

4 Tabulated Data on Density - Spiroalkanes and Spiroalkenes

4.1 Saturated Compounds

Spiro[2.2]pentane [157-40-4] C_5H_8 MW =68.12 473

Table 1. Experimental values with uncertainties.

T K	$\rho_{\text{exp}} \pm 2\sigma_{\text{est}}$ $\text{kg} \cdot \text{m}^{-3}$	Ref.
293.15	726.6 ± 2.0	13-zel/kra
293.15	755.1 ± 2.0	46-cle/she
293.15	755.1 ± 2.0	46-sla-1

Spiro[4.2]heptane [185-49-9] C_7H_{12} MW =96.17 474

Table 1. Experimental value with uncertainty.

T K	$\rho_{\text{exp}} \pm 2\sigma_{\text{est}}$ $\text{kg} \cdot \text{m}^{-3}$	Ref.
293.15	793.3 ± 0.6	49-ano-4

2-Methylspiro[2.4]heptane [500040-36-8] C_8H_{14} MW =110.20 475

Table 1. Experimental value with uncertainty.

T K	$\rho_{\text{exp}} \pm 2\sigma_{\text{est}}$ $\text{kg} \cdot \text{m}^{-3}$	Ref.
293.15	836.7 ± 1.0	56-gra/kos

Spiro[5.2]octane [185-65-9] C_8H_{14} MW =110.20 476

Table 1. Experimental value with uncertainty.

T K	$\rho_{\text{exp}} \pm 2\sigma_{\text{est}}$ $\text{kg} \cdot \text{m}^{-3}$	Ref.
293.15	828.2 ± 1.0	48-sho/cra

1,5-Dimethylspiro[3.3]heptane [500040-40-4] C_9H_{16} MW =124.23 477

Table 1. Experimental value with uncertainty.

T K	$\rho_{\text{exp}} \pm 2\sigma_{\text{est}}$ $\text{kg} \cdot \text{m}^{-3}$	Ref.
293.15	797.2 ± 2.0	13-leb

4-Methylspiro[5.2]octane [500031-51-6] C_9H_{16} MW =124.23 478

Table 1. Experimental value with uncertainty.

$\frac{T}{K}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref.
293.15	838.6 ± 1.0	48-sho/cra

Spiro[4.4]nonane [175-93-9] C_9H_{16} MW =124.23 479

Table 1. Experimental value with uncertainty.

$\frac{T}{K}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref.
293.15	863.4 ± 1.0	53-lev/tan

Spiro[5.3]nonane [185-02-4] C_9H_{16} MW =124.23 480

Table 1. Experimental value with uncertainty.

$\frac{T}{K}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref.
293.15	887.7 ± 2.0	29-zel/sch

Spiro[5.4.0^{6,10}]decane [500040-63-1] $C_{10}H_{16}$ MW =136.24 481

Table 1. Experimental value with uncertainty.

$\frac{T}{K}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref.
290.15	913.4 ± 2.0	30-zel/sch

Spiro[5.4]decane [176-63-6] $C_{10}H_{18}$ MW = 138.25 482

Table 1. Coefficients of the polynomial expansion equation. Standard deviations (see introduction):

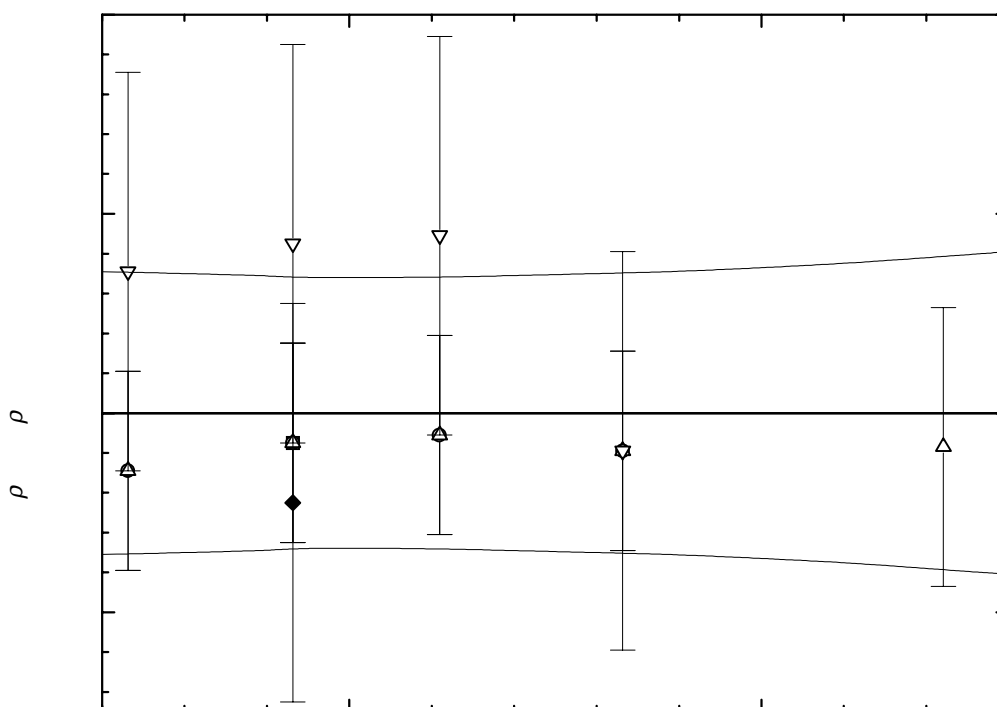
$\sigma_{c,w} = 2.7324 \cdot 10^{-1}$ (combined temperature ranges, weighted), $\sigma_{c,uw} = 1.1178 \cdot 10^{-1}$ (combined temperature ranges, unweighted).

Coefficient	$T = 273.15 \text{ to } 372.05 \text{ K}$ $\rho = A + BT + CT^2 + DT^3 + \dots$
A	$1.10307 \cdot 10^3$
B	$-7.66558 \cdot 10^{-1}$

cont.

Table 2. Experimental values with uncertainties and deviation from calculated values.

T K	$\rho_{\text{exp}} \pm 2\sigma_{\text{est}}$ $\text{kg} \cdot \text{m}^{-3}$	$\rho_{\text{exp}} - \rho_{\text{calc}}$ $\text{kg} \cdot \text{m}^{-3}$	Ref. (Symbol in Fig. 1)	T K	$\rho_{\text{exp}} \pm 2\sigma_{\text{est}}$ $\text{kg} \cdot \text{m}^{-3}$	$\rho_{\text{exp}} - \rho_{\text{calc}}$ $\text{kg} \cdot \text{m}^{-3}$	Ref. (Symbol in Fig. 1)
293.15	877.90 ± 1.00	-0.45	57-tur/sos(◆)	310.95	865.60 ± 1.00	0.89	65-nar(▽)
293.15	878.20 ± 0.50	-0.15	60-dix/nar(□)	333.15	847.50 ± 1.00	-0.19	65-nar(▽)
273.15	893.40 ± 0.50	-0.29	60-nar-1(O)	273.15	893.40 ± 0.50	-0.29	68-ano-1(Δ)
293.15	878.20 ± 0.50	-0.15	60-nar-1(O)	293.15	878.20 ± 0.50	-0.15	68-ano-1(Δ)
310.95	864.60 ± 0.50	-0.11	60-nar-1(O)	310.95	864.60 ± 0.50	-0.11	68-ano-1(Δ)
333.15	847.50 ± 0.50	-0.19	60-nar-1(O)	333.15	847.50 ± 0.50	-0.19	68-ano-1(Δ)
273.15	894.40 ± 1.00	0.71	65-nar(▽)	372.05	817.70 ± 0.70	-0.17	68-ano-1(Δ)
293.15	879.20 ± 1.00	0.85	65-nar(▽)				

**Fig. 1.** The symbols show the deviation of the calculated from the experimental values from Table 2. The curves above and below the zero line indicate the calculated error region of the recommended values given in Table 3. The error bars represent the experimental errors. (Error bars smaller than the symbols are omitted for clarity of the figure.)

cont.

Spiro[5.4]decane (cont.)**Table 3.** Recommended values (fit to the reliable experimental values according to the equations

$$\rho = A + BT + CT^2 + DT^3 + \dots \text{ or } \rho = [1 + 1.75(1 - T/T_c)^{1/3} + 0.75(1 - T/T_c)][\rho_c + A(T_c - T) + B(T_c - T)^2 + C(T_c - T)^3 + D(T_c - T)^4]$$

$\frac{T}{\text{K}}$	$\frac{\rho \pm \sigma_{\text{fit}}}{\text{kg} \cdot \text{m}^{-3}}$	$\frac{T}{\text{K}}$	$\frac{\rho \pm \sigma_{\text{fit}}}{\text{kg} \cdot \text{m}^{-3}}$	$\frac{T}{\text{K}}$	$\frac{\rho \pm \sigma_{\text{fit}}}{\text{kg} \cdot \text{m}^{-3}}$
270.00	896.10 ± 0.71	300.00	873.10 ± 0.68	350.00	834.78 ± 0.73
280.00	888.43 ± 0.70	310.00	865.44 ± 0.68	360.00	827.11 ± 0.75
290.00	880.77 ± 0.69	320.00	857.77 ± 0.69	370.00	819.44 ± 0.78
293.15	878.35 ± 0.68	330.00	850.11 ± 0.70	380.00	811.78 ± 0.81
298.15	874.52 ± 0.68	340.00	842.44 ± 0.71		

Spiro[5.5]undecane**[180-43-8]****C₁₁H₂₀****MW = 152.28****483****Table 1.** Coefficients of the polynomial expansion equation. Standard deviations (see introduction):

$\sigma_{c,w} = 1.8290 \cdot 10^{-1}$ (combined temperature ranges, weighted), $\sigma_{c,uw} = 4.6124 \cdot 10^{-2}$ (combined temperature ranges, unweighted).

Coefficient	T = 273.15 to 372.05 K $\rho = A + BT + CT^2 + DT^3 + \dots$
A	$1.09729 \cdot 10^3$
B	$-7.10741 \cdot 10^{-1}$

Table 2. Experimental values with uncertainties and deviation from calculated values.

$\frac{T}{\text{K}}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	$\frac{\rho_{\text{exp}} - \rho_{\text{calc}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref. (Symbol in Fig. 1)	$\frac{T}{\text{K}}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	$\frac{\rho_{\text{exp}} - \rho_{\text{calc}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref. (Symbol in Fig. 1)
293.15	888.70 ± 0.50	-0.23	60-dix/nar(□)	310.95	876.30 ± 0.50	0.02	65-nar(○)
273.15	903.70 ± 0.50	0.55	60-nar-1(∇)	333.15	860.60 ± 0.50	0.10	65-nar(○)
293.15	888.70 ± 0.50	-0.23	60-nar-1(∇)	372.05	832.80 ± 0.70	-0.06	65-nar(○)
310.95	876.30 ± 0.50	0.02	60-nar-1(∇)	273.15	903.10 ± 0.50	-0.05	68-ano-1(Δ)
333.15	860.60 ± 0.50	0.10	60-nar-1(∇)	293.15	888.90 ± 0.50	-0.03	68-ano-1(Δ)
372.05	832.80 ± 0.70	-0.06	60-nar-1(∇)	310.95	876.30 ± 0.50	0.02	68-ano-1(Δ)
273.15	903.10 ± 0.50	-0.05	65-nar(○)	333.15	860.60 ± 0.50	0.10	68-ano-1(Δ)
293.15	888.70 ± 0.50	-0.23	65-nar(○)	372.05	832.90 ± 0.70	0.04	68-ano-1(Δ)

¹⁾ Not included in Fig. 1.

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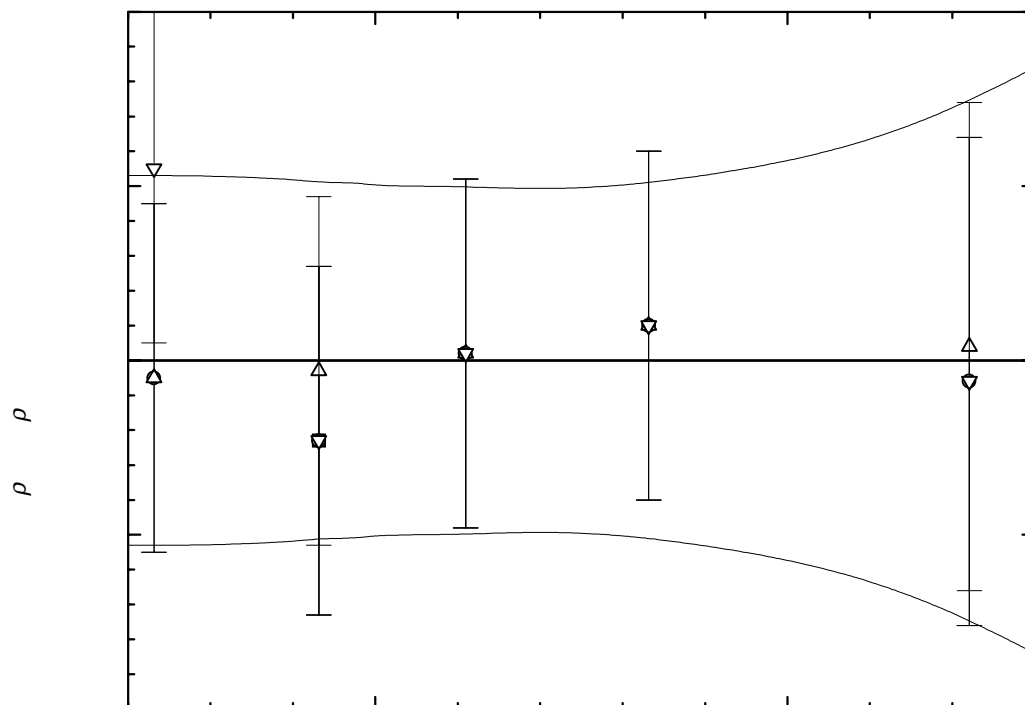


Fig. 1. The symbols show the deviation of the calculated from the experimental values from Table 2. The curves above and below the zero line indicate the calculated error region of the recommended values given in Table 3. The error bars represent the experimental errors. (Error bars smaller than the symbols are omitted for clarity of the figure.)

Table 3. Recommended values (fit to the reliable experimental values according to the equations $\rho = A + BT + CT^2 + DT^3 + \dots$ or $\rho = [1 + 1.75(1 - T/T_c)^{1/3} + 0.75(1 - T/T_c)][\rho_c + A(T_c - T) + B(T_c - T)^2 + C(T_c - T)^3 + D(T_c - T)^4]$).

$\frac{T}{\text{K}}$	$\frac{\rho \pm \sigma_{\text{fit}}}{\text{kg} \cdot \text{m}^{-3}}$	$\frac{T}{\text{K}}$	$\frac{\rho \pm \sigma_{\text{fit}}}{\text{kg} \cdot \text{m}^{-3}}$	$\frac{T}{\text{K}}$	$\frac{\rho \pm \sigma_{\text{fit}}}{\text{kg} \cdot \text{m}^{-3}}$
270.00	905.39 ± 0.53	300.00	884.06 ± 0.50	350.00	848.53 ± 0.57
280.00	898.28 ± 0.53	310.00	876.96 ± 0.50	360.00	841.42 ± 0.63
290.00	891.17 ± 0.52	320.00	869.85 ± 0.49	370.00	834.31 ± 0.72
293.15	888.93 ± 0.51	330.00	862.74 ± 0.50	380.00	827.21 ± 0.84
298.15	885.38 ± 0.51	340.00	855.63 ± 0.53		

Spiro[6.5]dodecane**[181-15-7]****C₁₂H₂₂****MW = 166.31****484****Table 1.** Coefficients of the polynomial expansion equation. Standard deviations (see introduction):
 $\sigma_{c,w} = 5.2872 \cdot 10^{-2}$ (combined temperature ranges, weighted), $\sigma_{c,uw} = 1.3466 \cdot 10^{-2}$ (combined temperature ranges, unweighted).

Coefficient	T = 273.15 to 372.05 K $\rho = A + BT + CT^2 + DT^3 + \dots$
A	$1.10483 \cdot 10^3$
B	$-6.87907 \cdot 10^{-1}$

Table 2. Experimental values with uncertainties and deviation from calculated values.

$\frac{T}{K}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	$\frac{\rho_{\text{exp}} - \rho_{\text{calc}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref. (Symbol in Fig. 1)	$\frac{T}{K}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	$\frac{\rho_{\text{exp}} - \rho_{\text{calc}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref. (Symbol in Fig. 1)
293.15	903.10 ± 0.50	-0.07	60-dix/nar(□)	310.95	890.90 ± 0.50	-0.03	65-nar(∇)
273.15	917.00 ± 0.50	0.07	60-nar-1(○)	333.15	875.70 ± 0.60	0.05	65-nar(∇)
293.15	903.10 ± 0.50	-0.07	60-nar-1(○)	372.05	848.90 ± 0.70	0.00	65-nar(∇)
310.95	890.90 ± 0.50	-0.03	60-nar-1(○)	273.15	917.00 ± 0.50	0.07	68-ano-1(Δ)
333.15	875.70 ± 0.70	0.05	60-nar-1(○)	293.15	903.10 ± 0.50	-0.07	68-ano-1(Δ)
372.05	848.90 ± 0.50	0.00	60-nar-1(○)	310.95	890.90 ± 0.50	-0.03	68-ano-1(Δ)
273.15	917.00 ± 0.50	0.07	65-nar(∇)	333.15	875.70 ± 0.50	0.05	68-ano-1(Δ)
293.15	903.10 ± 0.50	-0.07	65-nar(∇)	372.05	848.90 ± 0.70	0.00	68-ano-1(Δ)

Table 3. Recommended values (fit to the reliable experimental values according to the equations

$$\rho = A + BT + CT^2 + DT^3 + \dots \text{ or } \rho = [1 + 1.75(1 - T/T_c)^{1/3} + 0.75(1 - T/T_c)][\rho_c + A(T_c - T) + B(T_c - T)^2 + C(T_c - T)^3 + D(T_c - T)^4].$$

$\frac{T}{K}$	$\frac{\rho \pm \sigma_{\text{fit}}}{\text{kg} \cdot \text{m}^{-3}}$	$\frac{T}{K}$	$\frac{\rho \pm \sigma_{\text{fit}}}{\text{kg} \cdot \text{m}^{-3}}$	$\frac{T}{K}$	$\frac{\rho \pm \sigma_{\text{fit}}}{\text{kg} \cdot \text{m}^{-3}}$
270.00	919.10 ± 0.51	300.00	898.46 ± 0.52	350.00	864.06 ± 0.62
280.00	912.22 ± 0.51	310.00	891.58 ± 0.54	360.00	857.18 ± 0.64
290.00	905.34 ± 0.51	320.00	884.70 ± 0.55	370.00	850.31 ± 0.67
293.15	903.17 ± 0.52	330.00	877.82 ± 0.57	380.00	843.43 ± 0.70
298.15	899.73 ± 0.52	340.00	870.94 ± 0.59		

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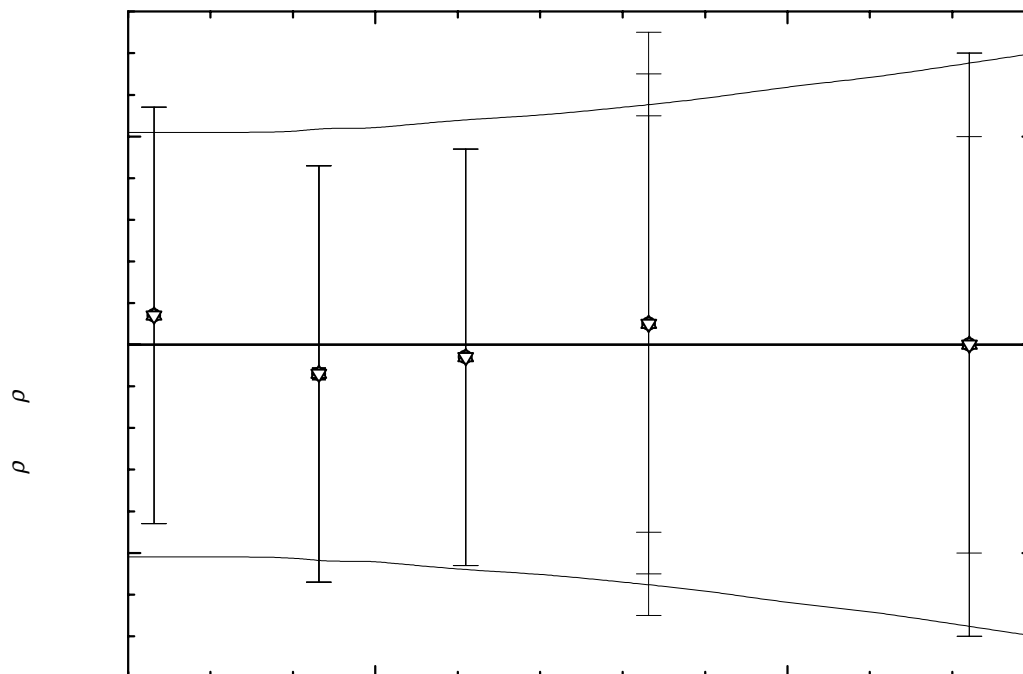


Fig. 1. The symbols show the deviation of the calculated from the experimental values from Table 2. The curves above and below the zero line indicate the calculated error region of the recommended values given in Table 3. The error bars represent the experimental errors. (Error bars smaller than the symbols are omitted for clarity of the figure.)

1,1,6,6-Tetramethyl-3-(1-methylethyl)-spiro[3.3]heptane [500040-84-6] $C_{14}H_{26}$ MW = 194.36 485

Table 1. Experimental value with uncertainty.

T K	$\rho_{\text{exp}} \pm 2\sigma_{\text{est}}$ $\text{kg} \cdot \text{m}^{-3}$	Ref.
293.15	838.0 ± 2.0	13-leb

7-Hexadecylspiro[5.4]decane [2307-06-4] $C_{26}H_{50}$ MW = 362.68 486

Table 1. Coefficients of the polynomial expansion equation. Standard deviations (see introduction):

$\sigma_{\text{c,w}} = 4.3973 \cdot 10^{-1}$ (combined temperature ranges, weighted), $\sigma_{\text{c,uw}} = 1.2831 \cdot 10^{-1}$ (combined temperature ranges, unweighted).

Coefficient	$T = 293.15 \text{ to } 372.05 \text{ K}$ $\rho = A + BT + CT^2 + DT^3 + \dots$
A	$1.04582 \cdot 10^3$
B	$-6.34425 \cdot 10^{-1}$

cont.

7-Hexadecylspiro[5.4]decane (cont.)

Table 2. Experimental values with uncertainties and deviation from calculated values.

$\frac{T}{\text{K}}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	$\frac{\rho_{\text{exp}} - \rho_{\text{calc}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref. (Symbol in Fig. 1)	$\frac{T}{\text{K}}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	$\frac{\rho_{\text{exp}} - \rho_{\text{calc}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref. (Symbol in Fig. 1)
310.85	848.20 ± 0.50	-0.41	60-dix/nar(\square)	310.95	849.20 ± 0.50	0.66	65-nar(∇)
293.15	859.60 ± 0.50	-0.24	60-nar-1(\circ)	333.15	835.10 ± 0.60	0.64	65-nar(∇)
310.95	848.20 ± 0.50	-0.34	60-nar-1(\circ)	372.05	810.60 ± 0.70	0.82	65-nar(∇)
333.15	834.10 ± 0.50	-0.36	60-nar-1(\circ)	293.15	859.60 ± 0.50	-0.24	68-ano-1(Δ)
352.55	821.90 ± 0.50	-0.25	60-nar-1(\circ)	310.95	848.20 ± 0.50	-0.34	68-ano-1(Δ)
372.05	809.60 ± 0.70	-0.18	60-nar-1(\circ)	333.15	834.10 ± 0.50	-0.36	68-ano-1(Δ)
293.15	860.60 ± 0.50	0.76	65-nar(∇)	372.05	809.60 ± 0.70	-0.18	68-ano-1(Δ)

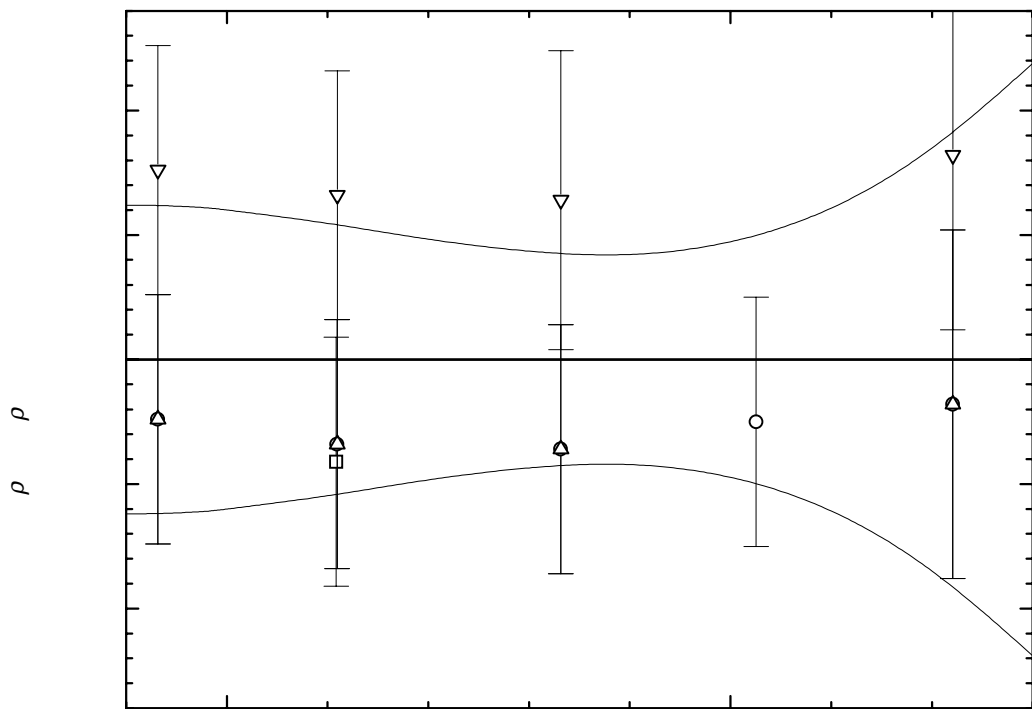


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cont.

Table 3. Recommended values (fit to the reliable experimental values according to the equations
 $\rho = A + BT + CT^2 + DT^3 + \dots$ or $\rho = [1 + 1.75(1 - T/T_c)^{1/3} + 0.75(1 - T/T_c)][\rho_c + A(T_c - T) + B(T_c - T)^2 + C(T_c - T)^3 + D(T_c - T)^4]$).

$\frac{T}{K}$	$\frac{\rho \pm \sigma_{\text{fit}}}{\text{kg} \cdot \text{m}^{-3}}$	$\frac{T}{K}$	$\frac{\rho \pm \sigma_{\text{fit}}}{\text{kg} \cdot \text{m}^{-3}}$	$\frac{T}{K}$	$\frac{\rho \pm \sigma_{\text{fit}}}{\text{kg} \cdot \text{m}^{-3}}$
290.00	861.83 \pm 0.62	310.00	849.15 \pm 0.55	350.00	823.77 \pm 0.46
293.15	859.84 \pm 0.62	320.00	842.80 \pm 0.48	360.00	817.42 \pm 0.59
298.15	856.66 \pm 0.61	330.00	836.46 \pm 0.43	370.00	811.08 \pm 0.83
300.00	855.49 \pm 0.60	340.00	830.11 \pm 0.41	380.00	804.74 \pm 1.19

3-(1-Butyloctadecyl)spiro[5.5]undecane [500050-04-4] $\text{C}_{33}\text{H}_{64}$ MW =460.87 487

Table 1. Experimental value with uncertainty.

$\frac{T}{K}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref.
298.15	867.0 \pm 2.0	36-mik

4.2 Unsaturated Compounds

1,5-Dimethylenespiro[3.3]heptane [4696-19-9] C_9H_{12} MW =120.19 488

Table 1. Experimental value with uncertainty.

$\frac{T}{\text{K}}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref.
293.15	826.4 ± 3.0	13-leb

Spiro[4.4]nona-1,3-diene [500039-10-1] C_9H_{12} MW =120.19 489

Table 1. Experimental value with uncertainty.

$\frac{T}{\text{K}}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref.
293.15	884.9 ± 1.0	53-lev/tan

Spiro[4.5]deca-6-ene [500019-34-1] $\text{C}_{10}\text{H}_{16}$ MW =136.24 490

Table 1. Experimental value with uncertainty.

$\frac{T}{\text{K}}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref.
293.15	899.5 ± 1.0	59-nar/dix

Spiro[5.5]undec-8-ene [500040-02-8] $\text{C}_{11}\text{H}_{18}$ MW =150.26 491

Table 1. Experimental value with uncertainty.

$\frac{T}{\text{K}}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref.
293.15	912.2 ± 2.0	60-dix/nar

1-Methylene-5-methyl-5-(1-methylethenyl)spiro[3.3]heptane [500040-71-1] $\text{C}_{12}\text{H}_{18}$ MW =162.27 492

Table 1. Experimental value with uncertainty.

$\frac{T}{\text{K}}$	$\frac{\rho_{\text{exp}} \pm 2\sigma_{\text{est}}}{\text{kg} \cdot \text{m}^{-3}}$	Ref.
293.15	934.6 ± 3.0	13-leb

