viscosity as a function of temperature is the relation;

$$\eta = Ae^{(B/T)} \tag{4.5}$$

where A and B are positive constants, and are characteristics of each substance. Originally proposed by de Guzman[12], the equation is popularly known as the Andrade equation.

4.3.1.1.a Duhne Representation

Duhne[13] presented Eq. (4.5) in the logarithmic form as

$$ln\, \eta = A + (B/T) \tag{4.6}$$

and evaluated the constants A and B for a number of substances. The constants A and B for several substances given by Duhne (rounded off to the necessary accuracy) along with the applicable temperature range are presented in Table 4.2. Also Table 4.2 includes experimental values of viscosity η (cP) at a specified temperature t (^{o}C) for each substance from an evaluated data source.

Table 4.2. Constants of the logarithmic form of the temperature dependence of liquid viscosity given by Duhne[13] [Temeperature in K and Viscosity in cP].

Formula	***Substance***	***A***	***B***	***Temperature Range, °C***	***η,cP (at, °C)***
Br_2	Bromine	– 3.112	907.5	– 4 to 29	0.99 (19.5)
CS_2	Carbon disulfide	– 3.442	713.8	– 13 to 40	0.36 (20.0)
$CHBr_3$	Bromoform	– 3.405	1195.0	5 to 90	1.89 (25.0)
$C_2H_2Br_2$	Methylene bromide	– 3.353	987.6	15 to 40	1.09 (15.0)
CH_2O_2	Formic acid	– 5.156	1679.0	8 to 110	1.80 (20.0)
CH_3Cl	Methyl chloride	– 5.073	981.9	0 to 130	0.18 (20.0)
CH_3I	Methyl iodide	– 3.366	774.1	0 to 50	0.50 (20.0)
CH_3NO_2	Nitro methane	– 3.989	1042.0	0 to 90	0.63 (25.0)
$C_2Cl_3F_3$	Trichloro trifluoro ethane	– 4.219	1126.0	20 to 50	0.70 (20.0)
C_2Cl_4	Tetra chloro ethylene	– 3.334	946.4	0 to 117	0.88 (22.0)
$C_2HF_3O_2$	Trifluoro acetic acid	– 4.750	1348.0	20 to 70	0.87 (20.0)
$C_2H_2Cl_4$	1,1,2,2 - Tetra chloro ethane	– 4.505	1490.0	0 to 90	1.64 (25.0)
$C_2H_4Br_2$	1,2 - Dibromo ethane	– 3.899	1299.0	0 to 130	1.71 (20.0)
$C_2H_4Cl_2$	1,1 - Dichloro ethane	– 3.970	949.3	7 to 60	0.49 (19.0)
$C_2H_4Cl_2$	1,2 - Dichloro ethane	– 3.926	1091.0	0 to 100	0.83 (20.0)
$C_2H_4F_2$	1,2 - Difluoro ethane	– 3.941	735.2	0 to 70	0.25 (25.0)
$C_2H_4O_2$	Methyl formate	– 3.932	836.3	0 to 40	0.35 (20.0)
$C_2H_4O_2$	Acetic acid	– 4.519	1384.0	15 to 20	1.30 (18.0)
C_2H_5Br	Ethyl bromide	– 3.859	851.5	– 100 to 50	0.40 (20.0)
C_2H_5Cl	Ethyl chloride	– 3.873	739.0	– 20 to 40	0.27 (20.0)
C_2H_5I	Ethyl iodide	– 3.467	853.9	0 to 80	0.59 (20.0)
C_2H_5NO	Acetamide	– 5.470	2173.0	105 to 120	1.32 (105.0)
$C_2H_6O_2$	Ethylene glycol	– 7.811	3143.0	20 to 110	19.90 (20.0)
C_3H_5Br	Allyl bromide	– 3.782	897.1	0 to 80	0.50 (18.0)
C_3H_5Cl	Allyl chloride	– 4.015	845.7	0 to 50	0.32 (22.0)
$C_3H_5F_3O$	Trifluoro - 2 - propanol	– 9.540	3115.0	15 to 60	3.67 (15.0)
C_3H_5I	Allyl iodide	– 3.675	979.8	0 to 100	0.75 (17.0)
$C_3H_6Br_2$	1,2 - Dibromo propane	– 3.921	1290.0	0 to 140	1.49 (25.0)
C_3H_6O	2-Propanol	– 5.947	1827.0	0 to 100	1.36 (20.0)
C_3H_6O	Acetone	– 4.033	845.6	– 80 to 60	0.32 (25.0)
C_3H_6O	Propanal	– 4.817	1513.0	10 to 30	0.41 (20.0)
$C_3H_6O_2$	Propionic acid	– 4.116	1232.0	5 to 150	1.10 (20.0)
$C_3H_6O_2$	Methyl acetate	– 4.200	940.9	0 to 70	0.38 (20.0)
$C_3H_6O_2$	Ethyl formate	– 4.081	923.1	0 to 70	0.37 (28.0)
C_3H_7Br	Propyl bromide	– 3.781	910.2	0 to 80	0.52 (19.0)
C_3H_7Br	Isopropyl bromide	– 3.761	892.2	0 to 50	0.49 (20.0)
C_3H_7Cl	Propyl chloride	– 3.715	999.5	0 to 100	0.73 (21.0)
C_3H_7Cl	Isopropyl chloride	– 3.323	705.2	0 to 40	0.31 (22.5)
C_3H_7I	Propyl iodide	– 3.715	999.5	0 to 100	0.73 (21.0)
C_3H_7I	Isopropyl iodide	– 3.743	984.1	0 to 100	0.66 (23.0)
$C_3H_7NO_2$	Ethyl carbamate	– 6.578	2454.0	105 to 120	0.92 (105.0)
C_3H_8O	Isopro panol	– 8.114	2624.0	0 to 90	0.98 (52.0)
$C_3H_8O_2$	Propylene glycol	– 7.577	3233.0	40 to 180	19.40 (40.0)

Formula	***Substance***	***A***	***B***	***Temperature Range, °C***	***η,cP (at, °C)***
$C_4H_4N_2$	Succino nitrile	– 5.183	2060.0	59 to 83	2.76 (59.0)
C_4H_4S	Thio phene	– 4.039	1065.0	0 to 83	0.64 (22.5)
$C_6H_6O_3$	Acetic anhydride	– 3.173	905.4	0 to 100	0.90 (18.0)
$C_4H_7F_3O$	Trifluoro - 2 - methyl propanol	– 10.01	3352.0	25 to 60	3.32 (25.0)
$C_4H_7NO_2$	2 - Nitro - 2 - butene	– 3.855	1101.0	30 to 70	0.81 (30.0)
$C_4H_8Br_2$	1,2 - Dibromo - 2 - methyl propane	– 4.335	1497.0	0 to 150	1.92 (27.0)
C_4H_8O	Methyl ethyl ketone	– 4.213	975.9	0 to 80	0.42 (21.0)
$C_4H_8O_2$	Butyric acid	– 4.592	1475.0	0 to 160	1.54 (20.0)
$C_4H_8O_2$	Iso butyric acid	– 4.355	1355.0	4 to 150	1.38 (17.0)
C_3H_5Br	Allyl bromide	– 3.782	897.1	0 to 80	0.50 (18.0)
C_3H_5Cl	Allyl chloride	– 4.015	845.7	0 to 50	0.32 (22.0)
$C_3H_5F_3O$	Trifluoro - 2 - propanol	– 9.540	3115.0	15 to 60	3.67 (15.0)
C_3H_5I	Allyl iodide	– 3.675	979.8	0 to 100	0.75 (17.0)
$C_3H_6Br_2$	1,2 - Dibromo propane	– 3.921	1290.0	0 to 140	1.49 (25.0)
C_3H_6O	2-Propanol	– 5.947	1827.0	0 to 100	1.36 (20.0)
C_3H_6O	Acetone	– 4.033	845.6	– 80 to 60	0.32 (25.0)
C_3H_6O	Propanal	– 4.817	1513.0	10 to 30	0.41 (20.0)
$C_3H_6O_2$	Propionic acid	– 4.116	1232.0	5 to 150	1.10 (20.0)
$C_3H_6O_2$	Methyl acetate	– 4.200	940.9	0 to 70	0.38 (20.0)
$C_3H_6O_2$	Ethyl formate	– 4.081	923.1	0 to 70	0.37 (28.0)
C_3H_7Br	Propyl bromide	– 3.781	910.2	0 to 80	0.52 (19.0)
C_3H_7Br	Isopropyl bromide	– 3.761	892.2	0 to 50	0.49 (20.0)
C_3H_7Cl	Propyl chloride	– 3.715	999.5	0 to 100	0.73 (21.0)
C_3H_7Cl	Isopropyl chloride	– 3.323	705.2	0 to 40	0.31 (22.5)
C_3H_7I	Propyl iodide	– 3.715	999.5	0 to 100	0.73 (21.0)
C_3H_7I	Isopropyl iodide	– 3.743	984.1	0 to 100	0.66 (23.0)
$C_3H_7NO_2$	Ethyl carbamate	– 6.578	2454.0	105 to 120	0.92 (105.0)
C_3H_8O	Isopro panol	– 8.114	2624.0	0 to 90	0.98 (52.0)
$C_3H_8O_2$	Propylene glycol	– 7.577	3233.0	40 to 180	19.40 (40.0)
$C_4H_4N_2$	Succino nitrile	– 5.183	2060.0	59 to 83	2.76 (59.0)
C_4H_4S	Thio phene	– 4.039	1065.0	0 to 83	0.64 (22.5)
$C_6H_6O_3$	Acetic anhydride	– 3.173	905.4	0 to 100	0.90 (18.0)
$C_4H_7F_3O$	Trifluoro - 2 - methyl propanol	– 10.01	3352.0	25 to 60	3.32 (25.0)
$C_4H_7NO_2$	2 - Nitro - 2 - butene	– 3.855	1101.0	30 to 70	0.81 (30.0)
$C_4H_8Br_2$	1,2 - Dibromo - 2 - methyl propane	– 4.335	1497.0	0 to 150	1.92 (27.0)
C_4H_8O	Methyl ethyl ketone	– 4.213	975.9	0 to 80	0.42 (21.0)
$C_4H_8O_2$	Butyric acid	– 4.592	1475.0	0 to 160	1.54 (20.0)
$C_4H_8O_2$	Iso butyric acid	– 4.355	1355.0	4 to 150	1.38 (17.0)
$C_4H_8O_2$	Methyl propionate	– 4.173	987.2	0 to 80	0.41 (30.0)
$C_4H_8O_2$	Ethyl acetate	– 4.171	984.1	0 to 80	0.46 (20.0)
$C_4H_8O_2$	Propyl formate	– 4.238	1043.0	0 to 90	0.51 (23.0)
C_4H_9Br	n-Butyl bromide	– 3.805	983.0	0 to 100	0.65 (20.0)
C_4H_9Br	1 - Bromo - 2 - methyl	– 4.011	1039.0	0 to 100	0.61 (24.0)

Formula	***Substance***	***A***	***B***	***Temperature Range, °C***	***η,cP (at, °C)***
	propane				
C_4H_9Cl	1 - Chloro - 2 - methyl propane	– 4.240	1007.0	0 to 80	0.46 (19.0)
C_4H_9I	1- Iodo - 2 - methyl propane	– 3.859	1089.0	0 to 120	0.84 (25.0)
C_4H_9I	Isobutyl iodide	– 3.783	1072.0	0 to 120	0.875 (20.0)
C_4H_{10}	*n* - Butane	– 3.821	612.1	– 90 to 0	0.22 (–5.0)
C_4H_{10}	2 - Methyl propane	– 4.093	696.6	– 80 to 0	0.27 (–20.0)
$C_4H_{10}O$	Isobutanol	– 3.821	2789.0	0 to 110	3.98 (19.0)
$C_4H_{10}O$	2 - Methyl propanol	– 11.92	397.9	20 to 90	5.89 (22.0)
$C_4H_{10}O$	Diethyl ether	– 4.267	813.1	– 80 to 100	0.23 (20.0)
$C_4H_{10}O$	Methyl propyl ether	– 4.189	814.9	0 to 40	0.25 (20.0)
$C_4H_{10}S$	Diethyl sulfide	– 3.925	915.6	0 to 88	0.43 (25.0)
$C_4H_{11}N$	Diethyl amine	– 4.759	1091.0	– 30 to 40	0.35 (25.0)
$C_5H_7F_3O_2$	Trifluoro acetic acid - 2 -propyl ester	– 4.780	1031.0	20 to 70	0.72 (20.0)
$C_5H_9NO_2$	2 - Nitro - 2 - pentene	– 3.938	1147.0	30 to 70	0.87 (30.0)
$C_5H_9NO_2$	3 - Nitro - 2 - pentene	– 4.070	1206.0	30 to 70	0.93 (30.0)
C_5H_{10}	1 - Pentene	– 4.023	702.9	– 90 to 0	0.24 (0.0)
C_5H_{10}	2 - Methyl - 2 - butene	– 4.115	742.5	0 to 40	0.21 (20.0)
$C_5H_{10}O$	Diethyl ketone	– 4.123	979.8	0 to 100	0.47 (19.0)
$C_5H_{10}O$	Methyl propyl ketone	– 4.149	1008.0	0 to 100	0.51 (18.0)
$C_5H_{10}O_2$	Valeric acid	– 4.921	1679.0	16 to 100	2.30 (20.0)
$C_5H_{10}O_2$	Methyl butyrate	– 4.334	1104.0	0 to 110	0.58 (20.0)
$C_5H_{10}O_2$	Ethyl propionate	– 4.289	1067.0	0 to 100	0.535 (20.0)
$C_5H_{10}O_2$	Propyl acetate	– 4.406	1127.0	0 to 110	0.58 (20.0)
$C_5H_{10}O_2$	Methyl iso butyrate	– 4.222	1039.0	0 to 100	0.47 (29.0)
$C_5H_{11}Br$	*n* - Amyl borate	– 3.881	1071.0	0 to 100	0.81 (20.0)
C_5H_{12}	*n* - Pentane	– 3.958	722.2	– 130 to 40	0.225 (25.0)
C_5H_{12}	2 - Methyl butane	– 4.415	845.8	– 50 to 30	0.21 (25.0)
C_5H_{12}	2,2 - Dimethyl propane	– 5.715	1248.0	– 10 to 10	0.30 (5.0)
$C_5H_{12}O$	*n* – Pentanol	– 7.581	2651.0	0 to 140	4.40 (20.0)
$C_5H_{12}O$	3 - Methyl butanol	– 7.568	2645.0	0 to 140	3.86 (24.0)
$C_5H_{12}O$	2 - Methyl butanol	– 8.289	2900.0	0 to 140	5.11 (20.0)
$C_5H_{12}O$	2 - Methyl butanol-2	– 10.27	3459.0	0 to 100	5.00 (18.5)
$C_5H_{12}O$	Ethyl propyl ether	– 4.315	920.7	0 to 70	0.32 (20.0)
$C_5H_{12}O$	Methyl - iso - butyl ether	– 4.270	897.2	0 to 70	0.30 (21.0)
C_6H_5Br	Bromo benzene	– 3.869	1170.0	0 to 150	1.17 (18.0)
C_6H_5ClO	*o* - Chloro phenol	– 6.236	2262.0	0 to 160	4.21 (20.0)
C_6H_5ClO	*m* - Chloro phenol	– 11.30	4088.0	25 to 60	11.50 (25.0)
C_6H^5ClO	*p* - Chloro phenol	– 11.69	4287.0	45 to 60	6.15 (45.0)
C_6H_5F	Fluoro benzene	– 4.116	1041.0	9 to 100	0.58 (20.0)
C_6H_5I	Iodo benzene	– 3.933	1303.0	4 to 140	1.78 (17.0)
$C_6H_5NO_2$	Nitro benzene	– 4.334	1480.0	0 to 200	2.02 (20.0)
$C_6H_5NO_3$	*o* - Nitro phenol	– 5.195	1932.0	40 to 90	2.75 (40.0)
C_6H_6ClN	3 - Chloro nitrile	– 6.283	2242.0	25 to 60	3.50 (25.0)

Formula	***Substance***	***A***	***B***	***Temperature Range, °C***	***η,cP (at, °C)***
C_6H_{10}	Hexadiene - 1,5	– 4.029	806.2	0 to 56	0.275 (20.0)
C_6H_{10}	2,3 - Dimethyl – 1 - 1,3 - butadiene	– 4.270	864.0	0 to 70	0.22 (40.0)
$C_6H_{11}NO_2$	2 - Nitro - 2 - hexene	– 4.123	1286.0	30 to 70	1.14 (30.0)
C_6H_{12}	1 - Hexene	– 4.162	823.0	– 55 to 70	0.25 (25.0)
C_6H_{12}	Methyl cyclo pentane	– 4.170	1014.0	– 25 to 80	0.48 (25.0)
$C_6H_{12}O$	Methyl butyl ketone	– 4.642	1218.0	20 to 40	0.63 (20.0)
$C_6H_{12}O_2$	Caproic acid	– 5.082	1827.0	16 to 100	3.23 (20.0)
$C_6H_{12}O_2$	Ethyl butyrate	– 4.270	1128.0	15 to 80	0.69 (20.0)
$C_6H_{12}O_2$	Butyl acetate	– 4.546	1238.0	0 to 50	0.73 (20.0)
$C_6H_{12}O_2$	Isobutyl acetate	– 4.546	1230.0	20 to 100	0.73 (20.0)
$C_6H_{13}Br$	*n* - Hexyl bromide	– 4.001	1172.0	0 to 100	1.01 (20.0)
C_6H_{14}	n - Hexane	– 4.034	835.4	– 95 to 70	0.30 (25.0)
C_6H_{14}	2 - Methyl pentane	– 4.247	884.5	0 to 70	0.285 (25.0)
C_6H_{14}	2,2 - Dimethyl butane	– 4.454	1010.0	0 to 40	0.35 (25.0)
C_6H_{14}	2,3 - Dimethyl butane	– 4.469	1023.0	0 to 40	0.36 (25.0)
$C_6H_{14}O$	*n* - Hexanol	– 7.651	2716.0	20 to 60	4.37 (25.0)
$C_6H_{14}O$	Dipropyl ether	– 4.391	1027.0	0 to 100	0.40 (25.0)
$C_6H_{14}O$	Ethyl isobutyl ether	– 4.404	998.3	0 to 80	0.37 (22.0)
$C_6H_{15}N$	Triethyl amine	– 4.106	921.6	– 33 to 25	0.36 (25.0)
$C_7H_5Cl_3$	Phenyl chloroform	– 6.567	2176.0	0 to 20	2.55 (17.0)
$C_7H_5F_3$	Trifluoro toluene	– 3.859	962.1	20 to 70	0.57 (20.0)
$C_7H_6O_2$	Benzoic acid	– 1.478	6027.0	122 to 140	1.26 (30.0)
$C_7H_7NO_2$	*o* - Nitro toluene	– 5.093	1750.0	0 to 70	2.37 (20.0)
$C_7H_7NO_2$	*p* - Nitrotoluene	– 5.966	2003.0	20 to 100	2.33 (20.0)
C_7H_8O	Benzyl alcohol	– 6.822	2505.0	20 to 60	5.58 (20.0)
C_7H_8O	*O* - Cresol	– 9.657	3531.0	0 to 120	9.56 (20.0)
C_7H_8O	*m* - Cresol	– 11.09	4111.0	0 to 120	16.40 (20.0)
C_7H_8O	*p* - Cresol	– 11.29	4207.0	0 to 120	18.90 (20.0)
C_7H_8O	Methyl phenyl ether	– 2.748	895.3	0 to 70	1.32 (20.0)
C_7H_9N	Benzyl amine	– 4.463	1466.0	25 to 130	1.59 (25.0)
C_7H_9N	*n* - Methyl aniline	– 6.333	2107.0	0 to 80	2.30 (20.0)
C_7H_9N	2 - Amino toluene	– 7.009	2499.0	0 to 100	4.39 (20.0)
C_7H_9N	3 - Amino toluene	– 6.036	2137.0	25 to 130	3.31 (20.0)
C_7H_9N	4 - Amino toluene	– 4.779	1701.0	40 to 175	1.56 (55.0)
$C_7H_{11}F_3$	Trifluoro methyl chclo hexane	– 4.329	1224.0	20 to 70	0.95 (20.0)
C_7H_{14}	1 - Heptene	– 3.961	848.9	0 to 100	0.34 (25.0)
C_7H_{14}	Methyl cyclo hexane	– 4.480	1217.0	– 25 to 110	0.68 (25.0)
C_7H_{14}	Ethyl cyclo pentane	– 4.000	998.9	– 20 to 110	0.53 (25.0)
$C_7H_{14}O_2$	Heptanoic acid	– 5.280	1973.0	17 to 100	4.34 (20.0)
$C_7H_{10}O_2$	Ethyl valerate	– 4.932	1386.0	20 to 60	0.84 (20.0)
$C_7H_{10}O_2$	Propyl butyrate	– 4.604	1290.0	20 to 60	0.83 (20.0)
$C_7H_{14}O_2$	Amyl acetate	– 1.379	4035.0	11 to 30	0.81 (25.0)
$C_7H_{15}Br$	*n* - Heptyl bromide	– 4.152	1291.0	0 to 100	1.29 (20.0)
C_7H_{16}	*n* - Heptane	– 4.325	1006.0	– 90 to 100	0.40 (25.0)
C_7H_{16}	2 - Methyl hexane	– 4.270	961.2	0 to 100	0.36 (25.0)
$C_7H_{16}O$	*n* - Heptanol	– 8.190	2964.0	15 to 100	5.68 (25.0)

Formula	*Substance*	*A*	*B*	*Temperature Range, °C*	*η,cP (at, °C)*
$C_8H_{18}O$	Aceto phenone	– 4.493	1494.0	12 to 100	1.62 (25.0)
$C_8H_{10}O$	2 – Phenyl ethanol	– 9.191	3393.0	25 to 60	7.61 (25.0)
$C_8H_{10}O$	Ethyl phenyl ether	– 4.869	1490.0	0 to 90	1.25 (20.0)
$C_8H_{10}O_2$	Phenyl acetic acid	– 5.819	2471.0	77 to 140	3.54 (77.0)
$C_8H_{11}N$	*n* - Ethyl aniline	– 5.786	1943.0	0 to 100	2.25 (20.0)
$C_8H_{11}N$	*n,n* - Dimethyl aniline	– 3.979	1273.0	0 to 180	1.40 (20.0)
C_8H_{16}	Propyl cyclo pentane	– 3.959	1046.0	– 20 to 120	0.64 (25.0)
C_8H_{16}	1 - Octene	– 4.058	964.0	0 to 125	0.45 (25.0)
C_8H_{16}	Ethyl cyclo hexane	– 4.153	1166.0	– 25 to 125	0.785 (25.0)
$C_8H_{16}O_2$	Octanoic acid	– 5.980	2255.0	20 to 100	5.75 (20.0)
$C_8H_{17}Br$	*n* - Otyl bromide	– 4.325	1412.0	0 to 100	1.63 (20.0)
C_8H_{18}	*n* - Octane	– 4.333	1091.0	– 55 to 125	0.51 (25.0)
$C_8H_{18}O$	*n* - Octanol	– 8.166	3021.0	15 to 100	7.21 (25.0)
$C_9H_{10}O_2$	3 - Phenyl propionic acid	– 6.488	2821.0	50 to 140	9.80 (50.0)
$C_9H_{10}O_2$	Ethyl benzoate	– 5.078	1719.0	20 to 80	2.24 (20.0)
C_9H_{12}	Propyl benzene	– 4.297	1215.0	– 25 to 160	0.80 (25.0)
C_9H_{12}	1 - Methyl - 4 - ethyl benzene	– 4.008	1067.0	10 to 90	0.66 (25.0)
C_9H_{12}	1,2,4 -Trimethyl benzene	– 6.749	2101.0	25 to 40	1.01 (25.0)
C_9H_{18}	1 - Nonene	– 4.189	1085.0	0 to 125	0.58 (25.0)
C_9H_{18}	Propyl cyclo hexane	– 4.301	1264.0	– 25 to 125	0.93 (25.0)
C_9H_{18}	Butyl cyclo pentane	– 4.159	1182.0	– 20 to 120	0.83 (25.0)
$C_9H_{18}O_2$	Nonanoic acid	– 6.002	2365.0	20 to 100	8.08 (20.0)
$C_9H_{19}Br$	*n* - Nonyl bromide	– 4.531	1535.0	0 to 100	2.05 (20.0)
C_9H_{20}	*n* - Nonane	– 4.447	1210.0	– 50 to 150	0.67 (25.0)
$C_{10}H_{14}$	Butyl benzene	– 4.386	1298.0	– 25 to 160	0.96 (25.0)
$C_{10}H_{15}N$	*n,n* - Diethyl aniline	– 5.577	1871.0	0 to 100	2.18 (20.0)
$C_{10}H_{20}$	1 - Decene	– 4.297	1194.0	0 to 125	0.75 (25.0)
$C_{10}H_{20}$	n - Butyl cyclo hexane	– 4.424	1378.0	– 20 to 125	1.20 (25.0)
$C_{10}H_{20}$	Pentyl cyclo hexane	– 4.309	1302.0	– 20 to 120	1.06 (25.0)
$C_{10}H_{20}O_2$	Decanoic acid	– 5.591	2275.0	50 to 80	4.34 (50.0)
$C_{10}H_{21}Br$	*n* - Decyl bromide	– 4.704	1641.0	0 to 100	2.55 (20.0)
$C_{10}H_{22}$	*n* - Decane	– 4.460	1286.0	– 25 to 175	0.86 (25.0)
$C_{11}H_{16}$	Pentyl benzene	– 4.658	1646.0	– 20 to 160	1.22 (25.0)
$C_{11}H_{22}$	1 - Undecene	– 4.422	1304.0	0 to 125	0.96 (25.0)
$C_{11}H_{22}$	*n* - Pentyl cyclo hexane	– 4.814	1569.0	– 10 to 120	1.56 (25.0)
$C_{11}H_{22}$	Hexyl cyclo pentane	– 4.463	1422.0	– 20 to 120	1.36 (25.0)
$C_{11}H_{24}$	n - Undecane	– 4.571	1394.0	– 25 to 200	1.09 (100.0)
$C_{12}H_{10}$	Biphenyl	– 4.572	1690.0	70 to 450	0.95 (100.0)
$C_{12}H_{11}N$	Diphenyl amine	– 6.629	2676.0	55 to 130	4.66 (55.0)
$C_{12}H_{18}$	Hexyl benzene	– 4.802	1575.0	– 20 to 160	1.52 (25.0)
$C_{12}H_{24}$	1 - Dodecene	– 4.572	1418.0	0 to 125	1.20 (25.0)
$C_{12}H_{24}$	*n* - Hexyl cyclo hexane	– 4.997	1697.0	– 10 to 120	1.99 (25.0)
$C_{12}H_{24}$	Heptyl cyclo pentane	– 4.526	1508.0	– 20 to 120	1.72 (25.0)

Formula	***Substance***	***A***	***B***	***Temperature Range, °C***	***η,cP (at, °C)***
$C_{12}H_{24}O_2$	Dodecanoic acid	– 6.146	2615.0	50 to 100	7.30 (50.0)
$C_{12}H_{26}$	*n* - Dodecane	– 4.562	1454.0	– 5 to 220	1.37 (25.0)
$C_{13}H_{10}O$	Benzo phenone	– 7.181	2886.0	25 to 130	13.60 (25.0)
$C_{13}H_{13}N$	Benzyl phenyl amine	– 6.415	2650.0	55 to 130	5.40 (55.0)
$C_{13}H_{13}N$	*n* - Methyl diphenyl amine	– 6.328	2428.0	10 to 130	7.30 (20.0)
$C_{13}H_{20}$	Heptyl benzene	– 4.916	1673.0	– 20 to 160	1.88 (25.0)
$C_{13}H_{26}$	1 - Tridecane	– 4.628	1516.0	0 to 125	1.50 (25.0)
$C_{13}H_{26}$	*n* - Heptyl cyclo hexane	– 5.164	1814.0	– 10 to 120	2.47 (25.0)
$C_{13}H_{26}$	Octyl cyclo pentane	– 4.628	1602.0	– 20 to 120	2.15 (25.0)
$C_{13}H_{28}$	*n* - Tridecane	– 4.605	1529.0	– 5 to 240	1.71 (25.0)
$C_{14}H_{12}O_2$	Diethyl phthalate	– 6.589	2606.0	25 to 60	10.10 (25.0)
$C_{14}H_{12}O_2$	Benzyl benzoate	– 6.589	2606.0	5 to 100	8.50 (25.0)
$C_{14}H_{22}$	Octyl benzene	– 5.190	1816.0	– 20 to 140	2.31 (25.0)
$C_{14}H_{28}$	1 - Tetra decene	– 4.778	1606.0	0 to 125	1.83 (25.0)
$C_{14}H_{28}$	*n* - Octyl cyclo hexane	– 5.353	1935.0	– 10 to 120	3.10 (25.0)
$C_{14}H_{28}$	Nonyl cyclo pentane	– 4.732	1693.0	– 20 to 120	2.63 (25.0)
$C_{14}H_{28}O_2$	Tetra decanoic acid	– 6.150	2705.0	60 to 100	7.43 (60.0)
$C_{14}H_{30}$	*n* - Tetra decane	– 4.615	1588.0	5 to 255	2.10 (25.0)
$C_{15}H_{24}$	Nonyl benzene	– 5.352	1924.0	– 20 to 140	2.80 (25.0)
$C_{15}H_{30}$	1 - Penta dodecene	– 4.898	1720.0	0 to 125	2.24 (25.0)
$C_{15}H_{30}$	*n* - Nonyl cyclo hexane	– 5.511	2042.0	– 10 to 120	3.80 (25.0)
$C_{15}H_{30}$	Decyl cyclo pentane	– 4.825	1777.0	– 20 to 120	3.20 (25.0)
$C_{15}H_{32}$	*n* - Penta decane	– 4.648	1654.0	10 to 280	2.56 (25.0)
$C_{16}H_{26}$	Decyl benzene	–5. 251	1944.0	– 15 to 160	3.36 (25.0)
$C_{16}H_{32}$	1 - Hexa decene	– 4.938	1767.0	5 to 125	2.70 (25.0)
$C_{16}H_{32}$	Undecyl cylo pentane	– 4.992	1882.0	– 10 to 120	3.84 (25.0)
$C_{16}H_{32}O_2$	Hexa decanoic acid	– 6.103	2785.0	70 to 100	7.80 (70.0)
$C_{16}H_{34}$	*n* - Hexa decane	– 4.643	1700.0	20 to 280	3.09 (25.0)
$C_{17}H_{28}$	Undecyl benzene	– 5.305	2008.0	– 10 to 160	4.00 (25.0)
$C_{17}H_{34}$	1 - Hepta decene	– 4.950	1820.0	15 to 125	3.24 (25.0)
$C_{17}H_{34}$	*n* - Undecyl cyclo hexane	– 5.710	2206.0	10 to 120	5.50 (25.0)
$C_{17}H_{34}$	Dodecyl cyclo pentane	– 5.100	1966.0	– 5 to 120	4.56 (25.0)
$C_{17}H_{36}$	*n* - Hepta decane	– 4.624	1745.0	25 to 200	3.79 (25.0)
$C_{18}H_{14}$	*o* - Terphenyl	– 5.461	2519.0	100 to 400	4.40 (100.0)
$C_{18}H_{14}$	*m* - Terphenyl	– 4.699	2167.0	150 to 400	1.60 (150.0)
$C_{18}H_{14}$	*p* - Terphenyl	– 4.549	2098.0	250 to 400	0.60 (250.0)
$C_{18}H_{30}$	Dodecyl benzene	– 5.285	2044.0	0 to 160	4.78 (25.0)
$C_{18}H_{34}O_2$	Octa decanoic acid	– 5.907	2760.0	20 to 200	29.40 (25.0)
$C_{18}H_{36}$	1 - Octa decene	– 4.986	1879.0	20 to 125	3.85 (25.0)
$C_{18}H_{36}$	*n* - Dodecyl cyclo hexane	– 5.815	2285.0	15 to 120	6.50 (25.0)
$C_{18}H_{36}$	Tridecyl cyclo pentane	– 5.228	2053.0	5 to 120	5.40 (25.0)
$C_{18}H_{36}O_2$	Octa decanoic acid	– 4.649	1790.0	30 to 300	3.88 (30.0)
$C_{19}H_{32}$	Tridecyl benzene	– 5.351	2108.0	5 to 160	5.63 (25.0)

Formula	*Substance*	*A*	*B*	*Temperature Range, °C*	*η,cP (at, °C)*
$C_{19}H_{38}$	1 - Nono decene	– 5.044	1944.0	25 to 125	4.56 (25.0)
$C_{19}H_{38}$	*n* - Tri decyl cyclo hexane	– 5.904	2357.0	20 to 120	7.67 (25.0)
$C_{19}H_{38}$	Tetra decyl cyclo pentane	– 5.328	2129.0	10 to 120	6.29 (25.0)
$C_{19}H_{40}$	*n* - Nona decane	– 4.643	1827.0	35 to 300	4.00 (35.0)
$C_{20}H_{34}$	Tetra decyl benzene	– 5.345	2147.0	15 to 160	6.60 (25.0)
$C_{20}H_{40}$	1 - Eicosene	– 5.033	1982.0	35 to 125	4.20 (35.0)
$C_{20}H_{40}$	Tetra decyl cyclo hexane	– 5.998	2428.0	25 to 120	9.00 (25.0)
$C_{20}H_{40}$	Penta decyl cyclo pentane	– 5.387	2189.0	20 to 120	7.30 (25.0)
$C_{20}H_{42}$	*n* - Eicosane	– 4.651	1868.0	40 to 300	4.14 (40.0)
$C_{21}H_{36}$	*n* - Pentyl decyl benzene	– 5.416	2206.0	20 to 160	7.72 (25.0)
$C_{21}H_{42}$	*n* - Pentyl decyl cyclo hexane	– 6.078	2493.0	30 to 120	8.91 (30.0)
$C_{21}H_{42}$	Hedecyl cyclo pentane	– 5.459	2251.0	25 to 120	8.44 (25.0)
$C_{22}H_{38}$	Hexa decyl benzene	– 5.428	2245.0	30 to 160	7.74 (30.0)
$C_{22}H_{44}$	n-Hexa decyl cyclo hexane	– 6.169	2560.0	35 to 120	8.76 (35.0)

4.3.1.1.b Viswanath and Natarajan Representation

Viswanath and Natarajan in their Databook on Viscosity of Liquids[14] tabulated the constants of the following (quite similar) equations for dynamic, as well as kinematic viscosity:

$$ln\,\eta = A + (B/T) \tag{4.7}$$

$$ln\,\upsilon = A' + (B'/T) \tag{4.8}$$

$$\eta = CT^{D} \tag{4.9}$$

and $\upsilon = C'T^{D'}$ (4.10)

Tables 4.3 to 4.6 summarize the representation of the experimental viscosity data on a variety of substances along with the applicable temperature range. The calculated values are generally within a few percent of the experimental values. The complete set of experimental data, calculated values, regression analysis and references to experimental viscosity-temperature data and representation by the selected equation (including the three constant forms noted in the next section) are given in Chapter 6. The data have been taken from their book are updated to include the literature upto 2003.

Table 4.3. Summary of the representation of the temperature dependence of pure liquid dynamic viscosity in the logarithmic form given by Eq. (4.7): $\ln\eta = A + (B/T)$. [Temperature in K and Viscosity in cP]. From: D. S. Viswanath and G. Natarajan, Data Book on Liquid Viscosity, Hemisphere, New York, 1989.

Name	***Formula***	***A***	***B***	***Temperature Range, K***
Allyl alcohol	C_3H_6O	– 5.5749	793.29	280 to 370
Allyl bromide	C_3H_5Br	– 4.6328	389.33	270 to 350
Allyl chloride	C_3H_5Cl	– 4.7522	372.37	270 to 320
Biphenyl	$C_{12}H_{10}$	– 4.9332	712.34	370 to 500
Boron trichloride	BCl_3	– 4.3146	232.51	230 to 290
4-Bromo aniline	C_6H_6NBr	– 4.9978	797.61	340 to 380
Bromo decane	$C_{10}H_{21}Br$	– 5.4375	884.04	290 to 320
1-Bromo propane	C_3H_7Br	– 4.6262	392.13	270 to 350
2-Bromo propane	C_3H_7Br	– 4.7088	408.46	270 to 330
4-Bromo toluene	C_7H_7Br	– 4.6202	501.53	300 to 380
2-Butane thiol	$C_4H_{10}S$	– 4.6839	407.84	280 to 330
1-Butanol	$C_4H_{10}O$	– 5.9719	1007.0	220 to 390
n-Butyl aniline	$C_{10}H_{15}N$	– 4.9610	685.21	370 to 520
Butyl benzene	$C_{10}H_{14}$	– 4.8735	551.98	280 to 360
s-Butyl titanate	$C_{16}H_{36}O_4Si$	– 4.7678	612.63	370 to 460
Butyraldehyde	C_4H_8O	– 4.8100	428.80	290 to 350
Butyric acid	$C_4H_8O_2$	– 4.9362	623.19	270 to 430
Butyro nitrile	C_4H_7N	– 4.8220	466.49	280 to 400
Butyryl chloride	C_4H_7ClO	– 4.7391	439.79	290 to 380
Cadmium chloride (molten)	$CdCl_2$	– 3.6505	889.51	840 to 1010
4 - Chloro aniline	C_6H_6ClN	– 4.8395	692.19	360 to 510
4 - Chloro bromo benzene	C_6H_4BrCl	– 3.5520	123.37	380 to 395
1 - Chloro difluoro ethane	$C_2H_3F_2Cl$	– 4.4480	279.56	240 to 340
4 - Chloro iodo benzene	C_6H_4ClI	– 4.5532	520.97	380 to 395
3 - Chloro nitro benzene	$C_6H_4ClNO_2$	– 4.6623	615.49	380 to 395
1 - Chloro propane	C_3H_7Cl	– 4.7401	376.91	270 to 320
2 - Chloro propane	C_3H_7Cl	– 4.8440	395.32	270 to 310
Corn syrup	–	– 5.5478	868.35	280 to 360
Corn syrup	–	– 5.8508	924.84	280 to 360
Cumene	C_9H_{12}	– 4.8910	524.64	270 to 320
4-Cyano pyridine	$C_6H_4N_2$	– 4.8871	662.18	350 to 400
1,3-Cyclo headiene	C_6H_8	– 4.8782	486.13	290 to 360
Cyclo hexane	C_6H_{12}	– 5.1466	625.44	280 to 360
Cyclo hexanone	$C_6H_{10}O$	– 5.0732	708.98	280 to 430
Cyclo hexene	C_6H_{10}	– 4.8401	487.75	270 to 360

Name	***Formula***	***A***	***B***	***Temperature Range, K***
Cyclo pentane	C_5H_{10}	– 4.7916	419.62	270 to 320
Decalin	$C_{10}H_{18}$	– 5.0322	720.71	290 to 350
Decanoic acid	$C_{10}H_{20}O_2$	– 5.3278	957.82	320 to 355
1,4-Di bromo benzene	C_6H_4Br	– 5.3410	873.38	380 to 400
1,2-Di bromo ethylene	$C_2H_2Br_2$	– 4.4549	421.62	270 to 380
1,4-Di chloro benzene	$C_6H_4Cl_2$	– 4.6319	497.21	330 to 450
1,1 - Di chloro - 2,2 - difluoro ethane	$C_2H_2Cl_2F_2$	– 4.8605	502.16	290 to 330
Di chloro difluoro methane	CCl_2F_2	– 4.3063	213.62	210 to 330
Trans-1,2-Di chloro ethane	$C_2H_2Cl_2$	– 4.6555	369.48	220 to 300
1,2 - Di chloro tetrafluoro ethane	$C_2Cl_2F_4$	– 4.7833	400.81	200 to 340
Di ethyl amine	$C_4H_{11}N$	– 5.1067	479.98	280 to 330
1,4 - Di methoxy benzene	$C_8H_{10}O_2$	– 4.9520	662.97	330 to 490
Di methyl amine	C_2H_7N	– 5.1197	413.84	280 to 310
2,6-Di methyl aniline	$C_8H_{11}N$	– 5.8154	991.16	290 to 330
2,6 - Di methyl - 4 - heptanone	$C_9H_{18}O$	– 5.2303	642.64	290 to 320
Di propyl amine	$C_6H_{15}N$	– 5.0577	528.10	270 to 390
Ethane thiol	C_2H_6S	– 4.6584	333.01	270 to 300
Ethyl caprate	$C_{12}H_{24}O_2$	– 5.1557	738.39	300 to 370
Ethyl tri fluoro acetate	$C_4H_5F_3O_2$	– 4.9103	453.77	290 to 340
Fluoro benzene	C_6H_5F	– 4.7298	438.23	270 to 360
1 - Fluoro hexane	$C_6H_{13}F$	– 4.8431	449.02	290 to 340
3 - Fluoro toluene	C_7H_7F	– 4.6993	434.02	290 to 340
Hexane dioic acid	$C_6H_{10}O_4$	– 5.8513	1586.0	445 to 465
1 - Hexyne	C_6H_{10}	– 4.9902	458.60	290 to 340
Hydrogen chloride	HCl	– 3.8799	104.76	160 to 190
Hydrogen sulfide	H_2S	– 4.1486	168.99	190 to 210
Indene	C_9H_8	– 5.0798	686.30	270 to 400
Iodo methane	CH_3I	– 4.4564	336.11	270 to 320
Iso amyl amine	$C_5H_{13}N$	– 4.9743	536.52	270 to 360
Iso amyl cyanide	$C_6H_{11}N$	– 4.9258	561.33	290 to 420
Iso valeraldehyde	$C_5H_{10}O$	– 4.9057	484.01	290 to 370
1 - Methoxy propane	$C_4H_{10}O$	– 4.8065	353.61	270 to 310
Methyl benzoate	$C_7H_8O_2$	– 5.4149	800.14	280 to 305
2 - Methyl -1,3 - buta diene	C_5H_8	– 4.7797	326.58	270 to 310
2 - Methyl butane	C_5H_{12}	– 4.8531	352.18	270 to 310
2 - Methyl - 2 - butane thiol	$C_5H_{12}S$	– 5.0016	534.84	280 to 340
2 - Methyl - 2 - butene	C_5H_{10}	– 4.7741	322.29	270 to 310
Methyl butyrate	$C_5H_{10}O_2$	– 4.8758	479.71	270 to 380
Methyl chloride	CH_3Cl	– 4.0591	140.54	250 to 310
3-Methyl hexane	C_7H_{16}	– 4.8727	422.23	280 to 310
Methyl iso butyrate	$C_5H_{10}O_2$	– 4.8272	451.96	270 to 370
Methyl oleate	$C_{19}H_{36}O_2$	– 4.9869	800.18	300 to 370

Name	***Formula***	***A***	***B***	***Temperature Range, K***
3 - Methyl pentane	C_6H_{14}	– 4.7141	357.91	270 to 310
4 - Methyl - 2 - pentanone	$C_6H_{12}O$	– 4.9190	493.54	290 to 340
2 - Methyl propane	C_4H_{10}	– 4.8098	312.65	200 to 280
Methyl sulfide	C_2H_6S	– 4.6126	317.90	270 to 310
Nickle - nitrate hexa hydrate	$Ni(NO_3)_2.6H_2O$	– 5.9846	1482.60	330 to 350
2 - Nitro - 2 - butene	$C_4H_7NO_2$	– 4.6679	477.91	300 to 340
Nitrogen dioxide	N_2O_4	– 4.7244	394.75	250 to 295
2 - Nitro - 2 - heptene	$C_7H_{13}NO_2$	– 4.8386	595.07	300 to 340
3 - Nitro - 2 - heptene	$C_7H_{13}NO_2$	– 4.9617	634.33	300 to 340
3 - Nitro - 3 - heptene	$C_7H_{13}NO_2$	– 4.9097	612.34	300 to 340
4 - Nitro - 3 - heptene	$C_7H_{13}NO_2$	– 4.8737	595.53	300 to 340
2 - Nitro - 2 - hexene	$C_6H_{11}NO_2$	– 4.7845	558.37	300 to 340
3 - Nitro - 2 - hexene	$C_6H_{11}NO_2$	– 4.8706	578.71	300 to 340
3 - Nitro - 3 - hexene	$C_6H_{11}NO_2$	– 4.7675	534.93	300 to 340
2 - Nitro - 2 - nonene	$C_9H_{17}NO_2$	– 5.0352	708.95	300 to 340
3 - Nitro - 2 - nonene	$C_9H_{17}NO_2$	– 5.1782	753.52	300 to 340
3 - Nitro - 3 - nonene	$C_9H_{17}NO_2$	– 5.0969	720.80	300 to 340
4 - Nitro - 3 - nonene	$C_9H_{17}NO_2$	– 5.1298	729.59	300 to 340
4 - Nitro - 4 - nonene	$C_9H_{17}NO_2$	– 5.0884	715.18	300 to 340
5 - Nitro - 4 - nonene	$C_9H_{17}NO_2$	– 5.1475	736.86	300 to 340
2 - Nitro - 2 - octene	$C_8H_{15}NO_2$	– 4.9726	665.91	300 to 340
3 - Nitro - 2 - octene	$C_8H_{15}NO_2$	– 5.0634	692.81	300 to 340
3 - Nitro - 3 - octene	$C_8H_{15}NO_2$	– 4.9554	648.82	300 to 340
4 - Nitro - 3 - octene	$C_8H_{15}NO_2$	– 4.9931	657.09	300 to 340
4 - Nitro - 4 - octene	$C_8H_{15}NO_2$	– 5.0407	680.29	300 to 340
2 - Nitro - 2 - pentene	$C_5H_9NO_2$	– 4.7037	498.04	300 to 340
3 - Nitro - 2 - pentene	$C_5H_9NO_2$	– 4.7613	523.36	300 to 340
Nitryl fluoride	FNO_2	– 4.0163	133.93	150 to 190
Nona decane	$C_{19}H_{40}$	– 5.5763	976.51	300 to 350
Nona decyl benzene	$C_{25}H_{44}$	– 5.7965	1163.9	300 to 350
1 - Nonanol	$C_9H_{20}O$	– 6.6238	1366.7	280 to 330
Oxirane	C_2H_4O	– 4.6446	312.90	220 to 290
Para Hydrogen	H_2	3.6446	– 1.876	15 to 32
2 - Pentanone	$C_5H_{10}O$	– 4.7986	438.45	270 to 380
1 - Pentene	C_5H_{10}	– 4.7345	305.20	180 to 280
1,2 - Phenyledene diamine	$C_6H_8N_2$	– 5.1842	967.30	380 to 400
Potassium nitrate	KNO_3	– 4.1228	971.07	610 to 750
1 - Propan amine	C_3H_9N	– 5.1626	518.12	280 to 320
2 - Propan amine	C_3H_9N	– 5.0248	456.33	280 to 310
1 - Propane thiol	C_3H_8S	– 4.6911	380.50	270 to 310
Propyl acetate	$C_5H_{12}O_2$	– 4.9024	488.31	270 to 380
Propyl ether	$C_6H_{14}O$	– 4.8897	443.44	270 to 360
3 - n - Propyl - 4 - methyl sydnone	$C_6H_{10}N_2O_2$	– 5.9837	1237.6	290 to 320
Propyl oleate	$C_{21}H_{40}O_2$	– 5.3227	936.52	300 to 370
Pyrene	$C_{16}H_{10}$	– 5.1320	1014.2	450 to 510

Name	Formula	A	B	Temperature Range, K
Pyridine - N - oxide	C_5H_5NO	– 4.9399	828.32	340 to 400
Sodium acetate hydrate	$CH_3COONa.3H_2O$	– 6.7211	1483.7	330 to 360
Sodium carbonate hydrate	$Na_2CO_3.10H_2O$	– 7.5193	1668.7	300 to 330
Sodium hydroxide hydrate	$NaOH. H_2O$	– 7.3900	1826.0	330 to 360
1,1,2,2 - Tetra bromo ethane	$C_2H_2Br_4$	– 5.7617	1117.2	290 to 320
Tetra - n - methyl germane	$Ge(CH_3)_4$	– 4.5041	307.67	270 to 310
Trifluoro acetic acid	$C_2HF_3O_2$	– 5.0399	580.67	290 to 340
1,1,1 - Trifluoro acetone	$C_3H_3F_3O$	– 5.0099	439.06	280 to 290
1,1,1 - Trifluoro isopropyl acetate	$C_5H_7F_3O_2$	– 5.0598	562.57	290 to 340
Trifluoro methyl cyclo hexane	$C_7H_{11}F_3$	– 4.8304	530.52	290 to 340
α,α,α - Trifluoro toluene	$C_6H_5CF_3$	– 4.6590	414.69	290 to 340
1,1,2 - Tri fluoro1,2,2 - trichloro ethane	$C_2F_2Cl_3$	– 4.8178	487.10	280 to 320
Tri- *n* - propyl - *ortho* - phosphate	$C_9H_{21}O_4P$	– 5.4955	863.50	290 to 320
Tri - *o* - tolyl phosphate	$C_{21}H_{21}O_4P$	– 9.8520	2619.9	290 to 320

Table 4.4. Summary of the representation of the temperature dependence of pure liquid kinematic viscosity in the logarithmic form given by Eq. (4.8): $ln\,\upsilon = A' + \left(B'/T\right)$ [Temperature in K and Viscosity in cSt]. From: D. S. Viswanath and G. Natarajan, Data Book on Liquid Viscosity, Hemisphere, New York, 1989.

Name	Formula	A′	B′	Temperature Range, K
n - Butyl diphenyl phosphate	$C_{16}H_{19}O_4P$	– 2.5388	1057.7	310 to 380
2 - Butyl hexyl diphenyl phosphate	$C_{22}H_{31}O_4P$	– 2.8627	1229.2	310 to 380
2 - Butyl hexyl ditolyl phosphate	$C_{24}H_{35}O_4P$	– 3.3026	1431.4	310 to 380
n - Decyl diphenyl phosphate	$C_{22}H_{31}O_4P$	– 2.6136	1143.1	310 to 380
n - Decyl ditolyl phosphate	$C_{24}H_{35}O_4P$	– 2.9999	1319.1	310 to 380
n - Decyl ortho silicate	$C_{40}H_{84}O_4Si$	– 2.0777	981.23	310 to 380
Di isobutyl carbinyl ortho silicate	$C_{36}H_{76}O_4Si$	– 3.0057	1432.0	310 to 380
2,2 - Di methyl butyl diphenyl phosphate	$C_{18}H_{23}O_4P$	– 2.8681	1219.3	310 to 380
Di penta erythritol hexa butanone	$C_{34}H_{58}O_{13}$	– 3.4633	1640.6	310 to 380
Di penta erythritol hexahexanoate	$C_{46}H_{82}O_{13}$	– 3.1655	1517.9	310 to 380
Di penta erythritol haxaisodecanoate	$C_{70}H_{142}O_{13}$	– 4.5422	2177.0	310 to 380
Di penta erythritol tributanoyl tri nonate	$C_{49}H_{88}O_{13}$	– 3.4349	1644.7	310 to 380
n - Dodecyl di phenyl phosphate	$C_{24}H_{35}O_4P$	– 2.6916	1190.5	310 to 380
n - Dodecyl di tolyl phosphate	$C_{26}H_{39}O_4P$	– 3.0263	1346.9	310 to 380
n - Dodecyl ortho silicate	$C_{48}H_{100}O_4Si$	– 2.2447	1091.1	310 to 380

Name	***Formula***	***A'***	***B'***	***Temperature Range, K***
2 - Ethyl butyl diphenyl phosphate	$C_{18}H_{23}O_4P$	– 2.6603	1118.7	310 to 380
2 - Ethyl butyl ditolyl phosphate	$C_{20}H_{27}O_4P$	– 3.0568	1307.4	310 to 380
2 - Ethyl hexyl diphenyl phosphate	$C_{20}H_{27}O_4P$	– 2.7414	1162.7	310 to 380
2 - Ethyl hexyl ditolyl phosphate	$C_{22}H_{31}O_4P$	– 3.2127	1380.6	310 to 380
n - Heptyl diphenyl phosphate	$C_{19}H_{25}O_4P$	– 2.5822	1094.6	310 to 380
n - Heptyl ortho silicate	$C_{28}H_{60}O_4Si$	– 1.8014	779.54	310 to 380
n - Hexa decyl diphenyl phosphate	$C_{28}H_{43}O_4P$	– 2.6196	1223.2	310 to 380
n - Hexyl diphenyl phosphate	$C_{18}H_{23}O_4P$	– 2.5945	1092.6	310 to 380
n - Hexyl ditolyl phosphate	$C_{20}H_{27}O_4P$	– 2.9680	1273.6	310 to 380
2 - Methyl butyl diphenyl phosphate	$C_{17}H_{21}O_4P$	– 2.6748	1123.4	310 to 380
3 - Methyl butyl diphenyl phosphate	$C_{17}H_{21}O_4P$	– 2.6516	1112.5	310 to 380
6 - Methyl heptyl diphenyl phosphate	$C_{20}H_{27}O_4P$	– 2.7338	1172.4	310 to 380
2 - Methyl pentyl diphenyl phosphate	$C_{18}H_{23}O_4P$	– 2.6888	1130.0	310 to 380
2 - Methyl propyl diphenyl phosphate	$C1_6H_{19}O_4P$	– 2.7234	1135.4	310 to 380
Octa decyl (branched) diphenyl phosphate	$C_{30}H_{47}O_4P$	– 4.1194	1828.1	310 to 380
n - Octyl diphenyl phosphate	$C_{20}H_{27}O_4P$	– 2.6142	1119.1	310 to 380
n - Octyl di tolyl phosphate	$C_{22}H_{31}O_4$	– 3.0082	1303.2	310 to 380
n - Octyl - 9 (10) - mono acetoxy stearate	$C_{28}H_{54}O_4$	– 2.9598	1316.2	260 to 380
n - Octyl ortho silicate	$C_{32}H_{68}O_4Si$	– 1.8636	843.43	240 to 380
Penta erythritol butanoyl hexanoyl octanoyl tetra decanoate	$C_{37}H_{68}O_8$	– 3.0006	1414.8	310 to 380
Penta erythriol decanoyl hepta decanoyl di iso octanoate	$C_{48}H_{90}O_8$	– 3.3534	1625.0	310 to 380
Penta erythritol di butanoyl - di (4 - cyclohexyl - butanoate)	$C_{33}H_{56}O_8$	– 3.8122	1775.8	310 to 380
Penta erythritol di butanoyl di iso decanoate	$C_{33}H_{60}O_8$	– 3.7086	1711.6	310 to 380
Penta erythritol di decanoyl di octanoate	$C_{41}H_{76}O_8$	– 3.3806	1597.0	310 to 380
Penta erythritol di ethanoyl di dacanoate	$C_{29}H_{52}O_8$	– 3.4243	1558.4	310 to 380
Pentaerythritol - di (2 - ethyl butanoyl) di iso decanoate	$C_{37}H_{68}O_8$	– 4.2805	1950.6	310 to 380
Penta erythritol di heptanoyl di iso decanoate	$C_{39}H_{72}O_8$	– 3.4067	1576.4	310 to 380
Penta erythritol diheptanoyl tetra - decanoyl-4-cyclo hexyl butanoate	$C_{43}H_{78}O_8$	– 3.3136	1584.4	310 to 380
Penta erythritol di hexanoyl di cyclo hexane carboxylate	$C_{31}H_{52}O_8$	– 4.0608	1884.4	310 to 380

Name	***Formula***	***A'***	***B'***	***Temperature Range, K***
Penta erythritol di hexanoyl di iso decanoate	$C_{37}H_{68}O_8$	– 3.4624	1592.1	310 to 380
Penta erythritol di hexanoyl di undecanoate	$C_{39}H_{72}O_8$	– 3.0970	1446.6	310 to 380
Penta erythritol di hexanoyl undecanoyl tetra decanoate	$C_{42}H_{78}O_8$	– 3.1058	1469.6	310 to 380
Penta erythritol di iso decanoyl hepta decanoyl - 4 - cyclo hexyl butane	$C_{52}H_{96}O_8$	– 3.7343	1801.0	310 to 380
Penta erythritol di nonanoyl benzoyl cyclo hexane carboxylate	$C_{37}H_{58}O_8$	– 4.0806	1901.1	310 to 380
Penta erythritol di nonanoyl di (2 - ethyl hexanoate)	$C_{39}H_{72}O_8$	– 3.4329	1576.8	310 to 380
Penta erythritol di nonanoyl di (2 - ethyl - 4 - methyl pentanoate)	$C_{39}H_{72}O_8$	– 3.8452	1743.7	310 to 380
Penta erythritol di nonanyl di iso octanoate	$C_{39}H_{72}O_8$	– 3.3614	1560.2	310 to 380
Penta erythritol di nonanyl octanoyl decanoate	$C_{41}H_{76}O_8$	– 3.0042	1417.9	310 to 380
Penta erythritol di octanoyl ethanoyl hexnoate	$C_{29}H_{52}O_8$	– 3.2125	1450.3	310 to 380
Penta erythritol di octanoyl di (2 - ethyl -hexanoate)	$C_{37}H_{68}O_8$	– 3.4545	1591.1	310 to 380
Penta erythritol di pentanoyl di nonanoate	$C_{33}H_{60}O_8$	– 2.7539	1256.9	310 to 380
Pentane ertthritol di pentanoyl di tetra decanoate	$C_{43}H_{80}O_8$	– 3.0442	1465.9	310 to 380
Pentane erythritol heptanoyl di undecanoyl - 4 - cyclo hexyl butane	$C_{44}H_{80}O_8$	– 3.2154	1540.3	310 to 380
Penta erythritol hexanoyl - 2 - ethyl hexanoyl undecanoyl trtra decanoate	$C_{44}H_{82}O_8$	– 3.1744	1512.4	310 to 380
Penta erythritol hexanoyl nonanoyl tetra decanoyl - 2 - ethyl hexanoate	$C_{42}H_{78}O_8$	– 3.2909	1534.6	310 to 380
Penta erythritol nonanoyl penta decanoyl di (2 - ethyl hexanoate)	$C_{45}H_{84}O_8$	– 3.3837	1619.0	310 to 380
Penta erythritol tetra (2 - ethyl butanoate)	$C_{29}H_{52}O_8$	– 4.1681	1851.8	310 to 380
Penta erythritol tetra heptanoate	$C_{33}H_{60}O_8$	– 2.9137	1325.5	310 to 380
Penta erythritol tetra nonoate	$C_{41}H_{76}O_8$	– 2.9910	1410.9	310 to 380
Penta erythritol tetra octanoate	$C_{37}H_{68}O_8$	– 2.9141	1353.9	310 to 380
Penta erythritol tetra pentanoate	$C_{25}H_{44}O_8$	– 2.8592	172.7	310 to 380
Penta erythritol tri hexanoyl cyclo hexane carboxylate	$C_{30}H_{52}O_8$	– 3.2303	1490.7	310 to 380
Penta erythritol tri hexanoyl tetra decanoate	$C_{37}H_{68}O_8$	– 3.0576	1436.0	310 to 380
Penta erythritol trinonoyl - 4 - cyclo hexane carboxylate	$C_{39}H_{70}O_8$	– 3.2993	1558.5	310 to 380

Name	***Formula***	***A'***	***B'***	***Temperature Range, K***
Penta erythritol trinonyl - 4 - cyclo hexyl butanoate	$C_{42}H_{76}O_8$	– 3.4924	1645.4	310 to 380
Penta erythritol trinonyl - 2 - ethyl - 4 -methyl pentanoate	$C_{40}H_{74}O_8$	– 3.2797	1526.2	310 to 380
Penta erythritol trinonoyl phenyl ethanoate	$C_{40}H_{66}O_8$	– 3.2164	1495.5	310 to 380
n - Pentyl diphenyl phosphate	$C_{17}H_{21}O_4P$	– 2.5961	1092.3	310 to 380
Tri decyl (branched) di toluyl phosphate	$C_{27}H_{41}O_4P$	– 3.8316	1680.6	310 to 380
Tri (2 - ethyl hexyl) phosphate	$C_{24}H_{51}O_4P$	– 2.4906	1054.1	310 to 380
3,3,5 - Tri methyl hexyl diphenyl phosphate	$C_{21}H_{29}O_4P$	– 2.7372	1189.4	310 to 380
Tri methylo propane di decanoyl ethanoate	$C_{28}H_{52}O_6$	– 3.0126	1360.1	310 to 380
Tri methylol propane di nonoyl - 4 - cyclo hexyl butanone	$C_{34}H_{62}O_6$	– 3.1466	1466.3	310 to 380
Tri methyl propane di undecanoyl - 4 - cyclo hexyl butanoate	$C_{38}H_{70}O_6$	– 3.0027	1449.7	310 to 380
Tri methylol propane heptanoyl di decanoate	$C_{33}H_{62}O_6$	– 3.8426	1305.8	310 to 380
Tri methylol propane nonanyl di iso decanoate	$C_{35}H_{66}O_6$	– 3.4104	1564.7	310 to 380
Tri methyl propane nonanoyl di (tri methyl ethanoate)	$C_{25}H_{46}O_6$	– 3.4284	1522.9	310 to 380
Tri methylol propane nonanoyl - 2 - ethyl hexanoyl cyclo hexane carboxalate	$C_{30}H_{54}O_6$	– 3.5930	1632.5	310 to 380
Tri methylol propane nonanoyl - 2 - ethyl hexanoyl phenyl ethanoate	$C_{31}H_{50}O_6$	– 3.0998	1401.2	310 to 380
Tri methylol propane pentanoyl - decanoyl hepta decanoate	$C_{38}H_{72}O_6$	– 2.8408	1368.7	310 to 380
Tri methylol propane pentanoyl iso decanoyl - 9 - octa decanoate	$C_{39}H_{74}O_6$	– 2.9295	1398.1	310 to 380
Tri methylol propane tri (2 - ethyl hexanoate)	$C_{30}H_{56}O_6$	– 3.6022	1580.3	310 to 380
Tri methylol propane tri nonoate	$C_{33}H_{65}O_6$	– 2.8305	1300.2	310 to 380
Tri octyl phosphate	$C_{24}H_{51}O_4P$	– 2.2406	985.34	310 to 380
Tri penta erythritol octanonanoate	$C_{87}H_{160}O_{18}$	– 3.6095	1802.6	310 to 380
Tri penta erythritol octa pentanoate	$C_{55}H_{96}O_{18}$	– 3.5271	1733.8	310 to 380

Table 4.5. Summary of the representation of the temperature dependence of pure liquid dynamic viscosity in the Logarithmic form given by Eq. (4.9): $\eta = CT^D$ [Temperature in K and Viscosity in cP]. From: D. S. Viswanath and G. Natarajan, Data Book on Liquid Viscosity, Hemisphere, New York, 1989.

Substance	***Formula***	***C***	***D***	***Temperature range, K***
Acetaldehyde	$C_2H_4O_2$	730.00	– 2.6402	270 to 300
Acetic acid	$C_2H_4O_2$	1.2106×10^6	– 3.6612	270 to 390
Allyl thiocynate	C_4H_5NS	1.3070×10^5	– 3.3473	290 to 400
Amyl amine	$C_5H_{13}N$	4.8213×10^7	– 4.3795	270 to 360
Bromoform	$CHBr_3$	4.9008×10^6	– 3.8075	280 to 350
Butyl amine	$C_4H_{11}N$	1.5597×10^7	– 4.2168	270 to 360
Ether	$C_4H_{10}O$	950.69	– 2.6785	270 to 410
n-Hexyl amine	$C_6H_{15}N$	1.8823×10^8	– 4.5741	270 to 380
Hexyl thio myrisate	$C_{20}H_{40}OS$	8.8939×10^{10}	– 5.2656	300 to 370
Hydrogen bromide	HBr	0.25449	– 1.0769	180 to 200
Hydrogen iodide	HI	5.8043	– 1.5299	220 to 240
Methyl acetate	$C_3H_6O_2$	1.4880×10^4	– 3.0759	270 to 420
Methyl ethyl ketone	C_4H_8O	2.2926×10^4	– 3.1332	240 to 360
Perfluoro-1-isopropoxy hexane	$C_9F_{20}O$	5.562×10^{10}	– 5.4777	290 to 320

Table 4.6. Constants C’ and D’ of Eq. (4.10): $\nu = C'T^{D'}$, which provides the temperature dependence of the kinematic viscosity of pure liquids. [Temperature in K and kinematic viscosity in cSt]. From: D. S. Viswanath and G. Natarajan, Data Book on the Viscosity of Liquids. Hemisphere, New York, 1989.

Name	***Formula***	***C'***	***D'***	***Temperature Range, K***
2 - Butyl octyl di phenyl phosphate	$C_{24}H_{35}O_4P$	1.0026×10^{22}	–8.3719	310 to 380
2 - Butyl octyl di tolyl phosphate	$C_{26}H_{39}O_4P$	6.1112×10^{25}	–9.8085	310 to 380
Penta erythritol di heptanoyl di nonanoate	$C_{37}H_{68}O_8$	1.2951×10^{25}	–9.4900	310 to 380
Penta erythritol di hexanoyl hepta - decanoyl - 2 - ethyl hexanoate	$C_{42}H_{78}O_8$	5.5035×10^{28}	–10.821	310 to 380
Penta erythritol di hexanoyl tetra - decanoyl cyclo hexane carboxylate	$C_{38}H_{68}O_8$	3.4420×10^{28}	–10.740	310 to 380
Penta erythritol di iso decanoyl tetra - decanoyl - 4 - cyclo hexyl – butanone	$C_{49}H_{90}O_8$	3.9036×10^{32}	–12.267	310 to 380
Penta erythritol di nonanoyl di iso decanoate	$C_{43}H_{80}O_8$	1.1028×10^{28}	–10.571	310 to 380
Penta erythritol di pentanoyl di heptanoate	$C_{29}H_{52}O_8$	1.2617×10^{23}	–8.7486	310 to 380
Penta erythritol di tetra decanoyl- di - (2 - ethyl hexanoate)	$C_{49}H_{92}O_8$	4.0859×10^{29}	–11.156	310 to 380
Penta erythritol hexanoyl decanoyl - 2 - ethyl hexanoate	$C_{39}H_{72}O_8$	7.1579×10^{27}	–10.528	310 to 380
Penta erythritol penta noyl - 2 - ethyl hexanoyl undecanoyl tetra decanoyl	$C_{43}H_{80}O_8$	1.4945×10^{27}	–10.228	310 to 380
Penta erythritol tetra hexanoate	$C_{29}H_{52}O_8$	5.2613×10^{23}	–8.9845	310 to 380
Penta erythritol tetra iso octanoate	$C_{37}H_{68}O_8$	2.5160×10^{33}	–12.244	310 to 380
Penta erythritol tri heptanoyl cyclo hexane carboxylate	$C_{33}H_{58}O_8$	3.2338×10^{28}	–10.748	310 to 380

Name	***Formula***	***C'***	***D'***	***Temperature Range, K***
Penta erythritol tri heptanoyl - 4 - cyclo hexyl butanone	$C_{36}H_{64}O_8$	3.3645×10^{27}	–10.380	310 to 380
Penta erythritol tri hexanoyl hepta decanoate	$C_{40}H_{74}O_8$	2.6257×10^{26}	–9.9417	310 to 380
Tetra decyl (branched) diphenyl phosphate	$C_{26}H_{39}O_4P$	1.9860×10^{25}	–9.6094	310 to 380
Tridecyl (branched) di phenyl phosphate	$C_{25}H_{37}O_4P$	2.7258×10^{24}	–9.2818	310 to 380
Tri methyl propane di nonanoyl benzoate	$C_{31}H_{50}O_6$	1.1313×10^{29}	–11.003	310 to 380
Tri methylol propane di nonyl tri methyle thanoate	$C_{29}H_{54}O_6$	4.2332×10^{24}	9.3327	310 to 380
Tri methylol propane di tetra decanoyl - 4 - cyclo hexyl butanoate	$C_{44}H_{82}O_6$	5.4398×10^{27}	–10.425	310 to 380
Tri methylol propane di tetra decanoyl iso decanoate	$C_{44}H_{84}O_6$	3.1843×10^{26}	–9.9726	310 to 380
Tri methylol propane pentanoyl iso decanoyl hepta decanoate	$C_{38}H_{72}O_6$	1.7555×10^{26}	–9.8727	310 to 380
Tri methylol propane tetra decanoyl pentanoyl - 2 - ethyl hexanoate	$C_{33}H_{62}O_6$	4.9081×10^{25}	–9.6965	310 to 380
Tri penta erythritol octa butanone	$C_{47}H_{80}O_{18}$	9.9311×10^{29}	–11.207	310 to 380

4.3.1.1.c Dutt and Prasad Representation

The constants of the two-constant equation given by Eq. 4.7 were obtained Dutt and Prasad[15] representing viscosity (in cP) as a function of temperature (in K) for the 100 substances that are also used in Section 4.4 for comparison of several methods for their predictive capabilities. An overall average absolute deviation of 1.4% is noted for these 100 subtances. The constants are given in Table 4.7.

Table 4.7. Constants of Eq. (4.7) $\ln\eta = A + \left(B/T\right)$ calculated by Dutt and Prasad[15] for determination of dynamic viscosity [Temperature in K; Viscosity in cP].

Substance	***A***	***B***	***Temperature range, K***
Acetaldehyde	–1.78	330.73	273 to 294
Acetic acid	–1.86	568.33	283 to 383
Acetone	–1.80	381.21	183 to 333
Acetophenone	–1.83	611.38	298 to 474
Allyl alcohol	–2.59	799.55	281 to 350
Amyl alcohol	–3.26	1140.44	248 to 310
Aniline	–3.01	1085.26	268 to 393
Benzene	–2.13	571.44	278 to 463
n-Butane	–1.71	279.56	183 to 323
Butanoic acid	–1.94	622.68	273 to 373
1-Butene	–1.68	258.05	163 to 233
n-Butyl alcohol	–2.95	1000.37	273 to 393
Butyl amine	–2.11	554.97	273 to 348
Butyl benzene	–1.88	554.64	283 to 353
Carbontetrachloride	–1.86	541.88	273 to 373
Chlorobenzene	–1.65	456.21	273 to 393
Chloroform	–1.58	390.29	248 to 333
m-Cresol	–3.68	1393.93	316 to 373
o-Cresol	–3.02	1124.15	322 to 393
Cyclohexane	–2.21	646.06	278 to 353
Cyclopentane	–1.75	406.98	253 to 323
Decane	–2.01	580.14	248 to 373
1,1-Dichloroethane	–1.72	412.30	280 to 327
Dichloromethane	–1.59	359.24	248 to 310

Substance	***A***	***B***	***Temperature range, K***
Diethyl amine	–2.09	473.46	283 to 323
Diethyl carbonate	–1.55	422.75	293 to 393
Diethyl ketone	–1.78	424.10	273 to 373
Diethyl sulfide	–1.74	406.09	273 to 348
Dimethyl carbonate	–2.02	529.85	293 to 353
N,N-Dimehyl formamide	–1.71	482.15	273 to 373
2,2-Dimethylpropane	–2.26	487.90	258 to 283
Dimethyl sulfide	–1.56	301.49	273 to 309
1,4-Dioxane	–2.18	670.37	288 to 348
Diphenyl ether	–2.12	791.32	313 to 473
Diphenyl methane	–1.89	693.62	333 to 434
Dipropyl amine	–2.06	527.18	273 to 373
Dodecane	–2.06	658.15	273 to 373
Ethane	–1.63	158.82	98 to 188
Ethanethiol	–1.66	334.66	270 to 298
Ethyl acetate	–2.04	498.79	273 to 463
Ethyl alcohol	–2.41	724.80	248 to 348
Ehyl benzene	–1.78	470.92	253 to 413
Ehyl bromide	–1.80	404.76	248 to 433
Ehylene	–1.79	169.30	103 to 173
Ethylene bromide	–1.68	561.22	293 to 393
Ehylene chloride	–1.83	512.37	273 to 353
Ehyl ether	–1.97	393.50	273 to 373
Ethyl formate	–1.76	400.16	273 to 328
Ethyl propionate	–1.86	463.79	273 to 373
Formic acid	–2.23	726.06	281 to 373
Furan	–1.74	387.81	248 to 303
Heptadecane	–2.03	767.33	303 to 553
Heptane	–1.91	449.20	183 to 373
Hexadecane	–2.11	771.69	298 to 393
Hexane	–1.72	355.79	213 to 343
1-Hexene	–1.82	363.33	248 to 333
1-Hexyne	–1.99	458.67	293 to 333
Isoamyl alcohol	–3.47	1215.57	283 to 373
Isobutane	–1.79	307.31	193 to 273
Isobutyl acetate	–2.01	549.61	293 to 373
Isobutyric acid	–1.88	587.27	273 to 373

Substance	***A***	***B***	***Temperature range, K***
Isopropyl alcohol	–3.52	1141.87	273 to 348
Isopropyl amine	–2.09	474.99	273 to 303
Methane	–1.97	116.22	88 to 113
Methyl acetate	–1.78	399.00	273 to 327
Mehyl alcohol	–2.07	539.26	248 to 333
Mehyl amine	–2.20	422.69	203 to 273
Methyl-n-amylketone	–2.84	800.82	293 to 353
2-Mehyl butane	–1.88	362.32	273 to 303
2-Methyl-2-butene	–1.78	323.90	273 to 305
Methyl butanoate	–1.87	478.86	273 to 373
Mehyl cyclopentane	–1.78	433.05	248 to 323
Mehyl formate	–1.70	364.46	274 to 302
Methyl isobutyrate	–1.84	456.70	273 to 362
Mehyl propionate	–1.81	429.37	273 to 348
Methyl-n-propylketone	–1.80	438.12	248 to 373
Nitromethane	–1.73	456.66	248 to 348
Nonane	–1.91	516.53	273 to 373
Octane	–2.24	853.67	273 to 373
Octadecane	–1.86	467.36	303 to 373
Pentadecane	–2.15	759.88	293 to 373
Pentane	–1.72	317.48	153 to 303
1-Pentene	–1.73	304.26	218 to 298
Phenol	–3.42	1279.67	313 to 363
Propane	–1.65	222.81	93 to 173
Propionic acid	–1.78	533.31	273 to 373
n-Propyl acetate	–1.90	487.96	273 to 373
n-Propyl alcohol	–2.90	950.27	248 to 348
Propyl formate	–1.84	454.07	273 to 348
Pyridine	–1.80	522.12	273 to 373
Pyrrole	–2.15	669.34	273 to 348
Quinoline	–2.53	911.42	288 to 373
Tetradecane	–2.16	742.57	283 to 373
Terahydrofuran	–1.63	387.67	248 to 323
Toluene	–1.83	469.86	253 to 383
Trichlorofluoromehane	–1.45	322.65	248 to 343

Substance	***A***	***B***	***Temperature range, K***
Tridecane	–2.12	702.75	273 to 373
Triethyl amine	–1.81	402.43	273 to 448
m-Xylene	–1.76	455.39	273 to 413
o-Xylene	–1.84	512.94	273 to 413

4.3.1.1.d Qung-Fang *et al.* Equation

Qun-Fang and coworkers[16] proposed a two-parameter model using Eyring's absolute rate theory for correlating the viscosity data of pure saturated liquids over a wide temperature range. The parameters of the proposed equation are dependent on vapor pressure, saturated liquid volume and enthalpy of vaporization.

The authors start with the absolute rate equation for liquid viscosity published by Eyring[17] and Kincaid *et al.*[18]

$$\eta = (Nh/V)exp\left(\Delta G^{*}/RT\right) \tag{4.11}$$

where η is the liquid viscosity, ΔG^* is the activation energy, V is the molar volume, h is the Planck's constant, N is the Avogadro number and R is the universal gas constant. The structure of liquid from Eyring's absolute rate theory is as shown in Fig. 4.2.

Qun-Fang *et al.* combine the rate equation with the viscous flow mechanism expressed by

$$\mathrm{a} \rightleftharpoons \mathrm{X} \longrightarrow \mathrm{b} \tag{4.12}$$

which means that the molecule in position *a* is in thermodynamic equilibrium with activated molecule *X*, the equilibrium constant being *K*. The rate of viscous flow from position *a* to vacancy *b* depends on the rate of flow of *X* to vacancy *b* (k_f) and is equal to the opposing process (k_b) and is given by:

$$k_f = k_b = pK\gamma\, exp\left(\Delta G^{*}/kT\right) \tag{4.13}$$

where p is the probability of having a vacancy at position b, γ is the frequency of the activated molecular flow to the vacancy b (the reciprocal of which can be considered to be the mean residence time τ_R), k is the Boltzmann constant and ΔG^* is the energy of activation. The chemical reaction anology of activated complex formation is used to describe the viscous flow in the liquid, and the authors arrived at the relation

$$\eta = \frac{RT}{\gamma V} exp\left[\frac{\alpha''(1+\alpha')\Delta U_{vap}}{RT}\right] exp\left(\frac{PV}{RT}\right) \tag{4.14}$$

Combining some of the constants, the final equations proposed are

$$ln(\eta V/RT) - (PV/RT) = ln(1/\gamma) + \alpha(\Delta U_{vap}/RT) \tag{4.15}$$

$$ln(\eta V/RT) - (PV/RT) = ln(\tau_R) + \alpha(\Delta U_{vap}/RT) \tag{4.16}$$

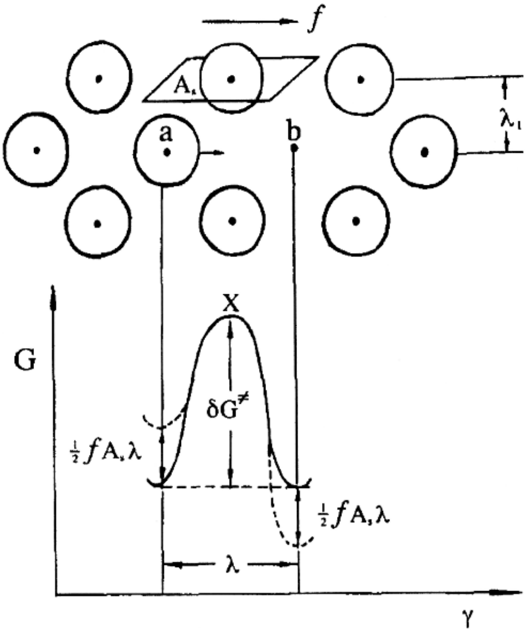


Figure 4.2. Flow cell of liquid (a) non-polar compounds, (b) polar compounds. Adopted from L. Qun-Fang, H. Yu-Chun, and L. Rui-Sen, Correlation of viscosities of pure liquids in a wide temperature range, *Fl. Ph. Equilib.*140(1-2), 221-231 (1997).

Eqs. (4.15) and (4.16) have two constants α and γ or $\tau_R = (1/\gamma)$, which are evaluated by regression analysis. This correlation is applicable in predicting the viscosity of saturated liquids if the data on vapor pressure (*P*), molar volume (*V*) and energy of vaporization (ΔU_{vap}) are all available, in addition to the characteristic coefficients tabulated for the 106 compounds given in their paper. In view of the large amount of data required for the application of the method we have not reproduced the table of the constants α, γ and τ.

4.3.1.1.e Two Constant Representation by Other Investigators

The two constant equation in the power law form, Eq. (4.9) has also been used as a correlation equations by several investigators. The constants A and B for some substances available in the literature and quoted by Reid *et al.*[19] are given in Table 4.8.

Table 4.8. Constants of the power law representation of the temperature dependence of liquid viscosity given by Eq. (4.9): $\eta = AT^B$. [Temperature in K and Viscosity in cP][19].

Chemical Formula	Name	A	B	Temperature range, °C	η at (t, °C)
CH_3NO	Formaldehyde	7.737×10^{23}	– 9.445	0 to 25	3.30(25)
C_2H_4O	Acetaldehyde	5.140×10^{7}	– 3.390	0 to 20	0.22(20)
$C_3H_4O_2$	Acrylicacid	1.510×10^{10}	– 4.089	20 to 40	–
C_3H_6O	Allyl alcohol	3.529×10^{13}	– 5.445	0 to 70	1.36(20)
$C_3H_8O_3$	Glycerol	3.4263×10^{73}	– 28.52	0 to 30	954.00(25)
$C_5H_4O_2$	Furfural	3.628×10^{14}	– 5.815	0 to 25	1.49(25)
$C_5H_{10}O_2$	*n*-Butyl formate	4.752×10^{10}	– 4.394	0 to 20	0.69(20)
C_6H_6BrN	*m*-Bromo nitrile	7.810×10^{18}	– 733.0	20 to 80	6.81(20)
C_6H_{10}	Cyclo hexane	4.566×10^{5}	– 2.367	13 to 20	0.66(20)
$C_7H_6O_3$	Salicylic acid	3.343×10^{14}	– 5.716	10 to 40	2.71(20)
$C_7H_{14}O_2$	*iso*-Amyl acetate	5.394×10^{10}	– 4.375	9 to 20	0.87(20)
C_8H_8O	Acetanilide	2.617×10^{16}	– 6.195	120 to 140	2.22(120)
$C_8H_{11}NO$	o-Phenetidine	2.908×10^{33}	– 13.24	0 to 30	6.08(20)
$C_6H_{11}NO$	p-Phenetidine	3.346×10^{33}	– 13.14	20 to 30	12.90(20)
$C_{10}H_{12}O_2$	Eugenol (1,2,3)	2.546×10^{36}	– 14.35	0 to 40	9.22(20)
$C_{13}H_{13}N$	Benzyl amine	5.344×10^{5}	– 2.168	33 to 130	2.18(33)
$C_{14}H_{14}O$	Benzyl ether	1.425×10^{22}	– 8.678	0 to 40	5.33(20)

4.3.1.2 Three Constant Equations

A simple three-constant representation (comparable in form to the popular Antoine equation for vapor pressure) proposed originally by Vogel[20] is given below.

$$ln\,\eta = A - \frac{B}{t + C} \tag{4.17}$$

This form of the equation is more accurate than the two-constant form and is often preferred for engineering design purposes.

4.3.1.2a Viswanath and Natarajan Representation

Viswanath and Natarajan[14] utlized a similar form for both dynamic and kinematic viscosities and the constants of their equations for dynamic (η) as well as the kinematic viscosity (υ) are presented in Tables 4.9 and 4.10, respectively. The equations are as follows:

$$log\,\eta = A + B/(C - T) \tag{4.18}$$

$$log\,\upsilon = A' + B'/(C' - T) \tag{4.19}$$

4.3.1.2b Dutt and Prasad Representation

The constants of the three-constant equation were also obtained by Dutt and Prasad[15] representing viscosity (in cP) as a function of temperature (in K) for the 100 substances that are listed in Table 4.7. An overall average deviation of 0.62% are noted for these 100 subtances compared to 1.4% when the two-constant equation was used. The constants are shown in Table 4.11.

Table 4.9. Constants of the Antoine type equation given by Eq. (4.18): $log\,\eta = A + B/(C - T)$ for calculation of pure liquid viscosity at different temperatures. [Temperature in K and Viscosity in cP]. From D. S. Viswanath and G. Natarajan, *Data Book on Liquid Viscosity*, Hemisphere, New York, 1989.

Name	*Formula*	*A*	*B*	*C*	*Temp. Range, K*
Acetamide	C_2H_5NO	– 4.6341	– 422.90	149.84	360 to 500
Acetic anhydride	$C_4H_6O_3$	– 4.5804	– 374.60	49.411	270 to 410
Acetone	C_3H_6O	– 4.6125	– 298.48	26.203	180 to 320
Aceto nitrile	C_2H_3N	– 4.8242	– 430.37	13.170	280 to 360
Aceto phenone	C_7H_8O	– 4.6251	– 468.30	45.007	370 to 480
Acetyl chloride	C_2H_3ClO	– 4.7447	– 407.10	12.418	290 to 330
Allyl ether	$C_6H_{10}O$	– 5.5716	– 938.43	– 130.23	290 to 360
Allyl iodide	C_3H_5I	– 4.5436	– 410.42	2.0868	270 to 380
Aluminum bromide	$AlBr_3$	– 4.2262	– 493.82	64.743	370 to 530

Name	***Formula***	***A***	***B***	***C***	***Temp. Range, K***
Aluminum iodide	AlI_3	– 3.8840	– 443.03	132.69	470 to 680
Ammonia	NH_3	– 4.3044	– 94.129	108.28	200 to 240
tert-Amyl alcohol	$C_5H_{12}O$	– 5.0567	– 359.53	161.29	270 to 380
Amyl butyrate	$C_9H_{18}O_2$	– 4.4732	– 321.43	87.301	270 to 380
Amyl titanate	$C_{20}H_{44}O_4Ti$	– 5.0964	– 493.76	214.92	400 to 490
2-Amyl undecanol	$C_{16}H_{34}O$	– 5.3143	– 656.98	125.18	290 to 380
2-Amyl undecyl acetate	$C_{18}H_{36}O_2$	– 4.1857	– 279.19	157.02	270 to 380
Aniline	C_6H_7N	– 4.4670	– 327.72	138.45	280 to 460
o-Anisaldehyde	C_8H_8O	– 4.6222	– 477.93	70.529	320 to 520
Benzo nitrile	C_7H_5N	– 4.2898	– 274.62	100.95	290 to 470
Benzo phenone	$C_{13}H_{10}O$	– 4.6614	– 416.84	148.97	300 to 380
Benzyl alcohol	C_7H_8O	– 4.6581	– 422.73	121.75	280 to 480
Benzyl amine	C_7H_9N	– 4.7265	– 480.83	49.937	290 to 460
Benzyl benzoate	$C_{14}H_{12}O_2$	– 3.9401	– 230.36	174.56	270 to 380
Benzyl chloride	C_7H_7Cl	– 3.8075	– 122.50	163.81	280 to 310
Benzyl cyanide	C_8H_7N	– 4.2563	– 292.41	109.28	290 to 420
Benzyl ether	$C_{14}H_{14}O$	– 4.0837	– 260.57	149.28	270 to 380
Bis dimethyl amino phosphoryl chloride	$C_4H_{12}ClN_2OP$	– 4.1079	– 297.31	118.96	240 to 350
1,3 - Bis (1 - Iso cyanato - 1- methyl) benzene	$C_{14}H_{16}N_2O_2$	– 4.3198	– 351.17	140.96	290 to 360
Bismuth	Bi	– 3.1717	– 93.808	343.93	550to1250
Bismuth chloride - molten	$BiCl_3$	– 5.7029	– 198.83	348.83	500 to 675
Bromal hydrate	$C_2H_3Br_3O_2$	– 4.7271	– 303.97	223.45	310 to 380
Bromine	Br_2	– 4.2380	– 329.88	26.153	270 to 330
Bromo ethane	C_2H_5Br	– 4.7817	– 468.12	– 47.339	200 to 300
1- Bromo - 2 - metehyl -propane	C_4H_9Br	– 5.1273	– 731.96	– 85.418	270 to 370
2 - Bromoaniline	C_6H_5NBr	– 4.1491	– 282.29	142.43	310 to 380
3 - Bromoaniline	C_6H_6Br	– 3.8310	– 175.81	187.13	290 to 380
Bromo benzene	C_6H_5Br	– 4.2367	– 279.94	77.353	270 to 420
1 - Bromo - 2 - methyl propane	C_4H_9Br	– 5.1273	– 731.96	– 85.418	270 to 370
2 - Bromo pyridine	C_6H_4BrN	– 4.2913	– 347.61	71.653	290 to 400
2 - Bromo toluene	C_7H_7Br	– 4.1812	– 252.67	107.57	270 to 380
3 - Bromo toluene	C_7H_7Br	– 4.1955	– 258.83	92.688	270 to 380
Butane	C_4H_{10}	– 5.1430	– 528.24	88.682	180 to 310
1 - Butane thiol	$C_4H_{10}S$	– 0.6575	– 1606.6	908.10	280 to 340
2 - Butanol	$C_4H_{10}O$	– 5.2749	– 452.89	134.40	280 to 370
1,3 - Butadiene	C_4H_6	– 6.0528	– 973.83	–145.12	250 to 400
Butyl acetate	$C_6H_{12}O_2$	– 4.7722	– 431.58	29.726	270 to 380
Butyl butyrate	$C_8H_{16}O_2$	– 4.5274	– 338.81	72.283	270 to 380
2-Butyl dodecanol	$C_{16}H_{34}O$	– 5.2109	– 614.37	132.35	290 to 380
Butyl dodecyl acetate	$C_{18}H_{36}O_2$	– 4.2089	– 287.19	154.82	270 to 380
Butyl ether	$C_8H_{18}O$	– 4.8090	– 449.86	20.676	270 to 380

Name	***Formula***	***A***	***B***	***C***	***Temp. Range, K***
Butyl formate	$C_5H_{10}O_2$	– 4.8197	– 448.59	22.748	270 to 380
2 - Butyl - 3 -hexyl deca hydro naphthalene	$C_{20}H_{38}$	– 4.2988	328.70	75.01	270 to 380
7-Butyl-1-hexyl -deca hydronaphathalene	$C_{20}H_{38}$	– 4.2931	– 341.18	165.42	270 to 380
2 - Butyl - 3 -hexyl naphthalene	$C_{20}H_{28}$	– 4.2679	– 328.24	169.89	270 to 380
3 - Butyl - 2 – oxazolidone	$C_7H_{13}NO_2$	– 4.2198	– 311.24	135.32	270 to 340
3 - *te t* - Butyl - 2 – oxazolidinone	$C_7H_{13}NO_2$	– 4.3212	– 352.73	127.83	270 to 340
Butyl phenyl ether	$C_{10}H_{14}O$	– 4.7979	– 500.67	51.416	290 to 490
Butyl propionate	$C_7H_{14}O_2$	– 4.6610	– 393.94	44.512	270 to 380
Butyl sydnone	$C_6H_{10}N_2O_2$	– 3.9759	– 279.00	150.51	310 to 400
Butyl titanate	$C_{16}H_{36}O_4Ti$	– 6.5798	– 1299.5	80.807	370 to 480
Tert - Butyl titanate	$C_{16}H_{36}O_4Ti$	– 4.8180	– 598.78	44.890	310 to 410
Butyl valerate	$C_9H_{18}O_2$	– 4.5554	– 370.73	67.95	270 to 380
Butyramide	C_4H_9NO	– 5.7069	– 1130.3	7.6121	390 to 490
Butyric anhydride	$C_8H_{14}O_3$	– 4.7648	– 512.55	31.910	290 to 420
Cadmium	Cd	– 3.6422	– 941.06	280.31	590 to 730
Chloro difluoro methane	$CHClF_2$	– 4.7458	– 328.78	25.019	200 to 300
Chloro fluoro methane	CH_2FCl	– 4.5953	– 281.37	12.76	190 to 320
Chloroform	$CHCl_3$	– 4.4573	– 325.76	23.789	210 to 360
2 - Chloro - 6 - methyl aniline	C_7H_8ClN	– 3.5853	– 76.581	216.40	290 to 330
1 - Chloro - 2 -methyl propane	C_4H_9Cl	– 5.0409	– 575.22	– 45.152	270 to 340
2 - Chloro phenol	C_6H_5ClO	– 4.2372	– 230.71	169.42	280 to 450
3 - Chloro phenol	C_6H_5ClO	– 3.4776	– 89.566	240.53	290 to 340
4 - Chloro phenol	C_6H_5ClO	– 4.7219	– 507.99	103.79	370 to 500
2 - Chloro phenyl methyl ether	C_7H_7ClO	– 4.5675	– 410.89	80.145	290 to 470
2 - Chloro pyridine	C_5H_4ClN	– 4.5143	– 420.08	33.573	290 to 400
2 - Chloro toluene	C_7H_7Cl	– 4.6558	– 464.57	14.885	270 to 440
3 - Chloro toluene	C_7H_7Cl	– 4.5776	– 405.97	26.217	270 to 440
4 - Chloro toluene	C_7H_7Cl	– 4.5492	– 380.43	39.664	280 to 440
Corn oil	-	– 3.5581	– 263.32	183.60	290 to 340
Corn syrup	-	– 4.4500	– 234.80	159.91	280 to 360
Corn syrup	-	– 4.0137	– 129.07	201.23	280 to 360
Corn syrup	-	– 3.8025	– 258.10	186.88	280 to 360
Corn syrup	-	– 3.9975	– 267.36	182.96	280 to 360
m - Cresol	C_7H_8O	– 4.4933	– 298.87	183.39	280 to 480
o - Cresol	C_7H_8O	– 4.3697	– 250.28	187.77	270 to 470
p - Cresol	C_7H_8O	– 4.3867	– 268.79	192.80	280 to 480
2 - Cyanopyridine	$C_6H_4N_2$	– 4.3011	– 315.45	100.85	300 to 400
3 - Cyanopyridine	C_6H_4N	– 4.2055	– 268.49	137.40	320 to 400

Name	***Formula***	***A***	***B***	***C***	***Temp. Range, K***
Cyclo hexanol	$C_6H_{12}O$	– 4.8184	– 388.21	189.65	300 to 440
Cyclo hexyl amine	$C_6H_{13}N$	– 4.6016	– 357.42	109.06	280 to 410
Cyclo hexyl bromide	$C_6H_{11}Br$	– 4.5225	– 412.40	76.454	280 to 440
Cyclo hexyl chloride	$C_6H_{11}Cl$	– 4.6971	– 460.15	51.188	290 to 420
Cis - Decalin	$C_{10}H_{18}$	– 4.4480	– 395.48	93.359	240 to 460
Trans - Decalin	$C_{10}H_{18}$	– 4.5844	– 443.20	61.638	240 to 440
Decane	$C_{10}H_{22}$	– 4.5740	– 343.92	68.462	240 to 380
1 - Decanol	$C_{10}H_{22}O$	– 5.2085	– 619.24	107.41	280 to 330
Decene	$C_{10}H_{20}$	– 4.9646	– 576.81	– 13.145	290 to 420
Deuterium oxide	D_2O	– 4.2911	– 164.97	174.24	280 to 310
1,2 - Diamino propane	$C_3H_{10}N_2$	– 4.0837	– 167.55	166.21	240 to 330
1,2 – Dibromo methane	$C_2H_4Br_2$	– 4.2416	– 300.36	90.197	280 to 400
1,2 - Dibromo - 2 - methyl propane	$C_4H_8Br_2$	– 4.5276	– 435.27	60.001	270 to 420
1,2 - Dibromo propane	$C_3H_6Br_2$	– 4.7088	– 562.02	1.9572	270 to 420
Dibutyl amine	$C_8H_{19}N$	– 4.6971	– 360.91	80.751	270 to 440
Dibutyl carbonate	$C_9H_{18}O_3$	– 3.9131	– 155.55	163.43	290 to 420
Dichloro acetic acid	$C_2H_2Cl_2O_2$	– 5.1869	– 929.48	– 25.087	290 to 470
1,2 - Dichloro benzene	C_6H_4Cl	– 4.5524	– 456.48	23.531	290 to 460
1,3 - Dichloro benzene	C_6H_4Cl	– 4.6277	– 490.14	– 1.1150	300 to 450
1,1 - Dichloro ethane	$C_2H_2Cl_2$	– 4.8360	– 486.96	– 25.909	280 to 330
1,2 - Dichloro ethane	$C_2H_4Cl_2$	– 4.5980	– 385.16	39.584	270 to 360
Cis - 1,2 - Dichloro - ethylenene	$C_2H_2Cl_2$	– 4.4812	– 315.48	– 18.953	200 to 300
Dichloro fluoro methane	$CHCl_2F$	– 4.6041	– 336.39	– 6.3451	220 to 350
Dichloro methane	CH_2Cl_2	– 4.5147	– 316.63	18.104	200 to 380
2,6 - Diethyl aniline	$C_{10}H_{15}N$	– 4.0635	– 207.07	171.42	290 to 380
Diethyl carbonate	$C_5H_{10}O_3$	– 3.7980	– 65.04	202.89	290 to 400
Diethylene glycol dinitrate	$C_4H_8N_2O_7$	– 3.8314	– 192.04	182.51	280 to 340
n,n - Diethyl - *m* - toludine	$C_{12}H_{17}NO$	– 4.9635	– 683.97	– 5.57	380 to 510
Difluoro acetic acid	$C_2H_2F_2O_2$	– 4.5695	– 380.88	106.79	290 to 340
2,5 - Difluoro aniline	$C_6H_5F_2N$	– 4.2269	– 264.07	127.26	290 to 340
1,3 - Difluoro benzene	$C_6H_4F_2$	– 4.7875	– 466.28	– 8.3165	290 to 340
1,4 - Difluoro benzene	$C_6H_4F_2$	– 4.9046	– 549.69	– 28.264	290 to 340
1,1 - Difluoro ethyl acetate	$C_4H_6F_2O_2$	– 5.0140	– 560.88	21.795	290 to 340
2,2 - Difluoro ethyl alcohol	$C_2H_4F_2O$	– 4.7550	– 380.84	118.36	290 to 340
Difluoro methane	CH_2F_2	– 6.6081	– 1079.9	– 185.87	200 to 290
Diheptyl amine	$C_{14}H_{31}N$	– 4.5966	– 429.86	91.79	290 to 430
Di iso butyl amine	$C_8H_{19}N$	– 4.6618	– 345.27	71.137	270 to 400
Di iso pentyl amine	$C_{10}H_{23}N$	– 4.7264	– 415.49	72.234	270 to 430
Diiso propenyl	C_6H_{10}	– 5.3047	– 701.2	– 109.18	270 to 330
Diiso propyl amine	$C_6H_{15}N$	– 5.0566	– 540.15	– 29.009	280 to 360

Name	***Formula***	***A***	***B***	***C***	***Temp. Range, K***
1,3 - Dimethoxy benzene	$C_8H_{10}O_2$	– 4.6919	– 461.09	70.728	310 to 490
n,n - Dimethyl acetamide	C_4H_9NO	– 4.8134	– 547.67	37.944	290 to 450
n,n - Dimethyl aniline	$C_8H_{11}N$	– 4.6940	– 483.96	30.46	270 to 470
2,2 - Dimethyl butane	C_8H_{14}	– 1.5347	– 651.45	637.56	270 to 310
Dimethyl carbonate	$C_3H_6O_3$	– 3.7328	– 35.269	227.61	290 to 380
n,n - Dimethyl - ethylene urea	$C_5H_{12}N_2O$	– 4.2477	– 295.33	105.93	290 to 380
n,n - Dimethyl formamide	C_3H_7NO	– 3.6398	– 56.047	194.25	270 to 320
2,7 - Dimethyl octane	$C_{10}H_{22}$	– 3.7054	– 38.588	236.15	290 to 340
1,4 - Dimethyl - 5 - octyl deca hydro naphthalene	$C_{20}H_{38}$	– 4.1480	– 302.82	168.39	270 to 380
2,6 - Dimethyl - 3 - octyl deca hydro naphthalene	$C_{20}H_{38}$	– 4.1606	– 302.58	171.06	290 to 380
1,4 - Dimethyl - 5 - octyl naphthalene	$C_{20}H_{28}$	– 4.1315	– 294.82	180.84	270 to 380
4,4 - Dimethyl -2 -oxa zolidine	$C_5H_9NO_2$	– 4.8411	– 497.42	168.44	270 to 340
2,4 - Dimethyl -3 - pentanone	$C_7H_{14}O$	– 5.2591	– 791.85	– 91.339	290 to 380
2,6 - Dimethyl pyridine-N-oxide	C_7H_9NO	– 4.0622	– 218.72	179.99	290 to 400
2,4 - Dimethyl sulfolane	$C_6H_{12}O_2S$	– 4.1963	– 331.93	143.99	290 to 400
1,3 - Dimethyl - 3,4,5,6 -tetra - hydro - 2 (1H) pyridimidinone	$C_6H_{12}N_2O$	– 4.1959	– 283.40	127.74	290 to 380
n,n - Dimethyl - *o* - toluidine	$C_9H_{13}N$	– 4.8977	– 598.28	2.4885	340 to 460
n,n - Dimethyl - *p* - toluidine	$C_9H_{13}N$	– 4.9002	– 645.00	– 24.571	370 to 490
1,3-Dinitro benzene	$C_6H_4N_2O_4$	– 3.9732	– 200.42	241.63	370 to 580
Dipentyl amine	$C_{10}H_{23}N$	– 4.5796	– 349.69	97.021	270 to 430
Diphenyl amine	$C_{12}H_{11}N$	– 4.2791	– 281.54	186.14	300 to 410
Diphenyl methane	$C_{13}H_{12}$	– 4.8400	– 654.74	11.031	330 to 540
Ditellurium deca fluoride	Te_2F_{10}	– 4.8292	– 170.32	105.09	240 to 320
2,2-Di - *p* - toly butane	$C_{18}H_{22}$	– 4.4205	– 278.15	202.10	270 to 480
1,1-Di - *m* - tolyethane	$C_{16}H_{18}$	– 4.4330	– 337.17	153.26	270 to 480
1,1-Di - *o* - tolyethane	$C_{16}H_{18}$	– 4.2025	– 236.66	209.88	270 to 480
1,1-Di - *p* - tolyethane	$C_{16}H_{18}$	– 4.5230	– 377.82	127.15	270 to 480
Dodecane	$C_{12}H_{26}$	– 4.5578	– 375.97	76.83	270 to 380
Dodecanoic acid	$C_{12}H_{24}O_2$	– 4.7935	– 643.12	78.509	320 to 440
Dodecyl thio palmitate	$C_{28}H_{56}OS$	– 3.8590	– 327.41	153.05	340 to 370

Name	***Formula***	***A***	***B***	***C***	***Temp. Range, K***
Eicosane	$C_{20}H_{42}$	– 4.5977	– 509.04	81.873	310 to 500
Ethanol	C_2H_6O	– 5.5972	– 846.95	24.124	210 to 350
2 - Ethoxy benzenamine	$C_8H_{11}NO$	– 4.0349	– 191.08	188.20	270 to 380
3 - Ethoxy benzenamine	$C_8H_{11}NO$	– 4.0694	– 203.67	210.01	300 to 380
4 - Ethoxy benzenamine	$C_8H_{11}NO$	– 4.1091	– 226.14	191.43	290 to 380
Ethoxy benzene	$C_8H_{10}O$	– 4.7732	– 469.95	44.325	290 to 450
2 - Ethoxy toluene	$C_9H_{12}O$	– 4.6820	– 425.29	60.601	280 to 450
3 - Ethoxy toluene	$C_9H_{12}O$	– 4.6888	– 429.81	50.995	290 to 450
4 - Ethoxy toluene	$C_9H_{12}O$	– 4.8518	– 530.68	21.765	280 to 450
Ethyl acetate	$C_4H_8O_2$	– 4.8721	– 452.07	– 3.4748	270 to 350
2 - Ethyl aniline	$C_8H_{11}N$	– 3.9240	– 157.75	193.75	290 to 380
n - Ethylaniline	$C_8H_{11}N$	– 4.5575	– 348.74	111.51	370 to 480
Ethyl benzene	C_8H_{10}	– 4.8421	– 519.36	– 18.754	270 to 410
Ethyl butyrate	$C_6H_{12}O_2$	– 2.6811	– 56.932	409.09	280 to 330
Ethyl caproate	$C_8H_{16}O_2$	– 4.7822	– 488.78	19.765	300 to 370
Ethyl cyano acetate	$C_5H_7NO_2$	– 4.9267	– 648.38	13.921	350 to 480
Ethyl cyclo hexane	C_8H_{16}	– 4.5094	– 338.98	56.684	270 to 320
Ethylene diamine	$C_2H_8N_2$	– 4.8506	– 458.11	72.151	290 to 390
Ethylene glycol	$C_2H_6O_2$	– 4.5448	– 417.05	146.53	280 to 420
Ethylene glycol dinitrate	$C_2H_4N_2O_6$	– 3.8971	– 190.90	167.79	280 to 340
Ethylene sulfite	$C_2H_4SO_3$	– 4.2577	– 316.63	96.579	290 to 350
Ethyl fluoro acetate	$C_4H_7FO_2$	– 4.4366	– 278.91	96.402	290 to 340
n-Ethyl formamide	C_3H_7NO	– 4.4950	– 403.12	79.019	290 to 350
Ethyl formate	C_3H_6O	– 4.5771	– 297.60	40.866	270 to 330
Ethyl heptanoate	$C_9H_{18}O_2$	– 4.5344	– 360.05	72.643	270 to 380
2 - Ethyl - 1 - hexanol	$C_8H_{18}O$	– 4.9651	– 436.77	140.04	270 to 380
2 - Ethyl - 1 - hexene	C_8H_{16}	– 5.0166	– 573.86	– 46.195	290 to 380
Ethyl lactate	$C_5H_{10}O_3$	– 4.7088	– 369.10	121.15	270 to 380
Ethyl laurate	$C_{14}H_{28}O_2$	– 4.6006	– 474.53	70.200	300 to 370
n - Ethyl - n - methyl aniline	$C_9H_{13}N$	– 4.6190	– 391.17	90.088	380 to 480
Ethyl - n - methyl carbamate	$C_4H_9NO_2$	– 4.5915	– 354.47	127.89	290 to 380
Ethyl myrisate	$C_{16}H_{32}O_2$	– 4.0528	– 250.11	149.25	300 to 370
3 - Ethyl - 2 – oxazolidinone	$C_5H_9NO_2$	– 4.1644	– 303.21	110.17	270 to 340
4 - Ethyl - 2 – oxazolidinone	$C_5H_9NO_2$	– 4.3902	– 367.67	180.81	280 to 340
Ethyl palmitate	$C_{18}H_{36}O_2$	– 4.3120	– 375.53	116.66	300 to 370
Ethyl propionate	$C_5H_{10}O_2$	– 5.0255	– 577.20	36.360	270 to 370
Ethyl stearate	$C_{20}H_{40}O_2$	– 4.2849	– 383.58	120.19	300 to 370
Ethyl sulfide	$C_2H_{10}S$	– 5.0494	– 622.24	– 73.352	270 to 370
Ethyl tetra decanol	$C_{16}H_{34}O$	– 5.0490	– 572.23	135.51	290 to 380
Ethyl tetra decyl acetate	$C_{18}H_{36}O_2$	– 4.2793	– 333.42	138.16	270 to 380
Ethyl valerate	$C_7H_{14}O_2$	– 4.6077	– 368.04	52.281	270 to 380

Name	***Formula***	***A***	***B***	***C***	***Temp. Range, K***
Eugenol	$C_{10}H_{12}O_2$	– 4.0814	– 207.80	191.38	270 to 380
Fluorine	F_2	– 4.0425	– 19.965	39.377	60 to 85
2 - Fluoro aniline	C_6H_6FN	– 4.4778	– 349.85	108.24	290 to 340
3 - Fluoro aniline	C_6H_6FN	– 3.7425	– 113.06	198.67	290 to 340
4 - Fluoro aniline	C_6H_6FN	– 4.1860	– 247.24	144.82	290 to 340
2 - Fluoro ethanol	C_2H_5FO	– 4.3059	– 237.31	144.01	290 to 340
Fluoro ethyl acetate	$C_4H_7FO_2$	– 4.3290	– 248.86	10.92	290 to 340
1 - Fluoro - 2 - nitro benzene	$C_6H_4FNO_2$	– 3.9207	– 190.52	152.29	290 to 340
1 - Fluoro - 3 - nitrobenzene	$C_6H_4FNO_2$	– 3.8976	– 168.21	162.25	290 to 340
1 - Fluoro - 4 - nitrobenzene	$C_6H_4FNO_2$	– 3.8909	– 168.55	167.51	300 to 340
1 - Fluoro pentane	$C_5H_{11}F$	– 5.5312	– 970.96	– 168.92	290 to 340
2 - Fluoro phenetole	C_8H_9FO	– 3.8508	– 114.33	182.48	290 to 330
3 - Fluoro phenetole	C_8H_9FO	– 3.6435	– 59.589	215.27	290 to 340
4 - Fluoro phenetole	C_8H_9FO	– 4.2889	– 237.60	125.43	290 to 340
2 - Fluoro toluene	C_7H_7F	– 4.9997	– 617.09	– 43.732	290 to 340
4 - Fluoro toluene	C_7H_7F	– 4.7711	– 463.94	– 3.3819	290 to 340
Formamide	CH_3NO	– 5.0263	– 559.54	78.757	270 to 320
Formic acid	CH_2O_2	– 4.4442	– 311.11	109.61	280 to 380
2 - Furaldehyde	$C_5H_4O_2$	– 4.3068	– 288.90	102.72	270 to 380
Ground nut oil		– 3.9621	– 407.46	151.23	290 to 340
Hepta decane	$C_{17}H_{36}$	– 4.8559	– 630.57	35.939	300 to 580
Heptane	C_7H_{16}	– 4.7163	– 356.13	24.593	190 to 370
2 - Heptane thiol	$C_7H_{16}S$	– 4.5611	– 364.98	52.252	270 to 380
Heptanoic acid	$C_7H_{14}O_2$	– 4.7200	– 529.62	68.313	285 to 395
2 - Heptanol	$C_7H_{16}O$	– 4.9431	– 408.06	137.51	300 to 430
3 - Heptanol	$C_7H_{16}O$	– 4.7334	– 288.89	180.49	310 to 420
4 - Heptanol	$C_7H_{16}O$	– 4.7847	– 307.04	170.68	290 to 420
2 - Heptanone	$C_7H_{14}O$	– 4.0164	– 55.937	233.86	290 to 360
1 - Heptene	C_7H_{14}	– 4.7028	– 367.41	0.52937	270 to 370
Heptyl acetate	$C_9H_{18}O_2$	– 4.5679	– 370.42	69.112	270 to 380
Heptyl amine	$C_7H_{17}N$	– 5.5848	– 937.05	– 48.457	280 to 400
Heptyl mercaptan	$C_7H_{16}S$	– 4.5069	– 354.88	61.388	270 to 380
2 - Heptyl nonanol	$C_{16}H_{34}O$	– 5.2286	– 622.89	130.58	290 to 380
2 - Heptyl nonyl acetate	$C_{18}H_{36}O_2$	– 4.2190	– 287.54	155.19	270 to 380
Heptyl thio aetate	$C_9H_{18}OS$	– 4.0926	– 244.09	121.75	300 to 370
Heptyl thio laurate	$C_{19}H_{38}OS$	– 3.9865	– 308.04	136.82	300 to 370
Hexa decane	$C_{16}H_{34}$	– 4.8174	– 578.33	46.605	290 to 520
2 - Hexa decanol	$C_{16}H_{34}O$	– 5.3662	– 672.23	124.54	290 to 380
Hexa decyl acetate	$C_{18}H_{36}O_2$	– 4.4106	– 403.22	118.00	290 to 380
2 - Hexa decyl acetate	$C_{18}H_{36}O_2$	– 4.2205	– 285.73	155.79	270 to 380
7 - n - Hexadecyl spiro (4,5) decane	$C_{26}H_{50}$	– 4.1827	– 387.10	147.17	290 to 380
Hexane	C_6H_{14}	– 4.2463	– 118.06	134.87	270 to 340

Name	***Formula***	***A***	***B***	***C***	***Temp. Range, K***
Hexane nitrile	$C_6H_{11}N$	– 4.7800	– 471.26	27.296	290 to 440
1 - Hexane thiol	$C_6H_{14}S$	– 4.5195	– 343.01	54.236	270 to 380
2 - Hexane thiol	$C_6H_{14}S$	– 4.5945	– 361.31	42.281	270 to 380
Hexyl ethanoate	$C_8H_{16}O_2$	– 4.6136	– 390.55	59.772	300 to 370
Hexyl thiohexanoate	$C_{12}H_{24}OS$	– 4.3053	– 384.59	78.571	310 to 370
Hexyl thio laurate	$C_{18}H_{36}OS$	– 4.1505	– 371.22	112.96	310 to 370
Hydrazine	H_4N_2	– 4.4407	– 296.75	83.603	280 to 450
Hydrogen cyanide	HCN	– 4.6541	– 217.40	61.204	250 to 300
2 - Hydroxy aceto phenone	$C_8H_8O_2$	– 4.5830	– 435.71	84.205	320 to 490
3 - Hydroxy aceto phenone	$C_8H_8O_2$	– 4.4802	– 415.71	189.61	370 to 570
4 - Hydroxy benzaldehyde	$C_7H_6O_2$	– 3.3974	– 106.24	303.06	400 to 440
Indan	C_9H_{10}	– 4.2327	– 250.37	114.78	270 to 400
Indium	In	– 3.3239	– 236.69	30.666	430 to 620
Iodine penta fluoride	F_5I	– 3.6707	– 114.50	183.24	280 to 350
Iodo benzene	C_6H_5I	– 4.2107	– 307.78	78.655	270 to 425
Iodo ethane	C_2H_5I	– 4.6258	– 446.10	– 27.294	270 to 350
1 - Iodo - 2 - methyl propane	C_4H_9I	– 4.6668	– 470.78	7.0839	270 to 390
1 - Iodo propane	C_3H_7I	– 4.3648	– 292.68	56.586	270 to 380
2 - Iodo propane	C_3H_7N	– 4.5880	– 409.62	6.1088	270 to 360
Isoamyl ether	$C_{10}H_{22}O$	– 4.5653	– 344.08	74.225	270 to 380
Isoamyl titanate	$C_{20}H_{44}O_4Ti$	– 5.2745	– 506.00	232.24	400 to 490
Isobutyl acetate	$C_6H_{12}O_2$	– 5.8472	– 1268.1	176.33	290 to 460
Isobutyl titanate	$C_{16}H_{36}O_4Ti$	– 4.7234	– 295.54	247.55	370 to 470
1 - (Iso cyanato - 1 - methyl ethyl) - 3 - (1 - methyl ethyl) benzene	$C_{13}H_{15}NO$	– 4.3230	– 334.25	114.34	290 to 360
Iso heptane	C_7H_{16}	– 5.3931	– 835.48	– 130.45	270 to 370
3 - Isopropyl - 2 - oxa zolidinone	$C_6H_{11}NO_2$	– 4.2344	– 323.09	118.18	270 to 340
3 - Iso propyl sydnone	$C_5H_8N_2O_2$	– 4.1797	– 338.42	141.61	330 to 400
Lead	Pb	– 3.1186	– 182.99	266.85	600 to 1200
Magnesium chloride hexahydrate (molten)	$MgCl_2.6H_2O$	– 3.8293	– 1261.0	90.022	990 to 1180
1 - Menthol	$C_{10}H_{20}O$	– 5.0390	– 324.74	214.31	320 to 380
Mercury	Hg	– 3.1105	– 51.209	124.04	290 to 380
Methanol	CH_4O	– 4.9016	– 449.49	23.551	180 to 290
n - 2 - Methoxy ethyl acetamide	$C_5H_{11}O_2$	– 4.3441	– 330.03	159.45	290 to 350
2 - Methoxy phenol	$C_7H_8O_2$	– 4.4351	– 313.21	151.10	320 to 480
3 - Methoxy phenol	$C_7H_8O_2$	– 4.5348	– 377.59	172.18	325 to 520
4 - Methoxy phenol	$C_7H_8O_2$	– 4.5900	– 412.70	162.01	340 to 520

Name	***Formula***	***A***	***B***	***C***	***Temp. Range, K***
Methyl amine	CH_5N	– 4.6228	– 198.43	71.960	200 to 300
n - Methyl aniline	C_7H_9N	– 4.3528	– 268.33	136.78	270 to 440
2 - Methyl benzene amine	C_7H_9N	– 4.4107	– 297.19	149.02	270 to 480
3 - Methyl benzene amine	C_7H_9N	– 4.4494	– 301.95	145.82	270 to 480
4 - Methyl benzene amine	C_7H_9N	– 4.3612	– 219.54	206.59	310 to 480
2-Methyl benzo nitrile	C_8H_7N	– 4.3838	– 319.82	96.496	290 to 420
3-Methyl benzo nitrile	C_8H_7N	– 4.4080	– 321.16	95.332	290 to 420
4-Methyl benzo nitrile	C_8H_7N	– 4.4654	– 360.83	80.619	300 to 420
2-Methyl-1- butanol	$C_5H_{12}O$	– 5.3355	– 551.30	113.41	290 to 400
2 - Methyl - 1 -butanol (optically active)	$C_5H_{12}O$	– 5.6363	– 703.07	82.578	270 to 400
3-Methyl-1- butanol (optically active)	$C_5H_{12}O$	– 5.7750	– 841.12	46.485	270 to 410
3-Methyl-2- butanol	$C_5H_{12}O$	– 4.8491	– 313.81	169.58	290 to 380
Methyl carbamate	C_2H_5NO	– 4.3167	– 280.14	166.40	320 to 370
n - Methyl - 2 - chloro acetamide	C_3H_6ClO	– 4.4456	– 371.19	140.22	320 to 350
Methyl cyclo hexane	C_7H_{14}	– 4.5348	– 319.07	64.712	270 to 380
2-Methyl cyclo hexanol	$C_7H_{14}O$	– 4.6708	– 304.32	191.82	290 to 370
3 - Methyl cyclo hexanol	$C_7H_{14}O$	– 5.9247	– 797.76	107.35	290 to 370
4 - Methyl cyclo hexanol	$C_7H_{14}O$	– 5.4635	– 558.96	158.00	310 to 370
2 - Methyl cyclo hexanone	$C_7H_{12}O$	– 3.8722	– 133.01	172.45	280 to 340
3 - Methyl cyclo hexanone	$C_7H_{12}O$	– 3.7405	– 97.894	194.36	280 to 340
4 - Methyl cyclo hexanone	$C_7H_{12}O$	– 3.8959	– 145.00	165.50	280 to 370
Methyl cyclo pentane	C_6H_{12}	– 5.5016	– 940.03	132.64	240 to 330
Methyl diphenyl amine	$C_{13}H_{13}N$	– 3.8079	– 170.88	191.05	270 to 360
2 - Methyl - 6 - ethyl aniline	$C_9H_{13}N$	– 4.1038	– 214.17	166.71	290 to 380
Methyl formate	$C_2H_2O_2$	– 4.0229	– 77.194	155.67	270 to 310
2-Methyl-2 - heptanol	$C_8H_{18}O$	– 4.8579	– 419.93	121.96	270 to 380
2-Methyl- 3 - heptanol	$C_8H_{18}O$	– 4.8686	– 319.77	179.53	270 to 380
2-Methyl- 4 - heptanol	$C_8H_{18}O$	– 5.3181	– 471.17	149.48	270 to 380
2-Methyl -5 - heptanol	$C_8H_{18}O$	– 4.8874	– 430.45	86.77	270 to 380
2-Methyl - 7 -heptanol	$C_8H_{18}O$	– 5.3070	– 637.23	99.314	270 to 380
3-Methyl -1 - heptanol	$C_8H_{18}O$	– 4.8480	– 455.08	83.39	270 to 380
3- Methyl -2 -heptanol	$C_8H_{18}O$	– 4.6390	– 334.29	116.43	270 to 380
3- Methyl -3 -heptanol	$C_8H_{18}O$	– 4.7910	– 307.09	173.98	270 to 380
3 - Methyl - 4 - heptanol	$C_8H_{18}O$	– 4.6737	– 326.66	130.98	270 to 380
3-Methyl -5 - heptanol	$C_8H_{18}O$	– 4.6993	– 369.64	89.383	270 to 380

Name	***Formula***	***A***	***B***	***C***	***Temp. Range, K***
3-Methyl- 6 - heptanol	$C_8H_{18}O$	– 4.9235	– 451.64	98.852	270 to 380
3-Methyl - 7 -heptanol	$C_8H_{18}O$	– 5.0466	– 513.98	111.97	270 to 380
4-Methyl- 3 - heptanol	$C_8H_{18}O$	– 4.6307	– 325.82	102.60	270 to 380
2-Methyl - 2 - hexanol	$C_7H_{16}O$	– 4.8188	– 322.52	165.66	300 to 410
Methyl - 4 - hydroxy benzoate	$C_8H_8O_3$	– 4.6510	– 501.30	184.86	410 to 570
2 - Methyl octane - 2 - thiol	$C_9H_{20}S$	– 4.5357	– 308.54	106.32	280 to 330
3 - Methyl - 2 – oxazolidinone	$C_4H_7NO_2$	– 4.5133	– 469.69	52.128	270 to 340
5 - Methyl -2 – oxazolidinone	$C_4H_7NO_2$	– 4.2193	– 323.59	167.86	270 to 340
2 - Methyl penta decyl acetate	$C_{18}H_{36}O_2$	– 4.1461	– 291.48	148.59	270 to 380
2 - Methyl pentane	C_6H_{14}	– 5.4697	– 862.57	– 149.90	270 to 330
2 - Methyl - 1 - pentene	C_6H_{12}	– 2.5684	– 236.49	536.99	290 to 330
2 - Methyl - 2 - propane thiol	$C_4H_{10}S$	– 4.7260	– 342.80	68.37	280 to 320
2 - Methyl - 1 - propanol	$C_4H_{10}O$	– 6.1025	– 946.92	37.007	270 to 380
2 - Methyl - 2 - propanol	$C_4H_{10}S$	– 4.7679	– 239.20	198.59	300 to 360
Methyl propionate	$C_4H_8O_2$	– 4.9955	– 553.64	– 41.506	270 to 350
2 - Methyl propionic acid	$C_4H_8O_2$	– 4.8990	– 597.55	– 2.4824	270 to 430
Methyl salicylate	$C_8H_8O_3$	– 4.6908	– 531.13	41.528	350 to 500
3 - Methyl sulfolane	$C_5H_6SO_2$	– 4.2086	– 376.51	132.99	290 to 400
Methyl sulfoxide	C_2H_6OS	– 4.3585	– 323.95	102.62	290 to 400
3 - Methyl sydnone	$C_3H_4N_2O_2$	– 3.9503	– 268.63	154.26	310 to 400
Methyl thio cyanate	C_2H_3SN	– 4.4357	– 314.04	57.847	270 to 380
Mono dimethyl amino phosphoryl chloride	$C_2H_6Cl_2NOP$	– 3.8387	– 175.69	142.04	250 to 350
Nitro benzene	$C_6H_5NO_2$	– 4.4054	– 372.85	75.641	270 to 500
2 - Nitro phenol	$C_6H_5NO_3$	– 4.3361	– 328.93	129.92	300 to 490
3 - Nitro phenol	$C_6H_5NO_3$	– 3.9333	– 216.26	223.80	360 to 400
4 - Nitro phenol	$C_6H_5NO_3$	– 5.1303	– 889.28	59.746	370 to 570
2 - Nitro phenyl methyl ether	$C_8H_9NO_3$	– 4.4960	– 422.07	106.85	280 to 520
2 - Nitro resorcinol	$C_6H_5NO_4$	– 4.5642	– 455.67	128.78	360 to 510
2 - Nitro toluene	$C_7H_7NO_2$	– 4.4923	– 404.73	76.683	270 to 500
3 - Nitro toluene	$C_7H_7NO_2$	– 4.1521	– 252.23	127.13	290 to 380
4 - Nitro toluene	$C_7H_7NO_2$	– 4.4681	– 404.79	71.717	330 to 520
Nonane	C_9H_{20}	– 4.7864	– 440.73	24.243	270 to 380
1 - Nonane thiol	$C_9H_{20}S$	– 4.3351	– 297.76	102.73	270 to 400
2 - Nonane thiol	$C_9H_{20}S$	– 4.4906	– 335.75	80.523	270 to 400
Nonanoic acid	$C_9H_{18}O_2$	– 4.6210	– 489.09	99.881	290 to 370
5 - Nonanone	$C_9H_{18}O$	– 4.4816	– 346.38	76.180	290 to 380

Name	***Formula***	***A***	***B***	***C***	***Temp. Range, K***
Nonyl thio palmitate	$C_{25}H_{50}OS$	– 3.6375	– 224.63	180.63	340 to 370
Octa decane	$C_{18}H_{38}$	– 4.3923	– 378.20	111.62	300 to 380
Octa decyl thio myrisate	$C_{32}H_{64}OS$	– 2.3386	– 6.4228	318.15	330 to 370
Octane	C_8H_{18}	– 5.1030	– 632.42	– 51.438	270 to 400
1 - Octane thiol	$C_8H_{18}S$	– 4.5008	– 366.58	68.840	270 to 380
2 - Octane thiol	$C_8H_{18}S$	– 4.4502	– 323.68	79.120	270 to 380
Octanoic acid	$C_8H_{16}O_2$	– 4.1803	– 272.88	153.08	290 to 370
trans - 2 - Octene	C_8H_{16}	– 5.3398	– 836.02	– 115.97	290 to 380
Octyl amine	$C_8H_{19}N$	– 4.9093	– 501.41	57.503	270 to 340
Octyl thio myrisate	$C_{22}H_{44}OS$	– 3.9509	– 316.58	143.12	300 to 370
Olive oil	-	– 4.9110	– 699.70	110.30	290 to 340
Palmitic acid	$C_{16}H_{32}O_2$	– 3.8383	– 267.36	188.83	340 to 370
Paracetaldehyde	$C_6H_{12}O_3$	– 4.7345	– 361.18	93.813	280 to 400
Penta chloro ethane	C_2H_5Cl	– 4.5124	– 438.07	63.314	270 to 360
Penta decane	$C_{15}H_{32}$	– 4.3494	– 323.33	114.00	290 to 380
Pentane	C_5H_{12}	– 4.4907	– 224.14	31.92	150 to 330
2 - Pentane thiol	$C_5H_{12}S$	– 4.9446	– 565.81	– 43.074	270 to 380
1 - Pentanol	$C_5H_{12}O$	– 5.4786	– 696.80	68.729	220 to 410
2 - Pentanol	$C_5H_{12}O$	– 4.9433	– 343.89	159.69	290 to 390
3 - Pentanol	$C_5H_{12}O$	– 4.7586	– 254.46	191.08	290 to 390
3 - Pentanone	$C_5H_{10}O$	– 5.0685	– 628.20	– 68.044	270 to 380
2 - Pentene	C_5H_{10}	– 4.0663	– 25.287	229.50	290 to 310
Pentyl ether	$C_{10}H_{22}O$	– 4.4828	– 311.96	87.694	270 to 380
Perfluoro -1,4 -di iso propoxy butane	$C_{10}F_{20}O_2$	– 2.9742	– 7.0538	273.86	290 to 320
Phenethyl alcohol	$C_8H_{10}O$	– 4.4593	– 324.57	168.71	270 to 380
Phenol	C_6H_6O	– 4.3571	– 267.31	181.96	300 to 460
Phenyl - n - amyl ether	$C_{11}H_{16}O$	– 4.8009	– 510.42	58.052	290 to 510
Phenyl iso thio cyanate	C_7H_5NS	– 4.1719	– 247.72	111.40	270 to 380
2 - Phenyl - 1 - propanol	$C_9H_{12}O$	– 2.7359	– 26.229	270.16	290 to 330
Phenyl propyl ketone	$C_{10}H_{12}O$	– 4.1646	– 232.50	142.01	270 to 380
Phosphorus trichloride	PCl_3	– 4.2542	– 270.00	21.934	200 to 340
Phosphoryl chloride	$POCl_3$	– 4.2043	– 249.22	92.575	270 to 360
2 - Picoline	C_6H_7N	– 4.6362	– 402.11	33.102	270 to 360
2 - Picoline - N - oxide	C_6H_7NO	– 4.1864	– 294.26	156.24	320 to 400
3 - Picoline - N -oxide	C_6H_7NO	– 4.0257	– 241.12	184.32	310 to 400
Pinacolone	$C_6H_{12}O$	– 4.9656	– 559.39	– 14.42	290 to 360
Pipiridine	$C_5H_{11}N$	– 4.5966	– 328.47	115.00	280 to 380
Potassium	K	– 4.4954	– 869.76	– 389.82	400 to1800
1,3 - Propane sulfone	$C_3H_6SO_3$	– 4.0403	– 346.70	126.85	300 to 350
2 - Propane thiol	C_3H_8S	– 4.7800	– 387.13	7.6593	270 to 320
1 - Propanol	C_3H_8O	– 5.7281	– 853.50	15.262	210 to 370

Name	***Formula***	***A***	***B***	***C***	***Temp. Range, K***
2 - Propanol	C_3H_8O	– 6.3050	– 1009.2	18.917	270 to 360
Propionaldehyde	C_3H_6O	– 5.1953	– 611.30	– 60.958	280 to 330
Propionamide	C_3H_7NO	– 4.3422	– 267.72	205.36	260 to 490
Propionic acid	$C_3H_6O_2$	– 4.8207	– 561.55	– 8.1224	270 to 420
Propionic anhydride	$C_6H_{10}O_3$	– 4.7818	– 492.35	24.606	270 to 440
Propio nitrile	C_3H_5N	– 4.7953	– 424.61	– 37.983	290 to 380
Propionyl chloride	C_3H_5ClO	– 4.7776	– 443.86	– 11.959	290 to 360
Propyl benzene	$C_9H_{12}O$	– 4.7786	– 473.64	53.513	280 to 460
Propyl benzene amine	$C_9H_{13}N$	– 4.8964	– 612.19	20.818	370 to 500
Propyl carbamate	C_4H_9NO	– 4.5234	– 342.48	164.26	330 to 380
Propylene glycol dinitrate	$C_3H_6N_2O_6$	– 3.9605	– 196.00	168.35	280 to 340
Propyl formate	$C_4H_8O_2$	– 5.3847	– 858.62	116.02	270 to 360
2 - p - propyl phenyl - 2 - p - toly butane	$C_{21}H_{22}$	– 4.1543	– 233.70	213.2	320 to 480
1 - p -Propyl phenyl - p - tolyl ethane	$C_{18}H_{22}$	– 4.4081	– 356.54	141.09	270 to 480
Propyl sulfone	$C_6H_{14}O_2S$	– 4.2525	– 290.93	156.68	300 to 400
Propyl sulfoxide	$C_6H_{14}OS$	– 4.2525	– 290.93	156.68	300 to 400
Propyl thioacetate	$C_5H_{10}OS$	– 4.4072	– 330.35	49.855	300 to 370
Propyl titanate	$C_{12}H_{27}O_4Ti$	– 5.4227	– 548.59	212.66	410 to 480
2 - Propyl tri decanol	$C_{16}H_{34}O$	– 5.0182	– 549.04	139.57	290 to 380
2 - Propyl tri decyl acetate	$C_{18}H_{36}O_2$	– 4.1444	– 271.06	157.55	270 to 380
Pyridine	C_5H_5N	– 4.1172	– 174.52	133.66	270 to 390
Pyrrole	C_4H_5N	– 4.2156	– 216.75	131.91	250 to 350
Pyrrolidine	C_4H_9N	– 4.2850	– 204.20	117.84	210 to 340
Rape seed oil		– 4.4802	– 597.20	119.99	290 to 340
Salicylic aldehyde	$C_7H_6O_2$	– 4.6526	– 502.49	49.163	340 to 470
Sodium phosphate, dibasic decahydrae	$Na_2HPO_4.12H_2O$	– 1.9749	– 14.524	351.62	310 to 330
Sodium thiosulfate penta hydrate	$Na_2S_2O_3.5H_2O$	– 3.0454	– 54.28	268.25	320 to 340
Soyabean oil		– 4.4977	– 581.28	115.28	290 to 340
Spiro (4,5) decane	$C_{10}H_{18}$	– 4.5205	– 426.25	64.537	270 to 340
Spiro (5,5) undecane	$C_{11}H_{20}$	– 4.4509	– 406.57	84.58	270 to 380
Spiro (5,6) dodecane	$C_{12}H_{22}$	– 4.3005	– 349.60	114.44	270 to 380
Strontium chloride hexahydrate (molten)	$SrCl_2.6H_2O$	– 3.6073	– 954.00	341.06	1150 to 1320
Styrene	C_8H_8	– 4.6087	– 343.56	61.746	270 to 420
Sucrose	C = 26, H_2O	– 4.3736	– 327.15	102.69	290 to 330
Sunflower oil	-	– 3.6505	– 304.27	168.98	290 to 340
Tetra butyl germane	$Ge(C_4H_9)_4$	– 4.0687	– 211.37	158.55	270 to 340
Tetra decane	$C_{14}H_{30}$	– 4.3480	– 307.14	114.12	280 to 380
Tetra decyl thiolaurate	$C_{26}H_{52}OS$	– 3.6644	– 241.20	176.10	300 to 370
Tetra decyl thio myrisate	$C_{28}H_{56}OS$	– 3.7246	– 275.40	167.88	300 to 370

Name	***Formula***	***A***	***B***	***C***	***Temp. Range, K***
Tetra - n - ethyl germane	$Ge(C_2H_5)_4$	– 3.8769	– 124.05	127.22	270 to 340
Tetra - n - hexyl germane	$Ge(C_6H_{13})_4$	– 4.1948	– 307.49	142.51	270 to 340
1,2,3,4 - Tetrahydro -6 - butyl -hexyl naphthalene	$C_{20}H_{32}$	– 4.4021	– 382.01	159.74	270 to 380
1,2,3,4 -Tetra hydro - 7 -butyl - 1 - n - hexyl naphthalene	$C_{20}H_{32}$	– 4.2780	– 335.62	163.76	270 to 380
1,2,3,4 - Tetra hydro - 1,6 -dimethyl - 7 - octyl naphthalene	$C_{20}H_{32}$	– 4.1609	– 298.25	176.95	290 to 380
1,2,3,4 -Tetra hydro - 5,8 -dimethyl - 1 - octyl naphthalene	$C_{20}H_{32}$	– 4.1062	– 288.48	183.98	290 to 390
Tetra - n -pentyl germane	$Ge(C_5H_{11})_4$	– 3.9447	– 210.02	166.92	270 to 340
Tetra - n - propyl germane	$Ge(C_3H_7)_4$	– 4.2442	– 244.89	114.56	270 to 350
Thallium	Tl	– 3.1959	– 282.64	118.24	570 to 740
Thio phosphoryl chloride	$PSCl_3$	– 4.1147	– 230.60	92.836	240 to 380
Tin	Sn	– 3.2469	– 207.80	88.744	510 to 770
1-m -Toly -1-p- tolyl ethane	$C_{16}H_{18}$	– 4.5124	– 362.96	141.19	270 to 480
1 - m - Toly - 1 - o - toly ethane	$C_{16}H_{18}$	– 4.2798	– 265.15	189.30	270 to 480
1 - o -Toly - 1 - p -toly ethane	$C_{16}H_{18}$	– 4.3054	– 275.75	179.94	270 to 480
Tri butyl borate	$C_{12}H_{27}BO_3$	– 4.8408	– 562.33	24.655	290 to 500
Tri butyl phosphate	$C_{12}H_{27}O_4P$	– 4.1597	– 282.50	131.38	205 to 340
Tri ethyl borate	$C_6H_{15}BO_3$	– 4.8708	– 497.40	– 15.747	290 to 370
Tri decane	$C_{13}H_{28}$	– 4.6835	– 453.60	61.909	270 to 480
Tri decyl thi opalmitate	$C_{29}H_{58}OS$	– 3.3966	– 176.63	204.38	340 to 370
1,1,1-Tri fluoro-tert-butyl alcohol	$C_4H_7F_3O$	– 4.5179	– 217.60	191.50	290 to 330
3,3,3 - Trifluoroethanol	$C_2H_3F_3O$	– 5.6152	– 735.51	40.809	290 to 340
1,1,1 - Trifluoro isopropyl alcohol	$C_3H_5F_3O$	– 5.0978	– 338.20	142.81	280 to 330
Tri hexyl amine	$C_{18}H_{39}N$	– 4.5462	– 412.41	105.78	280 to 430
Tri iso butyl borate	$C_{12}H_{27}BO_3$	– 4.7067	– 433.43	77.578	290 to 480
Tri iso propyl borate	$C_9H_{27}BO_3$	– 5.0367	– 584.29	– 2.532	290 to 410
Tri laurin	$C_{39}H_{74}O_2$	– 3.9293	– 336.14	170.15	310 to 360
Tri methyl borate	$C_3H_9BO_3$	– 4.1136	– 96.248	158.62	290 to 340
Tri methyl phosphite	$C_3H_9O_3P$	– 4.2594	– 195.02	102.02	240 to 380
Tri octyl phosphine oxide	$C_{24}H_{51}OP$	– 3.4379	– 126.97	249.94	330 to 380

Name	***Formula***	***A***	***B***	***C***	***Temp. Range, K***
Tri palmitin	$C_{51}H_{98}O_6$	– 3.7364	– 69.231	171.28	340 to 360
Tri phenyl phosphate	$C_{18}H_{15}O_4P$	– 3.4721	– 149.45	221.84	320 to 370
Tri phenyl phosphite	$C_{18}H_{15}O_3P$	– 3.8459	– 231.62	185.13	250 to 360
Tri propyl borate	$C_3H_7BO_3$	– 5.0077	– 633.51	–16.470	290 to 450
Tris dimethyl amino phosphine oxide	$C_6H_{18}N_3OP$	– 3.9327	– 226.35	143.09	280 to 350
Tris - (2 - ethyl hexyl) phosphate	$C_{24}H_{51}O_4P$	– 4.1967	– 332.10	151.17	220 to 350
Undecane	$C_{11}H_{24}$	– 4.7592	– 466.88	38.719	260 to 480
2 - Undecanone	$C_{11}H_{22}O$	– 4.5021	– 364.95	92.28	290 to 420
Undecyl thio palmitate	$C_{27}H_{54}OS$	– 3.7452	– 275.62	166.17	340 to 370
Undecyl thio stearate	$C_{29}H_{58}OS$	– 3.3186	– 155.73	213.36	340 to 370
Valero nitrile	C_5H_9N	– 4.8445	– 512.47	4.9088	270 to 420
Water	H_2O	– 4.5318	– 220.57	149.39	270 to 380
m - Xylene	C_8H_{10}	– 4.8271	– 505.32	– 19.347	270 to 410
o - Xylene	C_8H_{10}	– 4.8927	– 553.59	– 14.003	260 to 420
p - Xylene	C_8H_{10}	– 5.2463	– 826.32	– 109.48	280 to 410
Zinc	Zn	– 3.0413	– 186.99	405.78	690 to 1100
Zinc nitrate hexahydrate	$ZnNO_3.6H_2O$	– 2.4677	– 23.999	279.07	310 to 340

Table 4.10. Constants of the Antoine type equation [Eq. (4.19): $\log \nu = A' + B'/\left(C' - T\right)$] for the temperature dependence of the kinematic viscosity of pure liquids. From: D. S. Viswanath and G. Natarajan, Data Book on Viscosity of Liquids, Hemisphere, New York, 1989. [Temperature in K and Kinematic viscosity in cSt].

Name	***Formula***	***A'***	***B'***	***C'***	***Temperature Range, K***
n - Amyl ortho silicate	$C_{20}H_{44}O_4Si$	– 0.78717	– 209.01	138.38	240 to 380
Bis (φ′ - amyl) adipate	$C_{16}H_{30}O_4$	– 1.3371	– 383.88	157.86	290 to 470
Bis (φ′ - amyl) glutarate	$C_{16}H_{30}O_4$	– 1.3783	– 389.19	156.14	250 to 460
Bis (φ′ - amyl) 3 - glutarate	$C_{16}H_{30}O_4$	– 1.3833	– 384.66	161.46	250 to 470
Bis (φ′ - amyl) phthalate	$C_{18}H_{26}O_4$	– 1.3951	– 387.75	185.81	290 to 470
Bis (φ′ - amyl) sebacate	$C_{28}H_{38}O_4$	– 1.2532	– 388.68	157.01	290 to 470
Bis (φ′ - butyl) 3 - methyl glutarate	$C_{14}H_{26}O_4$	– 1.3511	– 309.44	157.13	240 to 470
Bis (φ′ - butyl) sebacate	$C_{18}H_{34}O_4$	– 1.2652	– 347.25	144.86	290 to 470
Bis (1 - ethyl hexyl) phthalate	$C_{24}H_{38}O_4$	– 1.2417	– 360.48	178.64	260 to 380
Bis (2 - ethyl hexyl) sebasate	$C_{26}H_{50}O_4$	– 1.2046	– 391.92	142.67	220 to 380
1,6 - Bis (φ′ - heptoxy) hexane	$C_{20}H_{42}O_2$	– 1.3703	– 387.17	155.44	245 to 380
Bis (φ′ - heptyl) adipate	$C_{20}H_{38}O_4$	– 1.3571	– 399.44	164.63	290 to 470
Bis (φ′ - heptyl) 3 - methyl glutarate	$C_{28}H_{38}O_4$	– 1.3656	– 388.52	171.31	290 to 470
Bis (φ′ - heptyl) pinate	$C_{23}H_{42}O_4$	0.37192	– 98.668	240.57	290 to 470
Bis (φ′ - hexyl) 3 - methyl glutarate	$C_{18}H_{34}O_4$	– 1.2709	– 315.37	168.73	250 to 370
Bis (φ′ - nonyl) 3 - tert - butyl adipate	$C_{28}H_{54}O_4$	– 1.2415	– 367.24	191.29	290 to 470
Bis (φ′ - nonyl) 3 - methyl glutarate	$C_{24}H_{46}O_4$	– 1.8101	– 561.16	150.09	290 to 470
Bis (φ′ - octyl) adipate	$C_{22}H_{42}O_4$	– 1.2903	– 344.03	172.88	290 to 470
Bis(φ′ - octyl) 3 - methyl glutarate	$C_{22}H_{42}O_4$	– 1.5185	– 404.07	166.12	290 to 470
Butyl - 2 -acetoxy stearate	$C_{24}H_{46}O_4$	– 0.9431	– 281.16	175.24	280 to 380
Butyl benzoxy - 9 (10) - mono acyloxy stearate	$C_{31}H_{50}O_6$	– 1.2756	– 435.71	152.65	245 to 380
Butyl - P,P - bis (2 - ethyl hexyl) phosphono undecane	$C_{31}H_{63}O_5P$	– 1.1567	– 445.65	152.19	240 to 380

Name	***Formula***	***A′***	***B′***	***C′***	***Temperature Range, K***
Butyl butyroxy - 9 (10) - mono acycloxy stearate	$C_{28}H_{52}O_6$	– 1.1232	– 370.10	145.99	245 to 380
Buty - 9,10 - di acetoxy stearate	$C_{26}H_{48}O_6$	– 1.0118	– 331.55	178.82	280 to 380
Butyl - P,P - diethyl phosphono laurate	$C_{20}H_{41}O_5P$	– 1.2634	– 365.75	152.47	225 to 380
Butyl - P,P - diethyl - 9 (10) - phosphono stearate	$C_{26}H_{53}O_5P$	– 1.2710	– 430.96	142.05	240 to 380
Butyl - 1,2 - mono acetoxy stearate	$C_{24}H_{46}O_4$	– 0.8427	– 277.50	171.73	260 to 380
Butyl - 1,2 - (mono methyl adipoxy) stearate	$C_{29}H_{54}O_6$	– 0.8443	– 306.22	170.43	260 to 380
n - Butyl ortho silicate	$C_{16}H_{36}O_4Si$	– 0.65246	– 150.77	146.79	240 to 380
Butyl phthalyl butyl glycolate	$C_{18}H_{24}O_6$	– 0.9835	– 279.77	192.43	290 to 380
1,10 - Deca methylene glycol di - (2 - ethyl hexanoate)	$C_{26}H_{50}O_4$	– 0.67869	– 221.10	186.01	270 to 380
1,10 - Decane diol bis (φ - butyrate)	$C_{18}H_{34}O_4$	– 1.3184	– 361.18	137.53	270 to 380
Diamyl adipate	$C_{22}H_{30}O_4$	– 0.72794	– 187.94	176.47	290 to 380
Di (2 - (2′ - ethyl butoxy) ethyl) adipate	$C_{22}H_{52}O_8$	– 0.78656	– 261.16	171.85	270 to 380
Di (2 - butoxy ethyl)azelate	$C_{14}H_{40}O_6$	– 0.82958	– 266.83	163.09	270 to 380
Di butyl lauroyl oxy ethyl phosphonate	$C_{22}H_{45}O_5P$	– 0.8672	– 270.17	170.31	260 to 380
Di butyl lauryloxy propyl phosphate	$C_{23}H_{47}O_6P$	– 5.5182	– 4270.8	- 341.12	310 to 380
Di butyl lauryloxy propyl phosphonate	$C_{23}H_{47}O_5$	– 0.7123	– 267.97	169.87	240 to 380
Di butyl phthalate	$C_{16}H_{22}O_4$	– 1.0202	– 274.01	174.53	270 to 380
Di butyl sebacate	$C_{18}H_{34}O_4$	– 0.92084	– 280.86	146.50	270 to 380
Di (1,3 - dimethyl butyl) adipate	$C_{18}H_{34}O_4$	– 0.89472	– 231.33	170.46	270 to 380
Di (1,3 - dimethyl butyl) sebacate	$C_{22}H_{42}O_4$	– 0.90909	– 274.33	164.89	270 to 380
Di (2 - (2′ - ethyl butoxy) ethyl) adipate	$C_{20}H_{52}O_6$	– 0.80589	– 248.17	170.59	270 to 380
Di (2 - ethyl butyl) adipate	$C_{18}H_{34}O_4$	– 0.94010	– 262.46	156.23	270 to 380
Di (2 - ethyl butyl) azile	$C_{21}H_{40}O_4$	– 0.86556	– 268.48	159.80	270 to 380

Name	*Formula*	*A′*	*B′*	*C′*	*Temperature Range, K*
Di (2 - etyl butyl) sebacate	$C_{22}H_{42}O_4$	– 0.87406	– 280.58	157.69	270 to 380
Di ethylene glycol di (1,2-mono acetoxy state)	$C_{44}H_{82}O_9$	– 0.7439	– 355.16	179.82	260 to 380
Di (2 - ethyl hexyl) adipate	$C_{22}H_{42}O_4$	– 0.86706	– 251.38	169.92	270 to 380
Di (2 - ethyl hexyl) azelate	$C_{25}H_{48}O_4$	– 0.92709	– 299.93	159.71	270 to 380
Di (1 - ethyl propyl) azelate	$C_{19}H_{36}O_4$	– 0.91797	– 259.82	162.23	270 to 380
Di ethyl lauroxylo ethyl phosphate	$C_{18}H_{37}O_6P$	– 2.0703	– 910.32	- 15.400	310 to 380
Di ethyl oleoxy butyl phosphate	$C_{26}H_{51}O_6P$	– 0.8135	– 307.28	163.12	280 to 380
Di ethyl oleoxyethyl phosphate	$C_{24}H_{47}O_6P$	– 0.8056	– 264.72	158.26	270 to 380
Di ethyl oleoxypropyl phosphate	$C_{25}H_{49}O_6P$	– 1.9035	– 786.53	65.381	310 to 380
Di ethyl phthalate	$C_{12}H_{14}O_4$	– 1.0000	– 242.82	175.92	270 to 380
Di (1 - ethyl propyl) adipate	$C_{16}H_{30}O_4$	– 0.94831	– 235.96	163.79	270 to 380
Di (1 - ethyl propyl) sebacate	$C_{20}H_{38}O_4$	– 0.91757	– 267.18	162.19	270 to 380
Di (hepta decyl) adipate	$C_{10}H_{78}O_4$	– 1.0937	– 376.58	172.49	270 to 380
1,6 - Di heptoxy hexane	$C_{20}H_{42}O_2$	– 0.59825	– 157.65	191.66	290 to 380
Di heptyl pinate	$C_{22}H_{42}O_4$	– 1.0851	– 358.73	146.78	290 to 380
Di hexyl lauroxylo propyl phosphonate	$C_{26}H_{53}O_5P$	– 0.9691	– 321.51	159.20	260 to 380
Di (3 - methyl butyl) adipate	$C_{16}H_{30}O_4$	– 0.96123	– 265.85	150.38	270 to 380
Di (3 - methyl butyl) azelate	$C_{19}H_{36}O_4$	– 0.92713	– 286.95	149.20	270 to 380
Di (3 - methyl butyl) sebacate	$C_{20}H_{38}O_4$	– 0.92532	– 294.57	149.72	270 to 380
Di (1 - methyl ethyl) adipate	$C_{12}H_{22}O_4$	– 0.95376	– 220.22	155.72	270 to 380
Di (1 - methyl ethyl sebacate)	$C_{16}H_{30}O_4$	– 0.96749	– 268.56	149.78	270 to 380
Di octyl adipate	$C_{22}H_{42}O_4$	– 0.88427	– 308.08	141.70	290 to 380
Di (tetra decyl) adipate	$C_{34}H_{66}O_4$	– 1.0341	– 332.90	181.24	270 to 380
Di (tetra decyl) glutarate	$C_{33}H_{60}O_4$	– 1.0642	– 335.45	180.23	290 to 380
Di (tetra decyl) sebacate	$C_{38}H_{74}O_4$	– 1.0140	– 357.75	176.42	270 to 380
Di undecyl adipate	$C_{28}H_{50}O_4$	– 0.90546	– 287.00	177.52	270 to 380
Di undecyl gultarate	$C_{27}H_{48}O_6$	– 0.88903	– 274.53	179.61	270 to 380
Di undecyl sebacate	$C_{32}H_{62}O_4$	– 0.93484	– 329.60	169.32	270 to 380

Name	***Formula***	***A'***	***B'***	***C'***	***Temperature Range, K***
Do decyl - P,P -dibutyl phosphono undecanoate	$C_{31}H_{63}O_5P$	– 1.0782	– 396.22	149.88	280 to 380
2 - Ethyl - 1 - butyl - 9 (10) -mono acetoxy stearate	$C_{26}H_{50}O_4$	– 1.1931	– 368.25	152.32	245 to 380
2 - Ethyl - 1 - butyl -1,2 -mono acetoxy stearate	$C_{26}H_{50}O_4$	– 1.1659	– 380.22	153.98	245 to 380
2 -Ethyl butyl ortho silicate	$C_{24}H_{52}O_4Si$	– 0.83425	– 244.28	141.00	240 to 380
Ethyl - P,P - dihexyl phosphono laurate	$C_{26}H_{53}O_5P$	– 1.2763	– 399.47	147.54	225 to 380
Ethylene glycol di (1,2 - mono acetoxy) sterate	$C_{42}H_{78}O_8$	– 0.5599	– 292.27	193.65	280 to 380
2 - Ethyl hexyl -P,P - dibutyl phosphono undecanoate	$C_{27}H_{55}O_5P$	– 1.0988	– 391.11	147.31	230 to 380
2 - Ethyl -P,P - diethyl - 9 (10) phosphono stearate	$C_{30}H_{61}O_5P$	– 1.2897	– 448.08	145.80	240 to 380
2 -Ethyl hexyl -P,P- diethyl phosphono undecanoate	$C_{23}H_{47}O_5P$	– 0.9721	– 336.22	158.21	240 to 380
2 - Ethyl - 1 -hexyl - 9 (10) - mono acetoxy stearate	$C_{28}H_{54}O_4$	– 1.1982	– 388.79	153.77	245 to 380
2 - Ethyl hexyl ortho silicate	$C_{32}H_{68}O_4Si$	– 0.81487	– 261.07	152.07	240 to 380
1 - Ethyl pentyl ortho silicate	$C_{28}H_{60}O_4Si$	– 0.88879	– 267.56	159.42	240 to 380
Ethyl phthalyl ethyl glycolate	$C_{14}H_{16}O_6$	– 0.93113	– 241.84	208.50	290 to 380
1 - Ethyl propyl ortho silicate	$C_{20}H_{44}O_4Si$	– 0.81339	– 220.03	152.92	240 to 380
1,6 - Hexa methylene glycol - di - (2 -ethyl - hexanoate)	$C_{22}H_{42}O_4$	– 0.94329	– 267.75	168.34	270 to 380
1,6 - Hexano diol bis (φ - butyrate)	$C_{14}H_{26}O_4$	– 1.2488	– 302.57	145.49	230 to 380
1,6 - Hexane diol bis (φ-heptanoate)	$C_{20}H_{38}O_4$	– 1.3115	– 385.81	158.74	220 to 370
1,6 - Hexanediol bsi (φ - octanoate)	$C_{22}H_{42}O_4$	– 1.3725	– 369.56	160.40	270 to 380
1,6- Hexane diol di octanoate	$C_{22}H_{42}O_4$	– 0.84339	– 270.04	157.70	290 to 380
Iosoctyl - 9 (10) -mono acetoxy stearate	$C_{28}H_{54}O_4$	– 1.1713	– 387.26	153.61	245 to 380

Name	***Formula***	***A′***	***B′***	***C′***	***Temperature Range, K***
Methoxy ethyl - 1,2 - mono acetoxy stearate	$C_{23}H_{48}O_5$	– 0.8759	– 287.63	171.85	260 to 380
3 - Methyl butyl ortho silicate	$C_{20}H_{44}O_4Si$	– 0.9658	– 251.34	132.50	240 to 380
Methyl butyroxy - 9 (10) - mono acycloxy stearare	$C_{25}H_{46}O_6$	– 1.0907	– 327.98	157.74	245 to 380
1 - Methyl hexyl ortho silicate	$C_{28}H_{60}O_4Si$	– 0.84824	– 244.45	155.20	240 to 380
2 - Methyl pentyl ortho silicate	$C_{24}H_{52}O_4Si$	– 0.83643	– 243.01	150.96	240 to 380
Methyl phthalyl ethyl glycolate	$C_{13}H_{14}O_6$	– 1.0000	– 249.06	214.89	270 to 380
1 - Methyl propyl ortho silicate	$C_{16}H_{36}O_4Si$	– 0.70813	– 168.62	147.37	240 to 380
2 - Methyl propyl ortho silicate	$C_{16}H_{36}O_4Si$	– 0.80601	– 198.05	138.35	240 to 380
φ′ - Nonyl - 2 - ethyl hexanoate	$C_{17}H_{34}O_2$	– 1.3723	– 319.28	163.32	240 to 450
Octadecyl - φ -butyrate	$C_{22}H_{44}O_2$	– 1.2581	– 390.69	123.53	290 to 470
Phenoxyethyl - 1,2 - mono acetoxy stearate	$C_{28}H_{46}O_5$	– 0.8673	– 295.55	190.29	260 to 380
Phenyl - 1,2 - acetoxy stearate	$C_{26}H_{42}O_4$	– 1.0200	– 329.23	175.74	280 to 380
Phenyl - 1,2 - benzoxy stearate	$C_{31}H_{44}O_4$	– 1.0715	– 540.53	158.83	280 to 380
Phenyl -P,P - dibutyl phosphono undecanoate	$C_{25}H_{43}O_5P$	– 1.0183	– 350.98	166.00	260 to 380
1,2 - Propylene glycol di (1,2 - mono acetoxy stearate)	$C_{43}H_{80}O_8$	– 0.8786	– 385.92	174.02	260 to 380
1,3 - Propylene glycol di (1,2 -mono acetoxy stearate)	$C_{43}H_{80}O_8$	– 0.8329	– 380.58	174.28	280 to 380
Tri amyl tri carballylate	$C_{21}H_{38}O_6$	– 0.83326	– 235.46	184.11	290 to 380
Tri butyl phosphono laurate	$C_{29}H_{39}O_5P$	– 1.4076	– 457.78	134.85	220 to 380
Tributyl - 9 (10) - phosphono stearate	$C_{30}H_{61}O_5P$	– 1.3604	– 497.64	131.87	240 to 380
Tributyl -1,1 - phosphono undecanoate	$C_{23}H_{47}O_5P$	– 0.9123	– 304.38	160.71	250 to 380
Tri ethylene glycol di - (2 - ethyl - hexanoate)	$C_{22}H_{32}O_8$	– 0.85248	– 238.59	178.64	270 to 380
Tri ethyl phosphono stearate	$C_{24}H_{49}O_5P$	– 0.8542	– 273.28	181.78	280 to 380

Name	***Formula***	***A′***	***B′***	***C′***	***Temperature Range, K***
Tri ethyl - 9 (10) - phosphono stearate	$C_{24}H_{49}O_5P$	– 1.2877	– 443.51	143.52	240 to 380
Tri hexyl phosphono caproate	$C_{29}H_{59}O_5P$	– 1.2703	– 356.36	138.54	210 to 380
Tri hexyl - 1,1 - phosphono undecanoate	$C_{29}H_{59}O_5P$	– 1.1533	– 424.06	139.62	240 to 380
3,3,5 - Tri methyl hexyl ortho silicate	$C_{36}H_{76}O_4Si$	– 0.83454	– 302.44	150.89	310 to 380
1,2,3 - Tri methylol propane tris (φ′ - butyrate)	$C_{15}H_{26}O_6$	– 1.5501	– 410.89	159.64	250 to 460
Trimethyl - 9 (10) - phosphono steareate	$C_{21}H_{43}O_5P$	– 1.3641	– 449.37	150.71	240 to 380
Trimethyl -1,1 - phosphono undecanoate	$C_{14}H_{29}O_5P$	– 0.8317	– 256.20	172.35	270 to 380
Tris (2 - ethyl hexyl) -1,1 -phosphono undecanoate	$C_{35}H_{71}O_5P$	– 1.1816	– 428.58	150.76	240 to 380

Table 4.11. Constants of the Antoine type equation given by Eq. (4.18): $\log \eta = A + B/(C - T)$ for estimating pure liquid viscosity at different temperatures for 100 substances as obtained by Dutt and Prasad[15] [Temperature in K and Viscosity in cP]].

Substance	***A***	***B***	***C***	***Temperature Range, K***
Acetaldehyde	–2.4286	–803.54	–158.49	273 to 294
Acetic acid	–1.4999	–353.33	69.11	283 to 383
Acetone	–1.4195	–214.96	58.71	183 to 333
Acetophenone	–1.6579	–490.08	37.75	286 to 474
Allyl alcohol	–2.3605	–658.66	28.99	281 to 350
Amyl alcohol	–2.4787	–696.70	68.61	273 to 373
Aniline	–1.1835	–224.31	170.82	268 to 393
Benzene	–2.7173	–1071.18	–129.51	278 to 463
n-Butane	–2.2494	–599.66	–109.85	183 to 323
Butanoic acid	–1.9294	–618.81	0.98	273 to 373
1-Butene	–1.8752	–337.89	–27.80	163 to 233
n-Butyl alcohol	–2.9918	–1026.78	–4.25	273 to 393
Butyl amine	–5.9761	–5487.69	–658.54	273 to 348
Butyl benzene	–1.6246	–403.89	46.09	283 to 353
Carbon tetrachloride	–1.4708	–324.45	71.19	273 to 373
Chloro benzene	–1.5481	–390.95	24.03	273 to 393
Chloroform	–1.3917	–288.76	39.69	248 to 333
m - Cresol	–1.4585	–289.19	185.08	316 to 373
o - Cresol	–1.1810	–197.71	204.14	323 to 393
Cyclo hexane	–1.9690	–501.37	37.20	278 to 353
Cyclo pentane	–2.0803	–617.63	–65.69	253 to 323
Decane	–1.5703	–342.46	68.73	248 to 373
1,1 - Dichloro ethane	–1.7305	–420.45	–2.98	280 to 327
Dichloro methane	–1.4815	–302.66	22.64	248 to 310
Diethyl amine	–2.3523	–648.13	–51.35	283 to 323
Diethyl carbonate	–0.9512	–114.23	159.97	293 to 393
Diethyl ketone	–2.0805	–638.76	–71.73	273 to 373
Diethyl sulfide	–2.0753	–640.74	–78.66	273 to 348
Dimethyl carbonate	–0.9700	–70.28	202.34	293 to 353
n,n-Dimethyl formamide	–0.6419	–56.54	193.62	273 to 323
2,2 - Dimehyl propane	–0.9128	–30.15	202.98	258 to 283
Di methyl sulfide	–0.7751	–18.09	217.66	273 to 309
1,4 - Dioxane	–1.4827	–302.77	103.40	288 to 348

Substance	***A***	***B***	***C***	***Temperature Range, K***
Di phenyl ether	–1.0746	–238.51	153.06	313 to 373
Di phenyl methane	–1.8959	–697.63	–1.09	333 to 434
Di propyl amine	–2.0439	–519.82	2.21	273 to 373
Dodecane	–1.5552	–374.71	77.07	273 to 373
Ethane	–1.5478	–135.98	9.67	98 to 188
Ethane thiol	–1.6159	–307.59	11.69	270 to 298
Ethyl acetate	–3.5169	–2089.32	–364.82	273 to 463
Ethyl alcohol	–2.8857	–1032.53	–55.95	248 to 348
Ethyl benzene	–1.7041	–425.99	15.31	253 to 413
Ethyl bromide	–3.2277	–1873.31	–370.72	248 to 433
Ethylene	–2.1350	–273.67	–35.34	103 to 173
Ethylene bromide	–1.3151	–339.42	74.11	293 to 393
Ethylene chloride	–1.8197	–507.87	1.36	273 to 353
Ethyl ether	–4.4735	–3623.26	–648.55	273 to 373
Ethyl formate	–1.5812	–299.33	40.27	273 to 328
Ethyl propionate	–2.0186	–572.05	–34.88	273 to 373
Formic acid	–1.4150	–297.43	114.74	281 to 373
Furan	–1.7446	–388.37	– 0.20	248 to 303
Hepta decane	–1.7847	–577.32	51.72	303 to 553
Heptane	–1.5365	–277.33	51.64	183 to 373
Hexa decane	–1.7148	–522.41	60.10	298 to 393
Hexane	–1.8040	–401.73	–16.29	213 to 343
1 - Hexene	–1.8076	–356.34	2.70	248 to 323
1 - Hexyne	–3.0941	–1404.92	–233.99	293 to 333
Isoamyl alcohol	–5.3532	–2741.77	–161.66	283 to 373
Iso butane	–2.2673	–566.04	–81.14	193 to 273
Iso butyl acetate	–2.8354	–1224.43	–161.32	293 to 373
Iso butyric acid	–1.8943	–594.97	–2.06	273 to 373
Iso propyl alcohol	–3.9124	–1399.28	–32.76	273 to 348
Iso propyl amine	–1.3472	–145.21	128.21	273 to 303
Methane	–1.5276	–44.35	37.69	88 to 113
Methyl acetate	–2.5116	–957.10	–164.01	273 to 327
Methyl alcohol	–2.2968	–675.41	–33.89	248 to 333
Methyl amine	–1.5510	–175.06	82.16	203 to 273
Methyl-n-amyl ketone	–1.0477	–61.19	229.68	293 to 353

Substance	***A***	***B***	***C***	***Temperature Range, K***
2 - Methyl butane	–1.8644	–351.70	3.82	223 to 303
2 - Methyl - 2 - butene	–1.8117	–342.53	–8.18	273 to 305
Methyl butanoate	–1.8739	–478.95	–0.03	273 to 373
Methyl cyclo pentane	–2.3800	–841.97	–110.74	248 to 323
Methyl formate	–1.4142	–217.54	65.39	274 to 302
Methyl iso butyrate	–2.0903	–624.72	–52.90	273 to 362
Methyl propionate	–2.0125	–565.15	–45.06	273 to 348
Methyl - n - propyl ketone	–1.8022	–440.84	–0.98	273 to 373
Nitro methane	–1.5306	–344.15	39.22	248 to 348
Nonane	–1.7903	–443.29	23.17	273 to 373
Octane	–2.1458	–664.14	–60.61	273 to 373
Octa decane	–1.3859	–375.22	112.28	303 to 373
Penta decane	–1.4073	–348.84	105.48	293 to 373
Pentane	–1.4835	–221.13	33.68	153 to 303
1 - Pentene	–1.8872	–389.41	–33.04	218 to 298
Phenol	–1.3164	–253.66	186.00	313 to 363
Propane	–1.3602	–147.59	23.80	93 to 203
Propionic acid	–1.8168	–558.84	–7.46	273 to 373
N - Propyl acetate	–1.8903	–480.50	2.42	273 to 373
N - Propyl alcohol	–2.7300	–854.52	14.96	248 to 348
Propyl formate	–1.8820	–482.16	–9.34	273 to 348
Pyridine	–0.9224	–108.01	171.49	273 to 373
Pyrrole	–1.1810	–206.12	135.32	273 to 348
Quinoline	–1.6854	–440.24	98.75	288 to 373
Tetra decane	–1.4424	–350.81	100.18	283 o 373
Tetra hydro furan	–5.9778	–6696.37	–886.12	248 to 323
Toluene	–1.7712	–433.71	12.03	253 to 383
Tri chloro fluoro methane	–0.9340	–92.22	133.28	248 to 343
Tri decane	–1.6833	–453.35	61.85	273 to 373
Tri ethyl amine	–2.5237	–963.82	–168.26	273 to 348
m - Xylene	–1.7884	–473.42	–6.46	273 to 413
o - Xylene	–1.7350	–445.93	22.25	273 to 413

4.3.1.2c Goletz and Tassios Generalization

Goletz and Tassios[21] applied the temperature dependence (Eq. 4.17) proposed by Vogel[20] over the full range, from the normal boiling temperature to the freezing point, extensively and also developed a generalized form. Based on the available literature on the application of the Antoine equation for vapor pressure, its generalization and their own analysis, Goletz and Tassios proposed the calculation of C from,

$$C = 239 - 0.19T_B \qquad (4.20)$$

where T_B is the normal boiling point in K. They fitted the available experimental liquid viscosity- temperature data to the form:

$$log\,\eta = A + B/(C + t) \qquad (4.21)$$

where t represents the temperature in °C. Incorporation of the value of C from Eq. (4.20) into Eq. (4.21) gives the following equation with two constants (A and B) and the normal boiling point (T_B).

$$log\,\eta = A + B/(239 - 0.19T_B + t) \qquad (4.22)$$

The method is shown to be good for the correlation of the viscosity-temperature data of liquid hydrocarbons and polar compounds (with weak or no hydrogen bonding) to within 5% of their reported values.

4.3.1.2d Dutt's Development

Dutt[22] used ideas similar to those of Goletz and Tassios and proposed that the kinematic viscosity (η/ρ) of petroleum crude oil fractions can be estimated from the equation

$$\ln(\eta/\rho) = -3.0171 + [(442.78 + 1.6452t_B)/\{t + (239 - 0.19t_B)\}] \qquad (4.23)$$

In this equation, η is the dynamic viscosity in cP, ρ is the density in g/mL and t_B is the normal boiling temperature in °C. The method has been shown to predict the kinematic viscosity of 15 crude oils and their fractions at 250 data points with an average absolute deviation of 6% and shown to perform better than the other prediction methods available at that time.

When applied to pure liquids, the equation generally fared better than other methods, probably due to the fact that it has been developed from the average properties of mixtures (crude oil fractions) like density (ρ) and normal boiling point (t_B) rather than any particular set of substances. However a careful examination of the results showed that experimental viscosity data for alcohols deviated in a systematic manner from the values predicted from Dutt's equation. To improve the performance, it is recommended that the values of the normal boiling point t_B in Dutt's equation be replaced by the dipole moment (μ in debyes) dependent expressions: $t_B' = t_B\,(1 + 0.6\mu)$ for aliphatic alcohols, and $t_B'' = t_B(1 + 0.3\mu)$ for other polar compounds.

Saturated liquid density (ρ) at the required temperature (T) can be calculated from the knowledge of liquid density at the reference temperature (T^{Ref}) from the following equations:

$$\rho = \frac{M}{V_S} \tag{4.24}$$

where, $$V_S = V_S^{Ref}\left(0.29056 - 0.0877\omega\right)^{\varphi} \tag{4.25}$$

and $$\varphi = \left(1 - \frac{T}{T_C}\right)^{2/\&} - \left(1 - \frac{T^{Ref}}{T_C}\right)^{2/\&} \tag{4.26}$$

Equations (4.23) to (4.26) are proposed for the calculation of the kinematic viscosity employing Eq. 4.23.

Application of this method requires the values of the normal boiling temperature (t_B), the critical temperature (T_C), the acentric factor (ω), the value of specific volume (V_S^{Ref}) or density (ρ_{Ref}) at the reference temperature, and the dipole moment (μ) in the case of alcohols. Application of the method for a set of 100 representative substances is shown in Section 4.4.

4.3.1.2e Girifalco Form

Girifalco[23] suggested the form

$$ln\,\eta = A + \left(B/T\right) + \left(C/T^2\right) \tag{4.27}$$

where C is close to zero except for polar or associated liquids. Girifalco mentions that the model represents the data of different classes of liquids - non-polar, polar as well as associated liquids - to good accuracy and presents the values of the constants A, B and C for some polar and associated liquids, as noted in Table 4.12.

Table 4.12. Constants of the Girifalco[23] form given by Eq. (4.27): $\ln\eta = A + (B/T) + \left(C/T^2\right)$ for calculating liquid viscosities [Temperature in K and Viscosity in cP].

Liquid	*A*	*B x 10⁻²*	*C x 10⁻⁴*
Acetic acid	–3.521	15.965	–15.759
Aniline	0.7008	–13.287	38.52
Butyric acid	–1.323	2.205	6.589
n-Butyl alcohol	–2.878	9.615	0.5588
Ethyl acetate	–1.059	0.09764	5.871
Ethyl alcohol	–2.459	7.807	–1.145
Ethylene glycol	–0.4312	–5.860	32.036
Formic acid	–0.9759	–0.7629	12.819
Glycerine	10.873	–72.23	145.78
n-Propyl alcohol	9.259	3.353	–1.875
Methyl alcohol	–1.567	2.750	3.428
Sulfuric acid	–0.09771	–4.690	26.37
Water	–0.3908	–6.8992	23.611

4.3.1.2f Thorpe and Rodger Equation

Thorpe and Rodger[24,24a] proposed the following functional form for the variation of liquid viscosity (η in cP) with temperature (t in ºC)

$$\eta = C/\left(1 + \alpha t + \beta t^2\right) \tag{4.28}$$

where C, α and β are the constants characteristic of each liquid. Table 4.13 gives a list of the constants C, α and β for several liquids.

Table 4.13. Constants of Eq. (4.28): $\eta = C/\left(1+\alpha t+\beta t^2\right)$ proposed by Thorpe and Rodger[24] for calculating viscosity of liquids. [Viscosity in cP, and Temperature, t, in ºC].

Substance	α	$\beta \times 10^4$	*C*
Acetaldehyde	0.00963	0.2953	0.002671
Acetic acid	0.01826	0.8537	0.016867
Acetic anhydride	0.01735	0.6122	0.012416
Acetone	0.01064	0.3115	0.003949
Allyl bromide	0.01177	0.2871	0.006190
Allyl chloride	0.01111	0.2629	0.004059
Allyl iodide	0.01316	0.3361	0.009296
Benzaldehyde	0.01801	0.6181	0.009296
Butyric acid	0.02109	1.1073	0.022747
iso - Butyric acid	0.01917	0.9215	0.018872
Carbon disulfide	0.00820	0.1302	0.004294
Carbon tetra chloride	0.01801	0.6747	0.013466
Chloroform	0.01149	0.2588	0.007006

Substance	α	$\beta \times 10^4$	C
Diallyl	0.01118	0.3107	0.003388
Ethyl benzene	0.01448	0.4530	0.008745
Ethyl bromide	0.01064	0.1822	0.004776
Ethylene bromide	0.02007	0.7018	0.024579
Ethylene chlorode	0.01653	0.5451	0.011269
Ethyl iodide	0.01113	0.2658	0.007190
Formic acid	0.02870	1.6950	0.029280
N - Heptane	0.01214	0.4004	0.005180
iso - Heptane	0.01199	0.3863	0.004767
n - Hexane	0.01122	0.3337	0.003965
iso - Hexane	0.01110	0.3599	0.003713
Isoprene	0.01002	0.1542	0.002600
Methyl ethyl ketone	0.01284	0.3639	0.005383
Methyl iodide	0.01067	0.1719	0.005940
Methyl propyl ketone	0.01325	0.3965	0.006464
n - Octane	0.01394	0.4296	0.007025
n - Pentane	0.01044	0.2301	0.002827
Propionic acid	0.01720	0.6941	0.015199
Propionic anhydride	0.02005	0.8315	0.016071
Thiophene	0.01518	0.4358	0.008708
Toluene	0.01462	0.4220	0.007684
m - Xylene	0.01418	0.3923	0.008019
o - Xylene	0.01701	0.5636	0.008457
p - Xylene	0.01472	0.4758	0.008457

4.3.1.2g Islam and Ibrahim Method

Islam and Ibrahim[25] examined the status of the applicability of the two-parameter as well as three-parameter equations with reference to the flow behavior of a set of representative liquids chosen by them from experimental studies. They attempted to answer the basic question whether a simple equation based on the molecular chaos implicit in the van der Waals' equation is adequate or whether it is necessary to imagine the presence of 'solid like' structures. Fig. 4.3 (given by Islam and Ibrahim) reveals that for glycerol, phenol and aniline, the plots of ln η versus $(1/T)$ show deviations from the Arrhenius behaviour in the low temperature region, which could be attributed to the presence of association in these liquids.

The plots of Fig. 4.4, showing *log* ϕ as a function of the reciprocal of free volume $\{1/(V-V_0)\}$ where V_0 is the molar volume extrapolated to zero degrees absolute without change of phase, are linear for only those liquids which follow Arrhenius equation. Plots for liquids like glycerol, phenol, aniline, m-toluidine, o-toluidine and quinoline (not shown in the figure) deviate from the linear behavior, indicating superiority of the Dolittle equation over identical temperature intervals.

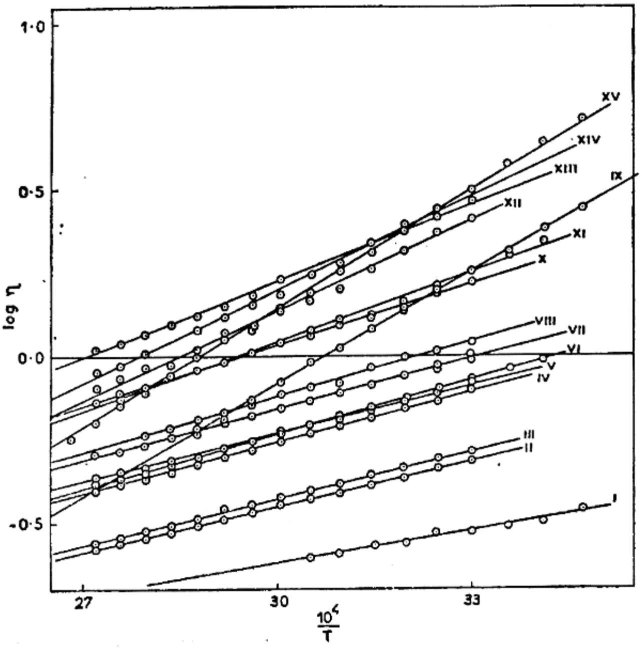


Figure 4.3. Plots of *log* η as a function of *(1/T)* for (I) acetone, (II) n-octane, (III) toluene, (IV) acetic anhydride, (V) pyridine, (VI) carbon tetrachloride, (VII) bromobenzene, (VIII) dioxane, (IX) isopropyl alcohol, (X) nitrobenzene, (XI) n-valeric acid, (XII) m-toluidine, (XIII) quinoline, (XIV) o-toluidine, and (XV) amyl alcohol (Adopted from N. Islam and M. Ibrahim, Status models for flow behaviour of organic liquids, *Indian J. Chem.* **20A**, 963-968, 1981).

For the above substances, the applicability of the Vogel-Tammann-Fulcher (VTF) equation given by;

$$\varphi = A\,exp\left[-k'/\left(T - T_0\right)\right] \qquad (4.29)$$

in which A and k' stand for the pre-exponential and exponential parameters respectively, has been examined. Plots of lnϕ versus $[1/(T\text{-}T_0)]$ for liquids showing non-Arrhenius behaviour are given in Fig. 4.5. The significant parameter T_0 known as the zero mobility temperature is obtained by least-squares fit. The constants A, k' and T_0 for some characteristic liquids are noted in Table 4.14.

Table 4.14. Values of the constants A, k' and T_0 for use in Vogel-Tammann-Fulcher Equation, given by Eq. (4.29): $\phi = A\exp\left[-k'/\left(T - T_0\right)\right]$.

Liquid	***A***	***k'***	T_0
Aniline	13902.0	1412.2	70.6
Glycol	38758.0	1860.8	85.9
Phenol	54729.0	1874.3	74.1
Quinoline	4923.9	1163.0	68.6
o - Toluidine	14010.0	1433.3	67.4
m - Toluidine	15096.0	1386.3	72.2

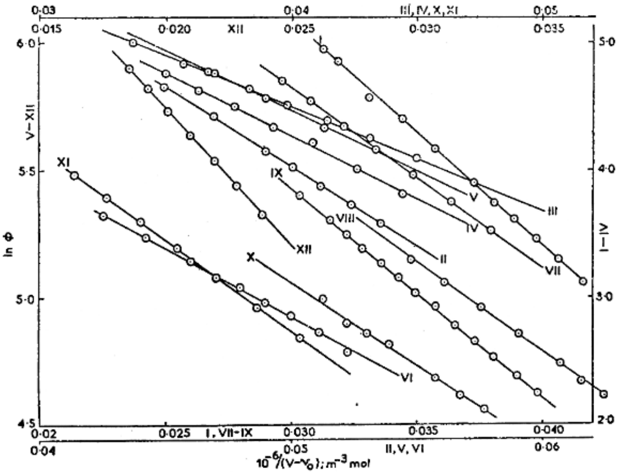


Figure 4.4. Plots of *ln* ϕ as a function of $[1/(V\text{-}V_0)]$ for : (I) amyl alcohol, (II) isopropyl alcohol, (III)nitrobenzene, (IV) n-valeric acid, (V) acetone, (VI) pyridine, (VII) toluene, (VIII) bromobenzene, (IX) carbon tetrachloride, (X) dioxane, (XI) acetic anhydride, and (XII) n-octane (Adopted from N. Islam and M. Ibrahim, Status models for flow behaviour of organic liquids, *Indian J. Chem.* **20A**, 963-968, 1981).

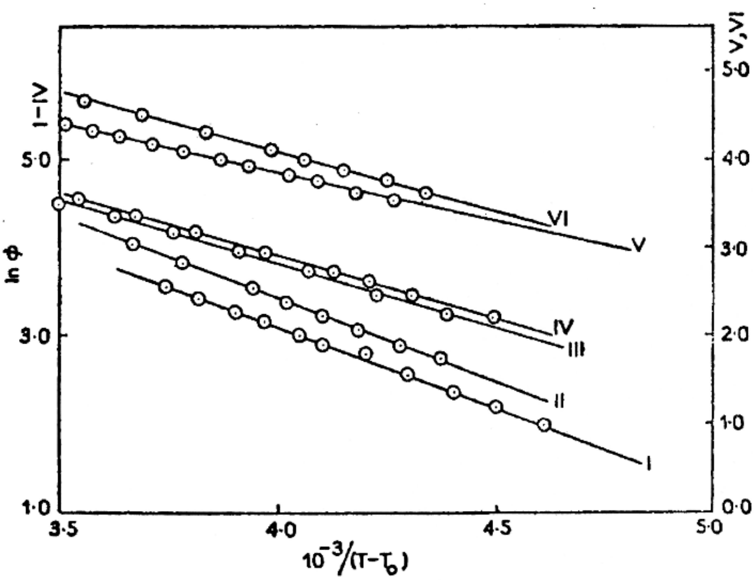


Figure 4.5. Plots of *ln* ϕ as a function of $[1/(T\text{-}T_0)]$ for: (I) glycol, (II) phenol, (III) o-toludine, (IV) aniline, (V) quinoline and (VI) m-toludine (Adopted from N. Islam and M. Ibrahim, Status models for flow behaviour of organic liquids, *Indian J. Chem.* **20A**, 963-968, 1981).

Fluidity has also been expressed in the form of modified Dolittle equation

$$\varphi = A' exp[-B_0/(V - V_0)] \tag{4.30}$$

where V_0 is the molar volume at T_0. The values of the constants of the modified Dolittle equation for some liquids selected for this study are given in Table 4.15.

Table 4.15. Values of the constants A', B_0 and V_0 to be used in the modified Dolittle Equation, Eq. (4.30): $\phi = A'\exp\left[-B_0/\left(V - V_0\right)\right]$.

Liquid	***A'***	B_0	V_0
Aniline	4830.0	74.22	77.13
Glycerol	410.18	13.07	52.83
Phenol	572.19	21.02	82.59
Quinoline	2715.8	78.20	101.16
o - Toluidine	5018.3	91.23	90.19
m - Toluidine	5101.4	90.63	90.70

The fluidity data of several liquids, plotted as a function of molar volume in Fig. 4.6, resulted in straight lines over the investigated experimental conditions, except for glycerol, phenol, aniline, amyl alcohol and isopropyl alcohol. The Hildebrand volumes (V_B) are obtained from the plots by extrapolation to zero fluidity and the values of B are obtained from the slopes. While V_B is characteristic of liquid which states that the liquid will cease to flow when it acquires the molar volume equal to V_B, the values of B depend on the nature of the molecule. The molecules with less mass and free rotation will have higher values of B. While the B values for toluene, nitrobenzene and bromobenzene vary according to the order of molecular weight, the larger B value for n-octane compared to that for acetone is anomalous. Table 4.16 lists the values of V_B and B for some chosen liquids.

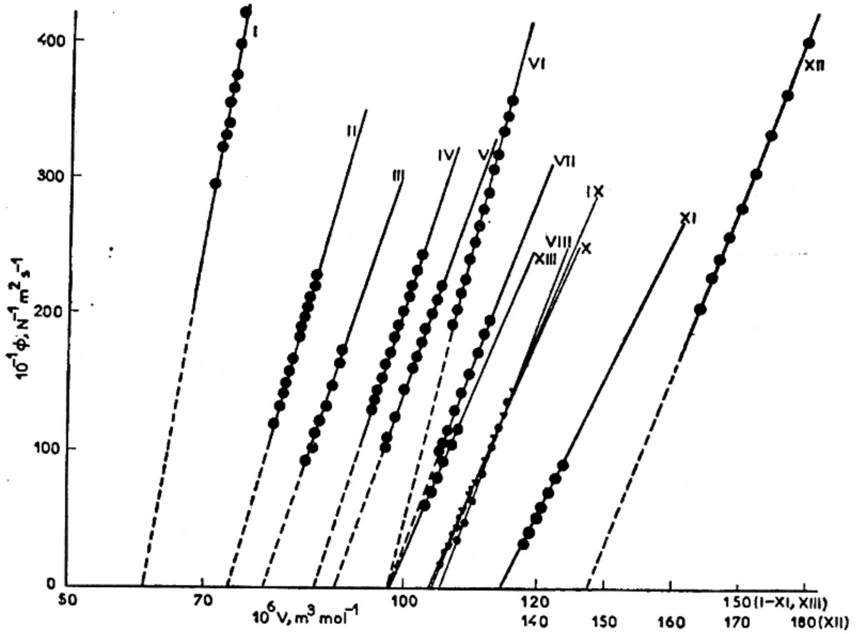


Figure 4.6. Plots of fluidity ϕ as a function of molar volume (V) for : (I) acetone, (II) pyridine, (III) dioxane, (IV) acetic anhydride, (V) carbon tetrachloride, (VI) toluene, (VII) bromobenzene, (VIII) m-toludine, (IX) o-toludine, (X) n-valeric acid, (XI) quinoline, (XII) n-octane and (XIII) nitrobenzene (Adopted from N. Islam and M. Ibrahim, Status models for flow behaviour of organic liquids, *Indian J. Chem.* **20A**, 963-968, 1981).

Table 4.16. Values of V_B and B for some typical liquids.

Liquid	$10^6\ V_B\ (m^3\ mol^{-1})$	$10^{-1}\ B\ (N^{-1}m^2s^{-1})$
Acetic anhydride	87.75	1426.2
Acetone	61.85	1793.9
Bromo benzene	98.34	1321.9
Carbon tetra chloride	91.13	1373.7
Dioxane	80.13	1337.2
Nitro benzene	98.17	1141.8
n - Octane	148.78	1931.4
Pyridine	74.59	1375.0
Quinoline	115.80	1187.2
Toluene	98.36	2036.6
m - Toluidine	106.75	1425.2
o - Toluidine	105.65	1351.8
n - Valeric acid	105.25	1257.1

For comparison purposes, the Hildebrand equation and Arrhenius equations are written as

$$\varphi = (1/\eta) = A''\, exp(-k'/T) = B[(V - V_B)/V_B] \tag{4.31}$$

and examined for the validity for some non-associated and non-polar liquids, well above their melting point.

Taking the logarithm and differentiating with respect to temperature, one can write

$$k'(V - V_B) = T^2 (dV/dT) \tag{4.32}$$

indicating that the plot of $T^2(dV/dT)$ versus molar volume should be linear and the slope should give the value of k' (= $E\phi/R$) and the intercept the value of $-k'V_B$. Implicitly, for liquids which follow the Hildebrand and Arrhenius equations, it should be possible to find not only the value of activation energy of flow but also the value of the Hildebrand volume V_B without measuring the fluidity data, from the density measurements alone. This has not been possible for even simple liquids.

On further differentiation with respect to temperature, one obtains

$$k' = T^2 (d^2V/dT^2)/(dV/dT) + 2T \tag{4.33}$$

For the liquids which follow the Arrhenius equation as well as the Hildebrand model, the value of $[2T + T^2\{(d^2V/dT^2)/(dV/dT)\}]$ should remain constant. In reality it has been found to increase with temperature even over small ranges of temperature.

Based on the analysis presented, Islam and Ibrahim suggested a modified Hildebrand equation for the flow behavior in the form:

$$\phi = B'\left[\left(\frac{V}{V'_B}\right)^n - 1\right] \tag{4.34}$$

where *n* has been found to be a measure of the intermolecular interactions leading to self-association.

On equating Arrhenius equation and the modified form of Hildebrand equation, one can write

$$\varphi = A\,exp\left(-k'/T\right) = B'\left[\left(V - V'_B\right)^n - 1\right] \tag{4.35}$$

In the logarithmic form

$$ln\,A - \left(k'/T\right) = ln\left(B'/V'_B\right)^n + ln\left(V^n - V'^n_B\right) \tag{4.36}$$

$$\text{or, } T = \frac{k'}{c - ln\left(V^n - V'^n_B\right)} \tag{4.37}$$

$$\text{where, } c = ln\left(\frac{AV'^n_B}{B'}\right) \tag{4.38}$$

The three parameters: *c*, *n* and V'_B are computed from the least-squares fit of the absolute temperature (*T*) to the molar volume (*V*) according to the equation noted above. Table 4.17 lists the parameters for some typical substances.

Table 4.17. Parameters C, n and V_B' for the application of the Islam and Ibrahim[25] approach using Eq. (4.36).

Liquid	*C*	*n*	*$10^6\ V'_B$ (m^3/mol)*
Type(i) Liquids			
Acetic anhydride	14.662	2.70	86.43
Acetone	6.449	1.25	62.64
Bromo benzene	17.000	3.175	97.29
Carbon tetra chloride	20.247	3.75	89.27
Dioxane	20.495	3.94	79.04
Toluene	12.065	2.17	97.41
Type(ii) Liquids			
Aniline	72.070	14.50	87.89
Niro benzene	30.655	5.85	96.24
Pyridine	12.779	2.45	74.00
Quinoline	60.421	11.62	113.55
m – Toluidine	67.951	13.17	104.12
o – Toluidine	69.709	13.55	103.29
Type(iii) Liquids			
Amyl alcohol	87.716	16.90	104.81
Ethylene glycol	88.634	19.80	55.16
Iso propyl alcohol	73.858	15.12	72.85
Phenol	80.140	17.74	86.22
n - Valeric acid	47.680	9.16	102.94

The only liquid of this study which has n some what near one is acetone ($n = 1.25$) and the one which has $n < 2$ is n-octane ($n = 1.67$) while ethylene glycol has a value as high as 19.8. It is interesting to note that the values of B' decrease as n increases implying that n is associated with a factor that causes restrictions to free rotation in the molecule, which may be due to molecular association or mass of the molecules or any type of molecular interaction. The parameter n can thus be considered as a measure of combined intermolecular forces in the liquid state, which is found to increase with k' indicating that it is a function of activation energy for flow which depends on the molecular environment as well as molecular interactions. Consequently, n may be taken as some function of molecular interactions which depend on the structure of the liquid.

To elaborate the significance of n and B', the liquids investigated may be categorized into there types: (i) Simple, either non-associated or insignificantly associated like acetone, n-octane, toluene, acetic anhydride, carbon tetrachloride, bromo-benzene and dioxane; (ii) nitrogen containing liquids like pyridine, nitrobenzene, quinoline, m-toludine, o-toludine and aniline, and (iii) hydroxyl containing liquids like n-valeric acid, isopropyl alcohol, amyl alcohol, phenol and glycerol.

In the non-associated liquids [type(i)], the main factor that causes the restriction in the movement and rotation of its molecules is the molecular weight of the liquid provided that the structure of the molecules is not such that it can cause hindrance to molecular rotation. Molecular interactions are the least in the non-associated liquids and consequently the values of B' should be large and the values of n should be small.

In the type (ii) liquids, which are all aromatic, nitrogen lone pair in amines seems to be responsible for strong molecular interaction and association due to hydrogen bond formation.

The liquids of type (iii) are alcohols, except for n-valeric acid. The association in acids is there but long chains are not expected, unlike alcohols wherein long chain three dimensional network is obtained. The attraction between the cations and anions in acids prevents the rotation and mobility of the ions and non-dissociated molecules. Thus in the case of n-valeric acid the n value should be higher than, but not as high as those for alcohols.

The proposed modified Hildebrand equation is found to be applicable to all sorts of aromatic liquids – non-associated, partially associated or highly associated or whether they are aliphatic or aromatic or whether they have simple or complicated structure and the parameters V'_B, B' and n assume significance in understanding the behaviour of liquids. The parameter B' is more informative than the corresponding parameter of the original Hildebrand equation and the parameter n is a measure of the relative intermolecular interactions and explains the activation energy and the combined strength of the intermolecular forces.

4.3.1.3 Multi-Constant Equations

Some equations with more than three constants have been proposed to improve upon the accuracy of representation, particularly over wider ranges of temperature. We present in this section, some of the multi-constant equations which have been applied to rather larger number of compounds.

4.3.1.3a Polynomial Representation

Liquid viscosity available in the literature over wider ranges of temperature have been represented in the polynomial form

$$ln\,\eta = A + (B/T) + CT + DT^2 \qquad (4.39)$$

The constants of Eq. (4.39) for several common substances given by Reid *et al.*[19] are noted in Table 4.18.

4.3.1.3b Yaws *et al.* Recommendation

Yaws *et al.*[26] recommended the use of an equation essentially similar to Eq. (4.39) using the logarithm to the base 10 instead of the natural logarithm and wrote

$$log\,\eta = A' + \left(B'/T\right) + C'T + D'T^2 \tag{4.40}$$

For liquid viscosity between the melting and critical points, they provided coefficients for 355 liquids along with the range of applicability. Table 4.19 gives the coefficients of the liquid viscosity equation tabulated by Yaws *et al.*[26]

Table 4.18. Constants of Eq. (4.39): $\ln\eta = A + \left(B/T\right) + CT + DT^2$, which is a polynomial representation of liquid viscosity [Viscosity (η) in cP and Temperature in K]. From: R. C. Reid, J. M. Prausnitz, and B. E. Poling, *Properties of Gases and Liquids*, McGraw-Hill, NY, (1987).

Formula	***Name***	***A***	***B***	***C***	***D***	***Temperature range, ^0C***	***η, cP(at °C)***
A	Argon	-28.51	1057.0	0.2429	-8.096×10^{-4}	-189 to -124	0.25(-185)
Cl_2	Chlorine	-1.768	348.6	-1.857×10^{-3}	7.80×10^{-7}	-101 to 144	0.34(25)
F_2	Fluorine	-3.629	197.2	-9.378×10^{-4}	-6.275×10^{-6}	-219 to -185	0.73(-215)
HBr	Hydrogen bromide	-21.27	1996.0	7.902×10^{-2}	-1.191×10^{-4}	-88 to 90	0.20(25)
HCl	Hydrogen chloride	-3.488	481.0	7.062×10^{-3}	-3.168×10^{-5}	-100 to 50	0.068(25)
HF	Hydrogen fluoride	-14.04	1879.0	2.975×10^{-2}	-3.060×10^{-5}	-80 to 180	0.20(25)
HI	Hydrogen iodide	-21.58	2337.0	7.336×10^{-2}	-9.717×10^{-5}	-50 to 150	0.60(25)
H_2	Hydrogen	-11.18	57.86	3.244×10^{-1}	-6.385×10^{-3}	-258 to -140	0.016(-256)
H_2O	Water	-24.71	4209.0	4.527×10^{-2}	-3.376×10^{-5}	0 to 370	0.90(25)
H_3N	Ammonia	-19.78	2018.0	6.173×10^{-2}	-8.317×10^{-5}	-75 to 130	0.13(25)
H_2N_2	Hydrazine	-18.848	2991.0	3.709×10^{-2}	-3.062×10^{-5}	2 to 370	0.90(25)
H_2O_2	Hydrogen peroxide	-3.719	1160.0	8.06×10^{-4}	-2.698×10^{-6}	0 to 400	1.19(25)
I_2	Iodine	-2.083	1195.0	-4.566×10^{-4}	1.08×10^{-7}	114 to 200	1.8(150)
NO	Nitric oxide	-11.50	548.7	8.448×10^{-2}	-3.092×10^{-4}	-160 to - 90	0.35(-160)
NO_2	Nitrogen dioxide	-19.41	2147.0	6.353×10^{-2}	-8.644×10^{-5}	-11 to 150	0.39(25)
N_2	Nitrogen	-27.95	866.0	2.763×10^{-1}	-1.084×10^{-3}	-205 to 195	0.18(-200)
N_2O	Nitrous oxide	1.090	50.20	-1.134×10^{-2}	-9.841×10^{-6}	-100 to 30	0.05(25)
Ne	Neon	-19.29	199.0	5.453×10^{-1}	-6.675×10^{-3}	-248 to - 229	0.137(-247)
O_2	Oxygen	-4.771	214.6	1.389×10^{-2}	-6.255×10^{-5}	-218 to -120	0.47(-210)
O_2S	Sulfur dioxide	-6.148	936.5	1.414×10^{-2}	-2.887×10^{-5}	-70 to 155	0.26(25)
O_3S	Sulfur trioxide	28.94	-2277.0	-9.392×10^{-2}	8.064×10^{-5}	16 to 210	1.60(25)
CCl_4	Carbon tetrachloride	-13.03	2290.0	233.9	-2.011×10^{-5}	-20 to 283	0.86(25)
CO	Carbon monoxide	-5.402	242.2	1.062×10^{-2}	-4.522×10^{-5}	-200 to 140	0.21(-200)
CO_2	Carbon dioxide	-3.097	48.86	2.381×10^{-2}	-7.840×10^{-5}	-56 to 30	0.06(25)
$CHCl_3$	Chloroform	-4.172	915.3	2.70×10^{-3}	-4.108×10^{-6}	-63 to 263	0.52(25)

Formula	***Name***	***A***	***B***	***C***	***D***	***Temperature range, ⁰C***	***η, cP(at °C)***
CH_4	Methane	-26.87	1150.0	1.871×10^{-1}	-5.211×10^{-4}	-180 to -84	0.14(-170)
CH_4O	Methanol	-39.35	4826.0	1.091×10^{-1}	-1.127×10^{-4}	-40 to 239	0.55(25)
C_2H_4	Ethylene	-17.74	1078.0	8.577×10^{-2}	-1.758×10^{-4}	-169 to 9	0.031(0)
C_2H_4O	Ethylene oxide	-3.864	719.3	7.44×10^{-4}	-1.805×10^{-6}	-112 to 195	0.25(25)
C_2H_6	Ethane	-1.023	668.0	4.386×10^{-2}	-9.588×10^{-5}	-183 to 32	0.032(25)
C_2H_6O	Ethanol	-6.210	1614.0	6.18×10^{-3}	-1.132×10^{-5}	-105 to 243	1.04(25)
C_3H_6	Propylene	-11.53	951.4	4.078×10^{-2}	-7.120×10^{-5}	-160 to 91	0.081(25)
C_3H_6	Cyclo propane	-3.074	267.6	2.55×10^{-4}	-8.83×10^{-8}	-127 to 124	0.12(25)
C_3H_7O	Propylene oxide	-2.717	700.0	-4.384×10^{-3}	5.363×10^{-6}	-112 to 209	0.30(25)
C_3H_8	Propane	-7.764	721.9	2.381×10^{-2}	-4.665×10^{-5}	-187 to 96	0.091(25)
C_3H_8O	n-Propanol	-12.28	2666.0	2.008×10^{-2}	-2.233×10^{-5}	-72 to 260	1.94(25)
C_4H_8	1-Butene	-10.63	981.6	3.525×10^{-2}	-5.593×10^{-5}	-140 to 146	0.17(25)
C_4H_8	Iso butylene	-6.477	813.5	1.320×10^{-2}	-2.438×10^{-5}	-140 to 144	0.14(25)
C_4H_8	Cyclo butane	-4.541	672.4	3.27×10^{-3}	-3.928	-90 to 190	0.19(25)
$C_4H_{10}O$	N – Butanol	-9.722	260.2	9.53×10^{-3}	-9.966×10^{-6}	-60 to 289	2.61(25)
C_5H_8	Isoprene	-2.228	635.7	$- 7.32 \times 10^{-3}$	7.665×10^{-6}	-146 to 210	0.20(25)
C_5H_{10}	Cyclo pentane	-6.021	1118.0	7.28×10^{-3}	-8.662×10^{-6}	-90 to 235	0.42(25)
C_6H_5Cl	Chloro benzene	-4.573	1196.0	1.37×10^{-3}	-1.378×10^{-6}	-45 to 350	0.76(25)
C_6H_6	Benzene	4.612	148.9	-2.544×10^{-2}	2.222×10^{-5}	6 to 288	0.61(25)
C_6H_6O	Phenol	-1.851	4350.0	2.429×10^{-2}	-1.547×10^{-5}	41 to 420	3.25(50)
C_6H_7N	Aniline	3.569	-32370	- 1.254	1.428×10^{-3}	-6 to 50	3.93(25)
C_6H_{12}	Cyclo hexane	-4.398	1380.0	$- 1.55 \times 10^{-3}$	1.157×10^{-6}	7 to 280	0.88(25)
C_7H_8	Toluene	-5.878	1287.0	4.575×10^{-3}	-4.449×10^{-6}	-40 to 315	0.55(25)
C_8H_8	Styrene	-2.717	946.1	- 3.173	1.683×10^{-6}	-30 to 360	0.71(25)
C_8H_{10}	O – Xylene	-3.332	1039.0	1768.0	1.076×10^{-6}	-25 to 350	0.76(25)
C_8H_{10}	M – Xylene	-3.820	1027.0	$- 6.38 \times 10^{-4}$	4.52×10^{-7}	-47 to 340	0.60(25)
C_8H_{10}	P – Xylene	-7.790	1580.0	8.73×10^{-3}	-6.735×10^{-6}	13 to 340	0.61(25)
C_8H_{10}	Ethyl benzene	-6.106	1353.0	5.112×10^{-3}	-4.552×10^{-6}	-40 to 340	0.64(25)
C_9H_{12}	Iso propyl benzene	-8.292	1700.0	1.003×10^{-2}	-7.829×10^{-6}	-20 to 360	0.74(25)

Table 4.19. Values of the coefficients of Eq. (4.40): $\log \eta = A' + \left(B'/T\right) + C'T + D'T^2$ for the polynomial representation of viscosity [Viscosity (η) in cP and Temperature in K]. From: C. L. Yaws, X. Lin and L. Bu, Calculate viscosities for 355 liquids, *Chem.Eng.* **101**(4) 119-20, 122, 124, 126, 128, (1994).

Formula	***Name***	A'	B'	C'	D'	***Temperature Range, K***
C_5Cl_6	Hexa chloro cyclotadiene	-10.4172	2.1941 x 10^{3}	1.6514 x 10^{-2}	-1.0745 x 10^{-5}	298 to 746
$C_5H_4O_2$	Furfural	-0.6087	2.8604 x 10^{2}	4.5345 x 10^{-4}	-3.0939 x 10^{-6}	273 to 657
C_5H_5N	Pyridine	-6.8100	1.1496 x 10^{3}	1.3229 x 10^{-2}	-1.1661 x 10^{-5}	232 to 620
C_5H_6	Cyclo penta diene	- 5.6949	6.5093 x 10^{2}	1.5245 x 10^{-2}	-1.7940 x 10^{-5}	188 to 507
C_5H_6	2 – Methyl – 1– butene – 3 – yne	- 2.9024	3.8325 x 10^{2}	6.6626 x 10^{-3}	-1.0295 x 10^{-5}	160 to 492
C_5H_6	1 – Pentene – 3 - yne	-3.6138	4.8914 x 10^{2}	7.2390 x 10^{-3}	-8.8128 x 10^{-6}	150 to 520
C_5H_6	1 – Pentene – 4 - yne	-3.0207	3.9788 x 10^{2}	7.0631 x 10^{-3}	-1.0509 x 10^{-5}	150 to 503
$C_5H_6N_2$	Glutano nitrile	-8.1374	1.8110 x 10^{3}	1.1719 x 10^{-2}	-7.6393 x 10^{-6}	244 to 782
$C_5H_6O_2$	Furfuryl alcohol	-12.3697	2.2704 x 10^{3}	2.3717 x 10^{-2}	-1.8564 x 10^{-5}	259 to 632
$C_5H_6O_3$	Glutaric anhydride	-8.9237	1.7641 x 10^{3}	1.2843 x 10^{-2}	-7.1214 x 10^{-6}	328 to 838
$C_5H_6O_4$	Citraconic acid	-26.2612	5.2278 x 10^{3}	4.2998 x 10^{-2}	-2.4625 x 10^{5}	356 to 829
$C_5H_6O_4$	Itaconic acid	-10.8903	2.8916 x 10^{3}	1.1869 x 10^{-2}	-5.2006 x 10^{-6}	439 to 821
C_5H_7N	n – Methyl pyrrole	-9.0619	2.8916 x 10^{3}	-1.1876 x 10^{-3}	-3.1716 x 10^{-6}	217 to 610
$C_5H_7NO_2$	Ethyl cyano acetate	-14.7933	3.6968 x 10^{2}	2.7355 x 10^{-2}	-1.9234 x 10^{-5}	251 to 679
C_5H_8	Cyclo pentene	-3.1576	2.5859 x 10^{3}	6.8491 x 10^{-3}	-9.1013 x 10^{-6}	138 to 507
C_5H_8	Isoprene	-9.9164	1.0172 x 10^{3}	2.9353 x 10^{-2}	-3.2692 x 10^{-5}	273 to 484
C_5H_8	3 – Methyl – 1,2 - butadiene	-5.0944	5.6342 x 10^{2}	1.3413 x 10^{-2}	1.6605 x 10^{-5}	160 to 490
C_5H_8	1,2 – Penta diene	-3.7920	4.2763 x 10^{2}	9.2560 x 10^{-3}	1.2181 x 10^{-5}	136 to 500

Formula	***Name***	*A′*	*B′*	*C′*	*D′*	***Temperature Range, K***
C_5H_8	Cis – 1,3 – Penta diene	-5.3378	5.8984 x 10^{2}	1.3932 x 10^{-2}	1.6748 x 10^{-5}	186 to 499
C_5H_8	Trans - 1,3 – Penta diene	-5.8162	6.5547 x 10^{2}	1.4971 x 10^{-2}	1.7425 x 10^{-5}	222 to 500
C_5H_8	1,4 – Penta diene	-2.6680	3.3442 x 10^{2}	5.2181 x 10^{-3}	-8.2626 x 10^{-6}	125 to 479
C_5H_8	2,3 – Penta diene	-4.7505	5.1167 x 10^{2}	1.2667 x 10^{-2}	1,5930 x 10^{-5}	148 to 497
C_5H_8	1 – Pentyne	-2.8855	3.9387 x 10^{2}	7.4684 x 10^{-3}	1.2463 x 10^{-5}	167 to 481
C_5H_8	3 – Methyl – 1- butyne	-2.6844	3.6528 x 10^{2}	7.3057 x 10^{-3}	-1.3270 x 10^{-5}	183 to 463
C_5H_8O	Cyclo pentanone	-53.1880	8.1650 x 10^{3}	1.1041 x 10^{-1}	-7.9251 x 10^{-5}	288 to 626
C_5H_8O	Methyl iso propenyl ketone	-7.3478	1.0035 x 10^{3}	1.7021 x 10^{-2}	-1.6781 x 10^{-5}	220 to 566
$C_5H_8O_2$	Acetyl acetone	-8.8988	1.3244 x 10^{3}	2.0022 x 10^{-2}	-1.8365 x 10^{-5}	273 to 602
$C_5H_8O_2$	Allyl acetate	-8.8594	1.2199 x 10^{3}	2.1012 x 10^{-2}	-2.0417 x 10^{-5}	240 to 559
$C_5H_8O_2$	Ethyl acrylate	-5.5960	8.1055 x 10^{2}	1.2995 x 10^{-2}	-1.4271 x 10^{-5}	250 to 553
$C_5H_8O_2$	Methyl methacrylate	-4.7825	7.3478 x 10^{2}	1.0258 x 10^{-2}	-1.1343 x 10^{-5}	260 to 564
$C_5H_8O_2$	Vinyl Propionate	-6.3902	9.2664 x 10^{2}	1.4476 x 10^{-2}	-1.5129 x 10^{-5}	230 to 546
$C_5H_8O_3$	2 – Hydroxy – ethyl acrylate	-20.5844	3.8501 x 10^{3}	3.6430 x 10^{-2}	-2.4036 x 10^{-5}	260 to 662
$C_5H_8O_3$	Levulinic acid	-21.8785	3.8805 x 10^{3}	4.0538 x 10^{-2}	-2.6906 x 10^{-5}	308 to 723
$C_5H_8O_3$	Methyl aceto acetate	-4.8619	9.5371 x 10^{2}	8.8042 x 10^{-3}	-8.6041 x 10^{-6}	210 to 642
$C_5H_8O_4$	Glutaric acid	-23.2118	4.5522 x 10^{3}	2.3667 x 10^{-5}	-2.3667 x 10^{-5}	371 to 807
C_5H_9N	Valero nitrile	-4.9993	8.1288 x 10^{2}	1.0342 x 10^{-2}	-1.0939 x 10^{-5}	275 to 603
C_5H_9NO	n – Methyl – 2 –pyrrolidone	-11.7394	2.0342 x 10^{4}	2.1569 x 10^{-2}	-1.5109 x 10^{-5}	249 to 724
$C_5H_9NO_4$	L - Glutamic acid	-60.7700	1.4128 x 10^{4}	8.4987 x 10^{-2}	-4.0318 x 10^{-5}	497 to 886
C_5H_{10}	Cyclo pentane	-0.5385	2.5255 x 10^{2}	-2.3007 x 10^{-3}	-2.3062 x 10^{-7}	225 to 512
C_5H_{10}	2 – Methyl – 1 – butene	-3.3641	4.2134 x 10^{2}	7.7836 x 10^{-3}	-1.1733 x 10^{-5}	136 to 465

Formula	***Name***	*A′*	*B′*	*C′*	*D′*	***Temperature Range, K***
C_5H_{10}	2 – Methyl – 2 – butene	-3.9960	4.7505×10^{2}	9.9954×10^{-3}	-1.3953×10^{-5}	139 to 471
C_5H_{10}	3 – Methyl – 1 – butene	-8.7648	1.0250×10^{3}	2.3732×10^{-2}	-2.7510×10^{-5}	273 to 450
C_5H_{10}	1 – Pentene	-5.5640	6.1906×10^{2}	1.5123×10^{-2}	-1.9316×10^{-5}	175 to 465
C_5H_{10}	Cis – 2 - Pentene	-3.4667	4.1022×10^{2}	8.4927×10^{-3}	-1.2319×10^{-5}	122 to 476
C_5H_{10}	Trans – 2 - Pentene	-3.7334	4.3487×10^{2}	9.3927×10^{-3}	-1.3291×10^{-5}	133 to 475
$C_5H_{10}Cl_2$	1,5 – Dichloro pentane	-2.8380	6.8497×10^{2}	3.8366×10^{-3}	-4.5639×10^{-6}	200 to 663
$C_5H_{10}O$	Methyl iso propyl ketone	-5.5433	7.9650×10^{2}	1.2368×10^{-2}	-1.3239×10^{-5}	181 to 553
$C_5H_{10}O$	2 – Pentanone	-7.4145	1.0492×10^{2}	1.6999×10^{-2}	-1.6941×10^{-5}	250 to 561
$C_5H_{10}O$	Diethyl ketone	-9.2905	1.2716×10^{3}	2.1925×10^{-2}	-2.1036×10^{-5}	274 to 561
$C_5H_{10}O$	Valeraldehyde	-2.4006	4.6830×10^{3}	4.0666×10^{-3}	-6.6593×10^{-6}	182 to 554
$C_5H_{10}O_2$	n – Butyl formate	-6.2873	9.9161×10^{2}	1.3347×10^{-2}	-1.3623×10^{-5}	250 to 559
$C_5H_{10}O_2$	Ethyl propionate	-7.3410	1.0413×10^{3}	1.7121×10^{-2}	-1.7852×10^{-5}	250 to 546
$C_5H_{10}O_2$	Iso butyl formate	-9.8983	1.4374×10^{3}	2.2751×10^{-2}	-2.1524×10^{-5}	289 to 551
$C_5H_{10}O_2$	Iso propyl acetate	-5.3287	8.2209×10^{2}	1.1484×10^{-2}	-1.2697×10^{-5}	216 to 538
$C_5H_{10}O_2$	n – Propyl acetate	-8.7395	1.0376×10^{3}	1.1484×10^{-2}	-1.2697×10^{-5}	293 to 549
$C_5H_{10}O_2$	Methyl – n - butyrate	-5.2565	8.0396×10^{2}	1.1391×10^{-2}	-1.2415×10^{-5}	200 to 555
$C_5H_{10}O_2$	2 – Methyl - butyric acid	-9.1382	1.6081×10^{3}	1.7951×10^{-2}	$- 1.1318 \times 10^{-5}$	298 to 643
$C_5H_{10}O_2$	Isovaleric acid	-6.7505	1.2740×10^{2}	1.2636×10^{-2}	-1.1318×10^{-5}	244 to 634
$C_5H_{10}O_2$	Valeric acid	-7.9425	1.4583×10^{3}	1.5088×10^{-2}	-1.2781×10^{-5}	288 to 651
$C_5H_{10}O_2$	Tetra hydro furfuryl alcohol	-19.7007	3.4266×10^{3}	3.7490×10^{-2}	-2.6468×10^{-5}	250 to 639
$C_5H_{10}O_2S$	3 – Methyl sulfolane	-5.1223	1.4211×10^{3}	5.9806×10^{-3}	-4.0278×10^{-6}	290 to 817
$C_5H_{10}O_3$	Diethyl carbonate	-6.9038	1.0458×10^{3}	1.5802×10^{-2}	-1.6047×10^{-5}	250 to 576
$C_5H_{10}O_3$	Ethyl lactate	-20.0105	3.2123×10^{3}	4.1891×10^{-2}	-3.2733×10^{-5}	247 to 588

Formula	***Name***	***A′***	***B′***	***C′***	***D′***	***Temperature Range, K***
$C_5H_{11}Cl$	1 – Chloro pentane	-3.9553	6.5614×10^{2}	7.6907×10^{-3}	8.8986×10^{-6}	174 to 568
$C_5H_{11}N$	n – Methyl pyrrolidone	-5.2640	8.7099×10^{2}	9.7493×10^{-3}	-9.7536×10^{-6}	183 to 550
$C_5H_{11}N$	Pipreidene	-0.5054	4.9531×10^{2}	-4.1245×10^{-3}	2.5391×10^{-6}	285 to 594
$C_5H_{11}NO$	Tert – Butyl formamide	11.3399	-1.0643×10^{3}	-2.8136×10^{-2}	1.7528×10^{-5}	289 to 692
C_5H_{12}	Iso pentane	-5.8108	7.0656×10^{2}	1.4826×10^{-2}	-1.8547×10^{-5}	210 to 460
C_5H_{12}	Neo pentane	-4.6261	7.8569×10^{2}	6.8775×10^{-3}	-8.1947×10^{-6}	258 to 434
C_5H_{12}	n – Pentane	-7.1711	7.4736×10^{2}	2.1697×10^{-2}	-2.7176×10^{-5}	143 to 470
$C_5H_{12}O$	2,2 – Dimethyl – 1 –propanol	-21.3537	4.0439×10^{3}	3.7271×10^{-2}	-2.3735×10^{-5}	327 to 550
$C_5H_{12}O$	2 – Methyl – 1 –butanol	-13.3823	2.5243×10^{3}	2.4256×10^{-2}	-1.9091×10^{-5}	273 to 546
$C_5H_{12}O$	2 – Methyl – 2 –butanol	-25.3557	4.2312×10^{3}	5.0802×10^{-2}	-3.8373×10^{-5}	264 to 545
$C_5H_{12}O$	3 – Methyl – 1 –butanol	-7.9943	1.7691×10^{3}	11475×10^{-2}	-8.9300×10^{-6}	273 to 579
$C_5H_{12}O$	3 – Methyl – 2 – butanol	-4.7191	1.3883×10^{3}	1.6744×10^{-3}	2.9612×10^{-7}	250 to 574
$C_5H_{12}O$	1 – Pentanol	-6.9286	1.5609×10^{3}	9.9633×10^{-3}	-8.3534×10^{-6}	253 to 586
$C_5H_{12}O$	2 – Pentanol	-21.4761	3.5740×10^{3}	4.3957×10^{-2}	-3.4712×10^{-5}	250 to 552
$C_5H_{12}O$	3 – Pentanol	-2.8804	1.1077×10^{3}	-1.8779×10^{-3}	2.1199×10^{-6}	222 to 547
$C_5H_{12}O$	Methyl – sec –butyl ether	-5.0497	6.4203×10^{2}	1.2303×10^{-2}	-1.4886×10^{-5}	150 to 498
$C_5H_{12}O$	Methyl – tert – butyl ether	-9.7896	1.2002×10^{3}	2.6168×10^{-2}	-2.8297×10^{-5}	219 to 497
$C_5H_{12}O$	Methyl iso butyl ether	-4.3746	5.8318×10^{2}	1.0287×10^{-2}	-1.3123×10^{-5}	150 to 497
$C_5H_{12}O$	Ethyl propyl ether	-5.7475	7.2196×10^{2}	1.4612×10^{-2}	-1.7401×10^{-5}	200 to 500
$C_5H_{12}O_2$	Ethylene glycol mono propyl ether	-70.1674	1.6490×10^{3}	1.1781×10^{-2}	-9.5068×10^{-6}	224 to 582
$C_5H_{12}O_2$	Neo pentyl glycol	-70.0464	1.2205×10^{3}	1.3211×10^{-1}	-8.4759×10^{-5}	400 to 643
$C_5H_{12}O_2$	1,5 – Pentane diol	-7.0464	2.3070×10^{3}	5.2107×10^{-3}	-2.3581×10^{-6}	263 to 673

Formula	***Name***	*A′*	*B′*	*C′*	*D′*	***Temperature Range, K***
$C_5H_{12}O_3$	2 - (Methoxy ethoxy) ethanol	-9.0629	1.7101 x 10^3	1.7174 x 10^{-2}	-1.4454 x 10^{-5}	240 to 630
$C_5H_{12}O_4$	Penta erythritol	50.8517	-1.1053 x 10^4	-7.2356 x 10^{-2}	3.0441 x 10^{-5}	534 to 780
$C_5H_{12}S$	n – Pentyl mercaptan	-4.6076	7.4223 x 10^2	9.1728 x 10^{-3}	-9.5706 x 10^{-6}	197 to 598
$C_5H_{13}N$	n – Pentyl amine	-6.7617	1.1650 x 10^3	1.3126 x 10^{-2}	-1.2846 x 10^{-5}	218 to 555
$C_5H_{13}NO_2$	Methyldiethanol amine	-12.0930	2.9675 x 10^3	1.6516 x 10^{-2}	-1.0129 x 10^{-5}	252 to 678
C_6Cl_6	Hexachlorobenzene	-33.4785	7.1609 x 10^3	5.2053 x 10^{-2}	-2.8454 x 10^{-5}	502 to 825
C_6F_6	Hexafluorobenzene	26.0147	-2.4756 x 10^3	-7.7839 x 10^{-2}	6.7076 x 10^{-5}	278 to 517
$C_6H_3ClNO_2O_4$	1-Chloro - 2,4 –dinitro benzene	-18.8604	3.8454 x 10^3	3.0491 x 10^{-2}	-1.7891 x 10^{-5}	327 to 814
$C_6H_3Cl_2NO_2$	1,2 – Dichloro – 4 –nitro benzene	-16.9196	3.2771 x 10^3	2.9025 x 10^{-2}	-1.8435 x 10^{-5}	316 to 758
$C_6H_3Cl_3$	1,2,4 –Tri chloro benzene	-7.5691	1.4901 x 10^3	1.3010 x 10^{-2}	-9.7071 x 10^{-6}	290 to 725
$C_6H_3N_3O_6$	1,3,5 – Tri nitro benzene	-25.8759	6.0592 x 10^3	3.4686 x 10^{-2}	-1.5994 x 10^{-5}	398 to 1005
$C_6H_4Br_2$	m – Di bromo benzene	-11.7673	2.1521 x 10^3	2.0981 x 10^{-2}	-1.3972 x 10^{-5}	266 to 761
$C_6H_4ClNO_2$	m – Chloro nitro benzene	-7.4607	1.4381 x 10^3	1.3542 x 10^{-2}	-1.0431 x 10^{-5}	318 to 742
$C_6H_4ClNO_2$	o – Chloro nitro benzene	-15.4421	2.8372 x 10^3	2.7503 x 10^{-2}	-1.8034 x 10^{-5}	306 to 757
$C_6H_4ClNO_2$	p – Chloro nitro benzene	-20.9286	3.7707 x 10^3	3.8037 x 10^{-2}	-2.4626 x 10^{-5}	357 to 751
$C_6H_4Cl_2$	m – Di chloro benzene	-4.6414	8.2076 x 10^2	8.8567 x 10^{-3}	-8.1810 x 10^{-6}	248 to 684
$C_6H_4Cl_2$	o – Di chloro benzene	-3.8623	7.8030 x 10^2	6.3271 x 10^{-3}	-5.8508 x 10^{-6}	256 to 705
$C_6H_4Cl_2$	p – Di chloro benzene	-6.6362	1.1967 x 10^3	1.2224 x 10^{-2}	-9.9914 x 10^{-6}	326 to 685
$C_6H_4N_2O_4$	m – Di nito benzene	-8.5112	1.8823 x 10^3	1.3927 x 10^{-2}	-9.7139 x 10^{-6}	364 to 805
$C_6H_4N_2O_4$	o – Di nitro benzene	-22.2948	4.6876 x 10^3	3.5439 x 10^{-2}	-2.0308 x 10^{-5}	390 to 831

Formula	***Name***	*A′*	*B′*	*C′*	*D′*	***Temperature Range, K***
$C_6H_4N_2O_4$	p – Di nitro benzene	-25.9514	5.3986×10^{3}	4.2022×10^{-2}	-2.4436×10^{-5}	447 to 803
C_6H_5Br	Bromo benzene	-6.5135	1.0984×10^{3}	1.2749×10^{-2}	-1.0749×10^{-5}	242 to 670
C_6H_5Cl	Chloro benzene	-4.8717	8.2340×10^{2}	0.1981×10^{-3}	-8.6530×10^{-6}	250 to 632
C_6H_5ClO	m – Chloro phenol	-39.6221	6.8879×10^{3}	7.3543×10^{-2}	-4.6375×10^{-5}	306 to 729
C_6H_5ClO	o – Chloro phenol	-15.0741	2.6314×10^{3}	2.9170×10^{-2}	-2.1317×10^{-5}	282 to 675
C_6H_5ClO	p – Chloro phenol	-16.6697	3.2044×10^{3}	2.9330×10^{-2}	-1.9280×10^{-5}	316 to 738
$C_6H_5Cl_2N$	3,4 –Di chloro aniline	15.9808	3.0119×10^{3}	2.4746×10^{-2}	-1.3793×10^{-5}	345 to 800
C_6H_5F	Fluoro benzene	-6.5062	9.7585×10^{2}	1.4152×10^{-2}	-1.4056×10^{-5}	232 to 560
C_6H_5I	Iodo benzene	-6.7338	1.2140×10^{3}	1.2409×10^{-2}	-9.6198×10^{-6}	242 to 721
$C_6H_5NO_2$	Nitro benzene	-7.7710	1.4019×10^{3}	1.4653×10^{-2}	1.1512 x 10-5	273 to 719
C_6H_6	Benzene	-7.4005	1.1815×10^{3}	1.4888×10^{-2}	-1.3713×10^{-5}	285 to 562
C_6H_6ClN	m – Chloro aniline	-14.2377	2.6141×10^{3}	2.4952×10^{-2}	-1.6249×10^{-5}	263 to 751
C_6H_6ClN	o – Chloro aniline	-12.7917	2.3163×10^{3}	2.3236×10^{-2}	-1.6047×10^{-5}	271 to 722
C_6H_6ClN	p – Chloro aniline	-10.8969	2.0918×10^{3}	1.9036×10^{-2}	-1.3102×10^{-5}	328 to 754
$C_6H_6N_2$	Cis – Di cyano – 1 – butene	-9.4027	2.0397×10^{3}	1.4323×10^{-2}	-9.9881×10^{-6}	249 to 691
$C_6H_6N_2$	Trans – Di cyano – 1 –butene	-10.3176	2.1809×10^{3}	1.6236×10^{-2}	-1.1299×10^{-5}	260 to 689
$C_6H_6N_2$	1,4 – Di cyano – 2 – butene	-30.6811	5.7439×10^{3}	5.3148×10^{-2}	-3.2357×10^{-5}	349 to 755
$C_6H_6N_2O_2$	m – Nitro aniline	-21.4002	4.5473×10^{3}	3.0755×10^{-2}	-1.5638×10^{-5}	387 to 815
$C_6H_6N_2O_2$	o – Nitro aniline	-15.2760	3.2868×10^{3}	2.1290×10^{-2}	-1.0953×10^{-5}	345 to 784
$C_6H_6N_2O_2$	p – Nitro aniline	-16.5136	3.7808×10^{3}	2.1340×10^{-2}	-1.0131×10^{-5}	421 to 851
C_6H_6O	Phenol	1.5349	4.2620×10^{2}	-9.1577×10^{-3}	6.2322×10^{-6}	318 to 694
$C_6H_6O_2$	1,2 – Benzene diol	-24.7533	4.8589×10^{3}	4.2834×10^{-2}	-2.6506×10^{-5}	385 to 764

Formula	***Name***	***A′***	***B′***	***C′***	***D′***	***Temperature Range, K***
$C_6H_6O_2$	1,3 – Benzene diol	-26.2943	5.6833 x 10^{3}	4.1514 x 10^{-2}	-2.3604 x 10^{-5}	400 to 810
$C_6H_6O_2$	P – Hydro quinone	-67.2454	1.5146 x 10^{4}	9.9970 x 10^{-2}	-5.1078 x 10^{-5}	445 to 822
$C_6H_6O_3$	1,2,3 – Benzene triol	2.2220	1.2238 x 10^{3}	-1.0975 x 10^{-2}	6.4587 x 10^{-6}	407 to 830
C_6H_6S	Phenyl mercaptan	-3.7030	7.2932 x 10^{2}	6.1906 x 10^{-3}	-5.9690 x 10^{-6}	258 to 689
C_6H_7N	Aniline	-13.8625	2.5109 x 10^{3}	2.5681 x 10^{-2}	-1.8281 x 10^{-5}	268 to 699
C_6H_7N	2 – Methyl pyridine	-5.4649	9.1344 x 10^{2}	1.0641 x 10^{-2}	-1.0072 x 10^{-5}	220 to 621
C_6H_7N	3 – Methyl pyridine	-10.9953	1.7608 x 10^{3}	2.2185 x 10^{-2}	-1.7629 x 10^{-5}	293 to 645
C_6H_7N	4 – Methyl pyridine	-8.2356	1.3239 x 10^{3}	1.6712 x 10^{-2}	-1.4085 x 10^{-5}	277 to 646
C_6H_8	1,3 –Cyclo hexa diene	-3.1367	5.9143 x 10^{2}	4.8065 x 10^{-3}	-5.9644 x 10^{-6}	180 to 558
C_6H_8	Methyl cyclo penta diene	-3.3654	5.2704 x 10^{2}	5.7171 x 10^{-3}	-6.6472 x 10^{-6}	150 to 541
$C_6H_8N_2$	Adipo nitrile	0.4949	4.1398 x 10^{2}	-4.2058 x 10^{-3}	1.5475 x 10^{-6}	276 to 781
$C_6H_8N_2$	Methyl glutaro nitrile	-4.3436	1.0468 x 10^{3}	6.5095 x 10^{-3}	-5.9407 x 10^{-6}	228 to 742
$C_6H_8N_2$	m – Phenylene diamine	-44.9990	8.9345 x 10^{3}	7.3255 x 10^{-2}	-4.0464 x 10^{-5}	363 to 824
$C_6H_8N_2$	o – Phenylene diamine	-12.6956	2.8298 x 10^{3}	1.9504 x 10^{-2}	-1.2084 x 10^{-5}	377 to 781
$C_6H_8N_2$	p – Phenylene diamine	-18.6581	3.9059 x 10^{3}	3.0083 x 10^{-2}	-1.8039 x 10^{-5}	413 to 796
$C_6H_8N_2$	Phenyl hydrazene	-29.5908	5.2240 x 10^{3}	5.4755 x 10^{-2}	-3.5011 x 10^{-5}	292 to 761
$C_6H_8N_2O$	Bis (Cyano ethyl) ether	-4.7689	1.2262 x 10^{3}	7.0649 x 10^{-3}	-6.0124 x 10^{-6}	247 to 783
$C_6H_8O_4$	Di methyl maleate	-2.1332	6.7918 x 10^{2}	2.3965 x 10^{-3}	-3.8790 x 10^{-6}	254 to 675
C_6H_{10}	Cyclo hexane	-4.4683	8.1472 x 10^{2}	7.3925 x 10^{-3}	7.7551 x 10^{-6}	273 to 560
C_6H_{10}	2,3 – Di methyl -1,3 – buta diene	-5.6382	6.9686 x 10^{2}	1.3722 x 10^{-2}	-1.5374 x 10^{-5}	197 to 526
C_6H_{10}	1,5 – Hexa diene	-3.6271	4.6186 x 10^{2}	8.2645 x 10^{-3}	-1.0973 x 10^{-5}	132 to 507

Formula	***Name***	*A′*	*B′*	*C′*	*D′*	***Temperature Range, K***
C_6H_{10}	Cis,trans -2,4 – Hexa diene	-6.1222	7.2326×10^{2}	1.5438	-1.6909×10^{-5}	177 to 538
C_6H_{10}	Trans,trans -2,4 –Hexa diene	-9.7857	1.1547×10^{3}	2.5456×10^{-2}	-2.5786×10^{-5}	228 to 535
C_6H_{10}	1 – Hexyne	-3.0390	4.3910×10^{2}	7.8827×10^{-3}	-1.2220×10^{-5}	141 to 516
C_6H_{10}	2 – Hexyne	-3.4983	5.3680×10^{2}	7.0308×10^{-3}	-8.9311×10^{-6}	184 to 549
C_6H_{10}	3 – Hexyne	-3.2573	5.0738×10^{2}	6.4200×10^{-3}	-8.5118×10^{-6}	170 to 544
$C_6H_{10}O$	Cyclo hexa none	-3.5761	9.3118×10^{2}	3.6856×10^{-3}	-3.7510×10^{-6}	275 to 629
$C_6H_{10}O$	Mesityl oxide	-5.4305	8.4932×10^{2}	1.1426×10^{-2}	-1.1624×10^{-5}	220 to 600
$C_6H_{10}O_2$	Epsolon Capro notrile	-7.5834	1.3332×10^{3}	1.2604×10^{-2}	-8.4577×10^{-6}	272 to 771
$C_6H_{10}O_2$	Ethyl methacrylate	-8.0496	1.1661×10^{3}	1.7964×10^{-2}	-1.6967×10^{-5}	223 to 577
$C_6H_{10}O_2$	n – Propyl acrylate	-11.6479	1.6509×10^{3}	2.7040×10^{-2}	-2.4607×10^{-5}	273 to569
$C_6H_{10}O_3$	Ethyl aceto acetate	-7.6190	1.3438×10^{3}	1.4739×10^{-2}	-1.2640×10^{-5}	234 to 643
$C_6H_{10}O_3$	Propionic anhydride	-11.7549	1.7933×10^{3}	2.5883×10^{-2}	-2.2100×10^{-5}	273 to 618
$C_6H_{10}O_4$	Adipic acid	-54.8285	1.1789×10^{4}	8.5563×10^{-2}	-4.6275×10^{-5}	433 to 809
$C_6H_{10}O_4$	Diethyl oxalate	-14.8918	2.4136×10^{3}	3.0683×10^{-2}	-2.3887×10^{-5}	260 to 646
$C_6H_{10}O_4$	Ethylene glycol di acetate	-3.1566	8.0484×10^{2}	4.5706×10^{-3}	-5.4906×10^{-6}	242 to 653
$C_6H_{10}O_4$	Ethyledene di acetate	-14.8918	2.3887×10^{3}	3.0890×10^{-2}	-2.4126×10^{-5}	292 to 635
$C_6H_{11}N$	Hexane nitrile	-3.1566	8.6235×10^{2}	9.0581×10^{-3}	-9.2062×10^{-6}	193 to 622
$C_6H_{11}NO$	Epsilon - Caprolactum	-21.8927	4.6844×10^{3}	3.4249×10^{-2}	-1.9662×10^{-5}	342 to 806
C_6H_{12}	Cyclo hexane	4.7423	-2.5322×10^{2}	-1.6927×10^{-2}	1.2472×10^{-5}	285 to 554
C_6H_{12}	2,3 – Dinethyl – 1 – butene	-3.0632	4.3429×10^{2}	6.0597×10^{-3}	-8.7246×10^{-6}	116 to 500
C_6H_{12}	2,3 – Dimethyl - 2- butene	-6.1147	7.5638×10^{2}	1.4993×10^{-2}	-1.6622×10^{-5}	199 to 524
C_6H_{12}	3,3 – Dimethyl –1 –butene	-3.5056	4.7789×10^{2}	7.6202×10^{-3}	-1.0831×10^{-5}	158 to 480

Formula	***Name***	*A′*	*B′*	*C′*	*D′*	***Temperature Range, K***
C_6H_{12}	2 – Ethyl – 1 - butene	-3.6762	4.9545×10^{2}	7.9274×10^{-3}	1.0337×10^{-5}	142 to 512
C_6H_{12}	1 – Hexene	-6.3469	7.8976×10^{2}	1.5694×10^{-2}	-1.7747×10^{-5}	218 to 504
C_6H_{12}	Cis – 2 - Hexene	-3.5211	4.7446×10^{2}	7.7214×10^{-3}	-1.0351×10^{-5}	132 to 513
C_6H_{12}	Trans - 2 - Hexene	-3.6519	4.8838×10^{2}	8.0942×10^{-3}	-1.0694×10^{-5}	140 to 513
C_6H_{12}	Cis – 3 - Hexene	-3.6154	4.8261×10^{2}	8.0850×10^{-3}	-1.0837×10^{-5}	135 to 509
C_6H_{12}	Trans – 3 - Hexene	-4.3388	5.5486×10^{2}	1.0354×10^{-2}	$-1,3080 \times 10^{-5}$	160 to 509
C_6H_{12}	Methyl cyclo pentane	-1.0639	3.1769×10^{2}	-4.7988×10^{-4}	-2.0504×10^{-6}	248 to 533
C_6H_{12}	2 – Methyl – 1 – pentene	-8.1875	1.0565×10^{3}	1.9948×10^{-2}	-2.0963×10^{-5}	230 to 507
C_6H_{12}	2 – Methyl – 2 – pentene	-3.7409	4.9959×10^{2}	8.1854×10^{-3}	-1.0587×10^{-5}	138 to 514
C_6H_{12}	3 – Methyl – 1 – pentene	-3.3186	4.5588×10^{2}	7.0761×10^{-3}	-9.9805×10^{-6}	120 to 495
C_6H_{12}	3 - Methyl - cis - 2 – pentene	-3.9620	5.1828×10^{2}	8.9503×10^{-3}	-1.1310×10^{-5}	138 to 515
C_6H_{12}	4 – Methyl – 1 –pentene	-3.1323	4.4203×10^{2}	6.3382×10^{-3}	-1.0661×10^{-6}	120 to 496
C_6H_{12}	4 – Methtyl –cis – 2 –pentene	-3.6002	4.8538×10^{2}	7.8742×10^{-3}	-9.6896×10^{-5}	138 to 499
C_6H_{12}	4 – Methyl – trans – 2 –pentene	-3.3633	4.6465×10^{2}	7.0194×10^{-3}	-4.9208×10^{-6}	132 to 501
$C_6H_{12}N_2$	Tri ethylene diamine	11.5928	-2.4836×10^{3}	-1.7095×10^{-2}	-1.1890×10^{-5}	434 to 655
$C_6H_{12}O$	Butyl vinyl ether	-4.7429	7.1709×10^{3}	1.0233×10^{-2}	-1.1890×10^{-5}	181 to 536
$C_6H_{12}O$	Cyclo hexanal	-5.3792	1.8793×10^{3}	1.7011×10^{-3}	1.0187×10^{-7}	303 to 625
$C_6H_{12}O$	1 – Hexanal	-1.5906	3.8705×10^{2}	2.1713×10^{-3}	-5.0434×10^{-6}	217 to 579
$C_6H_{12}O$	Ethyl iso propyl ketone	-6.0045	9.1123×10^{3}	1.2923×10^{-2}	-1.3230×10^{-5}	200 to 567
$C_6H_{12}O$	2 – Hexa none	-6.9812	1.0500×10^{3}	1.5094×10^{-2}	-1.4504×10^{-5}	217 to 587
$C_6H_{12}O$	3 – Hexa none	-6.7371	1.0210×10^{3}	1.4470×10^{-3}	-1.4069×10^{-5}	218 to 583
$C_6H_{12}O$	Methyl iso butyl ketone	-3.0570	5.0050×10^{2}	6.5038×10^{-3}	-8.8243×10^{-6}	246 to 571
$C_6H_{12}O_2$	n – Pentyl formate	-5.7440	9.1130×10^{2}	1.2435×10^{-2}	-1.3004×10^{-5}	200 to 576
$C_6H_{12}O_2$	n – Butyl acetate	-8.3884	1.3075×10^{3}	1.7671×10^{-2}	-1.3004×10^{-5}	275 to579

Formula	***Name***	*A′*	*B′*	*C′*	*D′*	***Temperature Range, K***
$C_6H_{12}O_2$	Sec – Butyl acetate	-4.2484	7.3709×10^{2}	8.1159×10^{-3}	-1.6145×10^{-5}	174 to561
$C_6H_{12}O_2$	Tert – Butyl acetate	-8.1645	1.2261×10^{3}	1.8000×10^{-2}	-9.2626×10^{-6}	283 to545
$C_6H_{12}O_2$	Ethyl – n - butyrate	-6.5990	1.0010×10^{3}	1.4580×10^{-2}	-1.7534×10^{-5}	250 to571
$C_6H_{12}O_2$	Ethyl – iso - butyrate	-5.4028	8.4827×10^{2}	1.1442×10^{-2}	-1.4750×10^{-5}	185 to553
$C_6H_{12}O_2$	Iso butyl acetate	-7.4697	1.1287×10^{3}	1.6664×10^{-2}	-1.2326×10^{-5}	275 to561
$C_6H_{12}O_2$	n - Propyl propionate	-5.4369	8.7969×10^{2}	1.1064×10^{-2}	-1.1348×10^{-5}	197 to 578
$C_6H_{12}O_2$	Di acetone alcohol	-16.5815	2.7668×10^{3}	3.4806×10^{-2}	-2.8348×10^{-5}	229 to 606
$C_6H_{12}O_2$	2 - Ethyl butyric acid	-7.1034	1.3882×10^{3}	1.2840×10^{-2}	-1.1012×10^{-5}	258 to 655
$C_6H_{12}O_2$	n - Hexanoic acid	-6.2881	1.3092×10^{3}	1.0624×10^{-2}	-9.1112×10^{-6}	275 to 667
$C_6H_{12}O_3$	2 – Ethoxy ethyl acetate	-7.3105	1.2304×10^{3}	1.4721×10^{-2}	-1.3742×10^{-5}	225 to 597
$C_6H_{12}O_3$	Hydroxy caproic acid	-3.7600	1.5809×10^{3}	4.4909×10^{-5}	1.4217×10^{-8}	334 to 758
$C_6H_{12}O_3$	Paraldehyde	-14.2350	2.1910×10^{3}	3.1012×10^{-2}	-2.6181×10^{-5}	286 to 579
$C_6H_{13}N$	Cyclo hexyl amine	-4.4924	1.0272×10^{3}	6.1023×10^{-3}	-5.7699×10^{-6}	288 to 615
$C_6H_{13}N$	Hexa methylene imine	-3.5971	9.3397×10^{2}	3.6596×10^{-3}	-3.7383×10^{-6}	303 to 615
C_6H_{14}	2,2 – Dimethyl butane	-3.6841	6.5672×10^{2}	5.5269×10^{-3}	-7.1890×10^{-6}	269 to 489
C_6H_{14}	2,3 – Dimethyl butane	-12.6145	1.7240×10^{3}	2.9725×10^{-2}	-2.8274×10^{-5}	273 to 500
C_6H_{14}	n – Hexane	-5.0715	6.5536×10^{2}	1.2349×10^{-2}	-1.5042×10^{-5}	178 to 507
C_6H_{14}	2 – Methyl pentane	-5.1822	6.7047×10^{2}	1.2528×10^{-2}	-1.5278×10^{-5}	258 to 498
C_6H_{14}	3 – Methyl pentane	-5.2757	6.8590×10^{2}	1.2664×10^{-2}	-1.5109×10^{-5}	220 to 504
$C_6H_{14}N_2O_2$	Lysine	-108.5082	2.2844×10^{4}	1.6947×10^{-1}	-8.8781×10^{-5}	498 to 821
$C_6H_{14}O$	2 – Ethyl – 1 - butanol	-6.9398	1.7143×10^{3}	8.2026×10^{-3}	-6.1032×10^{-5}	237 to 580
$C_6H_{14}O$	1 - Hexanol	-9.7166	2.0060×10^{3}	1.5908×10^{-2}	-1.2286×10^{-4}	278 to 611

Formula	***Name***	*A′*	*B′*	*C′*	*D′*	***Temperature Range, K***
$C_6H_{14}O$	2 - Hexanol	-19.7738	3.4234×10^3	3.8599×10^{-2}	2.9152×10^{-5}	230 to 586
$C_6H_{14}O$	2 – Methyl – 1 – pentanol	-18.4079	3.2619×10^3	3.5729×10^{-2}	2.7059×10^{-5}	270 to 582
$C_6H_{14}O$	4 - Methyl - 2 – pentanol	-25.3841	4.1810×10^3	5.2001×10^{-2}	-3.9665×10^{-5}	280 to 574
$C_6H_{14}O$	n – Butyl ether	-4.7316	7.1301×10^2	1.0253×10^{-2}	-1.2054×10^{-5}	170 to 531
$C_6H_{14}O$	Di iso propyl ether	-5.5350	7.4894×10^2	1.3145×10^{-2}	-1.5557×10^{-5}	188 to 500
$C_6H_{14}O$	Di – n – propyl ether	-3.7969	5.8653×10^2	7.7642×10^{-3}	-9.7923×10^{-6}	150 to 531
$C_6H_{14}O$	Methyl – tert - phenyl ether	-5.1638	7.1242×10^2	1.1515×10^{-2}	-1.2790×10^{-5}	160 to 534
$C_6H_{14}O_2$	Acetal	-6.7319	9.0418×10^2	1.6397×10^{-2}	1.7543×10^{-5}	200 to 541
$C_6H_{14}O_2$	2 – Butoxy ethanol	-7.3676	1.5830×10^3	1.1138×10^{-2}	-8.8708×10^{-6}	203 to 600
$C_6H_{14}O_2$	1,6 – Hexane diol	-72.9906	1.3107×10^4	1.3170×10^{-1}	-8.0122×10^{-5}	315 to 670
$C_6H_{14}O_2$	Hexylene glycol	-69.7580	1.0040×10^4	1.6420×10^{-1}	-1.3020×10^{-5}	230 to 621
$C_6H_{14}O_2S$	Di – n - propyl sulfone	-12.8643	2.5541×10^3	2.1501×10^{-2}	-1.4018×10^{-5}	303 to 763
$C_6H_{14}O_3$	Di ethylene glycol di methyl ether	-5.9960	1.0158×10^3	1.2239×10^{-2}	-1.2021×10^{-5}	203 to 604
$C_6H_{14}O_3$	Di propylene glycol	-13.6865	3.3862×10^3	1.6049×10^{-2}	-7.1661×10^{-6}	233 to654
$C_6H_{14}O_3$	2 (2 – Ethoxy ethoxy) ethanol	-9.7859	1.8448×10^3	1.8441×10^{-2}	-1.5177×10^{-5}	240 to 632
$C_6H_{14}O_4$	Tri ethylene glycol	-13.8883	3.0642×10^3	2.0531×10^{-2}	-1.0500×10^{-5}	285 to 700
$C_6H_{14}O_6$	Sorbitol	-26.2502	5.7927×10^3	3.4769×10^{-2}	-1.6250×10^{-5}	371 to 959
$C_6H_{14}S$	n – Hexyl mercaptan	-5.2857	8.5597×10^2	1.0430×10^{-2}	-1.0034×10^{-5}	193 to 623
$C_6H_{15}Al$	Triethyl aluminum	-4.3627	9.9686×10^2	5.9002×10^{-3}	-4.1150×10^{-6}	221 to 720
C6H15N	Di iso propyl amine	-9.4766	1.2451×10^3	2.3557×10^{-2}	-2.4018×10^{-5}	250 to 523
$C_6H_{15}N$	Di – n - Propyl amine	-15.3095	2.0644×10^3	3.7073×10^{-2}	-3.3467×10^{-5}	260 to 556
$C_6H_{15}N$	n – Hexyl amine	-4.3636	8.3506×10^2	7.3533×10^{-3}	-7.8672×10^{-6}	252 to 583

Formula	***Name***	*A′*	*B′*	*C′*	*D′*	***Temperature Range, K***
$C_6H_{15}N$	Tri ethyl amine	-8.2302	1.0707 x 10^{3}	2.0144 x 10^{-2}	-2.0640 x 10^{-5}	250 to535
$C_6H_{15}NO$	6 – Amino hexanol	-42.5962	7.8271 x 10^{3}	7.7049 x 10^{-2}	-4.8866 x 10^{-5}	331 to 681
$C_6H_{15}NO_2$	Di iso propanol amine	-110.6700	1.8305 x 10^{4}	2.2070 x 10^{-1}	-1.4706 x 10^{-4}	303 to 672
$C_6H_{15}NO_3$	Tri ethanol amine	-21.0078	4.7935 x 10^{3}	3.1279 x 10^{-2}	-1.7784 x 10^{-7}	294 to 787
$C_6H_{15}N_3$	n – Amino ethyl piperazine	-0.4594	7.1166 x 10^{2}	-3.0976 x 10^{-3}	8.2669 x 10^{-7}	254 to 708
$C_6H_{15}O_4P$	Tri ethyl phosphate	-10.0212	1.7337 x 10^{3}	1.8103 x 10^{-2}	-1.1778 x 10^{-5}	250 to 794
$C_6H_{16}N_2$	Hexa methylene diamine	-24.6252	4.1044 x 10^{3}	4.8655 x 10^{-2}	-3.4491 x 10^{-5}	314 to 663
$C_6H_{18}N_3OP$	Hexa methyl phosphor amide	-5.4288	1.2492 x 10^{3}	6.6845 x 10^{-3}	-2.8892 x 10^{-6}	280 to506
$C_6H_{18}N_4$	Tri ethylene tetramine	-40.9603	7.3562 x 10^{3}	7.6974 x 10^{-2}	-5.0374 x 10^{-5}	285 to 718
$C_6H_{18}Osi_2$	Hexa methyl di siloxane	-3.3863	5.7418 x 10^{2}	6.7648 x 10^{-3}	-9.7088 x 10^{-6}	240 to 519
$C_6H_{18}O_3Si_3$	Hexa methyl cyclo tri siloxane	-4.3150	8.3634 x 10^{2}	7.6570 x 10^{-3}	-9.1028 x 10^{-6}	337 to 554
$C_6H_{19}Nsi_2$	Hexa methyl di silazane	-3.3927	6.0328 x 10^{2}	6.8022 x 10^{-3}	-9.4801 x 10^{-6}	290 to 544
$C_7H_3ClF_3NO$	2,4 – Chloro – 3 – nitro benzo tri fluoride	-13.2679	2.5485 x 10^{3}	2.3563 x 10^{-2}	-1.6631 x 10^{-5}	293 to 686
$C_7H_3Cl_2F_3$	2,4 – Di chloro benzo tri fluoride	-6.6149	1.3248 x 10^{3}	1.1407 x 10^{-2}	-9.6282 x 10^{-6}	267 to 646
$C_7H_3Cl_2NO$	3,4 – Di chloro phenyl iso cyanate	-23.6469	4.1728 x 10^{3}	4.3080 x 10^{-2}	-2.7652 x 10^{-5}	316 to 733
$C_7H_4ClF_3$	p – Chlorobenzo tri fluoride	-8.3109	1.3727 x 10^{3}	1.7034 x 10^{-2}	-1.5091 x 10^{-5}	354 to 601
$C_7H_4Cl_2O$	m – Chloro benzoyl chloride	-7.4045	1.5604 x 10^{3}	1.2133 x 10^{-2}	-9.0082 x 10^{-6}	280 to724
$C_7H_4F_3NO_2$	3 – Nitro benzo tri fluoride	-11.9324	2.1272 x 10^{3}	2.2447 x 10^{-2}	-1.6797 x 10^{-5}	272 to 667

Formula	***Name***	*A′*	*B′*	*C′*	*D′*	***Temperature Range, K***
C_7H_5ClO	Benzoyl chloride	-11.9830	1.9357×10^{3}	2.3900×10^{-2}	-1.7861×10^{-5}	273 to 697
$C_7H_5ClO_2$	o – Chloro benzoic acid	-35.6472	7.0126×10^{3}	5.9808×10^{-2}	-3.4812×10^{-5}	415 to 792
$C_7H_5Cl_3$	Benzo tri chloride	-5.7549	1.2014×10^{3}	8.9628×10^{-3}	-6.7458×10^{-6}	273 to 737
$C_7H_5F_3$	Benzo tri fluoride	-8.3782	1.1826×10^{3}	1.9281×10^{-2}	-1.8350×10^{-5}	244 to 565
C_7H_5N	Benzo nitrile	-6.5416	1.1609×10^{3}	1.2160×10^{-2}	-1.0015×10^{-5}	270 to 699
$C_7H_5N_3O_6$	2,4,6 – Di chloro toluene	-14.9246	2.8645×10^{3}	2.8227×10^{-2}	-1.9563×10^{-5}	354 to 795
$C_7H_6Cl_2$	Benzyl dichloride	-5.2934	1.1077×10^{3}	7.6332×10^{-3}	-5.5580×10^{-6}	257 to 731
$C_7H_6Cl_2$	2,4 – Di chloro toluene	-7.5511	1.4411×10^{3}	1.3164×10^{-2}	-1.0027×10^{-5}	260 to 705
$C_7H_6N_2O_4$	2,4 – Di nitro toluene	-7.2273	1.5200×10^{3}	1.2525×10^{-2}	-9.1730×10^{-6}	343 to 814
$C_7H_6N_2O_4$	2,5 – Di nitro toluene	-21.6018	4.2975×10^{3}	3.5182×10^{-2}	-2.0389×10^{-5}	326 to 814
$C_7H_6N_2O_4$	2,6 – Di nitro toluene	-2.9240	8.1054×10^{2}	4.7543×10^{-3}	-5.0883×10^{-6}	339 to 770
$C_7H_6N_2O_4$	3,4 – Di nitro toluene	-7.1438	1.5239×10^{3}	1.1952×10^{-2}	-8.4090×10^{-6}	332 to 842
$C_7H_6N_2O_4$	3,5 – Di nitro toluene	-31.5919	6.1804×10^{3}	5.2284×10^{-2}	-2.9883×10^{-5}	366 to 814
C_7H_6O	Benzaldehyde	1.2039	2.2414×10	-3.9285×10^{-3}	5.5651×10^{-7}	247 to 695
$C_7H_6O_2$	Benzoic acid	-67.6079	1.3482×10^{4}	1.1017×10^{-1}	-6.2162×10^{-5}	396 to 751
$C_7H_6O_2$	P – Hydroxy benzaldehyde	-34.5840	7.6927×10^{3}	4.9247×10^{-2}	-2.4193×10^{-5}	390 to 844
$C_7H_6O_2$	Salicyl aldehyde	-9.9310	1.7245×10^{3}	1.9801×10^{-2}	-1.5708×10^{-5}	266 to 680
C_7H_7Br	p – Bromo toluene	-9.1633	1.5029×10^{3}	1.8358×10^{-2}	-1.4308×10^{-5}	300 to 699
C_7H_7Cl	Benzyl chloride	-6.4178	1.1281×10^{3}	1.1724×10^{-2}	-9.5598×10^{-6}	234 to 686
C_7H_7Cl	o – Chloro toluene	-5.0510	8.8285×10^{2}	9.5924×10^{-3}	-8.7952×10^{-6}	237 to 656
C_7H_7Cl	p – Chloro toluene	-8.5917	1.3598×10^{3}	1.7594×10^{-2}	-1.4550×10^{-5}	281 to 660
C_7H_7NO	Formanilide	-21.7761	4.4373×10^{3}	3.1566×10^{-2}	-2.0639×10^{-5}	328 to 787

Formula	***Name***	*A′*	*B′*	*C′*	*D′*	***Temperature Range, K***
$C_7H_7NO_2$	m – Nitro toluene	-20.0665	3.4718×10^3	3.6803×10^{-2}	-2.3950×10^{-5}	289 to 734
$C_7H_7NO_2$	o – Nitro toluene	-9.9050	1.7941×10^3	1.8107×10^{-2}	-1.8107×10^{-5}	270 to 720
$C_7H_7NO_2$	p – Nitro toluene	-11.3921	2.0234×10^3	2.1371×10^{-2}	-1.5415×10^{-5}	325 to 736
$C_7H_7NO_3$	o – Nitro anisole	-6.0024	1.2301×10^3	1.0354×10^{-2}	-8.0089×10^{-6}	284 to 782
C_7H_8	Toluene	-5.1649	8.1068×10^2	1.0454×10^{-2}	-1.0488×10^{-5}	200 to 592
C_7H_8O	Anisole	-8.8307	1.4337×10^3	1.7992×10^{-2}	-1.5096×10^{-5}	287 to 642
C_7H_8O	Benzyl alcohol	-25.0704	4.2124×10^3	4.9668×10^{-2}	-3.5036×10^{-5}	288 to 677
C_7H_8O	m – Cresol	-18.3829	3.4649×10^3	3.2787×10^{-2}	-2.1943×10^{-5}	298 to 706
C_7H_8O	o – Cresol	-18.6396	3.3896×10^3	3.4286×10^{-2}	-2.3373×10^{-5}	304 to 698
C_7H_8O	p – Cresol	-19.0715	3.5560×10^3	3.4524×10^{-2}	-2.3222×10^{-5}	308 to 705
$C_7H_8O_2$	Gauiacol	-16.0239	2.8581×10^3	3.0360×10^{-2}	-2.1530×10^{-5}	305 to 697
$C_7H_8O_2$	p – Methoxy phenol	-16.2546	3.3208×10^3	2.7118×10^{-2}	-1.7208×10^{-5}	345 to 758
C_7H_9N	Benzyl amine	-6.0952	1.1500×10^3	1.0800×10^{-2}	-9.0063×10^{-6}	227 to 684
C_7H_9N	2,6 – Dimethyl pyridene	-7.1740	1.1515×10^3	1.4740×10^{-2}	-1.3258×10^{-5}	267 to 624
C_7H_9N	n – Methyl aniline	-13.7299	2.2913×10^3	2.7208×10^{-2}	-2.0030×10^{-5}	250 to 702
C_7H_9N	m - Toludine	-13.5859	2.4293×10^3	2.5395×10^{-2}	-1.8204×10^{-5}	273 to 709
C_7H_9N	o - Toludine	-11.1346	2.1223×10^3	1.9780×10^{-2}	-1.4453×10^{-5}	273 to 694
C_7H_9N	p - Toludine	-12.3169	2.2349×10^3	2.2874×10^{-2}	-1.6774×10^{-5}	317 to 693
C_7H_{10}	2 - Norbornene	-9.3004	1.5318×10^3	1.8049×10^{-2}	-1.5132×10^{-5}	319 to 583
$C_7H_{10}N_2$	Toluene diamine	-33.0277	6.1042×10^3	5.7240×10^{-2}	-3.3853×10^{-5}	371 to 804
$C_7H_{12}O_2$	n – Butyl acrylate	-6.9308	1.1689×10^3	1.3471×10^{-2}	-1.2339×10^{-5}	250 to 598

Formula	***Name***	*A′*	*B′*	*C′*	*D′*	***Temperature Range, K***
$C_7H_{12}O_2$	Iso butyl acrylate	-7.4193	1.1066×10^{3}	1.6403×10^{-2}	-1.5787×10^{-5}	212 to 580
$C_7H_{12}O_2$	n – Propyl - methacrylate	-7.6284	1.1672×10^{3}	1.6216×10^{-2}	-1.4907×10^{-5}	223 to 599
$C_7H_{12}O_4$	Diethylmalonate	-9.1440	1.6103×10^{3}	1.7730×10^{-2}	-1.4503×10^{-5}	240 to 653
C_7H_{14}	Cyclo heptane	2.2571	-8.2344	-6.5186×10^{-3}	-1.3401×10^{-6}	265 to 604
C_7H_{14}	1,1 – Di methyl cyclo pentane	-2.9826	5.2928×10^{2}	5.0996×10^{-3}	-6.9685×10^{-6}	203 to 547
C_7H_{14}	Cis – 1,2 – Di methyl cyclo pentane	-3.9448	6.3812×10^{2}	7.6699×10^{-3}	-8.8791×10^{-6}	219 to565
C_7H_{14}	Trans – 1,2 – Di methyl cyclo pentane	-2.8753	5.1637×10^{2}	4.7706×10^{-3}	-6.5528×10^{-6}	156 to553
C_7H_{14}	Cis – 1,3 – Di methyl cyclo pentane	-2.7490	5.0276×10^{2}	4.4211×10^{-3}	-6.2776×10^{-6}	139 to551
C_7H_{14}	Trans -1,3 – Di methyl cyclo pentane	-2.7501	5.0315×10^{2}	4.4009×10^{-3}	-6.2776×10^{-6}	139 to 553
C_7H_{14}	Ethyl cyclo pentane	-3.1.46	5.4840×10^{2}	5.4107×10^{-3}	-6.2117×10^{-6}	253 to 570
C_7H_{14}	2 – Ethyl - 1 - pentene	-5.0433	6.7571×10^{2}	1.1550×10^{-2}	-6.9666×10^{-6}	168 to 543
C_7H_{14}	3 – Ethyl – 1 - pentene	-4.1071	5.7416×10^{2}	8.9597×10^{-3}	-1.2981×10^{-5}	146 to 530
C_7H_{14}	1 – Heptene	-8.3002	1.0763×10^{3}	2.0357×10^{-2}	-1.0906×10^{-5}	250 to 537
C_7H_{14}	Cis – 2 - Heptene	-4.1620	5.9928×10^{2}	8.8279×10^{-3}	-2.0890×10^{-5}	164 to 549
C_7H_{14}	Trans – 2 - Heptene	-4.4221	6.2108×10^{2}	9.8018×10^{-3}	-1.0428×10^{-5}	164 to 543
C_7H_{14}	Cis – 3 - Heptene	-3.4630	5.2468×10^{2}	6.8238×10^{-3}	-1.1566×10^{-5}	137 to 545
C_7H_{14}	Trans – 3 - Heptene	-3.6419	5.3868×10^{2}	7.5309×10^{-3}	-9.5346×10^{-6}	137 to 540
C_7H_{14}	Methyl cyclo hexane	-1.9879	5.0806×10^{2}	1.2152×10^{-3}	-2.7318×10^{-6}	248 to 572
C_7H_{14}	2 – Methyl – 1 – hexene	-4.9412	6.6561×10^{2}	1.1296×10^{-2}	-1.2911×10^{-5}	170 to 538

Formula	***Name***	*A′*	*B′*	*C′*	*D′*	***Temperature Range, K***
C_7H_{14}	3 – Methyl – 1 – hexene	-4.0259	5.6592×10^{2}	8.7407×10^{-3}	-1.0790×10^{-5}	145 to 528
C_7H_{14}	4 – Methyl – 1 – hexene	-3.4368	5.1940×10^{2}	6.8729×10^{-3}	-8.9153×10^{-6}	132 to 534
C_7H_{14}	2,3,3 – Tri methyl – 1 –butene	-3.3759	4.5743×10^{2}	7.5119×10^{-3}	-9.9892×10^{-6}	163 to 531
$C_7H_{14}O$	Di iso propyl ketone	-6.0698	9.6613×10^{2}	1.2535×10^{-2}	-1.2504×10^{-5}	205 to 576
$C_7H_{14}O$	2 - Heptanone	-6.3072	1.0186×10^{3}	1.2947×10^{-2}	-1.2369×10^{-5}	250 to 612
$C_7H_{14}O$	1 - Heptanal	-1.5042	3.8309×10^{2}	2.2617×10^{-3}	-5.1258×10^{-6}	230 to 603
$C_7H_{14}O$	1 – Methyl cyclo hexanal	2.8090	8.1555×10^{2}	-1.8028×10^{-2}	1.5145×10^{-5}	299 to 603
$C_7H_{14}O$	Cis – 2 – Methyl cyclo hexanol	-61.1284	9.7604×10^{3}	1.2667×10^{-1}	-8.9897×10^{-5}	298 to 614
$C_7H_{14}O$	Trans – 2 – methyl cyclo hexanol	-69.3044	1.1008×10^{4}	1.4418×10^{-1}	-1.0213×10^{-4}	280 to 616
$C_7H_{14}O$	Cis – 3 – Methyl cyclo hexanol	-47.3336	7.8174×10^{3}	9.5221×10^{-2}	-6.6657×10^{-5}	289 to 618
$C_7H_{14}O$	Trans – 3 – Methyl cyclo hexanol	-56.2704	9.1353×10^{3}	1.1490×10^{-1}	-8.0775×10^{-5}	289 to 617
$C_7H_{14}O$	Cis – 4 – Methyl cyclo hexanol	-1.1605	1.2470×10^{3}	-7.1483×10^{-3}	6.1622×10^{-6}	298 to 622
$C_7H_{14}O$	Trans – 4 – Methyl cyclo hexanol	2.2649	8.3276×10^{2}	-1.5347×10^{-2}	1.2225×10^{-5}	298 to 622
$C_7H_{14}O$	5 – Methyl – 2 – hexanone	-6.0147	9.7149×10^{2}	1.2143×10^{-2}	-1.1693×10^{-5}	199 to 601
$C_7H_{14}O_2$	n – Butyl propionate	-5.3815	9.0843×10^{2}	1.0671×10^{-2}	-1.0766×10^{-5}	184 to 594
$C_7H_{14}O_2$	Ethyl iso valerate	-4.5111	8.0507×10^{2}	8.2414×10^{-3}	-8.6925×10^{-6}	174 to 588
$C_7H_{14}O_2$	Iso pentyl acetate	-4.6434	8.2935×10^{2}	8.6638×10^{-3}	-9.0386×10^{-6}	195 to 599
$C_7H_{14}O_2$	n – Pentyl acetate	-6.3879	1.0379×10^{3}	1.3281×10^{-2}	-1.2904×10^{-5}	223 to 598

Formula	***Name***	*A′*	*B′*	*C′*	*D′*	***Temperature Range, K***
$C_7H_{14}O_2$	n – Propyl – n – butyrate	-5.3652	9.0990 x 10^{2}	1.0578 x 10^{-2}	-1.0705 x 10^{-5}	273 to 594
$C_7H_{14}O_2$	n - Heptanoic acid	-7.2247	1.4530 x 10^{3}	1.3212 x 10^{-2}	-1.1316 x 10^{-5}	280 to 680
$C_7H_{14}O_3$	Ethyl – 3 – ethoxy propionate	-8.0517	1.3544 x 10^{3}	1.6245 x 10^{-2}	-1.4468 x 10^{-5}	223 to 609
$C_7H_{15}Br$	1 – Bromo heptane	-5.9893	1.0290 x 10^{3}	1.1969 x 10^{-2}	-1.0905 x 10^{-5}	240 to 651
$C_7H_{15}N$	n – Methyl cyclo hexyl amine	-7.3265	1.4620 x 10^{3}	1.2053 x 10^{-2}	-9.8197 x 10^{-6}	265 to 622
C_7H_{16}	2,2 – Di methyl pentane	-2.8909	5.7125 x 10^{2}	3.5976 x 10^{-3}	-5.2719 x 10^{-6}	149 to 521
C_7H_{16}	2,3 – Di methyl pentane	-3.4160	5.9455 x 10^{2}	5.8631 x 10^{-3}	-7.5893 x 10^{-6}	160 to537
C_7H_{16}	2,4 – Di methyl pentane	-4.2276	6.8593 x 10^{2}	8.0689 x 10^{-3}	-9.8333 x 10^{-6}	170 to 520
C_7H_{16}	3,3 – Di methyl pentane	-2.9875	5.5438 x 10^{2}	4.4350 x 10^{-3}	-6.1370 x 10^{-6}	139 to 536
C_7H_{16}	3 – Ethyl pentane	-4.3369	6.3373 x 10^{2}	9.0780 x 10^{-3}	-1.0576 x 10^{-5}	155 to 541
C_7H_{16}	n – Heptane	-5.7782	8.0587 x 10^{2}	1.3355 x 10^{-2}	-1.4794 x 10^{-5}	183 to 540
C_7H_{16}	2 – Methyl hexane	-7.2033	9.7969 x 10^{2}	1.6986 x 10^{-2}	-1.7924 x 10^{-5}	273 to 530
C_7H_{16}	3 – Methyl hexane	-4.2439	6.2293 x 10^{2}	8.8962 x 10^{-3}	-1.0606 x 10^{-5}	154 to 535
C_7H_{16}	2,2,3 – Tri methyl butane	1.0062	1.0680 x 10^{2}	-6.3684 x 10^{-3}	3.1024 x 10^{-6}	249 to 531
$C_7H_{16}O$	1 - Heptanol	-13.9237	2.6296 x 10^{3}	2.5331 x 10^{-2}	-1.8972 x 10^{-5}	288 to 632
$C_7H_{16}O$	2 - Heptanol	-29.5002	4.7658 x 10^{3}	6.1363 x 10^{-2}	-4.6360 x 10^{-5}	275 to 588
$C_7H_{16}O$	5 – Methyl–1–hexanol	-16.5523	3.0409 x 10^{3}	3.0976 x 10^{-2}	-2.3331 x 10^{-5}	293 to 605
$C_7H_{16}S$	n – Heptyl mercaptan	-7.0230	1.1355 x 10^{3}	1.4051 x 10^{-2}	-1.2325 x 10^{-5}	230 to 645
$C_7H_{17}N$	1 – Amino heptane	-6.2343	1.1616 x 10^{3}	1.1379 x 10^{-2}	-1.0664 x 10^{-5}	254 to 607

4.3.1.3c Daubert and Danner Form

Daubert and Danner[27] utilized the formula:

$$\eta = exp\left[A + \frac{B}{T} + C\, ln\, T + DT^{E} \right] \tag{4.41}$$

to represent the dynamic viscosity data (in Pascal second) as a function of temperature (in Kelvin) for a large number of substances. Their representation is summarized in Table 4.20.

Table 4.20. Constants of Eq. (4.41) used for the polynomial representation of the viscosity [Viscosity (η) in Pa.s and Temparature in K]. From: T. E. Daubert and R. P. Danner, Physical and Thermodynamic Properties of Pure Chemicals –Data Compilation Design Institute for Physical Properties Data, AIChE, Taylor and Francis, Washington DC (1989-1994).

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
-	Air	-20.008	285.15	1.784	-6.24×10^{-22}	10	3.2765×10^{-4} (60.00)	4.2624×10^{-5} (130.00)
Al	Aluminum	-75.254	11425	8.370	-	-	3.1249×10^{-3} (933.00)	1.5995×10^{-3} (1273.10)
$AlCl_3$	Aluminum chloride	-35.863	3450.5	3.341	-	-	3.7427×10^{-4} (461.45)	2.0728×10^{-3} (549.15)
Ar	Argon	- 8.858	204.3	-0.3831	-1.30×10^{-22}	10	2.9194×10^{-4} (84.10)	3.8103×10^{-5} (150.00)
BCl_3	Boron trichloride	-10.362	680.27	0.5638	-	-	2.9131×10^{-3} (166.15)	3.1655×10^{-4} (284.65)
B_2H_6	Di borane	0.3890	139.98	- 1.941	-	-	6.1592×10^{-4} (107.65)	1.3333×10^{-4} (180.65)
BrH	Hydrogen bromide	-11.1633	316.38	0.5619	-	-	9.1481×10^{-4} (186.19)	8.2057×10^{-4} (206.45)
BrNa	Sodium bromide	- 9.1070	258.30	-	-	-	1.2870×10^{-3} (1053.60)	9.3320×10^{-4} (1212.60)
Br_2	Bromine	16.775	- 314.0	-3.9763	-	-	1.3529×10^{-3} (265.85)	6.0213×10^{-4} (350.00)
$CBrClF_2$	Bromo chloro difluoro methane	-6.0014	419.9	-0.5932	-	-	1.6823×10^{-3} (160.00)	2.4198×10^{-4} (360.00)
$CBrCl_3$	Bromo tri chloro methane	-8.7132	1223.8	-0.3353	-	-	3.2996×10^{-3} (252.15)	5.7217×10^{-4} (378.05)
$CBrF_3$	Bromo tri fluoro methane	-17.145	884.8	0.96828	-1.5638×10^{-26}	10	9.418×10^{-4} (170.00)	1.0856×10^{-4} (335.15)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
CBr_2F_2	Di bromo difluoro methane	-9.5595	603.7	-	-	-	1.0967 x 10^{-3} (220.0)	5.4237 x 10^{-4} (295.94)
$CClF_3$	Chloro tri fluoro methane	-14.902	673.0	0.6347	-2.70 x 10^{-26}	10	4.6012 x 10^{-4} (170.00)	1.3481 x 10^{-4} (270.00)
$CClN$	Cyanogen Chloride	-9.6785	99.451	-0.19824	-	-	8.6204 x 10^{-4} (266.65)	6.6055 x 10^{-4} (286.00)
CCl_2F_2	Di chloro di fluoro methane	-25.135	116.13	2.2632	-1.2211 x 10^{-26}	10	1.2549 x 10^{-3} (170.00)	8.2577 x 10^{-5} (380.00)
CCl_2O	Phosgene	9.9566	-254.85	-2.9339	-	-	6.8488 x 10^{-4} (253.15)	8.2577 x 10^{-5} (380.00)
CCl_3F	Tri chloro fluoro methane	-21.734	1234.9	1.7274	-2.20 x 10^{-27}	10	3.704 x 10^{-3} (170.00)	6.5366 x 10^{-5} (470.00)
CF_2O	Carbonyl Fluoride	-10.921	517.25	-0.025461	-	-	5.1954 x 10^{-3} (89.56)	2.0974 x 10^{-4} (200.00)
CF_4	Carbon tetra Fluoride	-10.477	962.81	-1.0851	-	-	6.0295 x 10^{-3} (161.89)	2.6321 x 10^{-3} (188.59)
$CHBr_3$	Bromo form	-13.586	1295.5	0.5190	-	-	2.3526 x 10^{-3} (281.20)	6.2307 x 10^{-4} (422.35)
$CHClF_2$	Chloro difluoro Methane	-29.062	1180.3	29300	-1.58 x 10^{-26}	10	8.4879 x 10^{-4} (170.00)	9.2302 x 10^{-5} (369.30)
$CHCl_2F$	Di chloro fluoro methane	-17.325	968.2	1.0602	-1.86 x 10^{-27}	10	2.0727 x 10^{-3} (170.00)	1.3060 x 10^{-4} (440.00)
$CHCl_3$	Chloroform	-14.109	104.92	0.5377	-	-	1.9511 x 10^{-3} (210.08)	3.4096 x 10^{-4} (353.20)
CH_5N	Methyl amine	-26.385	132.62	2.3426	-	-	1.0663 x 10^{-3} (179.69)	1.5131 x 10^{-4} (332.98)
CO	Carbon Monoxide	-4.9735	97.67	-1.1088	-	-	2.6488 x 10^{-4} (68.55)	6.5153 x 10^{-5} (131.37)
COS	Carbonyl sulfide	-8.9800	478.5	-0.34802	-	-	8.0039 x 10^{-4} (134.30)	1.6391 x 10^{-4} (222.30)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
CHF_3	Tri fluoro Methane	-20.134	763.3	1.5359	-1.67×10^{-25}	10	4.2804×10^{-4} (170.00)	8.5969×10^{-5} (285.00)
CNH	Hydrogen Cyanide	-21.927	1266.5	1.5927	-	-	2.7535×10^{-4} (259.85)	1.8327×10^{-4} (298.15)
CH_2BrCl	Bromo chloro methane	-10.774	999.07	0.014151	-	-	4.9639×10^{-3} (185.20)	4.2503×10^{-4} (341.20)
CH_2Br_2	Di bromo Methane	-32.680	1935.2	3.3806	-	-	2.7889×10^{-3} (230.00)	5.7621×10^{-4} (370.10)
CH_2Cl_2	Di chloro Methane	-13.071	940.03	0.3733	-	-	1.4065×10^{-3} (208.38)	2.3743×10^{-4} (373.93)
CH_2F_2	Di fluoro Methane	-6.1798	536.49	-0.76036	-2.964×10^{-26}	10	5.3466×10^{-4} (200.28)	1.6163×10^{-4} (287.31)
CH_2I_2	Diiodo Methane	-34.410	241.96	3.5698	-	-	3.5533×10^{-3} (279.25)	7.1407×10^{-4} (455.15)
CH_2O_2	Formic acid	-49.959	346.13	5.6018	-	-	2.3181×10^{-3} (281.45)	5.4793×10^{-4} (373.15)
CH_3Br	Methyl bromide	-20.960	1070.4	1.6309	-	-	1.0765×10^{-3} (193.15)	2.4719×10^{-4} (340.00)
CH_3Cl	Methyl chloride	-25.132	1318.9	2.0810	-4.50×10^{-27}	10	3.0247×10^{-4} (248.9)	5.9470×10^{-5} (403.15)
CH_3F	Methyl fluoride	-10.763	4277.8	0.0086309	-	-	5.733×10^{-4} (131.35)	1.991×10^{-4} (194.82)
CH_3I	Methyl iodide	-7.759	642.00	-0.3599	-	-	7.6306×10^{-4} (250.00)	4.1333×10^{-4} (315.00)
CH_3NO	Formamide	-62.009	447.02	7.2515	-	-	6.4315×10^{-3} (275.70)	3.4657×10^{-4} (490.00)
CH_3NO_2	Nitro methane	-17.684	1358.0	1.0110	-	-	1.3991×10^{-3} (244.60)	3.1403×10^{-4} (347.35)
CH_4	Methane	-6.1572	178.15	-0.95239	-9.0606×10^{-24}	10	2.064×10^{-4} (90.69)	2.2625×10^{-5} (188.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
CH_4O	Methanol	-7.288	1065.3	-0.6657	-	-	1.8803×10^{-3} (230.00)	2.265×10^{-4} (375.00)
CO_2	Carbon dioxide	18.775	-402.9	-4.6854	-7.0×10^{-26}	10	2.3975×10^{-3} (219.25)	5.4690×10^{-5} (304.19)
CS_2	Carbon Disulfide	-51.111	2466.5	6.1227	-	-	7.5571×10^{-4} (235.00)	3.0789×10^{-3} (320.00)
C_2BrF_3	Bromo tri fluoro ethylene	-10.331	1276.5	0.019011	-	-	2.1186×10^{-2} (173.00)	1.4913×10^{-3} (270.65)
$C_2Br_2F_4$	1,2 – Di bromo fluoro ethylene	6.6790	258.50	-2.5920	-	-	1.9426×10^{-3} (227.00)	3.2869×10^{-4} (378.00)
C_2ClF_3	Chloro tri fluoro ethylene	-11.101	1198.2	-0.027007	-	-	4.4485×10^{-1} (115.00)	1.7408×10^{-3} (245.30)
C_2ClF_5	Chloro penta fluoro ethane	-27.495	1362.1	2.5520	-2.7252×10^{-26}	10	9.7087×10^{-4} (190.00)	1.2521×10^{-4} (330.00)
$C_2Cl_2F_4$	1,2 –Di chloro tetraflouro ethane	-5.4262	761.93	-0.89299	-	-	2.8859×10^{-3} (180.62)	1.5070×10^{-4} (390.00)
$C_2Cl_3F_3$	1,1,2 – tri chloro fluoro ethane	-14.809	1325.5	0.5330	-	-	1.8430×10^{-3} (236.75)	2.69×10^{-4} (388.71)
C_2Cl_4	Tetra chloro Ethylene	-1.9780	555.0	-1.2216	-	-	1.4825×10^{-3} (250.80)	1.5884×10^{-4} (567.79)
$C_2Cl_4F_2$	1,1,2,2 – tetra – chloro ethylene	-3.4405	1184.0	-1.2548	-	-	1.312×10^{-3} (299.15)	4.9441×10^{-4} (366.00)
C_2Cl_4O	Tri chloro acetyl chloride	-11.037	1375.7	-0.019943	-	-	2.2153×10^{-3} (273.15)	4.8132×10^{-4} (391.15)
C_2F_4	Perfluoro ethylene	-10.753	1026.8	-0.07359	-	-	2.0513×10^{-2} (142.00)	2.6235×10^{-3} (197.51)
C_2F_5H	Penta fluoro Ethane	-17.128	1020.4	0.9250	-	-	1.6960×10^{-3} (170.15)	1.7417×10^{-4} (327.55)
C_2F_6	Hexa fluoro Ethane	-8.5570	446.00	-0.04331	-	-	2.7122×10^{-4} (173.10)	1.9299×10^{-4} (194.95)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_2HBrClF_3$	Halothane	-10.894	1208.1	-0.03697	-	-	3.4133×10^{-3} (233.15)	6.2896×10^{-4} (323.35)
C_2HClF_2	2 – Chloro -1,1 – di fluoro ethylene	-11.172	1053.9	0.0059133	-	-	3.6296×10^{-2} (134.65)	9.128×10^{-4} (245.55)
C_2HCl_3	Tri chloro Ethylene	-20.389	1260.0	1.5179	-	-	9.4156×10^{-2} (250.00)	3.5108×10^{-4} (360.00)
C_2HCl_3O	Di chloro acetyl chloride	-10.476	979.61	-0.053729	-	-	5.5596×10^{-4} (298.00)	2.6599×10^{-4} (382.15)
C_2HCl_5	Penta chloro Ethane	-6.7520	1321.5	-0.66603	-	-	6.731×10^{-3} (244.15)	4.335×10^{-4} (433.03)
$C_2HF_3O_2$	Tri fluoro acetic acid	-22.520	1851.5	1.6233	-	-	1.7867×10^{-3} (257.90)	4.6804×10^{-4} (344.95)
C_2H_2	Acetylene	6.2240	-151.0	-2.6554	-	-	1.9578×10^{-4} (193.15)	9.8192×10^{-5} (273.15)
$C_2H_2Br_4$	1,1,2,2 – Tetra bromo ethane	-7.5336	5578.3	9.0957	-	-	1.3337×10^{-2} (284.12)	4.5149×10^{-4} (513.15)
$C_2H_2Cl_2$	1,1 – Di chloro ethylene	-2.4749	650.68	-1.3232	-	-	8.3183×10^{-3} (150.59)	3.6803×10^{-4} (304.71)
$C_2H_2Cl_2$	Cis - 1,2 –Di chloro ethylene	-13.508	964.23	0.44868	-	-	1.5331×10^{-3} (208.15)	3.3173×10^{-4} (333.65)
$C_2H_2Cl_2$	Trans -1,2 – Di - chloroethylene	-14.078	981.81	0.51300	-	-	1.0038×10^{-3} (223.15)	3.1673×10^{-4} (320.85)
$C_2H_2Cl_2O$	Chloro acetyl Chloride	-11.710	1512.9	-0.01017	-	-	3.1924×10^{-3} (251.15)	4.1585×10^{-4} (379.15)
$C_2H_2Cl_4$	1,1,1,2 – Tetra chloro ethane	-12.211	1425.1	0.15555	-	-	1.2749×10^{-2} (202.94)	4.3200×10^{-4} (403.65)
$C_2H_2Cl_4$	1,1,2,2 – Tetra chloro ethane	-29.579	2285.4	2.7189	-	-	2.5823×10^{-3} (273.15)	3.6844×10^{-4} (453.15)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_2H_2F_2$	1,1 – Di fluoro ethylene	-10.944	676.53	-0.03327	-	-	3.9111×10^{-3} (129.15)	7.7574×10^{-4} (187.50)
$C_2H_2F_4$	1,1,2,2 – Tetra fluoroethane	-12.160	1073.9	-0.003162	-	-	1.7093×10^{-3} (185.00)	3.7656×10^{-4} (250.15)
C_2H_2O	Ketene	-8.4084	535.44	-0.28541	-	-	3.4174×10^{-3} (130.00)	5.4541×10^{-4} (400.00)
$C_2H_2O_2$	Gloxal	-10.899	1010.2	0.036804	-	-	7.5806×10^{-4} (200.00)	5.1877×10^{-4} (360.00)
C_2H_3Br	Vinyl bromide	-4.808	541.8	-0.8667	-	-	1.8248×10^{-3} (180.35)	3.9215×10^{-4} (288.95)
C_2H_3Cl	Vinyl chloride	2.5670	216.6	-2.1018	-	-	2.4851×10^{-3} (130.00)	7.6032×10^{-5} (400.00)
$C_2H_3ClF_2$	1 – Chloro -1,1 – difluoro ethane	15.574	-450.8	-3.8833	-	-	7.0666×10^{-4} (200.00)	1.9633×10^{-4} (360.00)
C_2H_3ClO	Acetyl chloride	6.9885	51.93	-2.6449	-	-	6.0669×10^{-4} (250.00)	2.9168×10^{-4} (323.90)
$C_2H_3ClO_2$	Chloro acetic acid	-228.76	13416	31.551	-	-	2.4928×10^{-3} (333.15)	1.8054×10^{-3} (400.00)
$C_2H_3Cl_3$	1,1,1 – Tri –chloro ethane	-16.455	1460.6	0.77524	-	-	2.0695×10^{-3} (242.75)	2.4500×10^{-4} (423.00)
$C_2H_3Cl_3$	1,1,2 – Tri –chloro ethane	0.3880	736.5	-1.7063	-	-	2.9546×10^{-3} (236.50)	3.8162×10^{-4} (386.50)
C_2H_3F	Vinyl fluoride	-10.330	466.48	-0.005236	-	-	2.0017×10^{-3} (112.65)	3.2347×10^{-4} (200.95)
$C_2H_3F_3$	1,1,1 – Tri –fluoro ethane	-12.234	505.25	0.16084	-	-	2.5011×10^{-4} (161.82)	1.0899×10^{-4} (225.75)
C_2H_3N	Aceto nitrile	14.486	-423.7	-3.6926	-	-	3.7171×10^{-4} (288.15)	2.2748×10^{-4} (354.65)
C_2H_3NO	Hydroxy aceto nitrile	-16.289	3442.7	-0.000524	-	-	2.3073 (201.00)	1.3365×10^{-4} (467.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
C_2H_4	Ethylene	-2.4020	194.5	-1.4576	-	-	6.5346×10^{-4} (105.00)	1.0597×10^{-4} (200.00)
C_2H4Br_2	1,2 – Di bromo ethane	-17,582	1635.4	0.9932	-	-	2.0424×10^{-3} (282.85)	5.1198×10^{-4} (404.51)
$C_2H_4Cl_2$	1,1 – Di chloro ethane	-8.9910	870.2	-0.2805	-	-	4.0760×10^{-3} (176.19)	3.4065×10^{-4} (330.45)
$C_2H_4Cl_2$	1,2 – Di chloro ethane	8.8750	264.0	-2.9714	-	-	1.6717×10^{-3} (245.00)	7.8187×10^{-5} (560.00)
$C_2H_4F_2$	1,1 – Di fluoro ethane	22.332	-754.61	-4.9405	-	-	3.6762×10^{-4} (242.55)	1.7859×10^{-4} (333.15)
$C_2H_4N_2$	Amino acetonitrile	-12.634	1575.3	0.00026104	-	-	2.6549×10^{-3} (250.00)	1.6867×10^{-4} (425.00)
$C_2H_4N_2O_6$	Ethylene gly-col dinitrate	-14.694	8272.3	19.936	-	-	1.4042×10^{-2} (260.00)	1.1738×10^{-3} (380.00)
C_2H_4O	Acetaldehyde	54.304	-2050.7	-9.8077	-	-	2.9729×10^{-4} (260.00)	2.3036×10^{-4} (290.00)
C_2H_4O	Ethylene oxide	-18.557	1015.6	1.2098	-	-	1.0448×10^{-3} (190.00)	2.2381×10^{-4} (320.00)
$C_2H_4O_2$	Acetic acid	-9.0300	1212.3	-0.332	-	-	1.2654×10^{-3} (289.81)	3.8903×10^{-4} (391.05)
$C_2H_4O_2$	Methyl formate	-44.497	2301.1	5.0483	-	-	5.9998×10^{-4} (250.00)	2.7857×10^{-4} (320.00)
$C_2H_4O_2S$	Thio glycolic Acid	-12.042	1714.2	0.0005885	-	-	4.7028×10^{-3} (256.65)	1.9138×10^{-3} (493.00)
$C_2H_4O_3$	Glycolic acid	-225.11	15017.0	30.170	-	-	3.8285×10^{-3} (352.65)	2.0940×10^{-3} (372.00)
$C_2H_4O_3$	Para acetic acid	20.205	-129.49	-4.6627	-	-	1.2017×10^{-3} (293.15)	4.2884×10^{-4} (373.15)
C_2H_5Br	Ethyl bromode	-8.3081	764.58	-0.37699	-	-	5.1891×10^{-3} (154.55)	3.2947×10^{-4} (311.50)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
C_2H_5Cl	Ethyl chloride	-10.216	702.0	-0.07200	-	-	2.7483×10^{-3} (150.00)	1.5671×10^{-4} (373.15)
C_2H_5ClO	2 - Chloro ethanol	-44.294	3703.3	4.5470	-	-	1.4616×10^{-2} (250.00)	4.7550×10^{-4} (401.75)
C_2H_5ClO	Chloro methyl methyl ether	-10.956	839.51	0.0004119	-	-	2.4654×10^{-3} (169.65)	2.1824×10^{-4} (332.65)
C_2H_5F	Ethyl fluoride	-10.758	558.81	-0.016459	-	-	1.4775×10^{-3} (129.95)	2.0872×10^{-4} (235.45)
C_2H_5I	Ethyl iodide	-6.7990	691.3	-0.05289	-	-	7.2191×10^{-4} (273.00)	3.7478×10^{-4} (345.45)
C_2H_5N	Ethylene imine	-11.612	967.4	-	-	-	7.9085×10^{-4} (250.00)	3.1299×10^{-4} (329.00)
C_2H_5NO	Acetamide	3.2700	1443.0	-2.3150	-	-	1.9423×10^{-3} (354.15)	2.8319×10^{-4} (494.15)
C_2H_5NO	N – Methyl - Formamide	9.9223	466.32	-3.1375	-	-	2.7288×10^{-3} (269.35)	2.2196×10^{-4} (472.66)
$C_2H_5NO_2$	Nitro ethane	-4.4380	746.5	-0.9385	-	-	3.4205×10^{-3} (200.00)	3.0273×10^{-4} (387.22)
C_2H_6	Ethane	-3.1434	197.05	-1.2193	-9.2023×10^{-26}	10	90.35×10^{-3} (90.35)	3.5196×10^{-5} (300.00)
C_2H_6O	Di methyl ether	-10.620	448.99	8.3967×10^{-5}	-	-	7.3982×10^{-4} (131.65)	1.721×10^{-4} (230.00)
C_2H_6O	Ethanol	8.0490	776.0	-3.068	-	-	3.9570×10^{-3} (240.00)	1.4173×10^{-4} (440.00)
C_2H_6OS	Di methyl sulfoxide	-68.744	4434.0	8.3724	-	-	2.4217×10^{-3} (291.67)	4.1902×10^{-4} (462.15)
$C_2H_6O_2$	Ethylene glycol	-10.352	7563.0	13.009	-	-	1.1650×10^{-1} (260.93)	7.1975×10^{-4} (449.82)
C_2H_6S	Ethyl mercaptan	-9.7574	729.43	-0.14912	-	-	9.5198×10^{-3} (125.26)	2.6895×10^{-4} (305.26)

Formula	*Name*	*A*	*B*	*C*	*D*	*E*	*Viscosity (Min. Temp.)*	*Viscosity (Max. Temp.)*
$C_2H_6S_2$	Di methyl sulfide	-10.577	1172.6	-014244	-	-	6.0934×10^{-3} (188.44)	2.3363×10^{-4} (382.90)
C_2H_7N	Di methyl amine	-10.930	699.5	-	-	-	3.3174×10^{-4} (239.65)	1.7338×10^{-4} (308.15)
C_2H_7N	Ethyl amine	-14.342	1166.5	0.3714	-	-	1.8030×10^{-3} (192.15)	2.7181×10^{-4} (289.73)
C_2H_7NO	Mono ethanol amine	-8.5830	3152.0	-1.0266	-	-	3.1481×10^{-2} (288.15)	4.3307×10^{-4} (444.15)
$C_2H_8N_2$	Ethyledene amine	-70.088	4954.8	8.2824	-	-	1.6350×10^{-3} (303.15)	1.7603×10^{-4} (483.15)
C_2N_2	Cyanogen	-11.518	4423.2	-1.8618	-	-	2.4073×10^{-2} (245.25)	6.1536×10^{-4} (300.00)
C_3F_6	Hexa fluororo propylene	-11.792	1093.9	0.058382	-	-	1.1806×10^{-1} (116.66)	9.3059×10^{-4} (245.88)
C_3F_6O	Hexa fluoro acetone	-11.486	988.93	0.027866	-	-	9.5494×10^{-3} (147.70)	6.6842×10^{-4} (245.88)
C_3F_8	Octa fluoro propane	-11.581	1012.0	0.023038	-	-	3.3261×10^{-2} (125.46)	7.6609×10^{-4} (236.40)
C_3H_3N	Aceto nitrile	-2.9660	473.0	-1.1632	-	-	6.3350×10^{-4} (240.00)	1.6877×10^{-4} (390.00)
C_3H_4	Methyl acetylene	2.8737	301.35	-1.2271	-	-	6.0450×10^{-4} (170.45)	8.8458×10^{-5} (373.15)
C_3H_4	Propadiene	8.4279	-163.83	-2.9373	-	-	4.7245×10^{-4} (173.15)	1.0886×10^{-4} (333.15)
C_3H_4O	Acrolein	-12.032	867.34	0.19534	-	-	8.3797×10^{-4} (222.89)	2.1813×10^{-4} (353.22)
C_3H_4O	Propargyl alcohol	-12.265	2151.4	-0.26367	-	-	1.8887×10^{-2} (221.35)	2.5529×10^{-4} (386.75)

Formula	**Name**	**A**	**B**	**C**	**D**	**E**	**Viscosity (Min. Temp.)**	**Viscosity (Max. Temp.)**
$C_3H_4O_2$	Acrylic acid	-28.120	2280.2	2.3956	-	-	1.1909×10^{-3} (293.15)	2.0860×10^{-4} (460.00)
$C_3H_4O_2$	β-Propio actone	-2.4776	467.94	-1.1975	-	-	8.3537×10^{-4} (293.75)	1.0355×10^{-4} (548.00)
$C_3H_4O_2$	Vinyl formate	-10.949	831.17	0.041756	-	-	1.3991×10^{-3} (200.00)	3.003×10^{-4} (320.00)
$C_3H_4O_3$	Ethylene carbonate	-11.653	1442.7	-	-	-	9.0006×10^{-4} (310.93)	4.2003×10^{-4} (372.04)
$C_3H_4O_3$	Pyruvicacid	-12.283	1962.7	0.031355			3.0036×10^{-3} (286.75)	2.8593×10^{-4} (438.15)
C_3H_5Cl	2 – Chloro - propene	-10.756	794.25	0.0041346	-	-	7.5601×10^{-3} (135.75)	3.1994×10^{-4} (295.80)
C_3H_5Cl	3 - Chloro - propene	0.3060	353.0	-1.6754	-	-	5.3531×10^{-4} (250.00)	2.6424×10^{-4} (318.11)
C_3H_5ClO	α - Epichloro hydrin	-14.616	1394.6	0.54437	-	-	4.3969×10^{-3} (223.32)	3.2761×10^{-4} (422.48)
$C_3H_5ClO_2$	Methyl Chloro acetate	-9.9576	1254.5	-0.19571	-	-	2.9489×10^{-3} (241.03)	3.2931×10^{-4} (402.97)
$C_3H_5Cl_3$	1,2,3 – Tri –chloro propane	9.6558	-1777.0	-18.344	-	-	4.2641×10^{-3} (258.45)	5.1280×10^{-4} (430.00)
C_3H_5N	Propio nitrile	-5.7136	703.6	-0.78123	-	-	7.3714×10^{-4} (250.00)	1.7772×10^{-4} (400.00)
C_3H_5NO	Acryl amide	-12.309	2239.4	-0.02281	-	-	2.0669×10^{-3} (357.65)	4.8036×10^{-4} (465.75)
C_3H_5NO	Hydrocrylo nitrile	-12.242	1433.6	0.028477	-	-	3.1003×10^{-3} (227.15)	1.0472×10^{-4} (449.15)
C_3H_6	Cyclo popane	-3.0761	291.39	-1.1627	-	-	1.0428×10^{-3} (145.59)	$1{,}4175 \times 10^{-4}$ (318.33)
C_3H_6	Propylene	-44.830	1337.0	5.6710	-	-	1.1608×10^{-2} (90.00)	2.8430×10^{-4} (220.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_3H_6Cl_2$	1,2 – Di chloro ethane	11.269	1195.3	0.012736	-	-	1.3808×10^{-2} (172.71)	3.7131×10^{-4} (362.21)
C_3H_6O	Acetone	-14.918	1023.4	0.05961	-	-	8.8134×10^{-4} (223.15)	2.3506×10^{-4} (329.44)
C_3H_6O	Methyl - vinyl ether	-10.340	519.61	-0.013899	-	-	9.3774×10^{-4} (151.15)	1.9287×10^{-4} (278.65)
C_3H_6O	N – Propan aldehyde	13.392	-143.28	-3.6775	-	-	3.9302×10^{-4} (280.00)	2.4387×10^{-4} (352.00)
C_3H_6O	1,2 - Propylene oxide	-11.967	1143.5	-	-	-	1.9314×10^{-3} (200.00)	2.6313×10^{-4} (307.05)
C_3H_6O	1,3 - Propylene oxide	3.7240	-39.795	-2.1038	-	-	3.0666×10^{-4} (255.00)	1.1634×10^{-4} (416.00)
$C_3H_6O_2$	Acetol	-15.673	3180.7	-0.00011	-	-	3.8532×10^{-2} (256.15)	3.1087×10^{-4} (418.65)
$C_3H_6O_2$	Ethyl formate	-9.8417	876.4	-0.17089	-	-	7.4348×10^{-4} (245.00)	2.4864×10^{-4} (345.00)
$C_3H_6O_2$	Methyl acetate	13.557	-187.3	-3.6592	-	-	6.1350×10^{-4} (250.00)	1.1982×10^{-4} (425.00)
$C_3H_6O_2$	Propionic acid	-11.010	1166.6	-0.12281	-	-	2.1161×10^{-3} (252.45)	3.2737×10^{-4} (424.32)
$C_3H_6O_3$	Lactic acid	-13.699	4061.3	-0.54266	-	-	5.9084×10^{-2} (291.15)	3.6161×10^{-4} (447.00)
$C_3H_6O_3$	Tri oxane	-11.434	1487.3	-	-	-	1.2803×10^{-1} (335.15)	1.1423×10^{-1} (387.65)
C_3H_7Br	1- Bromo propane	-5.4186	659.2	-0.7734	-	-	1.9886×10^{-3} (200.00)	3.2861×10^{-4} (344.15)
C_3H_7Br	2 – Bromo-propane	-90.325	4411.7	11.912	-	-	1.0012×10^{-3} (250.00)	3.7511×10^{-4} (332.56)
C_3H_7Cl	Iso propyl chloride	-15.458	1086.0	0.6540	-	-	5.5154×10^{-4} (250.00)	2.7674×10^{-4} (308.85)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
C_3H_7Cl	n – Propyl chloride	-28.768	1624.4	2.6912	-	-	6.0454×10^{-4} (250.00)	2.8427×10^{-4} (319.67)
C_3H_7I	Iso propyl Iodide	-0.8513	529.0	-1.4480	-	-	1.7595×10^{-3} (225.00)	3.6122×10^{-4} (362.65)
C_3H_7I	n – Propyl iodide	-10.638	984.0	0.1460	-	-	1.5680×10^{-3} (240.00)	3.5920×10^{-4} (357.60)
C_3H_7N	Allyl amine	-11.869	1208.5	-0.0145	-	-	4.4694×10^{-3} (184.95)	2.6100×10^{-4} (326.45)
C_3H_7NO	N,N–Di methyl formamide	-33.604	2173.0	3.3728	-	-	2.3234×10^{-3} (240.00)	3.0866×10^{-4} (375.60)
$C_3H_7NO_2$	1 – Nitro propane	-24.521	1788.6	1.9988	-	-	2.2121×10^{-3} (240.00)	3.0350×10^{-4} (326.45)
$C_3H_7NO_2$	2 – Nitro propane	-5.4102	833.52	-0.81426	-	-	6.3279×10^{-3} (181.83)	2.8686×10^{-4} (426.15)
C_3H_8	Propane	-6.9281	420.76	-0.63276	-1.713×10^{-26}	10	8.0682×10^{-3} (85.47)	4.0666×10^{-5} (360.00)
C_3H_8O	Iso propanol	-8.2300	2282.2	-0.98495			3.0037×10^{-1} (187.35)	5.1389×10^{-5} (354.45)
C_3H_8O	Methyl ethyl ether	-11.104	627.18	0.036581			2.7069×10^{-4} (133.15)	1.7036×10^{-4} (280.50)
C_3H_8O	n - Propanol	0.5710	1521.0	-2.0894			2.2713×10^{-2} (220.00)	2.0440×10^{-4} (425.00)
$C_3H_8O_2$	2 – Methoxy ethanol	-3.4217	1792.6	-1.5878	-	-	2.8227×10^{-2} (214.05)	1.1009×10^{-4} (448.05)
$C_3H_8O_2$	Methylol	-15.046	954.97	0.6630	-	-	2.5423×10^{-3} (168.35)	2.8904×10^{-4} (308.35)
$C_3H_8O_2$	1,2 - Proplene glycol	-293.07	17494	40.576	-	-	2.4359×10 (233.00)	1.7852×10^{-3} (420.00)
$C_3H_8O_2$	1,3 - Proplene glycol	-14.436	3177.9	0.012322	-	-	2.2914×10^{-1} (246.45)	3.9303×10^{-4} (487.55)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_3H_8O_3$	Glycerol	-237.03	16739	31.734	-	-	1.4068 (293.15)	1.7685×10^{-3} (500.00)
C_3H_9N	Iso propyl amine	-31.157	1926.0	2.9250	-	-	4.5436×10^{-4} (273.15)	1.2135×10^{-4} (453.15)
C_3H_9N	n – Propyl amine	-12.665	1281.8	0.088169	-	-	4.2480×10^{-3} (190.15)	2.8277×10^{-4} (321.65)
C_3H_9N	Tri methyl amine	10.142	-130.41	-3.2199	-	-	5.1564×10^{-4} (200.00)	1.6116×10^{-4} (308.15)
C_3H_9NO	1 – Amino – 2 - ropanol	-19.063	4559.2	-	-	-	8.3956×10^{-2} (274.89)	1.9851×10^{-4} (432.16)
C_3H_9NO	3 – Amino – 1 - ropanol	-16.567	3638.2	0.0095104	-	-	2.449×10^{-2} (284.15)	1.8215×10^{-4} (460.65)
C_4Cl_6	Hexa chloro -1,3 - butadiene	-11.818	1930.2	0.027303	-	-	1.8097×10^{-2} (225.15)	4.7796×10^{-4} (482.15)
C_4F_8	Octa fluoro - 2 - butene	-11.560	1075.6	0.021432	-	-	2.5511×10^{-2} (138.15)	5.7474×10^{-4} (270.36)
C_4F_8	Octa fluoro cyclo butene	-11.805	1138.6	0.027738	-	-	9.0788×10^{-4} (245.00)	2.6796×10^{-4} (335.00)
C_4F_{10}	Deca fluoro Butene	-11.536	1394.0	-0.015474	-	-	1.3589×10^{-1} (144.95)	1.5316×10^{-3} (271.14)
$C_4H_2O_3$	Maleic anhydride	-1.3320	1053.6	-1.4185	-	-	1.8202×10^{-3} (326.00)	3.9275×10^{-4} (473.15)
$C_4H_4N_2$	Succino nitrile	-4.8640	1222.0	-0.82114	-	-	2.6355×10^{-3} (331.16)	4.4560×10^{-4} (531.16)
C_4H_4O	Furan	-12.149	945.97	0.18419	-	-	1.0535×10^{-3} (220.00)	3.1288×10^{-4} (313.15)
$C_4H_4O_3$	Succinic anhydride	-10.191	1148.0	-0.12655	-	-	3.269×10^{-4} (393.00)	1.4382×10^{-4} (536.58)
$C_4H_4O_4$	Fumaric acid	-20.013	2771.4	1.0117	-	-	1.7284×10^{-4} (560.15)	1.6150×10^{-4} (570.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_4H_4O_4$	Maleic acid	-13.030	2469.5	-	-	-	9.9871×10^{-4} (403.45)	8.9055×10^{-4} (411.15)
C_4H_4S	Thiophene	-16.671	1342.5	0.8388	-	-	8.6307×10^{-4} (273.15)	2.6354×10^{-4} (393.15)
C_4H_5Cl	Chloroprene	-11.214	975.27	0.019147	-	-	1.3487×10^{-2} (143.15)	9.9164×10^{-5} (520.00)
C_5H_5N	Methacrylo nitrile	-7.3519	817.93	-0.53237	-	-	1.0943×10^{-3} (237.25)	2.7667×10^{-4} (357.35)
C_4H_5N	Pyrrole	-57.27	3672.0	6.7156	-	-	4.1123×10^{-3} (249.74)	3.8830×10^{-4} (400.00)
$C_4H_5NO_2$	Methyl cyano acetate	-12.365	1936.4	-	-	-	7.3021×10^{-3} (260.08)	2.4458×10^{-4} (478.24)
C_4H_6	1,2 - Buta diene	-9.0974	519.05	-0.2131	-9.8×10^{-28}	10	6.4568×10^{-4} (181.45)	8.1887×10^{-5} (431.91)
C_4H_6	1,3 - Buta diene	-17.844	-310.2	-4.5058	-	-	2.5471×10^{-4} (250.00)	4.8797×10^{-5} (400.00)
C_4H_6	Ethyl acetylene	-3.4644	334.50	-1.0811	-	-	5.974×10^{-4} (193.15)	1.2714×10^{-4} (373.15)
$C_4H_6Cl_2$	1,4 - Di chloro trans - 2 - butene	-10.411	595.25	0.016046	-	-	2.8883×10^{-4} (274.15)	1.3275×10^{-4} (429.26)
C_4H_6O	Trans - Croton aldehyde	-10.398	906.92	0.010129	-	-	2.0505×10^{-3} (196.65)	2.2693×10^{-4} (377.25)
C_4H_6O	Di vinyl ether	-12.595	649.52	0.0068511	-	-	9.9124×10^{-4} (172.05)	1.9682×10^{-4} (301.45)
C_4H_6O	Allyl alcohol	-11.671	200.20	0.5530	-	-	1.7925×10^{-3} (280.56)	3.8012×10^{-4} (368.39)
C_4H_6O	Methacrolein	-14.527	909.76	-0.067497	-	-	2.4338×10^{-3} (192.15)	3.1838×10^{-4} (2.15)
$C_4H_6O_2$	Cis - Crotonic acid	-12.595	1582.3			-	1.6399×10^{-3} (288.65)	2.6215×10^{-4} (440.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_4H_6O_2$	Trans - Crotonic acid	-11.671	1532.7	-0.0099432	-	-	6.8871×10^{-4} (344.55)	2.2792×10^{-4} (458.15)
$C_4H_6O_2$	Methacrylic acid	-14.527	1497.7	0.5174	-	-	1.4926×10^{-3} (295.00)	3.6847×10^{-4} (430.00)
$C_4H_6O_2$	Methyl acrylate	10.848	75.0	-3.297	-	-	6.288×10^{-4} (273.00)	1.3801×10^{-4} (420.00)
$C_4H_6O_2$	Vinyl acetate	-22.408	1462.8	1.7006	-	-	7.7163×10^{-4} (250.00)	2.5697×10^{-4} (350.00)
$C_4H_6O_3$	Acetic anhydride	-14.164	1350.3	0.4492	-	-	1.4129×10^{-3} (265.00)	2.7747×10^{-4} (413.15)
$C_4H_6O_4$	Succinic acid	-10.674	9695.5	13.001	-	-	2.5744×10^{-3} (460.65)	7.6175×10^{-4} (563.00)
$C_4H_6O_5$	Di glycolic acid	-13.682	2587.0	0.08995	-	-	9.1579×10^{-4} (421.15)	2.4230×10^{-4} (540.00)
$C_4H_7ClO_2$	Ethyl chloro acetate	-10.763	1373.9	0.11382	-	-	2.9346×10^{-3} (247.15)	2.8649×10^{-4} (417.35)
C_4H_7N	N - Butyro nitrile	-7.7634	925.92	-0.49345	-	-	1.0787×10^{-2} (161.25)	2.3837×10^{-4} (391.15)
C_4H_7N	Iso butyro nitrile	-12.142	1060.5	0.1793	-	-	2.6514×10^{-3} (201.70)	2.5771×10^{-4} (376.76)
C_4H_7NO	2 - Pyrrolodone	-9.0604	6780.6	11.146	-	-	1.2825×10^{-2} (298.15)	7.5178×10^{-4} (425.00)
C_4H_8	1 - Butene	-2.6725	336.1	-1.286	-	-	8.263×10^{-4} (160.00)	1.7916×10^{-4} (270.00)
C_4H_8	Cis - 2 - Butene	-10.175	664.92	-0.1195	-	-	5.6226×10^{-4} (200.00)	1.3424×10^{-4} (340.00)
C_4H_8	Trans - 2 - butene	-10.175	664.92	-0.1195	-	-	5.6226×10^{-4} (200.00)	1.1960×10^{-4} (360.00)
C_4H_8	Cyclo butene	-2.6678	340.02	-1.1776	-	-	9.7233×10^{-4} (182.48)	1.6640×10^{-4} (367.94)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
C_4H_8	Iso butene	-48.766	1907.0	5.9030	-	-	2.0887×10^{-4} (240.00)	1.2442×10^{-4} (350.00)
$C_4H_8Cl_2$	1,4 - Di chloro butene	-10.09	1245.3	-0.1270	-	-	4.0714×10^{-3} (235.85)	3.5503×10^{-4} (427.05)
C_4H_8O	N - Butyraldehyde	-7.8069	833.79	-0.48339	-	-	5.5863×10^{-4} (275.00)	2.1423×10^{-4} (375.00)
C_4H_8O	1,2 - Epoxy butane	-9.2718	431.64	-	-	-	1.0345×10^{-3} (180.00)	3.3906×10^{-4} (336.57)
C_4H_8O	Ethyl vinyl ether	-8.3337	695.51	-0.43253	-	-	2.2395×10^{-3} (157.35)	1.9160×10^{-4} (308.70)
C_4H_8O	Iso butyraldehyde	-10.669	972.04	-0.07416	-	-	1.6699×10^{-3} (208.15)	2.6963×10^{-4} (337.25)
C_4H_8O	Methyl ethyl ketone	-8.1340	509.78	-1.5324	-	-	2.1504×10^{-3} (188.71)	7.645×10^{-5} (533.15)
C_4H_8O	Tetra hydro furan	-10.335	883.60	-0.05265	-	-	5.3152×10^{-3} (164.65)	2.9787×10^{-4} (350.00)
$C_4H_8O_2$	Cis - 2 –butene - 1,4 - diol	-13.957	2957.0	-	-	-	2.871×10^{-2} (288.15)	2.9226×10^{-4} (508.15)
$C_4H_8O_2$	N - Butyric acid	-11.696	1488.0	0.033	-	-	2.5818×10^{-3} (268.00)	3.0787×10^{-4} (436.42)
$C_4H_8O_2$	1,4 - Dioxane	-36.706	2691.5	3.6741	-	-	1.4199×10^{-3} (288.15)	4.9871×10^{-4} (360.00)
$C_4H_8O_2$	Ethyl acetate	13.216	-97.094	-3.6239	-	-	5.7015×10^{-4} (273.15)	9.0487×10^{-5} (473.15)
$C_4H_8O_2$	Iso butyric acid	-11.497	1365.7	0.036966	-	-	2.9378×10^{-3} (250.00)	2.6487×10^{-4} (450.00)
$C_4H_8O_2$	Methyl propionate	-4.6795	697.66	-0.94943	-	-	5.7764×10^{-4} (273.15)	2.6403×10^{-4} (349.00)
$C_4H_8O_2$	Propyl ester	-5.2739	774.97	-0.86944	-	-	9.3534×10^{-4} (250.00)	2.3395×10^{-4} (375.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_4H_8O_2$	n - Propyl formate	-5.2739	774.97	-0.86944	-	-	9.3534×10^{-4} (250.00)	2.3395×10^{-4} (375.00)
$C_4H_8O_2S$	Sulfolane	-55.512	4380.0	6.3840	-	-	1.0894×10^{-2} (300.75)	6.8354×10^{-4} (558.15)
$C_4H_8O_2S$	Tetra hydro thiophene	-10.843	1165.2	-	-	-	1.08941×10^{-2} (293.15)	9.1247×10^{-4} (303.15)
C_4H_9Br	1 - Bromo butane	-8.5665	874.0	-0.3112	-	-	1.3196×10^{-3} (240.00)	3.1013×10^{-4} (375.75)
C_4H_9Br	2 - Bromo butane	-7.4231	818.5	-0.49436	-	-	1.7138×10^{-3} (220.00)	3.0580×10^{-4} (364.34)
C_4H_9Cl	n - Butyl chloride	8.9100	49.58	-2.9568	-	-	7.3434×10^{-4} (250.00)	2.5302×10^{-4} (351.58)
C_4H_9Cl	Sec - Butyl chloride	-42.417	2410.5	4.6466	-	-	8.0959×10^{-4} (250.00)	2.6088×10^{-4} (341.25)
C_4H_9Cl	Tert - Butyl chloride	-20.527	1630.1	1.2984	-	-	6.1801×10^{-4} (280.00)	3.3977×10^{-4} (323.75)
C_4H_9N	Pyrrolidine	-67.242	3754.9	8.3228	-	-	6.1472×10^{-3} (251.31)	4.0113×10^{-4} (359.72)
C_4H_9NO	n,n - Di methyl cetamide	22.738	-428.5	-4.967	-	-	1.5933×10^{-3} (253.15)	2.1134×10^{-4} (439.25)
C_4H_9NO	Morpholine	-50.434	3611.7	5.6368	-	-	3.1108×10^{-3} (280.00)	4.7623×10^{-4} (402.09)
C_4H_{10}	N - Butane	-7.2471	534.82	-0.57469	-4.6625×10^{-27}	10	2.2434×10^{-3} (134.86)	3.5664×10^{-5} (420.00)
C_4H_{10}	Iso butane	-18.345	1020.3	1.0978	-6.1×10^{-27}	10	7.3533×10^{-4} (190.00)	5.2408×10^{-5} (400.00)
$C_4H_{10}N_2$	Piperazine	-13.372	1678.0	0.20512	-	-	3.0171×10^{-4} (379.15)	2.0549×10^{-4} (419.15)
$C_4H_{10}O$	n - Butanol	-20.404	2689.0	0.9560	-	-	1.2658×10^{-2} (250.00)	4.0251×10^{-4} (390.81)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_4H_{10}O$	Sec - Butanol	-10.638	7434.0	13.285	-	-	4.7932×10^{-3} (288.15)	4.1659×10^{-4} (373.15)
$C_4H_{10}O$	Tert - Butanol	-216.40	13205.0	29.254	-2.4616×10^{-27}	10	4.3119×10^{-3} (298.15)	1.0137×10^{-4} (451.21)
$C_4H_{10}O$	Di ethyl ether	10.197	-63.8	-3.2260	-	-	4.6953×10^{-4} (233.15)	1.1412×10^{-4} (373.15)
$C_4H_{10}O$	Iso butanol	-48.035	4306.7	4.8948	-3.5×10^{-28}	10	2.4105×10^{-1} (210.93)	4.1665×10^{-5} (544.26)
$C_4H_{10}O_2$	1,3 - Butane diol	-151.99	11386	19.567	-	-	1.3590×10^{-1} (293.15)	5.7107×10^{-4} 480.15)
$C_4H_{10}O_2$	1,4 - Butane diol	-76.012	6966.8	8.7765	-	-	9.1615×10^{-2} (293.15)	5.2732×10^{-4} (501.15)
$C_4H_{10}O_2$	1,2 - dimethoxy ethane	-17.949	1257.0	1.0560	-	-	1.6053×10^{-3} (215.15)	2.6855×10^{-4} (357.20)
$C_4H_{10}O_2$	2 - Ethoxy ethanol	13.653	2393.7	-0.10063	-	-	6.1267×10^{-2} (210.00)	2.2640×10^{-4} (408.15)
$C_4H_{10}O_3$	Di ethylene glocol	-6.2425	5966.9	6.8296	-	-	4.7927×10^{-2} (288.15)	2.5046×10^{-3} (373.15)
$C_4H_{10}O_3S$	Di methyl sulfite	-10.902	1138.5	-	-	-	2.1160×10^{-3} (240.00)	5.8028×10^{-4} (330.00)
$C_4H_{10}S$	n - Butyl - mercaptan	-10.175	929.87	-11.533	-	-	7.8046×10^{-2} (157.46)	2.3516×10^{-4} (371.61)
$C_4H_{10}S$	Tert - Butyl - mercaptan	29.469	1988.5	2.6988	-	-	8.5252×10^{-4} (274.26)	3.8407×10^{-4} (337.37)
$C_4H_{10}S$	Di ethyl sulfide	-5.1350	667.50	-0.8553	-	-	1.1130×10^{-3} (225.00)	2.3539×10^{-4} (365.25)
$C_4H_{10}S$	Sec - Butyl mercaptan	-10.903	932.82	0.023034	-	-	2.2875×10^{-2} (133.02)	2.8505×10^{-4} (358.13)
$C_4H_{11}N$	n - Butyl amine	28.975	-564.10	-6.0622	-	-	7.6773×10^{-4} (278.15)	2.8601×10^{-4} (350.85)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_4H_{11}N$	Sec - Butyl amine	-11.397	1353.7	-0.1313	-	-	1.7543×10^{-2} (168.65)	2.9346×10^{-4} (336.15)
$C_4H_{11}N$	Tert - Butyl amine	-98.443	5193.4	12.869	-	-	9.9978×10^{-4} (260.00)	3.5089×10^{-4} (317.55)
$C_4H_{11}N$	Di ethyl amine	-11.854	1111.6	0.01293	-	-	7.8371×10^{-4} (240.00)	2.2456×10^{-4} (329.10)
$C_4H_{11}N$	Iso butyl amine	-12.070	1361.1	-	-	-	1.3260×10^{-3} (250.00)	3.1057×10^{-4} (340.88)
$C_4H_{11}NO_2$	Di ethanol amine	-35.726	6755.5	2.1822	-	-	4.3235×10^{-1} (301.15)	1.5641×10^{-3} (420.00)
$C_4H_{12}N_2O$	n - Amino ethanol amine	-17.993	4955.1	-0.14252	-	-	5.2102×10^{-1} (273.15)	9.1503×10^{-5} (517.00)
$C_4H_{13}N_3$	Di ethylene triamine	-12.658	2157.9	0.0013379	-	-	3.2231×10^{-2} (234.15)	2.8688×10^{-4} (480.25)
C_5Cl_6	Hexa chloro penta diene	-64.926	4699.6	7.7574	-	-	6.9785×10^{-3} (298.15)	1.6742×10^{-3} (373.15)
$C_5H_4O_2$	Furfural	-69.008	3950.4	8.6550	-	-	2.5094×10^{-3} (273.00)	6.4623×10^{-4} (434.85)
C_5H_5N	Pyridine	-51.584	3135.5	5.9733	-	-	4.0141×10^{-3} (231.51)	3.7143×10^{-4} (388.41)
C_5H_6	Cyclo penta diene	-10.330	649.24	-151.25	-	-	9.5051×10^{-4} (188.15)	2.3555×10^{-4} (314.65)
$C_5H_6O_2$	Furfuryl alcohol	-37.008	3555.0	3.4664	-	-	1.8299×10^{-2} (258.52)	3.8512×10^{-4} (443.15)
$C_5H_6O_3$	Glutaric anhydride	-11.367	1264.0	0.033923	-	-	6.6427×10^{-4} (328.00)	1.3560×10^{-4} (562.69)
C_5H_6S	2 - Methyl thiophene	-8.7259	1026.7	-0.35696	-	-	1.3740×10^{-3} (250.00)	2.4481×10^{-4} (385.71)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
C_5H_6S	3 - Methyl - thiophene	-29.553	1913.6	2.7693	-	-	1.6580×10^{-3} (240.00)	1.1690×10^{-4} (340.00)
C_5H_7NO	Ethyl - cyano acetate	-13.965	2369.0	-	-	-	1.0959×10^{-2} (250.65)	1.2087×10^{-4} (479.15)
C_5H_8	Cyclo pentene	-4.8610	426.69	-0.8761	-	-	2.2664×10^{-3} (138.13)	1.1503×10^{-4} (405.60)
C_5H_8	Isoprene	6.6348	-7.8543	-2.6494	-	-	2.5977×10^{-4} (273.00)	1.9062×10^{-4} (307.20)
C_5H_8	Cis -1,3 - Penta diene	-10.387	602.52	-0.030373	-	-	6.6714×10^{-4} (186.35)	1.7294×10^{-4} (317.22)
C_5H_8	Trans -1,3 - Penta diene	-10.261	597.29	-0.049439	-	-	3.9603×10^{-4} (221.71)	1.7508×10^{-4} (315.17)
C_5H_8	1,4 - Penta diene	-10.648	611.36	0.010148	-	-	3.3371×10^{-3} (124.86)	1.9428×10^{-4} (299.11)
C_5H_8	Cyclo pentene	-4.8610	426.69	-0.8761	-	-	2.2664×10^{-3} (138.13)	1.1503×10^{-4} (405.60)
C_5H_8	Isoprene	6.6348	-7.8543	-2.6494	-	-	2.5977×10^{-4} (273.00)	1.9062×10^{-4} (307.20)
C_5H_8	Cis - 1,3 - Penta diene	-10.387	602.52	-0.030373	-	-	6.6714×10^{-4} (186.35)	1.7294×10^{-4} (317.22)
C_5H_8	Trans -1,3 - Penta diene	-10.261	597.29	-0.049439	-	-	3.9603×10^{-4} (221.71)	1.7508×10^{-4} (315.17)
C_5H_8	1,4 - Penta diene	-10.648	611.36	0.010148	-	-	3.3371×10^{-3} (124.86)	1.9428×10^{-4} (299.11)
C_5H_8O	Cyclo pentanone	-23.530	5012.0	-	-	-	2.163×10^{-3} (288.15)	6.7204×10^{-5} (360.00)
$C_5H_8O_2$	Acetyl acetone	-10.956	1128.0	-	-	-	1.0848×10^{-3} (273.15)	4.0709×10^{-4} (358.15)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_5H_8O_2$	Allyl acetate	-10.544	1029.8	-0.091748	-	-	1.1639×10^{-3} (240.00)	2.3455×10^{-4} (377.15)
$C_5H_8O_2$	Ethyl acrylate	0.9132	447.0	-1.7439	-	-	9.8303×10^{-4} (250.00)	1.864×10^{-4} (425.00)
$C_5H_8O_2$	Methyl methacrylate	0.099	496.0	-1.5939	-	-	8.6353×10^{-4} (260.00)	2.290×10^{-4} (400.00)
$C_5H_8O_2$	Vinyl propionate	-11.482	1074.6	0.046541	-	-	1.4205×10^{-3} (230.00)	2.5914×10^{-4} (364.35)
$C_5H_8O_3$	Levulinic acid	-12.873	2295.7	-0.043631	-	-	3.4372×10^{-3} (308.15)	1.6296×10^{-4} (518.95)
$C_5H_8O_3$	Methyl aceto acetate	-10.948	1473.6	-0.07408	-	-	1.3207×10^{-2} (210.00)	2.5105×10^{-4} (473.15)
$C_5H_8O_4$	Glutaric acid	-12.676	2236.8	0.072811	-	-	2.0082×10^{-3} (370.65)	2.4076×10^{-4} (576.15)
C_5H_9N	Valero nitrile	-6.250	890.0	-0.072811	-	-	9.4115×10^{-4} (275.00)	1.890×10^{-4} (450.00)
C_5H_9NO	n - Methy - l,2 - pyrrolidone	-12.503	1850.2	-0.017697	-	-	5.6585×10^{-3} (249.15)	1.6359×10^{-4} (475.15)
$C_5H_9NO_4$	L - Glutanic acid	-14.627	3325.5	0.092851	-	-	6.3533×10^{-4} (497.15)	1.1630×10^{-4} (670.00)
C_5H_{10}	Cyclo pentane	-3.2612	614.16	-1.156	-	-	1.1220×10^{-3} (225.00)	3.1669×10^{-4} (325.00)
C_5H_{10}	2 - Methyl -1- butene	-10.755	705.48	-0.011113	-	-	3.6165×10^{-3} (136.00)	2.0343×10^{-4} (304.30)
C_5H_{10}	2 - Methyl - 2 - butene	-8.4453	639.21	-0.38409	-	-	3.1641×10^{-3} (139.39)	1.8747×10^{-4} (309.39)
C_5H_{10}	3 - Methyl - 1 - butene	-45.435	2289.4	5.1340	-	-	2.6082×10^{-4} (273.15)	1.9039×10^{-4} (305.74)
C_5H_{10}	1 - Pentene	-8.860	692.8	-0.3163	-	-	1.0131×10^{-3} (175.00)	1.7638×10^{-4} (310.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
C_5H_{10}	Cis - 2 - Pentene	-10.738	661.88	0.011126	-	-	5.257 x 10^{-3} (121.75)	1.9556 x 10^{-4} (310.08)
C_5H_{10}	Trans - 2 -Pentene	-10.815	664.14	0.023406	-	-	3.3363 x 10^{-3} (132.89)	1.9650 x 10^{-4} (309.49)
$C_5H_{10}Cl_2$	1,5 - Di chloro pentane	-8.15	1242.6	-0.43323	-	-	1.435 x 10^{-2} (200.35)	3.1169 x 10^{-4} (453.15)
$C_5H_{10}O$	Di ethyl ketone	-2.8695	596.3	-1.2025	-	-	5.8835 x 10^{-4} (273.16)	2.2854 x 10^{-4} (371.97)
$C_5H_{10}O$	Methyl iso propyl ketone	-11.381	1052.9	0.01703	-	-	4.1687 x 10^{-3} (181.1)	2.2135 x 10^{-4} (367.55)
$C_5H_{10}O$	2 - Pentanone	-13.181	1147.0	0.31253	-	-	9.1501 x 10^{-4} (250.00)	2.3419 x 10^{-4} (375.46)
$C_5H_{10}O$	Valeraldehyde	-10.806	987.12	0.017407	-	-	5.0333 x 10^{-3} (182.00)	3.1013 x 10^{-4} (376.15)
$C_5H_{10}O_2$	n - Butyl formate	-17.801	1497.8	0.9533	-	-	1.4356 x 10^{-3} (250.00)	2.8680 x 10^{-4} (375.00)
$C_5H_{10}O_2$	Ethyl propionate	-6.205	836.3	-0.7368	-	-	9.7995 x 10^{-4} (250.00)	2.3834 x 10^{-4} (375.00)
$C_5H_{10}O_2$	Iso butyl formate	-16.639	1428.0	0.7826	-	-	6.9879 x 10^{-4} (289.20)	2.8537 x 10^{-4} (371.22)
$C_5H_{10}O_2$	Iso propyl acetate	-15.099	1281.5	0.57233	-	-	2.2802 x 10^{-3} (215.75)	2.7905 x 10^{-4} (361.65)
$C_5H_{10}O_2$	Iso valeric acid	-3.857	1331.2	-1.1956	-	-	6.946 x 10^{-3} (243.85)	2.7831 x 10^{-4} (448.25)
$C_5H_{10}O_2$	Methyl - n - butyrate	-12.206	1141.7	0.15014	-	-	3.3392 x 10^{-3} (200.00)	2.5391 x 10^{-4} (375.90)
$C_5H_{10}O_2$	n - Propyl acetate	18.851	-303.96	-4.4468	-	-	5.8334 x 10^{-4} (293.15)	1.0297 x 10^{-4} (473.15)
$C_5H_{10}O_2$	Tetra hydro furyl alcohol	8.0669	2748.2	-1.1310	-	-	3.6194 x 10^{-2} (250.00)	1.4063 x 10^{-4} (450.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_5H_{10}O_2$	Valeric acid	-37.067	2856.7	3.7344	-	-	2.4704×10^{-3} (288.15)	5.2573×10^{-4} (400.00)
$C_5H_{10}O_2S$	3 - Methyl - sulfolane	-72.515	5360.1	8.7917	-	-	1.5237×10^{-2} (290.00)	1.0149×10^{-3} (450.00)
$C_5H_{10}O_3$	Di ethyl carbonate	-47.078	2783.2	5.3617	-	-	1.7629×10^{-3} (250.00)	3.3702×10^{-4} (399.95)
$C_5H_{10}O_3$	Ethyl acetate	-22.903	3042.7	1.1815	-	-	1.6877×10^{-2} (247.15)	1.7863×10^{-4} (427.65)
$C_5H_{11}Cl$	1 - Chloro pentene	-11.495	1089.5	0.060156	-	-	7.2374×10^{-3} (174.15)	2.5306×10^{-4} (381.54)
$C_5H_{11}N$	n - Metyl pyrrolidine	-11.992	1328.7	-0.013431	-	-	8.1701×10^{-3} (183.15)	2.4606×10^{-4} (352.30)
$C_5H_{11}N$	Piperidine	3.753	817.6	-2.296	-	-	1.7357×10^{-3} (285.00)	4.3998×10^{-4} (379.55)
C_5H_{12}	Iso pentane	-12.596	889.11	0.20496	-	-	6.9775×10^{-4} (210.00)	1.7745×10^{-4} (320.00)
C_5H_{12}	Neo pentane	-56.062	3029.1	6.5862	-	-	4.3014×10^{-4} (258.15)	2.1716×10^{-4} (303.15)
C_5H_{12}	n - Pentane	-20.383	1054.4	1.4874	-1.01188×10^{-22}	10	3.4377×10^{-3} (143.42)	4.7179×10^{-5} (465.15)
$C_5H_{12}O$	2,2 - Dimethyl -1 - propanol	-15.075	3253.1	-0.14998	-	-	2.4795×10^{-3} (327.15)	5.2817×10^{-4} (368.25)
$C_5H_{12}O$	Ethyl propyl ether	0.7109	386.51	-1.7754	-	-	1.1555×10^{-3} (200.00	2.0857×10^{-4} (337.01)
$C_5H_{12}O$	2 - Methyl - 1 - butanol	-68.504	5455.0	7.850	-	-	1.1169×10^{-2} (273.15)	3.7881×10^{-4} (403.15)
$C_5H_{12}O$	2 - Methyl - 2 - butanol	-195.84	11895.0	26.385	-	-	2.5201×10^{-2} (264.35)	4.3758×10^{-4} (375.15)
$C_5H_{12}O$	3 - Methyl - 1 - butanol	-38.131	3773.0	3.4876	-	-	8.6295×10^{-3} (273.15)	3.8731×10^{-4} (403.65)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_5H_{12}O$	3 - Methyl - 2 - butanol	24.821	937.0	-5.9198	-	-	1.6294×10^{-2} (250.00)	3.4236×10^{-4} (384.65)
$C_5H_{12}O$	Methyl - tert -butyl ether	-7.3165	810.5	-0.59662	-	-	1.0747×10^{-3} (219.25)	1.0517×10^{-4} (449.93)
$C_5H_{12}O$	1 - Pentanol	-22.758	2916.9	1.2839	-	-	1.6075×10^{-2} (253.15)	3.1659×10^{-4} (420.00)
$C_5H_{12}O$	2 - Pentanol	-12.233	8149.3	15.678	-	-	4.2116×10^{-2} (250.00)	3.6142×10^{-4} (392.15)
$C_5H_{12}O$	3 - Pentanol	26.244	911.06	-6.1542	-	-	5.4573×10^{-2} (222.15)	3.0264×10^{-4} (388.45)
$C_5H_{12}O_2$	Neo pentyl glycol	-18.174	4809.2	-0.24754	-	-	4.8366×10^{-4} (400.00)	5.8478×10^{-5} (483.00)
$C_5H_{12}O_2$	1,5 - Pentene diol	-76.248	7080.9	8.8187	-	-	8.2335×10^{-4} (263.15)	2.2748×10^{-5} (418.15)
$C_5H_{12}O_3$	2-(2-Methoxy - ethoxy) –ethanol	-12.907	2157.6	-	-	-	1.9901×10^{-1} (240.00)	4.2227×10^{-3} (420.00)
$C_5H_{12}O_4$	Pentacrythritol	11.247	727.12	-3.0295	-	-	1.6320×10^{-3} (534.15)	7.9849×10^{-4} (631.00)
$C_5H_{12}S$	n - Pentyl - mercaptan	-9.7415	1016.8	-19.367	-	-	3.6411×10^{-3} (197.45)	2.3441×10^{-4} (399.79)
$C_5H_{13}N$	n - Pentyl amine	-41.834	2849.8	4.4172	-	-	6.8529×10^{-3} (218.15)	3.1081×10^{-4} (377.65)
$C_5H_{13}NO_2$	Methyl di ethanol amine	-17.633	4360.8	0.094133	-	-	1.1996 (252.15)	1.7329×10^{-4} (520.15)
C_6Cl_6	Hexa chloro benzene	-11.083	2251.7	-0.13581	-	-	5.8768×10^{-4} (501.70)	2.7495×10^{-4} (600.00)
C_6F_6	Hexa fluoro benzene	13.687	1916.0	0.24197			4.3431×10^{-3} (278.25)	1.0640×10^{-3} (353.41)
$C_6H_3Cl_3$	1,2,4 - Tri chloro benzene	-11.525	1654.6	0.0086851	-	-	3.1098×10^{-3} (290.15)	3.134×10^{-4} (486.15)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_6H_3Cl_3$	1,3,5 – Tri chloro benzene	-31.798	2400.2	3.4295	-	-	8.9874×10^{-3} (336.65)	4.540×10^{-3} (425.00)
$C_6H_4ClNO_2$	m - Chloro nitro benzene	-38.422	2966.6	3.9615	-	-	2.0989×10^{-3} (317.65)	3.9211×10^{-4} (508.75)
$C_6H_4ClNO_2$	o - Chloro nitro benzene	-12.062	1975.5	-0.038019	-	-	2.9472×10^{-3} (306.15)	2.0483×10^{-4} (519.00)
$C_6H_4ClNO_2$	p - Chloro nitro benzene	-11.409	1747.3	-0.056164	-	-	1.0703×10^{-3} (356.65)	2.3221×10^{-4} (515.15)
$C_6H_4Cl_2$	m - Di chloro benzene	-30.663	2015.7	2.9903	-	-	1.7051×10^{-3} (265.15)	3.6982×10^{-4} (446.23)
$C_6H_4Cl_2$	o - Di chloro benzene	-22.216	1758.2	1.7011	-	-	2.2600×10^{-3} (265.15)	3.5844×10^{-4} (453.57)
$C_6H_4Cl_2$	p – Di chloro benzene	-12.307	1173.4	0.028397	-	-	8.5387×10^{-4} (326.14)	3.4755×10^{-4} (450.00)
C_6H_5Br	Bromo benzene	-12.307	1173.4	0.28397	-	-	2.842×10^{-3} (242.43)	3.3098×10^{-4} (429.24)
C_6H_5Cl	Chloro benzene	-20.611	1656.5	1.4415	-	-	1.419×0^{-3} (250.00)	1.2901×10^{-4} (540.00)
C_6H_5I	Iodo benzene	0.2500	535.2	-1.6207	-	-	1.5989×10^{-3} (232.15)	1.5419×10^{-4} (453.15)
C_6H_5F	Fluoro benzene	-10.064	1058.7	-0.17162	-	-	4.9103×10^{-3} (241.83)	3.4858×10^{-4} (461.48)
$C_6H_5NO_2$	Niacin	-14.539	3181.9	0.02935	-	-	2.9970×10^{-4} (509.65)	2.4706×10^{-4} (526.00)
$C_6H_5NO_2$	Nitro benzene	-34.557	2611.3	3.4283	-	-	3.1379×10^{-3} (273.15)	3.5114×10^{-4} (408.75)
C_6H_6	Benzene	6.7640	336.4	-2.6870	-	-	7.1453×10^{-4} (285.00)	3.3043×10^{-4} (350.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
C_6H_6ClN	m - Chloro aniline	-13.356	2315.4	-7639.1	-	-	1.0190×10^{-2} (262.75)	1.5356×10^{-4} (501.65)
C_6H_6ClN	o - Chloro aniline	-12.674	2051.3	-0.0034418	-	-	5.9444×10^{-3} (271.05)	2.1799×10^{-4} (481.05)
C_6H_6ClN	p - Chloro aniline	-13.271	2456.9	-0.067184	-	-	6.5872×10^{-4} (387.15)	7.8295×10^{-5} (579.00)
$C_6H_6N_2O_2$	o - Nitro aniline	-13.683	2589.1	-0.045521	-	-	1.6173×10^{-3} (344.65)	8.864×10^{-5} (588.00)
$C_6H_6N_2O_2$	p - Nitro aniline	-13.311	2356.8	-0.01794	-	-	4.0289×10^{-4} (420.65)	7.0702×10^{-5} (609.15)
C_6H_6O	Phenol	-6.2600	2083.3	-1.0060	-	-	4.0649×10^{-3} (318.00)	5.3904×10^{-5} (692.00)
$C_6H_6O_2$	p - Hydroxy quinone	-18.942	6247.2	0.18295	-	-	2.2896×10^{-2} (444.65)	1.3710×10^{-3} (558.15)
$C_6H_6O_3$	1,2,3 - Benzene triol	-15.785	5100.7	0.089054	-	-	6.6042×10^{-2} (407.00)	1.5778×10^{-3} (581.85)
C_6H_6S	Phenyl mercaptan	-7.1338	962.04	-0.50460	-	-	2.0064×10^{-3} (258.27)	3.2468×10^{-4} (442.29)
C_6H_7N	Aniline	-98.301	6524.4	1.8548	-	-	1.2347×10^{-2} (267.65)	3.9364×10^{-4} (457.15)
C_6H_7N	2 - Methyl - pyridine	-23.569	1733.2	-	-	-	3.3907×10^{-3} (220.00)	2.9202×10^{-4} (402.55)
C_6H_7N	3 - Methyl - pyridine	-11.299	1270.6	-	-	-	9.4465×10^{-4} (293.15)	5.6139×10^{-4} (335.15)
C_6H_7N	4 - Methyl - pyridine	-27.006	1981.4	2.3358	-	-	1.2167×10^{-3} (276.73)	2.8273×10^{-4} (418.50)
C_6H_8	1,4 - Cyclo - hexa diene	-9.9507	683.11	0.65495×10^{-4}	-	-	1.0077×10^{-3} (223.95)	3.1796×10^{-4} (360.15)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_6H_8N_2$	Adipo nitrile	-18.181	2014.8	1.0968	-	-	9.0188×10^{-3} (275.64)	9.8198×10^{-4} (440.00)
$C_6H_8N_2$	m - Phenylene diamine	-16.675	4115.0	-	-	-	4.7787×10^{-3} (363.15)	8.9008×10^{-5} (560.00)
$C_6H_8N_2$	o - Phenylene diamine	-11.882	2507.0	-0.12095	-	-	2.6091×10^{-3} (376.95)	3.8421×10^{-4} (525.00)
$C_6H_8N_2$	P - Phenylene diamine	-12.768	2411.7	0.050809	-	-	1.3301×10^{-3} (413.00)	3.4148×10^{-4} (540.00)
$C_6H_8N_2$	Phenyl hydrazine	-17.931	4052.0	-	-	-	1.7062×10^{-2} (292.35)	4.0933×10^{-4} (400.00)
C_6H_{12}	3-Methyl-trans - 2 - pentene	-10.952	803.91	-0.0004643	-	-	6.8321×10^{-3} (134.70)	1.8137×10^{-4} (343.59)
C_6H_{12}	2,3 - Di methyl -1- butene	-10.885	796.97	-0.010151	-	-	1.7313×10^{-2} (115.89)	1.9951×10^{-4} (328.76)
C_6H_{12}	2,3 - Dimethyl -2 - butene	-10.967	799.28	0.0029181	-	-	9.7463×10^{-4} (198.92)	1.7650×10^{-4} (346.35)
C_6H_{12}	2 - Ethyl - 1 - butene	-10.884	801.83	0.011203	-	-	5.1065×10^{-3} (141.61)	1.8864×10^{-4} (337.82)
C_6H_{12}	1 - Hexene	-6.9090	656.90	-0.062835	-	-	6.8812×10^{-4} (218.15)	1.8651×10^{-4} (333.15)
C_6H_{12}	Cis-2 -Hexene	-10.758	785.54	-0.01590	-	-	7.5623×10^{-3} (132.00)	1.9276×10^{-4} (342.03)
C_6H_{12}	Trans- 2 -Hexene	-10.862	788.68	-0.0003783	-	-	5.3346×10^{-3} (140.17)	1.9411×10^{-4} (341.02)
C_6H_{12}	Methyl cyclo pentane	-18.553	612.62	-1.3774	-	-	9.2883×10^{-4} (248.15)	2.7421×10^{-4} (353.15)
C_6H_{12}	2 - Methyl - 1 - pentene	-11.519	991.4	-	-	-	7.4022×10^{-4} (230.00)	1.9127×10^{-4} (335.25)
C_6H_{12}	2 - Methyl - 2 - pentene	-10.914	802.84	-0.0065431	-	-	5.9076×10^{-3} (138.07)	1.8522×10^{-4} (340.45)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
C_6H_{12}	4 - Methyl - 1 - pentene	-10.953	804.13	-0.00046565	-	-	1.4601 x 10^{-2} (119.51)	2.0415 x 10^{-4} (327.01)
C_6H_{12}	4 - Methyl - cis- 2 -pentene	-10.680	742.56	-0.031481	-	-	8.7272 x 10^{-4} (195.35)	1.8243 x 10^{-4} (329.53)
C_6H_{12}	4 - Methyl -trans-2-pentene	-10.724	744.61	-0.024965	-	-	9.8541 x 10^{-4} (189.35)	1.7967 x 10^{-4} (331.75)
$C_6H_{12}O$	Butyl vinyl ether	-10.676	1044.3	-0.0943	-	-	4.510 x 10^{-3} (181.15)	2.2728 x 10^{-4} (366.97)
$C_6H_{12}O$	Cyclo hexanol	-87.257	7419.6	10.327	-	-	2.3025 x 10^{-2} (303.15)	4.6253 x 10^{-4} (450.00)
$C_6H_{12}O$	1 - Hexanol	-10.582	1021.4	-0.55433 x 10^{-4}	-	-	2.7986 x 10^{-3} (217.15)	3.2294 x 10^{-4} (401.45)
$C_6H_{12}O$	2 - Hexanol	-11.477	1188.6	0.0076625	-	-	2.5615 x 10^{-3} (217.35	2.1053 x 10^{-4} (400.85)
$C_6H_{12}O$	Methyl isobutyl ketone	-33.781	1955.3	3.4673	-	-	1.1803 x 10^{-3} (245.89)	3.0559 x 10^{-4} (393.15)
$C_6H_{12}O_2$	n-Butyl acetate	-5.4020	688.0	-0.7296	-	-	9.0064 x 10^{-4} (275.00)	1.7403 x 10^{-4} (400.00)
$C_6H_{12}O_2$	Sec-Butyl acetate	-11.413	1226.9	-0.0056273	-	-	1.2315 x 10^{-2} (174.15)	2.5840 x 10^{-4} (385.15)
$C_6H_{12}O_2$	Ethyl - n -butyrate	-15.485	1325.6	0.6432	-	-	1.3186 x 10^{-3} (250.00)	2.5328 x 10^{-4} (394.65)
$C_6H_{12}O_2$	Di acetone alcohol	-325.94	16124	4.6683	-	-	1.5219 x 10^{-1} (229.15)	1.8334 x 10^{-3} (370.00)
$C_6H_{12}O_2$	2 -Ethyl butyric acid	-12.240	1836.4	0.021868	-	-	6.7053 x 10^{-3} (258.15)	2.8222 x 10^{-4} (466.95)
$C_6H_{12}O_2$	Propionic acid	-12.494	1254.7	0.14339	-	-	6.9899 x 10^{-3} (185.00)	2.3282 x 10^{-4} (383.00)
$C_6H_{12}O_2$	Hexanoic acid	-50.189	3620.3	5.6486	-	-	5.0047 x 10^{-3} (275.00)	6.7902 x 10^{-4} (400.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_6H_{12}O_2$	Iso butyl acetate	24.717	-531.5	-5.3105	-	-	8.7299×10^{-4} (275.00)	2.4140×10^{-4} (390.00)
$C_6H_{12}O_2$	n - Propyl propionate	-15.113	1381.7	0.54867	-	-	5.4685×10^{-3} (197.25)	2.3891×10^{-4} (395.00)
$C_6H_{12}O_3$	Propylene glycol methyl ether acetate	-12.452	1688.3	-0.011078	-	-	1.3907×10^{-2} (205.00)	2.0631×10^{-4} (418.65)
$C_6H_{12}O_3$	2 - Ethoxy ethyl acetate	-17.334	1778.8	0.7820	-	-	5.5563×10^{-3} (225.00)	2.1367×10^{-4} (429.45)
$C_6H_{12}O_3$	Paraldehyde	-30.920	2522.9	2.7415	-	-	1.3775×10^{-3} (285.75)	2.7821×10^{-4} (400.00)
$C_6H_{12}O_6$	Dextrose	-2267.4	138910	320.55	-	-	2.2252×10^{6} (323.15)	6.6361×10^{-1} (418.15)
$C_6H_{12}S$	Cyclo hexyl Mercaptan	-11.338	1304.1	0.924×10^{-4}	-	-	1.1553×10^{-2} (189.64)	2.440×10^{-4} (431.95)
$C_6H_{13}N$	Cyclo hexyl amine	-11.338	1304.1	3.4662	-	-	2.2376×10^{-3} (288.15)	4.0462×10^{-4} (405.65)
$C_6H_{13}N$	Hexamethylene amine	-35.730	2880.6	-	-	-	1.7256×10^{-3} (330.15)	3.7679×10^{-4} (411.15)
C_6H_{14}	2,2 - Di methyl butane	24.038	-498.77	-5.3231	-	-	4.999×10^{-4} (269.29)	2.5871×10^{-4} (322.88)
C_6H_{14}	2,3 - Di methyl butane	18.940	-7718.7	-30.095	-	-	4.5661×10^{-4} (273.15)	1.9613×10^{-4} (331.13)
C_6H_{14}	N - Hexane	-20.715	1207.5	1.4993	-	-	2.1182×10^{-3} (177.83)	2.1541×10^{-4} (343.15)
C_6H_{14}	2 - Methyl - pentane	12.092	-182.7	-3.4502	-	-	4.2232×10^{-4} (257.51)	2.0358×10^{-4} (333.41)
C_6H_{14}	3 - Methyl - pentane	-3.3394	529.14	-1.1568	-	-	4.0784×10^{-4} (265.62)	2.0402×10^{-4} (336.43)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_6H_{14}O$	N - Butyl ether	-13.278	1152.9	-1.1568	-	-	6.7474×10^{-3} (170.15)	2.2597×10^{-4} (365.35)
$C_6H_{14}O$	Di iso propyl ether	-11.500	993.0	0.29272	-	-	2.2585×10^{-3} (187.65)	2.1104×10^{-4} (341.45)
$C_6H_{14}O$	Di - n -Propyl ether	-8.2119	893.52	0.02200	-	-	1.0516×10^{-2} (149.95)	2.1249×10^{-4} (362.79)
$C_6H_{14}O$	2 - Ethyl - 1 - butanol	-9.2253	2722.5	-0.45940	-	-	7.2023×10^{-2} (236.75)	2.8693×10^{-4} (419.65)
$C_6H_{14}O$	1 - Hexanol	-38.503	3810.4	-0.89719	-	-	8.9570×10^{-3} (278.15)	3.4387×10^{-4} (428.15)
$C_6H_{14}O$	Methyl - tert - pentyl ether	-11.276	991.96	3.5693	-	-	5.6725×10^{-3} (160.00)	1.7911×10^{-4} (359.45)
$C_6H_{14}O$	2 - Methyl - 1 - pentanol	-95.728	7010	-0.18892	-	-	2.0010×10^{-2} (270.00)	3.3550×10^{-4} (421.15)
$C_6H_{14}O$	4 - Methyl - 2 - pentanol	-15.465	9891.9	203.56	-	-	9.8527×10^{-3} (280.00)	3.3248×10^{-4} (404.85)
$C_6H_{14}O_2$	Acetal	-11.059	983.63	203.56	-	-	2.1531×10^{-3} (200.00)	2.1428×10^{-4} (376.75)
$C_6H_{14}O_2$	2 - Butoxy ethanol	-5.6874	2197.4	-1.2979	-	-	1.7072×10^{-1} (203.15)	1.7396×10^{-4} (444.47)
$C_6H_{14}O_2$	1,6 - Hexane diol	-30.062	6665.6	1.0452	-	-	5.3393×10^{-2} (315.15)	2.3973×10^{-5} (516.15)
$C_6H_{14}O_2$	Hexylene glycol	-55.692	13861	-	-	-	6.1595×10^{2} (223.15)	7.86310^{-3} (240.00)
$C_6H_{14}O_3$	Di ethylene glycol di methyl ether	-12.272	1422.3	0.10585	-	-	9.0202×10^{-3} (203.15)	2.3782×10^{-4} (432.91)
$C_6H_{14}O_3$	Di propylene glycol	-21.291	5207.0	0.23598	-	-	10.412 (233.00)	7.4089×10^{-5} (504.95)
$C_6H_{14}O_3$	2 - (2 -Ethoxy ethoxy) ethanol	-13.242	2289.5	-	-	-	2.4664×10^{-2} (240.00)	4.1352×10^{-4} (420.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_6H_{14}O_4$	Tri ethylene glycol	-99.75	7640.0	12.430	-	-	6.8389×10^{-2} (285.00)	5.7935×10^{-4} (675.00)
$C_6H_{14}O_6$	Sorbitol	-10.185	3978.0	-1.2798	-	-	8.8744×10^{-4} (370.85)	2.6368×10^{-5} (525.00)
$C_6H_{15}Al$	Tri ethyl aluminum	-2.9929	1214.3	-1.2358	-	-	1.5628×10^{-2} (220.65)	3.6543×10^{-4} (458.15)
$C_6H_{15}N$	Di iso propyl amine	-1.7366	599.8	-1.4237	-	-	7.4785×10^{-4} (250.00)	2.1930×10^{-4} (357.05)
$C_6H_{15}N$	Di - n - propyl amine	-15.404	1390.0	0.5564	-	-	9.4542×10^{-4} (260.00)	2.1176×10^{-4} (382.35)
$C_6H_{15}N$	N - Hexyl amine	53.419	1608.7	-9.6679	-	-	1.7489×10^{-3} (251.85)	1.9921×10^{-4} (404.65)
$C_6H_{15}N$	Tri ethyl amine	-1.0330	458.2	-1.4867	-	-	6.0580×10^{-4} (250.00)	1.9720×10^{-4} (362.65)
$C_6H_{15}NO_3$	Tri ethanol amine	-198.58	14579	26.184	-	-	8.1830×10^{-1} (294.35)	2.7362×10^{-3} (430.00)
$C_6H_{16}N_2$	Hexamethylene diamine	-15.260	2283.0	0.288	-	-	1.7778×10^{-3} (313.95)	1.7012×10^{-4} (475.04)
$C_6H_{18}N_3OP$	Hexamethylene Phosphor amide	-51.263	3610.7	5.8603	-	-	4.7489×10^{-3} (280.1)	4.8168×10^{-4} (506.15)
$C_7H_3ClF_3NO_2$	Hexamethylene di amine	-15.260	2283.0	0.288	-	-	1.7778×10^{-3} (313.95)	1.7012×10^{-4} (475.04)
$C_7H_3Cl_2F_3$	2,4 - Di chloro benzo trifluoride	-11.903	1782.0	-191.21	-	-	4.8167×10^{-3} (267.00)	3.1481×10^{-4} (450.65)
$C_7H_3Cl_2NO$	3,4 - Di chloro benzo tri fluoride	-13.430	2282.0	-	-	-	2.0054×10^{-3} (316.15)	1.3983×10^{-4} (501.00)
$C_7H_4ClF_3$	p - Chloro benzo trifluoride	-32.50	2434.0	3.073	-	-	2.7364×10^{-3} (254.00)	3.0639×10^{-4} (412.15)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_7H_4Cl_2O$	m - Chloro benzyl chloride	-11.799	1937.6	-0.024368	-	-	6.6290×10^{-3} (280.00)	3.1606×10^{-4} (498.00)
C_7H_5ClO	Benzoyl chloride	6.0360	504.0	-2.546	-	-	1.6717×10^{-3} (272.65)	2.0360×10^{-4} (462.65)
$C_7H_5ClO_2$	o - Chloro benzoic acid	-12.372	2444.9	-0.060753	-	-	1.0605×10^{-3} (415.15)	2.2673×10^{-4} (560.15)
$C_7H_5Cl_3$	Benzo tri chloride	1.6400	920.0	-1.9018	-	-	3.4890×10^{-3} (273.00)	2.5050×10^{-4} (493.79)
$C_7H_5F_3$	Benzo tri fluoride	-7.1080	880.0	-0.5964	-	-	1.1336×10^{-3} (244.14)	2.4635×10^{-4} (376.61)
C_7H_5N	Benzo nitrile	-20.236	1737.4	1.3531	-	-	1.9774×10^{-3} (270.00)	3.0091×10^{-4} (450.00)
$C_7H_5N_5O_8$	Tetryl	-20.309	7221.5	-0.3548×10^{-3}	-	-	9.2903×10^{-2} (402.65)	1.3096×10^{-3} (528.15)
$C_7H_6Cl_2$	2,4 - Di chloro toluene	-11.852	1685.8	0.0091988	-	-	4.9505×10^{-3} (259.65)	2.6371×10^{-4} (474.25)
C_7H_6O	Benzaldehyde	-10.563	929.1	0.14846	-	-	2.5144×10^{-3} (247.15)	5.0075×10^{-4} (451.90)
$C_7H_6O_2$	Benzoic acid	-21.720	6055.0	-	-	-	1.6433×10^{-3} (395.52)	3.9895×10^{-5} (522.40)
$C_7H_6O_2$	Salicyl aldehyde	-21.992	2127.9	1.5447	-	-	4.6486×10^{-3} (266.15)	3.4978×10^{-4} (469.65)
C_7H_7Br	p - Bromo -toluene	-25.004	1863.0	2.1060	-	-	1.1350×10^{-3} (299.95)	3.2523×10^{-4} (475.50)
C_7H_7Cl	Benzyl chloride	-1.4084	892.4	-1.4713	-	-	3.6097×10^{-3} (234.15)	2.1759×10^{-4} (452.55)
C_7H_7Cl	o - Chloro toluene	-1.2784	654.2	-1.3845	-	-	1.2609×10^{-3} (275.00)	2.5281×10^{-4} (450.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
C_7H_7Cl	p - Chloro toluene	-14.985	1326.3	0.6051	-	-	1.0614×10^{-3} (280.65)	2.2673×10^{-4} (460.00)
C_7H_7NO	Formanilide	-14.800	3299.8	-	-	-	8.7017×10^{-3} (328.15)	1.6072×10^{-4} (544.15)
$C_7H_7NO_2$	m - Nitro toluene	23.575	200.0	-5.339	-	-	2.5032×10^{-3} (289.20)	9.4977×10^{-5} (505.00)
$C_7H_7NO_2$	o - Nitro toluene	-11.828	1701.0	-	-	-	3.9758×10^{-3} (269.98)	2.2575×10^{-4} (495.64)
$C_7H_7NO_2$	p - Nitro toluene	-11.020	1427.0	-	-	-	1.3257×10^{-3} (324.75)	2.7407×10^{-4} (506.41)
$C_7H_7NO_3$	o - Nitro anisole	-10.748	1480.6	-	-	-	3.9768×10^{-3} (283.60)	3.2327×10^{-4} (546.15)
C_7H_8	Toluene	-13.362	1183.0	0.3330	-	-	3.4045×10^{-3} (200.00)	2.2278×10^{-4} (400.00)
C_7H_8O	Anisole	-7.8930	1100.0	-0.4770	-	-	1.1594×10^{-3} (287.00)	2.7355×10^{-4} (426.73)
C_7H8O	m - Cresol	-124.95	8727.8	16.012	-	-	1.1793×10^{-2} (298.00)	3.7418×10^{-4} (475.20)
C_7H_8O	p - Cresol	-102.05	7478.8	12.725	-	-	7.8281×10^{-3} (307.90)	3.7907×10^{-4} (475.13)
C_7H_8O	o - Cresol	-102.80	7278.6	12.893	-	-	5.7734×10^{-3} (304.19)	3.5383×10^{-4} (463.15)
C_7H_8O	Benzyl alcohol	-14.859	2865.7	-	-	-	7.3443×10^{-3} (288.15)	3.3263×10^{-4} (427.00)
$C_7H_8O_2$	p -Methoxy phenol	-61.247	5452.3	6.8531	-	-	4.4784×10^{-3} (345.45)	3.7688×10^{-4} (517.15)
C_7H_8S	Benzyl mercaptan	-11.459	1334.4	0.00049649	-	-	2.5103×10^{-3} (243.95)	1.8308×10^{-4} (468.15)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
C_7H_9N	Benzyl amine	-12.192	1567.7	0.088259	-	-	8.1354×10^{-3} (227.15)	2.6767×10^{-4} (457.65)
C_7H_9N	2,6 - Di methyl pyridine	-17.863	1509.5	0.99728			1.3104×10^{-3} (267.00)	2.6716×10^{-4} (417.20)
C_7H_9N	n - Methyl aniline	-70.0953	4689.1	8.6022			9.9063×10^{-3} (250.00)	3.2030×10^{-4} (469.02)
C_7H_9N	m -Toludine	-105.05	6828.2	13.591			8.1787×10^{-3} (273.15)	3.6643×10^{-4} (476.55)
C_7H_9N	o - Toludine	-592.58	21015	97.020			1.0334×10^{-2} (273.15)	2.9956×10^{-4} (473.55)
C_7H_9N	p - Toludine	-63.748	4642.7	7.4466	-	-	1.9977×10^{-3} (316.90)	3.1178×10^{-4} (474.00)
$C_7H_{10}N_2$	Toluene diamine	-13.853	2064.1	0.19523	-	-	7.9435×10^{-4} (371.25)	1.3451×10^{-4} (557.15)
C_7H_{12}	Cyclo heptane	-9.6541	977.31	-0.81038	-	-	3.7369×10^{-3} (217.15)	4.9301×10^{-4} (387.50)
$C_7H_{12}O_2$	n - Butyl acrylate	-23.658	1830.3	1.8358	-	-	2.0284×10^{-3} (250.00)	6.0616×10^{-4} (325.00)
$C_7H_{12}O_2$	Iso butyl acrylate	-11.604	1234.6	0.014678	-	-	3.3400×10^{-3} (212.00)	2.0996×10^{-4} (405.15)
$C_7H_{12}O_2$	n -Propyl methyl crylate	-11.419	1256.4	-0.021579	-	-	2.7351×10^{-3} (223.00)	2.0059×10^{-4} (414.00)
$C_7H_{12}O_4$	Di ethyl malonate	-12.410	1835.3	-	-	-	8.5407×10^{-3} (240.00)	4.0092×10^{-4} (400.00)
C_7H_{14}	Cyclo pentane	-1.4077	805.33	-1.38110	-	-	8.6262×10^{-6} (391.94)	1.9895×10^{-5} (1000.0)
C_7H_{14}	Cis - 1,2 -Di methyl cyclo pentane	-11.140	999.69	0.030639	-	-	1.6361×10^{-3} (219.26)	2.5451×10^{-4} (372.68)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
C_7H_{14}	Trans -1,2 - Dimethyl - cyclo pentane	-10.765	985.28	-0.026512	-	-	1.0401×10^{-2} (155.58)	2.6863×10^{-4} (365.02)
C_7H_{14}	Ethyl cyclo pentane	-6.8940	818.60	-0.5941	-	-	9.6047×10^{-4} (253.15)	2.5985×10^{-4} (378.15)
C_7H_{14}	1 - Heptene	-21.866	1377.2	1.6214	-	-	6.0834×10^{-4} (250.00)	1.8716×10^{-4} (375.00)
C_7H_{14}	Cis - 2 - Heptene	-11.078	914.29	0.0091053	-	-	4.2679×10^{-3} (164.00)	1.9096×10^{-4} (371.56)
C_7H_{14}	Cis - 3 - Heptene	-11.046	913.23	0.0041889	-	-	1.3094×10^{-2} (136.51)	1.9438×10^{-4} (368.90)
C_7H_{14}	Methyl cyclo hexane	-10.537	1179.7	-0.12417	-	-	1.5528×10^{-3} (248.15)	2.9782×10^{-4} (374.08)
$C_7H_{14}O$	1 - Heptanol	-11.730	1111.7	0.18352	-	-	2.7352×10^{-3} (230.15)	3.3241×10^{-4} (425.95)
$C_7H_{14}O$	2 - Heptanone	-13.565	1308.2	0.34850	-	-	1.6484×10^{-3} (250.00)	2.3134×10^{-4} (425.05)
$C_7H_{14}O$	1 - Methyl cyclo hexanol	-24.062	3092.9	-2.0047	-	-	3.0321×10^{-2} (299.15)	6.2818×10^{-4} (430.15)
$C_7H_{14}O$	Cis-2-Methyl Cyclo hexanol	-21.1277	5147.2	-	-	-	1.8075×10^{-2} (298.15)	2.2285×10^{-4} (400.00)
$C_7H_{14}O$	Trans-2-Methyl cyclo hexanol	-26.937	7049.3	-	-	-	1.7189×10^{-1} (280.00)	5.2641×10^{-3} (325.00)
$C_7H_{14}O$	Cis-3 - Methyl cyclo hexanol	-13.478	2847.6	-	-	-	2.6657×10^{-2} (289.00)	9.9820×10^{-3} (321.00)
$C_7H_{14}O$	Trans-3-Methyl cyclo hexanol	-16.788	3906.8	-	-	-	3.8019×10^{-2} (289.00)	9.8796×10^{-3} (321.00)
$C_7H_{14}O$	Cis-4-Methyl cyclo hexanol	6.0809	2444.6	-3.1471	-	-	2.6120×10^{-2} (298.00)	5.0028×10^{-4} (444.15)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_7H_{14}O$	Trans-4- Methyl cyclo hexanol	-13.435	3586.8	-0.3329	-	-	3.7056×10^{-2} (298.00)	6.1816×10^{-4} (444.15)
$C_7H_{14}O$	5- Methyl - 2 - hexanone	-10.634	1249.7	-0.14656	-	-	5.8695×10^{-3} (199.25)	1.9776×10^{-4} (417.95)
$C_7H_{14}O_2$	n - Butyl propionate	-13.914	1430.5	0.34496	-	-	1.3225×10^{-2} (183.63)	2.1985×10^{-4} (419.75)
$C_7H_{14}O_2$	Ethyl - iso - valerate	-11.685	1325.5	0.0071708	-	-	1.7888×10^{-2} (173.85)	2.2741×10^{-4} (407.45)
$C_7H_{14}O_2$	n -Hepta noic acid	-30.329	2834.7	2.6785	-	-	6.0223×10^{-3} (280.00)	3.3867×10^{-4} (496.15)
$C_7H_{14}O_2$	Iso - pentyl acetate	-12.128	1332.8	0.10018	-	-	8.6278×10^{-3} (194.75)	2.4497×10^{-4} (415.25)
$C_7H_{14}O_2$	n - Pentyl acetate	-10.639	1263.6	-0.12151	-	-	3.5574×10^{-3} (223.35)	2.2934×10^{-4} (422.15)
$C_7H_{14}O_2$	n - Propyl - n - butyrate	15.197	-66.6	-3.8837	-	-	1.0760×10^{-3} (273.15)	7.8579×10^{-4} (553.15)
C_7H_{16}	2,2 - Di methyl pentane	-7.6415	1046.5	-0.63903	-	-	2.1642×10^{-2} (149.34)	2.2063×10^{-4} (352.34)
C_7H_{16}	2,3 - Di methyl pentane	-12.286	1128.8	0.13742	-	-	1.0742×10^{-3} (160.00)	2.3270×10^{-4} (362.93)
C_7H_{16}	2,4 - Di methyl pentane	-18.101	1388.3	0.98736	-	-	7.7223×10^{-3} (170.00)	2.2915×10^{-4} (353.65)
C_7H_{16}	3,3 - Di methyl pentane	-11.727	1112.4	0.047647	-	-	3.1065×10^{-2} (138.70)	2.3647×10^{-4} (359.21)
C_7H_{16}	3 - Ethyl pentane	-10.964	976.01	-0.049006	-	-	7.4776×10^{-3} (154.55)	1.8574×10^{-4} (366.62)
C_7H_{16}	n - Heptane	-24.451	1533.1	2.0087	-	-	3.7197×10^{-3} (182.57)	2.1455×10^{-4} (373.15)
C_7H_{16}	2 - Methyl hexane	-43.400	464.30	-1.5889	-	-	4.7701×10^{-4} (273.15)	1.9901×10^{-4} (363.20)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
C_7H_{16}	3 - Methyl hexane	-11.132	981.27	-0.02379	-	-	7.7316×10^{-3} (153.75)	1.8865×10^{-4} (365.00)
C_7H_{16}	2,2,3 - Tr imethyl butane	-22.545	1553.0	1.7221	-	-	8.0022×10^{-4} (268.57)	3.1888×10^{-4} (354.03)
$C_7H_{16}O$	1 - Heptanol	-88.623	6463.8	10.846	-	-	8.5245×10^{-3} (288.15)	3.3889×10^{-4} (448.95)
$C_7H_{16}O$	2 - Heptanol	-96.293	7180.2	11.732	-	-	1.3743×10^{-2} (275.00)	2.0730×10^{-4} (432.35)
$C_7H_{17}N$	1 - Amino heptane	-3.5830	1223.7	-1.2559	-	-	3.2692×10^{-3} (254.15)	2.3565×10^{-4} (430.05)
$C_8H_4O_3$	Phthalic anhydride	152.38	-8406.0	-23.041	-	-	1.2163×10^{-3} (405.15)	2.2508×10^{-4} (557.65)
C_8H_6	Ethynyl benzene	-2.7214	801.45	-1.2288	-	-	2.7834×10^{-3} (228.30)	1.4127×10^{-4} (520.00)
$C_8H_6O_3$	4 - Carboxy benzaldehyde	-14.186	3436.6	-0.8824×10^{-3}	-	-	5.0823×10^{-4} (520.15)	9.1759×10^{-5} (702.00)
$C_8H_6O_4$	Phthalic acid	-7.314	212.1	-	-	-	1.0520×10^{-3} (464.15)	1.007×10^{-3} (521.15)
C_8H_7N	Indole	27.947	443.92	-6.0250	-	-	3.8459×10^{-3} (326.15)	1.2852×10^{-4} (526.15)
C_8H_7N	Phenyl aceto nitrile	-25.663	2207.1	2.1116	-	-	5.7534×10^{-3} (249.35)	2.8699×10^{-4} (506.65)
C_8H_8	Styrene	-22.675	1758.0	1.6701	-	-	1.9191×10^{-3} (242.54)	2.2684×10^{-4} (418.31)
C_8H8O	Aceto phenone	2.3720	807.0	-2.0158	-	-	1.7989×10^{-3} (292.80)	4.5825×10^{-4} (400.00)
C_8H_8O	P - Tolual-dehyde	-9.9707	1017.3	0.0232	-	-	1.6888×10^{-3} (293.00)	4.4659×10^{-4} (477.15)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_8H_8O_2$	Benzyl formate	-12.282	1737.5	0.4541×10^{-3}	-	-	1.2503×10^{-2} (220.00)	1.7864×10^{-4} (476.15)
$C_8H_8O_2$	Methyl benzoate	-21.971	2267.4	1.4173	-	-	2.2989×10^{-3} (288.15)	2.1485×10^{-4} (472.65)
$C_8H_8O_2$	o - Toluic acid	-87.910	6358.9	10.946	-	-	1.9690×10^{-3} (385.00)	7.7094×10^{-4} (500.00)
$C_8H_8O_2$	p - Toluic acid	-12.378	2465.9	-0.062356	-	-	6.6692×10^{-4} (452.75)	2.554×10^{-4} (548.15)
$C_8H_8O_3$	Methyl salicilate	-18.86	1969.4	1.0930	-	-	4.8187×10^{-3} (265.15)	3.0009×10^{-4} (496.65)
C_8H_9NO	Acetanilide	-12.385	2467.1	-	-	-	2.4618×10^{-3} (386.65)	3.0085×10^{-4} (576.95)
C_8H_{10}	Ethyl benzene	-10.452	1048.4	-0.07150	-	-	2.9032×10^{-3} (210.00)	1.5080×10^{-4} (500.00)
C_8H_{10}	m - Xylene	-9.6470	983.0	-0.01928	-	-	1.7849×10^{-3} (225.30)	1.5598×10^{-4} (475.00)
C_8H_{10}	o - Xylene	-15.678	1404.0	0.66410	-	-	1.1970×10^{-3} (268.10)	1.7882×10^{-4} (475.00)
C_8H_{10}	p - Xylene	-5.7750	826.2	-0.77390	-	-	6.8227×10^{-4} (288.10)	1.3208×10^{-4} (500.00)
$C_8H_{10}O$	3,4 - Xylenol	-68.323	5556.8	7.9483	-	-	3.6768×10^{-3} (338.25)	4.0372×10^{-4} (500.00)
$C_8H_{10}O$	2,6 - Xylenol	-15.719	3869.0	0.031176	-	-	3.2290×10^{-2} (318.76)	6.1781×10^{-4} (474.22)
$C_8H_{10}O$	2,5 - Xylenol	-16.907	2303.1	0.65005	-	-	1.5269×10^{-3} (347.99)	2.9378×10^{-4} (484.33)
$C_8H_{10}O$	2,4 - Xylenol	-14.275	3662.9	-0.14822	-	-	1.0608×10^{-2} (345.71)	4.8790×10^{-4} (484.13)
$C_8H_{10}O$	2,3 - Xylenol	-15.875	3863.5	0.044157	-	-	1.1780×10^{-2} (345.71)	4.4479×10^{-4} (490.07)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_8H_{10}O$	p - Ethyl phenol	-18.461	4974.0	0.034450	-	-	7.1915×10^{-2} (318.23)	2.9751×10^{-4} (491.14)
$C_8H_{10}O$	Phenetole	-55.996	3521.6	6.5648	-	-	4.2389×10^{-3} (243.63)	3.2103×10^{-4} (443.15)
$C_8H_{10}O$	2 - Phenyl ethanol	-16.249	3383.2	0.0047964	-	-	8.0026×10^{-2} (247.00)	8.7529×10^{-5} (492.05)
$C_8H_{10}O$	3,5 - Xylenol	-54.468	4873.7	5.8890	-	-	3.2762×10^{-3} (336.59)	3.0886×10^{-4} (494.89)
$C_8H_{11}N$	n,n - Di methyl anilie	-16.696	1617.8	0.81091	-	-	1.8933×10^{-3} (275.60)	2.6234×10^{-4} (466.69)
$C_8H_{11}N$	n-Ethyl aniline	-40.633	3219.2	4.1507			1.7169×10^{-2} (230.00)	2.5079×10^{-4} (478.15)
C_8H_{12}	Vinyl cyclo hexane	-5.3887	708.55	-0.88104	-	-	3.8432×10^{-3} (164.00)	8.9422×10^{-5} (474.00)
$C_8H_{12}O_2$	Butyl methacrylate	32.827	-533.70	-6.668	-	-	3.620×10^{-3} (223.00)	1.3669×10^{-4} (434.00)
C_8H_{14}	Cyclo octene	-10.449	1159.9	0.015441	-	-	7.0846×10^{-3} (214.15)	5.1638×10^{-4} (416.15)
$C_8H_{14}O_3$	Butyric anhydride	-20.689	1921.5	1.3551	-	-	1.4686×10^{-3} (298.15)	2.6065×10^{-4} (468.15)
$C_8H_{14}O_4$	Di ethyl succinate	-14.178	2434.0	-	-	-	5.7234×10^{-3} (270.00)	1.0032×10^{-4} (489.65)
C_8H_{16}	Cyclo octane	-44.839	3413.6	4.7931	-	-	2.9013×10^{-3} (287.98)	4.1392×10^{-4} (423.84)
C_8H_{16}	1,1 - Di methyl cyclo hexane	-10.716	1140.5	-0.047736	-	-	1.9918×10^{-3} (239.66)	3.0449×10^{-4} (392.70)
C_8H_{16}	Cis - 1,2 -Di methyl cyclo hexane	-74.202	4193.9	9.3440	-	-	2.9267×10^{-3} (250.00)	4.3460×10^{-4} (402.94)

Formula	**Name**	**A**	**B**	**C**	**D**	**E**	**Viscosity (Min. Temp.)**	**Viscosity (Max. Temp.)**
C_8H_{16}	Tras -1,2 - di methyl cyclo hexane	-11.344	1168.9	0.045130	-	-	8.3151×10^{-3} (184.99)	2.9559×10^{-4} (396.58)
C_8H_{16}	Trans -1,3 -Di methyl cyclo hexane	-39.927	2347.1	4.3209	-	-	5.0016×10^{-3} (200.00)	2.8548×10^{-4} (397.61)
C_8H_{16}	Cis -1,4 - Di methyl cyclo hexane	-7.4864	1011.9	-0.53454	-	-	7.9830×10^{-3} (185.72)	2.9169×10^{-4} (397.47)
C_8H_{16}	Trans - 1,4 -Di methyl cyclo hexane	-35.557	2244.5	3.6330	-	-	1.4744×10^{-3} (250.00)	2.9153×10^{-4} (392.51)
C_8H_{16}	2,3 - Di methyl hexene	-11.097	923.29	-0.4086×10^{-3}	-	-	4.3900×10^{-3} (200.00)	2.7064×10^{-4} (383.65)
C_8H_{16}	Ethyl cyclo hexane	-22.110	1673.0	1.6410	-	-	1.8007×10^{-3} (248.15)	2.9563×10^{-4} (404.94)
C_8H_{16}	2 - Ethyl -1 - hexene	-5.5495	745.71	-0.81187	-	-	2.1131×10^{-3} (200.00)	1.9455×10^{-4} (393.15)
C_8H_{16}	Isopropyl cyclo pentene	-10.501	1084.0	-0.082854	-	-	1.4679×10^{-2} (161.79)	2.5271×10^{-4} (399.58)
C_8H_{16}	2 - Ethyl - 1 - hexene	-5.5495	754.71	0.81887			2.1131×10^{-3} (200.0)	1.9455×10^{-4} (393.15)
C_8H_{16}	1- Octene	15.841	-194.40	-4.0180	-	-	8.0875×10^{-4} (250.00)	2.0867×10^{-4} (390.00)
C_8H_{16}	Trans - 2 - Octene	-11.321	1035.8	0.025687	-	-	3.6923×10^{-3} (185.45)	1.9053×10^{-4} (398.15)
C_8H_{16}	Trans - 3 - Octene	-10.984	1023.3	-0.026041	-	-	7.8713×10^{-3} (163.15)	1.9188×10^{-4} (396.45)
C_8H_{16}	Trans - 4 - Octene	-	1030.9	0.063717	-	-	4.4511×10^{-3} (179.37)	1.9360×10^{-4} (395.41)

Formula	**Name**	**A**	**B**	**C**	**D**	**E**	**Viscosity (Min. Temp.)**	**Viscosity (Max. Temp.)**
C_8H_{16}	N - Propyl cyclo pentene	-11.195	1617.8	1.8473	-	-	4.3900×10^{-3} (200.00)	2.7064×10^{-4} (404.11)
C_8H_{16}	2,4,4 -Tri methyl - 1 - pentene	-10.880	851.80	-0.021434	-	-	1.9282×10^{-3} (179.70)	1.6117×10^{-4} (374.59)
C_8H_{16}	2,4,4-Trime-thyl-2-pentene	-11.057	858.10	-0.021434	-	-	2.7903×10^{-3} (166.84)	1.5795×10^{-4} (378.06)
$C_8H_{16}O$	2 - Ethyl - hexanol	-10.608	1107.5	0.064988	-	-	6.4993×10^{-3} (200.00)	3.3030×10^{-4} (433.80)
$C_8H_{16}O_2$	n - Butyl - n - butyrate	8.8040	440.60	-3.0270	-	-	2.6057×10^{-3} (240.00)	1.8368×10^{-4} (438.15)
$C_8H_{16}O_2$	Iso butyl - iso - Butyrate	-11.549	1404.1	-0.03868	-	-	1.1603×10^{-2} (192.45)	2.1502×10^{-4} (420.65)
$C_8H_{16}O_2$	n - Octanoic acid	-62.073	4648.8	7.2310	-	-	6.5185×10^{-3} (289.65)	8.0335×10^{-4} (400.00)
$C_8H_{16}O_4$	Di ethylene glycol ethyl ester acetate	-1.646	2017.1	0.16301	-	-	9.8665×10^{-3} (248.15)	1.9861×10^{-4} (490.55)
C_8H_{18}	2,2 - Di methyl hexane	-11.317	1104.7	-	-	-	6.7082×10^{-3} (175.00)	2.2267×10^{-4} (379.99)
C_8H_{18}	2,3 - Di methyl hexane	-11.106	1025.9	-	-	-	6.5239×10^{-3} (272.04)	2.1027×10^{-4} (388.76)
C_8H_{18}	2,4 - di methyl hexane	-11.530	1175.4	0.019385	-	-	8.2458×10^{-4} (272.04)	2.3820×10^{-4} (382.58)
C_8H_{18}	2,5 - di methyl hexane	-12.933	1107.1	0.26798	-	-	2.5348×10^{-3} (200.00)	2.1532×10^{-4} (382.26)
C_8H_{18}	3,3 - Di methyl hexane	-11.106	1027.1	-	-	-	4.5171×10^{-3} (180.00)	2.1626×10^{-4} (385.12)
C_8H_{18}	3,4 - Di methyl hexane	-11.037	1003.0	-	-	-	6.4257×10^{-4} (272.04)	2.0946×10^{-4} (390.88)

Formula	*Name*	*A*	*B*	*C*	*D*	*E*	*Viscosity (Min. Temp.)*	*Viscosity (Max. Temp.)*
C_8H_{18}	3 - Ethyl hexane	-8.137	909.0	-	-	-	6.0370×10^{-4} (272.04)	1.8350×10^{-4} (391.69)
C_8H_{18}	2 - Methyl - 3 - ethyl pentane	-11.235	1067.7	-	-	-	1.0398×10^{-2} (158.20)	1.8721×10^{-4} (388.80)
C_8H_{18}	2 - Methyl heptane	-9.4511	995.49	-	-	-	8.0238×10^{-3} (164.16)	1.8656×10^{-4} (390.80)
C_8H_{18}	3 - Methyl heptane	-10.247	1028.6	-0.16280	-	-	1.3233×10^{-2} (152.60)	1.8494×10^{-4} (392.08)
C_8H_{18}	4 - Methyl heptane	-11.432	1074.0	0.015358	-	-	1.3591×10^{-2} (152.20)	1.8548×10^{-4} (390.86)
C_8H_{18}	n - Octane	-20.463	1497.4	1.3790	-	-	2.1813×10^{-3} (216.38)	2.1383×10^{-4} (398.83)
C_8H_{18}	2,2,3,3 - Tetra - methyl butane	5.5351	632.38	-2.6576	-	-	1.9986×10^{-4} (373.96)	8.8594×10^{-5} (454.00)
C_8H_{18}	2,2,3 - Tri methyl pentane	-12.782	1220.4	0.21091	-	-	1.6080×10^{-2} (161.00)	2.4227×10^{-4} (381.00)
C_8H_{18}	2,2,4 - Tri methyl pentane	-15.811	1282.5	0.67791	-3.8617×10^{-28}	10	6.6643×10^{-4} (273.15)	4.5125×10^{-5} (541.15)
C_8H_{18}	2,3,3 - Tri methyl pentane	-4.0309	990.76	-1.1771	-	-	1.3054×10^{-2} (172.22)	2.0485×10^{-4} (387.91)
C_8H_{18}	2,3,4 -Tri methyl pentane	-9.1481	1021.4	-0.3103	-	-	1.1173×10^{-2} (163.95)	2.3675×10^{-4} (386.65)
$C_8H_{18}O$	Di - n -Butyl ether	8.0106	1046.1	-0.5013	-	-	1.4566×10^{-3} (246.75)	2.0482×10^{-4} (412.48)
$C_8H_{18}O$	2 - Ethyl - 1 - hexanol	8.6589	2685.5	-0.9440	-	-	6.3249×10^{-2} (203.15)	1.8823×10^{-4} (457.75)
$C_8H_{18}O$	1- Octanol	-67.577	5535.4	7.7383	-	-	1.0661×10^{-2} (288.15)	4.4402×10^{-4} (425.00)
$C_8H_{18}O$	2 - Octnol	-17.396	3740.1	-0.041083	-	-	5.7226×10^{-3} (300.00)	8.3551×10^{-5} (425.95)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_8H_{18}O_3$	Di ethylene glycol mono butyl ether	-8.2623	2522.5	-1.0247	-	-	2.4131×10^{-1} (205.15)	6.5373×10^{-5} (504.15)
$C_8H_{18}O_5$	Tetra ethylene Glycol	-18.728	4056.8	0.34542	-	-	1.8868×10^{-1} (268.15)	5.7608×10^{-5} (600.45)
$C_8H_{18}S$	Tert - Octyl Mercatan	-7.7185	1071.7	-0.40448	-	-	1.1400×10^{-2} (199.00)	4.6564×10^{-4} (429.00)
$C_8H_{19}N$	Di - n - butyl amine	-25.447	2104.0	-1.9985	-	-	2.4878×10^{-3} (250.00)	2.1308×10^{-4} (432.75)
$C_8H_{19}N$	n - Octyl amine	-21.631	2151.1	1.3882	-	-	2.5838×10^{-2} (272.75)	2.2701×10^{-4} (452.75)
$C_8H_{23}N_5$	Tetra ethylene pentamide	-10.408	2077.0	-001169	-	-	1.4589×10^{-1} (243.00)	8.6191×10^{-4} (606.15)
$C_9H_4O_5$	Tri mellitic anhydride	-11.910	1637.0	0.072999	-	-	4.3953×10^{-4} (438.15)	1.2987×10^{-4} (658.15)
C_9H_7N	Iso quinoline	-42.468	3361.4	4.4868	-	-	3.4851×10^{-3} (299.4)	3.5972×10^{-4} (516.40)
C_9H_7N	Quinoline	-51.162	3942.4	5.6579	-	-	6.6049×10^{-3} (274.15)	2.8553×10^{-4} (510.75)
C_9H_8	Indene	-18.972	1929.9	1.0707	-	-	2.8285×10^{-3} (271.70)	2.7941×10^{-4} (455.77)
C_9H_{10}	α - Mehyl styrene	-7.1110	1043.3	-0.6230	-	-	1.7007×10^{-3} (249.95)	1.9890×10^{-4} (438.65)
C_9H_{10}	Cis - 1 - Propynyl benzene	-11.320	1202.5	-0.22407×10^{-3}	-	-	3.5713×10^{-3} (211.47)	1.7319×10^{-4} (452.03)
C_9H_{10}	Trans-1-Propnyl benzene	-11.318	1202.4	-0.56928×10^{-3}	-	-	1.6789×10^{-3} (243.82)	1.7376×10^{-4} (451.41)
$C_9H_{10}O_2$	Benzyl acetate	-18.431	2179.5	0.8650	-	-	7.7321×10^{-3} (247.65)	1.8407×10^{-4} (486.65)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_9H_{10}O_2$	Ethyl benzoate	-40.706	3035.0	4.2655	-	-	2.6663×10^{-3} (284.15)	4.604×10^{-4} (420.00)
$C_9H_{11}NO_2$	1 - Phenyl aniline	-15.287	4067.1	0.27615×10^{-3}	-	-	3.4489×10^{-4} (556.15)	1.4939×10^{-4} (628.00)
C_9H_{12}	Mesitylene	-3.0300	1026.0	-1.3080	-	-	1.0257×10^{-3} (288.46)	1.7651×10^{-4} (434.89)
C_9H_{12}	Cumene	-24.438	1785.9	1.9720	-	-	6.3442×10^{-3} (200.00)	2.3033×10^{-4} (440.00)
C_9H_{12}	m - Ethyl toluene	-11.470	1306.4	-0.075202	-	-	1.5709×10^{-2} (177.61)	2.0167×10^{-4} (434.48)
C_9H_{12}	o - Ethyl toluene	-11.809	1421.8	0.000711	-	-	1.2112×10^{-2} (192.35)	1.9143×10^{-4} (438.33)
C_9H_{12}	p- Ethyl toluene	-24.158	1686.6	1.9619	-	-	8.0506×10^{-4} (283.15)	2.7829×10^{-4} (400.00)
C_9H_{12}	n - Propyl benzene	-18.594	1566.5	1.0901	-	-	1.8914×10^{-3} (248.15)	2.3523×10^{-4} (432.39)
C_9H_{12}	1,2,3-Trime- thyl benzene	-11.756	1483.1	-0.040387	-	-	1.5909×10^{-3} (267.79)	1.6633×10^{-4} (449.27)
C_9H_{12}	1,2,4-Trime- thyl benzene	7.1680	1156.0	-0.6556	-	-	2.0783×10^{-3} (250.38)	1.9355×10^{-4} (442.53)
$C_9H_{12}O$	Bezyl ethyl ether	-11.460	1497.0	-0.043397	-	-	1.8865×10^{-3} (275.65)	2.1211 x 10+ (458.15)?
$C_9H_{14}O$	Iso phorone	-12.505	1921.5	-	-	-	5.2087×10^{-3} (265.00)	3.5907×10^{-4} (420.00)
$C_9H_{14}O_6$	Glyeryl triacetate	-12.309	2025.7	-0.27413	-	-	5.7601×10^{-3} (277.25)	1.7090×10^{-4} (532.15)
$C_9H_{16}O_4$	Azelaic acid	-12.979	2720.6	0.071562	-	-	4.5716×10^{-3} (379.65)	2.7549×10^{-4} (629.65)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
C_9H_{18}	n - Butyl - cyclo pentane	-11.695	1235.2	0.0806400	-	-	2.2253×10^{-2} (165.18)	2.4073×10^{-4} (429.75)
C_9H_{18}	1 - Nonene	-21.920	1602.5	1.59730	-	-	8.3142×10^{-4} (273.15)	2.1253×10^{-4} (420.00)
C_9H_{18}	n - Propyl cylo hexane	-31.227	2179.0	2.9731	-	-	2.3526×10^{-3} (248.15)	2.9432×10^{-4} (429.90)
$C_9H_{18}O$	1 - Nonanol	-10.377	1110.4	0.007412	-	-	2.5188×10^{-3} (255.15)	2.4932×10^{-4} (468.15)
$C_9H_{18}O_2$	n-Heptyl acetate	-47.211	3152.6	5.2738	-	-	1.0510×10^{-2} (222.95)	3.2195×10^{-4} (465.65)
$C_9H_{18}O_2$	n-Nonanoic acid	-48.851	4095.0	5.2940	-	-	8.1601×10^{-3} (293.15)	1.7164×10^{-3} (363.15)
$C_9H_{18}O_4$	Di propylene glycol mono methyl ether	-12.926	2306.7	-0.00029876	-	-	2.9821×10^{-2} (245.00)	2.8971×10^{-4} (482.45)
C_9H_{20}	3,3 - Di methyl petane	-11.672	1088.9	0.048876	-	-	1.0392×10^{-3} (240.12)	1.5375×10^{-4} (419.34)
C_9H_{20}	2 - Methyl octane	-11.445	1154.1	0.0087285	-	-	4.4607×10^{-3} (192.78)	1.8029×10^{-4} (416.43)
C_9H_{20}	3 - Methyl octane	-11.321	1149.1	-0.010082	-	-	1.1898×10^{-2} (165.55)	1.7890×10^{-4} (417.38)
C_9H_{20}	4 - Methyl ocane	-11.276	1147.8	-0.017134	-	-	1.5192×10^{-2} (159.95)	1.8092×10^{-4} (415.59)
C_9H_{20}	n - Nonane	-21.149	1658.0	1.4540	-	-	3.1509×10^{-3} (219.63)	2.1662×10^{-4} (423.15)
C_9H_{20}	2,2,3,3 -Tetra methyl pentane	-3.4767	1208.4	-1.3623	-	-	1.5356×10^{-3} (263.26)	8.3060×10^{-5} (483.26)
C_9H_{20}	2,2,3,4 -Tetra methyl pentane	-6.5306	1195.9	-0.82227	-	-	6.0977×10^{-2} (152.06)	1.9834×10^{-4} (406.18)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
C_9H_{20}	2,2,4,4 - Tetra methyl petane	-5.1626	1307.9	-1.13400	-	-	7.5235×10^{-3} (206.95)	1.7751×10^{-4} (395.44)
C_9H_{20}	2,3,3,4 - Tetra methyl pentane	-6.036	1171.8	-0.89065	-	-	2.3220×10^{-2} (171.03)	1.1176×10^{-4} (481.03)
C_9H_{20}	2,2,5 - Tri methyl hexane	-11.294	990.04	0.0010059	-	-	4.6343×10^{-3} (167.39)	1.5139×10^{-4} (397.24)
$C_9H_{20}O$	2,6 - Di methyl -4 - heptanol	-210.29	13485.0	28.277	-	-	5.4642×10^{-2} (273.15)	4.1933×10^{-4} (400.00)
$C_9H_{20}O$	1 - Nonanol	-7.1348	2776.3	-1.2064	-	-	1.3137×10^{-2} (288.15)	5.9786×10^{-4} (400.00)
$C_9H_{20}O_4$	Tri propylene glycol	-5.9712	31872.	85.330	-	-	1.3945×10 (250.00)	6.6673×10^{-3} (350.00)
$C_9H_{21}N$	n - Nonyl amine	12.468	2047.6	0-.018554	-	-	6.2458×10^{-3} (273.15)	2.5486×10^{-4} (475.35)
$C_9H_{21}N$	Tri propyl amine	-17.102	1435.7	0.86043	-	-	4.6790×10^{-3} (200.00)	1.9477×10^{-4} (429.65)
$C_{10}H_7Cl$	1 - Chloro naphthalene	9.2058	1134.0	-3.3047	-	-	5.4655×10^{-3} (274.15)	2.1105×10^{-4} (450.10)
$C_{10}H_8$	Naphthalene	-19.308	1822.5	1.2180	-	-	9.0774×10^{-4} (353.43)	1.8923×10^{-4} (633.15)
$C_{10}H_9N$	Qunaldine	-12.757	2135.3	-	-	-	7.3654×10^{-3} (272.15)	1.7536×10^{-4} (519.75)
$C_{10}H_{10}$	m - Di vinyl benzene	-11.605	1308.4	0.0078808	-	-	5.4114×10^{-3} (265.25)	1.5252×10^{-4} (472.65)
$C_{10}H_{10}O_4$	Di methyl Phthalate	-28.482	16163	39.73	-	-	7.3654×10^{-3} (272.15)	1.7536×10^{-4} (400.00)
$C_{10}H_{10}O_4$	Di methyl tere phthalate	-37.986	1505.0	-6.8564	-	-	8.7938×10^{-4} (423.15)	4.0427×10^{-4} (523.15)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_{10}H_{12}$	Di cyclo pentadiene	-11.186	12587	-0.004513	-	-	8.1539×10^{-4} (307.00)	2.3121×10^{-4} (443.00)
$C_{10}H_{12}$	Tetralin	-45.327	3241.8	4.9583	-	-	3.5435×10^{-2} (273.15)	4.9419×10^{-4} (413.15)
$C_{10}H_{12}O_2$	n - Propyl benzoate	-12.781	2064.1	0.0003808	-	-	3.1357×10^{-2} (221.55)	1.6920×10^{-4} (505.15)
$C_{10}H_{12}O_4$	Dialyl maleate	-11.239	1833.2	-0.077321	-	-	2.8666×10^{-2} (226.15)	2.7543×10^{-4} (520.00)
$C_{10}H_{14}$	n - Butyl benzene	-25.102	1949.6	2.0385	-	-	2.4661×10^{-3} (248.15)	2.3685×10^{-4} (456.45)
$C_{10}H_{14}$	Sec - Butyl benzene	-124.57	6129.9	17.0290	-	-	2.9093×10^{-2} (197.72)	6.7013×10^{-4} (360.00)
$C_{10}H_{14}$	Tert - Butyl benzene	-11.510	1357.4	0.0088106	-	-	5.7584×10^{-3} (215.27)	2.2773×10^{-4} (442.30)
$C_{10}H_{14}$	m - Cymene	-3.2349	617.62	-1.0524	-	-	2.7019×10^{-3} (209.44)	1.7467×10^{-4} (525.60)
$C_{10}H_{14}$	o - Cymene	-6.9805	868.33	-0.50428	-	-	1.8519×10^{-3} (250.00)	2.0269×10^{-4} (529.60)
$C_{10}H_{14}$	p - Cymene	-3.1077	614.71	-1.0737	-	-	2.9399×10^{-3} (205.25)	1.7479×10^{-4} (522.53)
$C_{10}H_{14}$	m - Di ethyl benzene	-11.168	1303.2	-0.0020741	-	-	1.2389×10^{-2} (189.25)	2.1904×10^{-4} (454.29)
$C_{10}H_{14}$	o - Di ethyl benzene	-11.956	1541.1	0.002232	-	-	3.7963×10^{-3} (241.93)	1.9024×10^{-4} (456.61)
$C_{10}H_{14}$	p - Diethyl benzene	-11.182	1302.8	-0.01860	-	-	3.6091×10^{-3} (230.32)	2.1560×10^{-4} (456.94)
$C_{10}H_{14}$	3 - Ethyl - o - xylene	-12.153	1615.2	-0.6756×10^{-3}	-	-	7.1953×10^{-3} (223.64)	1.6670×10^{-4} (467.11)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_{10}H_{14}$	Iso butyl benzene	-11.681	1364.6	0.34472	-	-	4.7976×10^{-3} (221.70)	2.2248×10^{-4} (445.94)
$C_{10}H_{14}$	1,2,4,5 - Tetra methyl benzene	-11.273	1528.8	-0.0761	-	-	5.1796×10^{-4} (352.38)	1.6957×10^{-4} (469.99)
$C_{10}H_{14}O$	p - Tetra Butyl phenol	-18.295	4913.7	0.010093	-	-	6.6658×10^{-3} (371.56)	1.7488×10^{-4} (512.88)
$C_{10}H_{14}O_2$	p - Tetra Butyl cathecol	-15.839	3789.8	-0.0038813	-	-	1.4988×10^{-2} (325.00)	1.4860×10^{-4} (558.00)
$C_{10}H_{16}$	α - Pinene	-3.6988	994.27	-1.1031	-	-	7.9161×10^{-3} (209.15)	1.8412×10^{-4} (505.60)
$C_{10}H_{16}$	β - Pinene	-3.6180	1209.9	-1.2107	-	-	1.2483×10^{-2} (211.61)	1.2256×10^{-4} (541.93)
$C_{10}H_{16}O$	Camphor	-12.819	2470.0	-	-	-	6.3096×10^{-4} (453.15)	3.6744×10^{-4} (503.05)
$C_{10}H_{18}$	Cis - Decalin	-44.032	3379.6	4.7234	-	-	1.5239×10^{-2} (243.15)	4.2050×10^{-4} (468.76)
$C_{10}H_{18}$	Tras - Decalin	-28.692	2396.7	2.5297	-	-	7.2490×10^{-3} (242.79)	3.442×10^{-4} (46.46)
$C_{10}H_{18}O_4$	Sebacic acid	-12.184	2685.2	-7206.4	-	-	3.5518×10^{-3} (407.65)	3.5832×10^{-4} (625.00)
$C_{10}H_{20}$	n - Butyl cyclo hexane	-39.842	2686.6	4.2271	-	-	2.9717×10^{-3} (253.15)	3.2068×10^{-4} (454.13)
$C_{10}H_{20}$	1 - Decene	-15.858	1430.5	0.68113	-	-	-1.1140×10^{-3} (273.15)	2.0702×10^{-4} (443.75)
$C_{10}H_{20}O$	Decanol	-10.115	1111.9	-0.015659	-	-	2.3806×10^{-3} (267.15)	3.5829×10^{-4} (488.15)
$C_{10}H_{20}O_2$	n - Decanoic acid	-12.305	2324.1	-0.055494	-	-	6.7640×10^{-3} (304.75)	2.3044×10^{-4} (543.15)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_{10}H_{20}O_2$	2 - Ethyl hexyl acetate	-13.277	1687.0	0.18690	-	-	1.4811×10^{-2} (209.15)	1.9348×10^{-4} (471.75)
$C_{10}H_{20}O_2$	Iso pentyl iso Valerate	-12.574	1614.9	0.072451	-	-	1.0587×10^{-2} (215.00)	1.8155×10^{-4} (467.15)
$C_{10}H_{20}O_2$	Octyl acetate	-13.277	1687.0	0.1869	-	-	1.4811×10^{-2} (209.15)	1.9348×10^{-4} (471.75)
$C_{10}H_{22}$	n - Decane	-16.468	1533.5	0.7511	-	-	2.3753×10^{-3} (243.49)	2.1165×10^{-4} (448.15)
$C_{10}H_{22}O$	1 - Decanol	-80.656	6325.5	9.646	-	-	1.7010×10^{-2} (288.15)	3.1108×10^{-4} (503.35)
$C_{10}H_{22}O$	Iso - Decanol	-16.063	3587.5	-0.024705	-	-	2.8637×10^{-1} (240.00)	1.3113×10^{-4} (493.00)
$C_{10}H_{23}N$	n - Decyl amine	-12.517	2140.3	-0.018354	-	-	5.4548×10^{-3} (288.85)	2.4972×10^{-4} (493.65)
$C_{11}H_{10}$	2 - Methyl naphthalene	-6.3276	4219.9	7.5549	-	-	5.4548×10^{-3} (366.00)	2.4972×10^{-4} (535.15)
$C_{11}H_{16}O_3$	p - tert - Amyl phenol	-17.932	4850.1	-0.035032	-	-	7.543×10^{-3} (366.00)	1.129×10^{-4} (535.15)
$C_{11}H_{20}O_2$	2 - Ethyl hexyl acrylate	-12.232	1716.9	0.011529	-	-	6.0953×10^{-2} (183.15)	1.7502×10^{-4} (489.15)
$C_{11}H_{22}$	1 - Undecene	-30.381	2218.0	2.8071	-	-	5.0525×10^{-3} (223.99)	2.3096×10^{-4} (465.82)
$C_{11}H_{22}O_2$	n - Nonyl acetate	-12.131	1721.7	0.38161×10^{-3}	-	-	5.7263×10^{-3} (247.15)	1.7249×10^{-4} (497.10)
$C_{11}H_{24}$	n - Undecane	-19.325	1793.3	1.1432	-	-	3.0437×10^{-3} (248.15)	2.1070×10^{-4} (468.15)
$C_{11}H_{24}O$	1 - Undecanol	-83.771	6606.1	10.065	-	-	1.7248×10^{-2} (293.15)	7.1229×10^{-4} (420.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_{12}H_8$	Acenaphtha lene	0.86291	334.69	-1.5499	-	-	6.436×10^{-4} (362.65)	1.8266×10^{-4} (633.60)
$C_{12}H_9N_3O_4$	4,4′ - Di nitro phenyl amine	-18.388	60805	-0.3907×10^{-3}	-	-	2.4608×10^{-3} (491.05)	5.4680×10^{-5} (709.00)
$C_{12}H_{10}$	Acenaphthene	20.433	103.79	-4.6073	-	-	1.5245×10^{-3} (366.56)	2.1290×10^{-4} (550.54)
$C_{12}H_{10}$	Bi phenyl	-7.0860	1376.8	-0.60214	-	-	94702×10^{-4} (373.15)	1.0661×10^{-4} (723.15)
$C_{12}H_{10}O$	Di phenyl ether	-70.831	103.79	-4.6073	-	-	3.4909×10^{-3} (300.10)	6.8386×10^{-4} (420.00)
$C_{12}H_{11}N$	Di phenyl amine	-41.616	4158.5	4.0723	-	-	4.7449×10^{-3} (328.15)	3.3841×10^{-4} (500.00)
$C_{12}H_{12}N_2$	Benzidine	-13.821	2982.7	0.4227×10^{-3}	-	-	1.6899×10^{-3} (401.15)	8.2852×10^{-5} (675.85)
$C_{12}H_{12}N_2$	p - Amino -phenol amine	-13.297	4158.5	4.0723	-	-	5.2950×10^{-3} (341.15)	1.1955×10^{-4} (627.15)
$C_{12}H_{12}N_2$	Hydrazo benzene	-13.578	2992.9	0.029615	-	-	2.4916×10^{-3} (404.15)	2.8395×10^{-4} (573.00)
$C_{12}H_{14}$	1,2,3 - Tri methylidene	-5.5950	799.06	-0.62620	-	-	9.7300×10^{-4} (344.65)	3.6211×10^{-4} (508.00)
$C_{12}H_{14}O_4$	Diethyl - Phthalate	-14.110	2851.0	-	-	-	2.9677×10^{-2} (269.15)	1.1357×10^{-4} (567.15)
$C_{12}H_{14}O_6$	Bis - (2 -hydroxy - ethyl) tere phthalate	-24.453	9349.7	0.42131×10^{-3}	-	-	8.9944×10^{-1} (385.15)	2.1209×10^{-5} (683.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_{12}H_{16}$	Cyclo hexyl benzene	-12.051	1819.4	-	-	-	3.8627×10^{-3} (280.14)	2.022×10^{-4} (513.27)
$C_{12}H_{18}$	m - Di iso propyl benzene	-11.467	1529.0	-	-	-	9.3587×10^{-3} (225.00)	2.5943×10^{-4} (476.33)
$C_{12}H_{18}$	p - Di iso propyl benzene	-11.129	1224.8	-0.020812	-	-	1.5624×10^{-3} (256.08)	1.6253×10^{-4} (483.65)
$C_{12}H_{18}$	n - Hexyl benzene	-86.584	4983.6	11.128	-	-	4.902×10^{-3} (253.15)	5.545×10^{-5} (499.26)
$C_{12}H_{20}O_4$	Di butyl maleate	-11.694	1970.8	-0.042861	-	-	2.3602×10^{-1} (188.15)	2.2446×10^{-4} (553.15)
$C_{12}H_{22}$	Bi cyclo hexyl	24.519	-9629.1	-0.38364	-	-	4.8487×10^{-3} (276.78)	6.2861×10^{-4} (360.00)
$C_{12}H_{24}$	1 - Dodecene	-29.634	2287.3	2.6757	-	-	4.611×10^{-3} (237.79)	2.3004×10^{-4} (486.50)
$C_{12}H_{24}O$	1 - Dodecanol	-10.110	1130.1	0.010396	-	-	2.2698×10^{-3} (285.15)	3.7644×10^{-4} (523.15)
$C_{12}H_{24}O_2$	n - Dodecanoic acid	-27.215	3198.5	2.1373	-	-	8.0984×10^{-3} (316.98)	3.1837×10^{-4} (571.85)
$C_{12}H_{24}O_2$	n - Decyl acetate	-22.215	2239.0	1.5281	-	-	6.3802×10^{-3} (258.12)	2.3939×10^{-4} (517.15)
$C_{12}H_{26}$	n - Do decane	-20.607	1943.0	1.3205	-	-	2.9046×10^{-3} (262.15)	2.1348×10^{-4} (488.15)
$C_{12}H_{26}O$	Di - n - hexyl ether	-11.743	1718.8	-0.0042224	-	-	1.3599×10^{-2} (230.15)	2.4269×10^{-4} (498.85)
$C_{12}H_{26}O$	1 - Do decanol	-70.023	5998.0	8.0302	-	-	1.6509×10^{-2} (29.95)	2.3313×10^{-4} (535.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_{12}H_{26}S$	n - Do decyl mercapan	-11.674	1669.0	0.19645	-	-	5.1445×10^{-3} (265.15)	2.0284×10^{-4} (547.75)
$C_{12}H_{26}S$	Tert - Do decyl mercaptn	-10.585	160.7	-0.15053	-	-	6.920×10^{-3} (250.00)	2.2453×10^{-4} (515.65)
$C_{12}H_{27}N$	Do decyl amine	-12.931	2307.7	0.036387	-	-	6.2921×10^{-3} (301.47)	2.226×10^{-4} (532.35)
$C_{12}H_{27}N$	Tri - n - Butyl amie	-2.279	2355.1	2.4141	-	-	5.3254×10^{-3} (240.00)	2.0251×10^{-4} (487.15)
$C_{13}H_{10}$	Fluorene	4.1850	723.30	-2.1489	-	-	1.1595×10^{-3} (387.94)	2.7885×10^{-4} (570.44)
$C_{13}H_{10}O$	Benzo phenone	-13.427	2645.0	-	-	-	5.0491×10^{-3} (325.00)	5.2652×10^{-4} (450.00)
$C_{13}H_{12}$	Di phenyl methane	-29.165	2613.0	2.5526	-	-	2.8448×10^{-3} (298.39)	3.4844×10^{-4} (480.00)
$C_{13}H_{26}$	1 - Tri decane	-34.453	2608.5	3.3704	-	-	4.4639×10^{-3} (250.08)	1.772×10^{-4} (685.00)
$C_{13}H_{28}O$	1 - Tri decanol	-16.347	3754.8	0.16359	-	-	2.0404×10^{-2} (303.75)	8.4278×10^{-5} (457.15)
$C_{14}H_{10}$	Anthracene	-833.68	59007	114.03	-3.23×10^{-28}	10	7.8691×10^{-4} (488.93)	4.0651×10^{-4} (593.15)
$C_{14}H_{10}$	Di phenyl acetylene	-11.875	1884.4	0.047303	-	-	2.5145×10^{-3} (335.65)	2.5204×10^{-4} (573.00)
$C_{14}H_{10}$	Phenanthrene	0.7186	1105.5	-2.0693	-	-	1.9107×10^{-4} (372.39)	7.4993×10^{-5} (45315)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_{14}H_{12}O_2$	Benzyl benzoate	13.503	2616.0	-	-	-	1.0452×10^{-2} (292.55)	9.4625×10^{-4} (400.00)
$C_{14}H_{14}$	1,1 - Di phenyl ethane	114.4	6938.7	15.023	-	-	1.2377×10^{-2} (265.00)	8.7308×10^{-4} (400.00)
$C_{14}H_{14}$	1,2 - Di phenyl ethane	-11.716	1820.9	-	-	-	2.2388×10^{-3} (324.34)	2.1886×10^{-4} (553.65)
$C_{14}H_{14}O$	Di benzyl ether	-13.324	2375.0	-	-	-	8.719×10^{-3} (276.75)	3.2031×10^{-4} (450.00)
$C_{14}H_{28}$	1 - Tetra decene	-40.342	2975.4	4.2237	-	-	4.4279×10^{-3} (260.30)	3.6109×10^{-4} (450.00)
$C_{14}H_{28}O_2$	Tetra decanoic acid	-13.017	2702.1	-	-	-	8.501×10^{-3} (327.55)	2.0172×10^{-4} (599.35)
$C_{14}H_{30}$	n -Tetra decane	-20.486	2088.4	1.2852	-	-	3.1395×10^{-3} (279.01)	2.0874×10^{-4} (528.15)
$C_{14}H_{30}O$	1 - Tetra decanol	-16.218	3868.0	-0.028771	-	-	1.9608×10^{-2} (310.65)	7.5244×10^{-5} (560.15)
$C_{14}H_{31}N$	Tetra decyl amine	-12.542	2385.5	-0.00992	-	-	7.1768×10^{-3} (311.34)	2.2973×10^{-4} (564.45)
$C_{15}H_{16}O$	p - Cumyl phenol	-18.733	5042.8	-0.017518	-	-	1.411×10^{-2} (346.00)	2.6108×10^{-5} (608.15)
$C_{15}H_{16}O_2$	Bisphenol - A	-2.2572	2282.4	-1.2838	-	-	8.3796×10^{-3} (433.15)	2.8829×10^{-4} (833.15)
$C_{15}H_{24}O$	2,6 - Di - tert - butyl - p - cresol	-11.716	2228.8	-0.059917	-	-	3.7467×10^{-3} (344.00)	3.5266×10^{-4} (538.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_{15}H_{24}O$	Nonyl phenol	39.283	2785.8	-8.4414	-	-	5.5998 (279.15)	6.4453×10^{-5} (581.00)
$C_{15}H_{30}O_2$	Penta decanoic acid	-12.506	2605.4	-0.03396	-	-	9.0715×10^{-3} (325.68)	2.1028×10^{-4} (612.05)
$C_{15}H_{32}$	n - Penta decane	-19.299	2088.6	1.1091	-	-	3.4861×10^{-3} (283.07)	2.0910×10^{-4} (543.83)
$C_{16}H_{10}$	Fluoranthene	-26.811	3211.0	2.1614	-	-	3.7859×10^{-3} (383.33)	3.7194×10^{-4} (655.95)
$C_{16}H_{10}$	Pyrene	-11.909	2429.0	-	-	-	2.0777×10^{-3} (423.81)	2.5564×10^{-4} (667.95)
$C_{16}H_{12}$	1 - Phenal phthalene	-11.699	980.93	-1.3181	-	-	3.4059×10^{-3} (318.15)	3.3490×10^{-4} (607.15)
$C_{16}H_{22}O_4$	Di butyl phthalate	-250.53	14426	34.706	-	-	1.3275 (238.15)	1.9830×10^{-3} (420.00)
$C_{16}H_{26}$	n -Decyl benzene	-47.161	3622.5	5.1502	-	-	1.0590×10^{-2} (258.77)	2.9556×10^{-4} (571.04)
$C_{16}H_{32}$	1 - Hexa decene	-43.375	3289.1	4.6393	-	-	4.4149×10^{-3} (277.51)	3.8699×10^{-4} (475.00)
$C_{16}H_{32}O_2$	n - Hexa decanoic acid	-22.747	3128.1	1.4996	-	-	9.0415×10^{-3} (335.66)	3.0868×10^{-4} (624.15)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_{16}H_{34}O$	n - Hexa decane	-20.182	2203.5	1.2289			3.5364×10^{-3} (291.32)	2.0538×10^{-4} (560.01)
$C_{16}H_{34}O$	1 - Hexa decanol	-16.927	4066.0	-	-	-	1.3388×10^{-2} (322.35)	3.7393×10^{-4} (450.00)
$C_{17}H_{36}$	n - Hepta decane	-19.991	2245.1	1.1982	-	-	3.8136×10^{-3} (295.13)	2.0881×10^{-4} (575.30)
$C_{17}H_{36}O$	1 - Hepta decanol	-16.785	4244.7	-00012913	-	-	2.0109×10^{-2} (327.05)	5.6148×10^{-5} (597.15)
$C_{18}H_{12}$	Chrysene	-13.014	2845.5	-	-	-	2.7996×10^{-4} (588.75)	1.1982×10^{-4} (714.15)
$C_{18}H_{13}N_3O_4$	4,4 - Di nitro phenyl amine	-18.834	6582.9	0.0012913	-	-	6.0867×10^{-3} (479.65)	4.699×10^{-5} (743.00)
$C_{18}H_{14}$	o - Tere phenyl	-38.408	4405.8	3.5356	-	-	4.4138×10^{-3} (373.00)	1.4155×10^{-4} (750.00)
$C_{18}H_{14}$	p - Tere phenyl	-10.360	2007.0	-0.1428	-	-	7.3326×10^{-4} (498.15)	1.9849×10^{-4} (723.15)
$C_{18}H_{30}$	n - Do decyl benzene	-37.075	3263.6	3.6495	-	-	7.1263×10^{-3} (283.15)	6.8152×10^{-4} (423.15)
$C_{18}H_{32}O_2$	Linolic acid	-13.258	2887.8	0.011419	-	-	8.8495×10^{-2} (268.15)	8.1693×10^{-4} (475.15)
$C_{18}H_{34}O_2$	Oleic acid	-40.782	4211.3	4.0554	-	-	3.4086×10^{-2} (293.15)	7.7964×10^{-4} (500.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_{18}H_{34}O_4$	Di butyl sebacate	-12.554	2311.0	-	-	-	1.6175×10^{-2} (274.15)	6.0008×10^{-4} (450.00)
$C_{18}H_{34}O_4$	Di hexyl adipate	-12.619	2252.2	-0.014764	-	-	1.8006×10^{-2} (259.35)	1.130×10^{-4} (621.15)
$C_{18}H_{36}$	1 - Octa decane	-18.176	21383.0	0.94060	-	-	4.1433×10^{-3} (290.76)	5.0497×10^{-4} (440.00)
$C_{18}H_{36}O_2$	Stearic acid	5.4787	1616.7	-2.5466	-	-	9.3029×10^{-3} (343.15)	8.1362×10^{-4} (500.00)
$C_{18}H_{38}$	n - Octa decane	-20.5800	2308.9	1.2355	-	-	3.8698×10^{-3} (301.33)	2.0881×10^{-4} (589.86)
$C_{18}H_{38}O$	Di nonyl ether	-10.899	1969.8	-0.1193	-	-	2.1395×10^{-3} (297.15)	5.2328×10^{-4} (397.15)
$C_{18}H_{38}O$	1 - Octa decanol	-16.917	4361.3	-0.017534	-	-	7.088×10^{-3} (331.05)	1.290×10^{-3} (608.15)
$C_{19}H_{16}$	Tri phenyl methane	-12.840	2408.1	0.10823	-	-	3.6638×10^{-3} (365.30)	2.4054×10^{-4} (632.15)
$C_{19}H_{26}$	1 - n - Nonyl naphthalene	-2.7846	1345.8	-1.2385	-	-	6.4397×10^{-3} (284.15)	1.7011×10^{-4} (639.00)
$C_{19}H_{32}$	n - Tri decyl benzne	-44.14	3702.8	4.6612	-	-	8.6881×10^{-3} (283.15)	3.7369×10^{-4} (525.00)
$C_{19}H_{36}O_2$	Methyl oleate	-9.059	2116.7	-0.5587	-	-	6.6735×10^{-3} (293.05)	9.9243×10^{-5} (617.00)
$C_{19}H_{38}O_2$	Nona decanoic acid	-12.054	2667.1	-0.048148	-	-	1.0903×10^{-2} (341.23)	2.4353×10^{-4} (659.15)
$C_{19}H_{40}$	n - Nona decane	-18.530	2256.2	0.98525	-	-	4.0720×10^{-3} (305.53)	2.0668×10^{-4} (603.76)
$C_{20}H_{16}$	Tri phenyl ethyene	-6.2307	1833.2	-0.55548	-	-	1.6339×10^{-2} (342.15)	8.2115×10^{-4} (669.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_{20}H_{18}$	1,1,2 - Tri phenyl ethane	-11.896	2449.0	0.60534×10^{-3}	-	-	1.2030×10^{-3} (327.75)	3.5097×10^{-4} (622.00)
$C_{20}H_{28}$	1 - n - Decyl naphthalene	-10.494	7404.1	13.331	-	-	2.364×10^{-2} (288.15)	6.8584×10^{-4} (500.00)
$C_{20}H_{30}O_2$	Abietic Acid	-0.76294	2619.1	-2.0391	-	-	6.4828×10^{-4} (446.65)	4.8306×10^{-4} (649.70)
$C_{20}H_{40}$	1 - Eicosene	-20.807	2399.0	1.3117	-	-	4.6651×10^{-2} (301.75)	2.065×10^{-4} (615.54)
$C_{20}H_{40}$	n - Eicosene	-20.379	2412.6	1.2445	-	-	4.3023×10^{-4} (309.59)	2.0909×10^{-5} (616.93)
$C_{20}H_{42}$	n - Eicosane	-18.315	2283.5	0.95485	-	-	4.2425×10^{-3} (309.58)	2.0780×10^{-4} (616.93)
$C_{20}H_{42}O$	1 - Eicosanol	-17.073	4578.1	-0.026701	-	-	2.4579×10^{-2} (338.55)	4.6856×10^{-5} (629.15)
$C_{22}H_{44}O_2$	n - Butyl stearate	-43.68	3845.9	4.555	-	-	8.0006×10^{-3} (298.15)	1.9523×10^{-3} (363.15)
$C_{24}H_{38}O_4$	Di octyl phthalate	-362.29	20711	50.885			5.1581×10^{-1} (233.20)	3.5642×10^{-3} (400.00)
$C_{24}H_{38}O_4$	Di octyl tere phthalate	-14.539	3654.7	0.84549×10^{-4}			2.6544×10^{-2} (335.00)	9.1191×10^{-5} (698.00)
$C_{24}H_{42}O$	Di nonyl phenol	-14.231	2996.8	-0.0068146			3.3172×10^{-3} (350.00)	4.0059×10^{-5} (722.00)
$C_{24}H_{50}$	n - Tetra cosane	-20.613	2536.0	1.2945	-7.0438×10^{-30}	10	5.003×10^{-3} (323.75)	7.732×10^{-5} (793.15)
$C_{25}H_{20}$	Tere phenyl methane	-12.084	2934.3	-0.20184×10^{-2}	-	-	1.0409×10^{-3} (561.15)	2.8929×10^{-4} (743.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
$C_{26}H_{20}$	Tetra phenyl ethylene	-3.5155	2128.1	-0.90765	-	-	7.7509×10^{-3} (496.15)	1.1873×10^{-3} (760.00)
$C_{26}H_{22}$	1,1,2,2 -Tetra phenyl ethane	-12.128	3032.4	-0.95092×10^{-3}	-	-	2.7582×10^{-3} (485.15)	6.4598×10^{-4} (633.15)
$C_{28}H_{46}O_4$	Di iso decyl Phthalate	-16.376	4125.0	-	-	-	2.5259×10^{-4} (342.35)	4.6263×10^{-5} (823.15)
$C_{28}H_{58}$	Octa cosane	-23.166	2791.9	1.6621	-4.7423	10	7.6741×10^{-3} (349.05)	8.0662×10^{-5} (923.15)
$C_{32}H_{66}$	n - Do tria contane	-8.8892	2016.7	-0.34776	-	-	6.5525×10^{-3} (342.35)	1.5474×10^{-4} (823.15)
$C_{36}H_{74}$	n - Hexa tria contane	-29.462	3363.1	2.5545	-2.3313×10^{-30}	10	7.6741×10^{-3} (349.05)	8.0662×10^{-5} (923.15)
CaF	Calcium fluoride	-211.29	55518	23.084	-	-	8.810×10^{-4} (1772.00)	3.1223×10^{-4} (2000.00)
ClH	Hydrogen chloride	71.320	-2542.1	-0.1268	-	-	1.6483×10^{-4} (233.15)	6.3418×10^{-4} (313.15)
ClK	Potassium chloride	-10.568	2959.0	0.13119	-	-	1.0205×10^{-3} (1070.00)	3.855×10^{-4} (1710.00)
ClNa	Sodium chloride	-7.7059	2407.8	-0.20078	-	-	1.0298×10^{-3} (1080.00)	7.9214×10^{-4} (1210.00)
$ClNaO_3$	Sodium chlorate	-140.36	12720	17.766	-	-	7.7824×10^{-3} (525.00)	5.4287×10^{-3} (559.15)
Cl_2	Chlorine	-25.682	974.90	2.5575	-4.3×10^{-26}	10	7.9727×10^{-4} (190.00)	3.039×10^{-4} (300.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
Cl_2H_2Si	Dichloro silane	-5.0495	342.43	-0.78653	-2.5×10^{-27}	10	1.1933×10^{-3} (151.15)	8.9539×10^{-5} (413.15)
Cl_2OS	Thionyl chloride	-9.726	704.00	-	-	-	1.3643×10^{-3} (225.00)	4.4951×10^{-4} (348.75)
Cl_2O_2S	Sulfuryl chloride	-10.336	912.00	-	-	-	1.2458×10^{-3} (250.00)	4.6493×10^{-4} (342.55)
Cl_3Hsi	Trichlo silane	-10.651	782.00	-	-	-	4.4954×10^{-4} (265.65)	2.4673×10^{-4} (333.65)
Cl_3OP	Phosphorous oxy chloride	-50.860	2895.0	6.0174	-	-	1.4491×10^{-3} (275.15)	5.5784×10^{-4} (378.65)
Cl_3OV	Vandium oxy tri chloride	3.2595	0.8388	-1.8399	-	-	7.7949×10^{-4} (288.00)	4.2556×10^{-4} (400.00)
Cl_3P	Phosphorous tri chloride	-16.796	1013.2	1.0260	-	-	1.8475×10^{-3} (200.00)	3.7564×10^{-4} (349.25)
Cl_3PS	Phosphorous thio chloride	-32.276	2097.4	3.2216	-	-	2.6604×10^{-3} (242.15)	4.4343×10^{-4} (398.15)
Cl_3Sb	Antimony tri chloride	-65.986	4653.7	7.9743	-	-	2.676×10^{-3} (346.55)	8.2271×10^{-4} (493.40)
Cl_4Si	Silicon tetra chloride	16.800	-455.00	-4.0320	-	-	6.3976×10^{-4} (258.15)	2.8853×10^{-4} (354.05)
D_2O	Deuterium oxide	-56.433	3959.7	6.3816	-6.9862×10^{-29}	-	1.9360×10^{-3} (276.97)	3.1932×10^{-4} (374.55)
FH	Hydrogen fluoride	-55.977	2641.3	6.7795	-	-	9.3473×10^{-4} (204.00)	2.1367×10^{-4} (292.67)
FNa	Sodium fluoride	-12.209	5310.0	0.25061	-	-	1.9621×10^{-3} (1269.00)	4.4428×10^{-4} (2060.00)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
F_2	Fluorine	8.180	-75.600	-3.5148	-	-	4.0796×10^{-4} (69.19)	5.9539×10^{-5} (140.00)
F_6S	Sulfur hexa flouride	3.8305	41.210	-2.1342	-	-	5.3876×10^{-4} (223.15)	2.3825×10^{-4} (318.69)
Fe	Iron	-8.0891	5391.7	-	-	-	6.0534×10^{-3} (1808.10)	1.8513×10^{-3} (3000.00)
HI	Hydrogen iodide	56.385	-1948.3	-0.10017	-	-	1.4779×10^{-3} (233.30)	1.3540×10^{-3} (236.40)
HKO	Potassium hydroxide	9.3268	1109.5	-2.6812	-	-	2.2173×10^{-3} (679.00)	5.2731×10^{-4} (973.15)
HNO_3	Nitric acid	-28.86	1940.0	2.6780	-	-	2.1867×10^{-3} (240.00)	4.5125×10^{-4} (356.00)
HNaO	Sodium hydroxide	-46.121	5927.0	4.8301	-	-	3.9715×10^{-3} (623.10)	1.2568×10^{-3} (900.00)
H_2	Hydrogen	-11.986	26.26	-0.1774	-4.4×10^{-16}	10	2.5455×10^{-5} (14.00)	3.7852×10^{-6} (33.00)
H_2O	Water	-51.964	3670.6	5.7331	-5.349×10^{-29}	10	1.7237×10^{-3} (273.15)	5.3696×10^{-5} (643.15)
H_2O_2	Hydrogen peroxide	17.532	246.8	-4.4103	-	-	1.8393×10^{-3} (272.74)	1.9173×10^{-4} (423.35)
H_2O_4S	Sulfuric acid	-17.984	10694	24.611	-	-	4.3575×10^{-2} (283.46)	4.6773×10^{-3} (367.07)
H_2S	Hydrogen sulfide	-71.015	2332.5	9.7538	-	-	5.1991×10^{-4} (190.12)	4.0345×10^{-4} (223.18)
H_3N	Ammonia	-6.7430	598.30	-0.7341	-3.69×10^{-27}	10	5.2402×10^{-4} (194.51)	4.8567×10^{-5} (393.15)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
H_3O_4P	Phosphoric acid	-515.08	26794	74.366	-2.160×10^{-26}	10	2.6417×10^{-1} (293.15)	4.5609×10^{-3} (413.15)
H_3P	Phosphine	19.153	-295.21	-4.9919	-	-	4.1374×10^{-4} (148.15)	1.0460×10^{-4} (223.15)
H_4N_2	Hydrazine	12.785	316.4	3.6484	-	-	1.3032×10^{-3} (280.00)	2.9395×10^{-4} (386.65)
H_4Si	Silane	-11.060	341.95	-	-	-	2.0533×10^{-4} (133.10)	1.3155×10^{-4} (161.00)
He	Helium - 3	-13.922	0.9885	0.4026	-6.10×10^{-6}	10	2.4018×10^{-6} (1.01)	1.8215×10^{-6} (2.50)
He	Helium - 4	-9.6312	-3.841	-1.458	-1.065×10^{-8}	10	3.6284×10^{-6} (2.20)	2.5319×10^{-6} (5.10)
Hg	Mercury	-7.5698	31.62	0.0051174	-	-	2.0450×10^{-3} (234.31)	7.1772×10^{-4} (1073.10)
I	Iodine	45.173	-2026.0	-7.723	-	-	2.261×10^{-6} (389.00)	1.4691×10^{-6} (451.70)
K	Potassium	-8.033	576.5	-0.2126	-	-	5.2299×10^{-3} (336.35)	1.2930×10^{-4} (1037.00)
Li	Lithium	-4.5555	435.5	-0.6216	-	-	6.1267×10^{-4} (453.69)	1.3916×10^{-4} (1620.00)
MgO	Magnesium oxide	-9.724	9710.0	-	-	-	1.3647×10^{-3} (3105.00)	7.3398×10^{-4} (3872.20)
$NNaO_2$	Sodium nitrite	-9.4297	2049.7	-	-		3.1802×10^{-3} (557.15)	2.5438×10^{-3} (593.15)
$NNaO_3$	Sodium nitrate	29.677	345.70	-2.3485	-		2.9694×10^{-3} (580.15)	2.1031×10^{-3} (635.15)
NO	Nitric oxide	93.637	-458.28	-7.1026	-1.21×10^{-23}	10	3.8415×10^{-4} (109.50)	3.7658×10^{-5} (180.05)
NO_2	Nitrogen dioxide	-32.165	-3467.4	-15.773	-	-	5.2928×10^{-4} (273.15)	3.1023×10^{-4} (313.15)

Formula	***Name***	***A***	***B***	***C***	***D***	***E***	***Viscosity (Min. Temp.)***	***Viscosity (Max. Temp.)***
N_2	Nitrogen	26.236	496.9	3.9069	-1.08×10^{-21}	10	3.0311×10^{-4} (63.15)	3.2577×10^{-5} (125.00)
N_2O	Nitrous oxide	-5.8164	-381.68	-4.8618	-		1.9214×10^{-1} (214.95)	7.724×10^{-2} (283.09)
Na	Sodium	-5.8164	510.10	-0.4796	-	-	6.900×10^{-4} (370.97)	1.5726×10^{-4} (1156.00)
Na_2O_4S	Soidum sulfate	-145.36	-18326	-19.106	-	-	4.9286×10^{-3} (1180.10)	3.6776×10^{-3} (1267.10)
$Na_6O_{18}P_6$	Sodium hexa meta phosphate	-78.465	18062	8.6574	-	-	2.0426 (883.15)	1.5276×10^{-4} (1173.10)
Ne	Neon	-17.945	115.57	1.4280	2.14×10^{-17}	10	1.6018×10^{-4} (25.09)	2.7057×10^{-5} (44.13)
O_2	Oxygen	-17.270	287.5	1.2290	-1.040×10^{-22}	10	8.4974×10^{-4} (54.36)	5.5731×10^{-5} (150.00)
O_2S	Sulfur dioxide	-168.79	6638.5	24.393	$-7.640 \times 10\text{-}^{26}$	10	5.6240×10^{-4} (239.65)	2.6125×10^{-4} (323.15)
O_2Si	Silicon dioxide	-675.73	228930	75.788	-	-	3.3633×10^{7} (1883.20)	3.1966×10^{3} (2643.50)
O_2Ti	Titanium dioxide	75.281	-6083.0	-9.7343	-	-	1.5919×10^{-1} (2125.00)	2.5403×10^{-2} (2625.00)
O_3	Ozone	-41.329	988.91	5.3092	-		3.2937×10^{-3} (80.15)	2.7116×10^{-4} (161.85)
O_3S	Sulfur trioxide	-88.794	6400.7	10.709	-	-	2.4547×10^{-3} (290.15)	9.447×10^{-4} (318.15)
P	Phosphorous	-10.227	1231.8	-	-	-	1.7568×10^{-3} (317.25)	7.1337×10^{-4} (413.15)
S	Sulfur	52.077	-28595	-7.4037	9.6936×10^{-29}	10	9.0404×10 (468.00)	8.8879×10^{-2} (721.15)
Zn	Zinc	-6.6105	1342.2	-0.15188	-	-	3.4608×10^{-3} (692.7)	1.4322×10^{-3} (1181.7)

4.3.2 ESTIMATION METHODS

The methods in common use for the estimation of liquid viscosity can be described under the important categories of relationships with the other physical or molecular properties and generalized relationships, although any relationship with physical properties can probably be converted into a generalized relationship and the development of any generalized relation involves (as the necessary input) several physical or molecular properties. In this section, we will discuss the development of relationships in which the temperature dependence of viscosity has been expressed in the forms which require a minimum amount of experimental viscosity data taking advantage of the interrelationships among viscosity and different physical and molecular properties of the substances.

4.3.2.1 Relationships of Viscosity with Physical Properties

In this section, we will discuss the relation of liquid viscosity as a function of temperature and its dependence on the other physical properties like normal boiling point, density and surface tension, and the methods developed for the estimation of viscosity based on relation of liquid viscosity with these properties. In the next section, we will discuss the relationships of viscosity with molecular properties.

4.3.2.1.1 Correlations Based on the Temperature Dependence of Viscosity

The discussion so far centered around the liquid viscosity-temperature relations fitted to experimental data. The constants in two-, three- or multi-parameter relations were obtained by regression analysis. Here we will consider viscosity-temperature relations which can be used with a minimum amount (or no) viscosity versus temperature data, taking advantage of the general pattern of the viscosity-temperature relation and its dependence on the other physical and/or molecular parameters. The advantage of these methods lies in the fact that the viscosity of any liquid at the required temperature can be predicted from the knowledge of the viscosity at any one temperature and/or some other physical or molecular properties.

The simplest of the liquid viscosity-temperature relations given by Eq. (4.5) can be utilized for the estimation of liquid viscosity according to the methods proposed by Lewis and Squires[28] and van Velzen *et al.*[29] These and a few other similar methods are described below.

4.3.2.1.1.a Lewis and Squires Method

Lewis and Squires[28] presented the temperature dependence of liquid viscosity according to Eq. (4.5) graphically as shown in Fig. 4.7. Application of the method requires the knowledge of the value of viscosity (η^{Ref}) at any reference temperature (t^{Ref}). A convenient reference temperature for this purpose is the normal boiling point (t_B). Following the recommendation of Grain[11], in the absence of a measured value the liquid viscosity at the normal boiling pont (η_B) indicated by the class of the substance from the Table 4.1 (given in Section 4.2.2) can be used.

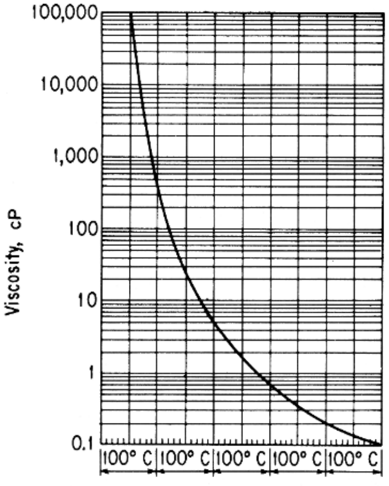


Figure 4.7. Variation of liquid viscosity (η in cP) with temperature (t in °C) (Adopted from: R.C. Reid, J.M. Prausnitz and B.E. Poling, *The Properties of Gases and Liquids,* 4th Ed., McGraw Hill, New York, 1987).

The following basic steps are suggested for the application of the method to determine the value of viscosity (η) at any temperature (t)

- Estimate η_B from the Table 4.1, if a measured value is not available.
- Find the reference point on the Δt-axis corresponding to η_B on the curve in Fig. 4.7.

At the temperature of interest (t), determine the temperature difference $\Delta t = (t_B - t)$, where t_B is the normal boiling point in °C. Move Δt degrees to the left from the reference point along the abscissa and locate the corresponding value of the viscosity η from the curve in Fig. 4.7.

Similar methodology is to be used in the case of substances for which the value of viscosity (η^{Ref}) at a reference temperature (t^{Ref}) is available.

Figure 4.7 can be expressed in equation form as

$$\eta^{-0.2661} = \eta_K^{-0.2661} + \left[\left(T - T_K\right)/233\right] \tag{4.42}$$

where η is the liquid viscosity at T in cP
η_K is the known value of the liquid viscosity at T_K in cP.
T and T_K may be expressed in either °C or K.

The graphical form (as well as the equation) generally predicts the values of liquid viscosity within 5 to 15 % of their true values. This shows that to predict the viscosity of any substance, one can use the data of similar compounds and construct relationships similar to Eq. (4.42).

4.3.2.1.1.b Jagannathan *et al.* Method

Starting from the determination of the constants *A* and *B* from a linear relation between the logarithm of liquid viscosity and the reciprocal of the absolute temperature

$$ln\,\eta = A + \left(B/T\right) \tag{4.43}$$

for over 70 substances, Jagannathan *et al.*[30] developed generalized correlations based on the relation of the constants *A* and *B* to the normal boiling point for each series of compounds. The authors also proposed a generalized correlation as a plot of the dimensionless viscosity ($\eta^* = \eta/\eta^{Ref}$) as a function of the dimensionless temperature ($T^* = T/T^{Ref}$) where η^{Ref} is the viscosity of the liquid at the reference temperature T^{Ref}, chosen as 293 K, for each series of compounds. Both the approaches produced estimation methods of accuracy comparable to the other methods available for the estimation of liquid viscosity in the literature at that time. The relation between the normal boiling temperature (T_B) and the viscosity parameters *A* and *B* is shown in Figs. 4.8 and 4.9. A linear relationship is obtained for compounds in each homologous series.

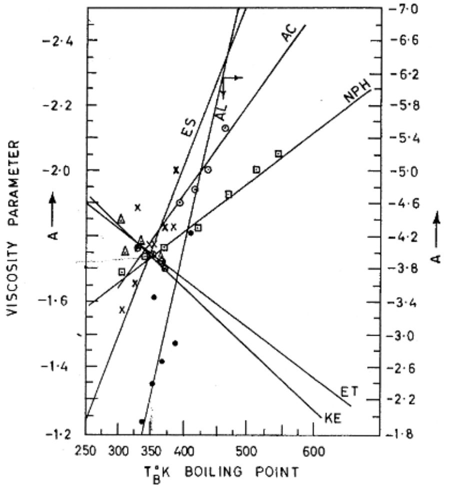


Figure 4.8. Viscosity parameter *A* as a function of the normal boiling point T_B (in K). AL - alcohols, ES - esters, KE - ketones, AC - acids, ET - ethers and NPH - normal parafin hydrocarbons (Adopted from T. K. Jagannathan, D. S. Viswanath, and N. R. Koloor, Predict organic liquids viscosity, *Hydrocarbon Process.* **47**(2), 133-136, 1968).

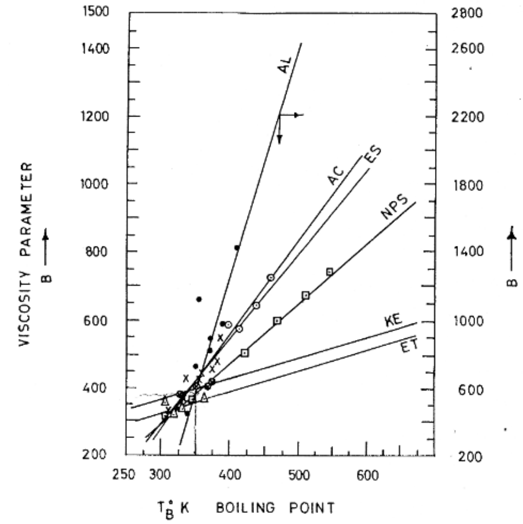


Figure 4.9. Viscosity parameter *B* as a function of the normal boiling point T_B (in K). AL – alcohols, ES – esters, KE – ketones, AC – acids, ET – ethers, and NPH – normal paraffin hydrocarbons (Adopted from T. K. Jagannathan, D. S. Viswanath, and N. R. Koloor, Predict organic liquids viscosity, *Hydrocarbon Process.* **47**(2), 133-136, 1968).

On applying this method, viscosities of hydrocarbons and related substances could be predicted to accuracy comparable to the other estimation methods available at that time with more uniform deviations. For quick estimation, the authors also presented plots of dimensionless viscosity as a function of dimensionless temperature (as defined in this section). This is reproduced in Fig. 4.10.

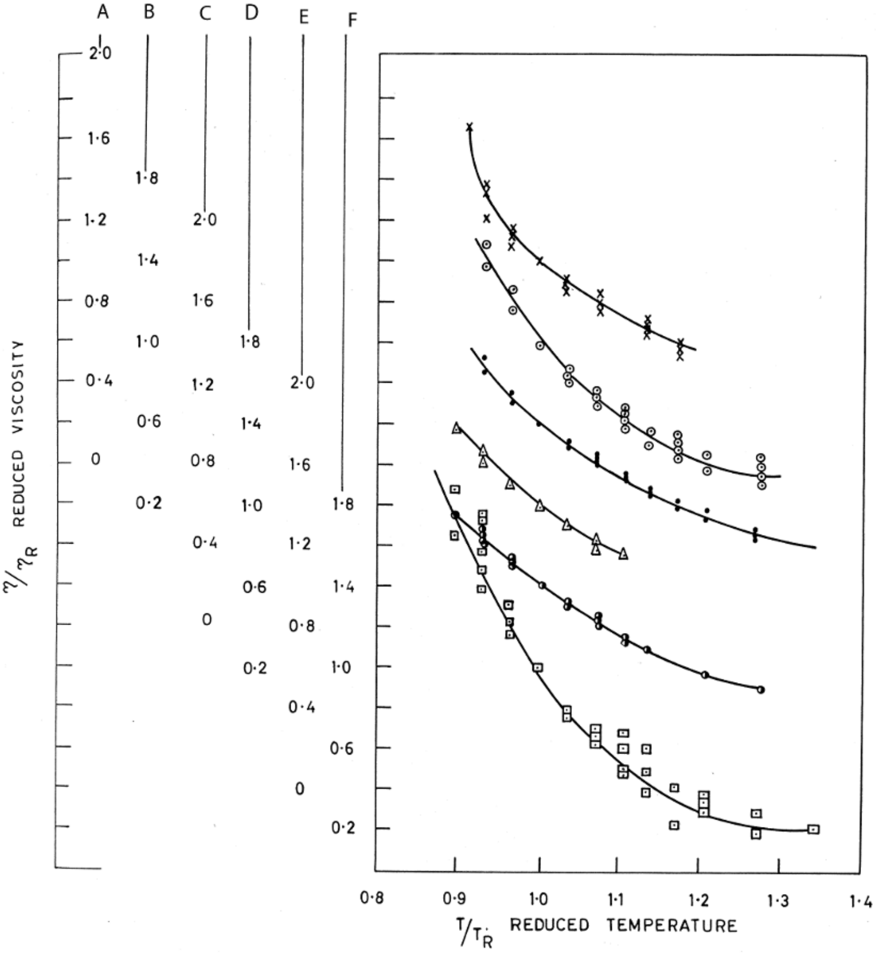


Figure 4.10. Dimensionless viscosity as a function of dimensional temperature for Aliphatic Alcohols (A), Acids (B), Ethers (C), Esters(D), Ketones (E), and Chlorides (F) (Adopted from T. K. Jagannathan, D. S. Viswanath, and N. R. Koloor, Predict organic liquids viscosity, *Hydrocarbon Process.* **47**(2), 133-136, 1968).

4.3.2.1.1.c Chartterjee and Kunte Method

Chatterjee and Kunte[31] proposed the equation

$$\log(\eta/\eta_B) = A + B(T_B/T) \tag{4.44}$$

and studied its application to different hydrocarbon groups. The parameters *A* and *B*, constant for each hydrocarbon group are noted in Table 4.21.

Table 4.21. Values of constants *A* and *B* of Eq. (4.44) proposed by Chatterjee and Kunte for different hydrocarbon groups.

Group	***A***	***B***
Acids	- 3.0944	3.1111
Alcohols	- 6.0866	6.1333
Esters	- 3.0009	2.9714
Ethers	- 2.7851	2.7742
Ketones	- 2.6105	2.6460
Normal Paraffins	- 2.6677	2.6613

The method usually predicts liquid viscosity with an average absolute deviation of about 2%, except for alcohols for which the average absolute deviation is about 7%. This method requires the values of the normal boiling point and the viscosity at the normal boiling point as the input data.

4.3.2.1.1.d van Velzen *et al.* Method

van Velzen *et al.*[29] proposed an estimation method for the temperature dependence of liquid viscosity based on the de Guzman-Andrade equation. They denote the temperature at which the liquid viscosity η becomes 1 by T_0. At this condition, one can write:

$$1 = A\,exp(B/T_0) \tag{4.45}$$

Taking logarithims, $log\,\eta = 0 = A' + (B/T_0)\big|_{\eta}$ (4.46)

where A′ = log A, resulting in

$$A' = -(B/T_0) \tag{4.47}$$

At any other temperature T

$$log\,\eta = B\left[(1/T) - (1/T_0)\right] \tag{4.48}$$

where T and T_0 are absolute temperatures.

van Velzen *et al.* presented the following equations which enable the estimation of B and T_0 for straight-chain hydrocarbons and described the methodology for the calculation of B and T_0 for the other molecules.

For straight-chain hydrocarbons containing N carbon atoms if $N \leq 20$:

$$B = 24.79 + 66.885N - 1.3173N^2 + 0.00377N^3 \tag{4.49}$$

$$T_0 = 28.86 + 37.439N - 1.3547N^2 + 0.02076N^3 \tag{4.50}$$

if $N > 20$:

$$B = 530.59 + 13.740N \tag{4.51}$$

$$T_0 = 238.59 + 8.164N \tag{4.52}$$

For molecules other than straight-chain hydrocarbons, N is replaced by the "equivalent chain length" (NE) which is a hypothetical alkane with viscosity equal to 1 cP at the temperature at which the viscosity of the compound is 1 cP. NE is calculated as the sum of N (the total number of carbon atoms) and one or more structural or configurational factors as

$$NE = N + \sum_i \Delta N_i \tag{4.53}$$

Similarly,

$$B = B_a + \Delta B \tag{4.54}$$

where B_a is the value of B for the hypothetical alkane with equivalent chain length NE and ΔB is the correction factor that varies with the structure of the compound. If the compound contains two or more functional groups, the ΔN correction must be multiplied by the number of groups. The ΔB correction is applied only once, regardless of the number of functional groups. NE can be used in the place of N for the calculation of B and T_0 in the equations given for straight-chain hydrocarbons. Table 4.22 gives the functions for ΔN and

ΔB for the commonly occurring functional groups and structural configurations.

Table 4.22. Functions to be used for ΔN and ΔB for use in the van Velzen *et al.*[29] method.

Functional Groups	ΔN	ΔB
n-Alkane	0	0
Alkene	- 0.152 – 0.042 N	- 44.94 + 5.410 NE
Acid 3 ≤ N ≤ 10	6.795 + 0.365 N	- 249.12 + 22.449 NE
Acid N > 10	10.710	- 249.12 + 22.449 NE
Ester	4.337 – 0.230 N	- 149.13 + 18.695 NE
Primary Alcohol	10.606 – 0.276 N	- 589.44 + 70.519 NE
Secondary Alcohol	11.200 – 0.605 N	497.58
Tertiary Alcohol	11.200 - 0.605 N	928.83
Diol	Alcohol Correction + Configurational Factor	557.77
Ketone	3.265 – 0.122 N	- 117.21 + 15.781 NE
Ether	0.298 + 0.209 N	- 9. 39 + 2.848 NE
Primary Amine	3.581 + 0.325 N	25.39 + 8.744 NE
Secondary Amine	1.390 + 0.461 N	25.39 + 8.744 NE
Tertiary Amine	3.27	25.39 + 8.744 NE
Fluoride	1.43	5.75
Chloride	3.21	- 17.03
Bromide	4.39	- 101.97 + 5.954 NE
Iodide	5.76	- 85.32
Aromatic & 1-Nitro-	7.812 – 0.236 N	- 213.14 + 18.330 NE
2-Nitro-	5.84	- 213.14 + 18.330 NE
3-Nitro-	5.56	- 338.01 + 25.086 NE
4,5-Nitro-	5.36	- 338.01 + 25.086 NE
CONFIGURATIONAL FACTORS		
Correction for Aromatic Nucleus		
Alkyl-, Halogen-, Nitro-benzenes, Secondary and Tertiary Amines		
8 ≤ N ≤ 15	0.60	- 140.04 + 13.869 NE
N > 15	3.055 – 0.161 N	- 140.04 + 13.869 NE
Acids	4.810	- 188.04 + 9.588 NE
Esters		
Alcohols : OH Attached to the Nucleus – for all Phenolic Compounds NE = 16.17[b]		213.68
Alcohols : OH in Side Chain	- 0.160	213.68
Ketones	2.700	- 760.65 + 50.478 NE
Ethers : All Aromatic Ethers	11.5 – N	- 140.04 + 13.869 NE

Functional Groups	***ΔN***	***ΔB***
Primary Amines : NH_2 in Side Chain	- 0.160	0
Polyphenyls	- 5.340 + 0.815 N	- 188.40 + 9.558 NE
Ortho Configuration -		
With OH Group	0.510	- 571.94
Without OH Group	0.510	54.84
Meta Configuration	0.110	27.25
Para Configuration	- 0.040	- 17.57
Cyclopentane $7 \leq N \leq 15$	0.205 + 0.069 N	- 45.96 + 2.224 NE
$N > 15$	3.971 - 0.172 N	- 339.67 + 23.135 NE
Cyclohexane $8 \leq N \leq 16$	1.480	- 272.85 + 25.041 NE
$N > 16$	6.517 – 0.311 N	- 272.85 + 25.041 NE
Iso Configuration		
Alkanes	1.389 – 0.238 N	15.510
Double iso in Alkanes (extra correction)	0.930	8.930
Alkenes	1.389 – 0.238 N	94.230
Alcohols	0.240	8.930
Esters, Alkylbenzenes, Halogenides, Ketones	- 0.240	-
Acids	- 0.240	-
Esters, Amines	- 0.500	8.930
Other Configurations		
$-C(Cl)_X$ Configuration	1.91 – 1.459 x	- 26.38
-CCl-CCl-	0.96	0
$-C(Br)_X$ Configuration	0.50	81.34 – 86.85 x
-CBr-CBr-	1.60	- 57.73
CF_X in Alcohols	- 3.93	341.68
CF_X in Other Compounds	- 3.93	25.55
Diols	- 2.50 + N	Alcohols Value

[a] Includes Pyridine

[b] Other Substituents like Cl, CH_3 and NO_2 are neglected for the determination of *NE*. For the calculation of *B*, they have been considered.

The following steps are recommended for the estimation of liquid viscosity by the method of van Velzen *et al.*

- Count the number of carbon atoms (*N*) in the molecular formula.
- Determine *N* correction using the above table.
- Sum *N* and *ΔN* to obtain *NE*.
- Calculate B_a by substituting *NE* into the appropriate equation given above.
- Determine the *ΔB* correction from the above table and add this to B_a to calculate *B*.

- Calculate T_0 by substituting the value of *NE* into the appropriate equation given above.
- Use the calculated values of T_0 and *B* to obtain log η from the equation relating log η to the temperature.

The authors tested 314 different compounds at a total of 4,500 data points. The method is fairly accurate, and can be used for estimation of liquid viscosity values within ± 10%. As expected, the first members of any homologous series gave large errors. In their first report on the topic, van Velzen *et al.*[32] tabulated liquid viscosity data on several substances and also provided the constants of the van Velzen *et al.* representation (Eq. 4.48) derived from the experimental liquid viscosity data. Table 4.23 gives the constants of Eq. (4.48) for different substances used in their study along with the equivalent chain length *NE*.

4.3.2.1.1.e van Velzen *et al.* Method

Another simple method was proposed by van Velzen et al. which can be considered an extension of the Lewis and Squires method or a variation of the van Velzen method proposed by Grain[33]. The method is based on the application of the equation expressing the linear dependence of the logarithm of liquid viscosity ($ln\,\eta$) on the reciprocal of the absolute temperature ($1/T$) to the normal boiling point (T_B). The resulting expression for viscosity is:

$$ln\,\eta_B = A + \left(B/T_B\right) \tag{4.55}$$

from which

$$A = ln\,\eta_B - \left(B/T_B\right) \tag{4.56}$$

At any other temperature *T*,

$$ln\,\eta = ln\,\eta_B + B\left[\left(1/T\right) - \left(1/T_B\right)\right] \tag{4.57}$$

This correlation requires the experimental or estimated value of the liquid viscosity at the normal boiling point (η_B). The viscosity at the normal boiling point can be taken from Table 4.1 depending on the type of compound, if an experimental value is not available.

Following the ideas of Eyring[34], the parameter *B* is equated to the energy of vaporization resulting in

$$B = \Delta E_V / n \tag{4.58}$$

where *n* is an integer. For an ideal gas, the energy of vaporization is related to the heat of vaporization according to

$$\Delta E_V = \Delta H_V - RT \tag{4.59}$$

Table 4.23. Constants *B*, *NE* at T_0 of the van Velzen et al. equation, $\left[\log\eta = B\left\{(1/T)-(1/T_0)\right\}\right]B$ derived from liquid viscosity measurements.

Compound	***Temp. Range, °C***	***Viscosity Range, cP***	***NE***	***B***	***T_0, K***
Methane	- 180 to -165	0.188 to 0.127	0.79	114.14	57.60
Ethane	- 175 to -90	0.982 to 0.172	1.91	156.60	95.57
Propane	- 185 to - 45	8.750 to 0.215	3.13	222.67	133.41
Butane	- 90 to - 5	0.628 to 0.218	4.07	265.84	160.20
Pentane	- 125 to 35	2.890 to 0.207	4.91	313.66	182.48
Hexane	- 95 to 65	2.140 to 0.213	5.91	362.79	207.09
Heptane	- 90 to 95	3.770 to 0.216	7.04	436.73	232.53
Octane	- 55 to 120	2.120 to 0.219	7.97	437.70	251.71
Nonane	- 50 to 150	2.990 to 0.211	9.05	525.56	272.12
Decane	- 25 to 175	2.239 to 0.207	9.99	558.61	288.37
Undecane	- 25 to 195	3.182 to 0.207	11.04	605.50	305.01
Dodecane	- 5 to 215	2.558 to 0.206	11.99	631.63	318.78
Tridecane	- 5 to 235	3.348 to 0.204	12.99	664.10	332.10
Tetradecane	10 to 250	2.932 to 0.206	13.98	689.85	344.21
Pentadecane	10 to 270	3.653 to 0.202	15.02	718.51	355.92
Hexadecane	20 to 260	3.471 to 0.237	16.00	738.30	366.11
Heptadecane	25 to 300	3.700 to 0.203	17.01	757.88	375.90
Octadecane	30 to 315	3.880 to 0.200	18.01	777.40	385.00
Nonadecane	35 to 325	4.021 to 0.200	19.00	739.62	393.54
Eicosane	40 to 340	4.142 to 0.200	19.98	811.29	401.67
Iso butane	- 80 to –15	0.626 to 0.252	4.44	302.51	170.20
Iso pentane	- 50 to 25	0.550 to 0.214	5.27	367.32	191.58
Iso hexane	0 to 60	0.371 to 0.205	5.96	384.13	208.27
Neo hexane	0 to 30	0.477 to 0.330	6.77	438.44	226.67
Iso heptane	0 to 90	0.476 to 0.198	6.70	417.46	225.13
Neo pentane	- 10 to 0	0.390 to 0.327	6.40	542.12	218.42
2,3–Di methyl butane	0 to 30	0.495 to 0.342	6.87	444.19	228.86
Ethene	-165 to – 105	0.600 to 0.160	1.86	168.98	93.94
Propene	-185 to – 95	15.0 to 0.350	3.07	273.84	131.63
1 – Butene	- 115 to – 35	0.880 to 0.250	3.77	256.30	151.86
1 – Pentene	- 90 to 0	0.850 to 0.240	4.61	305.25	174.70

Compound	***Temp. Range, °C***	***Viscosity Range, cP***	***NE***	***B***	***T_0, K***
1 – Hexene	- 55 to 60	0.690 to 0.190	5.52	357.43	197.74
1 – Heptane	0 to 90	0.440 to 0.200	6.22	368.69	214.32
1 – Octane	0 to 115	0.611 to 0.210	7.28	418.82	237.63
1 – Nonene	0 to 115	0.836 to 0.260	8.34	471.00	258.92
1 – Decene	0 to 115	1.127 to 0.300	9.37	518.37	277.80
1 – Un decene	0 to 115	1.500 to 0.360	10.39	566.26	294.89
1 – Do decene	0 to 115	1.960 to 0.410	11.38	615.67	310.07
1 – Tri decene	0 to 115	2.530 to 0.480	12.35	658.16	323.71
1–Tetra decene	0 to 115	3.220 to 0.550	13.31	697.49	336.13
1 – Penta decene	0 to 115	4.080 to 0.620	14.26	739.13	347.46
1 – Hexa decene	5 to 115	4.420 to 0.710	15.20	767.48	357.85
1 – Hepta decene	15 to 115	4.070 to 0.790	16.15	790.25	367.61
1 – Octa decene	20 to 115	4.310 to 0.890	17.12	816.19	376.93
1 – Nona decene	25 to 115	4.560 to 0.990	18.07	844.46	385.53
1 – Eicosane	35 to 115	4.220 to 1.100	19.04	860.96	393.88
2 – Methyl – 2 - butene	0.2 to 32.6	0.253 to 0.190	4.83	322.47	180.43
Isoprene	0 to 32	0.259 to 0.194	4.91	328.49	182.48
2,3 – Dimethyl - 1,3 -butadiene	0.4 to 56.2	0.337 to 0.197	5.71	375.21	202.33
Cyclo hexane	10 to 80	1.178 to 0.410	10.14	653.62	290.84
Methyl cyclo hexane	- 25 to 100	1.545 to 0.300	9.02	528.41	271.58
Ethyl cyclo hexane	- 25 to 110	1.794 to 0.300	9.54	506.43	280.76
Propyl cyclo hexane	- 25 to 110	2.343 to 0.390	10.33	549.08	293.93
Butyl cyclo hexane	- 20 to 110	2.931 to 0.469	11.47	598.30	311.39
Pentyl cyclo hexane	- 10 to 105	3.321 to 0.539	12.52	681.52	325.99
Hexyl cyclo hexane	- 10 to 110	4.488 to 0.590	13.59	736.92	339.56
Heptyl cyclo hexane	- 10 to 110	5.922 to 0.680	14.60	787.82	351.31
Octyl cyclo hexane	- 10 to 110	7.700 to 0.768	15.54	840.25	361.42
Nonyl cyclo hexane	-10 to 110	9.890 to 0.870	16.45	886.88	370.56
Decyl cyclo hexane	0 to 110	9.260 to 0.970	17.31	925.84	378.69
Un decyl cyclo hexane	10 to 110	8.440 to 1.080	18.16	957.97	386.32
Do decyl cyclo hehane	15 to 110	8.760 to 1.190	18.93	992.43	392.95

Compound	***Temp. Range, °C***	***Viscosity Range, cP***	***NE***	***B***	***T_0, K***
Tri decyl cyclo hexane	20 to 110	8.920 to 1.310	19.68	1023.62	399.21
Tetra decyl cyclo hexane	25 to 110	8.960 to 1.440	20.36	1054.46	404.78
Penta decyl cyclo hexane	30 to 110	8.910 to 1.570	21.01	1082.54	410.09
Hexa decyl cyclo hexane	35 to 110	8.760 to 1.700	21.60	1111.59	414.90
Cyclo pentane	- 25 to 45	0.780 to 0.338	7.00	406.69	231.67
Methyl cyclo pentane	- 25 to 70	0.930 to 0.299	7.55	440.52	243.24
Ethyl cyclo pentane	- 20 to 100	0.960 to 0.270	7.87	433.81	249.72
Propyl cyclo pentane	- 20 to 110	1.240 to 0.300	8.62	454.23	264.22
Butyl cyclo pentane	- 20 to110	1.710 to 0.350	9.74	513.25	284.18
Pentyl cyclo pentane	- 20 to 110	2.320 to 0.420	10.85	565.40	302.11
Hexyl cyclo pentane	- 20 to 110	3.120 to 0.490	11.98	617.57	318.65
Heptyl cyclo oentane	- 20 to 110	4.110 to 0.570	13.07	654.77	333.12
Octyl cyclo pentane	- 20 to 110	5.340 to 0.660	14.15	695.83	346.19
Nonyl cyclo pentane	- 20 to 110	6.830 to 0.750	15.19	735.19	357.74
Decyl cyclo pentane	- 20 to 110	8.630 to 0.850	16.22	771.74	368.30
Un decyl cyclo pentane	- 10 to 110	8.560 to 0.950	17.14	817.49	377.11
Do decyl cyclo pentane	- 5 to 110	9.310 to 1.070	18.07	853.90	385.53
Tri decyl cyclo pentane	5 to 110	8.800 to 1.180	18.91	891.80	392.78
Tetra decyl cyclo pentane	10 to 110	9.210 to 1.310	19.73	924.60	399.62
Penta decyl cyclo pentane	20 to 110	8.320 to 1.440	20.55	950.57	406.33
Hexa decyl cyclo pentane	25 to 110	8.440 to 1.580	21.28	977.42	412.29
Benzene	0 to 75	0.912 to 0.332	8.68	545.64	265.34
Toluene	- 25 to 105	1.170 to 0.258	8.15	467.33	255.24
Ethyl benzene	- 25 to 130	1.350 to 0.246	8.62	477.82	264.22
Propyl benzene	- 25 to 150	1.910 to 0.250	9.65	527.55	282.65
Butyl benzene	- 25 to 150	2.500 to 0.280	10.46	563.84	296.01
Pentyl benzene	- 20 to 150	3.820 to 0.320	11.67	635.80	314.27
Hexyl benzene	- 20 to 150	5.170 to 0.360	12.67	638.93	327.97

Compound	**Temp. Range, °C**	**Viscosity Range, cP**	**NE**	**B**	**T_0, K**
Heptyl benzene	- 20 to 150	6.930 to 0.400	13.65	726.49	340.29
Octyl benzene	- 20 to 120	9.230 to 0.610	14.48	788.79	349.96
Nonyl benzene	- 20 to 125	12.20 to 0.650	15.35	835.49	359.43
Decyl benzene	- 15 to 150	12.27 to 0.560	16.41	844.13	370.17
Un decyl benzene	- 10 to 150	12.44 to 0.610	17.30	872.17	378.59
Do decyl benzene	0 to 150	10.31 to 0.670	18.21	887.76	386.76
Tri decyl benzene	5 to 150	10.49 to 0.730	19.05	915.57	393.97
Tetra decyl benzene	15 to 150	8.940 to 0.790	19.90	932.51	401.02
Penta decyl benzene	20 to 150	8.990 to 0.850	20.67	957.98	407.31
Hexa decyl benzene	30 to 150	7.740 to 0.920	21.43	974.80	413.51
o – Xylene	- 5 to 140	1.212 to 0.253	9.38	513.54	277.98
m – Xylene	0 to 135	0.806 to 0.225	8.25	453.42	257.18
p – Xylene	16 to 135	0.696 to 0.224	8.47	475.16	261.40
Iso propyl benzene	0 to 60	1.073 to 0.489	9.28	517.17	276.22
1 – Methyl – 4 - ethyl benzene	10 to 80	0.805 to 0.381	8.72	463.17	266.08
1,2,4 -Tri - methyl benzene	25 to 35	1.008 to 0.810	10.57	872.74	297.75
Methanol	- 84.2 to 65.0	6.800 to 0.329	8.43	555.30	260.64
Ethanol	- 98.1 to 75.0	44.00 to 0.464	10.77	686.64	300.88
Propanol	0 to 95.6	3.833 to 0.477	12.66	951.04	327.83
1 – Butanol	- 50.9 to 114.1	36.10 to 0.425	13.51	1004.83	338.59
1 – Pentanol	0 to 130	8.79 to 0.390	14.45	1151.14	349.62
1 – Hexanol	25 to 50	4.370 to 2.160	14.93	1179.42	354.94
1 – Heptanol	15 to 90	8.530 to 1.000	15.58	1287.04	361.83
1 – Octanol	15 to 90	10.60 to 1.210	16.39	1312.09	379.97
Iso propanol	0.4 to 78.1	4.502 to 0.541	12.33	1139.72	323.44
Iso butanol	0.4 to 105.1	7.911 to 0.475	13.76	1211.09	341.61
Iso amyl alcohol	0.2 to 128.1	8.461 to 0.397	14.44	1148.76	349.51
D – Amyl alcohol	0 to 130	11.22 to 0.370	14.47	1259.39	349.85
Tert - Butyl alcohol	22.4 to 77.0	5.887 to 0.645	13.12	1727.96	333.75
Tert - Amyl alcohol	0.5 to 85	13.797 to 0.573	13.36	1502.01	336.75
Benzyl alcohol	20 to 50	5.582 to 2.574	16.11	1087.98	367.21
2 - Phenyl ethanol	25 to 50	7.610 to 3.200	15.72	1450.09	363.27
Phenol	18.3 to 90	12.70 to 1.306	16.40	1405.48	370.07
o – Chloro phenol	0 to 150	10.70 to 0.540	15.67	982.38	362.76
m – Chloro phenol	25 to 50	11.50 to 4.000	15.59	1775.58	361.94

Compound	***Temp. Range, °C***	***Viscosity Range, cP***	***NE***	***B***	***T_0, K***
p – Chloro phenol	45 to 50	6.150 to 5.000	16.07	1862.01	366.81
o – Cresol	0 to 110	39.70 to 0.890	15.95	1533.41	365.61
m – Cresol	0 to 110	84.40 to 1.020	16.47	1785.57	370.75
p – Cresol	0 to 110	98.40 to 1.080	16.67	1826.92	372.68
o – Nitro phenol	40 to 80	2.750 to 1.350	16.59	839.02	371.91
Allyl alcohol	0 to 95.2	2.145 to 0.379	11.19	793.52	307.26
Hexa hydro cresol	20 to 90	21.80 to 1.260	16.09	1864.02	367.01
Ethylene glycol	20 to 100	19.90 to 1.990	20.07	1364.99	402.41
Propylene glycol	40 to 180	19.45 to 0.783	23.05	1404.20	426.74
Formic acid	7.6 to 100	2.385 to 0.549	12.50	729.35	325.72
Acetic acid	30.9 to 112.6	1.025 to 0.406	11.12	600.94	306.21
Propionic acid	4.7 to 137	1.404 to 0.329	10.67	535.04	299.32
Butyric acid	0 to 155.8	2.286 to 0.327	12.16	640.42	321.13
Valeric acid	16.5 to 90	2.410 to 0.753	13.72	729.09	341.13
Caproic acid	16.1 to 90	3.56 to 0.980	15.36	793.55	359.54
Heptanoic acid	17.5 to 90	4.600 to 1.190	16.77	856.73	373.63
Octanoic acid	20 to 90	5.748 to 1.300	17.13	979.13	377.02
Nonanoic acid	20 to 90	8.080 to 1.730	19.05	1026.92	393.97
Decanoic acid	50 to 70	4.340 to 2.880	20.60	987.89	406.82
Do decanoic acid	50 to 90	7.300 to 2.990	22.90	1135.68	425.51
Tetra decanoic acid	60 to 90	7.222 to 3.691	24.65	1174.64	439.80
Hexa decanoic acid	70 to 95	7.800 to 4.470	26.67	1209.47	456.29
Stearic acid	70 to 98	11.6 to 5.18	25.92	1449.71	450.16
Oleic acid	20 to 180	36.56 to 1.336	28.01	1198.58	467.22
Iso butyric acid	3.7 to 147.5	1.761 to 0.323	11.46	588.65	311.24
Benzoic acid	122.5 to 130.0	1.670 to 1.260	20.74	2617.62	407.88
Phenyl acetic acid	77 to 130	3.540 to 1.400	22.79	1073.11	424.62
3 - Phenyl propionic acid	49.7to130.0	9.800 to 1.720	24.03	1224.95	434.74
Methyl formate	0.6 to 29.3	0.426 to 0.319	6.15	363.19	212.70
Methyl acetate	0 to 54.3	0.484 to 0.273	6.65	408.62	224.03
Methyl propionate	0.4 to 68.5	0.579 to 0.281	7.23	482.74	236.58
Methyl butyrate	0.3 to 98.3	0.755 to 0.259	8.12	479.35	254.66
Methyl laurate	25 to 50	3.080 to 1.850	15.28	853.20	358.70
Ethyl formate	0.5 to 52	0.502 to 0.294	6.75	400.91	226.23
Ethyl acetate	0 to 75	0.582 to 0.283	7.20	427.38	235.94
Ethyl propionate	0.4 to 89.7	0.689 to 0.263	7.82	463.31	248.72

Compound	***Temp. Range, °C***	***Viscosity Range, cP***	***NE***	***B***	***T_0, K***
Ethyl butyrate	15 to 70	0.711 to 0.381	8.62	489.95	264.22
Ethyl valerate	20 to 50	0.836 to 0.536	9.56	602.07	281.10
Ethyl caprylate	25 to 50	1.380 to 0.943	11.93	642.67	317.95
Ethyl pelargonate	25 to 50	1.690 to 1.110	12.76	703.62	329.14
Ethyl palmitate	25 to 50	5.76 to 3.14	17.77	1015.54	382.86
Propyl formate	0.3 to 77.5	0.665 to 0.286	7.69	452.97	246.09
Propyl acetate	0.4 to 96.9	0.765 to 0.260	8.18	489.53	255.83
Propyl butyrate	20 to 50	0.829 to 0.551	9.51	560.29	280.24
Amyl acetate	11 to 25	1.580 to 0.811	10.25	1752.25	292.64
n - Butyl acetate	0 to 40	1.004 to 0.563	9.06	537.58	272.30
Methyl isobutyrate	0.3 to 88.8	0.669 to 0.259	7.69	451.21	246.09
Iso butyl acetate	19.9 to 99.4	0.724 to 0.287	8.96	533.99	270.49
Phthalic acid diethyl ester	25 to 55	10.10 to 4.182	19.24	1131.83	395.56
Ethyl benzoate	20 to 70	2.238 to 0.950	13.50	746.50	338.47
Benzyl benzoate	5 to 100	19.28 to 1.655	19.24	1131.83	395.56
Acetone	- 80 to 60	1.487 to 0.226	6.02	367.25	209.68
Methyl ethyl ketone	0.3 to 76.3	0.536 to 0.246	7.00	423.84	231.67
Methyl propyl ketone	0.4 to 98.8	0.640 to 0.240	7.54	437.94	243.03
Diethyl ketone	0.5 to 98.8	0.591 to 0.227	7.28	425.53	237.63
Methyl – n – butyl ketone	20 to 25	0.626 to 0.584	8.52	528.91	262.34
Aceto phenone	11.9 to 95.0	2.280 to 0.653	13.02	648.82	332.49
Benzo phenone	25 to 120	13.61 to 1.38	20.01	1253.51	401.92
Methyl propyl ether	0.3 to 35.1	0.306 to 0.218	5.39	353.90	194.55
Di ethyl ether	- 80 to 100	0.958 to 0.118	5.23	353.14	190.58
Ethyl propyl ether	0.3 to 60.2	0.395 to 0.215	6.18	399.87	213.39
Ethyl hexyl ether	25 to 50	0.929 to 0.653	10.24	590.07	292.47
Di propyl ether	0.6 to 88	0.535 to 0.215	7.10	445.84	233.82
Methyl iso butyl ether	0.4 to 55.2	0.379 to 0.219	6.04	389.66	210.14
Ethyl iso butyl ether	0.4 to 77.5	0.480 to 0.214	6.77	433.54	226.67
Anisole	0 to 60	1.780 to 0.970	12.51	388.84	325.85
Phenetole	0 to 80	1.860 to 0.550	11.10	646.88	305.91
Methyl chloride	0 to 120	0.221 to 0.072	5.35	426.45	193.56
Ethyl chloride	- 20 to 40	0.392 to 0.224	5.24	320.94	190.83
Propyl chloride	0.4 to 44.7	0.432 to 0.278	6.25	374.77	215.00

Compound	**Temp. Range, °C**	**Viscosity Range, cP**	**NE**	**B**	**T_0, K**
Iso propyl chloride	0.3 to 33.0	0.400 to 0.282	6.13	306.25	212.24
Iso butyl chloride	0.3 to 65.3	0.582 to 0.267	7.27	437.19	237.42
Bromo ethane	- 100 to 30	2.890 to 0.348	6.50	369.80	22.68
Propyl bromide	0.4 to 67.9	0.641 to 0.332	7.43	395.31	240.76
n - Butyl bromide	0 to 100	0.820 to 0.331	8.31	426.90	258.34
n - Amyl bromide	0 to 100	1.057 t0 0.370	9.26	464.92	275.87
n - Hexyl bromide	0 to 100	1.362 to 0.432	10.27	509.06	292.26
n - Heptyl bromide	0 to 100	1.820 to 0.513	11.44	560.71	310.95
n - Octyl bromide	0 to 100	2.415 to 0.601	12.56	613.34	326.52
n - Nonyl bromide	0 to 100	3.155 to 0.692	13.52	666.45	338.71
n - Decyl bromide	0 to 100	4.115 to 0.797	14.38	712.69	348.83
Iso butyl bromide	0.3 to 87.9	0.820 to 0.323	8.35	451.38	259.11
Iodo methane	0 to 40	0.593 to 0.409	6.92	336.19	229.95
Iodo ethane	0.3 to 70	0.716 to 0.391	7.70	370.85	246.30
1 – Iodo propane	0.3 to 98.9	0.934 to 0.362	8.88	434.09	269.03
2 – Iodo propane	0.3 to 88.7	0.875 to 0.361	8.55	427.38	262.91
Iso butyl iodide	0.4 to 116.1	1.154 to 0.349	9.62	472.80	282.13
Iodo benzene	4.6 to 137.6	2.207 to 0.448	12.92	565.72	331.21
Bromo benzene	0.1 to 142.3	1.573 to 0.351	10.87	508.18	302.42
Chloro benzene	0 to 119.6	1.053 to 0.307	9.28	477.76	276.22
Fluoro benzene	9.3 to 100.0	0.647 to 0.275	8.03	452.06	252.89
Ethylene fluoride	0 to 60	0.289 to 0.180	5.07	319.27	186.56
Methylene chloride	0.5 to 37.5	0.532 to 0.370	6.70	359.55	225.13
Chloroform	- 13 to 60	0.855 to 0.389	7.71	394.81	246.50
Carbon tetrachloride	0 to 100	1.369 to 0.384	10.14	540.15	290.84
Ethylidene chloride	7.1 to 54.5	0.569 to 0.348	7.35	412.27	239.10
Ethylene chloride	0 to 100	0.417 to 1.123	9.38	473.95	277.98
1,1,2,2 - Tetra chloro ethane	0 to 80	2.656 to 0.760	12.88	647.05	330.69
Methylene bromide	15 to 30	1.090 to 0.920	10.37	428.91	294.57
Bromoform	6.4 to 76.5	2.381 to 1.009	14.57	519.07	350.97
Allyl bromide	0.3 to 68.7	0.616 to 0.319	7.26	389.59	237.21
Allyl iodide	0.3 to 98.4	0.926 to 0.358	8.75	425.52	266.64
Di ethyl amine	- 33.5 to 35	0.823 to 0.279	6.89	473.89	229.29
Aniline	0 to 120	10.20 to 0.653	15.14	1074.61	357.21
o – Toludine	0.3 to 100	10.105 to 0.831	15.07	1085.11	356.46
m – Toludine	25 to 130	3.310 to 0.500	14.85	928.12	354.07

Compound	***Temp. Range, °C***	***Viscosity Range, cP***	***NE***	***B***	***T_0, K***
p – Toludine	39.9 to 175	2.080 to 0.420	15.03	738.90	356.02
3 – Chloro aniline	25 to 55	3.500 to 1.760	15.11	973.87	356.89
Benzyl amine	25 to 130	1.590 to 0.442	12.70	636.49	328.46
n - Methyl aniline	0.3 to 70	4.265 to 0.886	13.04	915.12	332.74
n - Ethyl aniline	0.3 to 100	4.123 to 0.603	13.28	843.72	335.76
Di phenyl amine	55 to 130	4.660 to1.040	20.23	1162.20	403.72
Benzyl phenyl amine	55 to 130	5.390 to 1.200	21.38	1150.84	413.11
n – Methyl di phenyl amine	9.8 to130	11.00 to 0.810	17.86	1054.41	383.67
n,n – Di ethyl aniline	0.5 to 98	3.840 to 0.630	13.26	812.59	335.51
n,n – Di methyl aniline	0 to 177	2.020 to 0.341	12.08	553.02	320.03
Nitro methane	0 to 85	0.843 to 0.343	8.46	452.50	261.21
Nitro benzene	0.3 to 207.6	3.83 to 0.324	13.69	642.85	340.77
o – Nitro toluene	0 to 60	3.830 to 1.210	13.92	759.86	343.51
m – Nitro toluene	20 to 100	2.330 to 0.564	13.28	870.01	335.76
2 – Nitro butane	30 to 60	0.812 to 0.585	9.82	478.08	285.13
2–Nitro–2 -pentane	30 to 60	0.871 to 0.619	10.17	498.20	291.34
3–Nitro–2- pentane	30 to 60	0.925 to 0.646	10.47	523.53	296.17
2–Nitro–2- hexane	30 to 60	1.144 to 0.780	11.51	558.55	311.97
3–Nitro–2- hexene	30 to 60	1.091 to 0.737	11.26	571.84	308.30
3–Nitro–3- hexene	30 to 60	0.996 to 0.690	10.83	535.10	301.80
2-Nitro-2- heptene	30 to 60	1.336 to 0.888	12.28	595.27	322.77
3–Nitro–2- heptene	30 to 60	1.355 to 0.877	12.26	634.53	322.50
3-Nitr -3- heptene	30 to 60	1.292 to 0.849	12.06	612.54	319.75
4–Nitro–3- heptene	30 to 60	1.235 to 0.821	11.86	595.72	316.97
2–Nitro–2- octene	30 to 60	1.680 to 1.064	13.36	666.11	336.75
3–Nitro– 2- octene	30 to 60	1.673 to 1.040	13.21	693.02	334.88
3-Nitro- 3- octene	30 to 60	1.536 to 0.984	12.90	649.02	330.95
4–Nitro–3- octene	30 to 60	1.499 to 0.955	12.74	657.30	328.88

Compound	***Temp. Range, °C***	***Viscosity Range, cP***	***NE***	***B***	***T_0, K***
4-Nitro-4 - octene	30 to 60	1.603 to 1.005	13.02	680.49	332.49
2–Nitro– 2-nonene	30 to 60	2.019 to 1.241	14.27	709.17	347.58
3-Nitro-2- nonene	30 to 60	2.038 to 1.215	14.06	753.73	345.15
3–Nitro–3-nonene	30 to 60	1.915 to 1.168	13.87	721.02	342.92
4-Nitro-3-nonene	30 to 60	1.899 to 1.151	13.77	729.81	341.73
4–Nitro–4 -nonene	30 to 60	1.872 to 1.146	13.76	715.41	341.61
5-Nitro-4 -nonene	30 to 60	1.927 to 1.162	13.82	737.09	342.32
Tri fluoro methyl cyclo hexane	20 to 60	0.951 to 0.575	10.02	531.75	288.87
Tri fluoro toulene	20 to 60	0.573 to 0.387	7.85	417.84	249.32
Tri fluoro – 2 - propanol	15 to 55	3.668 to 0.994	12.56	1352.82	326.52
Tri fluoro iso butanol	25 to 55	3.320 to 1.190	13.00	1455.54	332.23
Tri fluoro acetic acid	20 to 65	0.873 to 0.473	9.72	585.54	283.84
Tri fluoro ethanoic acid, 2-propyl ester	20 to 60	0.724 to 0.425	9.05	564.92	272.12
Tri fluoro acetone	8 to 15	0.358 to 0.328	6.36	442.45	217.52
Tri fluoro tri chloro ethane	20 to 45	0.698 to 0.516	8.77	489.18	267.01

Combining Eq. 4.58 and Eq. 4.59, we finnaly get

$$B = (1/n)(\varDelta H_V - RT) \tag{4.60}$$

As a first approximation, the heat of vaporization at the normal boiling point $\varDelta H_{VB}$ can be substituted for $\varDelta H_V$. Fishtine[35] method can be used to estimate the value of $\varDelta H_{VB}$ according to the equation

$$\varDelta H_{VB} = K_F T_B (8.75 + R \ln T_B) \tag{4.61}$$

where R is the universal gas constant (1.987 cal/mol K) and K_F is the Fishtine constant. From a consideration of the dipole moments of several compounds, Fishtine presented the values of K_F, shown in Table 4.24, in relation to the structure of the molecule.

Important notes for the calculation of K_F

- Consider any phenyl group as a single carbon atom.
- K_F factors are the same for all aliphatic isomers of a given compound. For example, K_F=1.31 for n-butylalcohol, iso-butylalcohol, tert-butylalcohol and sec-butylalcohol.
- In organometallic compounds, consider any metallic atom as a carbon atom.
- For compounds not included in the above table, assume $K_F = 1.06$.

Combining the equations given above, we obtain

$$B = (1/n)[K_F T_B (8.75 + R \ln T_B) - RT] \tag{4.62}$$

The value of n depends on the type of compound and is given in Table 4.25.

Table 4.24. K_F factors for aliphatic and alicyclic organic compounds for calculation of parameters *B* in Eq. 4.61.

Type of Substance	***Number of Carbons***											
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12 – 20***
Hydrocarbons												
Alkane Isomers	-	-	-	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Mono- & Diole-fins & Isomers	-	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.00
Cyclic Saturated Hydro-Carbons	-	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Alkyl Derivatives of Cyclic Saturated Hydrocarbons	-	-	-	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Halides (Saturated & Unsaturated)												
Monochlorides	1.05	1.04	1.03	1.03	1.03	1.03	1.03	1.03	1.02	1.02	1.02	1.01
Monobromides	1.04	1.03	1.03	1.03	1.03	1.03	1.02	1.02	1.02	1.01	1.01	1.01
Monoiodides	1.03	1.02	1.02	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01	1.01
Polyhalides (not entirely halogenated)	1.05	1.05	1.05	1.04	1.04	1.04	1.03	1.03	1.03	1.02	1.02	1.01
Mixed halides (completely halogenated)	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Perfluoro carbons	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Compound Containing the Keto Group												
Esters	-	1.14	1.09	1.08	1.07	1.06	1.05	1.04	1.04	1.03	1.02	1.01
Ketones	-	-	1.08	1.07	1.06	1.06	1.05	1.04	1.04	1.03	1.02	1.01
Aldehydes	-	1.09	1.08	1.08	1.07	1.06	1.05	1.04	1.04	1.03	1.02	1.01
Nitrogen Compounds												
Primary Amines	1.16	1.13	1.12	1.11	1.10	1.10	1.09	1.09	1.08	1.07	1.06	1.05^b
Secondary Amines	-	1.09	1.08	1.08	1.07	1.07	1.06	1.05	1.05	1.04	1.04	1.03^b

Type of Substance	*Number of Carbons*											
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12 – 20*
Tertiary Amines	-	-	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Nitriles	-	1.05	1.07	1.06	1.06	1.05	1.05	1.04	1.04	1.03	1.02	1.01
Nitro Compounds	1.07	1.07	1.07	1.06	1.06	1.05	1.05	1.04	1.04	1.03	1.02	1.01
Sulfur Compounds												
Mercaptans	1.05	1.03	1.02	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Sulfides	-	1.03	1.02	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Alcohols												
Single OH group	1.22	1.31	1.31	1.31	1.31	1.30	1.29	1.28	1.27	1.26	1.24	1.24[b]
Diols (Glycols or Condensed Glycols)	-	1.33	1.33	1.33	1.33	1.33	1.33	1.33				
Triols (Glycerol, etc.)	-	-	1.38	1.38	1.38							
Cyclohexanol, Cyclohexyl methyl alcohol,etc.						1.20	1.20	1.21	1.24	1.26		
MiscellaneousCompounds												
Ethers (Aliphatic)	-	1.03	1.03	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.01	1.01
Oxides (Cyclic Ethers)	-	1.08	1.07	1.06	1.05	1.05	1.04	1.03	1.02	1.01	1.01	1.01

[a] Carboxylic or heterocyclic compounds having aliphatic properties.

[b] For N = 12 only; no prediction for K_F where N > 12.

Table 4.25. Values of *n* for different types of compounds.

Compound Type	***Value of n***
Aliphatic Hydrocarbons	8
Ketones(Aliphatic and Aromatic)	7
All Other Organic Compounds	5

The following basic steps are recommended for the estimation of liquid viscosity by the Grain method.

- Obtain η_B from Table 4.1.
- Obtain the Fishtine constant K_F from Table 4.24
- Obtain the value of n from Table 4.25
- Calculate B from Eq. 4.62
- Calculate ln η at the temperature T from Eq. 4.57.

4.3.2.1.2 Viscosity Correlations Based on Density

Density is one of the properties which can be measured accurately and with greater ease. We will outline in this section, some of the important methods relating viscosity to density.

4.3.2.1.2.a Bachinskii's Formula

Bachinskii's equation[36] is one of the first relationships developed between the viscosity and density of liquids. He proposed a linear dependency of fluidity (reciprocal of viscosity) on the specific volume (reciprocal of density) as

$$(1/\eta) = (A/\rho) - B \tag{4.63}$$

where A and B are constants characteristic of the substance.

The equation is often presented in the form:

$$V = \omega + C\varphi \tag{4.64}$$

where C is a constant characteristic of the substance,
V is the specific volume [$V = (1 / \rho)$],
φ is the fluidity [$\varphi = (1/\eta)$], and
ω is a constant related to the critical volume V_C by the approximate relation given by Eq. 4.65.

$$\omega = 0.307 V_C \tag{4.65}$$

Bachinskii's formula is not obeyed by alcohols, organic acids, halo-compounds like ethylene dichloride, water and mercury. With the exception of water, the compounds give convex curves instead of straight lines. The curve for water is concave.

Another popular form of the viscosity dependence on density is

$$\eta V^x = A\, exp\left[\frac{B}{V^y T}\right] \tag{4.66}$$

where V is the molar volume, A and B are constants, and the vaues of both x and y are in the range between zero and unity. The constants x and y are calculated from the experimental viscosity-temperature data of the substance. This equation as well as Batschinskii's formula are of historic importance.

4.3.2.1.2.b Przezdziecki and Sridhar Method

Przezdziecki and Sridhar[37] used the Hildebrand modification of the Batschinskii equation and obtained the following expression:

$$\eta = \frac{V_0}{E(V - V_0)} \tag{4.67}$$

where η is the liquid viscosity in cP and V is the liquid molar volume in cm^3/mol. The parameters E and V_0 are defined as follows.

$$E = -1.12 + \frac{V_C}{12.94 + 0.10M - 0.23P_C + 0.0424T_F - 11.58(T_F/T_C)} \tag{4.68}$$

$$V_0 = 0.0085\omega T_C - 2.02 + \frac{V_{mF}}{0.342(T_F/T_C) + 0.894} \tag{4.69}$$

where, T_C is the critical temperature in K,
P_C is the critical pressure in bar,
V_C is the critical volume in cm^3/mol,
M is the molecular weight in g/mol,
T_F is the freezing point in K,

ω is the acentric factor, and
V_{mF} is the liquid molar volume at T_F in cm^3/mol.

For the application of this method, one requires the values of T_C, P_C, V_C, T_F, V_{mF} and ω in addition to the liquid molar volume at the temperature of interest. Data on V and V_{mF} are often not available. Even if they are available, the authors recommend the Gunn-Yamada method[38] to be used for the estimation of V and V_{mF} from T and T_F.

Application of the Gunn-Yamada method requires the knowledge of the accurate value of the molar volume V^R at T^R. At any other temperature

$$V(T) = V^R\left[f(T)/f\left(T^R\right)\right] \tag{4.70}$$

where, $f(T) = H_1(1 - \omega H_2)$ (4.71)

$$H_1 = 0.33593 - 0.33953T_R + 1.51941T_R^2 - 2.02512T_R^3 + 1.11422T_R^4 \tag{4.72}$$

$$H_2 = 0.29607 - 0.09045T_R - 0.04842T_R^2 \tag{4.73}$$

Careful comparison of the method revealed that large errors resulted for alcohols and for other substances at low temperatures. Luckas and Lucas[39] suggested that the method should not be used below a reduced temperature of about 0.55.

4.3.2.1.3 Viscosity Correlations Based on Surface Tension

Surface tension is a characteristic property of liquid which indicates the forces determining the formation of different kinds of interfaces (particularly the liquid-vapor) while viscosity is characteristically a measure of capacity of the liquid to flow. It is reasonable to determine the relationships between the two characteristic physical properties, for use in estimations.

4.3.2.1.3.a Pelofsky equation

Pelofsky[40] proposed an empirical equation relating the liquid viscosity to the surface tension in the form:

$$\gamma = Ae^{(B/\eta)} \tag{4.74}$$

where A and B are dimensional constants. Based on a study of 32 liquids, both organic and inorganic, including water, benzene and toluene, B is shown to be a function of (Mk/R) where M is the molecular mass, k is the thermal conductivity and R is the gas constant.

The relationship can also be written in the form

$$\ln \gamma = (B/\eta) + \ln A \tag{4.75}$$

where B is the slope and $\ln A$ is the intercept of a plot of $\ln \gamma$ versus ($1/\eta$). The slopes are found to be directly proportional to the molecular mass of the substance while the intercept is probably indicative of the substance's solid phase, since $A = \gamma$ when the viscosity approaches infinity.

In terms of a non-dimensional constant C (which can be related to the Rheochor) the equation can be written as

$$\gamma = A' \, exp\left[\frac{CMk}{R\eta}\right] \tag{4.76}$$

where M is the molecular mass (g/mol), k is the thermal conductivity (cal/sec. cm^2), R is the universal gas constant (1.986 cal/mol K) and A' is an empirical constant.

4.3.2.1.3.b Schonhorn method

Schonhorn[41] extended the ideas of Pelfosky and proposed a relation between the absolute viscosity and surface tension in the form

$$\gamma = \gamma_N \, exp\left[-\frac{B}{(\eta_L - \eta_V)}\right] \tag{4.77}$$

where γ_N is the surface tension at temperature T_N (the temperature at which the viscosity becomes infinite), and η_L and η_V are the viscosity of liquid and vapor, respectively. T_N is related to the temperature of homogeneous nucleation. Schonhorn described the application of the methodology to 11 substances.

4.3.2.2 Viscosity Dependence on Molecular Properties

The viscosity of a liquid can be expected to depend on the properties of the molecules of which it is composed. A priori one can expect that molecular properties such as molar volume V_m, shape factor ϕ, molecular mass M, polarizability α and dipole moment μ should all have influence on liquid viscosity. Lutskii[42] studied the problem by comparing the viscosities of groups of substances which differ only in one molecular property.

4.3.2.2.1 Dependence of Viscosity on Molecular Weight

Comparison of the viscosities of isotopic compounds, the molecules of which differ only in mass (like liquefied methane and deuteriomethane) shows that the viscosities are proportional to $\sqrt{M}$ and can be expressed as

$$(\eta)_{P,T,\phi,\mu,\alpha} = A\sqrt{M} \tag{4.78}$$

where A is a constant.

4.3.2.2.2 Viscosity Dependence on Molar Refraction

Lutskii[42] considered the relationship between the quantity $(\eta/\sqrt{M})_{P,T,\phi,\mu}$ and molar refraction, R_D, and showed that ;

$$\left(\frac{\eta}{\sqrt{M}}\right)_{P,T,\phi,\mu} = A\,R_D^{(3/2)} \tag{4.79}$$

where A is a constant. When the relationship between the quantities $R_D^{(3/2)}$ and $(\eta/\sqrt{M})$ is plotted, the points corresponding to compounds with similar shape factors fall on a straight line.

4.3.2.2.3 Dependence of Viscosity on Dipole Moment

In an analogous manner, Lutskii[42] also examined the relationship between liquid viscosity and dipole moment, μ, for compounds with similar molecular mass, similar molecular shapes, and similar values of R_D resulting in a linear equation

$$\eta = A\,\mu + B \tag{4.80}$$

where constants A and B are obtained by regressing the experimental data.

4.3.2.2.4 Viscosity Dependence on Shape Factor

An investigation on the dependence of the liquid viscosity η on the shape factor φ of the molecules showed that at 25ºC the viscosities of tertiary compounds are 10 to 20% greater than those of compounds with straight chain molecules. The viscosities of compounds with cyclic molecules are 2 to 4 times as great as those of corresponding liquids with chain molecules. The ratio increases as the number of carbon atoms in the molecule increases.

4.3.2.2.5 Effect of Bonds, and Cyclic Structures on Viscosity

The observed regularities may be associated with the presence or absence of bonds, which permit free rotation in the molecule. Polycyclic molecules are comparatively rigid having a fixed shape with no mobile elements. Liquids composed of this type of molecules have high viscosities. On the other hand, the viscosities of liquids made up of molecules with a straight chain structure (in particular, normal aliphatic hydrocarbons) are low. In the latter case, the presence of a considerable number of bonds, permitting rotation of one part of the molecule with respect to the other, may enable the molecules to arrange and fit themselves so as to facilitate the process of flow.

4.3.2.2.6 Viscosity-Molecular Property Relation for Substances with Similar Shape Factors

It follows from Lutskii's analysis[42] that for molecules with similar shape factors φ, the following relationship can exist

$$\left[\frac{\eta}{\left(\sqrt{M}R_D^{(3/2)}\right)}\right]_{P,T,\varphi} = A + B\ \mu \tag{4.81}$$

where A and B are constants. This relationship is valid for the series of compounds which can be represented by the general formula C_6H_5X, where X denotes: $-CH_3$, $-OCH_3$, $-F$, $-Br$, $-Cl$, $-I$, $-N(CH_3)_2$, $-COOC_2H_5$, $-COCH_3$, $-CN$, $-NC$, $-NO_2$, $-NH_2$, $-OH$. While the deviations from the expected linear behavior are reasonable for most of the compounds, it should be noted that the compounds containing $-OH$, $-COOH$, and $-NH_2$ show large deviations. Lutskii explains the deviations from the rules just mentioned as due to the formation of intermolecular or intramolecular hydrogen bonds in associated liquids. For such liquids, the observed values of viscosity may be as much as five to ten times as great as those calculated on the basis of isologous series. Discrepancies caused by the shape factor φ are lower.

4.3.2.3 Generalized Relationships for Liquid Viscosity

Generalized methods for the estimation of liquid viscosity can be broadly described under the main categories of those based on additive principles (called group contribution methods) and those based on the theorem of corresponding states (denoted as corresponding states methods). There is a close relationship among all of them, in the sense that, often there is an element of interrelations between molecular properties in the so-called purely empirical methods and the characteristic properties used in the corresponding states methods can be estimated fairly reliably from constitutive and additive contributions.

4.3.2.3.1 Group Contribtion Methods

Several methods have been proposed for the estimation of liquid viscosity from the observed dependence of viscosity on some physical property and the relation of the constants of the resulting equation found to be dependent on the constitution and structure of the molecule (which can be calculated from the atomic/group/structural contributions). A few commonly used methods are described in this section.

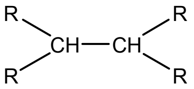
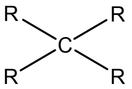
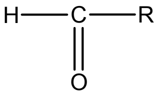
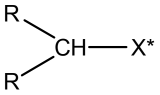
4.3.2.3.1.a Souders Method

Souders[43] found that the viscosity coefficient (I) in the following equation relating the density (ρ) and molecular mass (M) to the liquid viscosity (η) can be calculated additively by summing up the contributions corresponding to the respective groups and bonds present in the molecules.

$$log(log\,10\,\eta) = \left[(I/M)\rho\right] - 2.9 \tag{4.82}$$

The contributions of different groups and bonds to the viscosity constant (I) are given in Table 4.26.

Table 4.26. Contributions of different groups, structures and bonds for the calculation of the viscosity constant *I* of the Souders equation, Eq. (4.82): $log\left(log\,10\,\eta\right)=\left[\left(I/M\right)\rho\right]-2.9$.

Atom/Group/Bond	*Contribution*
H	2.7
O	29.7
C	50.2
N	37.0
Cl	60.0
Br	79.0
I	110.0
Double bond	- 15.5
5-Member ring	- 24.0
6-Member ring	- 21.0
Side Groups on a 6- Member ring	
Molecular weight < 17	- 9.0
Molecular weight > 16	- 17.0
Ortho – or *para* – position	3.0
Meta – position	- 1.0
	8.0
	10.0
-CH_2-	55.6
	10.0
- CH = CH – CH_2 – X*	4.0
	6.0
- OH	57.1
COO	90.0
COOH	104.4
NO_2	80.0

R: Hydrocarbon group; X*: Halide group

This method is applicable to aromatic and alicyclic compounds, giving an average deviation of about 10%. Satisfactory results are also obtained for the viscosity of esters. The viscosities calculated for unsaturated or branched chain hydrocarbons are less accurate with an average error of about 20%. Calculated viscosities for alcohols and compounds containing several halogen atoms in the molecule are usually too high while those for acids are too low.

Dutt *et al.*[44] extended the application of the Souders method to phosphorous containing compounds, by proposing a contribution of 67.1 for each phosphorous atom to the structural constant (*I*). When applied to 16 phosphorous containing compounds at 91 data points, the method gives an overall average absolute deviation of about 23%, comparable to the other group contribution methods.

4.3.2.3.1.b Thomas Method

Thomas[45] proposed the equation

$$log\left(8.569\frac{\eta}{\rho^{0.5}}\right)=\theta\left[\frac{1}{T_R}-1\right] \tag{4.83}$$

where η is the viscosity in cP, ρ is the density in g/mL, T_R is the reduced temperature (= T/T_C), where T and T_C are respectively the temperature of interest and the critical temperature in K, and θ is a coefficient which is related to the atoms, groups and bonds present in the molecule. The equation is applicable to the temperature region of $T_R < 0.7$. Contributions of atoms/groups/bonds to be used are given in Table 4.27.

Table 4.27. Contributions of atoms/bonds/groups for the calculation of the coefficient θ in the Thomas equation, Eq. (4.83): $\log\left(8.569\eta/\rho^{0.5}\right)=\theta\left[\left(1/T_R\right)-1\right]$.

Atom/Group/Bond	*Contribution to θ*
C	- 0.462
H	0.249
O	0.054
Cl	0.340
Br	0.326
I	0.335
Double Bond	0.487
C_6H_5	0.385
S	0.043
CO(Ketones, Esters)	0.105
CN(Cyanides)	0.381

For a large number of liquids, the method gives an average deviation of about 5%, with the exception of compounds like benzene and haloalkenes. Other investigations in the application of the method gave an average deviation of about 15%, with the exception of alcohols and acids. Thomas and co-workers published several other papers[46-50] with the main theme of proposing predictive methods for liquid viscosity and understanding the theoretical implications.

Thomas[46,47] proposed the following relationships between the liquid viscosity (η), molar volume (V) and saturated vapor pressure (P_V)

$$ln\left(\eta\sqrt{V}\right) = A - \left(B/T\right) \tag{4.84}$$

and $$ln\left(\eta\sqrt{V}\right) = \alpha - \beta \, ln \, P_V \tag{4.85}$$

where A, B, α and β are constants and T is the temperature in Kelvin. These equations, when plotted as $ln(\eta\sqrt{V})$ versus $(1/T)$ and $ln(\eta\sqrt{V})$ versus $ln(P_V)$, have been found to exhibit linearity in the case of non-associated liquids. The equations have been thoroughly examined by Thomas[47] in his subsequent work where no significant departures were found for non-associated compounds even at temperatures when the plot of $ln(\eta\sqrt{V})$ versus $(1/T)$ is manifestly non-linear.

Differentiation of Eqs (4.84) and (4.85) with respect to $(1/T)$ give

$$\frac{d\, ln\left(\eta\sqrt{V}\right)}{d\left(1/T\right)} = -B = -\beta \frac{d\, ln\, P_V}{d\left(1/T\right)} \tag{4.86}$$

At the temperatures where the vapor behaves ideally, we may utilize the thermodynamic relation

$$\frac{d\, ln\, P_V}{d\left(1/T\right)} = -\frac{L}{R} \tag{4.87}$$

in which L is the molar latent heat of vaporization (energy of vaporization).

Hence, $$B = \beta \, L/R \tag{4.88}$$

or $$\beta = R\, B/L \tag{4.89}$$

Although put forward on purely empirical grounds, Eq. (4.89) is intuitively attractive on the premise that the constant β is equal to the ratio of the viscous energy to the energy of vaporization. For compounds with molecules closely approaching spherical shape, β is sensibly constant at about 0.220 for all non-associated liquids and appears to be independent of size, polarity or the presence or otherwise of flexible bonds.

Thomas[49] proposed the vapor pressure equation

$$ln\,P_V = ln\,\psi - \left(I/T^{\theta}\right) \tag{4.90}$$

where ψ is shown to be a universal constant for non-associated liquids of diverse types and I and θ are constant for each substance. Combining this vapor pressure equation with Eq. (4.85) one easily gets

$$ln\left(\eta\sqrt{V}\right) = \alpha - \beta\,ln\,\psi + \beta\left(I/T^{\theta}\right) \tag{4.91}$$

Or, in terms of base 10 logarithms

$$log\left(\eta\sqrt{V}\right) = \{(\alpha/2.303) - \beta\,log\,\psi\} + \left\{\beta\left(I/2.303T^{\theta}\right)\right\} = \alpha' + \left(\beta'/T^{\theta}\right) \tag{4.92}$$

in which α' and β' are independent of temperature. This equation is similar to the Eyring-type equation except that an additional constant θ has been introduced.

The interesting aspect of the series of papers published by Thomas is the interrelations among various physical properties. Such an interrelationship allows one to use some of the equations judiciously to predict the viscosity for substances for which data is totally unavailable.

Dutt and Venugopal[51] extended the application of Thomas method to fluorinated hydrocarbons by proposing a contribution of 0.336 for each fluorine atom to the structural parameter, θ. The extension has been applied to 16 fluorinated hydrocarbons at 117 data points and is shown to predict the viscosity with an average absolute deviation of 16.6%.

4.3.2.3.1.c Morris Method

Morris[52] suggested the relation

$$log\left(\eta/\eta^{+}\right) = J\left[\left(1/T_R\right) - 1\right] \tag{4.93}$$

the parameter η^+ is a constant for each compound class (given in Table 4.28), T_R is the reduced temperature (= T/T_C) and J is a function of the molecular structure to be calculated from

$$J = \left[0.0577 + \sum_i \left(b_i n_i \right) \right]^{(1/2)} \tag{4.94}$$

The values of b_i for several commonly occurring groups are listed in Table 4.29.

Table 4.28. Pseudocritical viscosity η^+ (in cP) of different classes of compounds for use in the Morris Method, Eq. (4.93): $\log\left(\eta/\eta^+\right) = J\left[\left(1/T_R\right) - 1\right]$.

Class of Compound	***Pseudocritical Viscosity (η^+)***
Hydrocarbons	0.0875
Halogenated Hydrocarbons	0.148
Benzene Derivatives	0.0895
Halogenated Benzene Derivatives	0.123
Alcohols	0.0819
Organic Acids	0.117
Ethers, Ketones, Aldehydes, Acetates	0.096
Phenols	0.0126
Miscellaneous	0.100

Table 4.29. Structural contributions to J for use in the Morris Method, Eq. (4.94): $J = \left[0.0577 + \sum_i \left(b_i n_i \right) \right]^{(1/2)}$.

Group	***b_i***
CH_3, CH_2 and CH	0.0825
Halogen Substituted CH_3	0.0
Halogen Substituted CH_2	0.0893
Halogen Substituted CH	0.0667
Halogen Substituted C	0.0
Br	0.2058
Cl	0.1470
F	0.1344
I	0.1908
Double Bond	-0.0742
C_6H_4 Benzene Ring	0.3558
Additional H in the Ring	0.1446
CH_2 as Saturated Ring Member	0.1707
CH_3, CH_2 and CH Adjoining Ring	0.0520
NO_2, Adjoining Ring	0.4170
NH_2, Adjoining Ring	0.7645
F, Cl Adjoining Ring	0.0
OH for Alchols	2.0446

Group	b_i
COOH for Acids	0.8896
C = O for Ketones	0.3217
C = O – O for Acetates	0.4369
OH for Phenols	3.4420
- O – for Ethers	0.1090

4.3.2.3.1.d Orrick and Erbar Method

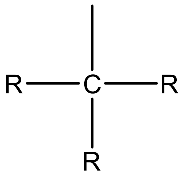
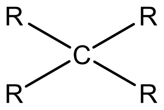
Orrick and Erbar[53] proposed group contribution methodology for the parameters *A* and *B* of the equation

$$ln\left[\frac{\eta}{\rho M}\right] = A + \left(\frac{B}{T}\right) \tag{4.95}$$

where η is the liquid viscosity in cP
ρ is the density at 20 ºC in g/cm^3
M is the molecular mass, and
T is the absolute temperature in K

The group contributions for estimating *A* and *B* are noted in Table 4.30. For liquids whose freezing point is above 20ºC, the density of liquid at the melting point should be used in the calculations.

Table 4.30. Group contributions to *A* and *B* of Orrick and Erbar Method.

Group	**Contribution to A**	**Contribution to B**
Carbon Atoms(n excluding those present in the groups shown below)	- (6.95 + 0.21 n)	275 + 99 n
	- 0.15	35
	- 1.20	400
Double Bond	0.24	- 90

Group	*Contribution to A*	*Contribution to B*
Five Membered Ring	0.10	32
Six Membered Ring	- 0.45	250
Aromatic Ring	0	20
Ortho Substitution	- 0.12	100
Meta Substituion	0.05	- 34
Para Substition	- 0.01	- 5
Chlorine	- 0.61	220
Bromine	- 1.25	365
Iodine	- 1.75	400
- OH	- 3.00	1600
- COO -	- 1.00	420
- O -	- 0.38	140
- C = O -	- 0.50	350
- COOH	- 0.90	770

4.3.2.3.1.e Rheochor Method[1]

Viscosities of liquids at the normal boiling point (η_B) can be calculated from values of molecular weight (M), liquid density at the normal boiling point (ρ_B), the density of the saturated vapor at the normal boiling temperature (ρ_{VB}) and the Rheochor (R_{Ch}), which can be estimated from the atomic and group contributions given in Table 4.31. The equation for the calculation of viscosity is

$$\left(10\eta_B\right)^{0.125} = R_{Ch}\,\frac{\left(\rho_{VB} + 2\rho_B\right)}{M} \tag{4.96}$$

Table 4.31. Atomic and group contributions to Rheochor (R_{Ch}).

Atom / Atomic Group	*Contribution*
C	12.8
H (in C – H)	5.5
H (in O – H)	10.0
O (in Ethers)	10.0
O (in Alcohols)	13.0
O (in Aldehydes, Ketones)	13.2
Cl	27.3
Br	37.8
N	6.6
NH_2	20.6
NH	13.6
ONO	39.3
NO_2	38.9
CN	33.0
COO(in Acids and Esters)	36.0
C_6H_5	101.7

4.3.2.3.1.f Group Contribution Method of Sastri and Rao

Based on the concept of linearity between vapor pressure and viscosity, Sastri and Rao[10] proposed a group contribution method using the relation

$$\eta = \eta_B \, P^{-N} \tag{4.97}$$

where η_B is viscosity at the normal boiling point, P is the vapor pressure, and N is a constant.

Practical application of Eq. (4.97) needs the not so readily available properties and parameters – vapor pressure, η_B (viscosity at the normal boiling point) and the exponential constant (N). The difficulty has been circumvented by proposing appropriate estimation equations for P (the vapor pressure) and group contributions for the estimation of η_B and N.

Grain[11] equation is recommended for calculation of the vapor pressure below the normal boiling point and is given by:

$$ln\,P = \frac{H_V}{\Delta Z_R R T_B}\left[1 - \frac{(3 - 2T/T_B)^{0.19}}{T/T_B} - 0.38(3 - 2T/T_B)^{-0.81}\, ln\left(\frac{T}{T_B}\right)\right] \tag{4.98}$$

Substituting for H_V by Kistiakowsky equation and taking Z_B = 0.97 as recommended by Miller[54], we can obtain

$$ln\,P = (4.5398 - 1.0309\, ln\, T_B)\begin{bmatrix} 1 - \dfrac{(3 - 2T/T_B)^{0.19}}{T/T_B} \\ - 0.38(3 - 2T/T_B)^{-0.81}\, ln\left(\dfrac{T}{T_B}\right)\end{bmatrix} \tag{4.99}$$

For P above the normal boiling point we can use

$$ln\,P = a - (b/T) \tag{4.100}$$

Where, $a = ln\,P_C\,(T_C/(T_C - T_B))$ (4.101)

$$\text{and } b = (a/T_B) \tag{4.102}$$

The final correlation becomes same as Eq. (4.97)

$$\eta = \eta_B \, P^{-N}$$

The value of P can be calculated as indicated above applying Eqs. (4.98)–(4.102) and the viscosity η can be calculated from Eq. (4.97) by substituting the values of η_B and N according to the following recommendations.

$$\eta_B = \sum \Delta\eta_B + \sum \Delta\eta_{Bcor} \tag{4.103}$$

The value of N can be obtained according to the following equations.

Below the normal boiling point:

$$N = 0.2 + \sum \Delta N + \sum \Delta N_{cor} \text{ (for all substances)} \tag{4.104}$$

Above the normal boiling point:

$$N = 0.375 \text{ for hydrocarbons, otherwise} \tag{4.105}$$

$$N = 0.35\text{, but for low temperature region } N = 0.3. \tag{4.106}$$

The contributions of different hydrocarbon functional groups for calculating η_B and N, for application below the normal boiling point are given in Tables 4.32 to 4.39.

Table 4.32. Contributions of hydrocarbon groups and structures for Sastri and Rao method.

Functional Group/ Structure	$\Delta\eta_B$	ΔN	***Remarks***
Non-ring			
$-CH_3$	0.105	0.000	For n - alkanes C > 8, ΔN = 0.050
$>CH_2$	0.000	0.000	
$>CH-$	- 0.110	0.050	If both groups are present ΔN = 0.05 only. ΔN values applicable in the case of aliphatic hydrocarbons and halogen derivatives of aliphatic compounds. Other cases, ΔN= 0
$>C<$	- 0.180	0.100	
$=CH_2$	0.085	0.000	For n-alkenes C > 8, ΔN = 0.050
$=CH-$	- 0.005	0.000	
$=C<$	- 0.100	0.000	
$HC\equiv C-$	0.190	0.000	For n-alkynes C > 8, ΔN = 0.050
Ring			
$>CH_2$	0.060	0.000	
$>CH-$	- 0.085	0.000	
$>C<$	- 0.180	0.000	
$=CH-$ (Alicyclic)	0.040	0.000	
$=CH-$ (Others)	0.050	0.000	
$=C<$ (Alicyclic)	- 0.100	0.000	
$=C<$ (Others)	- 0.120	0.000	

Table 4.33. Contributions of ring structures/chain length to *ΔN*.

Group	***Contribution to ΔN***	***Remarks***
Monocyclic and saturated polycyclic hydrocarbon rings (unsubstituted)	0.100	
Mehyl-substiuted compounds of the above	0.050	
Monocyclic mono-alkyl hydrocarbons(alicyclic)		
$1 < C_{br} \leq 5$	0.025	
$C_{br} > 5$	0.050	
Monocyclic multisubstiued alkyl Alicyclic hydrocarbons	0.025	
Monoalkylbenzenes $C_{br} > 1$	0.025	
Bicyclic hydrocarbons partly or fully unsaturated	0.050	
Unsaturated triycylic hydrocarbons	0.100	

Group	*Contribution to ΔN*	*Remarks*
Position correction for multiple substitution in aromatics by hydrocarbon/ nitro groups or combinations of these		
Ortho	0.050	
Meta or Para	0.000	
1,3,5	0.100	
1,2,4	0.050	
1,2,6	0.125	Contributions of other functional groups to be neglected

$\Delta\eta_{Bcor}$ for multiple substitutions in aromatics by hydrocarbon groups is 0.070.

Some general observations about the contributions are:

The contributions of the functional groups to η_B and N below the normal boiling point are in general found to be cumulative. However, if the compound contains more than one identical functional group, its contribution to N should be taken only once unless otherwise mentioned. The chain length has only marginal effect on η_B and ΔN as indicated, except in the case of hydroxyl ion in aliphatic alcohols. It has also been observed that contribution of aliphatic hydrocarbon functional groups to ΔN is limited to aliphatic hydrocarbons and their halogen derivatives. The contribution of non-hydrocarbon functional groups (other than halogen and hydroxyl groups) attached to the side chain in aromatic compounds are found to be the same as the corresponding ones for aliphatic compounds. In several cases where more than one functional group is present, special values or corrections are required and these are mentioned at appropriate places. The authors compared their method with the group contribution method of van Velzen *et al.*[29] and the corresponding states method of Letsou and Stiel[55] and found that the method produces results comparable in accuracy to the method of van Velzen et al. for the low temperature region and the method of Letsou and Stiel for the high temperature region.

In a personal communication Sastri[10a] recommends the use of the equation (developed using additionally the corresponding states theory)

$$\ln\eta = \left[\left(\frac{\ln\eta_B}{\ln(\alpha\eta_B)}\right)^{\varphi}\right]\ln(\alpha\eta_B) \qquad (4.107)$$

for the calculation of liquid viscosity from a reduced temperature of 0.7 to near the critical temperature. In Eq. (4.107), α is equal to 0.1175 for alcohols and 0.248 for the other compounds and η_B is the viscosity (mPa.s) at the normal boiling point to be calculated from the group contributions given in Tables 4.32 to 4.39. For reduced temperatures above 0.9, average deviations of about 10% are to be expected.

Table 4.34. Contribution of halogen groups.

Functional group/ structure	***$\Delta\eta_B$, halogen attached to***						***ΔN^b in***		
	-CH_3 or >CH_2[a]	***>CH-***	***>C<[a]***	***=CH-***	***=C<***	***Others***	***Aliphatics***	***Alicyclics***	***Aromatics***
- F[c]	0.185	0.155	0.115	n.d.	n.d.	0.185	0.000	0.075	0.025
- Cl[a]	0.185	0.185	0.170	0.180	0.150	0.170	0.000	0.075	0.025
- Br	0.240	0.240	0.210	0.240	0.210	0.210	0.000	0.075	0.025
- I	0.260	0.260	n.d.	n.d	n.d.	0.260	0.000	0.075	0.025

[a] Special configurations/function group structure

(1) X – (CH2)n – X where X is halogen, $\Delta N_{cor} = 0.050$

(2) Cl – C – Cl ring, $\Delta N_{cor} = 0.050$ for each group.

[b] Presence of non-hydrocarbon group in cyclic compounds functional group/structure combinations

(1) Halogen attached to ring carbon in compounds containing

(i) – NH_2, $\Delta N_{cor} = - 0.100$

(ii) other functional groups, $\Delta N_{cor} = - 0.050$

(2) Halogen attached to non-hydrocarbon functional group, $\Delta N_{cor} = - 0.050$

[c] Group contributions to the fluorine groups of perfluoro compounds are given in Table 4.34.

Table 4.35. Contributions of fluorine groups in perfluoro-compounds.

Group	$\Delta\eta_B$	ΔN
Non-ring		
– CF3	0.210	0.150 for all perfluoro n-compounds
>CF3	0.000	
>CF –	- 0.080	0.200 for all iso - compounds
Ring		
– CF2 –	0.120	0.200 for all cyclic compounds
– CF – |	0.170	

Table 4.36. Contributions of oxygen groups.

Functional group/ structure	***Location***	***$\Delta\eta_B$***	***ΔN***	***Remarks***
- O -	Non-ring, attached to ring	0.020	0.050	In compounds containing–NH_2 group attached to ring carbon special values $\Delta\eta_B = 0.150$, $\Delta N = 0.200$ for the combination
- O -	Ring	0.140	0.050	In compounds containing >CO group special value $\Delta N = 0.125$ for he combination
- O -	Others	0.000	0.050	In aliphatic compounds containing – OH special value of $\Delta N = 0.100$ for the combination In cyclic compounds >CO group(with or without other functional groups) special value $\Delta N = 0.125$ for the combination
>CO	Non-ring attached to ring carbon	0.030	0.050	In cyclic compounds containing – O – group(with or without other functional groups) special value $\Delta N = 0.125$ for combination In cyclic compounds >NH group $\Delta\eta_{Bcor} = 0.100$
>CO	Ring	0.055	0.100	In cyclic compounds containing >NH group $\Delta\eta_{Bcor} = 0.100$ In compounds containing – O – group special value $\Delta N = 0.125$ for the combination
>CO	Others	0.030	0.025	For aliphatic compounds containing–NH_2 groups $\Delta\eta_{Bcor} = 0.100$ For cyclic compounds containing >NH groups $\Delta\eta_{Bcor} = 0.100$ In aliphatic compounds containing – OH special value $\Delta N = 0.125$ for the combination
$O(CO\text{-})_2$	Anhydride	0.060	0.050	
- CHO		0.140	0.050	In compounds containing – OH (phenolic) special value $\Delta N = 0.125$ for the combination
- COO -		0.040	0.050	ΔN value for each – COO – group For – H in formates $\Delta\eta_B = 0.165$
- COOH	In aliphatics Saturated	0.220	0.100	For C = 3 or 4 $\Delta N = 0.050$
	Unsaturated	0.250	0.100	
- COOH	In aromatics	0.195	0.175	

Table 4.37. Contributions of hydroxyl groups.

Functional group/ structure	$\Delta\eta_B$	ΔN	***Remarks***
- OH in aliphatics saturated primary – n	$0.615 - 0.092\ C + 0.004\ C^2 - 10^{-0.58C}$ for $C \leq 10$ and 0.200 for $C > 10$	0.3 for $2 < C < 12$ 0.15 for others	In compounds containing – O – group special value $\Delta N = 0.100$ for the combination In compounds containing >NH groups special value $\Delta N = 0.300$ for the combination
Branched	$0.615 - 0.092\ C + 0.004\ C^2 - 10^{-0.58C}$	0.375	
Secondary saturated chain	$0.67 - 0.092\ C + 0.004\ C^2 - 10^{-0.58C}$	0.425 for $C \leq 5$ 0.300 for $C > 5$	
Secondary branched	$0.67 - 0.092\ C + 0.004\ C^2 - 10^{-0.58C}$	0.425 for $C \leq 10$ 0.300 for $C > 10$	
Tertiary	$0.615 - 0.092\ C + 0.004\ C^2 - 10^{-0.58C}$	0.650	In compounds containing >CO / - O – groups special value $\Delta N = 0.125$ for the combination
Unsaturated	0.300	0.200	
In cyclic alcohols	0.270	0.150	
Phenolic	0.210	0.275	In compounds containing – NO_2 / - CHO groups special value $\Delta N = 0.125$ for the combination

Table 4.38. Contributions of nitrogen groups.

Functional group/ structure	***Location***	$\Delta\eta_B{}^a$	ΔN	***Remarks***
- NH_2	Aliphatic n-amines	0.170	0.100	$\Delta\eta_B = 0.220$ in NH_2-(CH_2),-NH_2 In compounds containing >CO, $\Delta\eta_{Bcor} = 0.100$
- NH_2	Aliphatic isoamines attached to >CH	0.200	0.100	
- NH_2	Monocyclic compounds attached to side chain	0.170	0.100	
- NH_2	Monocyclic compounds attached to ring carbon	0.150	0.200	$\Delta\eta_{Bcor}$ for com-pounds containing halogens according to the earlier table
- NH_2	Other aromatics	0.150	0.100	
>NH	Aliphatics	0.020	0.075	
>NH	Aromatic compounds attached to side chain	0.020	0.075	
>NH	Aromatic compounds attached to ring carbon	0.020	0.010	In cyclic compounds containing >CO, $\Delta\eta_{Bcor} = 0.100$
>NH	Ring	0.200	0.050	In cyclic compounds containing >CO, $\Delta\eta_{Bcor} = 0.100$
>N -	Aliphatics	- 0.115	0.050	
>N -	Aromatic compounds attached to side chain	- 0.115	0.050	
>N -	Aromatic compounds attached to ring carbon	- 0.060	0.050	
>N -	Ring	0.100	0.050	
- NO_2	Aliphatics	0.180	0.050	For multiple presence, $\Delta N = 0.100$
- NO_2	Aromatics	0.160	0.050	For multiple presence, $\Delta N = 0.100$ Position correction to be applied as indicated in the first table In compounds containing – OH (phenolic) special value $\Delta N = 0.125$ for combination
- CN		0.110	0.050	$\Delta\eta_B = 0.135$ in CN- $(CH_2)_n$ – CN

[a] $\Delta\eta_B = 0.080$ for (– H) in compounds containing hydrocarbon functional groups like formanilide.

Table 4.39. Contributions of sulfur groups.

Functional Group/Structure	$\Delta\eta_B$	ΔN
- S – Non-ring	0.045	0.000
- S – Ring	0.150	0.050
- SH	0.150	0.025

4.3.2.3.1.g Luckas and Lucas Method

Luckas and Lucas[39] proposed a liquid viscosity estimation method, combining both the activation energy type expression and the free volume type expression with the concepts of additivity, applicable to the entire practical range for the alkanes.

The simple activation type expression originally proposed by Andrade[56] can be written in the form modified by van Velzen *et al.*[29] as

$$log\eta = B\left[\frac{1}{T} - \frac{1}{T_0}\right] \tag{4.108}$$

where T_0 is the temperature at which $\eta = 1$ cP.

In an analogous manner the simple free volume type expression, originally proposed by Batschinskii[36], can be written in the modified form as

$$\eta = \frac{V_R - V_0}{V - V_0} \tag{4.109}$$

where V_R represents the molar volume corresponding to the viscosity of 1 cP and V_0 is another volume parameter. Comparisons with the experimental information show that the activation energy type expression is obeyed better in the reduced temperature range of 0.4 to 0.6 while the free volume type expression is better obeyed in the reduced temperature range of 0.55 to 0.97. Figures 4.11 and 4.12 show the parameters of Eqs. (4.108) and (4.109) respectively, as a function of number of carbon atoms for alkanes.

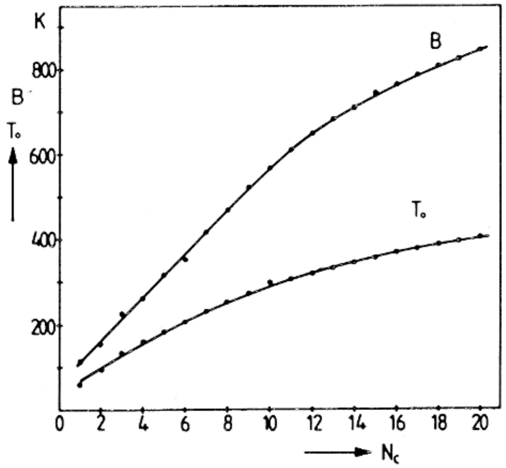


Figure 4.11. Parameters of Eq. (4.108) as a function of the number of carbon atoms for the alkanes (Adopted from M. Luckas and K. Lucas, Viscosity of liquids: An equation with parameters correlating with structural groups, *AIChE J.* **32**(1), 139-141, 1986).

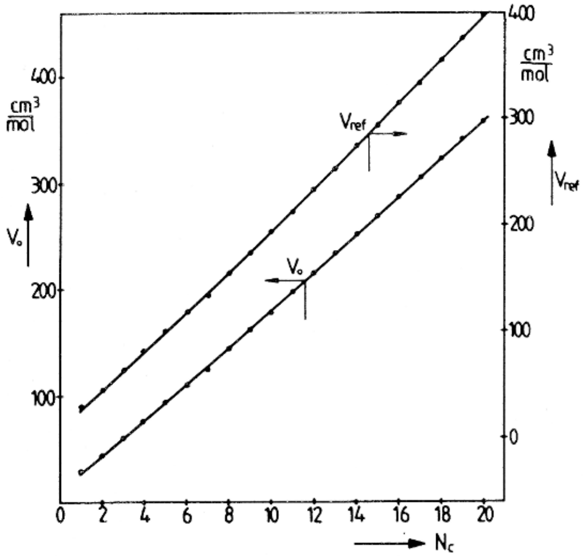


Figure 4.12. Parameters of Eq. (4.109) as a function of the number of carbon atoms for alkanes (Adopted from M. Luckas and K. Lucas, Viscosity of liquids: An equation with parameters correlating with structural groups, *AIChE J.* **32**(1), 139-141, 1986).

The final equation for the entire temperature range is

$$\eta = x_{TV}\ \eta_T + (1 - x_{TV})\ \eta_V \tag{4.110}$$

where, $$log\,\eta_T = B[(1/T) - (1/T_0)] \tag{4.111}$$

$$\eta_V = [(V_R - V_0)/(V - V_0)]^{1.15}, \text{ and} \tag{4.112}$$

$$x_{TV} = \frac{10^3\ exp[-0.5T_C\{(T/T_C) - 0.55\}]}{[1 + 10^3\ exp\{-0.5T_C\{(T/T_C) - 0.55\}\}]} \tag{4.113}$$

The parameter, x_{TV}, defined by Eq. (4.113) is a switching function which dampens the activation energy term for the reduced temperature >0.55 and the free volume term for the reduced temperature <0.55. Eq. (4.110) therefore reduces to the activation energy equation at low temperatures and to the free volume equation at high temperatures. This is a physically wrong situation. However the use of free volume equation at high temperatures in a viscosity correlation is practically undesirable, because the calculation of viscosity then becomes significantly dependent on the accuracy with which the volume (or density) is known or can be calculated. Volume (or density) in Eq. (4.112) can be eliminated, in favor of temperature by the methods such as that of Gunn and Yamada[38] and avoid the ambiguity of density determination. For lower temperatures, in the reduced temperature range of 0.3 to 0.4, Luckas and Lucas proposed the use of the following equation, Eq. (4.114)

$$\eta = \eta_T \left[\frac{0.4}{T/T_C}\right]^n \tag{4.114}$$

which contains an additional parameter n as a power. Five adjustable parameters have been used to cover the entire temperature range. However, it is worth noting that these are not fitted simultaneously. Only the first set of two parameters is fitted for the reduced temperature range between 0.4 and 0.6, another set of two parameters are fitted in the reduced temperature range of 0.55 and 0.97, where as the parameter n is only occasionally needed.

4.3.2.3.2 Corresponding States Method

According to the principle of corresponding states, a dimensionless property of one substance is equal to that of another reference substance if both are evaluated at the same reduced conditions. In the two parameter corresponding states, each fluid is characterized by an energy parameter (ε/k) and a shape distance parameter (σ). If the two fluids are in corresponding states (or are conformal), the reduced viscosity of the fluid *i* can be expressed in terms of the reference fluid *o* in the form:

$$\eta_{Ri}\left(V_{Ri}, T_{Ri}\right) = \eta_{Ro}\left(V_{Ro}, T_{Ro}\right) \tag{4.115}$$

At the same reduced conditions, $V_{Ri}=V_{Ro}$ and $T_{Ri}=T_{Ro}$, the above equation can be written as

$$\frac{\eta_i}{\eta_i^*}\left[\frac{V}{\sigma_i^3}, \frac{T}{\varepsilon_i/k}\right] = \frac{\eta_o}{\eta_o^*}\left[\frac{V}{\sigma_o^3}, \frac{T}{\varepsilon_0/k}\right] \tag{4.116}$$

where η^* is defined from simple kinetic theory for dilute gases as

$$\eta^* = \frac{R^{0.5} T_C^{0.5} M^{0.5}}{N_A^{0.333} V_V^{0.667}} = \frac{P_C^{0.667} M^{0.5}}{R^{0.167} N_A^{0.333} T_C^{0.167}} \tag{4.117}$$

where,

R	is the universal gas constant,
T_C	is the critical pressure,
M	is the molecular weight,
N_A	is the Avogadro's number,
V_C	is the critical volume, and
P_C	is critical pressure.

By describing viscosity in terms of density (ρ) and temperature (T), we get

$$\eta_i\left[\frac{\rho}{\rho_{Ci}}, \frac{T}{T_{Ci}}\right] = \eta_0\left[\frac{\rho}{\rho_{C0}}, \frac{T}{T_{C0}}\right]\left[\frac{M_i}{M_0}\right]^{0.5}\left[\frac{\rho_{Ci}}{\rho_{C0}}\right]^{0.667}\left[\frac{T_{Ci}}{T_{C0}}\right]^{0.5} \tag{4.118}$$

where, *i* is any fluid of interest and *o* is the reference fluid.

4.3.2.3.2.a Shape Factor Corrections

Eq. (4.118) is applicable to the fluids which conform to the two parameter corresponding states and is therefore not really applicable for polyatomic fluids (or mixtures). Hanley[57] integrated the shape factor approach which preserves the two parameter corresponding states form thorough the definition of the reducing parameters as follows

$$h_{io} = \left(V_{Ci}/V_{Co}\right)\varphi_{io} = \left(\rho_{Co}/\rho_{Ci}\right)\varphi_{i0} \tag{4.119}$$

$$f_{io} = \left(T_{Ci}/T_{Co}\right)\theta_{io} \tag{4.120}$$

where, θ_{io} and φ_{io} are the shape factors determined from the empirical expressions given in the paper of Ely and Hanley[61]. The final expression given for viscosity is

$$\eta_i\left(\rho,T\right) = \eta_o\left(h_{io},T/f_{io}\right)\left(M_i/M_o\right)^{0.5} h_{io}^{-0.667} f_{io}^{0.5} \tag{4.121}$$

This approach, described in detail in References 57, 60 and 61 needs information on the values of the acentric factor and critical compressibility factor of the reference liquid and the liquid of interest, besides an accurate equation of state for the reference fluid for its application.

4.3.2.3.2.b Extension to Heavier Molecules

Hanley[57] suggested that the predicted viscosity be multiplied by a correction term, which should be unity if fluids *i* and *o* follow simple corresponding states, otherwise should be a strong function of density and weak function of temperature. The correction term should also approach unity as density approaches zero. Hanley presented an empirical correction which resulted in significantly improved viscosity predictions for nitrogen, C_2, C_3 hydrocarbons and CO_2. Rowlinson and Watson[58] suggested that the shape factors of a fluid of interest (*i*) with respect to a reference fluid (*o*) could be determined exactly for any pure fluid by the simultaneous solution of the conformal equations

$$Z_i\left(V_i,T_i\right) = Z_o\left(V/h_{io},T/f_{io}\right), \text{ and} \tag{4.122}$$

$$A_i\left(V,T\right) = f_{io} A_o\left(V/h_{io},T/f_{io}\right) - RT\, ln\left(h_{io}\right) \tag{4.123}$$

where, *Z*, *V*, *T* are respectively, the compressibility factor, volume, and temperature, *h* is the volume reducing ratio, *f* is the temperature reducing ratio.

Leach[59] solved similar equations for C_1 to C_{15} paraffin's with methane as the reference fluid and generalized the results with the following empirical expressions:

$$\theta_{io} = 1 + (\omega_i - \omega_o)[a_1 + b_1 \ln T_{Ri} + (c_1 + d_1/T_{Ri})(V_{Ri} - 0.5)] \tag{4.124}$$

$$\varphi_o = [1 + (\omega_i - \omega_o)(a_2(V_{Ri} + b_2) + c_2(V_{Ri} + d_2)\ln T_{Ri})]\,(Z_{Co}/Z_{Ci}) \tag{4.125}$$

where, if $V_{Ri} \geq 2$, $V_{Ri} = 2.0$ and if $V_{Ri} \leq 0.5$, $V_{Ri} = 0.5$ and a similar constraint was imposed on T_{Ri}, and a_1, b_1, c_1, d_1, a_2, b_2, c_2, and d_2 are constants.

Ely[60] modified the Ely and Hanley[61] model to partially correct for non-correspondence between the reference fluid and pure high molar mass fluids and for size and mass differences in mixtures. The non-correspondence has been addressed by changing the reference fluid from methane to propane, since the non-correspondence in viscosity between propane and methane is the same as the one between n-C_{20} and methane, and since propane has the lowest reduced triple point amongst paraffin's. The low temperature data of Diller[62] made it possible to use propane as the reference fluid. A 32-term BWR type equation of state is used for density (which reproduces densities within 0.3%). Viscosity predictions using propane reference were much the same as in the case of the previous work using methane as the reference fluid, except for components lighter than propane – methane, ethane and ethylene - for which the results are slightly poorer. A correction factor for non-correspondence of pure fluids is no longer needed with the propane reference fluid.

Baltatu[63] applied the extended corresponding states model to petroleum fractions with the required critical properties and acentric factor obtained using a simple characterization. For the crude oil data of Amin and Maddox[64] the reported average deviations are about 6.5%, although maximum deviations are as high as 32.7%.

Haile *et al.*[65] defined fluid *i* to be in corresponding state with fluid *o* if the two following conformal equations are satisfied

$$Z_i(P,T) = Z_o(P/q_{io}, T/f_{io}) \tag{4.126}$$

$$\eta_i(P,T) = \eta_o(P/q_{io}, T/f_{io})(M_i/M_o)^{0.5} f_{io}^{-0.167} q_{io}^{0.667} \tag{4.127}$$

where, $f_{i,o}$ is defined as

$$f_{io} = \left(T_{Ci}/T_{Co}\right)\theta_{io}\text{, and} \tag{4.128}$$

$$q_{io} = \left(P_{Ci}/P_{Co}\right)\psi_{io} \tag{4.129}$$

The above functional representation for compressibility factor ensured that the reduced *PVT* surfaces would be the same for any two substances while the functional representation of viscosity ensured that the reduced viscosity surfaces would be the same. The shape factors have been determined by solving the two functional representations simultaneously for f_{io} and q_{io}.

Haile *et al.* found that these shape factors would not usually have the same values as those found for thermodynamic properties where the residual Helmholtz free energy is used as the second conformal equation instead of viscosity.

Hwang and Whiting[66] also emphasized that the shape factors may have different values if different properties have been used in conformal solution equations. Even though equating residual Helmholtz free energies ensures that the free energy surface will be the same in reduced form for two substances, it does not ensure that the transport property surfaces will be the same. This observation is made by simply changing the second conformal equation from equating residual Helmholtz free energies to equating viscosities. Viscosity shape factors are then compared with thermodynamic shape factors and it is shown that the deviation between viscosity and thermodynamic shape factors is significant except for non-polar straight chain hydrocarbons (which are the most conformal). They modified the Ely-Hanley method by expressing the temperature (or energy shape factor) as

$$\theta_{i,o} = 1 + \left(\omega_i^{\eta} - \omega_o^{\eta}\right) f\left(T_{r,i}, V_{r,i}\right) + k/T_{r,i} \tag{4.130}$$

where ω^{η} is the viscosity acentric factor and k is the associating parameter. The form k/T_r has been used because of its ability to meet the theoretical limit at high temperatures where the hydrogen bond loses its dominance. The viscosity acentric factor apparently characterized the effects of molecular shape, orientation, internal degrees of freedom and intermolecular forces besides the hydrogen bond. The generalized correlations and coefficients of the Leach shape factors are retained, but the viscosity acentric factor is allowed to vary for polar fluids. The density (or size) shape factor correlation of the earlier model is retained. Hwang and Whiting modified the temperature (or energy) shape factor $\theta_{i,o}$, with the density (or size) shape factor $\phi_{i,o}$ unchanged because $\theta_{i,o}$ seems to have a stronger effect than $\varphi_{i,o}$ on the calculation of viscosity. They retained the Leach functional form because the function $f(T_{r,i}, V_{r,i})$ in the expression for $\theta_{i,o}$ satisfies the essential temperature behavior for viscosity that the viscosity of gas increases with temperature while the viscosity of a liquid decreases with temperature. They presented optimum values of viscosity ω^{η} and k for 38 compounds. The modified method showed significant improvement over the method of Ely and Hanley for highly branched alkanes, naphthalenes, some aromatics and various polar associating compounds with overall average absolute deviations of 5.3% and 17.6% for the modified and original methods respectively.

Monnery *et al.*[67] also concluded that viscosity prediction is more sensitive to the shape factor θ and modified the extended corresponding states method. With their generalized correlations, viscosities of 46 common hydrocarbons have been predicted with an average absolute deviation of about 6 %. Details of the method are given in Section 4.3.2.5d.

4.3.2.3.2.c Tham and Gubbins Approach

Based on the time correlation function theory, Tham and Gubbins derived a corresponding states method for the calculation of viscosity for pure monoatomic dense fluids[68] and for nonpolar polyatomic dense fluids[69]. Although the time correlation function is difficult to solve for dense fluids, it may be used as a basis for rigorous derivation of the corresponding states principle for viscosity. Such a derivation is presented by Helfand and Rice[70] based on the following assumptions:

1. the intramolecular degrees of freedom (rotation, vibration) are independent of translational degrees of freedom and density,
2. intermolecular potentials are pair wise additive, and
3. the potential energy of a pair of molecules has the form

$$\varphi = \varepsilon\, f(r/\sigma) \tag{4.131}$$

where, ε and σ are respectively the energy and distance parameters of the potential function, r is the distance and f is a universal function of the reduced distance.

The resulting generalized relationship is

$$\eta^*(T^*, V^*) = \frac{\eta\sigma^2}{(M\varepsilon)^{0.5}} \tag{4.132}$$

where, $T^* = (kT/\varepsilon)$, $V^* = V/(N_0\ \sigma^3)$ and M is the molecular mass, k is the Boltzmann constant, and N_0 is the Avogadro's number. The essential simplification for monoatomic as opposed to polyatomic fluids is that the assumption (1) given above is satisfied. Tham and Gubbins[68] compared correspondence behavior of monoatomic fluids to provide some insight and validity of this assumption. The potential parameters ε and σ are determined by fitting the values reported by different researchers from gas phase viscosity data to empirical function of the acentric factor. Good agreement over the entire temperature and density range is obtained for reduced viscosity with the data for Ne, Ar, Kr and Xe at a given pressure. Reduced viscosities at a constant reduced pressure have been fitted to the following equation with an average absolute deviation of 6 %.

$$ln\,\eta^* = a_0 + \frac{a_1}{\left(T^*\right)^2} + \frac{a_3}{\left(T^*\right)^3} + \frac{a_4}{\left(T^*\right)^4} \tag{4.133}$$

Tham and Gubbins concluded that correspondence principle for transport properties is obeyed by inert gases over the entire range of temperature and pressure for which experimental data are available. Good agreement at the highest densities shows that errors introduced by assuming additivity pair potentials are within the limits of experimental errors.

After establishing that the simple corresponding states are obeyed by monatomic molecules over the entire range of temperature and pressure, Tham and Gubbins[69] reported that the same situation is not true for polyatomic fluids at high density. This has been demonstrated by a plot of reduced viscosity η^* computed from Eq. (4.132) as a function of ($1/T^*$) at $P^* \cong 0$, using the molecular parameters defined by Tham and Gubbins[69], where $T^* = k\ T/\alpha\ \varepsilon$, k being the Boltzmann constant, T is the absolute temperature and ε the energy parameter. According to Tham and Gubbins, parameter α may be thought of as a rotational coupling coefficient. When hindered rotation is absent, as in dilute gases and monatomic fluids at all densities, $\alpha \approx 1$, while for polyatomic fluids $\alpha > 1$. Ultimately, α is a third parameter in this application of corresponding states to transport properties. The parameter α has been treated as adjustable and assumed to be approximately constant at high fluid densities. The coefficient for polyatomic fluids has been determined by fitting experimental values of saturated liquid density to the reduced viscosity for the inert gases.

$$ln\,\eta^* = a_0 + \frac{a_1}{\left(T^*\right)^2} + \frac{a_3}{\left(T^*\right)^3} + \frac{a_4}{\left(T^*\right)^4} \tag{4.134}$$

The values of α have been reported by Tham and Gubbins[69] for 25 pure fluids, including inert gas fluids, some simple diatomic molecules, paraffin's upto n- C_9, benzene, cyclopentane and cyclohexane and found that its density dependence is only small. Average absolute deviations ranged from 6 to 10 % for the 25 fluids. A plot of η^* from the equation

$$\eta^*\left(T^*, V^*\right) = \frac{\left(\eta\sigma^2\right)}{\alpha\left(M\varepsilon\right)^{0.5}} \tag{4.135}$$

versus (*1/T**) for the polyatomic fluids shows that all the values of η^* fall on a single curve.

4.3.2.3.2.d Pederson *et al.* Relations

Pedersen *et al.*[71] proposed a corresponding states approach, similar to the Ely and Hanley[61] model, for the calculation of the viscosity of hydrocarbons and crude oils, based on the method of Tham and Gubbins[69] which can be applied to both the fluid of interest (subscript x) and the reference fluid (subscript 0) and is written in terms of pressure as:

$$\eta_x(P,T) = \left(\frac{T_{Cx}}{T_{C0}}\right)^{-0.167} \left(\frac{P_{Cx}}{P_{C0}}\right)^{0.667} \left(\frac{M_x}{M_0}\right)^{0.5} \left(\frac{\alpha T_{Gx}}{\alpha T_{G0}}\right)^{-0.167} \eta_0\left(P_0^*, T_0^*\right) \tag{4.136}$$

where $$T_0^* = T\left(T_{C0}/T_{Cx}\right)\left(\alpha_{TG0}/\alpha_{TGx}\right) \tag{4.137}$$

$$P_0^* = P\left(P_{C0}/P_{Cx}\right)\left(\alpha_{TG0}/\alpha_{TGx}\right) \tag{4.138}$$

and α_{TG} is the Tham-Gubbins rotational coupling coefficient.

Pedersen *et al.*[71] described the complete details of the method and applied the methodology to the prediction of viscosity of 15 pure substances at 67 data points (for a variety of substances including carbon dioxide, normal hydrocarbons upto C_7, cyclohexane and selected aromatic hydrocarbons upto C_{15}), 12 binary mixtures (formed by variety of hydrocarbons including normal and straight chain aliphatics and benzene) at 52 data points, and several crude oils (at 111 data points) covering a viscosity values beyond 2 cP. The average absolute deviations are generally less than the other generalized methods available in the literature and are about 12%, 8% and 5%, respectively for pure fluids, binary mixtures and crude oils.

4.3.2.3.2.e Onnes Method

Onnes[72] postulated that the group

$$\left[T_C/\left(M^3P_C^4\right)\right]^{(1/6)} \tag{4.139}$$

should have the same value for all the substances when in corresponding states. As a result of their empirical study, Smith and Brown[73] found that the equation:

$$\frac{\eta}{\sqrt{M}}=f\left(T_R,P_R\right) \tag{4.140}$$

provides a good representation of the viscosity data for liquid normal paraffins. The function f is the same for all paraffins. For homologous series of associated liquids, such as ethers, acids and alcohols, Smith and Brown[73] find it necessary to modify their relationship by replacing the molecular mass M by the viscosity constant I from Souder's equation[43] as

$$\frac{\eta}{\sqrt{I}}=f\left(T_R,P_R\right) \tag{4.141}$$

Smith and Brown[73] found that the form of the function f depends on the homologous series considered. If, for example, $\left(\eta/\sqrt{I}\right)$ is plotted as a function of the reduced temperature T_R, a set of separate curves, one for each series of compounds is obtained. These curves can be used to estimate the viscosity of any compound from the knowledge of the viscosity of one of the compounds belonging to the homologous series. Generality is shown in the plots of the reduced viscosity defined as (η/η_M) where η_M refers to the viscosity at the melting temperature and $\theta = (T-T_M)/(T_C-T_M)$ for the compounds with odd and even number of carbon atoms separately even when they belong to the same series.

4.3.2.3.2.f Stiel and Thodos Method

Stiel and Thodos[74] proposed corresponding states based correlation in the form

$$\eta\xi = f(Z_C, T_R) \tag{4.142}$$

where

η is viscosity in cP,
T_R is reduced temperature ($=T / T_C$),
T_C is critical temperature in Kelvin's,
Z_C is critical compressibility factor,
ξ is $T_C^{(1/6)} / M^{(1/2)} P_C^{(2/3)}$,
M is molecular mass, and
P_C is critical pressure in atmospheres.

The relationship is graphically represented in Fig.4.13 and is useful for rapid estimation of saturated liquid viscosities in the temperatures between the normal boiling and critical temperatures.

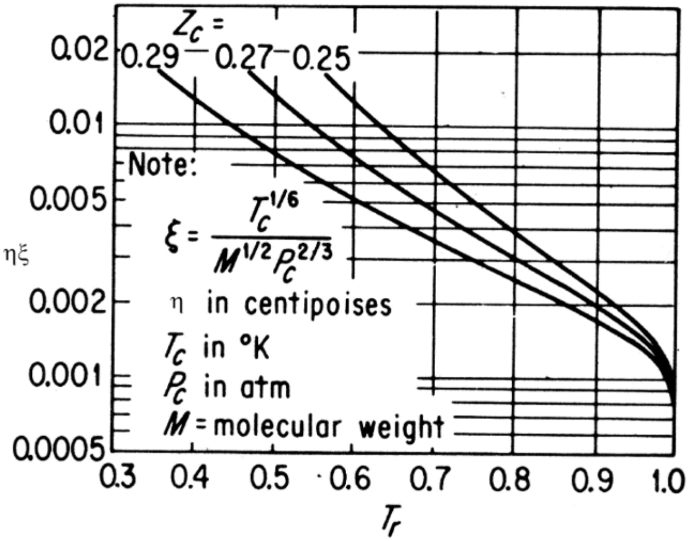


Figure 4.13. Reduced viscosity *($\eta\xi$)* as a function of T_R and Z_C (Adopted from R. C. Reid, J. M. Prausnitz, and T. K. Sherwood, *The Properties of Gases and Liquids*, McGraw-Hill, New York, 3rd Ed., 1977).

4.3.2.3.2.g Sastri and Rao Method

Sastri and Rao[75] proposed a generalized method relating liquid viscosity to the saturated vapor pressure. The relations presented by them are

$$\eta\xi = 0.0272P^{0.2} \; for \; T < T_B \tag{4.143}$$

and

$$\eta\xi = 0.1025P^{0.4} \; for \; T > T_B \tag{4.144}$$

where P is the vapor pressure at the temperature of interest and ξ is defined by Eq. (4.142). The method requires good vapor pressure data and the errors in the predicted values are often about ± 20 %.

The general form the equation can be written as:

$$\eta = AP^{-N} \tag{4.145}$$

with a sharp change at the normal boiling point. The equation at the normal boiling point is same as that of Eq. (4.97).

$$\eta = \eta_B P^{-N} \tag{4.104}$$

The values of η_B and N are found to be nearly constant for the liquids of similar nature like the members of a homologous series. This suggested a new direction for relating liquid viscosity to chemical structure. Sastri and Rao[10] proposed a group contribution method based on these ideas. The details of the group contribution method are presented earlier in this book in Section 4.3.2.3.1f.

4.3.2.3.2.h Letsou and Stiel Method

Letsou and Stiel[76] correlated the liquid viscosity data of argon, nitrogen, carbon dioxide, and ten hydrocarbons and proposed the equation

$$(\eta\xi) = (\eta\xi)^{(0)} + \omega(\eta\xi)^{(1)} \tag{4.146}$$

where $$(\eta\xi)^{(0)} = 10^{-4}\left(151.78 - 213.51T_R + 75.03T_R^2\right) \tag{4.147}$$

and $$(\eta\xi)^{(1)} = 10^{-4}\left(425.59 - 767.50T_R + 340.07T_R^2\right) \tag{4.148}$$

where $$\xi = \frac{T_C^{(1/6)}}{M^{(1/2)}P_C^{(2/3)}} \tag{4.149}$$

T_C is the critical temperature in Kelvin, P_C the critical pressure in atmosphere, M is the molecular mass and ω is the acentric factor.

4.3.2.3.2.i Two Fluid Approach of Teja and Rice

Based on the two fluid approach, Teja and Rice[77] proposed the relation:

$$ln(\eta\xi_{TR}) = ln(\eta\xi_{TR})^{r1} + \left[\frac{(\omega - \omega^{r1})}{(\omega^{r2} - \omega^{r1})}\right]\left[(ln\,\eta\xi_{TR})^{r2} - (ln\,\eta\xi_{TR})^{r1}\right] \tag{4.150}$$

where $$\xi_{TR} = \frac{V_C^{(2/3)}}{(MT_C)^{(1/2)}} \tag{4.151}$$

They correlated the reference fluid viscosities with an Andrade type equation

$$ln(\eta\xi) = A + (B/T_R) \tag{4.152}$$

Teja *et al.*[78] restated the Teja-Rice method in terms of P_C instead of V_C with the reducing parameter described as

$$\xi_{TR} = \frac{T_C^{0.167}}{\left(M^{0.5}P_C^{0.667}\right)} \tag{4.104}$$

Aasberg-Petersen *et al.*[79] proposed a method based on the Teja-Rice approach, using molar mass (instead of the acentric factor) as the third parameter.

4.3.2.3.2.j Okeson and Rowley Method

The extended Lee-Kesler method, proposed by Okeson and Rowley[80] can be viewed as a perturbation about a spherically symmetric reference fluid in terms of a size/shape parameter (α) and a polar parameter (β) resulting in a four parameter corresponding state method. Okeson and Rowley[80] based 'α'

on the radius of gyration 'r' to avoid inclusion of polar contributions. However, in view of the success of acentric factor in correlating non-polar fluid properties, 'α' has been chosen as 'ω' for non-polar fluids, which has been accomplished by correlating the acentric factor for eighty non-polar fluids as a function of 'α'.

The equation is given by:

$$\alpha = 7.7706 \times 10^{-4} + 0.0330r + 0.01506r^2 - 9.997 \times 10^{-4} r^3 \tag{4.153}$$

The equation correlates α for all fluids, but gives values of α equal to ω only for non-polar fluids. For polar fluids α and ω may differ considerably. According to the authors, liquid density is a good indicator of polarity interactions. Values of β are calculated from a single density value in terms of the compressibility factor Z to give

$$\beta = \frac{\left[(Z - Z_o) - \alpha(Z_1 - Z_o)/\alpha_1\right]}{\left(Z_2 - Z_2^*\right)} \tag{4.154}$$

where, $$Z_2^* = \frac{Z_o + \alpha_2(Z_1 - Z_o)}{\alpha_1} \tag{4.155}$$

Values of α and β for many fluids have been tabulated by Wilding and Rowley[81].

The final expression for viscosity is

$$(\eta\xi) = (\eta\xi)^{(0)} + \alpha(\eta\xi)^{(1)} + \beta(\eta\xi)^{(2)} \tag{4.156}$$

where $\eta\xi$ is the reduced viscosity and ξ is equal to $(1/\eta^*)$ wherein η^* is to be calculated from an appropriate equation.

4.3.2.3.2.k Application of Molar Polarization and Additional Parameter

Prabhakar *et al.*[82] proposed a simple generalized correlation for liquid viscosity based on the use of the constituents of molar polarization at the critical temperature, which are R_M (molar refraction, an additive and constitutive property) and P_P $(=4\pi N\mu^2/9kT_C)$ as the characteristic parameters. This provided an approximate equation for estimation of liquid viscosity.

$$log\, \eta_R = 0.01R_M + 0.005P_P - 0.63 - 2.8T_R \tag{4.157}$$

In this equation,

R_M is the molar refraction (which can be calculated from the atomic and structural contributions available in the literature),
η_R is the reduced viscosity $\left(= \eta / \left(P_C^{0.667} M^{0.5} / T_C^{0.167}\right)\right)$,
P_P is the polar contribution to molar polarization $(= 4\pi N\mu^2 / 9kT_C)$,
μ is the dipole moment in Debyes,
T_R is the reduced temperature $(= T / T_C)$,
T is the temperature of interest in K,
T_C is the critical temperature in K,
P_C is the critical pressure in atm,
M is the molecular mass,
N is the Avogadro's number, and
k is the Boltzmann constant.

The method has been shown to represent the liquid viscosity of several substances to about the same average absolution deviation as the methods of the same complexity available in the literature.

4.3.2.3.2.l Yucel and Ozdogan Relation

Yucel and Ozdogan[83] proposed a semi-theoretical method based on Enskog's hard sphere theory for dense fluids and the principle of corresponding states. Viscosities of a total of 75 organic liquids (37 acyclic and 38 cyclic hydrocarbons) could be represented to good accuracy in the reduced temperature range of 0.45 to 0.8.

Based on the van der Waals model of real fluid and Enskog's hard sphere theory the dynamic viscosity of monoatomic liquid can be written as

$$\eta_m = 4y\eta_0\left[\frac{1}{Z-1} + 0.8 + 0.761(Z-1)\right] \tag{4.158}$$

where Z is the hard sphere compressibility factor, η_0 is the viscosity of the dilute mono-atomic gas (Pa.s), $y = (\pi N_0 \sigma^3 \rho/6)$, with N_0 as the Avogadro's number, σ as the hard sphere diameter (m) and ρ as the molar density (kmol/m^3).

The parameters Z, η_0, and σ are given by the following expressions.

$$Z = \frac{\left(1 + y + y^2 + y^3\right)}{(1-y)^3} \tag{4.159}$$

$$\eta_0 = \frac{2.6693 \times 10^{-5} (MT)^{(0.5)}}{\sigma^2} \tag{4.160}$$

$$\sigma = \left(\frac{6V_C}{\pi N_0} \right)^{(1/3)} (0.549058 - 0.010827 T_R) \tag{4.161}$$

where T is the absolute temperature (K), M is the molar mass (kg/kmol), V_C is the critical volume (m^3/kmol), and T_R is the reduced temperature (T/T_C). For simple mono-atomic liquids, dynamic viscosities at any temperature and pressure can be calculated from the above equations from the knowledge of the critical properties, molar mass and molar density.

The method can be extended to the dynamic viscosity of polyatomic liquids through the equation

$$\eta^* (T_R, P_R, \alpha) = \eta_m^* (T_R, P_R) + \eta_f^* (T_R, P_R, \alpha) \tag{4.162}$$

in which η_m^* is the reduced dynamic viscosity of a hypothetical simple monoatomic liquid and η_f^* is a correction term which employs a third parameter α to account for the factors effecting viscosity of polyatomic liquids.

Neglecting the effect of pressure on dynamic viscosity, for conditions near atmospheric pressure, Eq. (4.162) can be written as

$$\eta^* (T_R, \alpha) = \eta_m^* (T_R) + \eta_f^* (T_R, \alpha) \tag{4.163}$$

where $$\eta_m^* = 10^{-9} \left[6.7994 - 8.7599 T_R + 2.8158 T_R^2 \right] \tag{4.164}$$

The dynamic viscosity data of the 75 selected organic compounds belonging to the four classes: alkanes, alkenes, aromatics and cycloalkanes are separately represented in the form

$$log\,\eta^* = log\left[\frac{\eta T_C^{0.167}}{M^{0.5} P_C^{0.667}} \right] = -A + \left(\frac{B}{T_R} \right) \tag{4.165}$$

which reproduced the experimental data well. The constants A and B for the selected compounds are given in Table 4.40.

Table 4.40. Constants of the reduced dynamic viscosity equation for selected liquids given by Eq. (4.165): $\log\eta^* = \log\left[\eta T_C^{0.167} / M^{0.5} P_C^{0.667}\right] = -A + (B/T_R)$.

Substance	***Temperature Range, K***	***A***	***B***
Alkanes			
n - Butane	183.15 to 268.15	5.1420	0.6264
n - Pentane	148.15 to 308.15	5.2168	0.6715
2 - Methyl butane	223.15 to 298.15	5.3925	0.7907
2 - Methyl pentane	178.15 to 338.15	5.2549	0.7214
3 - Methyl pentane	273.75 to 313.15	5.3343	0.7727
n - Heptane	183.15 to 368.15	5.3609	0.8058
2 - Methylhexane	273.15 to 361.55	5.3460	0.7870
n - Octane	218.15 to 398.15	5.3601	0.8285
n - Nonane	223.15 to 423.15	5.4240	0.8859
n - Decane	248.15 to 443.15	5.4234	0.9070
n - Un decane	248.15 to 468.15	5.4668	0.9480
n – Do decane	268.15 to 488.15	5.4566	0.9585
n – Tri decane	268.15 to 508.15	5.4829	0.9871
n – Tetra decane	283.15 to 523.15	5.4755	0.9932
n - Penta decane	283.15 to 543.15	5.4885	1.0167
n – Hexa decane	293.15 to 558.15	5.4769	1.0250
n – Hepta decane	298.15 to 573.15	5.4692	1.0349
n – Octa decane	303.15 to 588.15	5.4653	1.0411
n – Nona decane	308.15 to 598.15	5.4497	1.0494
n - Eicosane	313.15 to 613.15	5.4508	1.0573
Alkenes			
But – 1 - ene	158.15 to 238.15	5.1782	0.6108
Pent - 1 - ene	183.15 to 273.15	5.2436	0.6568
Hex – 1 - ene	218.15 to 333.15	5.3066	0.7092
Hept – 1 - ene	273.15 to 363.15	5.2165	0.6867
Oct – 1 - ene	273.15 to 388.15	5.2632	0.7394
Non – 1 - ene	273.15 to 388.15	5.3091	0.7927
Dec – 1 - ene	273.15 to 388.15	5.3576	0.8418
Un dec – 1 - ene	273.15 to 388.15	5.4050	0.8893
Do dec – 1 - ene	273.15 to 388.15	5.4625	0.9356
Tri dec - 1 - ene	273.15 to 388.15	5.4954	0.9725
Tetra dec – 1 - ene	273.15 to 388.15	5.5304	1.0099
Penta dec - 1 - ene	273.15 to 388.15	5.5768	1.0483
2 – Methyl butyl – 2 -ene	273.15 to 305.75	5.2755	0.6866
2 – Methyl butyl -1,3 – diene	273.15 to 303.15	5.3113	0.6794
Hexa dec – 1 – ene	278.15 to 388.15	5.5820	1.0689
Octa dec - 1 – ene	293.15 to 388.15	5.5804	1.1040
Aromatics			
Benzene	283.15 to 353.15	5.6385	0.9586
Toluene	248.15 to 383.15	5.4259	0.7949
Ethyl benzene	248.15 to 353.15	5.3664	0.7684
1,2 – Di methyl benzene	268.15 to 413.15	5.4288	0.8133
1,3 – Di methyl benzene	273.15 to 408.15	5.3346	0.7363
1,4 – Di methyl benzene	288.15 to408.15	5.3774	0.7669
n – Propyl benzene	248.15 to 423.15	5.4303	0.8252

Substance	***Temperature Range, K***	***A***	***B***
Iso propyl benzene	273.15 to 333.15	5.4391	0.8193
n - Butyl benzene	248.15 to 423.15	5.4612	0.8530
n – Pentyl benzene	253.15 to 423.15	5.5685	0.9337
n - Hexyl benzene	253.15 to 423.15	5.6224	0.9791
n – Heptyl benzene	253.15 to 423.15	5.6654	1.0166
n - Octyl benzene	253.15 to 423.15	5.7249	1.0605
n – Nonyl benzene	253.15 to 423.15	5.7824	1.1027
n – Decyl benzene	258.15 to 423.15	5.7961	1.1211
n – Undecyl benzene	263.15 to 423.15	5.8135	1.1422
n – Do decyl benzene	273.15 to 423.15	5.7994	1.1470
n – Tri decyl benzene	278.15 to 423.15	5.8235	1.1681
n - Tetra decyl benzene	288.15 to 423.15	5.8183	1.1777
n – Penta decyl benzene	293.15 to 423.15	5.8421	1.1988
n - Hexa decyl benzene	303.15 to 423.15	5.8406	1.2068
Cyclo alkanes			
Cyclo pentane	248.15 to 318.15	5.3179	0.7950
Methyl cyclo pentane	248.15 to 318.15	5.3564	0.8260
Ethyl cyclo pentane	253.15 to 373.15	5.2837	0.7618
n – Propyl cyclo pentane	253.15 to 383.15	5.2566	0.7543
n - Hexyl cyclo pentane	253.15 to 383.15	5.4265	0.9287
n – Heptyl cyclo pentane	253.15 to 383.15	5.4525	0.9622
n - Octyl cyclo pentane	253.15 to 383.15	5.4899	1.0007
n – Nonyl cyclo pentane	253.15 to 383.15	5.5262	1.0329
n - Decyl cyclo pentane	253.15 to 383.15	5.5571	1.0647
n – Do decyl cyclo pentane	268.15 to 383.15	5.6536	1.1374
n – Tri decyl cyclo pentane	278.15 to 383.15	5.7001	1.1713
Cyclo hexane	283.15 to 353.15	5.8156	1.1815
Methyl cyclo hexane	248.15 to 373.15	5.5030	9.9261
Ethyl cyclo hexane	248.15 to 383.15	3.3405	0.8320
n – Propyl cyclo hexane	248.15 to 383.15	5.4061	0.8589
n - Butyl cyclo hexane	253.15 to 383.15	5.5111	0.8956
n – Decyl cyclo hexane	273.15 to 383.15	5.8822	1.2329

In order to use Eq. (4.163), the values of η_f* are obtained using the available experimental data for the different groups of substances and the relation

$$\eta_f^* = \eta^* - \eta_m^* \tag{4.166}$$

The values of η_f*, thus obtained are correlated with reduced temperature T_R or reduced normal boiling temperature T_{BR}. The resulting relations are

$$\frac{\eta_f^*(T_R, \alpha_i)}{\eta_f^*(0.5, \alpha_i)} = f(T_R) \tag{4.167}$$

η_f^* can be expressed as $\eta_f^*(T_R,\alpha)=\eta'_f(T_R)\eta''_f f(\alpha)$ (4.168)

The reduced normal boiling temperature (T_{BR}) has been found to be a good characterizing parameter. Finally the following empirical equations resulted.

For normal and iso-alkanes:

$$\eta'_f(T_R)=0.0271T_R^{-5.2846} \tag{4.169}$$

$$\eta''_f(T_{BR})=10^{-9}\left[-130.53+720.48T_{BR}-1329T_{BR}^2+825.06T_{BR}^3\right] \tag{4.170}$$

For alkanes and alkadienes :

$$\eta'_f(T_R)=0.02051T_R^{-5.6132} \tag{4.171}$$

$$\eta''_f(T_{BR})=10^{-9}\left[17.929+136.36T_{BR}-573.47T_{BR}^2+502.25T_{BR}^3\right] \tag{4.172}$$

For cyclic hydrocarbons:

$$\eta'_f(T_R)=0.0103T_R^{-6.5398} \tag{4.173}$$

$$\eta''_f(T_{BR})=10^{-9}\left[268.53-1064.5T_{BR}+1349T_{BR}^2-522.17T_{BR}^3\right] \tag{4.174}$$

For cycloalkanes:

$$\eta'_f(T_R)=0.0205T_R^{-5.6472} \tag{4.175}$$

$$\eta''_f(T_{BR})=10^{-9}\left[883.63-3469.6T_{BR}+4445.2T_{BR}^2-1823.7T_{BR}^3\right] \tag{4.176}$$

The methodology described gave good results for the groups of compounds mentioned subject to the availability of the input data needed for the application of the relevant equations.

4.3.2.3.2.m Lee and Wei Approach

Lee and Wei[84] proposed a corresponding states model applicable to the calculation of the viscosity of liquids using oxygen (r1), octane (r2) and water (r3) as three reference fluids. The corresponding states model based on three reference fluids can be written as:

$$\begin{aligned}\eta_R(T_R,P_R)&=\eta_R^{r1}+\frac{\alpha-\alpha^{r1}}{\alpha-\alpha^{r2}}\left[\eta_R^{r2}-\eta_R^{r1}\right]\\&+\beta^*\left[\eta_R^{r3}-\left(\eta_R^{r1}+\frac{\alpha-\alpha^{r1}}{\alpha-\alpha^{r2}}\right)\left(\eta_R^{r2}-\eta_R^{r1}\right)\right]\end{aligned} \tag{4.177}$$

$$\text{with } \eta_R=ln\left(\frac{\eta}{\eta^*}+1\right);\ \eta^*=\frac{M^{(1/2)}P_C^{(2/3)}}{(RT_C)^{(1/6)}N^{(1/3)}} \tag{4.178}$$

$$T_R=T/(T_C\theta);\ P_R=(P/P_C);\ \beta^*=\left(\beta/\beta^{r3}\right) \tag{4.179}$$

where N is the Avagadro's number and the parameters are: α (radius of gyration), θ (energy correction factor) and β^* (an empirical dimensionless polar/association parameter relative to water) that characterize the size/shape and polar/hydrogen-bonding effects.

As already mentioned, the reference fluids selected are : oxygen, octane, and water. The reduced viscosity of the chosen reference fluids can be expressed as :

$$\eta_R^{(i)}=A_0+(A_1/T_R)+A_2T_R+A_3T_R^2+A_4P_R+A_5P_R^{0.5}+A_6T_RP_R \tag{4.180}$$

with the value of the parameter θ as unity. The coefficients of the equation for the reference fluids (chosen) are listed in Table 4.41.

Table 4.41. Coefficients of the reduced viscosity equation (Eq. 4.180) for the selected reference fluids, Eq. (4.180): $\eta_R^{(i)} = A_0 + (A_1/T_R) + A_2T_R + A_3T_R^2 + A_4P_R + A_5P_R^{0.5} + A_6T_RP_R$.

Substance	***Oxygen***	***Octane***	***Water***
A_0	- 6.6572	- 5.1080	- 44.7450
A_1	2.6327	2.72726	10.4698
A_2	11.4927	9.1402	75.4262
A_3	- 6.4140	- 5.5270	- 43.846
A_4	0.00392	- 0. 03138	- 0.05814
A_5	0.0092	0.0144	0.0013
A_6	0.0910	0.0883	0.1203

The method provides for the calculation of the dynamic viscosity from a knowledge of the model parameters (T_C, P_C, α, θ and β^*). While θ can be estimated from the following equation with the coefficients given for each class of compounds, β^* has to be calculated from a knowledge of the viscosity of the fluid at one known temperature and pressure.

$$\theta = B_0 + (B_1/Z_C) + B_2T_C^{0.5} \tag{4.181}$$

where Z_C is the critical compressibility factor and T_C is the critical temperature in K. The coefficients of Eq. (4.181) for different classes of organic compounds are given in Table 4.42.

Table 4.42. Coefficients of the generalized equation (Eq. 4.181) for θ for different classes of substances, Eq. (4.181): $\theta = B_0 + (B_1/Z_C) + B_2T_C^{0.5}$.

Substance Class	B_0	B_1	B_2
Alkanes	1.1403	- 0.1163	0.01366
Alkenes	0.6985	0.10294	- 0.00513
Alicyclics	3.2093	- 0.47549	- 0.01465
Alkylbenzenes	2.2787	- 0.34340	-
Alkylhalides	0.4126	-	0.03202
Alcohols	5.2358	- 0.30248	- 0.11702
Ethers	0.6162	0.10376	-
Ketones	0.8327	0.04327	-
Carboxylic acids	1.1199	0.00584	-
Esters	1.5208	- 0.11563	-
Nitriles, Amines, etc.	2.2758	- 0.00428	- 0.04924
Benzene derivatives	0.2938	0.18358	-

Pure liquid viscosities are predicted with an average absolute deviation of about 5 to 7%, depending on the types of substances and the temperature and pressure conditions.

4.3.2.4 Gas Viscosity Estimation Methods Recommended for Liquids

The following are some other corresponding states based methods for gas viscosities recommended for liquid viscosity estimation within the density limits of applicability.

4.3.2.4.1 Golubev Approach

Golubev[85] proposed the following equations for the estimation of gas viscosity

$$\eta = \eta_C^* T_R^{0.965} \qquad \text{for } T_R < 1 \qquad (4.182)$$

$$\eta = \eta_C^* T_R^{[0.71+(0.29/T_R)]} \text{, otherwise} \qquad (4.183)$$

$$\eta_C^* = 3.5\left[M^{(1/2)} P_C^{(2/3)} / T_C^{(1/6)}\right] \qquad (4.184)$$

4.3.2.4.2 Thodos *et al.* Equations

Thodos and coworkers[86-88] proposed the following expressions for calculating liquid viscosities that were based on gas viscosity models, and are presented below.

For Nonpolar Gases:

$$\eta\xi = 4.610 T_R^{0.618} - 2.04 e^{-0.449} T_R + 1.94 e^{-4.058} T_R + 0.1 \qquad (4.185)$$

For Hydrogen Bonded Type Polar Gases:

$$\eta\xi = (0.755 T_R - 0.055) Z_C^{-5.4} \qquad \text{for } T_R < 2.0 \qquad (4.186)$$

For Non-hydrogen Bonded Type Polar Gases:

$$\eta\xi = (1.90 T_R - 0.29)^{4.5} Z_C^{-2.3} \qquad \text{for } T_R < 2.5 \qquad (4.187)$$

where $\xi = T_C^{(1/6)} M^{(-1/2)} P_C^{(-2/3)}$, and (4.188)

Z_C is the critical compressibility factor.

4.3.2.4.3 Reichenberg Method

Reichenberg[89] method involved correction of the dilute gas viscosity (low pressure viscosity) for the effect of pressure at the same temperature by relating the ratio of the viscosity of the dense gas to the viscosity of the dilute gas at the same temperature to a function of pressure and temperature. The resulting equation was:

$$\frac{\eta}{\eta_0} = f(P_R, T_R) = 1 + \frac{Q\left(AP_R^{1.5}\right)}{BP_R + \left(1 + CP_R^D\right)^{-1}} \tag{4.189}$$

where

$$A = \left(\frac{1.9824 \times 10^{-3}}{T_R}\right) exp\left(5.2683 T_R^{-0.5767}\right) \tag{4.190}$$

$$B = A\left(1.6552 T_R - 1.2760\right) \tag{4.191}$$

$$C = \left(0.1319 / T_R\right) exp\left(3.7035 T_R - 79.8678\right) \tag{4.192}$$

$$D = \left(2.9496 / T_R\right) exp\left(2.9190 T_R^{-16.6169}\right) \tag{4.193}$$

$$Q = 1 - 1.5665 \mu_R \text{, and} \tag{4.194}$$

$$\mu_R = 52.46 \mu^2 \left(P_C / T_C^2\right) \tag{4.195}$$

where μ is the dipole moment in debyes, P_C is the critical pressure in bars and T_C is the critical temperature in Kelvin.

4.3.2.4.4 Jossi *et al.* Relation

Based on the dimensional analysis, Jossi *et al.*[90] derived the following relationship for calculating viscosity.

$$[\eta(P,T)-\eta_0(T)]\xi_T = f(\rho_R) \tag{4.196}$$

where ξ_T has the same meaning as that for dilute gases. They noted that the experimental data ranging from the dense gas to the liquid phase for 11 relatively non-polar substances fell essentially on a single curve, which has been fitted to the following equation for $0.1 < \rho_R < 3.0$

$$\begin{aligned}\left[(\eta-\eta_0)\xi+10^{-4}\right]^{0.25} &= 0.10230+0.023364\rho_R+0.058533\rho_R^2 \\ &\quad -0.040758\rho_R^3+0.009332\rho_R^4\end{aligned} \tag{4.197}$$

In an extension of the approach to polar substances, Stiel and Thodos[91] regressed the experimental data for 14 fluids and obtained the following equations

$$(\eta-\eta_0)\xi_T = 16.56\times10^{-5}\rho_R^{1.111} \qquad \mathit{for}\ \rho_R \le 0.10 \tag{4.198}$$

$$(\eta-\eta_0)\xi_T = 0.607\times10^{-5}\left[9.045\rho_R+0.63\right]^{1.739} \quad \mathit{for}\ \rho_R \le 0.90 \tag{4.199}$$

$$\begin{aligned}\mathit{log}\left[-\mathit{log}\{(\eta-\eta_0)\xi_T\}\right] &= 0.6439-0.1005\rho_R-\Delta \\ &\qquad \mathit{for}\ 0.90 \le \rho_R \le 2.6\end{aligned} \tag{4.200}$$

where

$$\Delta = 0 \qquad \text{for } 0.9 \le \rho_R \le 2.2 \tag{4.201}$$

$$\Delta = 4.75\times10^{-4}\left[\rho_{\mathrm{R}}^3-10.65\right]^2 \qquad \text{for } 2.2 \le \rho_R \le 2.6 \tag{4.202}$$

4.3.2.5 Potential Parameter Approaches

Several investigators developed methods for the estimation of viscosity of liquids based on potential parameters. Some of them are described in the following sections.

4.3.2.5a Bondi's Approach

From the considerations of the molecular theory, Bondi[92] suggested the relationship:

$$\eta^* \sim exp\left(1/T^*\right) = \eta\, r_0^2 \,/\left(m\varepsilon\right)^{1/2} \tag{4.203}$$

with $T^* = kT/\varepsilon$, r_0 is the inter molecular distance in cm at which the intermolecular potential is a minimum, ε is the minimum value of the potential energy in ergs and m (= M/N) is the mass of the molecule in grams. The representation is valid for several series of compounds including n-paraffinic, iso-paraffinic, naphthalenic and aromatic hydrocarbons, and ethers.

4.3.2.5b Malek and Stiel Relation

Malek and Stiel[93] proposed the following alternate forms for $\eta^*\xi$ for polar gases in terms of acentric factor ω and the Stiel's polar factor X.

The viscosity of a polar gas represented by the Stockmayer potential model can be written as

$$\eta^* = 2.669 \times 10^{-3} \frac{\sqrt{MT}}{o^2\, \Omega^{(2,2)*}\left(T^*, \Delta^*\right)} \tag{4.204}$$

where $T^* = \left(kT/\varepsilon\right)$ and $\Delta^* = 0.5\left(\mu^2/\varepsilon\, \sigma^3\right)$. Tables of $\Omega^{(2,2)*}$ as a function of T^* and Δ^* are available[94]. For polar fluids, the dimensionless parameters can be related to the macroscopic parameters ω and X through vapor pressure by the following equations

$$\omega = -1.0 - \log P_R \Big|_{T_R = 0.7} \tag{4.205}$$

$$X = 1.552 + 1.70\omega + \log P_R \Big|_{T_R = 0.6} \tag{4.206}$$

$\eta^*\xi$ is a function of T_R, ω and X, where η^* is the viscosity of gas at atmospheric pressure in cP, $\xi = T_C^{(1/6)}/\left[M^{(1/2)}P_C^{(2/3)}\right]$, $T_R = \left(T/T_C\right)$, T is the temperature of interest, and T_C is the critical temperature in K, P_C is the critical pressure in atmospheres, M is the molecular mass, ω the acentric factor and X is Stiel's polar factor.

The Stockmayer force constants (ε/k) and σ can be related to ω and X in the form

$$\begin{aligned}\sigma^* = \sigma\left(P_C/T_C\right)^{1/3} = 2.3454 + 0.2972\omega - 40.4271X \\ +61.7657\omega X - 15.8248X^2 - 0.9706\omega^2\end{aligned} \tag{4.207}$$

$$\begin{aligned}U^* = \left(\varepsilon/kT_C\right) = 0.8082 - 0.04504\omega - 27.3866X^2 \\ -48.9402\omega X - 48.7293X^2 + 0.8784\omega^2\end{aligned} \tag{4.208}$$

$$\Delta^* = 0.5\left(\mu^2/\varepsilon\sigma^3\right) = 86.0405X + 131.6080\omega X + 90.8009X^2 \tag{4.209}$$

4.3.2.5c Chung *et al.* Method

Chung *et al.*[95] presented generalized correlations in terms of potential parameters for the estimation of dilute gas viscosity as well as for the dense fluids (applicable for liquids as well). Their starting point was the Chapman and Enskog theory, written as:

$$\eta_0 = \left(26.69\times10^{-6}\right)\left[\frac{\left(MT\right)^{0.5}}{\sigma^2\Omega^*}\right] \tag{4.210}$$

where η_0 is the viscosity in poise, M is the molecular mass in g/mol, T is the absolute temperature in Kelvin, σ is the potential distance parameter in Angstroms and Ω^* is the reduced collision integral which depends on the chosen intermolecular potential. They used

$$\left(\varepsilon/k\right) = \left(T_C/1.2593\right) \tag{4.211}$$

$$\sigma = 0.809V_C^{(1/3)} \tag{4.212}$$

where (ε/k) and T_C are in Kelvin, σ in Angstroms, and V_C in cm^3/mol. Combining these equations with the Lennard-Jones Potential Energy function,

$$\psi(r) = 4\varepsilon\left[(\sigma/r)^{12} - (\sigma/r)^{6}\right], \text{ and} \tag{4.213}$$

$$T^* = 1.2593 T_R \tag{4.214}$$

The final expression proposed by Chung *et al.*[95] became,

$$\eta = 40.785 \times 10^{-5} F_C \frac{(MT)^{1/2}}{V_C^{(2/3)} \Omega^*} \tag{4.215}$$

where η is viscosity in μP
M is molecular weight in g/mol
T is temperature in K
V_C is critical volume, cc/mol, and
Ω_V is viscosity collision integral from the Neufeld *et al.*[96] equation, which is given by

$$\Omega^* = \frac{A}{T^{*B}} + \frac{C}{exp(DT^*)} + \frac{E}{exp(FT^*)} + GT^{*B}\, sin(ST^{*W} - H) \tag{4.216}$$

where A=1.16145, B=0.14874, C=0.52487, D=0.77320, E=2.16178, F=2.43787, G= -6.435x10^{-4}, H=7.27371, S=18.0323 and W = -0.76830. The dimensionless temperature T^* is related to the potential energy parameter (ε) and Boltzmann's constant (k) by

$$T^* = kT/\varepsilon \tag{4.217}$$

with

$$T^* = 1.2593 T_R, \text{ and} \tag{4.218}$$

$$F_C = 1 - 0.2756\,\omega + 0.059035 \mu_R^4 + \kappa \tag{4.219}$$

where ω is the acentric factor and κ is a correction factor for hydrogen bonding effect of associating substances such as alcohols, acids and water. The values of the factor κ for some important substances are noted in Table 4.43.

Table 4.43.The parameter (κ) for some important substances.

Compound	κ	***Compound***	κ
Methanol	0.215175	1-Pentanol	0.121555
Ethanol	0.174823	1-Hexanol	0.114230
1 - Propanol	0.143453	1-Heptanol	0.108674
2 - Propanol	0.143453	Acetic acid	0.091549
1 - Butanol	0.131671	Water	0.075908
2 – Methyl – 1 - propanol	0.131671		

The term μ_R is a dimensionless dipole moment defined as:

$$\mu_R = 131.3 \frac{\mu}{(V_C T_C)^{1/2}} \tag{4.220}$$

The above equations are applicable only to simple molecular gases such as argon and methane. To extend to polyatomic molecular gases, the viscosity calculated from the above equation has to be multiplied by a factor F_C to account for the molecular structure and polar effects. The following equations are also useful in the application of this method.

$$\sigma = 0.809 V_C^{(1/3)} \tag{4.221}$$

$$(\varepsilon / k) = (T_C / 1.2593) \tag{4.222}$$

where (ε/k) and the critical temperature T_C are in Kelvin, σ is in Angstrom, and the critical volume (V_C) is in cm^3/mol .

For dense fluids, the equation is extended to account for the effects of temperature and pressure by developing an empirically correlated function of density and temperature as shown below.

$$\eta = \eta_K + \eta_P \tag{4.223}$$

The viscosity is expressed in Poise.

$$\eta_K = \eta_0 \left[\frac{1}{G_2} + A_6 Y \right] \qquad (4.224)$$

$$\eta_P = \left[36.344 \times 10^{-6} - \frac{\left(M T_C \right)^{(1/2)}}{\left(V_C \right)^{(2/3)}} \right] A_7 Y^2 G_2 \exp\left[A_8 + \frac{A_9}{T^*} + \frac{A_{10}}{T^{*2}} \right] \qquad (4.225)$$

$$\text{where, } Y = \rho\ V_C / 6\,;\ G_1 = \frac{(1.0 - 0.5Y)}{(1 - Y)^3} \qquad (4.226)$$

$$G_1 = \frac{\left[\frac{A_1}{y} \left[1 - \exp\left(-A_4 Y \right) \right] + A_2 G_1 \exp\left(A_4 Y \right) + A_3 G_1 \right]}{\left(A_1 A_4 + A_2 + A_3 \right)} \qquad (4.227)$$

η_0 is the viscosity of the low-pressure gas given by Eq. 4.210 which accounts for the associating effects of hydrogen bonding. The constants A_1 to A_{10} are linear functions of the acentric factor (ω), the reduced dipole moment (μ_R) and the association factor (κ) in the form:

$$A_i = a_0(i) + a_1(i)\omega + a_2(i)\mu_R + a_3(i)\kappa \quad i = 1 \text{ to } 10 \qquad (4.228)$$

The values of a_0, a_1, a_2 and a_3 are given in Table 4.44. The constants a_0 and a_1 are determined from the viscosity data on non-polar fluids, while a_2 and a_3 are determined from the viscosity data on polar and associating fluids by regression. The first two terms are included for non-polar fluids while the third term is included for polar fluids and the fourth term is needed for hydrogen bonding substances.

Table 4.44. Constants to be used for the generalized viscosity equation proposed by Chung et al., Eq. (4.228): $A_i = a_0(i) + a_1(i)\omega + a_2(i)\mu_R + a_3(i)\kappa \quad i = 1 \text{ to } 10$.

(i)	*a_0(i)*	*a_1(i)*	*a_2(i)*	*a_3(i)*
1	6.32402	50.41190	- 51.68010	1189.02
2	0.0012102	0.0011536	- 0.0062571	0.0037283
3	5.28346	254.2090	- 168.481	3898.27
4	6.62263	38.09570	- 8.46414	31.4178
5	19.7454	7.63034	- 14.35440	31.52670
6	- 1.89992	- 12.53670	4.98529	- 18.15070
7	24.2745	3.44945	- 11.29130	69.34660
8	0.79716	1.11764	0.012348	- 4.11661
9	- 0.23816	0.067695	- 0.81630	4.02528
10	0.068629	0.34793	0.59256	- 0.72663

G_2 approaches unity as density approaches zero and sharply increases with density at higher values. At the limiting value of low density, the η_P term is negligible while at extremely high density, η_κ is small and η_P is the major contributor. The viscosity equation proposed by Chung *et al.*[95] is applicable to the entire *PVT* region.

A modified form of the Chung *et al.* equation is proposed by Brule and Starling[97] expressing viscosity as follows.

$$\eta = \text{viscosity} = \left[26.693\sqrt{\{M(\varepsilon/k)\}/\sigma^2}\right]\eta^* \text{ in micropoise} \qquad (4.229)$$

$$\eta^* = \text{reduced viscosity} = \eta^*_\kappa + \eta^*_\Phi \qquad (4.230)$$

$$\eta^*_\kappa = \text{kinetic contribution to reduced viscosity}$$
$$= \eta^*_0\left[E_6 y + \frac{1}{G_n(y)}\right] \qquad (4.231)$$

$$\eta^*_\Phi = \text{potential contribution to reduced viscosity}$$
$$= E_7 y_2\left[G_n(y)\right]\exp\left[E_8 + \left(E_9/T^*\right) + \left(\frac{E_{10}}{T^{*2}}\right)\right] \qquad (4.232)$$

$$\eta_0^* = \text{dilute gas contribution to reduced viscosity} \\ = E_0 \eta_{CE}^* \tag{4.233}$$

$$\eta_{CE}^* = \text{Chapman-Enskog relation for dilute gases} \\ = \sqrt{\left(T^*\right)/\Omega^{(2,2)*}} \tag{4.234}$$

$$G_n\left(y\right) = \frac{\left[\frac{E_1}{y}\left[1 - exp\left(-E_4 y\right)\right] + E_2 G\, exp\left(E_5 y\right) + E_3 G\right]}{\left[E_1 E_4 + E_2 + E_3\right]} \tag{4.235}$$

where y is the reduced density number defined as

$$y = \left(\frac{\pi}{6}\right)\rho^* = 0.318\frac{\pi}{6}\frac{\rho}{\rho_C} \tag{4.236}$$

ρ is the molar density calculated from for example modified BWR equation of state, and ρ_C is the critical density.

The viscosity correlation parameter E_i is calculated as a function of the orientation parameter γ using the relation:

$$E_i = a_i + b_i \gamma_i \tag{4.237}$$

and the universal constants a_i and b_i given in Table 4.45.

Table 4.45. Universal Constants ai and bi for obtaining the parameters Ei for the Brule and Starling viscosity correlation, Eq. (4.237): $E_i = a_i + b_i \gamma_i$.

(i)	***a_i***	***b_i***
0	1.0	- 0.2756
1	17.4499	34.0631
2	- 0.000961125	0.00723450
3	51.0431	169.460
4	- 0.605917	71.1743
5	21.3818	- 2.11014
6	4.66798	- 39.9408
7	3.76241	56.6234
8	1.00377	3.13962
9	- 0.0777423	- 3.58446

The collision integral $\Omega^{(2,2)}$ is evaluated as a function of temperature using an empirical expression that was developed based on the Lennard-Jones intermolecular potential model and is given below.

$$\Omega^{(2,2)} = \frac{A}{T^{*B}} + \frac{C}{exp\left(DT^{*}\right)} + \frac{E}{exp\left(FT^{*2}\right)} + RT^{*B}\, sin\left(ST^{*W} - P\right) \quad (4.238)$$

Using the coefficients given in Table 4.46.

Table 4.46. Coefficients for calculating the transport collision integrals for the Lennard-Jones (12-6) potential, Eq. (2.238): $\Omega^{(2,2)} = \left(A/T^{*B}\right) + C/\mathrm{e}^{DT^{*}} + E/\mathrm{e}^{FT^{*2}} + RT^{*B}\sin\left(ST^{*W} - P\right)$.

Coefficient	*Value*
A	1.16145
B	0.14874
C	0.52487
D	0.77320
E	2.16178
F	2.43787
R	- 0.0006435
S	18.0323
W	- 0.7683
P	7.27371

The proposed model of Chung-Lee-Starling is capable of predicting the viscosities of high molecular weight paraffins, typical of petroleum and polycyclic aromatic hydrocarbons preponderant in fossil fluids derived from petroleum residue, shale oil and coal. The viscosities of light gases and petroleum and coal liquids can be predicted over wide ranges of temperature and pressure.

4.3.2.5d Monnery *et al.* Approach for Non-polar Substances

Monnery *et al.*[67] described and discussed the evaluation and application of shape factors in the potential parameter based corresponding state method of Ely and Hanley for the prediction of the viscosities of liquid hydrocarbons. In this approach, the reduced viscosity of a fluid is written as:

$$\eta_R = \left(\eta / \eta_C\right) = f\left(T_R, \rho_R\right) \quad (4.239)$$

The critical viscosity η_C is defined from the kinetic theory as:

$$\eta_C = C\frac{(MT_C)^{(1/2)}}{(V_C)^{(2/3)}} \tag{4.240}$$

where *C* is a constant. According to the corresponding states theory, the functional form of the above equation should be the same for all conformal fluids and enable the expression of the viscosity of any fluid *i* in terms of the reference fluid *o* in the form

$$\eta_i(\rho,T) = \eta_o\left[\rho\left(\frac{\sigma_i}{\sigma_o}\right)^3, T\left(\frac{\varepsilon_o}{\varepsilon_i}\right)\right]\left(\frac{M_i}{M_o}\right)^{(1/2)}\left(\frac{\sigma_o}{\sigma_i}\right)^2\left(\frac{\varepsilon_i}{\varepsilon_o}\right)^{(1/2)} \tag{4.241}$$

Since (ε/k) is proportional to T_C and σ^3 is proportional to $(1/\rho_C)$ the expression can be rearranged as

$$\eta_i(\rho,T) = \eta_o\left[\rho\left(\frac{\rho_{Ci}}{\rho_{Co}}\right)^3, T\left(\frac{T_{Co}}{T_{Ci}}\right)\right]\left(\frac{M_i}{M_o}\right)^{(1/2)}\left(\frac{\rho_{Ci}}{\rho_{Co}}\right)^{2/3}\left(\frac{T_{Ci}}{T_{Co}}\right)^{(1/2)} \tag{4.242}$$

These expressions are applicable to conformal fluids only. For non-conformal fluids, the extended corresponding states method where the shape factors, *θ* and *Φ*, are introduced to account for the non-conformity of the molecules can be used. The reducing ratios *f* (for temperature) and *h* (for volume) are defined as

$$f_{i,o} = (T_{Ci}/T_{Co})\theta_{i,o} \tag{4.243}$$

$$h_{i,o} = (\rho_{Co}/\rho_{Ci})\Phi_{i,o} \tag{4.244}$$

On introduction of the reducing ratios, the equation for viscosity becomes:

$$\eta_i(\rho,T) = \eta_o\left[\rho h_{i,o}, T/f_{i,o}\right](M_i, M_o)^{(1/2)} h_{i,o}^{-(2/3)} f_{i,o}^{(1/2)} \tag{4.245}$$

which can be rewritten as:

$$\eta_i(\rho,T) = \eta_o(\rho_o, T_o)(M_i, M_o)^{(1/2)} h_{i,o}^{-(2/3)} f_{i,o}^{(1/2)} \tag{4.246}$$

where $\rho_o = \rho h_{i,o}$ and $T_o = T / f_{i,o}$ (4.247)

$\theta_{i,o}$ and $\Phi_{i,o}$ can be determined from the following density independent shape factor relations proposed by Ely[98]

$$\theta_{i,o} = \left[1 + \left(\omega_i - \omega_o\right)\left(a + b \ln T_R\right)\right] \tag{4.248}$$

and
$$\Phi_{i,o} = \left[1 - \left(\omega_i - \omega_o\right)\left(c + d \ln T_R\right)\right]\left(Z_{Ci} / Z_{Co}\right) \tag{4.249}$$

Generalized shape factor functions have been represented by the equation

$$f = A + B \ln T_R + C\left(\ln T_R\right)^2 \tag{4.250}$$

The coefficients A, B and C for different types of hydrocarbons are related to the ratio of the normal boiling point (T_B) of the substance and the normal boiling point of the reference substance (T_{Bo}); propane in the present case. The coefficients of the equations have the following form.

$$A = A_1 + A_2\left(T_B / T_{Bo}\right) + A_3\left(T_B / T_{Bo}\right)^2 \tag{4.251}$$

$$B = B_1 + B_2\left(T_B / T_{Bo}\right) + B_3\left(T_B / T_{Bo}\right)^2 \tag{4.252}$$

$$C = C_1 + C_2\left(T_B / T_{Bo}\right) + C_3\left(T_B / T_{Bo}\right)^2 \tag{4.253}$$

The values of the coefficients are provided for different series of compounds in Table 4.47.

Table 4.47. Coefficients of the generalized shape factor functions.

Series	***Paraffins M > 100***	***Paraffins M < 100***	***Olefins***	***Cyclo-pentanes***	***Cyclo-hexanes***	***Aromatics***
A_1	0.26272	0.13215	0.11160	0.99771	0.27932	0.88181
A_2	0.75213	0.85844	0.79508	0.13439	0.67150	0.23520
A_3	-	-	-	0.11630	0.03507	0.07400
B_1	0.45977	- 0.27418	0.0649	- 1.25286	- 11.1327	- 7.6852
B_2	- 0.39881	0.55865	- 0.1001	1.40528	11.4363	8.8326
B_3	-	- 0.29932	- 0.0405	- 0.49602	- 3.0526	- 2.5330

Series	*Paraffins M > 100*	*Paraffins M < 100*	*Olefins*	*Cyclo-pentanes*	*Cyclo-hexanes*	*Aromatics*
C_1	- 1.25725	0.04500	- 0.0002	0.28865	7.3664	1.18301
C_2	1.18289	- 0.08811	- 0.0010	- 0.40786	- 8.4463	- 1.36990
C_3	0.23304	0.04298	0.0065	0.14878	2.4357	0.39911

4.3.2.5e Monnery *et al.* Method Using Square-Well Potential Function

Monnery *et al.*[99] proposed a model based on statistical mechanics, for simultaneous calculation of liquid and gas viscosities. They employed the square well intermolecular potential for non-polar compounds. Employing theoretical results along with the modifications to correct the model for molecular chaos assumption and the inadequacy of the square well potential, final expressions have been proposed. Perturbation theory has been used to obtain the radial distribution function values. The model parameters are determined from liquid and gas viscosity data and generalized in terms of group contributions. The methodology described in detail by Monnery *et al.*[99] produces estimates of a variety of non-polar compoundes witnin 8%.

4.3.2.5f Monnery *et al.* Approach for Polar and Associated Substances

Monnery *et al.*[100] modified a stastical mechanical model based on the square well inter-molecular potential for calculating both liquid and gas phase viscosities of polar and associated compounds. Corrections have been incorporated into the original theory for the assumptions of only two body interactions and molecular chaos for velocities and the inadequacy of the square well potential. Further modifications have been carried out in such a manner that a consistent low density limit is approached and improved dilute gas temperature dependence results. The three model parameters appearing in the final expression are determined from gas and liquid viscosity data and generalized group contributions for the model are proposed. The scheme, discussed in detail by Monnery *et al.*[100] is shown to provide estimated values of gas and liquid viscosities of over 100 polar and hydrogen bonding substances with average deviations of 2.1% for gas and 6.8% for liquid.

4.3.2.6 Artificial Neural Net Approaches

In the recent past artificial neural net (ANN) has emerged as a powerful tool in representing the data difficult to be formulated and predicted by means of a well defined dependence on the variables known to be responsible. It is therefore no surprise that some recent efforts on the representation of liquid viscosity used the ANN approach.

4.3.2.6a Homer *et al.* Method for Liquid Viscosity and Other Physical Properties

Homer *et al.*[101] described an ANN and equilibrium property based predictive method for the viscosity, density, heat of vaporization, boiling point and Pitzer's acentric factor for pure organic liquid hydrocarbons applicable to the wide range of reduced temperatures between 0.45 and 0.7. This model, *COMMITTEE* ANN has been trained, using ten physicochemical and structural properties, along with absolute temperature as inputs, to correlate and predict viscosity. A set of 281 compounds, of diverse structure have been arbitrarily pooled into two sub sets, the first sub set of 200 compounds which have been used to train the *COMMITTEE* ANN, and a second sub set of 81 compounds which have been used to test the predictive performance of the *COMMITTEE* ANN. The viscosity and input data for each individual compound is compiled (on the average) at forty different temperatures, ranging from melting point to boiling point, for each of the chosen compounds. The mean average absolute deviation in viscosity predicted by the *COMMITTEE* ANN is 7.9% which reduces to 6.5% when the correlated data is also included in the comparison.

ANN's used for the prediction of physicochemical properties, have generally been multi-layered, feed forward and non-linear, trained via the back propagation rule to perform a function approximation. After evaluating a considerable number of differently structured neural networks, an ANN, consisting of ten ANNs, organized into a *COMMITTEE* by Homer *et al.* Each of the ten ANNs has a single hidden layer with seven neurons and an output layer with one neuron. The hidden layer has a *tansig* transfer function and the output layer has a *purelin* transfer function. Each ANN in the committee has been trained to different local minima of the error function.

The pool of compounds in this study consisted of an original set of 16 classifications of a total of 281 pure hydrocarbons as shown in Table 4.48.

Table 4.48. Details of the family classes and number of compound used in the work of Homer et al.

Class	*Family name*	*Number of compounds*
1	n-Alkanes	30
2	Methylalkanes	16
3	Dimethylalkanes	21
4	Other alkanes	20
5	Cycloalkanes	6
6	Alkylcyclopentanes	11
7	Alkylcyclohexanes	13
8	Alk-1-enes	19
9	Alk-2,3,4-enes	18

Class	*Family name*	*Number of compounds*
10	Methylalkenes	16
11	Ethyl and Higher alkenes	11
12	Cycloalkenes	7
13	Dialkenes	24
14	Alkynes	16
15	n-Alkylbenzenes	19
16	Other alkylbenzenes	34
	Total	281

Experimental viscosity values noted from the DIPPR data base every 5 K temperature difference, ranging from the melting point to the boiling point amounting to about 40 data points (as a function of temperature) for each compound have been used.

The inputs to the *COMMITTEE* ANN are: the absolute temperature, five physical properties and five structural indicators. The physical properties are molecular mass, Pitzer's acentric factor, normal boiling point, the temperature dependent density, and latent heat of vaporization. The structural inputs are the number of cyclic rings, the number of double bonds, the number of double bonds in the cyclic ring, the number of triple bonds, the number of triple bonds in the cyclic ring and the number of benzene rings in the compound. For each compound, the temperature dependent properties at the temperatures at which viscosities have been chosen are used. The method, as indicated, uses a large amount of input data and is quite complex, finally giving results better than the generalized methods based on a minimum amount of input data and can probably be effectively used if all the required input data are available.

4.3.2.6b Dutt *et al.* Approach

As ANNs gained importance over the last few years as nonlinear modeling tools in several applications, Dutt et al.[15], employing ANN as a model, predicted the viscosity of 100 compounds. A typical feed forward network with one input layer consisting of the independent variables, one hidden layer and one output layer with a single neuron for viscosity has been chosen. The input layer performs the task of scaling the inputs to a range of –5 to +5 according to

$$x_i = \left\{ \frac{Inp_i - Inp_{i,min}}{Inp_{i,max} - Inp_{i,min}} \times 10 \right\} - 5 \qquad i = 1,\ldots,n \tag{4.254}$$

where $Inp_{i,\mathrm{max}}$ and $Inp_{i,\mathrm{min}}$ are the maximum and minimum values of the i^{th} input variable Inp_i which are defined on the basis of the data considered for the model development. The task of each neuron in the hidden layer is summarized as follows:

$$h_j = f\left(\sum_{i=1}^{n} w_{ij}x_i + w_{0j}\right) \qquad j = 1,...,m \tag{4.255}$$

where

$$f(x) = \frac{1}{1+\exp(-x)} \tag{4.256}$$

The function *f(x)* represents the sigmoid activation function, *n* is the number of input nodes other than a bias node, *m* is the number of neurons in the hidden layer (excluding bias node), h_j is the output of the j^{th} neuron in the hidden layer, and w_{ij} represent the weights connecting the input layer and the hidden layer. The output, *y* is calculated according to the following equation;

$$y = f\left(\sum_{j=1}^{m} v_j h_j + v_0\right) \tag{4.257}$$

where v_j represent the weights connecting the hidden layer to the single output and *f(x)* is the sigmoid activation function. The output is then scaled back from 0 to 1 to the range of viscosities considered in the study as:

$$\eta = \eta_{\min} + y(\eta_{\max} - \eta_{\min}) \tag{4.258}$$

where $\eta_{\min}$ and $\eta_{\max}$ are the minimum and maximum values of the viscosity in the data considered for model development. The method used for training is the combined design and training algorithm (CDTA) based on back propagation with an adaptive learning rate and a constant acceleration factor[102]. The data on 100 compounds is divided into two parts – training data consisting of 90 compounds, and testing data consisting of 10 compounds. The training data is employed to update the weights, whereas the testing data is used for checking the convergence. Several input combinations including temperature, boiling point, dipole moment, acentric factor, critical temperature, density, and freezing temperature were explored, and for each combination, the number of neurons in the hidden layer was determined using the training algorithm. The ANN model resulting in minimum % absolute deviation had a configuration of 5 –19 – 1 (i.e., 5 inputs, 19 neurons in the hidden layer, and 1 output) and resulted in an overall absolute deviation of 13.86 % (training data: 13.20 %, testing data: 19.86 %). The inputs of the network were found to be temperature, boiling point, dipole moment, acentric factor and density. The weights of the resulting network are reported in Table 4.49. The % average absolute deviation values for all the100 compounds are reported in the section on comparison of the prediction methods.

In view of lesser complexity and need for the requirement of density, boiling point, acentric factor and dipole moment as the only inputs, the method can be considered to be a good estimation method.

Table 4.49. Weights of the ANN model for prediction of viscosity.

	Weights from input to hidden layer, w_{ij}						***Weights from hidden to output layer, v_j***	
Input ->	Temp.	Boiling Point	Dipole Moment	Acentric Factor	Density	Bias		Viscosity
Hidden Node No. (j)	1	2	3	4	5	0	Hidden Node No. (j)	
1	-1.71	-1.00	0.71	0.17	1.25	-1.21	1	-1.45
2	-3.72	0.96	1.70	-1.64	3.27	-0.78	2	2.74
3	-0.88	0.18	1.36	-2.92	3.13	-0.32	3	-2.75
4	1.77	0.16	0.00	-1.17	-0.81	1.27	4	-2.45
5	5.71	-1.42	-1.00	-1.97	-3.49	4.03	5	-1.69
6	-1.17	-3.03	-0.70	4.40	4.27	0.80	6	-1.33
7	0.01	-0.04	2.37	-2.46	-1.22	-2.49	7	-2.15
8	0.82	-2.53	2.38	-3.82	-4.40	0.88	8	-1.31
9	1.57	-2.02	0.01	-0.06	0.12	-0.69	9	-1.46
10	-1.67	-1.57	-0.39	-1.98	-1.62	1.16	10	-0.88
11	-1.97	-2.84	1.01	-0.67	0.63	1.11	11	-1.26
12	0.39	-1.58	0.46	-0.72	1.69	1.39	12	2.53
13	-1.40	-0.78	1.18	0.08	1.39	-0.97	13	-1.56
14	-0.67	0.38	0.34	1.90	4.15	0.71	14	-2.54
15	0.49	-0.93	0.68	-0.01	1.90	0.46	15	0.67
16	-0.83	0.81	0.20	-2.00	-0.36	0.87	16	1.13
17	1.23	0.05	0.37	-0.06	0.48	-0.50	17	-1.21
18	-0.90	0.18	0.61	-1.57	0.15	0.12	18	2.19
19	0.24	1.25	-6.97	1.81	2.43	0.18	19	-1.89
							Bias	2.88

4.3.2.7 Dedicated Equations for Selected Substances and Groups of Substances

4.3.2.7a Ammonia, Hydrogen and Water

Jossi *et al.*[90] in their attempt to develop generalized relations for dense gas and liquid phases of pure substances found that ammonia, hydrogen and water do not conform to the generalized pattern viscosity behavior of other substances and proposed the following dedicated equations for these substances.

Ammonia:

$$\left[\left(\eta-\eta^*\right)\xi+10^{-4}\right]^{0.25}=0.1067+0.022655\rho_R+0.034749\rho_R^2 +0.032153\rho_R^3+0.0089998\rho_R^4 \tag{4.259}$$

Hydrogen:

$$\left[\left(\eta-\eta^*\right)\xi+10^{-4}\right]^{0.25}=0.10616-0.042426\rho_R+0.17553\rho_R^2 +0.12295\rho_R^3+0.028149\rho_R^4 \tag{4.260}$$

Water:

$$\left[\left(\eta-\eta^*\right)\xi+10^{-4}\right]^{0.25}=0.10721-0.040646\rho_R+0.0026282\rho_R^2 +0.005443\rho_R^3+0.0017979\rho_R^4 \tag{4.261}$$

where η and η^* are the viscosities in cP at the conditions of interest (temperature in Kelvins and pressure in atmospheres) and at the same temperature and normal pressure of 1 atmosphere, respectively, ξ is the viscosity parameter [$=T_C^{(1/6)}/M^{(1/2)}P_C^{(2/3)}$], ρ_R [$=(\rho/\rho_C)$] is the reduced density, and ρ_C is the density at the critical point in g/cm^3.

4.3.2.7b Liquid Hydrocarbons

Abbott and Kaufman[103] proposed the following generalized form for the kinematic viscosity of liquid *n*-alkanes.

$$ln\,\upsilon_R = ln\left(\upsilon/\upsilon_C\right) = A(\rho_R - 1) + B(\rho_R - 1)^{(7/2)} + \sum_{j=1}^{5} C_j\left[exp(\rho_R - 1)^{\frac{j+1}{2}} - 1\right] \tag{4.262}$$

and established the following set of coefficients for n-alkanes

$$A = 0.51593\omega - 0.14696\omega^2 \tag{4.263}$$

$$B = 6.31284\times10^{-2} + 9.5999\times10^{-2}\,\omega \tag{4.264}$$

$$C_1 = 0.15976 \tag{4.265}$$

$$C_2 = 0.0 \tag{4.266}$$

$$C_3 = 2.60128\times10^{-3} \tag{4.267}$$

$$C_4 = 5.09402\times10^{-4} - 1.16879\times10^{-3}\,\omega + 6.19878\times10^{-4}\,\omega^2 \tag{4.268}$$

$$C_5 = 0.0 \tag{4.269}$$

The input data required for applying the method are: the critical properties (T_C and P_C), the normal boiling temperature (T_B), the acentric factor (ω) and the molecular mass (M) of the hydrocarbon of interest. The method gives an average absolute deviation of 2.7% for C_1 to C_{12} hydrocarbons at 522 data points that were used for comparison and can be considered a good estimation method for n-alkanes.

Dutt[104] proposed that the three constant equation for viscosity similar in form to the Antoine equation for vapor pressure can be applied successfully to hydrocarbons and correlated the constants of the equation to the normal boiling point for each homologous series. The equation proposed for the kinematic viscosity, υ, in cSt as a function of the temperature (t) in ^{o}C is

$$\ln \upsilon = A + \frac{(m + nt_B)}{(t + 239 - 0.19t_B)} \tag{4.270}$$

where t_B is the normal boiling point in °C. The values of A, m and n for the homologous series of hydrocarbons studied are given in Table 4.50.

Table 4.50. Constants to be used in Eq. (4.268) for the estimation of the kinematic viscosity (υ) in centi stokes from the temperatute (t) in °C for different classes of hydrocarbons.

S.No.	***Series***	***A***	***m***	***N***
1	Alkanes(normal) C_2 to C_{20}	- 2. 873	416.43	1.6139
2	Mono-Olefins(normal) C_2 to C_{20}	- 2.927	396.67	1.6977
3	Alkylcyclohexanes(normal) C_6 to C_{22}	- 3.252	372.62	2.1821
4	Alkanes(normal) C_1 to C_5	- 2.7315	404.06	1.5183
5	Alkylbenzenes(normal) C_1 to C_8	- 3.0967	593.71	0.5802
6	Cyclopentanes(normal) C_5 to C_{21}	- 2.8558	497.96	1.4250
7	Alkylbenzenes(normal) C_6 to C_{22}	- 3.1779	548.24	1.3072

The method gives results with an overall average absolute deviation of about 6% and can be considered as a dependable estimation method for viscosity of liquid hydrocarbons.

Allan and Teja[105] proposed a method based on the effective carbon number for the correlation and prediction of the viscosity of liquid hydrocarbons. Viscosity is expressed as:

$$\ln \eta = A\left[-\frac{1}{B} + \frac{1}{T + C}\right] \tag{4.271}$$

The constants A, B and C for n-alkanes (ethane to eicosane) are related to the number of carbon atoms (n) as:

$$A = 145.73 + 99.01n + 0.83n^2 - 0.125n^3 \tag{4.272}$$

$$B = 30.48 + 34.01n + 1.23n^2 - 0.017n^3 \tag{4.273}$$

$$C = -3.07 - 1.99n \tag{4.274}$$

The average absolute deviation for hydrocarbons is 3% with a maximum deviation of about 10%.

From the knowledge of one liquid viscosity data point, it is possible to extend the methodology to other pure hydrocarbons, through the definition of the effective carbon number (ECN). The known liquid viscosity at one temperature and the constants A, B and C can be used in these equations to arrive at a value for ECN which can subsequently be used to determine liquid viscosity at the other temperatures. As the expressions can give three roots for n (ECN), it is recommended that the root giving the value closest to the actual number of carbon atoms be chosen as the correct value. By testing well over 50 hydrocarbons, the method is found to predict the viscosity to an average absolute deviation of about 2.5%.

Kerps and Druin[106] developed a method for the prediction of the viscosity of liquid hydrocarbons and gave an empirical equation for each of the four series of homologous hydrocarbons studied by them: n-paraffins, n-1-alkenes, n-alkylcyclohexanes and n-alkylbenzenes.

The steps involved in developing the expression for viscosity is discussed below. The viscosity of a monatomic gas from the kinetic theory of gases can be written as:

$$\eta = \frac{1}{3} U \rho \lambda \tag{4.275}$$

where U is the mean molecular speed of the molecules (cm/sec), ρ is the density (g/cc), λ is the mean free path, cm. Adopting a similar approach to liquids with the assumtion that the liquid molecules are arranged in a cubic lattice, with center-to-center spacing is given by

$$\Delta = (V / N)^{(1/3)} \tag{4.276}$$

It is assumed that the momentum is transferred from one lattice plane to an adjacent plane at the sonic velocity (V_s) for the liquid. (Similar model for energy transport, with a cubic lattice similar to that of the solid state has been proposed earlier by Bridgman[107] for the thermal conductivity of pure liquids). Bridgman assumed that the energy transfer takes place from plane to plane at the sonic velocity by collisions arising out of molecular vibrations about the equilibrium lattice positions. Bridgman's equation for thermal conductivity can be written as

$$K = 3(N / V)^{(2/3)} k V_s \tag{4.277}$$

where N is the Avogadro number, V is the molar volume (cm^3/gmol), k is the Boltzman constant and V_s is the velocity of sound in the fluid.

Momentum transfer takes place by molecules reaching a given plane which have on the average suffered their last collision at a distance ‘Δ’ and can be expressed by:

$$\Delta = (2/3)\lambda = (V/N)^{(1/3)} \qquad (4.278)$$

Mean molecular speed is given by;

$$U = 2\left|U_y\right| \qquad (4.279)$$

In the above equation, ‘$|U_y|$’ is the absolute value of the *y* component of the mean molecular velocity. Similar relations apply to the velocity components in the *x* and *z* directions. Combining the above equations and replacing ‘$|U_y|$’ by the sonic velocity results in the following expression for viscosity.

$$\eta = \rho\ V_s \left(\frac{V}{N}\right)^{(1/8)} \qquad (4.280)$$

The velocity of sound in a liquid can be calculated from

$$V_s = (\beta\ \rho / M)^3 \qquad (4.281)$$

β being an empirical factor accounting for structural effects. Substituting the value of β and the other information, the equation for viscosity can be written as

$$\eta = \frac{\rho^{(11/3)}\beta^3}{M^{(8/3)}N^{(1/3)}} \qquad (4.282)$$

It can be shown that the ratio of the thermal conductivity (*K* in calories per second per centimeter per degree K) and viscosity (η in Poise) is given by

$$M(K/\eta) = 6 \qquad (4.283)$$

where *M* is the molecular mass.

The velocity of sound in liquids is generally five to ten times greater than the mean free speed of the molecules. In terms of the intermolecular distances one can write,

$$V_s = V_s'\left(V / NV_f\right)^{(1/3)} \tag{4.284}$$

The mean molecular speed of the liquid molecules, from the speed of sound arguments becomes

$$U_1 = U\left(\frac{V}{NV_f}\right)^{(1/3)} = \left(\frac{8kT}{m\pi}\right)^{(1/2)}\left(\frac{V}{N}\right)^{(1/3)} \tag{4.285}$$

Viscosity of a monoatomic liquid can be written as

$$\eta = 0.5\rho\left(\frac{V}{N}\right)^{(1/3)}\left(\frac{8kT}{m\pi}\right)^{(1/2)}\left(\frac{V}{NV_f}\right)^{(1/3)} \tag{4.286}$$

On eliminating the free volume V_f from the analysis, and writing γ for specific heat ratio, we get

$$V_s' = \left(\gamma kT / m\right)^{(1/2)} \tag{4.287}$$

For liquids, γ is nearly unity except near the critical point. The viscosity of the monoatomic liquid can be finally written as:

$$\eta = 0.8\rho\left(V / N\right)^{(1/3)} \tag{4.288}$$

This relation is the same as the one derived from the kinetic theory approach, except for the constant appearing 0.8 instead of 1.0 for the kinetic theory approach.

The equation for viscosity derived from the kinetic theory is given by:

$$\eta = \frac{\rho^{(11/3)}\beta^3}{M^{(8/3)}N^{(1/3)}} \tag{4.289}$$

When this equation is used for the calculation of the viscosity of normal paraffins, 1-alkanes, monoalkyl-cyclohexanes and monoalkylbenzenes over the ranges of the temperature of the available experimental data, average deviations ranging from 30 to 40 % have been reported. However, when the individual point deviations ($Z = \eta/\eta_R$) are plotted against the reduced temperatures with respect to the normal boiling point ($T_{RB} = T/T_B$) on log - log coordinates, it has been noticed that the predicted viscosities for each homologous series differed from the experimental values in a regular manner. For each series, a family of curves, parametric in the number of carbon atoms, may be drawn through the Z points. The Z function approaches a limiting value at about 20 carbon atoms.

For each series of homologous series, the parametric curves, may be approximated by a single line of best fit having the form;

$$Z = \exp\left[a + b\ln\left(T_{RB}\right) + c\left\{\ln\left(T_{RB}\right)\right\}^2\right] \tag{4.290}$$

The coefficients of the equation for the homologous series of hydrocarbons are given in Table 4.51.

Table 4.51. The coefficients to be used in Eq. (4.290) for different series of hydrocarbons.

Series	***A***	***B***	***C***
n-Paraffins,C_5 to C_{20}	0.323	0.239	- 3.56
n-1-Alkanes,C_5 to C_{20}	0.552	0.405	- 3.88
Mono-n-alkylcyclo-hexanes,C_8 to C_{22}	0.337	0.842	- 3.20
Mono-n-alkyl-benzenes,C_7 to C_{22}	0.442	- 0.270	- 4.60

Incorporating the above correction factor, the equation for viscosity becomes

$$\eta = \rho^{(11/3)}\beta^3 / \left\{M^{(8/3)}N^{(1/3)}Z\right\} \tag{4.291}$$

which generally predicts viscosities with average errors of about 5 to 10%.

The constants of the equation for Z have been further improved through the introduction of another variable, the number of carbon atoms (N equal to the total number of carbon atoms in the case of n-Paraffins and n-1-Alkenes and number of carbon atoms in the alkyl side chain in the case of mono-n-alkylcyclohexanes and mono-n-alkylbenzenes). The variables, a, b, and c of the equation for Z are expressed as follows:

$$a = a_1 + a_2 N + a_3 N^2 \tag{4.292}$$

$$b = b_1 + b_2 N + b_3 N^2 \tag{4.293}$$

$$c = c_1 + c_2 N + c_3 N^2 \tag{4.294}$$

The coefficients for different series studied are noted in Table 4.52.

Table 4.52. Coefficients to be used in Eqs. (4.292)-(4.294) for different Series of hydrocarbons.

Series	***n-Paraffins***	***n-1-Alkenes***	***Mono-n-alkyl cyclohexanes***	***Mono-n-alkylbenzenes***
a_1	0.496	1.01	0.573	1.32
a_2	- 0.0147	- 0.0642	- 0.141	- 0.240
a_3	0.0	0.0	0.0	0.0103
b_1	- 0.279	1.94	2.00	3.76
b_2	0.0978	- 0.213	- 0.705	- 1.08
b_3	- 0.00498	0.0	0.0406	0.0472
c_1	- 3.15	0.950	- 2.26	- 0.0534
c_2	- 0.0573	- 0.634	- 0.810	- 1.22
c_3	0.0	0.0144	0.0449	0.0564

The improvemrnt resulted in the prediction of viscosities of the hydrocarbons with average absolute deviations ranging from 1.5 to 5%.

Orbey and Sandler[108] presented empirical models for calculating the viscosity of hydrocarbons over wide ranges of temperature and pressure, choosing propane as the reference fluid. The viscosity of saturated liquid propane at atmospheric pressure is represented as:

$$\ln \eta_R = \ln\left(\eta / \eta_{ref}\right) = -1.6866 + 1.4010\left(T_B / T\right) + 0.2406\left(T_B / T\right)^2 \tag{4.295}$$

The reduced viscosity of the other hydrocarbons can be written as:

$$\ln\left(\eta / \eta_{ref}\right) = k \ln \eta_R \tag{4.296}$$

where k is a parameter, specific to each compound.

The parameter k is related to the normal boiling temperature (T_B) by the form :

$$k = 0.143 + 0.00463T_B - 0.00000405T_B^2 \tag{4.297}$$

On setting μ_{ref} = 0.225 mPa.s, the methodology becomes totally predictive for pure hydrocarbons and found to give an average absolute deviation of less than 3%. The effect of pressure could be well represented by:

$$\left[\eta(P)/\eta\left(P^{sat}\right) = \exp\left[m.\left(P - P^{sat}\right)\right]\right] \approx m.P \tag{4.298}$$

where $m = 0.98 \times 10^{-5}$ (kPa)$^{-1}$.

Monnery *et al.*[67] described and discussed the evaluation and application of shape factors in the potential parameter based corresponding state method of Ely and Hanley for the prediction of the viscosities of liquid hydrocarbons. This approach is described in detail in Section 4.3.2.5d. Using the methodology discussed, the viscosities of the hydrocarbons could be generally predicted with an average absolute deviation of less than 5%.

4.3.2.7c Liquid Halogenated Hydrocarbons

Hovrath[109] presented correlations for the viscosities of liquid halogenated hydrocarbons from their normal boiling points (capable of predicting within 5 to 10 % of their true values) for applications in engineering design calculations. Table 4.53 gives the normal boiling points and the viscosities of several halogenated hydrocarbons at their normal boiling temperature.

Table 4.53. Normal boiling points and viscosity at the normal boiling point for several halogenated hydrocarbons.

No.	***Name***	***Formula***	***Boiling Point, °C***	***Viscosity at the Normal Boiling Point, cP***
1	Fluoromethane	CH_3F	- 78.4	0.28
2	Difluoromethane	CH_2F_2	- 51.6	0.38
3	Trifluoromethane	CHF_3	- 82.0	0.38
4	Tetrafluoromethane	CF_4	- 128.0	0.39
5	Chloromethane	CH_3Cl	- 24.22	0.32
6	Dichloromethane	CH_2Cl_2	40.7	0.38
7	Trichloromethane	$CHCl_3$	61.3	0.38
8	Tetrachloromethane	CCl_4	76.5	0.48
9	Chlorofluoromethane	CH_2ClF	- 9.1	0.37
10	Dichlorofluoromethane	$CHCl_2F$	8.9	0.38
11	Chlorodifluoromethane	$CHClF_2$	- 40.8	0.37
12	Chlorotrifluoromethane	$CClF_3$	- 82.0	0.39
13	Dichlorodifluoromethane	CCl_2F_2	- 29.5	0.38

No.	***Name***	***Formula***	***Boiling Point, ºC***	***Viscosity at the Normal Boiling Point, cP***
14	Trichlorofluoromethane	CCl_3F	24.0	0.38
15	Fluoromethane	CH_3F	- 78.4	0.28
16	Fluoroethane	C_2H_5F	- 37.7	0.25
17	Fluoro-n-propane	C_3H_7F	2.5	0.24
18	Fluoro-n-butane	C_4H_9F	32.5	0.24
19	Fluoro-n-pentane	$C_5H_{11}F$	62.8	0.24
20	Fluoro-n-hexane	$C_6H_{13}F$	91.5	0.24
21	Fluoro-n-heptane	$C_7H_{15}F$	117.9	0.25
22	Fluoro-n-octane	$C_8H_{17}F$	142.5	0.24
23	Fluoro-n-nonane	$C_9H_{19}F$	166.0	0.24
24	Fluoro-n-decane	$C_{10}H_{21}F$	186.2	0.24
25	Chloromethane	CH_3Cl	- 24.22	0.32
26	Chloroethane	C_2H_5Cl	12.27	0.29
27	Chloro-n-propane	C_3H_7Cl	46.6	0.28
28	Chloro-n-butane	C_4H_9Cl	78.44	0.28
29	Chloro-n-pentane	$C_5H_{11}Cl$	107.8	0.28
30	Chloro-n-hexane	$C_6H_{13}Cl$	134.5	0.27
31	Chloro-n-heptane	$C_7H_{15}Cl$	159.0	0.29
32	Chloro-n-octane	$C_8H_{17}Cl$	182.0	0.28
33	Chloro-n-nonane	$C_9H_{19}Cl$	203.4	0.28
34	Chloro-n-decane	$C_{10}H_{21}Cl$	223.4	0.28
35	Bromomethane	CH_3Br	3.56	0.37
36	Bromoethane	C_2H_5Br	38.4	0.33
37	Bromo-n-propane	C_3H_8Br	71.0	0.33
38	Bromo-n-butane	C_4H_9Br	101.6	0.33
39	Bromo-n-pentane	$C_5H_{11}Br$	129.6	0.32
40	Bromo-n-hexane	$C_6H_{13}Br$	155.3	0.32
41	Bromo-n-heptane	$C_7H_{15}Br$	178.9	0.33
42	Bromo-n-octane	$C_8H_{17}Br$	200.8	0.33
43	Bromo-n-nonane	$C_9H_{19}Br$	221.0	0.33
44	Bromo-n-decane	$C_{10}H_{21}Br$	240.6	0.33
45	Iodomethane	CH_3I	42.4	0.40
46	Iodoethane	C_2H_5I	72.3	0.37
47	Iodo-n-propane	C_3H_7I	102.45	0.37
48	Iodo-n-butane	C_4H_9I	130.53	0.37
49	Iodo-n-pentane	$C_5H_{11}I$	157.0	0.37
50	Iodo-n-hexane	$C_6H_{13}I$	181.33	0.37
51	Iodo-n-heptane	$C_7H_{15}I$	204.0	0.36
52	Iodo-n-octane	$C_8H_{17}I$	225.5	0.37
53	Iodo-n-nonane	$C_9H_{19}I$	246.0	0.39
54	Iodo-n-decane	$C_{10}H_{21}I$	265.0	0.37

Viscosity (η) at any other temperature (T) can be estimated from the normal boiling temperature (T_B) and the viscosity at the normal boiling point (η_B) from the equation:

$$\eta = \eta_B \left(T/T_B\right)^n \tag{4.299}$$

where the constant n needs to be determined from the known viscosity-temperature data of the particular substance.

4.3.2.7d Isomeric Substituted Benzenes

Thomas *et al.*[110] presented a systematic study on the temperature dependence of viscosity and of isomeric substituted benzenes and found that abnormal increase in viscosity is not necessarily because of proximity to the freezing point. Disk shaped condensed ring aromatics are found to behave as normal fluids, in contrast, compounds containing ‘crowned’ benzene rings linked through flexible bonds appearing associated in the liquid state, also produce abnormal increase in viscosity. Experimental data on several substances has been presented and discussed.

Viscosity of a liquid can be represented in the form

$$\log\left[\eta\ V^{(1/2)}\right] = \alpha + \left(\beta/T^{\theta}\right) \tag{4.300}$$

where V is the specific volume and α, β and θ are constants. In terms of the same parameter θ, vapor pressure P of the liquid as a function of the temperature T can be written as

$$\log P = \log\psi - \left(I/T^{\theta}\right) \tag{4.301}$$

Ψ is a universal constant (= $1.9\mathrm{x}10^6$ mm) and I is a constant characteristic of each substance.

Differentiating Eq. (4.301) and introducing the thermodynamic relation, vapor pressure P can be eliminated.

$$L = RT^2\left[\frac{d\left(\ln P\right)}{dT}\right], \text{ and} \tag{4.302}$$

$$L = 2.303\ RI\theta/T^{(\theta-1)} \tag{4.303}$$

At any chosen pressure, θ is equal to the molar entropy of vaporization ΔS multiplied by a numerical constant, having the same value for all the non-associated liquids. For example, at 100 mmHg where the vapor can be assumed to behave ideally, one can write;

$$\theta = 0.05110\ \Delta S \tag{4.304}$$

When the vapor pressure data are not available, *ΔS* can readily be estimated from an aspherical factor *A* (which has additive properties) and the number of flexible bonds (*n*) appearing in the molecule.

Thomas[111] presented a detailed discussion of the method of calculation of *ΔS* from from aspherical factor *A* and the number of flexible bonds (*n*). A summary of the method of estimating *ΔS* for different classes of compounds is presented here.

For a Variety of Non-Associating Substances:

$$\Delta S = \frac{Z}{\left(0.03675Z + 0.0905\right)} \tag{4.305}$$

In this equation, *Z* represents the molecular number (equal to the sum of the atomic numbers) Equation 4.305 predicts the molar entropy of boiling at 100 mmHg (*ΔS*) of 41 compunds, including: SiH_4, eight tetrahalides, five tetramethyls, four hexafluorides, six tetrahalides of N, P and B, three mixed perhalides of methane, C_2Me_6, C_2F_6, four phosphoryl and triphosphoryl halides, and low molecular weight diatomic gases like: oxygen, notrogen, carbonmonoxide and fluorine (all of which have *ΔS* values in the range of 23 to 27) with an average absolute deviation of 0.8%.

For Inert Gases:

$$\Delta S = Z / \left(0.03675Z + 0.150\right) \tag{4.306}$$

can be applied to determine *ΔS* at 100 mmHg for argon, krypton, and xenon with good accuracy.

For Non-globular Inflexible Molecules:

$$\Delta S = Z / \left(0.03675Z + 0.0905 - A\right) \tag{4.307}$$

A is the Aspherical factor and can be used to calculate *ΔS* at 100 mmHg with good accuracy.

For Flexible Molecules:

$$\Delta S = \left[Z / \left(0.03675Z + 0.150 \right) \right] + 0.26n \tag{4.308}$$

where *n* is the number of flexible bonds. Table 4.54 provides the value of group contributions to *A*.

Additionally,

For paraffins the Me_3C group reduces *n* by 0.5 unit, and the CMe_2 reduces *n* by 0.5 unit on each side of the chain, except when attached to another such group, when no reduction should be applied to the $Me_2C\text{-}CMe_2$ bond.

For compounds like $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$, it is expected that the conformation corresponds to a stretching-out of the molecule in two planes at right angles and the value of $n = 3$ is recommended to be used.

For homologues containing methyl groups, the *n* values are to be calculated by adding 1 for each methyl group.

For ethyl and methoxy- derivatives, each group increases *n* by 1.5 units instead of 1.

The methodology described provides the values of *ΔS* in good agreement with the observed data as shown in Table 4.55.

The limitations of the method have also been described in detail by Thomas[111].

Table 4.54. Aspherical factors for different groups for the application of group contribution method to calculate *A*.

Group	***Location***	***A***
CH_3	Inflexible molecule in which the atoms, other than hydrogen, are arranged in non-branching sequence like in ethane, propane, methyl and ethyl halides and cyanides, dimethyl ether, acetaldehyde, propene, but-2-ene, methyl acetylene	0.015
CH_3	Other cases like flexible molecules and branched molecules like isobutane, CH_2:CMe_2, nitromethane, where the CH_3 does not lead to lengthening of the molecule	0
CH_2	Inflexible molecules	0
CH_2	Flexible molecules	0.004
H	In hydrohalides, HCN, H_2S, in the SH group of CH_2SH, C_2H_5SH, HCH= group of ethene, propene, allene, vinyl chloride, etc.	0.015
H	For branched compounds like CH_2:CCl_2	0
CH_2	In the ring	0
Three Membered Ring		0.045
Four Membered Ring		0.036
Five Membered Ring		0.036
Six Membered Ring		0.030
Seven Membered Ring		0.050
Eight Membered Ring		0.050
Halogen Atom	Perfluorohydrocarbon	0
Benzene Ring		0.087
o-,m-,p- distributed benzenes		0
Aromatic Double Bond		0.019
Double Bond in Alkanes, Dienes, Acetylenes		0
Double Bonds in Conjugated dienes, allenes, cycloalkanes		0.019
Carbon-Carbon Triple Bond		0.050

Group	***Location***	***A***
Fluorine		0.050
Chlorine		0.045
Bromine		0.040
Iodine		0.040
Fluorine	Attached to Benzene or Ethylene Molecule	0.022
Chlorine	Attached to Benzene or Ethylene Molecule	0.032
-S-		0.040
-O-		0.040
-S-S-		0.050
-CO-		0.090
-CN		0.080
$-NO_2$		0.120
$-O-NO_2$		0.125
>B-		0.015
>N-		0.030
-N=	In nitrogen Aromatics	0.060

Table 4.55. Prediction capabilites of the group contribution method proposed by Thomas[111] for the estimation of ΔS at 100 mmHg for different classes of compounds.

Compound Class or Type	***No. of Compounds***	***% Average Absolute Deviation***
Set of Compounds containing substances like SiH_4, tetrahalides, tetraethyls, hexafluorides, tetrahalides of N, P, B, mixed perhalides of methane, C_2Me_6, C_3F_6, phosphoryl and thiophosphoryl halides, lower diatomic gases	41	0.8
n-Paraffins from Ethane	19	0.3
Branched chain Paraffins	70	0.4
Cycloalkanes with 3,4,5,6,7 & 8-membered rings	40	0.4
Alkylbenzenes	37	0.3
Polycyclic aromatic hydrocarbons	9	0.7
Alkenes	46	0.5
Cyclopentenes & Cyclohexenes	12	0.7
Dienes & Allenes	12	0.7
Alkyl halides, HCl, HBr and HI	30	0.6
Saturated Aliphatic Poly halides	17	0.8
Halogenobenzenes	19	0.5
Vinyl type halides	8	0.3
Alkane thiols, Alkyl sulfides, Thia cyclopentanes,Cyclobutanes	40	0.4
Disulfides	7	0.3
Aliphatic ethers, Acetals, Tetrahydrofuran, Dioxan	15	0.9
Aliphatic Esters	17	0.5
Aliphatic aldehydes & Ketones	11	0.3
Cyanides including C_2N_2, HCH and Vinyl type compounds	14	0.5
Nitrates	5	0.3
Nitro compounds	9	0.3
Alkylborates, Alkyl borines & Alkoxychloborines	12	0.6
Tertiary amines & Tetramethylhydrazine	4	0.7
Silicon compounds	26	1.5
Furan, Thiophene, 2- and 3- Methylthiophene	4	0.6
Pyridine compounds	8	0.3
Vinylbenzenes, Aromatics containing CN, CO, NO_2, etc,	50	1.0

Combining Eqs. (4.300) and (4.301) one can write:

$$-\left[\frac{d\log\left(\eta V^{(1/2)}\right)}{d\log P}\right]=\left(\beta/I\right)=\alpha \qquad (4.309)$$

The parameter α (the ratio of the activation energy for viscous flow to the energy of vaporization) is equal to 0.220 for all non-associated liquids. Associated liquids have larger values of α due to additional contributions to

ΔS arising out of the rupture of intermolecular complexes on vaporization, as described in the foregoing paragraphs. The parameters of the equations for viscosity and vapor pressure, Eqs. (4.300) and (4.301), as well as some physical properties of selected substances are given in Table 4.56.

Entries of Table 4.56 indicate that the criteria of both entropies of vaporization, and the ratios of energy of viscous flow to energy of vaporization, lead to the conclusion that condensed ring compounds and compounds with open benzene rings behave as normal fluids when the temperature approaches the freezing point.

The bottom part of Table 4.56 presents the behavior of eight polyphenyl compounds in which the benzene rings are in crowned positions. With the single exception of o-terphenyl, vapor pressures have been measured at temperatures far removed from those of the viscosity measurements. 'β' being a variable for such materials (increasing rapidly with falling temperature), evaluation of α in the manner similar to non-associated materials is not correct. The value of α quoted for o-terphenyl in the table has been obtained by numerical differentiation of the $\log [\eta \ V^{(1/2)}]$ versus $\log P$ data. Its value is 0.5 at 90°C and about 0.6 at 80°C, considerably larger than the normal value of 0.22 for non-associated liquids. Therefore it can be concluded that o-terphenyl is associated in the liquid state. The degree of association for associated compounds can be written as:

$$\gamma = \frac{\beta' T^{(\theta-1)}}{0.220 L \theta'} \tag{4.310}$$

where β' refers to the hypothetical monomer. Degrees of association for some associating compounds as a function of temperature are given in Table 4.57.

In view of the non-availability of the data on such typical compounds, the measured values of the kinematic viscosity reported by Thomas *et al.*[110] are given in Table 4.58.

Marked difference in the behavior has to be noticed for the case of closely related isomeric compounds with similar boiling temperatures but significantly different melting points, if proximity to the melting point has any effect on the viscosity of liquid. *Ortho*-, *meta*-, and *para*- substituted benzenes are examples of such a set. The *para*- isomer generally possesses the highest melting point. Table 4.59 summarizes the information for eight sets of such isomers, whose data are represented with an overall average absolute deviation of about 1.5%.

Table 4.56. Parameters for use in Eqs. (4.300) and (4.301) and some important physical properties of isomeric substituted benzenes.

Compound	***Boiling Point, ^0C***	***Freezing Point, ^0C***	***Aspherical Factor***	***Flexible Bonds***	***θ Calc. from A & n***	***θ Calc. from Vapor Pressure***	***I***	***- α***	***B***	***A***
Diphenyl	256	70	0.174	1	1.44	1.4555	31257.4	0.3792	6914	0.22
Diphenyl ether	259	27	0.214	2	1.47	1.4673	33965.8	0.5882	9391.9	0.28
Diphenyl methane	266	26	0.178	2	1.45	1.4576	32543.4	0.2850	7190.9	0.22
Naphthalene	218	80	0.155	0	1.43	1.4228	22914.9	-	-	-
Triphenylene	432	199	0.291	0	1.46	-	-	0.3498	11799	0.24
Acenaphthene	278	93	0.191	0	1.44	1.4310	28459.0	0.3803	7313	0.26
Fluorene	298	114	0.291	0	1.44	1.4410	31865.6	0.2536	7045.3	0.22
Anthracene	340	216	0.223	0	1.44	1.4317	33411.0	-	-	0.26
Phenanthrene	339	100	0.223	0	1.44	1.4269	32198.1	0.2599	7246.5	0.27
Fluoranthene	379	110	0.278	0	1.46	1.4339	38297.0	0.3090	9837.4	0.20
Pyrene	395	150	0.272	0	1.46	1.4552	43686.7	0.4874	11557	
Triphenyl phosphate	414	50	0.590	6	1.59	-	-	0.4831	22445	
Triphenyl Amine		127	0.291	3	1.49	1.4755	47232.2			
Triphenyl Phosphine		80	0.291	3	1.49	1.4725	48752.4			
Triphenyl Arsine		61	0.291	3	1.48	1.5483	78991.7			
Triphenyl Stebine		55	0.291	3	1.48	1.6000	-			
Triphenyl methane		93	0.291	3	1.48	1.4300	-			
Triphenyl tin Chloride		106	0.306	3	1.47	-	-			
o-Terphenyl		55	0.261	2	1.47	1.5333	63521.3			0.50

Table 4.57. Degree of association of polyphenyl compounds as a function of temperature.

Temp, ^0C	***Tri-phenyl Amine***	***Tri-phenyl Phosphine***	***Tri-Phenyl arsine***	***Tri-phenyl stebine***	***o-Ter-phenyl***	***m-Ter-phenyl***	***Tri-Phenyl methane***	***Tri-phenyl tin chloride***
60			2.03	2.02	3.12			
70			1.83	1.78	2.64			
80			1.69	1.60	2.29			
90		1.60	1.56	1.44	2.06	1.48		
100		1.46	1.46	1.35	1.86	1.36	1.70	
110		1.39	1.35	1.27	1.72	1.27	1.60	
120		1.34	1.27	1.20	1.60	1.19	1.51	1.30
130	1.58	1.28	1.20	1.15	1.52	1.14	1.43	1.23
140	1.47	1.24	1.17	1.09	1.46	1.10	1.38	1.19
150	1.39	1.20	1.10	1.06	1.42		1.33	1.15
160	1.32	1.15		1.03	1.38		1.30	1.12
180	1.25	1.09		1.00	1.32		1.25	1.09
200	1.22				1.26		1.21	1.05
220					1.21			1.03
240					1.17			1.01
260					1.14			

Table 4.58. Measurevd Values of the kinematic viscosity(ν) in millistokes as a function of temperature(t) in ^{o}C.

Substance	***t, ^{0}C***	***ν, milliStokes***	***Substance***	***t, ^{0}C***	***ν, milliStokes***	***Substance***	***t, ^{0}C***	***ν, milliStokes***
p-Chlorotoluene	2.3	10.73	o-Chlorotoluene	- 10.1	15.13	p-Nitrotoluene	52.7	11.90
	7.7	9.93		- 0.5	12.77		60.0	10.78
	18.1	8.61					69.1	9.67
	28.2	7.75					79.8	8.56
m-Dichlorobenzene	- 17.5	15.54	o-Dichlorobenzene	-17.5	21.27	N,N-Dimethylaniline	3.0	20.19
	- 11.8	13.87		-11.9	18.71		9.7	17.74
	- 1.0	11.48		-1.1	15.10		30.4	12.67
							40.8	10.98
							55.2	9.21
							69.7	7.88
Diphenylmethane	18.1	34.6	Triphenylmethane	103.3	34.6	Triphenyl tin chloride	112.9	26.6
	21.7	31.8		108.0	31.2		120.5	23.2
	23.8	30.4		114.2	27.6		129.8	19.28
	27.7	28.0		118.7	25.2		139.6	17.24
	29.8	26.8		128.3	21.4		150.8	14.78
	34.8	24.2		134.8	19.27		160.5	13.18
	44.5	20.3		144.1	16.82		169.6	11.85
	54.2	17.32		150.9	15.28		179.8	10.65
	66.0	14.62		159.7	13.69		187.1	9.90
	73.9	13.31		169.2	12.22		201.8	8.63
	86.9	11.19		184.2	10.40		209.9	7.99
	95.4	10.25		200.0	8.91		220.6	7.34
	104.0	9.41		219.5	7.56		231.0	6.78
	110.1	8.88						

Substance	*t, ^{0}C*	*v, milliStokes*	*Substance*	*t, ^{0}C*	*v, milliStokes*	*Substance*	*t, ^{0}C*	*v, milliStokes*
	115.3	8.46						
	123.7	7.86						
Triphenyl amine	129.4	25.70	Triphenyl phosphine	82.6	66.30	Triphenyl arsine	45.8	255.9
	136.0	22.70		89.8	54.10		52.7	171.4
	143.3	20.00		95.0	47.00		56.4	142.3
	150.5	17.89		99.0	42.10		61.5	114.2
	158.3	16.00		106.0	36.70		64.9	99.7
	166.6	14.30		110.9	33.10		70.0	82.0
	175.1	12.77		115.5	30.20		79.9	59.0
	184.2	11.55		120.4	27.50		89.7	44.1
	195.1	10.24		139.6	20.00		100.4	34.3
	203.1	9.44		149.7	16.79		110.1	28.0
	213.4	8.59		160.1	14.67		119.7	23.4
				169.9	13.02		129.6	19.79
				179.5	11.71		140.7	16.78
Triphenyl stibine	54.8	136.1	Triphenyl stibine	138.8	15.97			
	59.6	110.9		149.5	13.9			
	64.4	89.2		164.6	11.6			
	69.3	76.0		179.6	9.97			
	74.4	64.2						
	79.4	54.4						
	84.4	45.7						
	94.5	35.4						
	104.2	28.9						
	114.4	23.8						
	124.9	19.79						

Table 4.59. Parameters of the Equation : log { η V (1/2) } = α + β / T θ [Units : Viscosity (η) in millipoise; Specific Volume(V) in cm^3/ g; Temperature(T) in Kelvin.

Compound	*Temperature Range, °C*	*Melting Point, °C*	*Θ*	*- α*	*B*
o-Xylene	- 5 to 130	- 25	1.415	0.2957	3882
m-Xylene	0 to 135	- 47	1.415	0.2546	3332
p-Xylene	15 to 130	13	1.415	0.2902	3509
o-Chlorotoluene	- 10 to 153	- 35	1.430	0.2338	4164
m-Chlorotoluene	0 to 150	- 48	1.430	0.2140	3846
p-Chlorotoluene	2 to 152	7	1.430	0.2453	3993
o-Dichlorobenzene	- 17 to 130	- 18	1.435	0.1683	4404
m-Dichlorobenzene	- 17 to 157	- 25	1.435	0.2053	4150
p-Dichlorobenzene	60 to 160	53	1.435	0.2205	4316
o-Methoxytoluene	15 to 165		1.440	0.3801	5458
m-Methoxytoluene	18 to 167		1.440	0.3496	5145
p-Methyxytoluene	17 to 165		1.440	0.3663	5278
o-Bromotoluene	0 to 100	- 26	1.420	0.2900	5145
m-Bromotoluene	0 to 100	- 40	1.420	0.2140	5278
p-Bromotoluene	30 to 100	28	1.420	0.2096	4450
o-Dimethoxybenzene	53 to 195	21	1.470	0.4608	8211
m-Dimethoxybenzene	40 to 201	- 52	1.470	0.3785	7323
p-Dimethoxybenzene	62 to 200	56	1.470	0.3593	7147
o-Cyanotoluene	20 to 140	- 14	1.450	0.2734	5706
m-Cyanotoluene	20 to 140	- 23	1.450	0.2896	5673
p-Cyanotoluene	30 to 140	29	1.450	0.2639	5641
o-Nitrotoluene	20 to 191	- 4	1.480	0.2470	7073
m-Nitrotoluene	20 to 100	16	1.480	0.2667	7145
p-Nitrotoluene	52 to 216	52	1.480	0.2166	6897
N,N-Dimethylaniline	3 to 189	2	1.430	0.2793	4887
n-Heptadecane	22 to 300	22	1.570	0.2114	14080
n-Octadecane	62 to 300	61	1.725	0.0155	41244

4.3.2.7e Fatty Esters and Vegetable Oils

An Andrade type equation for liquid viscosity (η) as a function of molecular mass (M) and temperature (T in K) was developed by Dutt *et al.*[112] and is given below.

$$\ln\left[\eta\left(M\right)^{1.5}\right] = -10.97 + \left(1037/T\right) \tag{4.311}$$

For fatty esters, the equation predicted values with an average absolute deviation of 9.1% for 28 substances at 95 data points.

Krishnakumari *et al.*[113] developed an equation for calculating viscosity (η, cP) as a function of temperature (T in K) for vegetable oils.

$$\ln\eta = -6.667 + (3189/T) \tag{4.312}$$

The equation provided an average absolute deviation of 13.3% when the data on 43 vegetable oils at 139 data points were tested.

Expressing the constants of Andrade model developed in terms of the cubic functions of the ratio of the iodine value (*IV*) to the saponification value (*SV*), the liquid viscosity of 21 vegetable oils at 85 data points could be represented with an average absolute deviation of 8.8% by the following equation

$$\ln\eta = \left[6.684 - 1.527\left(\frac{IV}{SV}\right) + 1.146\left(\frac{IV}{SV}\right)^2 + 1.1942\left(\frac{IV}{SV}\right)^3\right] + \left[\frac{3084 + 1302\left(\frac{IV}{SV}\right) + 1710\left(\frac{IV}{SV}\right)^2 + 88.59\left(\frac{IV}{SV}\right)^3}{N}\right] \tag{4.313}$$

4.4 COMPARISON OF SELECTED PREDICTION METHODS

4.4.1 COMPARISON OF PREDICTION CAPABILITIES OF SELECTED METHODS

In this section, ten methods have been selected for comparison of their relative prediction capabilities. These ten methods were selected based on their superior estimation capabilities compared to other methods described in this chapter. A summary of the results of comparison for 100 randomly selected representative compounds is shown in Tables 4.60 and 4.61.

Table 4.60. Summary of comparison of the prediction capabilities of Orrick and Erbar, Prabhakar *et al.*, Przezdzeicki and Sridhar, Dutt *et al.* and Souders methods.

	Percentage Average Absolute Deviation				
Substance (No.of Data Points)	***Orrick and Erbar***	***Prabhakar et al.***	***Przezdzeicki and Sridhar***	***Dutt et al.***	***Souders***
Acetaldehyde(6)	56.21	154.48	10.61	10.00	30.39
Acetic acid(7)	11.93	42.91	5.73	30.14	35.24
Acetone(7)	40.05	171.77	2.75	5.77	36.11
Acetophenone(6)	6.71	191.89	3.87	2.28	46.67
Allyl alcohol(6)	22.11	50.58	-	11.08	64.37
Amyl alcohol(5)	7.21	63.49	78.62	21.65	12.07
Aniline(7)		30.30	51.98	52.07	19.32
Benzene(6)	22.85	12.56	18.31	15.80	-
n-Butane(8)	18.92	17.84	7.34	7.94	9.30
Butanoic acid(5)	13.34	34.29	16.80	26.77	8.31
1-Butene(6)	20.53	28.16	-	13.85	29.10
n-Butyl alcohol(7)	1.21	59.53	73.48	20.73	10.04
Butyl amine(8)	-	16.94	28.06	35.02	22.07
Butyl benzene(6)	44.37	50.78	35.41	12.45	6.68
Carbontetrachloride(7)	-	18.50	9.53	10.58	59.84
Chlorobenzene(7)	2.12	80.00	3.82	11.24	7.55
Chloroform(6)	-	25.97	9.67	16.63	86.59
m-Cresol(6)	10.49	45.56	63.25	17.44	20.96
o-Cresol(6)	49.20	15.27	32.32	16.58	123.29
Cyclohexane(7)	41.64	35.29	25.24	51.78	2.92
Cyclopentane(5)	321.14	15.81	32.51	32.39	2.63
Decane(6)	2.84	21.30	31.26	1.08	3.48
1,1-Dichloroethane(6)	0.63	68.16	19.76	3.62	2.69
Dichloromethane(6)	27.35	53.84	25.47	14.50	68.88
Diethyl amine(6)	-	6.71	5.64	10.34	7.49
Diethyl carbonate(6)	26.37	13.73	3.25	7.94	15.74
Diethyl ketone(5)	21.43	170.93	8.42	8.20	11.33
Diethyl sulfide(5)	-	75.91	13.88	7.60	-
Dimethyl carbonate(6)	24.20	6.26	28.87	6.49	21.87
N,N-Dimethyl formamide(7)	-	5.28	14.70	9.76	4.59
2,2-Dimethylpropane(6)	18.91	15.28	25.81	37.91	23.41
Dimethylsulfide(6)	-	60.70	7.42	4.20	-
1,4-Dioxane(5)	44.06	41.64	14.95	44.50	88.46
Diphenyl ether(6)	25.37	32.80	24.95	7.56	-
Diphenyl methane(6)	56.77	48.15	25.00	4.75	78.92
Dipropyl amine(5)	-	16.21	20.24	6.81	4.51
Dodecane(5)	3.83	23.09	44.00	4.66	9.52
Ethane(6)	40.13	18.23	11.83	9.77	34.35
Ethanethiol(5)	-	64.61	22.81	0.32	-
Ethyl acetate(7)	43.42	28.05	7.66	7.70	11.46
Ethyl alcohol(6)	16.55	60.38	79.52	25.61	14.55
Ethyl benzene(8)	1.09	38.14	20.73	9.21	2.39

	Percentage Average Absolute Deviation				
Substance (No.of Data Points)	***Orrick and Erbar***	***Prabhakar et al.***	***Przezdzeicki and Sridhar***	***Dutt et al.***	***Souders***
Ethyl bromide(7)	33.55	142.33	17.56	41.47	17.51
Ethylene(6)	-	16.94	15.74	2.49	51.96
Ethylene bromide(7)	21.60	7.65	20.39	14.13	92.42
Ethylene chloride(6)	33.35	34.39	12.12	15.18	24.56
Ethyl ether(5)	3.50	21.49	5.06	8.50	7.22
Ethyl formate(5)	18.17	40.28	10.07	3.85	25.37
Ehyl propionate(5)	55.33	36.05	13.43	3.88	2.24
Formic acid(7)	47.00	64.97	26.66	47.33	52.23
Furan(6)	20.80	6.43	34.13	16.05	24.73
Heptadecane(6)	11.50	38.75	57.96	3.64	21.43
Heptane(7)	4.28	18.66	16.12	3.40	6.93
Hexadecane(6)	3.44	33.13	58.08	2.37	17.27
Hexane(6)	4.22	18.66	5.21	4.93	1.68
1-Hexene(5)	5.75	36.64	5.14	15.68	4.99
1-Hexyne(5)	-	16.98	20.97	5.50	-
Isoamyl alcohol(6)	11.84	61.84	80.69	24.80	7.57
Isobutane(7)	28.79	17.27	27.61	25.32	30.09
Isobutyl acetate(7)	57.05	39.14	39.36	8.92	11.52
Isobutyric acid(5)	28.09	39.65	34.33	23.80	10.79
Isopropyl alcohol(6)	14.67	76.46	81.04	54.07	35.52
Isopropyl amine(5)	-	4.32	24.96	31.00	31.86
Methane(6)	-	26.41	1.99	13.30	24.77
Methyl acetate(6)	26.42	26.61	10.56	4.75	2.89
Methyl alcohol(6)	14.67	76.46	100.00	24.93	43.67
Methyl amine(6)	-	6.08	76.84	23.20	16.92
Methyl-n-amylketone(7)	52.92	242.28	17.30	26.48	36.60
2-Methylbutane(6)	9.11	7.31	17.86	8.64	6.93
2-Methyl-2-butene(6)	5.35	20.38	0.57	13.67	9.19
Methylbutanone(5)	3.67	30.16	19.98	2.59	16.56
Methyl cyclopentane(6)	40.59	10.36	44.02	29.48	23.94
Methyl formate(7)	3.45	28.38	26.36	3.27	26.18
Methyl isobutyrate(6)	12.85	53.08	17.99	1.88	19.14
Methyl propionate(6)	57.99	32.09	11.25	4.17	15.32
Methyl-n-propylketone(5)	13.87	122.89	3.77	1.66	2.01
Niromethane(6)	-	133.71	-	5.36	54.94
Nonane(5)	0.97	19.14	29.40	0.90	0.99
Octane(5)	1.93	17.92	17.07	0.87	1.07
Octadecane(6)	1.71	39.79	63.53	0.47	19.08
Pentadecane(5)	2.67	29.37	56.40	2.56	14.47
Pentane(6)	5.89	15.63	6.74	12.85	35.39
1-Penene(6)	5.19	35.20	5.13	12.92	7.39
Phenol(6)	35.86	44.37	47.59	26.41	52.00
Propane(6)	20.64	20.61	21.60	22.46	49.49
Propionic acid(5)	27.95	28.76	7.01	14.01	9.59
n-Propyl acetate(5)	2.80	28.26	24.15	3.20	4.12

	Percentage Average Absolute Deviation				
Substance (No.of Data Points)	***Orrick and Erbar***	***Prabhakar et al.***	***Przezdzeicki and Sridhar***	***Dutt et al.***	***Souders***
n-Propyl alcohol(5)	8.03	72.50	84.13	39.36	13.82
Propyl formate(6)	10.92	36.33	21.35	6.24	4.75
Pyridine(7)	0.90	48.23	27.97	23.26	7.53
Pyrrole(7)	-	11.72	17.20	37.87	43.36
Quinoline(6)	-	40.18	42.31	19.00	28.32
Teradecane(7)	4.87	23.87	56.56	5.30	14.21
Tetrahydrofuran(5)	28.37	35.28	31.38	17.55	36.87
Toluene(7)	11.81	26.40	19.24	1.69	2.34
Trichlorofluoromethane (7)	-	20.46	16.47	5.58	-
Tridecane(5)	4.32	24.00	49.58	4.69	11.96
Triehyl amine(5)	-	49.06	10.39	11.16	24.62
m-Xylene(7)	0.90	48.23	4.70	19.11	3.97
o-Xylene(7)	3.91	33.49	2.94	1.39	3.34

Table 4.61. Summary of comparions of the prediction capabilities of Sastri and Rao, Morris, Thomas, van Velzen *et al*. and Dutt et al. ANN methods.

	Percentage Average Absolute Deviation				
Substance (Number of Data Points)	***Sastri and Rao***	***Morris***	***Thomas***	***van Velzen et al.***	***ANN Method***
Acetaldehyde(6)	9.17	8.36	3.94	-	3.41
Acetic acid(7)	27.84	2.92	45.62	25.81	24.16
Acetone(7)	22.90	38.90	7.93	3.64	26.24
Acetophenone(6)	13.40	11.02	9.50	5.80	13.11
Allyl alcohol(6)	10.87	17.99	43.76	44.75	15.28
Amyl alcohol(6)	21.72	14.27	76.20	7.31	2.79
Aniline(7)	23.95	42.62	-	16.71	5.75
Benzene(6)	7.89	11.55	19.06	21.16	10.24
n-Butane(8)	7.48	5.46	2.05	6.91	13.51
Butanoic acid(5)	17.84	15.88	45.69	3.09	6.82
1-Butene(6)	10.86	10.88	16.28	4.06	11.89
n-Butyl alcohol(7)	33.80	14.11	71.42	2.84	6.63
Butyl amine(8)	15.47	-	-	8.77	24.58
Butyl benzene(6)	18.65	15.00	1.56	3.20	20.87
Carbontetrachloride(7)	4.36	15.52	3.27	4.79	13.64
Chlorobenzene(7)	5.42	19.53	3.54	6.35	14.41
Chloroform(6)	2.60	10.77	18.20	7.19	19.32
m-Cresol(6)	71.85	23.60	4.68	41.79	3.02
o-Cresol(6)	105.94	29.67	54.54	10.04	5.93
Cyclohexane(7)	22.20	21.73	76.99	33.20	16.67
Cyclopentane(5)	8.56	5.99	69.75	32.16	15.60
Decane(6)	7.76	3.58	3.63	3.09	9.79

	Percentage Average Absolute Deviation				
Substance (Number of Data Points)	***Sastri and Rao***	***Morris***	***Thomas***	***van Velzen et al.***	***ANN Method***
1,1-Dichloroethane(7)	6.35	12.03	0.39	0.54	12.04
Dichloromethane(6)	1.26	4.15	8.07	11.03	14.39
Diethyl amine(6)	3.03	-	-	8.77	6.87
Diethyl carbonate(6)	19.52	18.66	11.18	39.63	20.59
Diethyl ketone(5)	3.64	17.91	7.32	3.36	16.33
Diethyl sulfide(5)	4.89	-	0.61	-	34.83
Dimethyl carbonate(6)	18.97	23.60	4.68	41.79	11.10
n,n-Dimethyl formamide(7)	11.14	-	-	79.03	17.58
2,2-Dimethylpropane(6)	20.43	34.26	31.72	13.43	22.91
Dimethyl sulfide(6)	7.42	-	1.39		24.05
1,4-Dioxane(5)	7.24	34.02	78.94	209.80	14.81
Diphenyl ether(6)	11.55	40.31	20.24	363.99	3.41
Diphenyl methane(6)	42.30	15.07	15.96	25.94	6.16
Dipropyl amine(5)	4.61	-	-	59.31	38.86
Dodecane(5)	13.70	6.68	3.54	1.89	12.30
Ethane(6)	22.09	4.64	31.93	9.39	9.66
Ethanethiol(5)	5.04	-	4.13	-	9.21
Ethyl acetate(7)	7.47	9.53	7.23	10.97	17.51
Ethyl alcohol(6)	15.19	4.93	71.13	52.55	18.00
Ethyl benzene(8)	9.33	3.79	2.78	3.21	10.33
Ethyl bromide(7)	11.14	12.31	9.57	11.36	48.02
Ethylene(6)	9.15	23.86	24.06	41.14	14.18
Ethylene bromide(7)	15.88	15.14	3.51	10.18	6.67
Ethylene chloride(6)	17.13	14.17	10.20	4.03	19.26
Ethyl ether(5)	7.75	18.45	9.65	4.24	8.90
Ethyl formate(5)	5.33	32.65	9.36	1.66	14.42
Ethyl propionate(5)	2.42	12.24	4.14	6.91	9.19
Formic acid(7)	53.58	35.16	60.79	56.31	10.60
Furan(6)	2.76			1311.18	2.75
Heptadecane(6)	11.90	21.33	13.01	2.57	9.09
Heptane(7)	16.98	4.31	4.84	4.26	17.51
Hexadecane(6)	16.82	28.77	13.64	1.78	6.40
Hexane(6)	6.12	2.91	2.77	3.33	7.34
1-Hexene(6)	5.86	4.43	15.13	7.51	50.48
1-Hexyne(5)	22.05	-	-	-	5.72
Isoamyl alcohol(6)	30.02	23.80	76.04	3.38	7.16
Isobutane(7)	22.14	24.25	17.27	4.90	10.40
Isobutyl acetate(7)	11.37	1.57	14.68	8.57	16.45
Isobuyric acid(5)	13.55	14.52	44.33	10.20	9.40
Isopropyl alcohol(6)	12.60	48.87	82.18	1.65	9.70
Isopropyl amine(5)	9.66	-	-	22.71	21.94
Methane(6)	16.22	23.77	52.00	110.64	7.88
Methyl acetate(6)	10.02	1.63	0.84	3.68	7.09
Methyl alcohol(6)	8.08	90.55	60.97	160.35	23.31
Methyl amine(6)	7.02			16.66	4.87

	Percentage Average Absolute Deviation				
Substance (Number of Data Points)	***Sastri and Rao***	***Morris***	***Thomas***	***van Velzen et al.***	***ANN Method***
Methyl-n-amylketone(7)	22.26	50.30	27.70	20.83	4.29
2-Mehyl butane(6)	7.78	7.86	2.57	1.96	16.56
2-Mehyl-2-butene(6)	1.11	0.82	11.59	5.28	4.12
Methyl butanoate(6)	6.02	10.37	6.01	0.66	14.97
Methyl cyclopentane(6)	29.36	14.68	72.83	23.11	7.16
Methyl formate(7)	22.60	40.51	4.62	4.49	5.10
Methylisobutyrate(6)	6.36	11.41	5.08	2.13	17.58
Methylpropionate(5)	11.25	8.66	2.16	3.71	2.83
Methyl-n-propylketone(6)	4.63	11.22	1.04	2.46	15.53
Nitromethane(6)	13.40	-	-	1.60	16.77
Nonane(5)	3.45	1.51	2.79	1.03	16.51
Octane(5)	11.14	1.06	28.78	2.79	12.73
Octadecane(6)	18.80	45.74	28.78	2.79	3.52
Pentadecane(5)	16.23	23.38	8.82	2.69	5.76
Pentane(6)	7.78	3.11	7.35	3.56	16.73
1-Pentene(6)	6.97	1.38	14.98	6.40	18.85
Phenol(6)	31.30	30.00	72.18	7.23	16.40
Propane(6)	10.88	18.28	9.34	13.00	9.13
Propionic acid(5)	10.27	21.54	37.89	3.87	7.00
n-Propyl acetate(5)	7.12	2.45	9.16	0.57	12.26
n-Propyl alcohol(5)	15.72	29.75	80.74	4.52	14.54
Propyl formate(6)	14.93	1.44	11.03	7.61	7.67
Pyridine(7)	9.97	-	-	-	9.97
Pyrrole(7)	14.95	-	-	62.74	24.05
Quinoline(6)	50.01			41.52	9.04
Tetradecane(7)	18.00	8.41	3.58	3.17	3.78
Tetrahydrofuran(5)	2.76	5.28	68.70	966.90	17.98
Toluene(7)	6.34	5.34	9.87	10.71	16.96
Trichlorofluoromethane(7)	9.39	4.90	-	86.32	26.88
Tridecane(5)	15.98	10.22	2.00	2.66	5.76
Triethylamine(5)	1.29	-	-	99.52	15.12
m-Xylene(7)	10.58	8.97	4.94	4.91	12.55
o-Xylene(7)	7.87	22.30	9.67	14.81	18.84

4.4.2 INPUT REQUIREMENTS AND OTHER DETAILS OF THE SELECTED PREDICTION METHODS

Table 4.62 summarizes the input data requirements and prediction capabilities of the methods compared in the previous section.

Table 4.62. Details of estimation methods considered for comparison.

Methods	***Inputs other than temperature***	***Eq. No. in text***	***No. of compounds***	***Average absolute deviation (%)***
Orrick & Erbar	Density at 20˚C (ρ_{20}) Molecular weight (M) A & B by Group Contribution	4.95	79	20.13
Prabhakar *et al.*	Molecular weight (M) Critical Temperature (T_c) Critical Pressure (P_c) Dipole moment (μ) Molar refraction (R_M)	4.157	100	42.91
Przezdzeicki & Sridhar	Molecular weight (M) Critical Volume (V_c) Critical Temperature (T_c) Critical Pressure (P_c) Freezing point (T_F) Acentric factor (ω) liquid molar volume at T_F (V_{MF})	4.66 to 4.72	97	26.63
Dutt *et al.*	Boiling point in ˚C (t_B) Acentric factor (ω) Reference temperature (T^{Ref}) Density at T^{Ref} (ρ^{Ref}) Dipole moment (μ)	4.23 to 4.26	100	14.63
Souders	Molecular weight (M) Density (ρ_L) Viscosity coefficient (I) by Group Contribution	4.82	93	23.69
Sastri & Rao	Vapor pressure at T (P) Viscosity at normal boiling point (η_B) & N by Group Contribution	4.97 to 4.106	100	14.83
Morris	Critical Temperature (T_c) Pseudo critical viscosity (η^+) & b_i by Group Contribution	4.93 & 4.94	84	17.11
Thomas	Density (ρ) Critical Temperature (T_c) Coefficient θ by Group Contribution	4.83	86	23.91
Van Velzen *et al.*	Temperature at which viscosity becomes one (T_0) & parameter (B) by Group Contribution	4.48 to 4.54	94	46.94
Artificial Neural Networks	Boiling point (T_B) Acentric factor (ω) Density (ρ) Dipole moment (μ)	4.252 to 4.256	100	13.86

From the information presented in Tables 4.61 and 4.62, it is clear that the methodologies for the prediction of liquid viscosity proposed by Dutt (Section 4.3.2.1.2d) and Sastri and Rao (Section 4.3.2.3.1f) and Artificial Neural Networks (Section 4.3.2.6b) provide the best estimates on an overall basis for the 100 substances considered here. The choice among the methods is to be decided on the availibility of the required input data mentioned in Table 4.62.

Prabhakar *et al.* method (Section 4.3.2.3.2k), applicable to all the 100 substances, can be considered as a method capable of providing a rough estimate, when the input data required for more precise methods are not available, but those for Prabhakar *et al.* method are either available or can be estimated.

Orrick and Erbar (Section 4.3.2.3.1d), Morris (Section 4.3.2.3.1c) and Thomas (Section 4.3.2.3.1b) methods could be applied to lesser number of compounds: 79, 84 and 86 respectively, due the lack of necessry information, but give good design estimates of liquid viscosity. It is worth noting that the fairly complex group contribution method of van Velzen *et al.* (Section 4.3.2.1.1d) gives results quite similar to the Prabhakar *et al.*

When applied with limitations in mind, the methods proposed by Thomas (Section 4.3.2.3.1b), Souders (Section 4.3.2.3.1a) and Przezdzeicki and Sridhar (Section 4.3.2.1.2b) can provide reasonable design estimates of liquid viscosity. It should be noted that the choice of the best estimation method has to be based mainly on the availability of dependable values of the required input data.

4.5 SUMMARY

This chapter presented most of the methods available in the literature for the correlation and estimation of liquid viscosity. The initial sections are devoted to the general discussion of the variation of liquid viscosity of organic liquids as a function of pressure at high pressures (noting that the effect of pressure on liquid viscosity is negligible at pressures upto a few atmospheres). A few methods for the estimation of the effect of pressure have also been mentioned.

The major effort is related to the more important aspect (from the industrial point of view) of the variation of liquid viscosity with temperature. The subject matter has been described under two broad sections – correlation and estimation methods. The correlation methods section is sub-divided into two-constant, three-constant and multi-constant equations, which essentially present the information available in the literature about the forms of equations describing the temperature dependence of liquid viscosity and the coefficients of the different forms of the equations given in the literature. Some of the important generalized forms have also been included in these subsections, while bulk of the effort in the development of generalized methods has been presented under the estimation methods section at appropriate places. The constants (or coefficients) of different equations have also been tabulated to facilitate direct and quick estimation. Some methods have also been included which provide thoughts towards the development of the prediction methods for specific applications.

In the section on estimation methods, the material has been presented under the broad classification of relationships with: physical or molecular properties and generalized relationships based on group contributions, the corresponding states theory, potential parameters, followed by artificial neural net approaches. A mention is also made about dedicated equations developed for selected sets or classes of substances.

Based on the analysis of various methods, the following general remarks are in order.

(i) The prediction accuracies generally improve with the amount of input data being used.
(ii) The choice of the best prediction method depends on the amount of reliable input data available.
(iii) Generalized methods based on group contributions or corresponding states theories are to be used only when no experimental viscosity data are available.
(iv) If the substance of interest is listed in any of the tables under correlation methods, the information should be used to predict the liquid viscosity in preference to any estimation method in the order of preference indicated by the complexity of the equation suggested and the conditions of interest.

It is suggested that if the coefficients of any correlating equation or under dedicated equations section are available, these methods should be used to get a design estimate of the liquid viscosity. A three constant or multi-constant equation is to be given preference to the simpler two constant equations, if the constants are available.

In the absence of constants of any correlation equation for the substance of interest, an estimation method depending on the availability of physical and molecular properties has to be selected and applied. The type of accuracies mentioned in the original papers are to be expected out of the prediction using any particular method.

REFERENCES

1. R. C. Reid, J. M. Prausnitz, and T. K. Sherwood, *The Properties of Gases and Liquids*, McGraw-Hill, New York, 3rd Ed. (1977).
2. K. Stephan and K. D. Lucas, *Viscosities of Dense Fluids*, Plenum, New York (1979).
3. K. Lucas, Ein einfaches verfahren zur berechnung der viskosität von Gasen und Gasgemischen, *Chem. Ing. Tech.* **46**(4), 157-158 (1974).

3a K. Lucas, Die druckabhängigkeit der viskosität von flüssigkeiten - eine einfache abschätzung**,** *Chem. Ing. Tech.* **53**(12), 959-960 (1981).

4. G. Scalbrin, L. Pizza, and V. Velisa, Viscosity correlation for ethane in the form of multilayer feedforward neural networks, *High Temp.-High Press.* **34**(4), 457-471 (2002).
5. G. Scalbrin and G. Cristofoli, The viscosity surfaces of propane in the form of multilayer feed forward neural networks, *Intl. J. Thermophys.* **24**(5), 1241-1263 (2003).
6. G. Scalbrin, G. Cristofoli, and M. Griginate, A corresponding states predictive viscosity model based on a new scaling parameter: application to hydrocarbons, halocarbons and mixtures, *Intl. J. Energy Res*. **26**(1), 1-26 (2002).
7. A. S. Teja and P. A. Thurner, The correlation and prediction of the viscosities of mixtures over a wide range of pressure and temperature, *Chem. Eng. Commun*. **49**(1-3), 69-79 (1986).
8. W. Kim and T. S. Chair, A calculation for the viscosity of fluid at the critical point, *Bull. Korean Chem. Soc*. **23**(11), 1524-1526 (2002).
9. G. J. Smith, W. V. Wilding, J .L. Oscarson, and R. L. Rowley: *Proceedings of the Fifteenth Symposium on Thermophysical Properties* Boulder, Colorado, USA (2003).
10. S. R. S. Sastri and K. K. Rao, A new group contribution method for predicting viscosity of organic liquids, *Chem. Eng. J.* **50**, 9-25 (1992).

10a. S. R. S. Sastri, *Personal Communication*, Regional Research Laboratory, Bhubaneswar, India (1998).

11. C. F. Grain, Liquid Viscosity*, in Handbook of Chemical Property Estimation Methods* (Ed. W.J. Lymqn, W.F. Reehl and D.H. Rosenblatt) pp. 22-1–22-20, American Chemical Society, Washington DC (1990).
12. J. de Guzman, Relation between fluidity and heat of fusion, *Anales Soc. Espan. Fia. Y. Quim.* **11**, 353-362 (1913).
13. C. R. Duhne, Viscosity-temperature correlations for liquids*, Chem.Eng.* **86** (15), 83 (1979).
14. D. S. Viswanath and G. Natarajan, *Databook on Viscosity of Liquids*, Hemisphere, New York (1989).
15. N. V. K. Dutt and D. H. L. Prasad, *Representation of the Temperature Dependence of the Viscosity of Pure Liquids*, Private Communication, Chemical Engineering Division, Indian Institute of Chemical Technology, Hyderabad (2004).
16. L. Qun-Fang, H. Yu-Chun, and L. Rui-Sen, Correlation of viscosities of pure liquids in a wide temperature range, *Fl. Ph. Equilib.***140**(1-2), 221-231 (1997).

17. H. Eyring, Viscosity, plasticity and diffusion as examples of absolute reaction rates, *J. Chem. Phys*. **4**, 283-291 (1936).

18. J. F. Kincaid, H. Eyring, and A. E. Stern, The theory of absolute reaction rates and its application to viscosity and diffusion in the liquid state, *Chem. Rev*. **28**, 301 (1941).

19. R. C. Reid, J. M. Prausnitz, and B. E. Poling, *Properties of Gases and Liquids*, McGraw-Hill, New York, 4 th Ed. (1987).

20. H. Vogel, Das Temperaturabhängigkeitsgesetz der Viskosität von Flüssigkeiten*, Physik Z*. **22**, 645-646 (1921).

21. E. Goletz, Jr. and D. Tassios, An Antoine type equation for liquid viscosity dependency to temperature, *Ind. Eng. Chem. Proc. Des. Dev*. **16**(1), 75-79 (1977).

22. N. V .K. Dutt, A simple method of estimating the viscosity of petroleum crude oil and fractions, *Chem. Eng. J.* **45**, 83-86 (1990).

23. L. A. Girifalco, Temperature dependence of viscosity and its relation to vapor pressure for associated liquids, *J. Chem. Phys*. **23**(12), 2446-2447 (1955).

24. T. E. Thorpe and J. W. Rodger, Bakerian Lecture: On the relations between the viscosity (internal friction) of liquids and their chemical nature, *Phil. Trans.* **185**, 397-710 (1895).

24a. T. E. Thorpe, J. W. Rodger, and R. E. Barnett, On the relations between the viscosity (internal friction) of liquids and their chemical nature. Part II, *Phil. Trans.* **189**, 71-107 (1897).

25. N. Islam and M. Ibrahim, Status models for flow behaviour of organic liquids, *Indian J. Chem.* **20A**, 963-968 (1981); Applicability of modified Hildebrand equation to flow behaviour of organic liquids*, Indian J Chem*. **20A**, 969-973 (1981).

26. C.L. Yaws, X. Lin and L. Bu, Calculate viscosities for 355 liquids, *Chem.Eng.* **101**(4) 119-20, 122, 124, 126, 128, (1994).

27. T. E. Daubert and R. P. Danner: *Physical and Thermodynamic Properties of Pure Chemicals –Data Compilation* Design Institute for Physical Properties Data, AIChE, Taylor and Francis, Washington DC (1989-1994).

28. W. K. Lewis and L. Squires, The structure of liquids and the mechanism of viscosity, *Refiner Nat. Gasoline Manuf.* **13**, 448 (1934).

29. D. van Velzen, R. L. Cordozo, and H. Langenkemp, A liquid viscosity-temperature-chemical constitution relation for organic compounds, *Ind. Eng. Chem. Fundm.* **11**(1), 20-25 (1972).

30. T. K. Jagannathan, D. S. Viswanath, and N. R. Koloor, Predict organic liquids viscosity, *Hydrocarbon Process.* **47**(2), 133-136 (1968).

31. A. Chatterjee and V. A. Kunte, Estimation of viscosity of organic liquids, *Chem. Ind. (London)* **11**, 375-376 (1982).

32. D. van Velzen, R. L. Cordozo, and H. Langenkemp, *Liquid Viscosity and Chemical Constitution of Organic Conpounds: A New Correlation and Compilation of Literature Data*, EUR 4735 e, Joint Nuclear Research Centre, Ispara Establishment – Italy (1972).

33. C. F. Grain, Liquid Viscosity, Chapter 22, *Handbook of Chemical Property Estimation Methods,* (Ed.) W. J. Lyman, W. F. Rheel and D. H. Rosenblatt, American Chemical Society, Washingtom DC(1990).
34. H. Eyring and R.P. Marchi, Significant structure theory of liquids, *J. Chem. Edu.* **40**, 563 (1963).
35. S. H. Fishtine, Reliable latent heats of vaporization, *Ind. Eng. Chem.* **55**(6), 47-56 (1963).
36. A. Bachinskii, *Vermennik obshchestva im. Ledentseva, priloz.* No.3 (1913), *Phys. Z.* **13**, 1157 (1912), *Z. phys. Chem.* **84**, 643 (1913).
37. J. W. Przezdziecki and T. Sridhar, Prediction of liquid viscosities, *AIChE J.* **31**(2), 333-335 (1985).
38. R. D. Gunn and T. Yamada, A corresponding states correlation of saturated liquid volumes*, AIChE J.* **17**(6), 1341-1345 (1971).
39. M. Luckas and K. Lucas, Viscosity of liquids: An equation with parameters correlating with structural groups, *AIChE J.* **32**(1), 139-141 (1986).
40. A. H. Pelofsky, Surface tension-viscosity relation for liquids, *J. Chem. Eng. Data* **11**(3), 394-397 (1966).
41. H. Schonhorn, Surface tension-viscosity relationship for liquids, *J.Chem.Eng.Data* **12**(4), 524-525 (1967).
42. A. E. Lutskii, *Zhurn. Fiz. Khim.* **29**, 1162 (1955).
43. M. Souders, Viscosity and chemical constitution, *J.Am.Chem.Soc.* **60**, 154-158 (1938).
44. N. V. K. Dutt, Y. V. L. Ravikumar, and A. Rajiah, Prediction of liquid viscosities of phosphorus-containing compounds by Souders' method, *Chem.Eng. J.* **51**(1), 41-44 (1993).
45. L. H. Thomas, The dependence of the viscosities of liquids on reduced temperature, and a relation of viscosity, density, and chemical constitution, *J. Chem. Soc.* 573-579 (1946).
46. L. H. Thomas, A relationship between viscosity, density, and vapor pressure of liquids, *J. Chem. Soc.* 822-829 (1947)**.**
47. L. H. Thomas, Viscosity and molecular association. Part I *, J. Chem. Soc.* 1345-1349 (1948); Viscosity and molecular association. Part II. A relationship between viscosity and vapor pressure of associated liquids, J. Chem. Soc. 1349-1354 (1948).
48. L. H. Thomas, Temperature variation of viscosity and the structure of liquids, *Trans. Faraday Soc.* **62**(518)**,** 328-335 (1966).
49. L. H. Thomas, An analytical expression for the variation of the vapor pressure of liquids with temperatures up to critical conditions, *Chem. Eng. J.* **11**, 191-200 (1976).
50. L. H. Thomas, Variation of the viscosity of liquids with temperature and the ratio of the energy of viscous flow to the energy of vaporization, *Chem.Eng. J.* **11***,* 201-206 (1976).
51. N. V. K. Dutt and D. Venugopal, Prediction of liquid viscosities of fluorinated hydrocarbons by the extended Thomas' method, *Chem. Eng. J.* **44**(3), 173-175 (1990).
52. P. S. Morris, *M.S. Thesis*, Polytechnic Institute of Brooklyn, Brooklyn, New York (1964).

53. C. Orrick and J. H. Erbar, [as reported in R. C. Reid, J. M. Prausnitz, and T. K. Sherwood, *The Properties of Gases and Liquids*, McGraw-Hill, New York, 3rd Ed., 1977].

54. D. G. Miller, Estimating vapor pressures-A comparison of equations, *Ind. Eng.Chem.* **56**(3), 46-57 (1964).

55. A. Letsou and L. I. Stiel, Viscosity of saturated nonpolar liquids at elevated pressures, *AIChE J.* **19**(2), 409-411 (1973).

56. E. N. da C. Andrade, The viscosity of liquids, *Nature* **125**, 309-310 (1930).

57. H. J. M. Hanley, Prediction of the viscosity and thermal conductivity coefficients of mixtures ,*Cryogenics* **16**(11), 643-651 (1976).

58. J. S. Rowlinson and I. D. Watson, Prediction of the thermodynamic properties of fluids and fluid mixtures. I. Principle of corresponding states and its extensions, *Chemical Eng. Sci.* **24**(10), 1565-1574 (1969).

59. J. H. Leach, *Molecular Structure Corrections for Application of the Theory of Corresponding States to Non-Spherical Pure Fluids and Mixtures*, PhD Thesis, Rice University, USA (1967).

60. J. F. Ely, An Enskog correction for size and mass difference effects in mixture viscosity prediction, *J. Res. Nat. Bur. Standards* **86**(6), 597-604 (1981).

61. J. F. Ely and H .J .M. Hanley, Prediction of transport properties. 1. Viscosity of fluids and mixtures, *Ind. Eng. Chem. Fundm.* **20**(4), 323-332 (1981).

62. D. E. Diller, Measurements of the viscosity of saturated and compressed liquid propane, *J. Chem. Eng. Data* **27**(3), 240-243 (1982).

63. M. E. Baltatu, Prediction of the liquid viscosity for petroleum fractions, *Ind. Eng. Chem. Process Des. and Develop.* **21**(1), 192-195 (1982).

64. M. B. Amin and R. N. Maddox, Estimate viscosity versus temperature*, Hydrocarbon Process. & Petrol. Ref.* **59,** 131-135 (1980).

65. J. M. Haile, K. C. Mo, and K. E. Gubbins, Viscosity of cryogenic liquid mixtures (including LNG) from corresponding states methods, *Adv. Cryo. Eng.* **21**, 501-508 (1976).

66. M. J. Hwang and W. B. Whiting, A corresponding-states treatment for the viscosity of polar fluids, *Ind. Eng. Chem. Res.* **26**(9), 1758-1766 (1987).

67. W. D. Monnery, A. K. Mehrotra, and W. Y. Svrcek, Modified shape factors for improved viscosity predictions using corresponding states, *Can. J. Chem. Eng.* **69**(5), 1217-1223 (1991).

68. M. J. Tham and K. E. Gubbins, Correspondence principle for transport properties of dense fluids. Pure monatomic fluids, *Ind. Eng. Chem. Fundm.* **8**(4), 791-795 (1969).

69. M. J. Tham and K. E. Gubbins, Correspondence principle for transport properties of dense fluids. Nonpolar polyatomic fluids, *Ind. Eng. Chem. Fundm.* **9**(1), 63-70 (1970).

70. E. Helfand and P. Rice, Principle of corresponding states for transport properties, *J.Chem.Phys.* **32**(6), 1642-1644 (1960).

71. K. S. Pedersen, A. Fredenslund, P. L. Christensen, and P. Thomassen, Viscosity of crude oils, *Chem. Eng. Sci.* **39**(6), 1011-1016 (1984).

72. H.K. Onnes, *Commun. Physic. Lab. Univ. Laiden*, No 12 (1894) [as quoted in S. Bretsznajder, Prediction of Transport and other Physical Properties of Fluids, Pergamon, Oxford, 1971].
73. A. S. Smith and G. G. Brown, Correlating fluid viscosity, *Ind.Eng.Chem.* **35**(6), 705-771 (1943).
74. L. I. Stiel and G. Thodos, Force constants for polar substances: Their prediction from critical properties, *AIChE J.* **10**(2), 266-269 (1964).
75. S. R. S. Sastri and M. V. Ramana Rao, Estimating liquid viscosities, *Chem. Age India* **21**(7), 675-680 (1970).
76. A. Letsou and L. I. Stiel, Viscosity of saturated nonpolar liquids at elevated pressures, *AIChE J.* **19**(2), 409-411 (1973).
77. A. S. Teja and P. Rice, Generalized corresponding states method for the viscosities of liquid mixtures, *Ind. Eng. Chem. Fundm.* **20**(1), 77-81 (1981).
78. A. S. Teja, P. A. Thurner, and B. Pasumarti, Calculation of transport properties of mixtures for synfuels process design, *Ind. Eng. Chem. Proc. Des. Dev.* **24**(2), 344-349 (1985).
79. K. Aasberg-Pattersen, K. Knudsen, and A. Fredenslund, Prediction of viscosities of hydrocarbon mixtures, *Fluid Phase Equil.* **70**(2-3), 293-308 (1991).
80. K. J. Okeson and R. L. Rowley, A four-parameter corresponding-states method for prediction of Newtonian, pure-component viscosity, *Int. J. Thermophys.* **12**(1), 119-136 (1991).
81. W. V. Wilding, J. K. Johnson, and R. L. Rowley, Thermodynamic properties and vapor pressures of polar fluids from a four-parameter corresponding-states method, *Int. J. Thermophys.* **8**(6), 717-735 (1987).
82. J. Prabhakar, M. V. Rao, and D. H. L. Prasad, A corresponding-states' method for the viscosity of liquids and liquid mixtures, *Indian Chem. Engr.* Trans. **30**(2), 55-59, 61 (1988).
83. H. G. Yucel and S. Ozdogan, A new method for predicting viscosity of pure organic liquids, *Can. J.Chem. Eng.* **76**(1), 148-155 (1998).
84. M. J. Lee and M. C. Wei, Corresponding – state model for viscosity of liquids and liquid mixtures, *J. Chem. Eng. Japan* **26**, 159 (1993).
85. I. F. Golubev, *Viscosity of Gases and Mixtures: A Handbook*, Natl. Tech. Inf. Ser., TT 70 50022, (1959).
86. L. W. Flynn and G. Thodos, The viscosity of hydrocarbon gases at normal pressures, *J. Chem. Eng. Data* **6**(3), 457-459 (1961).
87. G. P. Mathur and G. Thodos, The viscosity of dissociated and undissociated gases for temperatures up to 10,000° K, *AIChE J.* **9**(5), 596-599 (1963).
88. P. Yoonm and G. Thodos, Viscosity of nonpolar gaseous mixtures at normal pressures, *AIChE J.* **16**(2)**,** 300-304 (1970).
89. D. Reichenberg, New methods for the estimation of the viscosity coefficients of pure gases at moderate pressures (with particular reference to organic vapors) *AIChE J.*

21(1), 181-183 (1975); *Symposium on Transport Properties of Fluids and Fluid Mixtures*, National Engineering Laboratory, East Kilbridge, Glasgow, Scotland (1979).

90. J. A. Jossi, L. I. Stiel, and G. Thodos, The viscosity of pure substances in the dense gaseous and liquid phases, *AIChE J.* **8**(1), 59-63 (1962).
91. L. I. Stiel and G. Thodos, The viscosity of polar substances in the dense gaseous and liquid regions, *AIChE J.* **10**(2), 275-277 (1964).
92. A. Bondi, Viscosity of nonassociating liquids. Initial correlation, *Ind. Eng. Chem. Fundm.* **2**(2), 95-102 (1963).
93. K. R. Malek and L. I. Stiel, Stockmayer force constants for the viscosity of polar gases, *Can J. Chem. Eng.* **50**(4), 491-495 (1972).
94. L. Monchick and E. A. Mason, Transport properties of polar gases, *J. Chem. Phys.* **35**(5), 1676-1697 (1961).
95. T. H. Chung, M. Ajlan, L. L. Lee and K. E. Starling, Generalized multiparameter correlation for nonpolar and polar fluid transport properties, *Ind. Eng. Chem. Res.* **27**(4), 671-679 (1988).
96. P. D. Neufeld, A. R. Janzen, and R. A. Aziz, Empirical equations to calculate 16 of the transport collision integrals $\Omega^{(l,s)*}$ for the Lennard-Jones (12-6) potential, *J. Chem.Phy.* **57**(3), 1100-1102 (1972).
97. M. R. Brule and K. E. Starling, Thermophysical properties of complex systems: applications of multiproperty analysis, *Ind. Eng. Chem. Proc. Des. Dev.* **23**(4), 833-845 (1984).
98. J. F. Ely, *Proceedings of the Sixty Third Annual Conventions*, Natural Gas Processors Association, 9-22 (1984).
99. W. D. Monnery, A. K. Mehrotra, and W. Y. Svrcek, Viscosity prediction from a modified square well intermolecular potential model, *Fluid Phase Equilib.* **117**(1-2), 378-385 (1996).
100. W. D. Monnery, A. K. Mehrotra, and W. Y. Svrcek, Viscosity prediction from a modified square well intermolecular potential model: polar and associating compounds, *Fluid Phase Equilib.* **137**(1-2), 275-287 (1997).
101. J. Homer, C. Generalis, and J. H. Robinson, Artificial neural networks for the prediction of liquid viscosity, density, heat of vaporization, boiling point and Pitzer's acentric factor. Part I. Hydrocarbons, *Phys.Chem. Chem. Phys.* **1**(17), 4075-4081 (1999).
102. K. Y. Rani and V. S. R. Rao, CDTA for Neural Networks using Adaptive Learning Rate for Biochemical Systems, *Proc. Chemical and Process Engineering Conference (CPEC 2000)*, Singapore, Paper No. PDD2.2, 11-13 Dec. (2000).
103. M. M. Abbott and T. G. Kaufmann, Correlation of orthobaric kinematic viscosities of liquid n-alkane, *Can. J. Chem. Eng.* **48**(1), 90-92 (1970).
104. N. V. K. Dutt, *Indian Chem.Eng.* XXIV, Trans.25 (1982).
105. J. M. Allan and A. S. Teja, Correlation and prediction of the viscosity of defined and undefined hydrocarbon liquids, *Can. J. Chem.Eng.* **69**(4), 986-991 (1991).

106. M. L. Druin and S. I. Kerps, Prediction of viscosity of liquid hydrocarbons, *Ind .Eng. Chem. Fundm.* **9**(1), 79-83 (1970).
107. P. W. Bridgman, Thermal conductivity of liquids under pressure, *Proc. Am. Acad. Arts Sci.* **59**(7), 141-169 (1923).
108. H. Orbey and S. I. Sandler, The prediction of the viscosity of liquid hydrocarbons and their mixtures as a function of temperature and pressure, *Can.J.Chem.Eng.* **71**(3), 437-446 (1993).
109. A. L. Hovrath, Liquid viscosity of halogenated hydrocarbons*, Chem.Eng.* **83**(7) 121-124 (1976).
110. L. H. Thomas, H. Smith and G. D. Davies, The viscosity of liquids at temperatures approaching the freezing point, and molecular association of polyphenyls and related compounds, *Chem. Eng. J.* **16**(3)**,** 223-232 (1978).
111. L. H. Thomas, Entropy of vaporization and the structure of liquids, J. Chem. Soc. A: Inorganic, Physical, Theoretical, **11**, 2609-2615 (1968).
112. N. V .K. Dutt, A. Rajiah, and D. H. L. Prasad, Viscosity of fatty esters from molecular weight, *J. Oil Tech. Assoc. India* **24**(4), 141, 143, 145, 147 (1992).
113. B. Krishnakumari, Y. V .L. Ravikumar, C. K. S. Nair, and U. T. B. Rao, Estimation of vegetable oils viscosity from iodine and saponification values*, Indian J. Technol.* **31**(7), 547-549 (1993).

Chapter 5

VISCOSITIES OF SOLUTIONS AND MIXTURES

In industrial practice, viscosities of solutions (meaning homogeneous products of dissolution of solids or gases in liquids) and fluid mixtures (meaning homogeneous mixtures resulting out of mixing of two or more fluids) are often needed for the design of the different unit operations and processes involved. While it will be ideal to measure the viscosities of the solutions and mixtures at the conditions of interest, constraints on the availability of time, facilities and expertise, often force the designer to use an estimated value. The objective of this chapter is to outline the methods available in the literature for the estimation of the viscosity of solutions and mixtures.

5.1 VISCOSITIES OF SOLUTIONS

5.1.1 FALKENHAGEN RELATIONS

Falkenhagen[1] from his theoretical analysis proposed equations for the estimation of the viscosity of dilute as well as concentrated electrolyte solutions.

For dilute solutions the viscosity can be calculated from using the relation:

$$\frac{\eta_S}{\eta_0} = 1 + A\sqrt{c} \tag{5.1}$$

where η_S is the viscosity of the solution

η_0 is the viscosity of the solvent

c is the concentration of the solute, and

A is a constant > 0, dependent on the electrostatic forces between the ions.

Jones and Dole[2] also proposed a similar equation. Falkenhagen's theory enables the calculation of the constant A for the case of equal ionic valencies ($z_1 = z_2 = z$) and equal ionic mobilities ($L_1^\infty = L_2^\infty = L^\infty$) by the following equation.

$$A = \frac{0.517 z^2}{L^\infty \eta_0 \sqrt{\varepsilon_0}\, T} \qquad (5.2)$$

where ε_0 is the dielectric constant of the solvent
T is the absolute temperature, and
L^∞ is the ionic mobility at infinite dilution.

Values of A calculated from the above equation are found to agree closely with the values calculated from the viscosity data. The theoretical treatment has been extended by Onsager and Fuoss[3] to include the viscosities of the solutions containing any number of ionic species.

For more concentrated solutions, the equation becomes;

$$\frac{\eta_S}{\eta_0} = 1 + A\sqrt{c} + B\,c \qquad (5.3)$$

where, B is a constant, which depends on the interaction between the ions and molecules of the solvent. For still higher concentrations up to 1 mole per liter, a three-constant equation (Eq. 5.4) is necessary to represent the viscosity data.

$$\frac{\eta_S}{\eta_0} = 1 + A\sqrt{c} + B\,c + C\,c^2 \qquad (5.4)$$

Illustrative values of the constants of the three-constant equation given by Kaminsky[4] are noted in Table 5.1.

Table 5.1. Constants of the three-constant equation for the viscosity of aqueous solutions at 25°C.

Compound	***Valencies***	***$A/(mol\,/\,l)^{(-1/2)}$***	***$B/(mol\,/\,l)^{(-1)}$***	***$C/(mol\,/\,l)^{(-2)}$***
NaCl	1 – 1	0.0062	0.0793	0.0080
KCl	1 – 1	0.0052	- 0.0140	0.0010
KI	1 – 1	0.0047	- 0.0755	0.0000
K_2SO_4	1 – 2	0.0135	0.1973	0.0320
$MgCl_3$	2 – 1	0.0165	0.3712	0.0000
$MgSO_4$	2 – 2	0.0230	0.5937	0.0200
$CeCl_3$	3 – 1	0.0310	0.0555	0.0110

Values of the constant *B* can be calculated additively from the contributions of the cation and anion. Since the mobilities and the temperature coefficients of the mobilities of K^+ and Cl^- ions are similar, the values of *B* for these ions would also be similar. On this basis, Table 5.2 for ionic contributions has been compiled.

Table 5.2. Ionic contributions to constant *B* for aqueous solutions of electrolytes at 25°C.

Cation	***Contribution***	***Cation***	***Contribution***	***Anion***	***Contribution***
Li^+	0.1495	Be^{2+}	0.3923	Cl^-	- 0.0070
Na^+	0.0863	Mg^{2+}	0.3852	Br^-	- 0.0420
K^+	- 0.0070	Ca^{2+}	0.2850	I^-	- 0.0685
Rb^+	- 0.0300	Sr^{2+}	0.2650	OH^-	0.1200
Cs^+	- 0.0450	Ba^{2+}	0.2200	ClO_3^-	0.0240
NH_4^+	- 0.0074	Fe^{2+}	0.4160	NO_3^-	- 0.0460
Ag^+	0.0910	La^{3+}	0.5880	MnO_4^-	- 0.0590
H^+	0.0690	Ce^{3+}	0.5765	SO_4^{2-}	0.2085

The above equations are applicable not only to solutions of electrolytes in water but also to solutions of electrolytes in non-aqueous solvents like methanol, ethanol or nitrobenzene.

5.1.2 KERN RULE

A rough and readily usable rule proposed by Kern[5] suggests that viscosity twice that for water should be used for salts in water whose concentration is below 30 % when syrupy type solutions are not formed. A solution of sodium hydroxide in water should be considered syrupy even when it is dilute. The implication of this rule is

$$\left(\eta_{solution} < 2\eta_{water}\right)_{c<30\%} \tag{5.5}$$

5.1.3 DAVIS METHOD

Davis[6] developed a method based on the finding that a plot of *log(sin 10η)* against salt concentration is linear for solutions of a substantial number of inorganic electrolytes in water, when η is expressed in cP and the concentration is expressed in moles/1000g water.

5.1.4 DUHRING PLOT

It has been a common observation that a straight line results, if the temperature of a reference liquid (having a particular value for viscosity) is plotted against the temperature at which the liquid of interest has the same viscosity, over the ranges of availability of viscosity versus temperature data. This observation normally referred to as Porter's rule, forms the basis for the construction of Duhring plots. For the purpose of interpolating/extrapolating viscosity data for electrolytes as well as several other liquids and solutions (as a function of temperature) Duhring plot is convenient. It is obvious that the application of the method requires the viscosity data of the reference liquid (over the entire temperature range) and the viscosity of the liquid or solution of interest, at the minimum, at two temperatures.

Figure 5.1 is the Duhring plot (illustrating the application of Porter's rule) for $C_2H_4Cl_2$, CH_3OH and C_8H_{18}. The straight lines indicated with the labels have resulted by plotting the temperatures at which they have the same viscosity as the reference liquid (water) on the ordinate against the temperature of water as the abscissa. The curved line in the figure is a plot of the viscosity of the reference liquid (water) on the ordinate as a function of temperature on the abscissa. It may be noted that the values of viscosity are marked on the ordinate on the right side of the graph. Temperatures of the reference liquid (water) are written on the horizontal axis, where as the temperatures of liquids of interest are given on the vertical axis and marked towards the left side.

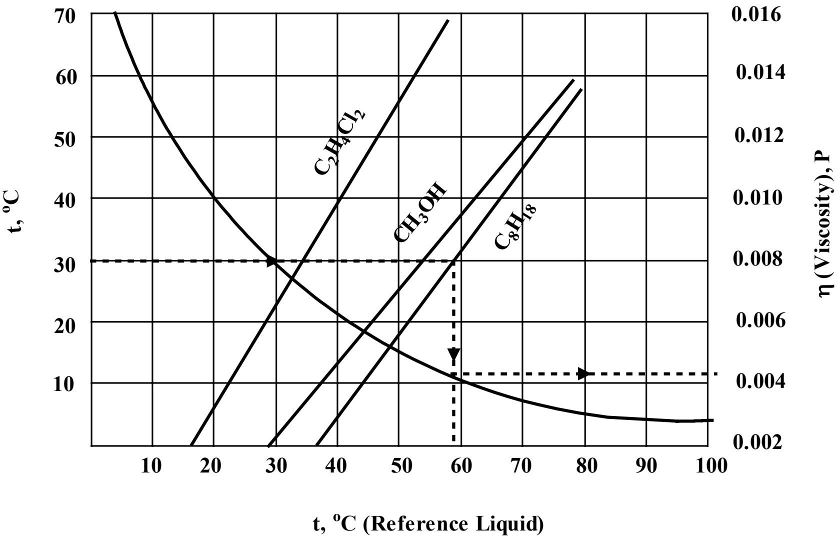


Figure 5.1. Illustration of Porter's rule.

As an example, to find viscosity of octane at 30°C, we draw a straight line, parallel to the abscissa starting from the point corresponding to 30°C mark on the ordinate given on the left side, till it intersects with the straight line corresponding to octane. From the point of intersection, a vertical line is dropped to the curve for the reference compound, water, in this case. The viscosity corresponding to this second point of intersection on the curve corresponding to water is the required viscosity. Thus, from the working shown by marking dashed lines in Fig. 5.1, it is predicted that the viscosity of octane at 30°C is the same as that of the reference liquid (water) at 58°C, and is 0.48 cP.

Examples of Duhring plots for solutions of specified compositions are given, in Figs. 5.2 and 5.3. Figure 5.2 gives Duhring plots for 10% and 25% solutions of aqueous sodium nitrate, while Duhring plots for a series of aqueous sucrose solutions are shown in Figure 5.3. In contrast to Figure 5.1, the values of viscosity of the reference liquid (water) have been marked by the investigators at the top on the horizontal axis, in Figures 5.2 and 5.3. However, the methodology of application remains similar to that mentioned above for pure liquids.

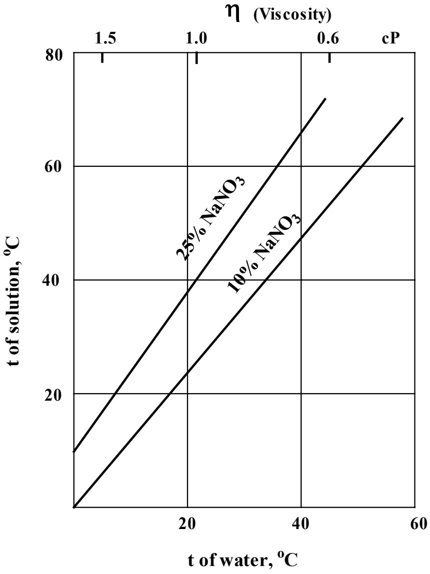


Figure 5.2. Duhring plots for the viscosity of aqueous solutions of sodium nitrate with water as the reference fluid.

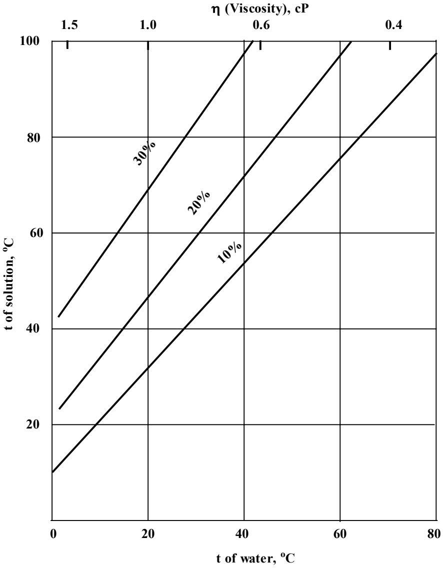


Figure 5.3. Duhring plot for the viscosity of aqueous sucrose solutions with water as the reference liquid.

5.1.5 SOLVATION/ASSOCIATION PRONE SOLUTIONS

If solvation or association occurs, straight lines will not necessarily result on the Duhring plots. Cornelissen and Waterman[7] showed that the effect of temperature on the kinematic viscosity of the solutions of associating type of solutions is well represented by:

$$\log \upsilon = A/T^{x} + B \tag{5.6}$$

where A, B and x are constants for each solution. They find that plots of $\log \upsilon$ versus A/T^{3} are linear for sulfuric acid solutions. The methodology has been applied to several mixtures and single liquids of both associated and non-associated type.

The viscosities of aqueous electrolyte solutions containing two salts (or hydroxides), which do not react with each other, can be estimated using the Zdanovskii's formula[8]:

$$\eta_S = \frac{\left(x_1\rho_1 + x_2\rho_2\right)}{x_1\left(\rho_1/\eta_1\right) + x_2\left(\rho_2/\eta_2\right)} \tag{5.7}$$

Where	η_s	is viscosity of solution
	x_1	is mole fraction of component 1
	x_2	is mole fraction of component 2
	ρ_1	is density of component 1
	ρ_2	is density of component 2
	η_1	is viscosity of pure component 1
	η_2	is viscosity of pure component 2

This equation can also be extended to ternary mixtures, treating as if each binary mixture is a pure liquid.

5.2 VISCOSITIES OF FLUID MIXTURES

Estimation of the viscosities of fluid mixtures is a more challenging task than the treatment of pure fluids. Two distinct approaches followed in the case of mixtures are:

1) Extension of pure viscosity estimation methods to mixtures mostly by means of semi-theoretical equations, and
2) Application of mixture rules to pure component viscosity models based on theory and/or experimental data.

Pure viscosity estimation methods using various models like those of Chapman and Enskog have been discussed in Chapter 3. On the other hand, a large number of parameter and mixing rules of varying degrees of complexity are also reported in the literature. Some of the characteristic parameters and mixing rules with general applications will be mentioned in the subsequent sections. The various properties used in mixture viscosity correlations subject to different mixing rules include critical properties, average molecular weight, dipole moment, hard sphere diameter, equivalent carbon number (ECN) and size and shape related parameters. Some of the methods developed using excess Gibbs free energy models include Wilson, NRTL (non-random two-liquid), UNIQUAC (universal quasi-chemical) and UNIFAC (universal functional activity coefficient) models. The commonly used empirical models in mixture viscosity estimation methods are Andrade - de Guzman method, Eq. (4.5) and Vogel method, Eq. (4.17). Some of the excellent reviews and data sources on viscosity of fluid mixtures include those by Monnery *et al.*[9], Poling *et al.*[10], Mehrotra *et al.*[11], Irving[12,13], Stephan and Heckenberger[14], Kouris and Panayiotou[15], Aucejo *et al.*[16], Kumagai and Takahashi[17] and Wu *et al.*[18]. In this section, a discussion of some of the fluid mixture viscosity estimation methods is presented.

5.2.1 LEAN MIXTURE VISCOSITY

Most of the estimation methods for low-pressure gas mixtures provide estimates within 10% of the experimental values. Wilke[19], Herning and Zipperer[20] and Reichenberg[21-23] proposed simplified versions of the rigorous kinetic theory of Chapman and Enskog, and applied to multi-component mixtures. Application of these methods requires the pure component viscosities as inputs. Reichenberg's method is more elaborate and complex than the methods of Herning and Zipperer[20] and Wilke[19], and needs critical temperature, critical pressure and dipole moment as additional inputs, but provides the most consistently accurate estimates of viscosity. A brief mention of the different methods proposed for lean gas mixture is given below.

5.2.1.1 Corresponding States Approaches

Lucas *et al.*[24, 25] and Chung *et al.*[26, 27] proposed corresponding states based methods. These methods do not need pure component viscosities and depend only upon the mixing rules for pure component critical properties. The method of Chung *et al.*[27], in addition to critical properties, uses the mixing rules for the acentric factor (ω), the Lennard-Jones potential parameters (ε/k and σ) and dipole moment (μ). In general, the corresponding states methods yield slightly large errors compared to the methods of Wilke[19], Herning and Zipperer[20] and Reichenberg[21-22].

Using simple linear additive rule for the critical properties: T_C, V_C and Z_C and the molecular mass M and the parameter ξ defined by Eq. (3.6), Dean and Stiel[28] have extended the method of Stiel and Thodos[29] for the calculation of the viscosity of non-polar lean gas mixtures. The method yields an average absolute deviation (AAD) of 1.7% for the data on 22 binary mixtures.

5.2.1.2 Computations from Pure Component Data

Brokaw[30] extended the application of the Chapman and Enskog theory to polar and non polar gas mixtures by applying several mixture rules to the pure component viscosities, molecular weights, reduced temperatures defined in terms of the L-J parameter, ε/k and dipole moments. The method yielded errors within 1 % over the data on 25 mixtures.

Hellemans *et al.*[31] tested their measurements on the binary mixtures of oxygen–krypton, oxygen–argon and nitrogen–oxygen in terms of the Chapman and Enskog theory and obtained agreement within ±0.5 % in most of the cases. Kestin *et al.*[32] correlated the data obtained by them on the binary mixtures of xenon with neon, argon, helium and krypton in the temperature range 25–500°C, (with the appropriate kinetic theory expressions reinforced by the extended law of corresponding states) with deviations less than ±0.5%. Vogel[33] has reported the data on the viscosity of the binary mixtures of benzene-toluene and benzene–p-xylene over the temperature ranges of 300–630K and 355–625K, respectively. By taking into account the initial density dependence of viscosity according to modified Enskog theory for gaseous mixtures, he could obtain consistent values of the interaction viscosity.

Oh and Campbell[34] reported the values of the group parameters needed for the estimation of the dilute gas mixtures formed by normal and branched alkanes, alkenes, nitrogen and carbon dioxide. The method yielded good agreement between the predicted and experimental data for the mixtures of nitrogen and carbon dioxide with alkenes. For a total of 2231 data points, the method predicts viscosities with an average absolute deviation of 1.35 %.

Galloway and Sage[35] considered the Chapman-Cowling mixture rules for the paraffin–nitrogen binaries from the empirical standpoint. van Houten and Ten Bosch[36], using Chapman and Enskog theory, derived a kinetic expression for the volume-viscosity (defined as the viscosity at any point where the flow involves a change in volume) of the binary mixtures of polyatomic and noble gases in terms of effective collision cross section, neglecting higher order polynomials in internal and translational relaxation (which is directly related to volume-viscosity) rate and the mixture composition. Using closed coupled scattering calculations, Clark and McCourt[37] have determined binary viscosity coefficients (in terms of the cross sections) for molecular (H_2) and atomic (H) hydrogen mixtures over the temperature range 40–2200 K.

5.2.2 DENSE FLUID MIXTURE VISCOSITY

Di Pippo *et al.*[38] reported a modified equation based on Enskog theory for the estimation of a dense mixture of real gases. The method needs the following information:

(i) the low density pure component viscosities,
(ii) low density value of the mixture viscosity,
(iii) viscosities of the component gases at the same molar density as the mixture,
(iv) equations of state of the pure components, and
(v) the second virial coefficients and their temperature derivatives of the component gases.

For the binaries He-Ar, Ne-Ar and H_2-CH_4 studied, the agreement with the experimental values was within 5%. Kestin *et al.*[39] compared the actual composition dependence of the viscosity of dense gas He-Ne and Ne-Ar mixtures with the predicted values based on the Enskog – Thorne theory for dense mixtures of gases of hard spheres.

Quinones-Cisneros *et al.*[40] proposed a novel friction theory for modeling viscosity, based on the concepts of classical mechanics and van der Waals theory. By partitioning the total viscosity into the dilute gas and friction terms, they could establish a connection between van der Waals attractive and repulsive pressure terms and the Amontons-Coulomb friction law. Since the cubic equations of state (EOS) are suitable for providing accurate estimates and the pressure is the main mechanical property related to friction, Quinones-Cisneros *et al.*[40] used two well-known cubic EOS to model the viscosity of n-alkanes from methane to n-decane and their mixtures with deviations within experimental accuracies.

Audonnet and Padua[41] reported data on the viscosities and densities of the binary mixtures of methane and n-decane at five compositions at pressures up to 75 MPa and temperatures ranging between 298K and 393K. The data could be well correlated by the predictive scheme of Assael *et al.* [42] and Dymond and Assael[43] that was based on the hard-sphere theory of transport properties. The scheme predicted the mixture data remarkably well, using the knowledge of the pure component properties.

A simple, yet efficient method of estimating viscosity of natural gases was reported by Elsharkawy[44]. The method, accounting for the presence of heptane, hydrogen sulfide and carbon dioxide in natural gases and based on a modification of the Lee *et al.* correlation[45], yielded average absolute deviations ranging between 6.5% and 14.7%. The results obtained by the method have been reported to be more accurate than the other EOS–based viscosity model and corresponding states methods.

Extension of the viscosity estimation methods for pure gases at high pressures proposed by Lucas *et al.*[23, 24, 46], Chung[26] and Millat *et al.*[47] to mixtures is described by Poling *et al.*[10] Yener *et al.*[48] measured viscosities of lipid – supercritical carbon dioxide mixtures with a high pressure capillary viscometer over the temperature and pressure ranges of 313.15–333.15 K and 11.5–30 MPa, respectively. The mixture behavior was found to be Newtonian. Employing a modified Arrhenius equation by means of Gibbs free energy using solubility parameters of the components based on regular solution theory, they could predict the liquid and fluid phase viscosities of the mixtures within ±2.5% and ± 1%, respectively.

5.2.3 GAS AND LIQUID MIXTURE VISCOSITY

The method of Tham and Gubbins[49] developed for polyatomic fluids has been extended to gaseous and liquid mixtures by Christiansen and Fredenslund[50] using Mo and Gubbins mixing rule[51] for the rotational coupling coefficient, α_{TG}. The mixing rule is given by the equation:

$$\alpha_{TG} = \sum_i \sum_j x_i x_j \left(\alpha_{TG,i} . \alpha_{TG,j}\right)^{0.5} \tag{5.8}$$

where x_i is mole fraction of component i,
x_j is mole fraction of component j,
$\alpha_{TG,i}$ is rotational coupling coefficient of pure component i, and
$\alpha_{TG,j}$ is rotational coupling coefficient of pure component j.

Equation (5.8) yields good results for mixtures of components of nearly equal size[52].

For poly-disperse mixtures, Pedersen *et al.*[53] used the equation for the mixture rotational coupling coefficient, α_m, from mixture molar mass M_m:

$$\alpha_m = 1 + b_2 \rho_R^{\,b_3} M_m^{\,b_4} \tag{5.9}$$

where, ρ_R is the reduced density, and b_2, b_3, and b_4 are constants. Using certain mixture rules for mixture pseudo-critical properties needed in the application of the method of Tham and Gubbins[49] and selecting methane as the reference fluid, Pedersen *et al.*[52] obtained an AAD of 6.4% for some binary mixtures of hydrocarbons. The method also predicted viscosities of crude oils to within 5% of the experimental data. Re-estimating the rotational coupling coefficient from Eq. (5.8), with additional data on viscosity and using a modified mixture rule for the mixture molecular mass, Pedersen and Fredenslund[53] could improve the viscosity predictions for mixtures of light components like C_2, C_3 hydrocarbons and CO_2, over the results obtained from the method of Pedersen *et al.*[52].

The work of Ely and associates on the viscosity of non-polar fluids is presented in Section 4.3.2.3.2a while its extension to heavier molecules is given in Section 4.3.2.3.2b. Application of the method is mentioned here.

By applying a correction (derived from experimental data) to the viscosity correlation of Hanley *et al.*[54], Ely and Hanley[55] obtained an overall deviation of 7% for alkane binaries and aromatic–alkane binary mixtures. The viscosity correlation of Hanley *et al.*[54] is based on reference fluid approach.

Using the mixture rule for the parameter ξ, defined by Eq. (3.6) for each component, becomes:

$$\xi_m = \frac{T_{Cm}^{\ 1/6}}{P_{Cm}^{\ 2/3} M_m^{\ 1/2}} \tag{5.10}$$

and a simple additive rule for the characteristic properties (*Prop*) - molecular mass (*M*), critical temperature (T_C), and critical pressure (P_C) is proposed:

$$Prop_m = \sum_i x_i \, Prop_i \tag{5.11}$$

Teja and Rice method, described in Section 4.3.2.3.2i, has been extended for application to mixtures using van der Waals one-fluid model to obtain the necessary pseudo-critical properties. The mixing rules used by them for various properties are as follows:

$$T_{Cm} = \sum_i \sum_j x_i x_j T_{Cij} V_{Cij} \tag{5.12}$$

$$V_{Cm} = \sum_i \sum_j x_i x_j V_{Cij} \tag{5.13}$$

$$\omega_m = \sum_i x_i \omega_i \tag{5.14}$$

$$M_m = \sum_i x_i M_i \tag{5.15}$$

For unlike parameters, the following expressions are useful

$$T_{Cij} V_{Cij} = \Psi_{ij} \left(T_{Ci} V_{Ci} T_{Cj} V_{Cj} \right)^{0.5} \tag{5.16}$$

$$V_{Cij} = (1/8)\left(V_{Ci}{}^{0.333} + V_{Cj}{}^{0.333} \right)^3 \tag{5.17}$$

where ψ_{ij} is a binary interaction parameter. Teja and Rice correlated the reference fluid viscosities with an Andrade type equation,

$$ln(\eta\xi) = A + (B/T_R) \tag{5.18}$$

ignoring the effect of pressure on liquid viscosity, which is believed to introduce little error. It is worth noting that the reference fluid viscosities are calculated at the corresponding reduced conditions, at T_R (= T_{Cref} / T_{Cm}).

Teja and Rice tested 1010 viscosity data points for six non-polar + non-polar, six polar + polar, eleven non-polar + polar and six aqueous binary mixtures, with the two components comprising the binary mixture as the reference components and fitted a binary interaction parameter. The method worked best for non-polar + non-polar systems with an average absolute deviation of 0.7%. For polar and aqueous systems, the average absolute deviations are 2.5 and 9%, respectively.

Two limitations of the method have been stated. First, the method requires the use of appropriate reference components (similar to the components of interest) and hence the viscosity data for the reference fluids may have to be extrapolated or interpolated. The second limitation arises from the use of van der Waals one-fluid model which works best for the mixtures of non-polar + non-polar fluids in which the components do not differ greatly in size (critical volume ratios less than 3.5). The following mixing rules of Wong *et al.*[56] have been adopted by Teja and Rice.

$$T_{Cm}{}^2 / P_C = \sum_i \sum_j x_i x_j \left(T_{Cij}{}^2 / P_{Cij} \right) \tag{5.19}$$

$$T_{Cm}/P_{Cm} = \sum_i \sum_j x_i x_j \left(T_{Cij}/P_{Cij}\right) \tag{5.20}$$

$$\omega_m \left(T_{Cm}/P_{Cm}\right) = \sum_i \sum_j x_i x_j \left(T_{Cij}/P_{Cij}\right)^{0.667} \omega_{ij} \tag{5.21}$$

The unlike parameters are described by

$$\left(T_{Cij}/P_{Cij}\right) = (1/8)\left(\left(T_{Ci}/P_{Ci}\right)^{0.333} + \left(T_{Cj}/P_{Cj}\right)^{0.333}\right)^3 \tag{5.22}$$

$$T_{Cij} = \xi_{ij}\left(T_{Ci}T_{Cj}\right)^{0.5} \tag{5.23}$$

$$\omega_{ij} = 0.5\left(\omega_i + \omega_j\right) \tag{5.24}$$

According to Wong *et al.*, these mixing rules are equivalent to those of van der Waals when the critical compressibilities of the components are equal (since V_C is replaced by RT_C / P_C). Wu and Asfour[57] described the extension and application of the methodology to ternary and quaternary n-alkane mixtures.

Aasberg-Petersen *et al.*[58] proposed a method based on the Teja-Rice approach, using molar mass (instead of the acentric factor) as the third parameter. Mixing rules similar to those of Pedersen et al.[52] were proposed.

Dean and Stiel[28] suggested an extension of the Jossi *et al.* method described in Section 4.3.2.4.4 to mixtures through the application of the following mixing rule for critical density.

$$\rho_{Cm} = \left(\sum_i x_i V_i\right)^{-1} \tag{5.25}$$

Applying certain mixture rules to the parameters of an equation of state based correlation for pure gases and liquids, Lawal[59] developed a method of estimating the viscosity of gas and liquid mixtures. The method, tested with a large database on binary and multi-component mixtures yielded an over all deviation of 3.5%. For oil, natural gas and gas condensate systems, however, the percent average absolute deviations have been much larger.

Sheng and Lu[60] extended their method of estimating liquid, vapor and dense phase viscosities of pure compounds to mixtures using Peng-Robinson equation of state[61]. The method predicted the viscosity of binary cryogenic mixtures argon-helium, argon-neon and neon-helium to within 0.5% of the measured values.

Palyvos *et al.*[62] used the Enskog theory for hard spheres along with mixing rules based on empirical data. Their method estimated krypton-methane, krypton-argon and argon-methane binaries with deviations below 5%. The dense fluid viscosities of a number of binary, two ternary and three quaternary mixtures of normal alkanes were correlated by Assael *et al.*[63] by means of a one-fluid model and simple linear mixing rules for close packed volume V_O and rough sphere factor C.

5.2.4 LIQUID MIXTURE VISCOSITY

Several data sources and reviews[9-10, 64-67] are available in the literature on liquid viscosity data and their correlation and estimation, including some information about liquid mixture viscosity as well. This section presents a discussion of the liquid mixture viscosity estimation methods. Jhunjhunwala *et al.*[68] presented an Enskog–Thorne based model for estimating viscosities of simple liquid mixtures and reported very good agreement with experimental data in the case of argon–krypton system. Application of the significant liquid structure theory to the binary mixtures of carbontetrachloride with acetone, benzene, chloroform and cyclohexane and acetone with benzene by Singh and Sinha[69] provided estimated viscosities in good agreement with the experimental values. Dizechi and Marschall[70] obtained a modified version of McAllister's equation for liquid mixtures with the temperature dependence. The equation correlates the viscosity data of 41 binary and 6 ternary mixtures very well. A survey of several equations for the estimation of liquid mixture viscosities by Irving[12] revealed only a few that do not contain the adjustable parameters. However, such simple equations were found to be applicable to the components of similar nature with comparable viscosities. From a later study on the evaluation of various equations[13], Irving recommended the following one-constant Grunberg-Nissan model for liquid mixtures[71].

$$ln\,\eta_{mix} = \sum_i x_i\, ln\,\eta_i + 0.5\sum_{i=1}^{n}\sum_{j=1}^{n} x_i x_j G_{ij} \tag{5.26}$$

This equation is found to be widely applicable with reasonable accuracies, except for aqueous solutions. The interaction parameter G_{ij} of Eq. (5.26) is dependent on the composition of the mixture and temperature. Testing Eq. (5.11) extensively, on a large data base comprising alcohols, ketones and carboxylic acids and non-associating mixtures, Isdale[72] reported an overall mean square deviation of 1.6% for 2000 data points. A group contribution method was also proposed by Isdale *et al.*[73] later for the estimation of the interaction parameter G_{ij} of Eq. (5.26). A two–reference fluid corresponding states method developed by Twu[74] for the estimation of kinematic viscosities at 372 K and 310.9 K of petroleum fraction yielded an AAD of 2%. A group contribution method similar to that of UNIFAC was proposed by Chevalier *et al.*[75] to predict the kinematic viscosities of liquid phase mixtures using the parameters related to molecular geometry and the interaction between the functional groups of the molecules involved.

Applying the method to the mixtures of esters, ketones, chlorinated alkanes and linear, branched, cyclic and aromatic hydrocarbons, the authors claimed closer agreement with the measured values compared to all the published correlations. Poling *et al.*[10] applied a modified UNIFAC method developed by Gaston-Bonhomme *et al.*[76] to 13 ternary alkane mixtures and obtained an AAD of 2.6%. They have also reported an AAD of 3.6% in the case of four quaternery systems studied. A group contribution method for prediction of mixture viscosity, based on Eyring's model for pure components, has been presented by Wu[77]. Group interaction parameters were obtained from regression of the viscosity data on more than 80 binary systems comprising of esters, water, ketones, alcohols and aromatics and chlorinated hydrocarbons. Awwad *et al.*[78] determined excess molar viscosities and activation energies of viscous flow for the binary mixtures of normal hexane, octane, decane, dodecane, tetra-decane and hexa-decane with benzene at 298.15 K. They have also studied the influence of orientation order of normal alkanes on solution viscosities. Adequacy of the free volume absolute rate theories to predict the solution viscosities was also investigated. Higher order alkanes showed the dependence of the excess molar viscosities with molar activation energies of viscous flow. Similar studies were carried out by Awwad *et al.*[79] on the mixtures of methyl acetate and n-butyl acetate with normal hexane, heptane, nonane, decane, dodecane, tetra-decane and hexa-decane at 298.15 K. The study revealed the negative values of the excess viscosities and activation energies in the case of lower alkane systems, turning positive for longer alkanes. Absolute rate and free volume theories were found inadequate in predicting the viscosity data. Islami and Quadri[80] determined the excess molar free energy of activation of flow from the measured viscosities of binary alcohol mixtures as functions of concentration and temperature. The negative values of the excess free energies obtained for the systems benzyl alcohol + iso-amyl alcohol and benzyl alcohol + iso-propyl alcohol imply strong interactions. Chhabra and Sridhar[81] reported results on the application of Hildebrand Fluidity Model to liquid mixtures. The liquid mixture viscosities were calculated using the parameters B and V_O for the mixtures, predicted from pure component values and molecular volumes as inputs. Using simple mixing rules for the calculation of the liquid mixture fluidity parameters from the corresponding values for pure components, Chhabra and Sheth[82] reported good agreement between the calculated and experimental viscosities for a number of liquid binary, ternary and quaternary mixtures.

Mamagakis and Panayiotou[83] presented the data on ternary and binary mixtures of acetone, isooctane, and toluene at 298.15 K. A model developed for ternary mixtures by combining the lattice fluid, free volume and Erying's rate theories for liquid viscosities yielded good agreement with the experimental data. Kanti *et al.*[84] applied Flory's theory and the relationship of Bloomfield and Dewan to the viscosity data on the liquid mixture system n- heptane + nonyl benzene at 40, 60 and 80°C obtained between 1 and 400 bar. Their method showed a mean deviation of 5.7 % over 105 data points. They have also tested the data by some other liquid viscosity mixture laws using adjustable empirical parameters. Cao *et al.*[85] reported overall mean relative standard deviations (MRSD) of 0.8% for 215 binary and 2.9% for 14 ternary liquid mixtures for a model developed by them based on statistical thermodynamics and Eyring's absolute rate theory. Sastry and Dave[86] found the data on 14 acrylic–organic solvent mixtures represented well by Grunberg–Nissan, Heric, Mc Allister and Auslander equations. An analysis of the results by the Bloomfield–Dewan relationship showed the predominance of dispersing interactions for aliphatic hydrocarbon and carbontetrachloride–containing mixtures, compared to the equal contributions by both the specific and dispersing interactions in binary mixtures of mono methyl methacrylate and chlorobenzenes. Sastry *et al.*[87] also correlated the viscosities of 15 binary liquid mixtures of alkyl alkanoate hydrocarbons measured at 308.15 K and 318.15 K by means of Grunberg-Nissan, Hind and Auslander equations. Ali *et al.*[88] determined excess viscosities and calculated molecular associations from the experimental data obtained by them on the binary mixtures of ethanol + 1-hexanol, ethanol + 1-octanol and acetone + N,N-dimethyl formamide at 303.15 K. A method of correlating the liquid mixture viscosity data of 47 binaries by Qun-Fang and Yu-Chun[89], when tested, yielded an overall AAD of 1.05%. The binary mixtures include different kinds like those having (i) no maximum and minimum viscosities, (ii) no maximum or one minimum viscosity, and (iii) one maximum and one minimum viscosity, covering the entire composition range. The method also yielded satisfactory results when compared to a free-volume type correlation. The Eyring–Patel–Teja viscosity model formed by the combination of Patel–Teja equation of state with Eryring's theory was used by Lee et al.[90] in correlating the viscosities of 60 non-aqueous binary mixtures with an average absolute deviation of 2.1%. The model, using a two–parameter Redlich–Kister type of mixing law fitted the data on 15 aqueous binaries with an AAD of 4.5%. The model could also be applied successfully to predict the ternary viscosities by means of the binary interaction parameters determined from the binary data. Martins et al.[91] applied a model based on Erying's absolute rate theory and UNIQUAC equation to 350 binary mixtures at 4619 data points. The model represented the data with a mean relative deviation of 1.2%. The model requires only two adjustable parameters besides the size and shape parameters for pure components. In their subsequent work, they[92] calculated the viscosities of 51 multi component non-electrolyte liquid mixtures with an overall MRSD of 2.95% for 1000 data points, using the model based on Eyring's theory of viscous flow combined with UNIQUAC equation. Out of the 51 systems studied, 48 were ternary and 3 were quaternary mixtures.

Protopas and Parlee[93] presented a calculation procedure for binary alloys, based on simulating an alloy by a hypothetical single component hard sphere liquid according to Enskog approach. Carnahan–Starling equation was used for obtaining the pair correlation function at contact needed for the application of Enskog approach. The theory developed provided satisfactory results when tested with the viscosity data obtained for 7 binary alloys. Chiriac *et al.*[94] attributed the higher values of kinematic viscosities of some transition metal–metalloid glass–forming alloys at melting point compared to those of liquid iron to strong interaction between the transition metal atoms and glass forming atoms. The viscosity minimum and glass formation for alloys at metalloid composition greater than 20% has been explained by a cluster structure developing in the melt.

Jung and Didion[95], comparing the measured viscosity data on seven azeotropes of refrigerants with some of the mixing rules, found strong dependence of pure refrigerant viscosity with volume. A correlation developed between excess viscosity and excess volume using the method of Grunberg and Nissan showed less than 2% deviations. Latini *et al.*[96] developed a simple empirical method of predicting liquid viscosities based on the molecular structure and physical properties. The scheme, applied to the refrigerant mixtures predicted the viscosities with the average and maximum deviations of 3% and 8%, respectively. Latini *et al.*[97] also reported a method for predicting the dynamic viscosity of mixtures from reduced temperature, using a simple mixing rule. The method has been applied to some azeotropic and non-azeotropic mixtures of refrigerants, and found to yield reasonable agreement with the experimental measurements. By combining a corresponding states approach with that of Hubet and Ely[98], Klein *et al.*[99] could obtain an AAD within 4%, when tested with the data on refrigerant mixtures.

Passman and Drew[100] presented an exact solution to the viscosity of multi-component liquid mixtures in steady flow between parallel plates of which one is kept stationary and the other moving at constant speed.

However, as pointed out by them, a set of four viscometric tests has to be conducted to characterize the system treated by them theoretically. Korsten[101] proposed an estimation method for the viscosity of petroleum fractions over wide ranges of temperature employing a new mixing rule describing both the positive and negative mixing effects correctly. The sharp increase in viscosity with the reduction of temperature due to dissolved solids could be described by the incorporation of a freezing distribution function in the model. Kapadi *et al.*[102] studied excess Gibbs free energy of activation of viscous flow, excess viscosity and excess molar volume from the viscosity and density measurements on propane-1,2-diol + water system over the entire range of composition at 303.15, 308.15, 313.15 and 318.15 K. The observed negative values for the excess viscosity have been attributed to the strength of intermolecular hydrogen bonding, molecular shape and size of the components. Assael *et al.*[103] applied the Vesovik–Wakeham scheme modified by the hard-sphere model of Dymond–Assael for the calculation of viscosity and thermal conductivity of some alkane + alkane, alkane + alcohol and refrigerant mixtures. They reported excellent agreement with the experimental data for all the cases, when the mass ratio of the pure components is close to unity. Vesovic[104] evaluated a simple viscosity prediction method by means of the data on the refrigerant mixtures R125 + R134a, R152a + R134a and propane + R134a and reported deviations to within ±4% for the first two mixtures. A large deviation of 20% found for the propane + R134a system at 250 K was attributed to the strong non-ideality of the mixture.

A model based on the Peng–Robinson–Stryjek–Vera cubic equation of state applied to binary non-ideal liquid viscosity mixtures of polar compounds over wide ranges of temperature, pressure and composition developed by Salinas[105] showed good agreement with the measurements at low pressures (ranging between 10 and 60 MPa). Rosal *et al.*[106] fitted the binary liquid mixture viscosity data on ortho, meta and para-cresols (in the range 313.15–333.15 K) with the McAllister three-body model and Auslander equation. Positive viscosity deviations were shown by meta and para-cresol mixtures. Enthalpy, entropy and activation energy of viscous flow were also determined for the systems using Eyring's theory of rate processes. Boned *et al.*[107] evaluated the performance of seven representative models by means of high-pressure viscosity data (up to 1000 MPa) of two synthetic hydrocarbon mixtures in the temperature range of 293.15 – 353.15 K. Some of the schemes have been shown to predict the viscosity of the mixtures with good accuracies. Queimada *et al.*[108] found that the generalized relationship between the natural logarithm of surface tension and reciprocal viscosity developed for pure n-alkanes with chain lengths greater than $C_{10}H_{12}$ to be valid for mixtures also. The relationship showed the slope to be dependent on the molecular weight. Rodriguez *et al.*[109] fitted the viscosity deviations for several systems of dimethyl carbonate with alcohols (at 293.15, 298.15, 303.15 and 313.15 K) to the Redlich–Kister equation. They have also determined the interaction parameters of (CH_3OH – OCOO) and (OH – OCOO) needed in the UNIFAC–VISCO method to predict the binary mixture viscosities. Barrufet and Dexheimer[110] developed an automatic data control algorithm for crude oil viscosity data and fitted with Pedersen's and Lohrenz, Bray and Clarke (LBC) compositional viscosity models. The models were reported to yield lower errors than those given by the currently available correlations. Elsharkawy *et al.*[111] developed models for viscosity of crude oils derived from the data obtained from Middle East, North Sea and Other crudes. These models proved to be more accurate compared to several empirical correlations, equation of state-based, and corresponding state models. Novak *et al.*[112] reported a segment–based Eyring–NRTL (non-random two liquid) model for polymer–solvent and polymer-polymer mixtures. For the several systems studied, the model proved to be more effective in fitting the data, besides having some predictive capability.

5.3 ARTIFICIAL NEURAL NET APPROACH FOR POLAR LIQUID MIXTURES

Lee *et al.*[113] proposed a method based on the Artificial Neural Net (ANN) for the calculation of the density and viscosity of mixtures of polar liquids. The authors have measured the densities and viscosities of the binary mixtures of butyl amine + ethanol, ternary mixtures of butyl amine + ethanol + water and butyl amine + benzyl amine + water at 303.15, 313.15 and 323.15 K, and at atmospheric pressure.

The authors developed three neural models – Network A, Network B and Network C. Network A was used to predict the properties of butyl amine + benzyl amine + water system over the entire composition range using binary data. Although the network predicted the density of ternary systems with a 2% AAD in 20 time steps, it required 100 time steps to predict dynamic viscosity with a deviation of 10%. On training, Network A predicted the binary data with an AAD of 0.43% for density and 4.28% for viscosity, and predicted the ternary data with an AAD of 0.68% and 3.96%, respectively.

Network B was tested with polar liquids. The structure of this network included eight nodes in the input layer corresponding to temperature and mole fractions, two hidden layers and two output nodes. The network was trained using 353 points from 12 binary systems. After 720 learning cycles, the network correlated the density of the binary systems with 0.32% AAD and viscosity with 2.88% AAD.

Network C with sixteen input nodes was trained using 583 binary data points from 20 binary systems. Network C correlated the data with an AAD of 3.82%.

The connection weights of the networks are determined from binary data. Using the Professional II/Plus package (Neural Ware Inc., USA), three neural networks have been developed for calculating the density and viscosity of polar liquid mixtures with emphasis on aqueous solutions. The network structures are summarized in Table 5.3.

Table 5.3. Network structures for Lee et al. method.

	Network-A	***Network-B***	***Nework-C***
Input layer	T, x_1, x_2, x_3	T, x_1, …., x_7	T, x_1, …, x_{15}
Hidden layer-1	10	15	32
Hidden layer-2	4	7	-
Output layer	ρ_m, η_m	ρ_m, η_m	η_m
Transfer function	Sigmoid	Sigmoid	Sigmoid

The trained networks are capable of calculating density to within ±1% for both the binary and ternary systems and calculating viscosity generally comparable to those calculated from the corresponding-state model of Lee and Wei[114] for aqueous systems. In these networks, temperature is an input variable to specify the condition of solutions. Mole fraction is used in this study to characterize the mixtures and each compound corresponds to a specific input node. The sigmoid transfer function is assigned to all the processing units and the back-propagation algorithm with the generalized delta rule is utilized for the learning process.

5.4 LIQUID MIXTURE VISCOSITIES BY EMPIRICAL METHODS

The simplest expectation of the mixture viscosity as a linear function of composition (expressed as – volume fraction, mole fraction or mass fraction) is generally not applicable even to the mixtures composed of substances behaving nearly ideal. Often some exponential type of dependence is observed in practical situations. This section mentions some of the empirical methods suggested for the estimation of liquid mixture viscosity.

5.4.1 KENDALL AND MONROE RELATION

Kendall and Monroe[115] proposed the following relation for mixture viscosity:

$$\eta_m^{(1/3)} = x_1 \eta_1^{(1/3)} + x_2 \eta_2^{(1/3)} \tag{5.27}$$

where, x_1 and x_2 are the mole fractions of the mixture, which holds good for several cases of mixtures consisting of non-polar and non-associated liquids.

5.4.2 ARRHENIUS EQUATION

Arrhenius[116] suggested the equation

$$log\, \eta_m = x_1\, log\, \eta_1 + x_2\, log\, \eta_2 \tag{5.28}$$

where, x_1 and x_2 are the mole fractions of the pure components. The equation gave good results for several binary mixtures.

For the Kendall and Monroe or the Arrhenius equation to be applicable, it is necessary that the two liquids constituting the mixture be of similar structure, non-polar and non-associated or one of the components should be present in dominant quantity in the mixture. Further, the difference between the viscosities of the two pure components making up the mixture should be small (below 15 cP).

5.4.3 PANCHENKOV EQUATION

Panchenkov[117] equation, derived on the basis of the mechanism of the flow of viscous liquid, is given by:

$$\eta_m = A_s \rho_m^{(4/3)} T^{(1/2)} \left[exp(\varepsilon_m / RT) - 1 \right] \tag{5.29}$$

where η_m is the mixture viscosity,
A_s is an empirical coefficient,
ρ_m is the density of the mixture,
T is the absolute temperature,
ε_m is the energy of bonds between the molecules in the mixture, and
R is the universal gas constant.

The quantities A_s and ε_m of the Panchenkov equation must be evaluated from the mixture viscosity data, and therefore at least viscosity of the mixture at two conditions must be known for the application of this method with good accuracy.

5.4.4 ANALOGY WITH VAPOR-LIQUID EQUILIBRIA – REIK METHOD

There is superficial resemblance between the behavior of vapor-liquid saturation and fluidities. For example, when considering the maxima or minima which appear in the viscosity-composition curves for multi-component systems, one cannot help thinking of an analogy with the phenomena of azeotropy. This analogy has been analyzed by Faust[118] in terms of the results obtained by Zawidzki[119] who discovered a relationship between the phenomena considered. Pursuing this analogy further, Reik[120] introduced the concept of fictitious partial viscosity. According to this author, the partial viscosity of the component *i* in a mixture is given by:

$$\eta_i = (x_i \eta_{io}) / \gamma_i^{(1/3)} \tag{5.30}$$

where x_i is the mole fraction of component *i* in the liquid mixture,
η_{io} is the viscosity of the pure component *i*, and
γ_i is the activity coefficient of the component *i* in the mixture.

This formula is analogous to the equation for the partial pressure of a constituent of the liquid mixture. According to Reik, the viscosity of the mixture may be estimated as the sum of the partial viscosities. His equation is difficult to use because it requires the values of the activity coefficients of the constituents of the mixture as the input.

In view of the fact that both Panchenkov and Reik equations are rather cumbersome for practical application in engineering calculations, equations involving only one adjustable constant, to be determined from a single data point of the mixture have been developed and tested for their prediction capabilities.

5.4.5 GRUNBERG - NISSAN EQUATION

The equation of Grunberg and Nissan[71] for the viscosities of binary liquid mixtures is given by:

$$log\, \eta_m = x_1\, log\, \eta_1 + x_2\, log\, \eta_2 + x_1 x_2 d \tag{5.31}$$

where η_m is the viscosity of the mixture,
η_1 is the viscosity of component 1,
η_2 is the viscosity of component 2,
x_1 and x_2 are the mole fractions of the components 1 and 2, and

d is an interaction coefficient which is dependent on temperature but independent of composition.

5.4.6 VAN DER WYK RELATION

Van der Wyk[121] obtained the relationship:

$$ln\,\eta_m = x_1^2\, ln\left(\frac{\eta_1\eta_2}{\eta_{12}^2}\right) + 2x_1\, ln\left(\frac{\eta_{12}}{\eta_2}\right) + ln\,\eta_2 \qquad (5.32)$$

where, η_{12} is a coefficient of interaction and the other symbols mean the same as in the earlier equation.

5.4.7 TAMURA AND KURATA EQUATION

Tamura and Kurata[122] proposed the equation:

$$log\,\eta_m = x_1\eta_1\varphi_1 + x_2\eta_2\varphi_2 + 2\eta_{12}\left(x_1x_2\varphi_1\varphi_2\right)^{0.5} \qquad (5.33)$$

In this equation, the notation is same as the earlier equations. Additionally φ_1 and φ_2 are the volume fractions of the components 1 and 2 in the mixture. The interaction coefficient η_{12} is constant at a chosen temperature. The temperature variation of this interaction coefficient is found to be similar to that of a pure liquid viscosity. The interaction constant can be determined from a single value of the mixture viscosity. The viscosities of nonpolar-polar, polar-polar and nonpolar-nonpolar mixtures (including the mixtures showing maxima/minima type behavior) could be represented well by the method with average errors of about 5-7 %.

In the situations where the viscosities of the pure liquids as well as mixtures are not available, the methods based on the principle of additivity may be employed.

5.4.8 LIMA FORM OF SOUDERS' EQUATION

Souders' equation has been rewritten by Lima[123] to suit the requirements of the estimation of liquid mixture viscosity in the form

$$log\left(log\,10\eta_m\right) = \rho_m\left[\frac{\left(x_1I_1 + x_2I_2\right)}{\left(x_1M_1 + x_2M_2\right)}\right] - 2.9 \qquad (5.34)$$

where	η_m	is the viscosity of the mixture,
	ρ_m	is the density of the mixture,
	x_1 and x_2	are the mole fractions of the components 1 and 2,
	I_1 and I_2	are the viscosity constants of the components 1 and 2 calculated from the atomic and structural contributions, and
	M_1 and M_2	are the molecular weights of the components.

Application of this method to several mixtures of nonpolar or slightly polar components gave an average deviation of 12 %.

In the absence of the values of η_1, η_2 and η_m the Rheochor method written in the following form for mixtures can be employed

$$\eta_m = \frac{\left(x_1 R_{ch1} + x_2 R_{ch2} + \dots\dots\dots + x_n R_{chn}\right)\rho_m}{M_m} \qquad (5.35)$$

where	η_m	is the viscosity of the mixture
	ρ_m	is the density of the mixture
	M_m	is the mean molecular weight of the mixture
	R_{ch1}, R_{ch2}…	are the Rheochors of the components 1, 2…
	x_1, x_2,..	are the mole fractions of the components 1, 2...

The values of the Rheochors of the pure components can be calculated from the atomic and structural contributions given earlier. Shukla and Bhatnagar[124] used the method for about a dozen mixtures including toluene + acetic acid, benzene + acetic acid, chloroform + acetic acid, toluene + acetone, toluene + methanol + benzene, ethanol + methanol + acetic acid and acetone + ethanol + methanol. The maximum errors are about 4.4 %.

5.4.9 MCALLISTER MODEL

From the point of view of understanding the mechanism of dependence of the activation energy for the flow of a two component mixture on the environment in which each molecule is placed, one can think that a molecule is placed between two other molecules – like or unlike (the basis of the three-body model); Refinements are also possible. On the basis of the three-body model, McAllister[125] arrived at the following formula for the kinematic viscosity of the liquid mixture.

$$\ln v_m = x_1^3 \ln v_1 + 3x_1^2 \ln v_{12} + 3x_1 \ln v_{21} + x_2^3 \ln v_2 - \ln\left[x_1 + x_2 \frac{M_1}{M_2}\right]$$
$$+ 3x_1^2 x_2 \ln\left(\frac{2 + M_2/M_1}{3}\right) + 3x_1 x_2^2 \ln\left(\frac{1 + M_2/M_1}{3}\right) + x_2^3 \ln \frac{M_2}{M_1} \qquad (5.36)$$

If the ratio of the molecular weights (M_1/M_2) = 1, the last four terms vanish. The equation has two interaction parameters v_{12} and v_{21}, which can be determined from two known values of the mixture viscosity. The equation has given good results for several mixtures. McAllister also showed that each of the quantities linear for v_1, v_2, v_{12} and v_{21} should vary linearly with the reciprocal of the absolute temperature. If the values of these quantities are known at two temperatures, it should be possible to read off the values at the other temperatures from suitable graphs. For mixtures containing substances like acetone and water, the formula derived from four-body model containing such parameters as ν_{1112}, ν_{1122} and ν_{2221} is in order.

5.4.10 DEDICATED EQUATION FOR CAMPHOR-PYRENE MIXTURE

Hind et al.[126] investigated the viscosity-temperature relationship for camphor-pyrine mixtures, and applied the equation

$$\eta_m = Ae^{B/RT} \qquad (5.37)$$

They found the quantity B to be approximately independent of composition of the mixture in contrast to A, which varies considerably with the mixture composition.

5.5 VISCOSITIES OF HETEROGENEOUS MIXTURES (COLLOIDAL SOLUTIONS, SUSPENSIONS, EMULSIONS)

Einstein[127] proposed the following equation for the viscosity (η) of a system consisting of perfectly rigid spheres suspended in liquid.

$$\eta_m = \eta_1(1 + 2.5\varphi) \qquad (5.38)$$

where η_l is the viscosity of the pure liquid and φ is the volumetric concentration. On inclusion of experimental data of several systems, the constant 2.5 has been replaced by 2.9.

Later investigations have shown that owing to the occurrence of complicating phenomena such as the formation of adsorbed layers on the surfaces of the particles, the Einstein equation, quite often fails to predict the viscosity of suspensions accurately. Table 5.4 summarizes the equations for the mixture viscosity proposed by later investigators for prescribed ranges of φ.

Table 5.4. Formulae for calculating the viscosities of suspensions of solids in liquids.

Equation: (η_m/η_l) =	***Range of Application***
$(1 + 2.5\,\varphi)$	$\varphi < 0.04$
$(1 + 0.5\,\varphi) / (1 - \varphi)^4$	$\varphi < 0.10$
$(1 + 0.5\,\varphi) / (1 - \varphi)^2$	$\varphi < \approx 0.20$
$(1 + 4.5\,\varphi)$	$\varphi < 0.40$
$[1 / \{1 - \varphi^{(1/3)}\}]$	$0.50 < \varphi < 0.90$
$(1 + 2.5\varphi + 7.17\,\varphi^2 + 16.2\,\varphi^3)$	$\varphi < 0.35$
$(1 + 2.5\,\varphi + 10.5\,\varphi^2)$	$\varphi < 0.30$
$[1 + \{2.5\,\varphi / 2(1 - 1.35\,\varphi)\}^2$	$\varphi < 0.50$
$\exp\,[2.5\,\varphi / (1 - 0.61)]$	$\varphi < \approx 0.40$

It should however be noted that only approximate results are to be expected from these equations and that the equations are not applicable to colloidal solutions or lyophiles.

For suspensions, the Kurgaev[128] proposed the following equation,

$$\eta_m/\eta_1 = \left[1 + \left(\frac{2C}{1 - 1.2C\,{}^{2}\!/_{3}}\right)^2\right] \tag{5.39}$$

where C is the concentration of the solid phase calculated from the number of particles per unit length of the liquid (n) and the diameter of the solid particle (d) using

$$C = \frac{n^3 \pi d^3}{6} \tag{5.40}$$

This equation can be applied with success for the values of $C < 0.25$.

5.6 VISCOSITIES OF EMULSIONS FORMED BY IMMISCIBLE LIQUIDS

The Taylor[129] formula is given by:

$$\frac{\eta_m}{\eta_l} = 1 + 2.5\varphi\left(\frac{\eta_d + 0.4\eta_l}{\eta_d + \eta_l}\right) \tag{5.41}$$

where, η_m is the viscosity of the mixture (emulsion),
η_l is the viscosity of the liquid appearing as the continuous phase,
η_d is the viscosity of the liquid appearing as the disperse phase, and
φ is the volume fraction of the disperse phase.

Equation 5.41 can be applied for $\varphi \le 0.03$.

Neogi and Ghosh[130] found Richardson's modification of Taylor's formula as below:

$$\frac{\eta_m}{\eta_l} = exp(k\varphi + c) \tag{5.42}$$

In this equation φ denotes the volume ratio of the phases, and k and c are constants. The equation provided good estimation of viscosity for emulsions of xylene, stabilized by various stabilizers and such systems.

5.7 SUMMARY

This chapter is devoted to presenting the methods described in the literature for the estimation of viscosities of solutions and mixtures. The main objective has been to describe the ideas used by different investigators to enable the user to pick up the method/concept that is suitable for the particular solution or mixture of interest.

In the section on viscosity of fluid mixtures, theoretical as well as applied aspects of dependence of viscosity data: lean mixture viscosity, dense fluid mixture viscosity and gas and liquid mixture viscosity have been presented in addition to liquid mixture viscosity to provide for probable thoughts in the practical situation of interest.

The sections on artificial neural net approach for polar fluids and liquid mixture viscosity are mainly written with the objective of either direct use or development of similar methodologies for the liquid mixture systems of interest.

In view of the vast diversity no particular attempt has been made to compare the relative merits and limitations of the different approaches presented. The information included while discussing each method can be employed as a rough guide. In general, it can be assumed that a properly chosen methodology can provide estimates of a solution or liquid mixture viscosity within ± 10% of its true value, when a properly chosen methodology is employed.

REFERENCES

1. H. Falkanhagen, The quantitative limiting law for the viscosity of strong binary electrolytes, *Physik. Z.* **32**, 745-764 (1931).
2. G. Jones and M. Dole, Viscosity of aqueous solutions of strong electrolytes with special reference to barium chloride, *J. Am. Chem. Soc.* **51**, 2950-2964 (1929).
3. L. Onsager and R. M. Fuoss, Irreversible processes in electrolytes. Diffusion, conductance and viscous flow in arbitrary mixtures of strong electrolytes, *J. Phys. Chem.* **36**, 2689-2778 (1932).
4. M. Kaminsky, The concentration and temperature dependence of the viscosity of aqueous solutions of strong electrolytes. III. KCl, K_2SO_4, $MgCl_2$, $BeSO_4$, and $MgSO_4$ solutions, *Z. Physik. Chem. Neue Floge* **12**, 206-231 (1957).
5. D. Q. Kern, *Process Heat Transfer*, McGraw Hill, New York (1950).
6. D. S. Davis, How to correlate viscosity data, *Brit. Chem. Eng.* **3**, 210 (1958).
7. J. Cornelissen and H. L. Waterman, The viscosity temperature relationship of liquids *Chem. Eng. Sci.* **4**(5), 238-246 (1955).
8. A. B. Zdanovskii, The laws of viscosity changes when two liquids are mixed, *Zhurn Fiz. Khim.* **29**, 209-218 (1955).
9. W. D. Monnery, W. Y. Svrcek, and A. K. Mehrotra, Viscosity: a critical review of practical predictive and correlative methods, *Can. J. Chem. Eng.* **73**(1), 3-40 (1995).
10. B. E. Poling , J. M. Prausnitz and J. P. O'Connell, *The Properties of Gases and Liquids*, 6th Ed., Mc Graw Hill, New York (2001).
11. A. K Mehrotra, W. D. Monnery, and W. Y. Svrcek, A review of practical calculation methods for the viscosity of liquid hydrocarbons and their mixtures, *Fl. Ph. Equlib.* **117**(1-2), 344-355 (1996).
12. J. B. Irving, *Viscosity of Binary Liquid Mixtures: A Survey of Mixture Equations*, National Engineering Laboratory, Report No. 630, East Kilbride, Scotland, England (1977).
13. J. B. Irving, *Viscosity of Binary Liquid Mixtures: The Effectiveness of Mixture Equations*, National Engineering Laboratory, Report No. 631, East Kilbridge, Scotland, England (1977).

14. K. Stefan and T. Heckenberger, *Thermal Conductivity and Viscosity of Fluid Mixtures*, Chemistry Data Series, Vol. X, Part 1, DECHEMA, Frankfurt (1988).
15. S. Kouris and C. Panayiotou, Dynamic viscosity of mixtures of benzene, ethanol, and n-heptane at 298.15 K, *J. Chem. Eng. Data,* **34**(2), 200-203 (1989).
16. A. Aucejo, M.C. Burget, R. Munoz, and J.L. Merques, Densities, Viscosities, and Refractive Indices of Some n-Alkane Binary Liquid Systems at 298.15 K, *J. Chem. Eng. Data,* **40**(1), 141-147 (1995).
17. A. Kumagai and A. Takahashi, Viscosity and density of liquid mixtures of *n*-alkanes with squalane, *Int. J. Thermophys*. **16**(3), 773-779 (1995).
18. J. Wu, A. Shan and A. F. A. Asfour, Viscometric properties of multicomponent liquid *n*-alkane systems, *Fl. Ph. Equlib*. **143**(1-2), 263-274 (1998).
19. C. R. Wilke, A Viscosity Equation for Gas Mixtures, *J. Chem. Phys*. **18**(4), 517-519 (1950).
20. F. Herning and L. Zipperer, Calculation of the viscosity of technical gas mixtures from the viscosity of the individual gases, *GWF, das Gas- und Wasserfach* **79**, 49-54, 69-73 (1936).
21. D. Reichenberg, *The Viscosities of Gas Mixtures at Moderate Pressures*, NPL Report No. 29, National Laboratory, Teddington, England (1974).
22. D. Reichenberg, *New Simple Methods for Estimation of Viscosities of Gas Mixtures at Moderate Pressures*, NEL Report No. 53, East Kilbridge, Glasgow, Scotland (1977).
23. D. Reichenberg, Paper Presented at – *Symposium on Transport Properties of Fluids and Mixtures*, National Engineering Laboratory, East Kilbridge, Glasgow, Scotland (1979).
24. K. Lucas, *Review of Present Status of Transport Properties Prediction, Phase Equilibria and Fluid Properties in Chemical Industry*, DECHEMA (1980).
25. K. Lucas, V. D. I. Warmeatlas, and D. A. Abschnitt: *Berischungs methoden fur Stoffeigenschoffen Deuscher Ingenieure*, Dusseldorf (1984).
26. T. H. Chung, L. L. Lee, and K. E. Starling, Applications of kinetic gas theories and multiparameter correlation for prediction of dilute gas viscosity and thermal conductivity, *Ind. Eng. Chem. Fundam*. **23**(1), 8-13 (1984).
27. T. H. Chung, M. Ajlan, L. L. Lee, and K. E. Starling, Generalized multiparameter correlation for nonpolar and polar fluid transport properties, *Ind. Eng. Chem. Res*. **27**(4), 671-679 (1988).
28. D. E. Dean and L. I. Stiel, The viscosity of nonpolar gas mixtures at moderate and high pressures, *AIChE J*. **11**(3), 526-532 (1965).
29. L. I. Stiel and G. Thodos, The viscosity of nonpolar gases at normal pressures, *AIChE J*. **7**(4), 611-615 (1961).
30. R. S. Brokaw, Predicting Transport Properties of Dilute Gases, *Ind. Eng. Chem. Proc. Des. Dev*. **8**(2), 240-253 (1959).
31. J. M. Hellemans, J. Kestin, and S. T. Ro, Viscosity of oxygen and of some of its mixtures with other gases, *Physica (Amsterdam)* **65**(2), 362-375 (1973).

32. J. Kestin, H. E. Khalifa, and W. A. Wakcham, The viscosity and diffusion coefficients of the binary mixtures of xenon with the other noble gases, *Physica A: Statistical Mechanics and its Applications,* **90**(2), 215-228 (1978).
33. E. Vogel, The viscosity of the binary vapor mixtures benzene-toluene and benzene-p-xylene and its initial density dependence, *Fl. Ph. Equilib.* **88**, 277-289 (1993).
34. S. K. Oh and S. W. Campbell, A group contribution model for thermodynamic and transport properties of dilute gases, *Fl. Ph. Equilib.* **129**(1-2), 69-88 (1997).
35. T. R. Galloway and B. H. Sage, Prediction of the transport properties of paraffin hydrocarbons, *Chem. Eng. Sci.* **22**(7), 979-995 (1967).
36. H. van Houten and B. I. M. Ten Bosch, Kinetic theory for the volume viscosity in binary mixtures of polyatomic and noble gases, *Physica A: Statistical Mechanics and its Applications*, **128**(1-2), 371-376 (1984).
37. G. B. Clark and F. R. W. McCourt, Accurate calculation of diffusion and shear viscosity coefficients for H2-H mixtures, *Chem. Phys. Lett.* **236**(3), 229-234 (1995).
38. R. Di Pippo, J. R. Dorfaman, J. Kestin, H. E. Khalifa, and E. A. Mason, Composition dependence of the viscosity of dense gas mixtures, *Physica A: Statistical Mechanics and its Applications*, **86**(2), 205-223 (1977).
39. J. Kestin, O. Korfali, J. V. Sengers, and B. Parsi, Density dependence and composition dependence of the viscosity of neon-helium and neon-argon mixtures, *Physica A: Statistical Mechanics and its Applications,* **106**(3), 415-442 (1981).
40. S. E. Quinones–Cisneros, C. K. Zedberg–Mikkelsen, and E.H. Stenby, The friction theory (*f-theory*) for viscosity modeling, *Fl. Ph. Equilib.* **169**(2), 249-276 (2000).
41. F. Audonnet and A. A. H. Padua, Viscosity and density of mixtures of methane and *n*-decane from 298 to 393 K and up to 75 MPa, *Fl. Ph. Equilib.* **216**(2), 235-244 (2004).
42. M. J. Assael, J. H. Dymond, M. Papadaki and P. M. Patterson, Correlation and prediction of dense fluid transport coefficients. III. *n*-alkane mixtures, *Int. J. Thermophys*. **13**(4), 659-669 (1992).
43. J. H. Dymond, and M. J. Assael: *Transport Properties of Fluids:Their Correlation, Prediction and Estimation* (Ed. J. Millat, J. H. Dymond and C. S. Nieto de Castro) IUPAC, Cambridge (1996).
44. A. M. Elsharkawy, Efficient methods for calculations of compressibility, density and viscosity of natural gases, *Fl. Ph. Equilib.* **218**(1), 1-13 (2004).
45. A. L. Lee and B. E. Eakin, Viscosity of Methane-*n*-Decane Mixtures, *J. Chem. Eng. Data,* **11**(3), 281-287 (1966).
46. K. Lucas, Pressure dependence of the viscosity of liquids - a simple estimate, *Chem. Ing. Tech.* **53**(12), 959-960 (1981).
47. J. Millat, J. H. Dymond, and C. S. Nieto de Castro: *Transport Properties of Fluids: Their Correlation, Prediction and Estimation*, IUPAC, Cambridge (1966).
48. M. E. Yener, P. Kashulines, S. S. H. Rizvi, and P. Harriott, Viscosity measurement and modeling of lipid-supercritical carbon dioxide mixtures, *J. Supercritical Fluids,* **11**(3), 151-162 (1998).

49. M. J. Tham and K. E. Gubbins, Correspondence Principle for Transport Properties of Dense Fluids. Nonpolar Polyatomic Fluids, *Ind. Eng. Chem. Fundam.* **9**(1), 63-70 (1970).
50. P. L. Christensen and A. Fredenslund, A corresponding states model for the thermal conductivity of gases and liquids, *Chem. Eng. Sci*. **35**(4), 871-875 (1980).
51. K. C. Mo and K. E. Gubbins, Conformal solution theory for viscosity and thermal conductivity of mixtures, *Mol. Phys*. **31**(3), 825-847 (1976).
52. K. S. Pedersen, A. Fredenslund, P .L. Christensen, and P. Thomassen, Viscosity of crude oils, *Chem. Eng. Sci*. **39**(6), 1011-1016 (1984).
53. K. S. Pedersen and A. Fredenslund, An improved corresponding states model for the prediction of oil and gas viscosities and thermal conductivities, *Chem. Eng. Sci*. **42**(1), 182-186 (1986).
54. H. J. M. Hanley, R. D. McCarty, and W. M. Haynes, Equations for the viscosity and thermal conductivity coefficients of methane, *Cryogenics,* **15**(7), 413-417 (1975).
55. J. F. Ely and H. J. M. Hanley, Prediction of transport properties. 1. Viscosity of fluids and mixtures, *Ind. Eng. Chem. Fundam.* **20**(4), 323-332 (1981).
56. D. S. H. Wong, S. I. Sandler, and A. S. Teja, Vapor-liquid equilibrium calculations by use of generalized corresponding states principle. 1. New mixing rules, *Ind. Eng. Chem. Fundam.* **23**(1), 38-44 (1984).
57. J. Wu and A. F. A. Asfour, Viscometric properties of n-alkane liquid mixtures, *Fl. Ph. Equilib*. **76**, 283-294 (1992).
58. K. Asberg-Pattersen, K. Knudsen, and A. Fredenslund, Prediction of viscosities of hydrocarbon mixtures, *Fl. Ph. Equilib*. **70**(2-3), 293-308 (1991).
59. A. S. Lawal. Prediction of vapor and liquid viscosities from the Lawal-Lake- Silberg equation of state, *SPE/DOE paper* 14926 (1986).
60. W. Sheng and B. C. Y. Lu, Calculation of shear viscosity of mixtures by means of an equation of state, *Adv. Cryo. Eng.* **35**(Pt. B), 1533-1540 (1990).
61. D. Y. Peng and D. B. Robinson, A New Two-Constant Equation of State, *Ind. Eng. Chem. Fundam.* **15**(1), 59-64 (1976).
62. J. Palyvos, K. D. Luks, I .L. McLaughlin, and H. T. Davis, Kinetic Theory of Dense-Fluid Mixtures. IV. Square-Well Model Computations, *J. Chem. Phys*. **47**(6), 2082-2089 (1967).
63. M. .J. Assael, J. H. Dymond, and P. M. Patterson, Correlation and prediction of dense fluid transport coefficients. V. Aromatic hydrocarbons, *Int. J. Thermophys*. **13**(5), 895-905 (1992).
64. Y. S. Touloukian, S. C. Saxena, and P. Hestermaus, *Thermo physical properties of matter,* PRS Data Series.Vol.II, Viscosity, Purdue Research Foundation (1975).
65. K. Stefan and K. D. Lucas, *Viscosity of Dense Fluids*. Plenum, New York (1979).
66. D. S. Viswanath and G. Natarajan, *Data Book on the Viscosity of Liquids*. Hemisphere, New York (1989).

67. A. K. Mehrotra, W. D. Monnery, and W. Y. Svrcek, A review of practical calculation methods for the viscosity of liquid hydrocarbons and their mixtures, *Fl. Ph. Equilib*. **117**(1-2), 344-355 (1996).
68. N. Jhunjhunwala, J. P. Boon, H. L. Frisch, and J. L. Lebowitz, Shear viscosity of simple fluid mixtures, *Physica* (Amsterdam) **41**(3), 536-540 (1969).
69. P. P. Singh and C. P. Sinha, Application of significant liquid structure theory to the mixture viscosity of apolar-apolar and polar-apolar binary liquid systems, *Ind. J. Chem. Section A: Inorganic, Physical, Theoretical & Analytical*, **16A**(10), 821-825 (1978).
70. M. Dizechi and E. Marschall, Correlation for viscosity data of liquid mixtures, *Ind. Eng. Chem. Proc. Des. Dev*. **21**(2), 282-289 (1982).
71. L. Grunberg and A. H. Nissan, Mixture law for viscosity, *Nature*, **164**, 799-800 (1949).
72. J .D. Isdale, *Symposium on Transport Properties of Fluids and Fluid Mixtures*, Natl. Eng. Lab. East Kilbride, Glasgow, Scotland (1979).
73. J. D. Isdale, J. C. MacGillivray, and G. Cartwright, *Prediction of Viscosity of Organic Liquid Mixtures by a Group Contribution Method,* Natl. Eng. Lab. Rept. East Kilbride, Glasgow, Scotland (1985).
74. C. H. Twu, Generalized method for predicting viscosities of petroleum fractions, *AIChE J*. **32**(12), 2091-2094 (1986).
75. J. L. Chevalier, P. Petrino, and Y. Gaston–Bonhomme, Estimation method for the kinematic viscosity of a liquid-phase mixture, *Chem. Eng. Sci*. **43**(6), 1303-1309 (1988).
76. Y. Glaston-Bonhomme, P. Petrino, and J. L. Chevalier, UNIFAC—VISCO group contribution method for predicting kinematic viscosity: extension and temperature dependence, *Chem. Eng. Sci*. **49**(11), 1799-1806 (1994).
77. D. T. Wu, Prediction of viscosities of liquid mixtures by a group contribution method, *Fl. Ph. Equilib*. **30**, 149-156 (1986).
78. A. M. Awwad, S. F. Al-Azzawi, and M. A. Salman, Volumes and viscosities of benzene + n-alkane mixtures, *Fl. Ph. Equilib*. **31**(2), 171-182 (1986).
79. A. M. Awwad, K. A. Jbara, and A. H. Al-Dujaili, Volumes of mixing and viscosities of methylacetate + n-alkanes and n-butylacetate + n-alkanes at 298.15 K: an interpretation in terms of the Van-Patterson, the absolute rate and free volume theories, *Thermochimica Acta*, **129**(2), 249-262 (1988).
80. M. R. Islami and S. K. Quadri, Ultrasonic velocity and viscosity of binary liquid mixtures, *Thermochimica Acta*, **115**, 335-344 (1987).
81. R. P. Chhabra and T. Sridhar, Estimation of viscosity of liquid mixtures using Hildebrand's fluidity model, *Chem. Eng. J.* (Amsterdam) **40**(1), 39-43 (1989).
82. R. P. Chhabra and D. K. Sheth, Temperature and composition dependence of the viscosity of liquid mixtures: a predictive approach, *Chem. Eng. Proc*. **27**(1), 53-58 (1990).
83. N. Mamagakis and C. Panayiotou, Excess volume and dynamic viscosity of ternary liquid mixtures, *Zeit. Fur. Physik. Chemie*. **162**(1), 57-72 (1989).

84. M. Kanti, B. Lagourette, J. Alliez, and C. Boned, Viscosity of binary heptane—nonylbenzene as a function of pressure and temperature: application of Flory's theory, *Fl. Ph. Equilib*. **65**, 291-304 (1991).

85. W. Cao, A. Fredenslund, and P. Rasmussen, Statistical thermodynamic model for viscosity of pure liquids and liquid mixtures, *Ind. Eng. Chem. Res*. **31**(11), 2603-2619 (1992).

86. N. V. Sastry and P. N. Dave, Thermodynamics of acrylic ester-organic solvent mixtures. II. Viscosities of mixtures of methyl methacrylate, ethyl methacrylate or butyl methacrylate with n-hexane, n-heptane, carbon tetrachloride, chlorobenzene or o-dichlorobenzene at 303.15 K, *Thermochimica Acta,* **286**(1), 119-130 (1996).

87. N. V. Sastry, N. J. Jain, A. George, and P. Bahadur, Viscosities, speeds of sound and excess isentropic compressibilities of binary mixtures of alkyl alkanoate–hydrocarbons at 308.15 K and 318.15 K, *Fl. Ph. Equilib*. **163**(2), 275-289 (1999).

88. A. Ali, S. Hyder, and A.K. Nain, Studies on molecular interactions in binary liquid mixtures by viscosity and ultrasonic velocity measurements at 303.15 K, *l. Mol. Liq*. **79**(2), 89-99 (1999).

89. L. Qun-Fang and H. Yu-Chun, Correlation of viscosity of binary liquid mixtures, *Fl. Ph. Equilib*. **154**(1), 153-163 (1999).

90. M. J. Lee, J. Y. Chiu, S. M. Hwang, and H. Lin, Viscosity Calculations with the Eyring-Patel-Teja Model for Liquid Mixtures, *Ind. Eng. Chem. Res*. **38**(7), 2867-2876 (1999).

91. R .J. Martins, M. J. E. deCardoso, and O. E. Barcia, Excess Gibbs Free Energy Model for Calculating the Viscosity of Binary Liquid Mixtures, *Ind. Eng. Chem. Res*. **39**(3), 849-854 (2000).

92. R. J. Martins, M. E. J. deCardoso, and O. E. Barcia, Calculation of Viscosity of Ternary and Quaternary Liquid Mixtures, *Ind. Eng. Chem. Res*. **40**(4), 1271-1275 (2001).

93. P. Protopapas and N. A. D. Parlee, Theory of transport in liquid metals. III. Calculation of shear viscosity coefficients of binary alloys, Chem.Phys. **11**(1), 201-215 (1975).

94. H. Chiriac, M. Tomut, and M. Grigorica, On the viscosity near the melting point of some liquid glass-forming transition metal alloys, *J. Non-Cryst. Solids*. **205-207**(Pt. 2), 504-507 (1996).

95. D. S. Jung and D. Didion, Mixing rule for liquid viscosities of refrigerant mixtures, *Intl. J. Refrig*. **13**(4), 243-247 (1990).

96. G. Latini, L. Laurenti, F. Marcotullio, and P. Pierpaoli, Liquid dynamic viscosity: a general prediction method with application to refrigerants and refrigerant mixtures, *Int. J. Refrig*. **13**(4), 248-255 (1990).

97. G. Latini , G. Passerini, and F. Polonara, A relationship between dynamic viscosity and reduced temperature of refrigerant fluids and their mixtures in the liquid phase , *Fl. Ph. Equilib*. **125**(1-2), 205-217 (1996).

98. M. L. Hubet and J. Ely, Prediction of viscosity of refrigerants and refrigerant mixtures, *Fl. Ph. Equilib*. **80**, 239-248 (1992).

99. S. A. Klein, M. O. McLinden, and A. Laesecke, An improved extended corresponding states method for estimation of viscosity of pure refrigerants and mixtures, *Intl. J.Refrig*. **20**(3), 208-217 (1997).

100. S. L. Passman, D. A. Drew, An exact solution for shearing flow of multicomponent mixtures, *Chem .Eng. Sci*. **46**(9), 2331-2338 (1991).

101. H. Korsten, Viscosity of liquid hydrocarbons and their mixtures, *AIChE J*. **47**(2), 453-462 (2001).

102. U. R. Kapadi, D. G. Hundiwale, N. B. Patil, M. K. Lande, and P. R. Patil, Studies of viscosity and excess molar volume of binary mixtures of propane-1,2 diol with water at various temperatures, *Fl. Ph. Equilib*. **192**(1-2), 63-70 (2001).

103. M. J. Assael, N. K. Dalouti, and I. Metaxa, On the correlation of transport properties of liquid mixtures, *Fl. Ph. Equilib*. **199**(1-2), 237-247 (2002).

104. V. Vesovic, Predicting the viscosity of halogenated hydrocarbon mixtures, *Fl. Ph. Equilib*. **199**(1-2), 295-306 (2002).

105. R. Macias-Salinas, F. Garcia-Sanchez, and S. Eliso-Jimenez, An equation-of-state-based viscosity model for non-ideal liquid mixtures, *Fl. Ph. Equilib*. **210**(2), 319-334 (2003).

106. R. Rosal, R. I. Medina, E. Foster, and J. MacInnes, Viscosities and densities for binary mixtures of cresols, *Fl. Ph. Equilib*. **211**(2), 143-150 (2003).

107. C. Boned, C. K. Z. Mikkelsen, A. Baylaucq, and P. Dauge, High-pressure dynamic viscosity and density of two synthetic hydrocarbon mixtures representative of some heavy petroleum distillation cuts, *Fl. Ph. Equilib*. **212**(1-2), 143-164 (2003).

108. A. J. Queimada, J. M. Marrucho, E. H. Stenby, and J. A. P. Coutinho, Generalized relation between surface tension and viscosity: a study on pure and mixed *n*-alkanes, *Fl. Ph. Equilib*. **222-223**, 161-168 (2004).

109. A. Rodriguez A. J. Canosa, and A. Dominguez, Viscosities of dimethyl carbonate with alcohols at several temperatures: UNIFAC-VISCO interaction parameters (---OCOO---/alcohol), *Fl. Ph. Equilib*. **216**(2), 167-174 (2004).

110. M. A. Barrufet and D. Dexheimer, Use of an automatic data quality control algorithm for crude oil viscosity data, *Fl. Ph. Equil*. **219**(2), 113-121 (2004).

111. A. M. Elsharkawy, S. A. Hassan, Y. SKh. Hashmi, and M. A. Fahim, New Compositional Models for Calculating the Viscosity of Crude Oils, *Ind. Eng.Chem. Res*. **42**(17), 4132-4142 (2003).

112. L. T. Novak, C. C. Chen, and Y. Song, Segment-Based Eyring-NRTL Viscosity Model for Mixtures Containing Polymers, *Ind. Eng. Chem. Res*. **43**(19), 6231-6237 (2004).

113. M. J. Lee, S. M. Hwang, and J. T. Chen, Density and viscosity calculations for polar solutions via neural networks, *J. Chem. Eng. Japan*. **27**(6), 749-754 (1994).

114. M. J. Lee and M. C. Wei, Corresponding-states model for viscosity of liquids and liquid mixtures, *J. Chem. Eng. Japan*, **26**(2), 159-165 (1993).

115. J. Kendall and K. P. Monroe, Viscosity of liquids. III. Ideal solutions of solids in liquids, *J. Am. Chem. Soc*. **39**, 1802-1806 (1917).

116. S. A. Arrhenius, Uber die Dissociation der in Wasser gelosten Stoffe, *Z. Phys. Chem*. **1**, 631-648 (1887).
117. G.M. Panchenkov, Calculation of absolute values of the viscosity of liquids, *Zhurn. Fiz. Khim*. **24**, 1390-1406 (1950).
118. O. Faust, The Inner Friction of Liquid Mixtures, its Dependence on Temperature, and the Relation between the Inner Friction of Liquids and their Vapor Pressure, *Z. Phys. Chem*. **79**, 97-123 (1912).
119. J. Zawidzki, *Z. Phys. Chem*. **39**, 129 (1909) [as quoted in S. Bretsznajder, Prediction of transport and other physical properties of fluids, Pergamon, Oxford (1971)].
120. H. G. Reik, The relation between viscosity and vapor pressure in binary mixtures. II, *Zeitschrift fuer Elektrochemie und Angewandte Physikalische Chemie*, **59**, 126-136 (1955).
121. A. J. A. van der Wijk, The viscosity of binary mixtures, *Nature,* **138**, 845 (1936).
122. M. Tamura and M. Kurata, Viscosity of a binary mixture of liquids, *Bull. Chem. Soc. Japan,* **25**, 32 (1952).
123. F. W. Lima, The viscosity of binary liquid mixtures, *J. Phys. Chem*. **56**, 1052-1054 (1952).
124. R. P. Shukla and R. P. Bhatnagar, Viscosity of mixtures. I. Liquid-liquid binary mixtures, *J. Phys. Chem*. **59**, 988-989 (1955); R. P. Shukla and R. P. Bhatnagar, Viscosity of mixtures. II. Liquid-liquid ternary mixtures, J Phys. Chem. **60**, 809-810 (1956).
125. R. A. McAllister, The viscosity of liquid mixtures, *AIChE J*. **6**(3), 427-431 (1960).
126. R. K. Hind, E. McLaughlin, and U. R. Ubbelohde, Structure and viscosity of liquids. Camphor + pyrene mixtures, *Trans. Farad. Soc*. **56**, 328-330 (1960).
127. A. Einstein, A new determination of molecular dimensions, *Ann. d. Physik* **19**, 289-306 (1906).
128. E. F. Kurgaev, Viscosity of suspensions, *Dokl. Akad. Nauk S.S.S.R.* **132**, 392-394 (1960).
129. G. J. Taylor, The viscosity of fluid containing small drops of another fluid, *Proc. Roy. Soc*.(London) **138A**, 41 (1932).
130. R. K. Neyogi and B. N. Ghosh, The viscosity of emulsions, *J. Ind. Chem. Soc*. **30**, 113-118 (1953).

Chapter 6

EXPERIMENTAL DATA

Experimnetal data on absolute and kinematic viscosity are presented in this chapter. The data are collected from the literature and evaluated based on the following criteria.

1. purity of the chemical and method of purification
2. temperature control mechanism and its accuracy
3. corrections made to the data
4. the overall consistency of the data set
5. calibration of the viscometers
6. density data, whether the data are taken as a part of the viscosity measurements or whether literature data are used.
7. accuracy and quality of the density data.

The data have been fitted to following three simple equations.

$$log\,\eta = A + \frac{B}{T} \tag{6.1}$$

$$\eta = AT^{B} \tag{6.2}$$

$$log\,\eta = A + \frac{B}{C - T} \tag{6.3}$$

In these equations viscosity (η) is in (N.s.m^{-2}) and temperature (T) is in Kelvin. To obtain the viscosity in centiPoise (N.s.m^{-2}) the viscosity data gien in the table must be multiplied by 10^{-3}.The kinematic viscosity is correlated with the same form of the equation, however, the unit for kinematic viscosity is cetiStokes *(cSt)* and temperature is given in Kelvin.

The experimental data are fitted to all three equations and the best correlating equation and the corresponding constants of the equation are given in the table along with the applicable temperature range. The viscosity calculated from these suggested equation should be accurate enough for most of the engineering calculations. The best fit equation is chosen based on the average absolute deviation (AAD) in percent (Eq. 6.4) and standard deviation (SD) of the data. Both AAD% and SD are given in the table.

$$\%AAD = \frac{1}{N}\sum \frac{\left(\eta_{exptl} - \eta_{calc}\right)}{\eta_{exptl}} \tag{6.4}$$

$$SD = \sqrt{\left[\frac{1}{N}\sum\left(\eta_{explt} - \eta_{calc}\right)^2\right]} \tag{6.5}$$

6.1 EXPERIMENTAL DATA FOR ABSOLUTE VISCOSITY

1-(Isocyanato-1-methylethyl)-3-(1-ethylethenyl) benzene

CAS RN : 2094-99-7 Source of Data: Reference 1

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	3.1282	313.15	2.2818	343.15	1.3731
303.15	2.8008	323.15	1.8954	353.15	1.1931
308.15	2.5215	333.15	1.6012		

Suggested Equation: 3; Constants: A = -4.3230 B = -334.25 C = 114.34.

% AAD = 0.1 SD = 3.90 x 10^{-7} Temperature Range (K): 290-360

1-(Isocyanato-1-methylethyl)-4-(1-ethylethenyl) benzene

CAS RN: 2889-58-9 Source of Data: Reference 1

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	3.9129	313.15	2.8531	343.15	1.6868
303.15	3.5057	323.15	2.3609	353.15	1.4519
308.15	3.1556	333.15	1.9825		

Suggested equation: 3; Constants: A = -4.5804 B = -483.62 C = 75.586

% AAD = 0.1 S.D. = 6.00 x 10^{-8} Temperature Range = 290-360.

1,1,1-Trifluoro acetone

CAS RN : 421-50-1, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
281.45	0.3566	284.40	0.3450	288.15	0.3280

Suggested Equation = 1; Constants: A = -5.0099 B = 439.06 C = 0.00

% AAD = 0.6 S.D. = 2.20 x 10^{-6} Temperature Range: 280-290.

1,1,1-Trifluoro isopropyl acetate

CAS RN : 17659-31-3; Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.00	0.7255	313.10	0.5447	333.15	0.4254
303.20	0.6232	323.30	0.4780		

Suggested Equation = 1; Constants: A = -5.0598 B = 562.57 C = 0.00

% AAD = 0.2 S.D. = 9.00 x 10^{-7} Temperature Range: 290-340.

1,1,1-Trifluoro isopropyl alcohol

CAS RN: Source of Data: Reference 2

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
288.15	3.6850	308.15	1.7720	328.15	0.9940
298.07	2.5860	318.15	1.3010		

Suggested Equation = 3; Constants: A = -5.0978 B = -388.20 C = 142.81

% AAD = 1.0 S.D. = 3.70 x 10^{-5} Temperature Range: 280-330

1,1,1-Trifluoro-tert-butyl alcohol

CAS RN: Source of Data: Reference 2

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
298.15	3.3201	308.15	2.2400	318.15	1.5900
303.15	2.7060	313.15	1.8450	328.15	1.1900

Suggested Equation = 3; Constants: A = -4.5179 B =-217.60 C = 191.50

% AAD = 0.5 S.D. = 2.20 x 10^{-6} Temperature Range: 290-330

1,1,2,2-Tetrabromo ethane

CAS RN: 79-27-6; Source of Data: Reference 3

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
298.08	9.687	308.11	7.313	313.15	6.406
303.10	8.414				

Suggested Equation = 1; Constants: A = -5.7617 B = 1117.2 C = 0.00

% AAD = 0.1 S.D. = 7.40 x 10^{-6} Temperature Range: 290-320

1,1,2-Trifluoro-1,2,2-trichloro ethane

CAS RN: Source of Data: Reference 2

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
293.15	0.6980	313.15	0.5465	318.15	0.5160
303.15	0.6140				

Suggested Equation = 1; Constants: A = -4.8178 B = 487.10 C = 0.00

% AAD = 0.1 S.D. = 7.00 x 10^{-5} Temperature Range: 290-320

1,1-Dichloro-2,2-difluoro ethane

CAS RN: 25915-78-0 Source of Data: Reference 2

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
293.15	0.7130	313.15	0.5540	328.15	0.4680
303.15	0.6260	323.15	0.4940		

Suggested Equation = 1; Constants: A = -4.8605 B = 502.16 C = 0.00

% AAD = 0.1 S.D. = 6.40 x 10^{-7} Temperature Range: 290-330

1,1-Dichloro ethane

CAS RN: 75-34-3 Source of Data: Reference 4

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
280.21	0.5686	296.37	0.4736	313.33	0.3976
284.39	0.5413	301.00	0.4506	316.89	0.3836
288.49	0.5156	304.70	0.4337	321.10	0.3695
292.46	0.4934	308.76	0.4160	327.69	0.3476

Suggested Equation = 3; Constants: A = -4.8360 B = -486.96 C = -25.91
% AAD = 0.1 S.D. = 3.40 x 10^{-6} Temperature Range: 280-330

1,1-Difluoro ethyl acetate

CAS RN: 454-31-9; Source of Data: Reference 2

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
293.15	1.1300	315.15	0.8160	333.15	0.6130
303.15	0.9530	323.15	0.7030		

Suggested Equation = 3; Constants: A = -5.0140 B = -560.88 C = 21.80
% AAD = 0.1 S.D. = 6.90 x 10^{-7} Temperature Range: 290-340

1,1-Di-m-tolyl ethane

CAS RN: 29036-13-3, Source of Data: Reference 5

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
273.15	23.830	422.95	0.658	473.15	0.425
323.15	3.600				

Suggested Equation = 3 Constants: A = -4.4330 B = -337.17 C = 153.26
% AAD = 0.8 S.D. = 6.80 x 10^{-5} Temperature Range: 270-480

1,1-Di-o-tolyl ethane

CAS RN: 33268-48-3, Source of Data: Reference 5

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
273.15	343.1000	422.95	0.8120	473.15	0.5010
323.15	7.8400				

Suggested Equation = 3 Constants: A = -4.2025 B = -236.66 C = 209.88
% AAD = 0.9 S.D. = 1.1 x 10^{-3} Temperature Range: 270-480

1,1-Di-p-tolyl ethane

CAS RN: 530-45-0, Source of Data: Reference 5

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
273.15	11.630	422.95	0.574	473.15	0.377
323.15	2.530				

Suggested Equation = -4.523 Constants: A = -377.8200 B = 127.15 C = 0.30
% AAD = 0.3 S.D. = 1.10 x 10^{-5} Temperature Range: 270-480

1,2 Diamino propane

CAS RN: 78-90-0, Source of Data: Reference 6

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
238.15	16.4700	268.15	3.6100	298.15	1.5700
243.15	13.2000	273.15	3.0320	303.15	1.3950
248.15	9.3720	278.15	2.7040	308.15	1.2270
253.15	6.9650	283.15	2.2060	313.15	1.1730
258.15	5.3220	288.15	1.9250	318.15	1.0450
263.15	4.3540	293.15	1.7090	323.15	0.9400

Suggested Equation = 3 Constants: A = -4.0837 B = -167.55 C = 166.21
% AAD = 2.1 S.D. = 3.30E-04 Temperature Range: 240-330

1,2 Dibromo propane

CAS RN: 78-75-1, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η(N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.51	2.2850	323.23	1.0720	374.33	0.6280
286.06	1.8160	336.34	0.9180	386.86	0.5650
298.42	1.4940	349.61	0.7970	401.12	0.5010
311.17	1.2470	362.28	0.7040	409.82	0.4680

Suggested Equation = 3 Constants: A = -4.7088 B = -562.02 C = 1.96
% AAD = 1.3 S.D. = 2.20 x 10^{-5} Temperature Range: 270-420

1,2,3,4-Tetrahydro-2,6-dimethyl-7-octyl naphthalene

CAS RN: Source of Data: Reference 7

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	25.42	333.15	5.593	372.05	2.333
310.95	11.64				

Suggested Equation = 3 Constants: A = -4.1609 B = -298.25 C = 176.95
% AAD = 0.2 S.D. = 2.30 x 10^{-5} Temperature Range: 290-380

1,2,3,4-Tetrahydro-5,8-dimethyl-1-octyl naphthalene

CAS RN: Source of Data: Reference 7

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	34.360	333.15	6.7010	388.15	2.0220
310.95	14.680	372.05	2.6880		

Suggested Equation = 3 Constants: A = -4.1062 B = -288.48 C = 183.98
% AAD = 0.3 S.D. = 1.90 x 10^{-5} Temperature Range: 290-390

1,2,3,4-Tetrahydro-6-butyl-7-hexyl naphthalene

CAS RN: Source of Data: Reference 7

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
273.15	92.05	310.95	13.30	372.05	2.500
293.15	29.21	333.15	6.287		

Suggested Equation = 3 Constants: A = -4.4021 B = -382.01 C = 159.74
% AAD = 0.5 S.D. = 2.50E-04 Temperature Range: 270-380

1,2,3,4-Tetrahydro-7-butyl-1-hexyl naphthalene

CAS RN: Source of Data: Reference 7

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
273.15	61.43	310.95	10.08	372.05	2.158
293.15	20.81	333.15	5.017		

Suggested Equation = 3 Constants: A = -4.2780 B = -335.62 C = 163.76
% AAD = 0.4 S.D. = 1.20E-04 Temperature Range: 270-380

1,2-Dibromo-2-methyl propane

CAS RN: 594-34-3, Source of Data: Reference 4

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
273.54	3.2903	326.33	1.2741	380.30	0.6808
286.82	2.4558	340.06	1.0648	394.89	0.5928
300.09	1.9163	353.75	0.9030	406.91	0.5322
303.95	1.5278	366.78	0.7815	415.59	0.4941

Suggested Equation = 3 Constants: A = -4.5276 B = -435.27 C = 60.00
% AAD = 0.4 S.D. = 1.30 x 10^{-6} Temperature Range: 270-420

1,2-Dibromo ethane

CAS RN: 106-93-4, Source of Data: Reference 4, 8, 9

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
282.64[4]	2.0530	346.63	0.8620	288.15[8]	1.8800
293.78	1.6980	359.12	0.7620	303.15	1.4900
304.36	1.4450	368.96	0.6940	340.45[9]	0.9220
314.79	1.2520	378.86	0.6340	355.35	0.7500
324.96	1.0990	390.16	0.5770	372.15	0.6480
336.02	0.9670	399.86	0.5320		

Suggested Equation = 3 Constants: A = -4.2416 B = -300.36 C = 90.20
% AAD = 1.2 S.D. = 1.40 x 10^{-5} Temperature Range: 280-400

1,2-Dibromo ethylene

CAS RN: 540-49-8, Source of Data: Reference 4

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
274.01	1.2170	312.64	0.7820	349.87	0.5650
284.10	1.0700	320.95	0.7220	359.10	0.5250
293.08	0.9600	331.11	0.6590	370.25	0.4830
303.29	0.8590	340.34	0.6100	378.87	0.4540

Suggested Equation = 1 Constants: A = -4.4549 B = 421.62 C = 0.00
% AAD = 0.2 S.D. = 2.00 x 10^{-6} Temperature Range: 270-380

1,2-Dichloro benzene

CAS RN: 95-50-1, Source of Data: Reference 10

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
296.45	1.3190	378.15	0.5444	427.15	0.3787
317.65	0.9940	393.15	0.4826	436.25	0.3577
339.10	0.7830	397.95	0.4660	451.75	0.3257
357.65	0.6517	417.35	0.4036		

Suggested Equation = 3 Constants: A = -4.5524 B = -456.48 C = 23.531

% AAD = 0.2 S.D. = 1.80 x 10^{-6} Temperature Range: 290-460

1,2-Dichloro ethane

CAS RN: 107-06-2, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.46	1.1211	301.93	0.7417	331.98	0.5239
280.38	1.0021	310.03	0.6695	338.68	0.4912
287.88	0.8961	317.04	0.6166	346.10	0.4558
294.99	0.8129	324.89	0.5668	354.22	0.4217

Suggested Equation = 3 Constants: A = -4.5980 B = -385.16 C = 39.58

% AAD = 0.2 S.D. = 1.30 x 10^{-6} Temperature Range: 270-360

1,2-Dichloro tetrafluoro ethane

CAS RN: 76-14-2, Source of Data: Reference 11

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
209.00	1.3650	245.00	0.7120	277.00	0.4610
213.00	1.2560	249.00	0.6710	281.00	0.4390
217.00	1.1610	253.00	0.6320	285.00	0.4200
221.00	1.0740	257.00	0.5970	289.00	0.4010
225.00	0.9960	261.00	0.5650	321.00	0.2920
229.00	0.9270	265.00	0.5360	325.00	0.2810
233.00	0.8650	269.00	0.5090	329.00	0.2720
237.00	0.8090	273.00	0.4840	333.00	0.2630
241.00	0.7590				

Suggested Equation = 1 Constants: A = -4.7833 B = 400.81 C = 0.00

% AAD = 0.2 S.D. = 1.50 x 10^{-6} Temperature Range: 200-340

1,2-Phenylene diamine

CAS RN: 95-54-5, Source of Data: Reference 12

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
383.15	2.17	388.15	2.03	393.15	1.87

Suggested Equation = 1 Constants: A = -5.1842 B = 967.30 C = 0.00

% AAD = 0.7 S.D. = 1.60 x 10^{-5} Temperature Range: 380-400

1, 3-Bis(1-Isocynato-1-methylethyl) benzene

CAS RN: 2778-42-9, Source of Data: Reference 1

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	8.2033	313.15	5.2477	343.15	2.6114
303.15	7.0074	323.15	4.0529	353.15	2.1651
308.15	6.0391	333.15	3.2153		

Suggested Equation = 3 Constants: A = -4.3198 B = -351.17 C = 140.96

% AAD = 0.1 S.D. = 3.10 x 10^{-6} Temperature Range: 290-360

1,3-Dichloro benzene

CAS RN: 541-73-1, Source of Data: Reference 10

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.75	0.9510	387.35	0.4310	417.45	0.3491
327.35	0.7325	393.15	0.4126	430.35	0.3221
348.75	0.5945	407.95	0.3722	445.45	0.2948
367.25	0.5050				

Suggested Equation = 3 Constants: A = -4.6277 B = -490.14 C = -1.1150

% AAD = 0.2 S.D. = 1.40 x 10^{-6} Temperature Range: 300-450

1,3-Difluoro benzene

CAS RN: 372-18-9, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	0.5743	315.15	0.4610	333.15	0.3786
303.15	0.5122	323.15	0.4156		

Suggested Equation = 1 Constants: A = -4.7496 B = 442.34 C = 0.00

% AAD = 0.1 S.D. = 4.20 x 10^{-7} Temperature Range: 290-340

1,3-Dimethoxy benzene

CAS RN: 151-10-0, Source of Data: Reference 13

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
313.65	1.6230	393.15	0.5476	453.15	0.3271
333.55	1.1460	412.85	0.4560	463.25	0.3039
353.15	0.8676	433.15	0.3827	474.15	0.2818
373.45	0.6731	443.35	0.3521	485.15	0.2622

Suggested Equation = 3 Constants: A = -4.6919 B = -461.09 C = 70.73

% AAD = 0.5 S.D. = 5.60 x 10^{-6} Temperature Range: 310-490

1,3-Dimethyl-3,4,5,6-tetrahydro-2 (1H) pyrimidinone

CAS RN: Source of Data: Reference 14

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	2.9340	318.15	1.9600	348.15	1.2330
308.15	2.3710	328.15	1.6500	373.15	0.9090

Suggested Equation = 3 Constants: A = -4.1959 B = -283.40 C = 127.74

% AAD = 0.1 S.D. = 1.90 x 10^{-6} Temperature Range: 290-380

1,3-Dinitrobenzene

CAS RN: 99-65-0, Source of Data: Reference 15

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
373.15	3.5900	451.15	0.9510	500.15	0.6573
402.65	1.6630	466.15	0.8424	573.15	0.4210
433.65	1.1160	478.15	0.7668		

Suggested Equation = 3 Constants: A = -3.9732 B = -200.42 C = 241.63

% AAD = 2.3 S.D. = 2.90 x 10^{-5} Temperature Range: 370-580

1,3-Propane sulfone

CAS RN: Source of Data: Reference 16

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
308.15	7.4470	328.15	4.8160	348.15	3.3620
318.15	5.9150	338.15	3.9800		

Suggested Equation = 3 Constants: A = -4.0403 B = -346.70 C = 126.85

% AAD = 0.1 S.D. = 4.30 x 10^{-6} Temperature Range: 300-350

1,4 Dibromo benzene

CAS RN: 106-37-6, Source of Data: Reference 12

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
383.15	0.8720	388.15	0.8070	393.15	0.7610

Suggested Equation = 1 Constants: A = -5.3410 B = 873.38 C = 0.00

% AAD = 0.4 S.D. = 4.00 x 10^{-6} Temperature Range: 380-400

1,4-Dichloro benzene

CAS RN: 106-46-7, Source of Data: Reference 10

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
333.85	0.7220	393.15	0.4295	423.15	0.3479
354.85	0.5862	403.15	0.3981	432.95	0.3277
374.45	0.4953	413.15	0.3719	445.45	0.3042

Suggested Equation = 1 Constants: A = -4.6319 B = 497.21 C = 0.00

% AAD = 0.4 S.D. = 2.30 x 10^{-6} Temperature Range: 330-450

1,4-Difluorobenzene

CAS RN: 540-36-3, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	0.6390	315.15	0.5075	333.15	0.4135
303.15	0.5680	323.15	0.4565		

Suggested Equation = 3 Constants: A = -4.9046 B = -549.69 C = -28.264

% AAD = 0.1 S.D. = 2.30 x 10^{-7} Temperature Range: 290-340

1,4-Dimethoxy benzene

CAS RN: 150-78-7, Source of Data: Reference 13

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
334.95	1.0870	414.75	0.4430	463.15	0.3024
356.85	0.8044	432.65	0.3811	472.15	0.2825
375.65	0.6296	443.25	0.3500	484.15	0.2613
395.05	0.5317	453.45	0.3242		

Suggested Equation = 1 Constants: A = -4.9520 B = 662.97 C = 0.00

% AAD = 0.6 S.D. = 9.10 x 10^{-6} Temperature Range: 330-490

1,4-Dimethyl-5-octyl decahydro naphthalene

CAS RN: Source of Data: Reference 7

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	55.230	310.95	9.496	372.05	2.184
293.15	19.030	333.15	4.881		

Suggested Equation = 3 Constants: A = -4.1480 B = -302.82 C = 168.39

% AAD = 0.2 S.D. = 2.90 x 10^{-5} Temperature Range: 270-380

1,4-Dimethyl-5-octyl naphthalene

CAS RN: Source of Data: Reference 7

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	114.800	310.95	13.710	372.05	2.580
293.15	31.420	333.15	6.303		

Suggested Equation = 3 Constants: A = -4.1315 B = -294.82 C = 180.84

% AAD = 0.7 S.D. = 3.30E-04 Temperature Range: 270-380

1, 3-Butadiene

CAS RN: 106-99-0, Source of Data: Reference 17

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
253.15	0.2440	283.15	0.1670	313.15	0.1190
263.15	0.2140	293.15	0.1490	323.15	0.1060
273.15	0.1880	303.15	0.1330	333.15	0.0950

Suggested Equation = 3 Constants: A = -6.0528 B = -973.83 C = -145.12

% AAD = 0.7 S.D. = 1.30E-04 Temperature Range: 250-400

1, 3-Cyclohexadiene

CAS RN: 592-57-4, Source of Data: Reference 15

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
292.00	0.6114	325.45	0.4128	354.65	0.3107
303.55	0.5287	336.75	0.3676		
313.45	0.4704	350.05	0.3236		

Suggested Equation = 1 Constants: A = -4.8782 B = 486.13 C = 0.00

% AAD = 0.1 S.D. = 2.70 x 10^{-7} Temperature Range: 290-360

1-Bromo-2,-2-difluoro ethane

CAS RN: Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.20	0.7840	313.15	0.6205	323.60	0.5550
303.15	0.6965				

Suggested Equation = 1 Constants: A = -4.7031 B = 468.61 C = 0.00

% AAD = 0.2 S.D. = 1.10 x 10^{-6} Temperature Range: 290-330

1-Bromo-2-methyl propane

CAS RN: 78-77-3, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.49	0.8200	305.32	0.5560	337.32	0.4040
280.55	0.7450	313.49	0.5100	345.72	0.3730
289.23	0.6690	321.54	0.4700	353.33	0.3480
296.86	0.6110	329.29	0.4350	361.08	0.3230

Suggested Equation = 3 Constants: A = -5.1273 B = -731.96 C = -85.418

% AAD = 0.3 S.D. = 1.60 x 10^{-6} Temperature Range: 270-370

1-Bromodecane

CAS RN: 112-29-8, Source of Data: Reference 3

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.08	3.3730	308.11	2.6890	313.11	2.4370
303.10	3.0240				

Suggested Equation = 1 Constants: A = -5.4375 B = 884.04 C = 0.00

% AAD = 0.3 S.D. = 8.80 x 10^{-6} Temperature Range: 290-320

1-Bromopropane

CAS RN: 106-94-5 Source of Data: Reference 8, 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.15[8]	0.5390	292.32	0.5209	324.16	0.3844
303.15	0.4590	298.59	0.4903	330.52	0.3633
273.6[4]	0.6414	305.03	0.4588	335.13	0.3495
281.01	0.5884	311.75	0.4300	341.00	0.3328
286.81	0.5523	318.79	0.4032		

Suggested Equation = 1 Constants: A = -4.6262 B = 392.13 C = 0.00

% AAD = 0.5 S.D. = 2.60 x 10^{-6} Temperature Range: 270-350

1-Butanethiol

CAS RN: 109-79-5, Source of Data: Reference 18

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
283.15	0.5970	303.15	0.4790	323.15	0.3940
293.15	0.5350	313.15	0.4400	333.15	0.3550

Suggested Equation = 3 Constants: A = -0.65755 B = -1606.60 C = 908.10

% AAD = 0.6 S.D. = 4.00 x 10^{-6} Temperature Range: 280-340

1-Butanol

CAS RN: 71-36-3, Source of Data: Reference 4, 8, 19, 20, 21, 187, 199, 179, 197, 176, 211, 196, 183

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.42[4]	5.1539	313.15	1.7200	308.15	1.929
283.84	3.7957	323.15	1.3610	313.15	1.705
294.98	2.8016	333.15	1.0850	308.15[199]	2.0170
304.88	2.1718	223.15[20]	34.7000	318.15	1.7930
316.06	1.6611	233.15	22.4000	298.15[179]	2.5562
325.32	1.3438	243.15	14.6000	313.15	1.7552
335.14	1.0903	253.15	10.3000	303.15[197]	2.2853
345.39	0.8860	263.15	7.4000	313.15	1.8170
356.28	0.7183	288.15[21]	3.1590	293.15[176]	2.9679
368.03	0.5817	298.15	2.5240	303.15	2.2896
376.11	0.5091	308.15	1.9690	313.15	1.7955
387.26	0.4259	318.15	1.5580	298.15[211]	2.6200
288.15[8]	3.3790	328.15	1.2460	293.15[196]	2.9620
303.15	2.2710	298.15[187]	2.509	298.15	2.5930
303.15[19]	2.2210	303.15	2.197	303.15[183]	2.2760

Suggested Equation = 1 Constants: A = -3.02 B = -1.03 x 10^{3} C = -3.81
%AAD = 1.6352 SD = 6.18 x 10^{-3} Temperature Range: 220-390

1-Chloro-2-methyl propane

CAS RN: 513-36-0, Source of Data: Reference 4

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	0.5816	296.62	0.4386	321.86	0.3359
279.12	0.5401	302.61	0.4102	326.89	0.3197
285.10	0.5015	310.47	0.3768	333.41	0.3007
291.84	0.4637	315.58	0.3575	338.45	0.2877

Suggested Equation = 3 Constants: A = -5.0409 B = -575.22 C = -45.15
% AAD = 0.1 S.D. = 5.40 x 10^{-7} Temperature Range: 270-340

1-Chlorodifluoro ethane

CAS RN: 75-68-3, Source of Data: Reference 11

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
241.00	0.5150	273.00	0.3770	305.00	0.2940
245.00	0.4940	277.00	0.3640	309.00	0.2860
249.00	0.4730	281.00	0.3520	313.00	0.2780
253.00	0.4540	285.00	0.3410	317.00	0.2710
257.00	0.4360	289.00	0.3310	321.00	0.2650
261.00	0.4200	293.00	0.3210	325.00	0.2580
265.00	0.4050	297.00	0.3110	329.00	0.2530
269.00	0.3900	301.00	0.3030	333.00	0.2460

Suggested Equation = 1 Constants: A = -4.4480 B = 279.56 C = 0.00
% AAD = 0.1 S.D. = 4.00 x 10^{-7} Temperature Range: 240-340

1-Chloropropane

CAS RN: 540-54-5, Source of Data: Reference 4, 22

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.6[4]	0.4327	293.86	0.3495	313.97	0.2887
278.39	0.4104	298.91	0.3344	317.83	0.2784
283.21	0.3894	303.53	0.3178	288.15[25]	0.3720
287.80	0.3709	308.53	0.3038	303.15	0.3180

Suggested Equation = 1 Constants: A = -4.7401 B = 376.91 C = 0.00
% AAD = 0.2 S.D. = 9.30 x 10^{-7} Temperature Range: 270-320

1-Decanol

CAS RN: 112-30-1, Source of Data: Reference 21, 196, 197, 199, 183, 198

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.15[21]	16.4650	293.15[196]	14.548	313.15	6.9555
298.15	10.9740	298.15	10.974	303.15[183]	9.342
308.15	7.5090	308.15[197]	8.174	298.15[198]	11.567
318.15	5.3580	318.15	6.841	303.15	9.652
328.15	3.9570	303.15[199]	8.8347	308.15	7.918

Suggested Equation = 3 Constants: A = -3.92 B = -1.57 x 10^{3} C = -1.71x 10^{1}
%AAD = 4.468665 SD = 1.07 x 10^{-2} Temperature Range: 280-330

1-Fluoro-2-nitrobenzene

CAS RN: 1493-27-2, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	2.427	313.15	1.835	333.15	1.346
303.15	2.190	323.15	1.585		

Suggested Equation = 3 Constants: A = -3.9207 B = -190.52 C = 152.29
% AAD = 0.5 S.D. = 1.10 x 10^{-5} Temperature Range: 290-340

1-Fluoro-3-nitrobenzene

CAS RN: 402-67-5, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	2.1800	308.15	1.7970	328.15	1.3050
303.25	1.9850	318.15	1.5200	337.95	1.1480

Suggested Equation = 3 Constants: A = -3.8976 B = -168.21 C = 162.25
% AAD = 0.3 S.D. = 5.90 x 10^{-6} Temperature Range: 290-340

1-Fluoro-4-nitrobenzene

CAS RN: 350-46-9, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.25	2.2450	323.15	1.5600	338.15	1.2480
313.20	1.8400	333.60	1.3320		

Suggested Equation = 3 Constants: A = -3.8909 B = -168.55 C = 167.51
% AAD = 0.2 S.D. = 3.20 x 10^{-6} Temperature Range: 300-340

1-Fluorohexane

CAS RN: 373-14-8, Source of Data: Reference 23

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15	0.4875	313.15	0.3894	333.15	0.3192
303.15	0.4345				

Suggested Equation = 1 Constants: A = -4.8431 B = 449.02 C = 0.00
% AAD = 0.1 S.D. = 5.00 x 10^{-7} Temperature Range: 290-340

1-Fluoropentane

CAS RN: 592-50-7, Source of Data: Reference 2

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15	0.3720	313.15	0.3035	333.15	0.2525
303.15	0.3350	323.15	0.2775		

Suggested Equation = 3 Constants: A = -5.5312 B = -970.96 C = -168.92
% AAD = 0.2 S.D. = 5.20 x 10^{-7} Temperature Range: 290-340

1-Heptene

CAS RN: 592-76-7, Source of Data: Reference 24

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	0.44	303.15	0.32	333.15	0.25
278.15	0.41	308.15	0.31	338.15	0.24
283.15	0.39	313.15	0.29	343.15	0.23
288.15	0.37	318.15	0.28	348.15	0.22
293.15	0.35	323.15	0.27	358.15	0.21
298.15	0.34	328.15	0.26	368.15	0.20

Suggested Equation = 3 Constants: A = -4.7028 B = -367.41 C = -0.52937
% AAD = 0.8 S.D. = 2.60 x 10^{-6} Temperature Range: 270-370

1-Hexanethiol

CAS RN: 111-31-9, Source of Data: Reference 25

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	1.1155	303.15	0.7215	353.15	0.4255
283.15	0.9497	313.15	0.6406	373.15	0.3583
293.15	0.8224	333.15	0.5157		

Suggested Equation = 3 Constants: A = -4.5195 B = -343.01 C = 54.236
% AAD = 0.3 S.D. = 2.00 x 10^{-6} Temperature Range: 270-380

1-Hexyne

CAS RN: 693-02-7, Source of Data: Reference 26

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15	0.3730	313.15	0.2980	333.15	0.2420
303.15	0.3330	323.15	0.2680		

Suggested Equation = 1 Constants: A = -4.9902 B = 458.60 C = 0.00
% AAD = 0.3 S.D. = 1.00 x 10^{-6} Temperature Range: 290-340

1-Iodo-2-methyl propane

CAS RN: 513-38-2, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.60	1.1540	317.71	0.6580	359.98	0.4420
284.38	0.9780	327.80	0.5930	370.99	0.4030
295.59	0.8440	338.26	0.5360	382.35	0.3680
306.99	0.7391	350.48	0.4800	389.22	0.3490

Suggested Equation = 1 Constants: A = -4.6697 B = 472.75 C = 0.00

% AAD = 0.4 S.D. = 4.10 x 10^{-6} Temperature Range: 270-390

1-Iodopropane

CAS RN: 107-08-4, Source of Data: Reference 4, 27

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.45[4]	0.9340	319.32	0.5640	363.93	0.3840
284.13	0.8170	328.74	0.5160	372.04	0.3620
293.96	0.7300	338.61	0.4740	288.15 [27]	0.8370
301.46	0.6730	347.53	0.4390	303.15	0.6700
311.98	0.6050	357.03	0.4060		

Suggested Equation = 1 Constants: A = -4.6003 B = 431.83 C = 0.00

% AAD = 1.3 S.D. = 1.60 x 10^{-5} Temperature Range: 270-380

1-Menthol

CAS RN: 15356-70-4, Source of Data: Reference 9

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
328.75	6.2893	353.35	1.8484	372.15	1.0406
347.75	2.4691				

Suggested Equation = 3 Constants: A = -5.0390 B = -324.74 C = 214.31

% AAD = 0.4 S.D. = 9.30 x 10^{-6} Temperature Range: 320-380

1-Methoxy propane

CAS RN: 557-17-5, Source of Data: Reference 28

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.45	0.3064	288.32	0.2630	302.63	0.2300
278.29	0.2914	293.25	0.2513	308.30	0.2187
283.62	0.2754	298.88	0.2385		

Suggested Equation = 1 Constants: A = -4.8065 B = 353.61 C = 0.00

% AAD = 0.2 S.D. = 4.60 x 10^{-7} Temperature Range: 270-310

1-m-Tolyl-1-o-tolylethane

Source of Data: Reference 5

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	76.56	422.95	0.724	473.15	0.454
323.15	5.03				

Suggested Equation = 3 Constants: A = -4.2798 B = -265.15 C = 189.30

% AAD = 0.4 S.D. = 1.00E-04 Temperature Range: 275-480

1-m-Tolyl-1-p-tolyl ethane

Source of Data: Reference 5

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	17.35	422.95	0.603	473.15	0.387
323.15	3.02				

Suggested Equation = 3 Constants: A = -4.5124 B = -362.96 C = 141.19

% AAD = 0.4 S.D. = 2.40 x 10^{-5} Temperature Range: 275-480

1-Nonanethiol

CAS RN: 1455-21-6, Source of Data: Reference 25

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
272.75	2.5780	303.15	1.4069	353.15	0.7188
283.15	2.0478	313.15	1.2013	373.15	0.5850
293.15	1.6814	333.15	0.9111	393.15	0.4872

Suggested Equation = 3 Constants: A = -4.3351 B = -297.76 C = 102.73

% AAD = 0.6 S.D. = 1.40 x 10^{-5} Temperature Range: 270-400

1-Nonanol

CAS RN: 143-08-8, Source of Data: Reference 21, 199, 196

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
288.15[21]	13.146	318.15	4.677	318.15	5.7070
298.15	9.101	328.15	3.476	293.15[196]	11.7280
308.15	6.522	308.15[199]	6.7410	298.15	9.7150

Suggested Equation = 1 Constants: A = -4.83 B = -2.27 x 10^3 C = -9.22x 10^{1}

%AAD = 4.598179 SD = 6.09 x 10^{-3} Temperature Range: 280-330

1-Octanethiol

CAS RN: 111-88-6, Source of Data: Reference 25

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	1.9724	303.15	1.1570	353.15	0.6188
283.15	1.6168	313.15	0.9970	373.15	0.5033
293.15	1.3554	333.15	0.7710		

Suggested Equation = 3 Constants: A = -4.5008 B = -366.58 C = 68.840

% AAD = 0.3 S.D. = 3.60 x 10^{-6} Temperature Range: 270-380

1-o-Tolyl-1-p-tolyl ethane

CAS RN: Source of Data: Reference 5

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	45.14	422.95	0.684	473.15	0.434
323.15	4.14				

Suggested Equation = 3 Constants: A = -4.3054 B = -275.75 C = 179.94

% AAD = 0.5 S.D. = 8.00 x 10^{-5} Temperature Range: 270-480

1-Pentanol

CAS RN: 71-41-0, Source of Data: Reference 29, 30, 199, 204, 196, 197, 198

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.05 [29]	3.4410	223.15[30]	101.0000	318.15	2.3330
314.45	2.2100	233.15	58.0000	298.15[204]	3.5110
326.95	1.6250	243.15	33.0000	293.15[196]	4.0510
343.25	1.1400	253.15	20.7000	298.15	3.4970
356.25	0.8770	263.15	13.0000	303.15[197]	2.8315
372.95	0.6460	273.15	8.7600	313.15	2.3443
387.35	0.5130	283.15	6.1000	298.15[198]	3.5100
393.85	0.4640	293.15	4.3700	303.15	2.9610
402.95	0.4080	308.15[199]	2.6520	308.15	2.5180

Suggested Equation = 3 Constants: A = -2.46 B = -6.90 x 10^2 C = 6.97x 10^1

%AAD = 3.11815 SD = 9.08 x 10^{-3} Temperature Range: 220-410

1-Pentene

CAS RN: 109-67-1, Source of Data: Reference 24

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
183.15	0.8500	218.15	0.4600	253.15	0.3000
188.15	0.7700	223.15	0.4300	258.15	0.2800
193.15	0.7000	228.15	0.4000	263.15	0.2700
198.15	0.6400	233.15	0.3800	268.15	0.2500
203.15	0.5900	238.15	0.3500	273.15	0.2400
208.15	0.5400	243.15	0.3300		
213.15	0.5000	248.15	0.3100		

Suggested Equation = 1 Constants: A = -4.7345 B = 305.20 C = 0.00

% AAD = 0.6 S.D. = 3.00 x 10^{-6} Temperature Range: 180-280

1-p-Propyl phenyl-p-tolylethane

Source of Data: Reference 5

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	19.57	422.95	0.719	473.15	0.463
323.15	3.55				

Suggested Equation = 3 Constants: A = -4.4081 B = -356.54 C = 141.09

% AAD = 0.1 S.D. = 6.50 x 10^{-7} Temperature Range: 275-480

1-Propanamine

CAS RN: 107-10-8, Source of Data: Reference 31

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
283.15	0.4640	303.15	0.3500	313.15	0.3110
293.15	0.4050				

Suggested Equation = 1 Constants: A = -5.1626 B = 518.12 C = 0.00

% AAD = 0.4 S.D. = 1.70 x 10^{-6} Temperature Range: 280-320

1-Propanethiol

CAS RN: 107-03-9, Source of Data: Reference 18

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	0.5030	293.15	0.4042	303.15	0.3662
283.15	0.4496				

Suggested Equation = 1 Constants: A = -4.6911 B = 380.50 C = 0.00

% AAD = 0.1 S.D. = 2.70 x 10^{-7} Temperature Range: 270-310

1-Propanol

CAS RN: 71-23-8, Source of Data: Reference 4, 27, 30, 21, 199, 204, 196, 184, 211, 197, 187

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
280.46[4]	3.1450	303.15	1.7220	328.15	0.9908
288.21	2.5555	213.15[30]	38.6000	308.15[199]	1.5460
296.01	2.1010	223.15	23.6000	318.15	1.3850
303.98	1.7320	233.15	15.4000	298.15[204]	1.9510
304.17	1.7240	243.15	10.3000	293.15[196]	2.2030
311.94	1.4400	253.15	7.1600	298.15	1.9530
319.62	1.2180	263.15	5.1300	298.15[184]	1.9510
327.48	1.0300	273.15	3.8800	298.15[211]	1.9700
334.89	0.8880	283.15	2.9200	303.15[197]	1.7843
342.19	0.7710	293.15	2.2600	313.15	1.3970
349.90	0.6660	288.15[21]	2.3179	298.15[187]	1.8980
357.97	0.5760	298.15	1.8980	303.15	1.6760
366.25	0.4990	308.15	1.4360	308.15	1.4860
368.74	0.4770	318.15	1.2230	313.15	1.3190
288.15[27]	2.5220				

Suggested Equation = 3 Constants: A = -2.74 B = -8.64 x 10^{2} C = 1.34x 10^{1}

%AAD = 1.94022 SD = 7.00 x 10^{-3} Temperature Range: 210-370

2,2-Difluoroethyl alcohol

CAS RN: 359-13-7, Source of Data: Reference 2

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15	2.6500	315.15	1.5800	333.15	1.0420
303.15	2.0300	323.15	1.2750		

Suggested Equation = 3 Constants: A = -4.7550 B = -380.84 C = 118.36

% AAD = 0.3 S.D. = 4.50 x 10^{-6} Temperature Range: 290-340

2,2-Dimethyl butane

CAS RN: 79-29-8, Source of Data: Reference 32

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	0.4770	293.15	0.3750	303.15	0.3300
288.15	0.3970	298.15	0.3510		

Suggested Equation = 3 Constants: A = -1.5347 B = -651.45 C = 637.56

% AAD = 0.3 S.D. = 1.10 x 10^{-6} Temperature Range: 270-310

2,2-Di-p-tolylbutane

CAS RN: 734-17-8, Source of Data: Reference 5

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	311.150	422.95	0.753	473.15	0.468
323.15	7.450				

Suggested Equation = 3 Constants: A = -4.4205 B = -278.15 C = 202.10

% AAD = 1.1 S.D. = 1.10E-02 Temperature Range: 270-480

2,4-Dimethyl-3-pentanone

CAS RN: 565-80-0, Source of Data: Reference 26

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	0.6320	323.15	0.4480	373.15	0.2790
303.15	0.5590	333.15	0.4040		
313.15	0.5000	353.15	0.3330		

Suggested Equation = 3 Constants: A = -5.2591 B = -791.85 C = -91.339

% AAD = 0.1 S.D. = 4.60 x 10^{-7} Temperature Range: 290-380

2,4-Dimethyl sulfolane

CAS RN: 1003-78-7, Source of Data: Reference 33

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	9.0790	323.15	4.5190	373.15	1.2850
303.15	7.7550	333.15	2.6930		
313.15	5.8190	353.15	1.7930		

Suggested Equation = 3 Constants: A = -4.1963 B = -331.93 C = 143.99

% AAD = 0.2 S.D. = 1.20 x 10^{-5} Temperature Range: 290-400

2,5-Difluoro aniline

CAS RN: 367-30-6, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	2.3200	315.15	1.5640	333.15	1.1350
303.15	1.8750	323.15	1.3250		

Suggested Equation = 3 Constants: A = -4.2269 B = -264.07 C = 127.26

% AAD = 0.2 S.D. = 3.60 x 10^{-6} Temperature Range: 290-340

2,6-Dimethyl-4-heptanone

CAS RN: 108-83-8, Source of Data: Reference 34

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	1.3200	303.15	0.7650	313.15	0.6650
293.15	0.9300				

Suggested Equation = 2 Constants: A = 3111100000 B = -5.08 C = 0.00

% AAD = 0.9 S.D. = 8.00 x 10^{-6} Temperature Range: 270-320

2,6-Diethyl aniline

CAS RN: 579-68-8, Source of Data: Reference 35

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.00	4.3700	308.00	2.8500	318.00	2.2000
298.00	3.6500	311.00	2.6800	323.00	2.0000
303.00	3.2450	313.00	2.5450	372.00	0.9300

Suggested Equation = 3 Constants: A = -4.0635 B = -207.07 C = 171.42

% AAD = 1.0 S.D. = 3.80 x 10^{-5} Temperature Range: 290-380

2,6-Dimethyl-3-octyl decahydro naphthalene

Source of Data: Reference 7

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	20.78	333.15	5.08	372.05	2.21
310.95	10.07				

Suggested Equation = 3 Constants: A = -4.1606 B = -302.58 C = 171.06

% AAD = 0.1 S.D. = 8.50 x 10^{-6} Temperature Range: 290-380

2,6-Dimethyl aniline

CAS RN: 87-62-7, Source of Data: Reference 35

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.00	3.7400	308.00	2.5000	318.00	1.9500
298.00	3.2600	313.00	2.2200	323.00	1.8570
303.00	2.8320				

Suggested Equation = 1 Constants: A = -5.8154 B = 999.16 C = 0.00

% AAD = 1.6 S.D. = 4.00 x 10^{-5} Temperature Range: 290-330

2,6-Dimethyl pyridine-N-oxide

CAS RN: 1073-23-0, Source of Data: Reference 36

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	6.1650	348.15	1.7320	398.15	0.8690
323.15	2.9040	373.15	1.1820		

Suggested Equation = 3 Constants: A = -4.0622 B = -218.72 C = 179.99

% AAD = 0.4 S.D. = 1.10E-04 Temperature Range: 290-400

2,7-Dimethyl octane

CAS RN: 1072-16-8, Source of Data: Reference 37

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	0.8278	321.15	0.5540	338.15	0.4686
308.15	0.6702				

Suggested Equation = 3 Constants: A = -3.7054 B = -38.588 C = 236.15

% AAD = 0.7 S.D. = 5.00 x 10^{-6} Temperature Range: 290-340

2-Amyl undecanol

CAS RN: 25355-02-6, Source of Data: Reference 38

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.00	39.3856	313.15	15.2230	353.15	3.6941
303.15	23.9406	333.15	6.9589	373.15	2.1659

Suggested Equation = 3 Constants: A = -5.3143 B = -656.98 C = 125.18

% AAD = 0.3 S.D. = 8.00 x 10^{-5} Temperature Range: 290-380

2-Amyl undecyl acetate

Source of Data: Reference 38

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	16.5563	303.15	5.2938	353.15	1.7352
283.15	10.6655	313.15	3.9952	373.15	1.2734
293.15	7.3314	333.15	2.5132		

Suggested Equation = 3 Constants: A = -4.1857 B = -279.19 C = 157.02

% AAD = 0.2 S.D. = 9.70 x 10^{-6} Temperature Range: 270-380

2-Bromo aniline

CAS RN: 615-36-1, Source of Data: Reference 39

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
313.15	3.1867	353.15	1.5430	373.15	1.8850
333.15	2.1575				

Suggested Equation = 3 Constants: A = -4.1491 B = -282.29 C = 142.43

% AAD = 0.4 S.D. = 9.20 x 10^{-6} Temperature Range: 310-380

2-Bromopropane

CAS RN: 75-26-3, Source of Data: Reference 4, 40

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
272.38[4]	0.6021	298.61	0.4551	324.06	0.3555
278.27	0.5688	303.09	0.4343	329.91	0.3371
283.29	0.5371	309.05	0.4095	288.15[56]	0.5360
288.45	0.5068	314.32	0.3894	303.15	0.4370
293.43	0.4803	319.51	0.3704		

Suggested Equation = 1 Constants: A = -4.7088 B = 408.46 C = 0.00

% AAD = 0.7 S.D. = 7.20 x 10^{-6} Temperature Range: 270-330

2-Bromopyridine

CAS RN: 109-04-6, Source of Data: Reference 41

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	1.7540	323.15	1.2310	398.15	0.5920
303.15	1.6220	348.15	0.9270		
313.15	1.4030	373.15	0.7290		

Suggested Equation = 3 Constants: A = -4.2913 B = -347.61 C = 71.65

% AAD = 0.2 S.D. = 2.20 x 10^{-6} Temperature Range: 290-400

2-Bromotoluene

CAS RN: 95-46-5, Source of Data: Reference 39

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	2.2080	303.15	1.2912	353.15	0.7061
283.15	1.8051	313.15	1.1191	373.15	0.5862
293.15	1.5119	333.15	0.8737		

Suggested Equation = 3 Constants: A = -4.1812 B = -252.67 C = 107.57

% AAD = 0.3 S.D. = 3.60 x 10^{-6} Temperature Range: 270-380

2-Butanethiol

CAS RN: 513-53-1, Source of Data: Reference 18

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
283.15	0.5700	303.15	0.4570	323.15	0.3760
293.15	0.5090	313.15	0.4190		

Suggested Equation = 1 Constants: A = -4.6839 B = 407.84 C = 0.00

% AAD = 0.4 S.D. = 2.20 x 10^{-6} Temperature Range: 280-330

2-Butanol

CAS RN: 78-92-2, Source of Data: Reference 29, 211, 205, 212, 190, 179

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
287.95[29]	4.6600	348.55	0.6920	298.15	3.5010
298.45	3.0810	357.05	0.5680	303.15	2.9580
306.95	2.2610	368.65	0.4600	298.15[190]	3.0427
318.95	1.5240	298.15[211]	3.1150	313.15	1.7913
327.05	1.1900	303.15[205]	2.4920	298.15[179]	3.0596
339.45	0.8500	293.15[212]	3.9670	313.15	1.7854

Suggested Equation = 3 Constants: A = -2.28 B = -4.51 x 10^2 C = 1.36 x 10^2
%AAD = 2.944715 SD = 6.69 x 10^{-3} Temperature Range: 280-370

2-Butyl-3-hexyl decahydro naphthalene

Source of Data: Reference 7

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
273.15	111.7000	310.95	13.1700	372.05	2.3460
293.15	30.7600	333.15	5.9770		

Suggested Equation = 3 Constants: A = -4.2988 B = -328.70 C = 175.01
% AAD = 0.5 S.D. = 3.30E-04 Temperature Range: 270-380

2-Butyl-3-hexyl naphthalene

Source of Data: Reference 7

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
273.15	81.3100	310.95	11.4900	372.05	2.2710
293.15	24.8900	333.15	5.5060		

Suggested Equation = 3 Constants: A = -4.2679 B = -328.24 C = 169.89
% AAD = 0.3 S.D. = 7.20 x 10^{-5} Temperature Range: 270-380

2-Butyl dodecanol

Source of Data: Reference 38

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
293.15	40.5022	313.15	7.0373	373.15	2.1978
303.15	24.3902	353.15	3.7065		

Suggested Equation = 3 Constants: A = -5.2109 B = -614.37 C = 132.35
% AAD = 0.5 S.D. = 1.00E-04 Temperature Range: 290-380

2-Chloro-6-methyl aniline

CAS RN: 87-63-8, Source of Data: Reference 25

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
293.00	2.5600	308.00	1.7990	318.00	1.4500
298.00	2.2630	313.00	1.6140	323.00	1.3650
303.00	2.0140				

Suggested Equation = 3 Constants: A = -3.5853 B = -76.58 C = 216.40
% AAD = 0.9 S.D. = 2 E-5 Temperature Range: 290-330

2-Chloroaniline

CAS RN: 95-51-2, Source of Data: Reference 42, 35

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
290.4[42]	3.8460	422.55	0.5432	303.00	2.9310
319.15	1.9390	441.55	0.4645	308.00	2.6260
334.05	1.5140	462.35	0.3957	313.00	2.3680
348.25	1.2330	483.15	0.3400	318.00	2.1500
364.05	1.0070	293.15[35]	3.9440	323.00	1.9560
393.65	0.7195	298.00	3.4000		

Suggested Equation = 3 Constants: A = -4.3779 B = -329.53 C = 124.58

% AAD = 2.2 S.D. = 8.00 x 10^{-5} Temperature Range: 290-490

2-Chloro phenol

CAS RN: 95-57-8, Source of Data: Reference 10, 43

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
313.85[10]	2.1710	414.15	0.5117	303.15	3.0800
334.15	1.4070	425.15	0.4630	313.15	2.3200
357.65	0.9715	436.15	0.4212	333.15	1.5130
376.65	0.7564	447.15	0.3843	353.15	1.0700
395.05	0.6216	283.15[43]	6.3900	363.15	0.7600
404.75	0.5617	293.15	4.2100	423.15	0.5460

Suggested Equation = 3 Constants: A = -4.2372 B = -230.71 C = 169.42

% AAD = 1.6 S.D. = 6.20 x 10^{-5} Temperature Range: 280-450

2-Chloro phenyl methyl ether

CAS RN: 6707-01-3, Source of Data: Reference 10

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
290.45	2.4610	392.25	0.5644	447.15	0.3570
322.85	1.3090	413.05	0.4672	456.15	0.3296
352.95	0.8650	432.35	0.3996	469.15	0.3061
372.85	0.6870	446.15	0.3591		

Suggested Equation = 3 Constants: A = -4.5675 B = -410.89 C = 80.145

% AAD = 0.6 S.D. = 1.2 E-5 Temperature Range: 290-470

2-Chloropropane

CAS RN: 75-29-6, Source of Data: Reference 4, 40

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.42[4]	0.4000	289.62	0.3341	306.17	0.2829
279.83	0.3714	295.65	0.3137	288.15[40]	0.3350
284.17	0.3540	301.37	0.2962	303.15	0.2860

Suggested Equation = 1 Constants: A = -4.8440 B = 395.32 C = 0.00

% AAD = 0.7 S.D. = 2.20 x 10^{-6} Temperature Range: 270-310

2-Chloropyridine

CAS RN: 109-09-1, Source of Data: Reference 41

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	1.1870	333.15	0.8630	373.15	0.5290
303.15	1.1060	348.15	0.6630	398.15	0.4340
323.15	0.9710				

Suggested Equation = 3 Constants: A = -4.5143 B = -420.08 C = 33.57

% AAD = 0.2 S.D. = 1.50 x 10^{-6} Temperature Range: 290-400

2-Chlorotoluene

CAS RN: 95-49-8, Source of Data: Reference 10, 39

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
308.55[10]	0.8564	408.15	0.3348	293.15	1.0225
330.25	0.6597	419.05	0.3114	303.15	0.8928
348.85	0.5465	426.25	0.2970	313.15	0.7893
368.05	0.4567	432.15	0.2861	333.15	0.6338
387.45	0.3912	273.15[39]	1.4029	353.15	0.5222
393.15	0.3743	283.15	1.1885	373.15	0.4388
398.15	0.3606				

Suggested Equation = 3 Constants: A = -4.6558 B = -464.57 C = 14.89

% AAD = 0.5 S.D. = 5.80 x 10^{-6} Temperature Range: 270-440

2-Cyanopyridine

CAS RN: 100-70-9, Source of Data: Reference 41

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	1.8160	323.15	1.3060	373.15	0.7220
313.15	1.5280	348.15	0.9460	398.15	0.5740

Suggested Equation = 3 Constants: A = -4.3011 B = -315.45 C = 100.85

% AAD = 0.3 S.D. = 3.40E-04 Temperature Range: 300-400

2-Ethoxybenzenamine

CAS RN: 94-70-2, Source of Data: Reference 39

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.21	16.5071	303.15	4.2212	353.15	1.3328
283.15	9.4518	313.15	3.1230	373.52	0.9930
293.15	6.0790	333.15	1.9301		

Suggested Equation = 3 Constants: A = -4.0349 B = -191.08 C = 188.20

% AAD = 0.4 S.D. = 4.80 x 10^{-5} Temperature Range: 270-380

2-Ethoxytoluene

CAS RN: 614-71-1, Source of Data: Reference 10

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.15	1.5690	368.25	0.5019	418.35	0.3214
308.05	1.0810	378.55	0.4534	427.55	0.2988
318.15	0.9250	388.15	0.4146	438.15	0.2780
328.25	0.7965	393.15	0.3971	443.75	0.2672
348.25	0.6226	398.15	0.3808		
358.25	0.5580	408.15	0.3493		

Suggested Equation = 3 Constants: A = -4.6820 B = -425.29 C = 60.60

% AAD = 0.5 S.D. = 8.60 x 10^{-6} Temperature Range: 280-450

2-Ethyl-1-hexanol

CAS RN: 104-76-7, Source of Data: Reference 44

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.19	20.7151	303.15	5.1446	353.15	1.2191
283.15	12.1971	313.15	3.6113	373.15	0.8077
293.15	7.7036	333.15	1.9830		

Suggested Equation = 3 Constants: A = -4.9651 B = -436.77 C = 140.04

% AAD = 0.2 S.D. = 2.30 x 10^{-5} Temperature Range: 270-380

2-Ethyl-1-hexene

CAS RN: 1632-16-2, Source of Data: Reference 26

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	0.4720	323.15	0.3450	353.15	0.2630
303.15	0.4230	333.15	0.3130	373.15	0.2250
313.15	0.3810				

Suggested Equation = 3 Constants: A = -5.0166 B = -573.86 C = -46.20

% AAD = 0.1 S.D. = 4.20 x 10^{-7} Temperature Range: 290-380

2-Ethylaniline

CAS RN: 578-54-1, Source of Data: Reference 35

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.00	4.5000	308.00	2.9150	318.00	2.1800
298.00	3.8500	311.00	2.5900	323.00	1.9500
303.00	3.3250	313.00	2.5240	372.00	0.9100

Suggested Equation = 3 Constants: A = -3.9240 B = -157.40 C = 193.75

% AAD = 1.1 S.D. = 4.50 x 10^{-5} Temperature Range: 290-380

2-Fluoroaniline

CAS RN: 348-54-9, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.42	2.5650	313.15	1.7000	333.15	1.1980
303.20	2.0900	323.15	1.4050		

Suggested Equation = 3 Constants: A = -4.4778 B = -349.85 C = 108.24

% AAD = 0.5 S.D. = 1.10 x 10^{-5} Temperature Range: 290-340

2-Fluoroethanol

CAS RN: 371-62-0, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	1.9240	313.15	1.2470	333.15	0.8890
303.15	1.5400	323.15	1.0440		

Suggested Equation = 3 Constants: A = -4.3059 B = -237.31 C = 144.01

% AAD = 0.2 S.D. = 4.40 x 10^{-6} Temperature Range: 290-340

2-Fluorophenetole

CAS RN: 50919-06-7, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
292.20	1.5200	313.15	1.0570	323.10	0.9170
303.15	1.2500				

Suggested Equation = 3 Constants: A = -3.8508 B = -114.33 C = 182.48
% AAD = 0.1 S.D. = 3.20 x 10^{-7} Temperature Range: 290-330

2-Fluorotoluene

CAS RN: 95-52-3, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	0.6795	313.15	0.5375	333.15	0.4340
303.15	0.6005	323.15	0.4810		

Suggested Equation = 3 Constants: A = -4.9997 B = -617.09 C = -43.732
% AAD = 0.1 S.D. = 7.20 x 10^{-6} Temperature Range: 290-340

2-Furaldehyde

CAS RN: 98-01-1, Source of Data: Reference 45, 46

T (K)	η *(N.s.m^{-2})*	T (K)	η *(N.s.m^{-2})*	T (K)	η *(N.s.m^{-2})*
273.15[45]	2.4313	313.15	1.1600	373.15	0.5760
283.15	1.9639	333.15	0.8977	273.15[46]	2.4750
293.15	1.6173	353.15	0.7023	298.15	1.4940
303.15	1.3570				

Suggested Equation = 3 Constants: A = -4.3068 B = -288.90 C = 102.72
% AAD = 0.6 S.D. = 1.20 x 10^{-5} Temperature Range: 270-380

2-Heptanethiol

CAS RN: 628-00-2, Source of Data: Reference 25

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
272.89	1.2422	303.15	0.7802	353.15	0.4553
283.15	1.0453	313.15	0.6881	373.15	0.3735
293.15	0.8971	333.15	0.5468		

Suggested Equation = 3 Constants: A = -4.5611 B = -364.98 C = 52.252
% AAD = 0.5 S.D. = 3.20 x 10^{-6} Temperature Range: 270-380

2-Heptanol

CAS RN: 543-49-7, Source of Data: Reference 29

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	3.321	348.35	0.980	391.85	0.460
319.05	2.021	365.45	0.702	408.25	0.3658
333.25	1.376	376.85	0.581	423.35	0.3047

Suggested Equation = 3 Constants: A = -4.9431 B = -408.06 C = 137.51
% AAD = 0.3 S.D. = 4.20 x 10^{-6} Temperature Range: 300-430

2-Heptanone

CAS RN: 110-43-0, Source of Data: Reference 26

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	0.835	308.15	0.553	333.15	0.337
298.15	0.709	313.15	0.495	353.15	0.285
303.15	0.623	323.15	0.405		

Suggested Equation = 3 Constants: A = -4.0164 B = -55.937 C = 233.86

% AAD = 1.0 S.D. = 6.10 x 10^{-6} Temperature Range: 290-360

2-Heptyl nonanol

CAS RN: 25355-03-7, Source of Data: Reference 38

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	40.7664	313.15	15.7233	353.15	3.7023
303.15	22.7066	333.15	7.1480	373.15	2.1720

Suggested Equation = 3 Constants: A = -5.2286 B = -622.89 C = 130.58

% AAD = 2.2 S.D. = 6.50E-04 Temperature Range: 290-380

2-Heptyl nonyl acetate

Source of Data: Reference 38

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	16.5728	303.15	5.2938	353.15	1.7138
283.15	10.6689	313.15	3.9904	373.15	1.2583
293.15	7.3260	333.15	2.5000		

Suggested Equation = 3 Constants: A = -4.2190 B = -287.54 C = 155.19

% AAD = 0.1 S.D. = 1.00 x 10^{-5} Temperature Range: 270-380

2-Hexadecanol

CAS RN: 14852-31-4, Source of Data: Reference 38

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	41.4422	313.15	15.8529	353.15	3.7300
303.15	25.1383	333.15	7.1685	373.15	2.1834

Suggested Equation = 3 Constants: A = -5.3662 B = -672.23 C = 124.54

% AAD = 0.5 S.D. = 1.50E-04 Temperature Range: 290-380

2-Hexadecyl acetate

CAS RN: 162214-39-3, Source of Data: Reference 38

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	16.3961	303.15	5.2219	353.15	1.6920
283.15	10.5430	313.15	3.9324	373.15	1.2398
293.15	7.2254	333.15	2.4637		

Suggested Equation = 3 Constants: A = -4.2205 B = -285.73 C = 155.79

% AAD = 0.2 S.D. = 1.10 x 10^{-5} Temperature Range: 270-380

2-Hexanethiol

CAS RN: 1679-06-7, Source of Data: Reference 25

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
273.15	0.9309	303.15	0.6168	353.15	0.3708
283.15	0.7999	313.15	0.5494	373.15	0.3129
293.15	0.6990	333.15	0.4468		

Suggested Equation = 3 Constants: A = -4.5945 B = -361.31 C = 42.281

% AAD = 0.4 S.D. = 2.50 x 10^{-6} Temperature Range: 270-380

2-Hydroxy acetophenone

CAS RN: 118-93-4, Source of Data: Reference 10

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
321.15	1.8160	404.65	0.6010	459.15	0.3805
344.45	1.2240	423.15	0.5020	470.55	0.3502
364.25	0.9290	424.15	0.5007	486.15	0.3148
384.15	0.7420	443.15	0.4303		

Suggested Equation = 3 Constants: A = -4.5830 B = -435.71 C = 84.205

% AAD = 0.6 S.D. = 6.00 x 10^{-6} Temperature Range: 320-490

2-Iodopropane

CAS RN: 75-30-9, Source of Data: Reference 4, 27

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
273.45 [4]	0.8750	313.82	0.5550	353.60	0.3880
282.33	0.7820	322.58	0.5090	361.87	0.3610
289.07	0.7220	330.16	0.4750	288.15[27]	0.7320
296.58	0.6640	338.59	0.4400	303.15	0.6200
305.64	0.6010	344.64	0.4180		

Suggested Equation = 1 Constants: A = -4.6119 B = 425.18 C = 6.1088

% AAD = 0.3 S.D. = 2.00 x 10^{-6} Temperature Range: 270-360

2-Methoxyphenol

CAS RN: 90-05-1, Source of Data: Reference 13

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
320.35	2.6170	405.65	0.6256	442.35	0.4361
345.15	1.5020	413.35	0.5754	453.05	0.3996
366.35	1.0370	423.15	0.5222	464.35	0.3670
384.75	0.8034	433.25	0.4727	478.15	0.3325

Suggested Equation = 3 Constants: A = -4.4351 B = -313.21 C = 151.10

% AAD = 0.3 S.D. = 5.90 x 10^{-6} Temperature Range: 320-480

2-Methyl-1,3-butadiene

CAS RN: 78-79-5, Source of Data: Reference 4

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
273.15	0.2600	293.15	0.2155	303.15	0.1980
283.15	0.2362				

Suggested Equation = 1 Constants: A = -4.7797 B = 326.58 C = 0.00

% AAD = 0.2 S.D. = 5.00 x 10^{-7} Temperature Range: 270-310

2-Methyl-1-butanol

CAS RN: 137-32-6, Source of Data: Reference 29

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
292.45	5.5050	334.25	1.4540	373.05	0.6120
302.05	3.8680	343.65	1.1490	381.75	0.5230
318.85	2.2490	353.35	0.9140	396.15	0.4140
325.15	1.8530	362.75	0.7450		

Suggested Equation = 3 Constants: A = -5.3355 B = -551.30 C = 113.41

% AAD = 0.4 S.D. = 1.40×10^{-5} Temperature Range: 290-400

2-Methyl-1-butanol (optically active)

CAS RN: 1565-80-6, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.55	10.9672	320.55	2.0880	365.03	0.7075
284.78	6.9581	330.09	1.5956	373.18	0.6033
296.45	4.5372	340.67	1.2183	385.93	0.4819
307.90	3.0788	352.40	0.9254	397.51	0.4008

Suggested Equation = 3 Constants: A = -5.6363 B = -703.07 C = 82.578

% AAD = 0.7 S.D. = 5.00×10^{-5} Temperature Range: 270-400

2-Methyl-1-heptanol

CAS RN: 60435-70-3, Source of Data: Reference 44

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.25	8.3101	303.15	2.8748	353.15	0.9105
283.15	5.5695	313.15	2.1805	372.82	0.6531
293.15	3.9185	333.15	1.3582		

Suggested Equation = 3 Constants: A = -4.8579 B = -419.93 C = 121.96

% AAD = 0.3 S.D. = 1.90×10^{-5} Temperature Range: 270-380

2-Methyl-1-pentene

CAS RN: 763-29-1, Source of Data: Reference 26

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	0.2900	303.15	0.2630	313.15	0.2370
298.15	0.2770	308.15	0.2490	323.15	0.2120

Suggested Equation = 3 Constants: A = -2.5684 B = -236.49 C = 536.99

% AAD = 0.2 S.D. = 6.00×10^{-7} Temperature Range: 290-330

2-Methyl-1-propanol

CAS RN: 78-83-1, Source of Data: Reference 4, 40, 47, 205, 179

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.6 [4]	7.9111	339.10	1.0697	293.15 [47]	4.0200
283.05	5.5735	347.76	0.8748	298.15	3.3800
292.16	3.9779	357.10	0.7173	303.15	2.8900
300.92	3.0658	367.00	0.5864	308.15	2.4700
311.31	2.2392	378.22	0.4753	303.15[205]	2.8720
320.59	1.7217	288.15 [40]	4.7030	298.15[179]	3.3603
329.63	1.3571	303.15	2.8760	313.15	2.0925

Suggested Equation = 3 Constants: A = -3.09 B = -9.40×10^{2} C = $3.82\text{x } 10^{1}$

%AAD = 0.714456 SD = 3.45×10^{-4} Temperature Range: 270-380

2-Methyl-2-butanethiol

CAS RN: 1679-09-0, Source of Data: Reference 18

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
283.15	0.7720	303.15	0.5750	323.15	0.4520
293.15	0.6650	313.15	0.5150	333.15	0.3990

Suggested Equation = 1 Constants: A = -5.0016 B = 534.84 C = 0.00

% AAD = 1.1 S.D. = 7.80 x 10^{-6} Temperature Range: 280-340

2-Methyl-2-butene

CAS RN: 513-35-9, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.35	0.2529	288.97	0.2192	303.84	0.1931
278.61	0.2406	293.18	0.2114	305.74	0.1903
283.36	0.2306	298.90	0.2015		

Suggested Equation = 1 Constants: A = -4.7741 B = 322.29 C = 0.00

% AAD = 0.2 S.D. = 4.30 x 10^{-7} Temperature Range: 270-310

2-Methyl-2-hexanol

CAS RN: 625-23-0, Source of Data: Reference 38

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
305.65	3.0160	348.95	0.8820	395.45	0.3840
318.35	1.9740	363.95	0.6430	407.05	0.3321
333.35	1.2830	383.75	0.4480		

Suggested Equation = 3 Constants: A = -4.8188 B = -322.52 C = 165.66

% AAD = 0.9 S.D. = 1.60 x 10^{-5} Temperature Range: 300-410

2-Methyl-2-propanethiol

CAS RN: 75-66-1, Source of Data: Reference 18

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
283.15	0.7440	303.15	0.5380	313.15	0.4750
293.15	0.6290				

Suggested Equation = 3 Constants: A = -4.7260 B = -342.80 C = 68.37

% AAD = 0.4 S.D. = 2.70 x 10^{-6} Temperature Range: 280-320

2-Methyl-2-propanol

CAS RN: 75-65-0, Source of Data: Reference 4, 27, 205, 179

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15[4]	3.3490	335.24	0.9678	308.15	2.5750
305.15	3.0047	341.50	0.8102	313.15	2.0390
310.37	2.3676	346.62	0.7057	303.15[205]	3.3180
315.56	1.9094	350.20	0.6447	298.15[179]	4.4126
320.97	1.5501	303.15[27]	3.3160	313.15	2.0885
326.14	1.0976				

Suggested Equation = 3 Constants: A = -2.23 B = -3.58 x 10^2 C = 1.73 x 10^2

%AAD = 2.870523 SD = 5.98 x 10^{-3} Temperature Range: 300-360

2-Methyl-3-heptanol

CAS RN: 18720-62-2, Source of Data: Reference 44

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.21	33.9570	303.15	5.2953	353.15	0.9267
283.15	16.7196	313.15	3.3444	373.52	0.6108
293.15	9.0346	333.15	1.6019		

Suggested Equation = 3 Constants: A = -4.8686 B = -319.77 C = 179.53

% AAD = 1.6 S.D. = 3.90E-04 Temperature Range: 270-380

2-Methyl-4-heptanol

CAS RN: 21570-35-4, Source of Data: Reference 44

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.37	29.0875	303.15	5.6881	353.15	0.9696
283.15	16.6525	313.15	3.6387	373.54	0.6208
293.15	9.4308	333.15	1.7245		

Suggested Equation = 3 Constants: A = -5.3181 B = -471.17 C = 149.48

% AAD = 2.5 S.D. = 6.30E-04 Temperature Range: 270-380

2-Methyl-5-heptanol

CAS RN: 18720-66-6, Source of Data: Reference 44

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.44	2.6162	303.15	1.2638	353.15	0.5346
283.15	2.0125	313.15	1.0332	373.15	0.4117
293.15	1.5811	333.15	0.7256		

Suggested Equation = 3 Constants: A = -4.8874 B = -430.45 C = 86.77

% AAD = 0.2 S.D. = 2.10×10^{-6} Temperature Range: 270-380

2-Methyl-6-ethyl aniline

CAS RN: 24549-06-2, Source of Data: Reference 35

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.00	3.8700	308.00	2.6000	318.00	2.0450
298.00	3.3500	311.00	2.3900	323.00	1.8200
303.00	2.9500	313.00	2.3520	372.00	0.8700

Suggested Equation = 3 Constants: A = -4.1038 B = -214.17 C = 166.71

% AAD = 0.9 S.D. = 2.80×10^{-5} Temperature Range: 290-380

2-Methyl-7-heptanol

CAS RN: 1653-40-3, Source of Data: Reference 44

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.37	22.5596	303.15	6.5998	353.15	1.5949
283.15	14.4096	313.15	4.7059	373.57	1.0409
293.15	9.5657	333.15	2.6190		

Suggested Equation = 3 Constants: A = -5.3070 B = -637.23 C = 99.314

% AAD = 0.1 S.D. = 9.80E-04 Temperature Range: 270-380

2-Methyl octane-2-thiol

CAS RN: 55646-15-6, Source of Data: Reference 18

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
283.15	1.6160	303.15	1.0700	323.15	0.7670
293.15	1.3080	313.15	0.9140		

Suggested Equation = 3 Constants: A = -4.5357 B = -308.54 C = 106.32

% AAD = 0.5 S.D. = 6.00 x 10^{-6} Temperature Range: 280-330

2-Methyl pentadecyl acetate

Source of Data: Reference 38

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	15.6715	303.15	5.4915	353.15	1.9004
283.15	10.4504	313.15	4.2212	373.15	1.4180
293.15	7.4074	333.15	2.7159		

Suggested Equation = 3 Constants: A = -4.1461 B = -291.48 C = 148.59

% AAD = 0.1 S.D. = 1.70 x 10^{-5} Temperature Range: 270-380

2-Methyl pentane

CAS RN: 107-83-5, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.76	0.3688	293.66	0.2987	314.22	0.2450
278.74	0.3487	298.66	0.2841	318.53	0.2355
283.40	0.3316	305.12	0.2670	324.32	0.2235
288.41	0.3147	309.78	0.2550	328.58	0.2151

Suggested Equation = 3 Constants: A = -5.4697 B = -862.57 C = -149.90

% AAD = 0.1 S.D. = 2.30 x 10^{-7} Temperature Range: 270-330

2-Methyl benzenamine

CAS RN: 95-53-4, Source of Data: Reference 42, 48

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
374.95 (1)	0.8110	465.65	0.3320	323.25	1.9190
398.55	0.6189	471.85	0.3160	333.15	1.5782
410.55	0.5457	273.81 (2)	10.1056	343.15	1.3018
423.15	0.4818	293.15	4.3922	353.15	1.1092
436.45	0.4249	303.15	3.1964	363.15	0.9525
448.65	0.3813	313.15	2.4358	373.15	0.8379
460.95	0.3450				

Suggested Equation = 3 Constants: A = -4.4107 B = -297.19 C = 149.02

% AAD = 1.9 S.D. = 1.50E-04 Temperature Range: 270-480

2-Methyl benzonitrile

CAS RN: 529-19-1, Source of Data: Reference 26

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	1.755	323.15	1.063	373.15	0.594
303.15	1.456	333.15	0.928	393.15	0.497
313.15	1.233	353.15	0.727	413.15	0.421

Suggested Equation = 3 Constants: A = -4.3838 B = -319.82 C = 96.496

% AAD = 0.3 S.D. = 3.20 x 10^{-6} Temperature Range: 290-420

2-Methyl butane

CAS RN: 78-78-4, Source of Data: Reference 28, 8

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
273.86[28]	0.2703	288.97	0.2322	299.53	0.2102
279.55	0.2547	294.18	0.2212	273.15[8]	0.2740
285.06	0.2407	297.42	0.2144	288.15	0.2340

Suggested Equation = 1 Constants: A = -4.8531 B = 353.18 C = 0.00
% AAD = 0.1 S.D. = 4.50 x 10^{-7} Temperature Range: 270-310

2-Methyl cyclohexanol

CAS RN: 583-59-5, Source of Data: Reference 49, 50

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
312.25[49]	6.9784	363.15	1.2601	293.15[50]	21.7014
339.05	2.5661				

Suggested Equation = 3 Constants: A = -4.6708 B = -304.32 C = 191.82
% AAD = 2.0 S.D. = 1.50E-04 Temperature Range: 290-370

2-Methyl cyclohexanone

CAS RN: 583-60-8, Source of Data: Reference 49, 51

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
290.45[49]	1.8222	339.05	0.8379	303.15	1.4060
312.25	1.2167	288.15[51]	1.8450		

Suggested Equation = 3 Constants: A = -5.0593 B = 670.87 C = 0.00
% AAD = 1.3 S.D. = 2.60 x 10^{-5} Temperature Range: 280-340

2-Methyl propane

CAS RN: 75-28-5, Source of Data: Reference 17

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
203.15	0.5300	233.15	0.3430	263.15	0.2380
213.15	0.4540	243.15	0.3010	273.15	0.2140
223.15	0.3920	253.15	0.2670		

Suggested Equation = 1 Constants: A = -4.8098 B = 312.65 C = 0.00
% AAD = 0.6 S.D. = 2.80 x 10^{-6} Temperature Range: 200-280

2-Methyl propionic acid

CAS RN: 79-31-2, Source of Data: Reference 4

T (K)	η *(N.s.m^{-2})*	**T (K)**	η *(N.s.m^{-2})*	**T (K)**	η *(N.s.m^{-2})*
276.84	1.7610	327.69	0.8110	382.93	0.4500
290.15	1.3830	343.64	0.6740	394.12	0.4070
302.48	1.1370	361.21	0.5600	407.65	0.3610
315.68	0.9450	372.09	0.4990	420.62	0.3230

Suggested Equation = 3 Constants: A = -4.8990 B = -597.55 C = -2.4824
% AAD = 0.7 S.D. = 8.30 x 10^{-6} Temperature Range: 270-430

2-Nitro-2-butene

CAS RN: 4812-23-1, Source of Data: Reference 52

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
303.15	0.812	313.15	0.719	333.15	0.585

Suggested Equation = 1 Constants: A = -4.6679 B = 477.91 C = 0.00
% AAD = 0.3 S.D. = 1.90 x 10^{-6} Temperature Range: 300-340

2-Nitro-2-heptene

CAS RN: 6065-14-1, Source of Data: Reference 52

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15	1.336	313.15	1.147	333.15	0.888

Suggested Equation = 1 Constants: A = -4.8386 B = 595.07 C = 0.00
% AAD = 0.4 S.D. = 4.20 x 10^{-6} Temperature Range: 300-340

2-Nitro-2-hexene

CAS RN: 6065-17-4, Source of Data: Reference 52

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15	1.144	313.15	0.993	333.15	0.780

Suggested Equation = 1 Constants: A = -4.7845 B = 558.37 C = 0.00
% AAD = 0.3 S.D. = 2.70 x 10^{-6} Temperature Range: 300-340

2-Nitro-2-nonene

CAS RN: 4812-25-3, Source of Data: Reference 52

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15	2.019	313.15	1.683	333.15	1.241

Suggested Equation = 1 Constants: A = -5.0352 B = 708.95 C = 0.00
% AAD = 0.4 S.D. = 7.70 x 10^{-6} Temperature Range: 300-340

2-Nitro-2-octene

CAS RN: 6065-11-8, Source of Data: Reference 52

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15	1.680	313.15	1.419	333.15	

Suggested Equation = 1 Constants: A = -4.9726 B = 665.91 C = 0.00
% AAD = 0.3 S.D. = 4.70 x 10^{-6} Temperature Range: 300-340

2-Nitro-2-pentene

CAS RN: 6065-19-6, Source of Data: Reference 52

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15	0.871	313.15	0.768	333.15	0.619

Suggested Equation = 1 Constants: A = -4.7037 B = 498.04 C = 0.00
% AAD = 0.2 S.D. = 1.70 x 10^{-6} Temperature Range: 300-340

2-Nitrophenol

CAS RN: 88-75-5, Source of Data: Reference 53, 10

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15[53]	3.721	328.15	2.072	382.15[10]	0.9400
308.15	3.285	330.15	2.008	393.15	0.8340
310.15	3.116	333.15	1.895	409.15	0.7080
313.15	2.899	335.15	1.847	423.15	0.6230
315.15	2.776	338.15	1.724	433.65	0.5675
318.15	2.586	340.15	1.658	458.15	0.4646
320.15	2.487	343.15	1.596	473.15	0.4159
323.15	2.312	345.15	1.535	488.15	0.3740
325.15	2.207	348.15	1.456		

Suggested Equation = 3 Constants: A = -4.3361 B = -328.93 C = 129.92
% AAD = 1.2 S.D. = 2.50 x 10^{-5} Temperature Range: 300-490

2-Nitrophenyl methyl ether

CAS RN: 91-23-6, Source of Data: Reference 10

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
286.40	7.4900	412.85	0.7745	498.15	0.3829
323.75	2.661	423.15	0.7000	508.15	0.3585
353.45	1.579	428.25	0.6674	523.15	0.3258
382.45	1.073	443.15	0.5821	538.15	0.2981
393.15	0.9504	458.25	0.5152		
397.15	0.9115	482.15	0.4315		

Suggested Equation = 3 Constants: A = -4.4960 B = -422.07 C = 106.85

% AAD = 1.8 S.D. = 9.40 x 10^{-5} Temperature Range: 280-520

2-Nitroresorcinol

CAS RN: 601-89-8, Source of Data: Reference 13

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
369.85	2.131	423.25	0.9581	453.65	0.6952
392.75	1.4400	432.85	0.8604	505.15	0.4415
412.90	1.0970	443.15	0.7708		

Suggested Equation = 3 Constants: A = -4.5642 B = -455.67 C = 128.78

% AAD = 0.5 S.D. = 6.90 x 10^{-6} Temperature Range: 360-510

2-Nitrotoluene

CAS RN: 88-72-2, Source of Data: Reference 39, 10

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
273.15[39]	3.8344	353.15	0.9401	412.65	0.5201
283.15	2.9560	273.15	0.7584	423.15	0.4780
293.15	2.3669	292.85[10]	2.359	433.65	0.4404
303.15	1.9440	334.15	1.174	453.95	0.3818
313.15	1.6318	373.75	0.7417	464.05	0.3565
333.15	1.2080	393.15	0.6170	494.65	0.2944

Suggested Equation = 3 Constants: A = -4.4923 B = -404.73 C = 76.683

% AAD = 1.1 S.D. = 3.50 x 10^{-5} Temperature Range: 270-500

2-Nonanethiol

CAS RN: 13281-11-3, Source of Data: Reference 25

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
273.15	2.2336	303.15	1.2478	353.15	0.6445
283.15	1.7976	313.15	1.0689	373.15	0.5252
293.15	1.4817	333.15	0.8156	393.15	0.4350

Suggested Equation = 3 Constants: A = -4.4906 B = -353.75 C = 80.523

% AAD = 0.5 S.D. = 6.80 x 10^{-6} Temperature Range: 270-400

2-Octanethiol

CAS RN: 3001-66-9, Source of Data: Reference 25

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
273.15	1.6559	303.15	0.9867	353.15	0.5380
283.15	1.3665	323.15	0.8577	373.15	0.4471
293.15	1.1510	333.15	0.6684		

Suggested Equation = 3 Constants: A = -4.4502 B = -323.68 C = 79.120

% AAD = 0.2 S.D. = 2.00 x 10^{-6} Temperature Range: 270-380

2-Pentanethiol

CAS RN: 2084-19-7, Source of Data: Reference 25

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.17	0.7010	303.15	0.4891	353.15	0.3043
283.15	0.6156	313.15	0.4426	373.15	0.2597
293.15	0.5443	333.15	0.3628		

Suggested Equation = 3 Constants: A = -4.9446 B = -565.81 C = -43.074

% AAD = 0.2 S.D. = 1.50 x 10^{-6} Temperature Range: 270-380

2-Pentanol

CAS RN: 6032-29-7, Source of Data: Reference 29

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.55	3.3900	333.15	1.0930	372.65	0.460
306.75	2.4860	347.65	0.7720	386.45	0.3742
323.15	1.4520	361.95	0.5700		

Suggested Equation = 3 Constants: A = -4.9433 B = -343.89 C = 159.69

% AAD = 0.3 S.D. = 8.50 x 10^{-6} Temperature Range: 290-390

2-Pentanone

CAS RN: 107-87-9, Source of Data: Reference 4, 26

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.53[4]	0.6404	327.09	0.3525	293.15[26]	0.489
282.55	0.5692	335.39	0.3262	303.15	0.438
291.45	0.5109	345.89	0.2980	313.15	0.394
300.92	0.4592	353.79	0.2787	323.15	0.357
308.58	0.4234	363.21	0.2574	333.15	0.324
318.44	0.3831	371.92	0.2400	353.15	0.271

Suggested Equation = 1 Constants: A = -4.7986 B = 438.45 C = 0.00

% AAD = 1.1 S.D. = 4.50 x 10^{-6} Temperature Range: 270-380

2-Pentene

CAS RN: 109-68-2, Source of Data: Reference 26

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15	0.2140	303.15	0.1890	308.15	0.1800
298.10	0.2010				

Suggested Equation = 3 Constants: A = -4.0663 B = -25.287 C = 229.50

% AAD = 0.2 S.D. = 3.30 x 10^{-7} Temperature Range: 290-310

2-Phenyl-1-propanol

CAS RN: 1123-85-9, Source of Data: Reference 54

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	15.6006	313.15	7.4074	328.15	5.2110
303.15	11.7649				

Suggested Equation = 3 Constants: A = -2.7359 B = -26.229 C = 270.16

% AAD = 1.4 S.D. = 2.10E-04 Temperature Range: 290-330

2-Picoline

CAS RN: 109-06-8, Source of Data: Reference 55

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.50	1.0970	303.15	0.7096	333.15	0.5054
283.15	0.9351	313.15	0.6296	343.15	0.4585
293.15	0.8102	323.15	0.5621	353.15	0.4165

Suggested Equation = 3 Constants: A = -4.6362 B = -402.11 C = 33.102

% AAD = 0.2 S.D. = 1.90 x 10^{-6} Temperature Range: 270-360

2-Picoline N-oxide

CAS RN: 931-19-1, Source of Data: Reference 36

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
323.15	3.7920	373.15	1.4830	398.15	1.0740
348.15	2.2280				

Suggested Equation = 3 Constants: A = -4.1864 B = -294.26 C = 156.24

% AAD = 0.1 S.D. = 2.20 x 10^{-6} Temperature Range: 320-400

2-p-Propyl phenyl-2-p-tolylbutane

Source of Data: Reference 5

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
323.15	9.36	422.95	0.913	473.15	0.556

Suggested Equation = 3 Constants: A = -4.1543 B = -233.70 C = 213.2

% AAD = 0.1 S.D. = 8.00 x 10^{-7} Temperature Range: 320-480

2-Propanamine

CAS RN: 75-31-0, Source of Data: Reference 31

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
283.15	0.3860	293.15	0.3440	303.15	0.3020

Suggested Equation = 1 Constants: A = -5.0248 B = 456.33 C = 0.00

% AAD = 0.4 S.D. = 2.00 x 10^{-6} Temperature Range: 280-310

2-Propanethiol

CAS RN: 75-33-2, Source of Data: Reference 25

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
272.97	0.4779	293.15	0.3768	313.15	0.3070
283.15	0.4217	303.15	0.3392		

Suggested Equation = 3 Constants: A = -4.7800 B = -387.13 C = 7.6593

% AAD = 0.1 S.D. = 1.80 x 10^{-6} Temperature Range: 270-320

2-Propanol

CAS RN: 67-63-0, Source of Data: Reference 4, 27, 211, 205, 212, 187

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.51 [4]	4.5018	332.54	0.8157	293.15[212]	2.2920
280.36	3.5568	339.75	0.6923	298.15	2.0150
287.56	2.8157	345.17	0.6141	303.15	1.7970
295.37	2.2204	351.24	0.5407	308.15	1.5070
303.70	1.7275	288.15 [27]	2.8590	298.15[187]	1.936
311.07	1.4053	303.15	1.7650	303.15	1.731
318.30	1.1604	298.15[211]	2.0980	308.15	1.494
325.12	0.9770	303.15[205]	1.7620	313.15	1.287

Suggested Equation = 3 Constants: A = -3.17 B = -9.31 x 10^{2} C = 3.00x 10^{1}

%AAD = 1.240898 SD = 1.45 x 10^{-3} Temperature Range: 270-360

2-Propyl tridecanol

CAS RN: Source of Data: Reference 38

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15	35.8166	313.15	14.0667	353.15	3.5398
303.15	21.8627	333.15	6.5703	373.15	2.1589

Suggested Equation = 3 Constants: A = -5.0182 B = -549.04 C = 139.57

% AAD = 0.5 S.D. = 1.10E-04 Temperature Range: 290-380

2-Propyl tridecyl acetate

Source of Data: Reference 38

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	15.8604	313.15	3.9620	353.15	1.7409
293.15	7.1582	333.15	2.5088	373.15	1.2977
303.15	5.2138				

Suggested Equation = 3 Constants: A = -4.1444 B = -271.06 C = 157.55

% AAD = 0.1 S.D. = 2.80 x 10^{-6} Temperature Range: 270-380

2-Undecanone

CAS RN: 112-12-9, Source of Data: Reference 26

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15	2.0650	323.15	1.1950	373.15	0.6280
303.15	1.6890	333.15	1.0300	393.15	0.5160
313.15	1.4150	353.15	0.7900	413.15	0.4300

Suggested Equation = 3 Constants: A = -4.5021 B = -364.95 C = 92.28

% AAD = 0.2 S.D. = 2.10 x 10^{-6} Temperature Range: 290-420

3,3,3-Trifluoroethanol

CAS RN: 28606-06-6, Source of Data: Reference 2

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15	1.9950	313.15	1.2160	333.15	0.7960
303.15	1.5430				

Suggested Equation = 3 Constants: A = -5.6152 B = -735.51 C = 40.809

% AAD = 0.1 S.D. = 2.00 x 10^{-6} Temperature Range: 290-340

3-Bromoaniline

CAS RN: 591-19-5, Source of Data: Reference 39

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	6.8074	313.15	3.6955	353.15	1.6955
303.15	4.9044	333.15	2.3844	373.15	1.3080

Suggested Equation = 3 Constants: A = -3.8310 B = -175.81 C = 187.53

% AAD = 0.2 S.D. = 7.30 x 10^{-6} Temperature Range: 290-380

3-Bromotoluene

CAS RN: 591-17-3, Source of Data: Reference 39

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	1.7289	303.15	1.0830	353.15	0.6298
283.15	1.4529	313.15	0.9546	373.15	0.5313
293.15	1.2447	333.15	0.7641		

Suggested Equation = 3 Constants: A = -4.1955 B = -258.83 C = 92.69

% AAD = 0.3 S.D. = 3.00 x 10^{-6} Temperature Range: 270-380

3-Butyl-2-oxazolidone

CAS RN: 23288-01-9, Source of Data: Reference 56

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
278.15	9.0942	308.15	3.8099	328.15	2.4768
288.15	6.5645	318.15	3.0344	338.15	2.0654
298.15	4.9203				

Suggested Equation = 3 Constants: A = -4.2198 B = -311.24 C = 135.32

% AAD = 0.1 S.D. = 5.40 x 10^{-6} Temperature Range: 270-340

3-Chloronitrobenzene

CAS RN: 121-73-3, Source of Data: Reference 12

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
383.15	0.8800	388.15	0.8370	393.15	0.8010

Suggested Equation = 1 Constants: A = -4.6623 B = 615.49 C = 0.00

% AAD = 0.1 S.D. = 9.70 x 10^{-7} Temperature Range: 380-395

3-Chlorophenol

CAS RN: 108-43-0, Source of Data: Reference 57

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	16.6667	313.15	5.5556	333.15	3.0211
303.15	8.8496	318.15	5.0570		

Suggested Equation = 3 Constants: A = -3.4776 B = -89.57 C = 240.53

% AAD = 2.6 S.D. = 1.70E-04 Temperature Range: 290-340

3-Chlorotoluene

CAS RN: 108-41-8, Source of Data: Reference 10, 39

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
308.55[10]	0.8564	408.15	0.3348	293.15	1.0225
330.25	0.6597	419.05	0.3114	303.15	0.8928
348.85	0.5465	426.25	0.2970	313.15	0.7893
368.05	0.4567	432.15	0.2861	333.15	0.6338
387.45	0.3912	273.15[39]	1.4029	353.15	0.5222
393.15	0.3743	283.15	1.1885	373.15	0.3920
398.15	0.3606				

Suggested Equation = 3 Constants: A = -4.5776 B = -405.97 C = 26.217

% AAD = 0.7 S.D. = 1.10E-04 Temperature Range: 270-440

3-Cyanopyridine

CAS RN: 100-54-9, Source of Data: Reference 41

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
323.15	1.7310	348.15	1.1770	398.15	0.6650
333.15	1.4630	373.15	0.8610		

Suggested Equation = 3 Constants: A = -4.2055 B = -268.49 C = 137.40

% AAD = 0.4 S.D. = 4.60 x 10^{-6} Temperature Range: 320-400

3-Ethoxy benzenamine

CAS RN: 621-33-0, Source of Data: Reference 39

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15	12.9232	333.15	3.7979	373.15	1.4981
313.15	7.9302	353.15	2.2356		

Suggested Equation = 3 Constants: A = -4.0694 B = 203.07 C = 210.01

% AAD = 0.1 S.D. = 5.60 x 10^{-6} Temperature Range: 300-380

3-Ethoxytoluene

CAS RN: 621-32-9, Source of Data: Reference 10

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
291.45	1.2710	363.05	0.4892	412.95	0.3156
312.55	0.8940	373.05	0.4446	423.25	0.2931
318.15	0.8250	383.25	0.4039	431.15	0.2743
333.15	0.6765	393.15	0.3707	440.15	0.2606
352.95	0.5426	403.35	0.3414	448.65	0.2460

Suggested Equation = 3 Constants: A = -4.6888 B = -429.81 C = 51.00

% AAD = 0.5 S.D. = 5.20 x 10^{-6} Temperature Range: 290-450

3-Ethyl-2-oxazolidionone

CAS RN: 5261-18-7, Source of Data: Reference 56

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
278.15	4.3691	308.15	2.3283	338.15	1.4645
288.15	3.4622	318.15	1.9646		
298.15	2.8099	328.15	1.6843		

Suggested Equation = 3 Constants: A = -4.1644 B = -303.21 C = 110.17

% AAD = 0.1 S.D. = 1.10 x 10^{-6} Temperature Range: 270-340

3-Fluoroaniline

CAS RN: 372-19-0, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	2.4750	313.15	1.7500	333.15	1.2500
303.15	2.2000	323.15	1.4800		

Suggested Equation = 3 Constants: A = -3.7425 B = -113.06 C = 198.67
% AAD = 0.6 S.D. = 9.90 x 10^{-6} Temperature Range: 290-340

3-Fluorophenetole

CAS RN: 459-26-7, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
292.15	1.314	313.18	0.930	323.15	0.804
303.25	1.090	318.10	0.860	333.15	0.730

Suggested Equation = 3 Constants: A = -3.6435 B = -59.589 C = 215.27
% AAD = 0.6 S.D. = 6.80 x 10^{-6} Temperature Range: 290-340

3-Fluorotoluene

CAS RN: 352-70-5, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	0.6080	313.15	0.4810	333.15	0.3955
303.15	0.5340	323.15	0.4537		

Suggested Equation = 1 Constants: A = -4.6993 B = 434.02 C = 0.00
% AAD = 1.4 S.D. = 7.60 x 10^{-6} Temperature Range: 290-340

3-Heptanol

CAS RN: 589-82-2, Source of Data: Reference 29

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
311.55	2.986	359.65	0.760	404.45	0.3601
327.05	1.688	371.55	0.600	418.25	0.3026
346.65	1.024	390.25	0.4404		

Suggested Equation = 3 Constants: A = -4.7334 B = -288.89 C = 180.49
% AAD = 0.7 S.D. = 1.80 x 10^{-6} Temperature Range: 310-420

3-Hydroxy acetophenone

CAS RN: 121-71-1, Source of Data: Reference 10

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
375.15	5.8140	452.45	1.2540	504.15	0.7000
402.85	2.9160	472.35	0.9783	518.35	0.6155
423.15	2.0000	488.15	0.8194	569.15	0.4087
433.15	1.6690				

Suggested Equation = 3 Constants: A = -4.4802 B = -415.71 C = 189.61
% AAD = 0.7 S.D. = 2.00 x 10^{-5} Temperature Range: 370-570

3-Isopropyl-2-oxazolidinone

CAS RN: 40482-44-8, Source of Data: Reference 56

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
278.15	6.0966	308.15	2.9264	328.15	2.0146
288.15	4.6430	318.15	2.4049	338.15	1.7164
298.15	3.6400				

Suggested Equation = 3 Constants: A = -4.2344 B = -323.09 C = 118.18

% AAD = 0.1 S.D. = 2.00 x 10^{-6} Temperature Range: 270-340

3-Isopropylsydnone

CAS RN: 6939-17-9, Source of Data: Reference 58

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
333.15	3.8640	373.15	1.9130	398.15	1.3790
348.15	2.8790				

Suggested Equation = 3 Constants: A = -4.1797 B = -338.42 C = 141.61

% AAD = 0.1 S.D. = 1.50 x 10^{-6} Temperature Range: 330-400

3-Methoxyphenol

CAS RN: 150-19-6, Source of Data: Reference 13

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
329.20	7.5870	412.65	1.0890	482.35	0.4856
353.35	3.4770	432.75	0.8239	493.25	0.4390
373.05	2.1770	452.95	0.6506	503.15	0.4024
393.15	1.4760	468.15	0.5562	518.35	0.3546

Suggested Equation = 3 Constants: A = -4.5348 B = -377.59 C = 172.18

% AAD = 1.1 S.D. = 5.60 x 10^{-5} Temperature Range: 325-520

3-Methyl-1-butanol (optically inactive)

CAS RN: 123-51-3, Source of Data: Reference 4, 30, 205

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.39[4]	8.4610	355.02	0.8888	243.15	33.0
285.06	5.6249	368.09	0.6872	253.15	20.7
296.98	3.8633	377.72	0.5795	263.15	13.0
307.40	2.8303	390.75	0.4654	273.15	8.8
320.81	1.9654	401.25	0.3974	283.15	6.1
331.89	1.4847	223.15[30]	101	293.15	4.4
344.20	1.1210	233.15	58.0	303.15[205]	2.9610

Suggested Equation = 3 Constants: A = -2.71 B = -8.03 x 10^{2} C = 5.34x 10^{1}

%AAD = 1.232313 SD = 1.51 x 10^{-3} Temperature Range: 270-410

3-Methyl-1-heptanol

CAS RN: 99427-18-6, Source of Data: Reference 44

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.19	3.5613	303.15	1.6672	353.15	0.6919
283.15	2.6822	313.15	1.3577	373.62	0.5235
293.15	2.0881	333.15	0.9459		

Suggested Equation = 3 Constants: A = -4.8480 B = -455.08 C = 83.39

% AAD = 0.3 S.D. = 7.80 x 10^{-6} Temperature Range: 270-380

3-Methyl-2-butanol

CAS RN: 598-75-4, Source of Data: Reference 29

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
291.35	5.3580	332.55	1.1910	372.35	0.5016
303.95	3.0660	349.65	0.7870	379.95	0.4364
320.65	1.6760	359.65	0.6360		

Suggested Equation = 3 Constants: A = -4.8491 B = -313.81 C = 169.58

% AAD = 0.4 S.D. = 7.40 x 10^{-6} Temperature Range: 290-380

3-Methyl-2-heptanol

CAS RN: 31367-46-1, Source of Data: Reference 44

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.20	3.0867	303.15	1.4136	353.15	0.5937
283.15	2.3569	313.15	1.1490	373.15	0.4581
293.15	1.7805	333.15	0.8029		

Suggested Equation = 3 Constants: A = -4.6390 B = -334.29 C = 116.43

% AAD = 0.5 S.D. = 1.60 x 10^{-5} Temperature Range: 270-380

3-Methyl-2-oxazolidinone

CAS RN: 19836-78-3, Source of Data: Reference 56

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
278.15	3.6766	308.15	2.0934	338.15	1.3661
288.15	2.9911	318.15	1.7928		
298.15	2.4811	328.15	1.5558		

Suggested Equation = 3 Constants: A = -4.5133 B = -469.69 C = 52.13

% AAD = 0.4 S.D. = 7.60 x 10^{-6} Temperature Range: 270-340

3-Methyl-3-heptanol

CAS RN: 5582-82-1, Source of Data: Reference 44

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.23	19.7316	303.15	3.8917	353.15	0.8290
283.15	10.6056	313.15	2.6056	373.54	0.5658
293.15	6.1831	333.15	1.3563		

Suggested Equation = 3 Constants: A = -4.7910 B = -307.09 C = 173.98

% AAD = 1.0 S.D. = 1.30E-04 Temperature Range: 270-380

3-Methyl-4-heptanol

CAS RN: 1838-73-9, Source of Data: Reference 44

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.20	4.1958	303.15	1.6731	353.15	0.6238
283.15	2.9689	313.15	1.3153	373.12	0.4742
293.15	2.1933	333.15	0.8784		

Suggested Equation = 3 Constants: A = -4.6737 B = -326.66 C = 130.98

% AAD = 0.2 S.D. = 2.40 x 10^{-6} Temperature Range: 270-380

3-Methyl-5-heptanol

CAS RN: 18720-65-5, Source of Data: Reference 44

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.19	2.0599	303.15	1.0693	353.15	0.5046
283.15	1.6124	313.15	0.8954	373.20	0.4002
293.15	1.2997	333.15	0.6584		

Suggested Equation = 3 Constants: A = -4.6993 B = -369.64 C = 89.383

% AAD = 0.2 S.D. = 3.50 x 10^{-6} Temperature Range: 270-380

3-Methyl-6-heptanol

CAS RN: 54630-50-1, Source of Data: Reference 44

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.20	4.6551	303.15	1.9318	353.15	0.7178
283.15	3.3593	313.15	1.5244	373.50	0.5221
293.15	2.5088	333.15	1.0168		

Suggested Equation = 3 Constants: A = -4.9235 B = -451.64 C = 98.852

% AAD = 0.50 S.D. = 7.00 x 10^{-6} Temperature Range: 270-380

3-Methyl-7-heptanol

CAS RN: 57803-73-3, Source of Data: Reference 44

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.32	13.7608	303.15	4.3783	353.15	1.2164
283.15	9.0375	313.15	3.2206	373.22	0.8334
293.15	6.2004	333.15	1.8950		

Suggested Equation = 3 Constants: A = -5.0466 B = -513.98 C = 111.97

% AAD = 0.1 S.D. = 4.20 x 10^{-6} Temperature Range: 270-380

3-Methyl pentane

CAS RN: 96-14-0, Source of Data: Reference 32

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	0.3940	288.15	0.3390	298.15	0.3070
283.15	0.3566	293.15	0.3229	303.15	0.2920

Suggested Equation = 1 Constants: A = -4.7141 B = 357.91 C = 0.00

% AAD = 0.4 S.D. = 1.30 x 10^{-6} Temperature Range: 270-310

3-Methyl sulfolane

CAS RN: 872-93-5, Source of Data: Reference 36

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	11.8100	323.15	5.8820	398.15	1.6250
303.15	10.0900	348.15	3.4880		
313.15	7.5960	373.15	2.2890		

Suggested Equation = 3 Constants: A = -4.2086 B = -376.51 C = 132.99

% AAD = 2.0 S.D. = 1.70 x 10^{-5} Temperature Range: 290-400

3-Methyl sydnone

CAS RN: 6939-12-4, Source of Data: Reference 58

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
313.15	5.5010	333.15	3.5460	373.15	1.8900
323.15	4.3670	348.15	2.7310	398.15	1.4130

Suggested Equation = 3 Constants: A = -3.9503 B = -268.63 C = 154.26

% AAD = 0.2 S.D. = 7.00 x 10^{-6} Temperature Range: 310-400

3-Methyl benzenamine

CAS RN: 108-44-1, Source of Data: Reference 42, 59

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
373.85[42]	0.7430	437.05	0.3904	471.85	0.2955
399.65	0.5580	448.85	0.3538	273.15[59]	8.6580
412.35	0.4900	460.15	0.3232	293.15	3.8052
424.45	0.4366	465.95	0.3088	353.15	1.0041

Suggested Equation = 3 Constants: A = -4.4494 B = -301.95 C = 145.82

% AAD = 1.6 S.D. = 1.00E-04 Temperature Range: 270-480

3-Methyl benzonitrile

CAS RN: 620-22-4, Source of Data: Reference 26

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	1.653	323.15	0.999	373.15	0.564
303.15	1.370	333.15	0.873	393.15	0.468
313.15	1.160	353.15	0.691	413.15	0.399

Suggested Equation = 3 Constants: A = -4.4080 B = -321.16 C = 95.332

% AAD = 0.4 S.D. = 4.80 x 10^{-6} Temperature Range: 290-420

3-Methyl cyclohexanol

CAS RN: 591-23-1, Source of Data: Reference 49, 50

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
312.25[49]	9.6760	363.15	1.5678	293.15[50]	22.7998
339.05	3.2040				

Suggested Equation = 3 Constants: A = -5.9247 B = -797.76 C = 107.35

% AAD = 2.4 S.D. = 3.50E-04 Temperature Range: 290-370

3-Methyl cyclohexanone

CAS RN: 591-24-2, Source of Data: Reference 49, 51

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
290.45[49]	1.8386	339.05	0.8570	303.15	1.5120
312.25	1.2261	288.15[51]	1.9990		

Suggested Equation = 3 Constants: A = -3.7405 B = -97.894 C = 197.36

% AAD = 1.9 S.D. = 4.00 x 10^{-5} Temperature Range: 280-340

3-Methyl hexane

CAS RN: 589-34-4, Source of Data: Reference 60

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15 (1)	0.3720	288.15 (2)	0.3860	303.15	0.3290

Suggested Equation = 1 Constants: A = -4.8727 B = 422.23 C = 0.00

% AAD = 1.3 S.D. = 5.40 x 10^{-6} Temperature Range: 280-310

3-Nitro-2-heptene

CAS RN: 6065-13-0, Source of Data: Reference 52

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	1.355	313.15	1.154	333.15	0.877

Suggested Equation = 1 Constants: A = -4.9617 B = 634.33 C = 0.00

% AAD = 0.3 S.D. = 3.50 x 10^{-6} Temperature Range: 300-340

3-Nitro-2-hexene

CAS RN: 6065-16-3, Source of Data: Reference 52

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	1.097	313.15	0.943	333.15	0.737

Suggested Equation = 1 Constants: A = -4.8706 B = 578.71 C = 0.00

% AAD = 0.5 S.D. = 4.60 x 10^{-6} Temperature Range: 300-340

3-Nitro-2-nonene

CAS RN: 6065-05-0, Source of Data: Reference 52

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	2.038	313.15	1.680	333.15	1.215

Suggested Equation = 1 Constants: A = -5.1782 B = 753.52 C = 0.00

% AAD = 0.4 S.D. = 8.00 x 10^{-6} Temperature Range: 300-340

3-Nitro-2-octene

CAS RN: 6065-10-7, Source of Data: Reference 52

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	1.673	313.15	1.402	333.15	1.040

Suggested Equation = 1 Constants: A = -5.0634 B = 692.81 C = 0.00

% AAD = 0.4 S.D. = 5.50 x 10^{-6} Temperature Range: 300-340

3-Nitro-2-pentene

CAS RN: 6065-18-5, Source of Data: Reference 52

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	0.925	313.15	0.810	333.15	0.646

Suggested Equation = 1 Constants: A = -4.7613 B = 523.36 C = 0.00

% AAD = 0.3 S.D. = 2.10 x 10^{-6} Temperature Range: 300-340

3-Nitro-3-heptene

CAS RN: 6187-24-2, Source of Data: Reference 52

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	1.292	313.15	1.107	333.15	0.849

Suggested Equation = 1 Constants: A = -4.9097 B = 612.34 C = 0.00

% AAD = 0.3 S.D. = 3.00 x 10^{-6} Temperature Range: 300-340

3-Nitro-3-hexene

CAS RN: 4812-22-0, Source of Data: Reference 52

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	0.996	313.15	0.869	333.15	0.690

Suggested Equation = 1 Constants: A = -4.7675 B = 534.93 C = 0.00

% AAD = 0.3 S.D. = 2.60 x 10^{-6} Temperature Range: 300-340

3-Nitro-3-nonene

CAS RN: 6065-04-9, Source of Data: Reference 52

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
303.15	1.915	313.15	1.595	333.15	1.168

Suggested Equation = 1 Constants: A = -5.0969 B = 720.80 C = 0.00

% AAD = 0.3 S.D. = 5.80 x 10^{-6} Temperature Range: 300-340

3-Nitro-3-octene

CAS RN: 6065-09-4, Source of Data: Reference 52

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
303.15	1.536	313.15	1.301	333.15	0.984

Suggested Equation = 1 Constants: A = -4.9554 B = 648.82 C = 0.00

% AAD = 0.4 S.D. = 5.10 x 10^{-6} Temperature Range: 300-340

3-Nitrophenol

CAS RN: 554-84-7, Source of Data: Reference 53

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
363.15	4.139	373.15	3.261	383.15	2.667
365.15	3.988	375.15	3.137	388.15	2.428
367.15	3.730	377.15	3.006	393.15	2.206
369.15	3.581	379.15	2.872	398.15	2.017
371.15	3.423	381.15	2.761		

Suggested Equation = 3 Constants: A = -3.9333 B = -216.26 C = 223.80

% AAD = 0.4 S.D. = 1.60 x 10^{-5} Temperature Range: 360-400

3-Nitrotoluene

CAS RN: 99-08-1, Source of Data: Reference 39

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
293.15	2.3326	313.15	1.5972	353.15	0.9212
303.15	1.9066	333.15	1.1818	273.15	0.7462

Suggested Equation = 3 Constants: A = -4.1521 B = -252.23 C = 127.13

% AAD = 0.1 S.D. = 2.00 x 10^{-6} Temperature Range: 290-380

3-n-Propyl-4-methylsydnone

CAS RN: 18358-66-2, Source of Data: Reference 58

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
298.15	14.7	313.15	9.3		

Suggested Equation = 1 Constants: A = -5.9837 B = 1237.6 C = 0.00

% AAD = 0.1 S.D. = 1.30E-09 Temperature Range: 290-320

3-Pentanol

CAS RN: 584-02-1, Source of Data: Reference 25

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
293.25	5.3420	320.35	1.6240	352.65	0.6530
302.95	3.2970	328.25	1.2420	361.55	0.5420
310.05	2.4280	344.25	0.7990	382.15	0.3750

Suggested Equation = 3 Constants: A = -4.7586 B = -254.46 C = 191.08

% AAD = 0.5 S.D. = 2.00 x 10^{-5} Temperature Range: 290-390

3-Pentanone

CAS RN: 96-22-0, Source of Data: Reference 4, 61

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.61[4]	0.5914	317.85	0.3623	364.12	0.2426
282.25	0.5302	326.59	0.3339	371.97	0.2279
291.85	0.4748	335.58	0.3079	288.15[61]	0.4930
300.22	0.4328	345.35	0.2834	313.15	0.4230
309.36	0.3939	354.62	0.2623		

Suggested Equation = 3 Constants: A = -5.0685 B = -628.20 C = -68.044
% AAD = 0.3 S.D. = 1.30 x 10^{-6} Temperature Range: 270-380

3-Picoline N-oxide

CAS RN: 1003-73-2, Source of Data: Reference 36

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
318.15	5.9750	348.15	2.7940	398.15	1.2640
323.15	5.1330	373.15	1.7850		

Suggested Equation = 3 Constants: A = -4.0257 B = -241.12 C = 184.32
% AAD = 0.1 S.D. = 4.50 x 10^{-6} Temperature Range: 310-400

3-tert-Butyl-2-oxazolidinone

CAS RN: 40482-46-0, Source of Data: Reference 56

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
278.15	10.5910	308.15	4.3141	338.15	2.2712
288.15	7.5759	318.15	3.4026		
298.15	5.6254	328.15	2.7503		

Suggested Equation = 3 Constants: A = -4.3212 B = -352.73 C = 127.83
% AAD = 0.1 S.D. = 5.30 x 10^{-6} Temperature Range: 270-340

4,4-Dimethyl-2-oxazolidinone

CAS RN: 26654-39-7, Source of Data: Reference 56

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
278.15	491.340	308.15	52.279	338.15	12.382
288.15	207.850	318.15	30.106		
298.15	99.066	328.15	18.691		

Suggested Equation = 3 Constants: A = -4.8411 B = -497.42 C = 168.44
% AAD = 0.5 S.D. = 7.80E-02 Temperature Range: 275-340

4-Bromoaniline

CAS RN: 106-40-1, Source of Data: Reference 39

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
343.15	2.1277	353.15	1.8146	373.15	1.3818

Suggested Equation = 1 Constants: A = -4.9978 B = 797.61 C = 0.00
% AAD = 0.3 S.D. = 6.20 x 10^{-6} Temperature Range: 340-380

4-Bromotoluene

CAS RN: 106-38-7, Source of Data: Reference 39

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	1.0950	333.15	0.7680	373.15	0.5310
313.15	0.9440	353.15	0.6300		

Suggested Equation = 1 Constants: A = -4.6202 B = 501.53 C = 0.00

% AAD = 0.6 S.D. = 8.60 x 10^{-6} Temperature Range: 300-380

4-Chloroaniline

CAS RN: 106-47-8, Source of Data: Reference 42, 35

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
365.15[42]	1.1870	444.65	0.5249	485.15	0.3864
385.15	0.9290	454.65	0.4834	503.15	0.3420
404.95	0.7550	465.15	0.4467	383.15[35]	0.8960
425.05	0.6220	474.15	0.4174	388.15	0.8440
435.25	0.5682	483.15	0.3910	393.15	0.8050

Suggested Equation = 1 Constants: A = -4.8395 B = 692.19 C = 0.00

% AAD = 1.6 S.D. = 1.80 x 10^{-5} Temperature Range: 360-510

4-Chlorobromobenzene

CAS RN: 106-39-8, Source of Data: Reference 12

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
383.15	0.5890	388.15	0.5830	393.15	0.5780

Suggested Equation = 1 Constants: A = -3.5520 B = 123.37 C = 0.00

% AAD = 0.1 S.D. = 1.90 x 10^{-7} Temperature Range: 380-395

4-Chloroiodobenzene

CAS RN: 637-87-6, Source of Data: Reference 12

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
383.15	0.6400	388.15	0.6160	393.15	0.5910

Suggested Equation = 1 Constants: A = -4.5532 B = 520.97 C = 0.00

% AAD = 0.1 S.D. = 6.20 x 10^{-7} Temperature Range: 380-395

4-Chlorophenol

CAS RN: 106-48-9, Source of Data: Reference 10

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
371.85	1.5000	423.65	0.7345	460.10	0.5072
389.95	1.1270	435.25	0.6486	473.25	0.4508
398.65	0.9956	447.15	0.5730	483.15	0.4131
410.35	0.8560	448.65	0.5662	491.15	0.3868

Suggested Equation = 3 Constants: A = -4.7219 B = -507.99 C = 103.79

% AAD = 0.4 S.D. = 4.20 x 10^{-6} Temperature Range: 370-500

4-Chlorotoluene

CAS RN: 106-43-4, Source of Data: Reference 10, 39

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
305.45[10]	0.7590	398.25	0.3242	293.15	0.8925
327.55	0.5820	408.15	0.3043	303.15	0.7843
348.85	0.4753	418.65	0.2845	313.15	0.6976
367.95	0.4046	425.25	0.2733	333.15	0.5642
388.05	0.3483	434.85	0.2587	353.15	0.4686
393.15	0.3361	283.15[39]	1.0322	373.15	0.3975

Suggested Equation = 3 Constants: A = -4.5492 B = -380.43 C = 39.66

% AAD = 0.6 S.D. = 4.00 x 10^{-6} Temperature Range: 280-440

4-Cyanopyridine

CAS RN: 100-48-1, Source of Data: Reference 41

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
353.15	0.9770	373.15	0.7700	398.15	0.5980
363.15	0.8600	383.15	0.6940		

Suggested Equation = 1 Constants: A = -4.8871 B = 662.18 C = 0.00

% AAD = 0.3 S.D. = 2.70 x 10^{-6} Temperature Range: 350-400

4-Ethoxy benzenamine

CAS RN: 156-43-4, Source of Data: Reference 39

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	12.9016	313.15	5.6117	353.15	1.9417
303.15	8.2988	333.15	3.0618	373.15	1.3676

Suggested Equation = 3 Constants: A = -4.1091 B = -226.14 C = 191.43

% AAD = 0.4 S.D. = 5.20 x 10^{-5} Temperature Range: 290-380

4-Ethoxy toluene

CAS RN: 622-60-6, Source of Data: Reference 10

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
289.90	1.3590	358.85	0.5304	408.15	0.3323
308.75	0.9830	367.85	0.4812	417.65	0.3083
318.15	0.8640	378.15	0.4355	428.75	0.2834
328.75	0.7510	387.75	0.3972	438.45	0.2639
338.15	0.6190	393.15	0.3785	449.15	0.2446
347.85	0.5950	397.95	0.3631		

Suggested Equation = 3 Constants: A = -4.8518 B = -530.68 C = 21.765

% AAD = 0.3 S.D. = 5.30 x 10^{-6} Temperature Range: 280-450

4-Ethyl-2-oxazolidinone

CAS RN: 16112-60-0, Source of Data: Reference 56

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
278.15	234.38	308.15	31.464	338.15	8.8635
288.15	108.01	318.15	19.303		
298.15	55.606	328.15	12.694		

Suggested Equation = 3 Constants: A = -4.3902 B = -367.67 C = 180.81

% AAD = 0.3 S.D. = 1.90E-04 Temperature Range: 280-340

4-Fluoroaniline

CAS RN: 371-40-4, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	3.0250	313.15	1.9250	333.15	1.3400
303.15	2.3700	323.15	1.5800		

Suggested Equation = 3 Constants: A = -4.1860 B = -247.24 C = 144.82

% AAD = 0.2 S.D. = 5.20 x 10^{-6} Temperature Range: 290-340

4-Fluorophenetole

CAS RN: 7589-27-7, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.30	1.3400	313.15	0.9500	333.15	0.7150
303.15	1.1130	323.15	0.8200		

Suggested Equation = 3 Constants: A = -4.2889 B = -237.60 C = 125.43

% AAD = 0.2 S.D. = 2.40 x 10^{-6} Temperature Range: 290-340

4-Fluorotoluene

CAS RN: 352-32-9, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	0.6215	313.15	0.4950		
303.15	0.5525	333.15	0.4050		

Suggested Equation = 3 Constants: A = -4.7711 B = -463.94 C = -3.3819

% AAD = 0.1 S.D. = 4.10E-08 Temperature Range: 290-340

4-Heptanol

CAS RN: 589-55-9, Source of Data: Reference 29

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
291.15	5.7450	352.05	0.8120	398.75	0.3637
307.95	2.8660	367.65	0.5910	414.45	0.2985
323.15	1.7030	382.65	0.4590	419.45	0.2828
336.95	1.1520				

Suggested Equation = 3 Constants: A = -4.7847 B = -307.04 C = 170.68

% AAD = 0.5 S.D. = 2.30 x 10^{-5} Temperature Range: 290-420

4-Hydroxy benzaldehyde

CAS RN: 123-08-0, Source of Data: Reference 10

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
403.65	4.5500	422.85	3.0970	433.15	2.6190
413.25	3.6800	423.15	3.0800		

Suggested Equation = 3 Constants: A = -3.3974 B = -106.24 C = 303.06

% AAD = 0.3 S.D. = 9.00 x 10^{-6} Temperature Range: 400-440

4-Methoxy phenol

CAS RN: 150-76-5, Source of Data: Reference 13

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
345.45	4.5800	424.05	0.9782	481.35	0.5055
365.15	2.7450	445.75	0.7260	494.65	0.4495
385.15	1.8130	456.15	0.6489	507.15	0.4016
404.65	1.2960	468.15	0.5713	517.15	0.3733

Suggested Equation = 3 Constants: A = -4.5900 B = -412.70 C = 162.01

% AAD = 0.5 S.D. = 7.90 x 10^{-6} Temperature Range: 340-520

4-Methyl-2-pentanone

CAS RN: 108-10-1, Source of Data: Reference 47, 19, 62

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15[47]	0.5750	303.15[19]	0.4970	293.15[62]	0.5878
298.15	0.5430	313.15	0.4430	298.15	0.5463
303.15	0.5180	323.15	0.4010	308.15	0.4871
308.15	0.4940	333.15	0.3650	318.15	0.4373

Suggested Equation = 1 Constants: A = -4.9190 B = 493.54 C = 0.00

% AAD = 1.4 S.D. = 7.90 x 10^{-6} Temperature Range: 290-340

4-Methyl-3-heptanol

CAS RN: 14979-39-6, Source of Data: Reference 44

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.18	1.8985	303.15	0.9872	353.15	0.4673
283.15	1.4932	313.15	0.8258	373.15	0.3745
293.15	1.2005	333.15	0.6061		

Suggested Equation = 3 Constants: A = -4.6307 B = -325.82 C = 102.60

% AAD = 0.1 S.D. = 1.60 x 10^{-6} Temperature Range: 270-380

4-Methyl cyclohexanol

CAS RN: 589-91-3, Source of Data: Reference 49

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
312.25	14.3600	339.05	4.2570	363.15	1.8290

Suggested Equation = 3 Constants: A = -5.4635 B = -558.96 C = 158.00

% AAD = 0.8 S.D. = 5.90 x 10^{-5} Temperature Range: 310-370

4-Methyl benzenamine

CAS RN: 106-49-0, Source of Data: Reference 42, 63

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
408.75[42]	0.5180	463.15	0.3137	352.95	1.5810
426.45	0.4320	473.15	0.2890	373.05	1.1150
440.65	0.3790	313.05[63]	4.7900	398.15	0.7700
451.15	0.3466	333.05	2.5200		

Suggested Equation = 3 Constants: A = -4.3612 B = -219.54 C = 206.59

% AAD = 2.0 S.D. = 9.80 x 10^{-5} Temperature Range: 310-480

4-Methyl benzonitrile

CAS RN: 104-85-8, Source of Data: Reference 26

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	1.437	333.15	0.916	393.15	0.491
313.15	1.220	353.15	0.722	413.15	0.415
323.15	1.050	373.15	0.588		

Suggested Equation = 3 Constants: A = -4.4654 B = -360.83 C = 80.619

% AAD = 0.3 S.D. = 2.50 x 10^{-6} Temperature Range: 300-420

4-Methyl cyclohexanone

CAS RN: 589-92-4, Source of Data: Reference 49, 51

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
290.45[49]	1.8382	339.05	0.8688	288.15[51]	1.9160
312.25	1.2337	363.15	0.6882	303.15	1.4570

Suggested Equation = 3 Constants: A = -3.8959 B = -145.00 C = 165.50

% AAD = 0.5 S.D. = 1.10 x 10^{-5} Temperature Range: 280-370

4-Nitro-3-heptene

CAS RN: 6065-12-9, Source of Data: Reference 52

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	1.235	313.15	1.063	333.15	0.821

Suggested Equation = 1 Constants: A = -4.8737 B = 595.53 C = 0.00

% AAD = 0.2 S.D. = 2.60 x 10^{-6} Temperature Range: 300-340

4-Nitro-3-nonene

CAS RN: 6065-03-8, Source of Data: Reference 52

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	1.899	313.15	1.576	333.15	1.151

Suggested Equation = 1 Constants: A = -5.1298 B = 729.59 C = 0.00

% AAD = 0.4 S.D. = 6.80 x 10^{-6} Temperature Range: 300-340

4-Nitro-3-octene

CAS RN: 6065-08-3, Source of Data: Reference 52

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	1.499	313.15	1.268	333.15	0.955

Suggested Equation = 1 Constants: A = -4.9931 B = 657.09 C = 0.00

% AAD = 0.3 S.D. = 4.60 x 10^{-6} Temperature Range: 300-340

4-Nitro-4-nonene

CAS RN: 4812-24-2, Source of Data: Reference 52

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	1.872	313.15	1.560	333.15	1.146

Suggested Equation = 1 Constants: A = -5.0884 B = 715.18 C = 0.00

% AAD = 0.4 S.D. = 6.30 x 10^{-6} Temperature Range: 300-340

4-Nitro-4-octene

CAS RN: 6065-07-2, Source of Data: Reference 52

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	1.603	313.15	1.347	333.15	1.005

Suggested Equation = 1 Constants: A = -5.0407 B = 680.29 C = 0.00

% AAD = 0.4 S.D. = 5.50 x 10^{-6} Temperature Range: 300-340

4-Nitrophenol

CAS RN: 100-02-7, Source of Data: Reference 53, 10

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
379.15[53]	4.633	393.15	3.410	402.15[10]	2.941
381.15	4.408	395.15	3.281	422.65	2.096
383.15	4.236	398.15	3.099	423.15	2.080
384.15	4.106	400.15	2.999	442.45	1.580
385.15	4.036	403.15	2.816	453.95	1.365
386.15	3.902	405.15	2.762	486.15	0.914
387.15	3.814	408.15	2.605	496.30	0.811
388.15	3.755	413.15	2.385	568.15	0.410
390.15	3.630				

Suggested Equation = 3 Constants: A = -5.1303 B = -889.28 C = 59.746

% AAD = 1.2 S.D. = 4.40 x 10^{-5} Temperature Range: 370-570

4-Nitrotoluene

CAS RN: 99-99-0, Source of Data: Reference 39, 10

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
333.15[39]	1.1986	397.35	0.5946	450.65	0.3992
353.15	0.9374	411.75	0.5278	460.85	0.3737
373.15	0.7577	423.15	0.4820	473.65	0.3465
372.15[10]	0.7534	423.45	0.4807	488.65	0.3184
393.15	0.6140	435.35	0.4424	510.65	0.2838

Suggested Equation = 3 Constants: A = -4.4681 B = -404.79 C = 71.72

% AAD = 0.3 S.D. = 3.00 x 10^{-6} Temperature Range: 330-520

5-Methyl-2-oxazolidinone

CAS RN: 1072-70-4, Source of Data: Reference 56

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
278.15	51.611	308.15	12.216	338.15	4.811
288.15	29.704	318.15	8.554		
298.15	18.442	328.15	6.284		

Suggested Equation = 3 Constants: A = -4.2193 B = -323.59 C = 167.86

% AAD = 0.3 S.D. = 1.10E-04 Temperature Range: 270-340

5-Nitro-4-nonene

CAS RN: 6065-01-6, Source of Data: Reference 52

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	1.927	313.15	1.595	333.15	1.162

Suggested Equation = 1 Constants: A = -5.1475 B = 736.86 C = 0.00

% AAD = 0.4 S.D. = 7.50 x 10^{-6} Temperature Range: 300-340

5-Nonanone

CAS RN: 502-56-7, Source of Data: Reference 45

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	1.3040	313.15	0.9542	353.15	0.5882
303.15	1.1071	333.15	0.7353	373.15	0.4836

Suggested Equation = 3 Constants: A = -4.4816 B = -346.38 C = 76.180

% AAD = 0.1 S.D. = 8.20 x 10^{-7} Temperature Range: 290-380

7-Butyl-1-hexyl decahydro naphthalene

Source of Data: Reference 7

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	74.5500	310.95	11.2400	372.05	2.2830
293.15	24.0300	333.15	5.4910		

Suggested Equation = 3 Constants: A = -4.2931 B = -341.18 C = 165.42

% AAD = 0.3 S.D. = 1.30E-04 Temperature Range: 270-380

7-n-Hexadecyl spiro(4,5)decane

CAS RN: 2307-06-04, Source of Data: Reference 64

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	29.450	333.15	7.923	372.05	3.456
310.95	15.150				

Suggested Equation = 3 Constants: A = -4.1827 B = -387.10 C = 147.17

% AAD = 0.1 S.D. = 8.20 x 10^{-6} Temperature Range: 290-380

α,α,α-Trifluorotoluene

CAS RN: 98-08-8, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
292.95	0.5740	313.15	0.4624	333.15	0.3878
303.15	0.5120	323.15	0.4204		

Suggested Equation = 1 Constants: A = -4.6590 B = 414.69 C = 0.00

% AAD = 0.3 S.D. = 1.90 x 10^{-6} Temperature Range: 290-340

Acetaldehyde

CAS RN: 75-07-0, Source of Data: Reference 65, 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.16[65]	0.2711	289.35	0.2326	278.50	0.2538
277.55	0.2600	293.35	0.2237	282.71	0.2442
281.35	0.2509	294.75	0.2213	287.07	0.2345
285.35	0.2414	273.48[4]	0.2663	292.32	0.2234

Suggested Equation = 2 Constants: A = 730.3300 B = -2.64 C = 0.00

% AAD = 0.6 S.D. = 1.60 x 10^{-6} Temperature Range: 270-300

Acetamide

CAS RN: 60-35-5, Source of Data: Reference 66

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
364.25 (1)	2.1820	424.35	0.8039	483.15	0.4320
384.95	1.4610	443.45	0.6405	495.95	0.3857
404.85	1.0560	463.95	0.5180		

Suggested Equation = 3 Constants: A = -4.6341 B = -422.90 C = 149.84

% AAD = 0.2 S.D. = 1.7E- 6 Temperature Range: 360-500

Acetic Acid

CAS RN: 64-19-7, Source of Data: Reference 67, 68, 4

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15[67]	1.1390	353.50	0.5622	341.25	0.6380
273.15[68]	1.2289	363.69	0.5061	349.81	0.5800
298.15	1.1365	304.01[4]	1.0250	357.68	0.5340
310.95	0.9384	313.03	0.9030	367.12	0.4840
323.20	0.7979	321.62	0.8060	376.04	0.4450
333.26	0.7042	330.61	0.7210	385.72	0.4060
343.35	0.6272				

Suggested Equation = 2 Constants: A = 1.2106E+06 B = -3.6612 C = 0.00

% AAD = 2.9 S.D. = 6.00 x 10^{-5} Temperature Range: 270-390

Acetic anhydride

CAS RN: 108-24-7, Source of Data: Reference 4, 22, 26

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.33[4]	1.2380	357.57	0.4340	303.15	0.7830
285.67	1.0070	368.24	0.3940	273.15[26]	1.2448
297.25	0.8520	.382.07	0.3510	293.15	0.9010
308.55	0.7340	393.38	0.3200	303.15	0.7860
321.30	0.6300	406.54	0.2890	313.15	0.6910
333.54	0.5510	288.15[22]	0.9710	323.15	0.6150
344.19	0.4940				

Suggested Equation = 3 Constants: A = -4.5804 B = -374.60 C = 49.41

% AAD = 0.5 S.D. = 3.10 x 10^{-6} Temperature Range: 270-410

Acetone

CAS RN: 67-64-1, Source of Data: Reference 69, 4

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
183.15[69]	1.9930	263.15	0.4457	300.37	0.3007
193.15	1.4970	273.15	0.3976	305.58	0.2863
203.15	1.1710	283.15	0.3562	309.15	0.2772
213.15	0.9495	281.01[4]	0.3638	313.19	0.2675
223.15	0.7897	284.87	0.3495	317.27	0.2584
233.15	0.6708	288.39	0.3376	320.00	0.2503
243.15	0.5783	292.17	0.3258	325.35	0.2405
253.15	0.5050	296.16	0.3131	327.01	0.2377

Suggested Equation = 3 Constants: A = -4.6125 B = -298.48 C = 26.20

% AAD = 0.7 S.D. = 1.10 x 10^{-5} Temperature Range: 180-330

Acetonitrile

CAS RN: 75-05-8, Source of Data: Reference 65

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
289.75 (1)	0.3950	334.95	0.2583	354.65	0.2217
314.55	0.3080	341.85	0.2445		
324.75	0.2816	359.95	0.2295		

Suggested Equation = 3 Constants: A = -4.8242 B = -430.37 C = -13.17

% AAD = 0.1 S.D. = 1.60 x 10^{-7} Temperature Range: 280-360

Acetophenone

CAS RN: 98-86-2, Source of Data: Reference 15, 70

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
372.15[15]	0.6349	435.15	0.3788	298.15[70]	1.6810
395.15	0.5165	460.65	0.3184		
414.65	0.4393	474.45	0.2900		

Suggested Equation = 3 Constants: A = -4.6251 B = -468.30 C = 45.01

% AAD = 0.5 S.D. = 2.70 x 10^{-7} Temperature Range: 370-480

Acetyl chloride

CAS RN: 75-36-5, Source of Data: Reference 66

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
294.25 (1)	0.3820	312.05	0.3234	322.05	0.2967
305.35	0.3450	316.15	0.3120	328.25	0.2820

Suggested Equation = 3 Constants: A = -4.7447 B = -407.10 C = -12.42

% AAD = 0.1 S.D. = 5.30 x 10^{-7} Temperature Range: 290-330

Allyl thiocynate

CAS RN: 764-49-8, Source of Data: Reference 71, 72

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15[71]	0.6730	373.15[72]	0.3160		
323.15	0.5410	398.15	0.2630		

Suggested Equation = 2 Constants: A = 130700.00 B = -3.35 C = 0.00

% AAD = 2.0 S.D. = 1.20 x 10^{-5} Temperature Range: 290-400

Allyl alcohol

CAS RN: 107-18-6, Source of Data: Reference 4, 61

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
280.56[4]	1.8100	319.51	0.8110	357.65	0.4400
288.46	1.5080	327.25	0.7080	365.41	0.3940
295.96	1.2830	333.92	0.6330	368.39	0.3790
303.65	1.0996	342.01	0.5570	288.15[61]	1.4860
311.65	0.9460	349.96	0.4920	303.15	1.0720

Suggested Equation = 1 Constants: A = -5.5749 B = 793.29 C = 0.00

% AAD = 0.6 S.D. = 1.10 x 10^{-5} Temperature Range: 280-370

Allyl bromide

CAS RN: 106-95-6, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.45 (1)	0.6168	297.88	0.4727	321.01	0.3805
279.79	0.5730	303.99	0.4449	327.70	0.3587
285.57	0.5372	310.37	0.4198	334.30	0.3402
291.49	0.5046	315.99	0.3988	341.82	0.3193

Suggested Equation = 1 Constants: A = -4.6328 B = 389.33 C = 0.00

% AAD = 0.2 S.D. = 1.00 x 10^{-6} Temperature Range: 270-350

Allyl chloride

CAS RN: 107-05-1, Source of Data: Reference 26, 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.15[26]	0.3475	313.15	0.2730	295.08	0.3230
293.15	0.3300	273.68[4]	0.4035	301.47	0.3039
298.15	0.3130	279.13	0.3800	307.12	0.2885
303.15	0.3020	284.34	0.3598	311.52	0.2774
308.15	0.2860	289.81	0.3408	315.25	0.2681

Suggested Equation = 1 Constants: A = -4.7522 B = 372.37 C = 0.00

% AAD = 0.3 S.D. = 1.60 x 10^{-6} Temperature Range: 270-320

Allyl ether

CAS RN: 557-40-4, Source of Data: Reference 26

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15 (1)	0.4410	313.15	0.3500	353.15	0.2340
298.15	0.4170	323.15	0.3150		
303.15	0.3920	333.15	0.2850		

Suggested Equation = 3 Constants: A = -5.5716 B = -938.43 C = -130.23

% AAD = 0.2 S.D. = 6.30 x 10^{-7} Temperature Range: 290-360

Allyl iodide

CAS RN: 556-56-9, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.48	0.9260	308.92	0.6140	344.29	0.4430
282.48	0.8250	317.33	0.5650	354.44	0.4100
289.92	0.7540	328.31	0.5100	365.01	0.3750
299.27	0.6790	336.59	0.4760	371.60	0.3580

Suggested Equation = 3 Constants: A = -4.5436 B = -410.42 C = 2.0868

% AAD = 0.1 S.D. = 1.00 x 10^{-6} Temperature Range: 270-380

Aluminum bromide

CAS RN: 7727-15-3, Source of Data: Reference 73

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
373.15	2.3700	473.15	0.9600		
423.15	1.4200	523.15	0.7100		

Suggested Equation = 3 Constants: A = -4.2262 B = -493.82 C = 64.74

% AAD = 0.1 S.D. = 1.50 x 10^{-6} Temperature Range: 370-530

Aluminum iodide

CAS RN: 7784-23-8, Source of Data: Reference 73

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
473.15	2.6200	573.15	1.3200	673.15	0.8600
513.15	1.9000	613.15	1.1000		

Suggested Equation = 3 Constants: A = -3.8840 B = -443.03 C = 132.69

% AAD = 0.4 S.D. = 6.10 x 10^{-6} Temperature Range: 470-680

Ammonia

CAS RN: 7664-41-7, Source of Data: Reference 6

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
208.15	0.4314	228.05	0.3035	233.35	0.2794
213.15	0.3906	228.15	0.3002	233.65	0.2800
218.15	0.3562	230.95	0.2900	235.15	0.2714
219.15	0.3470	231.35	0.2900	235.95	0.2710
222.75	0.3310	323.55	0.2826	236.45	0.2690
223.15	0.3285	233.05	0.2817	238.15	0.2632
225.35	0.3190	233.15	0.2823		

Suggested Equation = 1 Constants: A = -5.0722 B = 354.72 C = 0.00

% AAD = 0.4 S.D. = 1.60 x 10^{-6} Temperature Range: 200-240

Amyl amine

CAS RN: 110-58-7, Source of Data: Reference 31

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
278.15	0.9150	308.15	0.6220	343.15	0.3690
288.15	0.8230	318.15	0.5350	353.15	0.3330
298.15	0.7180	328.15	0.4610		

Suggested Equation = 2 Constants: A = 48213000.0000 B = -4.3795 C = 0.00

% AAD = 1.8 S.D. = 2.00 x 10^{-5} Temperature Range: 270-360

Amyl butyrate

CAS RN: 540-18-1, Source of Data: Reference 74

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	1.7749	303.15	1.0328	353.15	0.5445
283.15	1.5118	313.15	0.8911	373.15	0.4465
293.15	1.2133	333.15	0.6879		

Suggested Equation = 3 Constants: A = -4.4732 B = -321.43 C = 87.301

% AAD = 0.9 S.D. = 1.80 x 10^{-5} Temperature Range: 270-380

Amyl titanate

CAS RN: Source of Data: Reference 75

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
403.05	3.3500	447.35	1.0650	487.15	0.5360
418.15	2.1600	462.35	0.7830		
431.95	1.5300	477.25	0.6080		

Suggested Equation = 3 Constants: A = -5.0964 B = -493.76 C = 214.92

% AAD = 0.7 S.D. = 1.30 x 10^{-5} Temperature Range: 400-490

Aniline

CAS RN: 62-53-3, Source of Data: Reference 42, 76, 77, 35, 178

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
378.95[42]	0.7880	288.15[77]	5.2990	311.00	2.6300
407.35	0.5708	303.15	3.1760	313.00	2.5970
428.75	0.4613	293.00[35]	4.7080	318.00	2.2550
442.55	0.4052	298.00	3.9950	323.00	2.0000
456.35	0.3600	303.00	3.4200	372.00	0.9100
303.15[76]	3.1457	303.15[178]	3.7080	313.15	2.3270

Suggested Equation = 3 Constants: A -1.40 B -3.01 x 10^{2} C 1.47 x 10^{2}

%AAD 3.215621 SD 6.40 x 10^{-3} Temperature Range: 280-460

Anisole

CAS RN: 100-66-3, Source of Data: Reference 42, 177

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
287.70[42]	1.2420	374.15	0.4236	415.25	0.2945
329.05	0.6920	387.65	0.3726	425.35	0.2735
353.65	0.5236	401.15	0.3320	288.15[177]	1.2388
298.15	1.0849				

Suggested Equation = 3 Constants: A -2.02 B -6.39 x 10^{2} C -1.47x 10 x 10^{1}

%AAD 0.453163 SD 1.02 x 10^{-4} Temperature Range: 280-430

Antimony

CAS RN: 7440-36-0, Source of Data: Reference 78

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
897.15	1.4970	915.65	1.4380	970.45	1.3100
904.65	1.4700	935.65	1.3790		
909.65	1.4550	951.65	1.3470		

Suggested Equation = 3 Constants: A = -3.0270 B = -36.85 C = 715.23

% AAD = 0.1 S.D. = 1.60 x 10^{-6} Temperature Range: 890-980

Barium chloride dihydrate (Molten)

CAS RN: 10326-27-9, Source of Data: Reference 79

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
1239.15	3.7096	1273.75	3.3291	1334.25	2.8146
1252.95	3.5507	1293.85	3.1421	1350.35	2.7041
1271.65	3.3706	1313.15	2.9798	1371.75	2.5616

Suggested Equation = 3 Constants: A = -3.5539 B = -890.83 C = 446.48

% AAD = 0.2 S.D. = 6.00 x 10^{-6} Temperature Range: 1230-1380

Benzene

CAS RN: 71-43-2, Source of Data: Reference 4, 80, 68, 192, 177, 203, 206, 217

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
280.82 [4]	0.7890	324.81	0.4285	283.05	0.7660
286.61	0.7172	330.52	0.4017	293.15 [68]	0.6502
292.54	0.6544	336.44	0.3767	298.15	0.6042
299.11	0.5946	342.56	0.3535	310.95	0.5076
305.22	0.5470	348.51	0.3329	323.20	0.4363
311.62	0.5021	299.15 [80]	0.6190	343.35	0.3507
318.50	0.4615	298.15[192]	0.6100	303.15	0.5690
308.15	0.5330	288.15[177]	0.7322	293.15	0.6862
298.15	0.6489	298.15[203]	0.5990	298.15[206]	0.6470
303.15	0.6300	308.15	0.6040	313.15	0.5980
318.15	0.5530			298.15[217]	0.6844

Suggested Equation = 3 Constants: A = -3.20 B = -1.51×10^3 C = -2.07×10^2

%AAD = 3.691071 SD = 1.53×10^{-2} Temperature Range: 280-350

Benzonitrile

CAS RN: 100-47-0, Source of Data: Reference 65, 48, 177

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
292.85 [65]	1.4710	453.85	0.3023	323.15	0.8639
348.15	0.7000	463.65	0.2850	333.15	0.7673
373.85	0.5440	273.15 [48]	1.9570	343.15	0.6876
393.15	0.4626	293.15	1.3298	353.15	0.6227
413.05	0.3961	303.15	1.1331	373.15	0.5137
433.55	0.3487	313.15	0.9838	288.15[177]	1.4915
293.15	1.3817	298.15	1.2815		

Suggested Equation = 3 Constants: A= -1.34 B = -3.05×10^2 C = 8.71×10^1

%AAD = 2.443616 SD = 3.05×10^{-3} Temperature Range: 290-470

Benzophenone

CAS RN: 119-61-9, Source of Data: Reference 81, 82

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15[81]	10.9890	333.15	3.9683	373.15	1.5773
313.15	7.5758	353.15	2.4038	328.15[82]	4.6471

Suggested Equation = 3 Constants: A = -4.6614 B = -416.84 C = 148.97

% AAD = 0.4 S.D. = 2.50×10^{-5} Temperature Range: 300-380

Benzyl alcohol

CAS RN: 100-51-6, Source of Data: Reference 83, 10

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
288.15[83]	7.7600	380.35	0.9460	451.85	0.4207
303.15	4.6500	400.75	0.7223	458.25	0.3970
321.75[10]	2.8360	421.15	0.5721	466.15	0.3700
341.05	1.8450	435.65	0.4920	478.15	0.3340
360.85	1.2840				

Suggested Equation = 3 Constants: A = -4.6581 B = -422.73 C = 121.75

% AAD = 0.7 S.D. = 4.00×10^{-5} Temperature Range: 280-480

Benzyl amine

CAS RN: 100-46-9, Source of Data: Reference 42, 84

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
294.35 [42]	1.7800	392.15	0.4777	451.35	0.2948
334.05	0.9120	414.05	0.3935	457.15	0.2830
353.85	0.7140	429.35	0.3478	298.15[84]	1.5900
374.15	0.5721	443.15	0.3122	403.15	0.4420

Suggested Equation = 3 Constants: A = -4.7265 B = -480.83 C = 49.94

% AAD = 0.9 S.D. = 1.60 x 10^{-5} Temperature Range: 290-460

Benzyl benzoate

CAS RN: 120-51-4, Source of Data: Reference 85, 86, 87

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
278.15[85]	19.2800	333.15	3.2590	373.15	1.6550
288.15	12.1200	353.15	2.2450	298.15[86]	8.4538
298.15	8.2920	363.15	1.9120	298.15[87]	8.5143
313.15	5.2430				

Suggested Equation = 3 Constants: A = -3.9401 B = -230.36 C = 174.56

% AAD = 0.6 S.D. = 7.00 x 10^{-5} Temperature Range: 270-380

Benzyl Chloride

CAS RN: 100-44-7, Source of Data: Reference 83

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.15	1.5010	303.15	1.1750		
298.15	1.2800	308.15	1.0990		

Suggested Equation = 3 Constants: A = -3.8075 B = -122.50 C = 163.81

% AAD = 0.4 S.D. = 6.10 x 10^{-6} Temperature Range: 280-310

Benzyl cyanide

CAS RN: 140-29-4, Source of Data: Reference 26, 65

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15[26]	2.1610	373.15	0.7120	413.45	0.5083
303.15	1.7790	393.15	0.5860	433.85	0.4303
313.15	1.5050	413.15	0.5120	453.65	0.3754
323.15	1.2930	291.35[65]	2.3250	473.25	0.3312
333.15	1.1250	363.35	0.8046	504.15	0.2760
353.15	0.8800	393.65	0.6005		

Suggested Equation = 3 Constants: A = -4.2563 B = -292.41 C = 109.28

% AAD = 0.4 S.D. = 4.40 x 10^{-6} Temperature Range: 290-420

Benzyl ether

CAS RN: 103-50-4, Source of Data: Reference 59

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	10.5300	303.15	4.0617	353.15	1.5686
283.15	7.2516	313.15	3.2062	373.15	1.2003
293.15	5.3333	333.15	2.1645		

Suggested Equation = 3 Constants: A = -4.0837 B = -260.57 C = 149.28

% AAD = 0.3 S.D. = 2.60 x 10^{-5} Temperature Range: 270-380

Biphenyl

CAS RN: 92-52-4, Source of Data: Reference 88, 89, 182

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
373.15 [88]	0.9500	473.15	0.3800	448.15	0.4400
398.15	0.7300	498.15	0.3200	473.15	0.3700
423.15	0.5700	398.15 [89]	0.7100	498.15	0.3100
448.15	0.4600	423.15	0.5500	574.15[182]	0.2820
584.15	0.2610	594.15	0.2300	604.15	0.2150
614.15	0.1990	624.15	0.1870	634.15	0.1720
644.15	0.1580	654.15	0.1510	664.15	0.1420
674.15	0.1340				

Suggested Equation = 1 Constants: A = 1.57 x 10^{-2} B = 6.60 x 10^{2} C = 0.00

% AAD = 1.6 S.D. = 8.40 x 10^{-6} Temperature Range: 370-500

Bis dimethyl aminophosphoryl chloride

Source of Data: Reference 90

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
248.15	15.6600	273.15	6.5700	313.15	2.6400
253.15	12.7500	291.15	4.1800	333.15	1.9200
263.15	9.0400	298.15	3.5500	348.15	1.5400

Suggested Equation = 3 Constants: A = -4.1079 B = -297.31 C = 118.96

% AAD = 0.5 S.D. = 3.50 x 10^{-5} Temperature Range: 240-350

Bismuth

CAS RN: 7440-69-9, Source of Data: Reference 91

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
535.15	1.9240	773.15	1.1200	899.15	1.0800
551.15	1.8890	775.15	1.2300	979.15	1.0170
551.15	1.8400	806.15	1.1110	981.15	0.9500
552.15	1.8330	814.15	1.0900	1026.15	0.9770
562.15	1.7830	818.15	1.0500	1029.15	0.9100
652.15	1.3100	848.15	0.9910	1077.15	0.9170
669.15	1.3300	863.15	1.1360	1198.15	0.8780
729.15	1.2500	873.15	1.0400	1276.15	0.8450
749.15	1.2480	889.15	0.9750		

Suggested Equation = 3 Constants: A = -3.1717 B = -93.808 C = 343.93

% AAD = 2.2 S.D. = 3.40 x 10^{-5} Temperature Range: 550-1250

Bismuth chloride (molten)

CAS RN: 7787-60-2, Source of Data: Reference 92

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
507.00	5.1100	536.00	3.1000	593.50	1.7760
508.50	4.8100	537.00	2.9000	595.00	1.7710
509.00	4.6000	543.00	2.8000	616.00	1.5500
510.00	4.5100	553.00	2.4880	630.00	1.4000
511.00	4.2780	579.00	1.9900	635.00	1.4700
512.00	4.2000	584.00	1.9800	652.00	1.1400
514.00	4.0400	585.00	1.9000	678.00	0.9900

Suggested Equation = 3 Constants: A = -3.5703 B = -198.83 C = 348.44

% AAD = 3.8 S.D. = 1.30E-01 Temperature Range: 500-675

Boron trichloride

CAS RN: 10294-34-5, Source of Data: Reference 93

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
233.15	0.4794	253.15	0.4024	273.15	0.3429
238.15	0.4599	258.15	0.3850	278.15	0.3325
243.15	0.4406	263.15	0.3684	283.15	0.3236
248.15	0.4215	268.15	0.3548		

Suggested Equation = 1 Constants: A = -4.3146 B = 232.51 C = 0.00

% AAD = 0.4 S.D. = 1.80 x 10^{-6} Temperature Range: 230-290

Bromal hydrate

CAS RN: 75-96-7, Source of Data: Reference 94

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
313.15	46.0829	353.15	4.2017		
333.15	10.9051	373.15	2.0000		

Suggested Equation = 3 Constants: A = -4.7271 B = -303.97 C = 223.45

% AAD = 1.0 S.D. = 1.30E-04 Temperature Range: 310-380

Bromine

CAS RN: 7726-95-6, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.71	1.2450	294.22	0.9830	314.08	0.8090
278.46	1.1730	299.14	0.9340	319.34	0.7720
283.60	1.1040	304.35	0.8880	323.43	0.7440
289.31	1.0350	309.01	0.8480	329.56	0.7060

Suggested Equation = 3 Constants: A = -4.2380 B = -329.88 C = 26.15

% AAD = 0.1 S.D. = 9.00 x 10^{-7} Temperature Range: 270-330

Bromobenzene

CAS RN: 108-86-1, Source of Data: Reference 95, 8, 178

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.05[95]	1.5060	306.25	0.9720	384.85	0.4730
279.05	1.4410	316.75	0.8530	394.85	0.4460
279.75	1.4230	322.65	0.8040	405.45	0.4130
283.25	1.3300	334.55	0.7100	415.65	0.3850
289.75	1.2040	344.35	0.6450	288.15[8]	1.1960
291.35	1.1730	353.85	0.6000	293.15	0.9850
295.05	1.1230	364.15	0.5490	303.15[178]	0.9850
296.55	1.1000	375.35	0.5100	313.15	0.8950
301.45	1.0290				

Suggested Equation = 3 Constants: A = -1.24 B = -2.84 x 10^{2} C = 7.35x 10^{1}

%AAD = 1.714843 SD = 4.71 x 10^{-3} Temperature Range: 270-420

1-Bromodecane

CAS RN: 112-29-8, Source of Data: Reference 3

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.08	3.3730	308.11	2.6890		
303.10	3.0240	313.11	2.4370		

Suggested Equation = 1 Constants: A = -5.4375 B = 884.04 C = 0.00

% AAD = 0.3 S.D. = 8.80 x 10^{-6} Temperature Range: 290-320

Bromoethane

CAS RN: 74-96-4 Source of Data: Reference 4

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.49	0.4759	288.61	0.4087	303.18	0.3181
278.33	0.4525	263.69	0.3903	309.30	0.3394
282.82	0.4327	298.43	0.3734		

Suggested Equation = 3 Constants: A = -4.7817 B = -468.12 C = -47.34

% AAD = 0.1 S.D. = 2.00 x 10^{-7} Temperature Range: 200-310

Bromoform

CAS RN: 75-25-2 Source of Data: Reference 96, 40

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
283.15[96]	2.2173	303.15	1.7410	288.15[40]	2.1520
288.15	2.1530	349.65	1.0091	303.15	1.7410

Suggested Equation = 2 Constants: A = 4900800.0000 B = -3.8075 C = 0.00

% AAD = 1.0 S.D. = 2.90 x 10^{-5} Temperature Range: 280-350

Butane

CAS RN: 106-97-8 Source of Data: Reference 97, 98

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15[97]	0.2080	303.15	0.1592	213.15	0.4030
283.15	0.1894	323.15	0.1370	243.15	0.2820
293.15	0.1720	183.15[98]	0.6300	273.15	0.2100

Suggested Equation = 3 Constants: A = -5.1430 B = -528.24 C = -88.68

% AAD = 0.4 S.D. = 1.30 x 10^{-6} Temperature Range: 180-310

Butyl acetate

CAS RN: 123-86-4 Source of Data: Reference 74, 99

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15[74]	1.0035	303.15	0.6372	353.15	0.3656
283.15	0.8511	313.15	0.5626	373.15	0.3044
293.15	0.7322	333.15	0.4476	308.15[99]	0.6042

Suggested Equation = 3 Constants: A = -4.7722 B = -431.58 C = 29.726

% AAD = 0.3 S.D. = 2.20 x 10^{-6} Temperature Range: 270-380

Butyl butyrate

CAS RN: 109-21-7 Source of Data: Reference 74

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	1.4409	303.15	0.8718	353.15	0.4785
283.15	1.1955	313.15	0.7599	373.15	0.3949
293.15	1.0130	333.15	0.5938		

Suggested Equation = 3 Constants: A = -4.5274 B = -338.81 C = 72.28

% AAD = 0.3 S.D. = 2.60 x 10^{-6} Temperature Range: 270-380

Butyl ether

CAS RN: 142-96-1 Source of Data: Reference 59

T (K)	*η (N.s.m⁻²)*	*T (K)*	*η (N.s.m⁻²)*	*T (K)*	*η (N.s.m⁻²)*
273.15	0.9425	303.15	0.6064	353.15	0.3500
283.15	0.8032	313.15	0.5365	373.15	0.2931
293.15	0.6920	333.15	0.4288		

Suggested Equation = 3 Constants: A = -4.8090 B = -449.86 C = 20.676

% AAD = 0.2 S.D. = 1.70 x 10^{-6} Temperature Range: 270-380

Butyl formate

CAS RN: 592-84-7 Source of Data: Reference 74

T (K)	*η (N.s.m⁻²)*	*T (K)*	*η (N.s.m⁻²)*	*T (K)*	*η (N.s.m⁻²)*
273.15	0.9398	303.15	0.6010	353.15	0.3463
283.15	0.7987	313.15	0.5313	373.15	0.2882
293.15	0.6897	333.15	0.4223		

Suggested Equation = 3 Constants: A = -4.8197 B = -448.59 C = 22.75

% AAD = 0.2 S.D. = 1.30 x 10^{-6} Temperature Range: 270-380

Butyl phenyl ether

CAS RN: 1126-79-0 Source of Data: Reference 15

T (K)	*η (N.s.m⁻²)*	*T (K)*	*η (N.s.m⁻²)*	*T (K)*	*η (N.s.m⁻²)*
296.10	1.7860	402.65	0.4307	445.65	0.2985
353.85	0.7031	413.55	0.3916	455.95	0.2754
374.45	0.5526	422.15	0.3623	468.15	0.2512
383.15	0.5094	435.15	0.3251	482.45	0.2270
393.15	0.4670				

Suggested Equation = 3 Constants: A = -4.7979 B = -500.67 C = 51.42

% AAD = 1.3 S.D. = 8.20 x 10^{-6} Temperature Range: 290-490

Butyl propionate

CAS RN: 590-01-2 Source of Data: Reference 74

T (K)	*η (N.s.m⁻²)*	*T (K)*	*η (N.s.m⁻²)*	*T (K)*	*η (N.s.m⁻²)*
273.15	1.1550	303.15	0.7262	353.15	0.4131
283.15	0.9747	313.15	0.6394	373.15	0.3435
293.15	0.8354	333.15	0.5094		

Suggested Equation = 3 Constants: A = -4.6610 B = -393.94 C = 44.51

% AAD = 0.3 S.D. = 2.10 x 10^{-6} Temperature Range: 270-380

Butyl titanate

CAS RN: 9022-96-2 Source of Data: Reference 75

T (K)	*η (N.s.m⁻²)*	*T (K)*	*η (N.s.m⁻²)*	*T (K)*	*η (N.s.m⁻²)*
373.15	6.9000	426.75	1.5100	455.75	0.7550
389.15	4.4300	435.75	1.2000	468.05	0.5940
405.55	2.7300	446.05	0.9380	476.05	0.5160
417.75	1.8970				

Suggested Equation = 3 Constants: A = -6.5798 B = -1299.50 C = 80.81

% AAD = 1.7 S.D. = 1.00E-04 Temperature Range: 370-480

Butyl valerate

CAS RN: 591-68-4 Source of Data: Reference 74

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
273.15	1.7899	303.15	1.0473	353.15	0.5559
283.15	1.4663	313.15	0.9058	373.15	0.4556
293.15	1.2285	333.15	0.6983		

Suggested Equation = 3 Constants: A = -4.5554 B = -370.73 C = 67.95

% AAD = 0.3 S.D. = 3.20 x 10^{-6} Temperature Range: 270-380

Butyl amine

CAS RN: 109-73-9, Source of Data: Reference 31, 42, 197

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
278.15 [31]	0.7690	333.15	0.3600	344.85	0.3745
288.15	0.6480	291.85 [42]	0.6450	346.20	0.3034
298.15	0.5780	306.15	0.5130	350.85	0.2880
308.15	0.5110	315.40	0.4480	303.15[197]	0.4442
318.15	0.4490	324.85	0.3945	313.15	0.3927

Suggested Equation = 2 Constants: A = 8.03 x 10^{-3} B = 5.50 x 10^{2} C = 0.00

% AAD = 5.098 S.D. = 1.63 x 10^{-2} Temperature Range: 270-360

Butyl benzene

CAS RN: 104-51-8, Source of Data: Reference 17

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
283.15	1.2040	313.15	0.7670	343.15	0.5440
293.15	1.0201	323.15	0.6810	353.15	0.4920
303.15	0.8800	333.15	0.6080		

Suggested Equation = 1 Constants: A = -4.8735 B = 551.98 C = 0.00

% AAD = 0.5 S.D. = 5.90 x 10^{-6} Temperature Range: 280-360

Butyl dodecylacetate

Source of Data: Reference 38

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
273.15	16.6113	303.15	5.2966	353.15	1.7310
283.15	10.6451	313.15	4.0866	373.15	1.2778
293.15	7.3260	333.15	2.5189		

Suggested Equation = 3 Constants: A = -4.2089 B = -287.19 C = 154.82

% AAD = 0.5 S.D. = 4.50 x 10^{-5} Temperature Range: 270-380

Butyl sydnone

CAS RN: 64180-21-8, Source of Data: Reference 58

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
313.15	5.5010	333.15	3.5460	373.15	1.8990
323.15	4.3670	348.15	2.7310	398.15	1.4130

Suggested Equation = 3 Constants: A = -3.9759 B = -279.00 C = 150.51

% AAD = 0.2 S.D. = 8.50 x 10^{-6} Temperature Range: 310-400

Butyraldehyde

CAS RN: 123-72-8, Source of Data: Reference 58

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
291.50	0.4575	323.95	0.3267	345.35	0.2696
311.85	0.3673	333.50	0.2989	348.05	0.2640

Suggested Equation = 1 Constants: A = -4.8100 B = 428.80 C = 0.00

% AAD = 0.1 S.D. = 3.90 x 10^{-7} Temperature Range: 290-350

Butyramide

CAS RN: 541-35-5, Source of Data: Reference 66

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
394.15	1.4550	449.55	0.6266	478.35	0.4366
412.55	1.0720	463.25	0.5242	489.15	0.3858
432.65	0.7916				

Suggested Equation = 3 Constants: A = -5.7609 B = -1130.30 C = 7.61

% AAD = 0.1 S.D. = 4.80 x 10^{-7} Temperature Range: 390-490

Butyric acid

CAS RN: 107-92-6, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
276.36	2.1280	332.54	0.8600	388.39	0.4700
291.17	1.5910	346.51	0.7270	403.41	0.4080
304.98	1.2630	359.70	0.6280	418.12	0.3580
317.64	1.0490	374.70	0.5370	428.91	0.3270

Suggested Equation = 1 Constants: A = -4.9362 B = 623.19 C = 0.00

% AAD = 0.8 S.D. = 1.10 x 10^{-5} Temperature Range: 270-430

Butyric anhydride

CAS RN: 106-31-0, Source of Data: Reference 26

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	1.5710	353.15	0.6800	373.15	0.5530
303.15	1.3370	323.15	0.9830	393.15	0.4530
313.15	1.1400	333.15	0.8610	413.15	0.3760

Suggested Equation = 3 Constants: A = -4.7648 B = -512.55 C = 31.91

% AAD = 0.6 S.D. = 4.10 x 10^{-6} Temperature Range: 290-420

Butyronitrile

CAS RN: 109-74-0, Source of Data: Reference 27, 65

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.15[27]	0.6240	332.55	0.3832	374.45	0.2667
303.15	0.5150	343.05	0.3467	385.65	0.2430
291.15[65]	0.6028	352.55	0.3177	391.15	0.2340
313.75	0.4678	363.25	0.2901		

Suggested Equation = 1 Constants: A = -4.8220 B = 466.49 C = 0.00

% AAD = 0.5 S.D. = 2.80 x 10^{-6} Temperature Range: 280-400

Butyryl chloride

CAS RN: 141-75-3, Source of Data: Reference 66

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.75	0.5735	348.75	0.3322	373.45	0.2750
318.05	0.4408	358.55	0.3073		
332.75	0.3823	368.45	0.2849		

Suggested Equation = 1 Constants: A = -4.7391 B = 439.79 C = 0.00
% AAD = 0.1 S.D. = 4.00 x 10^{-7} Temperature Range: 290-380

Cadmium

CAS RN: 7440-43-9, Source of Data: Reference 100

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
595.35	2.7000	625.35	2.4860	690.15	2.1320
599.35	2.6770	647.15	2.3670	713.25	2.0120
607.35	2.6210	668.25	2.2440	724.95	1.9650

Suggested Equation = 3 Constants: A = -3.6422 B = -941.06 C = -280.31
% AAD = 0.2 S.D. = 6.10 x 10^{-6} Temperature Range: 590-730

Cadmium chloride (molten)

CAS RN: 10108-64-2, Source of Data: Reference 92

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
842.00	2.6200	863.00	2.4170	943.00	1.9210
844.00	2.5800	864.00	2.3240	966.00	1.8430
851.00	2.4680	866.00	2.4170	968.00	1.8380
853.00	2.4600	885.00	2.2620	969.00	1.8330
854.00	2.4480	894.00	2.1660	1005.00	1.7990
857.00	2.4330	908.00	2.1350		

Suggested Equation = 1 Constants: A = -3.6505 B = 889.51 C = 0.00
% AAD = 1.4 S.D. = 3.90 x 10^{-5} Temperature Range: 840-1010

Cadmium nitrate tetrahydrate

CAS RN: 10022-68-1, Source of Data: Reference 101

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
330.00	27.5600	343.00	19.8500		
337.00	24.1300	347.50	17.4100		

Suggested Equation = 3 Constants: A = -3.5460 B = -257.02 C = 203.64
% AAD = 0.2 S.D. = 4.20 x 10^{-5} Temperature Range: 330-350

Calcium chloride dihydrate (molten)

CAS RN: 10035-04-8, Source of Data: Reference 79

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
987.05	4.1695	1075.25	3.0352	1192.85	2.1830
1014.25	3.7469	1103.75	2.7798	1222.65	2.0337
1044.35	3.3635	1104.35	2.7698	1238.65	1.9597
1059.55	3.1964	1133.45	2.5492		
1073.05	3.0571	1161.95	2.3594		

Suggested Equation = 3 Constants: A = -3.6550 B = -927.76 C = 259.33
% AAD = 0.4 S.D. = 1.50 x 10^{-6} Temperature Range: 980-1240

Camphor

CAS RN: 76-22-2, Source of Data: Reference 102

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
453.15	0.6460	468.05	0.5240	493.35	0.3720
458.15	0.5920	476.15	0.4450		
463.25	0.5590	482.85	0.4080		

Suggested Equation = 3 Constants: A = -3.9803 B = -92.51 C = 335.91

% AAD = 0.5 S.D. = 2.80 x 10^{-6} Temperature Range: 450-510

Carbon disulfide

CAS RN: 75-15-0, Source of Data: Reference 4, 40

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.55[4]	0.4280	298.49	0.3560	273.15[40]	0.4360
278.03	0.4130	303.45	0.3420	288.15	0.3800
282.60	0.3970	308.66	0.3280	293.15	0.3630
288.06	0.3810	313.77	0.3170		
293.09	0.3670	319.11	0.3060		

Suggested Equation = 1 Constants: A = -4.3896 B = 279.27 C = 0.00

% AAD = 0.7 S.D. = 4.60 x 10^{-6} Temperature Range: 270-320

Carbon tetrachloride

CAS RN: 56-23-5, Source of Data: Reference 4, 103

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.75[4]	1.3322	343.04	0.5246	373.15	0.3830
280.30	1.1884	347.31	0.5017	383.15	0.3520
288.04	1.0476	293.15[103]	0.9650	393.15	0.3220
294.36	0.9517	303.15	0.8430	403.15	0.2990
300.71	0.8705	313.15	0.7390	413.15	0.2760
308.36	0.7855	323.15	0.6510	423.15	0.2550
315.23	0.7198	333.15	0.5850	433.15	0.2340
322.66	0.6567	343.15	0.5270	443.15	0.2190
329.44	0.6078	353.15	0.4660	453.15	0.2010
336.02	0.5659	363.15	0.4260		

Suggested Equation = 3 Constants: A = -5.1325 B = -722.90 C = -47.67

% AAD = 0.7 S.D. = 6.00 x 10^{-6} Temperature Range: 270-460

Catechol

CAS RN: 120-80-9, Source of Data: Reference 12, 13

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
283.15[12]	2.5800	433.15	1.1351	483.25	0.6368
388.15	2.3600	443.15	0.9954	493.75	0.5794
393.15	2.1800	452.45	0.8932	505.15	0.5152
394.15[13]	2.1710	463.15	0.7898	518.15	0.4554
413.85	1.5010	473.85	0.7024		

Suggested Equation = 3 Constants: A = -4.7182 B = -528.40 C = 135.77

% AAD = 0.8 S.D. = 1.90 x 10^{-5} Temperature Range: 380-520

Chloral

CAS RN: 75-87-6, Source of Data: Reference 94

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
203.15	13.7930	313.15	1.0101	353.15	0.5959
303.15	1.1710	333.15	0.7692		

Suggested Equation = 3 Constants: A = -5.3253 B = -855.91 C = -54.20

% AAD = 0.2 S.D. = 2.40 x 10^{-6} Temperature Range: 290-360

Chlorine trifluoride

CAS RN: 7790-91-2, Source of Data: Reference 104

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
290.45	0.4480	299.15	0.4070	312.95	0.3520
290.85	0.4470	305.70	0.3800	321.15	0.3230
292.55	0.4380	309.45	0.3650		

Suggested Equation = 2 Constants: A = 46831.0000 B = -3.2556 C = 0.00

% AAD = 0.1 S.D. = 4.70 x 10^{-7} Temperature Range: 290-325

Chlorodifluoromethane

CAS RN: 75-45-6, Source of Data: Reference 105

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
200.66	0.5128	244.90	0.2967	285.54	0.2058
215.41	0.4161	257.74	0.2654	299.12	0.1834
230.05	0.3477	271.07	0.2329		

Suggested Equation = 3 Constants: A = -4.7458 B = -328.78 C = -25.02

% AAD = 0.6 S.D. = 2.10 x 10^{-6} Temperature Range: 200-300

Chlorofluoromethane

CAS RN: 593-70-4, Source of Data: Reference 105

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
192.20	0.9383	270.66	0.3127	284.16	0.2768
210.93	0.6671	241.03	0.4364	299.75	0.2431
225.88	0.5293	255.39	0.3662	314.55	0.2167

Suggested Equation = 3 Constants: A = -4.5953 B = -281.37 C = 12.76

% AAD = 0.2 S.D. = 1.10 x 10^{-6} Temperature Range: 190-320

Chloroform

CAS RN: 67-66-3, Source of Data: Reference 4, 105, 106, 175, 212

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.48[4]	0.6979	325.87	0.4156	319.42	0.4450
278.41	0.6594	330.09	0.4006	334.41	0.3922
283.41	0.6242	210.08[105]	1.9615	353.20	0.3397
289.07	0.5876	224.43	1.4600	288.15[106]	0.5960
294.57	0.5562	237.96	1.1538	303.15	0.5140
299.08	0.5314	252.55	0.9278	298.15[175]	0.5320
304.62	0.5039	264.34	0.7931	293.15[212]	0.5760
309.97	0.4787	277.33	0.6779	298.15	0.5450
315.21	0.4565	289.51	0.5939	303.15	0.5340
320.03	0.4378	304.73	0.5093	308.15	0.4980

Suggested Equation = 3 Constants: A = -1.47 B = -3.34 x 10^{2} C = 2.04x 10^{1}

%AAD = 0.7964 SD = 6.44 x 10^{-4} Temperature Range: 210-360

cis-1,2-Dichloroethylene

CAS RN: 156-59-2, Source of Data: Reference 107

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
208.15	1.5380	243.15	0.8430	273.15	0.5770
213.15	1.3930	248.15	0.7910	278.15	0.5460
218.15	1.2710	253.15	0.7380	283.15	0.5160
223.15	1.1560	258.15	0.6900	288.15	0.4900
228.15	1.0570	263.15	0.6470	293.15	0.4670
233.15	0.9730	268.15	0.6090	298.15	0.4440
238.15	0.9040				

Suggested Equation = 3 Constants: A = -4.4812 B = -315.48 C = 18.95

% AAD = 0.3 S.D. = 3.40 x 10^{-6} Temperature Range: 200-300

cis-Decahydro naphthalene

CAS RN: 493-01-6, Source of Data: Reference 108

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
243.15	15.7610	313.15	2.2390	383.15	0.8190
253.15	10.6770	321.15	1.8670	393.15	0.7520
263.15	7.5820	333.15	1.5880	403.15	0.6840
273.15	5.6200	343.15	1.3630	423.15	0.5690
283.15	4.3000	353.15	1.1880	433.15	0.5210
293.15	3.3810	363.15	1.0450	443.15	0.4790
303.15	2.7230	373.15	0.9200	453.15	0.4390

Suggested Equation = 3 Constants: A = -4.4480 B = -395.48 C = 93.36

% AAD = 0.6 S.D. = 4.40 x 10^{-5} Temperature Range: 240-460

Corn Oil

CAS RN: 8001-30-7, Source of Data: Reference 109

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	70	313.15	30	333.15	16

Suggested Equation = 3 Constants: A = -3.5581 B = -263.32 C = 183.60

% AAD = 0.5 S.D. = 1.30E-04 Temperature Range: 290-340

Cumene

CAS RN: 98-82-8, Source of Data: Reference 17

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	1.0750	293.15	0.7880	313.15	0.6110
283.15	0.9150	303.15	0.6910		

Suggested Equation = 1 Constants: A = -4.8910 B = 524.64 C = 0.00

% AAD = 0.3 S.D. = 3.00 x 10^{-6} Temperature Range: 270-320

Cyclohexane

CAS RN: 110-82-7, Source of Data: Reference 42, 8, 17, 180, 197, 190, 209

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
284.35[42]	1.1580	303.15	0.8220	308.15	0.644
310.85	0.7560	313.15	0.7060	298.15[190]	0.8859
327.15	0.5924	323.15	0.6100	313.15	0.6983
340.15	0.4926	333.15	0.5380	298.15[209]	0.8958
348.85	0.4408	343.15	0.4740	303.15	0.8224
353.85	0.4130	353.15	0.4260	308.15	0.7575
288.15[8]	1.0560	298.15[180]	0.8945	313.15	0.6995
303.15	0.8200	313.15	0.7038	318.15	0.6536
333.15	0.5340	298.15[197]	0.8760	323.15	0.6045
293.15[17]	0.9700	303.15	0.702		

Suggested Equation = 1 Constants: A = -2.12 B = 6.15 x 10^{2} C = 0.00

% AAD = 2.25 S.D. = 1.00 x 10^{-2} Temperature Range: 280-360

Cyclohexanol

CAS RN: 108-93-0, Source of Data: Reference 42, 49, 110

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
372.55[42]	2.0770	412.45	0.8510	312.25[49]	20.3200
389.65	1.3730	420.55	0.7250	339.05	5.8380
397.85	1.1520	424.15	0.7560	363.15	2.4590
405.15	0.9880	431.65	0.5890	303.15[110]	41.0670

Suggested Equation = 3 Constants: A = -4.8184 B = -388.21 C = 189.65

% AAD = 3.8 S.D. = 7.20E-04 Temperature Range: 300-440

Cyclohexanone

CAS RN: 108-94-1, Source of Data: Reference 10, 110, 49

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
289.5[10]	2.5180	402.15	0.4940	303.15	1.8030
330.90	1.1720	420.15	0.4147	290.45[49]	2.3000
358.65	0.7990	426.65	0.3910	312.25	1.5490
382.80	0.6000	288.15[110]	2.4530	339.05	1.0120

Suggested Equation = 1 Constants: A = -5.0732 B = 708.98 C = 0.00

% AAD = 1.5 S.D. = 4.50 x 10^{-5} Temperature Range: 280-430

Cyclohexene

CAS RN: 110-83-8, Source of Data: Reference 15, 17

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
291.85[15]	0.6893	343.90	0.3821	283.15	0.7590
314.75	0.5680	352.75	0.3471	293.15	0.6600
323.15	0.4720	356.85	0.3350	303.15	0.5810
333.25	0.4231	273.15[17]	0.8830	313.15	0.5150

Suggested Equation = 1 Constants: A = -4.8401 B = 487.75 C = 0.00

% AAD = 0.8 S.D. = 5.40 x 10^{-6} Temperature Range: 270-360

Cyclohexyl bromide

CAS RN: 108-85-0, Source of Data: Reference 42

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
289.35	2.6000	394.15	0.5975	435.15	0.4240
361.75	0.8350	407.55	0.5300		
379.65	0.6869	428.15	0.4460		

Suggested Equation = 3 Constants: A = -4.5225 B = -412.40 C = 76.454

% AAD = 0.2 S.D. = 1.60 x 10^{-6} Temperature Range: 280-440

Cyclohexyl chloride

CAS RN: 542-18-7, Source of Data: Reference 42

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
291.35	1.6590	359.45	0.6258	394.65	0.4391
320.85	1.0190	370.95	0.5536	406.55	0.3966
334.25	0.8440	383.25	0.4891	415.15	0.3680
346.95	0.7230				

Suggested Equation = 3 Constants: A = -4.6971 B = -460.15 C = 51.188

% AAD = 0.0 S.D. = 2.10 x 10^{-6} Temperature Range: 290-420

Cyclohexyl amine

CAS RN: 108-91-8, Source of Data: Reference 42

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
288.25	2.4720	355.25	0.7117	398.95	0.4269
316.65	1.3070	374.95	0.5543	405.65	0.4000
339.55	0.8935	386.85	0.4853		

Suggested Equation = 3 Constants: A = -4.6016 B = -357.42 C = 109.06

% AAD = 0.4 S.D. = 4.60 x 10^{-5} Temperature Range: 280-410

Cyclopentane

CAS RN: 287-92-3, Source of Data: Reference 110, 17

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
288.15[110]	0.4600	283.15	0.4910	313.15	0.3540
303.15	0.3880	293.15	0.4390		
273.15[17]	0.5550	303.15	0.3930		

Suggested Equation = 1 Constants: A = -4.7916 B = 419.62 C = 0.00

% AAD = 0.4 S.D. = 1.90 x 10^{-6} Temperature Range: 270-320

Decahydro naphthalene

CAS RN: 91-17-8, Source of Data: Reference 111

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
298.15	2.4149	323.15	1.5830	348.15	1.0853

Suggested Equation = 1 Constants: A = -5.0332 B = 720.71 C = 0.00

% AAD = 0.4 S.D. = 7.00 x 10^{-6} Temperature Range: 290-350

Decane

CAS RN: 124-18-5, Source of Data: Reference 17, 25, 203, 213, 214

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
243.15[17]	2.5100	283.15	1.0595	373.15	0.3569
253.15	1.9300	293.15	0.9019	298.15[203]	0.8590
263.15	1.5500	303.15	0.7772	293.15[213]	0.9183
273.15	1.2700	313.15	0.6786	298.15	0.8505
283.15	1.0700	333.15	0.5333	308.15[214]	0.7406
293.15	0.9070	353.15	0.4314	313.15	0.6924
273.28[25]	1.2645				

Suggested Equation = 3 Constants: A = -1.60 B = -3.58 x 10^{2} C = 6.36x 10^{1}

%AAD = 0.857368 SD = 3.47 x 10^{-4} Temperature Range: 240-380

Decanoic acid

CAS RN: 334-48-5, Source of Data: Reference 112

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
323.15	4.3400	343.15	2.8800	353.15	2.4390

Suggested Equation = 1 Constants: A = -5.3278 B = 957.82 C = 0.00

% AAD = 0.6 S.D. = 2.00 x 10^{-5} Temperature Range: 320-355

Decene

CAS RN: 872-05-9, Source of Data: Reference 26

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15	0.8280	323.15	0.5600	373.15	0.3380
303.15	0.7250	333.15	0.5040	393.15	0.2880
313.15	0.6360	353.15	0.4060	413.15	0.2430

Suggested Equation = 3 Constants: A = -4.9646 B = -576.81 C = -13.15

% AAD = 0.4 S.D. = 1.90 x 10^{-6} Temperature Range: 290-420

Deuterium oxide

CAS RN: 7789-20-0, Source of Data: Reference 113

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
283.15	1.6740	293.15	1.2477	303.15	0.9741
288.15	1.4355	298.15	1.0975	308.15	0.8324

Suggested Equation = 3 Constants: A = -4.2911 B = -164.97 C = 174.24

% AAD = 0.1 S.D. = 4.10 x 10^{-7} Temperature Range: 280-310

Dibutyl amine

CAS RN: 111-92-2, Source of Data: Reference 31, 65

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
278.15[31]	1.2790	353.15	0.4210	383.75	0.3090
288.15	1.1330	373.15	0.3540	394.15	0.2835
298.15	0.9460	398.15	0.2810	403.45	0.2626
308.15	0.7930	423.15	0.2320	412.85	0.2441
318.15	0.6760	332.05[65]	0.5343	424.35	0.2242
328.15	0.5830	374.45	0.3354	432.15	0.2124
338.15	0.5090				

Suggested Equation = 3 Constants: A = -4.6971 B = -360.91 C = 80.751

% AAD = 1.7 S.D. = 2.00 x 10^{-5} Temperature Range: 270-440

Dibutyl carbonate

CAS RN: 10411-36-4, Source of Data: Reference 26

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	1.9200	333.15	0.9820	393.15	0.6020
303.15	1.5800	353.15	0.8580	413.15	0.4920
313.15	1.3260	373.15	0.7560	433.15	0.4100
323.15	1.1320				

Suggested Equation = 3 Constants: A = -3.9131 B = -155.55 C = 163.43
% AAD = 2.5 S.D. = 2.50 x 10^{-5} Temperature Range: 290-420

Dichloroacetic acid

CAS RN: 79-43-6, Source of Data: Reference 10

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
292.45	5.4800	393.15	1.0830	453.15	0.5034
360.95	1.6720	413.45	0.8530	462.65	0.5272
372.65	1.4130	433.15	0.7000		

Suggested Equation = 3 Constants: A = -5.1869 B = -929.48 C = -25.087
% AAD = 0.6 S.D. = 8.20 x 10^{-6} Temperature Range: 290-470

Dichlorofluoromethane

CAS RN: 75-43-4, Source of Data: Reference 105, 11

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
207.78[105]	0.9280	221.00	0.7320	277.00	0.3290
222.42	0.7347	225.00	0.6820	281.00	0.3150
236.96	0.6008	229.00	0.6380	285.00	0.3020
250.74	0.5066	233.00	0.5970	289.00	0.2890
263.34	0.4405	237.00	0.5600	293.00	0.2770
276.81	0.3841	241.00	0.5270	297.00	0.2660
291.18	0.3367	245.00	0.4970	301.00	0.2560
306.03	0.2978	249.00	0.4690	305.00	0.2470
319.60	0.2687	253.00	0.4440	309.00	0.2380
333.64	0.2434	257.00	0.4210	313.00	0.2290
346.71	0.2320	261.00	0.4000	317.00	0.2210
209.00[11]	0.9180	265.00	0.3800	325.00	0.2070
213.00	0.8490	269.00	0.3620	329.00	0.2000
217.00	0.7870	273.00	0.3450		

Suggested Equation = 3 Constants: A = -4.6041 B = -336.39 C = -6.3451
% AAD = 0.1 S.D. = 5.90 x 10^{-7} Temperature Range: 200-350

Dichloromethane

CAS RN: 75-09-2, Source of Data: Reference 4, 105, 61, 175

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
273.61[4]	0.5329	208.38[105]	1.4157	328.22	0.3208
278.88	0.5023	221.89	1.0867	343.22	0.2877
283.33	0.4794	249.64	0.7090	358.16	0.2608
288.60	0.4545	265.81	0.5793	373.98	0.2366
293.68	0.4330	277.21	0.5093	288.15[61]	0.4490
298.74	0.4137	288.45	0.4548	303.15	0.3930
304.13	0.3933	300.76	0.4043	298.15[175]	0.4060
310.66	0.3707	313.21	0.3619		

Suggested Equation = 3 Constants: A = -1.52 B = -3.18 x 10^{2} C = 1.76x 10^{1}
%AAD = 0.428442 SD = 1.44 x 10^{-4} Temperature Range: 200-380

Diclorodifluoromethane

CAS RN: 75-71-8, Source of Data: Reference 11

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
213.00	0.4978	253.00	0.3453	293.00	0.2654
217.00	0.4770	257.00	0.3352	297.00	0.2588
221.00	0.4578	261.00	0.3253	301.00	0.2531
225.00	0.4400	265.00	0.3162	305.00	0.2478
229.00	0.4235	269.00	0.3075	309.00	0.2427
233.00	0.4080	273.00	0.2994	313.00	0.2378
237.00	0.3938	277.00	0.2917	317.00	0.2331
241.00	0.3805	281.00	0.2840	321.00	0.2286
245.00	0.3680	285.00	0.2774	325.00	0.2243
249.00	0.3563	289.00	0.2710	329.00	0.2203

Suggested Equation = 1 Constants: A = -4.3063 B = 213.62 C = 0.00
% AAD = 0.1 S.D. = 3.20 x 10^{-7} Temperature Range: 210-330

Diethyl carbonate

CAS RN: 105-58-8, Source of Data: Reference 26, 202

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
293.15[26]	0.8130	333.15	0.4950	298.15[202]	0.7490
303.15	0.7070	353.15	0.4450	308.15	0.6580
313.15	0.6230	373.15	0.4030	318.15	0.5780
323.15	0.5530	393.15	0.3340		

Suggested Equation = 3 Constants: A = -8.97E-01 B -9.59x 10^{1} C = 1.74 x 10^{2}
%AAD = 1.625183 SD = 1.01 x 10^{-3} Temperature Range: 290-400

Diethylamine

CAS RN: 109-89-7, Source of Data: Reference 65, 31

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
283.35 (1)	0.3878	329.10	0.2250	303.15	0.2990
310.75	0.2732	283.15 (2)	0.3860	313.15	0.2680
317.55	0.2540	293.15	0.3380	323.15	0.2360
324.85	0.2357				

Suggested Equation = 1 Constants: A = -5.1067 B = 479.98 C = 0.40
% AAD = 0.4 S.D. = 1.40 x 10^{-6} Temperature Range: 280-330

Diethylene glycol dinitrate

CAS RN: 693-21-0, Source of Data: Reference 114

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
283.15	11.9048	303.15	5.7143	323.15	3.4965
288.15	9.7087	313.15	4.3668	328.15	3.0581
293.15	8.0645	318.15	3.8314	333.15	2.7473
298.15	6.7114				

Suggested Equation = 3 Constants: A = -3.8314 B = -192.04 C = 182.51
% AAD = 0.7 S.D. = 3.70 x 10^{-5} Temperature Range: 280-340

Difluoroacetic acid

CAS RN: 381-73-7, Source of Data: Reference 2

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
293.15	2.9828	315.15	1.9040	333.15	1.2960
303.15	2.3320	323.15	1.5500		

Suggested Equation = 3 Constants: A = -4.5695 B = -380.88 C = 106.79
% AAD = 0.4 S.D. = 9.20 x 10^{-6} Temperature Range: 290-340

Difluoro methane

CAS RN: 75-10-5, Source of Data: Reference 105

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
200.28	0.5353	229.35	0.3407	246.77	0.2688
211.36	0.4438	233.72	0.3206	271.04	0.1984
222.88	0.3735	244.75	0.2766	287.31	0.1617

Suggested Equation = 2 Constants: A = 1.8082E4 B = -3.27 C = 0.00
% AAD = 0.4 S.D. = 1.60 x 10^{-6} Temperature Range: 200-290

Diheptyl amine

CAS RN: 2470-68-0, Source of Data: Reference 31

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
298.15	3.1060	328.15	1.6500	373.15	0.8830
308.15	2.4340	338.15	1.3990	398.15	0.6370
318.15	1.9950	348.15	1.2000	423.15	0.4980

Suggested Equation = 3 Constants: A = -4.5966 B = -429.86 C = 91.79
% AAD = 1.1 S.D. = 2.00 x 10^{-5} Temperature Range: 290-430

Diisobutyl amine

CAS RN: 110-96-3, Source of Data: Reference 31

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
278.15	1.0090	308.15	0.6300	353.15	0.3650
288.15	0.8490	318.15	0.5420	373.15	0.3090
298.15	0.7260	328.15	0.4740	398.15	0.2450

Suggested Equation = 3 Constants: A = -4.6618 B = -345.27 C = 71.14
% AAD = 0.8 S.D. = 4.30 x 10^{-6} Temperature Range: 270-400

Diisopentyl amine

CAS RN: 544-00-3, Source of Data: Reference 31

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
278.15	1.9530	318.15	0.9330	373.15	0.4500
288.15	1.5720	328.15	0.7890	398.15	0.3540
298.15	1.2850	338.15	0.6810	423.15	0.2870
308.15	1.0930	353.15	0.5640		

Suggested Equation = 3 Constants: A = -4.7264 B = -415.49 C = 72.234

% AAD = 0.5 S.D. = 6.70 x 10^{-6} Temperature Range: 270-430

Diisopropenyl

CAS RN: 540-49-8, Source of Data: Reference 4

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
273.52	0.3374	293.91	0.2719	315.14	0.2229
279.10	0.3169	298.61	0.2599	319.91	0.2137
283.83	0.3010	303.86	0.2474	324.69	0.2047
288.61	0.2866	309.21	0.2355	329.35	0.1966

Suggested Equation = 3 Constants: A = -5.3047 B = -701.20 C = -109.18

% AAD = 0.1 S.D. = 3.00 x 10^{-7} Temperature Range: 270-330

Diisopropyl amine

CAS RN: 108-18-9, Source of Data: Reference 31

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
283.15	0.4730	313.15	0.3330	353.15	0.2270
293.15	0.4150	333.15	0.2730		

Suggested Equation = 3 Constants: A = -5.0566 B = -540.15 C = -29.01

% AAD = 0.3 S.D. = 1.10 x 10^{-6} Temperature Range: 280-360

Dimethyl carbonate

CAS RN: 616-38-6, Source of Data: Reference 26, 202

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
293.15[26]	0.6250	333.15	0.3920	298.15[202]	0.5890
303.15	0.5490	353.15	0.3550	308.15	0.5200
313.15	0.4870	373.15	0.3230	318.15	0.4720
323.15	0.4350				

Suggested Equation = 3 Constants: A = -8.22E-01 B -5.50x 10^{1} C = 2.05 x 10^{2}

%AAD = 1.128617 SD = 3.98 x 10^{-4} Temperature Range: 290-380

Dimethyl amine

CAS RN: 124-40-3, Source of Data: Reference 115

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
288.15	0.2070	298.15	0.1860	308.15	0.1670

Suggested Equation = 1 Constants: A = -5.1197 B = 413.84 C = 0.00

% AAD = 0.2 S.D. = 3.50 x 10^{-7} Temperature Range: 280-310

Dipentyl amine

CAS RN: 2050-92-2, Source of Data: Reference 31

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
278.15	2.2560	318.15	1.0060	373.15	0.4870
288.15	1.7740	328.15	0.8550	398.15	0.3830
298.15	1.4380	338.15	0.7470	423.15	0.3100
308.15	1.1890	348.15	0.6480		

Suggested Equation = 3 Constants: A = -4.5796 B = -349.69 C = 97.021

% AAD = 0.4 S.D. = 4.60 x 10^{-6} Temperature Range: 270-430

Diphenyl amine

CAS RN: 122-39-4, Source of Data: Reference 44, 87

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	13.5682	334.15	4.1701	403.15	1.0400
313.15	8.5179	354.15	2.5252		

Suggested Equation = 3 Constants: A = -4.8400 B = -654.74 C = 11.031

% AAD = 0.3 S.D. = 2.10 x 10^{-6} Temperature Range: 330-540

Diphenyl methane

CAS RN: 101-81-5, Source of Data: Reference 15

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
332.75	1.5640	418.55	0.5820	464.45	0.4025
373.15	0.9310	434.65	0.5072	484.15	0.3492
403.05	0.6805	451.45	0.4420	533.65	0.2590

Suggested Equation = 3 Constants: A = -4.8400 B = -654.74 C = 11.031

% AAD = 0.3 S.D. = 2.10 x 10^{-6} Temperature Range: 330-540

Dipropyl amine

CAS RN: 142-84-7, Source of Data: Reference 31, 65

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
278.15[31]	0.6930	333.15	0.3360	337.65	0.3179
288.15	0.6130	353.15	0.2780	352.65	0.2744
289.15	0.5250	293.25[65]	0.5335	366.45	0.2422
303.15	0.4900	310.35	0.4267	376.65	0.2215
308.15	0.4530	325.45	0.3610	382.05	0.2116
313.15	0.4350				

Suggested Equation = 1 Constants: A = -5.0577 B = 528.10 C = 0.00

% AAD = 1.3 S.D. = 8.50 x 10^{-6} Temperature Range: 270-390

Ditellurium decafluoride

CAS RN: 53214-07-6, Source of Data: Reference 116

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
243.15	0.2542	273.15	0.1533	305.35	0.1053
250.15	0.2210	291.35	0.1209	318.05	0.0930
262.15	0.1791	298.15	0.1140		

Suggested Equation = 3 Constants: A = -4.8292 B = -170.32 C = 105.09

% AAD = 0.4 S.D. = 6.30 x 10^{-7} Temperature Range: 240-320

Dodecane

CAS RN: 112-40-3, Source of Data: Reference 25

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.27	2.2935	303.15	1.2670	353.15	0.6363
283.15	1.8285	313.15	1.0915	373.22	0.5118
293.15	1.4930	333.15	0.8134		

Suggested Equation = 3 Constants: A = -4.5578 B = -375.97 C = 76.83

% AAD = 0.6 S.D. = 1.20 x 10^{-5} Temperature Range: 270-380

Dodecanoic acid

CAS RN: 143-07-7, Source of Data: Reference 25

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
323.15	6.8770	373.15	2.4570	433.15	1.0410
333.15	5.3670	393.15	1.7890		
353.15	3.5100	413.15	1.3500		

Suggested Equation = 3 Constants: A = -4.7935 B = -643.12 C = 78.51

% AAD = 0.5 S.D. = 2.00 x 10^{-5} Temperature Range: 320-440

Dodecyl thiopalmitate

CAS RN: , Source of Data: Reference 117

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
333.15	9.1000	348.15	6.5970	363.15	5.0040

Suggested Equation = 3 Constants: A = -3.8590 B = -327.41 C = 153.05

% AAD = 0.1 S.D. = 2.70 x 10^{-6} Temperature Range: 330-370

Eicosane

CAS RN: 112-95-8, Source of Data: Reference 17

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
313.15	4.0720	363.15	1.6140	433.15	0.7170
323.15	3.2590	373.15	1.4030	453.15	0.5980
333.15	2.6650	393.15	1.0940	473.15	0.5050
343.15	2.2200	413.15	0.8760	493.15	0.4320
353.15	1.1880				

Suggested Equation = 3 Constants: A = -4.5977 B = -509.04 C = 81.873

% AAD = 0.8 S.D. = 2.10 x 10^{-5} Temperature Range: 310-500

Ethanethiol

CAS RN: 75-08-1, Source of Data: Reference 25

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.24	0.3632	293.15	0.2999		
283.15	0.3298	298.15	0.2876		

Suggested Equation = 1 Constants: A = -4.6584 B = 333.01 C = 0.00

% AAD = 0.1 S.D. = 3.20 x 10^{-7} Temperature Range: 270-300

Ethanol

CAS RN: 64-17-5, Source of Data: Reference 21, 30, 4, 105, 197, 183, 212, 189

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
288.15 [21]	1.2800	292.37	1.2094	289.15	1.0920
298.15	1.0560	298.39	1.0792	303.15	0.9960
308.15	0.8818	305.04	0.9560	308.15	0.9100
318.15	0.7461	310.66	0.8644	313.15	0.8330
328.15	0.6302	315.99	0.7875	323.15	0.7010
213.15 [30]	9.5900	322.52	0.7047	328.15	0.6450
223.15	6.8400	328.72	0.6354	333.15	0.5950
233.15	4.9000	334.22	0.5815	338.15	0.5490
243.15	3.5800	340.70	0.5233	343.15	0.5080
253.15	2.7600	346.72	0.4764	348.15	0.4700
263.15	2.1800	273.15 [105]	1.7850	303.15[197]	0.993
273.15	1.7700	278.15	1.6110	313.15	0.8291
283.15	1.4500	283.15	1.4560	303.15[183]	0.9950
293.15	1.1900	288.15	1.3210	298.15[212]	1.105
280.31 [4]	1.5328	293.15	1.2000	298.15[189]	1.0694
286.38	1.3573				

Suggested Equation = 3 Constants: A = -2.52 B = -7.99×10^{2} C = -1.59×10^{1}

%AAD = 1.695452 SD = 6.46×10^{-3} Temperature Range: 210-350

Ether

CAS RN: 60-29-7, Source of Data: Reference 4, 40

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
280.32[4]	0.2660	291.20	0.2389	302.81	0.2152
282.69	0.2595	293.70	0.2334	304.29	0.2118
284.86	0.2540	290.24	0.2276	305.19	0.2096
286.97	0.2489	298.02	0.2243	273.15[40]	0.2790
289.03	0.2438	300.19	0.2196	288.15	0.2470

Suggested Equation = 2 Constants: A = 950.6900 B = -2.679 C = 0.00

% AAD = 0.4 S.D. = 1.40×10^{-6} Temperature Range: 270-310

Ethoxybenzene

CAS RN: 103-73-1, Source of Data: Reference 15

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
291.15	1.3560	370.25	0.4673	422.45	0.2970
330.95	0.7246	390.15	0.3899	438.15	0.2619
350.75	0.5738	410.65	0.3261	445.15	0.2480

Suggested Equation = 3 Constants: A = -4.7732 B = -469.95 C = 44.325

% AAD = 0.8 S.D. = 4.50×10^{-6} Temperature Range: 290-450

Ethyl acetate

CAS RN: 141-78-6, Source of Data: Reference 28, 22, 198

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.40[28]	0.5763	317.27	0.3455	288.15[22]	0.4730
282.04	0.5142	324.30	0.3224	303.15	0.4000
287.62	0.4795	333.32	0.2960	298.15[198]	0.4240
293.53	0.4418	341.59	0.2741	303.15	0.4000
301.17	0.4096	347.75	0.2594	308.15	0.3850
309.69	0.3738				

Suggested Equation = 3 Constants: A = -2.00 B = -5.38 x 10^2 C = -3.28x 10^1

%AAD = 0.315849 SD = 7.78 x 10^{-5} Temperature Range: 270-350

Ethyl benzene

CAS RN: 100-41-4, Source of Data: Reference 4, 8, 178

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.56[4]	0.8690	336.96	0.3810	404.55	0.2410
284.56	0.7440	356.77	0.3490	288.15[8]	0.6970
294.81	0.6540	368.75	0.3160	304.15	0.5810
306.05	0.5720	381.12	0.2870	303.15[178]	0.5840
320.26	0.4910	392.34	0.2630	313.15	0.5310
333.66	0.4300				

Suggested Equation = 3 Constants: A = -1.77 B = 4.67 x 10^2 C = 0.00

% AAD = 1.243 S.D. = 1.34 x 10^{-3} Temperature Range: 270-410

Ethyl butyrate

CAS RN: 105-54-4, Source of Data: Reference 118, 119, 61, 112

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15[118]	0.6680	288.15[61]	0.7110	298.15[112]	0.6350
293.15[119]	0.6810	303.15	0.5950	323.15	0.4500

Suggested Equation = 3 Constants: A = -2.6811 B = -56.93 C = 409.09

% AAD = 1.0 S.D. = 6.60 x 10^{-6} Temperature Range: 280-330

Ethyl caprate

CAS RN: 110-38-3, Source of Data: Reference 120

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
308.15	1.7390	338.15	1.0870	368.15	0.7290
323.15	1.3530	353.15	0.8174		

Suggested Equation = 1 Constants: A = -5.1557 B = 738.29 C = 0.00

% AAD = 2.1 S.D. = 2.40 x 10^{-5} Temperature Range: 300-370

Ethyl caproate

CAS RN: 125-66-0, Source of Data: Reference 120

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
308.15	0.8182	338.15	0.5665	368.15	0.4174
323.15	0.6734	353.15	0.4832		

Suggested Equation = 3 Constants: A = -4.7822 B = -488.78 C = 19.77

% AAD = 0.1 S.D. = 4.90 x 10^{-7} Temperature Range: 300-370

Ethyl cyanoacetate

CAS RN: 105-56-6, Source of Data: Reference 65

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
352.85	0.9710	414.75	0.4907	458.95	0.3389
384.15	0.6667	429.15	0.4332	473.75	0.3049
400.35	0.5643	444.15	0.3812	480.15	0.2910

Suggested Equation = 3 Constants: A = -4.9267 B = -648.38 C = 13.921

% AAD = 0.2 S.D. = 8.80 x 10^{-7} Temperature Range: 350-490

Ethyl cyclohexane

CAS RN: 1678-91-7, Source of Data: Reference 17

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	1.1390	293.15	0.8390	313.15	0.6490
283.15	0.9720	303.15	0.7350		

Suggested Equation = 3 Constants: A = -4.5094 B = -338.98 C = 56.68

% AAD = 0.1 S.D. = 4.70 x 10^{-7} Temperature Range: 270-320

Ethyl fluoroacetate

CAS RN: 459-72-3, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	0.9580	313.15	0.7078	333.15	0.5530
303.15	0.8176	323.15	0.6191		

Suggested Equation = 3 Constants: A = -4.4366 B = -278.91 C = 96.40

% AAD = 0.2 S.D. = 1.40 x 10^{-6} Temperature Range: 290-340

Ethyl formate

CAS RN: 109-94-4, Source of Data: Reference 4, 61

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.61[4]	0.5024	295.74	0.3916	316.52	0.3178
279.72	0.4656	301.05	0.3698	321.78	0.3031
284.67	0.4409	306.40	0.3501	325.18	0.2942
289.73	0.4172	311.24	0.3344	288.15[61]	0.4190

Suggested Equation = 3 Constants: A = -4.5771 B = -297.60 C = 40.87

% AAD = 0.2 S.D. = 1.50 x 10^{-6} Temperature Range: 270-330

Ethyl heptanoate

CAS RN: 106-30-9, Source of Data: Reference 74

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	1.8308	303.15	1.0642	353.15	0.5614
283.15	1.4959	313.15	0.9201	373.15	0.4606
293.15	1.2505	333.15	0.7050		

Suggested Equation = 3 Constants: A = -4.5344 B = -360.05 C = 72.64

% AAD = 0.2 S.D. = 3.00 x 10^{-6} Temperature Range: 270-380

Ethyl lactate

CAS RN: 687-47-8, Source of Data: Reference 25

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.33	5.2851	303.15	2.0420	353.15	0.7797
283.15	3.6805	313.15	1.6085	373.15	0.5595
293.15	2.6810	336.15	1.0795		

Suggested Equation = 3 Constants: A = -4.7088 B = -369.10 C = 121.15

% AAD = 1.7 S.D. = 4.20 x 10^{-5} Temperature Range: 270-380

Ethyl laurate

CAS RN: 106-33-2, Source of Data: Reference 121

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
308.15	2.4440	338.15	1.4630	368.15	0.9677
323.15	1.8540	353.15	1.1770		

Suggested Equation = 3 Constants: A = -4.6066 B = -474.53 C = 70.200

% AAD = 0.2 S.D. = 3.04 x 10^{-6} Temperature Range: 300-370

Ethyl myristate

CAS RN: 124-06-1, Source of Data: Reference 120

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
308.15	3.3180	338.15	1.8690	368.15	1.2310
323.15	2.4330	353.15	1.4890		

Suggested Equation = 3 Constants: A = -4.0528 B = -250.11 C = 149.25

% AAD = 0.1 S.D. = 2.70 x 10^{-6} Temperature Range: 300-370

Ethyl palmitate

CAS RN: 628-97-7, Source of Data: Reference 120

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
308.15	4.4590	338.15	2.4150	368.15	1.5160
323.15	3.2080	353.15	1.8920		

Suggested Equation = 3 Constants: A = -4.3120 B = -375.53 C = 116.66

% AAD = 0.1 S.D. = 2.90 x 10^{-6} Temperature Range: 300-370

Ethyl propionate

CAS RN: 105-37-3, Source of Data: Reference 28, 22, 191

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.54 [28]	0.6890	323.14	0.3818	362.84	0.2627
283.24	0.6037	332.29	0.3478	288.15 [22]	0.5640
293.24	0.5317	342.19	0.3155	303.15	0.4730
302.89	0.4736	345.27	0.3074	308.15[191]	0.4670
313.03	0.4231	353.30	0.2855	318.15	0.4360

Suggested Equation = 3 Constants: A = -2.82 B = -1.28 x 10^3 C = -2.08 x 10^2

%AAD = 1.413701 SD = 1.32 x 10^{-3} Temperature Range: 270-370

Ethyl stearate

CAS RN: 111-61-5, Source of Data: Reference 120

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
308.15	5.6890	338.15	2.9860	368.15	1.8310
323.15	4.0410	353.15	2.2920		

Suggested Equation = 3 Constants: A = -4.2849 B = -383.58 C = 120.19
% AAD = 0.2 S.D. = 8.50 x 10^{-6} Temperature Range: 300-370

Ethyl sulfide

CAS RN: 352-93-2, , Source of Data: Reference 4

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.36	0.5575	305.78	0.3899	336.65	0.2947
281.47	0.5059	313.24	0.3628	344.40	0.2761
289.00	0.4645	320.90	0.3381	353.46	0.2563
297.79	0.4237	329.64	0.3126	361.14	0.2406

Suggested Equation = 3 Constants: A = -5.0494 B = -622.24 C = -73.35
% AAD = 0.2 S.D. = 6.20 x 10^{-7} Temperature Range: 270-370

Ethyl tetradecanol

CAS RN: , Source of Data: Reference 38

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15	38.0518	313.15	14.9098	353.15	3.7893
303.15	21.1374	333.15	7.0274	373.15	2.2894

Suggested Equation = 3 Constants: A = -5.0490 B = -572.23 C = 135.51
% AAD = 0.2 S.D. = 2.80 x 10^{-5} Temperature Range: 290-380

Ethyl tetradecyl acetate

Source of Data: Reference 38

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	15.1057	303.15	5.5218	353.15	1.8639
283.15	10.7818	313.15	4.2105	373.15	1.3833
293.15	7.4850	333.15	2.6795		

Suggested Equation = 3 Constants: A = -4.2793 B = -333.42 C = 138.16
% AAD = 1.0 S.D. = 1.80E-04 Temperature Range: 270-380

Ethyl valerate

CAS RN: 539-82-2, Source of Data: Reference 74

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.24	1.1472	303.15	0.7239	353.15	0.4140
283.15	0.9664	313.15	0.6254	373.15	0.3456
293.15	0.8322	333.15	0.5038		

Suggested Equation = 3 Constants: A = -4.6077 B = -368.04 C = 52.28
% AAD = 0.2 S.D. = 1.50 x 10^{-6} Temperature Range: 270-380

Ethylene glycol

CAS RN: 107-21-1, Source of Data: Reference 122, 83, 25, 184

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15 [122]	14.78	313.15	9.1316	393.15	1.3966
288.15 [83]	26.09	333.15	4.9468	404.35	1.1816
303.15	13.35	353.15	3.0166	413.15	1.0385
293.15[25]	19.9164	371.15	2.0627	298.15[184]	17.8770
303.15	13.1544				

Suggested Equation = 3 Constants: A = -1.55 B = -4.18 x 10^{2} C = 1.47 x 10^{2}

%AAD = 2.102127 SD = 3.61 x 10^{-3} Temperature Range: 280-420

Ethylene glycol dinitrate

CAS RN: 629-96-6, Source of Data: Reference 114

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
283.15	5.73	303.15	3.29	323.15	2.14
288.15	4.87	308.15	2.92	328.15	1.95
293.15	4.21	313.15	2.60	333.15	1.82
298.15	3.69	318.15	2.36		

Suggested Equation = 3 Constants: A = -3.8971 B = -190.90 C = 167.79

% AAD = 0.4 S.D. = 1.40 x 10^{-5} Temperature Range: 280-340

Ethylene sulfite

CAS RN: 3741-38-6, Source of Data: Reference 16

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	2.056	318.15	1.483	338.15	1.130
308.15	1.734	328.15	1.287	348.15	1.002

Suggested Equation = 3 Constants: A = -4.2577 B = -316.63 C = 96.579

% AAD = 0.1 S.D. = 4.30 x 10^{-7} Temperature Range: 290-350

Ethylenediamine

CAS RN: 107-15-3, Source of Data: Reference 42

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
292.75	1.6860	350.65	0.6246	382.45	0.4223
325.45	0.9020	361.35	0.5435	389.85	0.3890
336.85	0.7580	372.75	0.4721		

Suggested Equation = 3 Constants: A = -4.8506 B = -458.11 C = 72.15

% AAD = 0.3 S.D. = 2.60 x 10^{-6} Temperature Range: 290-390

Ethyl-N-methyl carbamate

CAS RN: 105-40-8, Source of Data: Reference 123

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	3.096	328.15	1.505	358.15	0.889
313.15	2.097	343.15	1.137	373.15	0.713

Suggested Equation = 3 Constants: A = -4.5915 B = -354.47 C = 127.89

% AAD = 0.2 S.D. = 2.20 x 10^{-6} Temperature Range: 290-380

Ethyltrifluoro acetate

CAS RN: 383-63-1, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	0.4342	313.15	0.3449	333.30	0.2820
303.15	0.3848	323.15	0.3120		

Suggested Equation = 1 Constants: A = -4.9103 B = 453.77 C = 0.00

% AAD = 0.2 S.D. = 6.80 x 10^{-7} Temperature Range: 290-340

Eugenol

CAS RN: 97-53-0, Source of Data: Reference 59

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	28.8600	303.15	5.9916	353.15	1.5934
283.15	15.2369	313.15	4.2159	373.15	1.1533
293.15	9.1241	333.15	2.4301		

Suggested Equation = 3 Constants: A = -4.0814 B = -207.80 C = 191.38

% AAD = 0.1 S.D. = 8.90 x 10^{-6} Temperature Range: 270-380

Fluorine

CAS RN: 7782-41-4, Source of Data: Reference 124

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
69.2	0.414	75.3	0.328	80.9	0.275
73.2	0.349	78.2	0.299	83.2	0.257

Suggested Equation = 3 Constants: A = -4.0425 B = -19.97 C = 39.38

% AAD = 0.6 S.D. = 2.40 x 10^{-6} Temperature Range: 60-90

Fluorobenzene

CAS RN: 462-06-6, Source of Data: Reference 95, 83, 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.35[95]	0.7520	317.15	0.4510	303.15	0.5170
282.45	0.6530	323.35	0.4260	293.15 [2]	0.5822
289.05	0.6220	333.65	0.3860	303.15	0.5164
293.05	0.5850	345.05	0.3520	313.10	0.4600
302.25	0.5240	354.05	0.3250	323.15	0.4147
296.35	0.5060	288.15[83]	0.6200	333.19	0.3750
311.25	0.4800				

Suggested Equation = 1 Constants: A = -4.7298 B = 438.23 C = 0.00

% AAD = 1.0 S.D. = 5.60 x 10^{-6} Temperature Range: 270-360

Fluoroethylacetate

CAS RN: 459-72-3, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	1.086	313.15	0.796	333.15	0.618
303.15	0.927	323.15	0.697		

Suggested Equation = 3 Constants: A = -4.3290 B = -248.86 C = 110.92

% AAD = 0.2 S.D. = 1.80 x 10^{-6} Temperature Range: 290-340

Formamide

CAS RN: 75-12-7, Source of Data: Reference 125

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
278.15	6.0338	298.15	3.3511	318.15	2.0432
288.15	4.4052	308.15	2.5932		

Suggested Equation = 3 Constants: A = -5.0263 B = -559.54 C = 78.76

% AAD = 0.3 S.D. = 1.10 x 10^{-6} Temperature Range: 270-320

Formic acid

CAS RN: 64-18-6, Source of Data: Reference 4, 22

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
280.74 [4]	2.3850	321.18	1.0640	361.34	0.6190
289.11	1.9510	329.45	0.9370	370.38	0.5580
297.31	1.6350	337.35	0.8380	280.15[22]	1.9660
306.01	1.3790	345.20	0.7540	303.15	1.4430
313.51	1.2080	353.37	0.6810		

Suggested Equation = 3 Constants: A = -4.4442 B = -311.11 C = 109.61

% AAD = 0.4 S.D. = 9.00 x 10^{-6} Temperature Range: 280-380

Freon-12

CAS RN: 75-71-8, Source of Data: Reference 11

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
213.00	0.4978	241.00	0.3805	269.00	0.3075
217.00	0.4770	245.00	0.3680	273.00	0.2994
221.00	0.4578	249.00	0.3563	277.00	0.2917
225.00	0.4400	253.00	0.3453	281.00	0.2840
229.00	0.4235	257.00	0.3352	285.00	0.2774
233.00	0.4080	261.00	0.3253	289.00	0.2710
237.00	0.3938	265.00	0.3162	293.00	0.2654

Suggested Equation = 1 Constants: A = -4.3063 B = 213.62 C = 0.00

% AAD = 0.1 S.D. = 3.20 x 10^{-7} Temperature Range: 210-330

Groundnut oil

CAS RN: 8002-03-7, Source of Data: Reference 109

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	81	313.15	36	333.15	19

Suggested Equation = 3 Constants: A = -3.9621 B = -407.46 C = 151.23

% AAD = 0.4 S.D. = 1.20 x 10^{-4} Temperature Range: 290-340

Heptadecane

CAS RN: 629-78-7, Source of Data: Reference 17

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	3.2910	363.15	1.1610	473.15	0.3920
313.15	2.6520	373.15	1.0140	493.15	0.3390
323.15	2.1690	393.15	0.7940	513.15	0.2960
333.15	1.8290	413.15	0.6550	533.15	0.2600
343.15	1.5570	433.15	0.5460	553.15	0.2290
353.15	1.3400	453.15	0.4600	573.15	0.2030

Suggested Equation = 3 Constants: A = -4.8559 B = -630.57 C = 35.94

% AAD = 1.4 S.D. = 2.70 x 10^{-5} Temperature Range: 300-580

Heptane

CAS RN: 142-82-5, Source of Data: Reference 4, 17, 210

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
279.58 [4]	0.4797	365.36	0.2096	303.15	0.3750
279.71	0.4795	193.15 [17]	2.5700	313.15	0.3390
286.60	0.4418	203.15	1.9200	323.15	0.3090
294.89	0.4027	213.15	1.4600	333.15	0.2830
303.42	0.3685	223.15	1.1800	343.15	0.2610
311.49	0.3397	233.15	0.9650	353.15	0.2410
320.40	0.3112	243.15	0.8070	373.15	0.2090
328.18	0.2890	253.15	0.6890	298.15[210]	0.3880
335.19	0.2714	263.15	0.5990	303.15	0.3680
343.24	0.2526	273.15	0.5260	308.15	0.3500
350.85	0.2372	283.15	0.4660	313.15	0.3330
358.64	0.2218	293.15	0.4170	318.15	0.3170

Suggested Equation = 3 Constants: A = -1.66 B = -3.31 x 10^{2} C = 3.22x 10^{1} %AAD = 1.063016 SD = 1.33 x 10^{-3} Temperature Range: 190-370

Heptanoic acid

CAS RN: 111-14-8, Source of Data: Reference 126, 25

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
290.65[126]	4.6019	363.15	1.1898	333.15	1.8910
293.15	4.3290	284.15[25]	5.5340	353.15	1.3815
298.15	3.8023	293.15	4.3371	373.15	1.0565
323.15	2.2999	313.15	2.7385	393.50	0.8191
343.15	1.6098				

Suggested Equation = 3 Constants: A = -4.7200 B = -529.62 C = 68.313
% AAD = 0.6 S.D. = 2.00 x 10^{-5} Temperature Range: 290-400

Heptyl acetate

CAS RN: 112-06-1, Source of Data: Reference 74

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	1.7749	303.15	1.0328	353.15	0.5445
283.15	1.4518	313.15	0.8911	373.15	0.4465
293.15	1.2133	333.15	0.6879		

Suggested Equation = 3 Constants: A = -4.5679 B = -370.42 C = 69.11
% AAD = 0.3 S.D. = 3.40 x 10^{-6} Temperature Range: 270-380

Heptyl mercaptan

CAS RN: 1639-09-4, Source of Data: Reference 44

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
272.75	1.4861	303.15	0.9123	353.15	0.5129
283.15	1.2350	313.15	0.7989	373.15	0.4269
293.15	1.0560	333.15	0.6313		

Suggested Equation = 3 Constants: A = -4.5069 B = -354.88 C = 61.388
% AAD = 0.2 S.D. = 2.00 x 10^{-6} Temperature Range: 270-380

Heptyl thioacetate

CAS RN: 2307-11-1, Source of Data: Reference 117

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	1.7920	333.15	1.1510	363.15	0.8266
318.15	1.4110	348.15	0.9731		

Suggested Equation = 3 Constants: A = -4.0926 B = -244.09 C = 121.75

% AAD = 0.3 S.D. = 3.30 x 10^{-6} Temperature Range: 300-370

Heptyl thiolaurate

Source of Data: Reference 117

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	7.3450	333.15	3.8160	363.15	2.3620
318.15	5.1430	348.15	2.9760		

Suggested Equation = 3 Constants: A = -3.9865 B = -308.04 C = 136.82

% AAD = 0.3 S.D. = 1.10 x 10^{-5} Temperature Range: 300-370

Heptylamine

CAS RN: 111-68-2, Source of Data: Reference 31

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.15	1.583	318.15	0.929	353.15	0.559
298.15	1.317	328.15	0.803	373.15	0.437
308.15	1.102	338.15	0.692	398.15	0.325

Suggested Equation = 3 Constants: A = -5.5848 B = -937.05 C = -48.46

% AAD = 0.4 S.D. = 3.00 x 10^{-6} Temperature Range: 280-400

Hexadecane

CAS RN: 544-76-3, Source of Data: Reference 17, 127, 203

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15 [17]	3.4510	353.15	1.1610	453.15	0.4090
303.15	2.7540	363.15	1.0140	473.15	0.3490
313.15	2.2320	373.15	0.8920	493.15	0.2990
323.15	1.8520	393.15	0.7160	513.15	0.2590
333.15	1.5600	413.15	0.5840	298.15 [127]	3.0600
343.15	1.3380	433.15	0.4860	298.15 [203]	3.0390

Suggested Equation = 3 Constants: A = -1.78 B = -5.51 x 10^{2} C = 5.44x 10^{1}

%AAD = 1.082455 SD = 5.33 x 10^{-4} Temperature Range: 290-520

Hexadecyl acetate

CAS RN: 629-70-9, Source of Data: Reference 38

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	7.8064	313.15	4.4843	353.15	2.0404
303.15	5.8651	333.15	2.9019	373.15	1.4684

Suggested Equation = 3 Constants: A = -4.4106 B = -403.22 C = 118.00

% AAD = 0.6 S.D. = 2.20 x 10^{-5} Temperature Range: 290-380

Hexane

CAS RN: 110-54-3, Source of Data: Reference 4, 40, 128, 129, 181, 203, 210

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15[4]	0.3965	303.15	0.2780	298.15[181]	0.2950
283.15	0.3550	298.15[128]	0.2937	298.15[203]	0.2940
293.15	0.3200	289.5[129]	0.3280	298.15[210]	0.2980
303.15	0.2900	291.70	0.3200	303.15	0.2850
313.15	0.2640	293.15	0.3180	308.15	0.2690
323.15	0.2410	294.55	0.3130	313.15	0.2570
333.15	0.2210	296.37	0.3100	318.15	0.2470
288.15[40]	0.3370				

Suggested Equation = 1 Constants: A = -1.41 B = -1.78 x 10^2 C = 9.73x 10^1

%AAD = 1.034801 SD = 6.24 x 10^{-4} Temperature Range: 270-340

Hexanedioic acid

CAS RN: 124-04-9, Source of Data: Reference 130

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
449.7	4.8	457.0	4.0	464.2	3.7

Suggested Equation = 1 Constants: A = -5.8513 B = 1586.00 C = 0.00

% AAD = 1.6 S.D. = 8.00 x 10^{-5} Temperature Range: 445-465

Hexanenitrile

CAS RN: 628-73-9, Source of Data: Reference 65

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
290.05	1.0330	381.65	0.3551	421.25	0.2610
330.85	0.5908	391.25	0.3270	429.85	0.2455
352.45	0.4662	401.15	0.3030	435.85	0.2359
371.15	0.3898	410.95	0.2812		

Suggested Equation = 3 Constants: A = -4.7800 B = -471.26 C = 27.296

% AAD = 0.2 S.D. = 7.20 x 10^{-7} Temperature Range: 290-440

Hexyl ethanoate

CAS RN: 142-92-7, Source of Data: Reference 120

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
308.15	0.9102	338.15	0.6154	368.15	0.4491
323.15	0.7390	353.15	0.5233		

Suggested Equation = 3 Constants: A = -4.6136 B = -390.55 C = 59.77

% AAD = 0.1 S.D. = 8.70 x 10^{-7} Temperature Range: 300-370

Hexyl thiohexanoate

Source of Data: Reference 117

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
318.15	1.9960	348.15	1.3280		
333.15	1.6000	363.15	1.1100		

Suggested Equation = 3 Constants: A = -4.3053 B = -384.59 C = 78.571

% AAD = 0.3 S.D. = 3.90 x 10^{-6} Temperature Range: 310-370

Hexyl thiolaurate

Source of Data: Reference 117

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
318.15	4.5600	348.15	2.6910		
333.15	3.4190	363.15	2.1500		

Suggested Equation = 3 Constants: A = -4.1505 B = -371.22 C = 112.96
% AAD = 0.3 S.D. = 9.10 x 10^{-6} Temperature Range: 310-370

Hexyl thiomyristate

Source of Data: Reference 117

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
318.15	5.8130	348.15	3.6610		
333.15	4.7540	363.15	2.9230		

Suggested Equation = 2 Constants: A = 8.8939E+10 B = -5.2656 C = 0.00
% AAD = 1.3 S.D. = 7.70 x 10^{-5} Temperature Range: 310-370

Hydrazine

CAS RN: 302-01-2, Source of Data: Reference 131

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.16	1.0225	366.49	0.4028	449.83	0.2344
310.94	0.7268	394.27	0.3266		
338.72	0.5363	422.05	0.2728		

Suggested Equation = 3 Constants: A = -4.4407 B = -296.75 C = 83.603
% AAD = 0.5 S.D. = 4.00 x 10^{-6} Temperature Range: 280-450

Hydrogen bromide

CAS RN: 10035-10-6, Source of Data: Reference 132

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
186.80	0.911	190.80	0.890	197.30	0.857
188.80	0.902	193.70	0.877	199.40	0.851

Suggested Equation = 2 Constants: A = 0.2545 B = 1.0769 C = 0.00
% AAD = 0.1 S.D. = 1.30 x 10^{-6} Temperature Range: 180-200

Hydrogen chloride

CAS RN: 7647-01-0, Source of Data: Reference 132

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
160.8	0.590	171.7	0.530	183.2	0.493
166.7	0.569	177.0	0.514	188.2	0.477

Suggested Equation = 1 Constants: A = -3.8799 B = 104.76 C = 0.00
% AAD = 0.7 S.D. = 4.80 x 10^{-6} Temperature Range: 160-190

Hydrogen cyanide

CAS RN: 74-90-8, Source of Data: Reference 133

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
259.85	0.2756	278.15	0.2228	291.15	0.1955
263.15	0.2644	283.15	0.2114	295.15	0.1885
268.15	0.2492	288.15	0.2014	298.15	0.1834
273.15	0.2355				

Suggested Equation = 3 Constants: A = -4.6541 B = -217.40 C = 61.204
% AAD = 0.1 S.D. = 1.00 x 10^{-7} Temperature Range: 250-300

Hydrogen iodide

CAS RN: 10034-85-2, Source of Data: Reference 132

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
223.3	1.479	229.6	1.426	236.4	1.353
225.6	1.454	231.5	1.402		
227.2	1.437	233.9	1.377		

Suggested Equation = 2 Constants: A = 5.8043 B = -1.5299 C = 0.00

% AAD = 0.2 S.D. = 3.80 x 10^{-6} Temperature Range: 220-240

Hydrogen sulfide

CAS RN: 7783-06-4, Source of Data: Reference 132

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
191.0	0.547	198.2	0.510	206.1	0.470
193.3	0.528	201.2	0.488	209.8	0.454

Suggested Equation = 1 Constants: A = -4.1486 B = 168.99 C = 0.00

% AAD = 0.5 S.D. = 2.80 x 10^{-6} Temperature Range: 190-210

Indan

CAS RN: 496-11-7, Source of Data: Reference 134

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	2.2400	323.15	0.9290	363.15	0.5950
283.15	1.800	333.15	0.8180	373.15	0.5450
293.15	1.4800	343.15	0.7280	383.15	0.5020
303.5	1.2500	353.15	0.6560	393.15	0.4660
313.15	1.0700				

Suggested Equation = 3 Constants: A = -4.2327 B = -250.37 C = 114.78

% AAD = 0.2 S.D. = 3.50 x 10^{-6} Temperature Range: 270-400

Indene

CAS RN: 95-13-6, Source of Data: Reference 134

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	2.9400	323.15	1.1100	363.15	0.6530
283.15	2.1000	333.15	0.9660	373.15	0.5780
293.15	1.7500	343.15	0.8440	383.15	0.5130
303.15	1.4900	353.15	0.7410	393.15	0.4570
313.15	1.2800				

Suggested Equation = 1 Constants: A = -5.0798 B = 686.30 C = 0.00

% AAD = 2.2 S.D. = 7.00 x 10^{-5} Temperature Range: 270-400

Indium

CAS RN: 7440-74-6, Source of Data: Reference 100

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
432.15	1.842	507.15	1.497	563.65	1.318
441.75	1.786	525.15	1.427	583.85	1.278
450.35	1.736	534.65	1.391	599.55	1.233
464.05	1.668	554.45	1.348	619.65	1.194
486.65	1.567				

Suggested Equation = 3 Constants: A = -3.3239 B = -236.69 C = 30.666

% AAD = 0.3 S.D. = 4.30 x 10^{-6} Temperature Range: 430-620

Iodine pentafluoride

CAS RN: 7183-66-6, Source of Data: Reference 116

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
287.70	2.666	307.45	1.784	335.90	1.201
298.15	2.111	321.90	1.430	342.45	1.117

Suggested Equation = 3 Constants: A = -3.6707 B = -114.50 C = 183.24
% AAD = 0.1 S.D. = 2.80 x 10^{-6} Temperature Range: 280-350

Iodobenzene

CAS RN: 591-50-4, Source of Data: Reference 95, 61

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
277.75[95]	2.1939	341.35	0.9191	400.65	0.5640
290.55	1.7715	353.75	0.8137	410.75	0.5241
300.65	1.5042	362.35	0.7502	421.95	0.4883
309.95	1.3214	371.15	0.7003	288.15[61]	1.7400
321.25	1.1455	380.65	0.6523	303.15	1.4170
331.25	1.0198	390.85	0.6013		

Suggested Equation = 3 Constants: A = -4.2107 B = -307.78 C = 78.66
% AAD = 1.0 S.D. = 2.30 x 10^{-5} Temperature Range: 270-420

Iodoethane

CAS RN: 75-03-6, Source of Data: Reference 4, 40

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.43[4]	0.7167	366.13	0.5151	336.87	0.3966
280.85	0.6605	311.89	0.4891	342.53	0.3792
286.33	0.6235	318.37	0.4621	288.15[40]	0.6170
293.95	0.5782	324.54	0.4387	303.15	0.5400
299.24	0.5496	330.66	0.4168		

Suggested Equation = 3 Constants: A = -4.6258 B = -446.10 C = -27.294
% AAD = 0.4 S.D. = 3.20 x 10^{-6} Temperature Range: 270-350

Iodomethane

CAS RN: 74-88-4, Source of Data: Reference 4, 27, 135

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.57[4]	0.5914	294.52	0.4810	288.15[27]	0.5180
279.21	0.5576	300.37	0.4564	303.15	0.4600
283.68	0.5330	306.53	0.4323	273.15[135]	0.5940
288.96	0.5064	313.11	0.4090		

Suggested Equation = 1 Constants: A = -4.4564 B = 336.11 C = 0.00
% AAD = 0.7 S.D. = 4.60 x 10^{-6} Temperature Range: 270-320

Isoamyl ether

CAS RN: 544-01-4, Source of Data: Reference 59

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	1.4620	303.15	0.8658	353.15	0.4673
283.15	1.2024	313.15	0.7513	373.15	0.3836
293.15	1.0122	333.15	0.5831		

Suggested Equation = 3 Constants: A = -4.5653 B = 344.08 C = 74.225
% AAD = 0.3 S.D. = 3.00 x 10^{-6} Temperature Range: 270-380

Isoamyl titanate

Source of Data: Reference 75

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
402.75	4.9200	447.05	1.1980	487.35	0.5180
420.25	2.6120	462.75	0.8170		
431.95	1.8470	477.45	0.6150		

Suggested Equation = 3 Constants: A = -5.2745 B = -506.00 C = 232.24

% AAD = 0.8 S.D. = 1.50 x 10^{-5} Temperature Range: 400-490

Isoamylamine

CAS RN: 107-85-7, Source of Data: Reference 31

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
278.15	0.9080	308.15	0.5720	343.15	0.3980
288.15	0.7800	318.15	0.5140	353.15	0.3500
298.15	0.6660	328.15	0.4520		

Suggested Equation = 1 Constants: A = -4.9743 B = 536.52 C = 0.00

% AAD = 1.0 S.D. = 7.00 x 10^{-5} Temperature Range: 270-360

Isoamylcyanide

CAS RN: 542-54-1, Source of Data: Reference 26

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	0.9800	323.15	0.6460	373.15	0.3810
303.15	0.8430	333.15	0.5730	393.15	0.3190
313.15	0.7340	353.15	0.4600	413.15	0.2700

Suggested Equation = 1 Constants: A = -4.9258 B = 561.33 C = 0.00

% AAD = 0.3 S.D. = 2.10 x 10^{-6} Temperature Range: 290-420

Isobutyl acetate

CAS RN: 110-19-0, Source of Data: Reference 136

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	0.7233	353.15	0.3507	413.15	0.2010
303.15	0.6334	363.15	0.3168	423.15	0.1860
313.15	0.5574	373.15	0.2856	433.15	0.1724
323.15	0.4930	383.15	0.2597	443.15	0.1594
333.15	0.4381	393.15	0.2374	453.15	0.1471
343.15	0.3912	403.15	0.2180	463.15	0.1351

Suggested Equation = 3 Constants: A = -5.8472 B = -1268.10 C = -176.23

% AAD = 0.7 S.D. = 4.50 x 10^{-6} Temperature Range: 290-460

Isobutyl titanate

CAS RN: 7425-80-1, Source of Data: Reference 75

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
376.05	3.6800	407.95	1.3270	447.95	0.5540
387.65	2.4660	418.05	1.0210	457.15	0.4840
399.75	1.6860	431.35	0.7610	467.35	0.4240

Suggested Equation = 3 Constants: A = -4.7234 B = -295.54 C = 247.55

% AAD = 1.3 S.D. = 3.50 x 10^{-5} Temperature Range: 370-470

Isobutylamine

CAS RN: 78-81-9, Source of Data: Reference 31

T (K)	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})
278.15	0.7460	293.15	0.6090	323.15	0.3790
283.15	0.6900	298.15	0.5690	333.15	0.3870
288.15	0.6440	313.15	0.4360		

Suggested Equation = 3 Constants: A = -2.4453 B = -102.87 C = 427.06

% AAD = 1.5 S.D. = 9.00 x 10^{-6} Temperature Range: 270-330

Isoheptane

CAS RN: 591-76-4, Source of Data: Reference 4

T (K)	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})
273.57	0.4743	305.46	0.3333	337.07	0.2484
280.85	0.4343	313.20	0.3092	344.99	0.2316
289.03	0.3954	322.16	0.2839	353.84	0.2149
297.78	0.3607	329.61	0.2651	361.56	0.2012

Suggested Equation = 3 Constants: A = -5.3931 B = -835.48 C = -130.45

% AAD = 0.2 S.D. = 6.30 x 10^{-7} Temperature Range: 270-370

Isovaleraldehyde

CAS RN: 590-86-3, Source of Data: Reference 65

T (K)	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})
294.25	0.5490	328.55	0.3693	358.15	0.2798
308.15	0.4615	347.85	0.3063	365.65	0.2610
318.45	0.4113				

Suggested Equation = 1 Constants: A = -4.9057 B = 484.01 C = 0.00

% AAD = 0.2 S.D. = 5.40 x 10^{-7} Temperature Range: 290-370

Lead

CAS RN: 7439-92-1, Source of Data: Reference 137, 138, 91

T (K)	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})
604.15[137]	2.580	641.15	2.349	773.15	1.740
641.15	2.344	661.15	2.233	833.15	1.704
661.15	2.229	680.55	2.129	876.15	1.470
680.55	2.118	720.15	1.970	976.15	1.470
720.15	1.969	602.15[91]	2.650	979.15	1.390
733.35	1.921	623.15	2.430	1176.15	1.220
604.15[138]	2.586	684.15	2.100	1254.15	1.160
622.65	2.457	722.15	1.900		

Suggested Equation = 3 Constants: A = -3.1186 B = -182.99 C = 266.85

% AAD = 1.6 S.D. = 3.90 x 10^{-5} Temperature Range: 600-1200

Magnesium chloride hexahydrate (molten)

CAS RN: 7791-18-6, , Source of Data: Reference 79

T (K)	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})
993.25	2.1605	1053.25	1.8785	1142.45	1.5609
1023.75	2.0095	1083.95	1.7582	1172.75	1.4772
1052.55	1.8791	1113.05	1.6554		

Suggested Equation = 3 Constants: A = -3.8293 B = -1261.00 C = -90.022

% AAD = 0.1 S.D. = 1.10 x 10^{-6} Temperature Range: 990-1180

m-Cresol

CAS RN: 108-39-4, Source of Data: Reference 10, 76, 110

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
315.2[10]	5.7670	414.75	0.6383	465.45	0.3622
335.15	2.9080	423.15	0.5800	472.85	0.3362
355.10	1.7320	343.15	0.5087	313.15[76]	6.1800
375.45	1.1970	445.15	0.4490	288.15[110]	24.6660
396.65	0.8201	455.25	0.4034	303.15	9.8070

Suggested Equation = 3 Constants: A = -4.4933 B = -298.87 C = 183.39
% AAD = 2.5 S.D. = 4.70E-04 Temperature Range: 280-480

Mercury

CAS RN: 7439-97-6, Source of Data: Reference 138

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
296.95	1.5320	332.85	1.3650	373.75	1.2440
313.55	1.4460	353.15	1.2950		

Suggested Equation = 3 Constants: A = -3.1105 B = -51.21 C = 124.04
% AAD = 0.1 S.D. = 1.50 x 10^{-6} Temperature Range: 290-380

Methanol

CAS RN: 67-56-1, Source of Data: Reference 21, 4, 69, 204, 211

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
288.15 [21]	0.6305	308.87	0.4770	213.15	2.8680
298.15	0.5470	314.06	0.4460	223.15	2.1840
308.15	0.4745	319.25	0.4160	233.15	1.7150
318.15	0.4194	325.44	0.3850	243.15	1.3800
328.15	0.3722	330.84	0.3660	253.15	1.1340
276.92 [4]	0.7610	334.71	0.3440	263.15	0.9425
281.89	0.6990	336.41	0.3360	273.15	0.7966
287.68	0.6410	183.15 [69]	8.6240	283.15	0.6795
292.62	0.5950	193.15	5.5960	298.15[204]	0.5500
298.57	0.5490	203.15	3.8990	298.15[211]	0.5530
303.47	0.5130				

Suggested Equation = 3 Constants: A = -1.84 B = -4.24 x 10^{2} C = 2.97x 10^{1}
%AAD = 1.258766 SD = 1.34 x 10^{-3} Temperature Range: 180-290

Methyl-4-hydroxy benzoate

CAS RN: 99-76-3, Source of Data: Reference 10

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
413.15	3.5080	452.15	1.6360	498.65	0.8990
423.15	2.9000	470.65	1.2570	514.15	0.7590
432.85	2.3060	485.15	1.0470	563.15	0.4660

Suggested Equation = 3 Constants: A = -4.6510 B = -501.30 C = 184.86
% AAD = 1.4 S.D. = 3.00 x 10^{-5} Temperature Range: 410-570

Methyl acetate

CAS RN: 79-20-9, Source of Data: Reference 28, 103, 211

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.49 [28]	0.4762	301.53	0.3491	327.48	0.2732
279.49	0.4436	307.01	0.3304	353.55 [103]	0.2170
284.56	0.4186	313.60	0.3100	383.35	0.1670
290.21	0.3948	319.17	0.2943	412.15	0.1320
295.89	0.3706	323.49	0.2828	298.15[211]	0.3800

Suggested Equation = 2 Constants: A = -3.10 B = -1.56 x 10^3 C = -2.86 x 10^2 %AAD = 0.790241 SD = 4.57 x 10^{-4} Temperature Range: 270-420

Methyl butyrate

CAS RN: 623-42-7, Source of Data: Reference 28, 112

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.47[28]	0.7551	323.45	0.4058	363.78	0.2768
283.60	0.6528	333.36	0.3668	371.43	0.2592
293.53	0.5728	344.65	0.3297	293.15[112]	0.5415
303.79	0.5050	352.61	0.3057	323.15	0.4070
313.73	0.4503				

Suggested Equation = 1 Constants: A = -4.8758 B = 479.71 C = 0.00
% AAD = 0.3 S.D. = 1.30 x 10^{-6} Temperature Range: 270-380

Methyl carbamate

CAS RN: 598-55-0, Source of Data: Reference 9, 139

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
328.75[9]	2.2779	328.15[139]	2.6050	358.15	1.3980
347.75	1.3699	338.15	2.0560		
355.35	1.2376	348.15	1.6790		

Suggested Equation = 3 Constants: A = -4.3167 B = -280.14 C = 166.40
% AAD = 0.2 S.D. = 4.00 x 10^{-6} Temperature Range: 320-370

Methyl chloride

CAS RN: 74-87-3, Source of Data: Reference 140

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
253.15	0.3090	273.15	0.2890	293.15	0.2650
263.15	0.3010	283.15	0.2760	303.15	0.2500

Suggested Equation = 1 Constants: A = -4.0591 B = 140.54 C = 0.00
% AAD = 1.1 S.D. = 3.20 x 10^{-6} Temperature Range: 250-310

Methyl ethyl ketone

CAS RN: 78-93-3, Source of Data: Reference 80, 141, 40, 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
240.75[80]	0.8010	288.15[40]	0.4230	308.57	0.3586
248.45	0.7200	303.15	0.3650	315.64	0.3342
260.95	0.6030	273.47[4]	0.5361	321.87	0.3149
271.45	0.5470	280.19	0.4923	329.07	0.2944
283.05	0.4710	287.25	0.4522	336.89	0.2750
299.15	0.4010	294.46	0.4170	343.41	0.2595
308.15[141]	0.3657	301.51	0.3861	349.40	0.2465

Suggested Equation = 2 Constants: A = 2.2926E+04 B = -3.1332 C = 0.00
% AAD = 1.4 S.D. = 9.00 x 10^{-6} Temperature Range: 240-360

Methyl formate

CAS RN: 107-31-3, Source of Data: Reference 28, 22

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
273.73[28]	0.4263	288.79	0.3626	302.41	0.3190
279.54	0.3999	293.30	0.3467	288.15[22]	0.3600
284.03	0.3810	298.67	0.3298	298.15	0.3280

Suggested Equation = 3 Constants: A = -4.7074 B = 365.68 C = 0.00
% AAD = 0.4 S.D. = 1.70 x 10^{-6} Temperature Range: 270-310

Methyl isobutyrate

CAS RN: 547-63-7, Source of Data: Reference 4

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
273.44	0.6689	308.96	0.4317	349.37	0.3037
282.55	0.5916	317.82	0.3933	352.92	0.2813
291.27	0.5299	325.70	0.3631	362.00	0.2589
302.13	0.4660	335.88	0.3289		

Suggested Equation = 1 Constants: A = -4.8272 B = 451.96 C = 0.00
% AAD = 0.7 S.D. = 3.80 x 10^{-6} Temperature Range: 270-370

Methyl oleate

CAS RN: 112-62-9, Source of Data: Reference 141

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
303.15	4.4800	333.15	2.6200	363.15	1.1400

Suggested Equation = 1 Constants: A = -4.9869 B = 800.18 C = 0.00
% AAD = 0.5 S.D. = 1.50 x 10^{-5} Temperature Range: 300-370

Methyl propionate

CAS RN: 554-12-1, Source of Data: Reference 28, 192

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
273.53[28]	0.5788	311.81	0.3746	341.62	0.2811
282.88	0.5142	318.74	0.3477	349.00	0.2637
289.94	0.4725	325.81	0.3255	308.15[192]	0.4370
296.60	0.4368	333.53	0.3028	318.15	0.4160
302.77	0.4098				

Suggested Equation = 3 Constants: A = -2.93 B = -1.44 x 10^{3} C = -2.60 x 10^{2}
%AAD = 3.599153 SD = 6.70 x 10^{-3} Temperature Range: 270-350

Methyl salicylate

CAS RN: 119-36-8, Source of Data: Reference 10

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
353.65	1.0330	412.00	0.5531	459.85	0.3800
383.05	0.7310	423.15	0.5020	472.85	0.3475
393.15	0.6560	427.75	0.4844	487.75	0.3159
398.25	0.6252	443.05	0.4295	491.65	0.2991

Suggested Equation = 3 Constants: A = -4.6908 B = -531.13 C = 41.528
% AAD = 0.3 S.D. = 2.70 x 10^{-6} Temperature Range: 350-500

Methyl sulfide

CAS RN: 75-18-3, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.42	0.3529	287.90	0.3075	304.50	0.2655
278.71	0.3351	293.34	0.2927	308.96	0.2559
283.20	0.3209	299.29	0.2776		

Suggested Equation = 1 Constants: A = -4.6126 B = 317.90 C = 0.00

% AAD = 1.3 S.D. = 4.00 x 10^{-6} Temperature Range: 270-310

Methyl Sulfoxide

CAS RN: 67-68-5, Source of Data: Reference 33

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	1.9910	323.15	1.2860	398.15	0.5460
303.15	1.8080	348.15	0.9160		
313.15	1.5110	373.15	0.6910		

Suggested Equation = 3 Constants: A = -4.3585 B = -323.95 C = 102.62

% AAD = 0.2 S.D. = 2.50 x 10^{-6} Temperature Range: 295-400

Methyl thiocyanate

CAS RN: 556-64-9, Source of Data: Reference 74

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	1.0505	303.15	0.7023	353.15	0.4235
283.20	0.9058	313.15	0.6238	373.15	0.3629
293.34	0.7915	333.15	0.5086		

Suggested Equation = 3 Constants: A = -4.4357 B = -314.04 C = 57.847

% AAD = 0.3 S.D. = 2.00 x 10^{-6} Temperature Range: 270-380

Methyl amine

CAS RN: 74-89-5, Source of Data: Reference 142, 143

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
202.45[142]	0.8050	229.05	0.4370	258.35	0.2830
204.35	0.7550	230.45	0.4250	263.05	0.2660
205.15	0.7400	233.05	0.4050	263.55[143]	0.2560
206.35	0.7130	235.75	0.3850	273.25	0.2310
207.95	0.6810	237.95	0.3750	278.55	0.2170
212.45	0.6140	241.15	0.3580	280.00	0.2120
212.95	0.6050	242.95	0.3500	283.05	0.2060
214.75	0.5820	245.75	0.3370	283.25	2.0600
217.85	0.5410	248.55	0.3810	285.65	0.2020
222.45	0.4940	253.05	0.3010	288.65	0.1960
222.55	0.4950	255.05	0.2950	291.65	0.1900
223.05	0.4860	257.59	0.2810	295.25	0.1840
227.95	0.4450				

Suggested Equation = 3 Constants: A = -4.6228 B = -198.43 C = 71.960

% AAD = 0.7 S.D. = 4.30 x 10^{-6} Temperature Range: 200-310

Methyl benzoate

CAS RN: 93-58-3, Source of Data: Reference 77, 119

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.15[77]	2.2980	303.15	1.6730	293.15[119]	2.051

Suggested Equation = 1 Constants: A = -5.4149 B = 800.14 C = 0.00
% AAD = 0.3 S.D. = 7.60 x 10^{-6} Temperature Range: 280-305

Methyl cyclohexane

CAS RN: 108-87-2, Source of Data: Reference 17, 8, 42

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15[17]	0.9910	288.15[8]	0.7770	339.95	0.4254
283.15	0.8470	303.15	0.6390	357.15	0.3607
293.15	0.7310	285.60[42]	0.8380	370.65	0.3211
303.15	0.6390	325.45	0.5046	373.65	0.3130
313.15	0.5620				

Suggested Equation = 3 Constants: A = -4.5348 B = -319.07 C = 64.712
% AAD = 0.8 S.D. = 8.00 x 10^{-6} Temperature Range: 270-380

Methyl cyclopentane

CAS RN: 96-37-7, Source of Data: Reference 110, 24, 32

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.15[110]	0.5340	278.15	0.6090	313.15	0.4050
303.15	0.4480	283.15	0.5720	318.15	0.3840
248.15[24]	0.9300	288.15	0.5380	323.15	0.3650
253.15	0.8600	293.15	0.5070	273.15[32]	0.6649
258.15	0.8000	298.15	0.4780	283.15	0.5821
263.15	0.7450	303.15	0.4520	293.15	0.5128
268.15	0.6950	308.15	0.4270	303.15	0.4560
273.15	0.6500				

Suggested Equation = 3 Constants: A = -5.5016 B = -940.03 C = -132.64
% AAD = 0.5 S.D. = 4.00 x 10^{-6} Temperature Range: 240-330

Methyl diphenyl amine

CAS RN: 1205-64-7, Source of Data: Reference 43

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	18.3486	303.15	5.1308	333.15	2.4802
283.15	10.9529	313.15	3.8403	353.15	1.7349
293.15	7.2516				

Suggested Equation = 3 Constants: A = -3.8079 B = -170.08 C = 191.05
% AAD = 0.6 S.D. = 3.30 x 10^{-5} Temperature Range: 270-360

Monodimethyl aminophosphoryl chloride

CAS RN: , Source of Data: Reference 90

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
255.15	5.30	291.15	2.21	333.15	1.22
263.15	3.94	298.15	1.96	348.15	1.02
273.15	3.16	313.15	1.53		

Suggested Equation = 3 Constants: A = -3.8387 B = -175.69 C = 142.04
% AAD = 1.5 S.D. = 7.00 x 10^{-5} Temperature Range: 250-350

m-Xylene

CAS RN: 108-38-3, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	0.8000	323.15	0.4445	373.15	0.2890
283.15	0.6975	333.15	0.4040	383.15	0.2690
293.15	0.6150	343.15	0.3690	393.15	0.2500
303.15	0.5470	353.15	0.3391	403.15	0.2330
313.15	0.4910	363.15	0.3130		

Suggested Equation = 3 Constants: A = -4.8271 B = -505.32 C = -19.347

% AAD = 0.3 S.D. = 1.60 x 10^{-6} Temperature Range: 270-410

N-2-Methoxyethyl acetamide

CAS RN: 5417-42-5, Source of Data: Reference 16

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	10.840	318.15	5.437	338.15	3.178
308.15	7.515	328.15	4.096	348.15	2.542

Suggested Equation = 3 Constants: A = -4.3441 B = -330.03 C = 159.45

% AAD = 0.1 S.D. = 5.80 x 10^{-6} Temperature Range: 290-350

N,N-Diethyl-m-toluidine

CAS RN: 134-62-3, Source of Data: Reference 65

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
387.85	0.5947	449.15	0.3467	479.35	0.2796
408.15	0.4904	458.45	0.3237	491.15	0.2591
428.65	0.4095	467.85	0.3030	503.15	0.2406
438.55	0.3773				

Suggested Equation = 3 Constants: A = -4.9635 B = -683.97 C = -5.57

% AAD = 0.1 S.D. = 5.20 x 10^{-7} Temperature Range: 380-510

N,N-Diethylaniline

CAS RN: 91-66-7, Source of Data: Reference 65, 96, 48

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
289.05[65]	2.4740	489.45	0.2650	293.15	2.1844
373.45	0.6210	273.15[96]	3.8380	313.15	1.4249
413.15	0.4394	349.65	0.7830	333.15	1.0211
435.15	0.3676	273.65[48]	3.8403	353.15	0.7768
461.15	0.3132	283.15	2.8498	371.15	0.6306

Suggested Equation = 3 Constants: A = -4.2714 B = -243.69 C = 143.02

% AAD = 1.8 S.D. = 1.10E-04 Temperature Range: 270-490

N,N-Dimethylacetamide

CAS RN: 127-19-5, Source of Data: Reference 66

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.55	2.1410	365.35	0.7244	423.85	0.4032
325.55	1.2250	384.25	0.5883	433.15	0.3724
345.95	0.9207	405.75	0.4751	441.45	0.3500

Suggested Equation = 3 Constants: A = -4.8134 B = -547.67 C = 37.944

% AAD = 0.3 S.D. = 3.60 x 10^{-6} Temperature Range: 290-450

N,N-Dimethylaniline

CAS RN: 121-69-7, Source of Data: Reference 48, 43, 83

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
283.15[48]	1.6875	273.15[43]	2.0251	395.05	0.4354
293.15	1.4125	283.15	1.6551	408.15	0.3923
303.15	1.2019	293.15	1.3850	423.95	0.3477
313.15	1.0359	303.15	1.1755	439.35	0.3111
323.15	0.9054	313.15	1.0240	453.25	0.2824
333.15	0.8003	333.15	0.7980	462.35	0.2667
343.15	0.7143	353.15	0.6588	466.15	0.2603
353.15	0.6423	288.15[83]	1.5280		
363.15	0.5784	313.15	1.1590		
371.15	0.5368	360.05	0.5953		

Suggested Equation = 3 Constants: A = -4.6940 B = -483.96 C = 30.46

% AAD = 1.0 S.D. = 1.30 x 10^{-5} Temperature Range: 270-470

N,N-Dimethylethyleneurea

CAS RN: 21243-32-3, Source of Data: Reference 14

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	1.9440	318.15	1.3930	348.15	0.9380
308.15	1.6330	328.15	1.2040	373.15	0.7200

Suggested Equation = 3 Constants: A = -4.2477 B = -295.33 C = 105.93

% AAD = 0.1 S.D. = 1.00 x 10^{-6} Temperature Range: 290-380

N,N-Dimethylformamide

CAS RN: 68-12-2, Source of Data: Reference 125

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
278.15	1.0673	298.15	0.7912	318.15	0.6474
288.15	0.9055	308.15	0.7166		

Suggested Equation = 3 Constants: A = -3.6398 B = -56.05 C = 194.25

% AAD = 0.3 S.D. = 2.60 x 10^{-6} Temperature Range: 270-320

N,N-Dimethyl-o-toluidine

CAS RN: 609-72-3, Source of Data: Reference 65

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
345.45	0.7050	399.75	0.4073	443.15	0.2885
365.95	0.5580	415.35	0.3574	454.65	0.2659
383.15	0.4689	428.15	0.3231	458.15	0.2596

Suggested Equation = 3 Constants: A = -4.8977 B = -598.28 C = 2.4885

% AAD = 0.4 S.D. = 1.70 x 10^{-6} Temperature Range: 340-460

N,N-Dimethyl-p-toluidine

CAS RN: 99-97-8, Source of Data: Reference 68

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
374.15	0.5215	418.25	0.3601	463.15	0.2646
387.95	0.4608	433.65	0.3217	477.35	0.2423
404.25	0.4027	448.15	0.2910	483.65	0.2341

Suggested Equation = 3 Constants: A = -4.9002 B = -645.00 C = -24.571

% AAD = 0.1 S.D. = 2.20 x 10^{-7} Temperature Range: 370-490

N-Butylaniline

CAS RN: 1126-78-9, Source of Data: Reference 65

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
372.05	0.7600	433.45	0.4163	480.35	0.2917
404.05	0.5440	447.75	0.3712	493.75	0.2673
417.35	0.4783	466.25	0.3226	512.65	0.2375

Suggested Equation = 1 Constants: A = -4.9610 B = 685.21 C = 0.00

% AAD = 0.1 S.D. = 5.60 x 10^{-6} Temperature Range: 370-520

N-Ethyl formamide

CAS RN: 627-45-2, Source of Data: Reference 16

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	2.21	318.15	1.55	338.15	1.15
308.15	1.84	328.15	1.33	348.15	1.01

Suggested Equation = 3 Constants: A = -4.4950 B = -403.12 C = 79.02

% AAD = 0.1 S.D. = 1.80 x 10^{-6} Temperature Range: 290-350

N-Ethylaniline

CAS RN: 103-69-5, Source of Data: Reference 65, 48

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
372.65[65]	0.5981	443.35	0.3127	293.15	2.2510
382.65	0.5401	458.15	0.2801	313.15	1.4340
394.55	0.4792	469.45	0.2585	333.15	1.0130
407.55	0.4240	478.15	0.2436	353.15	0.7645
419.25	0.3816	273.42[48]	4.1280	363.15	0.6745
430.45	0.3466	283.15	2.9790	373.15	0.6037

Suggested Equation = 3 Constants: A = -4.5575 B = -348.74 C = 111.51

% AAD = 1.3 S.D. = 4.40 x 10^{-5} Temperature Range: 270-480

N-Ethyl-N-methyl aniline

CAS RN: 613-97-8, Source of Data: Reference 65

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
382.45	0.5142	420.65	0.3696	458.85	0.2764
395.55	0.4593	433.15	0.3343	468.15	0.2595
407.95	0.4119	445.15	0.3054	477.85	0.2437

Suggested Equation = 3 Constants: A = -4.6190 B = -391.17 C = 90.088

% AAD = 0.6 S.D. = 3.60 x 10^{-6} Temperature Range: 380-480

N-Hexylamine

CAS RN: 111-26-2, Source of Data: Reference 31

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
278.15	1.2400	318.15	0.6910	348.15	0.4560
288.15	1.0560	328.15	0.6000	358.15	0.3800
298.15	0.9050	338.15	0.5190	373.15	0.3260
308.15	0.8050				

Suggested Equation = 2 Constants: A = 1.8823E+08 B = -4.574 C = 0.00

% AAD = 1.7 S.D. = 1.30 x 10^{-5} Temperature Range: 270-380

Nickel nitrate hexahydrate

CAS RN: 13478-00-7, Source of Data: Reference 101

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
333.00	29.39	343.00	18.77		
337.00	23.39	347.50	15.28		

Suggested Equation = 1 Constants: A = -5.9846 B = 1482.60 C = 0.00

% AAD = 0.5 S.D. = 1.10E-04 Temperature Range: 330-350

Nitrobenzene

CAS RN: 98-95-3, Source of Data: Reference 15, 48, 177, 178, 172

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
369.55[15]	0.7447	293.15	2.0140	288.15[177]	2.1873
412.65	0.5084	303.15	1.6830	293.15	2.079
434.05	0.4351	313.15	1.4380	298.15	1.8733
453.15	0.3837	323.15	1.2510	303.15[178]	1.19337
472.65	0.3394	333.15	1.0940	313.15	1.18367
480.75	0.3240	343.15	0.9668	298.15[172]	1.8112
273.45[48]	3.0830	363.15	0.7793	308.15	1.4573
283.15	2.5090	373.15	0.7045	318.15	1.1032

Suggested Equation = 3 Constants: A = -1.17 B = -2.50 x 10^{2} C = 1.21 x 10^{2}

%AAD = 6.202789 SD = 3.31 x 10^{-2} Temperature Range: 270-490

Nitrogen dioxide

CAS RN: 10102-44-0, Source of Data: Reference 144, 4

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
253.15[144]	0.6870	273.15	0.5270	273.88[4]	0.5221
254.75	0.6630	274.75	0.5120	278.24	0.4954
258.15	0.6410	285.95	0.4680	282.30	0.4720
258.75	0.6150	289.95	0.4350	285.02	0.4578
263.15	0.5990	291.25	0.4260	288.51	0.4402
267.15	0.5650	293.15	0.4200		

Suggested Equation = 1 Constants: A = -4.7244 B = 394.75 C = 0.00

% AAD = 0.3 S.D. = 2.20 x 10^{-6} Temperature Range: 250-295

Nitryl fluoride

CAS RN: 10022-50-1, Source of Data: Reference 145

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
154.65	0.707	168.65	0.591	182.35	0.521
157.15	0.687	170.70	0.562	184.85	0.516
159.75	0.669	174.95	0.555	185.65	0.501
161.65	0.653	176.95	0.547	188.95	0.502
166.15	0.621	178.90	0.541		

Suggested Equation = 1 Constants: A = -4.0163 B = 133.93 C = 0.00

% AAD = 0.8 S.D. = 8.00 x 10^{-6} Temperature Range: 150-190

N-Methyl-2-chloroacetamide

CAS RN: 96-30-0, Source of Data: Reference 16

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
323.15	3.8240	338.15	2.6870		
328.15	3.3980	348.15	2.1860		

Suggested Equation = 3 Constants: A = -4.4456 B = -371.19 C = 140.22
% AAD = 0.2 S.D. = 8.10E-01 Temperature Range: 320-350

N-Methyl aniline

CAS RN: 100-61-8, Source of Data: Reference 48, 83, 65

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.45[48]	4.2689	323.15	1.2168	395.95	0.4950
283.15	3.0651	343.15	0.8876	423.15	0.3913
293.15	2.3020	288.15[83]	2.5680	453.65	0.3180
303.15	1.8109	303.15	1.7660	469.15	0.2780
313.15	1.4654	368.65[65]	0.6585		

Suggested Equation = 3 Constants: A = -4.3528 B = -268.33 C = 136.78
% AAD = 1.8 S.D. = 5.50 x 10^{-5} Temperature Range: 270-470

Nonadecane

CAS RN: 629-29-5, Source of Data: Reference 146

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
308.15	3.91	323.15	2.97	338.15	2.05
313.15	3.49	328.15	2.51	343.15	1.86
318.15	3.11	333.15	2.26		

Suggested Equation = 1 Constants: A = -5.5763 B = 976.51 C = 0.00
% AAD = 0.1 S.D. = 3.30 x 10^{-6} Temperature Range: 300-350

Nonadecyl benzene

CAS RN: 29136-19-4, Source of Data: Reference 146

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
308.15	9.56	323.15	6.39	338.15	4.42
313.15	8.33	328.15	5.62	343.15	3.94
318.15	7.27	333.15	4.98		

Suggested Equation = 1 Constants: A = -5.7965 B = 1163.9 C = 0.00
% AAD = 0.1 S.D. = 4.80 x 10^{-6} Temperature Range: 300-350

Nonane

CAS RN: 111-84-2, Source of Data: Reference 25

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	0.9603	303.15	0.6200	353.15	0.3595
283.15	0.8245	313.15	0.5480	373.15	0.2987
293.15	0.7105	333.15	0.4383		

Suggested Equation = 3 Constants: A = -4.7864 B = -440.77 C = 24.243
% AAD = 0.3 S.D. = 1.60 x 10^{-6} Temperature Range: 270-380

Nonanoic acid

CAS RN: 112-05-0, Source of Data: Reference 126

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	8.0775	323.15	3.7907	363.15	1.7322
298.15	6.9979	343.15	2.4096		

Suggested Equation = 3 Constants: A = -4.6210 B = -489.09 C = 99.881

% AAD = 1.0 S.D. = 4.50 x 10^{-5} Temperature Range: 290-370

Nonyl thiopalmitate

Source of Data: Reference 117

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
333.15	6.8490	348.15	5.0630	363.15	3.9170

Suggested Equation = 3 Constants: A = -3.6375 B = -224.63 C = 180.63

% AAD = 0.2 S.D. = 1.00 x 10^{-5} Temperature Range: 330-370

o-Anisaldehyde

CAS RN: 135-02-4, Source of Data: Reference 10

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
329.55	1.6850	416.85	0.5730	463.15	0.3951
359.15	1.0720	423.15	0.5420	486.15	0.3378
387.95	0.7580	432.25	0.5026	513.15	0.2852
402.05	0.6570	448.35	0.4410		

Suggested Equation = 3 Constants: A = -4.6222 B = -477.93 C = 70.53

% AAD = 0.5 S.D. = 5.60 x 10^{-6} Temperature Range: 320-520

o-Anisidine

CAS RN: 90-04-0, Source of Data: Reference 42

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
371.85	1.0510	436.35	0.5104	473.15	0.3698
397.45	0.7670	448.65	0.4554	483.15	0.3413
410.85	0.6608	460.85	0.4094	490.95	0.3280
423.35	0.5791				

Suggested Equation = 1 Constants: A = -5.0842 B = 782.40 C = 0.00

% AAD = 0.4 S.D. = 2.30 x 10^{-6} Temperature Range: 370-500

o-Cresol

CAS RN: 95-48-7, Source of Data: Reference 10, 43

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
326.55[10]	2.7050	425.95	0.4943	293.15	9.5600
345.65	1.6610	439.95	0.4238	303.15	6.1250
364.75	1.1340	450.65	0.3802	313.15	4.1000
379.25	0.8890	458.15	0.3528	333.15	2.2400
393.15	0.7370	463.15	0.3366	353.15	1.4310
408.95	0.6005	273.15[43]	39.7000	373.15	0.8970
423.15	0.5070	283.15	17.9000		

Suggested Equation = 3 Constants: A = -4.3679 B = -250.28 C = 187.77

% AAD = 2.8 S.D. = 7.10E-04 Temperature Range: 270-470

Octadecane

CAS RN: 593-45-3, Source of Data: Reference 17

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15	3.813	333.15	2.060	363.15	1.297
313.15	3.060	343.15	1.748	373.15	1.131
323.15	2.491	353.15	1.484		

Suggested Equation = 3 Constants: A = -4.3923 B = -378.20 C = 111.62

% AAD = 0.3 S.D. = 6.50 x 10^{-6} Temperature Range: 300-380

Octadecyl thiomyristate

Source of Data: Reference 117

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
333.15	11.940	348.15	7.3800	363.15	6.3770

Suggested Equation = 3 Constants: A = -2.3386 B = -6.4228 C = 318.15

% AAD = 2.2 S.D. = 2.70E-04 Temperature Range: 330-370

Octane

CAS RN: 111-65-9, Source of Data: Reference 4, 40, 207, 210, 214, 213

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.38[4]	0.7000	361.48	0.2690	303.15	0.4770
285.33	0.5940	371.67	0.2470	308.15	0.4500
296.07	0.5200	382.22	0.2270	313.15	0.4250
306.12	0.4630	395.22	0.2040	318.15	0.4030
317.04	0.4110	288.15[40]	0.5790	308.15[214]	0.4545
327.88	0.3670	303.15	0.4720	313.15	0.4296
339.61	0.3280	323.15[207]	0.3875	293.15[213]	0.5433
350.97	0.2960	298.15[210]	0.5060	298.15	0.5105

Suggested Equation = 3 Constants: A = -2.10 B = -6.30 x 10^{2} C = -5.06x 10^{1}

%AAD = 0.460682 SD = 1.40 x 10^{-4} Temperature Range: 270-400

Octanoic acid

CAS RN: 124-07-2, Source of Data: Reference 112, 119

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
323.15[112]	2.620	363.15	1.3000		
343.15	1.8450	293.15[119]	5.8600		

Suggested Equation = 3 Constants: A = -4.1803 B = -272.88 C = 153.08

% AAD = 1.2 S.D. = 3.00 x 10^{-5} Temperature Range: 290-370

Octyl thiomyristate

Source of Data: Reference 117

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
318.15	7.2050	348.15	3.9150		
333.15	5.1930	363.15	3.0760		

Suggested Equation = 3 Constants: A = -3.9509 B = -316.58 C = 143.12

% AAD = 0.1 S.D. = 3.30 x 10^{-6} Temperature Range: 310-370

Octylamine

CAS RN: 111-86-4, Source of Data: Reference 31

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
278.15	2.313	318.15	1.036	373.15	0.459
288.15	1.802	328.15	0.887	398.15	0.362
298.15	1.474	338.15	0.778	423.15	0.292
308.15	1.232	348.15	0.673		

Suggested Equation = 3 Constants: A = -4.9093 B = -501.41 C = 57.503

% AAD = 1.5 S.D. = 1.70 x 10^{-5} Temperature Range: 270-430

Olive oil

CAS RN: 8001-25-0, Source of Data: Reference 109

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	82	303.15	35	333.15	17

Suggested Equation = 3 Constants: A = -4.9110 B = -699.70 C = 110.30

% AAD = 0.9 S.D. = 3.20E-04 Temperature Range: 290-340

Oxirane

CAS RN: 75-21-8, Source of Data: Reference 147, 110

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
223.25[147]	0.5776	251.55	0.3937	283.88	0.2895
227.45	0.5387	259.55	0.3637	273.15[110]	0.309
234.95	0.4883	273.15	0.3202	278.15	0.295
240.55	0.4505	282.45	0.2927	288.15	0.283

Suggested Equation = 1 Constants: A = -4.6446 B = 312.90 C = 0.00

% AAD = 1.1 S.D. = 4.50 x 10^{-6} Temperature Range: 220-290

o-Xylene

CAS RN: 95-47-6, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	1.0970	324.30	0.5490	373.86	0.3430
286.15	0.8940	339.07	0.4700	388.80	0.3030
300.03	0.7350	350.63	0.4200	401.84	0.2750
311.88	0.6320	363.52	0.3740	413.04	0.2540

Suggested Equation = 1 Constants: A = -4.8315 B = 510.59 C = 0.00

% AAD = 0.5 S.D. = 6.40 x 10^{-6} Temperature Range: 260-420

Palmitic acid

CAS RN: 57-10-3, Source of Data: Reference 126

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
343.15	7.8370	363.15	5.0000		
353.15	6.1350	368.15	4.4703		

Suggested Equation = 3 Constants: A = -3.8383 B = -267.36 C = 188.83

% AAD = 0.4 S.D. = 2.50 x 10^{-5} Temperature Range: 340-370

Para Hydrogen

CAS RN: 1333-74-0, Source of Data: Reference 148

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
14.000	25.07	20.000	13.54	30.000	6.49
15.000	22.13	21.000	12.53	31.000	5.81
16.000	19.75	22.000	11.61	32.000	5.19
17.000	17.77	24.000	10.08	32.500	4.75
18.000	16.05	26.000	8.72	32.700	4.39
19.000	14.70	28.000	7.52		

Suggested Equation = 2 Constants: A = 3.6446 B = -1.8760 C = 0.00

% AAD = 2.0 S.D. = 2.60E-04 Temperature Range: 15-32

Paracetaldehyde

CAS RN: 123-63-7, Source of Data: Reference 65, 96

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.15[65]	1.3240	343.15	0.5206	390.35	0.3027
315.75	0.7750	352.35	0.4642	397.25	0.2832
324.45	0.6747	364.35	0.4018	283.15[96]	1.5270
333.25	0.5957	377.05	0.3495	349.65	0.4780

Suggested Equation = 3 Constants: A = -4.7345 B = -361.18 C = 93.813

% AAD = 0.9 S.D. = 1.30 x 10^{-5} Temperature Range: 280-400

p-Cresol

CAS RN: 106-44-5, Source of Data: Reference 10, 43

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
332.71[10]	3.4600	433.15	0.5470	293.15	18.9500
353.45	1.9560	447.85	0.4661	303.15	10.5400
373.79	1.2710	463.15	0.3971	313.15	6.5400
387.40	1.0090	472.85	0.3610	333.15	3.2800
403.15	0.8010	273.15[43]	98.4000	353.15	1.9370
407.45	0.6582	283.15	39.6500	373.15	1.0810
423.15	0.6150				

Suggested Equation = 3 Constants: A = -4.3867 B = -268.79 C = 192.80

% AAD = 2.8 S.D. = 1.80E-03 Temperature Range: 280-480

Pentachloroethane

CAS RN: 76-01-7, Source of Data: Reference 8, 149

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.15[8]	2.7510	283.15	3.0120	313.15	1.7361
303.15	2.0700	293.15	2.5000	333.15	1.2853
273.15[149]	3.7313	303.15	2.0492	353.15	1.0000

Suggested Equation = 3 Constants: A = -4.5124 B = -438.07 C = 63.314

% AAD = 0.6 S.D. = 1.60 x 10^{-5} Temperature Range: 270-360

Pentadecane

CAS RN: 629-62-9, Source of Data: Reference 17, 213, 214

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15[17]	2.8410	343.15	1.1550	293.15[213]	2.8410
303.15	2.2910	353.15	1.0100	298.15	2.5340
313.15	1.8730	363.15	0.8880	308.15[214]	2.0559
323.15	1.5700	373.15	0.7860	313.15	1.8680
333.15	1.3350				

Suggested Equation = 3 Constants: A = -1.38 B = -3.35 x 10^2 C = 1.10 x 10^2
%AAD = 0.24231 SD = 2.13 x 10^{-5} Temperature Range: 290-380

Pentane

CAS RN: 109-66-0, Source of Data: Reference 83, 4, 17

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
288.15[83]	0.2410	303.56	0.2110	233.15	0.419
303.15	0.2050	305.81	0.2070	243.15	0.375
323.15	0.1879	153.15[17]	2.31	253.15	0.341
273.89[4]	0.2805	173.15	1.25	263.15	0.311
280.62	0.2620	193.15	0.768	273.15	0.283
286.31	0.2481	203.15	0.640	283.15	0.259
292.06	0.2351	213.15	0.546	293.15	0.240
299.45	0.2192	223.15	0.474	303.15	0.220

Suggested Equation = 3 Constants: A = -4.4907 B = -224.14 C = 31.92
% AAD = 2.1 S.D. = 1.10 x 10^{-5} Temperature Range: 150-330

Pentyl ether

CAS RN:693-65-2, Source of Data: Reference 59

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.15	1.5813	303.15	0.9243	353.15	0.4926
283.15	1.2930	313.15	0.7987	373.15	0.4062
293.15	1.0823	333.15	0.6173		

Suggested Equation = 3 Constants: A = -4.4828 B = -311.96 C = 87.694
% AAD = 0.3 S.D. = 3.00 x 10^{-6} Temperature Range: 270-380

Perfluoro-1,4-diisopropoxybutane

CAS RN: 23228-90-2, Source of Data: Reference 150

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	2.0579	308.15	1.6961		
303.15	1.8676	313.15	1.6045		

Suggested Equation = 3 Constants: A = -2.9742 B = -7.0538 C = 273.86
% AAD = 0.6 S.D. = 1.30 x 10^{-5} Temperature Range: 290-320

Perfluoro-1-isopropoxy hexane

CAS RN: 37340-18-4, Source of Data: Reference 150

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	1.5405	308.15	1.2852		
303.15	1.4118	313.15	1.1790		

Suggested Equation = 2 Constants: A = 5.5620E+10 B = -5.4777 C = 0.00
% AAD = 0.2 S.D. = 2.40 x 10^{-6} Temperature Range: 290-320

Phenethyl alcohol

CAS RN: 60-12-8, Source of Data: Reference 74

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.21	44.2480	303.15	8.9847	353.15	2.0117
283.15	23.8095	313.15	6.1087	373.15	1.3405
293.15	14.2653	333.15	3.2552		

Suggested Equation = 3 Constants: A = -4.4593 B = -324.57 C = 168.71
% AAD = 0.5 S.D. = 9.00 x 10^{-5} Temperature Range: 270-380

Phenol

CAS RN: 108-95-2, Source of Data: Reference 151, 152, 10, 110

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
308.15[151]	6.0241	358.15	1.4393	392.95	0.8340
313.15	4.8031	363.15	1.3062	412.95	0.6426
318.15	4.0000	340.65[152]	2.1102	423.15	0.5721
323.15	3.4200	343.15	1.9861	433.95	0.5091
328.15	2.9386	348.15	1.7721	447.85	0.4416
333.15	2.5621	353.15	1.5711	456.15	0.4060
338.15	2.2492	358.15	1.4160	318.15[110]	4.0760
343.15	1.9976	336.0[10]	2.5770	333.15	2.5780
348.15	1.7800	353.35	1.6080		
353.15	1.5964	373.35	1.1080		

Suggested Equation = 3 Constants: A = -4.3571 B = -267.31 C = 181.96
% AAD = 1.0 S.D. = 5.00 x 10^{-5} Temperature Range: 300-460

Phenyl isothiocyanate

CAS RN: 103-72-0, Source of Data: Reference 74

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	2.2910	303.15	1.3248	353.15	0.7133
283.15	1.8549	313.15	1.1360	373.15	0.5950
293.15	1.5557	333.15	0.8790		

Suggested Equation = 3 Constants: A = -4.1719 B = -247.72 C = 111.40
% AAD = 0.3 S.D. = 4.30 x 10^{-6} Temperature Range: 270-380

Phenyl propyl ketone

CAS RN: 495-40-9, Source of Data: Reference 74

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	4.0700	303.15	1.8932	353.15	0.8648
283.15	3.0331	313.15	1.5603	373.15	0.6927
293.15	2.3624	333.15	1.1319		

Suggested Equation = 3 Constants: A = -4.1646 B = -232.50 C = 142.01
% AAD = 0.2 S.D. = 5.50 x 10^{-6} Temperature Range: 270-380

Phenyl-N-amyl ether

CAS RN: 2050-04-6, Source of Data: Reference 15

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
290.00	2.5620	403.65	0.4802	454.35	0.3112
334.15	1.0840	412.45	0.4432	468.15	0.2793
372.95	0.6504	423.45	0.4037	483.15	0.2500
382.65	0.5861	438.65	0.3527	502.65	0.2190
392.45	0.5342				

Suggested Equation = 3 Constants: A = -4.8009 B = -510.92 C = 58.052
% AAD = 1.4 S.D. = 1.80 x 10^{-5} Temperature Range: 290-510

Phosphorus trichloride

CAS RN: 7719-12-2, Source of Data: Reference 90

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
208.05	1.573	269.15	0.696	308.15	0.487
227.15	1.146	298.15	0.535	323.15	0.438
244.95	0.902	298.75	0.519	333.25	0.411
256.95	0.786				

Suggested Equation = 3 Constants: A = -4.2542 B = -270.00 C = 21.934
% AAD = 0.6 S.D. = 4.40 x 10^{-6} Temperature Range: 200-340

Phosphoryl chloride

CAS RN: 10025-87-3, Source of Data: Reference 90

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
278.15	1.3680	308.15	0.8920	343.15	0.6140
288.15	1.1840	323.15	0.7500	353.15	0.5640
298.15	1.0180	333.15	0.6870		

Suggested Equation = 3 Constants: A = -4.2043 B = -249.22 C = 92.575
% AAD = 0.5 S.D. = 5.60 x 10^{-6} Temperature Range: 270-360

Pinacolone

CAS RN: 75-97-8, Source of Data: Reference 26

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15	0.713	313.15	0.552	333.15	0.440
303.15	0.625	323.15	0.492	353.15	0.360

Suggested Equation = 3 Constants: A = -4.9656 B = -559.39 C = -14.42
% AAD = 0.1 S.D. = 2.80 x 10^{-7} Temperature Range: 290-360

Piperdine

CAS RN: 110-89-4, Source of Data: Reference 65

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
286.70	2.075	349.75	0.6377	378.35	0.4457
324.25	0.9340	359.25	0.5600		
337.65	0.7580	368.35	0.5025		

Suggested Equation = 3 Constants: A = -4.5966 B = -328.47 C = 115.00
% AAD = 0.3 S.D. = 2.90 x 10^{-6} Temperature Range: 280-380

Potassium

CAS RN: 7440-09-7, Source of Data: Reference 153

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
400.00	0.413	900.00	0.151	1400.00	0.0984
500.00	0.301	1000.00	0.135	1500.00	0.0920
600.00	0.238	1100.00	0.123	1600.00	0.0875
700.00	0.198	1200.00	0.114	1700.00	0.0830
800.00	0.171	1300.00	0.105	1800.00	0.0791

Suggested Equation = 3 Constants: A = -4.4954 B = -869.76 C = -389.82

% AAD = 0.7 S.D. = 2.90 x 10^{-6} Temperature Range: 400-1800

Potassium nitrate

CAS RN: 7757-79-1, Source of Data: Reference 154

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
613.00	2.893	648.00	2.383	683.00	1.995
618.00	2.800	653.00	2.341	693.00	1.884
623.00	2.711	658.00	2.260	703.00	1.813
628.00	2.655	663.00	2.186	743.00	1.530
643.00	2.446	673.00	2.083		

Suggested Equation = 1 Constants: A = -4.1228 B = 971.07 C = 0.00

% AAD = 0.4 S.D. = 1.10 x 10^{-5} Temperature Range: 610-750

Propionaldehyde

CAS RN: 123-38-6, Source of Data: Reference 65

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.55	0.3568	308.5	0.2885	320.95	0.2540
299.85	0.3167	313.15	0.2742		
304.35	0.3006	317.55	0.2628		

Suggested Equation = 3 Constants: A = -5.1953 B = -611.30 C = -60.958

% AAD = 0.2 S.D. = 6.80 x 10^{-7} Temperature Range: 280-330

Propionamide

CAS RN: 79-05-0, Source of Data: Reference 66

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
364.85	2.092	423.35	0.785	473.05	0.446
386.05	1.398	443.15	0.614	492.35	0.407
404.45	1.022	462.95	0.495	486.25	0.391

Suggested Equation = 3 Constants: A = -4.3422 B = -267.72 C = 205.36

% AAD = 2.3 S.D. = 2.90 x 10^{-5} Temperature Range: 360-490

Propionic acid

CAS RN: 79-09-4, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
277.85	1.4040	336.78	0.6420	385.52	0.4050
290.02	1.1510	349.85	0.5620	386.13	0.4030
301.36	0.9790	362.71	0.4960	396.82	0.3680
313.19	0.8390	374.16	0.4480	410.20	0.3290
325.18	0.7290				

Suggested Equation = 3 Constants: A = -4.8207 B = -561.55 C = -8.1224

% AAD = 0.5 S.D. = 5.20 x 10^{-6} Temperature Range: 270-420

Propionic anhydride

CAS RN: 123-62-6, Source of Data: Reference 4, 26

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
273.62 [4]	1.5980	377.67	0.4120	313.15	0.8390
287.85	1.2200	392.72	0.3610	323.15	0.7330
303.12	0.9600	407.80	0.3190	333.15	0.6530
318.01	0.7800	421.81	0.2870	353.15	0.5240
332.67	0.6510	437.71	0.2540	373.15	0.4310
348.02	0.5490	283.15[26]	1.1270	393.15	0.3600
368.02	0.4500	303.15	0.9670	413.15	0.3060

Suggested Equation = 3 Constants: A = -4.7818 B = -492.35 C = 24.606

% AAD = 0.5 S.D. = 6.20 x 10^{-6} Temperature Range: 270-440

Propionitrile

CAS RN: 107-12-0, Source of Data: Reference 65

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
293.25	0.4305	330.55	0.2982	366.25	0.2250
304.35	0.3828	342.65	0.2694	370.25	0.2187
317.05	0.3373	365.15	0.2423		

Suggested Equation = 3 Constants: A = -4.7953 B = -424.61 C = 3.7983

% AAD = 0.1 S.D. = 1.30 x 10^{-7} Temperature Range: 290-380

Propionitrile chloride

CAS RN: 79-03-8, Source of Data: Reference 66

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
293.65	0.4729	330.05	0.3314	352.85	0.2749
309.25	0.4019	337.25	0.3112		
320.45	0.3614	344.05	0.2946		

Suggested Equation = 3 Constants: A = -4.7776 B = -443.86 C = -11.959

% AAD = 0.1 S.D. = 1.60 x 10^{-7} Temperature Range: 290-360

Propoxybenzene

CAS RN: 622-85-5, Source of Data: Reference 15

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
289.05	1.7270	393.15	0.4179	433.65	0.2940
333.65	0.7872	403.45	0.3833	440.65	0.2780
372.65	0.5054	413.65	0.3476	448.15	0.2620
382.65	0.4592	424.15	0.3178	457.35	0.2440

Suggested Equation = 3 Constants: A = -4.7786 B = -473.64 C = 53.513

% AAD = 1.1 S.D. = 1.10 x 10^{-5} Temperature Range: 280-460

Propyl acetate

CAS RN: 109-60-4, Source of Data: Reference 28

***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**	***T* (K)**	***η* (N.s.m^{-2})**
273.54	0.7662	312.91	0.4563	353.16	0.3029
282.94	0.6659	323.19	0.4081	362.65	0.2775
293.74	0.5762	334.51	0.3625	370.05	0.2602
303.28	0.5109	343.05	0.3331		

Suggested Equation = 1 Constants: A = -4.9024 B = 488.31 C = 0.00

% AAD = 0.4 S.D. = 2.80 x 10^{-6} Temperature Range: 270-380

Propyl carbamate

CAS RN: 3359-38-4, Source of Data: Reference 123

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
338.15	2.7970	358.15	1.7470	378.15	1.2000
348.15	2.1820	368.15	1.4290		

Suggested Equation = 3 Constants: A = -4.5234 B = -342.48 C = 164.26

% AAD = 0.2 S.D. = 3.30 x 10^{-6} Temperature Range: 330-380

Propyl ether

CAS RN: 111-43-3, Source of Data: Reference 28, 22

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.74[28]	0.5359	313.62	0.3360	354.62	0.2284
281.73	0.4826	321.21	0.3114	361.17	0.2154
290.10	0.4358	329.30	0.2877	288.15[22]	0.4480
297.80	0.3985	337.31	0.2664	303.15	0.3760
305.61	0.3655	345.74	0.2469		

Suggested Equation = 1 Constants: A = -4.8897 B = 443.44 C = 0.00

% AAD = 0.3 S.D. = 1.00 x 10^{-6} Temperature Range: 270-360

Propyl formate

CAS RN: 110-74-7, Source of Data: Reference 28

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.50	0.6648	303.92	0.4557	334.71	0.3315
280.49	0.6041	311.69	0.4185	340.28	0.3131
288.69	0.5458	318.88	0.3876	348.14	0.2928
296.31	0.4975	327.30	0.3564	350.70	0.2861

Suggested Equation = 1 Constants: A = -4.8378 B = 454.39 C = 0.00

% AAD = 0.3 S.D. = 1.80 x 10^{-6} Temperature Range: 270-360

Propyl oleate

CAS RN: 111-59-1, Source of Data: Reference 155

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	5.8600	333.15	3.0600	363.15	1.8100

Suggested Equation = 1 Constants: A = -5.3227 B = 936.52 C = 0.00

% AAD = 0.4 S.D. = 1.60 x 10^{-5} Temperature Range: 300-370

Propyl sulfone

CAS RN: 598-03-8, Source of Data: Reference 3

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	5.432	323.15	3.109	373.15	1.236
313.15	4.043	348.15	1.855	398.15	0.895

Suggested Equation = 3 Constants: A = -4.2525 B = -290.93 C = 156.68

% AAD = 0.3 S.D. = 9.90 x 10^{-6} Temperature Range: 300-400

Propyl sulfoxide

CAS RN: 4253-91-2, Source of Data: Reference 33

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15	2.526	323.15	1.630	373.15	0.772
313.15	2.002	348.15	1.076		

Suggested Equation = 1 Constants: A = -5.1274 B = 752.57 C = 0.00

% AAD = 0.3 S.D. = 9.90 x 10^{-6} Temperature Range: 300-380

Propyl thioacetate

CAS RN: 2307-10-0, Source of Data: Reference 117

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15	0.7889	333.15	0.5729	363.15	0.4432
318.15	0.6669	348.15	0.5030		

Suggested Equation = 3 Constants: A = -4.4072 B = -330.35 C = 49.855

% AAD = 0.2 S.D. = 8.80 x 10^{-7} Temperature Range: 300-370

Propyl titanate

Source of Data: Reference 75

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
413.75	2.0160	443.05	0.9090	472.35	0.4940
422.45	1.5650	453.05	0.7200		
430.45	1.2480	463.15	0.5810		

Suggested Equation = 3 Constants: A = -5.4227 B = -548.59 C = 212.66

% AAD = 0.4 S.D. = 4.40 x 10^{-6} Temperature Range: 410-480

Propylbenzenamine

CAS RN: 622-80-0, Source of Data: Reference 65

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
379.65	0.6458	438.85	0.3698	483.65	0.2667
409.15	0.4778	452.85	0.3320	495.15	0.2480
424.05	0.4183	467.65	0.2978		

Suggested Equation = 3 Constants: A = -4.8964 B = -612.19 C = 20.818

% AAD = 0.1 S.D. = 4.80 x 10^{-7} Temperature Range: 370-500

Propyleneglycol dinitrate

CAS RN: 6423-43-4, Source of Data: Reference 114

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
283.15	5.5556	303.15	3.1348	323.15	2.0284
288.15	4.7619	308.15	2.7778	328.15	1.8315
293.15	4.0650	313.15	2.4570	333.15	1.7094
298.15	3.5461	318.15	2.2075		

Suggested Equation = 3 Constants: A = -3.9605 B = -196.00 C = 168.35

% AAD = 0.5 S.D. = 1.70 x 10^{-5} Temperature Range: 280-340

p-Xylene

CAS RN: 106-42-3, Source of Data: Reference 4, 8, 192

T (K)	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})
281.46[4]	0.7513	350.53	0.3503	408.34	0.2249
293.67	0.6387	363.03	0.3197	303.15[8]	0.5680
304.35	0.5611	373.96	0.2903	298.15[192]	0.613
315.07	0.4875	384.91	0.2665	303.15	0.574
326.76	0.4410	396.98	0.2447	308.15	0.542
341.57	0.3958				

Suggested Equation = 1 Constants: A = -1.95 B = -5.81×10^{2} C = $-3.72\text{x } 10^{1}$

%AAD = 0.774584 SD = 3.95×10^{-4} Temperature Range: 280-410

Pyrene

CAS RN: 129-00-0, Source of Data: Reference 102

T (K)	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})
452.95	1.280	473.25	1.029	493.35	0.839
463.15	1.142	483.05	0.924	503.05	0.767

Suggested Equation = 1 Constants: A = -5.132 B = 1014.2 C = 0.00

% AAD = 0.2 S.D. = 2.20×10^{-6} Temperature Range: 450-510

Pyridine

CAS RN: 110-86-1, Source of Data: Reference 43, 110, 156

T (K)	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})
273.15[43]	1.3230	383.15	0.3850	303.15	0.8290
283.15	1.1080	288.15[110]	1.0380	313.15	0.7240
293.15	0.9410	303.15	0.8290	323.15	0.6390
303.15	0.8210	273.15[156]	1.3600	333.15	0.5690
333.15	0.5780	283.15	1.1300	343.15	0.5080
353.15	0.4870	293.15	0.9580	353.15	0.4620

Suggested Equation = 3 Constants: A = -4.1172 B = -174.52 C = 133.66

% AAD = 1.2 S.D. = 1.20×10^{-5} Temperature Range: 270-390

Pyridine N-oxide

CAS RN: 694-59-7, Source of Data: Reference 36

T (K)	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})	*T (K)*	η (N.s.m^{-2})
343.15	2.9950	360.65	2.2060	385.65	1.5570
348.15	2.7340	383.15	1.8340	398.15	1.3330

Suggested Equation = 1 Constants: A = -4.9399 B = 828.32 C = 0.00

% AAD = 3.5 S.D. = 8.00×10^{-5} Temperature Range: 340-400

Pyrrole

CAS RN: 109-97-7, Source of Data: Reference 102

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
252.65	3.788	293.15	1.352	323.15	0.829
263.45	2.702	303.15	1.132	333.15	0.728
273.05	2.113	313.15	0.955	343.55	0.641
283.25	1.608				

Suggested Equation = 3 Constants: A = -4.2156 B = -216.75 C = 131.91

% AAD = 0.7 S.D. = 1.70 x 10^{-5} Temperature Range: 250-350

Pyrrolidine

CAS RN: 123-75-1, Source of Data: Reference 102

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
215.45	6.485	253.55	1.661	293.15	0.756
221.15	4.865	261.35	1.348	303.15	0.655
228.05	3.714	270.05	1.140	319.05	0.539
234.15	2.946	277.15	0.999	327.15	0.491
241.05	2.339	284.45	0.836	334.75	0.451
247.75	1.925				

Suggested Equation = 3 Constants: A = -4.2850 B = -204.20 C = 117.84

% AAD = 0.5 S.D. = 2.50 x 10^{-5} Temperature Range: 210-340

Rapseed Oil

Source of Data: Reference 109

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	93	313.15	41	333.15	21

Suggested Equation = 3 Constants: A = -4.4802 B = -597.20 C = 119.99

% AAD = 0.2 S.D. = 8.00 x 10^{-5} Temperature Range: 290-340

Salicylaldehyde

CAS RN: 90-02-8, Source of Data: Reference 10

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
344.25	1.1340	394.45	0.6324	445.15	0.4140
355.95	0.9670	406.45	0.5675	457.45	0.3789
369.45	0.8216	419.95	0.5049	464.35	0.3611
382.45	0.7124	423.15	0.4910	468.35	0.3516
393.15	0.6410	432.95	0.4550		

Suggested Equation = 3 Constants: A = -4.6526 B = -502.49 C = 49.163

% AAD = 0.3 S.D. = 3.50 x 10^{-6} Temperature Range: 340-470

s-Butyl titanate

Source of Data: Reference 75

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
371.95	0.7470	401.35	0.5760	431.15	0.4520
381.75	0.6940	411.05	0.5310	440.95	0.4160
391.45	0.6260	420.85	0.4910	450.35	0.3880

Suggested Equation = 1 Constants: A = -4.7678 B = 612.63 C = 0.00

% AAD = 0.7 S.D. = 4.80 x 10^{-6} Temperature Range: 370-460

Sodium acetate hydrate

CAS RN: 6131-90-4, Source of Data: Reference 101

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
333.50	5.315	343.20	4.111	348.00	3.455
338.80	4.535	346.50	3.608		

Suggested Equation = 1 Constants: A = -6.7211 B = 1483.7 C = 0.00

% AAD = 1.1 S.D. = 5.30 x 10^{-5} Temperature Range: 330-360

Sodium carbonate hydrate

CAS RN: 497-19-8, Source of Data: Reference 101

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
308.00	7.925	318.00	5.371		
313.00	6.466	323.00	4.429		

Suggested Equation = 1 Constants: A = -7.5193 B = 1668.7 C = 0.00

% AAD = 0.3 S.D. = 1.60 x 10^{-5} Temperature Range: 300-330

Sodium hydroxide hydrate

CAS RN: 12179-02-1, Source of Data: Reference 101

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
337.20	10.542	343.00	8.541	353.00	6.057
340.00	9.657	348.00	8.541		

Suggested Equation = 1 Constants: A = -7.3900 B = 1826.0 C = 0.00

% AAD = 0.5 S.D. = 5.30 x 10^{-5} Temperature Range: 330-360

Sodium phosphate, dibasic decahydrate

CAS RN: 7558-79-4, Source of Data: Reference 101

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
310.00	4.778	318.00	3.927		
313.00	4.410	323.00	3.300		

Suggested Equation = 3 Constants: A = -1.9749 B = -14.524 C = 351.62

% AAD = 0.6 S.D. = 3.00 x 10^{-5} Temperature Range: 310-330

Sodium thiosulfatepentahydrate

CAS RN: 10102-17-7, Source of Data: Reference 101

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
321.50	9.368	328.00	7.260	338.00	5.377
323.00	8.877	330.00	6.269		

Suggested Equation = 3 Constants: A = -3.0454 B = -54.28 C = 268.25

% AAD = 0.6 S.D. = 4.60 x 10^{-5} Temperature Range: 320-340

Soybean oil

Source of Data: Reference 109

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15	60	303.15	28	333.15	15

Suggested Equation = 3 Constants: A = -4.4977 B = -581.28 C = 115.71

% AAD = 0.2 S.D. = 3.50 x 10^{-5} Temperature Range: 290-340

Spiro (4,5) decane

CAS RN: 176-63-6, Source of Data: Reference 64

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	3.332	310.95	1.619		
293.15	2.208	333.15	1.165		

Suggested Equation = 3 Constants: A = -4.5205 B = -426.25 C = 64.537

% AAD = 0.1 S.D. = 1.20 x 10^{-7} Temperature Range: 270-340

Spiro(5,5)undecane

CAS RN: 180-43-8, Source of Data: Reference 64

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	5.079	310.95	2.212	372.05	0.919
293.15	3.144	333.15	1.534		

Suggested Equation = 3 Constants: A = -4.4509 B = -406.57 C = 84.58

% AAD = 0.2 S.D. = 4.80 x 10^{-6} Temperature Range: 270-380

Spiro(5,6)dodecane

CAS RN: 181-15-7, Source of Data: Reference 64

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	8.001	310.95	3.009	372.05	1.138
293.15	4.507	333.15	1.992		

Suggested Equation = 3 Constants: A = -4.3005 B = -349.60 C = 114.44

% AAD = 0.2 S.D. = 1.20 x 10^{-5} Temperature Range: 270-380

Strontium chloride hexahydrate (molten)

CAS RN: 10025-70-4, Source of Data: Reference 79

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
1152.05	3.7079	1213.75	3.0636	1302.65	2.4251
1182.05	3.3635	1243.65	2.8161	1318.15	2.3389
1212.75	3.0678	1273.75	2.6066		

Suggested Equation = 3 Constants: A = -3.6073 B = -954.00 C = 341.06

% AAD = 0.1 S.D. = 1.50 x 10^{-6} Temperature Range: 1150-1320

Styrene

CAS RN: 100-42-5, Source of Data: Reference 17

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.15	1.0470	323.15	0.5020	373.15	0.3090
283.15	0.8790	333.15	0.4530	383.15	0.2890
293.15	0.7490	343.15	0.4130	393.15	0.2690
303.15	0.6480	353.15	0.3740	403.15	0.2490
313.15	0.5650	363.15	0.3490	413.15	0.2320

Suggested Equation = 3 Constants: A = -4.6087 B = -343.56 C = 61.746

% AAD = 0.8 S.D. = 5.00 x 10^{-6} Temperature Range: 270-420

Sucrose

CAS RN: 57-50-1, Source of Data: Reference 157

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	1.996	318.15	1.396		
308.15	1.654	328.15	1.195		

Suggested Equation = 3 Constants: A = -4.3736 B = -327.15 C = 102.69
% AAD = 0.1 S.D. = 3.30 x 10^{-7} Temperature Range: 290-330

Sunflower oil

Source of Data: Reference 109

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	63	313.15	29	333.15	16

Suggested Equation = 3 Constants: A = -3.6505 B = -304.27 C = 168.98
% AAD = 0.4 S.D. = 1.20E-04 Temperature Range: 290-340

Trans-Decahydronaphthalene

CAS RN: 493-02-7, Source of Data: Reference 108

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
243.15	7.3100	313.15	1.4930	383.15	0.6260
253.15	5.3940	321.15	1.2820	393.15	0.5720
263.15	4.0940	333.15	1.1140	403.15	0.5210
273.15	3.2330	343.15	0.9780	423.15	0.4380
283.15	2.5880	353.15	0.8650	433.15	0.4060
293.15	2.1280	363.15	0.7720	443.15	0.3750
303.15	1.7740	373.15	0.6920	453.15	0.3500

Suggested Equation = 3 Constants: A = -4.5844 B = -443.20 C = 61.638
% AAD = 0.5 S.D. = 2.60 x 10^{-5} Temperature Range: 240-440

t-Butyl titanate

Source of Data: Reference 75

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
313.53	2.5830	353.15	1.3360	389.75	0.8300
323.15	2.1580	364.95	1.1250	405.75	0.6920
343.15	1.5470	389.75	0.9990		

Suggested Equation = 3 Constants: A = -4.8180 B = -598.78 C = 44.89
% AAD = 0.2 S.D. = 2.50 x 10^{-6} Temperature Range: 310-410

tert-Amyl alcohol

CAS RN: 75-85-4, Source of Data: Reference 4

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
273.64	13.7969	318.20	1.7135	354.21	0.6400
282.46	8.2034	326.33	1.3199	363.09	0.5301
291.63	4.9978	336.10	0.9943	368.85	0.4718
300.39	3.3643	345.06	0.7931	369.85	0.4643
309.57	2.3322				

Suggested Equation = 3 Constants: A = -5.0576 B = -359.53 C = 161.29
% AAD = 0.3 S.D. = 3.40 x 10^{-5} Temperature Range: 270-380

Tetradecane

CAS RN: 629-59-4, Source of Data: Reference 17

***T* (*K*)**	***η* (*N.s.m^{-2}*)**	***T* (*K*)**	***η* (*N.s.m^{-2}*)**	***T* (*K*)**	***η* (*N.s.m^{-2}*)**
283.15	2.960	323.15	1.322	353.15	0.868
293.15	2.322	333.15	1.135	363.15	0.769
303.15	1.889	343.15	0.908	373.15	0.685
313.15	1.560				

Suggested Equation = 3 Constants: A = -4.3480 B = -307.14 C = 114.12
% AAD = 0.3 S.D. = 6.40 x 10^{-6} Temperature Range: 280-380

Tetradecyl thiolaurate

CAS RN: , Source of Data: Reference 117

***T* (*K*)**	***η* (*N.s.m^{-2}*)**	***T* (*K*)**	***η* (*N.s.m^{-2}*)**	***T* (*K*)**	***η* (*N.s.m^{-2}*)**
333.15	7.4440	348.15	5.4770	363.15	4.2160

Suggested Equation = 3 Constants: A = -3.6644 B = -241.20 C = 176.10
% AAD = 0.2 S.D. = 1.10 x 10^{-5} Temperature Range: 330-370

Tetradecyl thiomyristate

Source of Data: Reference 117

***T* (*K*)**	***η* (*N.s.m^{-2}*)**	***T* (*K*)**	***η* (*N.s.m^{-2}*)**	***T* (*K*)**	***η* (*N.s.m^{-2}*)**
333.15	8.7500	348.15	6.3610	363.15	4.8500

Suggested Equation = 3 Constants: A = -3.7246 B = -275.40 C = 167.88
% AAD = 0.1 S.D. = 5.00 x 10^{-6} Temperature Range: 330-370

Tetra-n-butyl germane

CAS RN: 1067-42-1, Source of Data: Reference 158

***T* (*K*)**	***η* (*N.s.m^{-2}*)**	***T* (*K*)**	***η* (*N.s.m^{-2}*)**	***T* (*K*)**	***η* (*N.s.m^{-2}*)**
275.6	5.358	303.1	2.495	323.4	1.648
282.2	4.317	308.0	2.232	328.2	1.512
288.0	3.685	313.7	1.991	334.3	1.362
295.0	3.032	318.6	1.804	339.3	1.255
299.9	2.690	320.3	1.651		

Suggested Equation = 3 Constants: A = -4.0687 B = -211.37 C = 158.55
% AAD = 1.1 S.D. = 3.70 x 10^{-5} Temperature Range: 270-340

Tetra-n-ethyl germane

CAS RN: 597-63-7, Source of Data: Reference 158

***T* (*K*)**	***η* (*N.s.m^{-2}*)**	***T* (*K*)**	***η* (*N.s.m^{-2}*)**	***T* (*K*)**	***η* (*N.s.m^{-2}*)**
277.90	0.8800	319.50	0.5866	325.80	0.5613
284.30	0.8202	301.20	0.6835	331.80	0.5360
288.80	0.7789	307.30	0.6460	337.10	0.5170
295.30	0.7298	313.40	0.6163		

Suggested Equation = 3 Constants: A = -3.8769 B = -124.05 C = 127.22
% AAD = 0.3 S.D. = 2.10 x 10^{-6} Temperature Range: 270-340

Tetra-n-hexyl germane

CAS RN: 4828-44-8, Source of Data: Reference 158

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
276.6	12.460	302.1	5.425	326.0	3.024
284.0	9.524	313.0	4.006	331.8	2.696
289.8	7.874	318.7	3.567	338.2	2.379
296.5	6.345				

Suggested Equation = 3 Constants: A = -4.1948 B = -307.49 C = 142.51

% AAD = 0.5 S.D. = 3.90 x 10^{-6} Temperature Range: 270-340

Tetra-n-methyl germane

CAS RN: 865-52-1, Source of Data: Reference 158

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
276.7	0.4049	287.3	0.3690	289.7	0.3348
282.5	0.3855	293.0	0.3512	303.8	0.3233

Suggested Equation = 1 Constants: A = -4.5041 B = 307.67 C = 0.00

% AAD = 0.2 S.D. = 6.40 x 10^{-7} Temperature Range: 270-310

Tetra-n-pentyl germane

CAS RN: 3634-47-7, Source of Data: Reference 158

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
276.2	9.511	301.0	4.199	325.8	2.377
282.8	7.311	308.7	3.438	331.8	2.132
288.9	6.005	314.0	3.040	338.2	1.915
294.8	4.991				

Suggested Equation = 3 Constants: A = -3.9447 B = -210.02 C = 166.92

% AAD = 0.3 S.D. = 2.30 x 10^{-5} Temperature Range: 270-340

Tetra-n-propyl germane

CAS RN: 994-65-0, Source of Data: Reference 158

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
276.6	1.842	300.5	1.192	324.4	0.8370
280.6	1.700	305.6	1.085	330.2	0.7892
284.4	1.576	310.5	1.007	335.9	0.7297
289.0	1.444	320.5	0.8782	340.7	0.6832
294.8	1.308				

Suggested Equation = 3 Constants: A = -4.2442 B = -244.89 C = 114.56

% AAD = 0.5 S.D. = 5.60 x 10^{-6} Temperature Range: 270-350

Thallium

CAS RN: 7440-28-0, Source of Data: Reference 159

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
576.65	2.6360	615.45	2.3570	691.45	1.9838
579.15	2.6106	633.95	2.2504	711.15	1.9085
592.45	2.5145	651.95	2.1569	730.15	1.8436
605.65	2.4224	671.65	2.0629		

Suggested Equation = 3 Constants: A = -3.1959 B = -282.64 C = 118.24

% AAD = 0.1 S.D. = 1.60 x 10^{-6} Temperature Range: 570-740

Thiophosphoryl chloride

CAS RN: 3982-91-0, Source of Data: Reference 90

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
242.75	2.627	273.15	1.496	348.15	0.611
252.75	2.102	298.15	1.017	358.15	0.569
263.15	1.741	318.15	0.806	371.65	0.519
267.75	1.605	338.15	0.655		

Suggested Equation = 3 Constants: A = -4.1147 B = -230.60 C = 92.836

% AAD = 0.7 S.D. = 1.50×10^{-5} Temperature Range: 240-380

Tin

CAS RN: 7440-31-5, Source of Data: Reference 137

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
511.95	1.742	614.15	1.412	715.35	1.218
527.85	1.684	642.55	1.342	737.55	1.184
539.65	1.644	669.15	1.290	766.45	1.148
558.25	1.574	693.45	1.244		

Suggested Equation = 3 Constants: A = -3.2469 B = -207.80 C = 88.744

% AAD = 0.3 S.D. = 5.10×10^{-6} Temperature Range: 510-770

trans-1,2-Dichloroethylene

CAS RN: 156-60-5, Source of Data: Reference 107

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
223.15	1.0050	248.15	0.6820	273.15	0.4980
228.15	0.9250	253.15	0.6370	278.15	0.4710
233.15	0.8470	258.15	0.5970	283.15	0.4470
238.15	0.7830	263.15	0.5600	288.15	0.4230
243.15	0.7290	268.15	0.5260	293.15	0.4040

Suggested Equation = 1 Constants: A = -4.6555 B = 369.48 C = 0.00

% AAD = 0.3 S.D. = 2.30×10^{-6} Temperature Range: 220-300

trans-2-Octene

CAS RN: 13389-42-9, Source of Data: Reference 26

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15	0.5060	323.15	0.3660	373.15	0.2340
303.15	0.4510	333.15	0.3330		
313.15	0.4060	353.15	0.2770		

Suggested Equation = 3 Constants: A = -5.3398 B = -836.02 C = -115.97

% AAD = 0.1 S.D. = 4.70×10^{-7} Temperature Range: 290-380

Tributyl borate

CAS RN: 688-74-4, Source of Data: Reference 160

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	1.6434	343.15	0.8393	423.15	0.3728
303.15	1.5182	353.15	0.7413	443.15	0.3183
313.15	1.2814	363.15	0.6607	463.15	0.2764
323.15	1.1029	383.15	0.5334	473.15	0.2587
333.15	0.9582	403.15	0.4421	493.15	0.2290

Suggested Equation = 3 Constants: A = -4.8408 B = -562.33 C = 24.655

% AAD = 0.2 S.D. = 2.90×10^{-6} Temperature Range: 290-500

Tributyl phosphate

CAS RN: 126-73-8, Source of Data: Reference 90

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
208.15	333.0	248.15	17.7	308.15	2.77
218.15	121.0	258.15	11.1	318.15	2.23
228.15	56.6	268.15	8.50	338.15	1.61
238.15	32.9	298.15	3.39		

Suggested Equation = 3 Constants: A = -4.1597 B = -282.50 C = 131.38

% AAD = 2.6 S.D. = 1.5 x 10^{-3} Temperature Range: 205-340

Tridecane

CAS RN: 629-50-5, Source of Data: Reference 17, 214, 213

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
273.15[17]	2.9620	343.15	0.8490	453.15	0.2990
283.15	2.3390	353.15	0.7500	473.15	0.2600
293.15	1.8780	363.15	0.6680	308.15[214]	1.4059
303.15	1.5610	373.15	0.5980	313.15	1.2920
313.15	1.3120	393.15	0.4890	293.15[213]	1.8630
323.15	1.1140	413.15	0.4080	298.15	1.6880
333.15	0.9690	433.15	0.3470		

Suggested Equation = 3 Constants: A = -1.64 B = -4.31 x 10^{2} C = 6.85x 10 ^{1}

%AAD = 0.914731 SD = 4.42 x 10^{-4} Temperature Range: 270-480

Tridecyl thiopalmitate

Source of Data: Reference 117

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
333.15	9.4500	348.15	6.8440	363.15	5.1870

Suggested Equation = 3 Constants: A = -3.3966 B = -176.63 C = 204.38

% AAD = 0.4 S.D. = 3.70 x 10^{-5} Temperature Range: 330-370

Triethyl borate

CAS RN: 150-46-9, Source of Data: Reference 160

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
298.15	0.5178	323.15	0.3945	343.15	0.3278
303.15	0.4875	333.15	0.3586	353.15	0.3010
313.15	0.4392				

Suggested Equation = 3 Constants: A = -4.8708 B = -497.40 C = -15.747

% AAD = 0.2 S.D. = 7.30 x 10^{-7} Temperature Range: 290-370

Trifluoroacetic acid

CAS RN: 76-05-1, Source of Data: Reference 2

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
292.90	0.8760	313.70	0.6530	333.55	0.5020
303.20	0.7500	325.50	0.5690	338.57	0.4730

Suggested Equation = 1 Constants: A = -5.0399 B = 580.67 C = 0.00

% AAD = 0.1 S.D. = 2.00 x 10^{-7} Temperature Range: 290-340

Trifluoro methyl cyclohexane

CAS RN: 401-75-2, Source of Data: Reference 2

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	0.9510	313.15	0.7335	333.15	0.5750
303.15	0.8290	323.15	0.6485		

Suggested Equation = 1 Constants: A = -4.8304 B = 530.52 C = 0.00
% AAD = 0.3 S.D. = 2.40 x 10^{-6} Temperature Range: 290-340

Trihexylamine

CAS RN: 102-86-3, Source of Data: Reference 31

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
283.15	6.0660	333.15	1.8440	398.15	0.7400
298.15	3.9110	353.15	1.3220	423.15	0.5620
313.15	2.7750	373.15	0.9940		

Suggested Equation = 3 Constants: A = -4.5462 B = -412.41 C = 105.78
% AAD = 0.6 S.D. = 3.00 x 10^{-6} Temperature Range: 280-430

Triisobutyl borate

CAS RN: 13195-76-1, Source of Data: Reference 160

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	1.8218	343.15	0.8405	423.15	0.3529
303.15	1.6426	353.15	0.7356	443.15	0.3011
313.15	1.3498	363.15	0.6496	463.15	0.2612
323.15	1.1374	383.15	0.5145	473.15	0.2442
333.15	0.9771	403.15	0.4217		

Suggested Equation = 3 Constants: A = -4.7067 B = -433.43 C = 77.578
% AAD = 0.3 S.D. = 4.00 x 10^{-6} Temperature Range: 290-480

Triisopropyl borate

CAS RN: 1776-16-5, Source of Data: Reference 160

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	0.8049	333.15	0.5048	363.15	0.3647
303.15	0.7502	343.15	0.4516	383.15	0.3009
313.15	0.6490	353.15	0.4059	403.15	0.2524

Suggested Equation = 3 Constants: A = -5.0367 B = -584.29 C = -2.532
% AAD = 0.3 S.D. = 1.50 x 10^{-6} Temperature Range: 290-410

Trilaurin

CAS RN: 538-24-9, Source of Data: Reference 161

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
318.15	21.9800	343.15	10.3000	353.15	8.0900
333.15	13.5900	348.15	9.1100	358.15	7.2200

Suggested Equation = 3 Constants: A = -3.9293 B = -336.14 C = 170.15
% AAD = 0.1 S.D. = 1.0 x 10^{-3} Temperature Range: 310-360

Trimethyl borate

CAS RN: 121-43-7, Source of Data: Reference 160

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	0.3750	313.15	0.3245	333.15	0.2733
303.15	0.3568	323.15	0.2969		

Suggested Equation = 3 Constants: A = -4.1136 B = -96.248 C = 158.62

% AAD = 0.3 S.D. = 1.20 x 10^{-6} Temperature Range: 290-340

Trimethyl phosphite

CAS RN: 121-45-9, Source of Data: Reference 90

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
243.15	1.323	324.95	0.413	371.95	0.292
297.85	0.547	337.55	0.369		
310.95	0.474	354.05	0.331		

Suggested Equation = 3 Constants: A = -4.2594 B = -195.02 C = 102.02

% AAD = 0.4 S.D. = 2.00 x 10^{-6} Temperature Range: 240-380

Tri-n-propyl ortho phosphate

CAS RN: 513-08-6, Source of Data: Reference 162

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15	2.8329	303.15	2.2462	313.15	1.8359
298.15	2.5110	308.15	2.0300		

Suggested Equation = 1 Constants: A = -5.4955 B = 863.50 C = 0.00

% AAD = 0.4 S.D. = 1.00 x 10^{-5} Temperature Range: 290-320

Trioctyl phosphine oxide

CAS RN: 78-50-2, Source of Data: Reference 90

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
338.15	10.05	358.15	5.48		
348.15	7.11	371.65	4.02		

Suggested Equation = 3 Constants: A = -3.4379 B = -126.97 C = 249.94

% AAD = 0.5 S.D. = 3.40 x 10^{-5} Temperature Range: 330-380

Tri-o-tolyl phosphate

CAS RN: 1330-78-5, Source of Data: Reference 162

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	86.6551	303.15	61.0128	313.15	32.7332

Suggested Equation = 1 Constants: A = -9.8520 B = 2619.9 C = 0.00

% AAD = 0.6 S.D. = 9.00E-04 Temperature Range: 290-320

Tripalmitin

CAS RN: 555-44-2, Source of Data: Reference 163

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
343.15	1.6790	353.15	1.2920		
348.15	1.4670	358.15	1.1440		

Suggested Equation = 3 Constants: A = -3.7364 B = -69.231 C = 271.28

% AAD = 0.5 S.D. = 7.00 x 10^{-6} Temperature Range: 340-360

Triphenyl phosphate

CAS RN: 115-86-6, Source of Data: Reference 90

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
323.15	10.04	338.15	6.56	353.15	4.61
328.15	8.62	343.15	5.77	358.15	4.19
333.15	7.34	348.15	5.17	363.15	3.86

Suggested Equation = 3 Constants: A = -3.4721 B = -149.45 C = 221.84

% AAD = 0.6 S.D. = 4.10 x 10^{-5} Temperature Range: 320-370

Triphenyl phosphite

CAS RN: 101-02-0, Source of Data: Reference 90

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	16.05	328.15	5.90	358.15	3.10
308.15	10.70	338.15	4.68		
318.15	7.98	348.15	3.76		

Suggested Equation = 3 Constants: A = -3.8459 B = -231.62 C = 185.13

% AAD = 0.8 S.D. = 9.00 x 10^{-5} Temperature Range: 290-360

Tripropyl borate

CAS RN: 688-71-1, Source of Data: Reference 160

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	1.0220	333.15	0.6405	383.15	0.3757
303.15	0.9393	343.15	0.5718	403.15	0.3169
313.15	0.8165	353.15	0.5066	423.15	0.2716
323.15	0.7142	363.15	0.4619	443.15	0.2351

Suggested Equation = 3 Constants: A = -5.0077 B = -633.51 C = -16.470

% AAD = 0.5 S.D. = 4.00 x 10^{-6} Temperature Range: 290-450

Tris-(2-ethylhexyl) phosphate

CAS RN: 78-42-2, Source of Data: Reference 90

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
213.15	8080	252.65	133.0	318.65	6.07
223.15	2560	298.65	11.4	338.15	3.76
243.15	260.0	308.15	8.21	348.65	3.12

Suggested Equation = 3 Constants: A = -4.1967 B = -332.10 C = 151.17

% AAD = 1.5 S.D. = 1.90E-02 Temperature Range: 220-350

Trisdimethyl aminophosphine oxide

Source of Data: Reference 90

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
283.15	4.85	298.15	3.34	333.15	1.82
291.15	3.94	313.15	2.52	348.15	1.48

Suggested Equation = 3 Constants: A = -3.9327 B = -226.35 C = 143.09

% AAD = 0.5 S.D. = 1.70 x 10^{-5} Temperature Range: 280-350

Undecane

CAS RN: 1120-21-4, Source of Data: Reference 128, 25, 17, 213, 214

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15 [128]	1.0810	283.15	1.4250	373.15	0.4370
273.15 [25]	1.7241	293.15	1.1820	393.15	0.3650
283.15	1.4061	298.15	1.0810	413.15	0.3110
293.15	1.1721	303.15	1.0100	433.15	0.2680
303.15	0.9960	313.15	0.8710	453.15	0.2330
313.15	0.8643	323.15	0.7590	473.15	0.2040
333.15	0.6618	333.15	0.6710	293.15[213]	1.1740
353.15	0.5274	343.15	0.5970	298.15	1.0810
373.15	0.4348	353.15	0.5350	308.15[214]	0.9273
263.15[17]	2.1630	363.15	0.4820	313.15	0.8633
273.15	1.7420				

Suggested Equation = 3 Constants: A = -1.68 B = -4.21 x 10^{2} C = 5.35x 10^{1}
%AAD = 0.934327 SD = 6.80 x 10^{-4} Temperature Range: 260-480

Undecyl thiopalmitate

Source of Data: Reference 117

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
333.15	8.0500	348.15	5.8920	363.15	4.5070

Suggested Equation = 3 Constants: A = -3.7452 B = -275.62 C = 166.17
% AAD = 0.2 S.D. = 1.00 x 10^{-5} Temperature Range: 330-370

Undecyl thiostearate

Source of Data: Reference 117

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
333.15	9.5920	348.15	6.9150	363.15	5.2510

Suggested Equation = 3 Constants: A = -3.3186 B = -155.73 C = 213.36
% AAD = 0.4 S.D. = 3.50 x 10^{-5} Temperature Range: 330-370

Valeronitrile

CAS RN: 110-59-8, Source of Data: Reference 27, 45, 65

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.15[27]	0.7790	333.15	0.4695	367.55	0.3405
303.15	0.6370	353.15	0.3873	378.15	0.3118
273.15[45]	1.0160	373.15	0.3246	387.25	0.2908
283.15	0.8666	291.75[65]	0.7746	398.35	0.2679
293.15	0.7350	326.95	0.5044	406.75	0.2508
303.15	0.6596	347.15	0.4114	413.15	0.2400
313.15	0.5838	359.15	0.3675		

Suggested Equation = 3 Constants: A = -4.8445 B = -512.47 C = -4.9088
% AAD = 0.8 S.D. = 9.00 x 10^{-6} Temperature Range: 270-420

Water

CAS RN: 7732-18-5, Source of Data: Reference 163, 4

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
273.64[163]	1.7608	279.11	1.4732	303.88	0.7861
274.14	1.7311	280.11	1.4287	312.82	0.6623
274.63	1.7018	280.61	1.4030	320.18	0.5761
275.13	1.6737	281.11	1.3863	328.69	0.5010
275.63	1.6465	281.61	1.3660	337.13	0.4416
276.13	1.6196	282.11	1.3461	345.69	0.3915
276.63	1.5936	282.61	1.3265	353.90	0.3524
277.13	1.5680	283.11	1.3072	363.02	0.3164
277.63	1.5433	278.62[4]	1.4929	371.24	0.2889
278.13	1.5191	286.68	1.1808		
278.61	1.4964	295.17	0.9550		

Suggested Equation = 3 Constants: A = -4.5318 B = -220.57 C = 149.39

% AAD = 0.24 S.D. = 3.80 x 10^{-6} Temperature Range: 270-380

Zinc

CAS RN: 7440-66-6, Source of Data: Reference 138, 91

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
692.75[138]	3.955	783.15	2.933	769.15	3.050
705.15	3.776	693.15[91]	3.785	826.15	2.488
717.75	3.626	694.15	3.710	874.15	2.270
725.75	3.520	703.15	3.421	933.15	2.008
735.85	3.375	705.15	3.669	989.15	2.101
753.35	3.230	719.15	3.660	1032.15	1.766
762.85	3.139	753.15	3.085	1096.15	1.713
766.55	3.089				

Suggested Equation = 3 Constants: A = -3.0413 B = -186.99 C = 405.78

% AAD = 2.0 S.D. = 8.50 x 10^{-5} Temperature Range: 690-1100

Zinc nitrate hexahydrate

CAS RN: 10196-18-6, Source of Data: Reference 101

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
312.00	17.82	322.00	12.61	337.50	8.08
316.00	15.44	330.00	9.90		

Suggested Equation = 3 Constants: A = -2.4677 B = -23.999 C = 279.07

% AAD = 1.6 S.D. = 2.60E-04 Temperature Range: 310-340

2-Amino-2-methyl-1-propanol

CAS RN : 124-68-5, Source of Data: Reference 171

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15	99.4748	323.15	24.2108	343.15	8.6418
313.15	46.9258	333.15	13.9977	353.15	5.6485

Suggested Equation = 3; A = -2.63 B = -6.24 x 10^2 C = 1.68 x 10^2

%AAD = 1.365 S.D. = 2.95 x 10^{-4} Temperature Range: 280-360

Butanoic acid

CAS RN: 428519-36-2, Source of Data: Reference 172

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
298.15	1.5243	308.15	1.2421	318.15	0.9562

Suggested Equation = 3; A = -3.96 B = -1.62 x 10^3 C = -9.27 x 10^1

%AAD = 1.512 S.D. = 1.47 x 10^{-4} Temperature Range: 280-320

2-Butoxyethanol

CAS RN: 111-76-2, Source of Data: Reference 173, 174

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
298.15[173]	3.1480	313.15	1.8690		
303.15	2.4080	308.15[174]	2.1980		

Suggested Equation = 3; A = -2.99 B = -7.84 x 10^2 C = 7.25 x 10^1

%AAD = 3.042 S.D. = 9.72 x 10^{-4} Temperature Range: 280-320

2-(2-Butoxyethoxy) ethanol

CAS RN: 112-34-5, Source of Data: Reference 175

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
298.15	5.2320				

Butyl acrylate

CAS RN: 141-32-2, Source of Data: Reference 176

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
293.15	0.8763	303.15	0.7568	313.15	0.6609

Suggested Equation = 3 A = -1.78 B = -4.52 x 10^2 C = 3.13 x 10^1

%AAD = 0.0168 S.D. = 1.79 x 10^{-8} Temperature Range: 280-320

Carbon tetrachloride

CAS RN : 56-23-5, Source of Data: Reference 175

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
298.15	0.9050				

Chlorobenzene

CAS RN: 108-90-7, Source of Data: Reference 177, 178

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
288.15[177]	0.9132	298.15	0.8131	313.15	0.6390
293.15	0.8522	303.15[178]	0.7140		

Suggested Equation = 1 A = 9.38 x 10^{-3} B = 5.74 x 10^2 C = 0

%AAD = 1.347 S.D. = 1.01 x 10^{-3} Temperature Range: 280-320

1-Chlorobutane

CAS RN: 109-69-3, Source of Data: Reference 179

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
298.15	0.4229	313.15	0.3583		

Chlorocyclohexane

CAS RN: 542-18-7, Source of Data: Reference 180

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
298.15	1.5690	313.15	1.2180		

1,8-Cineole

CAS RN: 470-82-6, Source of Data: Reference 181

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	2.5560				

p-Cymene

CAS RN: 99-87-6, Source of Data: Reference 181

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	0.7980				

Decafluoro biphenyl

CAS RN: 434-90-2, Source of Data: Reference 182

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
251	0.2890	281	0.2190	301	0.1870
261	0.2670	291	0.2030	311	0.1640
271	0.2460				

Suggested Equation = 3 A = -2.86 B = -1.21×10^{3} C = -2.67×10^{2}

%AAD = 1.474 S.D. = 3.87×10^{-4} Temperature Range: 250-320

Dibutyl phthalate

CAS RN: 84-74-2, Source of Data: Reference 183

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15	13.329				

1,4-Dichlorobutane

CAS RN: 110-56-5, Source of Data: Reference 179

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	1.2989	313.15	1.0380		

Diethyl oxalate

CAS RN: 95-92-1, Source of Data: Reference 183

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15	1.6610				

Di ethylene glycol dibutyl ether

CAS RN: 112-73-2, Source of Data: Reference 183

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	2.1220				

Di ethylene glycol diethyl ether

CAS RN: 112-36-7, Source of Data: Reference 184

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	1.2410				

Di ethylene glycol dimethyl ether

CAS RN: 111-96-6, Source of Data: Reference 184, 202, 194

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15[184]	0.9850	308.15	0.9296	298.15[194]	1.0030
298.15[202]	0.9900	318.15	0.9193		

Suggested Equation = 3 A = -3.36 x 10^{-1} B = -5.34 x 10^{1} C = 1.37 x 10^{2}

%AAD = 0.934 S.D. = 1.20 x 10^{-4} Temperature Range: 298-320

Di ethylene glycol monomethyl ether

CAS RN: 111-77-3, Source of Data: Reference 185

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	3.5645	308.15	2.6268		

1,1-Difluoroethane (R152a)

Source of Data: Reference 186

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
254.71	0.2630	282.94	0.1893	313.20	0.1358
258.04	0.2530	289.46	0.1749	322.27	0.1214
263.27	0.2366	300.98	0.1541	323.00	0.1211
272.24	0.2124	313.13	0.1347		

Suggested Equation = 3 A = -3.14 B = -1.16 x 10^{3} C = -1.97 x 10^{2}

%AAD = 0.59 S.D. = 1.06 x 10^{-4} Temperature Range: 250-340

Diglyme

CAS RN: 111-96-6, Source of Data: Reference 187

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	0.9910	303.15	0.9140	308.15	0.8420

Suggested Equation = 3 A = -2.33 B = -7.44 x 10^{2} C = -2.13 x 10^{1}

%AAD = 0.081 S.D. = 4.25 x 10^{-7} Temperature Range: 280-310

Dimethoxymethane

CAS RN: 109-87-5, Source of Data: Reference 188

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	0.3120				

1,2-Dimethoxyethane

CAS RN: 110-71-4, Source of Data: Reference 188

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	0.414				

3,3-Dimethyl-2-butanol

Source of Data: Reference 189

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	4.4307				

N,N-Dimethylformamide

Source of Data: Reference 178

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
303.15	0.7370	313.15	0.6710		

1,3-Dioxolane

CAS RN: 646-06-0, Source of Data: Reference 190

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	0.5886	313.15	0.4985		

1,2-Diphenylbenzene

CAS RN: 84-15-1, Source of Data: Reference 182

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
574	0.3570	614	0.2840	654	0.2290
584	0.3390	624	0.2680	664	0.2200
594	0.3210	634	0.2510	674	0.2100
604	0.3010	644	0.2420		

Suggested Equation = 3   A = -1.95   B = -8.13 x 10^{2} C = 3.44 x 10^{1}

%AAD = 0.491   S.D. = 7.79 x 10^{-5} Temperature Range: 570-680

1,2-Ethanediol

Source of Data: Reference 174

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
308.15	10.4730				

Ethanoic acid

CAS RN: 64-19-7, Source of Data: Reference 172

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	1.1310	308.15	0.9487	318.15	0.7667

Suggested Equation = 3   A = -3.35   B = -1.31 x 10^{3} C = -8.53 x 10^{1}

%AAD = 1.04   S.D. = 6.98 x 10^{-5} Temperature Range: 280-320

2-Ethoxyethanol

CAS RN: 110-80-5, Source of Data: Reference 173, 174, 187

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15[173]	1.8460	308.15[174]	1.3700	308.15	1.4710
303.15	1.6430	298.15[187]	1.8380	313.15	1.3330
313.15	1.2930	303.15	1.6440		

Suggested Equation = 2   A = -2.90   B = 9.43 x 10^{2} C = 0

%AAD = 1.539   S.D. = 8.34 x 10^{-4} Temperature Range: 280-320

Ethyl butanoate

Source of Data: Reference 191

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
308.15	0.5760	318.15	0.5380		

2-Ethyl-1-butanol

CAS RN: 97-95-0, Source of Data: Reference 189

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	5.8191				

Ethyl chloroacetate

CAS RN: 105-39-5, Source of Data: Reference 192

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
298.15	1.0950	303.15	1.0130	308.15	0.9300

Suggested Equation = 3 A = -2.39 B = -8.12×10^{2} C = -3.52×10^{1}

%AAD = 0.222 S.D. = 3.18×10^{-6} Temperature Range: 280-310

Ethyl laurate

CAS RN: 106-33-2, Source of Data: Reference 176

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
293.15	3.3803	303.15	2.6951	313.15	2.0454

Suggested Equation = 3 A = -3.81 B = -1.64×10^{3} C = -8.50×10^{1}

%AAD = 1.371 S.D. = 1.22×10^{-4} Temperature Range: 280-320

Ethylene glycol diethyl ether

CAS RN: 629-14-1, Source of Data: Reference 185

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
298.15	0.6020	308.15	0.5220		

Ethylene glycol dimethyl ether

CAS RN: 110-71-4, Source of Data: Reference 193, 194, 195

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
298.15[193]	0.4166	298.15[194]	0.4200		
308.15	0.3726	298.15[195]	0.4200		

Suggested Equation = 2 A = -1.94 B = 4.67×10^{2} C = 0

%AAD = 0.271 S.D. = 8.31×10^{-6} Temperature Range: 280-310

Ethylene glycol monomethyl ether

CAS RN: 109-86-4, Source of Data: Reference 193, 194, 195

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
298.15[193]	0.9515	308.15	1.2522		
298.15[194]	1.5315	298.15[195]	1.5320		

Suggested Equation = 1 A = 1.72e-01 B = 2.65×10^{2} C = 0

%AAD = 16.47 S.D. = 2.24×10^{-1} Temperature Range: 280-310

1-Heptanol

CAS RN: 111-70-6, Source of Data: Reference 196, 197, 198

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
293.15[196]	7.0560	313.15	3.5786	303.15	4.9950
298.15	5.9420	298.15[198]	5.9370	308.15	4.1750
303.15[197]	4.7853				

Suggested Equation = 3 A = -3.03 B = -9.30×10^{2} C = 5.34×10^{1}

%AAD = 0.998 S.D. = 2.56×10^{-4} Temperature Range: 280-320

1-Hexanol

CAS RN: 111-27-3, Source of Data: Reference 196, 189, 197, 198

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293.15[196]	5.3710	313.15	3.1101	308.15	3.2520
298.15[189]	4.4862	298.15[198]	4.5740		
303.15[197]	3.7635	303.15	3.7810		

Suggested Equation = 3 A = -1.89 B = -4.92 x 10^2 C = 1.05 x 10^2

%AAD = 2.647 S.D. = 1.22 x 10^{-3} Temperature Range: 280-310

2-Hexanol

CAS RN: 626-93-7, Source of Data: Reference 189

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	4.0474				

3-Hexanol

CAS RN: 623-37-0, Source of Data: Reference 189

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	4.3405				

(s)-(-)-Limonene

Source of Data: Reference 181

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	0.8460				

Linalool

CAS RN: 78-70-6, Source of Data: Reference 181

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	4.3810				

Mesitylene

CAS RN: 108-67-8, Source of Data: Reference 192

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	0.6710	303.15	0.6240		

2-Methoxyethanol

CAS RN: 109-86-4, Source of Data: Reference 173, 174

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15(1)	1.5970	313.15	1.1890		
303.15	1.4760	308.15(2)	1.1890		

Suggested Equation = 3 A = -2.03 B = -4.90 x 10^2 C = 7.94 x 10^1

%AAD = 3.575 S.D. = 1.41 x 10^{-3} Temperature Range: 280-310

Methyl butanoate

Source of Data: Reference 191

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	0.5400	308.15	0.5060	318.15	0.4690

Suggested Equation = 3 A = -1.47 B = -4.52 x 10^2 C = -7.63 x 10^1

%AAD = 0.32259 S.D. = 6.67 x 10^{-6} Temperature Range: 280-320

2-Methyl-1-pentanol

CAS RN: 105-30-6, Source of Data: Reference 189

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	5.3039				

3-Methyl-3-pentanol

CAS RN: 77-74-7, Source of Data: Reference 189

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	3.9176				

4-Methyl-2-pentanol

CAS RN: 108-11-2, Source of Data: Reference 189

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	3.8229				

Methyl tert-butyl ether

Source of Data: Reference 177

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
288.15	0.4008	293.15	0.3861	298.15	0.3687

Suggested Equation = 3 A = -1.65 B = -4.24×10^2 C = -4.89×10^1

%AAD = 0.220373 S.D. = 3.12 x 10(-06) Temperature Range: 280-300

N-Methyldiethanolamine

Source of Data: Reference 171

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	57.8599	323.15	21.6716	343.15	9.9789
313.15	34.3085	333.15	14.3856	353.15	7.0875

Suggested Equation = 3 A = -2.36 B = -7.28×10^2 C = 1.26×10^2

%AAD = 0.543 S.D. = 4.26×10^{-5} Temperature Range: 300-360

Monoethanolamine

CAS RN: 141-43-5, Source of Data: Reference 171

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
303.15	15.1088	323.15	6.9715	343.15	3.7793
313.15	10.0209	333.15	5.0473	353.15	2.9120

Suggested Equation = 3 A = -1.79 B = -4.69×10^2 C = 1.45×10^2

%AAD = 0.130 S.D. = 3.02×10^{-6} Temperature Range: 300-360

Naphthalene

CAS RN: 91-20-3, Source of Data: Reference 182

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
574	0.2040	614	0.1520	654	0.1170
584	0.1900	624	0.1420	664	0.1090
594	0.1770	634	0.1340	674	0.1020
604	0.1630	644	0.1240		

Suggested Equation = 3 A = -3.41 B = -2.19×10^3 C = -2.32×10^2

%AAD = 0.380 S.D. = 4.36×10^{-5} Temperature Range: 570-680

1-Octanol

CAS RN: 111-87-5, Source of Data: Reference 196, 197, 199, 198, 183

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
293.15[196]	9.2230	318.15	4.6460	303.15[183]	6.1000
298.15	7.6630	298.15[198]	7.3680	303.15	6.1200
303.15[197]	6.1023	303.15	6.1200	308.15	5.3520
313.15	4.4132	308.15	5.3520	303.15	6.1000
308.15[199]	5.4580				

Suggested Equation = 3 A = -1.42 B = -3.72 x 10^2 C = 1.36 x 10^2

%AAD = 4.00 S.D. = 4.84 x 10^{-3} Temperature Range: 280-320

Oxane

Source of Data: Reference 200

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
297.15	0.824	299.15	0.801	305.15	0.737
298.15	0.813	301.15	0.779	307.15	0.717

Suggested Equation = 3 A = -2.02 B = -5.99 x 10^2 C = -1.24 x 10^1

%AAD = 0.026 S.D. = 1.01 x 10^{-7} Temperature Range: 280-310

Oxolane

CAS RN: 109-99-9, Source of Data: Reference 200

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
297.15	0.473	299.15	0.464	305.15	0.434
298.15	0.468	301.15	0.454	307.15	0.425

Suggested Equation = 3 A = -1.89 B = -5.05 x 10^2 C = -2.62 x 10^1

%AAD = 0.106 S.D. = 1.53 x 10^{-6} Temperature Range: 280-310

Pentafluoroethane (R125)

Source of Data: Reference 186

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
255.95	0.2592	273.19	0.2021	298.17	0.1398
263.08	0.2339	283.12	0.1751	303.07	0.1287
265.20	0.2267	293.79	0.1493		

Suggested Equation = 3 A = -3.37 B = -1.09 x 10^3 C = -1.33 x 10^2

%AAD = 0.820 S.D. = 1.65 x 10^{-4} Temperature Range: 250-310

α-Pinene

Source of Data: Reference 181

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	1.2930				

β-Pinene

Source of Data: Reference 181

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	1.5930				

Poly ethylene glycol 200

Source of Data: Reference 188, 200

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
298.15[188]	48.097	299.15	45.766	307.15	31.341
297.15[200]	50.686	301.15	41.437		
298.15	48.157	305.15	34.38		

Suggested Equation = 3 A = -4.32 B = -1.68×10^{3} C = 1.80×10^{1}

%AAD = 0.137 S.D. = 3.71×10^{-6} Temperature Range: 280-310

Poly ethylene glycol 400

Source of Data: Reference 188, 200

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
298.15[188]	92.663	299.15	88.086	307.15	59.406
297.15[200]	97.909	301.15	79.668		
298.15	92.797	305.15	65.28		

Suggested Equation = 3 A = -4.35 B = -1.79×10^{3} C = 1.45×10^{1}

%AAD = 0.107 S.D. = 2.17×10^{-6} Temperature Range: 280-310

Poly(methylsiloxane)-1.5

Source of Data: Reference 201

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
293	1.3700	373	0.4800	453	0.3100
313	0.9500	393	0.4300	473	0.2700
333	0.7100	413	0.3600	493	0.2300
353	0.6100	433	0.3300		

Suggested Equation = 3 A = -1.25 B = -2.37×10^{2} C = 1.21×10^{2}

%AAD = 2.943 S.D. = 2.36×10^{-3} Temperature Range: 280-500

Poly(methylsiloxane)-5

Source of Data: Reference 201

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
293	4.7000	373	1.5500	453	0.6800
313	3.5400	393	1.3000	473	0.5900
333	2.2000	413	1.0100	493	0.4800
353	2.0700	433	0.8600		

Suggested Equation = 3 A -1.15 B -1.71×10^{3} C -1.56×10^{2}

%AAD 2.270302 SD 1.20×10^{-3} Temperature Range: 280-500

Poly(methylsiloxane)-10

Source of Data: Reference 201

T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})	T (K)	η (N.s.m^{-2})
293	9.1800	373	2.5700	453	0.9900
313	6.6500	393	2.0900	473	0.8500
333	4.5900	413	1.5500	493	0.6600
353	3.5700	433	1.2900		

Suggested Equation = 3 A -2.67 B -1.62×10^{3} C -1.95×10^{2}

%AAD 3.816788 SD 6.121.20 x 10^{-3} Temperature Range: 280-500

Poly(methylsiloxane)-50

Source of Data: Reference 201

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
293	40.4000	373	12.5000	453	4.7500
313	30.4000	393	10.2000	473	3.9900
333	21.6000	413	7.5700	493	3.0900
353	17.2000	433	6.2700		

Suggested Equation = 3 A -2.821.20 x 10^{-1} B -1.09 x 10^{3} C -5.80 x 10^{1}

%AAD 2.013219 SD 9.841.20 x 10^{-4} Temperature Range: 290-500

Poly(methylsiloxane)-100

Source of Data: Reference 201

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
293	104.0000	373	24.8000	453	9.9500
313	69.7000	393	20.1000	473	8.7200
333	45.8000	413	15.1000	493	7.0100
353	34.8000	433	12.8000		

Suggested Equation = 3 A -3.24 B -2.27 x 10^{3} C -2.48 x 10^{2}

%AAD 2.308704 SD 1.231.20 x 10^{-3} Temperature Range: 280-500

Poly(methylsiloxane)-200

Source of Data: Reference 201

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
293	209.0000	373	50.3000	453	18.1000
313	143.0000	393	39.8000	473	15.3000
333	95.3000	413	29.1000	493	11.9000
353	71.8000	433	24.1000		

Suggested Equation = 3 A -8.92E-01 B -8.76 x 10^{2} C -7.99

%AAD 2.267081 SD 1.221.20 x 10^{-3} Temperature Range: 290-500

Poly(methylsiloxane)-400

Source of Data: Reference 201

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
293	383.0000	373	98.4000	453	33.0000
313	274.0000	393	77.4000	473	27.1000
333	185.0000	413	56.1000	493	20.3000
353	141.0000	433	44.7000		

Suggested Equation = 3 A -1.68 B -1.79 x 10^{3} C -1.55 x 10^{2}

%AAD 2.224689 SD 1.171.20 x 10^{-3} Temperature Range: 280-500

Poly(methylsiloxane)-476

Source of Data: Reference 201

T (K)	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*	*T (K)*	η *(N.s.m^{-2})*
293	453.0000	373	117.0000	453	44.3000
313	319.0000	393	94.5000	473	37.8000
333	215.0000	413	69.9000	493	30.1000
353	166.0000	433	58.2000		

Suggested Equation = 3 A -3.38 B -4.43 x 10^{3} C -4.50 x 10^{2}

%AAD 2.251277 SD 1.171.20 x 10^{-3} Temperature Range: 290-500

Poly(methylsiloxane)-700

Source of Data: Reference 201

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293	677.0000	373	175.0000	453	70.0000
313	468.0000	393	142.0000	473	60.8000
333	315.0000	413	107.0000	493	49.7000
353	243.0000	433	90.1000		

Suggested Equation = 3 A -8.281.20 x 10^{-1} B -1.72 x 10^{3} C -1.56 x 10^{2}

%AAD 1.989518 SD 9.251.20 x 10^{-4} Temperature Range: 290-500

Poly(methylsiloxane)-1000

Source of Data: Reference 201

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
293	984.0000	373	254.0000	453	95.6000
313	691.0000	393	204.0000	473	81.0000
333	468.0000	413	151.0000	493	64.9000
353	357.0000	433	125.0000		

Suggested Equation = 3 A -3.77 B -4.15 x 10^{3} C -4.78 x 10^{2}

%AAD 2.344138 SD 1.231.20 x 10^{-3} Temperature Range: 290-500

Propylene Carbonate

CAS RN: 108-32-7, Source of Data: Reference 202

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	2.4930	308.15	2.0410	318.15	1.7180

Suggested Equation = 3 A -1.77 B -5.38 x 10^{2} C 5.01 x 10^{1}

%AAD 0.295925 SD 5.60 x 10^{-6} Temperature Range: 290-320

Quinoline

CAS RN: 91-22-5, Source of Data: Reference 182

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
301	0.2250	341	0.1750	380	0.1390
311	0.2120	351	0.1640	391	0.1320
321	0.1990	361	0.1550	401	0.1250
331	0.1870	371	0.1460		

Suggested Equation = 3 A -2.32 B -9.19 x 10^{2} C -2.47 x 10^{2}

%AAD 0.336236 SD 3.62 x 10^{-5} Temperature Range: 300-405

Squalane

CAS RN: 111-01-3, Source of Data: Reference 203

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	31.1230				

Tert-Amyl methyl ether

Source of Data: Reference 204

T (K)	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*	*T (K)*	*η (N.s.m^{-2})*
298.15	0.4380				

Tert-Butyl methyl ether

Source of Data: Reference 204

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	0.3400				

Tetrachloroethylene

CAS RN: 127-18-4, Source of Data: Reference 173, 205

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15[173]	0.7960	313.15	0.7310		
303.15	0.7960	303.15[205]	0.7960		

Suggested Equation = 3 A -1.24 B -4.70 x 10^2 C -1.10 x 10^2

%AAD 1.384126 SD 1.521.20 x 10^{-4} Temperature Range: 290-305

Tetraethylene glycol dimethyl ether

CAS RN: 143-24-8, Source of Data: Reference 194

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	3.2940				

Tetrahydrofuran

CAS RN : Source of Data: Reference 180

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	0.4680	313.15	0.4023		

1,2,3,4 Tetra hydronaphthalene

Source of Data: Reference 187

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	1.9680	308.15	1.6120		
303.15	1.7780	313.15	1.4730		

Suggested Equation = 3 A -2.06 B -6.21 x 10^2 C 3.36 x 10^1

%AAD 0.106092 SD 1.04 x 10^{-6} Temperature Range: 290-320

Toluene

CAS RN: 108-88-3, Source of Data: Reference 192, 206, 207, 178

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15[192]	0.5650	303.15	0.5230	298.15[207]	0.5542
303.15	0.5340	308.15	0.4990	323.15	0.4216
308.15	0.5030	313.15	0.4780	303.15[178]	0.5210
298.15[206]	0.5540	318.15	0.4580	313.15	0.4780

Suggested Equation = 3 A -2.07 B -6.79 x 10^2 C -7.66 x 10^1

%AAD 0.949845 SD 2.501.20 x 10^{-4} Temperature Range: 290-320

Tri-n-Butyl Phosphate

Source of Data: Reference 206

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	3.3880	308.15	2.6800	318.15	2.2100
303.15	2.9700	313.15	2.4300		

Suggested Equation = 3 A -1.85 B -5.66 x 10^2 C 5.99 x 10^1

%AAD 0.612239 SD 4.55 x 10^{-5} Temperature Range: 290-320

Trichloro ethylene

CAS RN: 79-01-6, Source of Data: Reference 173

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	0.5300	303.15	0.5150	313.15	0.4860

Suggested Equation = 3 A -1.15 B -2.92 x 10^2 C -3.53 x 10^1

%AAD 0.043679 SD 1.301.20 x 10^{-7} Temperature Range: 290-320

Triethylene glycol dimethyl ether

Source of Data: Reference 184, 194

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15(1)	1.9500	298.15(2)	2.0090		

Triethyleneglycolmonomethylether

Source of Data: Reference 185

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	6.5855	308.15	4.6419		

1,1,1-Trifluoroethane (R143a)

Source of Data: Reference 186

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
255.62	0.1966	285.58	0.1349	302.64	0.1080
260.67	0.1845	290.14	0.1274	306.87	0.1017
267.38	0.1697	295.07	0.1190	308.43	0.0992
273.74	0.1566				

Suggested Equation = 3 A -3.64 B -1.39 x 10^3 C -2.17 x 10^2

%AAD 0.936091 SD 2.091.20 x 10^{-4} Temperature Range: 250-310

Trifluoroiodomethane

Source of Data: Reference 208

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
253.15	0.4513	283.15	0.3284	313.15	0.2469
258.15	0.4259	288.15	0.312	318.15	0.236
263.15	0.4024	293.15	0.297	323.15	0.2251
268.15	0.3824	298.15	0.2834	328.15	0.2157
273.15	0.3629	303.15	0.2706	333.15	0.2074
278.15	0.345	308.15	0.2586	338.15	0.1996

Suggested Equation = 3 A -2.51 B -9.38 x 10^2 C -1.80 x 10^2

%AAD 0.213858 SD 2.01 x 10^{-5} Temperature Range: 250-340

3,5,5-trimethylhexan-1-ol

Source of Data: Reference 198

T (K)	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***	***T (K)***	***η (N.s.m^{-2})***
298.15	10.4370	303.15	10.9310	308.15	9.6080

Suggested Equation = 3 A -4.73E-01 B -6.25 x 10^2 C -1.17 x 10^2

%AAD 3.890588 SD 9.76E-04 Temperature Range (K) =

2,2,4-Trimethylpentane

Source of Data: Reference 209, 210

***T* (K)**	**η (N.s.m^{-2})**	***T* (K)**	**η (N.s.m^{-2})**	***T* (K)**	**η (N.s.m^{-2})**
298.15[209]	0.4784	318.15	0.3848	308.15	0.4260
303.15	0.4517	323.15	0.3652	313.15	0.4040
308.15	0.4264	298.15[210]	0.4780	318.15	0.3810
313.15	0.4056	303.15	0.4510		

Suggested Equation = 3 A -1.71 B -3.74 x 10^{2} C 2.86 x 10^{1}

%AAD 0.177422 SD 1.41 x 10^{-5} Temperature Range: 290-320

1-Undecanol

CAS RN: 112-42-5, Source of Data: Reference 196, 199

***T* (K)**	**η (N.s.m^{-2})**	***T* (K)**	**η (N.s.m^{-2})**	***T* (K)**	**η (N.s.m^{-2})**
293.15[196]	16.9520	298.15	13.8300	308.15[199]	9.3800

Suggested Equation = 3 A -4.25 B -1.67 x 10^{3} C -1.16 x 10^{1}

%AAD 0.003843 SD 1.041.20 x 10^{-9} Temperature Range: 290-310

Vinyl acetate

CAS RN: 108-05-4, Source of Data: Reference 183

***T* (K)**	**η (N.s.m^{-2})**	***T* (K)**	**η (N.s.m^{-2})**	***T* (K)**	**η (N.s.m^{-2})**
303.15	0.3720				

Water

Source of Data: Reference 171

***T* (K)**	**η (N.s.m^{-2})**	***T* (K)**	**η (N.s.m^{-2})**	***T* (K)**	**η (N.s.m^{-2})**
303.15	0.8149	323.15	0.5591	343.15	0.4123
313.15	0.668	333.15	0.4765	353.15	0.3625

Suggested Equation = 3 A -1.75 -3.09 x 10^{2} C 1.17 x 10^{2}

%AAD 0.183957 SD 7.00 x 10^{-6} Temperature Range: 300-360

6.2 EXPERIMENTAL DATA FOR KINEMATIC VISCOSITY

Acetone

CA SRN: 67-64-1, Source of Data: Reference 217

T(K)	*υ (cSt)*
298.15	0.3831

n-Amyl orthosilicate

CAS RN: 12-3-6382, Source of Data: Reference 166

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
233.15	26.2	310.95	2.66		
300.00	3.20	372.05	1.28		

Suggested Equation = 3 Constants: A = -0.78717 B = -209.01 C = 138.38

% AAD = 0.1 S.D. = 4.70E-03 Temperature Range: 240-380

Benzene

CA SRN: 71-43-2, Source of Data: Reference 217

T(K)	*υ (cSt)*
298.15	0.6844

Bis(2-ethylhexyl) phthalate

CAS RN: 117-81-7, Source of Data: Reference 168

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
263.15	1050	311.15	29.9		
283.15	163	371.75	4.22		

Suggested Equation = 3 Constants: A = -1.2417 B = -360.48 C = 178.64

% AAD = 0.6 S.D. = 3.00E-03 Temperature Range: 260-380

Bis(2-ethylhexyl) sebacate

CAS RN: 122-62-3, Source of Data: Reference 168

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
223.15	4220	263.15	118	311.15	12.6
243.15	550	283.15	37.2	371.75	3.26

Suggested Equation = 3 Constants: A = -1.2046 B = -391.92 C = 142.67

% AAD = 5.8 S.D. = 1.70E-01 Temperature Range: 220-380

Bis(ϕ'-amyl) 3-methyl glutarate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
255.38	522	310.95	15.9	477.61	0.68
293.16	33.0	372.05	2.79		

Suggested Equation = 3 Constants: A = -1.3833 B = -384.66 C = 161.46

% AAD = 1.8 S.D. = 3.0 Temperature Range: 250-470

Bis(ϕ'-amyl) adipate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
293.16	31.80	372.05	2.86		
310.95	14.70	477.61	0.73		

Suggested Equation = 3 Constants: A = -1.3371 B = -383.88 C = 157.86

% AAD = 0.4 S.D. = 9.71E-02 Temperature Range: 290-470

Bis(ϕ'-amyl) glutarate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
255.38	349	310.95	13.7	477.61	0.68
293.16	29.0	372.05	2.65		

Suggested Equation = 3 Constants: A = -1.3783 B = -389.19 C = 156.14

% AAD = 0.2 S.D. = 2.20E-01 Temperature Range: 250-460

Bis(ϕ'-amyl) phthalate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
293.16	160.0	372.05	4.80		
310.95	52.60	477.61	0.86		

Suggested Equation = 3 Constants: A = -1.3951 B = -387.75 C = 185.81

% AAD = 2.1 S.D. = 2.62 Temperature Range: 290-470

Bis(ϕ'-amyl) sebacate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
293.16	40.10	372.05	3.59		
310.95	18.60	477.61	0.91		

Suggested Equation = 3 Constants: A = -1.2532 B = -388.68 C = 157.01

% AAD = 0.3 S.D. = 8.45E-02 Temperature Range: 290-470

Bis(ϕ'-butyl) 3-methyl glutarate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
244.27	158	293.16	8.30	372.05	1.25
255.38	63.9	310.95	4.50	477.61	0.41

Suggested Equation = 3 Constants: A = -1.3511 B = -309.44 C = 157.13

% AAD = 12 S.D. = 4.70E-01 Temperature Range: 240-470

Bis(ϕ'-butyl) sebacate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
293.16	12.0	372.05	1.84		
310.95	6.63	477.61	0.60		

Suggested Equation = 3 Constants: A = -1.2652 B = -347.25 C = 144.86

% AAD = 0.5 S.D. = 4.95E-02 Temperature Range: 290-470

1,6-Bis(ϕ'-heptoxy) hexane

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
244.27	925	293.16	28.1	372.05	2.59
255.38	332	310.95	13.0	477.61	0.68

Suggested Equation = 3 Constants: A = -1.3703 B = -387.17 C = 155.44

% AAD = 2.1 S.D. = 1.70E+01 Temperature Range: 245-480

Bis(ϕ'-heptyl) 3-methyl glutarate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
293.16	66.0	372.05	3.70		
310.95	26.4	477.61	0.80		

Suggested Equation = 3 Constants: A = -1.3656 B = -388.52 C = 171.31

% AAD = 0.6 S.D. = 3.00E-01 Temperature Range: 290-470

Bis(ϕ'-heptyl) adipate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
293.16	56.50	372.05	3.71		
310.95	23.50	477.61	0.83		

Suggested Equation = 3 Constants: A = -1.3571 B = -399.44 C = 164.63

% AAD = 0.2 S.D. = 9.66E-02 Temperature Range: 290-470

Bis(ϕ'-heptyl) pinate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
293.16	177.0	310.95	59.40	477.61	6.14

Suggested Equation = 3 Constants: A = 0.37192 B = -98.668 C = 240.57

% AAD = 0.1 S.D. = 1.33 x 10^{-5} Temperature Range: 290-470

Bis(ϕ'-hexyl) 3-methyl glutarate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
255.38	235	310.95	9.10		
293.16	17.8	372.05	1.90		

Suggested Equation = 3 Constants: A = -1.2709 B = -315.37 C = 168.73

% AAD = 1.7 S.D. = 6.80E-01 Temperature Range: 250-370

Bis(ϕ'-nonyl) 3-methyl glutarate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
293.16	130.0	372.05	5.25		
310.95	47.40	477.61	0.80		

Suggested Equation = 3 Constants: A = -1.8101 B = -561.16 C = 150.09

% AAD = 0.3 S.D. = 3.04E-01 Temperature Range: 290-470

Bis(ϕ'-nonyl) 3-tert-butyl adipate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
293.16	228.80	372.05	6.14		
310.95	68.10	477.61	1.10		

Suggested Equation = 3 Constants: A = -1.2415 B = -367.24 C = 191.29

% AAD = 0.7 S.D. = 1.15 Temperature Range: 290-470

Bis(ϕ'-octyl) 3-methyl glutarate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
293.16	46.60	372.05	2.80		
310.95	18.30	477.61	0.60		

Suggested Equation = 3 Constants: A = -1.5185 B = -404.07 C = 166.12

% AAD = 1.1 S.D. = 3.80E-01 Temperature Range: 290-470

Bis(ϕ'-octyl) adipate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
293.16	37.0	372.05	2.73		
310.95	16.0	477.61	0.69		

Suggested Equation = 3 Constants: A = -1.2903 B = -344.03 C = 172.88

% AAD = 0.3 S.D. = 9.27E-02 Temperature Range: 290-470

Butyl 2-acetoxy stearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
283.15	45.8	311.15	13.5	371.75	3.08

Suggested Equation = 3 Constants: A = -0.9431 B = -281.16 C = 175.24

% AAD = 0.7 S.D. = 1.20E-04 Temperature Range: 280-380

Butyl 9,10-diacetoxy stearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
283.15	146.1	311.15	31.5	371.75	5.10

Suggested Equation = 3 Constants: A = -1.0118 B = -331.55 C = 178.82

% AAD = 0.7 S.D. = 3.10E-04 Temperature Range: 280-380

Butyl benzoxy-9(10)-monoacyloxy stearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
243.15	3239	283.15	116.0	371.75	5.20
263.15	499.9	311.15	28.4		

Suggested Equation = 3 Constants: A = -1.2756 B = -435.71 C = 152.56

% AAD = 3.9 S.D. = 8.30E-02 Temperature Range: 245-380

Butyl butyroxy-9(10)-monoacyloxy stearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
243.15	461.5	283.15	37.1	371.75	3.30
263.15	117.8	311.15	12.8		

Suggested Equation = 3 Constants: A = -1.1232 B = -370.1 C = 145.99

% AAD = 3.5 S.D. = 1.20E-02 Temperature Range: 245-380

n-Butyl diphenyl phosphate

CAS RN: 2752-95-6, Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	7.30	350.00	3.03	372.05	2.02

Suggested Equation = 1 Constants: A = -2.5388 B = 1057.7 C = 0

% AAD = 0.3 S.D. = 9.70 x 10^{-6} Temperature Range: 310-380

2-Butyl hexyl ditolyl phosphate

Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	20.05	350.00	6.06	372.05	3.53

Suggested Equation = 1 Constants: A = -3.3026 B = 1431.4 C = 0

% AAD = 0.7 S.D. = 5.50 x 10^{-5} Temperature Range: 310-380

2-Butyl octyl ditolyl phosphate

Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	21.78	350.00	6.74	372.05	3.76

Suggested Equation = 2 Constants: A = 6.1112E+25 B = -9.8085 C = 0

% AAD = 0.6 S.D. = 5.70 x 10^{-5} Temperature Range: 310-380

n-Butyl orthosilicate

CAS RN: 4766-57-8, Source of Data: Reference 166

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
233.15	12.4	310.95	1.85		
300.00	2.14	372.05	1.04		

Suggested Equation = 3 Constants: A = -0.65246 B = -150.77 C = 146.79

% AAD = 0.2 S.D. = 4.10E-03 Temperature Range: 240-380

Butyl P,P-bis(2-ethylhexyl) phosphonoundecanoate

Source of Data: Reference 168

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
243.15	4950	283.15	195	371.75	7.59
263.15	800	311.15	39.6		

Suggested Equation = 3 Constants: A = -1.1567 B = -445.65 C = 152.19

% AAD = 8.9 S.D. = 2.60E-01 Temperature Range: 240-380

Butyl P,P-diethyl 9(10)-phosphonostearate

Source of Data: Reference 168

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
243.15	965	283.15	60.7	371.75	4.04
263.15	199	311.15	18.7		

Suggested Equation = 3 Constants: A = -1.2710 B = -430.96 C = 142.05

% AAD = 1.2 S.D. = 7.40E-03 Temperature Range: 240-380

Butyl P,P-diethyl phosphonolaurate

Source of Data: Reference 168

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
223.15	7880	263.15	117	311.15	10.5
243.15	595	283.15	34.1	371.75	2.57

Suggested Equation = 3 Constants: A = -1.2634 B = -365.75 C = 152.47

% AAD = 2.9 S.D. = 1.10E-01 Temperature Range: 225-380

Butyl phthalyl butyl glycolate

Source of Data: Reference 165

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
298.16	46.0	327.61	12.2		
310.95	23.8	372.05	3.75		

Suggested Equation = 3 Constants: A = -0.98350 B = -279.77 C = 192.43

% AAD = 0.1 S.D. = 1.70E-02 Temperature Range: 290-380

Butyl-12-(monomethyladipoxy) stearate

Source of Data: Reference 164

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
263.15	290.3	311.15	21.8		
283.15	72.8	371.75	4.74		

Suggested Equation = 3 Constants: A = -0.8443 B = -306.22 C = 170.43

% AAD = 1.3 S.D. = 1.70E-03 Temperature Range: 260-380

Butyl-12-monoacetoxy stearate

Source of Data: Reference 164

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
263.15	154.4	311.15	13.9		
283.15	45.3	371.75	3.51		

Suggested Equation = 3 Constants: A = -0.8427 B = -277.50 C = 171.73

% AAD = 1.0 S.D. = 8.60E-04 Temperature Range: 260-380

2-Butylhexyl diphenyl phosphate

Source of Data: Reference 167

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	12.37	350.00	4.39	372.05	2.79

Suggested Equation = 1 Constants: A = -2.8627 B = 1229.2 C = 0

% AAD = 1.0 S.D. = 5.60 x 10^{-5} Temperature Range: 310-380

2-Butyloctyl diphenyl phosphate
Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	13.52	350.00	5.10	372.05	3.00

Suggested Equation = 2 Constants: A = 1.0026E+22 B = -8.3719 C = 0
% AAD = 0.8 S.D. = 4.80 x 10^{-5} Temperature Range: 310-380

1-Chlorohexadecane
CA SRN: 4860-03-1, Source of Data: Reference 217

T(K)	*υ (cSt)*
298.15	6.3050

1-Chlorohexane
CA SRN: 544-10-5, Source of Data: Reference 217

T(K)	*υ (cSt)*
298.15	0.7856

Cyclohexane
CA SRN: 110-82-7, Source of Data: Reference 217, 216

T(K)	*υ (cSt)*
298.15(1)	1.1480
303.15(2)	1.0670

Cyclohexanone
CA SRN: 108-94-1, Source of Data: Reference 216

T(K)	*υ (cSt)*
303.15	1.9250

1,10-Decamethylene glycol di-(2-ethylhexanoate)
Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	68.70	310.95	13.00	372.05	3.26
298.16	20.80	327.61	7.10		

Suggested Equation = 3 Constants: A = -0.678969 B = -221.10 C = 186.01
% AAD = 4.9 S.D. = 1.7 Temperature Range: 270-380

Decane
CA SRN: 124-18-5, Source of Data: Reference 213

T(K)	*υ (cSt)*
293.15	1.2580
298.15	1.1720

1,10-Decanediol bis (ϕ-butyrate)

Source of Data: Reference 121

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
233.15	291	293.16	9.70	477.61	0.55
244.27	115	310.95	5.76		
255.38	56.8	372.05	1.72		

Suggested Equation = 3 Constants: A = -1.3184 B = -361.18 C = 137.53
% AAD = 1.8 S.D. = 1.40E-01 Temperature Range: 230-470

n-Decyl diphenyl phosphate

CAS RN: 14167-87-4, Source of Data: Reference 167

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	11.54	350.00	4.51	372.05	2.87

Suggested Equation = 1 Constants: A = -2.6136 B = 1143.1 C = 0
% AAD = 0.3 S.D. = 1.30 x 10^{-5} Temperature Range: 310-380

n-Decyl ditolyl phosphate

Source of Data: Reference 167

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	17.42	350.00	5.93	372.05	3.49

Suggested Equation = 1 Constants: A = -2.9999 B = 1319.1 C = 0
% AAD = 0.7 S.D. = 4.80 x 10^{-5} Temperature Range: 310-380

n-Decyl orthosilicate

CAS RN: 18845-54-0, Source of Data: Reference 166

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	12.1	350.00	5.25	372.05	3.66

Suggested Equation = 1 Constants: A = -2.0777 B = 981.23 C = 0
% AAD = 1.0 S.D. = 8.80E-02 Temperature Range: 310-380

Di (1,3-dimethylbutyl) adipate

Source of Data: Reference 165

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15	22.80	310.95	5.64	372.05	1.79
298.16	8.27	327.61	3.78		

Suggested Equation = 3 Constants: A = -0.89472 B = -231.33 C = 170.46
% AAD = 0.1 S.D. = 7.50E-03 Temperature Range: 270-380

Di (1-ethylpropyl) azelate

Source of Data: Reference 165

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15	26.6	310.95	6.77	372.05	2.09
298.16	9.80	327.61	4.50		

Suggested Equation = 3 Constants: A = -0.91797 B = -259.82 C = 162.23
% AAD = 0.2 S.D. = 2.90E-02 Temperature Range: 270-380

Di (1-ethylpropyl) sebacate

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	30.8	310.95	7.51	372.05	2.27
298.16	11.3	327.61	4.97		

Suggested Equation = 3 Constants: A = -0.91757 B = -267.18 C = 162.19
% AAD = 0.6 S.D. = 9.10E-02 Temperature Range: 270-380

Di (1-methylethyl) adipate

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	8.34	310.95	2.92	372.05	1.16
298.16	3.92	327.61	2.12		

Suggested Equation = 3 Constants: A = -0.95376 B = -220.22 C = 155.72
% AAD = 0.2 S.D. = 6.20E-03 Temperature Range: 270-380

Di (1-methylethyl) sebacate

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	16.2	310.95	4.98	372.05	1.74
298.16	6.96	327.61	3.50		

Suggested Equation = 3 Constants: A = -0.96749 B = -268.56 C = 149.78
% AAD = 0.2 S.D. = 1.10E-02 Temperature Range: 270-380

Di (2-(2'-ethylbutoxy) ethyl) adipate

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	41.9	310.95	9.23	372.05	2.68
298.16	14.0	327.61	6.01		

Suggested Equation = 3 Constants: A = -0.80589 B = -248.17 C = 170.95
% AAD = 0.2 S.D. = 2.40E-02 Temperature Range: 270-380

Di (2-(2'-ethylbutoxy)ethyl) adipate

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	62.0	310.95	12.2	372.05	3.29
298.16	19.1	327.61	7.85		

Suggested Equation = 3 Constants: A = -0.78656 B = -261.16 C = 171.85
% AAD = 0.5 S.D. = 8.50E-02 Temperature Range: 270-380

Di (2-butoxyethyl) azelate

Source of Data: Reference 165

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15	39.4	310.95	9.49	372.05	2.80
298.16	13.9	327.61	6.20		

Suggested Equation = 3 Constants: A = -0.82958 B = -266.83 C = 163.09

% AAD = 0.3 S.D. = 5.50E-02 Temperature Range: 270-380

Di (2-ethylbutyl) adipate

Source of Data: Reference 165

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15	20.10	310.95	5.68	372.05	1.89
298.16	8.20	327.61	3.89		

Suggested Equation = 3 Constants: A = -0.94010 B = -262.46 C = 156.23

% AAD = 0.5 S.D. = 5.27E-02 Temperature Range: 270-380

Di (2-ethylbutyl) azelate

Source of Data: Reference 165

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15	31.80	310.95	8.17	372.05	2.51
298.16	11.90	327.61	5.40		

Suggested Equation = 3 Constants: A = -0.86556 B = -268.48 C = 159.80

% AAD = 0.3 S.D. = 2.70E-02 Temperature Range: 270-380

Di (2-ethylbutyl) sebacate

Source of Data: Reference 165

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15	36.2	310.95	9.13	372.05	2.73
298.16	13.3	327.61	6.00		

Suggested Equation = 3 Constants: A = -0.87406 B = -280.85 C = 157.69

% AAD = 0.2 S.D. = 2.90E-02 Temperature Range: 270-380

Di (2-ethylhexyl) adipate

Source of Data: Reference 165

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15	37.0	310.95	8.22	372.05	2.38
298.16	12.4	327.61	5.34		

Suggested Equation = 3 Constants: A = -0.86706 B = -251.38 C = 169.92

% AAD = 0.1 S.D. = 6.10E-03 Temperature Range: 270-380

Di (2-ethylhexyl) azelate

Source of Data: Reference 165

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15	52.0	310.95	11.4	372.05	3.06
298.16	17.4	327.61	7.20		

Suggested Equation = 3 Constants: A = -0.92709 B = -299.93 C = 159.71

% AAD = 0.3 S.D. = 5.10E-02 Temperature Range: 270-380

Di (3-methyl butyl) adipate

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	16.0	310.95	4.94	372.05	1.73
298.16	6.89	327.61	3.46		

Suggested Equation = 3 Constants: A = -0.96123 B = -265.85 C = 150.38

% AAD = 0.1 S.D. = 5.30E-03 Temperature Range: 270-380

Di (3-methylbutyl) azelate

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	24.50	310.95	7.03	372.05	2.29
298.16	9.90	327.61	4.83		

Suggested Equation = 3 Constants: A = -0.92713 B = -286.95 C = 149.20

% AAD = 0.4 S.D. = 5.10E-02 Temperature Range: 270-380

Di (3-methylbutyl) sebacate

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	28.9	310.95	7.95	372.05	2.51
298.16	11.5	327.61	5.38		

Suggested Equation = 3 Constants: A = -0.92532 B = -294.57 C = 149.72

% AAD = 0.2 S.D. = 2.40E-02 Temperature Range: 270-380

Di (heptadecyl) adipate

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	443.0	310.95	42.6	372.05	6.22
298.16	80.0	327.61	21.4		

Suggested Equation = 3 Constants: A = -1.0937 B = -376.58 C = 172.49

% AAD = 0.4 S.D. = 4.20E-01 Temperature Range: 270-380

Di (tetradecyl) adipate

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	387.0	310.95	34.3	372.05	5.14
298.16	65.0	327.61	17.3		

Suggested Equation = 3 Constants: A = -1.0341 B = -332.90 C = 181.24

% AAD = 0.3 S.D. = 2.00E-01 Temperature Range: 270-380

Di (tetradecyl) glutarate

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
298.16	60.0	327.61	16.2		
310.95	32.1	372.05	4.84		

Suggested Equation = 3 Constants: A = -1.0642 B = -335.45 C = 180.23

% AAD = 0.6 S.D. = 2.30E-01 Temperature Range: 290-380

Di (tetradecyl) sebacate

Source of Data: Reference 165

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15	483.00	310.95	44.40	372.05	6.53
298.16	84.00	327.61	22.40		

Suggested Equation = 3 Constants: A = -1.0140 B = -357.75 C = 176.42

% AAD = 0.3 S.D. = 2.00E-01 Temperature Range: 270-380

Di(1,3-dimethylbutyl) sebacate

Source of Data: Reference 165

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15	42.2	310.95	9.29	372.05	2.60
298.16	14.1	327.61	6.00		

Suggested Equation = 3 Constants: A = -0.90909 B = -274.33 C = 164.89

% AAD = 0.2 S.D. = 1.90E-02 Temperature Range: 270-380

Di-(1-ethyl propyl) adipate

Source of Data: Reference 165

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15	16.2	310.95	4.54	372.05	1.53
298.16	6.40	327.61	3.10		

Suggested Equation = 3 Constants: A = -0.94831 B = -235.96 C = 163.79

% AAD = 0.2 S.D. = 1.40E-02 Temperature Range: 270-380

Diamyl adipate

Source of Data: Reference 121

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
293.16	7.50	310.95	4.80	372.05	1.72

Suggested Equation = 3 Constants: A = -0.72794 B = -187.94 C = 176.47

% AAD = 1.6 S.D. = 9.40E-02 Temperature Range: 290-380

Dibutyl lauroyloxyethyl phosphonate

Source of Data: Reference 168

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
263.15	110.0	311.15	11.2		
283.15	33.9	371.75	2.98		

Suggested Equation = 3 Constants: A = -0.8672 B = -270.17 C = 170.31

% AAD = 0.4 S.D. = 2.30E-04 Temperature Range: 260-380

Dibutyl lauroyloxypropyl phosphate

Source of Data: Reference 168

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
311.15	10.7	340.00	5.65	371.75	2.97

Suggested Equation = 3 Constants: A = -5.5182 B = -4270.8 C = -341.12

% AAD = 0.1 S.D. = 6.10 x 10^{-7} Temperature Range: 310-380

Dibutyl lauroyloxypropyl phosphonate

Source of Data: Reference 168

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
243.15	910	283.15	57.5	371.75	3.89
263.15	100	311.15	17.1		

Suggested Equation = 3 Constants: A = -0.7123 B = -267.97 C = 169.87

% AAD = 17.3 S.D. = 2.50E-02 Temperature Range: 240-380

Dibutyl phthalate

Source of Data: Reference 165

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15	57.2	310.95	9.72	372.05	2.33
298.16	15.8	327.61	5.87		

Suggested Equation = 3 Constants: A = -1.0202 B = -274.01 C = 174.53

% AAD = 0.3 S.D. = 6.60E-02 Temperature Range: 270-380

Dibutyl sebacate

Source of Data: Reference 165, 121

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15 (1)	19.8	327.61	4.27	310.95	6.11
298.16	8.54	372.05	2.11	372.05	2.11
310.95	6.11	293.16 (2)	10.0		

Suggested Equation = 3 Constants: A = -0.92084 B = -280.86 C = 146.50

% AAD = 0.1 S.D. = 7.60E-03 Temperature Range: 270-380

1,2-Dichloro ethane

CAS RN: 107-06-2, Source of Data: Reference 216

T(K)	***υ (cSt)***
303.15	0.5880

Dichloromethane

CAS RN: 75-09-2, Source of Data: Reference 216

T(K)	***υ (cSt)***
303.15	0.3010

Diethyl lauroyloxyethyl phosphate

Source of Data: Reference 168

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
311.15	5.22	340.00	3.16		
320.00	4.45	371.75	1.91		

Suggested Equation = 3 Constants: A = -2.0703 B = -910.32 C = -15.400

% AAD = 0.1 S.D. = 2.70 x 10^{-6} Temperature Range: 310-380

Diethyl oleoyloxybutyl phosphate

Source of Data: Reference 168

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
283.15	55.8	340.00	8.39		
311.15	18.3	371.75	4.56		

Suggested Equation = 3 Constants: A = -0.8135 B = -307.28 C = 163.12

% AAD = 0.1 S.D. = 1.70 x 10^{-6} Temperature Range: 280-380

Diethyl oleoyloxyethyl phosphate

Source of Data: Reference 168

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15	31.2	311.15	8.39		
283.15	20.9	371.75	2.72		

Suggested Equation = 3 Constants: A = -0.8056 B = -264.72 C = 158.26

% AAD = 0.8 S.D. = 2.20E-04 Temperature Range: 270-380

Diethyl oleoyloxypropyl phosphate

Source of Data: Reference 168

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
311.15	19.8	340.00	9.13		
320.00	15.34	371.75	4.61		

Suggested Equation = 3 Constants: A = -1.9035 B = -786.53 C = 65.381

% AAD = 0.1 S.D. = 1.60 x 10^{-6} Temperature Range: 310-380

Diethyl phthalate

CAS RN: 84-66-2, Source of Data: Reference 165

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
273.15	31.4	310.95	6.26	372.05	1.73
298.16	9.73	327.61	3.99		

Suggested Equation = 3 Constants: A = -1.0000 B = -242.82 C = 175.92

% AAD = 0.2 S.D. = 2.50E-02 Temperature Range: 270-380

Diethylene glycol di(12-monoacetoxy stearate)

Source of Data: Reference 164

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
263.15	3327	311.15	92.4		
283.15	484.4	371.75	12.76		

Suggested Equation = 3 Constants: A = -0.7439 B = -355.16 C = 179.82

% AAD = 1.0 S.D. = 1.50E-02 Temperature Range: 260-380

Diethylene glycol dibutyl ether

CAS RN: 112-73-2, Source of Data: Reference 215

T(K)	***υ (cSt)***
298.15	1.6700
323.15	0.7350

Diethylene glycol dimethyl ether

CAS RN: 111-96-6, Source of Data: Reference 215

T(K)	***υ (cSt)***
298.15	1.0070
323.15	0.7350

1,6-Diheptoxy hexane

Source of Data: Reference 121

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
293.16	8.80	310.95	5.48	372.05	1.90

Suggested Equation = 3 Constants: A = -0.59825 B = -157.65 C = 191.66

% AAD = 2.2 S.D. = 1.50E-01 Temperature Range: 290-380

Diheptyl pinate

Source of Data: Reference 121

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
293.16	23.0	310.95	12.70	372.05	3.22

Suggested Equation = 3 Constants: A = -1.0861 B = -358.73 C = 146.78
% AAD = 0.7 S.D. = 1.10E-01 Temperature Range: 290-380

Dihexyl lauroyloxypropyl phosphonate

Source of Data: Reference 168

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
263.15	132	311.15	13.9		
283.15	42.8	371.75	3.50		

Suggested Equation = 3 Constants: A = -0.9691 B = -321.51 C = 159.20
% AAD = 0.8 S.D. = 6.00×10^{-5} Temperature Range: 260-380

Diisobutyl carbinyl orthosilicate

Source of Data: Reference 166

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
310.95	40.0	350.00	12.1	372.05	7.02

Suggested Equation = 1 Constants: A = -3.0057 B = 1432.0 C = 0
% AAD = 0.6 S.D. = 1.40E-01 Temperature Range: 310-380

2,2-Dimethylbutyl diphenyl phosphate

Source of Data: Reference 167

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
310.95	11.29	350	4.14	372.05	2.56

Suggested Equation = 1 Constants: A = -2.8681 B = 1219.3 C = 0
% AAD = 0.2 S.D. = 1.10×10^{-5} Temperature Range: 310-380

1,2-Dimethyl cyclohexane (cis+trans)

Source of Data: Reference 217

T(K)	υ (cSt)
298.15	1.1540

Dioctyl adipate

CAS RN: 123-79-5 , Source of Data: Reference 121

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
293.16	14.0	310.95	8.75	372.05	2.85

Suggested Equation = 3 Constants: A = -0.88427 B = -308.08 C = 141.70
% AAD = 0.9 S.D. = 8.66E-02 Temperature Range: 290-380

Dipentaerythritol hexabutanoate

Source of Data: Reference 169

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
310.95	65.0	340.00	23.0	372.05	8.84

Suggested Equation = 1 Constants: A = -3.4633 B = 1640.6 C = 0
% AAD = 0.1 S.D. = 5.20×10^{-5} Temperature Range: 310-380

Dipentaerythritol hexahexanoate

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	52.0	340.00	19.9	372.05	8.21

Suggested Equation = 1 Constants: A = -3.1655 B = 1517.9 C = 0

% AAD = 0.1 S.D. = 2.10 x 10^{-6} Temperature Range: 310-380

Dipentaerythritol hexaisodecanoate

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	288.0	340.00	72.5	372.05	20.4

Suggested Equation = 1 Constants: A = -4.5422 B = 2177.0 C = 0

% AAD = 0.1 S.D. = 1.20E-04 Temperature Range: 310-380

Dipentaerythritol tributanoyl trinonanoate

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	71.6	340.00	25.2	372.05	9.69

Suggested Equation = 1 Constants: A = -3.4349 B = 1644.7 C = 0

% AAD = 0.2 S.D. = 6.10 x 10^{-5} Temperature Range: 310-380

Diundecyl adipate

CAS RN: 14641-32-8, Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	124.0	310.95	17.5	372.05	3.72
298.16	30.2	327.61	10.1		

Suggested Equation = 3 Constants: A = -0.90546 B = -287.00 C = 177.52

% AAD = 0.7 S.D. = 3.60E-01 Temperature Range: 270-380

Diundecyl glutarate

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	111.0	310.95	15.9	372.05	3.45
298.16	26.8	327.61	9.22		

Suggested Equation = 3 Constants: A = -0.88903 B = -274.53 C = 179.61

% AAD = 0.2 S.D. = 8.00E-02 Temperature Range: 270-380

Diundecyl sebacate

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	172.00	310.95	24.50	372.05	4.92
298.16	43.00	327.61	13.90		

Suggested Equation = 3 Constants: A = -0.93484 B = -329.60 C = 169.32

% AAD = 1.0 S.D. = 8.30E-01 Temperature Range: 270-380

n-Dodecyl diphenyl phosphate

CAS RN: 27460-02-2, Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	13.76	350.00	5.06	372.05	3.25

Suggested Equation = 1 Constants: A = -2.6916 B = 1190.5 C = 0

% AAD = 0.9 S.D. = 5.20 x 10^{-5} Temperature Range: 310-380

n-Dodecyl ditolyl phosphate

Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	20.25	350.00	6.57	372.05	3.95

Suggested Equation = 1 Constants: A = -3.0263 B = 1346.9 C = 0

% AAD = 0.7 S.D. = 5.40 x 10^{-5} Temperature Range: 310-380

n-Dodecyl ortho silicate

CAS RN: 18840-77-2, Source of Data: Reference 166

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	18.5	350.00	7.40	372.05	4.90

Suggested Equation = 1 Constants: A = -2.2447 B = 1091.1 C = 0

% AAD = 0.6 S.D. = 8.30E-02 Temperature Range: 310-380

Dodecyl P,P-dibutyl phosphonoundecanoate

Source of Data: Reference 168

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
283.15	78.0	311.15	24.3	371.75	5.12

Suggested Equation = 3 Constants: A = -1.0782 B = -396.22 C = 149.88

% AAD = 1.0 S.D. = 3.20E-04 Temperature Range: 280-380

Ethyl acetate

CA SRN: 141-78-6, Source of Data: Reference 217

T(K)	*υ (cSt)*
298.15	0.4714

2-Ethyl butyl ditolyl phosphate

Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	14.02	350.00	4.81	372.05	2.85

Suggested Equation = 1 Constants: A = -3.0568 B = 1307.4 C = 0

% AAD = 0.5 S.D. = 2.80 x 10^{-5} Temperature Range: 310-380

2-Ethyl butyl orthosilicate

CAS RN: 78-13-7, Source of Data: Reference 166

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
233.15	65.6	310.95	4.04		
300.00	5.00	372.05	1.67		

Suggested Equation = 3 Constants: A = -0.83425 B = -244.28 C = 141.00

% AAD = 0.4 S.D. = 2.70E-02 Temperature Range: 240-380

2-Ethyl hexyl ditolyl phosphate

Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	16.94	350.00	5.33	372.05	3.17

Suggested Equation = 1 Constants: A = -3.2127 B = 1380.6 C = 0

% AAD = 0.8 S.D. = 5.40 x 10^{-5} Temperature Range: 310-380

Ethyl P,P-dihexyl phosphonolaurate

Source of Data: Reference 168

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
223.15	9720	263.15	161	371.75	3.25
243.15	815	311.15	13.8		

Suggested Equation = 3 Constants: A = -1.2763 B = -399.47 C = 147.54

% AAD = 4.1 S.D. = 2.00E-01 Temperature Range: 225-380

Ethyl phthalyl ethyl glycolate

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
298.16	57.9	327.61	12.5		
310.95	26.6	372.05	3.51		

Suggested Equation = 3 Constants: A = -0.93113 B = -241.48 C = 208.50

% AAD = 0.1 S.D. = 4.70E-02 Temperature Range: 290-380

1-Ethyl propyl orthosilicate

Source of Data: Reference 166

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
233.15	85.0	310.95	3.83		
300.00	4.77	372.05	1.55		

Suggested Equation = 3 Constants: A = -0.81339 B = -220.03 C = 152.92

% AAD = 0.5 S.D. = 3.70E-02 Temperature Range: 240-380

2-Ethyl-1-butyl-12-monoacetoxy stearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
243.15	1188	283.15	59.8	371.75	3.83
263.15	225.1	311.15	17.3		

Suggested Equation = 3 Constants: A = -1.1659 B = -380.22 C = 153.98

% AAD = 3.6 S.D. = 3.00E-02 Temperature Range: 245-380

2-Ethyl-1-butyl-9(10)-monoacetoxy stearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
243.15	1081.0	283.15	57.3	371.75	3.72
263.15	214.3	311.15	16.7		

Suggested Equation = 3 Constants: A = -1.1931 B = -386.25 C = 152.32

% AAD = 3.9 S.D. = 3.10E-02 Temperature Range: 245-380

2-Ethyl-1-hexyl-9(10)-monoacetoxy stearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
243.15	1340.0	283.15	64.2	371.75	3.88
263.15	246.9	311.15	18.0		

Suggested Equation = 3 Constants: A = -1.1982 B = -388.79 C = 153.77

% AAD = 3.8 S.D. = 3.60E-02 Temperature Range: 245-380

2-Ethylbutyl diphenyl phosphate

Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	8.71	350.00	3.37	372.05	2.25

Suggested Equation = 1 Constants: A = -2.6603 B = 1118.7 C = 0

% AAD = 1.3 S.D. = 5.20 x 10^{-5} Temperature Range: 310-380

Ethylene glycol di(12-monoacetoxy stearate)

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
283.15	506.5	311.15	82.2	371.75	12.07

Suggested Equation = 3 Constants: A = -0.5599 B = -292.27 C = 193.65

% AAD = 0.4 S.D. = 6.50E-04 Temperature Range: 280-380

Ethylene glycol dimethyl ether

CA SRN:, Source of Data: Reference 215

T(K)	*υ (cSt)*
298.15	0.4960
323.15	0.3680

2-Ethylhexyl diphenyl phosphate

CAS RN: 1241-94-7, Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	10.01	350.00	3.74	372.05	2.45

Suggested Equation = 1 Constants: A = -2.7414 B = 1162.7 C = 0

% AAD = 1.2 S.D. = 5.50 x 10^{-5} Temperature Range: 310-380

2-Ethylhexyl orthosilicate

CAS RN: 115-82-2, Source of Data: Reference 166

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
233.15	260.0	310.95	6.83		
300	8.90	372.05	2.36		

Suggested Equation = 3 Constants: A = -0.81487 B = -261.07 C = 152.31

% AAD = 0.5 S.D. = 7.70E-02 Temperature Range: 240-380

2-Ethylhexyl P,P-dibutyl phosphonoundecanoate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
233.15	2790	263.15	198	311.15	18.7
243.15	960	283.15	60.9	371.75	4.44

Suggested Equation = 3 Constants: A = -1.0988 B = -391.11 C = 147.31

% AAD = 2.2 S.D. = 3.20E-02 Temperature Range: 230-380

2-Ethylhexyl P,P-diethyl 9(10)-Phosphonostearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
243.15	2010	283.15	94.8	371.75	4.96
263.15	349	311.15	25.7		

Suggested Equation = 3 Constants: A = -1.2897 B = -448.08 C = 145.80
% AAD = 1.9 S.D. = 2.20E-02 Temperature Range: 240-380

2-Ethylhexyl P,P-diethyl phosphonoundecanoate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
243.15	1020	283.15	58.5	371.75	3.93
263.15	142	311.15	17.4		

Suggested Equation = 3 Constants: A = -0.9721 B = -336.22 C = 158.21
% AAD = 8.1 S.D. = 2.60E-02 Temperature Range: 240-380

1-Ethylpentyl orthosilicate

Source of Data: Reference 166

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
233.15	550.0	310.95	7.60		
300.00	10.3	372.05	2.34		

Suggested Equation = 3 Constants: A = -0.88879 B = -267.56 C = 159.42
% AAD = 0.5 S.D. = 1.50E-01 Temperature Range: 240-380

n-Heptyl diphenyl phosphate

CAS RN: 29143-34-8, Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	8.72	350.00	3.44	372.05	2.32

Suggested Equation = 1 Constants: A = -2.5822 B = 1094.6 C = 0
% AAD = 1.3 S.D. = 5.30 x 10^{-5} Temperature Range: 310-380

n-Heptyl orthosilicate

CAS RN: 18759-42-7, Source of Data: Reference 166

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	5.14	350.00	2.64	372.05	1.98

Suggested Equation = 1 Constants: A = -1.8014 B = 779.54 C = 0
% AAD = 1.0 S.D. = 4.20E-02 Temperature Range: 310-380

n-Hexadecyl diphenyl phosphate

CAS RN: 56827-92-0, Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	20.70	350.00	7.40	372.05	4.70

Suggested Equation = 1 Constants: A = -2.6196 B = 1223.2 C = 0
% AAD = 0.9 S.D. = 8.30 x 10^{-5} Temperature Range: 310-380

1,6-Hexamethylene glycol di-(2-ethylhexanoate)

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	40.90	310.95	8.64	372.05	2.35
298.16	13.10	327.61	5.46		

Suggested Equation = 3 Constants: A = -0.94329 B = -267.75 C = 168.34
% AAD = 0.2 S.D. = 3.60E-02 Temperature Range: 270-380

1,6-Hexanediol bis (ϕ-octanoate)

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
293.16	25.9	372.05	2.37		
310.95	12.0	477.61	0.62		

Suggested Equation = 3 Constants: A = -1.3725 B = -369.56 C = 160.40
% AAD = 0.4 S.D. = 7.60E-02 Temperature Range: 290-470

1,6-Hexanediol bis(ϕ-butyrate)

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
233.15	158	255.38	32.1	310.95	3.85
244.27	66.0	293.16	6.20	372.05	1.22

Suggested Equation = 3 Constants: A = -1.2488 B = -302.57 C = 145.49
% AAD = 1.0 S.D. = 7.30E-01 Temperature Range: 230-380

1,6-Hexanediol bis(ϕ-heptanoate)

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
255.38	480	310.95	16.8		
293.16	36.0	372.05	3.14		

Suggested Equation = 3 Constants: A = -1.3115 B = -385.81 C = 158.74
% AAD = 0.3 S.D. = 2.90E-01 Temperature Range: 250-370

1,6-Hexanediol dioctanoate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
293.16	14.0	310.95	8.42	372.05	2.62

Suggested Equation = 3 Constants: A = -0.84339 B = -270.04 C = 157.70
% AAD = 1.0 S.D. = 9.28E-02 Temperature Range: 290-380

n-Hexyl diphenyl phosphate

CAS RN: 20026-19-1, Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	8.36	350.00	3.30	372.05	2.23

Suggested Equation = 1 Constants: A = -2.5945 B = 1092.6 C = 0
% AAD = 1.4 S.D. = 5.30 x 10^{-5} Temperature Range: 310-380

n-Hexyl ditolyl phosphate

Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	13.39	350.00	4.72	372.05	2.83

Suggested Equation = 1 Constants: A = -2.9680 B = 1273.6 C = 0
% AAD = 0.5 S.D. = 2.50 x 10^{-5} Temperature Range: 310-380

Isooctyl-9(10)-monoacetoxy stearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
243.15	1353.0	283.15	66.3	371.75	4.05
263.15	249.2	311.15	18.6		

Suggested Equation = 3 Constants: A = -1.1713 B = -387.26 C = 153.61
% AAD = 3.6 S.D. = 3.30E-02 Temperature Range: 245-380

Methoxyethyl-12-monoacetoxy stearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
263.15	189.4	311.15	15.6		
283.15	50.3	371.75	3.65		

Suggested Equation = 3 Constants: A = -0.8759 B = -287.63 C = 171.85
% AAD = 0.9 S.D. = 7.70E-04 Temperature Range: 260-380

2-Methyl butyl orthosilicate

Source of Data: Reference 166

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
233.15	35.7	310.95	2.80		
300.00	3.35	372.05	1.33		

Suggested Equation = 3 Constants: A = -0.70218 B = -181.19 C = 152.79
% AAD = 0.5 S.D. = 2.00E-02 Temperature Range: 240-380

2-Methyl pentyl orthosilicate

Source of Data: Reference 166

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
233.15	132.0	310.95	4.85		
300.00	6.18	372.05	1.83		

Suggested Equation = 3 Constants: A = -0.83643 B = -243.01 C = 150.96
% AAD = 0.4 S.D. = 4.10E-02 Temperature Range: 240-380

Methyl butyroxy-9(10)-monoacyloxy stearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
243.15	553.1	283.15	34.7	371.75	2.78
263.15	104.4	311.15	10.8		

Suggested Equation = 3 Constants: A = -1.0907 B = -327.98 C = 157.74
% AAD = 1.9 S.D. = 3.80E-03 Temperature Range: 245-380

Methyl ethyl ketone

CA SRN: 78-93-3, Source of Data: Reference 217

T(K)	υ (cSt)
298.15	0.4676

2-Methyl pentyl orthosilicate

Source of Data: Reference 166

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
233.15	132.0	310.95	4.85		
300.00	6.18	372.05	1.83		

Suggested Equation = 3 Constants: A = -0.83643 B = -243.01 C = 150.96
% AAD = 0.4 S.D. = 4.10E-02 Temperature Range: 240-380

Methyl phthalyl ethyl glycolate

Source of Data: Reference 165

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
298.16	85.8	327.61	14.2		
310.95	34.1	372.05	3.36		

Suggested Equation = 3 Constants: A = -1.0583 B = -249.06 C = 214.89
% AAD = 0.2 S.D. = 1.00E-01 Temperature Range: 290-380

1-Methyl propyl orthosilicate

Source of Data: Reference 166

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
233.15	18.1	310.95	2.14		
300.00	2.45	372.05	1.10		

Suggested Equation = 3 Constants: A = -0.70813 B = -168.62 C = 147.37
% AAD = 0.9 S.D. = 2.90E-02 Temperature Range: 240-380

2-Methyl propyl orthosilicate

CAS RN: 681-98-1, Source of Data: Reference 166

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
233.15	19.2	310.95	2.20		
300.00	2.62	372.05	1.10		

Suggested Equation = 3 Constants: A = -0.80601 B = -198.05 C = 138.35
% AAD = 0.1 S.D. = 3.90E-03 Temperature Range: 240-380

2-Methylbutyl diphenyl phosphate

Source of Data: Reference 167

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
310.95	8.72	350.00	3.36	372.05	2.24

Suggested Equation = 1 Constants: A = -2.6748 B = 1123.4 C = 0
% AAD = 1.3 S.D. = 5.20 x 10^{-5} Temperature Range: 310-380

3-Methylbutyl diphenyl phosphate

Source of Data: Reference 167

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
310.95	8.49	350.00	3.30	372.05	2.21

Suggested Equation = 1 Constants: A = -2.6516 B = 1112.5 C = 0
% AAD = 1.3 S.D. = 5.20 x 10^{-5} Temperature Range: 310-380

Methylcyclohexane

CA SRN: 108-87-2, Source of Data: Reference 217

T(K)	*υ (cSt)*
298.15	0.8807

6-Methylheptyl diphenyl phosphate

Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	10.87	350.00	4.14	372.05	2.61

Suggested Equation = 1 Constants: A = -2.7338 B = 1172.4 C = 0

% AAD = 0.2 S.D. = 8.30 x 10^{-6} Temperature Range: 310-380

1-Methylhexyl orthosilicate

Source of Data: Reference 166

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
233.15	194.0	310.95	5.30		
300.00	6.87	372.05	1.90		

Suggested Equation = 3 Constants: A = -0.84824 B = -244.45 C = 155.20

% AAD = 0.4 S.D. = 5.10E-02 Temperature Range: 240-380

2-Methylpentyl diphenyl phosphate

Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	8.87	350.00	3.40	372.05	2.26

Suggested Equation = 1 Constants: A = -2.6888 B = 1130 C = 0

% AAD = 1.3 S.D. = 5.20 x 10^{-5} Temperature Range: 310-380

2-Methylpropyl diphenyl phosphate

CAS RN: 38299-60-4, Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	8.53	350.00	3.25	372.05	2.16

Suggested Equation = 1 Constants: A = -2.7234 B = 1135.4 C = 0

% AAD = 1.4 S.D. = 5.30 x 10^{-5} Temperature Range: 310-380

ϕ'-Nonyl 2-ethylhexanoate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
244.27	360	293.16	12.0	372.05	1.44
255.38	131	310.95	6.18	477.61	0.44

Suggested Equation = 3 Constants: A = -1.3723 B = -319.28 C = 163.32

% AAD = 1.8 S.D. = 6.0 Temperature Range: 240-450

Octadecyl (branched) diphenyl phosphate

CAS RN: 15724-25-1, Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	57.70	350.00	12.57	372.05	6.27

Suggested Equation = 1 Constants: A = -4.1194 B = 1828.1 C = 0

% AAD = 0.7 S.D. = 1.40E-04 Temperature Range: 310-380

Octadecyl ϕ-butyrate

Source of Data: Reference 121

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
293.16	11.9	372.05	2.13		
310.95	6.99	477.61	0.71		

Suggested Equation = 3 Constants: A = -1.2581 B = -390.69 C = 125.53
% AAD = 0.6 S.D. = 5.50E-02 Temperature Range: 290-470

Octane

CA SRN: 111-65-9, Source of Data: Reference 213

T(K)	*υ (cSt)*
293.15	0.7734
298.15	0.7309

n-Octyl diphenyl phosphate

CAS RN: 115-88-8, Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	9.73	350.00	3.77	372.05	2.51

Suggested Equation = 1 Constants: A = -2.6142 B = 1119.4 C = 0
% AAD = 1.2 S.D. = 5.30 x 10^{-5} Temperature Range: 310-380

n-Octyl ditolyl phosphate

Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	15.30	350.00	5.13	372.05	3.15

Suggested Equation = 1 Constants: A = -3.0082 B = 1303.2 C = 0
% AAD = 0.8 S.D. = 5.30 x 10^{-5} Temperature Range: 310-380

n-Octyl orthosilicate

CAS RN: 78-14-8, Source of Data: Reference 166

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	7.12	350.00	3.50	372.05	2.54

Suggested Equation = 1 Constants: A = -1.8636 B = 843.43 C = 0
% AAD = 0.6 S.D. = 3.90E-02 Temperature Range: 310-380

n-Octyl-9(10)-monoacetoxy stearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
263.15	102.3	311.15	16.9		
283.15	57.2	371.75	3.86		

Suggested Equation = 1 Constants: A = -2.9598 B = 1316.2 C = 0
% AAD = 8.5 S.D. = 5.80E-03 Temperature Range: 260-380

Pentadecane

CA SRN: 629-62-9, Source of Data: Reference 213

T(K)	*υ (cSt)*
293.15	3.6680
298.15	3.3140

Pentaerythritol butanoyl hexanoyl octanoyl tetradecanoate

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	35.5	340.00	14.4	372.05	6.37

Suggested Equation = 1 Constants: A = -3.0006 B = 1414.8 C = 0

% AAD = 0.3 S.D. = 6.30 x 10^{-5} Temperature Range: 310-380

Pentaerythritol decanoyl heptadecanoyl diisooctanoate

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	74.8	340.00	26.5	372.05	10.37

Suggested Equation = 1 Constants: A = -3.3534 B = 1625.0 C = 0

% AAD = 0.4 S.D. = 1.70E-04 Temperature Range: 310-380

Pentaerythritol dibutanoyl diisodecanoate

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	62.6	340.00	21.1	372.05	7.81

Suggested Equation = 1 Constants: A = -3.7086 B = 1711.6 C = 0

% AAD = 0.2 S.D. = 6.60 x 10^{-5} Temperature Range: 310-380

Pentaerythritol dibutanoyl-di(4-cyclohexylbutanoate)

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	79.3	340.00	25.7	372.05	9.15

Suggested Equation = 1 Constants: A = -3.8122 B = 1775.8 C = 0

% AAD = 0.2 S.D. = 5.80 x 10^{-5} Temperature Range: 310-380

Pentaerythritol dideconyl dioctanoate

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	57.1	340.00	20.6	372.05	8.19

Suggested Equation = 1 Constants: A = -3.3806 B = 1597.0 C = 0

% AAD = 0.4 S.D. = 1.20E-04 Temperature Range: 310-380

Pentaerythritol diheptanoyl diisodecanoate

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	46.1	340.00	16.9	372.05	6.78

Suggested Equation = 1 Constants: A = -3.4067 B = 1576.4 C = 0

% AAD = 0.3 S.D. = 6.70 x 10^{-5} Temperature Range: 310-380

Pentaerythritol diheptanoyl dinonanoate

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	28.7	340.00	12.2	372.05	5.23

Suggested Equation = 2 Constants: A = 1.2951E+25 B = -9.4900 C = 0

% AAD = 0.4 S.D. = 5.80 x 10^{-5} Temperature Range: 310-380

Pentaerythritol diheptanoyl tetradecanoyl-4-cyclohexylbutanoate

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	60.5	340.00	22.2	372.05	8.81

Suggested Equation = 1 Constants: A = -3.3136 B = 1584.4 C = 0

% AAD = 0.1 S.D. = 1.70 x 10^{-6} Temperature Range: 310-380

Pentaerythritol dihexanoyl dicyclohexanecarboxylate

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	99.9	340.00	30.3	372.05	10.1

Suggested Equation = 1 Constants: A = -4.0608 B = 1884.4 C = 0

% AAD = 0.1 S.D. = 1.70 x 10^{-5} Temperature Range: 310-380

Pentaerythritol dihexanoyl diisodecanoate,

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	45.6	340.00	16.5	372.05	6.58

Suggested Equation = 1 Constants: A = -3.4624 B = 1592.1 C = 0

% AAD = 0.4 S.D. = 1.00E+06 Temperature Range: 310-380

Pentaerythritol dihexanoyl diundecanoate,

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	36.0	340.00	14.3	372.05	6.20

Suggested Equation = 1 Constants: A = -3.0970 B = 1446.6 C = 0

% AAD = 0.4 S.D. = 7.10 x 10^{-5} Temperature Range: 310-380

Pentaerythritol dihexanoyl heptadecanoyl-2-ethylhexanoate,

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	58.6	340.00	22.1	372.05	8.41

Suggested Equation = 1 Constants: A = 5.5035E+28 B = -10.821 C = 0

% AAD = 0.4 S.D. = 1.20E-04 Temperature Range: 310-380

Pentaerythritol dihexanoyl tetradecanoyl cyclohexanecarboxylate,

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	58.3	340.00	22.3	372.05	8.49

Suggested Equation = 1 Constants: A = 3.4420E+28 B = -10.740 C = 0

% AAD = 0.1 S.D. = 2.50 x 10^{-5} Temperature Range: 310-380

Pentaerythritol dihexanoyl undecanoyl tetradecanoate,

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	41.8	340.00	16.4	372.05	7.00

Suggested Equation = 1 Constants: A = -3.1058 B = 1469.5 C = 0

% AAD = 0.3 S.D. = 5.90 x 10^{-5} Temperature Range: 310-380

Pentaerythritol diisodecanoyl heptadecanoyl-4-cyclohexylbutanoate,

Source of Data: Reference 169

T(K)	υ ***(cSt)***	***T(K)***	υ ***(cSt)***	***T(K)***	υ ***(cSt)***
310.95	114.3	340.00	36.5	372.05	12.79

Suggested Equation = 1 Constants: A = -3.7343 B = 1801.0 C = 0

% AAD = 0.1 S.D. = 5.20 x 10^{-5} Temperature Range: 310-380

Pentaerythritol diisodecanoyl tetradecanoyl-4-cyclohexylbutanoate,

Source of Data: Reference 169

T(K)	υ ***(cSt)***	***T(K)***	υ ***(cSt)***	***T(K)***	υ ***(cSt)***
310.95	103.4	340.00	34.5	372.05	11.45

Suggested Equation = 2 Constants: A = 3.9036E+32 B = -12.267 C = 0

% AAD = 0.1 S.D. = 5.00 x 10^{-5} Temperature Range: 310-380

Pentaerythritol dinonanoyl benzoyl cyclohexanecarboxylate,

Source of Data: Reference 169

T(K)	υ ***(cSt)***	***T(K)***	υ ***(cSt)***	***T(K)***	υ ***(cSt)***
310.95	108.0	340.00	32.4	372.05	10.7

Suggested Equation = 1 Constants: A = -4.0806 B = 1901.1 C = 0

% AAD = 0.1 S.D. = 2.80 x 10^{-5} Temperature Range: 310-380

Pentaerythritol dinonanoyl di (2-ethyl-4-methyl pentanoate) ,

Source of Data: Reference 169

T(K)	υ ***(cSt)***	***T(K)***	υ ***(cSt)***	***T(K)***	υ ***(cSt)***
310.95	58.0	340.00	19.1	372.05	6.96

Suggested Equation = 1 Constants: A = -3.8452 B = 1743.7 C = 0

% AAD = 0.4 S.D. = 1.00E-04 Temperature Range: 310-380

Pentaerythritol dinonanoyl di(2-ethyl hexanoate) ,

Source of Data: Reference 169

T(K)	υ ***(cSt)***	***T(K)***	υ ***(cSt)***	***T(K)***	υ ***(cSt)***
310.95	43.6	340.00	15.9	372.05	6.41

Suggested Equation = 1 Constants: A = -3.4329 B = 1576.8 C = 0

% AAD = 0.5 S.D. = 1.20E-04 Temperature Range: 310-380

Pentaerythritol dinonanoyl diisodecanoate,

Source of Data: Reference 169

T(K)	υ ***(cSt)***	***T(K)***	υ ***(cSt)***	***T(K)***	υ ***(cSt)***
310.95	49.3	340.00	19.1	372.05	7.40

Suggested Equation = 2 Constants: A = 1.1028E+28 B = -10.571 C = 0

% AAD = 0.3 S.D. = 8.10 x 10^{-5} Temperature Range: 310-380

Pentaerythritol dinonanoyl diisooctanoate,

Source of Data: Reference 169

T(K)	υ ***(cSt)***	***T(K)***	υ ***(cSt)***	***T(K)***	υ ***(cSt)***
310.95	45.4	340.00	16.8	372.05	6.81

Suggested Equation = 1 Constants: A = -3.3614 B = 1560.2 C = 0

% AAD = 0.3 S.D. = 7.60 x 10^{-5} Temperature Range: 310-380

Pentaerythritol dinonanoyl octanoyl decanoate,

Source of Data: Reference 169

T(K)	υ *(cSt)*	*T(K)*	υ *(cSt)*	*T(K)*	υ *(cSt)*
310.95	36.0	340.00	14.6	372.05	6.42

Suggested Equation = 1 Constants: A = -3.0042 B = 1417.9 C = 0

% AAD = 0.3 S.D. = 4.80 x 10^{-5} Temperature Range: 310-380

Pentaerythritol dioctanoyl di (2-ethylhexanoate) ,

Source of Data: Reference 169

T(K)	υ *(cSt)*	*T(K)*	υ *(cSt)*	*T(K)*	υ *(cSt)*
310.95	46.1	340.00	16.7	372.05	6.66

Suggested Equation = 1 Constants: A = -3.4545 B = 1591.1 C = 0

% AAD = 0.4 S.D. = 9.50 x 10^{-5} Temperature Range: 310-380

Pentaerythritol dioctanoyl ethanoyl hexanoate,

Source of Data: Reference 169

T(K)	υ *(cSt)*	*T(K)*	υ *(cSt)*	*T(K)*	υ *(cSt)*
310.95	28.4	340.00	11.2	372.05	4.87

Suggested Equation = 1 Constants: A = -3.2125 B = 1450.3 C = 0

% AAD = 0.6 S.D. = 9.00 x 10^{-5} Temperature Range: 310-380

Pentaerythritol dipentanoyl diheptanoate,

Source of Data: Reference 169

T(K)	υ *(cSt)*	*T(K)*	υ *(cSt)*	*T(K)*	υ *(cSt)*
310.95	19.6	340.00	9.05	372.05	4.08

Suggested Equation = 2 Constants: A = 1.2617E+23 B = -8.7486 C = 0

% AAD = 0.4 S.D. = 4.50 x 10^{-5} Temperature Range: 310-380

Pentaerythritol dipentanoyl dinonanoate,

Source of Data: Reference 169

T(K)	υ *(cSt)*	*T(K)*	υ *(cSt)*	*T(K)*	υ *(cSt)*
310.95	19.5	340.00	8.70	372.05	4.23

Suggested Equation = 1 Constants: A = -2.7539 B = 1256.9 C = 0

% AAD = 0.5 S.D. = 6.00 x 10^{-5} Temperature Range: 310-380

Pentaerythritol dipentanoyl ditetradecanoate,

Source of Data: Reference 169

T(K)	υ *(cSt)*	*T(K)*	υ *(cSt)*	*T(K)*	υ *(cSt)*
310.95	46.9	340.00	18.4	372.05	7.89

Suggested Equation = 1 Constants: A = -3.0442 B = 1465.9 C = 0

% AAD = 0.4 S.D. = 9.40 x 10^{-5} Temperature Range: 310-380

Pentaerythritol ditetradecanoyl-di(2-ethylhexanoate) ,

Source of Data: Reference 169

T(K)	υ *(cSt)*	*T(K)*	υ *(cSt)*	*T(K)*	υ *(cSt)*
310.95	63.7	340.00	23.5	372.05	8.61

Suggested Equation = 2 Constants: A = 4.0859E+29 B = -11.156 C = 0

% AAD = 0.1 S.D. = 1.30 x 10^{-5} Temperature Range: 310-380

Pentaerythritol heptanoyl diundecanoyl-4-cyclohexylbutanoate,
Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	54.8	340.00	20.6	372.05	8.42

Suggested Equation = 1 Constants: A = -3.2154 B = 1540.3 C = 0
% AAD = 0.2 S.D. = 5.10 x 10^{-5} Temperature Range: 310-380

Pentaerythritol hexanoyl-2-ethyl hexanoyl undeconanoyl tetradecanoate,
Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	49.0	340.00	18.7	372.05	7.79

Suggested Equation = 1 Constants: A = -3.1744 B = 1512.4 C = 0
% AAD = 0.3 S.D. = 7.60 x 10^{-5} Temperature Range: 310-380

Pentaerythritol hexanoyl decanoyl isodecanoyl-2-ethylhexanoate,
Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	42.9	340.00	16.9	372.05	6.49

Suggested Equation = 2 Constants: A = 7.5179E+27 B = -10.528 C = 0
% AAD = 0.4 S.D. = 9.20 x 10^{-5} Temperature Range: 310-380

Pentaerythritol hexanoyl nonanoyl tetradeconanoyl-2-ethyl hexanoate,
Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	44.2	340.00	16.6	372.05	6.84

Suggested Equation = 1 Constants: A = -3.2909 B = 1534.6 C = 0
% AAD = 0.4 S.D. = 8.90 x 10^{-5} Temperature Range: 310-380

Pentaerythritol nonanoyl pentadecanoyl di (2-ethyl hexanoate) ,
Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	66.6	340.00	23.8	372.05	9.30

Suggested Equation = 1 Constants: A = -3.3837 B = 1619.0 C = 0
% AAD = 0.2 S.D. = 7.40 x 10^{-5} Temperature Range: 310-380

Pentaerythritol pentanoyl-2-ethylhexanoyl undecanoyl tetradecanoate,
Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	47.8	340.00	19.1	372.05	7.63

Suggested Equation = 2 Constants: A = 1.4945E+27 B = -10.228 C = 0
% AAD = 0.3 S.D. = 7.60 x 10^{-5} Temperature Range: 310-380

Pentaerythritol tetraheptanoate,
Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	22.4	340.00	9.60	372.05	4.47

Suggested Equation = 1 Constants: A = -2.9137 B = 1325.5 C = 0
% AAD = 0.4 S.D. = 4.90 x 10^{-5} Temperature Range: 310-380

Pentaerythritol tetrahexanoate,

Source of Data: Reference 169

T(K)	υ *(cSt)*	*T(K)*	υ *(cSt)*	*T(K)*	υ *(cSt)*
310.95	21.2	340.00	9.45	372.05	4.23

Suggested Equation = 2 Constants: A = 5.2613E-+23 B = -8.9845 C = 0

% AAD = 0.3 S.D. = 3.10 x 10^{-5} Temperature Range: 310-380

Pentaerythritol tetraisooctanoate,

Source of Data: Reference 169

T(K)	υ *(cSt)*	*T(K)*	υ *(cSt)*	*T(K)*	υ *(cSt)*
310.95	75.9	340.00	25.6	372.05	8.44

Suggested Equation = 2 Constants: A = 2.5218E+32 B = -12.244 C = 0

% AAD = 0.3 S.D. = 1.20E-04 Temperature Range: 310-380

Pentaerythritol tetranonanoate,

Source of Data: Reference 169

T(K)	υ *(cSt)*	*T(K)*	υ *(cSt)*	*T(K)*	υ *(cSt)*
310.95	35.3	340.00	14.3	372.05	6.35

Suggested Equation = 1 Constants: A = -2.9910 B = 1410.9 C = 0

% AAD = 0.5 S.D. = 9.60E-04 Temperature Range: 310-380

Pentaerythritol tetraoctanoate,

Source of Data: Reference 169

T(K)	υ *(cSt)*	*T(K)*	υ *(cSt)*	*T(K)*	υ *(cSt)*
310.95	27.6	340.00	11.65	372.05	5.32

Suggested Equation = 1 Constants: A = -2.9141 B = 1353.9 C = 0

% AAD = 0.3 S.D. = 4.10 x 10^{-5} Temperature Range: 310-380

Pentaerythritol tetrapentanoate,

Source of Data: Reference 169

T(K)	υ *(cSt)*	*T(K)*	υ *(cSt)*	*T(K)*	υ *(cSt)*
310.95	17.2	340.00	7.60	372.05	3.66

Suggested Equation = 1 Constants: A = -2.8592 B = 1272.7 C = 0

% AAD = 0.5 S.D. = 5.10 x 10^{-5} Temperature Range: 310-380

Pentaerythritol triheptanoyl-4-cyclohexylbutanoate,

Source of Data: Reference 169

T(K)	υ *(cSt)*	*T(K)*	υ *(cSt)*	*T(K)*	υ *(cSt)*
310.95	45.0	340.00	17.7	372.05	6.99

Suggested Equation = 2 Constants: A = 3.3645E+27 B = -10.380 C = 0

% AAD = 0.3 S.D. = 6.70E-04 Temperature Range: 310-380

Pentaerythritol triheptanoyl cyclohexanecarboxylate,

Source of Data: Reference 169

T(K)	υ *(cSt)*	*T(K)*	υ *(cSt)*	*T(K)*	υ *(cSt)*
310.95	52.2	340.00	19.9	372.05	7.59

Suggested Equation = 2 Constants: A = 3.2338E+28 B = -10.748 C = 0

% AAD = 0.2 S.D. = 5.60E-04 Temperature Range: 310-380

Pentaerythritol trihexanoyl cyclohexanecarboxylate,

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	36.7	340.00	14.2	372.05	5.99

Suggested Equation = 1 Constants: A = -3.2303 B = 1490.7 C = 0
% AAD = 0.3 S.D. = 5.70 x 10^{-5} Temperature Range: 310-380

Pentaerythritol trihexanoyl heptadecanoate,

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	43.5	340.00	17.8	372.05	7.31

Suggested Equation = 2 Constants: A = 2.6257E+26 B = -9.9417 C = 0
% AAD = 0.3 S.D. = 6.20 x 10^{-5} Temperature Range: 310-380

Pentaerythritol trihexanoyl tetradecanoate,

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	36.4	340.00	14.6	372.05	6.35

Suggested Equation = 1 Constants: A = -3.0576 B = 1436.0 C = 0
% AAD = 0.3 S.D. = 4.50 x 10^{-5} Temperature Range: 310-380

Pentaerythritol trinonanoyl-2-ethyl-4-methyl pentanoate,

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	42.6	340.00	16.1	372.05	6.66

Suggested Equation = 1 Constants: A = -3.2797 B = 1526.2 C = 0
% AAD = 0.4 S.D. = 7.60 x 10^{-5} Temperature Range: 310-380

Pentaerythritol trinonanoyl-4-cyclohexane carboxylate,

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	51.7	340.00	19.2	372.05	7.77

Suggested Equation = 1 Constants: A = -3.2993 B = 1558.5 C = 0
% AAD = 0.2 S.D. = 5.50 x 10^{-5} Temperature Range: 310-380

Pentaerythritol trinonanoyl-4-cyclohexylbutanoate,

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	62.6	340.00	22.5	372.05	8.46

Suggested Equation = 1 Constants: A = -3.4924 B = 1645.4 C = 0
% AAD = 0.8 S.D. = 2.60E-04 Temperature Range: 310-380

Pentaerythritol trinonanoyl phenylethanoate,

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	39.2	340.00	15.2	372.05	6.36

Suggested Equation = 1 Constants: A = -3.2164 B = 1495.5 C = 0
% AAD = 0.1 S.D. = 1.10 x 10^{-5} Temperature Range: 310-380

Pentaerythritol-di(2-ethyl butanoyl)diisodecanoate

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	98.5	340.00	28.5	372.05	9.19

Suggested Equation = 1 Constants: A = -4.2805 B = 1950.6 C = 0

% AAD = 0.3 S.D. = 1.30E-04 Temperature Range: 310-380

Pentaerythritol-tetra (2-ethyl butanoate) ,

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	61.4	340.00	18.9	372.05	6.46

Suggested Equation = 1 Constants: A = -4.1681 B = 1851.8 C = 0

% AAD = 0.3 S.D. = 9.10 x 10^{-5} Temperature Range: 310-380

n-Pentyl diphenyl phosphate

CAS RN: 105234-62-6, Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	8.26	350.00	3.34	372.05	2.19

Suggested Equation = 1 Constants: A = -2.5961 B = 1092.3 C = 0

% AAD = 0.2 S.D. = 5.90 x 10^{-6} Temperature Range: 310-380

Phenoxyethyl-12-monoacetoxy stearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
263.15	1550	311.15	38.0		
283.15	205.4	371.75	5.77		

Suggested Equation = 3 Constants: A = -0.8673 B = -295.55 C = 120.29

% AAD = 0.4 S.D. = 2.40E-03 Temperature Range: 260-380

Phenyl 12-acetoxy stearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
283.15	113.3	311.15	26.2	371.75	4.58

Suggested Equation = 3 Constants: A = -1.0200 B = -329.23 C = 175.74

% AAD = 1.0 S.D. = 3.90E-04 Temperature Range: 280-380

Phenyl 12-benzoxy stearate

Source of Data: Reference 164

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
283.15	1880	311.15	304.6	371.75	29.4

Suggested Equation = 3 Constants: A = -1.0715 B = -540.53 C = 158.83

% AAD = 0.9 S.D. = 5.50E-04 Temperature Range: 280-380

Phenyl P,P-dibutyl phosphono undecanoate

Source of Data: Reference 168

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
263.15	393	311.15	25.1		
283.15	95.0	371.75	4.87		

Suggested Equation = 3 Constants: A = -1.0183 B = -350.98 C = 166.00

% AAD = 0.1 S.D. = 1.70 x 10^{-5} Temperature Range: 260-380

1,2-Propylene glycol di(12-monoacetoxy stearate)

Source of Data: Reference 164

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
263.15	2803	311.15	85.4		
283.15	462.1	371.75	11.85		

Suggested Equation = 3 Constants: A = -0.8786 B = -385.92 C = 174.02

% AAD = 0.9 S.D. = 1.20E-02 Temperature Range: 260-380

1,3-Propylene glycol di(12-monoacetoxy stearate)

Source of Data: Reference 164

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
283.15	458.5	311.15	89.5	371.75	12.45

Suggested Equation = 3 Constants: A = -0.8329 B = -380.58 C = 174.28

% AAD = 0.6 S.D. = 8.70E-04 Temperature Range: 280-380

Tetradecyl (branched) diphenyl phosphate

Source of Data: Reference 167

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	22.19	350.00	7.03	372.05	3.97

Suggested Equation = 2 Constants: A = 1.9860E+25 B = -9.6094 C = 0

% AAD = 0.6 S.D. = 5.80 x 10^{-5} Temperature Range: 310-380

Tetraethylene glycol dimethyl ether

Source of Data: Reference 215

T(K)	***υ (cSt)***
298.15	3.4220
323.15	2.0200

Toluene

CA SRN: 108-88-3, Source of Data: Reference 217

T(K)	***υ (cSt)***
298.15	0.6345

Tri (2-ethylhexyl) phosphate

CAS RN: 78-42-2, Source of Data: Reference 167

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	7.98	350.00	3.26	372.05	2.23

Suggested Equation = 1 Constants: A = -2.4906 B = 1054.1 C = 0

% AAD = 1.3 S.D. = 5.00 x 10^{-5} Temperature Range: 310-380

Triamyl tricarballylate

Source of Data: Reference 121

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
293.16	21.0	310.95	10.70	372.05	2.64

Suggested Equation = 3 Constants: A = -0.83326 B = -235.46 C = 184.11

% AAD = 1.0 S.D. = 1.20E-01 Temperature Range: 290-380

Tributyl 1,1-phosphonoundecanoate

Source of Data: Reference 168

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
253.15	250	283.15	37.5	371.75	3.37
263.15	108	311.15	13.2		

Suggested Equation = 3 Constants: A = -0.9123 B = -304.38 C = 160.71

% AAD = 2.6 S.D. = 5.30E-03 Temperature Range: 250-380

Tributyl 9(10)-phosphonostearate

Source of Data: Reference 168

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
243.15	1250	283.15	86.1	371.75	5.21
263.15	232	311.15	25.2		

Suggested Equation = 3 Constants: A = -1.3604 B = -497.64 C = 131.87

% AAD = 2.6 S.D. = 2.00E-02 Temperature Range: 240-380

Tributyl phospholaurate

Source of Data: Reference 168

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
223.15	4660	263.15	133	311.15	12.2
243.15	610	283.15	40.5	371.75	2.92

Suggested Equation = 3 Constants: A = -1.4760 B = -457.78 C = 134.85

% AAD = 5.9 S.D. = 1.80E-01 Temperature Range: 220-380

1,1,1-Trichloro ethane

Source of Data: Reference 216

T(K)	*υ (cSt)*
303.15	0.5490

Trichloro ethane

Source of Data: Reference 216

T(K)	*υ (cSt)*
303.15	0.3550

Trichloro methane

Source of Data: Reference 216

T(K)	*υ (cSt)*
303.15	0.3500

Tridecane

CA SRN: 629-50-5, Source of Data: Reference 213

T(K)	*υ (cSt)*
293.15	2.4640
298.15	2.2430

Tridecyl (branched) diphenyl phosphate

Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	19.97	350.00	6.57	372.05	3.79

Suggested Equation = 2 Constants: A = 2.7258E+24 B = -9.2818 C = 0

% AAD = 0.7 S.D. = 5.80 x 10^{-5} Temperature Range: 310-380

Tridecyl (branched) ditolyl phosphate

Source of Data: Reference 167

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	37.50	350.00	9.27	372.05	4.87

Suggested Equation = 1 Constants: A = -3.8316 B = 1680.6 C = 0

% AAD = 0.5 S.D. = 6.20 x 10^{-5} Temperature Range: 310-380

Triethyl 9(10)-phosphonostearate

Source of Data: Reference 168

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
243.15	1390	283.15	78.4	371.75	4.56
263.15	281	311.15	21.9		

Suggested Equation = 3 Constants: A = -1.2877 B = -443.51 C = 143.52

% AAD = 3.5 S.D. = 3.20E-02 Temperature Range: 240-380

Triethyl phosphonostearate

Source of Data: Reference 170

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
283.15	69.2	340.00	7.40		
311.15	18.3	371.75	3.85		

Suggested Equation = 3 Constants: A = -0.8542 B = -273.28 C = 181.78

% AAD = 0.6 S.D. = 1.60E-04 Temperature Range: 280-380

Triethylene glycol di-(2-ethyl-hexanoate)

Source of Data: Reference 165

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
273.15	46.90	310.95	8.91	372.05	2.41
298.16	14.00	327.61	5.60		

Suggested Equation = 3 Constants: A = -0.85148 B = -238.59 C = 178.64

% AAD = 0.2 S.D. = 5.30E-02 Temperature Range: 270-380

Trihexyl 1,1-phosphonoundecanoate

Source of Data: Reference 168

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
243.15	860	283.15	65.2	371.75	4.74
263.15	193	311.15	20.2		

Suggested Equation = 3 Constants: A = -1.1533 B = -424.06 C = 139.62

% AAD = 2.0 S.D. = 7.40E-03 Temperature Range: 240-380

Trihexyl phosphonocaproate

Source of Data: Reference 168

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
213.15	3170	263.15	40.4	371.75	1.84
223.15	835	283.15	15.7		
243.15	145	311.15	5.86		

Suggested Equation = 3 Constants: A = -1.2703 B = -356.36 C = 138.54

% AAD = 3.4 S.D. = 2.10E-02 Temperature Range: 210-380

Trimethyl 1,1-phosphonoundecanoate

Source of Data: Reference 168

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
273.15	51	311.15	10.3		
283.15	30.5	371.75	2.84		

Suggested Equation = 3 Constants: A = -0.8317 B = -256.20 C = 172.35

% AAD = 0.5 S.D. = 2.00E-04 Temperature Range: 270-380

Trimethyl 9(10)-phosphonostearate

Source of Data: Reference 168

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
243.15	2630	283.15	106	371.75	4.71
263.15	543	311.15	25.5		

Suggested Equation = 3 Constants: A = -1.3641 B = -449.37 C = 150.71

% AAD = 9.9 S.D. = 2.40E-01 Temperature Range: 240-380

3,3,5-Trimethyl hexyl orthosilicate

Source of Data: Reference 166

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
233.15	695.0	310.95	11.4	372.05	3.41

Suggested Equation = 3 Constants: A = -0.83454 B = -302.44 C = 150.89

% AAD = 0.3 S.D. = 1.10E-01 Temperature Range: 240-380

1,2,4-Trimethylcyclohexane(cis+trans)

Source of Data: Reference 217

T(K)	υ (cSt)
298.15	0.9976

3,3,5-Trimethylhexyl diphenyl phosphate

Source of Data: Reference 167

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
310.95	12.30	350.00	4.52	372.05	2.91

Suggested Equation = 1 Constants: A = -2.7372 B = 1189.4 C = 0

% AAD = 0.9 S.D. = 5.10 x 10^{-5} Temperature Range: 310-380

Trimethylolpropane didecanoyl ethanoate

Source of Data: Reference 169

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
310.95	23.0	340.00	9.70	372.05	4.40

Suggested Equation = 1 Constants: A = -3.0126 B = 1360.1 C = 0

% AAD = 0.2 S.D. = 1.70 x 10^{-5} Temperature Range: 310-380

Trimethylolpropane dinonanoyl-4-cyclohexylbutanoate,

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	37.2	340.00	14.7	372.05	6.25

Suggested Equation = 1 Constants: A = -3.1466 B = 1466.8 C = 0
% AAD = 0.1 S.D. = 4.00 x 10^{-6} Temperature Range: 310-380

Trimethylolpropane dinonanoyl benzoate

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	42.4	340.00	15.8	372.05	5.89

Suggested Equation = 2 Constants: A = 1.1313E+29 B = -11.003 C = 0
% AAD = 0.2 S.D. = 4.60 x 10^{-5} Temperature Range: 310-380

Trimethylolpropane dinonanoyl trimethylethanoate,

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	23.1	340.00	10.0	372.05	4.33

Suggested Equation = 2 Constants: A = 4.2332E+24 B = -9.3327 C = 0
% AAD = 0.2 S.D. = 2.20 x 10^{-5} Temperature Range: 310-280

Trimethylolpropane ditetradecanoyl-4-cyclohexylbutanoate,

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	56.2	340.00	22.1	372.05	8.66

Suggested Equation = 2 Constants: A = 5.4398E+27 B = -10.425 C = 0
% AAD = 0.1 S.D. = 3.10 x 10^{-5} Temperature Range: 310-380

Trimethylolpropane ditetradecanoyl isodecanoate,

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	44.1	340.00	18.1	372.05	7.37

Suggested Equation = 2 Constants: A = 3.1843E+26 B = -9.9726 C = 0
% AAD = 0.1 S.D. = 1.50 x 10^{-6} Temperature Range: 310-380

Trimethylolpropane diundecanoyl-4-cyclohexylbutanoate,

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	45.7	340.00	18.2	372.05	7.84

Suggested Equation = 1 Constants: A = -3.0027 B = 1449.7 C = 0
% AAD = 0.2 S.D. = 3.90 x 10^{-5} Temperature Range: 310-380

Trimethylolpropane heptanoyl didecanoate,

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	22.8	340.00	9.90	372.05	4.66

Suggested Equation = 1 Constants: A = -2.8426 B = 1305.8 C = 0
% AAD = 0.4 S.D. = 4.70 x 10^{-5} Temperature Range: 310-380

Trimethylolpropane nonanoyl-2-ethyl hexanoyl phenylethanoate,

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	25.5	340.00	10.5	372.05	4.64

Suggested Equation = 1 Constants: A = -3.0998 B = 1401.2 C = 0

% AAD = 0.1 S.D. = 4.90 x 10^{-6} Temperature Range: 310-380

Trimethylolpropane nonanoyl-2-ethylhexanoyl cyclohexanecarboxylate,

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	45.5	340.00	16.1	372.05	6.25

Suggested Equation = 1 Constants: A = -3.5930 B = 1632.5 C = 0

% AAD = 0.3 S.D. = 6.40 x 10^{-5} Temperature Range: 310-380

Trimethylolpropane nonanoyl di(trimethylethanoate) ,

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	29.5	340.00	11.2	372.05	4.63

Suggested Equation = 1 Constants: A = -3.4284 B = 1522.9 C = 0

% AAD = 0.2 S.D. = 3.50 x 10^{-5} Temperature Range: 310-380

Trimethylolpropane nonanoyl diisodecanoate,

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	41.9	340.00	15.5	372.05	6.25

Suggested Equation = 1 Constants: A = -3.4104 B = 1564.7 C = 0

% AAD = 0.2 S.D. = 4.80 x 10^{-5} Temperature Range: 310-380

Trimethylolpropane pentanoyl decanoyl heptadecanoate,

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	36.4	340.00	15.3	372.05	6.89

Suggested Equation = 1 Constants: A = -2.8408 B = 1368.7 C = 0

% AAD = 0.1 S.D. = 6.60 x 10^{-6} Temperature Range: 310-380

Trimethylolpropane pentanoyl isodecanoyl-9-octadecanoate,

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	36.9	340.00	15.2	372.05	6.74

Suggested Equation = 1 Constants: A = -2.9295 B = 1398.1 C = 0

% AAD = 0.1 S.D. = 2.20 x 10^{-5} Temperature Range: 310-380

Trimethylolpropane pentanoyl isodecanoyl heptadecanoate,

Source of Data: Reference 169

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
310.95	43.2	340.00	17.8	372.05	7.35

Suggested Equation = 2 Constants: A = 1.7555E+26 B = -9.8727 C = 0

% AAD = 0.2 S.D. = 5.30 x 10^{-5} Temperature Range: 310-380

Trimethylolpropane tetradecanoyl pentanoyl-2-ethylhexanoate,

Source of Data: Reference 169

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
310.95	33.2	340.00	13.9	372.05	5.83

Suggested Equation = 2 Constants: A = 4.9081E+25 B = -9.6965 C = 0
% AAD = 0.2 S.D. = 3.90 x 10^{-5} Temperature Range: 310-380

Trimethylolpropane tri(2-ethylhexanoate)

Source of Data: Reference 169

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
310.95	30.2	340.00	11.1	372.05	4.42

Suggested Equation = 1 Constants: A = -3.6022 B = 1580.3 C = 0
% AAD = 0.1 S.D. = 7.80 x 10^{-6} Temperature Range: 310-380

Trimethylolpropane trinonanoate,

Source of Data: Reference 169

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
310.95	22.5	340.00	9.80	372.05	4.63

Suggested Equation = 1 Constants: A = -2.8305 B = 1300.2 C = 0
% AAD = 0.4 S.D. = 4.90 x 10^{-5} Temperature Range: 310-380

1,2,3-Trimethylolpropane tris (ϕ-butyrate)

Source of Data: Reference 121

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
255.38	560	310.95	14.5	477.61	0.55
293.16	33.0	372.05	2.47		

Suggested Equation = 3 Constants: A = -1.5501 B = -410.89 C = 159.64
% AAD = 1.4 S.D. = 3.70E-01 Temperature Range: 250-460

Trioctyl phosphate

CAS RN: 1806-54-8, Source of Data: Reference 167

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
310.95	8.48	350.00	3.75	372.05	2.56

Suggested Equation = 1 Constants: A = -2.2406 B = 985.34 C = 0
% AAD = 0.1 S.D. = 4.50 x 10^{-6} Temperature Range: 310-380

Tripentaerythritol octabutanoate

Source of Data: Reference 169

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
310.95	115.0	340.00	42.2	372.05	15.4

Suggested Equation = 2 Constants: A = 9.9311E-29 B = -11.207 C = 0
% AAD = 0.1 S.D. = 4.30 x 10^{-5} Temperature Range: 310-380

Tripentaerythritol octaheptanoate

Source of Data: Reference 169

T(K)	υ (cSt)	T(K)	υ (cSt)	T(K)	υ (cSt)
310.95	115.0	340.00	40.7	372.05	14.3

Suggested Equation = 2 Constants: A = 1.0638E+31 B = -11.620 C = 0
% AAD = 0.1 S.D. = 2.30 x 10^{-5} Temperature Range: 310-380

Tripentaerythritol octahexanoate

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	107.0	340.00	38.7	372.05	13.9

Suggested Equation = 2 Constants: A = 2.4427E+30 B = -11.377 C = 0

% AAD = 0.1 S.D. = 2.30 x 10^{-5} Temperature Range: 310-380

Tripentaerythritol octanonanoate

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	154.0	340.00	49.2	372.05	17.2

Suggested Equation = 1 Constants: A = -3.6095 B = 1802.6 C = 0

% AAD = 0.1 S.D. = 2.10 x 10^{-5} Temperature Range: 310-380

Tripentaerythritol octapentanoate

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	112.0	340.00	37.3	372.05	13.6

Suggested Equation = 1 Constants: A = -3.5271 B = 1733.8 C = 0

% AAD = 0.1 S.D. = 6.50 x 10^{-5} Temperature Range: 310-380

Tripentaerythritol tetrahexanoyl tetraisodecanoate

Source of Data: Reference 169

T(K)	***υ (cSt)***	***T(K)***	***υ (cSt)***	***T(K)***	***υ (cSt)***
310.95	234.0	340.00	71.1	372.05	21.4

Suggested Equation = 2 Constants: A = 4.0250E+35 B = -13.333 C = 0

% AAD = 0.1 S.D. = 2.10 x 10^{-5} Temperature Range: 310-380

Tris(2-ethylhexyl) 11-phosphonoundecanoate

Source of Data: Reference 168

T(K)	*υ (cSt)*	*T(K)*	*υ (cSt)*	*T(K)*	*υ (cSt)*
243.15	2840	283.15	115	371.75	5.74
263.15	432	311.15	30.5		

Suggested Equation = 3 Constants: A = -1.1816 B = -428.58 C = 150.76

% AAD = 1.0 S.D. = 1.20E-02 Temperature Range: 240-380

Undecane

CA SRN: 1120-21-4, Source of Data: Reference 213

T(K)	***υ (cSt)***
293.15	1.5870
298.15	1.4680

o-Xylene

CA SRN: 95-47-6, Source of Data: Reference 217

T(K)	***υ (cSt)***
298.15	0.8542

p-Xylene

CA SRN: 106-42-3, Source of Data: Reference 217

T(K)	υ *(cSt)*
298.15	0.6975

REFERENCE

1. P. J. Achorn, W. G. Haseltine, and J. K. Miller, Physicochemical properties of mono- and diisocyanates, *J. Chem. Eng. Data,* **31**(4), 385-387 (1986).
2. F. Swarts, The viscosity of organic fluorine compounds, *J. Chim. Phys.* **28**, 622-650 (1931).
3. G. R. Cokelet, F. J. Hollander, and J. H. Smith, Density and viscosity of mixtures of 1,1,2,2-tetrabromoethane and 1-bromododecane *J. Chem. Eng. Data,* **14**(4), 470-473 (1969)
4. T. E. Thorpe and J. W. Rodger, Bakerian Lecture: On the Relations between the Viscosity (Internal Friction) of Liquids and Their Chemical Nature, *Phil. Trans. Roy. Soc*. (London) **A185**, 397-710 (1894).
5. R. J. Best, Physical Properties of Diarylalkanes, *J. Chem. Eng. Data*, **8**(2), 267-270 (1963)
6. R. C. Makhija and R. A. Stairs, Viscosity of associated liquids, *Canadian J. Chemistry*, **48**(8), 1214-1218 (1970).
7. J. A. Dixon, G. R. Yarnell, and J. A. Mountain, Physical Properties of Twelve Isomeric Alkyl-Substituted Naphthalenes, Tetrahydronaphthalenes, and Decahydronaphthalenes, *J. Chem. Eng. Data,* **8**(4), 572-573 (1963).
8. J. Timmermans and F. Martin, The work of the International Bureau of Physical-Chemical Standards. I. Methods and Apparatus, *J. Chim. Phys.* **23**, 733-746 (1926).
9. O. Scheuer. Physico-chemical Studies of Binary Mixtures with One Optically Active Component, *Z. Physik. Chem*. **72**, 513-608 (1911).
10. J. N. Friend, and W. D. Hargreaves, Viscosity and the hydrogen bond. Hydroxyl and ortho effects. *Phil. Mag.* **36**, 731-756 (1945).
11. Z. I. Geller, R. K Nikul'shin, and N. I. Pyatnitskaya, Viscosity of liquid Freons, *Kholodilnaia tekhnika*, **46**(4) 60-61 (1969).
12. R. K. Nigam, and M. S. Dhillon, Viscosities of binary liquid mixtures of nonelectrolytes, *J. Chem. Eng. Data,* **17**(1), 35-37 (1972).
13. J. N. Friend, and W. D. Hargreaves, Viscosities of the dihydroxy benzenes and some of their derivatives, *Phil. Mag.* **37**, 120-126 (1946).
14. J. Rosenfarb, H. L. Huffman, Jr. and J. A. Caruso, Dielectric constants, viscosities, and related physical properties of several substituted liquid ureas at various temperatures, *J. Chem. Eng. Data,* **21**(2), 150-153 (1976).
15. J. N Friend, and W. D. Hargreaves, Viscosities of unsaturated six-membered isocyclic compounds, *Phil. Mag.* **35**, 136-147 (1944).

16. P. G. Sears and W. C. J. O'Brien, Dielectric constants and viscosities of some mono-N-substituted amides and cyclic esters, *J. Chem. Eng. Data* **13**(1), 112-115 (1968).
17. I. F. Golubev, *Viscosity of Gases and Gas Mixtures*, Fizmat Press, Moscow (1959).
18. V. K. Agarwal, A. K. Sharma, and P. J. Sharma, Some physical properties of ten alkanethiols as a function of temperature, *J. Chem. Eng. Data*, **22**(2), 127-130 (1977).
19. P. Dakshinamurthy, K.V. Rao, P.V. Rao, and C. Chiranjivi, Viscosity data of binary mixtures in the system methyl isobutylketone-butyl alcohol, *J. Chem. Eng. Data,* **18**(1), 39-41 (1973).
20. N. B. Vargaftik, *Tables on the Thermophysical Properties of Liquids and Gases*, 2nd Ed. P. 421, Hemisphere, Washington, D.C. 1975.
21. M. A. Rauf, G. H. Stewart, and J. Farhataziz, Viscosities and densities of binary mixtures of 1-alkanols from 15 to 55°C, *J. Chem. Eng. Data,* **28**(3), 324-328 (1983).
22. J. Timmermans, and M. Hennaut-Roland, The work of the International Bureau of Physical-Chemical Standards. IV. Study of the physical constants of twenty organic compounds, *J. Chim. Phys*. **27**, 401-442 (1930).
23. V. Desreux, The parachor, Bull. Soc. Chim. Belg. **44**, 249-287 (1935) as quoted by Bingham, E.C. and Spooner, L.W. Physics, 4, 387 (1933).
24. F. D. Rossinni, et al., *Selected Values of Physical and Thermodynamic Properties of Hydrocarbons and Related Compound*, NBS, Pittsburg, 1953.
25. E. C. Bingham, and H. J. Fornwalt, Chemical constitution and association, *J. Rheology*, **1**, 372-417 (1930).
26. F. J. Wright, Influence of Temperature on Viscosity of Nonassociated Liquids, *J. Chem. Eng. Data*, **6**(3), 454-456 (1961).
27. J. Timmermans and Y. Delcourt, Work of the International Bureau of Physico-Chemical Standards. VI. Physical constants of twenty organic compounds, *J. Chim. Phys.* **31**, 85-124 (1934).
28. T. E. Thorpe, J. W. Rodger, and R. E. Barnett, On the Relations between the Viscosity (Internal Friction) of Liquids and their Chemical Nature. Part II, *Phil. Trans. Roy. Soc.* (London) **A189**, 71 (1897).
29. L. H. Thomas, and R. J. Meatyard, Viscosity and molecular association. Part IV. Association of monohydric alcohols and some hindered phenols, *J. Chem. Soc.* (London) 1986-1995 (1963).
30. S. Mizushima, The anomalous dispersion and absorption of electric waves. IV. Anomalous dispersion and Debye's dipole theory, *Bull. Chem. Soc.* (Japan) **1**, 143-145 (1926).
31. J. K. Shah, K. J. DeWitt, and C. E. Stoops, Viscosity-temperature correlation for liquid aliphatic amines, *J. Chem. Eng. Data,* **14**(3), 333-335 (1969).
32. G. Chavanne, and H. Van Rissenhem, *Bull. Soc. Chim. Belg*. **31**, 87 (1922) as quoted by E.C. Bingham and L. W. Spooner, Physica, 4, 387 (1933).
33. J. F. Casteel and P. G. Sears, Dielectric constants, viscosities, and related physical properties of 10 liquid sulfoxides and sulfones at several temperatures, *J. Chem. Eng. Data,* **19**(3), 196-200 (1974).

34. F. H. Stross C. M. Gable, and G. C. Rounds, The Vapor Pressures and Some Other Properties of Di-i-butyl Ketone and Di-i-butylcarbinol, *J. Am. Chem. Soc.* **69**(7), 1629-1630 (1947).
35. E. Vertesi, Viscosity of ortho-substituted aromatic amines, *J. Chem. Eng. Data,* **25**(4), 387-388 (1980).
36. J. F. Casteel, and P. G. Sears, Dielectric constants, viscosities, and related physical properties of four liquid pyridine-N-oxides at several temperatures, *J. Chem. Eng. Data,* **19**(4), 303-306 (1974).
37. E. C. Bingham, G. F. White, A. Thomas, and J. L. Caldwell, Fluidity and the Hydrate Theory. II, *Z. Physik. Chem*. **83**, 641-673 (1913).
38. E. C. Bingham, and R. A. Stephens, Fluidity and association of alcohols and esters of high molecular weight, *Physica*, **4**, 206-207 (1933).
39. E. C. Bingham and J. A. Geddes, The relation between constitution and association, especially in reference to aromatic compounds, *Physica*, **5**, 42-52 (1934).
40. J. Timmermans and F. Martin, The work of the International Bureau of Physical-Chemical Standards. III. Study of the physical constants of twenty organic compounds, *J. Chim. Phys*. **25**, 411-451 (1928).
41. J. F. Casteel and P. G. Sears, Dielectric constants, viscosities, and related physical properties of five cyano- and halopyridines at several temperatures, *J. Chem. Eng. Data,* **20**(1), 10-13 (1975).
42. J. N. Friend and W. D. Hargreaves, Viscosities at the boiling point of some primary amines, cyclohexane and some of its derivatives, *Phil. Mag.* **35**, 57-64 (1944).
43. A. Bramley, The study of binary mixtures. Part II. The densities and viscosities of mixtures containing substituted phenols, *J. Chem. Soc.* (London) **109**, 434-469 (1916).
44. E. C. Bingham and L. B. Darral, A study of the fluidities and densities of the octyl alcohols. The association of liquids, *J. Rheology*, **1**, 174-205 (1930).
45. E. C. Bingham and L. W. Spooner, The fluidity method for the determination of association. II, *Physica*, **4**, 387-400 (1933).
46. P. Walden, *Z. Physik. Chem*. **54**, 129 (1906).
47. R. Riggio, H. E. Martinez, J. A. Espindola, and J. F. Ramos, Viscosities, densities and refractive indexes of mixtures of methyl isobutyl ketone-isobutyl alcohol, *J. Chem. Eng. Data,* **29**(1), 11-13 (1984).
48. E. C. Bingham, H. S. Van Klooster, and W. C. Kleinspehn, The fluidities and volumes of some nitrogenous organic compounds, *J. Phys. Chem*. **24**, 1-20 (1920).
49. W. Herz and W. Bloch, Physical-chemical investigation of compounds of the cyclohexane series, *Z. Physik. Chem*. **110**, 23-39 (1924).
50. G. Weissenberger and F. Schuster, Über die Molekülverbindungen der Phenole: III. Das Verhalten binärer Systeme mit hydrierten Phenolen, *Monatshefte für Chemie / Chemical Monthly*, **45**(7-8), 413-424 (1924).
51. G. Chiurdoglu, The trans and cis forms of 1,2-, 1,3- and 1,4-dimethylcyclohexan-1-ol. Their rate of dehydration with formic acid, *Bull. Soc. Chim. Belg*. **47**, 241-259; 1,2- and

2,3-Dimethyl-1-cyclopentene and the cis- and trans-1,2-dimethylcyclopentanes, *Bull. Soc. Chim. Belg*. **47**, 363-381 (1938).

52. A. P. Mills and K. Lampe, Physical property correlations for conjugated aliphatic nitro-olefins viscosity**,** *J. Chem. Eng. Data,* **11**(4), 599-601 (1966).
53. U. S. Tewari, P. Vasudevan, and V. Ramakrishna, Studies in molten state: viscosity of nitrophenol melts, *J. Chem. Eng. Data,* **21**(1), 1-4 (1976).
54. A. E. Dunstan, T. P. Hilditch, and F. B. Thole, The relation between viscosity and chemical constitution. Part VII. The effect of the relative position of two unsaturated groups on viscosity*, J. Chem. Soc*. (London) **103**, 133-144 (1913).
55. H. Freiser and W. L. Glowacki, Some Physical Properties of 2-Picoline, *J. Am. Chem. Soc*. **70**(7), 2575-2578 (1948).
56. H. L. Huffman and P. G. Sears, Liquid 2-oxazolidones. I. Dielectric constants, viscosities, and other physical properties of several liquid 2-oxazolidones, *J. Solution Chemistry*, **1**(2), 187-196 (1972).
57. F. B. Thole, Viscosity and association. Part I. Association of the phenols, *J. Chem. Soc*. (London) **97**, 2596-2606 (1910).
58. R. J. Lemire and P. G. Sears, Dielectric constants, viscosities, densities, and refractive indices of some alkylsydnones at several temperatures, *J. Chem. Eng. Data,* **22**(4), 376-379 (1977).
59. E. C. Bingham and L. W. Spooner, Fluidity method for the determination of association, *J. Rheology*, **3**, 221-244 (1932).
60. C. P. Smyth and W. N. Stoops, The dielectric polarization of liquids. III. The polarization of the isomers of heptane, *J. Am. Chem. Soc.* **50**(7), 1883-1890 (1928).
61. J. Timmermans and M. Hennaut-Roland, The work of the International Bureau of Physical-Chemical Standards. V. Study of the physical constants of twenty organic compounds, *J. Chim. Phys*. **29**, 529-568 (1932).
62. M. Hafez and S. Hartland, Densities and viscosities of binary systems toluene-acetone and 4-methyl-2-pentanone-acetic acid at 20, 25, 35, and 45^{o}C, *J. Chem. Eng. Data,* **21**(2), 179-182 (1976).
63. A. Bramley, The study of binary mixtures. Part I. The densities and viscosities of mixtures containing phenol, *J. Chem. Soc.* (London) **109**, 10-45 (1916).
64. P. A. Naro, Physical Properties of Four Spiro Hydrocarbons, *J. Chem. Eng. Data,* **10**(1), 86-87 (1965).
65. J. N. Friend and W. D. Hargreaves, Viscosities and rheochors of aldehydes, nitriles and of secondary and tertiary amines, *Phil. Mag.* **35**, 619-631 (1944).
66. J. N. Friend and W. D. Hargreaves, The viscosities and structures of acid chlorides and amides, *Phil. Mag.* **37**, 201-206 (1946).
67. V. Vitagliano, and A. Zagari, and R. Sartorio, Diffusion and viscosity in chloroform-acetic acid system at 25^{o}C, *J. Chem. Eng. Data,* **18**(4), 370-372 (1973).
68. K. S. Howard and F. P. Pike, Viscosities and Densities of Acetone-Benzene and Acetone-Acetic Acid Systems up to Their Normal Boiling Points, *J. Chem. Eng. Data,* **4**(4), 331-333 (1959).

69. F. Kurata, T. W. Yergovich, and G. W. Swift, Density and viscosity of aqueous solutions of methanol and acetone from the freezing point to 10°C, *J. Chem. Eng. Data,* **16**(2), 222-226 (1971).
70. J. Kendall and E. Brakeley, Compound formation and viscosity in solutions of the types acid: ester, acid: ketone, and acid: acid, *J. Am. Chem. Soc*. **43**(8), 1826-1834 (1921).
71. N. Kurnakov, and S. Zemcuzny, Inner Friction of Binary Mixtures, Z. Physik. Chem. **83**, 481-506 (1913).
72. N. Kurnakov, and I. Kviat, Viscosity in the system aniline-allyl mustard oil, Z. Physik. Chem. **88**, 401-413 (1914).
73. K. H. Grothe and P. Kleinschmit, Angew. Chem. Intl. Ed. **6**, 713 (1967).
74. E. C Bingham and H. L. DeTruck, A further study of association by the fluidity method*, J. Rheology*, **3**, 479-493 (1932).
75. L. H. Thomas and G. H. Davies, Viscosity and molecular association. Part VII. Association of alkyl orthotitanates, *J. Chem. Soc*. (London) **A** 1271-1274 (1969).
76. P. K. Katti and M. M. Chaudhri, Viscosities of Binary Mixtures of Benzyl Acetate with Dioxane, Aniline, and m-Cresol, *J. Chem. Eng. Data,* **9**(3), 442-443 (1964).
77. J. Timmermans and M. Hennaut-Roland, Work of the International Bureau of physicochemical standards. VII. Physical constants of twenty organic compounds, *J.Chim. Phys*. **32**, 589-617, (1935).
78. A. F. Crawley and D. R. Kiff, Density and viscosity of liquid antimony, Met. Trans. **3**(1), 157-159 (1972).
79. K. Toerklep and H. A. Oeye, Viscostiy of molten alkaline-earth chlorides, *J. Chem. Eng. Data,* **27**(4), 387-391 (1982).
80. A. J. Teller and T. J. Walsh, Viscosities of Benzene-Methyl Ethyl Ketone Systems, *J. Chem. Eng. Data,* **4**(3), 279-283 (1959).
81. N. S. Kurnakov, D. Krotkov, and M. Oksmann, *J. Russ. Phys. Chem*. **49**, 583 (1915)
82. J. W. McBain, C. E. Harvey, and L. E. Smith, The Apparent Viscosity of Solutions of Nitro Cotton in Various Solvents, *J. Phys. Chem*. **30**(3), 312-352 (1926).
83. J. Timmermans and M. Hennaut-Roland, Work of the International Bureau of physicochemical standards. VII. Physical constants of twenty organic compounds, *J.Chim. Phys*. **32**, 501-26 (1935).
84. A. G. Mussell, F. B. Thole, and A. E. Dunstan, The viscosity of compounds containing tervalent nitrogen. Part I. The amines*, J. Chem. Soc.* (London) **101**, 1008-1016 (1912).
85. E. C. Bingham and L. A. Sarver, Fluidities and specific volumes of mixtures of benzyl benzoate and benzene. XXIX, *J. Am. Chem. Soc.* **42**(10), 2011-2022 (1920).
86. J. Kendall and K. P. Monroe, The viscosity of liquids. Ii. The viscosity-composition curve for ideal liquid mixtures, *J. Am. Chem. Soc*. **39**(9), 1787-1802 (1917).
87. J. Kendall and A. H. Wright, The viscosity of liquids. Iv. Ideal mixtures of the types ether-ether and ester-ester, *J. Am. Chem. Soc*. **42**(9), 1776-1784 (1920).
88. W. H Hedley, M. V. Milnes, and W. H. Yanko, Thermal conductivity and viscosity of biphenyl and the terphenyls, *J. Chem. Eng. Data,* **15**(1), 122-127 (1970).

89. J. P. Stone, C. T. Ewing, C. H. Blachly, B. E. Walker, and R. R. Miller. Heat Transfer Studies on a Forced Convection Loop with Biphenyl and Biphenyl Polymers**,** Ind. Eng. Chem. **50**(6), 895-902 (1958).
90. M. F. Mole, W. S. Holmes, and J. C. McCoubrey, Temperature-dependence of the liquid viscosities of some phosphorus compounds, *J. Chem. Soc*. (London) 5144-5149 (1964).
91. D. Ofte, and L. J. Wittenberg, Viscosity of bismuth, lead, and zinc to 1000□, *Trans. Met. Soc. AIME*, **227**, 706-711 (1963).
92. J. Galka, L. Stachowicz, and L. Suski, Viscosity of molten cadmium and bismuth chlorides, *J. Chem. Eng. Data,* **25**(4), 297-298 (1980).
93. T. J. Ward, Density, viscosity, and thermal conductivity of liquid boron trichloride, *J. Chem. Eng. Data,* **14**(2), 167-168 (1969).
94. N. Efremov, Internal friction of the systems water-bromal and chloral-dimethylethylcarbinol, *J. Russ. Phys. Chem. Soc* (Zhurnal Russkago Fiziko-Khimicheskago Obshchestva), **50**(1), 338-371 (1918).
95. J. Meyer, and B. Z. Mylius, Viscosity of binary liquid mixtures, *Z. Physik. Chem*. **95**, 349-377 (1920).
96. E. Drucker, and R. Kassel, The Fluidity of Binary Mixtures, *Z. Physik. Chem*. **76**, 367-384 (1911).
97. J. P. Kuenen and S. W. Visser, *Proc. Roy. Acad. Sci*, **16**, 355 (1913).
98. Landolt-Bornstien Tables, **4**, Pt 1 (1955).
99. P. B. Rao and R. Thayumanasundaram, Viscosities of binary mixtures of n-butyl acetate-methyl ethyl ketone or isoamyl alcohol at 35.deg, *J. Chem. Eng. Data,* 16(3), 323-324 (1971).
100. A. F. Crawley and H. R. Thresh, Viscosities of cadmium and indium, *Trans. Met. Soc. AIME*, **245**(2), 424-425 (1969).
101. S. K. Sharma, C. K. Jotshi, and A. Singh, An empirical correlation for viscosity of molten salt hydrates**,** *Canadian J. Chem. Eng*. **62**(3), 431-433 (1984).
102. R. K. Hind, E. McLaughlin, and A. R. Ubbelohde, Structure and viscosity of liquids. Camphor + pyrene mixtures, *Trans. Faraday Soc*. **56**, 328-330 (1960).
103. T. Titani, The viscosity of liquids above their boiling points. I, *Bull. Chem. Soc*. (Japan) **2**, 95-105 (1927).
104. A. A. Banks, A. Davies, and A. J. Rudge, The determination of the surface tension and viscosity of liquid chlorine trifluoride, *J. Chem. Soc*. (London) 732-735 (1953).
105. T. W. Phillips, and K.P. Murphy, Liquid viscosity of halocarbons, *J. Chem. Eng. Data,* **15**(2), 304-307 (1970).
106. J. Timmermans and F. Martin, The work of the International Bureau of Physical-Chemical Standards. II. Study of twenty hydrocarbons and halogen derivatives, *J. Chim. Phys*. **23**, 747-787 (1926).
107. J. A. A. Ketelaar, L. De Vries, P. F. van Velden, and J. S. Kooy, Viscosities of cis- and trans-1, 2-dichloroethylene, in connection with Eyring's theory of viscous flow, *Recueil*

des Travaux Chimiques des Pays-Bas et de la Belgique, (Rec. trav. Chim.) **66**, 733-745 (1947).

108. W. F. Seyer and J. D. Leslie, The Viscosity of cis and trans Decahydronaphthalene, *J. Am. Chem. Soc.* **64**(8), 1912-1916 (1942).
109. A. J. Haighton, K. Van Putte, and L. F. Vermaas, Determination of the solid contents of fats by wide-line nuclear magnetic resonance. Signal of liquid oils, *J. Am. Oil Chemist's Soc.* **49**(3), 153-156 (1972).
110. J. Timmermans, and M. Hennaut-Roland, Work of the International Bureau of Physicochemical Standards. VIII. Physical constants of twenty organic compounds, *J. Chim. Phys.* **34**, 693-739 (1937).
111. W. Herz, and P. Schuftan, Physico-chemical studies with tetralin and decalin, *Z. Physik, Chem.* **101**, 269-286 (1922).
112. A. E. Dunstan, F. B. Thole, and P. Benson, The relation between viscosity and chemical constitution. Part VIII. Some homologous series, *J. Chem. Soc., Trans.*, (London) **105**, 782-795 (1914).
113. A. Kellomaki, Viscosities of water-water-d2 mixtures at various temperatures, *Finn. Chem. Lett.* **2**, 51-54 (1975).
114. J. Peterson, The viscosities of glycerol trinitrate and certain related glycol nitric esters, *J. Am. Chem. Soc.* **52**(9), 3669-3676 (1930).
115. E. Swift, Jr. and D. L. Wolfe, The Viscosities of Dimethyl and Trimethylamine at 15, 25 and 35°, *J. Am. Chem. Soc.* **66**(3), 498-499 (1944).
116. G. Hetherington, and P. L. Robinson, Viscosities of iodine pentafluoride and ditellurium deca-fluoride, *J. Chem. Soc.* (London) 3681 (1961).
117. J. E. Fountaine, R. Sasin, G. S. Sasin, and L. P. Witnauer, Viscosity studies of some long-chain thiol esters*, J. Am. Oil Chemist's Soc.* **42**(1), 25-27 (1965).
118. J.H. Mathews, and K.E. Faville, The Physical Properties of a Number of Pure Esters, *J. Phys. Chem.* **22**(1), 1-21 (1918).
119. R. Gartenmeister, *Z. Physik. Chem.* **6**, 524 (1890).
120. J. W. Shigley, C. W. Bonhorst, C. C. Liang, P. M. Althouse, and H. O. Triebold, Physical characterization of (a) a series of ethyl esters and (b) a series of ethanoate esters, *J. Am. Oil Chmist's Soc.* **32**, 213-215 (1955).
121. P. D. Faurote, C. M. Henderson, C. M. Murphy, J. G. O'Rear, and H. Ravner, Partially Fluorinated Esters and Ethers as Temperature-Stable Liquids, *Ind. Eng. Chem.* **48**(3), 445-454 (1956).
122. F. S. Jerome, J. T. Tseng, and L. T. Fan, Viscosities of aqueous glycol solutions, *J. Chem. Eng. Data,* **13**(4), 496 (1968).
123. M. D. Jackson and P. G. Sears, Dielectric constants, viscosities, and related physical properties of some liquid carbamates at several temperatures, *J. Chem. Eng. Data,* **24(**2), 85-87 (1979).
124. G. Elverum and R. Doescher, Physical Properties of Liquid Fluorine, *J. Chem. Phys.* **20**, 1834-1836 (1952).

125. S. Taniewska-Osinska, A. Piekarska, and A. Kacperska, Viscosities of sodium iodide in water-formamide and water-N,N-dimethylformamide mixtures from 5 to 45° C, *J. Solution Chemistry,* **12**(10), 717-727 (1983).
126. A. E. Dunstan, The relation between viscosity and chemical constitution. Part IX. The viscosity and fluidity of the aliphatic acids, *J. Chem. Soc. Trans*. **107**, 667-672 (1915).
127. B. M. Coursey and E. L. Heric, Viscosity of some binary systems of hexadecane and normal chloroalkanes, *J. Chem. Eng. Data,* **14**(4) , 426-430 (1969).
128. A. F. Shepard, A. L. Henne, and T. Midgley, Physical properties of the normal paraffin hydrocarbons, pentane to dodecane*, J. Am. Chem. Soc*. **53**(5), 1948-1958 (1931).
129. P. Drapier, Viscosity of Binary Liquid Mixtures in the Neighborhood of the Critical Solution Temperature, *Bull. Classe. Sci. Acad. Roy. Belg*. 621-640 (1911).
130. G. Berchiesi, M. A. Berchiesi, and G. Gioia-Lobbia, Density and viscosity in the binary system octadecanoic acid-hexanedioic acid, *J. Chem. Eng. Data,* **26**(1), 20-22 (1981).
131. R. G. Ahlert, G. L. Bauerle, and J. V. Lecce, Density and Viscosity of Anhydrous Hydrazine at Elevated Temperatures, *J. Chem. Eng. Data,* **7**(1), 158-160 (1962).
132. B. D. Steele, D. McIntosh, and E.H. Archibald, The halogen hydrides as conducting solvents, *Phil. Trans. Roy. Soc*. (London) **A205**, 99 (1905).
133. J. E. Coates and R. H. Davies, Studies on hydrogen cyanide. Part XVIII. Some physical properties of anhydrous hydrogen cyanide*, J. Chem. Soc*. (London) 1194-1199 (1950).
134. A. P. Kudchadker and S. A. Kudchadker, API Publ. No. 714, Am. Pet. Inst. Washington, D.C. 1980.
135. A. Sachanow and N. Ryachovskii, Viscosity of liquid mixtures. I**.**, *Z. Physik, Chem*. **86**, 529-537 (1914).
136. A. Haydweiller, The viscosity of liquids above their boiling points, *Ann. d. Physik*. **59**, 193 (1896).
137. H. R Thresh and A. F. Crawley, Viscosities of lead, tin, and lead-tin alloys, *Met. Trans.* **1**, 1531-1535 (1970).
138. H.R. Thresh, Viscosity of liquid zinc by oscillating a cylindrical vessel, *Trans. Met. Soc. AIME*, **233**(1), 79-88 (1965).
139. M. D. Jackson and P. G. Sears, Dielectric constants, viscosities, and related physical properties of some liquid carbamates at several temperatures, *J. Chem. Eng. Data,* **24**(2), 85-87 (1979).
140. I. S. Badylkes, Kholodilnaya tekhnika, Encyclopedic Dictionary, Vol. 1, Gosenergo Press Moscow, 1960
141. L. J. P. Keffler and J. H. MacLean, *J. Soc. Chem. Ind*. (London) **54**, 178 (1935) as quoted by Bingham, E.C. and Spooner, L.W. Physics **4**, 387 (1933).
142. Stairs, R.A, Viscosity of associated liquids. 2. Methylamine, *J. Chem. Eng. Data,* **25**(4), 379 (1980).
143. R.C. Makhija, and R.A. Stairs, Viscosity of associated liquids, *Canadian J. Chemistry*, **48**(8), 1214-1218 (1970).
144. C. C. Addison and B. C. Smith, The viscosity of dinitrogen tetroxide and its binary mixtures with organic solvents, *J. Chem. Soc*. (London) 1783-1788 (1960).

145. G. Hetherington and P.L. Robinson, Some physical properties of nitryl fluoride, *J. Chem. Soc*. (London) 2230-2233 (1955).
146. L. T. Chu, C. Sindilariu, A. Freilich, and V. Fried, Some physical properties of long chain hydrocarbons*, Canadian J. Chemistry*, **64**(3), 481-483 (1986).
147. O. Maass and E. H. Boomer, Vapor densities at low pressures and over an extended temperature range. I. The properties of ethylene oxide compared to oxygen compounds of similar molecular weight, *J. Am. Chem. Soc*. **44**(8), 1709-1728 (1922).
148. D. E. Diller, Measurements of the Viscosity of Parahydrogen, *J. Chem. Phys*. **42**(6), 2089-2100 (1965).
149. W. Herz and W. Rathmann, *Z. anorg. allgem. Chem*. **44**, 589 (1913).
150. M. .K. Tham, R. D. Walker, and J. H. Modell, Physical properties and gas solubilities in selected fluorinated ethers, *J. Chem. Eng. Data,* **18**(4), 385-386 (1973).
151. E. C. Bingham and G. F. White, The viscosity and fluidity of emulsions, crystallin liquids and colloidal solutions, *J. Am. Chem. Soc*. **33**(8), 1257-1275 (1911).
152. O. Scarpa*, J. Chim. Phys*. 2, 447 (1904).
153. V. A. Kirillin, *Thermophysical Properties of Alkali Metals*, Standards Press, 1970 as quoted by N.B. Vargaftik, *Tables on the Thermophysical Properties of Liquids and Gases*, Wiley, New York, 1975.
154. G. J. Janz, S. W. Lurie, and G. L. Gardner, Viscosity of molten lithium nitrate, *J. Chem. Eng. Data,* **23**(1), 14-16 (1978).
155. L. Keffler and J. H. MacLean*,* Homology in long-chain compounds. I. Oleic acid and the alkyl oleates, *J. Soc. Chem. Ind*. **54**, 178-185T (1935) as quoted by E. C. Bingham and L. W. Spooner, The fluidity method for the determination of association. II, Physica, **4**, 387-400 (1933).
156. P. Dutoit and H. Duperthuis, Viscosity and Limiting Conductivity*, J. Chim. Phys*. **6**, 726-731 (1908).
157. P. G. Sears, W. D. Siegfried, and D. E. Sands, Viscosities, Densities, and Related Properties of Solutions of Some Sugars in Dimethyl Sulfoxide, *J. Chem. Eng. Data,* **9**(2), 261-263 (1964).
158. P. H. Mogul, M. C. Hochberg, R. Michiel, G. K. Nestel, B. L. Wamsley, and S. D. Coren, Physical properties of tetra-n-alkylgermanes (C1-C6), *J. Chem. Eng. Data,* **19**(1), 4-6 (1974).
159. A. F. Crawley, Density and viscosity of liquid thallium, *Trans. Met. Soc. AIME*, **242**(11), 2309-2311 (1968).
160. P. M. Christopher and H. W. Washington, Jr. Densities and viscosities of trialkyl borates, *J. Chem. Eng. Data,* **14**(4), 437-439 (1969).
161. R. B. Joglekar and H. E. Watson, Physical properties of pure triglycerides, *J. Soc. Chem. Ind*. **47**, 365-368T (1928) as quoted by E. C. Bingham and L. W. Spooner, The fluidity method for the determination of association. II, Physica, **4**, 387-400 (1933).
162. D. P. Evans and W. J. Jones, Viscosities of phosphoric esters**,** *J. Chem. Soc*. (London) 985 (1932).

163. D. J. Kingham, W. A. Adams, and M. J. MeGuire, Viscosity measurements of water in region of its maximum density, *J. Chem. Eng. Data,* **19**(1), 1-3 (1974).
164. D. Swern, W. E. Palm, H. B. Knight, and L. P. Witnauer, Viscosity Characteristics of Esters of Hydroxystearic Acids, *J. Chem. Eng. Data,* **5**(2), 231-233 (1960).
165. E. Bried, H. F. Kidder, C. M. Murphy, and W. A. Zisman, Synthetic Lubricant Fluids from Branched-Chain Diesters Physical and Chemical Properties of Pure Diesters, *Ind. Eng. Chem*. **39**(4), 484-491 (1947).
166. R. Morgan, and W. F. Olds, Viscosity-Temperature Properties of Alkyl Silicates, *Ind. Eng. Chem.* **45**(11), 2592-2594 (1953).
167. H. R. Gamrath, R. E. Hatton, and W. E. Weesner, Chemical and Physical Properties of Alkyl Aryl Phosphates, *Ind. Eng. Chem.* **46**(1), 208-212 (1954).
168. D. Swern, W. E. Palm, R. Sasin, and L. P. Witnauer, Viscosity Characteristics of Long-Chain Phosphorus Compounds, *J. Chem. Eng. Data,* **5**(4), 486-488 (1960).
169. G. E. Bohner, J. A. Krimmel, J. J. Schmidt-Collerus, and R. D. Stacy, Properties of Polyester Fluids with Desirable Synthetic Lubricant Characteristics, *J. Chem. Eng. Data,* **7**(4), 547-553 (1962).
170. D. Swern, W. E. Palm, R. Sasin, and L. P. Witnauer, *J. Chem. Eng. Data,* **5**, 932 (1960)
171. M. H. Li and Y. C. Lie, Densities and viscosities of solutions of monoethanolamine + n-methyldiethanolamine + water and monoethanolamine + 2-Amino-2-methyl-1-propanol + water, *J. Chem. Eng. Data*, **39**(3), 444-447 (1994).
172. R. Ahluwalia, R. K Wanchoo, S. K Sharma, and J. L Vashisht, Density, viscosity, and surface tension of binary liquid systems: Ethanoic acid, propanoic acid, and butanoic acid with nitrobenzene, *J. Solution Chemistry*, **25**(9), 905-917 (1996).
173. D. Venkatesulu, P. Venkatesu, and M. V. P. Rao, Viscosities and densities of trichloroethylene or tetrachloroethylene with 2-alkoxyethanols at 303.15 K and 313.15 K, *J. Chem. Eng. Data*, **42**(2), 365-367 (1997).
174. V. K. Reddy, K. S. Reddy, and A. Krishnaiah, Excess volumes, speeds of sound, and viscosities for mixtures of 1,2-ethanediol and alkoxy alcohols with water at 308.15 K, *J. Chem. Eng. Data*, **39**(3), 615-617 (1994).
175. C. Pal and A. Kumar, Excess molar volumes and viscosities of binary mixtures of 2-(2-butoxyethoxy)ethanol with chloroalkanes at 298.15 K, *Fl. Phase Eq*. **143**(1-2), 241-251 (1998).
176. W.-R.Liau, M. Tang, and Y.-P. Chen, densities and viscosities of butyl acrylate + 1-butanol and ethyl laurate + 1-butanol at 293.15, 303.15, and 313.15 K, *J. Chem. Eng. Data*, **43**(5), 826-829 (1998).
177. S. Viswanathan, M. A. Rao, and D. H. L. Prasad, Densities and Viscosities of Binary Liquid Mixtures of Anisole or Methyl tert-Butyl Ether with Benzene, Chlorobenzene, Benzonitrile, and Nitrobenzene, *J. Chem. Eng. Data*, **45**(5), 764-770 (2000).
178. R. S. Ramadevi, P. Venkatesu, and M. V. P. Rao, Viscosities of binary liquid mixtures of N,N-dimethylformamide with substituted benzenes at 303.15 and 313.15 K, *J. Chem. Eng. Data,* **41**(3), 479-481 (1996).

179. C. Lafuente, H. Artigas, J. Pardo, F. M. Royo, and J. S. Urieta, Viscosities of 1-chlorobutane and 1,4-dichlorobutane with isomeric butanols at 25 and 40°C, *J. Solution Chem.* **25**(3), 303-313 (1996).
180. I. Gascon, C. Lafuente, P. Cea, F. M. Royo, and J. S. Urieta, Viscosities of the ternary mixture (cyclohexane+tetrahydrofuran+chlorocyclohexane) at 298.15 and 313.15 K, *Fl. Phase Eq.* **164**(1), 143-155 (1999).
181. F. Comelli, S. Ottani, R. Francesconi, and C. Castellari, Densities, viscosities, and refractive indices of binary mixtures containing n-Hexane + components of pine resins and essential oils at 298.15 K, *J. Chem. Eng. Data*, **47**(1), 93-97 (2002).
182. L. R. Grzyll, C. Ramos, and D. D. Back, Density, viscosity, and surface tension of liquid quinoline, naphthalene, biphenyl, decafluorobiphenyl, and 1,2-diphenylbenzene from 300 to 400oC, *J. Chem. Eng. Data*, **41**(3), 446-450 (1996).
183. I-C. Pan, M. Tang, and Y.-P. Chen, Densities and viscosities of binary liquid mixtures of vinyl acetate, diethyl oxalate, and dibutyl phthalate with normal alkanols at 303.15 K, *J. Chem. Eng. Data*, **45**(6), 1012-1015 (2000).
184. A. Pal, and S. Sharma, Excess molar volumes and viscosities of 1-propanol + ethylene glycol, + ethylene glycol monomethyl, + ethylene glycol dimethyl, + diethylene glycol dimethyl, + triethylene glycol dimethyl, + diethylene glycol diethyl, and + diethylene glycol dibutyl ethers at 298.15 K, *J. Chem. Eng. Data*, **43**(4), 532-536 (1998).
185. Pal, and S. Sharma, excess molar volumes and viscosities of binary liquid mixtures of ethylene glycol dimethyl ether + ethylene glycol monomethyl, + diethylene glycol monomethyl, and + triethylene glycol monomethyl ethers at 298.15 and 308.15 K, *J. Chem. Eng. Data*, **44**(2), 212-215 (1999).
186. D. Ripple, and D. Defibaugh, Viscosity of the saturated liquid phase of three fluorinated ethanes: R152a, R143a, and R125, *J. Chem. Eng. Data*, **42**(2), 360-364 (1997).
187. T. M. Aminabhavi, and B. Gopalakrishna, Densities, viscosities, and refractive indices of bis(2-methoxyethyl) ether + cyclohexane or + 1,2,3,4-tetrahydronaphthalene and of 2-ethoxyethanol + propan-1-ol, + propan-2-ol, or + butan-1-ol, *J. Chem. Eng. Data*, **40**(2), 462-467 (1995).
188. F. Comelli, S. Ottani, R. Franscosconi, and C. Castellari, Densities, viscosities, refractive indices, and excess molar enthalpies of binary mixtures containing poly(ethylene glycol) 200 and 400 + dimethoxymethane and + 1,2-dimethoxyethane at 298.15 K, *J. Chem. Eng. Data*, **47** (5), 1226-1231 (2002).
189. A. Aucejo, M. C. Burguet, and R. Muñoz, Densities, viscosities, and refractive indices of some binary liquid systems of ethanol + isomers of hexanol at 298.15 K, *J. Chem. Eng. Data*, **41**(5), 1131-1134 (1996).
190. Gascon, A. M. Mainar, F. M. Royo, J. S. Urieta, and L. Alvarez-Cerdeiriña, Experimental viscosities and viscosity predictions of the ternary mixture (cyclohexane + 1,3-dioxolane + 2-butanol) at 298.15 and 313.15 K, *J. Chem. Eng. Data*, **45**(5), 751-755 (2000).

191. N. V. Sastry, N. J. Jain, A. George, P. Bahadur, Viscosities, speeds of sound and excess isentropic compressibilities of binary mixtures of alkyl alkanoate–hydrocarbons at 308.15 K and 318.15 K, *Fl. Phase Eq*. **163**(2), 275-289 (1999).
192. J. N. Nayak, M. I. Aralaguppi, and T. M. Aminabhavi, Density, viscosity, refractive index, and speed of sound in the binary mixtures of ethyl chloroacetate with aromatic liquids at 298.15, 303.15, and 308.15 K, *J. Chem. Eng. Data*, **47**(4), 964-969 (2002).
193. A. Pal, and S. Sharma, Excess molar volumes and viscosities of binary liquid mixtures of ethylene glycol diethyl Ether + ethylene glycol monomethyl, + diethylene glycol monomethyl, + triethylene glycol monomethyl Ethers at 298.15 and 308.15 K, *J. Chem. Eng. Data*, **44**(5), 1067-1070 (1999).
194. A. Pal, and Y.P. Singh, Viscosity in water + ethylene glycol dimethyl, +diethylene glycol dimethyl, +triethylene glycol dimethyl, and +Tetraethylene glycol dimethyl Ethers at 298.15 K, *J. Chem. Eng. Data*, **41**(5), 1008-1011 (1996).
195. Pal, and S. Sharma, Excess molar volumes and viscosities of binary liquid mixtures of ethylene glycol diethyl Ether + ethylene glycol monomethyl, + diethylene glycol monomethyl, + triethylene glycol monomethyl Ethers at 298.15 and 308.15 K, *J. Chem. Eng. Data*, **44**(5), 1067-1070 (1999).
196. Z. Shan, and A. A. Asfour, Viscosities and densities of nine binary 1-alkanol systems at 293.15 K and 298.15 K, *J. Chem. Eng. Data*, **44**(1), 118-123 (1999).
197. S. L. Oswal, and H. S. Desai, Studies of viscosity and excess molar volume of binary mixtures: 2. Butylamine+1-alkanol mixtures at 303.15 and 313.15 K, *Fl. Phase Eq.* **161**(1), 191-204 (1999).
198. P. S. Nikam, T. R. Mahale, and M. Hasan, Densities and viscosities for ethyl acetate + Pentan-1-ol, + Hexan-1-ol, + 3,5,5-trimethylhexan-1-ol, + heptan-1-ol, + octan-1-ol, and + decan-1-ol at (298.15, 303.15, and 308.15) K, *J. Chem. Eng. Data*, **43**(3), 436-440 (1998).
199. Z. Shan, and A. A. Asfour, Viscosities and densities of eight binary 1-alkanol systems at 308.15 and 313.15 K, *Fl. Phase Eq*. **143**(1-2), 253-262 (1998).
200. S. Ottani, D. Vitalini, F. Comelli, C. Castellari, Densities, viscosities, and refractive indices of poly(ethylene glycol) 200 and 400 + cyclic ethers at 303.15 K, *J. Chem. Eng. Data*, **47** (5), 1197-1204 (2002).
201. V. G. Nemzer, and L. V. Nemzer, Thermophysical properties of liquid poly(methylsiloxane)s, *J. Chem. Eng. Data*, **43**(2), 171-174 (1998).
202. A. Pal, and A. Kumar, Excess molar volumes, viscosities, and refractive indices of diethylene glycol dimethyl Ether with dimethyl carbonate, diethyl carbonate, and propylene carbonate at (298.15, 308.15, and 318.15) K, *J. Chem. Eng. Data*, **43**(2), 143-147 (1998).
203. K. Lal, N. Tripathi, and G. P. Dubey, Densities, viscosities, and refractive indices of binary liquid mixtures of hexane, decane, hexadecane, and squalane with benzene at 298.15 K, *J. Chem. Eng. Data*, **45**(5), 961-964 (2000).

204. A. Pal, and G. Dass, Excess Molar Volumes and Viscosities for Binary Liquid Mixtures of Methyl tert-Butyl Ether and of tert-Amyl Methyl Ether with Methanol, 1-Propanol, and 1-Pentanol at 298.15 K, *J. Chem. Eng. Data*, **44**(6), 1325-1329 (1999).
205. D. Venkatesulu, P. Venkatesu, and M. V. P. Rao, Excess volumes and viscosities of tetrachloroethylene with branched alcohols at 303.15 K, *J. Chem. Eng. Data*, **41**(4), 819-820 (1996).
206. N. Swain, D. Panda, S. K. Singh, and V. Chakravortty, Viscosity and density of tri-n-butyl phosphate + benzene + toluene from 30°C to 45°C, *J. Chem. Eng. Data*, **44**(1), 32-34 (1999).
207. K. R. Harris, R. Malhotra, and L. A. Woolf, Temperature and density dependence of the viscosity of octane and toluene, *J. Chem. Eng. Data*, **42**(6), 1254-1260 (1997).
208. K. Y.-Y. Duan, L. Shi, L.-Z. Han, and M.-S. Zhu, Viscosity of saturated liquid trifluoroiodomethane from 253 to 338 K, *Fl. Phase Eq*. **162**(1-2), 303-312 (1999).
209. D. Gómez-Díaz, J. C. Mejuto, and J. M. Navaza, Physicochemical properties of liquid mixtures. 1. Viscosity, density, surface tension and refractive index of cyclohexane + 2,2,4-trimethylpentane binary liquid systems from 25°C to 50°C, *J. Chem. Eng. Data*, **46**(3), 720-724 (2001).
210. T. M. Aminabhavi, M. I. Aralaguppi, G. Bindu, and R. S. Khinnavar, Densities, shear viscosities, refractive indices, and speeds of sound of bis(2-methoxyethyl) ether with hexane, heptane, octane, and 2,2,4-trimethylpentane in the temperature interval 298.15-318.15 K, *J. Chem. Eng. Data*, **39**(3), 522-528 (1994).
211. Canosa, J., Rodríguez, A., and Tojo, J., Dynamic viscosities of (methyl acetate or methanol) with (ethanol, 1-proponal, 2-proponal, 1-butanol, and 2-butanol) at 298.15K. *J. Chem. Eng. Data*, **43**(3), 417-421 (1998).
212. M. N. Sovilj, Kinematic viscosities of binary and ternary liquid mixtures involving chloroform, 2-propanol, and 2-butanol at several temperatures. *J. Chem. Eng. Data*, **40**(5), 1058-1061 (1995).
213. J. Wu, A. H. Nhaesi, and A. A. Asfour, Viscosities of eight binary liquid n-alkane systems at 293.15 K and 298.15 K, *J. Chem. Eng. Data*, **44**(5), 990-993 (1999).
214. Wu, J., Nhaesi, A.H., and Asfour, A.A., Viscometric properties of eight binary liquid n-alkane systems at 308.15 and 313.15 K. *Fl. Phase Eq*., 164, 285 (1999)
215. R. Burgdof, A. Zocholl, W. Arlt, and H. Knapp, Thermophysical properties of binary liquid mixtures of polyether and n-alkane at 298.15 and 323.15 K: heat of mixing, heat capacity, viscosity, density and thermal conductivity, *Fl Phase Equl*. **164**(2), 225-255 (1999).
216. J. Nath, and S. K. Misra, Excess molar volumes and kinematic viscosities of binary liquid mixtures of cyclohexanone + dichloromethane, + trichloromethane, + 1,2-dichloroethane, + trichloroethene, + 1,1,1-trichloroethane, and + cyclohexane, *J. Chem. Eng. Data* , **43**(2), 196-200 (1998).
217. P. J. Petrino, Y. H. Gaston-Bonhomme, and J. L. E. Chevalier, Viscosity and density of binary liquid mixtures of hydrocarbons, esters, ketones, and normal chloroalkanes, *J. Chem. Eng. Data*, **40**(1), 136-140 (1995).

Index

Compound Index: Experimental Data for Absolute Viscosity

Compound Index: Experimental Data for Kinematic Viscosity