

# **Pesticide Synthesis Handbook**

**Thomas A. Unger**

**np**

## **ABOUT THE AUTHOR**

**Dr. Thomas A. Unger** obtained his Bachelor of Science degree in Chemical Engineering at the Massachusetts Institute of Technology (M.I.T.), and his Doctor of Science degree in Chemical Engineering in 1958, also at M.I.T.

From 1960 to 1982 he was Manager and Director of Rhodia S.A. (affiliate of Rhone Poulenc) chemicals, pesticides, pharmaceuticals, veterinary products, synthetic fibers, consumer products, minerals. He is also a Director of the Brazilian Association of Chemical industry.

From 1983 onwards he has been a consultant to the pesticide, chemical and petrochemical industries as well as to financial institutions. In 1992, he founded and is president of Prochrom Industrias Quimicas S/A. Prochrom is one of the largest manufacturers of intermediates and active ingredients for crop protection products in Latin America.

He is a member of the New York Academy of Sciences, and serves on the Board of Administration of several chemical and plastics manufacturers.

## PREFACE

Pesticide synthesis is based upon obtaining a certain function and constructing the rest of the molecule that goes around that function. Pesticides are classified in families according to the leading function.

For instance amide pesticides all contain the function

$$\text{R}_3-\text{C}(=\text{O})-\text{N}(\text{R}_1)(\text{R}_2)$$

carbamate pesticides contain

$$\text{R}_3-\text{O}-\text{C}(=\text{O})-\text{N}(\text{R}_1)(\text{R}_2)$$

and so on.

Though the main function is important for the efficiency and mode of action of the pesticide, it is by no means sufficient as such.

It is the radicals and chemical groups surrounding the main function which make all the difference between a great product and a mediocre one, which is why it is difficult to design a successful pesticide. Success in the pesticide industry still depends upon the trial and error screening of many products, before a great product is found.

A successful pesticide is imitated, in one way or another, thus giving rise to a family of products. That is why over 98% of all pesticides can be classified in one of the main families of products, the remaining being products one-of-a-kind.

While the synthesis of pesticides varies considerably even within the same family of products, certain general principles hold true for each family which helps in understanding the synthesis path. This is why the products are grouped together by the main function.

Finally, some pesticides have several of the main functional groups in the molecule and can be classified within more than one family.

## HOW TO USE THIS HANDBOOK

The main objective of this handbook is to describe the basic synthesis route(s) for the manufacture of pesticides.



Important sidelines are a list of the main raw materials and intermediates used in the synthesis of pesticides, as well as a list of all pesticides which are made using a given raw material or intermediate.

For this purpose there are five Appendices.

### **I. Generic Names**

The Generic Name Appendix indicates the chemical function of the compound. If the compound has more than one function, all functions are indicated. In this case, the synthesis route of the compound is found under the first function indicated in this Appendix.

*Example:* Quizalofop—This compound is listed as phenoxy carboxylic acid, quinoxaline. Phenoxy carboxylic acid is the first chemical function in the listing, indicating that the synthesis route of quizalofop is found in the chapter under phenoxy carboxylic acids in the main text.

### **II. Trade Names**

When only the trade name of the product is known the corresponding generic name is found in this Appendix.

*Example:* Targa—Corresponding generic name is quizalofop.

### **III. Raw Materials and Intermediates**

This appendix lists all pesticides, the synthesis of which uses a given raw material or intermediate. For example, the synthesis route for quizalofop described in the main text requires propionic acid, chloropropionic acid, hydroquinone and 2,6 dichloroquinoxaline. It is also indicated that the synthesis of 2,6 dichloroquinoxaline is described in the synthesis of propaquizalofop.

If one wishes to know which other pesticides use any of these raw materials or intermediates, the answer is given in this Appendix. If the compound is indicated with an asterisk, this means that its synthesis is either described in the main text itself, or in Appendix IV.

### **IV. Synthesis of Raw Materials and Intermediates**

The synthesis routes of Raw Materials and Intermediates are presented in this Appendix.

### **V. Chemical Functions**

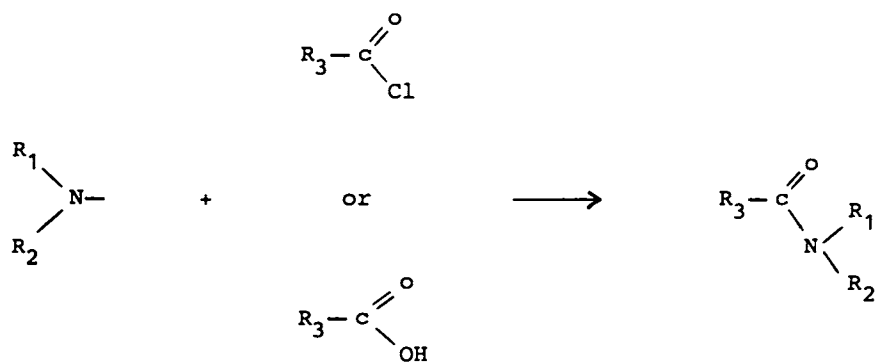
This appendix lists all products which have the same chemical function. The synthesis route(s) for each product are described under the heading of the main function. When a product has more than one main chemical function, it is listed under all its functions. However, whenever a function is indicated in parenthesis, this means that this is the function under which the synthesis route of the compound is described in the main text.

*Example:* Quizalofop—In the generic name index, this compound was found to be a phenoxy carboxylic acid and a quinoxaline. Quizalofop, therefore, appears twice in the chemical function index, once under the heading phenoxy carboxylic acids and once under quinoxalines. However, the listing under quinoxalines shows also (phenoxy carboxylic acid) which means that this is the chapter of the main text in which the synthesis of quizalofop is described.

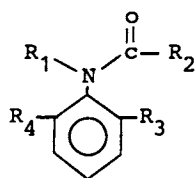


# AMIDES

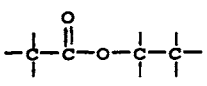



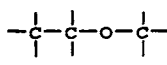



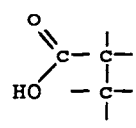
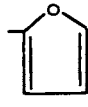


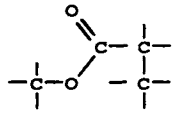
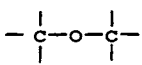


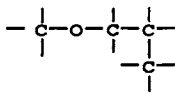
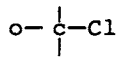


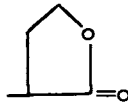



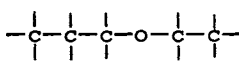



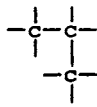

The amide function is usually obtained by reacting an amine either with the chloride of an acid or with the acid itself.



A significant number of amide pesticides have a general structure of the type

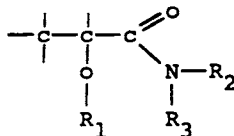


	$\text{R}_1$	$\text{R}_2$	$\text{R}_3$	$\text{R}_4$
acetochlor	$\begin{array}{c}   &   \\ -\text{C}-\text{C}-\text{O}-\text{C}- \\   &   \end{array}$	$\begin{array}{c}   \\ -\text{C}-\text{Cl} \\   \end{array}$	$\begin{array}{c}   \\ -\text{C}- \\   \end{array}$	$\begin{array}{c}   &   \\ -\text{C}-\text{C}- \\   &   \end{array}$
alachlor	$\begin{array}{c}   &   \\ -\text{C}-\text{O}-\text{C}- \\   &   \end{array}$	$\begin{array}{c}   \\ -\text{C}-\text{Cl} \\   \end{array}$	$\begin{array}{c}   &   \\ -\text{C}-\text{C}- \\   &   \end{array}$	$\begin{array}{c}   &   \\ -\text{C}-\text{C}- \\   &   \end{array}$
butachlor	$\begin{array}{c}   &   &   &   \\ -\text{C}-\text{C}-\text{C}-\text{C}-\text{O}-\text{C}- \\   &   &   &   \end{array}$	$\begin{array}{c}   \\ -\text{C}-\text{Cl} \\   \end{array}$	H	H
butenachlor	$\begin{array}{c}   \\ \text{Cl}-\text{C}- \\   \end{array}$	$\begin{array}{c}   \\ -\text{C}-\text{Cl} \\   \end{array}$	$\begin{array}{c}   &   \\ -\text{C}-\text{C}- \\   &   \end{array}$	$\begin{array}{c}   &   \\ -\text{C}-\text{C}- \\   &   \end{array}$

	$R_1$	$R_2$	$R_3$	$R_4$
	$\text{---}$	$\text{---}$	$\text{---}$	$\text{---}$
diethatyl				
dimethachlor				
furalaxyl				
metalaxyl				
metolachlor				
ofurace				
pretilachlor				
propachlor			H	H

## 4 Pesticides Synthesis Handbook

Other common amide structures are:



R<sub>1</sub>

\_\_\_\_\_

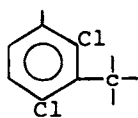
R<sub>2</sub>

\_\_\_\_\_

R<sub>3</sub>

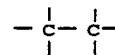
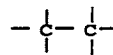
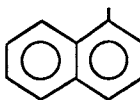
\_\_\_\_\_

clomeprop

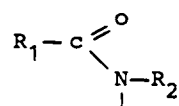


H

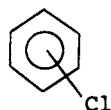
napropamide



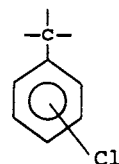




where either  $\text{R}_1$  or  $\text{R}_2$  are



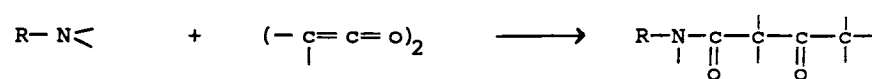
or



	$\text{R}_1$	$\text{R}_2$
pentanochlor		
pronamide		
propanil		
tecloftalam		

## 6 Pesticides Synthesis Handbook

An unusual route for amide formation is by reaction between an amine and diketene which leads to an acetoacetamide



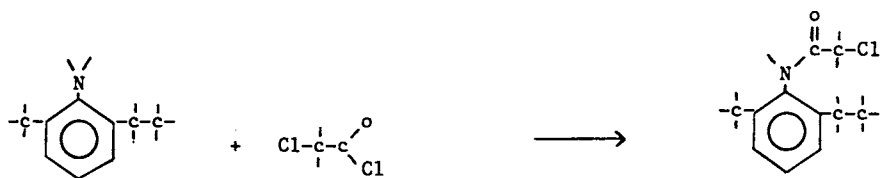
## Acetochlor

Uses: herbicide, soyabeans

Trade names: Harness (Monsanto)

Type: amide

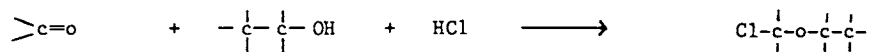
Synthesis:



2ethyl 6methyl  
aniline

chloroacetyl  
chloride

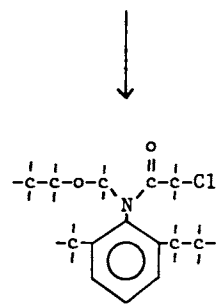
+



formaldehyde

ethanol

chloromethylethyl  
ether



acetochlor



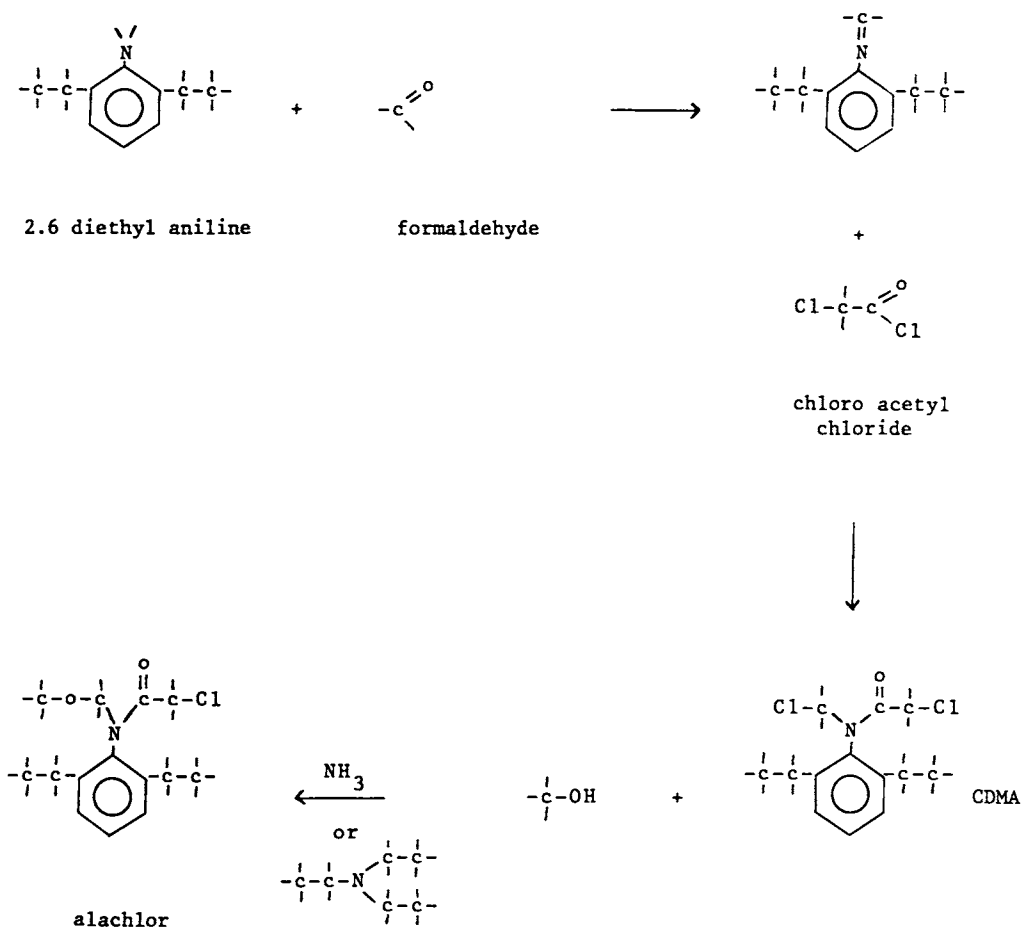
## Alachlor

Uses: herbicide, cotton, maize, peanuts, soyabeans, sugarcane

Trade names: Lasso (Monsanto)

Type: amide

Synthesis:



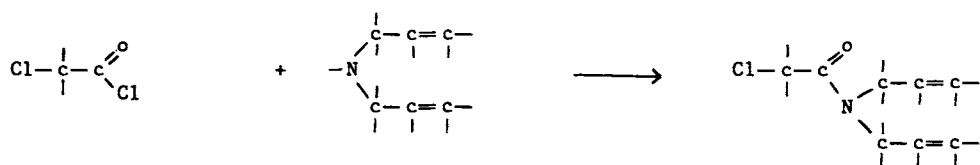
## Allidochlor CDAA

Uses: herbicide

Trade names: Radox (Monsanto)

Type: amide

Synthesis:



chloro acetyl  
chloride

diallyl amine

allidochlor

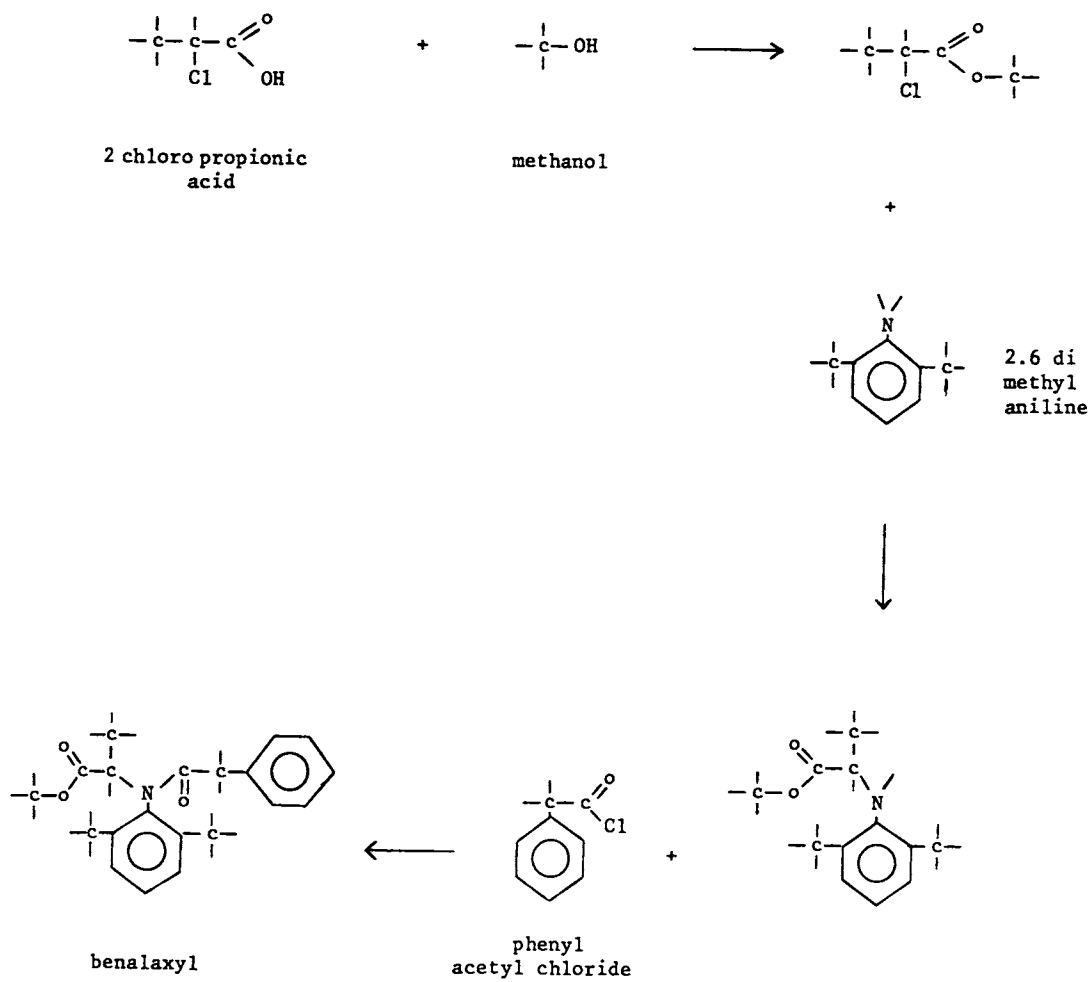
## Benalaxyl

Uses: fungicide, potatoes, tomatoes, ornamentals, tobacco, onions, soyabeans

Trade names: Galbsen, Tairel (Agrimont)

Type: amide

**Synthesis:**





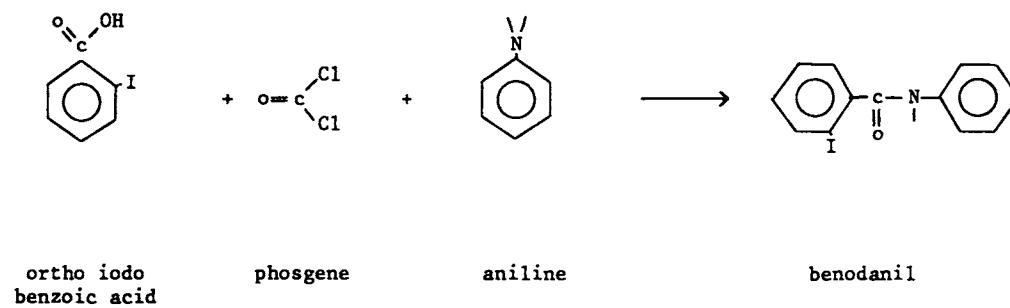
## Benodanil

Uses: fungicide, cereals, coffee, vegetables, ornamentals, rice, soyabeans  
tobacco, turf

Trade names: Calirus (BASF)

Type: amide

Synthesis:



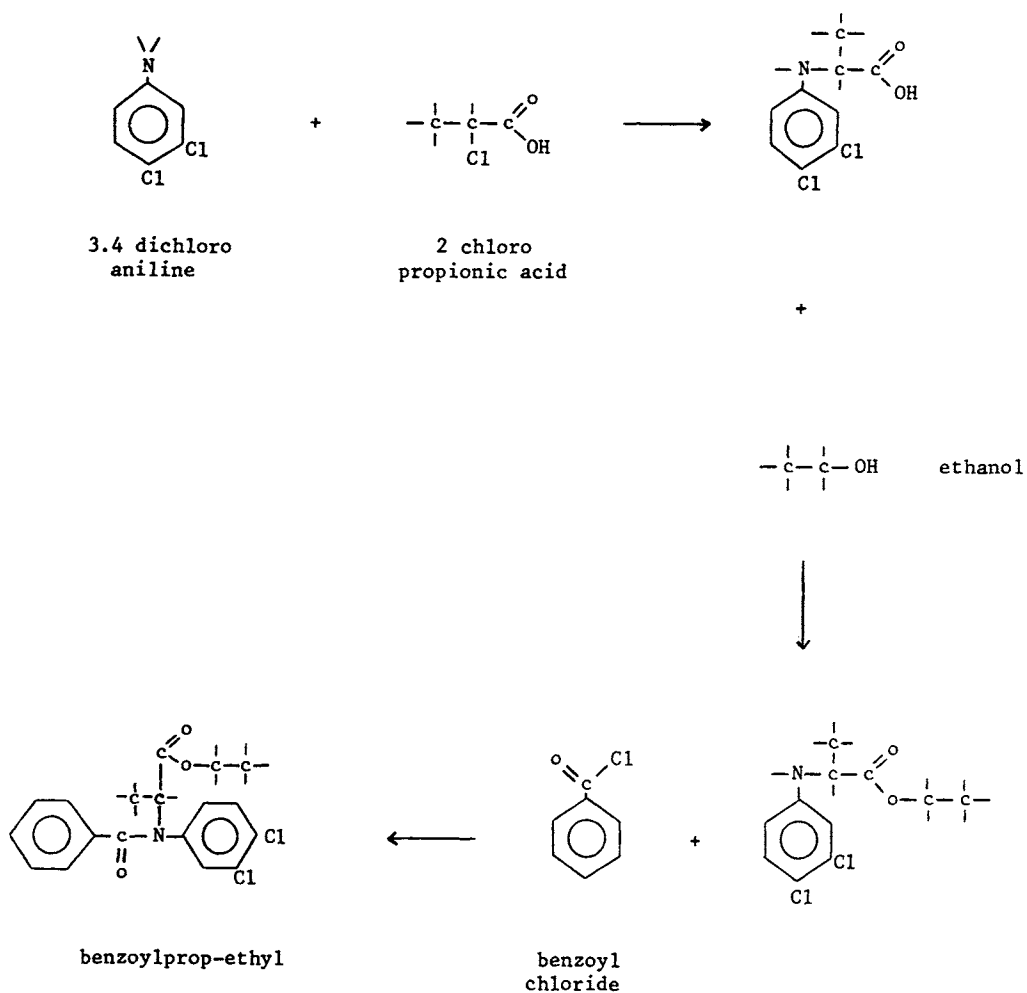
## Benzoylprop-Ethyl

Uses: herbicide, wheat, beans

Trade names: Suffix, Endaven (Shell)

Type: amide

Synthesis:



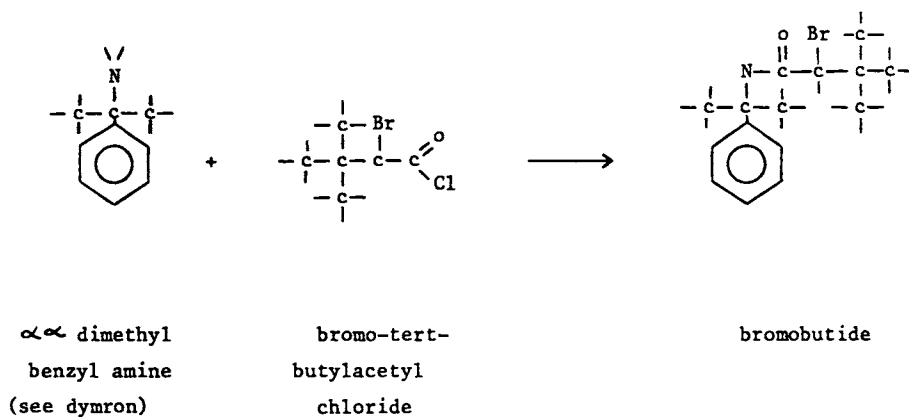
## Bromobutide

Uses: herbicide, rice

Trade names: Sumiherb (Sumitomo)

Type: amide

Synthesis:





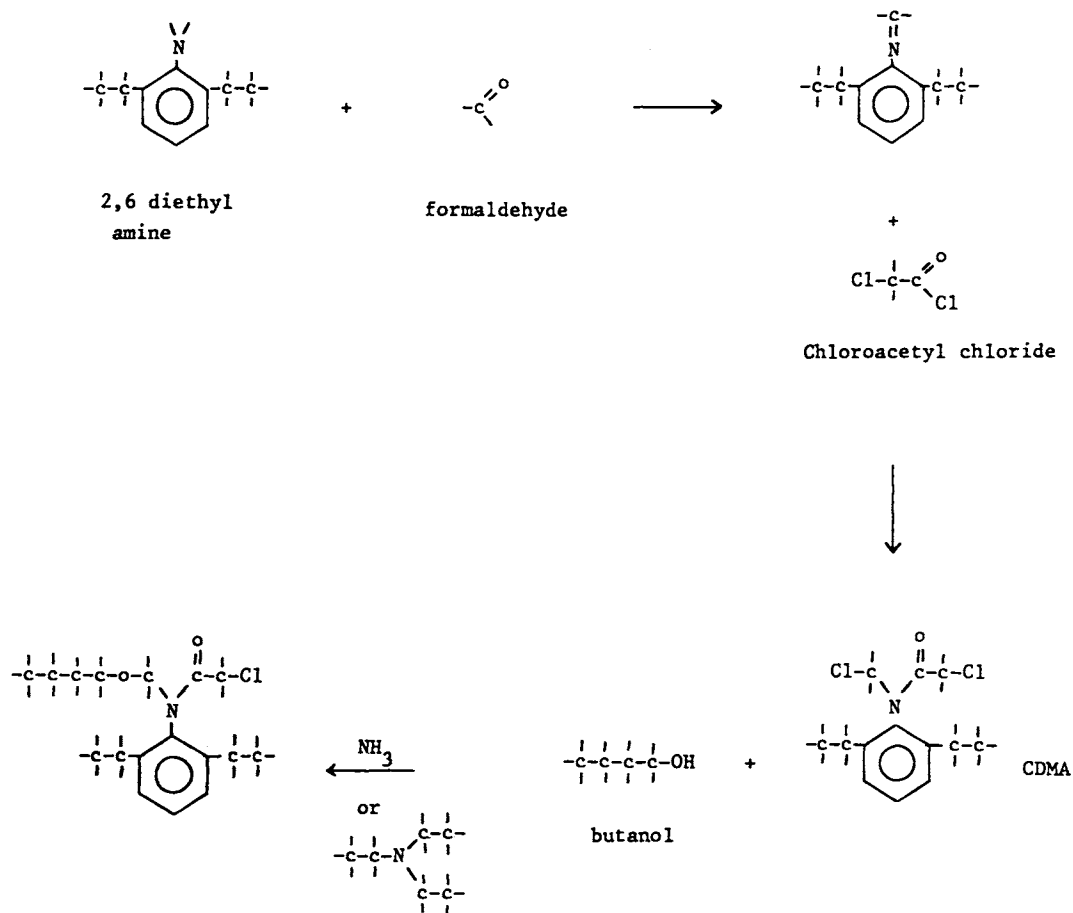
## Butachlor

Uses: herbicide, rice, barley, cotton, peanuts, sugarbeet, wheat

Trade names: Machete (Monsanto)

Type: amide

Synthesis:





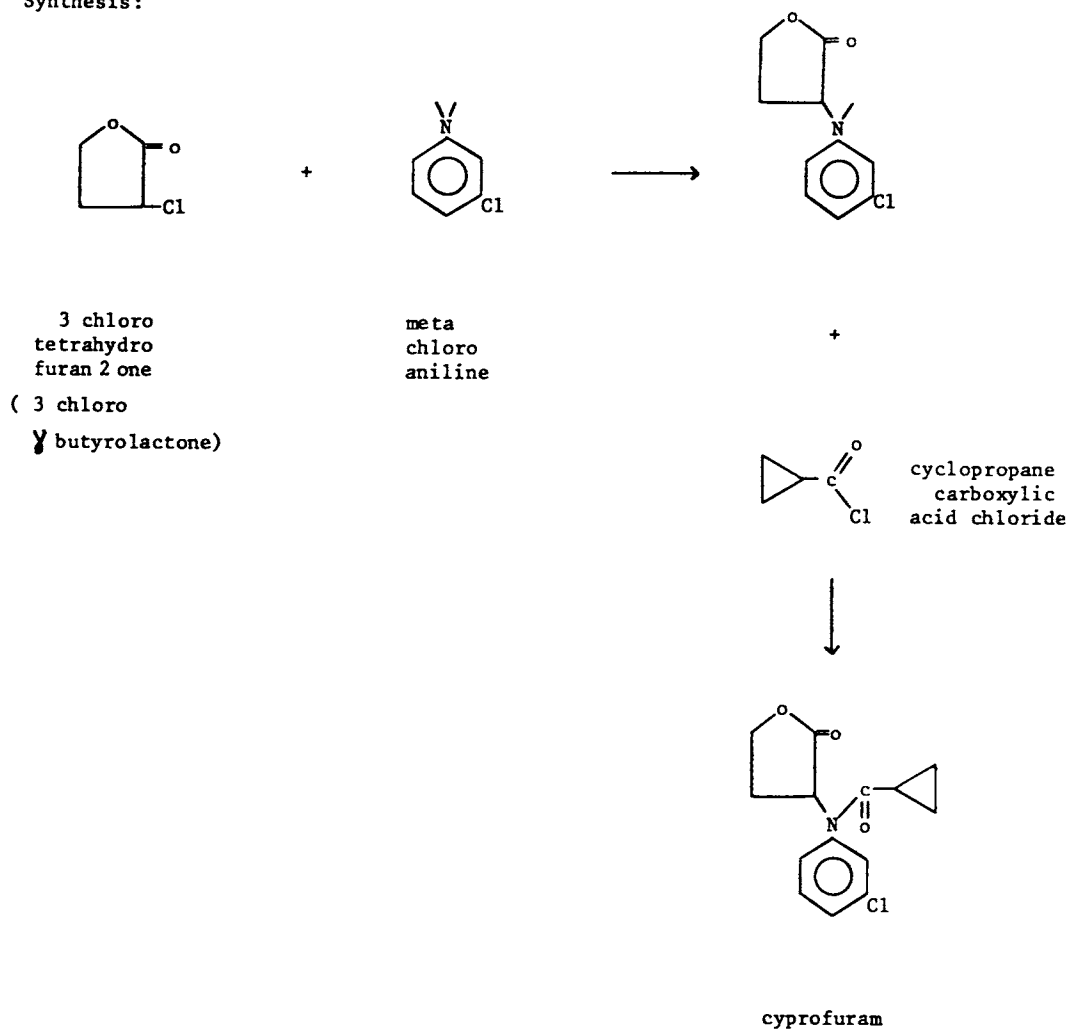
## Cyprofuram

Uses: fungicide, vine, potatoes

Trade names: Vinicur (Schering)

Type: amide

Synthesis:



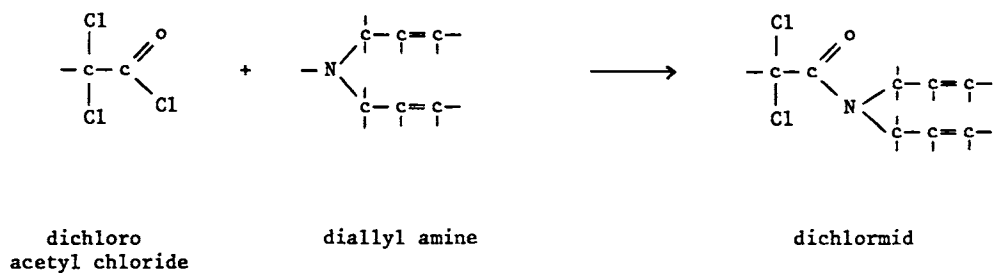
## Dichlormid

Uses: herbicide, safener, maize

Trade names: (Zeneca)

Type: amide

Synthesis:



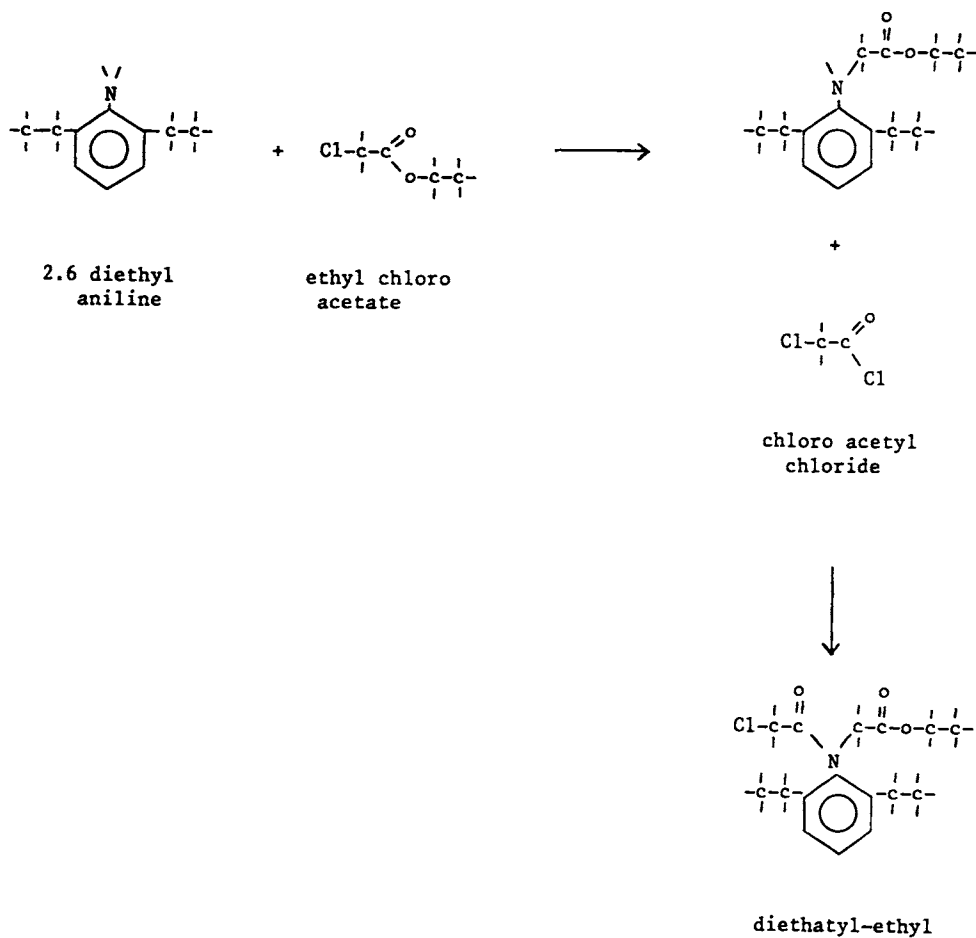
## Diethatyl-Ethyl

Uses: herbicide, potatoes, red beet, soyabeans, sugarbeet, wheat

Trade names: Antor (NorAm)

Type: amide

Synthesis:



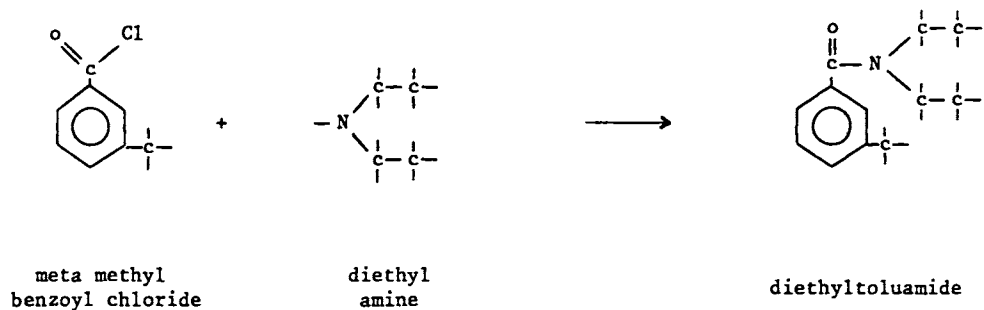
## Diethyltoluamide

Uses: insect repellent

Trade names: Metadelphene (Hercules)

Type: amide

Synthesis:



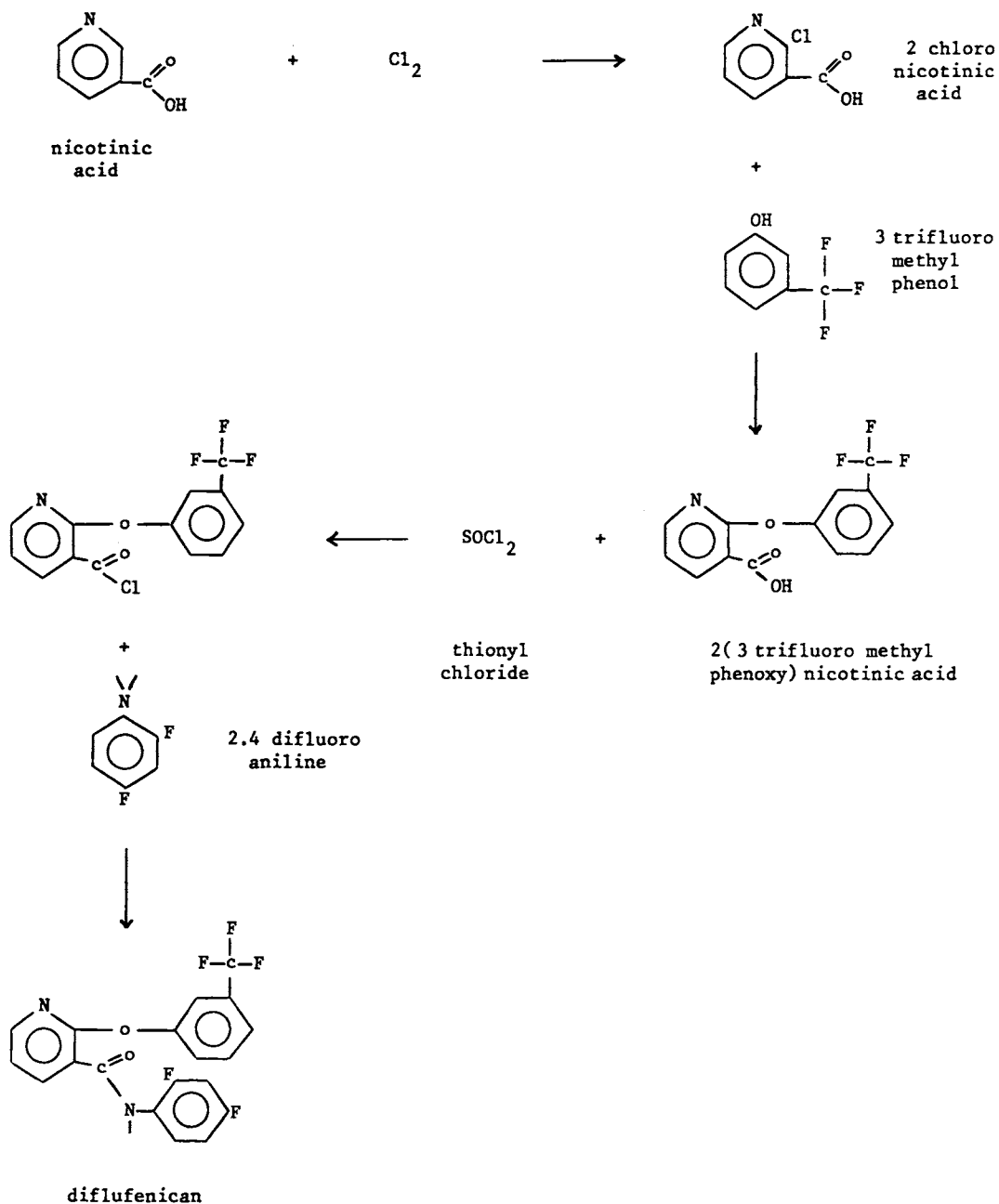
## Diflufenican

Uses: herbicide, wheat, barley

Trade names: Quartz (Rhône Poulenc)

Type: amide, pyridine

Synthesis:



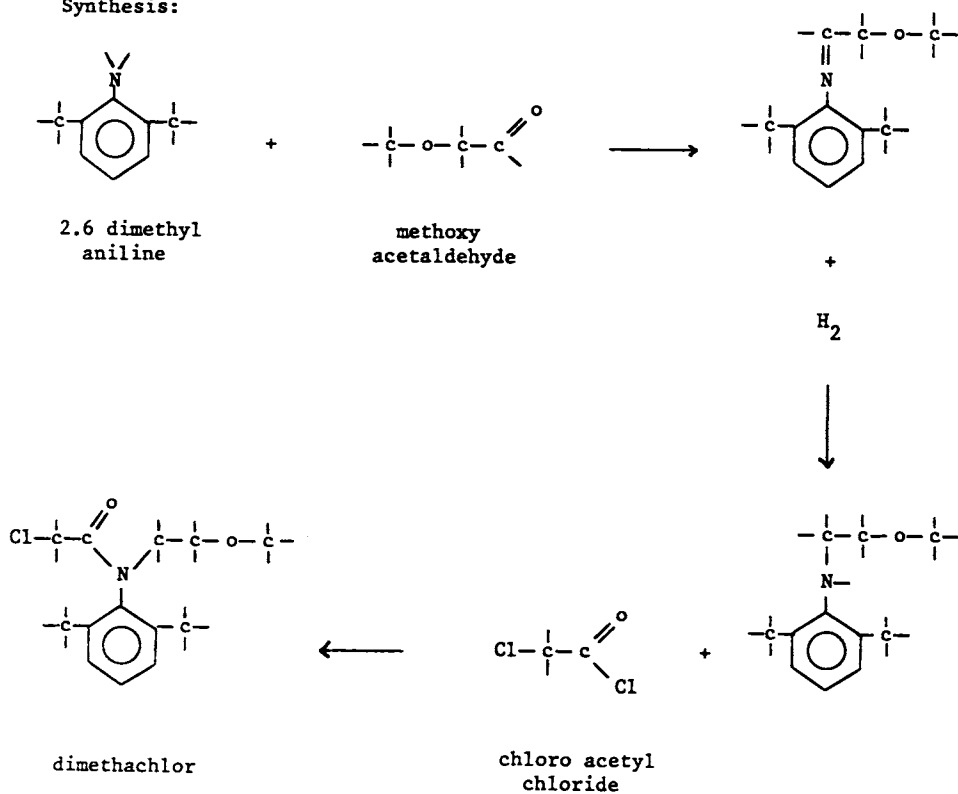
## Dimethachlor

**Uses:** herbicide

Trade names: Teridox (Ciba)

Type: amide

**Synthesis:**



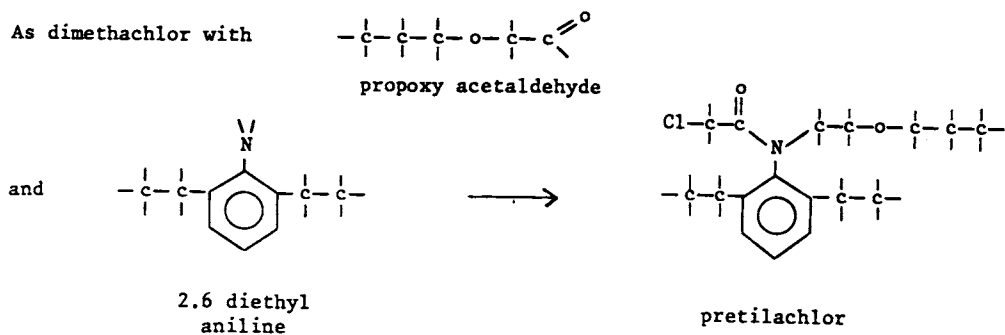
## Pretilachlor

Uses: herbicide, rice

Trade names: Rifit (Ciba)

Type: amide

**Synthesis:**





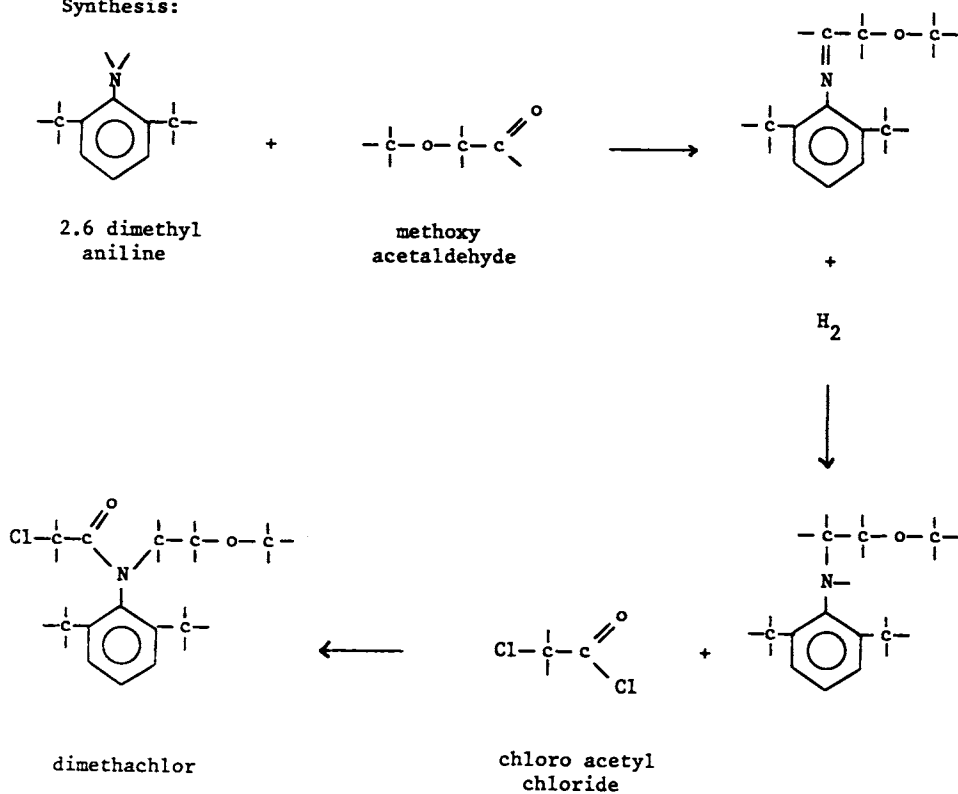
## Dimethachlor

**Uses:** herbicide

Trade names: Teridox (Ciba)

Type: amide

**Synthesis:**



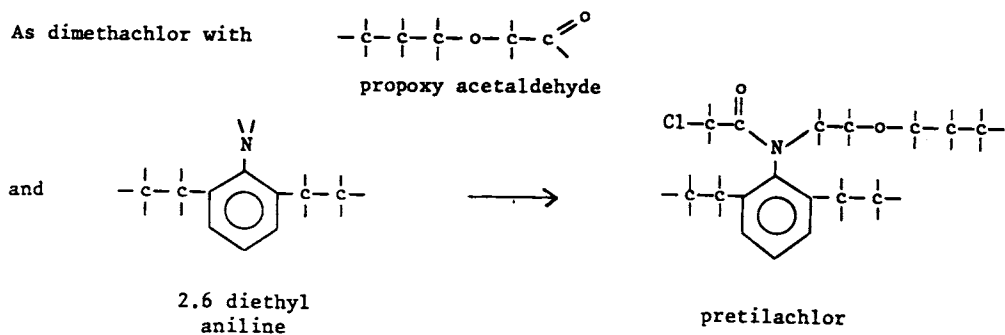
## Pretilachlor

Uses: herbicide, rice

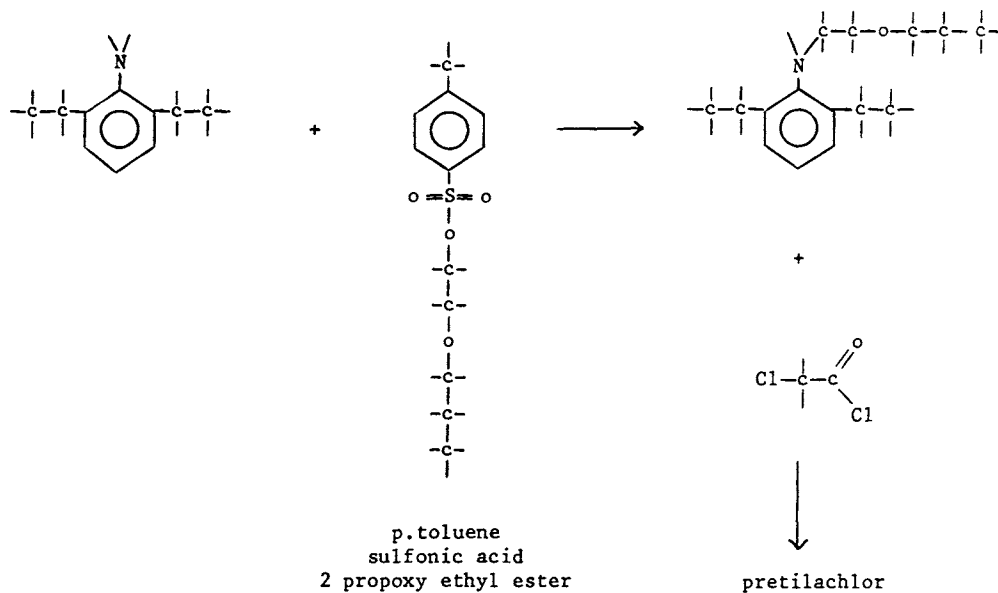
Trade names: Rifit (Ciba)

Type: amide

**Synthesis:**



alternate route :



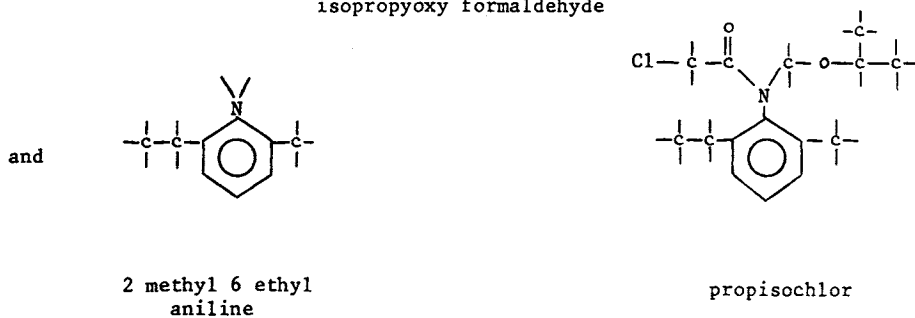
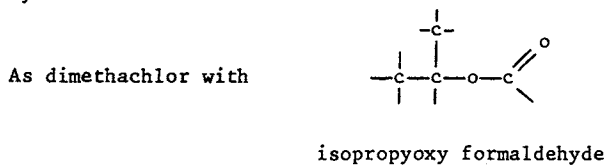
## Propisochlor

Uses: herbicide, maize, sunflowers, soyabeans, potatoes

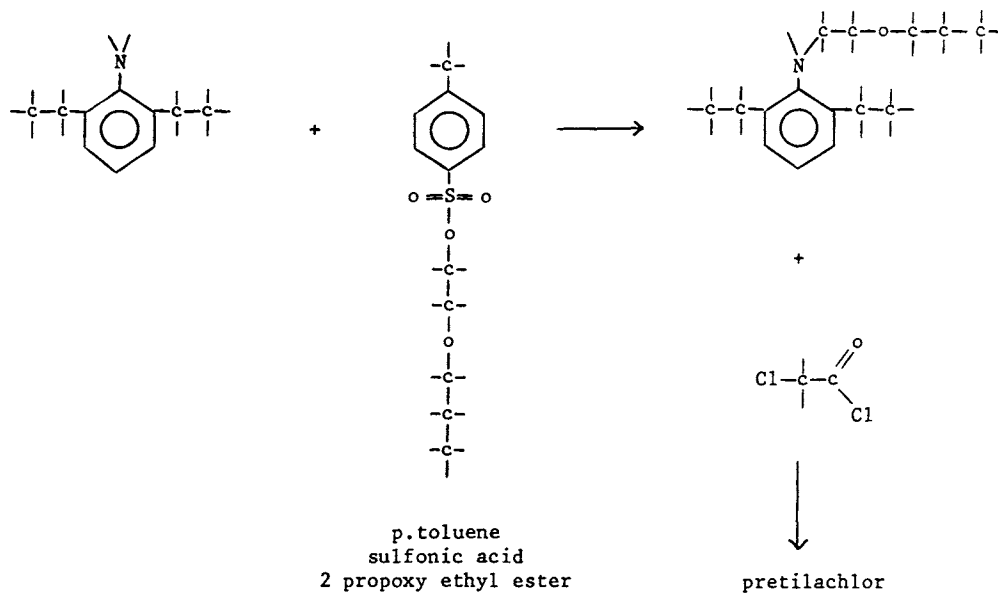
Trade names: Proponit (Nitrokemia)

Type: amide

Synthesis:



alternate route :



## Propisochlor

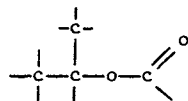
Uses: herbicide, maize, sunflowers, soyabeans, potatoes

Trade names: Proponit (Nitrokemia)

Type: amide

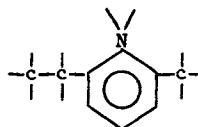
Synthesis:

As dimethachlor with

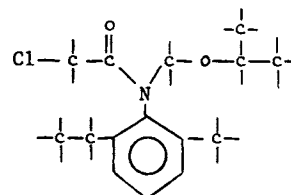


isopropoxy formaldehyde

and



2 methyl 6 ethyl  
aniline



propisochlor

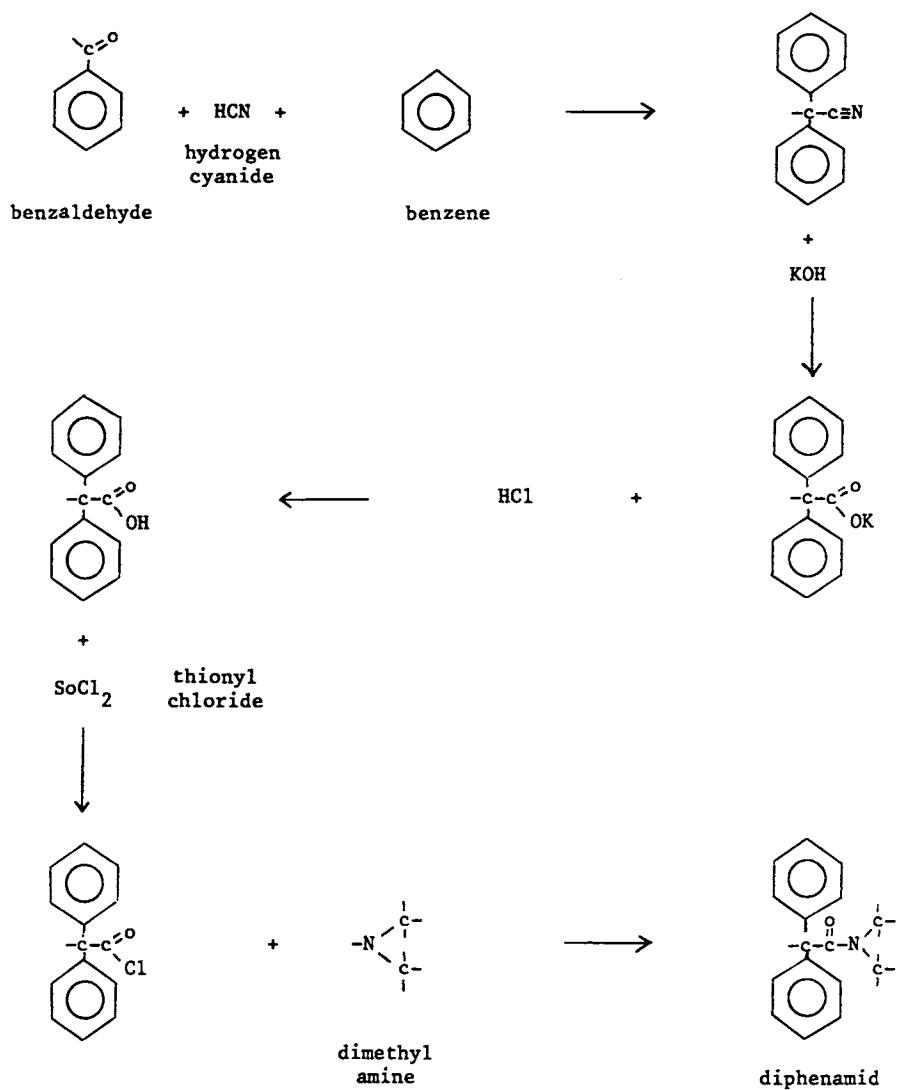
## Diphenamid

Uses: herbicide, cotton, soyabeans, potatoes, fruit, ornamentals, vegetables, tobacco

Trade names: Dymid (Lilly), Enide (UpJohn)

Type: amide

Synthesis:



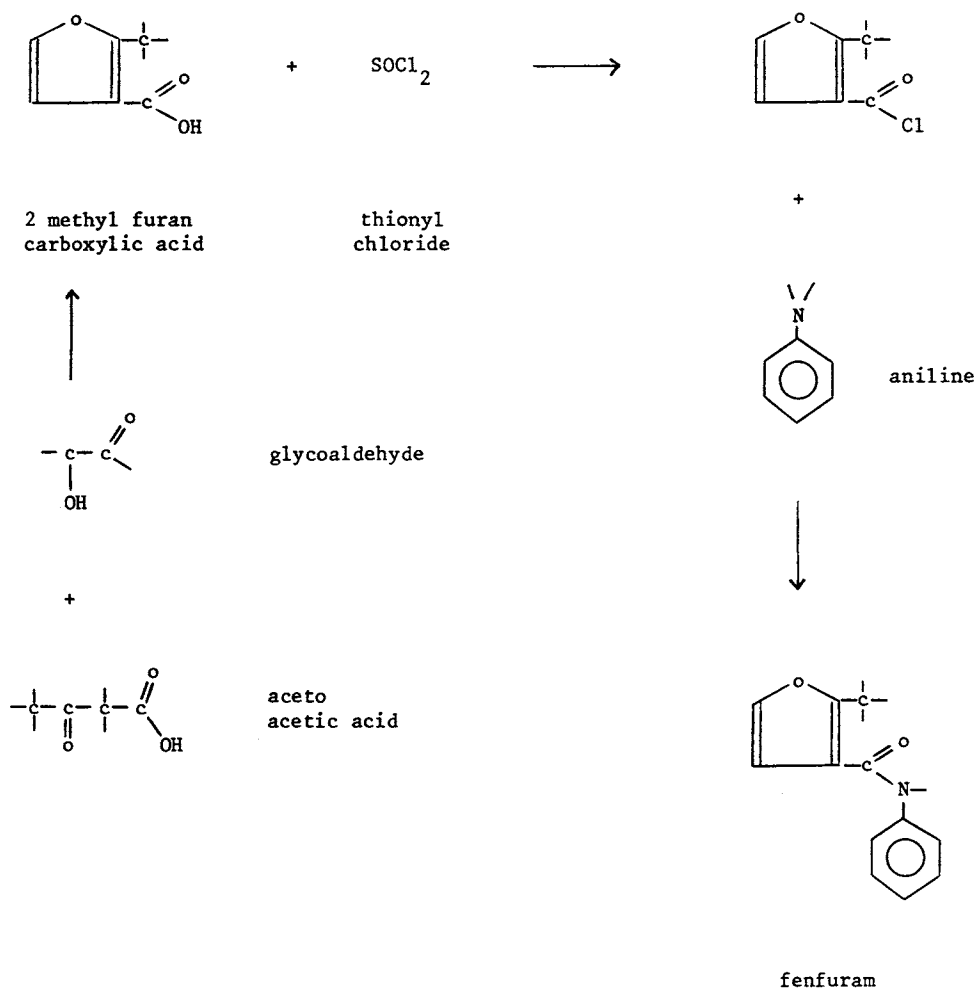
## Fenfuram

Uses: fungicide

Trade names: Panoram (Keno Gard)

Type: amide, furan

Synthesis:



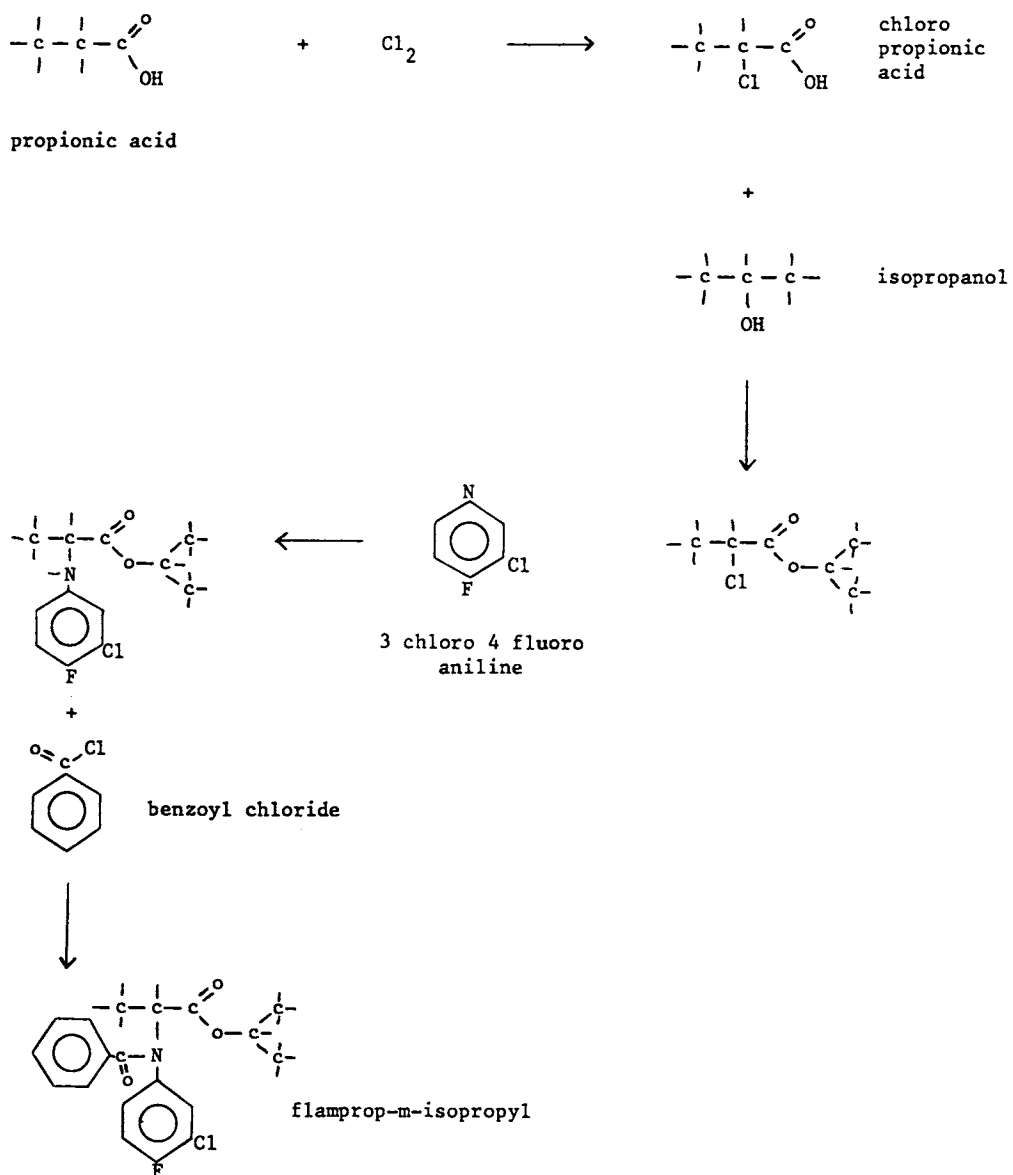
## Flamprop-M-Isopropyl

Uses: herbicide

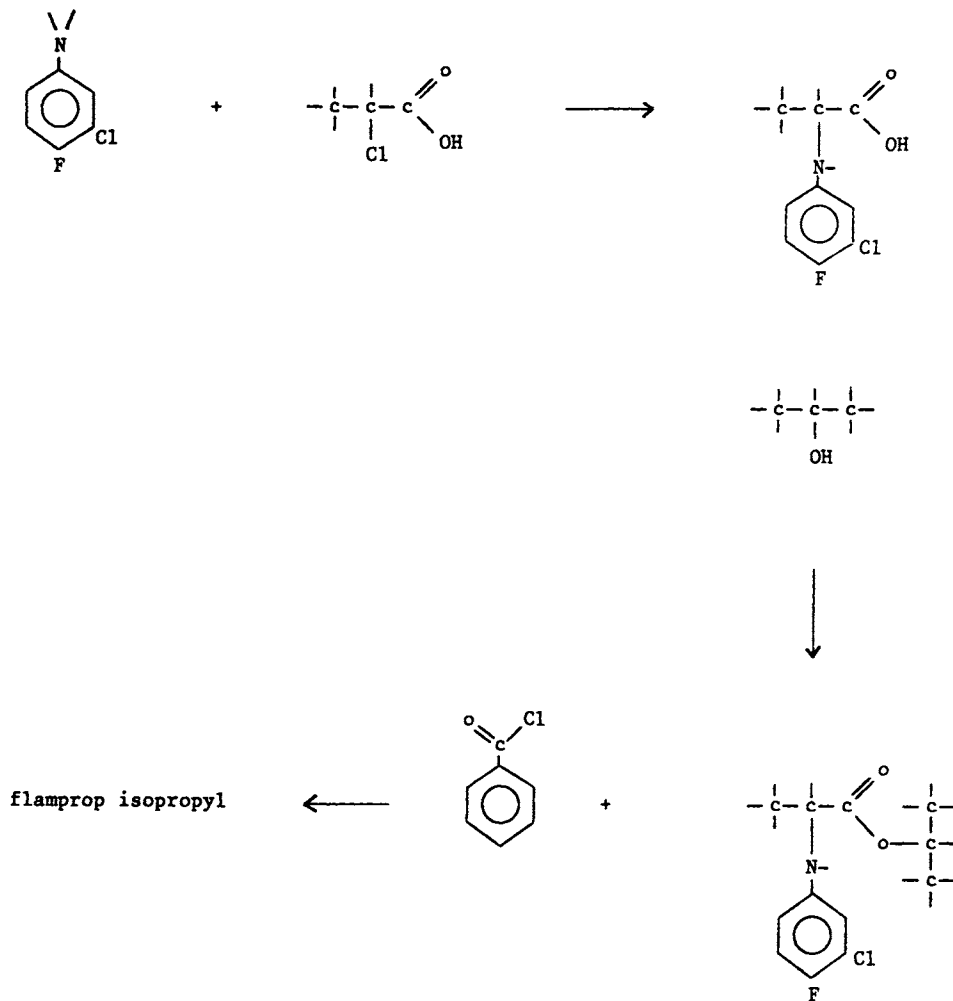
Trade names: Commando, Suffix BW, Super Baunon, Mataven (Shell)

Type: amide

Synthesis:



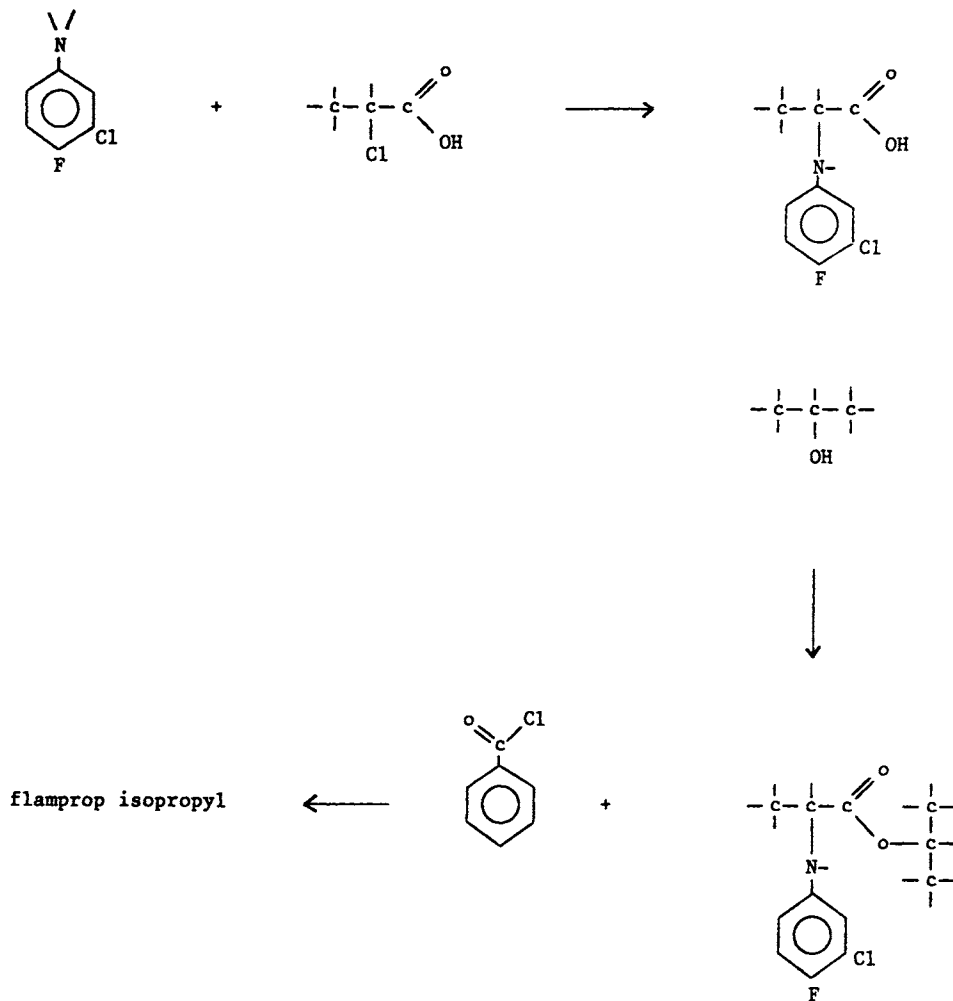
alternate route :



## Flamprop-M-Methyl

- methanol is used instead of isopropanol

alternate route :



## Flamprop-M-Methyl

- methanol is used instead of isopropanol



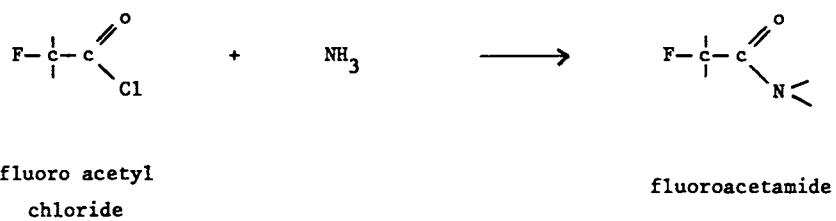
## Fluoroacetamide

Uses: rodenticide

Trade names: Rodex (Jewin-Joffe)

Type: amide

Synthesis:



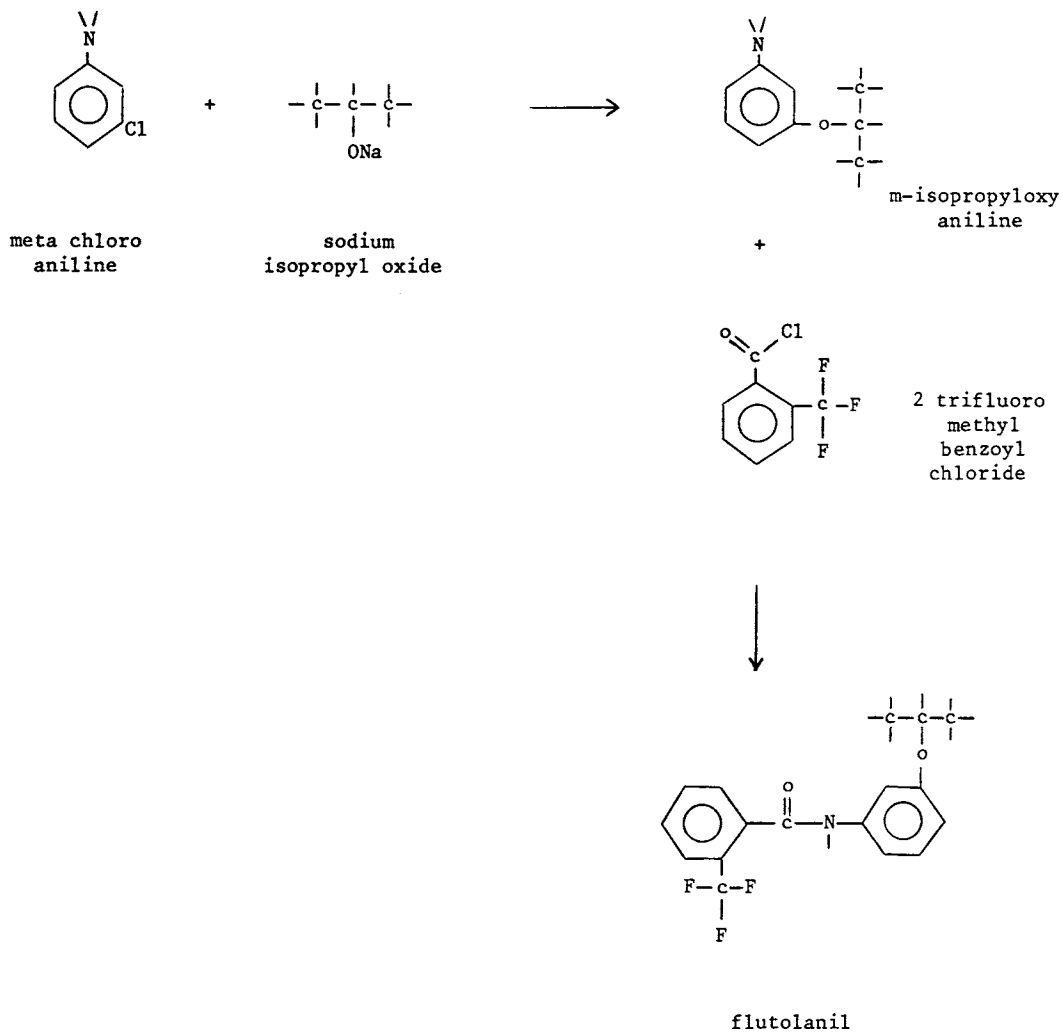
## Flutolanil

Uses: fungicide, rice, potatoes, vegetables, turf, cereals

Trade names: Moncut (Nihon Nohyaku)

Type: amide

Synthesis:



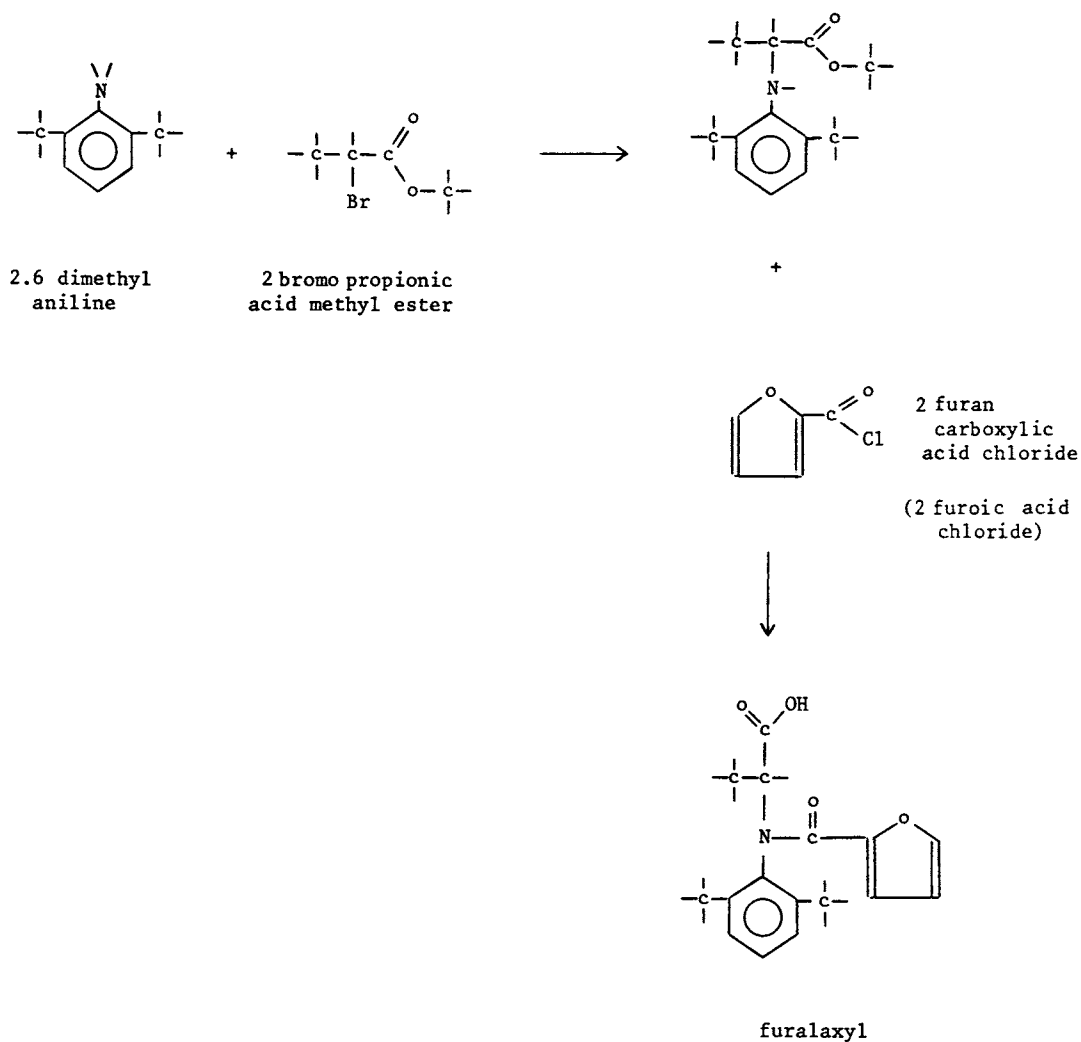
## Furalaxyl

Uses: fungicide, ornamentals

Trade names: Fongarid (Ciba)

Type: amide, furan

Synthesis:



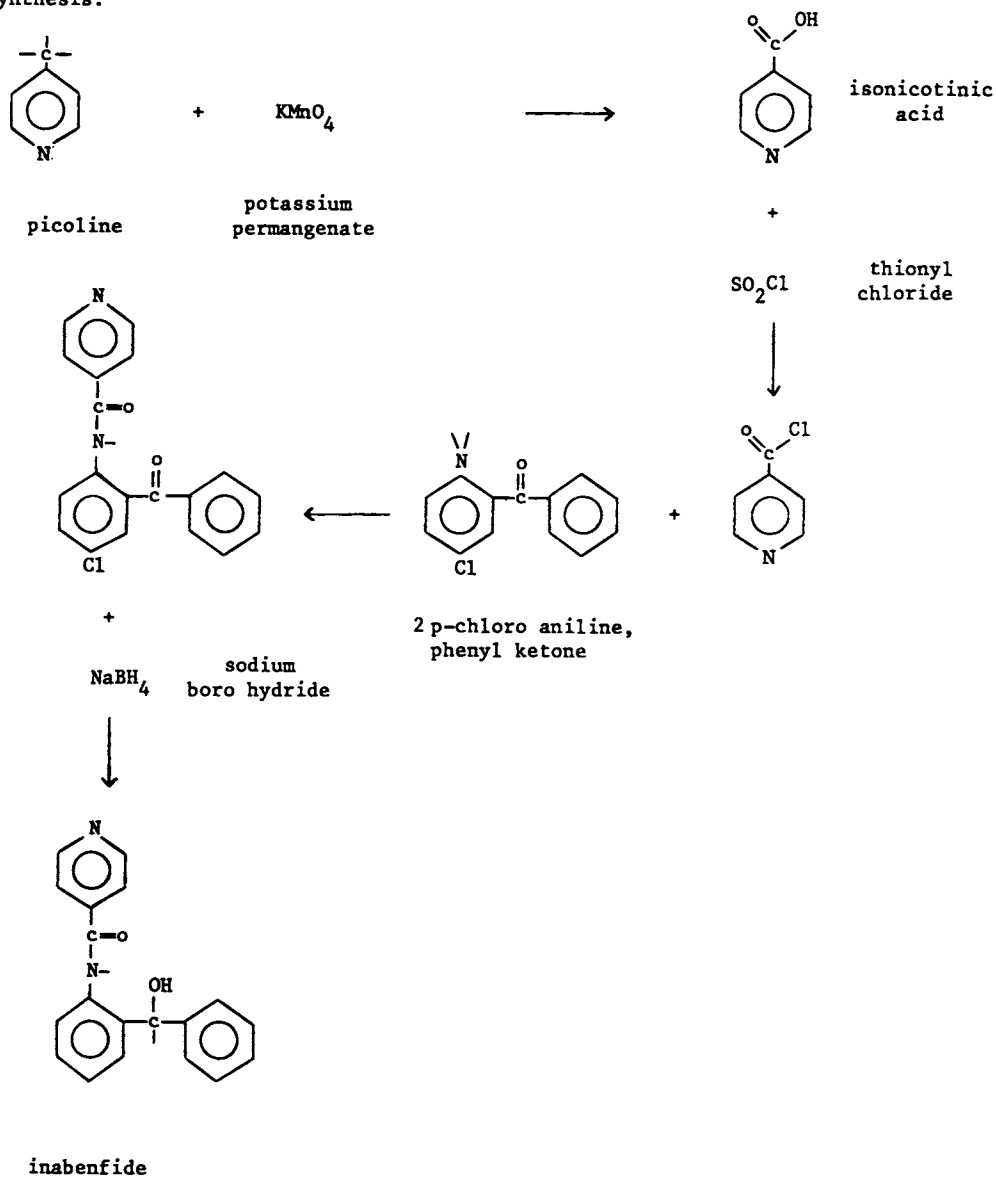
## Inabenfide

Uses: growth regulator, rice

Trade names: Seritard (Chugai)

Type: amide, pyridine

Synthesis:



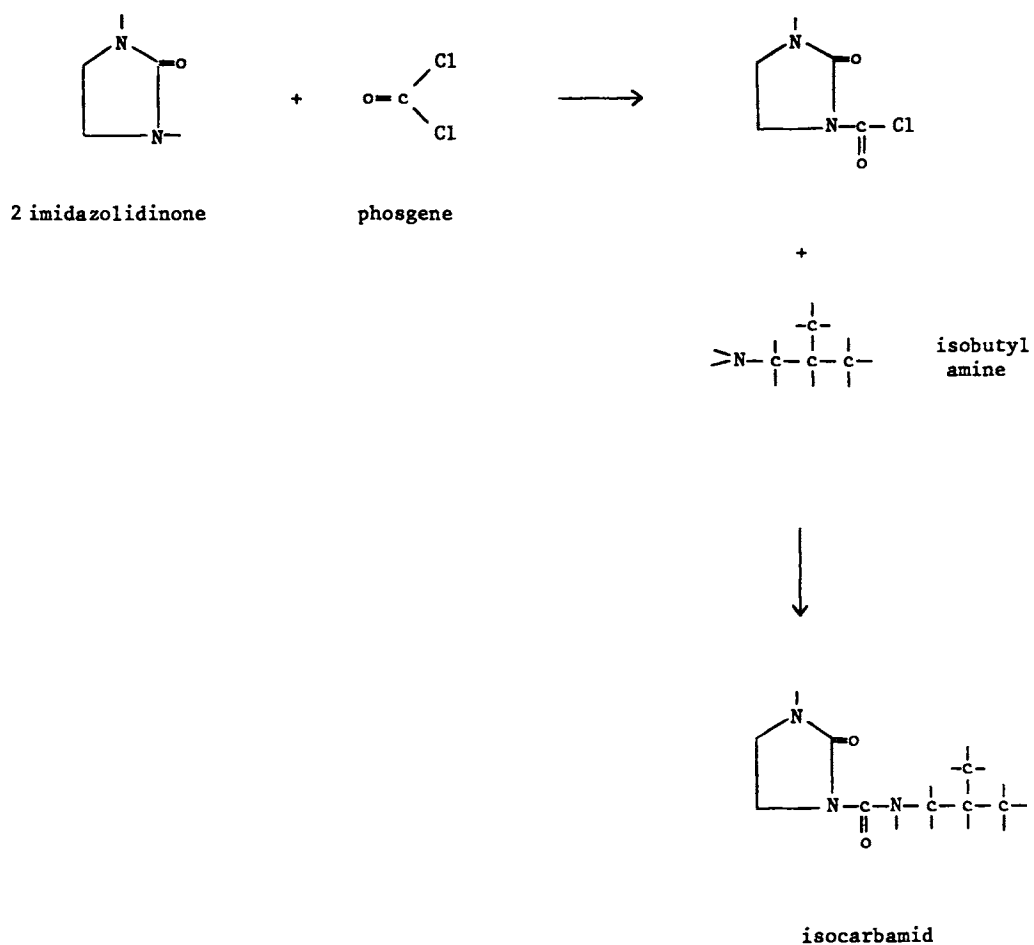
## Isocarbamid

Uses: herbicide, beets

Trade names: Merpelan AZ, Terratop (Bayer)

Type: amide, imidazolidinone

Synthesis:



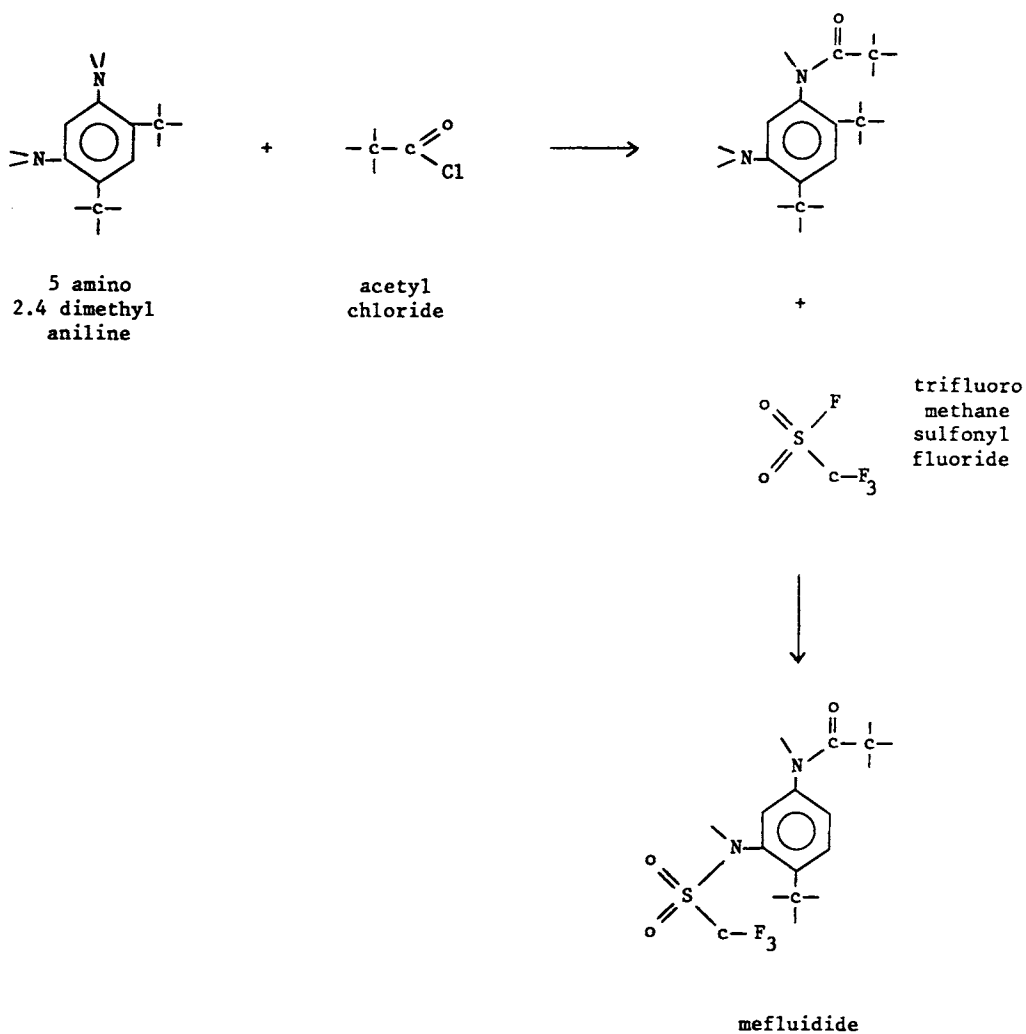
## Mefluidide

Uses: growth regulator, sugar cane, soya beans

Trade names: Embark (3M)

Type: amide, sulfonamide

Synthesis:



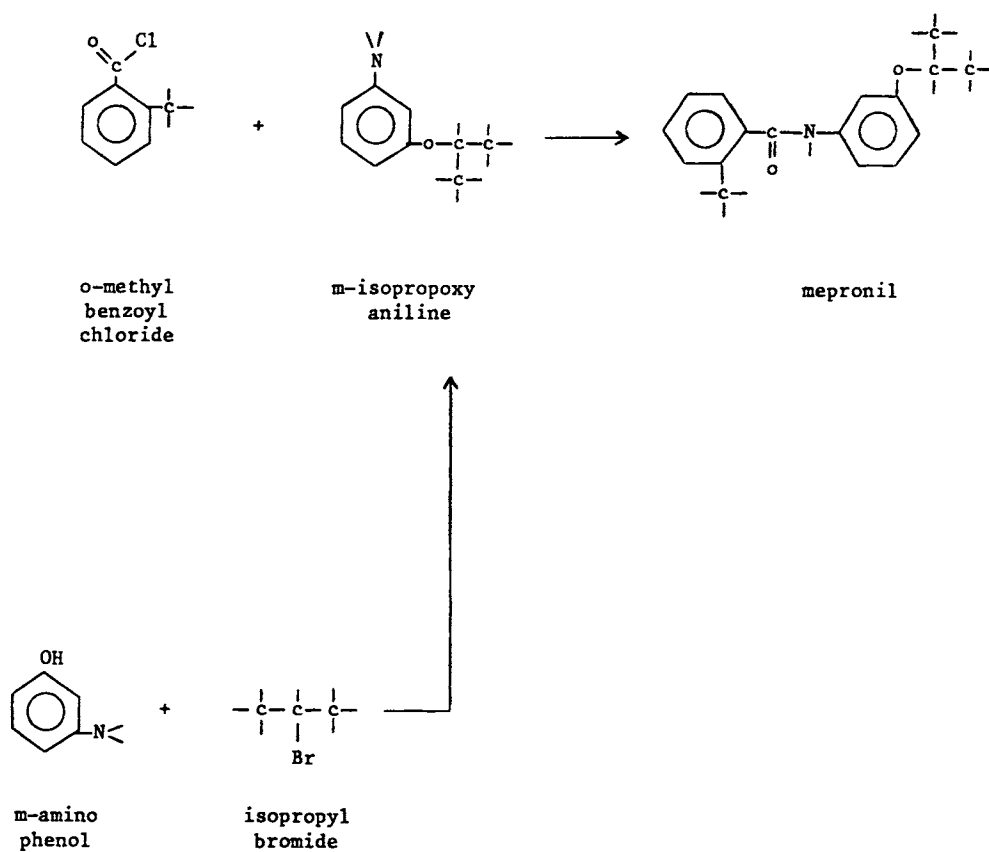
## Mepronil

Uses: fungicide, rice, potatoes

Trade names: Basitac (Kumiai)

Type: amide

Synthesis:



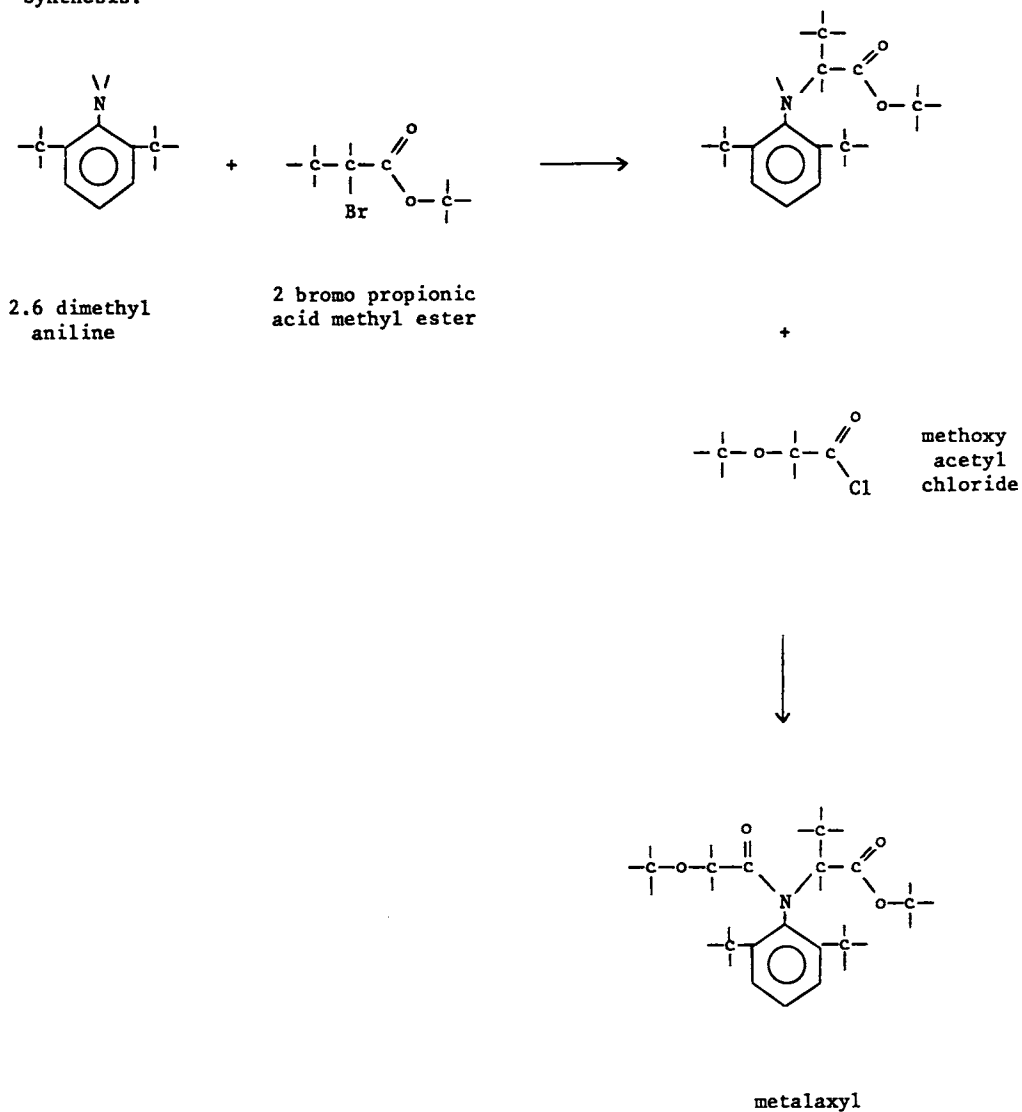
## Metalaxyl

Uses: fungicide, hops, tobacco, vines, citrus, maize, sorghum, sunflowers

Trade names: Apron, Ridomil (Ciba)

Type: amide

Synthesis:





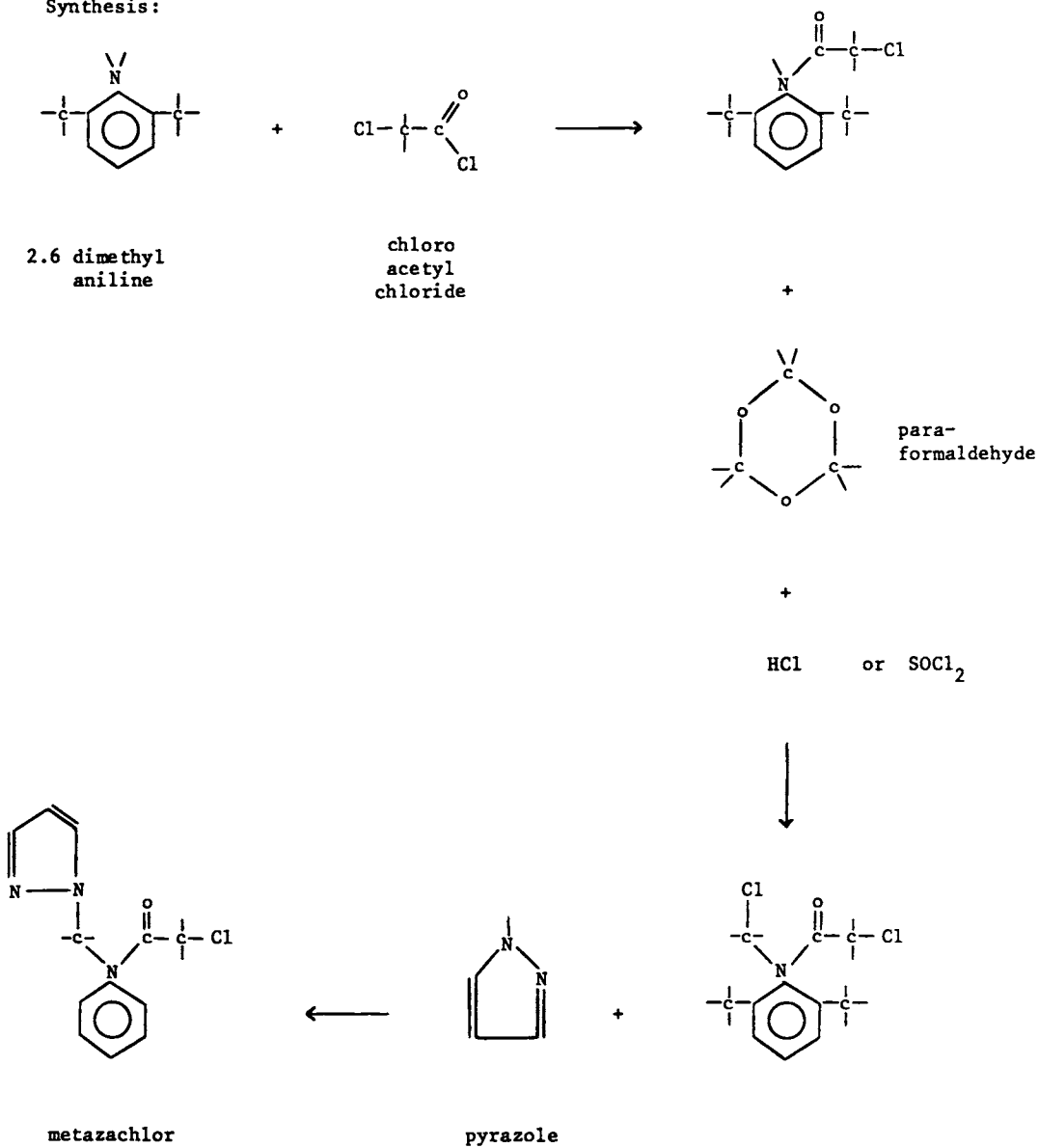
## Metazachlor

Uses: herbicide, potatoes, tobacco, cabbage

Trade names: Butisan S (BASF)

Type: amide, pyrazole

Synthesis:



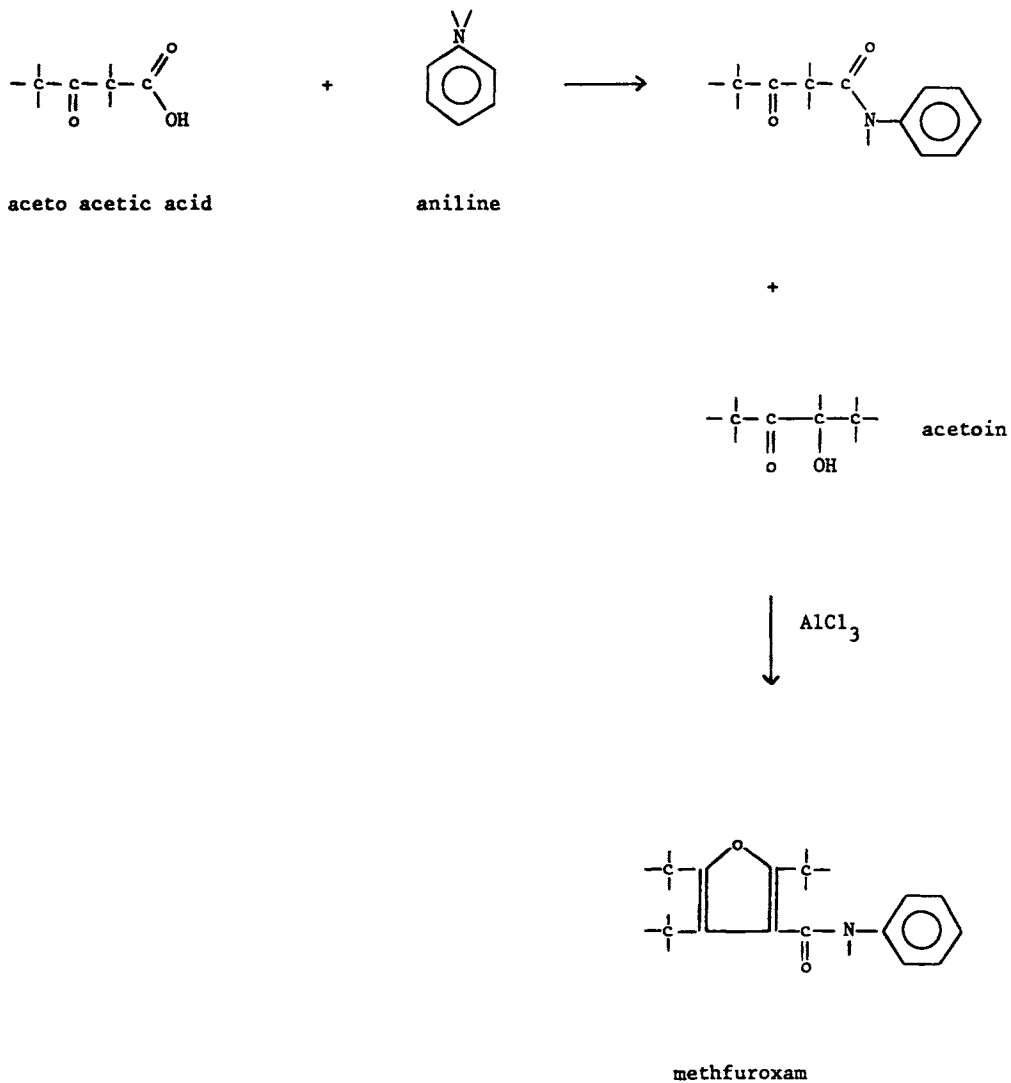
## Methfuroxam

Uses: fungicide, cereals

Trade names: Trivax (Uniroyal)

Type: amide, furan

Synthesis:



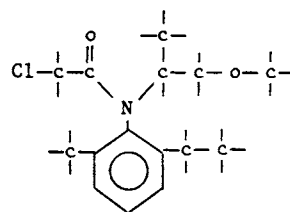
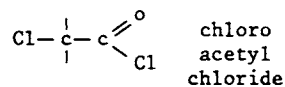
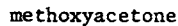
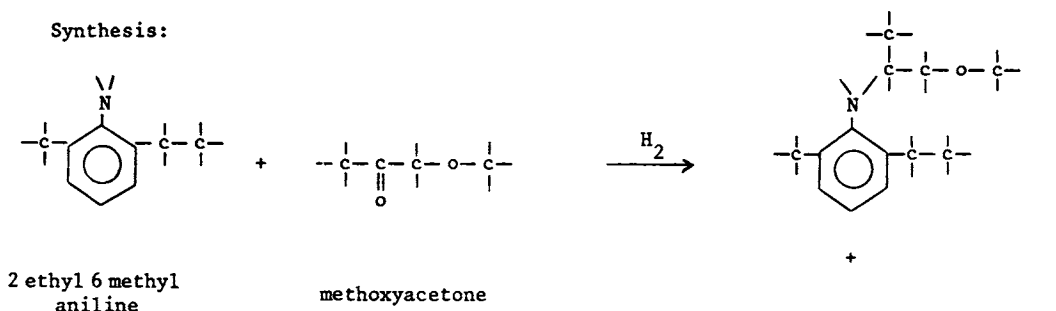
## Metolachlor

Uses: herbicide, cotton, ground nuts, maize, potatoes, sorghum, sugarbeet, sugarcane, sunflowers

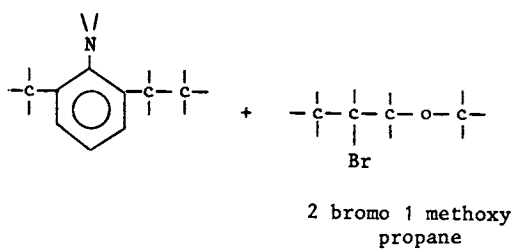
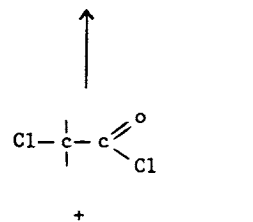
Trade names: Dual (Ciba)

Type: amide

**Synthesis:**



alternate route :



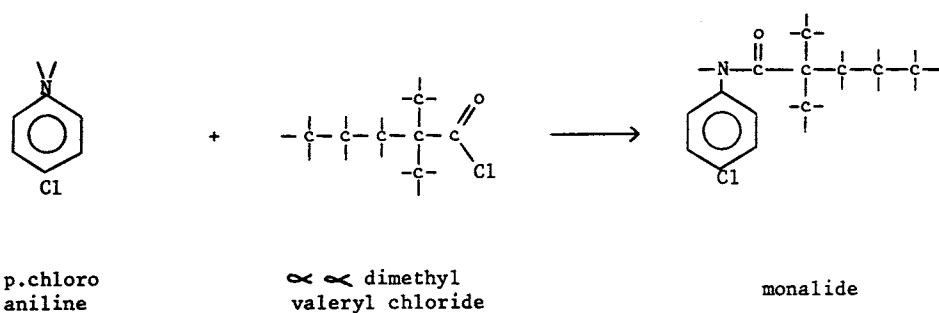
## Monalide

Uses: herbicide, carrots, vegetables

Trade names: Potablan (Schering)

Type: amide

Synthesis:



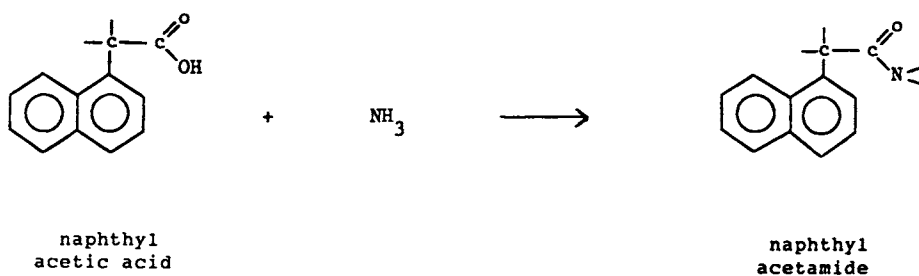
## Naphthyl Acetamide

Uses: growth regulator, fruit trees

Trade names: Amid-Thin (Rhône Poulenc)

Type: amide

Synthesis:



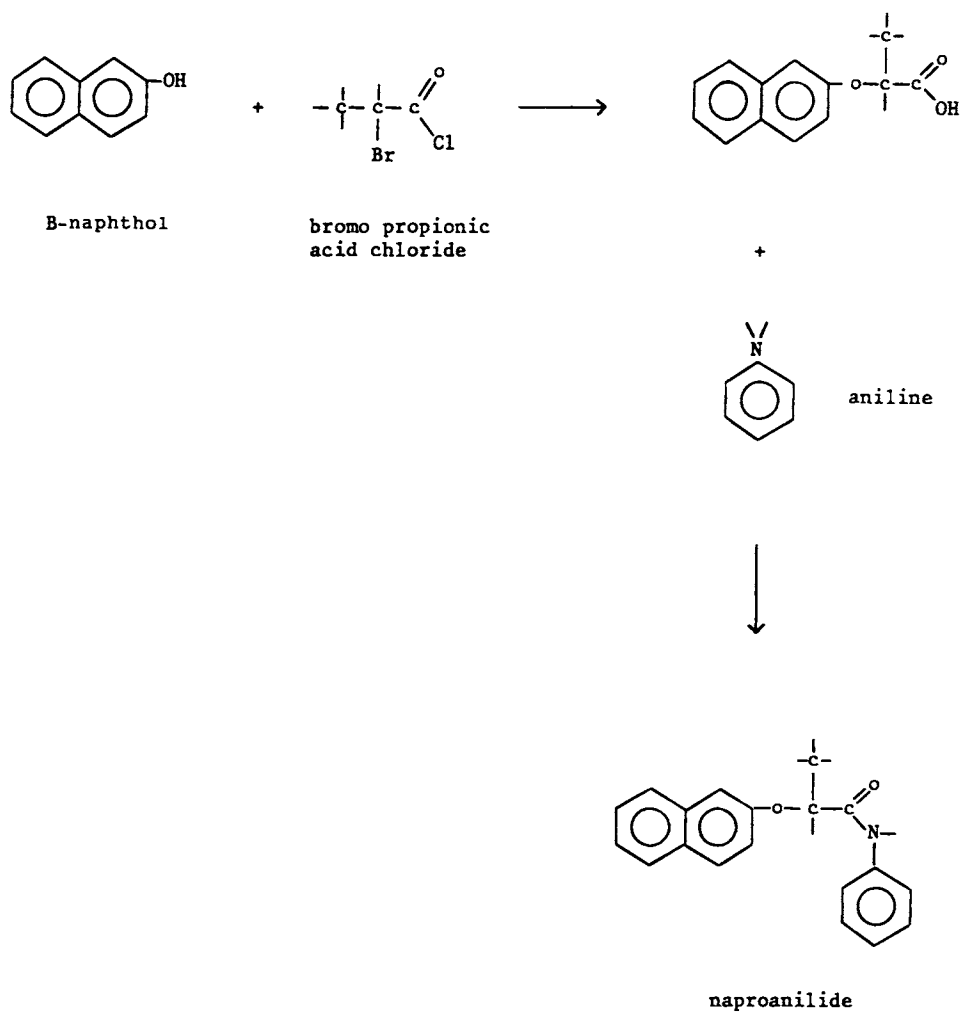
## Naproanilide

Uses: herbicide, rice

Trade names: Uribest (Mitsui)

Type: amide

Synthesis:



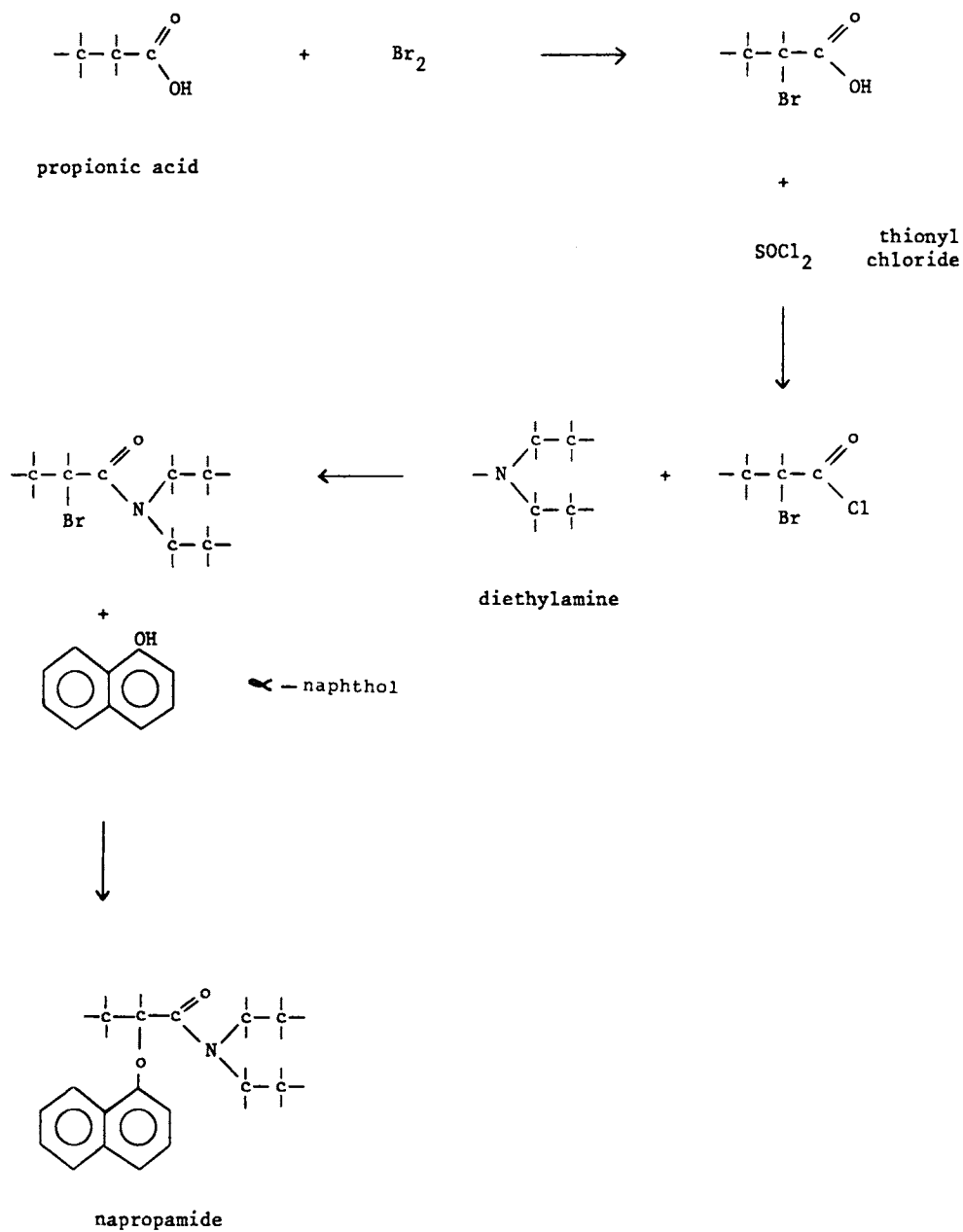
## Napropamide

Uses: herbicide, citrus, sunflowers, tobacco, tomatoes, fruit trees

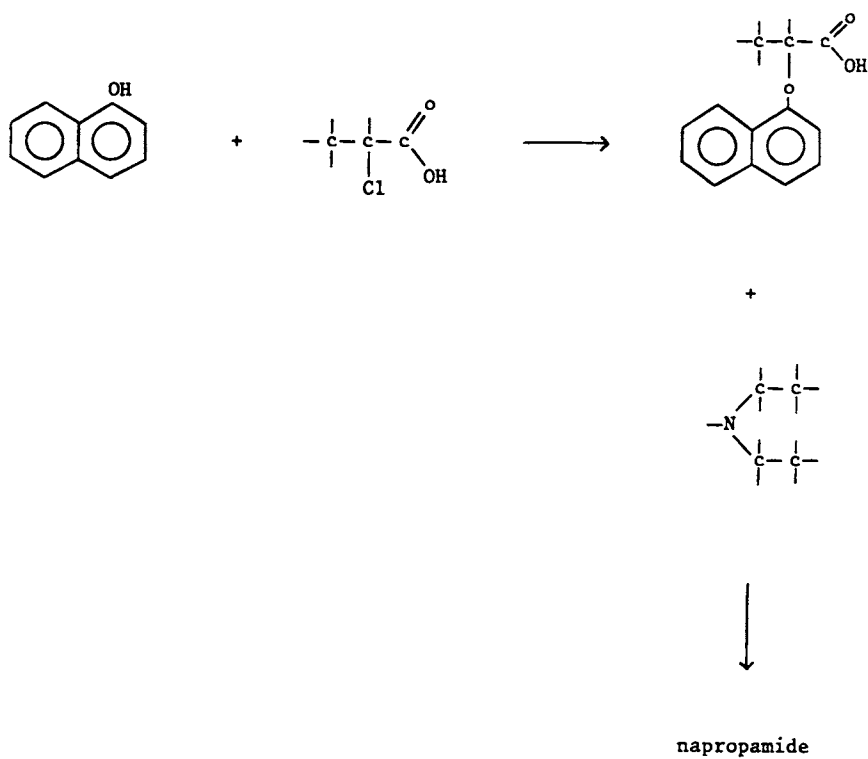
Trade names: Devrinol (ICI)

Type: amide

Synthesis:



alternate route :





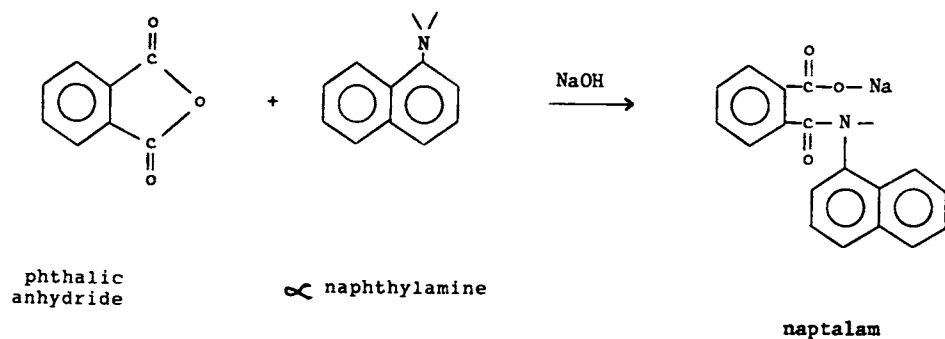
## Naptalam

Uses: herbicide, ground nuts, soyabeans

Trade names: Alanap (Uniroyal)

Type: amide

Synthesis:



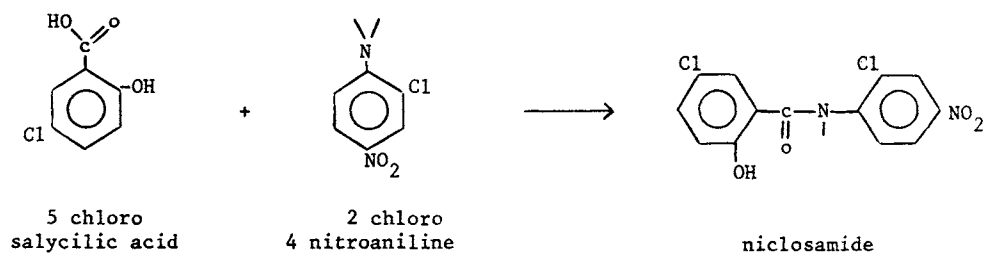
## Niclosamide

Uses: molluscicide, aquatic use (shistosomiasis)

Trade names: Bayluscid, Bayluscide (Bayer)

Type: amide

Synthesis:



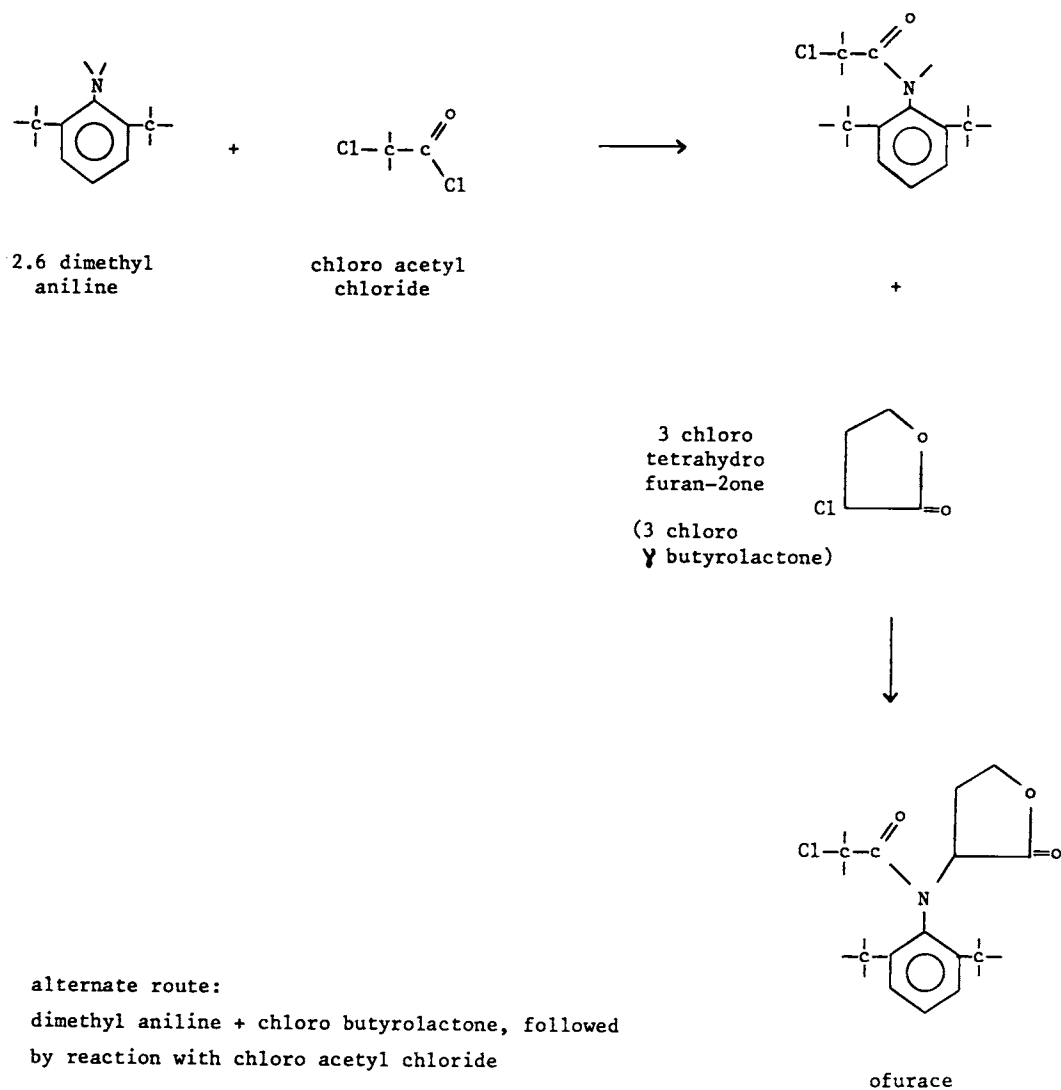
## Ofurace

Uses: fungicide, grapes, potatoes

Trade names: Ortho 20615 (Chevron)

Type: amide, furanone

Synthesis:



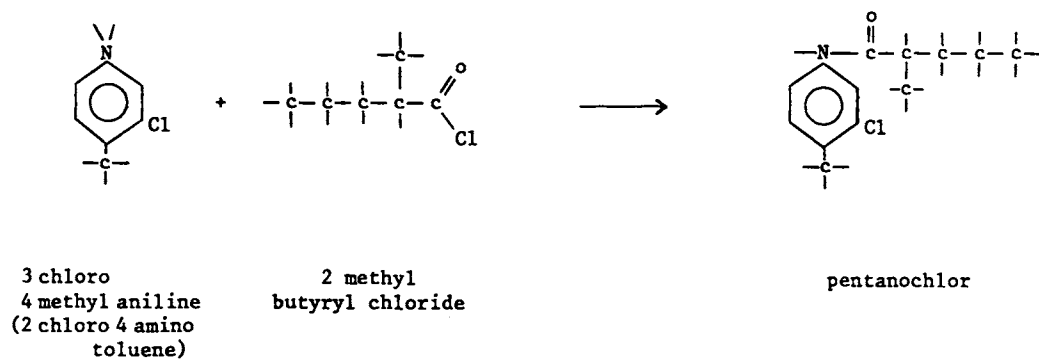
## Pentanochlor

Uses: herbicide, carrots, vegetables, tomatoes, ornamentals

Trade names: Solan (Atlas)

Type: amide

Synthesis:



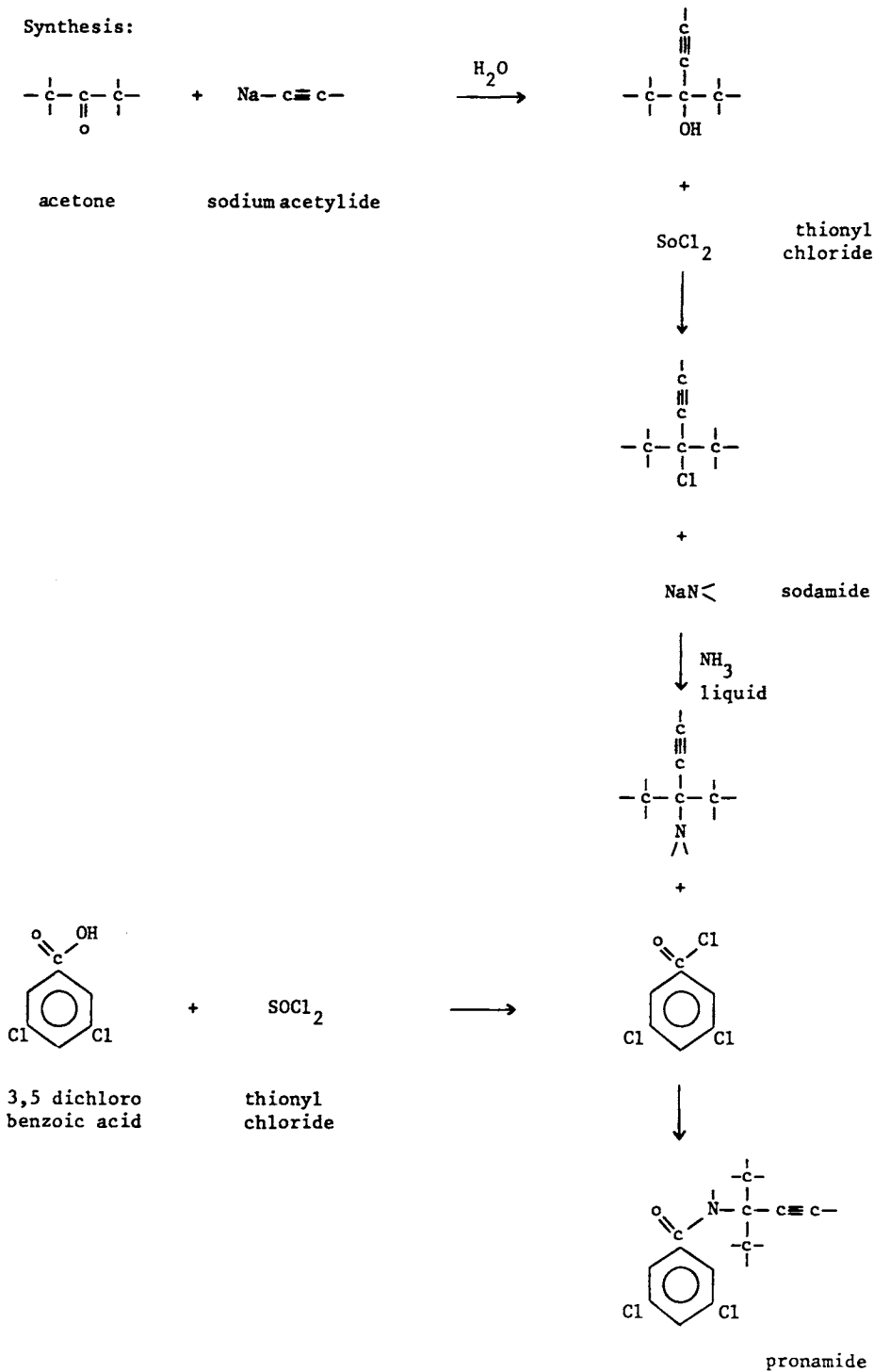
## Pronamide (Propyzamide)

Uses: herbicide, trees, ornamentals, vegetables

Trade names: Kerb (Rohn & Haas)

Type: amide

Synthesis:



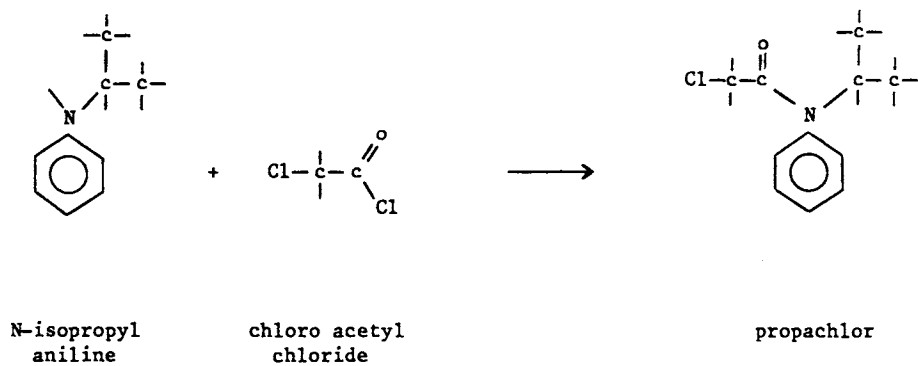
## Propachlor

Uses: herbicide, cotton, groundnuts, maize, onions, soyabeans, sugarcane, ornamentals

Trade names: Ramrod (Monsanto)

Type: amide

Synthesis:



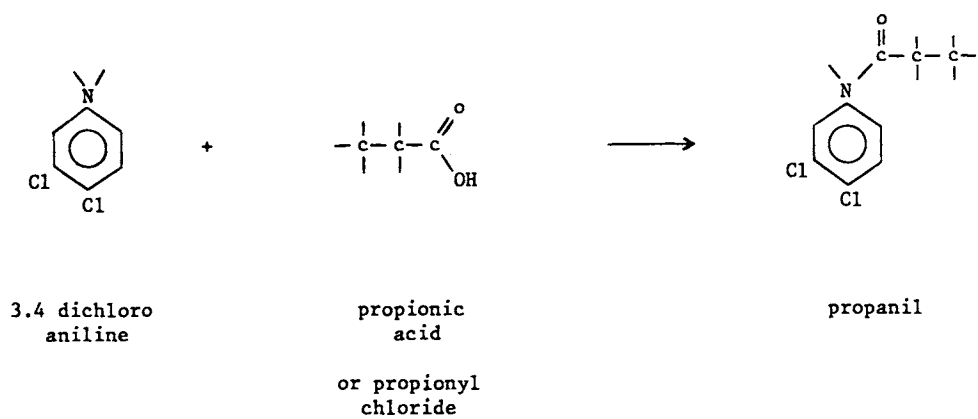
## Propanil

Uses: herbicide, rice, wheat

Trade names: Stam F-34 (Rohm & Haas), Surcopur (Bayer), Rogue (Monsanto)

Type: amide

Synthesis:



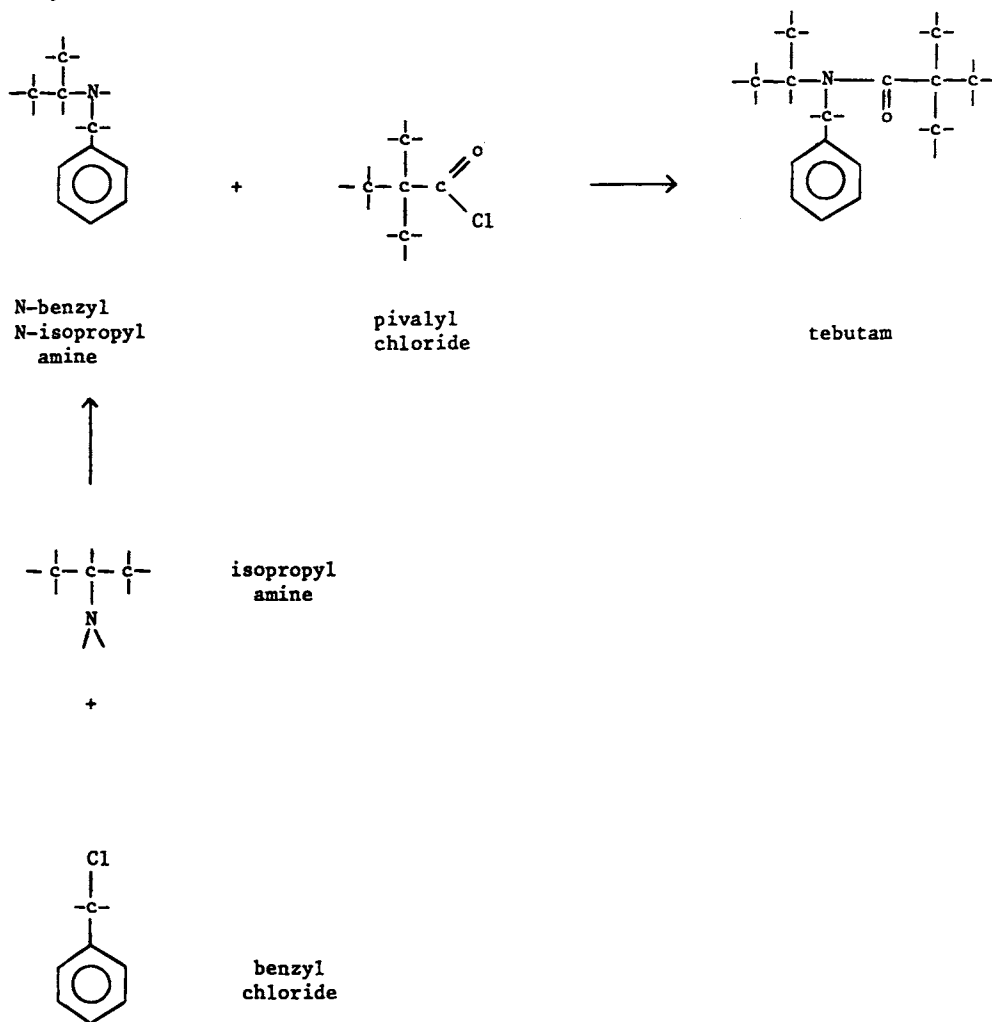
## Tebutam

Uses: herbicide, tobacco, tomatoes, vegetables

Trade names: Comodor (Ciba)

Type: amide

Synthesis:





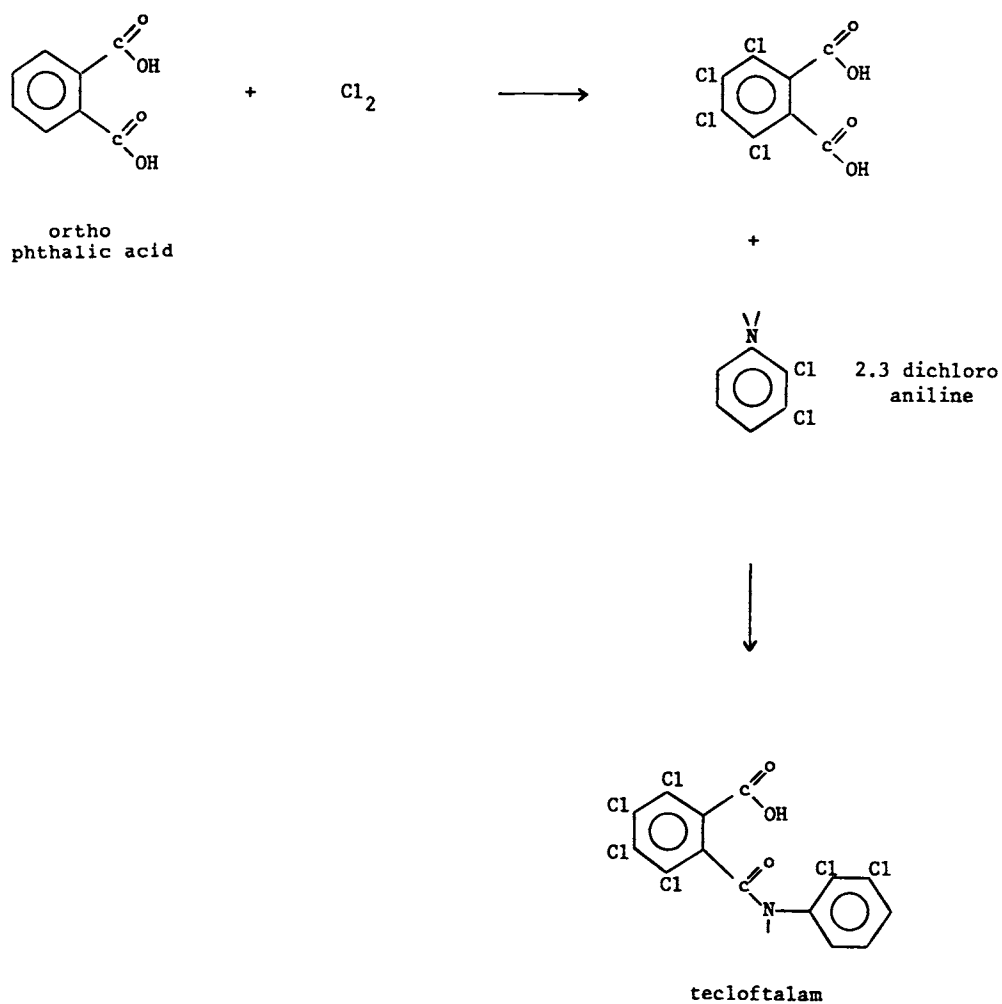
## Tecloftalam

Uses: bactericide, rice

Trade names: Shirahagen-S, Shiragen (Sankyo)

Type: amide

Synthesis:



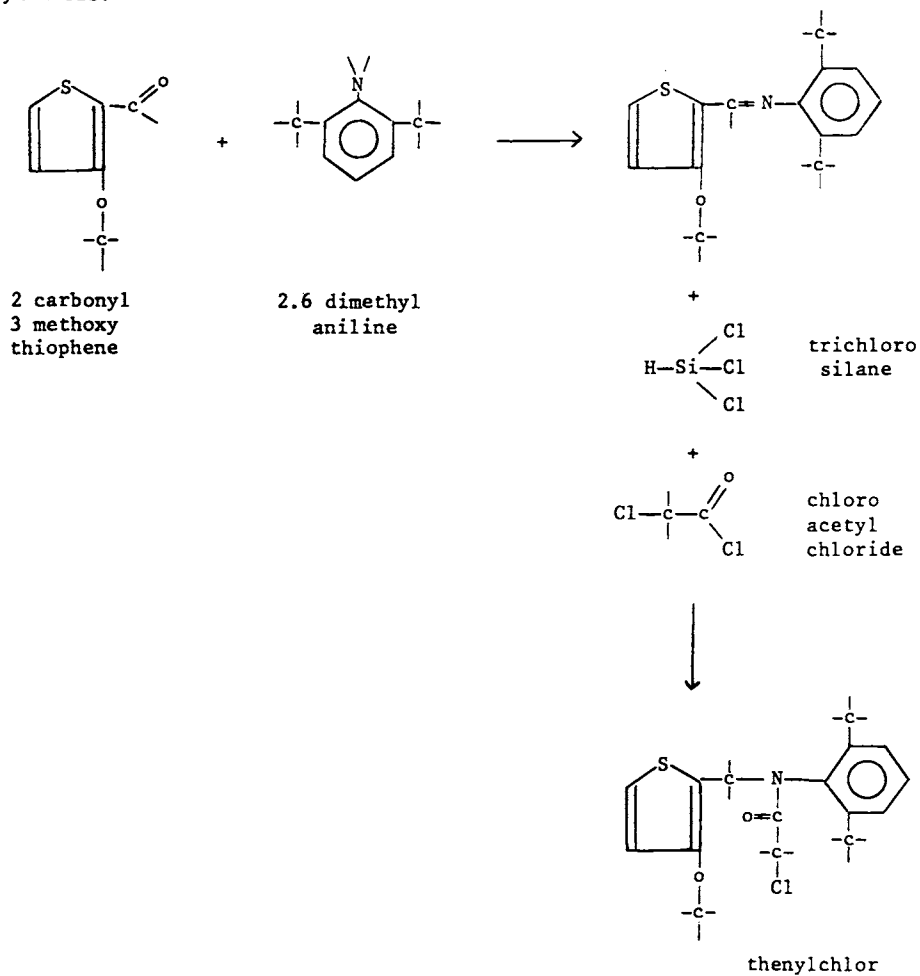
## Thenylchlor

Uses: herbicide, rice

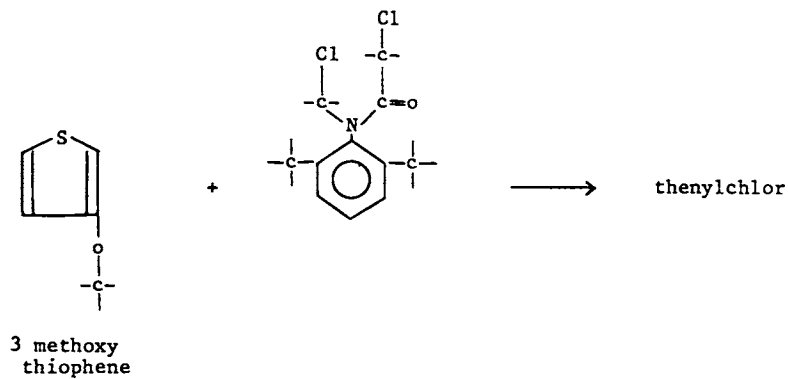
Trade names: (Tokuyama Corp)

Type: amide, heterocyclic sulfur, thiophene

Synthesis:



alternate route:



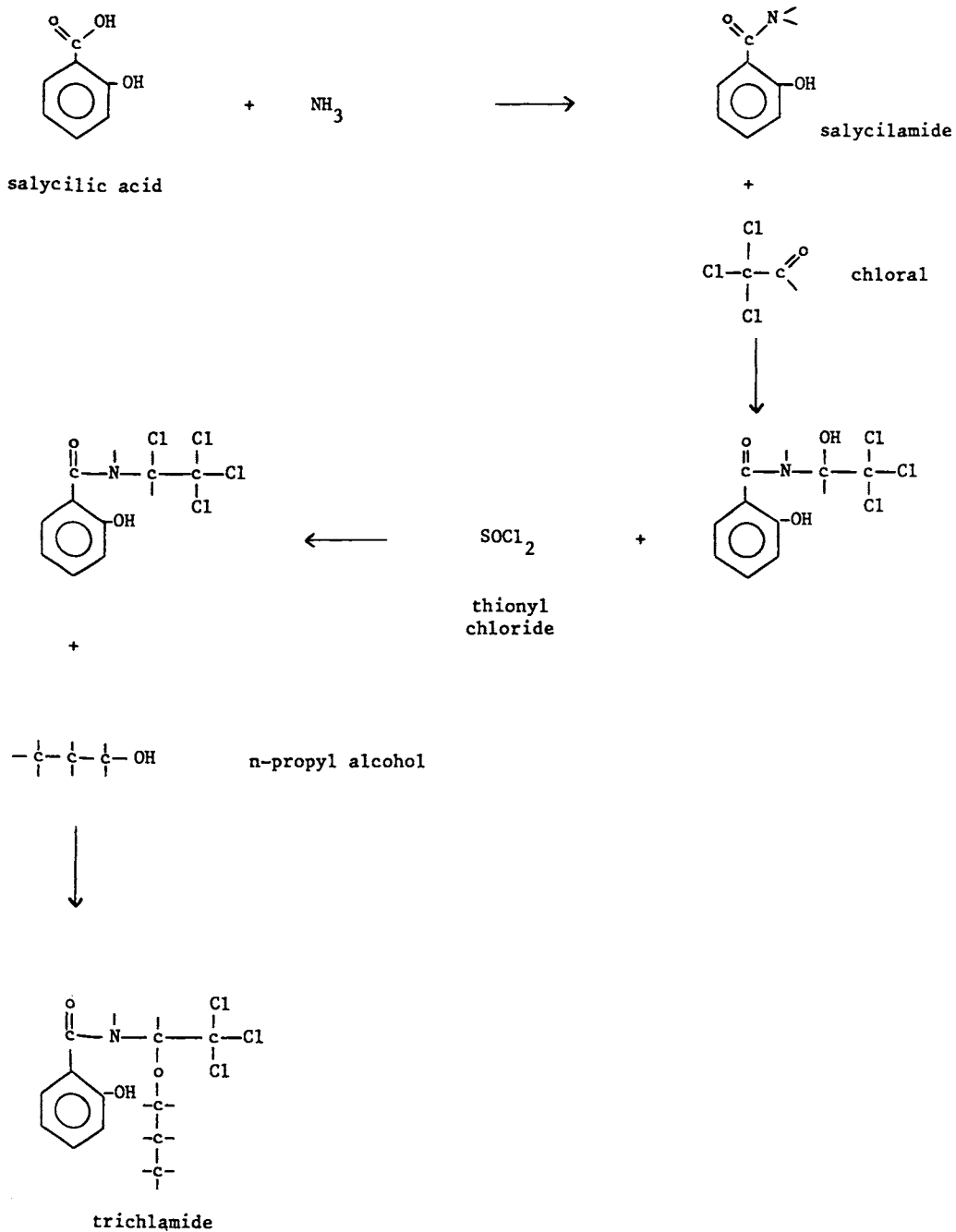
## Trichlamide

Uses: fungicide, cabbage

Trade names: Hataclean (Nippon)

Type: amide

Synthesis:



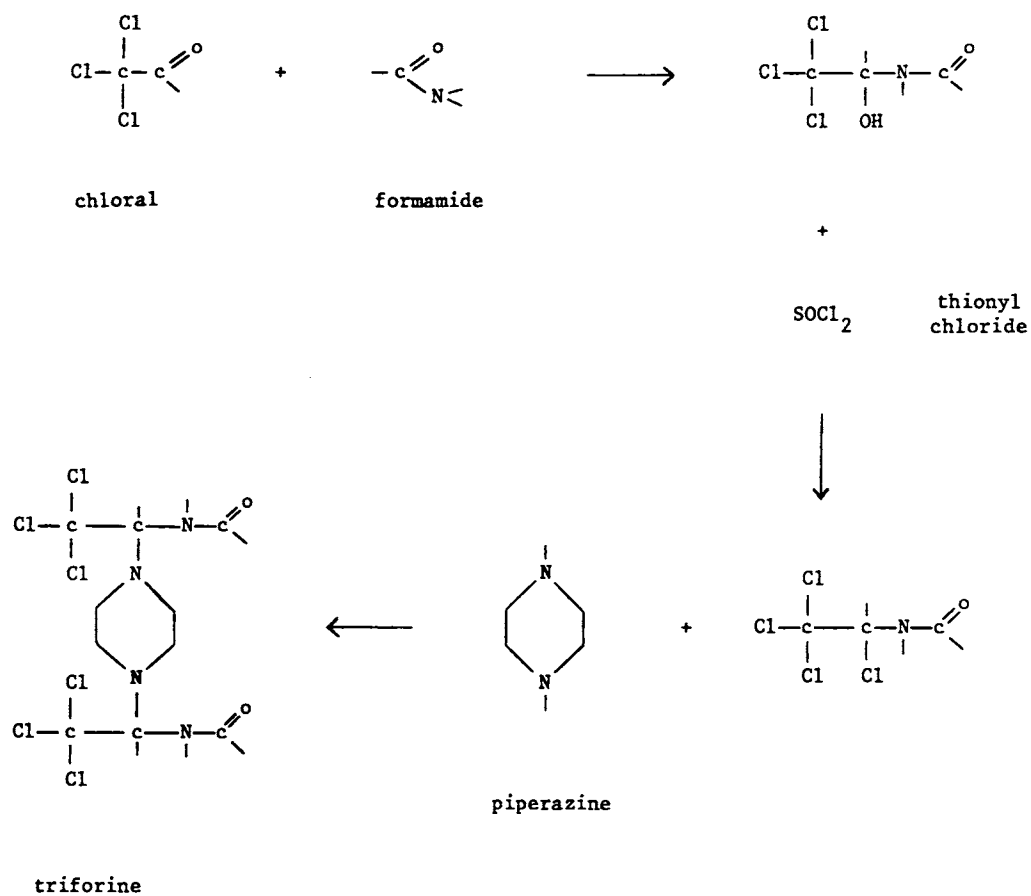
## Triforine

Uses: fungicide, ornamentals, vegetables, fruit

Trade names: Ceta W524 (Shell)

Type: amide, piperazine

Synthesis:



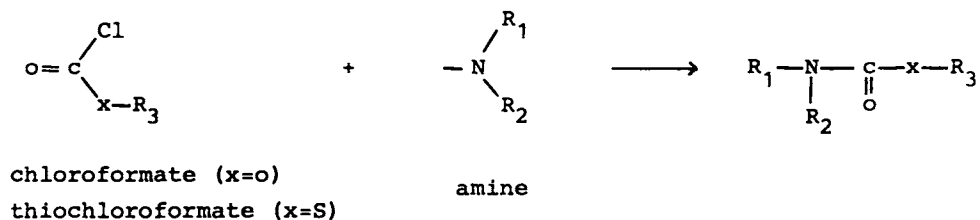
# CARBAMATES AND THIOCARBAMATES

Carbamates and thiocarbamates are an important family of pesticides, finding applications both as insecticides and herbicides.

The  $\begin{array}{c} R_1-N-C-O-R_3 \\ | \quad || \\ R_2 \quad O \end{array}$  function for carbamates ,

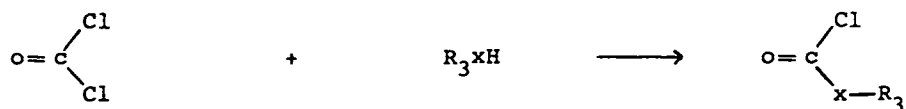
or  $\begin{array}{c} R_1-N-C-S-R_3 \\ | \quad || \\ R_2 \quad O \end{array}$  function for thiocarbamates can be obtained

by the following reaction:



The first step consists in producing the chloroformate  $\begin{array}{c} \text{Cl} \\ \diagup \\ \text{O}=\text{C} \\ \diagdown \\ \text{x}-\text{R}_3 \end{array}$

by reaction between phosgene (the starting point for nearly all carbamates) and the respective alcohol or mercaptan



## 56 Pesticides Synthesis Handbook

A variation of the above route consists in inverting the order of the two reactions that is instead of



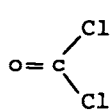
+

amine

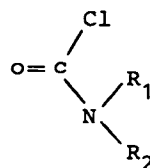
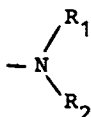


carbamate

one can have



+



phosgene

amine

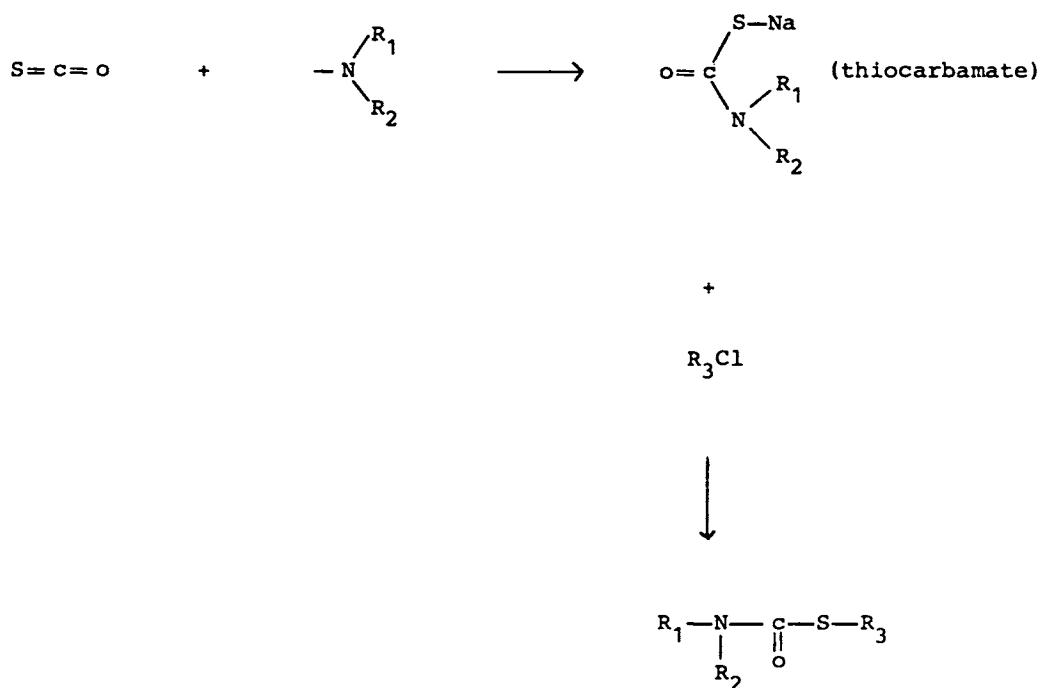
carbonyl chloride

+



carbamate

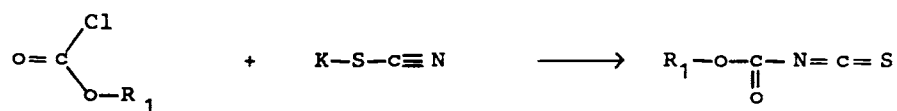
A variation to this latter route is to start from carbonyl sulfide, thus incorporating both N and S in the first step



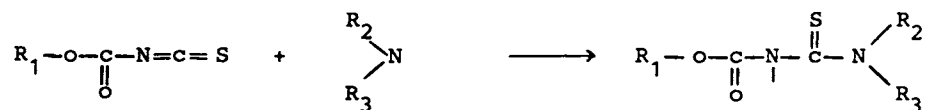
An important alternative route for producing carbamates is by the reaction between an isocyanate and an alcohol ( or an oxime )



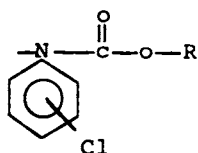
An unusual method for obtaining a carbamate consists in starting from a chloroformate and an isothiocyanate ( see thiophanate )



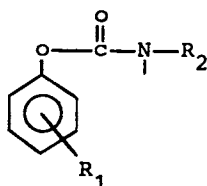
This latter compound is then converted to a carbamate by reaction with an amine



The most common structures for carbamates are as follows :

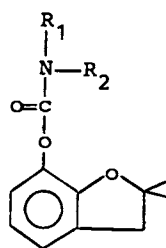


barban  
chlorbufam  
chlorpropham  
propham

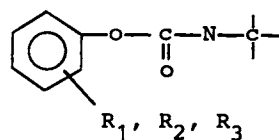


ethiofencarb  
dioxacarb  
fenobucarb

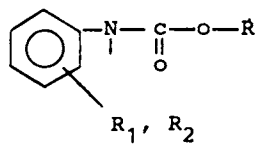




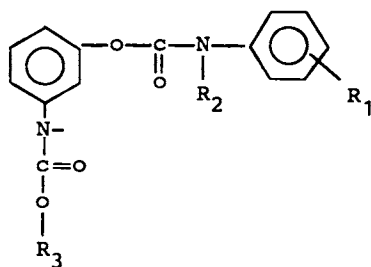
benfuracarb  
 carbofuran  
 carbosulfan  
 furathiocarb



aminocarb  
 bendiocarb  
 cloethocarb  
 dioxacarb  
 ethiofencarb  
 fenobucarb  
 formetanate  
 isoprocarb  
 methiocarb  
 metolcarb  
 mexacarbate  
 promecarb  
 propoxur  
 trimethocarb  
 xylilcarb  
**XX**



barban  
 carbetamide  
 chlorbufam  
 chlorpropham  
 diethofencarb  
 propham



desmedipham  
 phenisopham  
 phenmedipham

# CARBAMATES

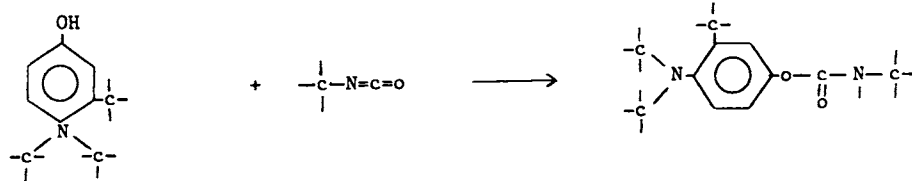
## Aminocarb

Uses: insecticide, cotton, forestry

Trade names: Matacil (Bayer)

Type: carbamate

Synthesis:



4-dimethyl amino  
3-methyl phenol

methyl isocyanate

aminocarb

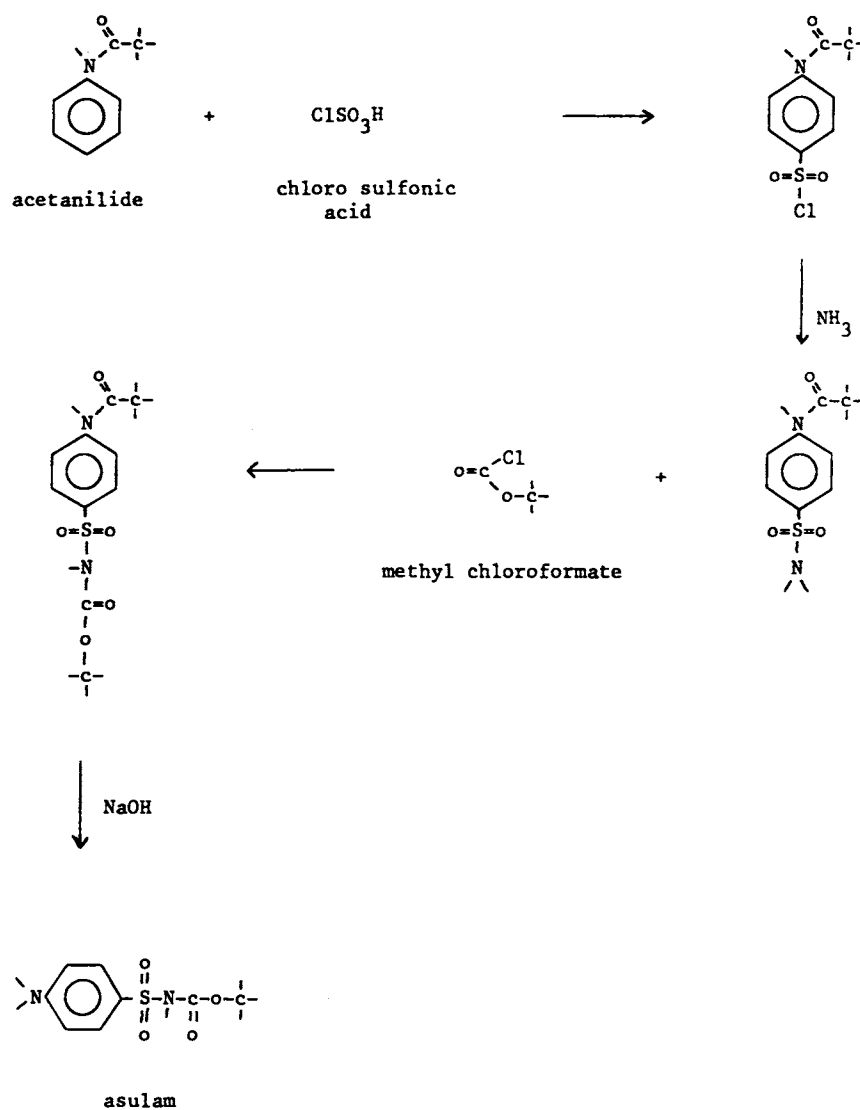
## Asulam

**Uses:** herbicide, pastures, sugarcane, forestry, tree crops

**Trade names:** Asulox (Rhone Poulenc)

Type: carbamate, sulfonamide

**Synthesis:**



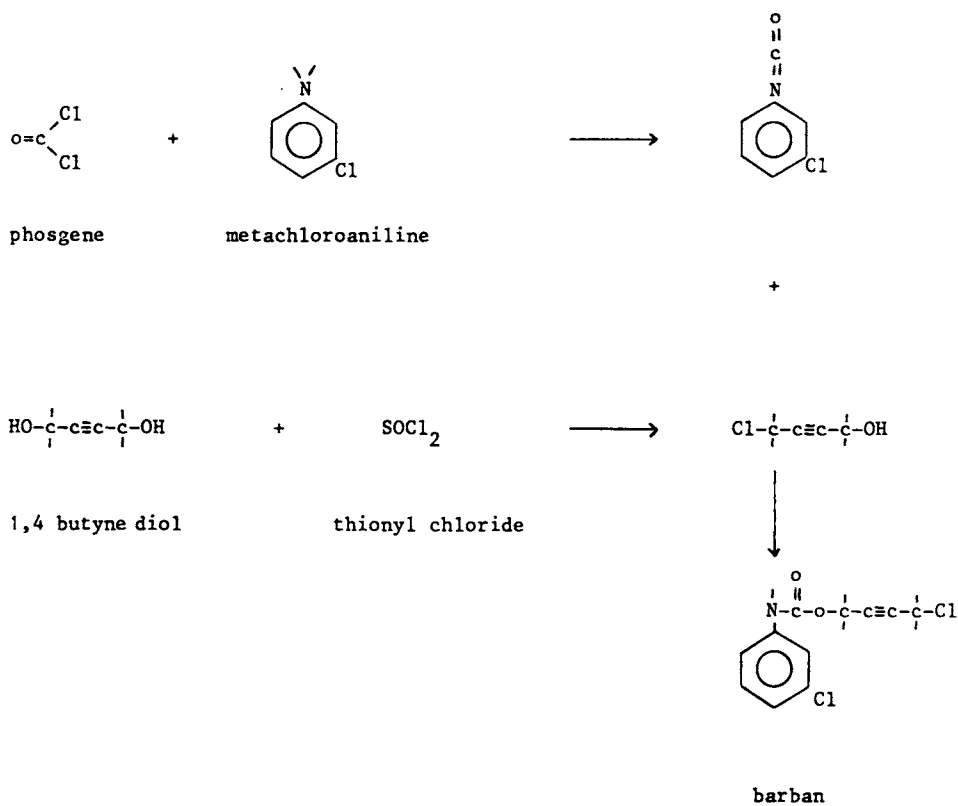
## Barban

Uses: herbicide, wheat, barley, soyabeans, sugarbeet, sunflowers

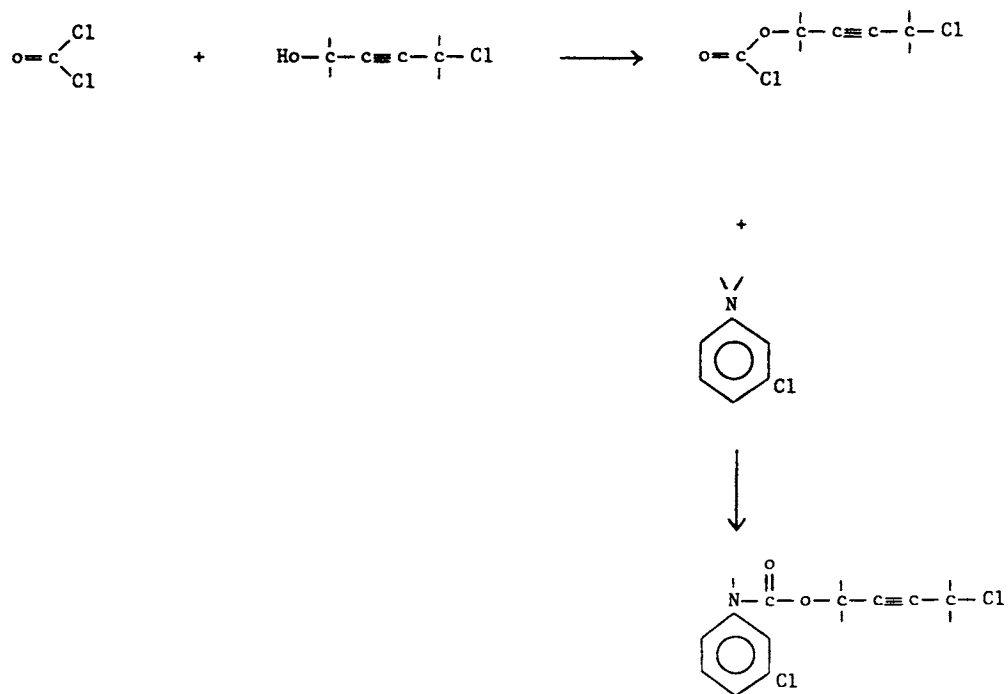
Trade names: Carbyne, Caryne, Neobyne (Schering); Wipout (Uniroyal)

Type: carbamate

Synthesis:



alternate route :



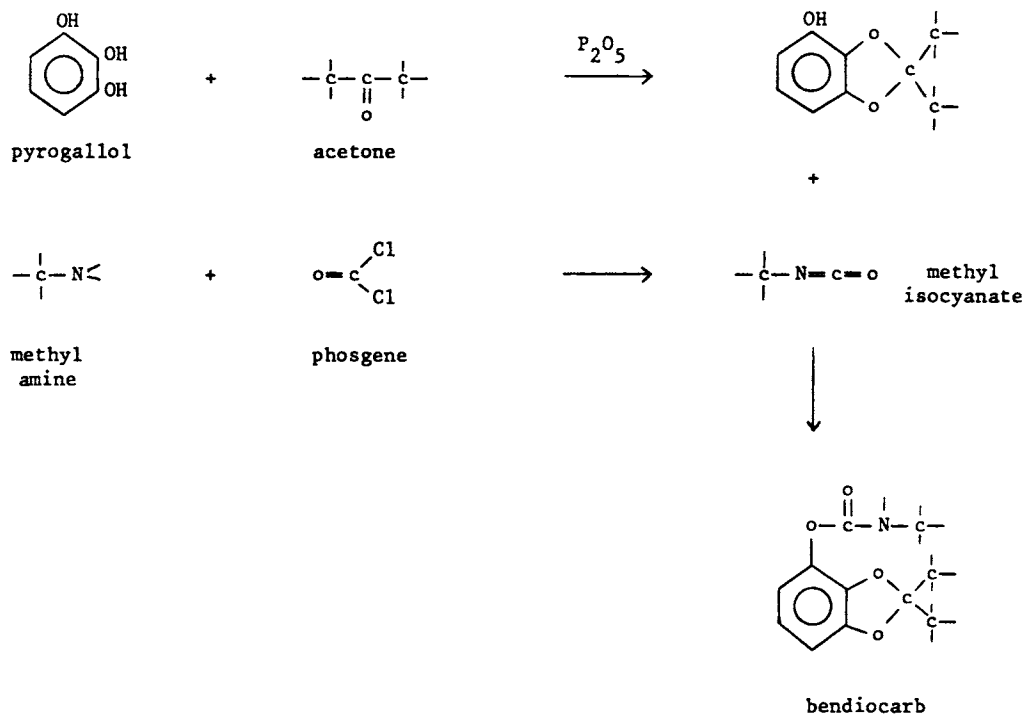
## Bendiocarb

Uses: insecticide, public health, buildings, maize, sugarbeet

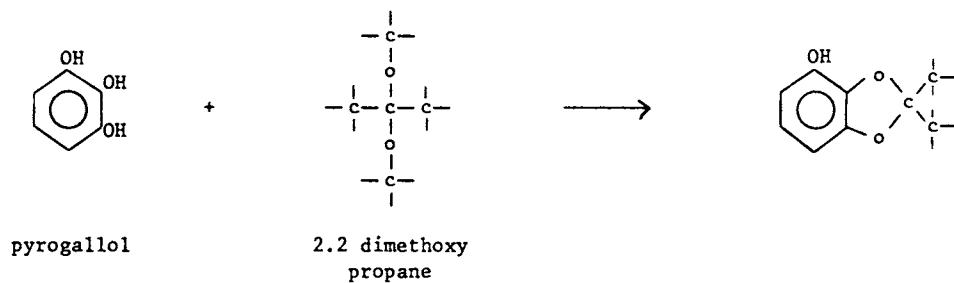
Trade names: Ficam, Gartox, Seedox (Schering)

Type: carbamate

Synthesis:



alternate route



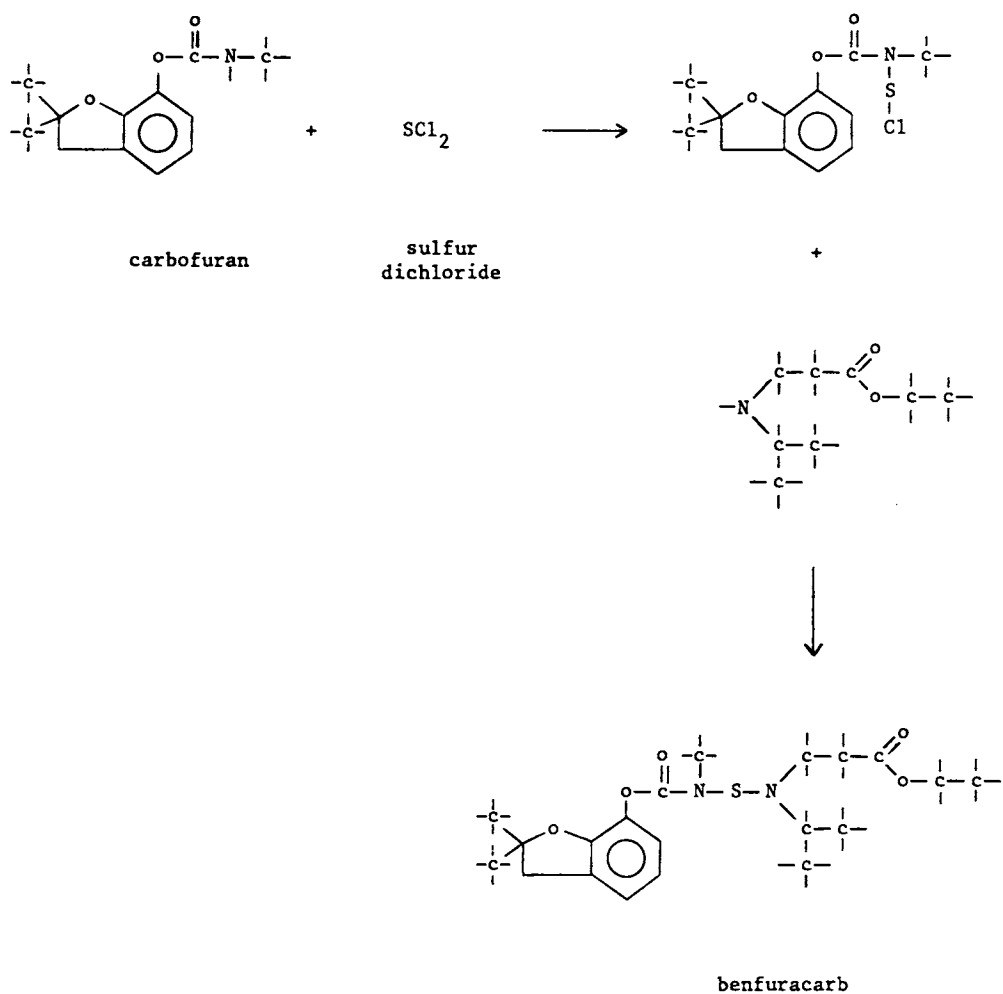
## Benfuracarb

Uses: insecticide, citrus, maize, rice, sugarbeet, vegetables

Trade names: Oncol (Otsuka)

Type: carbamate, benzofuran

Synthesis:





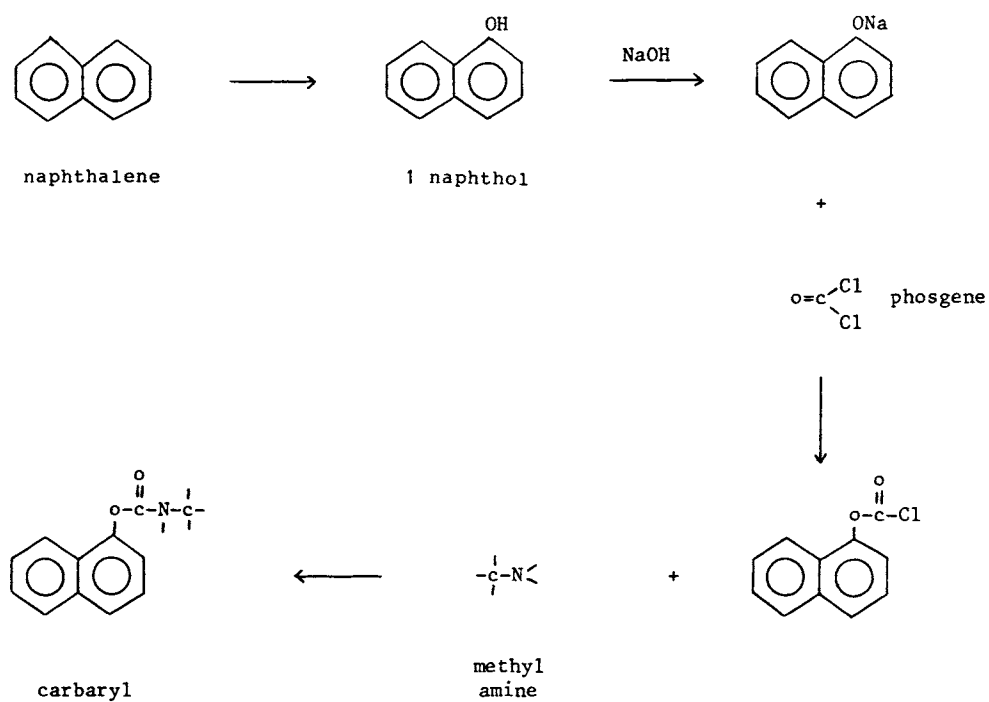
## Carbaryl

Uses: insecticide, cotton, fruit, vegetables

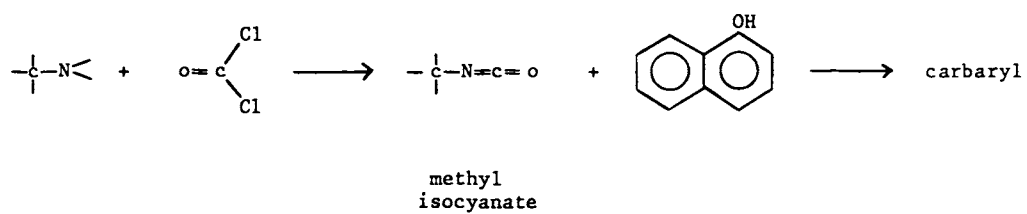
Trade names: Sevin (Rhône Poulenc)

Type: carbamate

Synthesis:



alternate route:



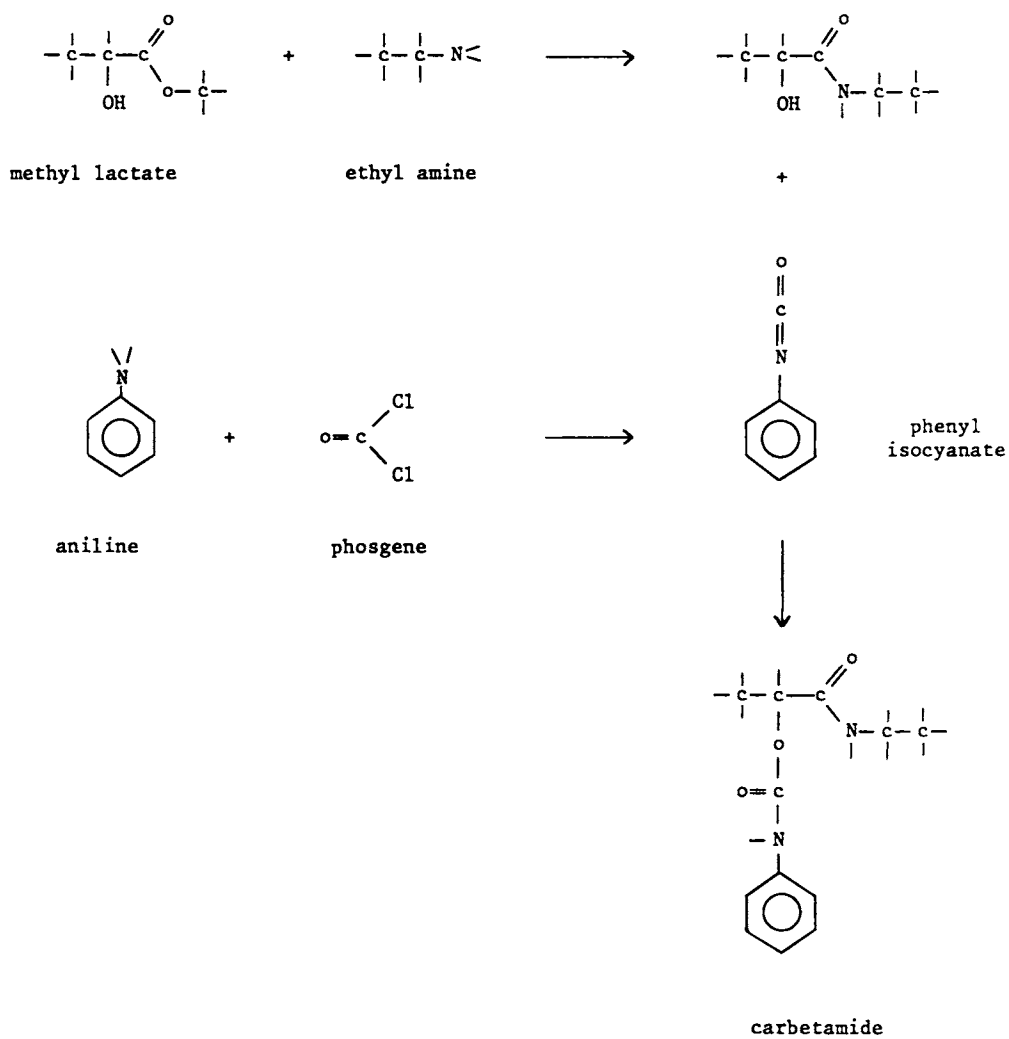
## Carbetamide

Uses: herbicide, vegetables

Trade names: Legurame (Rhône Poulenc)

Type: carbamate

Synthesis:



## Carbofuran

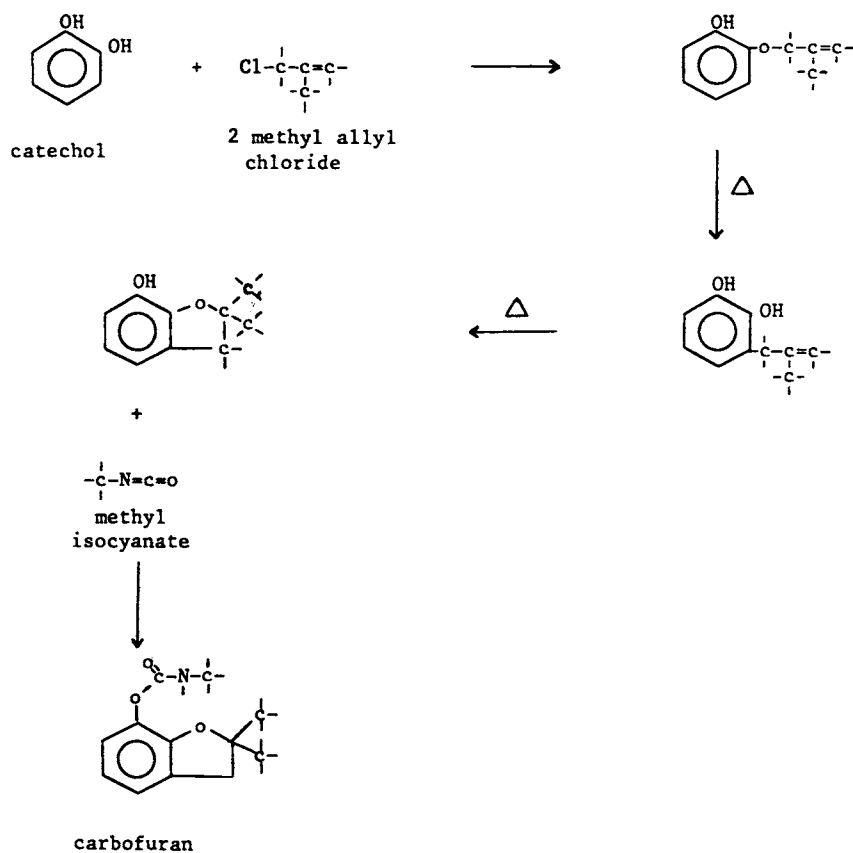
Uses : insecticide, mainly for corn, also alfalfa, sorghum, tobacco

Trade names: FMC (Furadan), Rallis (India), Hungary (State)

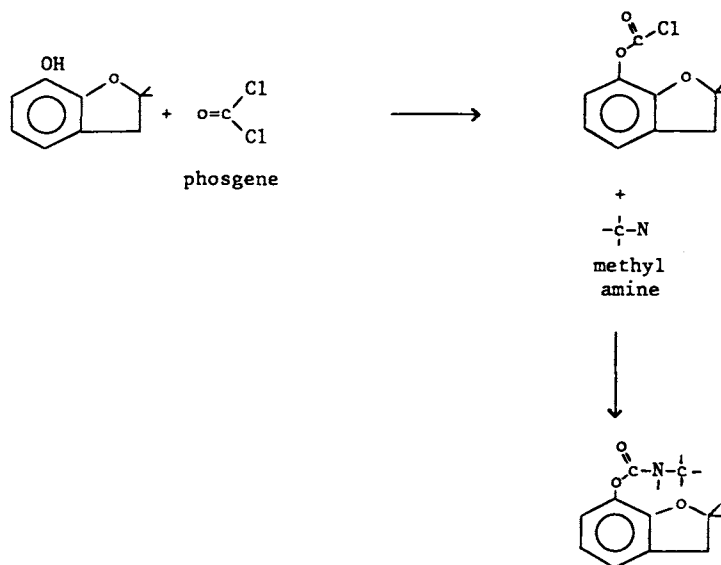
Type: carbamate

### Synthesis

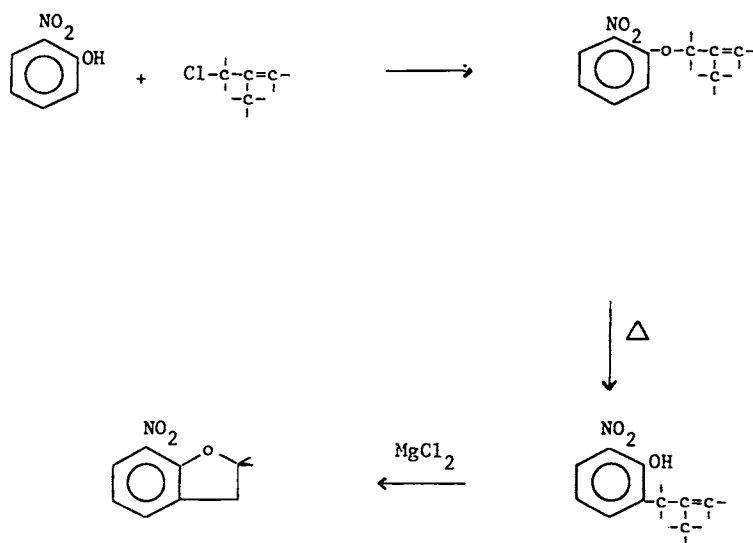
main route:

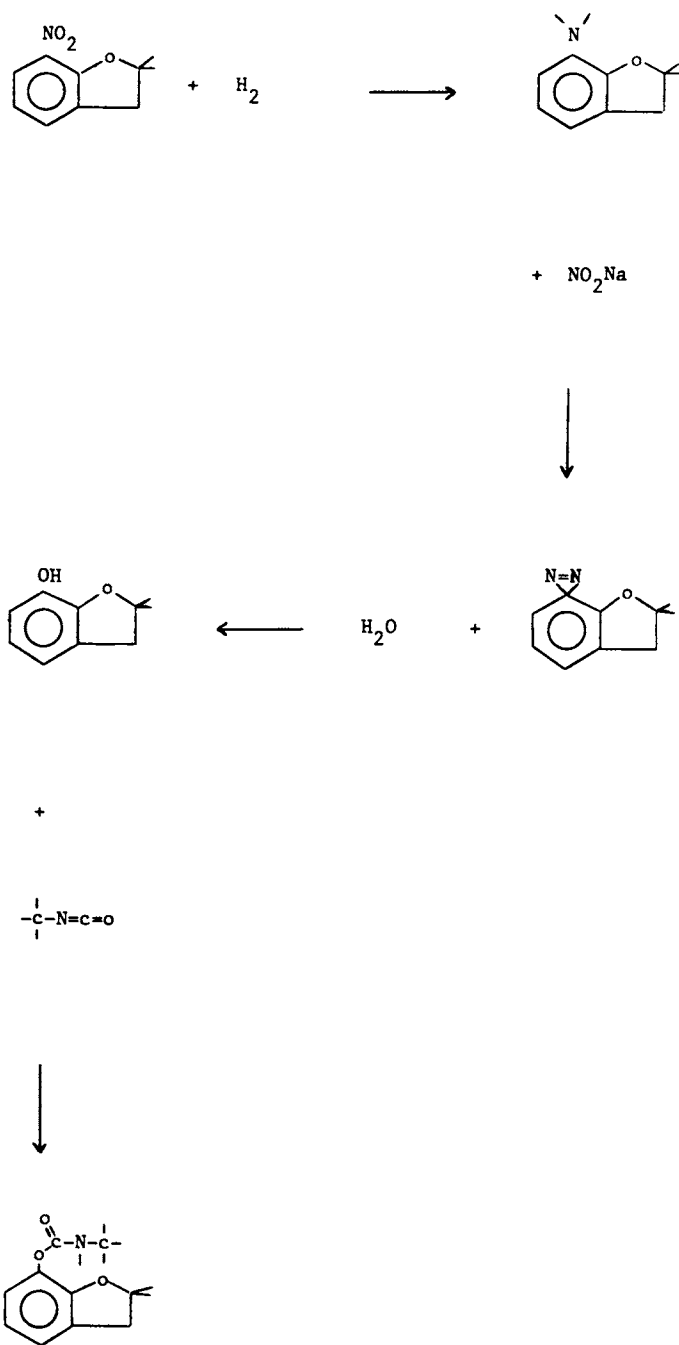


alternate route without methylisocyanate :



alternate route based upon ortho-nitrophenol instead of catechol :





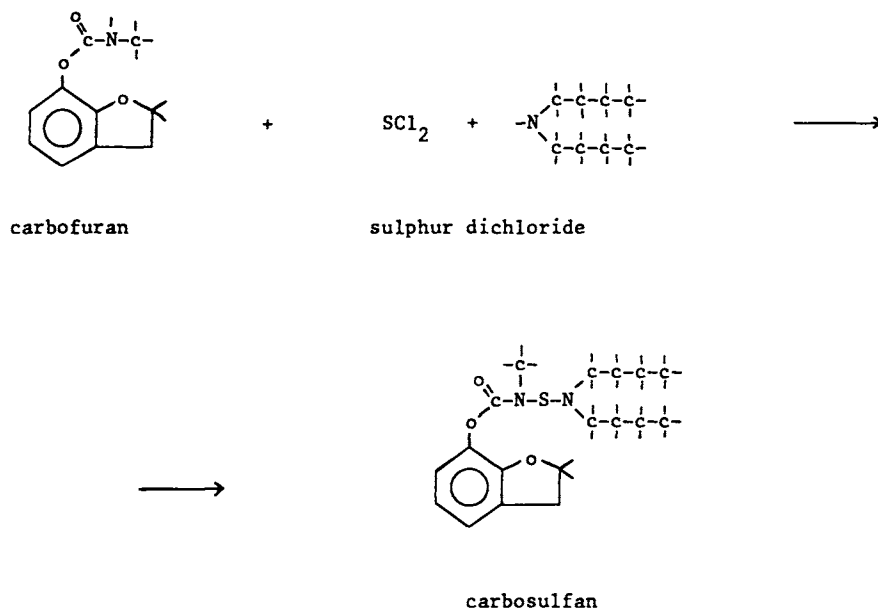
## Carbosulfan

Uses: insecticide, sugarbeet, rice, citrus, maize, potatoes

Trade names: Marshal (FMC)

Type: carbamate

Synthesis:



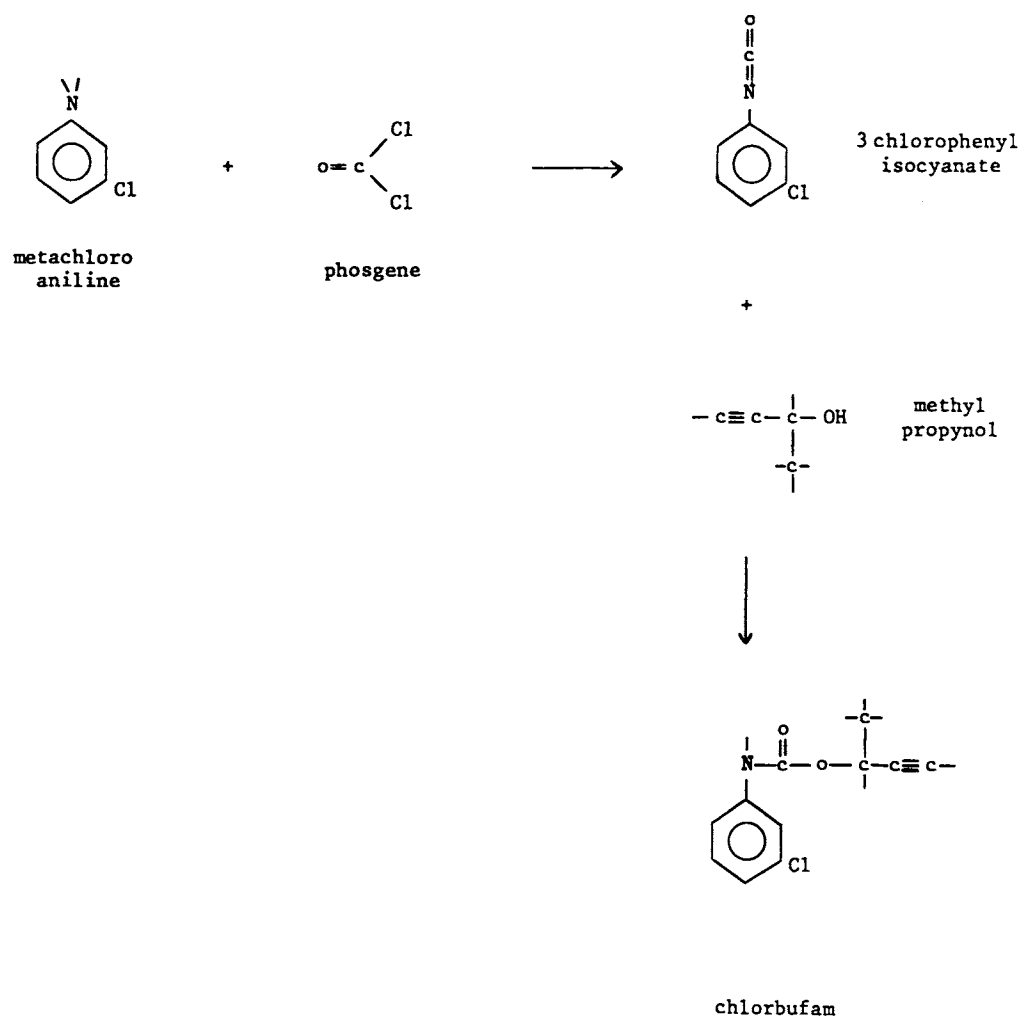
## Chlorbufam

Uses: herbicide, onions

Trade names: BiPC (BASF)

Type: carbamate

Synthesis:





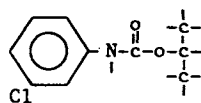
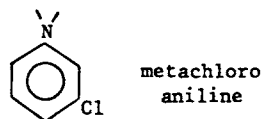
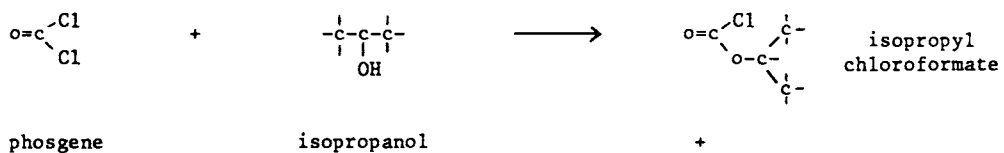
## Chlorpropham

Uses: herbicide, carrots, onions

Trade names: Provenol (AgrEvo), CIPC (Elf Atochem)

Type: carbamate

Synthesis:



chlorpropham

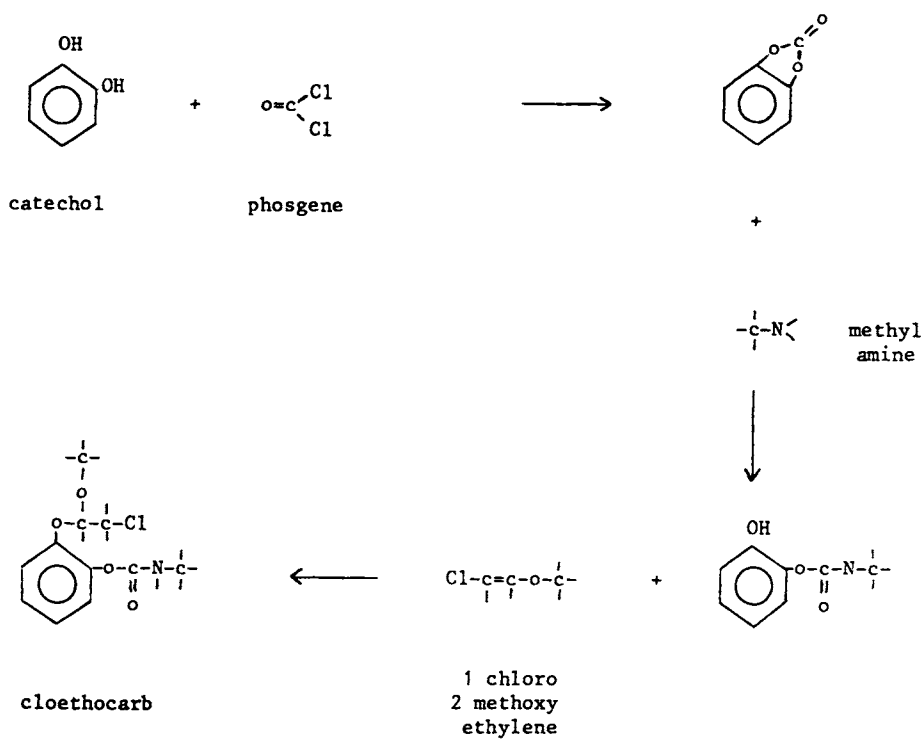
## Cloethocarb

Uses: insecticide, cereals, maize, potatoes, soyabeans

Trade names: Lance (BASF)

Type: carbamate

Synthesis:



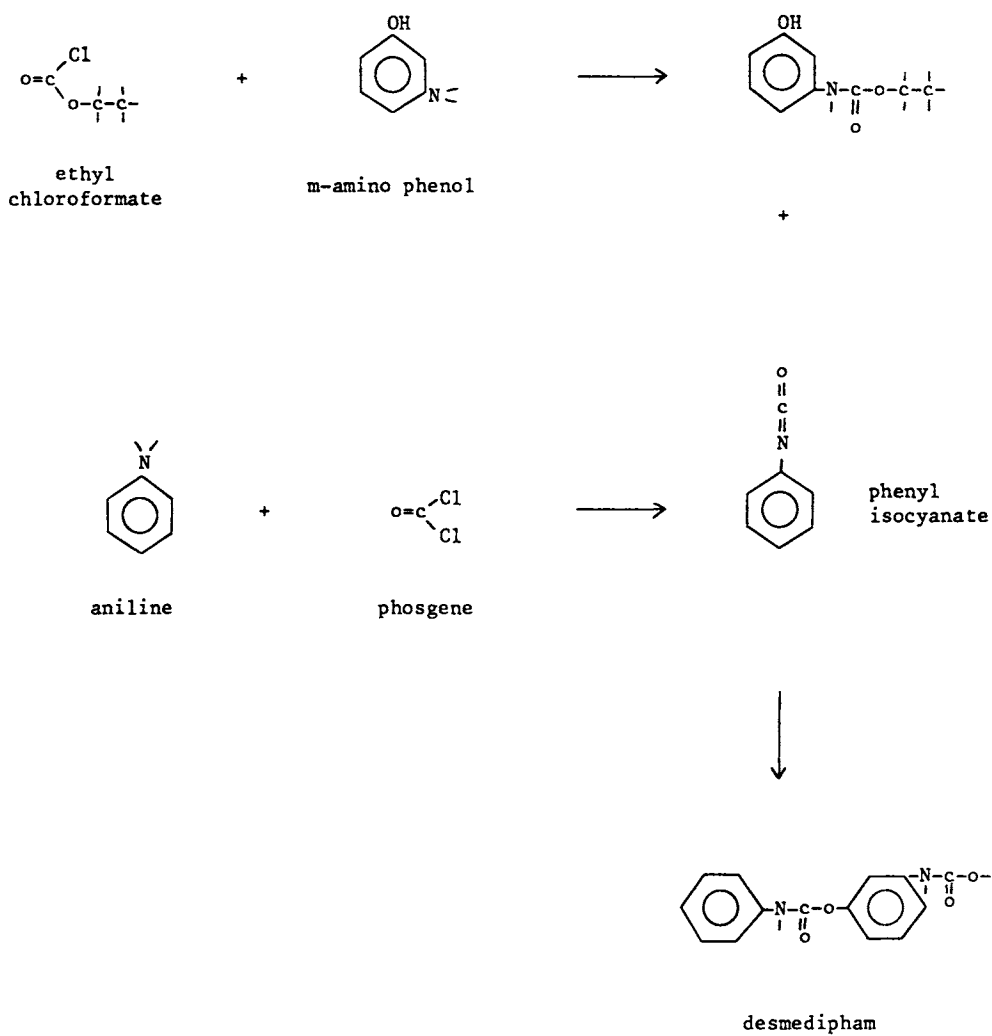
## Desmedipham

Uses: herbicide, sugarbeet

Trade names: Betanal AM, Betanex (Schering)

Type: carbamate

Synthesis:



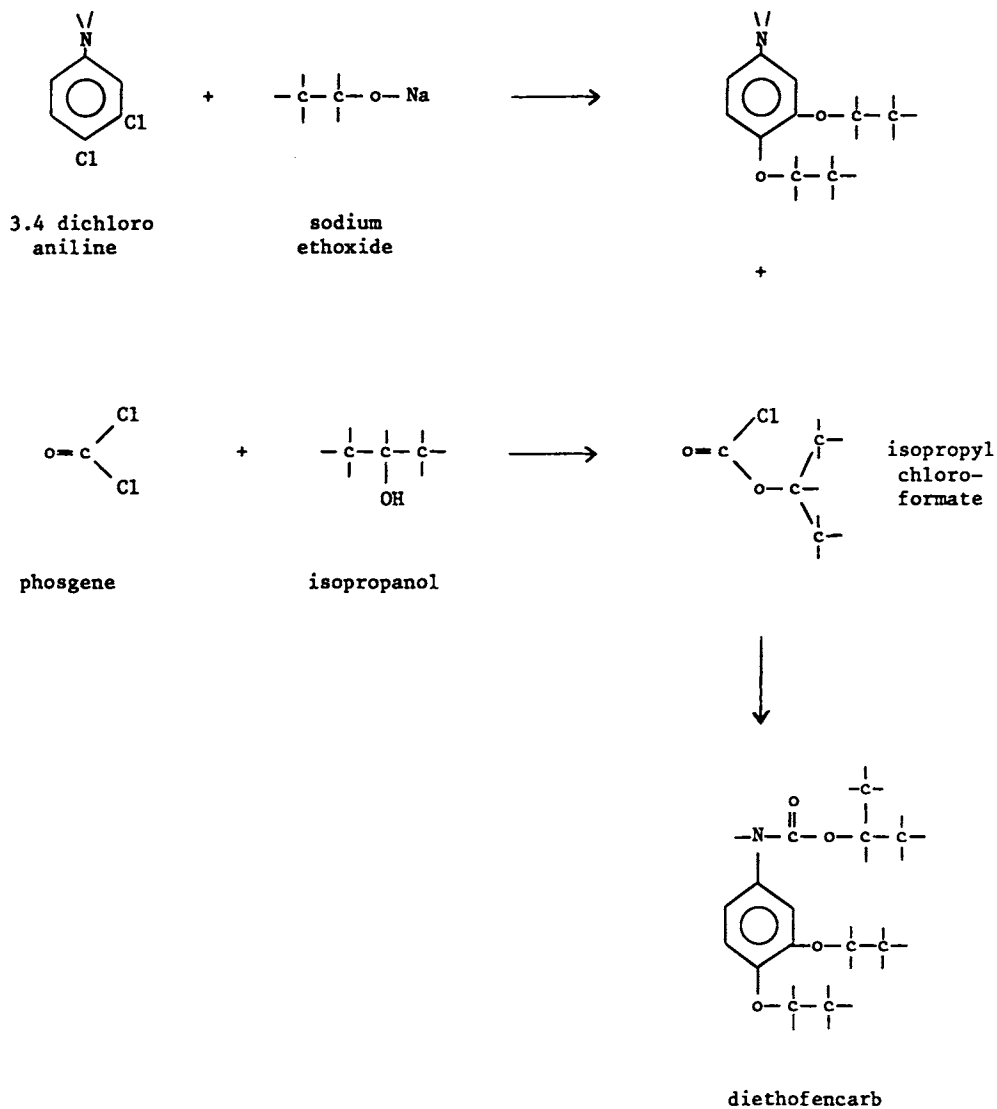
## Diethofencarb

Uses: fungicide, grapes, vegetables

Trade names: Sumico (Sumitomo)

Type: carbamate

Synthesis:



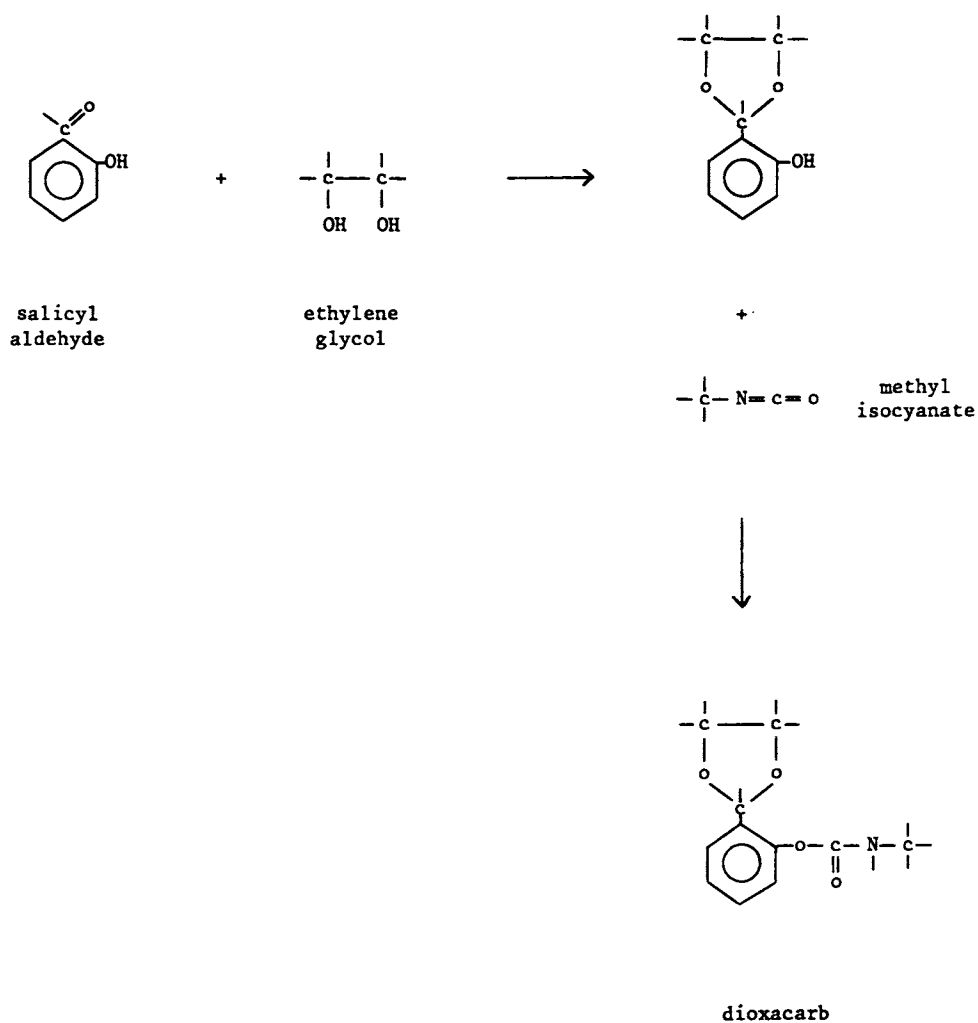
## Dioxacarb

Uses: insecticide, rice, cocoa

Trade names: Elocron, Famid (Ciba)

Type: carbamate

Synthesis:



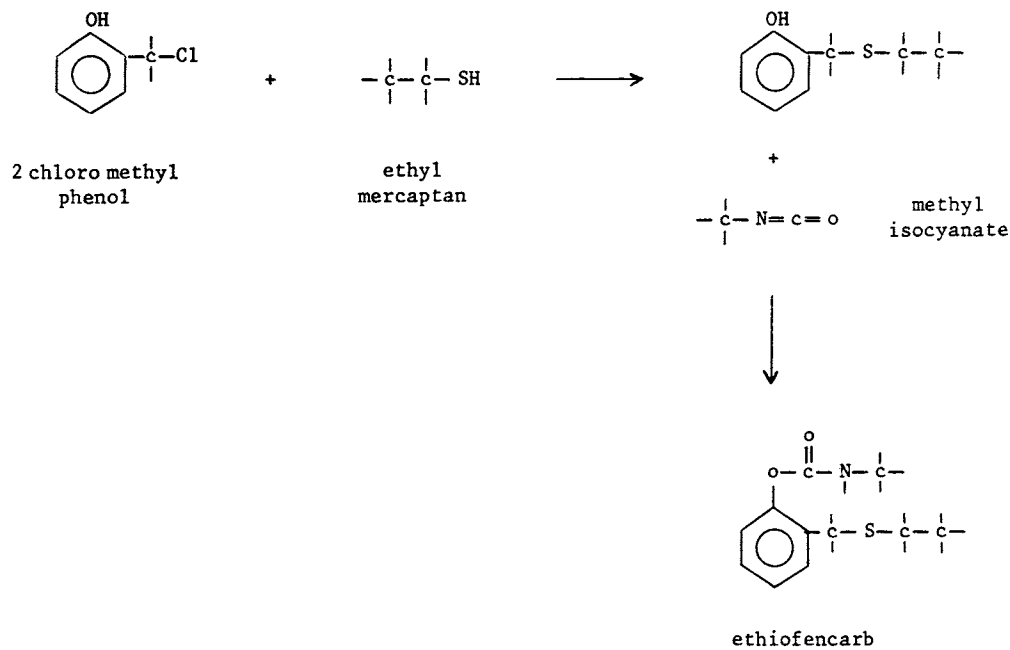
## Ethiofencarb

Uses: insecticide, cereals, cotton, maize, potatoes, sugarbeet, tobacco, vegetables

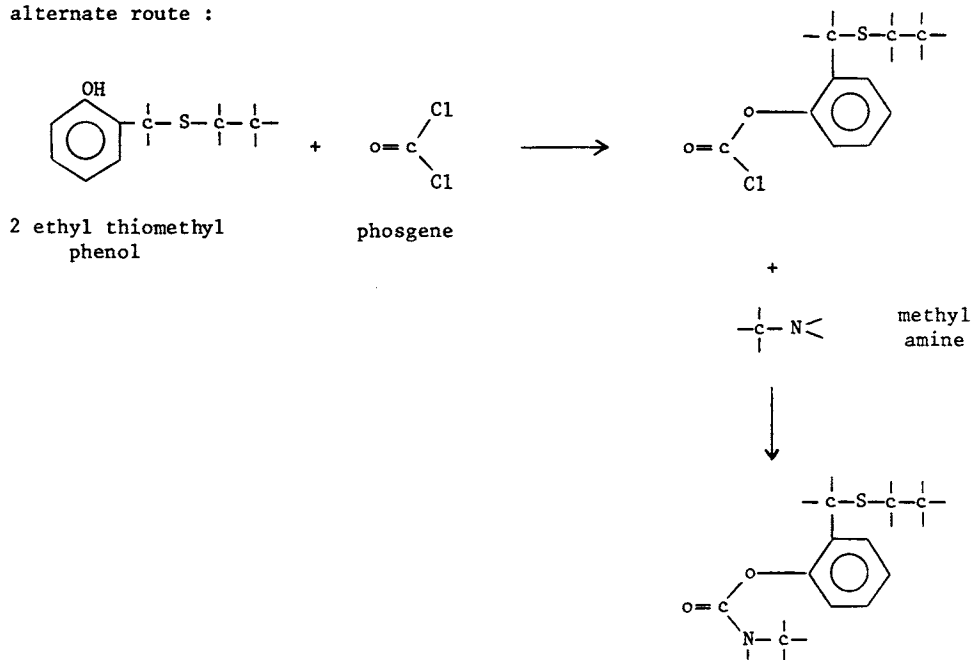
Trade names: Croneton (Bayer)

Type: carbamate

Synthesis:



alternate route :



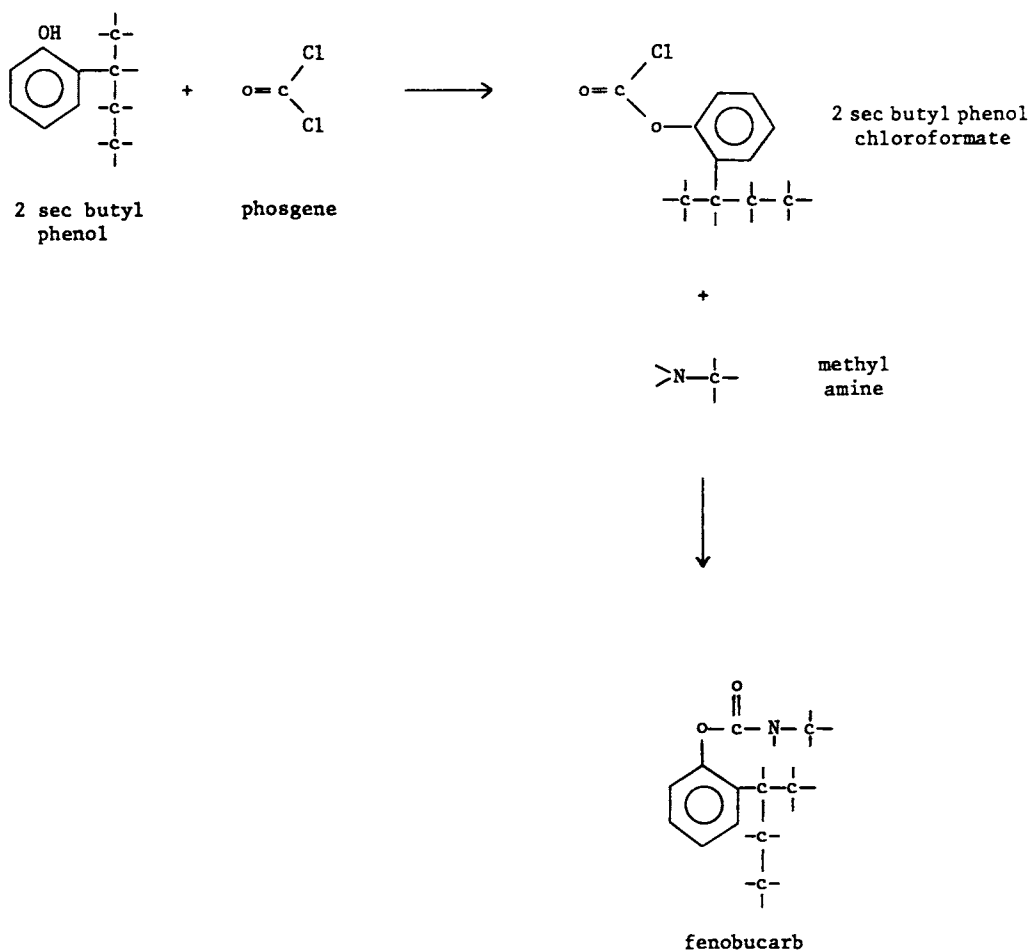
## Fenobucarb

Uses: insecticide, rice, sugarcane, tea, wheat, vegetables

Trade names: Osbac (Sumitomo), Bassa (Kumiai), Baycarb (Bayer)

Type: carbamate

Synthesis:



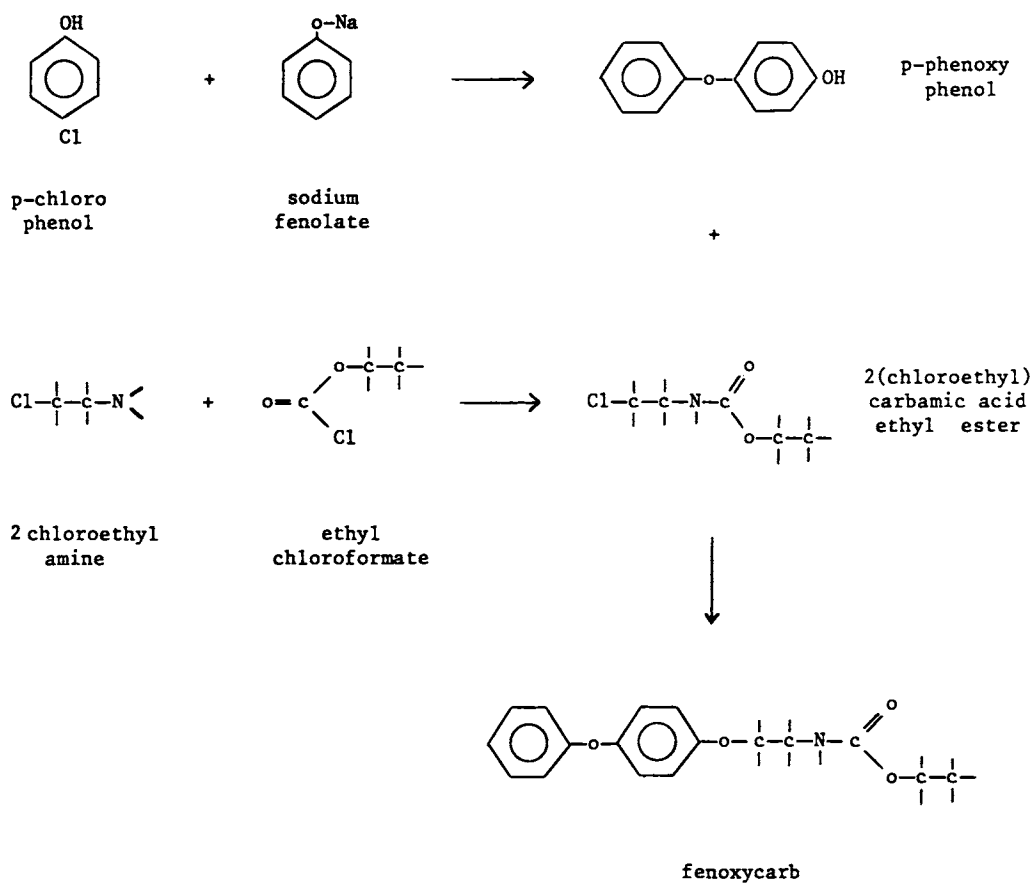
## Fenoxycarb

Uses: insecticide, citrus, olives, vines

Trade names: Insegar (Ciba)

Type: carbamate, phenyl ether

Synthesis:





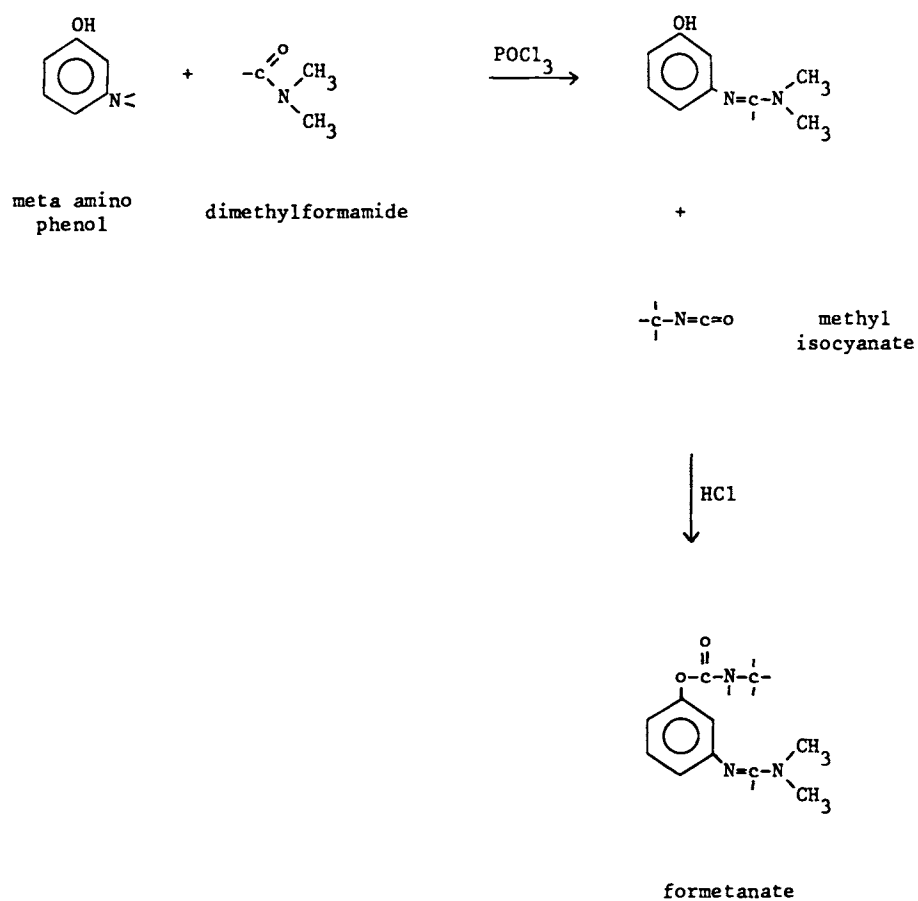
## Formetanate

Uses: acaricide, citrus, fruit, vegetables

Trade names: Carzol, Dicarzol (Schering)

Type: carbamate, amidine

Synthesis:



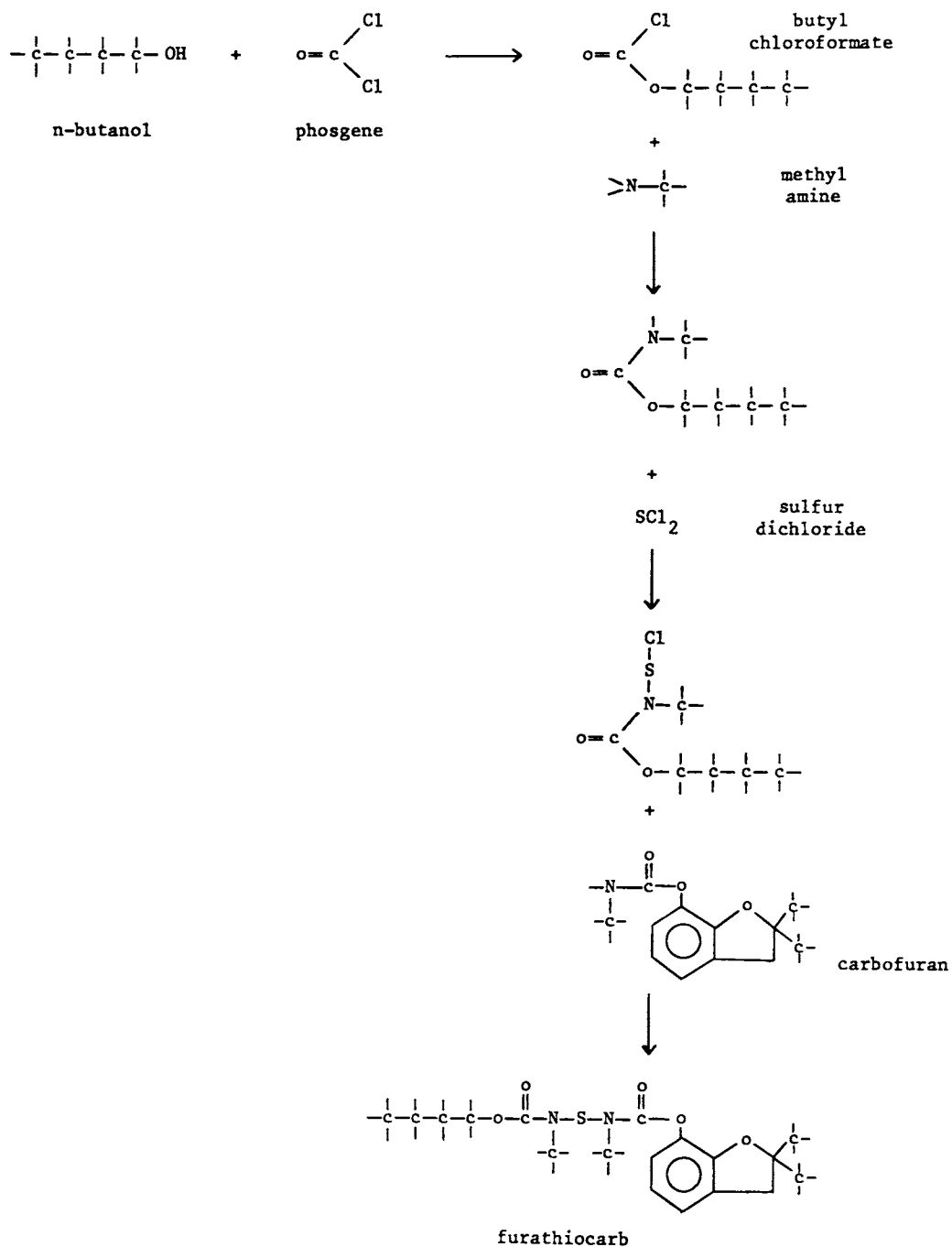
## Furathiocarb

Uses: insecticide, maize, sugarbeet, vegetables

Trade names: Deltanet (Ciba)

Type: carbamate, benzofuran

**Synthesis:**



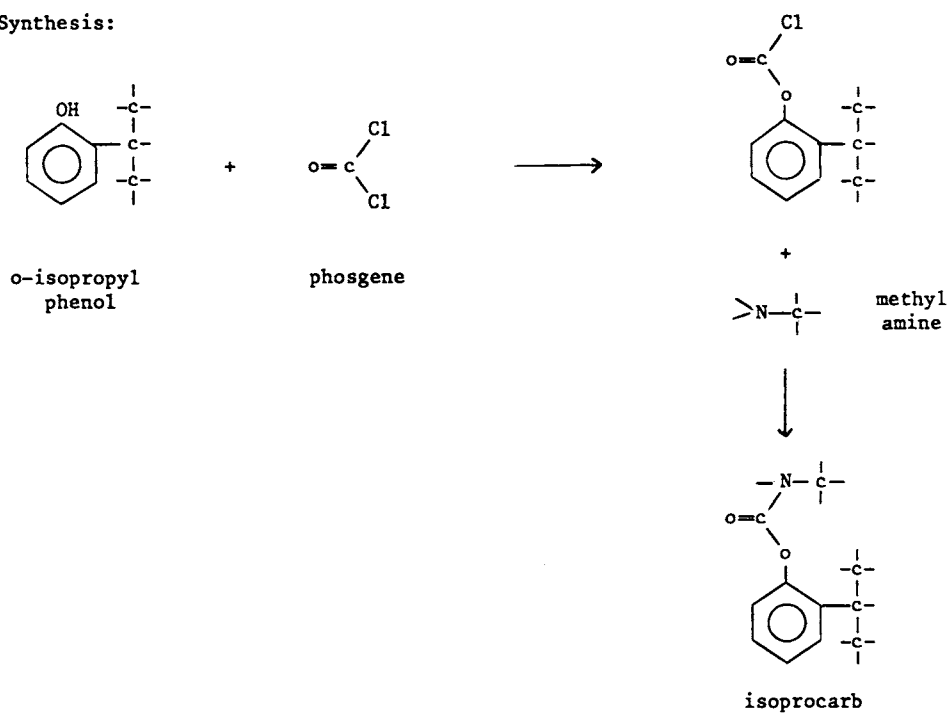
## Isoprocarb

Uses: insecticide, rice

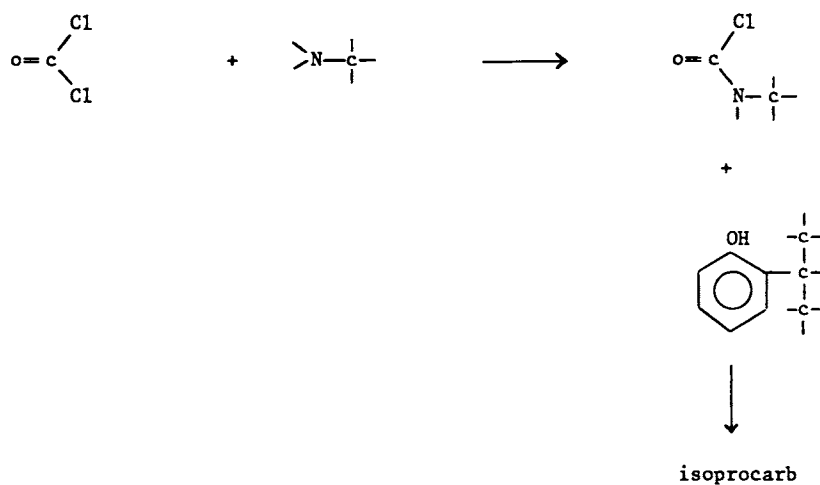
Trade names: Etrofolan (Bayer), Mipcin (Mitsubishi)

Type: carbamate

Synthesis:



alternate route :



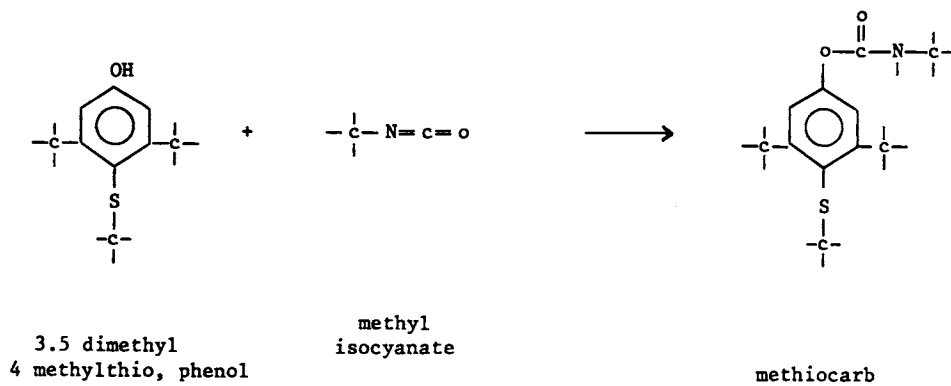
## Methiocarb

Uses: insecticide, cereals, citrus, ornamentals, potatoes, sugarbeet, vegetables

Trade names: Mesurol, Draza (Bayer)

Type: carbamate

Synthesis:



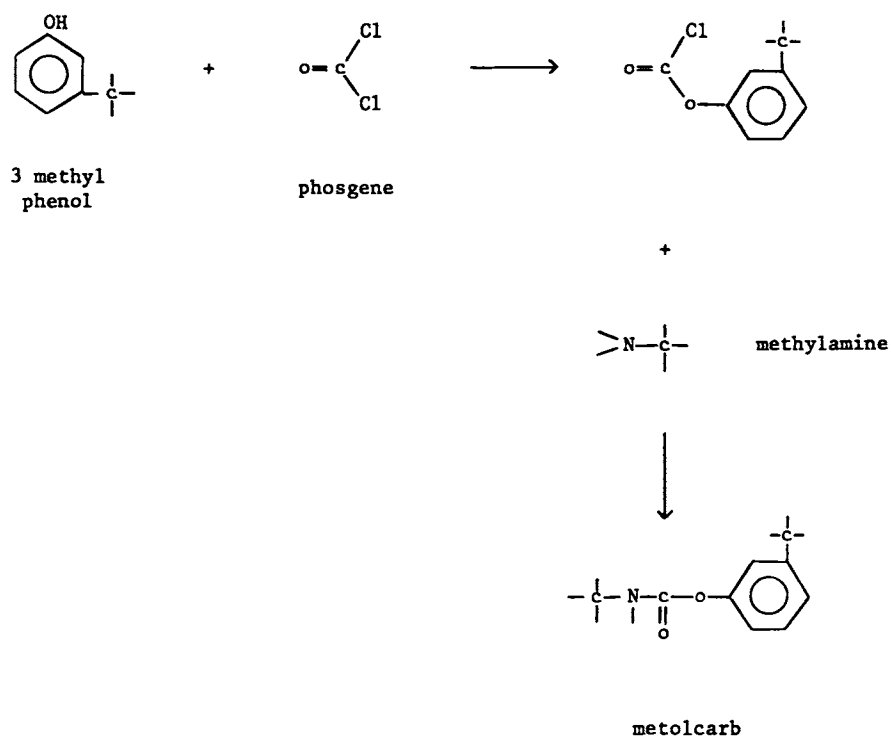
## Metolcarb

Uses: insecticide, rice

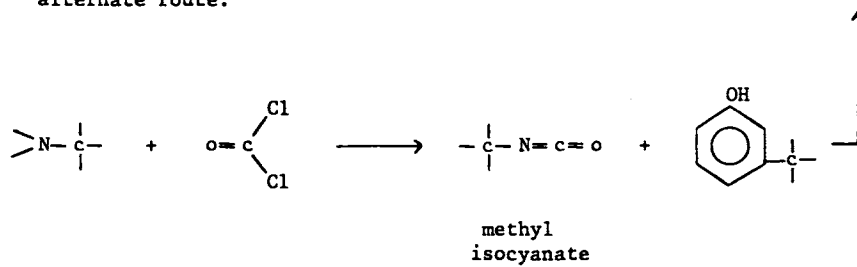
Trade names: Tsumacide (Nihon), Metacrate (Sumitomo)

Type: carbamate

Synthesis:



alternate route:



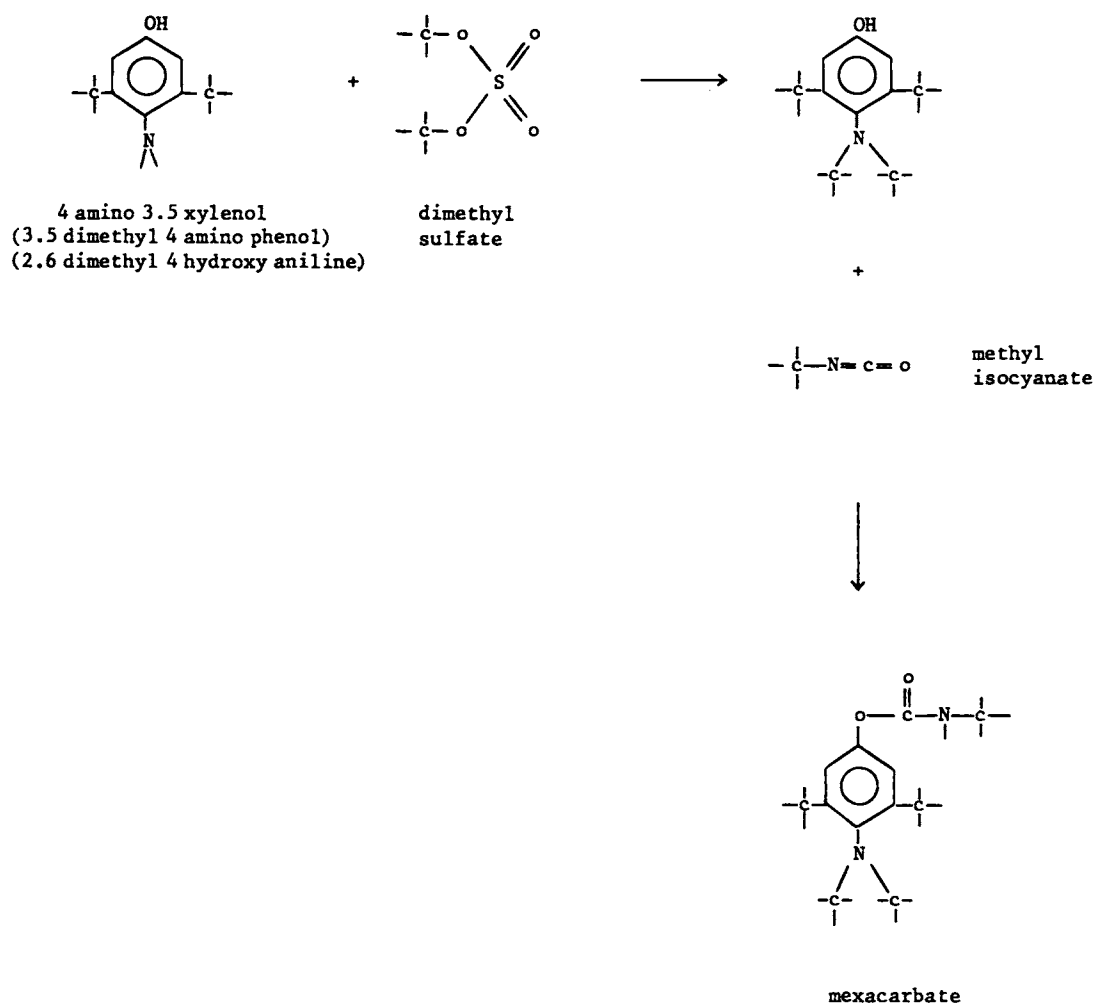
## Mexacarbate

Uses: insecticide, acaricide, molluscicide, ornamentals, turf, forestry

Trade names: Zectran (Rhône Poulenc)

Type: carbamate

Synthesis:



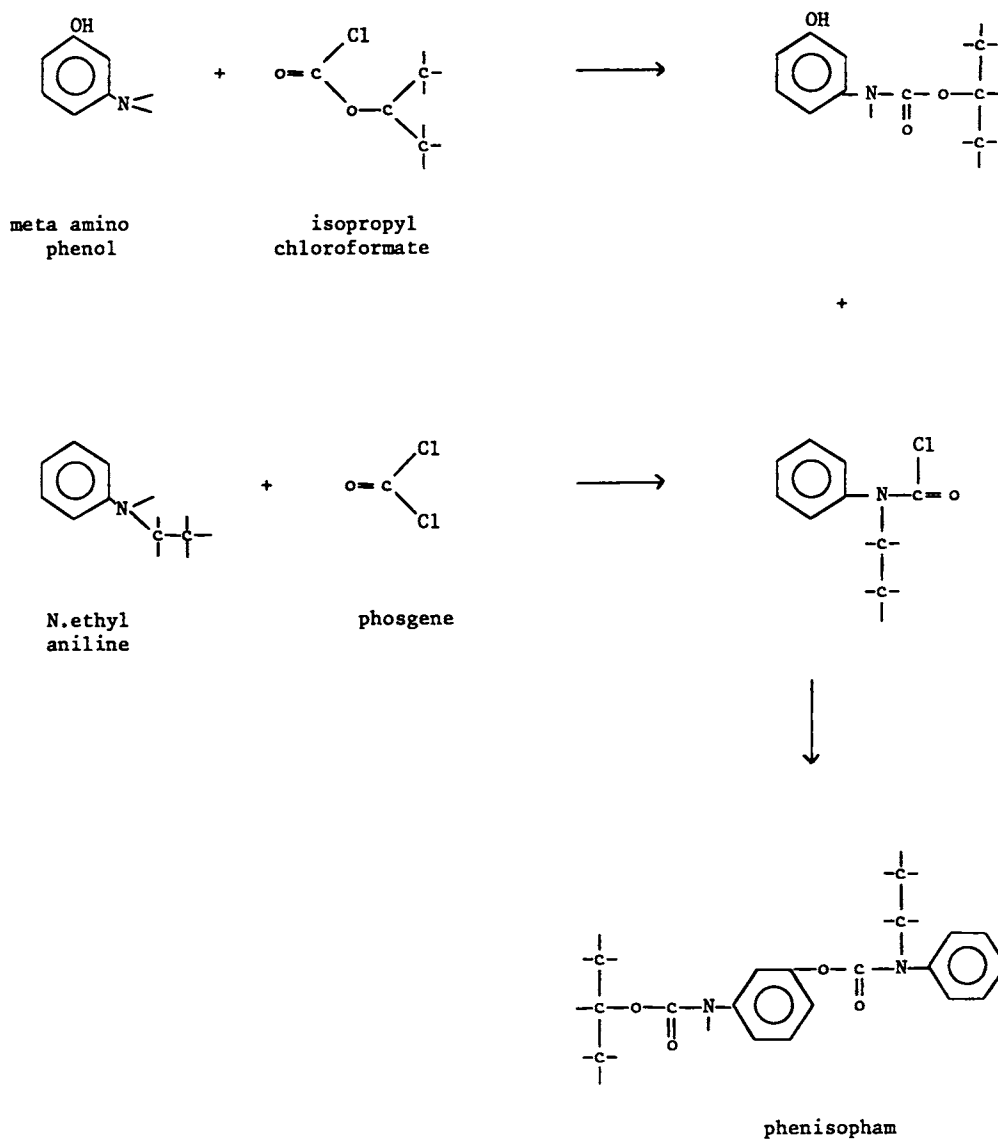
## Phenisopham

Uses: herbicide, cotton

Trade names: Verdinal (Schering)

Type: carbamate

Synthesis:



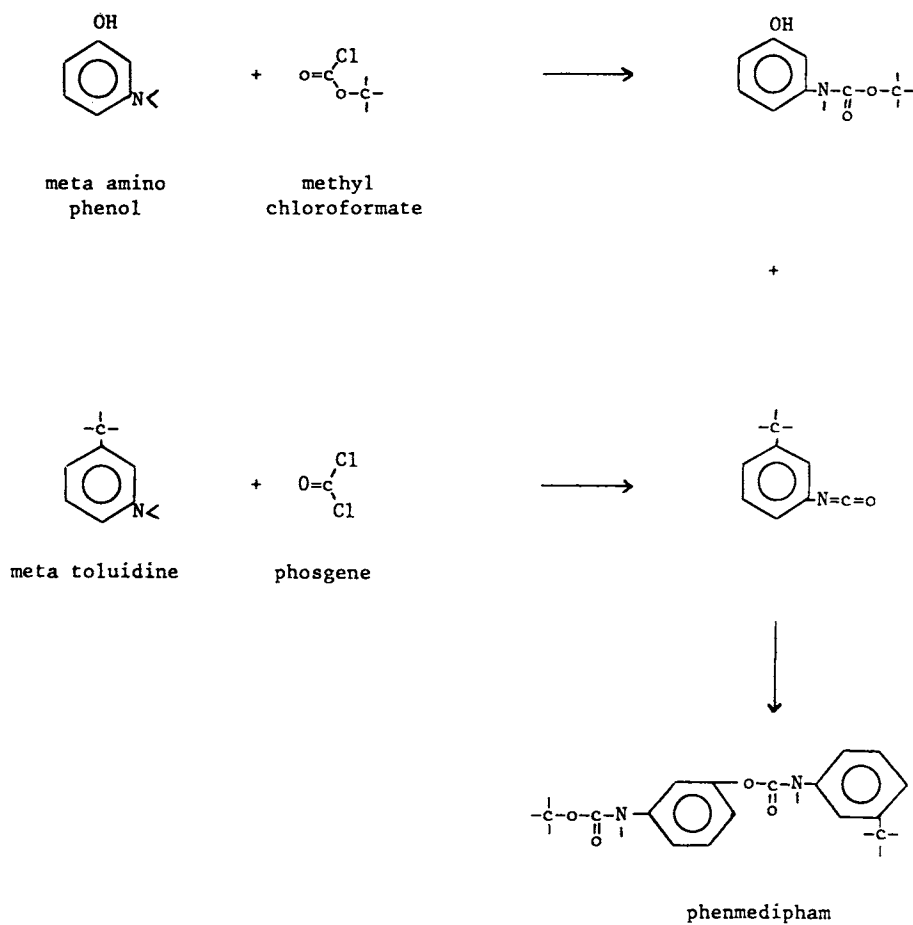
## Phenmedipham

Uses : herbicide, sugar beet

Trade names: Betanal (Schering)

Type : carbamate

Synthesis :





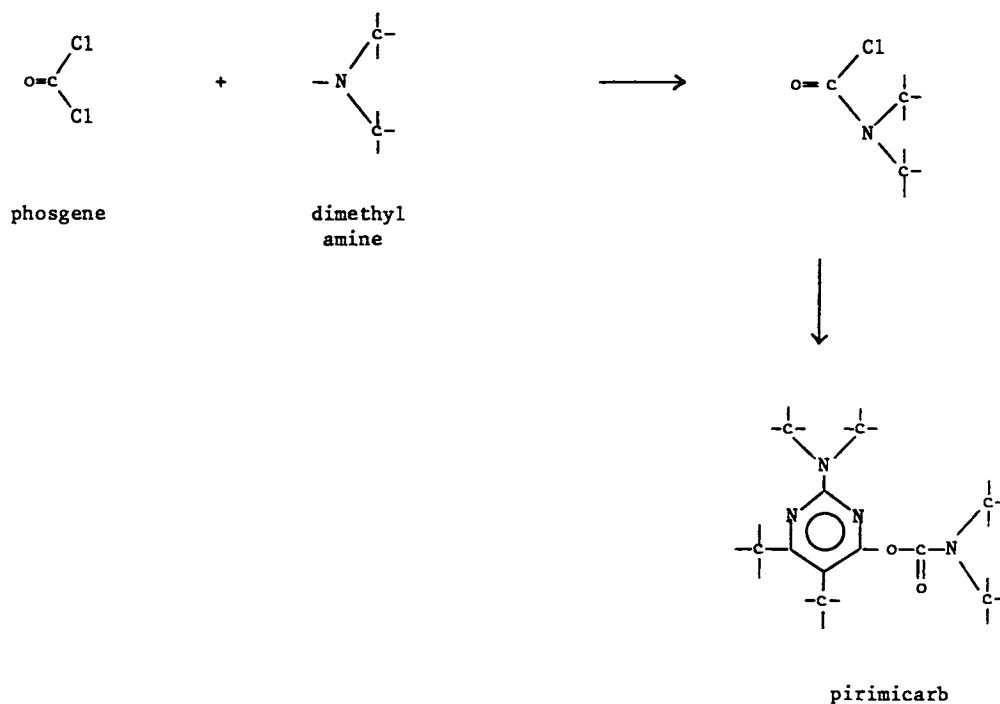
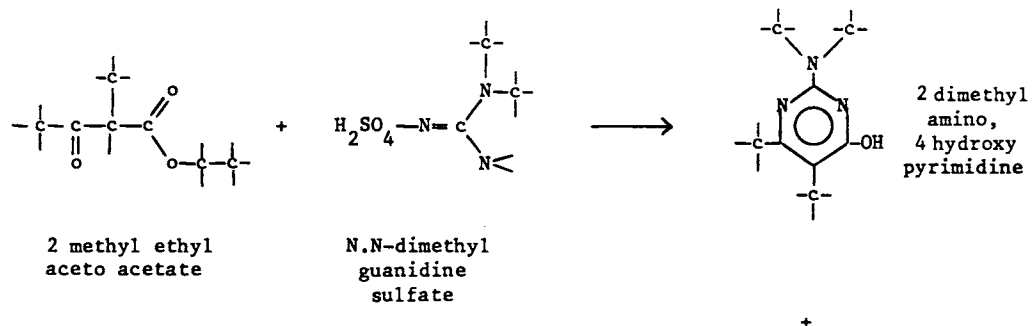
## Pirimicarb

Uses: insecticide, cereals, ornamentals, vegetables, fruits

Trade names: Pirimor, Aphox (ICI)

Type: carbamate, pyrimidine

Synthesis:



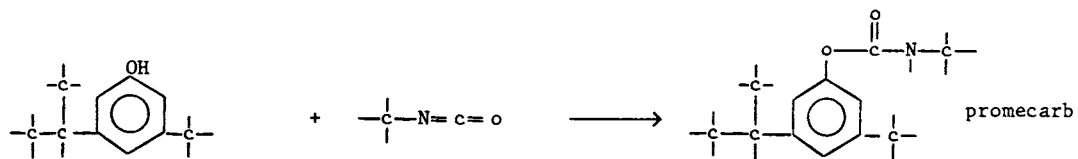
## Promacyl

Uses: insecticide, cattle, horses

Trade names: Promicide (ICI)

Type: carbamate

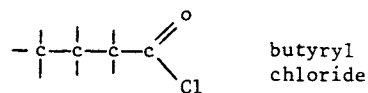
Synthesis:



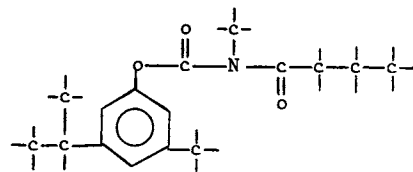
3 methyl  
5 isopropyl  
phenol

methyl  
isocyanate

+



butyryl  
chloride



promacyl

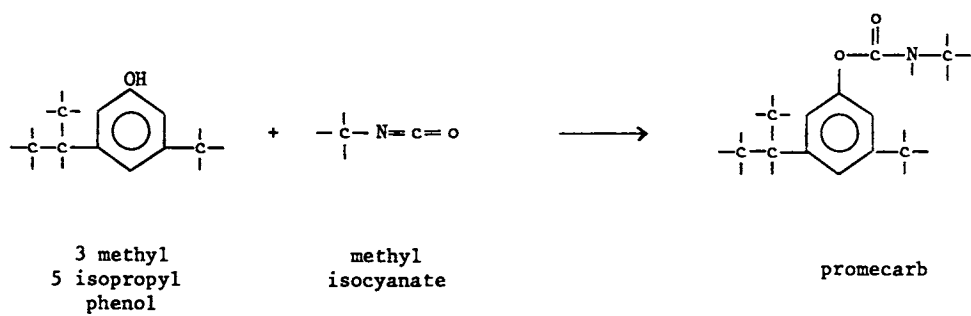
## Promecarb

Uses: insecticide, citrus, potatoes

Trade names: Carbamult (Schering)

Type: carbamate

Synthesis:



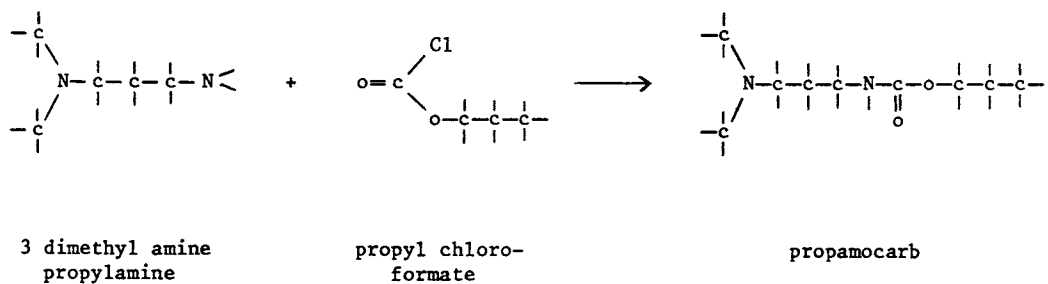
## Propamocarb

Uses: fungicide, ornamentals, potatoes, tobacco, vegetables

Trade names: Previcur N (Schering)

Type: carbamate

Synthesis:



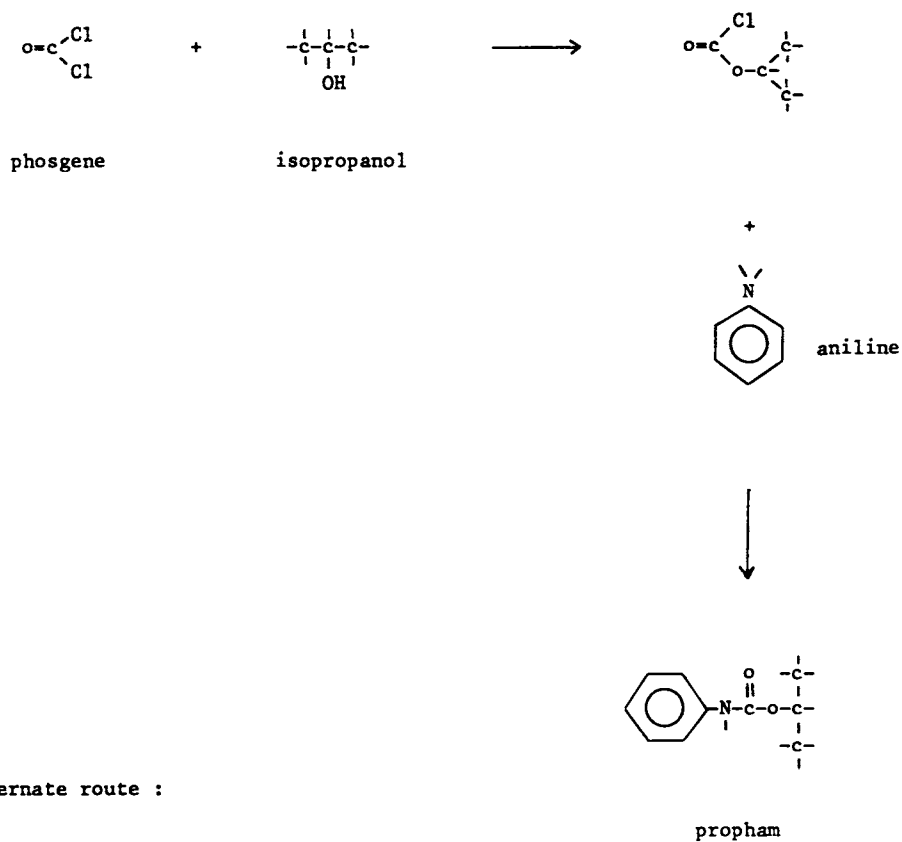
## Propham

Uses: herbicide, sugar beet

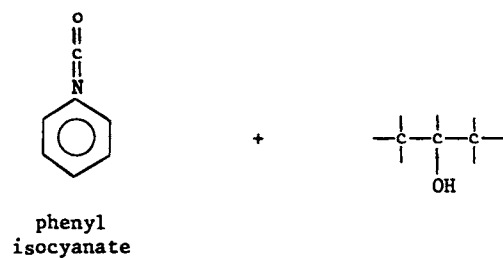
Trade names: Birgin (Bayer)

Type: carbamate

Synthesis:



alternate route :



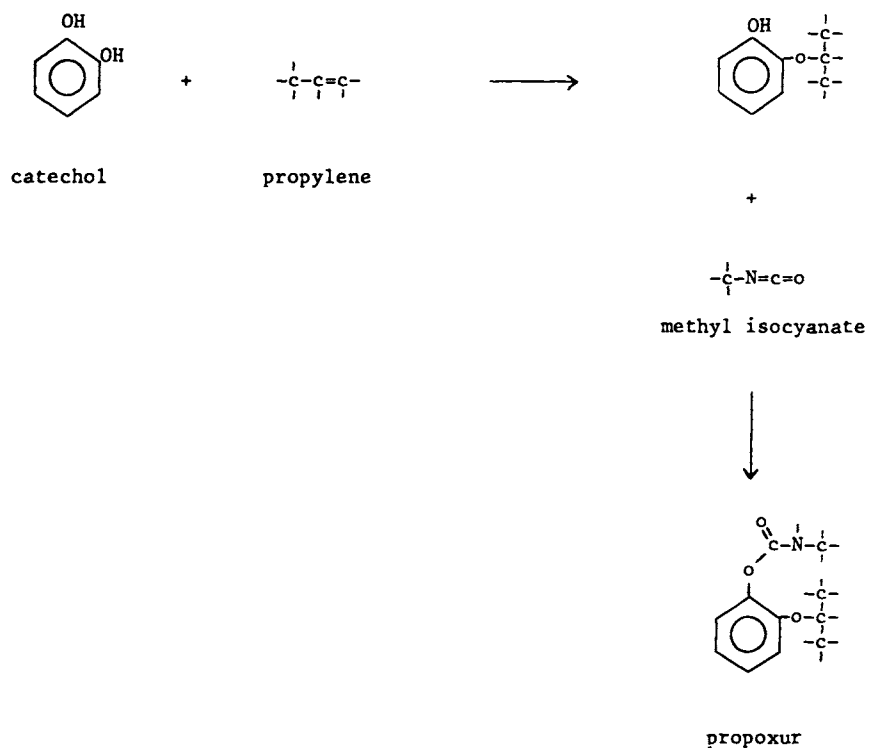
## Propoxur

Uses: insecticide, cocoa, rice, vegetables, households

Trade names: Baygon, Blattanex, Unden, Undene (Bayer)

Type: carbamate

Synthesis:



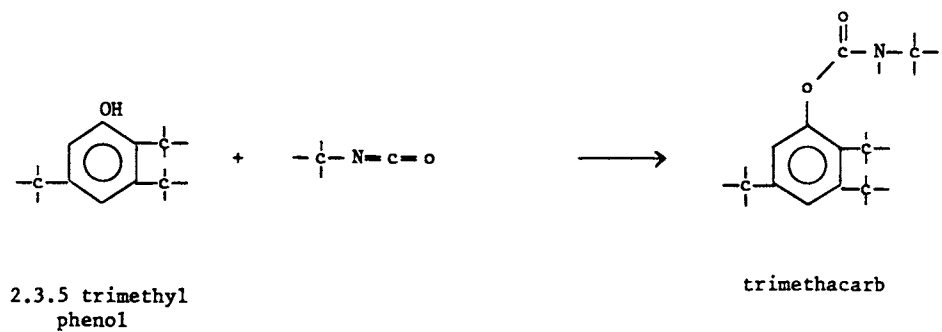
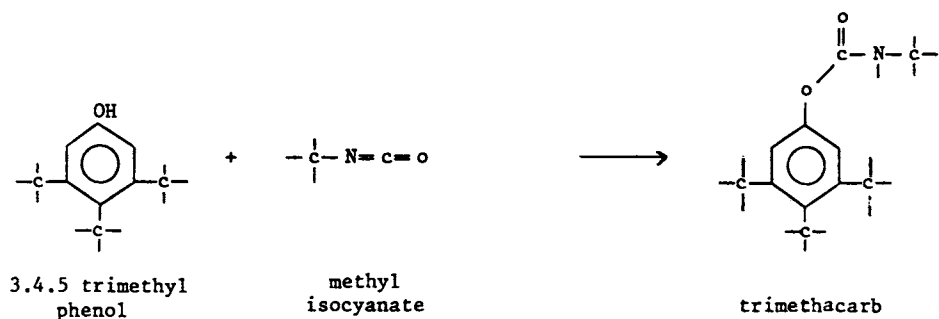
## Trimethacarb

Uses: insecticide, molluscicide, maize

Trade names: Broot (Rhône Poulenc), Landrin (Shell)

Type: carbamate

Synthesis:



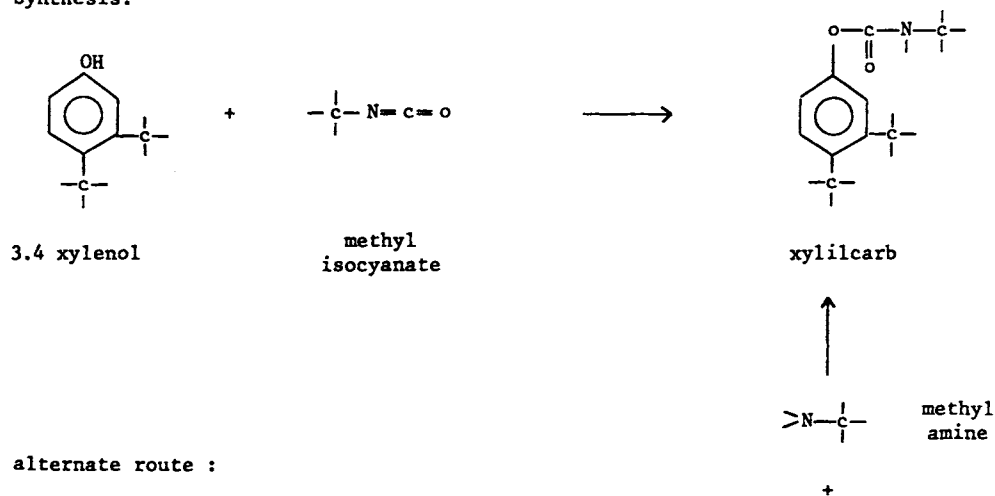
## Xylilcarb

Uses: insecticide, rice, tea

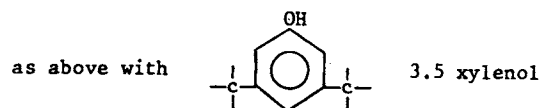
Trade names: Meobal (Sumitomo)

Type: carbamate

Synthesis:



## X M C





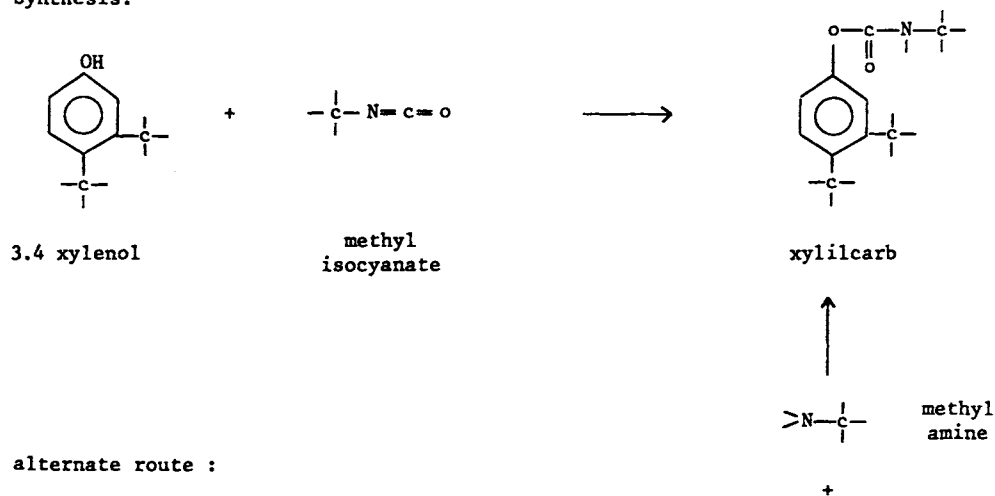
## Xylilcarb

Uses: insecticide, rice, tea

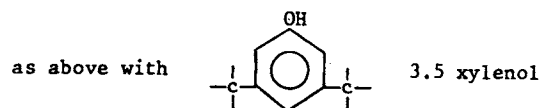
Trade names: Meobal (Sumitomo)

Type: carbamate

### Synthesis:



## X M C



# THIOCARBAMATES

The most common routes for the synthesis of thiocarbamates with a

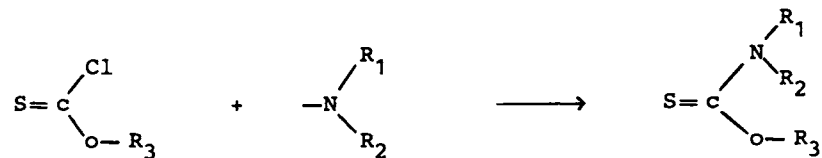
structure  $\begin{array}{c} \text{—N—C—S—} \\ | \quad || \\ \quad \text{O} \end{array}$  are similar to those for carbamates.

Thiocarbamates of the type  $\begin{array}{c} \text{R}_1\text{—N—C—O—R}_3 \\ | \quad || \\ \text{R}_2 \quad \text{S} \end{array}$  are usually

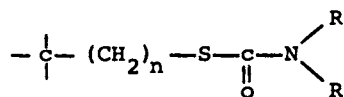
synthesized by reacting an alcohol with thiophosgene



followed by reaction of the thiochloroformate with an amine



Common structures for thiocarbamates are :

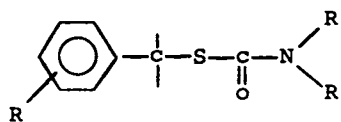


n = 1

butylate  
cycloate  
EPTC  
molinate  
prothiocarb

n = 2

pebulate  
vernolate



esprocarb  
orbencarb  
prosulfocarb  
thiobencarb  
tiocarbazil

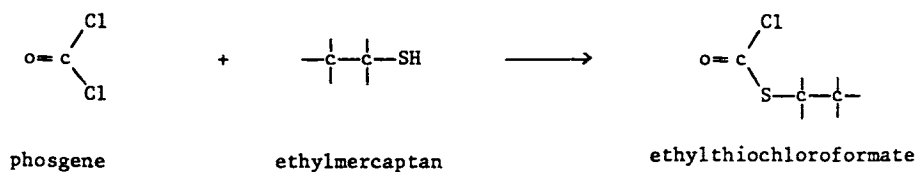
## Butylate

Uses: herbicide, maize

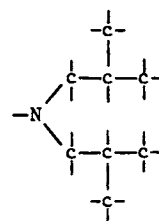
Trade names: Sutan (ICI)

Type: thiocarbamate

Synthesis:

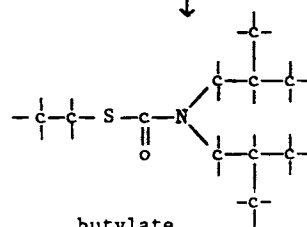


+



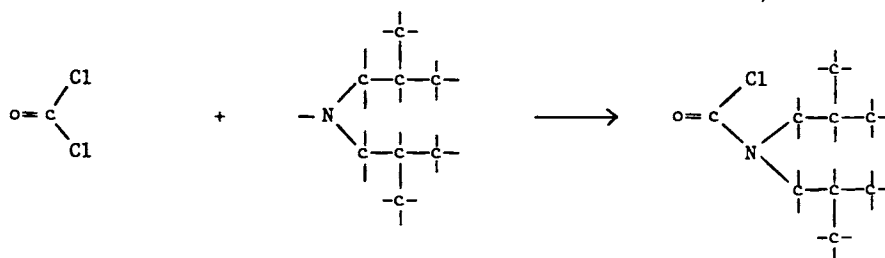
diisobutylamine

safener



butylate

alternate route:



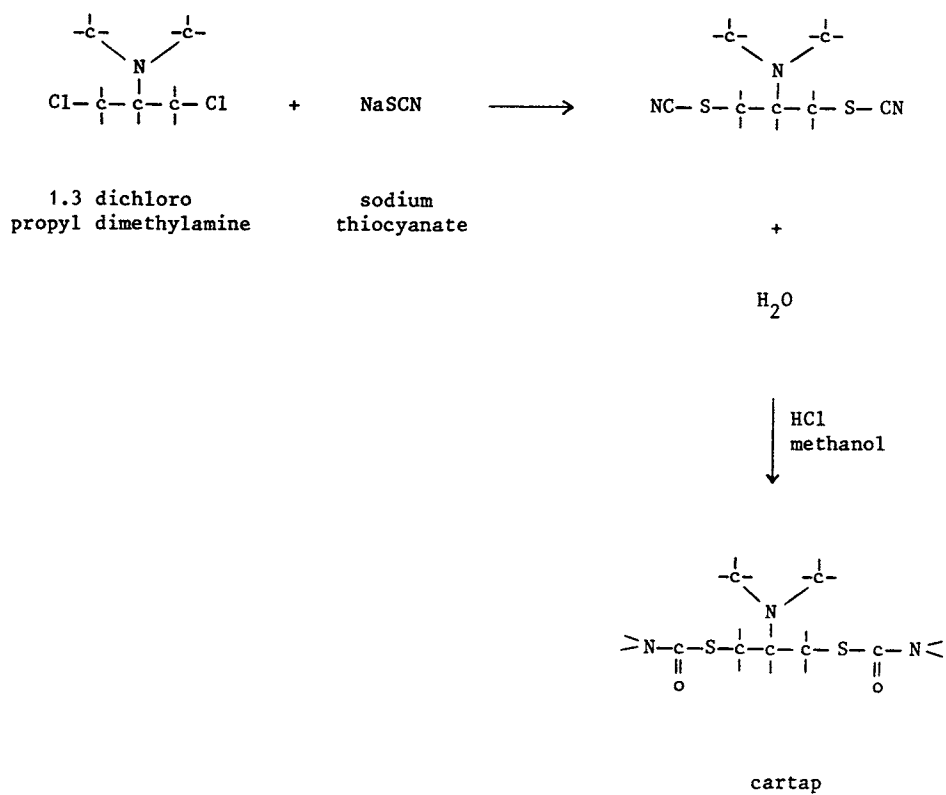
## Cartap

Uses: insecticide, rice, vegetables

Trade Names: Padan, Cadan, Patap, Sanvex, Thiobel, Vegetox (Takeda)

Type: thiocarbamate

Synthesis:



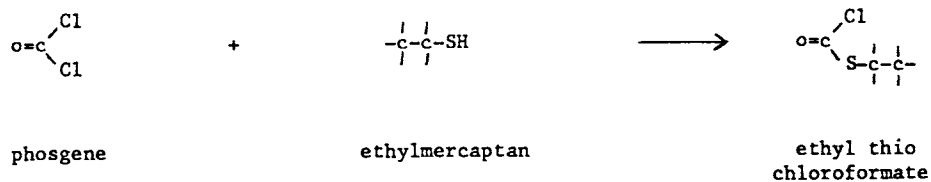
## Cycloate

Uses: herbicide, sugar beet, vegetables

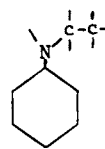
Trade names: Ro-Neet (ICI)

Type: thiocarbamate

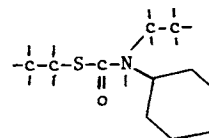
Synthesis:



+



N-ethylcyclohexyl  
amine



cycloate

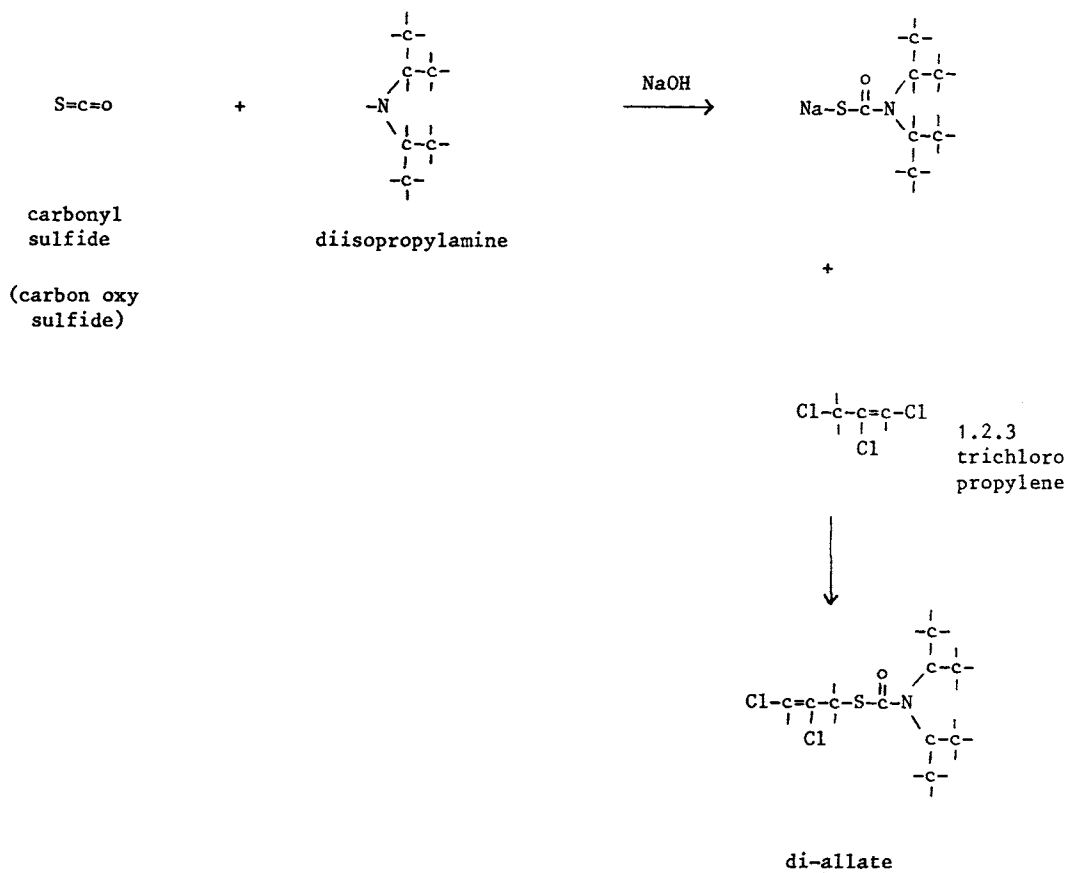
## Di-Allate

Uses: herbicide, barley, potatoes, soyabeans, sugar beet, maize

Trade names: Avadex (Monsanto)

Type: thiocarbamate

Synthesis:



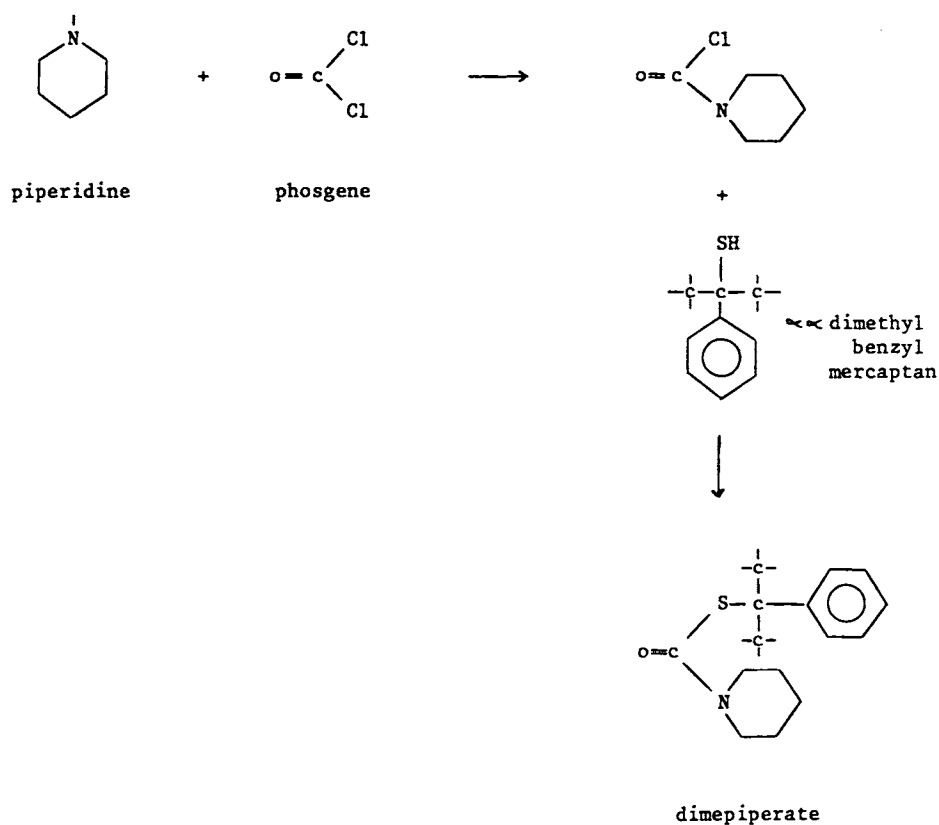
## Dimepiperate

Uses: herbicide, rice

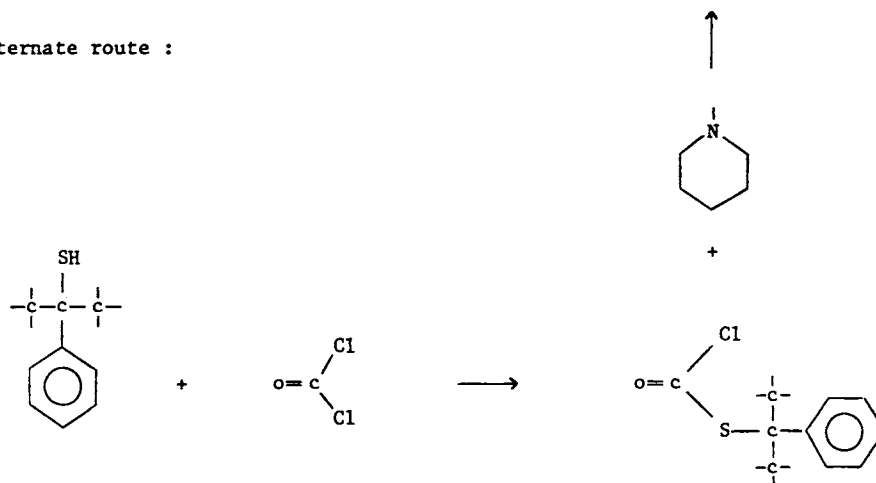
Trade names: Yukamate (Mitsubishi)

Type: thiocarbamate, piperidine

Synthesis:



alternate route :





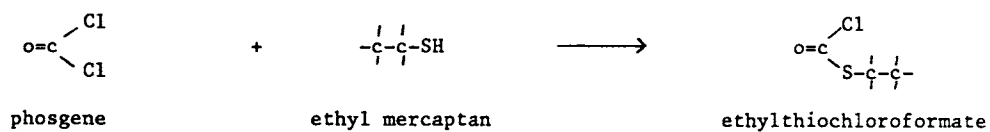
## EPTC

Uses: herbicide, potatoes, sugar beet, cotton, sunflowers, citrus, nuts  
ornamentals, maize

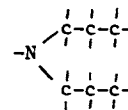
Trade names: Eptam (ICI)

Type: thiocarbamate

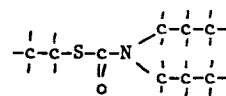
Synthesis:



+

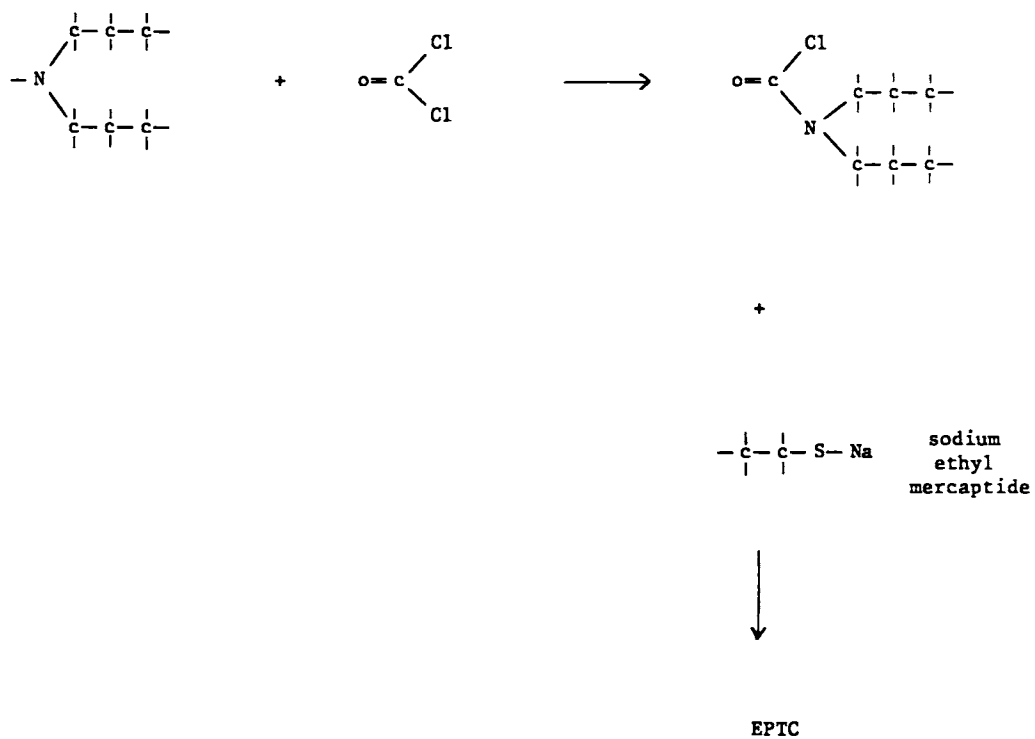


di-n propylamine



EPTC

alternate route :



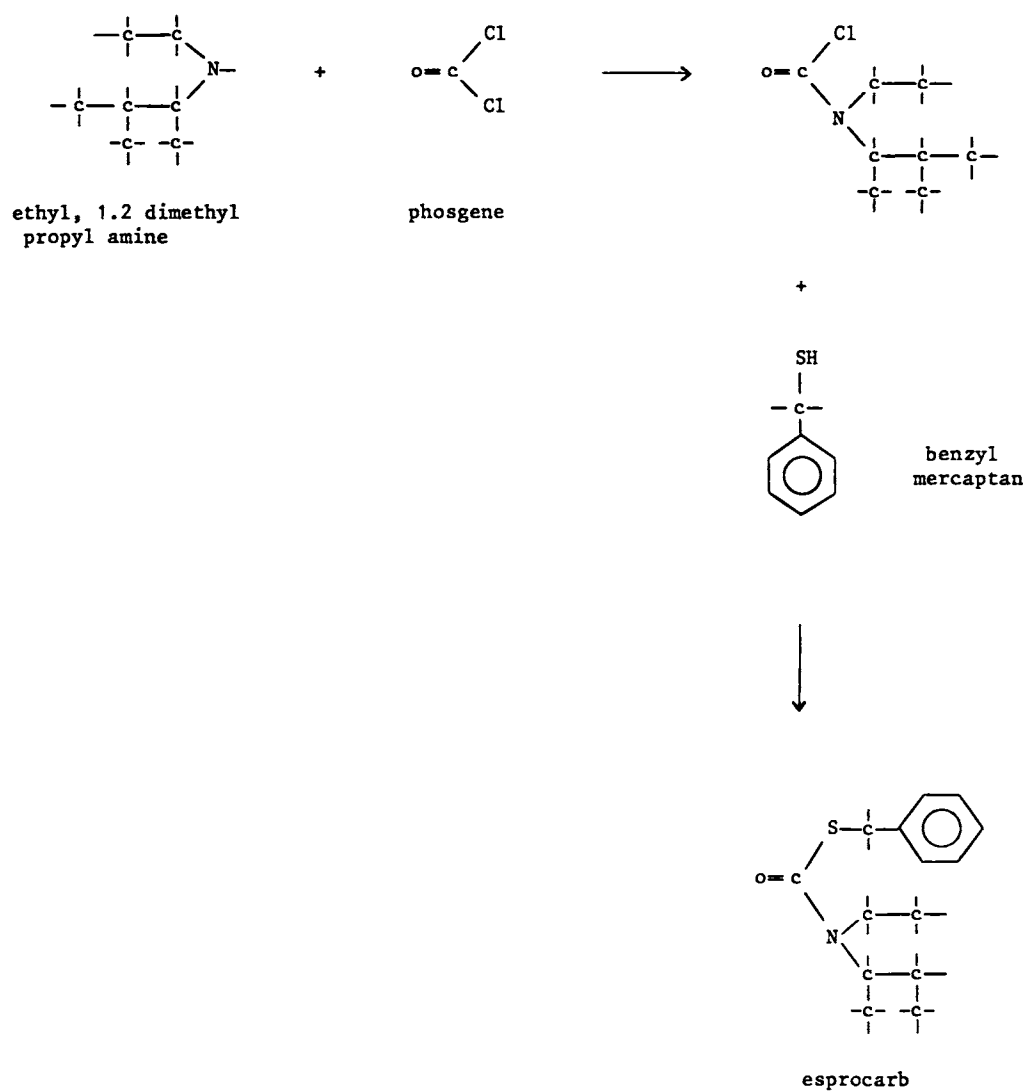
## Esprocarb

Uses: herbicide, rice

Trade names: Fugi-grass (ICI)

Type: thiocarbamate

Synthesis:



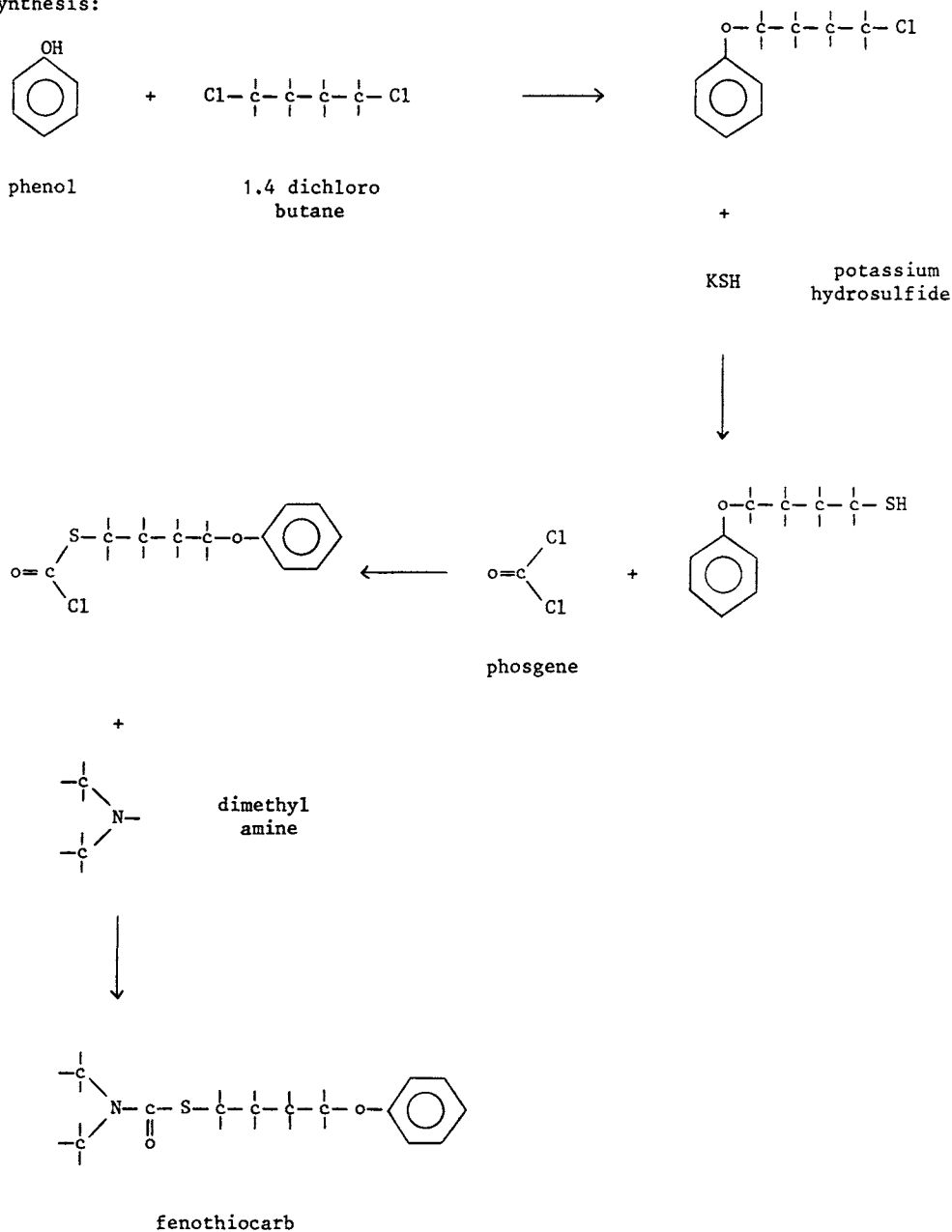
## Fenothiocarb

Uses: acaricide, citrus

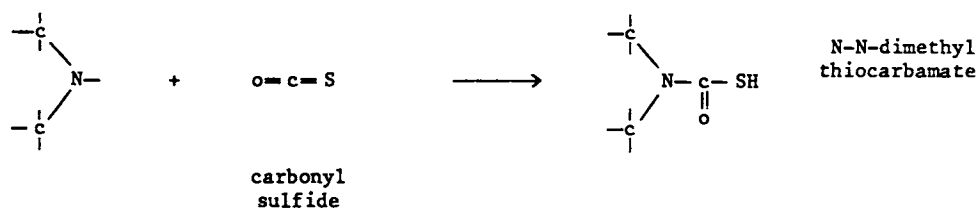
Trade names: Panocon (Kumiai)

Type: thiocarbamate

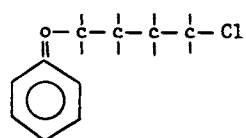
Synthesis:



alternate route:



+



fenothiocarb

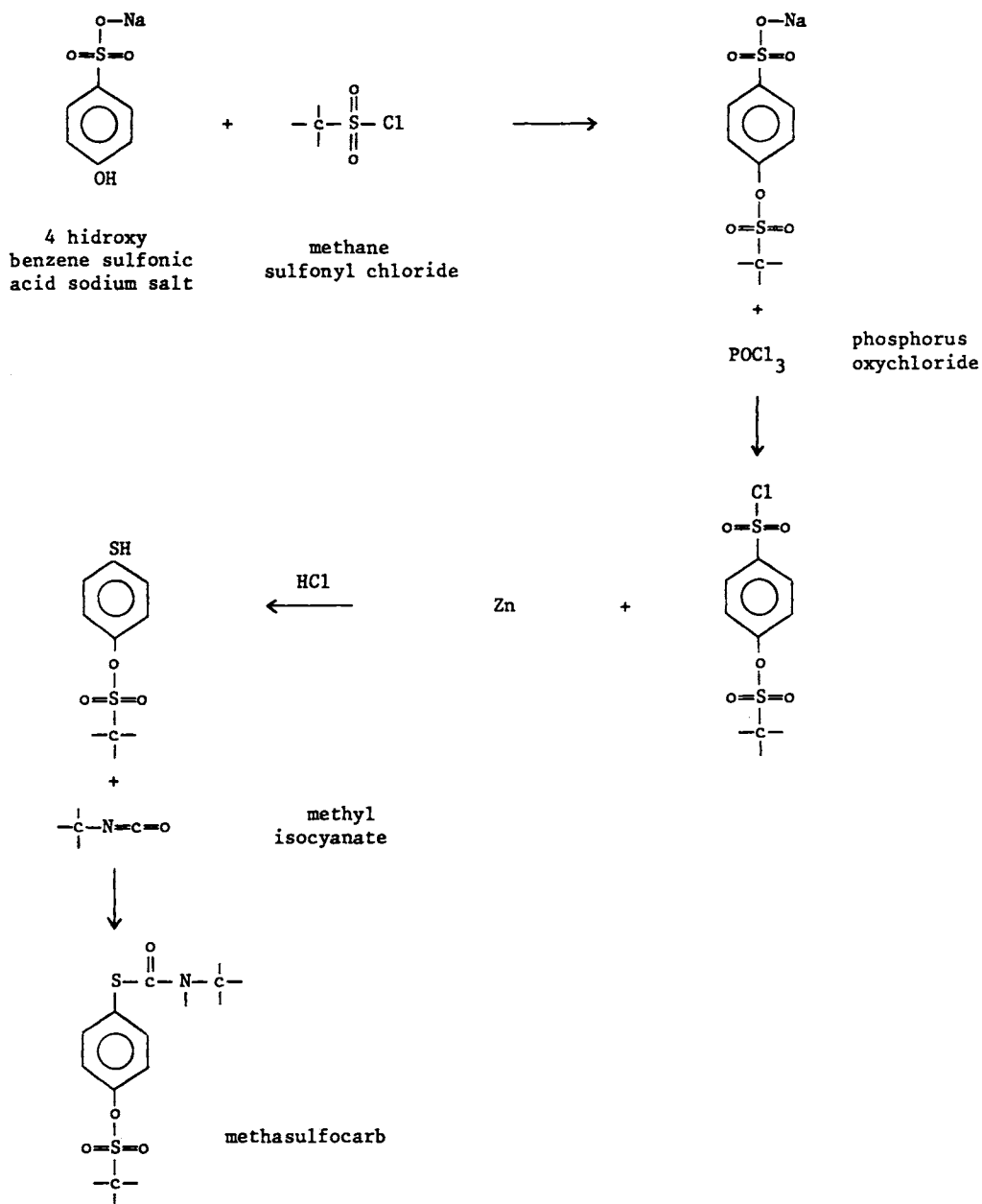
## Methasulfocarb

Uses: fungicide, rice

Trade names: Kayabest (Nippon)

Type: thiocarbamate, sulfonate

Synthesis:



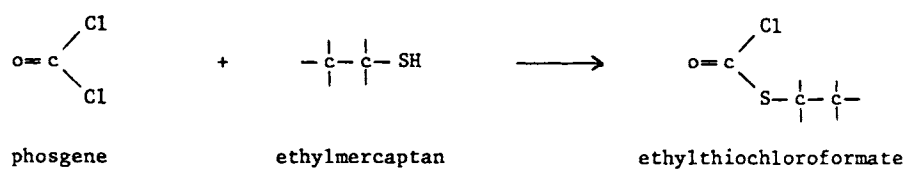
## Molinate

Uses: herbicide, rice

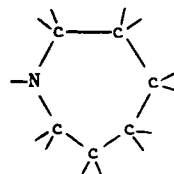
Trade names: Ordram (ICI)

Type: thiocarbamate

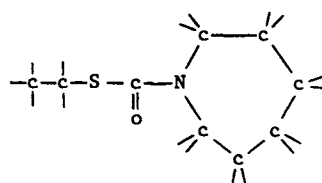
Synthesis:



+



hexamethyleneimine



molinate

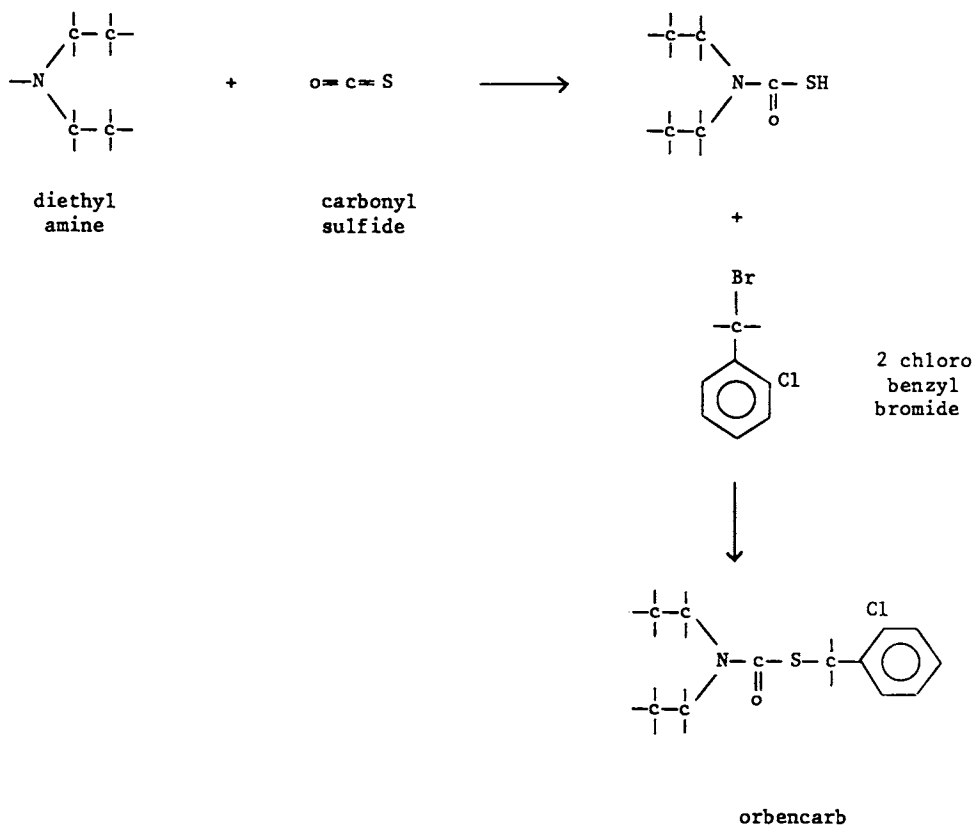
## Orbencarb

Uses: herbicide, wheat, barley, turf

Trade names: Lanray (Kumiai)

Type: thiocarbamate

Synthesis:





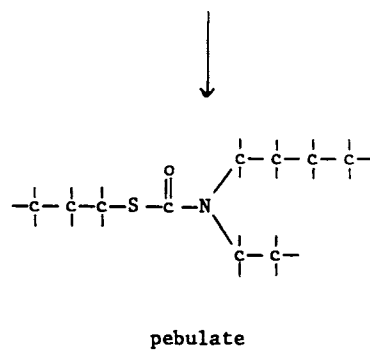
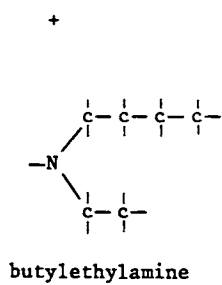
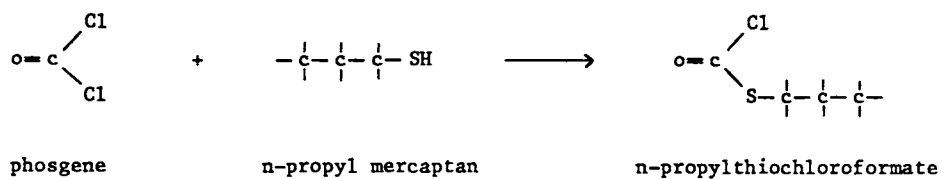
## Pebulate

Uses: herbicide, sugar beet, tomatoes, tobacco

Trade names: Tillam (ICI)

Type: thiocarbamate

**Synthesis:**





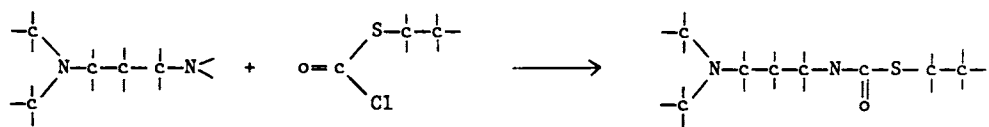
## Prothiocarb

Uses: fungicide

Trade names: Previcur, Dynone (Schering)

Type: thiocarbamate

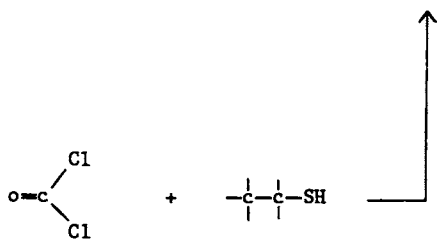
Synthesis:



N-N-dimethyl  
propane diamine

S ethyl chloro  
thioformate

prothiocarb



phosgene

ethyl  
mercaptan

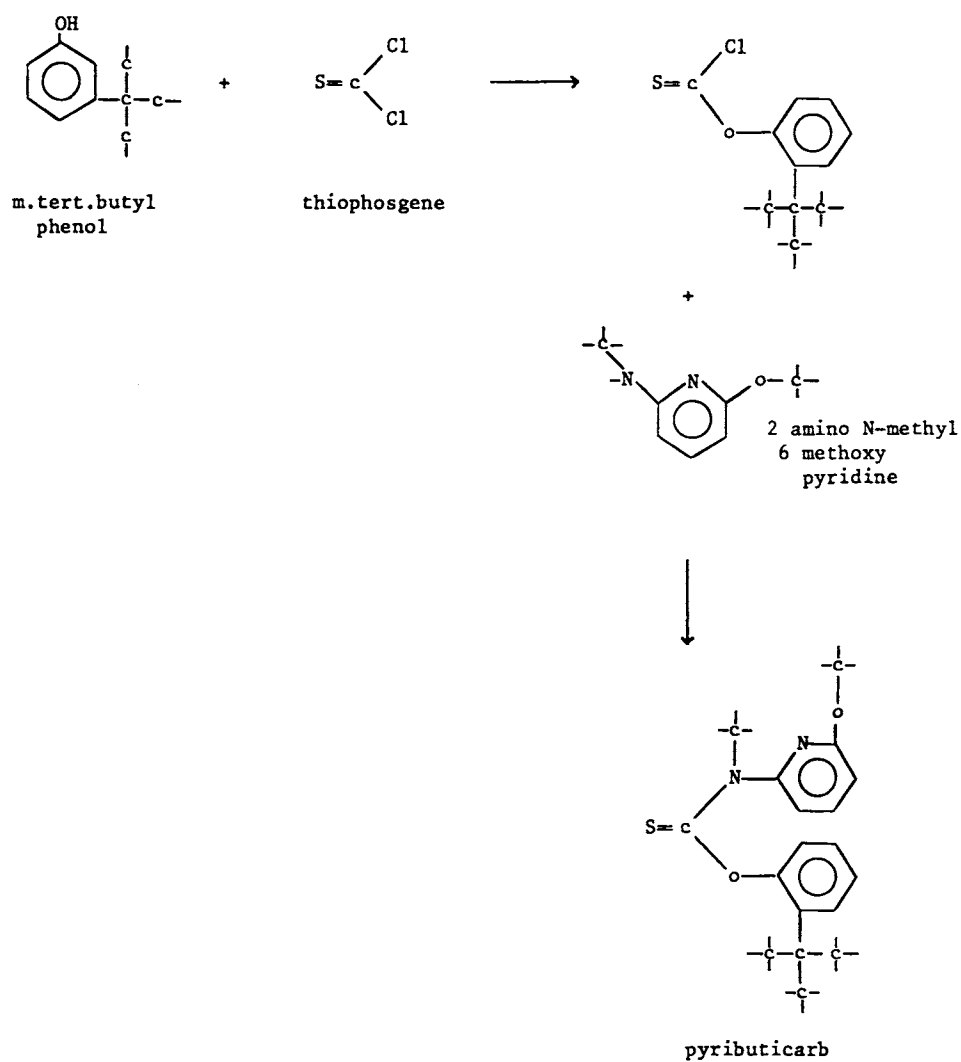
## Pyributicarb

Uses: herbicide

Trade names: (Tosoh)

Type: thiocarbamate, pyridine

Synthesis:



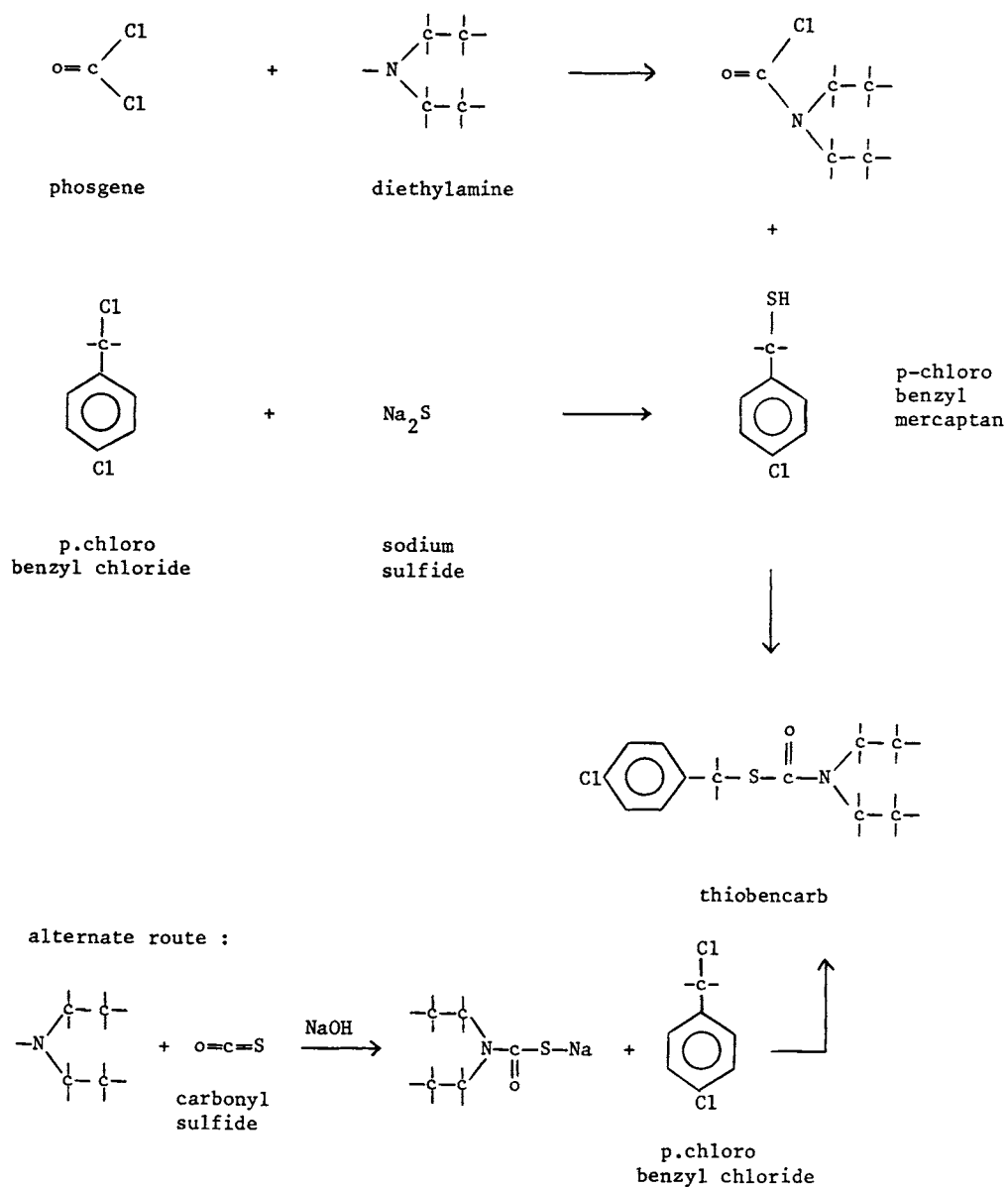
## Thiobencarb

Uses: herbicide, rice

Trade names: Saturn (Kumiai), Bolero (Chevron)

Type: thiocarbamate

**Synthesis:**



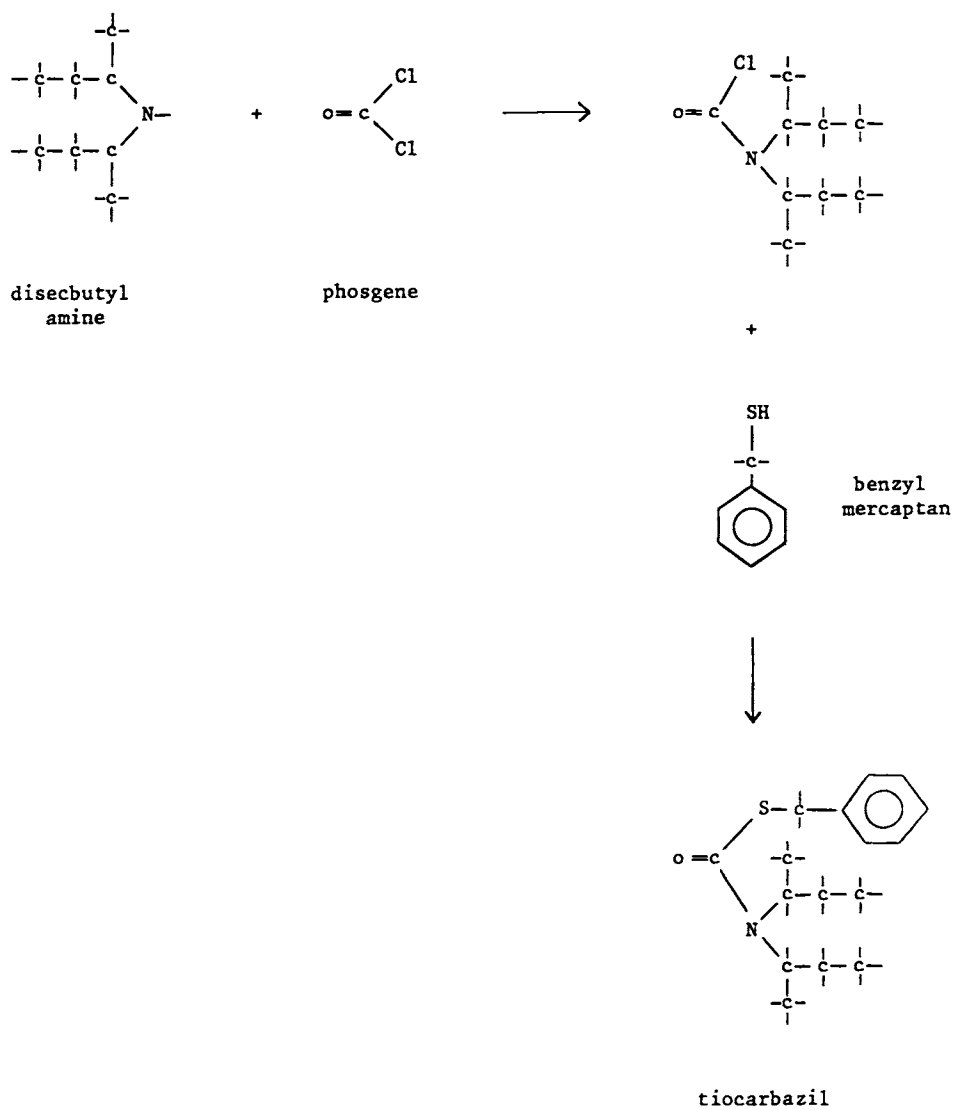
## Tiocarbazil

Uses: herbicide, rice

Trade names: Drepamon (Agrimont)

Type: thiocarbamate

Synthesis:



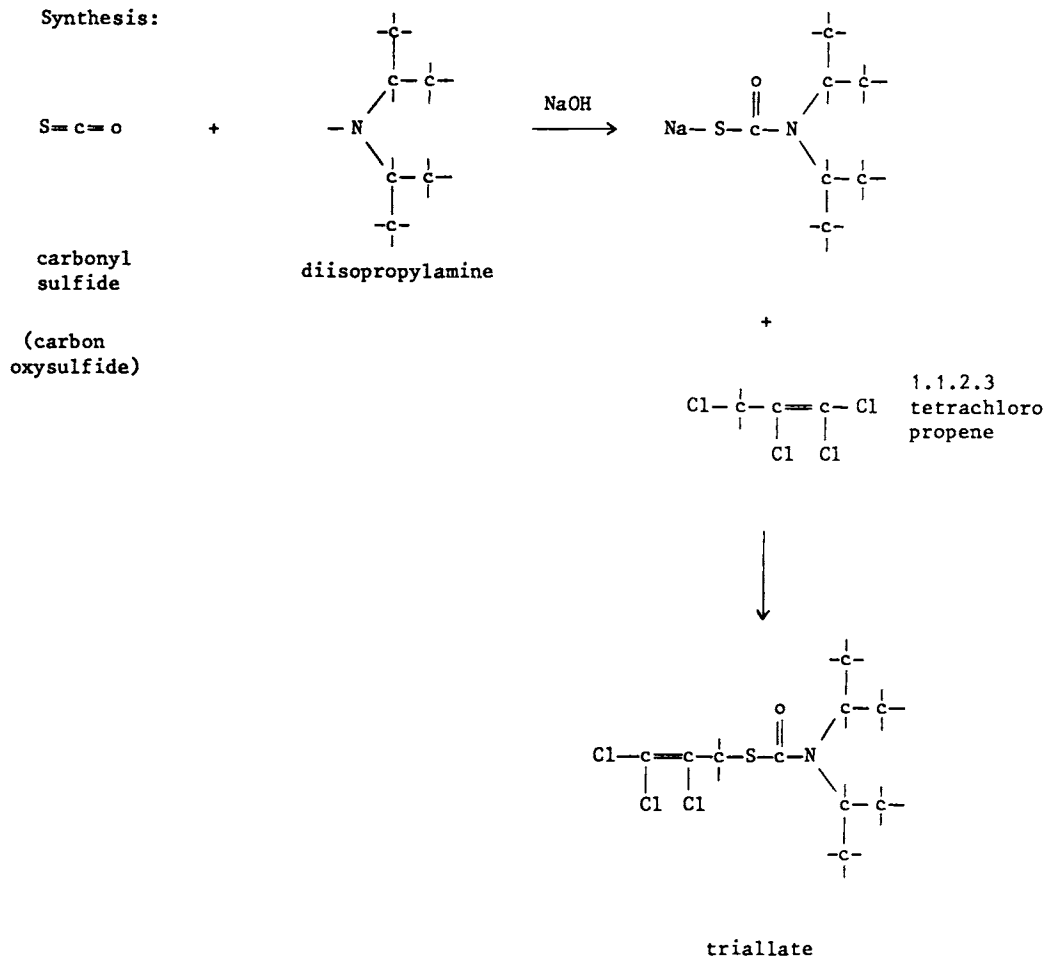
## Triallate

Uses: herbicide, barley, wheat

Trade names: Avadex BW, Far-60 (Monsanto)

Type: thiocarbamate

Synthesis:



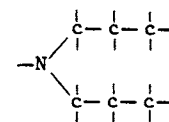
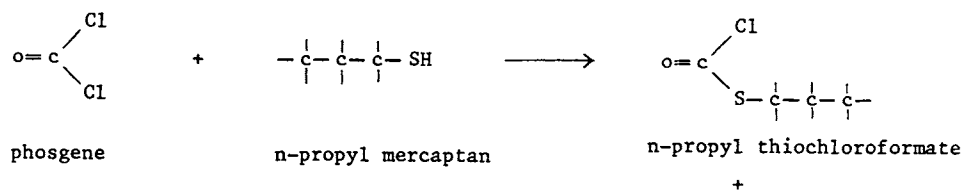
## Vernolate

Uses: herbicide, ground nuts, soyabeans

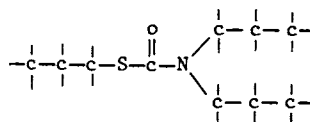
Trade names: Vernam (ICI)

Type: thiocarbamate

Synthesis:



di n-propylamine

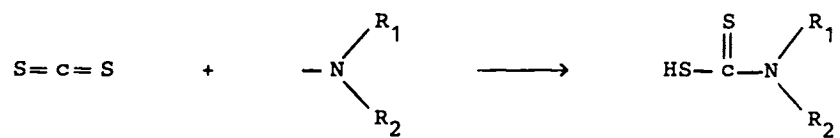


vernolate



## DITHIOCARBAMATES

Carbon disulfide is the starting point for dithiocarbamate synthesis via reaction with an amine



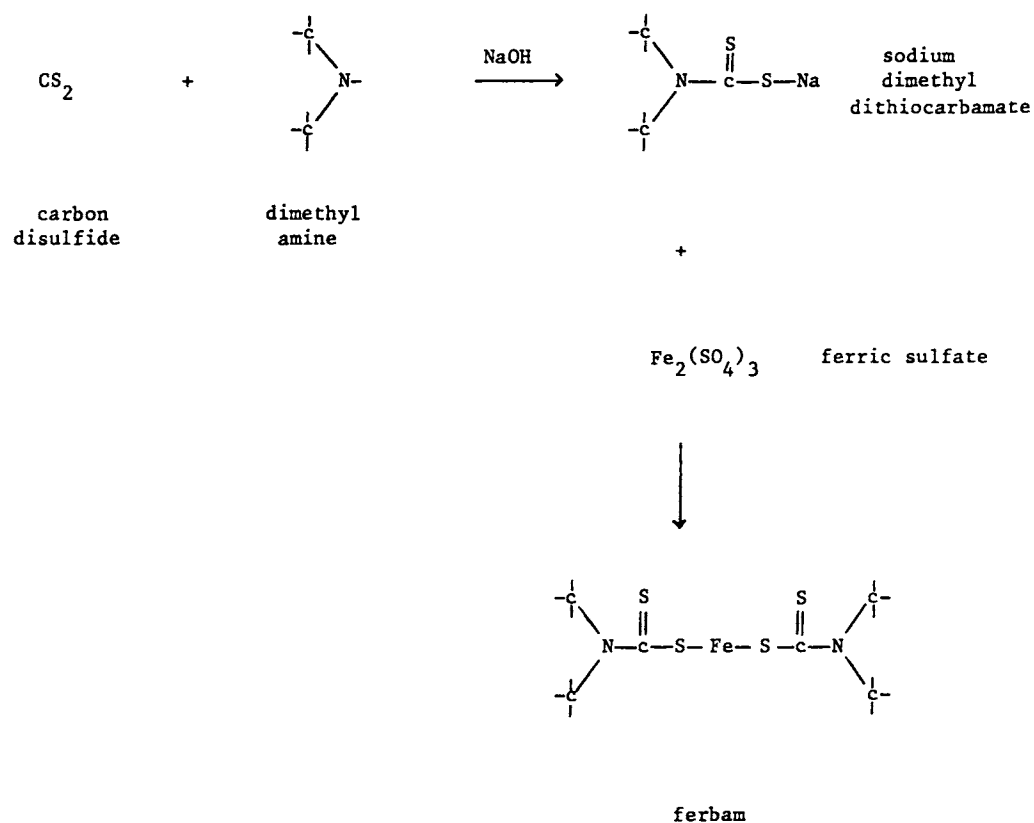
## Ferbam

Uses: fungicide, fruit

Trade names: Fermate (Dupont)

Type: dithiocarbamate

Synthesis:



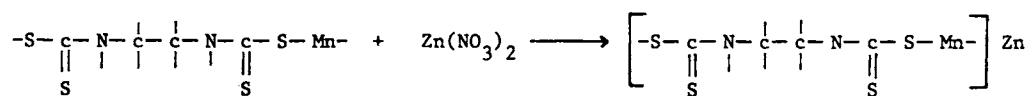
## Mancozeb

Uses: fungicide, fruit, ornamentals, vegetables, potatoes, cereals

Trade names: Dithane M-45 (Rohm & Haas), Manzate (Dupont)

Type: dithiocarbamate

Synthesis:



Maneb  
manganese ethylene  
bis thiocarbamate

zinc  
nitrate

mancozeb

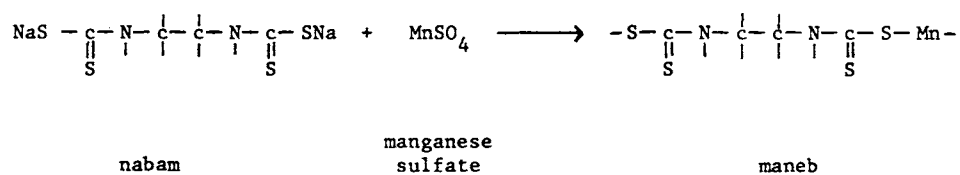
## Maneb

Uses: fungicide, bananas, fruit, nuts, ornamentals, turf, vegetables, potatoes, cereals

Trade names: Manzate (Dupont), Dithane M-22 (Rohm & Haas)

Type: dithiocarbamate

**Synthesis:**



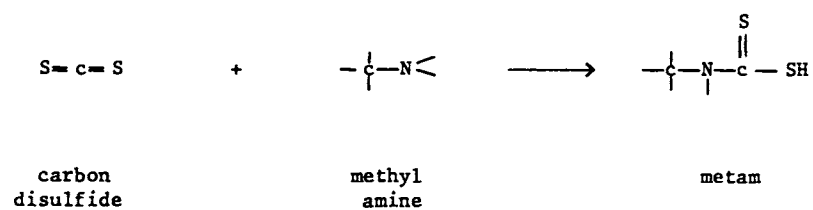
## Metam

Uses: fungicide

Trade names: Vapam (ICI), VPM (Dupont)

Type: dithiocarbamate

Synthesis:



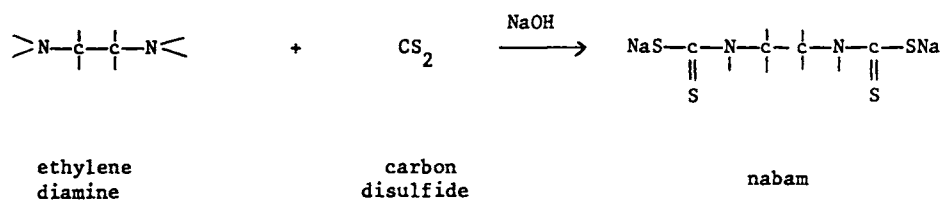
## Nabam

Uses: fungicide, rice, cotton, onions

Trade names: Parzate (Dupont), Dithane D-14 (Rohm & Haas)

Type: dithiocarbamate

Synthesis:



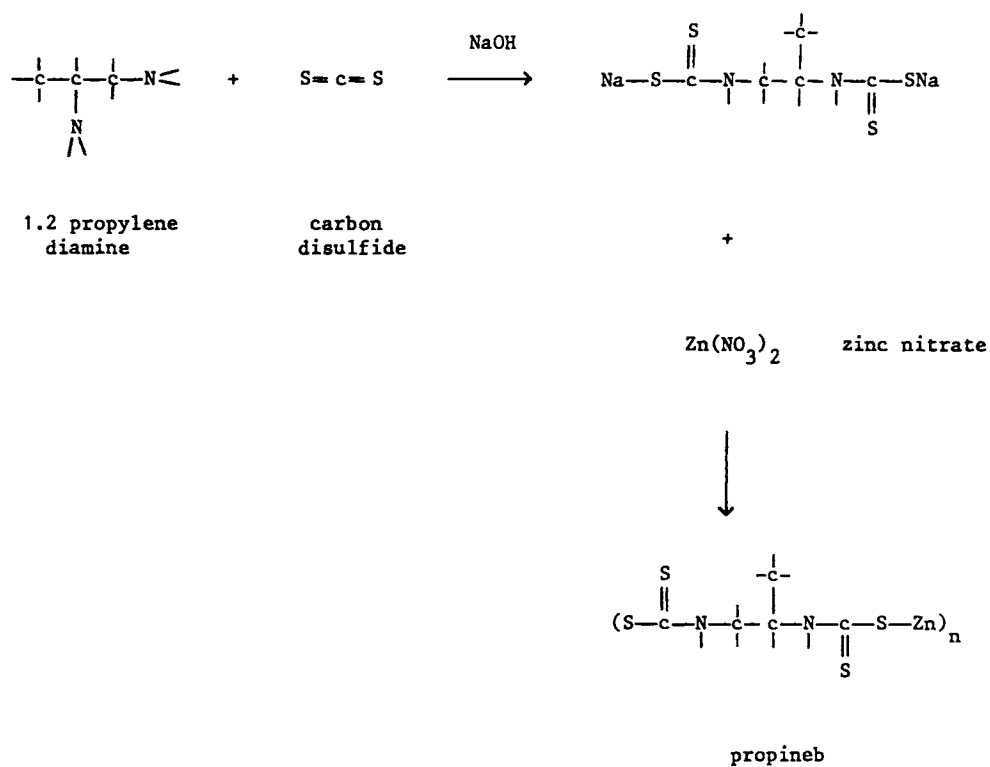
## Propineb

Uses: fungicide, potatoes, tomatoes, apples

Trade names: Antracol (Bayer)

Type: dithiocarbamate

Synthesis:



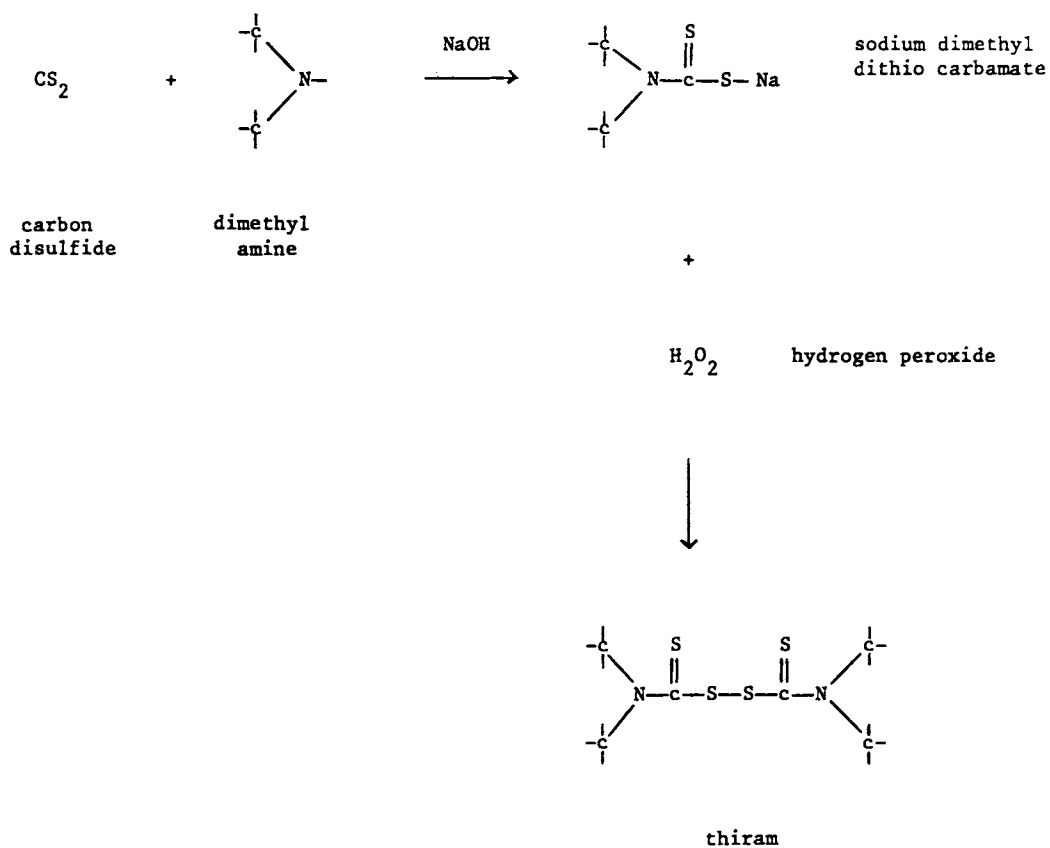
## Thiram

Uses: fungicide, ornamentals, vegetables, fruit, maize, repellent to birds, rodents

Trade names: Arasan, Tersan (Dupont), Pomarsol (Bayer), Fernasan (ICI)

Type: dithiocarbamate, disulfide

Synthesis:





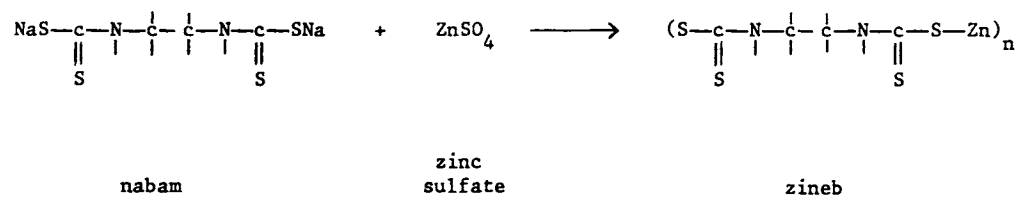
## Zineb

Uses: fungicide, potatoes, tomatoes

Trade names: Dithane Z-78 (Rohm & Haas), Tiezene (Agrimont), Parzate (Dupont)

Type: dithiocarbamate

Synthesis:



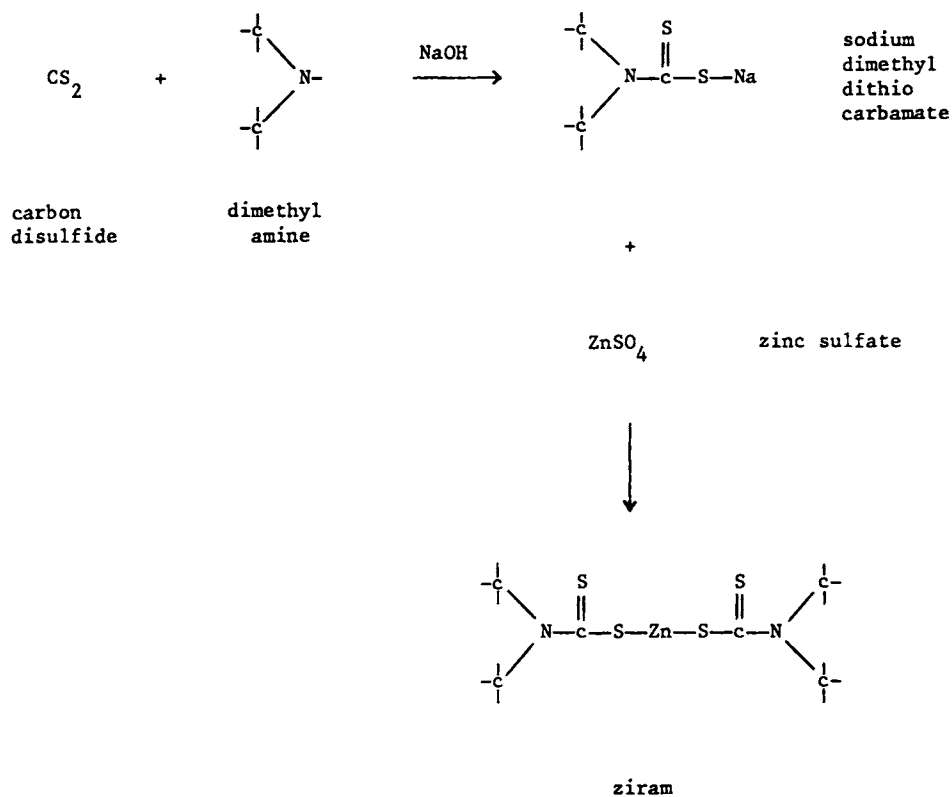
## Ziram

Uses: fungicide, fruit, vegetables, repellent to birds, animals

Trade names: Milbam, Zerlate, Fuklasin (Schering)

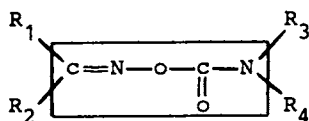
Type: dithiocarbamate

Synthesis:

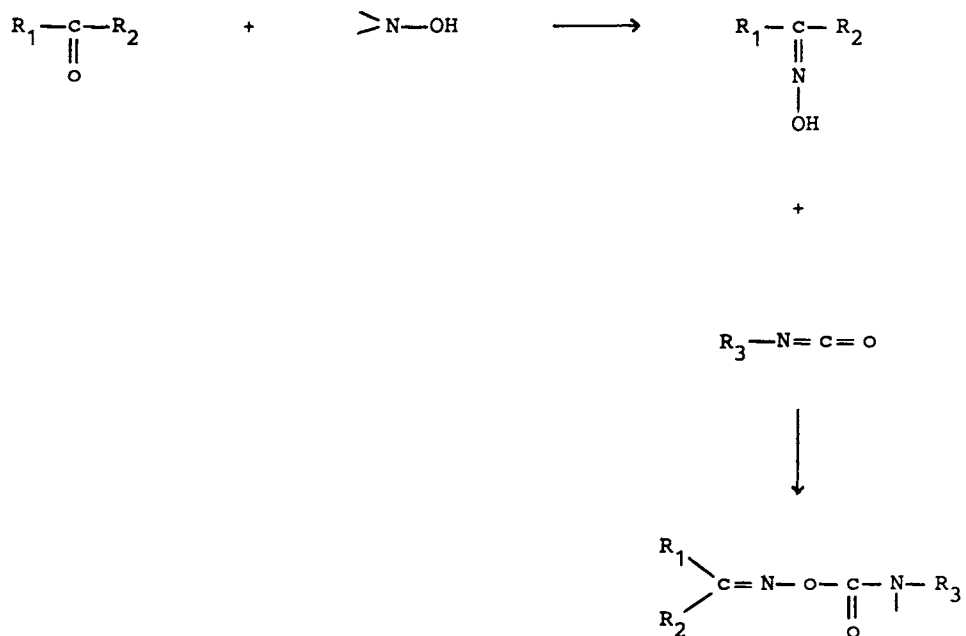


## OXIME AMIDES

Oxime amides (Carbamoyl oximes or oxyimino amides) are compounds with the function



The synthesis consists in forming the oxime by reaction of a carbonyl compound ( aldehyde or ketone ) with hydroxylamine followed by reaction with an isocyanate





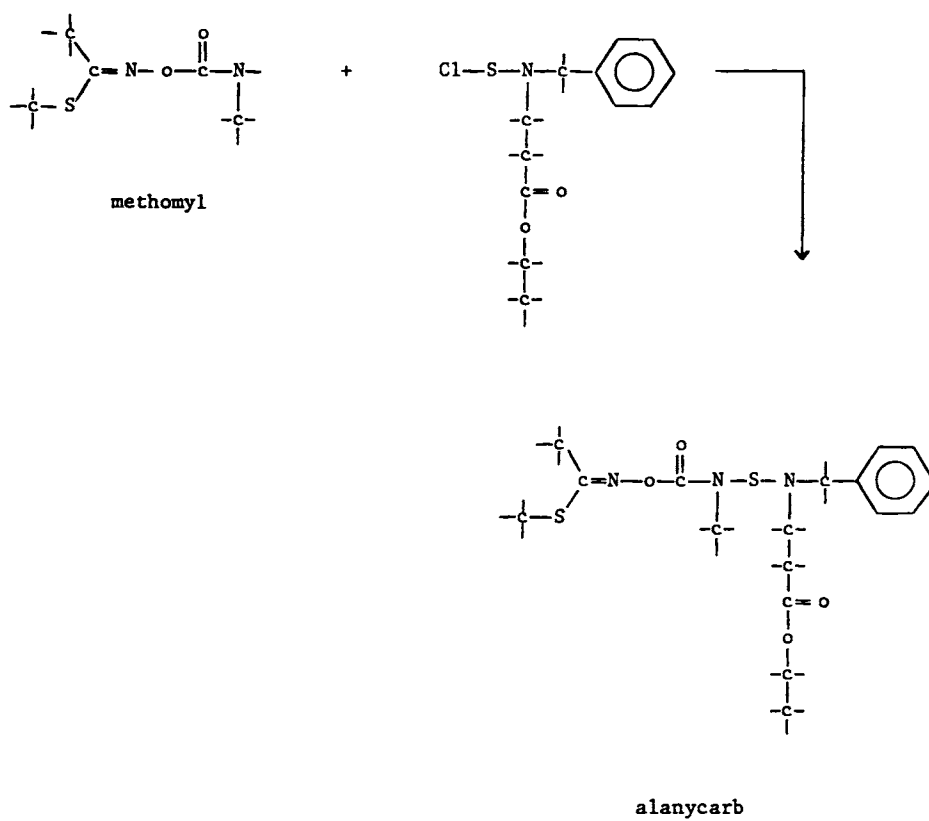
## Alanycarb

Uses: insecticide, grapes, tobacco, vegetables

Trade names: Orion (Otsuka)

Type: oxime amide

**Synthesis:**



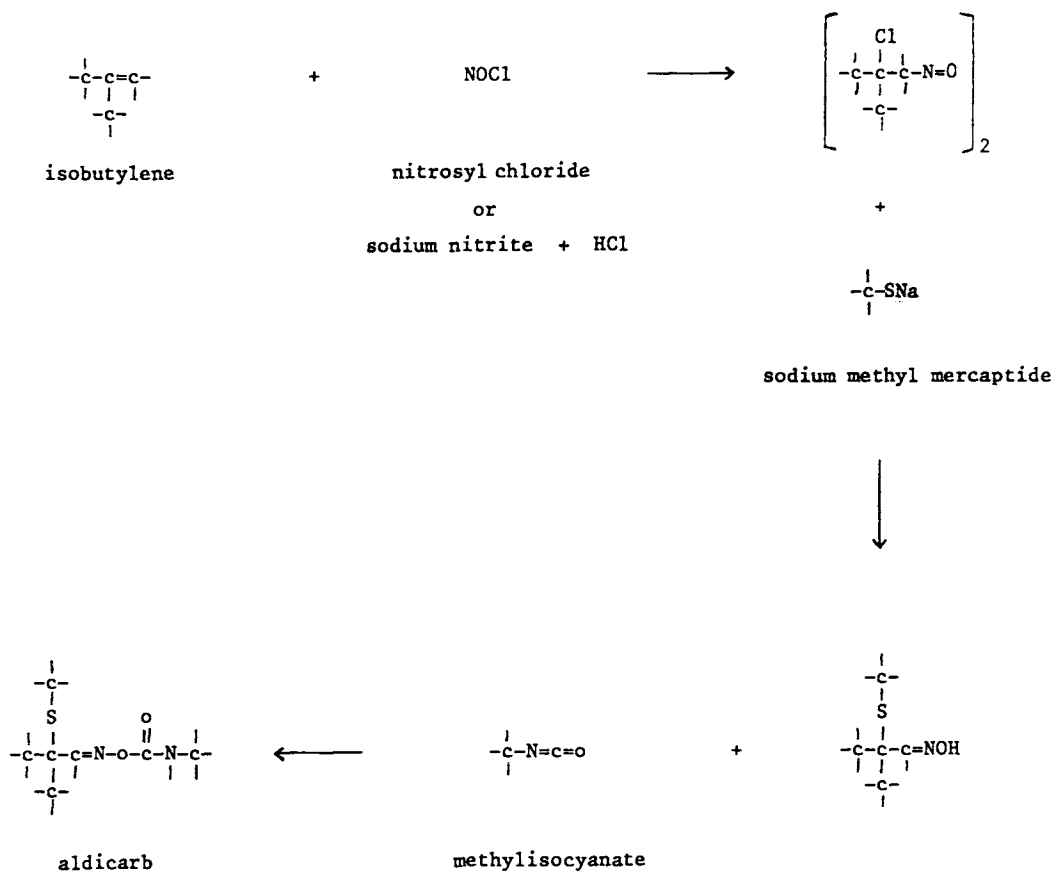
## Aldicarb

Uses: insecticide, cotton

Trade names: Temik (Rhone Poulenc)

Type: oxime amide

Synthesis:



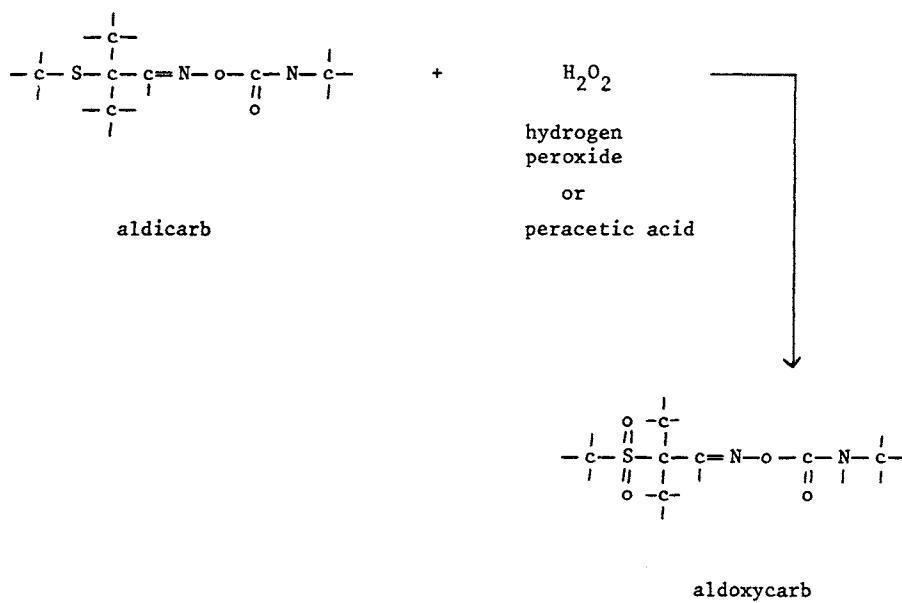
## Aldoxycarb

Uses: insecticide, tobacco

Trade names: Standak (Rhone Poulenc)

Type: oxime amide

**Synthesis:**



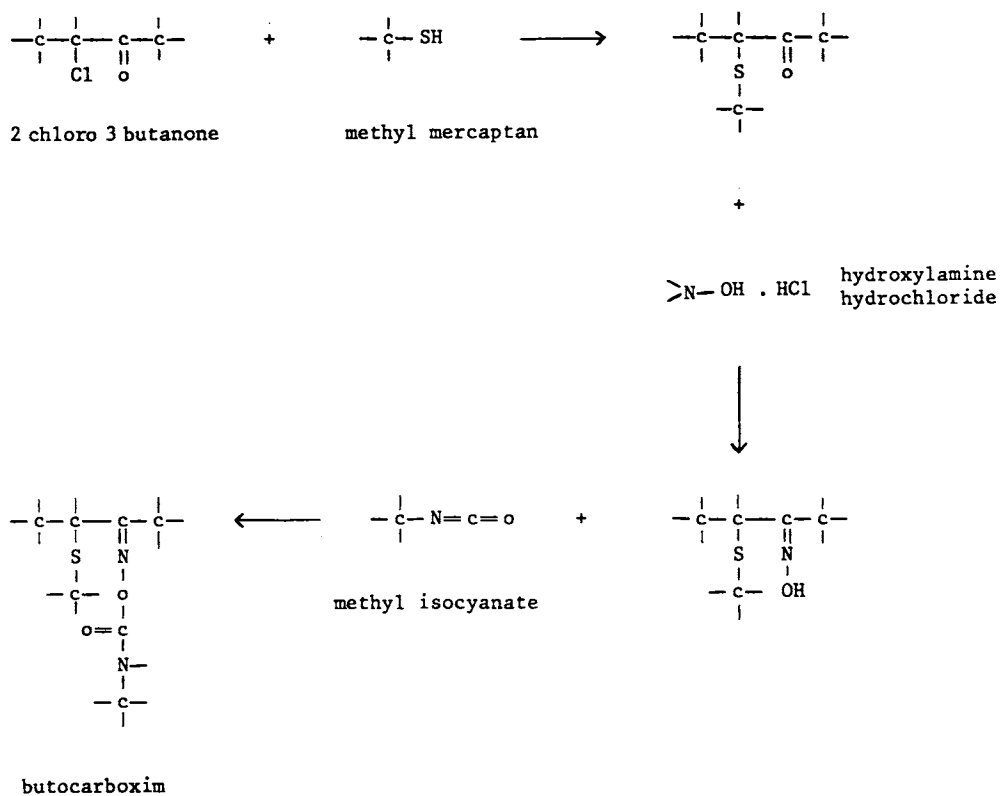
## Butocarboxim

Uses: insecticide, citrus, cotton, vegetables, ornamentals, fruit

Trade names: Drawin 755, Afilene (Wacker)

Type: oxime amide

Synthesis:





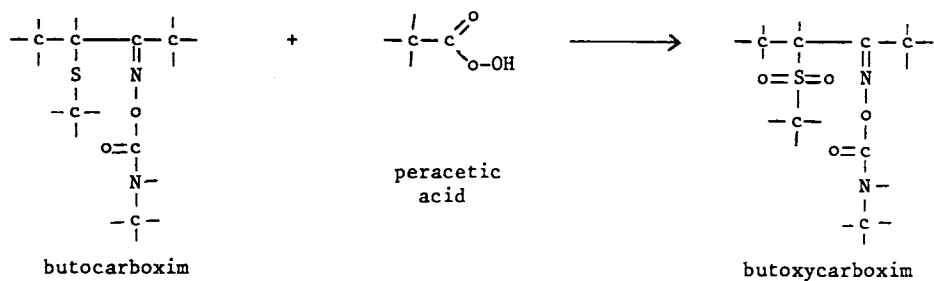
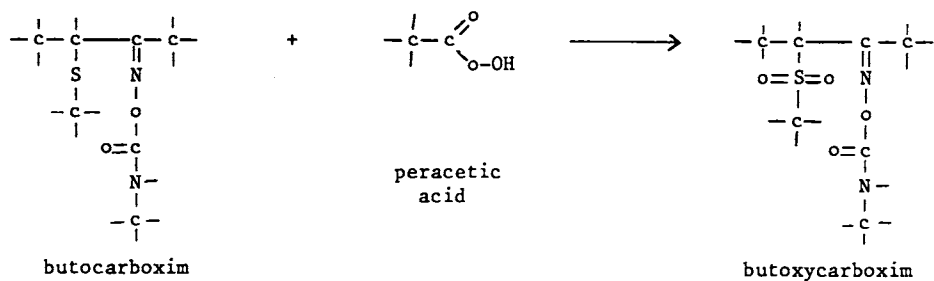
## Butoxycarboxim

Uses: insecticide, ornamentals

Trade names: Plant Pin (Wacker)

Type: oxime amide, sulfone

### Synthesis:





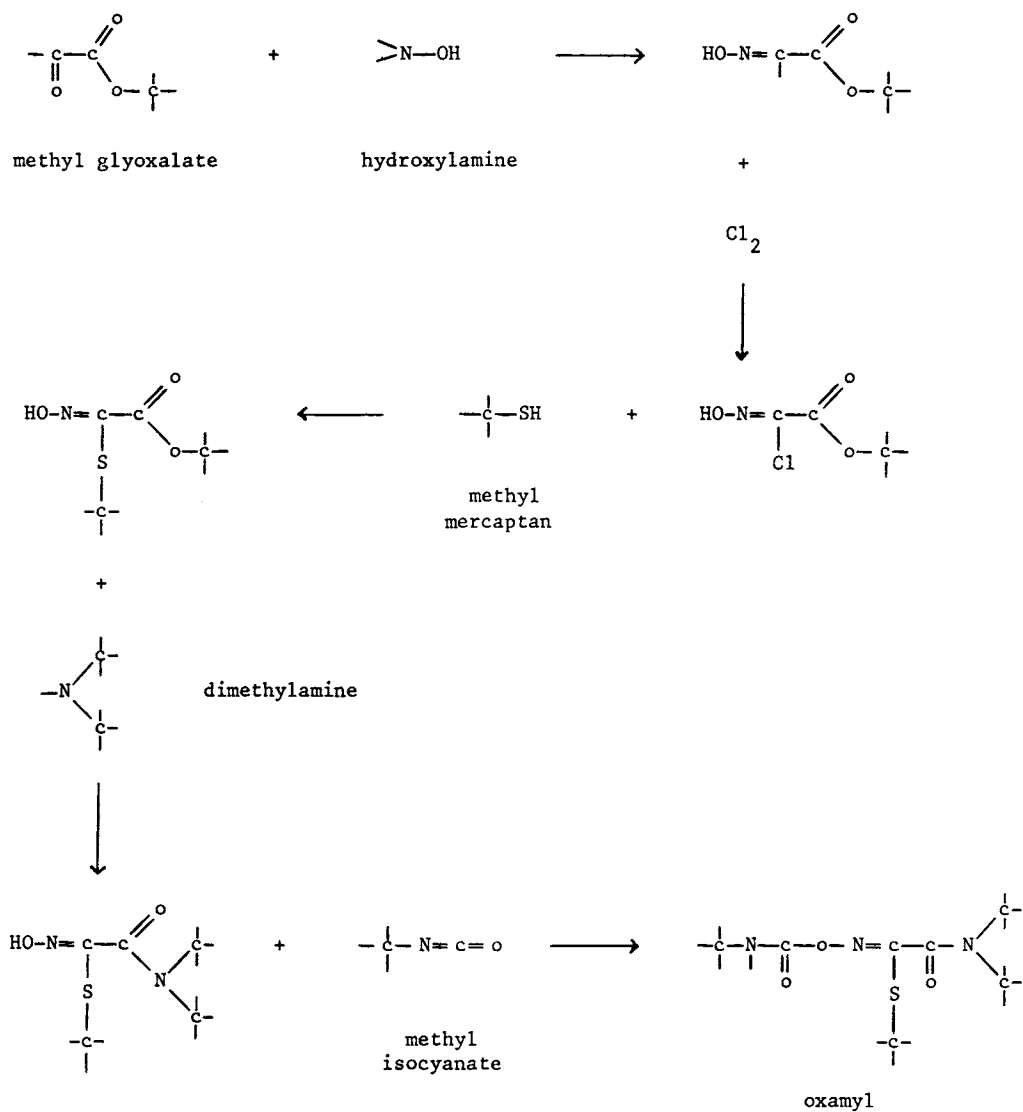
## Oxamyl

Uses: insecticide, citrus, cotton, ornamentals, potatoes, soyabeans, tobacco, fruit, vegetables

Trade names: Vydate (Dupont)

Type: oxime amide

Synthesis:



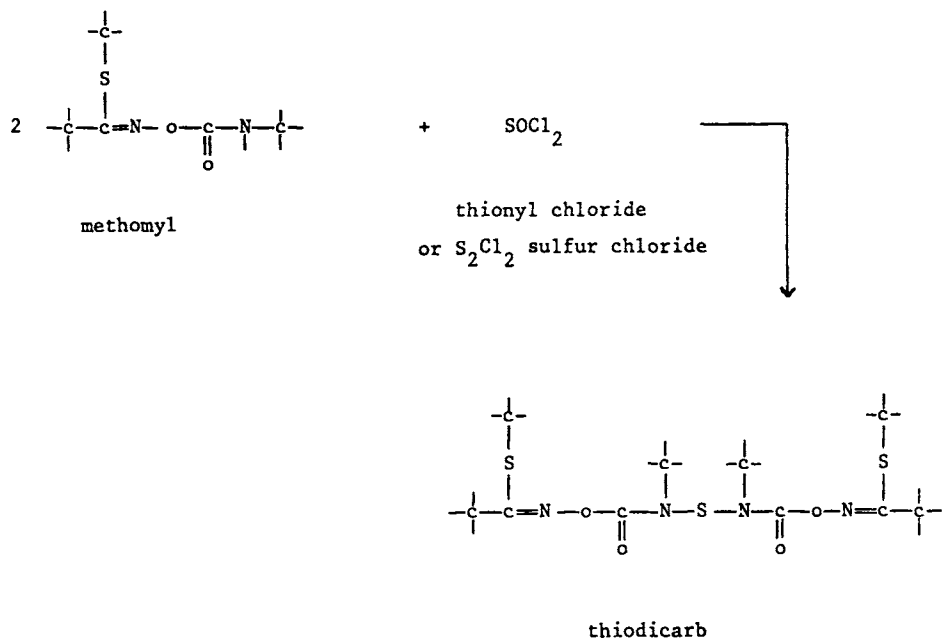
## Thiodicarb

Uses: insecticide, cotton, soyabeans, maize, vegetables, vines

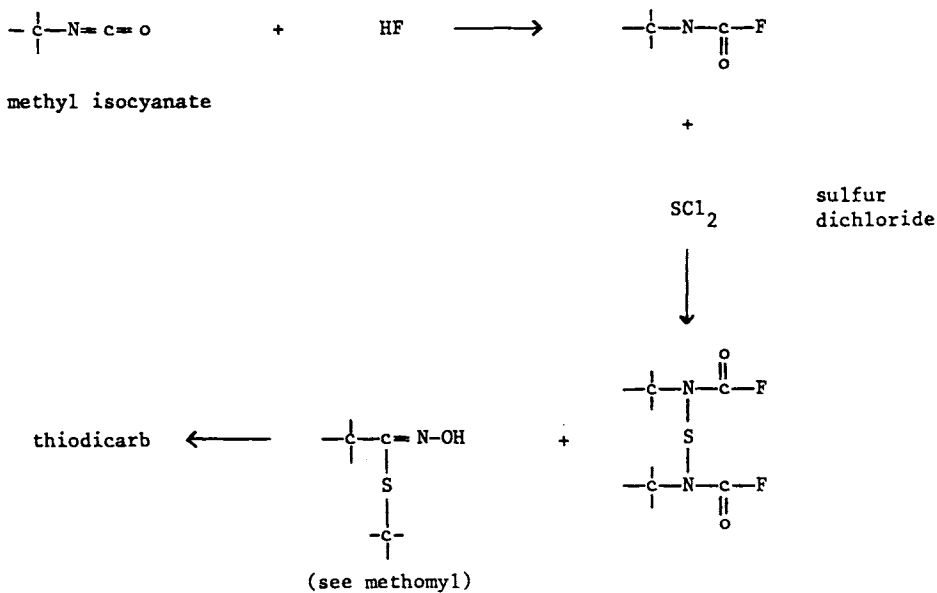
Trade names: Larvin, Semevin (Rhône Poulenc)

Type: oxime amide

Synthesis:



alternate route :



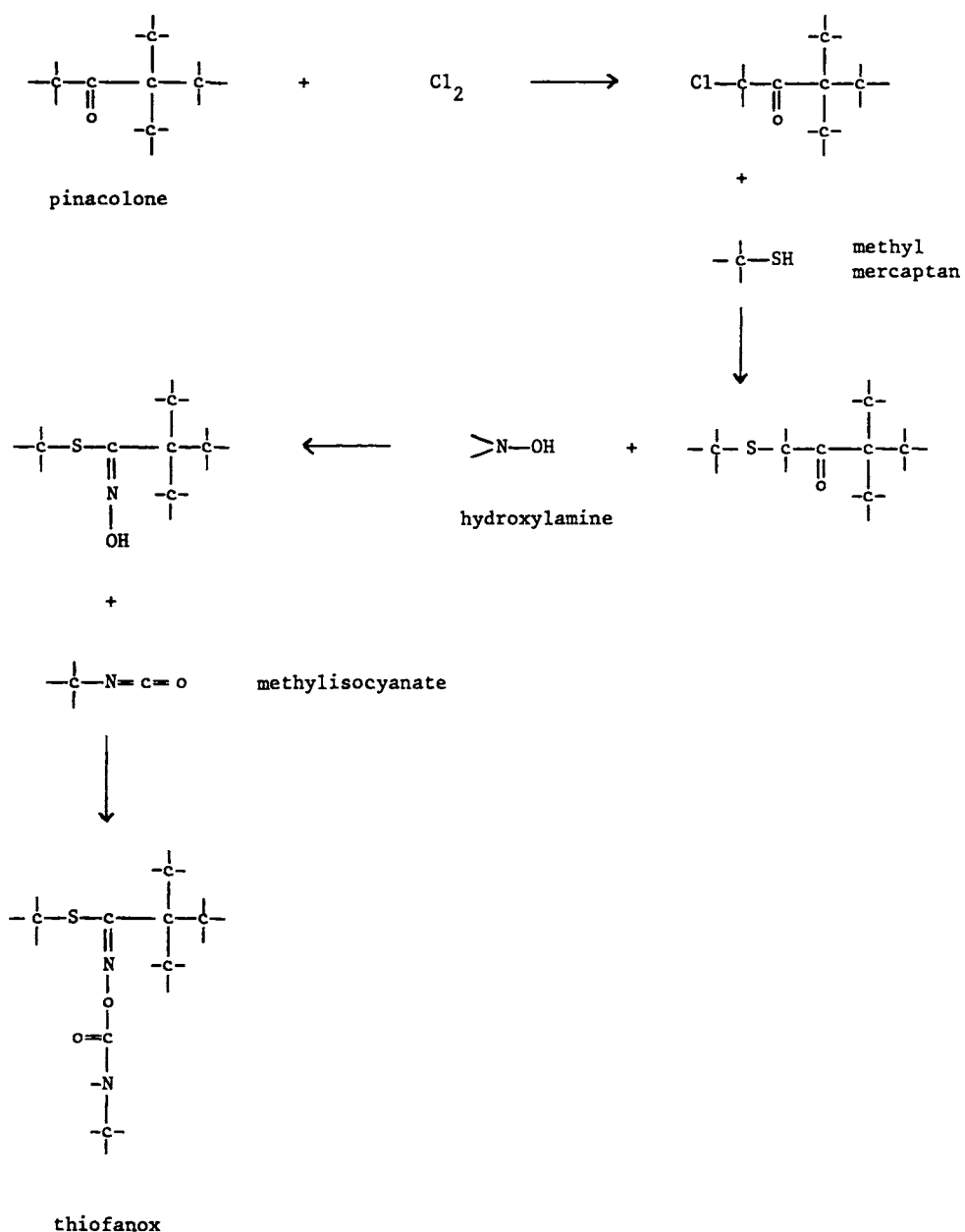
## Thiofanox

Uses: insecticide, sugarbeet, potatoes

Trade names: Dacamox (Fermenta)

Type: oxime amide

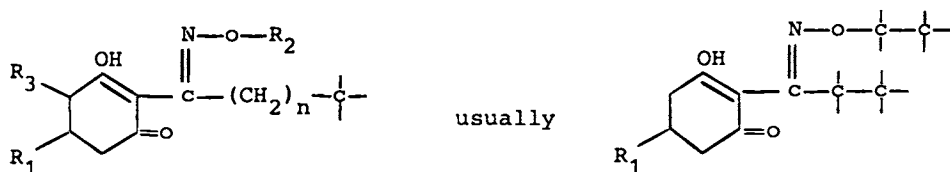
Synthesis:



# OXIMES

Oximes are produced by the well known reaction between a carbonyl and hydroxylamine or an ethoxyamine.

A common structure of some oxime pesticides is



that is  $R_2$  is often  $-\text{C}-\text{C}-$ ,  $n$  is 1 or 2, and  $R_3$  is nearly always H

	$R_1$	$R_2$	$n$	$R_3$
aloxymdim	$-\text{C}-\text{C}-$ (2)	$-\text{C}-\text{C}-$	2	$-\text{C}-\text{O}-\text{C}(=\text{O})-$
clethodim	$-\text{C}-\text{C}-\text{S}-\text{C}-\text{C}-$	$-\text{C}-\text{C}=\text{C}-\text{Cl}$	1	H
cycloxydim		$-\text{C}-\text{C}-$	2	H

	$\text{R}_1$	$\text{R}_2$	$n$	$\text{R}_3$
sethoxidim	$  \begin{array}{c}  \text{---C---C---C---} \\    \\  \text{S} \\    \\  \text{---C---} \\    \\  \text{---C---} \\     \end{array}  $	$  \begin{array}{c}  \text{---C---C---} \\    \quad    \end{array}  $	2	H
tralkoxydim	$  \begin{array}{c}  \text{---C---} \\    \\  \text{---C---} \\    \\  \text{---C---}  \end{array}  $	$  \begin{array}{c}  \text{---C---C---} \\    \quad    \end{array}  $	1	H

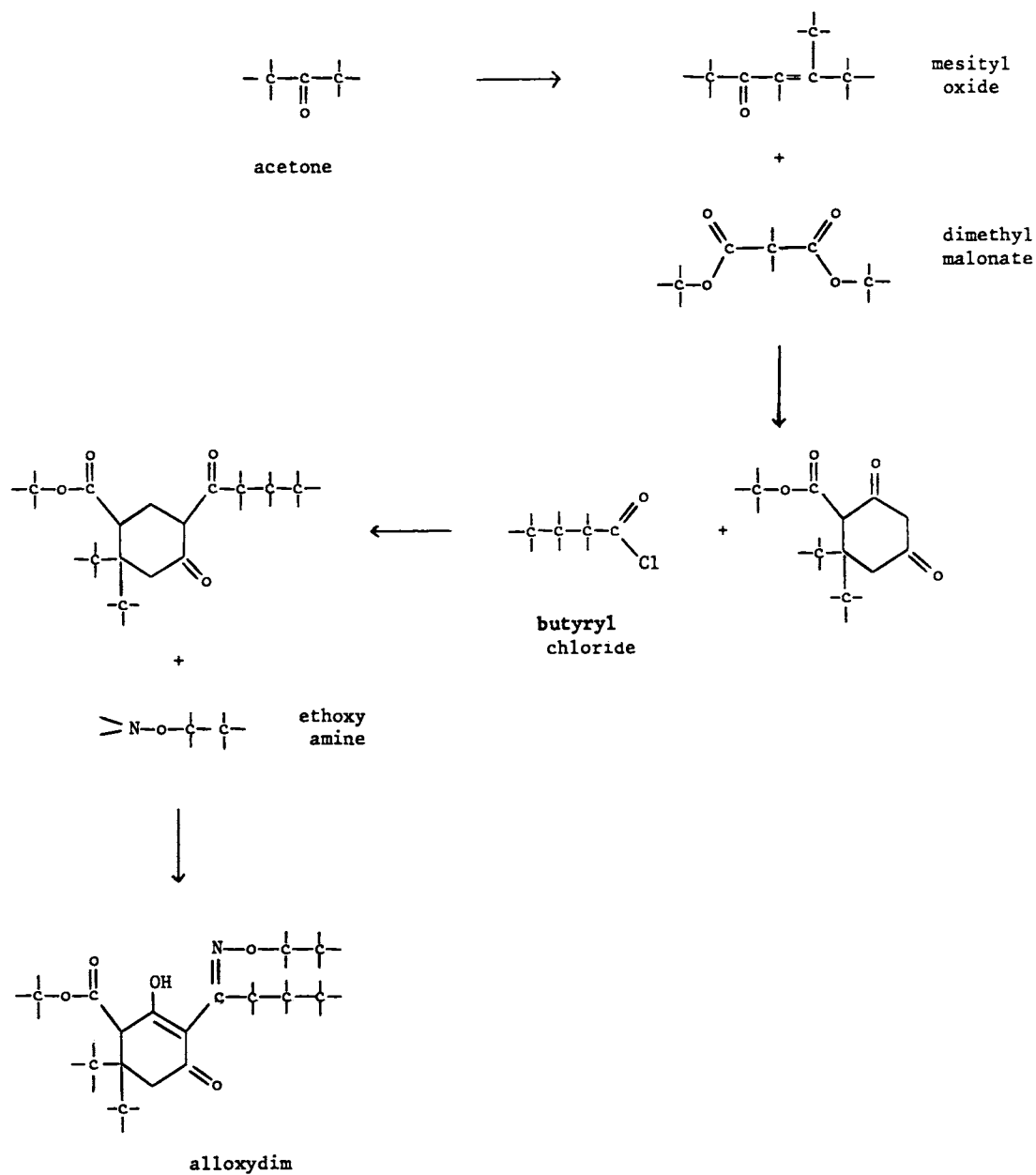
## Alloxydim

Uses: herbicide, cereals, sugarbeet, vegetables

Trade names: Kusagard (Nippon)

Type: oxime

Synthesis:





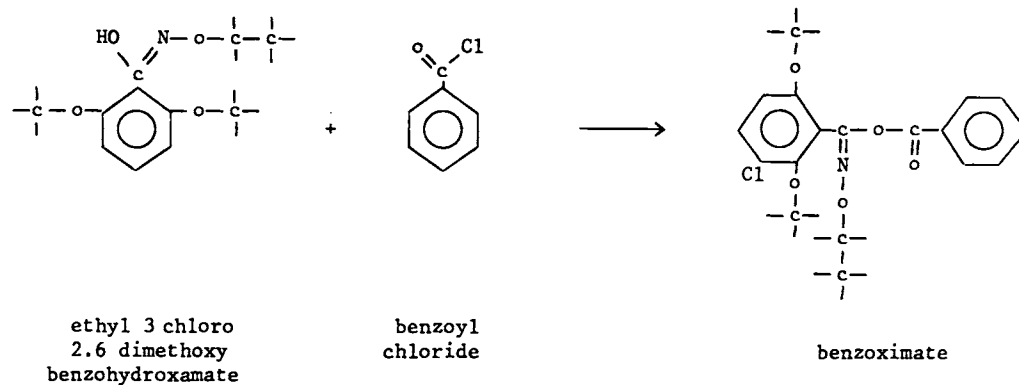
## Benzoximate

Uses: acaricide, apples, citrus, grapes

Trade names: Citrazon, Aazomate (Nippon)

Type: oxime

Synthesis:



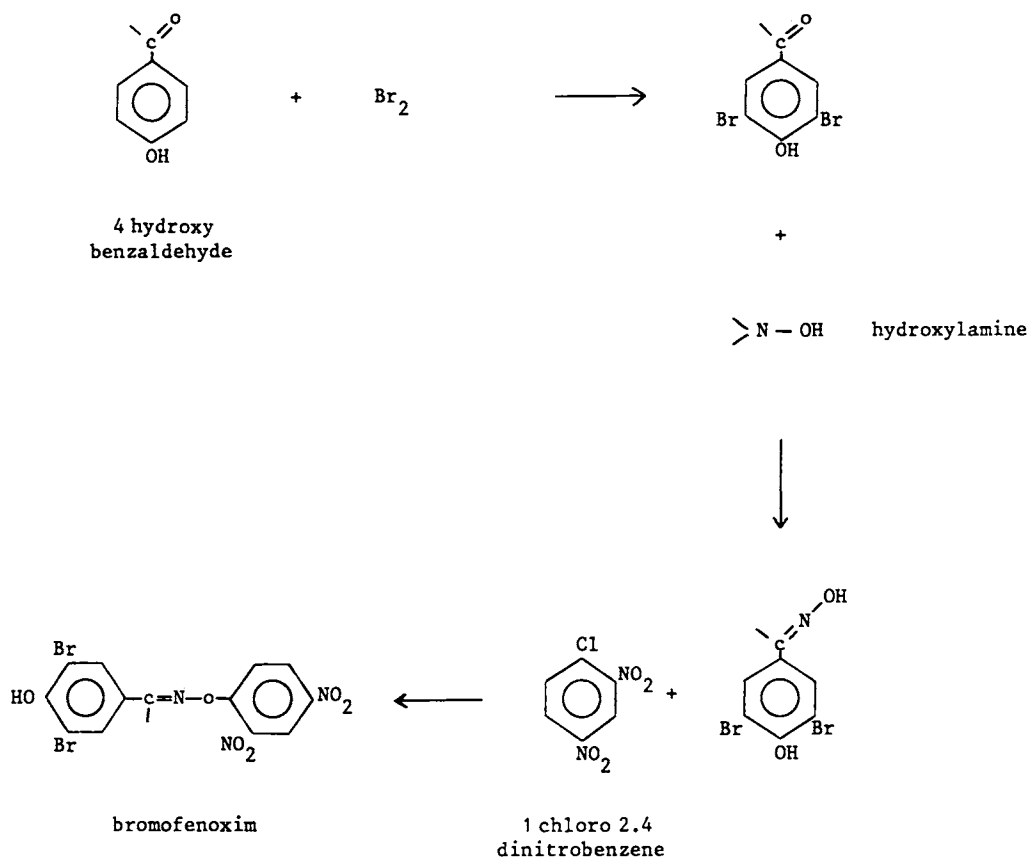
## Bromofenoxim

Uses: herbicide, cereals

Trade names: Faneron (Ciba)

Type: oxime

Synthesis:



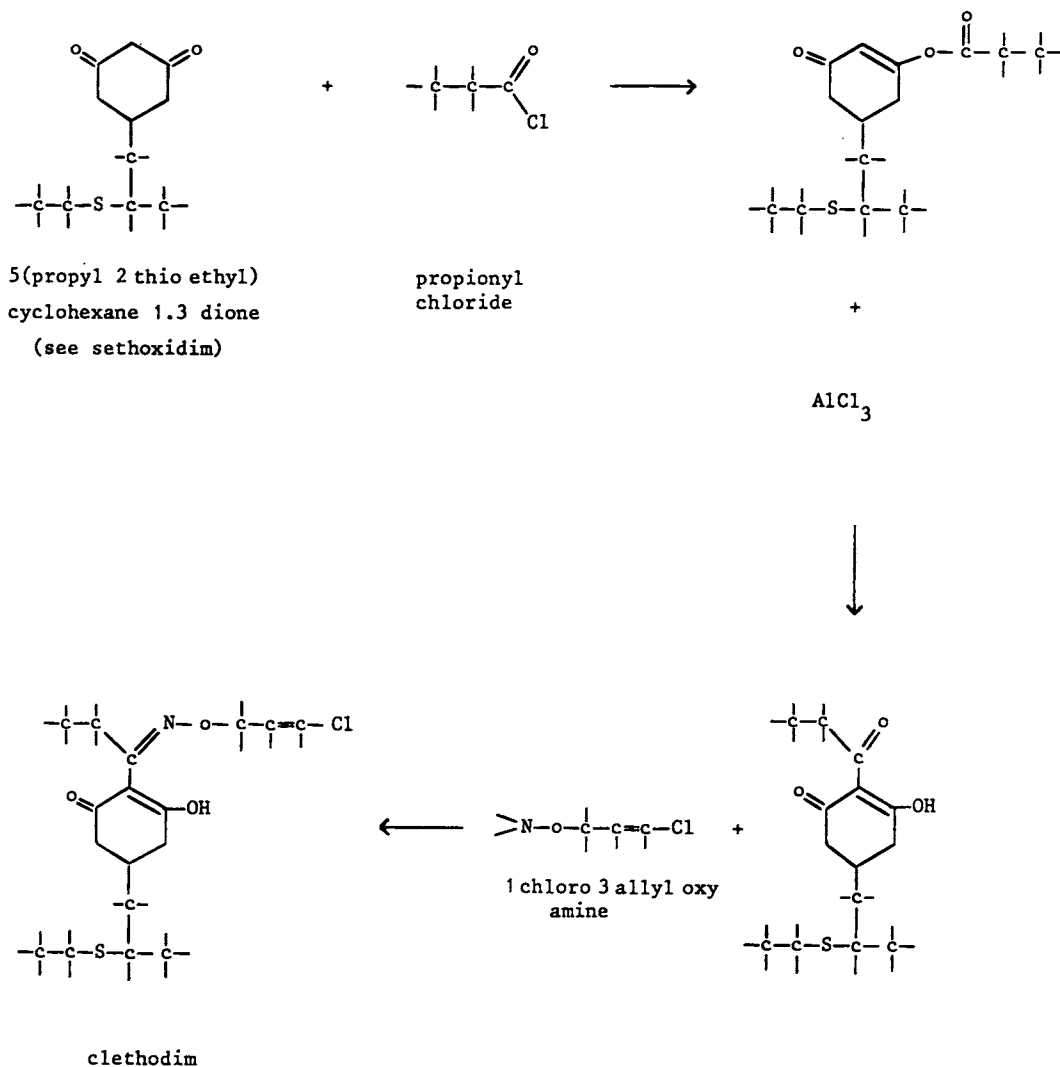
## Clethodim

Uses: herbicide

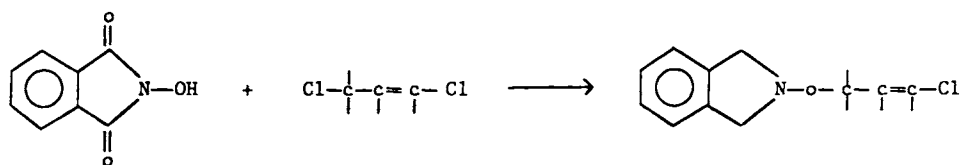
Trade names: Select (Chevron)

Type: oxime

Synthesis:



Preparation of  $\text{>N-O-CH}_2\text{-CH=CH}_2\text{-Cl}$  :

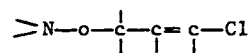


N-hydroxy  
phthalimide

1,3 dichloro  
propene

+

$\text{>N=N< . HCl}$       hydrazine  
hydrochloride



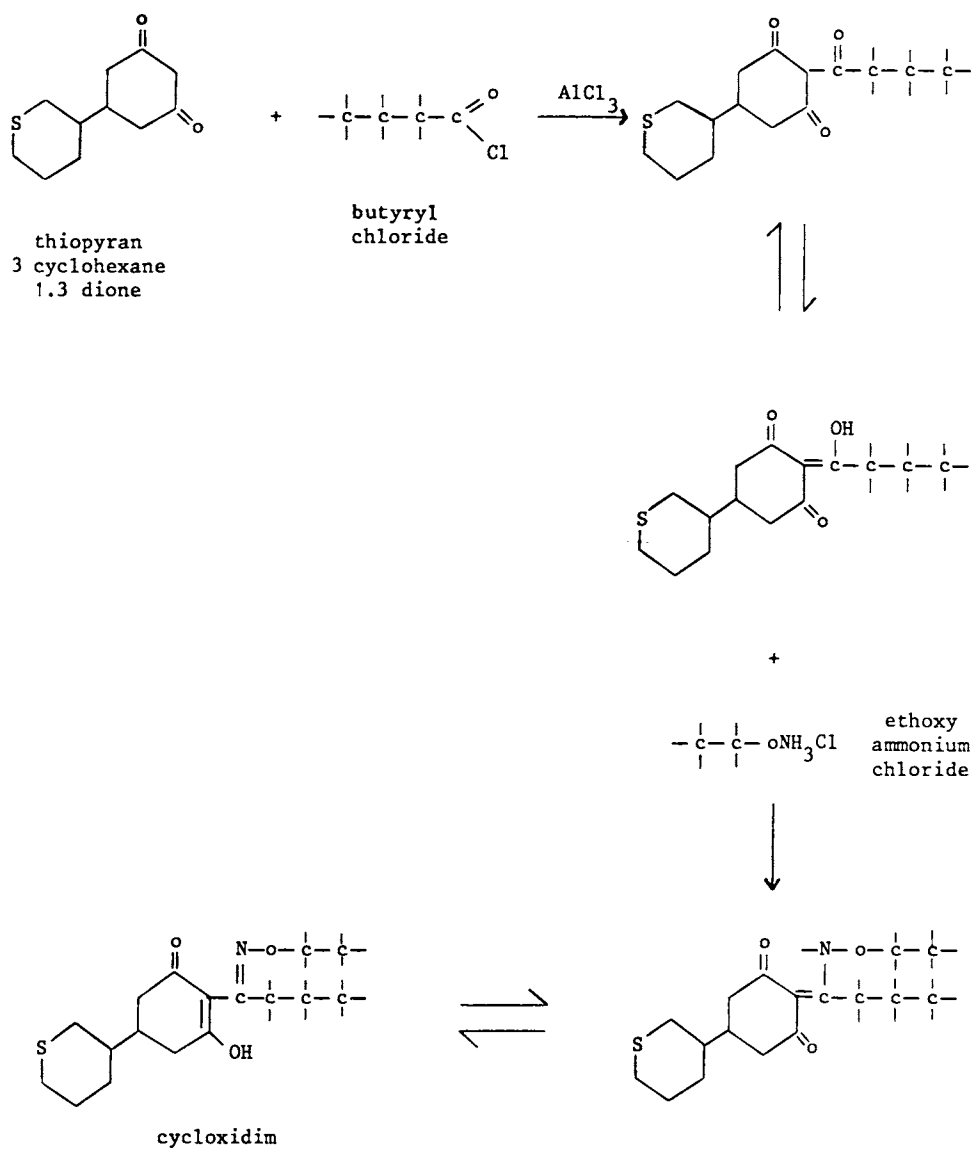
## Cycloxdim

Uses: herbicide, cotton, soyabeans, potatoes, sugarbeet, sunflowers  
vegetables

Trade names: Focus, Laser, Stratos (BASF)

Type: oxime, thiopyran

Synthesis:



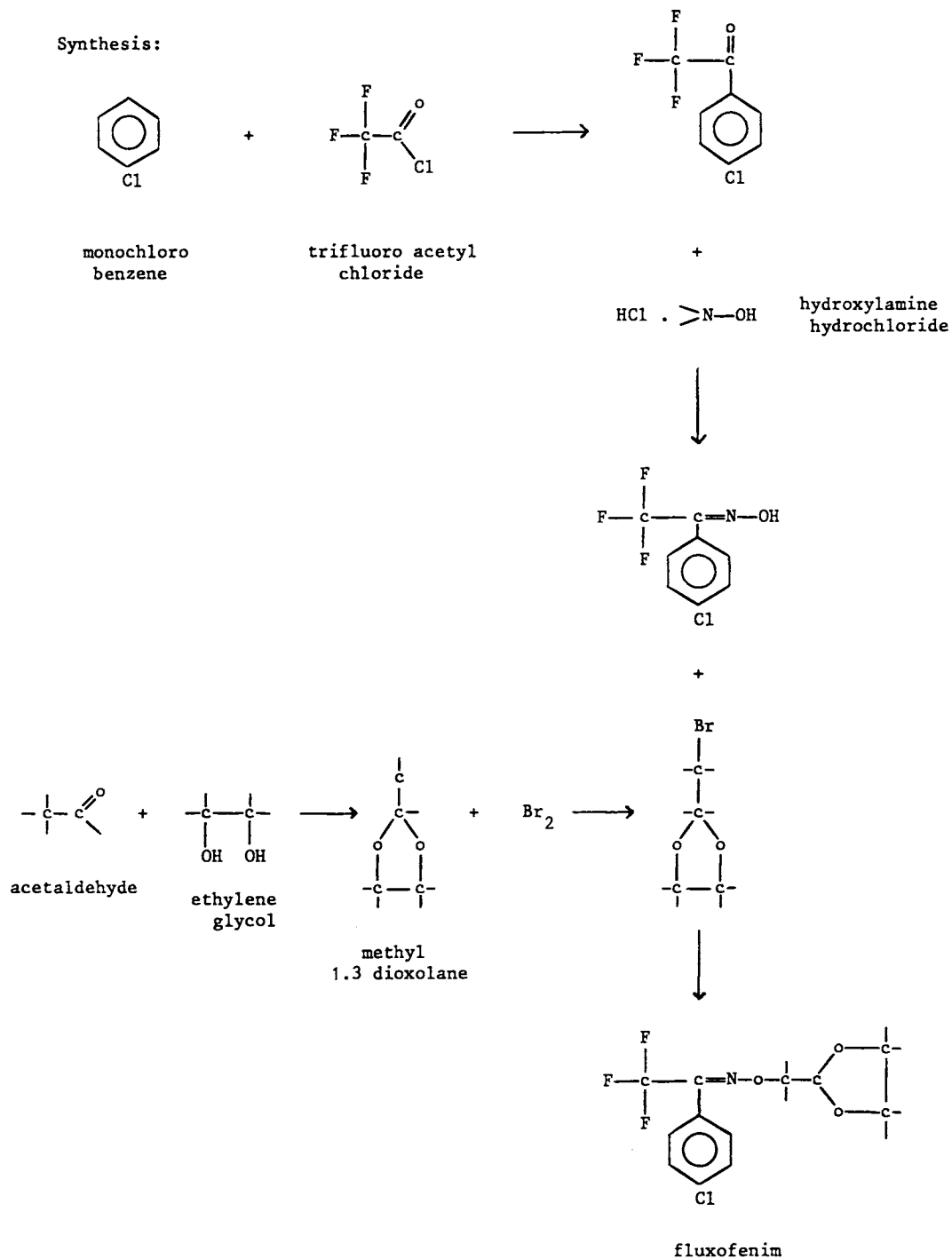
## Fluxofenim

Uses: herbicide

Trade names: Concep III (Ciba)

Type: oxime

Synthesis:



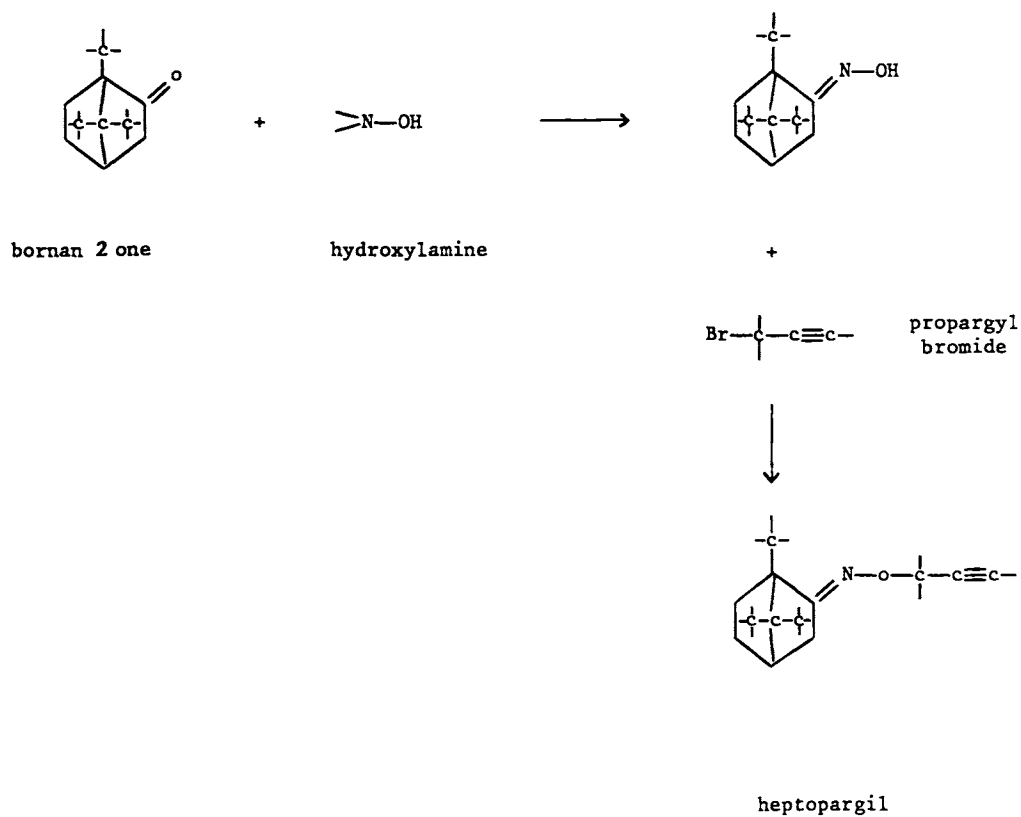
## Heptopargil

Uses: growth regulator, maize, rice, sugarbeet, sunflowers, vegetables

Trade names: Limbolid (Egyt)

Type: oxime

Synthesis:



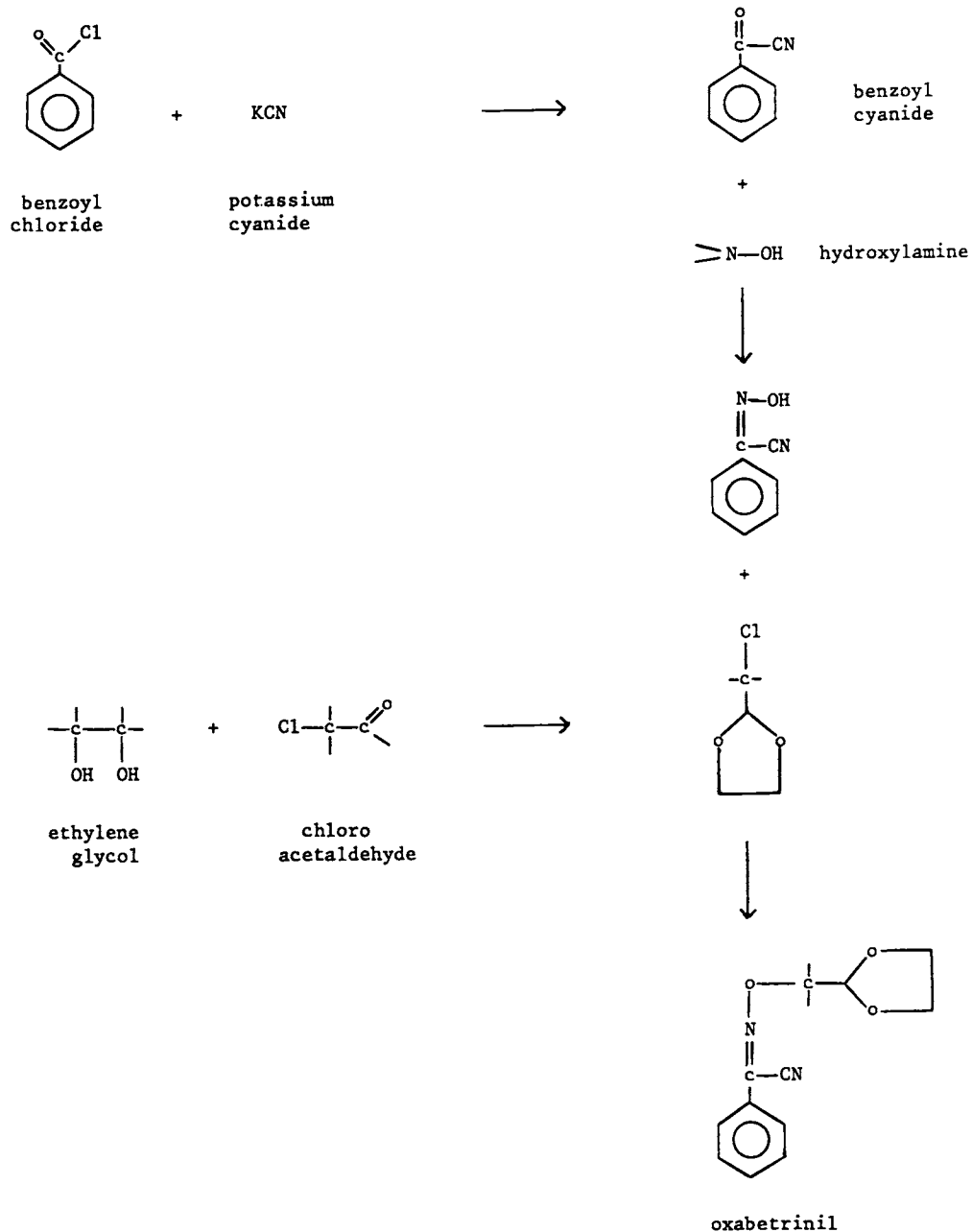
## Oxabetrinil

Uses: herbicide safener for metolachlor, sorghum

Trade names: Concep II (Ciba)

Type: oxime

Synthesis:





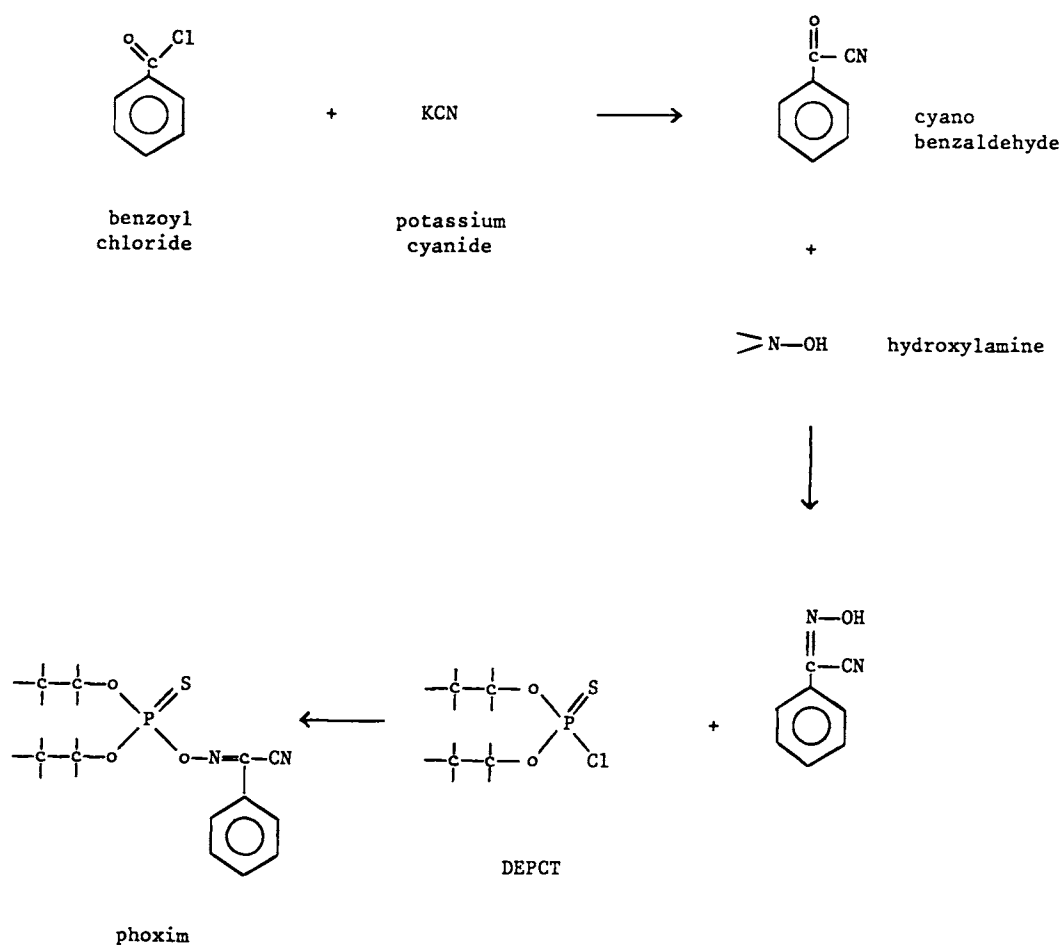
## Phoxim

Uses: insecticide, maize, vegetables

Trade names: Baythion, Volaton (Bayer)

Type: oxime, phosphoro organic, phosphoro thioate

Synthesis:



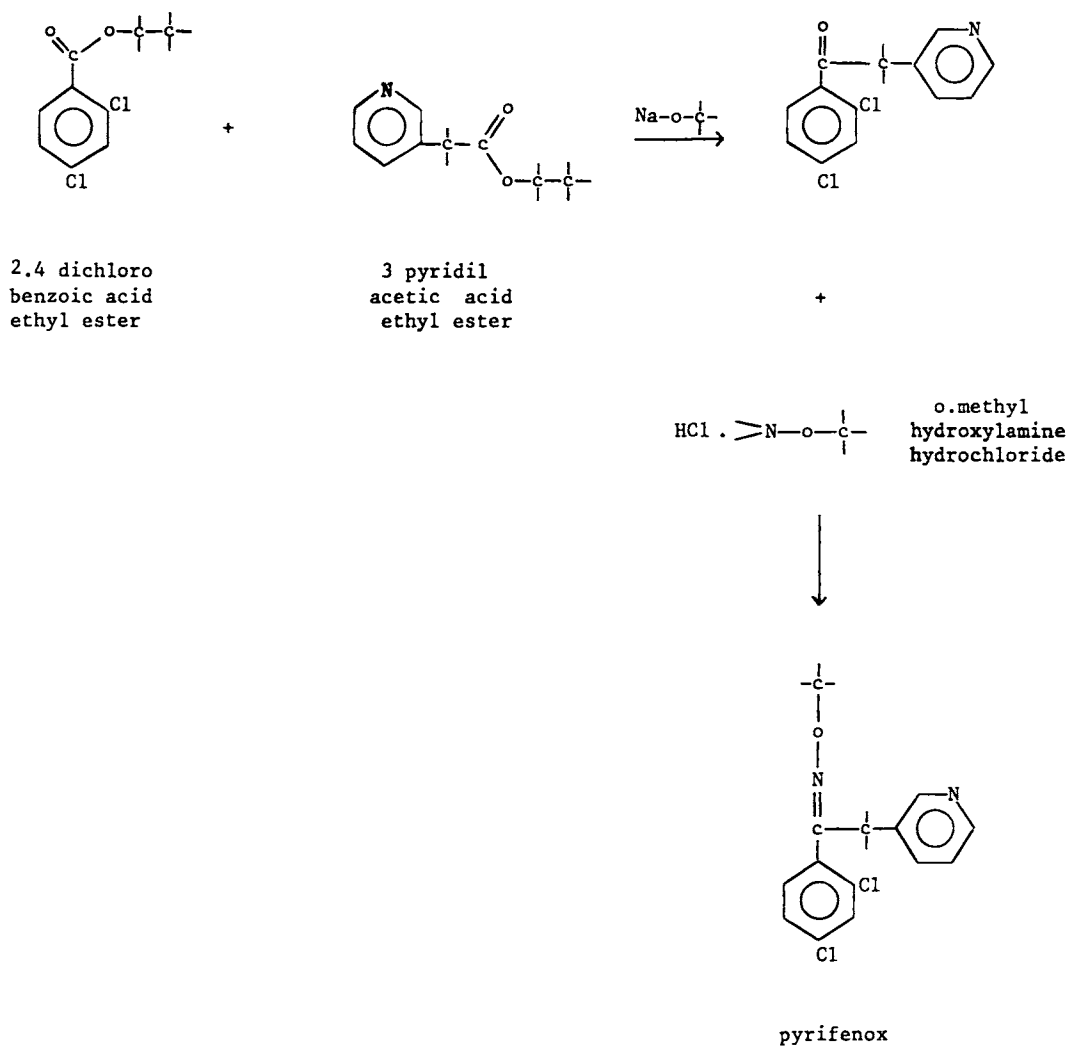
## Pyrifenoxy

Uses: fungicide, bananas, grapes, peanuts, vegetables

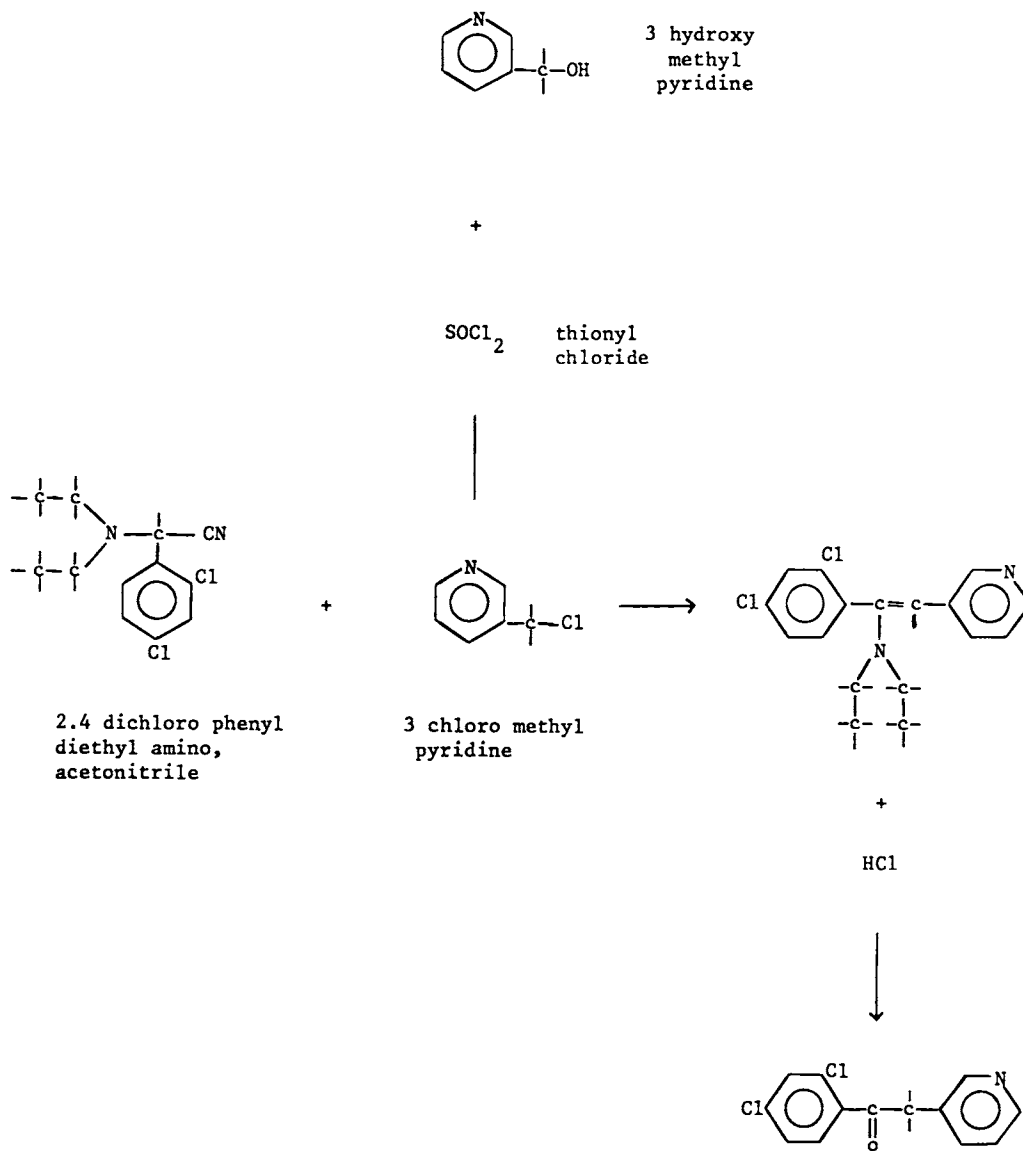
Trade names: Rondo (Ciba)

Type: oxime, pyridine

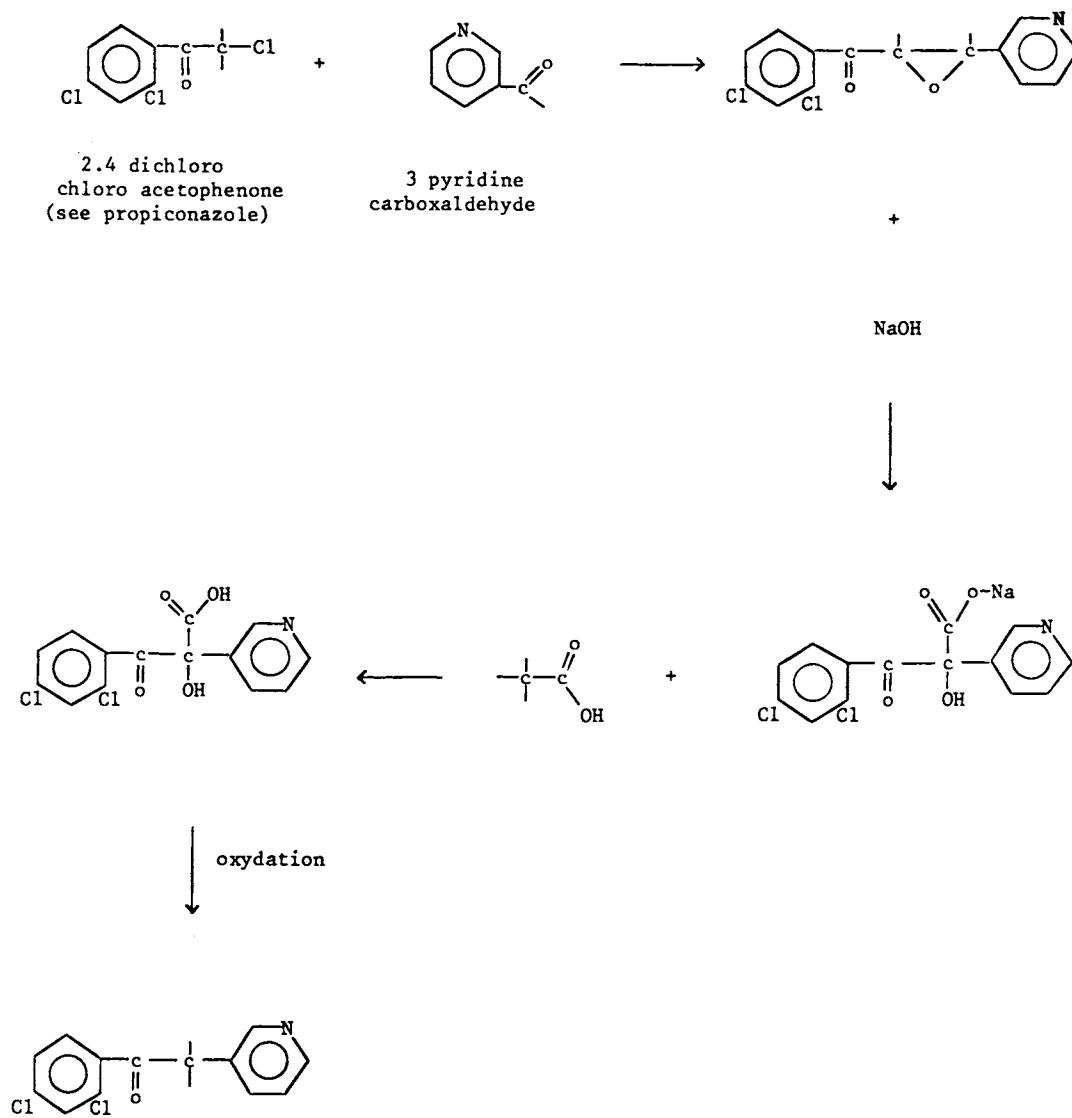
Synthesis:



alternate route :



alternate route :



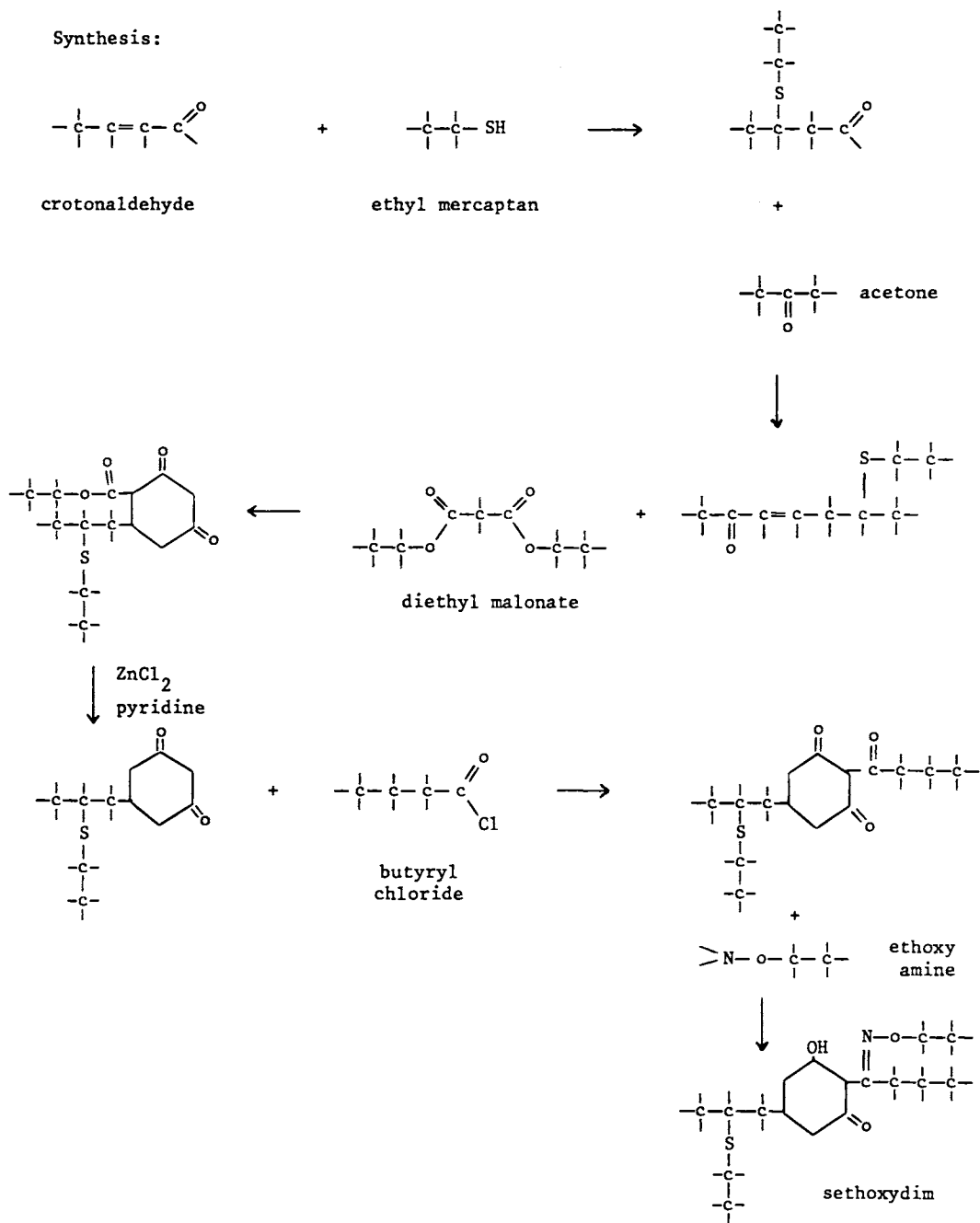
## Sethoxydim

Uses: herbicide , cotton, potatoes, soyabeans, flax, sunflowers, vegetables

Trade names: Nabu , Poast, Fervinal (Nippon)

Type: oxime

Synthesis:



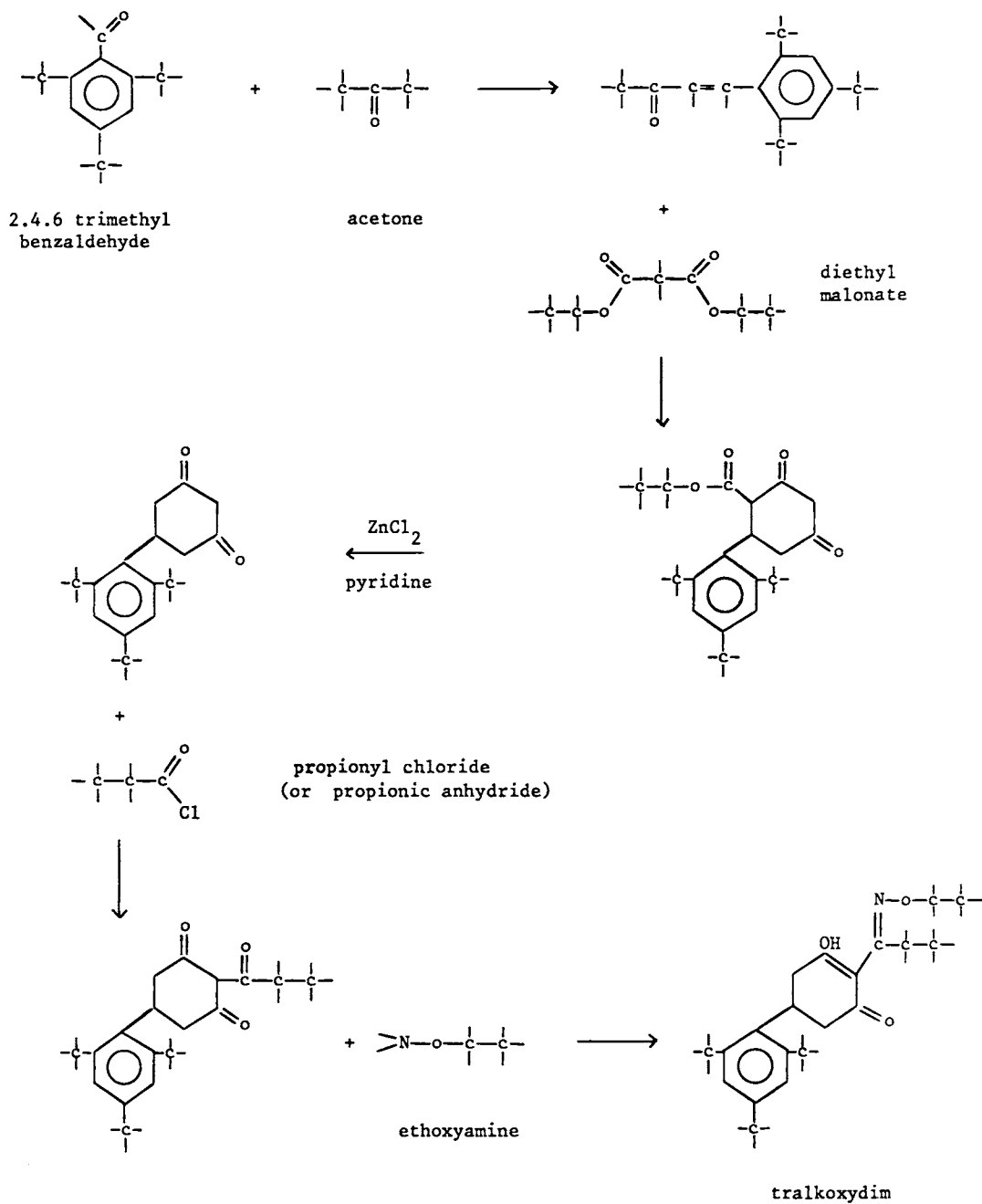
## Tralkoxydim

Uses: herbicide, wheat, barley

Trade names: Grasp, Splendor (ICI)

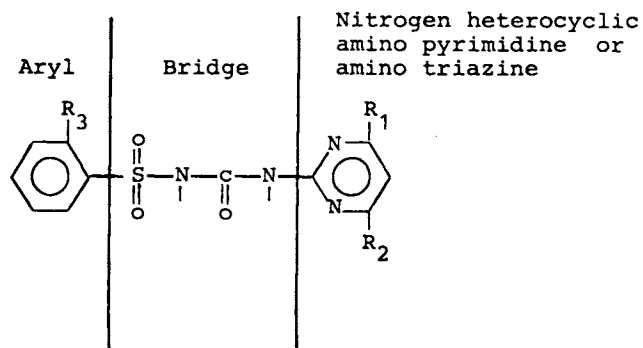
Type: oxime

Synthesis:



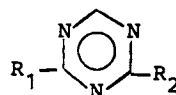
## SULFONYL-UREAS

Sulfonyl-ureas are herbicides of the general formula :



Among the most frequently used heterocyclic groups are:

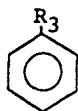
	$R_1$	$R_2$
<div style="display: flex; align-items: center;"> <div>           bensulfuron, flazasulfuron, nicosulfuron         </div> </div>	$\text{O}-\text{C}-$	$\text{O}-\text{C}-$
<div style="display: flex; align-items: center;"> <div>           chlorimuron         </div> </div>	$\text{O}-\text{C}-$	Cl
<div style="display: flex; align-items: center;"> <div>           primisulfuron         </div> </div>	$\begin{array}{c} \text{F} \\   \\ \text{O}-\text{C}- \\   \\ \text{F} \end{array}$	$\begin{array}{c} \text{F} \\   \\ \text{O}-\text{C}- \\   \\ \text{F} \end{array}$
<div style="display: flex; align-items: center;"> <div>           sulfometuron         </div> </div>	$\begin{array}{c}   \\ \text{C}- \\   \end{array}$	$\begin{array}{c}   \\ \text{C}- \\   \end{array}$
<div style="display: flex; align-items: center;"> <div>           trifensulfuron, triasulfuron, tribenuron         </div> </div>	$\text{O}-\text{C}-$	$\begin{array}{c}   \\ \text{C}- \\   \end{array}$

		$\text{R}_1$	$\text{R}_2$
		<hr/>	<hr/>
	chlorsulfuron	$\text{O}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-$	$\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-$
	cinosulfuron	$\text{O}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-$	$\text{O}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-$
	metsulfuron	$\text{O}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-$	$\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-$

**Synthesis:**

The  $\text{R}_3$  moiety on the aryl group usually  $\text{COOH}$  (or ester),  $\text{Cl}$ ,  $\text{OR}$ , hardly ever gives an ortho orientation to the sulfonation reaction.

Therefore the starting point for the sulfonamide can not be obtained by reaction of

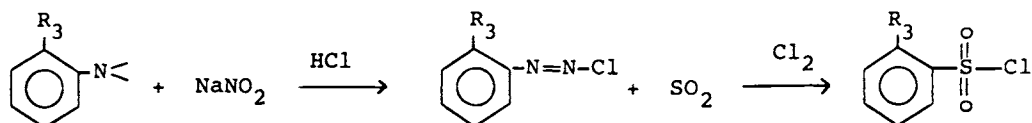


and chlorosulfonic acid.

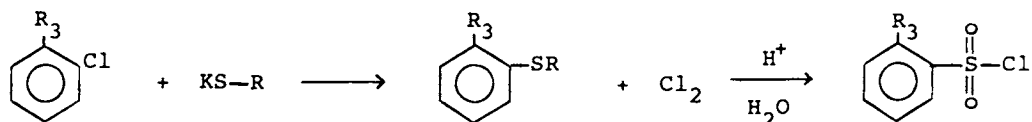


Among the more common procedures are :

- diazotisation of an ortho aniline followed by reaction with  $\text{SO}_2$  and  $\text{Cl}_2$

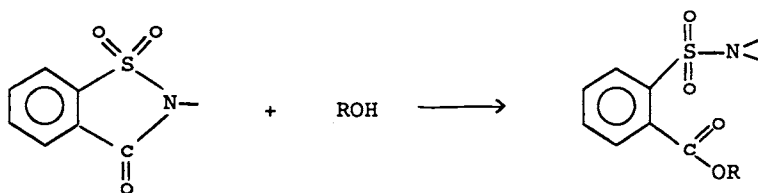


- reaction between an ortho chlorobenzene and a mercaptan followed by acid chlorination

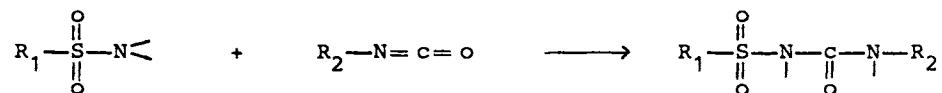


The chloro sulfonyl compound is converted to a sulfonamide by ammoniation.

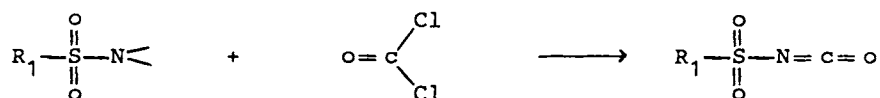
- if  $\text{R}_3 = \text{COOR}$  then reaction between saccharin and an alcohol will yield the carboxyl sulfonamide directly



The sequence is either reaction of the sulfonamide with an isocyanate



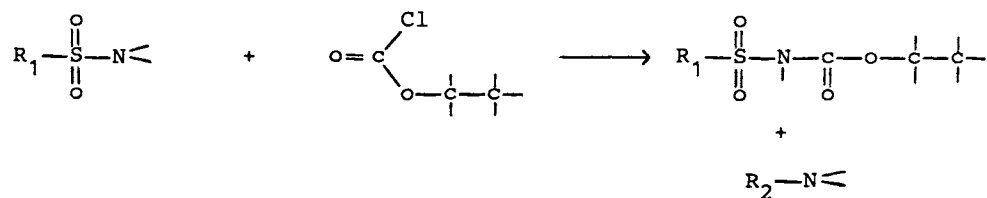
or phosgenation of the sulfonamide to an isocyanate



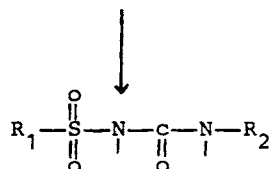
followed by reaction with an amine, usually an amino pyrimidine or amino triazine



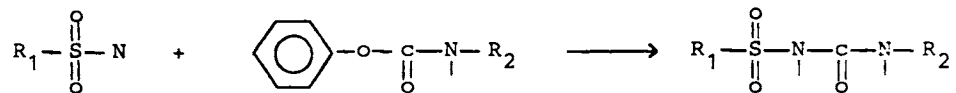
An alternative route is the reaction between the sulfonamide and an ethyl chloroformate



followed by amination



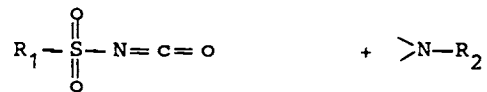
Also commonly used reaction paths are sulfonamide + the phenyl carbamate



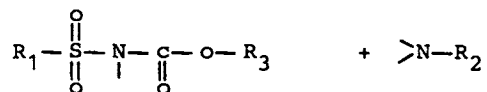
sulfonamide + isocyanate



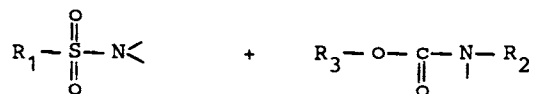
sulfonamide isocyanate + amine



sulfonamide carbamate + amine



sulfonamide + carbamate



where  $R_3$  is usually phenyl

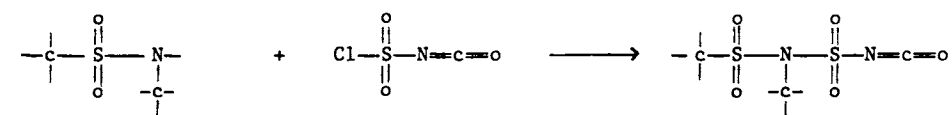
## Amidosulfuron

Uses: herbicide, wheat, barley, rye, oats

Trade names: Gratil (AgrEvo)

Type: sulfonyl urea

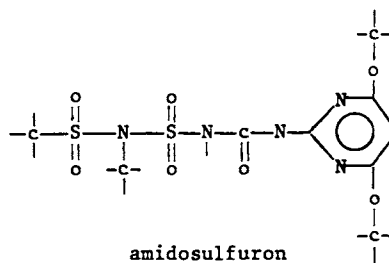
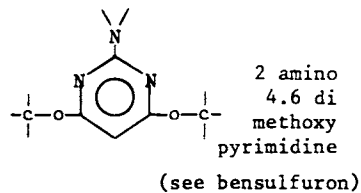
**Synthesis:**



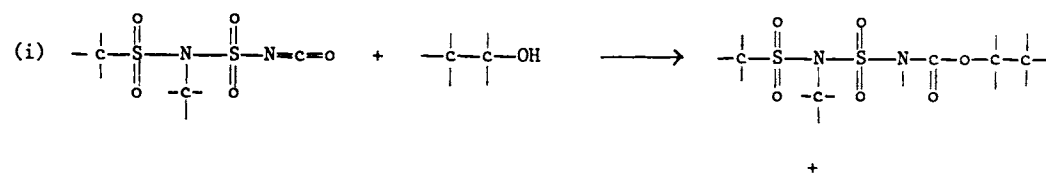
methane N-methyl  
sulfonamide

chloro sulfonyl  
isocyanate

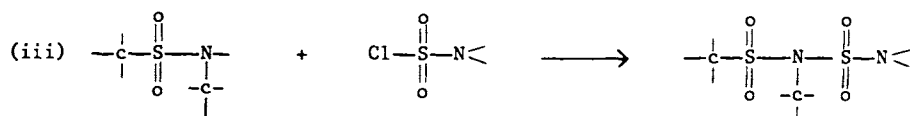
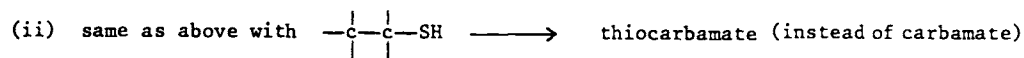
+



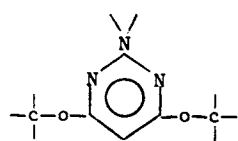
alternate routes :

2 amino 4.6 dimethoxy  
pyrimidine

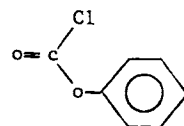
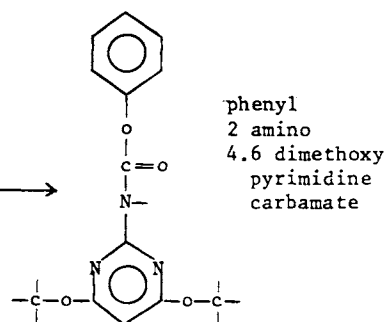
amidosulfuron

chloro  
sulfonamide

+



+

phenyl  
chloroformatephenyl  
2 amino  
4.6 dimethoxy  
pyrimidine  
carbamate

amidosulfuron

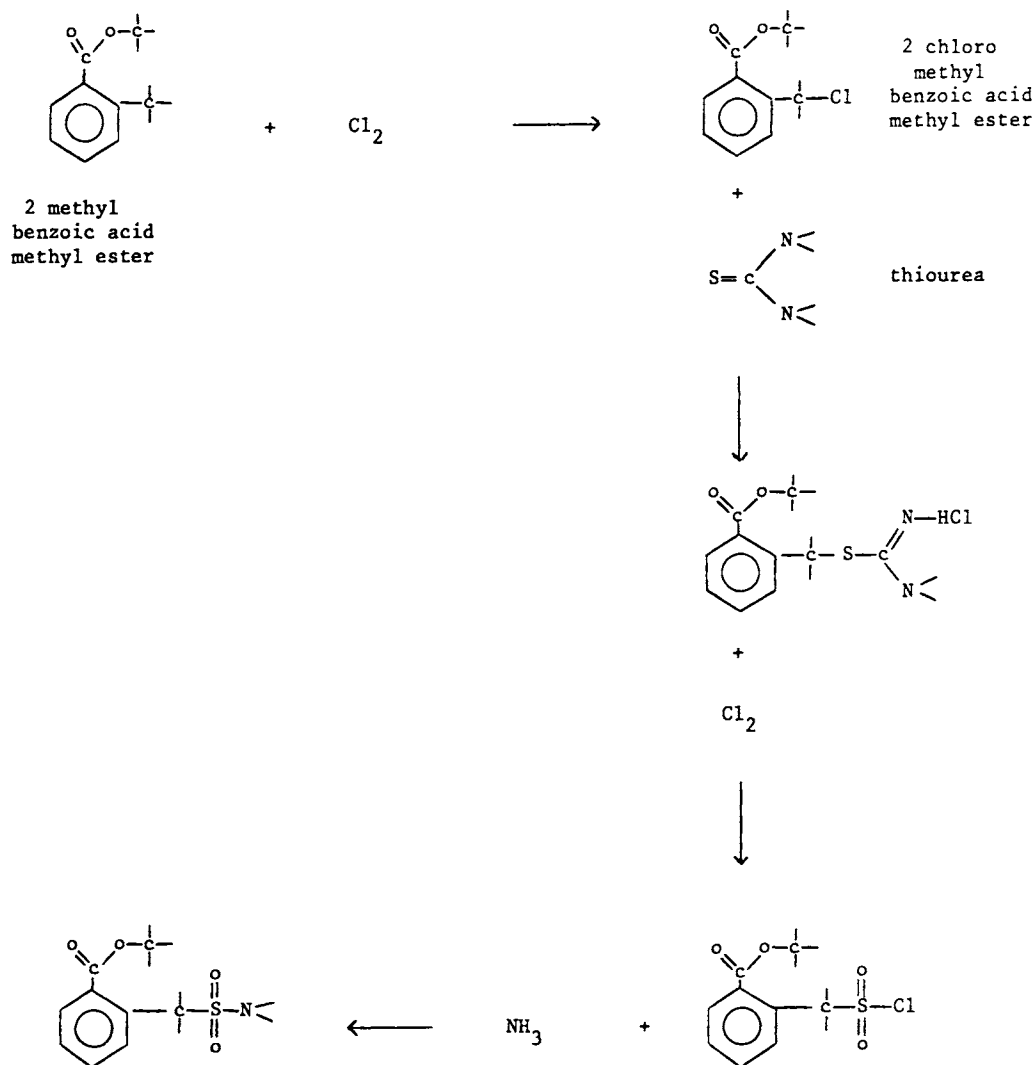
## Bensulfuron

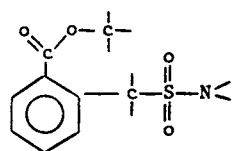
Uses: herbicide, rice

Trade names: Londax (Dupont)

Type: sulfonyl urea

Synthesis:

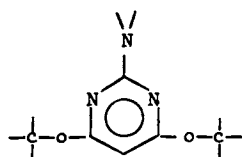
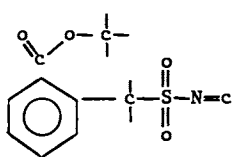




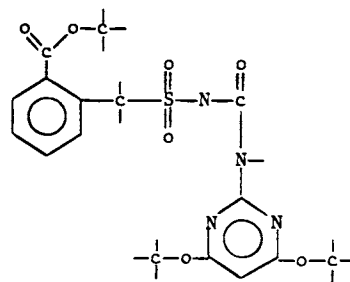
+



phosgene

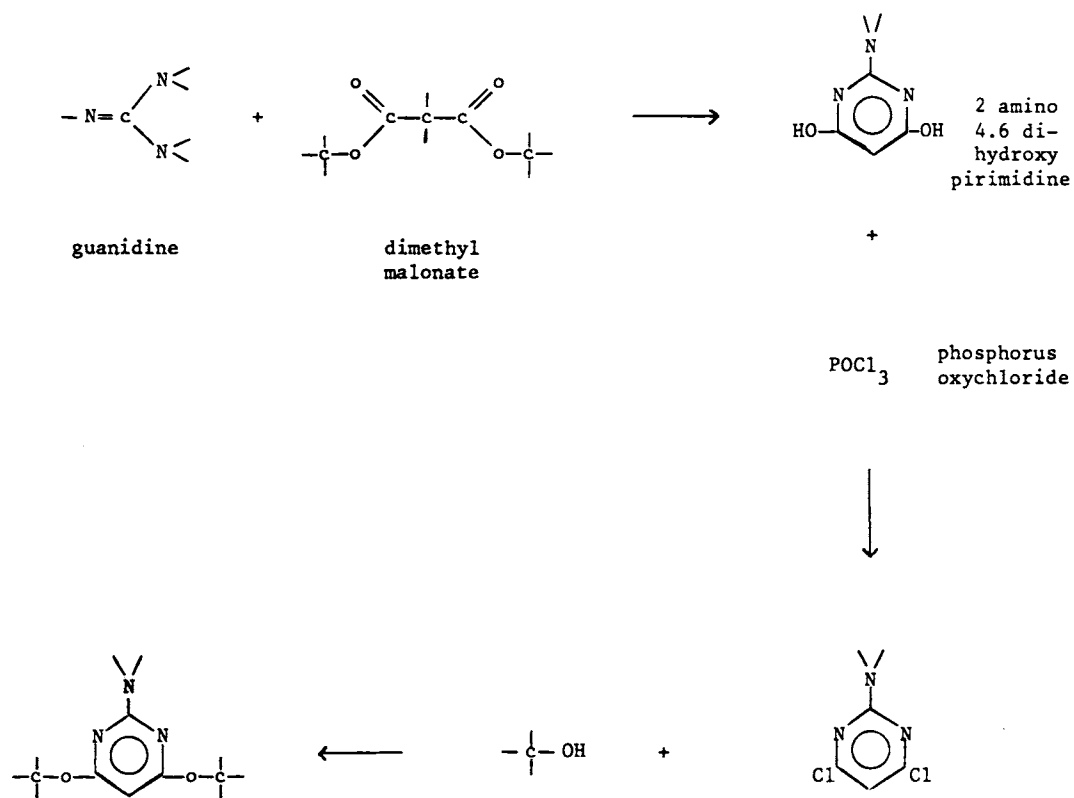


2 amino 4,6 dimethoxy  
pyrimidine



bensulfuron

preparation of 2 amino 4.6 dimethoxy pyrimidine :





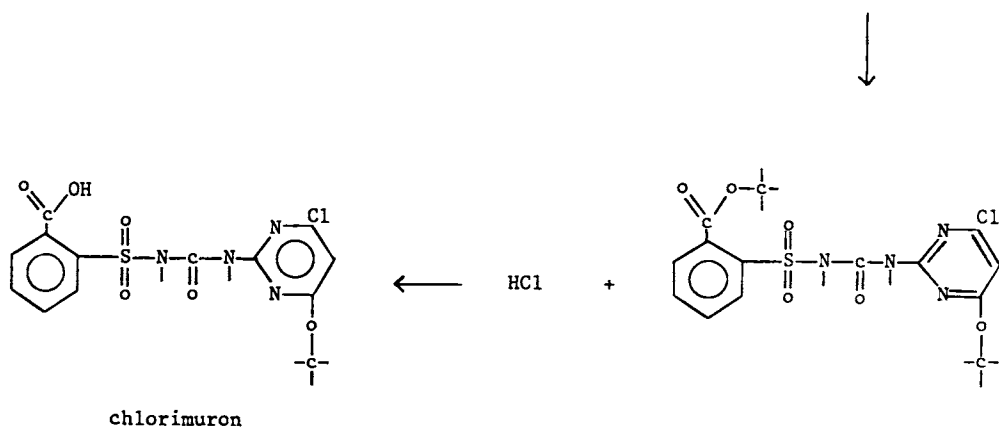
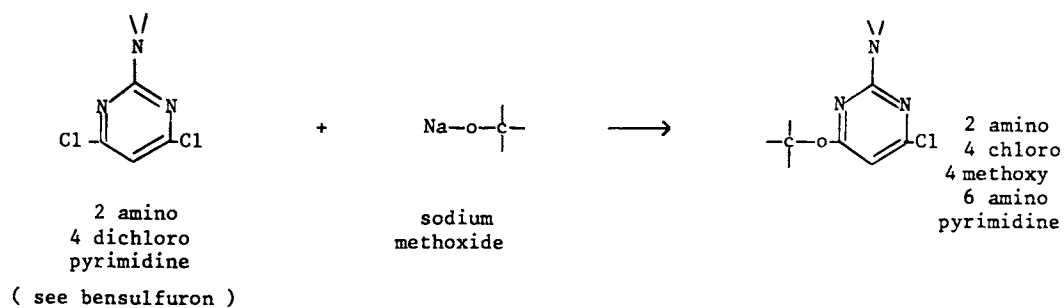
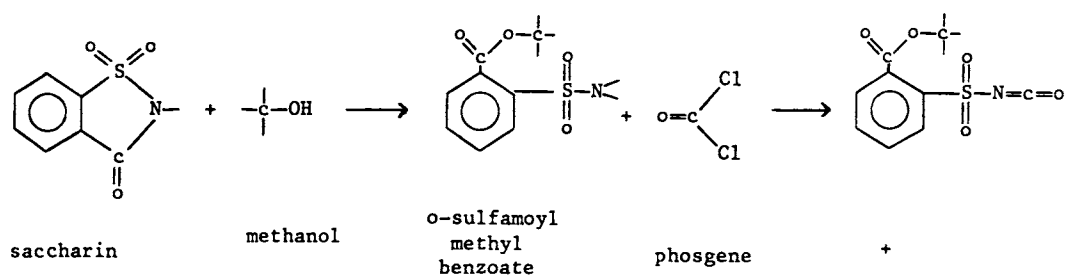
## Chlorimuron

Uses: herbicide, soyabeans

Trade names: Classic (Dupont)

Type: sulfonyl urea

Synthesis:



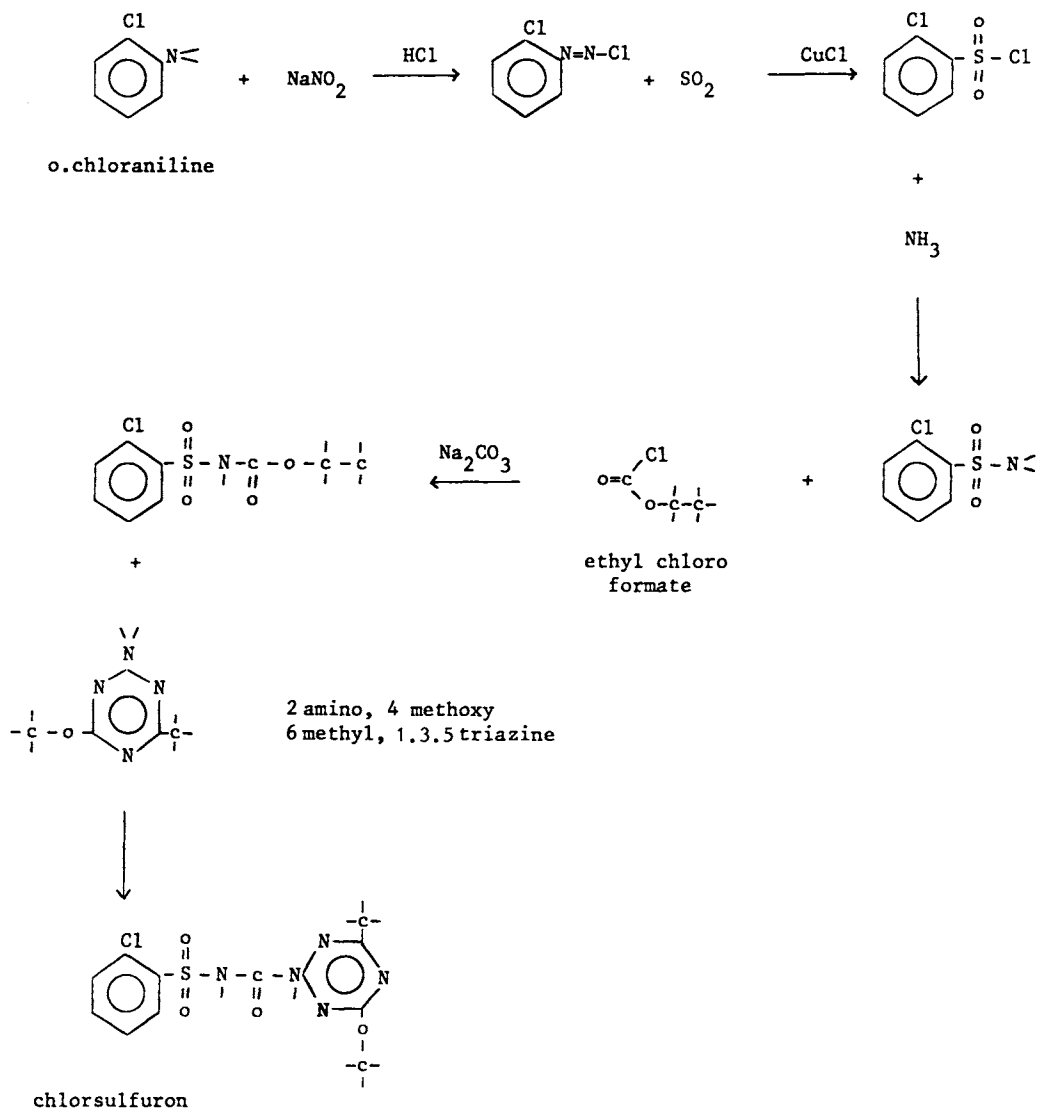
## Chlorsulfuron

Uses: herbicide, cereals

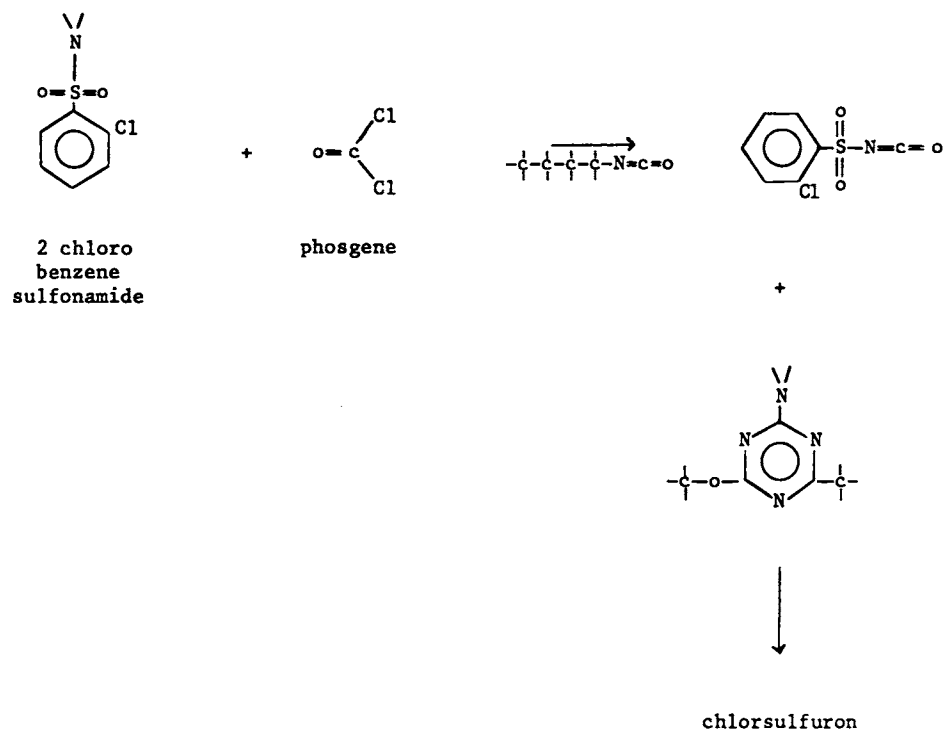
Trade names: Glean, Telar (Dupont)

Type: sulfonyl urea

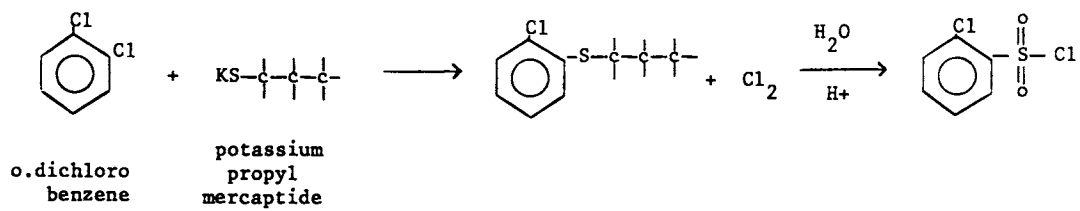
Synthesis:



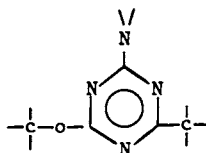
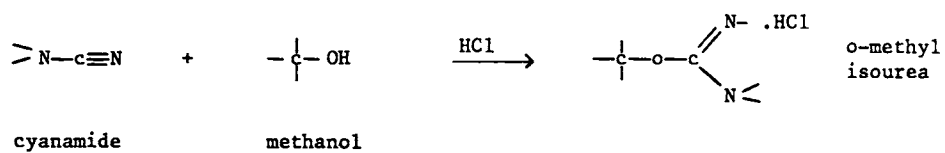
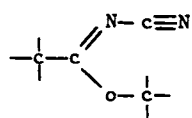
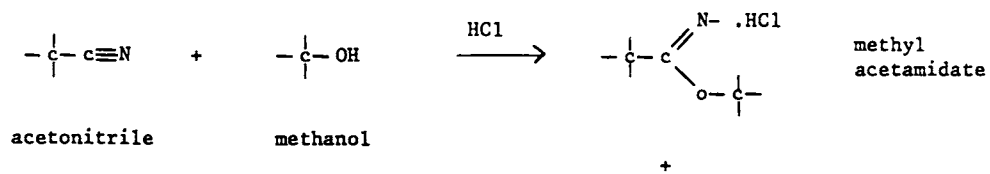
alternate route: (i)



alternate route: (ii)



preparation of 2 amino 4 methoxy 6 methyl 1.3.5 triazine



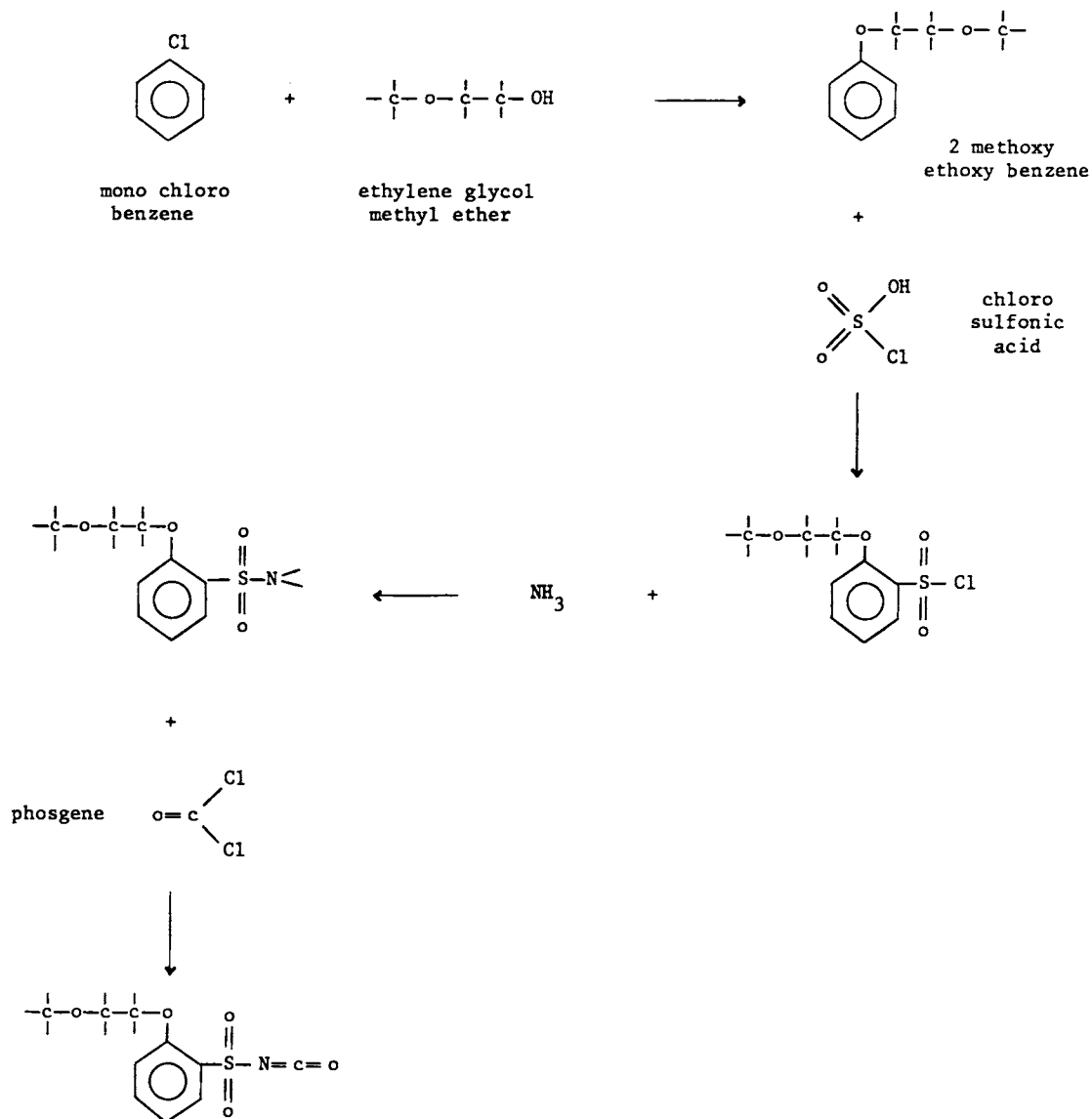
## Cinosulfuron

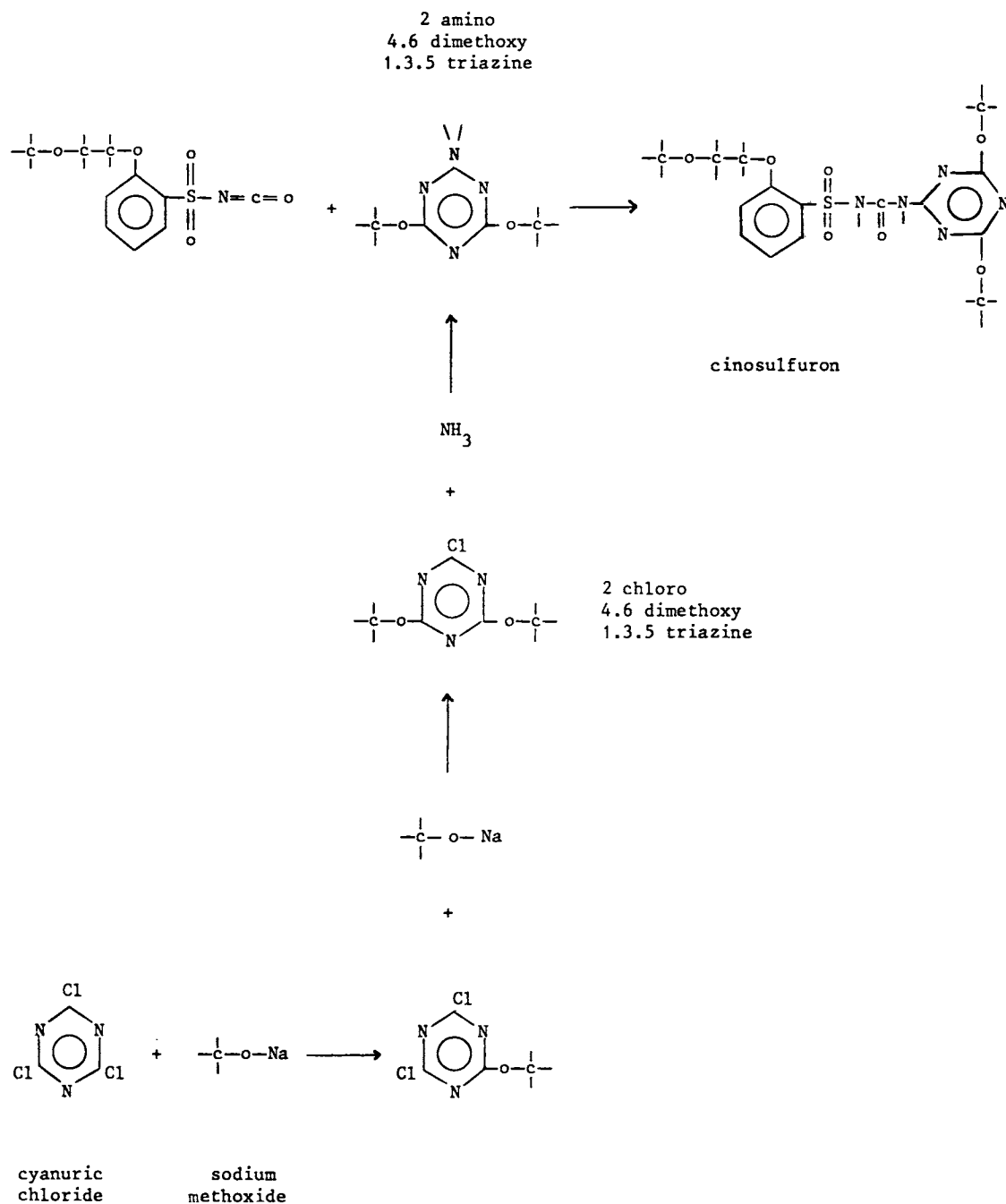
Uses: herbicide, rice, grass, tropical plantations

Trade names: Setoff (Ciba)

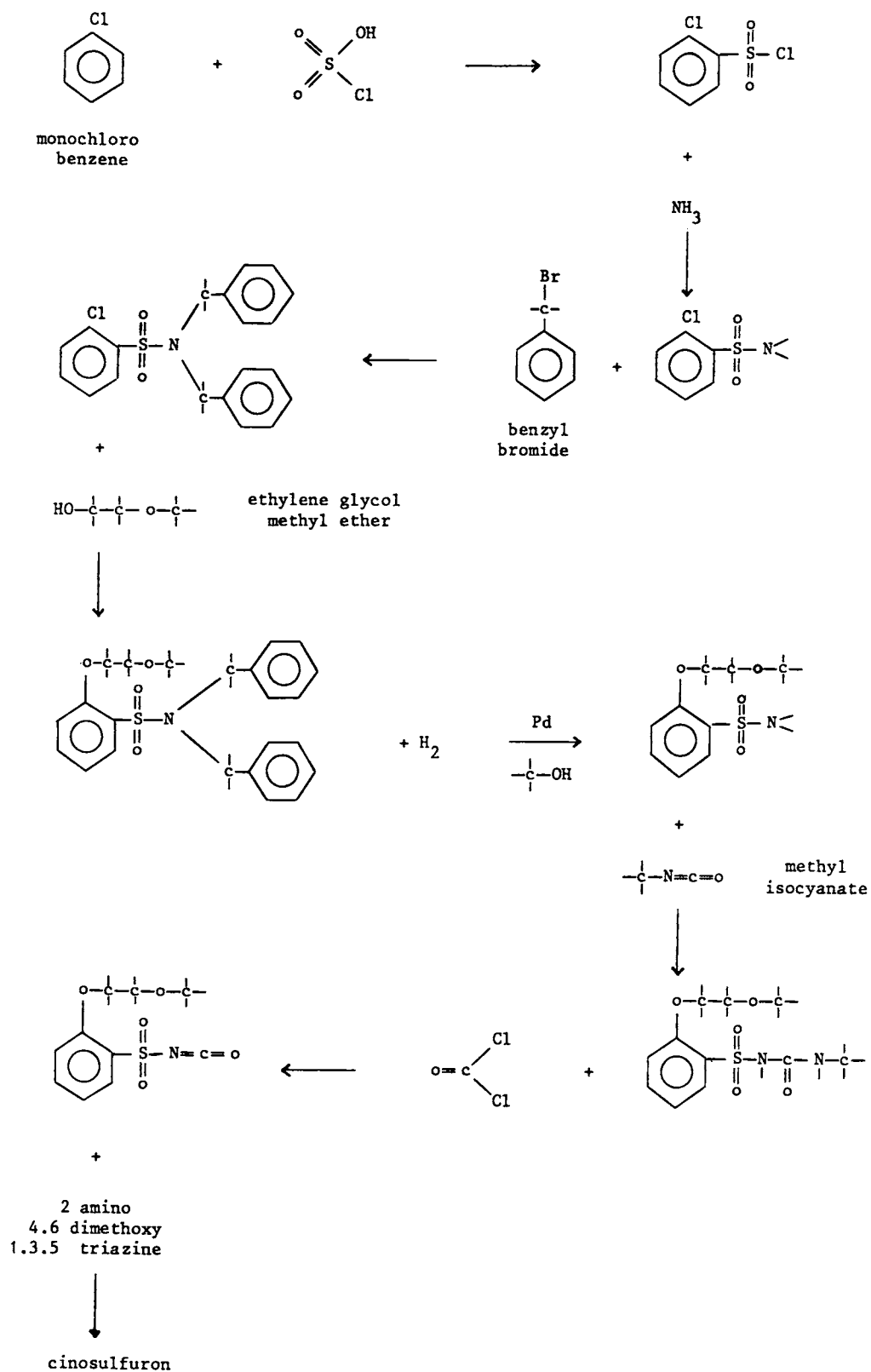
Type: sulfonyl urea

Synthesis:

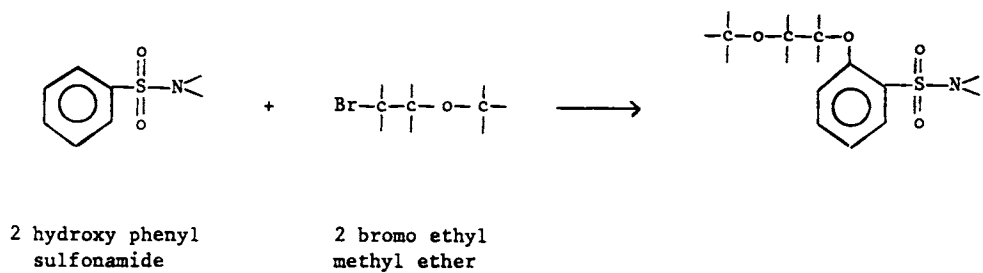




alternate route:



alternate route :





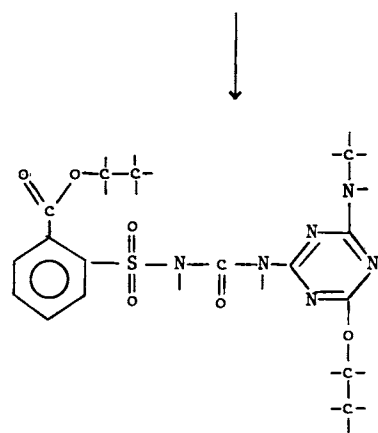
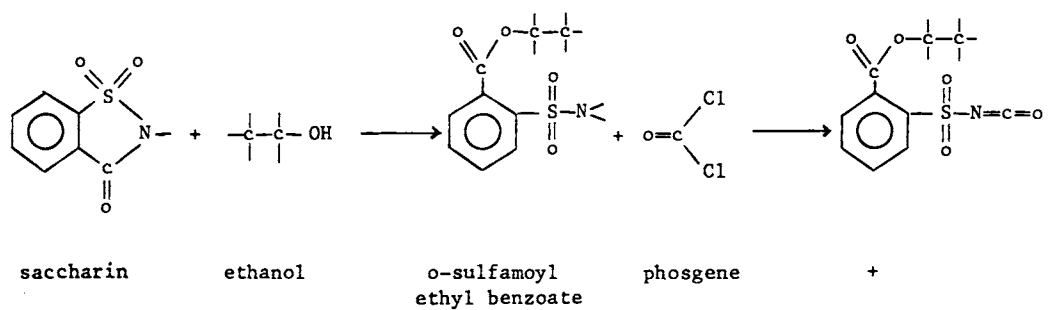
## Ethametsulfuron-Methyl

Uses: herbicide, oilseed rape

Trade names: Muster (DuPont)

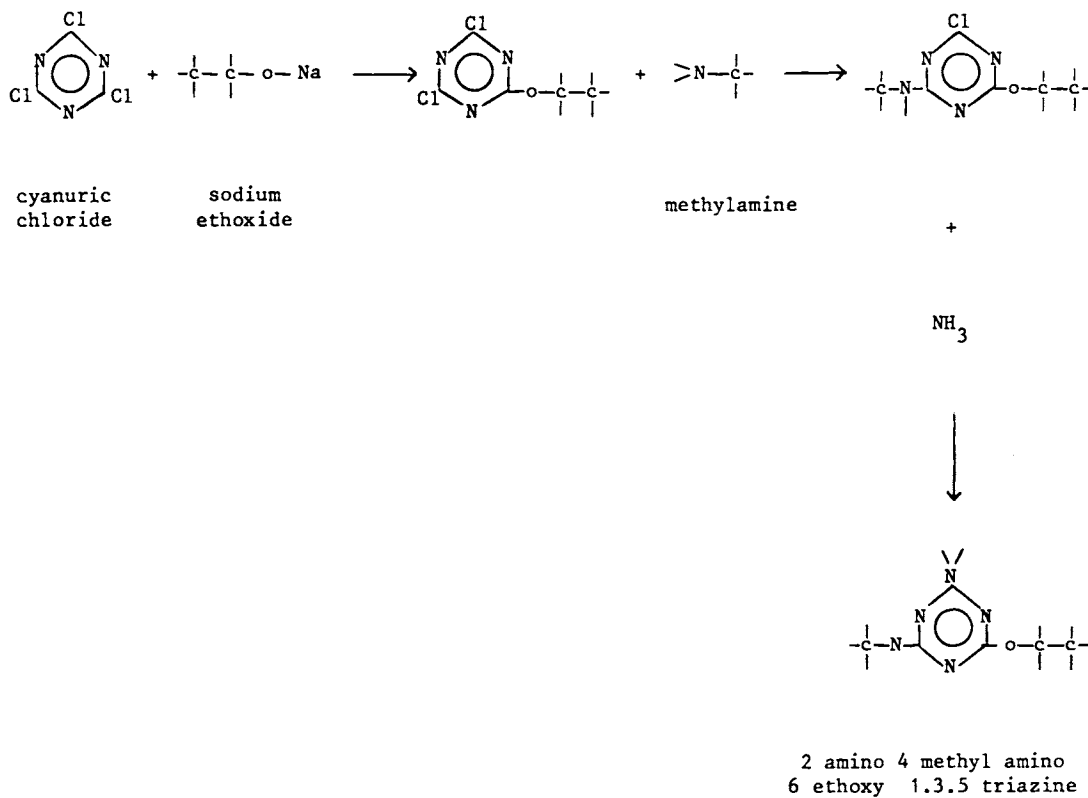
Type: sulfonyl urea

Synthesis:



ethametsulfuron-methyl

Preparation of 2 amino 4 methyl amino, 6 ethoxy 1.3.5 triazine :



Inverse order: Reaction first with methylamine and then with the alcohol is also feasible.

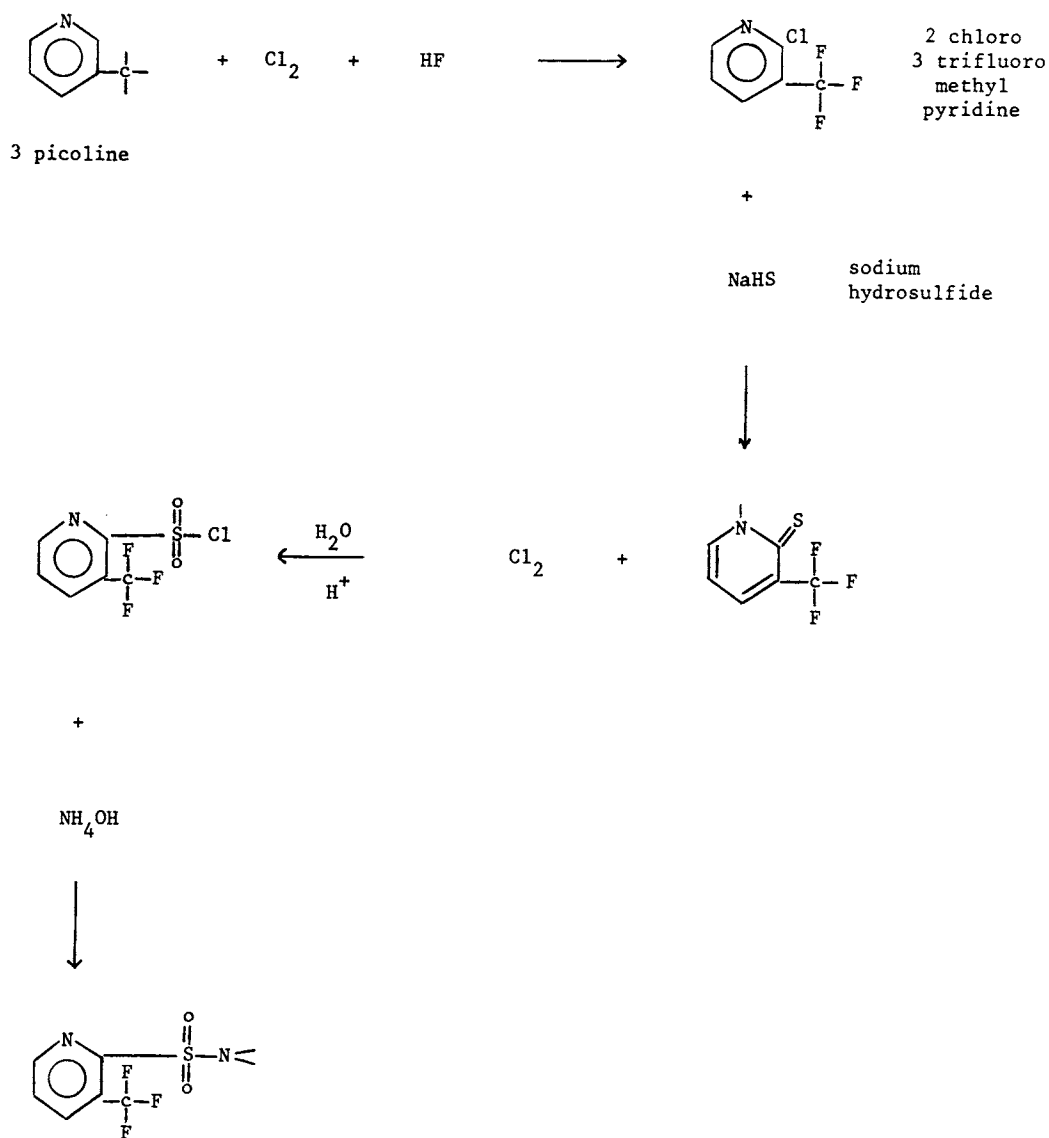
## Flazasulfuron

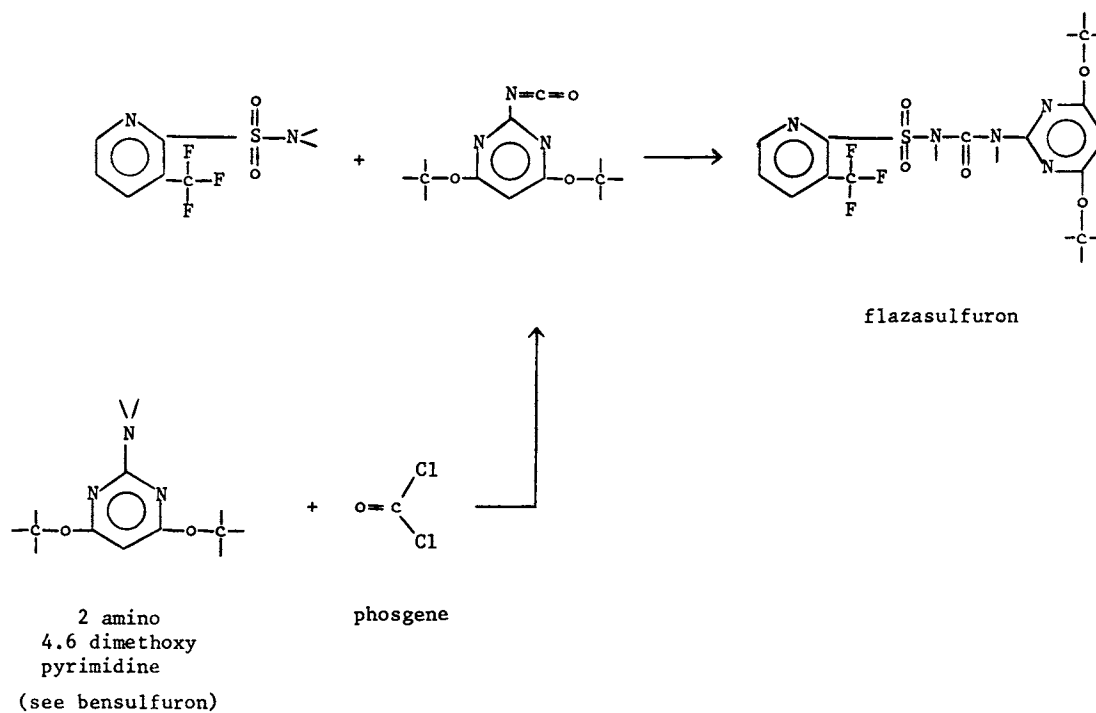
Uses: herbicide

Trade names: Shibagen (Ishihara)

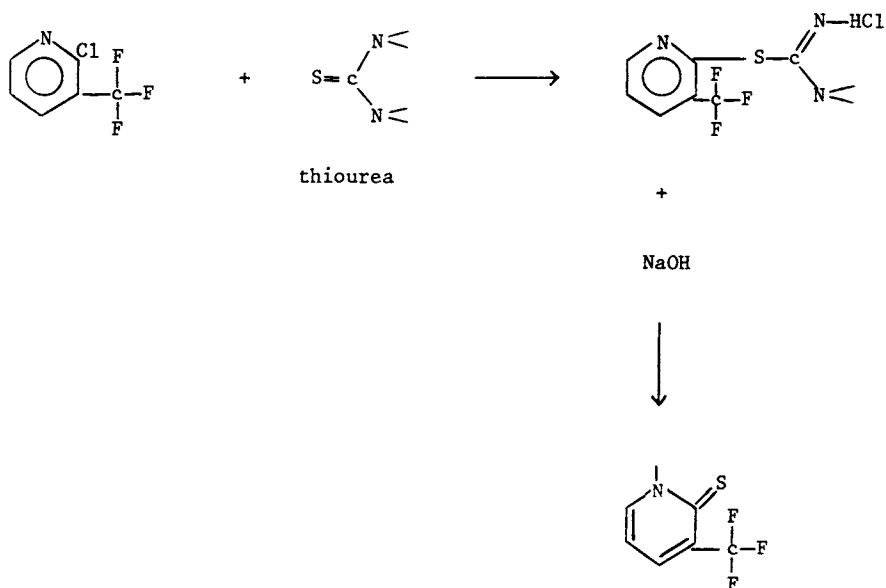
Type: sulfonyl urea

Synthesis:



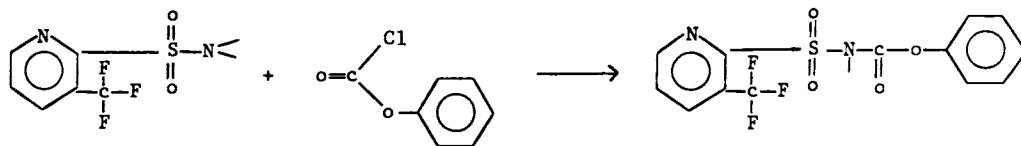


alternate route :



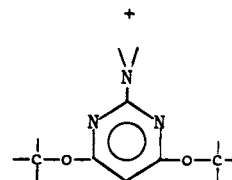
alternate route :

(i)



3 trifluoro  
methyl 2 pyridine  
sulfonamide

phenyl chloroformate

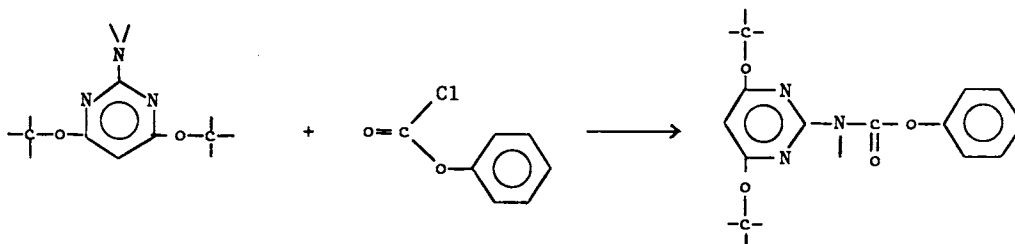


flazasulfuron

(ii)

3 trifluoro  
methyl 2 pyridine  
sulfonamide

+



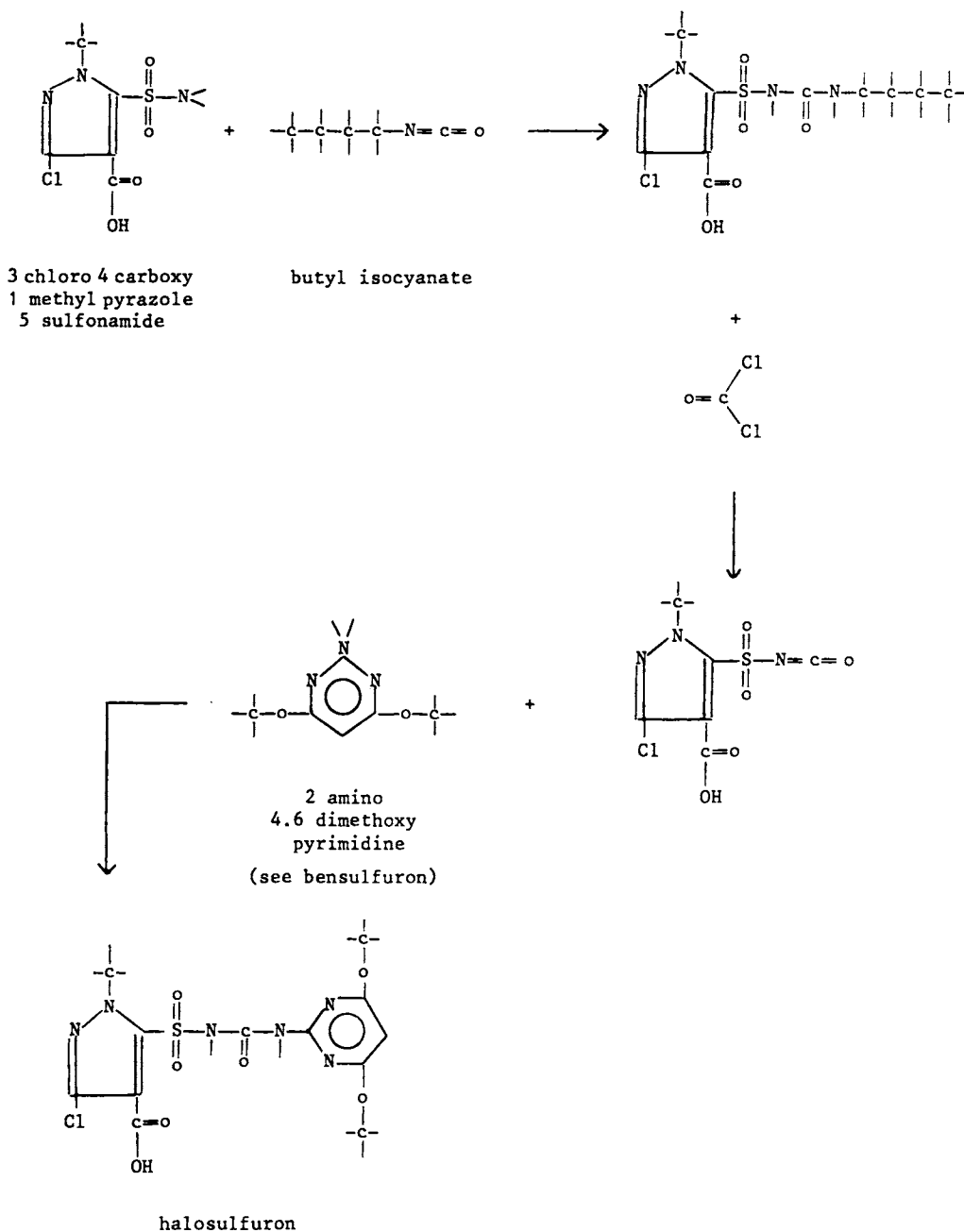
## Halosulfuron

Uses: herbicide, maize, sugarcane, rice, turf

Trade names: Permit (Nissan)

Type: sulfonyl urea, pyrazole

Synthesis:



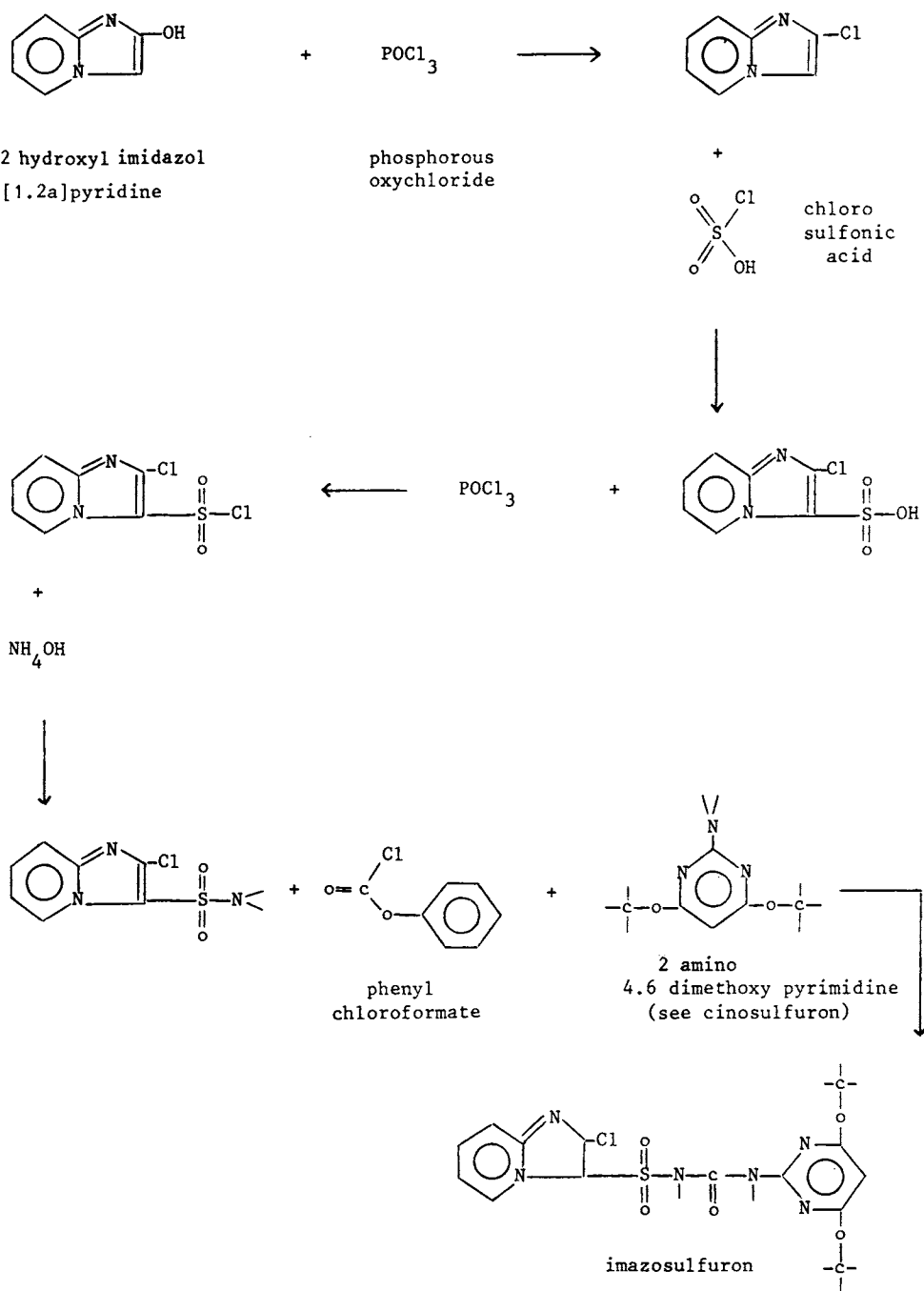
## Imazosulfuron

Uses: herbicide, rice

Trade names: Sibatito, Takeoff (Takeda)

Type: sulfonyl urea

Synthesis:



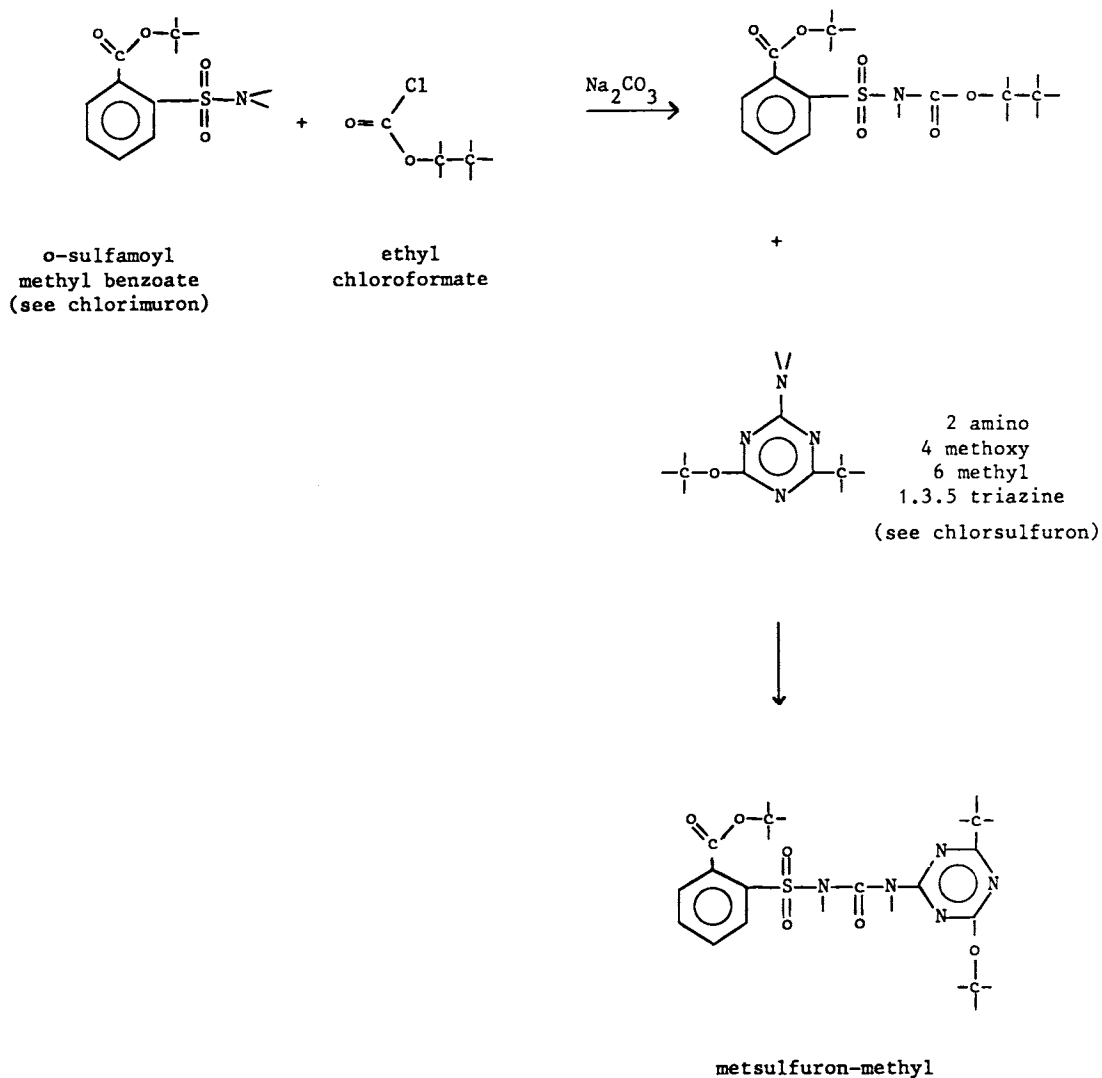
## Metsulfuron-Methyl

Uses: herbicide, wheat, barley, cereals

Trade names: Ally, Allie (Dupont)

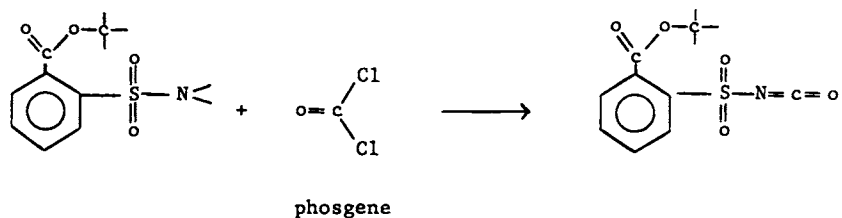
Type: sulfonyl urea

Synthesis:





alternate route :



+

2 amino 4 methoxy  
6 methyl, 1.3.5 triazine



metsulfuron

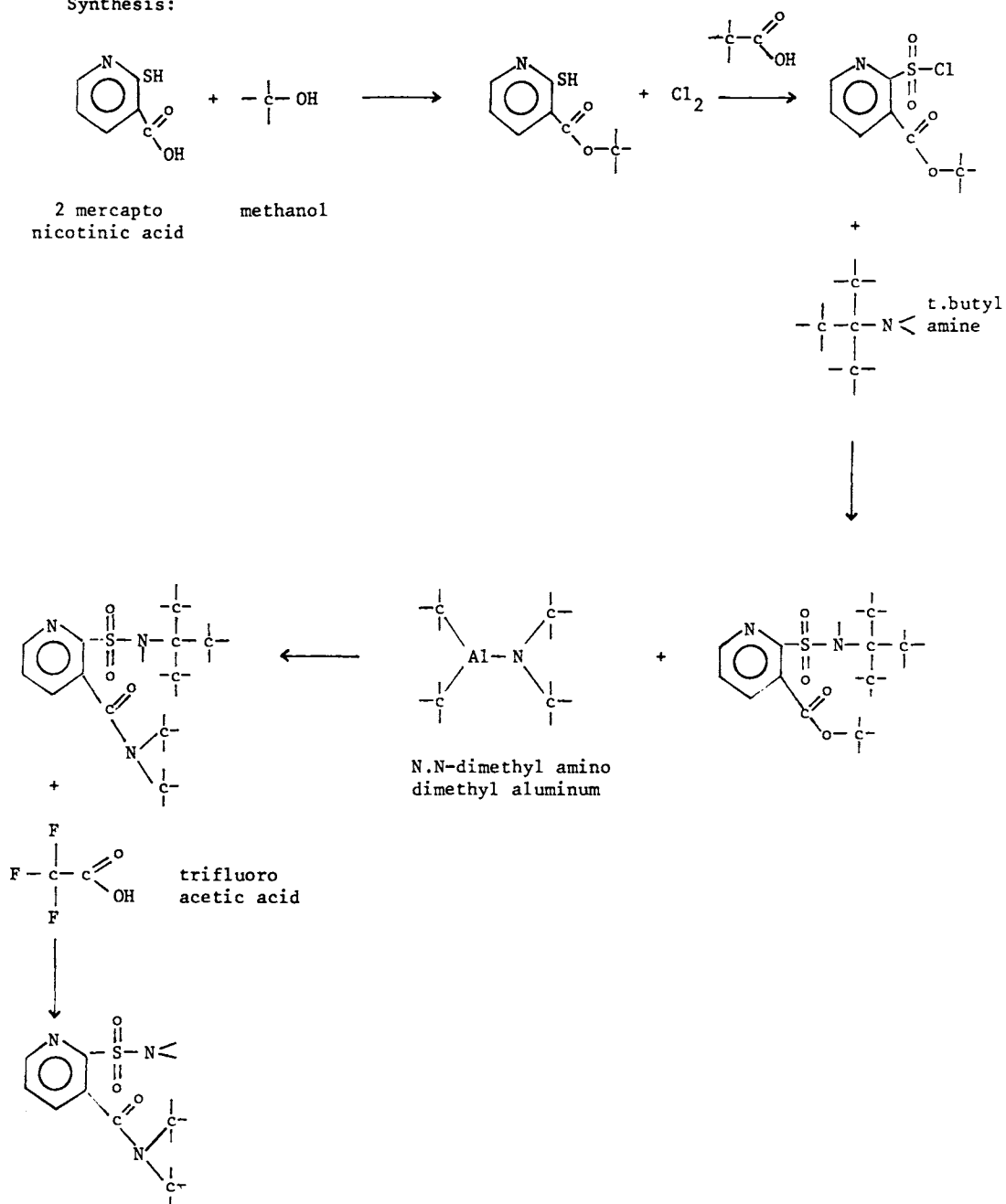
## Nicosulfuron

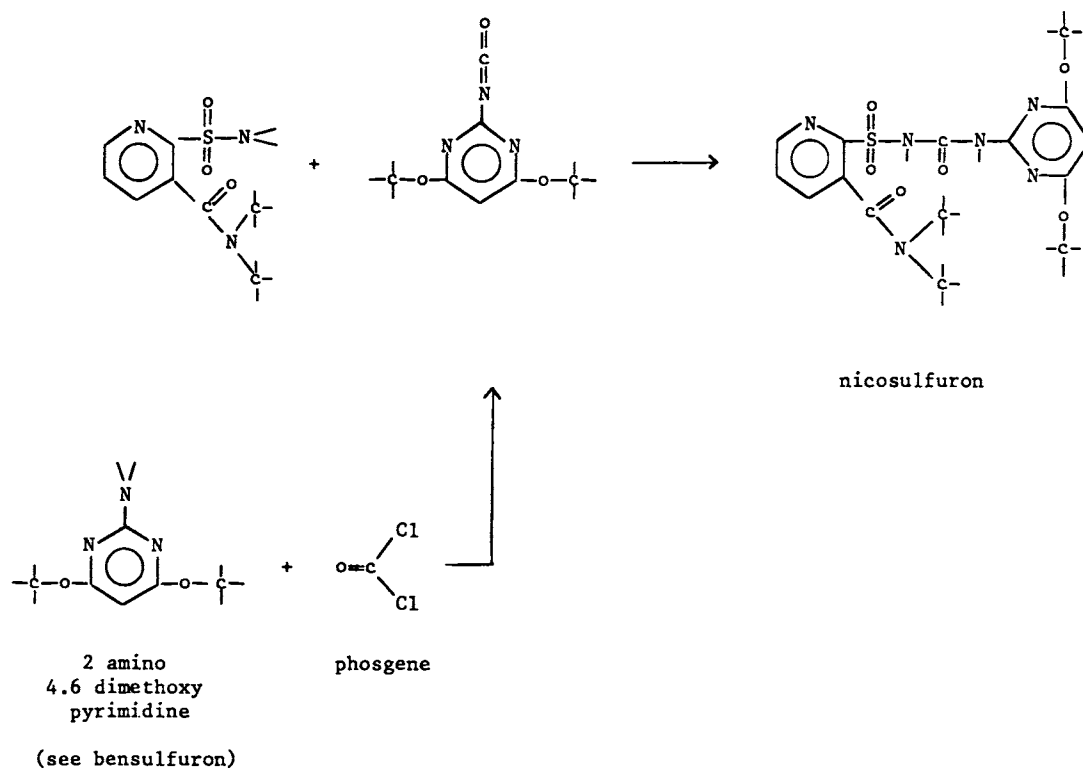
Uses: herbicide, maize

Trade names: Accent (Ishihara)

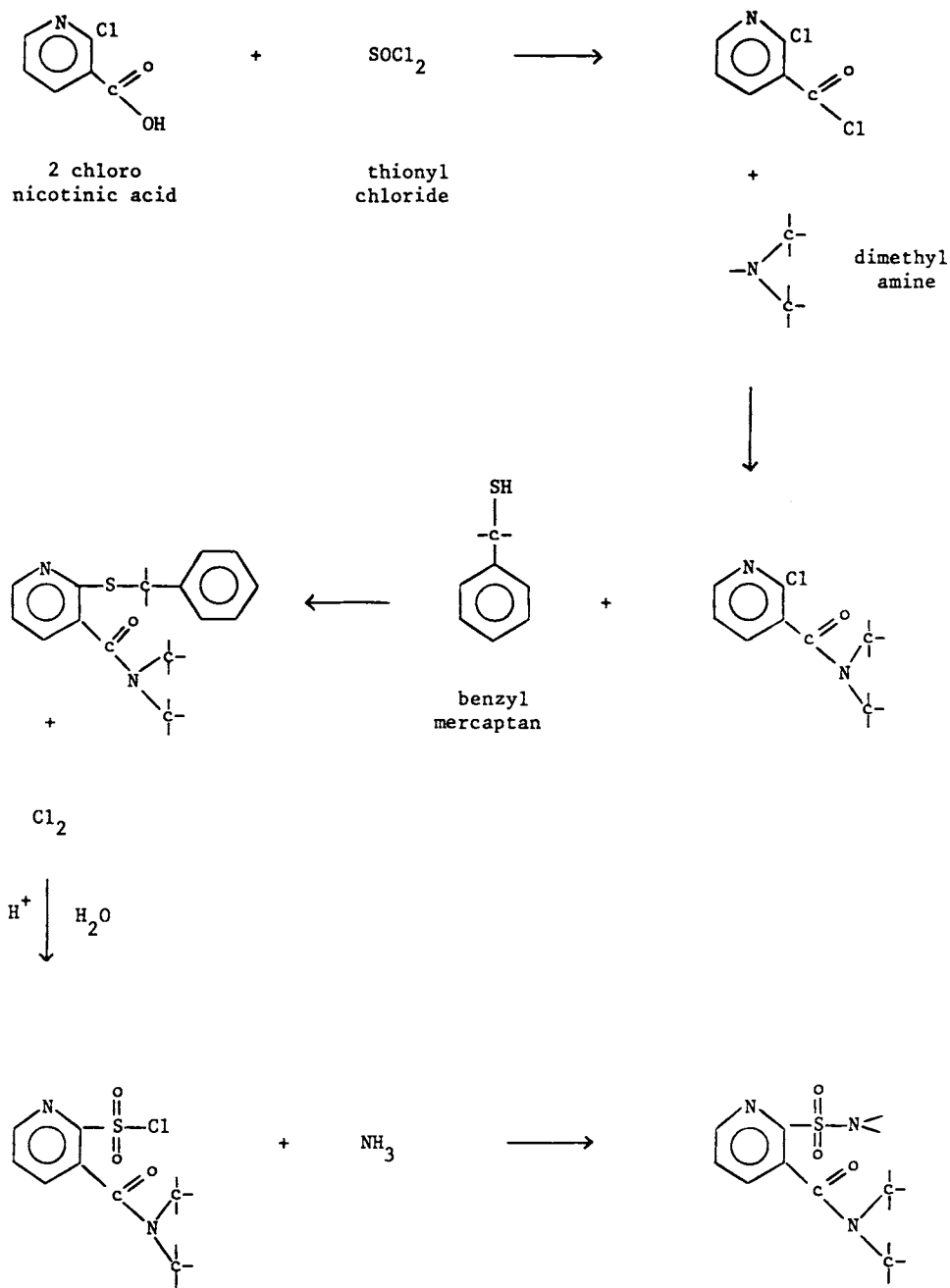
Type: sulfonyl urea

Synthesis:





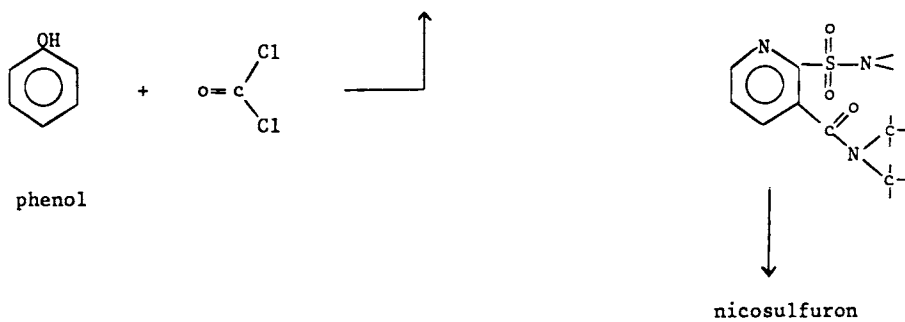
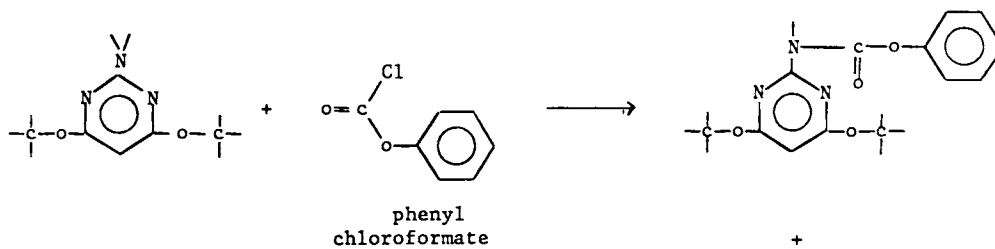
alternate route :



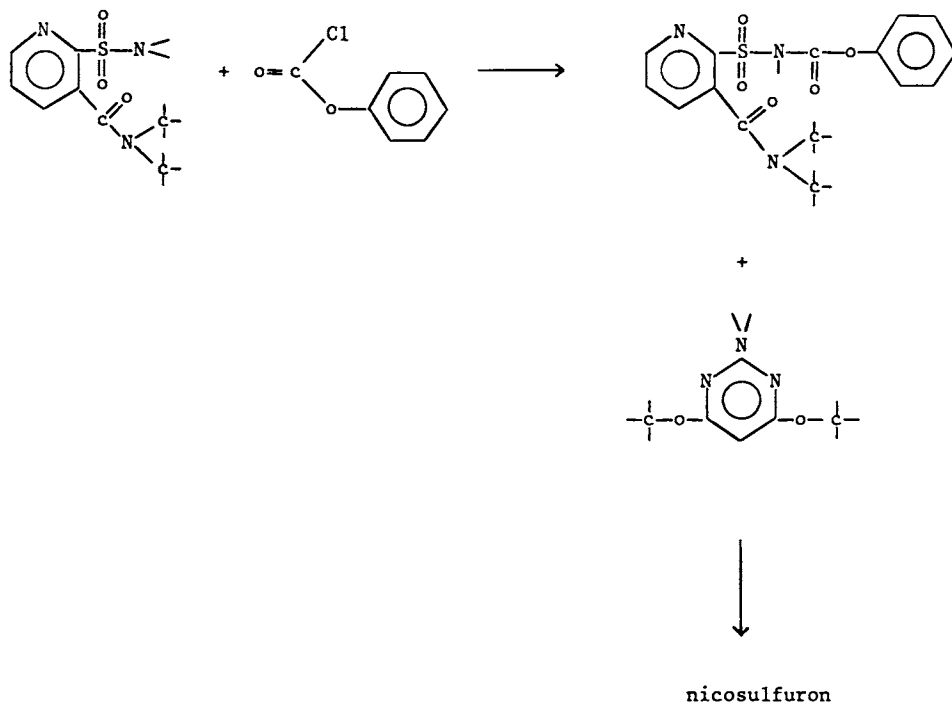
alternate route:

as above starting with mercaptanicotinic acid (instead of chloronicotinic acid)  
and reacting with benzyl chloride (instead of benzyl mercaptan)

alternate route :



alternate route :



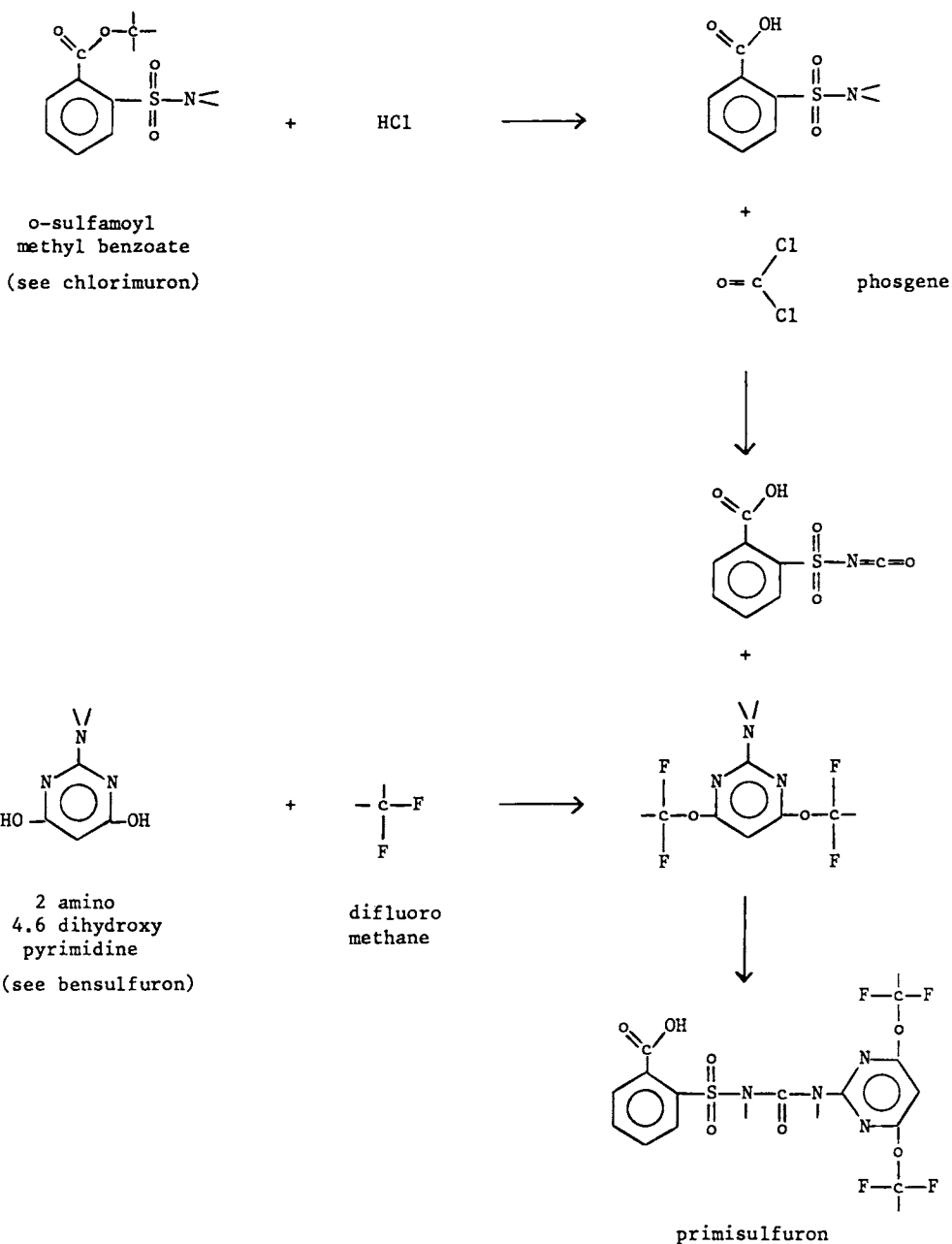
## Primisulfuron

Uses: herbicide, maize

Trade names: Beacon, Tell (Ciba)

Type: sulfonyl urea

Synthesis:



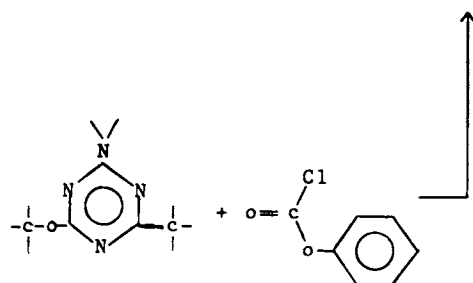
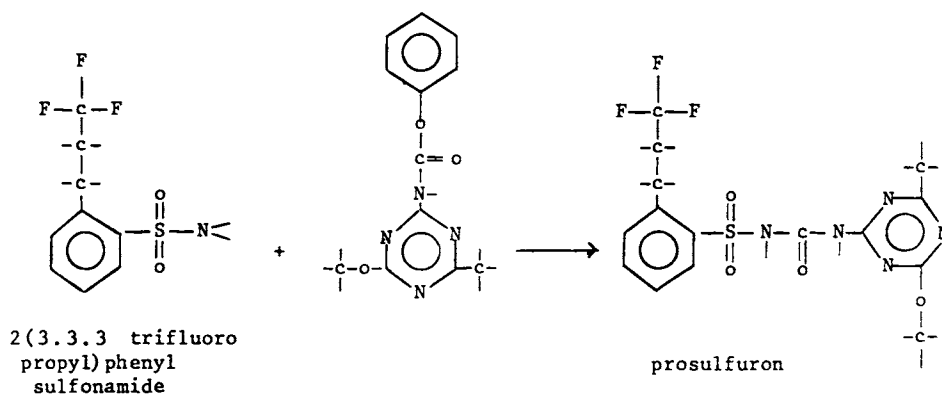
## Prosulfuron

Uses: herbicide, maize, sorghum

Trade names: Exceed, Peak (Ciba)

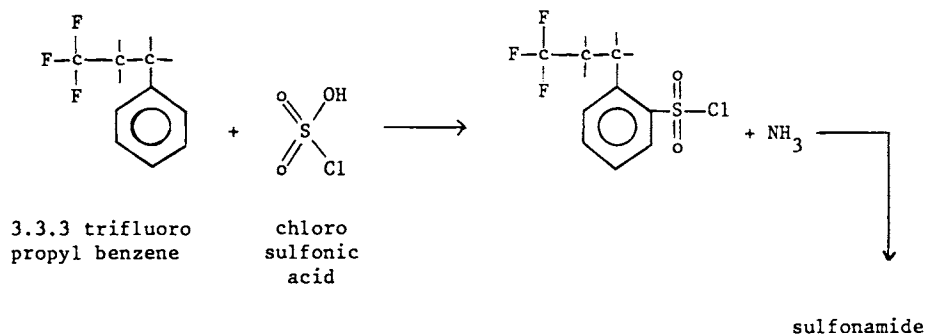
Type: sulfonyl urea

Synthesis:

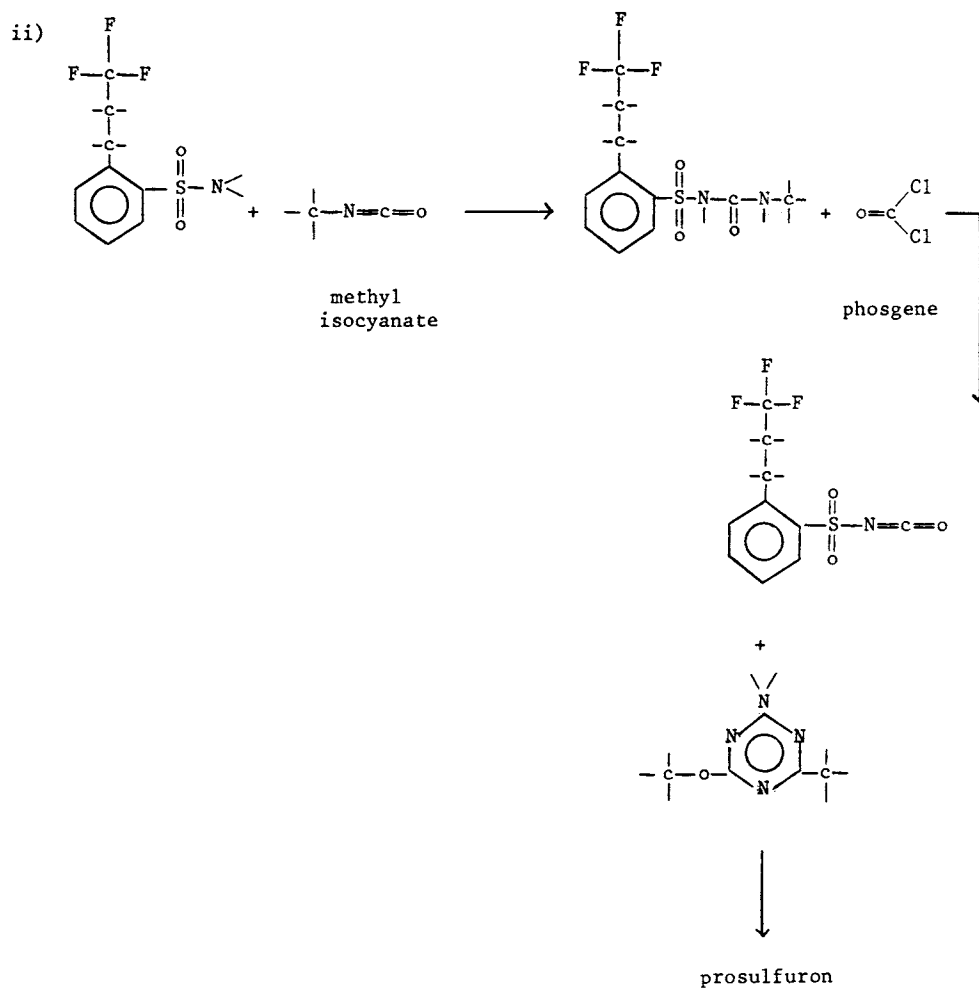
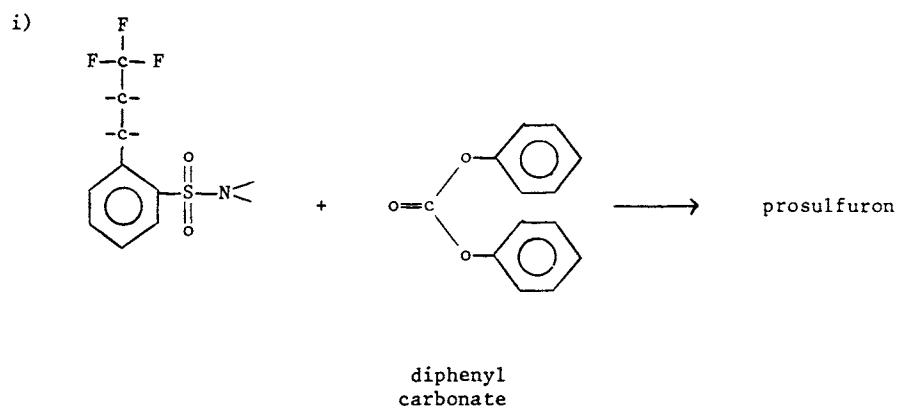


2 amino  
4 methoxy  
6 methoxy  
1.3.5 triazine  
(see chlorsulfuron)

preparation of sulfonamide:



alternate routes :





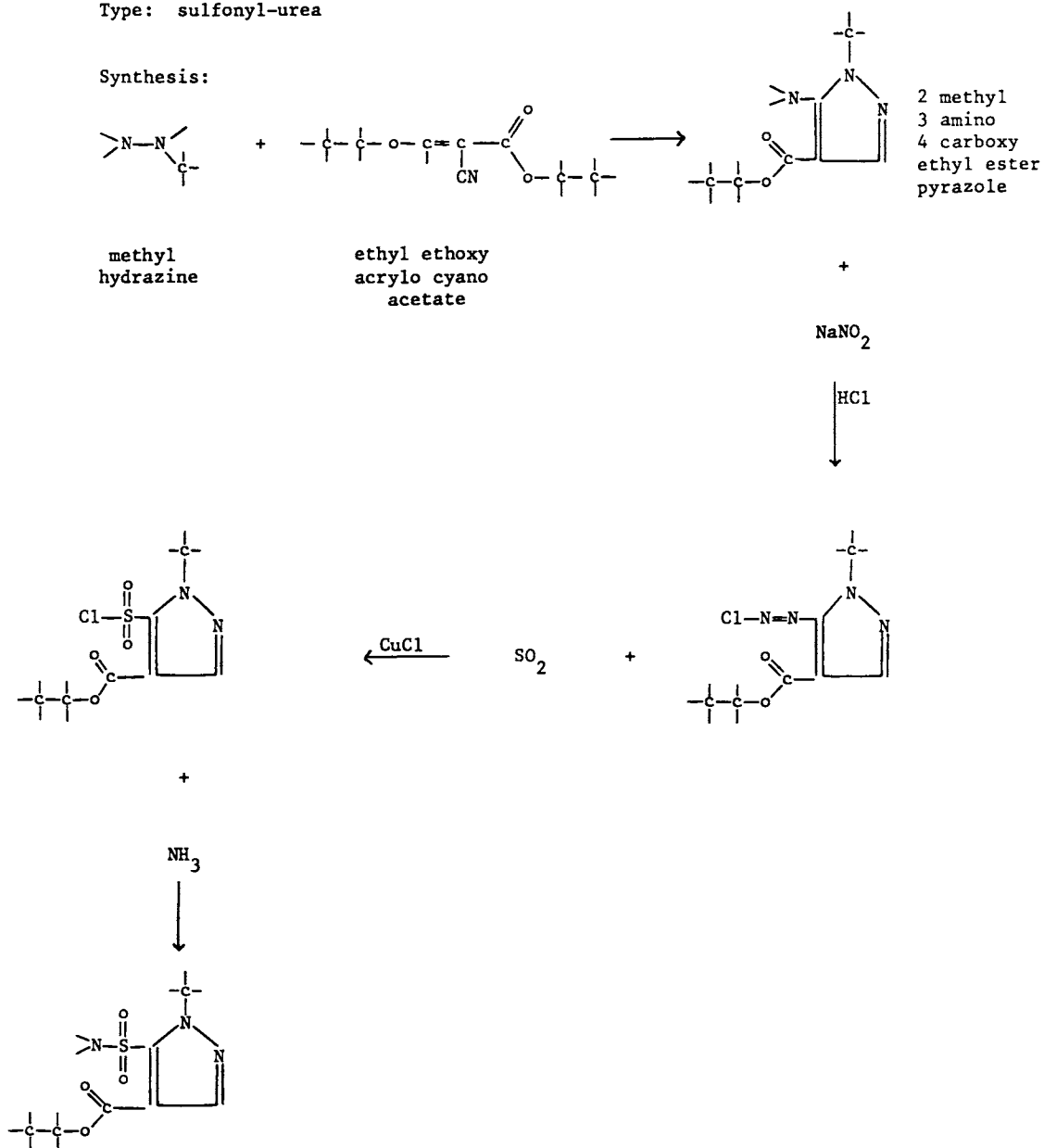
## Pyrazosulfuron

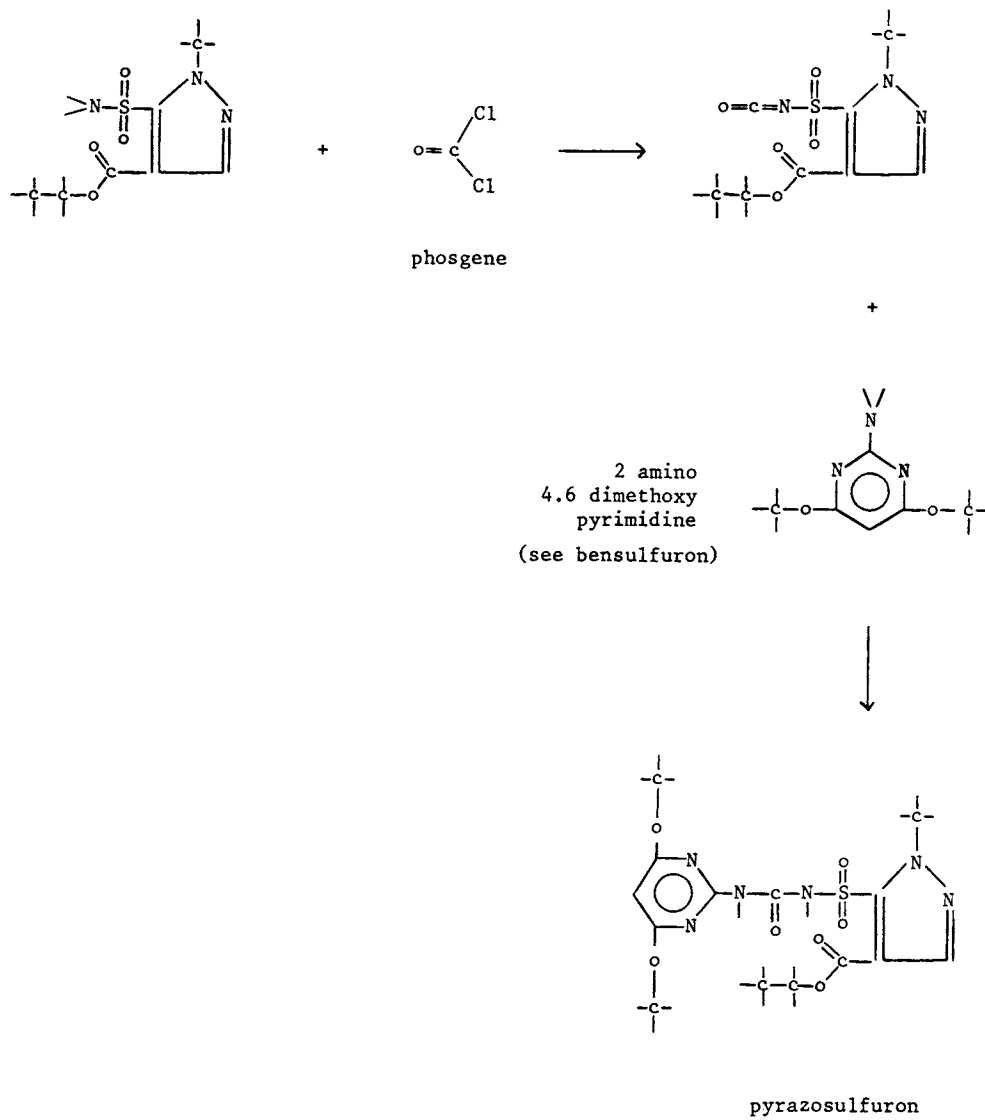
Uses: herbicide, rice

Trade names: Agreeen, Sirius (Nissan)

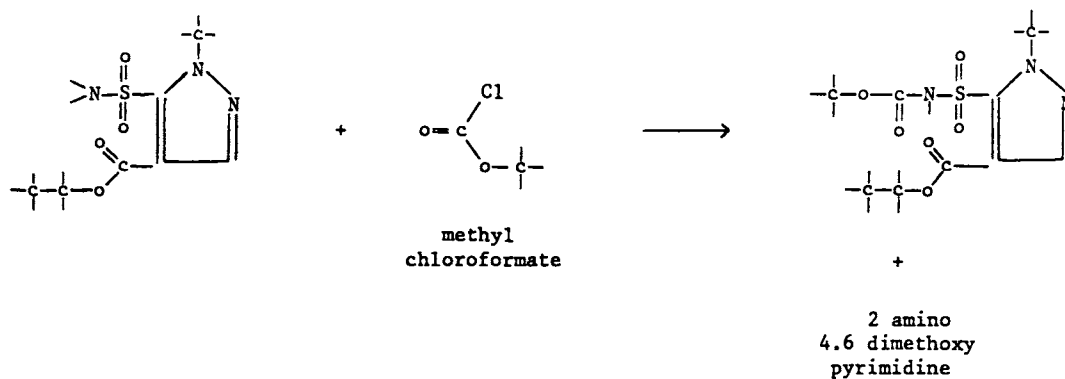
Type: sulfonyl-urea

Synthesis:



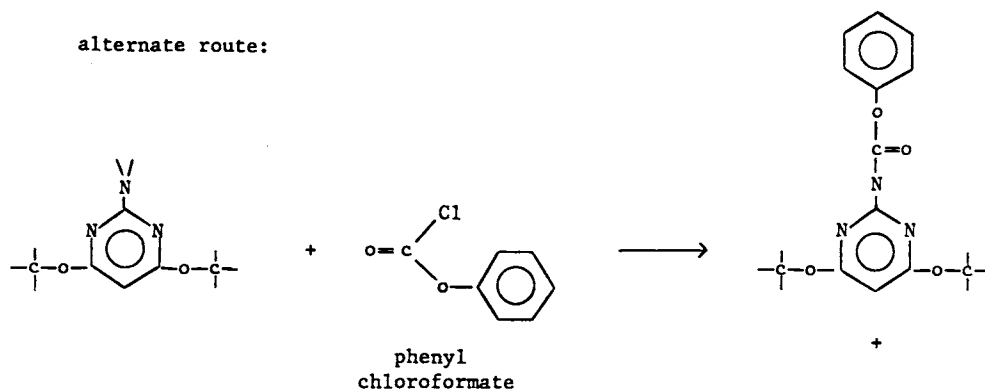


alternate route:



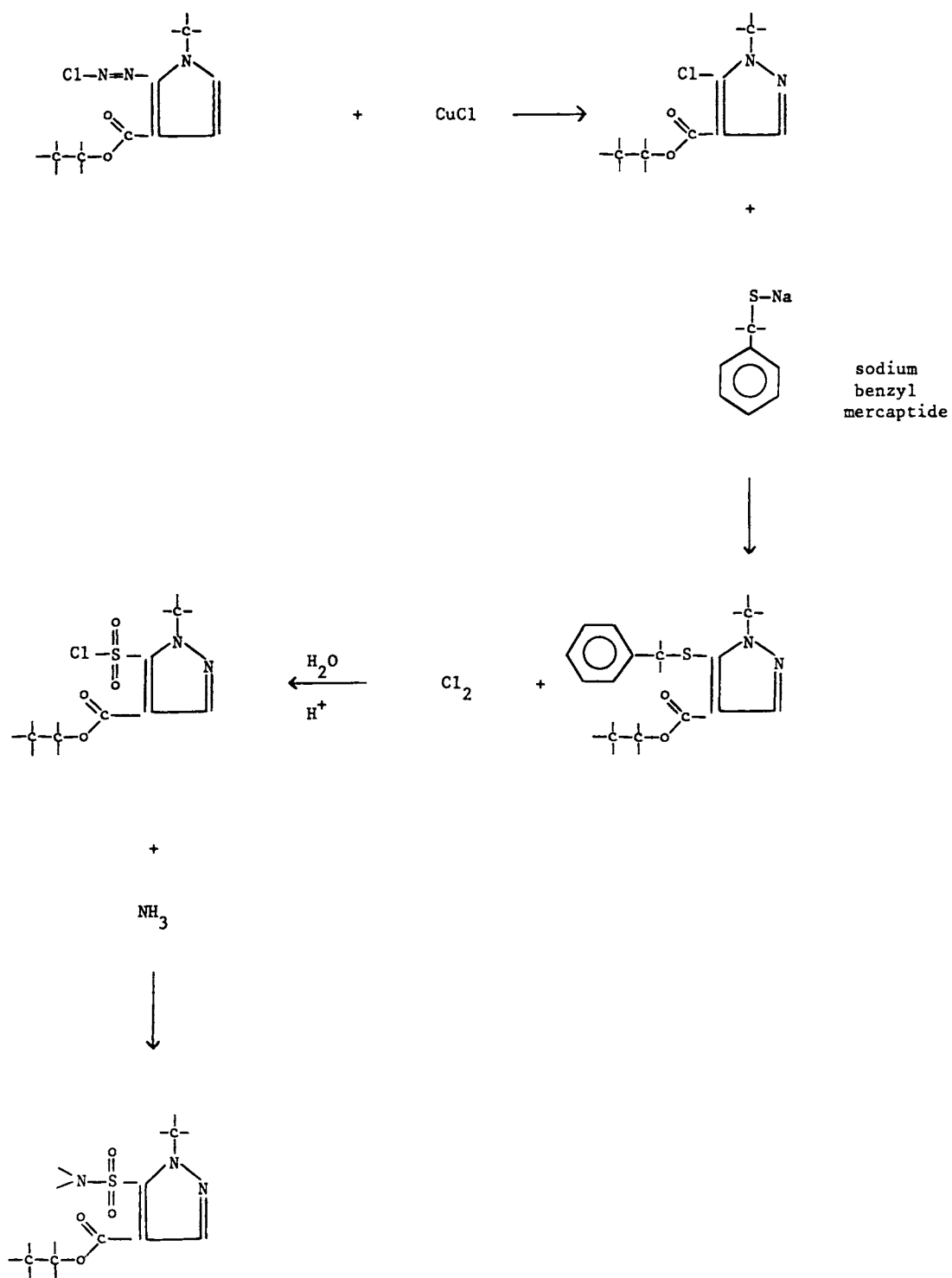
↓  
pyrazosulfuron

alternate route:



↓  
pyrazosulfuron

alternate route :



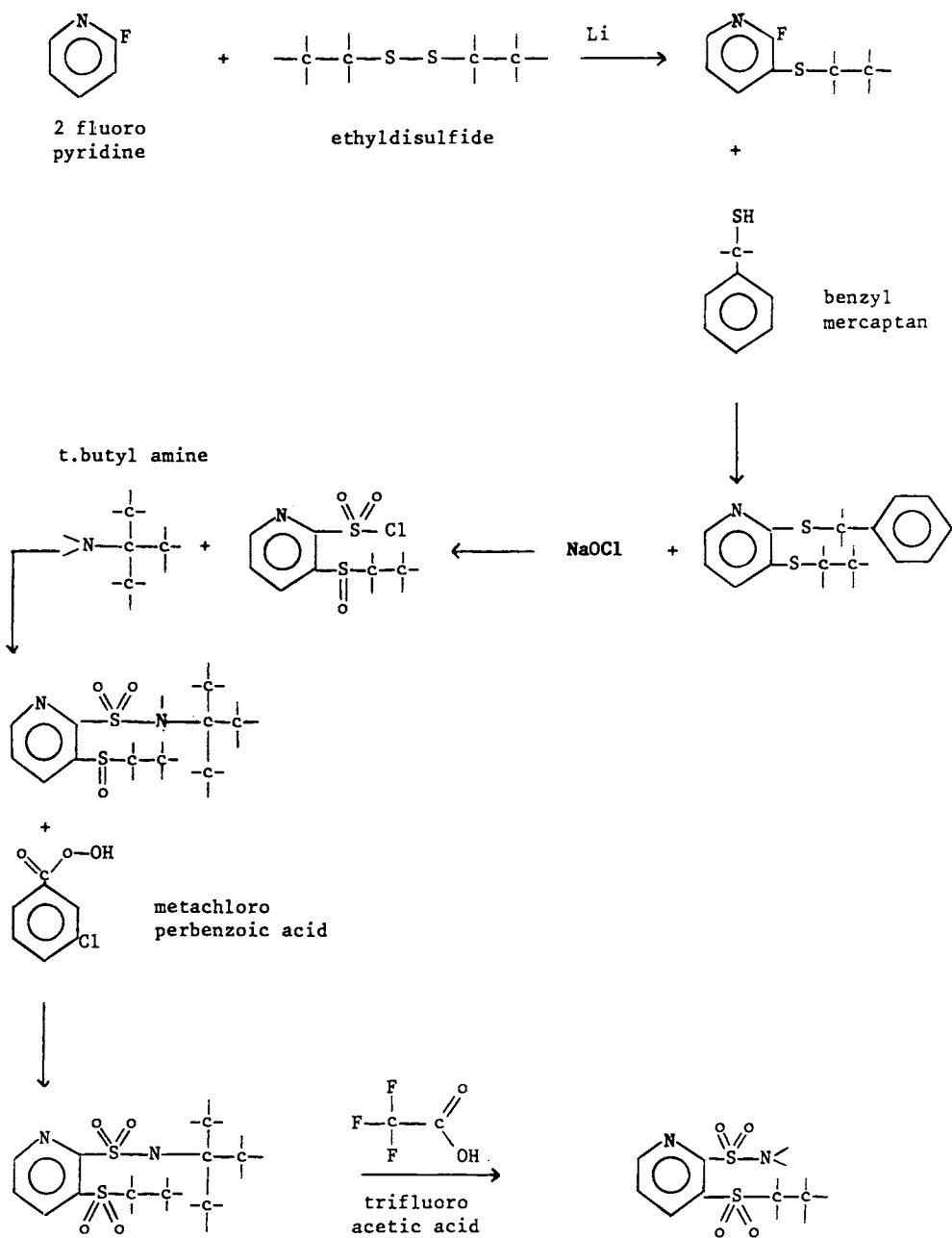
## Rimsulfuron

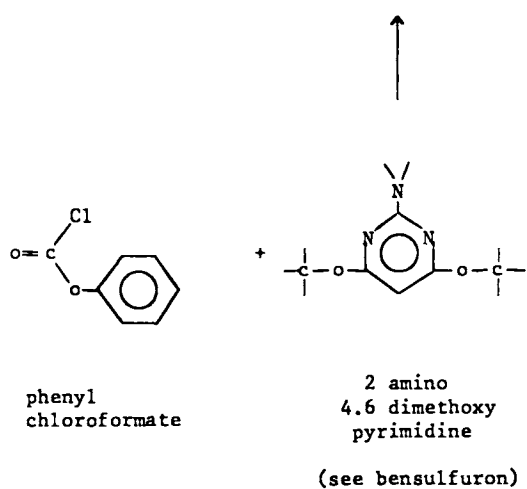
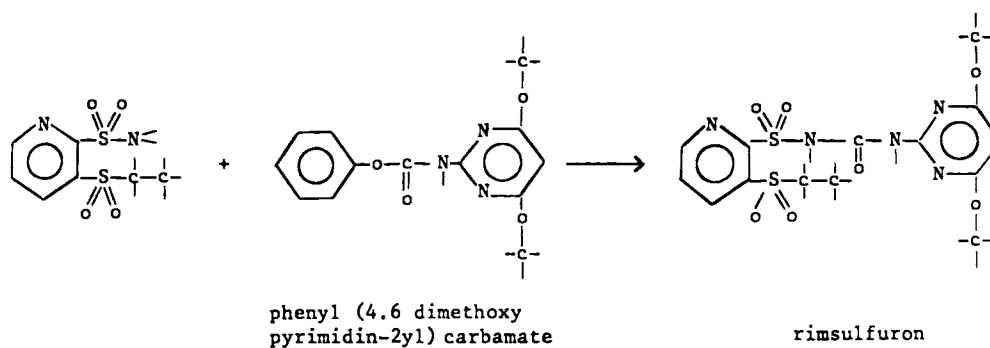
Uses: herbicide, maize

Trade names: Titus (DuPont)

Type: sulfonyl urea

Synthesis:





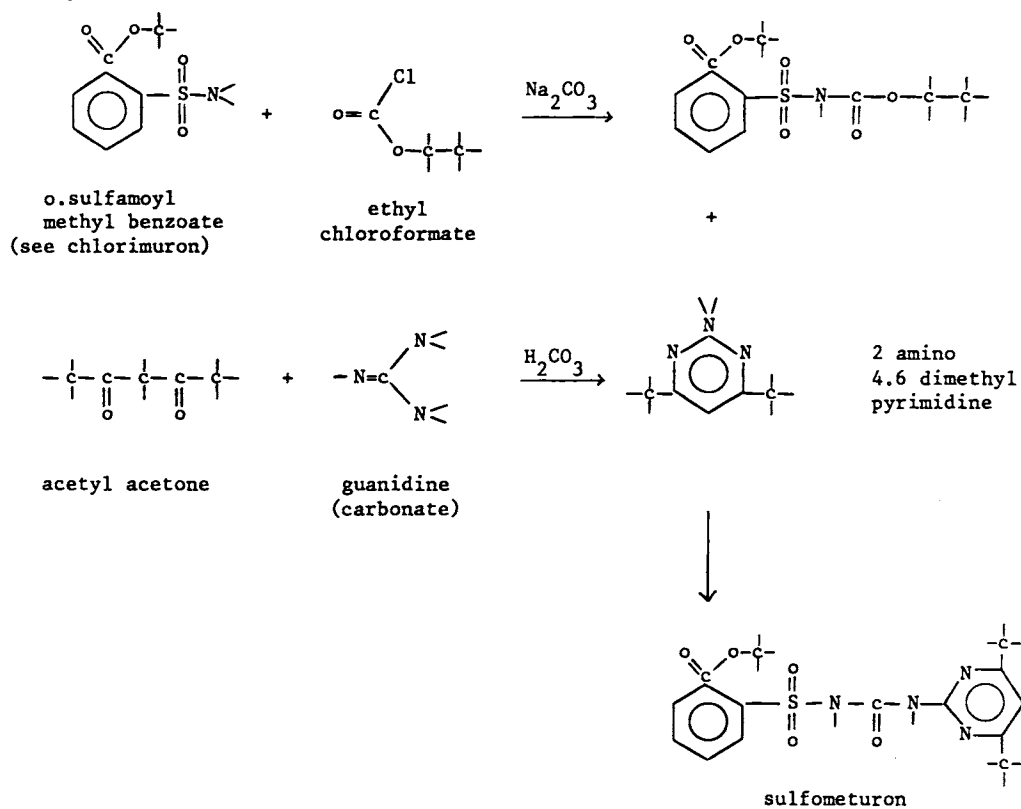
## Sulfometuron

Uses: herbicide

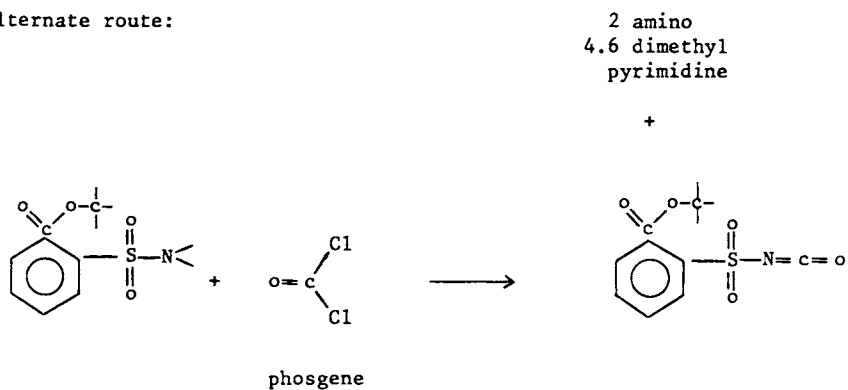
Trade names. Oust (Dupont)

Type: sulfonyl urea

Synthesis:



alternate route:



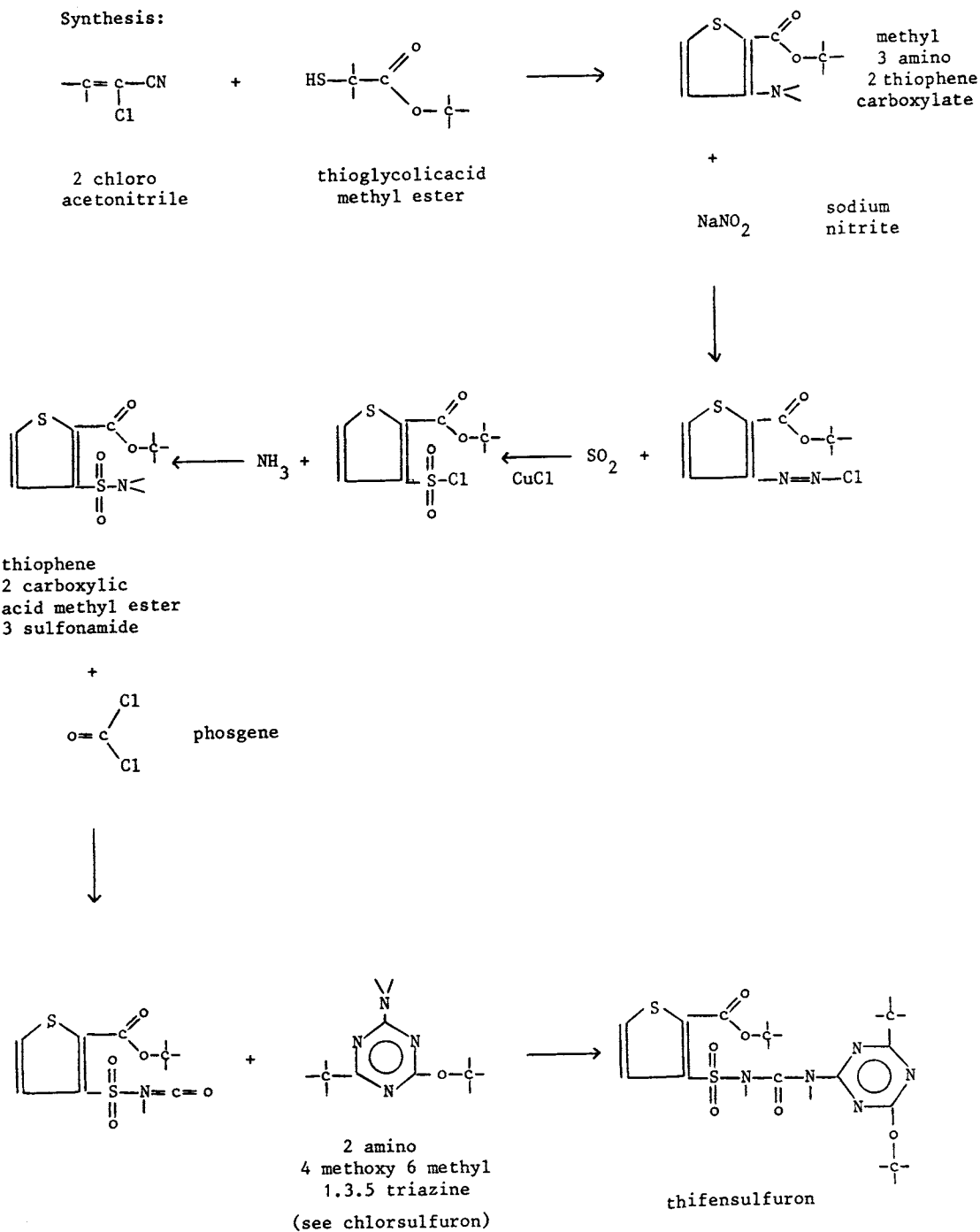
## Thifensulfuron

Uses: herbicide, cereals

Trade names: Harmony (Dupont)

Type: sulfonyl urea

Synthesis:





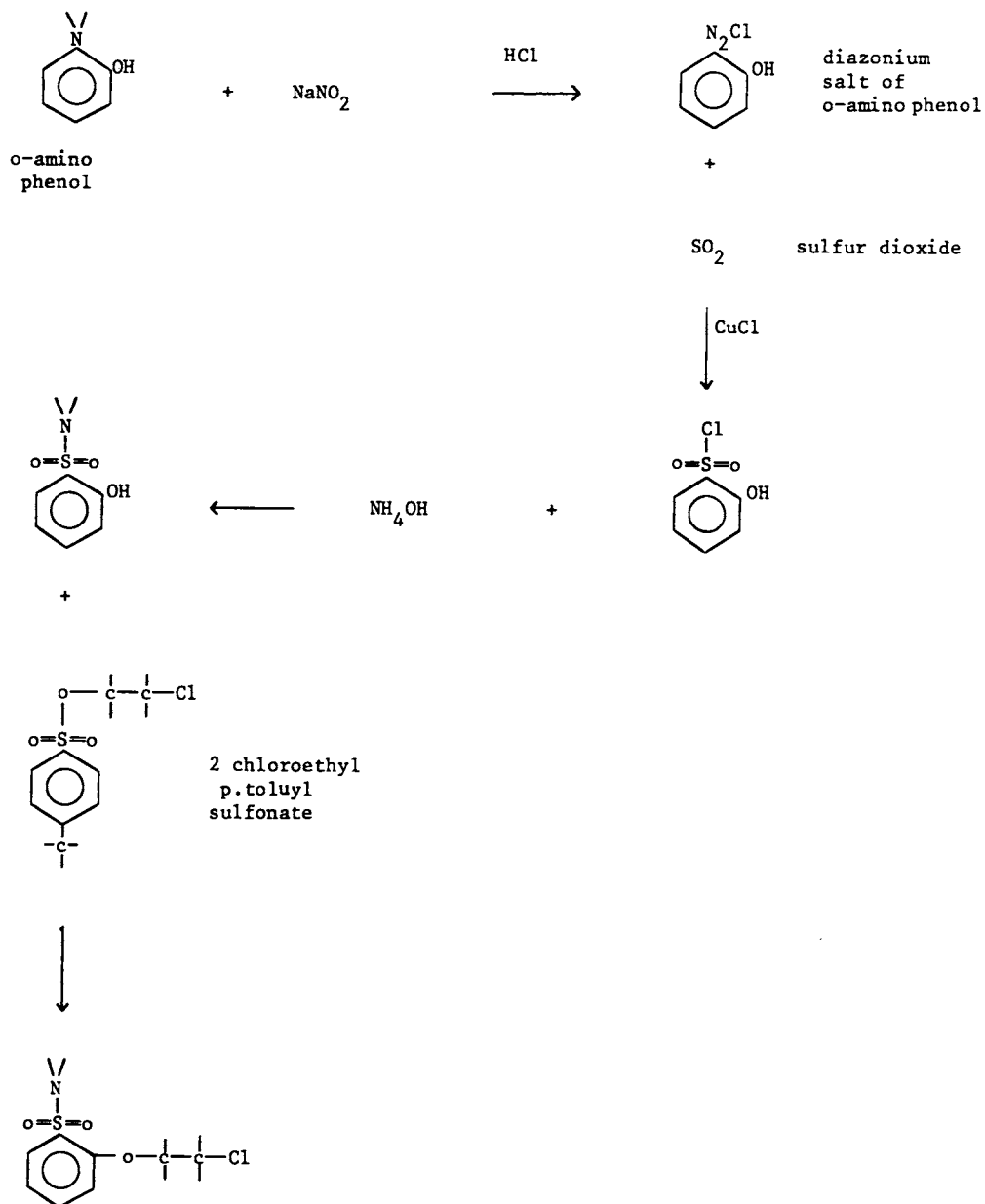
## Triasulfuron

Uses: herbicide, cereals

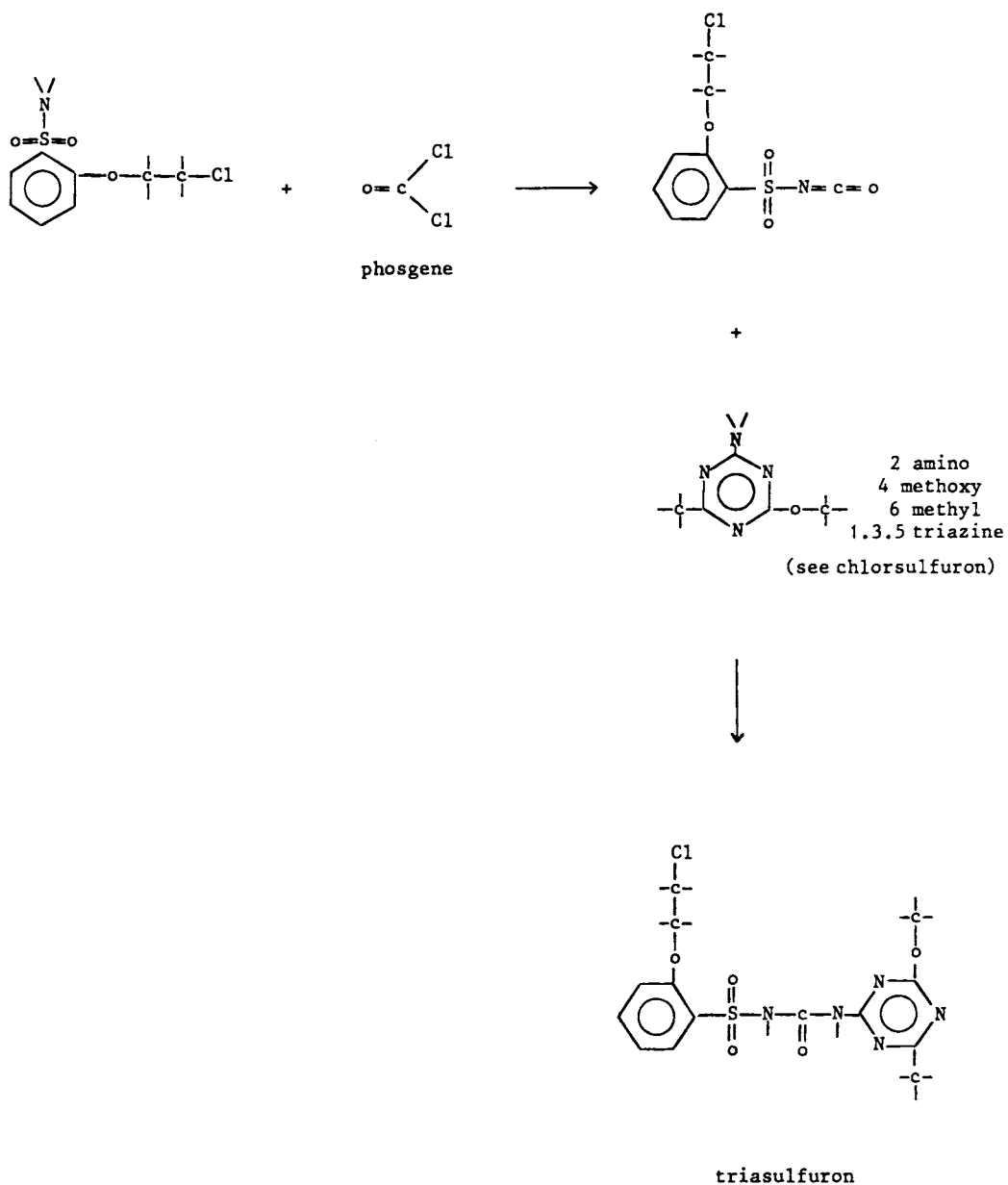
Trade names: Amber, Logran (Ciba)

Type: sulfonyl urea

Synthesis:



CONT.



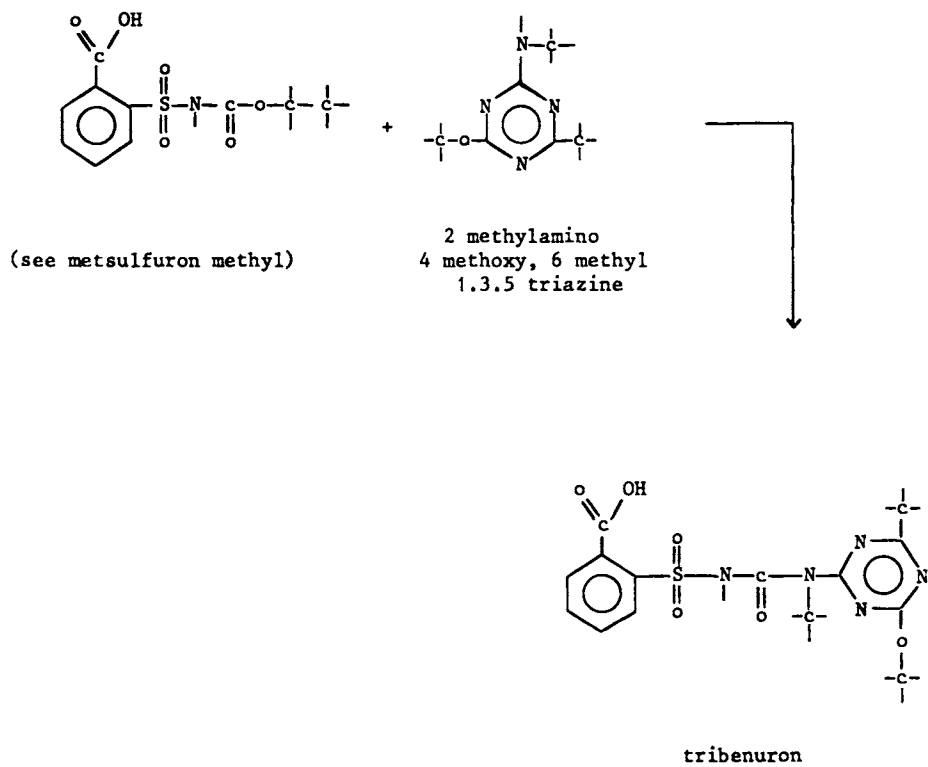
## Tribenuron

Uses: herbicide, cereals

Trade names: Express (Dupont)

Type: sulfonyl urea

Synthesis:



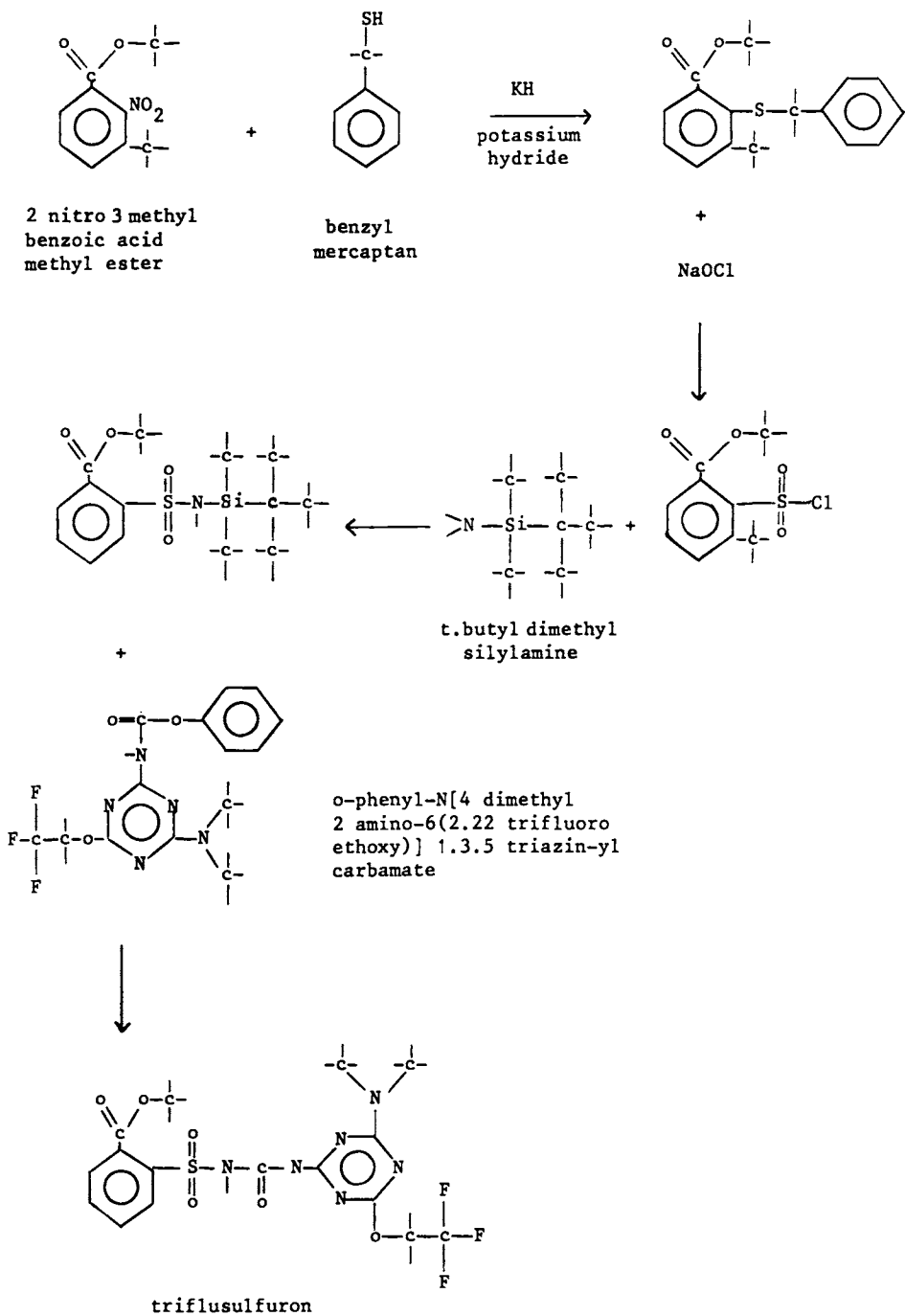
## Triflusulfuron

Uses: herbicide, sugarbeet

Trade names: Safari (DuPont)

Type: sulfonyl urea

Synthesis:



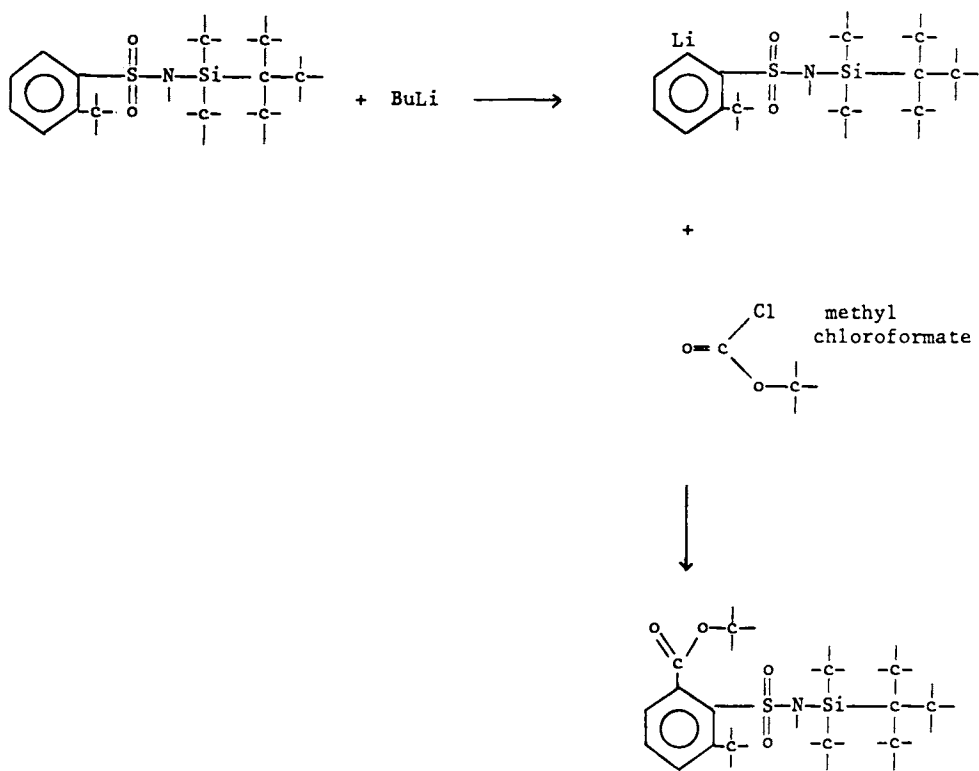
Preparation of the triazine :

see ethametsulfuron-methyl; same reaction sequence starting with cyanuric chloride and

dimethylamine, followed by

$$\begin{array}{c} \text{F} \\ | \\ \text{F}-\text{C}-\text{C}-\text{ONa} \\ | \\ \text{F} \end{array}$$

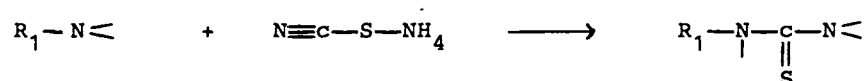
alternate route :



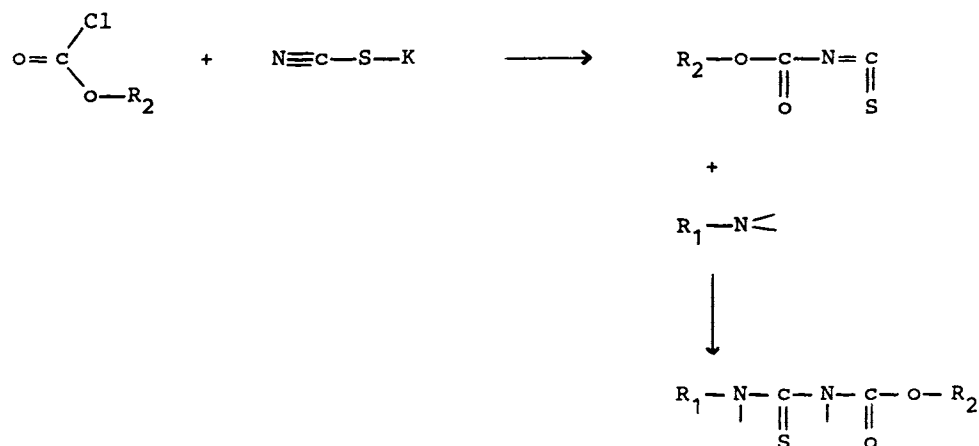
# THIOUREAS

Thioureas are obtained by one of the following routes:

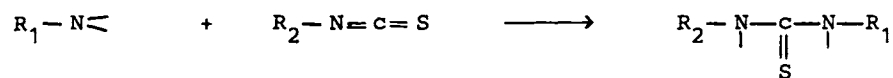
- reaction between ammonium thiocyanate and an amine



- reaction between a thiocyanate and a chloroformate followed by reaction with an amine



- reaction between an isothiocyanate and an amine



The isothiocyanate is usually obtained by reaction between thiophosgene and an amine.

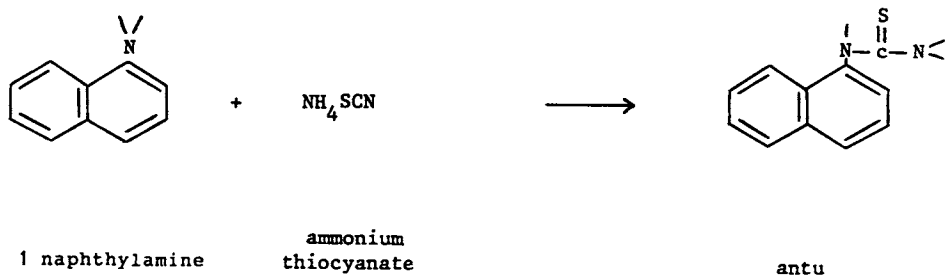
## Antu

Uses: rodenticide

Trade names:

Type: thiourea

Synthesis:



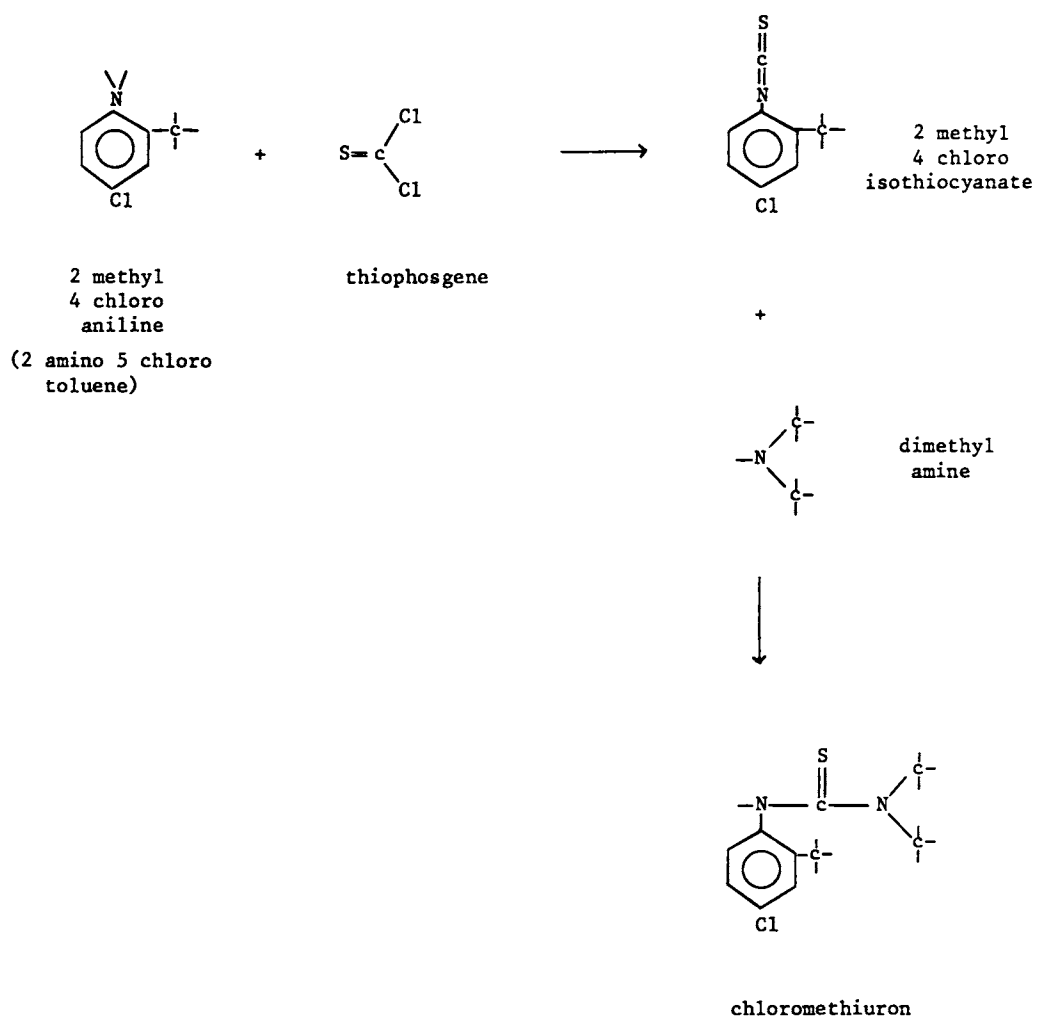
## Chloromethiuron

Uses: ixodicide, cattle, sheep, horses, dogs

Trade names: Dipofene (Ciba)

Type: thiourea

Synthesis:





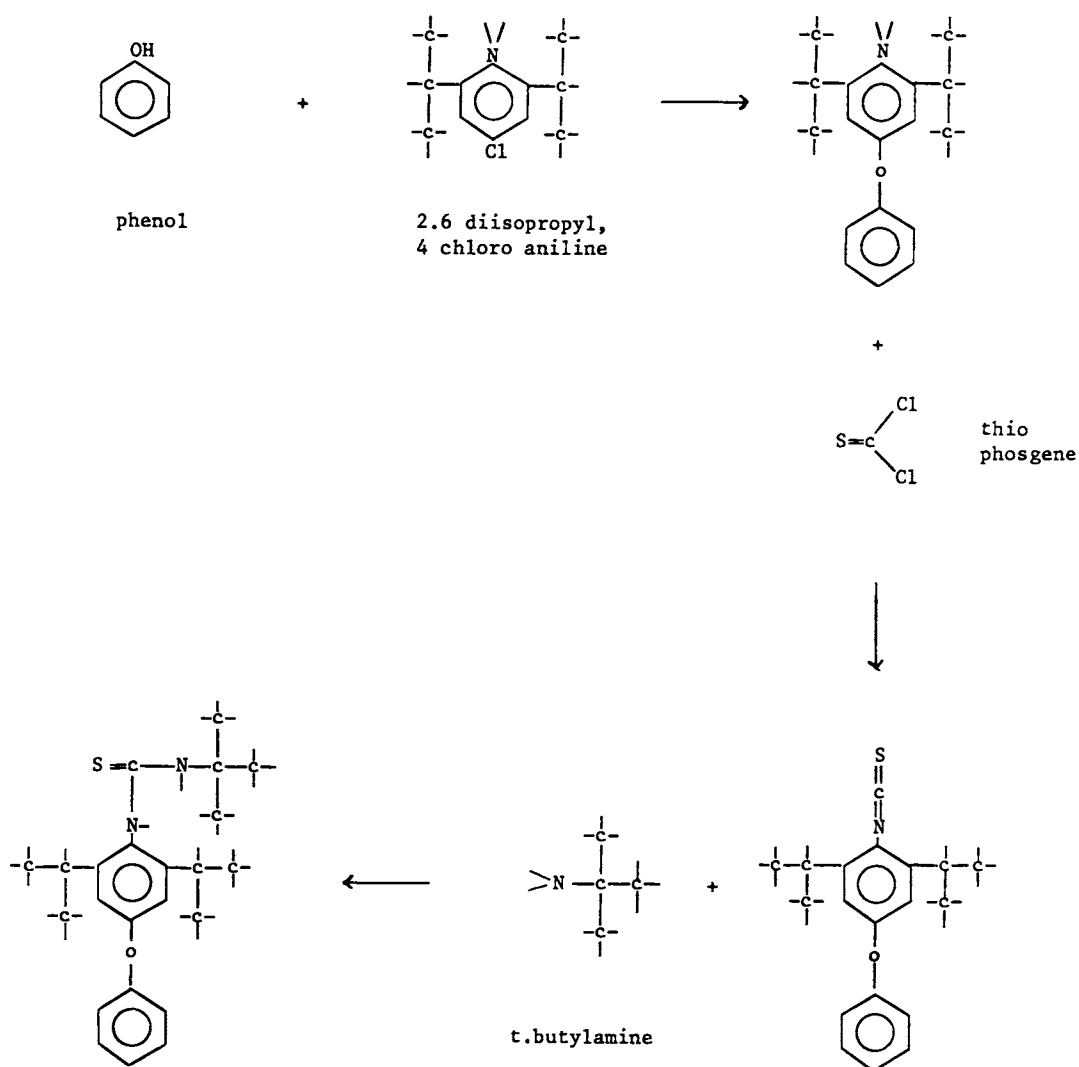
## Diafenthiuron

Uses: insecticide, cotton, fruit, ornamentals, soyabeans, vegetables

Trade names: Pegasus, Polo (Ciba)

Type: thiourea

Synthesis:



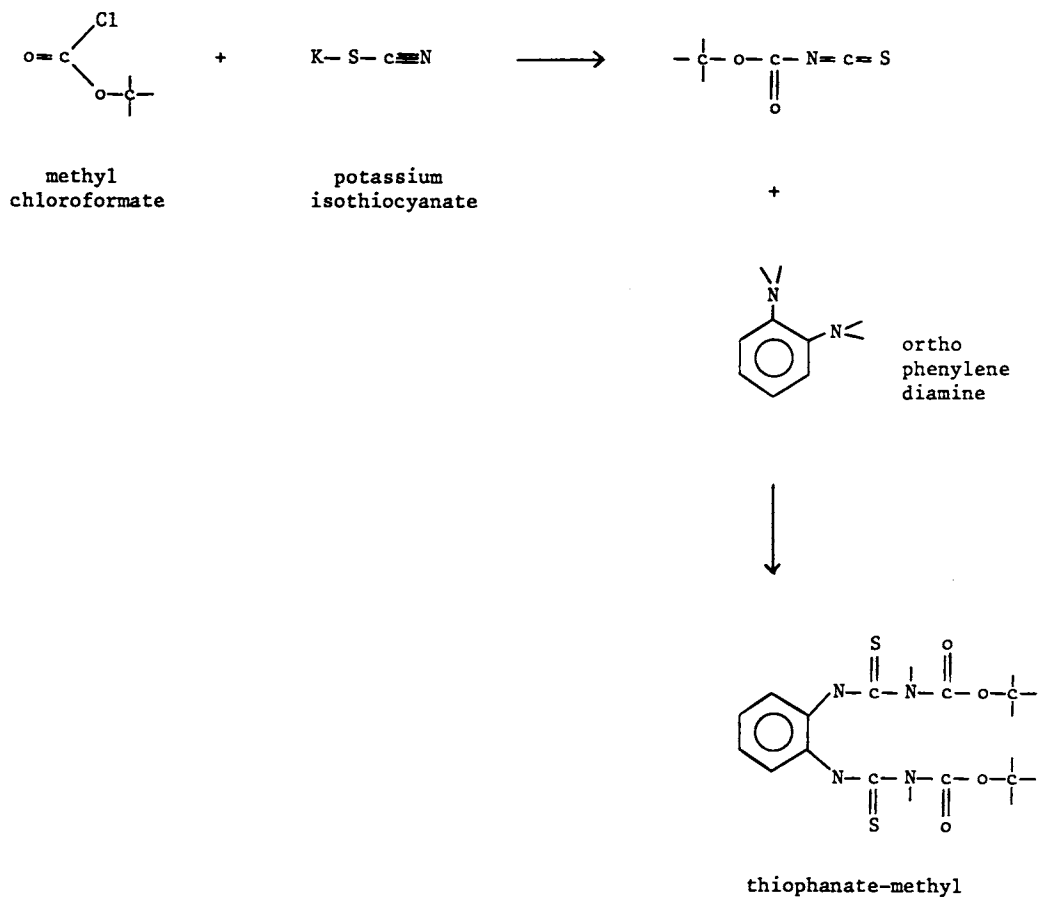
## Thiophanate-Methyl

Uses: fungicide, fruit, apples, bananas, cereals, rice, vine

Trade names: Topsin M, Cercobin M (Nippon Soda), Mildothane (Rhone Poulenc), Cycosin (Cyanamid)

Type: thiourea, carbamate

Synthesis:



## Thiophanate-Ethyl

As above with ethyl chloroformate

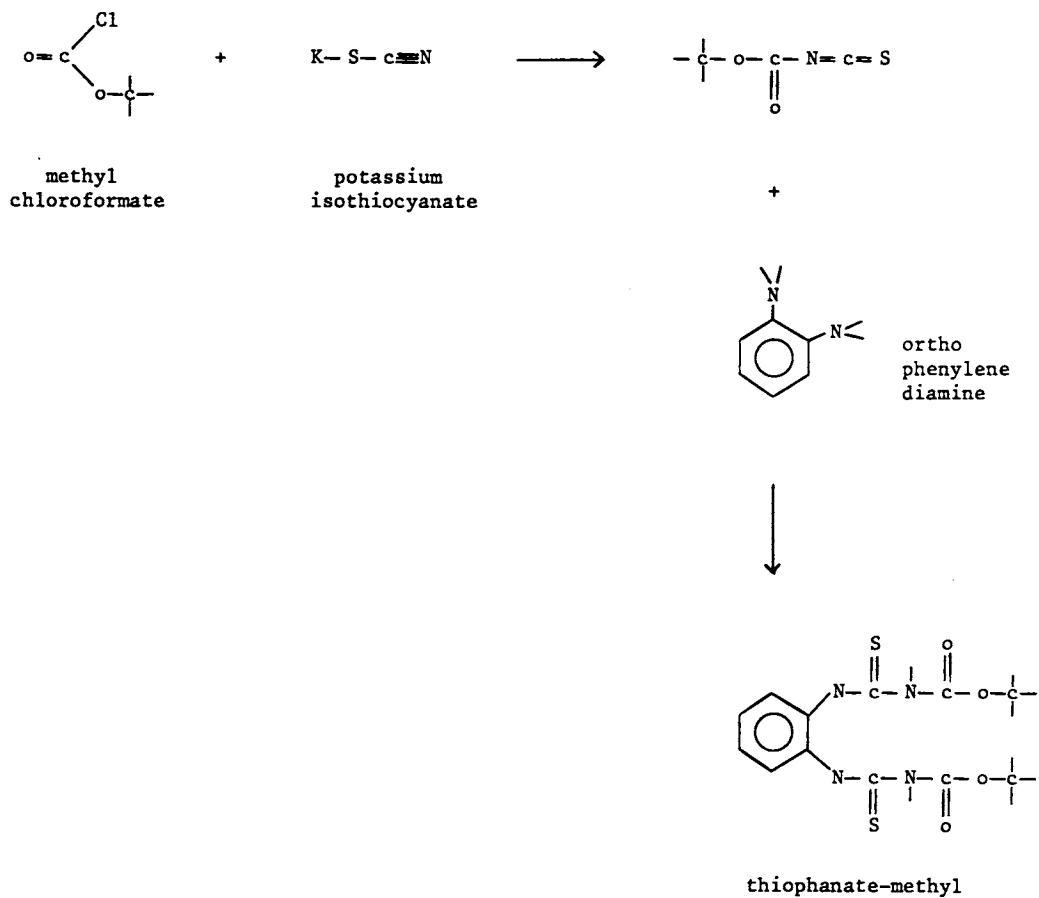
## Thiophanate-Methyl

Uses: fungicide, fruit, apples, bananas, cereals, rice, vine

Trade names: Topsin M, Cercobin M (Nippon Soda), Mildothane (Rhone Poulenc), Cycosin (Cyanamid)

Type: thiourea, carbamate

Synthesis:

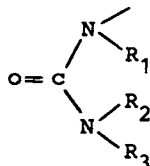


## Thiophanate-Ethyl

As above with ethyl chloroformate

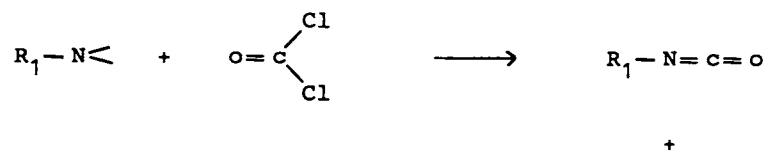
## UREA COMPOUNDS

These products are of the general formula

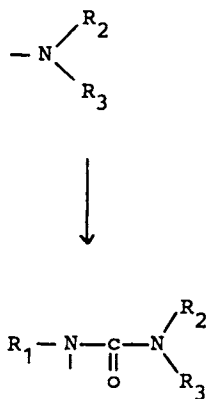


The synthesis consists of two main steps:

- i) reaction between an amine (usually aromatic) and phosgene in order to produce an isocyanate

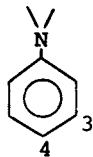


- ii) amination of the isocyanate in order to obtain the urea



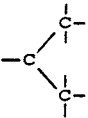

More often than not  $\text{R}_1-\text{N}<$  is a chloroaniline, frequently aniline, chloroaniline or dichloroaniline.

The frequent use of an aryl amine in urea pesticides is illustrated by the following compounds:

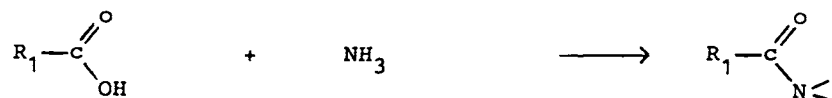


	<u>3 position</u>	<u>4 position</u>
clorobromuron	Cl	Br
chlorfluazuron (Cl in 5 position)	Cl	OH
clorotoluron	Cl	
chloroxuron	H	
difenoxuron	H	Cl
diflubenzuron, monolinuron, monuron	H	Cl
diuron, linuron, neburon, sulcofuran	Cl	Cl
fenuron, forchlorfenuron, siduron, thidiazuron	H	H
flucofuron	CF <sub>3</sub>	Cl

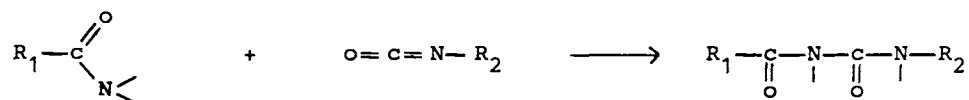
cont.

	<u>3 position</u>	<u>4 position</u>
fluometuron	CF <sub>3</sub>	H
isoproturon	H	
metobromuron	H	Br
metoxuron	Cl	

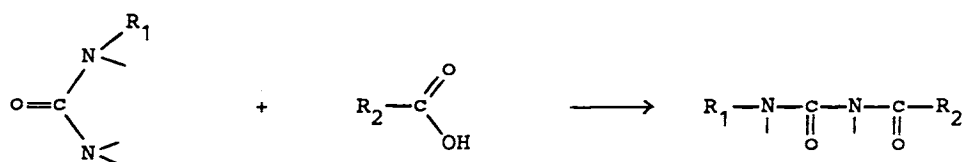
A particular group of ureas are carbonyl ureas produced by ammoniation of an acid to the amide



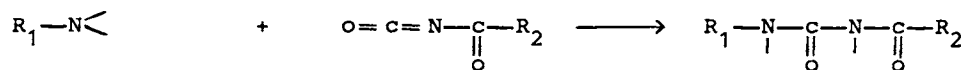
followed by reaction of the amide with an isocyanate



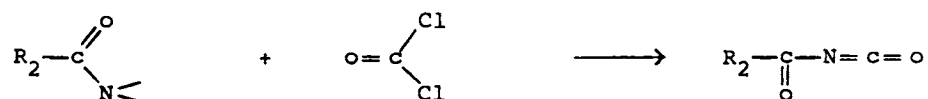
an alternative routes being the reaction of a urea with an acid



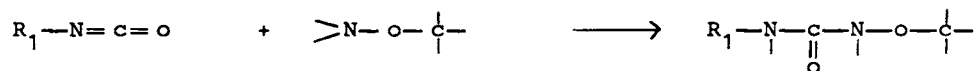
or of a carbonyl isocyanate with an amine



the carbonyl isocyanate being obtained either by phosgenation of an amide



or whenever a methoxy urea is desired, methyl hydroxylamine is used instead of an amine



Tebuthiuron is practically the only compound of this family for which  $\text{R}_1-\text{N} <$  is not an aromatic amine. Also the synthesis route is different from the general pattern, being based upon hydrazine.



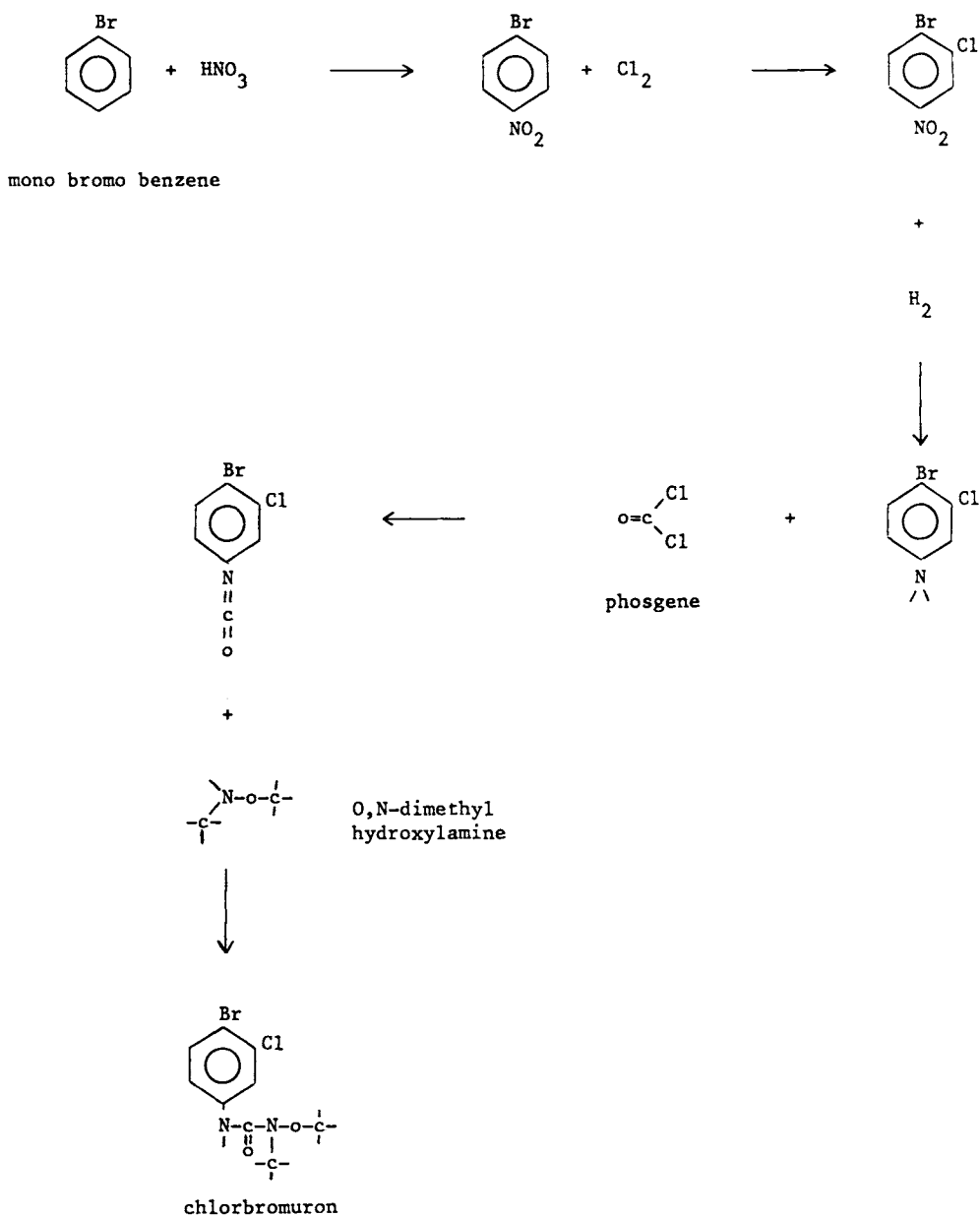
## Chlorbromuron

Uses: herbicide, carrots, potatoes, soyabeans, sunflowers

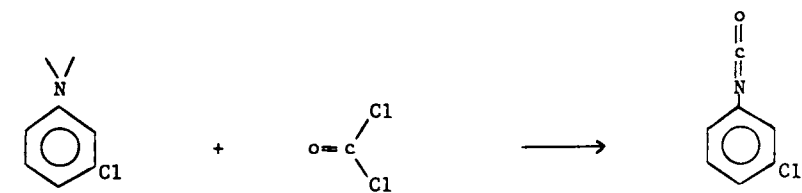
Trade names: Maloran (Ciba)

Type: urea

Synthesis:

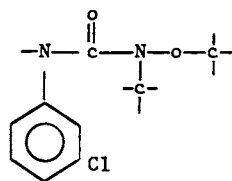
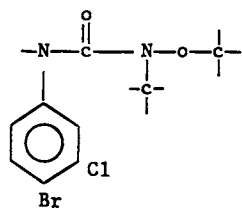
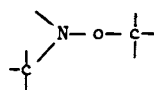


alternate route :



metachloro  
aniline

+



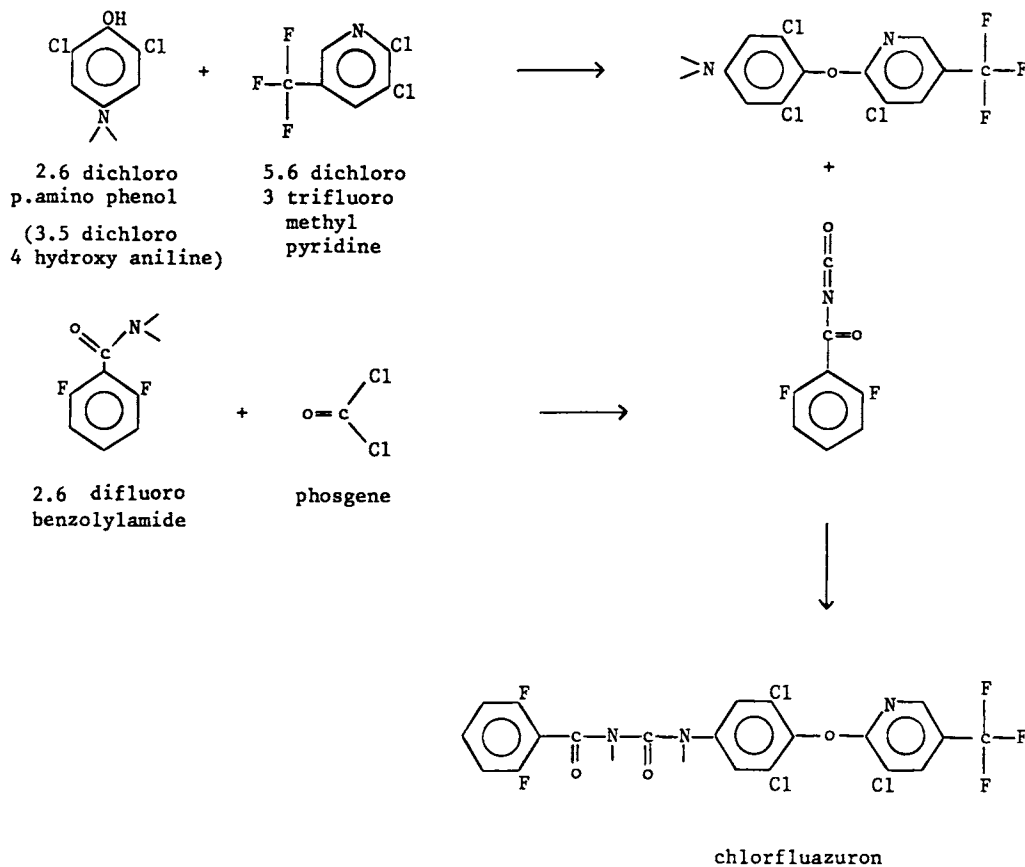
## Chlorfluazuron

Uses: insecticide, cotton

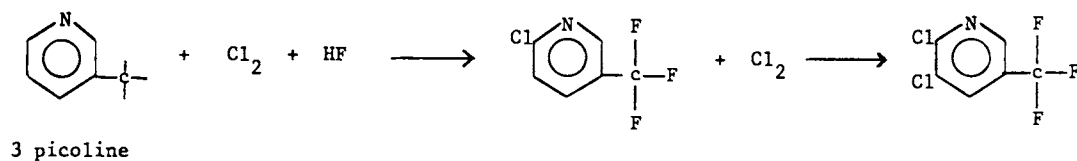
Trade names: Atabron (Ishihara)

Type: urea

Synthesis:



preparation of 5,6 dichloro 3 trifluoro methyl pyridine :



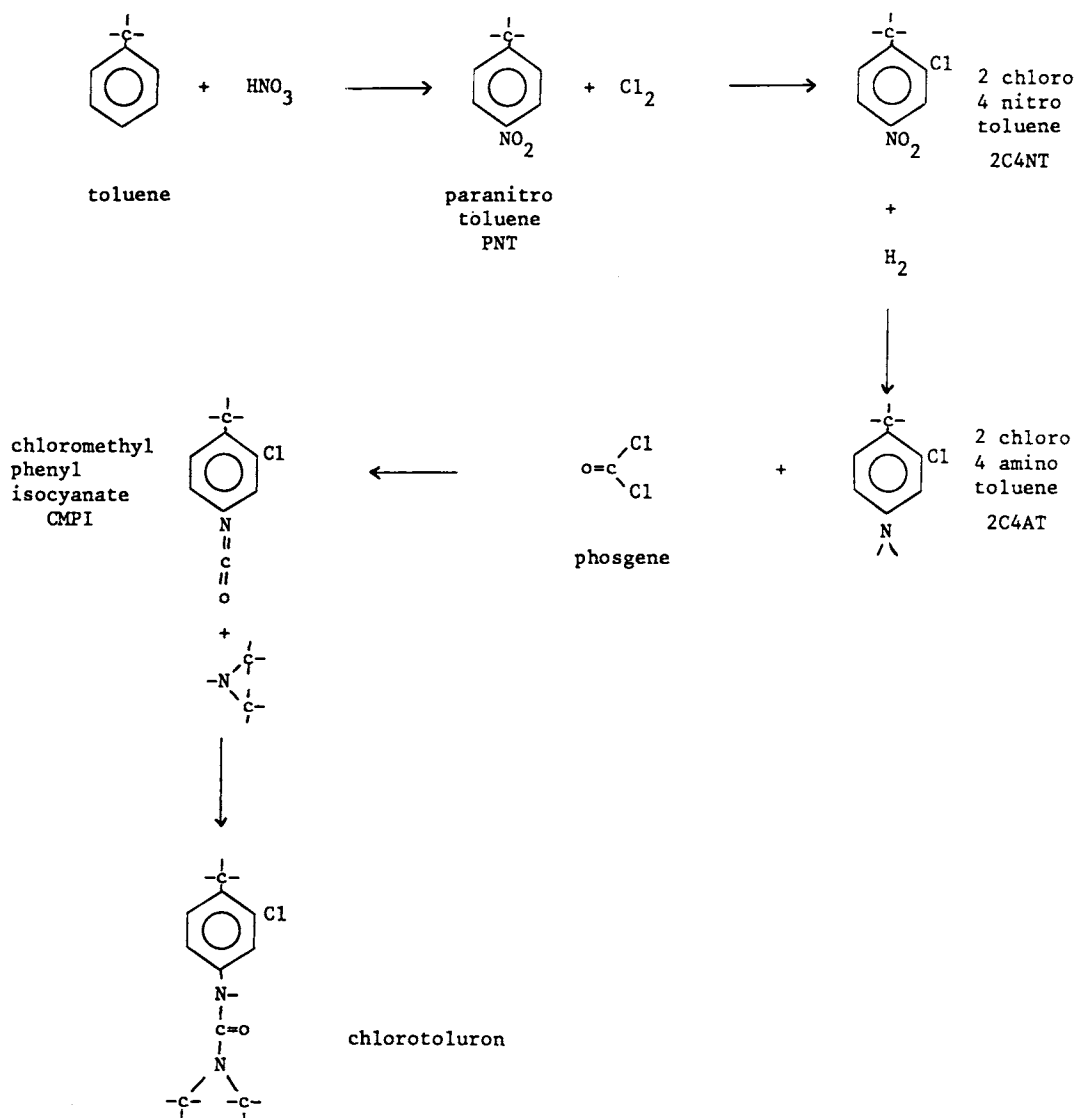
## Chlorotoluron

Uses: herbicide, cereals

Trade names: Dicuran (Ciba)

Type: urea

Synthesis:



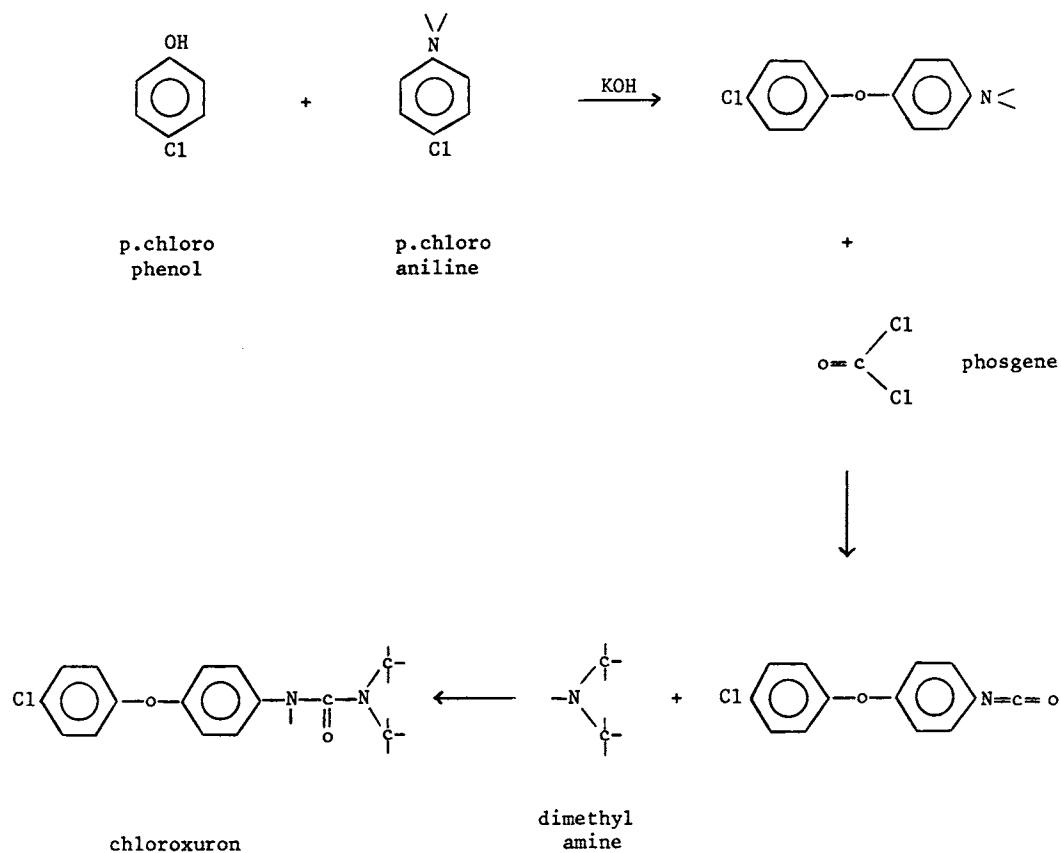
## Chloroxuron

Uses: herbicide, onions, carrots, lawns, sport fields, ornamentals

Trade names: Tenoran (Ciba)

Type: urea, phenyl ether

Synthesis:



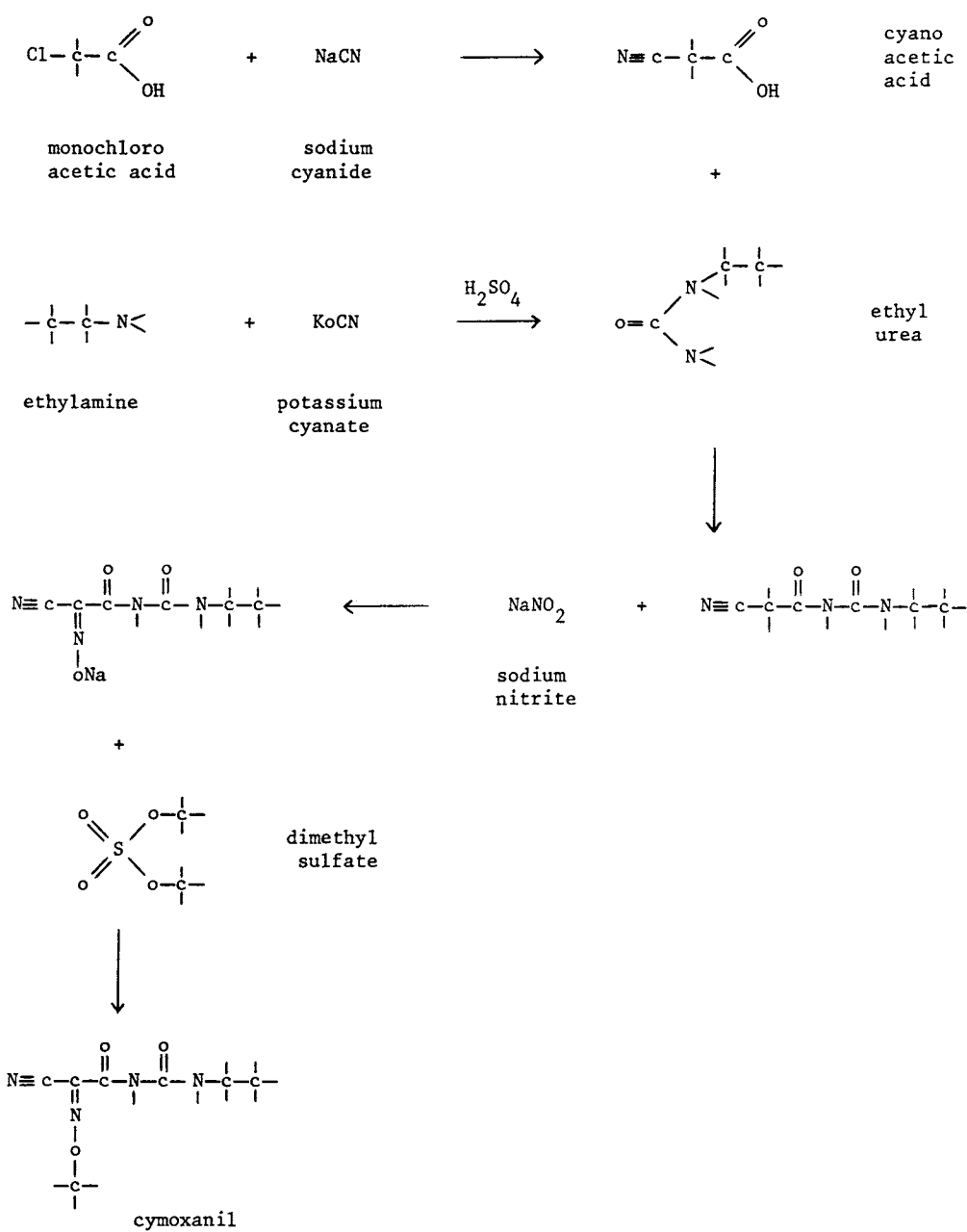
## Cymoxanil

Uses: fungicide, vine, potatoes

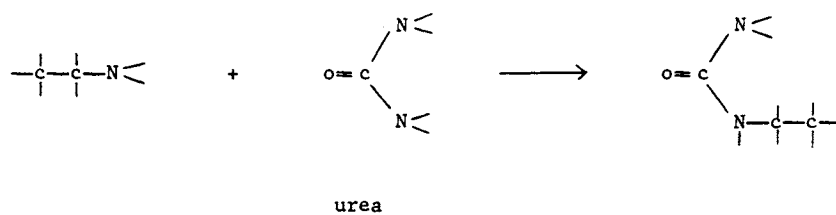
Trade names: Curzate (DuPont)

Type: urea, oxime

Synthesis:



alternate route :



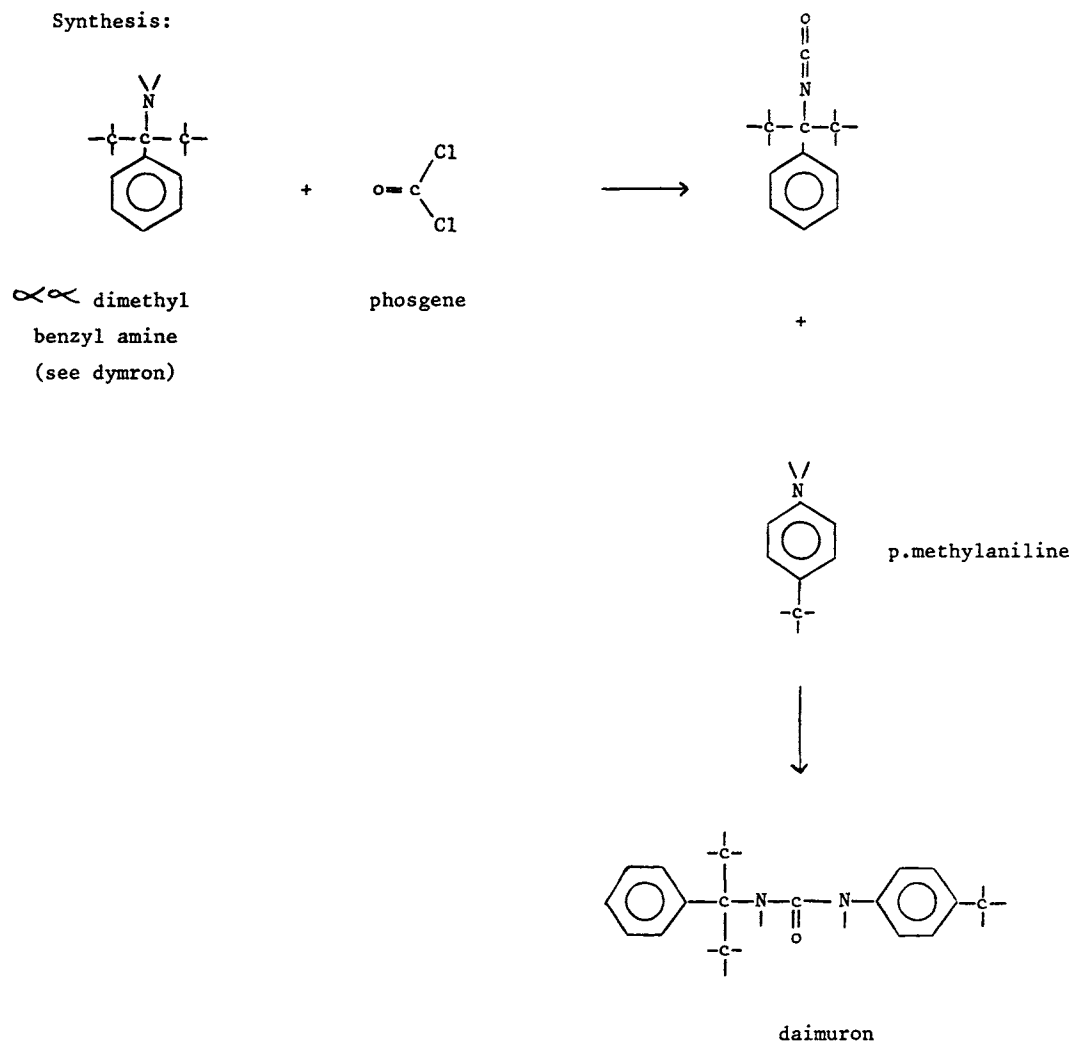
## Daimuron

Uses: herbicide, rice

Trade names: Showrone (Showa Denko)

Type: urea

Synthesis:





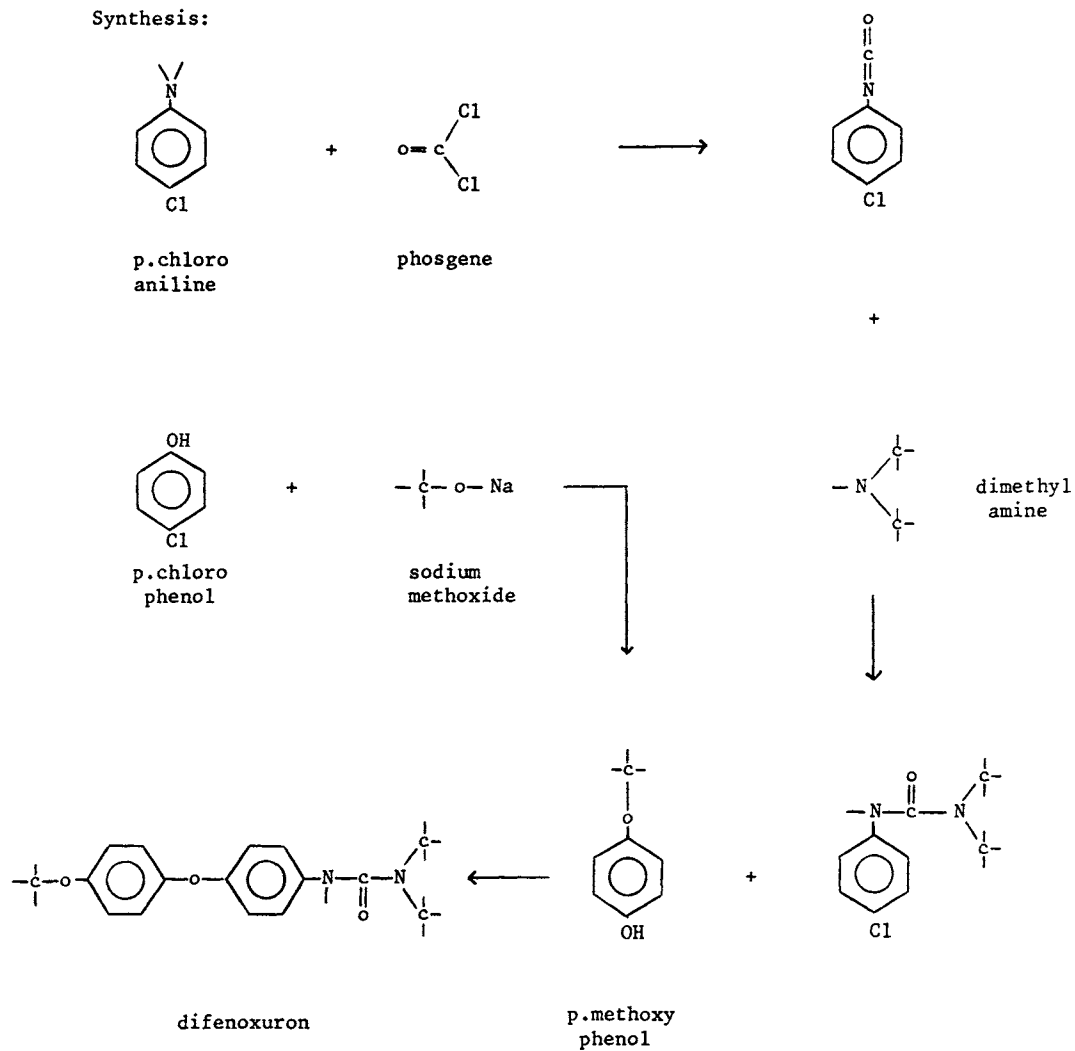
## Difenoxuron

Uses: herbicide, onions, garlic

Trade names: Lironion (Ciba)

Type: urea

Synthesis:



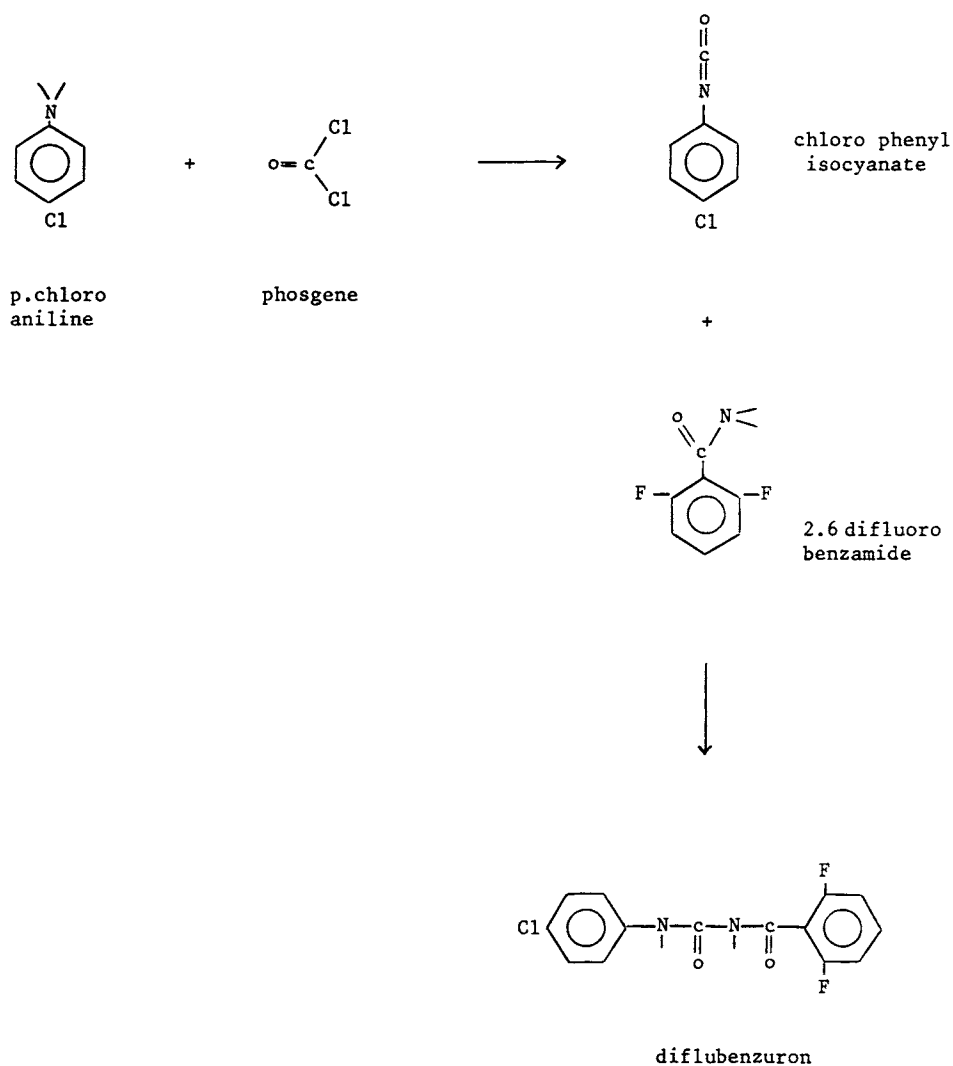
## Diflubenzuron

Uses: insecticide, forestry, citrus, soyabeans, cotton, cattle, pigs, poultry

Trade names: Dimilin (Duphar)

Type: carbonyl urea

Synthesis:



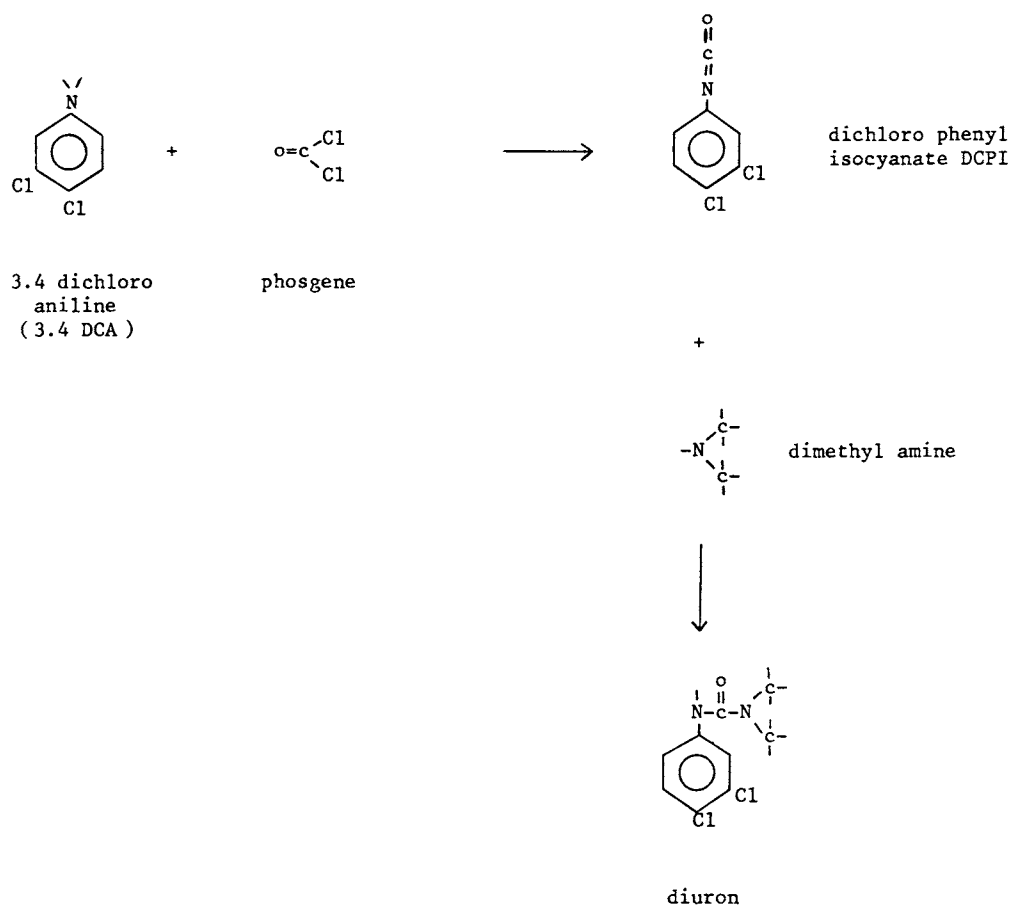
## Diuron

Uses: herbicide, citrus, cotton, sugarcane

Trade names: Karmex (Dupont)

Type: urea

Synthesis:



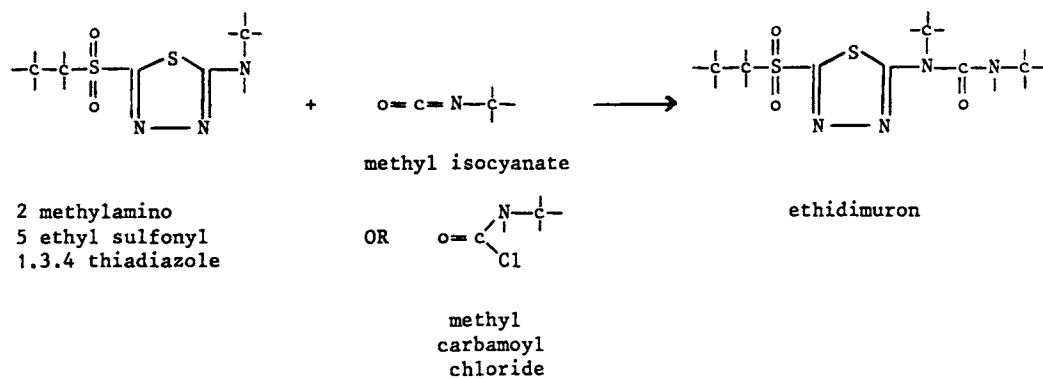
## Ethidimuron

Uses: herbicide, non crop areas

Trade names: Ustilan (Bayer)

Type: urea, thiadiazole, sulfone

Synthesis:



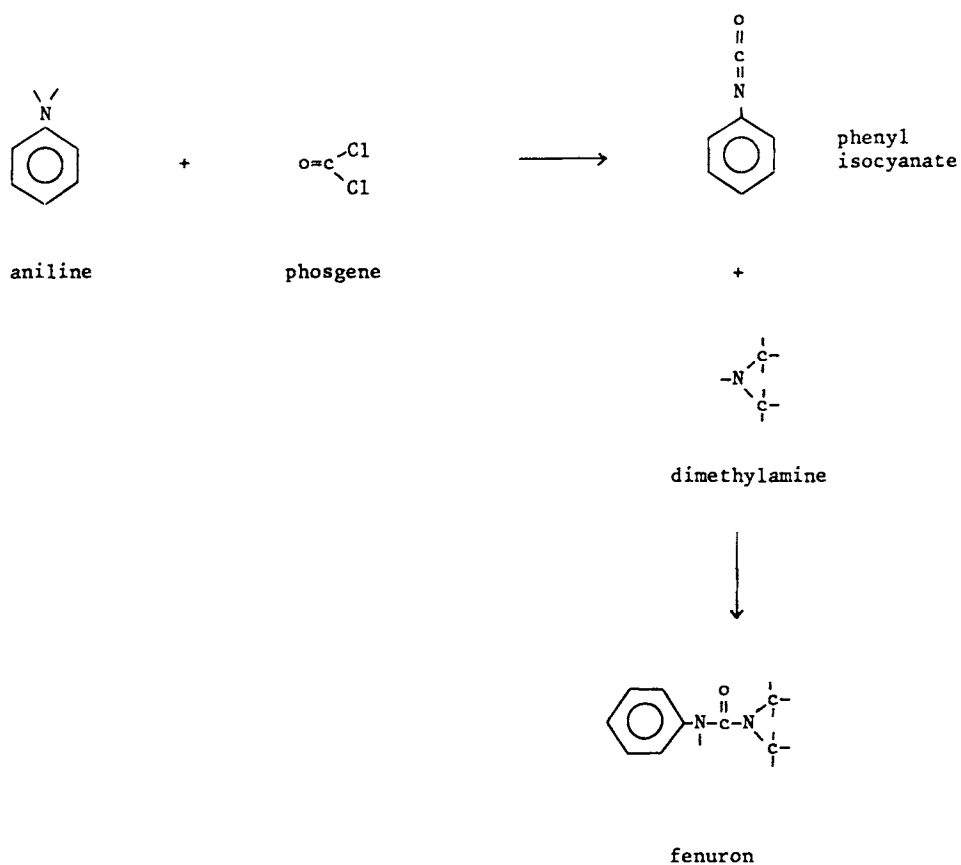
## Fenuron

Uses: herbicide, vegetables, onions, fruit

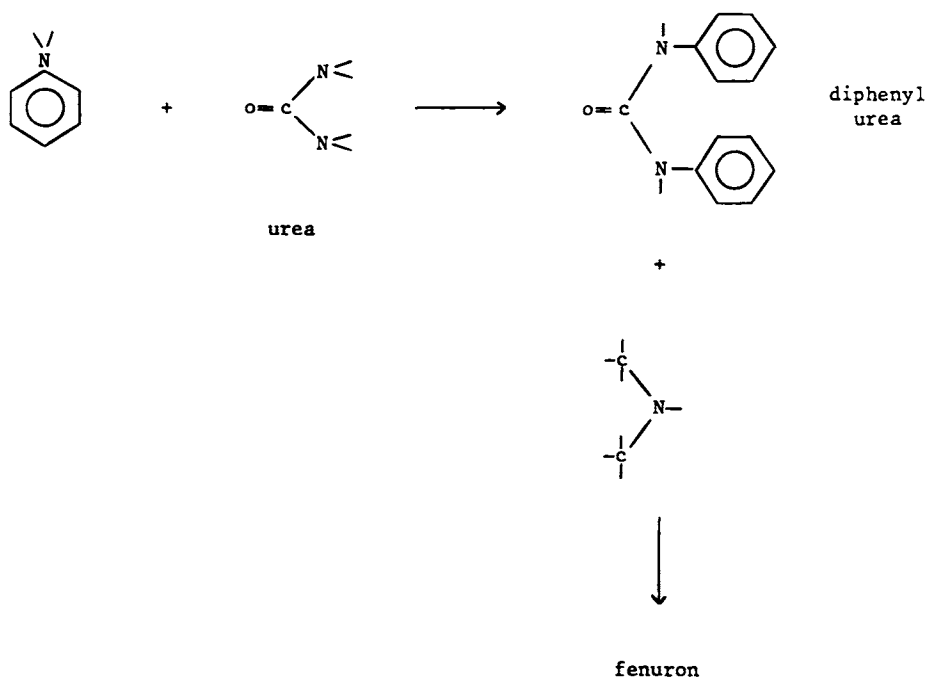
Trade names: Dybar (Dupont)

Type: urea

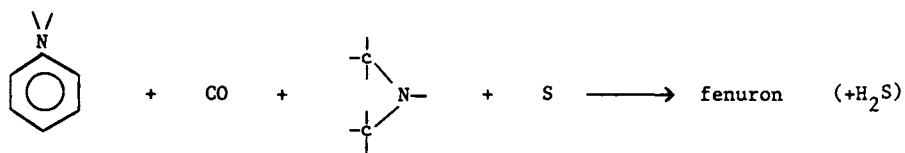
Synthesis:



alternate route :



alternate route :



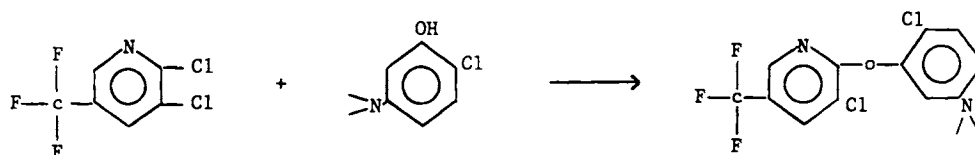
## Fluazuron

Uses: anti-helminthic, cattle tick

Trade names: Acatak (Ciba)

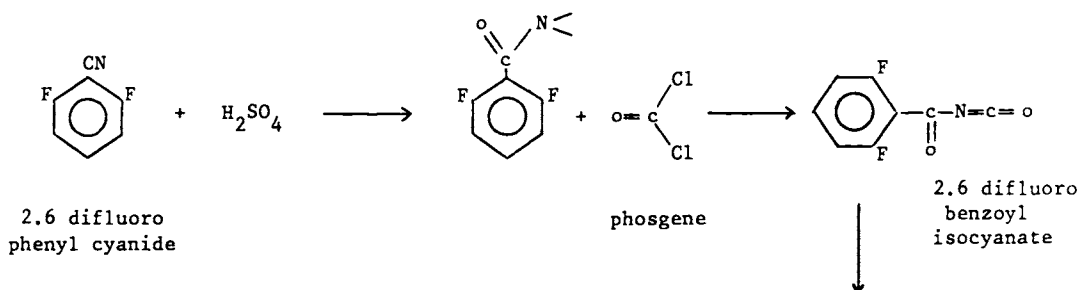
Type: carbonyl urea, pyridine

### Synthesis



2,3 dichloro  
5 trifluoro methyl  
pyridine  
(see chlorfluazuron)

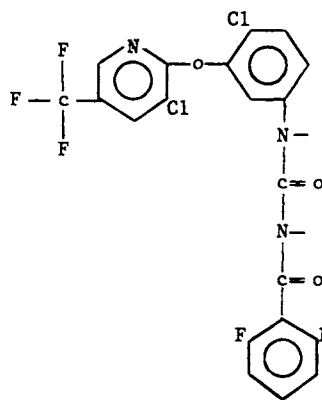
5 chloro  
meta amino  
phenol



2,6 difluoro  
phenyl cyanide

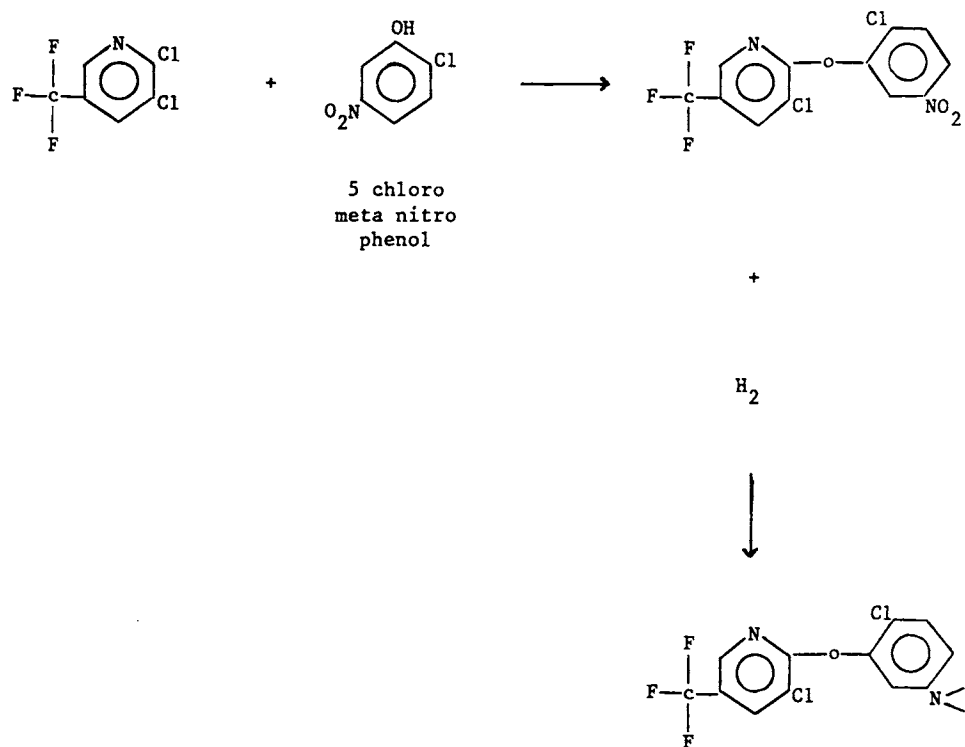
phosgene

2,6 difluoro  
benzoyl  
isocyanate



fluazuron

alternate route :





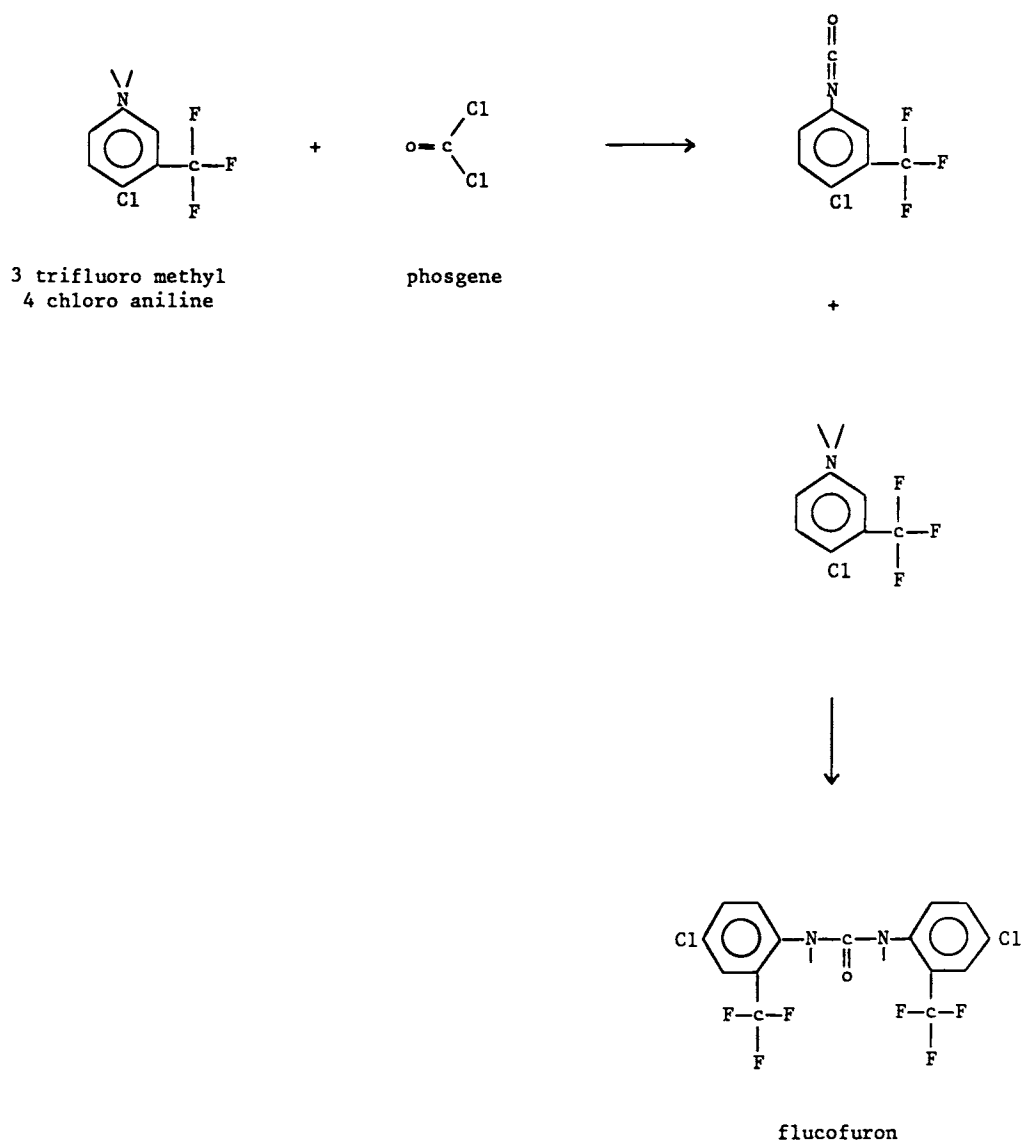
## Flucofuron

Uses: insecticide, cotton, fabrics

Trade names: Mitin N (Ciba)

Type: urea

Synthesis:



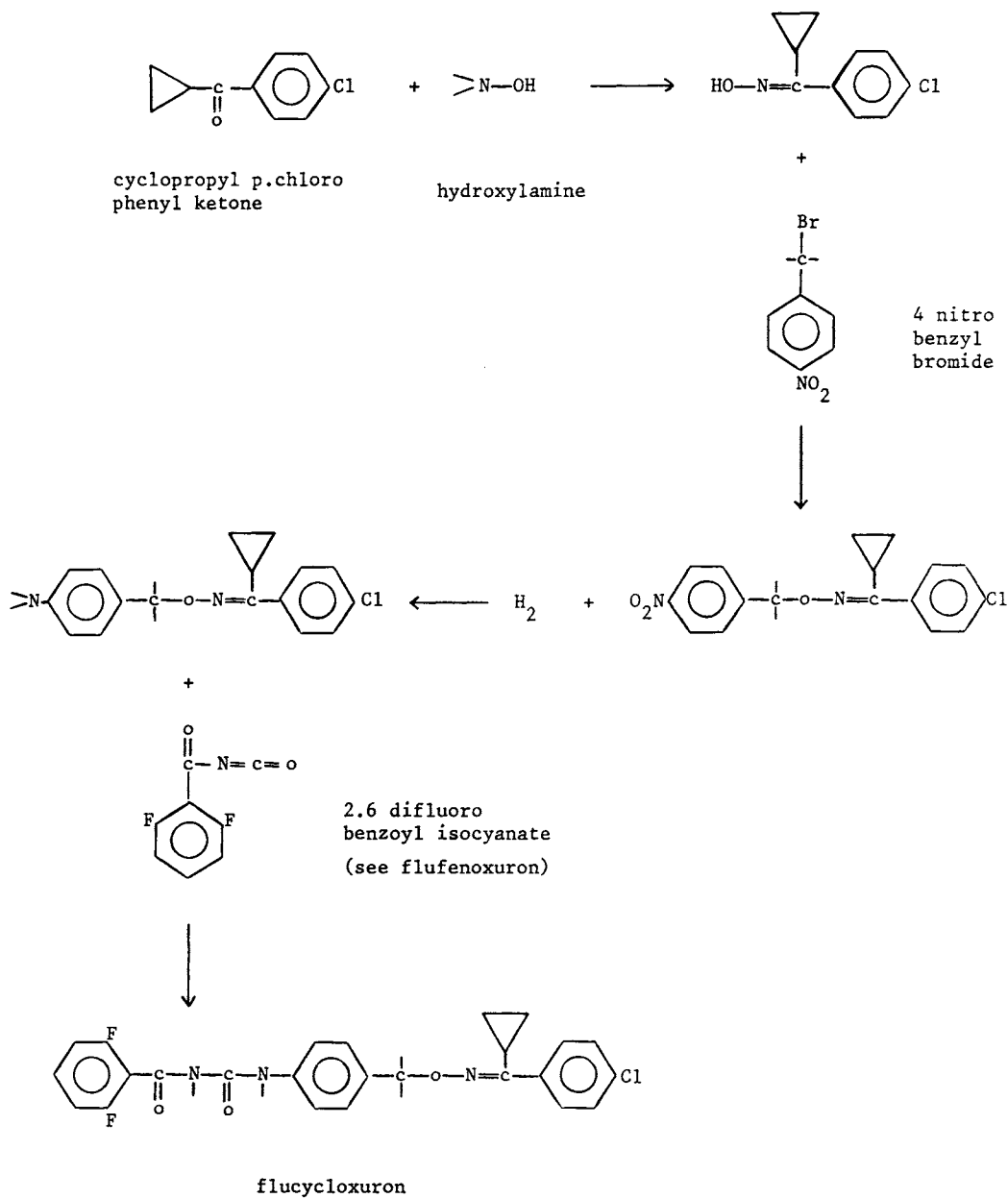
## Flucycloxuron

Uses: acaricide, soyabeans, apples, fruit

Trade names: Andalin (Duphar)

Type: carbonyl urea, oxime

Synthesis:



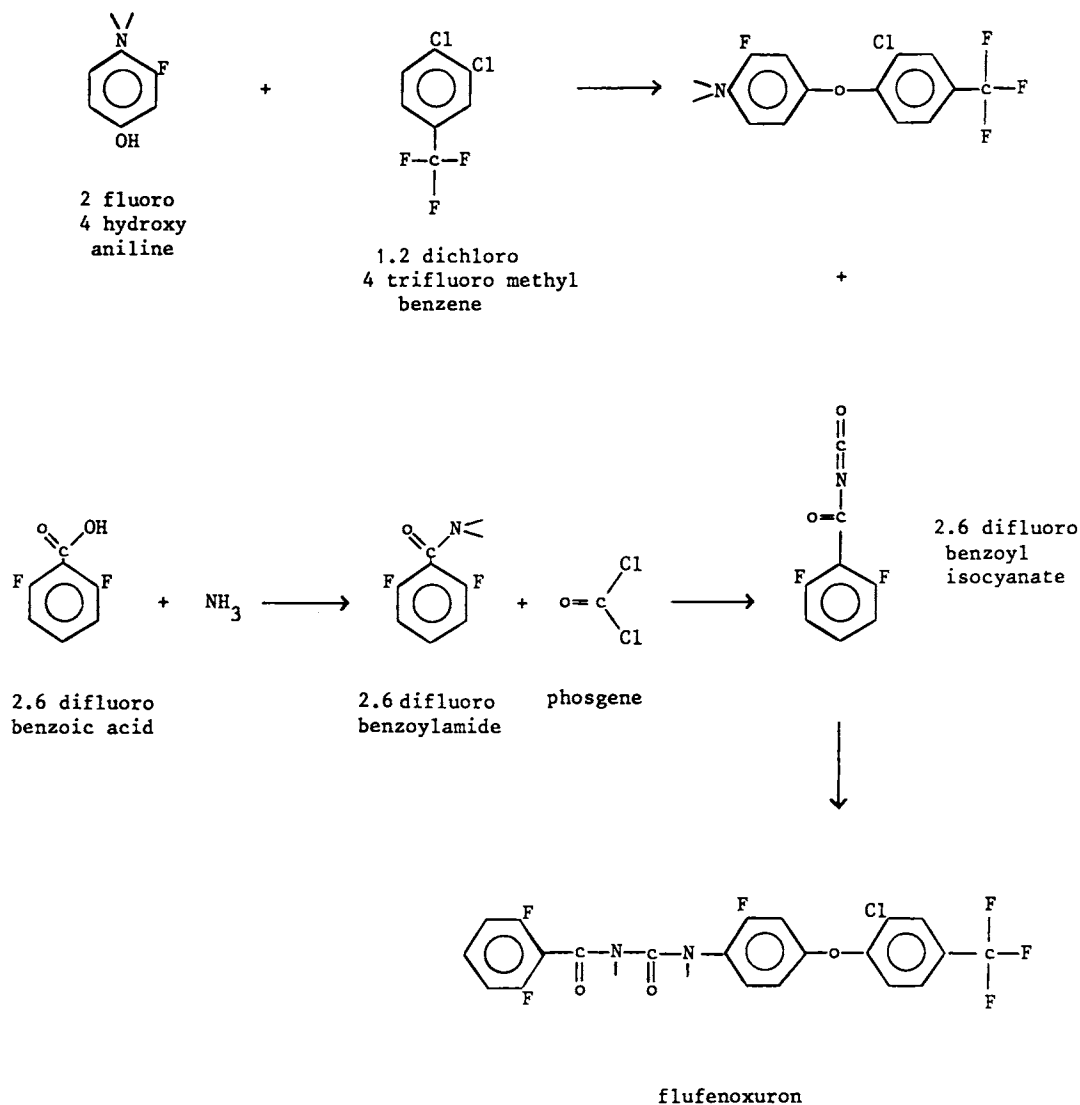
## Flufenoxuron

Uses: insecticide, citrus, cotton, grapes, soyabeans, tea

Trade names: Cascade (Shell)

Type: carbonyl urea

Synthesis:



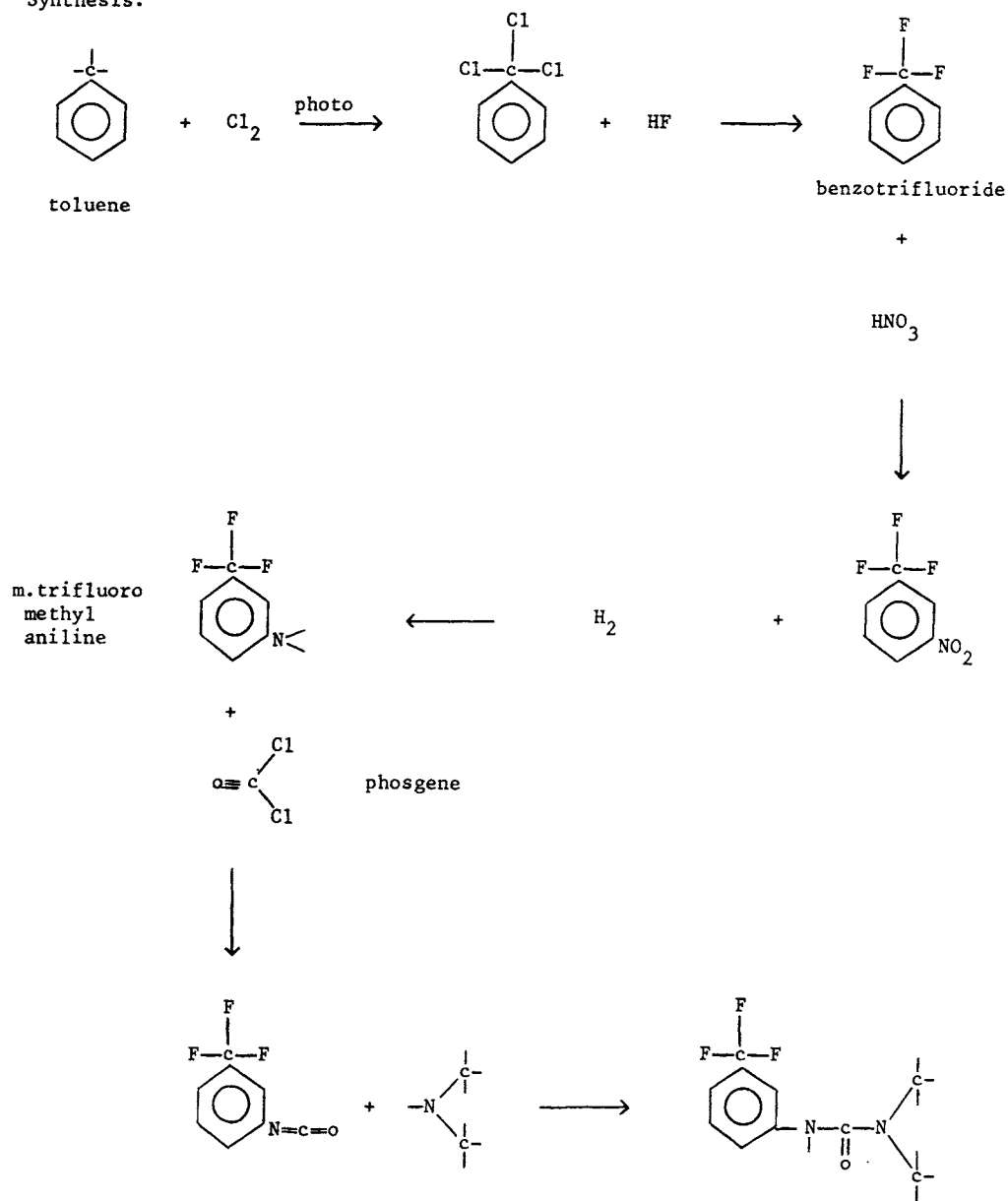
## Fluometuron

Uses: herbicide, cotton

Trade names: Cotoran (Ciba)

Type: urea

Synthesis:



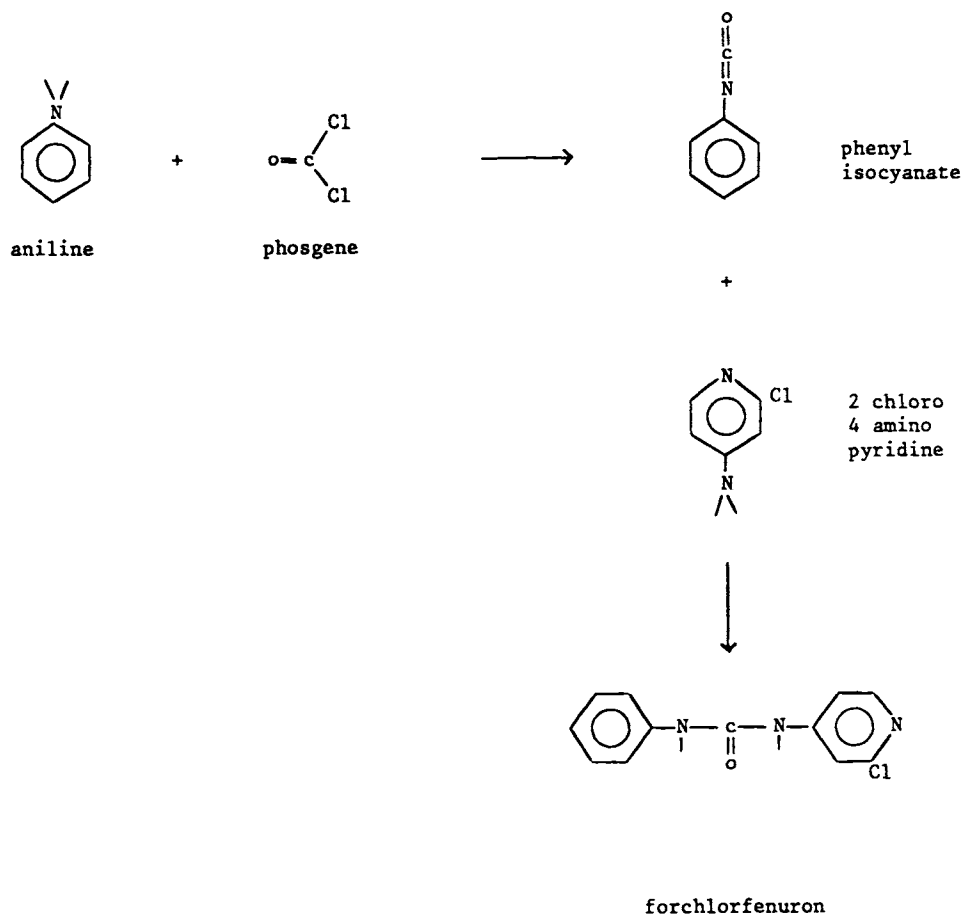
## Forchlorfenuron

Uses: plant growth regulator

Trade names: Sitofex (Sandoz)

Type: urea, heterocyclic nitrogen, pyridine

Synthesis:



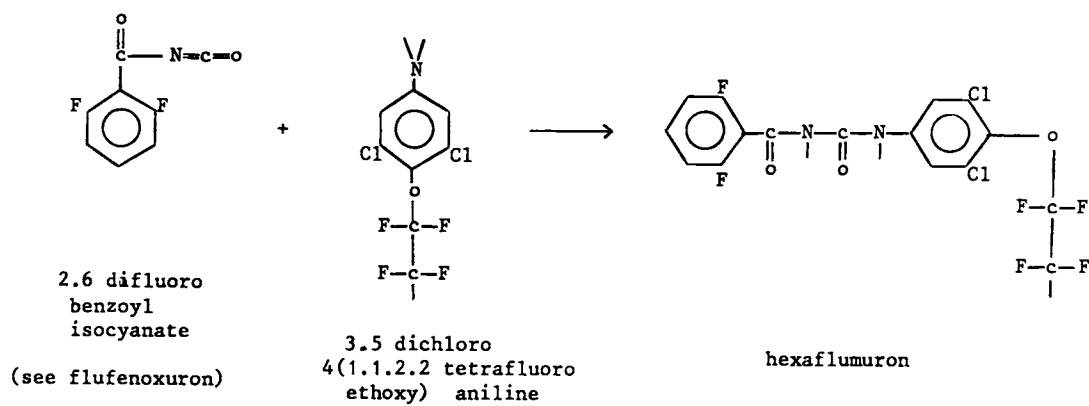
## Hexaflumuron

Uses: insecticide, cotton, potatoes, fruit

Trade names: Consult, Trueno (Dow Elanco)

Type: urea

Synthesis:



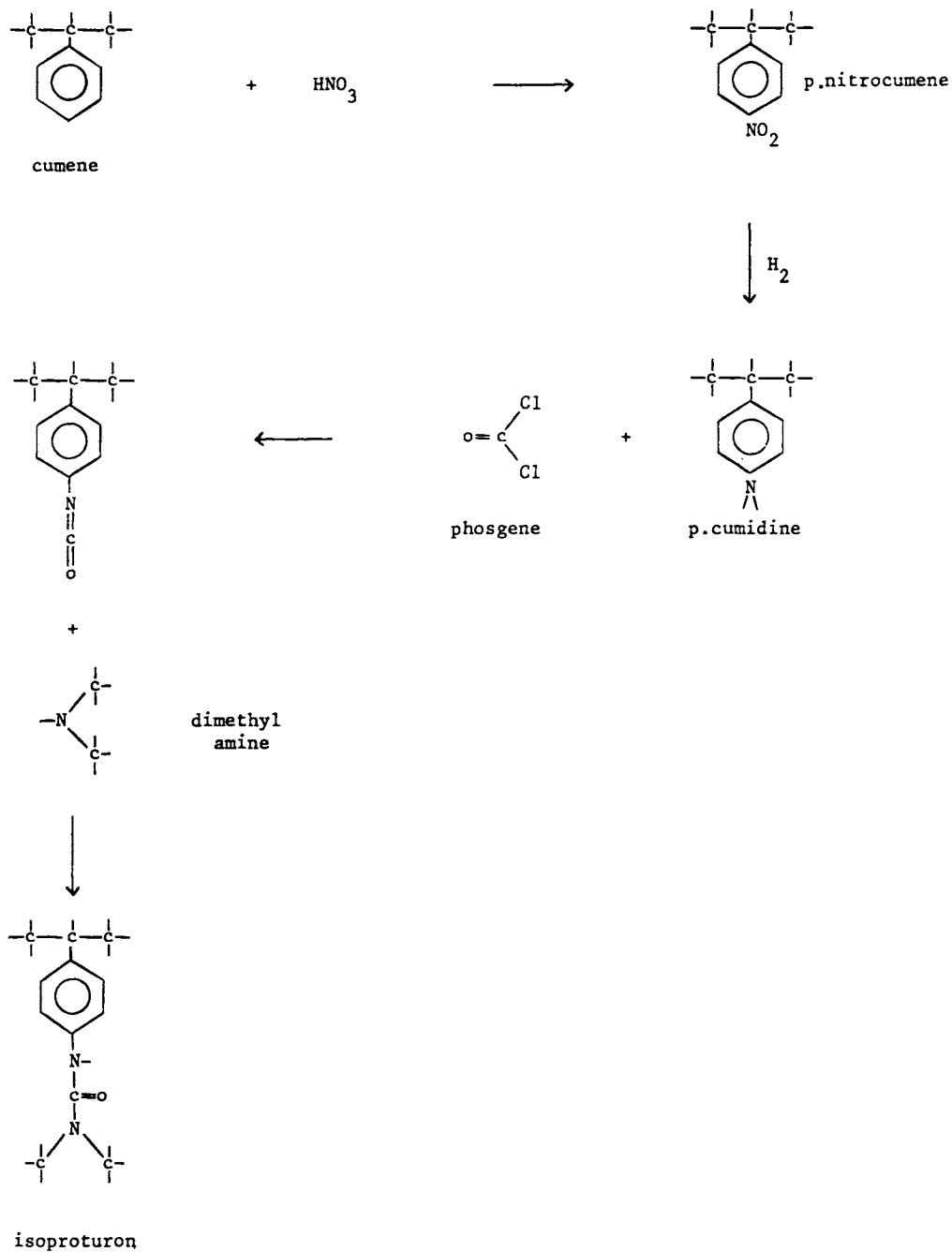
## Isoproturon

Uses: herbicide, barley, rye, wheat

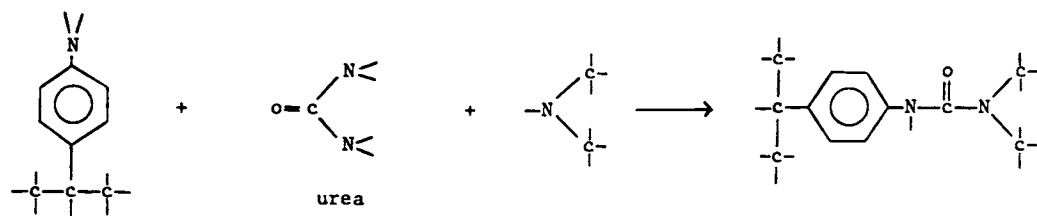
Trade names: Alon, Arælon (Hoechst), Graminon (Ciba), Tolkan (Rhône Poulenc)

Type: urea

Synthesis:



alternate route :





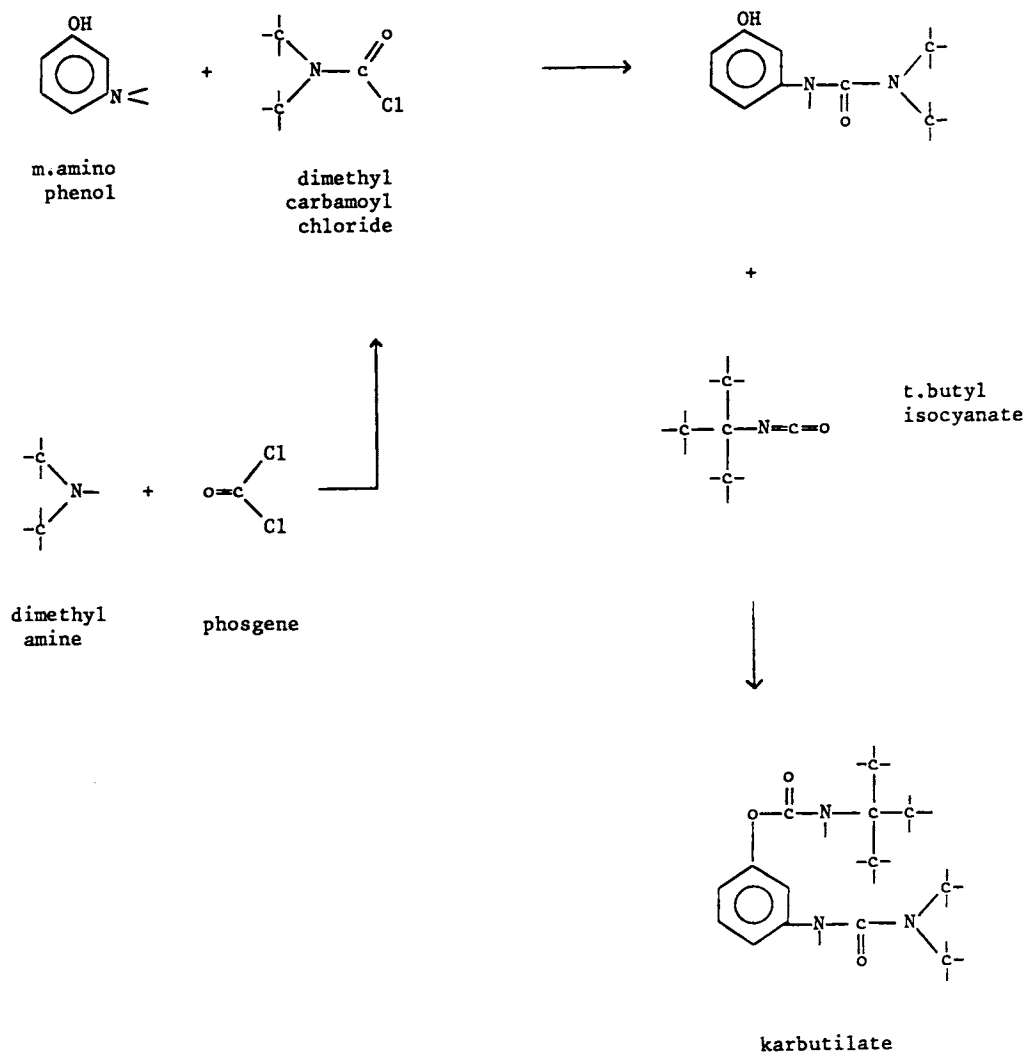
## Karbutilate

Uses: herbicide

Trade names: Tandex (Ciba)

Type: urea

Synthesis:



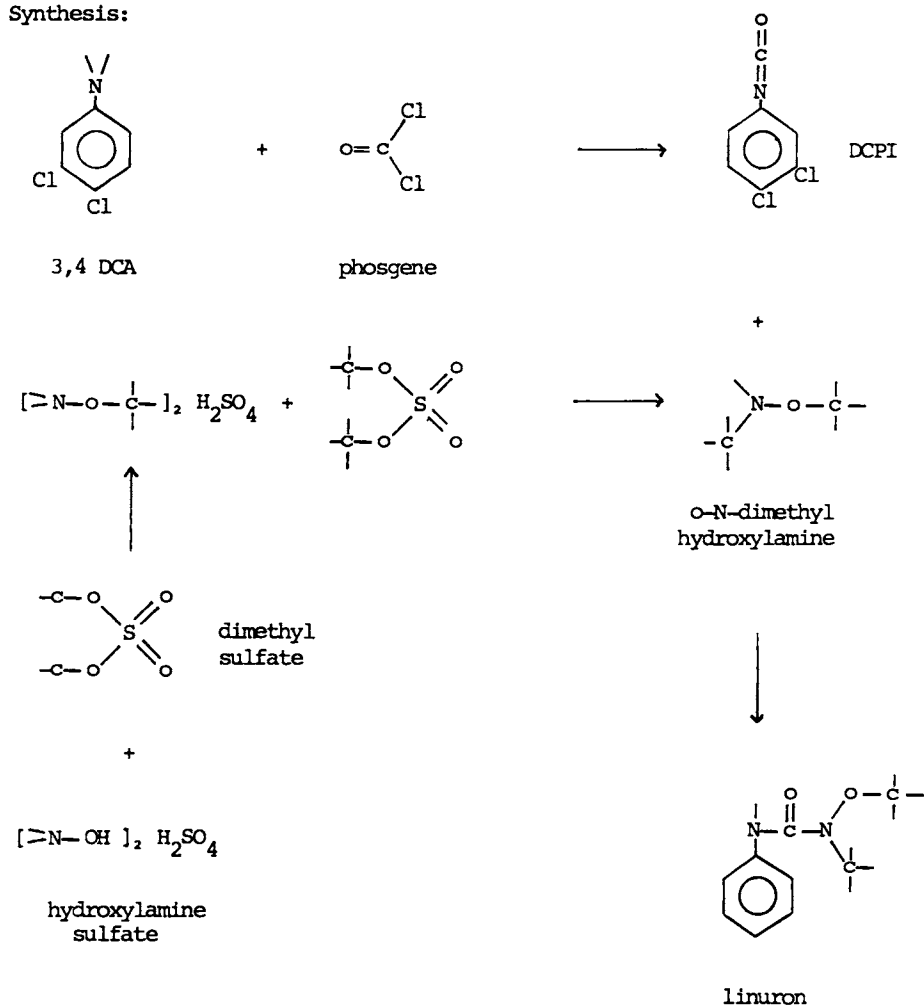
## Linuron

Uses: herbicide, soyabeans, corn, cotton, maize, potatoes, beans, wheat

Trade names: Lorox (Dupont), Afalon (Hoechst)

Type: urea

Synthesis:





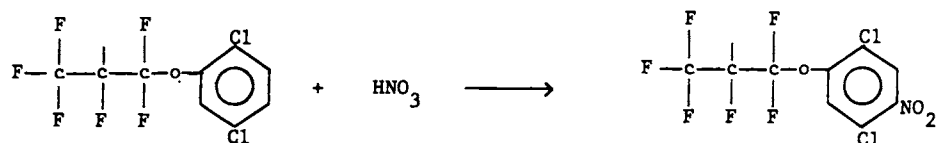
## Lufenuron

Uses: insecticide, acaricide, cotton, vegetables, citrus

Trade names: Match (Ciba)

Type: carbonyl urea

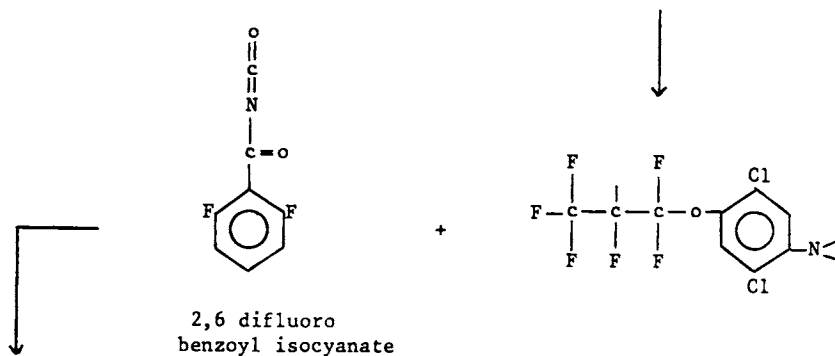
Synthesis:



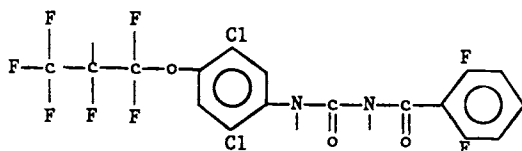
1,1,2,3,3,3 hexafluoro  
propoxy 2,5 dichloro  
benzene

+

$\text{H}_2$

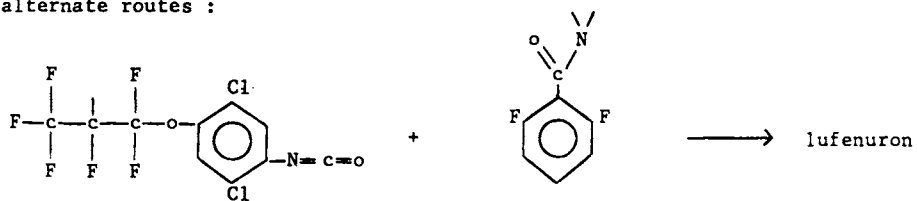


2,6 difluoro  
benzoyl isocyanate



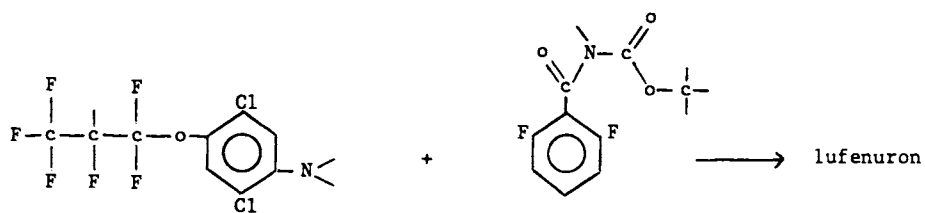
lufenuron

alternate routes :



1,1,2,3,3,3 hexafluoro  
propoxy 2,5 dichloro  
isocyanate

2,6 difluoro  
benzoylamide



N-methyl formyl  
2,6 difluoro  
benzamide

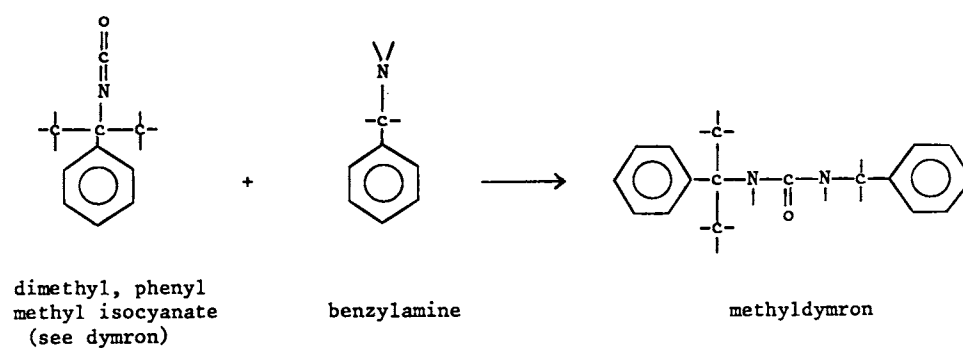
## Methyldymron

Uses: herbicide, turf

Trade names: Stacker (SDS)

Type: urea

Synthesis:



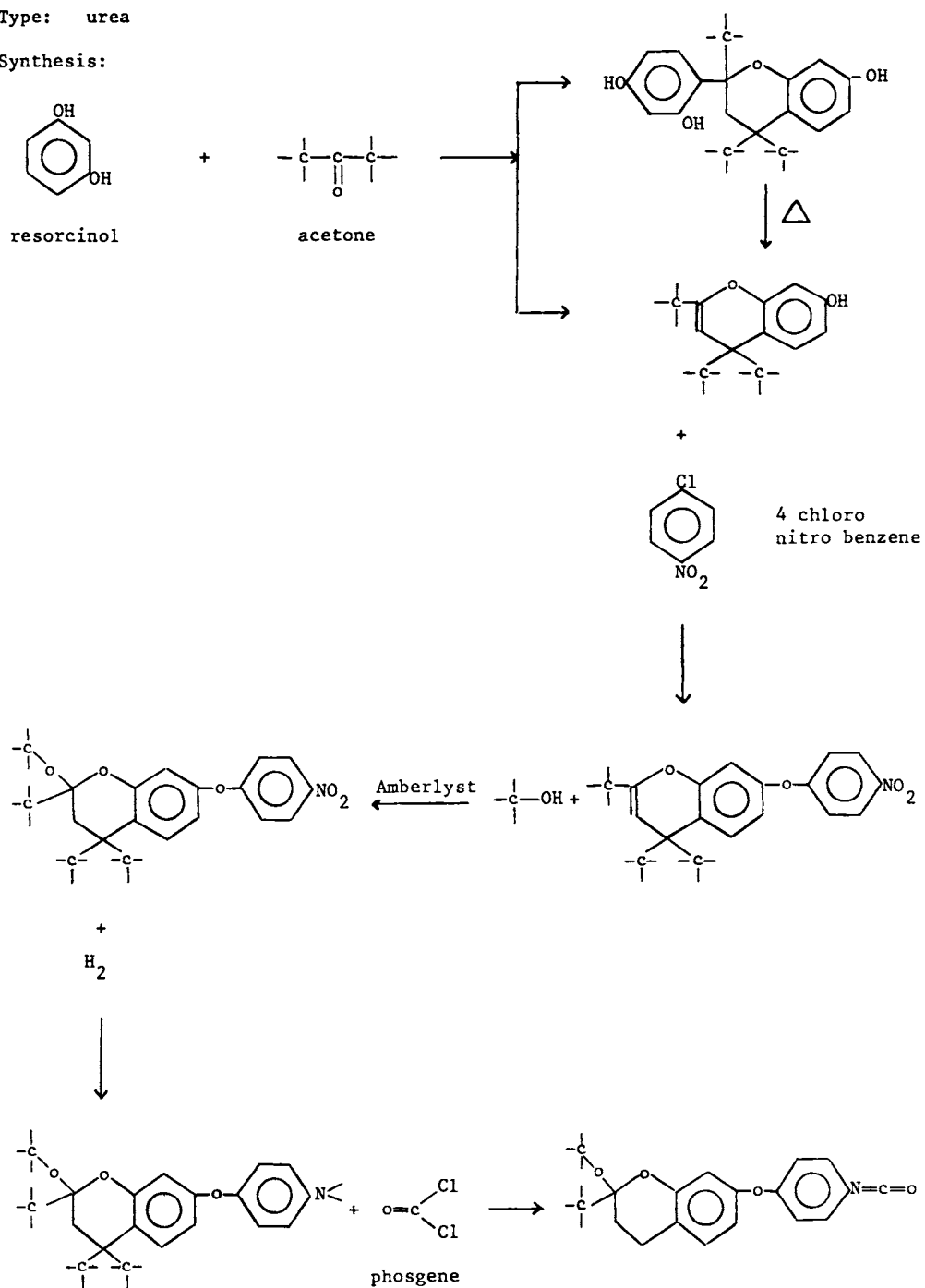
## Metobenzuron

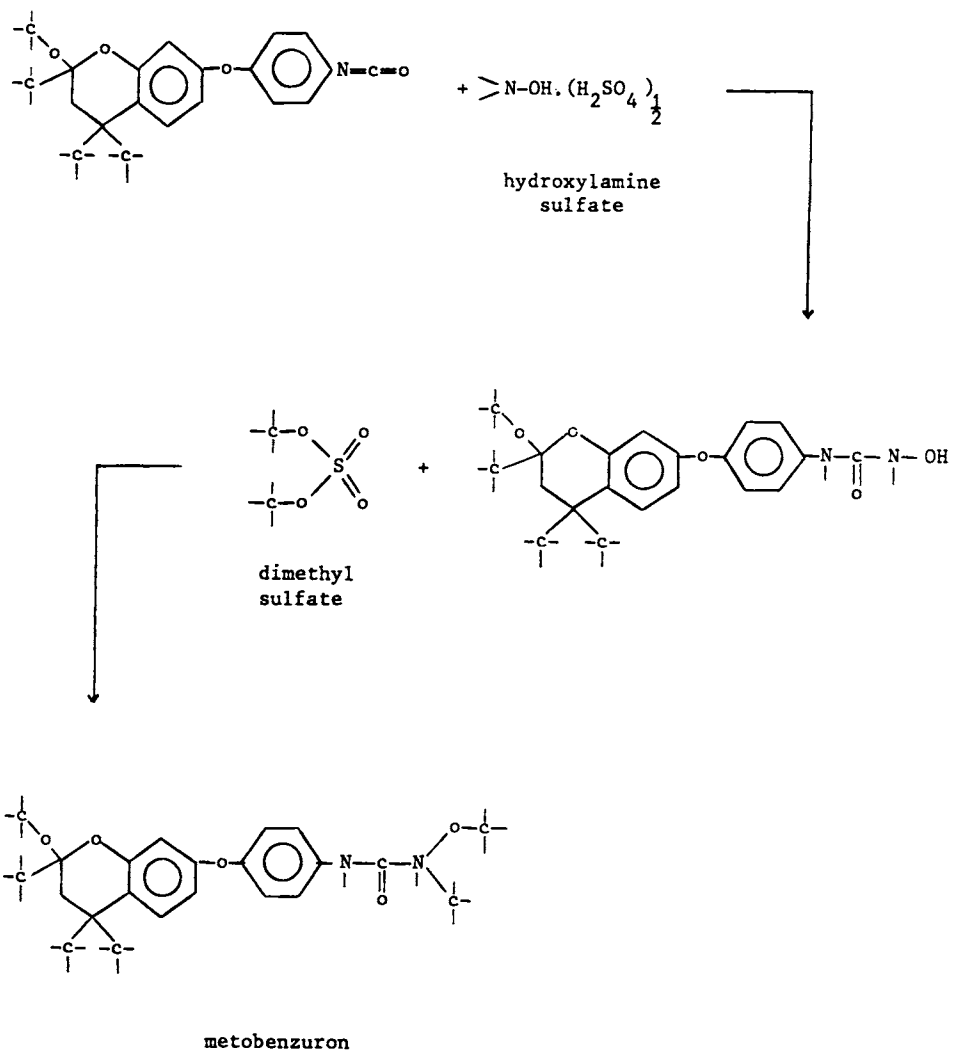
Uses: herbicide, maize

Trade names: (Mitsui)

Type: urea

Synthesis:







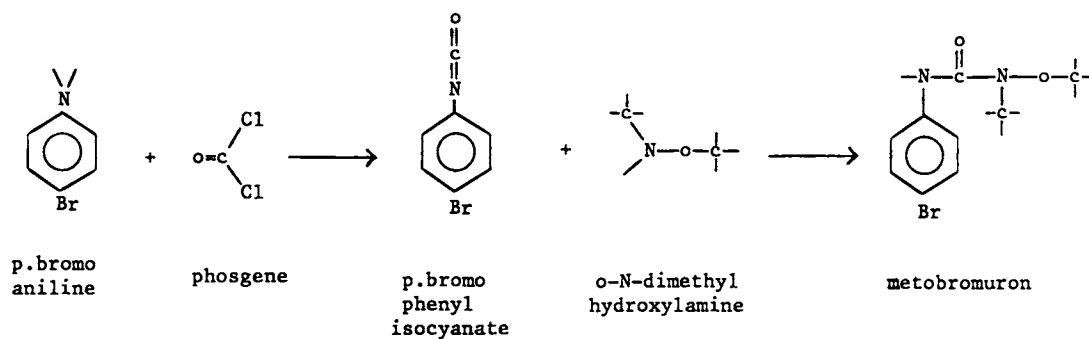
## Metobromuron

Uses: herbicide, tobacco, tomatoes, soyabeans, sunflowers

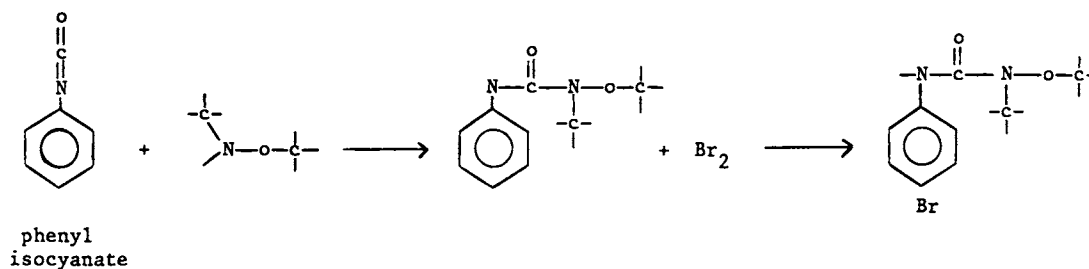
Trade names: Patoran (Ciba)

Type: urea

Synthesis:



alternate route :



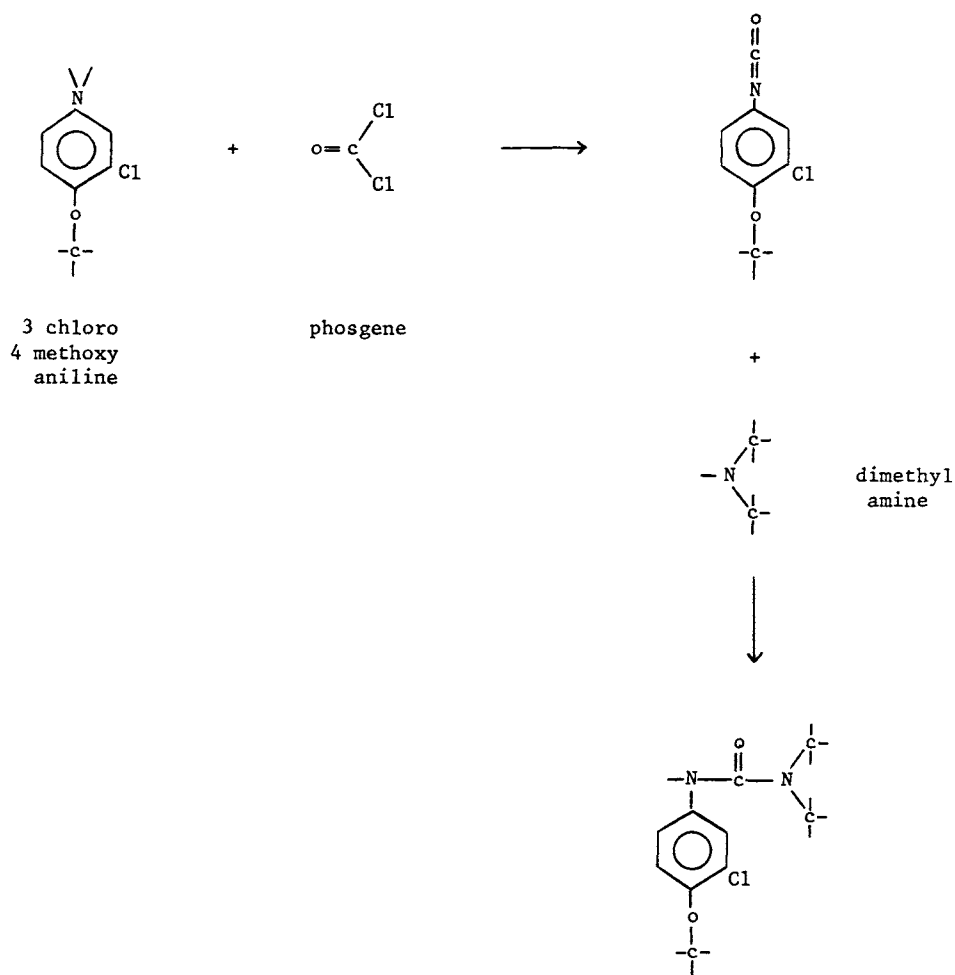
## Metoxuron

Uses: herbicide, cereals, carrots, wheat, barley, rye

Trade names: Dosanex (Sandoz)

Type: urea

Synthesis:



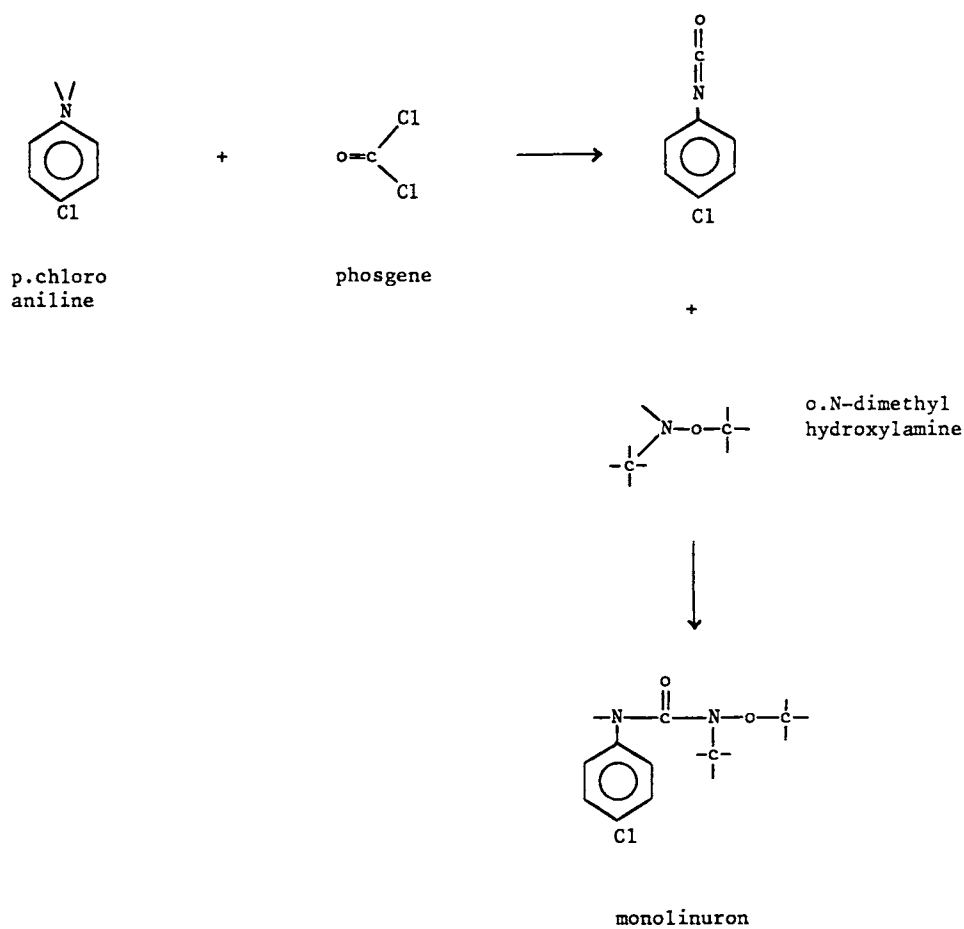
## Monolinuron

Uses: herbicide, beans, maize, potatoes, vine, ornamentals

Trade names: Aresin (Hoechst)

Type: urea

Synthesis:



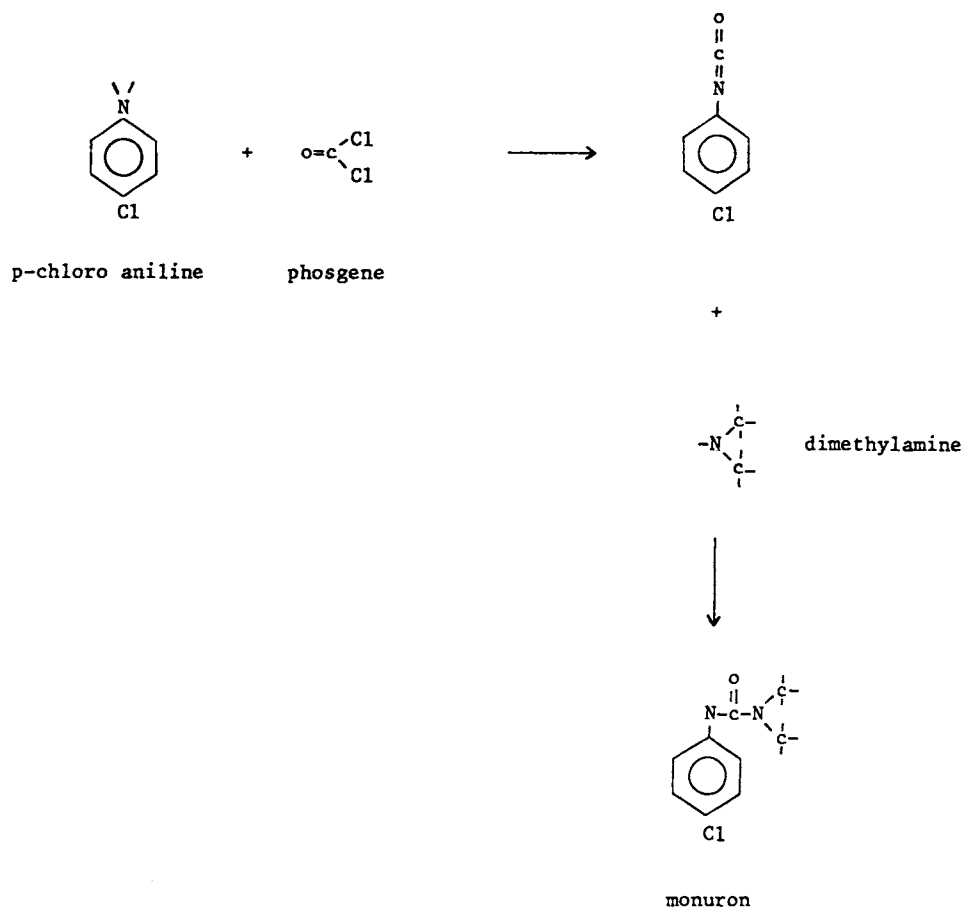
## Monuron

Uses: herbicide, non crop areas

Trade names: Telvar (DuPont), Urox (Hopkins)

Type: urea

Synthesis:



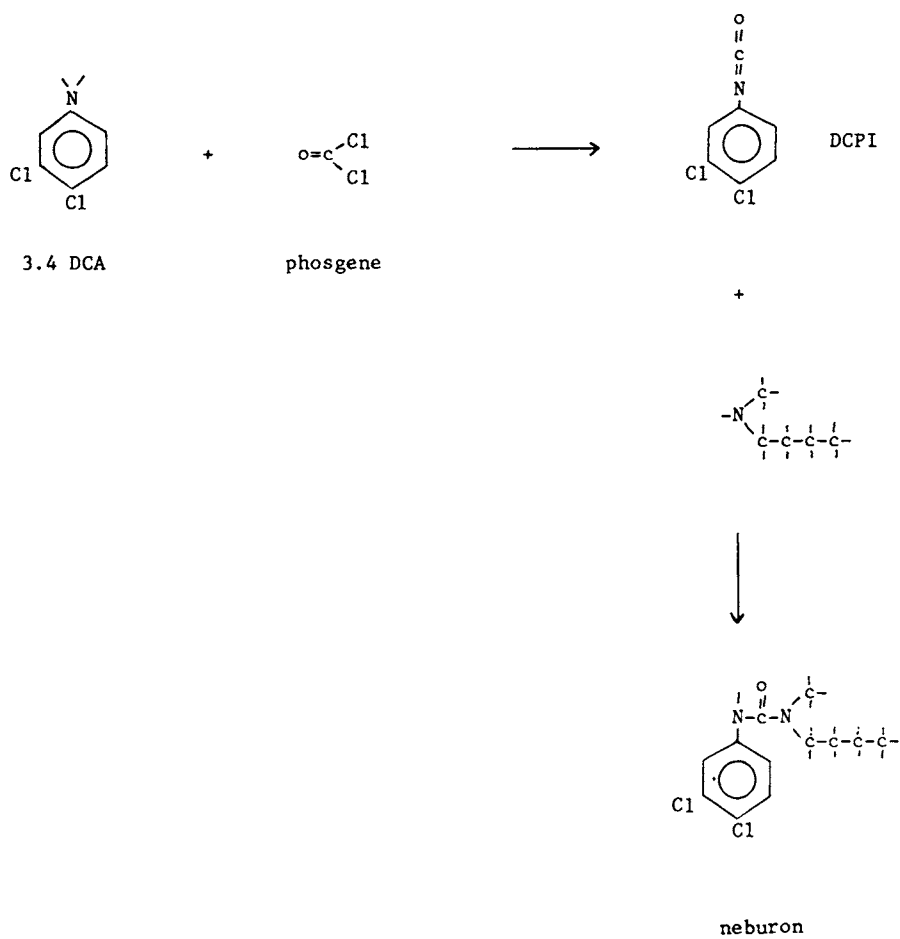
## Neburon

Uses: herbicide, wheat, fruit, ornamentals

Trade names: Kloben (Dupont)

Type: urea

Synthesis:



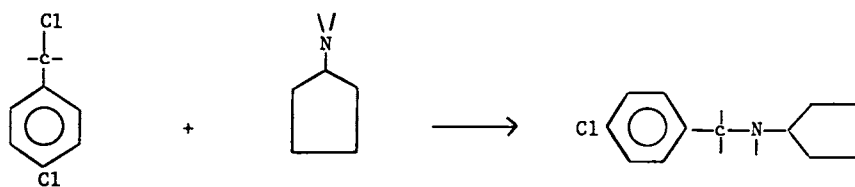
## Pencycuron

Uses: fungicide, rice, potatoes, vegetables, ornamentals

Trade names: Monceren (Bayer)

Type: urea

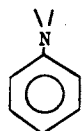
Synthesis:



4 chloro  
benzyl  
chloride

cyclopentyl  
amine

+

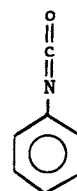


aniline

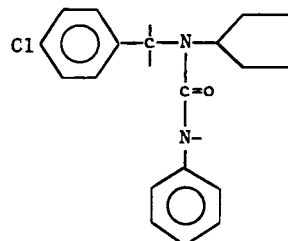
+



phosgene



phenyl  
isocyanate



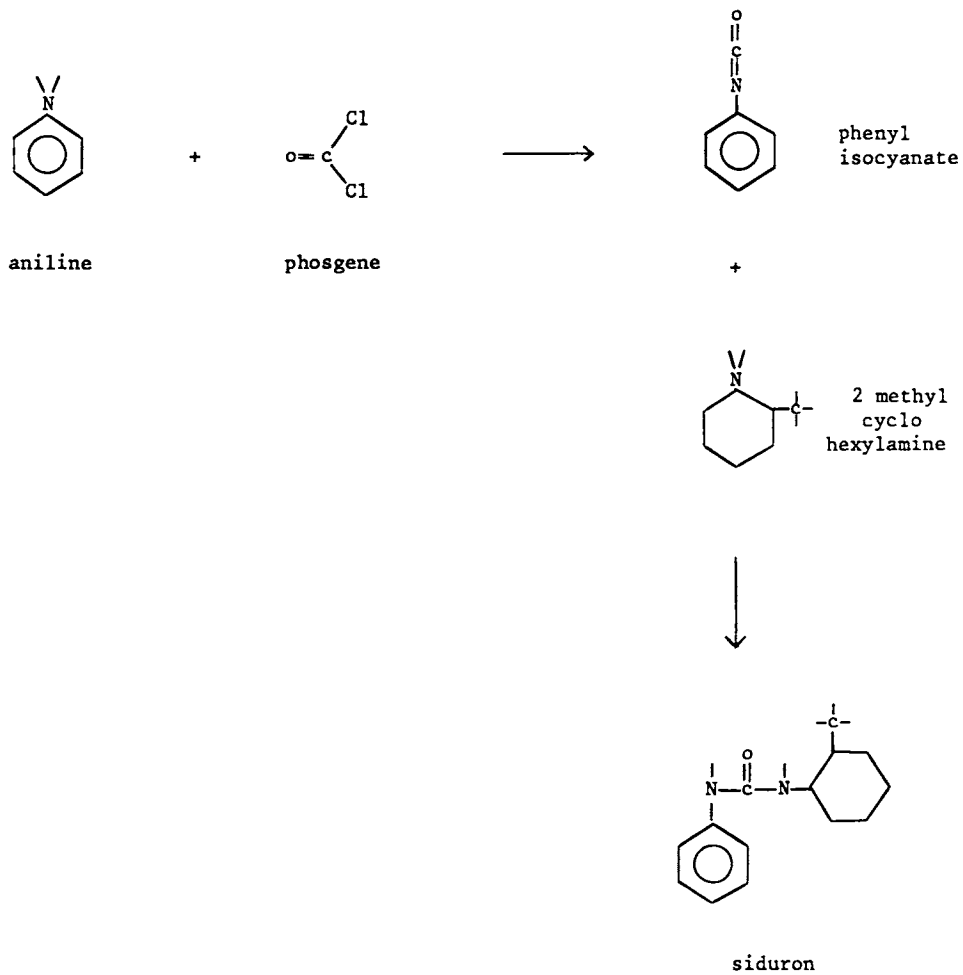
## Siduron

Uses: herbicide, cereals, turf

Trade names: Tupersan (Dupont)

Type: urea

Synthesis:



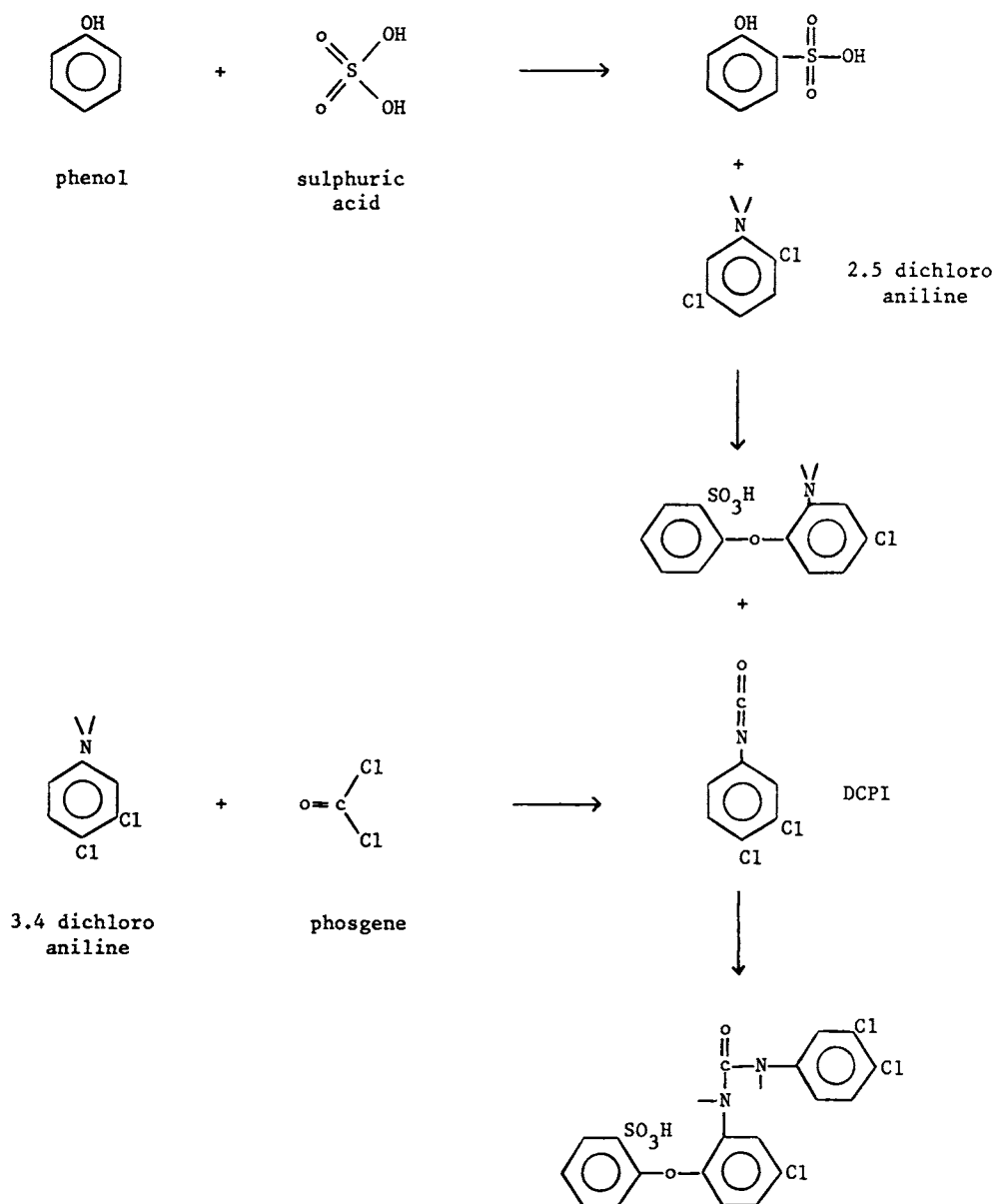
## Sulcofuron

Uses: insecticide, cotton, fabrics

Trade names: Mitin FF (Ciba)

Type: urea, phenyl ether

Synthesis:





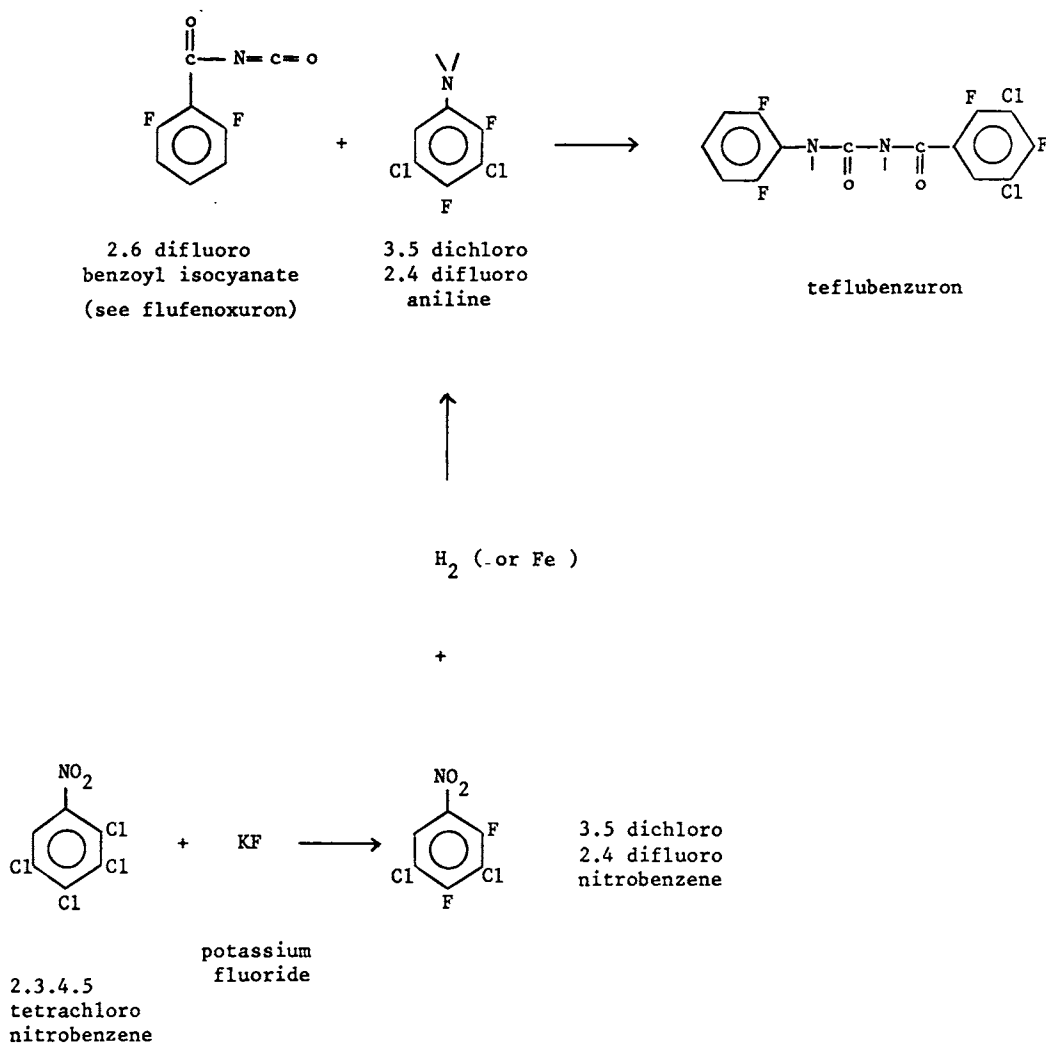
## Teflubenzuron

Uses: insecticide, citrus, cotton, grapes, fruit, vegetables, potatoes, sorghum, soyabeans, tobacco

Trade names: Nomolt (Shell)

Type: carbonyl urea

Synthesis:



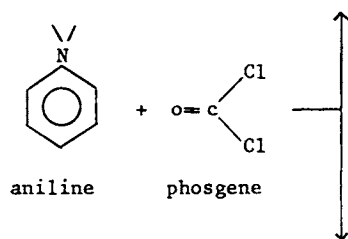
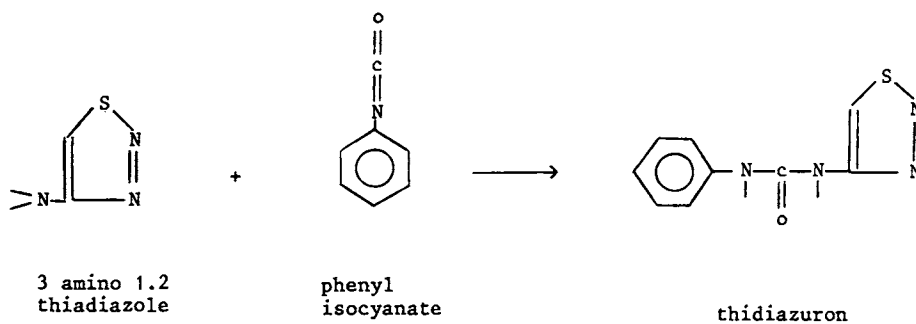
## Thidiazuron

Uses: plant growth regulator, cotton

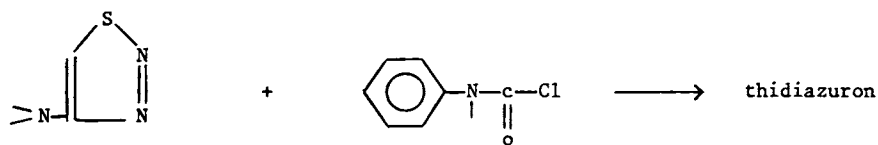
Trade names: Dropp (Schering)

Type: urea, thiadiazole

Synthesis:



alternate route:



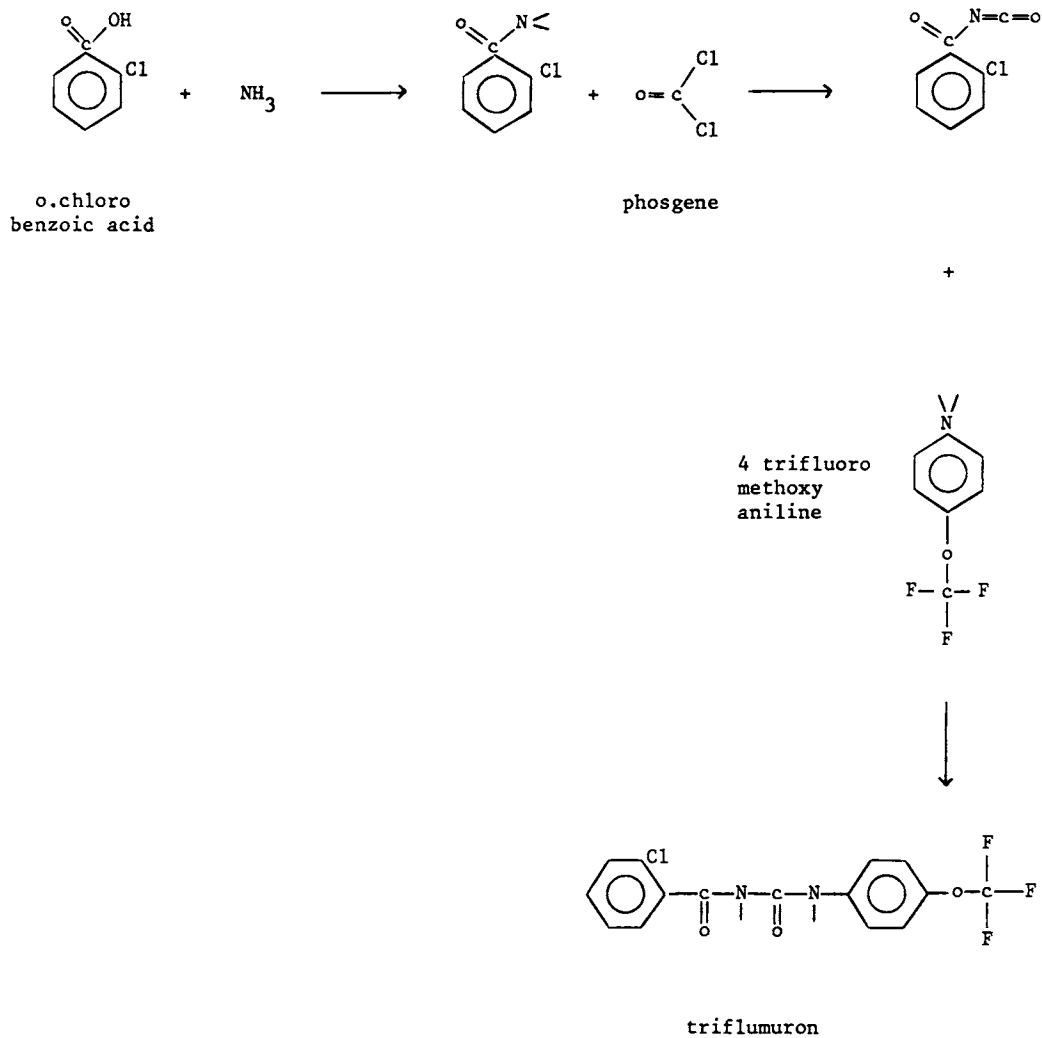
## Triflumuron

Uses: insecticide, cotton, trees, fruit, soyabeans

Trade names: Alystin (Bayer)

Type: carbonyl urea

Synthesis:



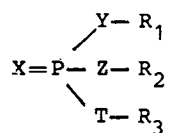
# PHOSPHORO ORGANICS

Phosphonates and similar products are characterised by at least one P-H or P-C bond

Phosphonothioates have in addition to a P-H or P-C bond a P=S or P-S bond

Phosphonodithioates have both a P=S and a P-S bond

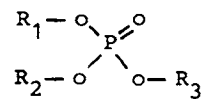
Other phosphoro organics have a general structure of the type



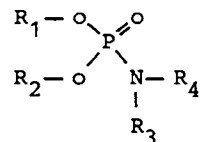
where X, Y, Z, T are oxygen and/or sulfur (and in the special case of amides one of Y, Z, T is nitrogen).

The main families are:

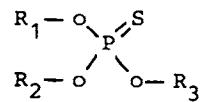
phosphate esters



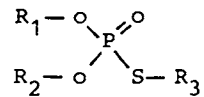
phosphoro amidates



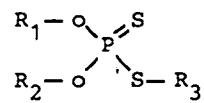
phosphoro thioates



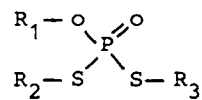
or



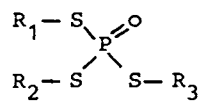
phosphoro dithioates



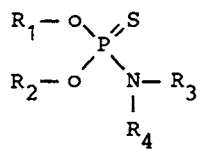
or



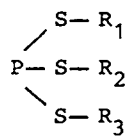
phosphoro trithioates



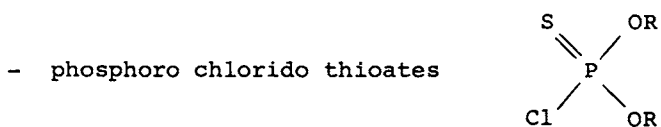
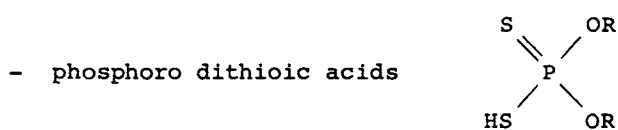
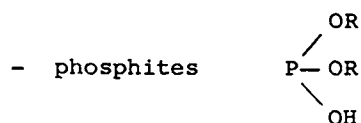
phosphoro amido thioates



phosphoro trithioites

In all these cases usually  $\text{R}_1 = \text{R}_2$

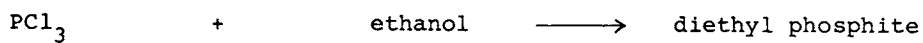
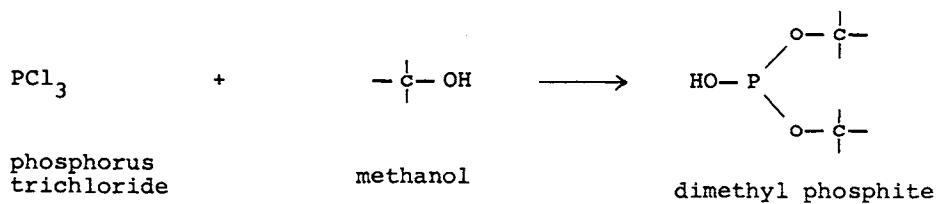
Nearly all synthesis of phosphate esters, phosphorothioates and phosphoroamidoates use as starting materials one of the following:



These compounds are obtained as follows :

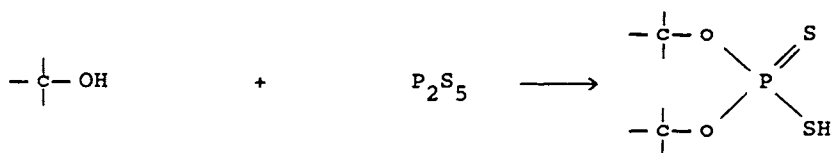
DIMETHYL PHOSPHITE

DIETHYL PHOSPHITE



DMPA - DIMETHYL PHOSPHORO DITHIOIC ACID

DEPA - DIETHYL PHOSPHORO DITHIOIC ACID



methanol

phosphorus  
pentasulfide

DMPA - dimethyl phosphoro  
dithioic acid

ethanol

+

$\text{P}_2\text{S}_5$

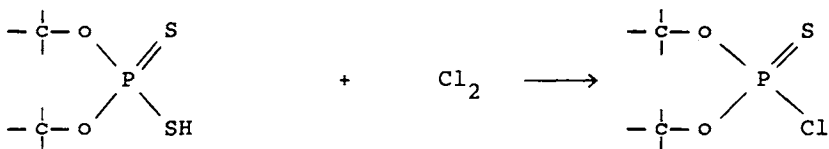
$\longrightarrow$

DEPA - diethyl phosphoro  
dithioic acid

DMPCT - DIMETHYL PHOSPHORO CHLORIDO THIOATE

DEPCT - DIETHYL PHOSPHORO CHLORIDO THIOATE

DIPCT - DIISOPROPYL PHOSPHORO CHLORIDO THIOATE



DMPA - dimethyl phosphoro  
dithioic acid

DMPCT - dimethyl phosphoro  
chlorido thioate

DEPA - diethyl phosphoro  
dithioic acid

+

$\text{Cl}_2$

$\longrightarrow$

DEPCT - diethyl phosphoro  
chlorido thioate

DIPA - diisopropyl  
phosphoro dithioic acid

+

$\text{Cl}_2$

$\longrightarrow$

DIPCT - diisopropyl phosphoro  
chlorido thioate

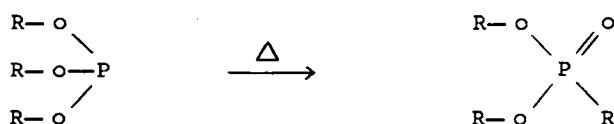


# PHOSPHONATES PHOSPHINATES PHOSPHONIC ACIDS

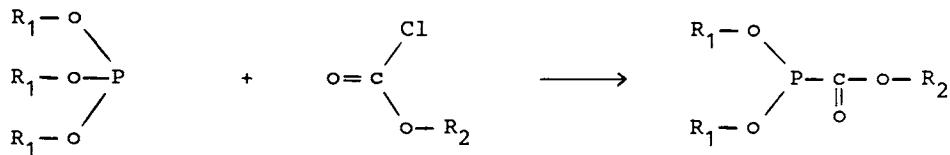
Phosphonates are produced by a variety of different reactions , practically each product being a case in itself.

The most important methods for obtaining phosphonates are the following:

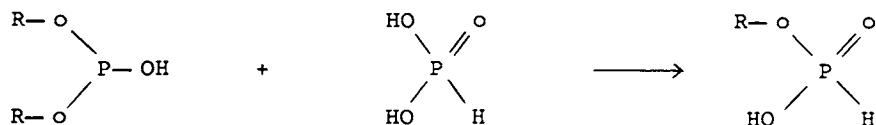
- isomerisation of a phosphite :



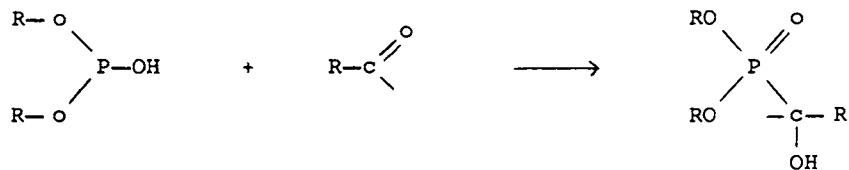
- reaction between a phosphite and a chloroformate



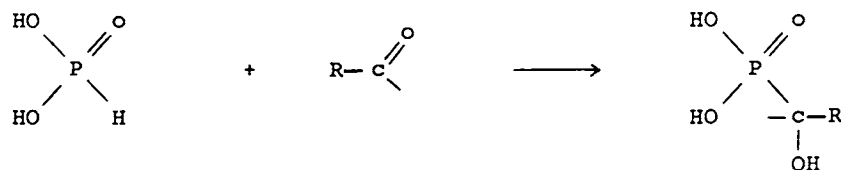
- reaction between a dialkyl phosphite and phosphorous acid



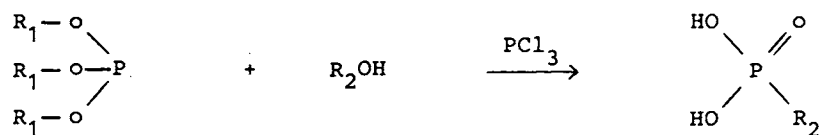
- reaction between a dialkyl phosphite or phosphorous acid and an aldehyde



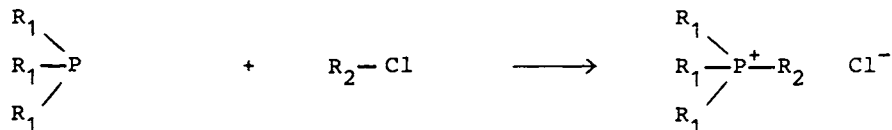
or



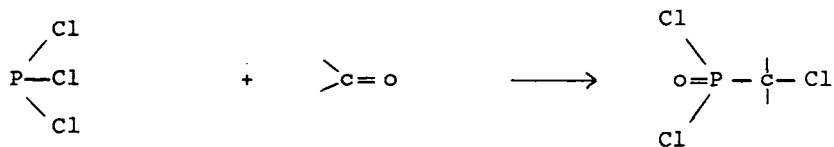
- reaction between a trialkyl phosphite and an alcohol in presence of  $\text{PCl}_3$



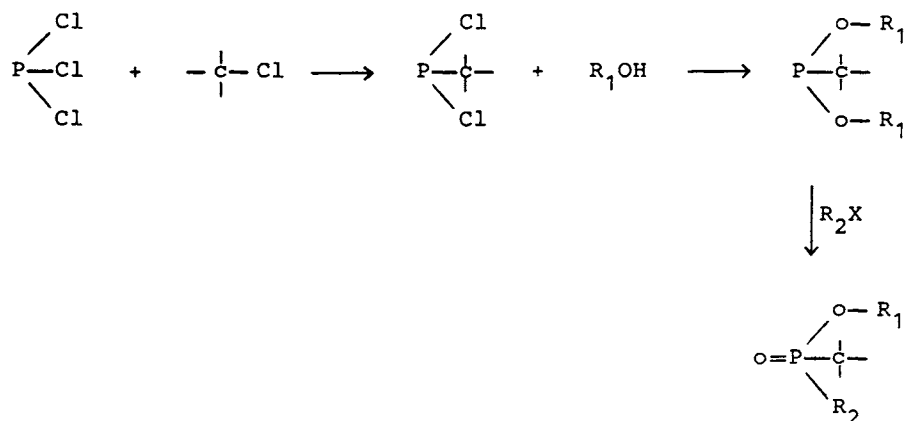
- reaction between a trialkyl phosphine and an alkyl halide



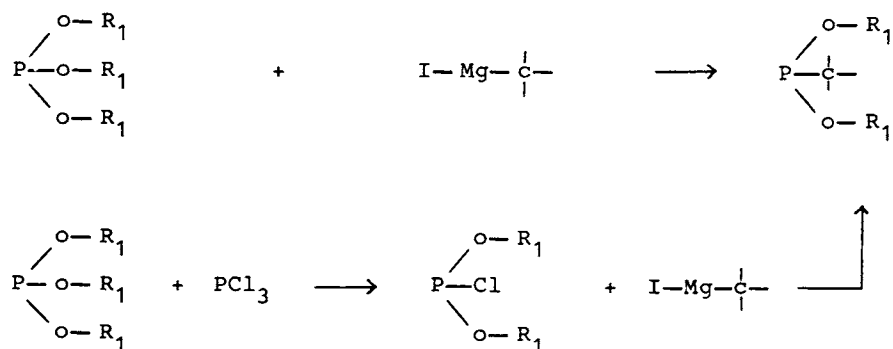
- reaction between phosphorus trichloride and formaldehyde



Phosphinates are obtained by reaction between  $\text{PCl}_3$  and methyl chloride followed by alcoholysis and oxidation to the pentavalent form with a halo alkyl compound



Alternate routes to the methyl dialkyl phosphonite are by reaction between a trialkyl phosphite and a Grignard reagent directly, or after previous treatment with  $\text{PCl}_3$



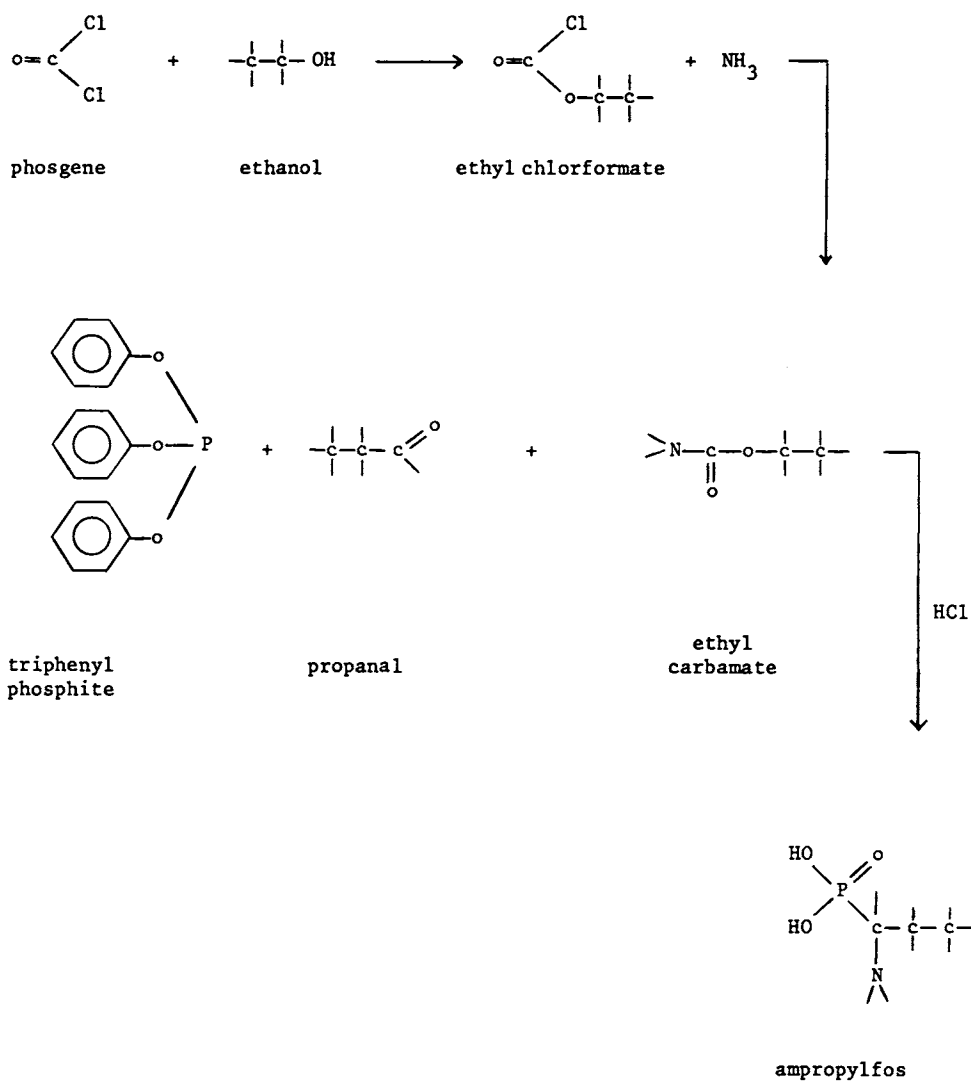
## Ampropylfos

Uses: fungicide

Trade names: Appa (Rhône Poulenc)

Type: phosphonic acid

Synthesis:



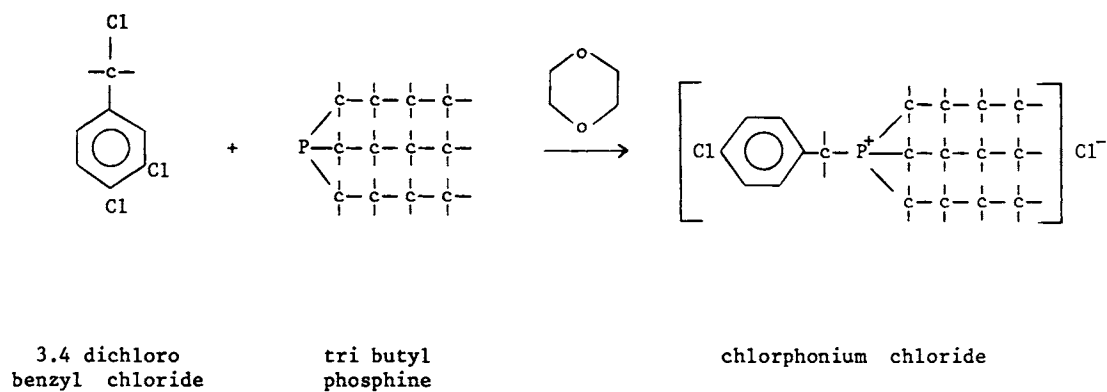
## Chlorphonium Chloride

Uses: plant growth regulator, flowers

Trade names: Phosphon (Mobil)

Type: phosphonate

Synthesis:





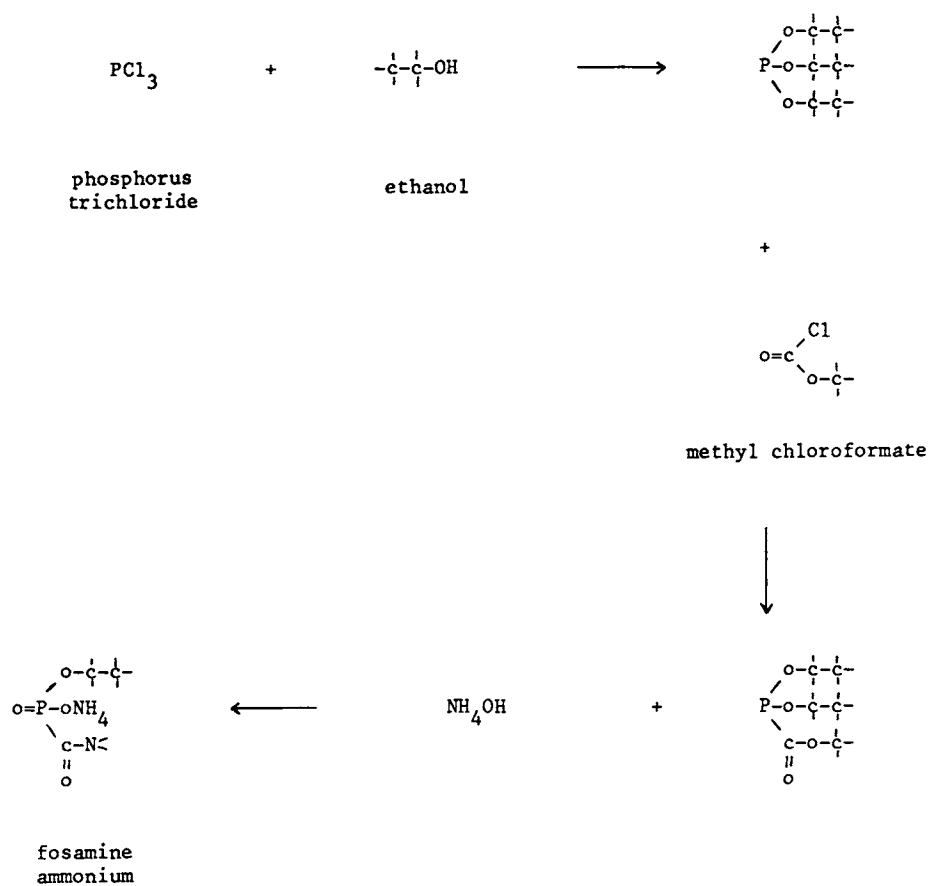
## Fosamine Ammonium

Uses: herbicide, small trees

Trade names: Krenite (DuPont)

Type: phosphonate

Synthesis:



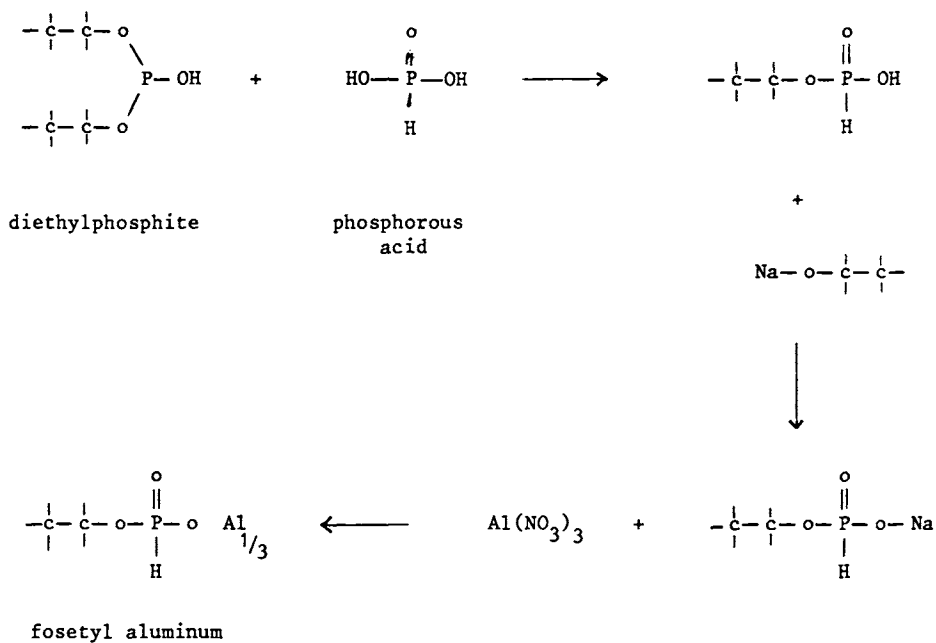
## Fosetyl Aluminum

Uses: fungicide, fruit, onions, cocoa, rubber, tobacco, ornamentals

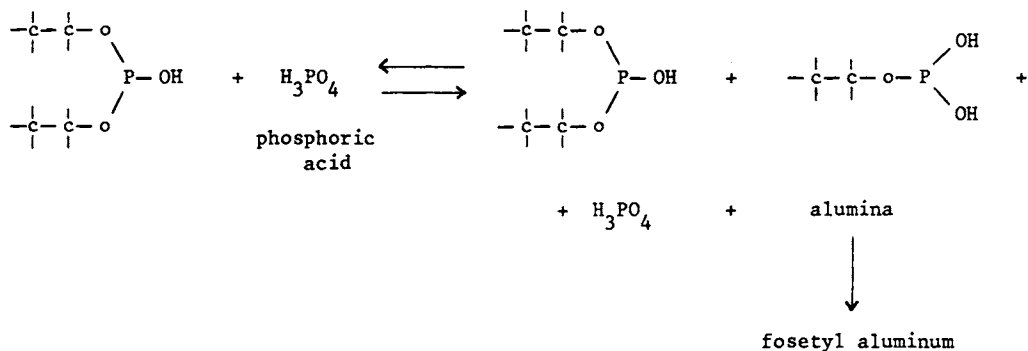
**Trade names:** Aliette (Rhone Poulenc)

Type: phosphonate

**Synthesis:**



alternate route:





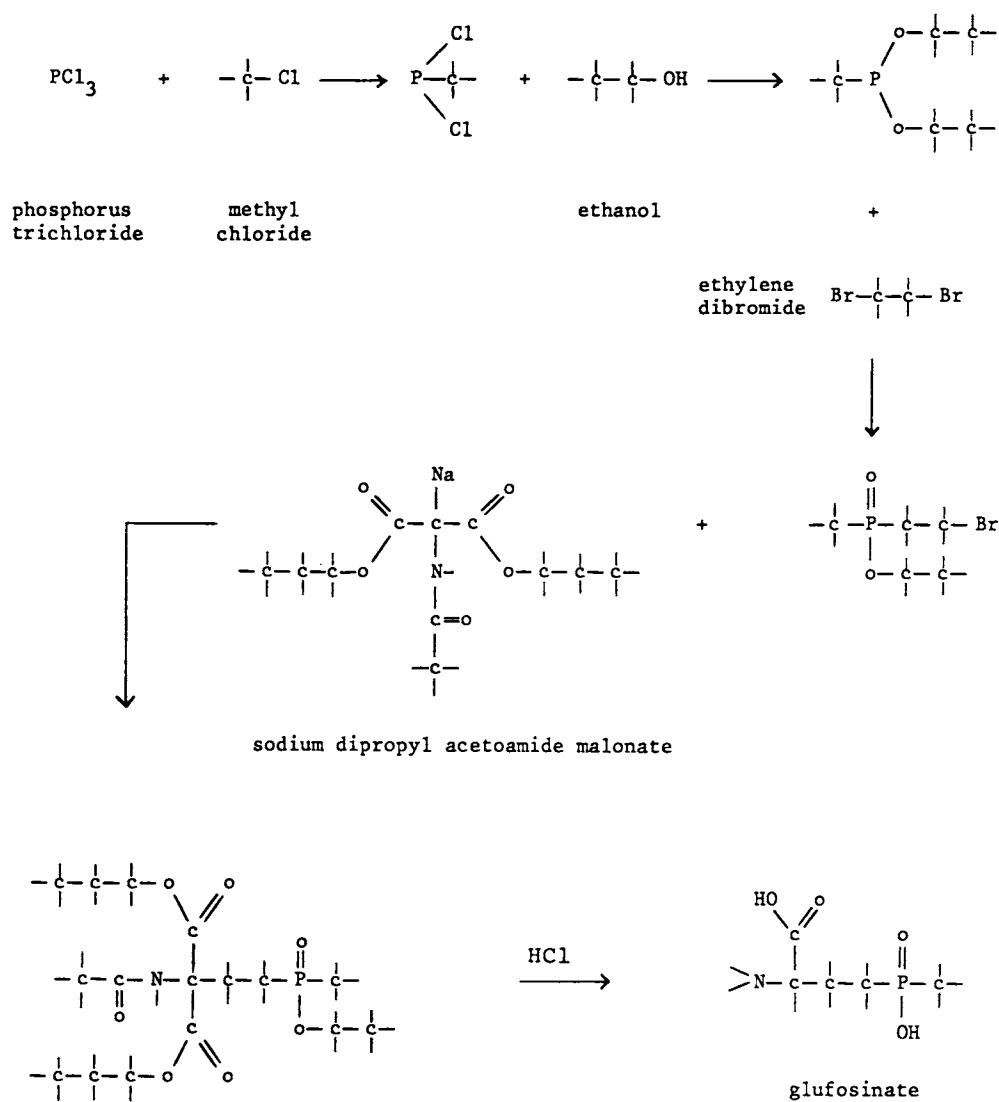
## Glufosinate

Uses: herbicide

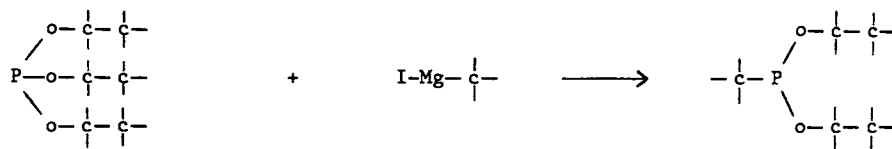
Trade names: Basta, Buster, Finale, Ignite (Hoechst)

Type: phosphinate

Synthesis:

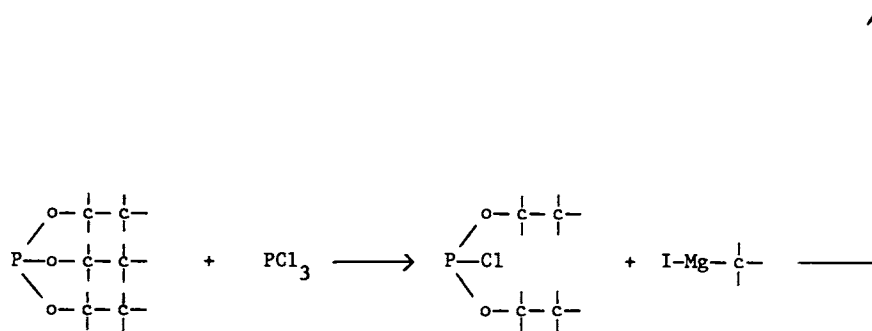


alternate routes :



triethyl  
phosphite

methyl  
grignard  
reagent



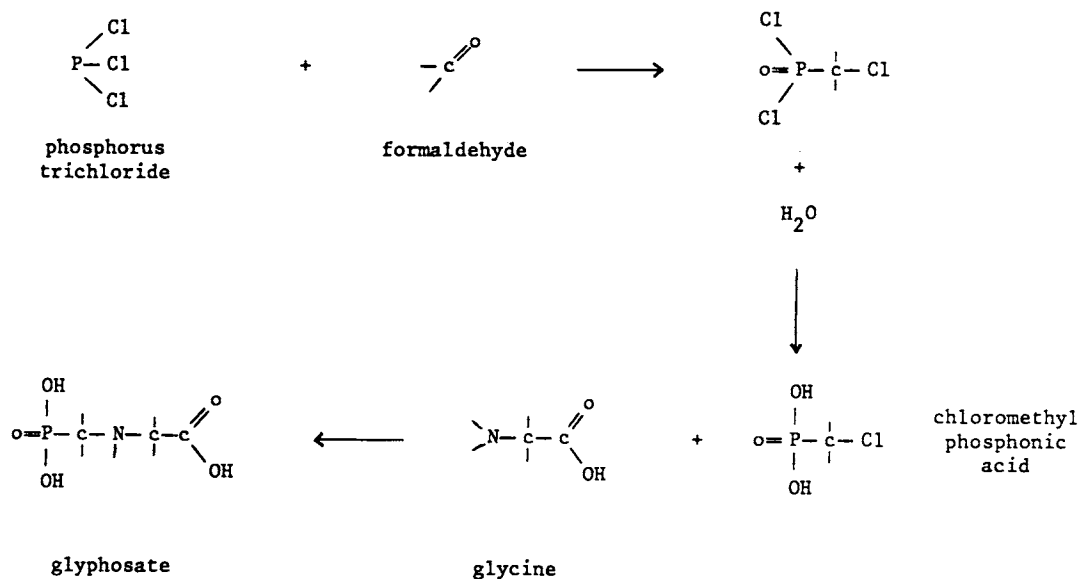
## Glyphosate

Uses: herbicide, coffee, tea, bananas, rubber, coconut, cocoa, cereals, cotton, soyabeans, fruit

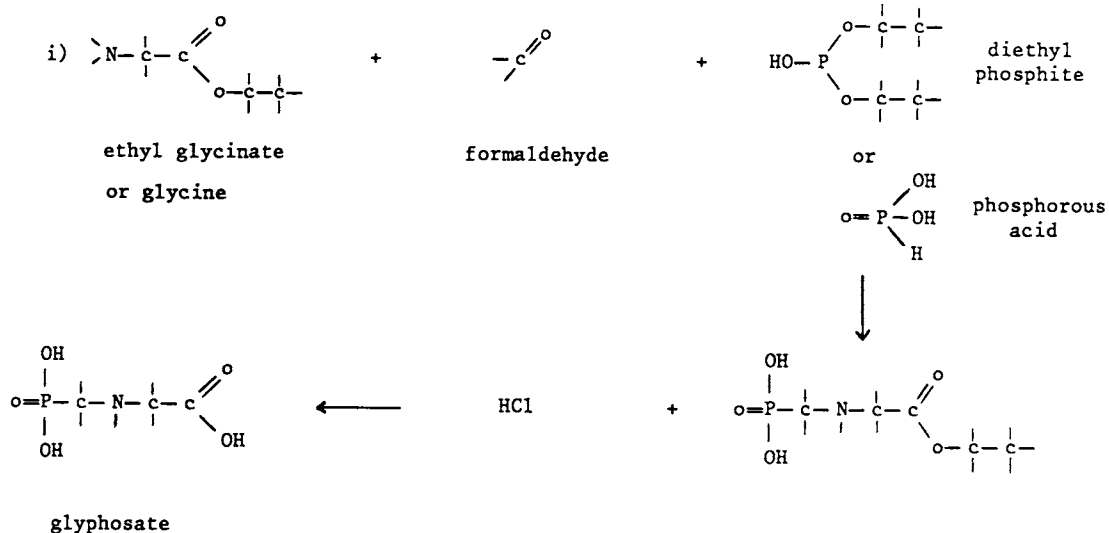
Trade names: Round-up (Monsanto)

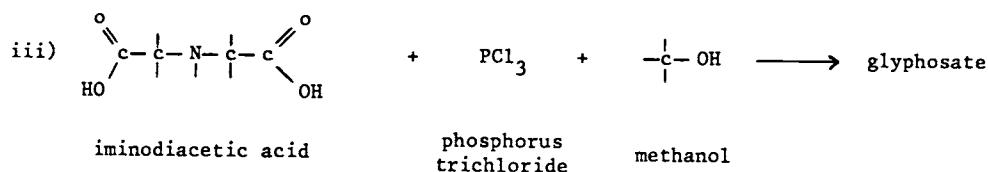
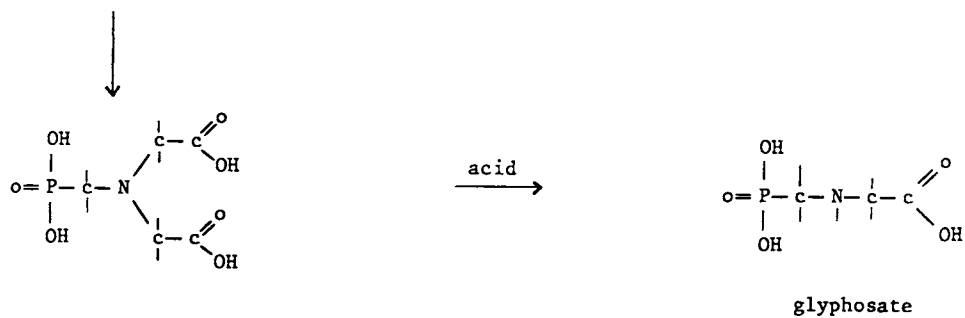
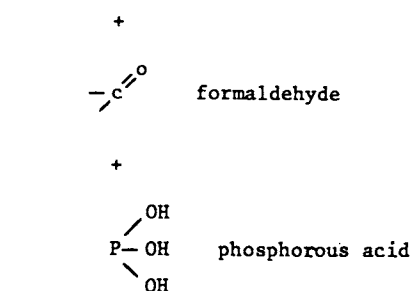
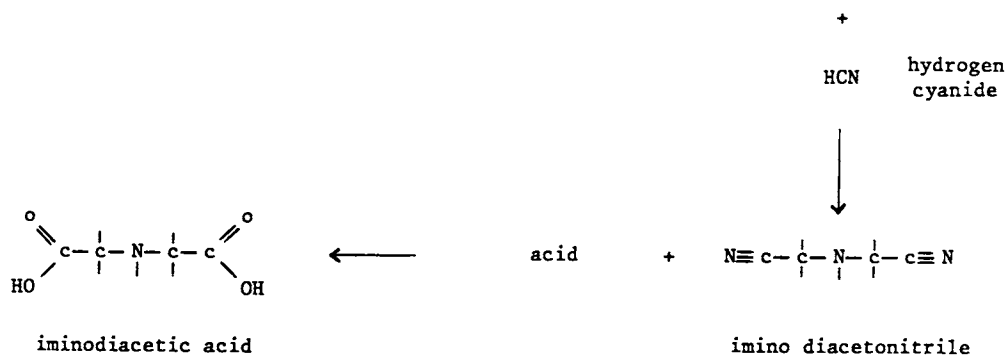
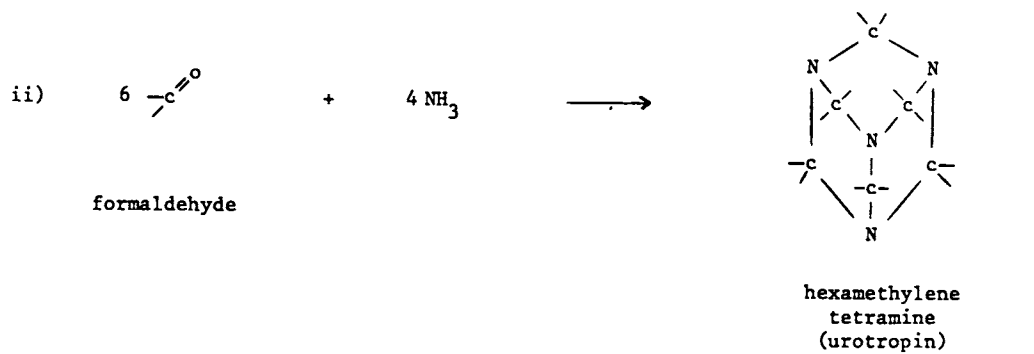
Type: phosphonate

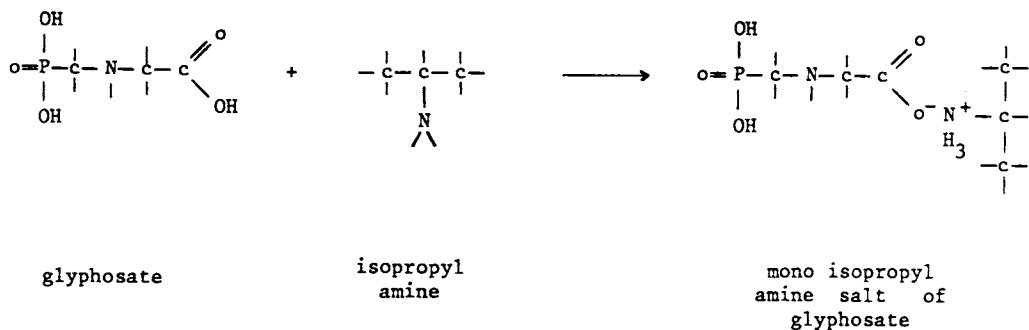
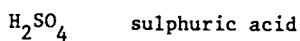
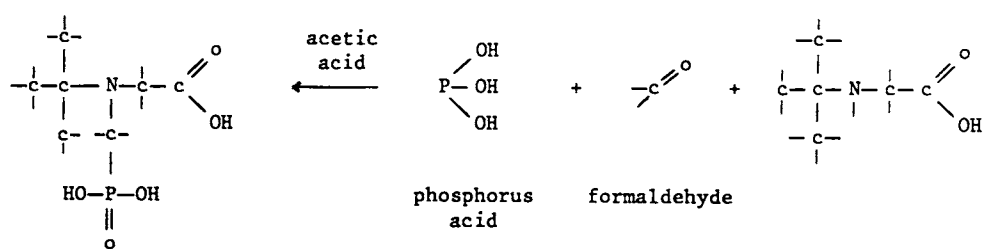
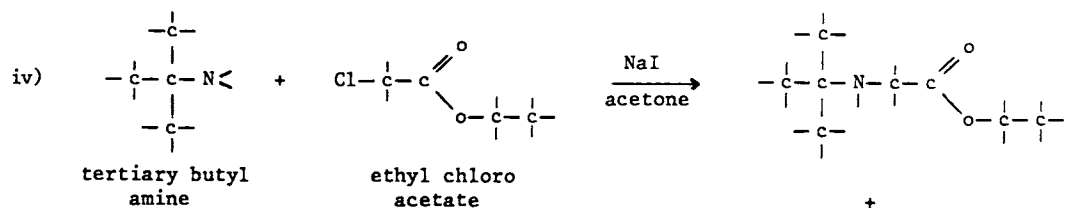
### Synthesis:

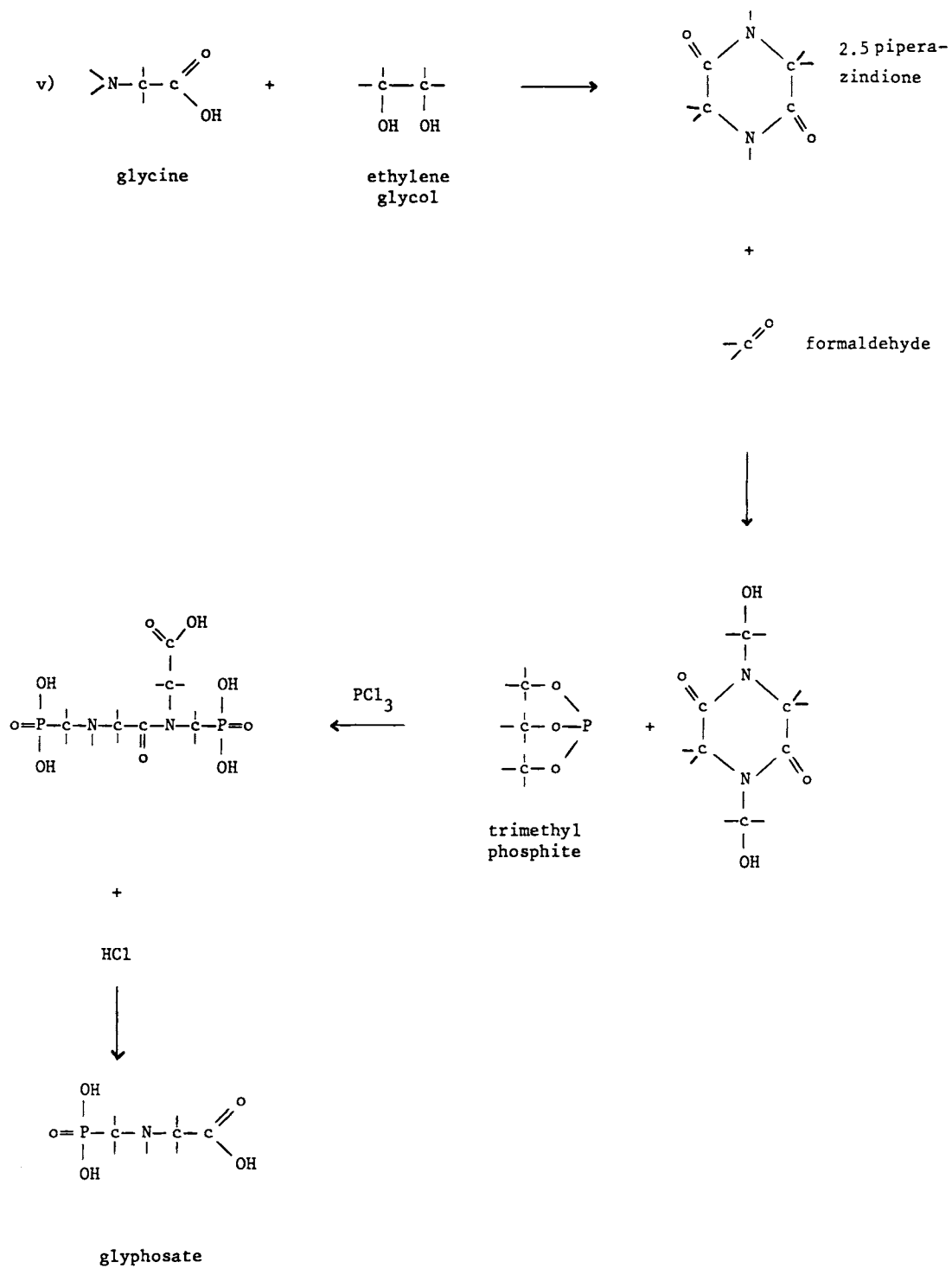


### alternate routes :









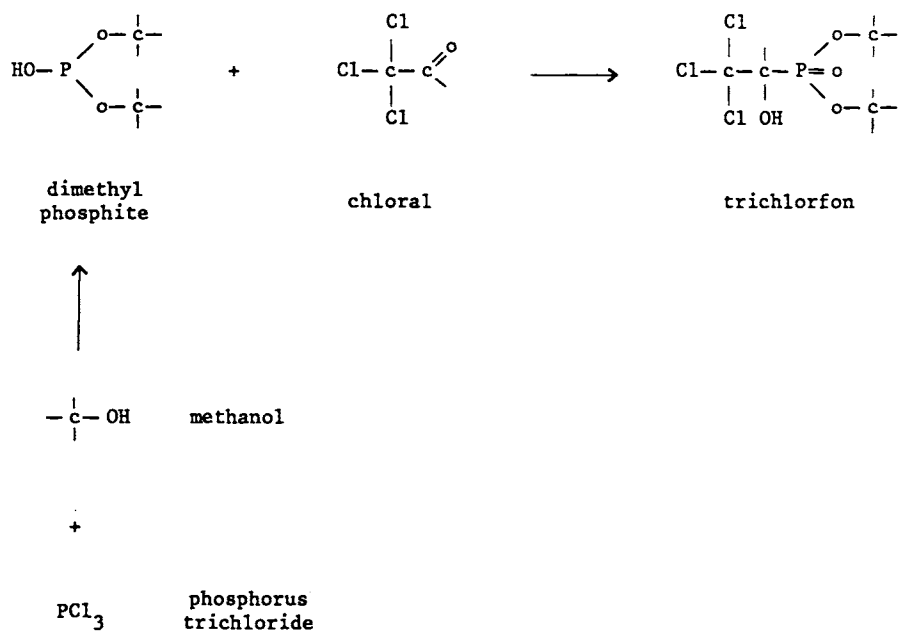
## Trichlorfon

Uses: insecticide, beets, cereals, cotton, fruit, vegetables, households

Trade names: Dipterex, Neguvon, Tugon, Dylox (Bayer)

Type: phosphonate

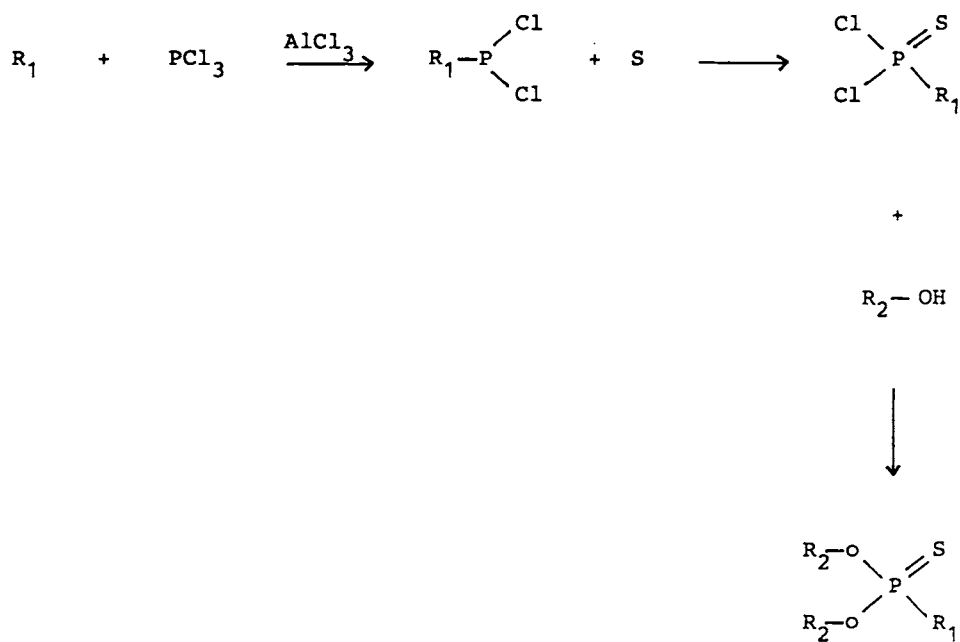
Synthesis:



# PHOSPHONOTHIOATES

For compounds of the type  $\begin{array}{c} \text{R}_1\text{-O} \\ \diagup \\ \text{P}=\text{S} \\ \diagdown \\ \text{R}_1\text{-O} \end{array} \text{R}_2$  there are 2 basic routes:

- i) reaction between  $\text{PCl}_3$  and a hydrocarbon in presence of aluminum trichloride, followed by reaction with sulfur and an alcohol

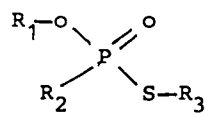


- ii) use of a strong dehydrating agent makes it possible to start from a chloridothioate (see phosphorothioates)



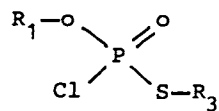


Phosphonothioates with a structure



are obtained

starting from



( see phosphorothioates )

which is then reacted with



(phosphonoamidothioate) or

with  $\text{R}_2\text{—OH}$  in presence of  $\text{PCl}_3$

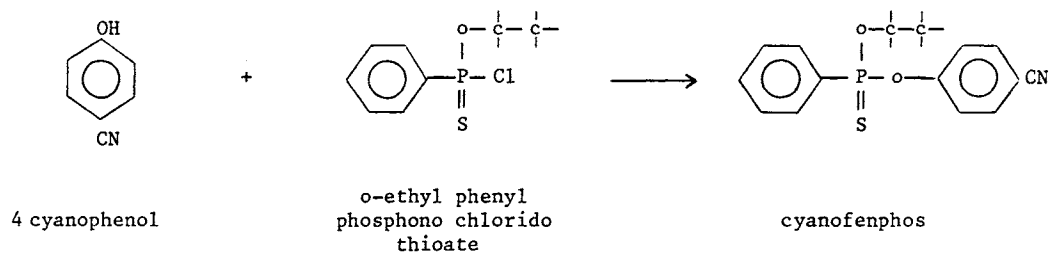
## Cyanofenphos

Uses: insecticide, fruit, vegetables, cotton, rice

Trade names: Surecide (Sumitomo)

Type: phosphonothioate

Synthesis:



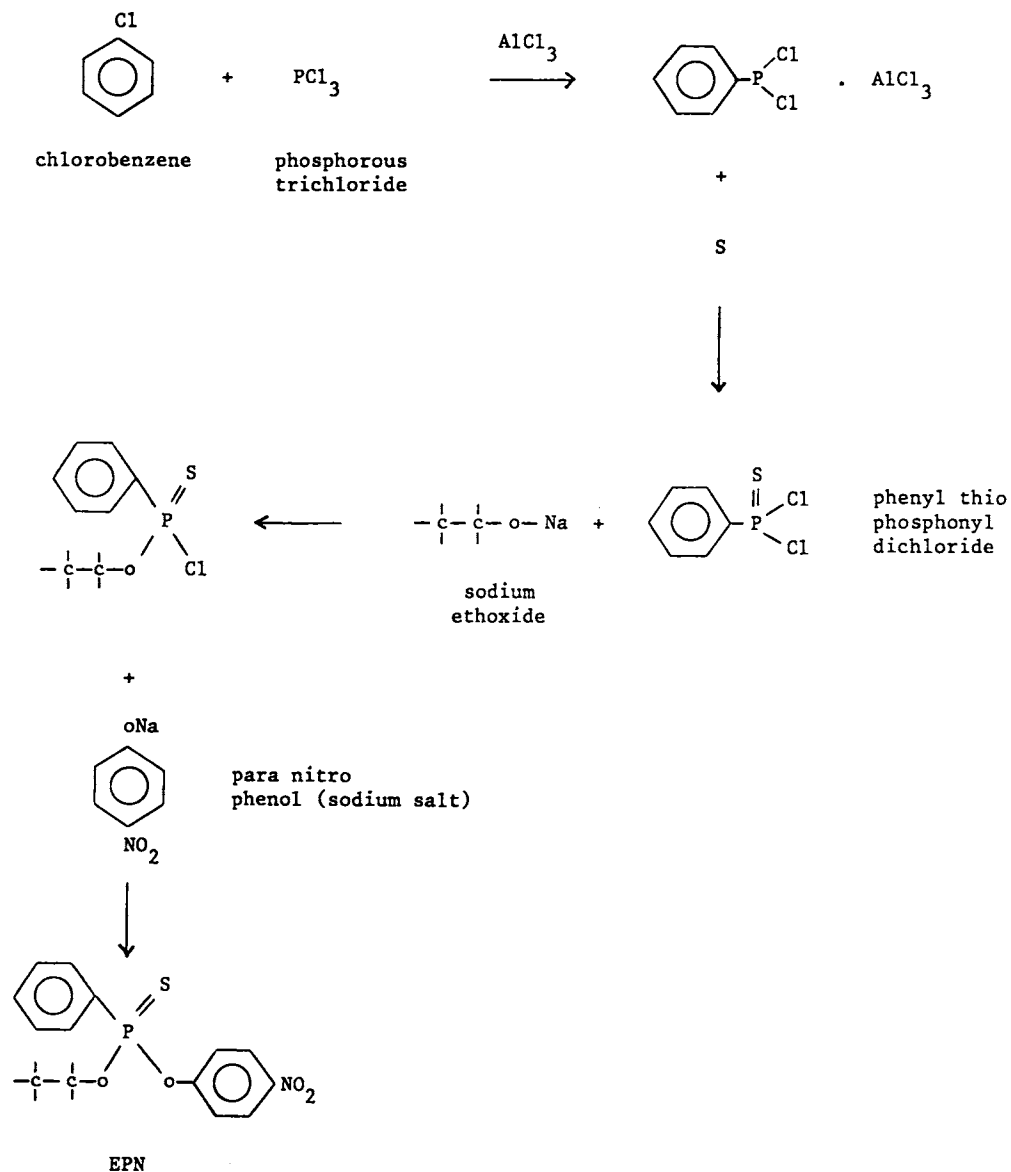
## EPN

Uses: insecticide, rice, fruit, vegetables

Trade names: EPN (Nissan)

Type: phosphonothioate

Synthesis:





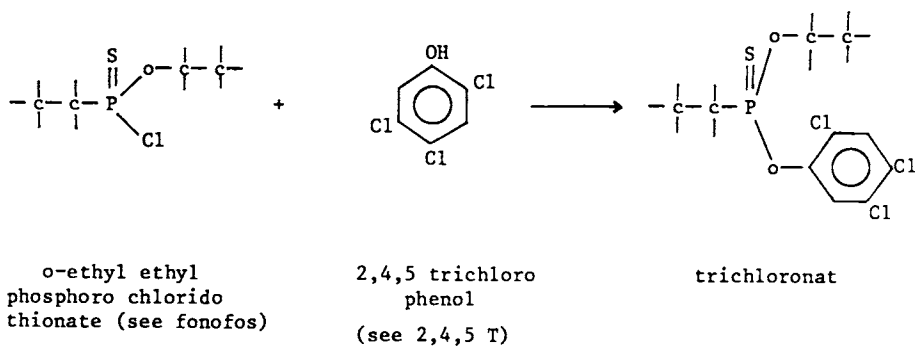
## Trichloronat

Uses: insecticide, cabbage, onions, carrots, beans, celery, bananas, turf

Trade names: Phytosil, Agritox, Agrisil (Bayer)

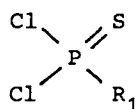
Type: phosphonothioate

Synthesis:

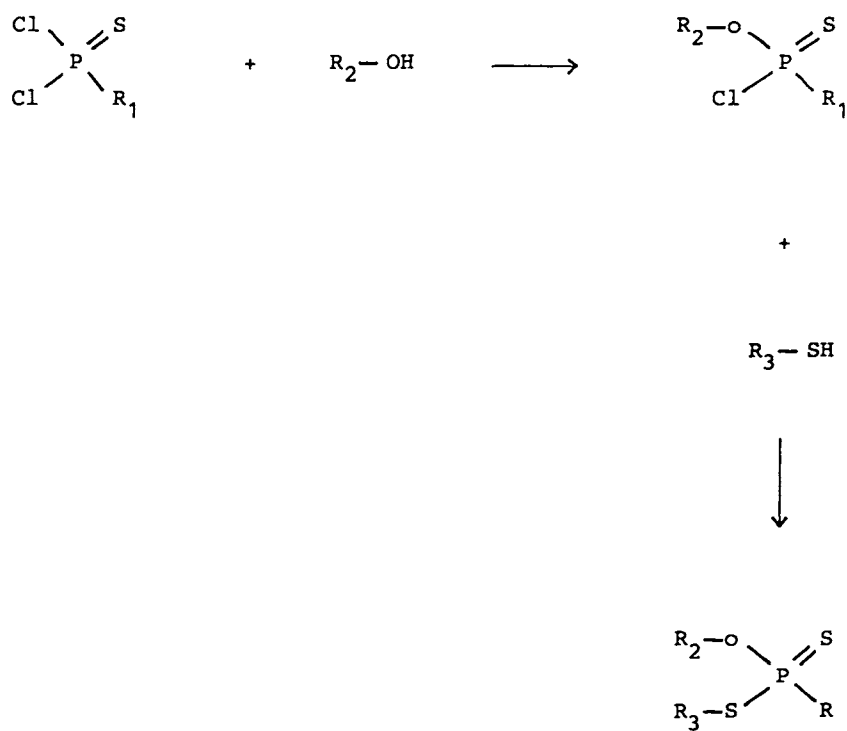


# PHOSPHONODITHIOATES

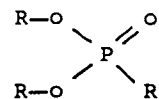
Phosphonodithioates may be prepared using the same path as for phosphonothioates to



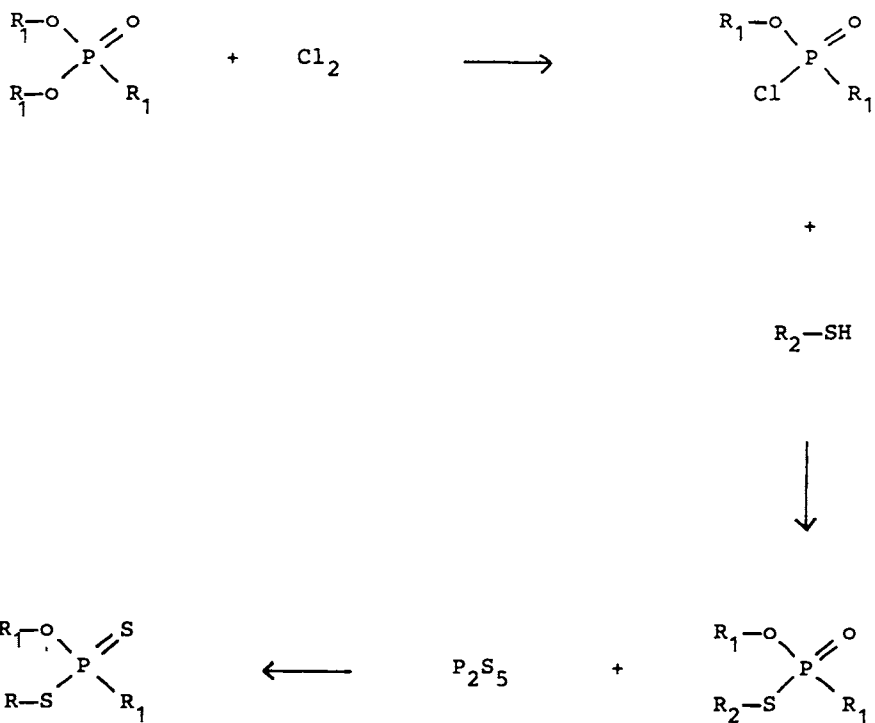
and then by successive reactions with an alcohol and a mercaptan



An alternate route starts from a phosphonate



obtained by isomerisation of a trialkyl phosphite (see phosphonates), followed by chlorination, reaction with a mercaptan and finally substitution of the oxygen by sulfur



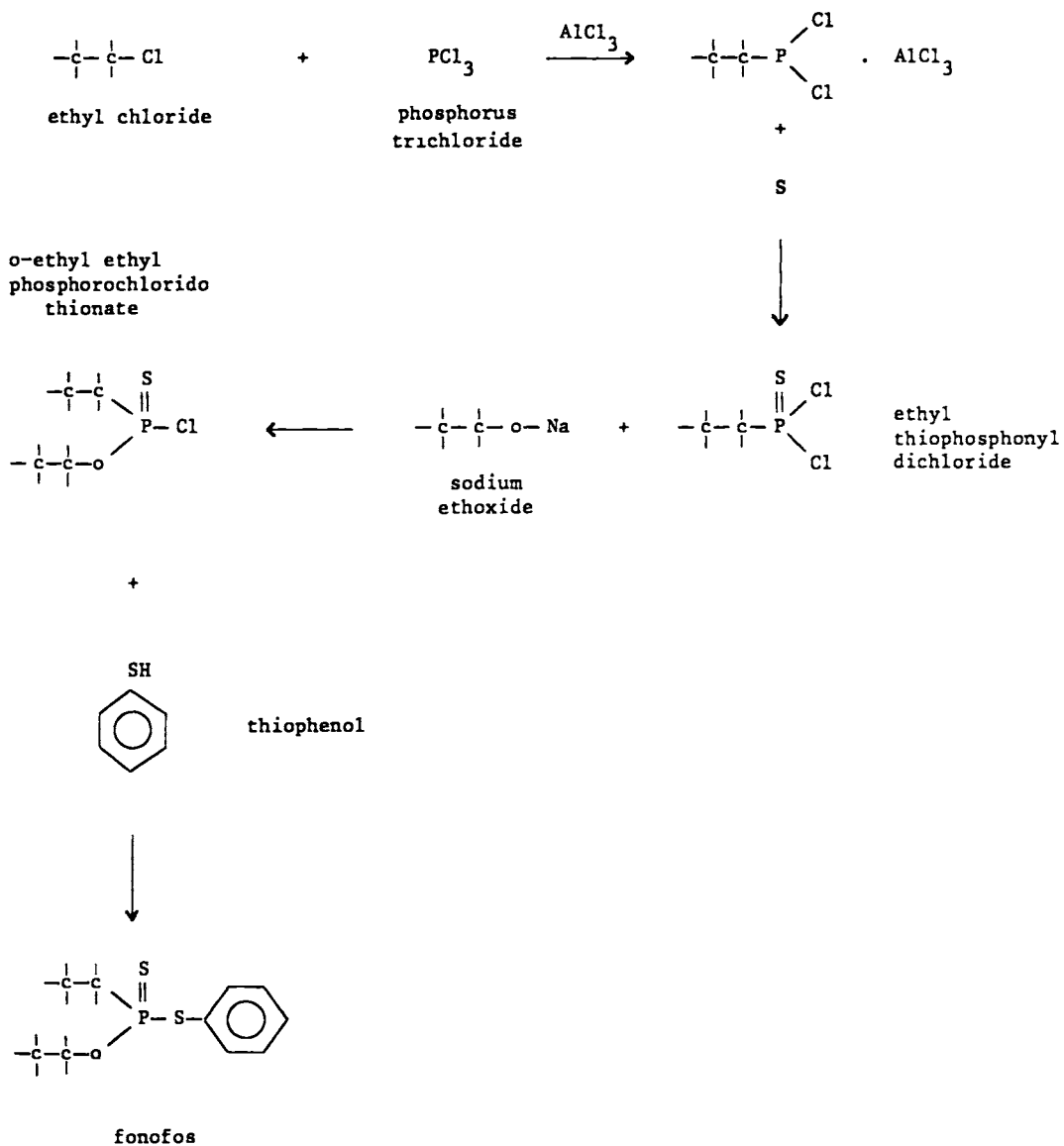
## Fonofos

Uses: insecticide

Trade names: Dyfonate (ICI)

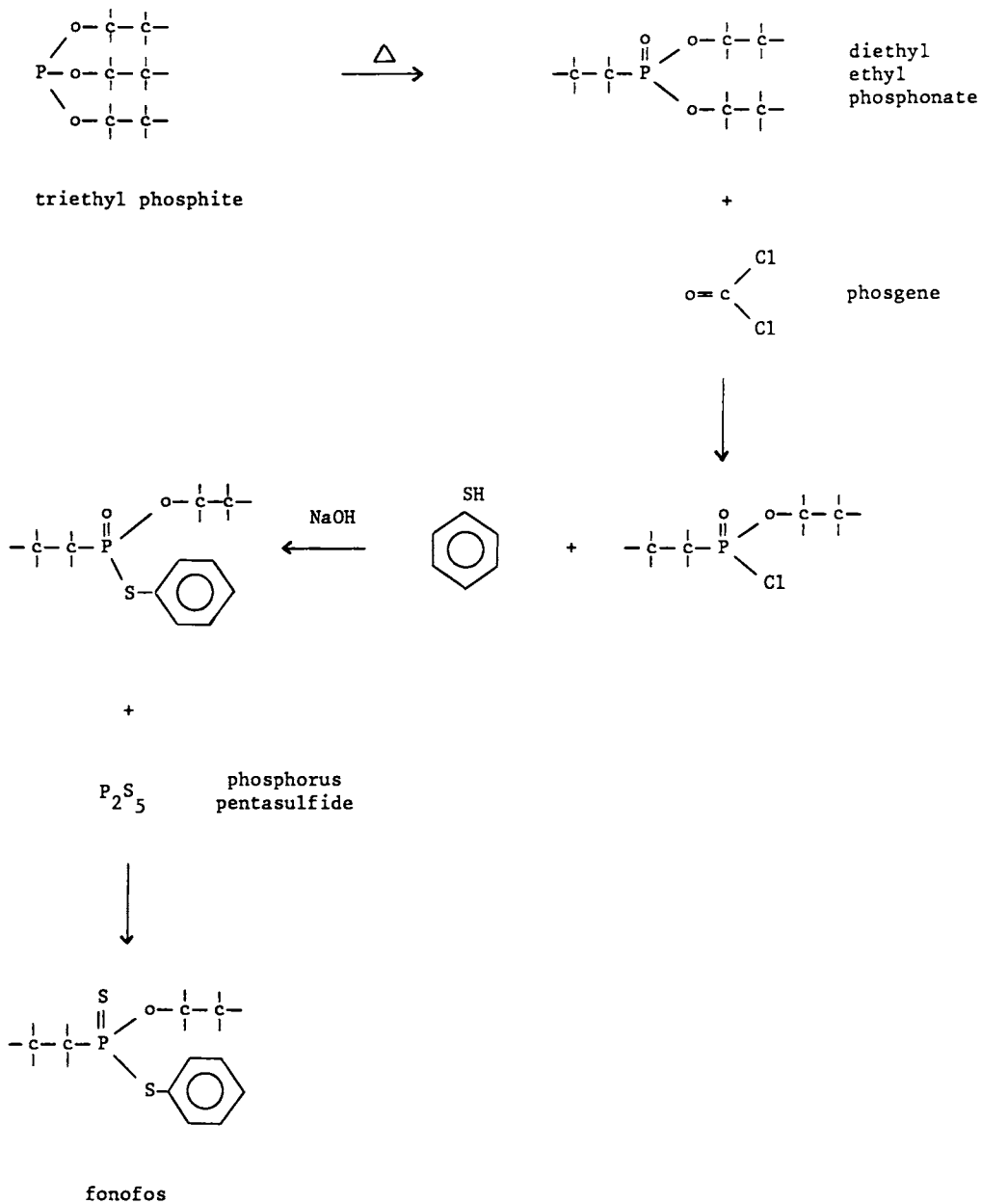
Type: phosphonodithioate

Synthesis:



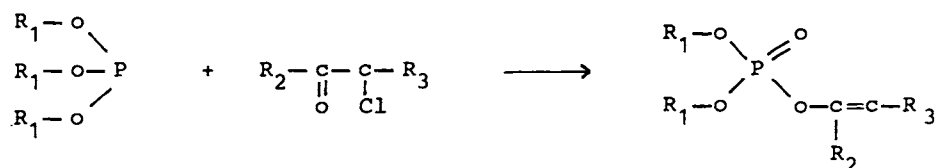
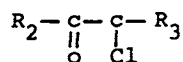


alternate route:



# PHOSPHATE ESTERS

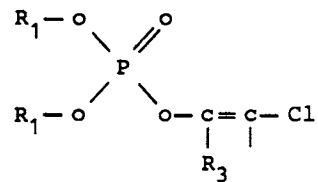
The synthesis of phosphate esters is by reaction between a trialkyl phosphate, usually trimethyl or triethyl phosphite, and



An alternate route is by reaction between a mono or di chlorophosphate ester (obtained from phosphorus oxychloride) and an alcohol



Common structures of phosphate esters are



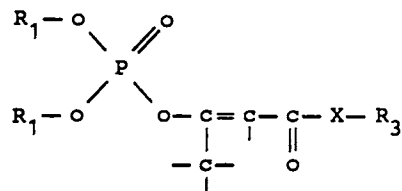
chlorfenvinphos

dichlorvos

dimethylvinphos

naled

tetrachlorvinphos



	X
	—
crotoxyphos	O
mevinphos	O
dicrotophos	N
monocrotophos	N
phosphamidon	N

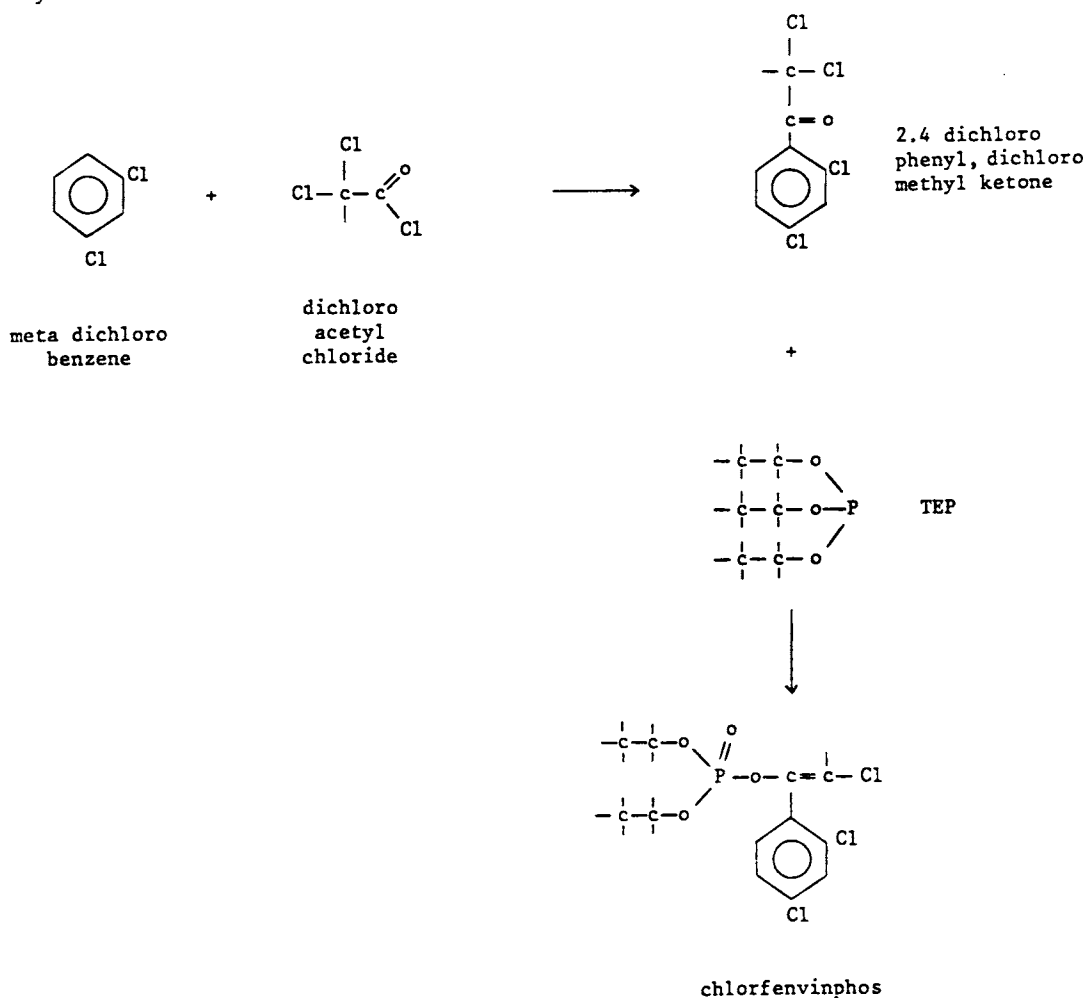
## Chlorfenvinphos

Uses: insecticide for potatoes, maize, rice, sugarcane

Trade names: Birlane, Supona (Shell), Sapecron, Steladone (Ciba),  
Apachlor (Rhone Poulenc)

Type: phosphate ester

Synthesis:



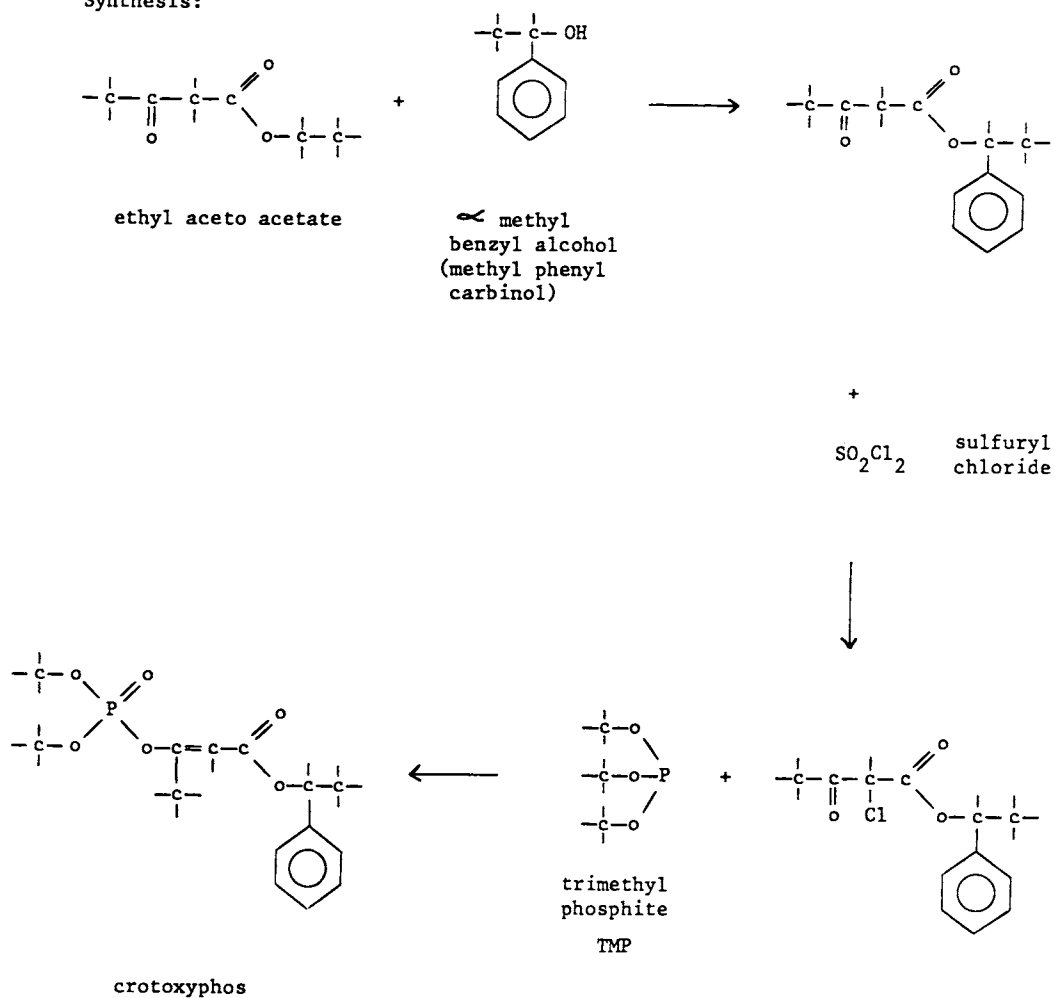
## Crotoxyphos

Uses: insecticide no longer in use

Trade names: Ciodrin (Shell)

Type: phosphate ester

Synthesis:



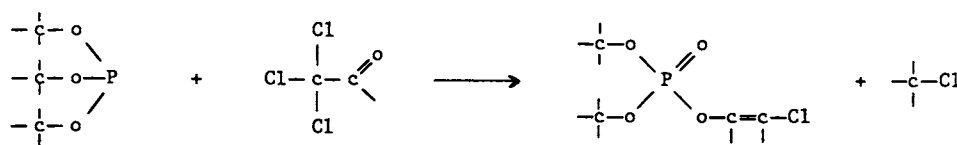
## Dichlorvos DDVP

Uses: insecticide for cotton, fruit, vegetables, household protection

Trade names: Dede vap, Mafu, Oko (Bayer), Nogos (Ciba), Vapona, Atgard, Task (Shell)

Type: phosphate ester

Synthesis:



trimethyl  
phosphite

chloral

dichlorvos

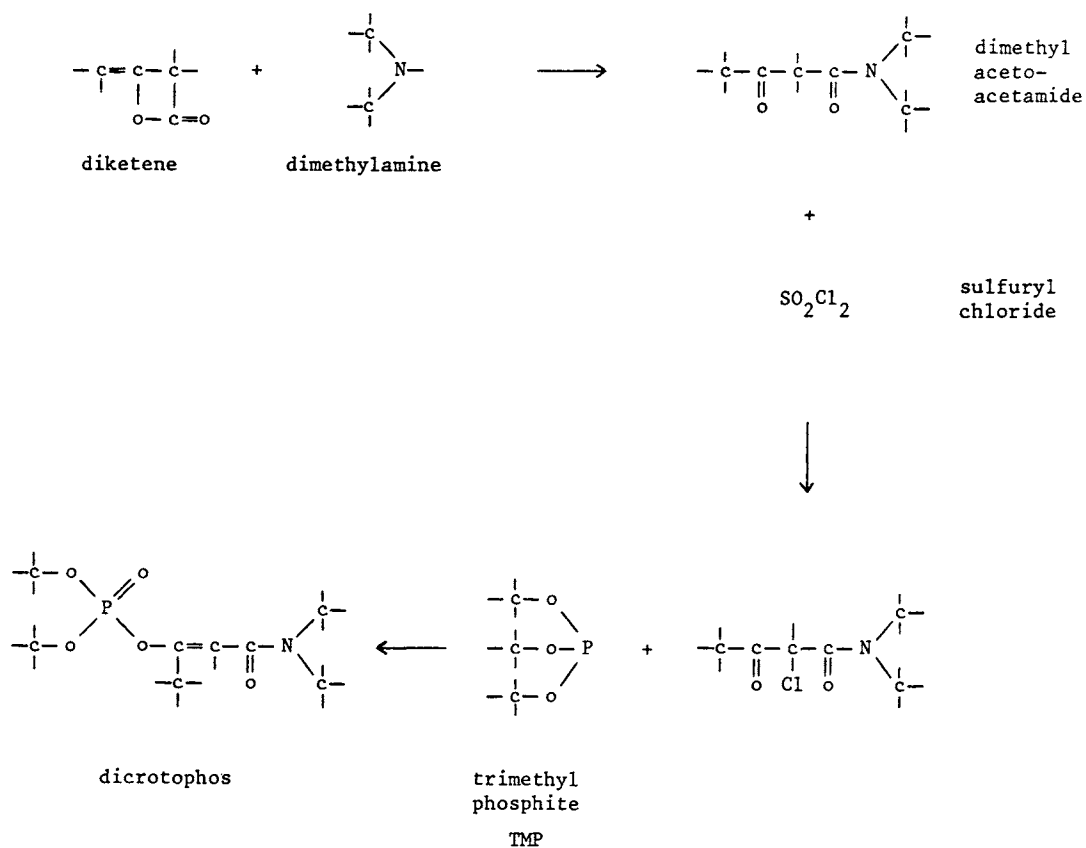
## Dicrotophos

Uses: insecticide for coffee, cotton, rice

Trade names: Bidrin (Shell), Carbicron, Ektafos (Ciba)

Type: phosphate ester, amide

**Synthesis:**



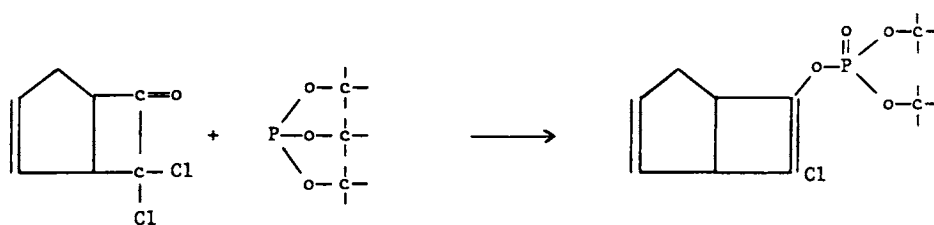
## Heptenophos

Uses: insecticide

Trade names: Hostaquick (Hoechst)

Type: phosphate ester

Synthesis:



7.7 dichlorobicyclo  
2.6 hepten 2 one 6

TMP

heptenophos



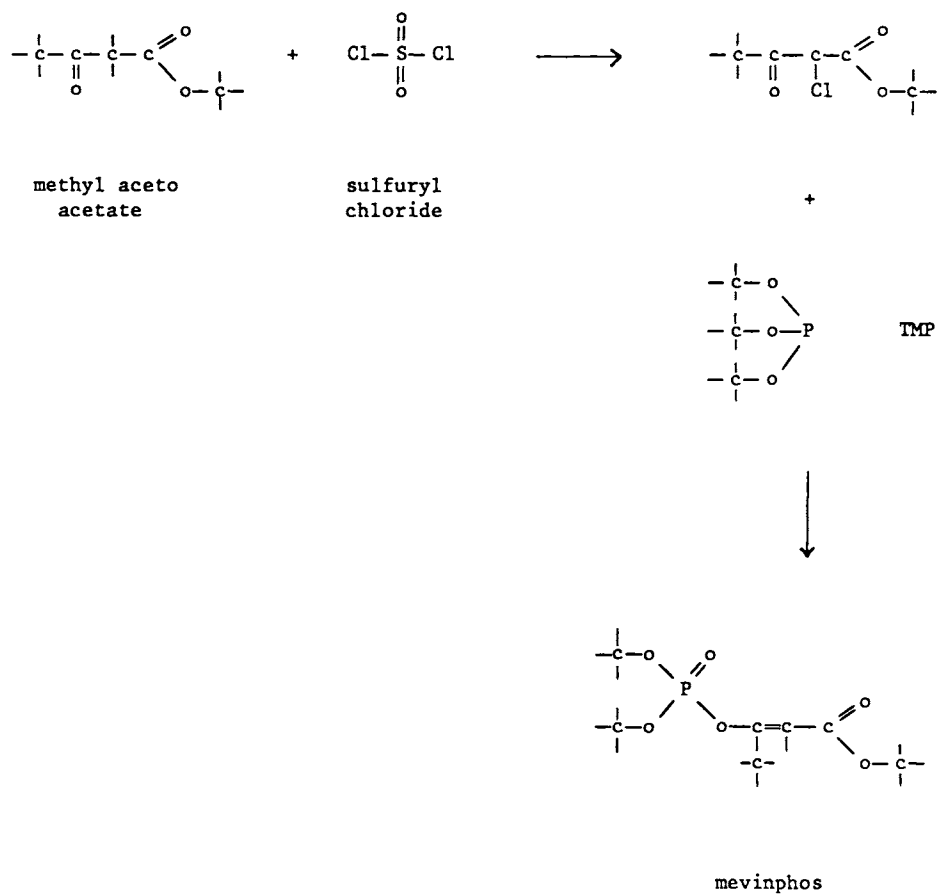
## Mevinphos

Uses: insecticide for hops, tobacco, vegetables

Trade names: Phosdrin (Shell)

Type: phosphate ester

**Synthesis:**



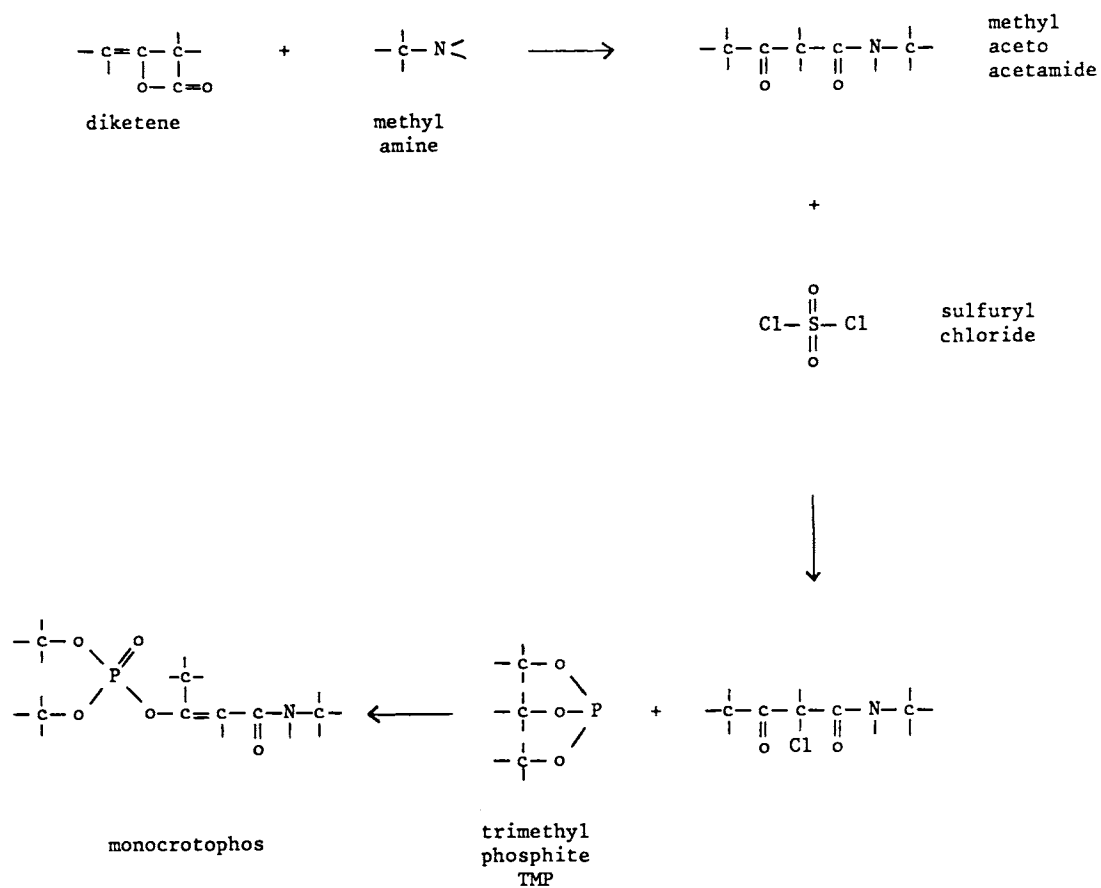
## Monocrotophos

Uses: insecticide

Trade names: Azodrin (Shell), Nuvacron, Bilobran (Ciba)

Type: phosphate ester, amide

Synthesis:



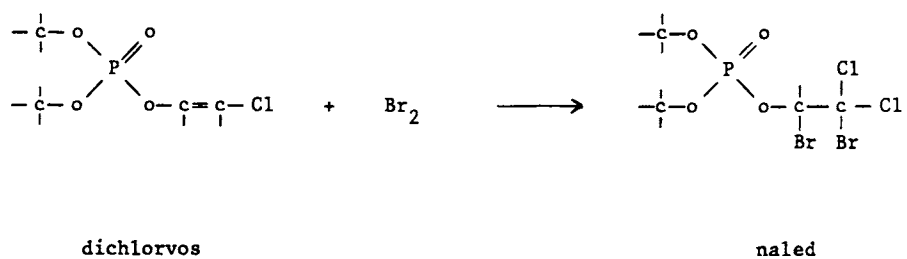
## Naled

Uses: insecticide

Trade names: Dibrom (Chevron)

Type: phosphate ester

Synthesis:



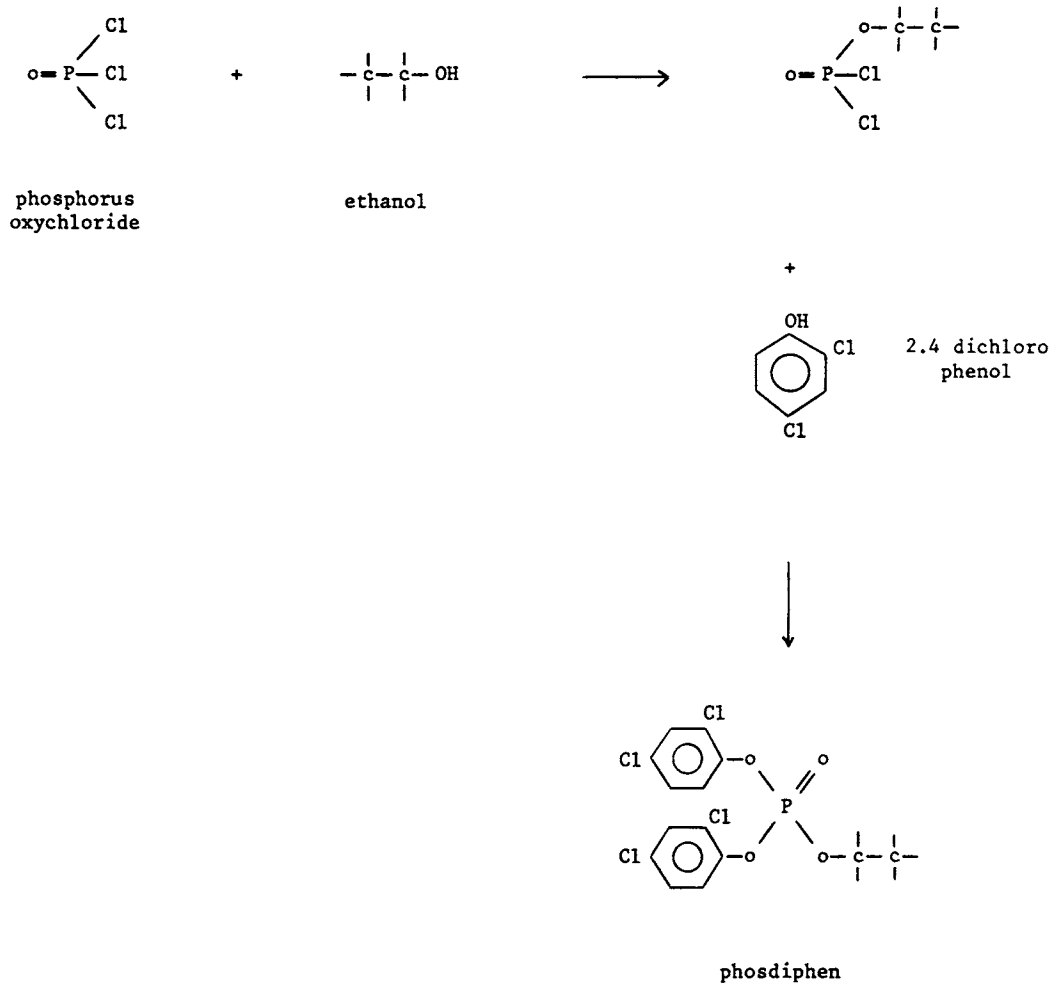
## Phosdiphen

Uses: fungicide for rice

Trade names: MTO 460 (Mitsui)

Type: phosphate ester

Synthesis:



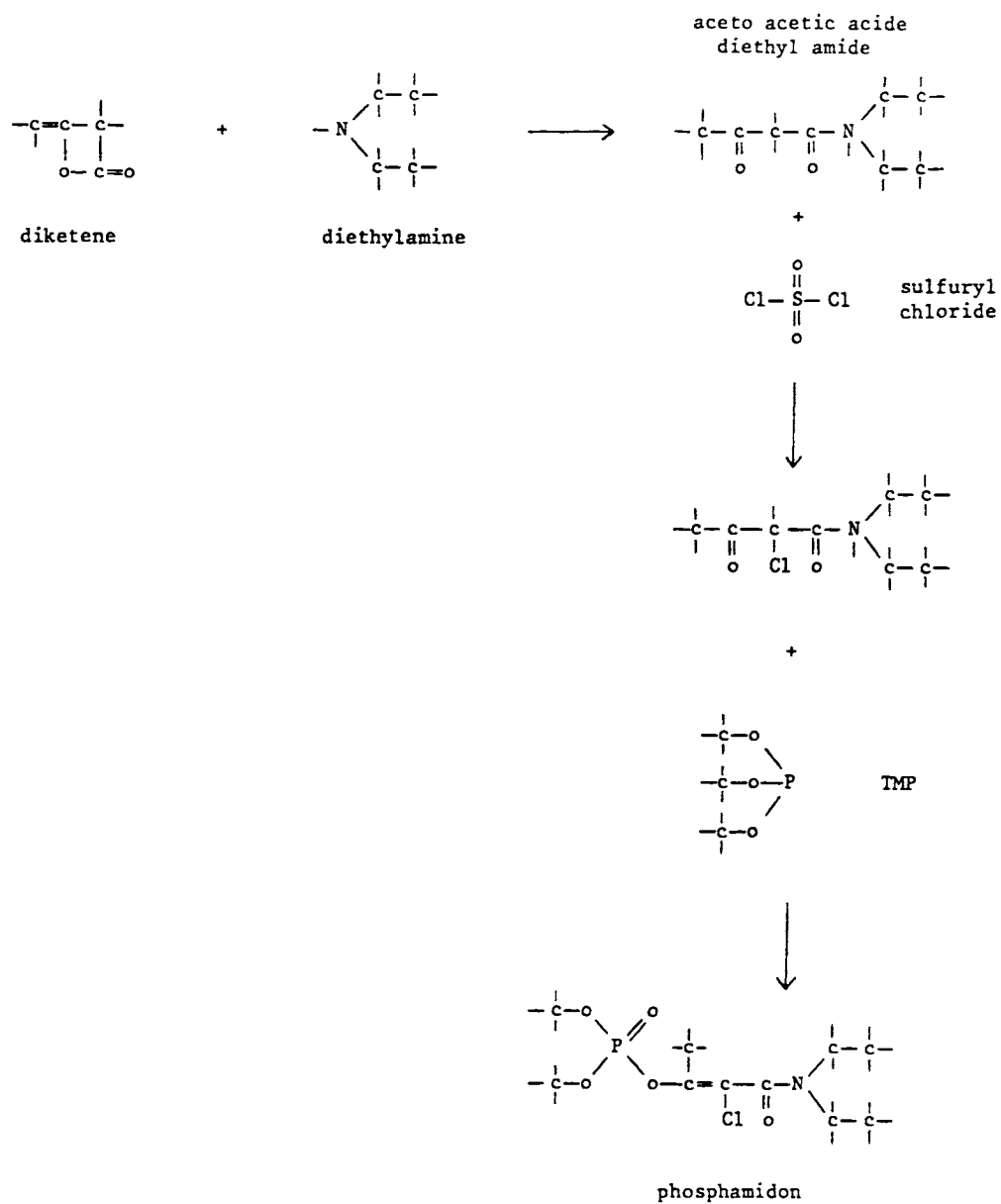
## Phosphamidon

**Uses:** insecticide for rice

Trade names: Dimecron (Ciba)

Type: phosphate ester, amide

Synthesis:



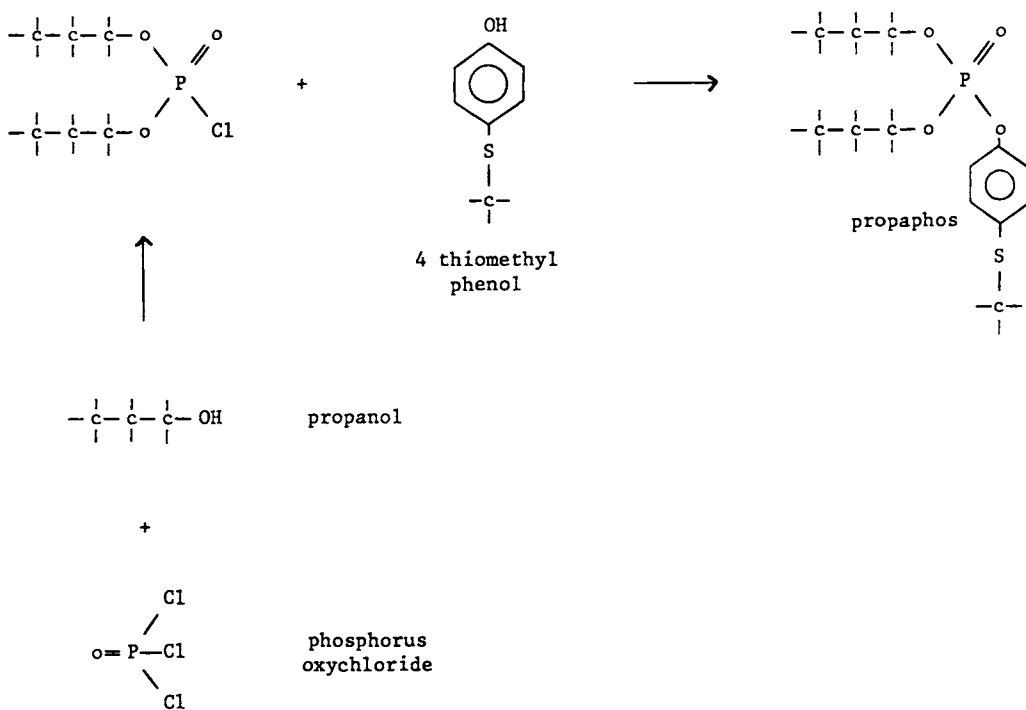
## Propaphos

Uses: insecticide for rice

Trade names: Kayaphos (Nippon)

Type: phosphate ester

Synthesis:



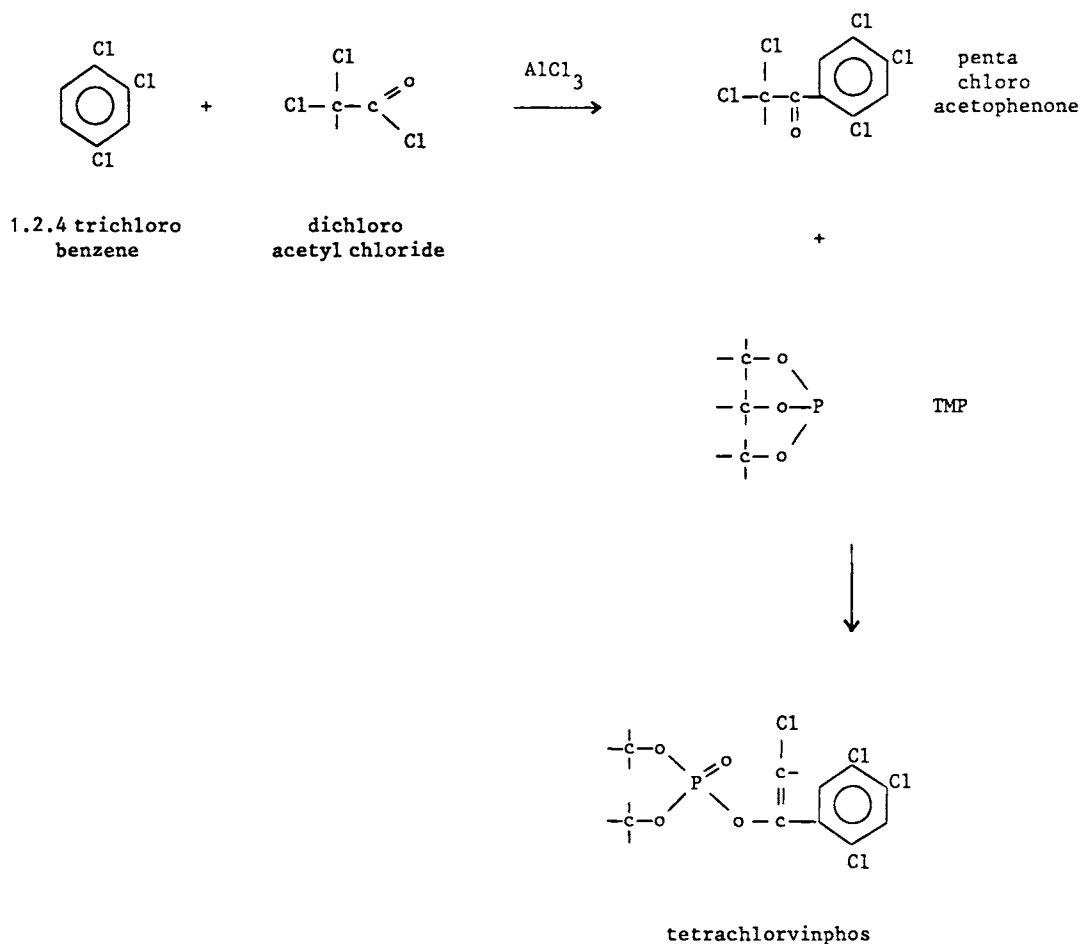
## Tetrachlorvinphos

Uses: insecticide for cotton, maize, fruit

Trade names: Gardona, Rabon, Debantic (DuPont, Cyanamid)

Type: phosphate ester

Synthesis:



## Dimethylvinphos

same as above with meta dichlorobenzene

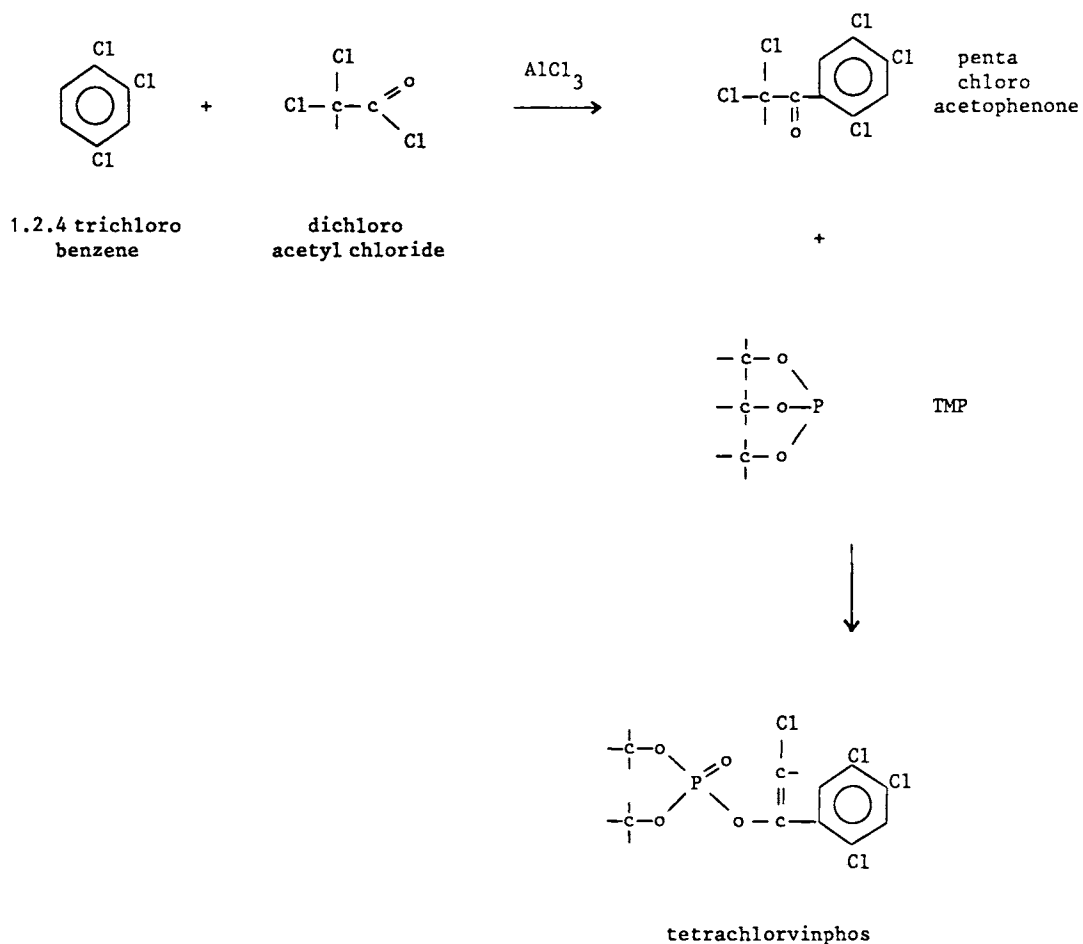
## Tetrachlorvinphos

Uses: insecticide for cotton, maize, fruit

Trade names: Gardona, Rabon, Debantic (DuPont, Cyanamid)

Type: phosphate ester

Synthesis:



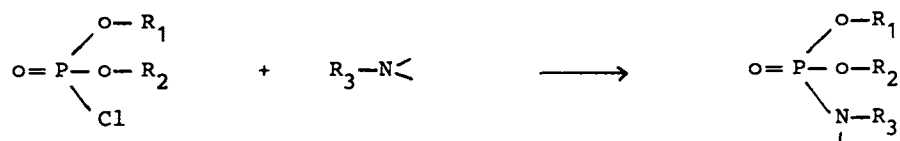
## Dimethylvinphos

same as above with meta dichlorobenzene

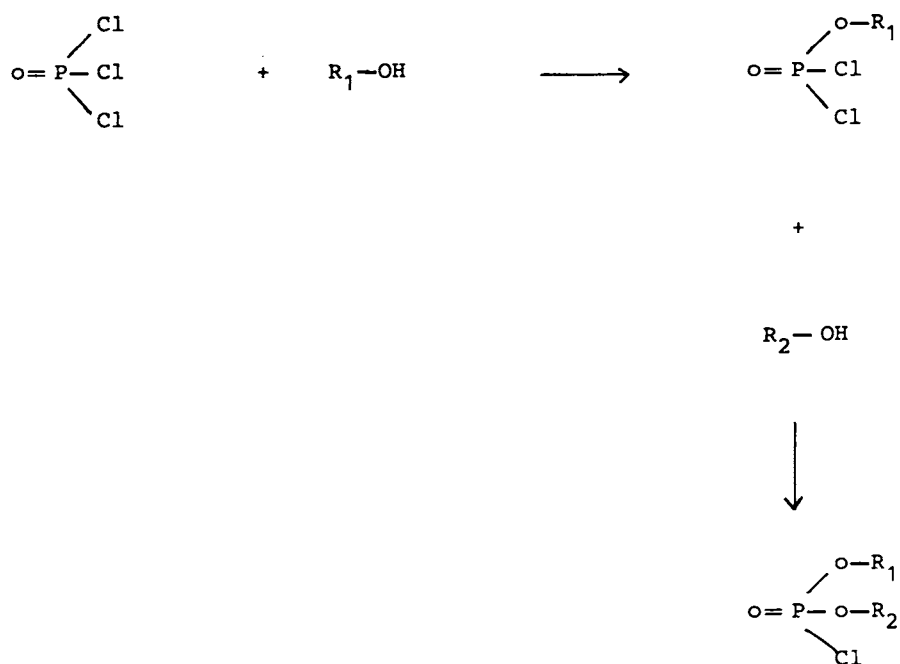


# PHOSPHOROAMIDATES

The synthesis is by reaction between a phosphate chloro ester and an amine:



The phosphate chloro ester is obtained by reaction between phosphorous oxychloride and an alcohol



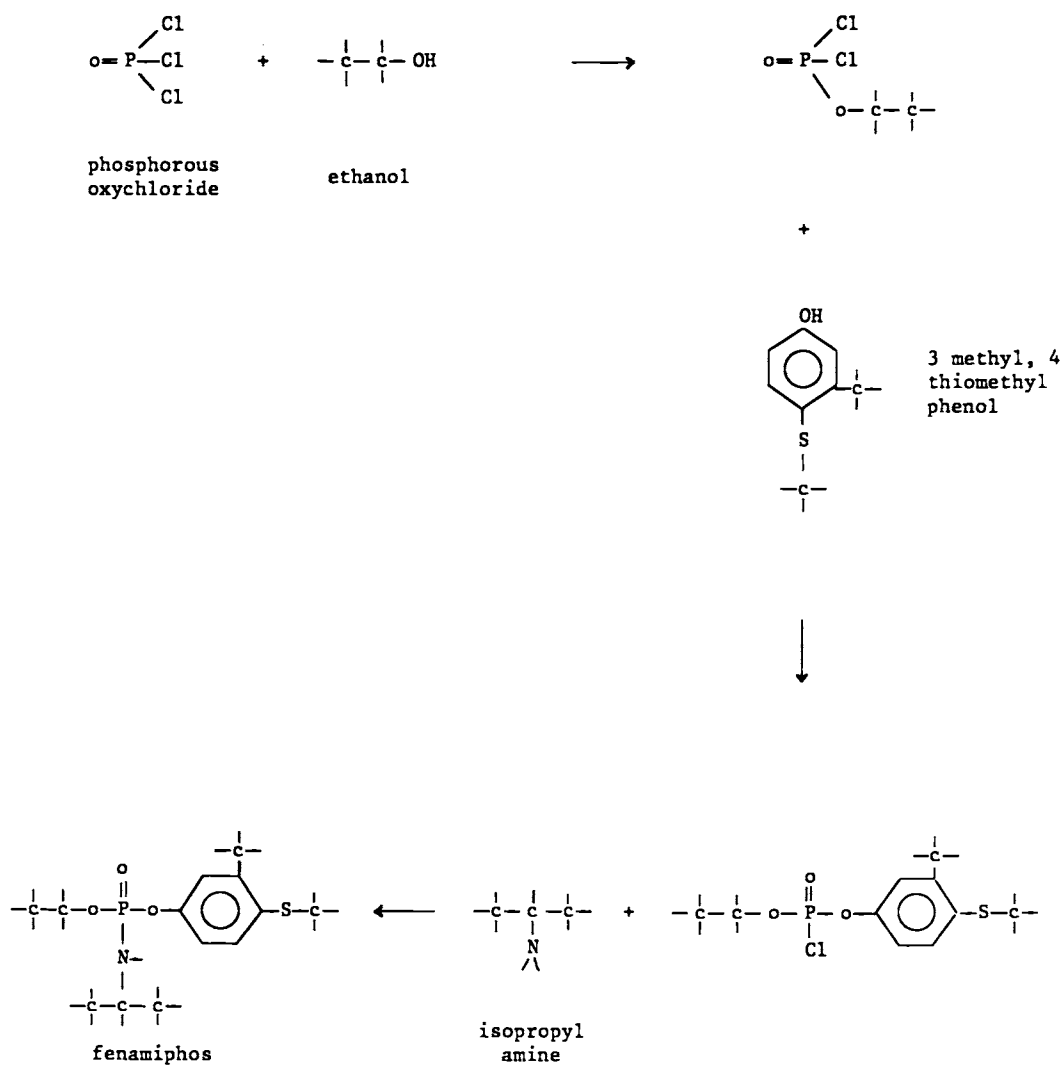
## Fenamiphos

**Uses:** nematicide for bananas, citrus, tobacco, vegetables

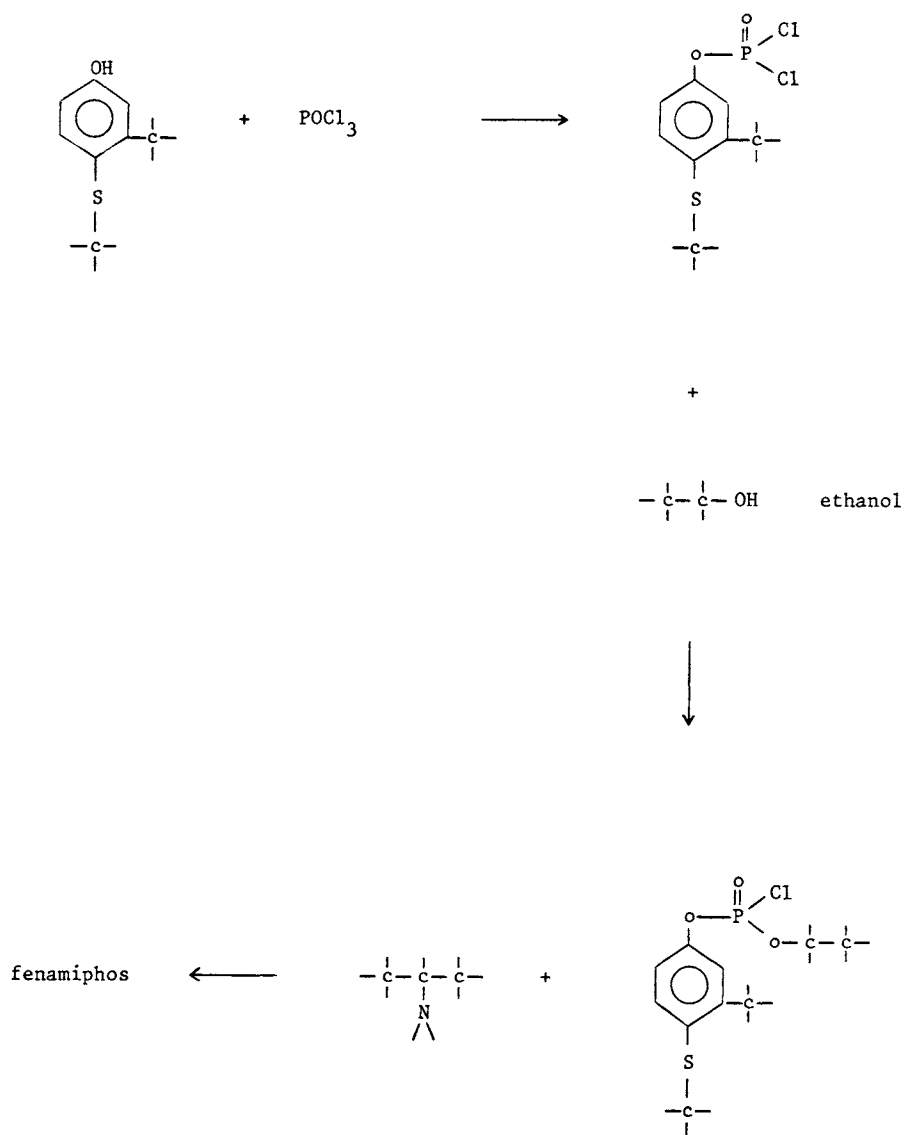
Trade names: Nematicur (Bayer)

Type: phosphoroamidate

**Synthesis:**



alternate route :

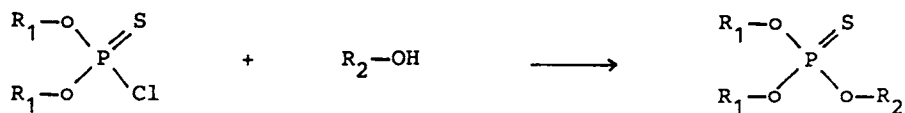


## PHOSPHOROTHIOATES

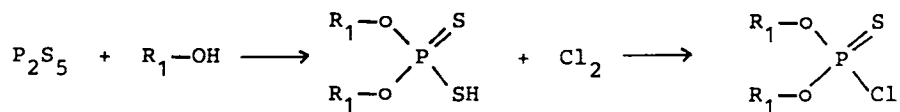
Nearly all phosphorothioates are compounds of the type

$$\begin{array}{c} \text{R}_1\text{-O} \quad \text{S} \\ \quad \diagdown \quad \diagup \\ \quad \text{P} \\ \quad \diagup \quad \diagdown \\ \text{R}_1\text{-O} \quad \text{O-R}_2 \end{array}$$

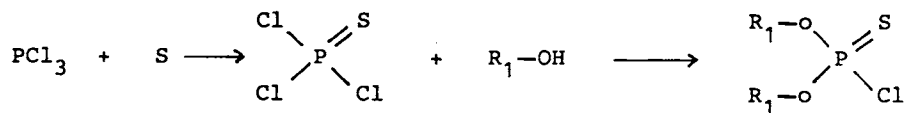
and are synthesized by reaction between a phosphorochloridothioate ( DMPCT or DEPCT ) and an alcohol (R<sub>1</sub> is nearly always methyl or ethyl)



The phosphorochloridothioate is obtained from phosphorous pentasulfide as follows:



An alternative route being



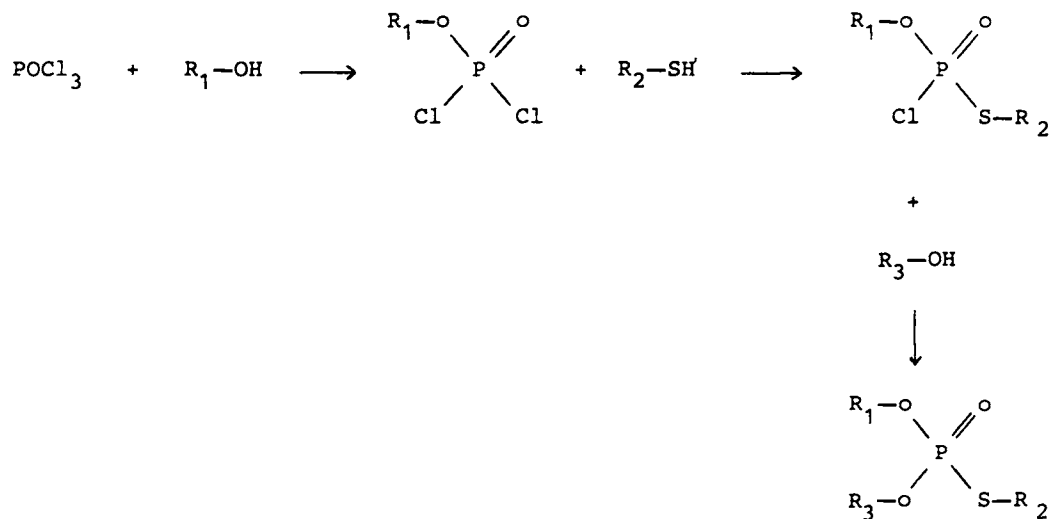
Phosphorothioates of the type

$$\begin{array}{c} \text{R}_1\text{-O} \quad \text{O} \\ \quad \diagdown \quad \diagup \\ \quad \text{P} \\ \quad \diagup \quad \diagdown \\ \text{R}_1\text{-O} \quad \text{S-R}_2 \end{array}$$

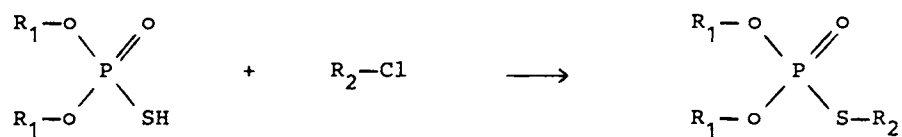
appear less frequently.

Their synthesis follows several possible routes.

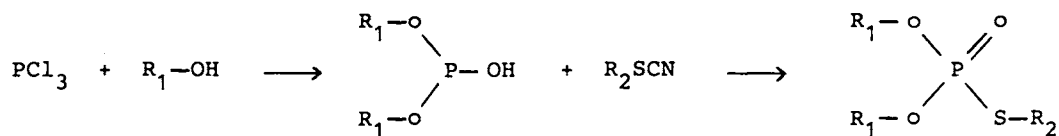
The most common path is



Another route being by reaction between a phosphoro thioic acid and R-X



Finally a more unusual route is



(dimethyl or  
diethyl phosphite)

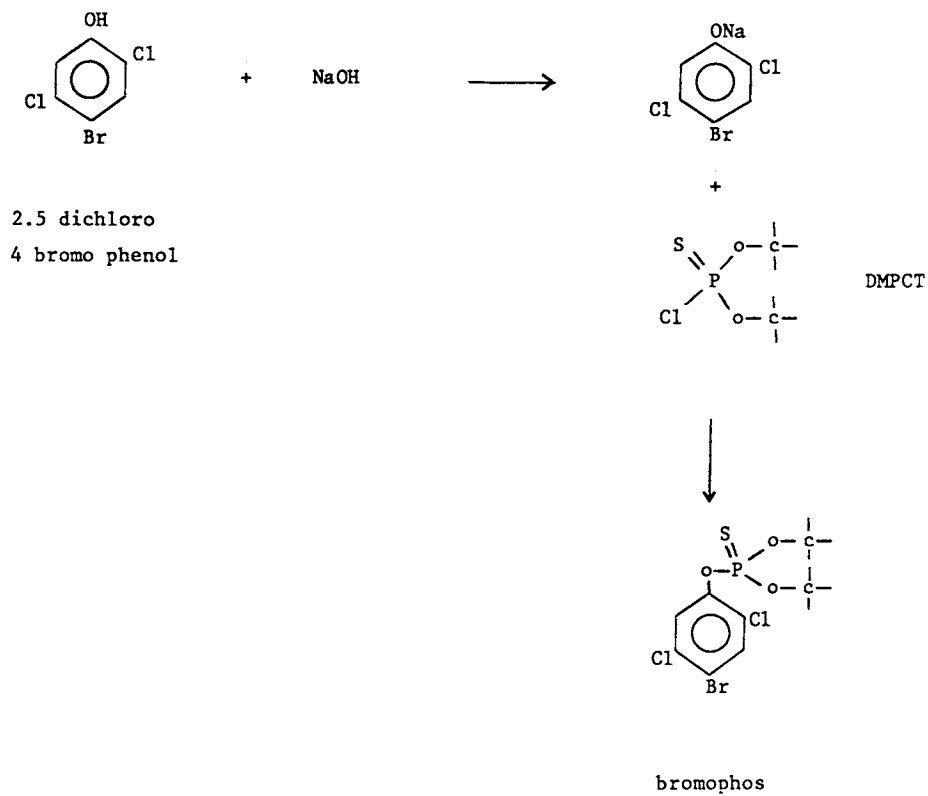
## Bromophos

Uses: insecticide, flies in cabbage, carrots, onions, cereals, mosquitoes

Trade names: Nexion, Omexan (Celamerck)

Type: phosphorothioate

Synthesis:



bromophos ethyl is made with DEPCT

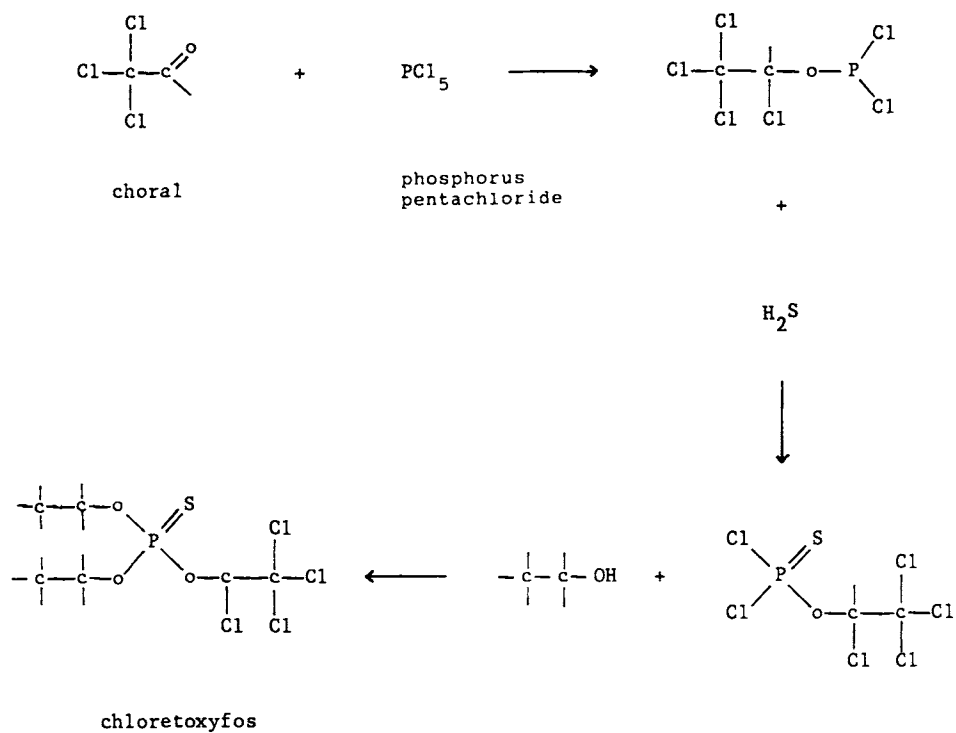
## Chloretoxyfos

Uses: insecticide, corn

Trade names: Fortress (DuPont)

Type: phosphorothioate

Synthesis:



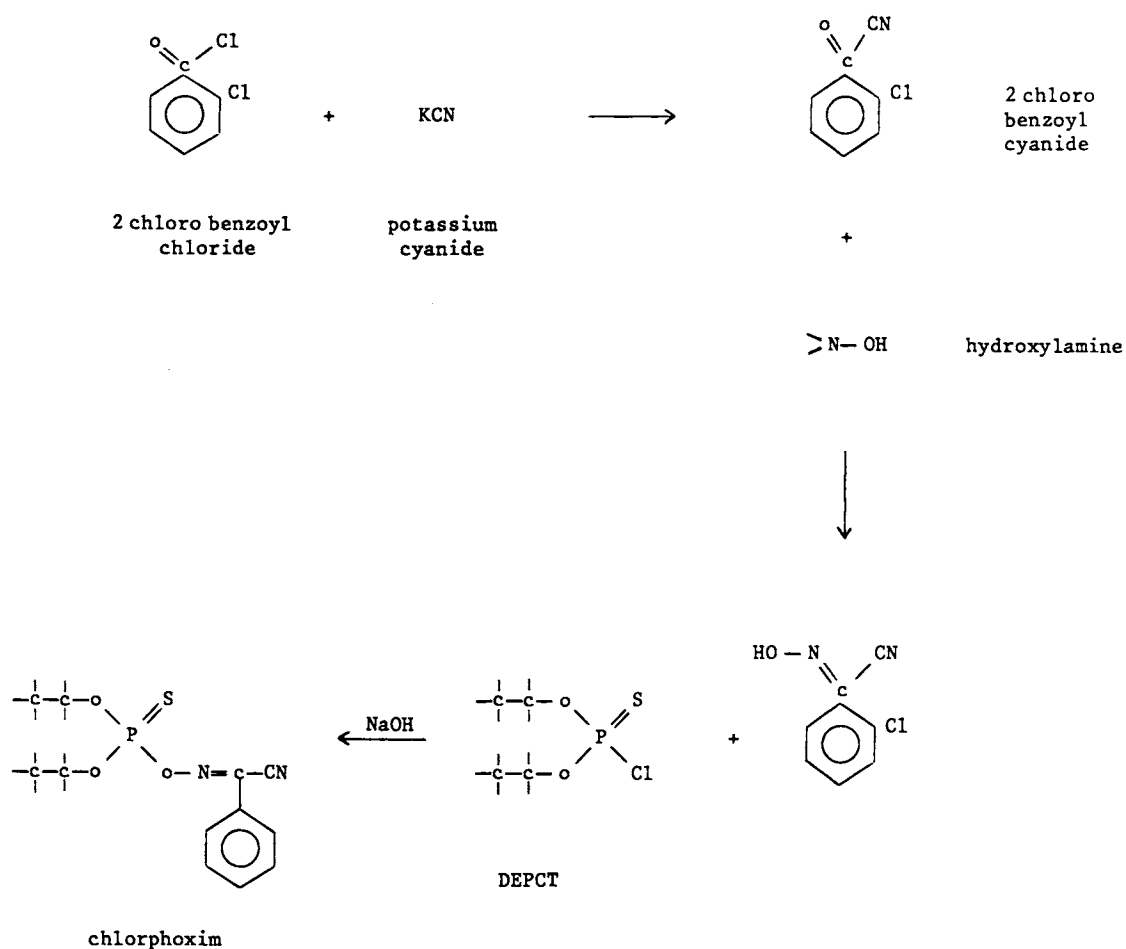
## Chlorphoxim

Uses: insecticide, mosquitoes

Trade names: Baythion (Bayer)

Type: phosphorothioate

Synthesis:





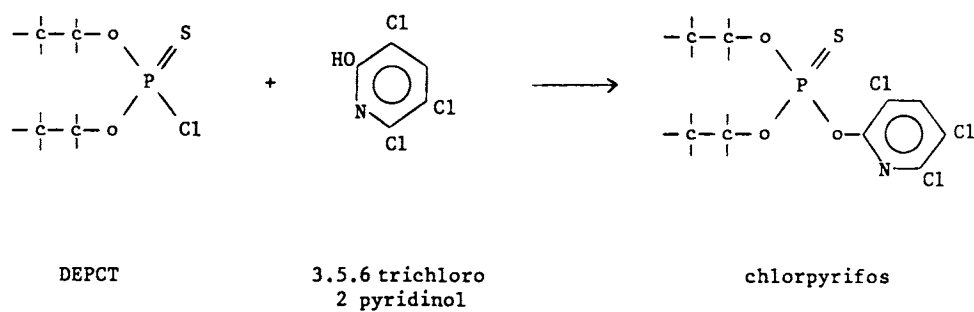
## Chlorpyrifos

Uses: insecticide, citrus, coffee, cotton, maize, sugar beets

Trade names: Dursban, Lorsban (Dow)

Type: phosphorothioate, pyridine

Synthesis:



chlorpyrifos methyl as above with DMPCT

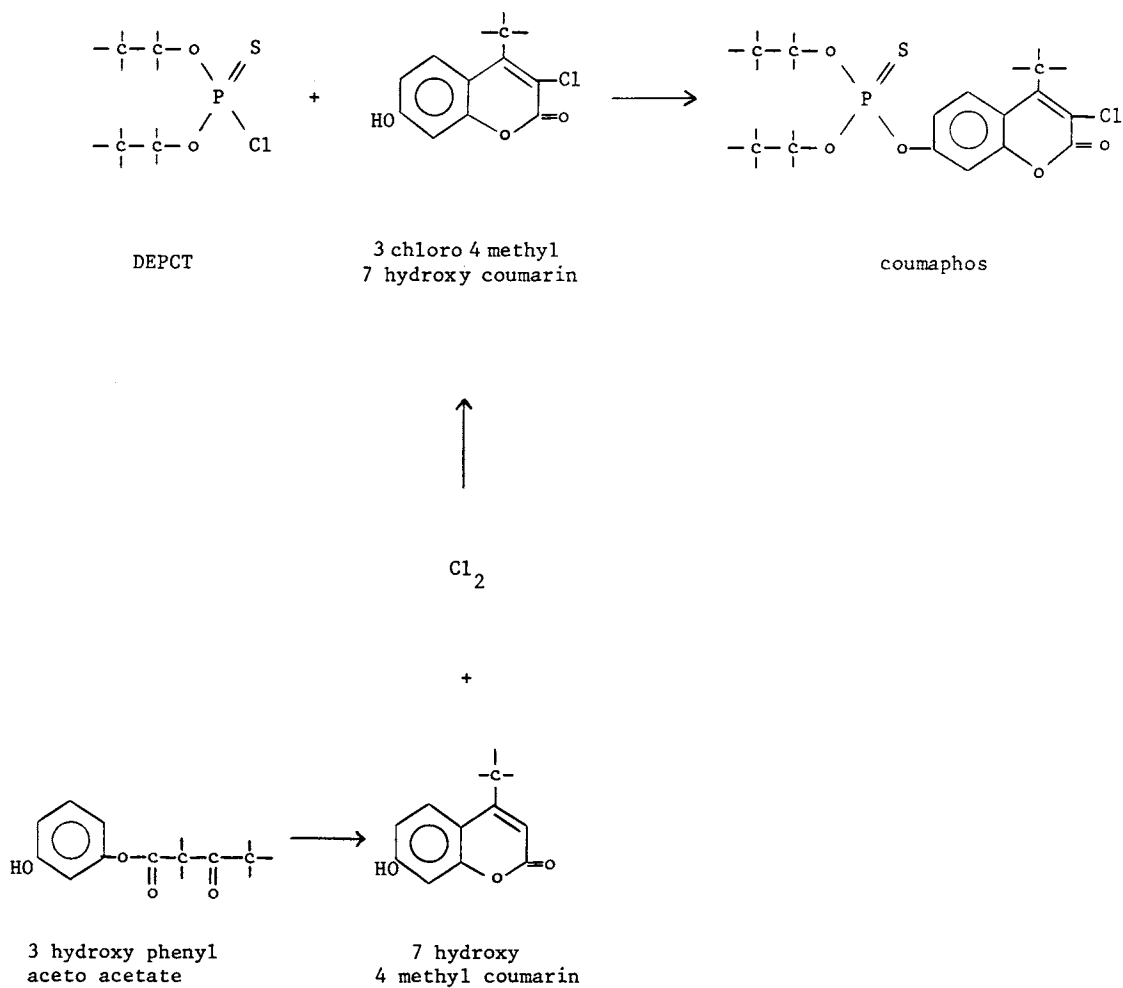
## Coumaphos

Uses: insecticide (veterinary)

Trade names: Asuntol, Perizin (Bayer)

Type: phosphorothioate, coumarin

Synthesis:



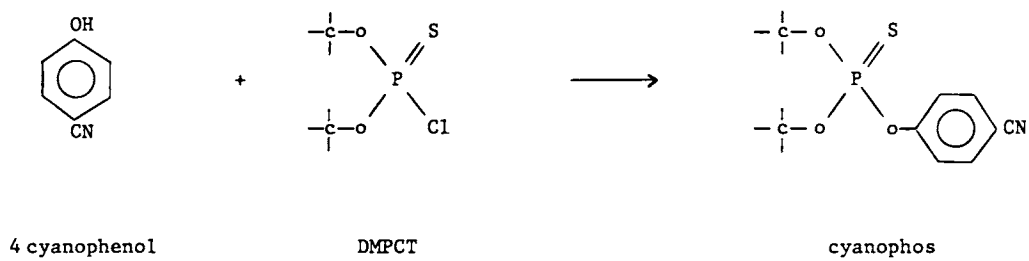
## Cyanophos

Uses: insecticide, cotton, fruit, vegetables

Trade names: Cyanox (Sumitomo)

Type: phosphorothioate

**Synthesis:**



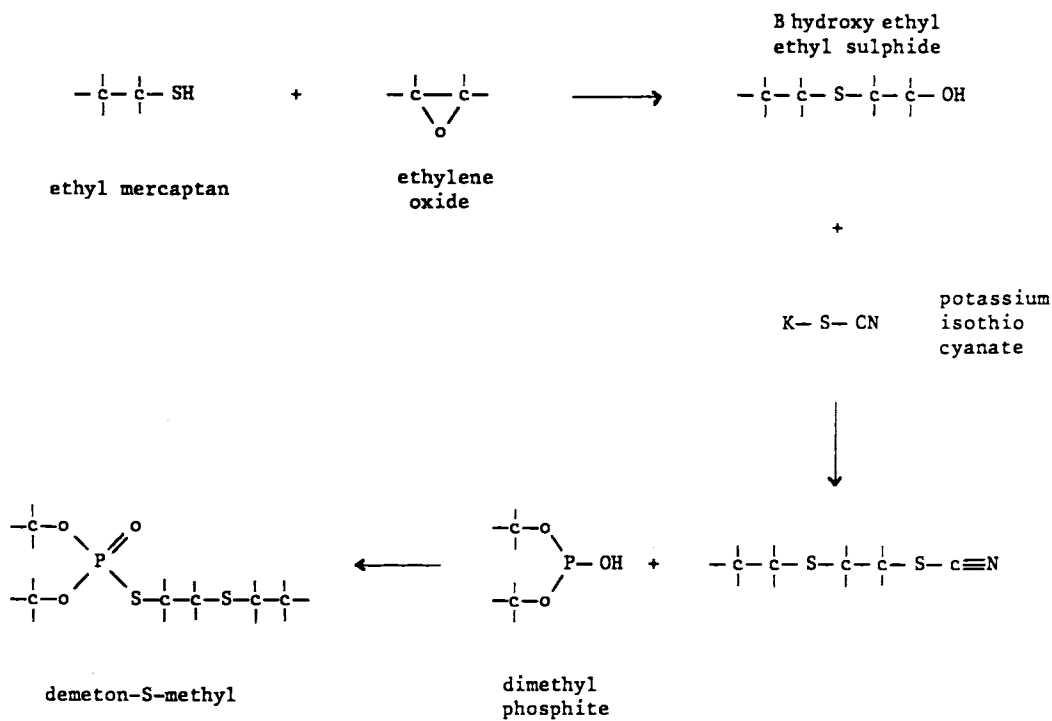
## Demeton-S-Methyl

Uses: insecticide, cereals, fruits, vegetables

Trade names: Metasystox (Bayer)

Type: phosphorothioate

Synthesis:



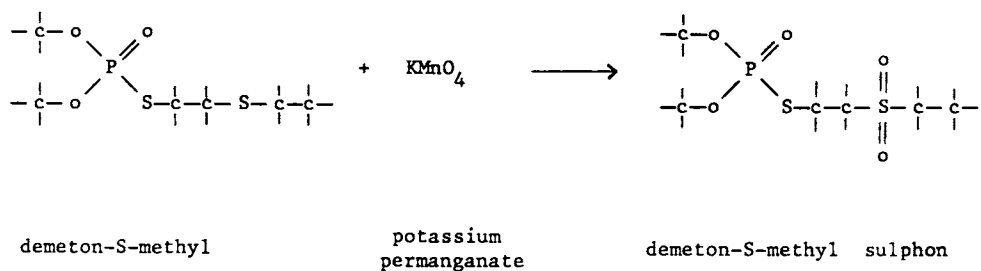
## Demeton-S-Methyl Sulphon

Uses: insecticide, fruits and grapes

Trade names: Metaisostox sulton (Bayer)

Type: phosphorothioate

Synthesis:



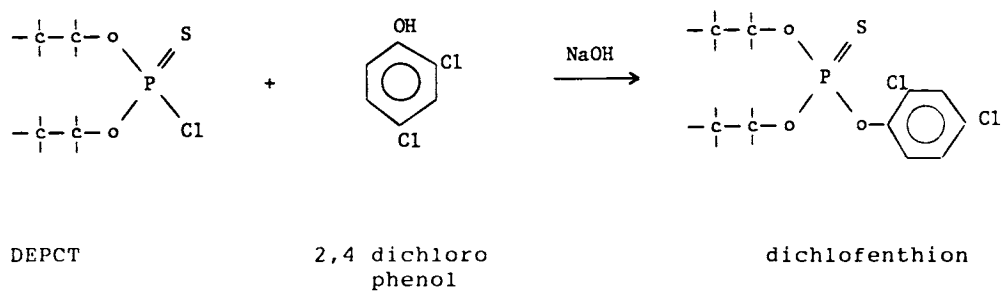
## Dichlofenthion

Uses: insecticide, nematocide, onions, carrots, turf

Trade names:

Type: phosphorothioate

Synthesis:



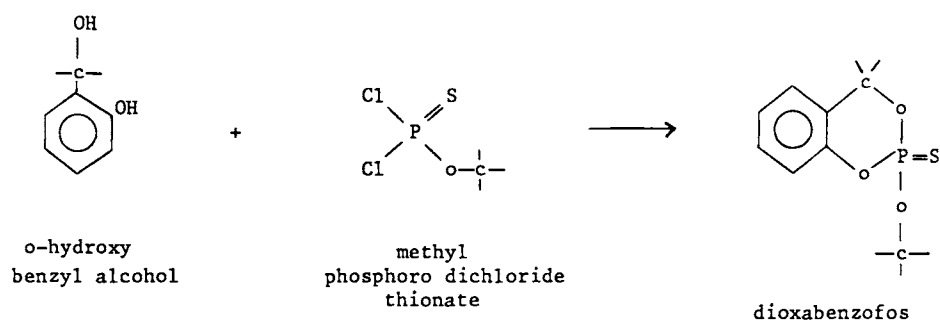
## Dioxabenzofos

Uses: insecticide, fruit, rice, tea, tobacco, vegetables

Trade names: Salithion (Sumitomo)

Type: phosphorothioate

Synthesis:



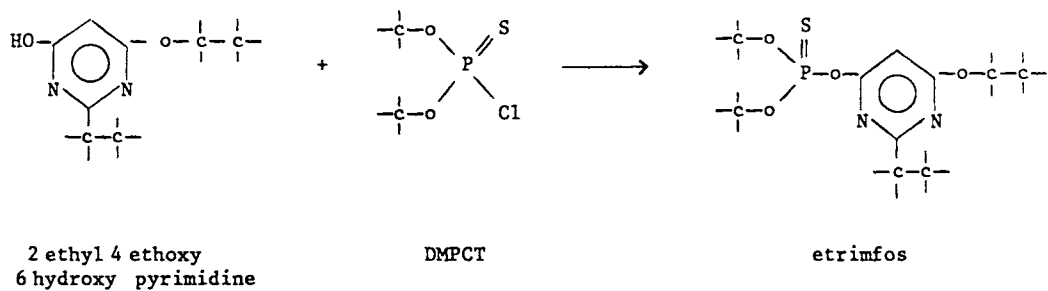
## Etrimfos

Uses: insecticide, citrus, fruit, grapes, olives, potatoes, vegetables

Trade names: Ekamet, Satisfar (Sandoz)

Type: phosphorothioate, pyrimidine

Synthesis:





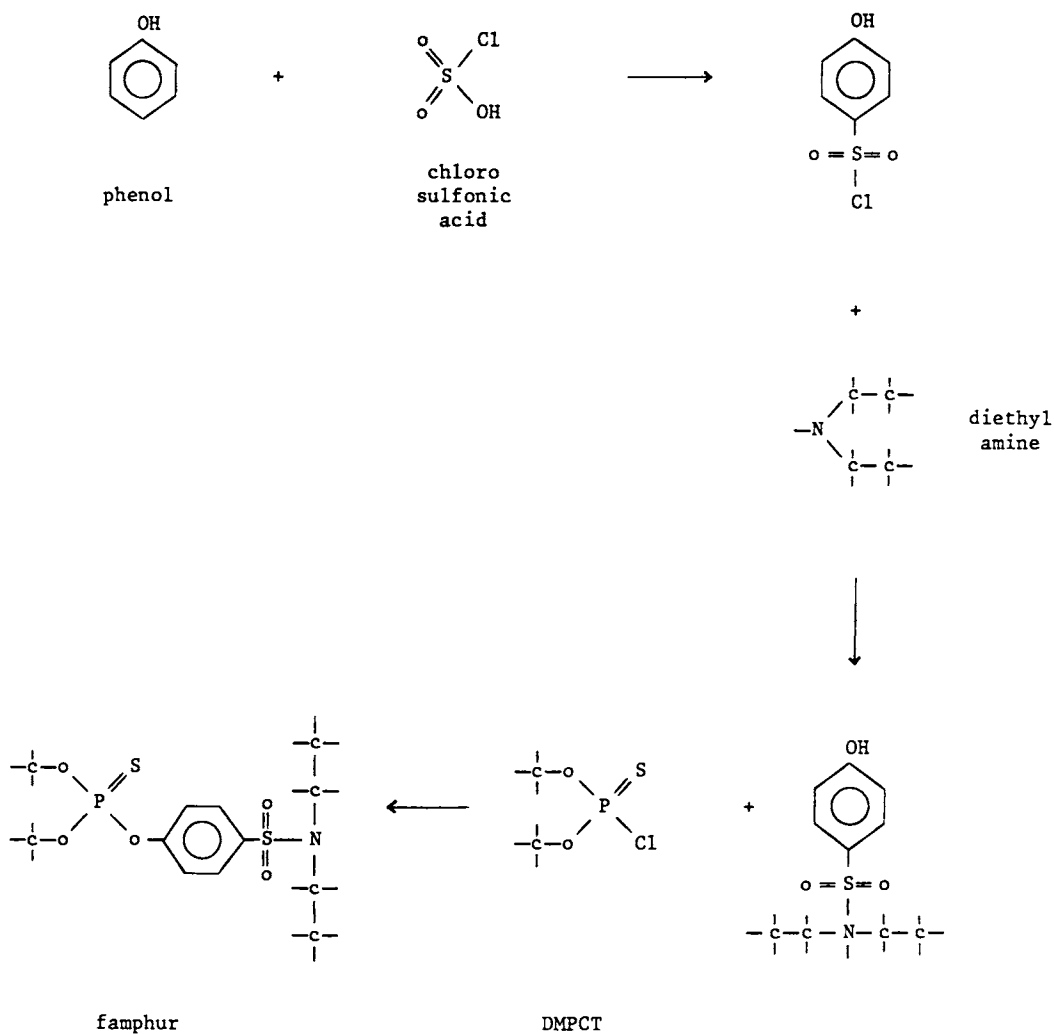
## Famphur

Uses: insecticide, cattle

Trade names: Warbex, Bo-Ana (Cyanamid), Warbexol (Schering)

Type: phosphorothioate, sulfonamide

Synthesis:



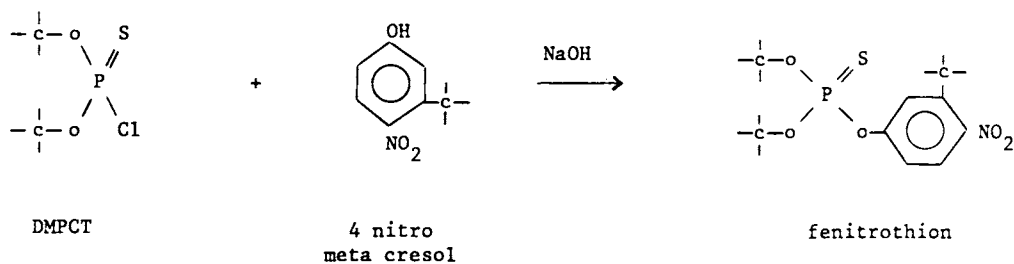
## Fenitrothion

Uses: insecticide, coffee, wheat

Trade names: Accothion, Cytel, Cyfen (Cyanamid), Folithion (Bayer)  
Sumithion (Sumitomo)

Type: phosphorothioate

Synthesis:



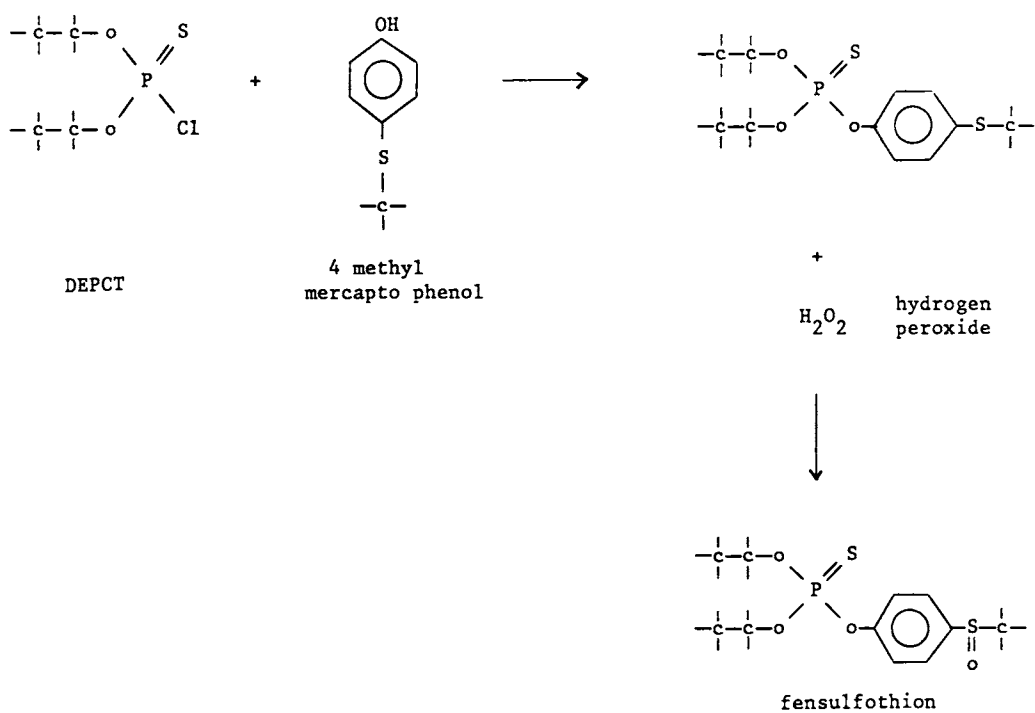
## Fensulfothion

Uses: insecticide, bananas, cacao, cereals, coffee, cotton, oranges, potatoes

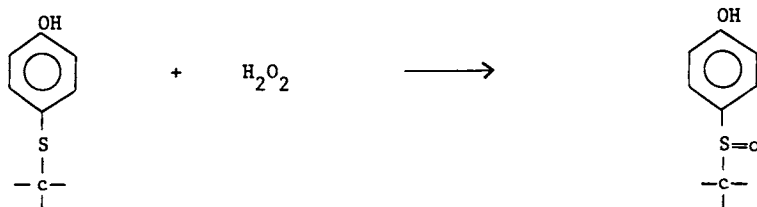
Trade names: Dasanit, Terracur (Bayer)

Type: phosorothioate

Synthesis:



alternate route:



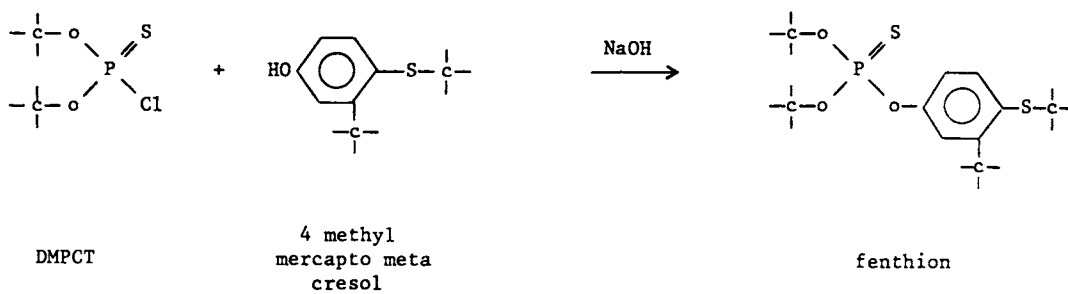
## Fenthion

Uses: insecticide, fruit, cereals

Trade names: Baycid, Baytex, Entex, Lebaycid, Tiguvon (Bayer)

Type: phosphorothioate

Synthesis:



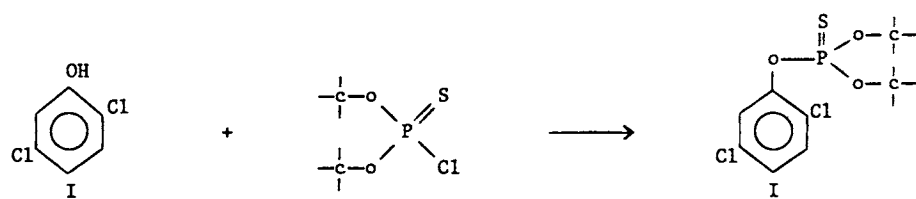
## Iodofenphos

Uses: insecticide, farms, poultry

Trade names: Nuvanol (Ciba)

Type: phosphorothioate

Synthesis:



2,5 dichloro  
4 iodo phenol

DMPCT

iodofenphos

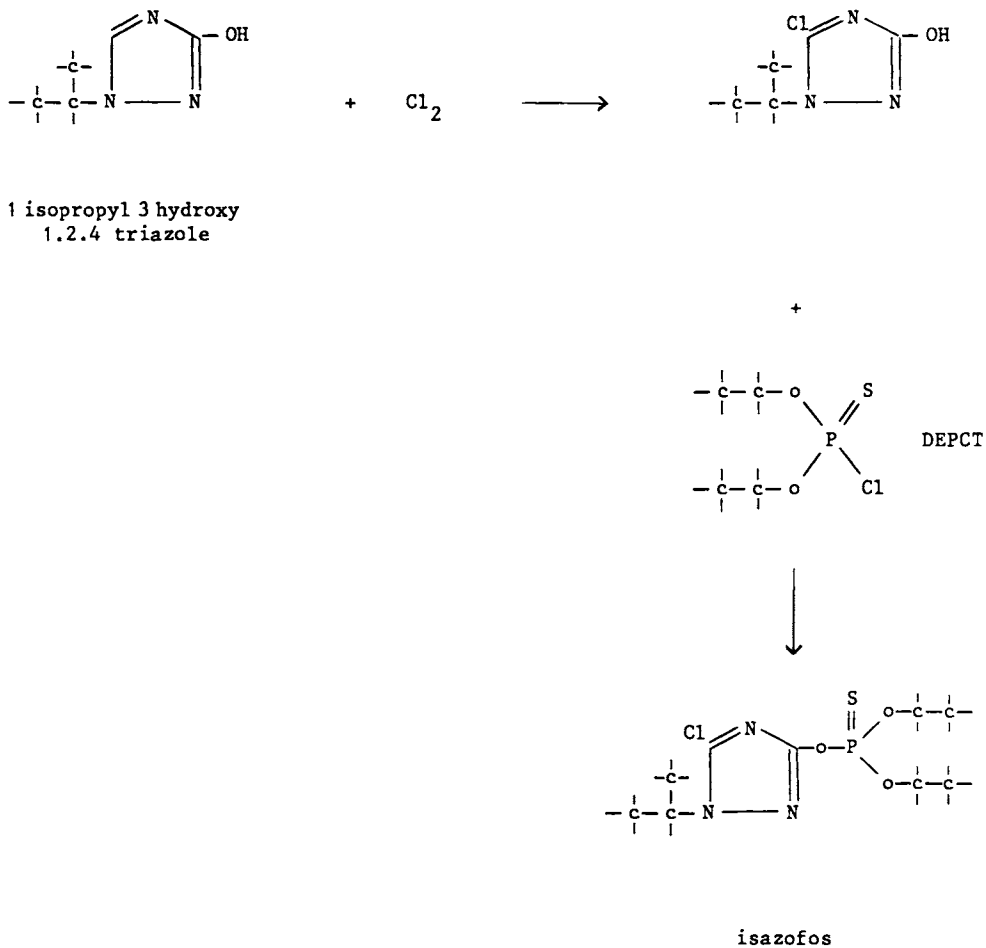
## Isazofos

Uses: nematocide, insecticide, bananas, turf

Trade names: Miral (Ciba)

Type: phosphorothioate, triazole

Synthesis:



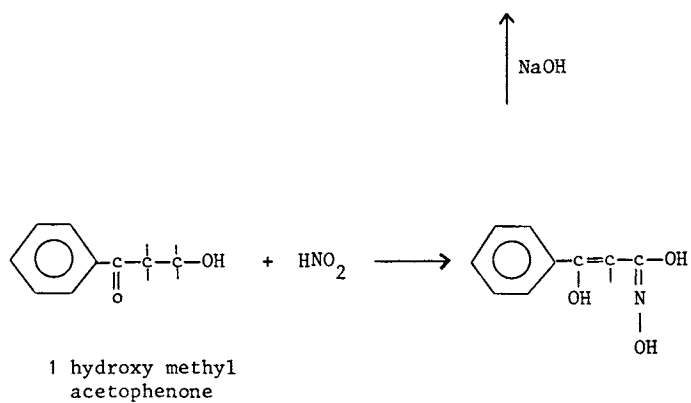
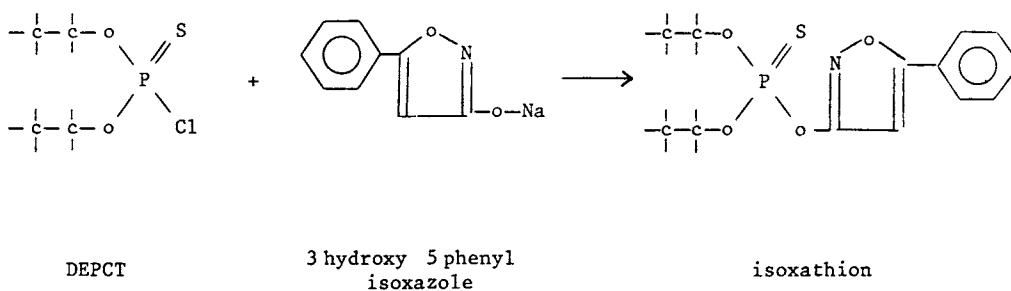
## Isoxathion

Uses: insecticide, trees, turf, fruit

Trade names: Karpfos (Sankyo)

Type: phosphorothioate, isoxazole

Synthesis:



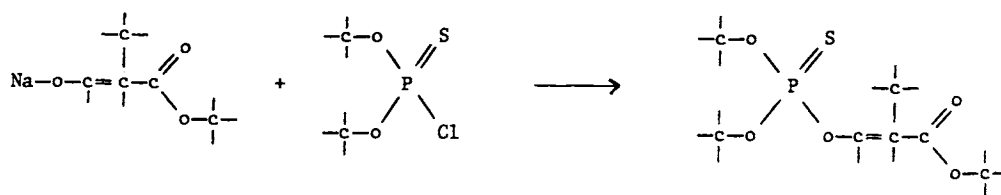
## Methacrifos

Uses: insecticide

Trade names: Damfin (Ciba)

Type: phosphorothioate

Synthesis:



sodium salt of

DMPCT

methacrifos

hydroxy methylene

acrylic acid

methyl ester



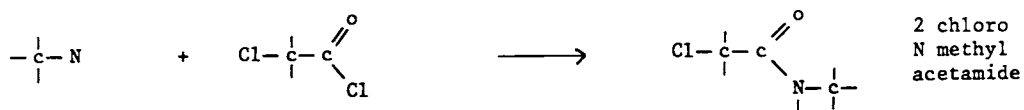
## Omethoate

Uses: insecticide, cereals, fruit, vegetables, ornamentals

Trade names: Folimat (Bayer)

Type: phosphorothioate

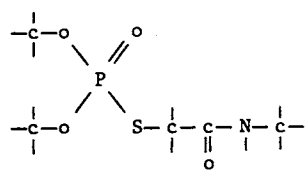
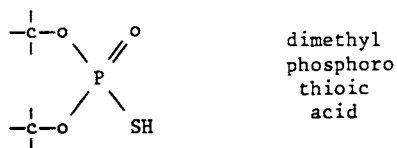
Synthesis:



methyl amine

chloro acetyl  
chloride

+



omethoate

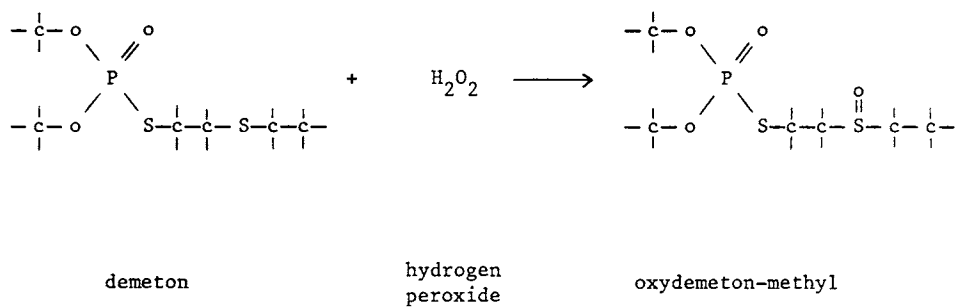
## Oxydemeton-Methyl

Uses: insecticide, cereals, fruit, vegetables

Trade names: Metasystox R , Metasystemox (Bayer)

Type: phosphorothioate

Synthesis:



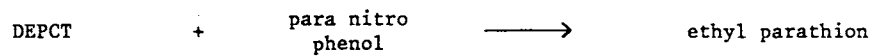
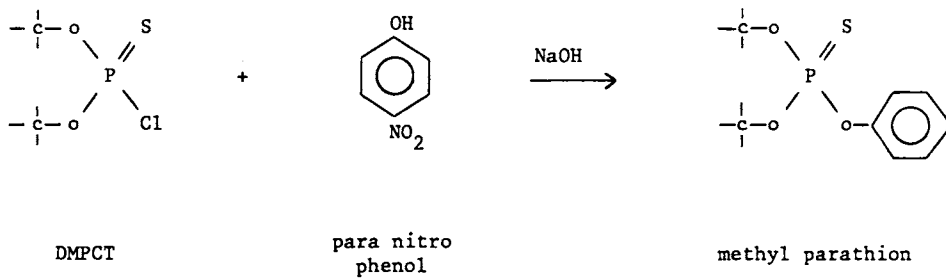
## Parathion

Uses: insecticide, cotton, fruit, vegetables

Trade names: Bladan, Folidol (Bayer), Thiophos (Cyanamid), Fosferno (ICI),  
Niran (Monsanto)

Type: phosphorothioate

Synthesis:



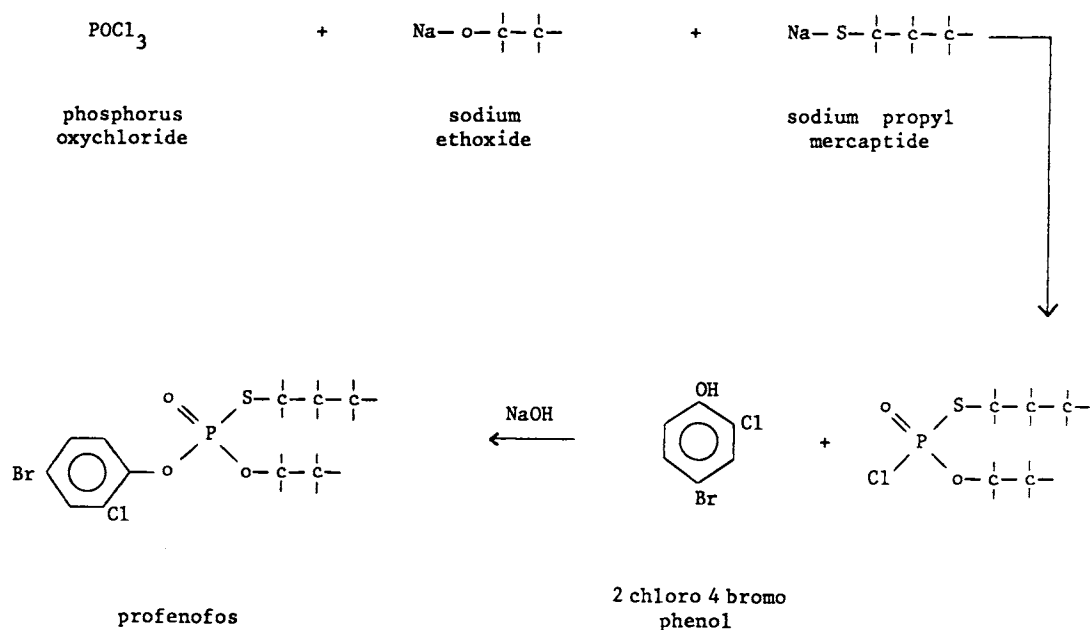
## Profenofos

Uses: insecticide, cotton

Trade names: Curacron, Selecron (Ciba)

Type: phosphorothioate

Synthesis:



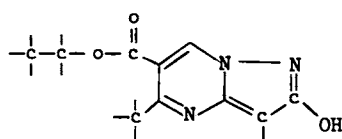
## Pyrazophos

Uses: fungicide, cereals

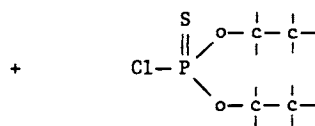
Trade names: Afugan, Curamil, Missile (Hoechst)

Type: phosphorothioate, pyrimidine, pyrazole

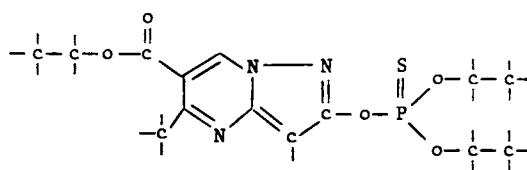
Synthesis:



2 hydroxy 5 methyl  
6 carbethoxy pyrazolo  
pyrimidine



DEPCT



pyrazophos

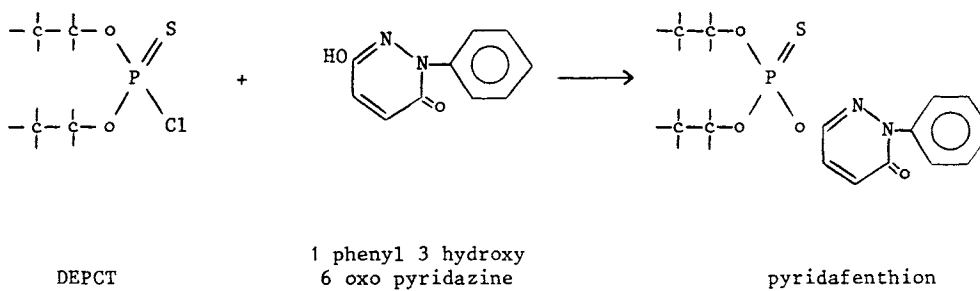
## Pyridafenthion

Uses: insecticide, acaricide, rice, vegetables, fruit

Trade names: Ofunack, Ofnacks, Ofnak (Mitsui)

Type: phosphorothioate, pyrimidinone

Synthesis:



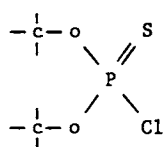
## Temephos

Uses: insecticide, mosquitoes

Trade names: Abate, Abathion, Abat (Cyanamid)

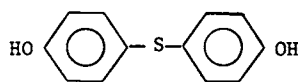
Type: phosphorothioate

Synthesis:

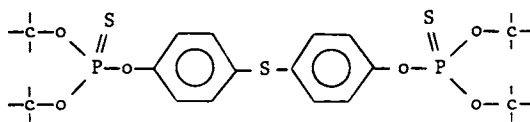


DMPCT

+



4,4' thiodiphenol



temephos

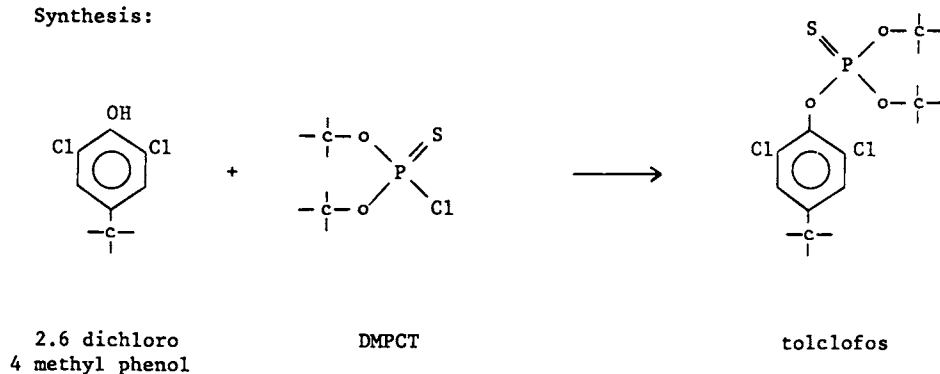
## Tolclofos

Uses: fungicide, cotton, potatoes, sugar beet, ornamentals

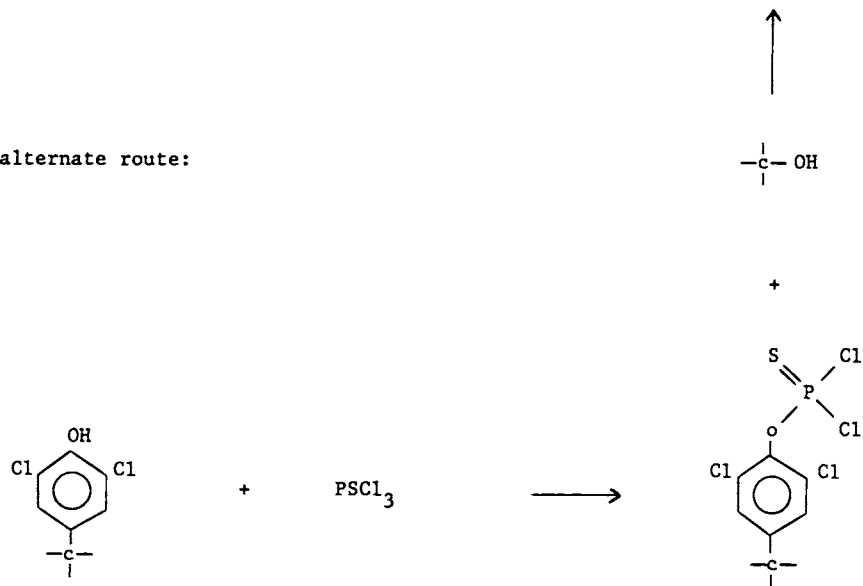
Trade names: Rizolex (Sumitomo)

Type: phosphorothioate

### Synthesis:



### alternate route:





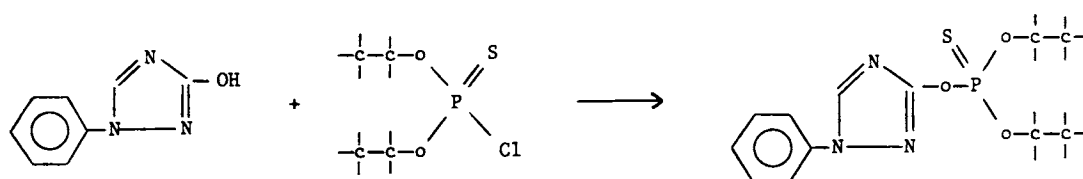
## Triazophos

Uses: insecticide, fruit, cereals, vegetables

Trade names: Hostathion (Hoechst)

Type: phosphorothioate, triazole

Synthesis:



1 phenyl  
3 hydroxy  
1.2.4 triazole

DEPCT

triazophos

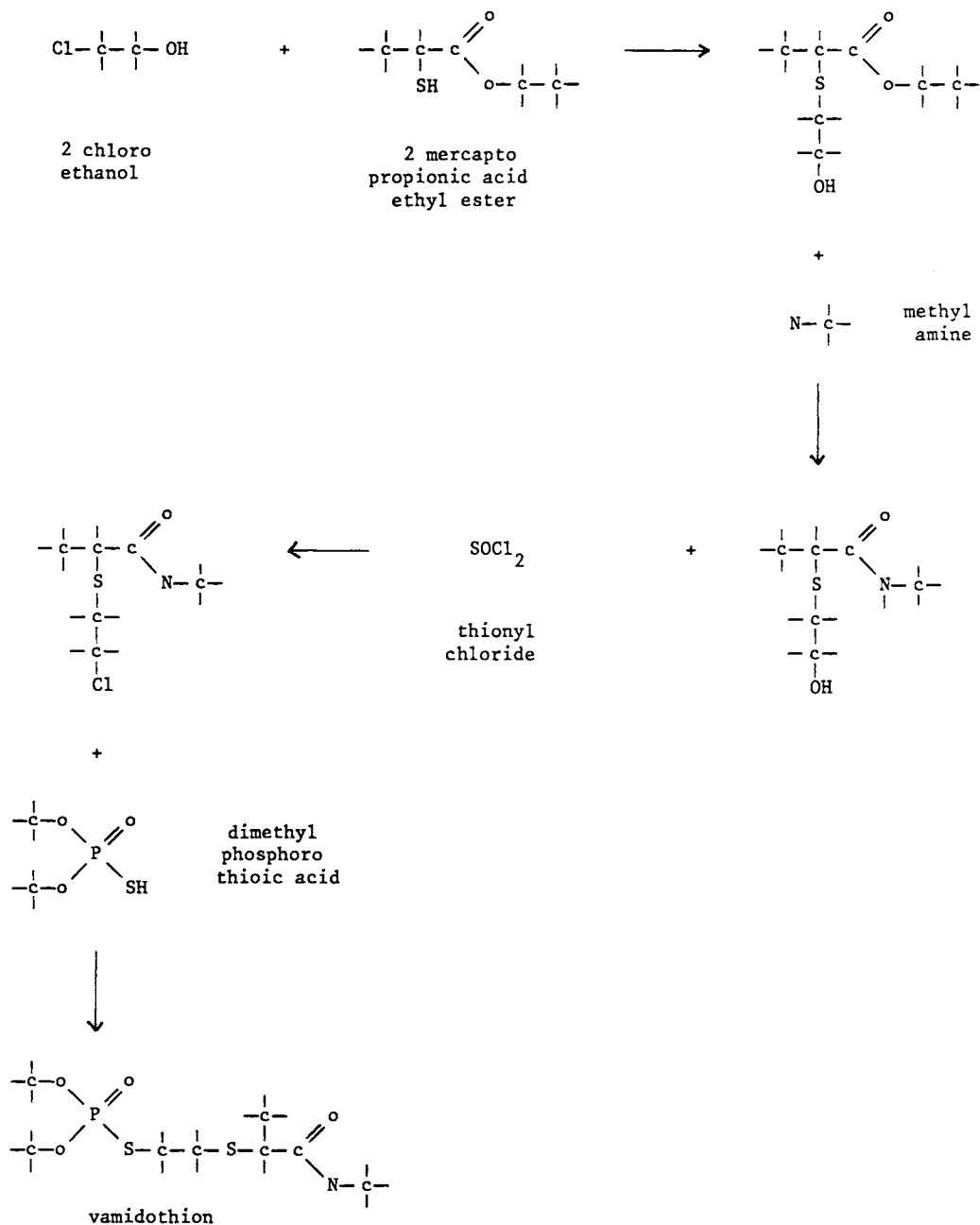
## Vamidothion

Uses: insecticide, cotton, rice

Trade names: Kilval (Rhône Poulenc)

Type: phosphorothioate

Synthesis:

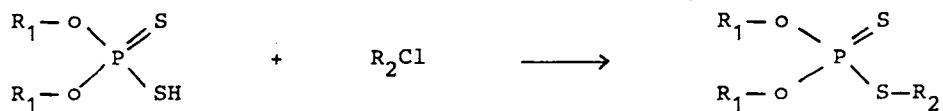


# PHOSPHORODITHIOATES

Most phosphorodithioates are compounds of the type

$$\begin{array}{c} \text{R}_1-\text{O} \quad \text{S} \\ \quad \diagdown \quad \diagup \\ \quad \text{P} \\ \quad \diagup \quad \diagdown \\ \text{R}_1-\text{O} \quad \text{S}-\text{R}_2 \end{array}$$

The synthesis is generally carried out starting with a dialkyl phosphoro dithioic acid



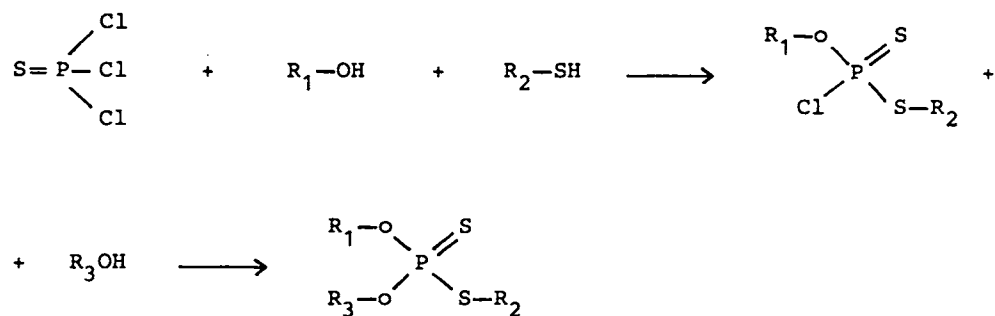
the dithioic acid having been obtained from  $\text{P}_2\text{S}_5$  (see phosphorothioates).

An alternative less frequently used route is

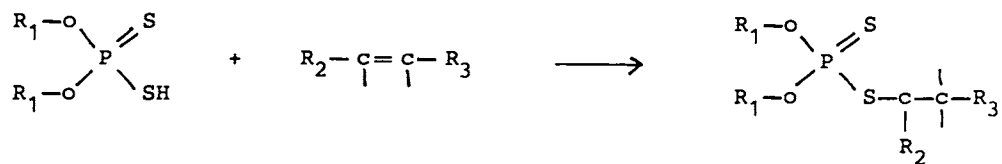


the chloridothioate being obtained from  $\text{P}_2\text{S}_5$  as previously described (see phosphorothioates), by chlorination of the dithioic acid.

The inverse order - reaction first with a mercaptan and then with the alcohol is feasible but not frequently used. The starting point is  $\text{SPCl}_3$



Unusual synthesis routes are:

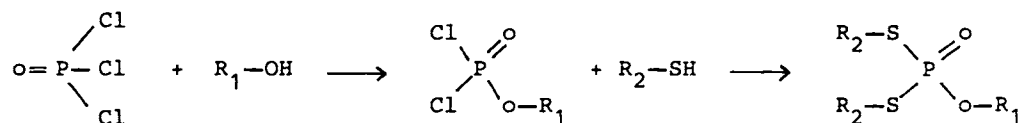


When a phosphorodithioate of the type

$$\begin{array}{c} \text{R}_2\text{-S} \quad \text{O} \\ \quad \diagdown \quad // \\ \text{P} \\ \quad \diagup \quad \backslash \\ \text{R}_2\text{-S} \quad \text{O-R}_1 \end{array}$$

is desired

the starting point of the synthesis is phosphorous oxychloride



The reaction order may also be inverted, that is first the mercaptan and then the alcohol.

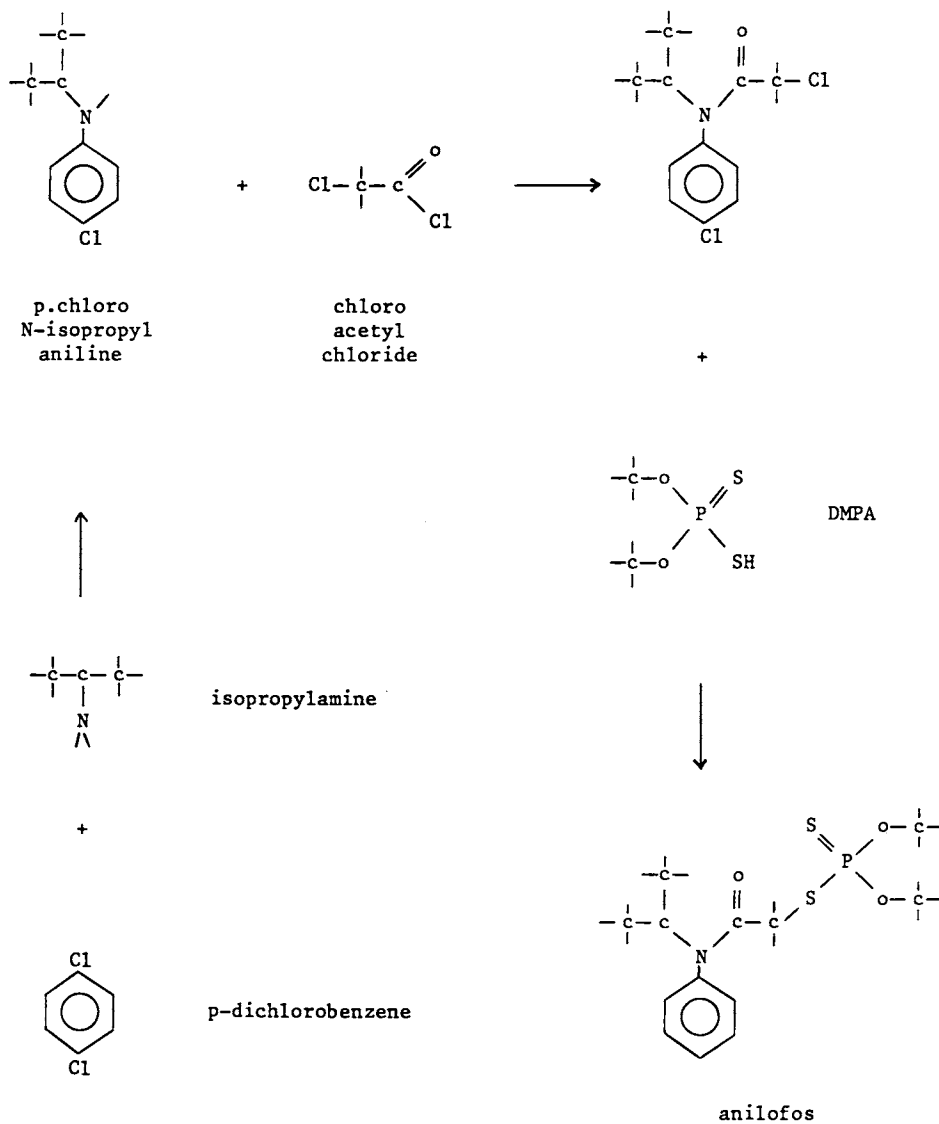
## Anilofos

Uses: herbicide, rice, grass

Trade names: Arozin, Rico (Hoechst)

Type: phosphorodithioate

Synthesis:



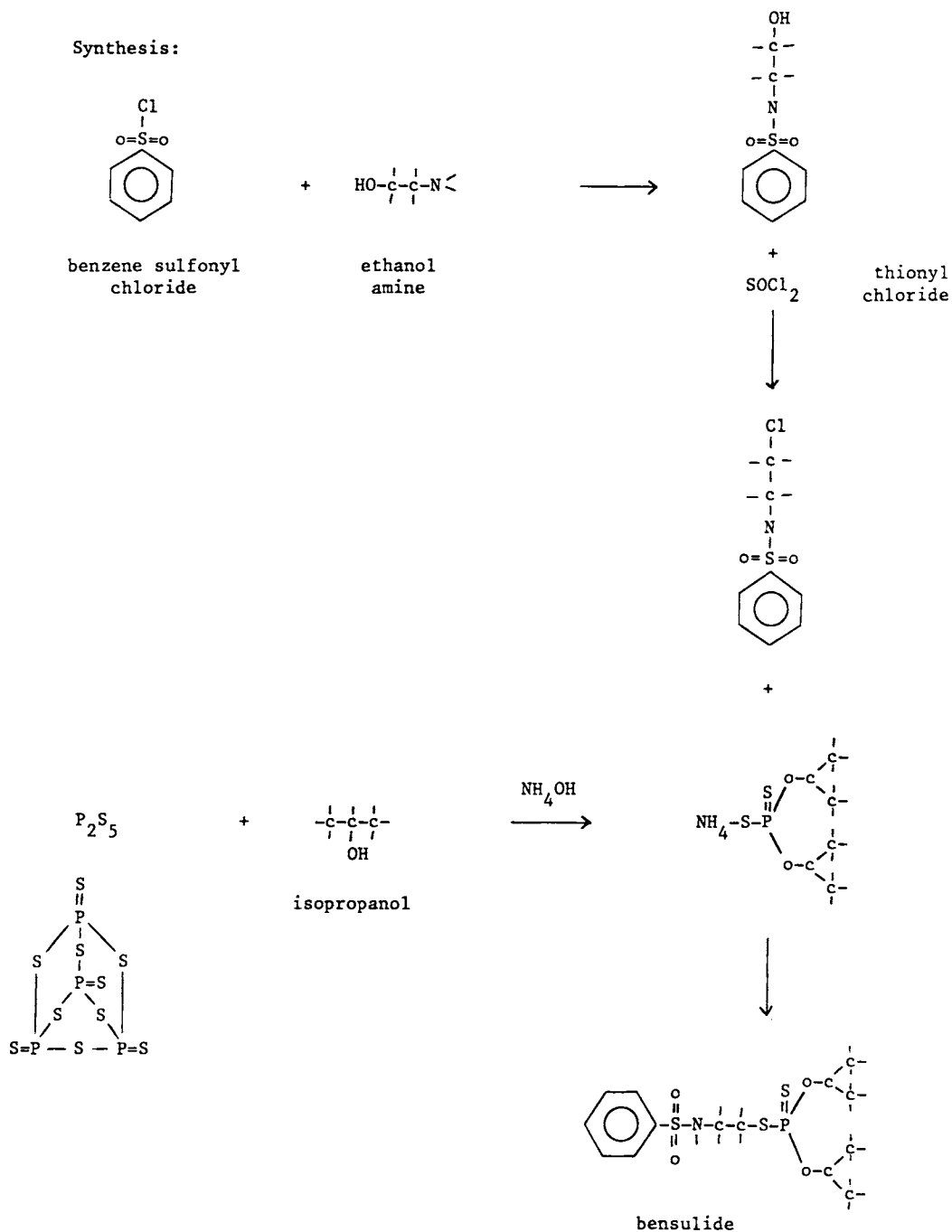
## Bensulide

Uses: herbicide, cotton, turf

Trade names: Betasan, Prefor (ICI)

Type: phosphorodithioate, sulfonamide

Synthesis:



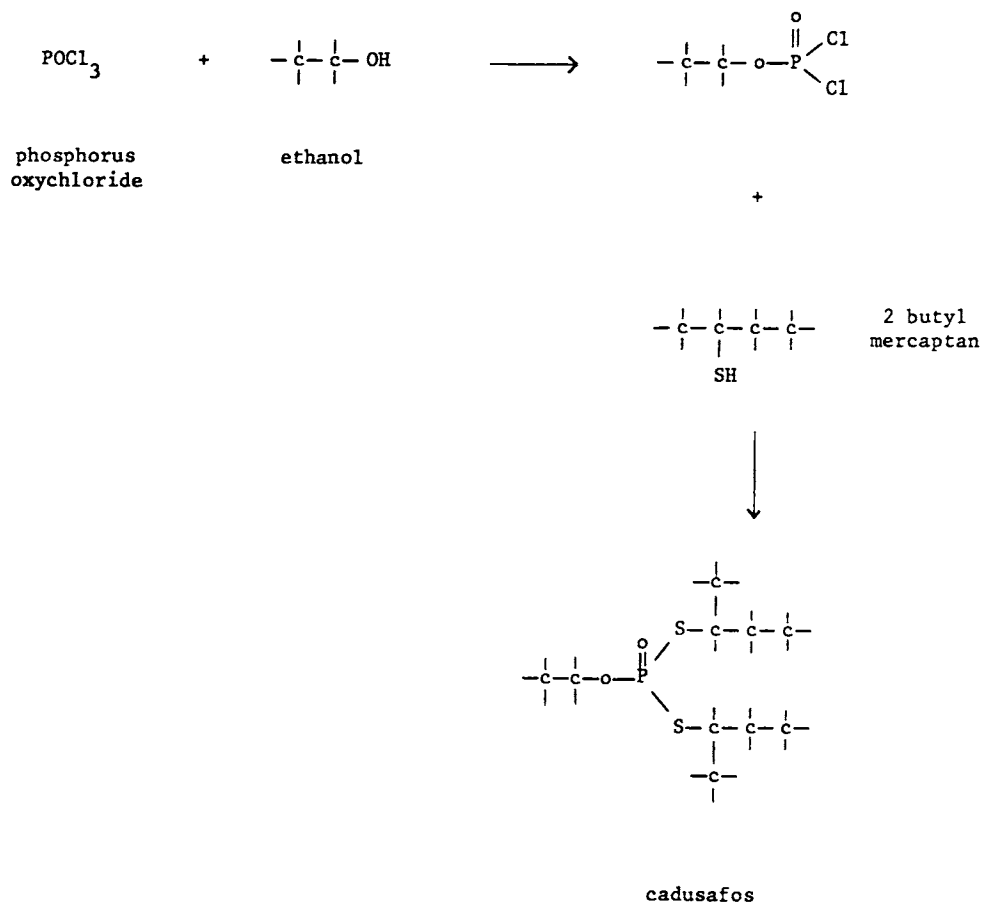
## Cadusafos (Ebufos)

Uses: insecticide, sugar cane, tobacco, potatoes, maize, citrus, bananas

**Trade names:** Apache, Rugby, Taredan (FMC)

Type: phosphorodithioate

**Synthesis:**





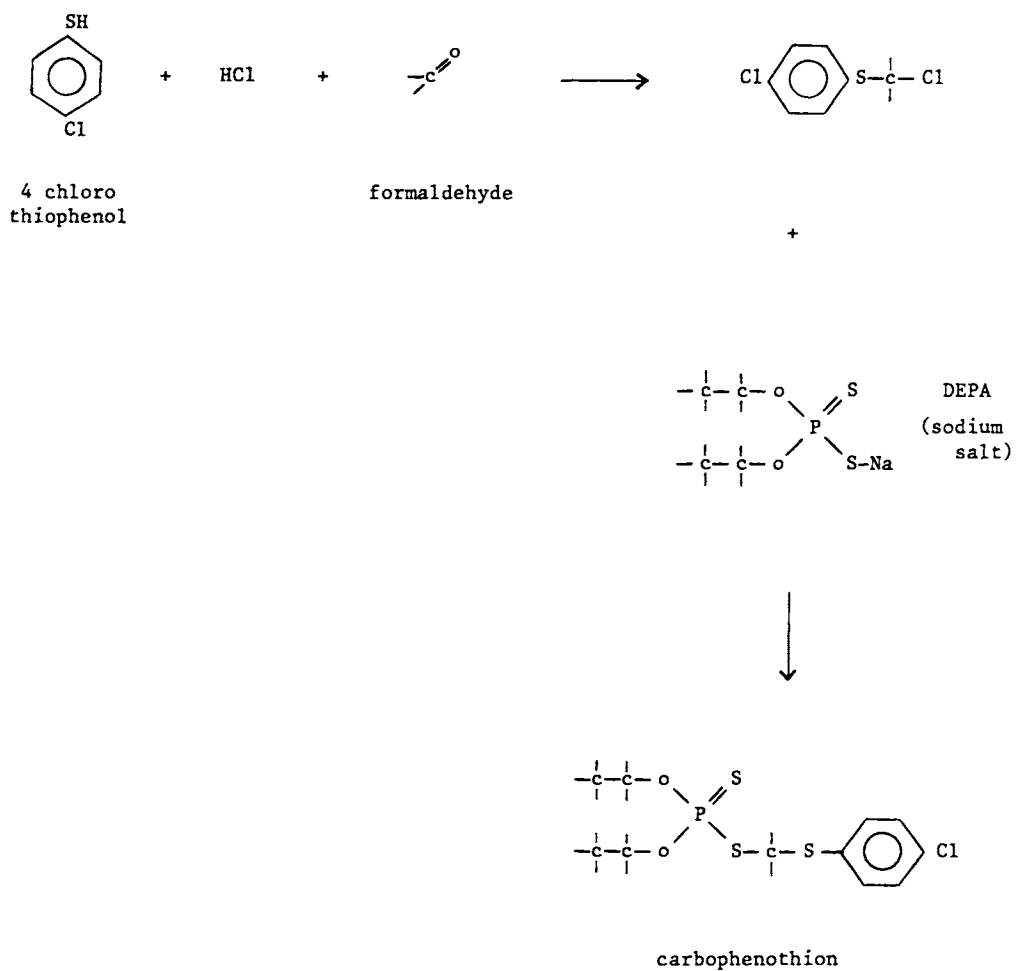
## Carbophenothion

Uses: insecticide, citrus, cotton, wheat, soyabeans, maize, vegetables

Trade names: Trithion, Garrathion (ICI)

Type: phosphorodithioate

Synthesis:



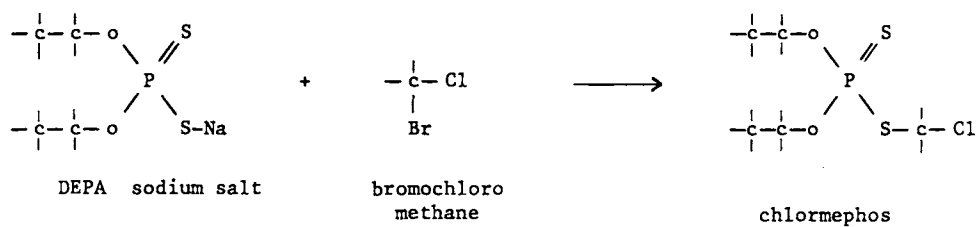
## Chlormephos

Uses: insecticide, maize, sugar beet

Trade names: Dotan (Rhône Poulenc)

Type: phosphorodithioate

Synthesis:



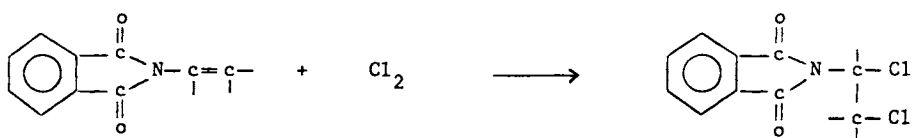
## Dialifos

Uses: insecticide, potatoes, vegetables, fruit, cotton

Trade names: Torak (Shell)

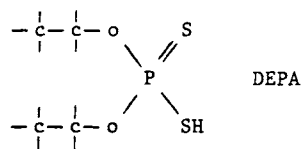
Type: phosphorodithioate

Synthesis:

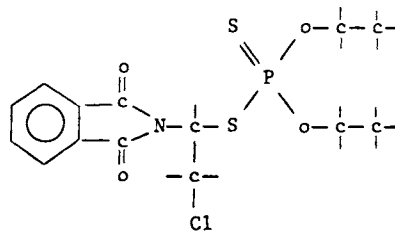


vinyl phthalimide

+



DEPA



dialifos

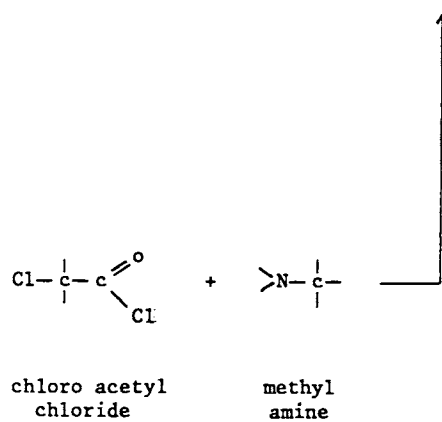
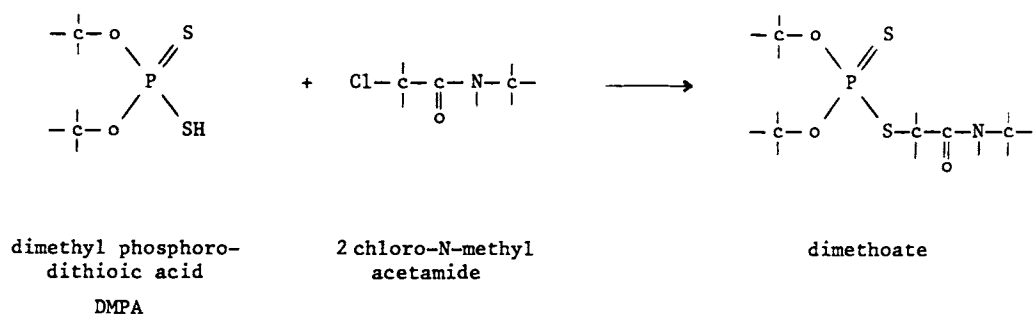
## Dimethoate

Uses: insecticide, cereals, citrus, coffee, cotton, fruit, pastures, tobacco

Trade names: Cygon (Cyanamid), Perfekthion (BASF), Roxion (Shell)

Type: phosphorodithioate

**Synthesis:**



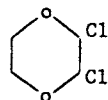
## Dioxathion

Uses: insecticide, ornamentals, lawns, industrial areas, parasiticide

Trade names: Delnar, Deltic (Noram)

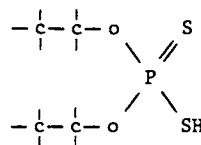
Type: phosphorodithioate

Synthesis:

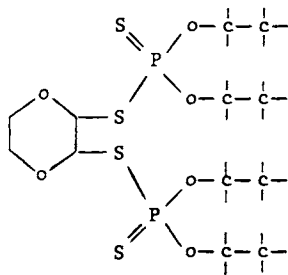


dioxane

+



DEPA



dioxathion

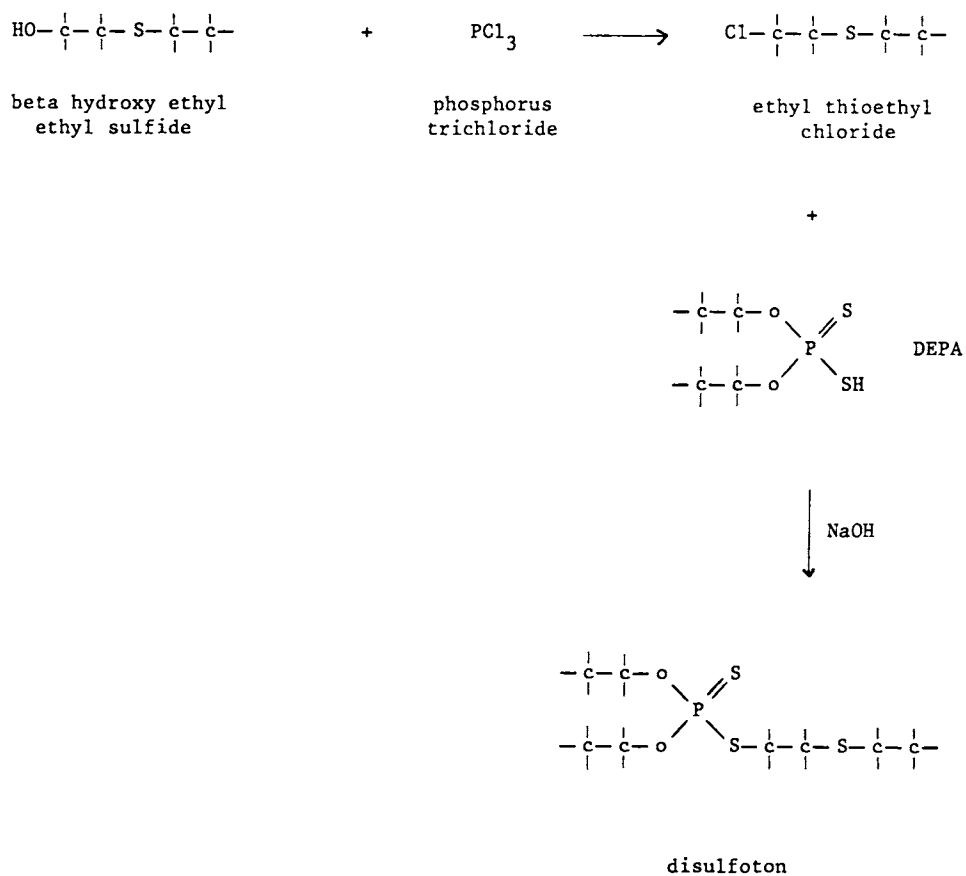
## Disulfoton

Uses: insecticide, cereals, coffee, cotton, peanuts, potatoes, vegetables

Trade names: Disyston, Dithiosystox (Bayer), Frumin, Solvirex (Sandoz)

Type: phosphorodithioate

Synthesis:



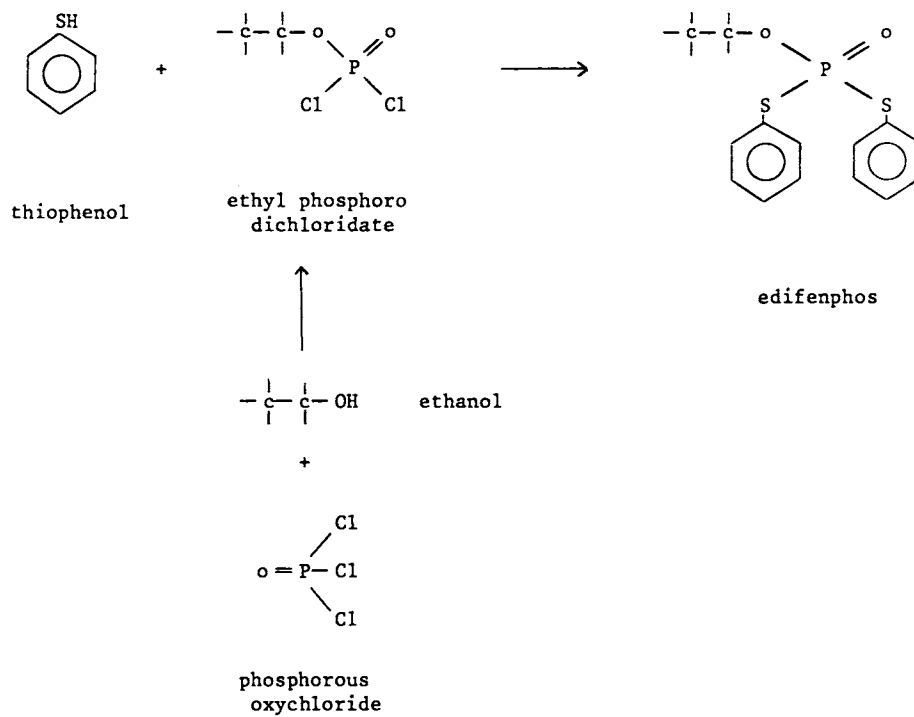
## Edifenphos

Uses: fungicide, rice

Trade names: Hinosan (Bayer)

Type: phosphorodithioate

Synthesis:



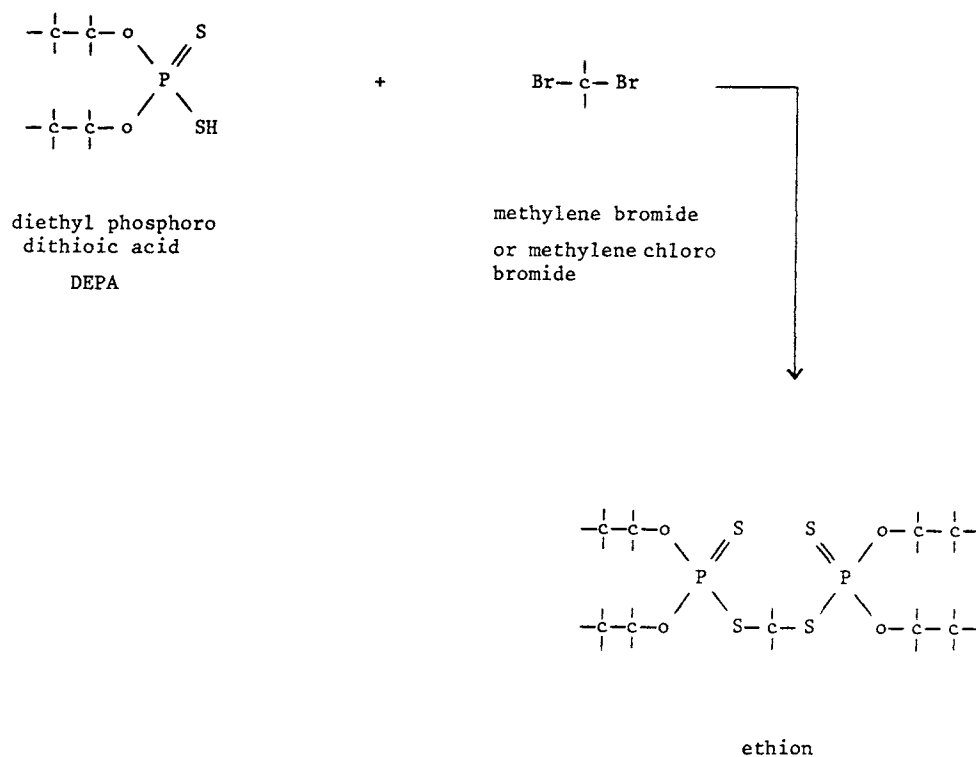
## Ethion

Uses: insecticide, fruit trees, citrus, cattle

Trade names: Cethion (Cheminova), Ethiol (Rhône Poulenc)

Type: phosphorodithioate

Synthesis:





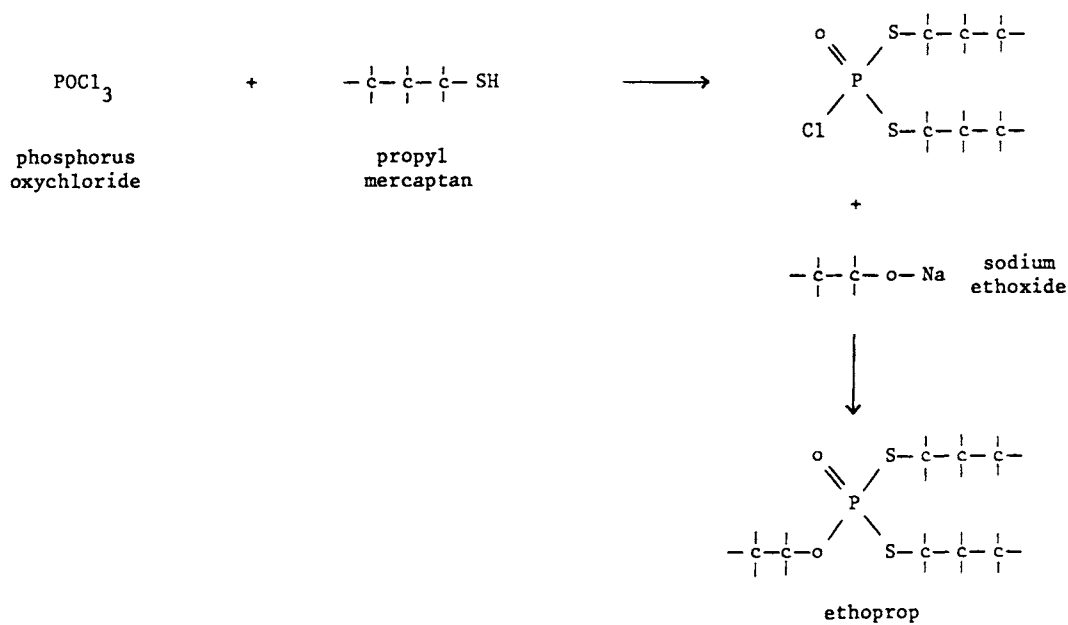
## Ethoprop (Ethoprophos)

Uses: insecticide

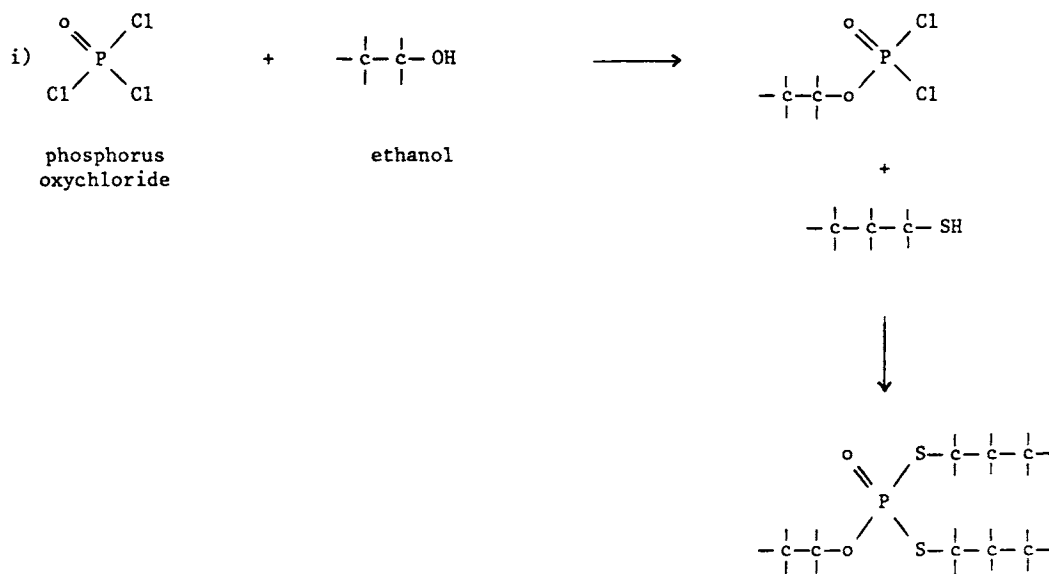
Trade names: Mocap, Prophos (Rhône Poulenc)

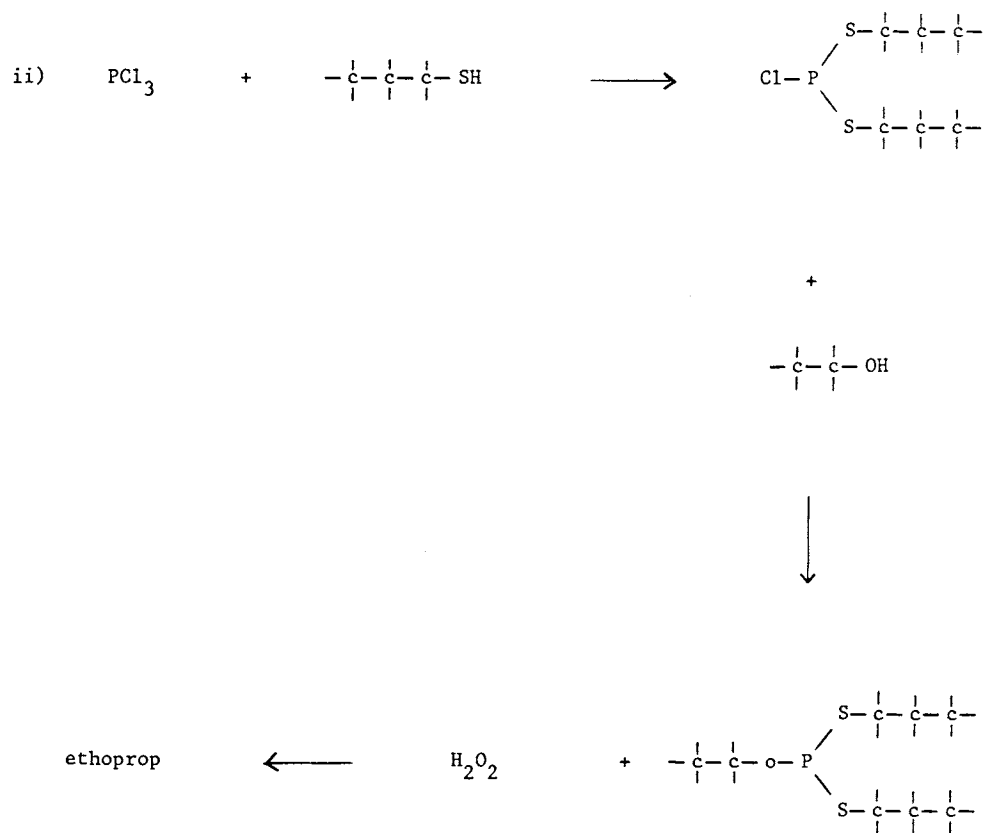
Type: phosphorodithioate

Synthesis:



alternate route:





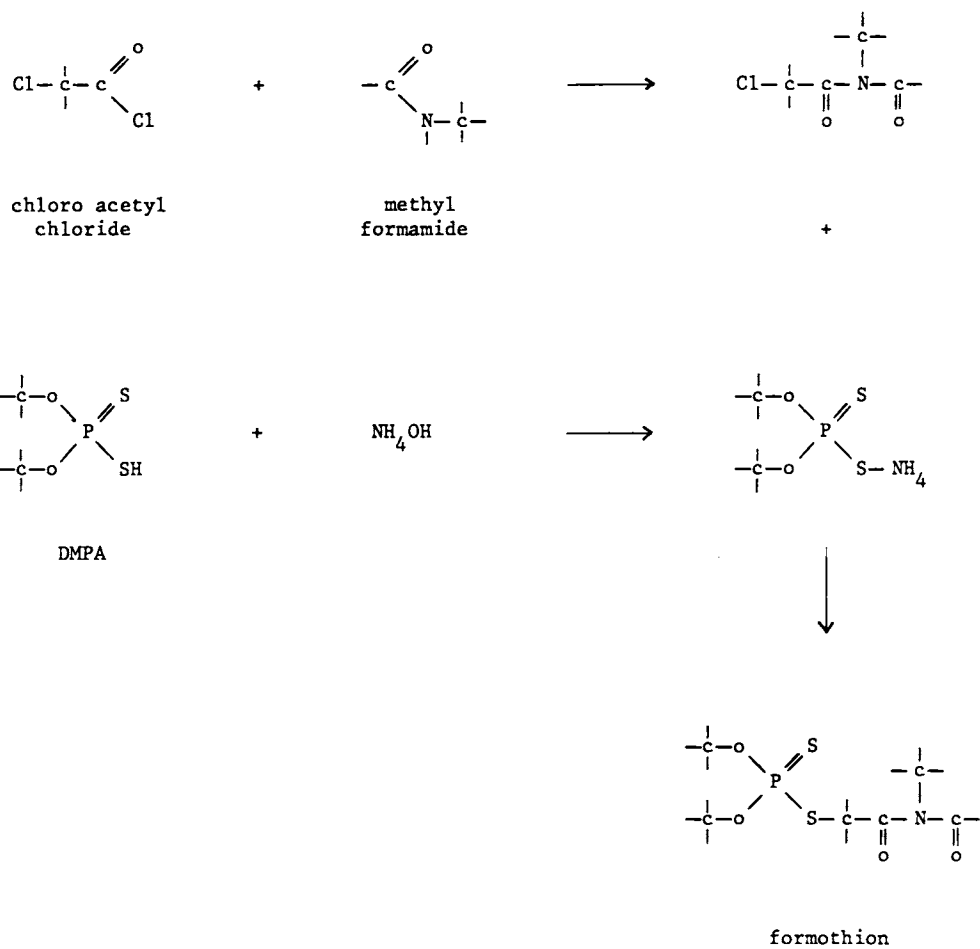
## Formothion

Uses: insecticide, cotton, rice, sugar cane, tobacco, vegetables, fruit trees

Trade names: Anthio, Aflix (Sandoz)

Type: phosphorodithioate

Synthesis:



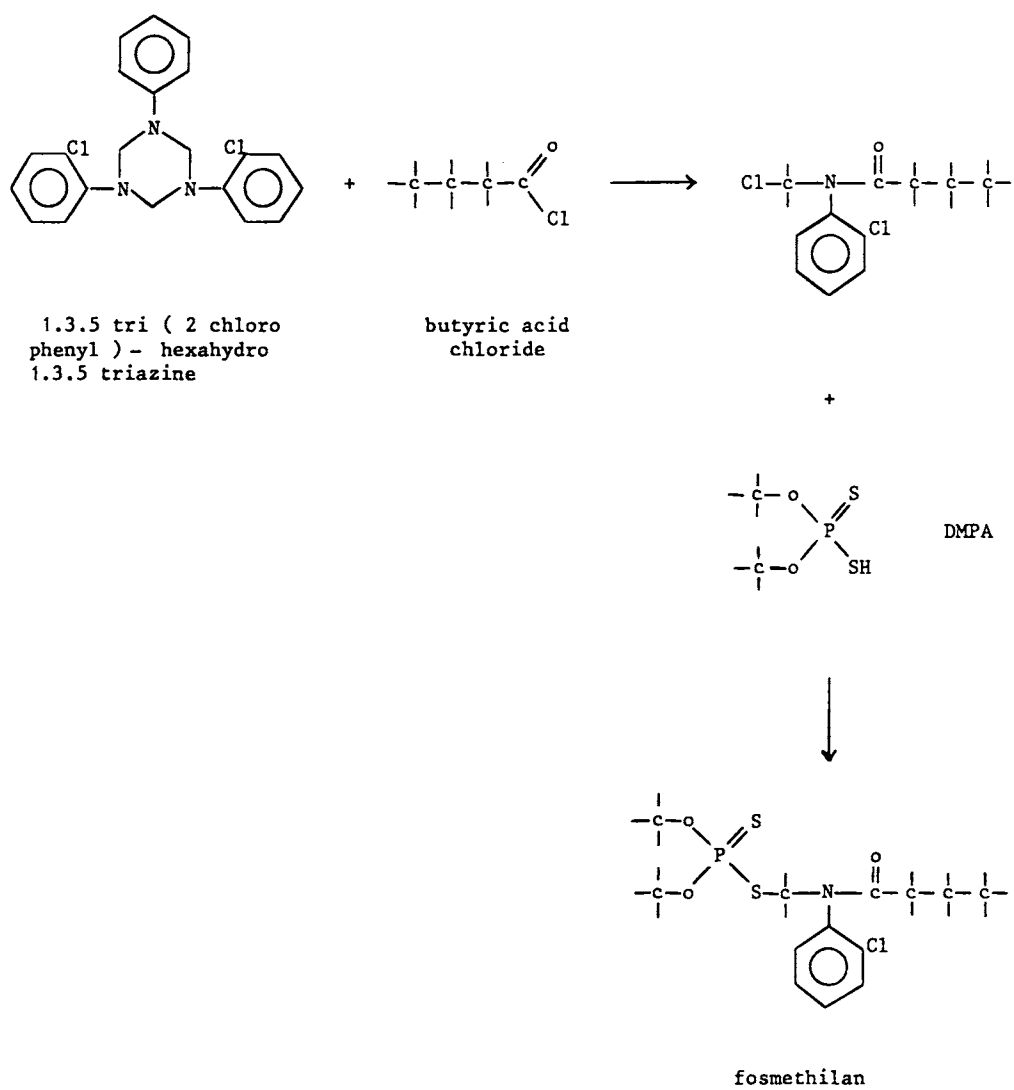
## Fosmethilan

Uses: insecticide, fruit, vegetables, crops

Trade names:

Type: phosphorodithioate, amide

Synthesis:



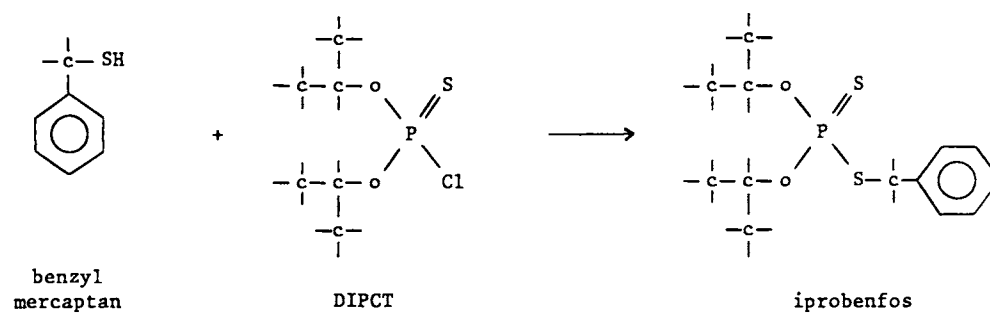
## Iprobenfos

Uses: fungicide, rice

Trade names: Kitazin (Kumiai)

Type: phosphorodithioate

Synthesis:



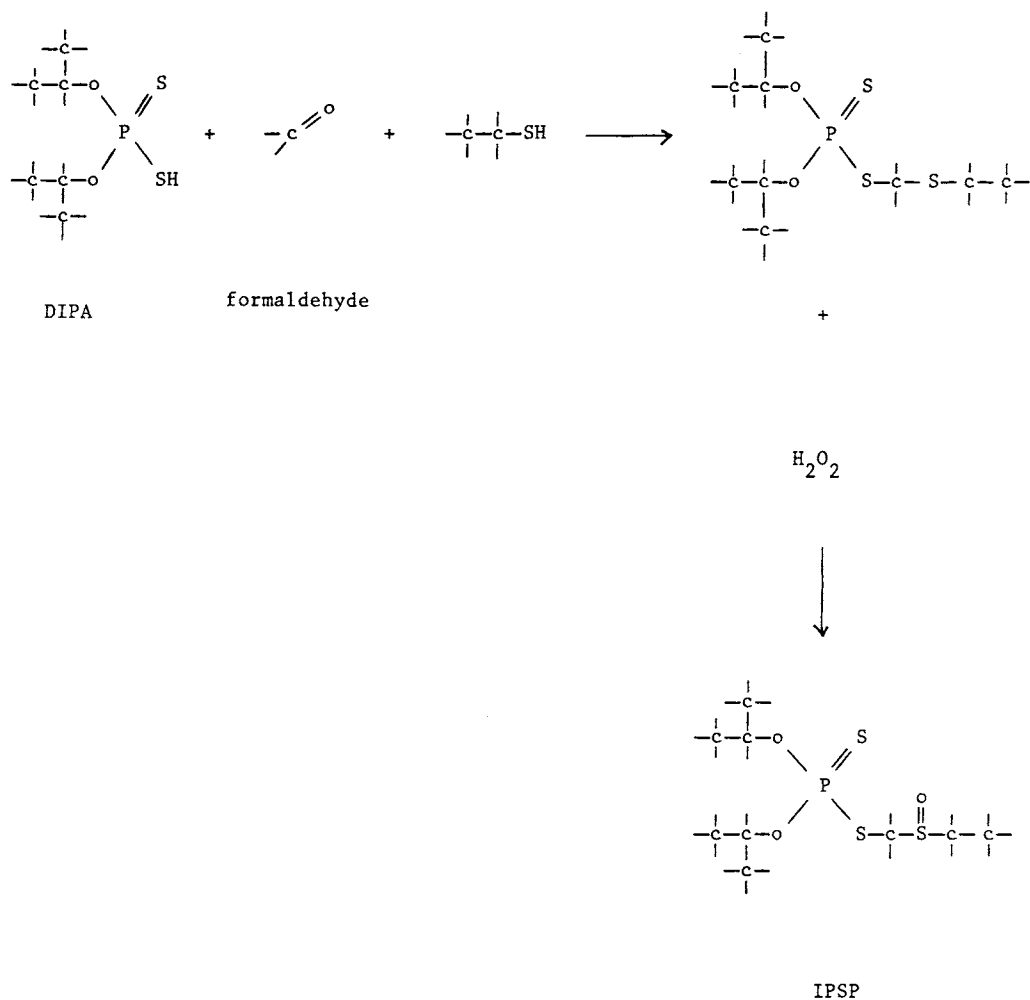
**IPSP**

Uses: insecticide, potatoes, vegetables

Trade names: PSP, Aphidan (Hokko)

Type: phosphorodithioate

Synthesis:



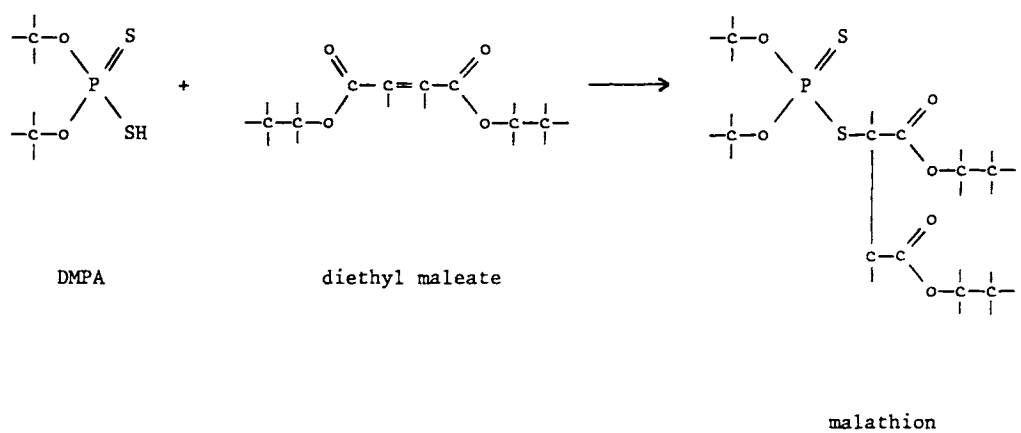
## Malathion

Uses: insecticide, cotton, potatoes, rice, vegetables, grain, poultry, dogs, cats, lice

Trade names: Cythion (Cyanamid)

Type: phosphorodithioate

Synthesis:



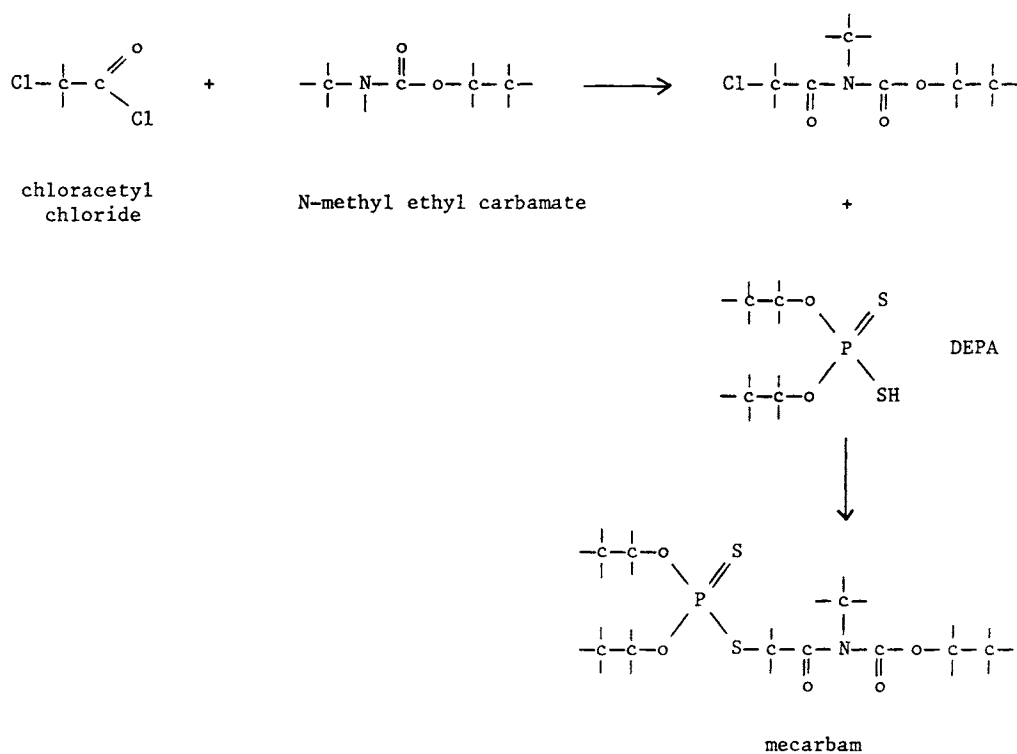
## Mecarbam

Uses: insecticide, cotton, citrus

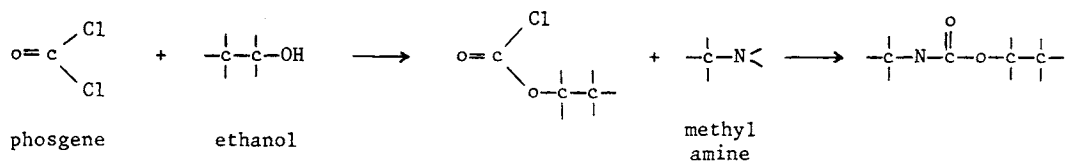
Trade names: Murfotox (Dow Elanco)

Type: phosphorodithioate, carbamate

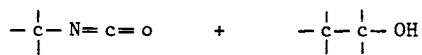
Synthesis:



N-methyl ethyl carbamate:



alternate route:





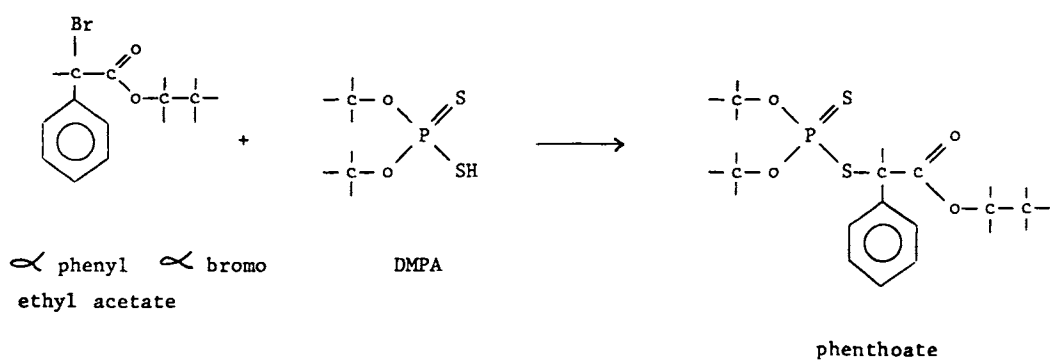
## Phenthoate

Uses: insecticide, citrus, coffee, cotton, rice, tea, fruits, tobacco, vegetables

Trade names: Cidial, Elsan (Agrimont), Papthion (Sumitomo)

Type: phosphorodithioate

Synthesis:



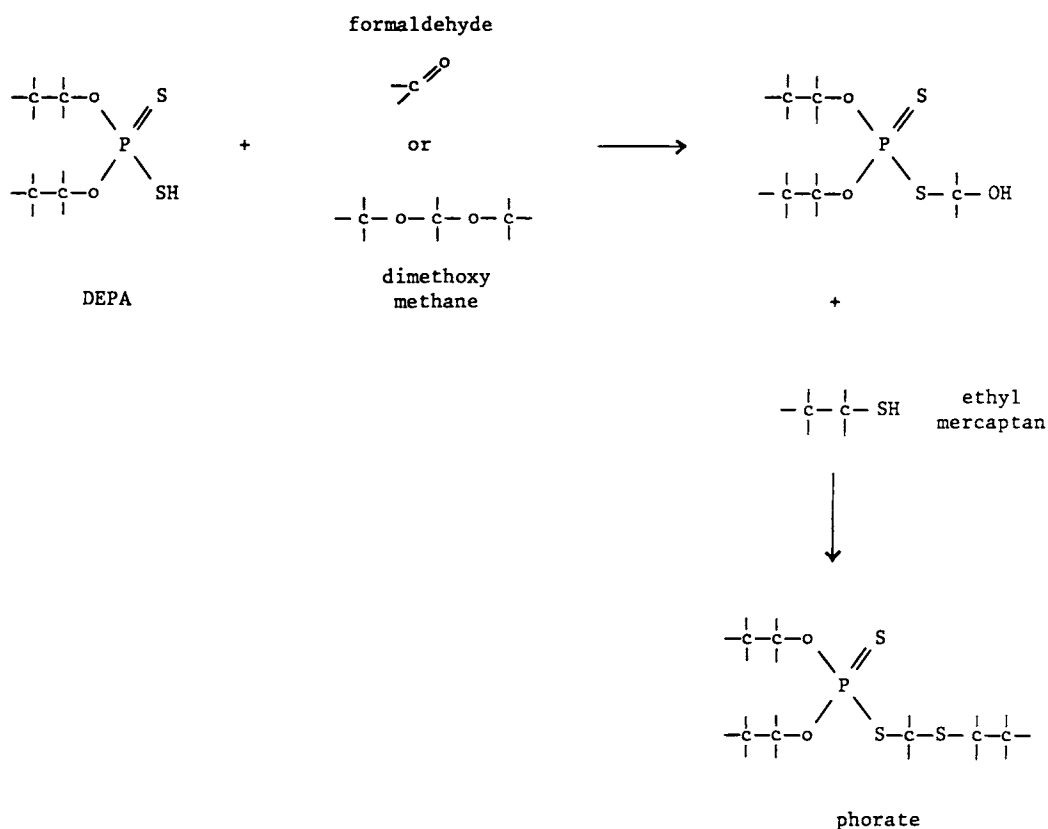
## Phorate

Uses: insecticide, coffee, cotton, maize, sugar beet

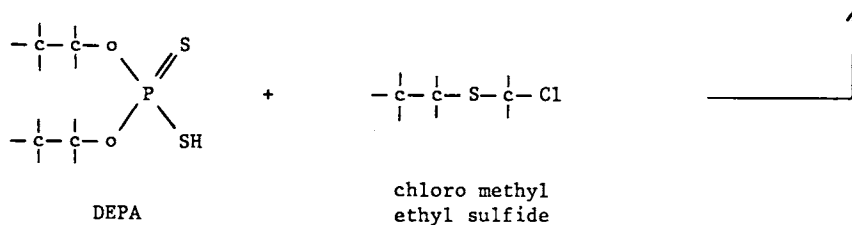
Trade names: Thimet, Agrimet (Cyanamid)

Type: phosphorodithioate

Synthesis:



alternate route:



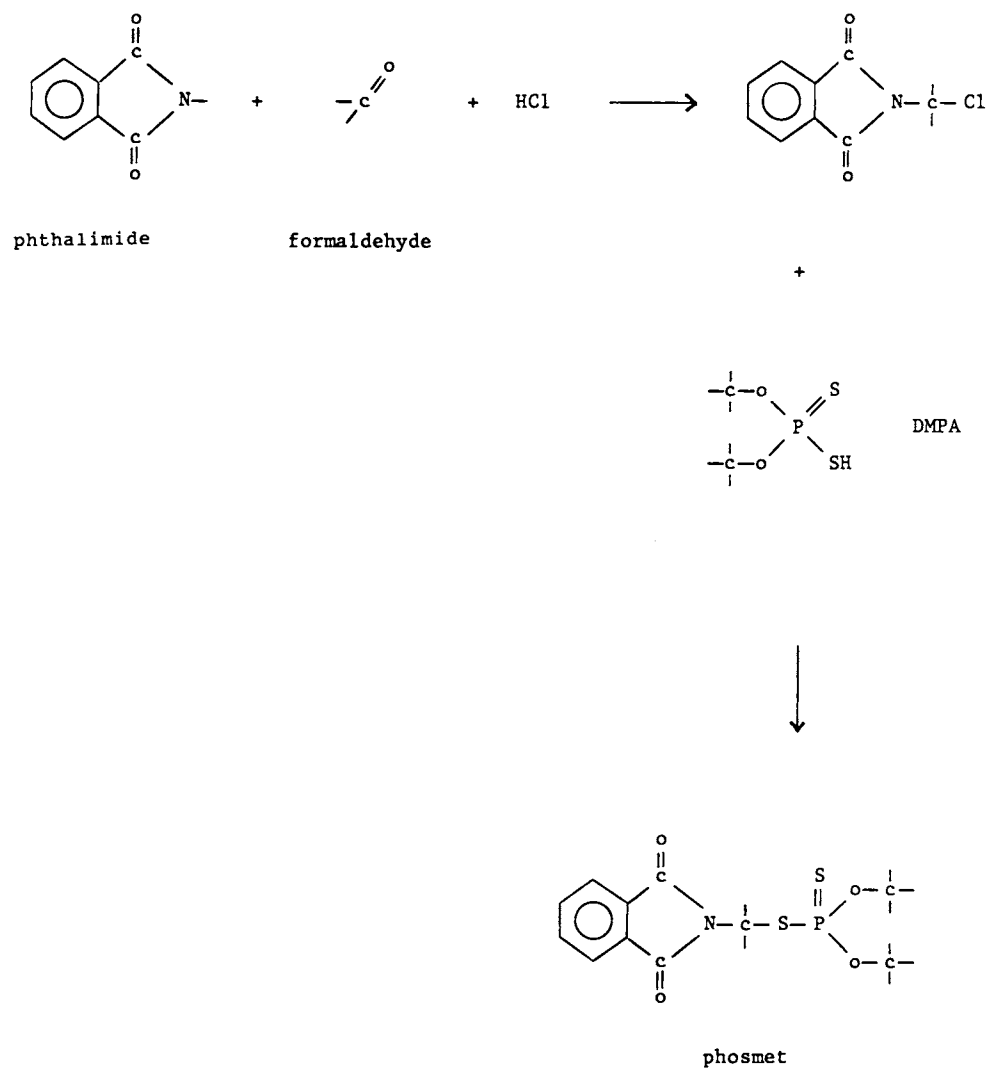
## Phosmet

Uses: insecticide, grapes, potatoes

Trade names: Imidan (ICI)

Type: phosphorodithioate

Synthesis:



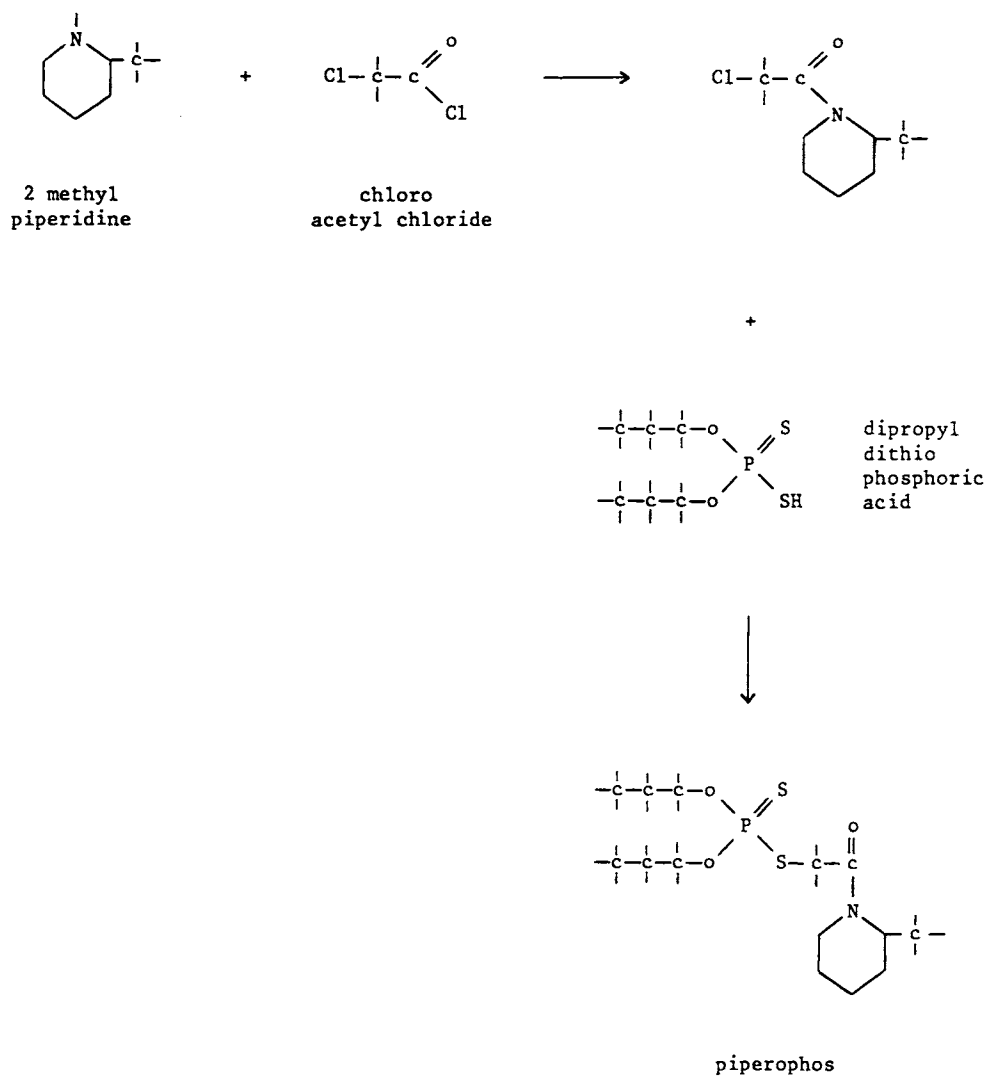
## Piperophos

Uses: herbicide, rice

Trade names: Rilof (Ciba)

Type: phosphorodithioate, piperidine

Synthesis:



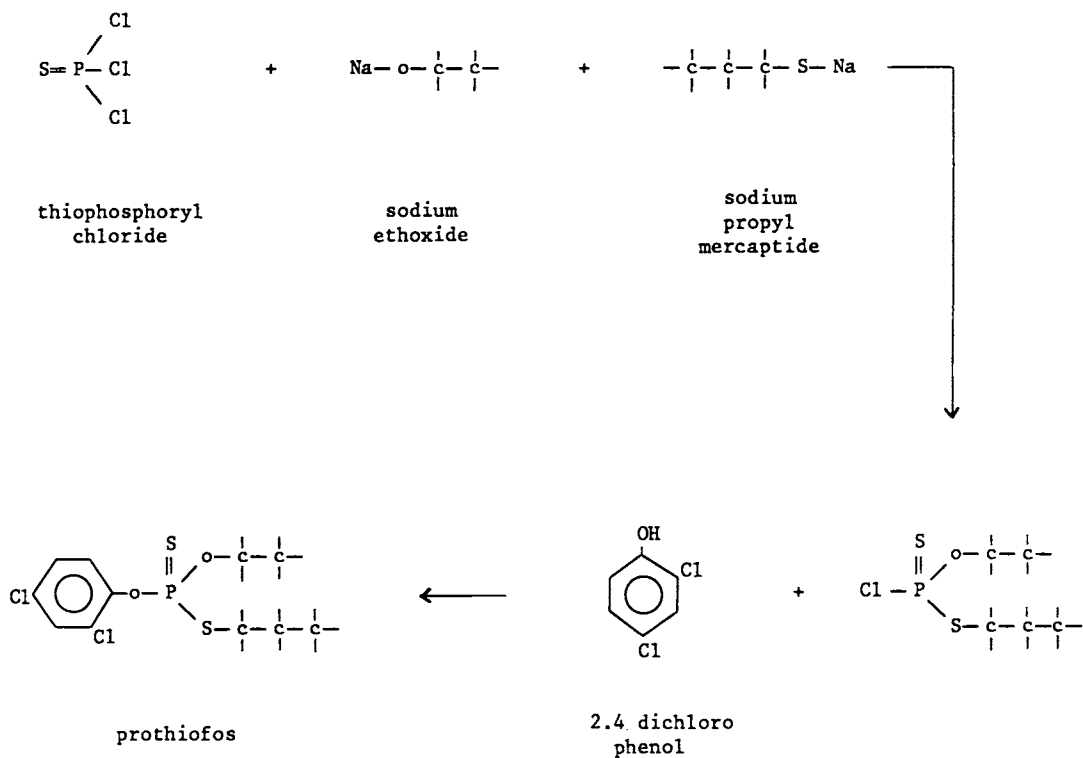
## Prothiofos

Uses: insecticide, fruit, vegetables, public health

Trade names: Tokuthion, Bideron (Bayer)

Type: phosphorodithioate

Synthesis:



alternate route:

1st step reaction with 2,4 dichlorophenol instead of propylmercaptide

2nd step with propylmercaptide

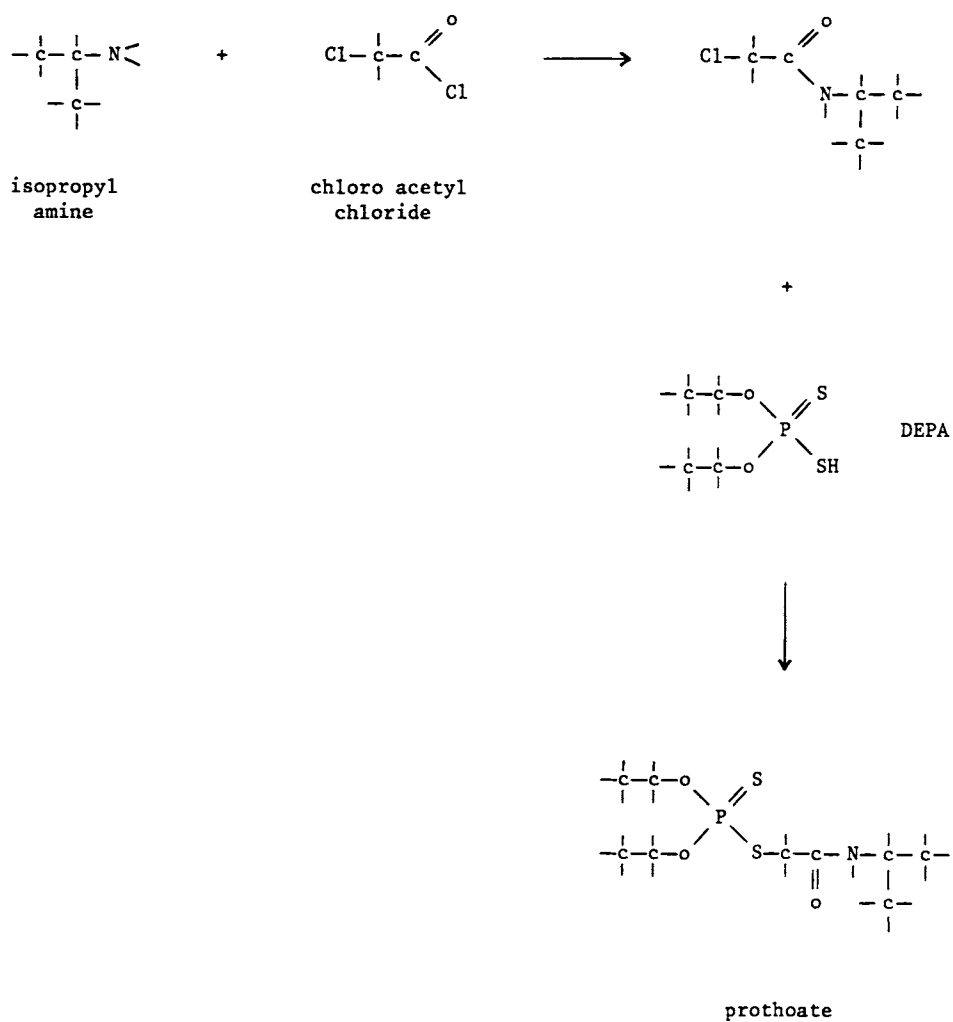
## Prothoate

Uses: insecticide, citrus, cotton, fruit, vegetables

Trade names: Fac (Agrimont)

Type: phosphorodithioate, amide

Synthesis:



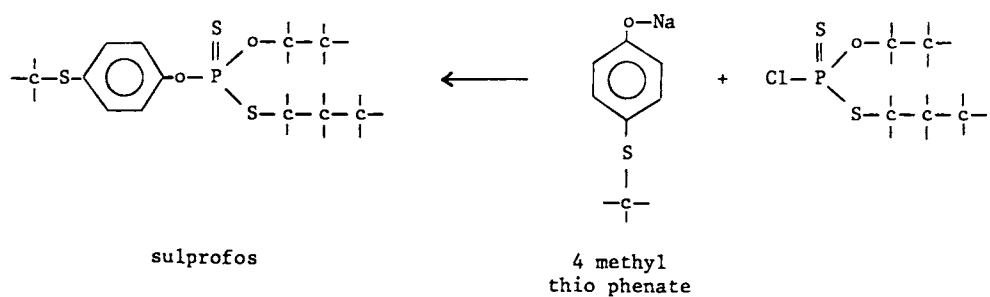
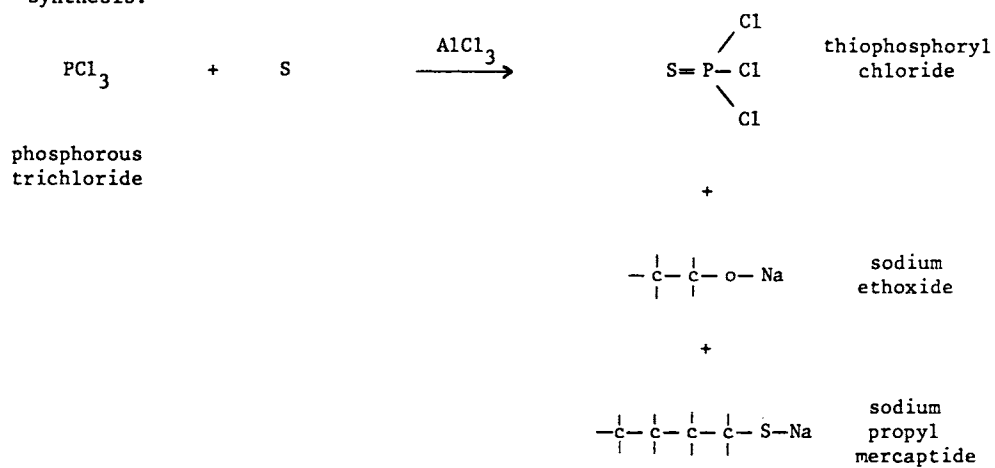
## Sulprofos

Uses: insecticide, cotton, peanuts, soya beans, vegetables

**Trade names:** Bolstar, Helothion (Bayer)

Type: phosphorodithioate

**Synthesis:**



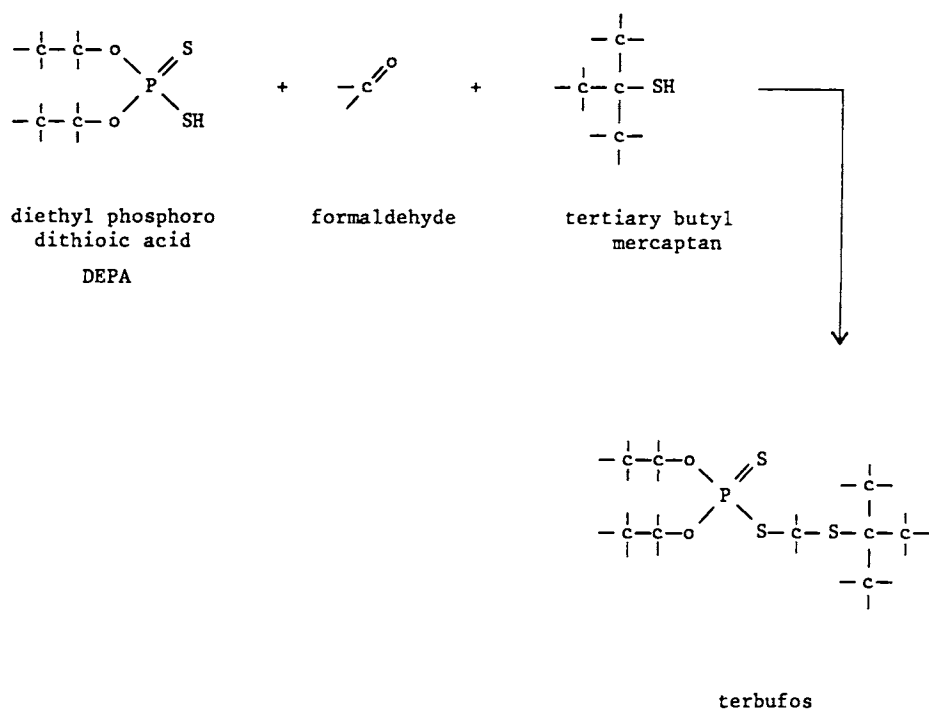
## Terbufos

Uses: insecticide, maize, sugar beet, cabbages, onions, bananas

Trade names: Counter (Cyanamid)

Type: phosphorodithioates

**Synthesis:**





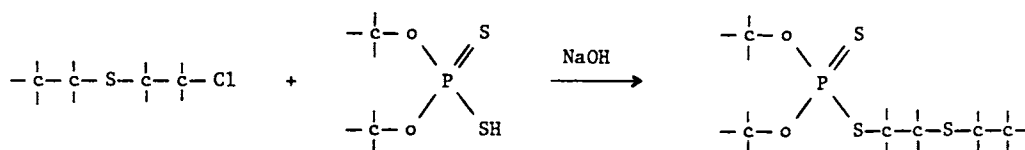
## Thiometon

Uses: insecticide

Trade names: Ekatin (Sandoz)

Type: phosphorodithioate

Synthesis:

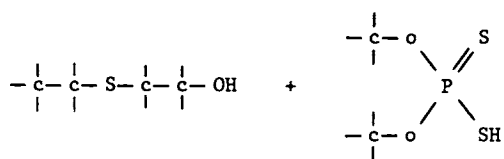


2 ethyl thio ethyl  
chloride  
(see disulfoton)

DMPA

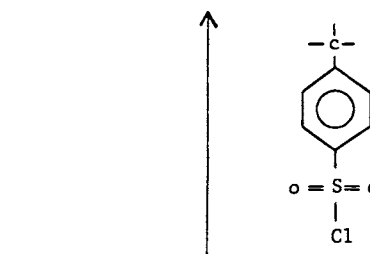
thiometon

alternate route:



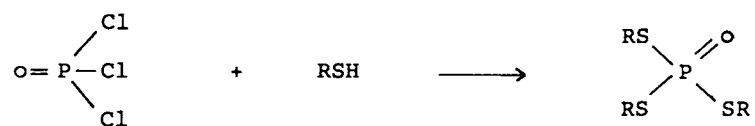
2 ethyl thio  
ethanol

dimethyl  
phosphoro  
thioic acid

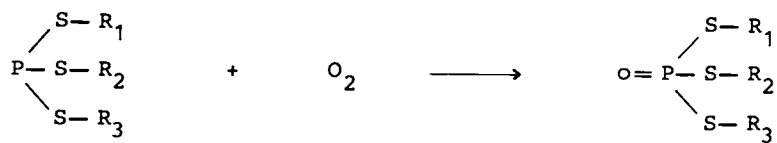


## PHOSPHOROTRITHIOATES

The synthesis is by reaction between phosphorous oxychloride and a mercaptan



or via oxydation of a phosphorotrithioite



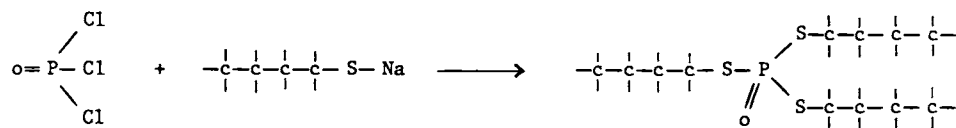
## S,S,S-Tributyl Phosphorotrithioate

Uses: plant growth regulator, cotton

Trade names: DEF Defoliant (Chemagro)

Type: phosphorotrithioate

Synthesis:



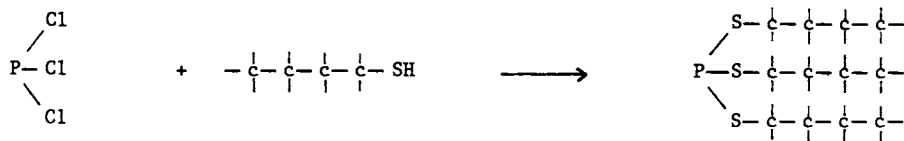
phosphorus  
oxychloride

sodium butyl  
mercaptide

S, S, S - tributyl  
phosphoro trithioate



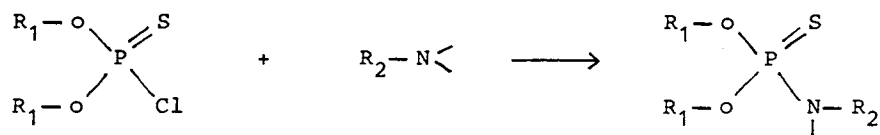
alternate route:



phosphorus  
trichloride

## PHOSPHOROAMIDOTHIOATES

DEPCT or DMPCT ( see phosphorothioates ) react with an amine to form the amido thioate



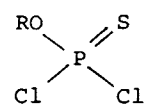
The synthesis of acephate and methamidophos involves the isomerisation of



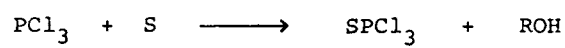
via treatment with dimethyl sulfate.

Another starting point is

thiophosphoro dichloridates



obtained by



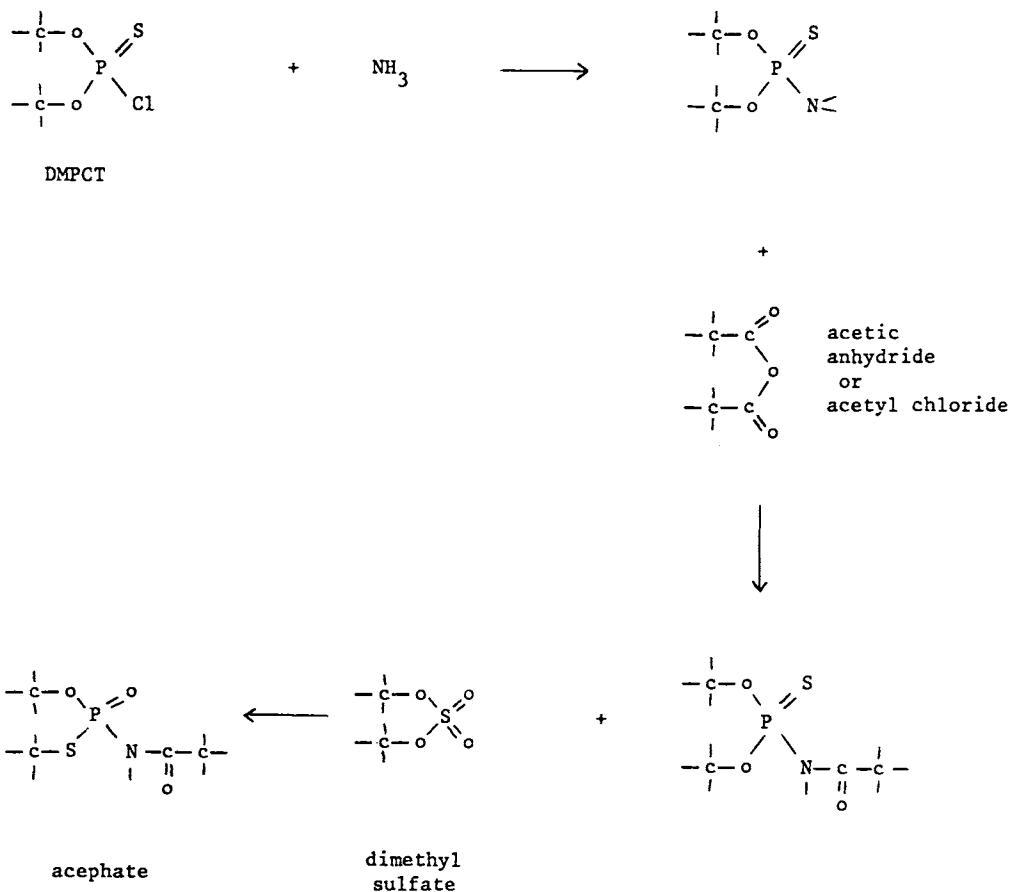
## Acephate

Uses: insecticide, tobacco, fruit, cotton, soya beans

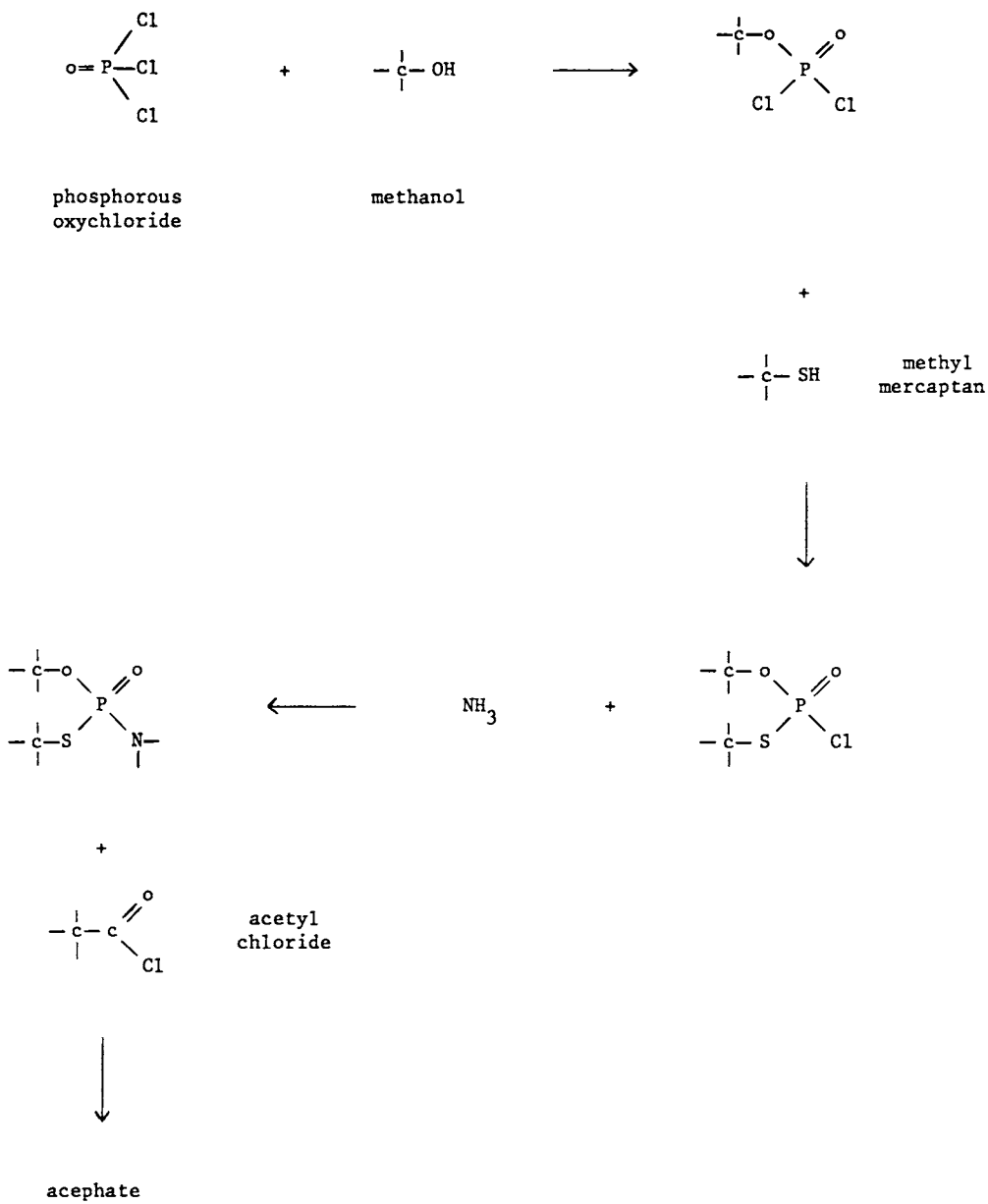
Trade names: Orthene (Chevron)

Type: phosphoramidothioate, amide

**Synthesis:**



alternate route :



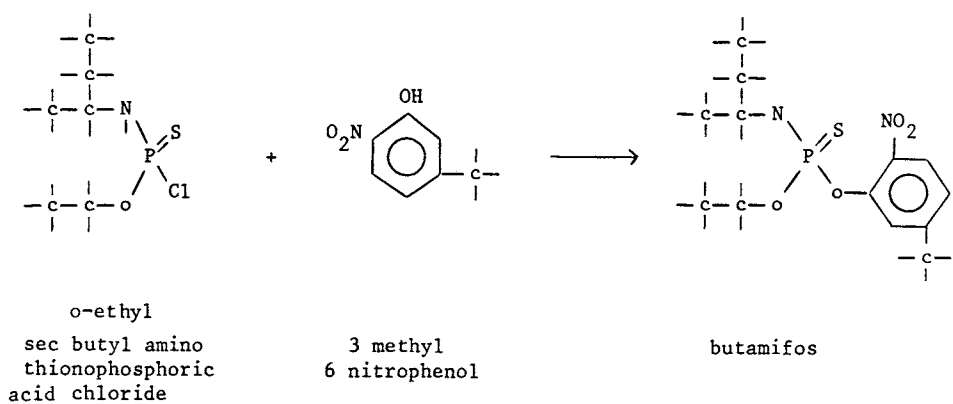
## Butamifos

Uses: herbicide, beans, lawns, vegetables

Trade names: Cremart (Sumitomo)

Type: phosphoramidothioate

Synthesis:





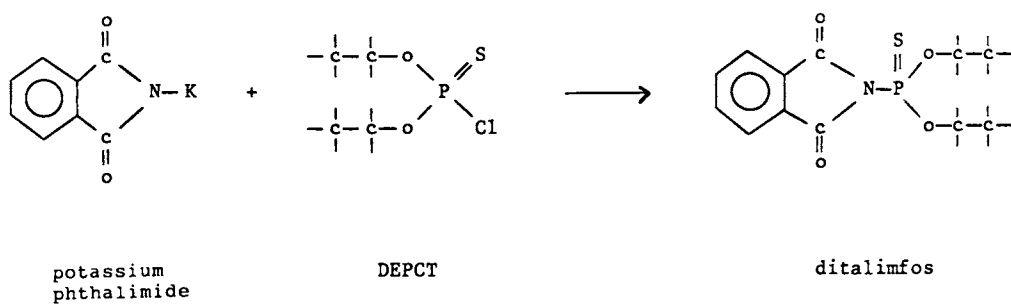
## Ditalimfos

Uses: fungicide, fruit

Trade names: Plondrel, Laptran, Millie, Farmil, Dowco (Dow)

Type: phosphoroamidothioate

Synthesis:



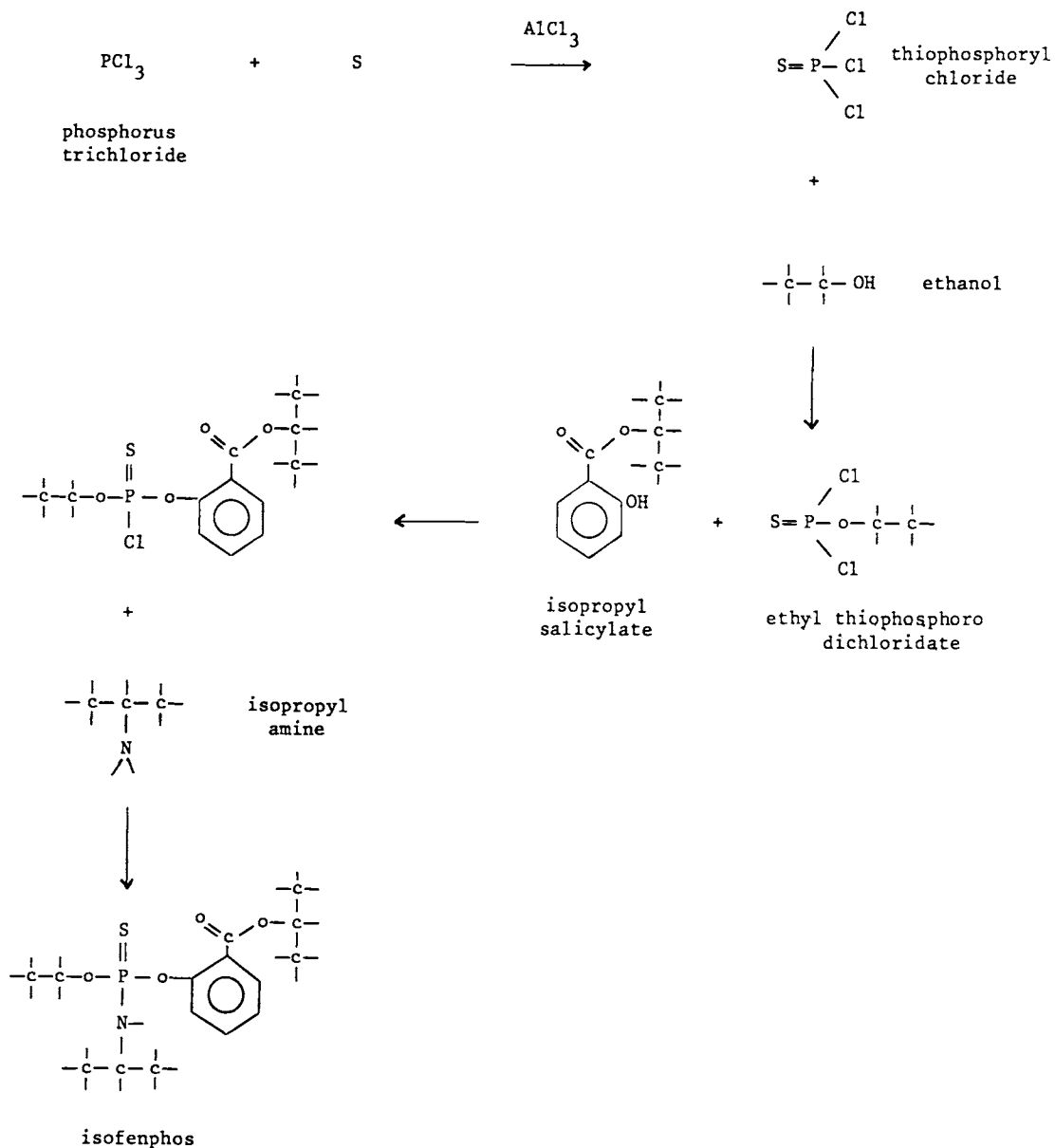
## Isofenphos

Uses: insecticide, maize, vegetables

Trade names: Oftanol (Bayer), Amaze (Mobay)

Type: phosphoramidothioates

**Synthesis:**



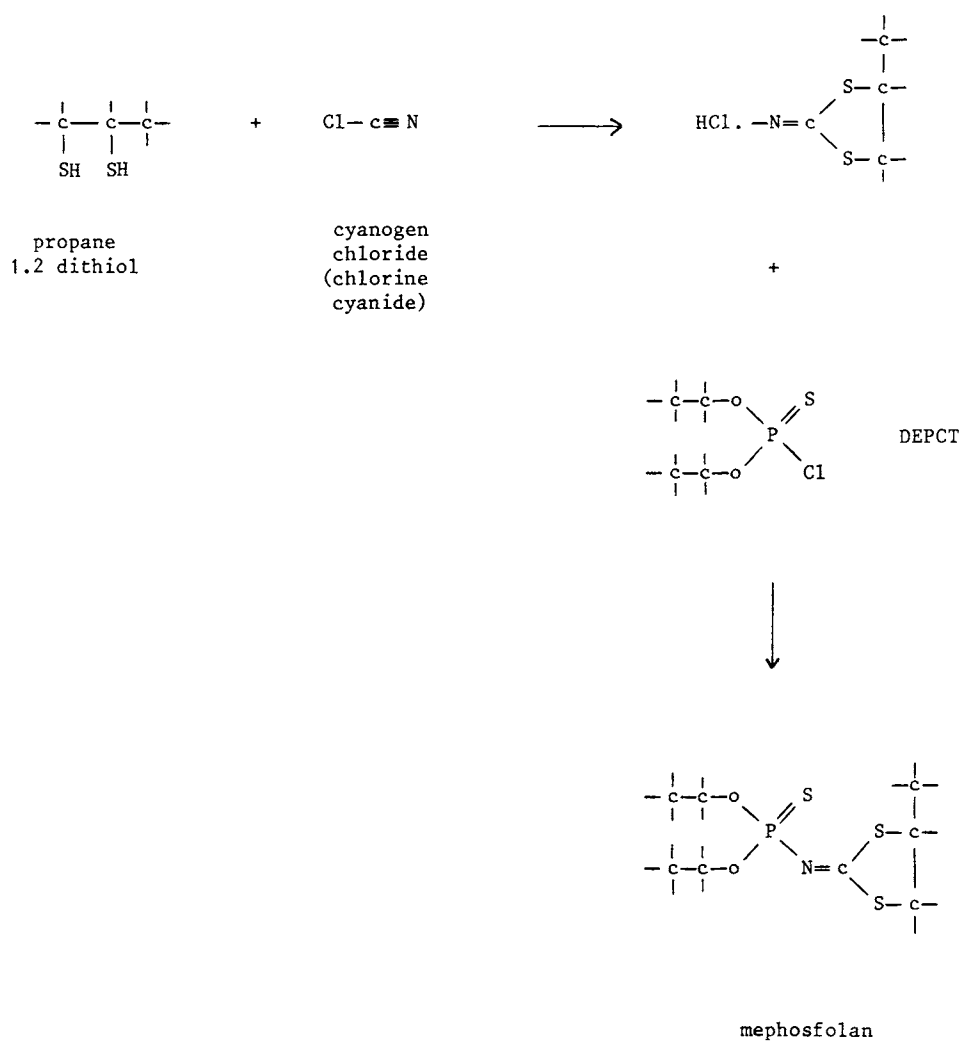
## Mephosfolan

Uses: insecticide, cotton, maize, rice, potatoes, sorghum

Trade names: Cytrolane (Cyanamid)

Type: phosphoroamidothioate

Synthesis:



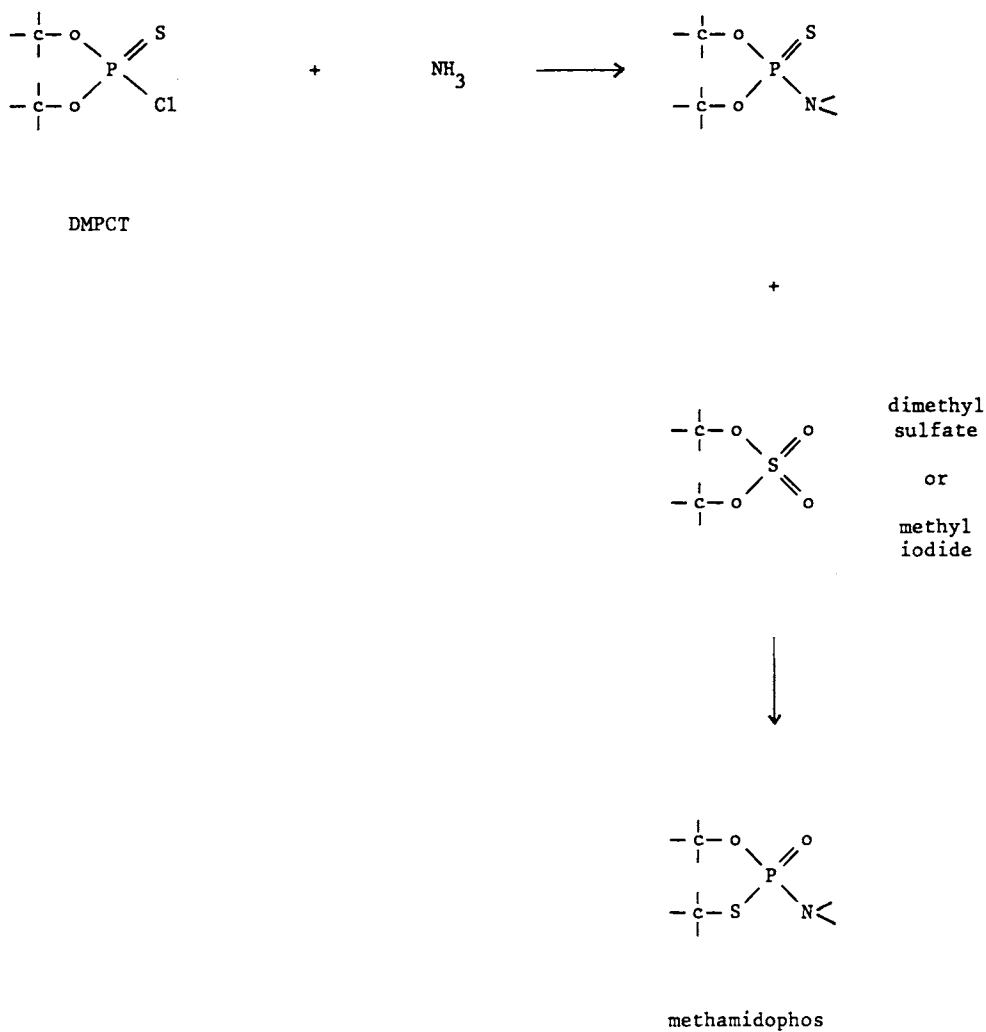
## Methamidophos

Uses: insecticide, cotton, fruit, potatoes, tobacco, vegetables

Trade names: Monitor (Chevron), Tamaron (Bayer)

Type: phosphoroamidothioate

Synthesis:



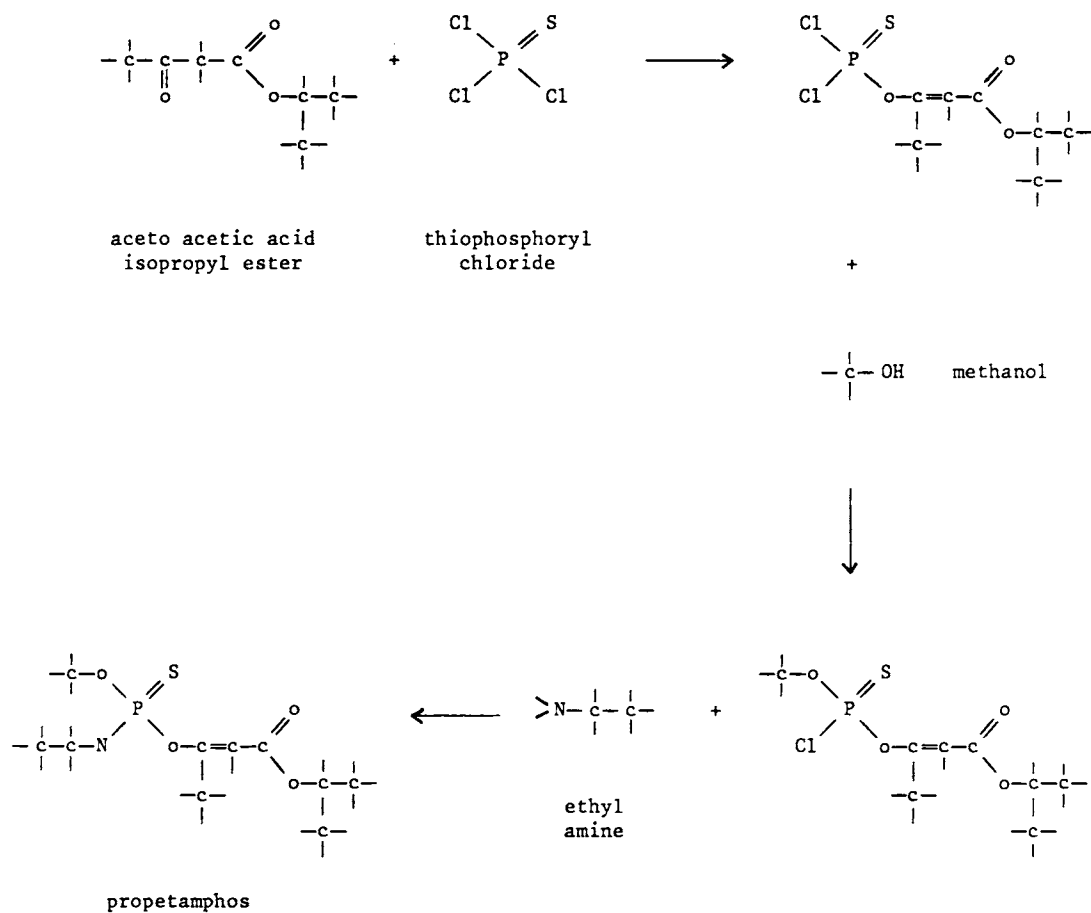
## Propetamphos

Uses: insecticide, household, public health

Trade names: Safrotin (Sandoz)

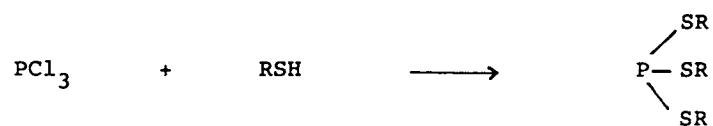
Type: phosphoroamidothioate

Synthesis:



## PHOSPHOROTRITHIOITES

Are obtained by reaction between phosphorous trichloride and a mercaptan



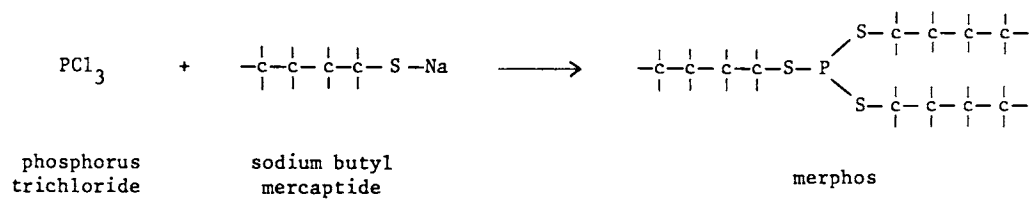
## Merphos

Uses: growth regulator, cotton

Trade names: Folex (Rhone Poulenc)

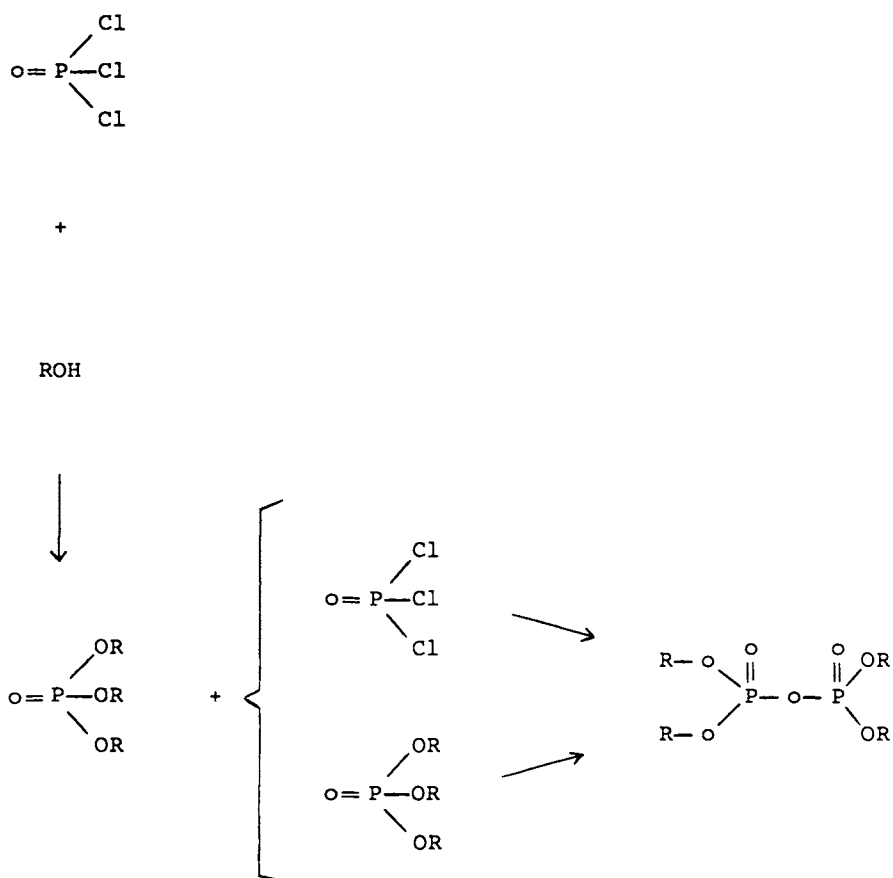
Type: phosphorotrithioite

Synthesis:



# PYROPHOSPHATES

Pyrophosphates are usually obtained from phosphorus oxychloride by reaction with an alcohol, followed by reaction with phosphorus oxychloride or a phosphate





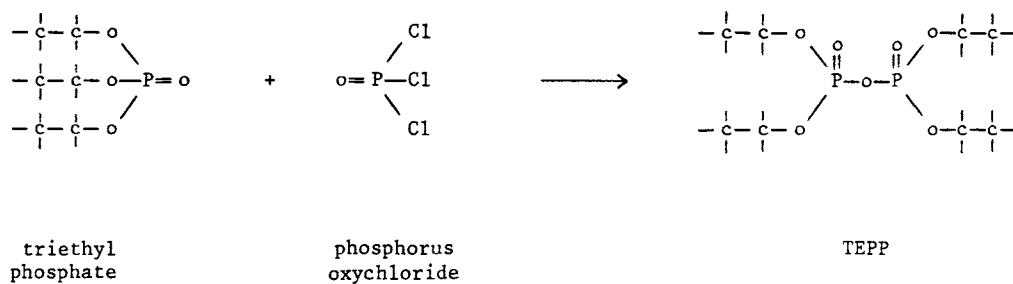
## TEPP

Uses: insecticide, fruit, vegetables, trees

Trade names: Vapotone, Tetron, Neotox (Chevron)

Type: pyrophosphate

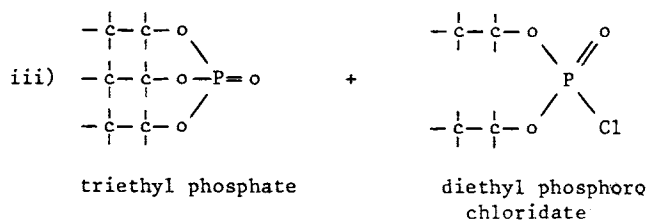
Synthesis:



alternate routes :

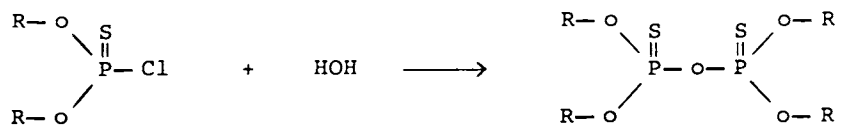
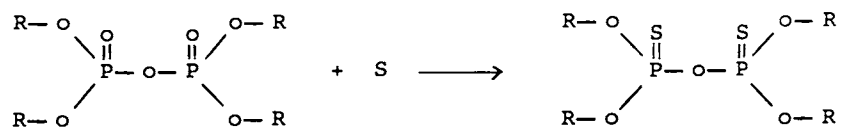
i) triethyl phosphate +  $\text{P}_2\text{O}_5$

ii)  $\text{---C---C---OH}$  + phosphorus oxychloride



## THIOPYROPHOSPHATES

Thiopyrophosphates are obtained by reaction of a pyrophosphate and sulfur or by hydrolysis of DEPCT in an alkaline medium.



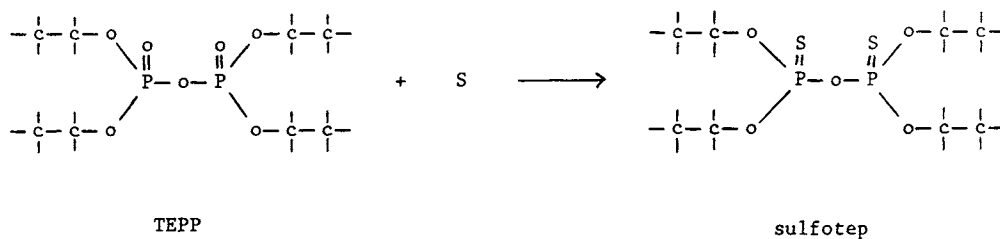
## Sulfotep

Uses: insecticide, vegetables

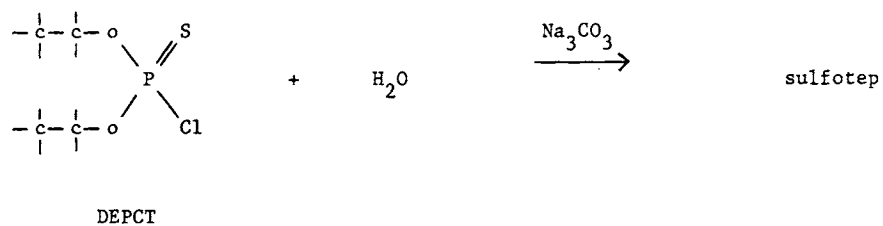
Trade names: Bladafum (Bayer)

Type: thiopyrophosphate

Synthesis:



alternate route :



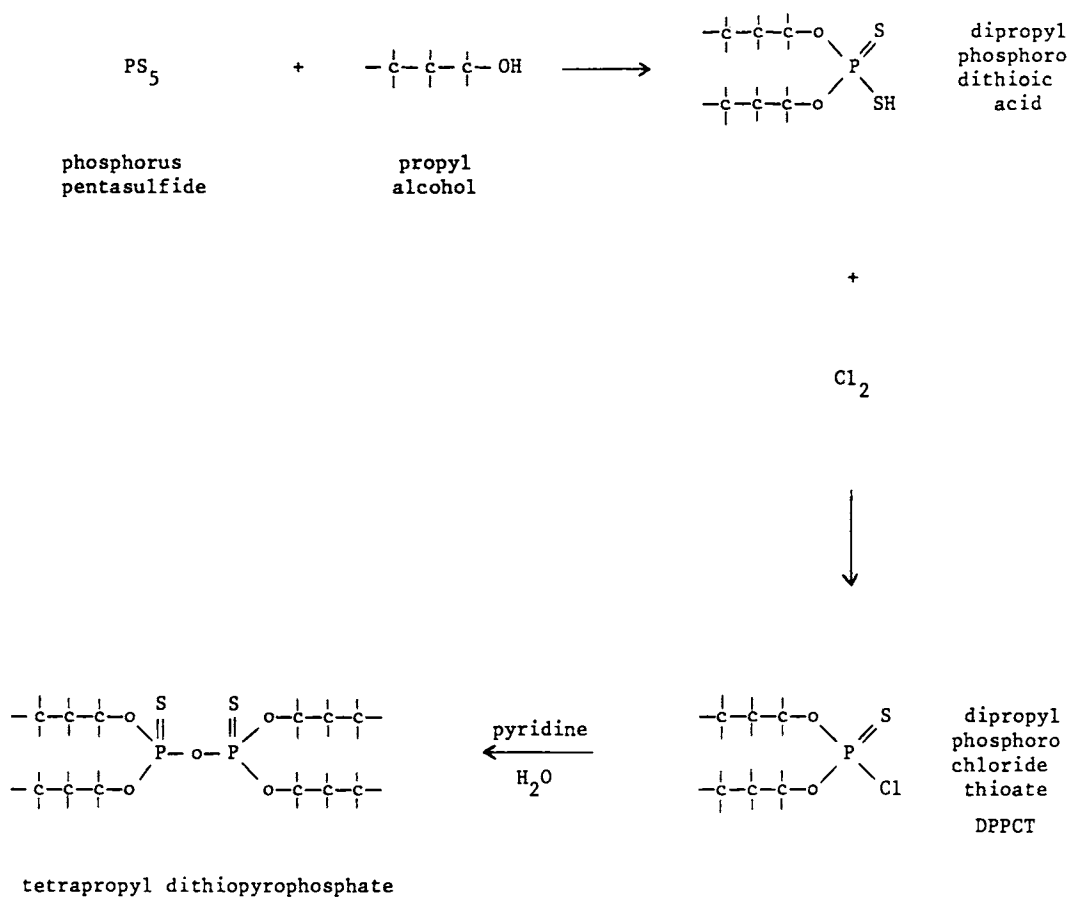
**o,o,o',o', Tetrapropyl Dithiopyrophosphate**

Uses: insecticide, turf

Trade names: Aspon (ICI)

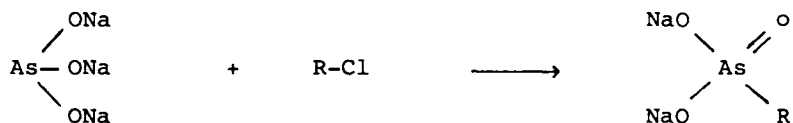
Type: thiopyrophosphate

Synthesis:



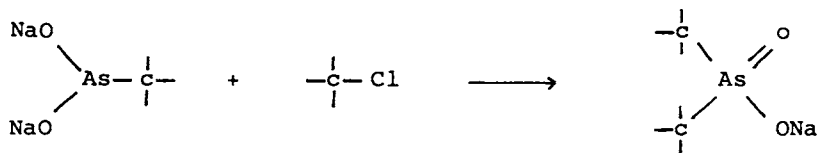
## ORGANO ARSENIC

Arsenates are synthesized by reacting an organo halogen with sodium arsenite



The chemistry of arsenic is basically similar to that of phosphorous.

For instance in the synthesis of dimethyl arsinic acid (cacodylic acid) trivalent arsenic is isomerised to the pentavalent state



Arsenic based products however have nowhere near the importance of phosphoro organics.

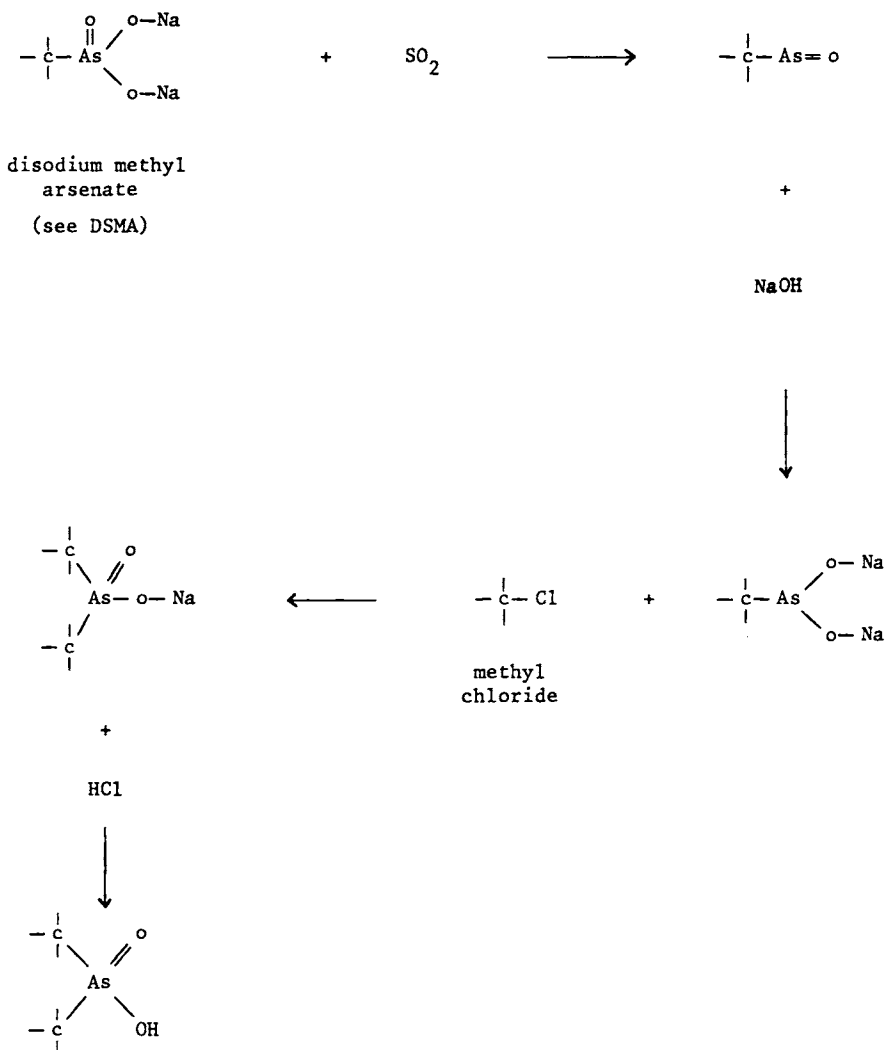
## Cacodylic Acid (Dimethyl Arsenic Acid)

Uses: herbicide, non crop land

Trade names: Phytar, Boll's-Eye (Vertac)

Type: organo arsenic

Synthesis:



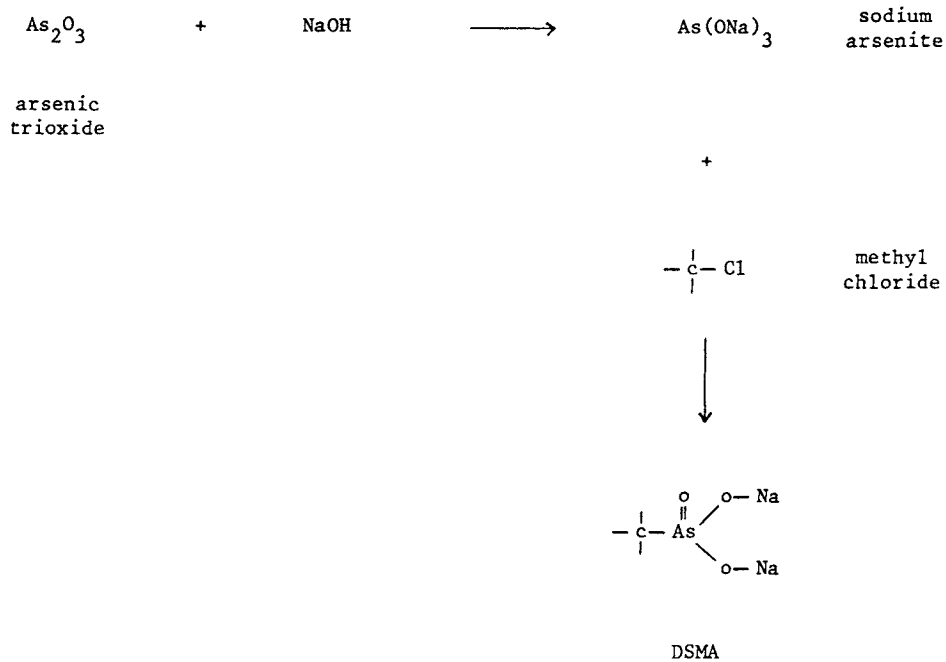
## DSMA (Disodium Methyl Arsonate)

Uses: herbicide, cotton, citrus, non crop lands

Trade names: Ansar (Fermenta)

Type: organo arsenic

Synthesis:



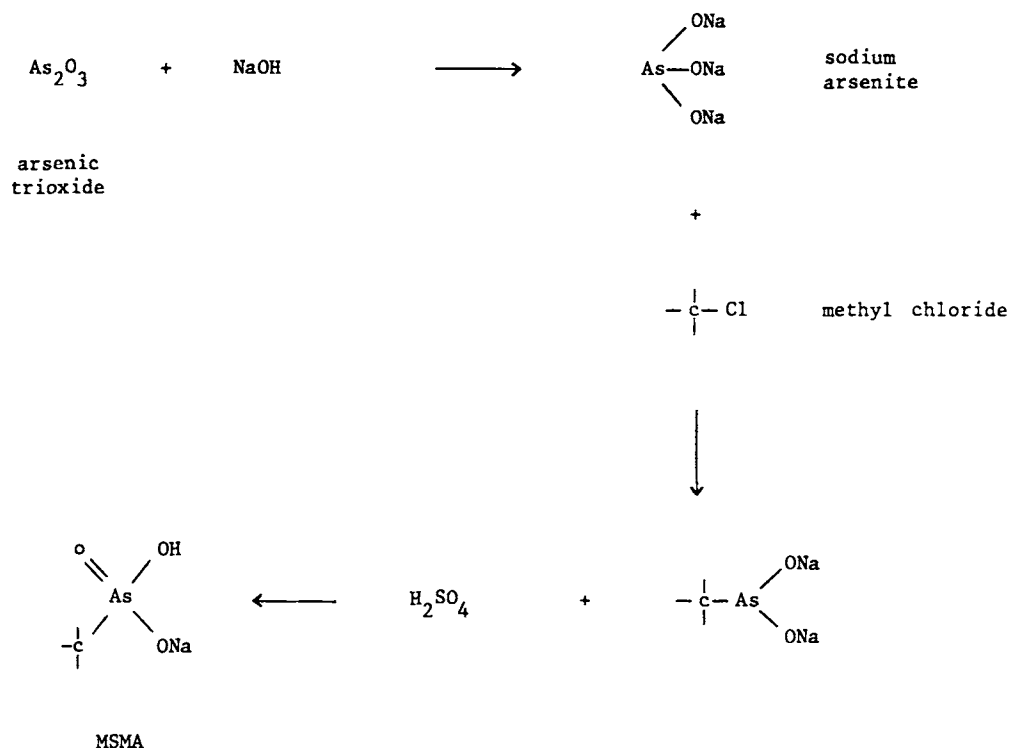
## MSMA (Monosodium Methane Arsonate)

Uses: herbicide, cotton, sugar cane, non crop lands

Trade names: Ansar, Daconate, Bueno, Arsonate, Super Argonate (Diamond Shamrock),  
Fermenta, Mesamate (Vertac), Trans-Vert (U.Carbide)

Type: organo arsenic

Synthesis:





## ORGANO MERCURICS

Mercury is incorporated in the organic molecule by using mercury acetate as the starting point for synthesis.

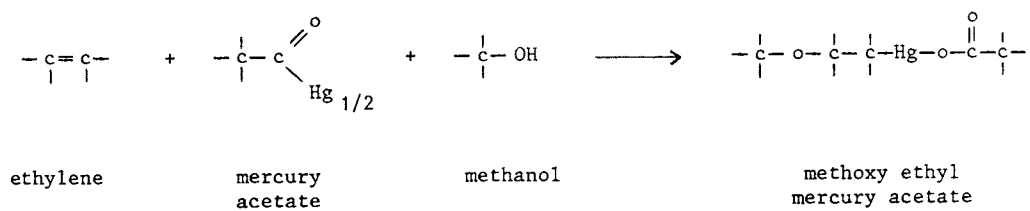
## Methoxy Ethyl Mercury Acetate

Uses: fungicide, wheat, barley, oats, rye

Trade names: Panogen (Shell)

Type: organo mercuric

Synthesis:



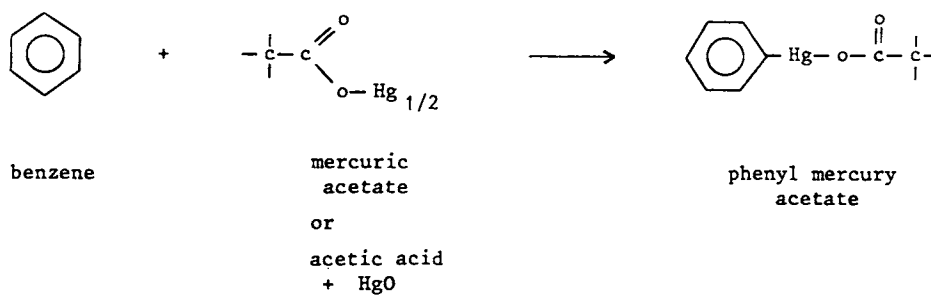
## Phenylmercury Acetate

Uses: fungicide, cereal seeds

Trade names: Agrosan, Cerasol (ICI), Mist-o-Matic (Dow Elanco)

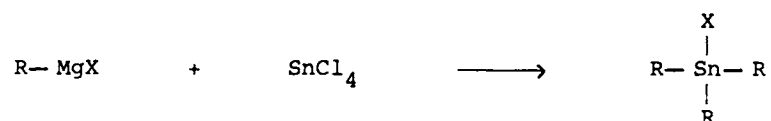
Type: organo mercuric

Synthesis:



## ORGANO TINS

Organotins are obtained by reaction between the Grignard reagent and tin tetra chloride



Hydrolysis or other substitution of the halogen X leads to the final product.

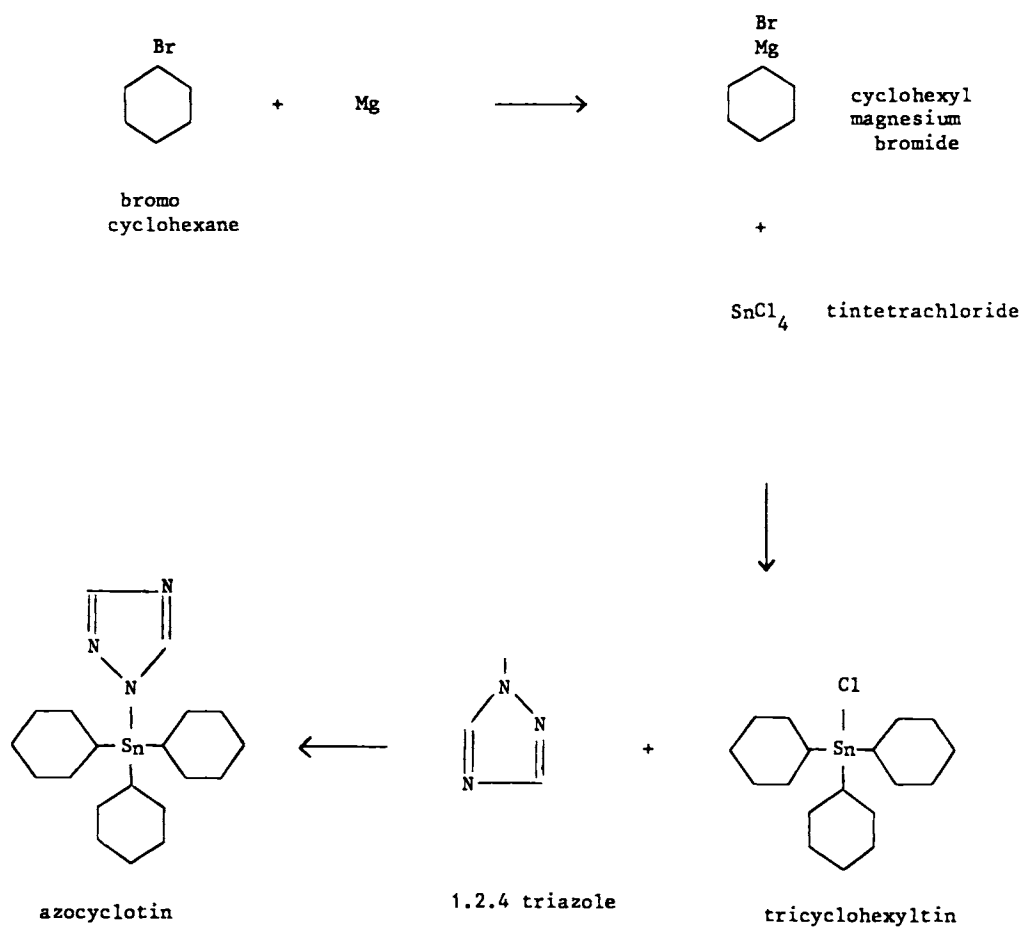
## Azocyclotin

Uses: acaricide, citrus, cotton, fruit, grapes, vegetables

Trade names: Clermait, Peropal (Bayer)

Type: organotin, triazole

Synthesis:



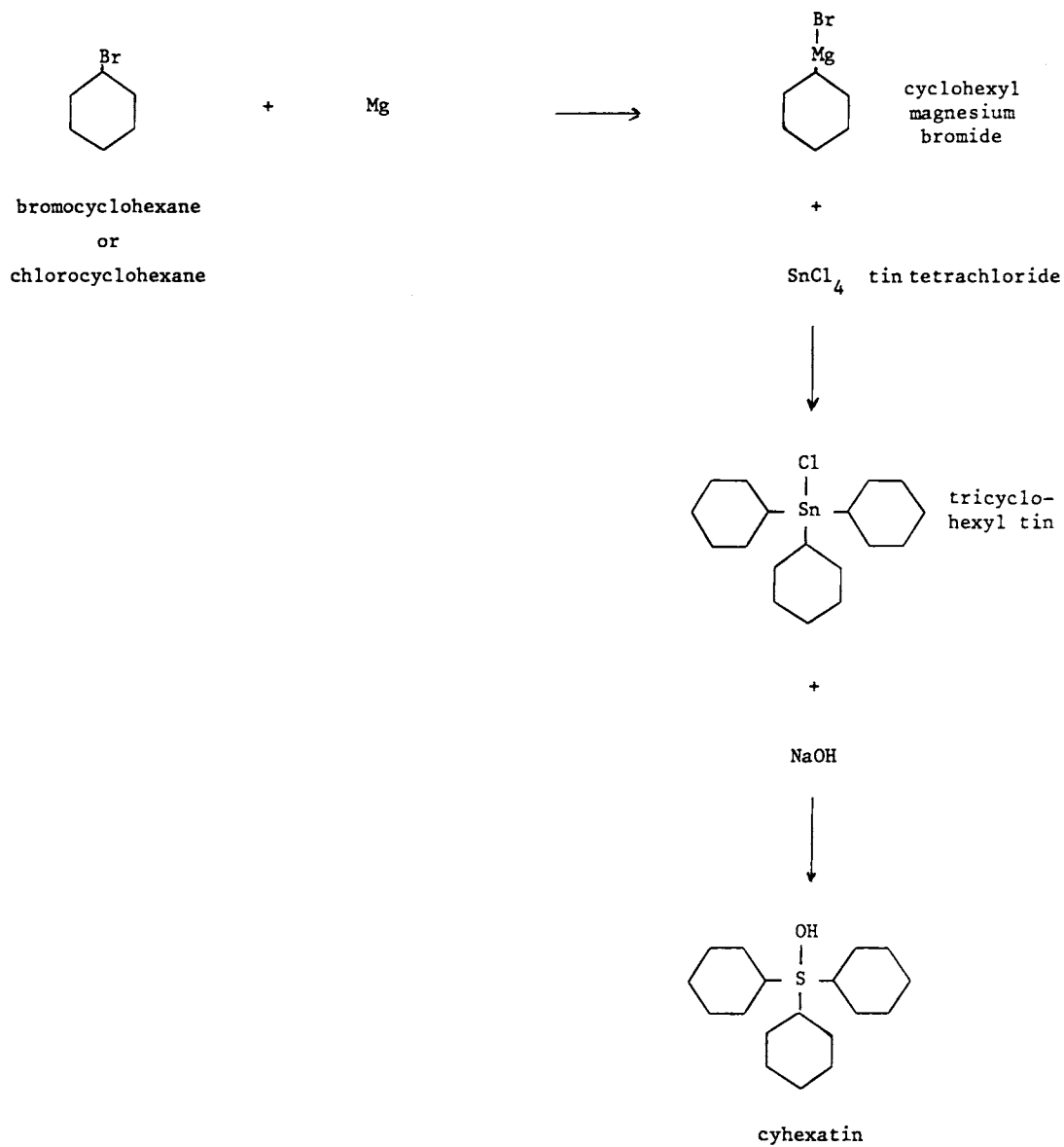
## Cyhexatin

Uses: acaricide, citrus

Trade names: Plictran (Dow)

Type: organotin

Synthesis:



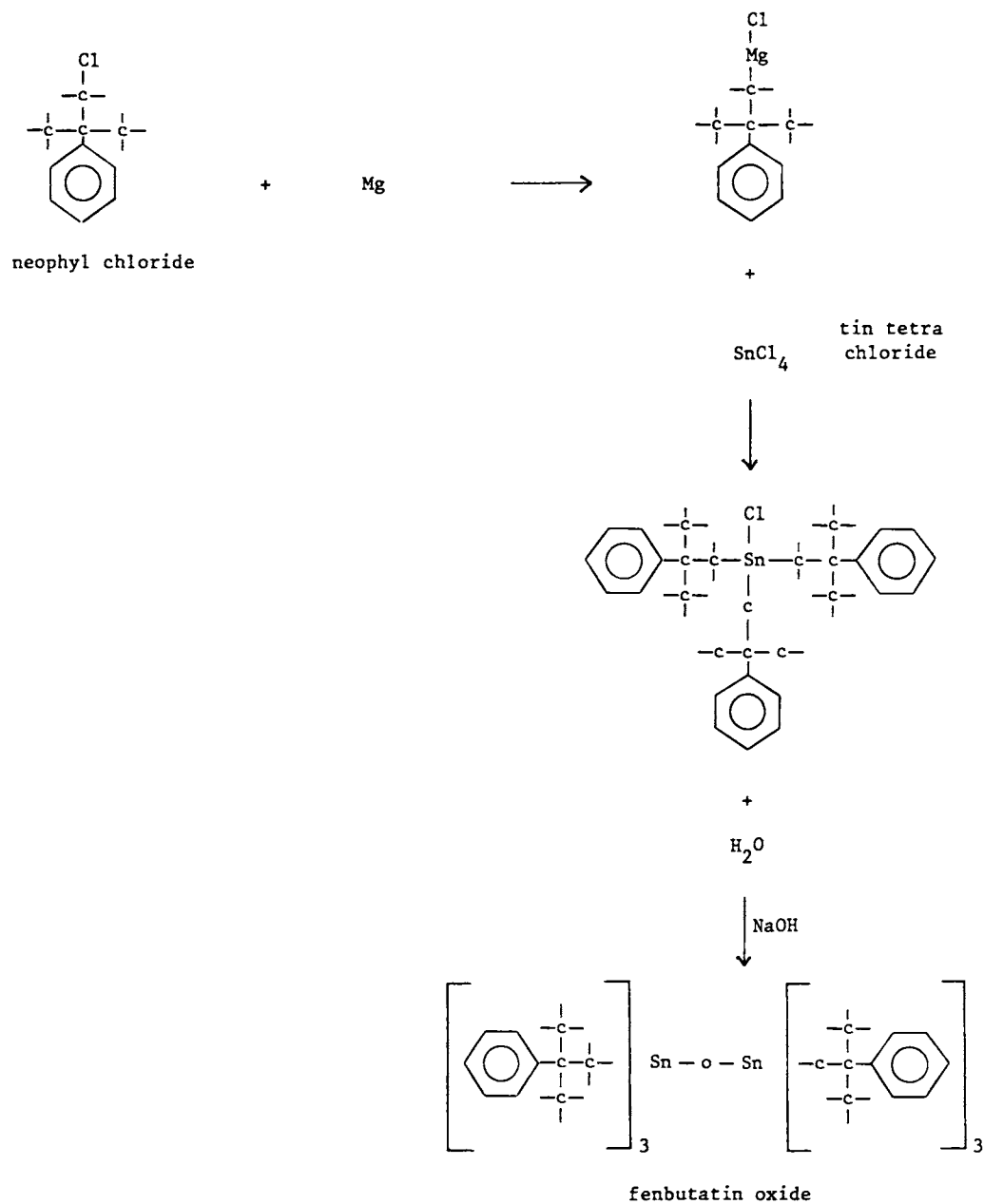
## Fenbutatin Oxide

Uses: acaricide, citrus, grapes, fruit, vegetables

Trade names: Vendex, Osadan, Torque (Shell)

Type: organotin

Synthesis:



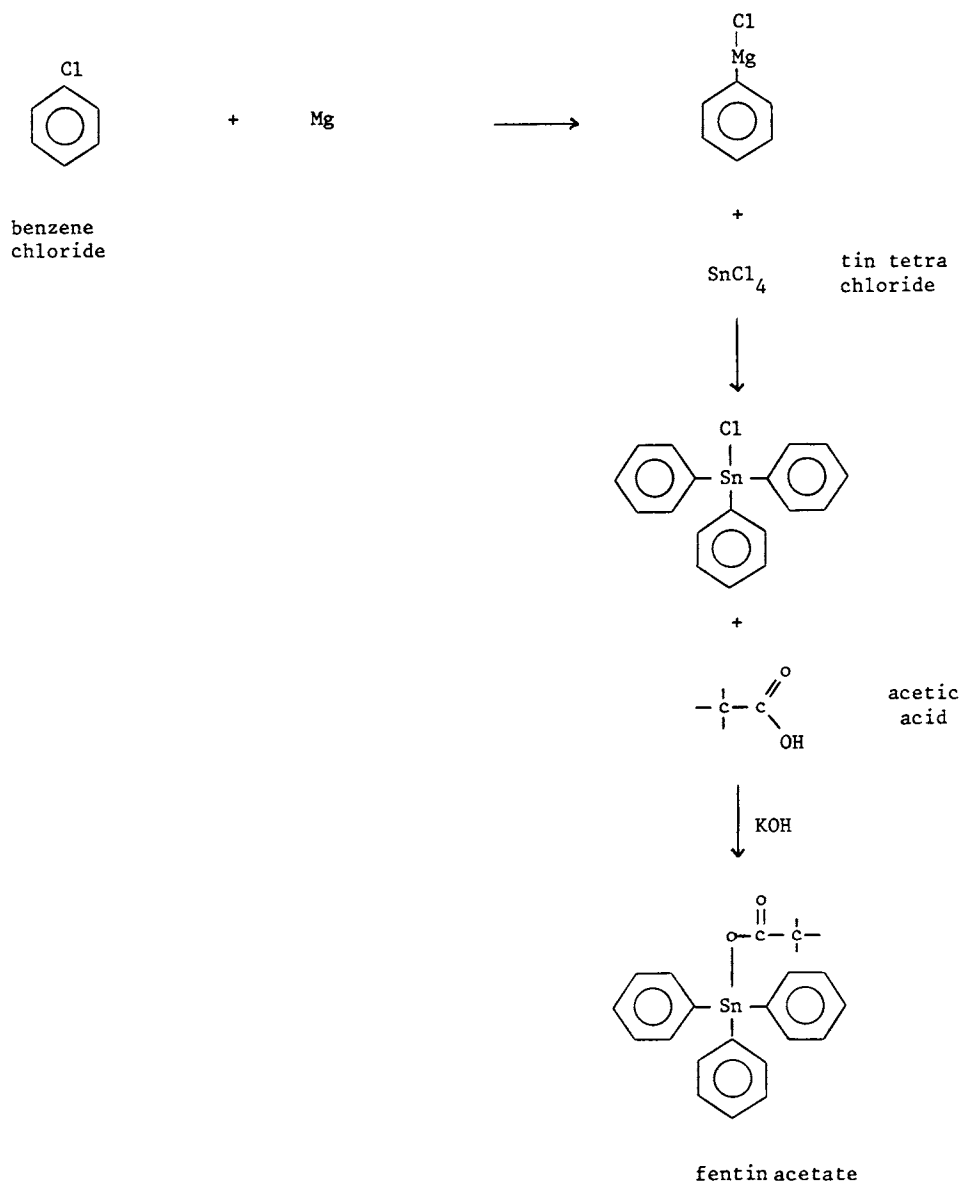
## Fentin Acetate

Uses: fungicide, potatoes, tobacco, coffee, sugar beet, rice

Trade names: Brestan (Hoechst)

Type: organotin

Synthesis:





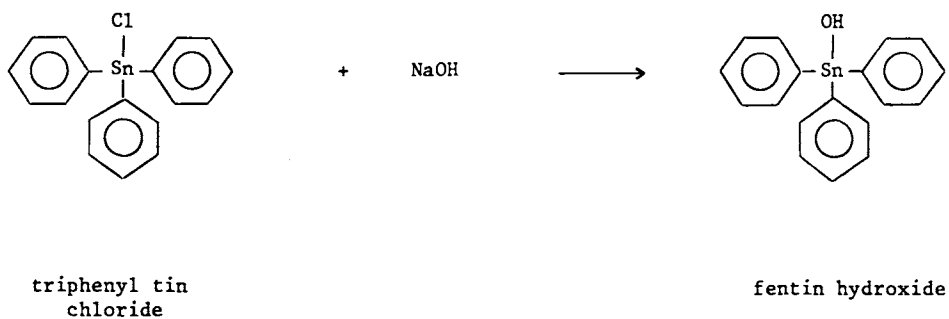
## Fentin Hydroxide

Uses: fungicide, potatoes, tobacco, coffee, sugar beet, rice

Trade names: Duter (Shell), Tubotin (Rhone Poulenc), Brestan (Hoechst)

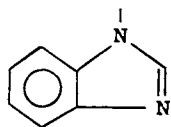
Type: organotin

Synthesis:

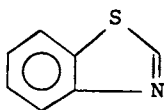


(see fentin acetate)

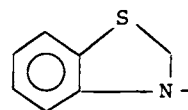
## HETEROCYCLIC NITROGEN COMPOUNDS



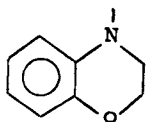
benzimidazole



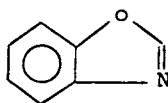
benzothiazole



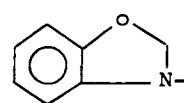
benzothiazoline



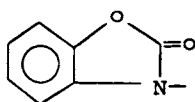
benzoxazine



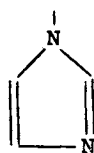
benzoxazole



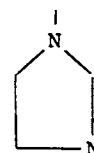
benzoxazoline



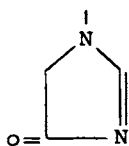
benzoxazolinone



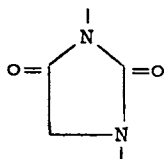
imidazole



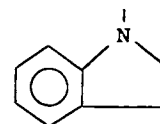
imidazoline



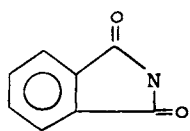
imidazolinone



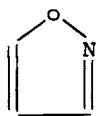
imidazolidinone



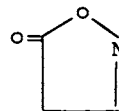
indole



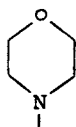
indole-1,2-dione



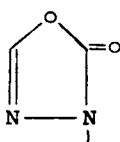
isoxazole



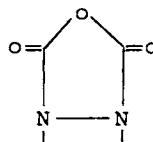
isoxazolone



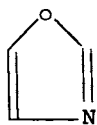
morpholine



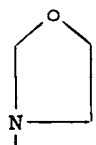
oxadiazolone



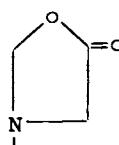
oxadiazoledione



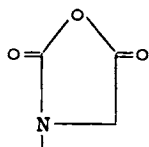
oxazole



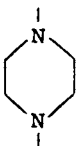
oxazolidine



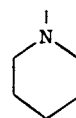
oxazolidinone



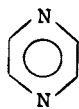
oxazolidinedione



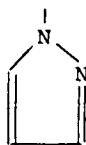
piperazine



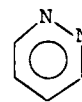
piperidine



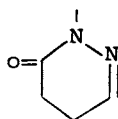
pyrazine



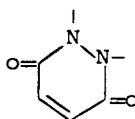
pyrazole



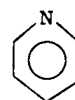
pyridazine



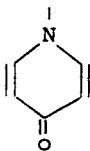
pyridazinone



pyradazinedione



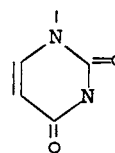
pyridine



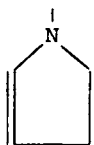
pyridone



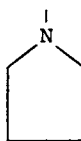
pyrimidine



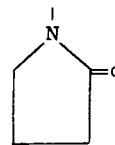
pyrimidinedione



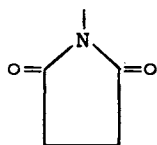
pyrrole



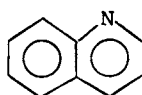
pyrrolidine



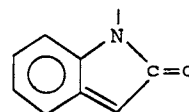
pyrrolidinone  
pyrrolidone



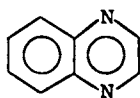
pyrrolidinedione



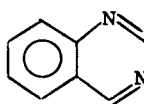
quinoline



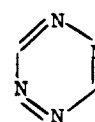
quinolinone



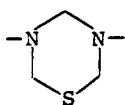
quinoxaline



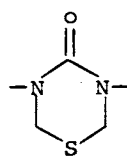
quinazoline



tetrazine



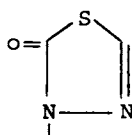
thiadiazine



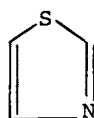
thiadiazinone



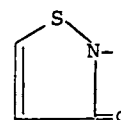
thiadiazole



thiadiazolone



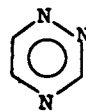
thiazole



thiazolone



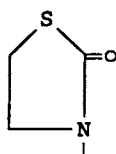
1.3.5 triazine



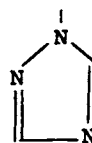
1.2.4 triazine



thiazolidine



thiazolidinone



1.2.4 triazole

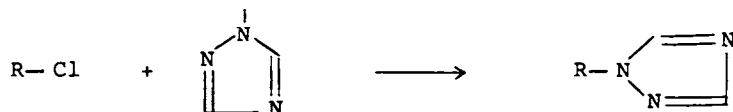
The generic term refers to a large variety of different products all of which have a cyclic amine ring in the molecule.

From the point of view of their synthesis they can be classified in two main groups:

- A) Products in which the cyclic amine being a fairly common product - usually commercially available - is hooked on, ready made, to the rest of the molecule.

This is the case for instance of imidazoles, triazoles, and triazines derived from cyanuric chloride among others.

For a triazole for instance the common synthesis path is:



- B) Amine rings which are cyclised tailor made during the synthesis of the pesticide.

These are either:

- B-1) Special products such as for instance thiadiazoles, isoxazoles, pyridazinones, pyrazines, pyrazoles, etc.

or

- B-2) More common rings, which however can not be adequately treated once cyclised. For instance it is difficult to halogenate pyridine in certain ring positions. Therefore when a halogen is required in those positions, it is introduced into an aliphatic molecule which is then cyclised during the synthesis.

On the other hand if a pyridine structure which is amenable to halogenation is required, then the pyridine is halogenated and connected ready made with the rest of the molecular structure no special cyclisation being required.

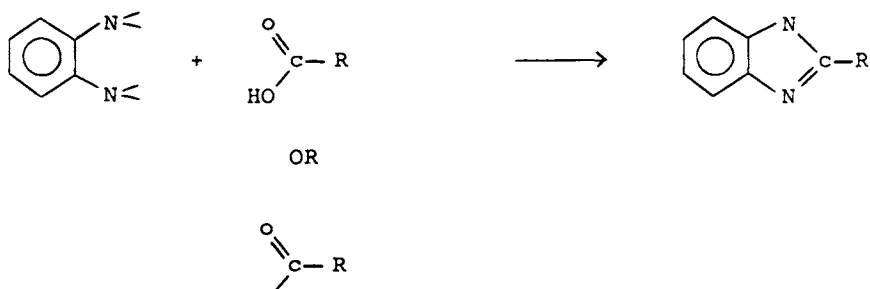
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Heterocyclic nitrogen rings also appear frequently together with other leading functions such as amides, sulfonyl ureas, etc.

## BENZIMIDAZOLES

Orthophenylene diamine is the starting point for the synthesis of benzimidazoles.

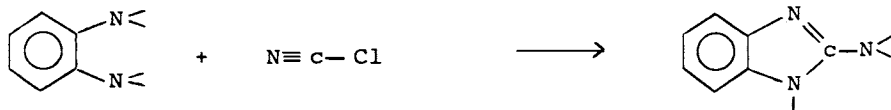
One route is by reaction between ortho phenylene diamine and a carboxylic group (or a carbonyl group in oxidising media)



Another route is by reaction with a nitrile

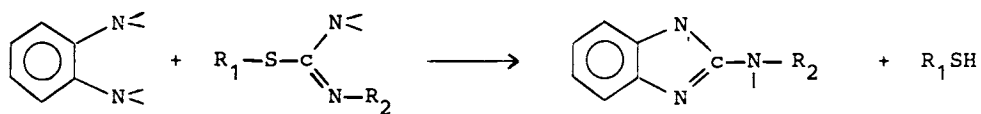


When N≡C-Cl (chlorine cyanide) is used amino benzimidazole is obtained

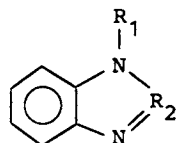




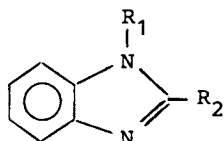
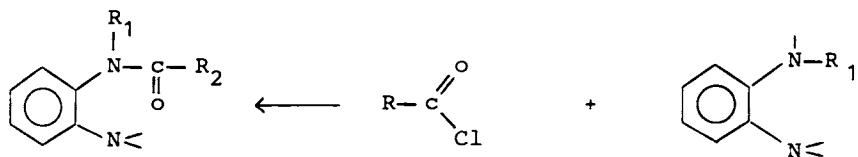
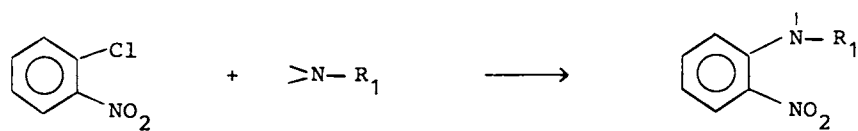
Reaction with a pseudo thiourea also leads to the benzimidazole rings



If the desired product is



then the starting point is ortho nitro chlorobenzene, and an acid chloride is used



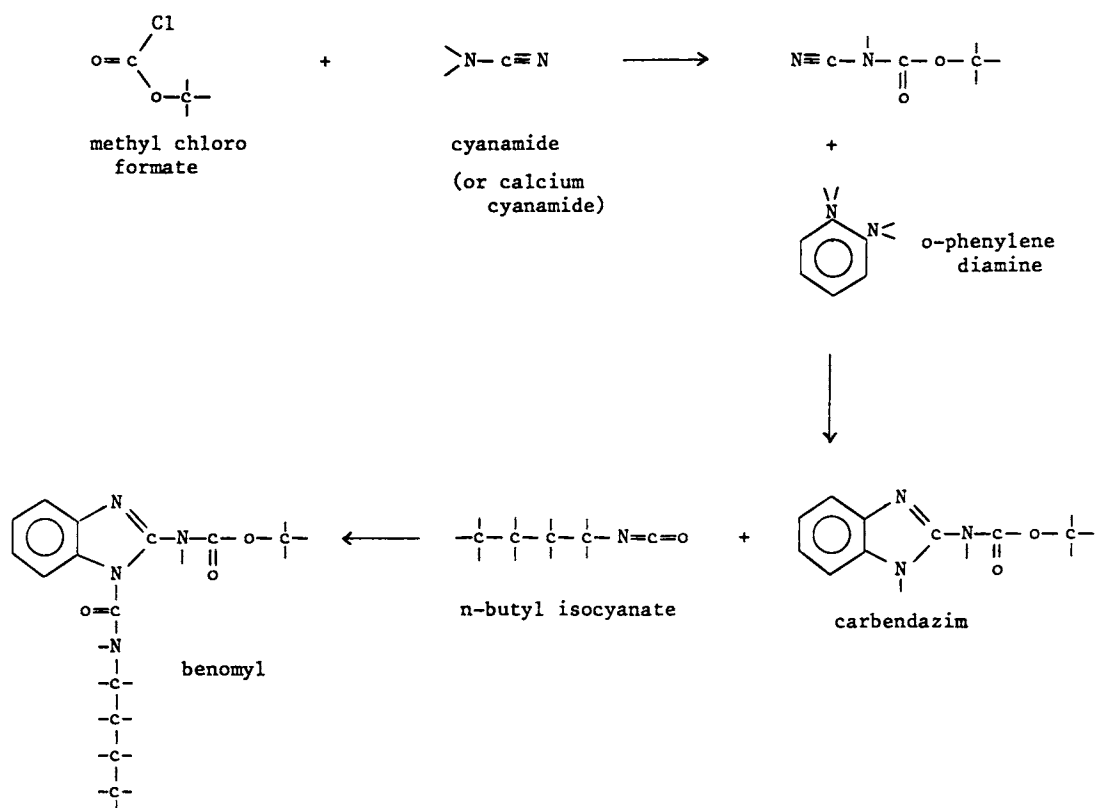
## Benomyl

Uses: fungicide, cereals, grapes, rice, vegetables

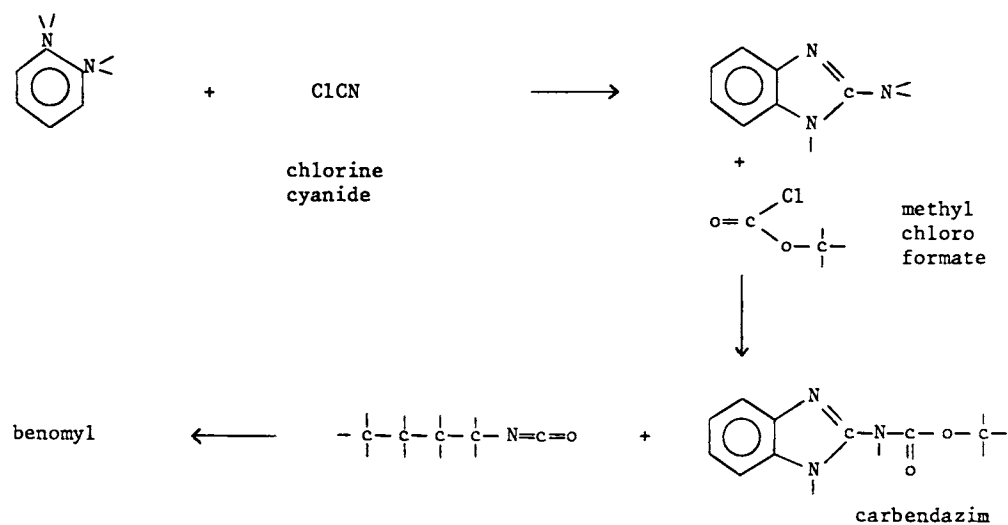
Trade names: Benlate (Dupont)

Type: benzimidazole, carbamate

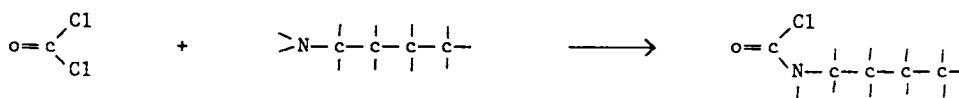
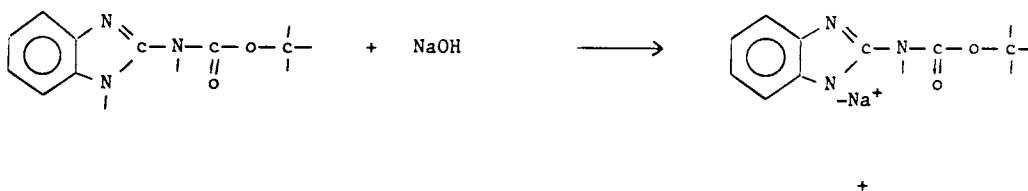
**Synthesis:**



alternate route :



alternate route



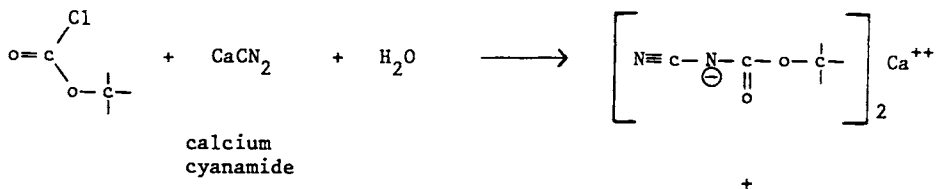
phosgene

butyl amine



benomyl

alternate route



o-phenylene diamine



carbendazim

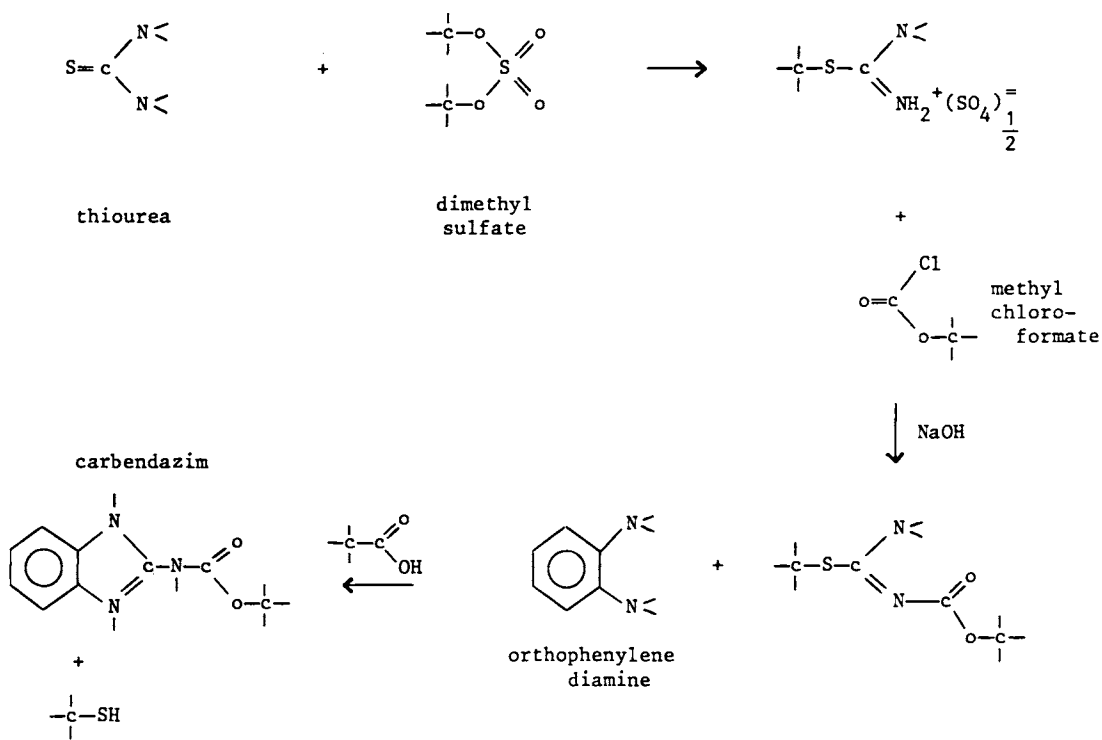
## Carbendazim

Uses: fungicide, bananas, cereals, grapes, rice, sugarbeet, vegetables

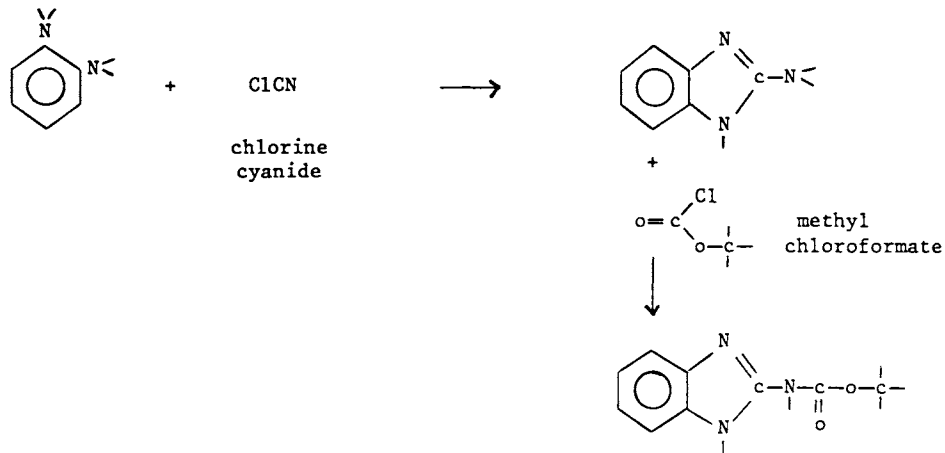
Trade names: Bavistin (BASF), Derosal (Hoechst), Delsene (Dupont)

Type: benzimidazole, carbamate

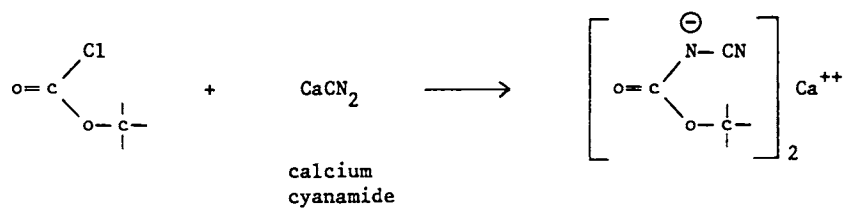
**Synthesis:**



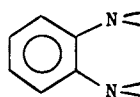
alternate route :



alternate route :



+



HCl

carbendazim

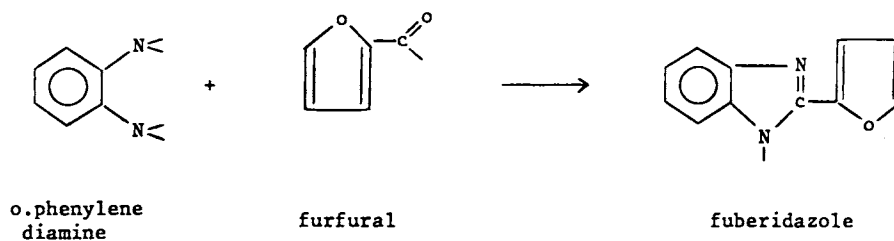
## Fuberidazole

Uses: fungicide, cereal, seed

Trade names: Voronit (Bayer)

Type: benzimidazole

Synthesis:



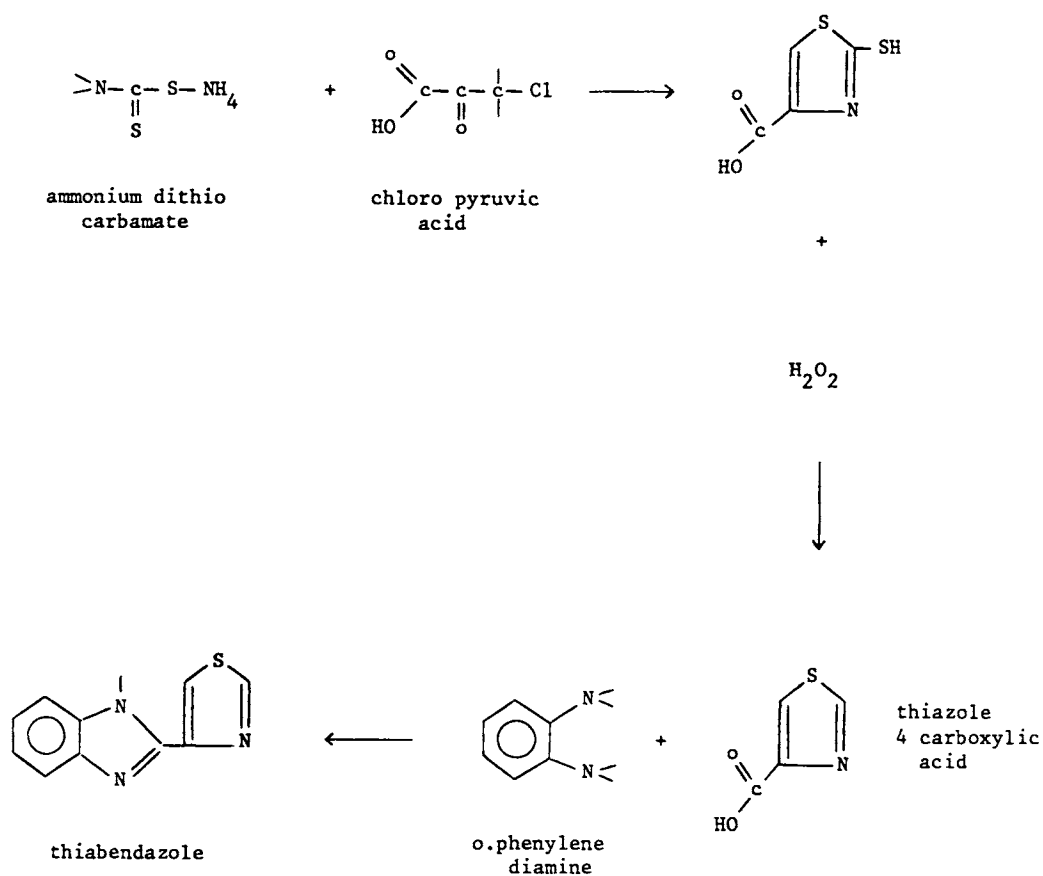
## Thiabendazole

Uses: fungicide, bananas, fruits, citrus, cotton, onions, rice, potatoes, soya beans, sugarbeet, tobacco, tomatoes, wheat

Trade names: Mertect, Tecto, Storite (Merck)

Type: benzimidazole, thiazole

Synthesis:



alternates routes :

- ethyl ester or acid chloride of thiazole 4 carboxylic acid
- thiazole 4 aldehyde instead of the carboxylic acid

# BENZOTHAZOLES BENZOTHAZOLINES BENZISOTHAZOLES

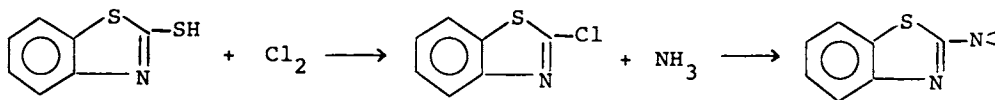
Benzothiazoles and benzothiazolines can be obtained by several routes:

i) amino benzothiazole

- cyclisation of chlorophenyl thiourea



- from mercapto benzothiazole by chlorination and ammoniation



ii) benzothiazolines

- reaction of o-chloro aniline with ammonium thiocyanate





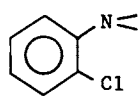
## Benazolin

Uses: herbicide, cereals, soya beans

Trade names: Cornox (Schering)

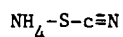
Type: benzothiazoline, carboxylic acid

Synthesis:

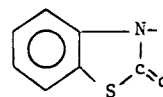


2 chloro  
aniline

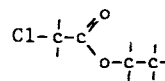
+



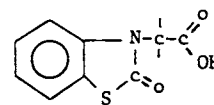
ammonium thio  
cyanate



+

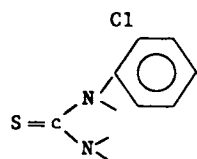


ethyl  
chloroacetate

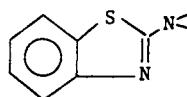


benazolin

alternate route



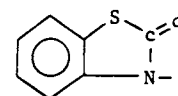
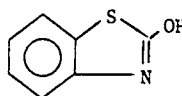
2 chlorophenyl  
thio urea



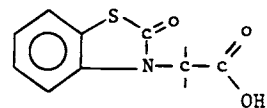
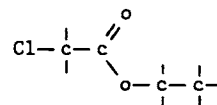
2 amino 4 chloro  
benzothiazole



hydrolysis



+



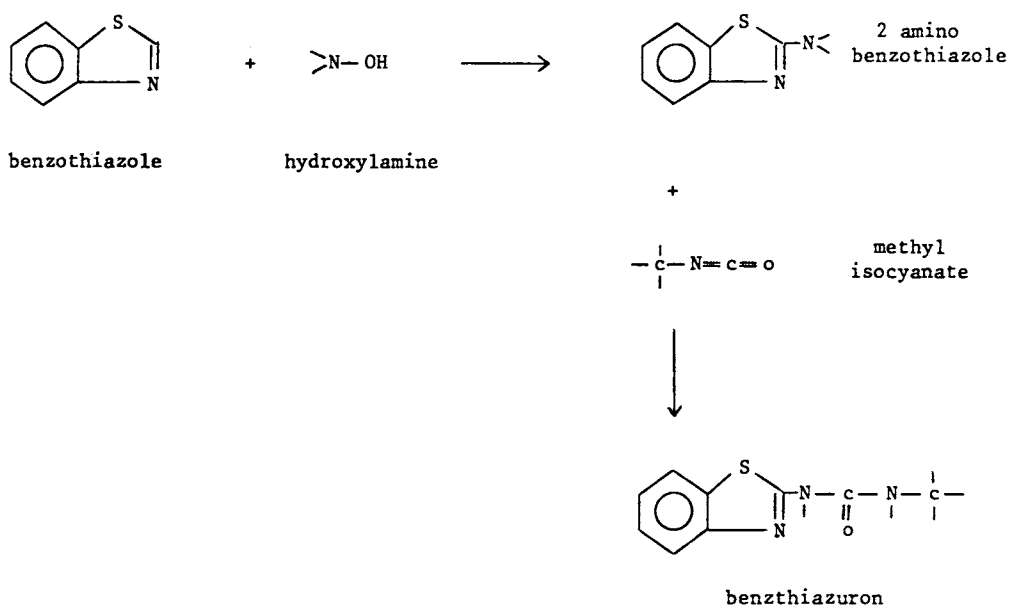
## Benzthiazuron

Uses: herbicide, sugar beet

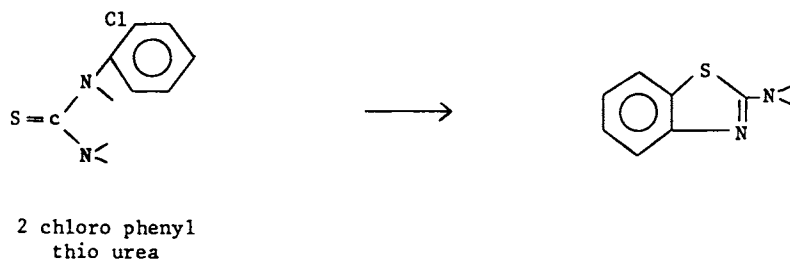
Trade names: Gatnon (Bayer)

Type: benzothiazole, urea

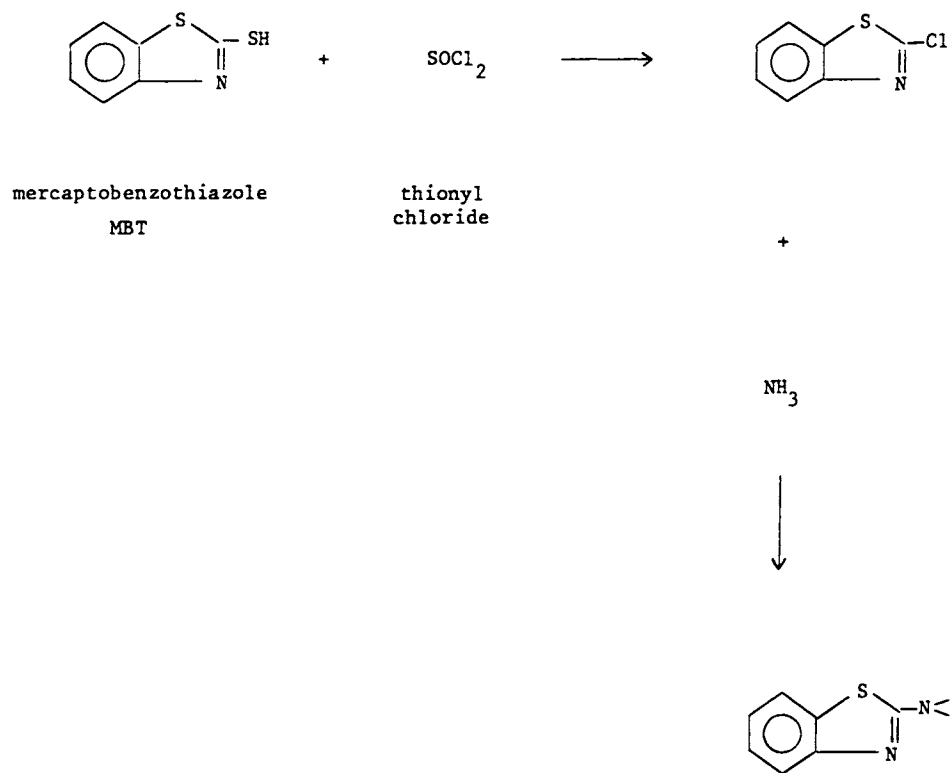
Synthesis:



alternate route



alternate route:



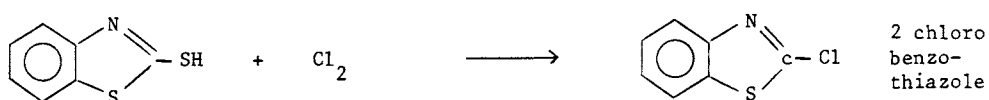
## Mefenacet

Uses: herbicide, rice

Trade names: Hinochloa, Rancho (Bayer)

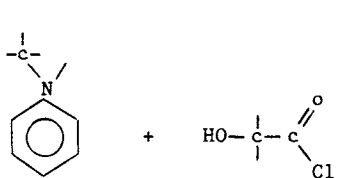
Type: benzothiazole, amide

Synthesis:



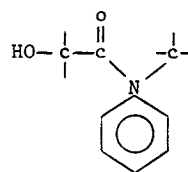
mercapto benzo  
thiazole MBT

+

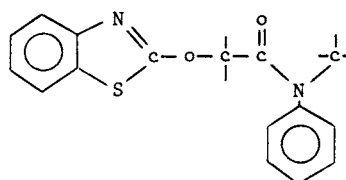


N-methyl  
aniline

hydroxy  
acetyl chloride



hydroxy acetic  
acid N-methyl,  
anilide



mefenacet

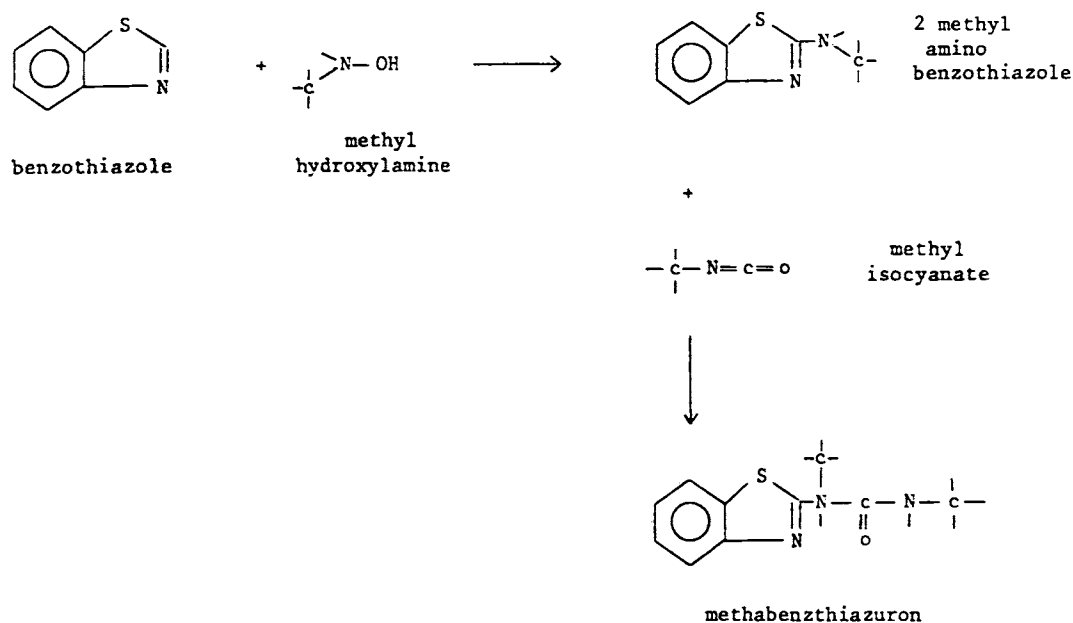
## Methabenzthiazuron

Uses: herbicide, cereals, onions

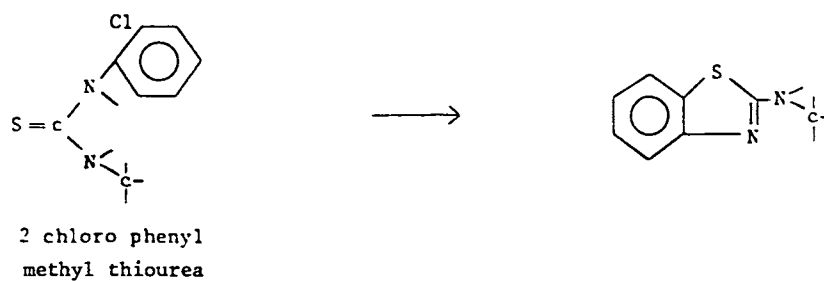
Trade names: Tribunil (Bayer)

Type: benzothiazole, urea

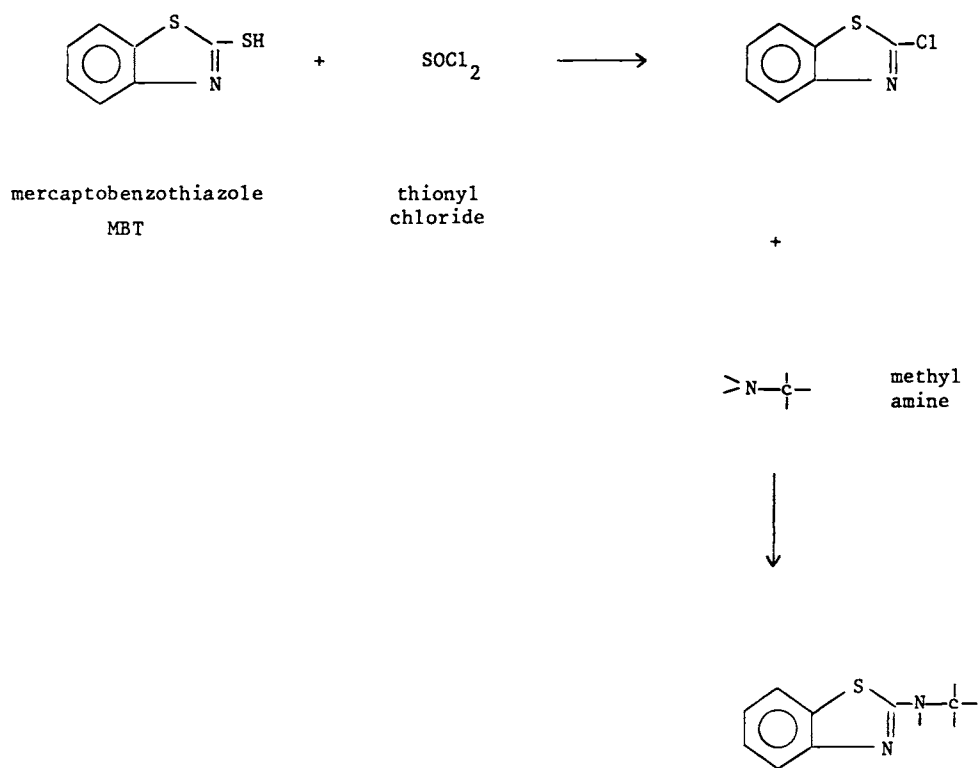
Synthesis:



alternate route



alternate route:



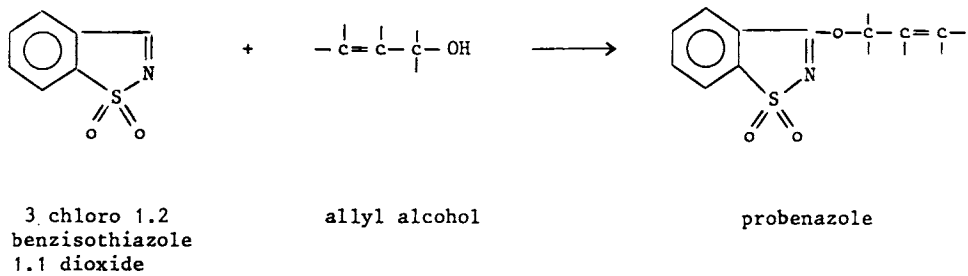
## Probenazole

Uses: fungicide, rice

Trade names: Oryzemat, Oryzaemat (Meiji Seika)

Type: benzisothiazole

Synthesis:





# BENZOXAZINE

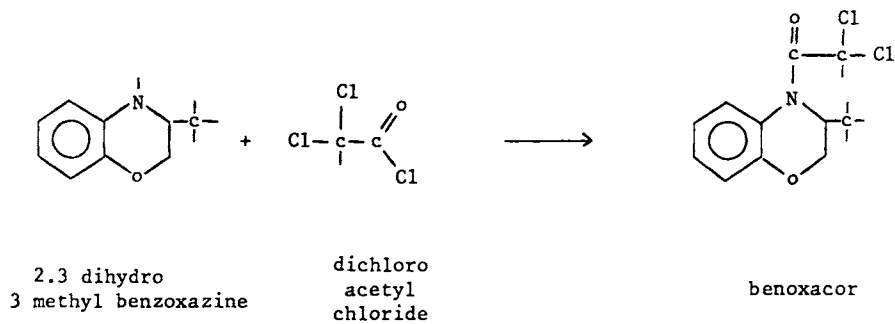
## Benoxacor

Uses: herbicide, maize

Trade names: Dual (Ciba)

Type: benzoxazine, amide

Synthesis:



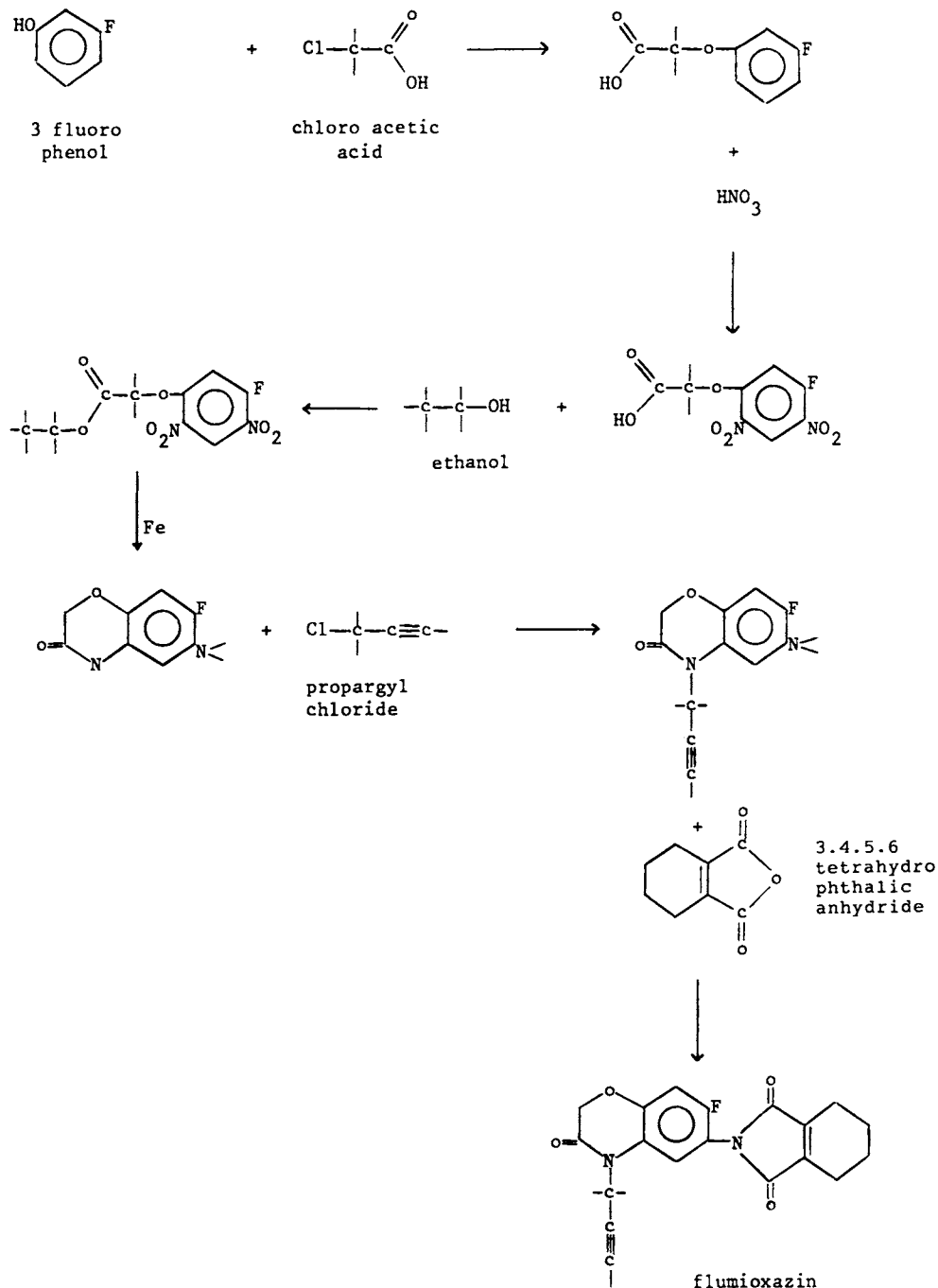
## Flumioxazin

Uses: herbicide, soyabeans, peanuts

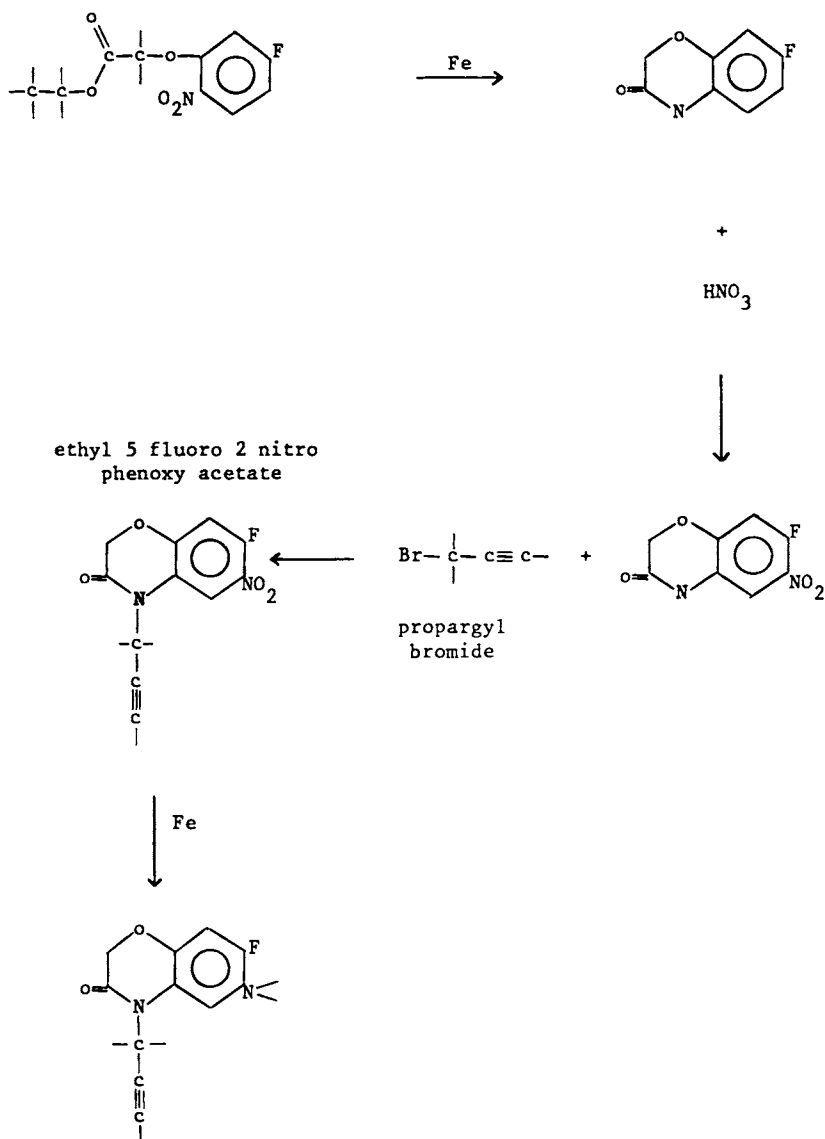
Trade names: Sumisoya (Sumitomo)

Type: heterocyclic nitrogen benzoxazine, indole

Synthesis:

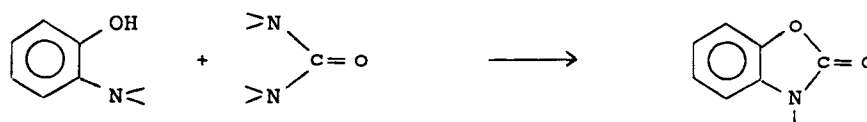


alternate route :



# BENZOXAZOLES BENZOXAZOLINES BENZOXAZOLINONES BENZOXAZOLONES

Benzoxazolone is synthesized by reaction between ortho amino phenol and urea



Benzoxazoles may be obtained from mercapto benzaxazole eliminating the SH radical by chlorination, followed by further synthesis steps



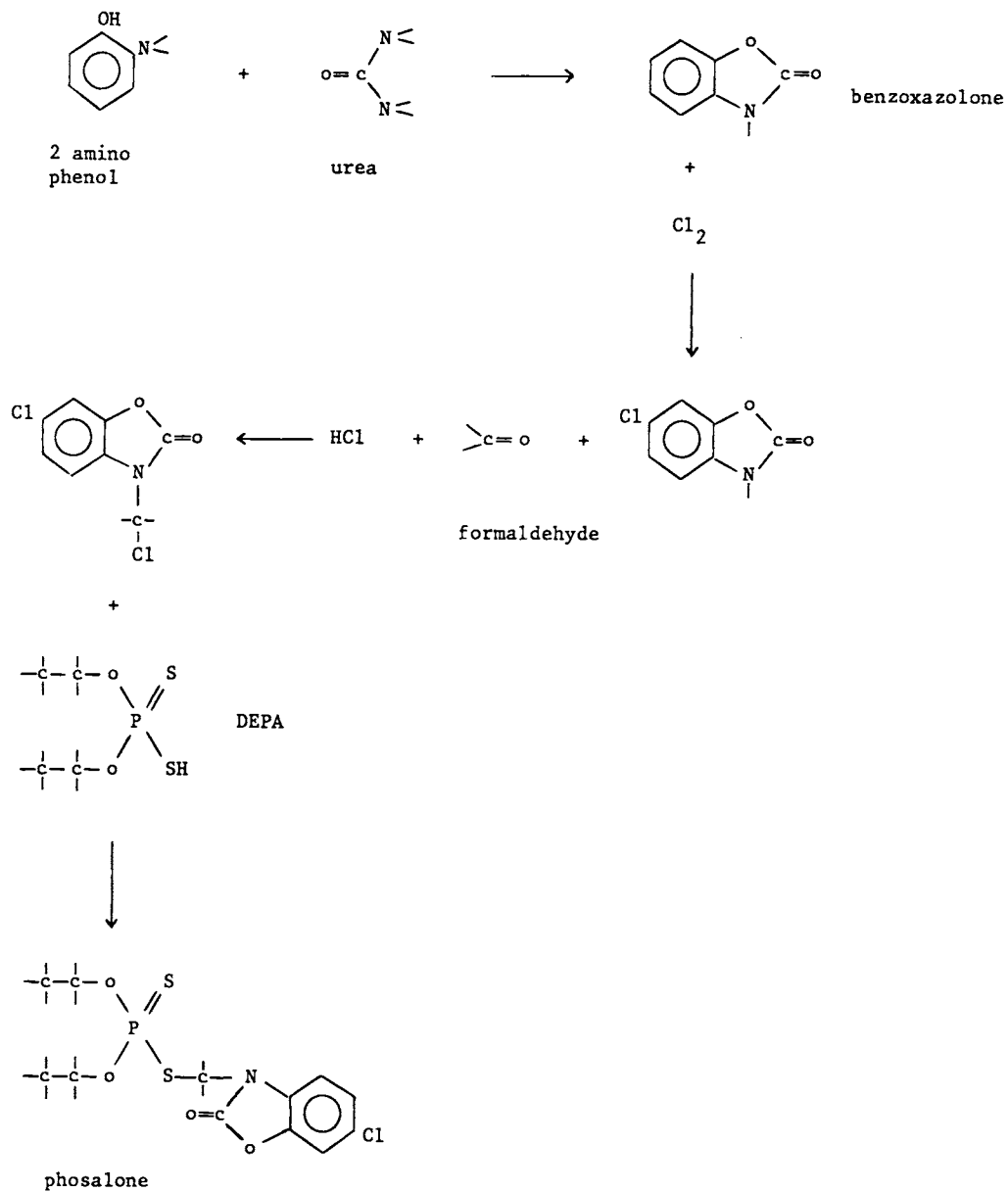
## Phosalone

Uses: insecticide, fruit trees, grapes, potatoes, vegetables

Trade names: Zolone (Rhône Poulenc)

Type: benzoxazolinone, phosphoro dithioate

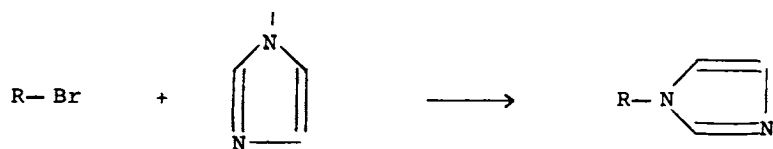
Synthesis:



## IMIDAZOLES

Imidazole is obtained by reaction between glyoxal, ammonia and formaldehyde.

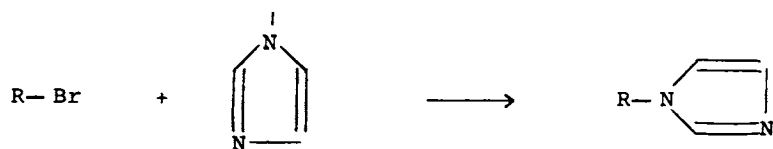
The imidazole ring is joined to the molecule by substitution of a halogen.



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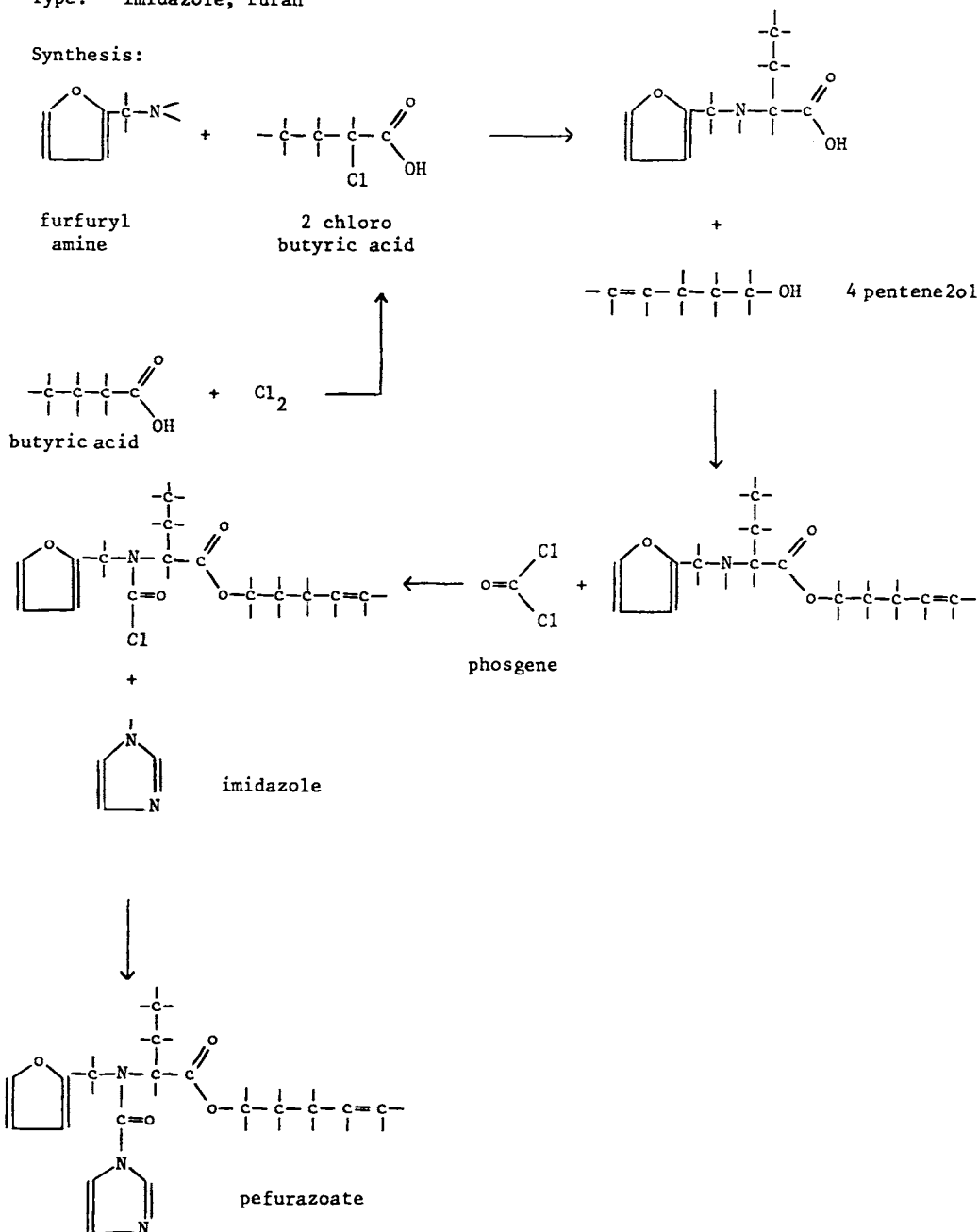
## Pefurazoate

Uses: fungicide

Trade names: Healthied (Hokko, Ube)

Type: imidazole, furan

**Synthesis:**





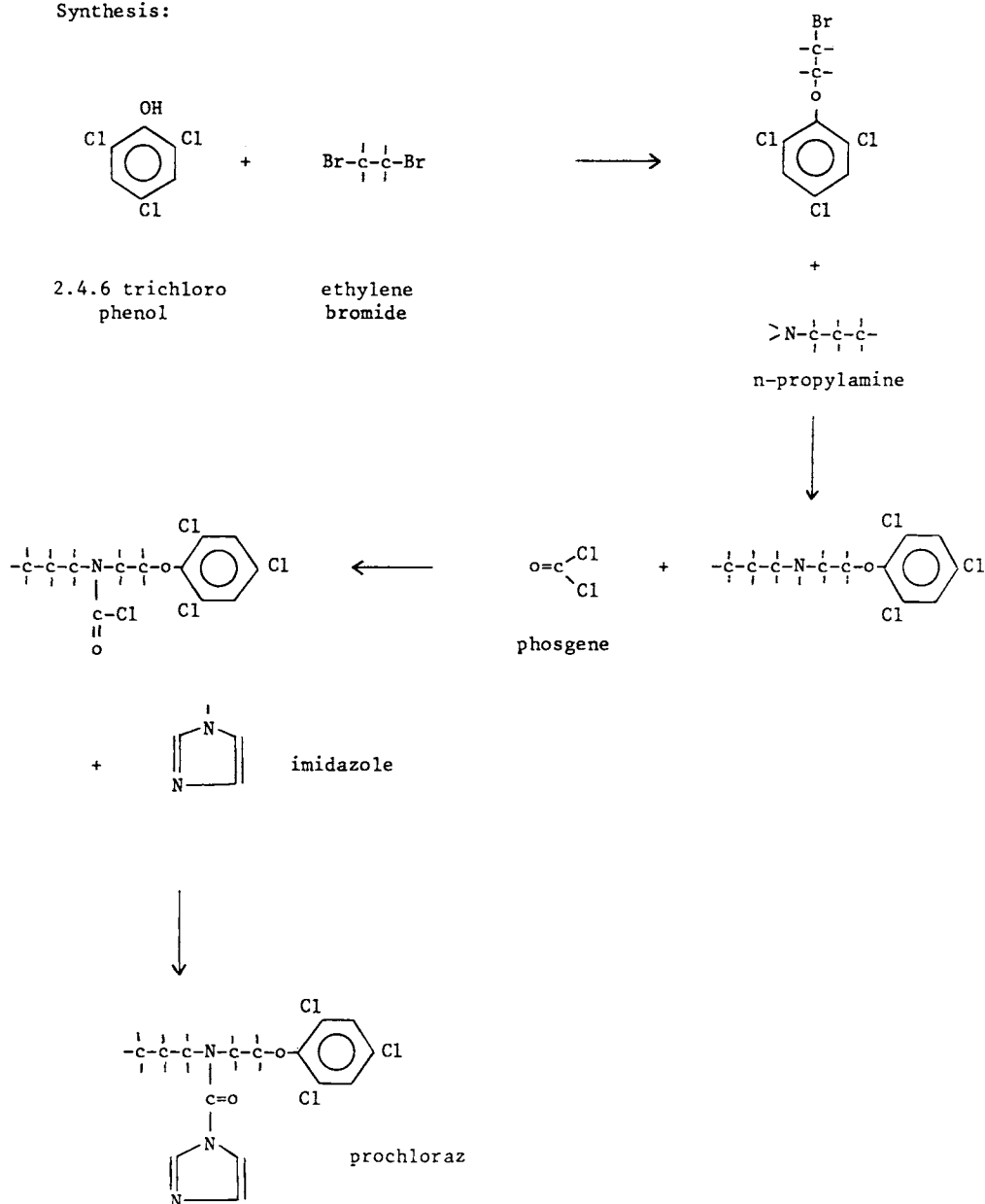
## Prochloraz

Uses: fungicide, cereals, coffee, rice, vegetables, fruit

Trade names: Schering (Sportak)

Type: imidazole

Synthesis:



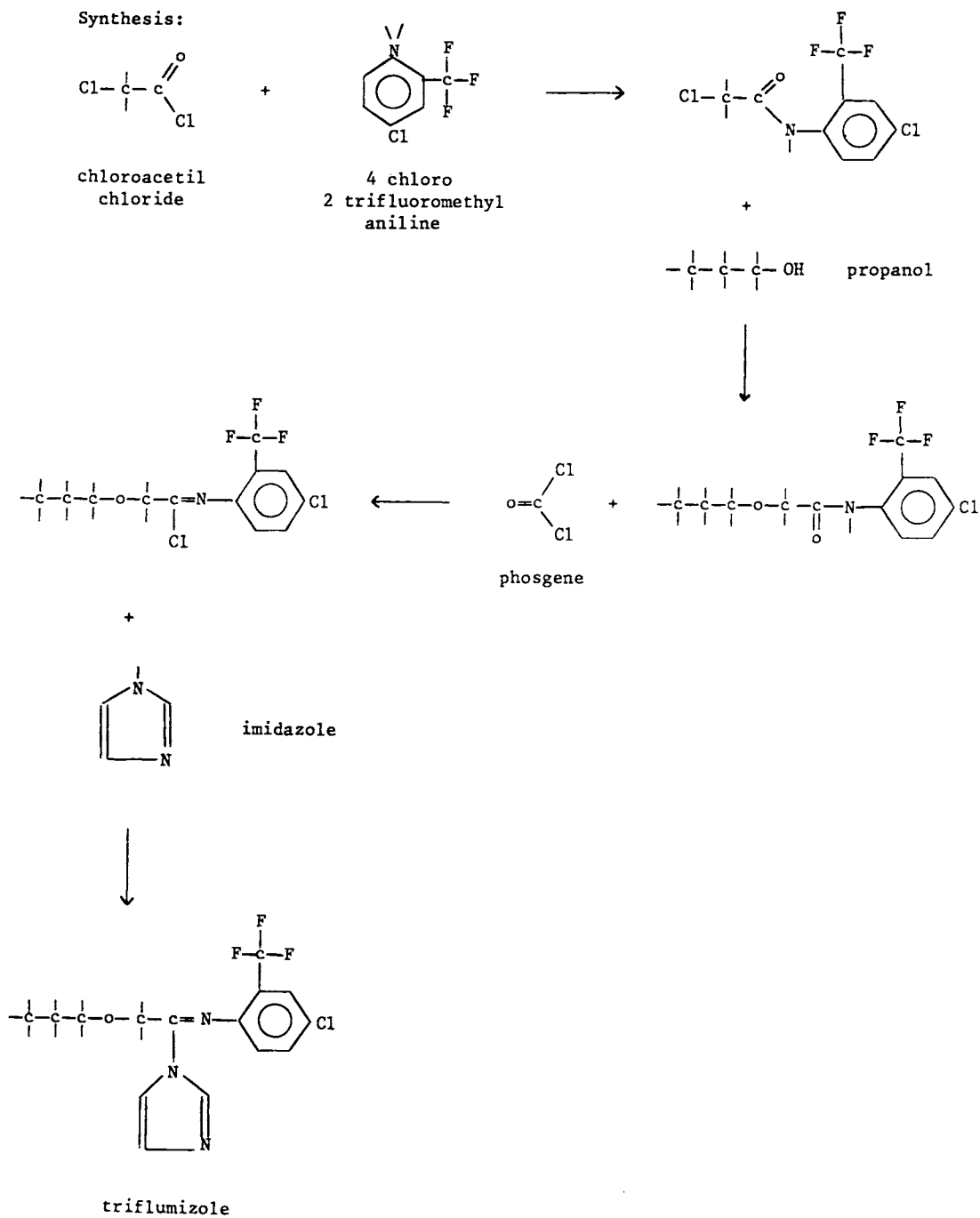
## Triflumizole

Uses: fungicide, fruit, vegetables, cereals

Trade names: Trifumine (Nippon Soda)

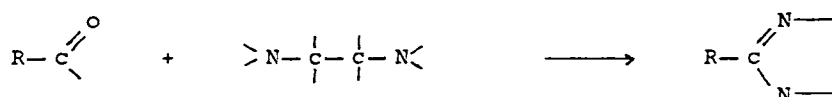
Type: imidazole

Synthesis:



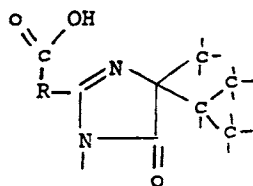
## IMIDAZOLINES

The imidazoline ring is obtained by reaction between ethylene diamine and an aldehyde



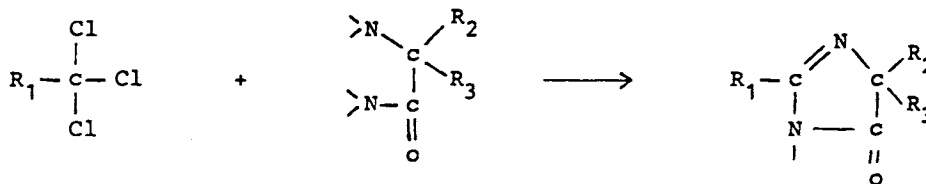
## IMIDAZOLINONES

Most imidazolinones are herbicides of general structure



The imidazolinone structure is obtained either by

1) Reaction between an  $\alpha$  amino amide and a trihalogen carbon

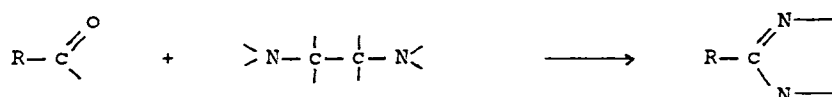


The  $\alpha$  amino amide employed is usually 2 amino 2,3 dimethyl butyramide



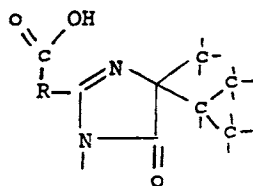
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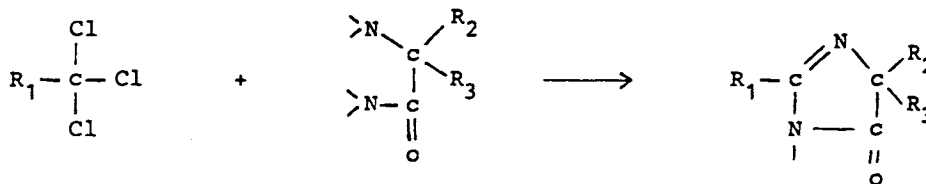
## IMIDAZOLINONES

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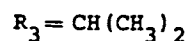
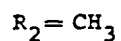


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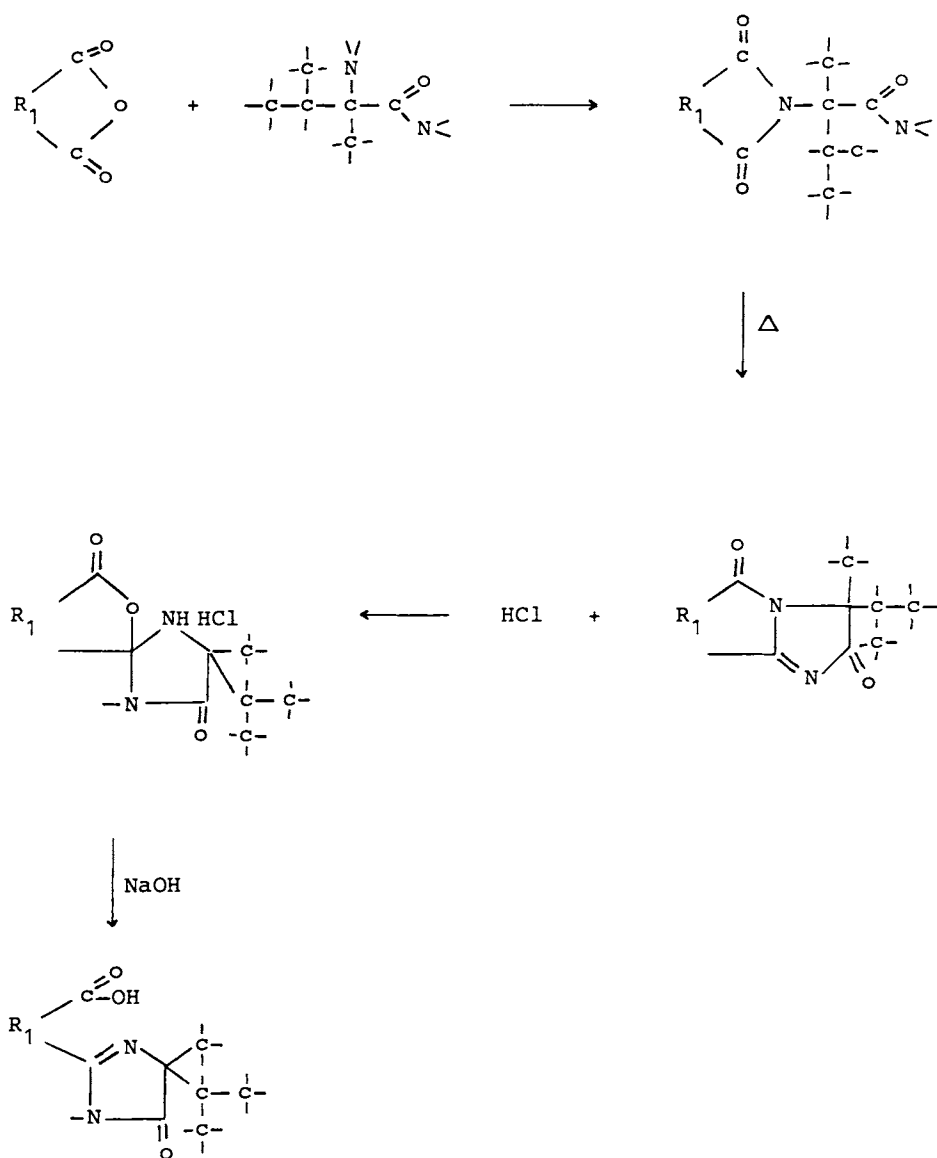
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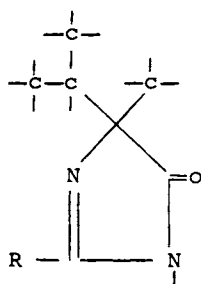


ii) Formation of a phthalimide followed by cyclisation and reaction with HCl and NaOH



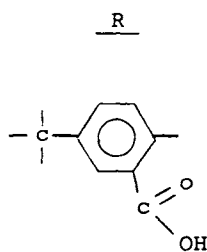
The main compounds of this type are imazamethabenz, imazapyr, imazaquin, imazethapyr.

The basic imidazolinones structure is :

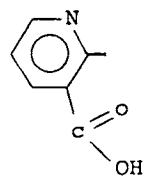


The main pesticides being :

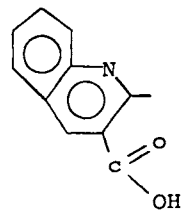
imazamethabenz



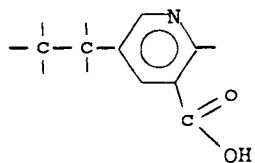
imazapyr



imazaquin



imazethapyr



## IMIDAZOLIDINONE

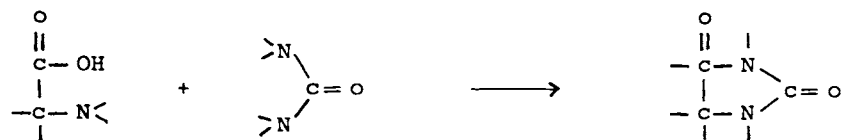
Imidazolidinone is obtained by reaction between urea and ethylene diamine



or by reaction of ethylene diamine with  $\text{CO}_2$  under heat and pressure

The ring is joined to the pesticide molecule by substitution of a halogen as in the synthesis of isocarbamid.

The imidazolidinedione ring (hydantoin) is synthesized by reaction between glycine and urea



## IMIDAZOLIDINE

The reaction between ethylene diamine and a cyanogen halide leads to the imine-imidazolidine



## IMIDAZOLIDINONE

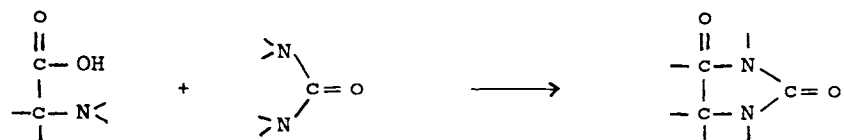
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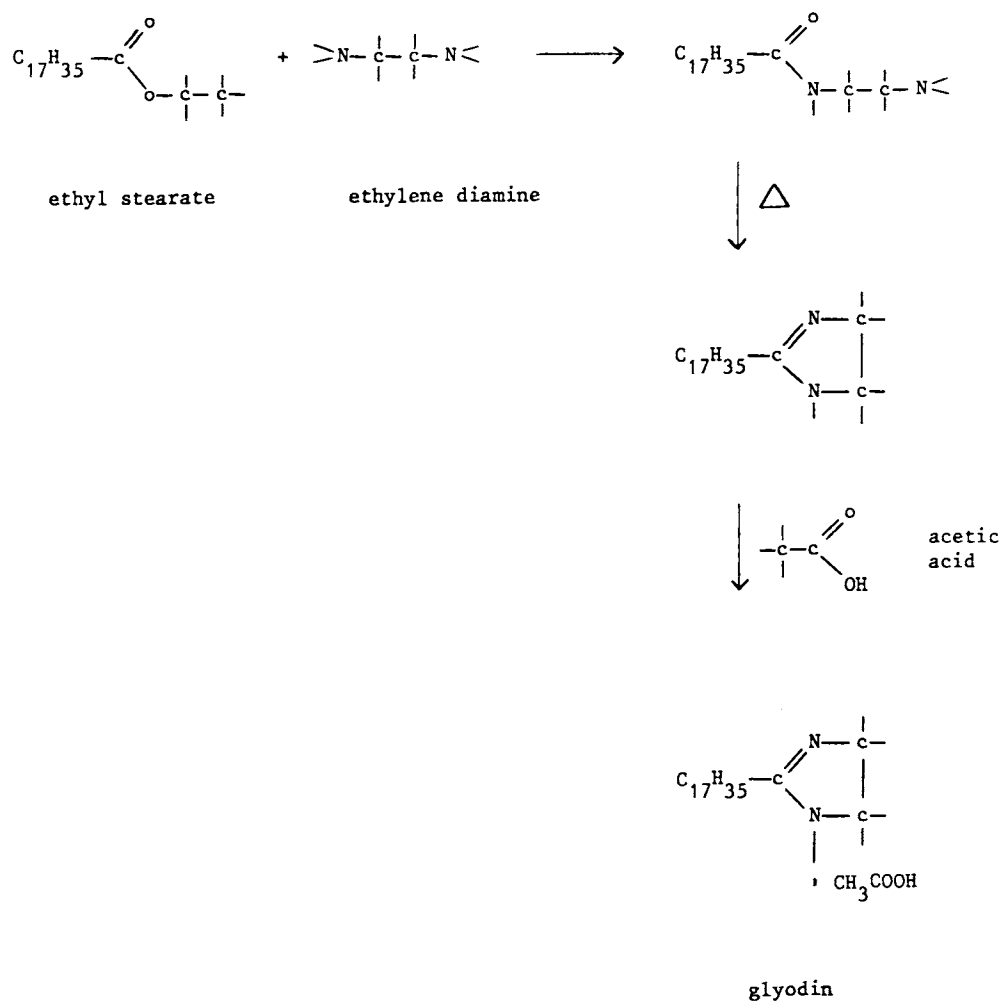
## Glyodin

Uses: fungicide, fruit trees

Trade names:

Type: imidazoline

Synthesis:



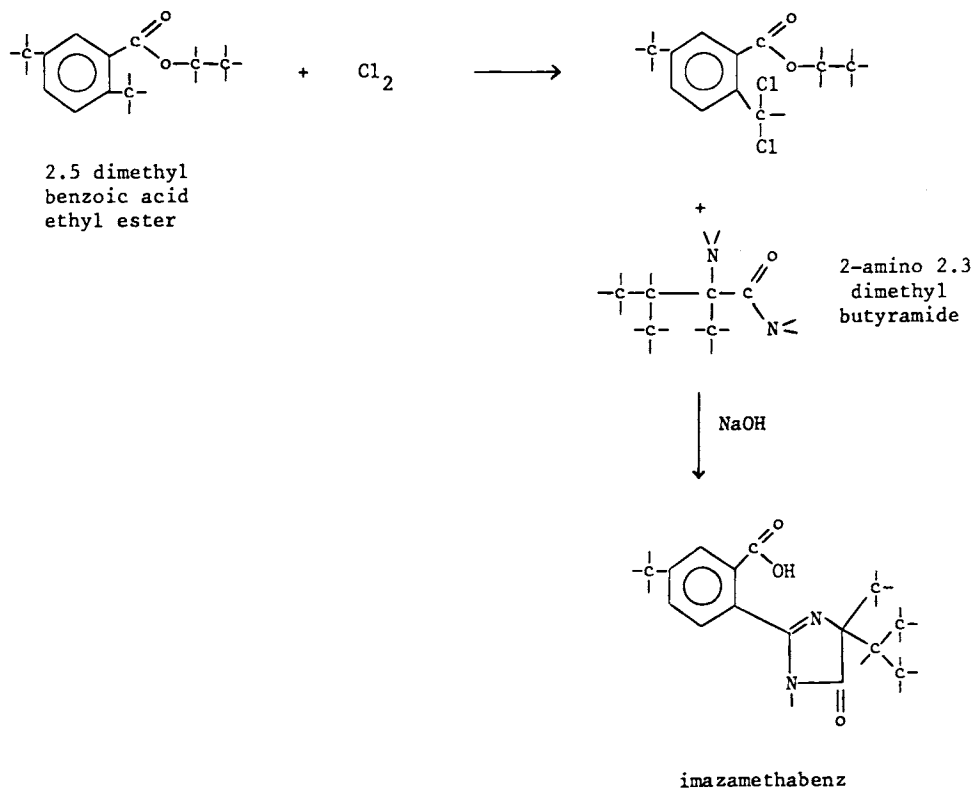
## Imazamethabenz

Uses: herbicide, wheat, barley, rye, sunflowers

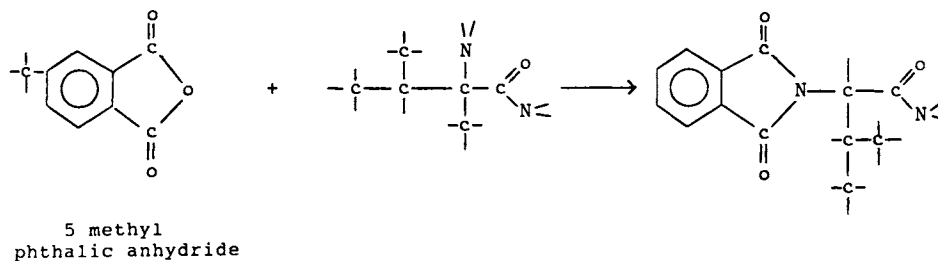
Trade names: Assert (Cyanamid)

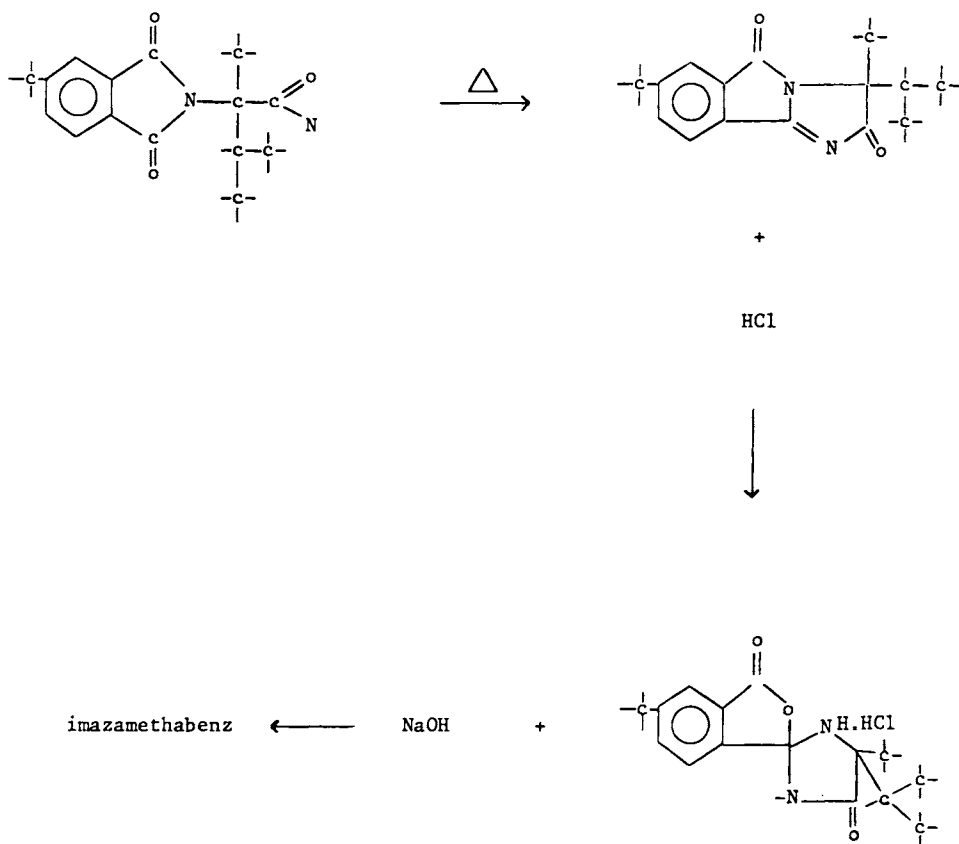
Type: imidazolinone

Synthesis:



alternate route :





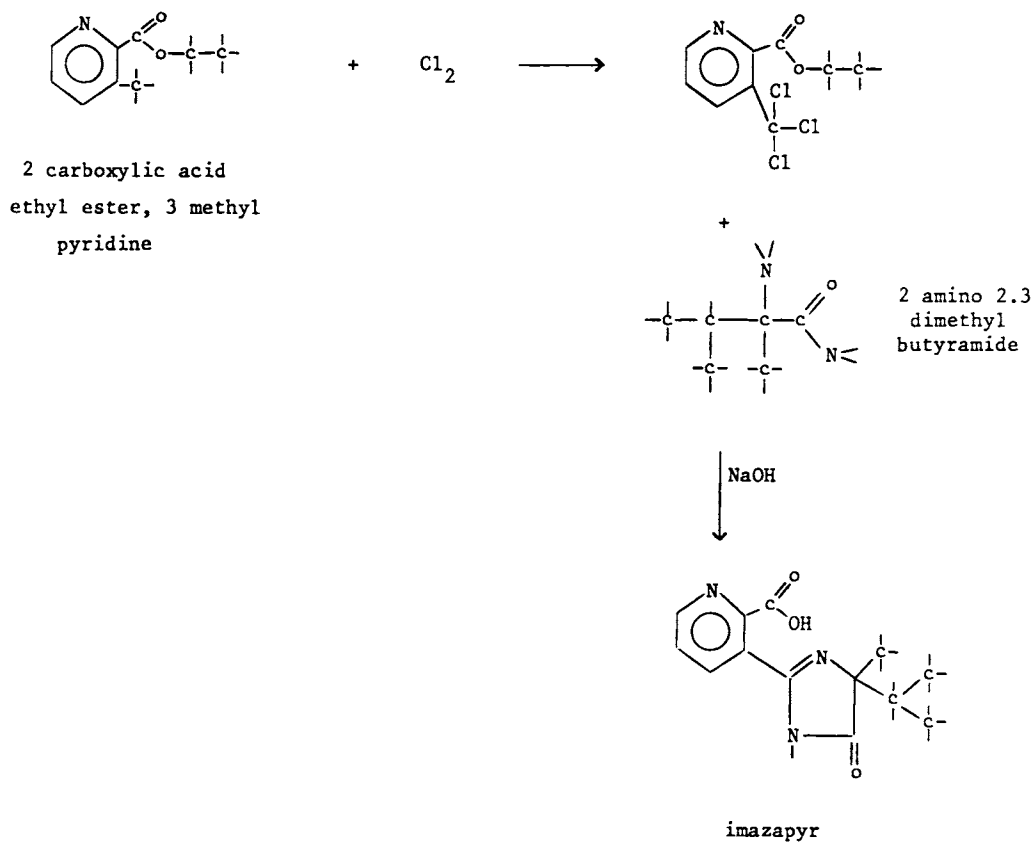
## Imazapyr

Uses: herbicide, rubber, oil palm

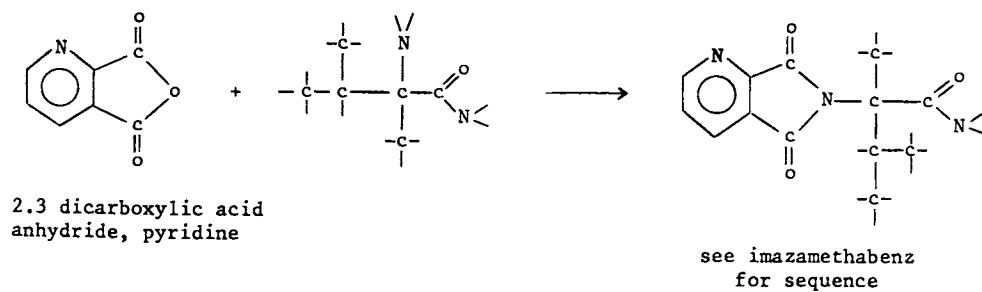
Trade names: Arsenal (Cyanamid)

Type: imidazolinone, pyridine

Synthesis:



alternate route :



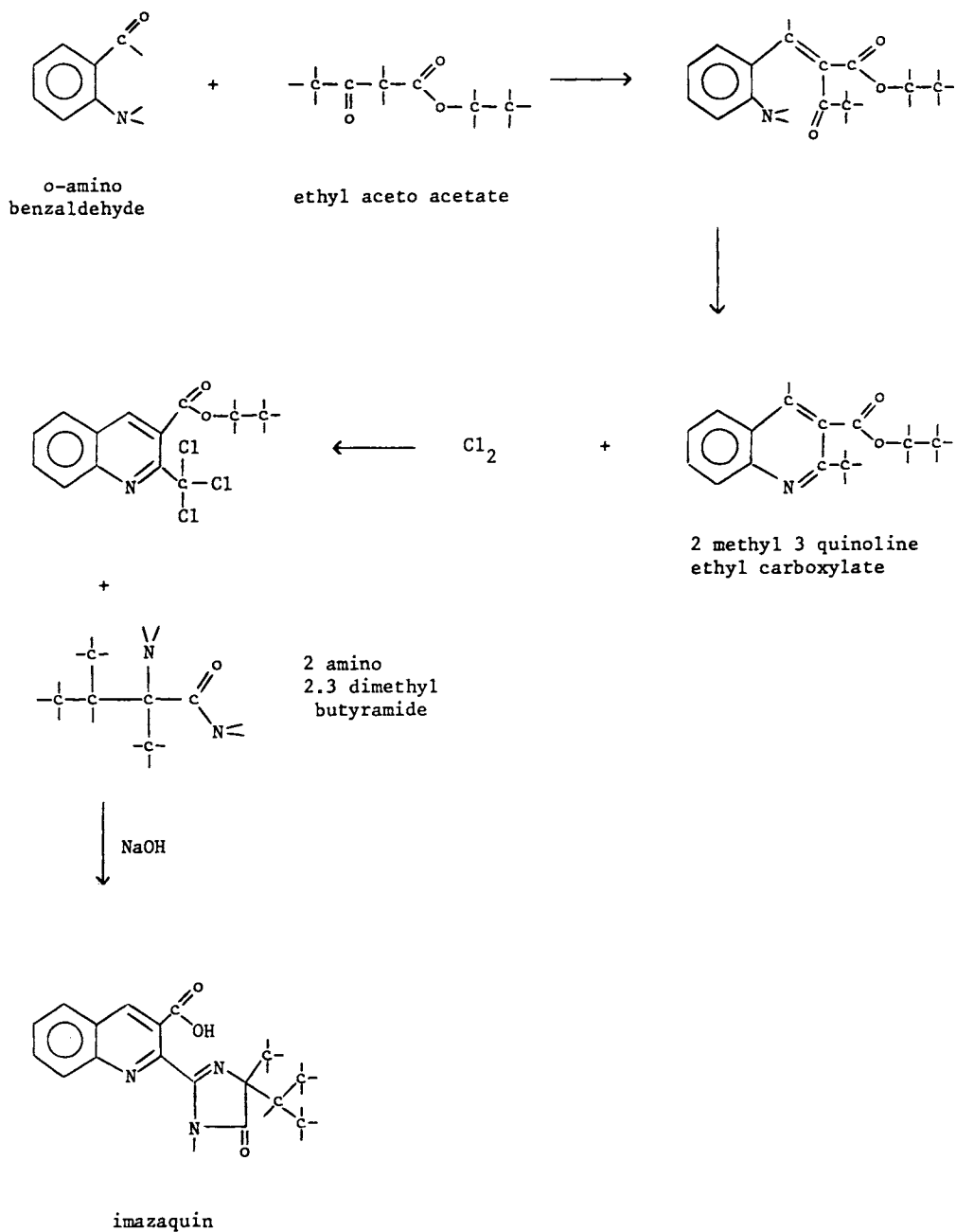
## Imazaquin

Uses: herbicide, soyabeans

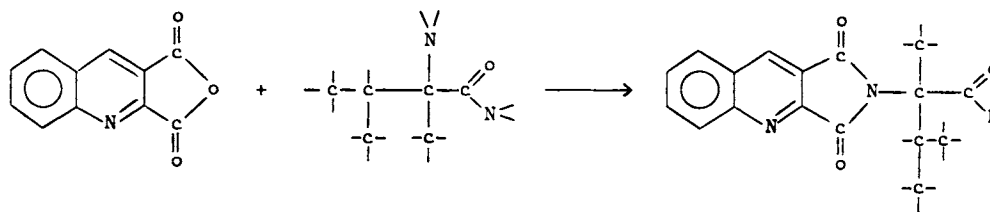
Trade names: Scepter (Cyanamid)

Type: imidazolinone, quinoline

Synthesis:



alternate route :



2,3 dicarboxylic acid  
anhydride, quinoline

see imazamethabenz  
for sequence

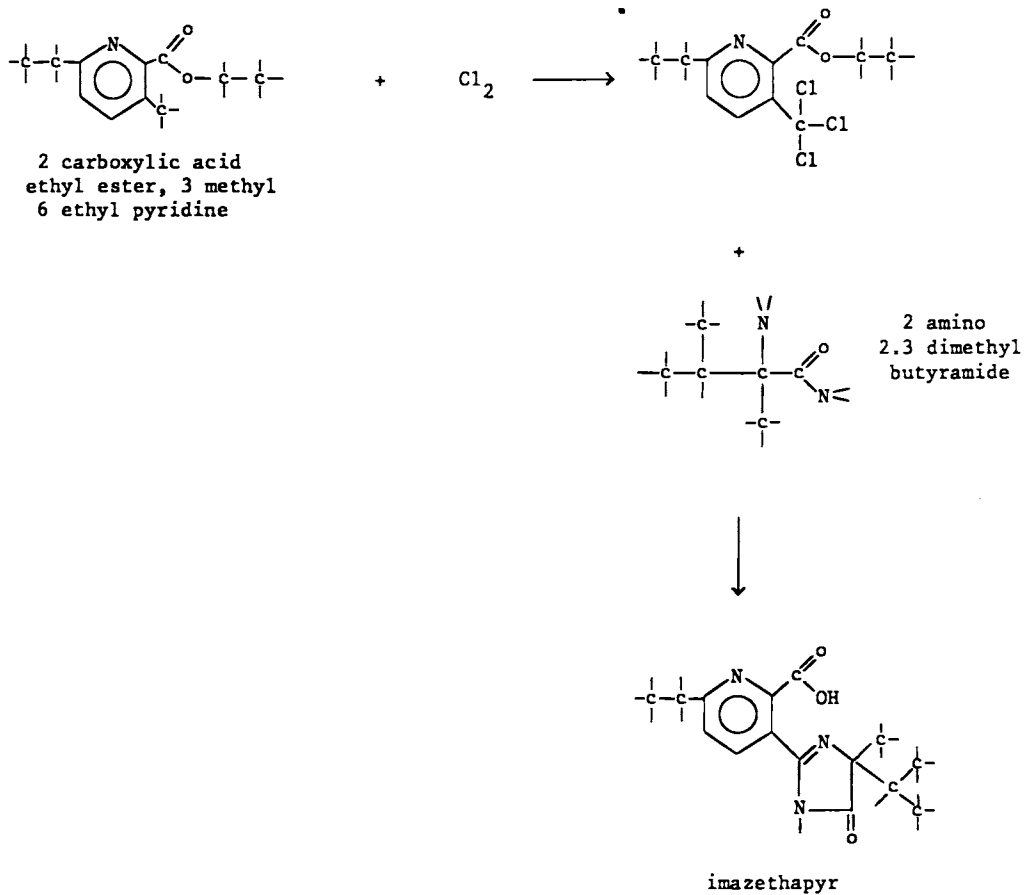
## Imazethapyr

Uses: herbicide, soya beans

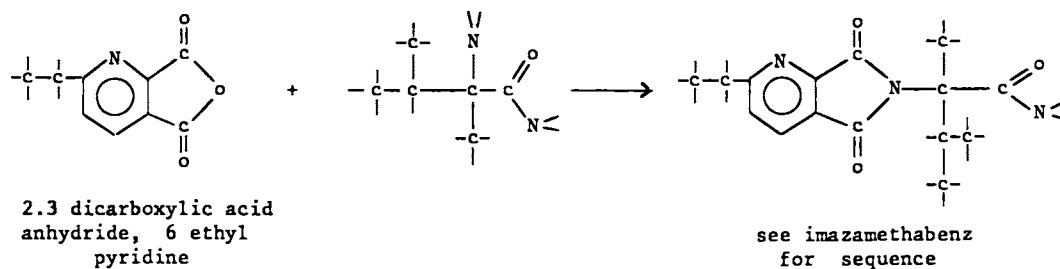
Trade names: Pursuit, Pivot (Cyanamid)

Type: imidazolinone, pyridine

Synthesis:



alternate route :



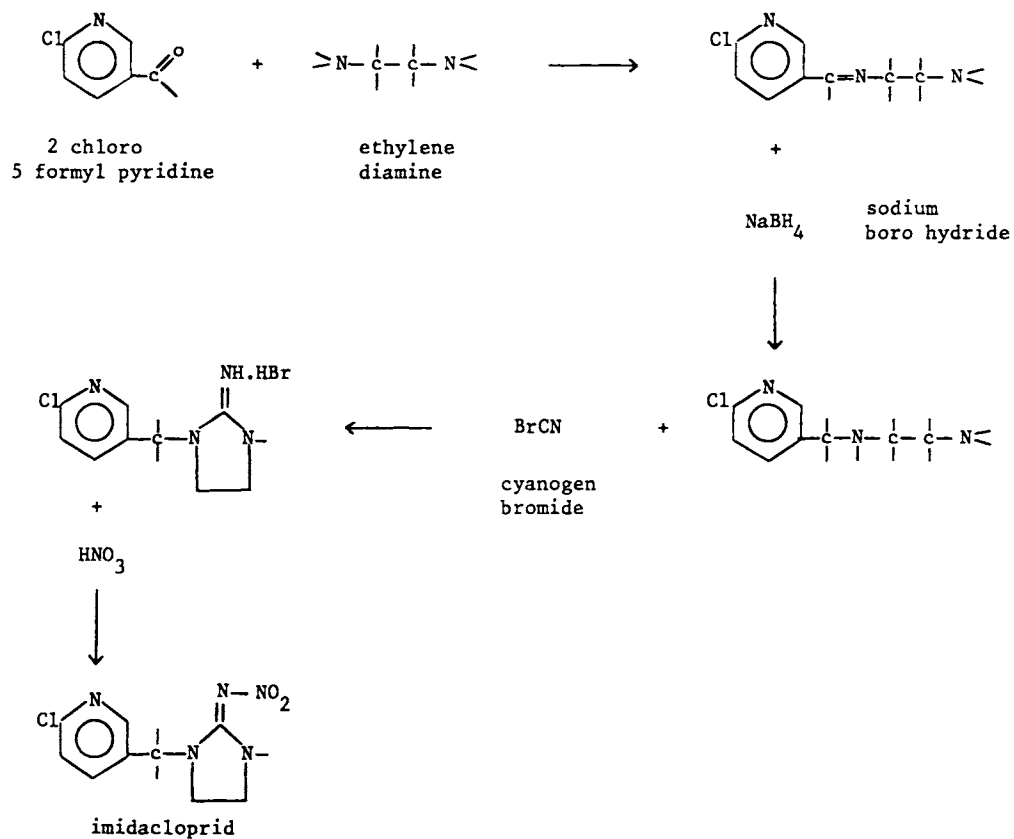
## Imidacloprid

Uses: insecticide

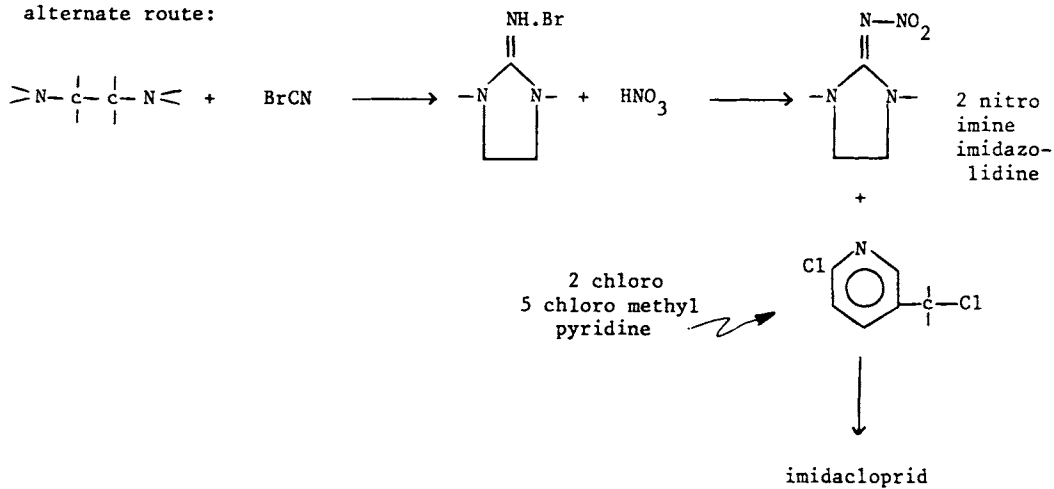
Trade names: Admire, Confidor, Gaucho (Bayer)

Type: imidazolidine, pyridine

Synthesis:



alternate route:





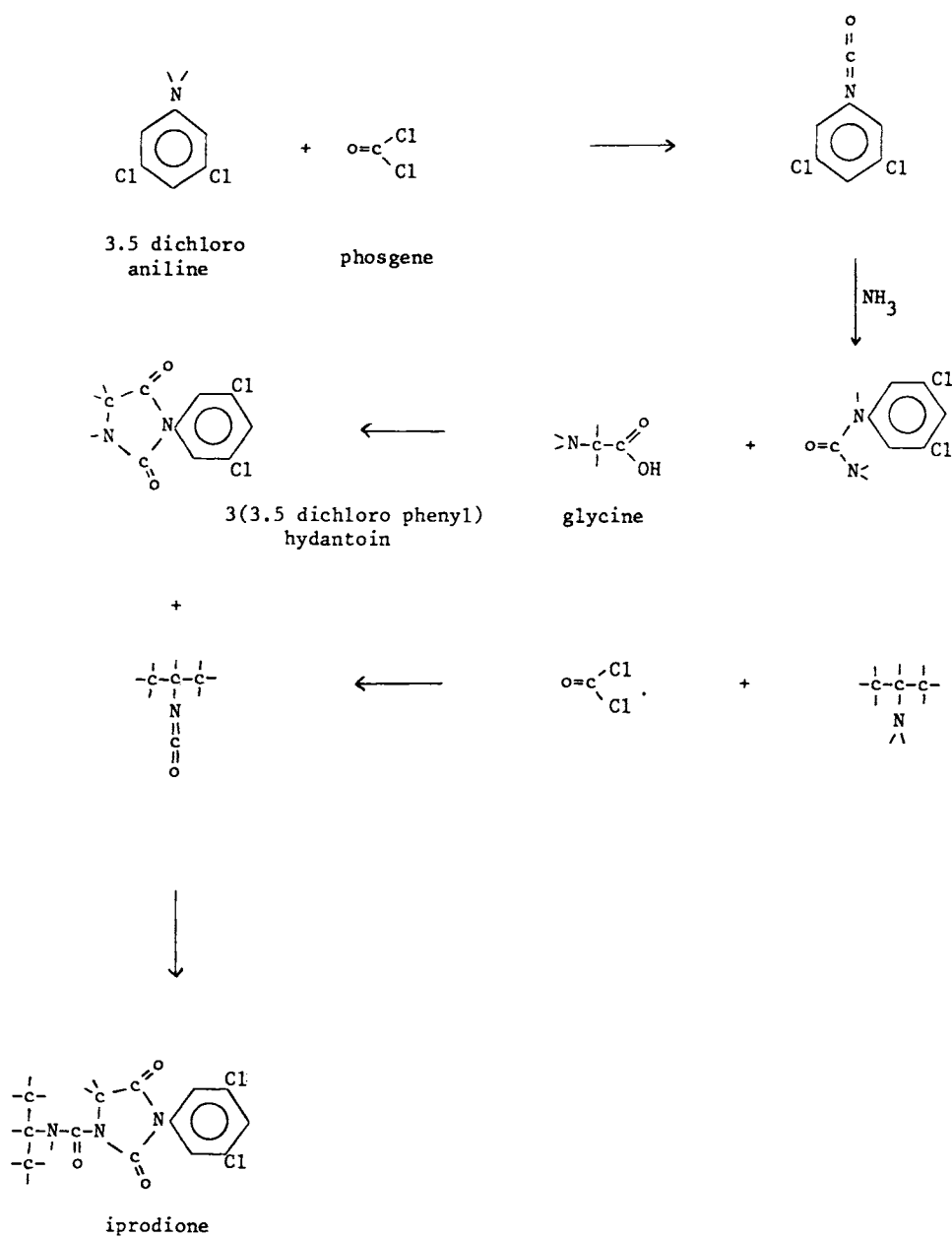
## Iprodione

Uses: fungicide, cereals, fruit, rice, vegetables

Trade names: Rovral (Rhone Poulenc)

Type: imidazolidinone

Synthesis:



# INDAZOLES

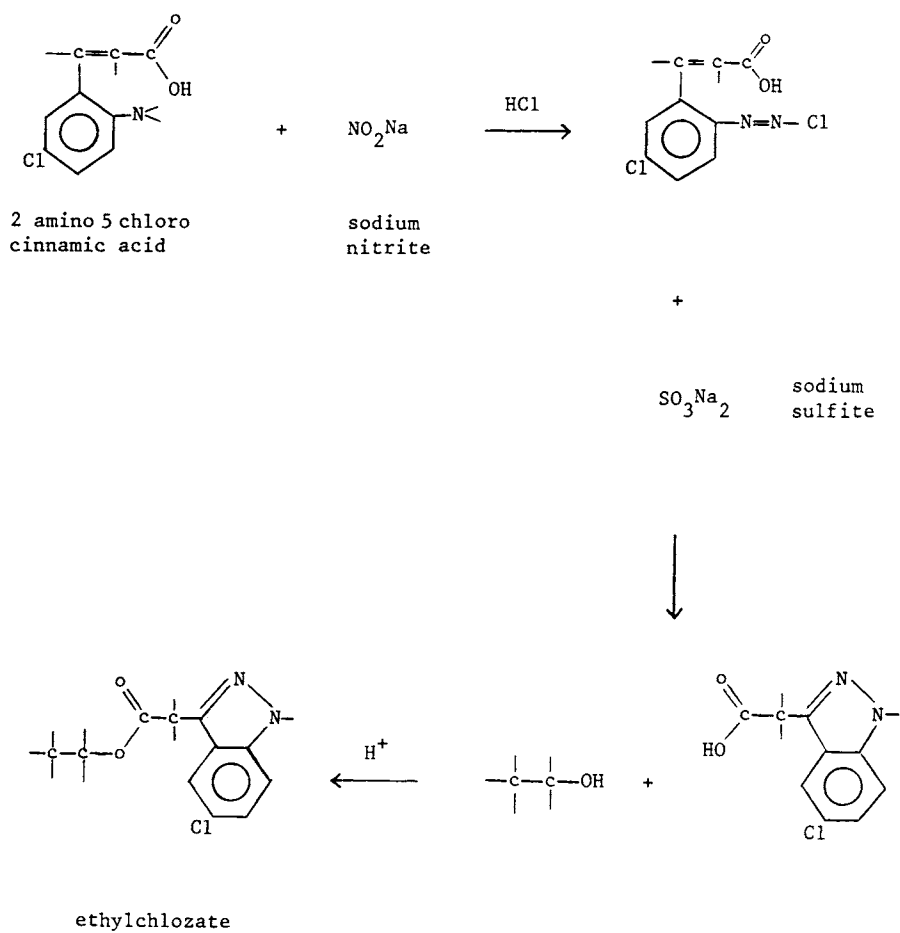
## Ethylchlozate

Uses: growth regulator, citrus, fruit

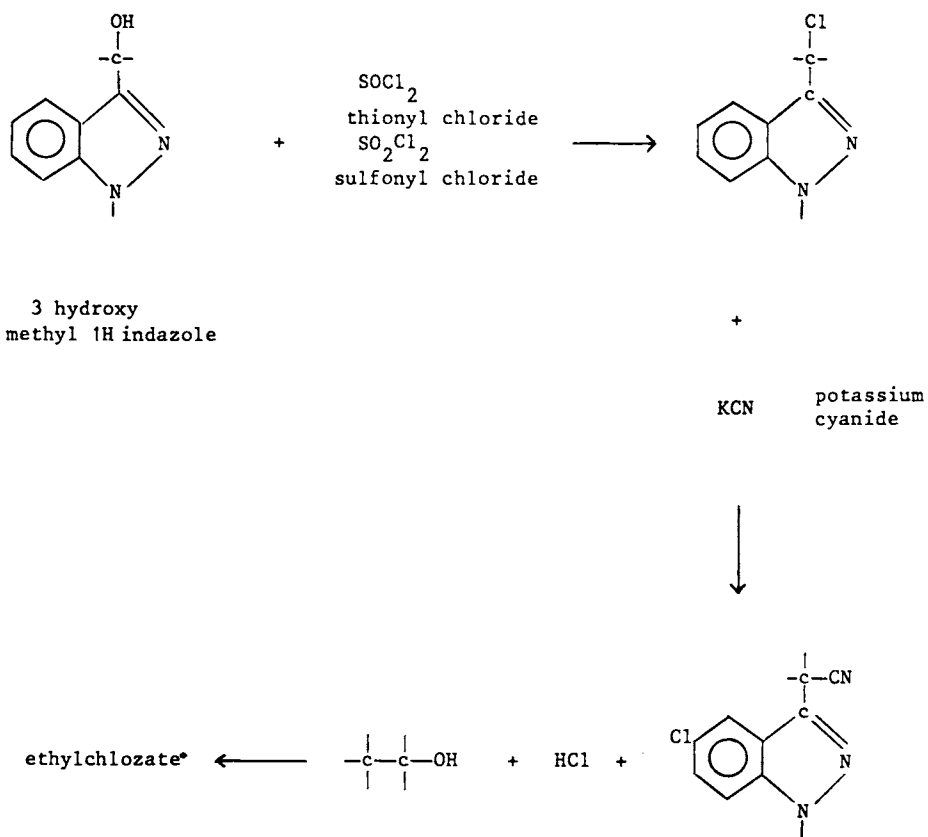
Trade names: Figaron (Nissan)

Type: indazole

Synthesis:

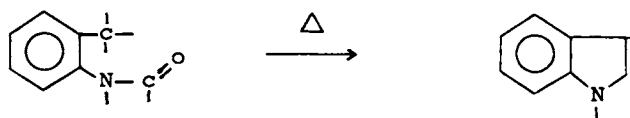


alternate route :

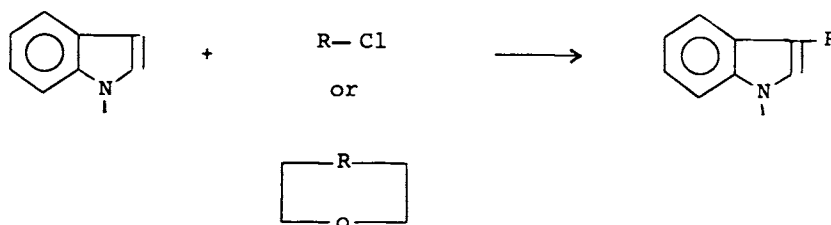


## INDOLES INDOLEDIONES

Indole is obtained by cyclisation of orthoformyl toluidine



The pesticide synthesis follows by addition to the reactive carbon (nº 3) either using a lactone or a halogen



Indoledione (phthalimide) is obtained by ammoniation of phthalic anhydride.

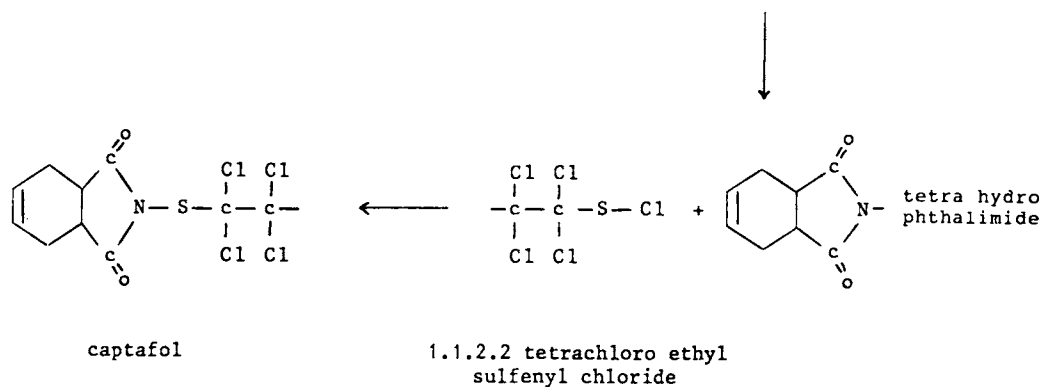
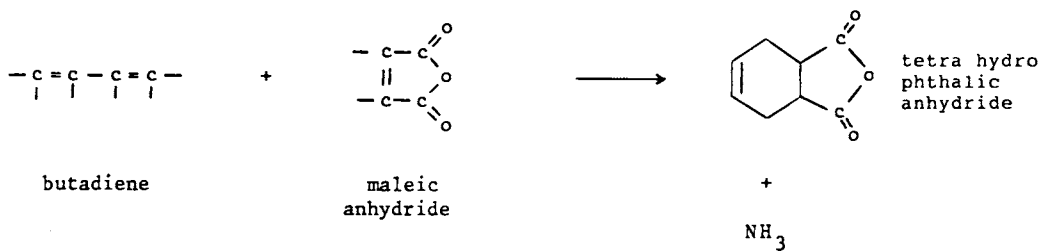
## Captafol

Uses: fungicide, coffee, tomatoes, rubber, wood, fruit

Trade names: Difolatan (Chevron)

Type: indoledione

Synthesis:



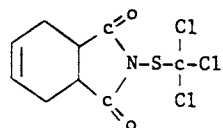
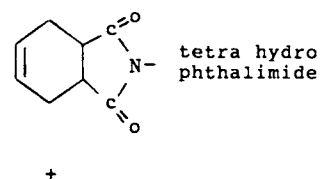
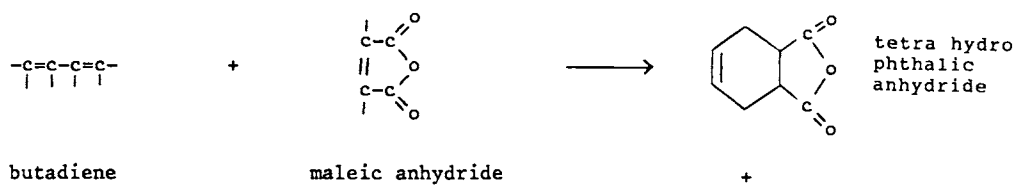
## Captan

Uses: fungicide, fruit, vegetables

Trade names: Orthocide (Chevron)

Type: indoledione

Synthesis:



captan

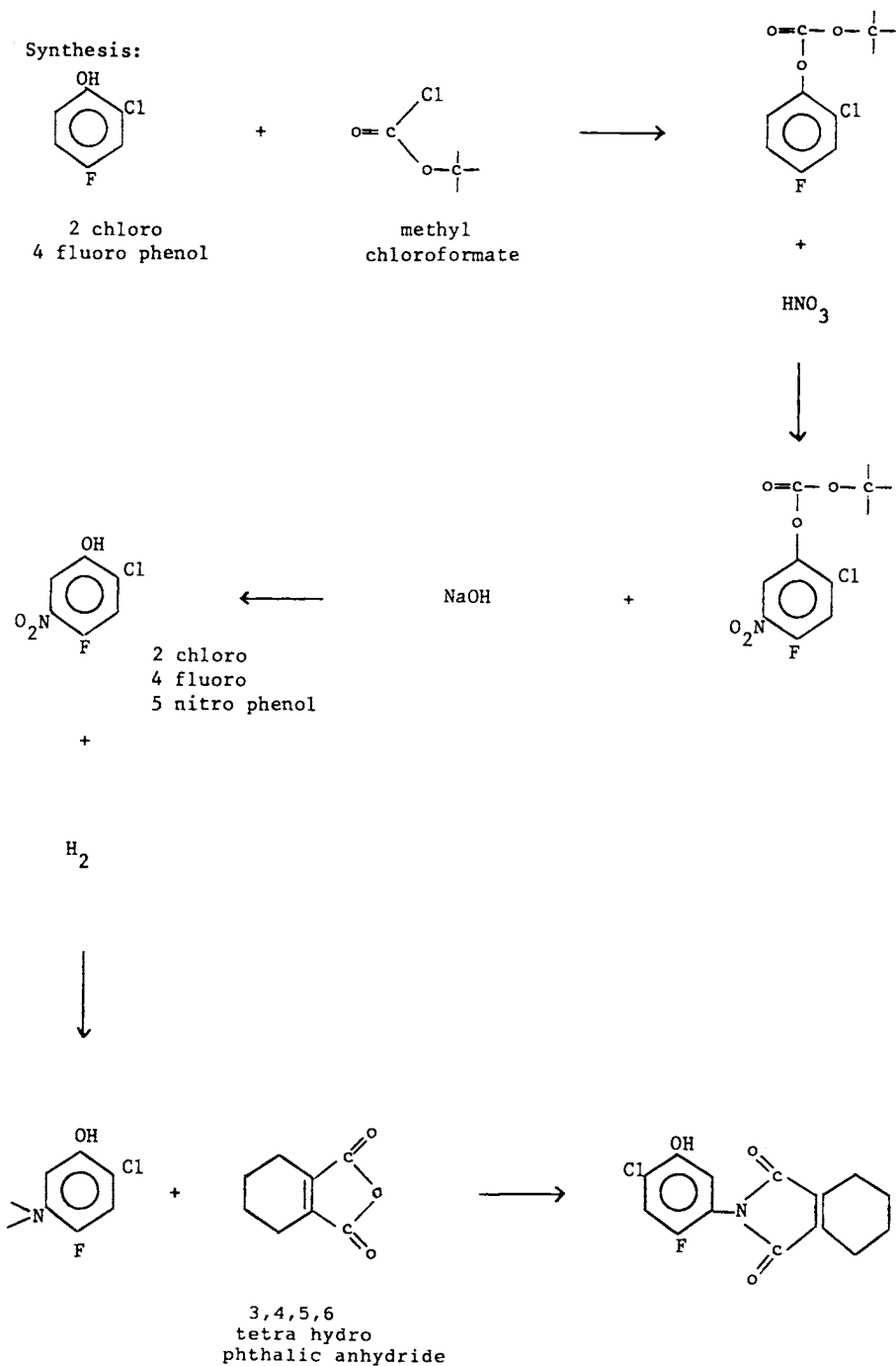
## Flumiclorac

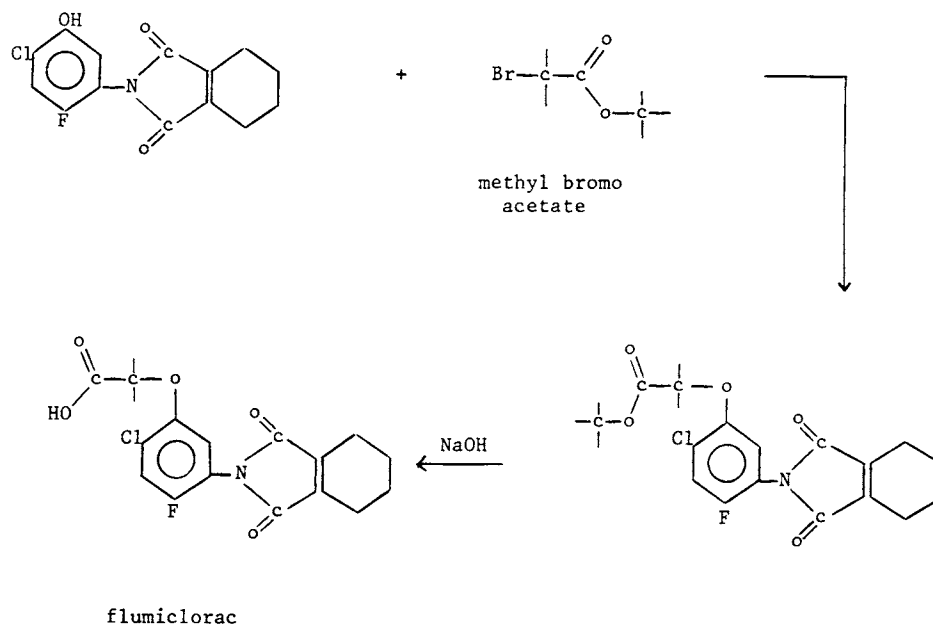
Uses: herbicide, soyabeans, maize

Trade names: Resource (Sumitomo)

Type: indole

Synthesis:







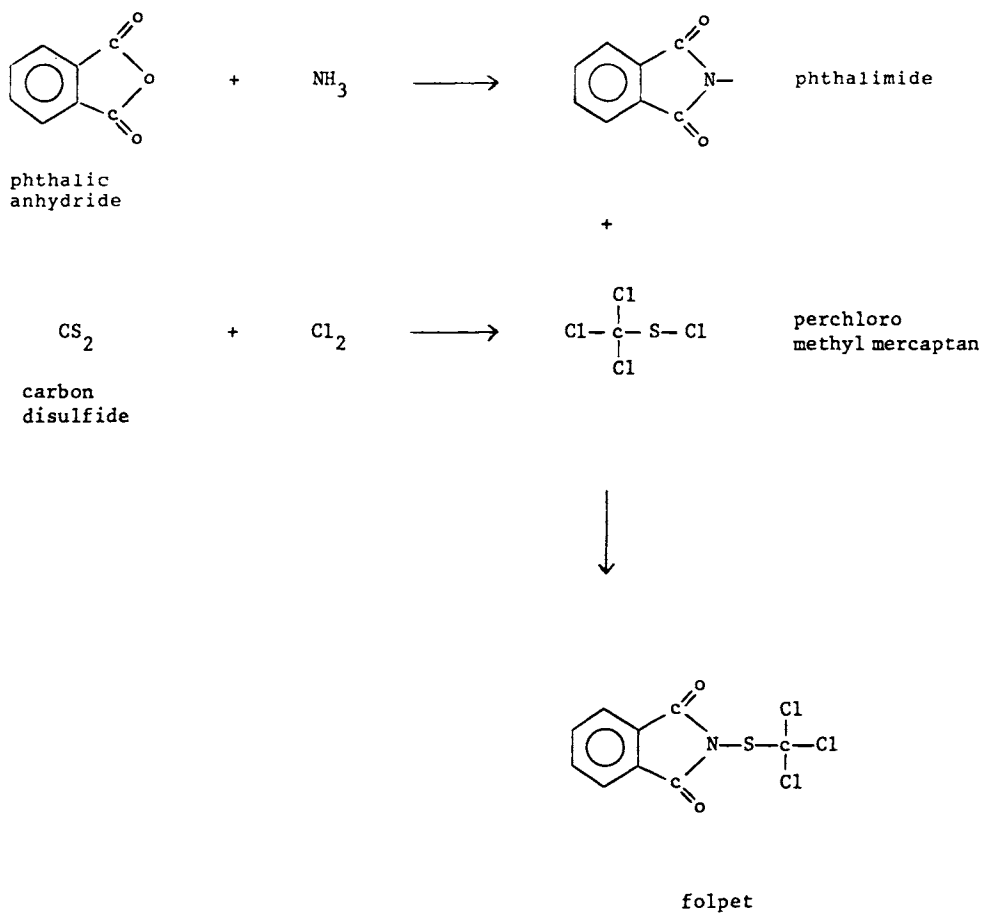
## Folpet

Uses: fungicide, cucumbers, fruit, onions, tomatoes

Trade names: Phaltan (Chevron)

Type: imidodione

Synthesis:



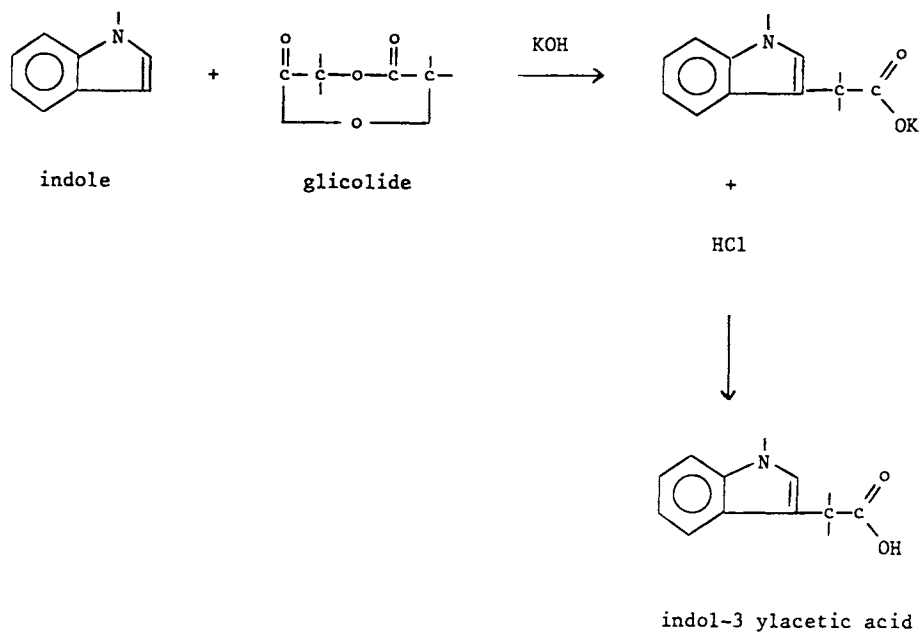
## Indol-3-yl Acetic Acid

Uses: hormone, induces rooting in cuttings

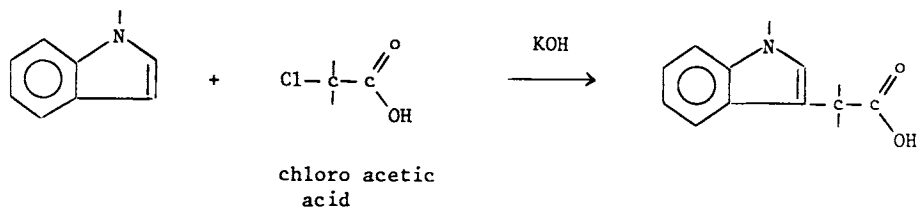
Trade names: Rhizipon (Chemie Farma)

Type: indole

### Synthesis:



alternate route :



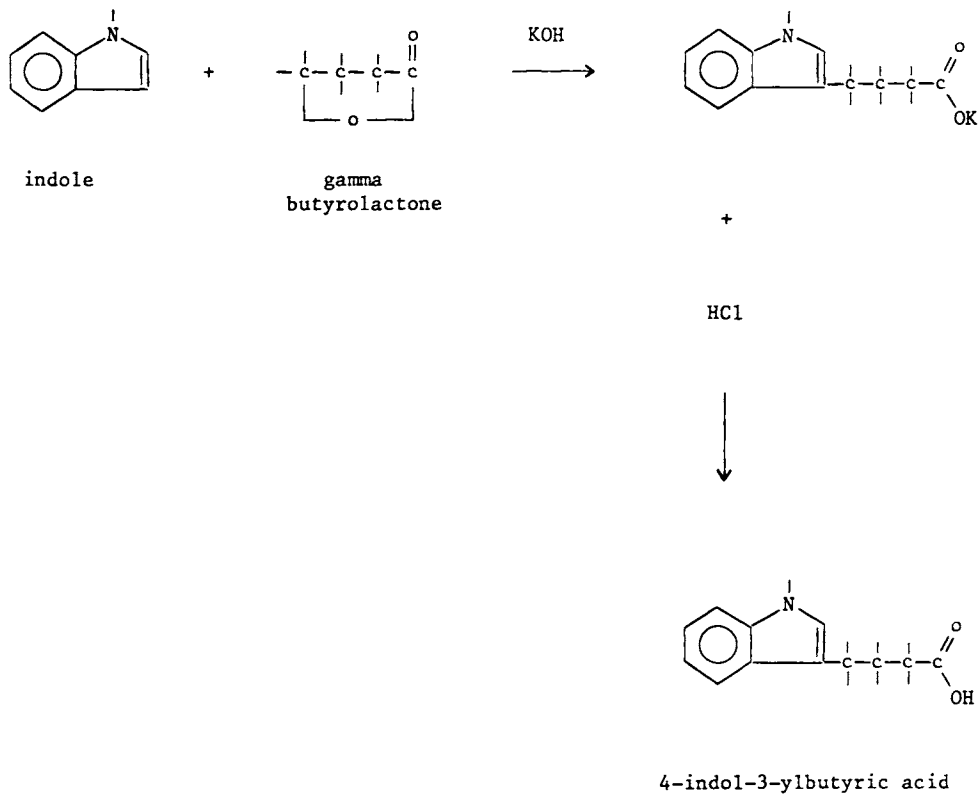
## 4-Indol-3-yl Butyric Acid

Uses: growth regulator, induces rooting in cuttings

Trade names: RootoneF (Rhône Poulenc)

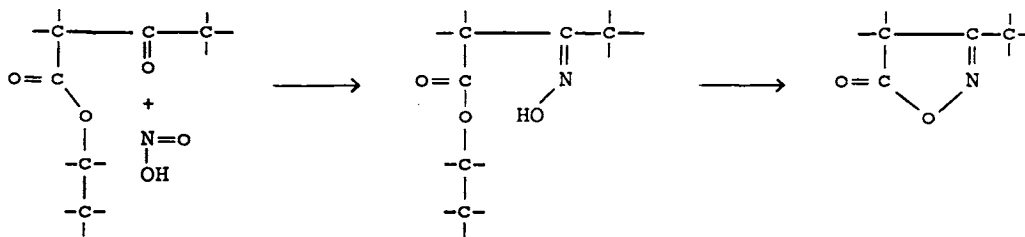
Type: indole

Synthesis:

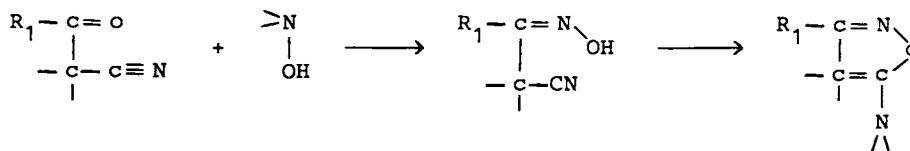


# ISOXAZOLONES ISOXAZOLES

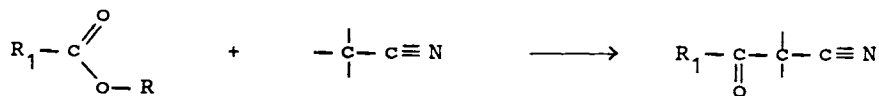
Methyl isoxazolone is obtained by reaction between ethyl acetate and nitrous acid



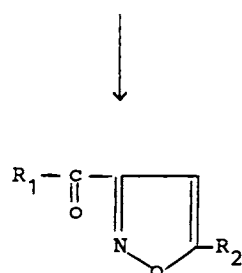
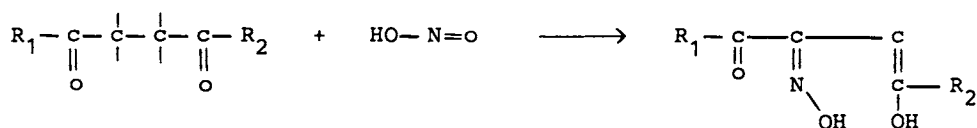
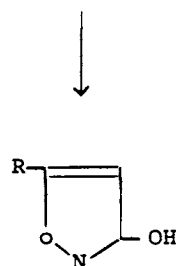
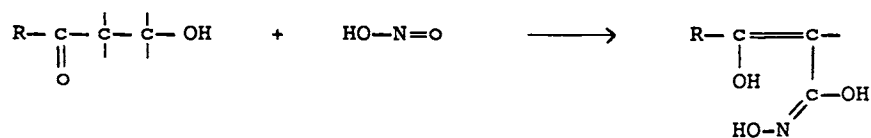
Amino isoxazole is obtained by reaction between a carbonyl nitrile and hydroxylamine



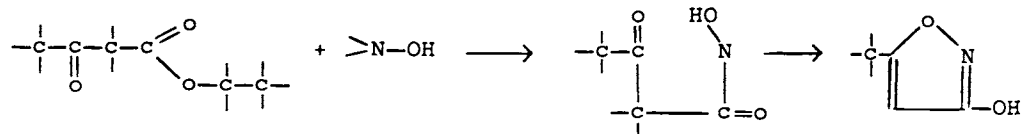
The carbonyl nitrile compound is obtained by reaction between aceto nitrile and an ester



An appropriate diketone or a ketoalcohol may also be used as starting point for the synthesis of isoxazoles'

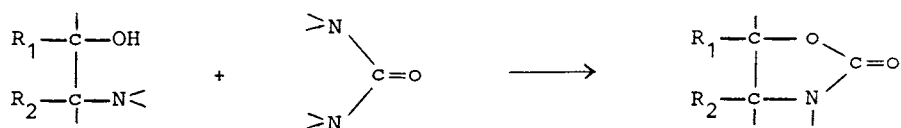


The reaction between ethyl aceto acetate and hydroxylamine yields the hydroxamic acid which is cyclised to a hydroxy isoxazole



## OXAZOLONES

The preferred route is via reaction of an  $\alpha$  hydroxy amine and urea



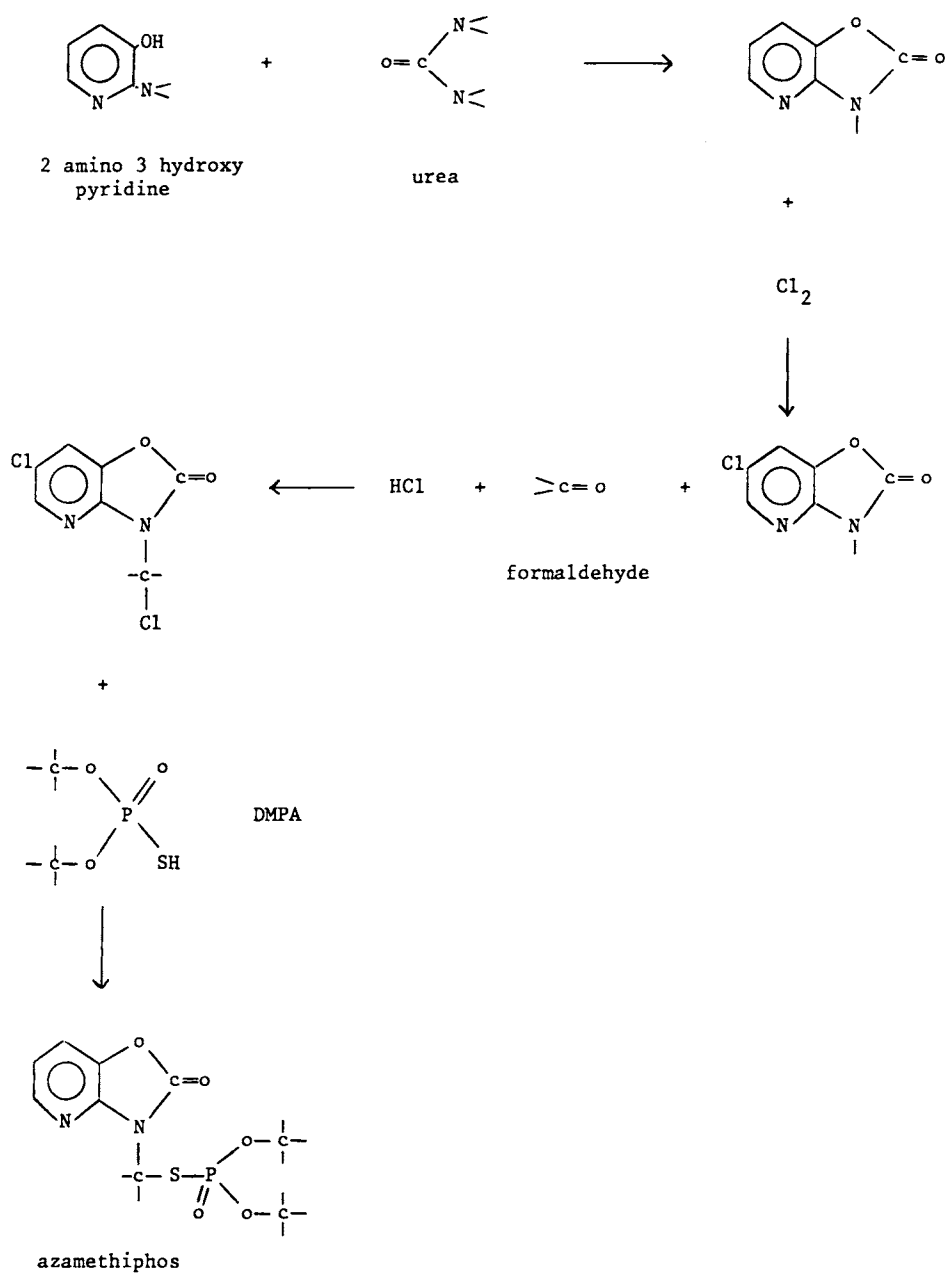
## Azamethiphos

Uses: insecticide, animals, public hygiene, house holds

Trade names: Alfacron (Ciba)

Type: oxazolone, pyrimidine, phosphoro thioate

Synthesis:



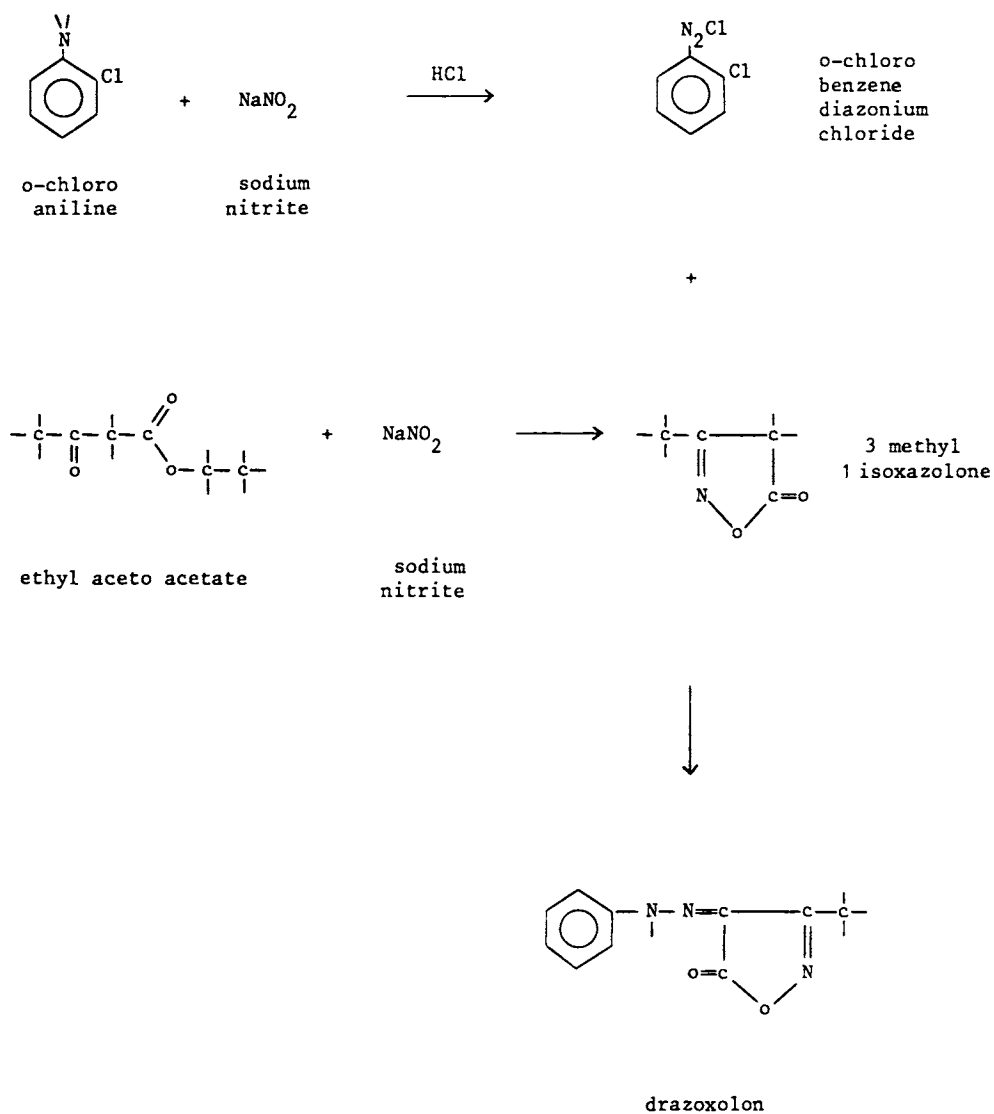
## Drazoxolon

Uses: fungicide, beans seeds, maize seeds, flowers

Trade names: Mil-Col (Zeneca)

Type: isoxazalone

Synthesis:





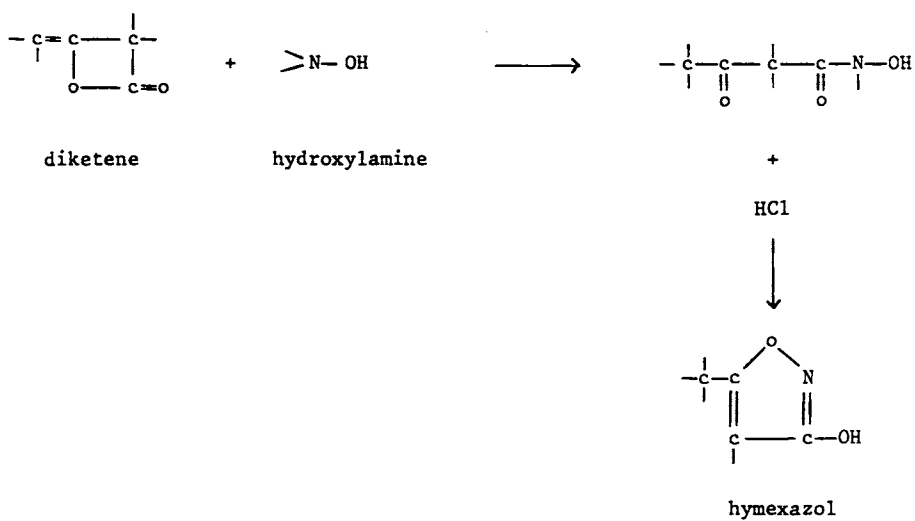
## Hymexazol

Uses: fungicide, rice, sugar beet, vegetables, ornamentals

Trade names: Tachigaren (Sankyo)

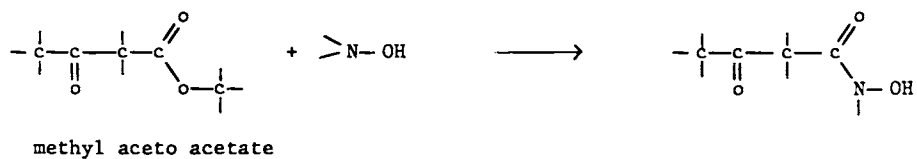
Type: isoxazole

Synthesis:

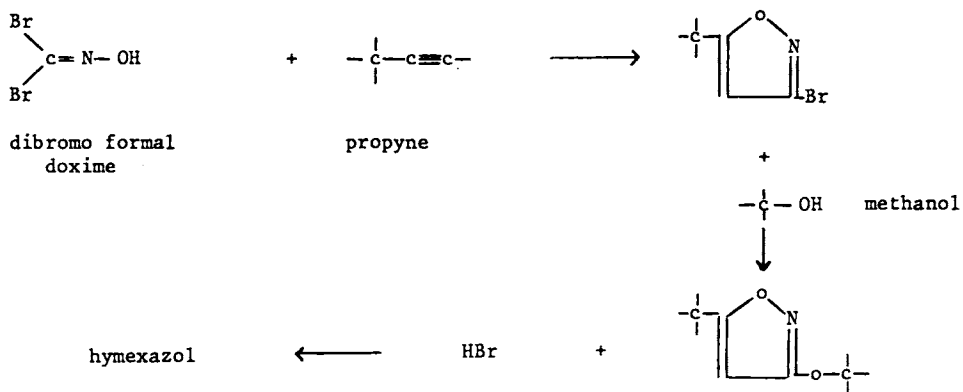


alternate routes :

i)



ii)



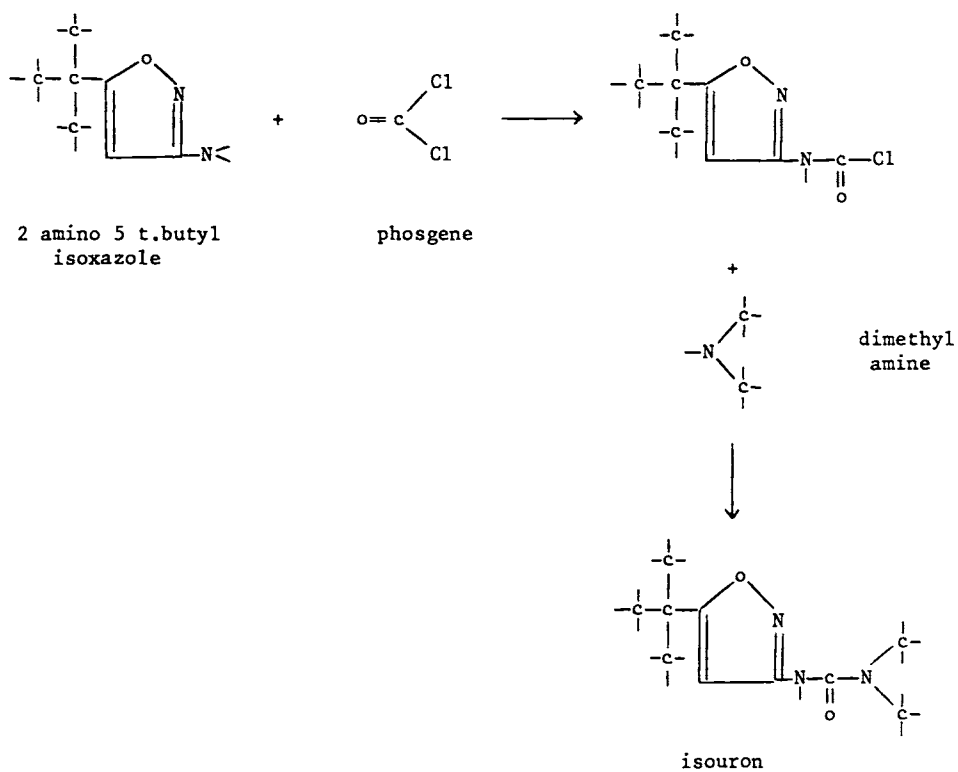
## Isouron

Uses: herbicide for sugar cane

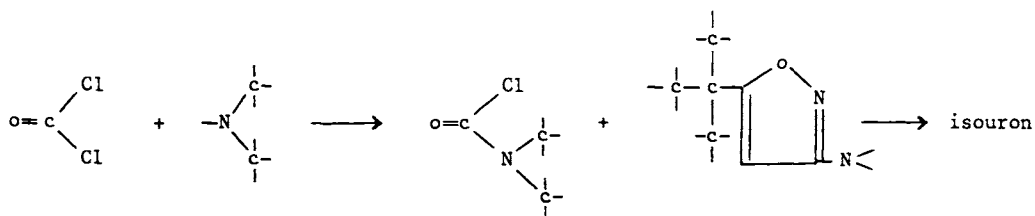
Trade names: Isoxyl (Shionogi)

Type: isoxazole, urea

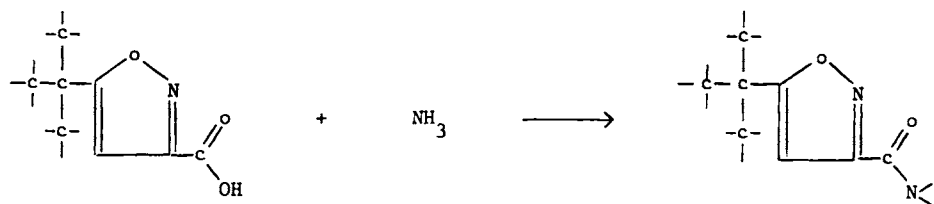
Synthesis:



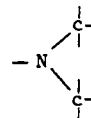
alternate route :



alternate route :



2 carboxy 5 t.butyl  
isoxazole



isouron

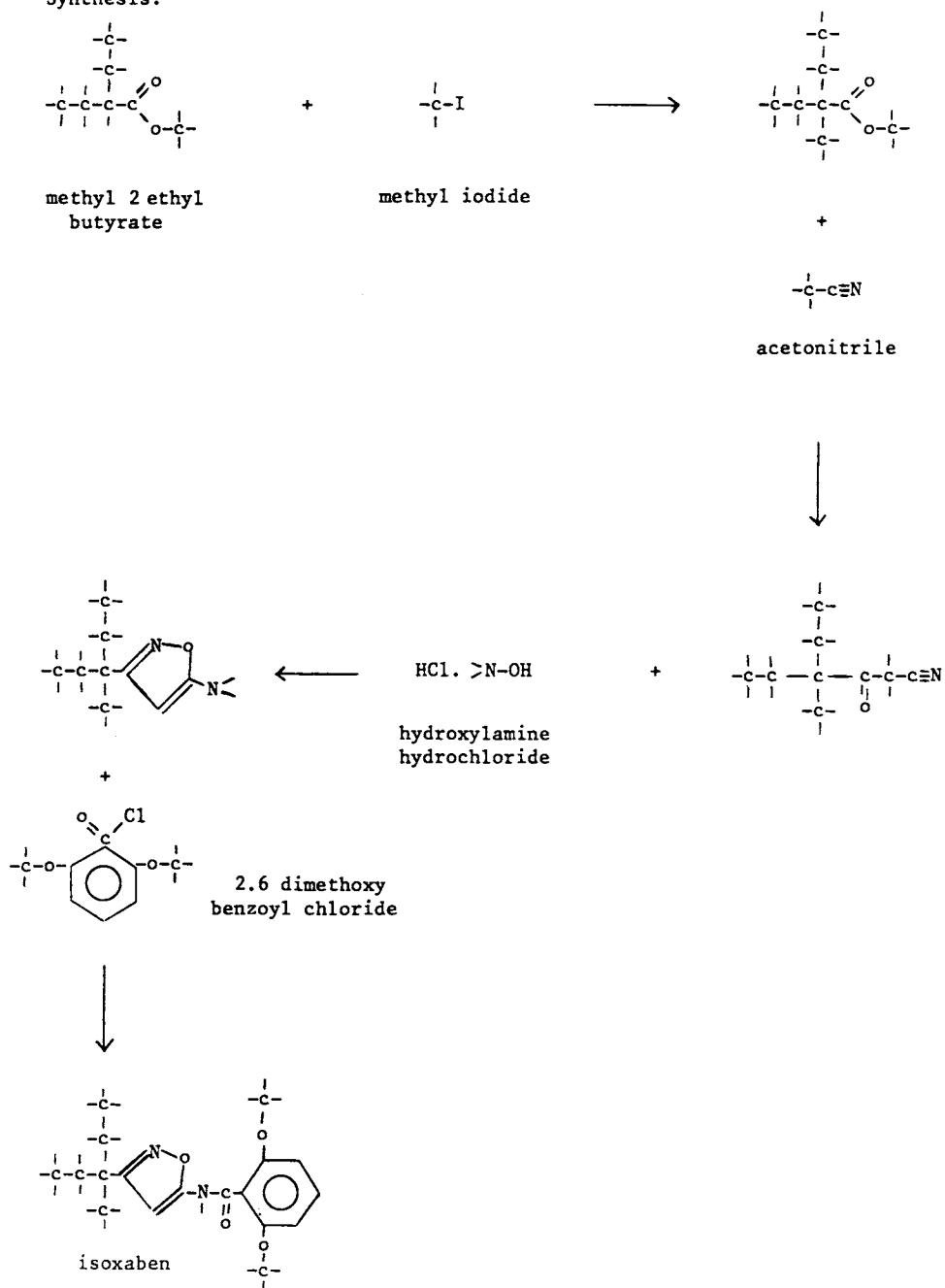
## Isoxaben

**Uses:** herbicide, cereals, vine, turf

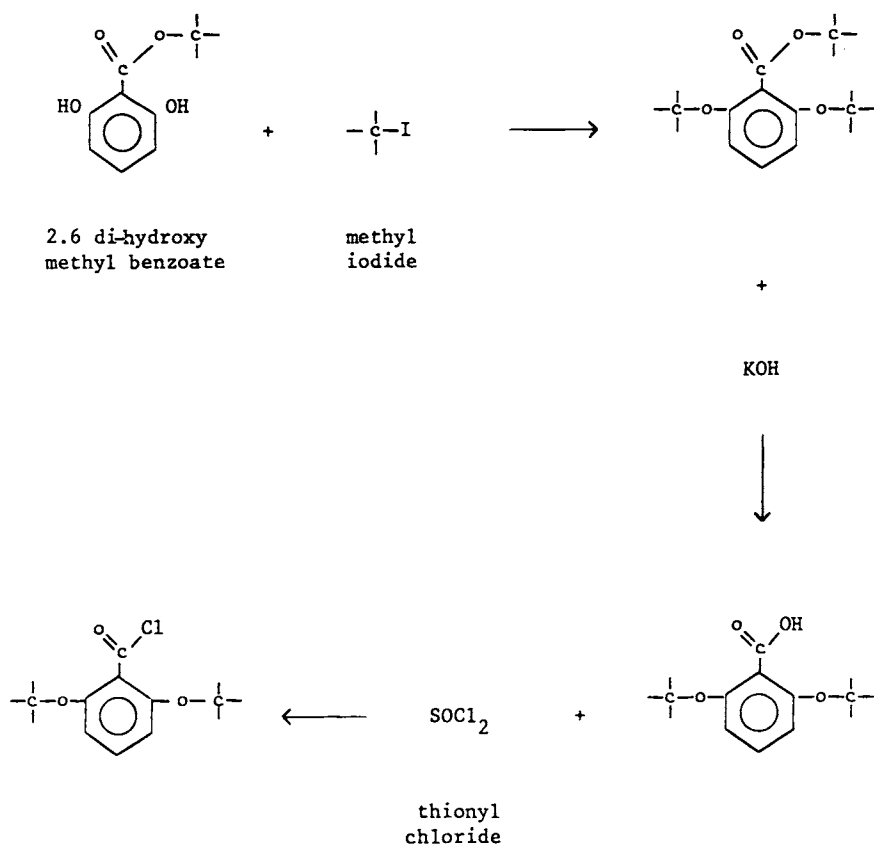
**Trade names:** Flexidor (Dow Elanco)

Type: isoxazole, amide

**Synthesis:**

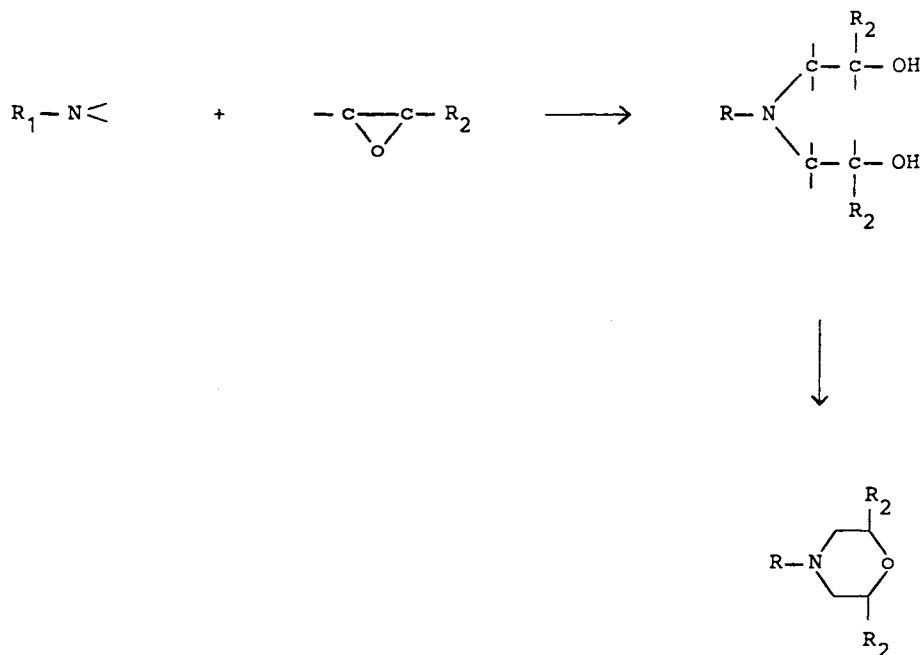


synthesis of 2,6 dimethoxy benzoyl chloride



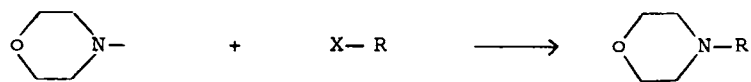
# MORPHOLINES

The morpholine ring is obtained by reaction between a primary amine and an oxide, followed by dehydration



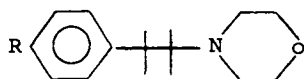
The synthesis of morpholine pesticides follows one of several routes :

- i) formation of the morpholine ring as illustrated above
- ii) tacking on the morpholine by reaction with a halogen or hydroxyl



where X = OH, Cl, Br

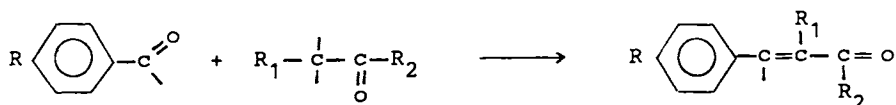
iii) Compounds with a structure :



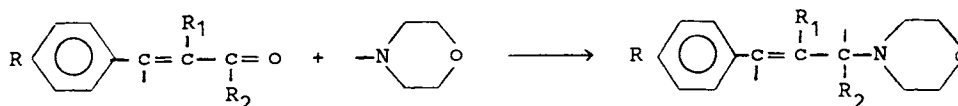
Y=c piperidine

Y=o morpholine

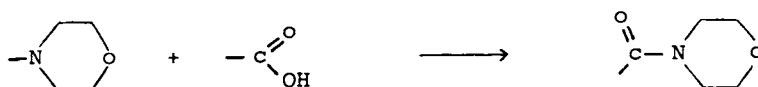
are made by tacking an alkyl aldehyde or ketone on to a benzaldehyde



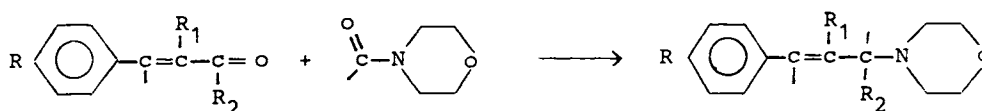
Then either reacting the carbonyl group with the amine



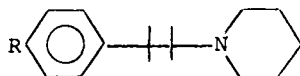
or first reacting the amine with formic acid



and then combining the 2 carbonyl groups with liberation of CO<sub>2</sub>



The same synthesis route is also employed for piperidine compounds of the type



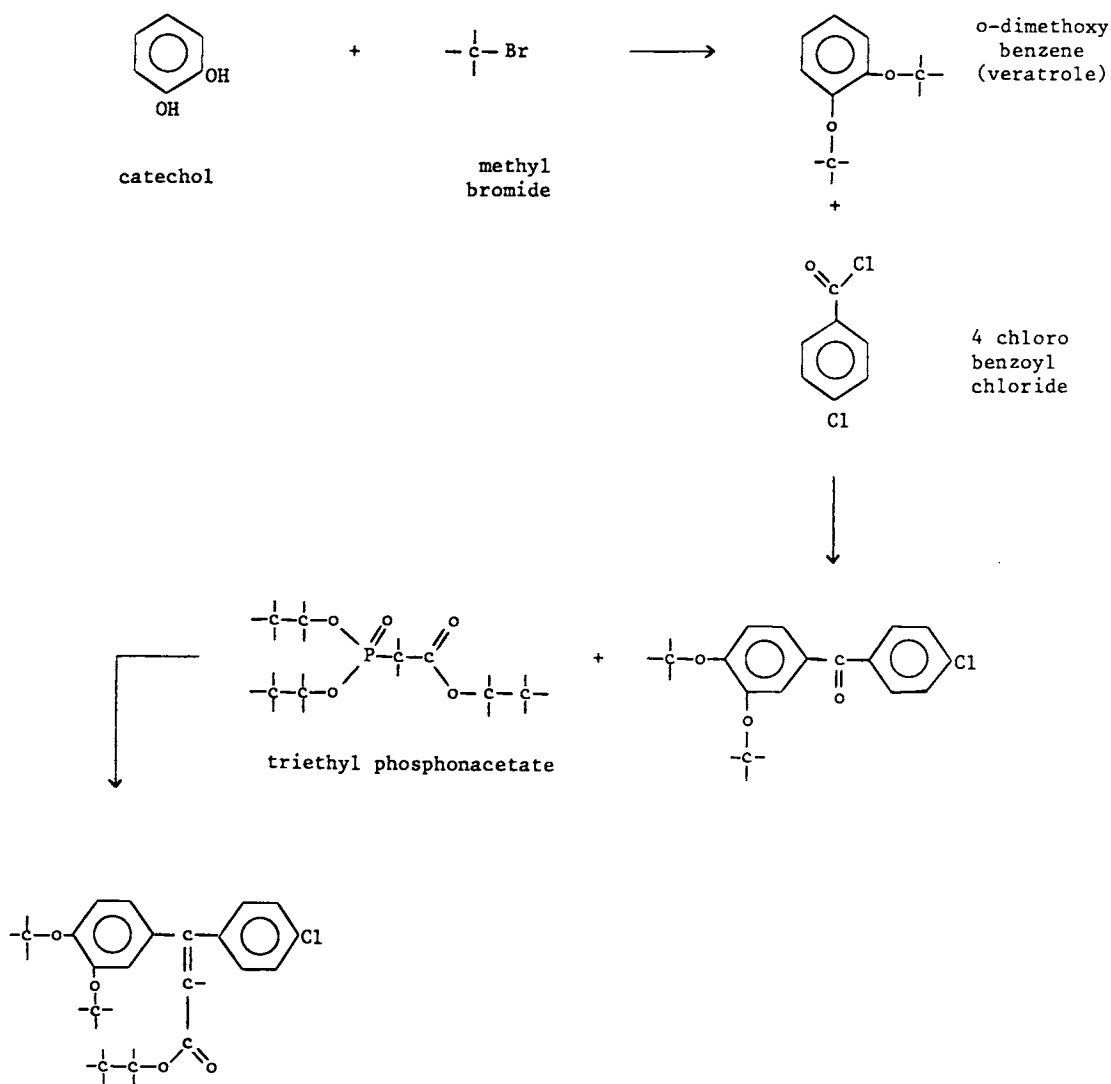
## Dimethomorph

Uses: fungicide, potatoes, tomatoes, vines

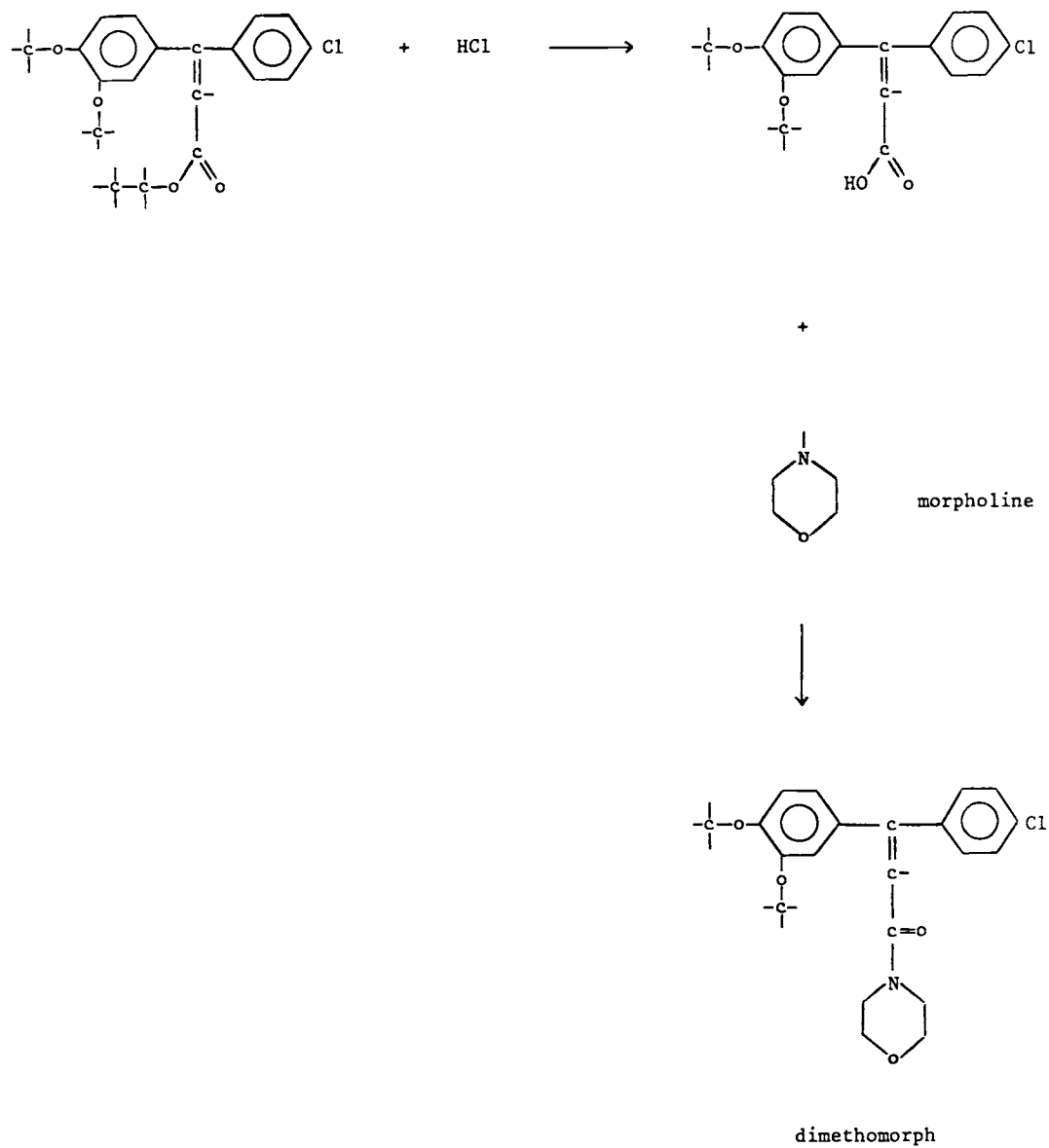
Trade names: Acrobat, Forum (Cyanamid)

Type: morpholine

Synthesis:

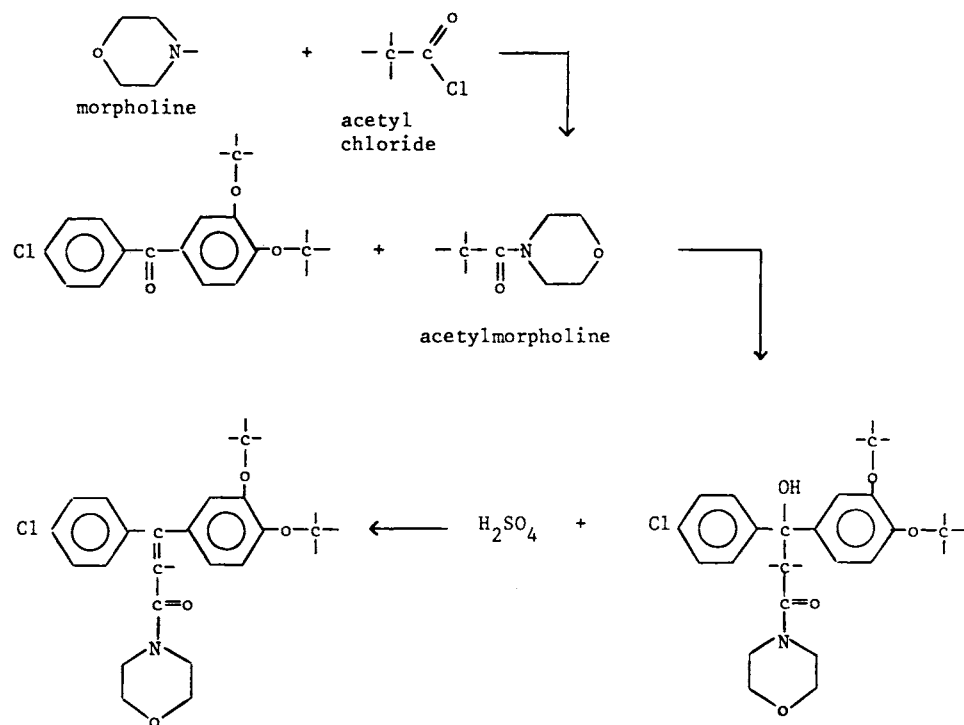






alternate routes :

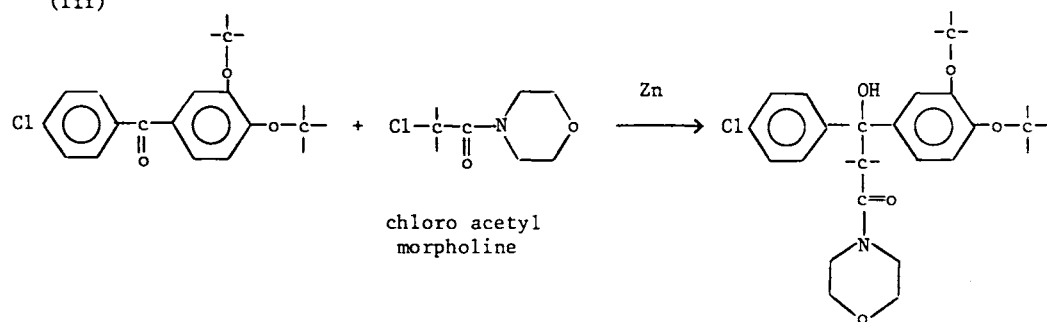
(i)



(ii)

single step reaction without going through the hydroxy propionic intermediary

(iii)



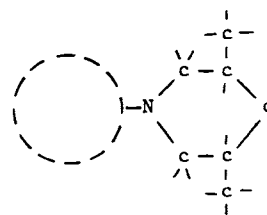
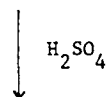
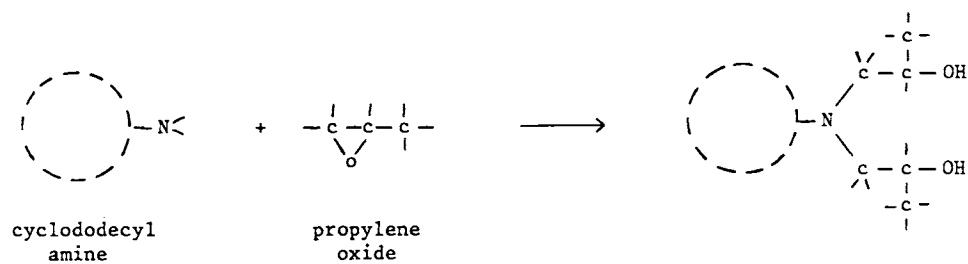
## Dodemorph

Uses: fungicide, ornamentals

Trade names: Meltatox, Mehltaumittel, Milban (BASF)

Type: morpholine

Synthesis:



dodemorph

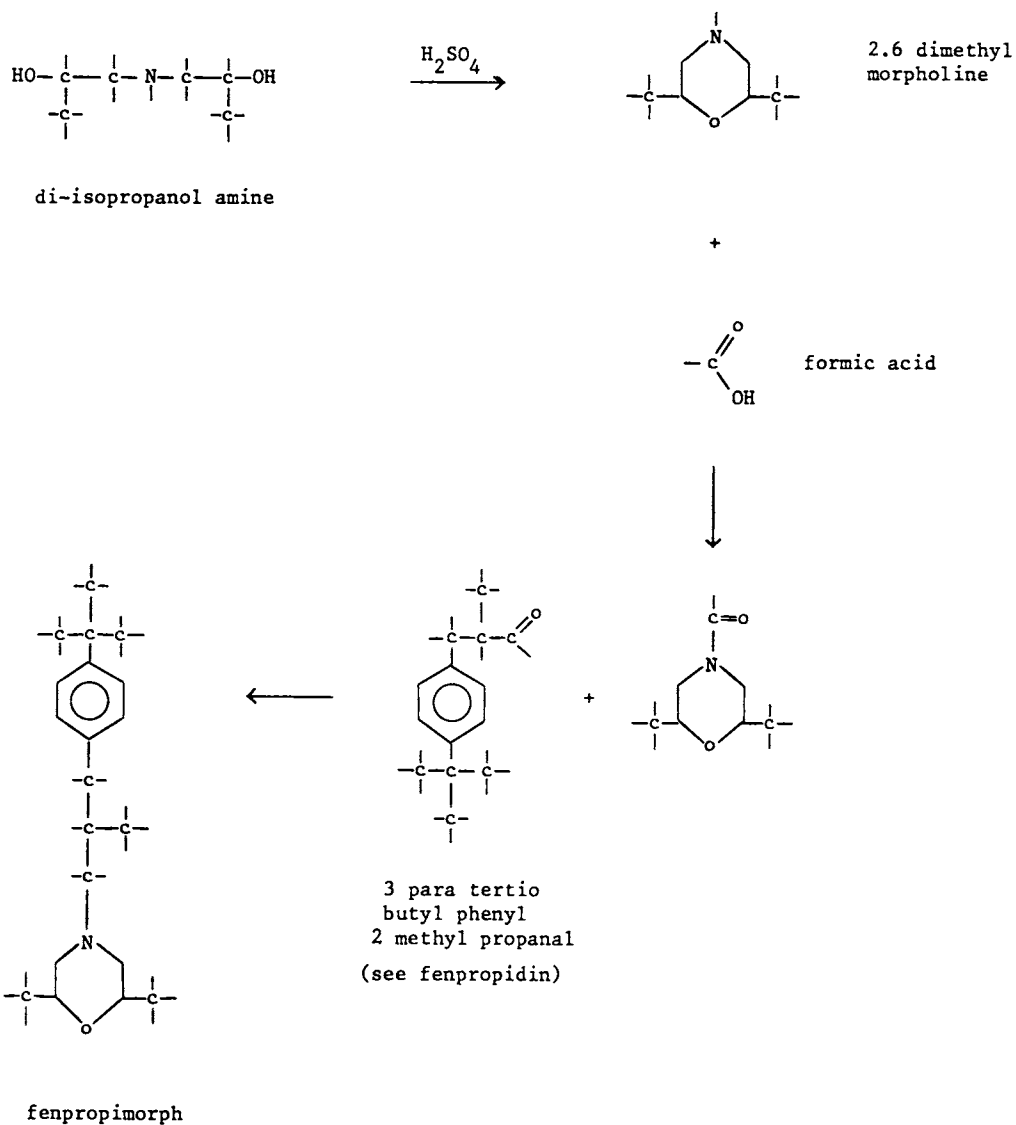
## Fenpropimorph

Uses: fungicide, cereals, sugar beet, beans

Trade names: Corbel (BASF)

Type: morpholine

Synthesis:



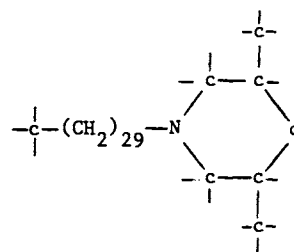
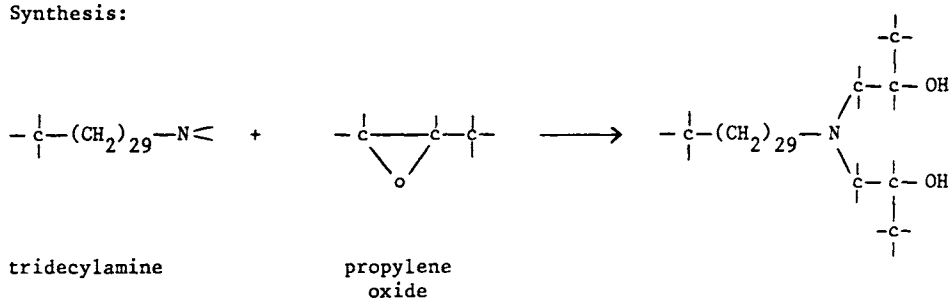
## Tridemorph

Uses: fungicide, bananas, tea, rubber

Trade names: Calixin (BASF)

Type: morpholine

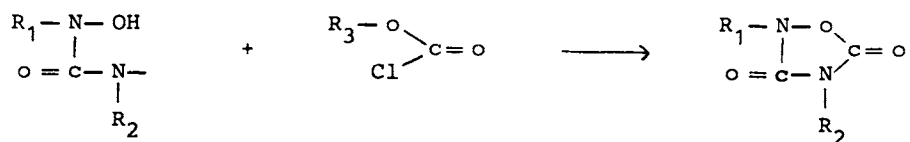
Synthesis:



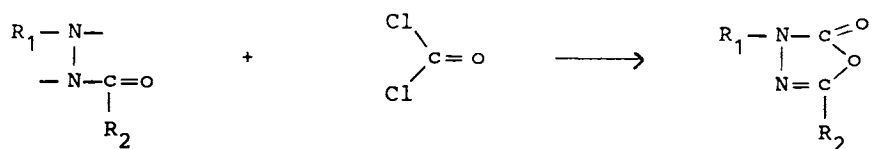
tridemorph

## OXADIAZOLONES OXADIAZOLIDINONES

Ring synthesis is achieved by cyclisation of a hydroxyurea with a chloroformate



or of a carbonyl hydrazide with phosgene



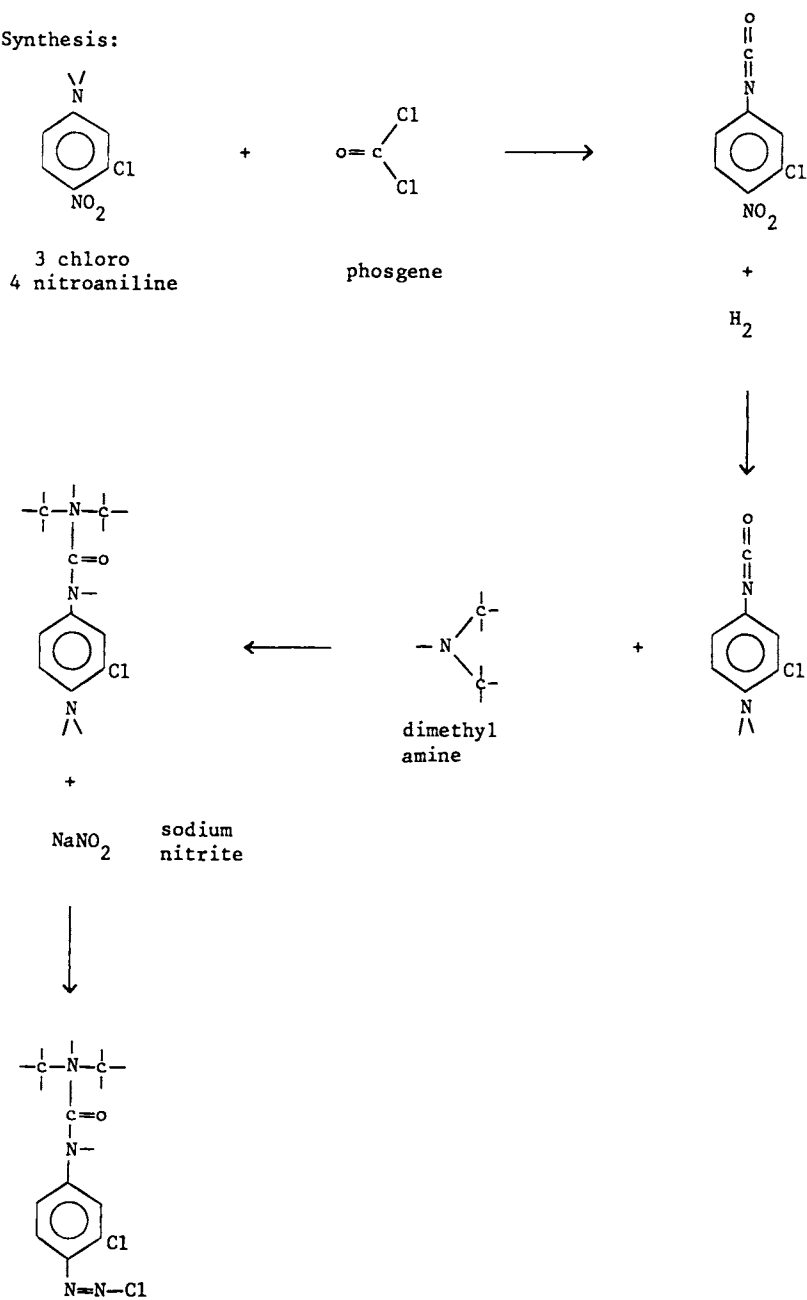
## Dimefuron

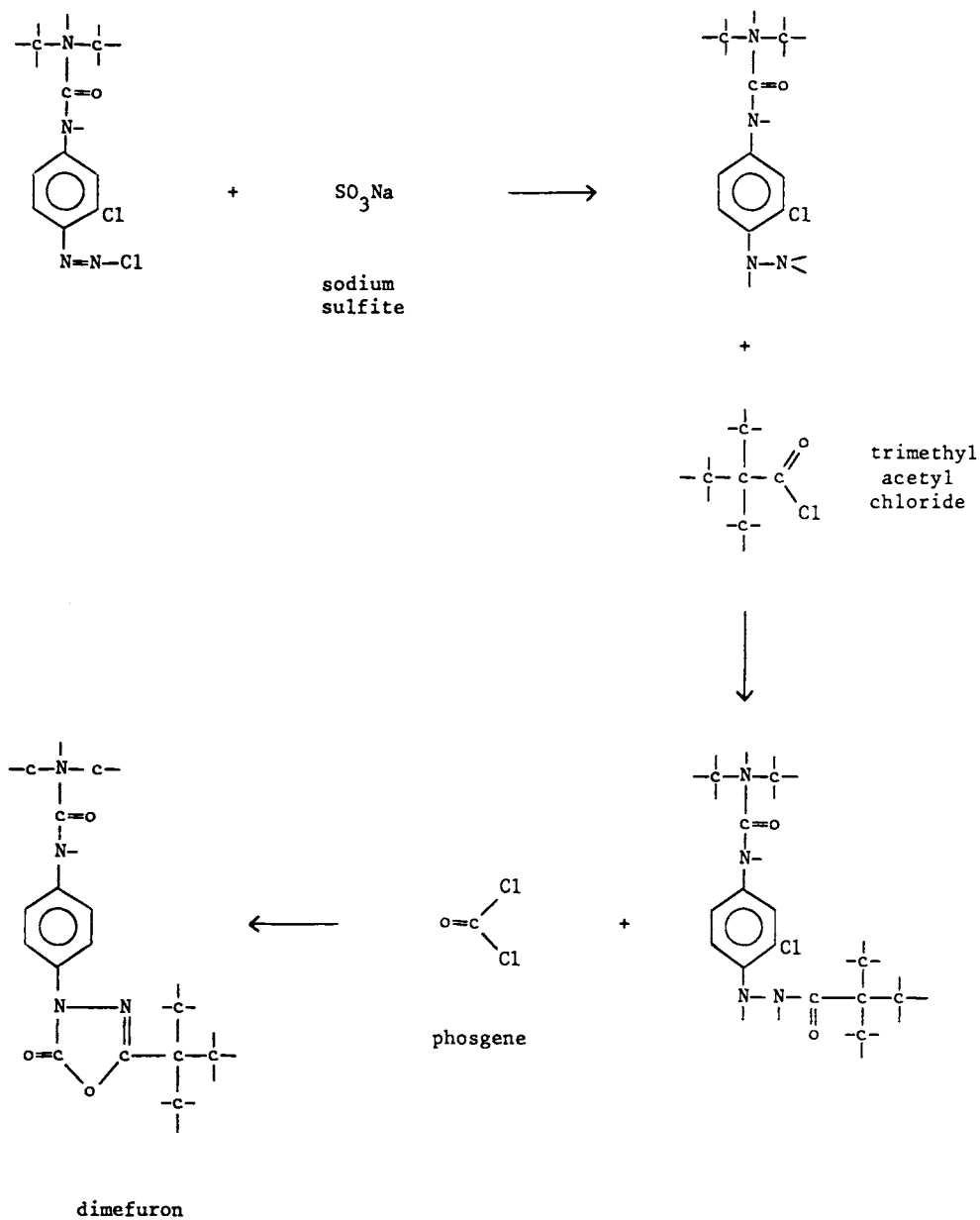
Uses: herbicide, cereals, cotton, groundnuts, beans

Trade names:

Type: oxadiazolone, urea

Synthesis:







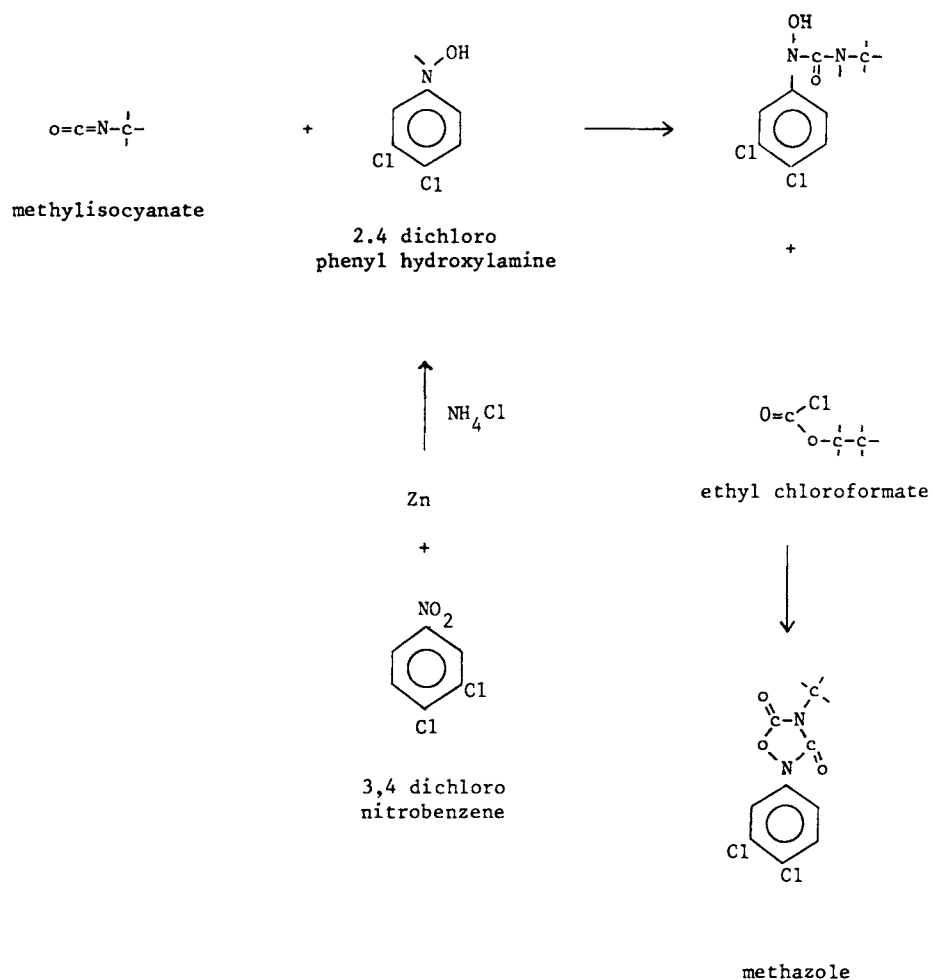
## Methazole

Uses: herbicide, onions, potatoes, citrus, tea, cotton, vines, nuts

Trade names: Probe (Velsicol)

Type: oxadiazolidinone, urea

Synthesis:



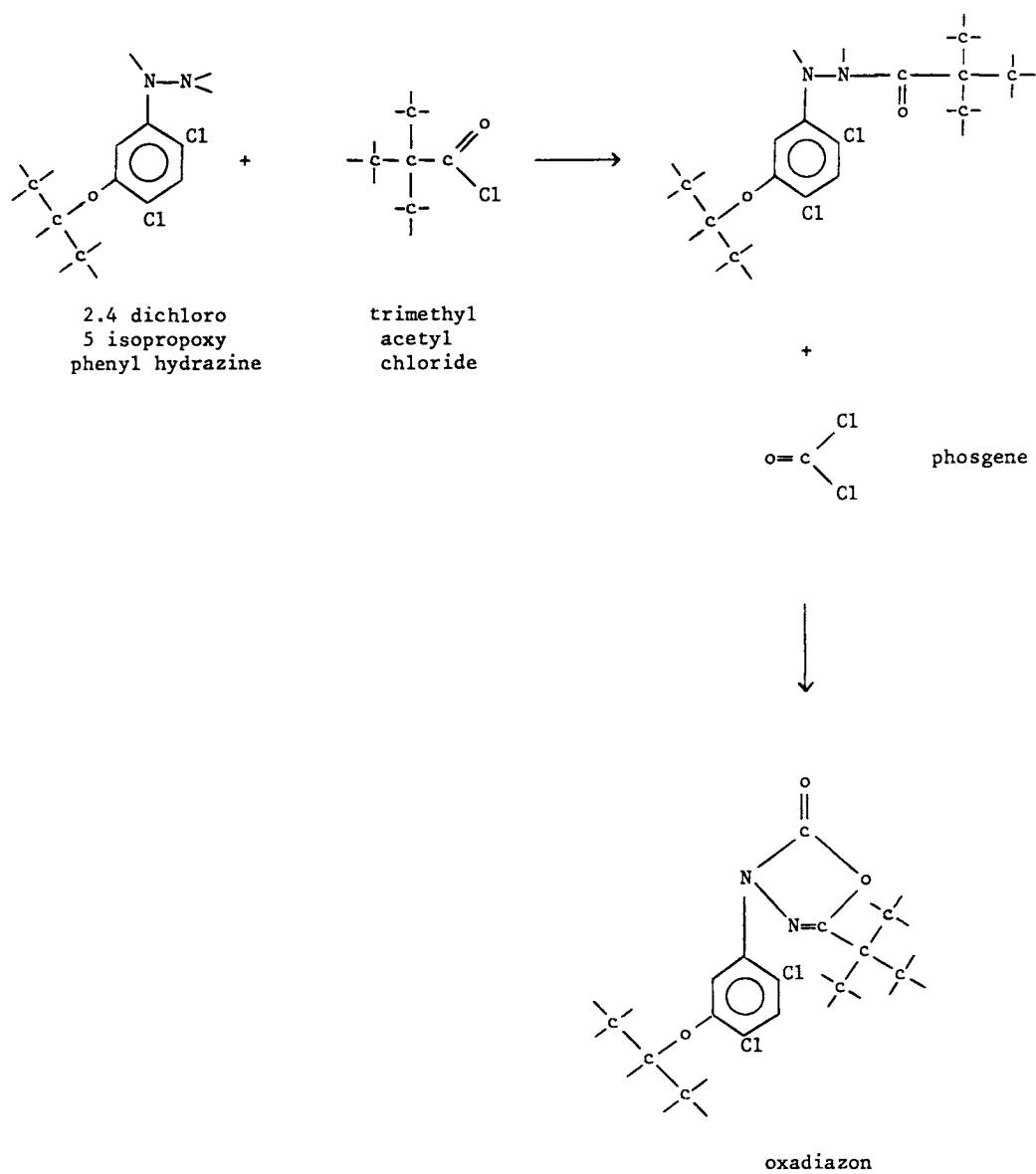
## Oxadiazon

Uses: herbicide, rice, orchards, vine

Trade names: Ronstar (Rhône Poulenc)

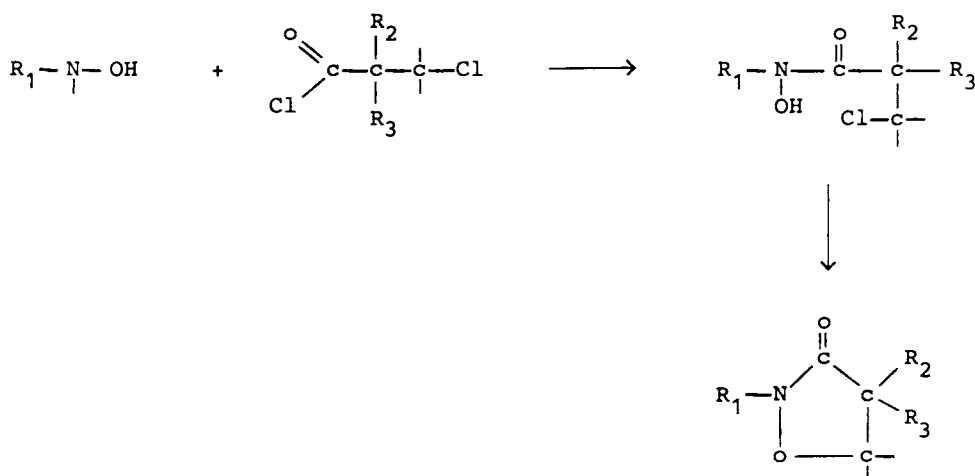
Type: oxadiazolone

Synthesis:

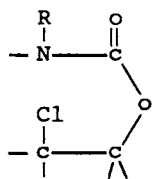


# OXAZOLIDINES OXAZOLIDINONES OXAZOLIDINEDIONES OXAZOLES

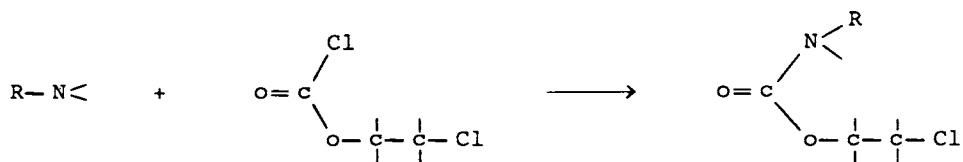
Oxazolidinones are usually obtained by reaction between a hydroxylamine and a chloro acid chloride followed by cyclisation



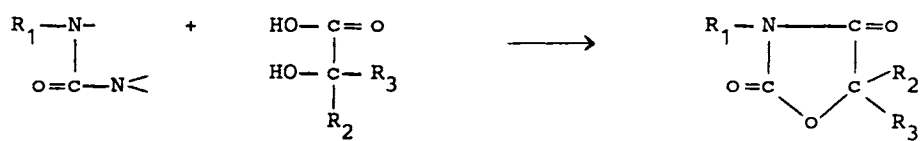
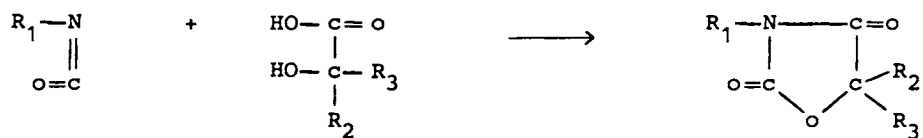
An alternate route is by cyclisation of a compound



obtained for example by reaction between 2 chloroethyl chloroformate and an amine



Oxazolidinediones are synthesized by reaction between an isocyanate or a urea and an  $\alpha$  hydroxy carboxylic acid

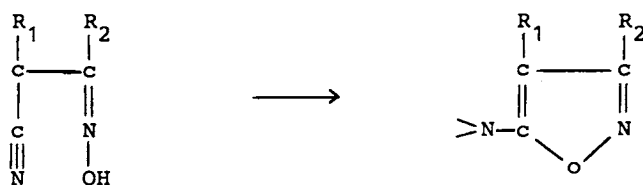


Amino oxazoles may be obtained by several routes :

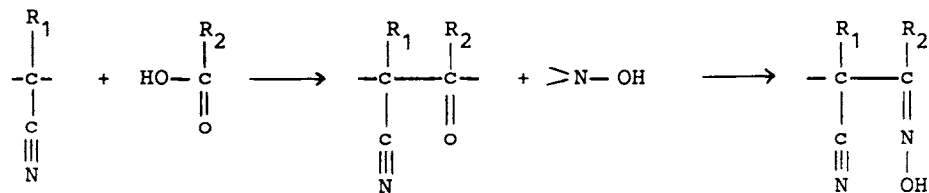
i) reaction between cyanamide and acetoin



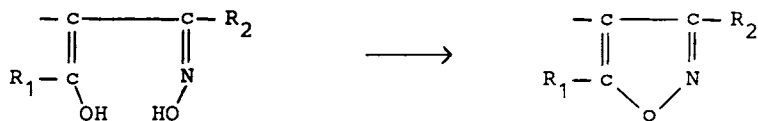
ii) cyclisation of a nitrile-oxime compound



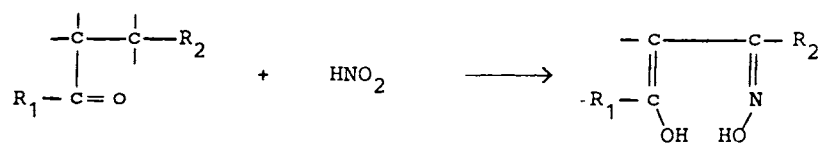
the compound to be cyclised having been obtained by reaction between a nitrile and an acid ( or ester ) followed by hydroxylamination



iii) cyclisation of a hydroxy oxime compound



The compound to be cyclised having been obtained by nitrosation of a ketone



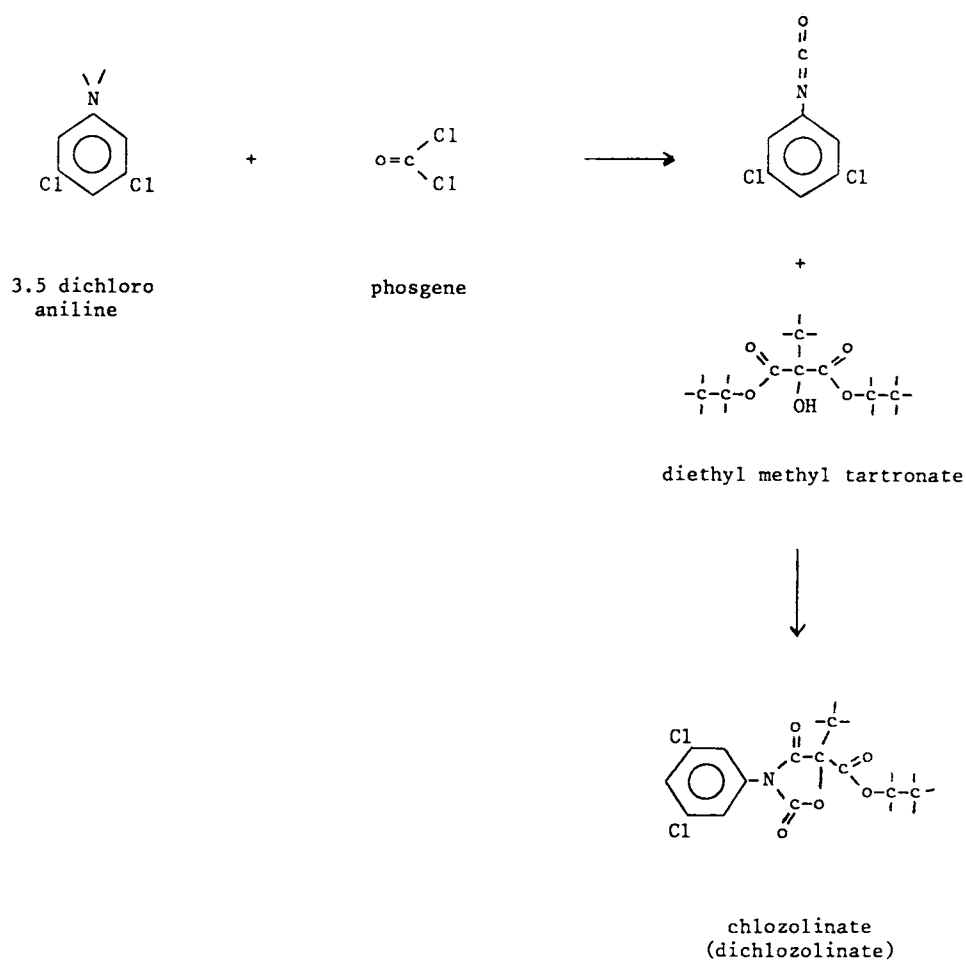
## Chlozoline (Dichlozoline)

Uses: fungicide, fruit, vegetables, ornamentals

Trade names: Serinal (Agrimont)

Type: oxazolidinedione

Synthesis:



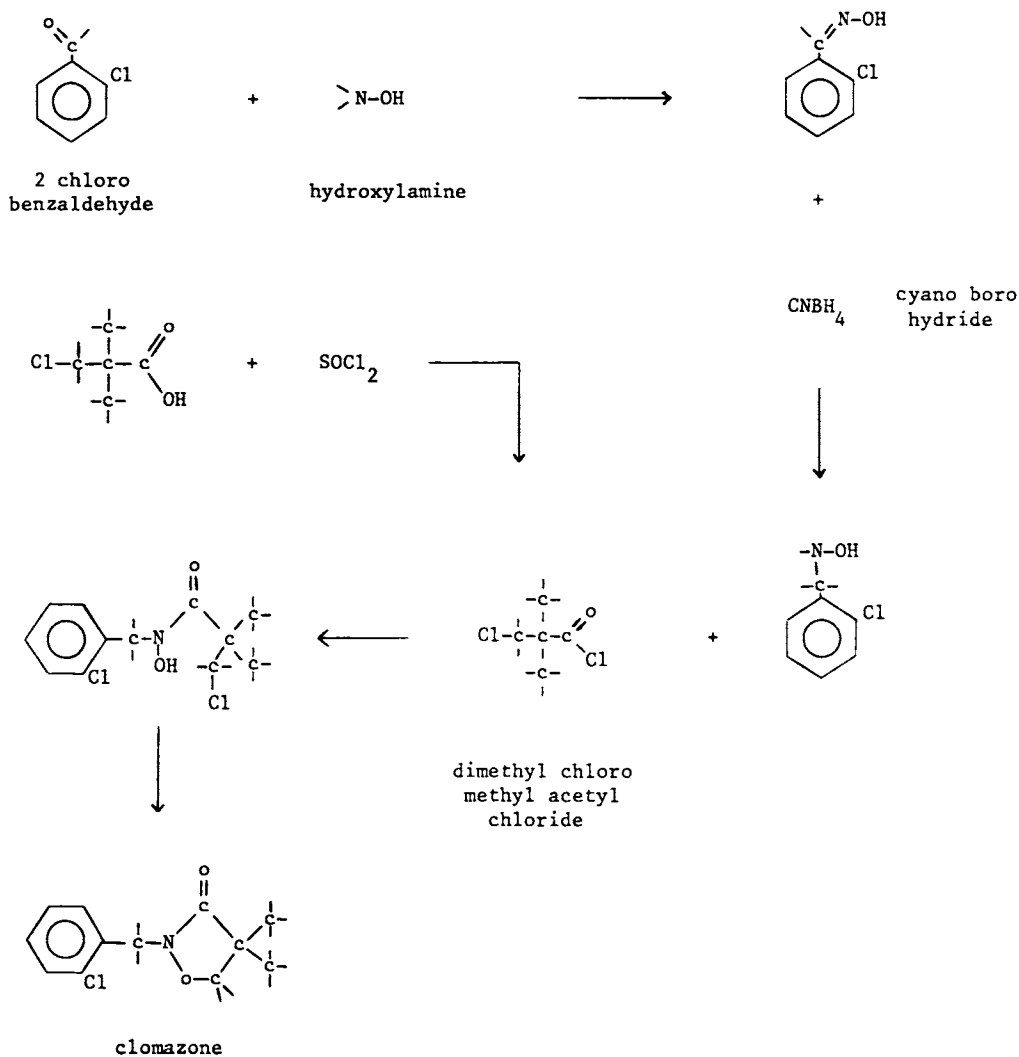
## Clomazone (Dimethazone)

Uses: herbicide, soyabeans, maize, sugarcane, tobacco, cassava

Trade names: Command (FMC)

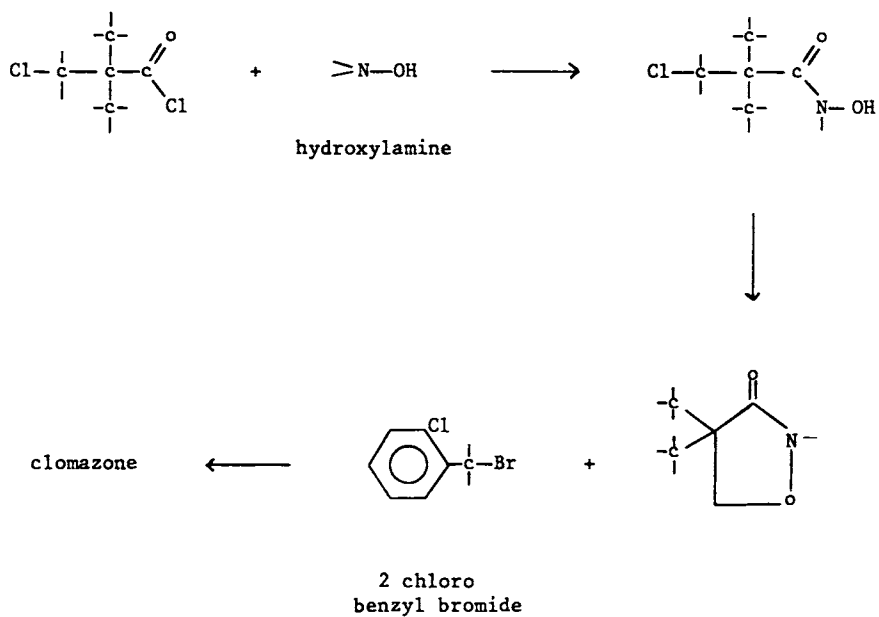
Type: oxazolidinone

Synthesis:





alternate route:



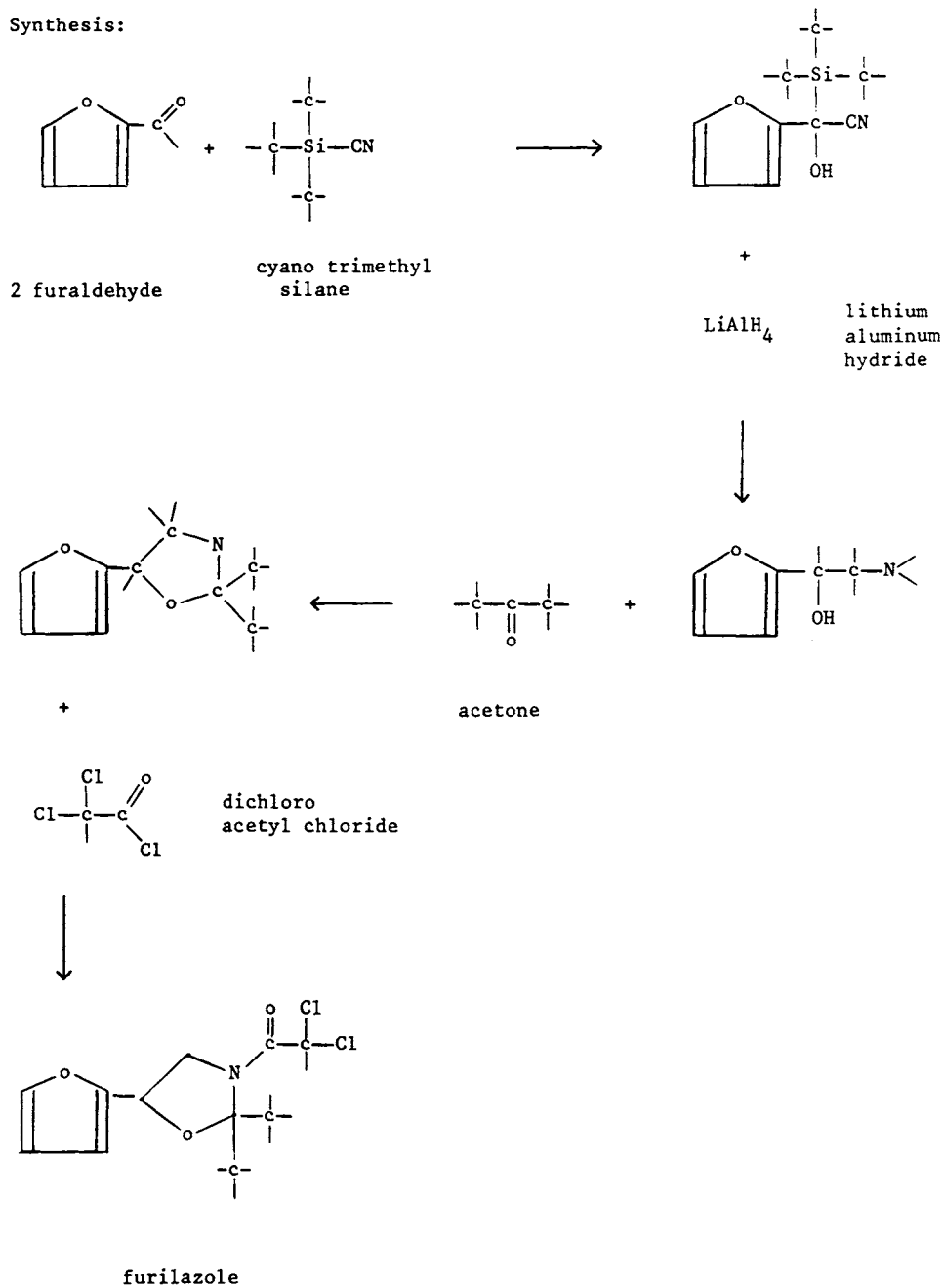
## Furilazole

Uses: herbicide safener, maize, sorghum

Trade names: (Monsanto)

Type: oxazolidine, furane

Synthesis:



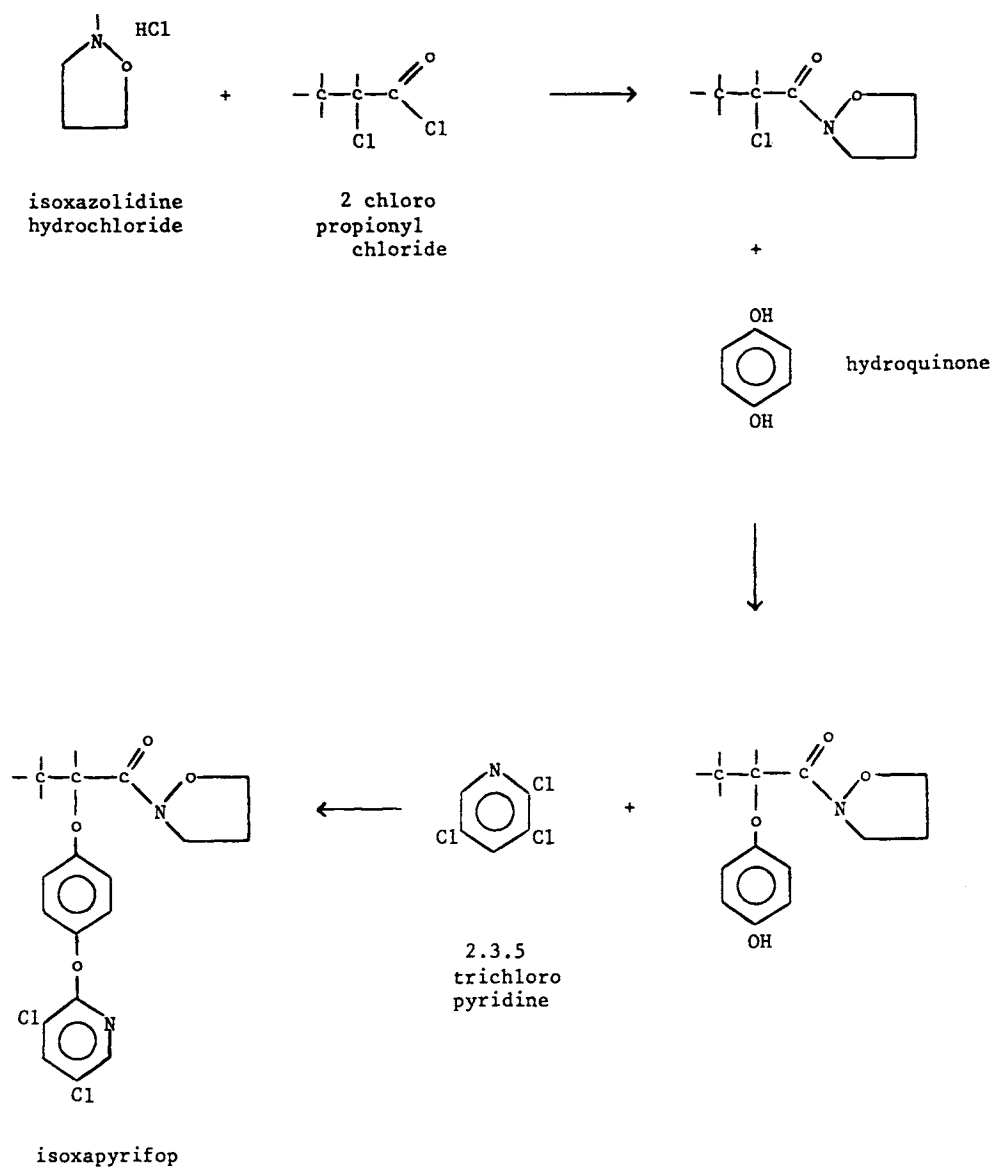
## Isoxapyrifop

Uses: herbicide, rice, wheat

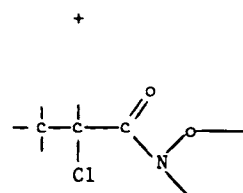
Trade names: (Rohm & Haas)

Type: oxazolidine

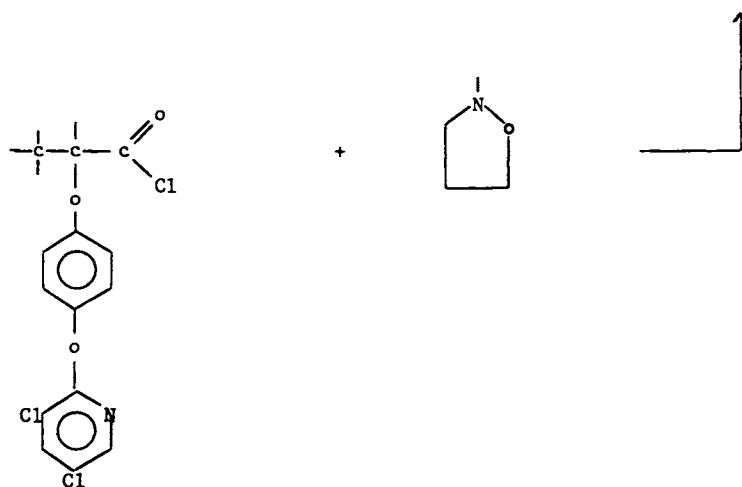
Synthesis:



alternate routes :



isoxapyrifop



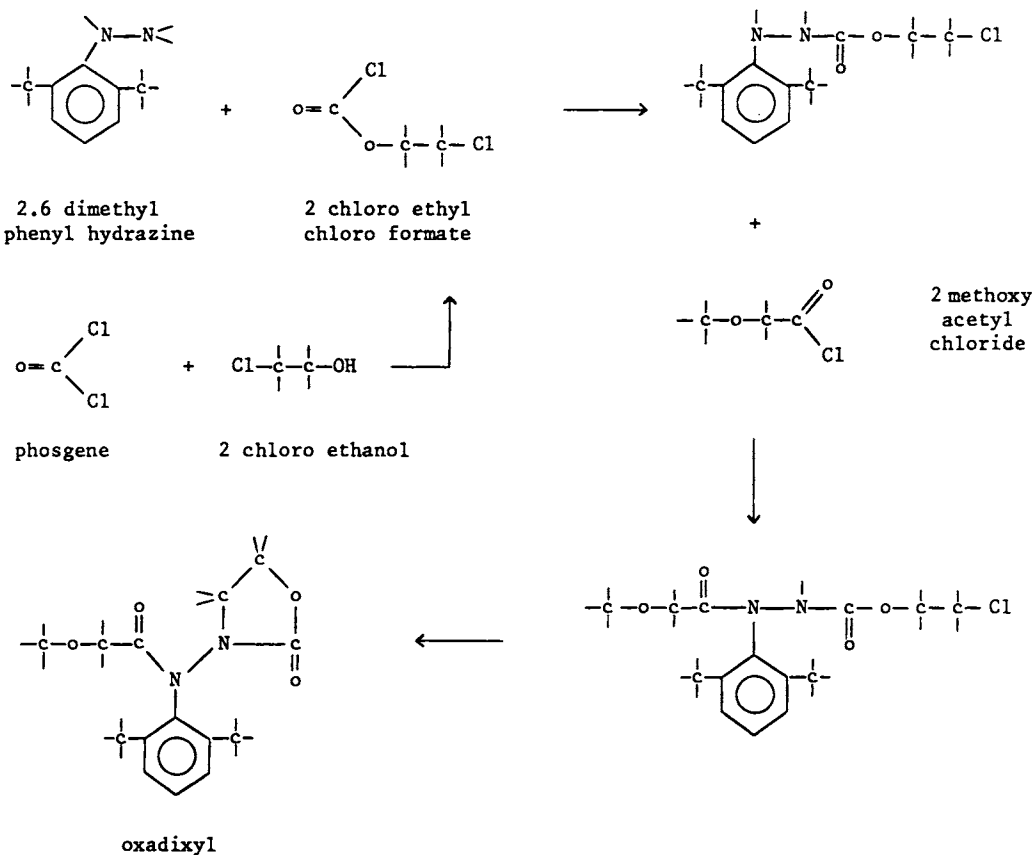
## Oxadixyl

Uses: fungicide, cereals, cotton, soyabeans, maize, sunflowers, tobacco, sugarbeat potatoes, tomatoes, turf, vegetables, citrus, fruit, ornamentals

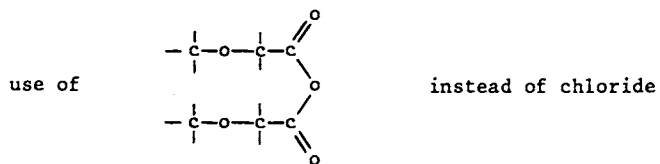
Trade names: Sandofan (Sandoz)

Type: oxazolidinone , amide

Synthesis:



alternate route :



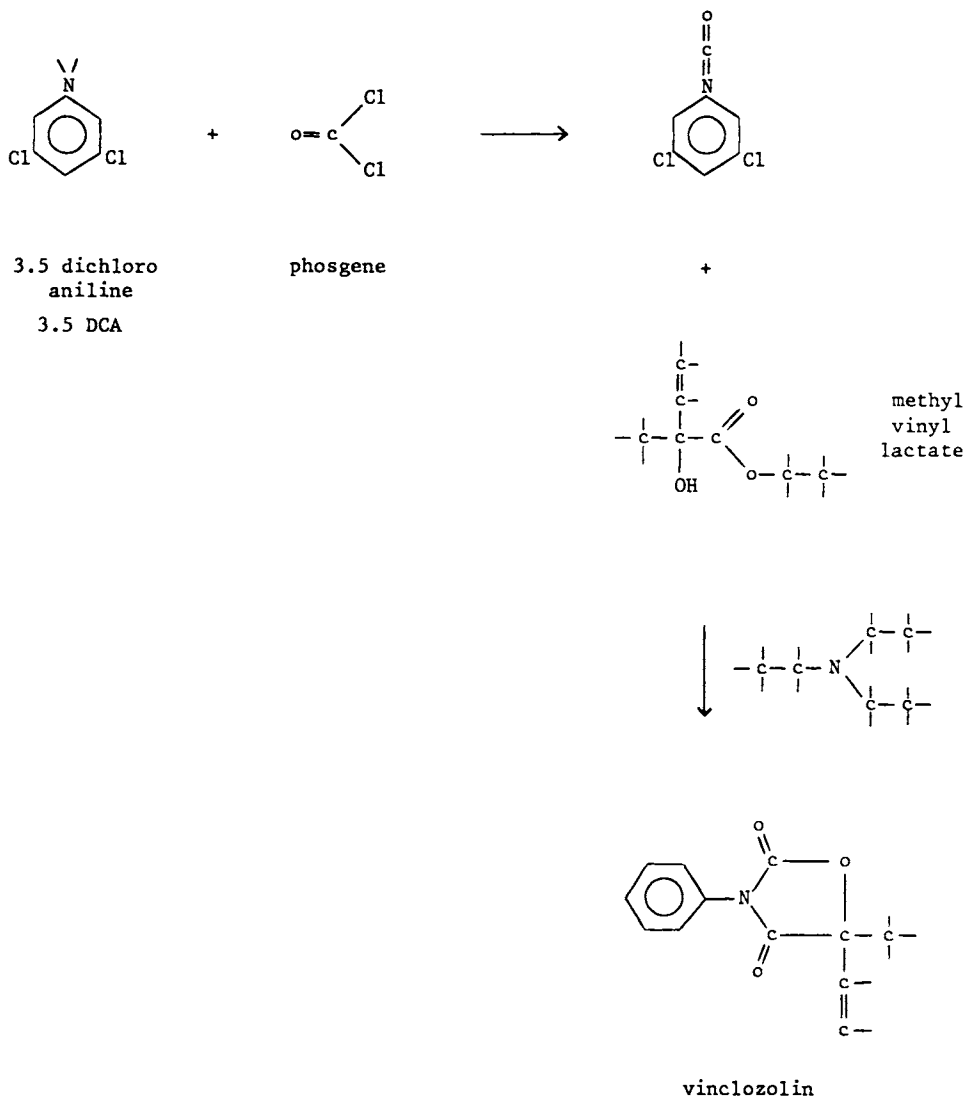
## Vinclozolin

Uses: fungicide, grapes, fruit, vegetables, ornamentals

Trade names: Ronilan, Ornalin (BASF)

Type: oxazolidinedione

Synthesis:



## PIPERAZINES

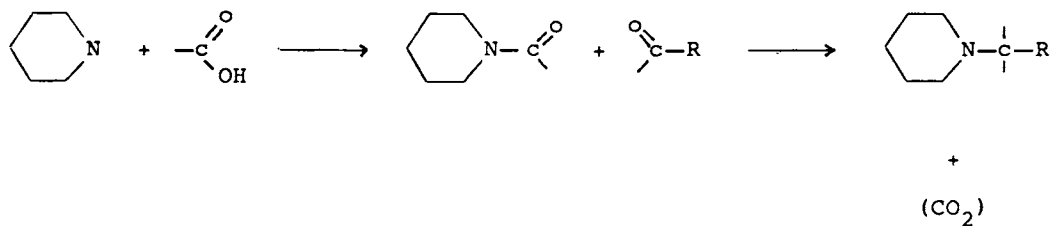
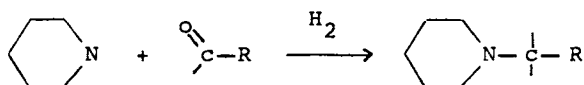
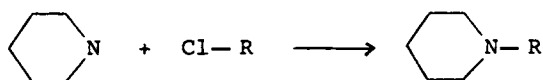
Piperazines are introduced by tacking on to a halogen of the main molecule



see TRIFORINE (amides)

## PIPERIDINES

The piperidine ring may either be tacked on to the main molecule by a halogen, or via a carbonyl



A further synthesis route is as illustrated in route (iii) for morpholines.



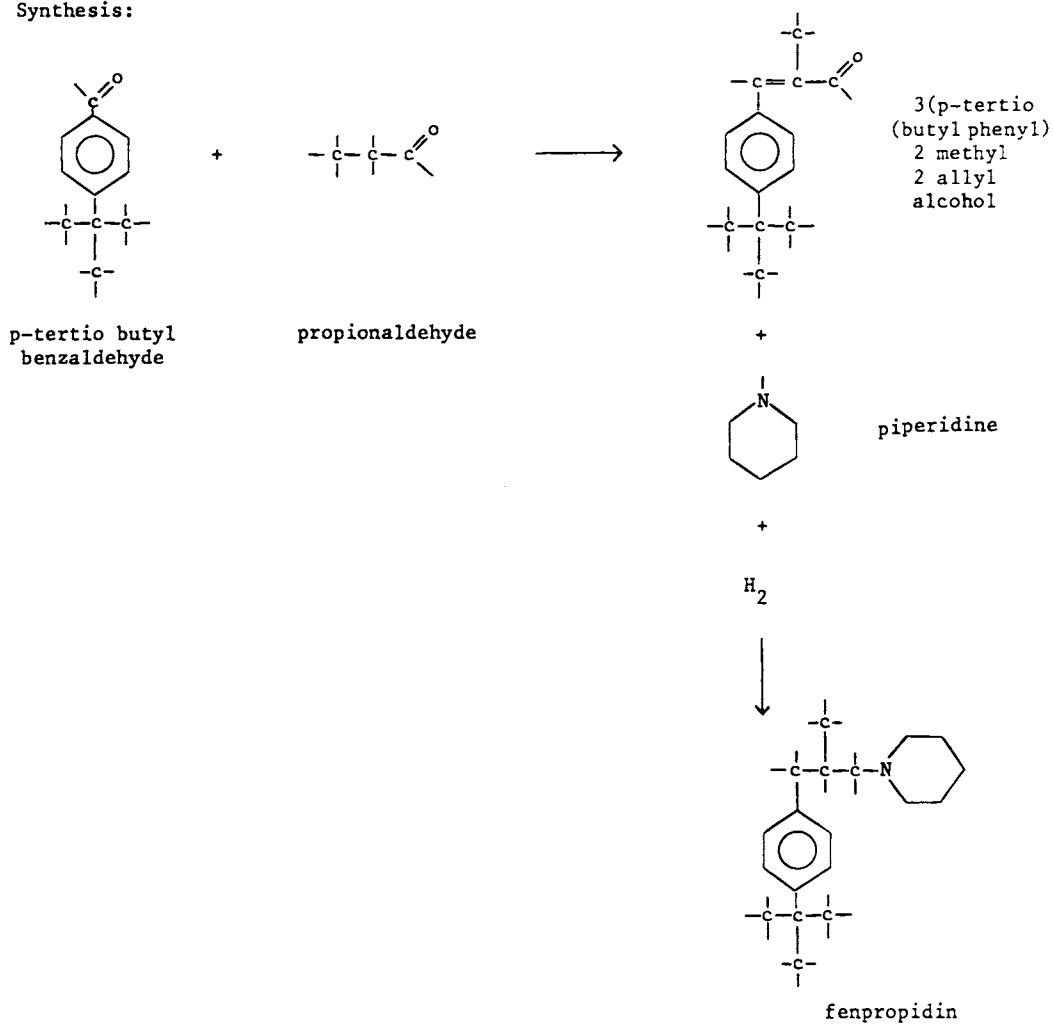
## Fenpropidin

Uses: fungicide, cereals

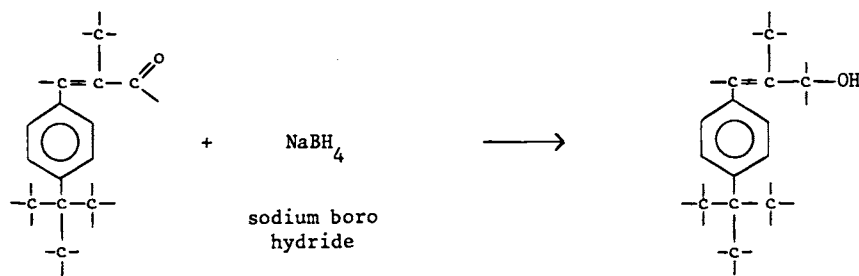
Trade names: Patrol, Sorilan (Ciba)

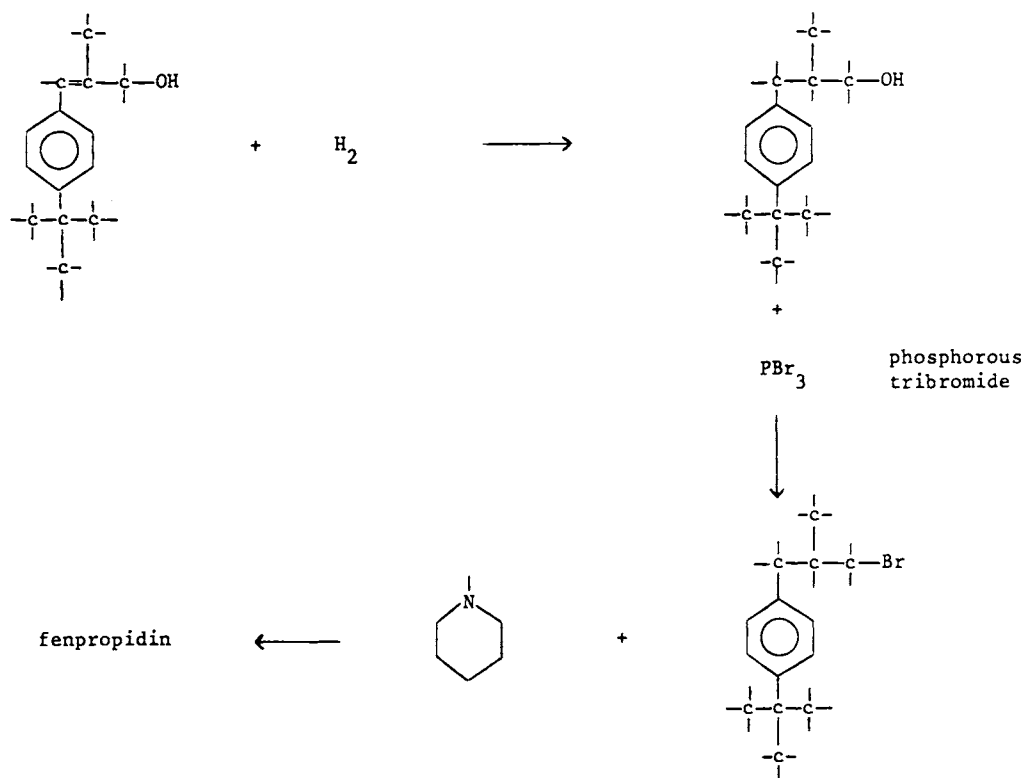
Type: piperidine

Synthesis:

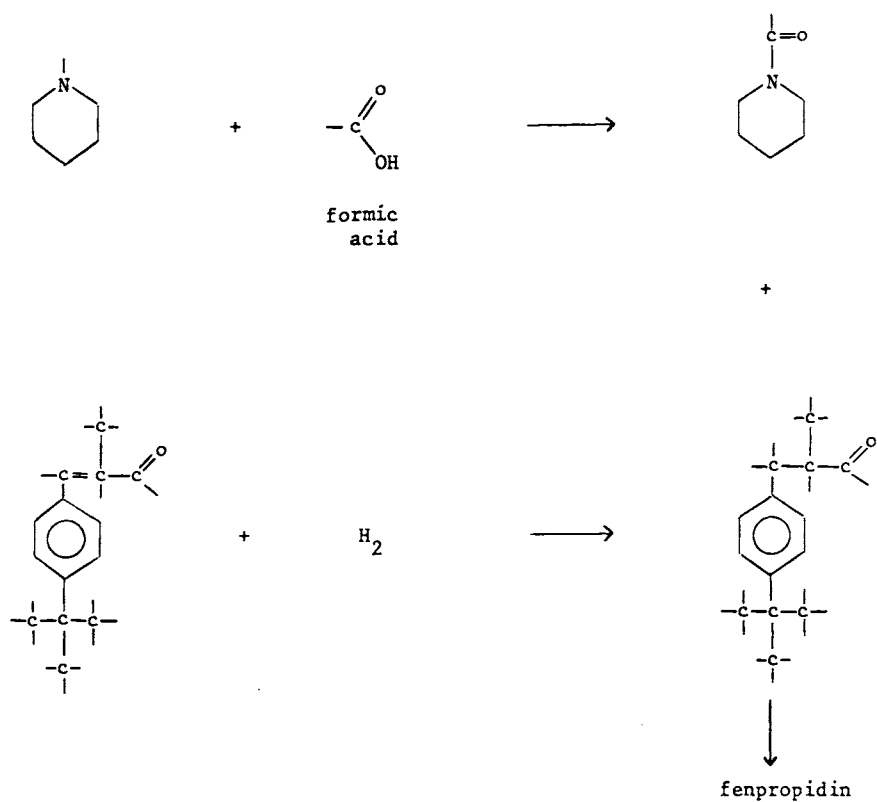


alternate route :





alternate route :



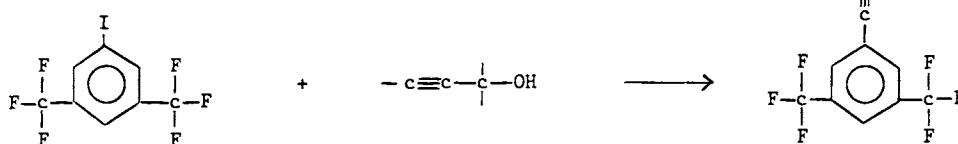
## Flupropadine

Uses: rodenticide

Trade names: (Rhône Poulenc)

Type: piperidine

Synthesis:

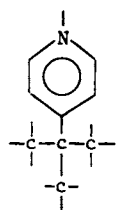


3,5 bis trifluoro  
methyl, iodo benzene

2 propyn-1 ol

+

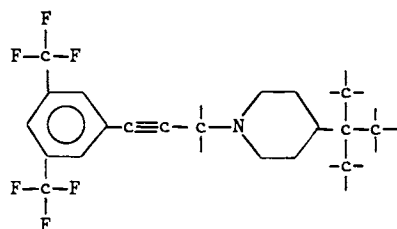
Br<sub>2</sub>



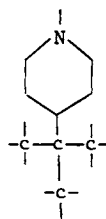
4 tert butyl  
pyridine

+

H<sub>2</sub>

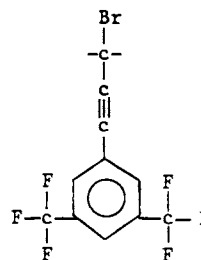


flupropadine

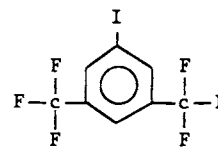
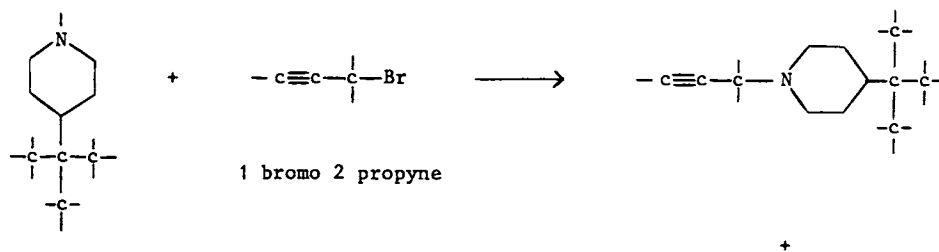


4 tert butyl  
piperidine

+



alternate route :



flupropadine

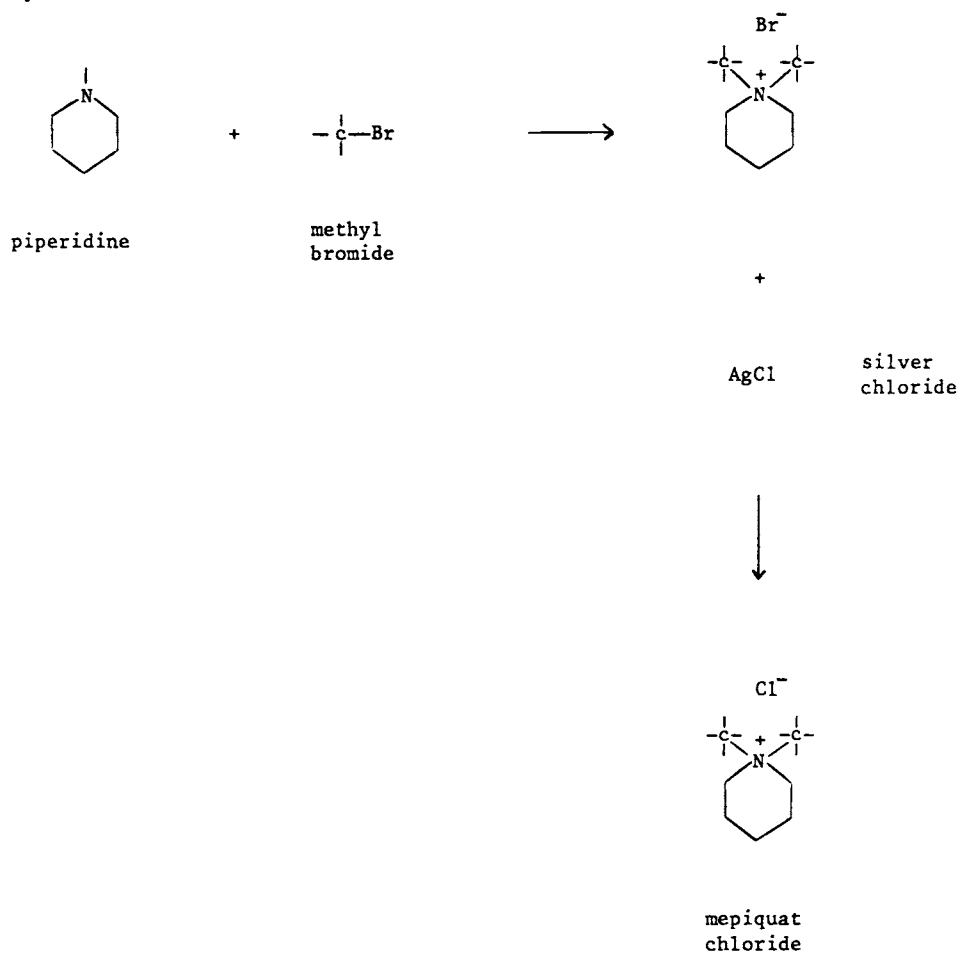
## Mepiquat Chloride

Uses: growth regulator, cotton, barley, rye, wheat

Trade names: Pix (BASF)

Type: piperidine, quaternary ammonium

Synthesis:



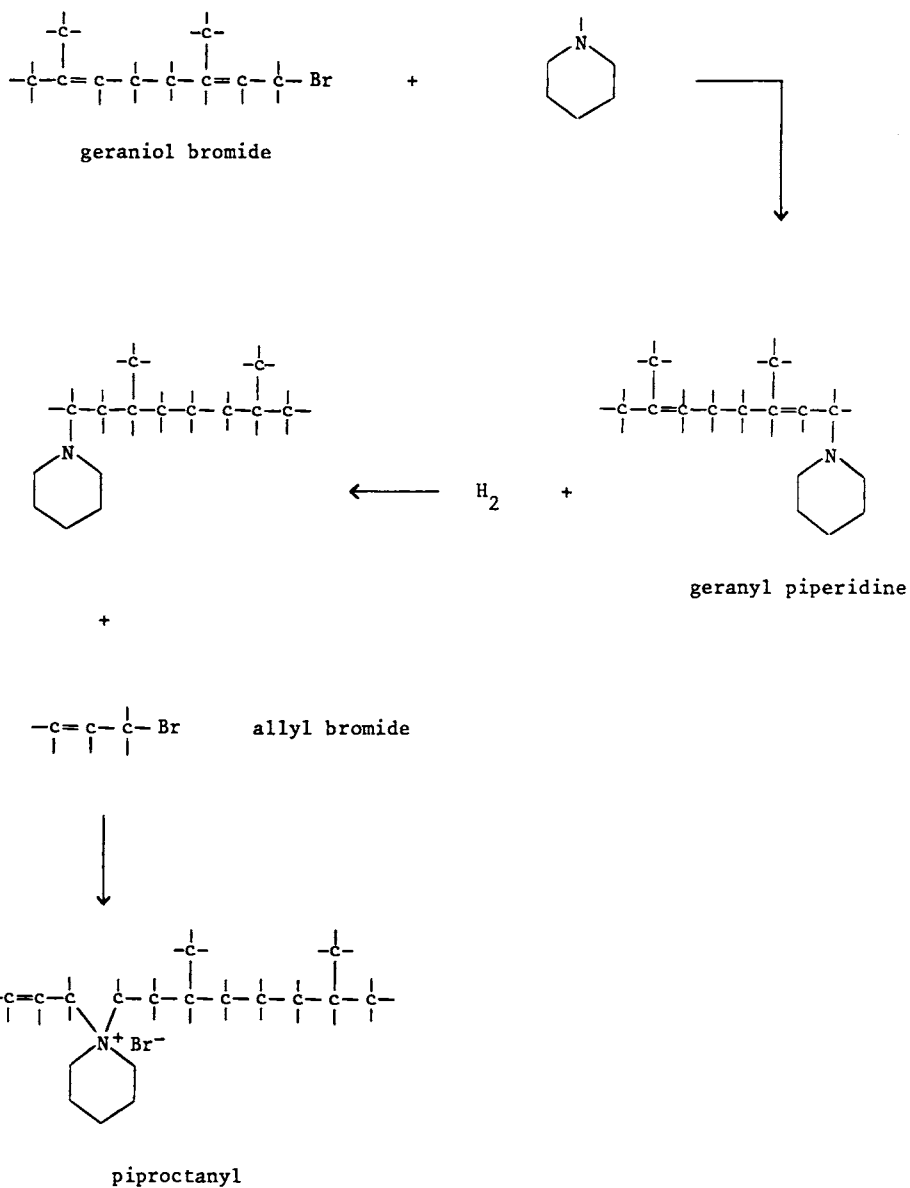
## Piproctanyl

Uses: growth regulator

Trade names: Alden, Stamtrol (Ciba)

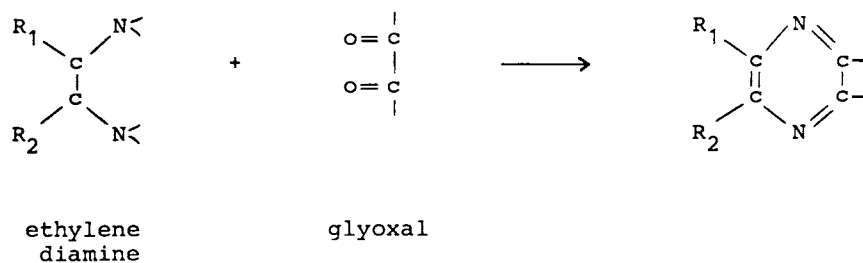
Type: piperidine, quaternary ammonium

Synthesis:

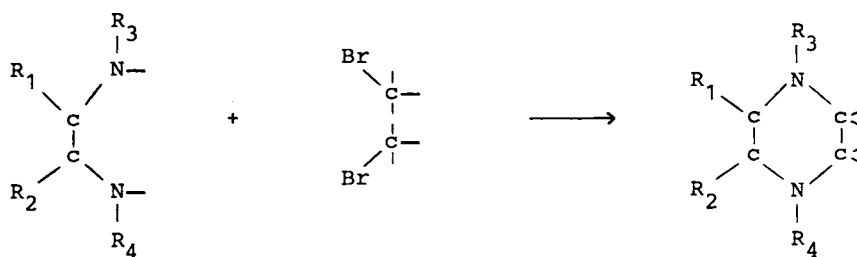


# PYRAZINES

The pyrazine ring can be obtained by reaction of a primary diamine with glyoxal or of a secondary diamine with ethylene dibromide



or



the latter method being used in the synthesis of diquat.

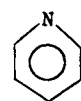
## Diquat

Uses: herbicide, potatoes, aquatic weed control

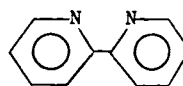
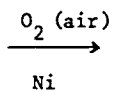
Trade names: Reglone (ICI)

Type: pyrazine, pyridine, quaternary ammonium

Synthesis:

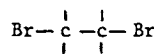


pyridine

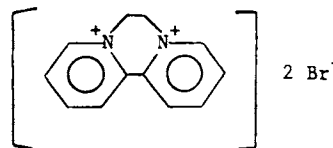


2,2' bipyridil

+



ethylene dibromide



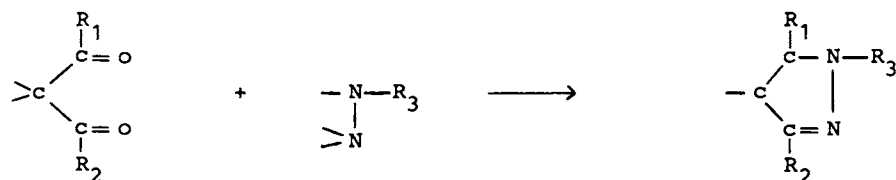
diquat



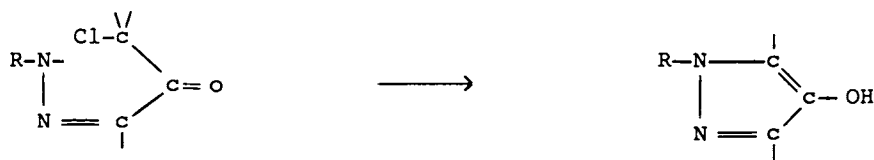
# PYRAZOLES

The pyrazole ring may be obtained

- by reaction between a hydrazine and a diketone

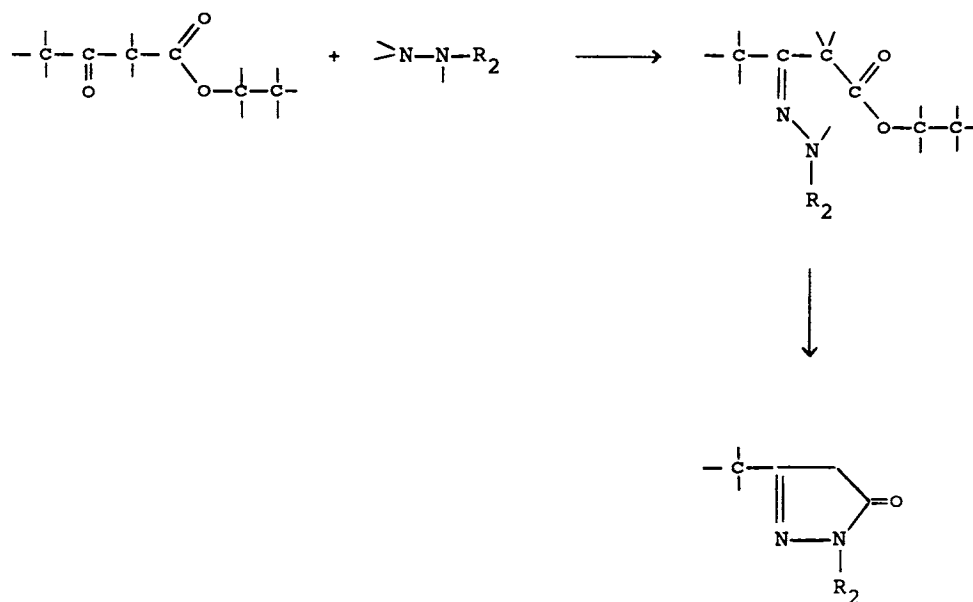


- by cyclisation of



the compound to be cyclised being a hydrazone (or diazonium salt)

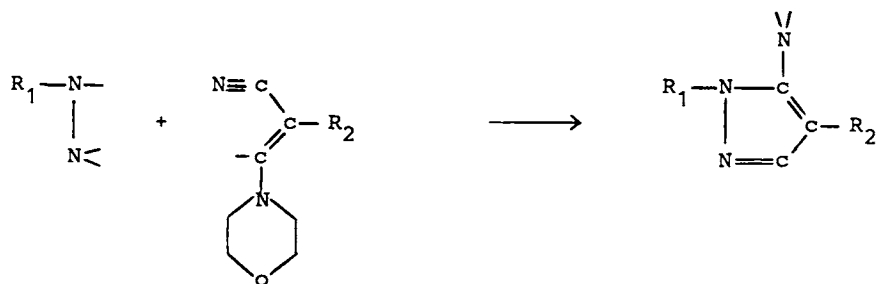
- by cyclisation of the hydrazone resulting from the reaction between ethyl aceto acetate and a hydrazine



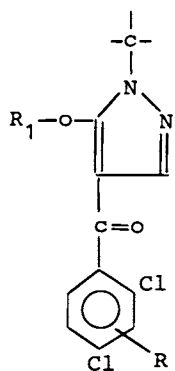
by reaction between a hydrazine and a halo acrylonitrile



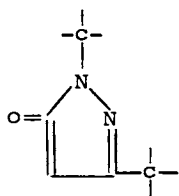
by reaction between a hydrazine and a morfolynil acrylonitrile



A common structure of pyrazole pesticides is



where



obtained from the reaction between

ethyl aceto acetate and methyl hydrazine followed by cyclisation is reacted in succession with a benzoyl chloride and  $R_1-X$  where  $X$  is a halogen.

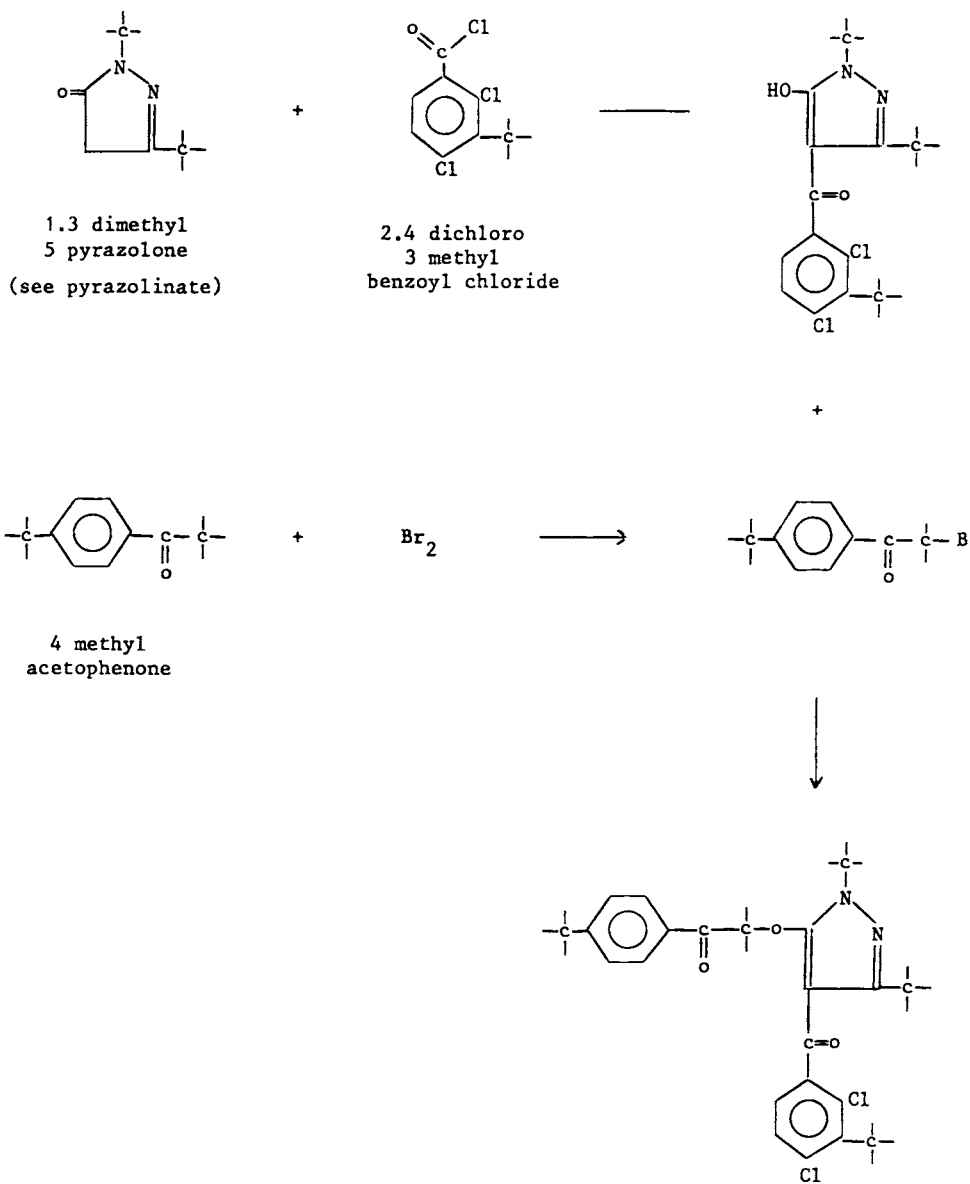
## Benzofenap

Uses: herbicide

Trade names: (Mitsubishi)

Type: pyrazole

Synthesis:



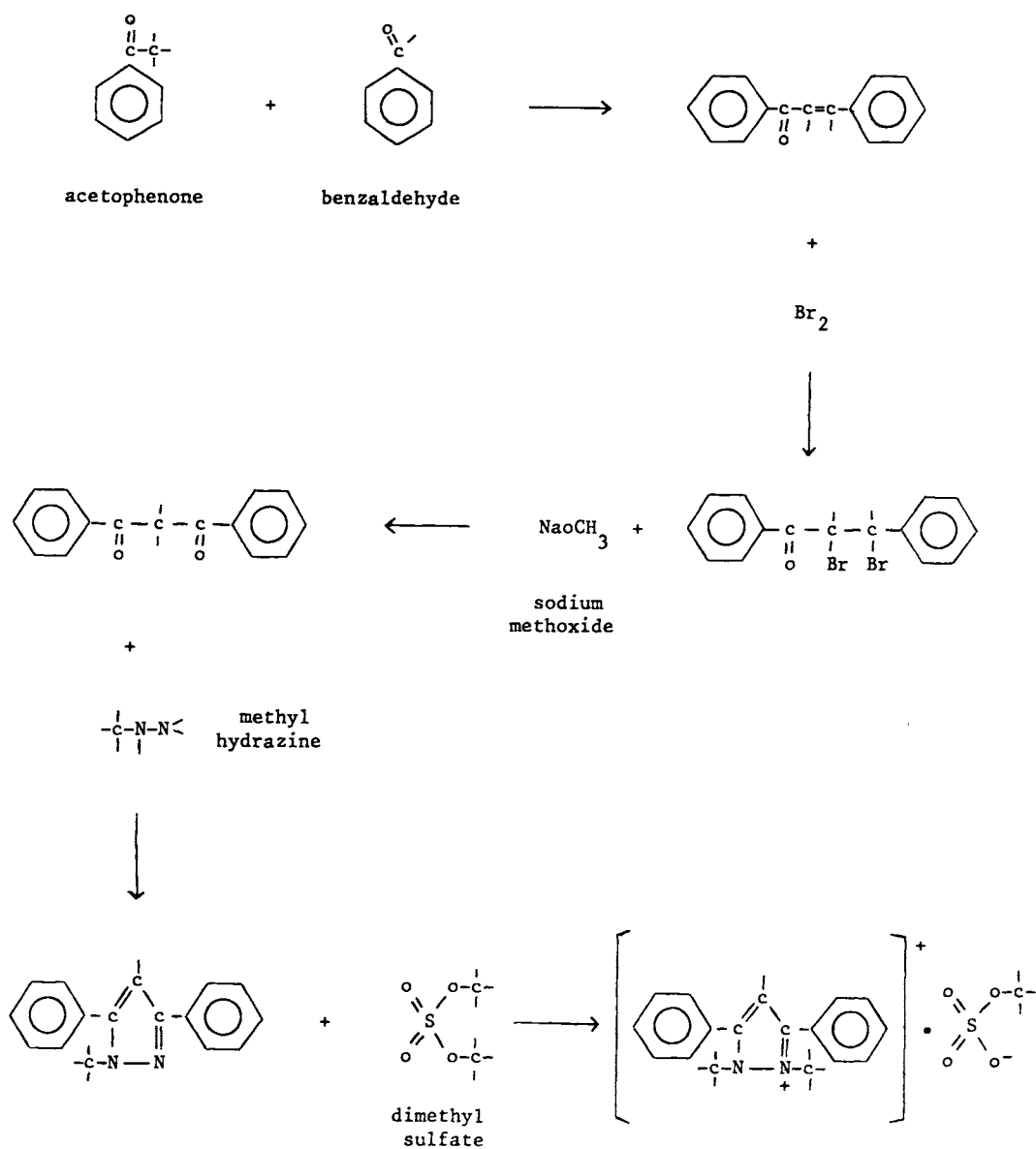
## Difenzoquat

Uses: herbicide, wheat, barley

**Trade names:** Avenge, Finaven (Cyanamid)

Type: pyrazole, quaternary ammonium

**Synthesis:**



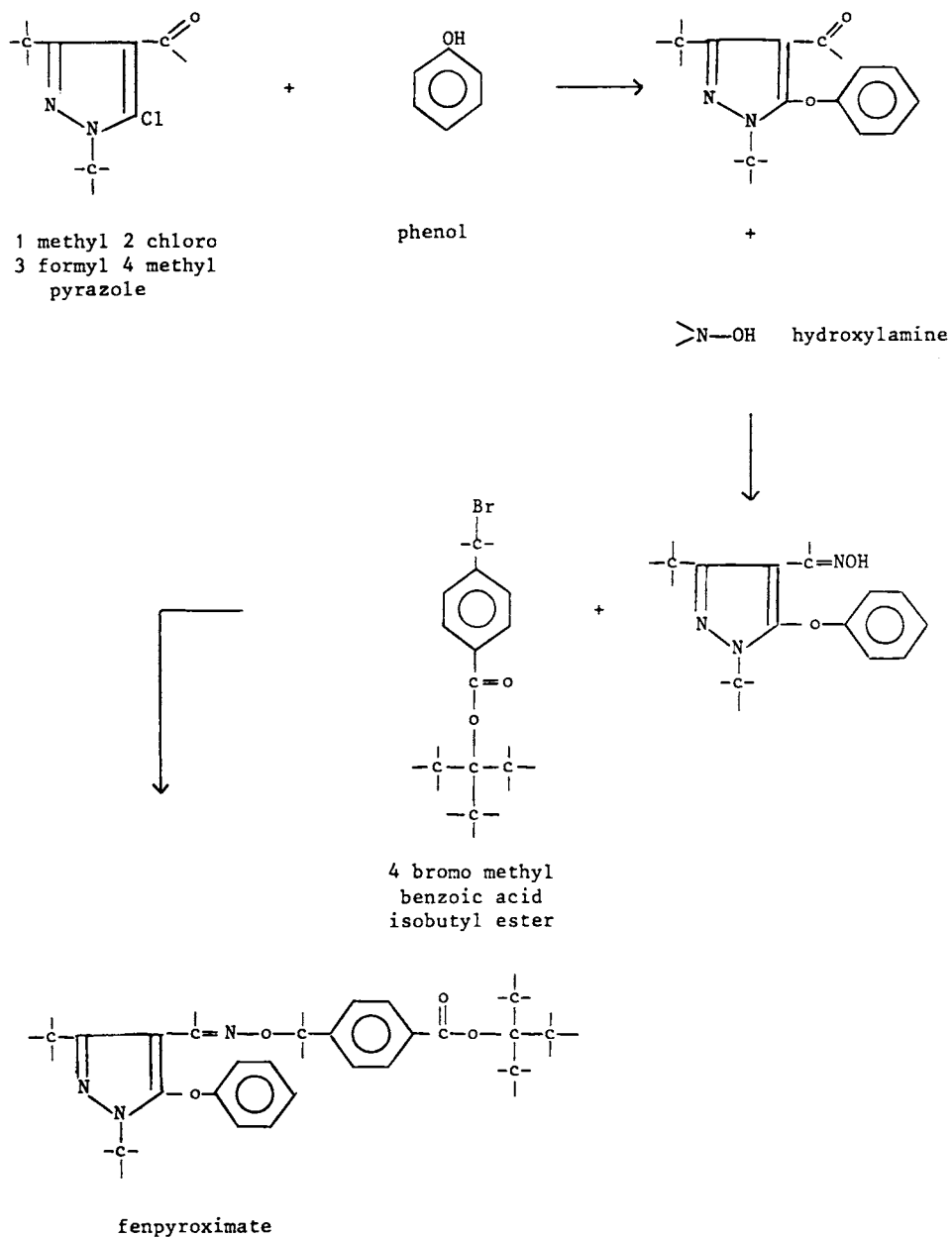
## Fenpyroximate

Uses: acaricide, citrus, fruit, tea

Trade names: Danitron, Ortus (Nihon Nohyaku)

Type: pyrazole

Synthesis:



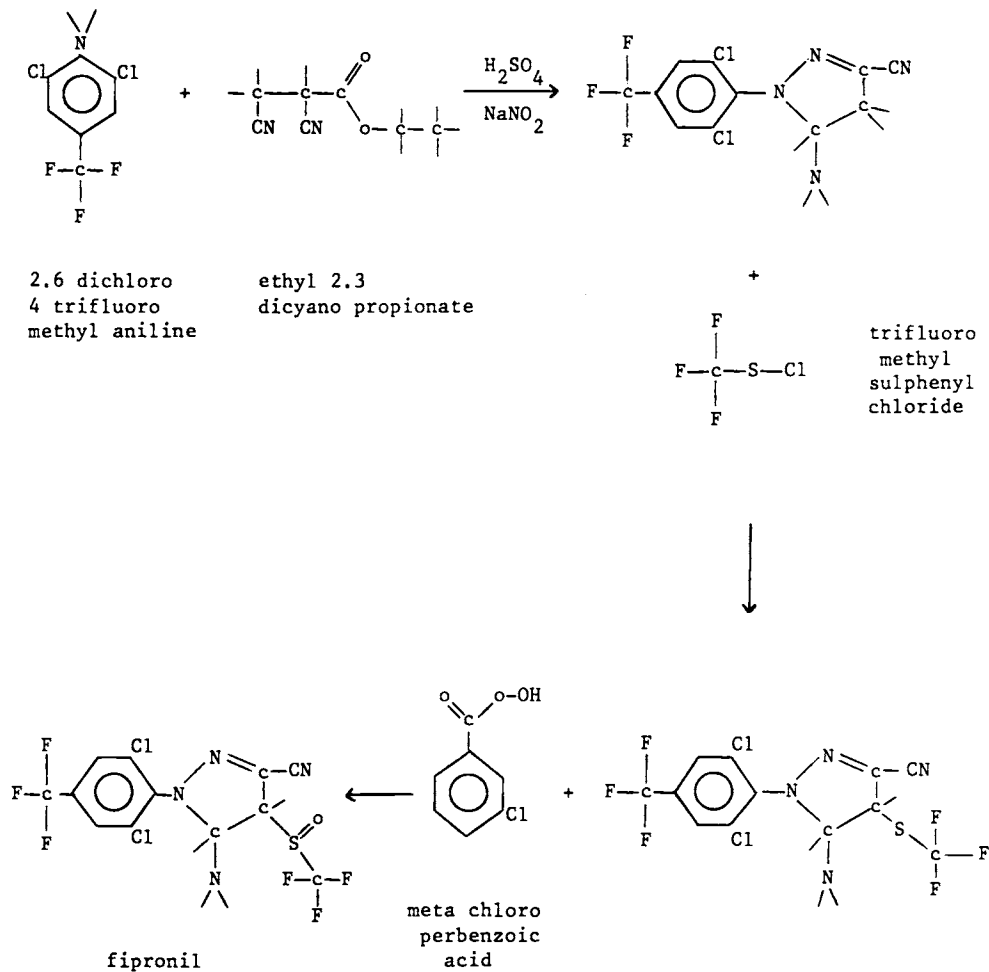
## Fipronil

Uses: insecticide, acaricide, potatoes, rice

Trade names: Regent (Rhône Poulenc)

Type: pyrazole

Synthesis:



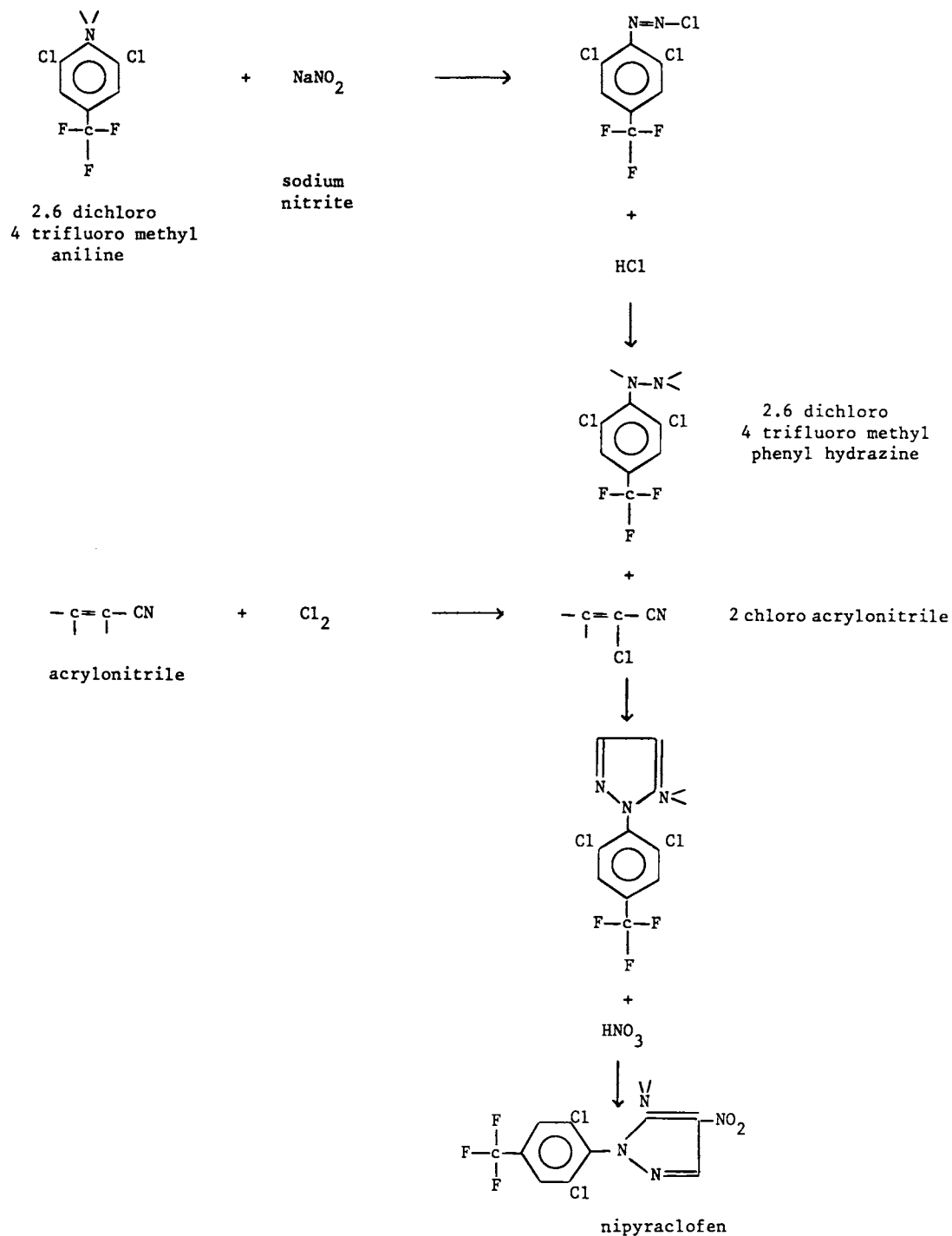
## Nipyraclofen

Uses: herbicide

Trade names: (Bayer)

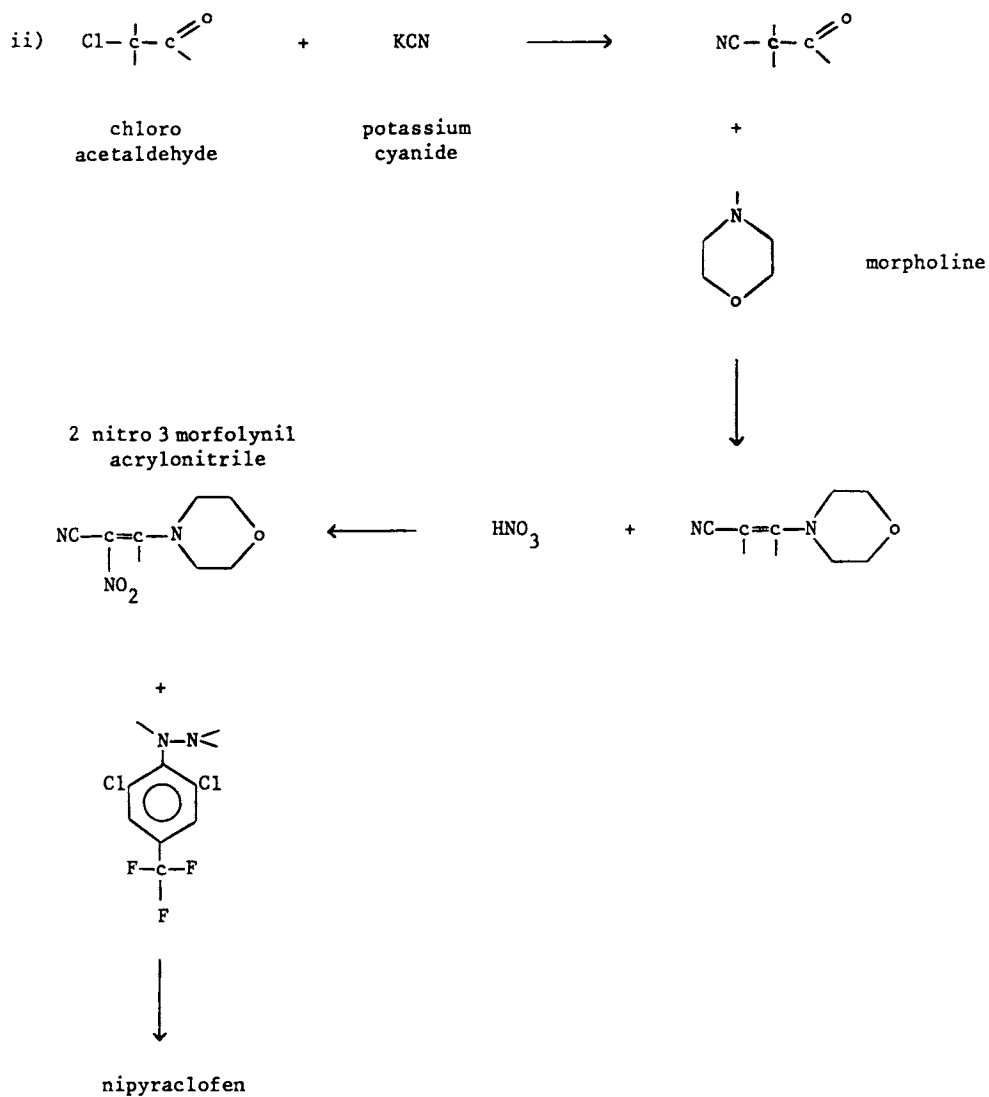
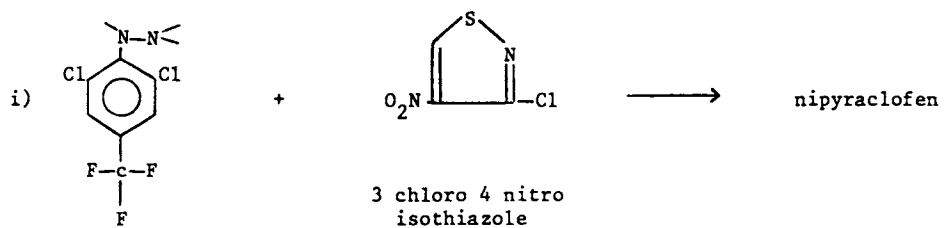
Type: pyrazole

Synthesis:





alternate routes :



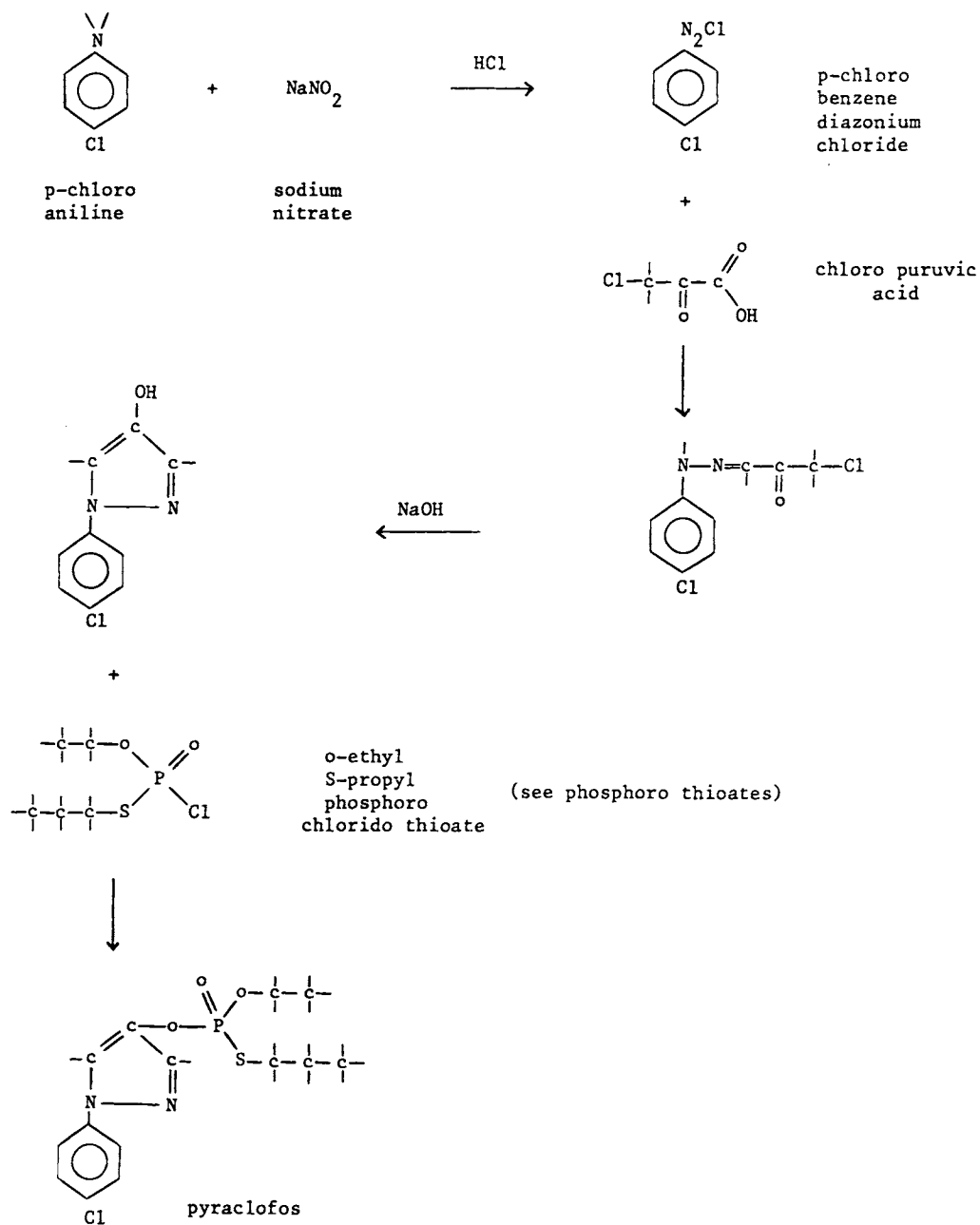
## Pyraclofos

Uses: insecticide, vegetables

Trade names: Boltage, Voltage (Takeda)

Type: pyrazole, phosphoro thioate

Synthesis:



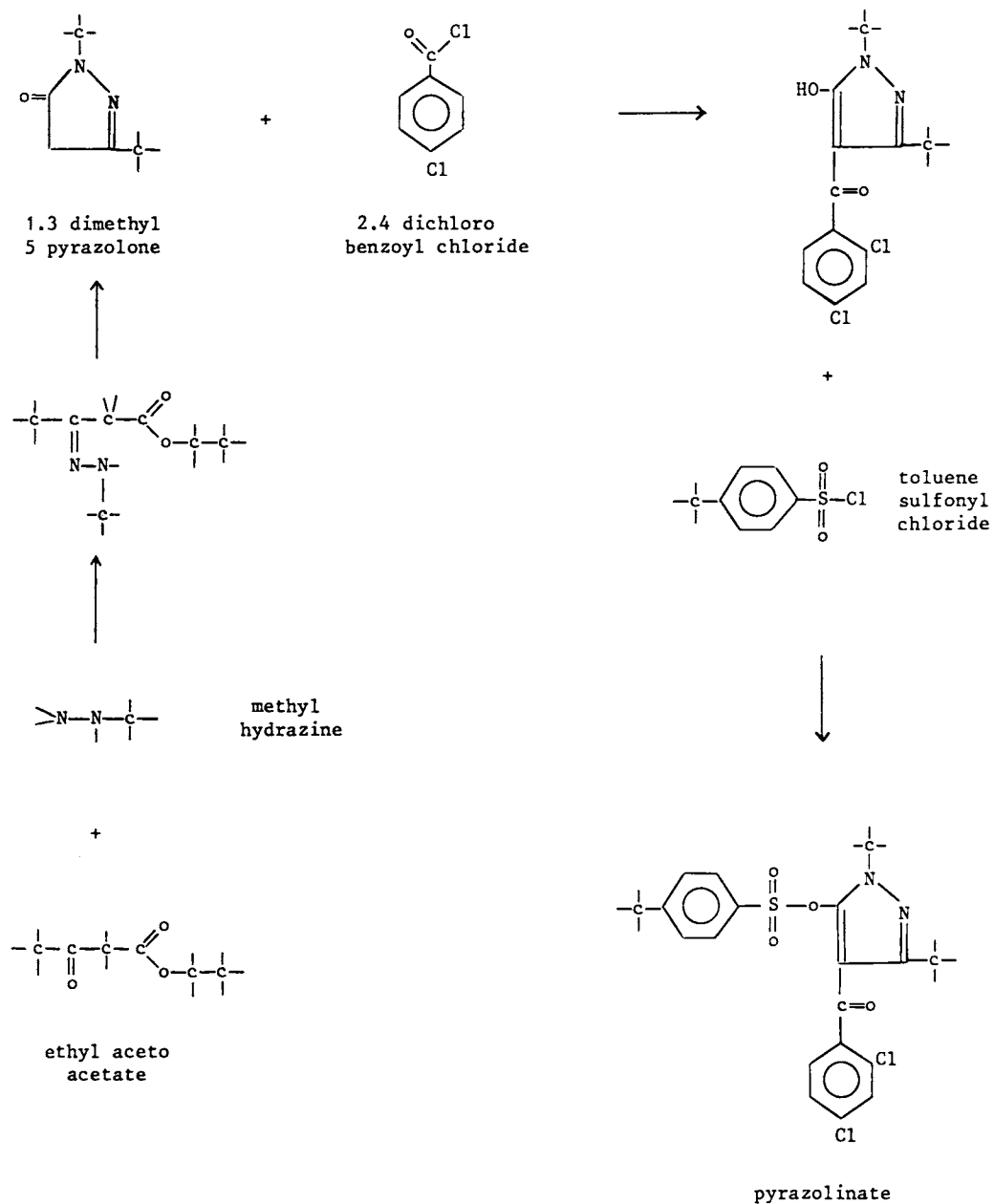
## Pyrazolinate

Uses: herbicide, rice

Trade names: Sanbird (Sankyo)

Type: pyrazole

Synthesis:



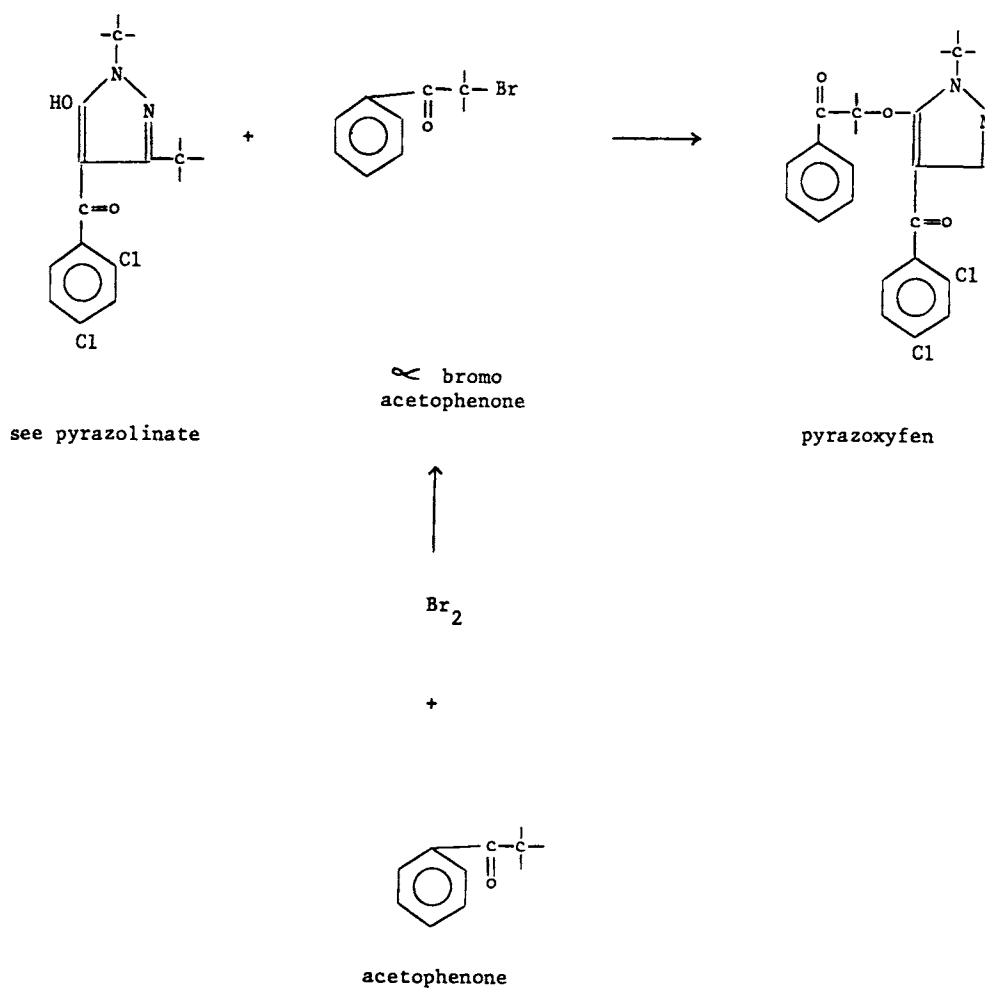
## Pyrazoxyfen

Uses: herbicide, rice

Trade names: Paicer (Sangyo)

Type: pyrazole

Synthesis:



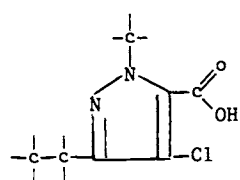
## Tebufenpyrad

Uses: acaricide, vines, citrus, vegetables, cotton, fruit

Trade names: Masai, Pyranica (Mitsubishi)

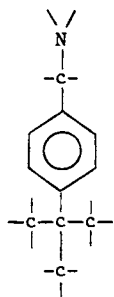
Type: pyrazole, amide

Synthesis:

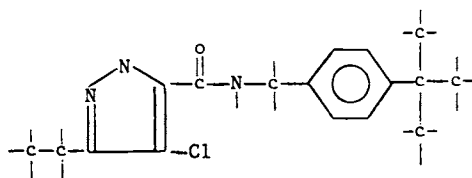


1 methyl 3 ethyl  
4 chloro 5 carboxylate  
pyrazole

+



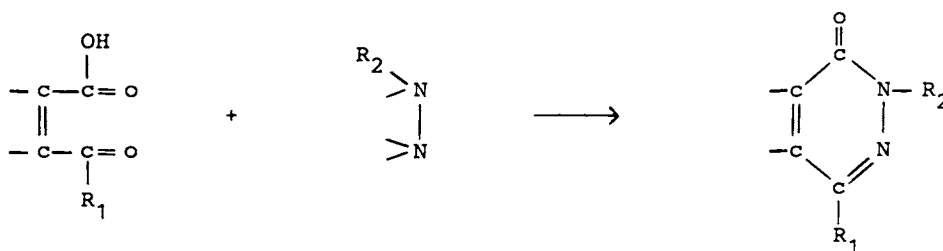
4 tert butyl  
benzylamine



tebufenpyrad

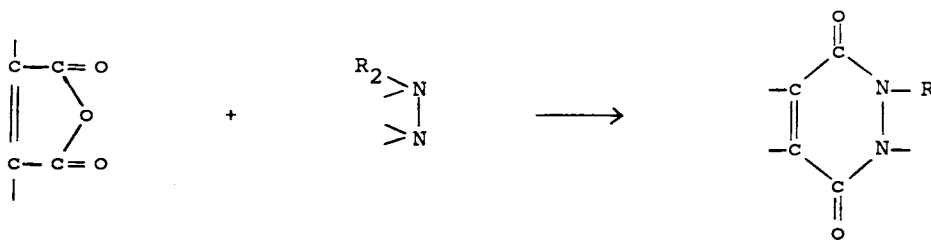
# PYRIDAZINES PYRIDAZINONES PYRIDAZINEDIONES

The synthesis of pyridazinone is by reaction between a hydrazine and a carbonyl carboxylic acid



The c=c double bond need not necessarily be present in the carboxylic acid since it can also be obtained after cyclisation by dehydrogenation.

Pyridazinedione is obtained by reaction of a hydrazine with maleic anhydride



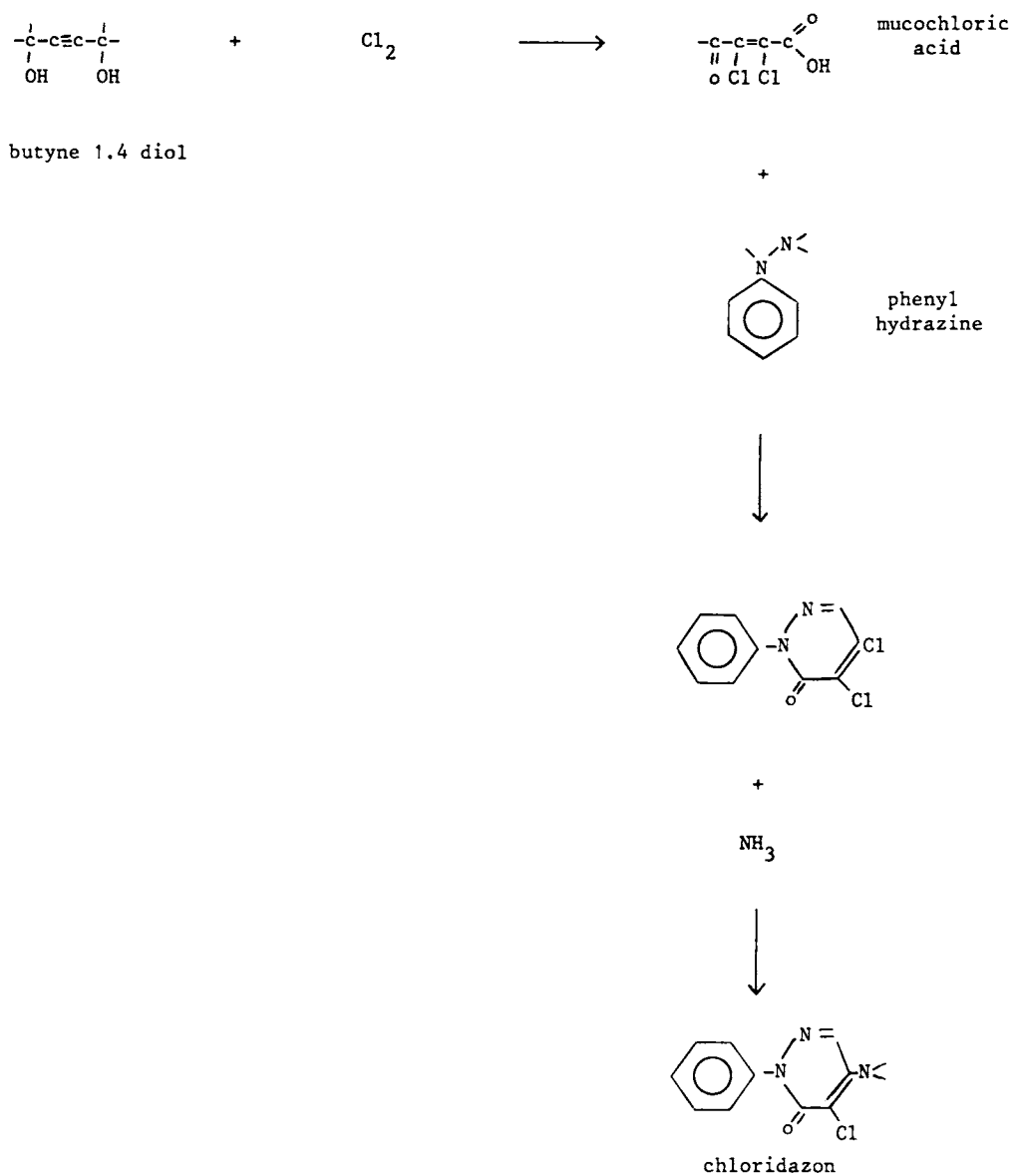
## Chloridazon

Uses: herbicide, sugar beet

Trade names: Pyramin (BASF)

Type: pyridazinone

Synthesis:



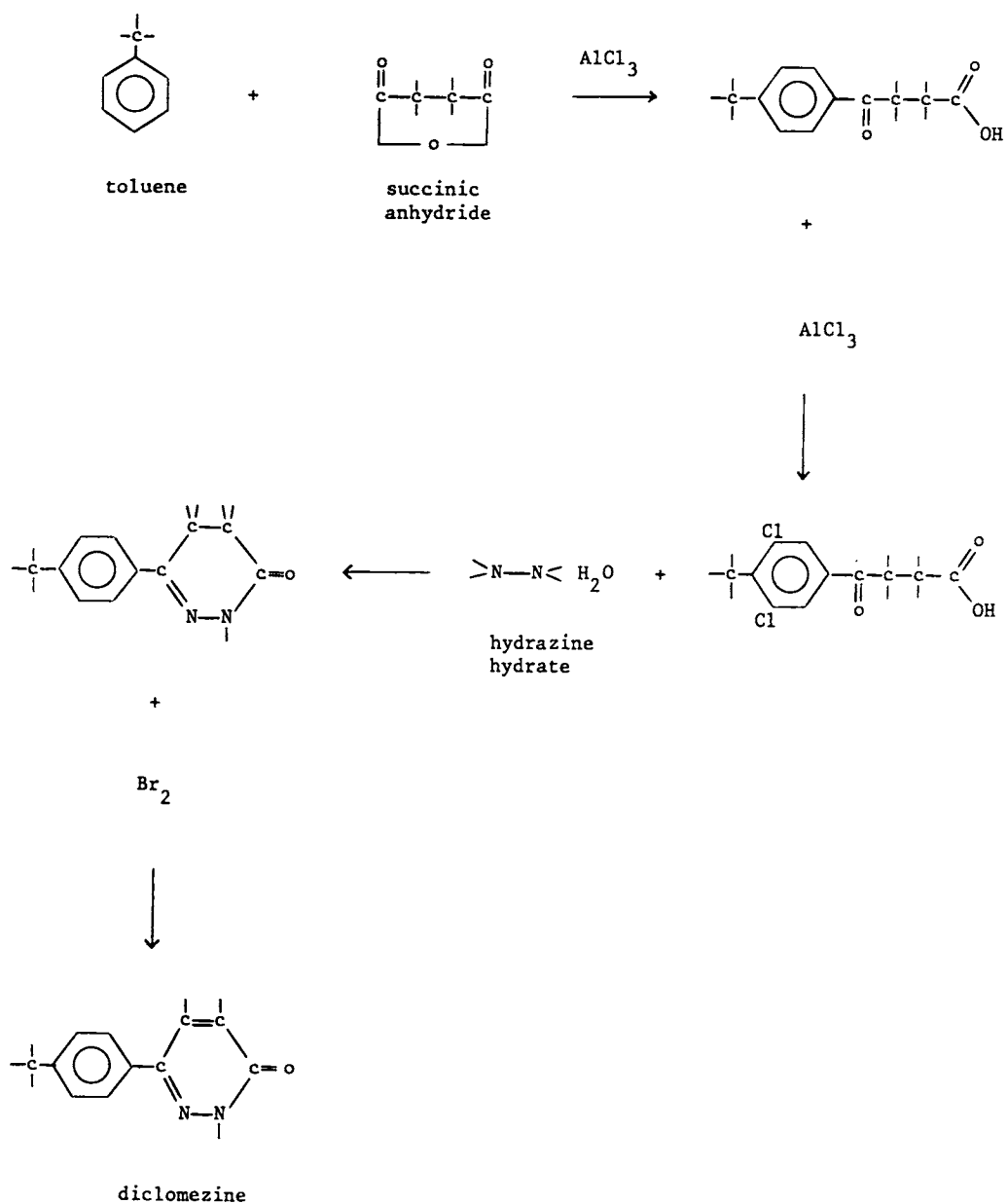
## Diclomezine

Uses: fungicide, rice

Trade names: Monguard (Sankyo)

Type: pyridazinone

Synthesis:





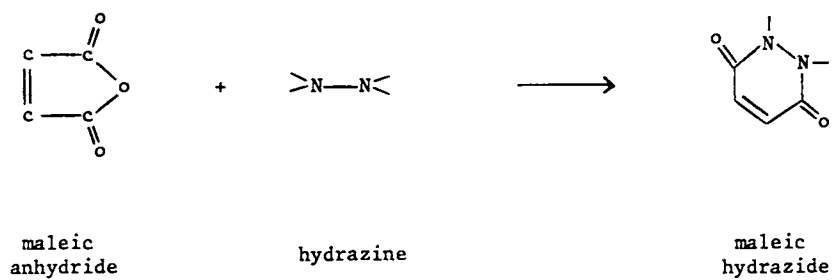
## Maleic Hydrazide

Uses: growth regulator, beets, carrots, onions, potatoes, tobacco

Trade names: MH-30 (Uniroyal)

Type: pyridazinone

Synthesis:



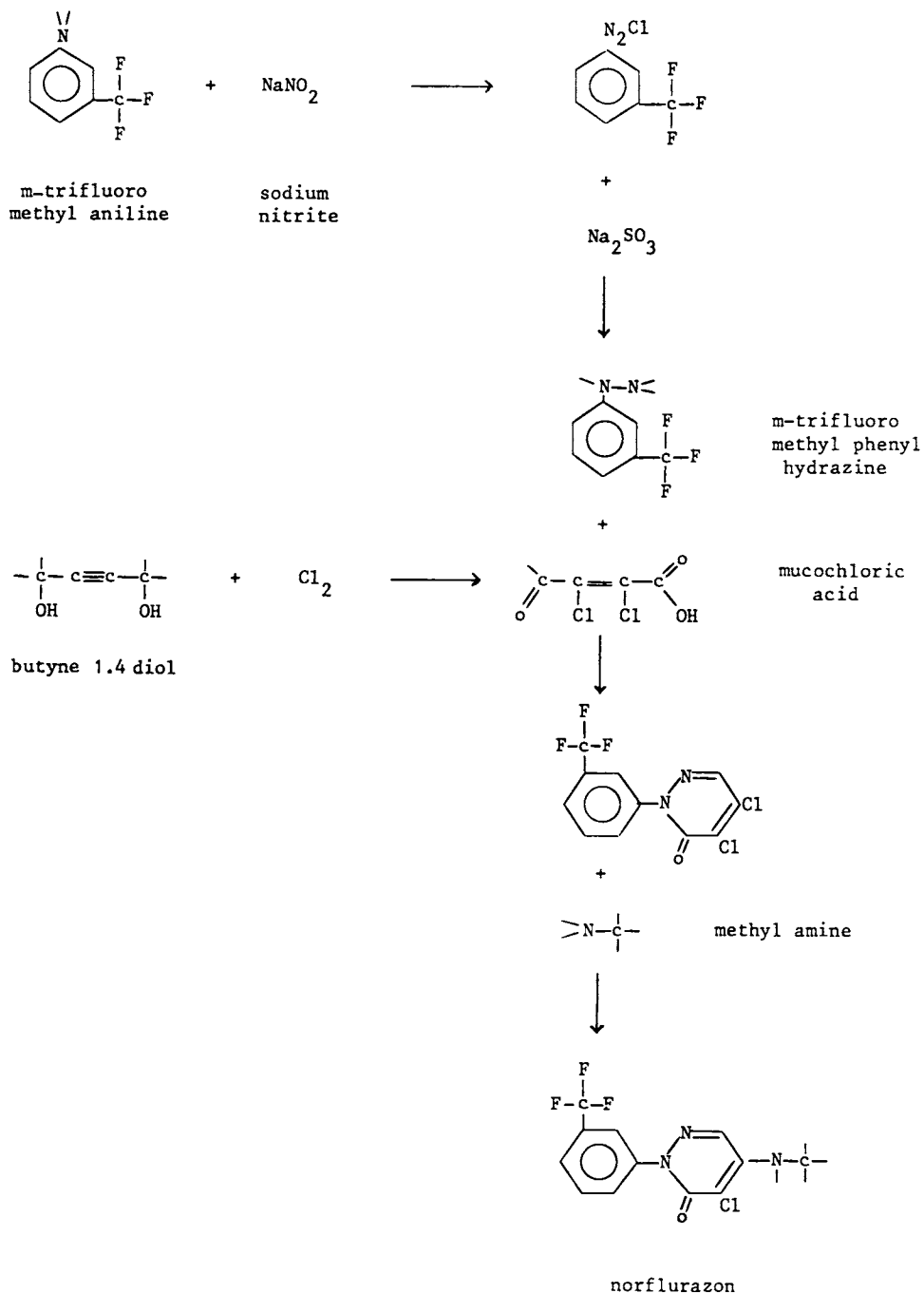
## Norflurazon

Uses: herbicide, citrus, cotton, nuts, soyabeans

Trade names: Zorial, Evital, Solicam (Sandoz)

Type: pyridazinone

**Synthesis:**



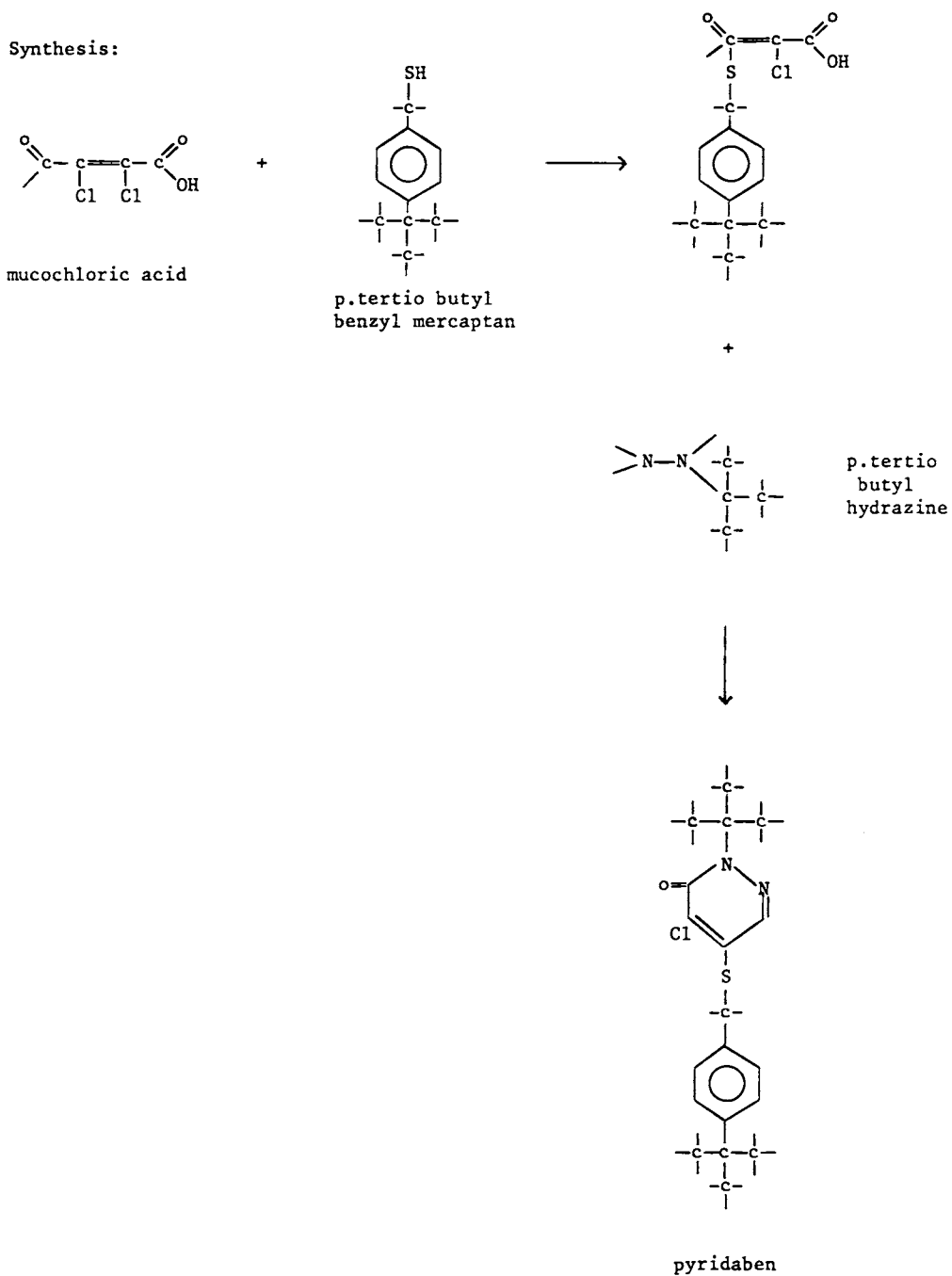
## Pyridaben

Uses: insecticide, acaricide, field crops, fruit trees, ornamentals, vegetables

Trade names: Sanmite (Nissan)

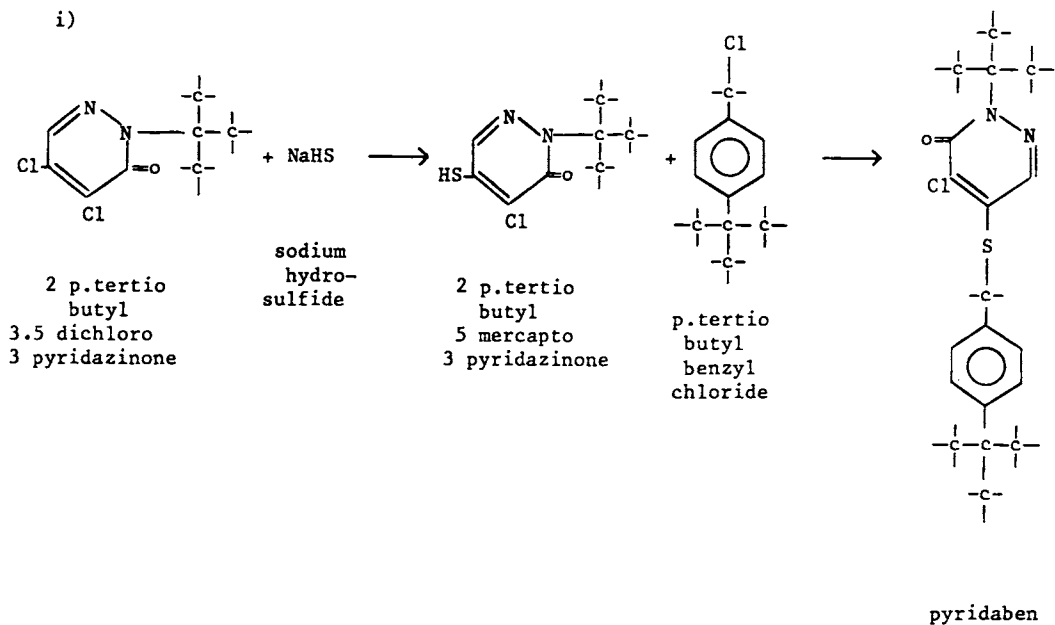
Type: pyridazinone

Synthesis:

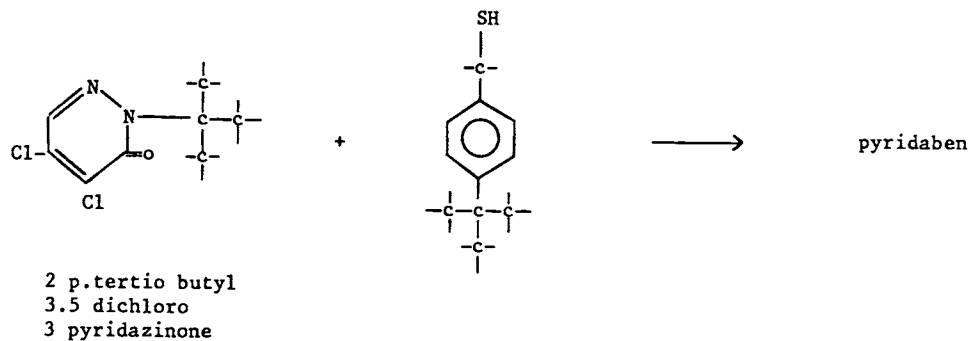


alternate routes :

i)



ii)



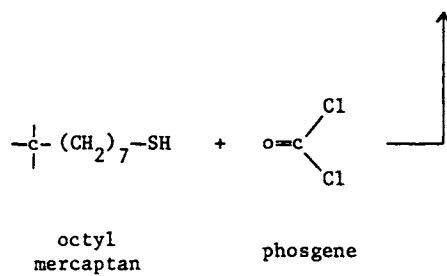
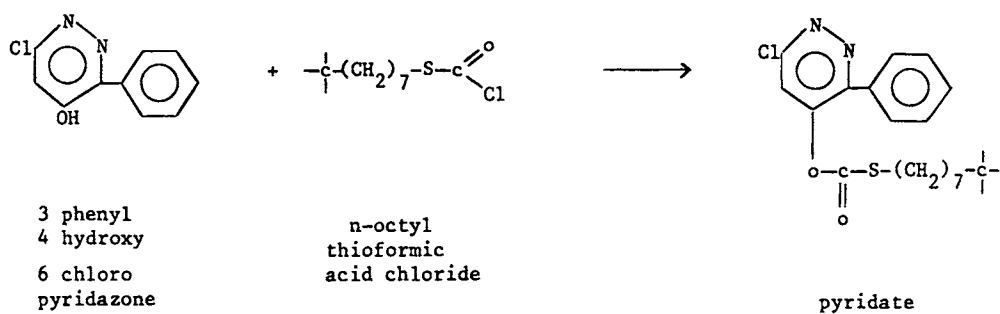
## Pyridate

Uses: herbicide, cereals, maize, rice

Trade names: Lenta gran (Chemie Linz)

Type: pyridazine

Synthesis:

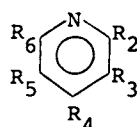


## PYRIDINES

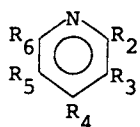
Pyridine pesticides are usually synthesized by starting with pyridine or a picoline nucleus, which is then further treated by halogenation, ammoniation, oxidation, etc. Quite often however it is impossible to introduce the desired substituents into the adequate ring position, in which case the corresponding aliphatic compound is prepared and then cyclised.

The basic similarities between many pyridine pesticides appear from the following table where one may observe that pyridine pesticides vary mainly in the 2 position. The remaining positions of the ring are always halogen, hydro or sometimes amino groups

### Pyridine nucleus

		<u>R<sub>2</sub></u>	<u>R<sub>3</sub></u>	<u>R<sub>4</sub></u>	<u>R<sub>5</sub></u>	<u>R<sub>6</sub></u>
	fluroxypyr	OCH <sub>2</sub> COOH	Cl	NH <sub>2</sub>	Cl	F
	triclopyr	OCH <sub>2</sub> COOH	Cl	H	Cl	Cl
	chlorpyrifos	(C <sub>2</sub> H <sub>5</sub> O) <sub>2</sub> <sup>O</sup> P=O-	Cl	H	Cl	Cl

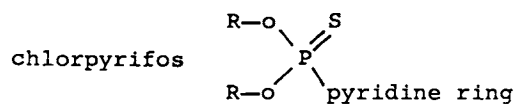
### Picoline nucleus

	clopyralid	COOH	Cl	H	H	Cl
	nitrapyrin	CCl <sub>3</sub>	H	H	H	Cl
	picloram	COOH	Cl	NH <sub>2</sub>	Cl	Cl

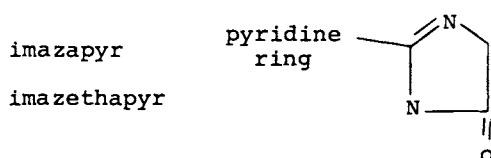
Pyridine rings are frequently used in combination with other functional pesticides. These pyridine compounds have structures which are determined by the main function involved, the pyridine ring being an attachment to the main function.

For instance

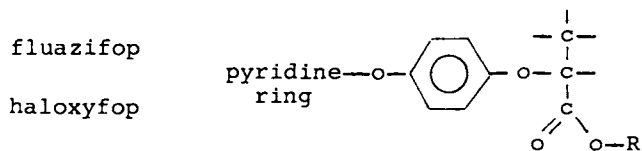
### phosphoro organics



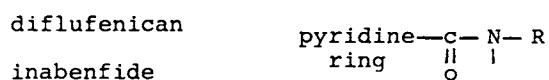
### imidazolidinones



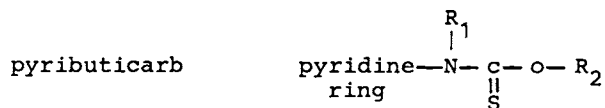
### phenoxy carboxylic acids



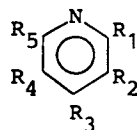
### amides



### thiocarbamates



Pyridine pesticides vary mainly in the 2 position. The remaining positions of the ring are nearly always halogen, hydro or sometimes amino groups.



	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	R <sub>4</sub>	R <sub>5</sub>
chlorpyrifos		Cl	H	Cl	Cl
clopyralid		Cl	H	H	Cl
fluroxypyr		Cl	N<	Cl	F
nitropirin	-C-Cl <sub>3</sub>	H	H	H	Cl
picloram		Cl	N<	Cl	Cl
triclopyr		Cl	H	Cl	Cl



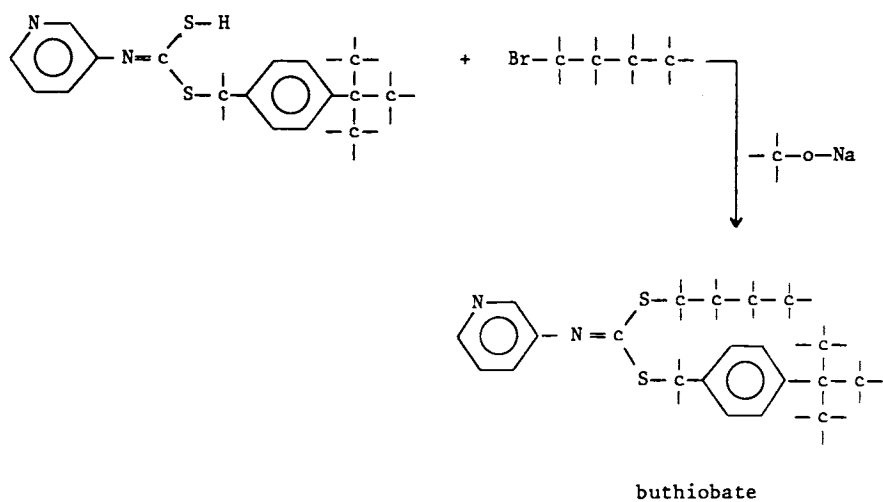
# Buthiobate

Uses: fungicide, fruit trees, fruit, vegetables, ornamentals

Trade names: Denmert (Sumitomo)

Type: pyridine

Synthesis:



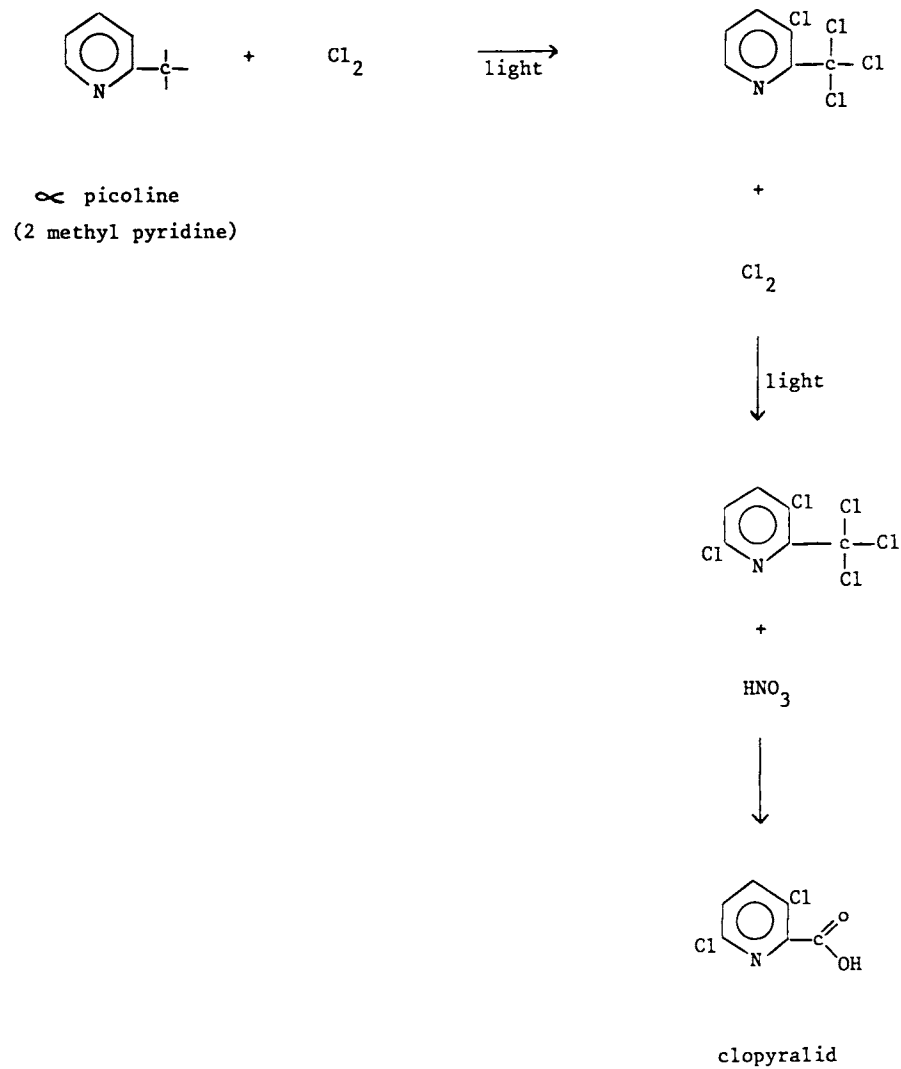
## Clopylarid

Uses: herbicide, sugar beet, cereals

Trade names: Lontral (Dow Elanco)

Type: pyridine

Synthesis:



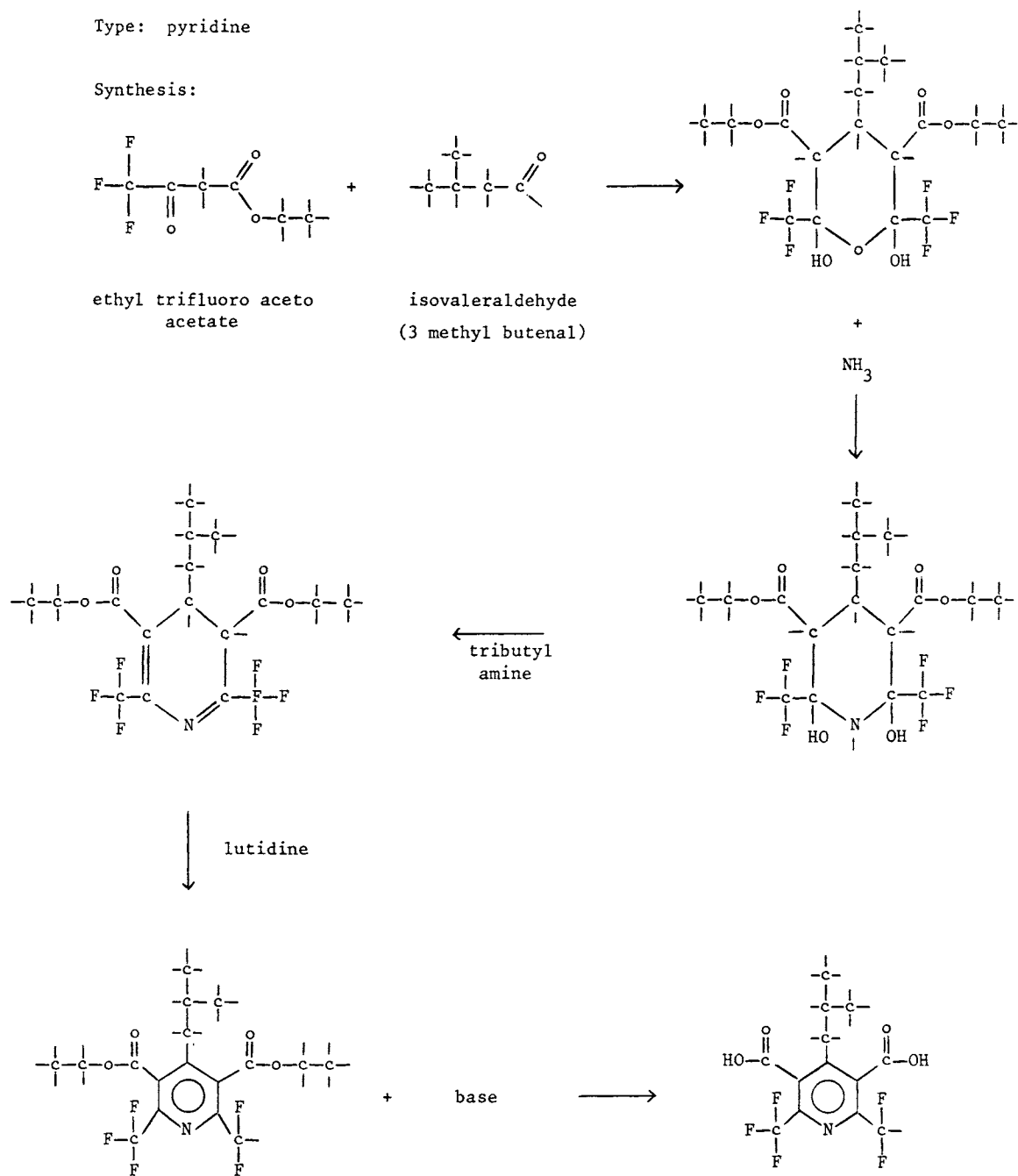
## Dithiopyr

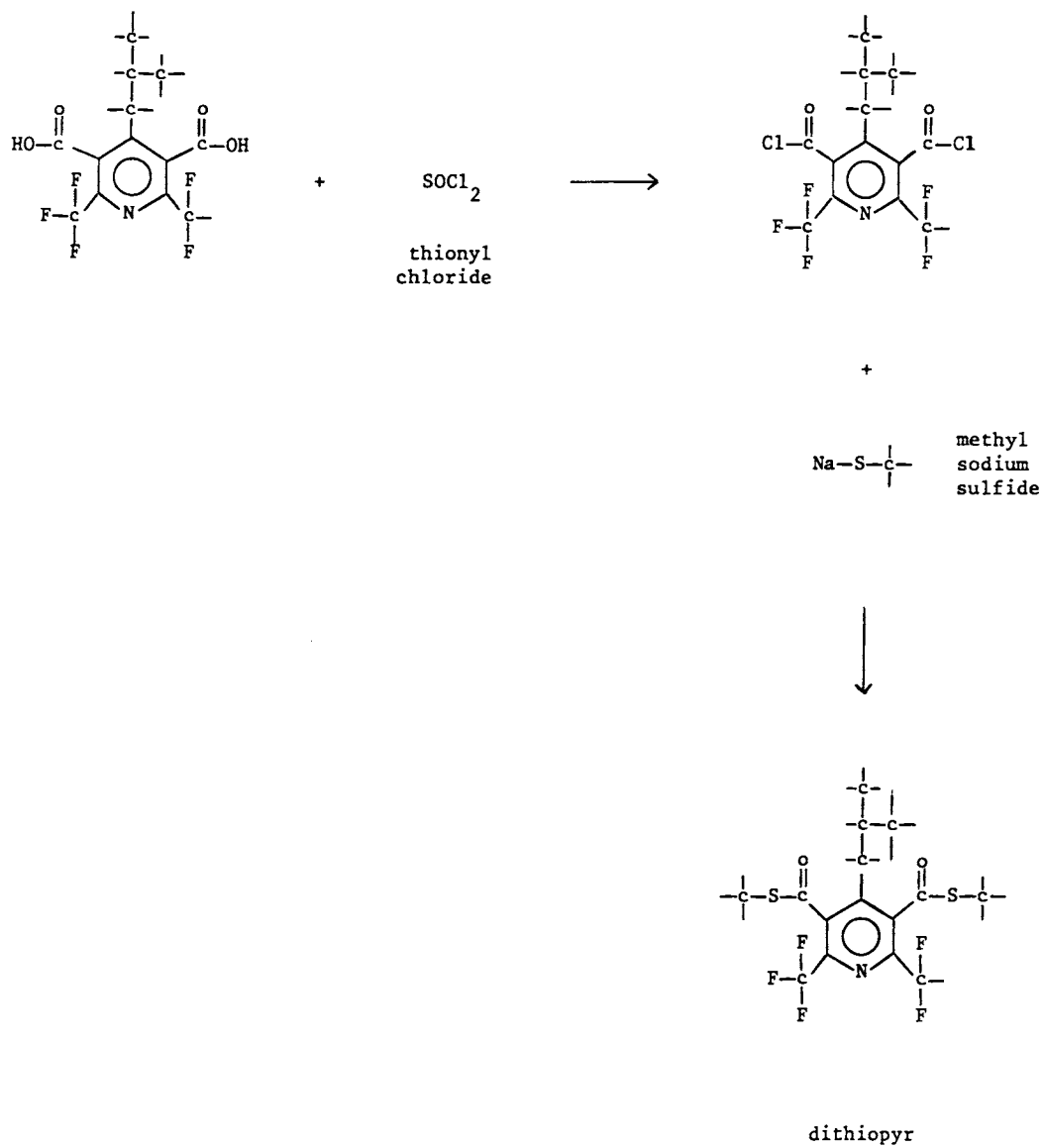
Uses: herbicide

Trade names: Dimension Herbicide (Monsanto)

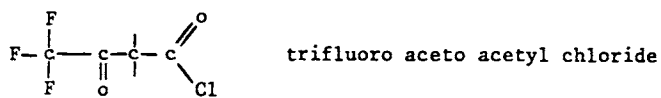
Type: pyridine

Synthesis:

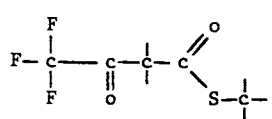
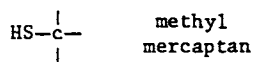




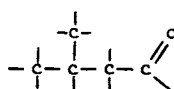
alternate route :



+

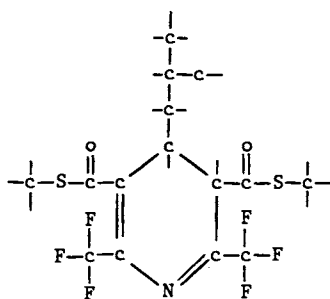


methyl trifluoro aceto thioate

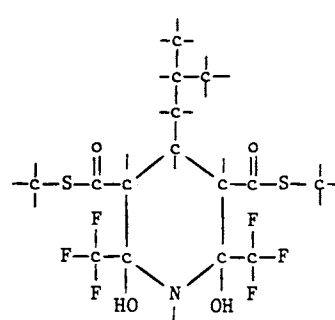


dithiopyr

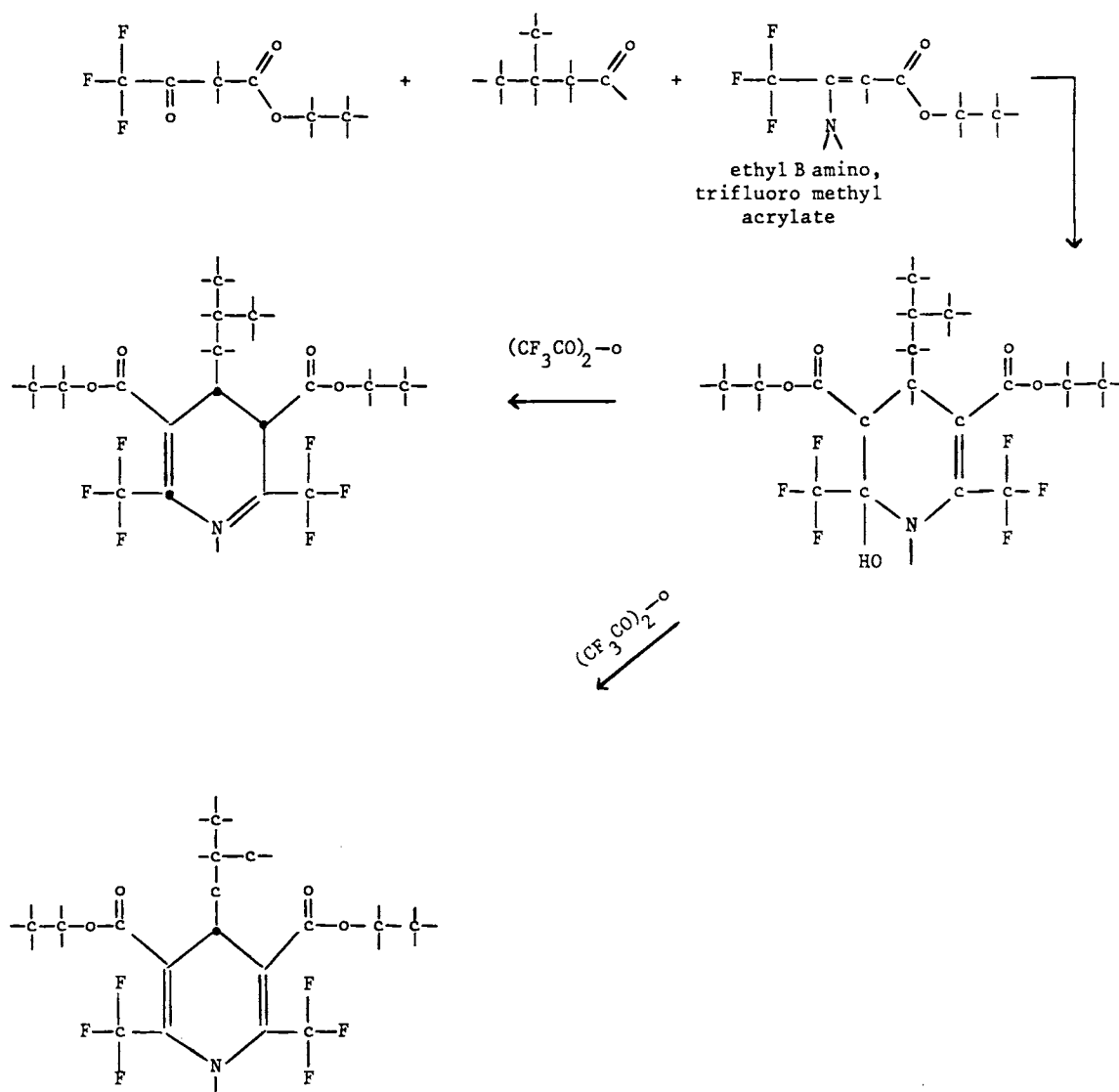
← tributyl amine



← HCl  
(or PCl<sub>3</sub>)



alternate route:



both of which are oxidised to the pyridine

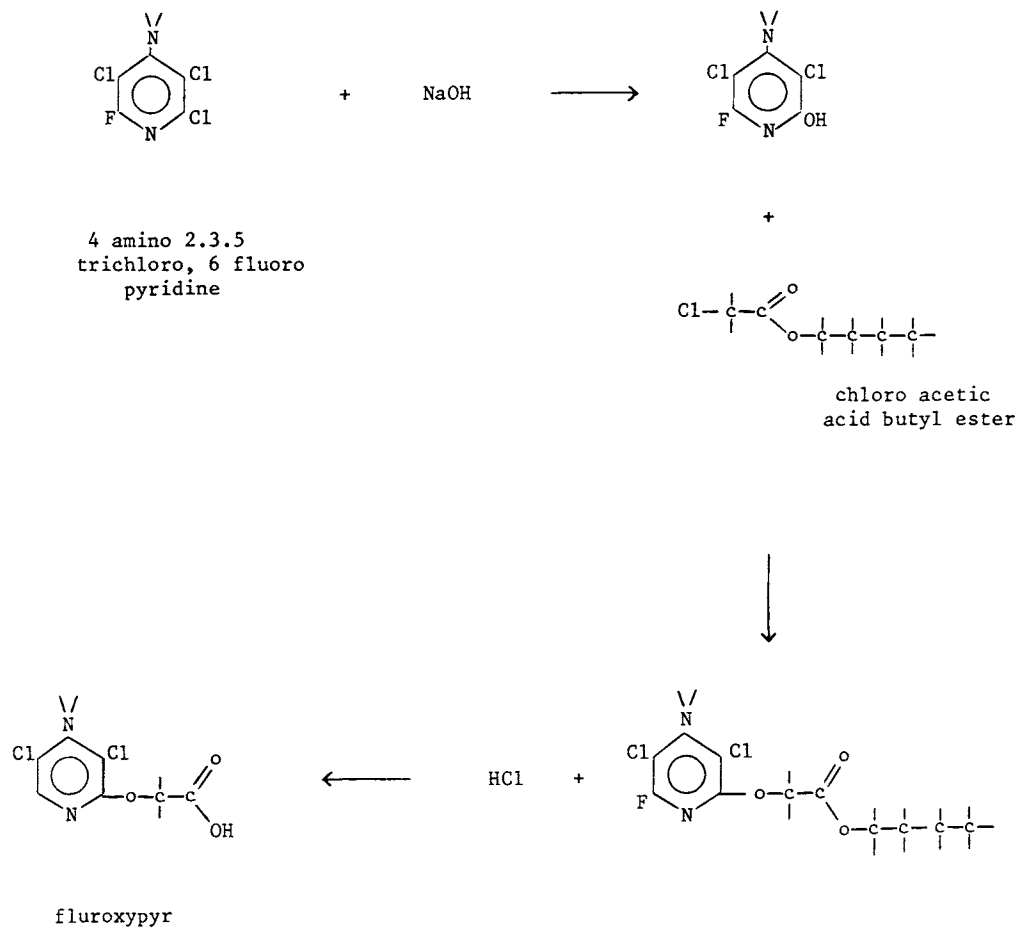
## Fluroxypyr

Uses: herbicide, cereals, rubber, oil palm, conifers

Trade names: Starane (Dow Elanco)

Type: pyridine

Synthesis:



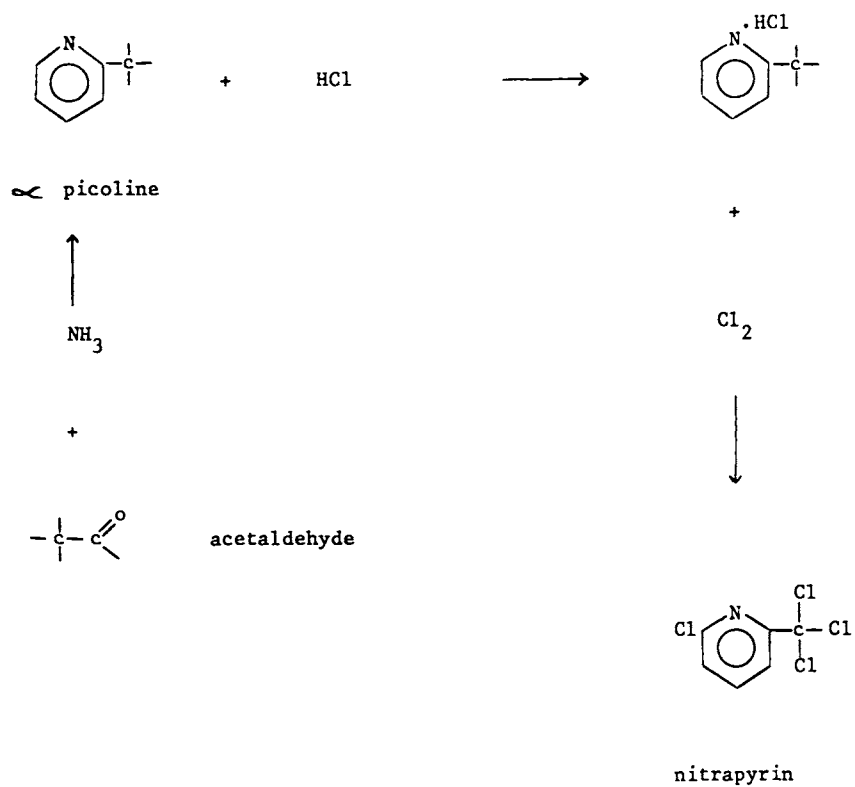
## Nitrapyrin

Uses: bactericide

Trade names: N-Serve ( Dow Elanco )

Type: pyridine

Synthesis:





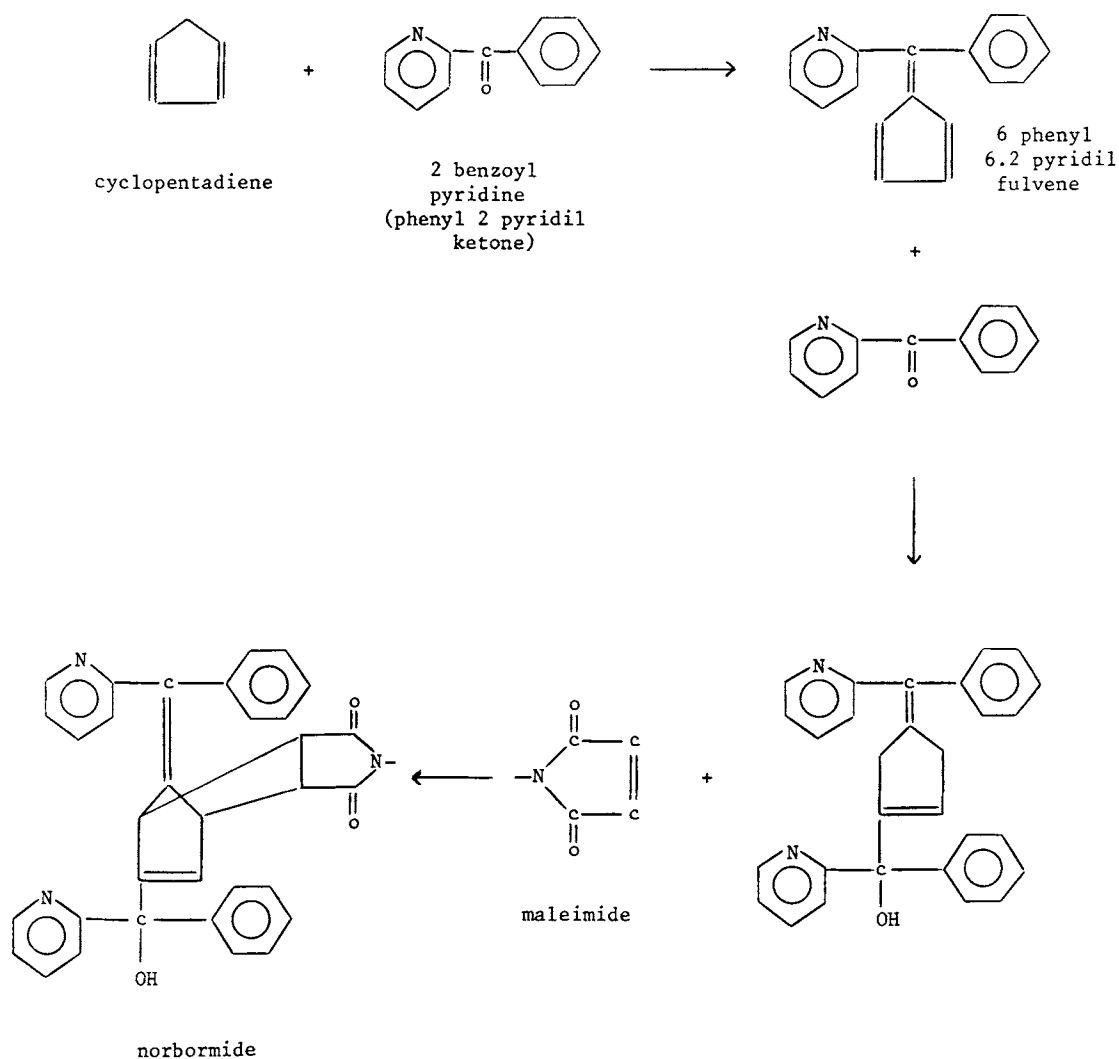
## Norbormide

Uses: rodenticide

Trade names: Shoxin, Raticate ( Mc Neil )

Type: pyridine

Synthesis:



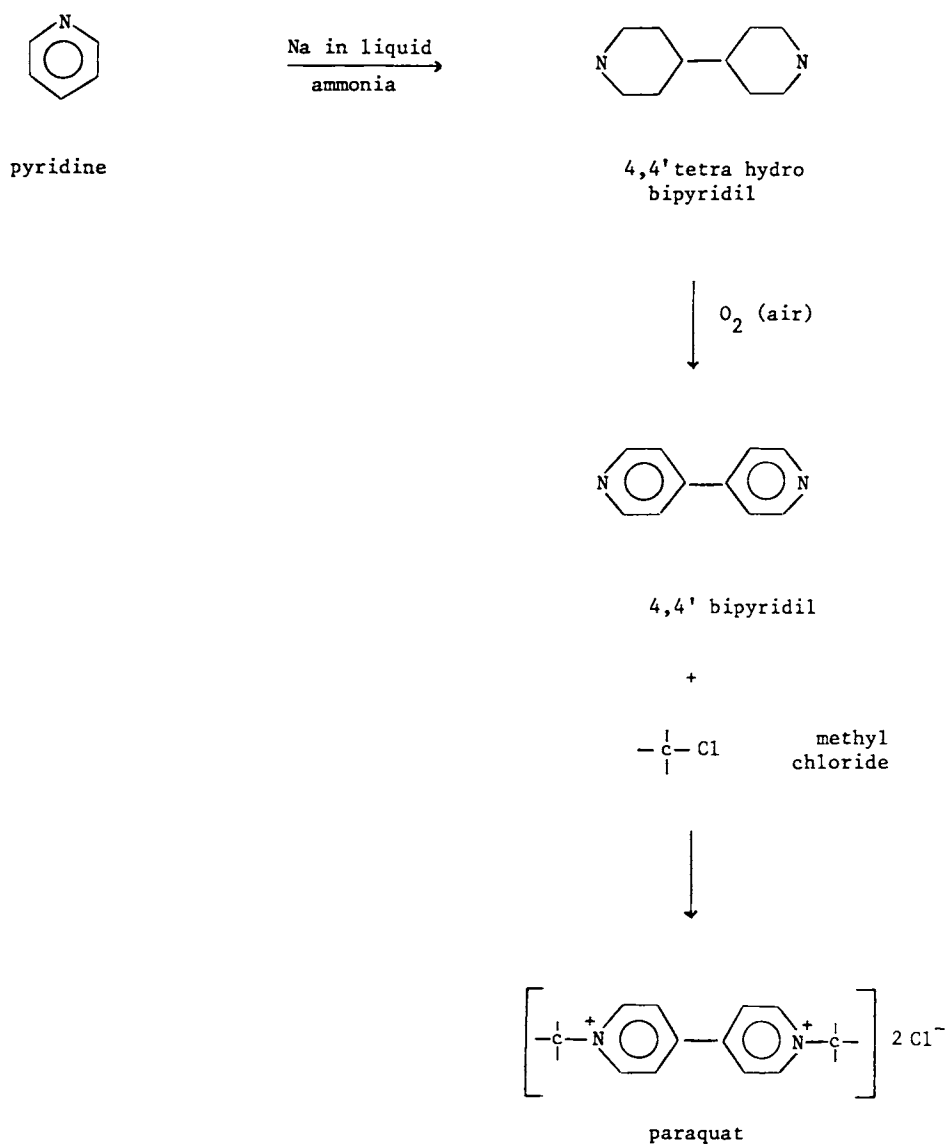
## Paraquat

Uses: herbicide, vegetables, plantations, pastures

Trade names: Gramoxone, Dextrone X, Esgram (ICI)

Type: pyridine

Synthesis:



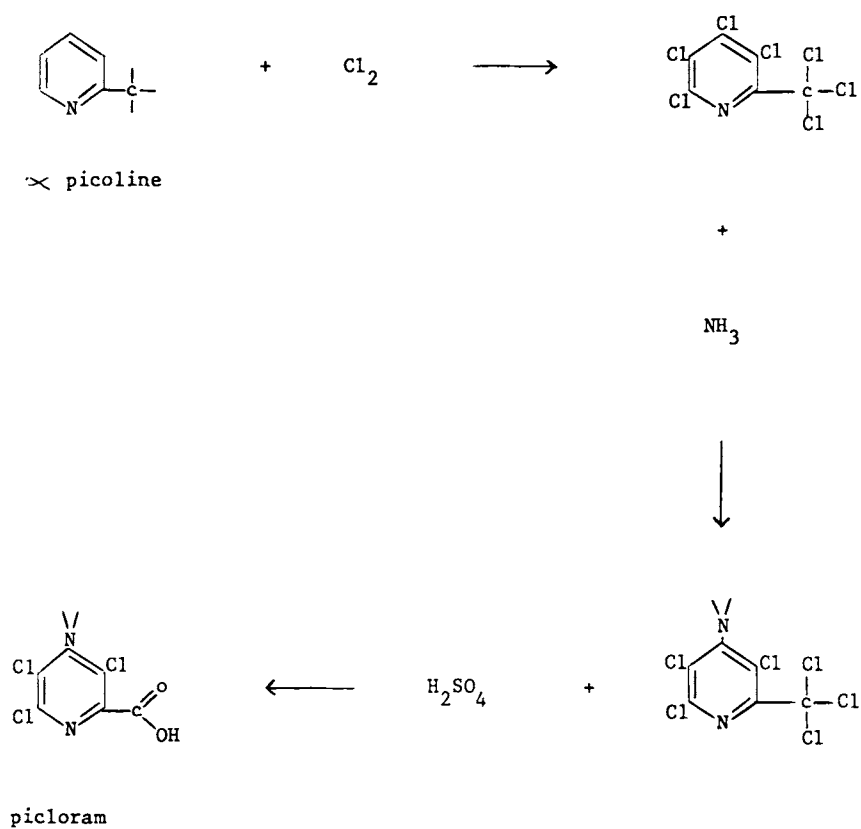
## Picloram

Uses: herbicide, grassland, non crop areas

Trade names: Tordon (Dow Elanco)

Type: pyridine

Synthesis:



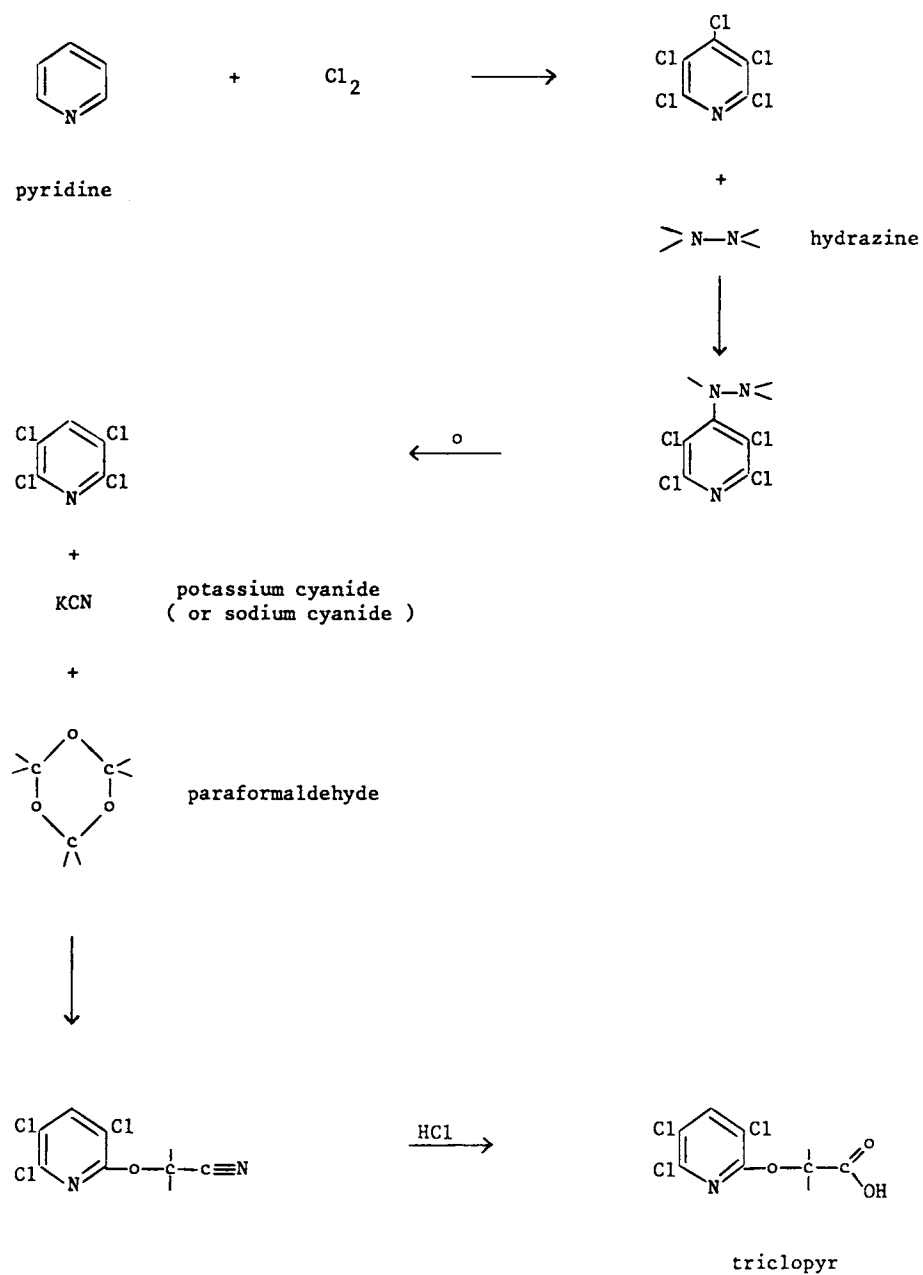
## Triclopyr

Uses: herbicide, rice, wheat, pastures, industrial sites

Trade names: Garlon (Dow Elanco)

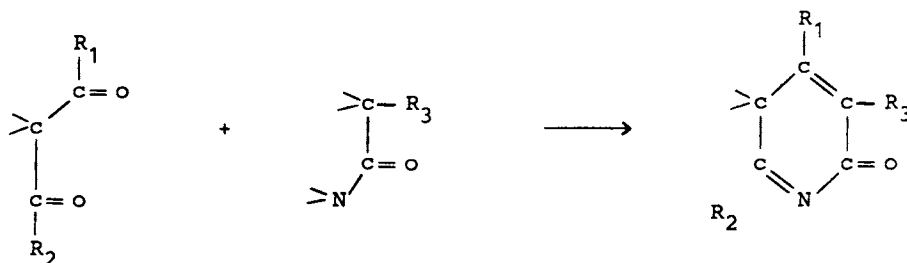
Type: pyridine

Synthesis:

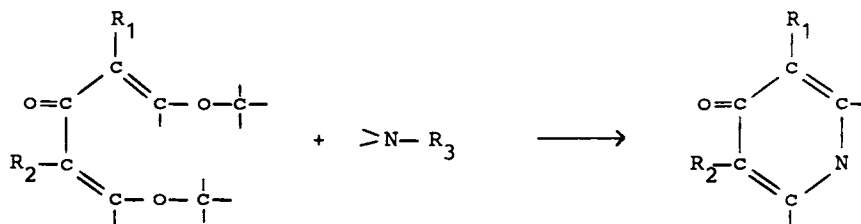


# PYRIDONES

Are synthesized by reaction between a diketone and an amide



or between a dienediether and a amine:



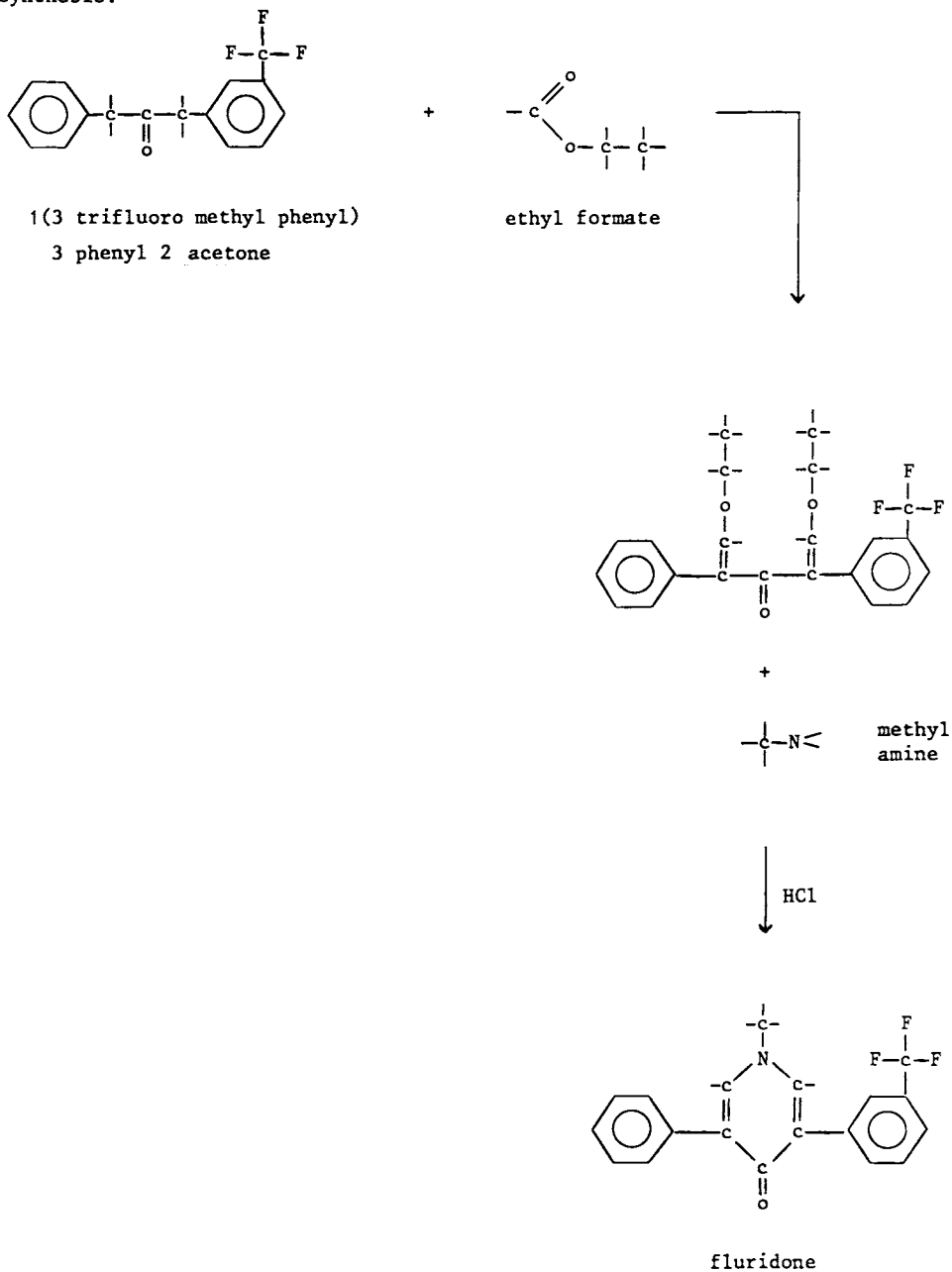
## Fluridone

Uses: herbicide, aquatic plants

Trade names: Sonar, Pride (Dow Elanco)

Type: pyridone

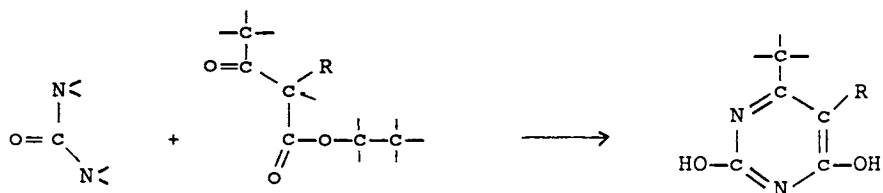
Synthesis:



# PYRIMIDINES

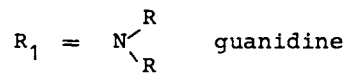
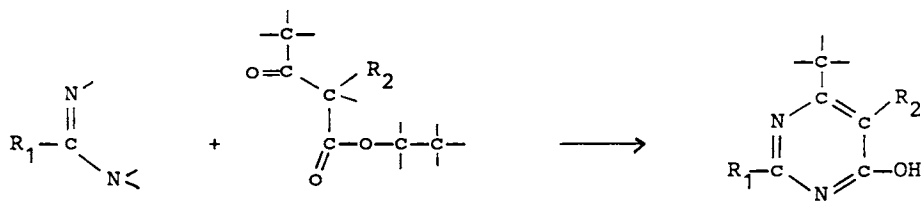
(see also sulfonyl ureas for synthesis of amino pyrimidines)

The most common route for synthesis is by reaction between a urea and ethyl (or methyl) aceto acetate



The hydroxyl groups are then substituted, for instance by chlorination and amination.

An alternative route is the reaction between ethyl aceto acetate with an amidine or with guanidine sulfate (or hydrochloride)



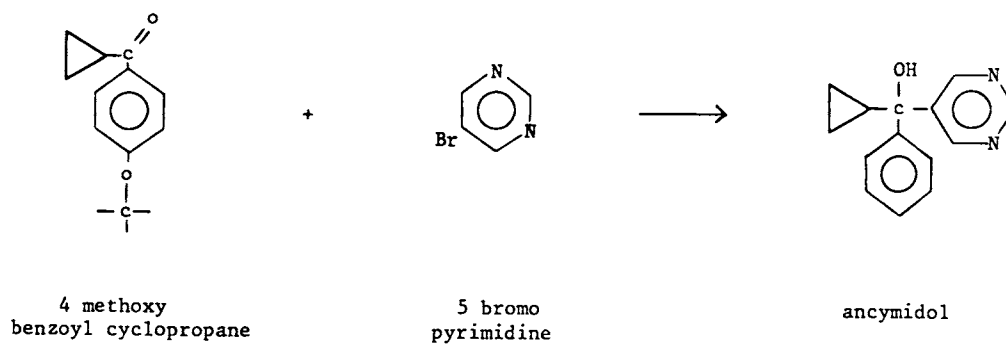
## Ancymidol

Uses: plant growth regulator, holly, foliage

Trade names: A-Rest, Reducymol (Dow Elanco)

Type: pyrimidine

Synthesis:





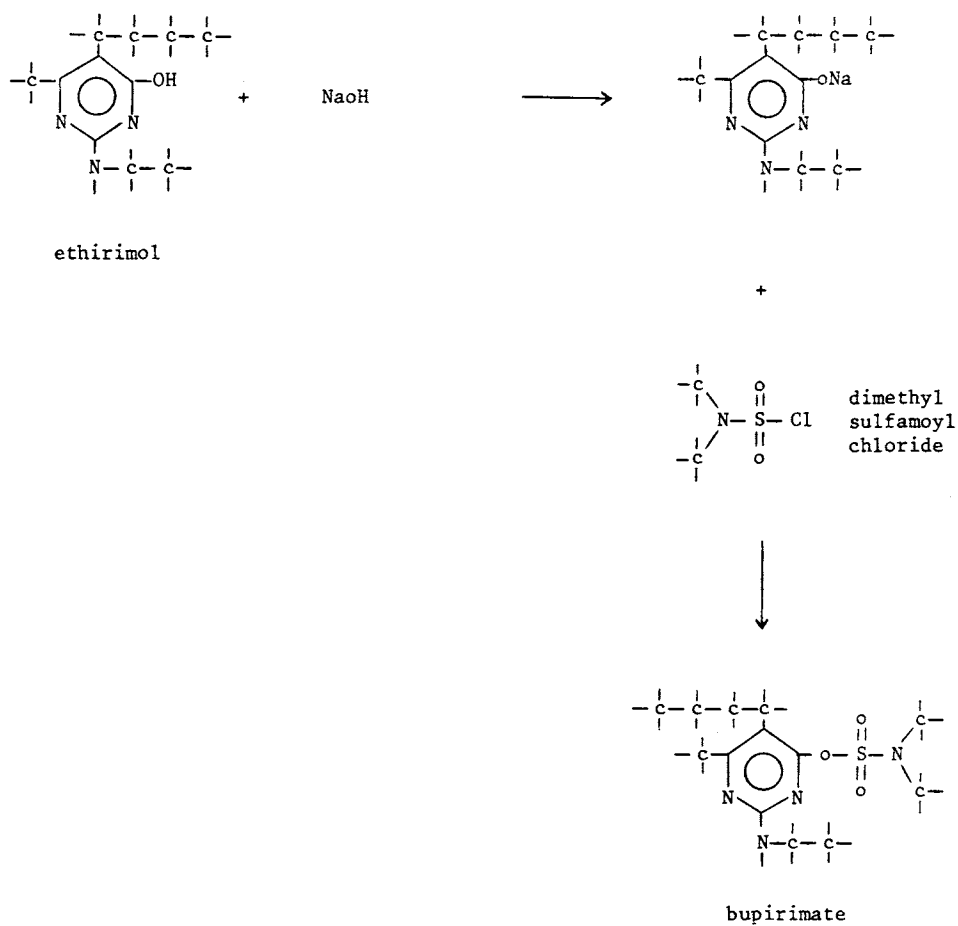
## Bupirimate

Uses: fungicide, apples

Trade names: Nimrod (ICI)

Type: pyrimidine, sulfamate

Synthesis:



for different routes for preparing dimethyl sulfamoyl chloride  
see bentazon ( isopropyl sulfamoyl chloride )

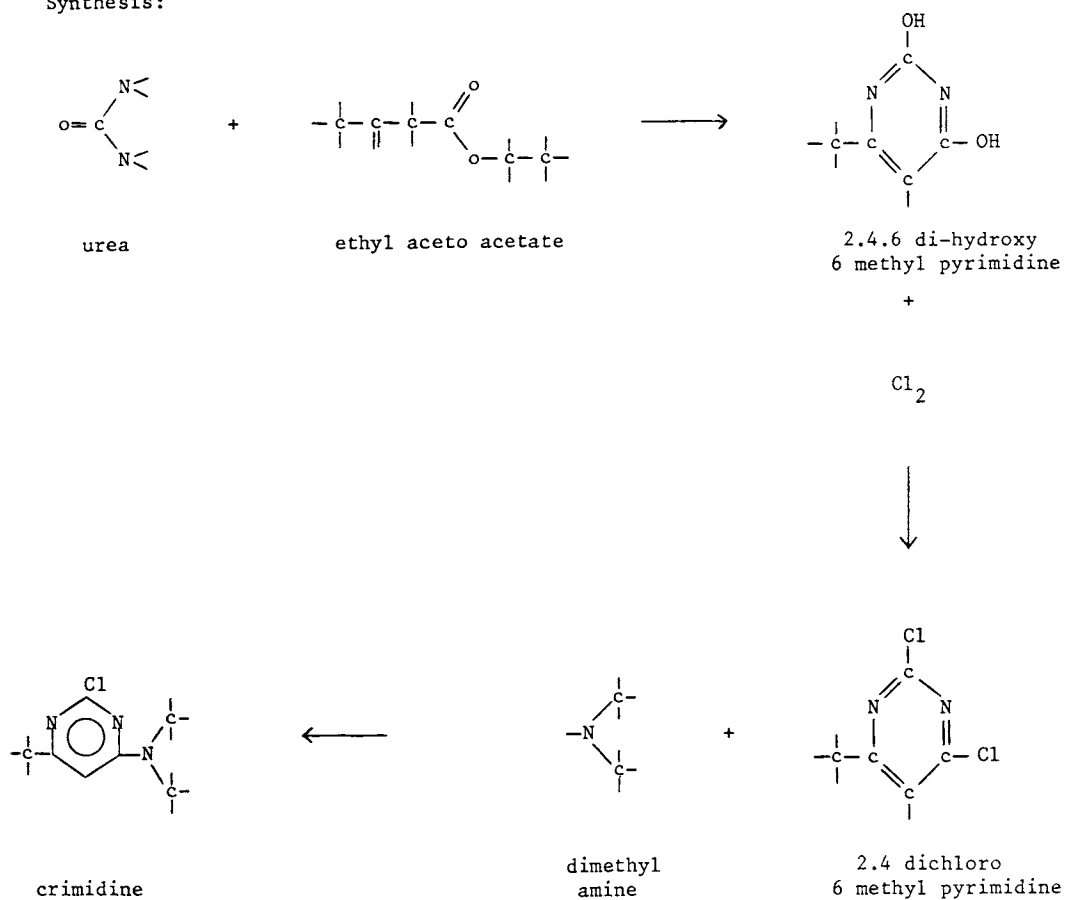
## Crimidine

Uses: rodenticide

Trade names: Castrix (Bayer)

Type: pyrimidine

Synthesis:



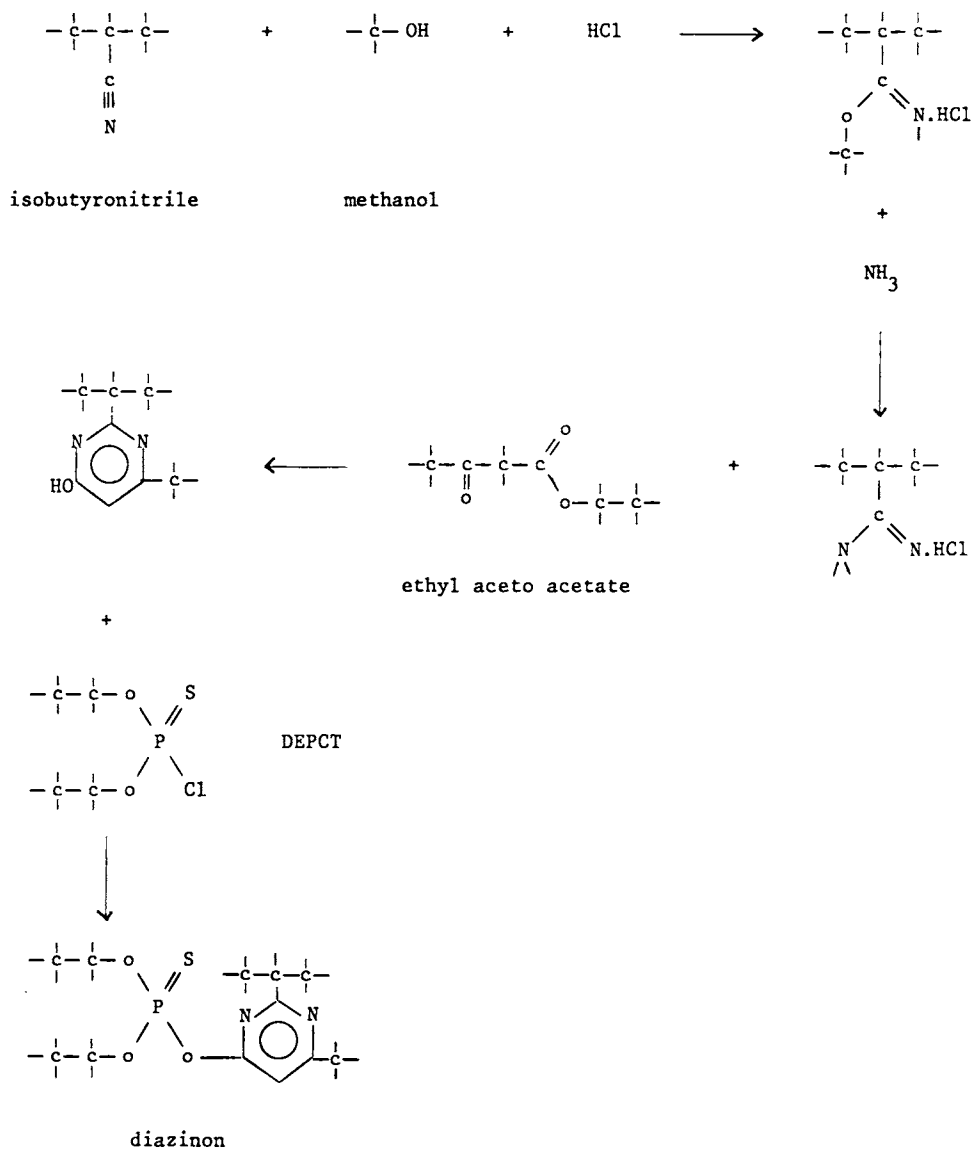
## Diazinon

Uses: insecticide, fruit trees, maize, potatoes, rice, sugar cane, tobacco

Trade names: Basudin, Diazitol (Ciba)

Type: pyrimidine, phosphorothioate

Synthesis:



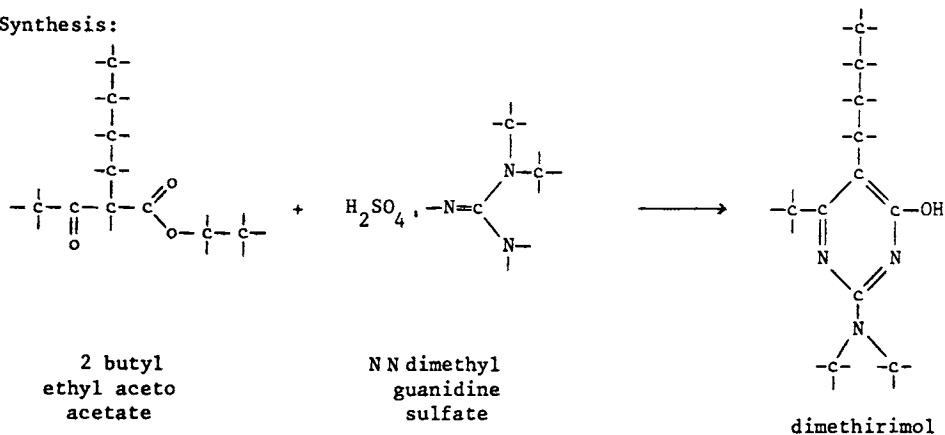
## Dimethirimol

Uses: fungicide, flowers

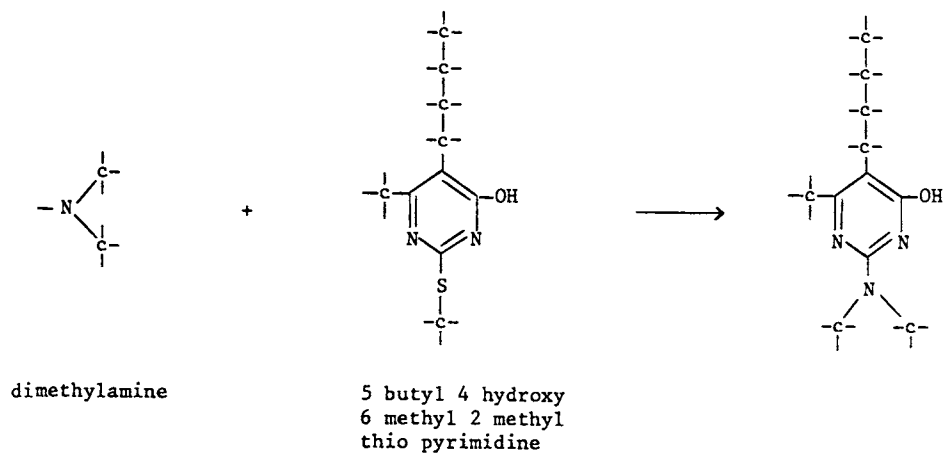
Trade names: Milcurb (ICI)

Type: pyrimidine

Synthesis:



alternate route:



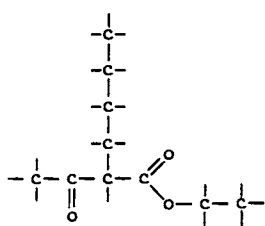
## Ethirimol

Uses: fungicide, cereals

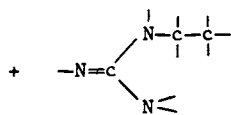
Trade names: Milgo (Zeneca)

Type: pyrimidine

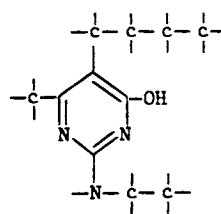
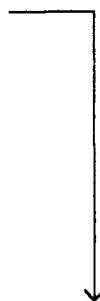
Synthesis:



2 butyl ethyl aceto  
acetate



ethyl guanidine



ethirimol

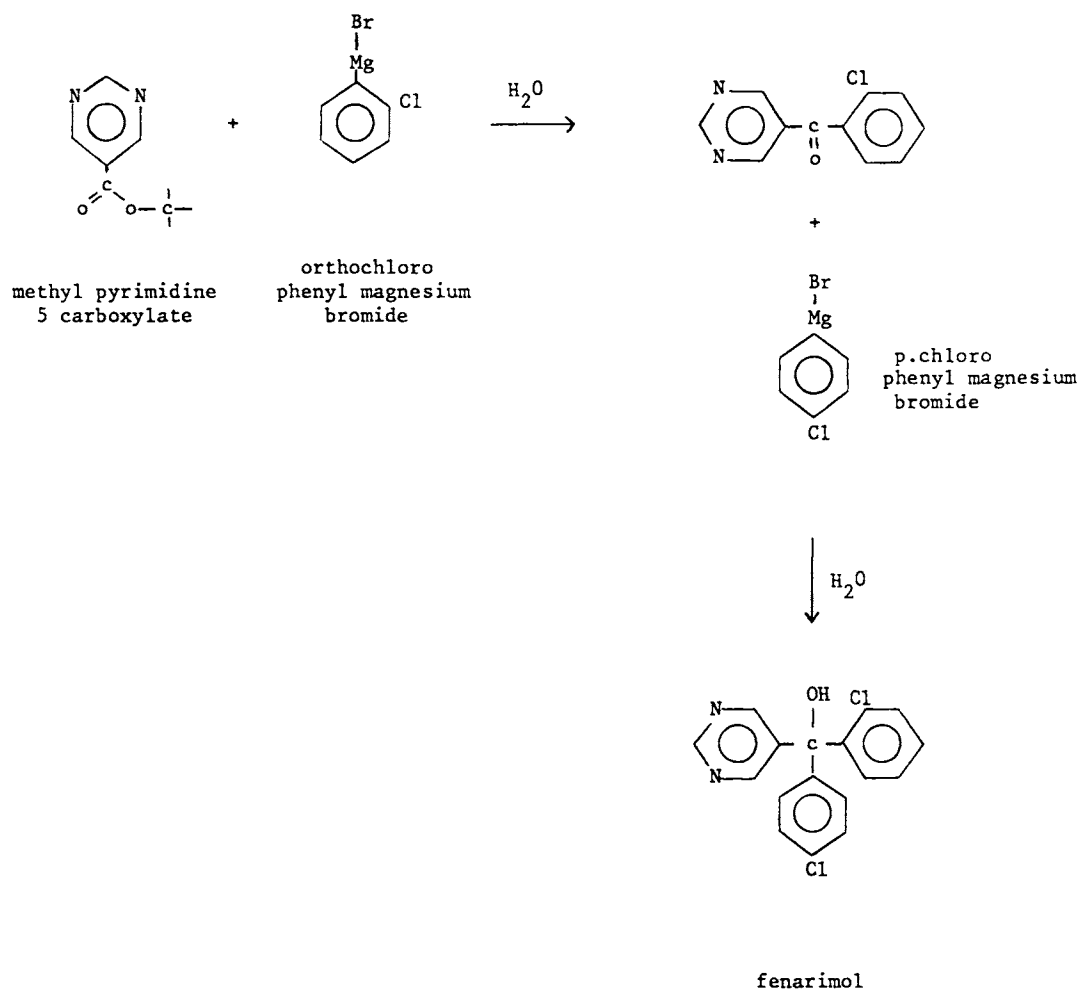
## Fenarimol

Uses: fungicide, fruit, peppers, tomatoes

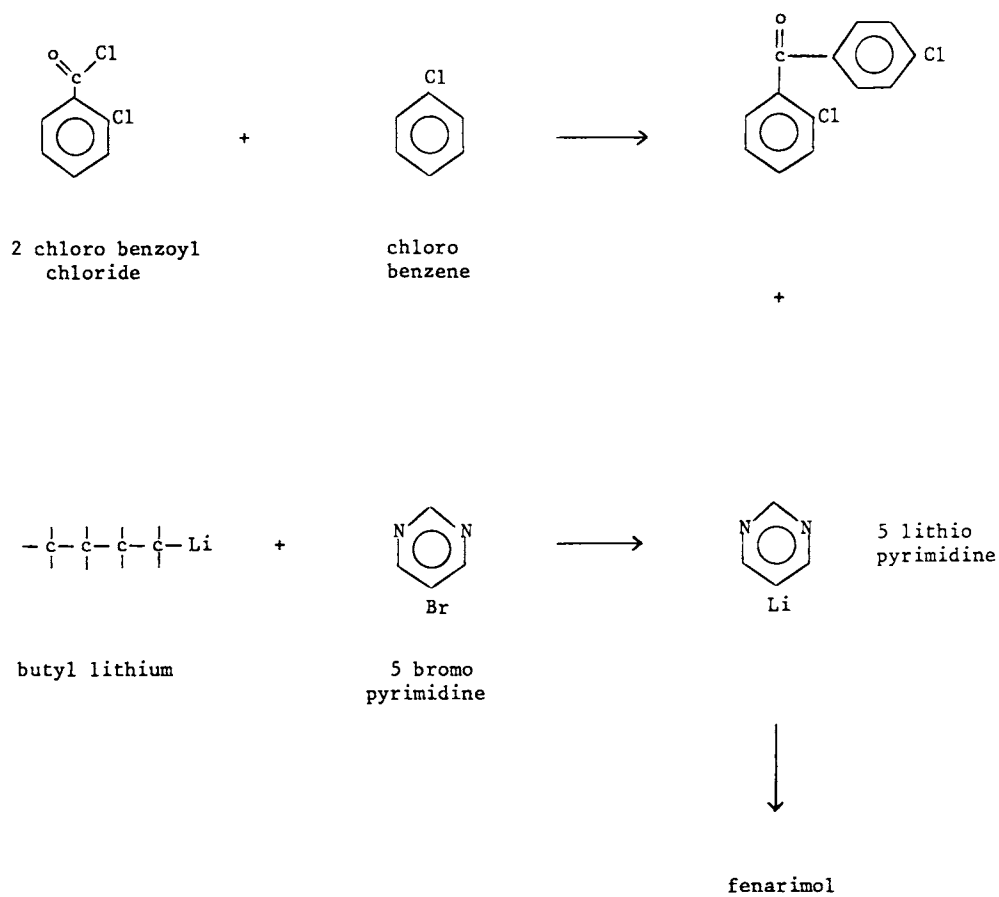
Trade names: Bloc, Rimidin, Rubigan (Dow Elanco)

Type: pyrimidine

Synthesis:



alternate route :



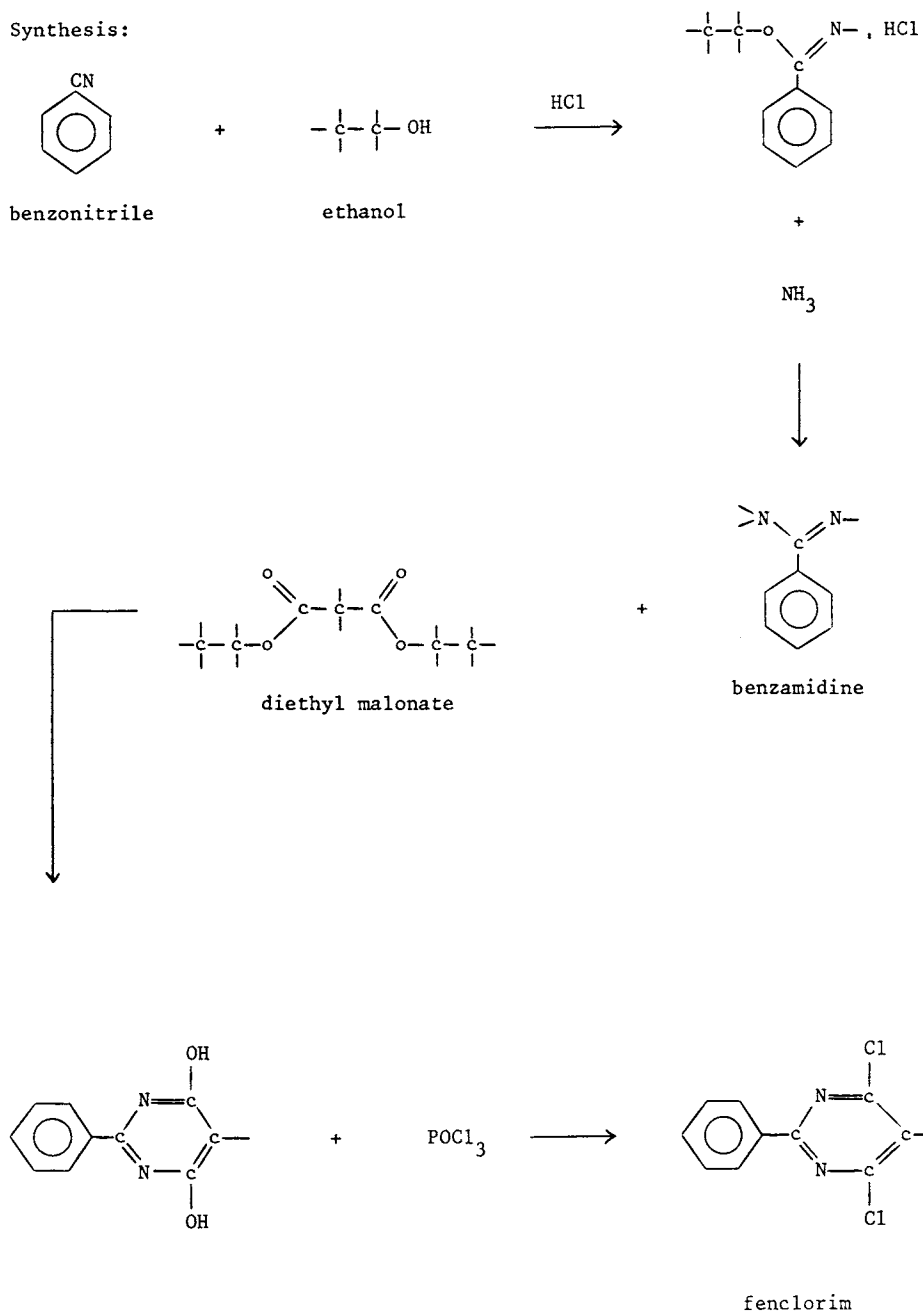
## Fenclorim

Uses: safener, rice

Trade names: Sofit (Ciba)

Type: pyrimidine

Synthesis:





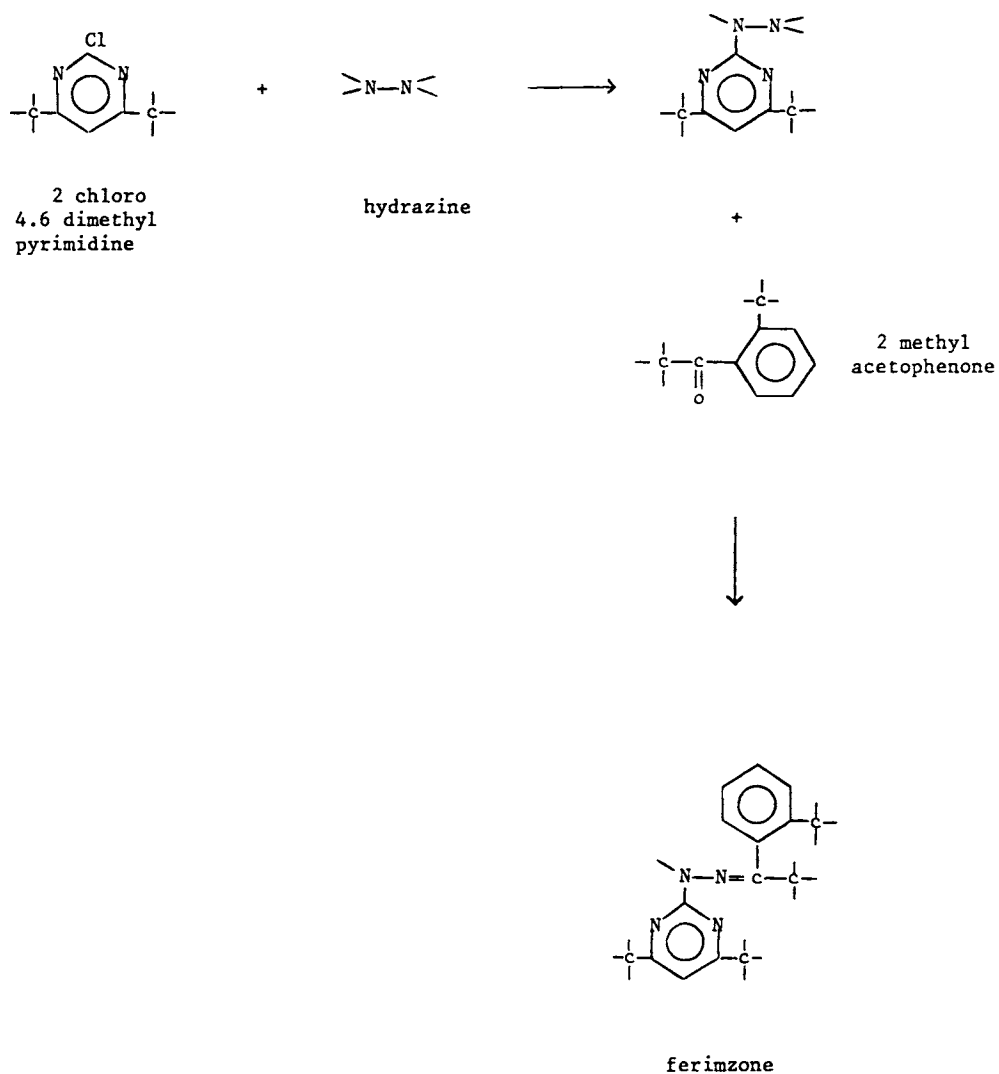
## Ferimzone

Uses: fungicide, rice

Trade names: (Takeda)

Type: pyrimidine

Synthesis:



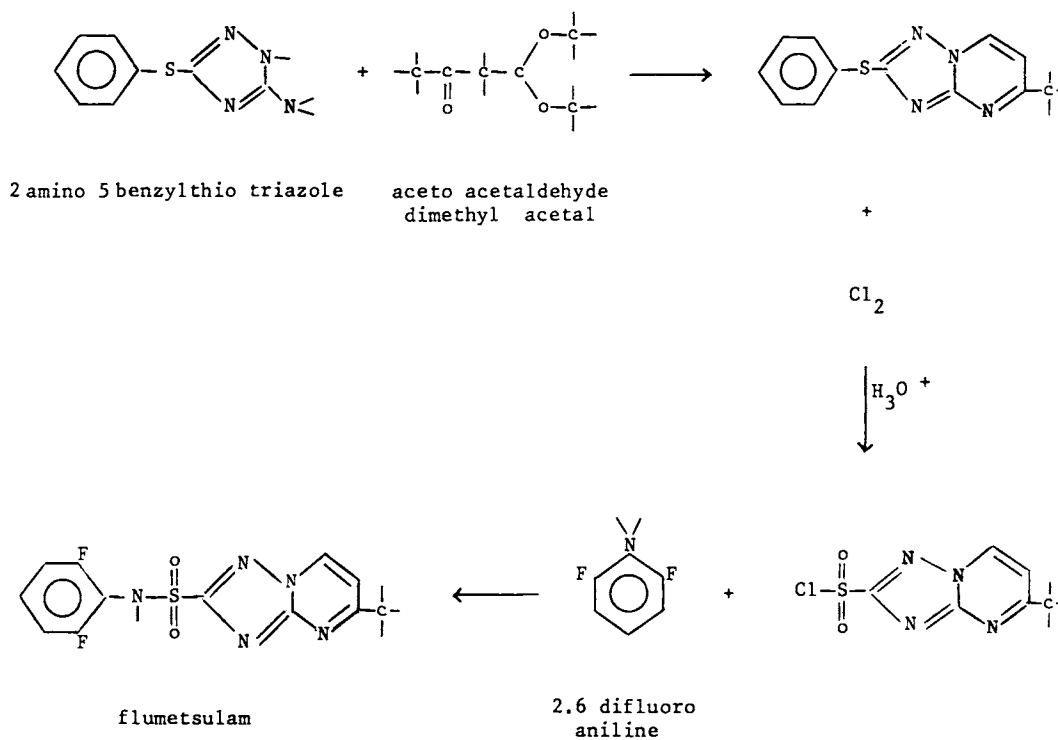
## Flumetsulam

Uses: herbicide, soyabeans, maize

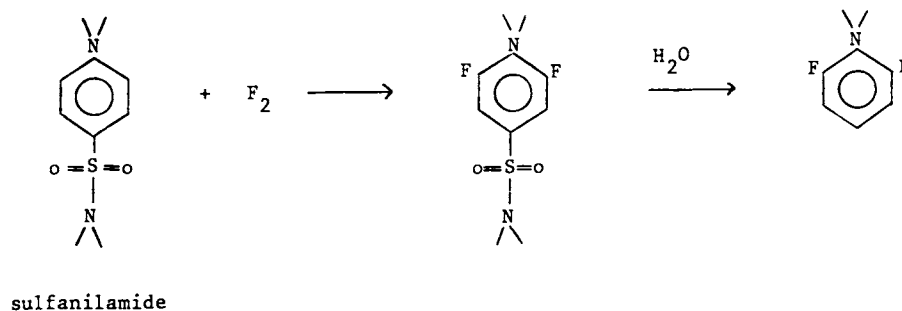
Trade names: Broadstrike, (DowElanco)

Type: pyrimidine, triazole, sulfonamide

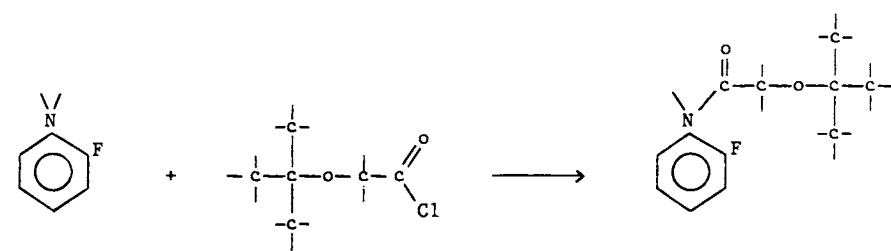
Synthesis:



Preparation of 2,6 difluoroaniline :



alternate route :



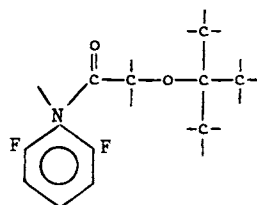
2 fluoro  
aniline

2 isobutoxy  
acetyl chloride

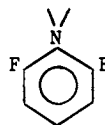
+

F<sub>2</sub>

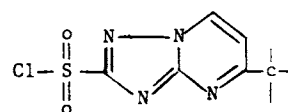
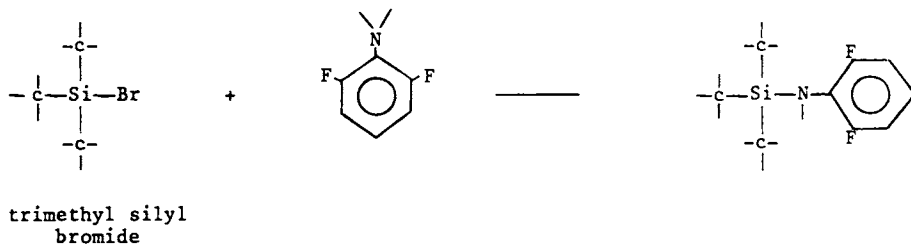
butyl lithium



HCl | H<sub>2</sub>O



alternate route :



flumetsulam

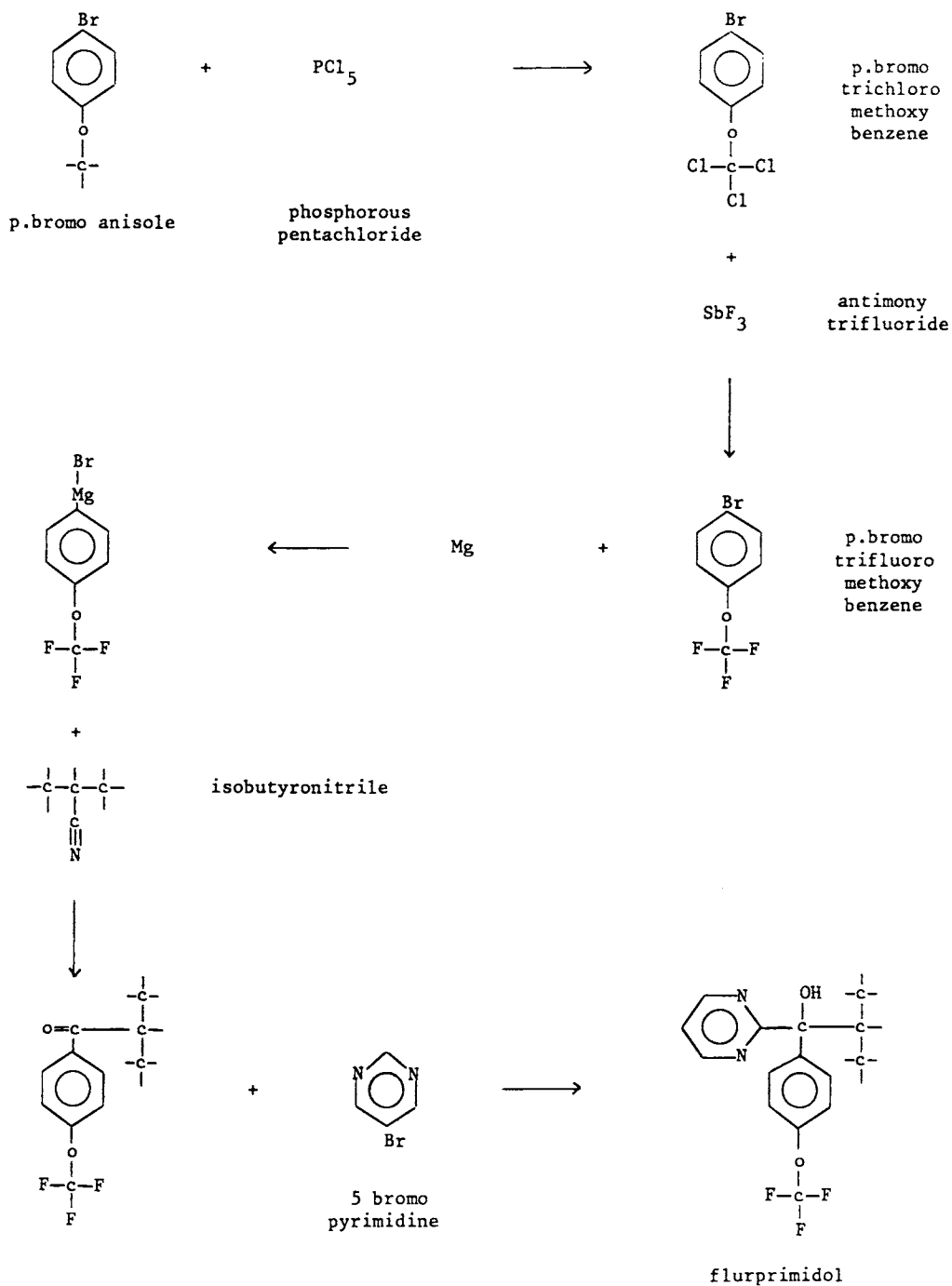
## Flurprimidol

Uses: growth regulator, turf, ornamentals, coniferous trees

Trade names: Cutless (Dow Elanco)

Type: pyrimidine

Synthesis:



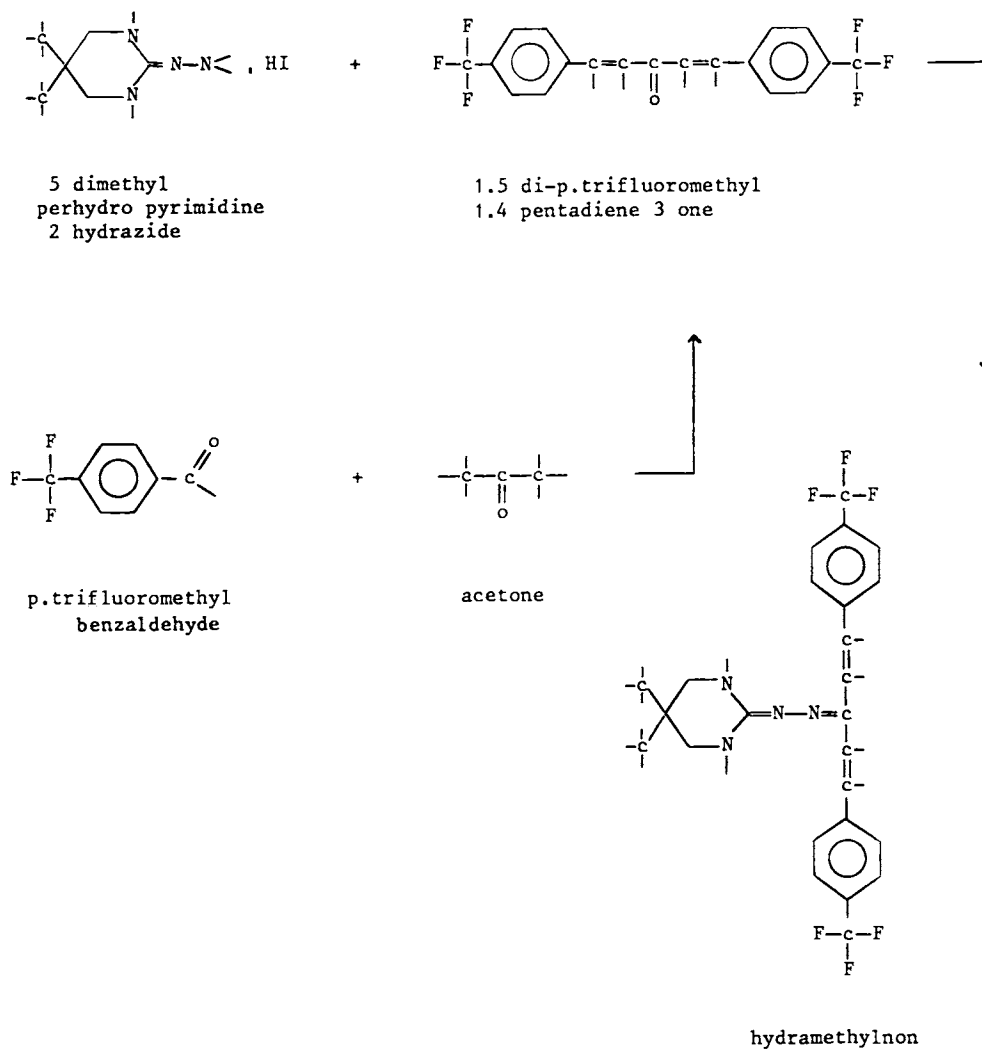
## Hydramethylnon

Uses: insecticide, ants

Trade names: Ambro, Combat, Maxforce (Cyanamid)

Type: pyrimidine

Synthesis:



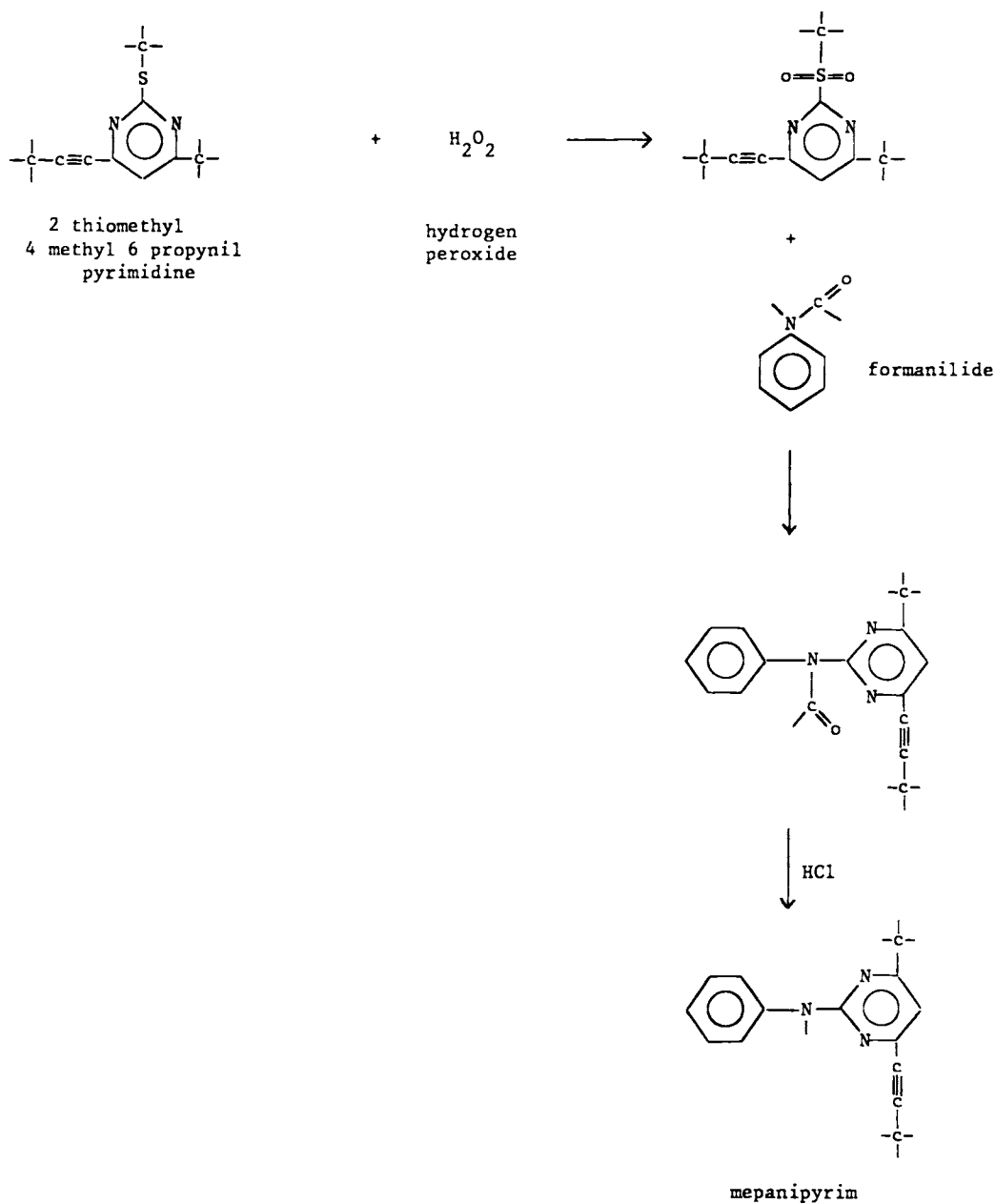
## Mepanipyrim

Uses: fungicide, fruit, cucumbers, tomatoes

Trade names: (Ihara, Kumiai)

Type: pyrimidine

Synthesis:



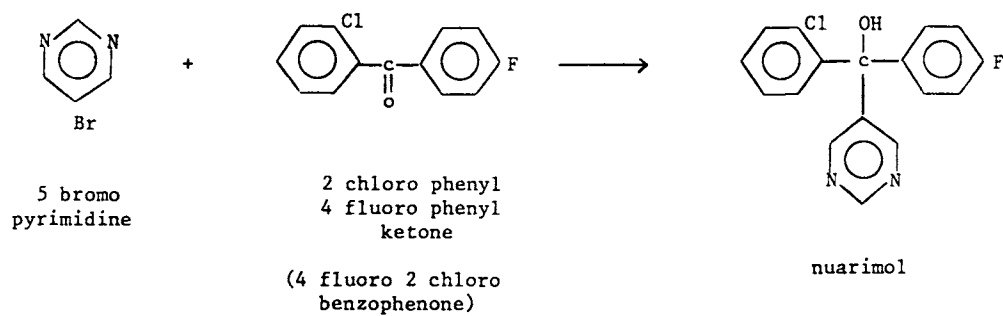
## Nuarimol

Uses: fungicide, barley seeds, wheat seeds

Trade names: Trimidal, Triminol, Gauntlet, Murox (Dow Elanco)

Type: pyrimidine

Synthesis:





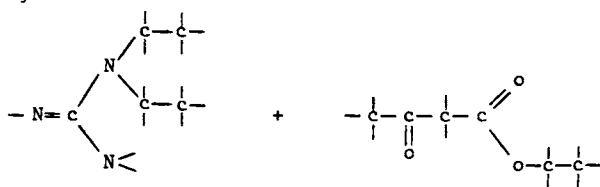
## Pirimiphos-Methyl Pirimiphos-Ethyl

Uses: insecticide

Trade names: Fernex (ICI)

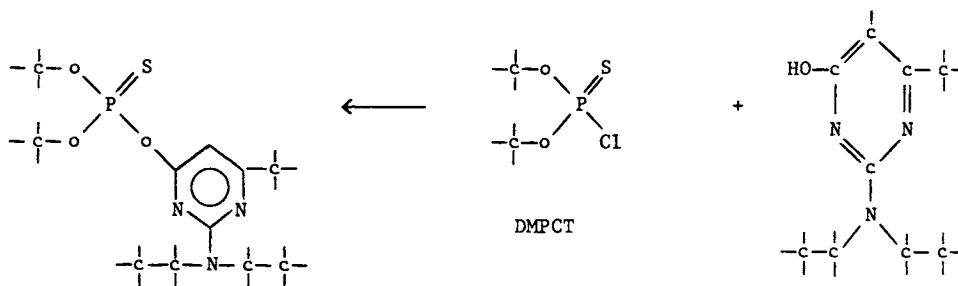
Type: pyrimidine, phosphorothioate

Synthesis:



NN diethyl guanidine

ethyl aceto acetate



pirimiphos-methyl

Pirimiphos-ethyl is made with DEPCT instead of DMPCT

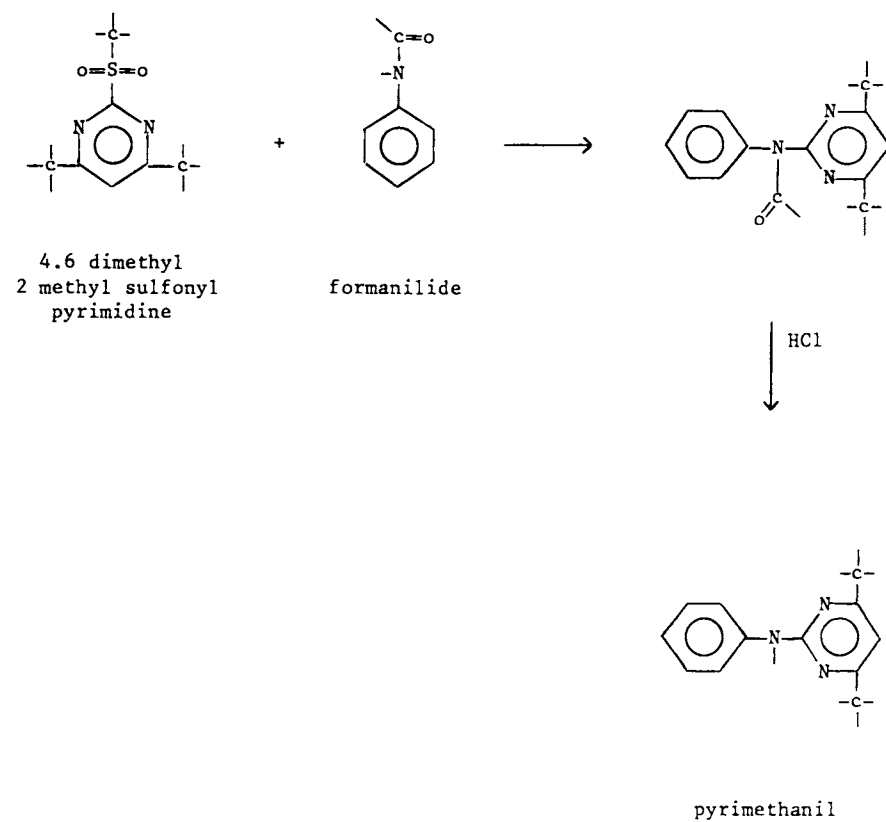
## Pyrimethanil

Uses: fungicide, vines, fruit, vegetables

Trade names: Mythos, Scala (AgrEvo)

Type: pyrimidine

Synthesis:



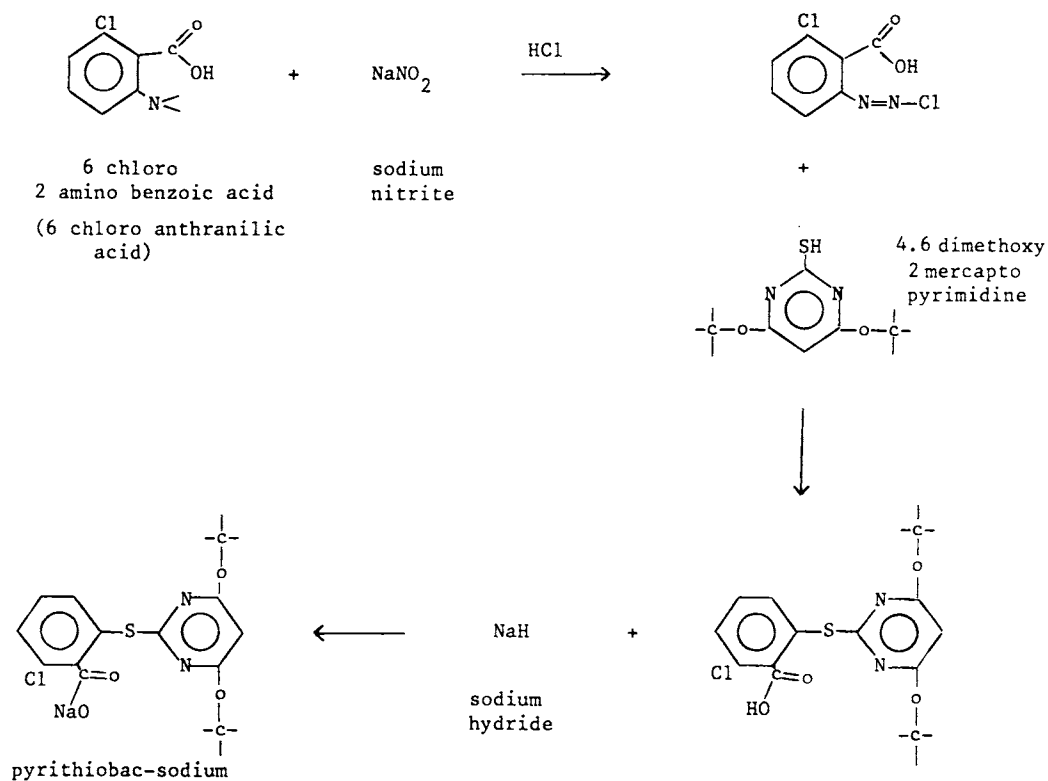
## Pyrithiobac-Sodium

Uses: herbicide, cotton

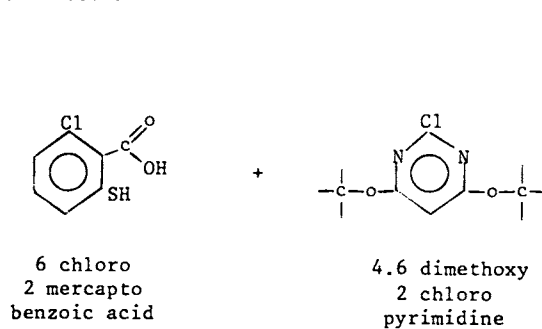
Trade names: Staple (DuPont)

Type: pyrimidine

Synthesis:

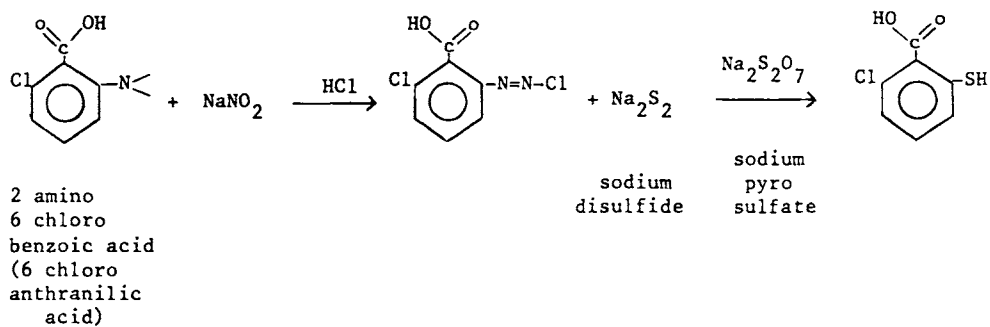


alternate route:

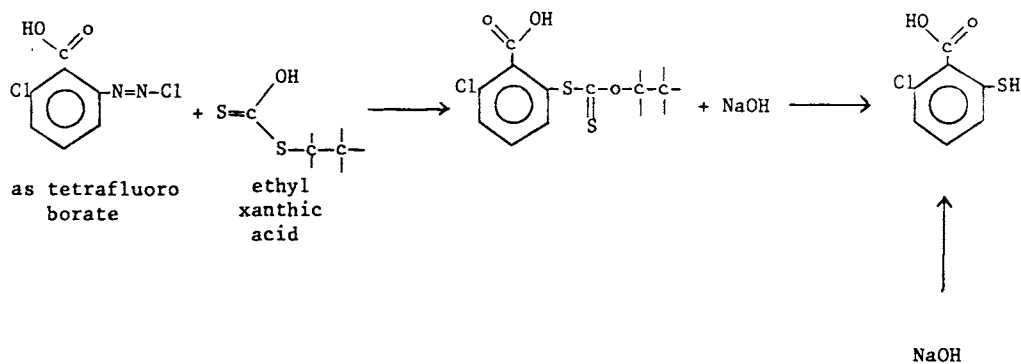


Preparation of 6 chloro 2 mercapto benzoic acid :

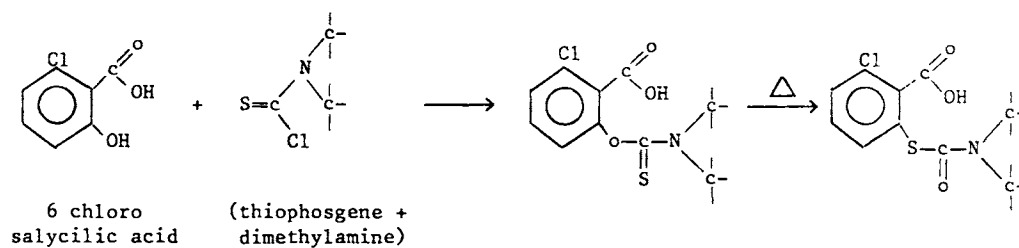
(i)



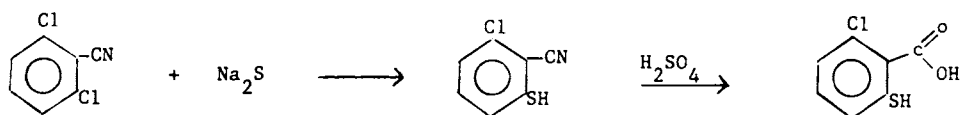
(ii)



(iii)

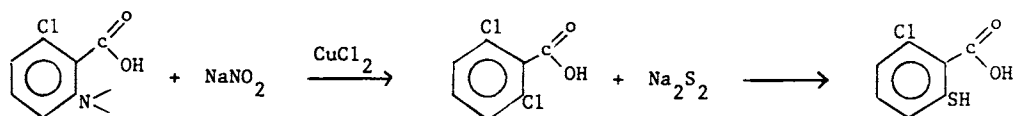


(iv)



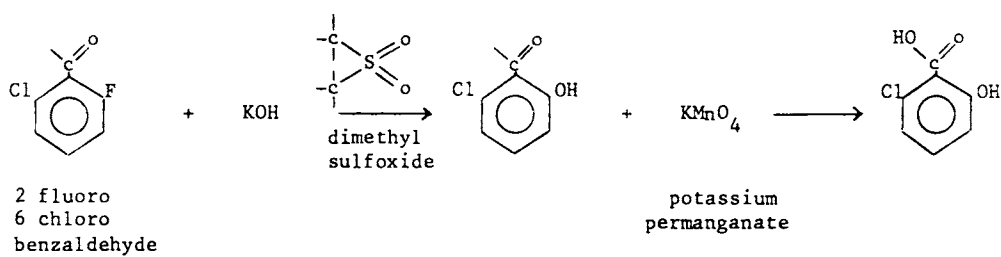
2,6 dichloro      sodium  
benzonitrile      sulfide

(v)

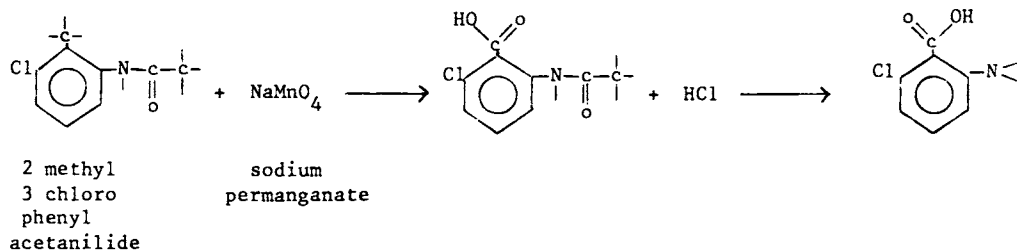


preparation of 6 chloro salycilic acid :

(i)



(ii)



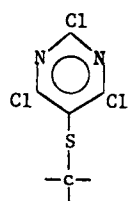
## Tioclorim

Uses: herbicide

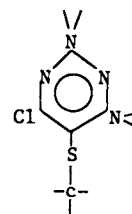
Trade names:

Type: pyrimidine

Synthesis:



+

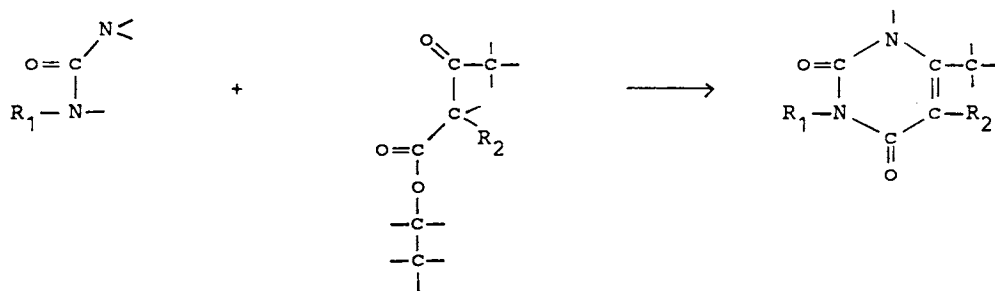


2,4,6 trichloro  
5 thio methyl  
pyrimidine

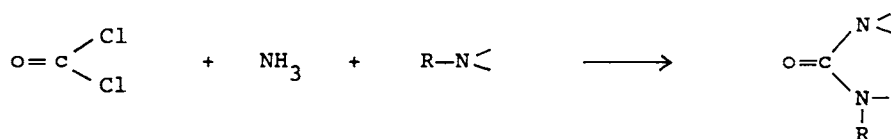
tioclorim

# PYRIMIDINEDIONES

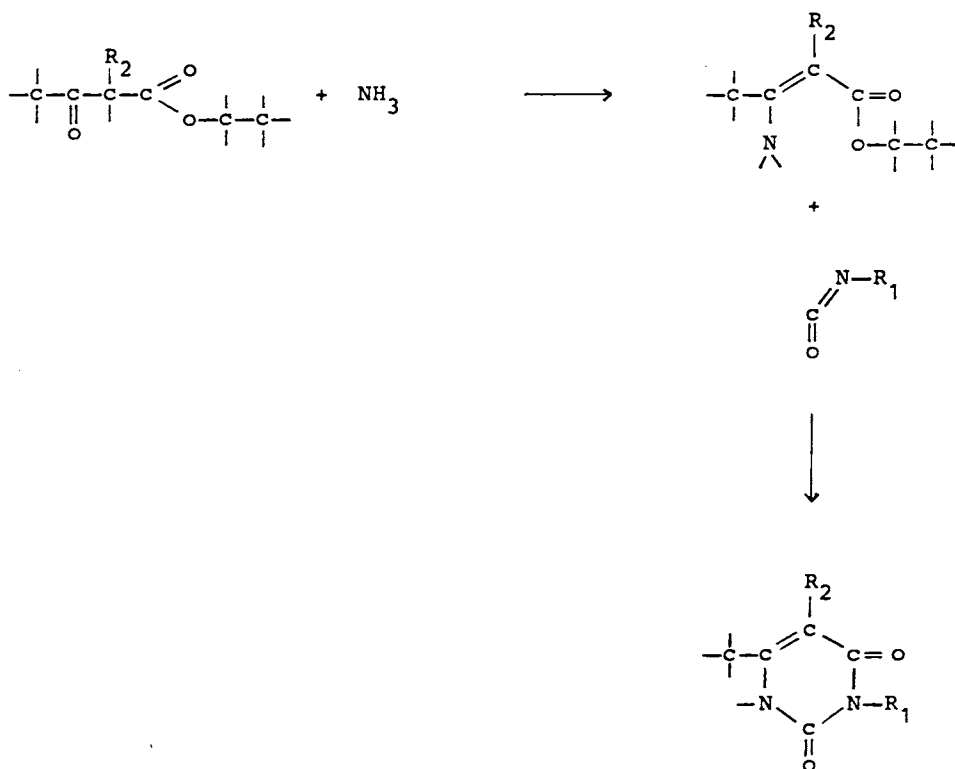
The synthesis is by reaction between an alkyl urea and ethyl (or methyl) aceto acetate



The alkyl urea is obtained from phosgene



An alternative route makes use of an isocyanate



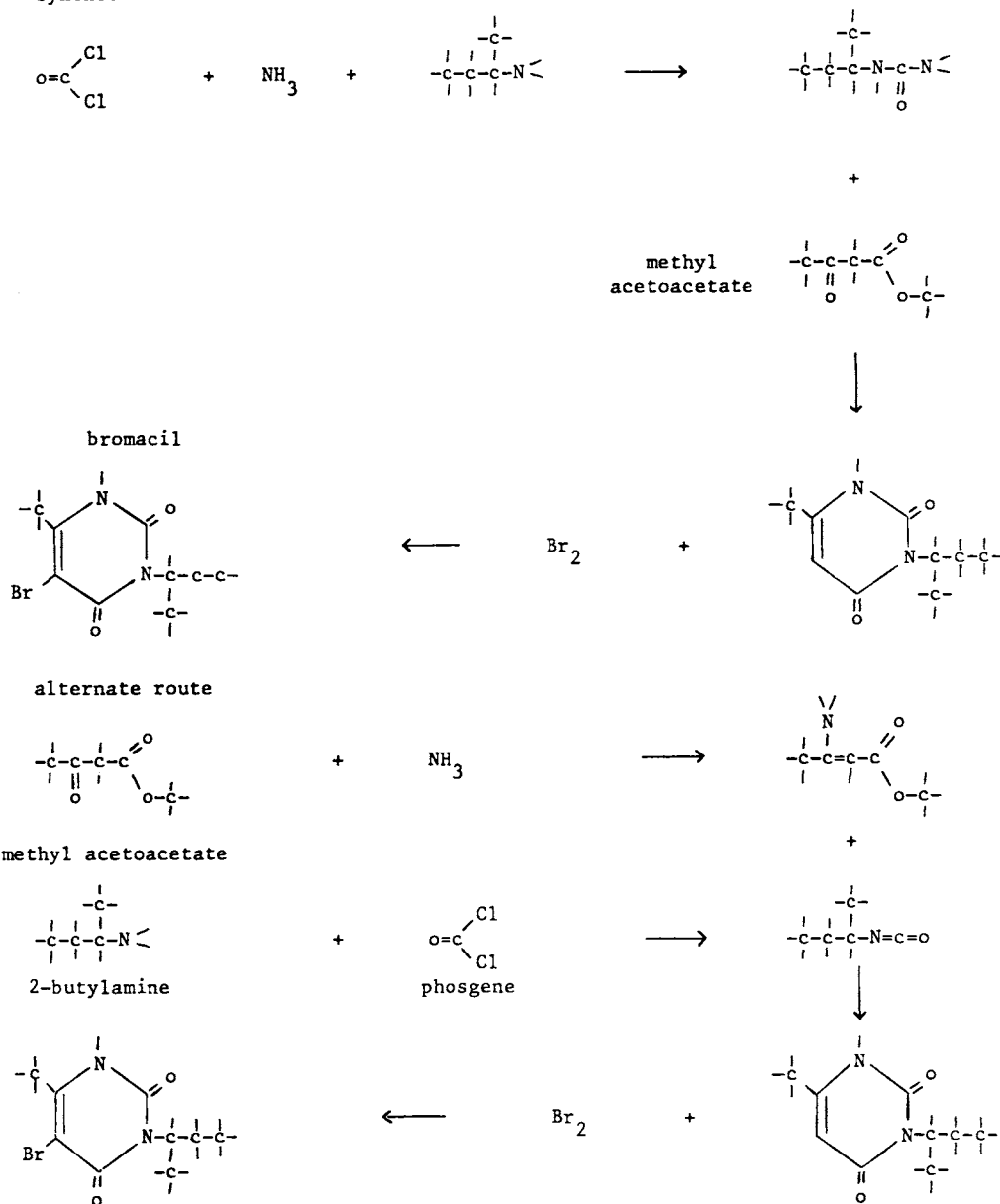
## Bromacil

Uses: herbicide, citrus, pineapple

Trade names: HyvarX (Dupont)

Type: pyrimidinedione

**Synthesis:**





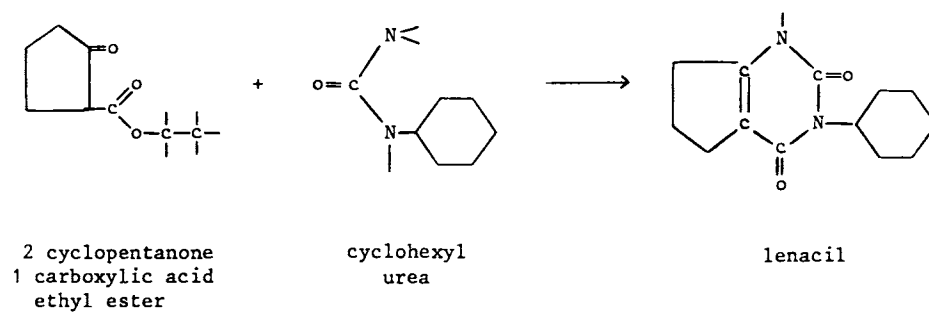
## Lenacil

Uses: herbicide, sugar beet, vegetables, fruit

Trade names: Venzar (Dupont)

Type: pyrimidinedione

Synthesis:



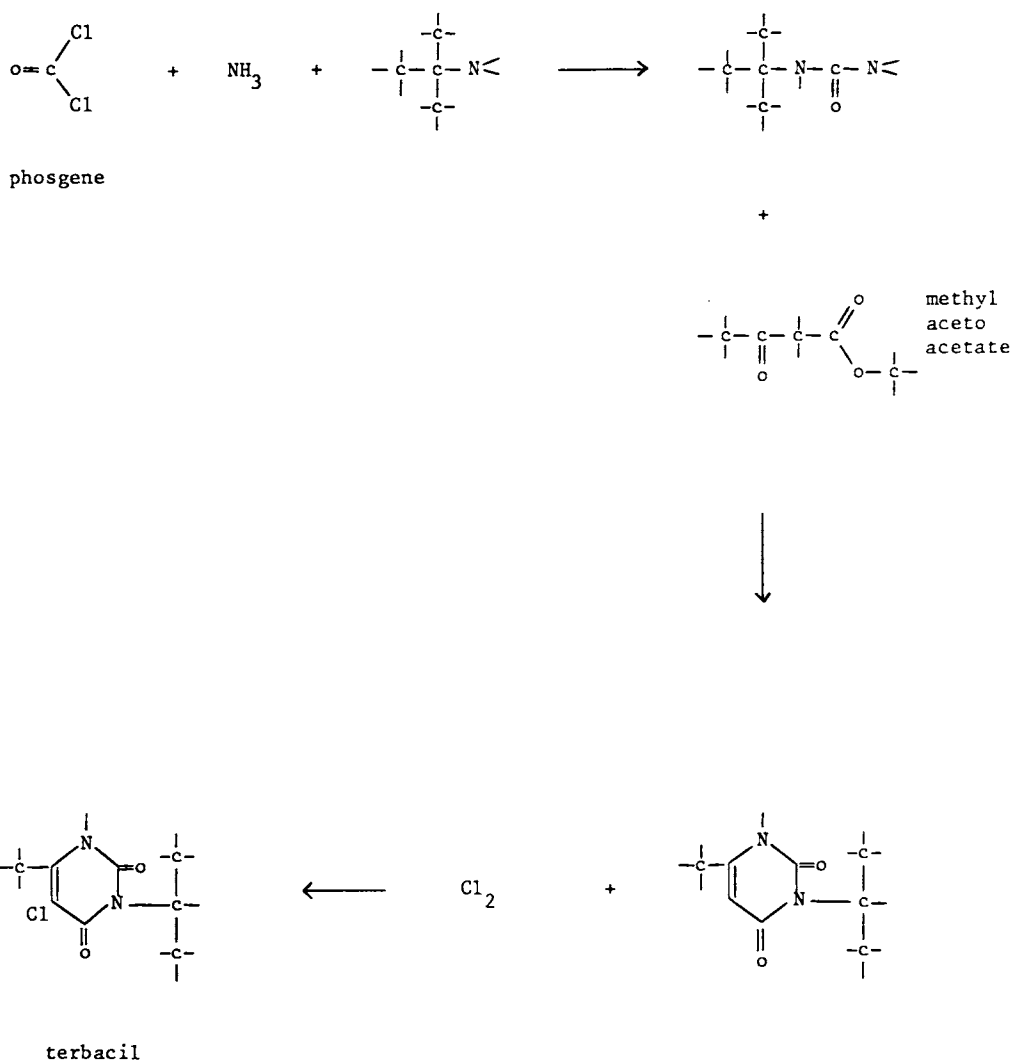
## Terbacil

Uses: herbicide, citrus, sugar cane, fruit trees

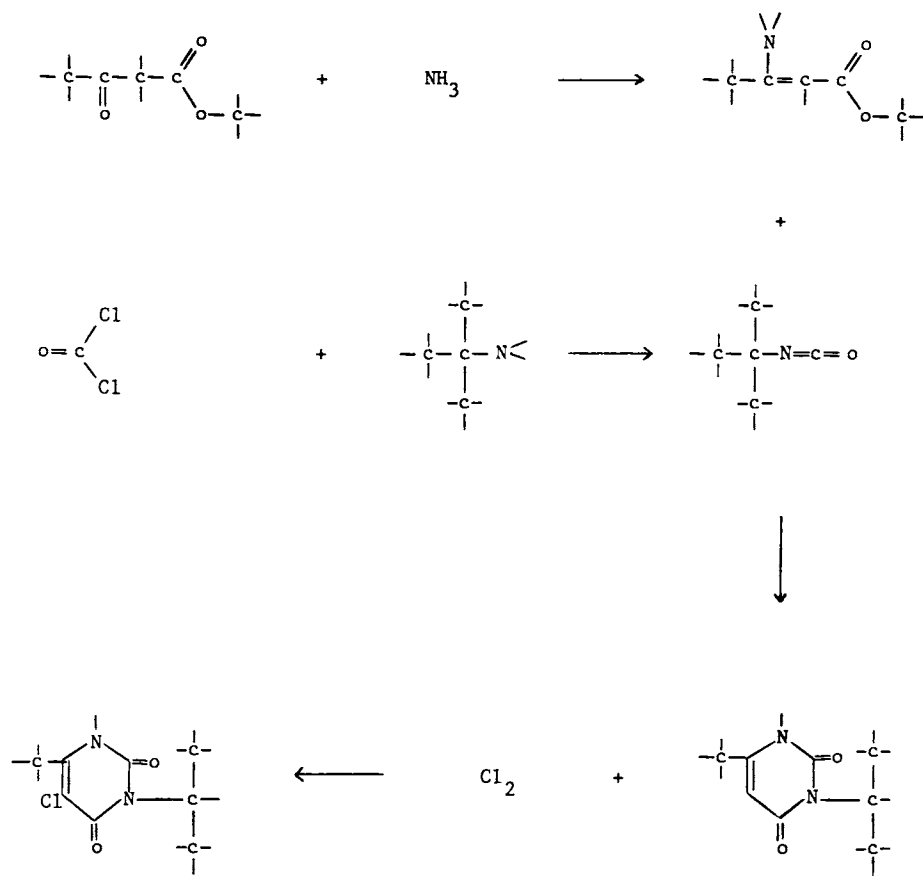
Trade names: Sinbar (Dupont)

Type: pyrimidinedione

**Synthesis:**



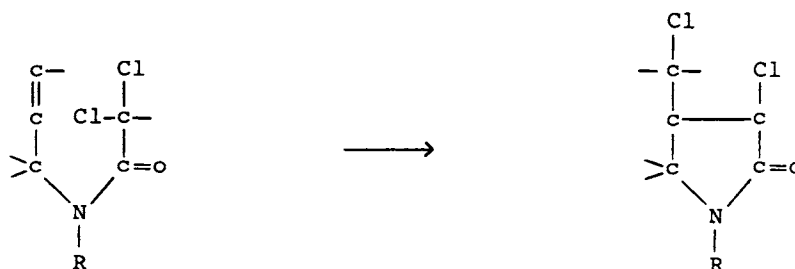
alternate route :



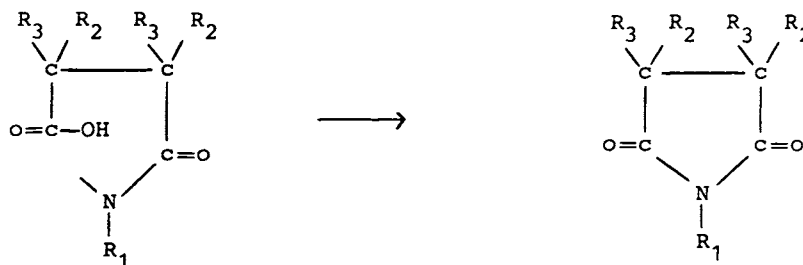
## PYRROLIDINONES

Synthesis of pyrrolidinones does not follow any single route but varies according to the compound to be produced.

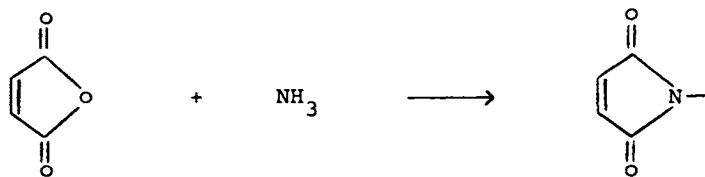
Flurochloridone is produced by ring closure of



Procymidone by ring closure of



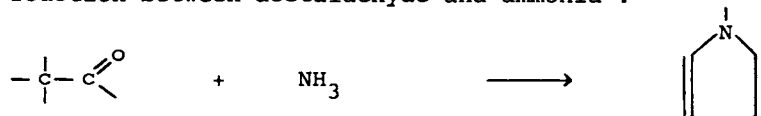
Ammoniation of maleic anhydride produce a pyrroledione



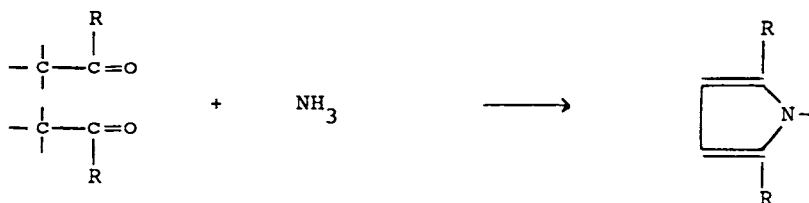
# PYRROLES

Pyrroles may be synthesized by a great number of different routes, some of which are illustrated below.

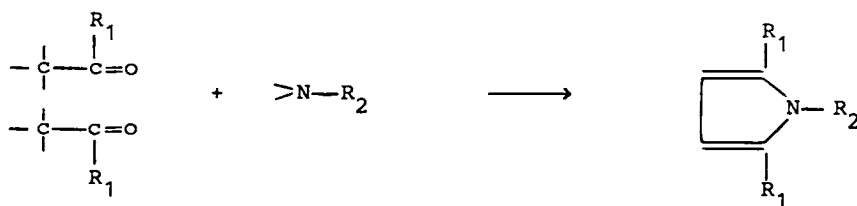
- reaction between acetaldehyde and ammonia :



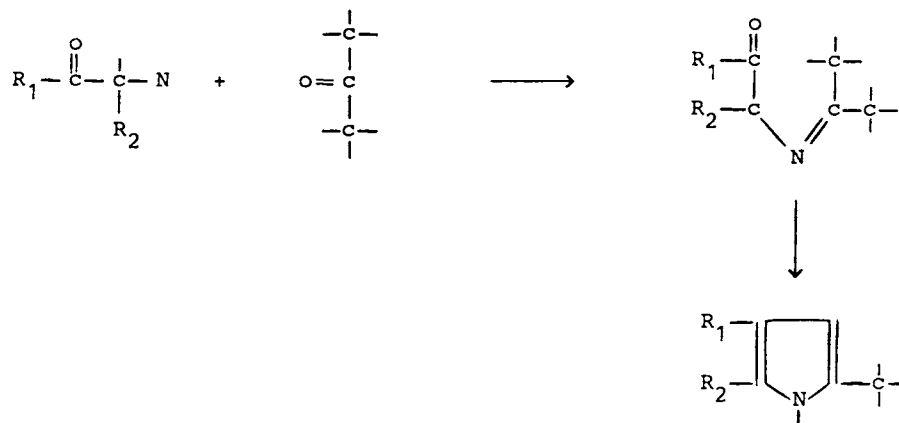
- reaction between acetyl acetone and ammonia :



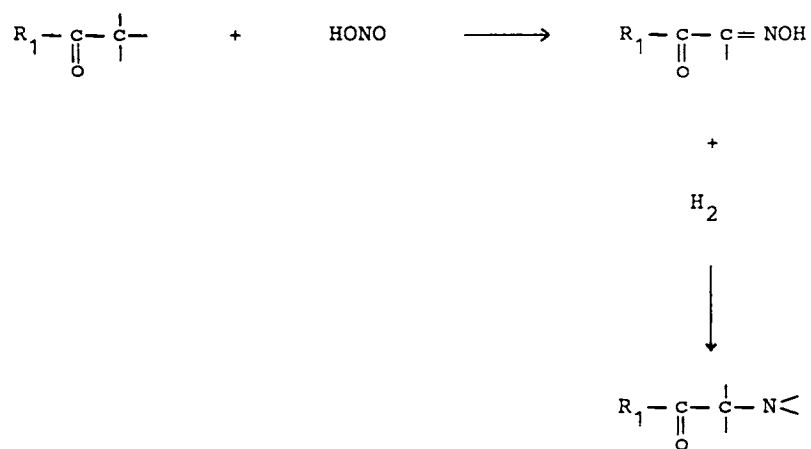
- reaction between acetyl acetone and an amine :



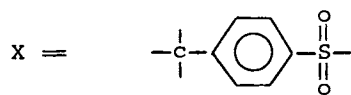
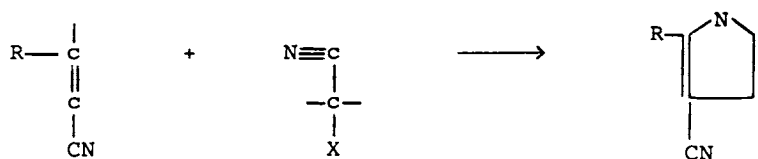
- condensation of a ketone with an  $\alpha$  amino ketone



The  $\alpha$  amino ketone is prepared from the ketone via the oxime followed by hydrogenation



- reaction between acrylonitrile (or derivate) and a tosyl methyl isocyanide



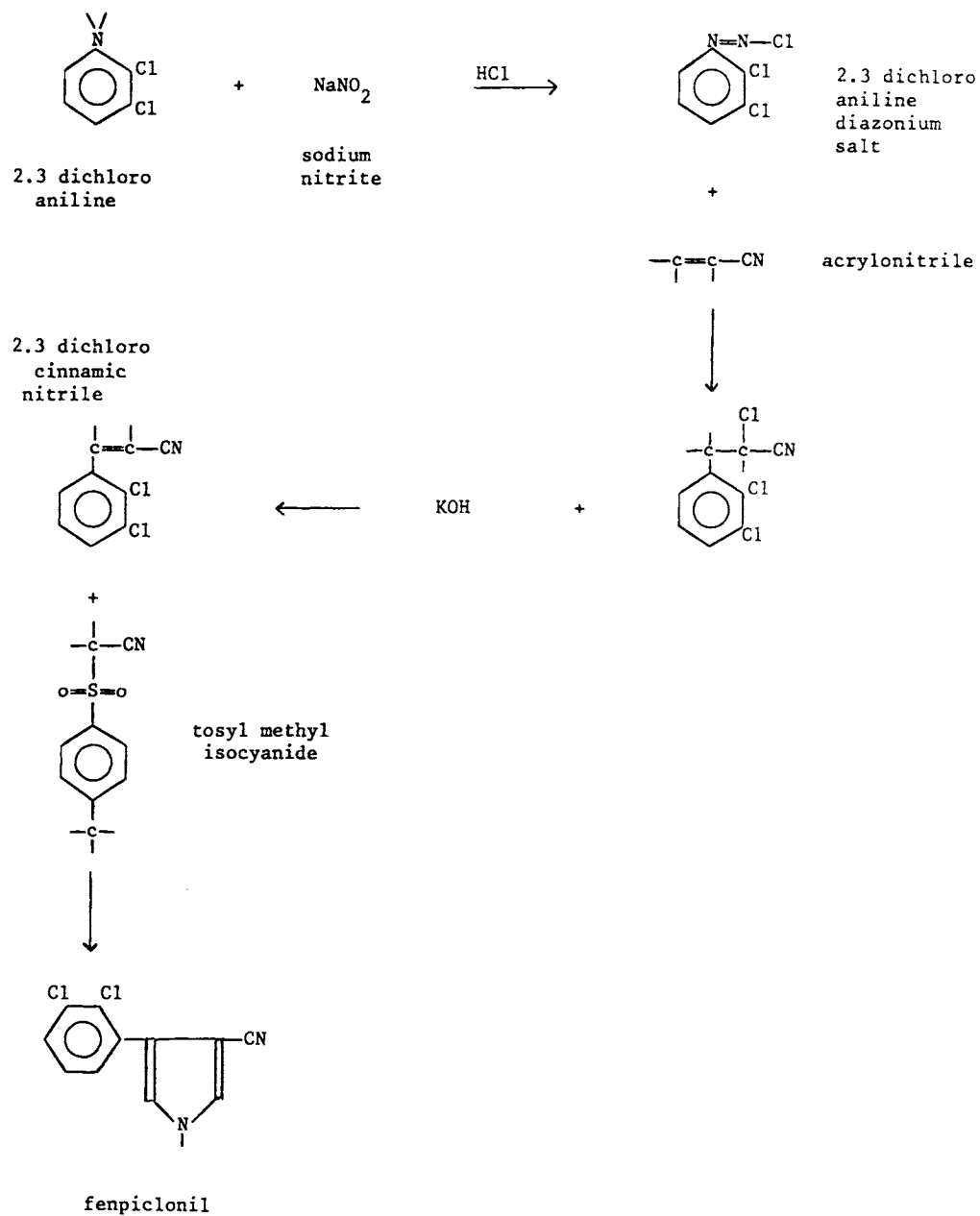
## Fenpiclonil

Uses: fungicide, cereals

Trade names: Beret (Ciba)

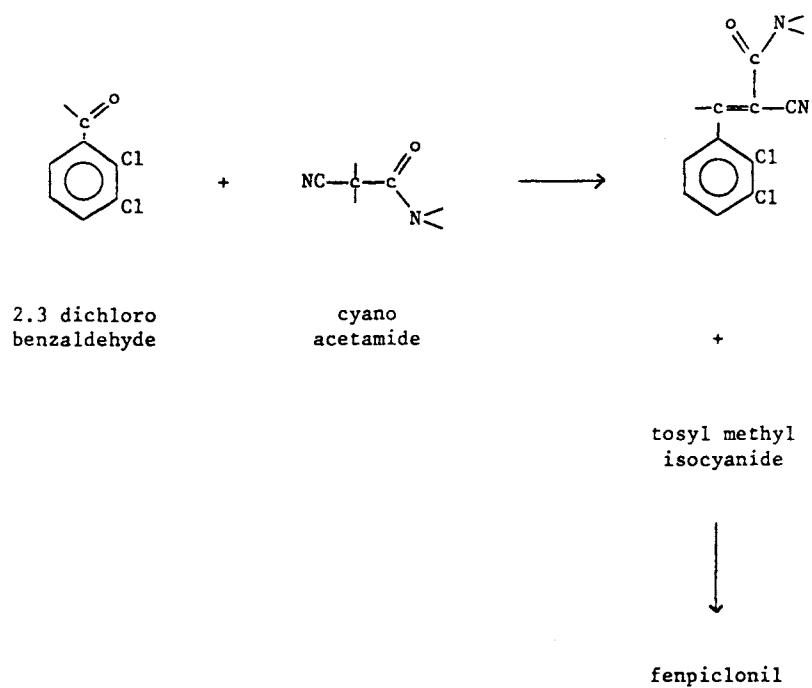
Type: pyrrole

Synthesis:





alternate route :



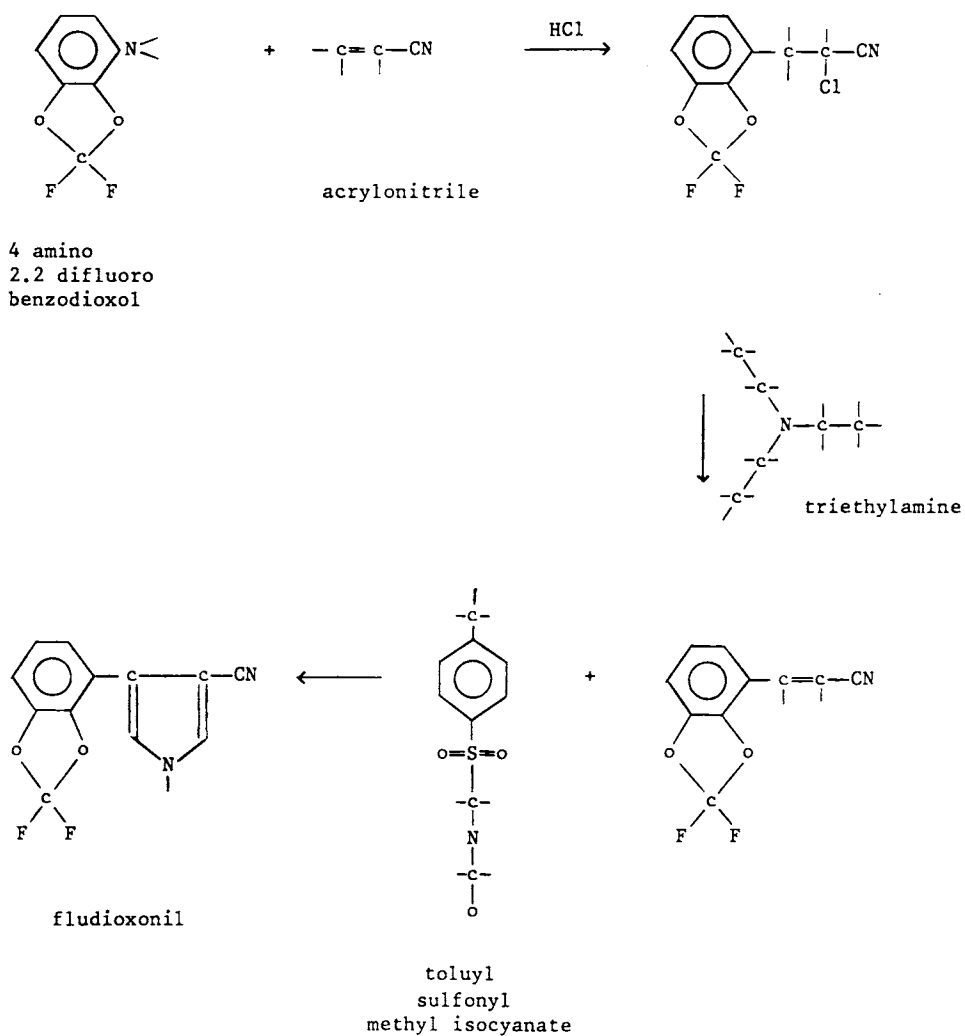
## Fludioxonil

Uses: fungicide, cereals, vegetables, rice

Trade name: Celest (Ciba)

Type: pyrrole

Synthesis:



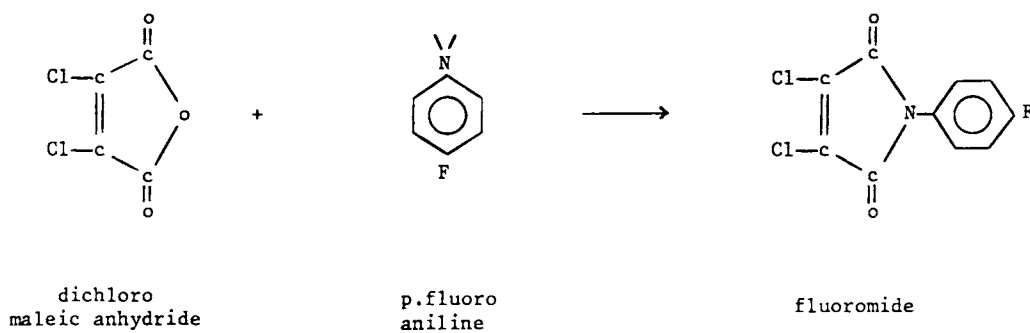
## Fluoromide

Uses: fungicide, apples, rubber trees, citrus

Trade names: Sparticide (Kumiai)

Type: pyrroledione

Synthesis:



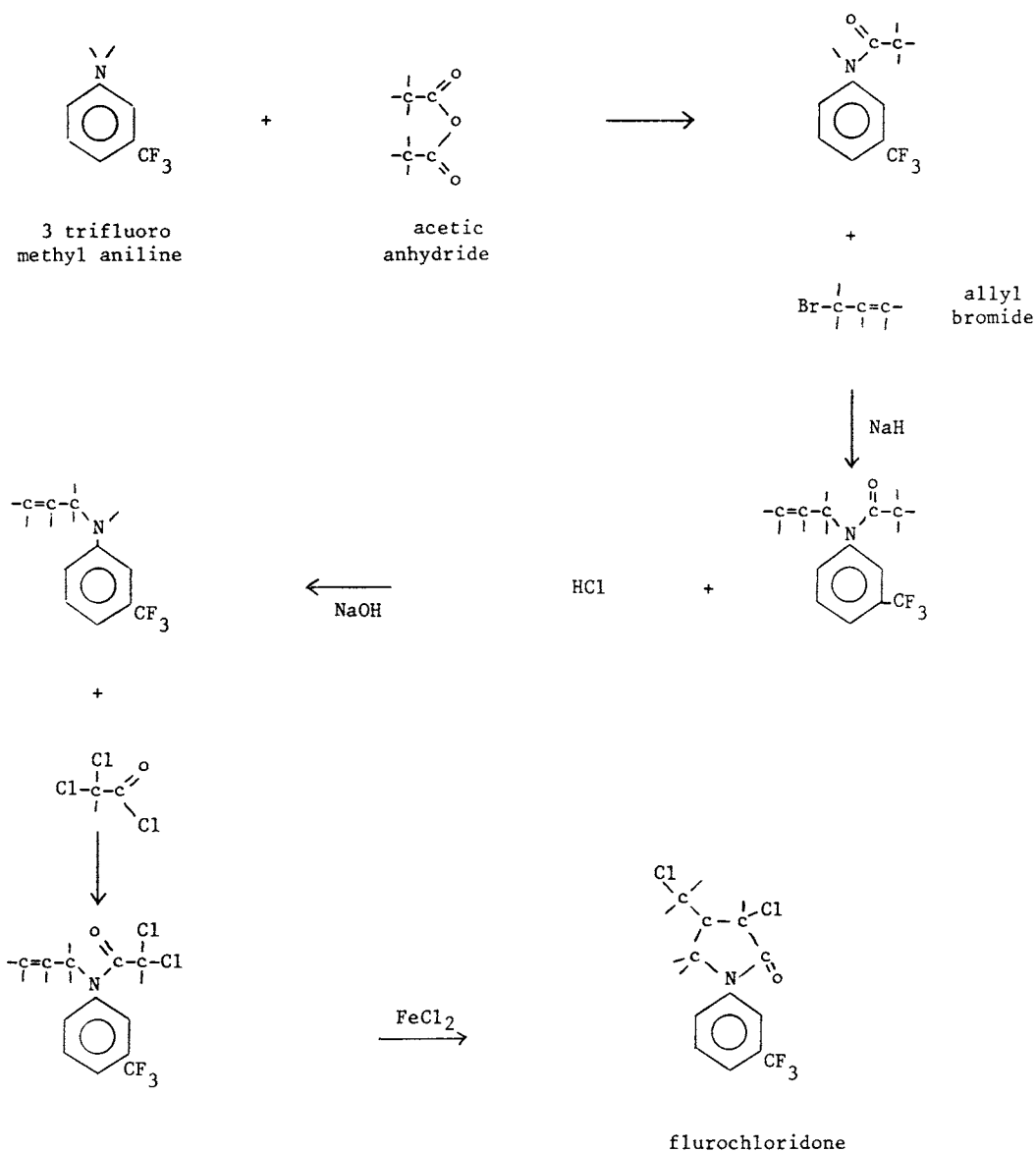
## Flurochloridone

Uses: herbicide, wheat, rye, cotton, potatoes, sunflowers

Trade names: Racer (ICI)

Type: pyrrolidinone

Synthesis:



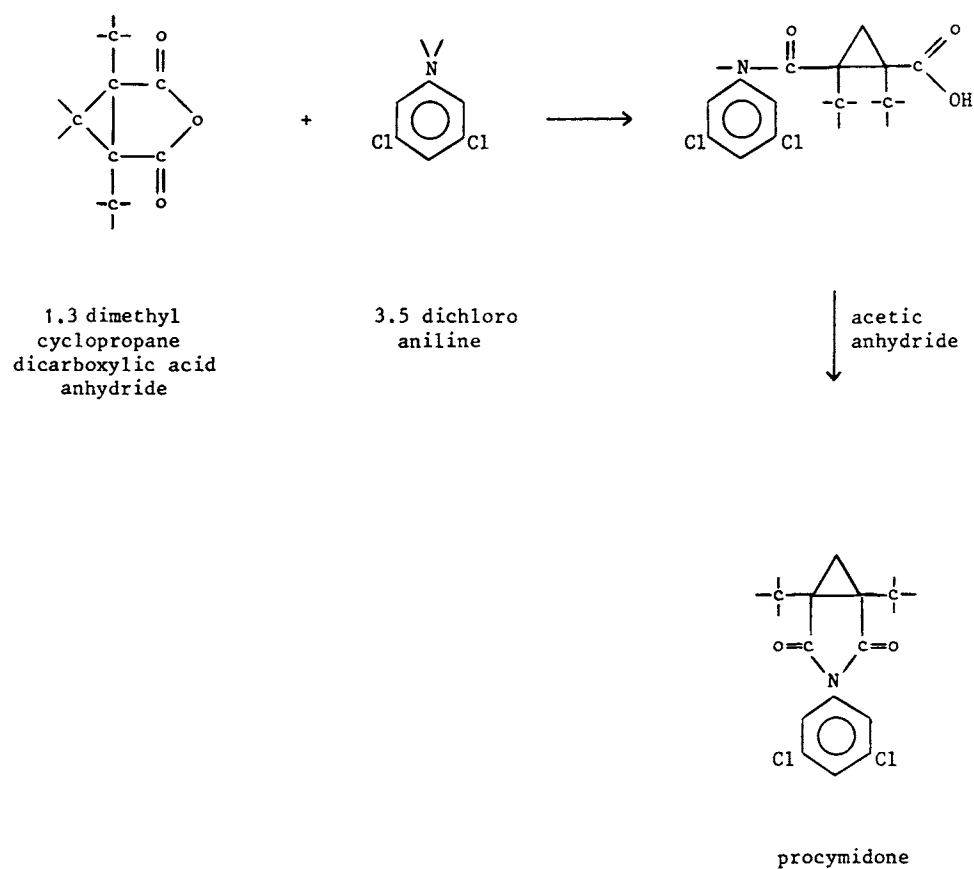
## Procymidone

Uses: fungicide, cereals, sunflowers, vine, greenhouses, fruit

Trade names: Sumisclex, Sumilex (Sumitomo)

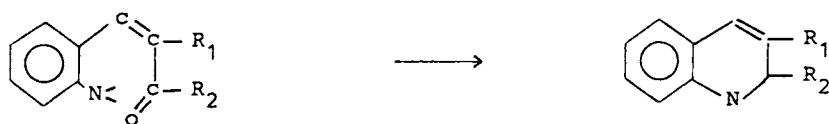
Type: pyrrolidinones

Synthesis:

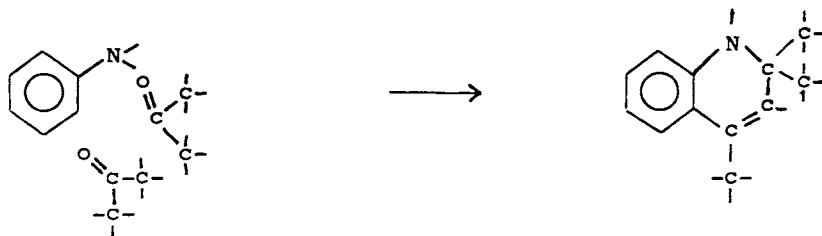


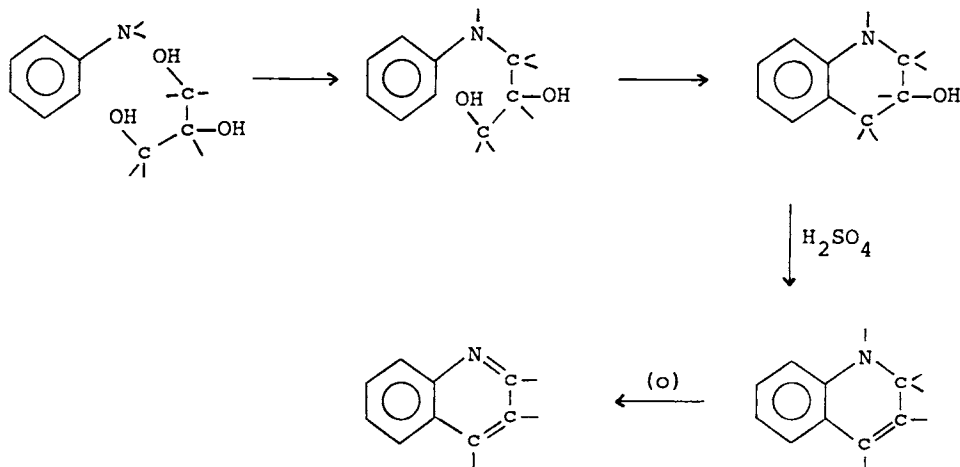
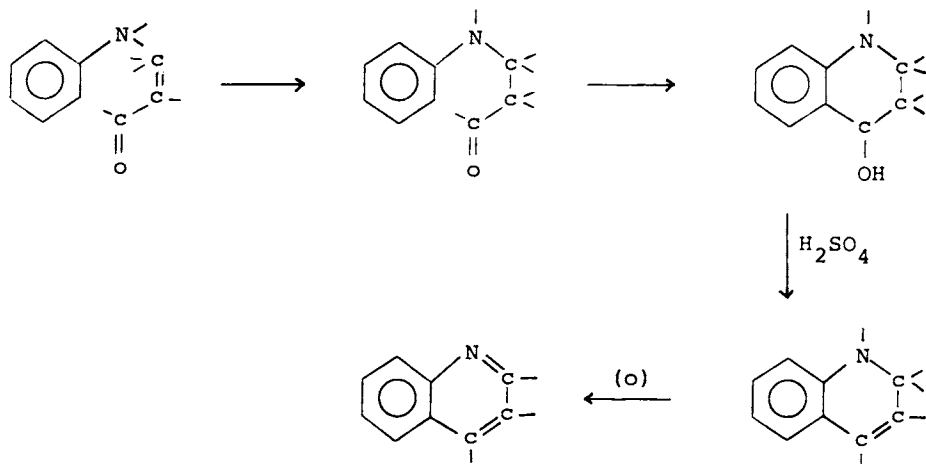
## QUINOLINES

The most common route to synthesis of the quinoline ring (such as for instance in imazaquin) is by cyclisation of ortho amino cinnamaldehyde

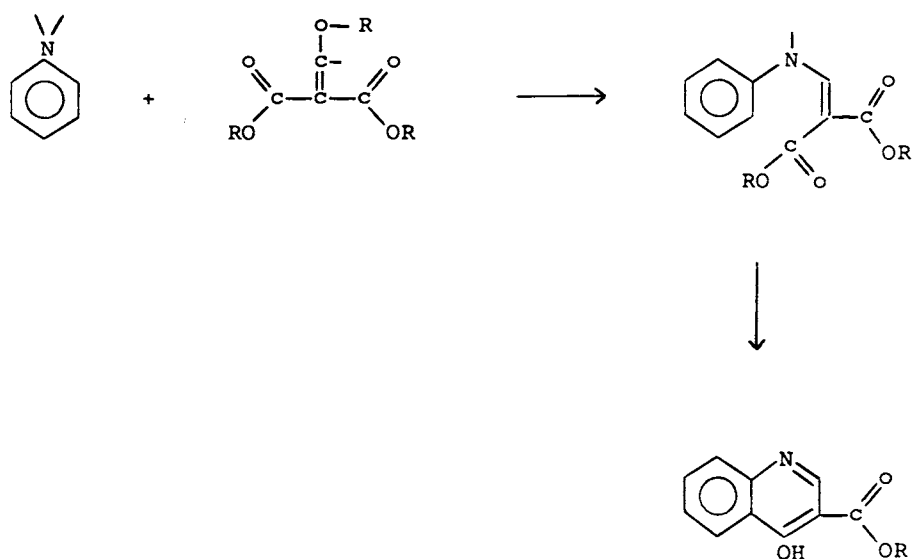


Other routes are by condensation of an aniline with acetone; or with acrolein or glycerol in presense of a dehydrating agent followed by oxidation

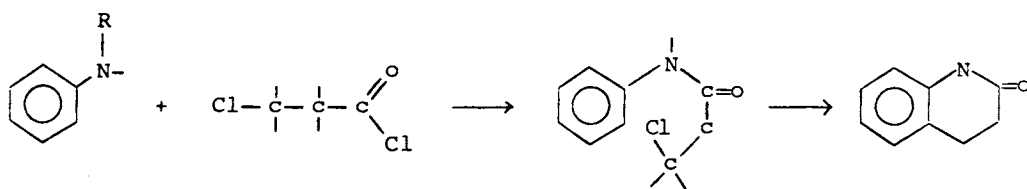




Finally less common routes are by reaction between an aniline and diethyl ethoxy methylene malonate followed by cyclisation



or by condensation between an aniline and chloro propionyl chloride followed by cyclisation



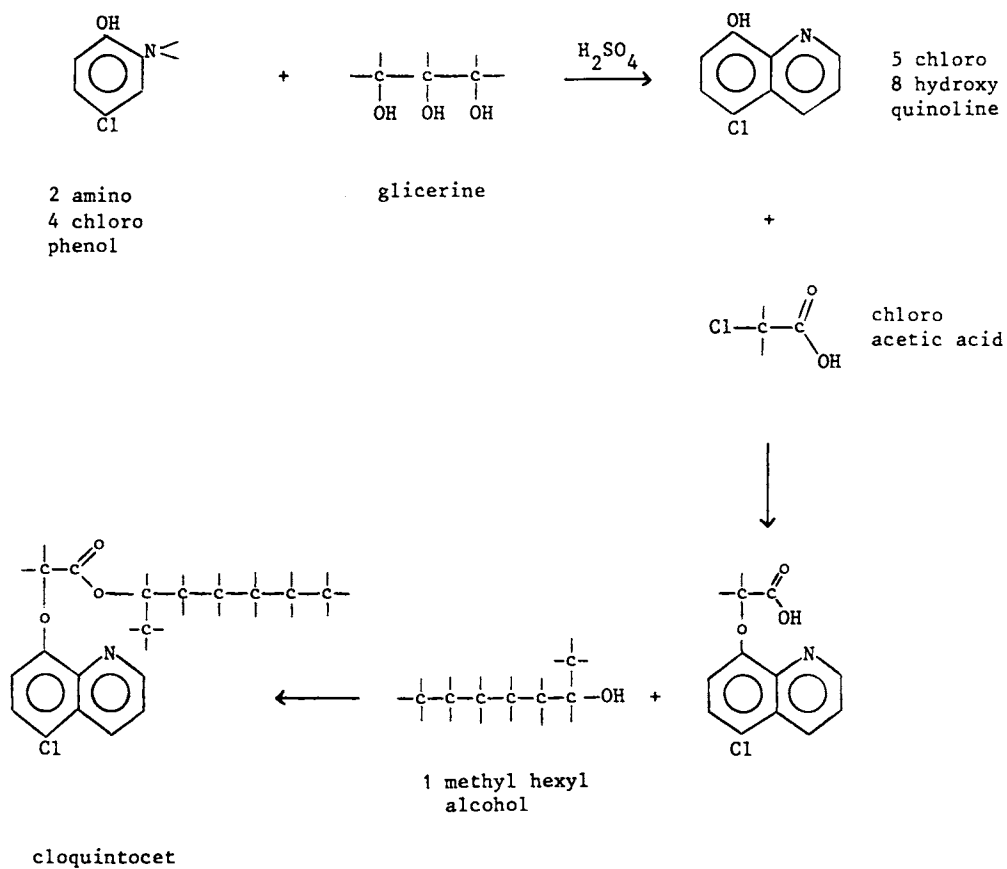


## Cloquintocet

Uses: herbicide safener, in combination with clodinafop

Trade names: (Ciba)

Type: quinoline



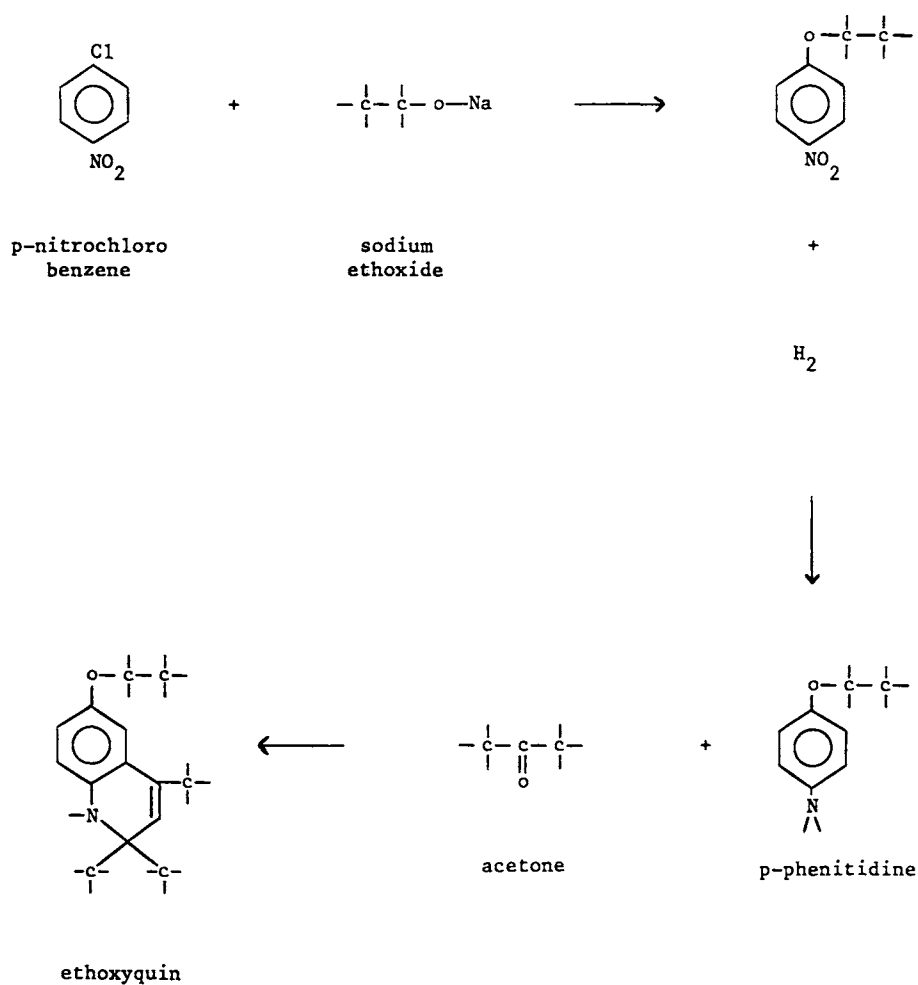
## Ethoxyquin

Uses: fungicide

Trade names: Stop-Scald (Monsanto)

Type: quinoline

Synthesis:



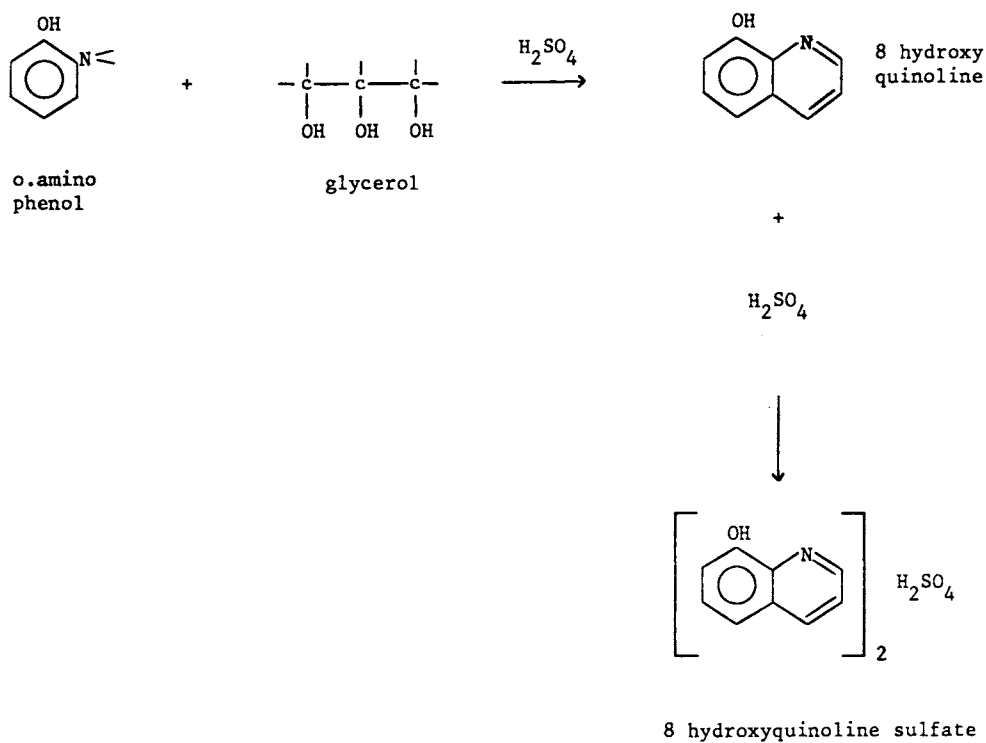
## 8-Hydroxyquinoline Sulfate

Uses: fungicide, ornamentals, benches, equipment

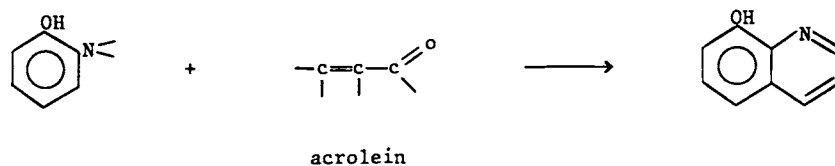
Trade names: Chinosol (Hoechst), Cryptonol (Ciba)

Type: quinoline

Synthesis:



alternate route :



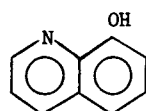
## Oxine-Copper

Uses: fungicide, cereals, sugar beet, sunflowers

Trade names: Quinolate (Ciba)

Type: quinoline, copper organic

Synthesis:

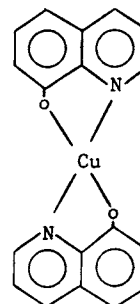


8 hydroxy  
quinoline

+



copper  
sulfate



oxine-copper

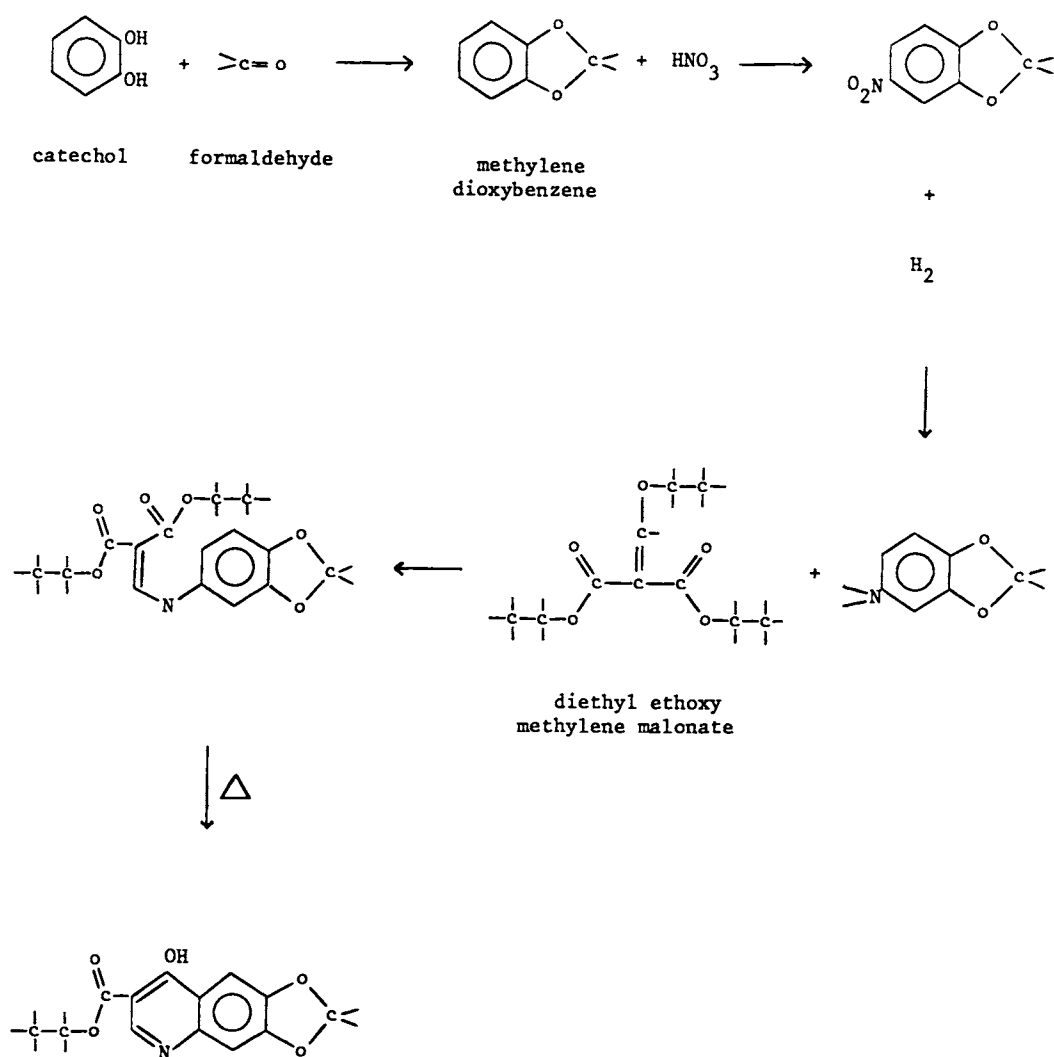
## Oxolinic Acid

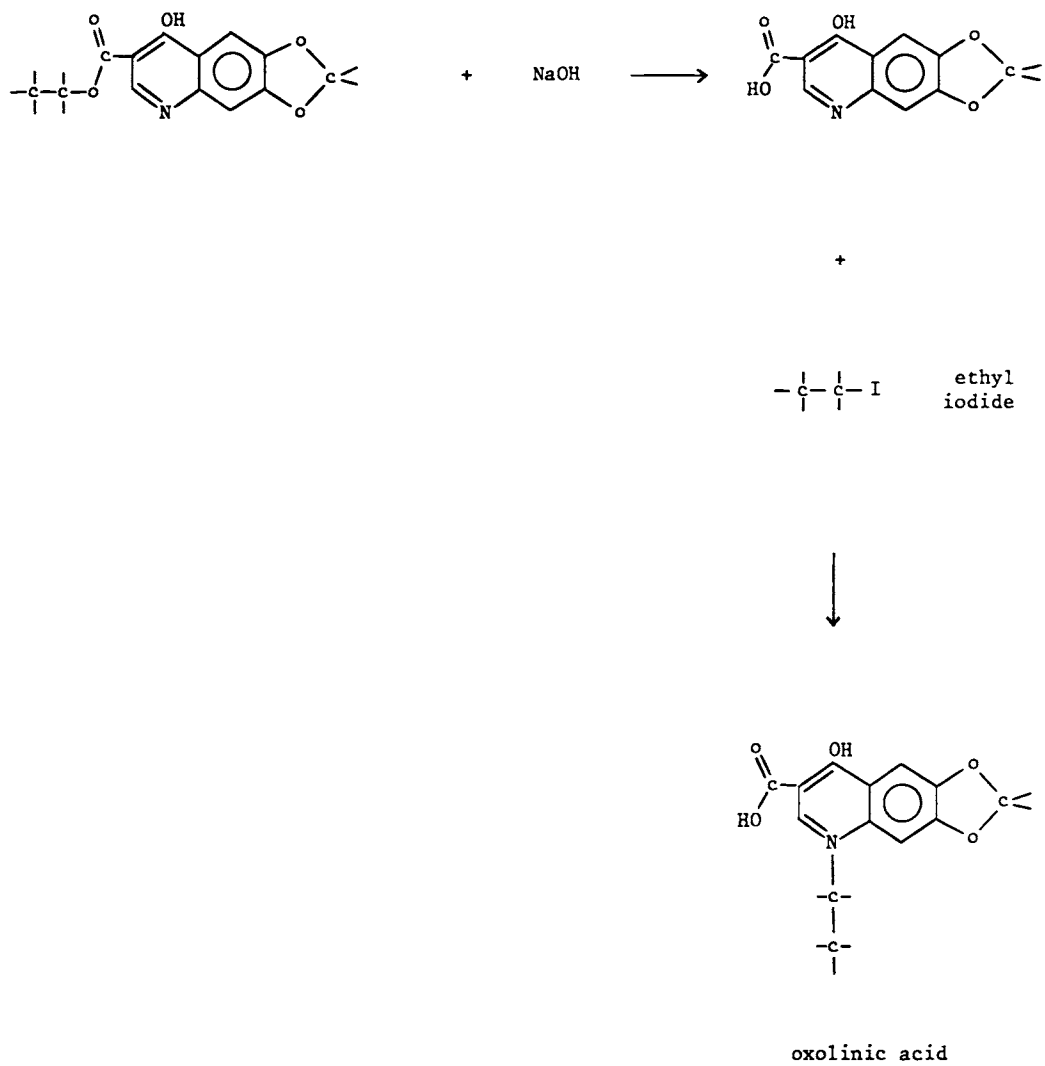
Uses: bactericide, rice

Trade names: Starner (Sumitomo)

Type: quinoline

Synthesis:





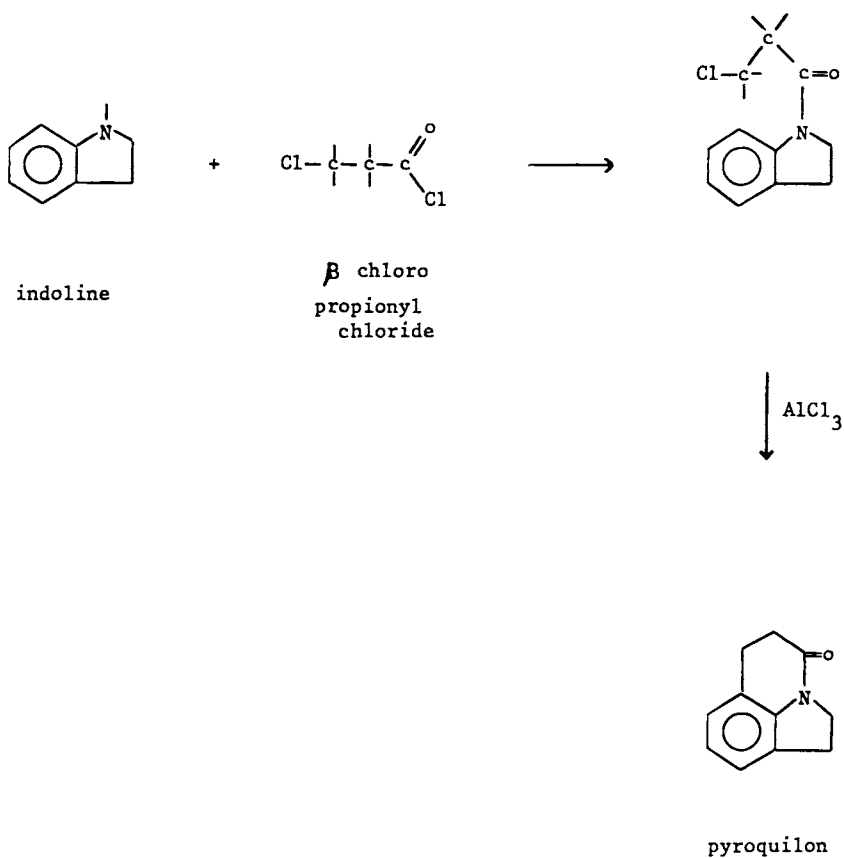
## Pyroquilon

Uses: fungicide, rice

Trade names: Fongoren, Fongorene (Ciba)

Type: quinoline, pyrrole

Synthesis:



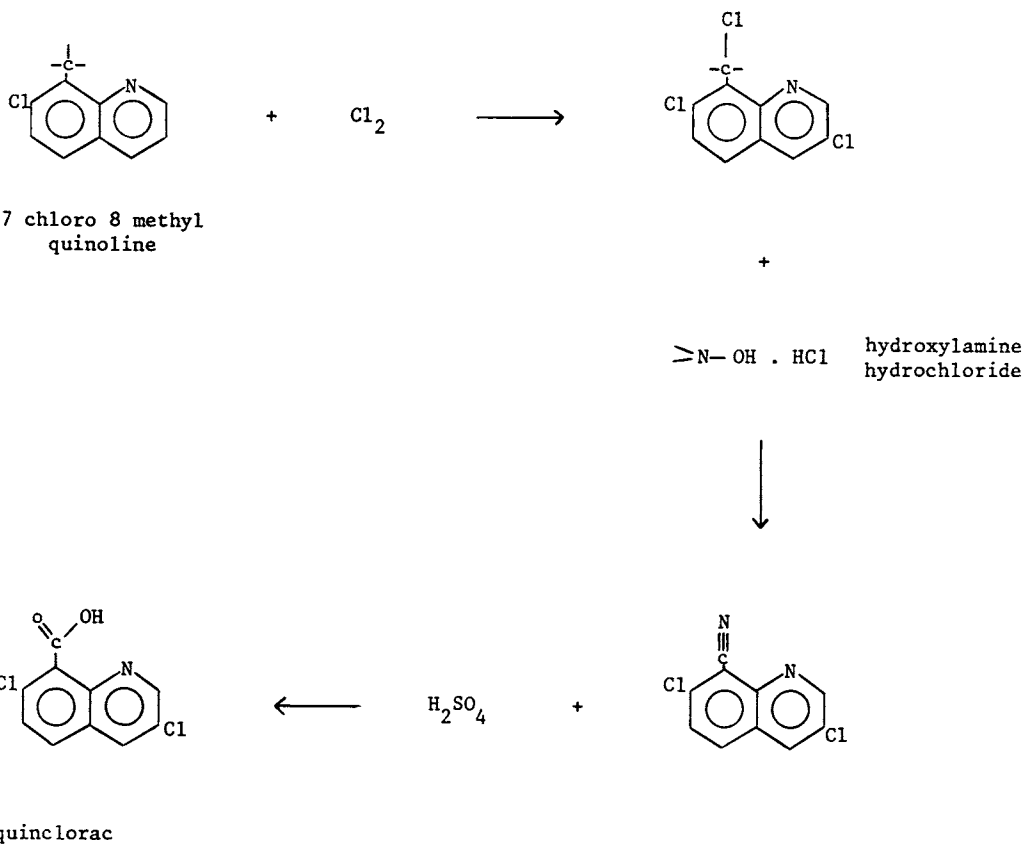
## Quinclorac

Uses: herbicide, rice

Trade names: Facet (BASF)

Type: quinoline

Synthesis:





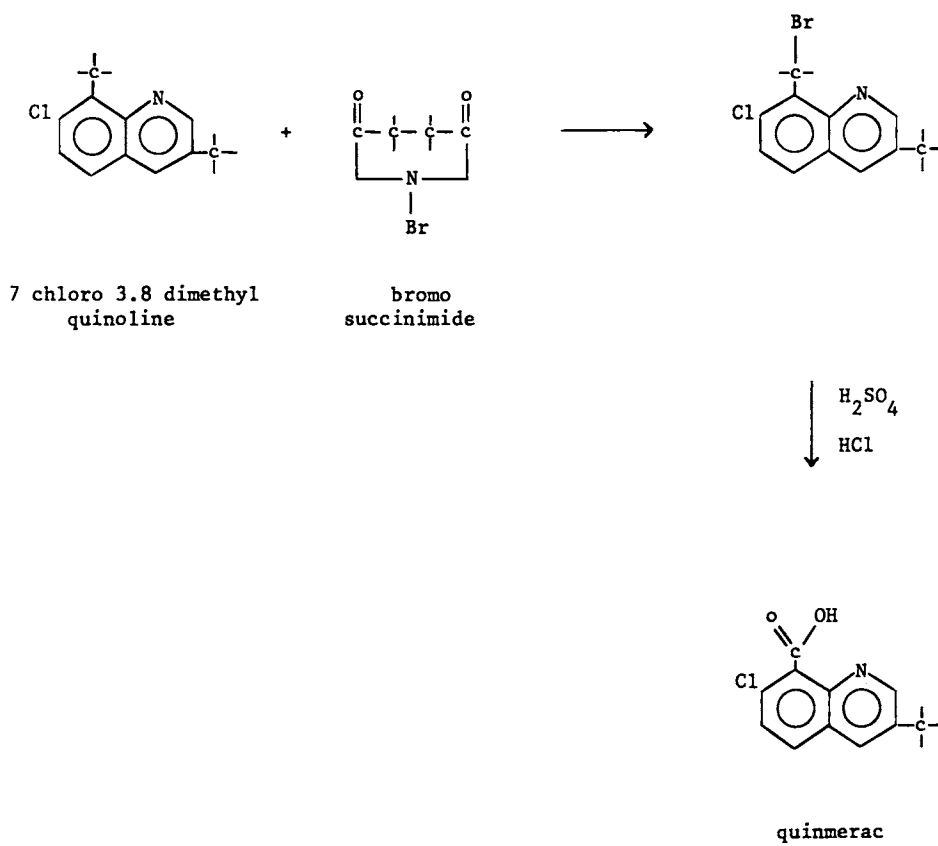
## Quinmerac

Uses: herbicide, cereals, sugar beet

Trade names: Fiesta (BASF)

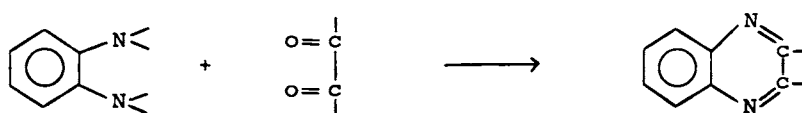
Type: quinoline

Synthesis:

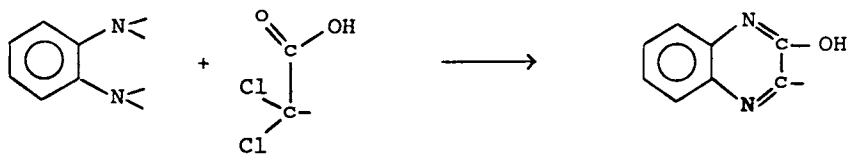


## QUINAZOLINES QUINOXALINES

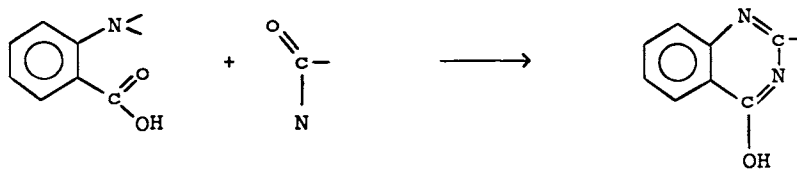
The quinoxaline ring is produced by the reaction between ortho-phenylene diamine and glyoxal



Hydroxy quinoline is obtained by the reaction between o.phenylene diamine and dichloro acetic acid



Hydroxy quinazoline is synthesized by reaction between anthranilic acid and formamide



2-Hydroxy quinoxaline is obtained by many different routes  
(see propaquizafop) all of which start from ortho-nitro  
aniline.

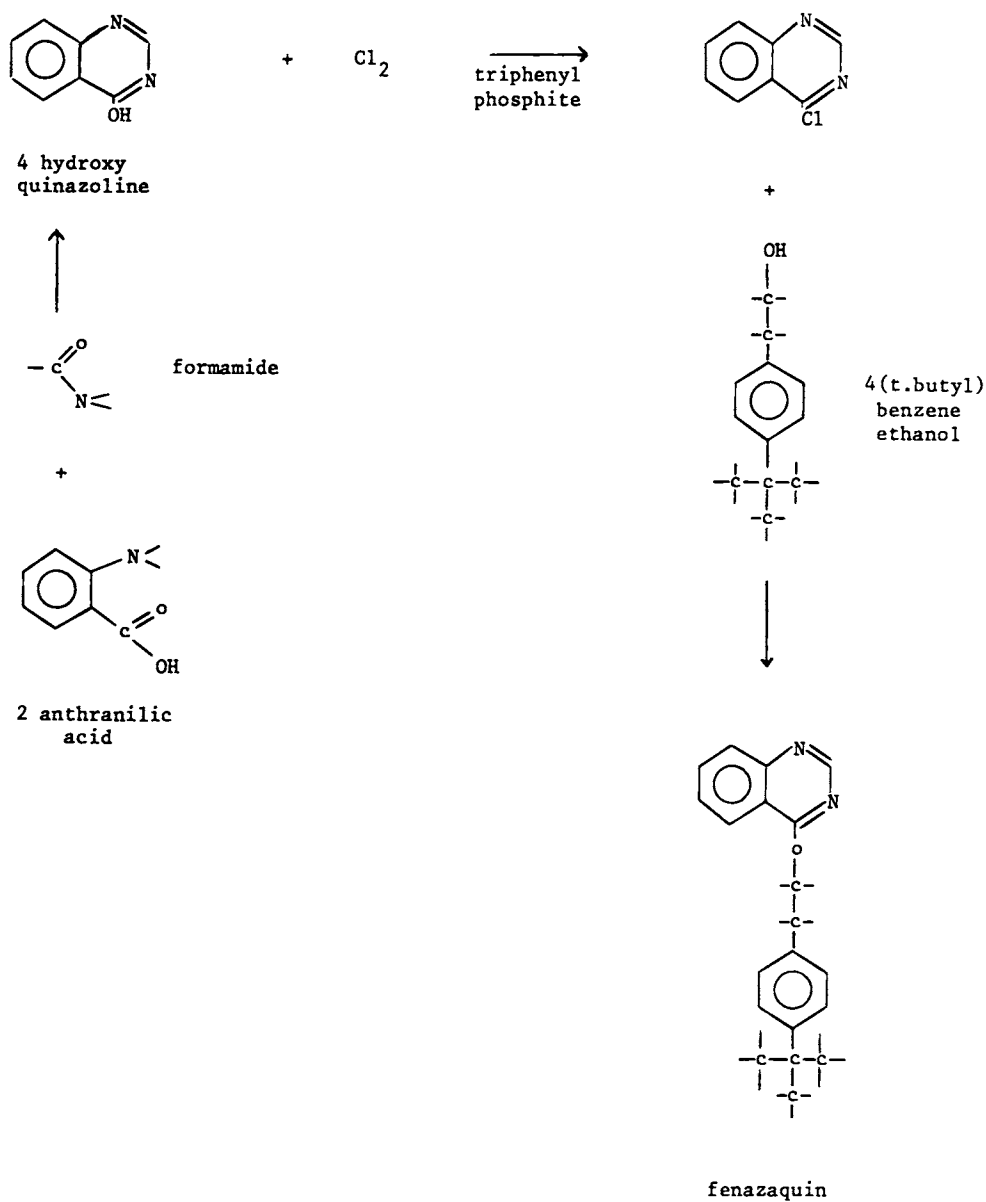
## Fenazaquin

Uses: acaricide, nuts, fruit, cotton, grapes, citrus, ornamentals

Trade names: Magister (Dow Elanco)

Type: quinazoline

Synthesis:



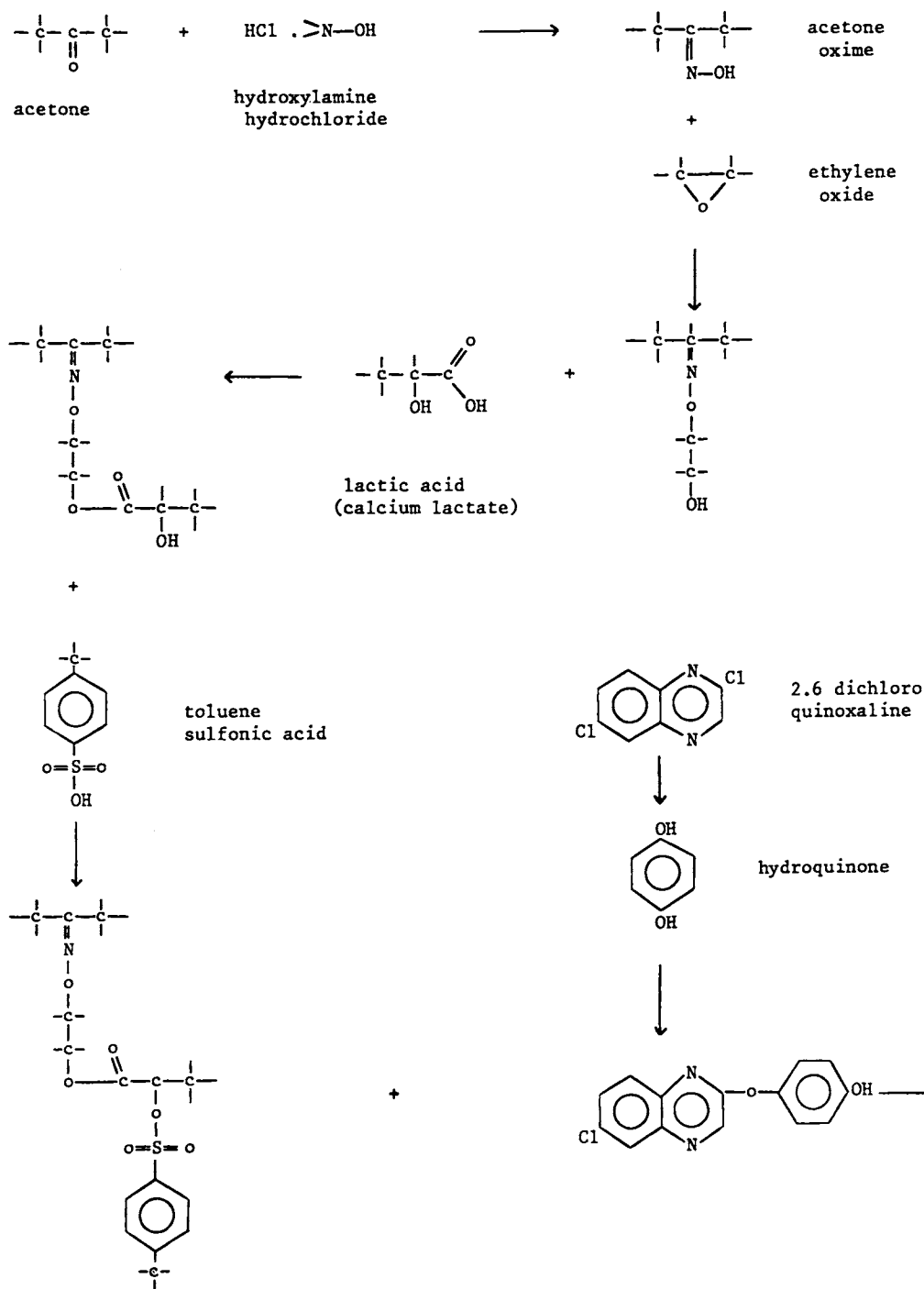
## Propaquizafop

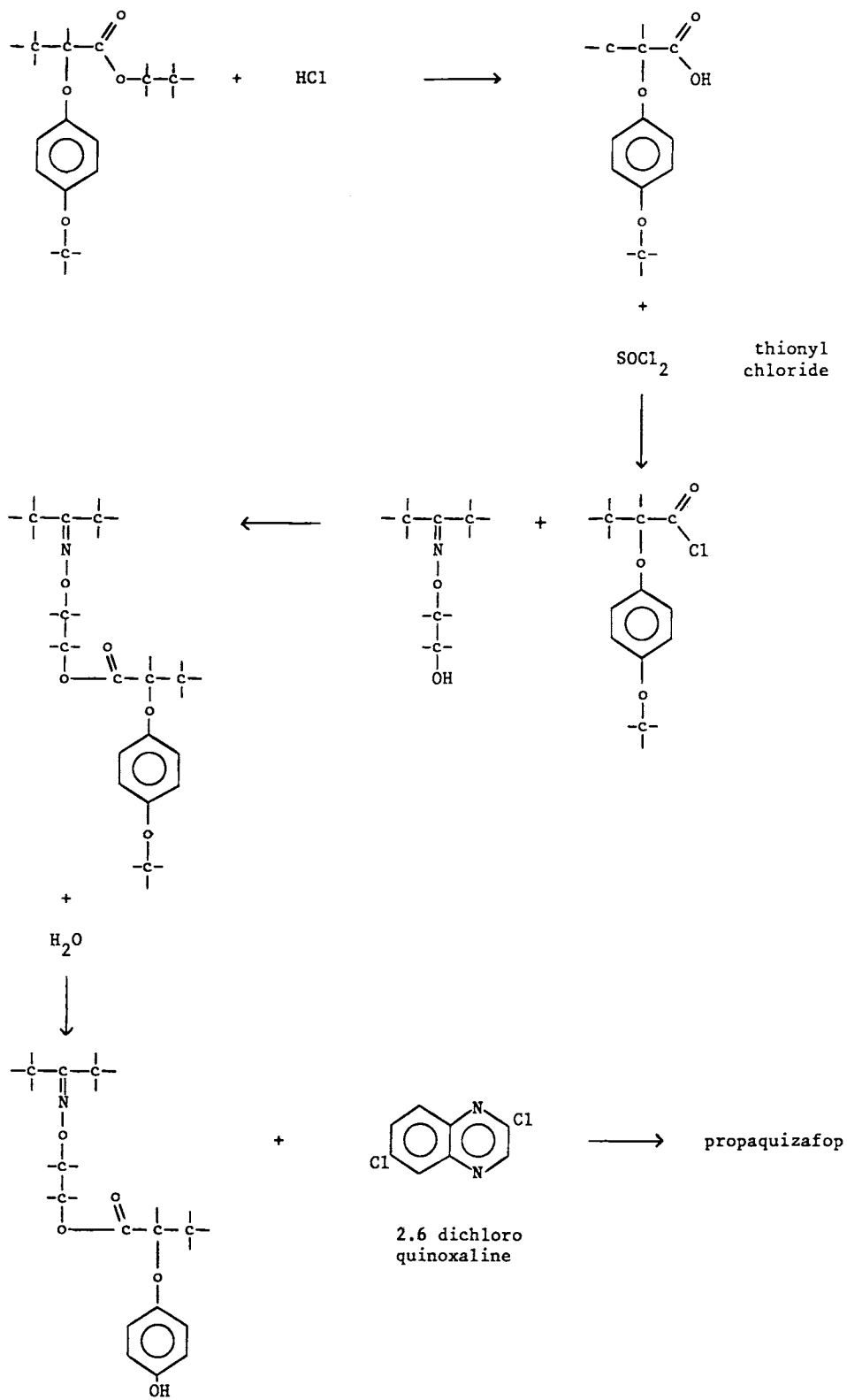
Uses: herbicide, cotton, peanuts, potatoes, soyabeans, sugar beet, vegetables

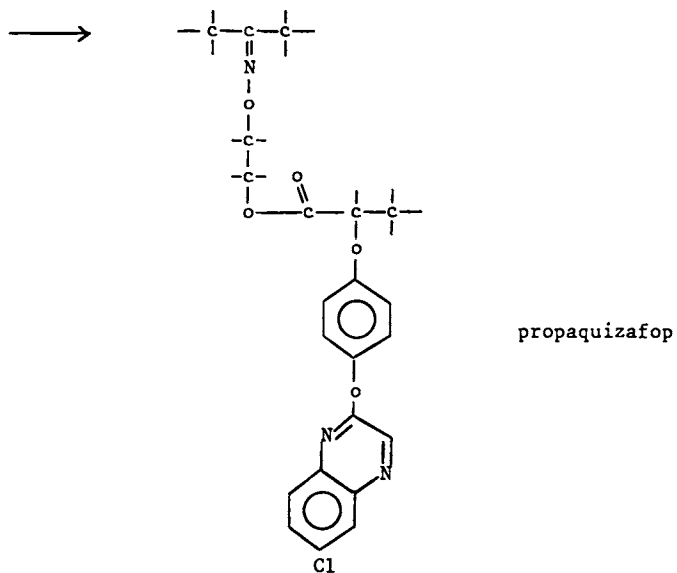
Trade names: Agil, Shogun (Ciba)

Type: quinoxaline

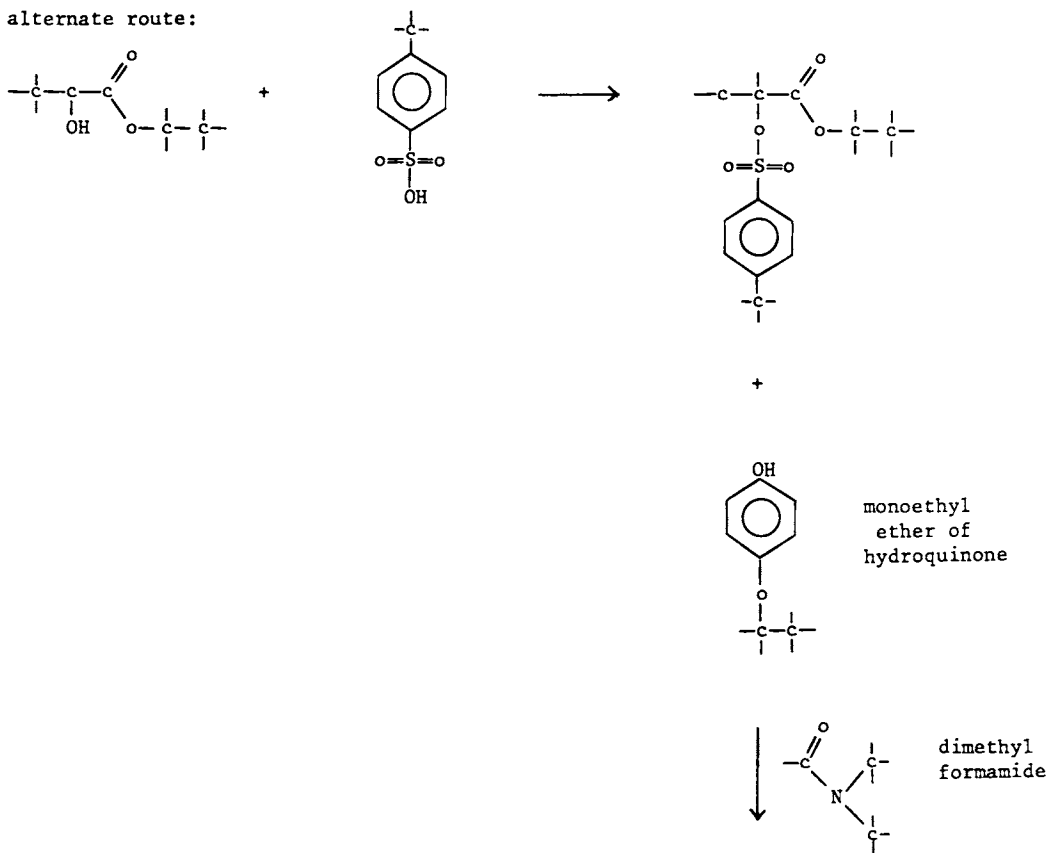
**Synthesis:**



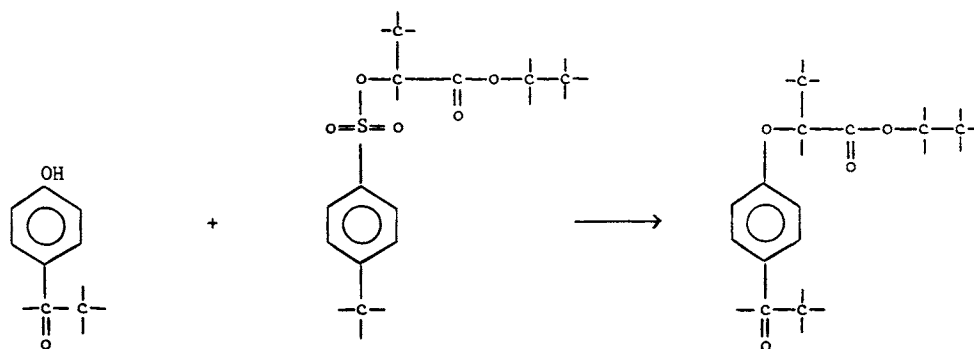




alternate route:

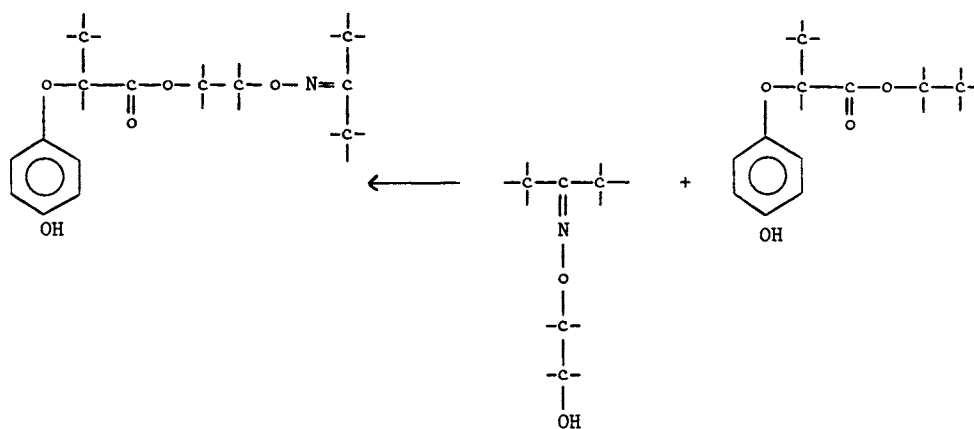


alternate route :



4 hydroxy  
acetophenone

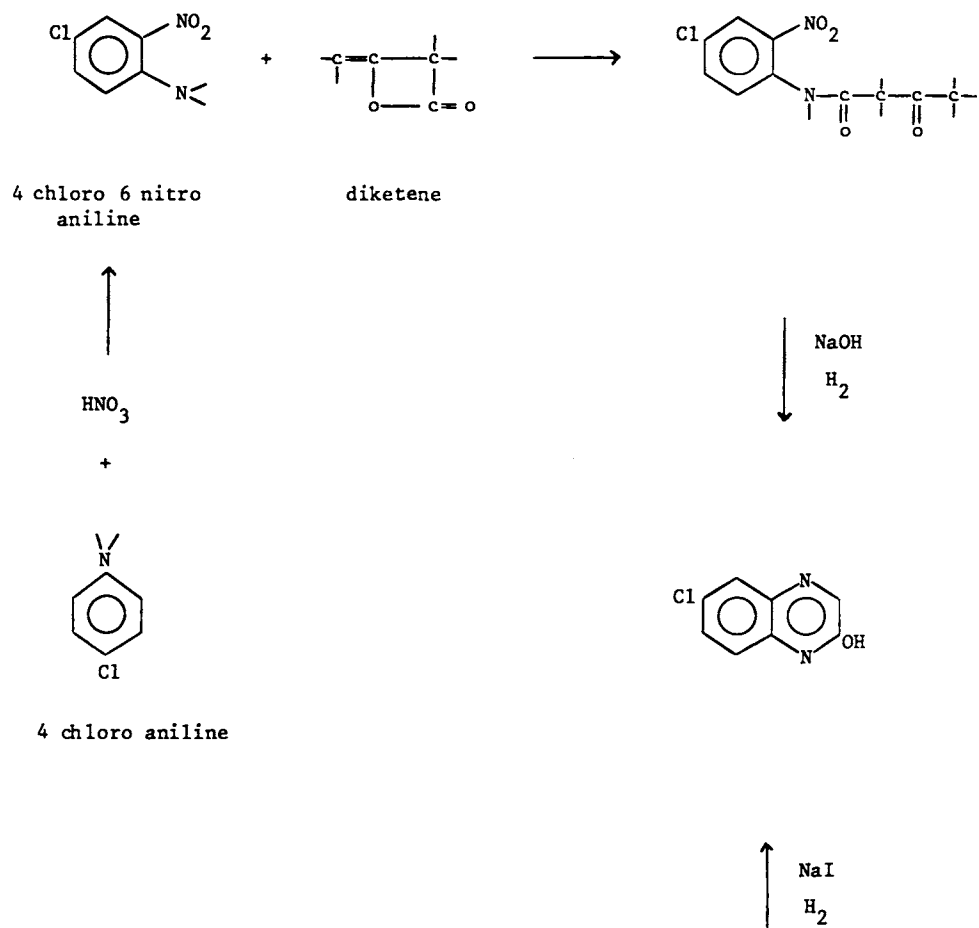
peracetic  
acid  
↓



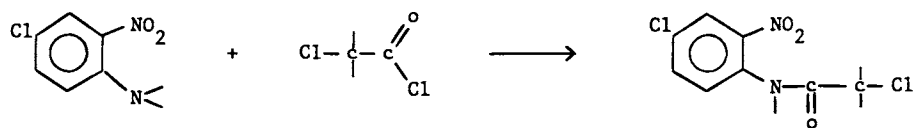


# Synthesis of 2,6 dichloroquinoxaline

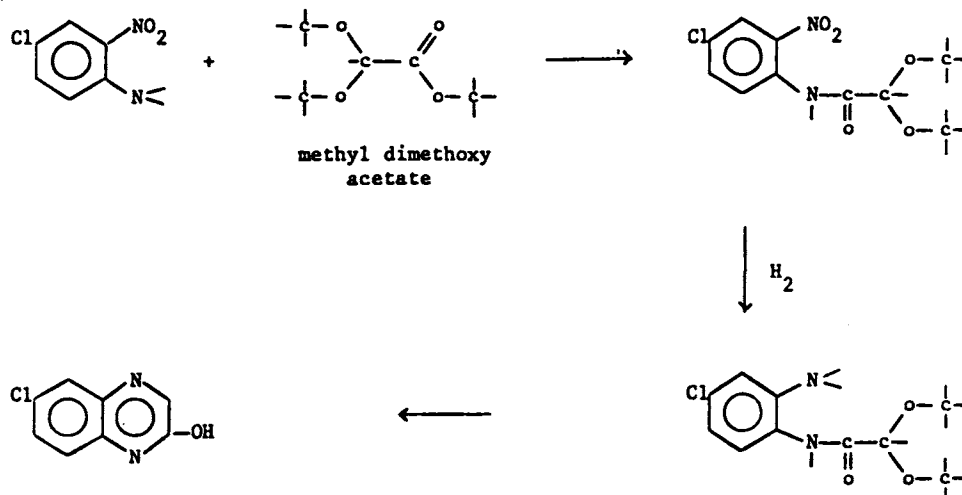
i)



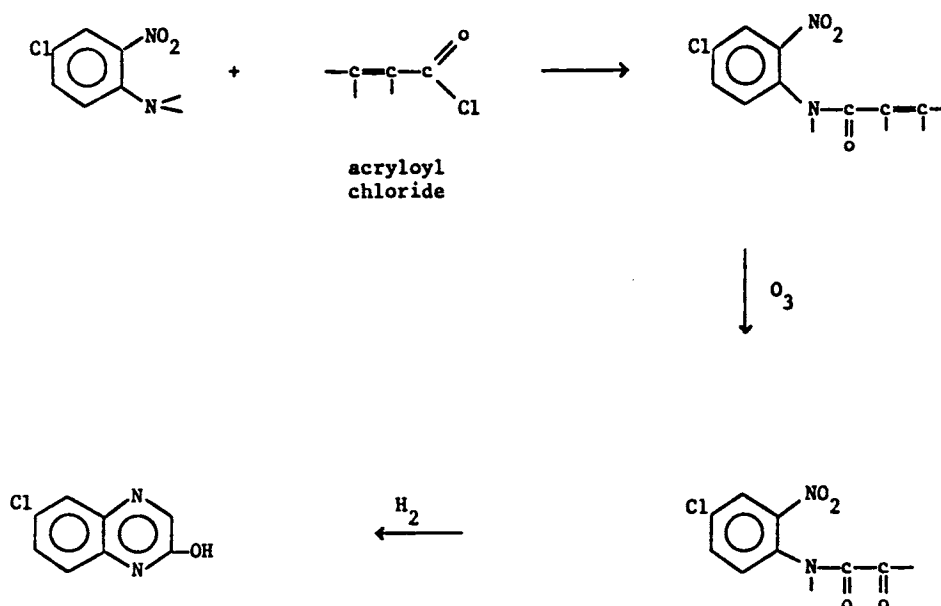
ii)

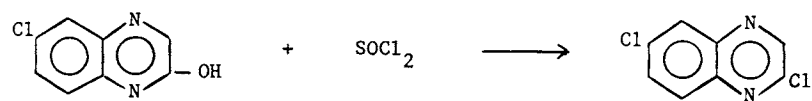


iii)



iv)





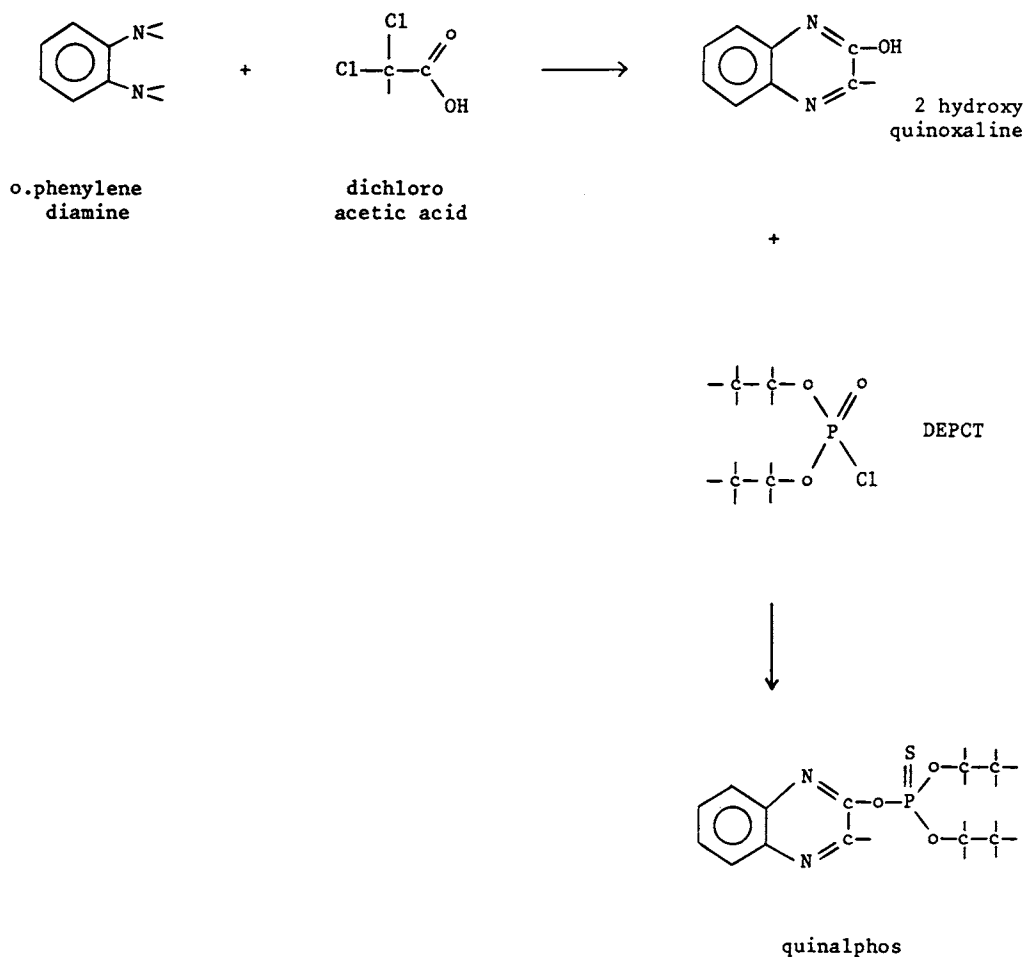
## Quinalphos

Uses: insecticide, cotton, fruit trees, ground nuts, vegetables

Trade names: Bayrusil (Bayer), Ekalux (Sandoz)

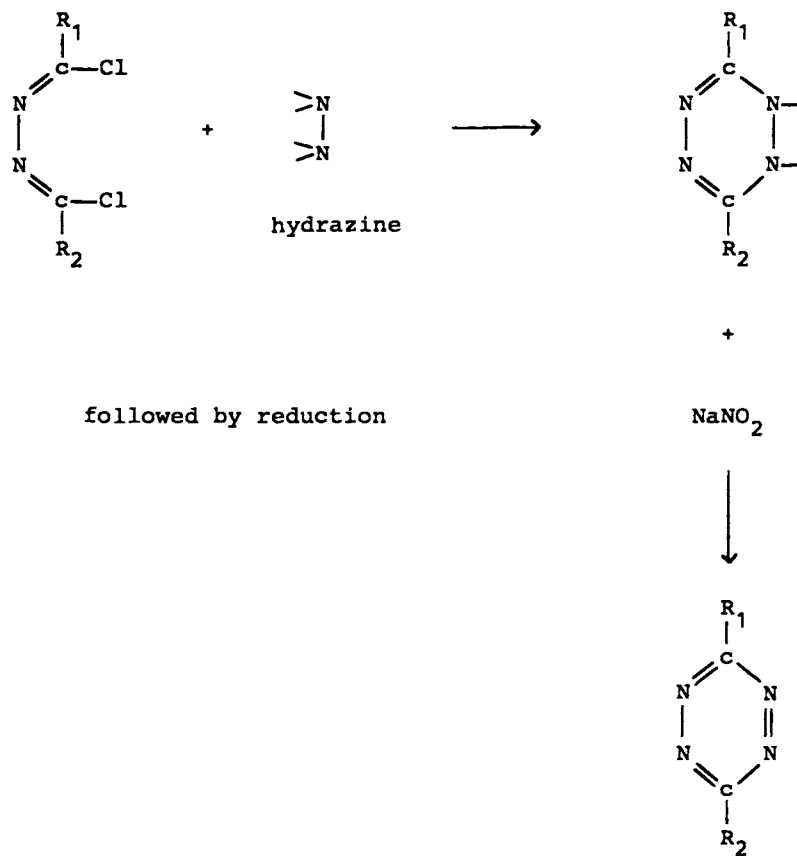
Type: quinoxaline, phosphoro thioate

Synthesis:



# TETRAZINES

The tetrazine ring is synthesized by the following reaction:



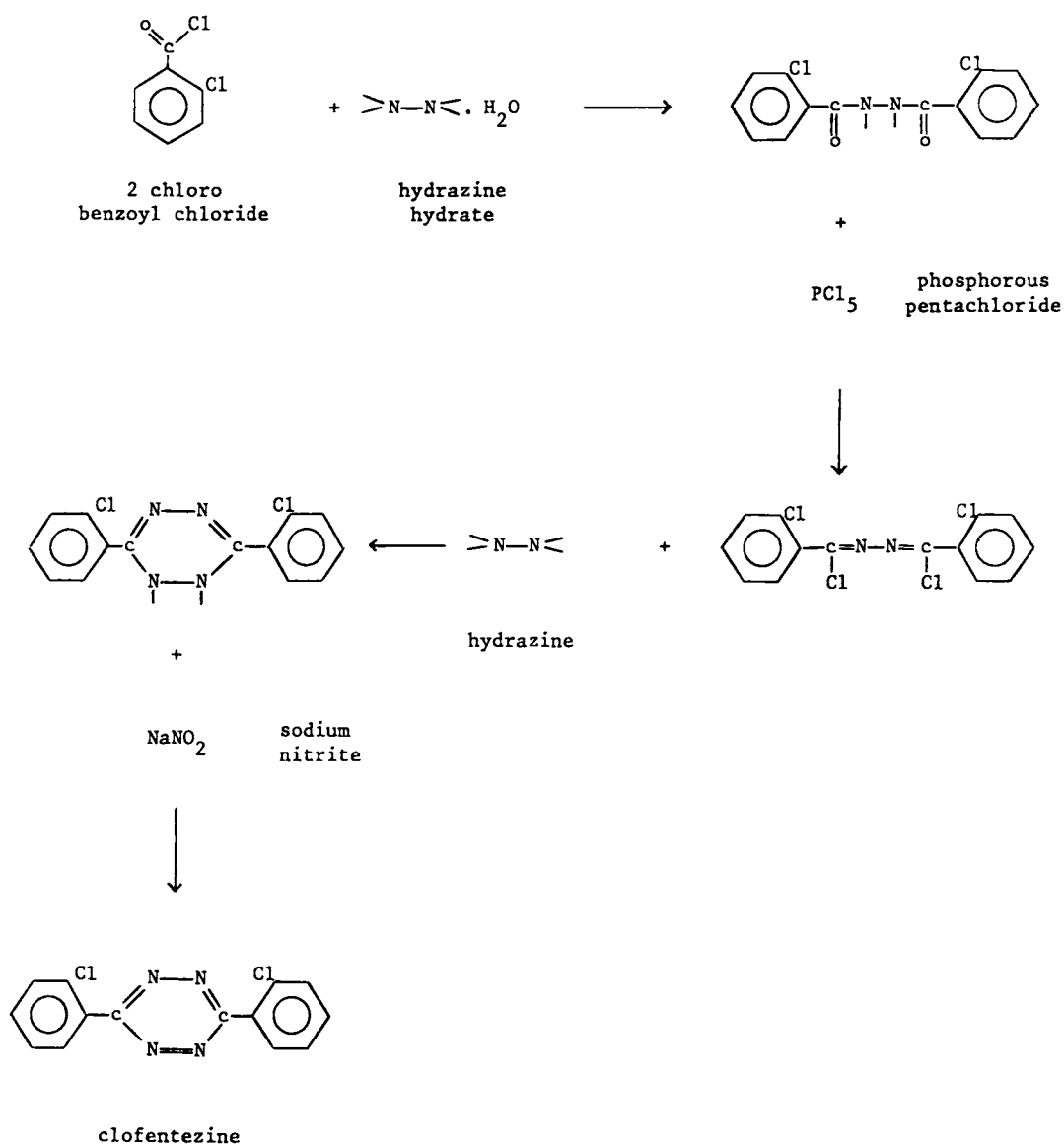
## Clofentezine

Uses: acaricide, citrus, cotton, fruit, nuts, ornamentals

Trade names: Apollo (Schering)

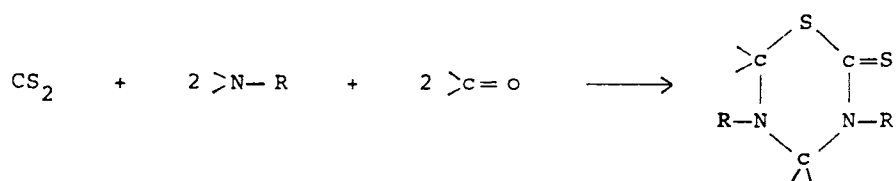
Type: tetrazine

Synthesis:

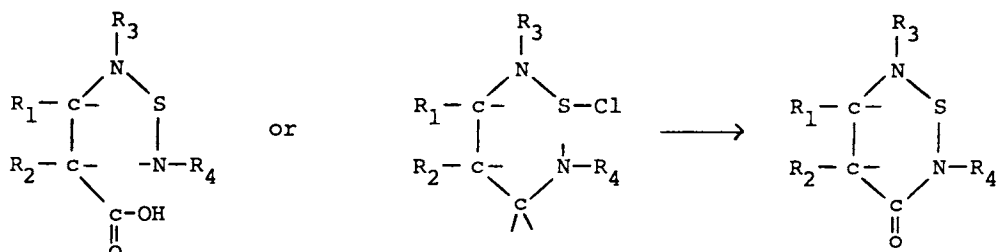


# THIADIAZINES THIADIAZINONES

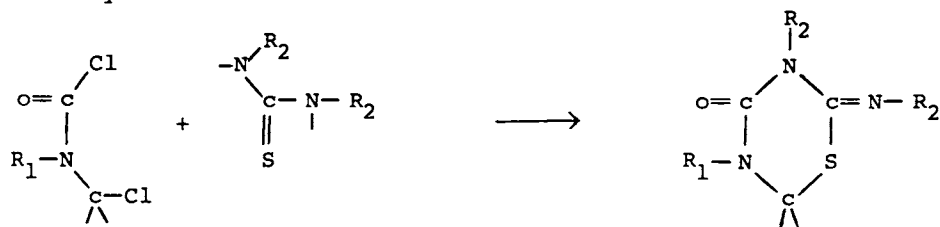
Thiadiazine thione is obtained by the following reaction:



Thiadiazines and thiadiazinones are synthesized by cyclisation of



Also by the reaction:



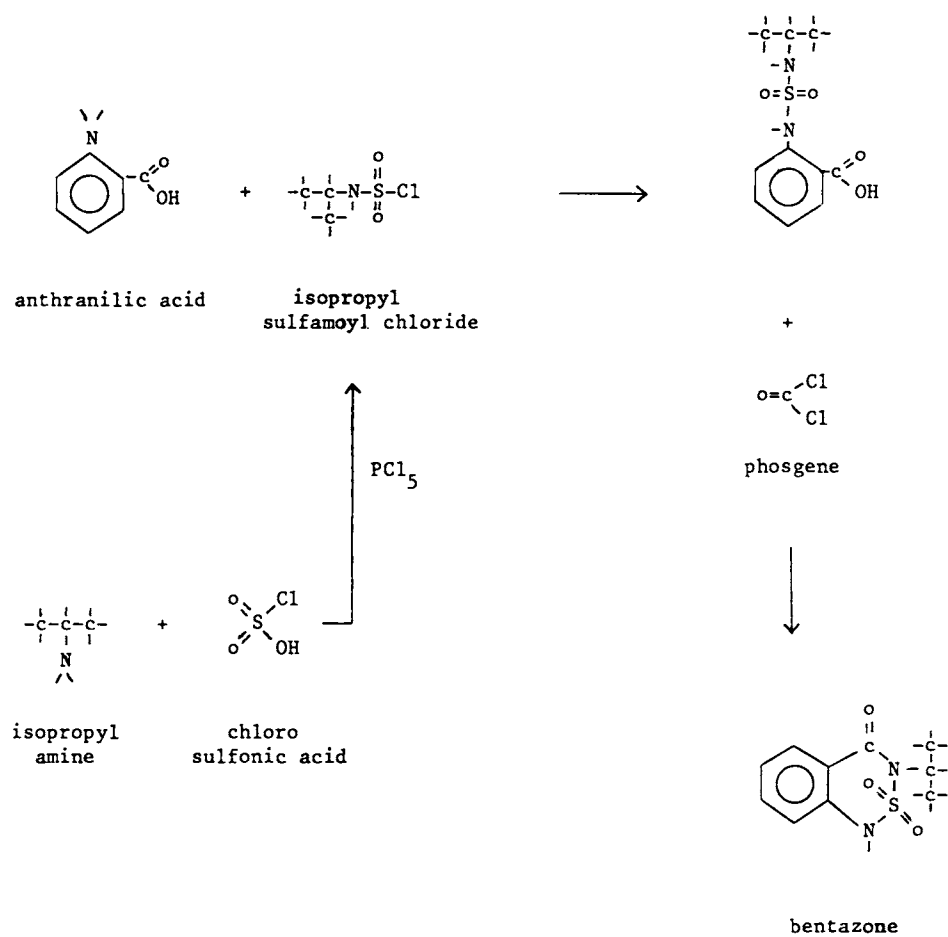
## Bentazone

Uses: herbicide, soyabeans, corn, rice, cereals, peanuts

Manufacturers: Basf (Basagran)

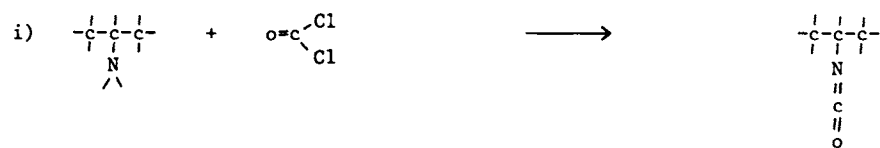
Type: benzothiadiazinone

Synthesis:

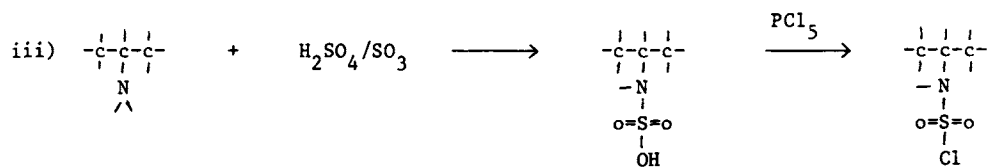
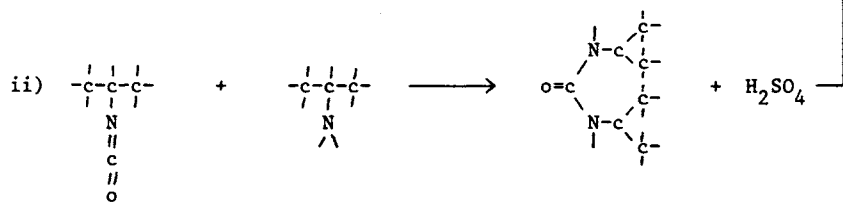
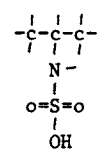
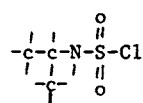




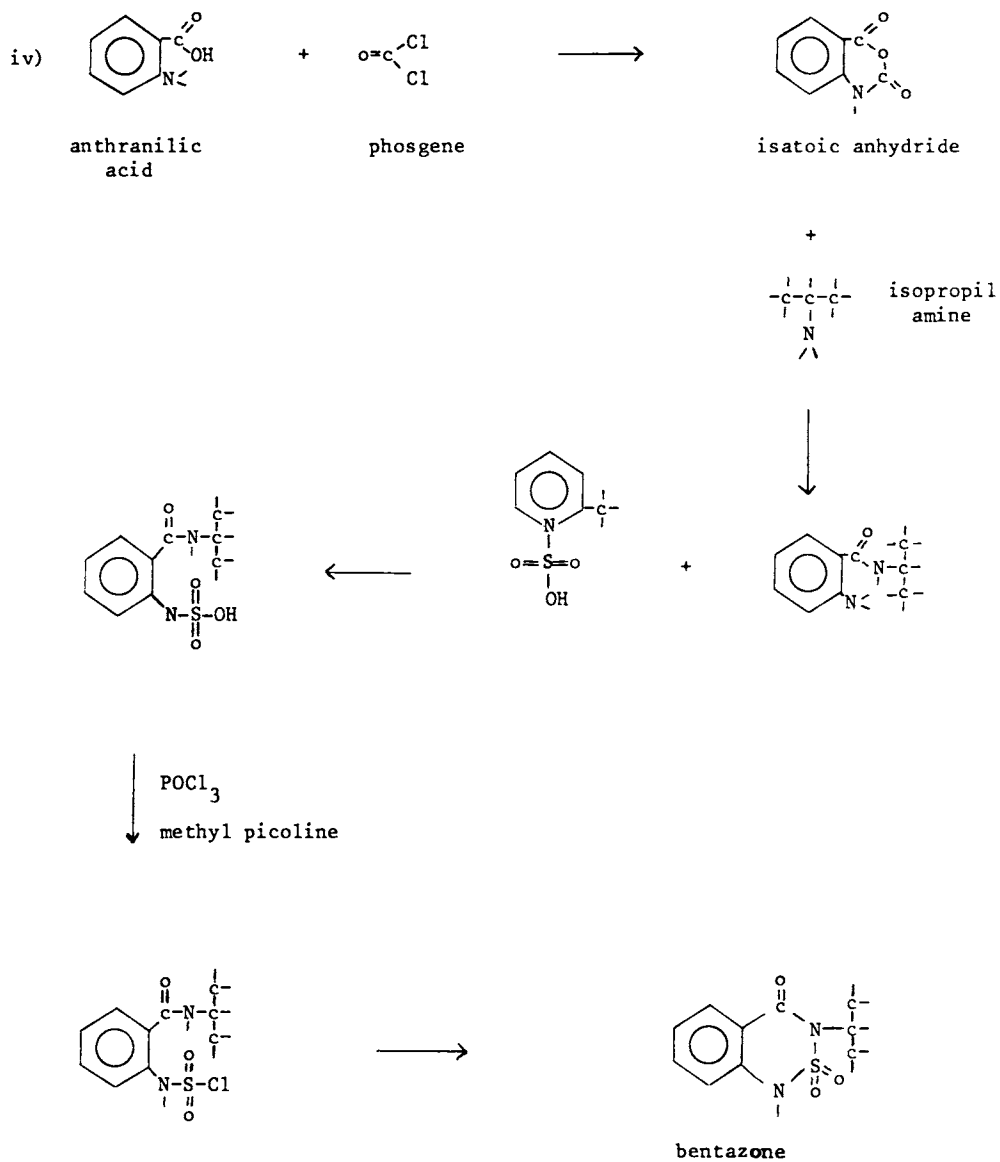
alternate routes for isopropyl sulfamoyl chloride :



+



alternate route:



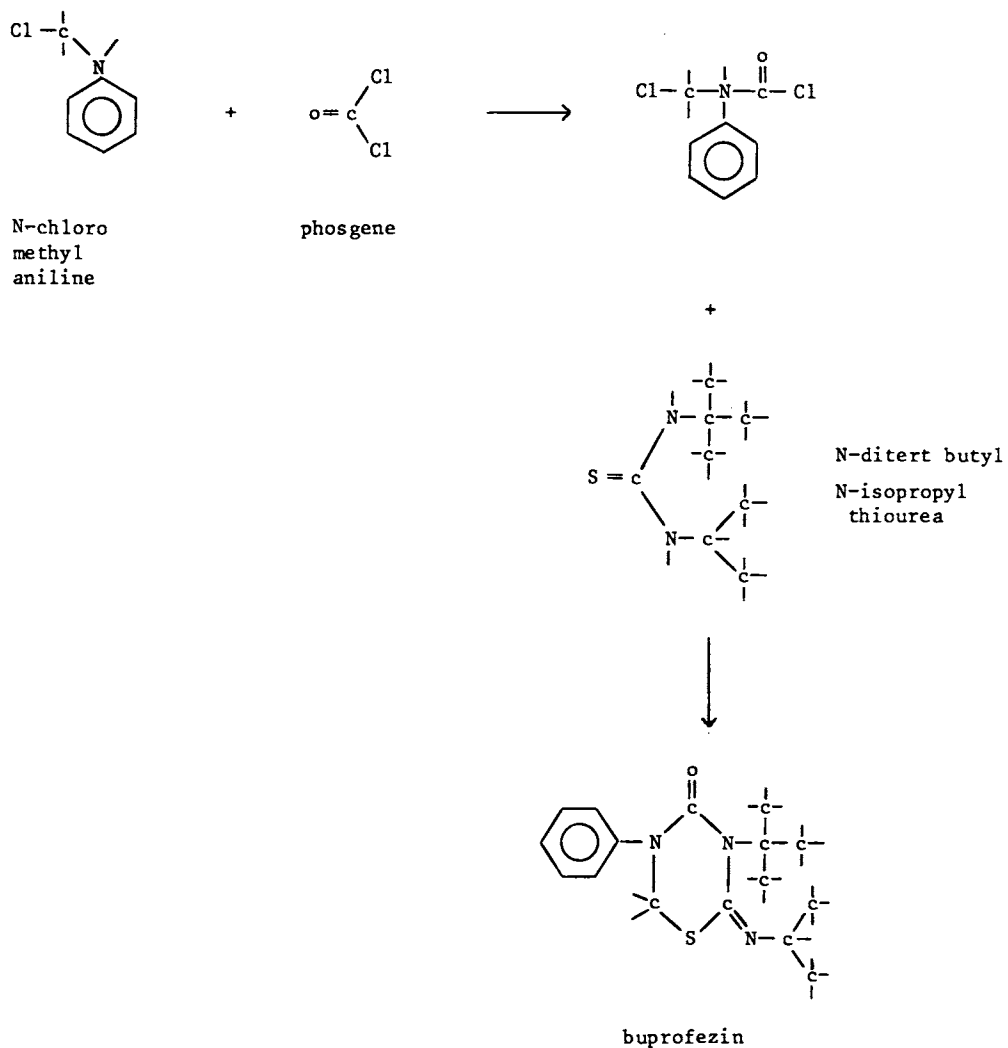
## Buprofezin

Uses: insecticide, growth regulator, citrus, rice, potatoes, cotton, vegetables

Trade names: Applaud (ICI)

Type: thiadiazinone

Synthesis:



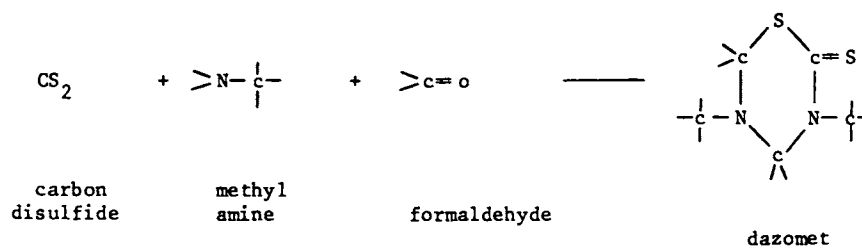
## Dazomet

Uses: fumigant

Trade names: Salvo (ICI), Mylone (Rhone Poulenc), Basamid (BASF)

Type: thiadiazine

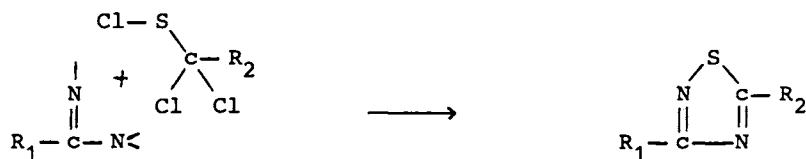
Synthesis:



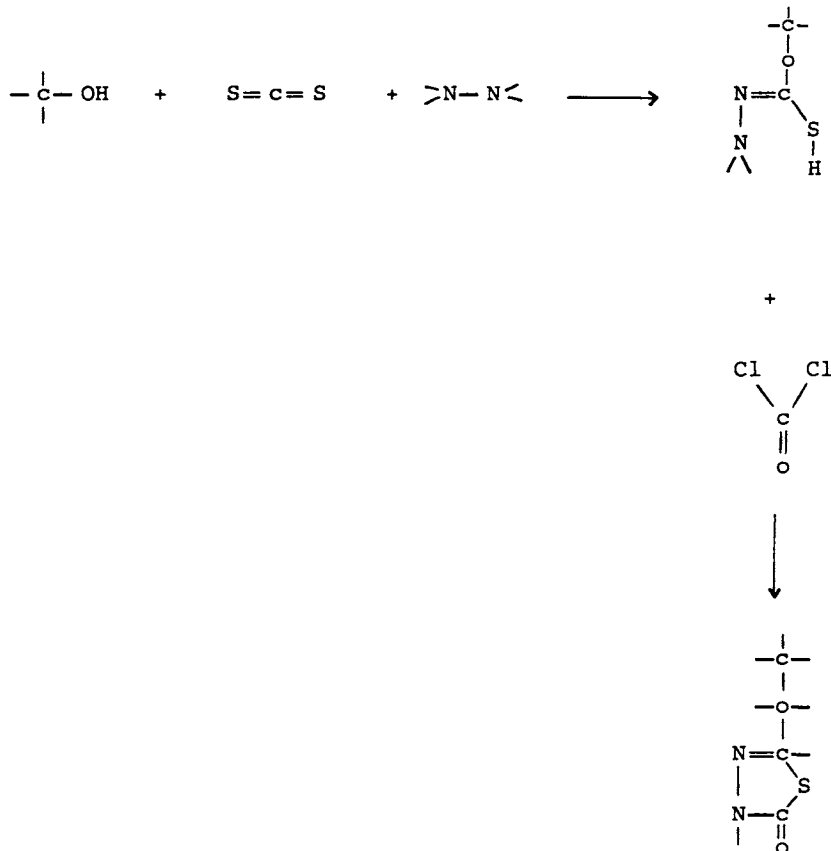
# THIADIAZOLES THIADIAZOLONES

Several alternative routes may be used

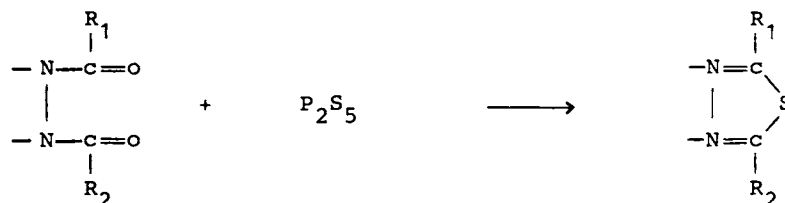
- i) reaction between an acetamidine and dichloro methane sulfonyl chloride (1.3.5 thiadiazole)



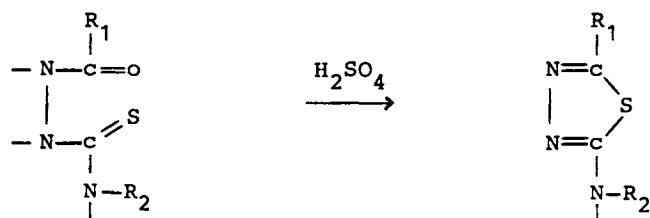
- ii) phosgenation of the ester of thiocarbazic acid (1.3.4 thiadiazolone)



- iii) cyclisation of a carbonyl hydrazide in presence of phosphorous pentasulfide (1.3.4 thiadiazole)



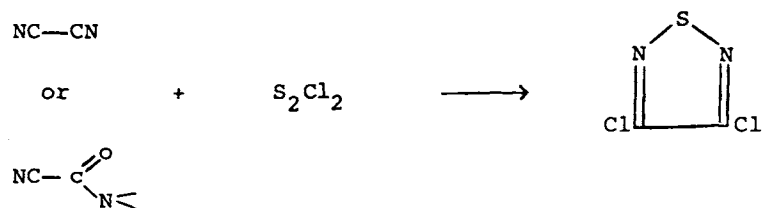
- iv) cyclisation of an amino thionyl hydrazide in presence of a dehydrating agent (1.3.4 thiadiazole)



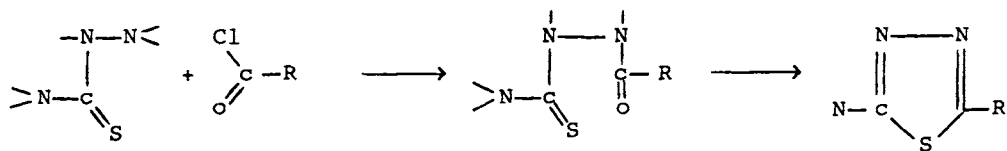
the thionyl hydrazide may be obtained by reaction between a thiosemicarbazide and an acyl chloride or an anhydride



1,2,5 thiadiazole is obtained by reaction between cyanogen or cyano formamide and disulfur chloride



2 amino 1,3,4 thiadiazole is synthesized from thio semi carbazide and an acyl chloride



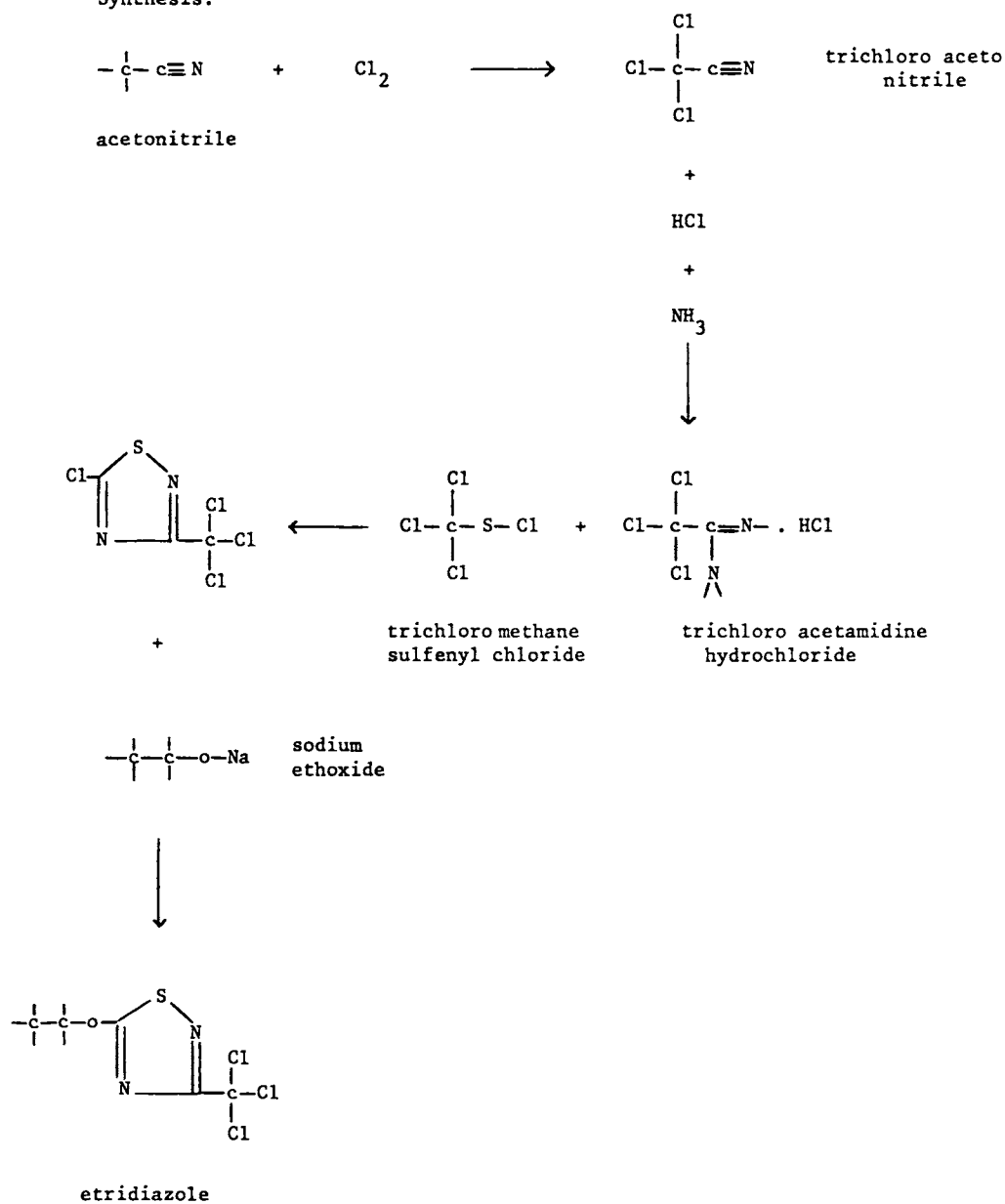
## Etridiazole

Uses: fungicide, cotton, fruit, groundnuts, ornamentals, turf, vegetables

Trade names: Terrazole (Uniroyal)

Type: thiadiazole

**Synthesis:**





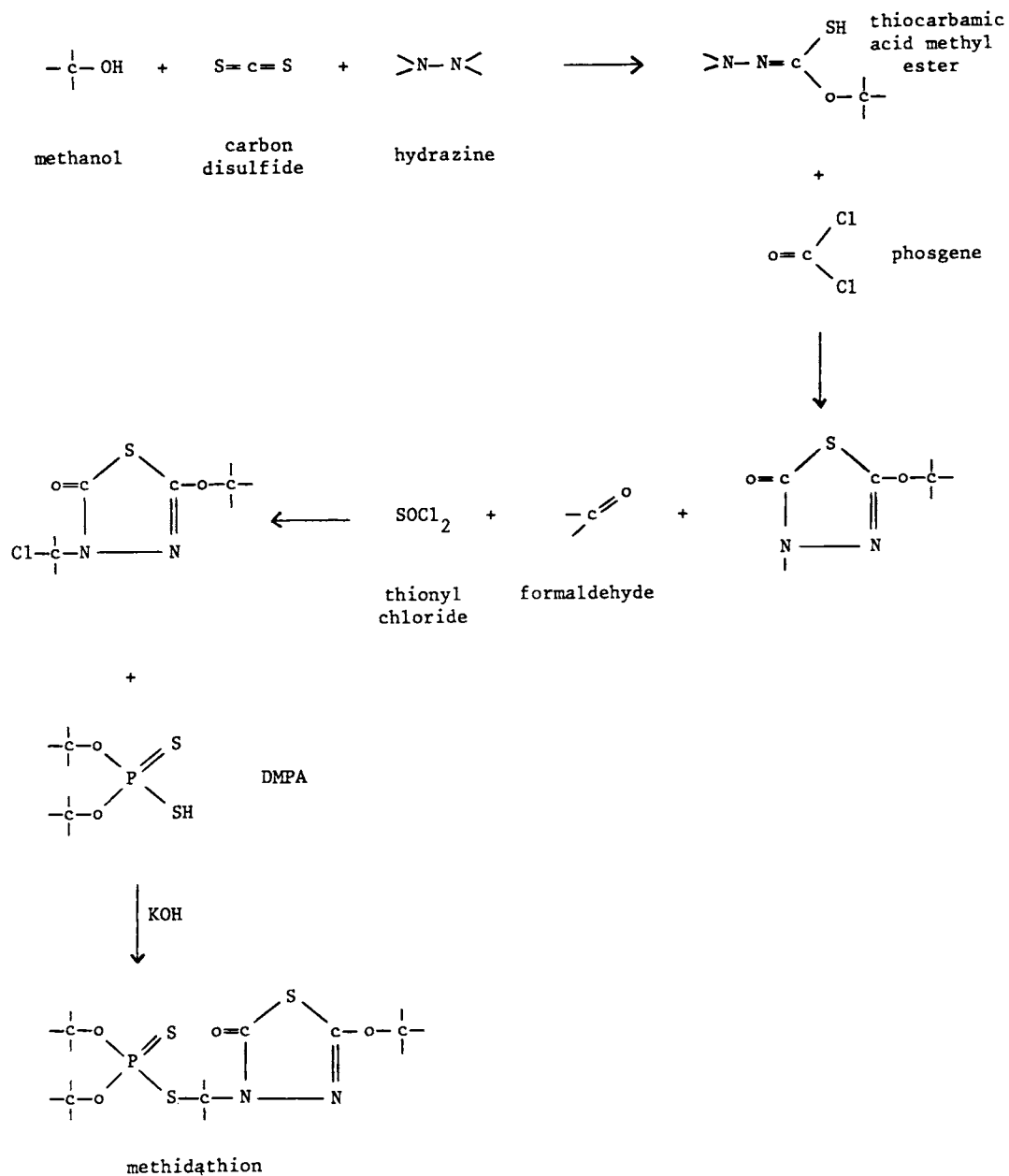
## Methidathion

**Uses:** insecticide

Trade names: Supracide, Ultracide (Ciba)

Type: thiadiazolone, phosphoro dithioate

**Synthesis:**



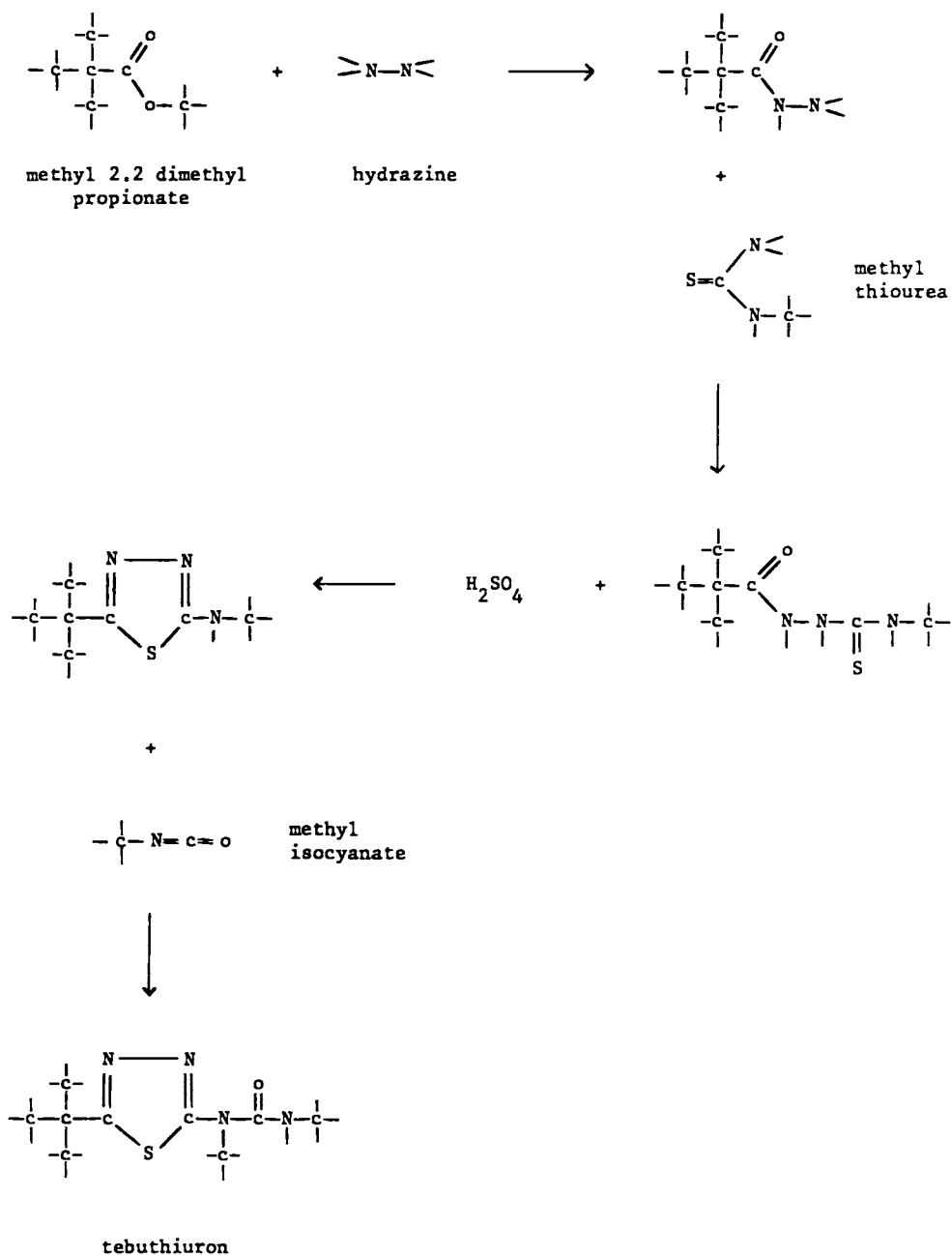
## Tebuthiuron

Uses: herbicide, pastures, sugarcane

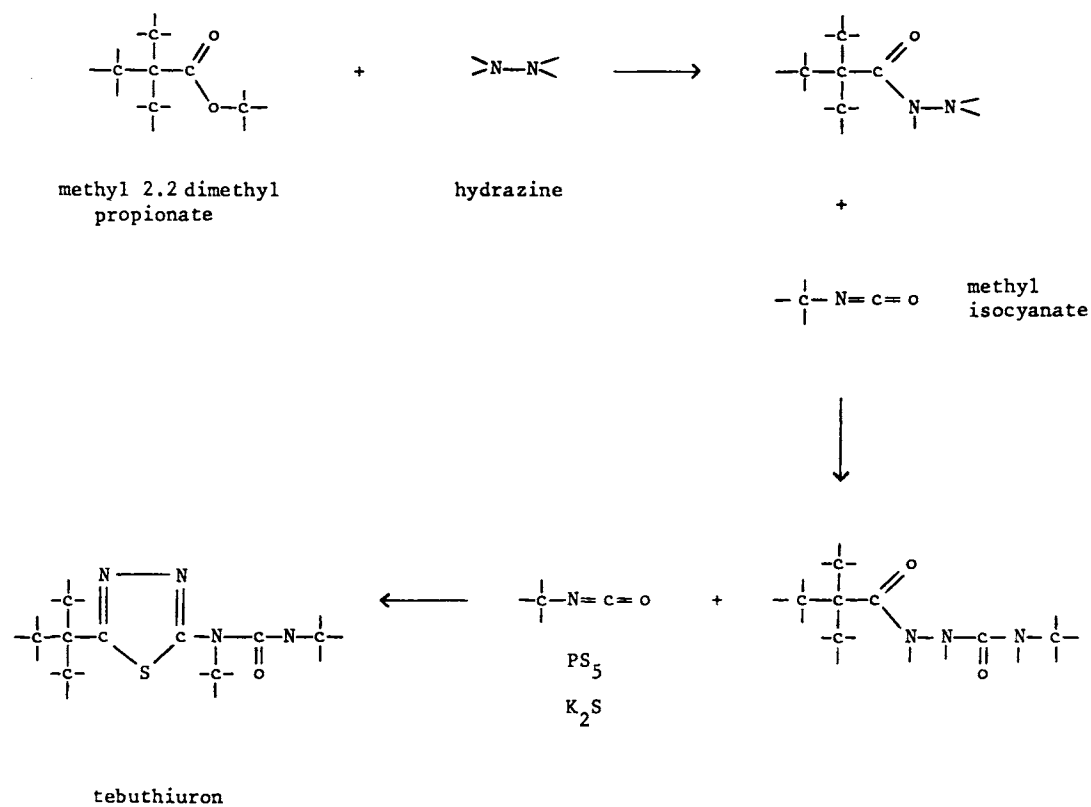
Trade names: Spike, Perflan (Dow Elanco)

Type: thiadiazole

Synthesis:



alternate route:



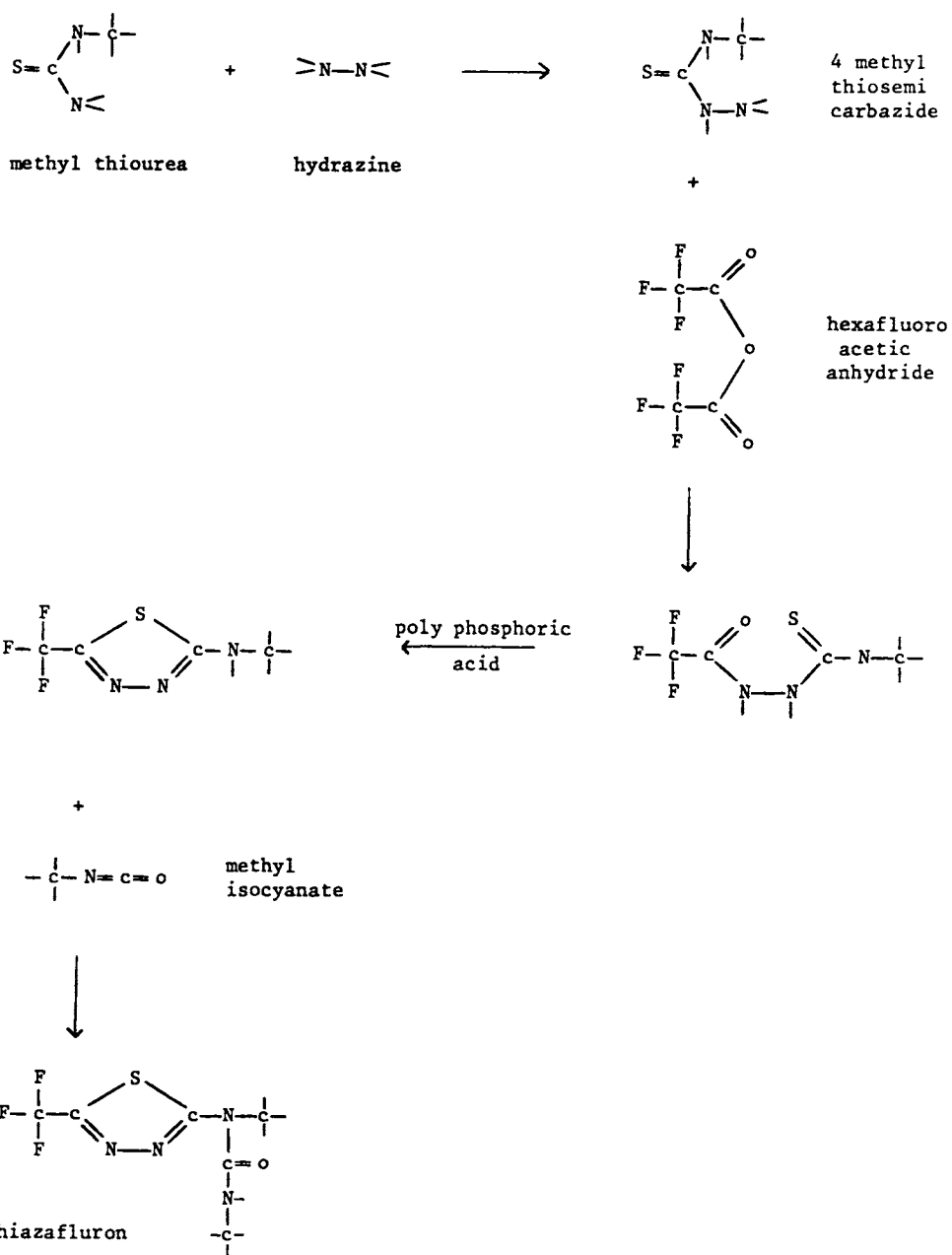
## Thiazafluron

Uses: herbicide

Trade names: Erbotan (Ciba)

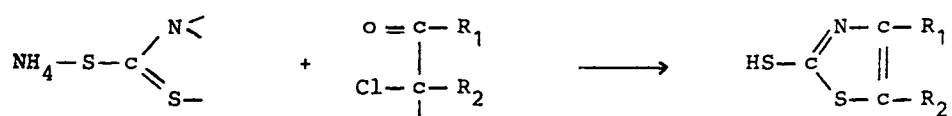
Type: thiadiazole, urea

Synthesis:



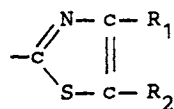
# THIAZOLES THIAZOLONES

Thiazoles are cyclised by the reaction between ammonium dithiocarbamate and an  $\alpha$  chloro carbonyl compound



+

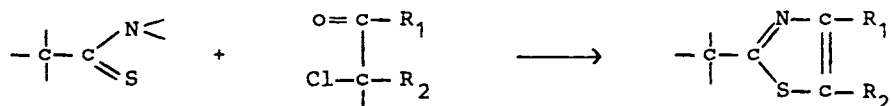
The mercapto group is then removed by oxidation



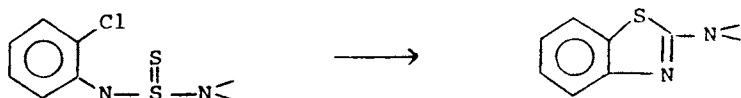
Thus for instance if  $\text{R}_1 = \text{R}_2 = \text{H}$  thiazole is obtained.

If  $\text{R}_2 = \text{H}$ ,  $\text{R}_1 = \text{COOH}$ , there results thiazole 4 carboxylic acid.

If thio acetamide is used a 2 methyl thiazole is obtained

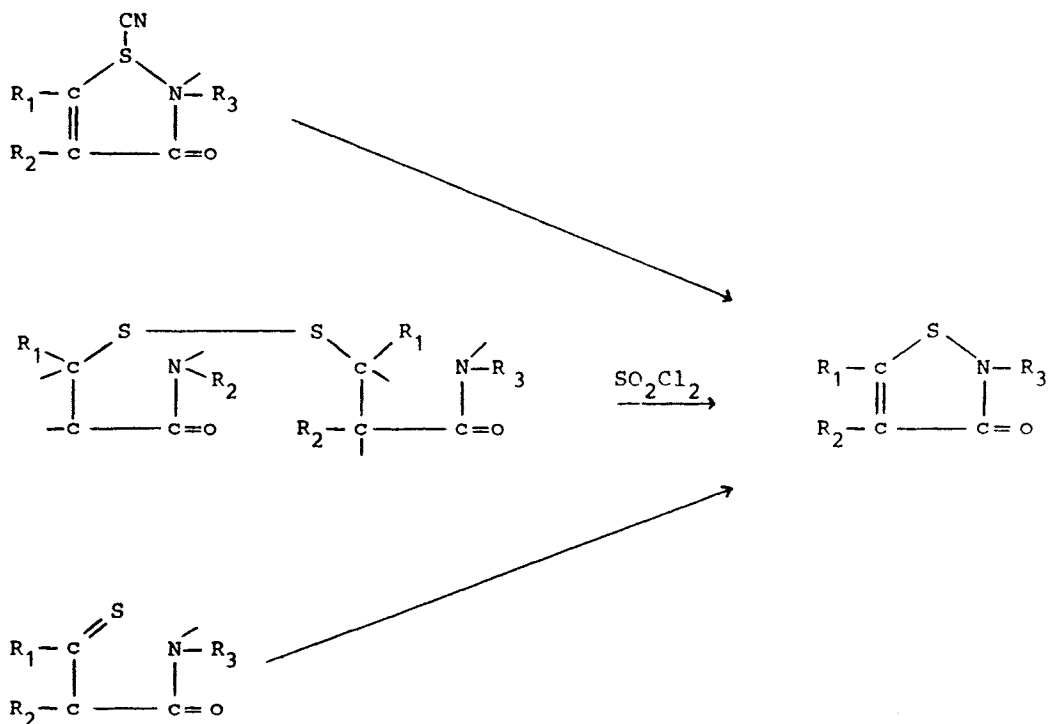


Amino benzothiazole is made by cyclisation of 2-chlorophenyl thiourea



(see benzthiazuron)

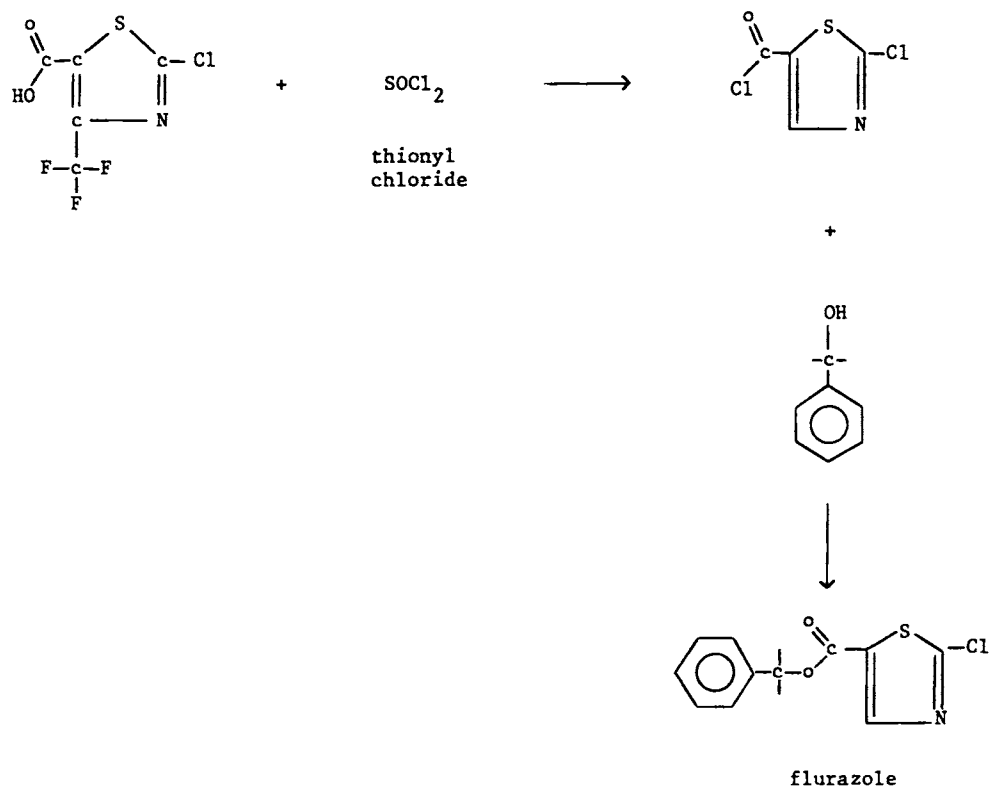
Thiazolones are obtained by cyclisation of the appropriate thiocyanates, disulfides or  $\beta$ -thioketo amides :



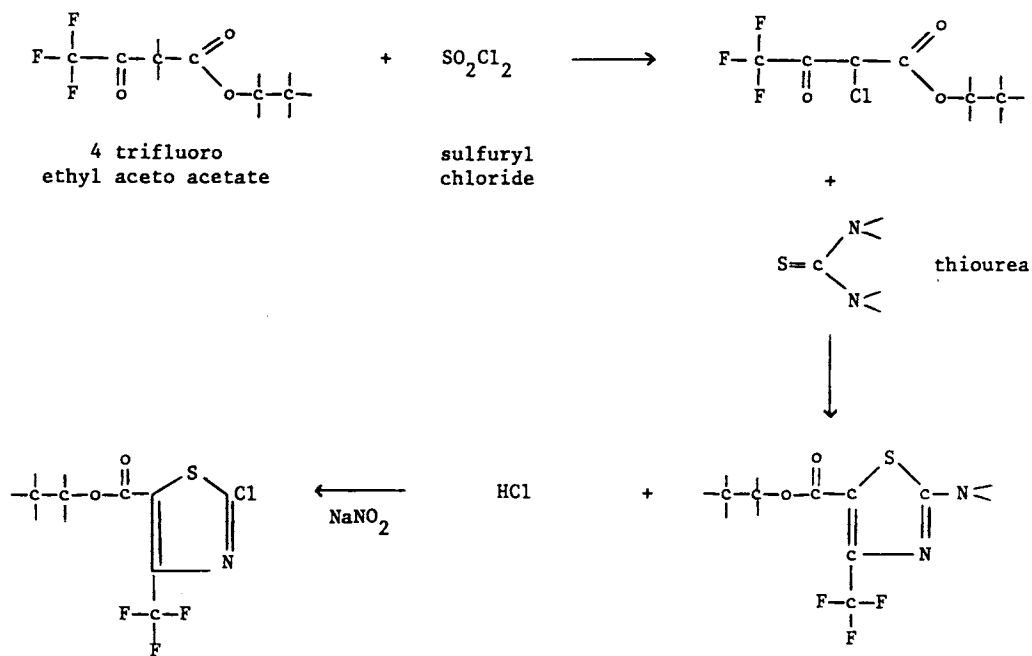
An alternate route is by reaction between chloro carbonyl sulfonyl chloride and an amine with a double bond on the  $\alpha$  carbon







alternate route:





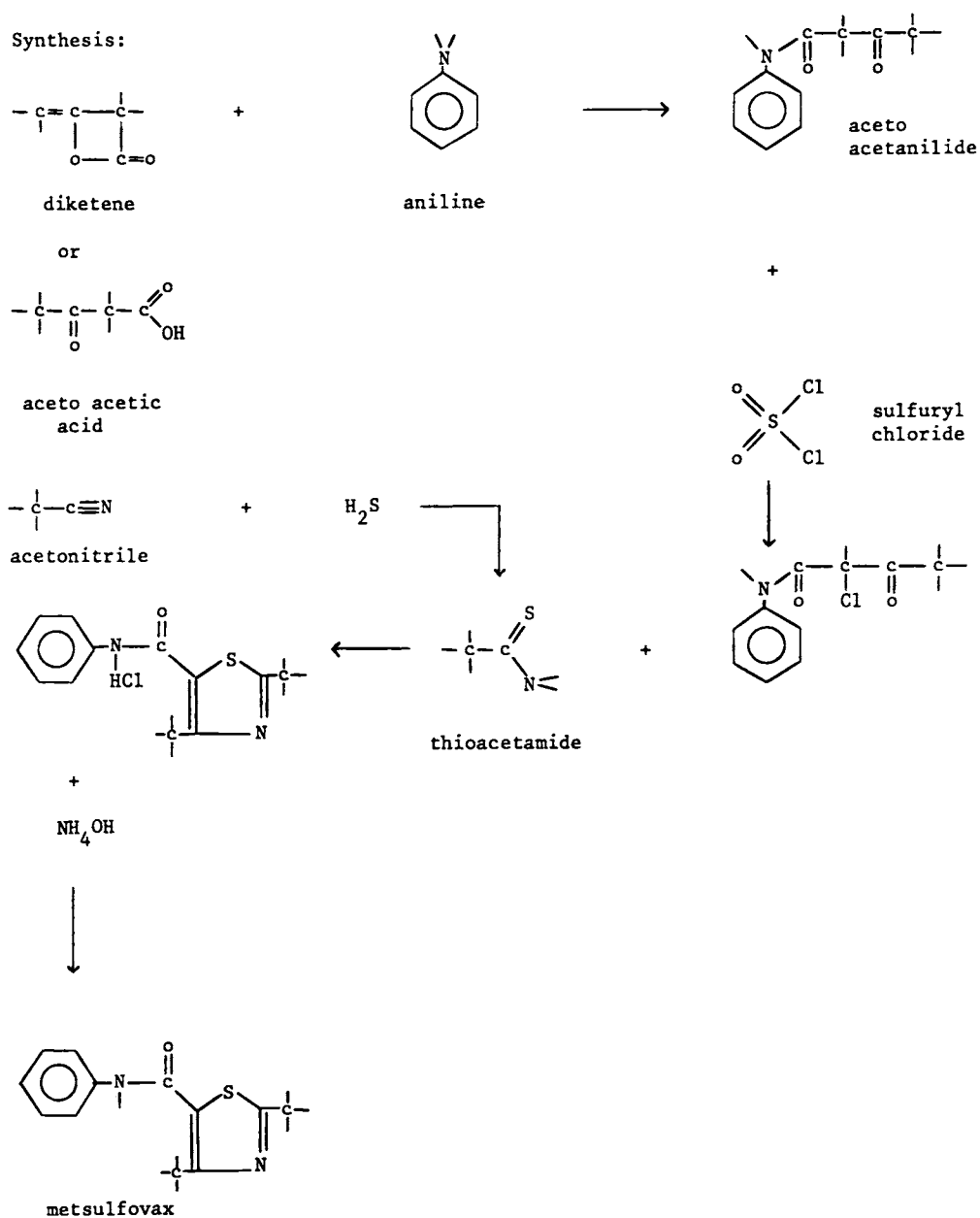
## Metsulfovax

Uses: fungicide, cereals, cotton, potatoes, ornamentals

Trade names:    Provax (Uniroyal)

Type: thiazole, amide

**Synthesis:**



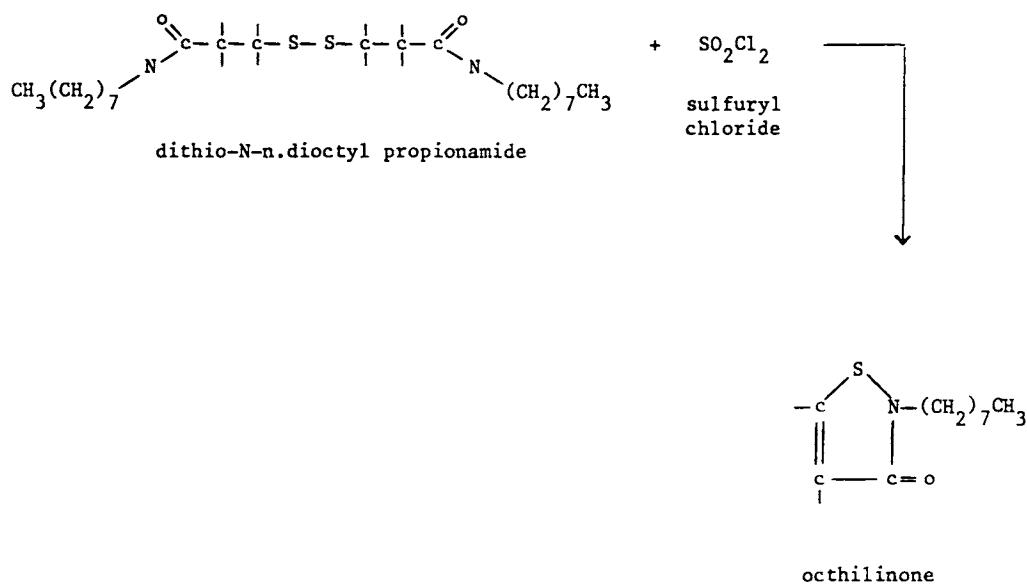
## Octhilinone

Uses: fungicide, fruit trees, citrus

Trade names: Pancil-T (Rohm & Haas)

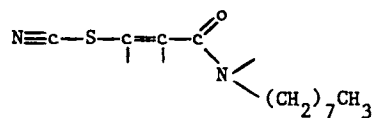
Type: thiazolone

Synthesis:



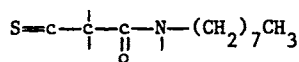
alternate routes:

(i)

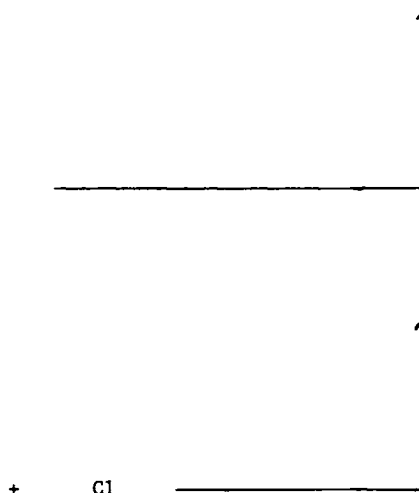


octyl acrylamide thiocyanate

(ii)



Bthial-N-octyl propionamide



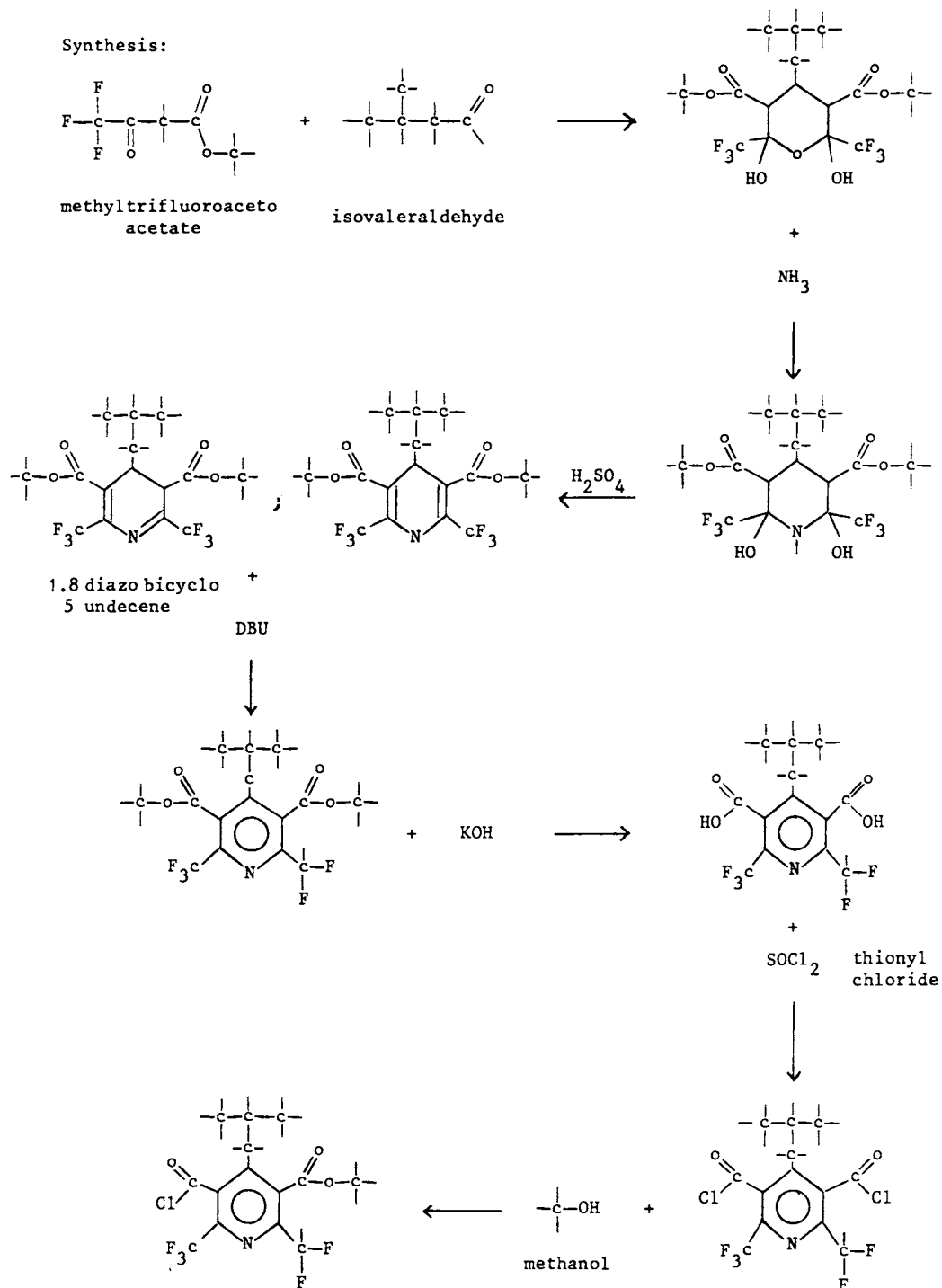
## Thiazopyr

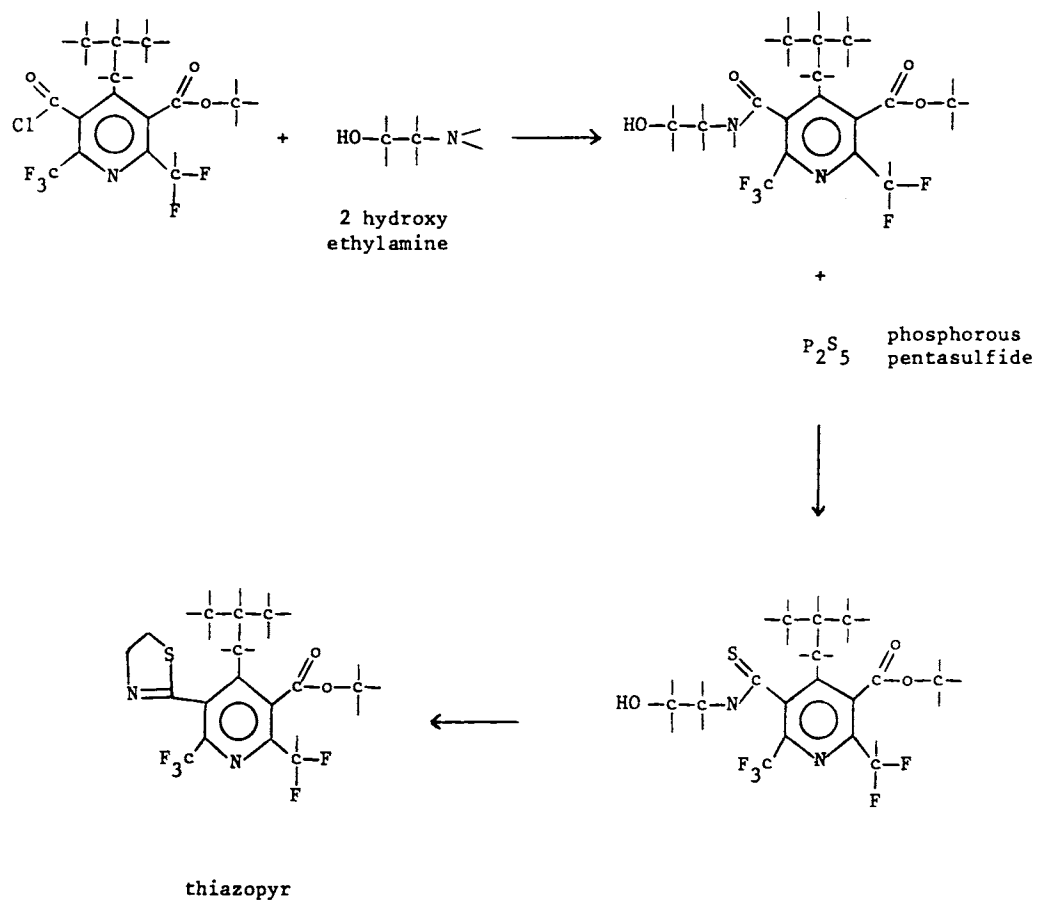
Uses: herbicide, cotton, alfalfa, peanuts, soybeans, sugarcane, vine, citrus, forestry

Trade names: Visor (Monsanto)

Type: thiazole, pyridine

Synthesis:





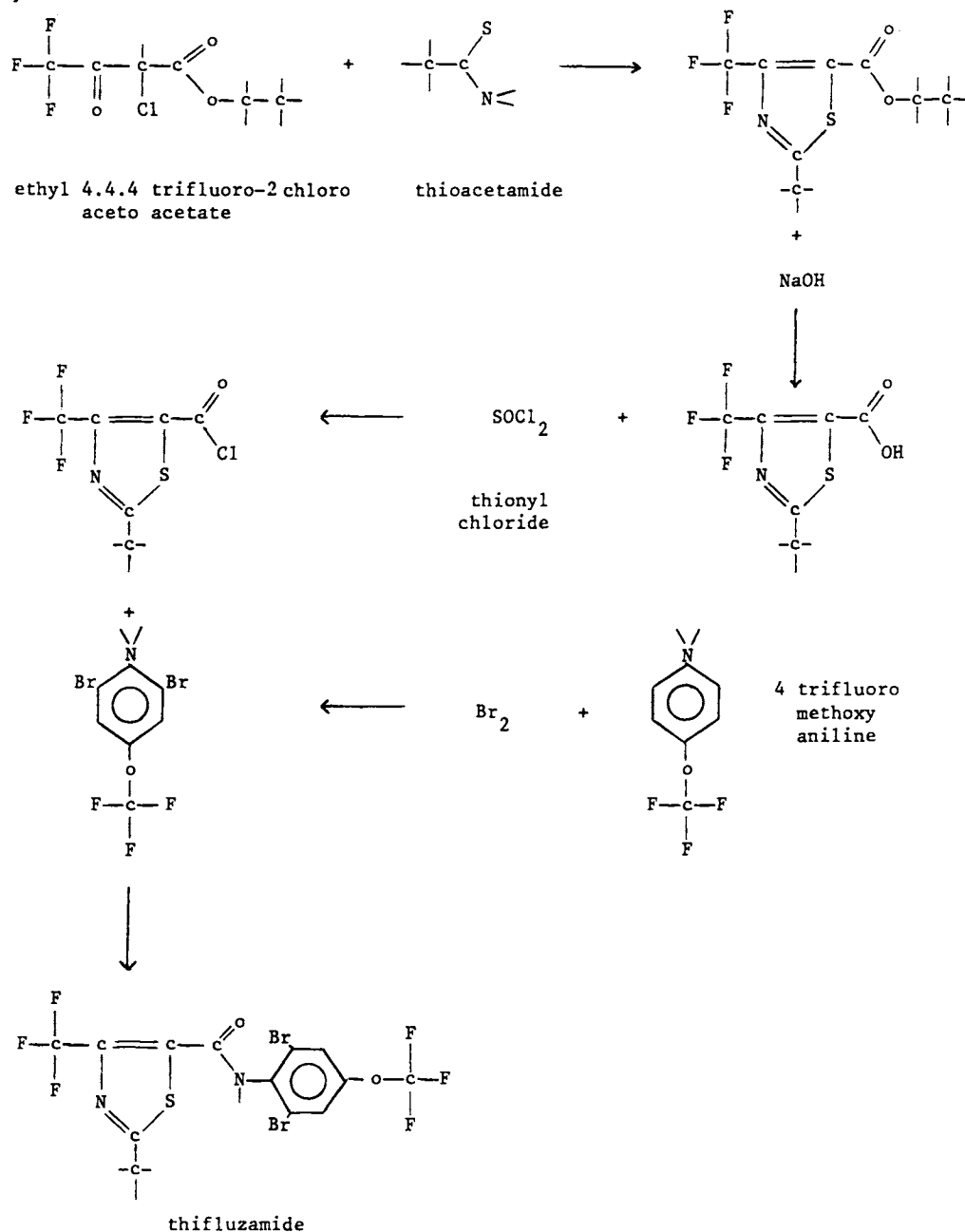
## Thifluzamide

Uses: fungicide, rice, cereals, turf

Trade names: (Monsanto)

Type: thiazole, amide

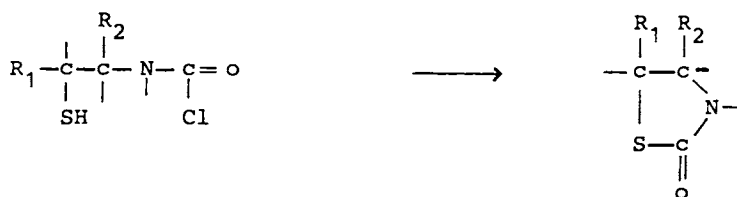
Synthesis:



# THIAZOLIDINES

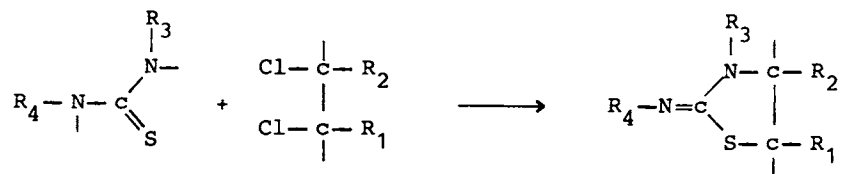
Several routes may be used to obtain a thiazolidine ring:

i) cyclisation of a compound of the type



The starting intermediate being obtained by phosgenation of a mercapto amine.

ii) reaction between a thio urea and a dihalogen aliphatic compound



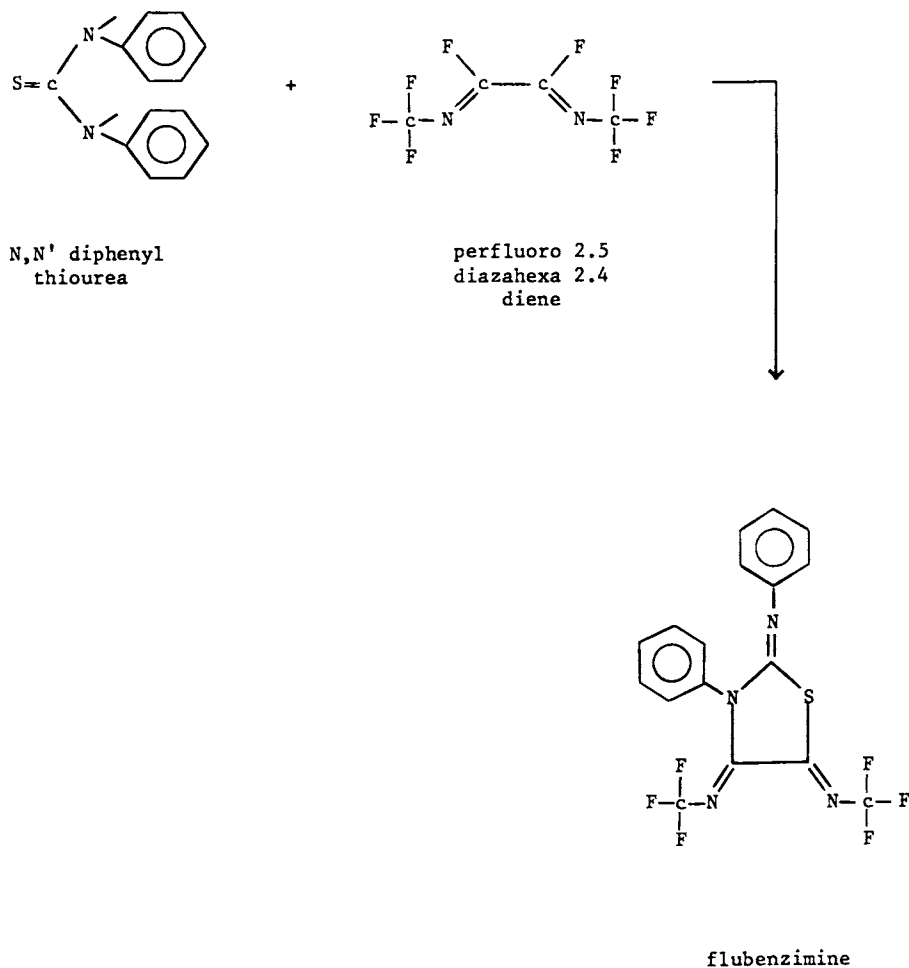
## Flubenzimine

Uses: acaricide, fungicide, fruit, citrus, tea, coffee, tomatoes, cucumbers

Trade names: Cropotex (Bayer)

Type: thiazolidine

Synthesis:



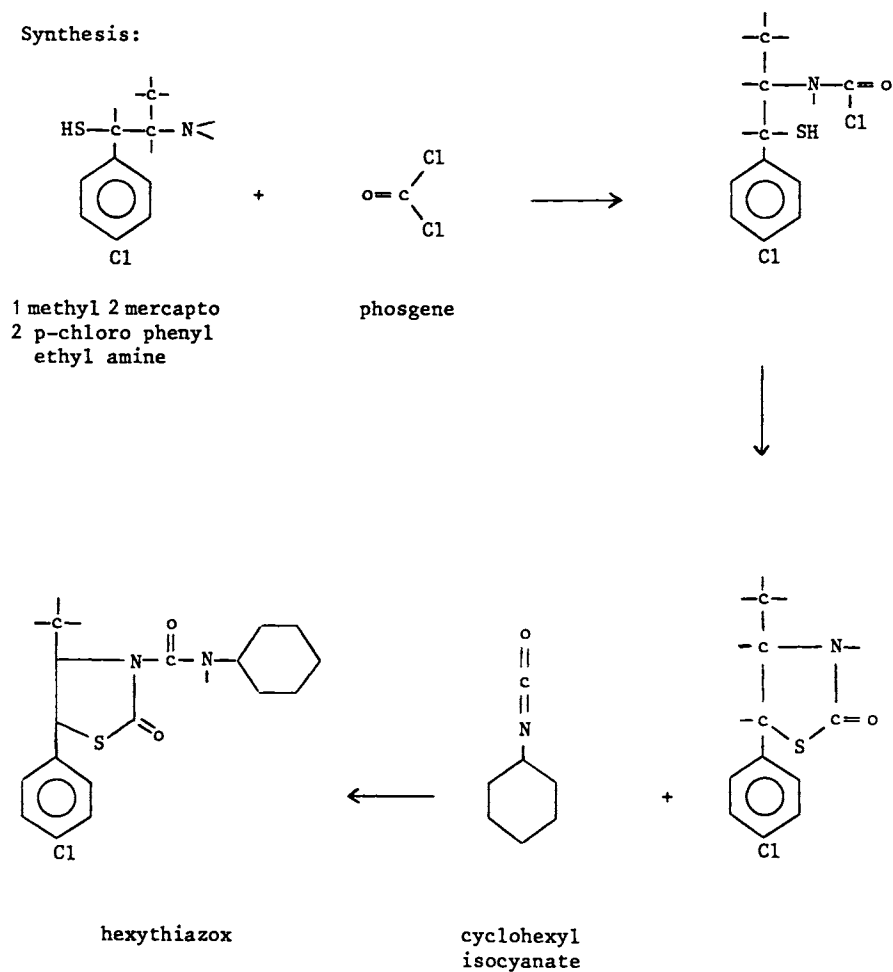
## Hexythiazox

Uses: acaricide, citrus, cotton, tea, vegetables, grapes

Trade names: Nissorun (Nippon Soda)

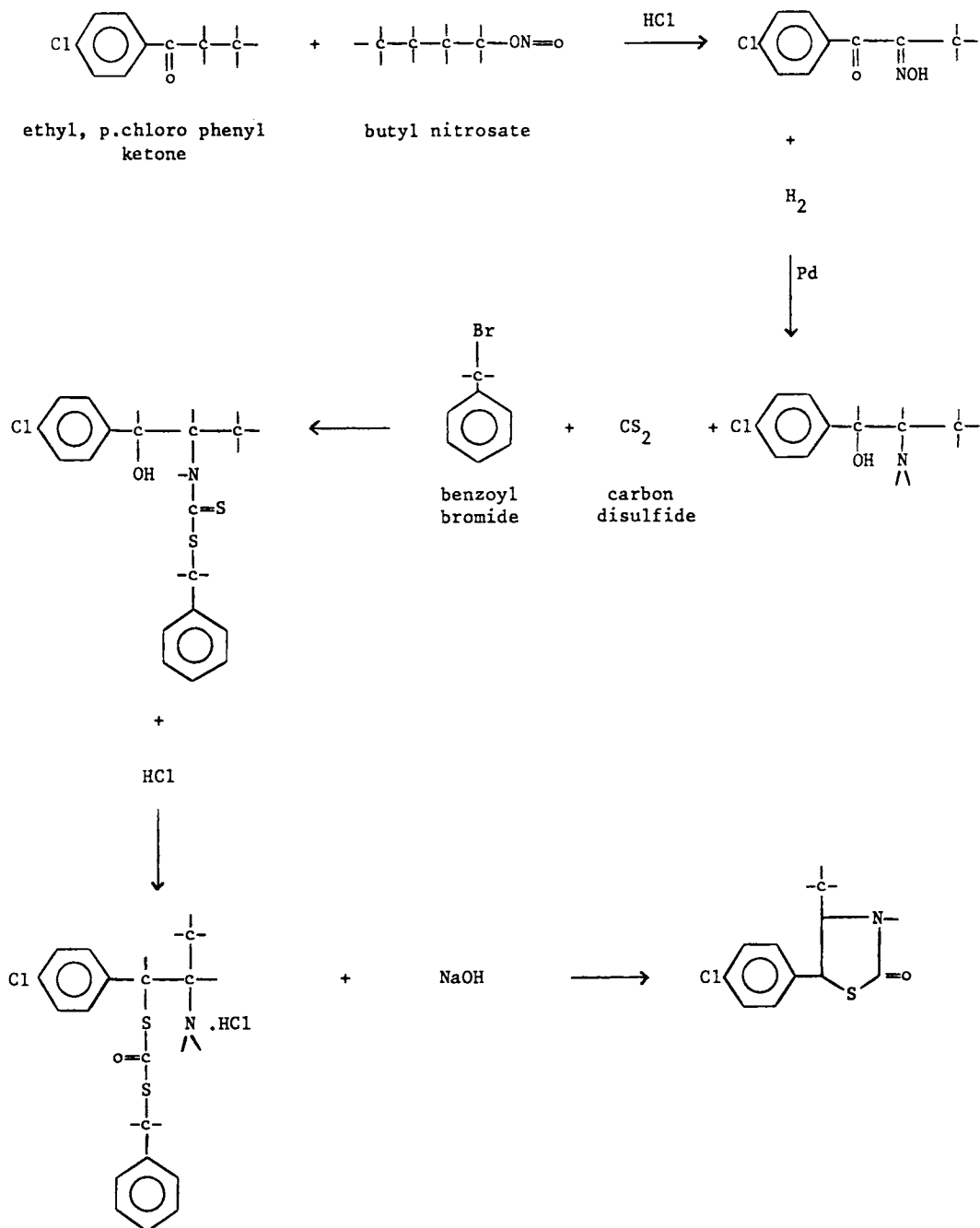
Type: thiazolidine, amide

Synthesis:

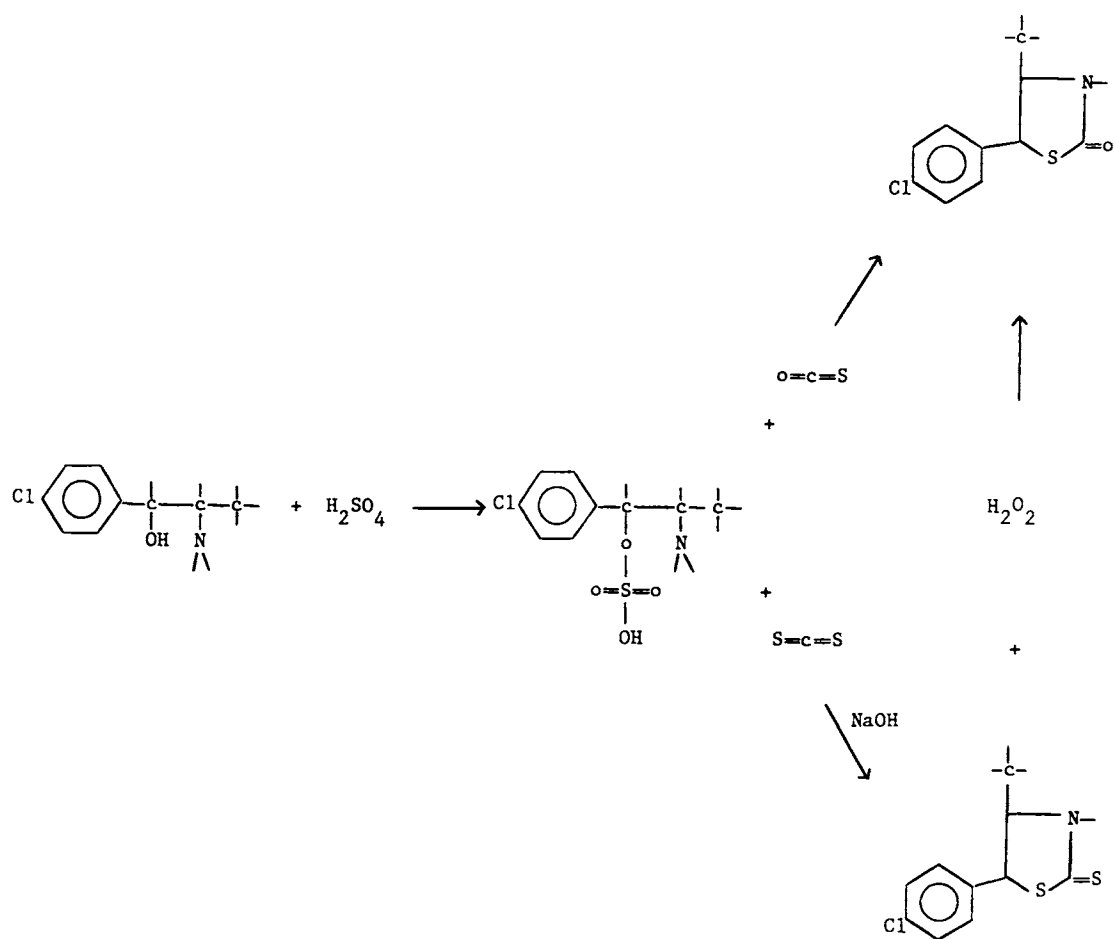




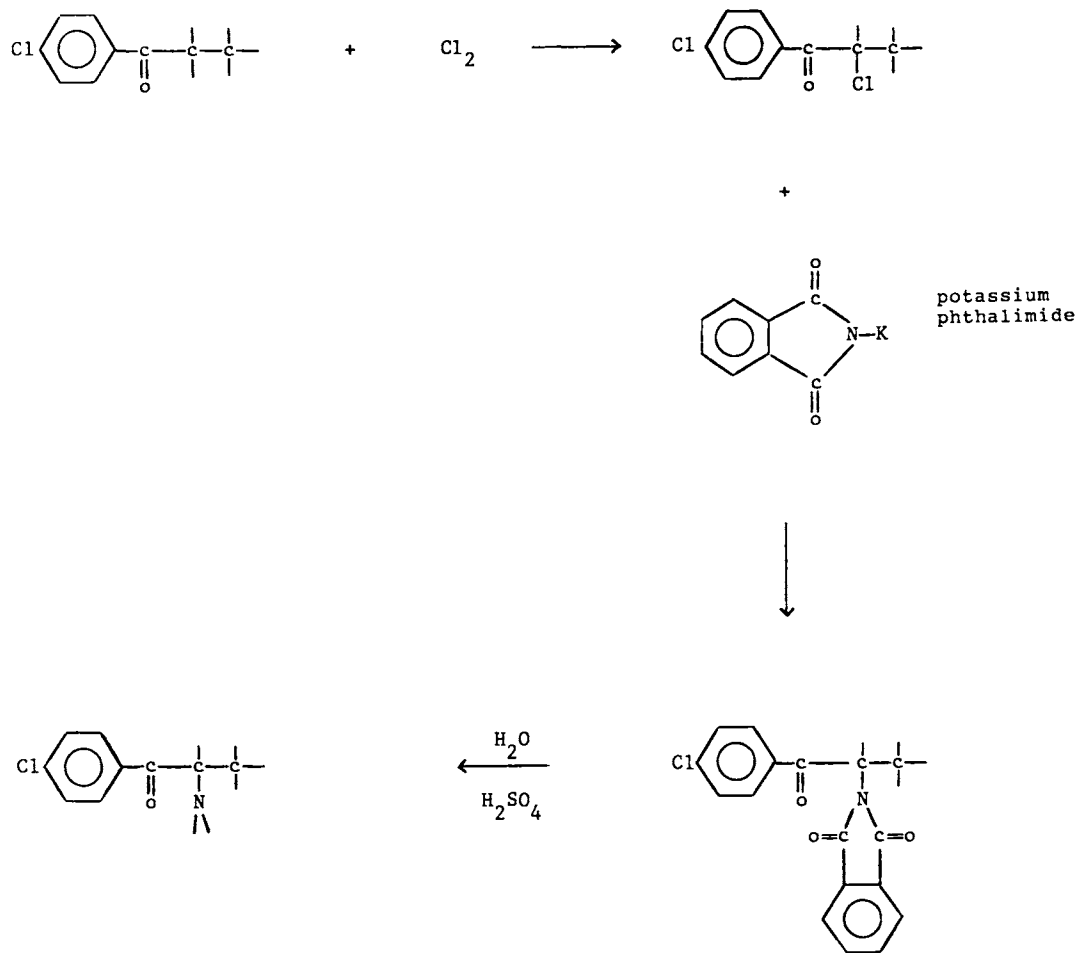
alternate route : (i)



alternate route : (ii)



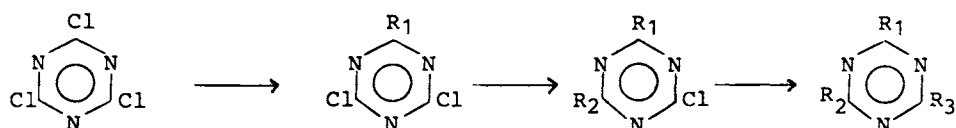
alternate route : (iii)



## TRIAZINES

(from cyanuric chloride)

First the basic ring structure is obtained from  $\text{CNCl}$ . Then the chlorine atoms are replaced by different substitutes, by means of successive reactions:



The most common substitutes are

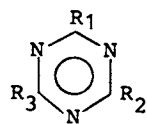
- amine groups (reactions with amines)
- methoxy groups (reactions with sodium methoxide)
- mercaptans (reactions with mercaptans)

Usually  $\text{R}_1 = \text{Cl}$ ,  $\text{O}-\overset{\textstyle |}{\underset{\textstyle |}{\text{C}}}-$ ,  $\text{S}-\overset{\textstyle |}{\underset{\textstyle |}{\text{C}}}-$




$$\text{R}_2 = \underset{\textstyle |}{\text{N}}-\text{R}_4$$

$$\text{R}_3 = \underset{\textstyle |}{\text{N}}-\text{R}_5$$

The most common amines are isopropyl amine and ethyl amine. Methyl substituted triazines, such as used in sulfanyl ureas are synthesized by another route.



	$\text{R}_1$	$\text{R}_2$	$\text{R}_3$
ametryn	$\text{S}-\text{C}-\text{C}-$	$\text{N}-\text{C}-\text{C}-$	$\begin{array}{c} \text{---C---} \\   \\ \text{---N---C---C---C---} \\   \quad   \quad   \\ \text{---C---} \end{array}$
anilazine	Cl	Cl	$\text{N}-\text{C}_6\text{H}_5$
atrazine	Cl	$\begin{array}{c} \text{---C---} \\   \\ \text{N---C---} \\   \\ \text{---C---} \end{array}$	$\text{N}-\text{C}-\text{C}-$
aziprotryne	$\text{N}_3$	$\text{S}-\text{C}-$	$\begin{array}{c} \text{---C---} \\   \\ \text{N---C---} \\   \\ \text{---C---} \end{array}$
cyanazine	Cl	$\begin{array}{c} \text{---C---} \\   \\ \text{N---C---C}\equiv\text{N} \\   \\ \text{---C---} \end{array}$	$\text{N}-\text{C}-\text{C}-$

	$R_1$	$R_2$	$R_3$
cyprazine	Cl	$  \begin{array}{c}    \\  -C- \\    \\  N-C- \\    \\  -C- \\     \end{array}  $	
cypromazine	Cl	$  \begin{array}{c}  N < \\     \end{array}  $	
desmetryn	$  \begin{array}{c}    \\  S-C- \\     \end{array}  $	$  \begin{array}{c}    \\  -C- \\    \\  N-C- \\    \\  -C- \\     \end{array}  $	$  \begin{array}{c}    \\  N-C- \\     \end{array}  $
dimethametrin	$  \begin{array}{c}    \quad   \\  S-C-C- \\    \quad    \end{array}  $	$  \begin{array}{c}    \quad   \quad   \\  N-C-C- \\    \quad   \quad    \end{array}  $	$  \begin{array}{c}    \\  -C- \\    \\  N-C-C-C- \\    \quad   \quad   \\  -C- \\     \end{array}  $
dipropetryn	$  \begin{array}{c}    \quad   \\  S-C-C- \\    \quad    \end{array}  $	$  \begin{array}{c}    \\  -C- \\    \\  N-C- \\    \\  -C- \\     \end{array}  $	$  \begin{array}{c}    \\  -C- \\    \\  N-C- \\    \\  -C- \\     \end{array}  $
procyzine	Cl	$  \begin{array}{c}    \\  -C- \\    \\  N-C-C \equiv N \\    \\  -C- \\     \end{array}  $	
prometon	$  \begin{array}{c}    \\  O-C- \\     \end{array}  $	$  \begin{array}{c}    \\  -C- \\    \\  N-C- \\    \\  -C- \\     \end{array}  $	$  \begin{array}{c}    \\  -C- \\    \\  N-C- \\    \\  -C- \\     \end{array}  $

	$\underline{R_1}$	$\underline{R_2}$	$\underline{R_3}$
prometryn	$\text{S}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-$	$\begin{array}{c}   \\ -\text{C}- \\   \\ \text{N}-\text{C}- \\   \quad   \\ -\text{C}- \\   \end{array}$	$\begin{array}{c}   \\ -\text{C}- \\   \\ \text{N}-\text{C}- \\   \quad   \\ -\text{C}- \\   \end{array}$
propazine	Cl	$\begin{array}{c}   \\ -\text{C}- \\   \\ \text{N}-\text{C}- \\   \quad   \\ -\text{C}- \\   \end{array}$	$\begin{array}{c}   \\ -\text{C}- \\   \\ \text{N}-\text{C}- \\   \quad   \\ -\text{C}- \\   \end{array}$
simazine	Cl	$\text{N}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-$	$\text{N}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-$
simetryn	$\text{S}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-$	$\text{N}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-$	$\text{N}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-$
terbutryn	$\text{S}-\overset{\textstyle  }{\underset{\textstyle  }{\text{C}}}-$	$\begin{array}{c}   \\ -\text{C}- \\   \quad   \quad   \\ \text{N}-\text{C}-\text{C}- \\   \quad   \quad   \\ -\text{C}- \\   \end{array}$	$\begin{array}{c}   \quad   \quad   \\ \text{N}-\text{C}-\text{C}- \\   \quad   \quad   \end{array}$
terbuthylazine	Cl	$\begin{array}{c}   \\ -\text{C}- \\   \quad   \quad   \\ \text{N}-\text{C}-\text{C}- \\   \quad   \quad   \\ -\text{C}- \\   \end{array}$	$\begin{array}{c}   \quad   \quad   \\ \text{N}-\text{C}-\text{C}- \\   \quad   \quad   \end{array}$
trietazine	Cl	$\begin{array}{c}   \quad   \quad   \\ \text{N}-\text{C}-\text{C}- \\   \quad   \quad   \end{array}$	$\begin{array}{c}   \quad   \\ \text{C}-\text{C}- \\   \quad   \\ \text{N} \diagup \quad \diagdown \\   \quad   \\ \text{C}-\text{C}- \\   \quad   \end{array}$

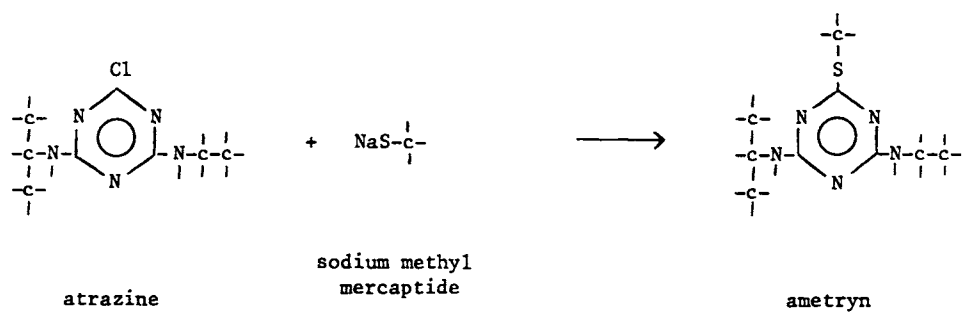
## Ametryn

Uses: herbicide, bananas, citrus, cocoa, coffee, maize, sugarcane, tea, potatoes, pineapples

Trade names: Gesapax, Evik (Ciba)

Type: triazine

Synthesis:





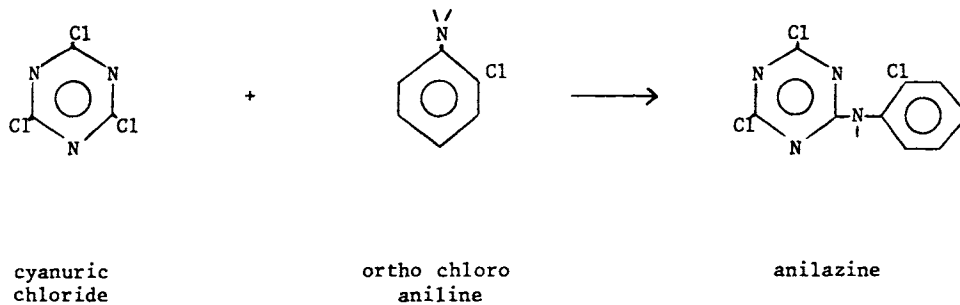
## Anilazine

Uses: fungicide, tobacco

Trade names: Dyrene, Direz, Kemate (Bayer)

Type: triazine

Synthesis:



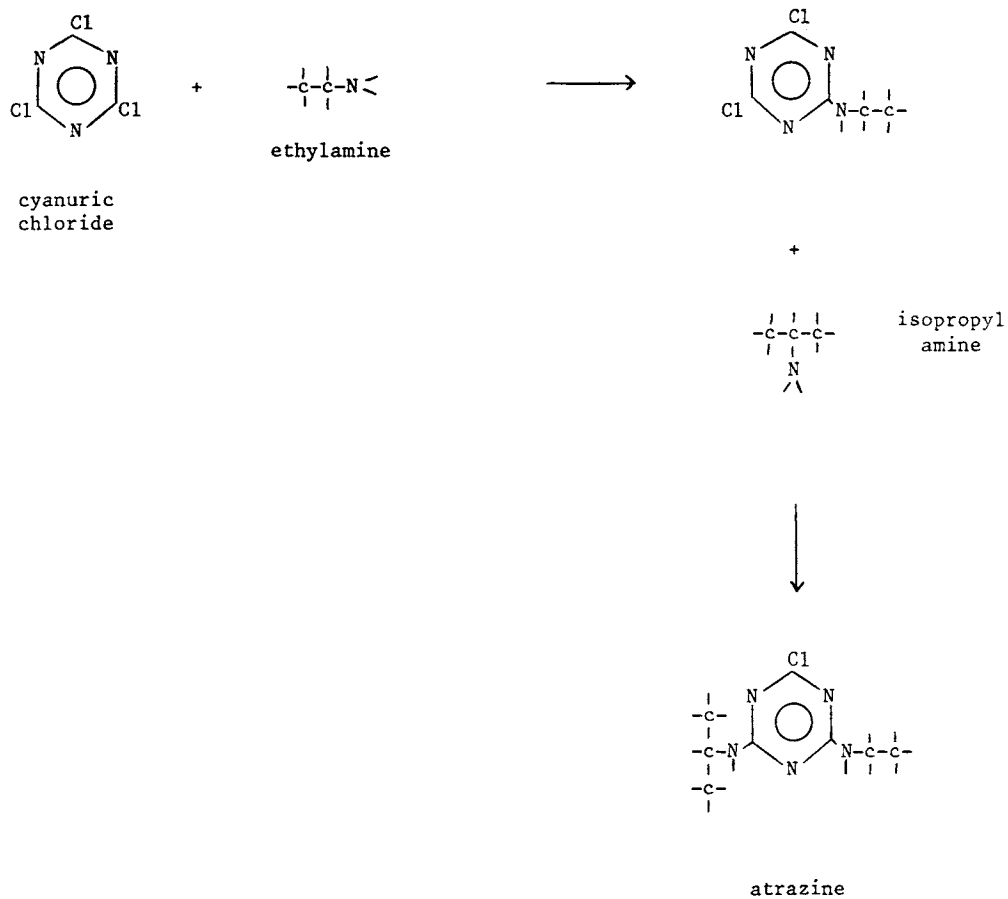
## Atrazine

Uses: herbicide, forestry, grasslands, maize, flowers, sorghum, sugarcane

Trade names: Gesaprim (Ciba)

Type: triazine

Synthesis:



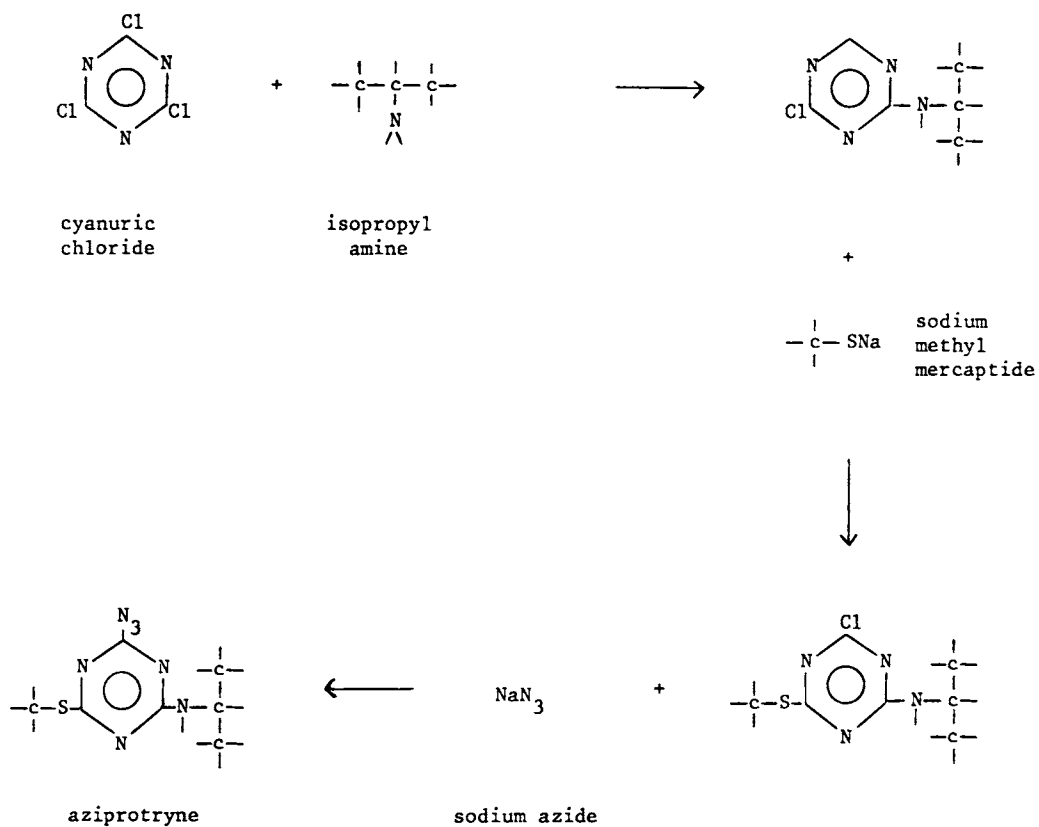
## Aziprotryne

Uses: herbicide, onions, vegetables

Trade names: Mesoranil (Ciba)

Type: triazine

Synthesis:



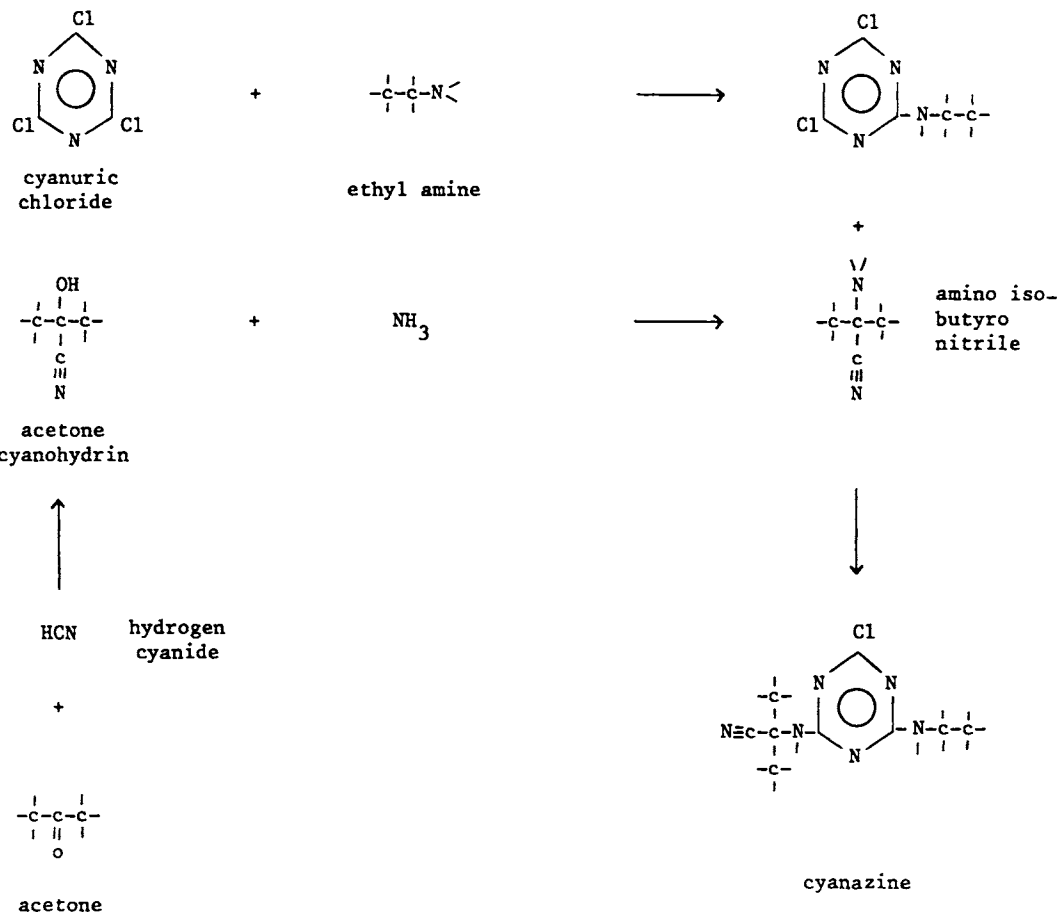
## Cyanazine

Uses: herbicide, maize, barley, wheat, cotton, forestry, potatoes, soyabeans, sugarcane

Trade names: Bladex, Fortrol (Shell)

Type: triazine

Synthesis:



alternate route:

reaction first with amino isobutyro nitrile and then with ethylamine

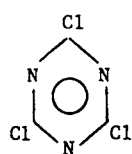
## Cyprazine

Uses: herbicide, maize

Trade names: Outfox (Gulf Oil)

Type: triazine

Synthesis:

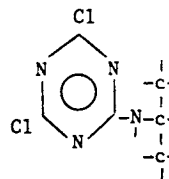


cyanuric  
chloride

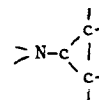
+



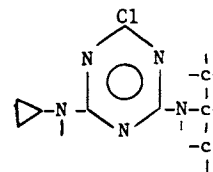
isopropyl  
amine



+



cyclopropyl  
amine



cyprazine

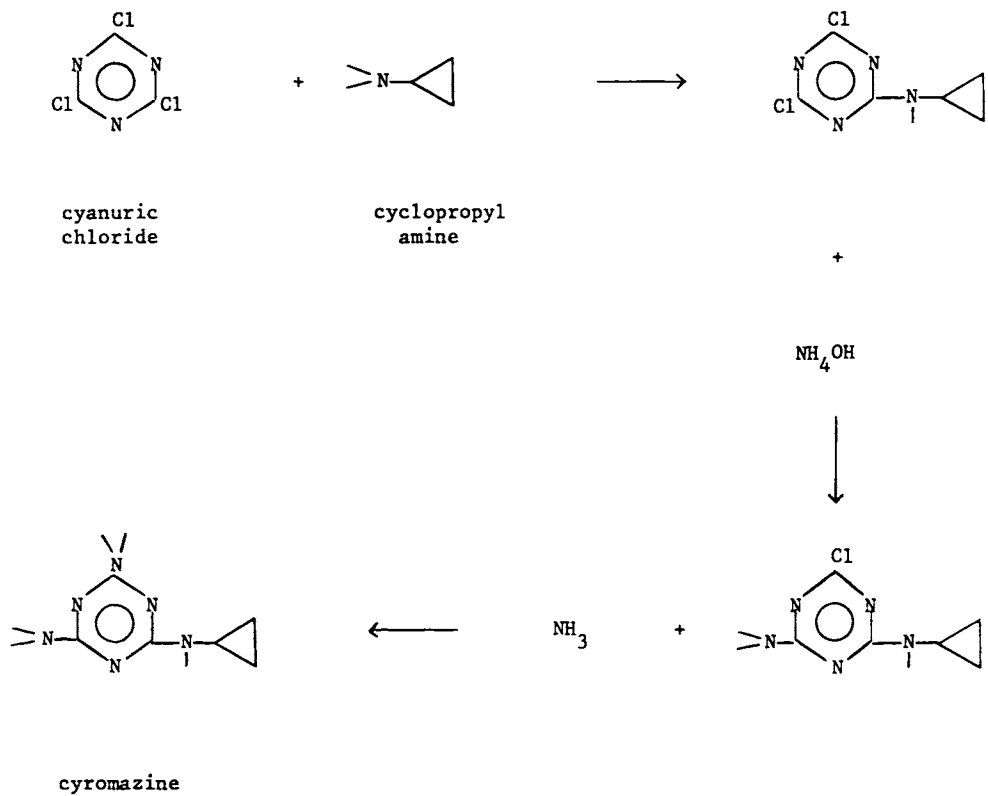
## Cyromazine

Uses: insecticide, growth regulator, sheep, chicken, ornamentals, vegetables

Trade names: Vetrazine, Trigard, Larvadex, Neoprex (Ciba)

Type: triazine

Synthesis:



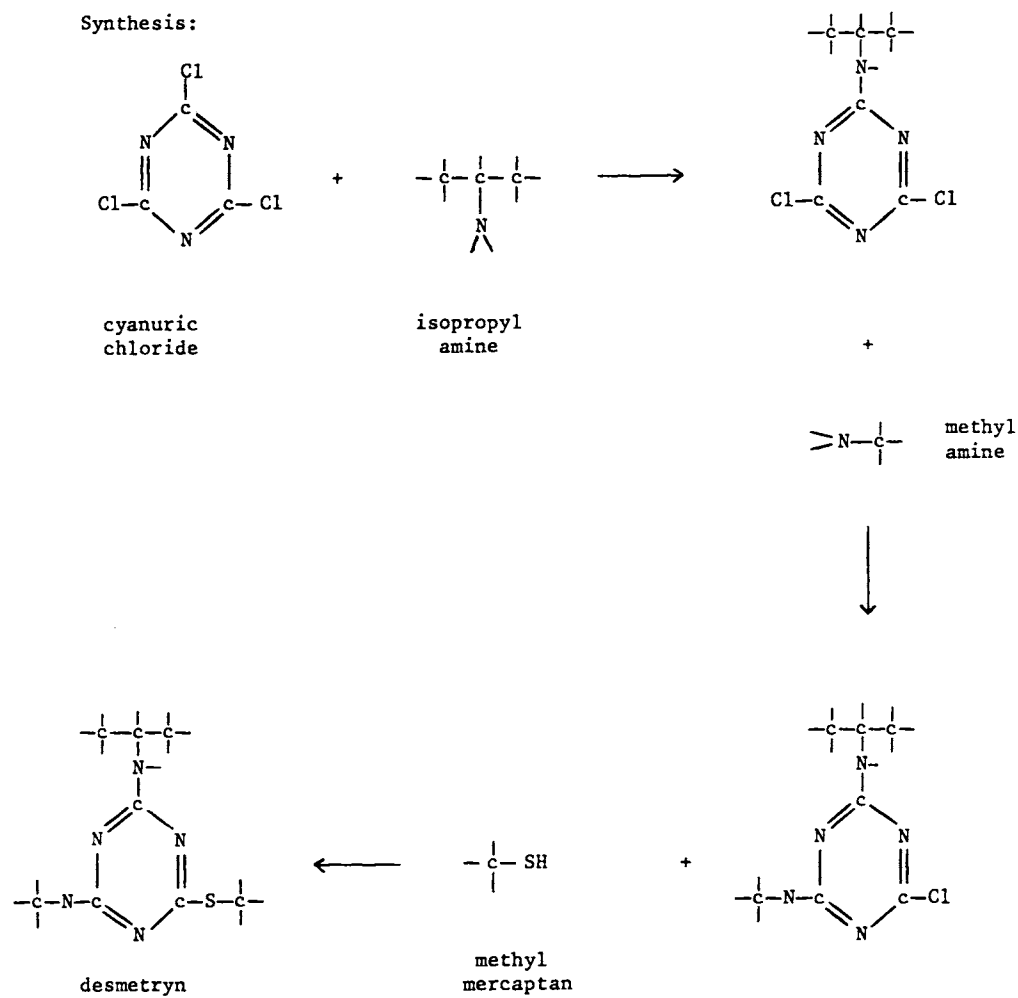
## Desmetryn

Uses: herbicide

Trade names: Semeron (Ciba)

Type: triazine

Synthesis:



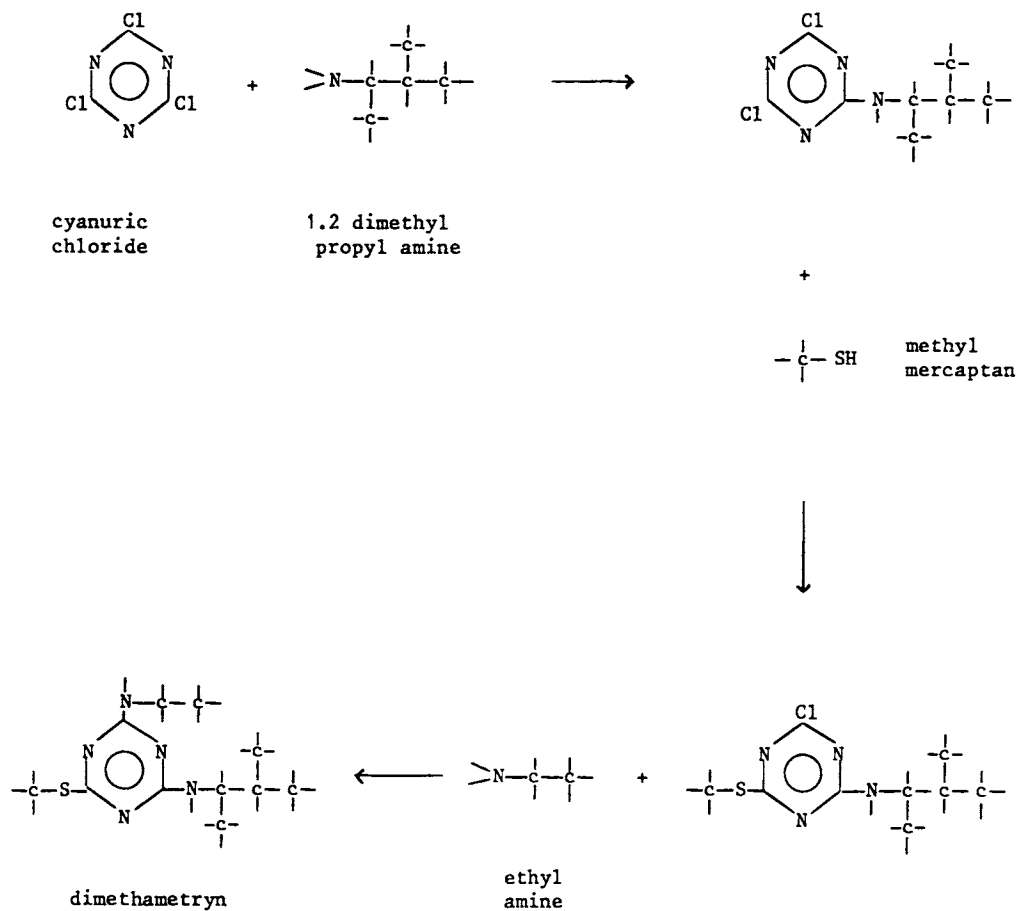
## Dimethametryn

Uses: herbicide, rice

Trade names: Dimepax (Ciba)

Type: triazine

Synthesis:





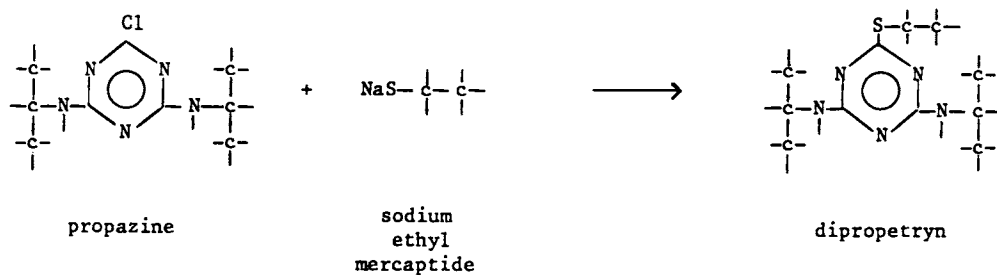
## Dipropetryn

Uses: herbicide, cotton, water melons

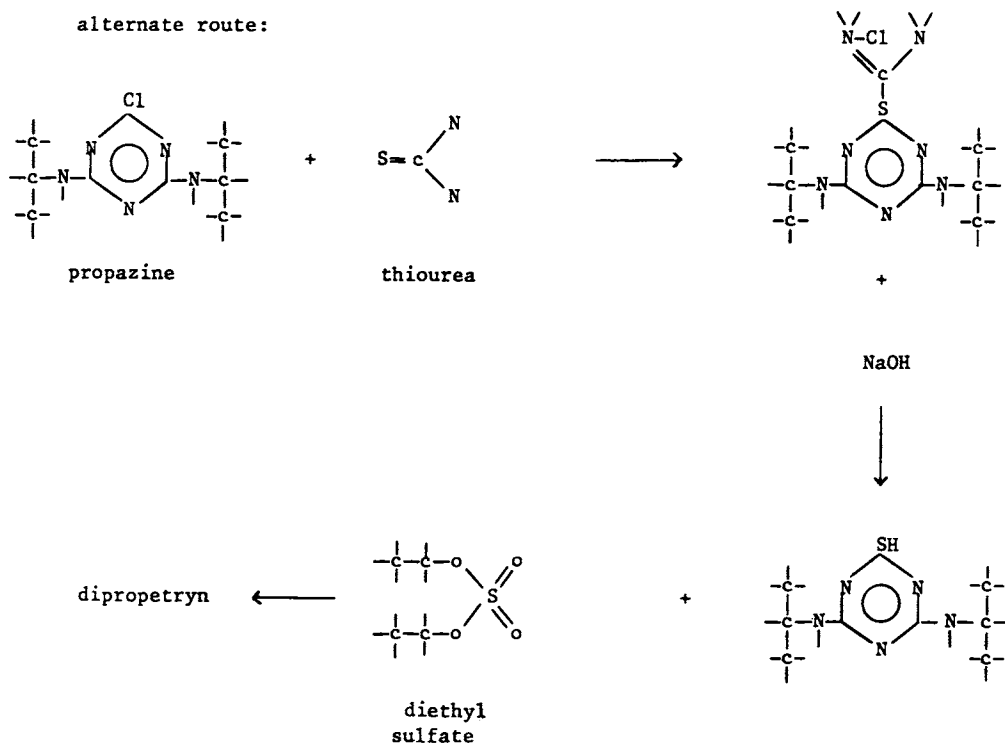
Trade names: Sancap, Cotofor (Ciba)

Type: triazine

Synthesis:



alternate route:



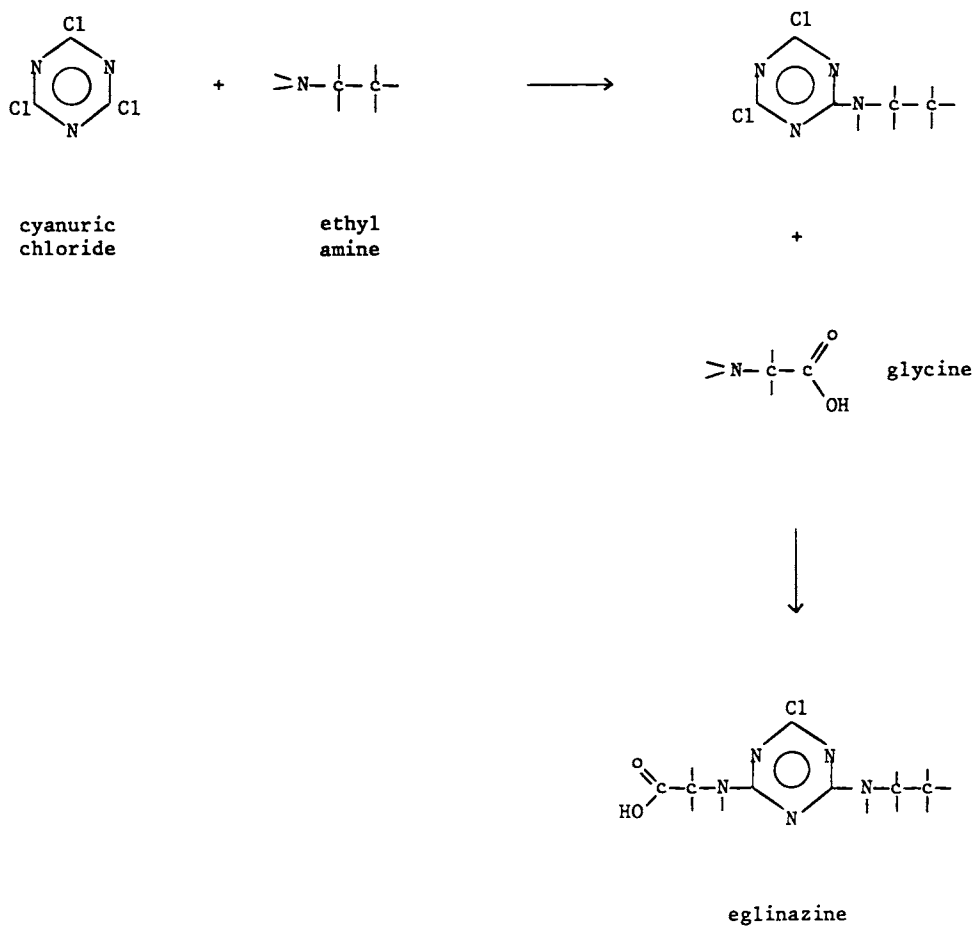
## Eglinazine

Uses: herbicide, cereals

Trade names: MG-06 (Nitrokemia)

Type: triazine

Synthesis:



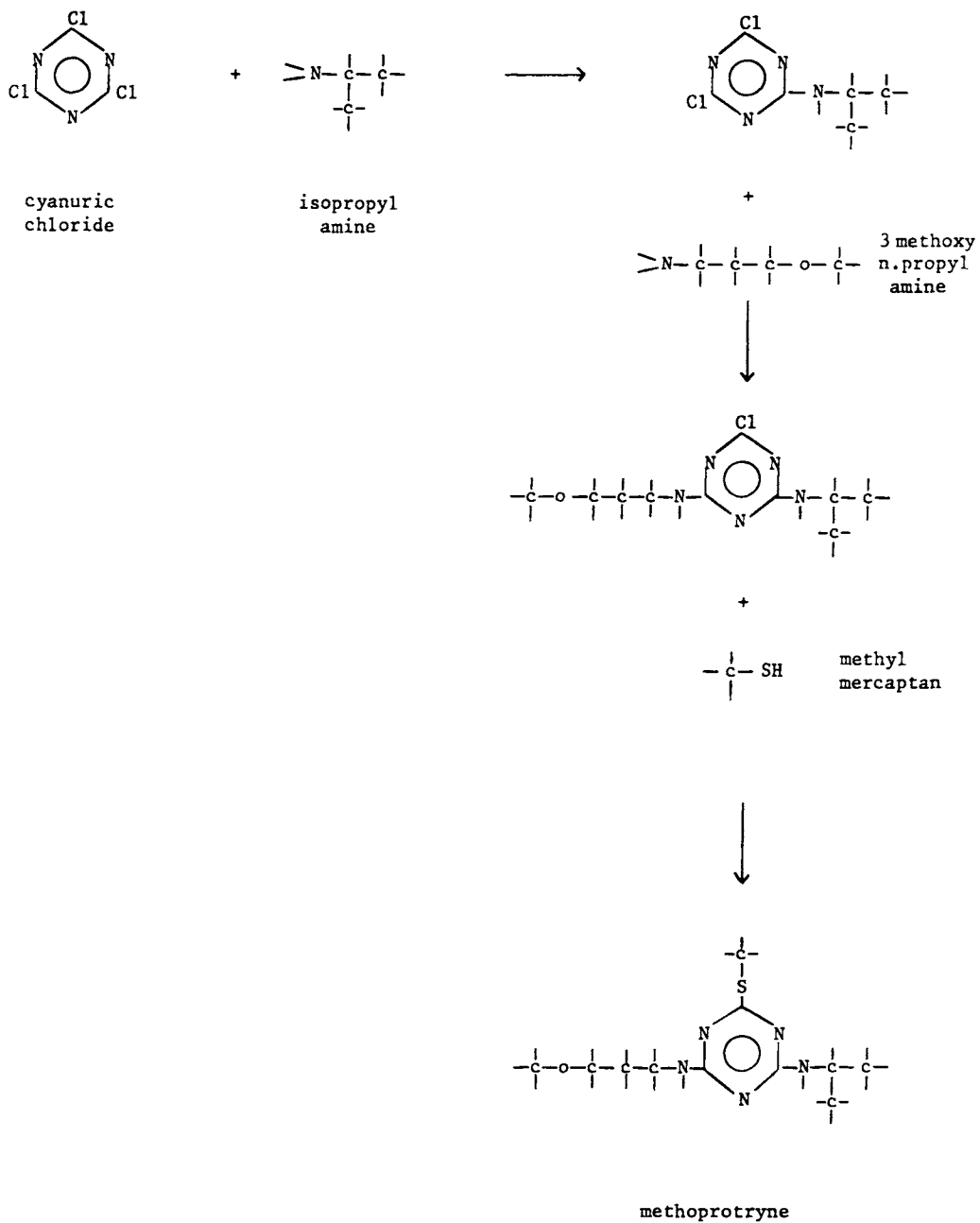
## Methoprotryne

Uses: herbicide, cereals

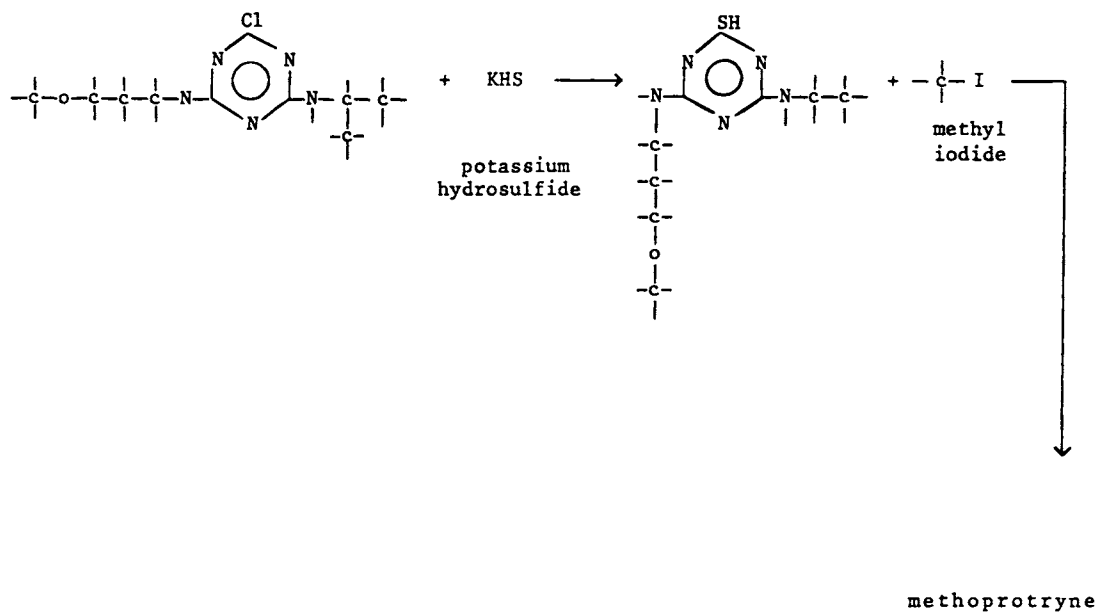
Trade names: Gesaran (Ciba)

Type: triazine

Synthesis:



alternate route:



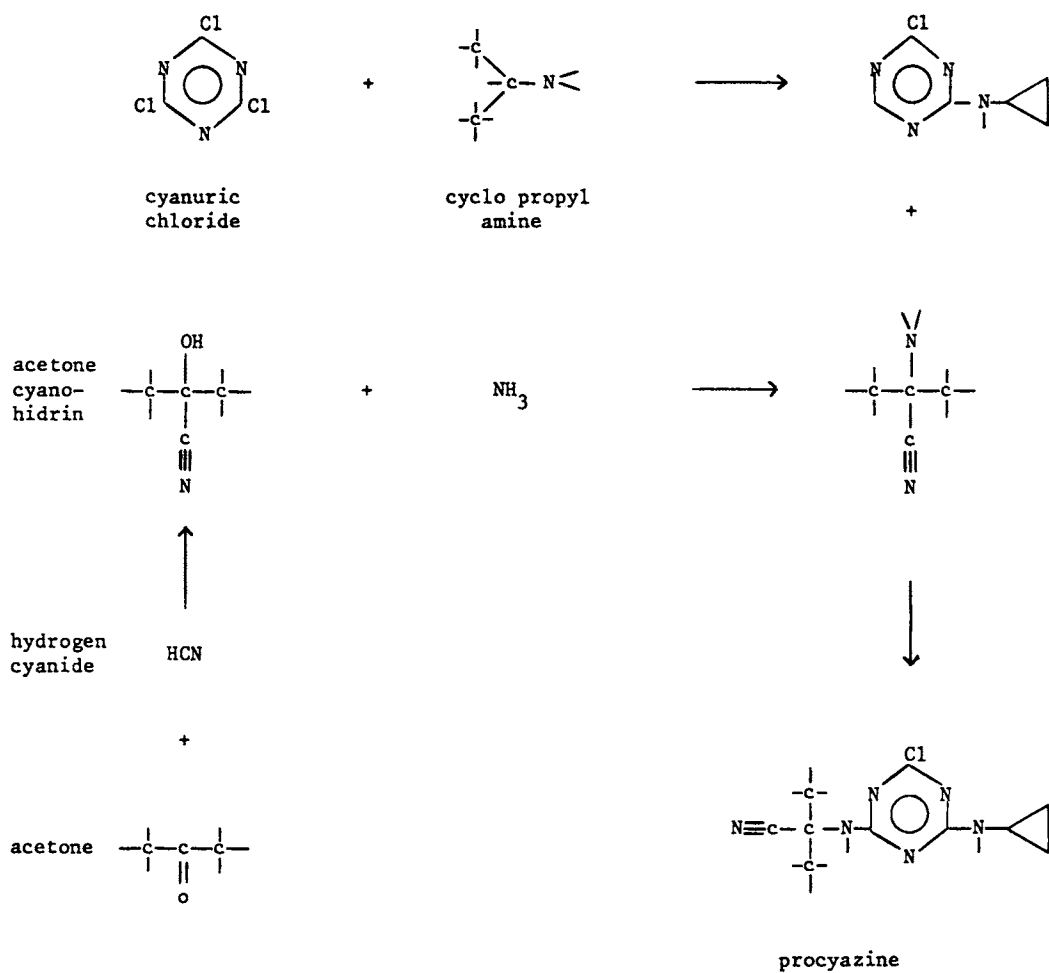
## Procyazine

Uses: herbicide

Trade names: (Ciba)

Type: triazine

Synthesis:



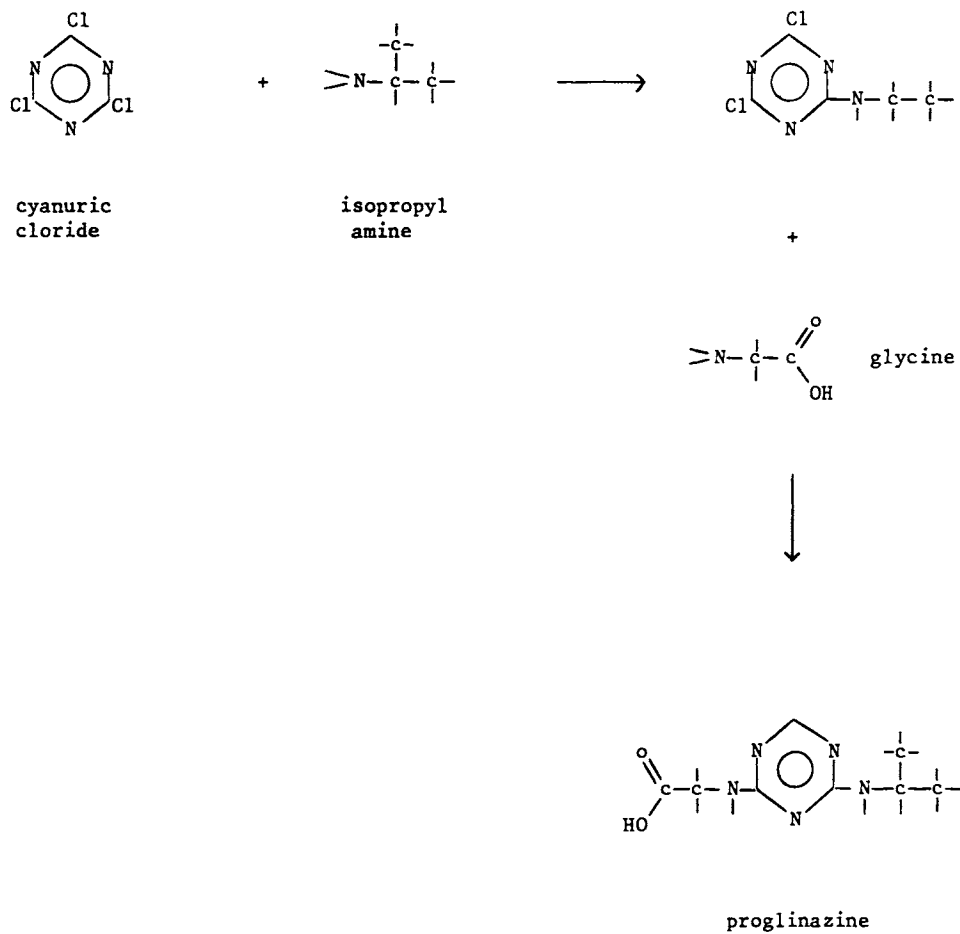
## Proglinazine

Uses: herbicide, maize

Trade names: (Nitrokemia)

Type: triazine

Synthesis:



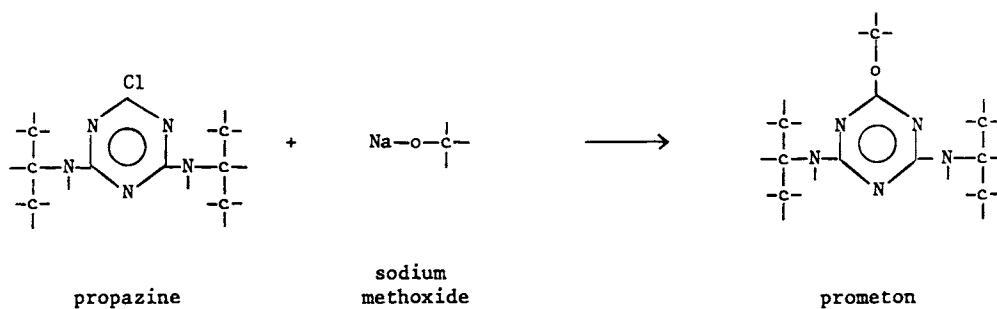
## Prometon

Uses: herbicide, ground (for asphalt), non crop areas

Trade names: Gesagram, Primatol (Ciba)

Type: triazine

Synthesis:



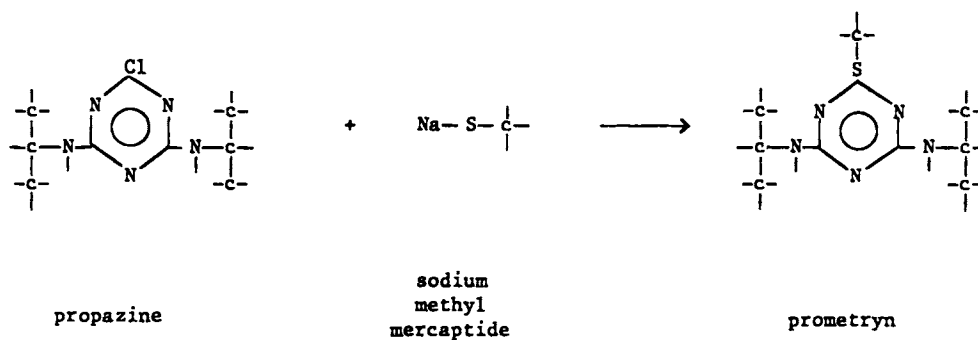
## Prometryn

Uses: herbicide, cotton, vegetables, potatoes, sunflowers

Trade names: Caparol, Gesagard (Ciba)

Type: triazine

Synthesis:





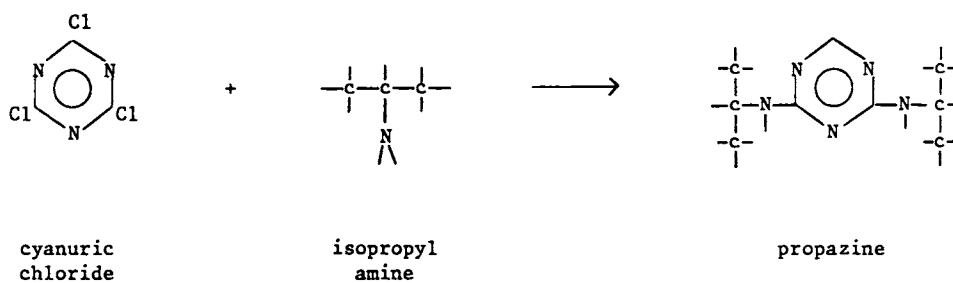
## Propazine

Uses: herbicide, sorghum

Trade names: Gesamil, Milogard (Ciba)

Type: triazine

Synthesis:



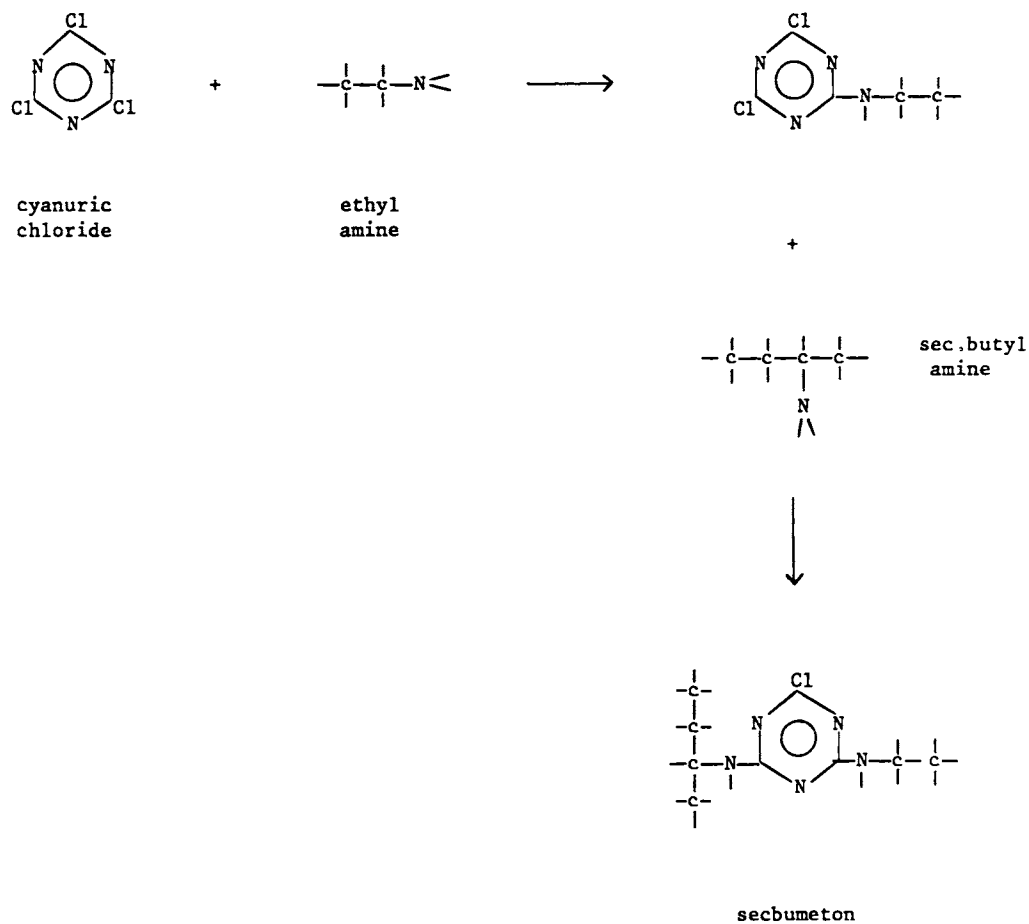
## Sebumeton

Uses: herbicide

Trade names: Etazine (Ciba)

Type: triazine

Synthesis:



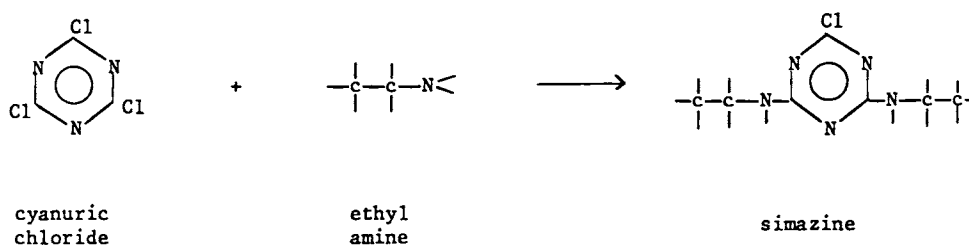
## Simazine

Uses: herbicide, vegetables, citrus, coffee, cocoa, rubber, ornamentals, sugarcane, sisal, tea, turf, vineyards

Trade names: Gesatop, Weedex, Aquazine (Ciba)

Type: triazine

Synthesis:



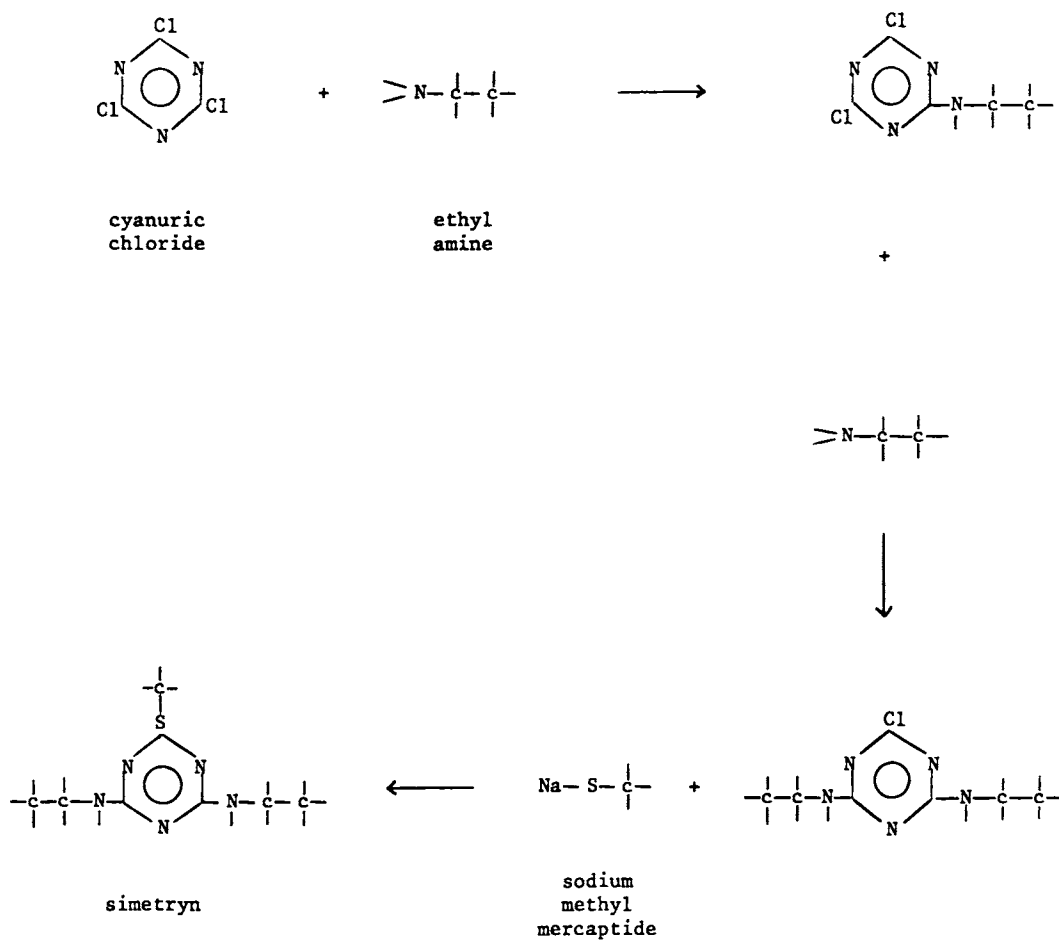
## Simetryn

Uses: herbicide, rice

Trade names: Gybon (Nippon, Hokko)

Type: triazine

**Synthesis:**



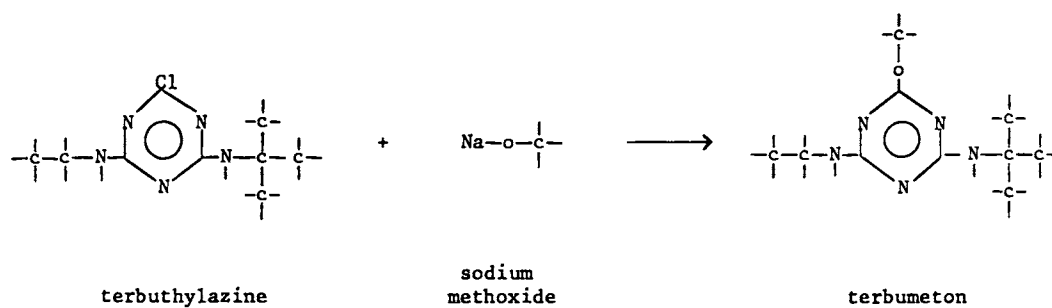
## Terbumeton

Uses: herbicide, citrus, forestry, vineyards

Trade names: Caragard (Ciba)

Type: triazine

Synthesis:



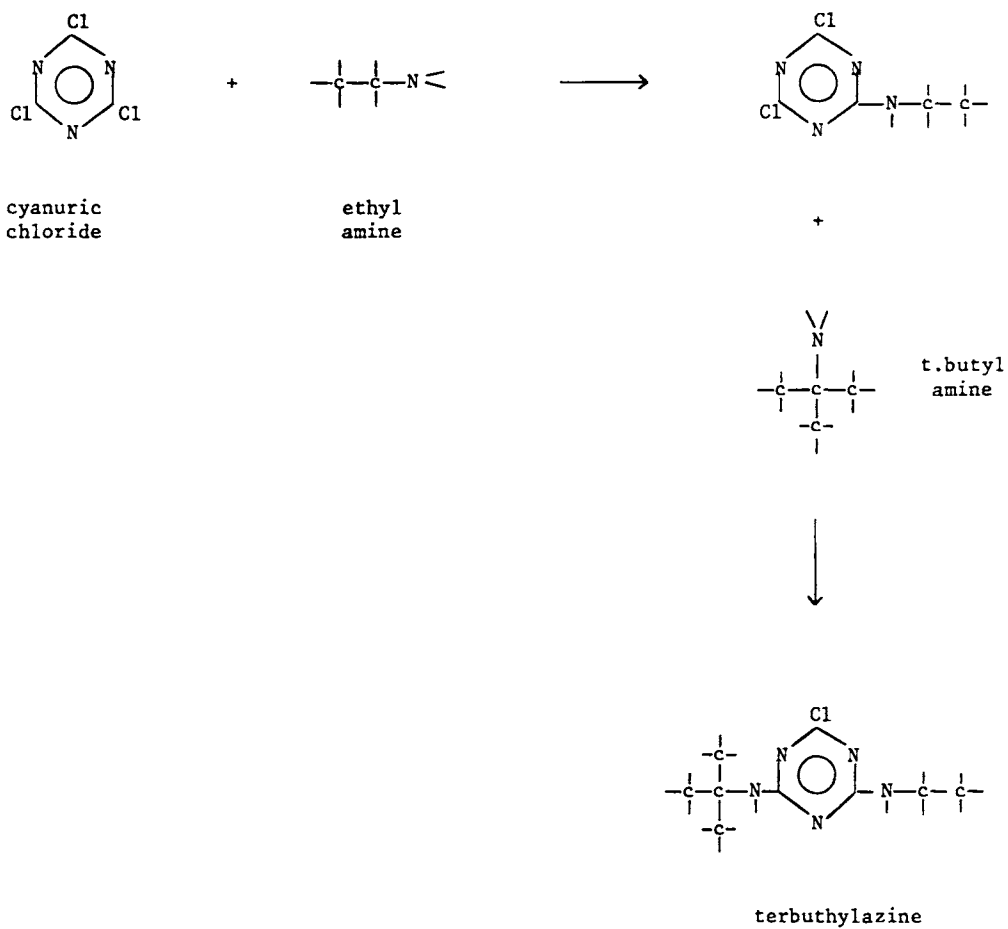
## Terbuthylazine

Uses: herbicide, sorghum, citrus, maize, vineyards, cereals

Trade names: Gardoprim (Ciba)

Type: triazine

Synthesis:



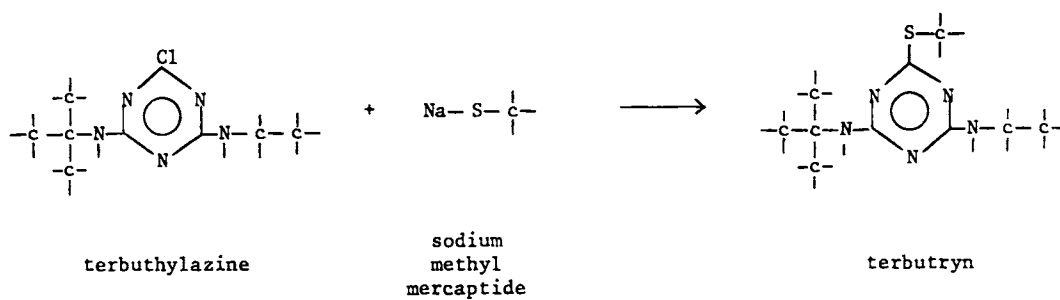
## Terbutryn

Uses: herbicide, sugarcane, sunflowers, potatoes, waterways, reservoirs, fishponds

Trade names: Igran, Clarosan, Prebane (Ciba)

Type: triazine

Synthesis:



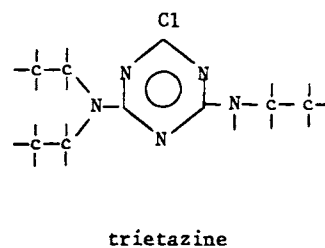
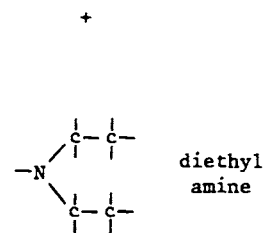
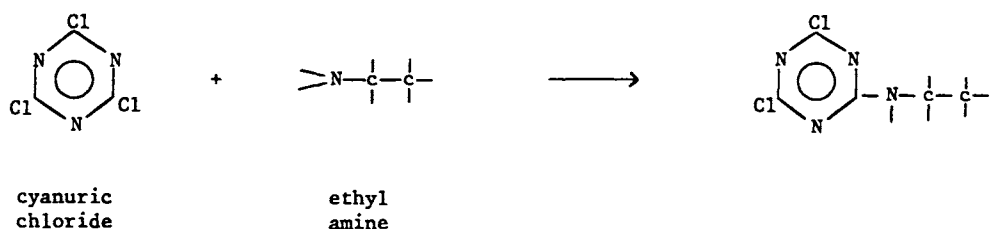
## Trietazine

Uses: herbicide, potatoes, vegetables

Trade names: Bromox, Rental (Schering)

Type: triazine

Synthesis:





# TRIAZINES

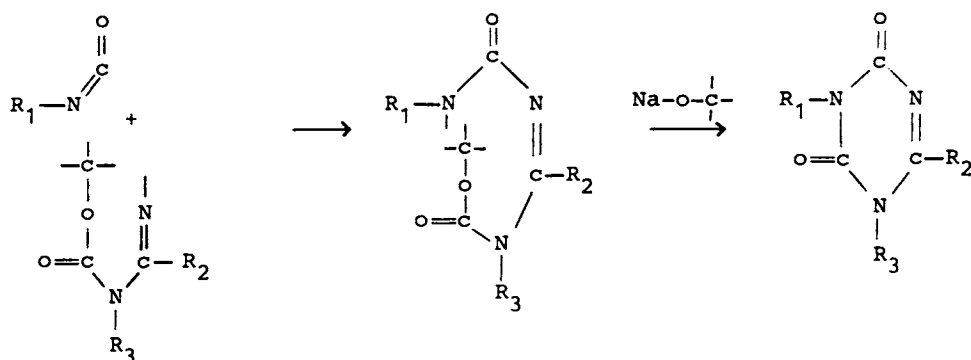
(not derived from cyanuric chloride)

(see also sulfonyl ureas for synthesis of amino 1.3.5 triazines)

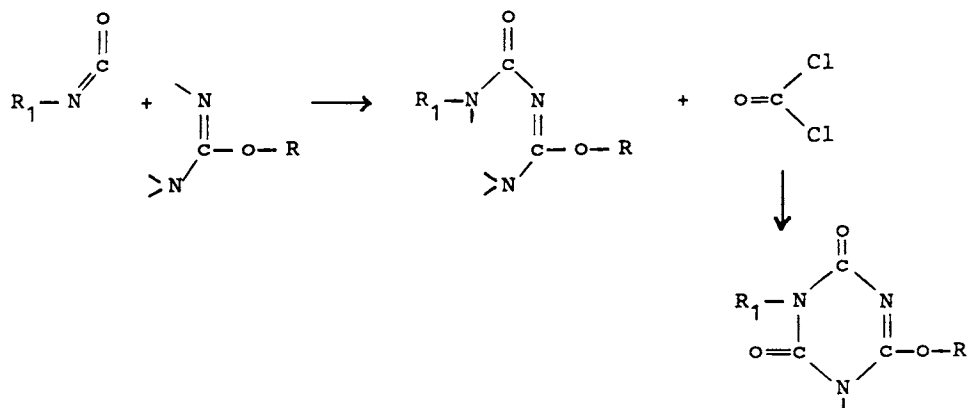
Each compound is a case in itself, since there are many synthesis routes:

## 1.3.5 triazines

- i) reaction between an isocyanate and an amino or imino carbonate, followed by cyclisation



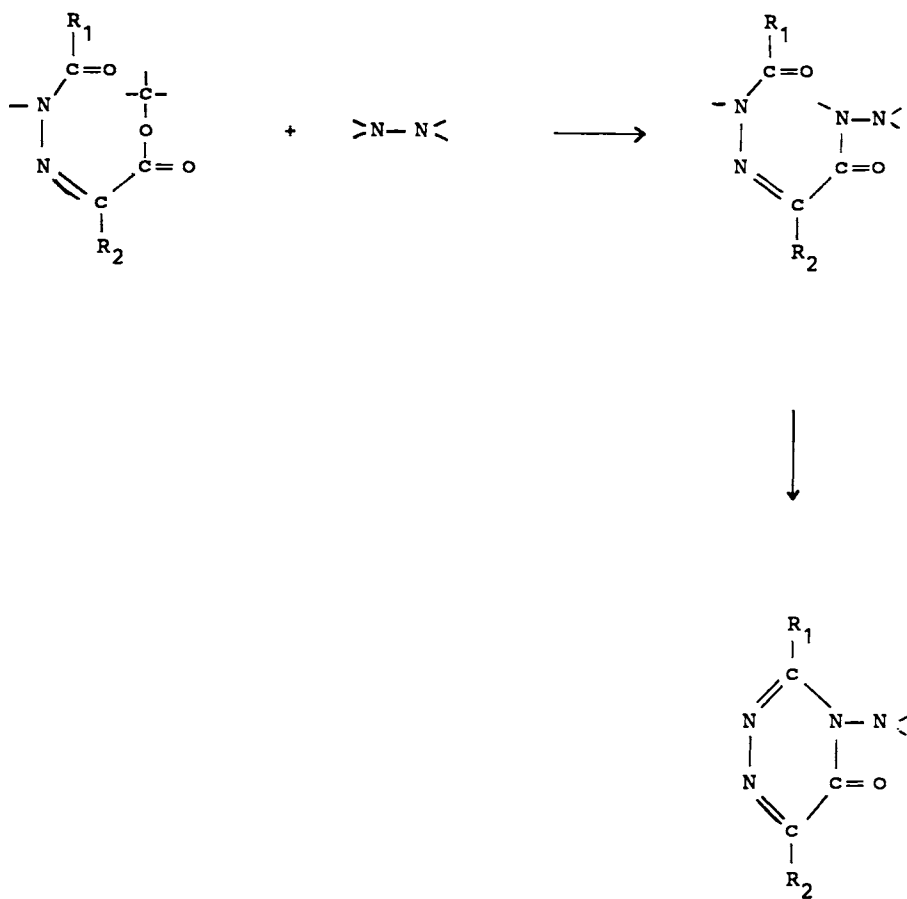
- ii) reaction between an isocyanate and an alkyl pseudo urea (or an alkyl thio pseudo urea) followed by cyclisation with phosgene or a chloroformate



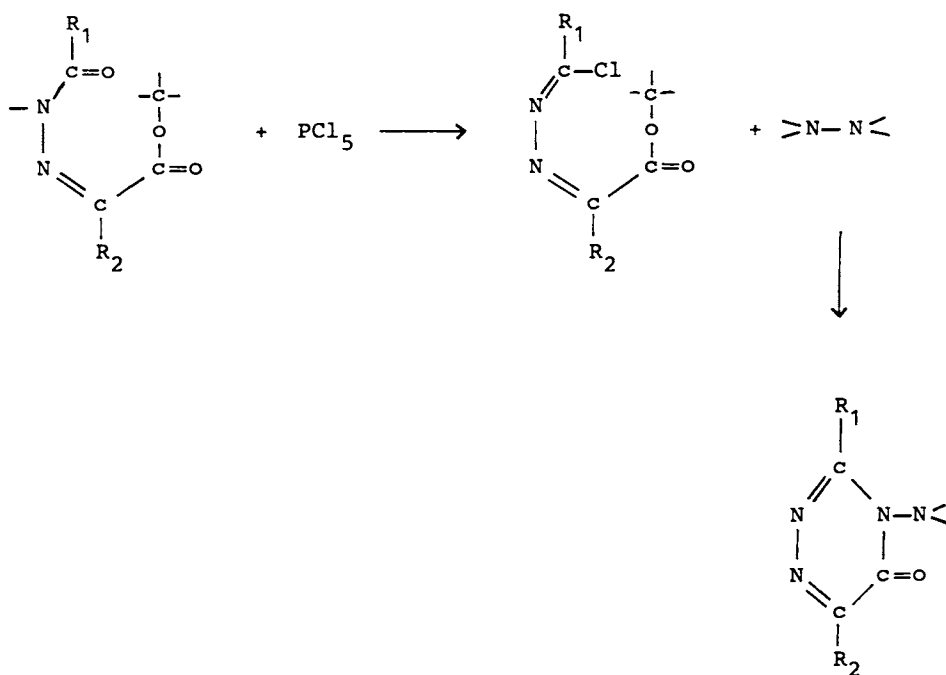
1.2.4 triazoles

i) reaction of a compound of the type  $R_1-\overset{\overset{O}{\parallel}}{C}-N-N=\overset{\overset{O}{\parallel}}{C}-R_2$  with

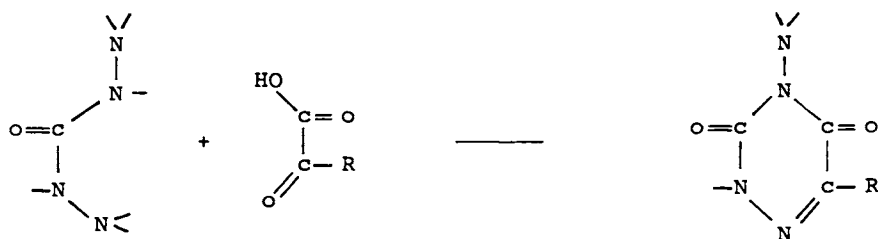
hydrazine followed by cyclisation



ii) reaction of a compound as in (iii) with  $\text{PCl}_5$  followed by cyclisation with hydrazine



iii) reaction between a carbohydrazide (or a thiocarbohydrazide) and an  $\alpha$  keto acid



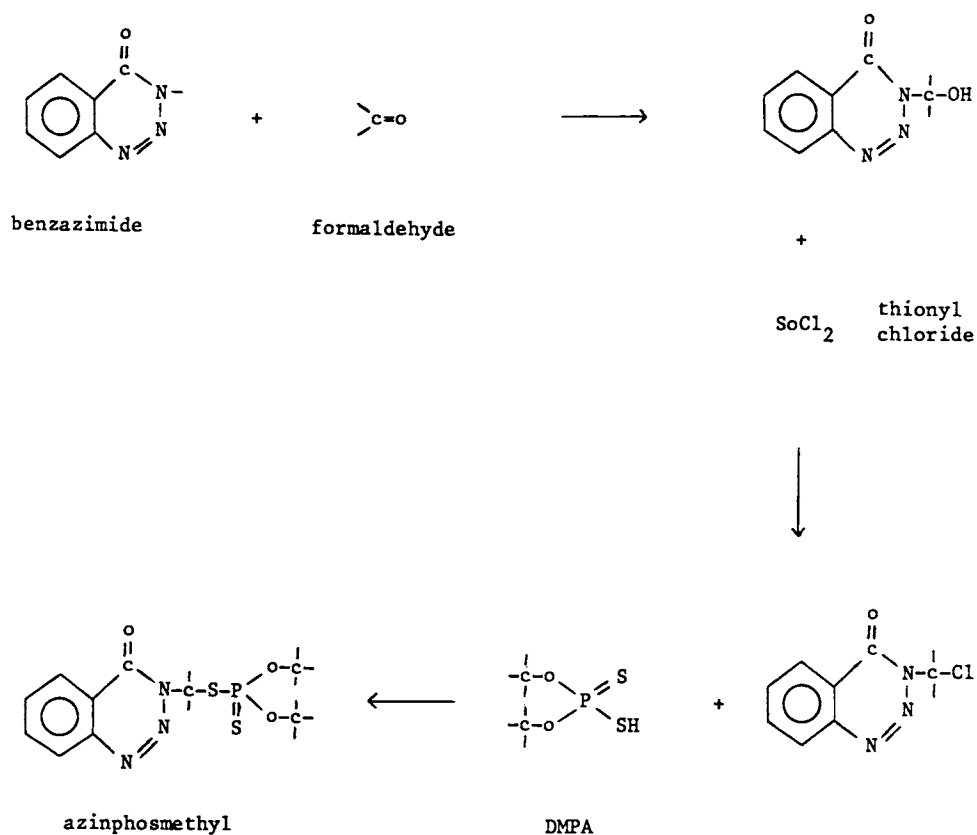
## Azinphosmethyl Azinphosethyl

Uses: insecticide, acaricide, citrus, cotton, grapes, rice, vegetables

Trade names: Guthion, Gusathion (Bayer)

Type: benzotriazine, phosphoro dithioate

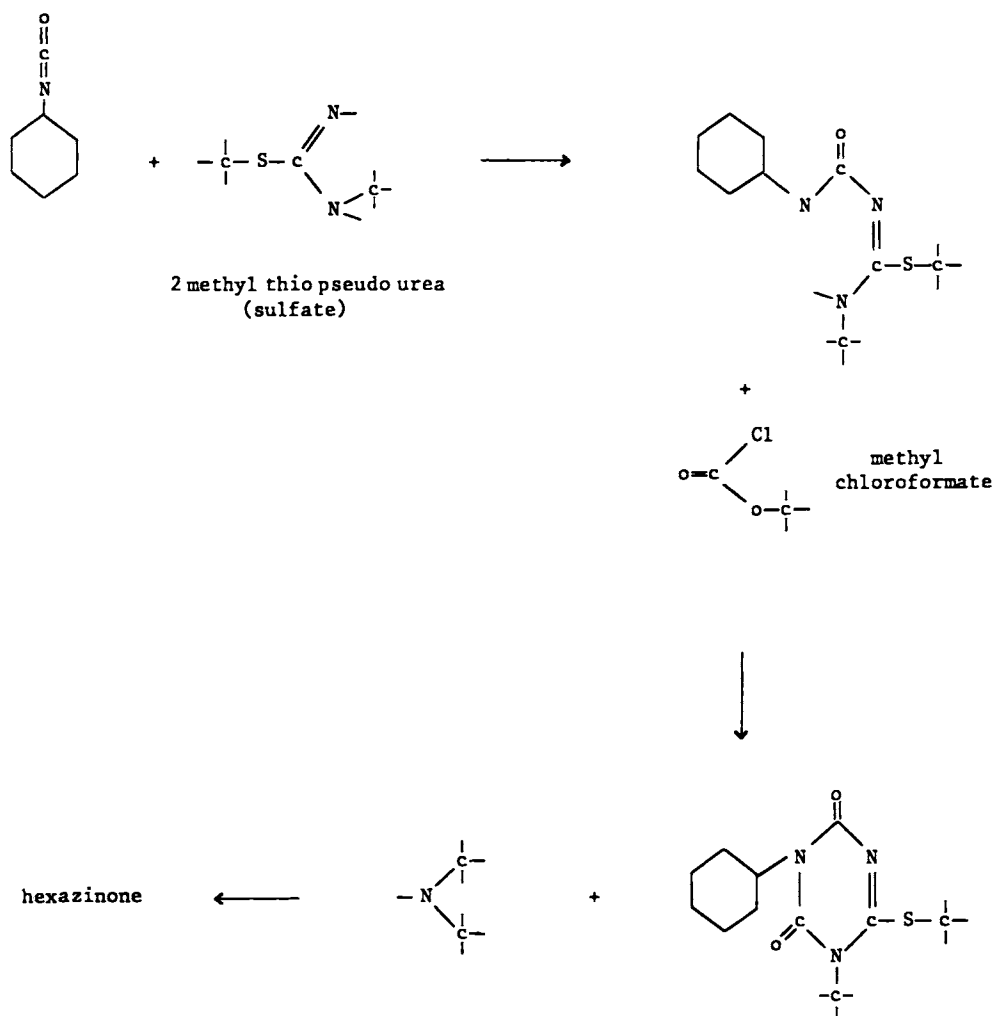
Synthesis:



azinphosethyl: reaction with DEPA instead of DMPA



alternate route :



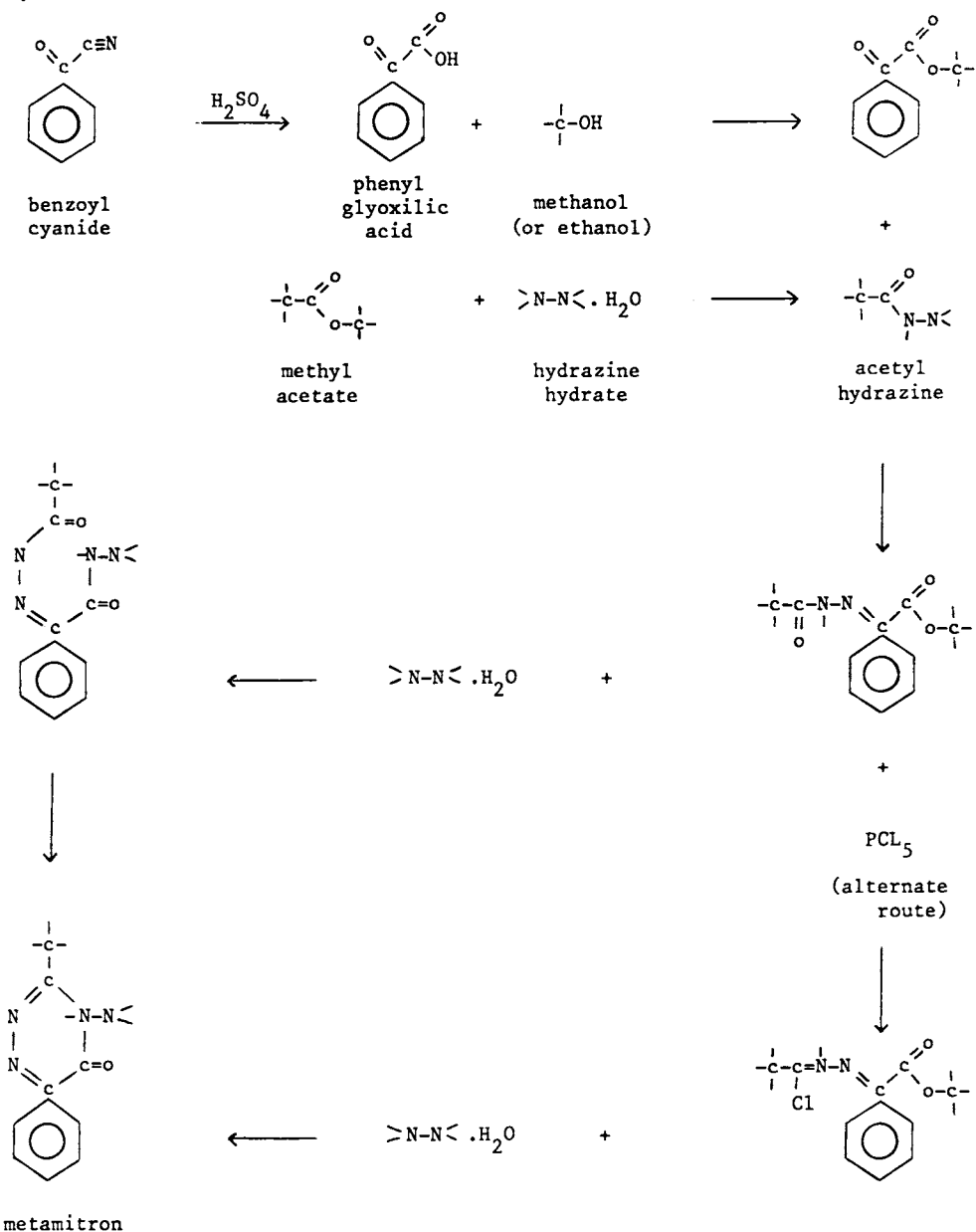
## Metamitron

Uses: herbicide , beets

Trade names: Goltix (Bayer)

Type: triazine ( not derived from cyanuric chloride )

### Synthesis:



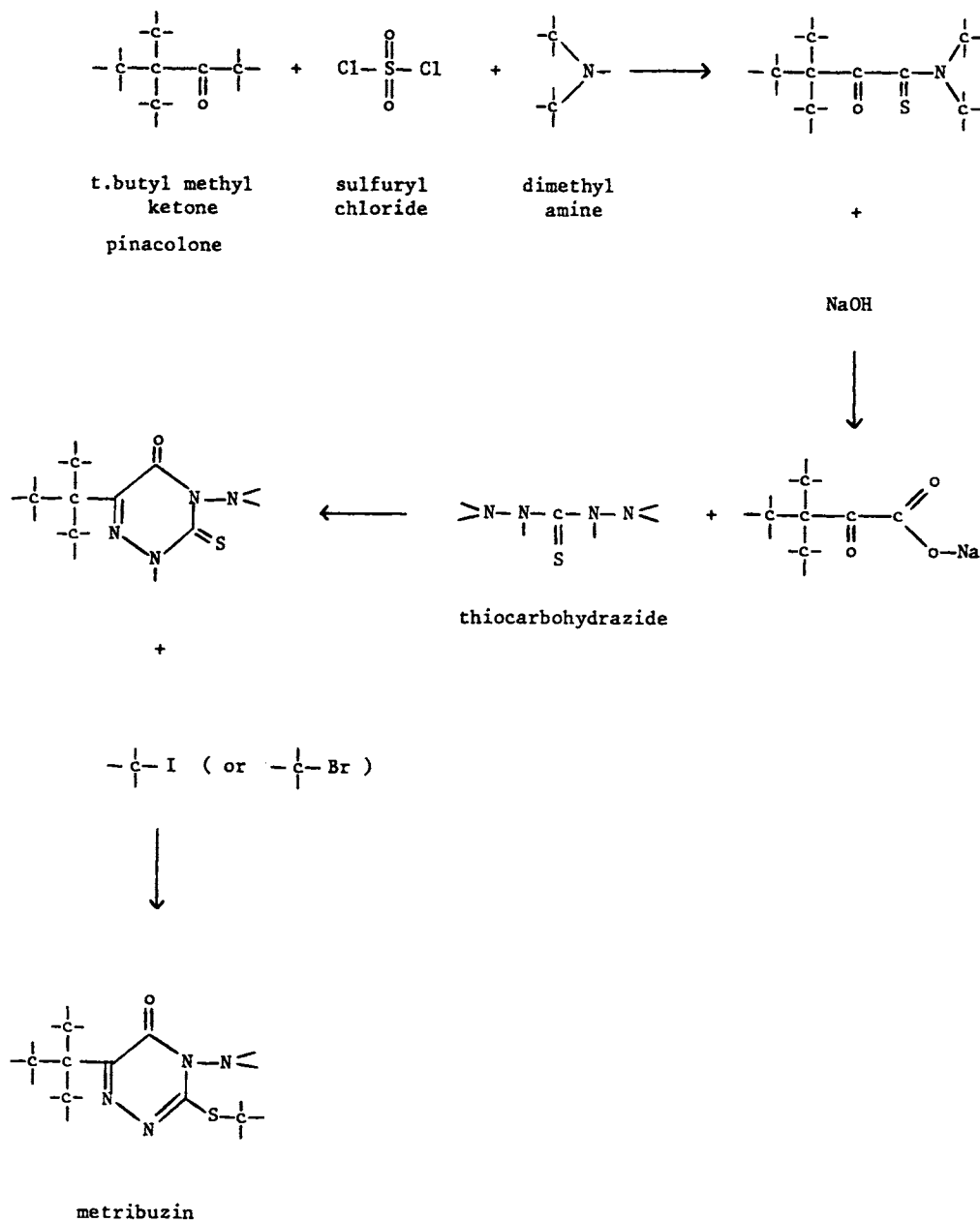
## Metribuzin

Uses: herbicide for tomatoes, potatoes, soya, sugarcane, cereals

**Trade names:** Sencorex, Sencoral, Sencor (Bayer), Lexone (Bayer)

Type: triazine (not derived from cyanuric chloride)

**Synthesis:**

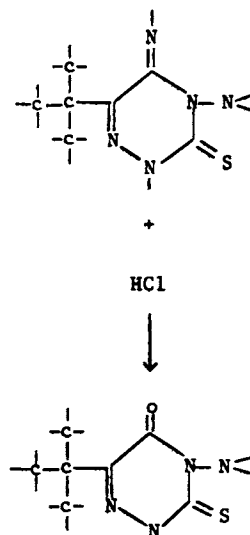




alternate route :



2 imino 3.3 dimethyl  
butyronitrile



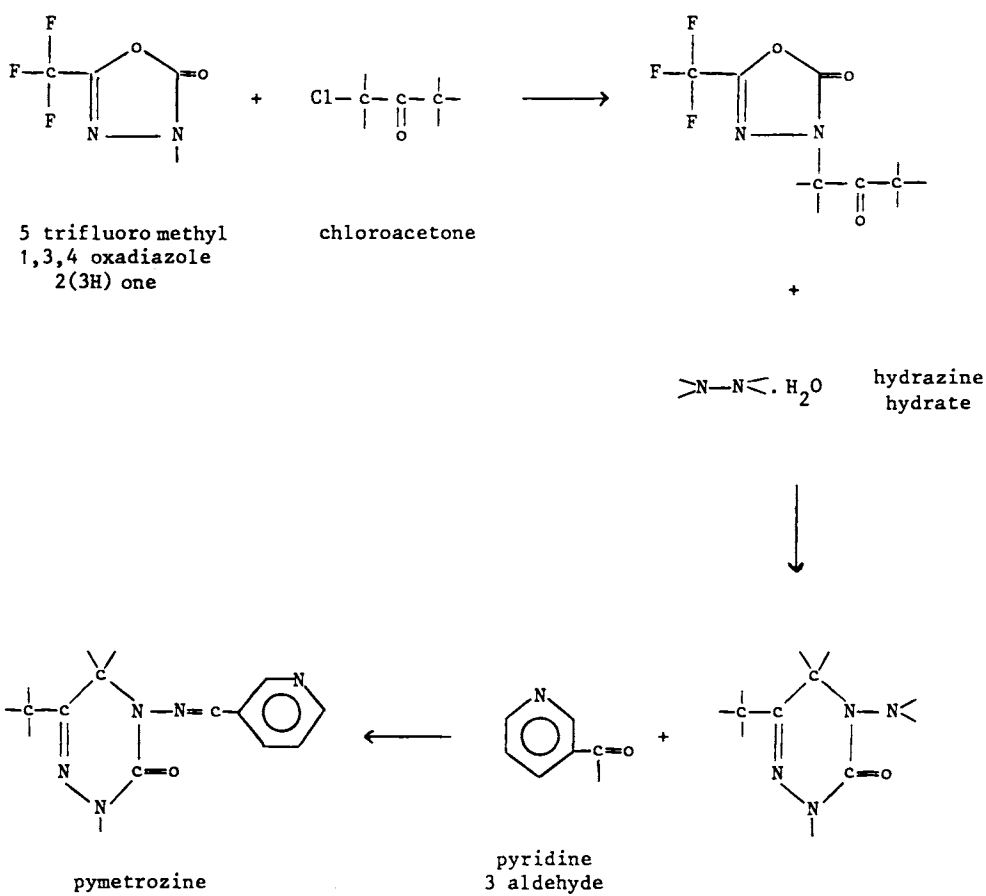
## Pymetrozine

Uses: insecticide, vegetables, ornamentals, cotton, citrus

Trade names: Chess (Ciba)

Type: triazine, pyridine

Synthesis:



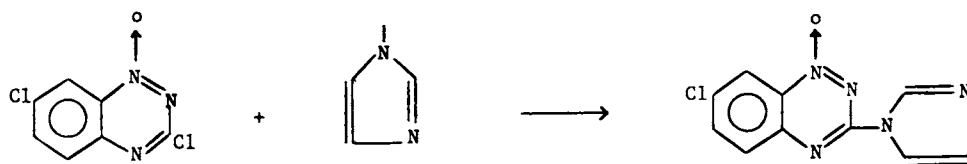
## Triazoxide

Uses: fungicide, seeds

Trade names: (Bayer)

Type: benzotriazine, imidazole

Synthesis:



3,7 dichloro  
1,2,4 benzo  
triazine 1 oxide

imidazole

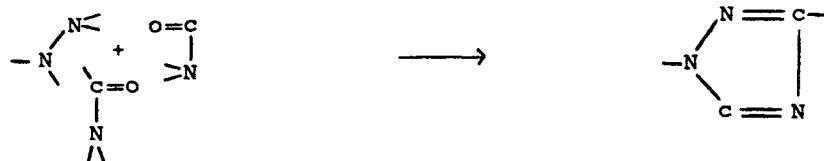
triazoxide

# TRIAZOLES

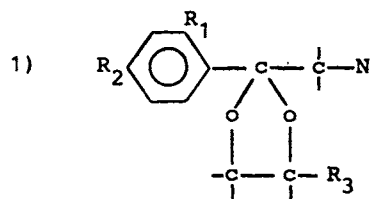
Triazole pesticides are made by reaction between 1,2,4 triazole and a halo-compound



1,2,4 triazole is synthesized from formamide and hydrazine



There are 4 most common structures for triazole pesticides



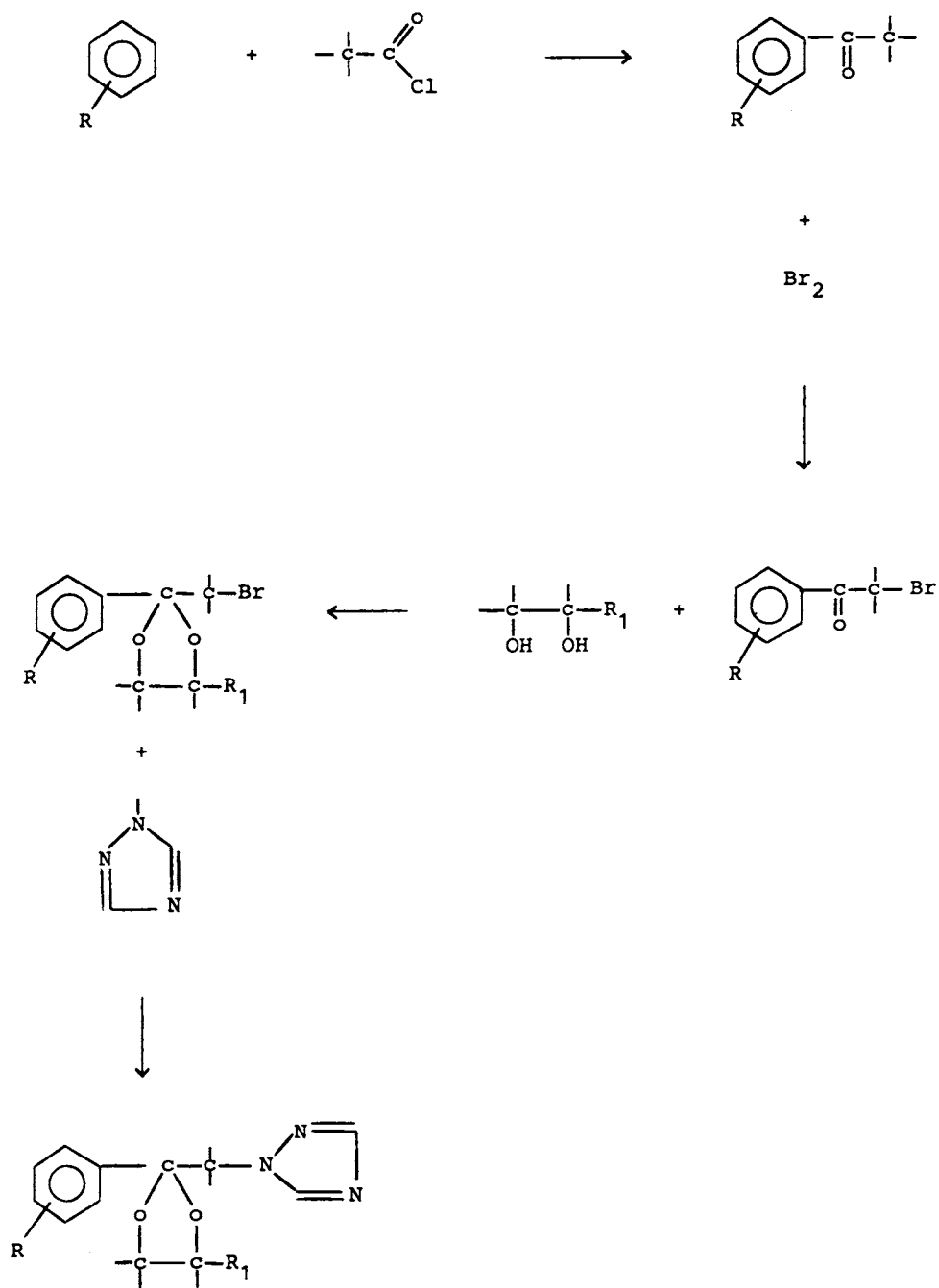
azaconazole

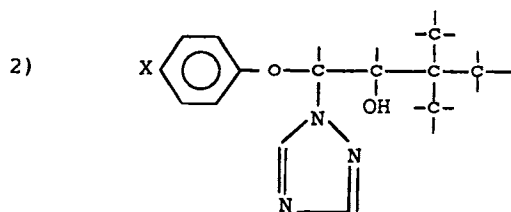
difenoconazole

etaconazole

propiconazole

The synthesis follows the route





X is usually Cl but may also be another radical  
OH may also be =O

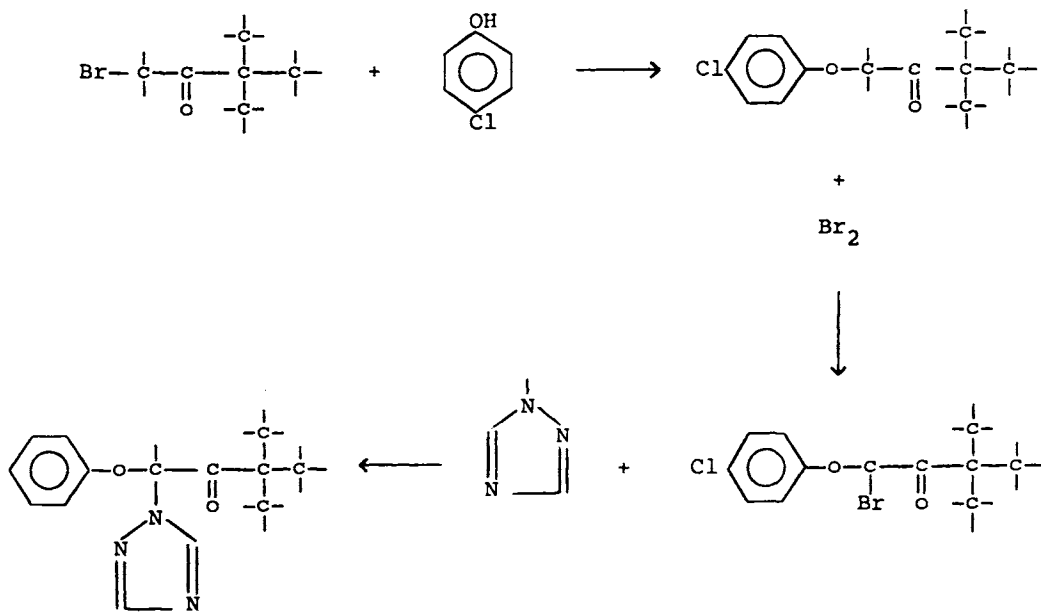
Examples of this structure are

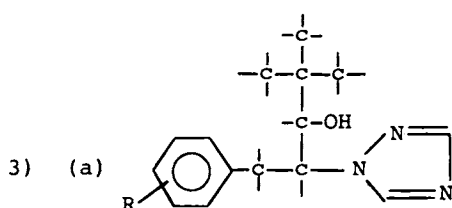
bitertanol

triadimefon

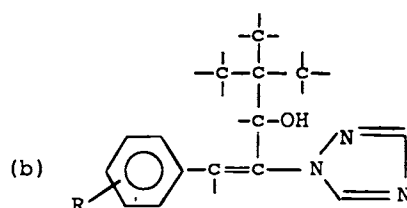
triadimenol

The synthesis route is by reaction of bromopinacolone with  
p.chloro phenol, followed by bromination and reaction with  
triazole



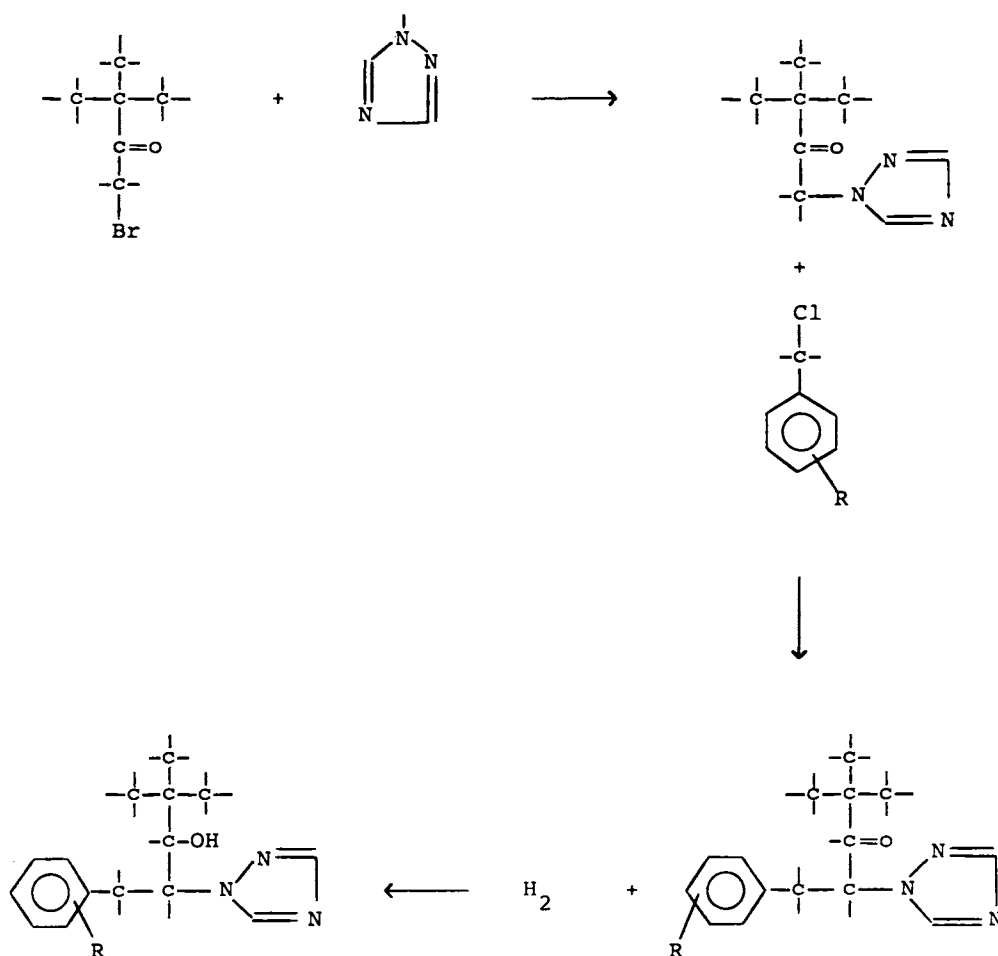


diclobutrazol  
paclobutrazol



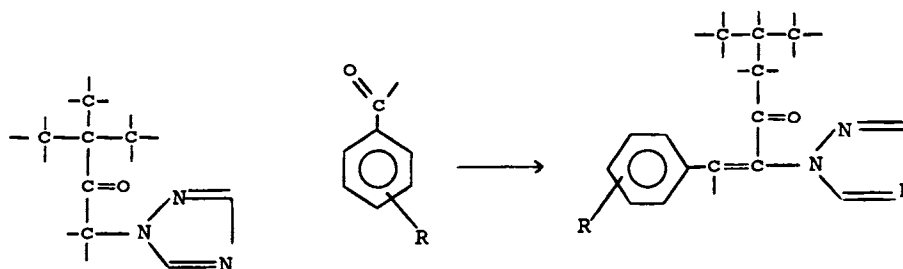
diniconazole  
triapenthanol  
uniconazole

The synthesis route for (a) starts with the reaction between bromo pinacolone and triazole, followed by addition of a benzyl chloride derivate and hydrogenation of the carbonyl



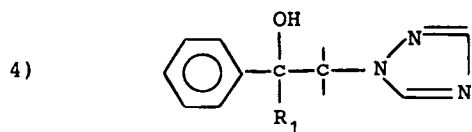
The synthesis route for (b) is similar to (a) but using a benzaldehyde derivate instead of benzyl chloride.

The second step is thus



followed by reduction of the carbonyl.



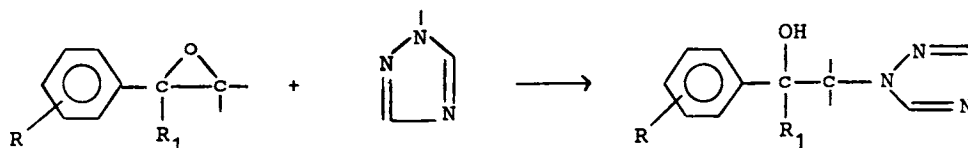


cyproconazole

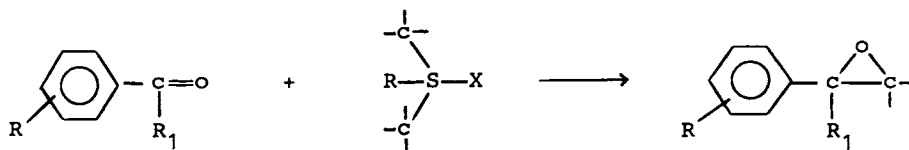
hexaconazole

tebuconazole

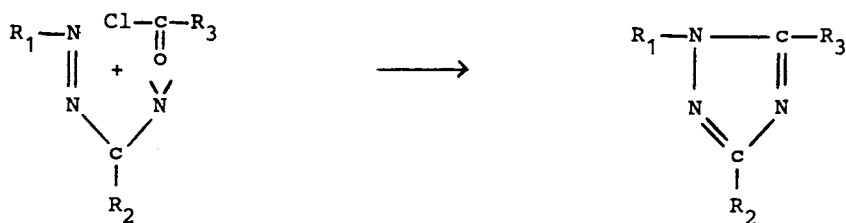
The synthesis route is by reaction between the oxirane and triazole



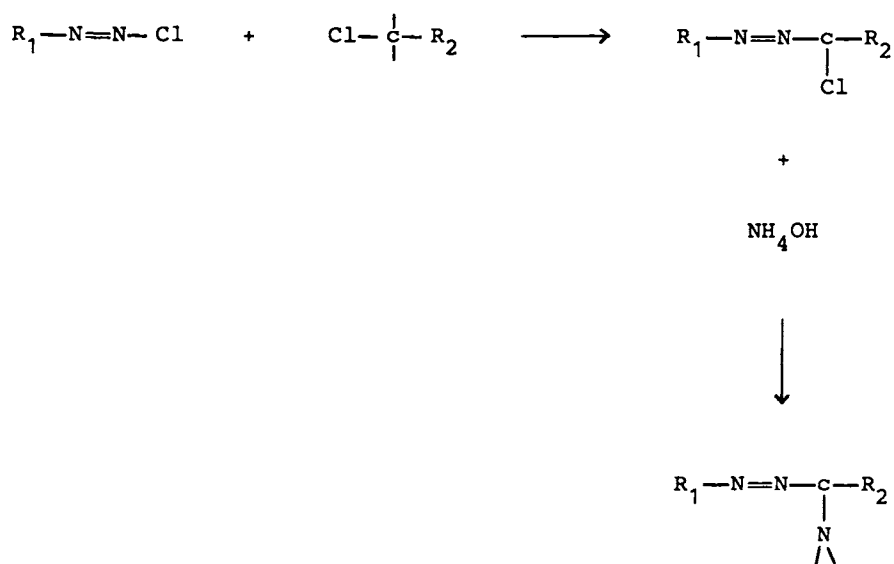
The oxirane is obtained by action of a methyl sulfonium ion in an oxidising medium on the ketone



An unusual route to triazole pesticide synthesis is by cyclisation of the triazole ring as a synthesis step, by reaction between an  $\alpha$  amine hydrazone derivate and an acid chloride



The  $\alpha$  amino hydrazone compound is obtained from the diazonium salt



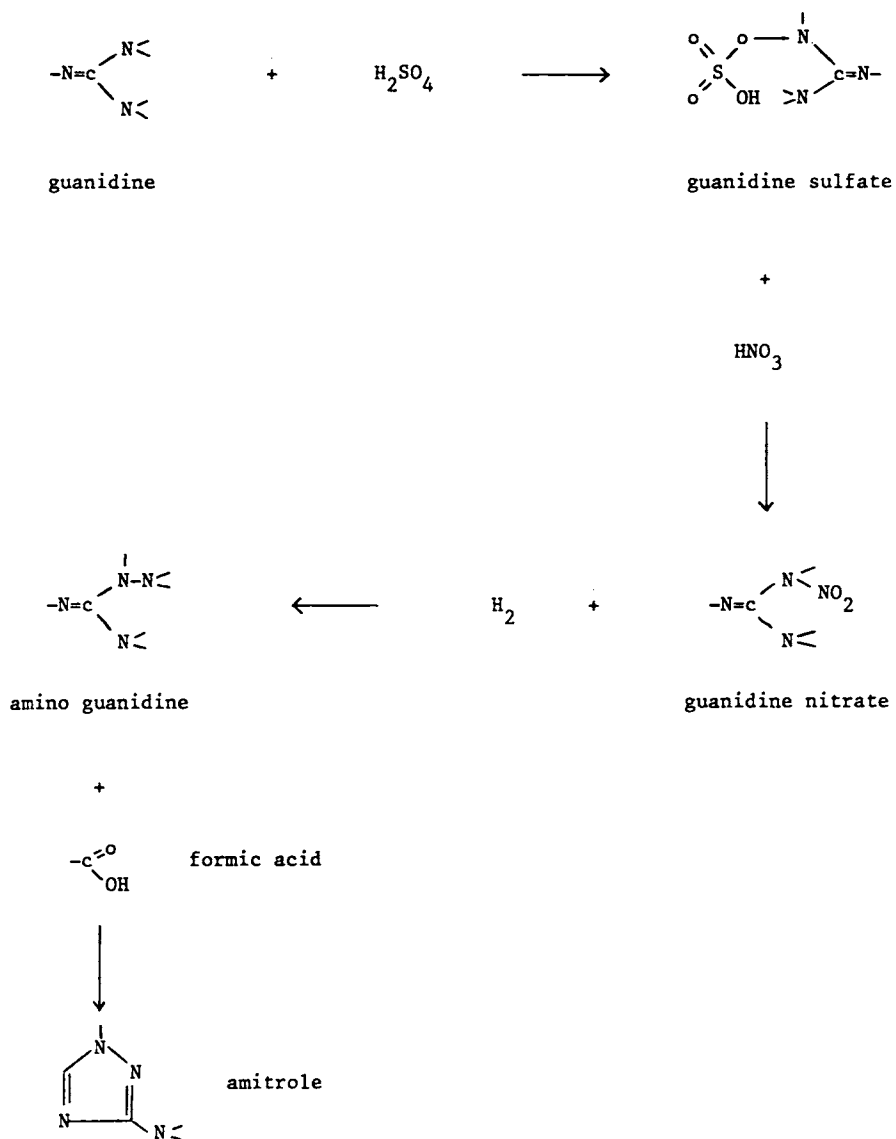
## Amitrole

Uses: herbicide, maize, potatoes, wheat

Trade names: Weedazol (Rhone Poulenc)

Type: triazole

Synthesis:



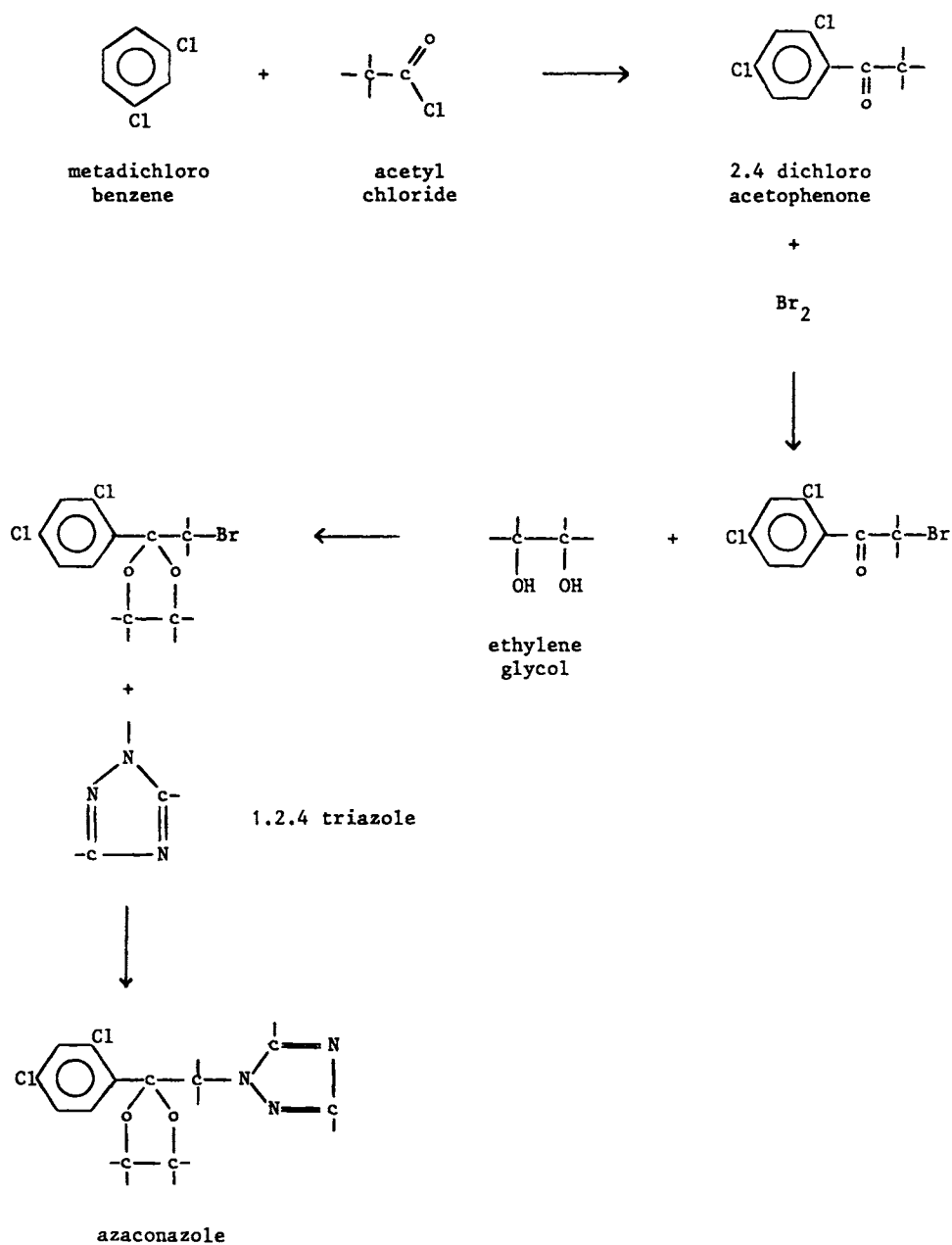
## Azaconazole

Uses: fungicide, wood, fruit, vegetables

Trade names: Rodewood, Safetroy (Janssen)

Type: triazole

Synthesis:



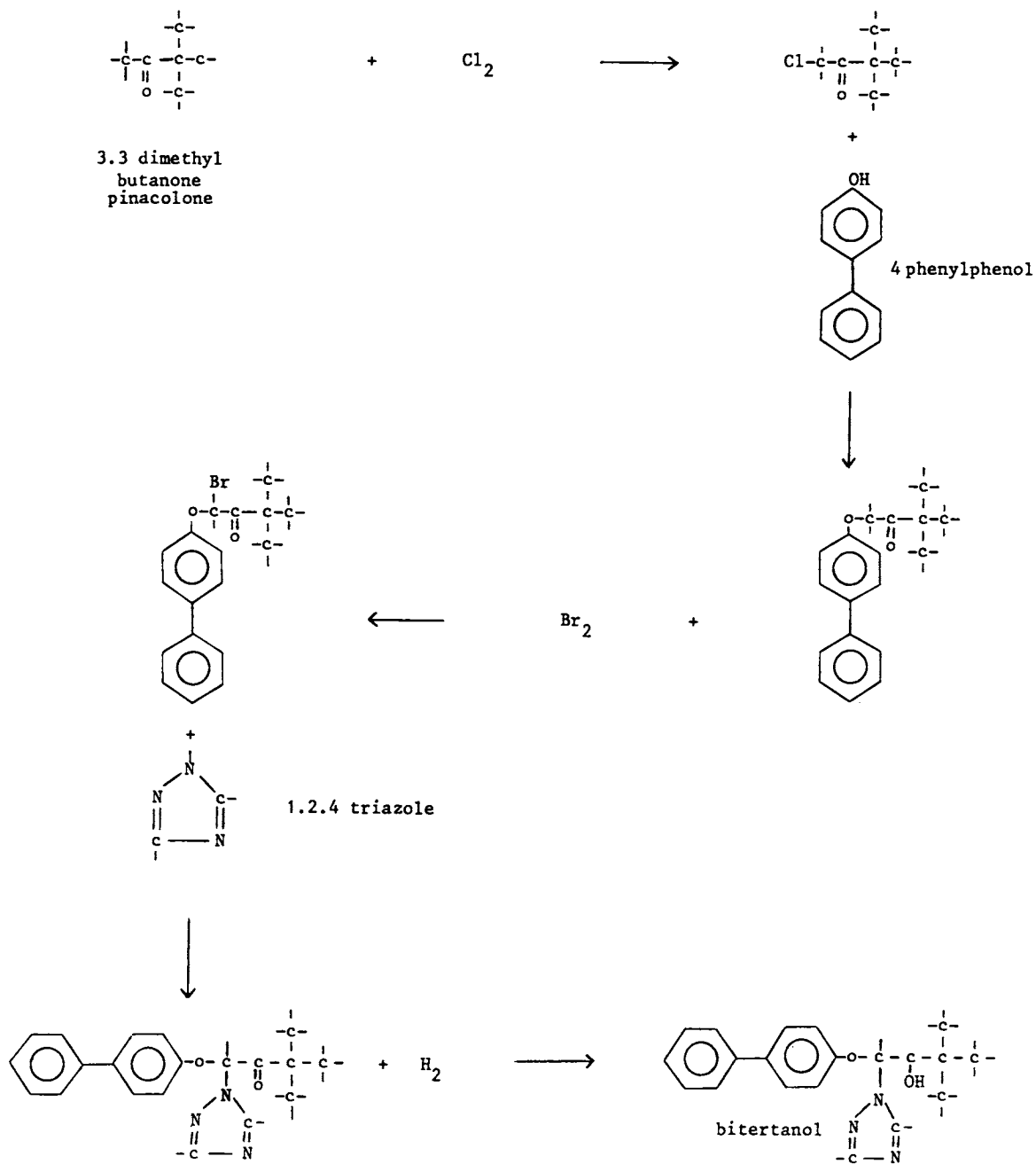
## Bitertanol

Uses: fungicide, bananas, groundnuts

Trade names: Baycor (Bayer)

Type: triazole

Synthesis:



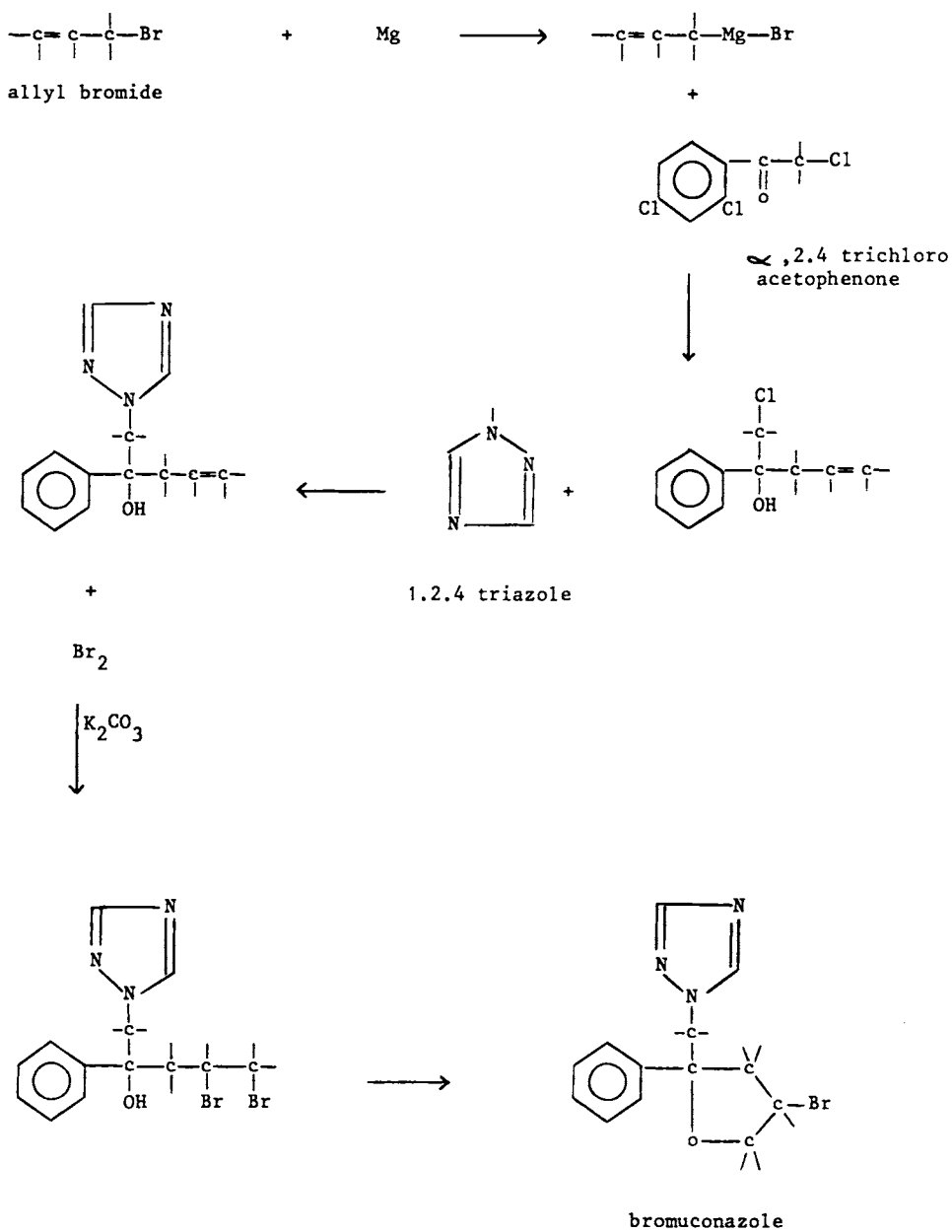
## Bromuconazole

Uses: fungicide, bananas, cereals, grape, rice, fruit, vegetables, turf

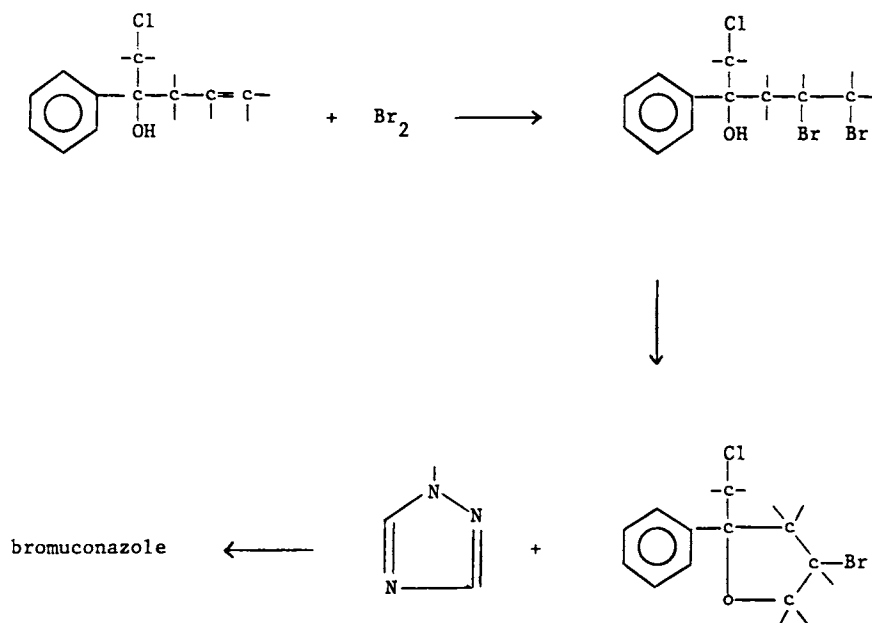
Trade names: Granit, Vectra (Rhone Poulenc)

Type: triazole, furan

**Synthesis:**



alternate route :



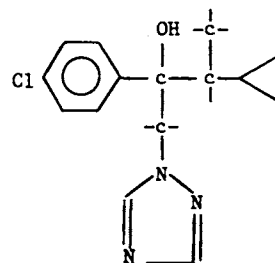
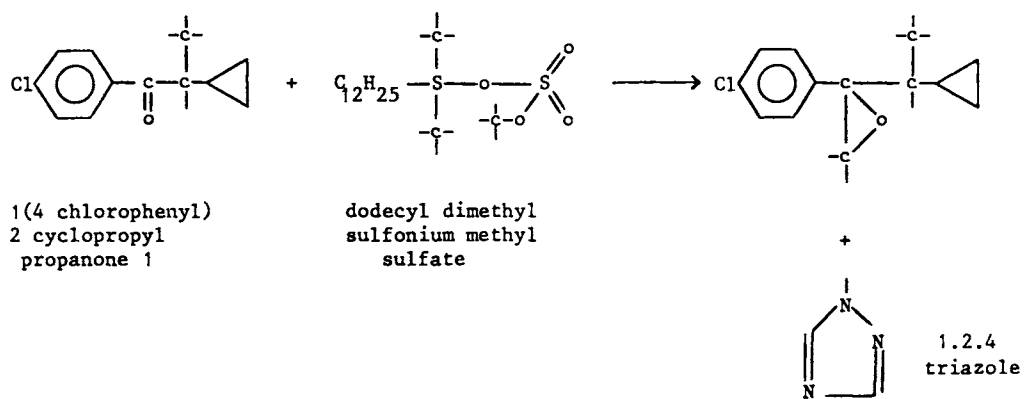
## Cyproconazole

Uses: fungicide, cereals, coffee, sugarbeet, fruit trees, vines

Trade names: Alto, Atemi, Biallor, Bialor (Sandoz)

Type: triazole

Synthesis:



cyproconazole



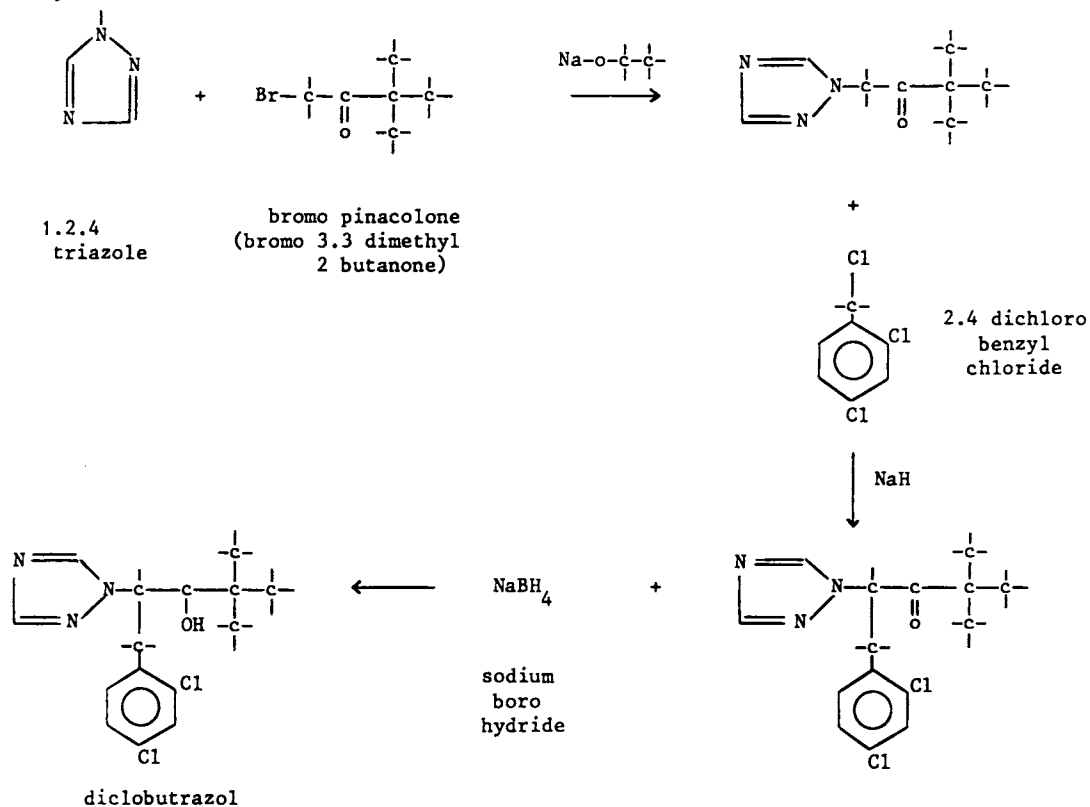
## Diclobutrazol

Uses: fungicide, cereals, coffee

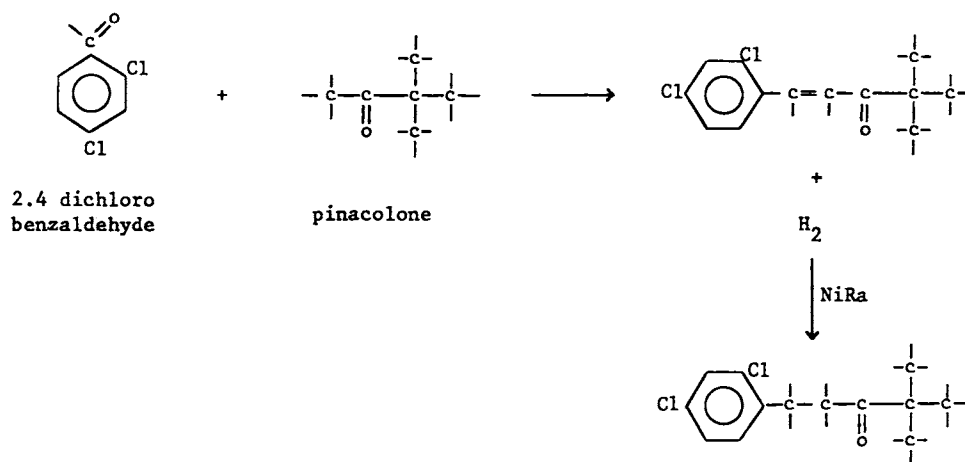
Trade names: Vigil (ICI)

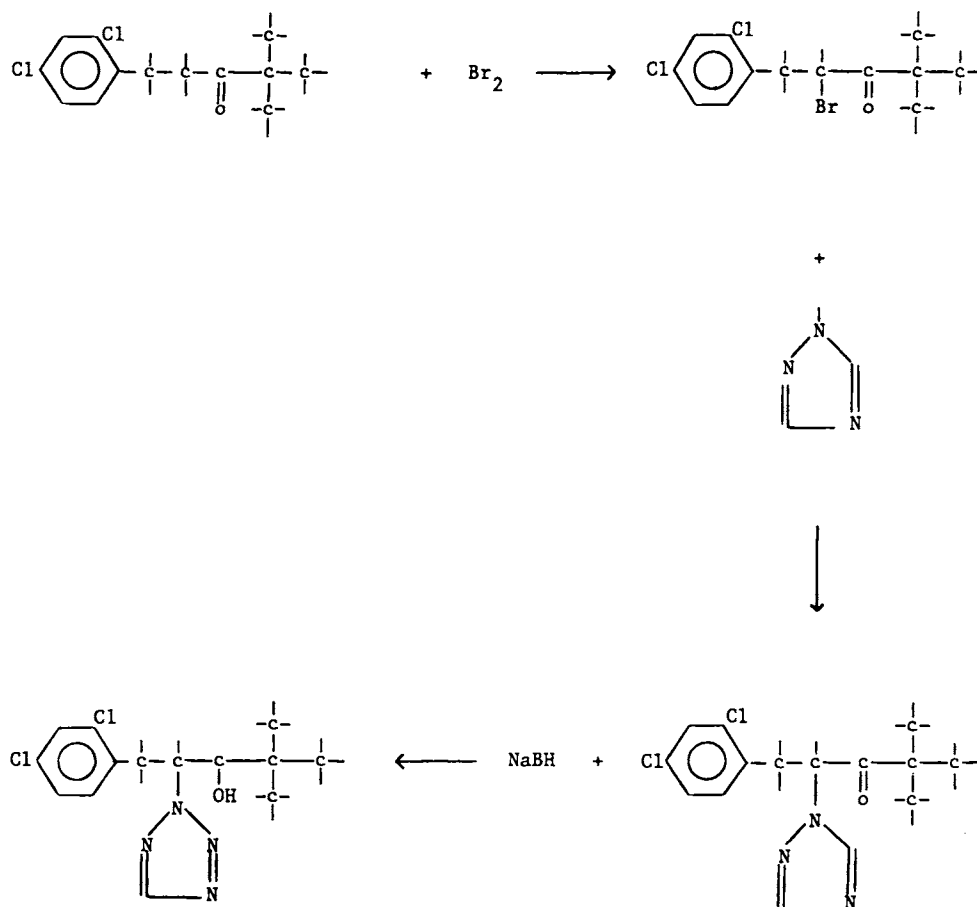
Type: triazole

Synthesis:



alternate route:





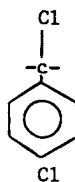
## Paclobutrazol

Uses: growth regulator, ornamentals, fruit trees

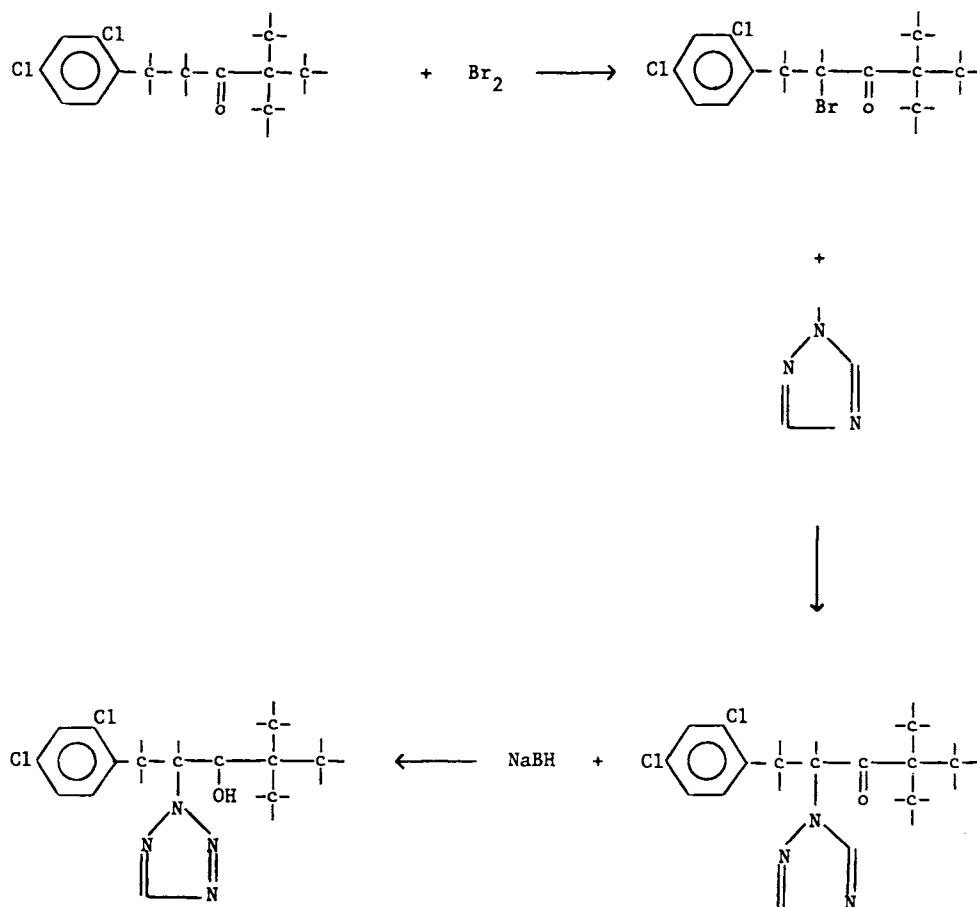
Trade names: Bonzo, Clipper, Cultar, Parlay (ICI)

Type: triazole

Same as DICLOBUTRAZOL with



p.chloro  
benzyl  
chloride



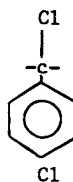
## Paclobutrazol

Uses: growth regulator, ornamentals, fruit trees

Trade names: Bonzo, Clipper, Cultar, Parlay (ICI)

Type: triazole

Same as DICLOBUTRAZOL with



p.chloro  
benzyl  
chloride

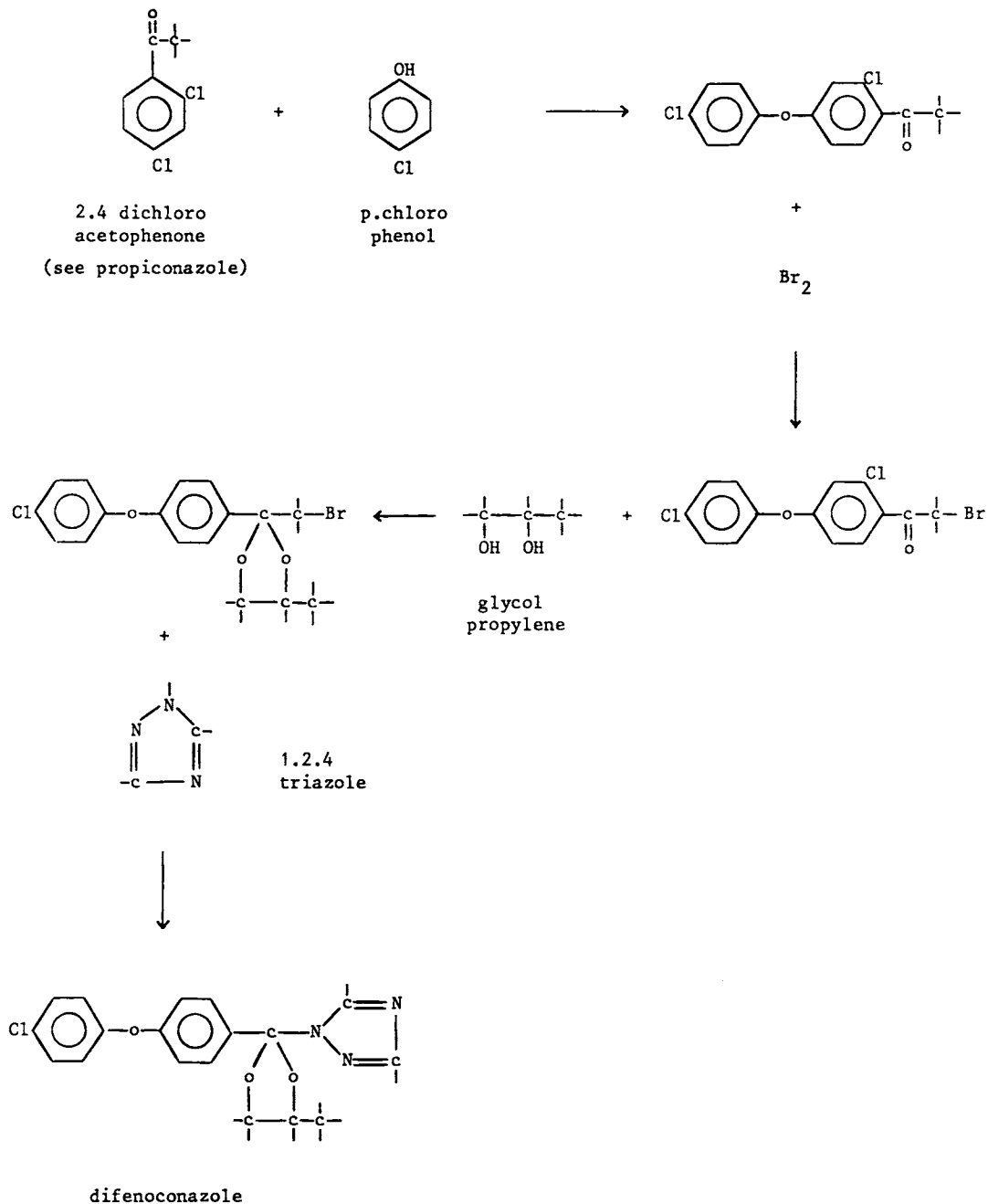
## Difenoconazole

Uses: fungicide, potatoes, wheat, vegetables, peanuts, seeds

Trade names: Geyser, Score (Ciba)

Type: triazole

Synthesis:



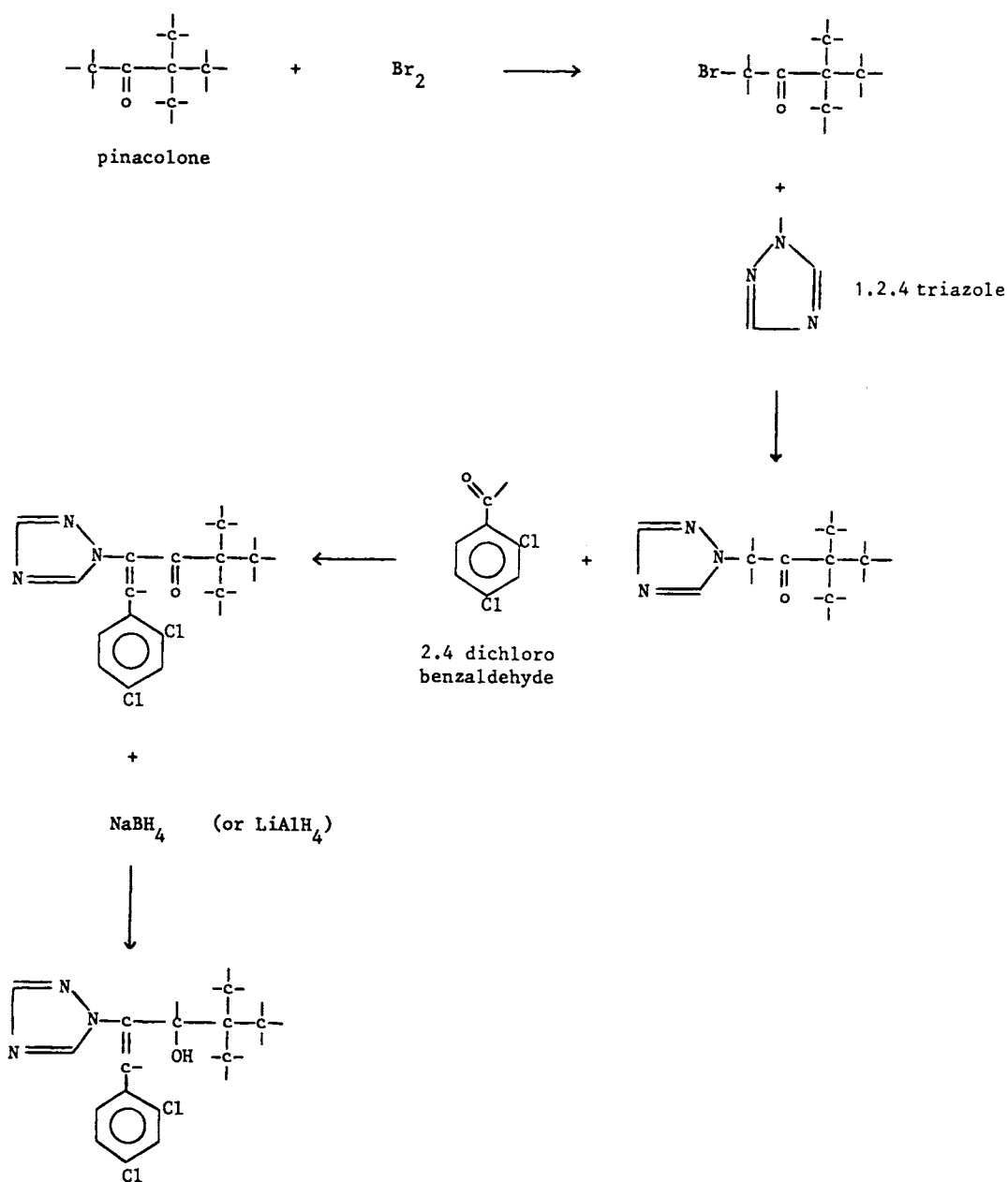
## Diniconazole

Uses: fungicide, grapes, cereals, coffee, bananas, peanuts, seeds

Trade names: Sumi-8, Sumi-Eight, Spotless (Sumitomo)

Type: triazole

Synthesis:



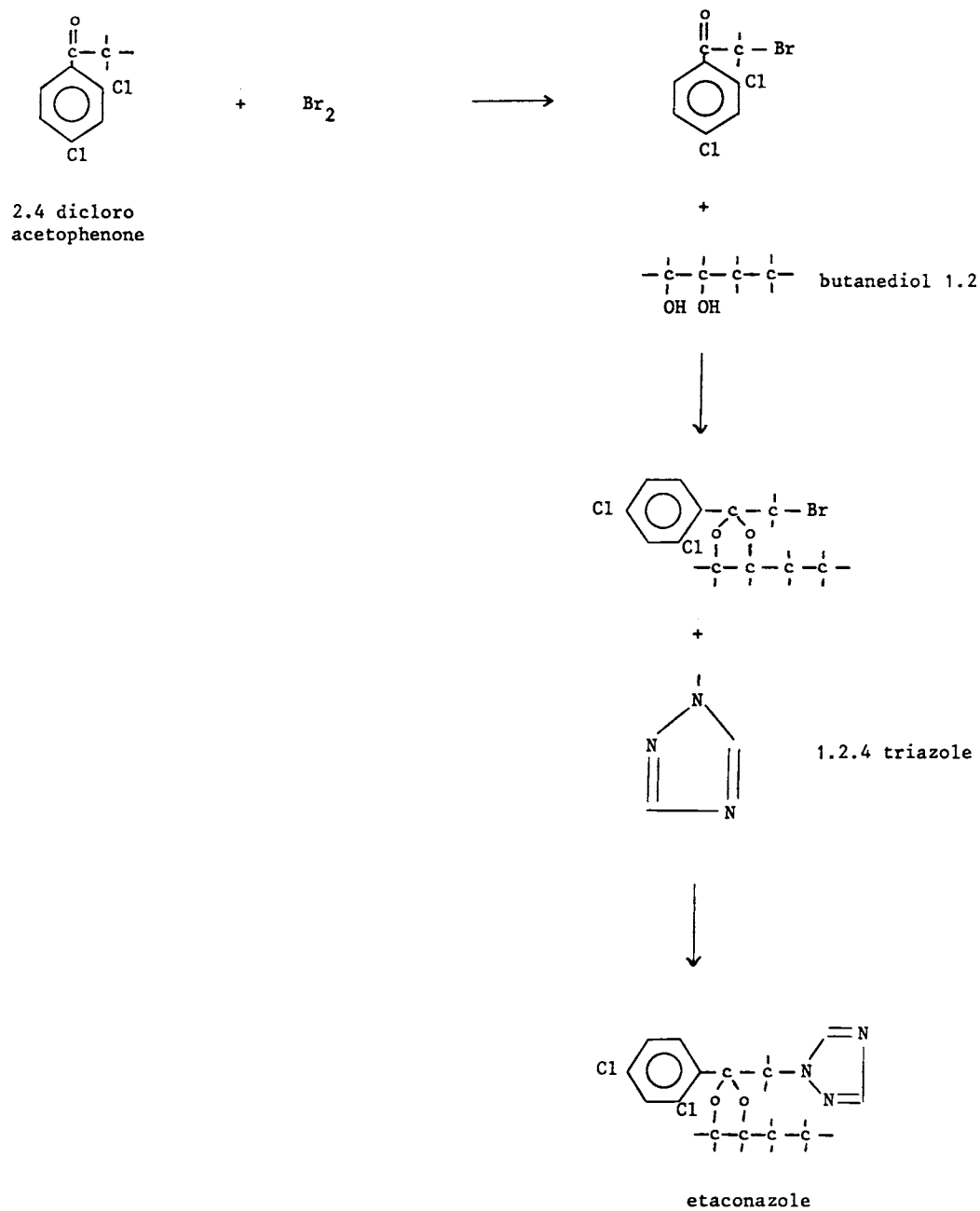
## Etaconazole

Uses: fungicide, cereals, seeds

Trade names: Benit, Sonax, Vanguard (Ciba)

Type: triazole

Synthesis:



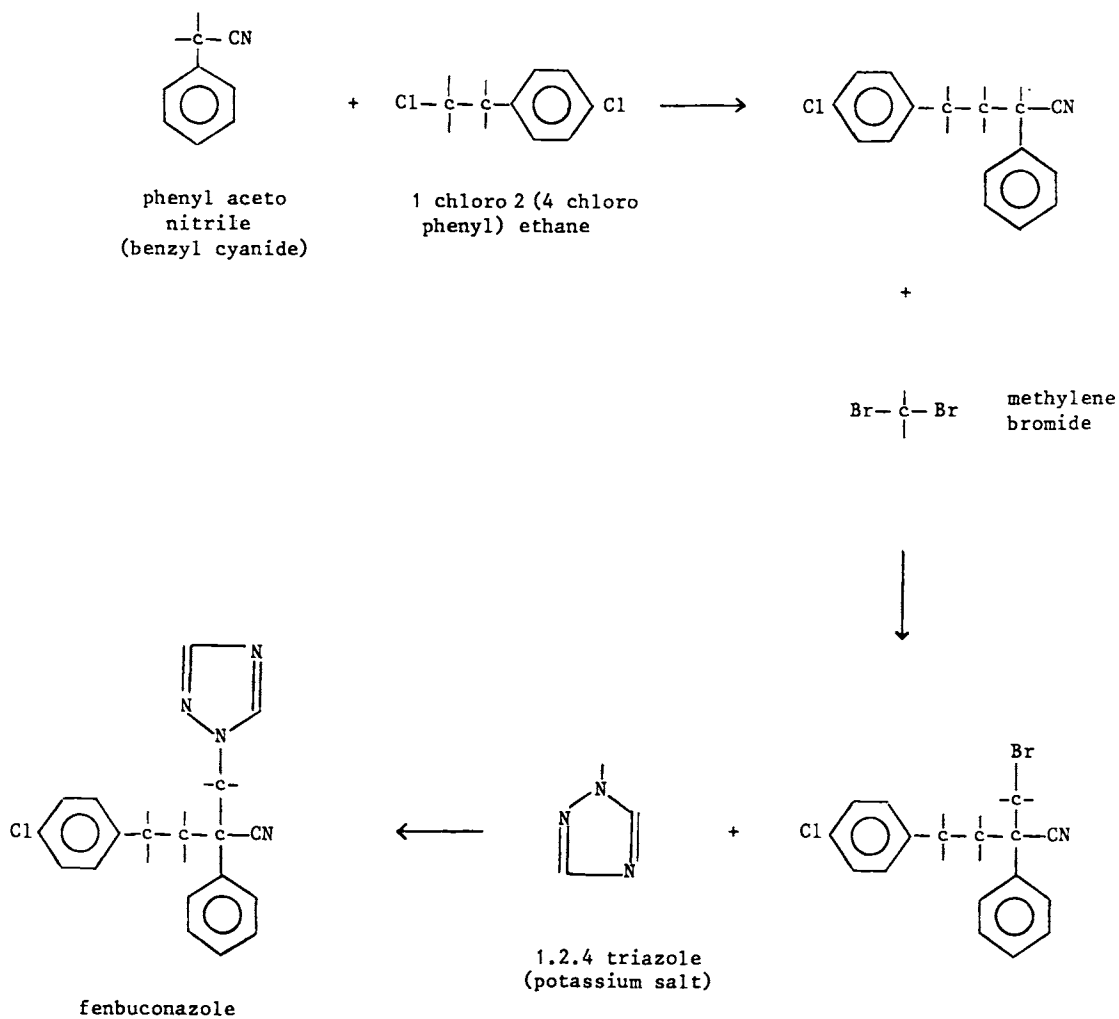
## Fenbuconazole

Uses: fungicide, cereals, beans, sugarbeet, rice, bananas, vegetables

Trade names: (Rohm & Haas)

Type: triazole

Synthesis:



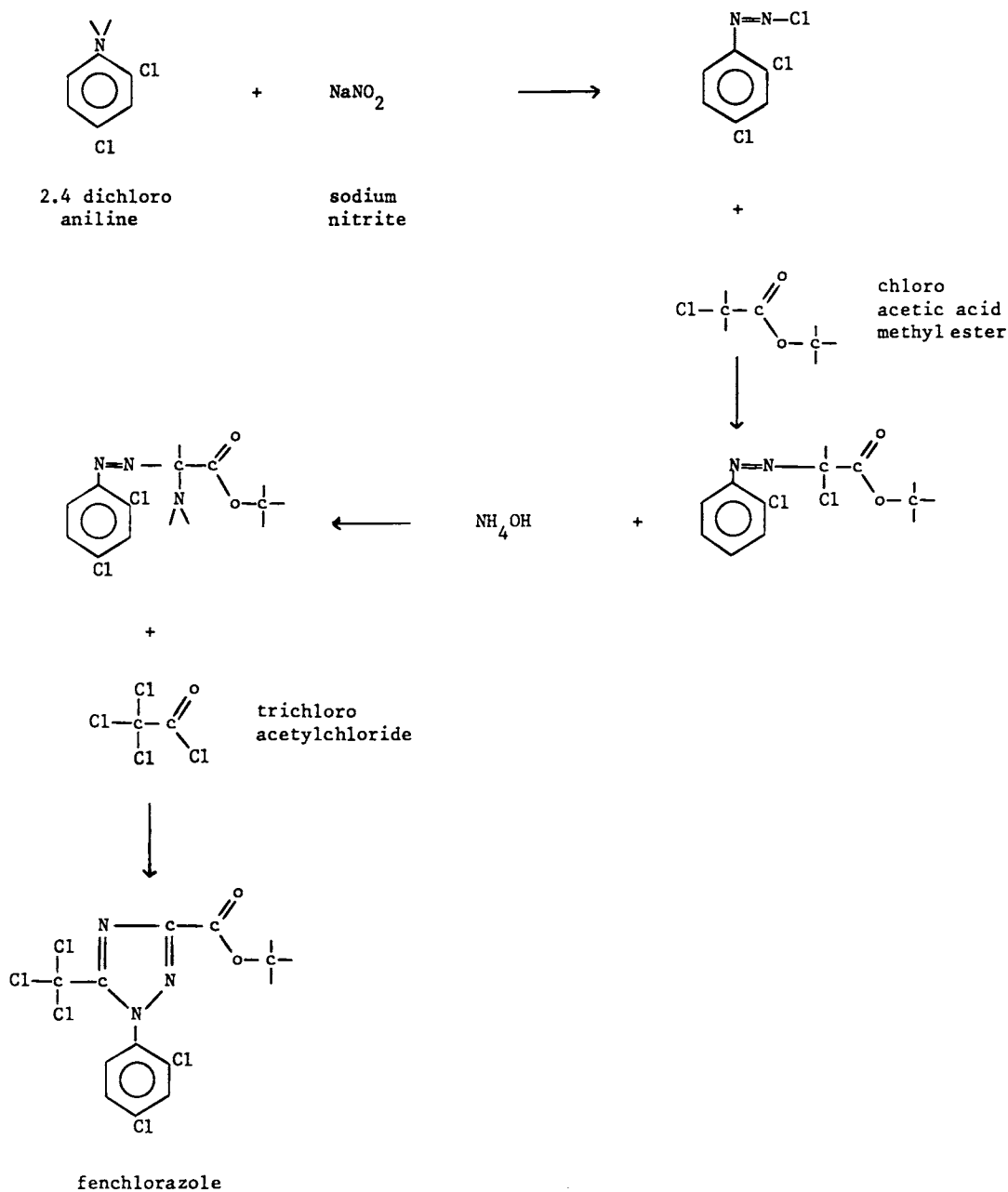
## Fenchlorazole

Uses: herbicide, safener, wheat, rye

Trade names: (AgrEvo)

Type: triazole

Synthesis:





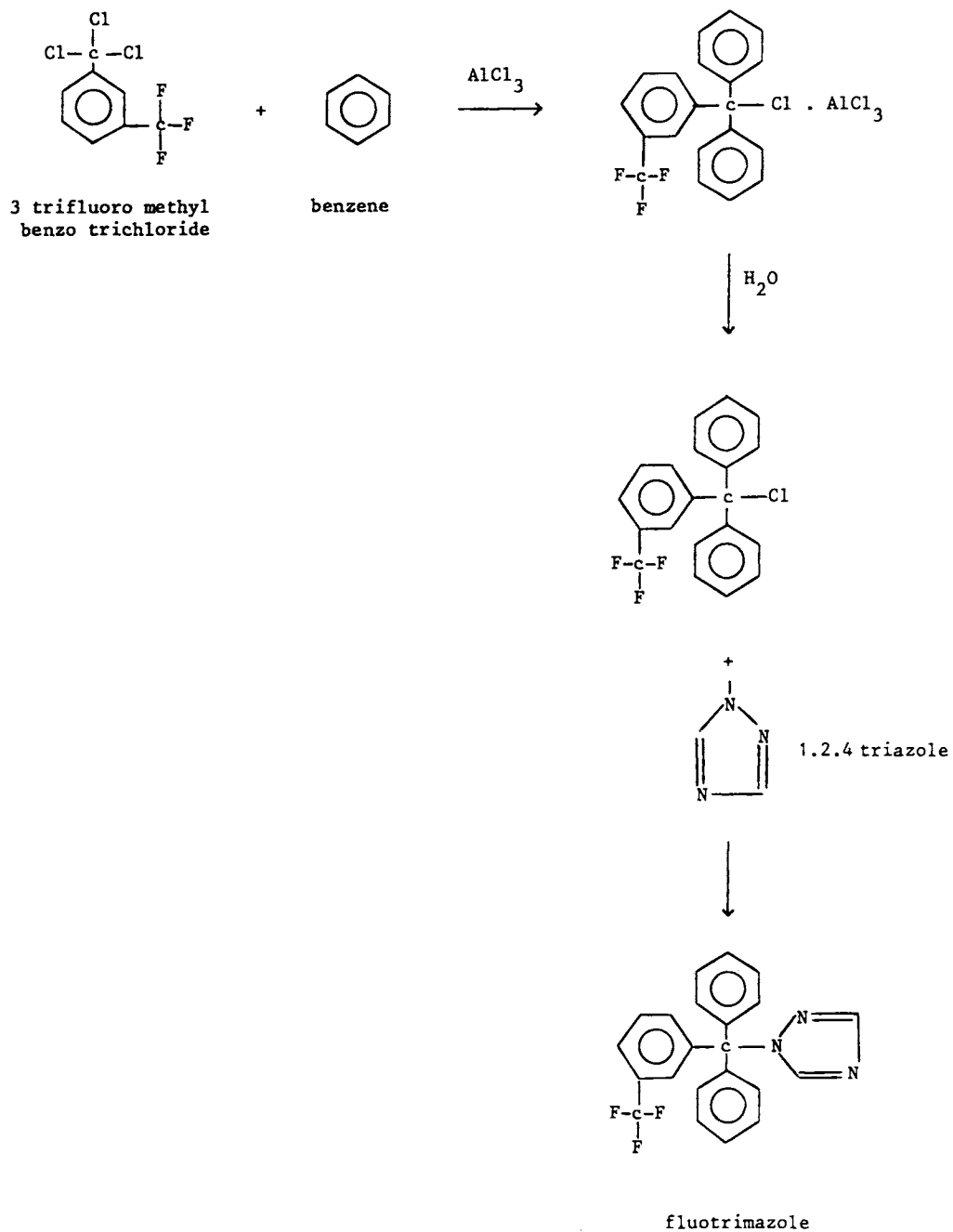
## Fluotrimazole

Uses: fungicide

Trade names: Persulon (Bayer)

Type: triazole

Synthesis:



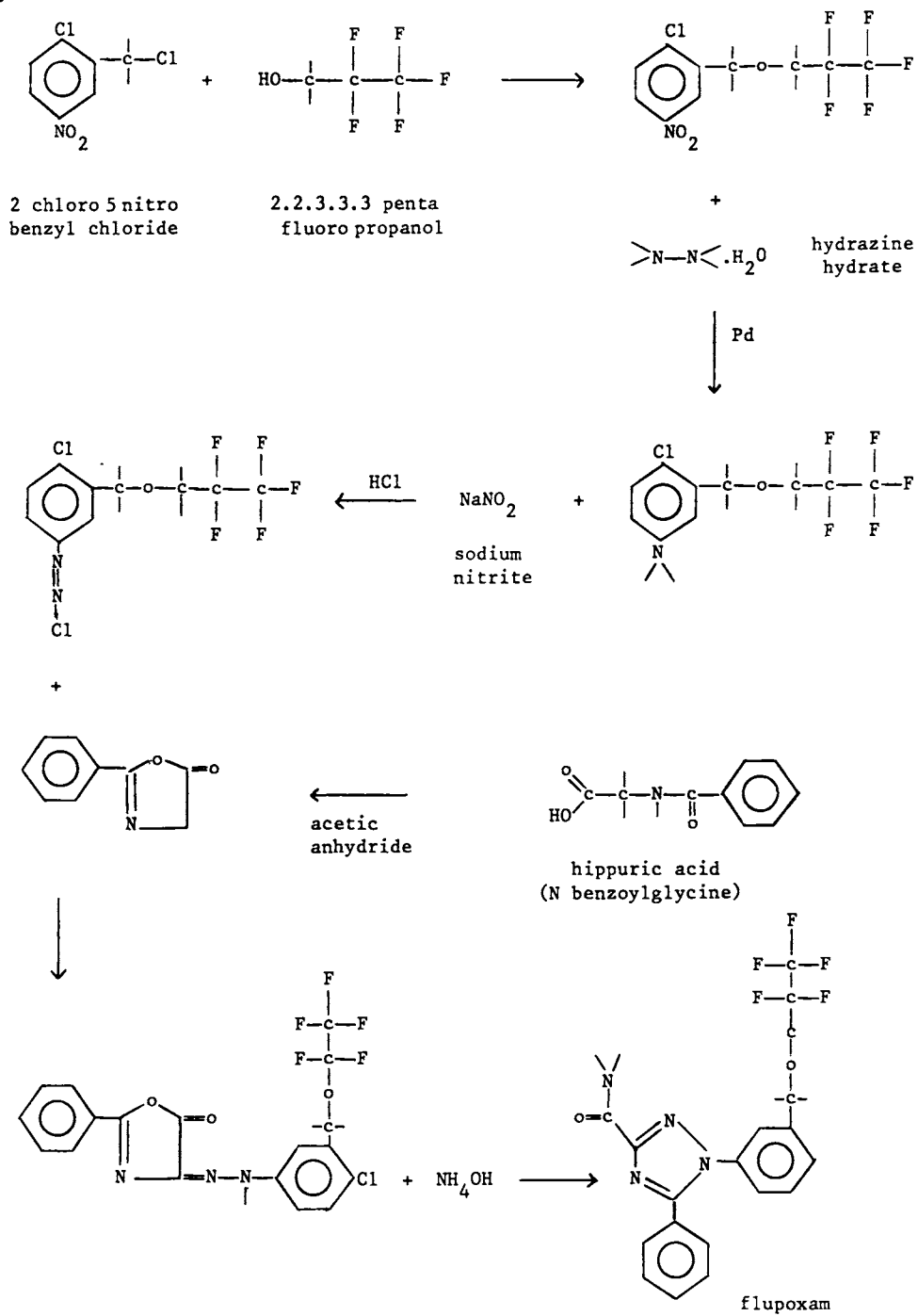
## Flupoxam

Uses: herbicide, wheat, barley

Trade names: Synexus (Kureka)

Type: triazole

Synthesis:



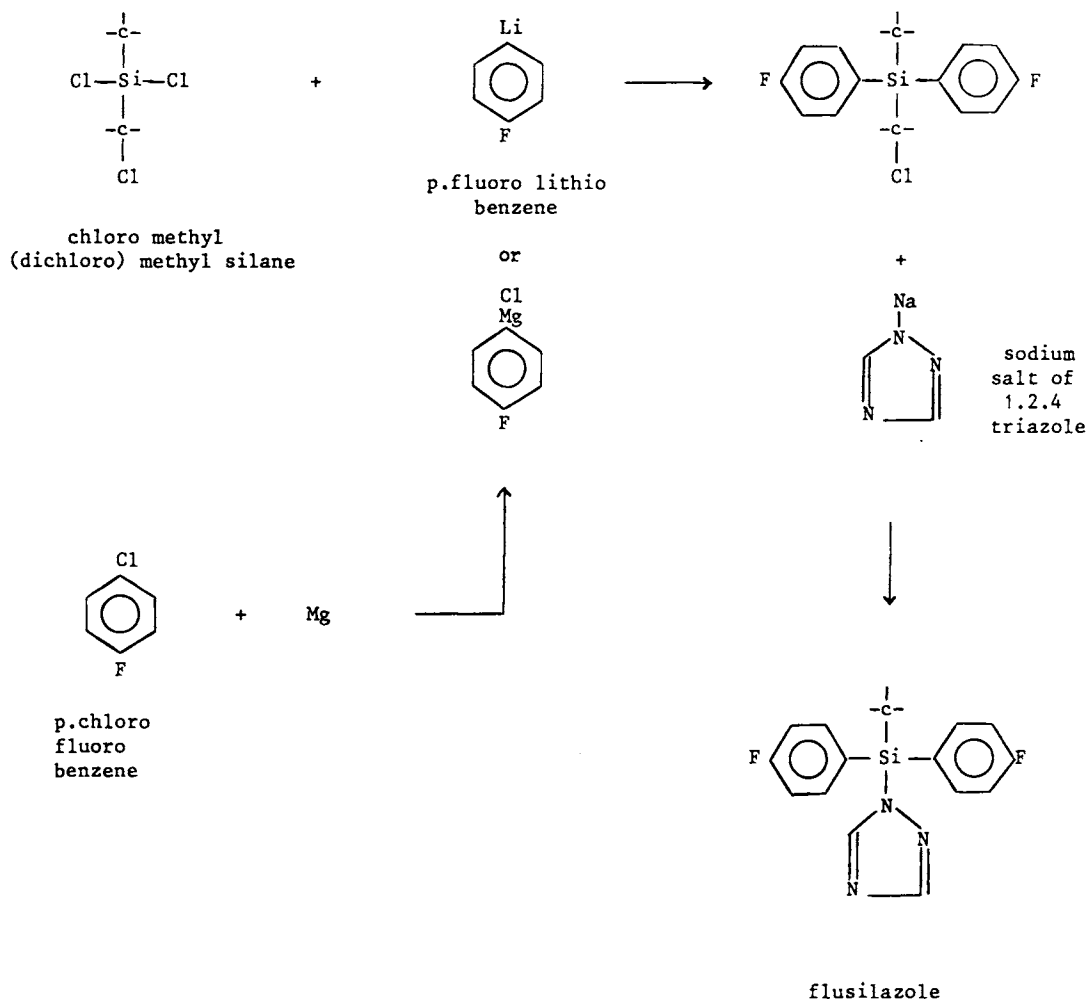
## Flusilazole

Uses: fungicide, cereals, sugarbeet, grapes

Trade names: Nustar, Olymp (Dupont)

Type: triazole

Synthesis:



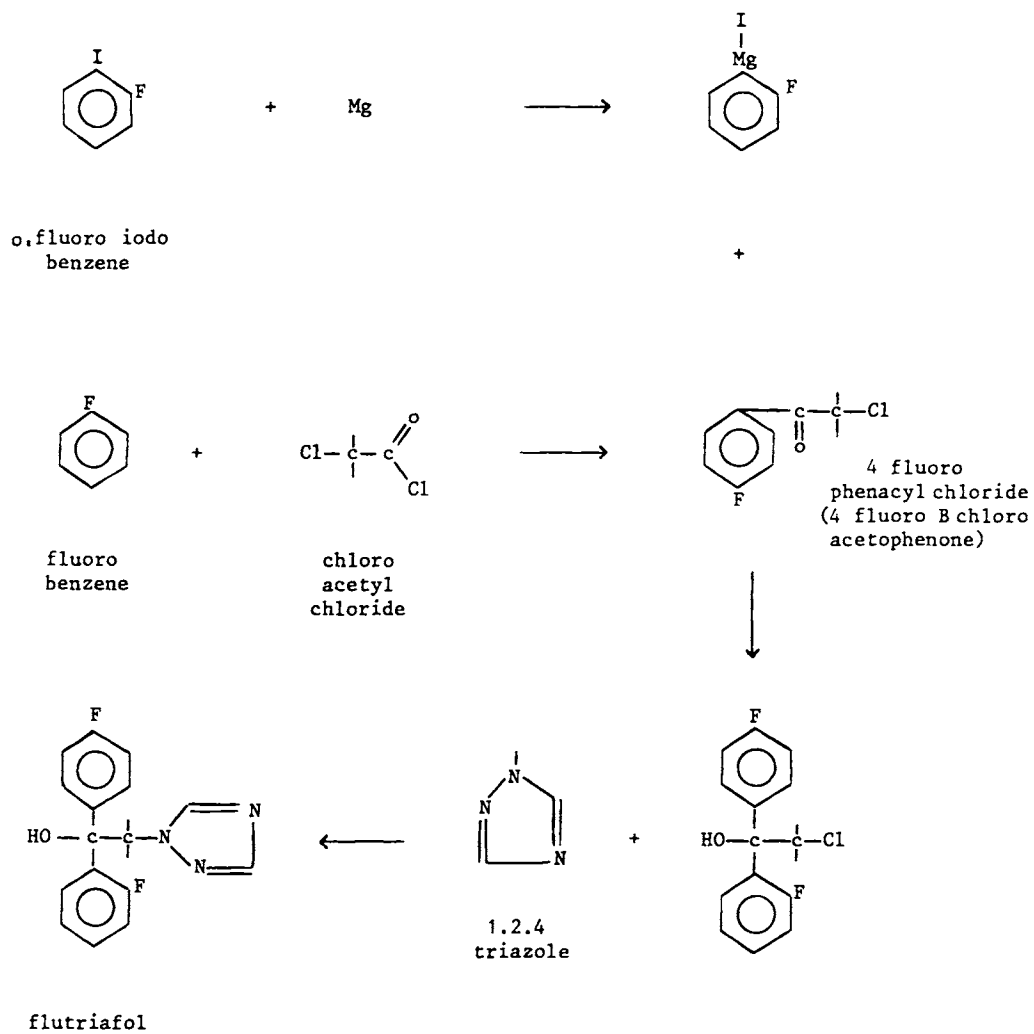
## Flutriafol

Uses: fungicide, cereals, seeds

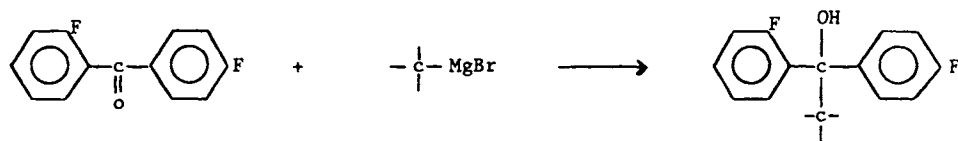
Trade names: Impact (ICI)

Type: triazole

Synthesis:

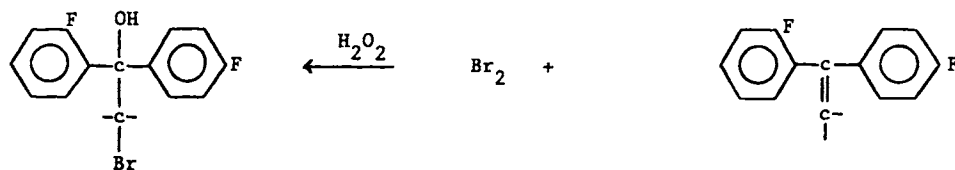


alternate route :

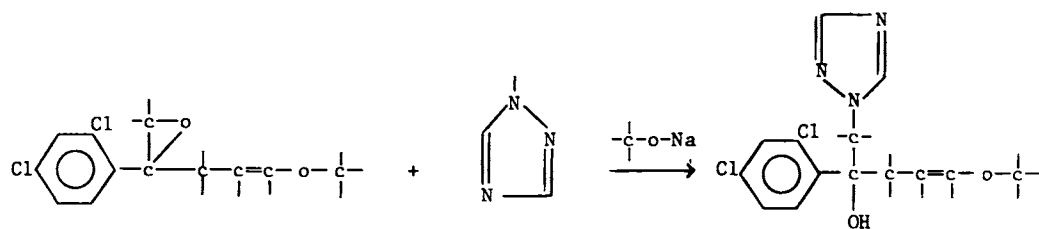


2 fluoro phenyl  
4 fluoro phenyl  
ketone

methyl  
magnesium  
bromide

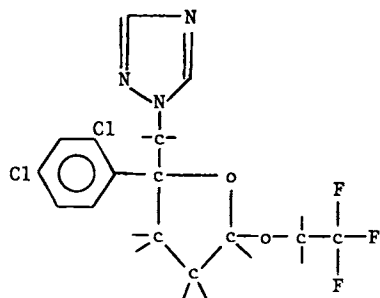
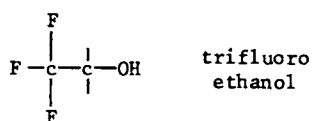
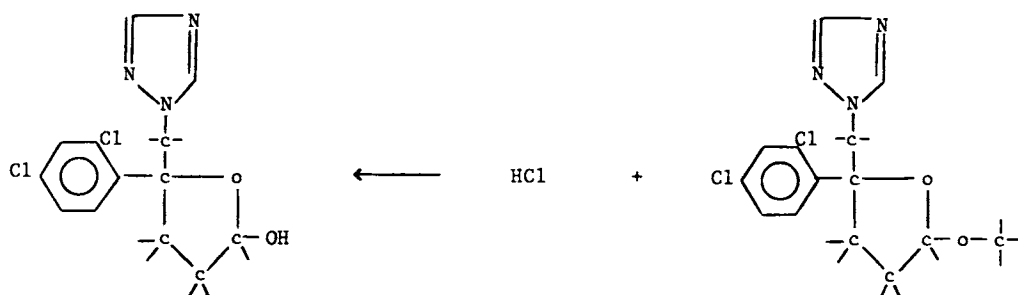






1,2,4 triazole

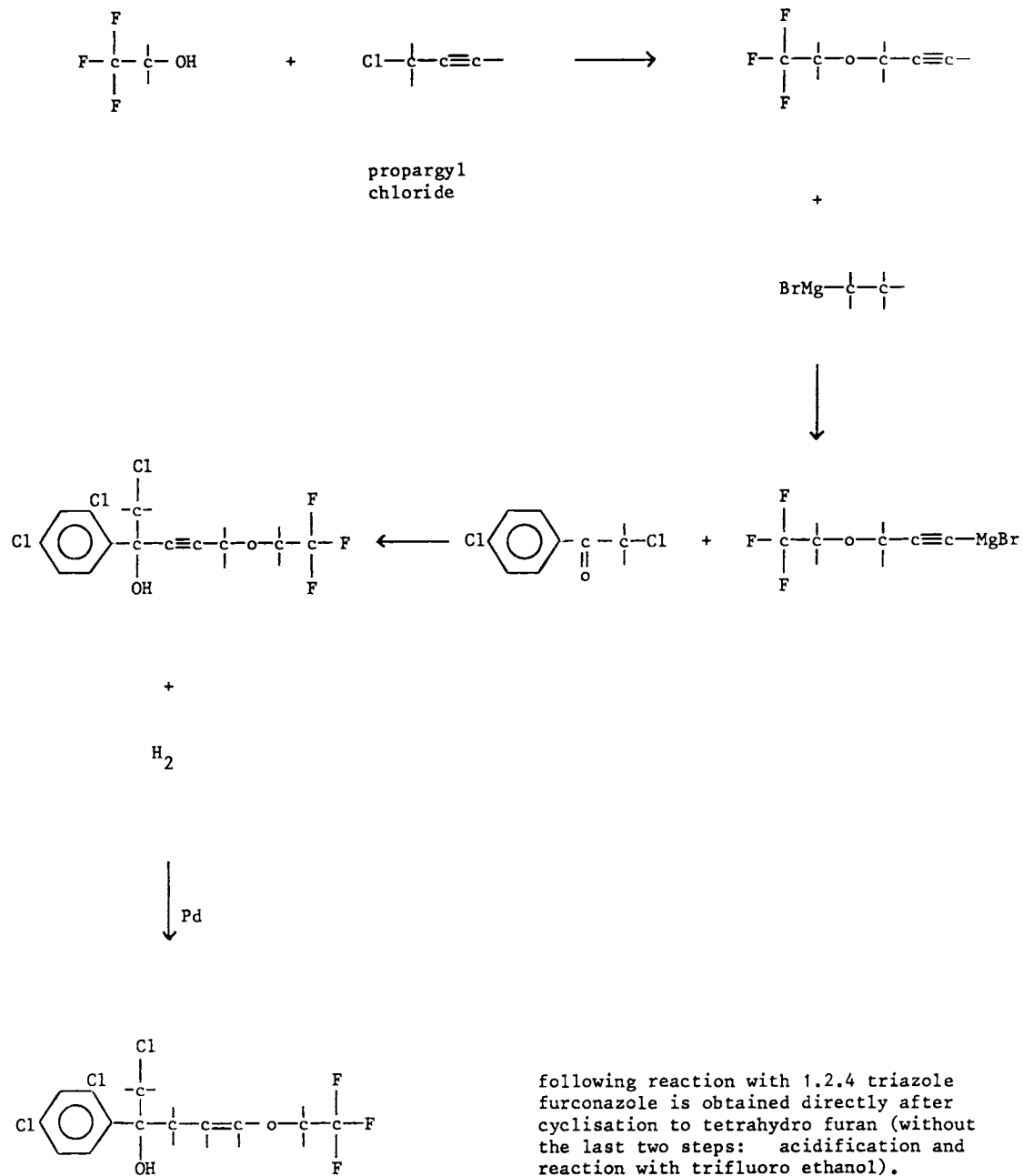
Ru  
p.toluene  
↓  
sulfonic acid



furconazole

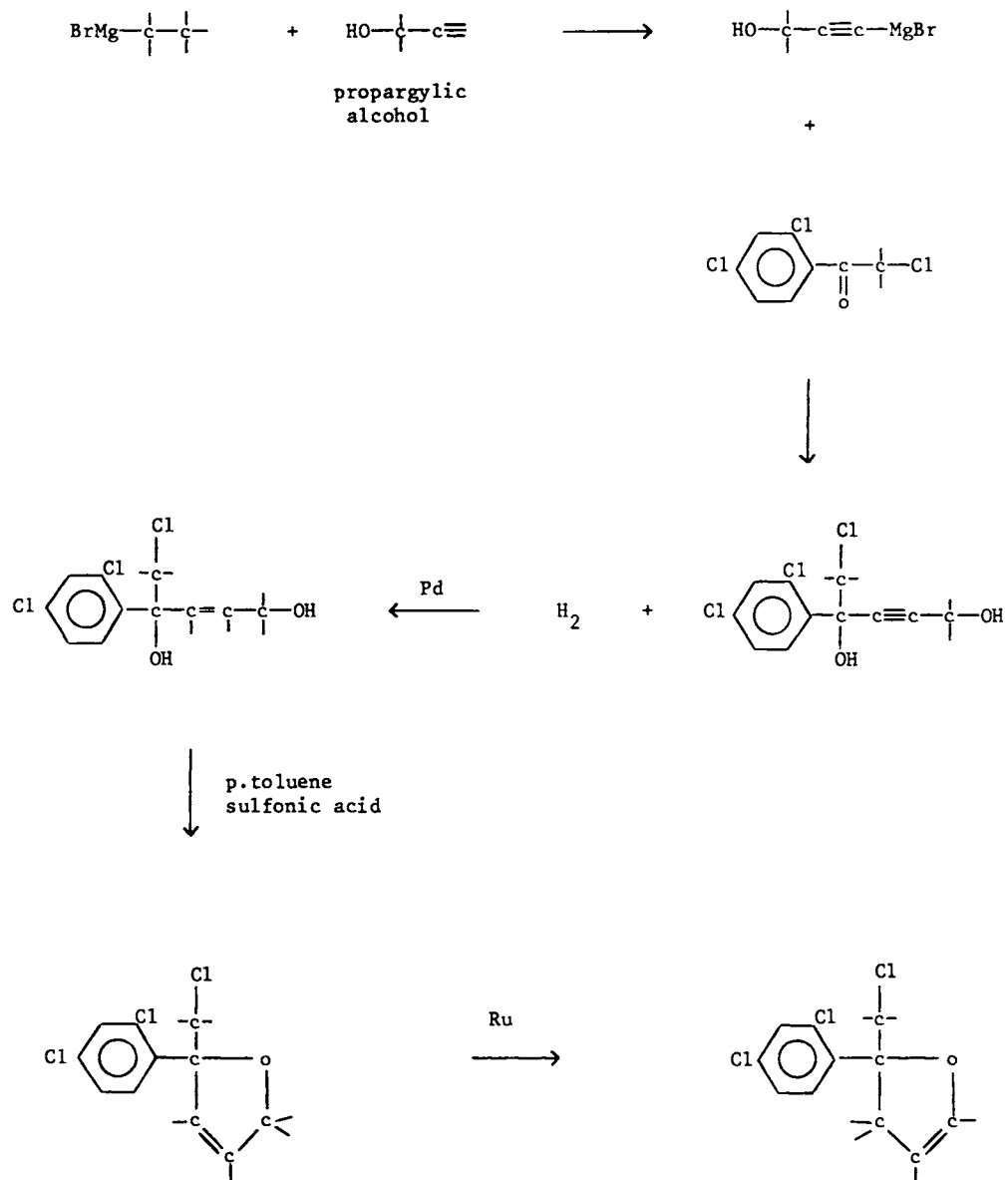
alternate routes :

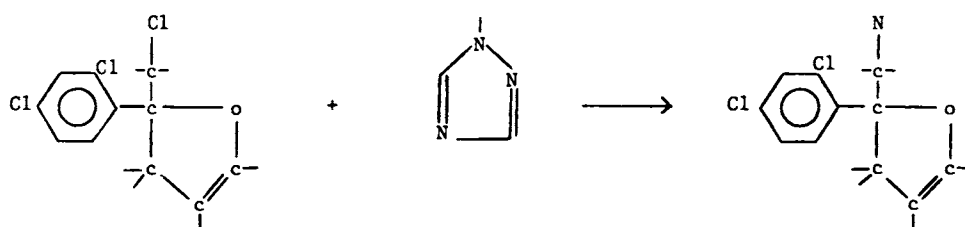
(i)



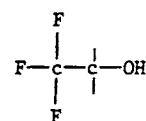


alternate route (ii) :





+



furconazole

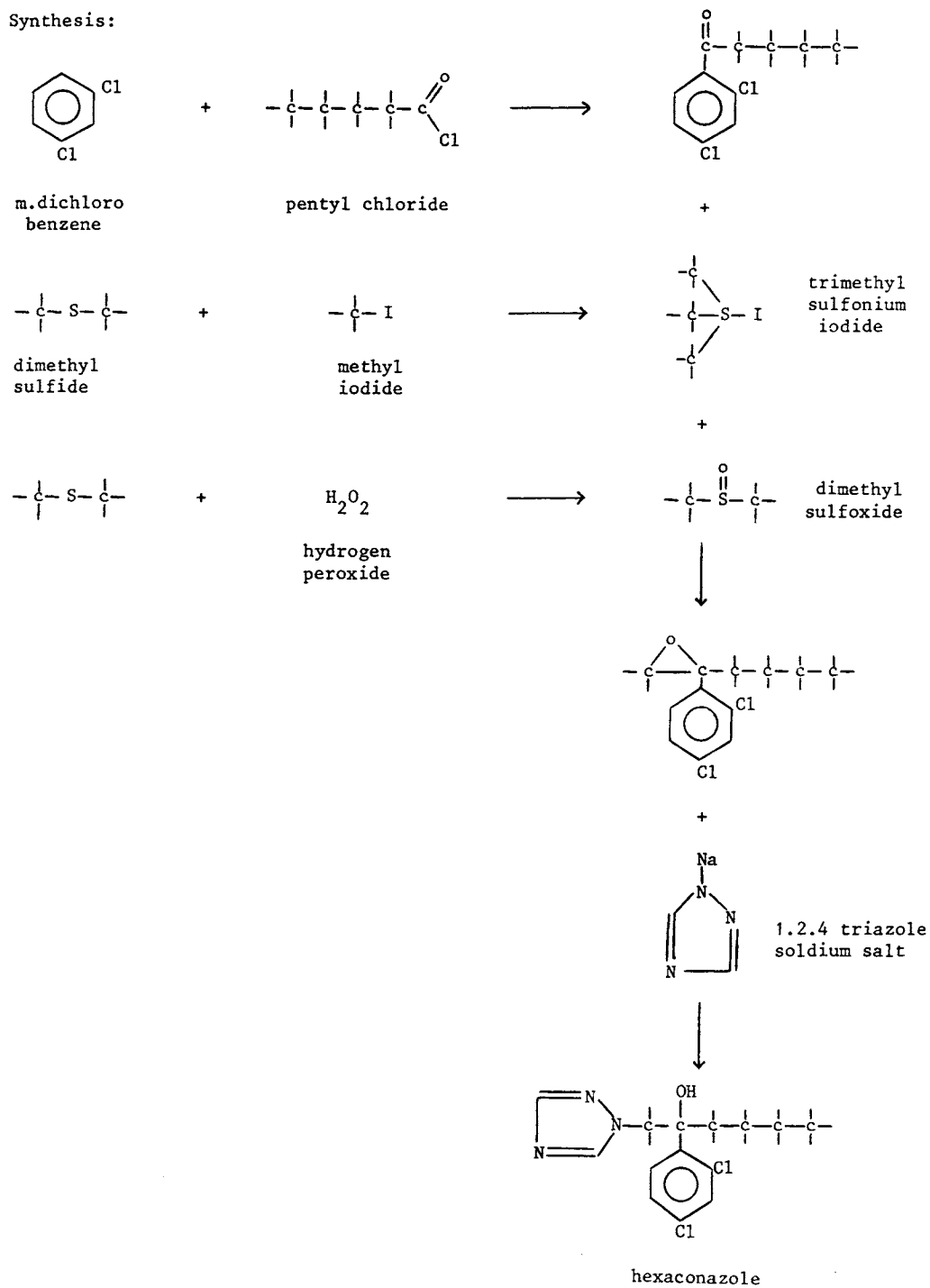
## Hexaconazole

Uses: fungicide, vines, coffee, peanuts

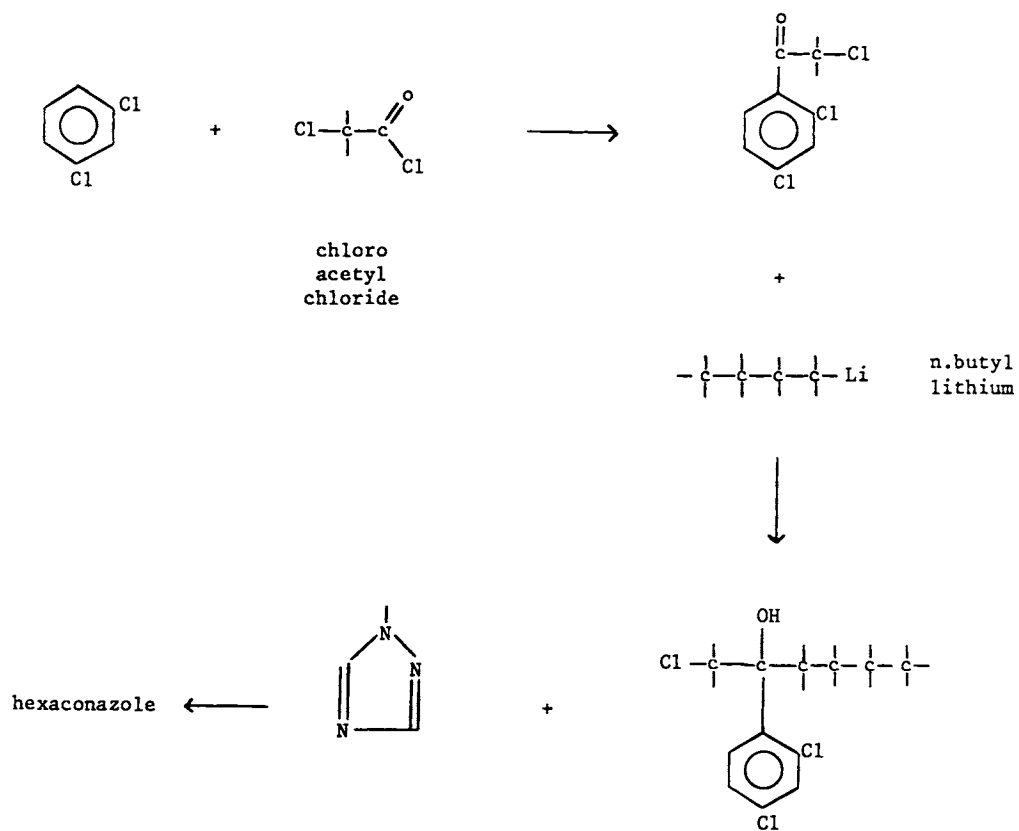
Trade names: Anvil (ICI)

Type: triazole

Synthesis:



alternate route:



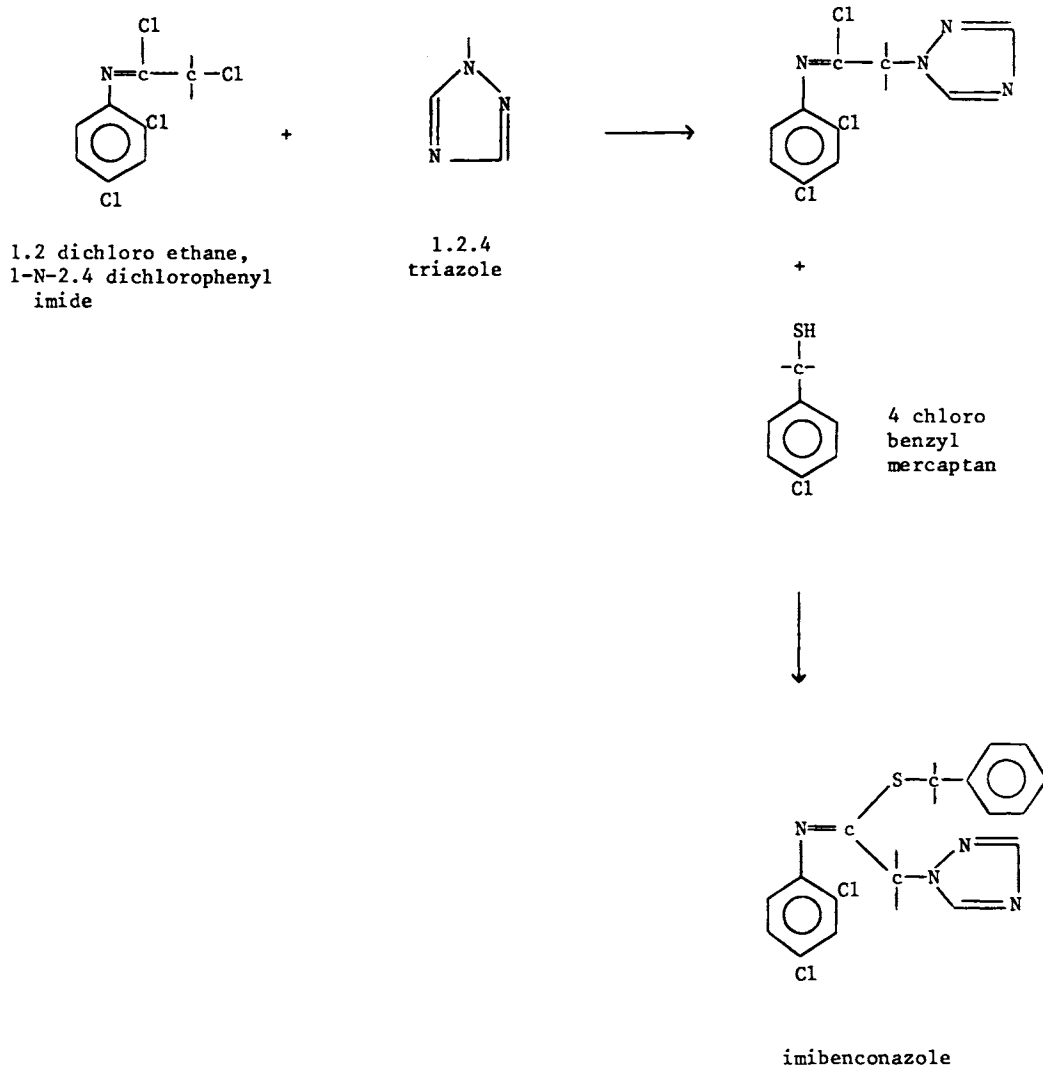
## Imibenconazole

Uses: fungicide, cereals, grapes, fruit

Trade names: Manage (Hokko)

Type: triazole

Synthesis:



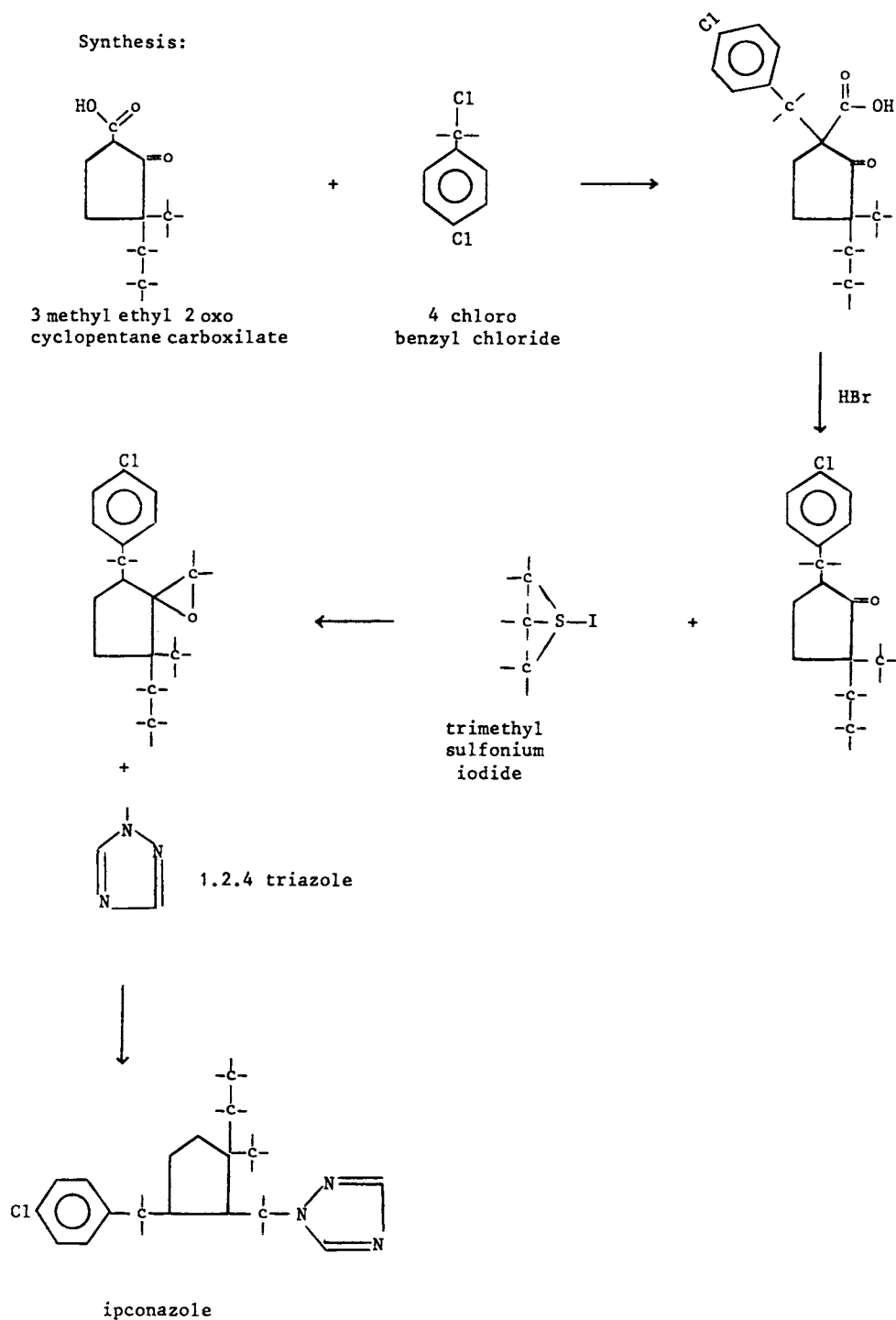
## Ipconazole

Uses: fungicide, rice

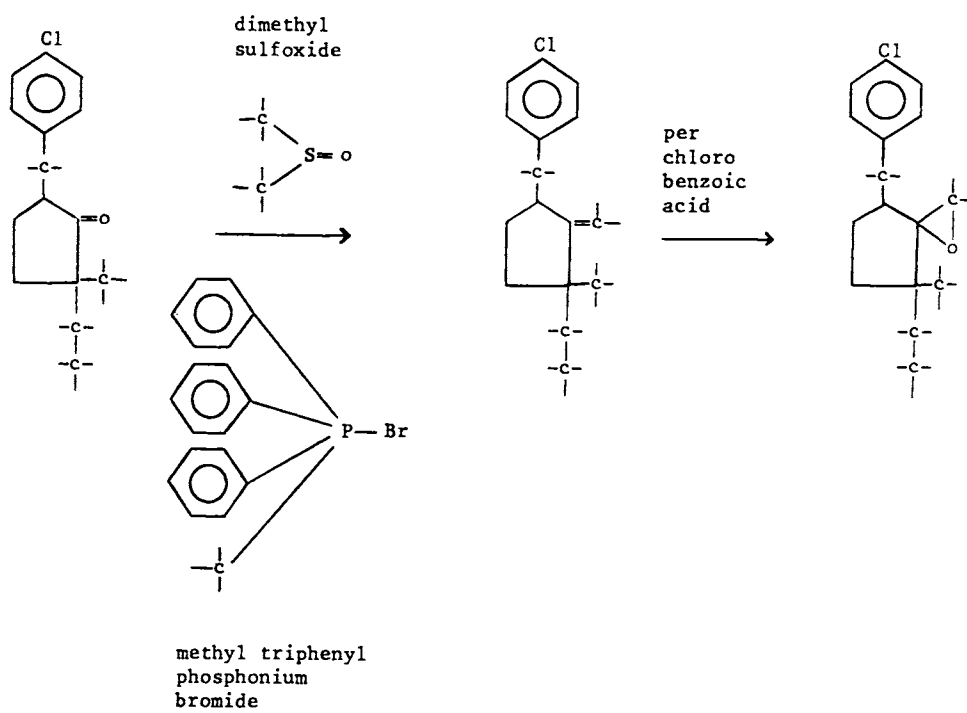
Trade names: Techlead (Kureka)

Type: triazole

Synthesis:



alternate route :



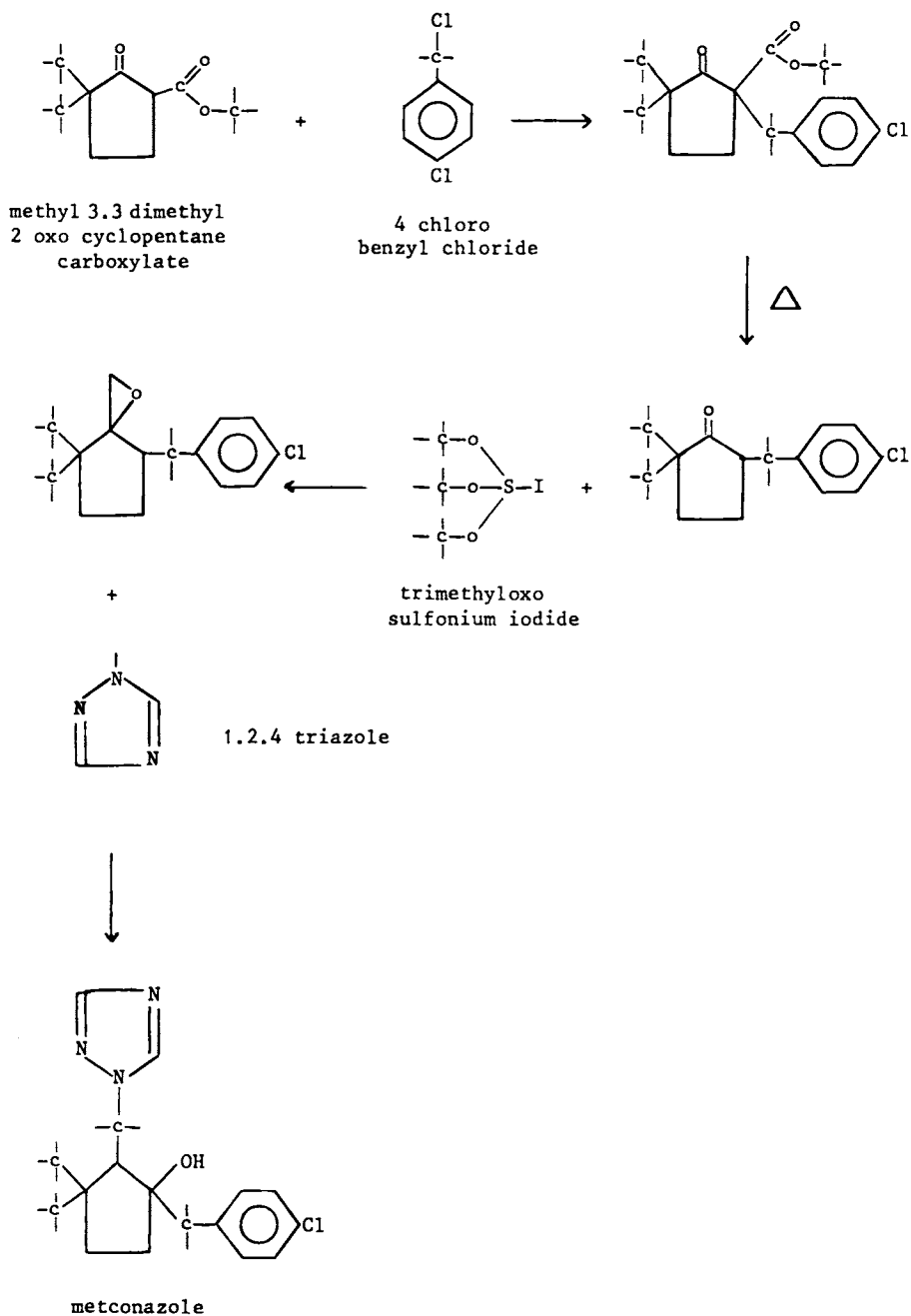
## Metconazole

Uses: fungicide, cereals

Trade names: Caramba (Cyanamid)

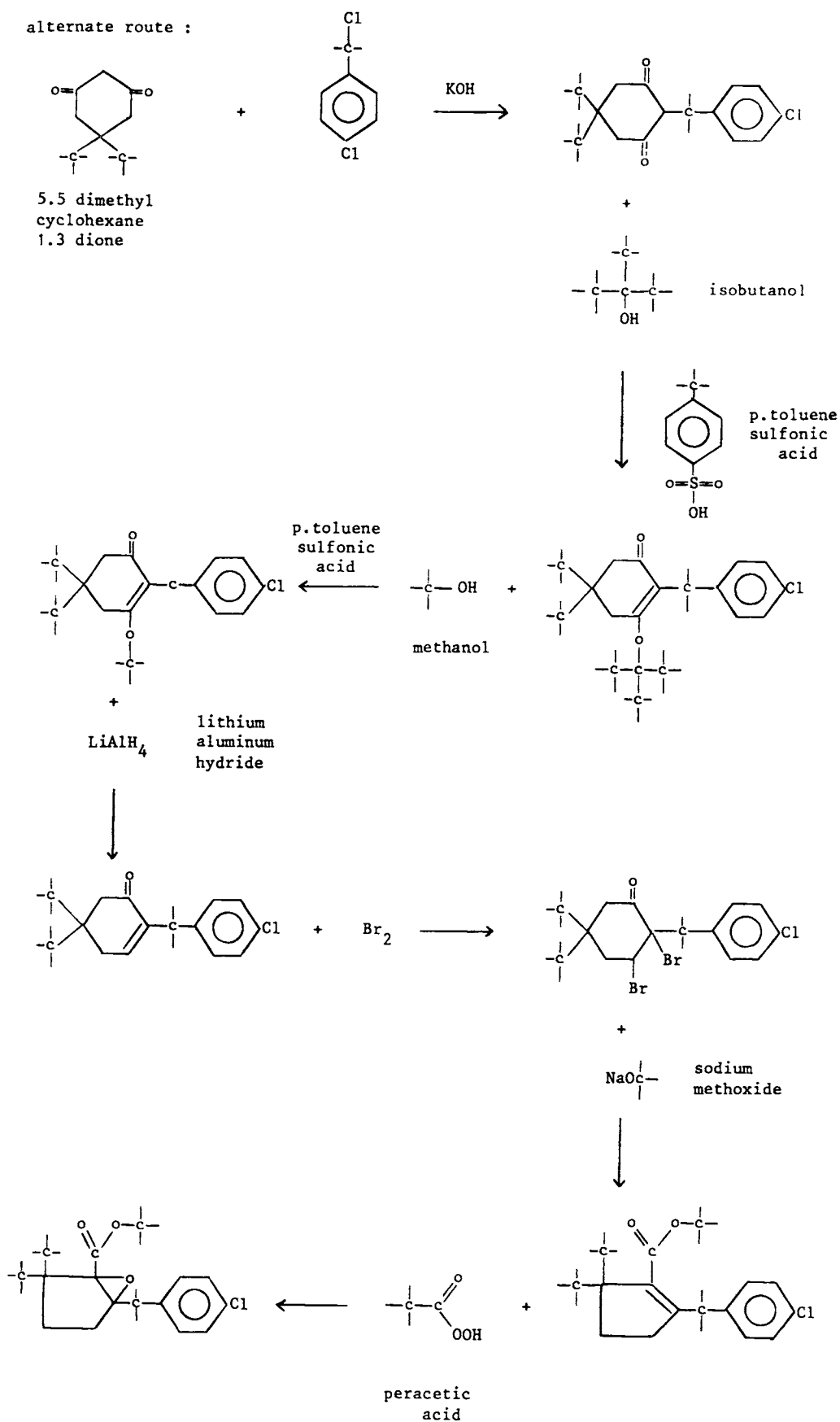
Type: triazole

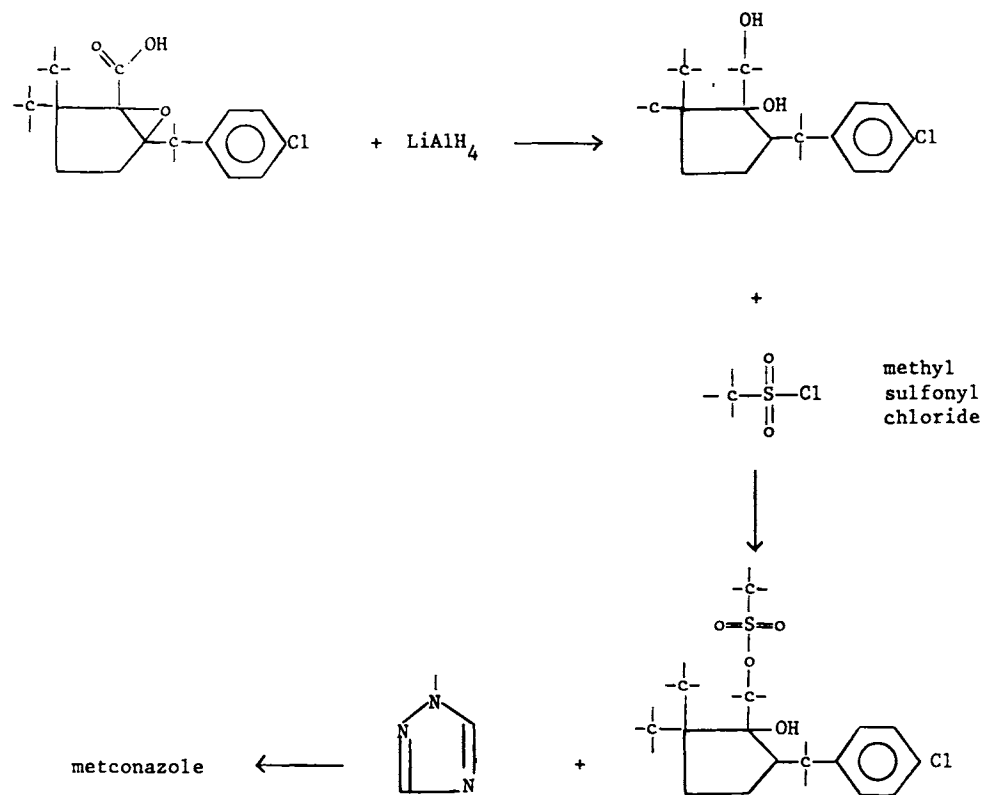
Synthesis:





alternate route :





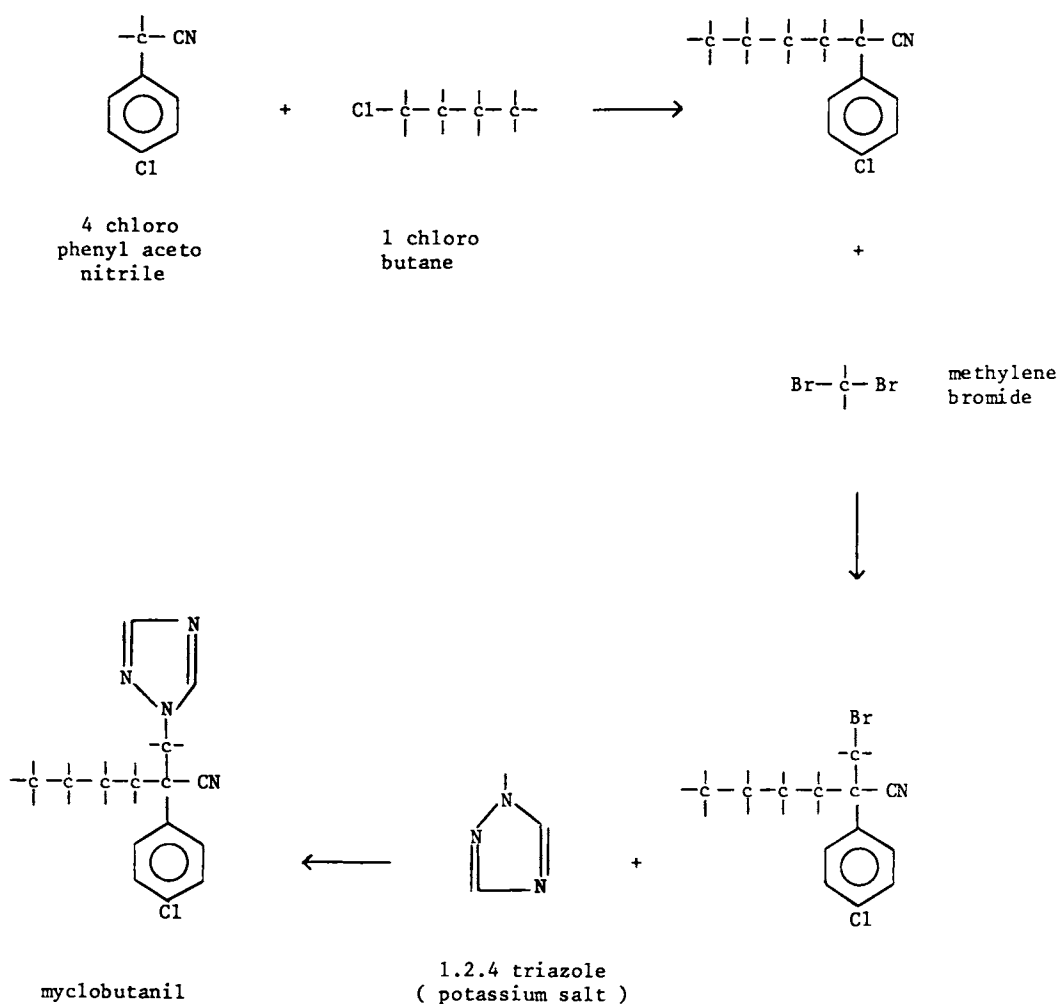
## Myclobutanil

Uses: fungicide, grapes

Trade names: Systhane (Rohm & Haas)

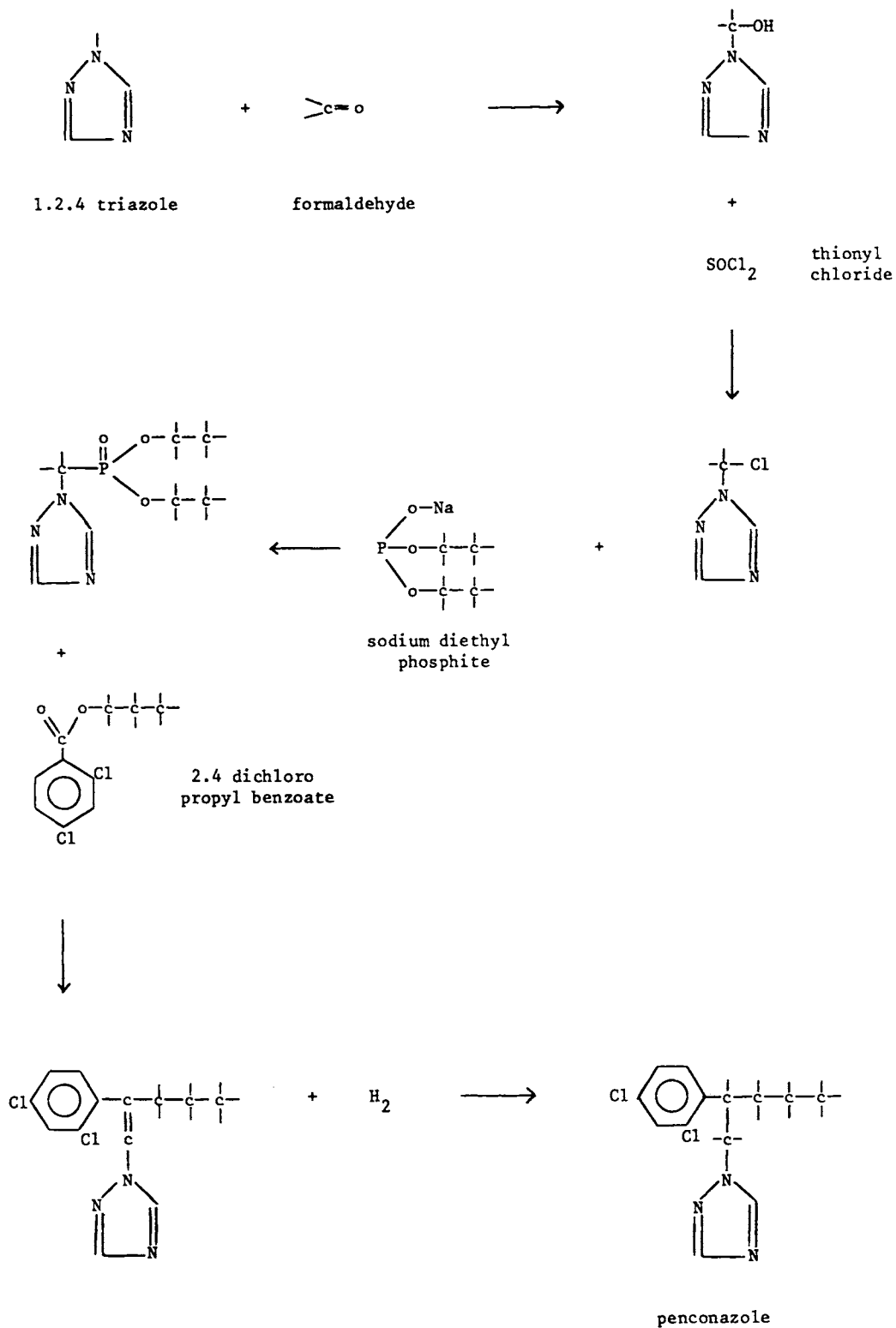
Type: triazole

Synthesis:





alternate route :



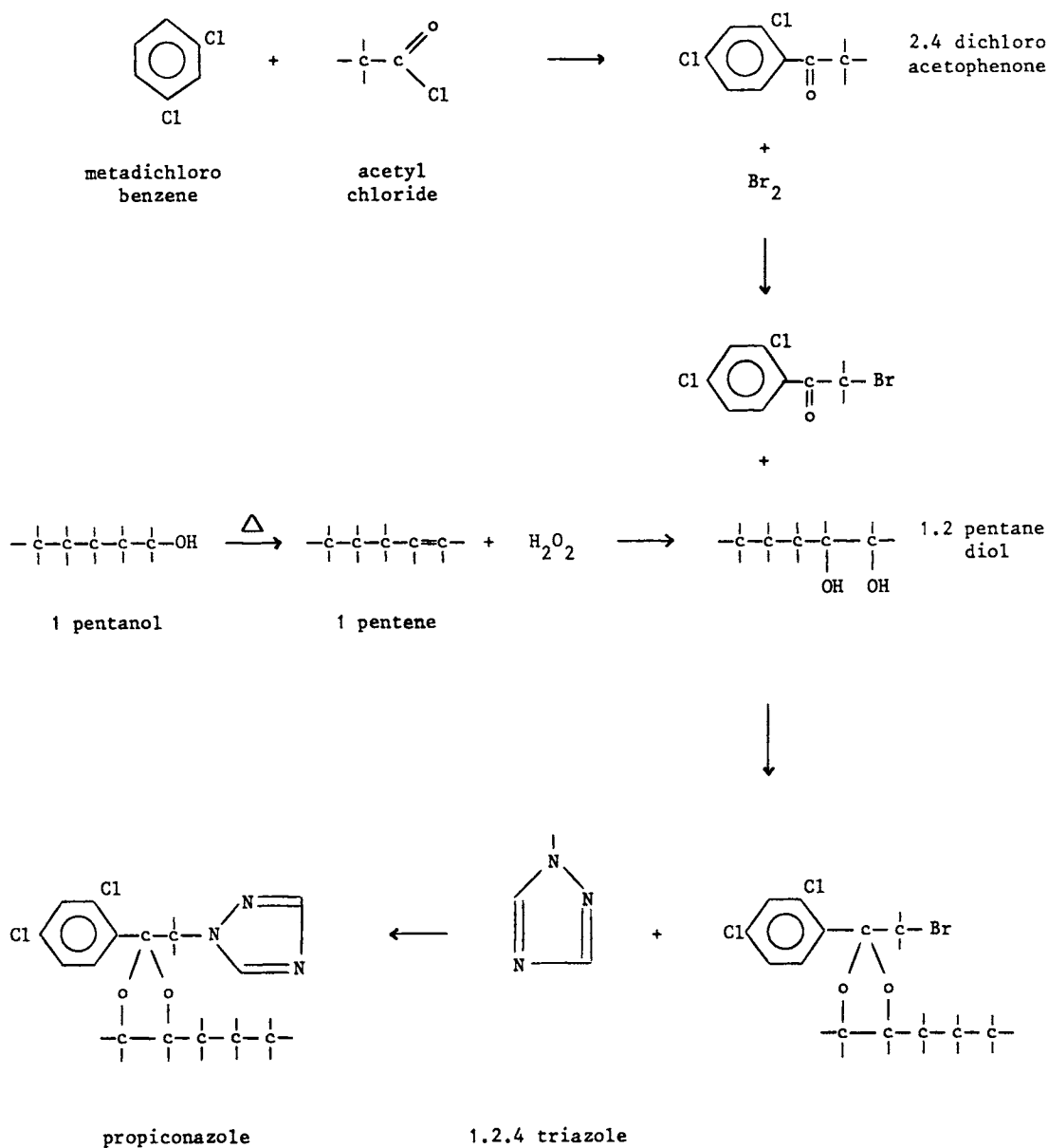
## Propiconazole

Uses: fungicide, cereals, grapes

Trade names: Tilt, Radar, Desmel (Ciba)

Type: triazole

Synthesis:



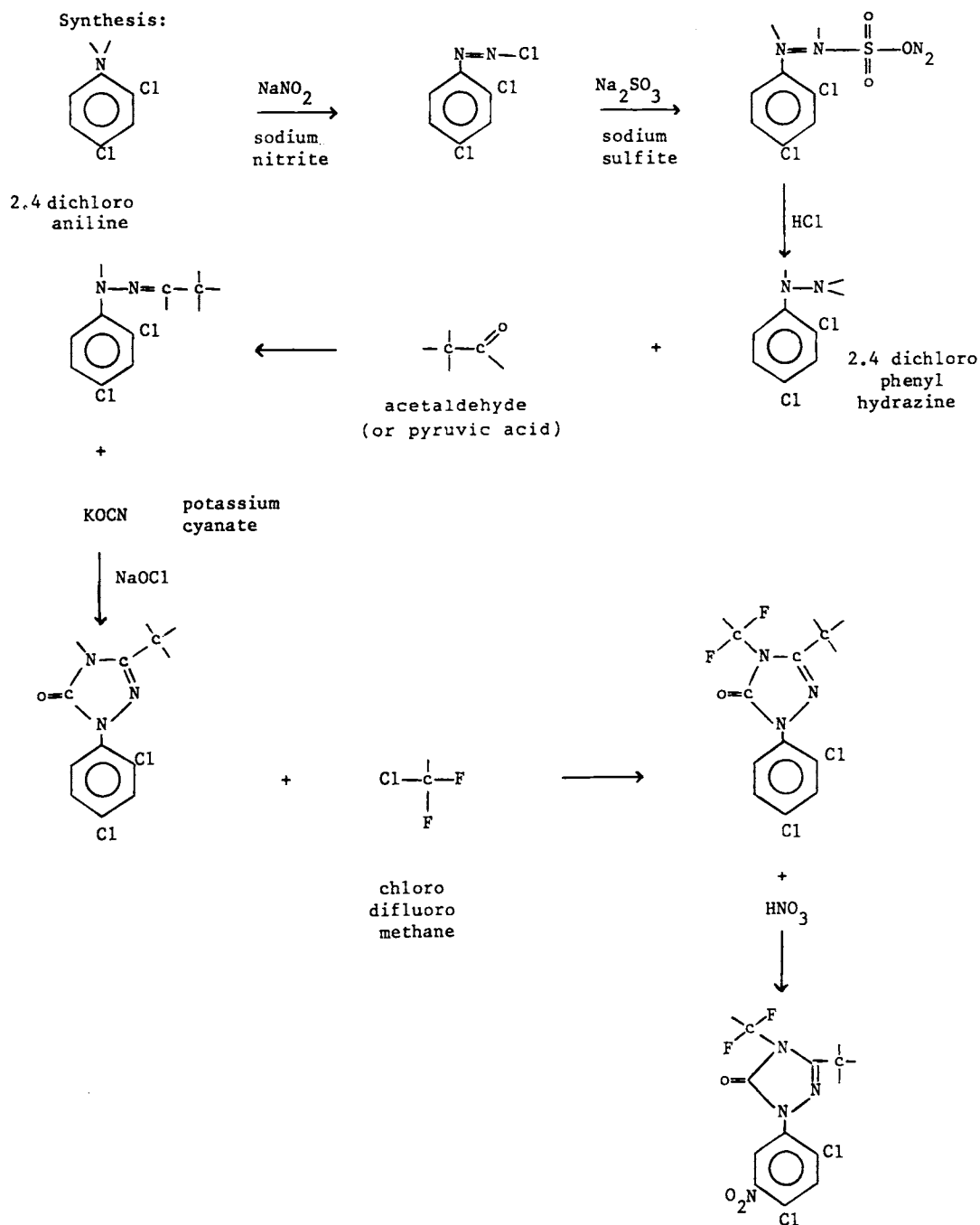
## Sulfentrazone

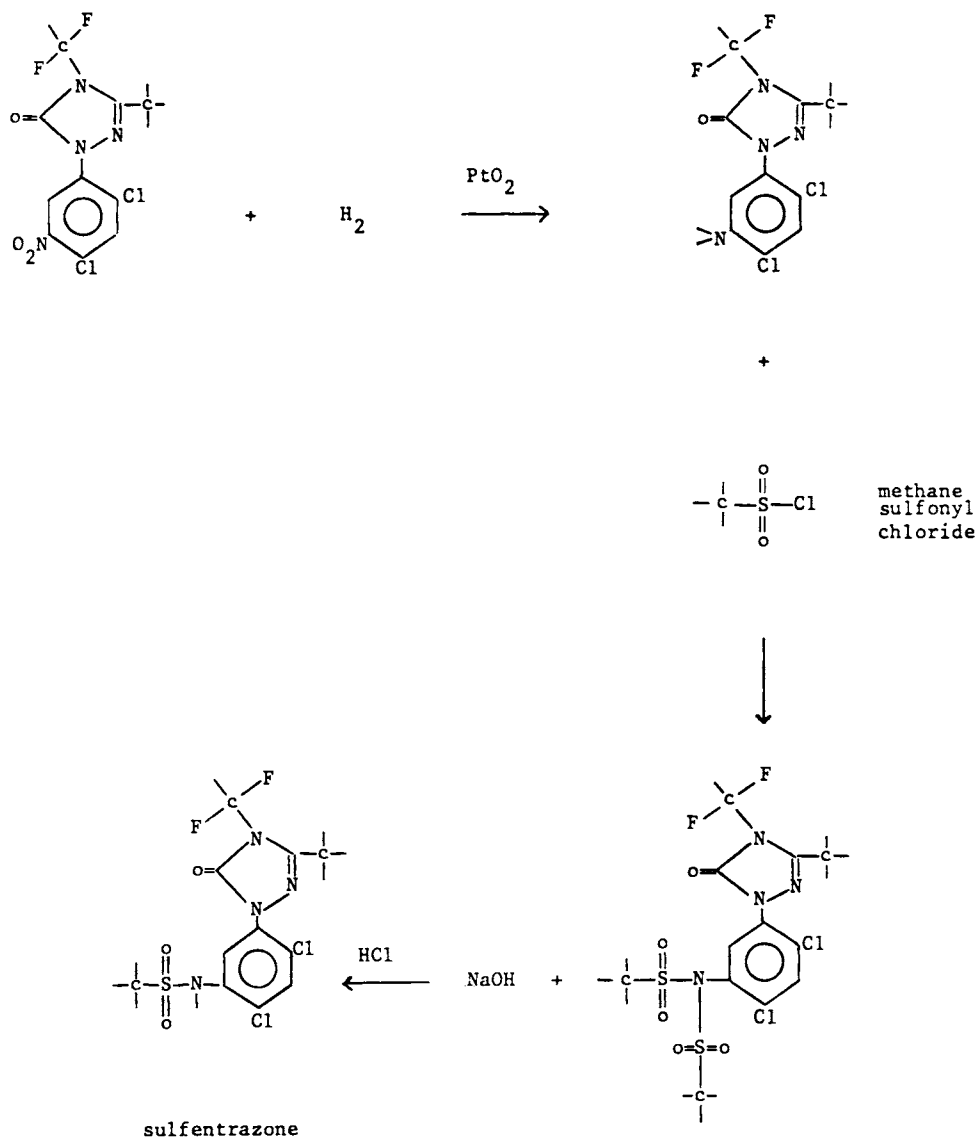
Uses: herbicide, soyabeans

Trade names: (FMC)

Type: triazole, sulfonamide

## Synthesis:







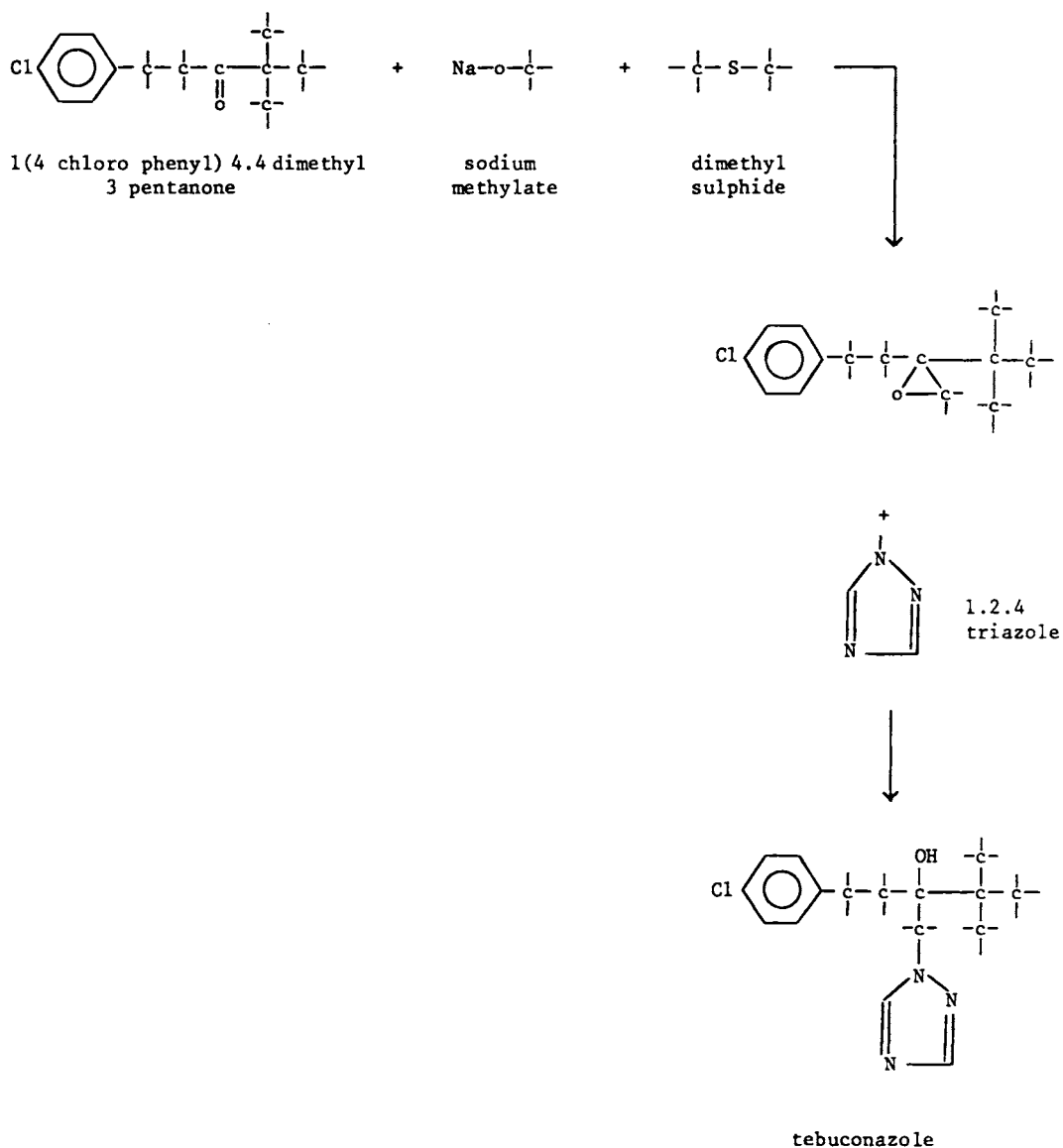
## Tebuconazole

Uses: fungicide, cereals, seeds

Trade names: Elite, Folicur, Horizon, Lynx, Raxil, Silacur (Bayer)

Type: triazole

Synthesis:



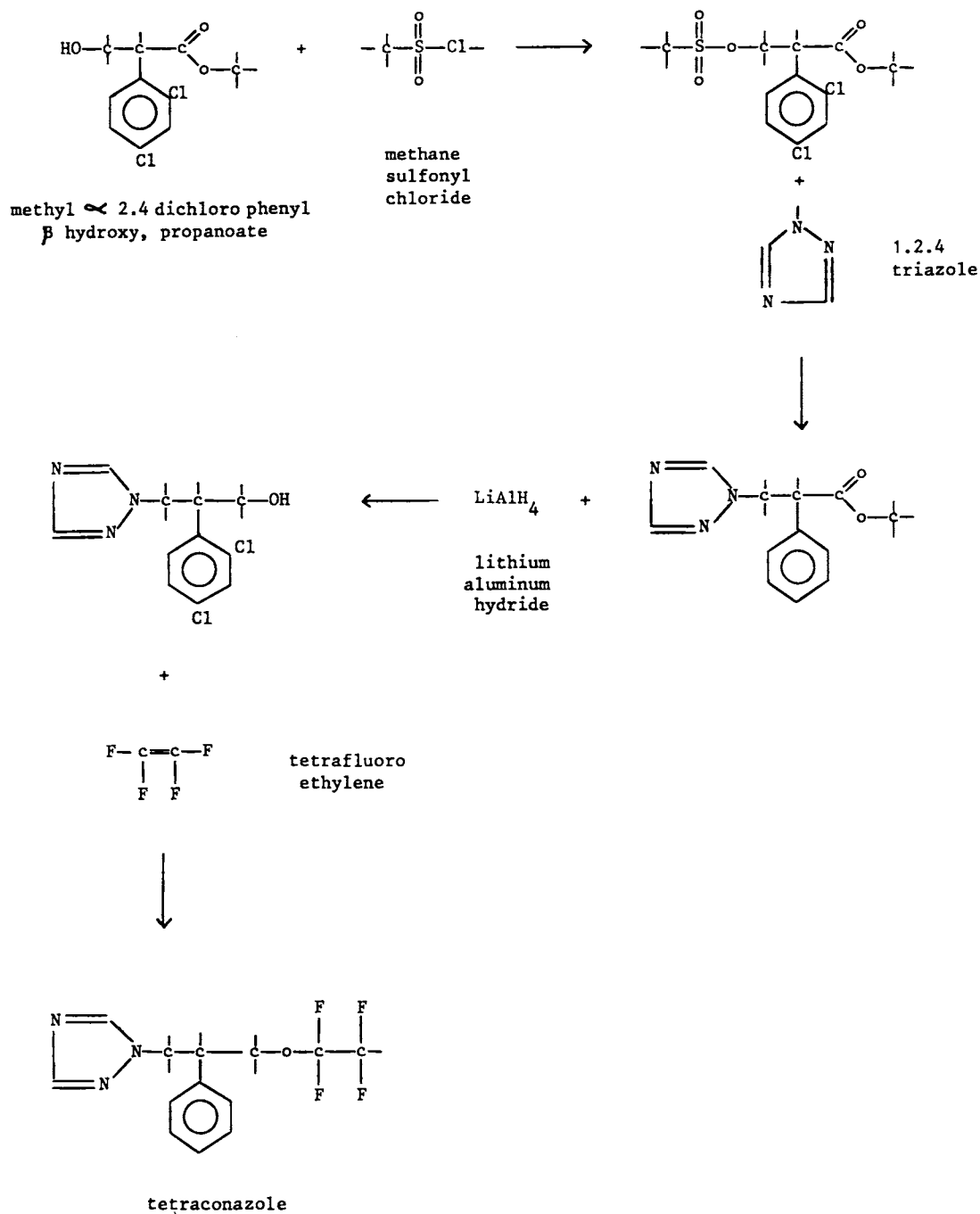
## Tetraconazole

Uses: fungicide, cereals, sugar beet, grapes, vegetables

Trade names: Domark, Eminent (Isagro)

Type: triazole

Synthesis:



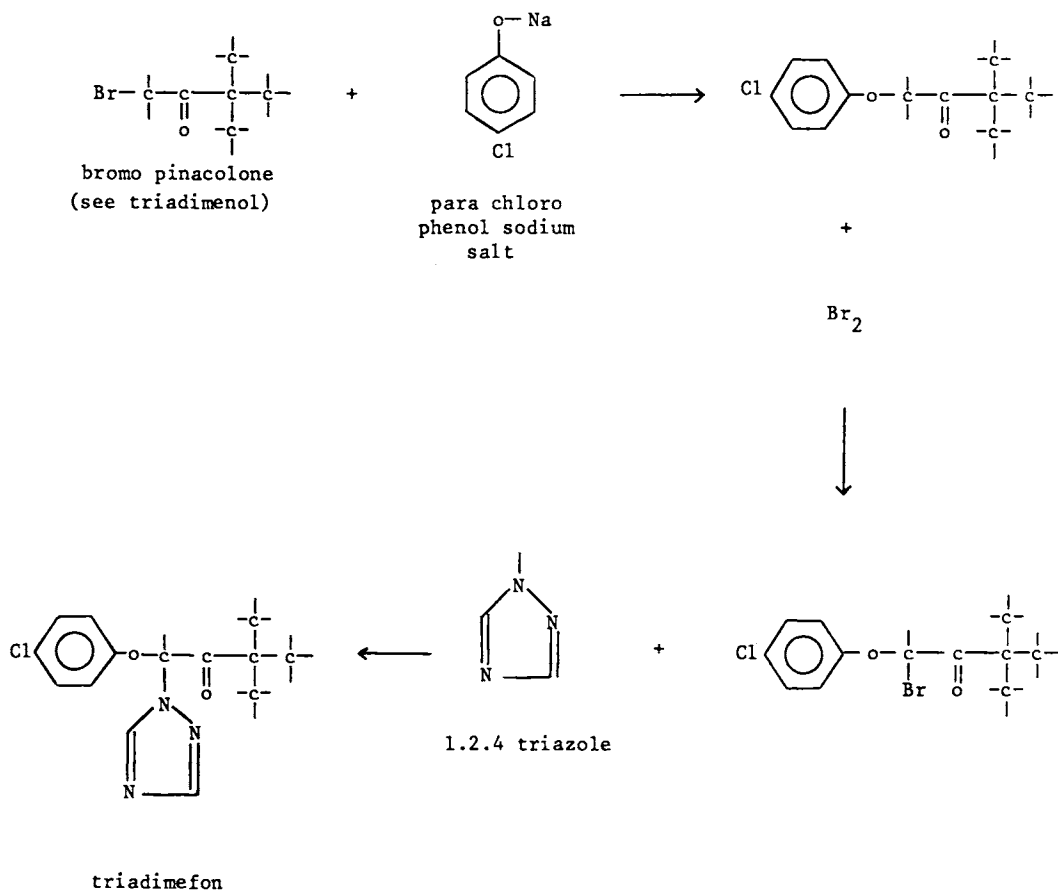
## Triadimefon

Uses: fungicide, cereals, coffee, vegetables

Trade names: Bayleton (Bayer)

Type: triazole

**Synthesis:**



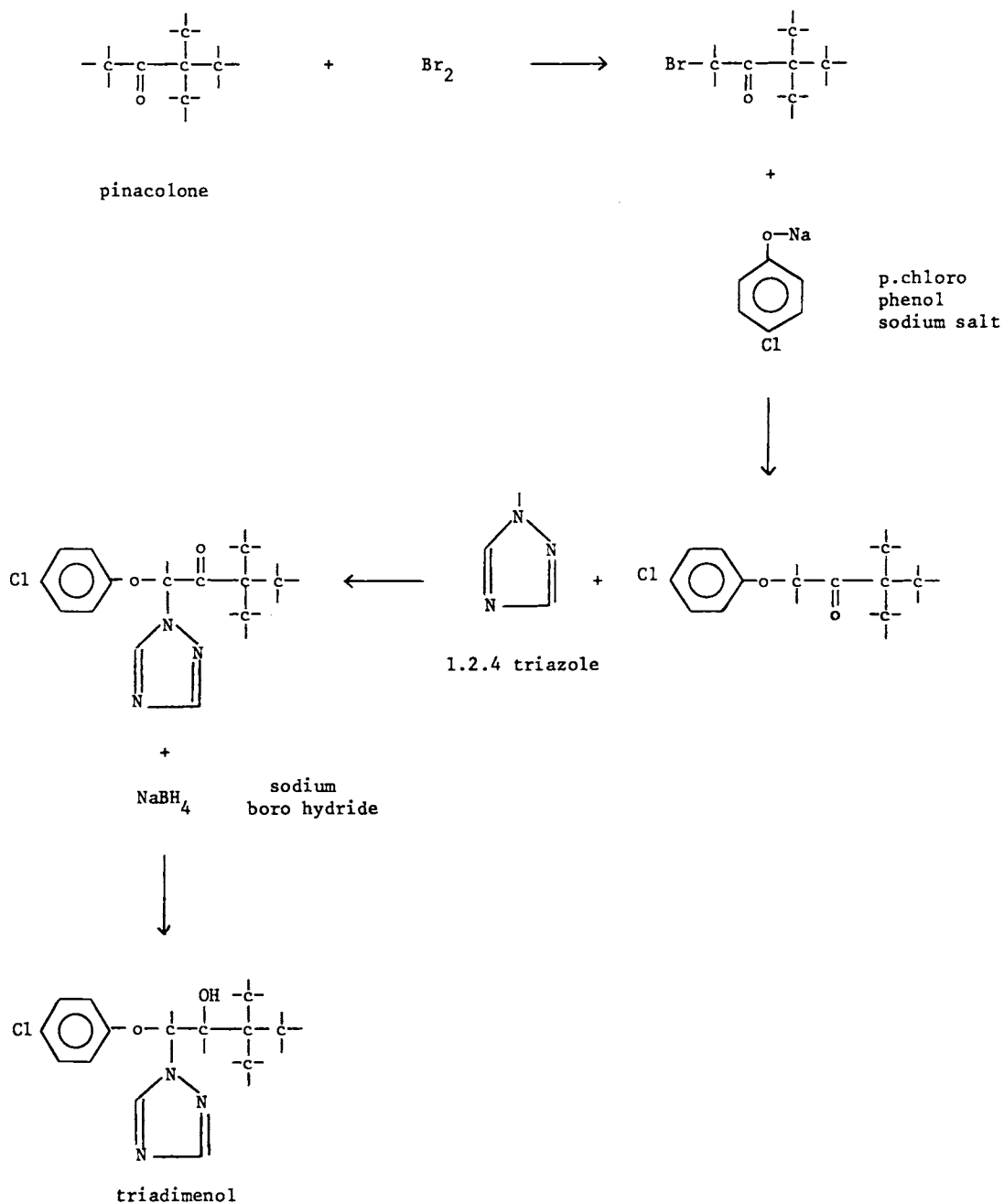
## Triadimenol

Uses: fungicide, cereals, bananas, coffee

Trade names: Baytan (Bayer)

Type: triazole

**Synthesis:**



## Triapenthenol

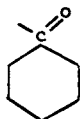
Uses: growth regulator

Trade names: Baronet (Bayer)

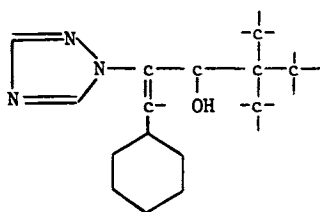
Type: triazole

Synthesis:

Same as diniconazole with



cyclohexyl aldehyde (instead of 2,4 dichloro benzaldehyde)



## Uniconazole

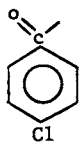
Uses: growth regulator, ornamentals, trees, rice

Trade names: Prunit, Sumagic (Sumitomo)

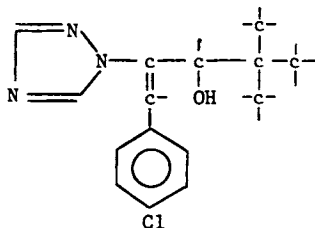
Type: triazole

Synthesis:

Same as diniconazole with



p.chloro benzaldehyde



## Triapenthenol

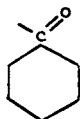
Uses: growth regulator

Trade names: Baronet (Bayer)

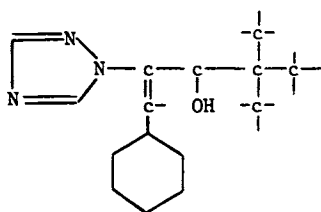
Type: triazole

Synthesis:

Same as diniconazole with



cyclohexyl aldehyde (instead of 2,4 dichloro benzaldehyde)



## Uniconazole

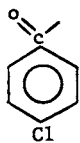
Uses: growth regulator, ornamentals, trees, rice

Trade names: Prunit, Sumagic (Sumitomo)

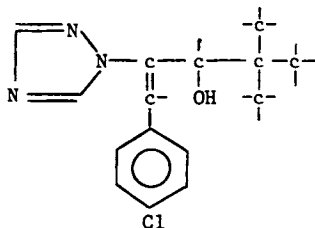
Type: triazole

Synthesis:

Same as diniconazole with



p.chloro benzaldehyde





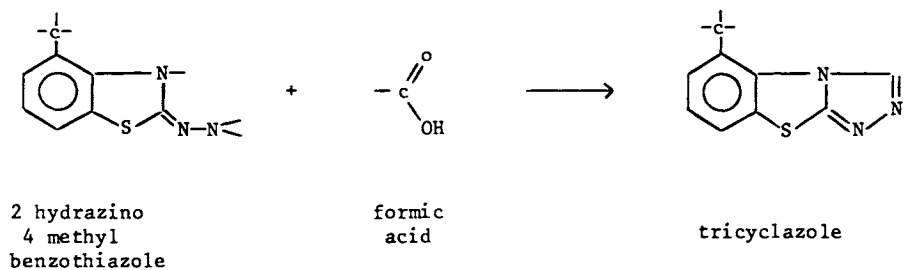
## Tricyclazole

Uses: fungicide, rice

Trade names: Beam, Bim, Blescide (Dow Elanco)

Type: triazole, benzothiazole

Synthesis:





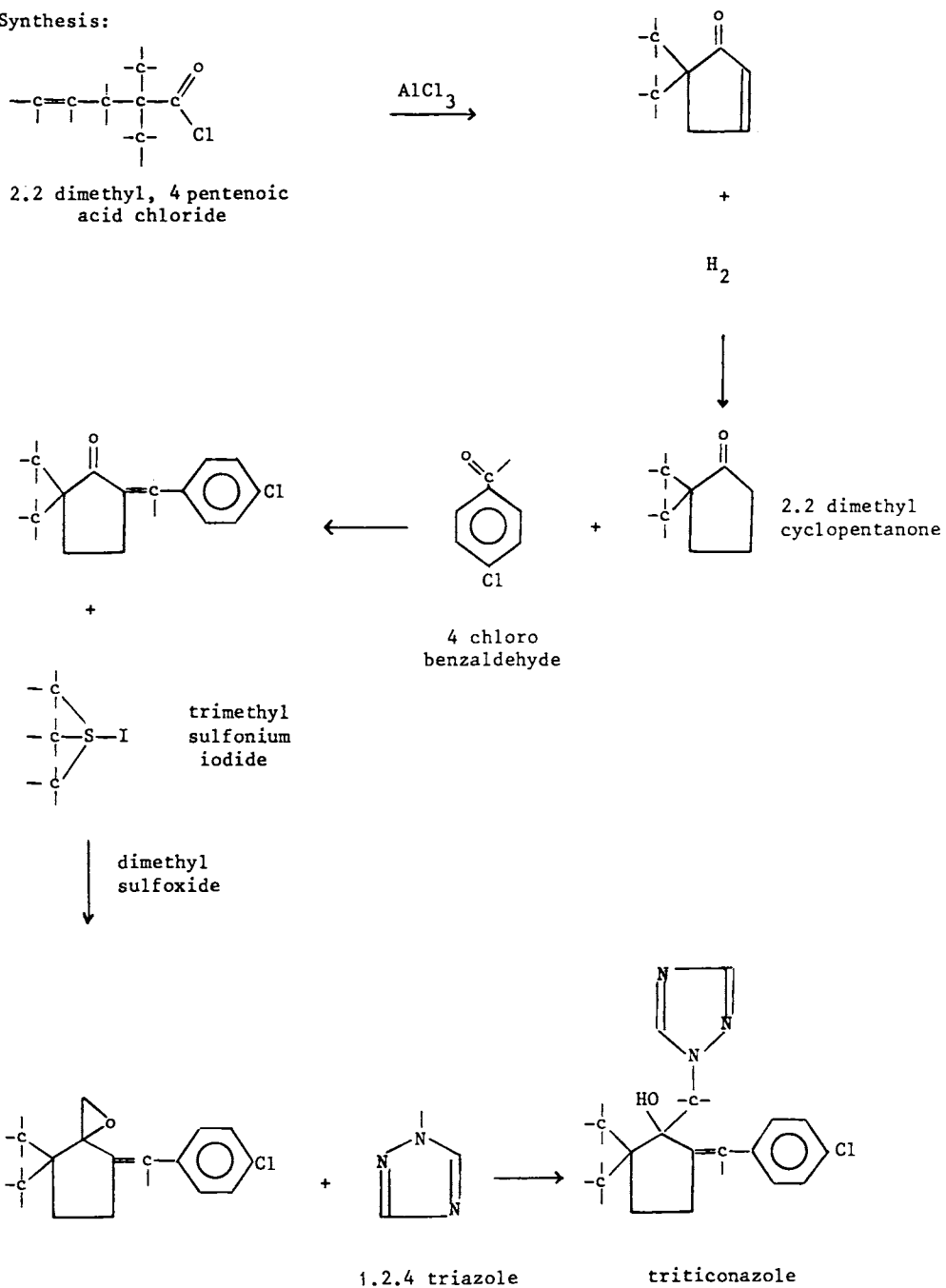
## Triticonazole

Uses: fungicide, cereals, maize

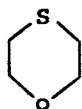
Trade names: Real (Rhône Poulenc)

Type: triazole

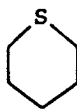
Synthesis:



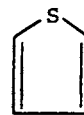
# HETEROCYCLIC SULFUR



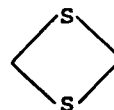
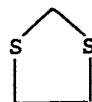
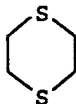
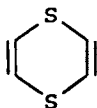
oxathiin



thiopyran



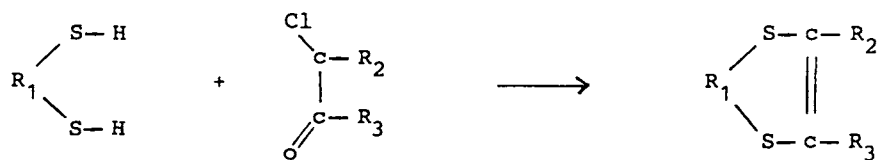
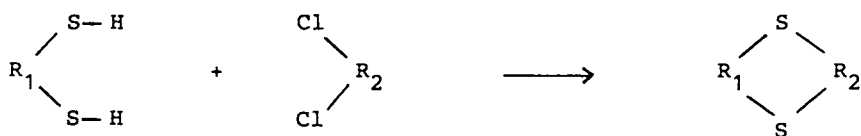
thiophene



dithiins

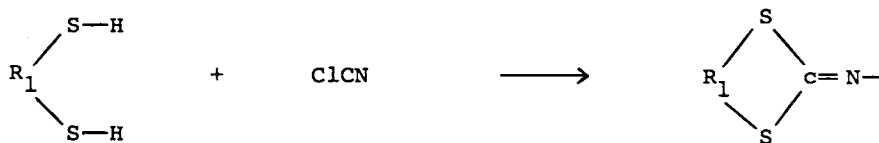
## DITHIINS DITHIOLANES

Dithiins are cyclised by reaction between a dithiol and an alkyl dihalogen or ketohalogen



If the alkyl dihalogen contains a carbonyl group (for instance phosgene) a dithiinone is obtained.

If cyanogen chloride is used instead of an alkyl dihalogen a dithiin imine is obtained



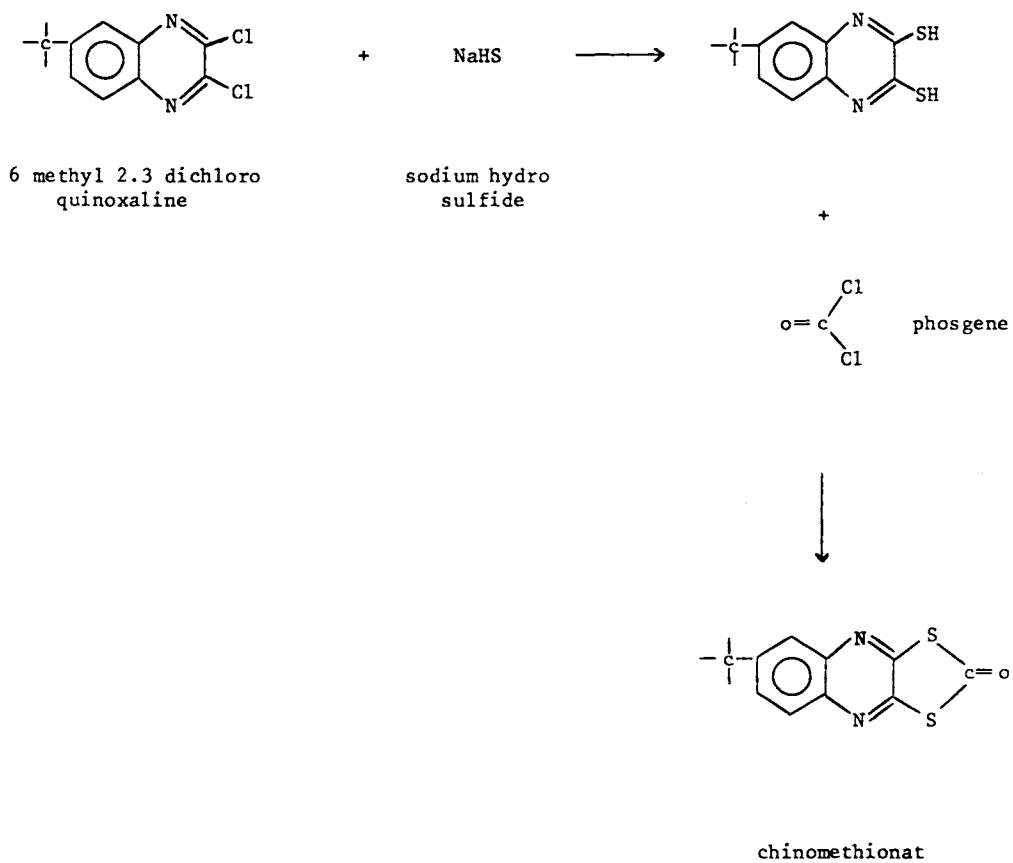
## Chinomethionat Quinomethionate

Uses: acaricide, fungicide, fruits, vegetables, ornamentals

Trade names: Morestan (Bayer)

Type: dithiin, quinoxaline

Synthesis:



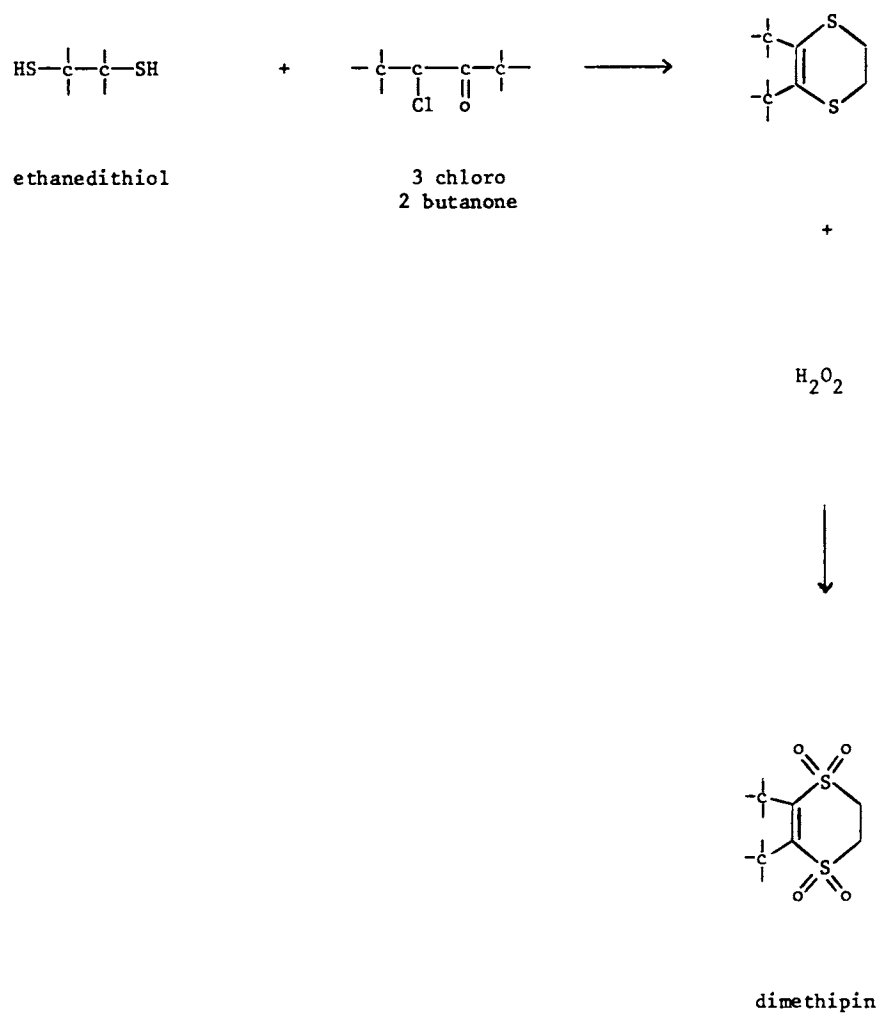
## Dimethipin

Uses: growth regulator, cotton, rubber, vines, rice, sunflower

Trade names: Harvade (Uniroyal)

Type: dithiin, sulfone

Synthesis:



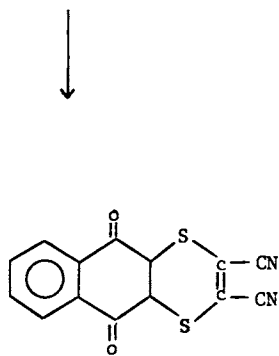
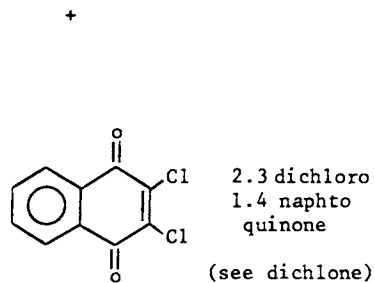
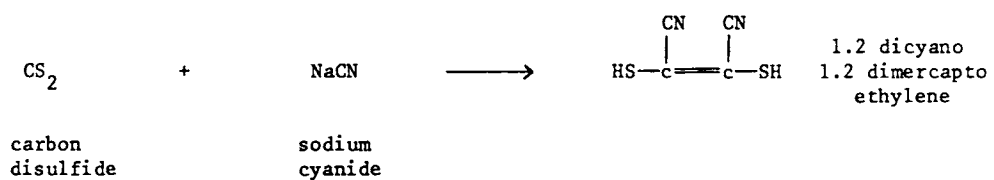
## Dithianon

Uses: fungicide, germination, inhibitor, coffee, fruit

Trade names: Delan (Shell)

Type: dithiin, quinone

Synthesis:



dithianon

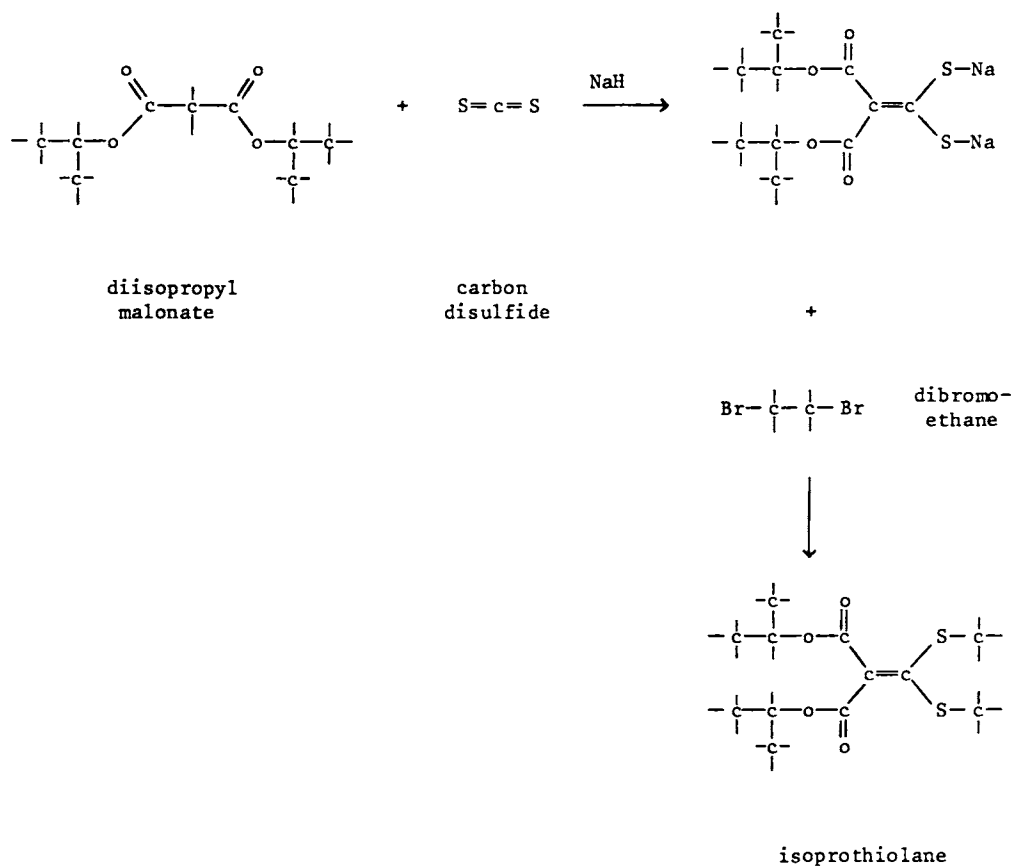
## Isoprothiolane

Uses: fungicide, rice

Trade names: Fuji-one (Nikon)

Type: dithiin

**Synthesis:**



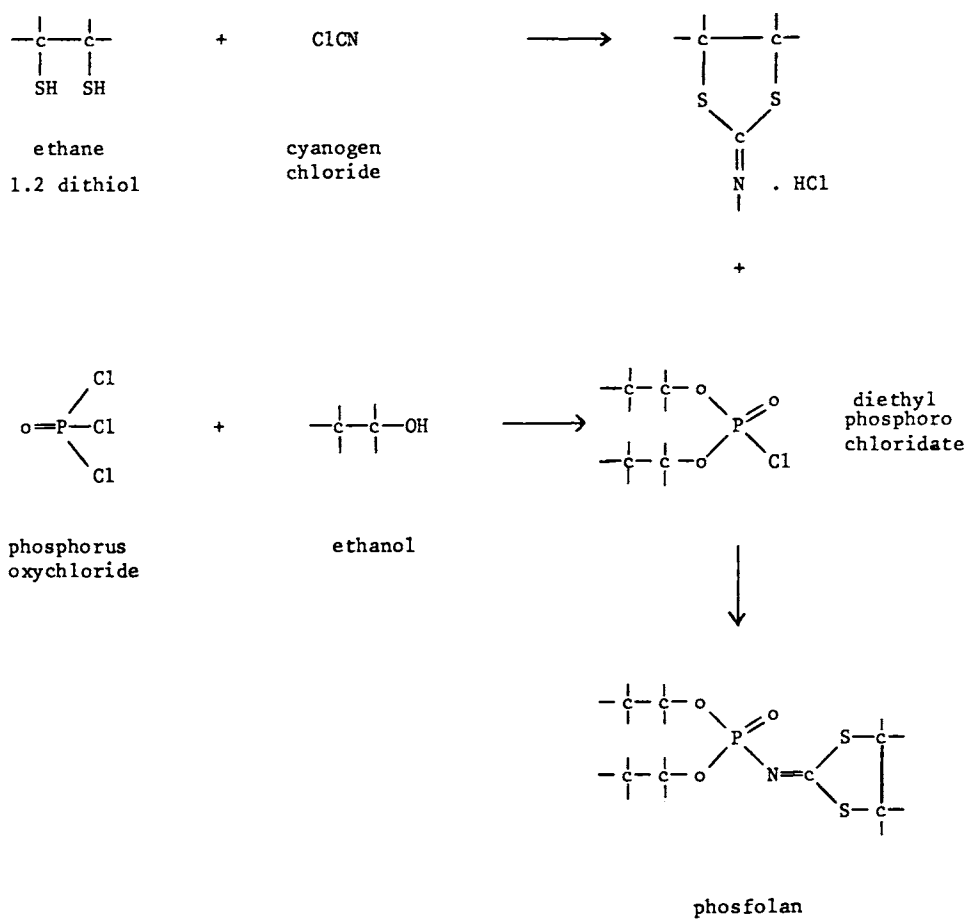
## Phosfolan

Uses: insecticide, cotton

Trade names: Cyolane, Cyolan, Cyalane, Cylan

Type: imino dithiin, phosphoroamidate

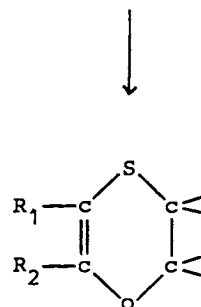
Synthesis:



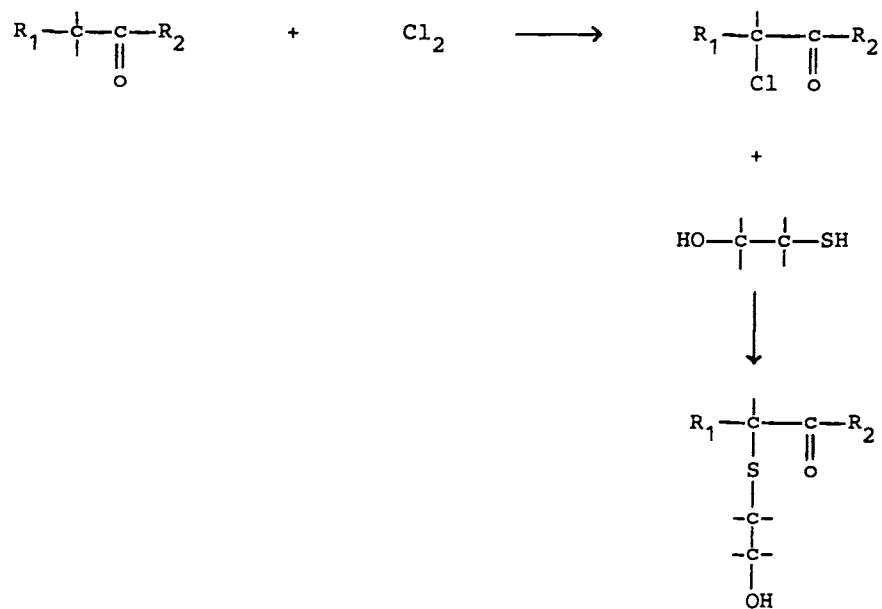


# OXATHIINS

Oxathiins are obtained by cyclisation of

$$\begin{array}{c} \text{R}_1-\text{C}-\text{S}-\text{C}-\text{C}-\text{OH} \\ | \quad | \quad | \\ \text{C}=\text{O} \\ \text{R}_2 \end{array}$$


The compound to be cyclised is synthesized by chlorinating a ketone followed by reaction with mercapto ethanol.



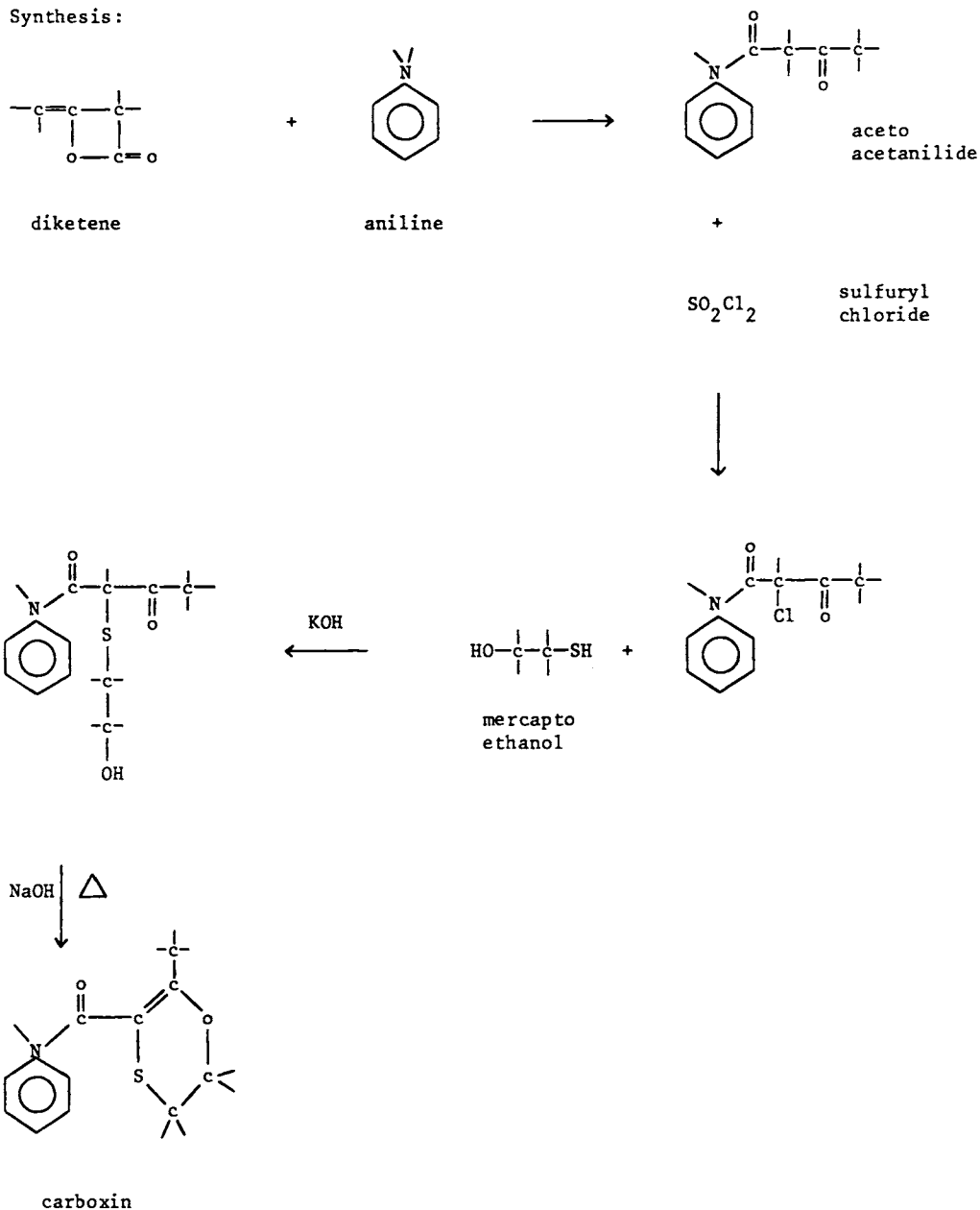
## Carboxin

Uses: fungicide, cereals, maize, cotton, peanuts, soyabeans

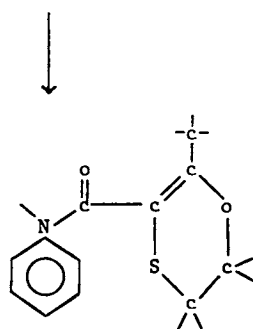
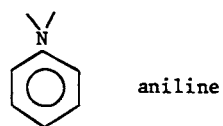
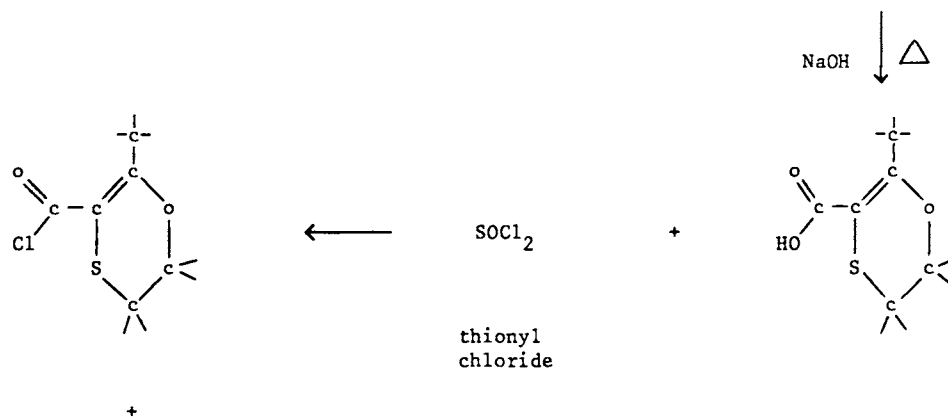
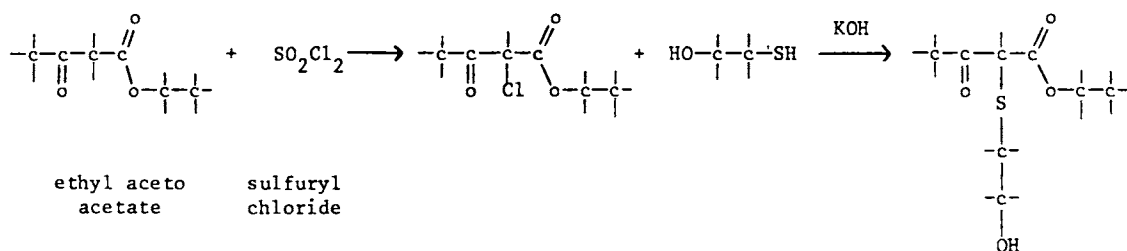
Trade names: Vitavax (Uniroyal)

Type: oxathiin, amide

Synthesis:



alternate route :



carboxin

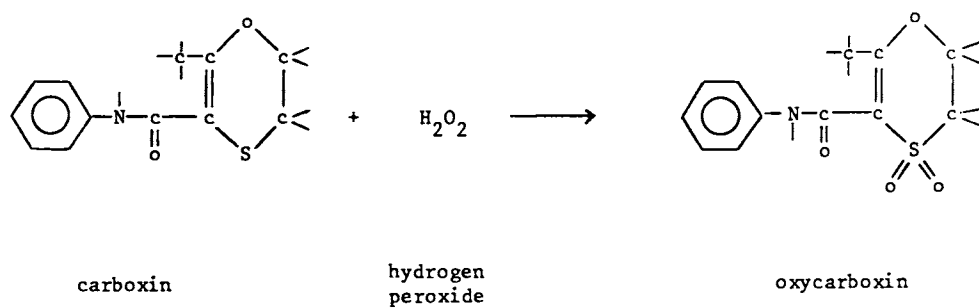
## Oxycarboxin

Uses: fungicide, cereals, ornamentals

Trade names: Plantvax (Uniroyal)

Type: oxathiin, amide, sulfone

Synthesis:



# THIOPHENES THIOPYRANES TRITHIANES

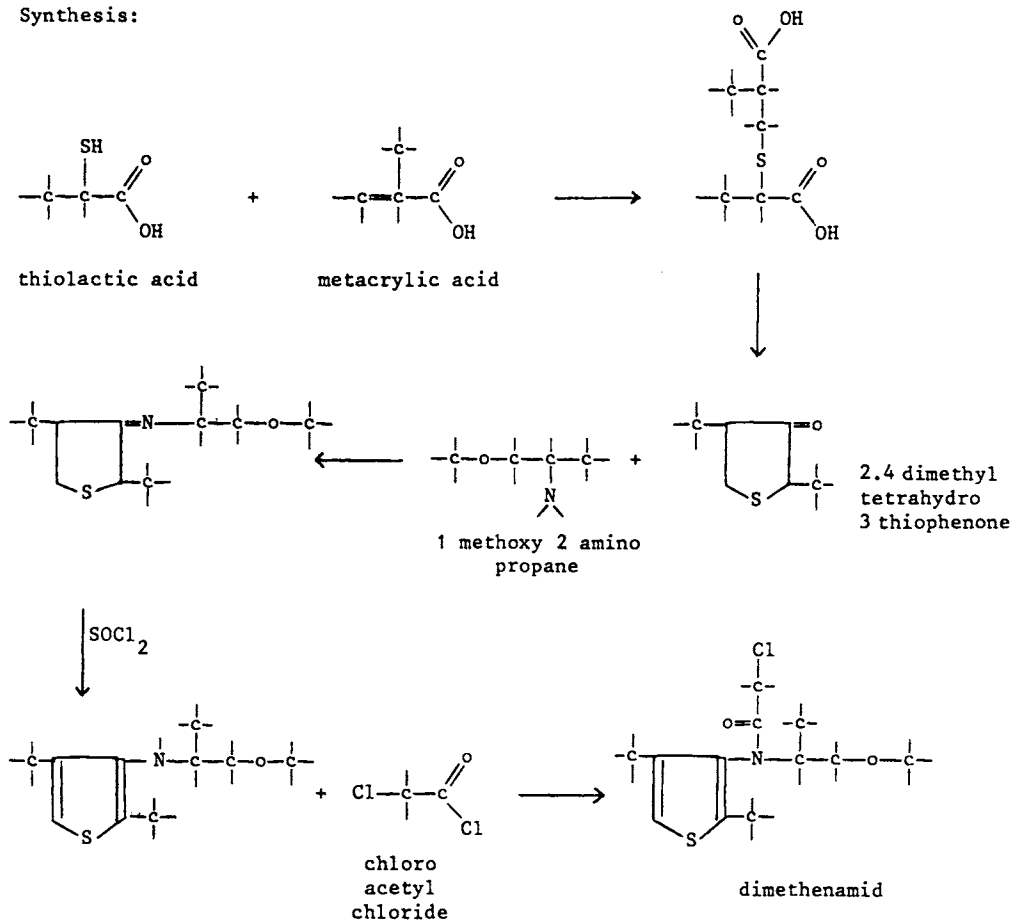
## Dimethenamid

Uses: herbicide, maize, soyabeans

Trade names: Frontier (Sandoz)

Type: thiophene, amide

Synthesis:



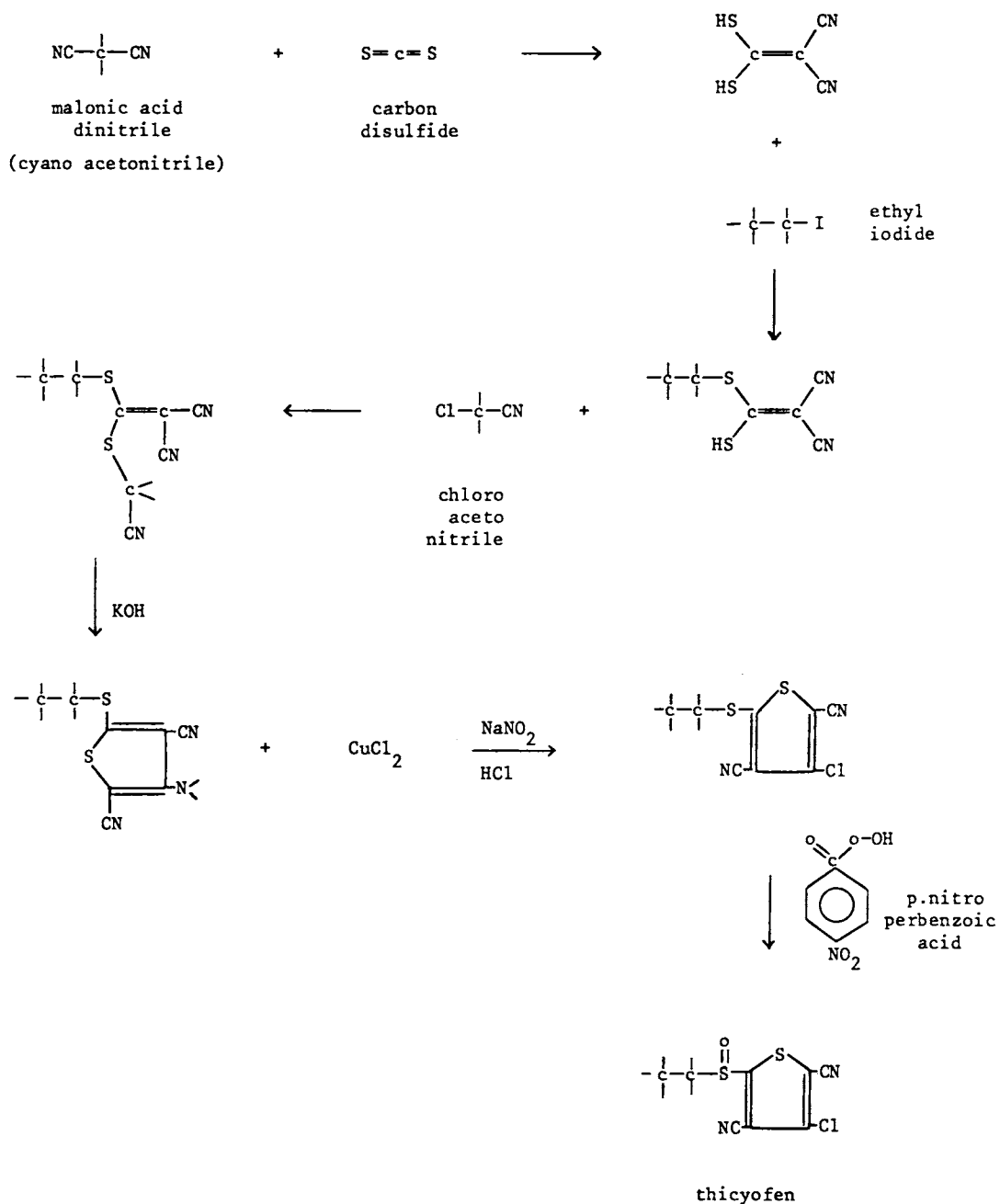
## Thicyofen

Uses: fungicide, cereals, cotton, maize

Trade names: (Duphar)

Type: thiophene

Synthesis:



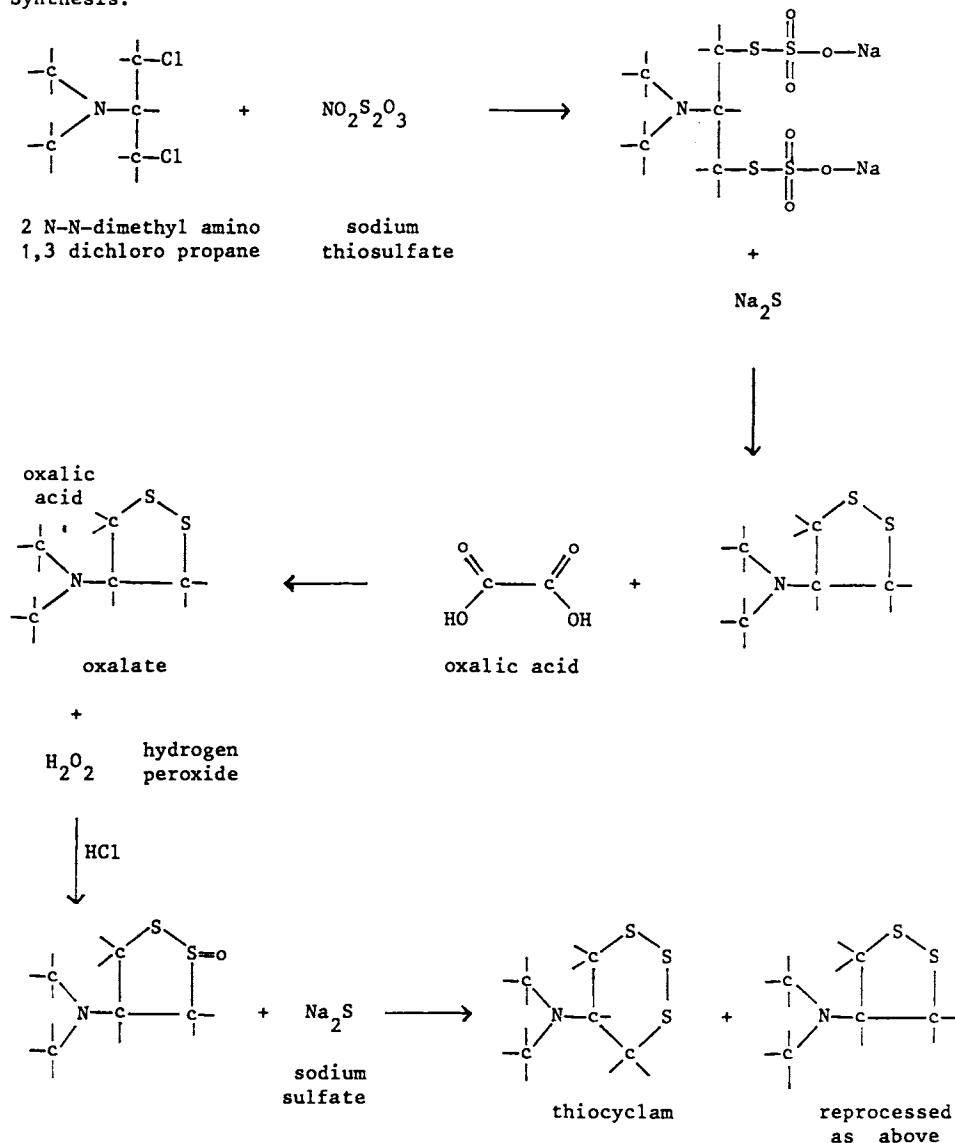
## Thiocyclam

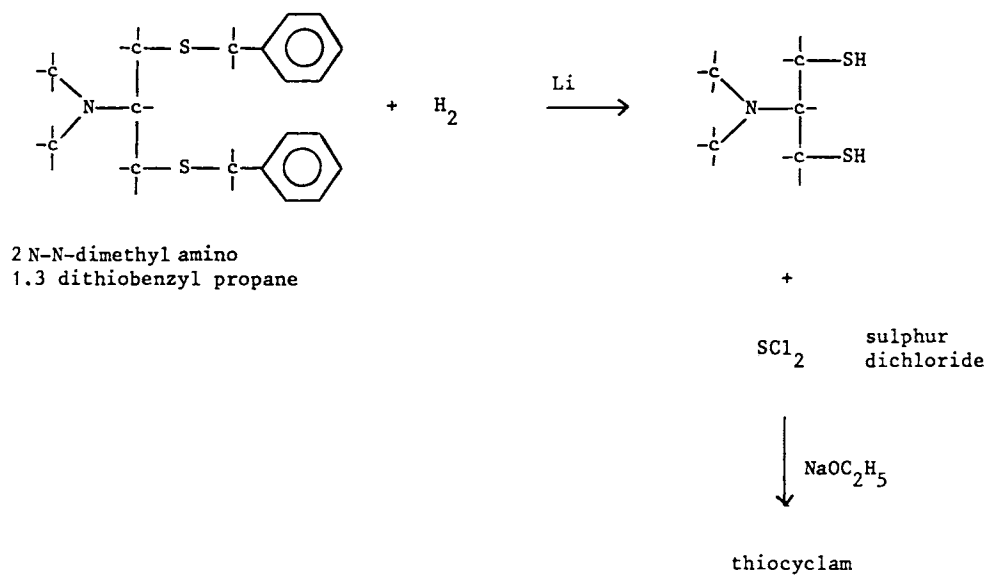
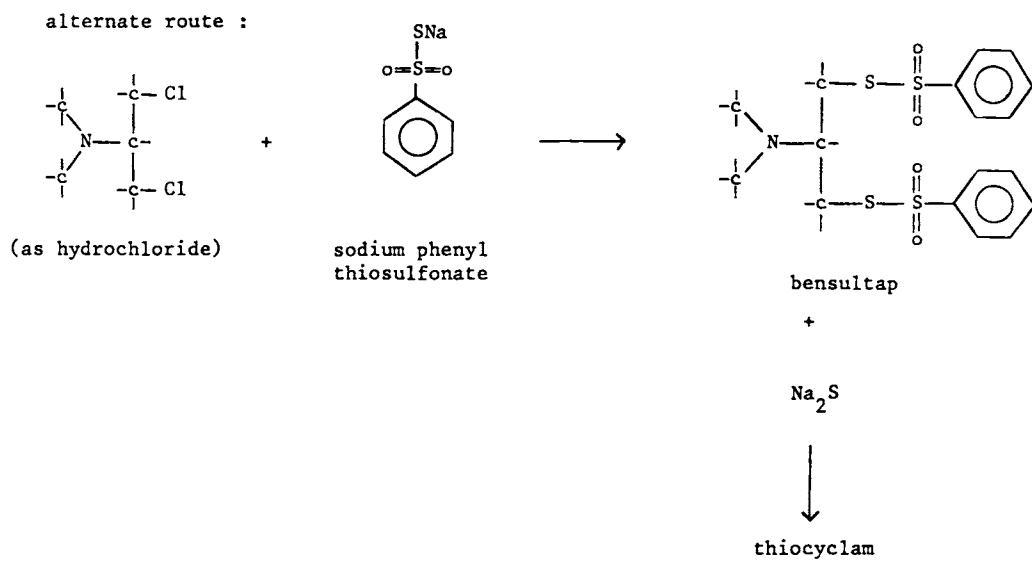
Uses: insecticide, cotton, rice, sugarcane, potatoes, vegetables

Trade names: Evisect, Evisekt (Sandoz)

Type: trithiane

Synthesis:



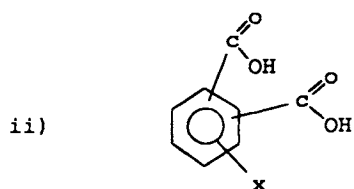




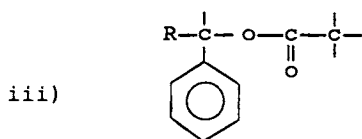
## AROMATIC CARBOXYLIC ACIDS

These products are usually of 3 types

- i) fluorenone derivates, the carboxy function being obtained by acidification of the cyano alcohol resulting from reaction between fluorenone and HCN



obtained from the respective anhydrides or diacids



resulting from the reaction between the sodium salt of the aromatic alcohol and acetyl chloride

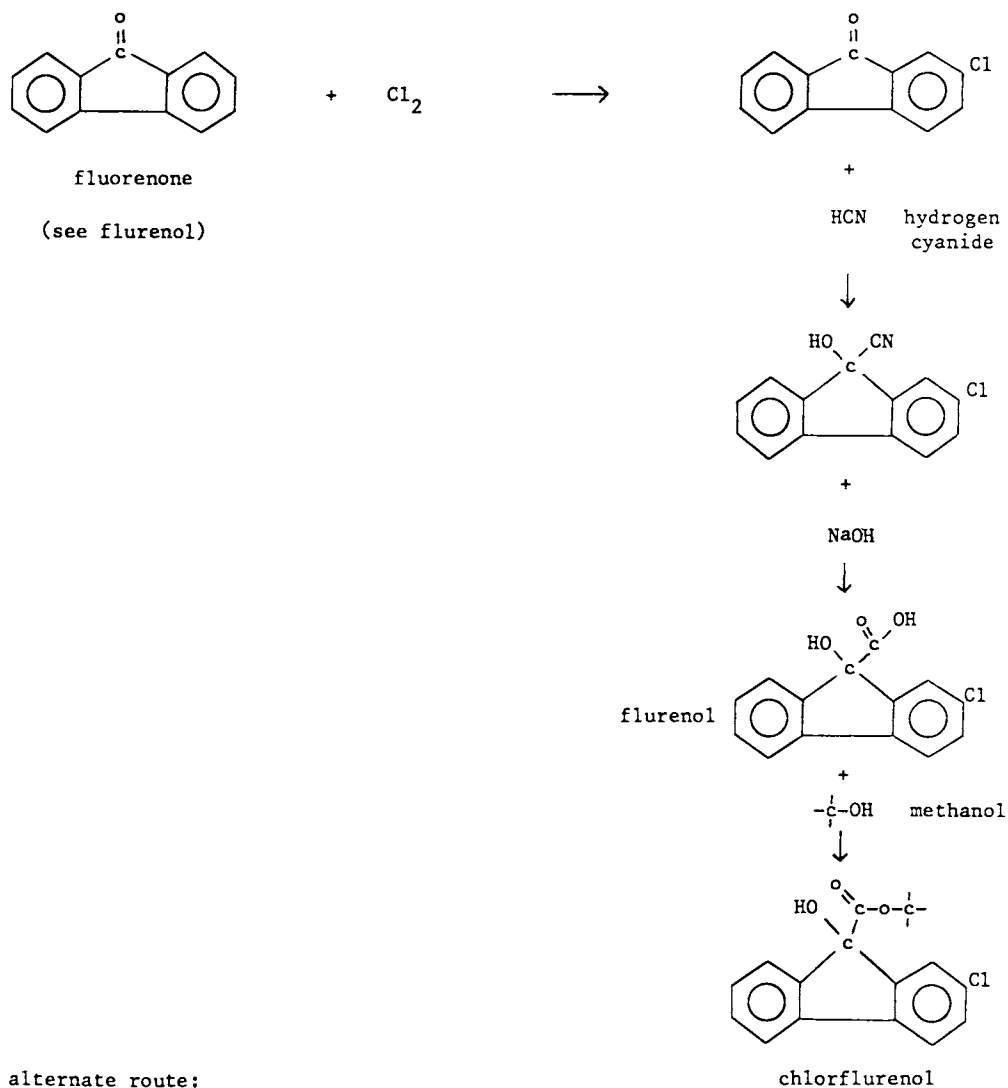
## Chlorflurenol-Methyl Ester

Uses: growth regulator, grass, roadsides, railways

Trade names: Curbiset, Multiprop (Celamerck)

Type: aromatic carboxylic acid

### Synthesis:



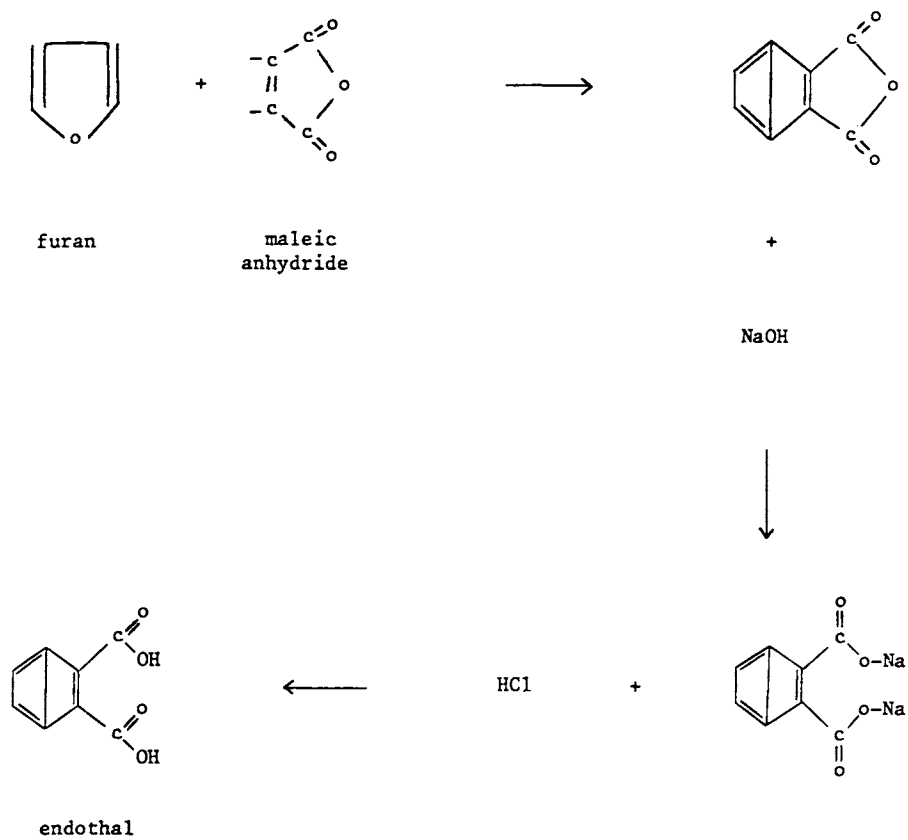
## Endothal

Uses: herbicide, red beet, sugar beet, potatoes, cotton

Trade names: Accelerate (Elf Atochem)

Type: aromatic carboxylic acid

Synthesis:



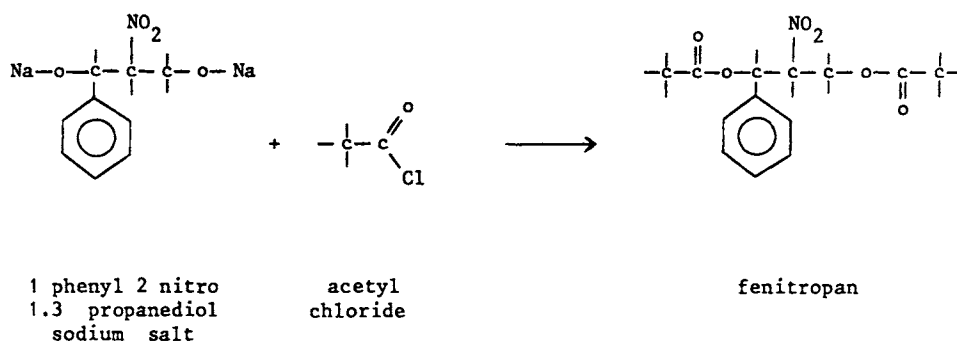
## Fenitropan

Uses: fungicide, cereals, maize, rice, sugar beet

Trade names: Volparox (Egyt)

Type: aromatic carboxylic acid

Synthesis:



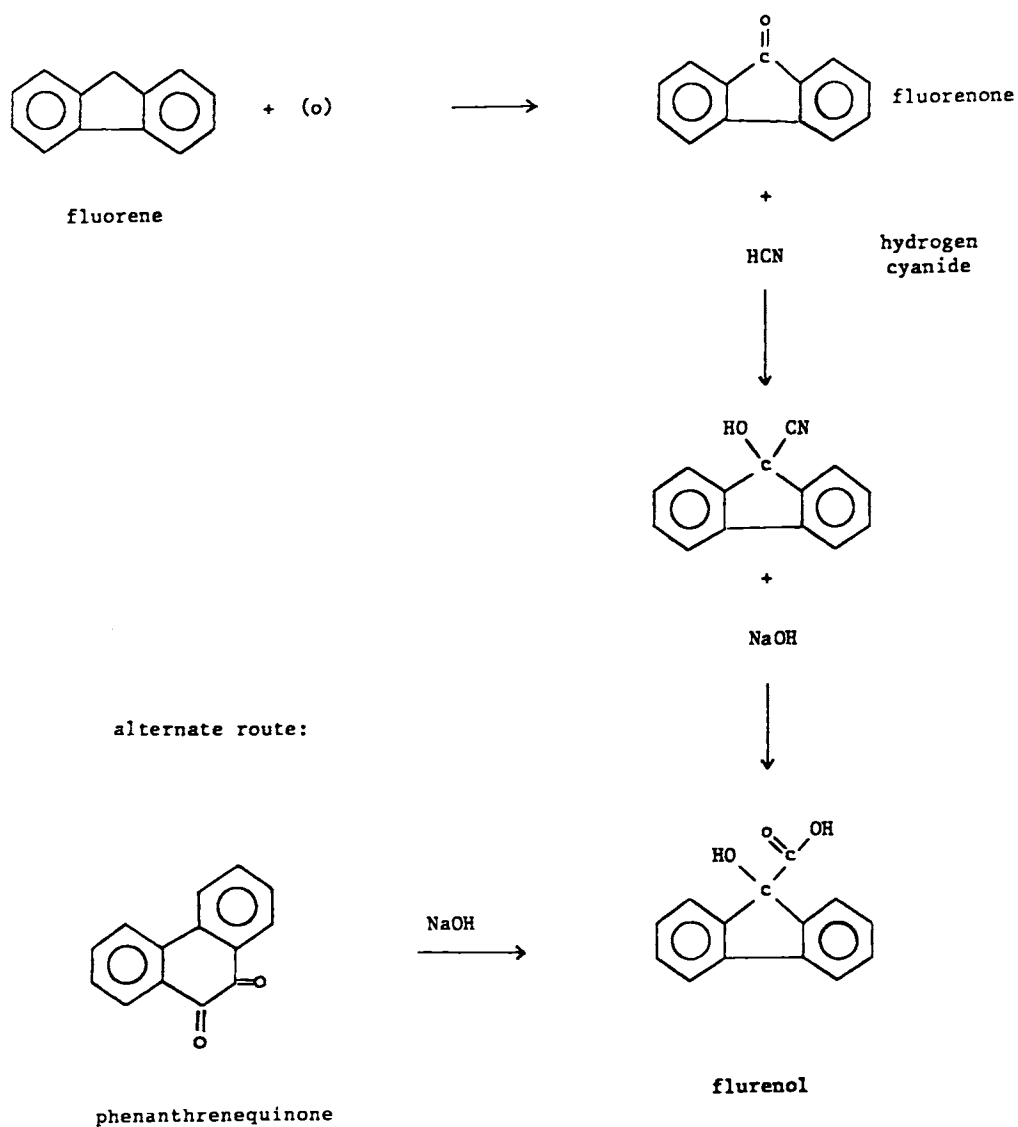
## Flurenol

Uses: growth regulator, cereals

Trade names: Anten (Cyanamid)

Type: aromatic carboxylic acid

Synthesis:



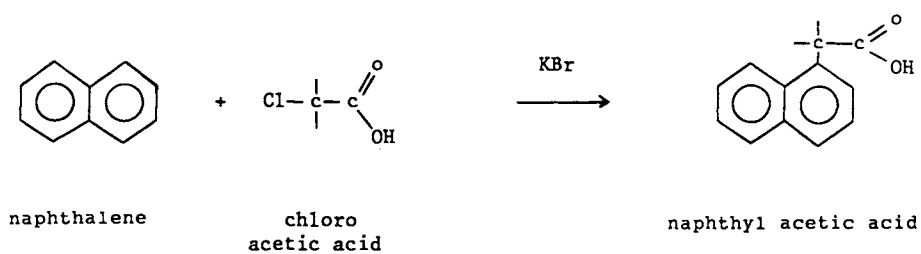
## Naphthyl Acetic Acid

Uses: growth regulator, fruit

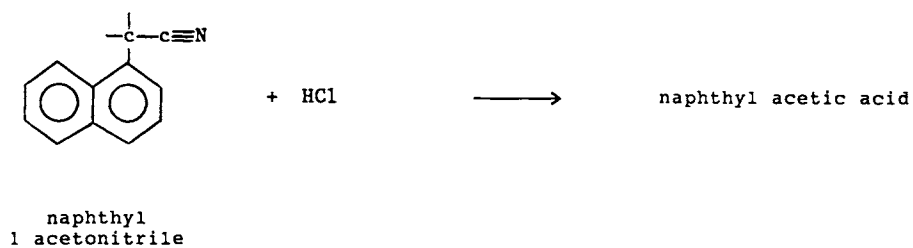
Trade names: Fruitone, Rootone (Rhône Poulenc), Phymone (ICI)

Type: aromatic carboxylic acid

Synthesis:



alternate route:



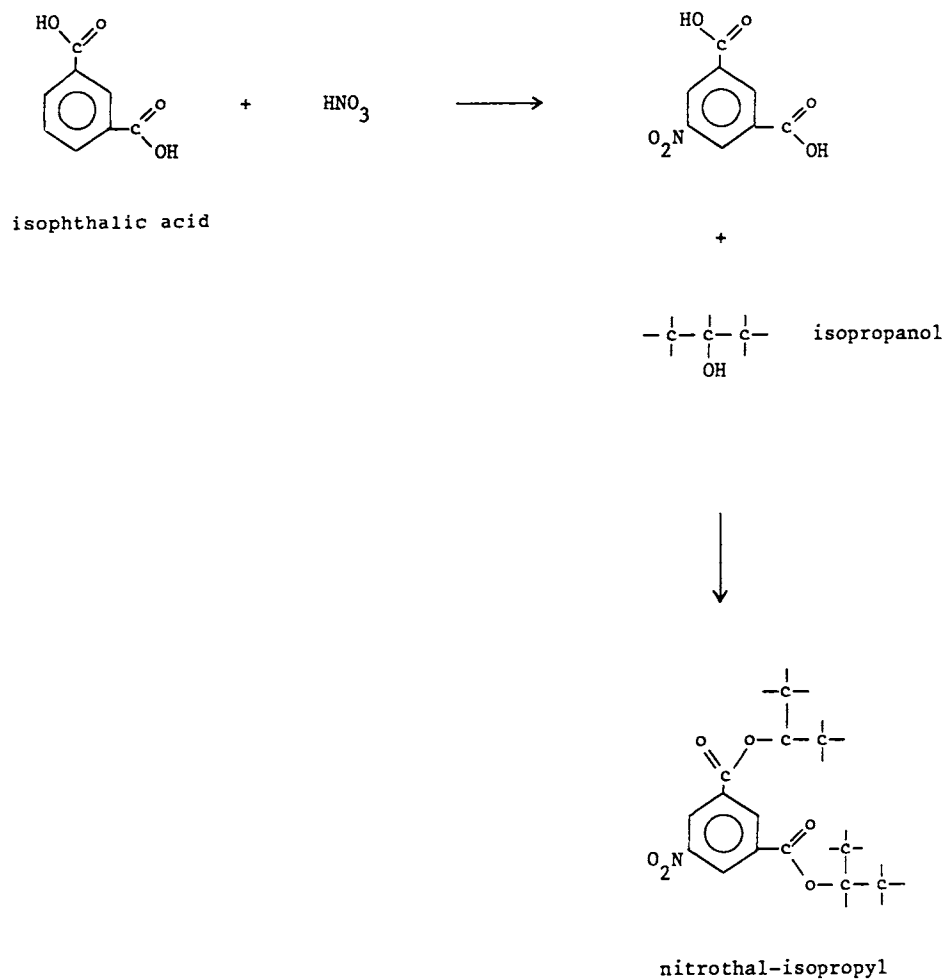
## Nitrothal-Isopropyl

Uses: fungicide, fruit

Trade names: Kumulan, Pallinal (BASF)

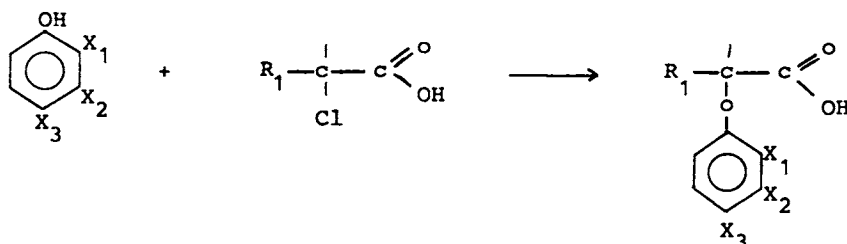
Type: aromatic carboxylic acid

Synthesis:



## PHENOXY CARBOXYLIC ACIDS AND AMIDES

The synthesis is by reaction between a phenol and a halo aliphatic acid



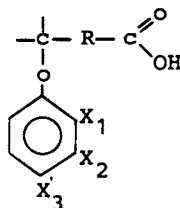
The halo aliphatic acid is chloro acetic or chloro propionic acid, the phenol being usually chlorinated before the final step.

Typical products are	<u>X<sub>1</sub></u>	<u>X<sub>2</sub></u>	<u>X<sub>3</sub></u>	<u>acid</u>
clomeprop	Cl	$\begin{array}{c}   \\ -\text{C}- \\   \end{array}$	Cl	chloropropionic (amide)
cloprop	H	Cl	H	chloropropionic
cloxyfonac	$\begin{array}{c}   \\ -\text{C}-\text{OH} \\   \end{array}$	H	Cl	chloro acetic
3 CPA	H	Cl	H	chloropropionic (amide)
4 CPA	H	H	Cl	chloro acetic
2,4 D	Cl	H	Cl	chloro acetic
dichlorprop	Cl	H	Cl	chloropropionic
fenoprop*	H	Cl	Cl	chloropropionic
MCPA	H	Cl	H	chloro acetic
mecoprop	$\begin{array}{c}   \\ -\text{C}- \\   \end{array}$	H	Cl	chloropropionic
2,4.5 T *	H	Cl	Cl	chloro acetic

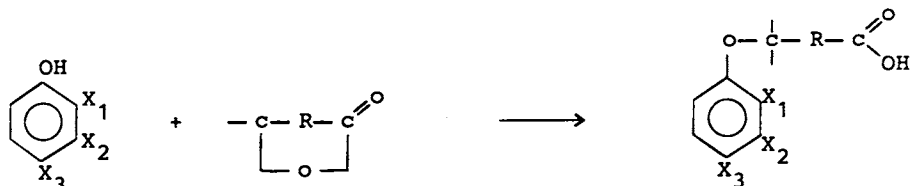
\* also an extra chlorine in the 6 position



When a structure of the type

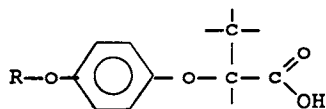


is required, since it is difficult to chlorinate the aliphatic acid in the terminal position, the preferred synthesis is by reaction of the phenol with a lactone



Thus 2,4 DB and MCPB are synthesized by this route.

Finally there is a group of phenoxy carboxylic acid pesticides with a structure



where R is an aromatic or heterocyclic nitrogen group.

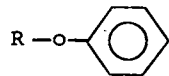
In this case either the



compound is synthesized

first (see phenyl ethers) and then joined to the halo propionic acid, as in the case of diclofop, fenoxaprop, fluazifop and haloxyfop;

or the phenoxy carboxylic acid is obtained as usual and the



bridge constitutes the last step (see quizalofop).

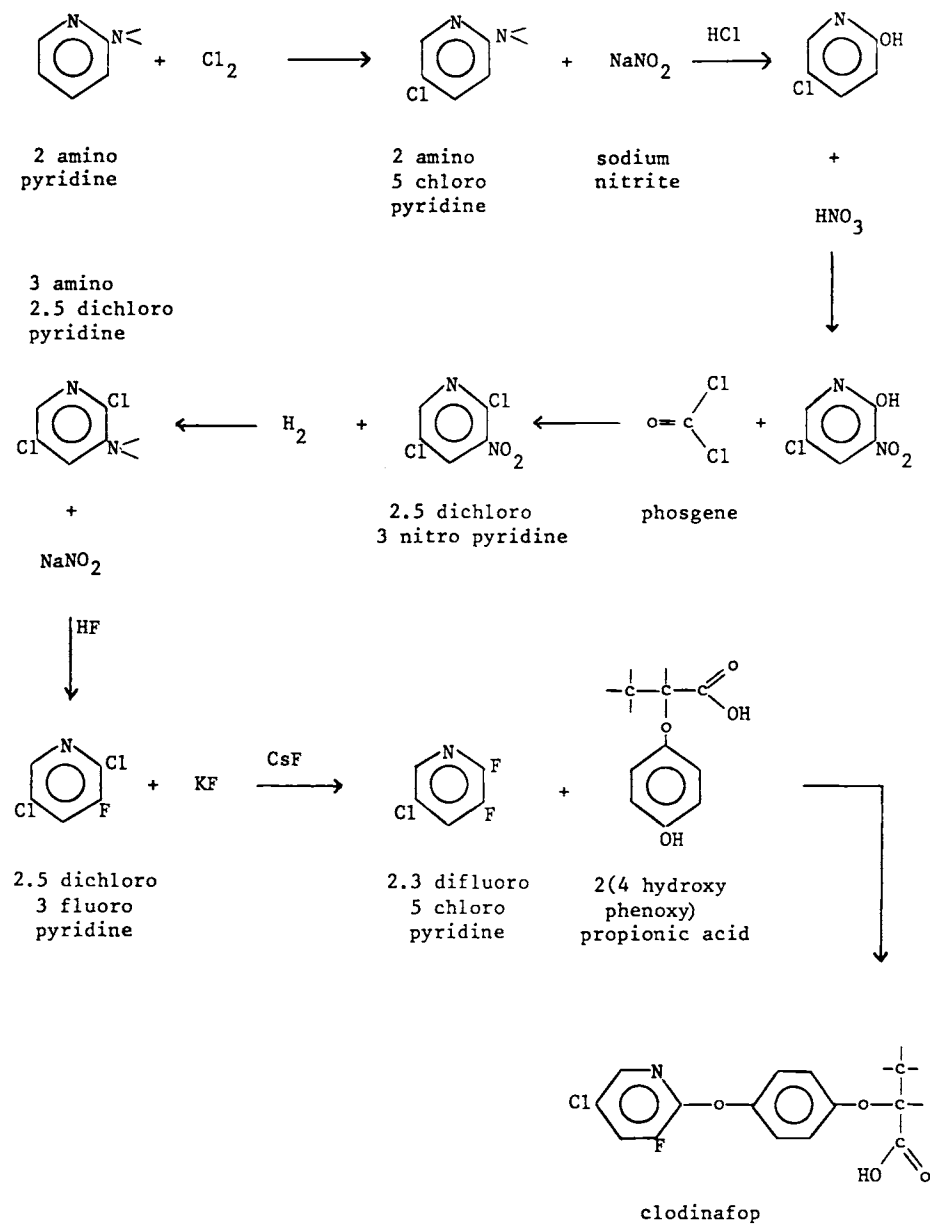
## Clodinafop

Uses: herbicide, cereals

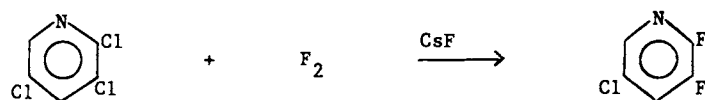
Trade names: Celio, Topik (Ciba)

Type: phenoxy carboxylic acid, phenyl ether, pyridine

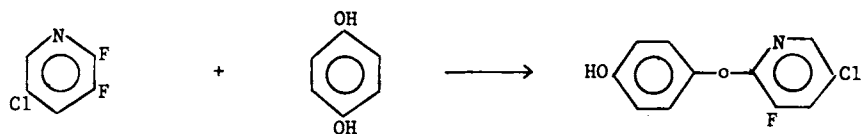
Synthesis:



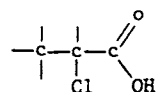
alternate route :



2,3,5 trichloro  
pyridine



hydroquinone



2 chloro  
propionic  
acid



clodinafop

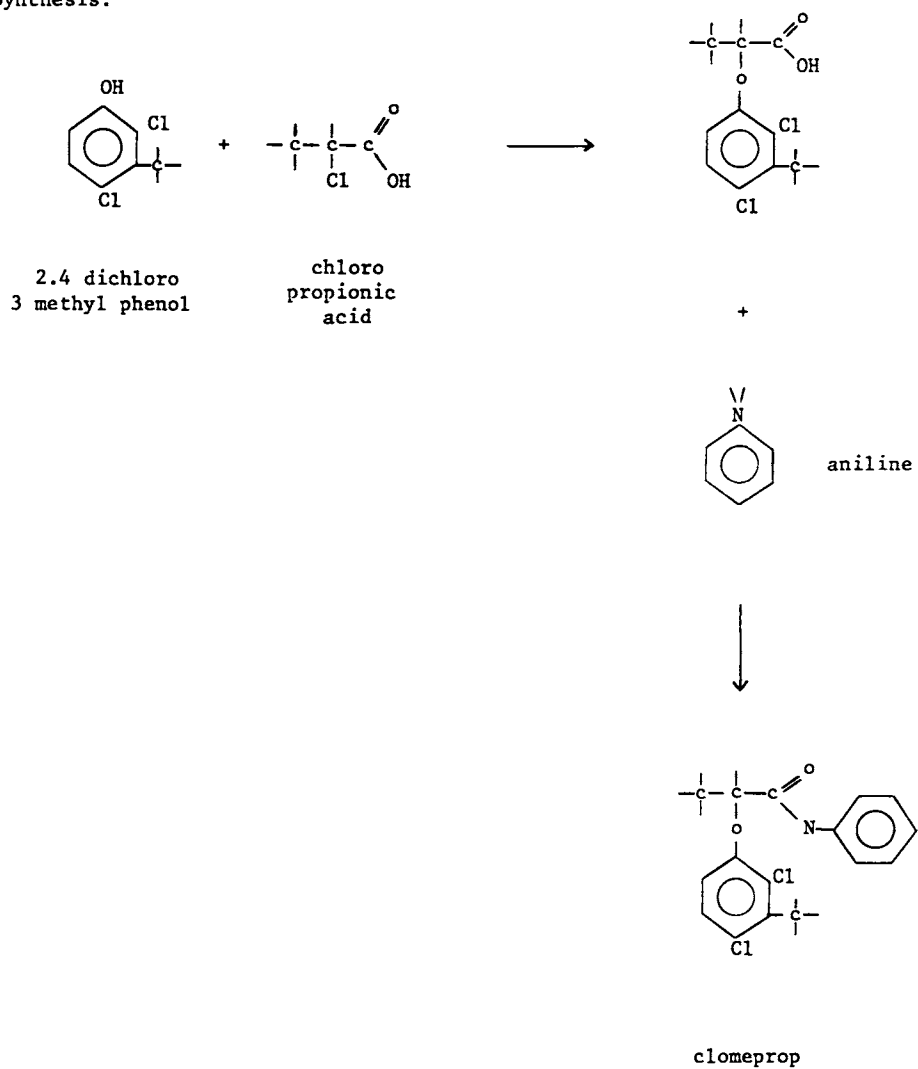
## Clomeprop

Uses: herbicide, paddy rice

Trade names: Cente (Mitsubishi)

Type: phenoxy carboxylic acid, amide

Synthesis:



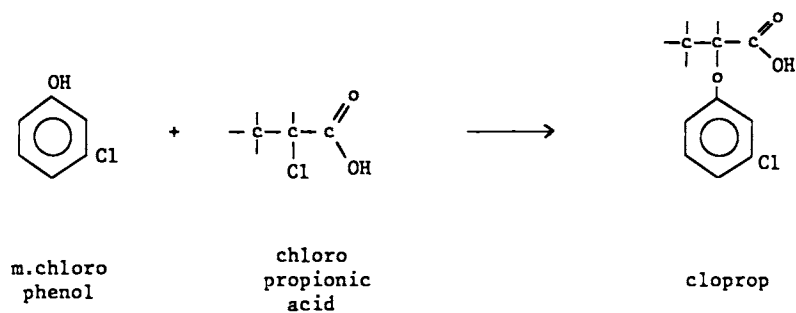
## Cloprop

Uses: growth regulator, pineapples, plums

Trade names: Fruitone CPA (Rhône Poulenc)

Type: phenoxy carboxylic acid

Synthesis:



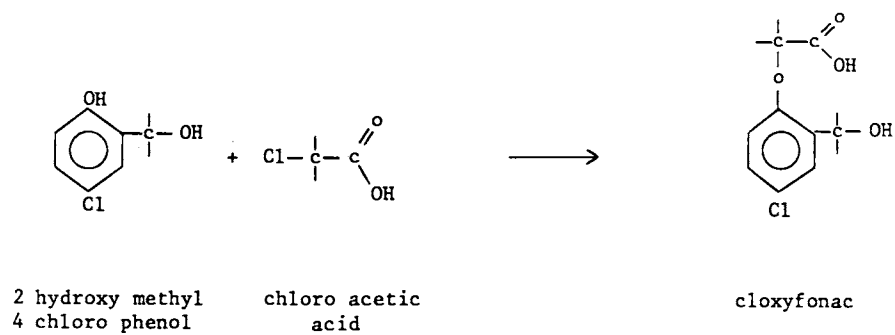
## Cloxyfonac

Uses: growth regulator, tomatoes, eggplants

Trade names: Tomatlane (Shionogi)

Type: phenoxy carboxylic acid

Synthesis:



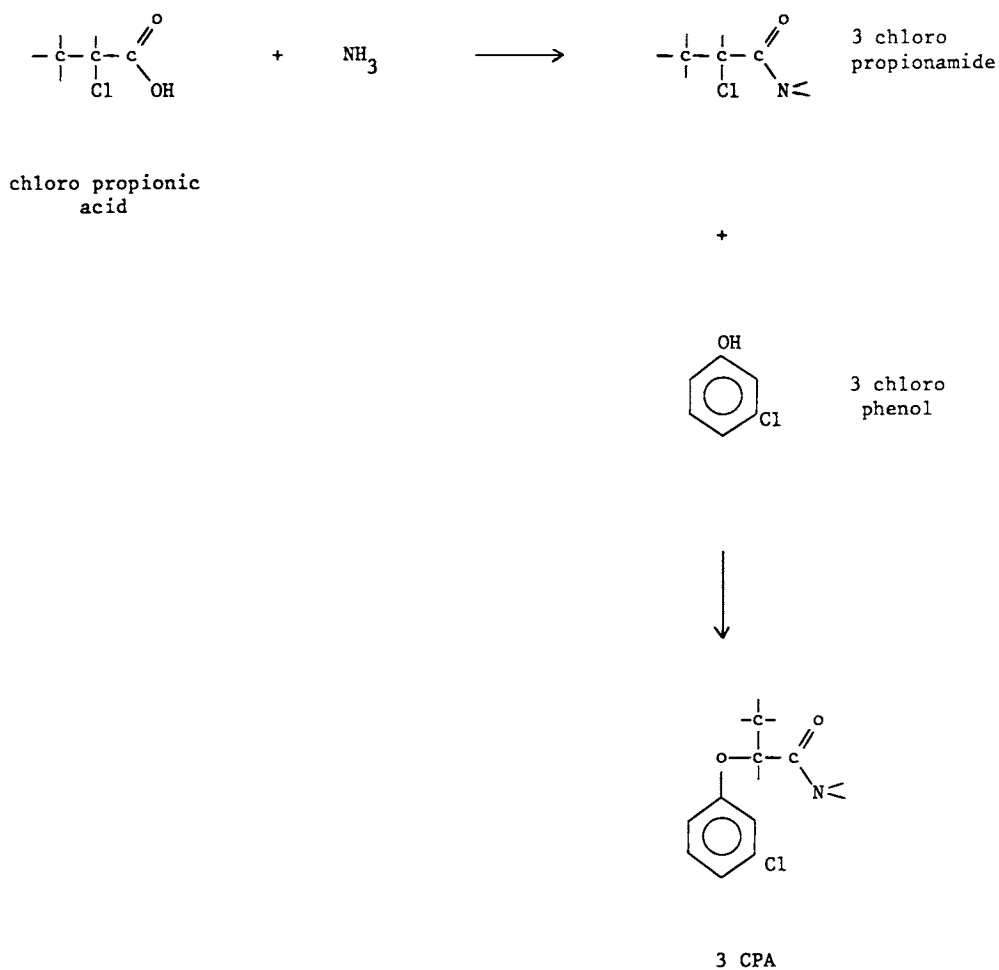
### 3 CPA

Uses: growth regulator, pineapples, plums

Trade names: Amchem 64-50 (Rhône Poulenc)

Type: phenoxy carboxylic acid, amide

Synthesis:



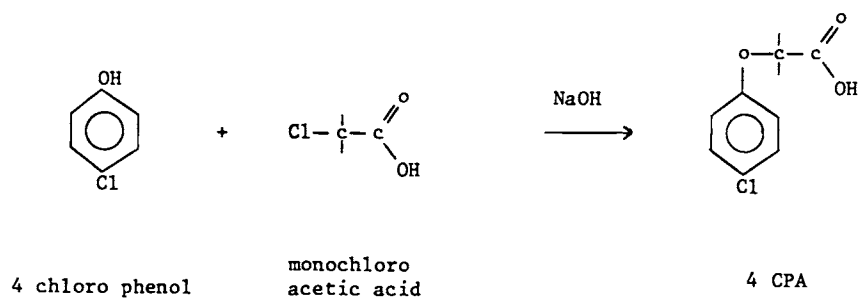
## 4 CPA

Uses: growth regulator, tomatoes

Trade names: Tomatofix, Tomato hold (Amvac)

Type: phenoxy carboxylic acid

Synthesis:





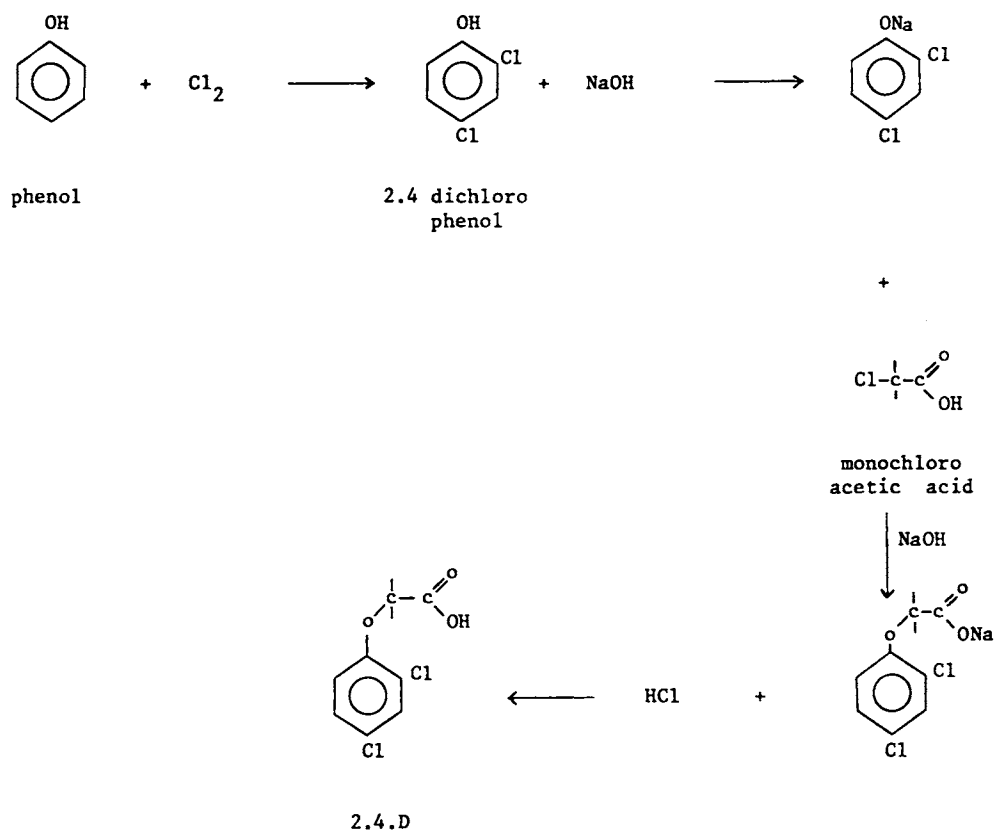
**2,4,D**

Uses: herbicide, cereals

Trade names: Hedonal (Bayer), Fernimine, Fernoxone, Agroxone (ICI), Desormone, Netogrone, Planotox (Rhône Poulenc)

Type: phenoxy carboxylic acid

Synthesis:



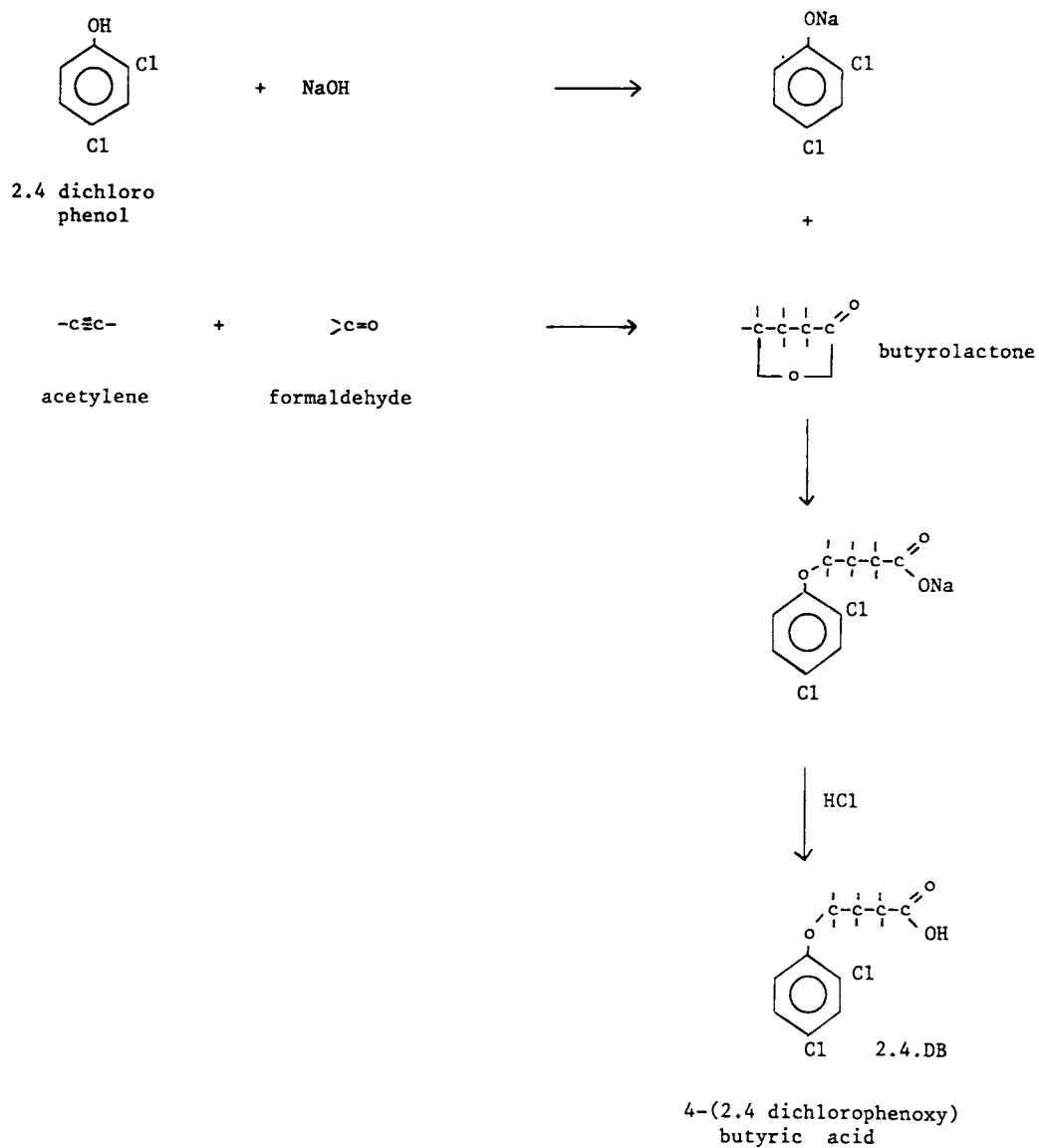
## 2,4,DB

Uses: herbicide, cereals, grassland

Trade names : Embutox (Rhône Poulenc)

Type: phenoxy carboxylic acid

Synthesis:



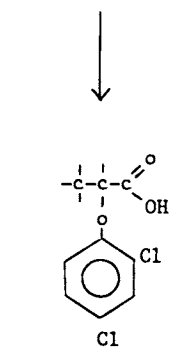
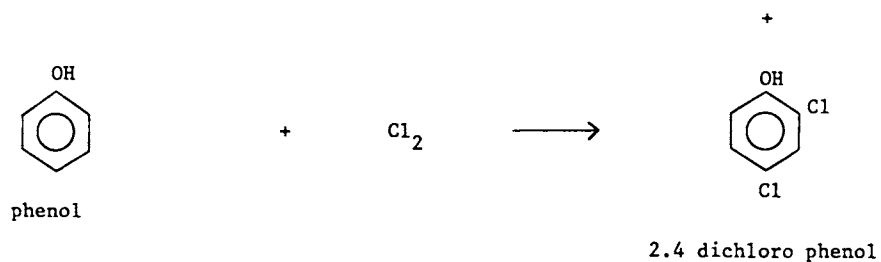
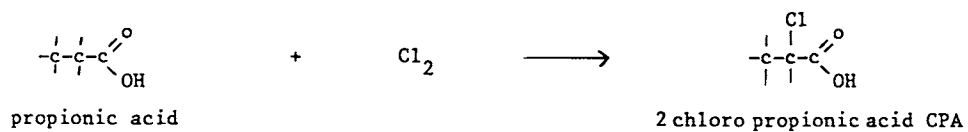
## Dichlorprop

Uses: herbicide, cereals, grass, turf

Trade names: Cornox (Schering)

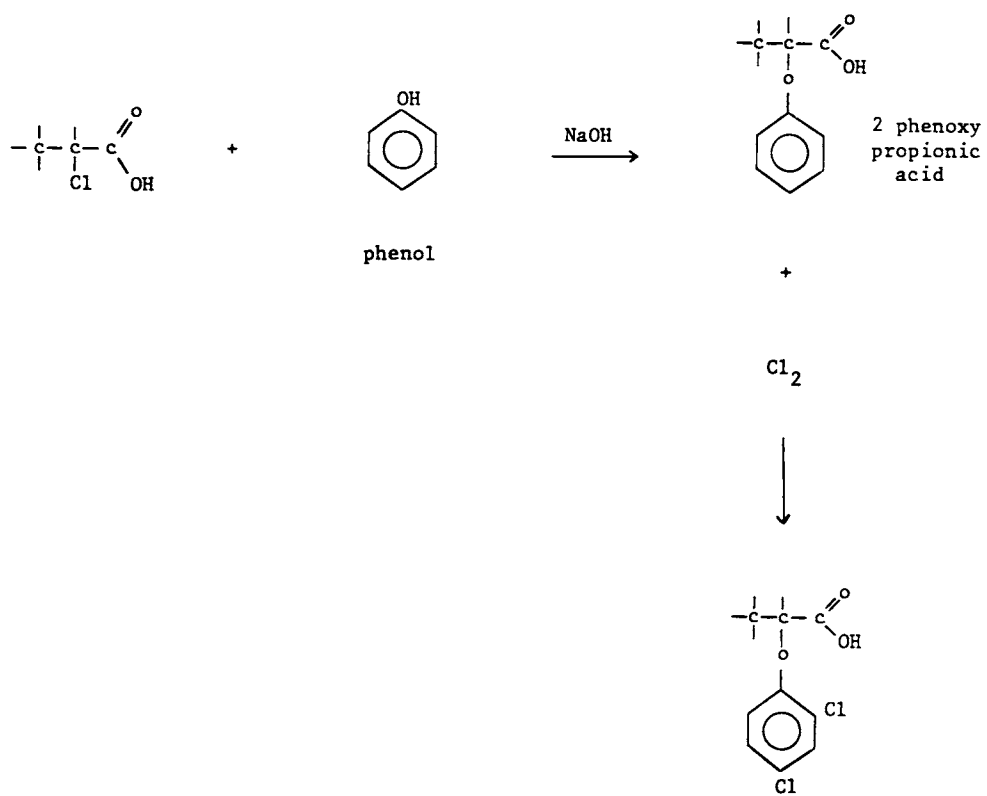
Type: phenoxy carboxylic acid

Synthesis:



dichlorprop

alternate route:



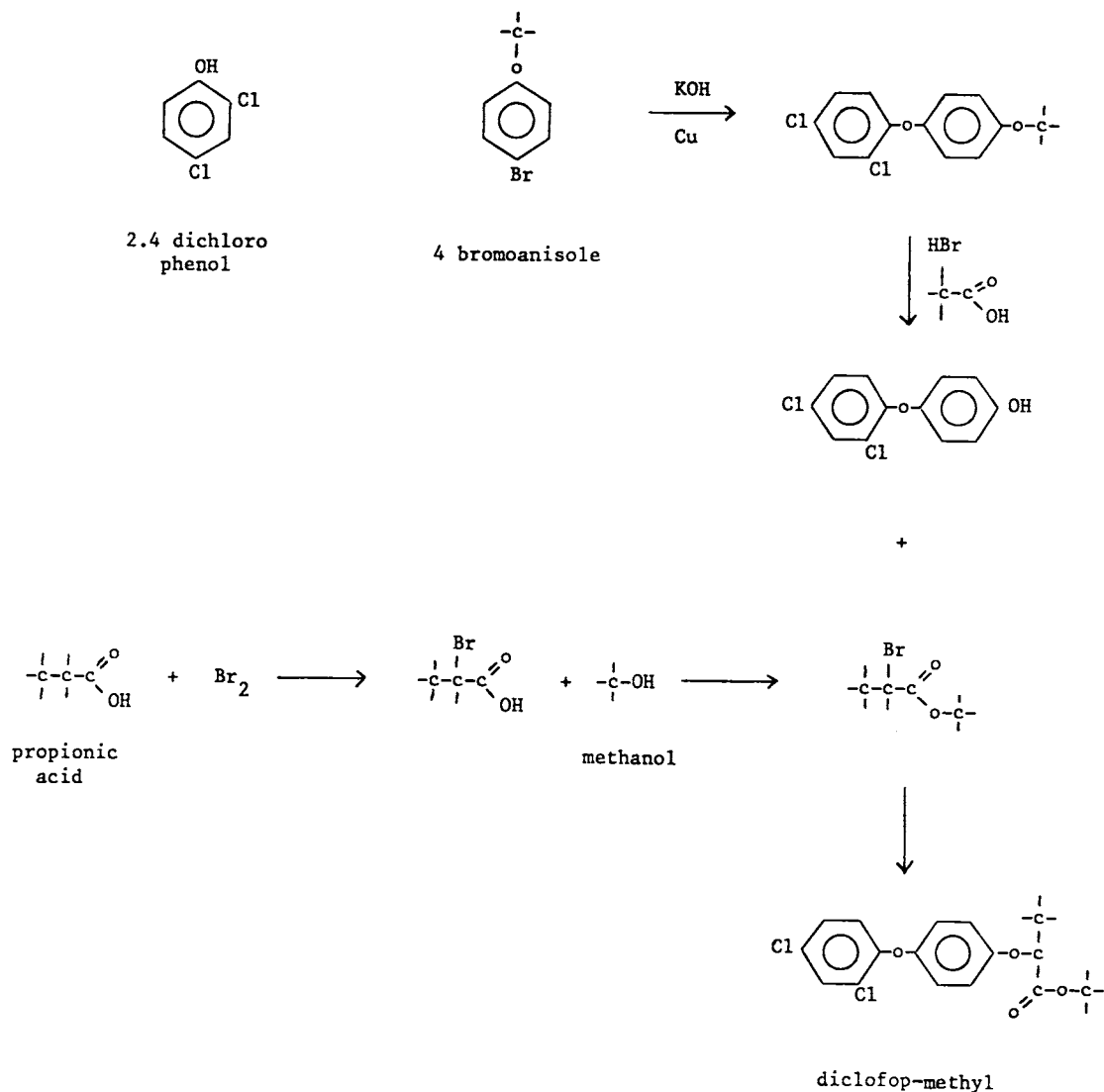
## Diclofop-Methyl

Uses: herbicide for wheat, barley, rye, soya, potatoes, sugar beets, sunflowers, tomatoes, vegetables

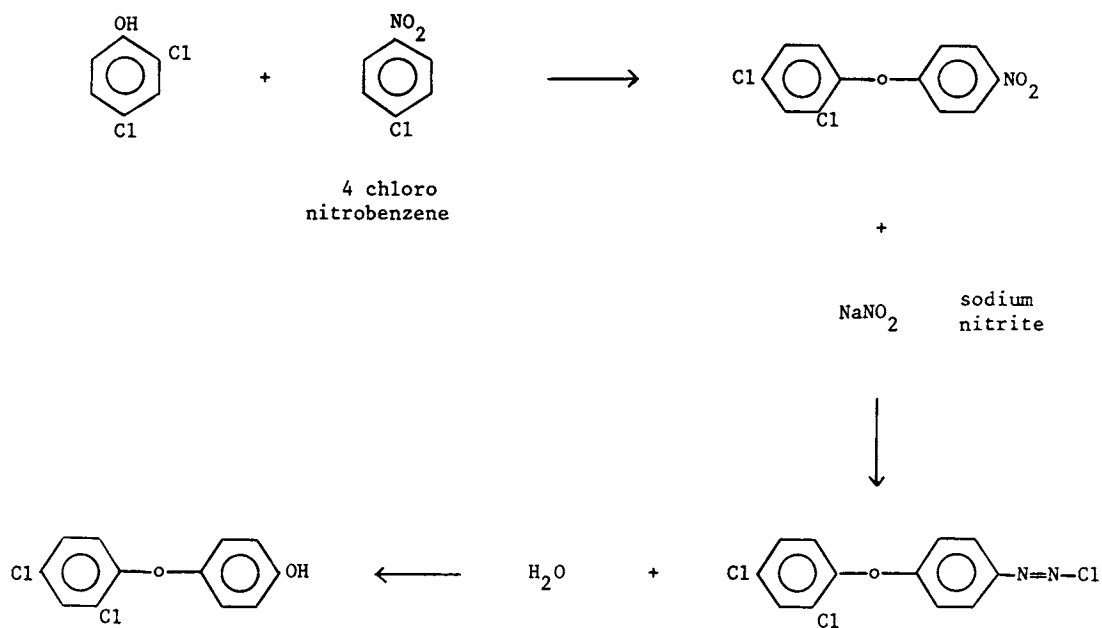
Trade names: Hoe Grass, Hoelon, Illoxan (Hoechst)

Type: phenoxy carboxylic acid, phenyl-ether

Synthesis:



alternate route :



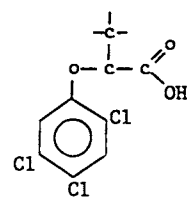
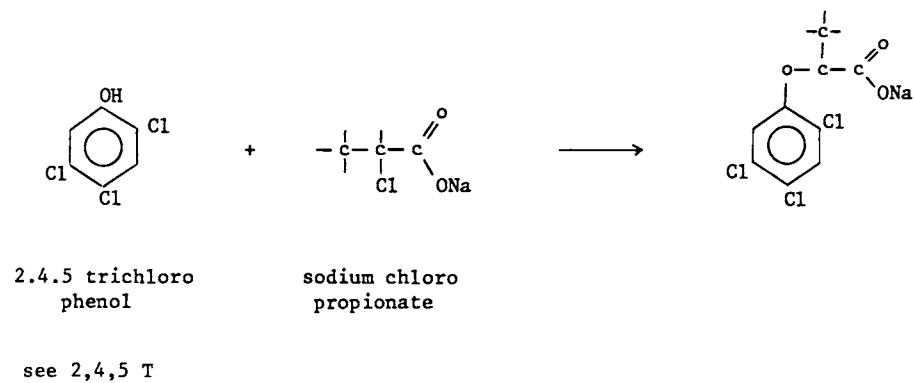
## Fenoprop

Uses: herbicide, growth regulator, non crop lands, pastures, maize, sugar cane, rice

Trade names: Kuron, Kurozal (Dow), Fruitone T (U.Carbide)

Type: phenoxy carboxylic acid

Synthesis:



fenoprop

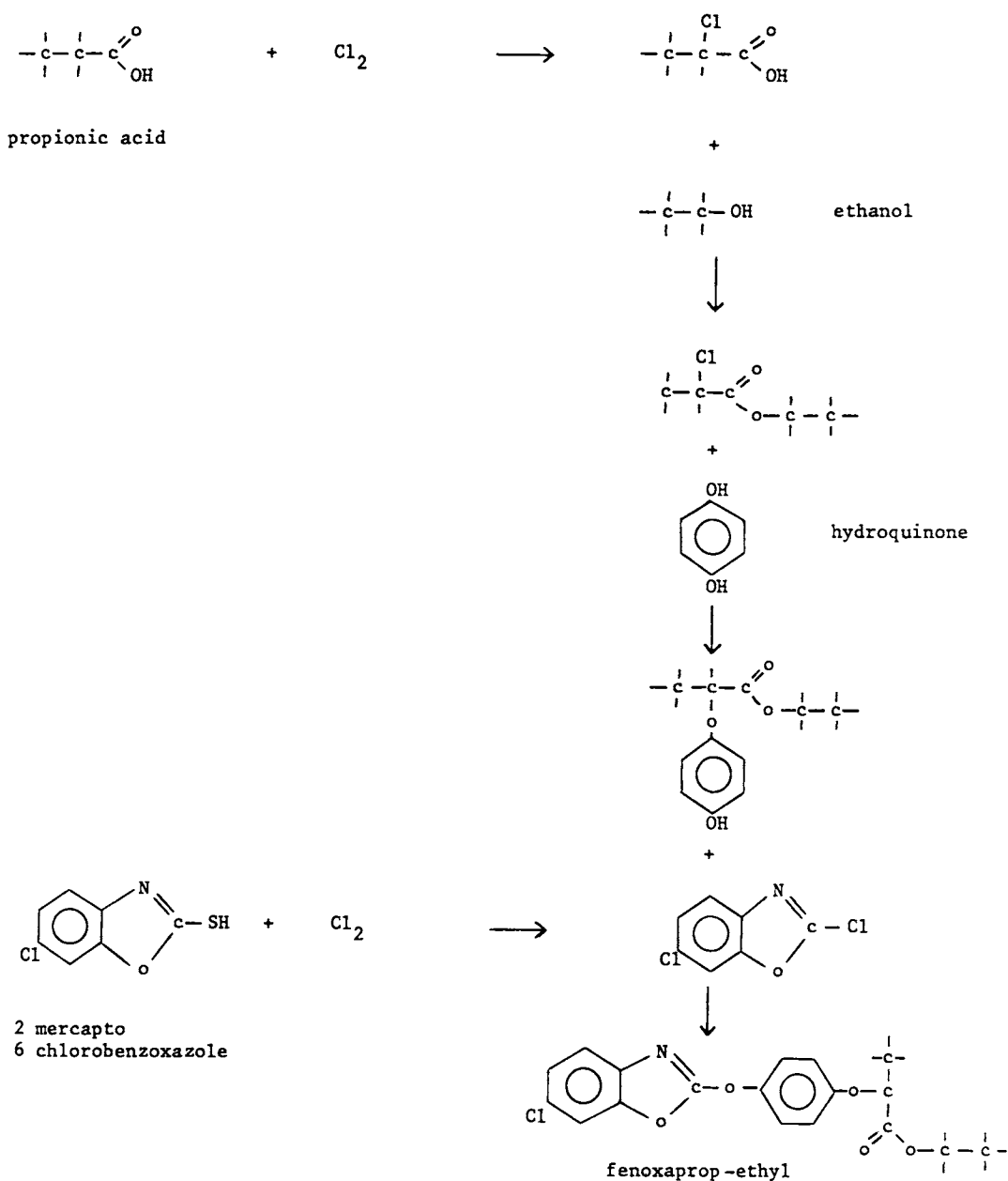
## Fenoxaprop-Ethyl

Uses: herbicide, beets, cotton, potatoes, soya beans, vegetables

Trade names: Furore, Whip, Acclaim, Puma (Hoechst)

Type: phenoxy carboxylic acid, benzoxazole

Synthesis:





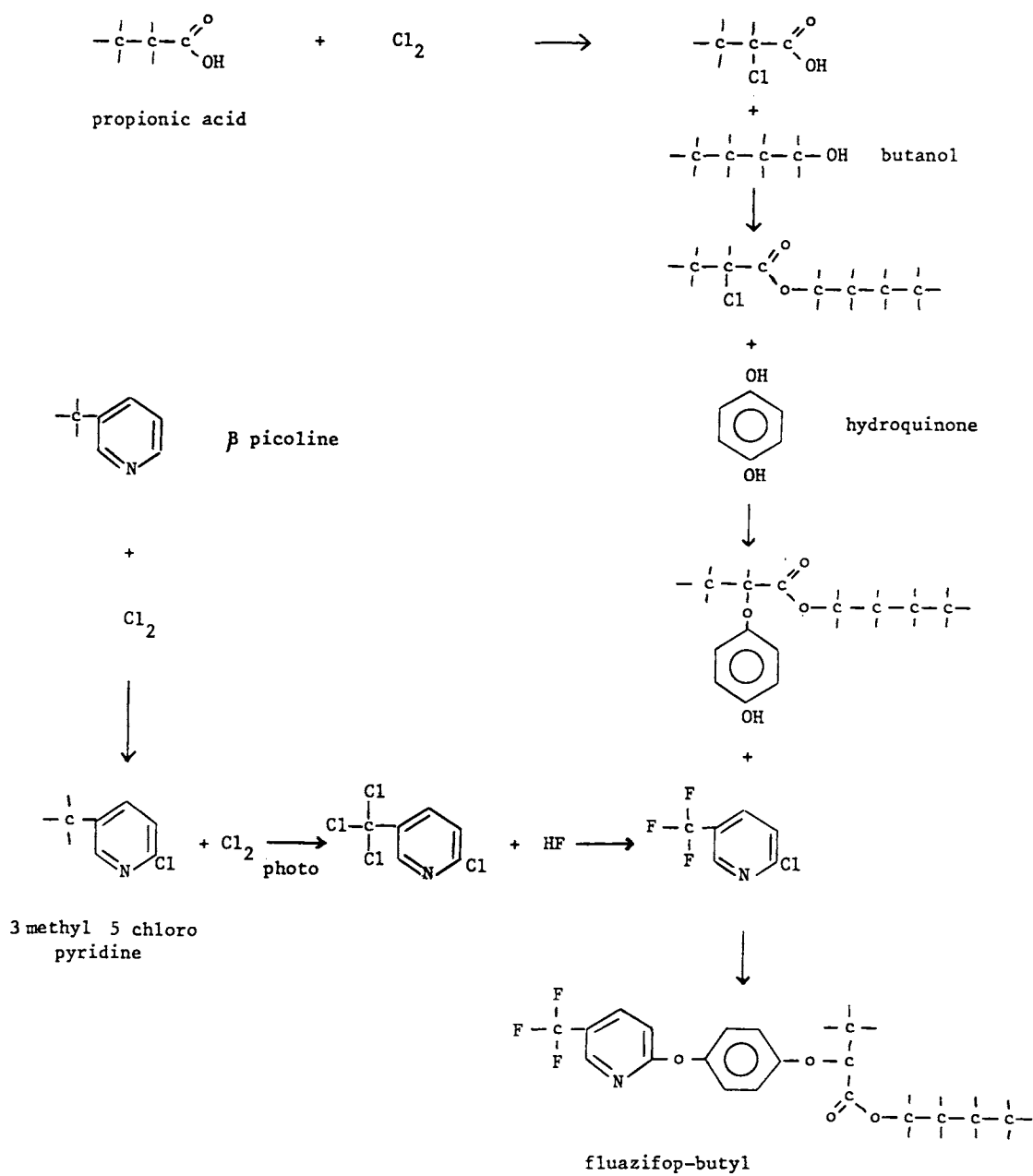
## Fluazifop-Butyl

Uses: herbicide

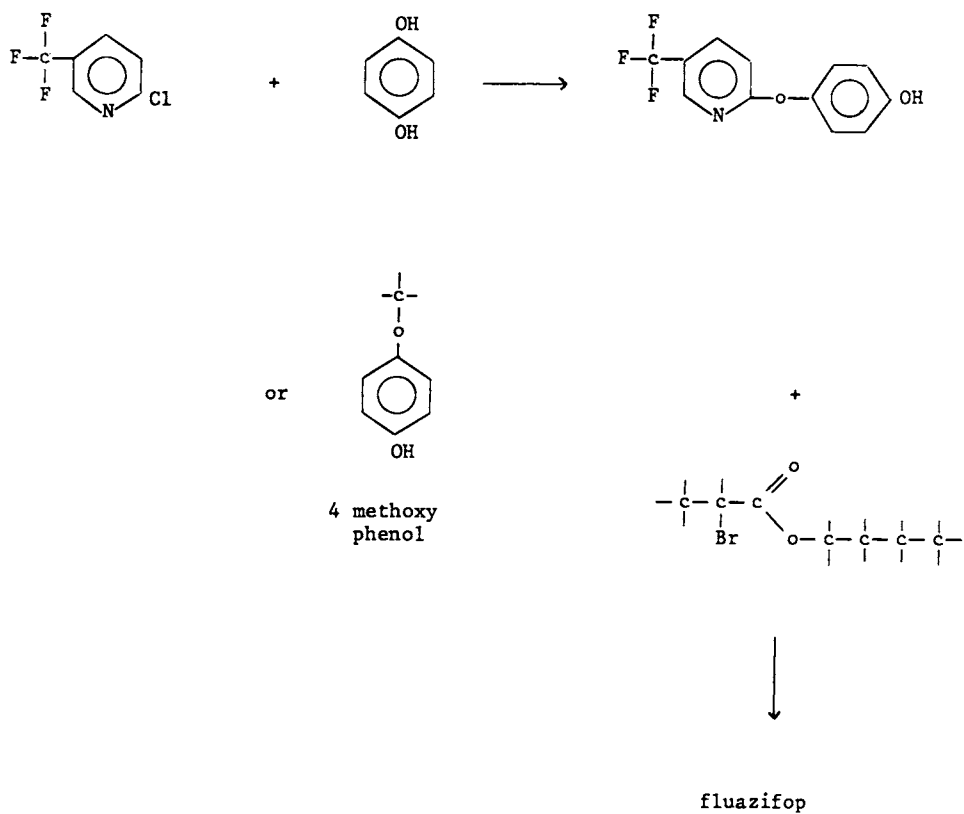
Trade names: Fusilade (ICI)

Type: phenoxy carboxylic acid, pyridine

Synthesis:



alternate route:



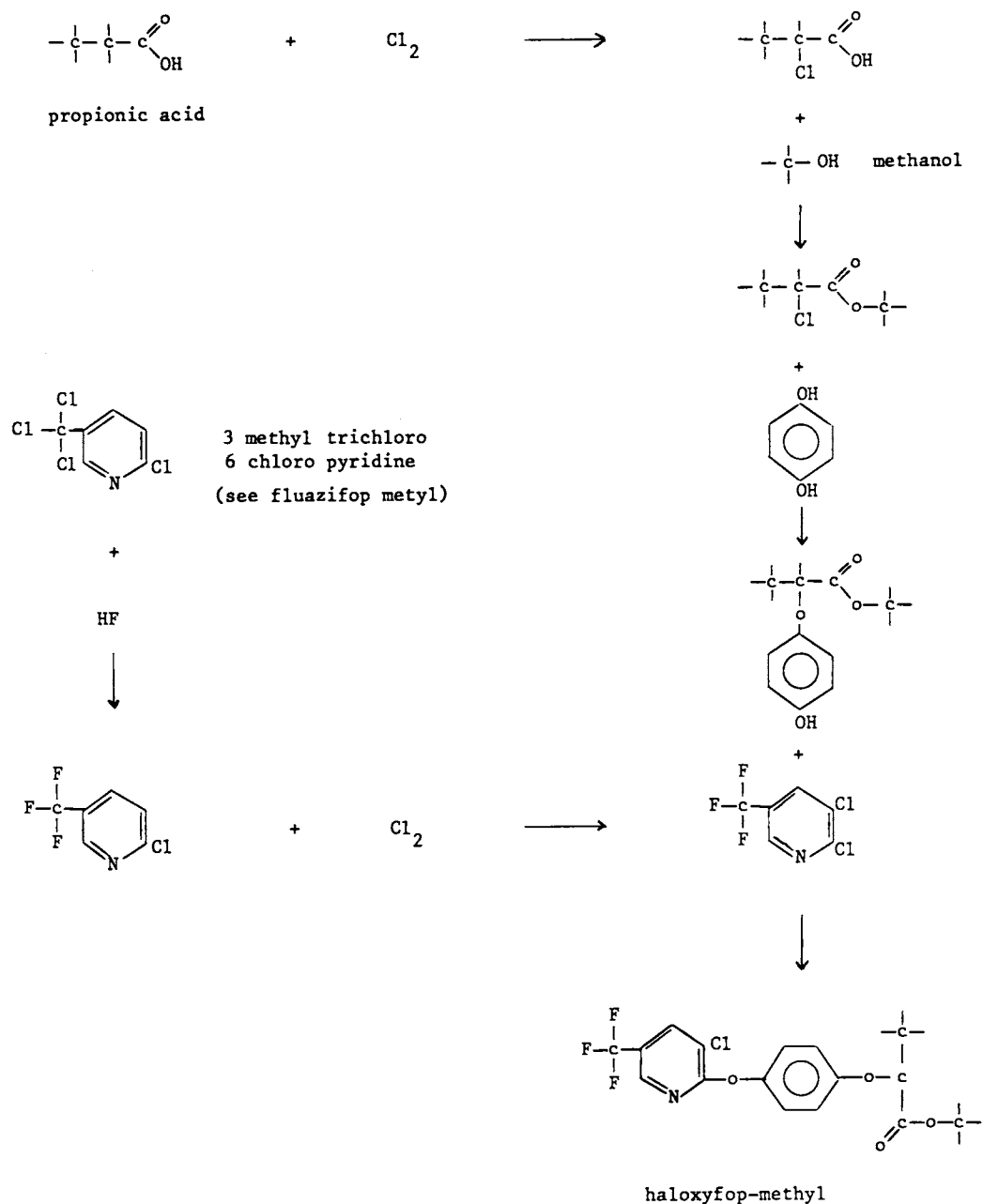
## Haloxypop-Methyl

Uses: herbicide, sugar beet, potatoes, onions, vegetables, sunflowers, soyabeans

Trade names: Gallant, Zellek, Verdict (Dow Elanco)

Type: phenoxy carboxylic acid

Synthesis:



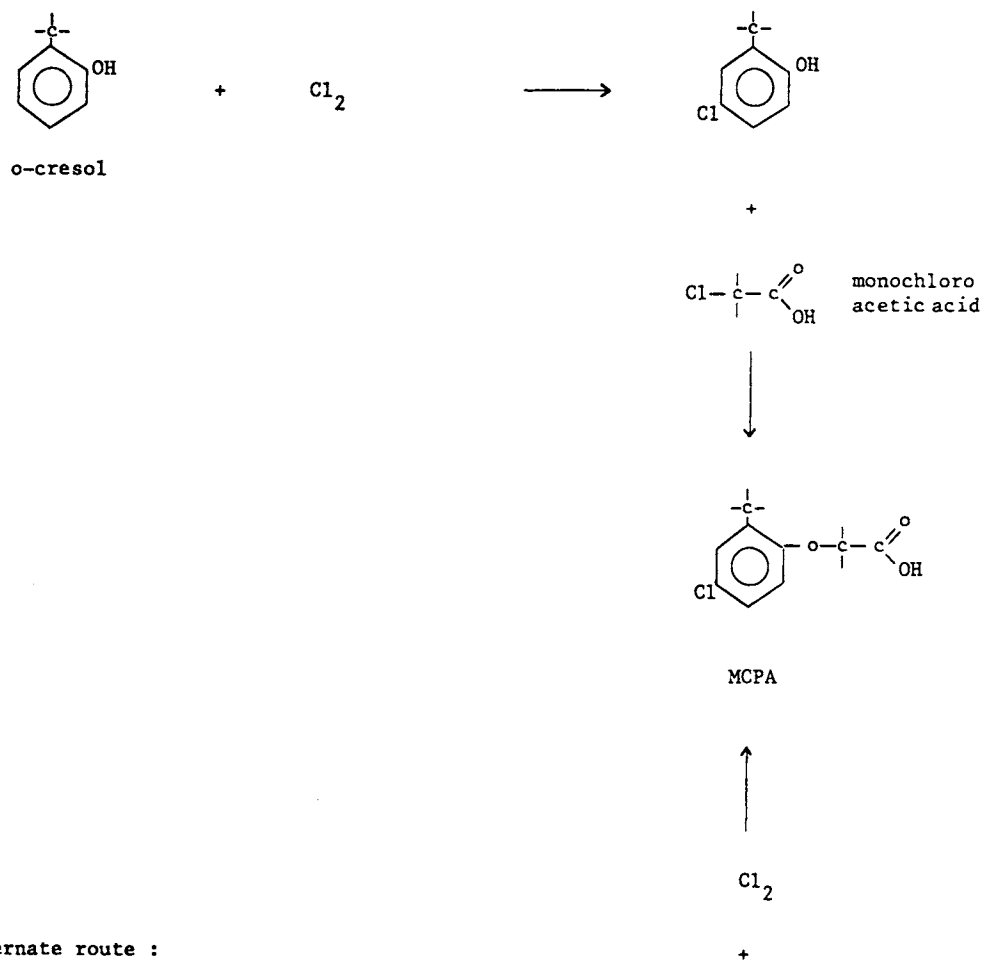
## MCPA

Uses: herbicide, cereals, grass land, turf

Trade names: Cornox M (Schering)

Type: phenoxy carboxylic acid

Synthesis:



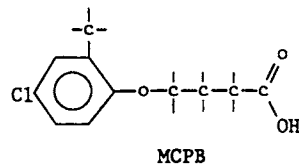
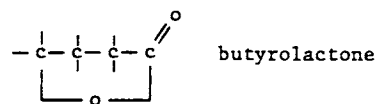
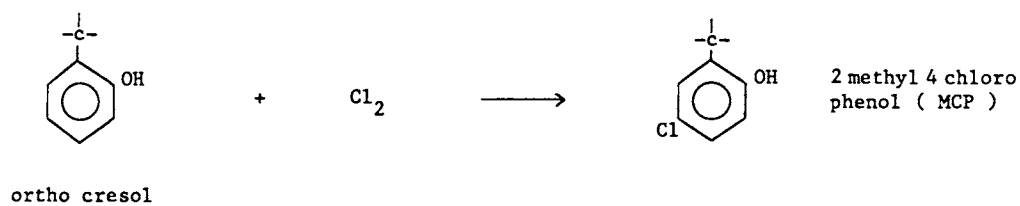
## MCPB

Uses: herbicide, cereals, peas, grass

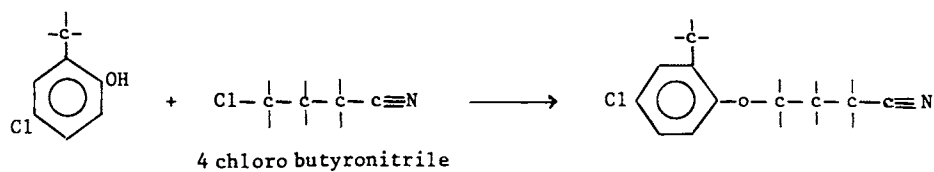
Trade names: Tropotox (Rhône Poulenc)

Type: phenoxy carboxylic acid

Synthesis:



alternate route :



## Mecoprop

Uses: herbicide, cereals, grassland

Trade names: Iso Cornox (Schering)

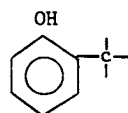
Type: phenoxy carboxylic acid

Synthesis:



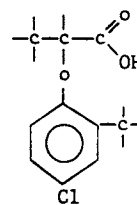
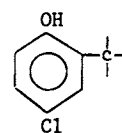
propionic acid

+



o-cresol

+



mecoprop

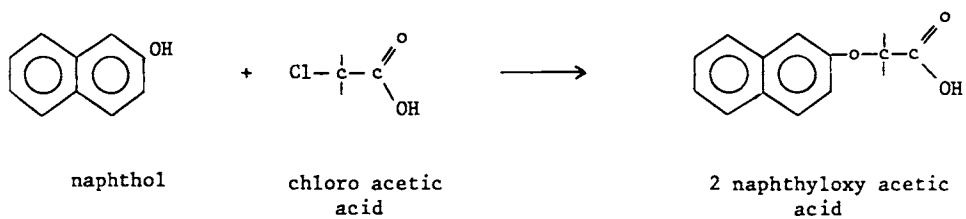
## 2 Naphthyloxy Acetic Acid (Naphthoxy Acetic Acid)

Uses: growth regulator, tomatoes, fruit

Trade names: (Bitterfeld)

Type: phenoxy carboxylic acid

**Synthesis:**



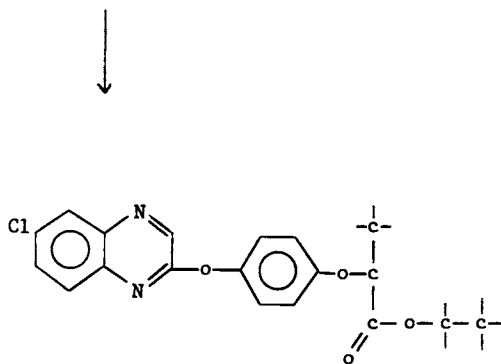
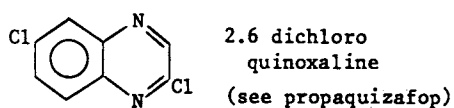
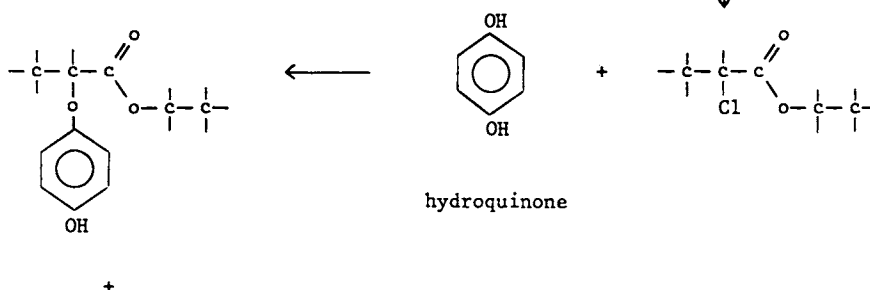
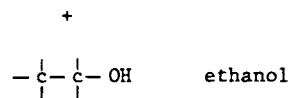
## Quizalofop-Ethyl

Uses: herbicide, sugar beet

Trade names: Assure (DuPont), Pilot (Schering), Targa (Rhône Poulenc)

Type: phenoxy carboxylic acid, pyrimidine

Synthesis:



quizalofop-ethyl



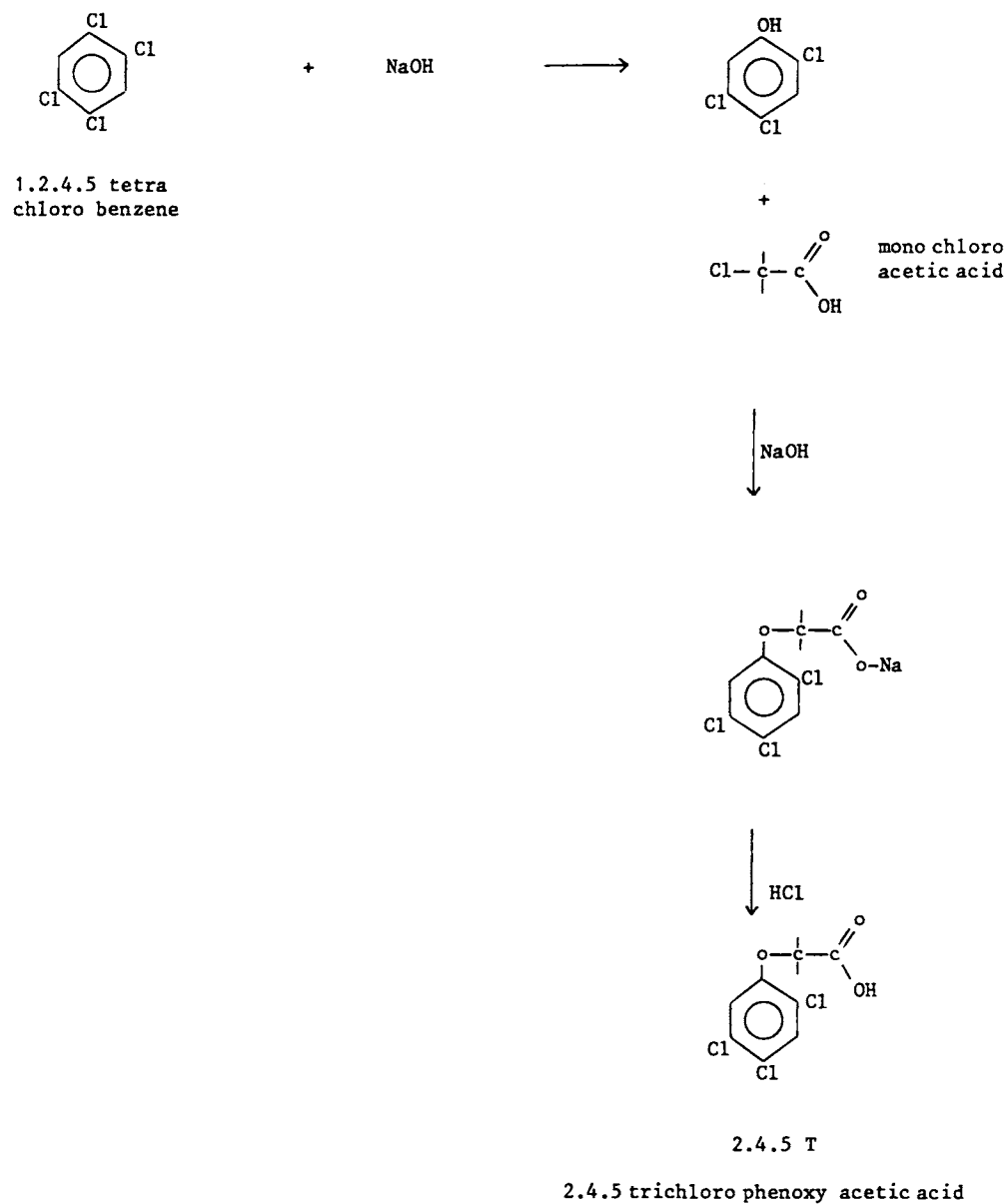
## 2,4,5 T

Uses: herbicide, trees

Trade names: Weedone (Rhône Poulenc)

Type: phenoxy carboxylic acid

Synthesis:



# HALOGENATED ALIPHATIC ACIDS

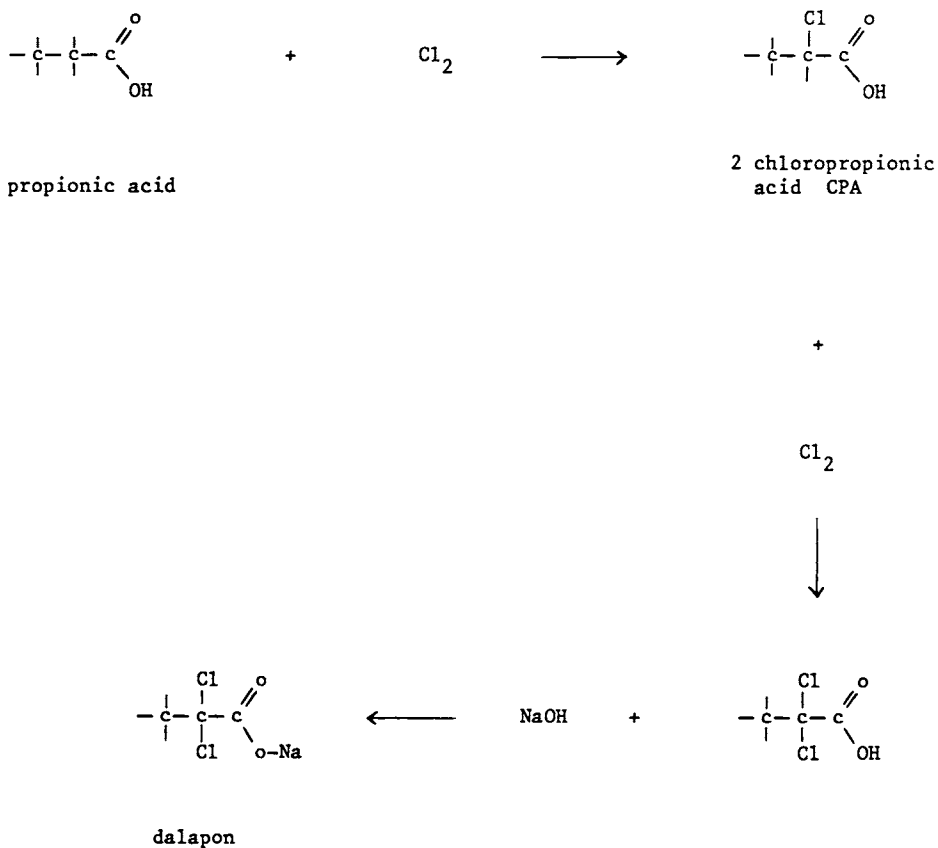
## Dalapon

Uses: herbicide for grass, citrus, sugar cane, rubber, coffee, industrial sites roadside, railway tracks, orchards, olive, bananas, asparagus, potatoes

Trade names: Dowpon (Dow), Radapon, Basfapon (BASF)

Type: chlorinated aliphatic acid

Synthesis:



## Flupropanate

Uses: herbicides , pastures

Trade names: Frenock (Daikin)

Type: halogenated aliphatic acids

Synthesis:



tetrafluoro  
ethylene

sodium  
cyanide

flupropanate

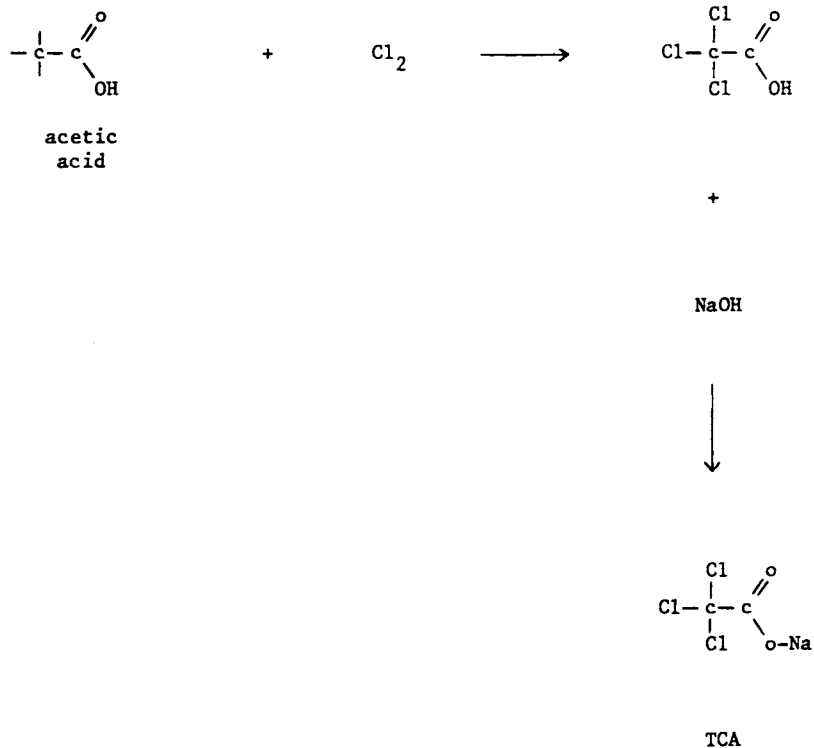
## TCA Trichloroacetate

Uses: herbicide, sugar beet

Trade names: NaTa (Hoechst), Tecane (Schering), Varitox (Rhône Poulenc)

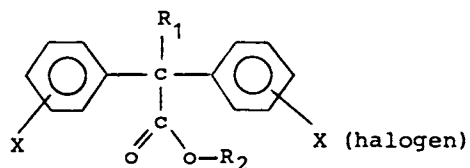
Type: chlorinated aliphatic acid

Synthesis:



# HALOGENATED AROMATIC, CARBOXYLIC ACIDS

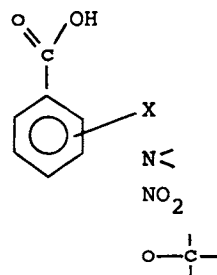
The most common structures are :



bromopropylate

chlorobenzilate

chloropropylate



chloramben

chlorthal

dicamba

2.3.6 TBA

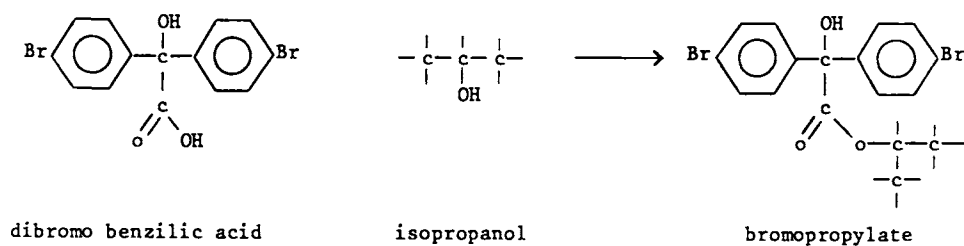
## Bromopropylate

Uses: acaricide, cotton, fruit, grapes, soya beans, vegetables

Trade names: Neoron, Acarol (Ciba)

Type: halogenated aromatic carboxylic acid

Synthesis:



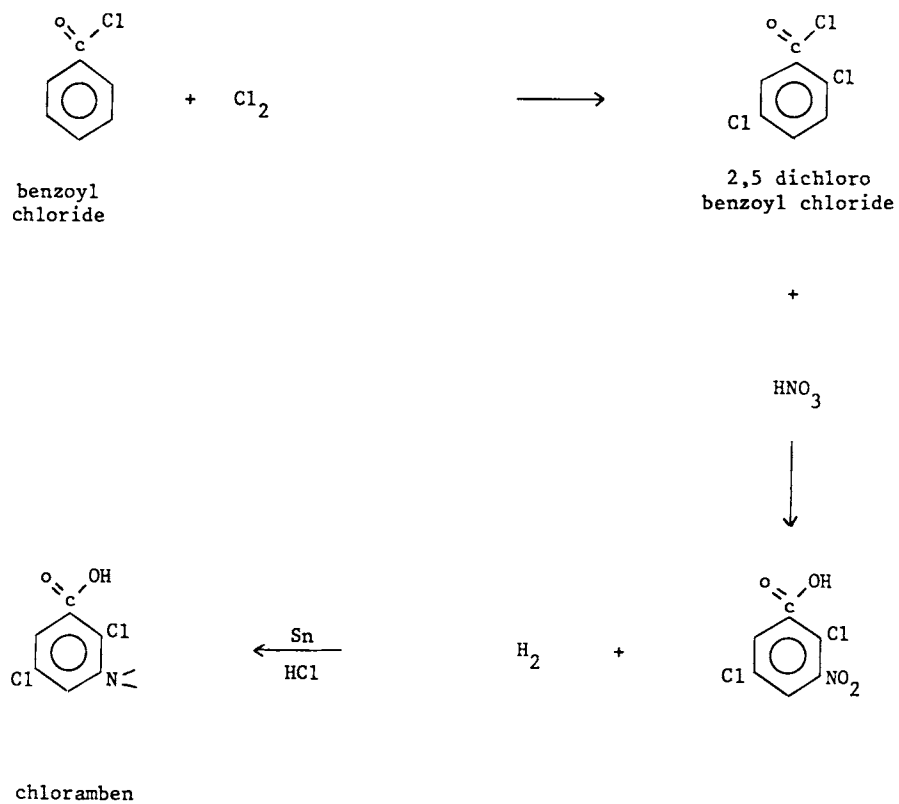
## Chloramben

Uses: herbicide, maize, soya beans, vegetables, sunflowers, ornamentals

Trade names: Amiben (Rhône Poulenc)

Type: halogenated aromatic carboxylic acid

Synthesis:



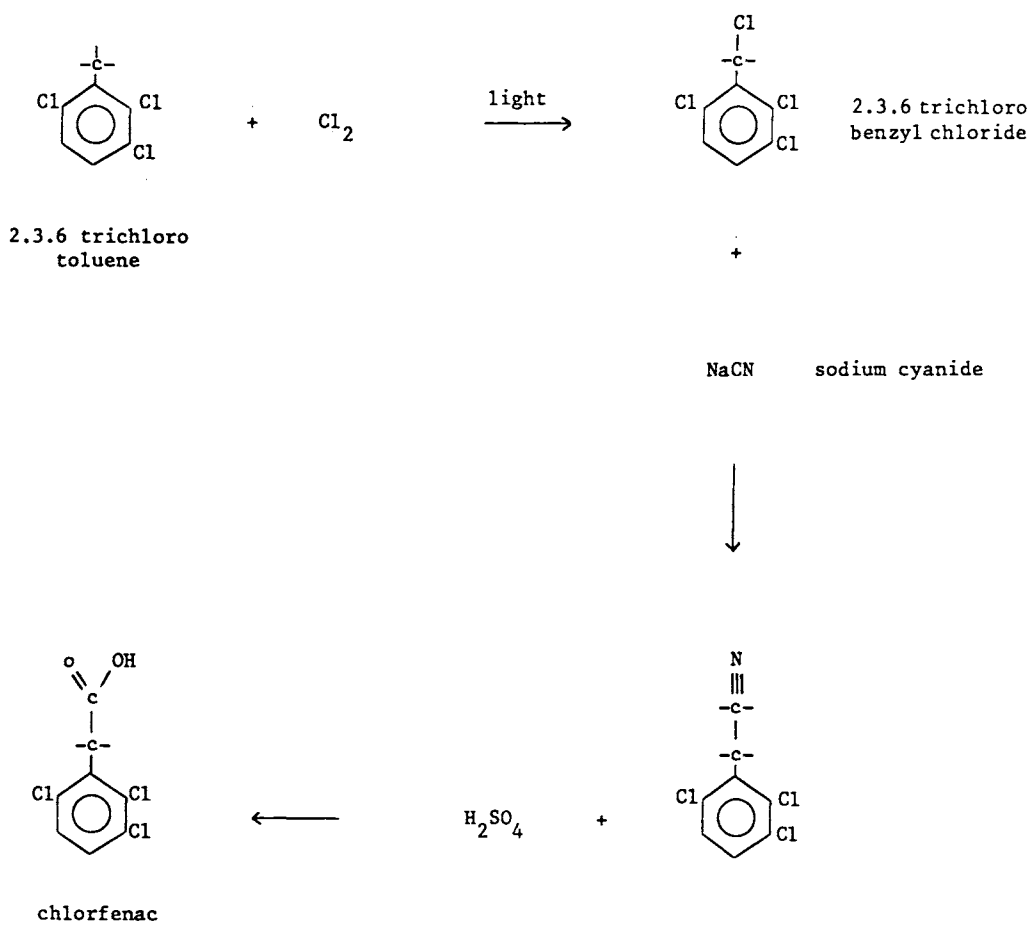
## Chlorfenac

Uses: herbicide, sugar cane, non crop lands, lakes, ponds, ditches

Trade names: Fenac, Fenatrol (U.Carbide)

Type: halogenated aromatic carboxylic acid

Synthesis:





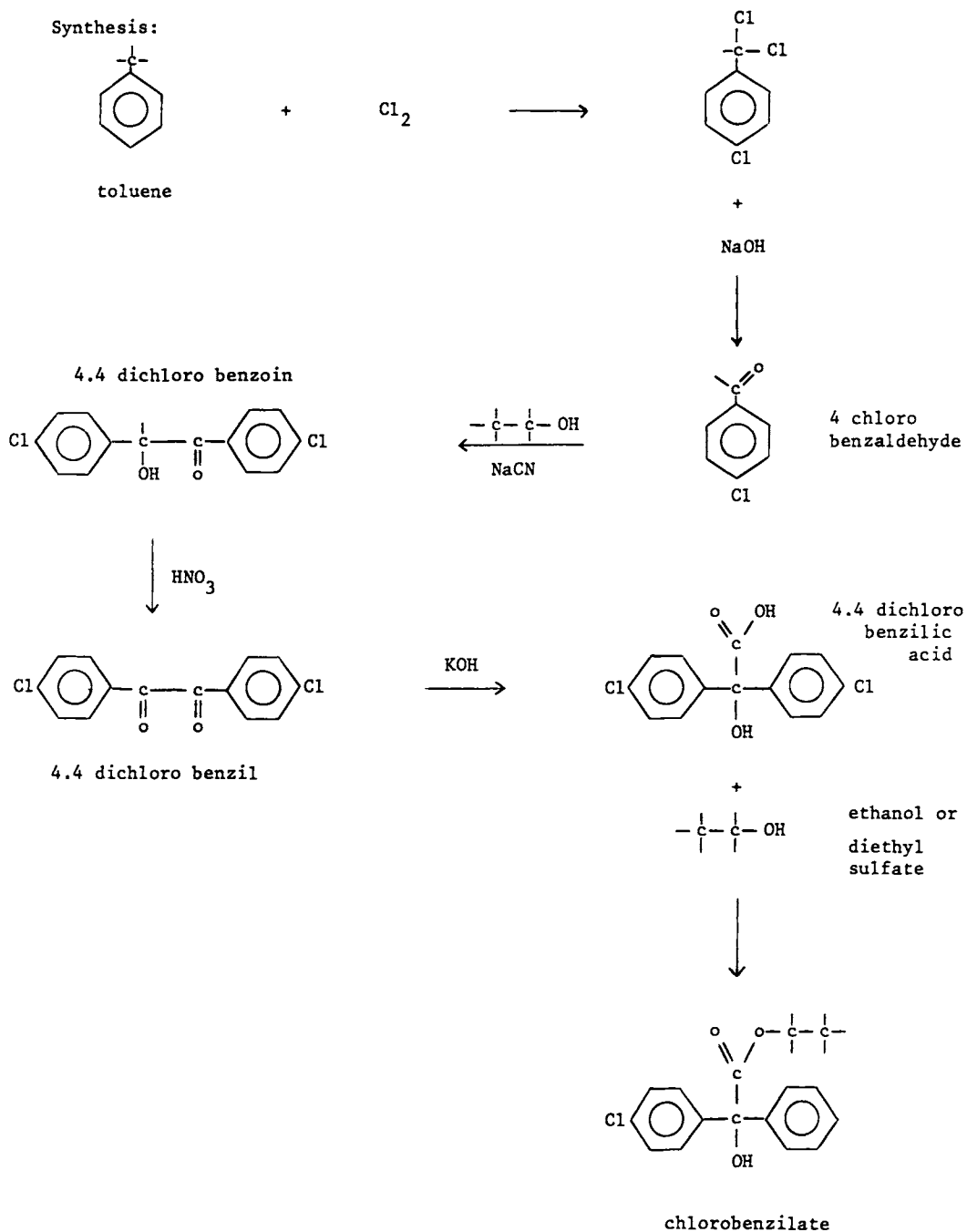
## Chlorobenzilate

Uses: acaricide, citrus, cotton, soya beans, grapes, tea, vegetables

Trade names: Akar, Folbex, Acaraben (Ciba)

Type: halogenated aromatic carboxylic acid

Synthesis:



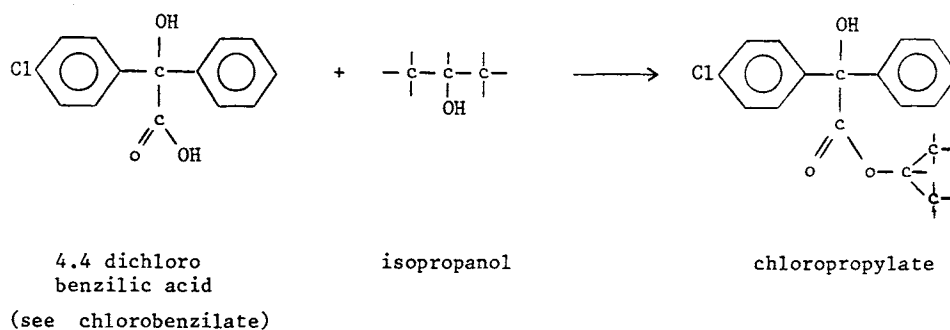
## Chloropropylate

Uses: acaricide, fruit, vegetables, tea, cotton, sugar beet, nuts

Trade names: Rospin, Chlormite (Ciba)

Type: halogenated aromatic carboxylic acid

Synthesis:



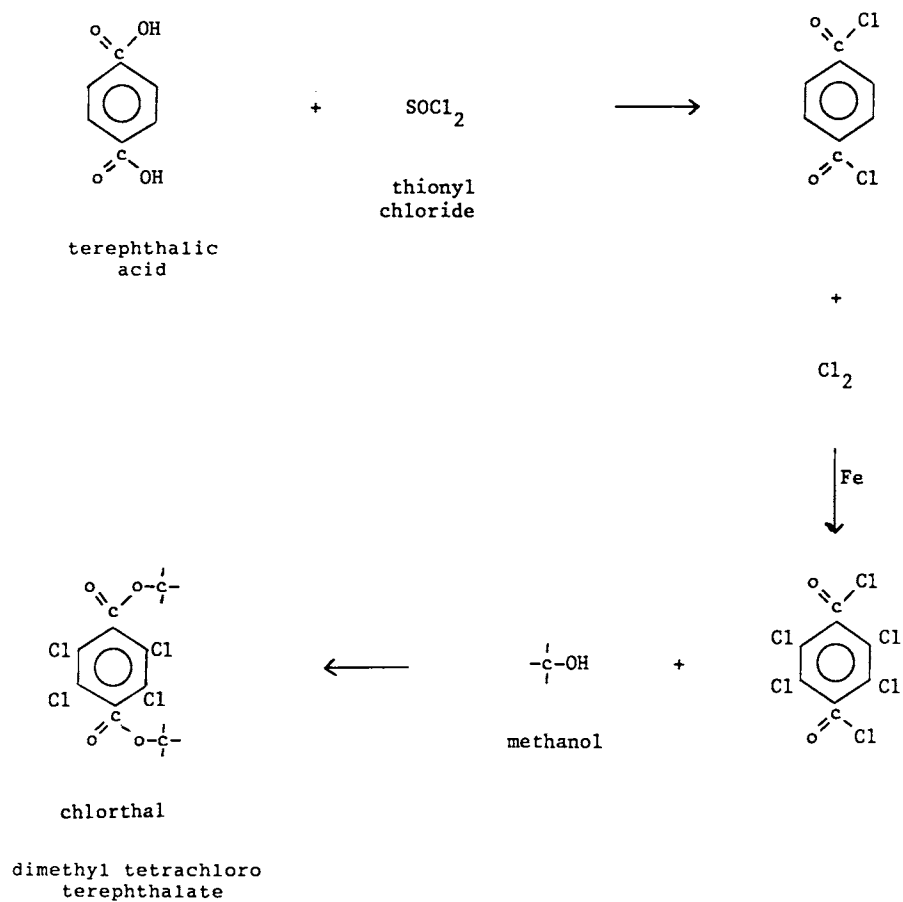
## Chlorthal-Dimethyl

Uses: herbicide for grass, onions, tomatoes, lettuce, potatoes, cotton, soya, turf

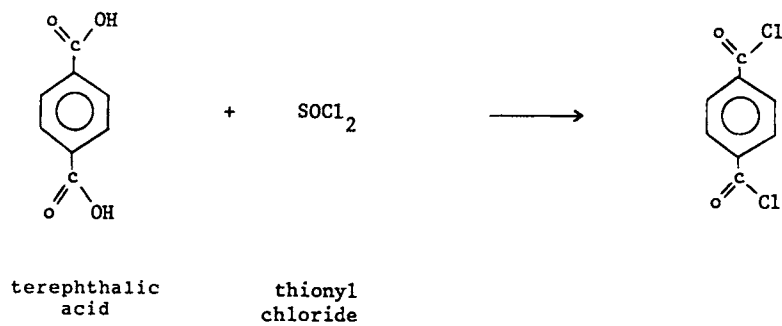
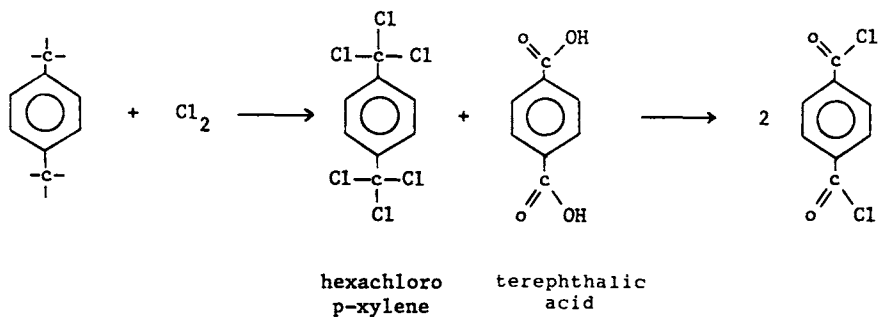
Trade names: Dacthal (Fermenta)

Type: halogenated aromatic carboxylic acid

Synthesis:



alternate routes to terephthalyl dichloride:



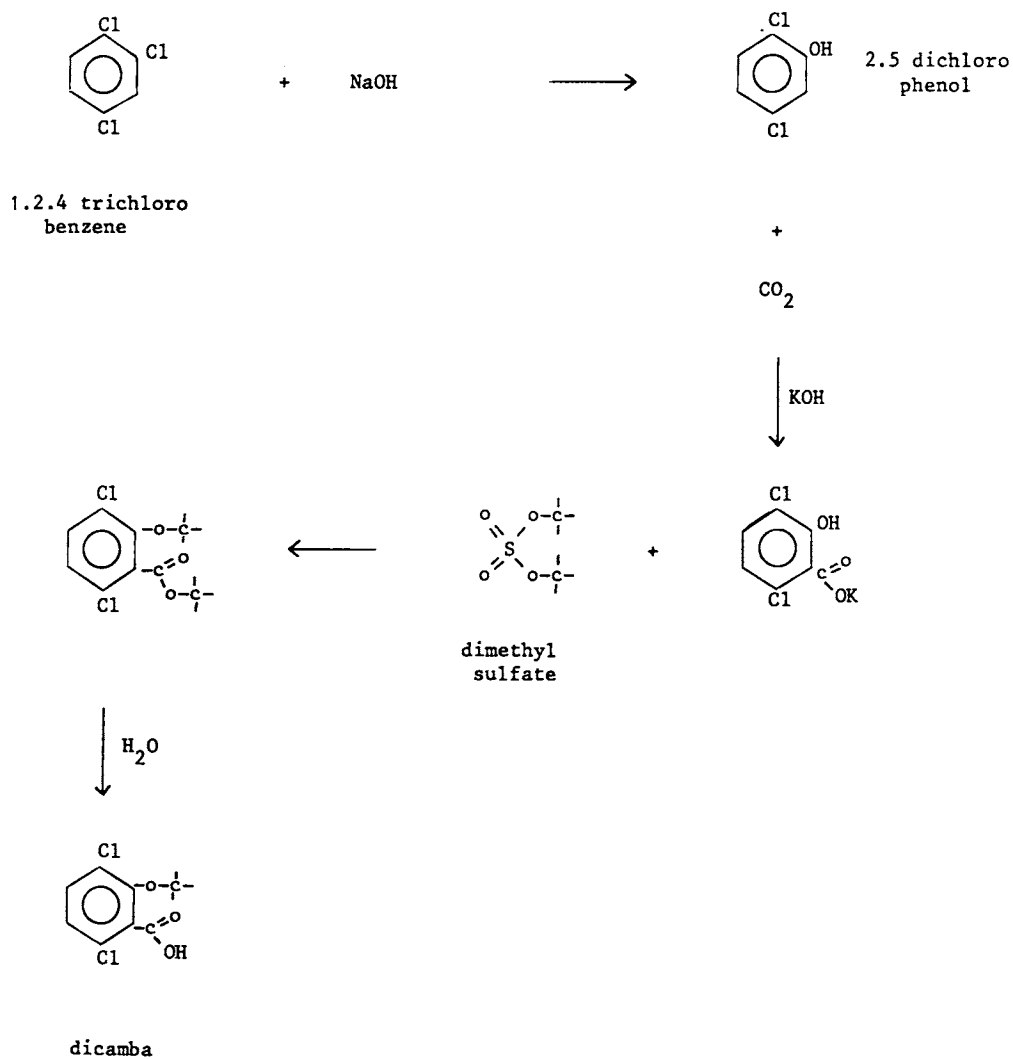
## Dicamba

Uses: herbicide for maize, sorghum, sugar cane, pastures

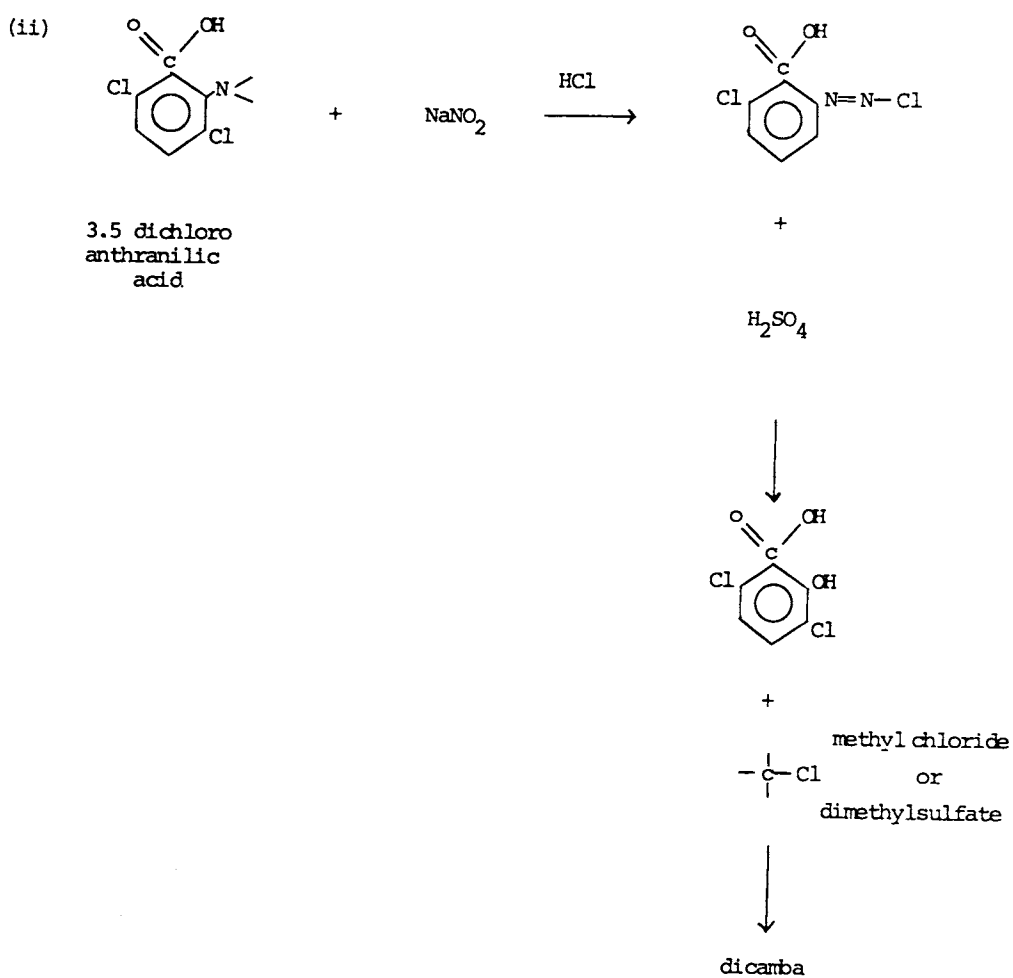
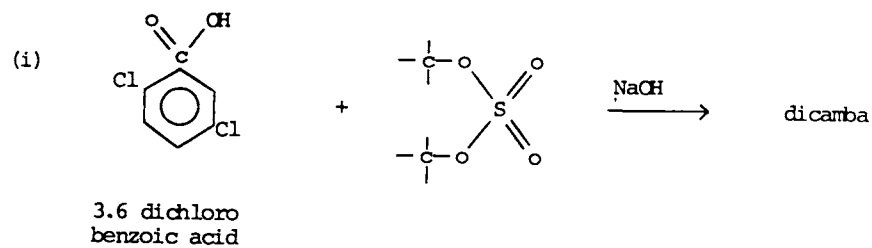
Trade names: Banvel, Mediben (Sandoz)

Type: halogenated aromatic carboxylic acid

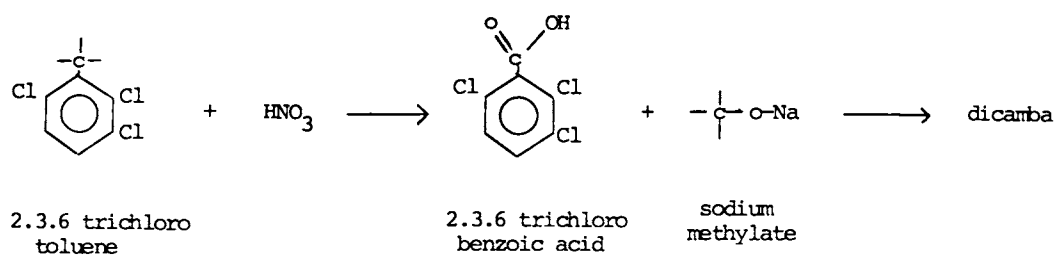
**Synthesis:**



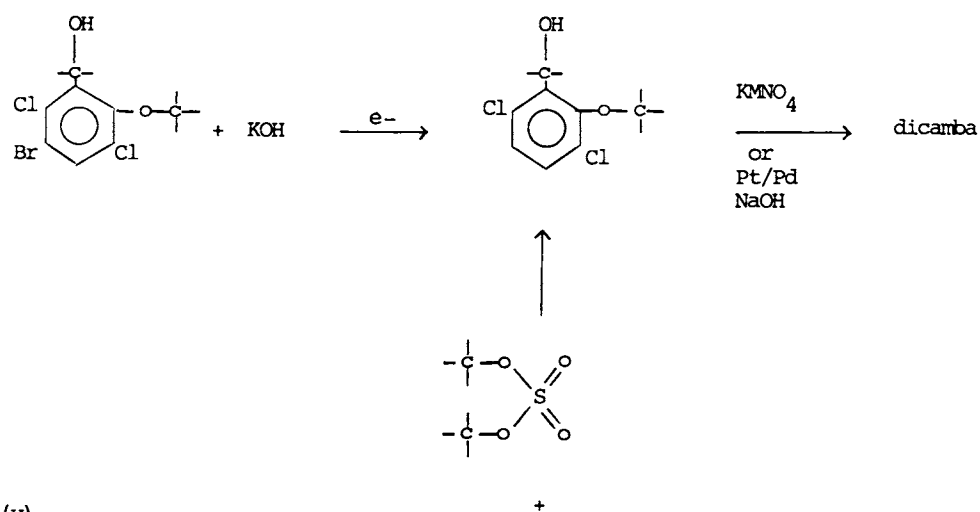
alternate routes :



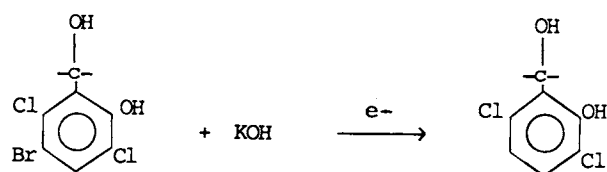
(iii)



(iv)



(v)



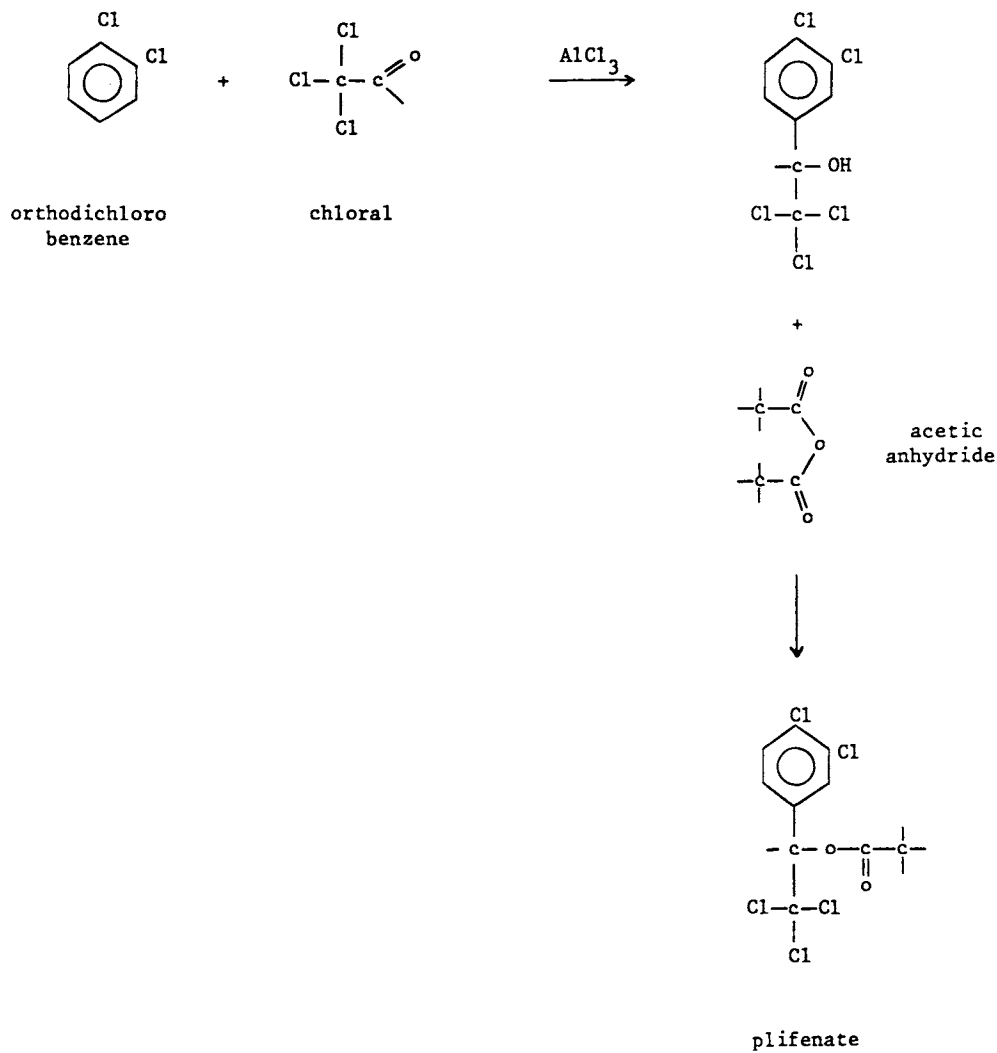
## Plifenate

Uses: insecticide, house holds, public health

Trade names: Baygon MEB (Bayer)

Type: halogenated aromatic carboxylic acid

Synthesis:





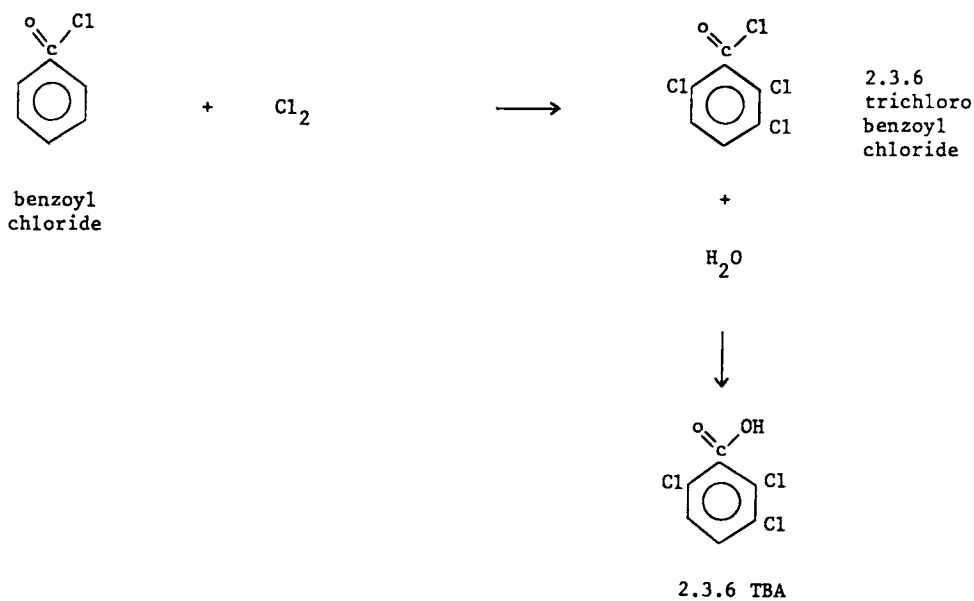
## 2,3,6 TBA

Uses: herbicide, sugar beet, peas

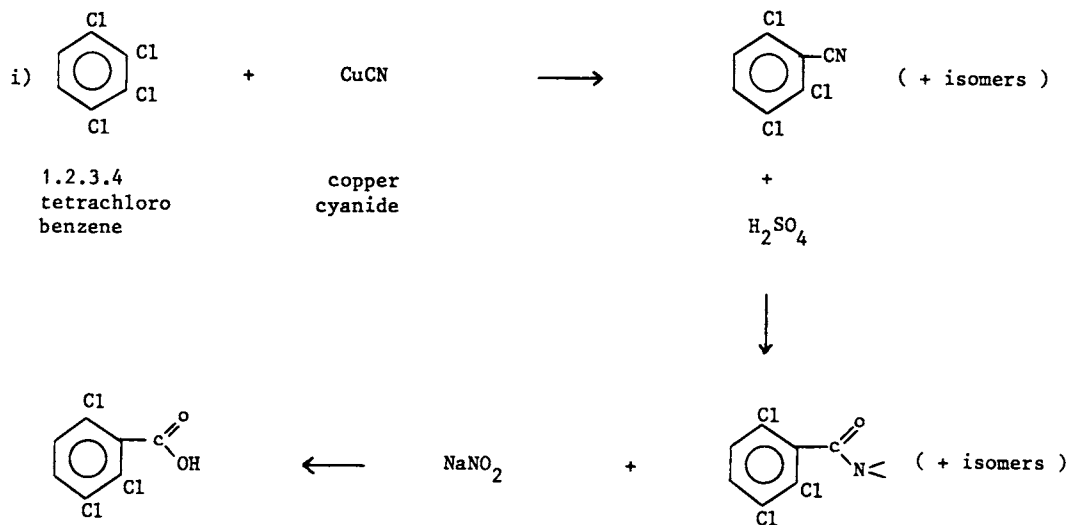
Trade names: Tryoben (DuPont)

Type: halogenated aromatic carboxylic acid

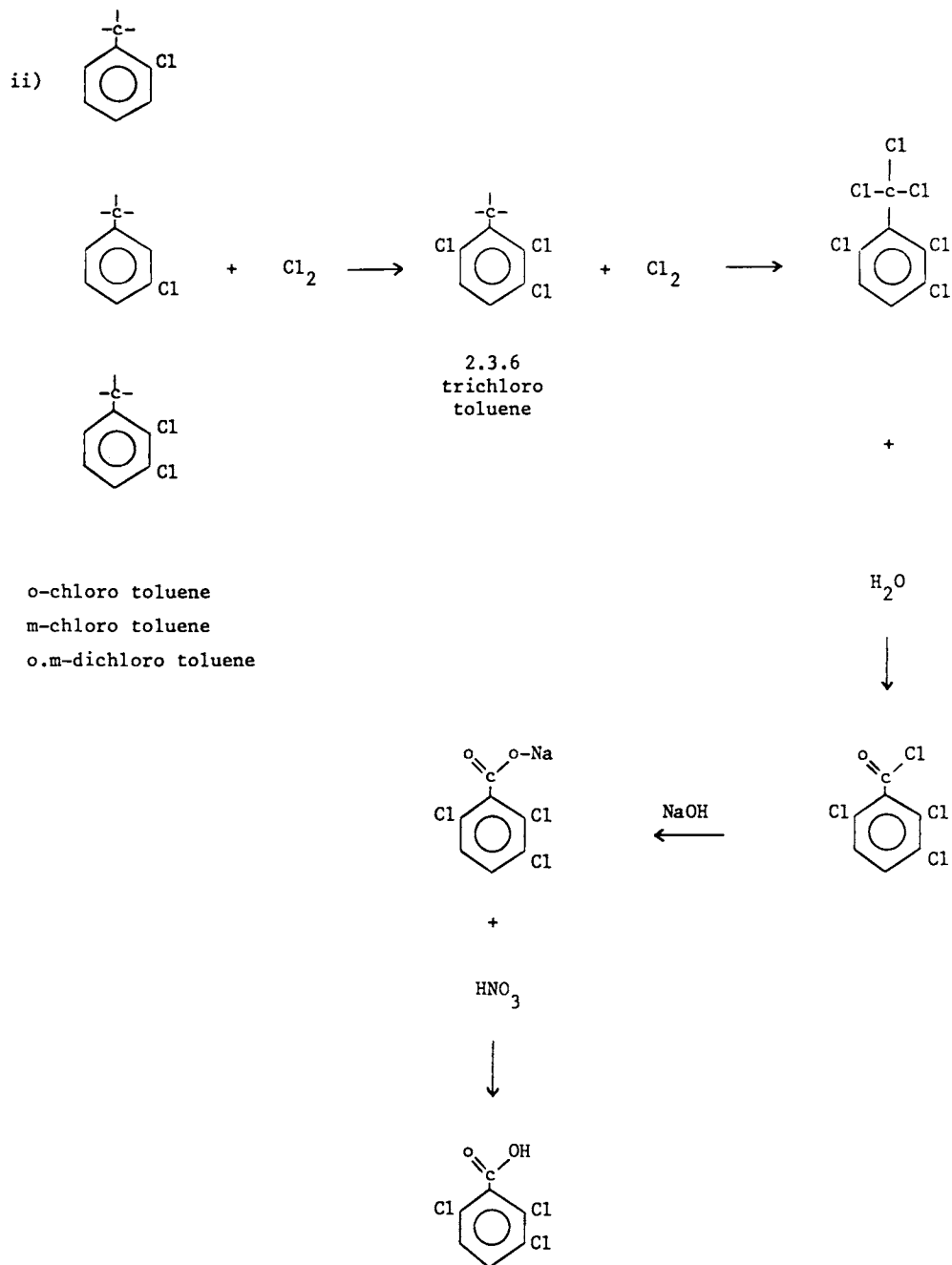
Synthesis:



alternate routes :

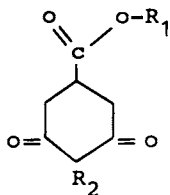


alternate routes : (cont.)



## HEXANEDIONE CARBOXYLIC ACIDS

These are structures of the type



The cyclohexane ring is obtained either via hydrogenation of the aromatic ring or by cyclisation.

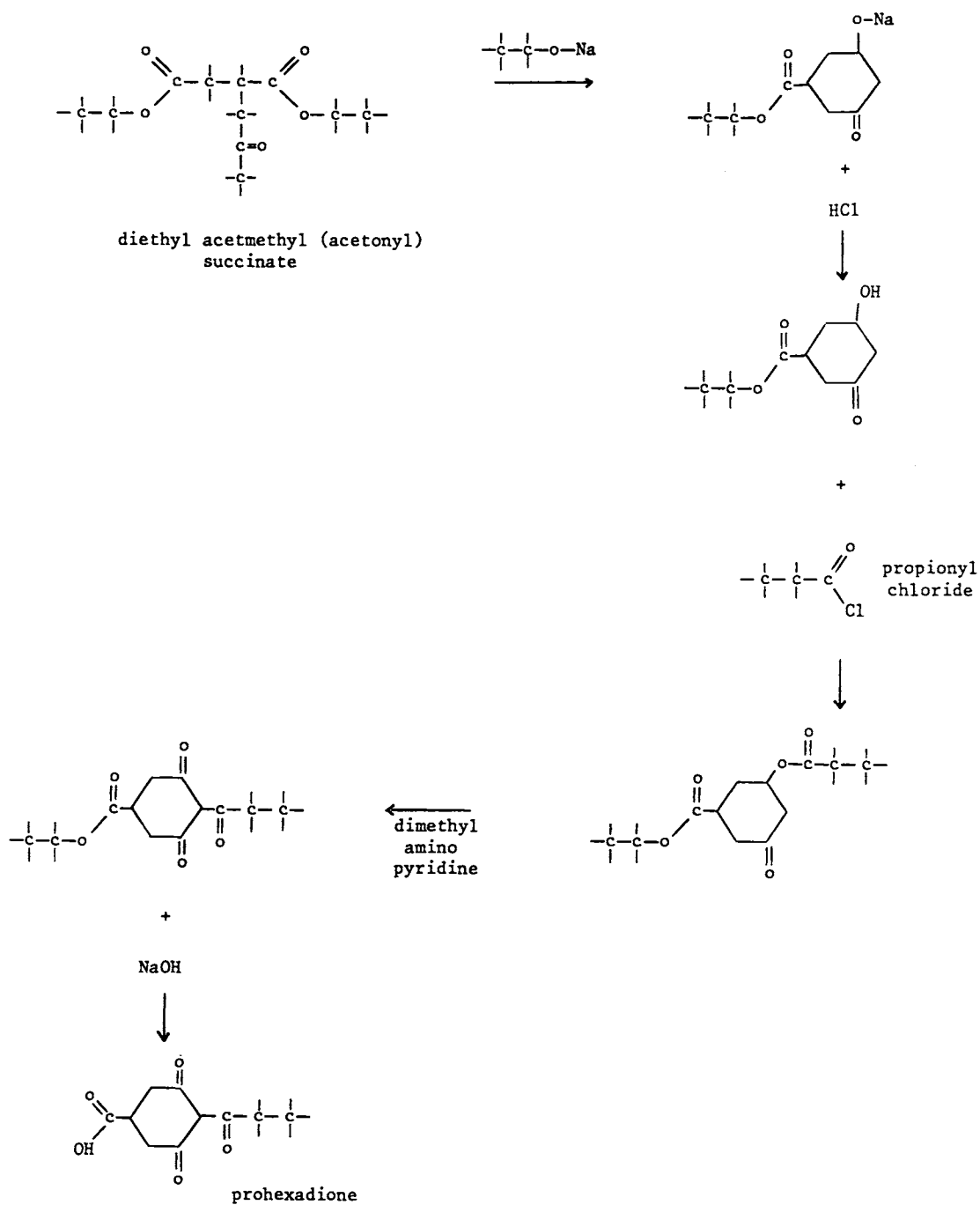
## Prohexadione

Uses: growth regulator, barley, rice, wheat, turf

Trade names: (Kumiai)

Type: hexanedione carboxylic acid

Synthesis:



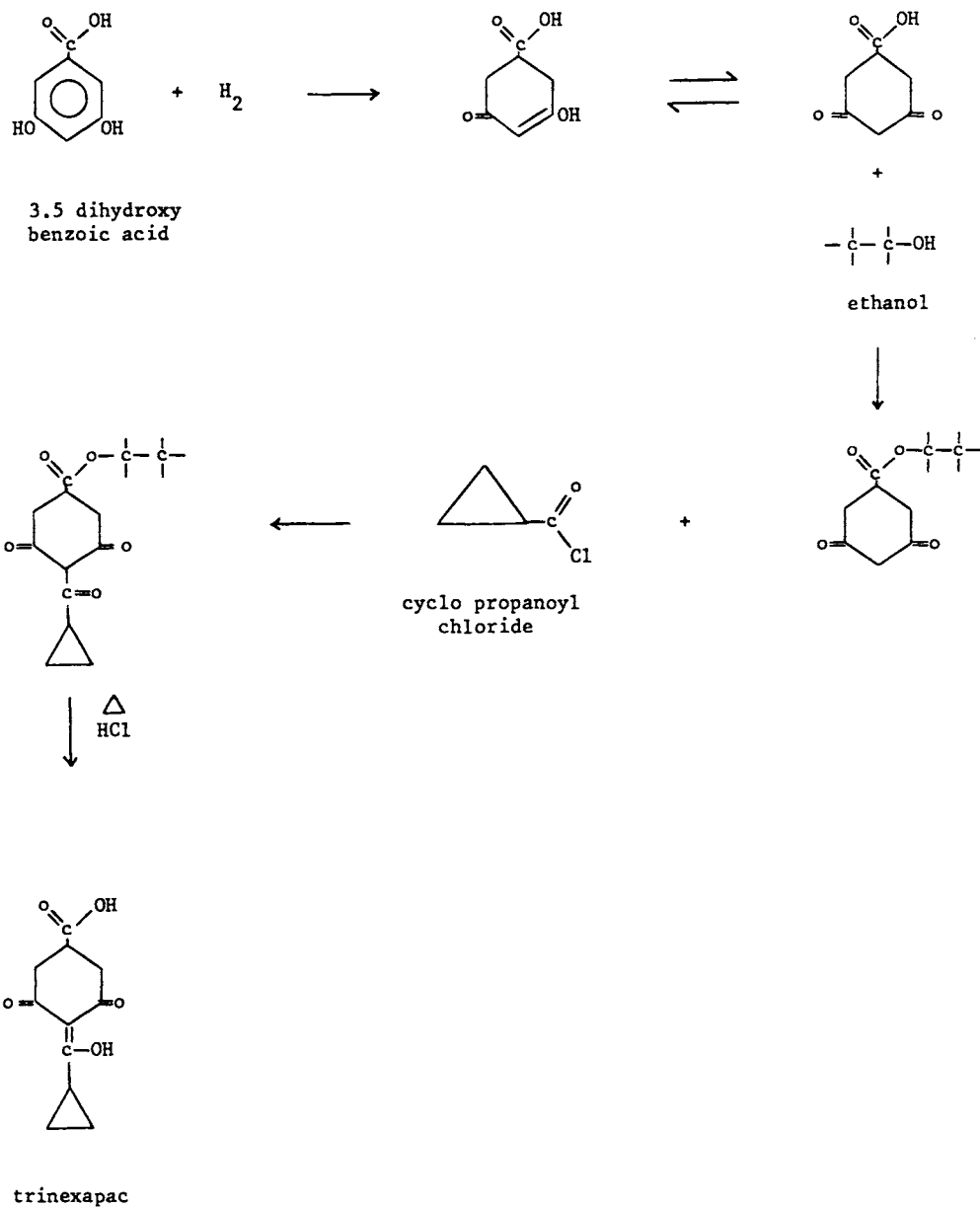
## Trinexapac

Uses: growth regulator, cereals, rice, sunflowers, turf

Trade name: Primo, Moddus (Ciba)

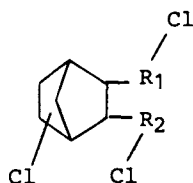
Type: hexanedione carboxylic acid

Synthesis:

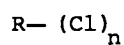


# HALOGENATED HYDROCARBONS

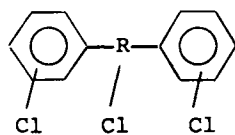
Most halogenated hydrocarbons have the following basic structures:



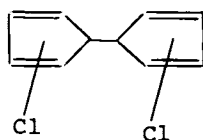
aldrin  
camphechlor  
chlordan  
endosulfan  
endrin  
heptachlor



chloropicrin  
dibromochloro propane  
dichloropropene



DDT  
dicofol  
hexachlorophene



dienochlor



lindane  
PCNB

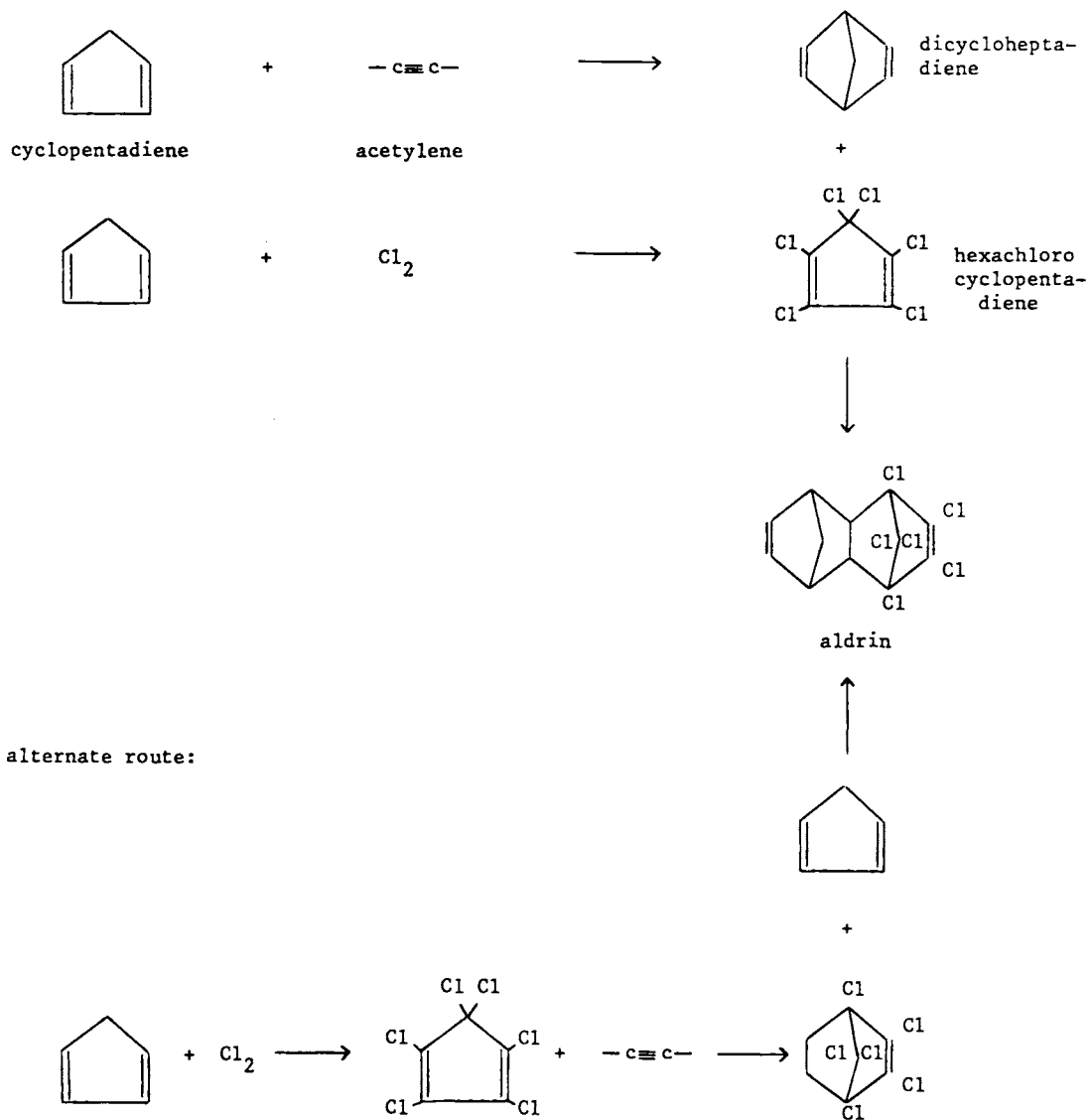
## Aldrin

Uses: insecticide

Trade names: Aldrex, Aldrite (Shell), Octalene (Sandoz)

Type: halogenated hydrocarbon

Synthesis:



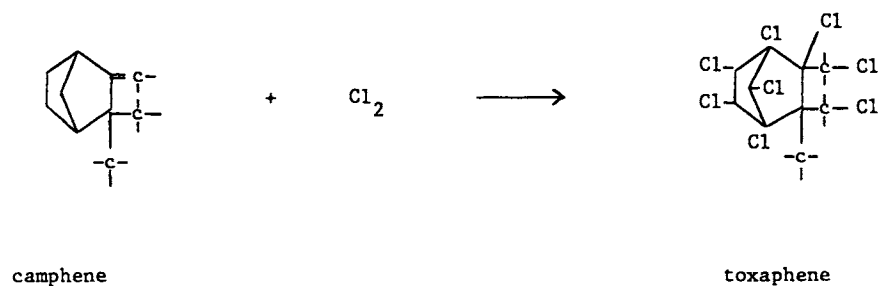
## Camphechlor (Toxaphene)

Uses: insecticide, cotton, fruit, maize, vegetables, soyabeans

Trade names: Phenacide, Phenatox, Toxakil (FMC)

Type: halogenated hydrocarbon

Synthesis:





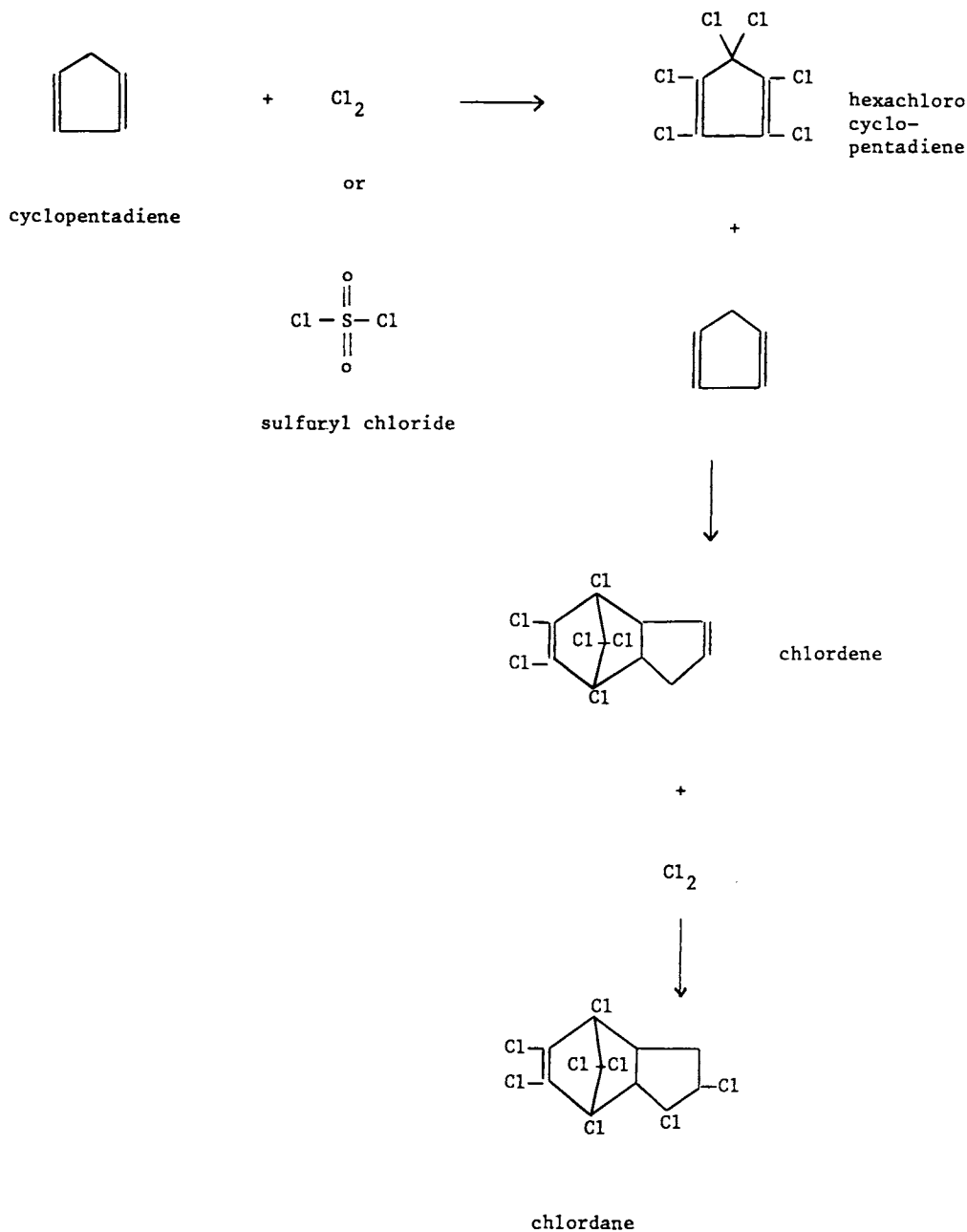
## Chlordane

Uses: insecticide, households, wood, lawns

Trade names: Octachlor (Velsicol)

Type: halogenated hydrocarbon

### Synthesis:



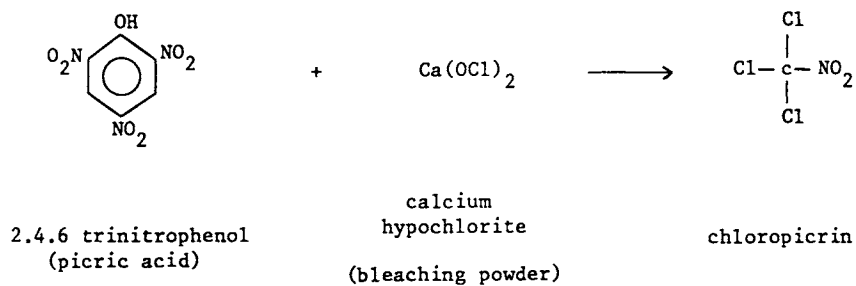
## Chloropicrin

Uses: insecticide, stored grain

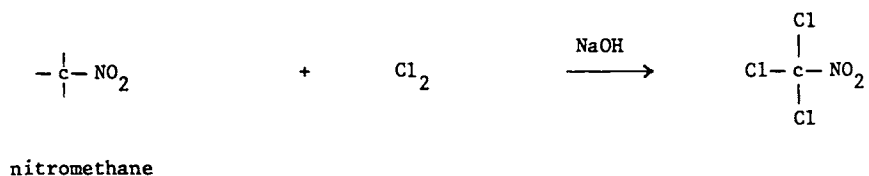
Trade names: Dorochlor, Picrin 80 (Mitsui)

Type: halogenated hydrocarbon

Synthesis:



alternate route :



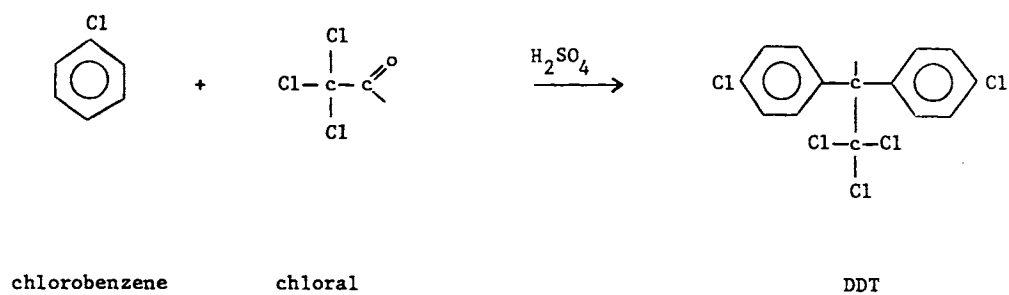
## DDT

Uses: insecticide

Trade names: Gesarol, Guesarol, Neocid (Ciba)

Type: halogenated hydrocarbon

Synthesis:



## DBCP

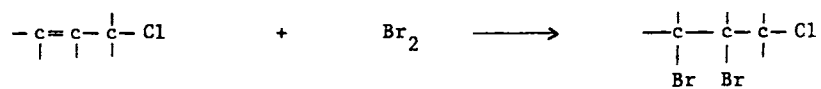
### Dibromochloropropane

Uses: nematocide

Trade names: Nemagon (Shell), Fumazone (Dow)

Type: halogenated hydrocarbon

Synthesis:



allyl chloride

dibromochloropropane

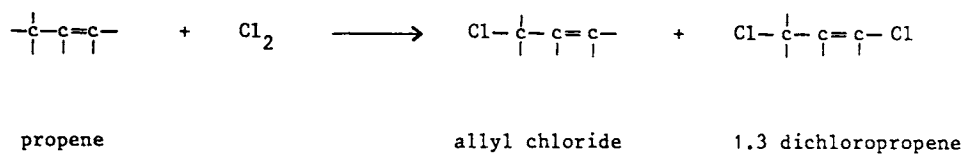
## 1,3 Dichloropropene

Uses: fumigant, nematicide

Trade names: Telone, Dorlone (Dow Elanco)

Type: halogenated hydrocarbon

Synthesis:



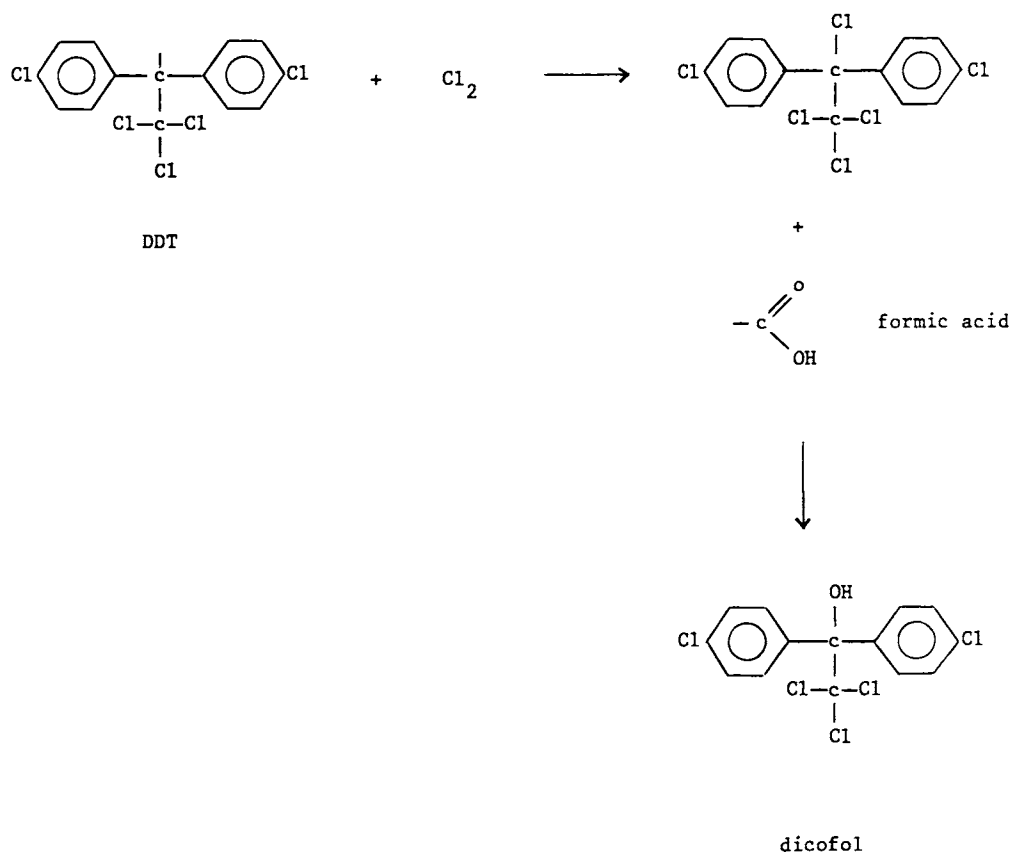
## Dicofol

Uses: acaricide, citrus, cotton

Trade names: Kelthane (Rohm & Haas)

Type: halogenated hydrocarbon

Synthesis:



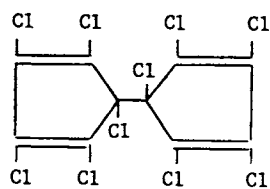
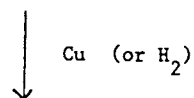
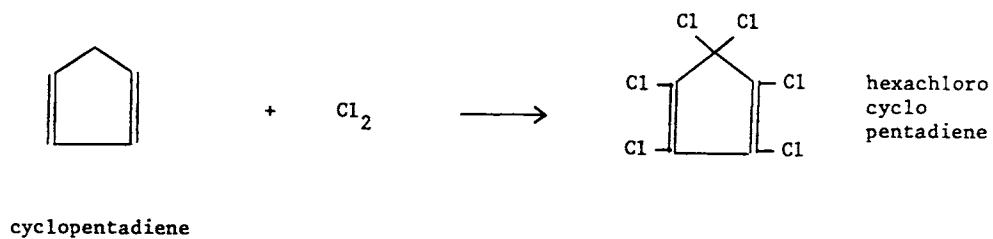
## Dienochlor

Uses: acaricide

Trade name: Pentac (Sandoz)

Type: halogenated hydrocarbon

Synthesis:



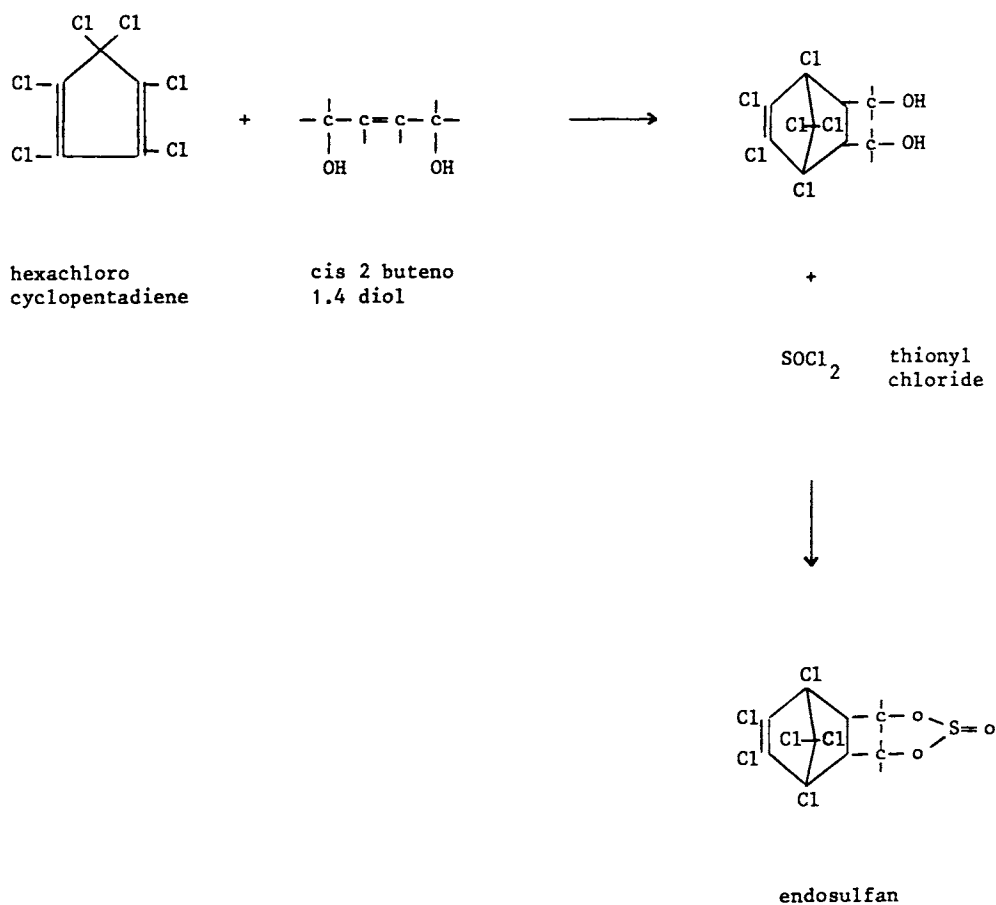
# Endosulfan

Uses: insecticide, cereals, coffee, cotton, potatoes, tea, vegetables

Trade names: Thiodan, Cycloclan, Beosit, Malix, Thimul, Thifor (Hoechst)

Type: halogenated hydrocarbon, sulfite

Synthesis:





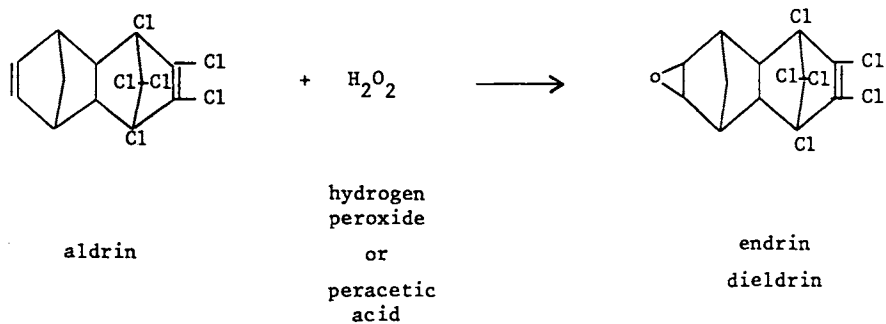
**Endrin**  
**Dieldrin**

Uses: insecticide, cotton, maize, sugarcane, rice, cereals

Trade names: Octalox (Velsicol), Dioldrex, Dieltrite, Endrex, Panoram (Shell)

Type: halogenated hydrocarbon

**Synthesis:**



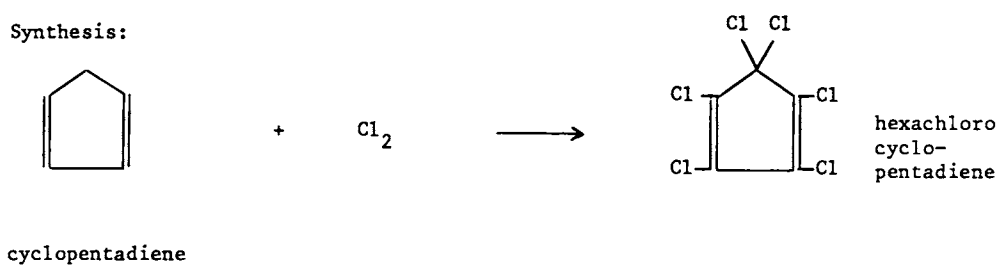
# Heptachlor

Uses: insecticide, maize, grain, sorghum, households

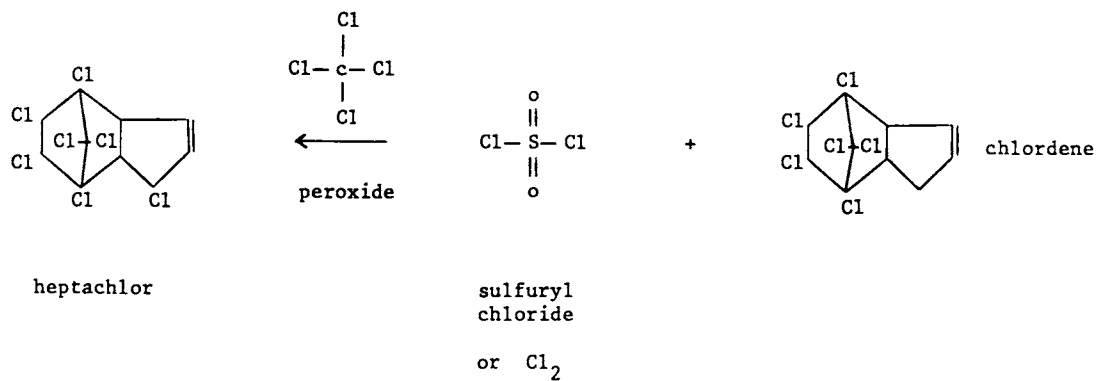
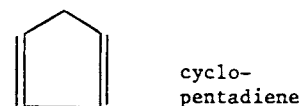
Trade name: Velsicol 104 (Velsicol)

Type: halogenated hydrocarbon

Synthesis:



+



## Lindane

Uses: insecticide

Trade names: Gammexane, Gammalin (ICI), Isotox (Chevron), Inexit, Agronexe, Nexit (Celamerck), Exagama, Gallogama, Lindafor, Lindagranox, Lindaterra, Lindamul (Rhone Poulenc)

Type: halogenated hydrocarbon

Synthesis:



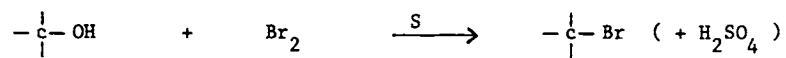
## Methyl Bromide

Uses: insecticide, nematocide, ships, mills, stores

Trade names: Dowfume (Dow)

Type: brominated hydrocarbon

Synthesis:



methanol

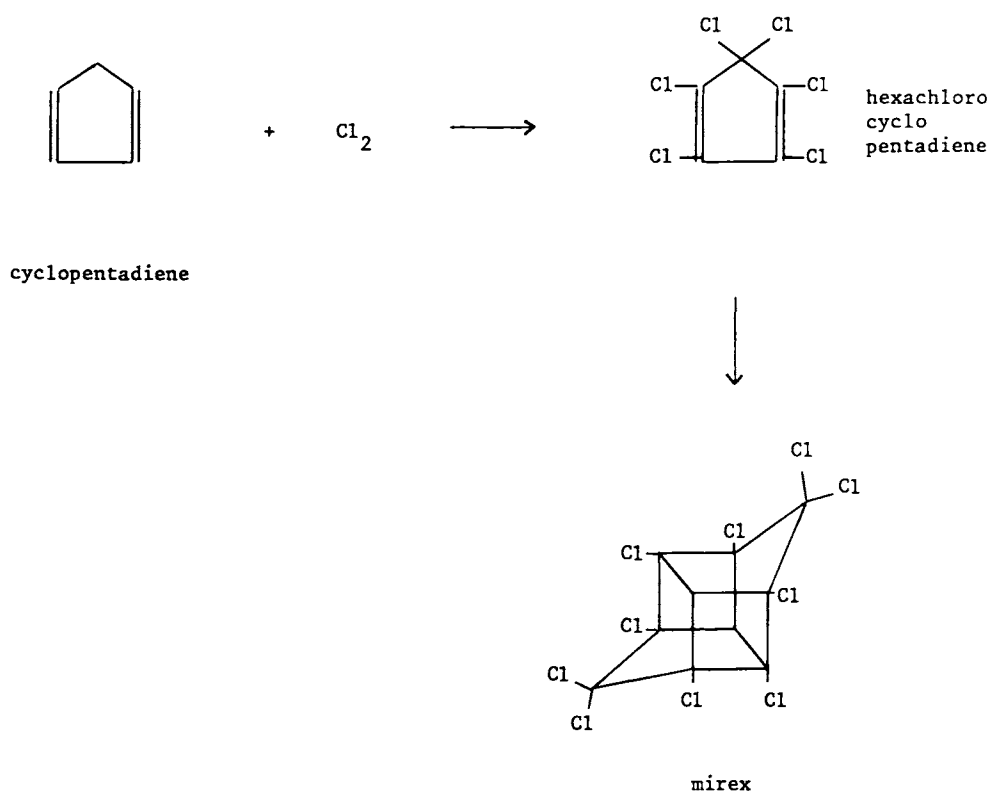
## Mirex

Uses: insecticide,

Trade names:

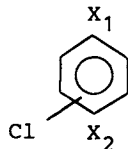
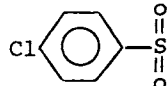
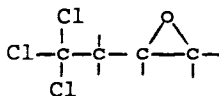
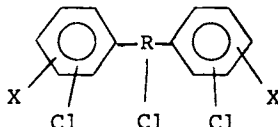

Type: halogenated hydrocarbon

Synthesis:



# HALOGENATED AROMATICS

These compounds have the following basic structures :

	<u>X<sub>1</sub></u>	<u>X<sub>2</sub></u>	
	bromoxynil	CN	OH
	chloroneb	OCH <sub>3</sub>	OCH <sub>3</sub>
	chlorotalonil	CN	CN
	DCNA	NH <sub>2</sub>	NO <sub>2</sub>
	dichlobenil	CN	H
	hexachlorobenzene	Cl	Cl
	ioxynil	CN	OH
	pentachlorophenol	OH	H
	quintozene	NO <sub>2</sub>	H
	tecnazene	NO <sub>2</sub>	H
	tetradifon		H
	tridiphane		H
		<u>X</u>	
	dichlorophen	OH	
	methoxychlor		
	tetrasul	R = S	NH <sub>2</sub>

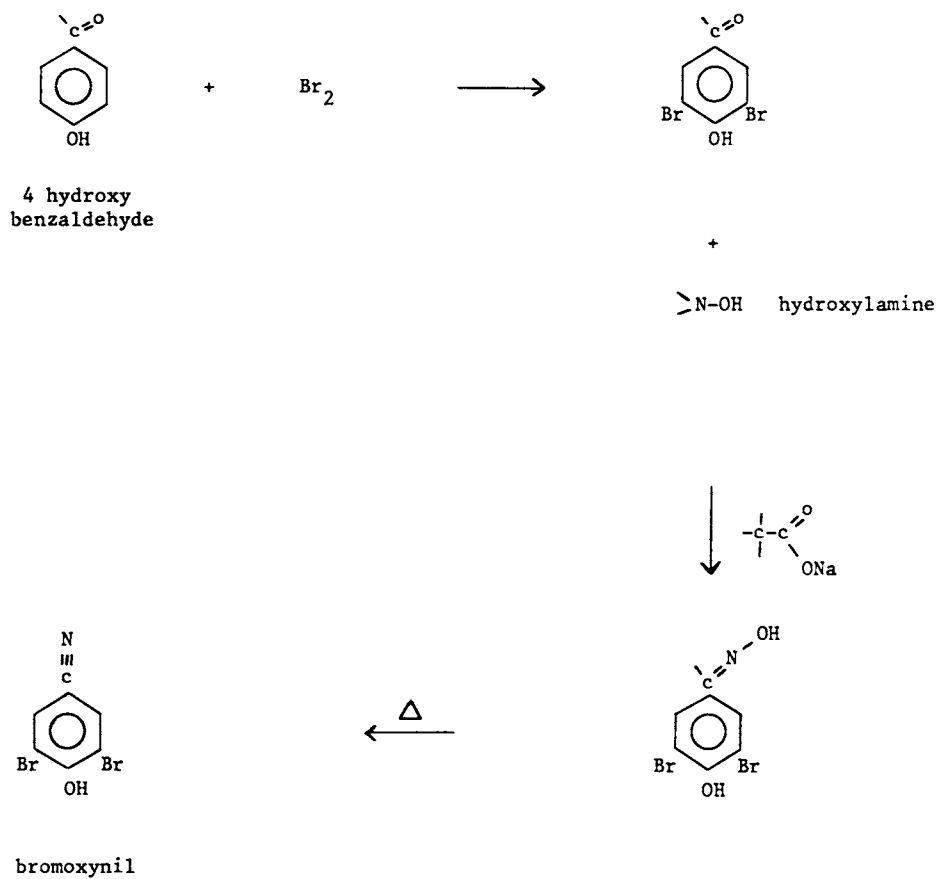
## Bromoxynil

Uses: herbicide, cereals, garlic, onions, sorghum

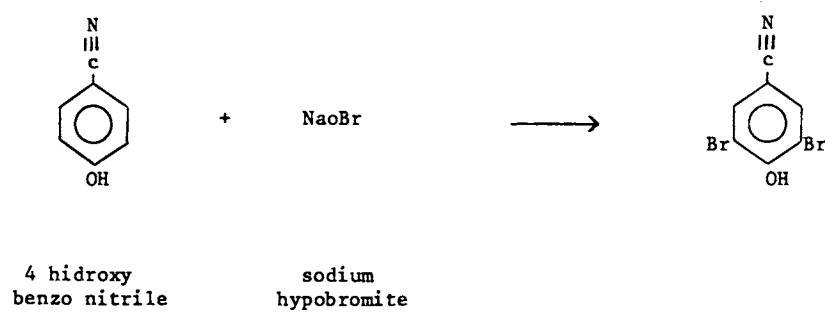
Trade names: Brominal, Buctril (Rhône Poulenc)

Type: halogenated aromatic

Synthesis:



alternate route :





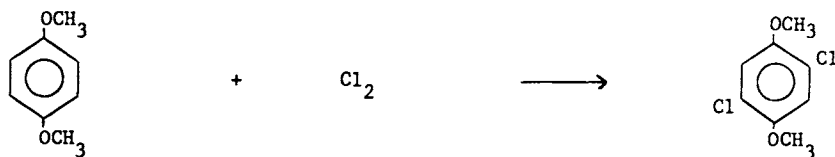
## Chloroneb

Uses: fungicide used for cotton, soya, sugar beets

Trade names: Demosan (Dupont)

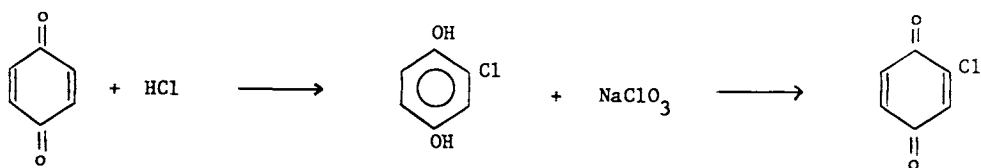
Type: halogenated aromatic

Synthesis:

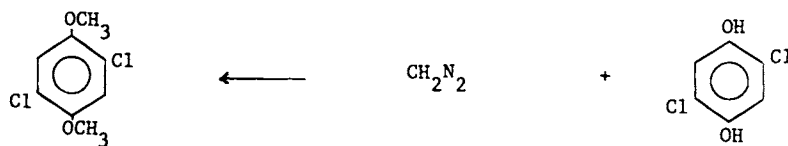


p-dimethoxy  
benzene

alternate route:



benzoquinone



diazomethane

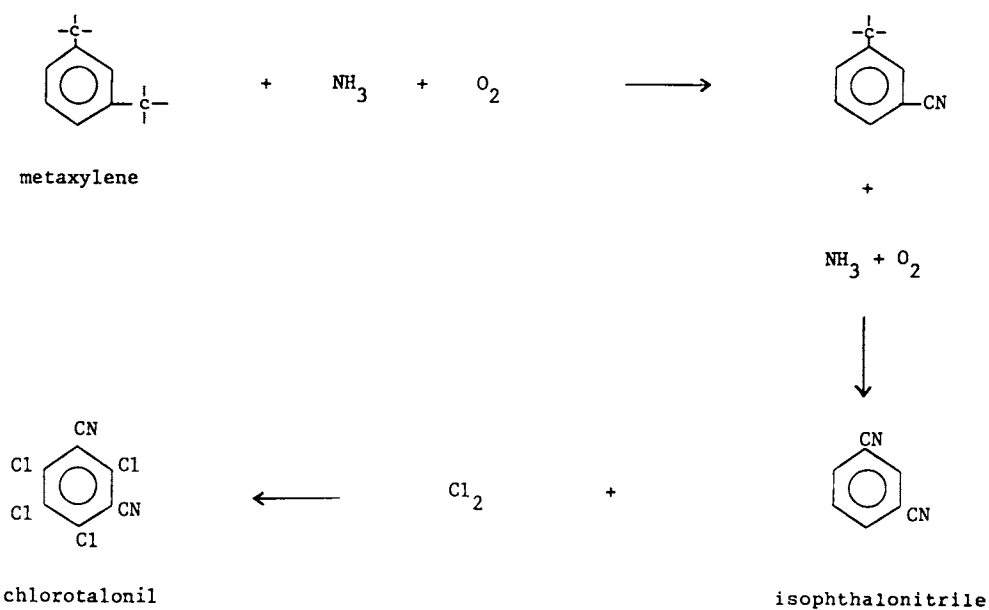
# Chlorotalonil

Uses: fungicide for vegetables, soyabeans, coffee, fruit

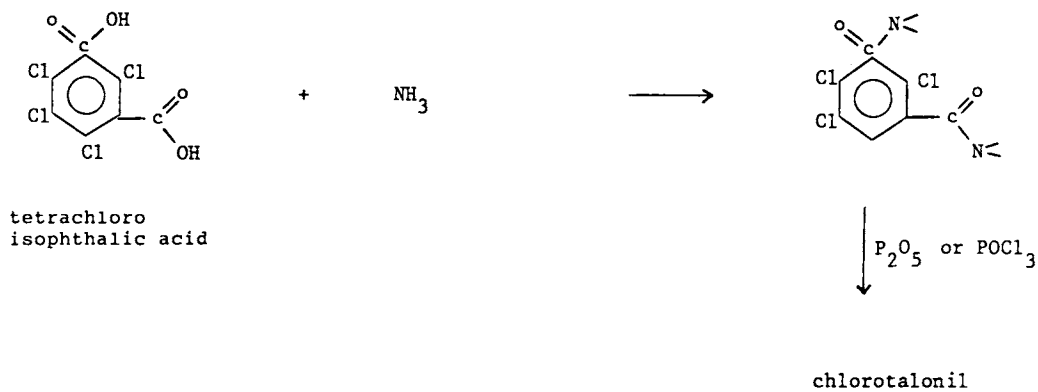
Trade names: Daconil, Bravo, Exotherm, Termil (Fermenta)

Type: halogenated aromatic

Synthesis:



alternate route :



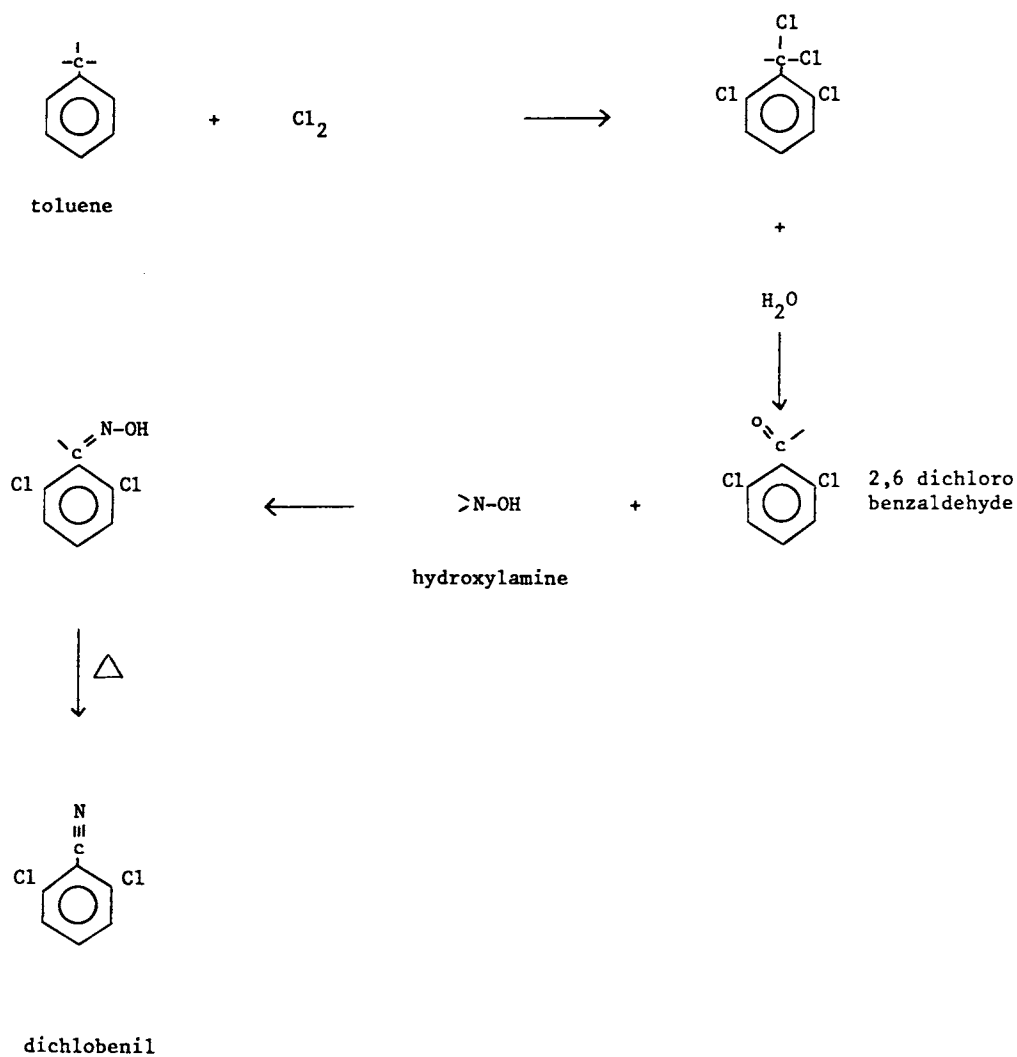
## Dichlobenil

Uses: herbicide, fruit

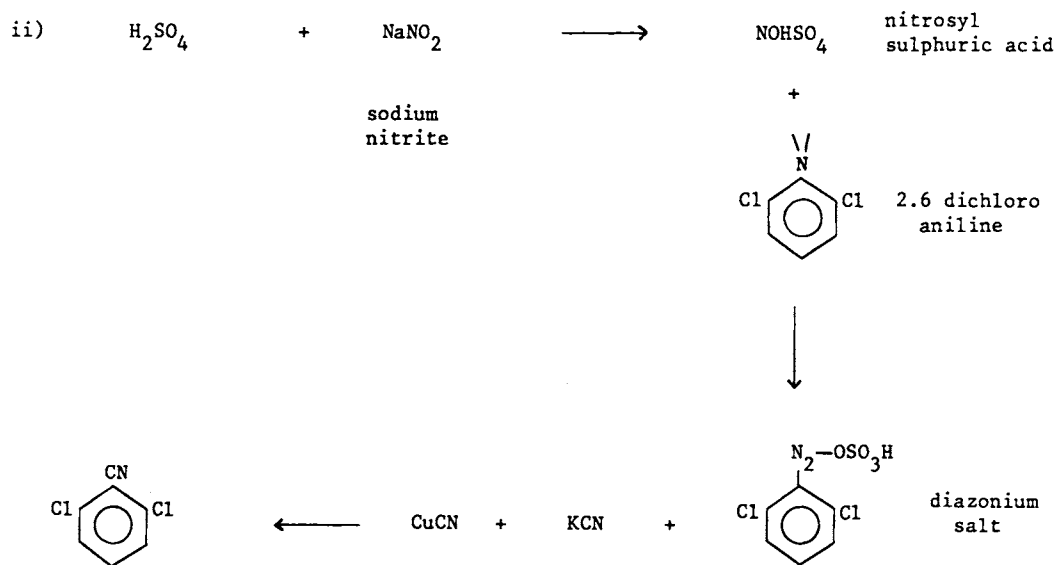
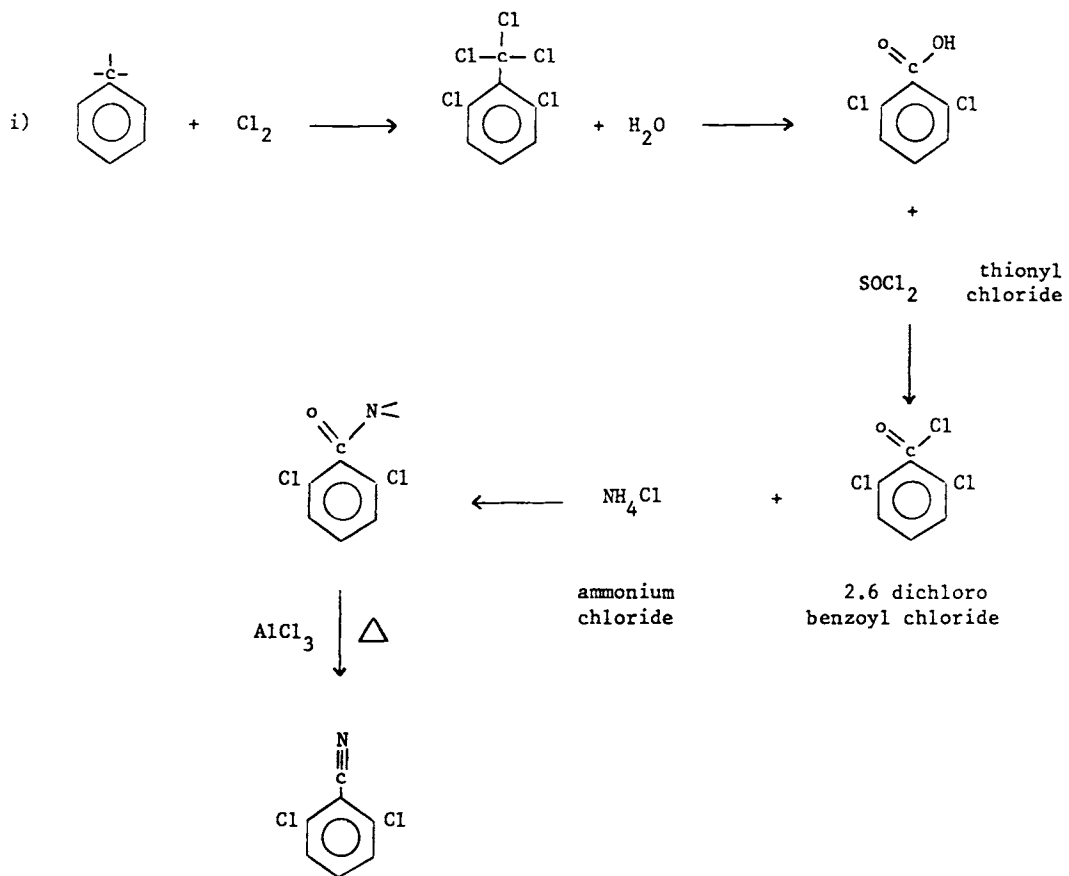
Trade names: Casoron (Duphar)

Type: halogenated aromatic

Synthesis:



alternate routes :



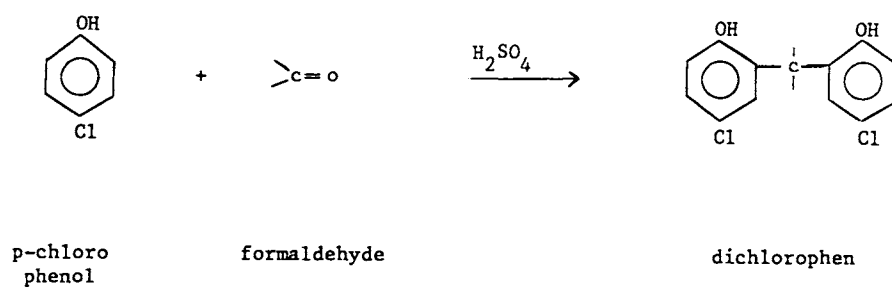
## Dichlorophen

Uses: fungicide, textiles, anti-mould, athletes foot

Trade names: Super Mosstox, Antiphen (Rhône Poulenc)

Type: halogenated aromatic

Synthesis:



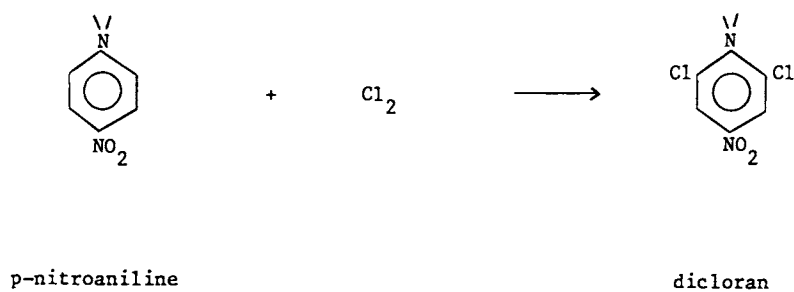
**Dicloran**  
**DCNA**  
**Dichloronitroaniline**

Uses: fungicide, fruit, ornamentals, vegetables

Trade names: Botran (Upjohn), Allison (Schering), Resiran (Nissan)

Type: halogenated aromatic

Synthesis:



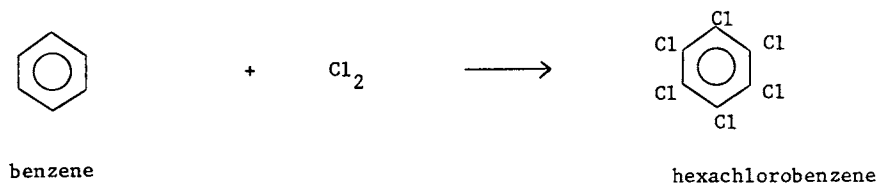
## Hexachlorobenzene

Uses: fungicide

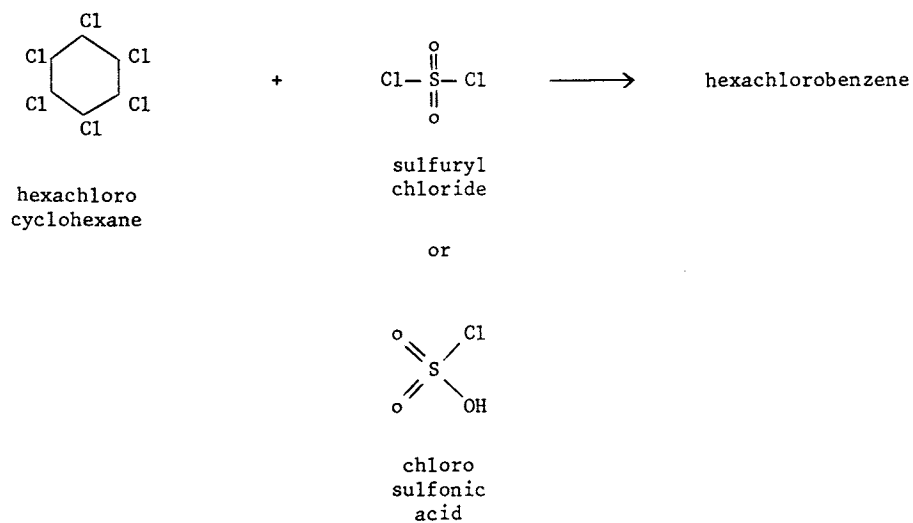
Trade names:

Type: halogenated aromatic

Synthesis:



alternate route :



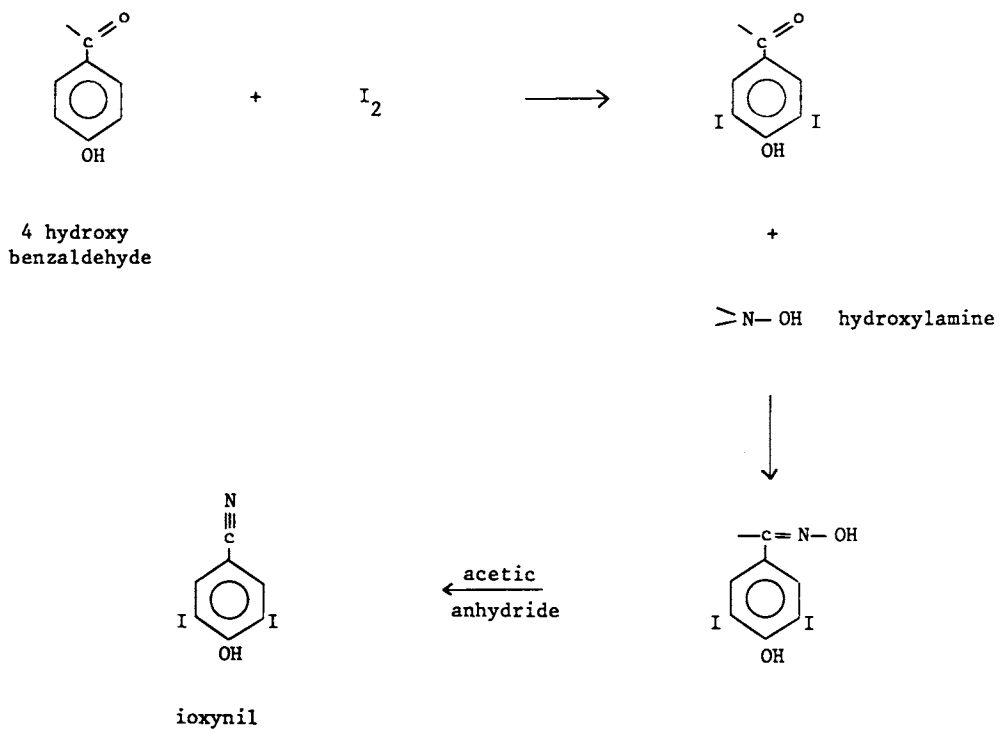
# Ioxynil

Uses: herbicide, onions, cereals, sugarcane

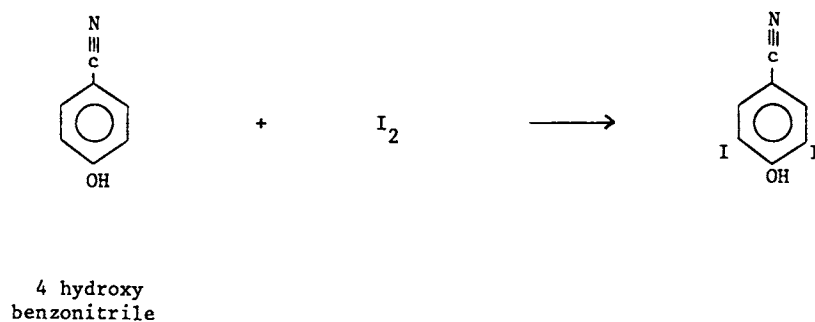
Trade names: Certrol, Actril, Totril (Rhône Poulenc), Mylone (U. Carbide)

Type: halogenated aromatic

Synthesis:



alternate route :





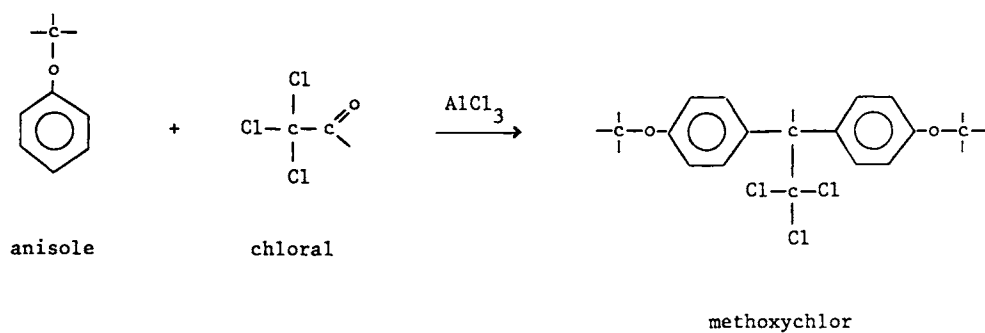
## Methoxychlor

Uses: insecticide fields, forage, fruit, vegetables

Trade names: Marlate (Dupont)

Type: halogenated aromatic

Synthesis:



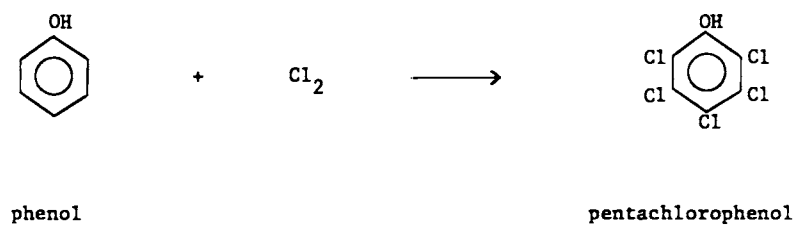
## Pentachlorophenol

Uses: fungicide, wood

Trade names: Dowicide EC7, Dowicide G, Penta (Dow), Santobrite (Monsanto)

Type: halogenated aromatic

Synthesis:



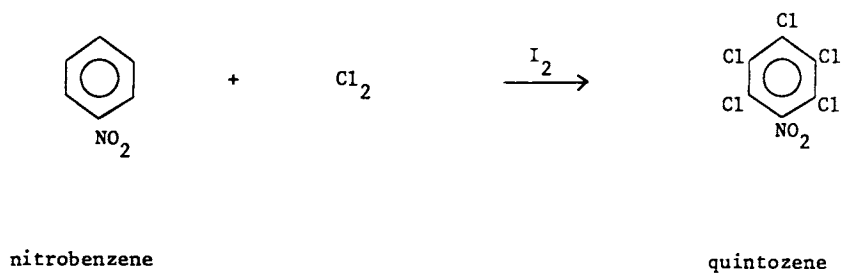
## Quintozene

Uses: fungicide, vegetables, ornamentals

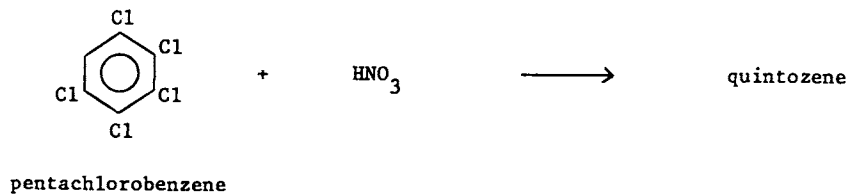
Trade names: Botrilex (ICI), Tritisan (Hoechst), Folosan, Terrachlor (Olin)

Type: halogenated aromatic

Synthesis:



alternate route :



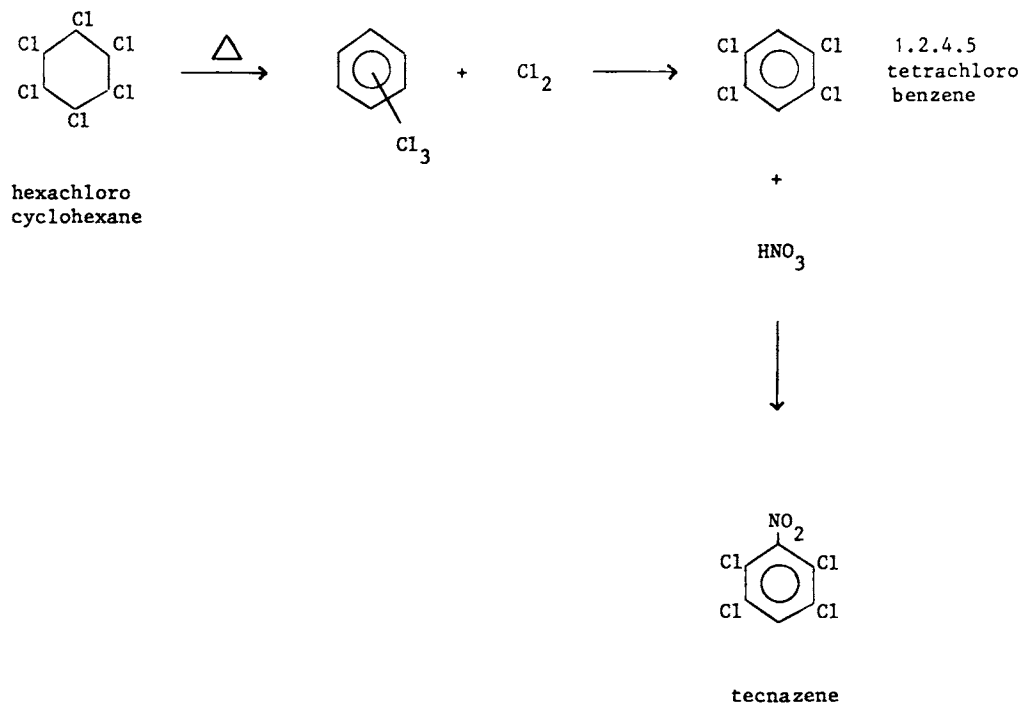
## Tecnazene

Uses: fungicide, potatoes

Trade names: Foloran (Bayer), Fusarex (ICI)

Type: halogenated aromatic

Synthesis:



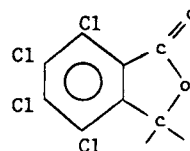
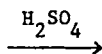
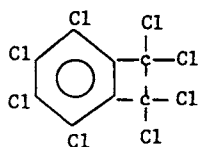
## Tetrachlorophthalide

Uses: fungicide, rice

Trade names: Rabcide (Kureha)

Type: halogenated aromatic

Synthesis:



tetrachloro  
1,2 bis dichloro  
methyl benzene

tetrachlorophthalide

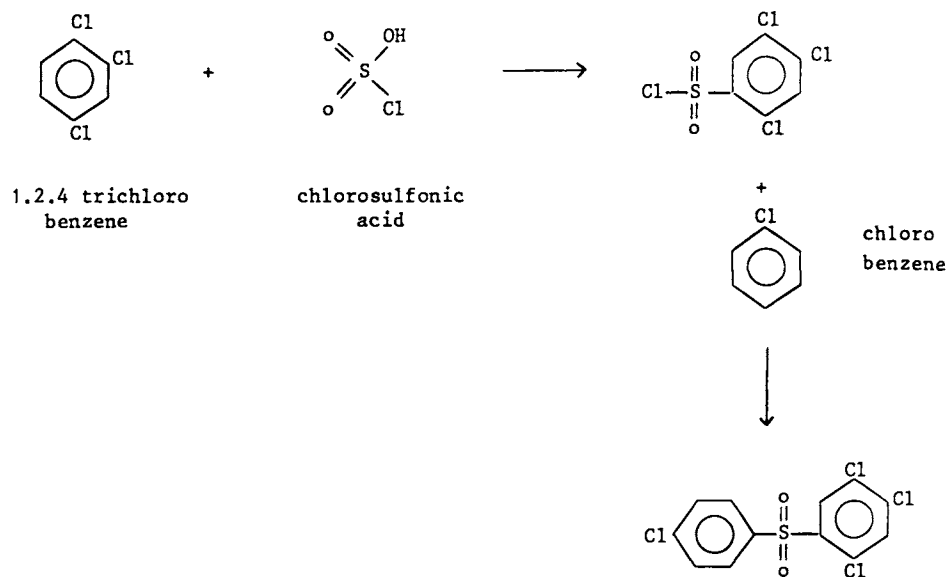
# Tetradifon

Uses: acaricide, fruit, grapes, vegetables

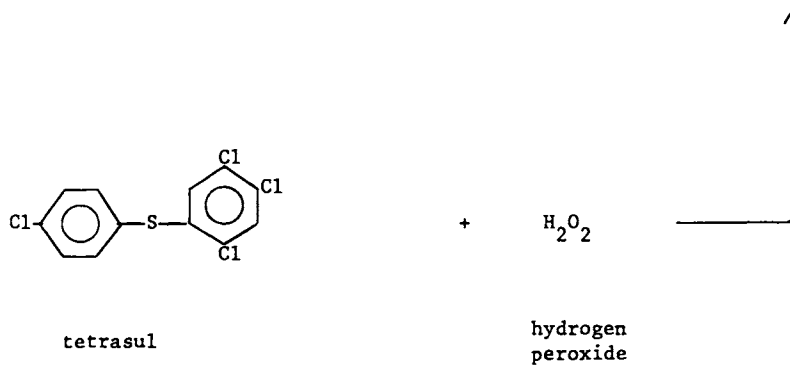
Trade names: Tedion (Duphar)

Type: halogenated aromatic, sulfone

Synthesis:



alternate route :



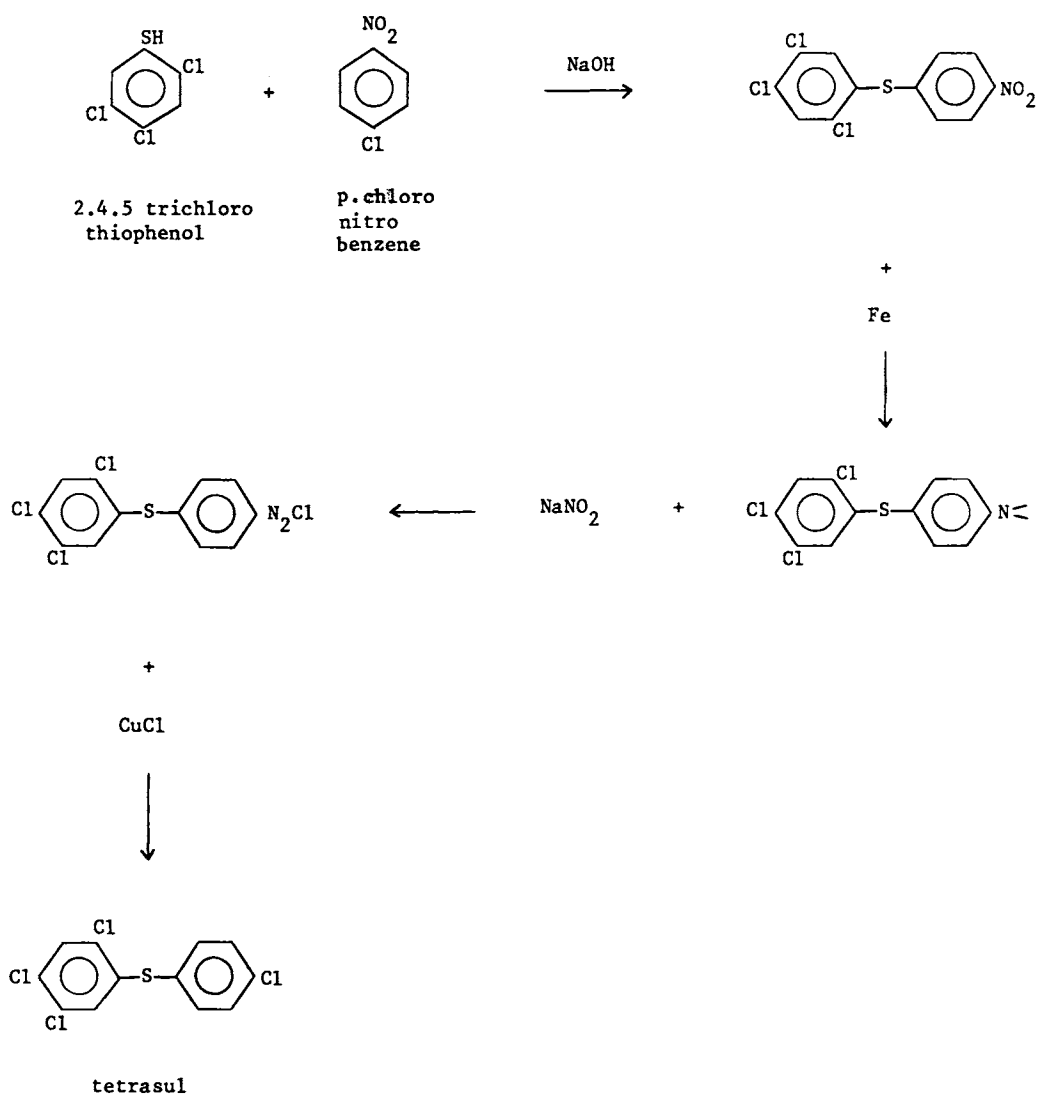
## Tetrasul

Uses: acaricide, fruit, vines, ornamentals

Trade names: Animert (Duphar)

Type: halogenated aromatic

Synthesis:



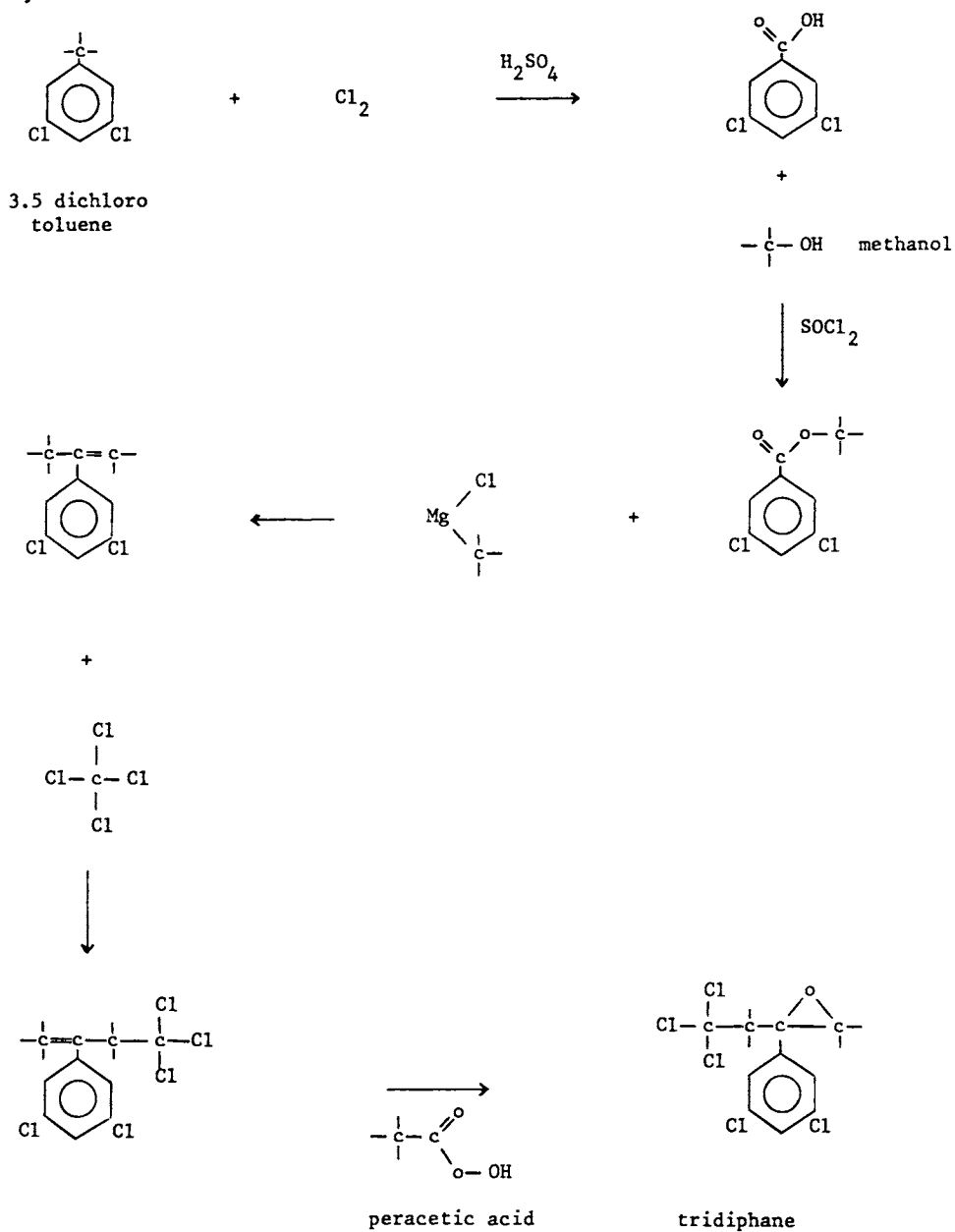
# Tridiphane

Uses: herbicide, maize

Trade names: Nelpon, Tandem, Dowco 356 (Dow)

Type: halogenated aromatic, oxirane

Synthesis:

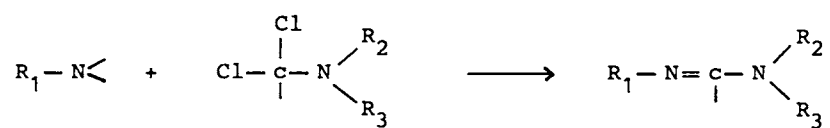




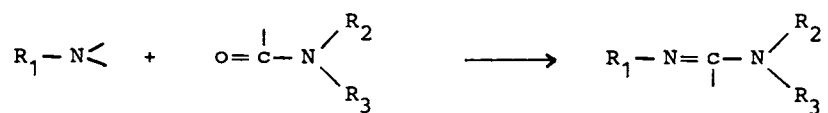
# AMIDINES

The amidine function is obtained by 2 routes :

i) reaction of a dihaloamine with an amine



ii) reaction of an amine with a formamide derivate



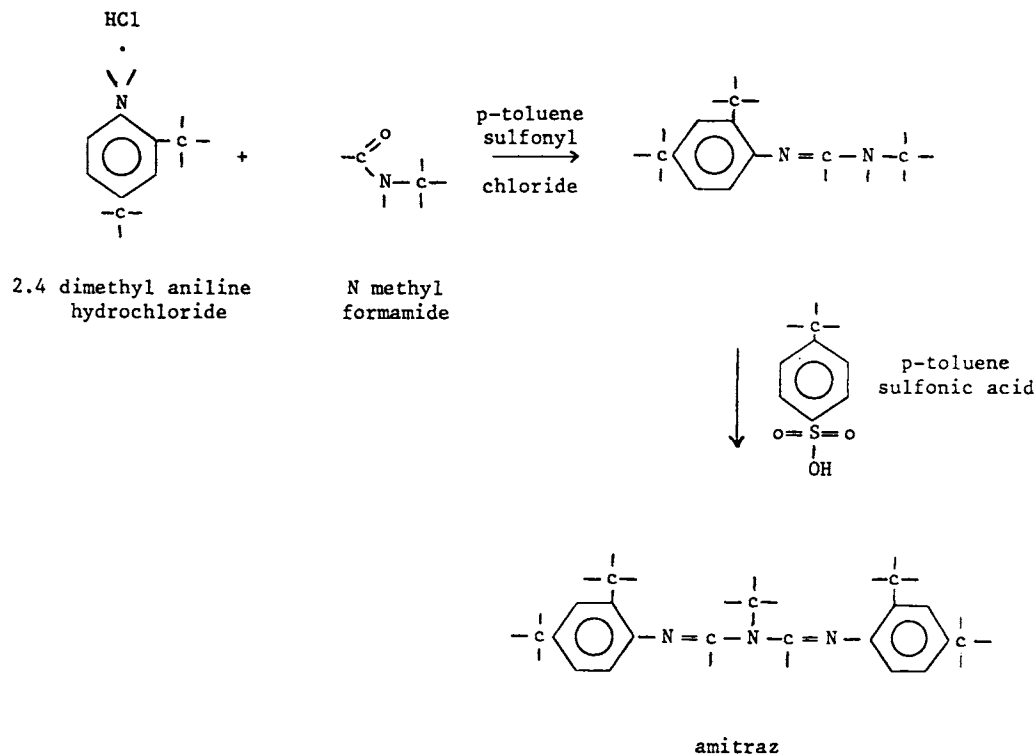
## Amitraz

Uses: insecticide, acaricide, citrus, cotton, tomatoes

Trade names: Mitac, Taktic (Schering)

Type: amidine

### Synthesis:



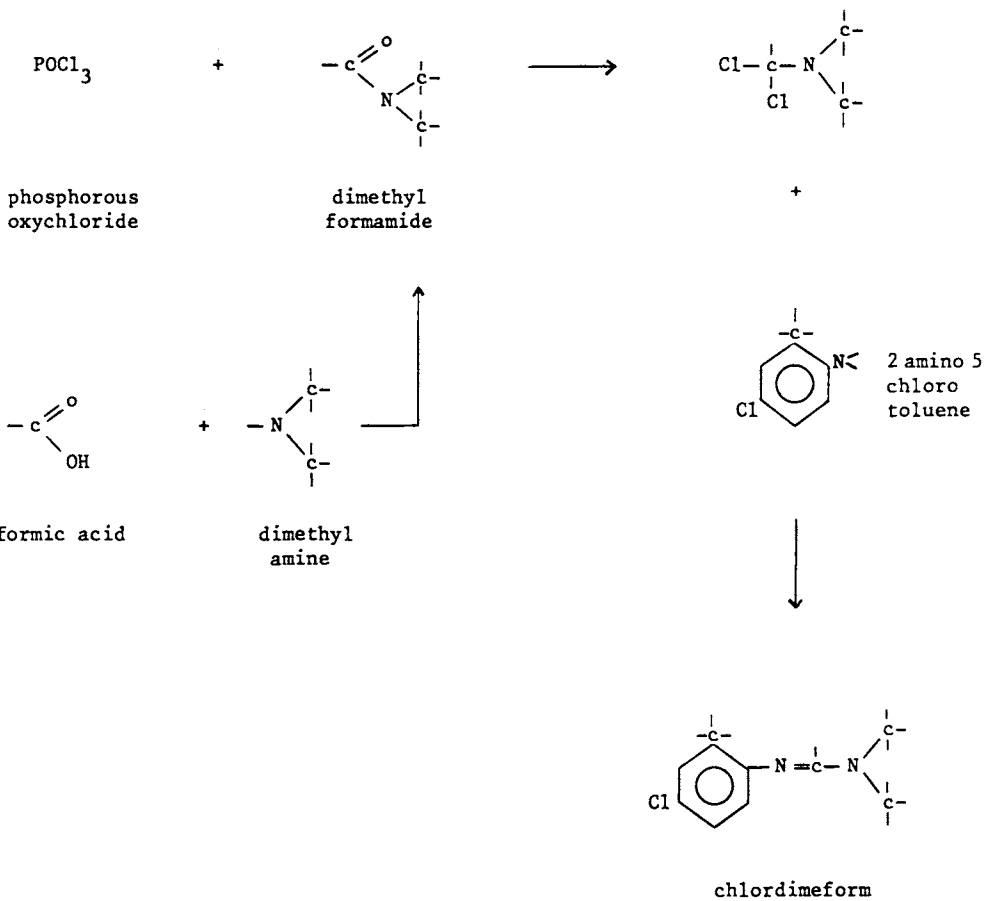
## Chlordimeform

Uses: acaricide, insecticide

Trade names: Galecron (Ciba), Fundal (Schering)

Type: amidine

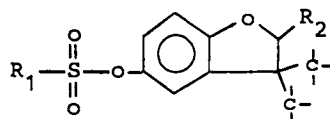
Synthesis:



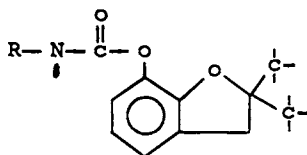
## BENZOFURANS

The benzofurans ring in itself does not exhibit strong pesticidal activity. Therefore benzofuran pesticides always have another main function which gives the molecule its leading characteristics.

Thus benfuresate and ethofumesate are sulfonates with a structure

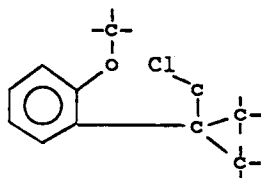


while carbofuran and furathiocarb are carbamates with a structure

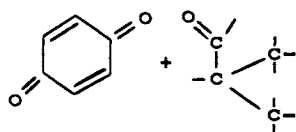


Benzofurans have been grouped together in this chapter in order to show the different ways of synthesizing the benzofuran ring

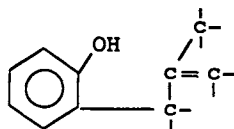
Ring closure methods are



benfuresate



ethofumesate



carbofuran  
furathiocarb

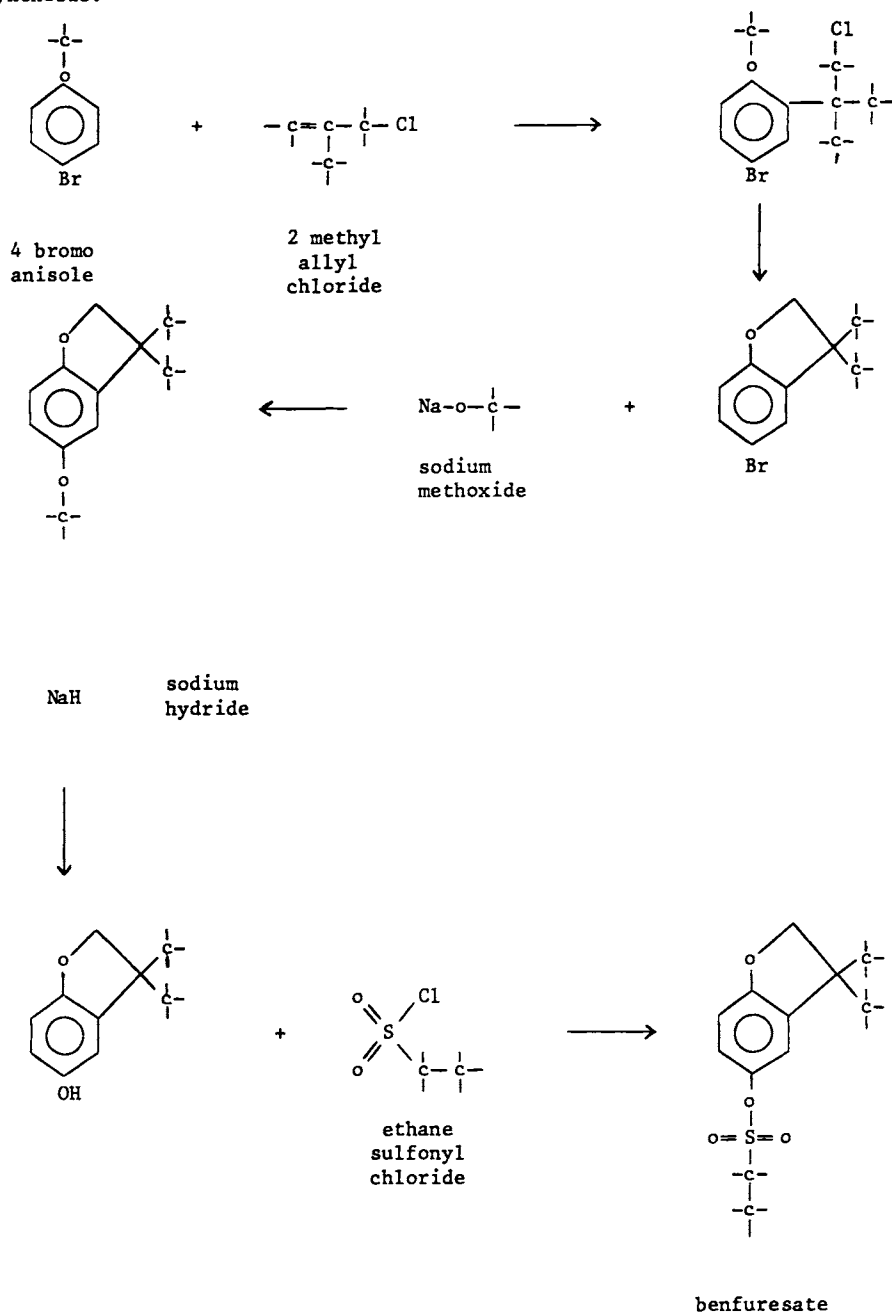
## Benfuresate

Uses: herbicide, cotton

Trade names: Cyperal (Schering)

Type: benzofuran, sulfonate

Synthesis:



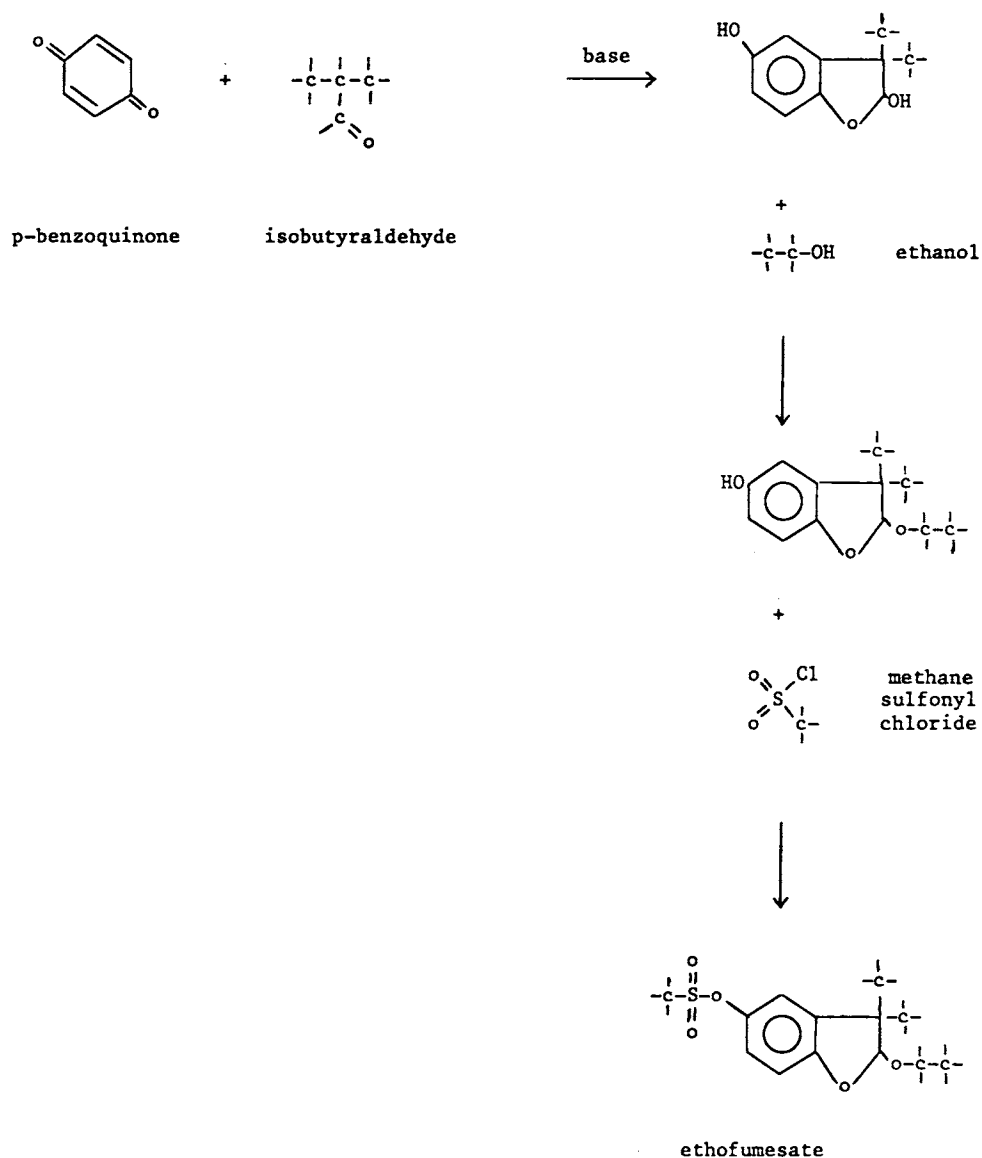
## Ethofumesate

Uses: herbicide, sugar beet, pasture, tobacco, sunflowers

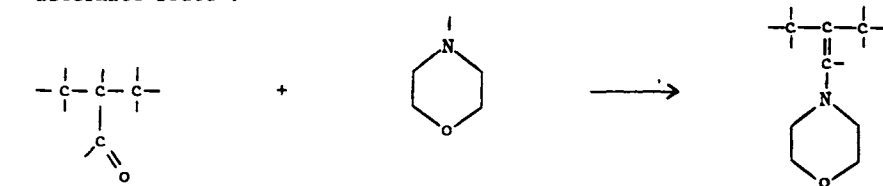
Trade names: Nortron, Trammat (Schering)

Type: benzofuran, sulfonate

Synthesis:

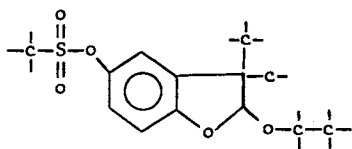
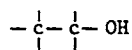
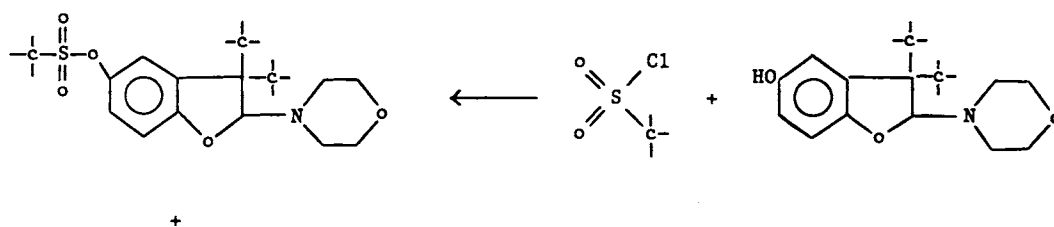
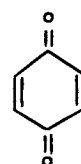


alternate route :



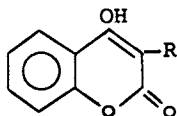
isobutyraldehyde

morpholine



## COUMARIN AND SIMILAR DERIVED PRODUCTS

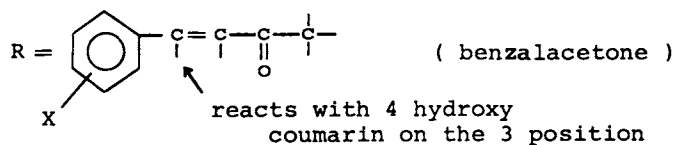
Nearly all coumarin pesticides have a structure



obtained by reaction between 4 hydroxy coumarin and one of the following :

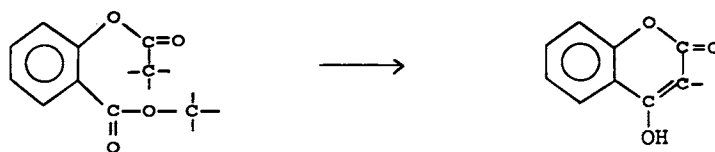
$R-X$  where X is a halogen

$R-OH$



A more unusual starting material is 3 carbethoxy 4 hydroxy coumarin (obtained by reaction between salicylaldehyde and malonic acid) which undergoes decarboxylation when reacting with benzalacetone.

4 hydroxy coumarin itself is synthesized from methyl acetyl salicylate by treatment with metallic sodium





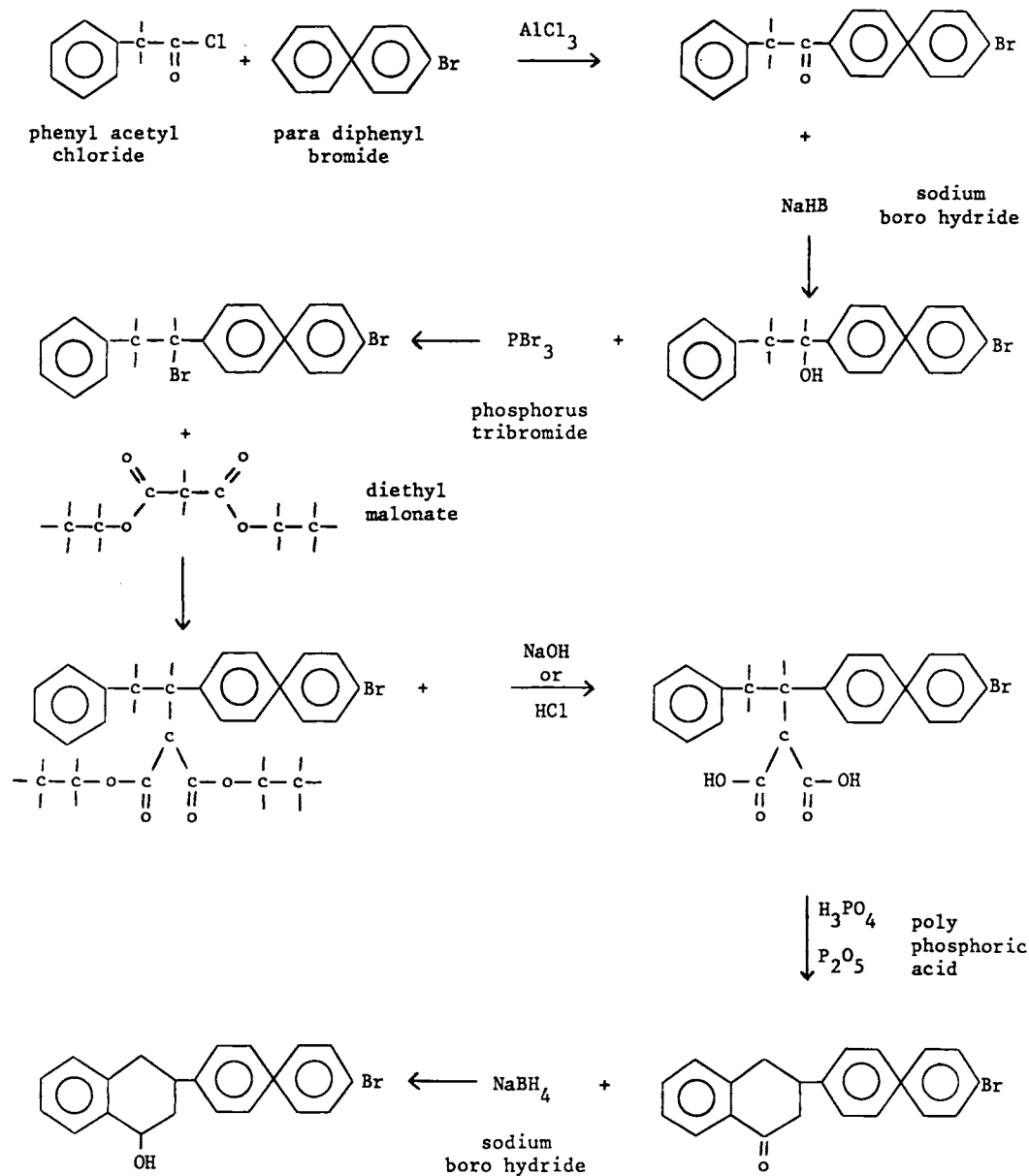
## Brodifacoum

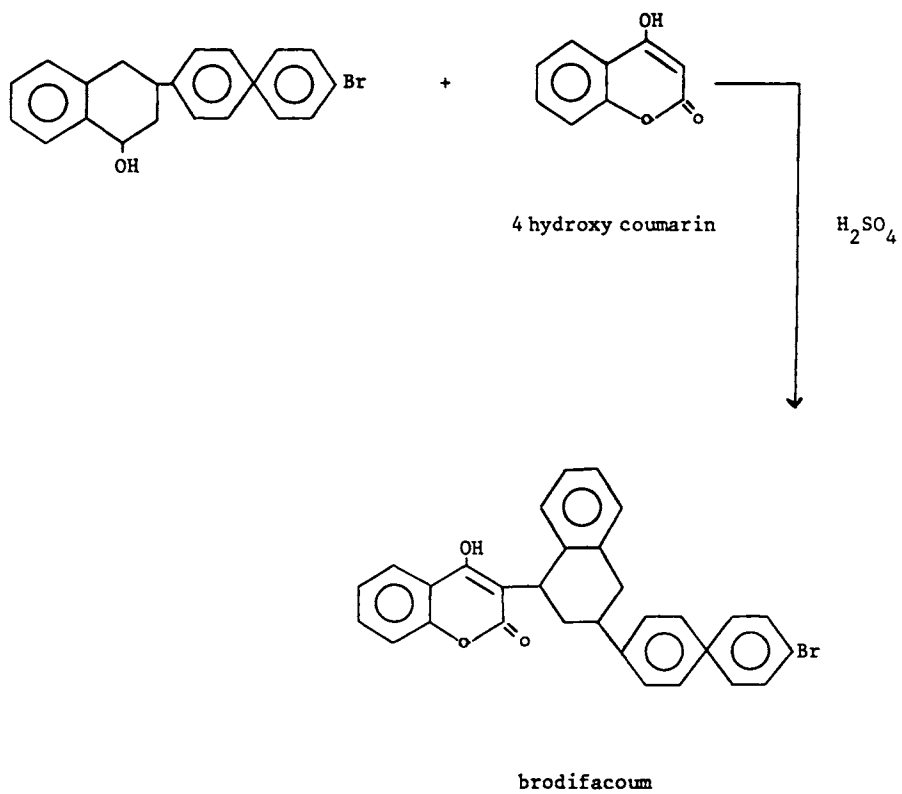
Uses:        rodenticide

Trade names:    Talon, Ratak (ICI)

Type:        coumarin

Synthesis:





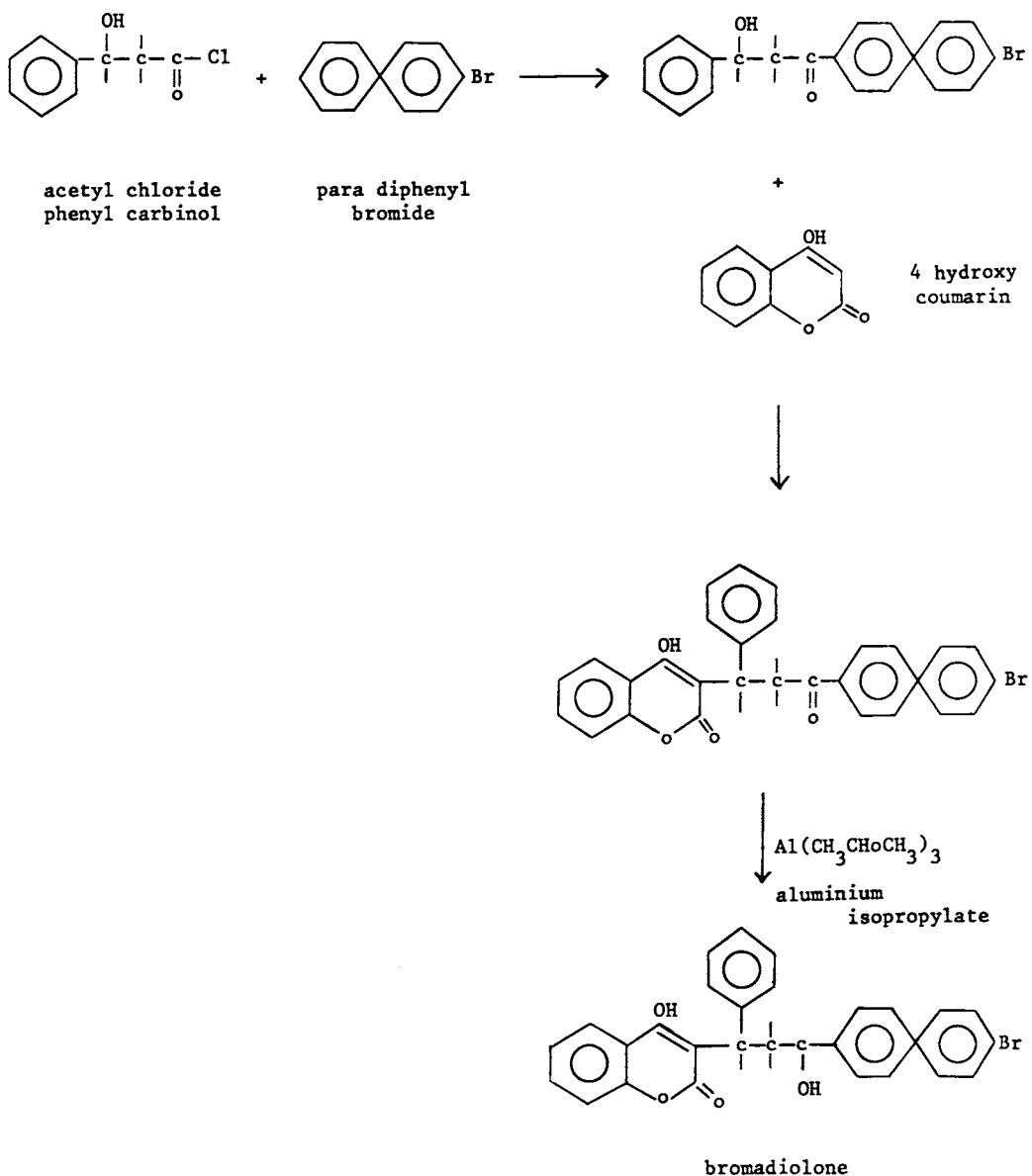
## Bromadiolone

Uses: rodenticide

Trade names: Deadline, Lanirat (Ciba), Maki, Super Caid (Lipha)

Type: coumarin

Synthesis:



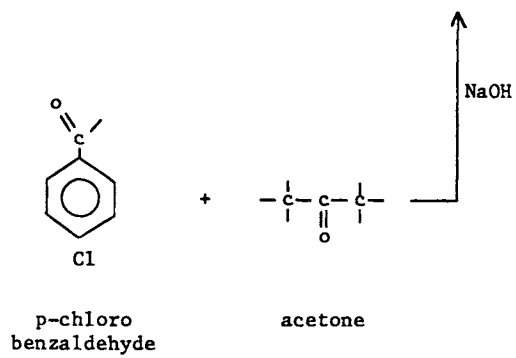
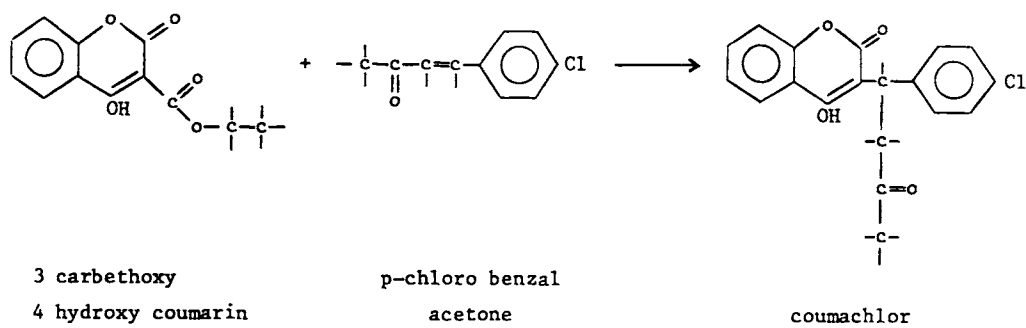
## Coumachlor

Uses: rodenticide

Trade names: Tomorin, Ratilan (Ciba)

Type: coumarin

Synthesis:



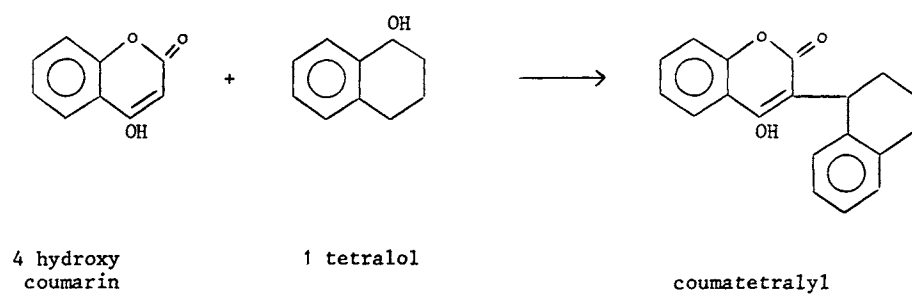
## Coumatetralyl

Uses: rodenticide

Trade names: Racumin (Bayer)

Type: coumarin

Synthesis:



## Difenacoum

Uses: rodenticide

Trade names: Ratak (ICI)

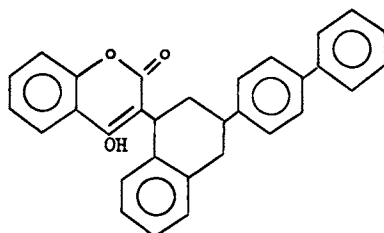
Type: coumarin

Synthesis:

SEE BRODIFACOUM. First reaction is with diphenyl  
of p-diphenyl bromide )



( Instead



difenacoum

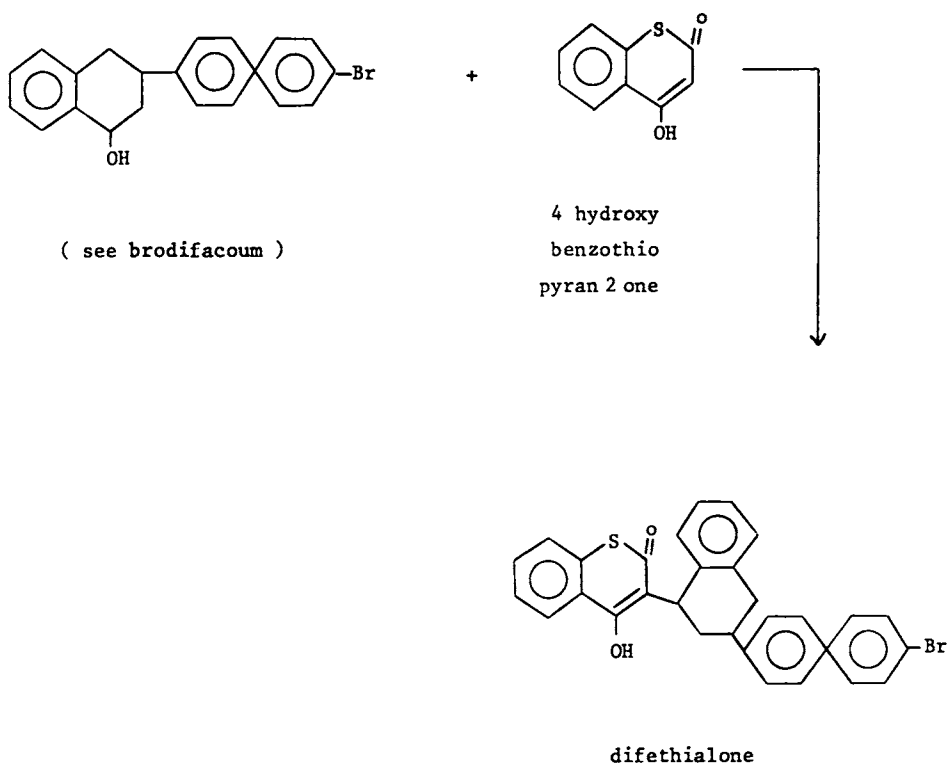
## Difethialone

Uses: rodenticide

Trade names: Baraki (Lipha, Rhone Poulenc)

Type: coumarin (benzothiopyranone)

Synthesis:



## Flocoumafen

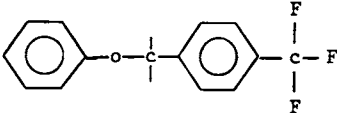
Uses: rodenticide

Trade names: Storm, Stratagem (Shell)

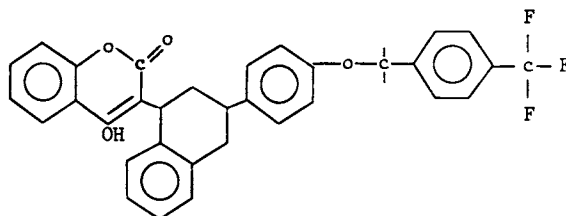
Type: coumarin

Synthesis:

See brodifacoum.

First reaction is with  4 trifluoro methyl

methyloxy benzene instead of diphenyl bromide



flocoumafen



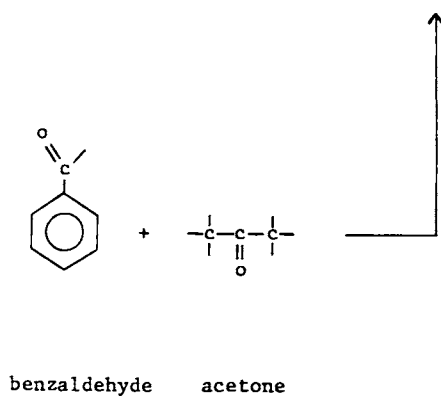
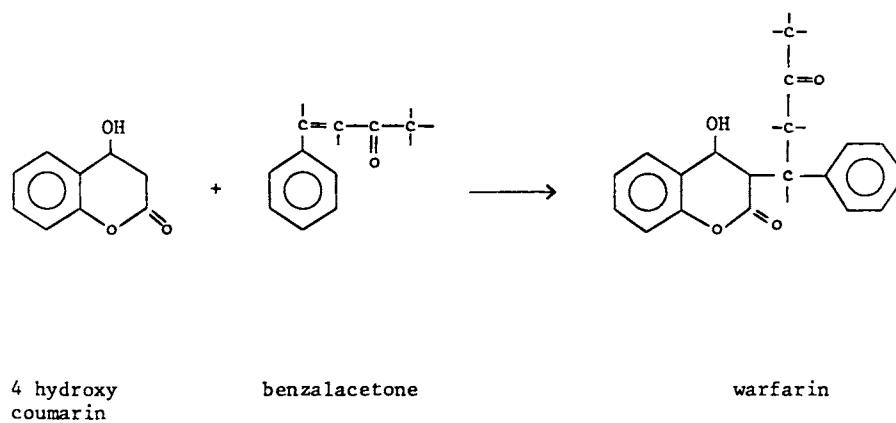
## Warfarin

Uses: rodenticide

Trade names:

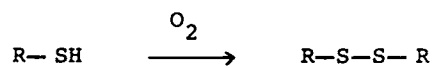
Type: coumarin

Synthesis:



## DISULFIDES

Disulfide pesticides are obtained by condensation of 2 molecules of the corresponding mercapto compound in presence of an oxidising agent such as  $\text{H}_2\text{O}_2$  ,  $\text{O}_2$  ,  $\text{Cl}_2$



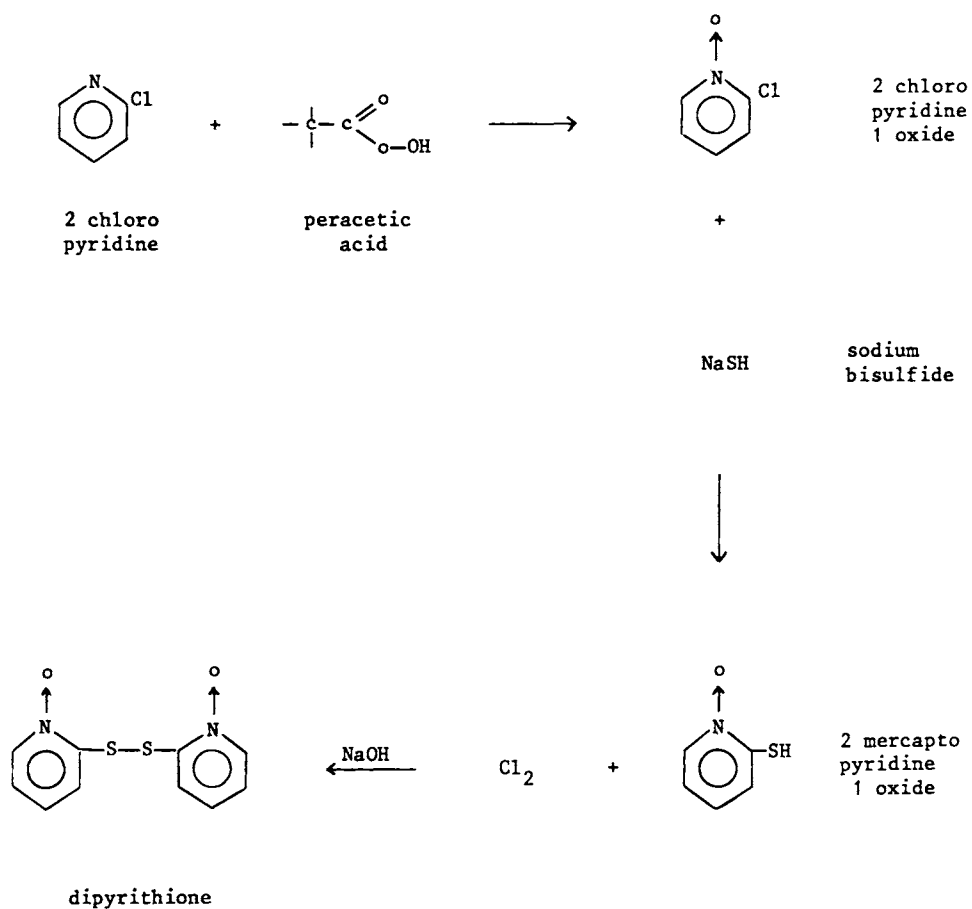
## Dipyrithione

Uses: fungicide

Trade names: Omadine (Yashima)

Type: disulfide, pyridine

Synthesis:



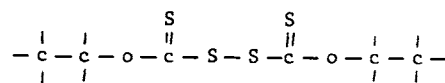
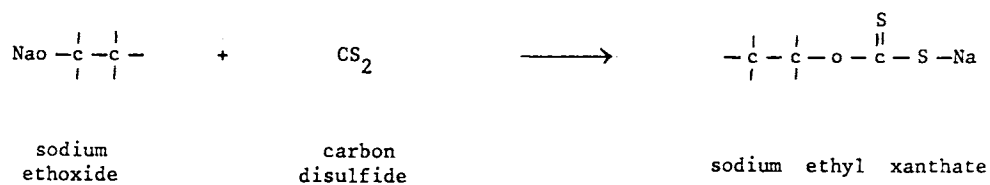
## E X D

Uses: herbicide

Trade names: Sulfasen (Monsanto)

Type: disulfide

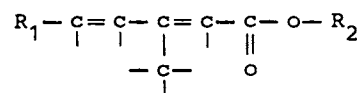
Synthesis:



E X D

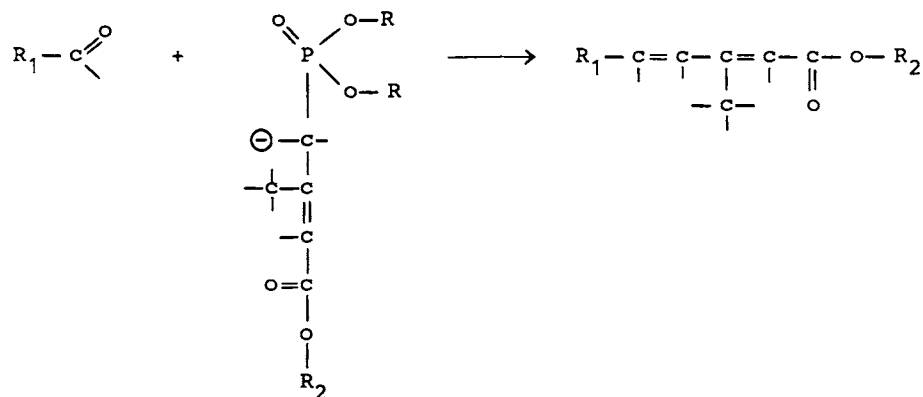
# DIENEDODECANOATES

These compounds have the following basic structure



where  $R_1$  has 7 straight chain carbons in addition to side branches and/or other functions ( 7 carbons plus the five indicated lead to the dodecanoate ).

The diene structure is obtained by reaction between an octanal and a phosphonate



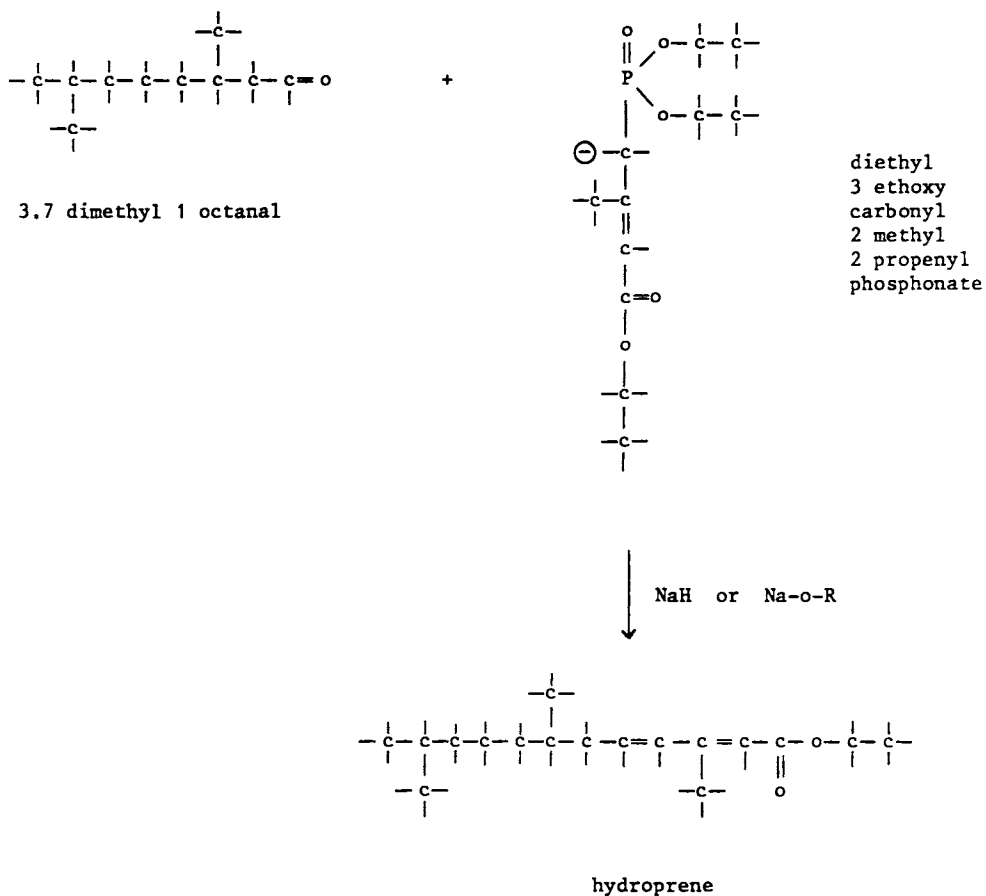
## Hydroprene

Uses: insecticide

Trade names: Altozar, Gencor (Sandoz)

Type: dienedodecanoate

Synthesis:



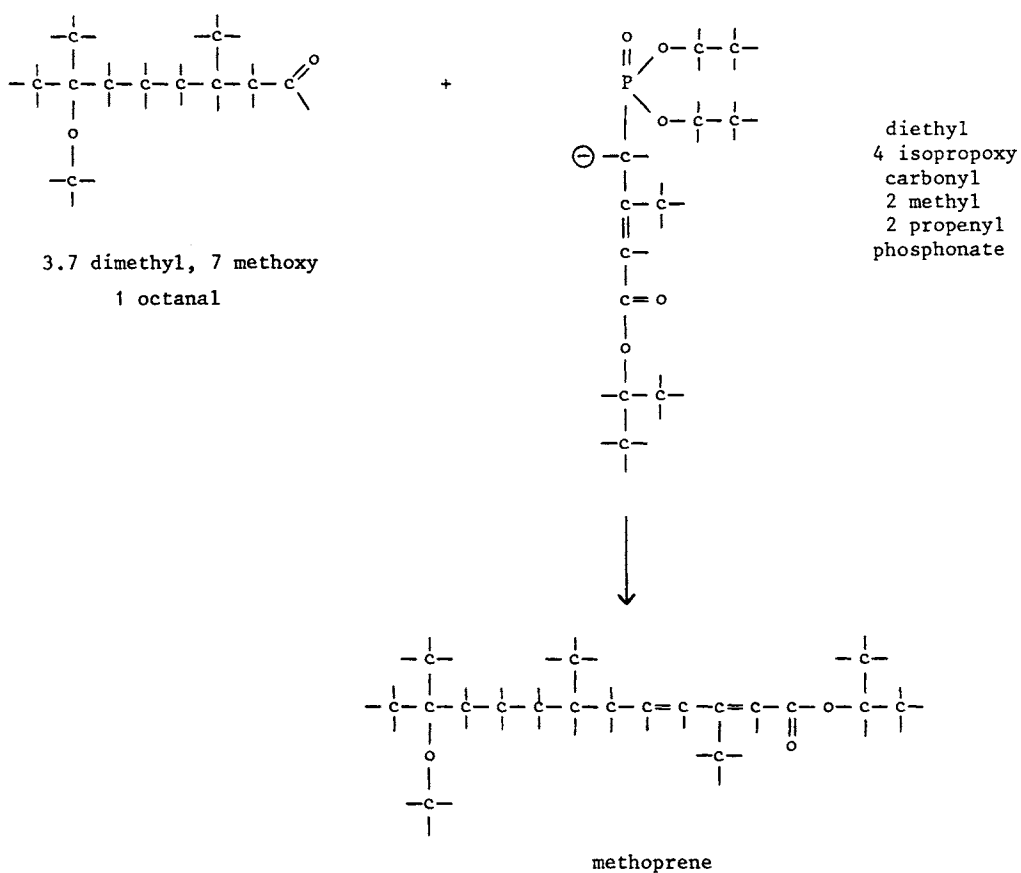
## Methoprene

Uses: insecticide, farm animals, cats, dogs, cattle, public health

Trade names: Altosid, Pharoid (Sandoz)

Type: dienedodecanoate

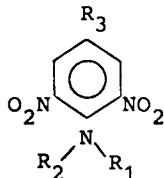
Synthesis:



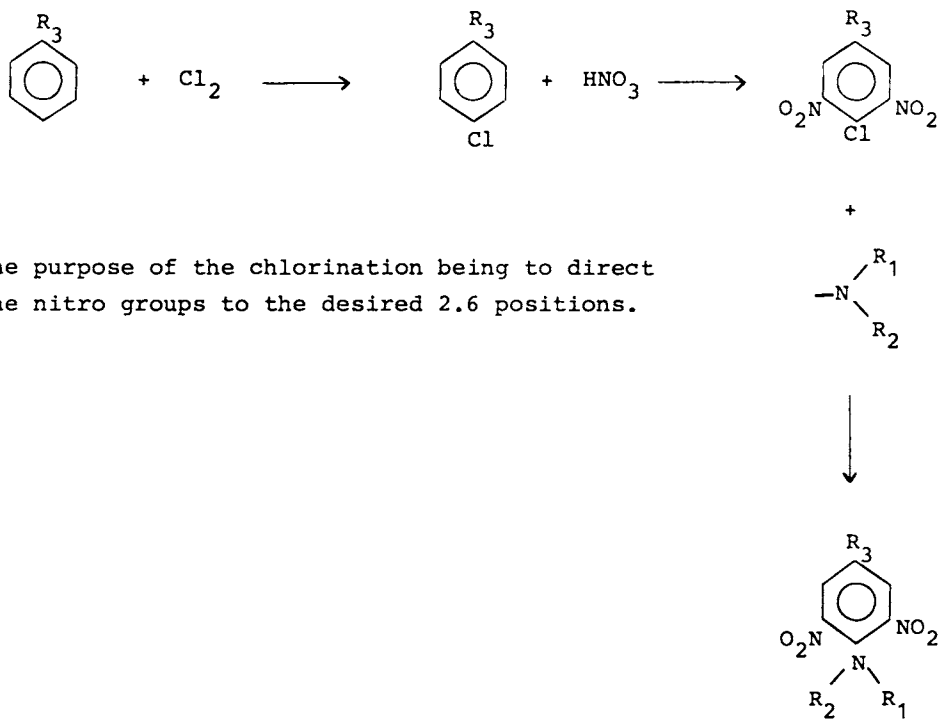
## DINITROANILINE HERBICIDES

These compounds are aromatic amines with nitro groups in the 2,6 positions adjacent to the amino function.

Their general formula is



The synthesis is as follows:



When ortho chloro toluene is used instead of the para isomer, nitration will yield the 2,4 derivate (with respect to the chlorine). Fluorination of the  $R_3$  group involves an extra step after chlorination and before nitration.



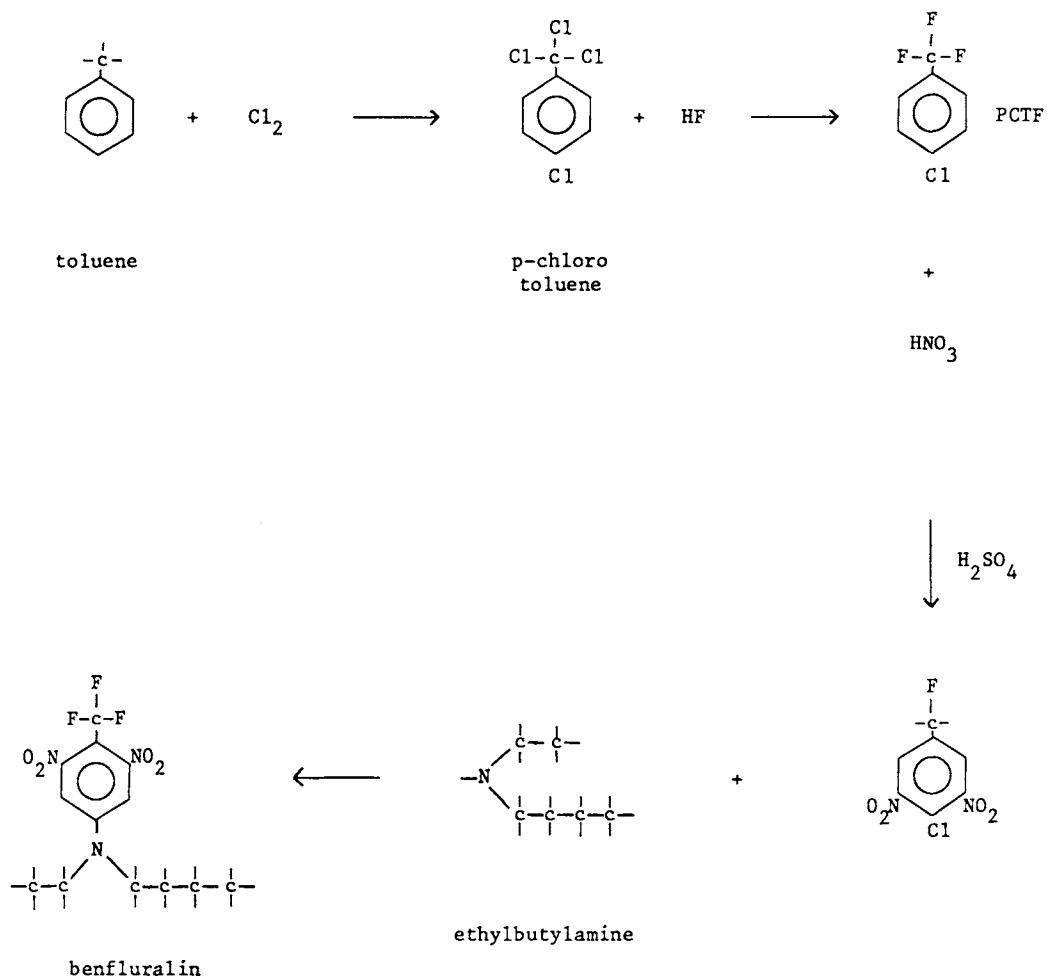
## Benfluralin

Uses: herbicide, tobacco, lettuce, cucumbers, vegetables

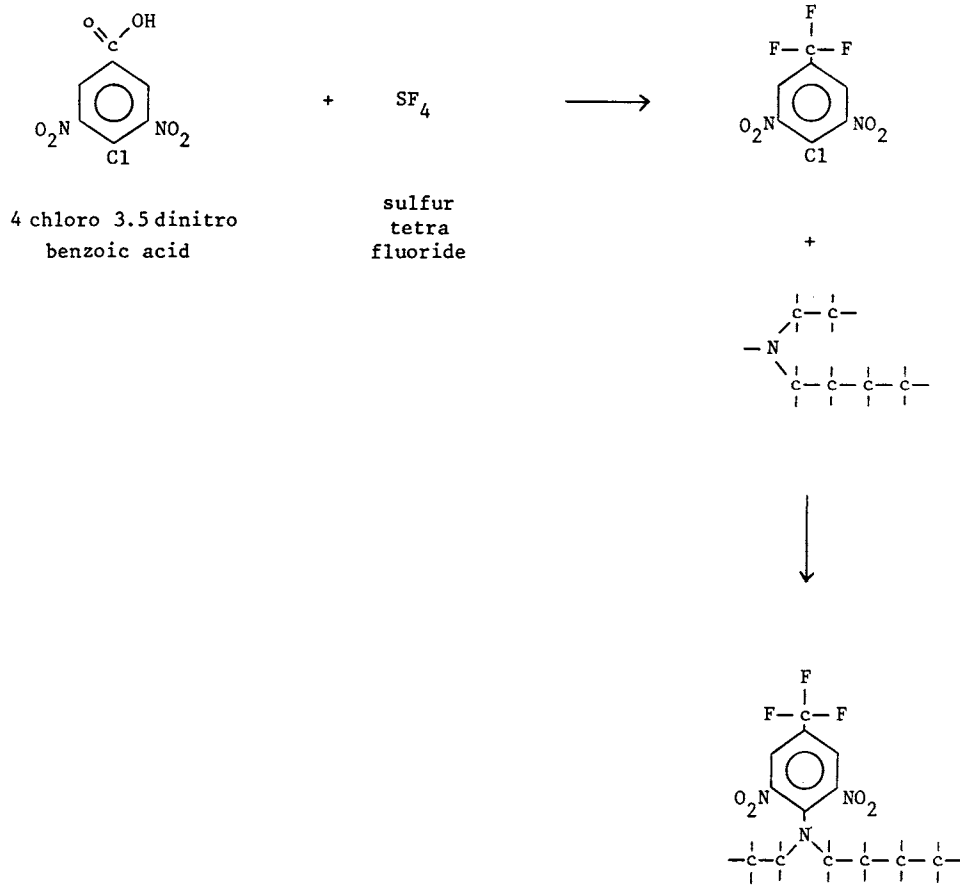
Trade names: Balan, Banalan (Dow Elanco)

Type: dinitroaniline

### Synthesis:



alternate route



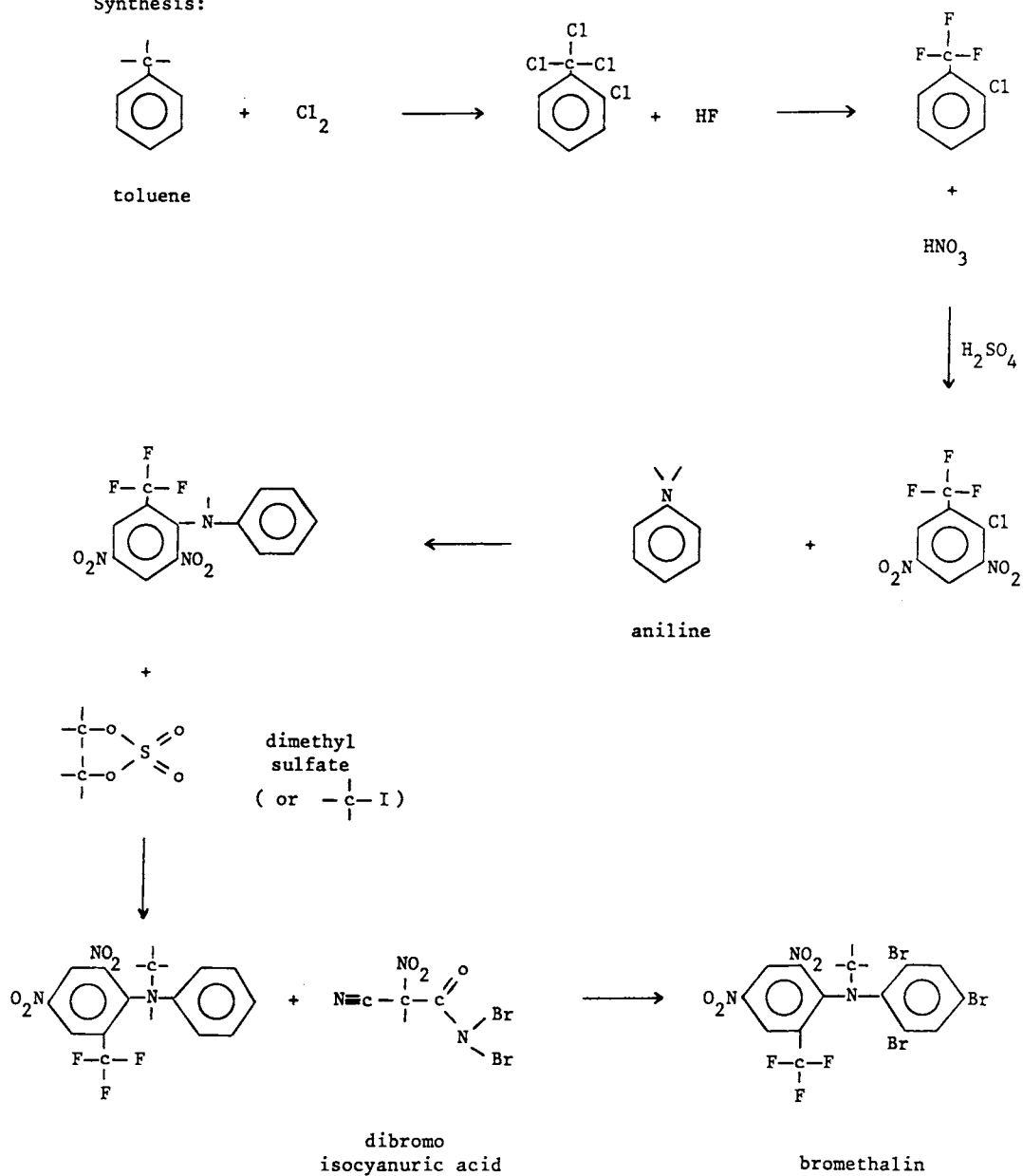
## Bromethalin

Uses: rodenticide

Manufacturers: (Dow Elanco)

Type: dinitroaniline

Synthesis:



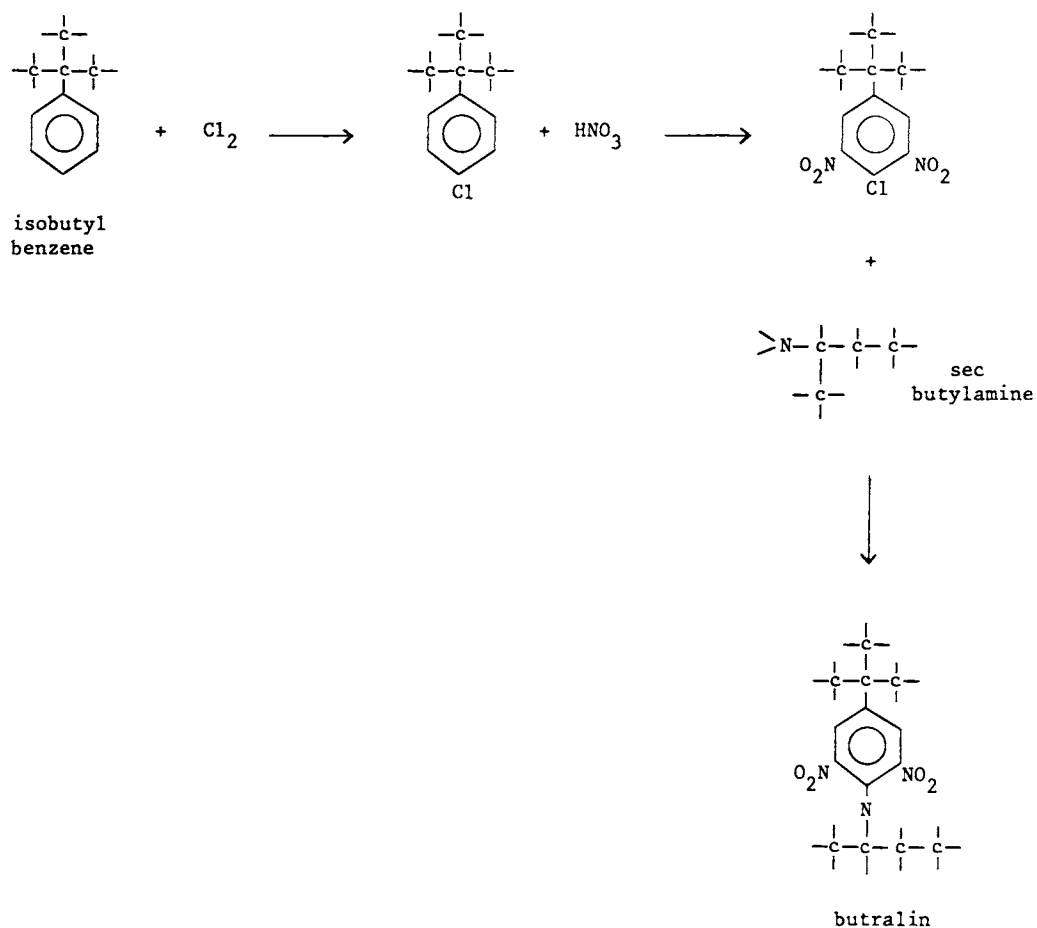
## Butralin

Uses: herbicide, soyabeans, cotton, tobacco

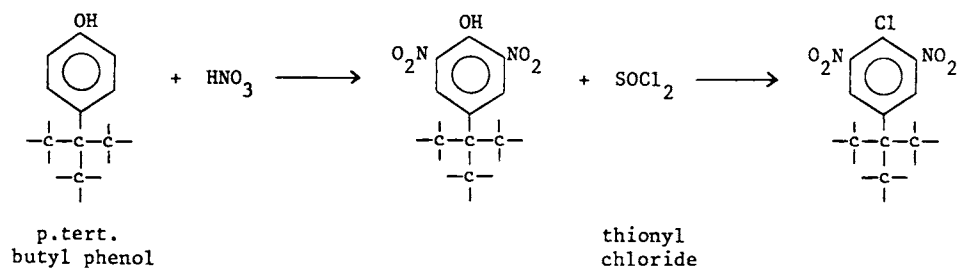
Trade names: Amexine, Tamex (Rhône Poulenc)

Type: dinitroanilines

Synthesis:



alternate route :



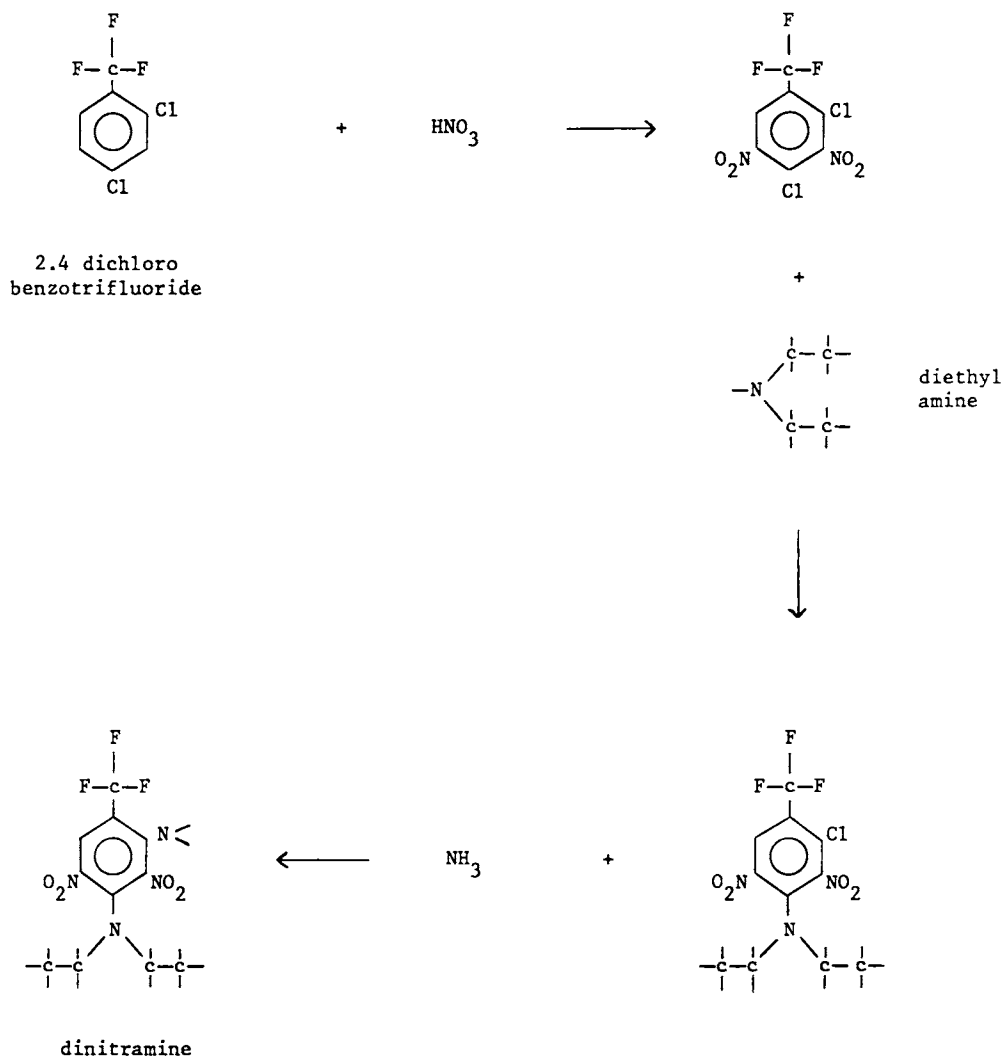
## Dinitramine

Uses: herbicide, cotton, sunflowers, soyabeans, carrots

Trade names: Cobex (Wacker)

Type: dinitroaniline

Synthesis:



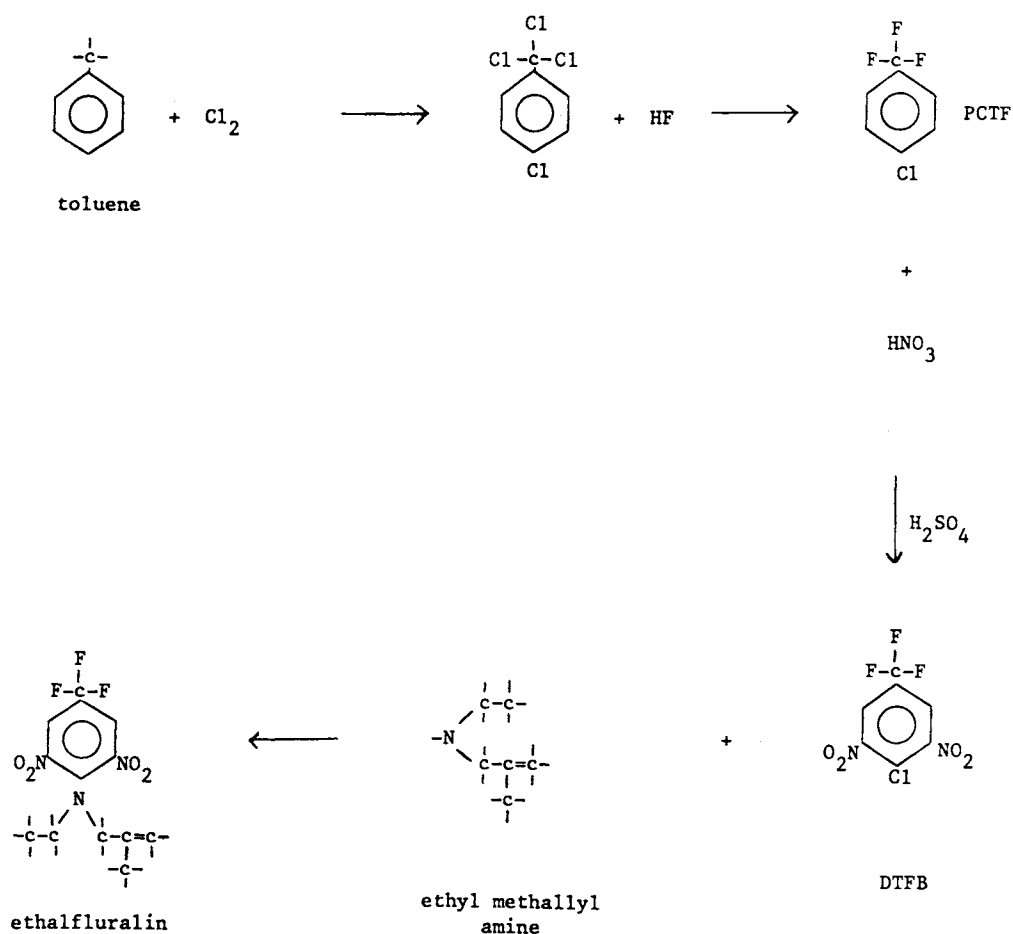
## Ethalfluralin

Uses: herbicide, cotton, soyabeans

Trade names: Sonalan, Sonalen (Dow Elanco)

Type: dinitroaniline

Synthesis:



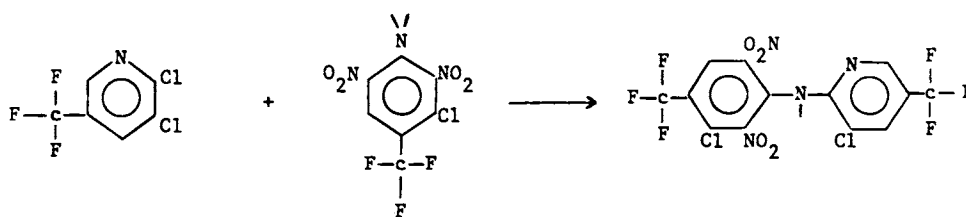
## Fluazinam

Uses: fungicide, grapes

Trade names: Shirlan (ICI)

Type: dinitroaniline

Synthesis:



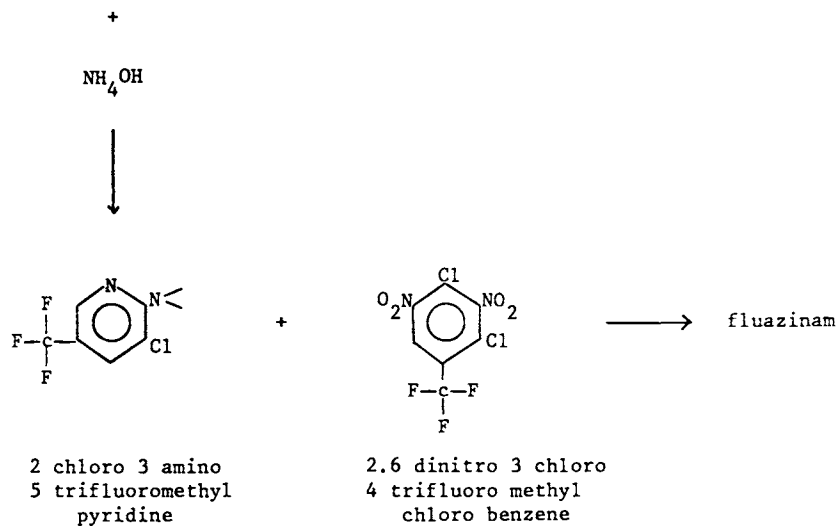
5,6 dichloro  
3 trifluoro methyl  
pyridine

2,6 dinitro  
3 chloro  
4 trifluoro methyl  
aniline

fluazinam

(see chlorfluazuron)

alternate route:



2 chloro 3 amino  
5 trifluoromethyl  
pyridine

2,6 dinitro 3 chloro  
4 trifluoro methyl  
chloro benzene

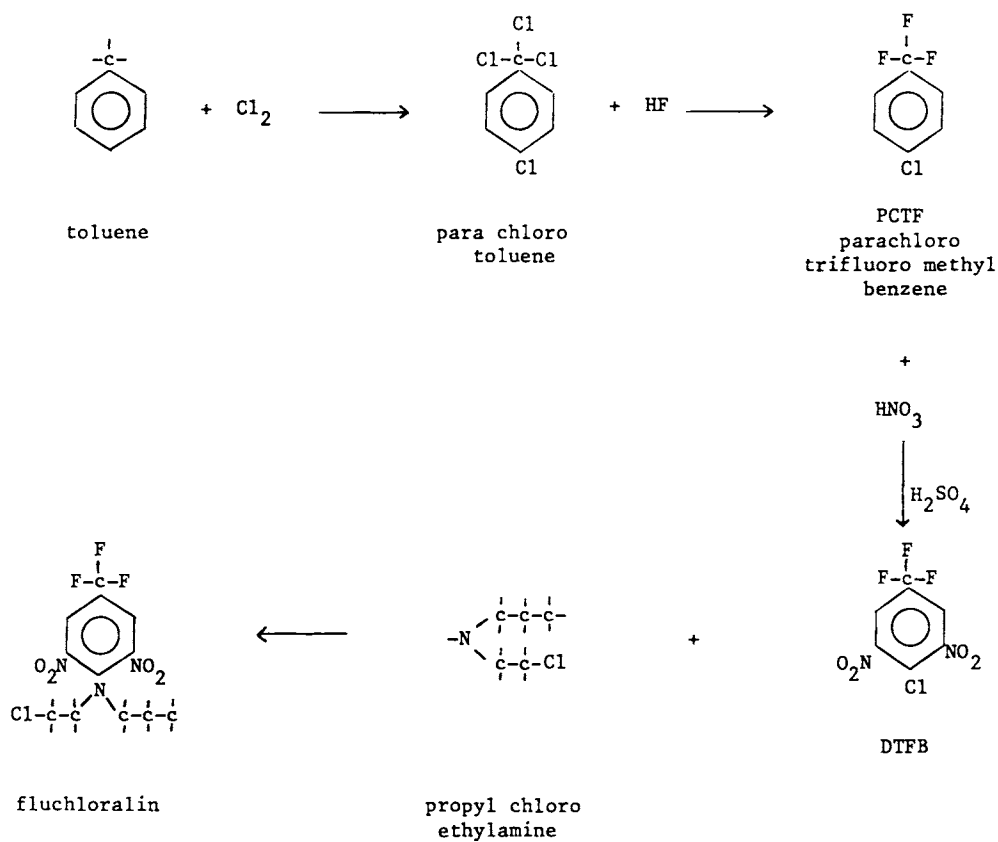
## Fluchloralin

Uses: herbicide, rice, potatoes, soyabeans, sunflower, cotton, ground nuts

Trade names: Basalin (BASF)

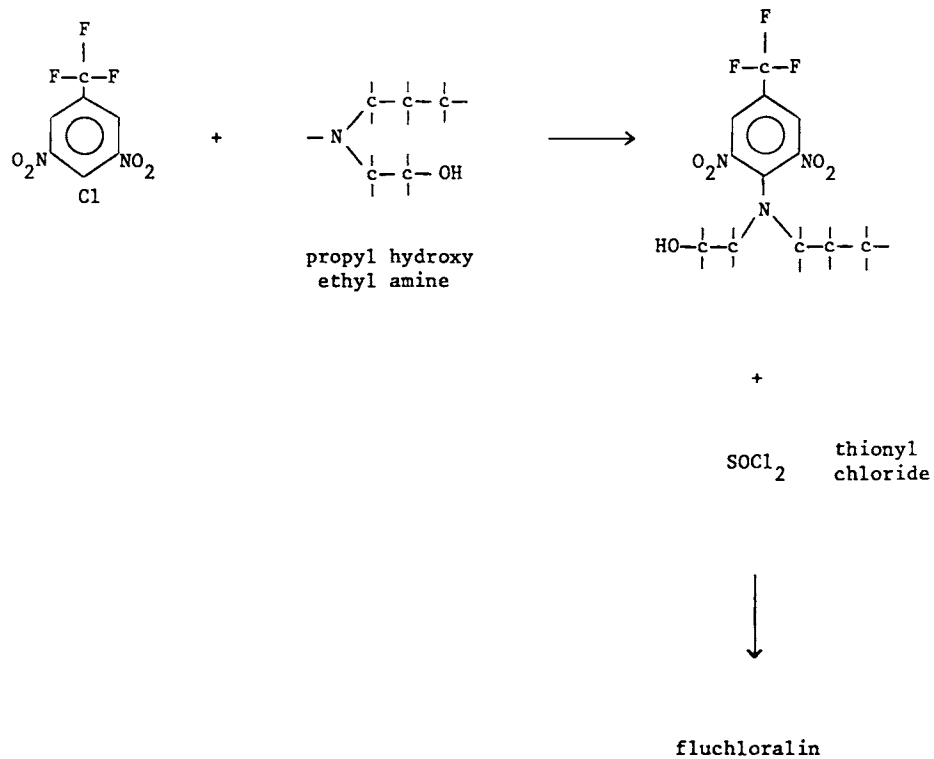
Type: dinitroaniline

Synthesis:





alternate route :



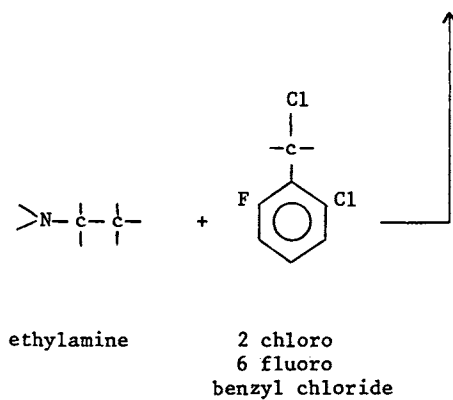
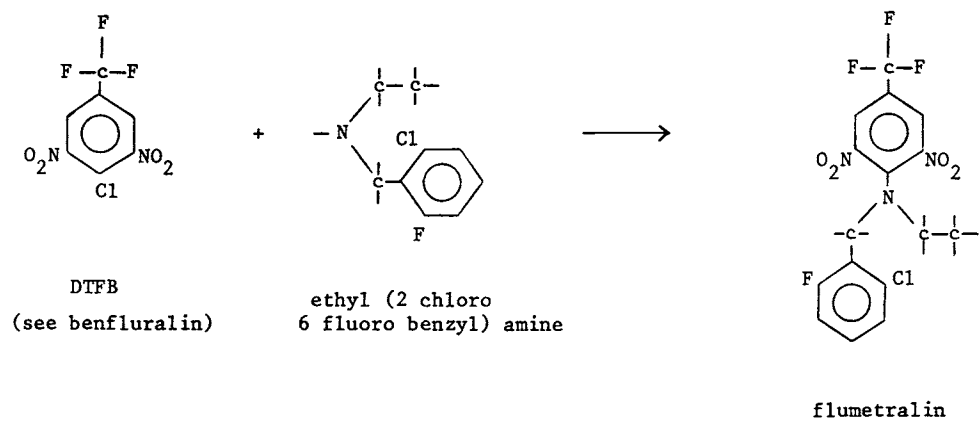
## Flumetralin

Uses: growth regulator, tobacco

Trade names: Prime (Ciba)

Type: dinitroaniline

Synthesis:



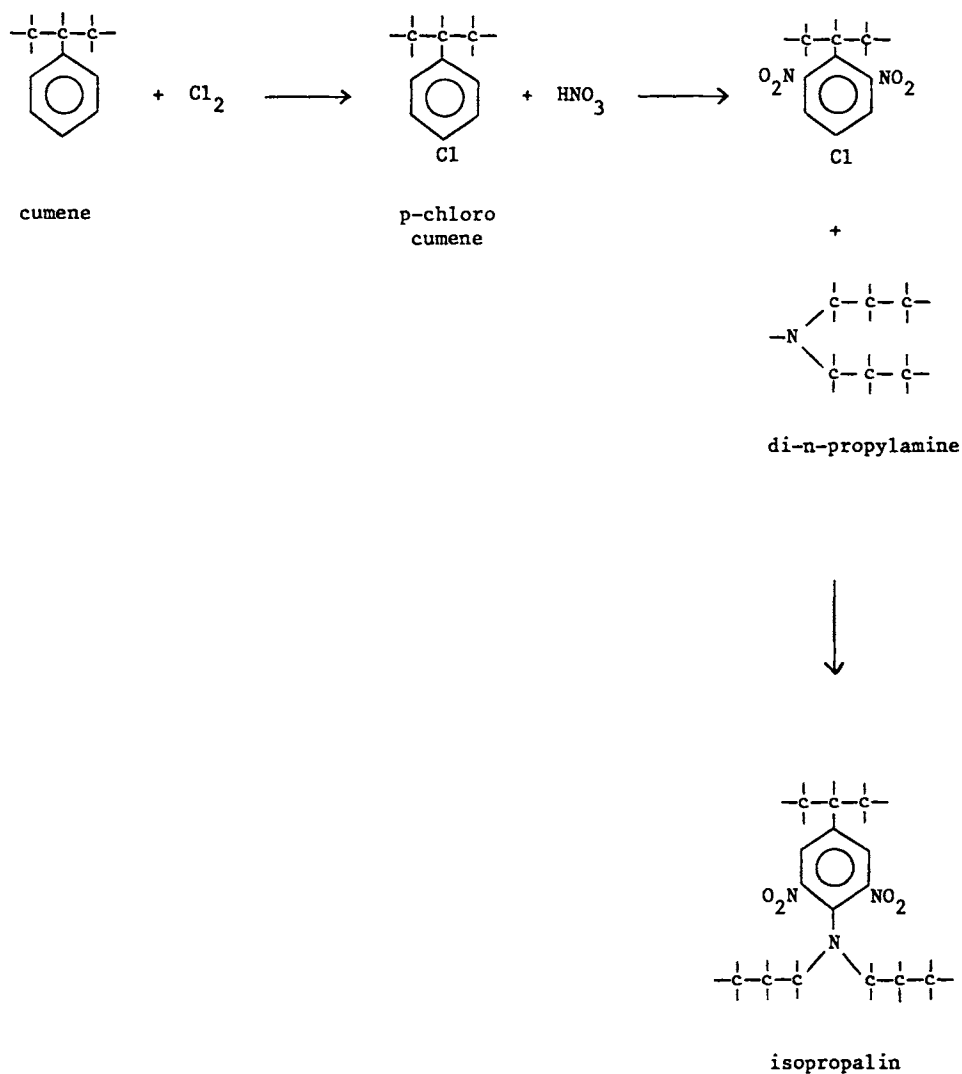
## Isopropalin

Uses: herbicide, peppers, tomatoes, tobacco

Trade names: Paarlan (Dow Elanco)

Type: dinitroaniline

Synthesis:



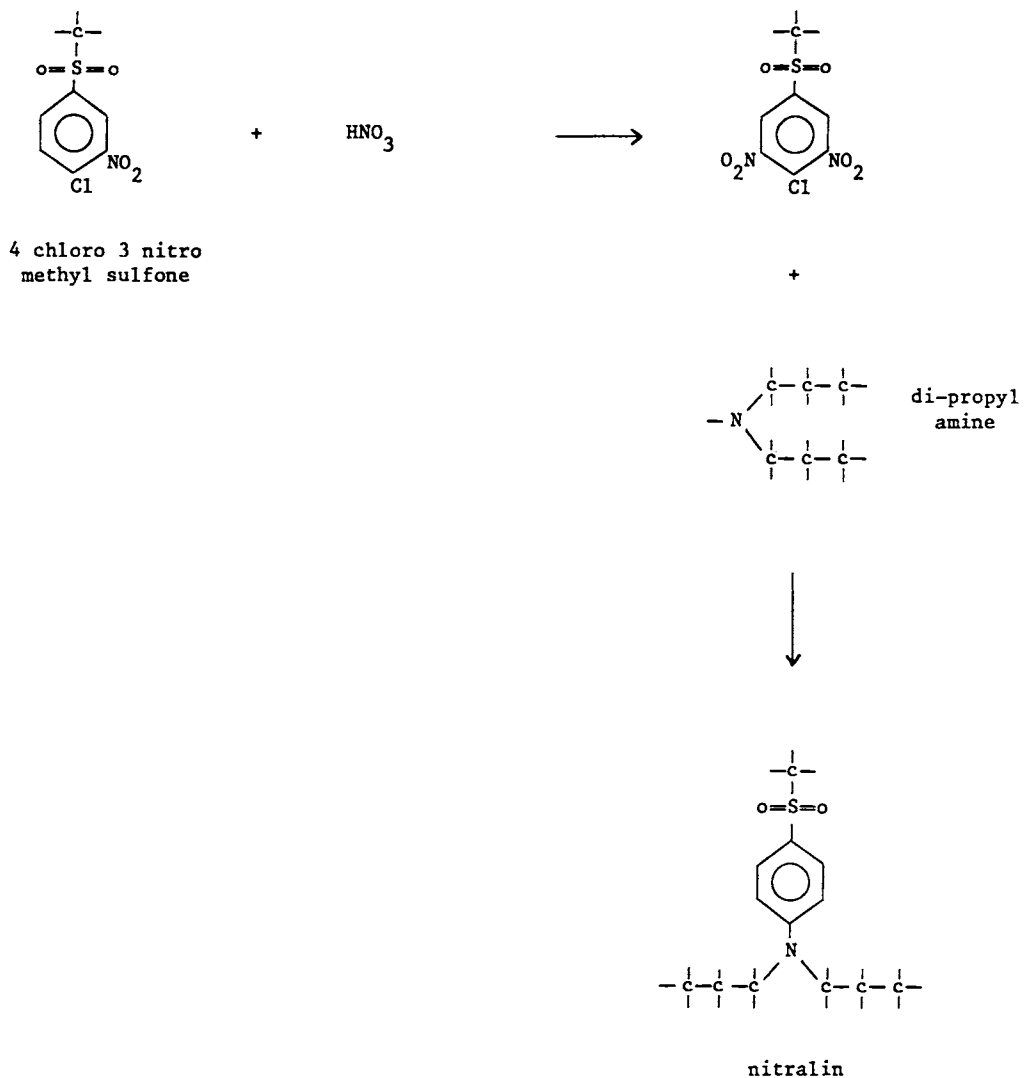
## Nitralin

Uses: herbicide, beans, cotton, groundnuts, soyabeans, sunflowers, tobacco, tomatoes

Trade names: Planavin (Shell)

Type: dinitroaniline, sulfone

Synthesis:



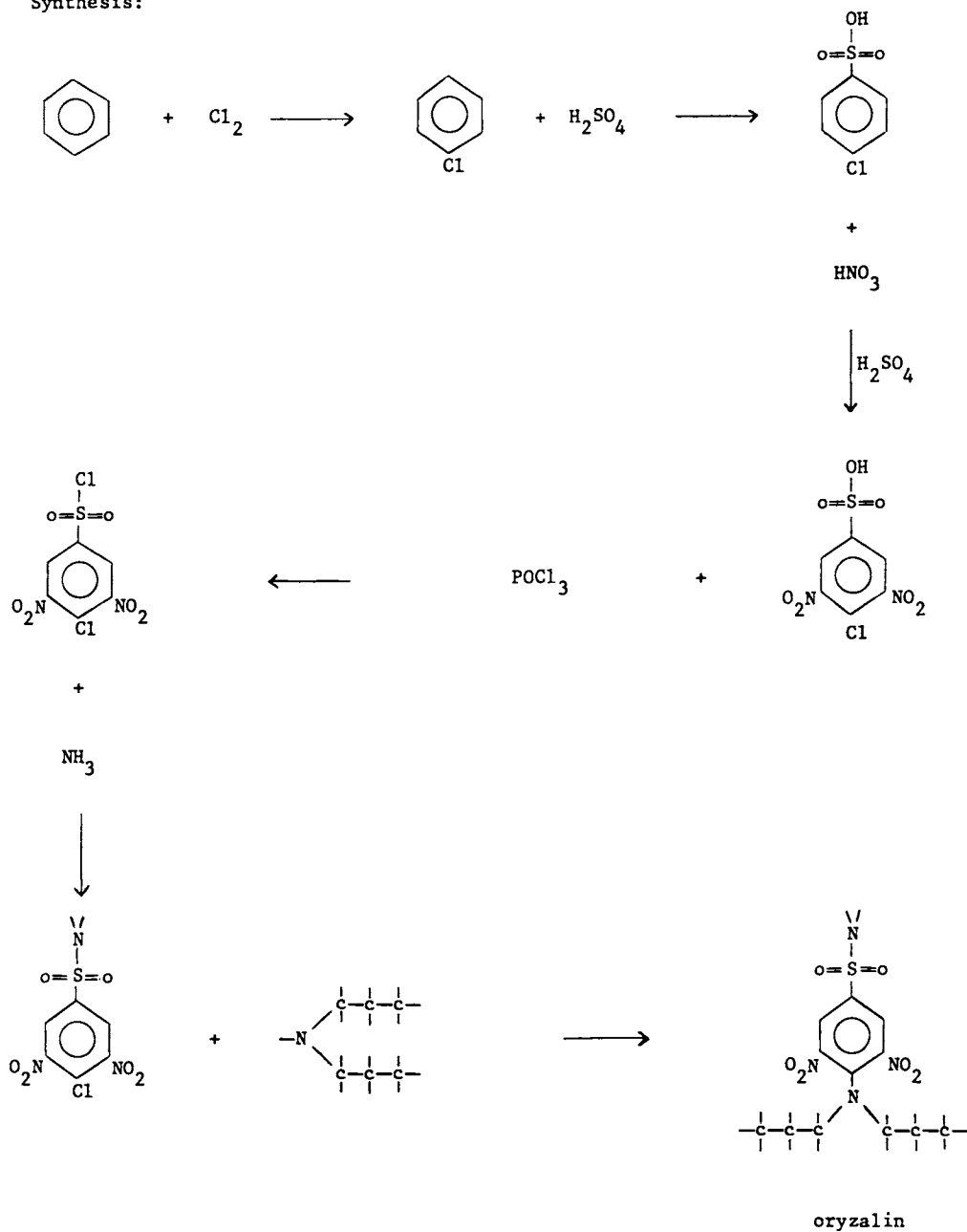
## Oryzalin

Uses: herbicide, cotton, groundnuts, sunflowers, soyabeans

Trade names: Dirimal, Ryzelan, Surflan (Dow Elanco)

Type: dinitroaniline, sulfonamide

Synthesis:



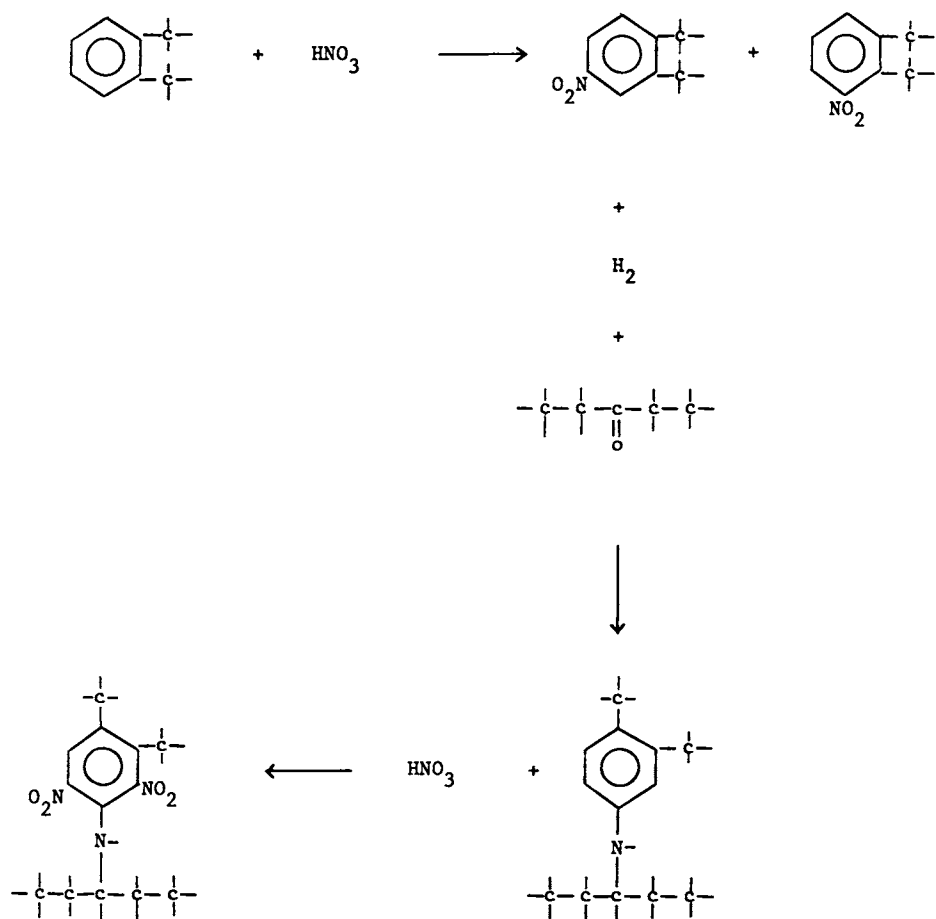
## Pendimethalin

Uses: herbicide for maize, sorghum, rice, soya, onions, carrots, celery, peas, beans, flowers

Trade names: Prowl, Stomp, Herbadox (Cyanamid)

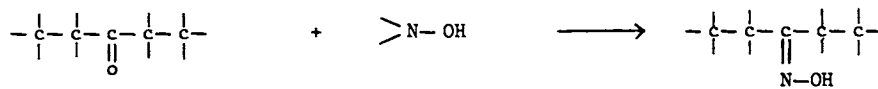
Type: dinitroaniline

**Synthesis:**





## Synthesis of pentaneamine



diethylketone

hydroxylamine

+

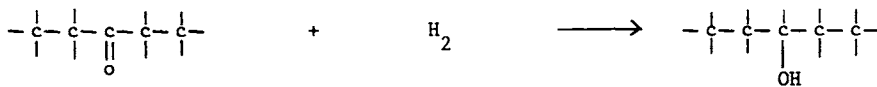
 $H_2$ 

alternate route:

pentaneamine

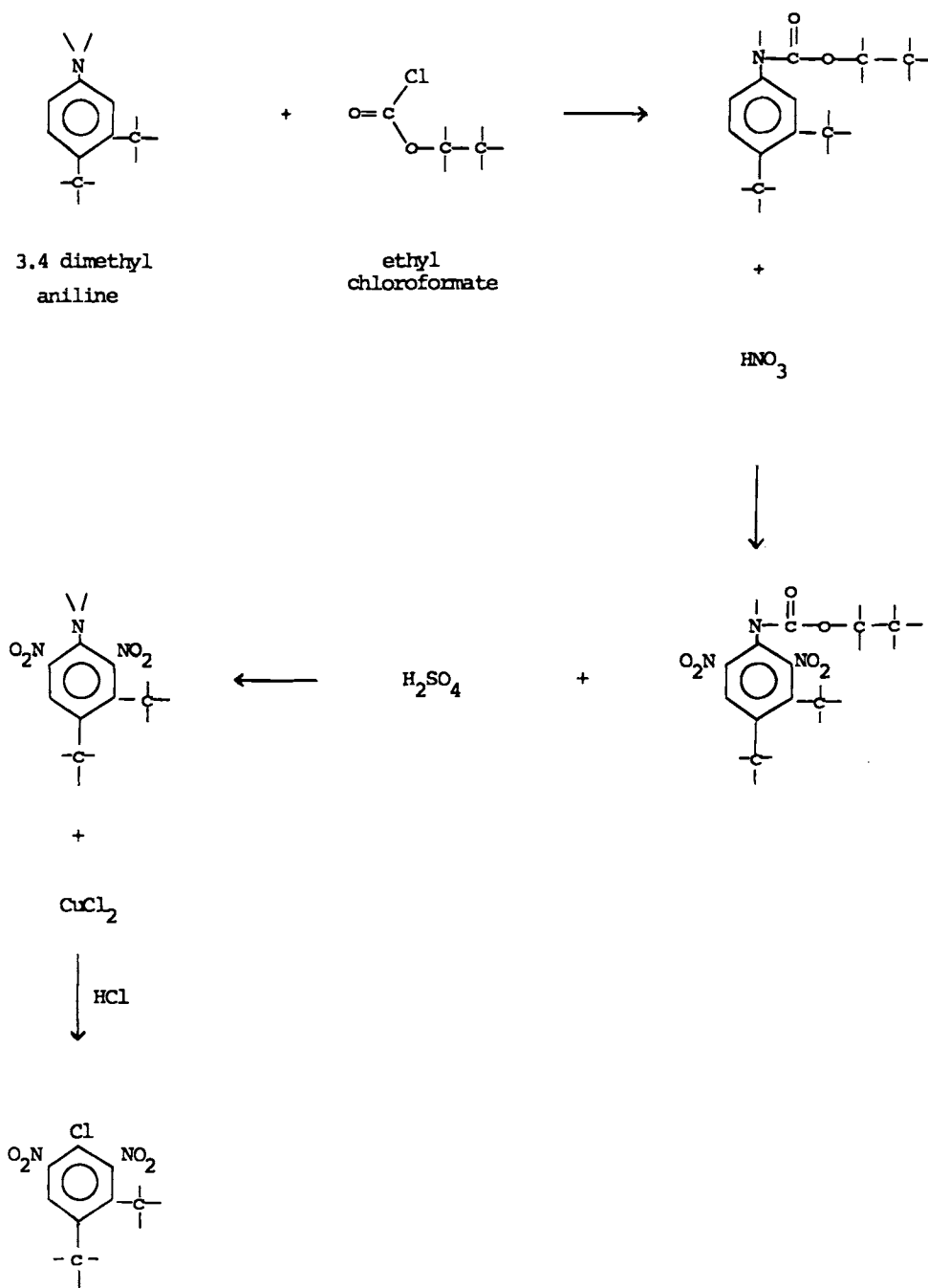
 $NH_3$ 

+

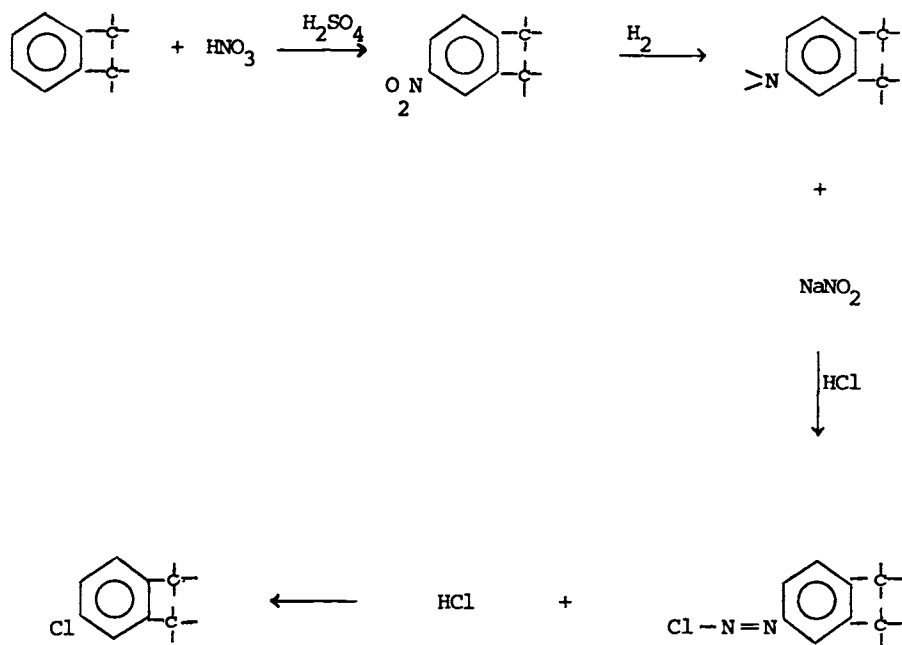




alternate route :



alternate route :



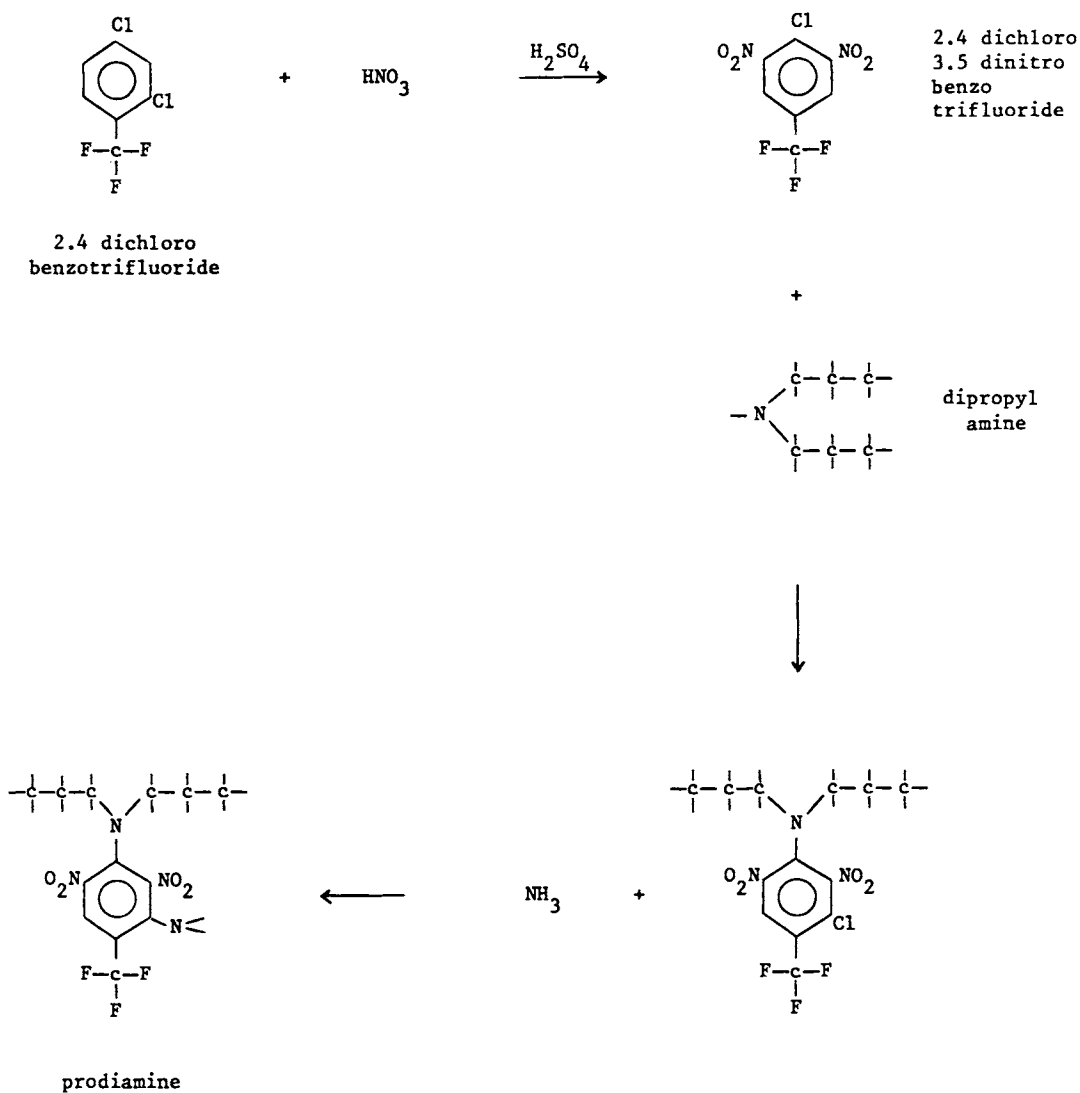
## Prodiamine

Uses: herbicide, cotton, soyabeans

Trade names: Barricade (Sandoz), Marathion (Velsicol)

Type: dinitroaniline

Synthesis:



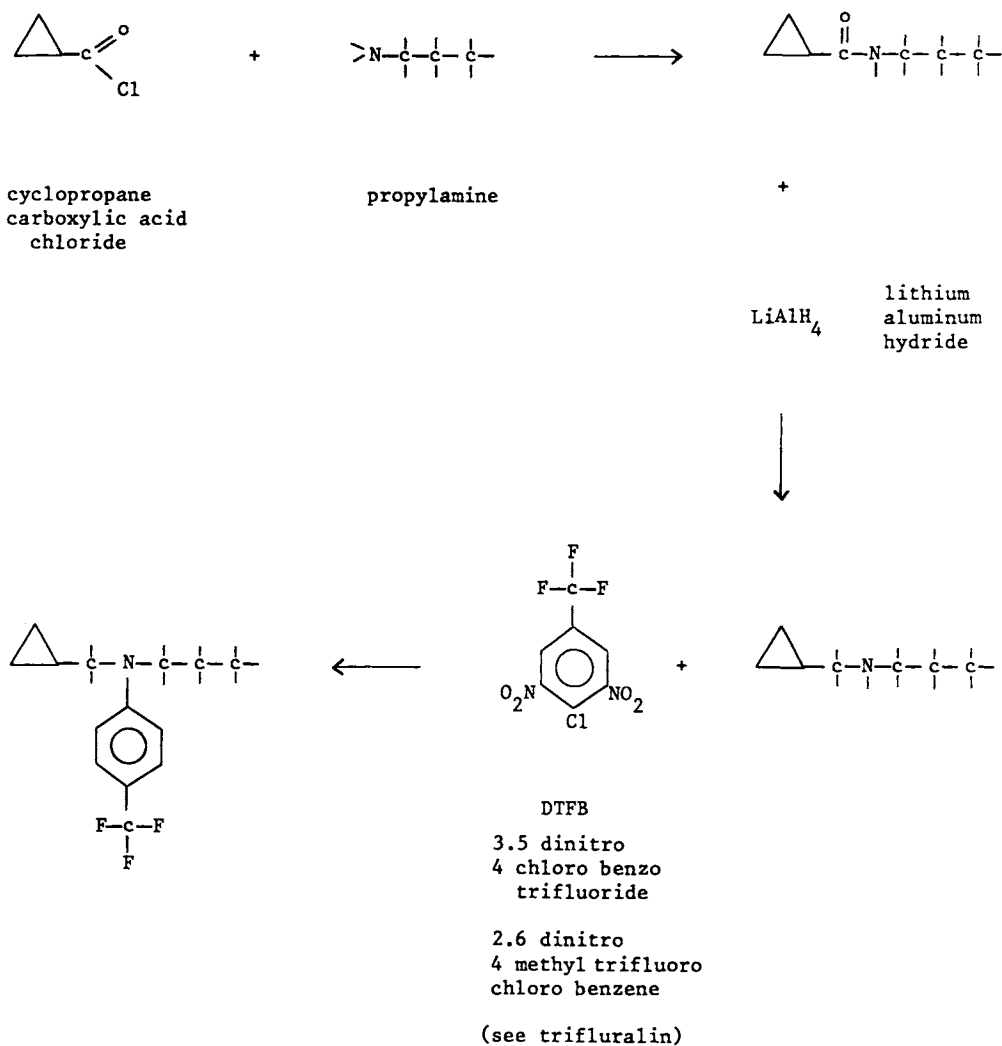
## Profluralin

Uses: herbicide, cotton, soyabeans

Trade names: Tolban, Pregard (Ciba)

Type: dinitroaniline

Synthesis:



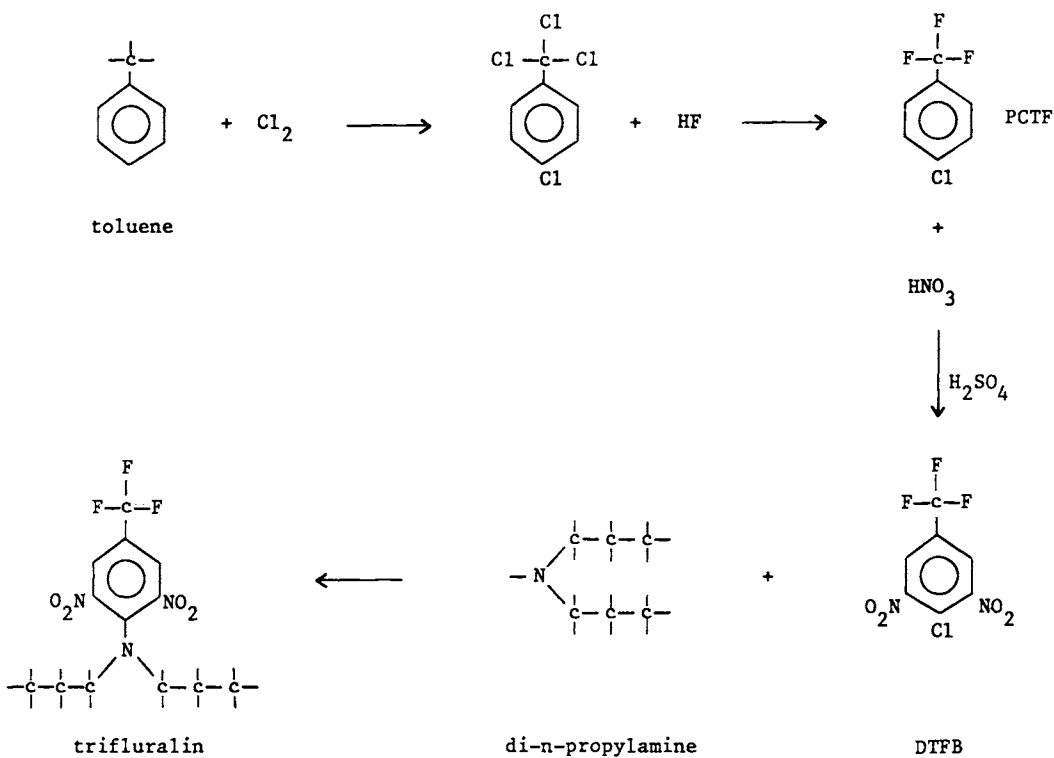
## Trifluralin

Uses: herbicide, cotton, groundnuts, soyabeans, tomatoes, sunflowers, sugarbeet, peppers, ornamentals, vine

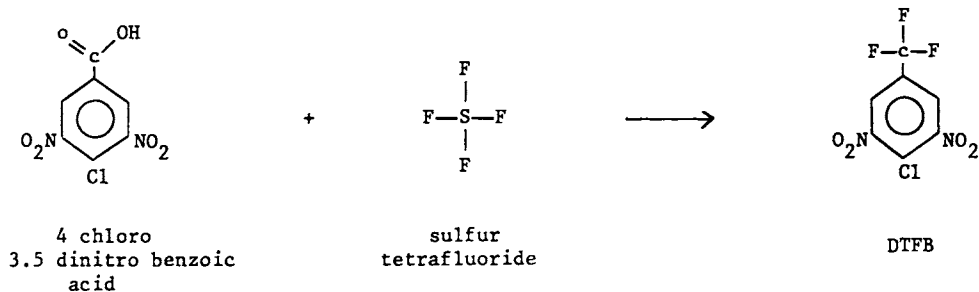
Trade names: Treflan, Elancolan (Dow Elanco)

Type: dinitroaniline


Synthesis:




alternate route :



## DINITRO PHENOLS AND DERIVATIVES

Nitration of  leads to the 4.6 dinitro product which is

characteristic of this family.

Nitration of  leads to the 2.6 dinitro derivate of

which dinocap is the only significant example.

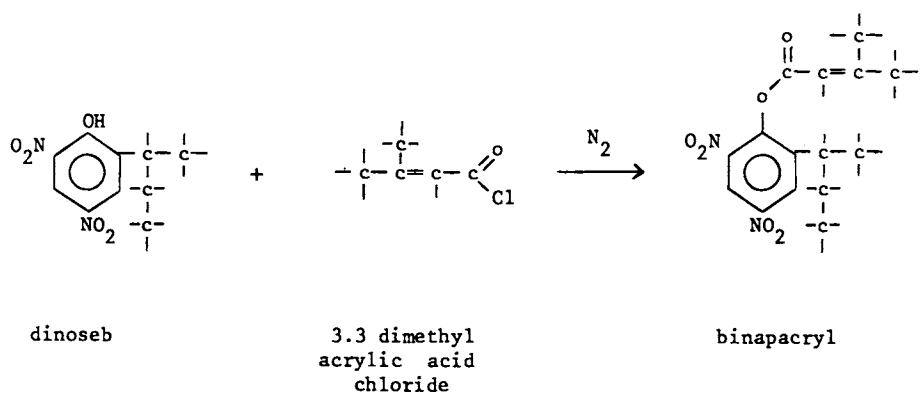
## Binapacryl

Uses: acaricide, fungicide

Trade names: Acricid, Endosan, Morocide, Ambox, Depacryl, Morrocid (Hoechst)

Type:     dinitrophenol

**Synthesis:**

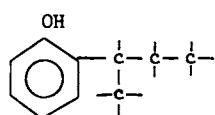


## Dinobuton

Uses: acaricide, fungicide, fruit, citrus, vegetables, tomatoes, cotton, cucumbers

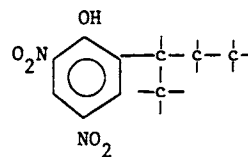
Trade names: Dessin (U.Carbide)

Type: dinitrophenol

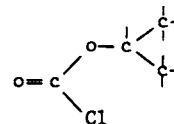


o-sec butyl  
phenol

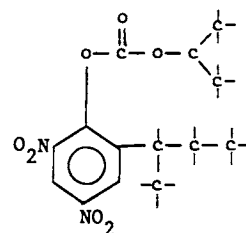
+



+



isopropyl  
chloroformate



dinobuton



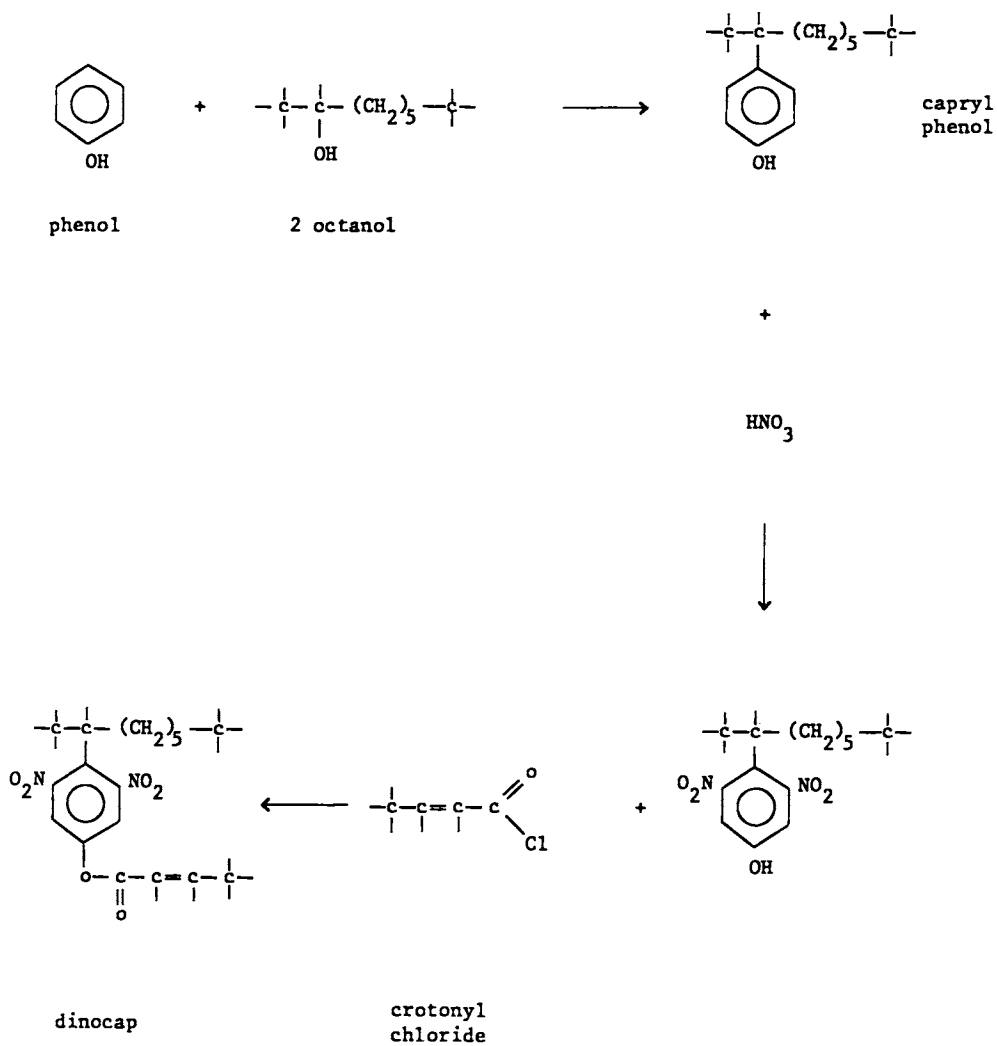
## Dinocap

Uses: acaricide, fungicide, citrus, vegetables

Trade names: Karathane (Rohm & Haas)

Type: dinitrophenol

Synthesis:



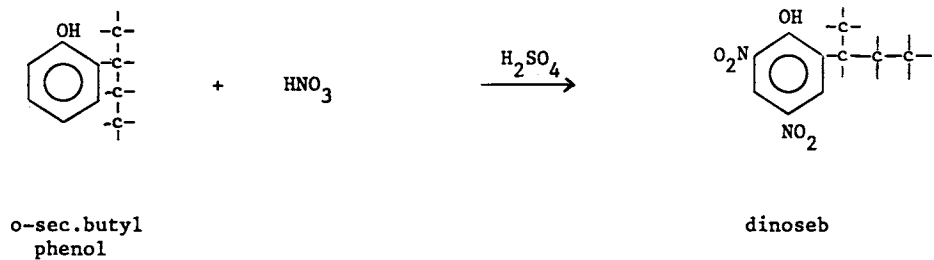
## Dinoseb

Uses: herbicide for soya, maize, pear, beans, onion, orchards

Trade names: Premerge (Dow), Gebutox, Caldon, Subitex (Hoechst), Basanite (BASF)

Type: dinitrophenol

Synthesis:



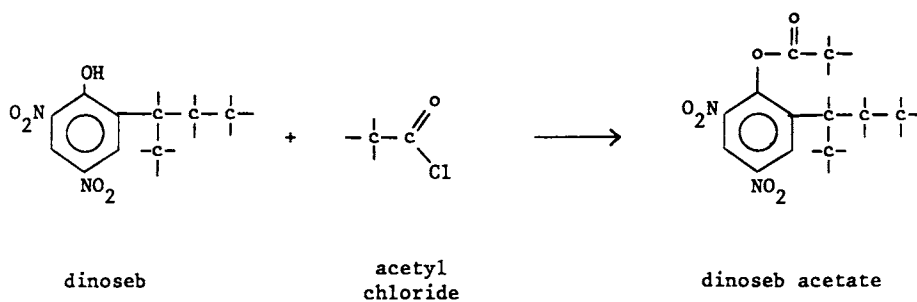
## Dinoseb-Acetate

Uses: herbicide, maize, sorghum, potatoes, onions

Trade names: Aretit, Ivosit (Hoechst), Phenotan (Rhône Poulenc)

Type: dinitrophenol

Synthesis:



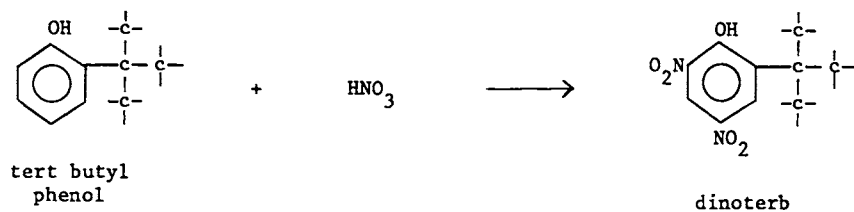
## Dinoterb

Uses: herbicide, cereals, maize

Trade names: Herbogil (Rhône Poulenc)

Type: dinitrophenol

Synthesis:



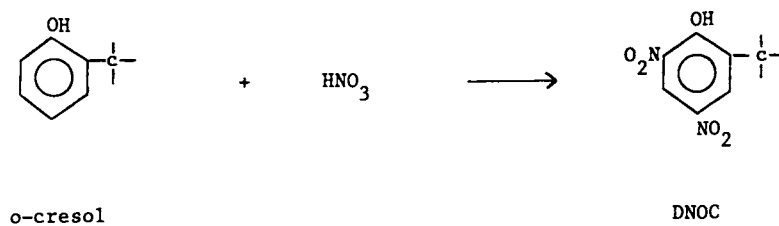
## DNOC

Uses: herbicide, fruit trees, cereals

Trade names: Antinnonin (Bayer)

Type: dinitrophenol

Synthesis:

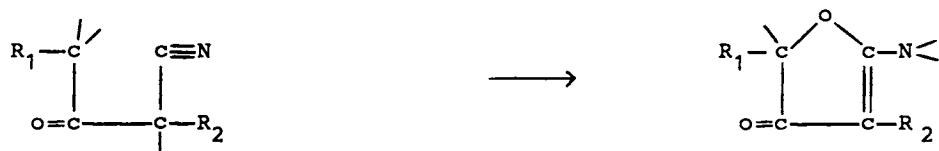


# FURANS FURANONES HYDROFURANS

The furan ring is synthesized by reaction between aceto acetic acid (or acetamide) and a compound with adjacent hydroxy carbonyl groups



Cyclisation of a keto nitrile in presence of a halogen and an acid leads to an amino furanone



Hydrofurans are obtained by different routes, the cyclisation of a butenediol or butenol-ether being a common one :



$\text{R}_3 = \text{H}$  or methyl



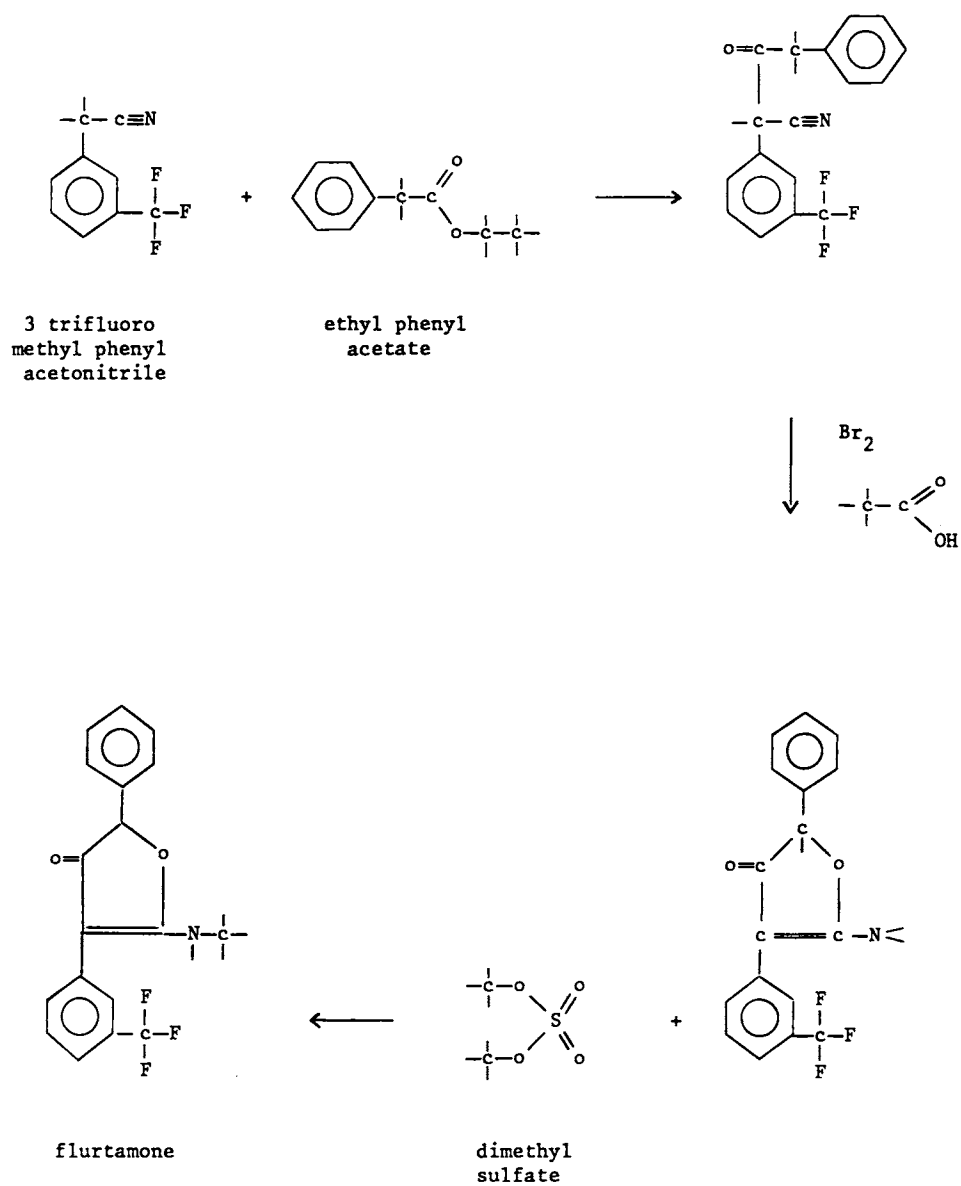
## Flurtamone

Uses: herbicide, cotton, peanuts, sorghum, sunflowers

Trade names: Benchmark (Chevron)

Type: furanone

Synthesis:



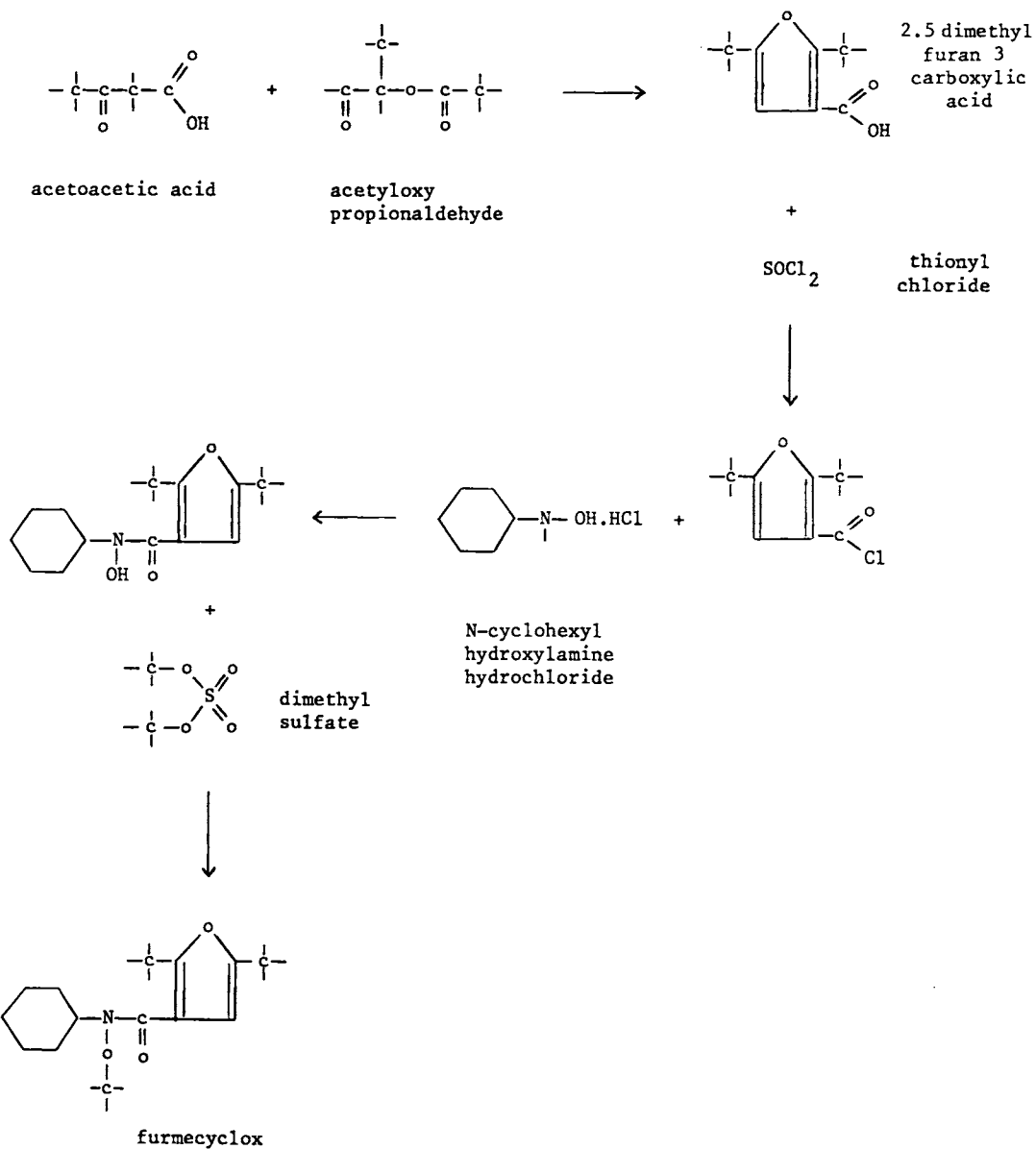
## Furmecyclox

Uses: fungicide, cereals, cotton, potatoes

Trade names: Campogran, Xyligen (BASF)

Type: furan, carboxamide

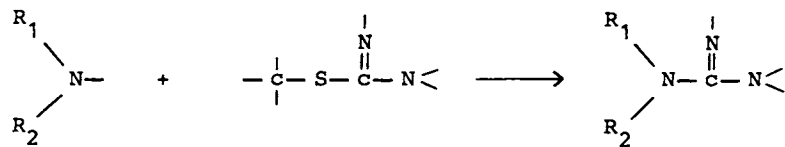
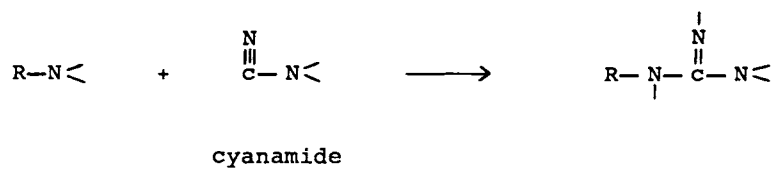
Synthesis:





# GUANIDINES

Guanidines are obtained by reaction between an amine and cyanamide or a pseudo thio urea



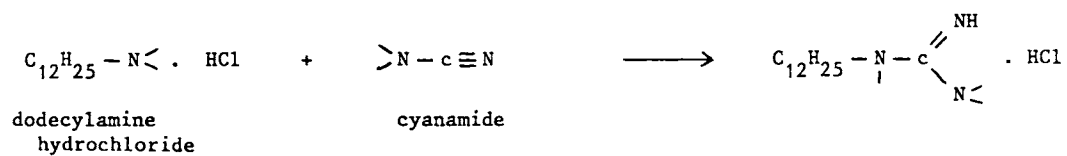
## Dodine

Uses: fungicide, fruits, vegetables, trees

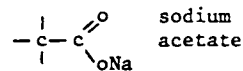
Trade names: Cyprex, Melprex (Cyanamid)

Type: guanidine

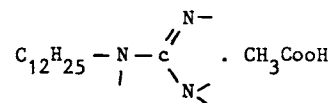
Synthesis:



+



↓



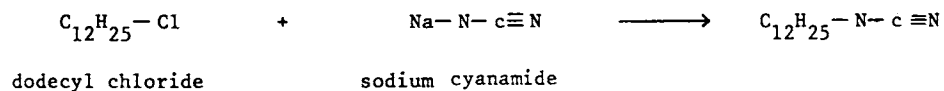
dodine

↑

$\text{NH}_3$

+

alternate route:



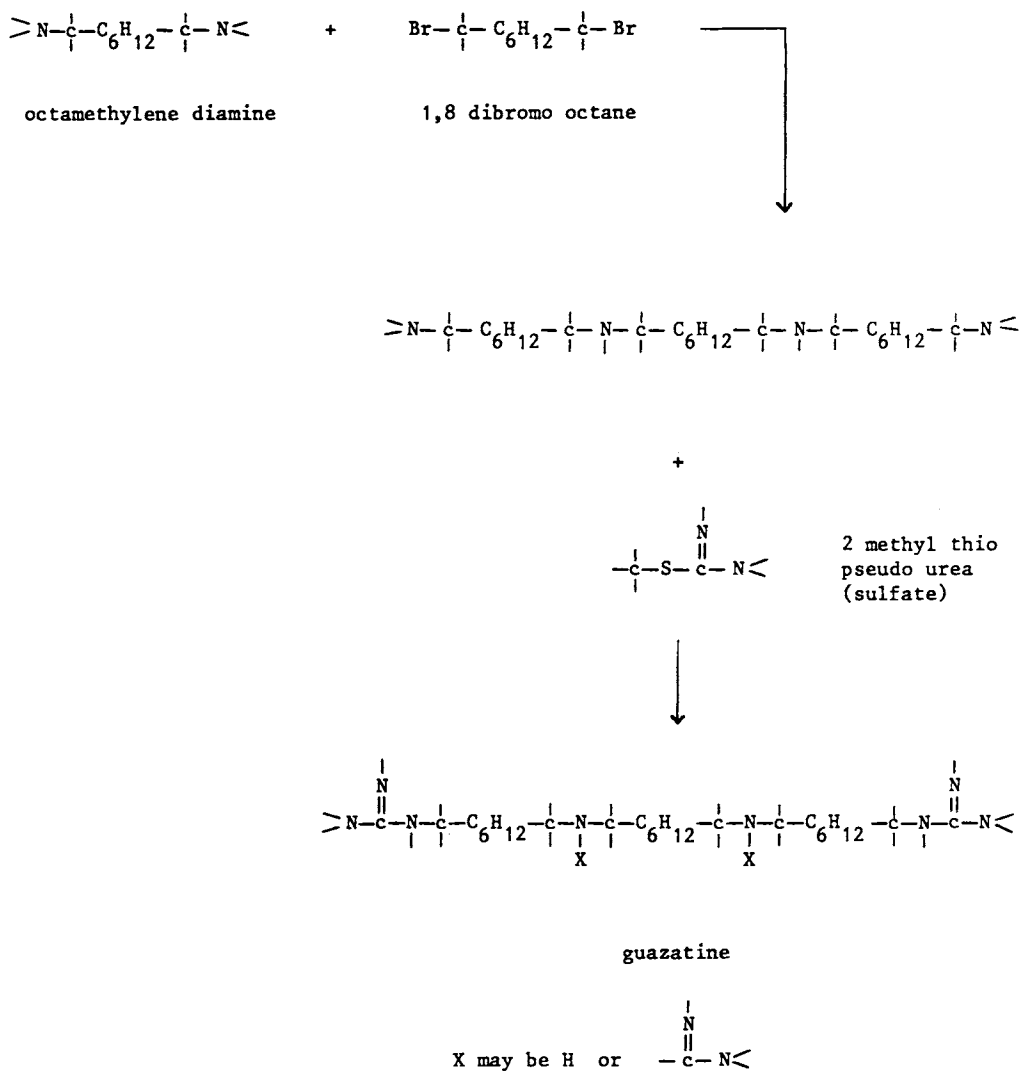
## Guazatine

Uses: fungicide, cereal seeds, potato seeds, cotton, rice, wood,  
citrus, sugar cane

Trade names: Parroctine (Rhône Poulenc)

Type: guanidine

Synthesis:



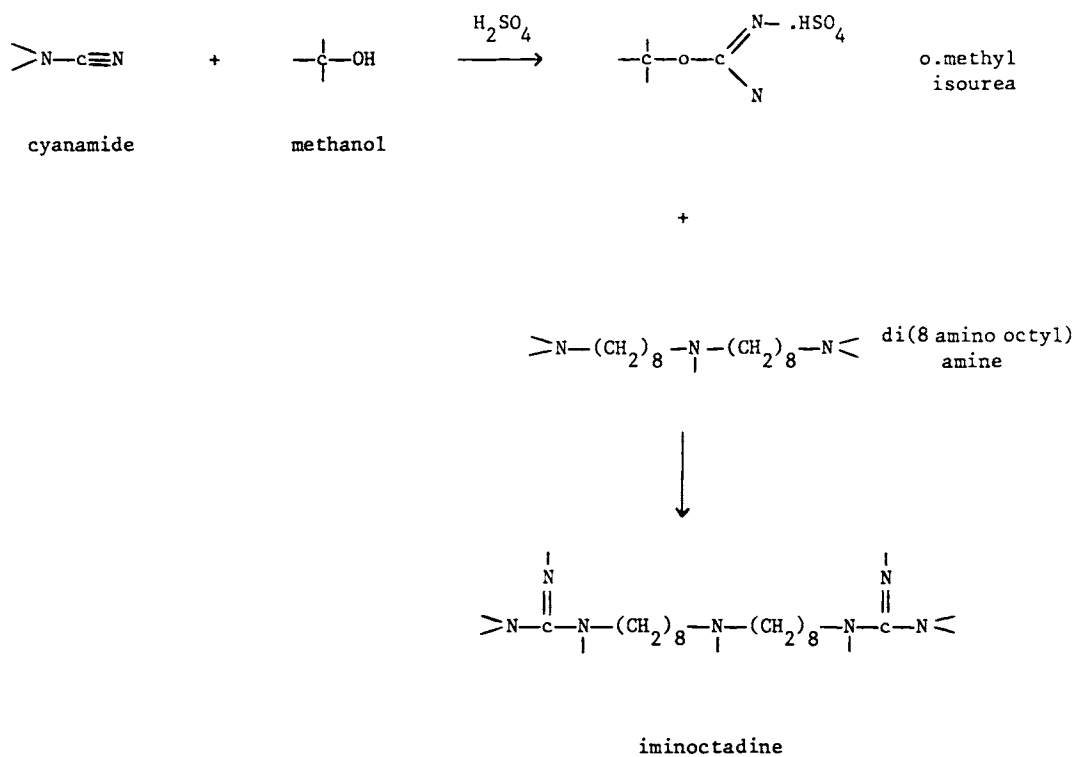
## Iminoctadine

Uses: fungicide, cereals, citrus

Trade names: Betran (Dainippon)

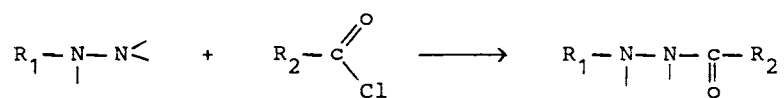
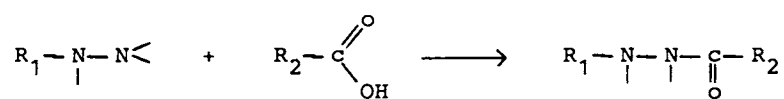
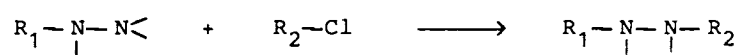
Type: guanidine

**Synthesis:**



# HYDRAZIDES

Hydrazides are generally obtained by the reaction between a hydrazine and an active halogen particularly acid halides, an acid or anhydride.



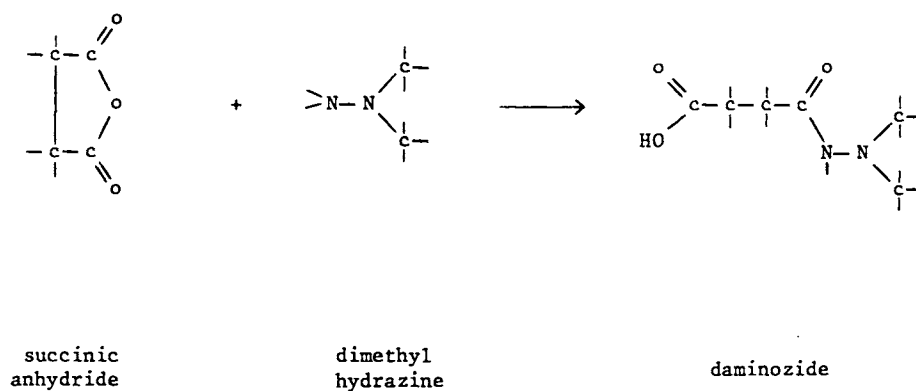
## Daminozide

Uses: growth regulator, ornamentals

Trade names: Alar, B-Nine (Uniroyal)

Type: hydrazide carboxylic acid

Synthesis:



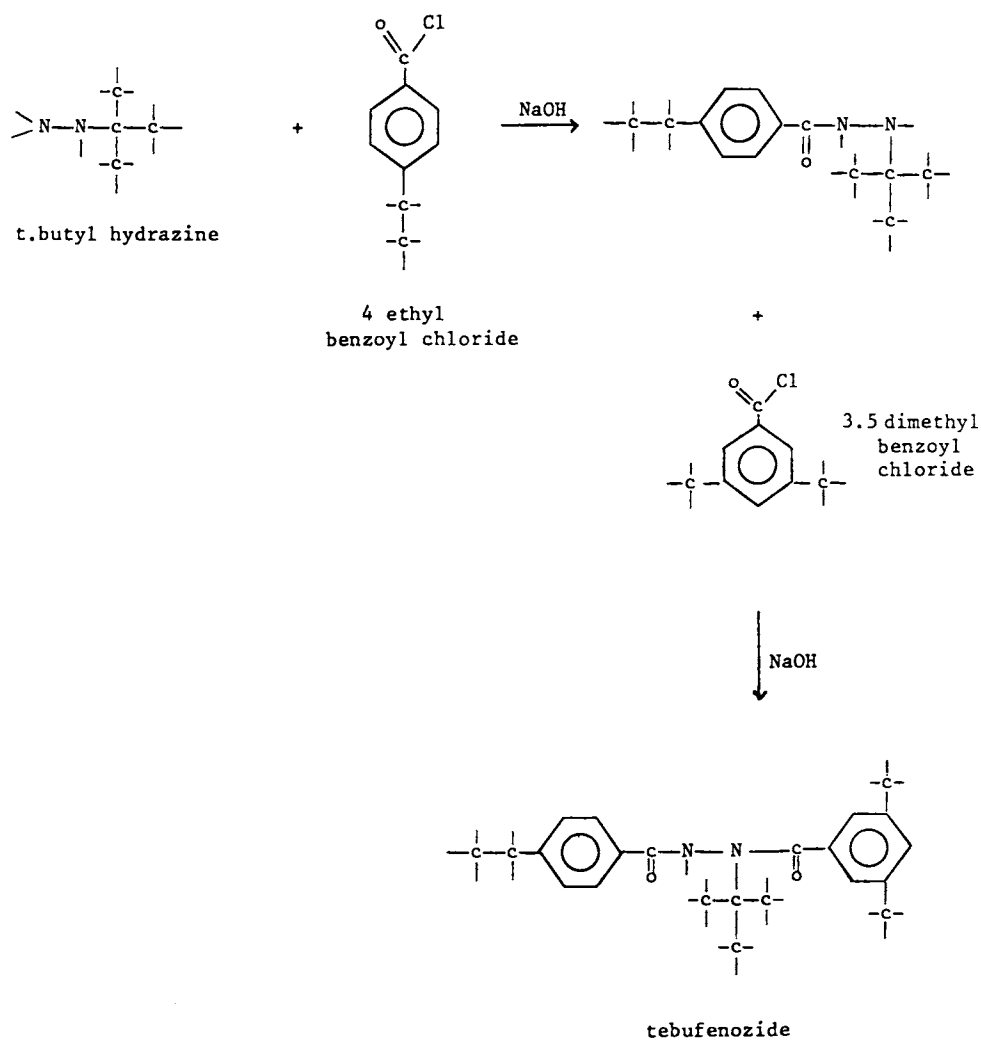
## Tebufenozide

Uses: insecticide, rice, fruit, nuts, vegetables, vines

Trade names: Mimic (Rohn & Haas)

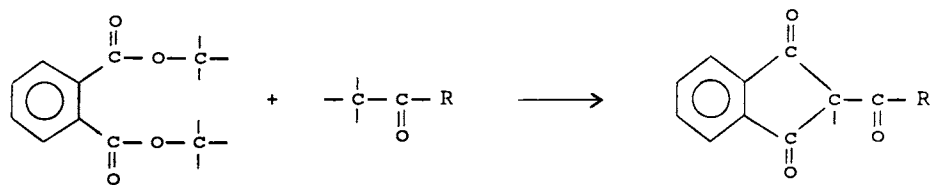
Type: hydrazide (amide)

Synthesis:

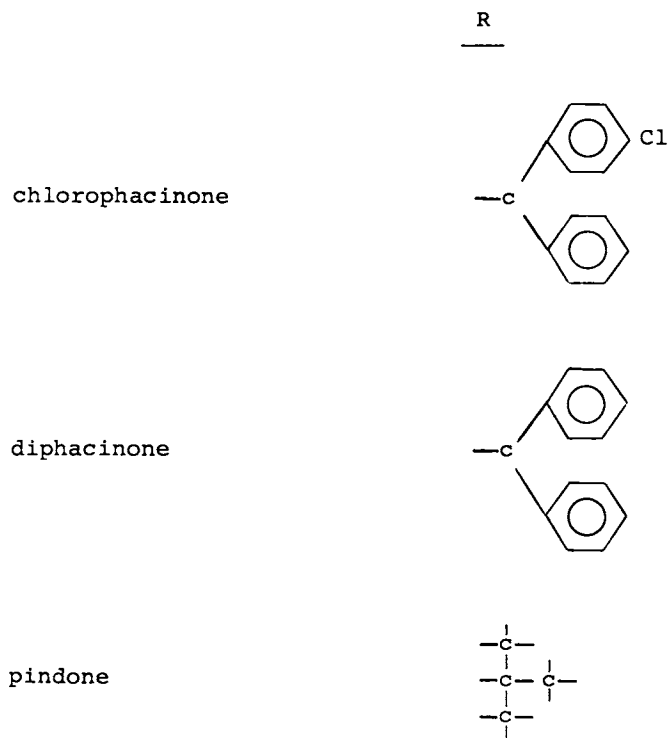


## INDANEDIONES

Indanediones are obtained by cyclization of diethyl or dimethylphthalate with a ketone



The main Indanedione pesticides are





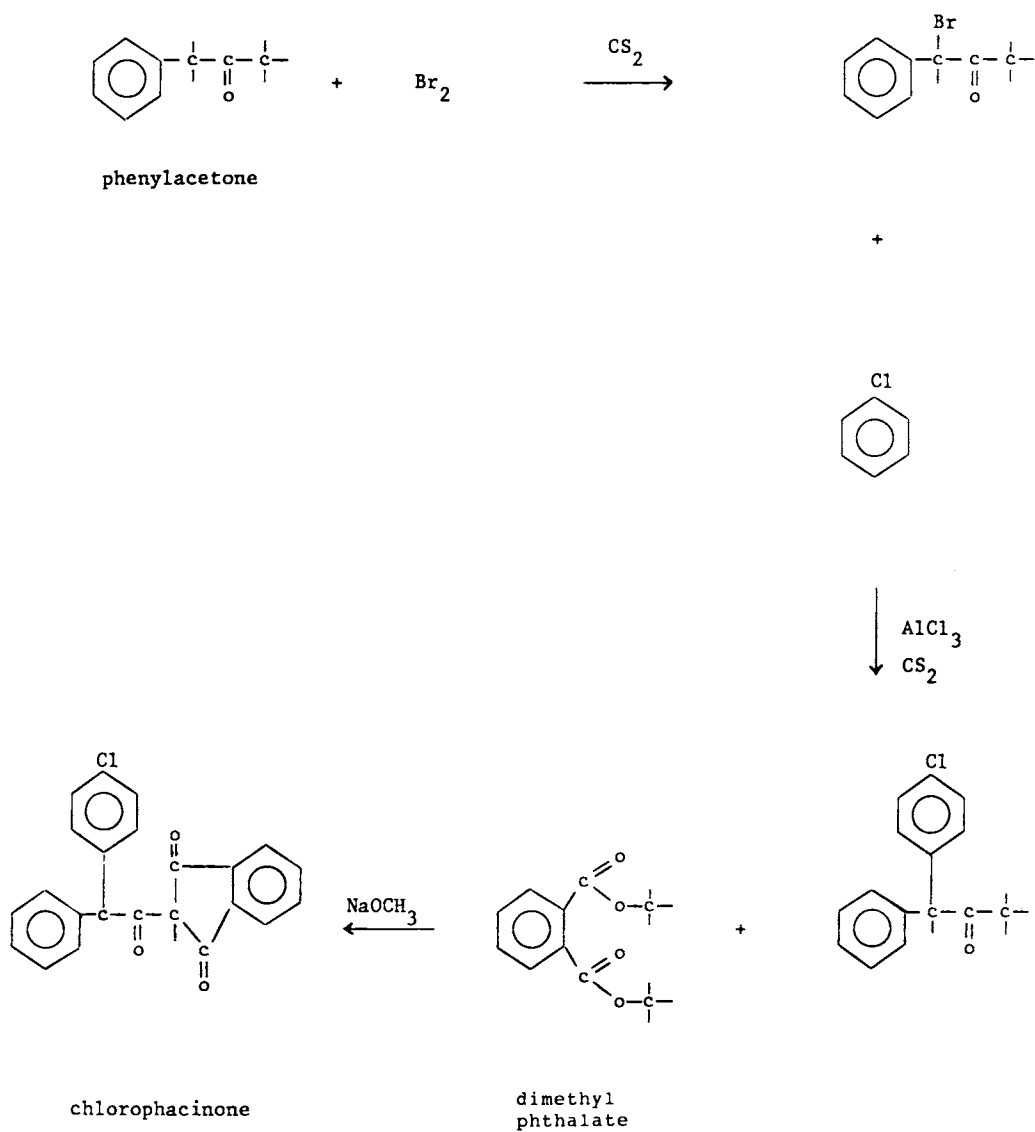
## Chlorophacinone

Uses: rodenticide

Trade names: Drat, Quick (Rhône Poulenc), Caid, Liphadione, Roviac (Lipha)

Type: indanedione

Synthesis:



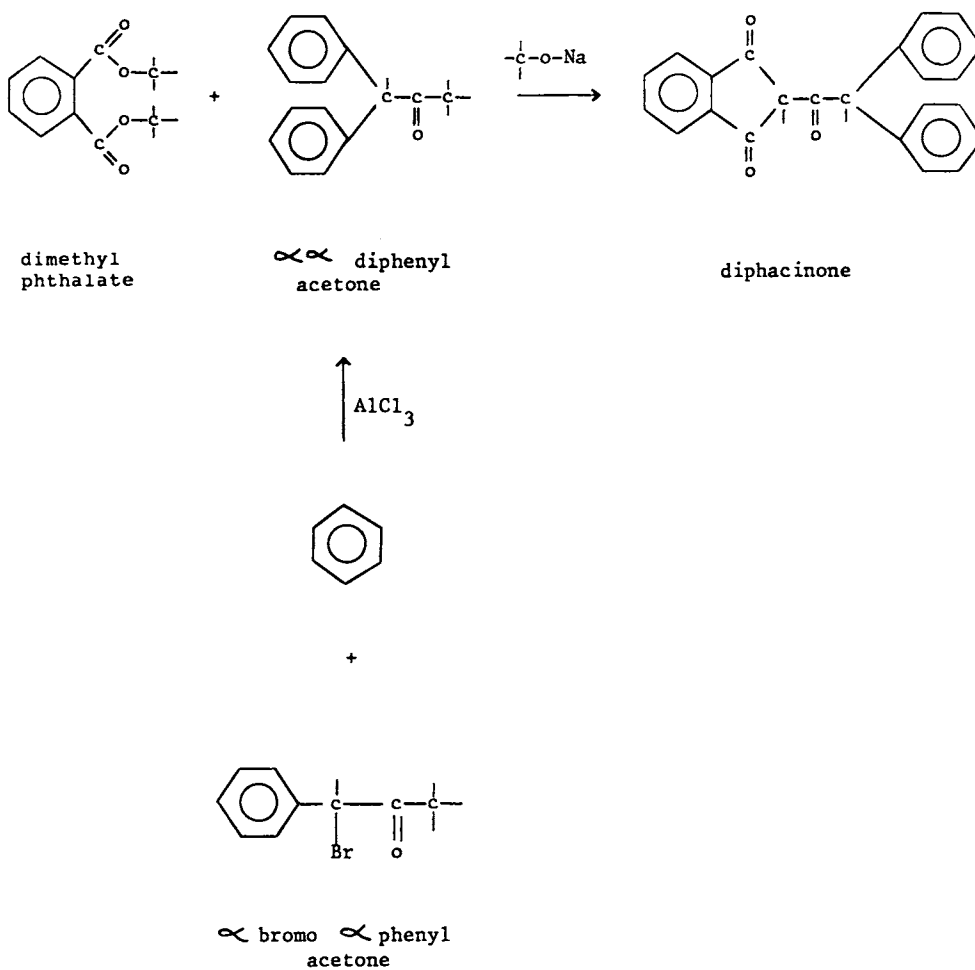
## Diphacinone

Uses: rodenticide

Trade names: Diphacin, Ramita (Sandoz)

Type: indanedione

Synthesis:



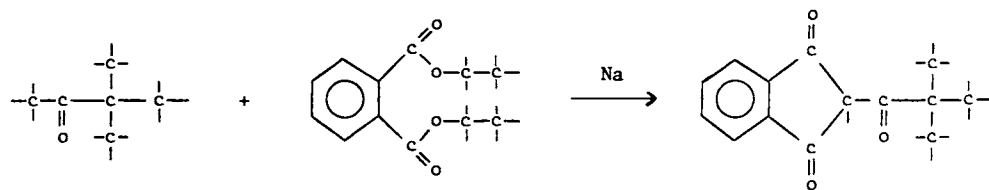
## Pindone

Uses: rodenticide

Trade names: Pival, Pivalyn (Motomco)

Type: indanedione

Synthesis:



methyl t.butyl  
ketone  
pinacolone

diethyl  
phthalate

pindone

## PHENYL-ETHERS

The synthesis consists in the reaction



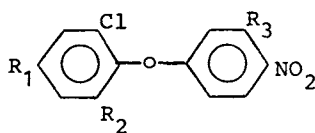
in presence of an alkali.

Sometimes bromine is used instead of chlorine, and the sodium or potassium salt may be used instead of OH.

The phenyl ether formation is always one of the last steps of the synthesis, the benzene rings being first subjected to nitration, chlorination, carboxylation, etc.

Nearly always the phenyl groups contain attached  $\text{NO}_2$  and Cl radicals, and often acid, ester or  $\text{CF}_3$ .

Nearly all products in this class have a structure



$R_1$   
—

$CF_3$	acifluorfen, fluoroglycofen, fomesafen, lactofen, oxyfluorfen
Cl	bifenox, chlomethoxifen, chlornitrofen, fluoronitrofen, nitrofen

$R_2$   
—

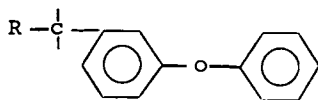
H	acifluorfen, aclonifen, bifenox, chlomethoxyfen, fluoroglycofen, fomesafen, lactofen, nitrofen, oxyfluorfen
Cl	chlornitrofen
F	fluoronitrofen

$R_3$   
—

COOH	or ester, acifluorfen, bifenox, fluoroglycofen, fomesafen, lactofen
o-R	chlomethoxyfen, oxyfluorfen
N	aconifen
H	chlornitrofen, fluoronitrofen, nitrofen

All these phenyl ethers are herbicides.

Etofenprox which has a structure



derived from m.phenoxy benzyl alcohol, a pyrethroid precursor has an insecticide activity.

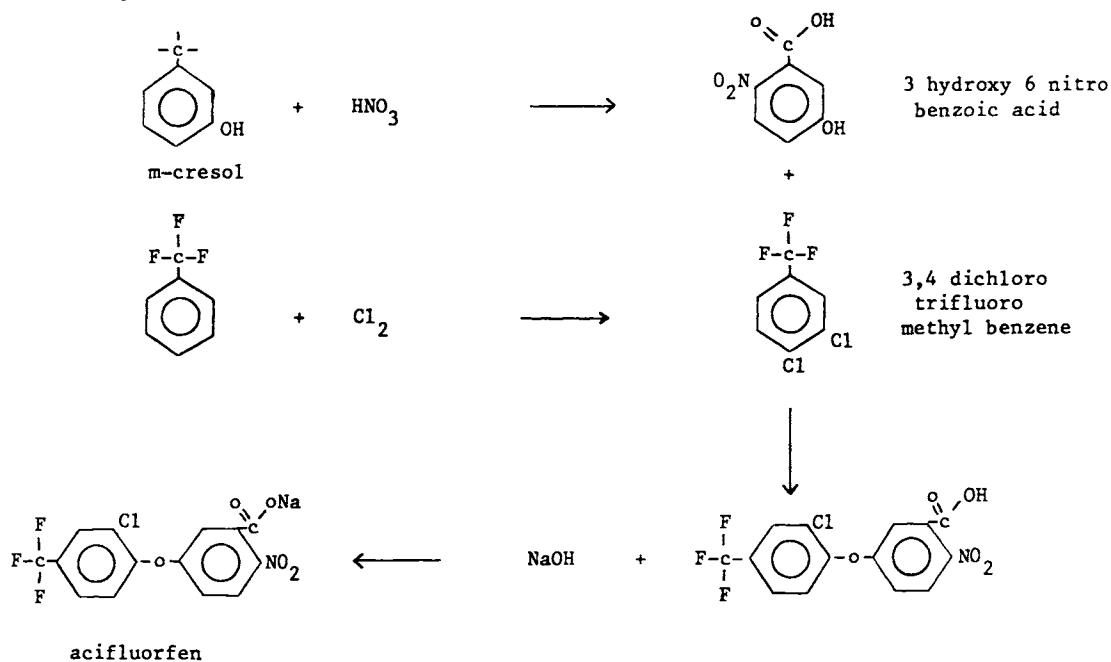
## Acifluorfen

Uses: herbicide, peanuts, rice, soyabeans

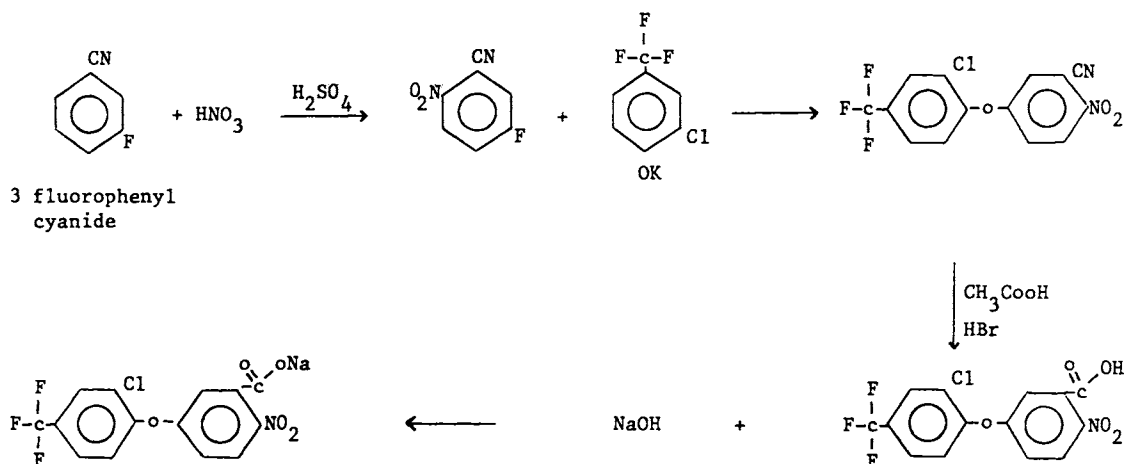
Trade names: Tackle (Rhone Poulenc), Blazer (BASF)

Type: phenyl ether

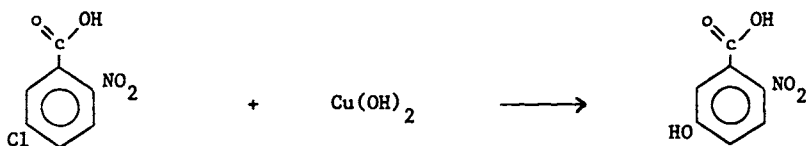
### Synthesis:



### alternate routes :

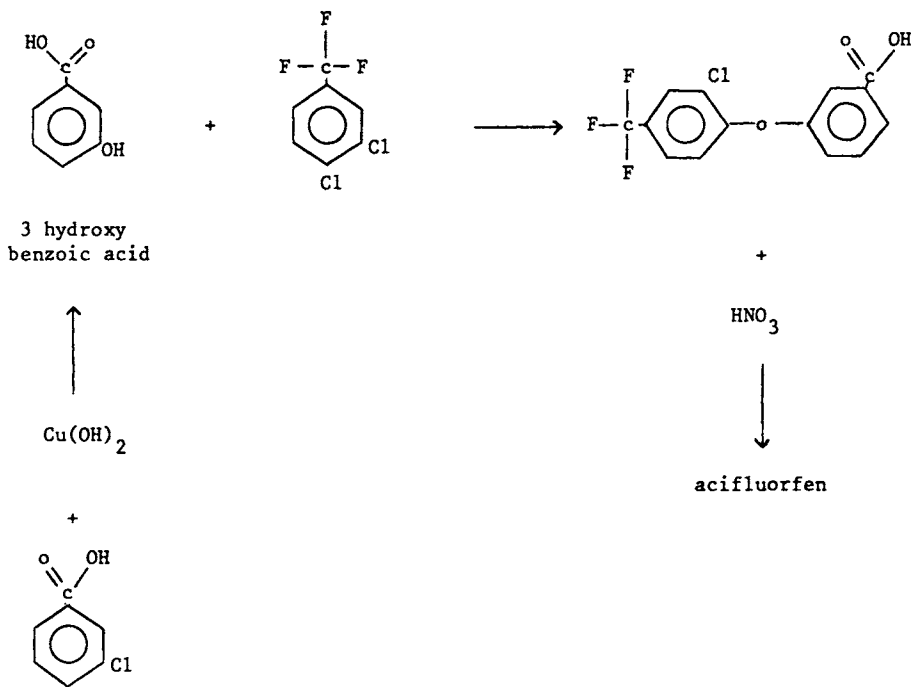


preparation of 3 hydroxy 6 nitrobenzoic acid



3 chloro 6 nitro  
benzoic acid  
(see bifenox)

alternate route:



3 chloro benzoic acid

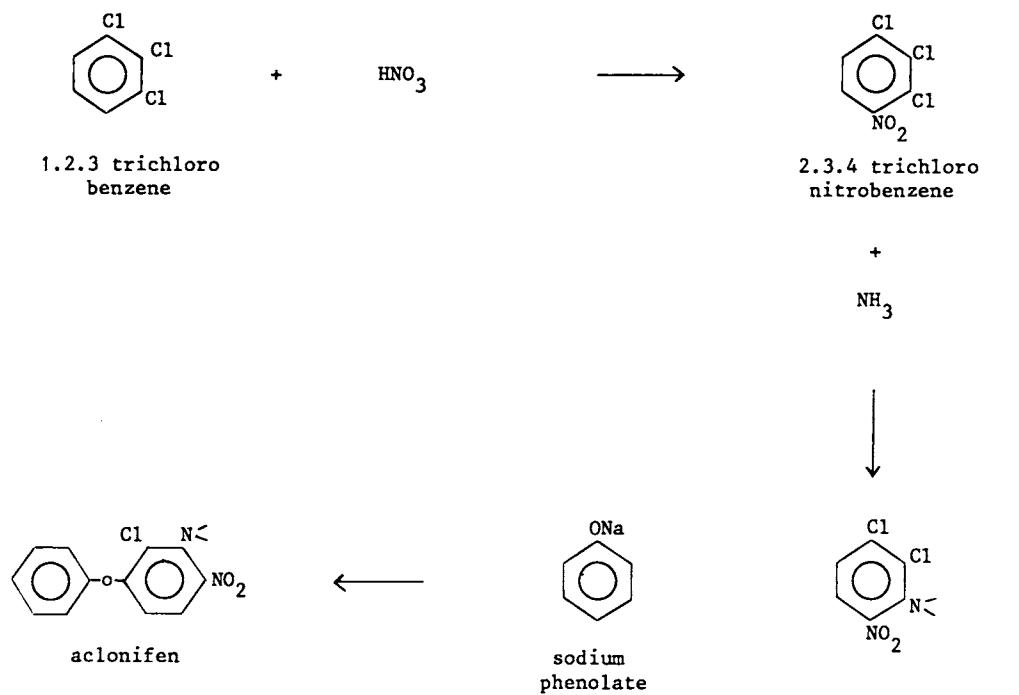
## Aclonifen

Uses: herbicide, potatoes, sunflower, wheat

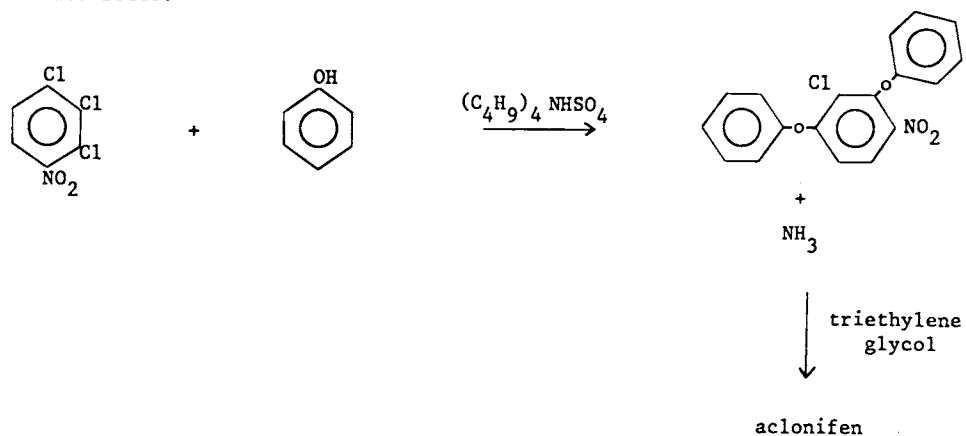
Trade names: Bandren, Bandur (Rhône Poulenc)

Type: phenyl ether

Synthesis:

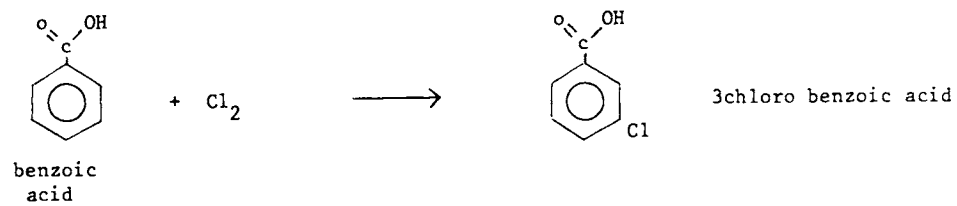


alternate route:





alternate route



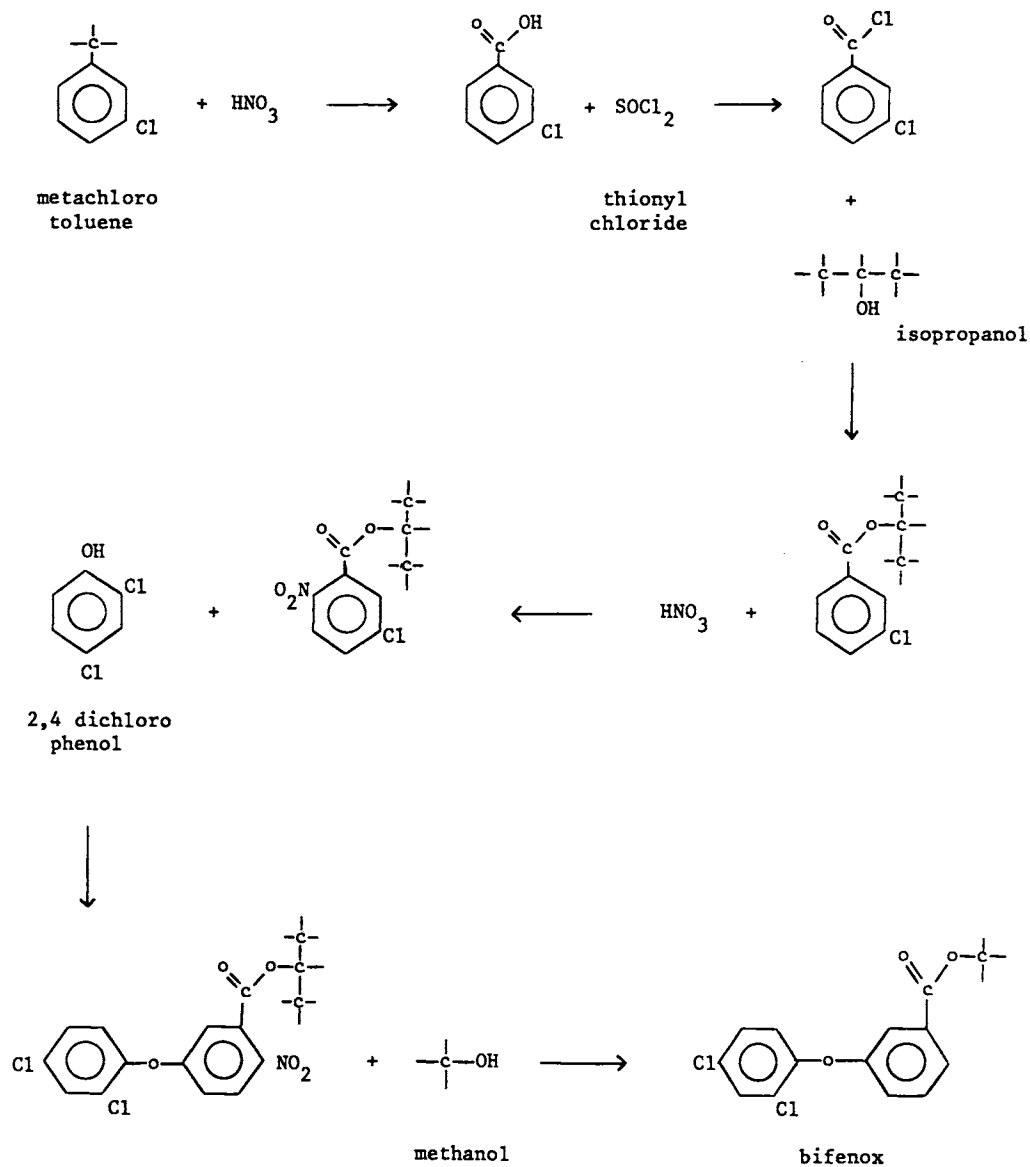
## Bifenox

Uses: herbicide, wheat, soyabeans, rice, sorghum, grain particularly wheat

Trade names: Modown (Rhône Poulenc)

Type: phenyl ether

### Synthesis:



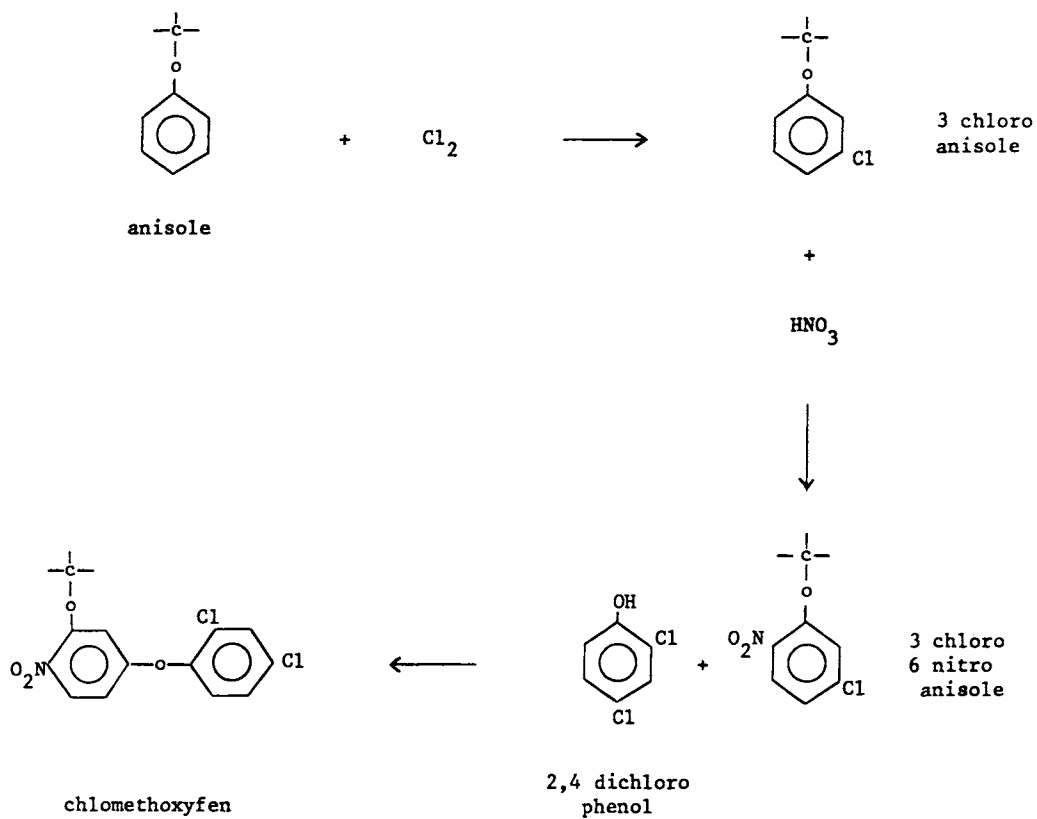
## Chlomethoxyfen

Uses: herbicide, rice

Trade names: Ekkusugoni (Nikon)

Type: phenyl ether

Synthesis:



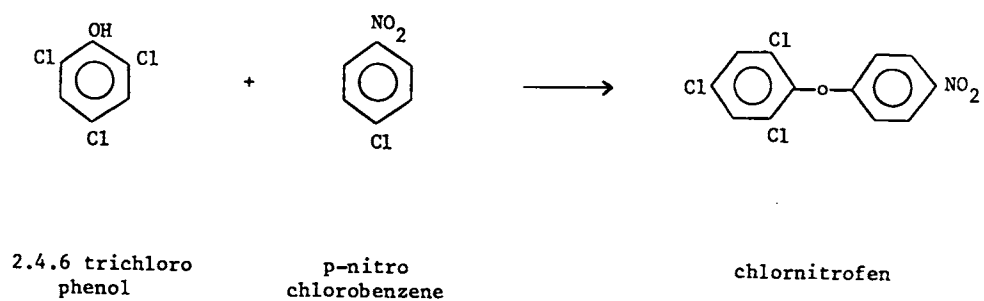
## Chlornitrofen

Uses: herbicide

Trade names: Mo (Mitsui)

Type: phenyl ether

Syntheses:



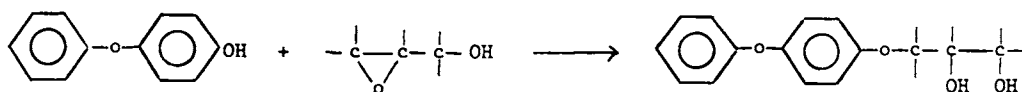
## Diofenolan

Uses: insecticide, citrus, fruit, olives, tea, ornamentals

Trade names: Aware (Ciba)

Type: phenyl ether

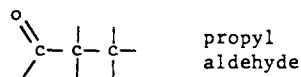
Synthesis:



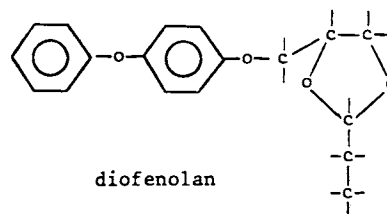
4 phenoxy phenol  
(4 hydroxy diphenyl  
ether)

1 hydroxy  
propylene  
oxide

+

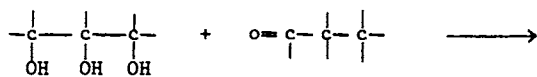


propyl  
aldehyde

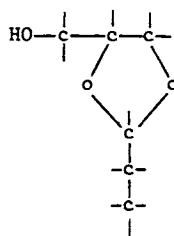


diofenolan

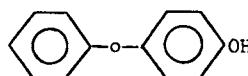
alternate route:



glycerine



+



diofenolan

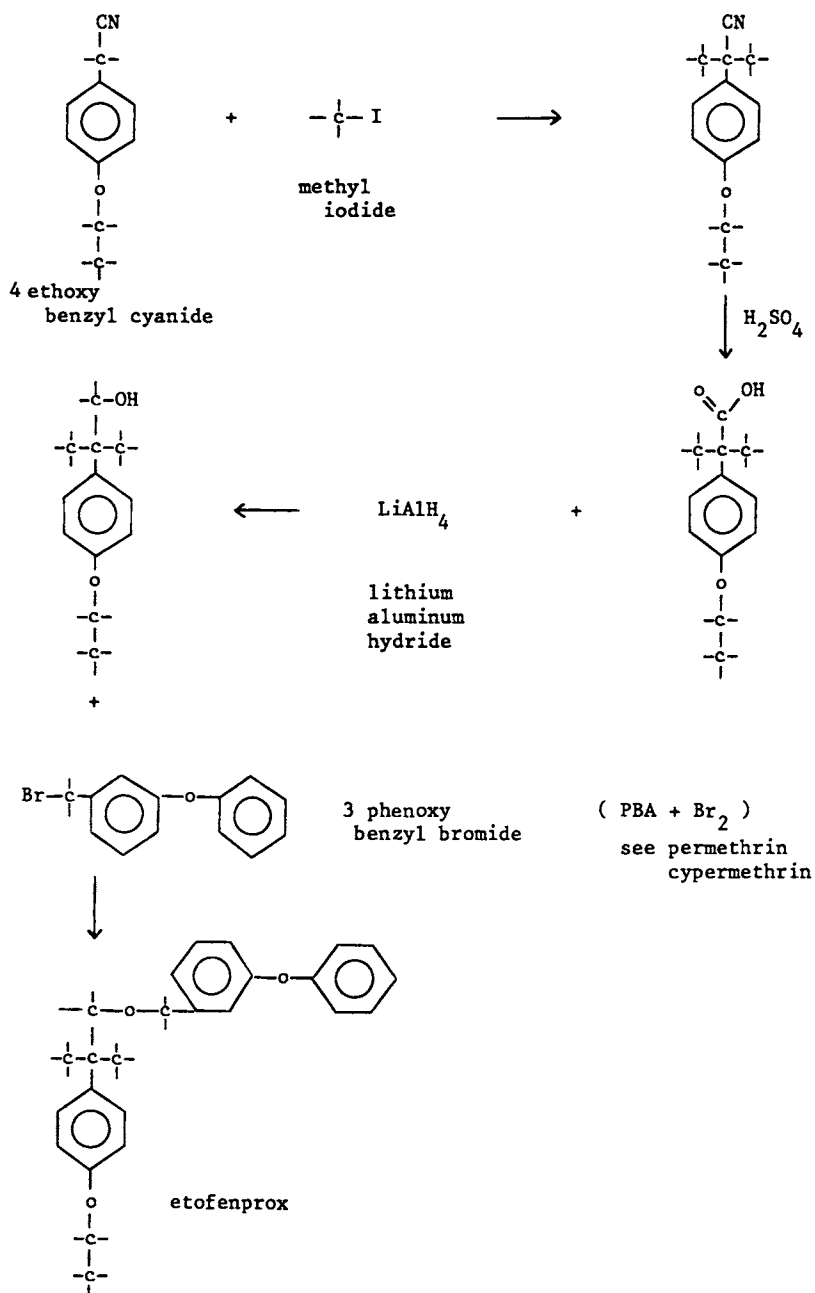
## Etofenprox

Uses: insecticide, cereals, rice, vegetables, tomatoes

Trade names: Trebon (Mitsui)

Type: phenyl ether

Synthesis:



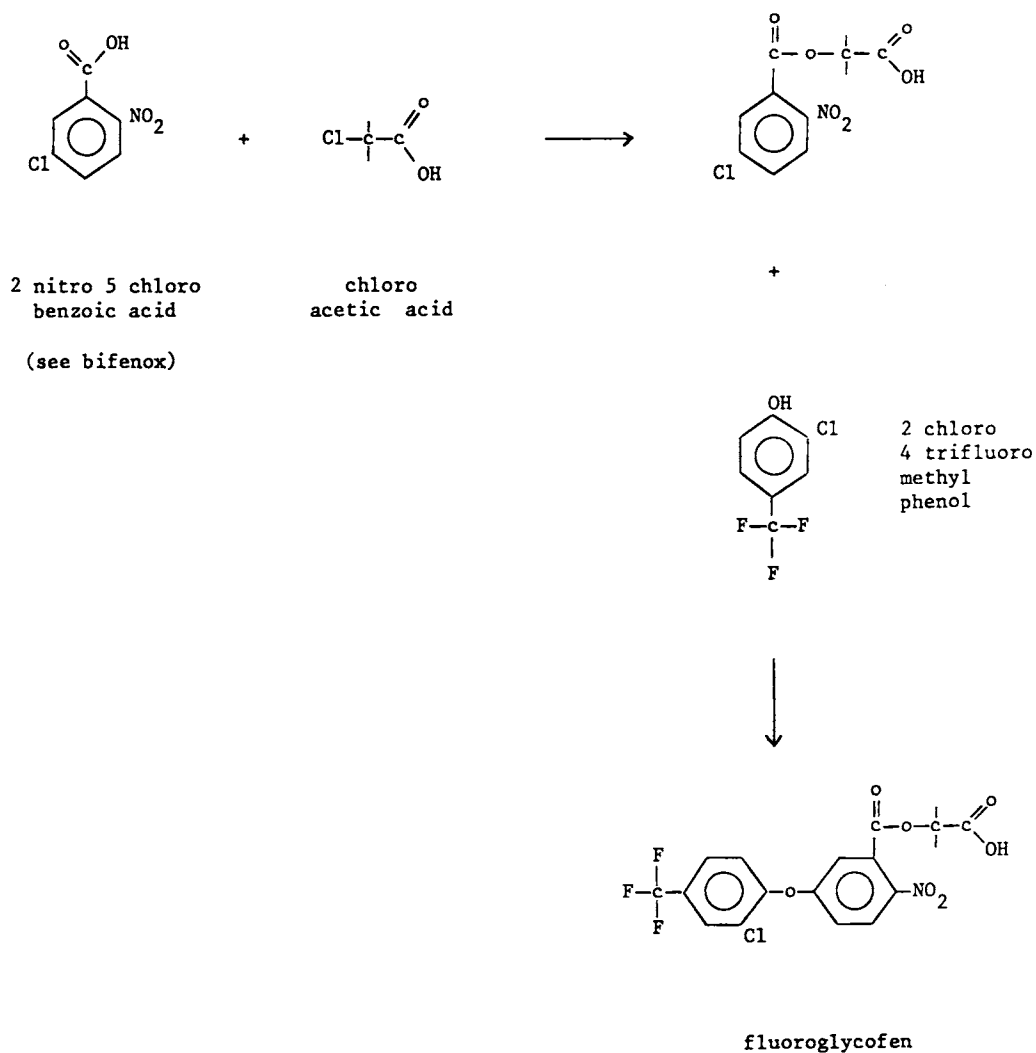
## Fluoroglycofen

Uses: herbicide, wheat, barley, peanuts, soyabeans, rice

Trade names: Compete (Rohm & Haas)

Type: phenyl ether

Synthesis:



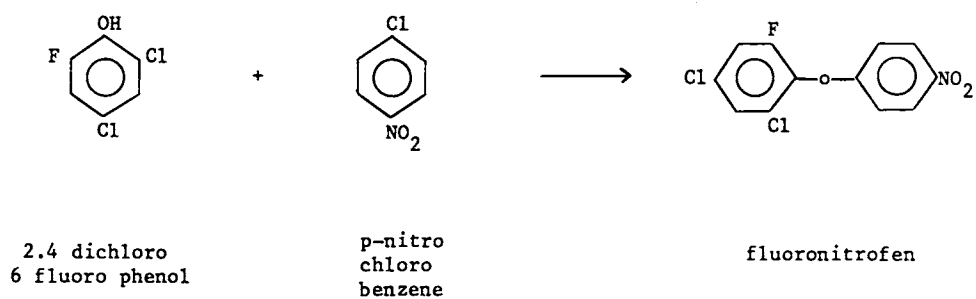
## Fluoronitrofen

Uses: herbicide

Trade names: Mo 500 (Mitsui)

Type: phenyl ether

Synthesis:





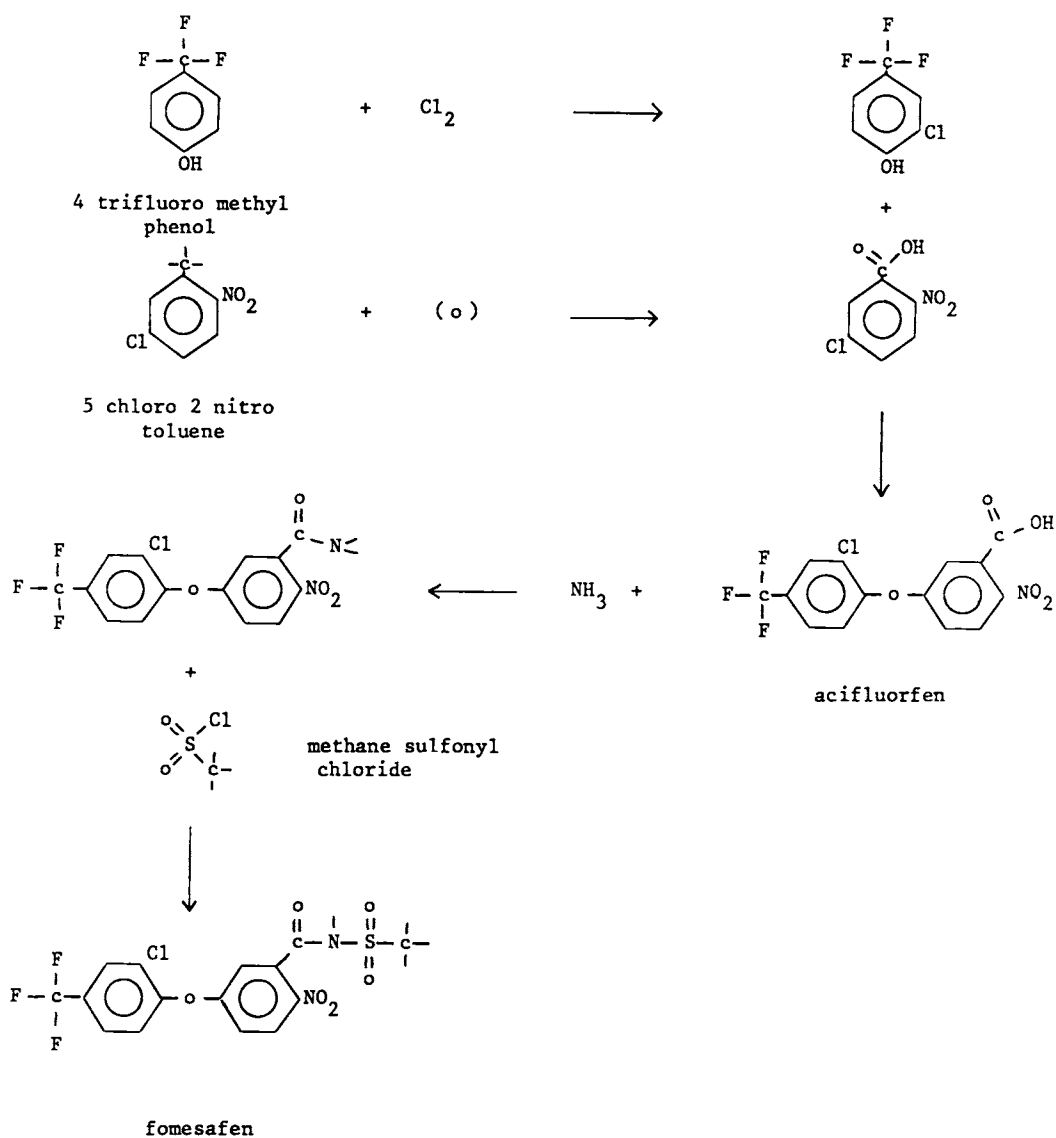
## Fomesafen

Uses: herbicide, soyabeans

Trade names: Flex, Reflex (ICI)

Type: phenyl ether

Synthesis:



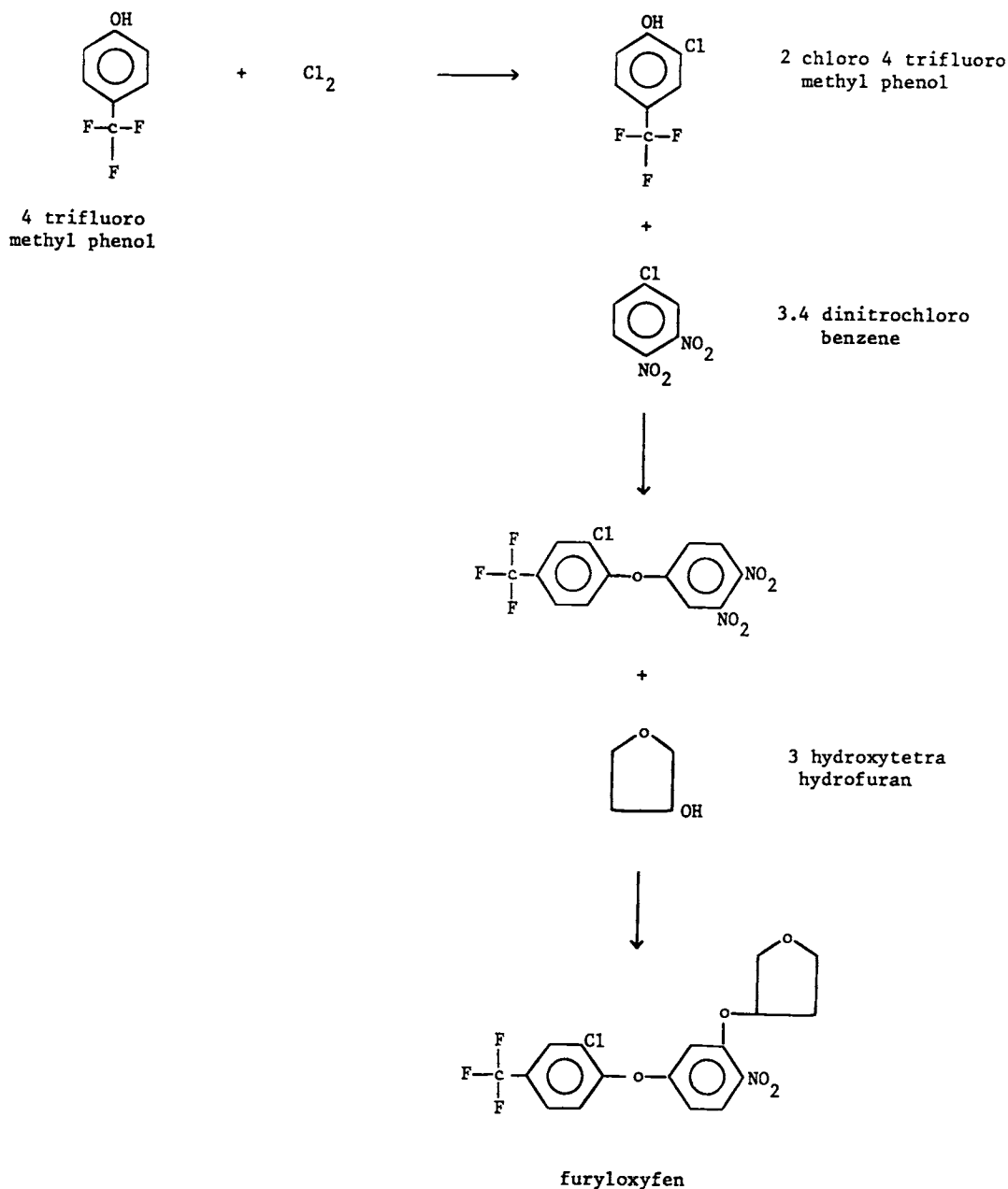
## Furyloxyfen

Uses: herbicide

Trade names: (Mitsui)

Type: phenyl ether, furan

Synthesis:



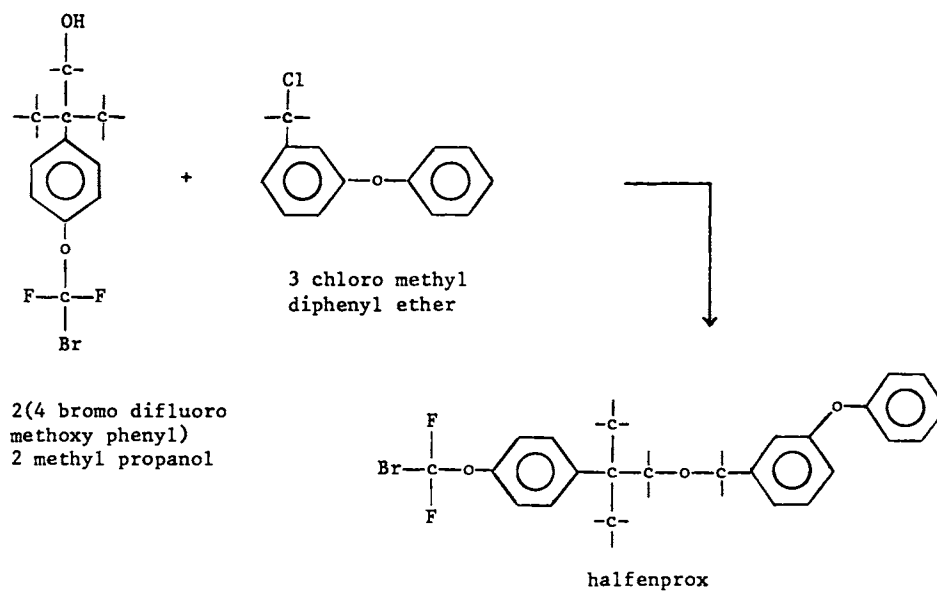
## Halfenprox

Uses: citrus, vines, fruit, vegetables, tea, ornamentals

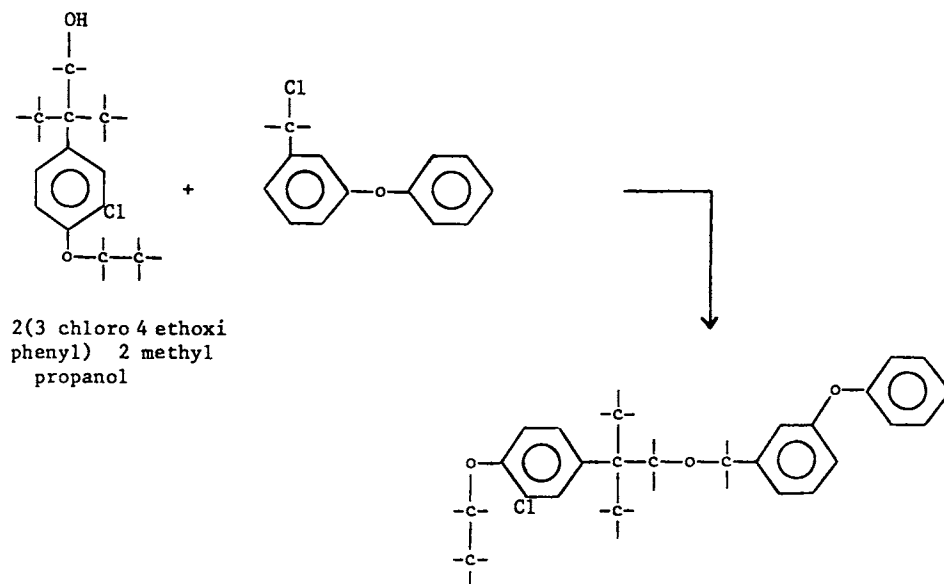
Trade names: Anniverse, Cyprene, Sirbon (Mitsui)

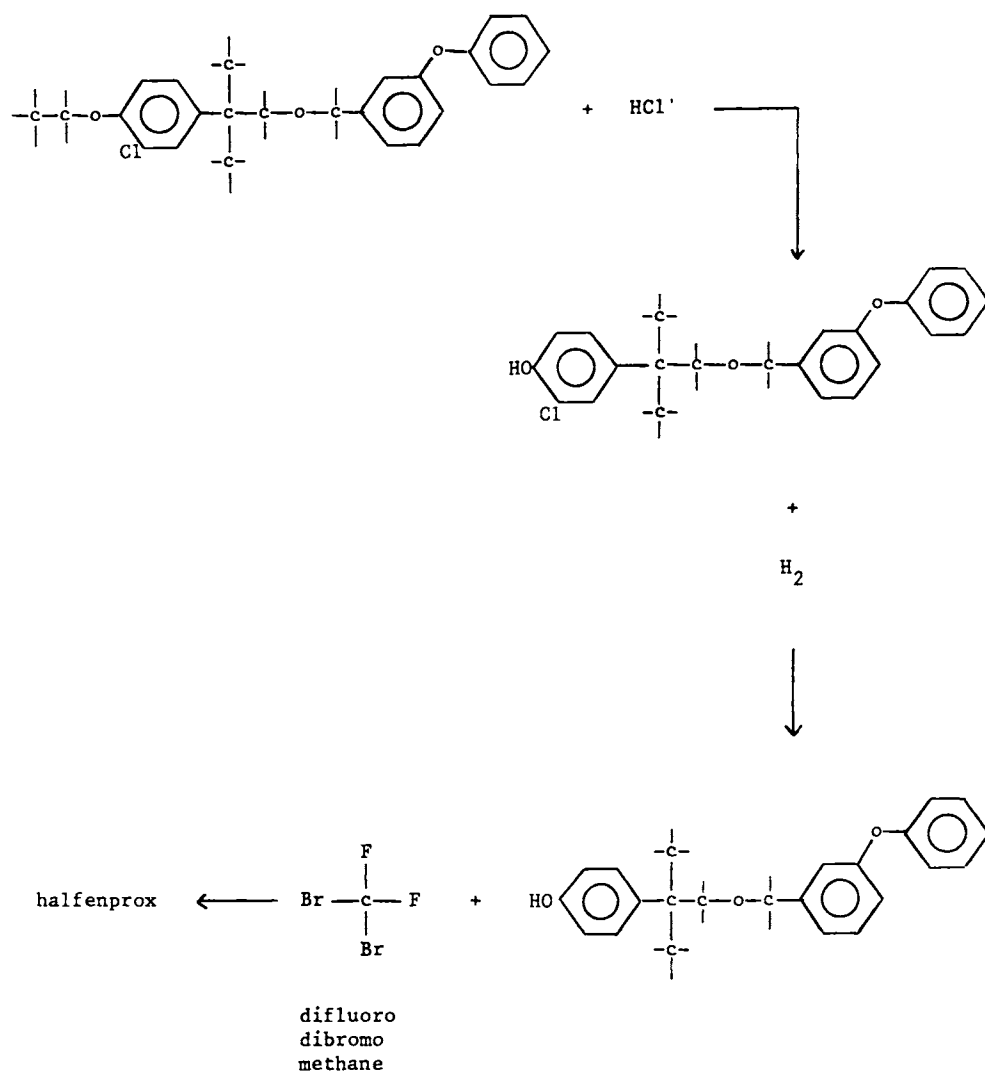
Type: phenyl ether

Synthesis:



alternate route :





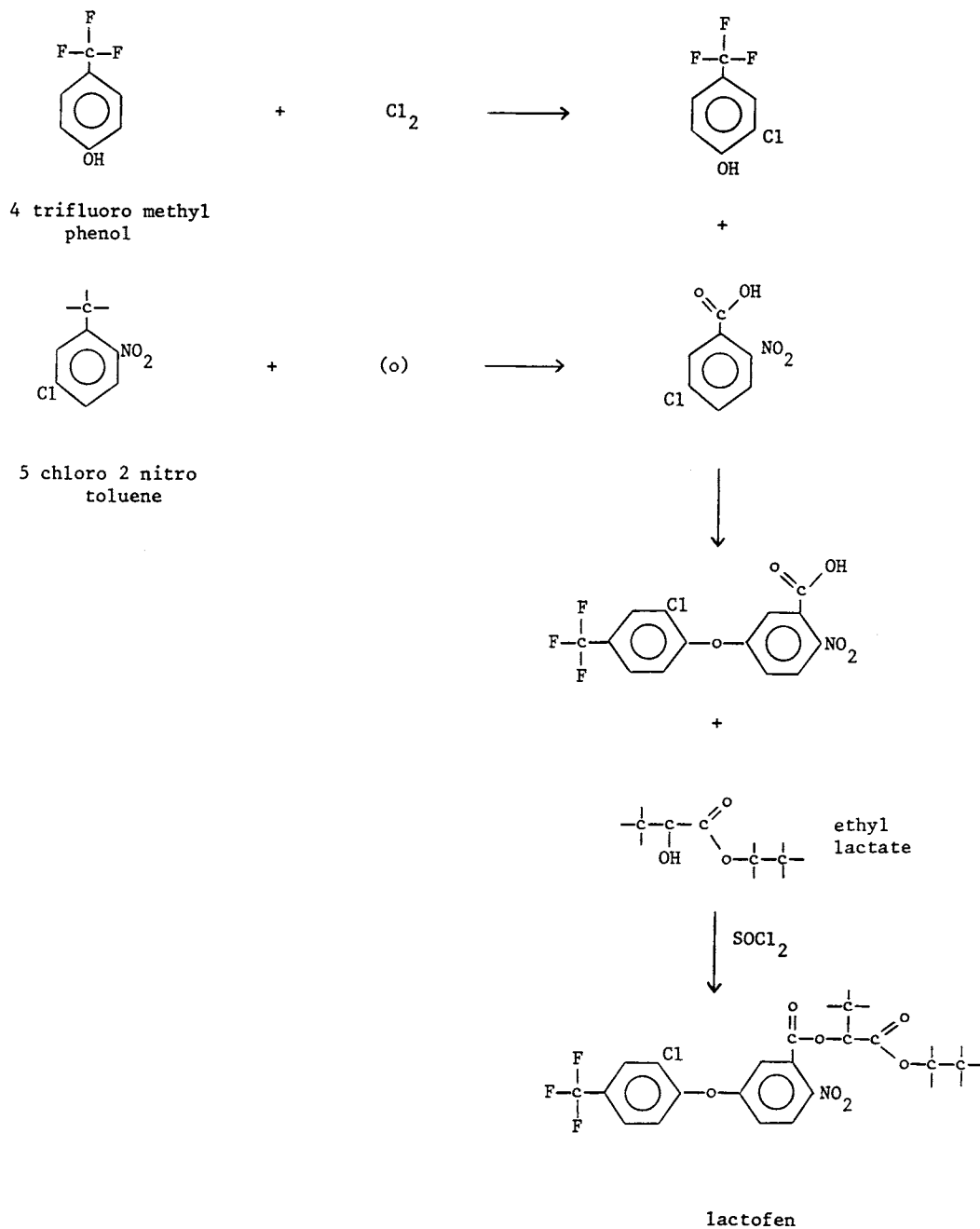
## Lactofen

Uses: herbicide

Trade names: Cobra (PP6)

Type: phenyl ether

Synthesis:



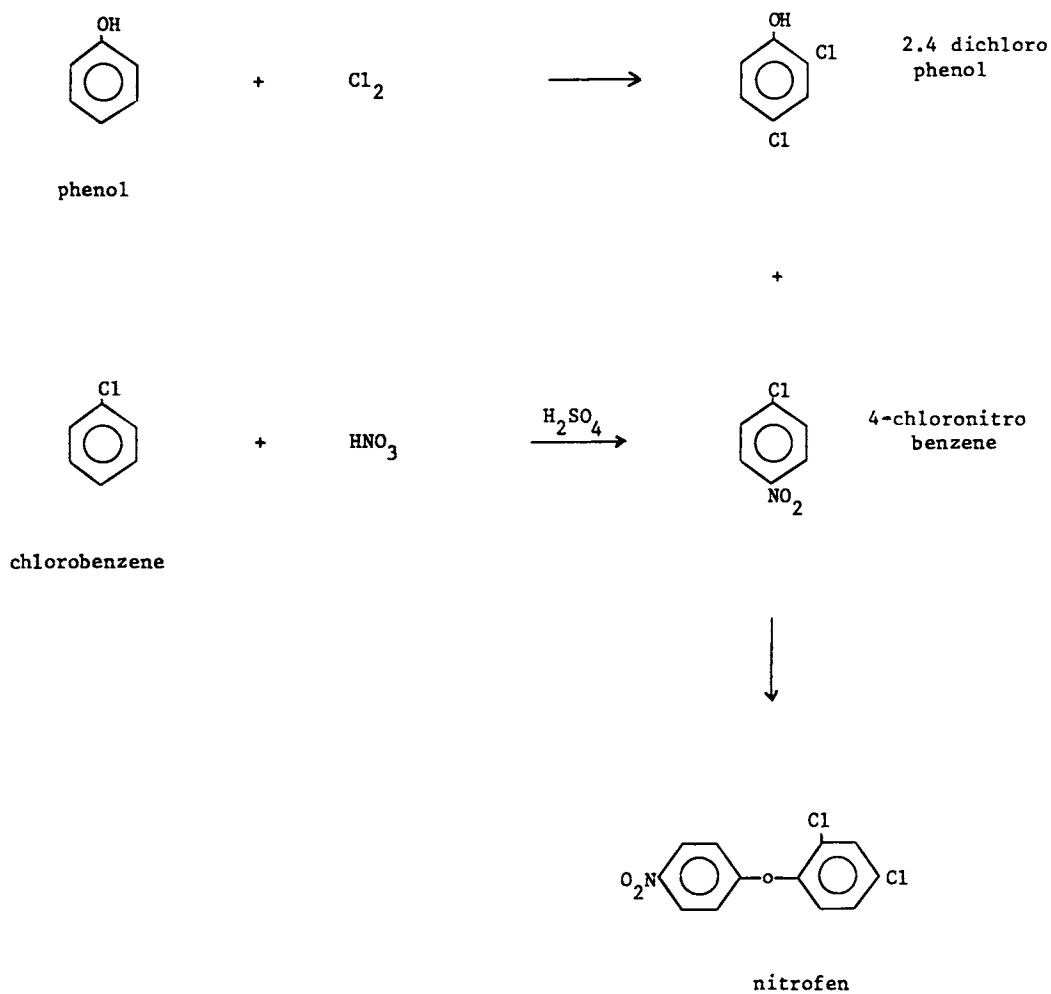
## Nitrofen

Uses: herbicide, rice, sugarbeet, cereals, vegetables

Trade names: Tok, Tokkorn (Rohm & Haas)

Type: phenyl ether

Synthesis:



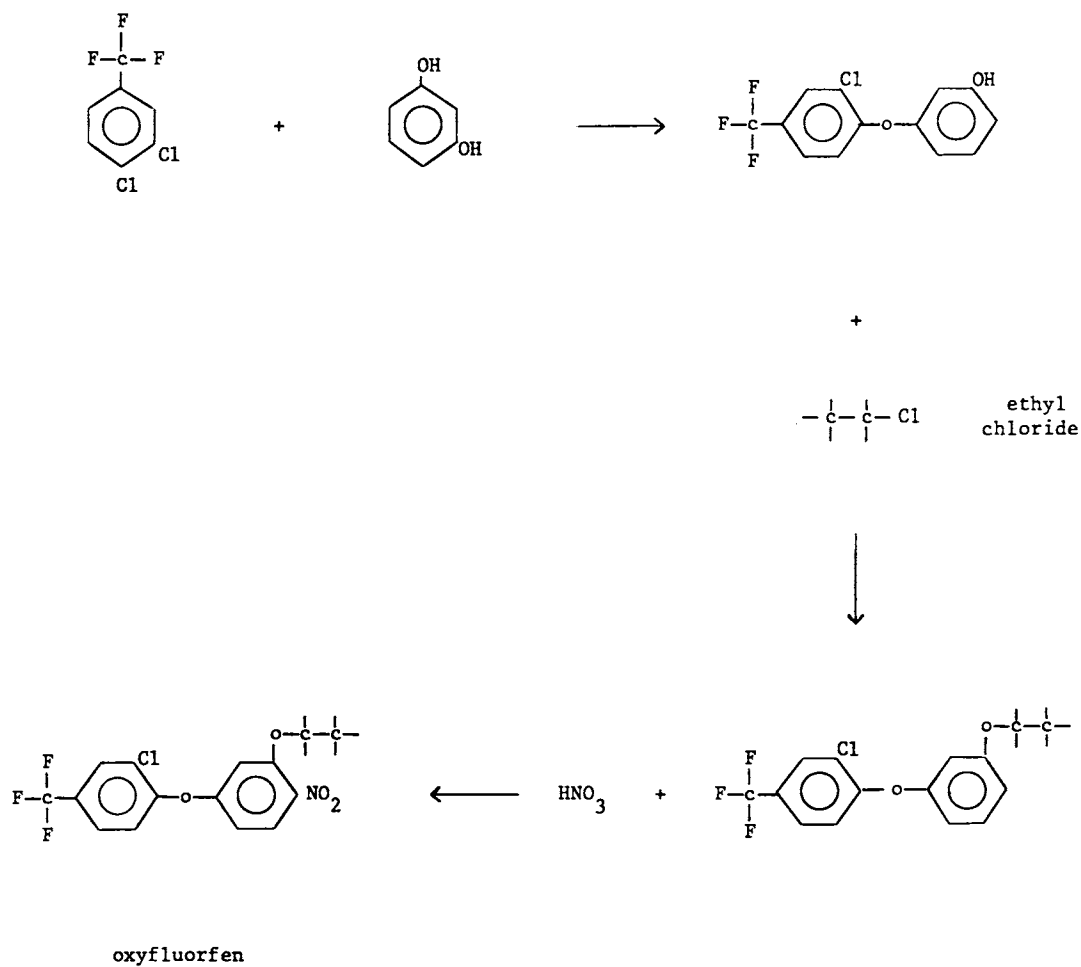
## Oxyfluorfen

Uses: herbicide, coffee, cotton, citrus

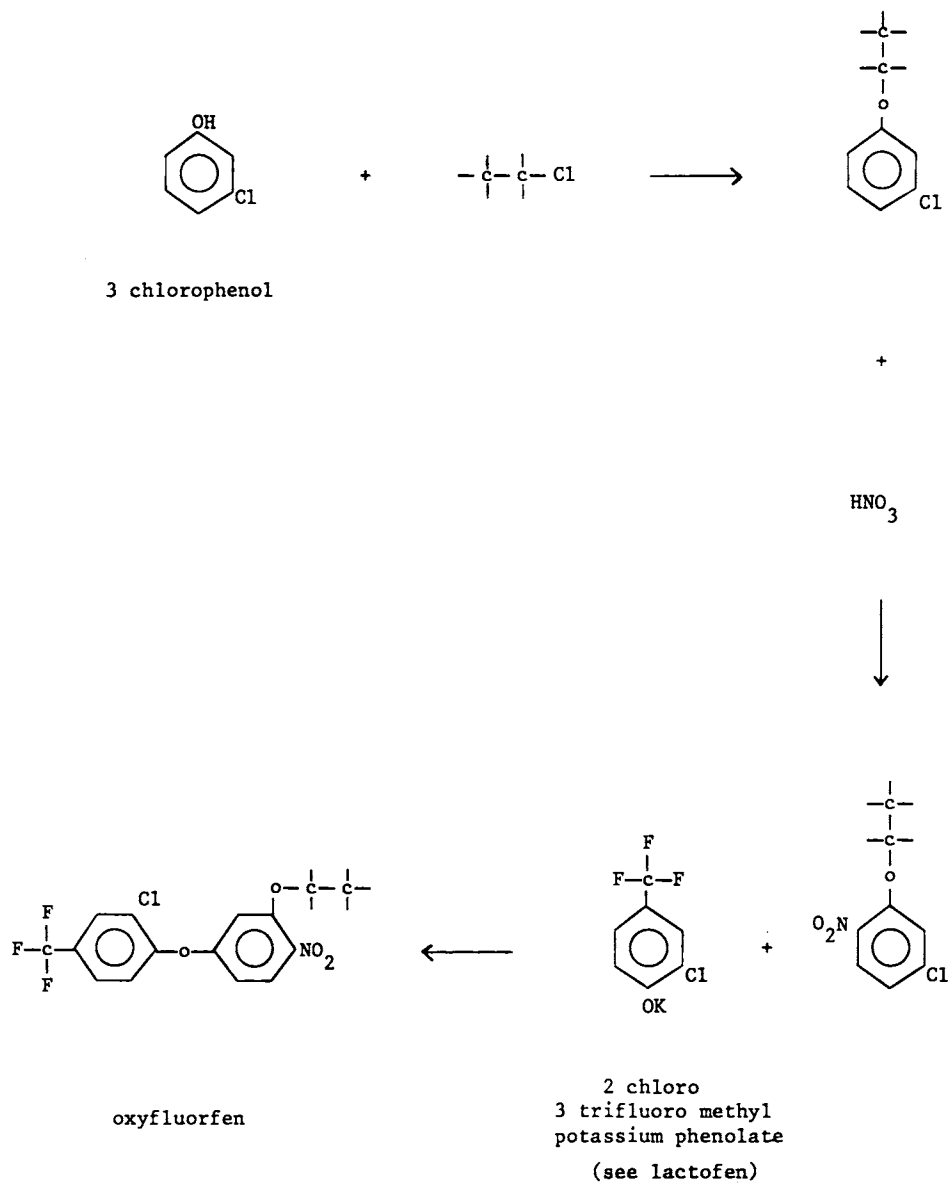
Trade names: Goal (Rohm & Haas)

Type: phenyl ether

Synthesis:



alternate route :





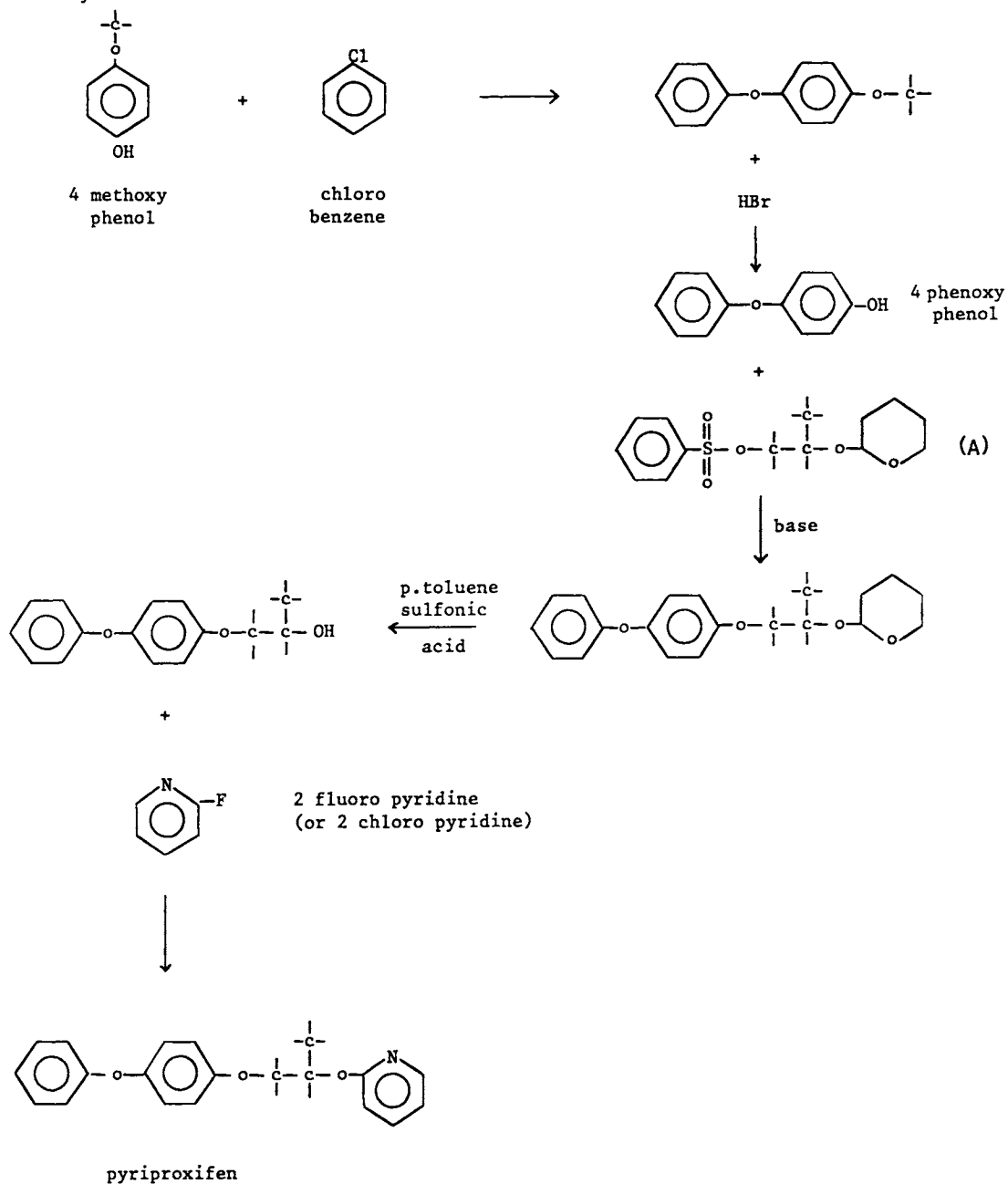
## Pyriproxifen

Uses: insecticide, public health, mosquitoes

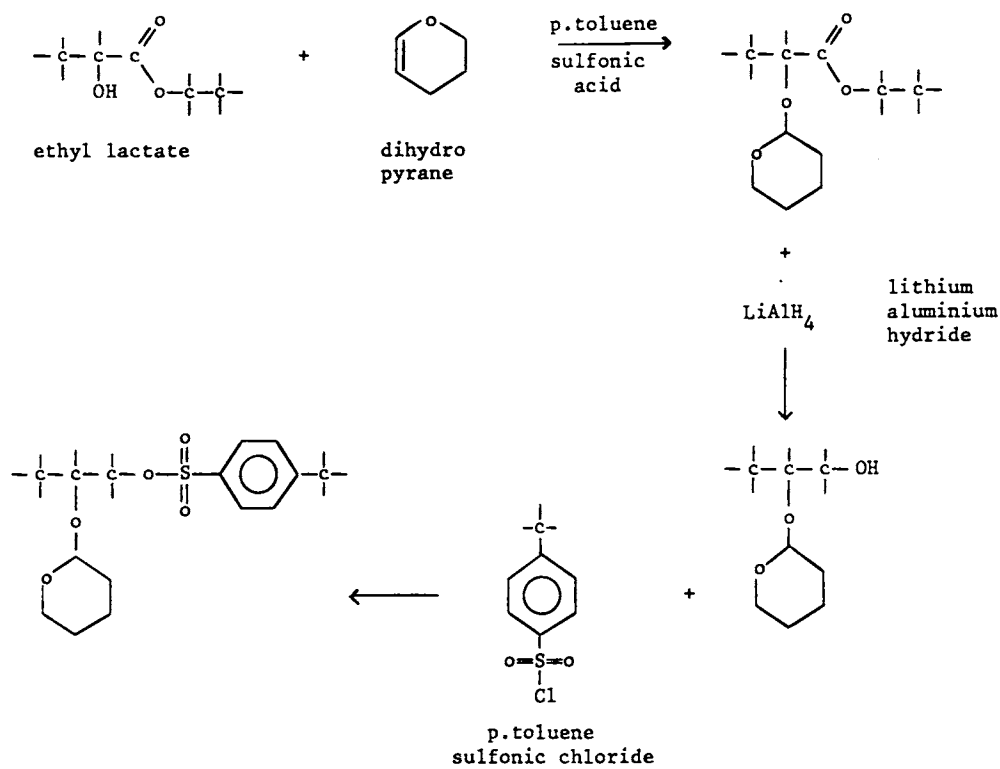
Trade name: Sumilarv (Sumitomo)

Type: phenyl ether, pyridine

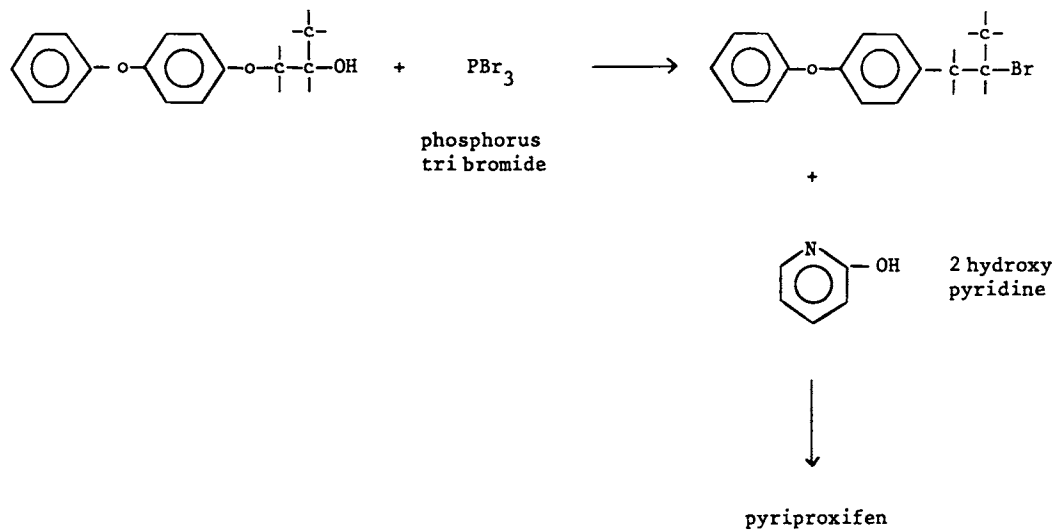
Synthesis:



## Preparation of intermediary (A)



## alternate route :



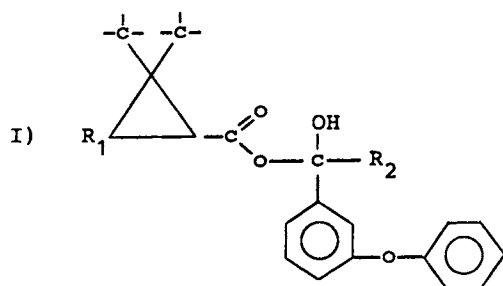
# PYRETHROIDS

Pyrethroid insecticides have three basic general structures:

I) Chrysanthemic acid nucleus and m.phenoxy cyanobenzyl alcohol (PCBA)

II) Another acid and PCBA

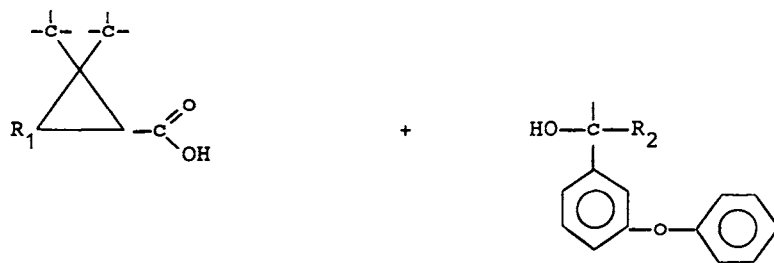
III) Chrysanthemic acid nucleus and another alcohol



where  $R_2$  is nearly always  $C\equiv N$

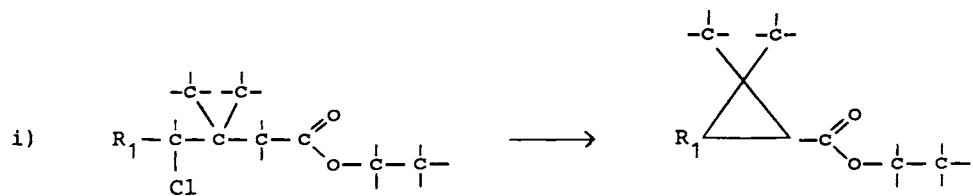
The structure consists of a chrysanthemic acid nucleus and m.phenoxy (cyano)benzyl alcohol (PCBA).

The synthesis is by reaction between



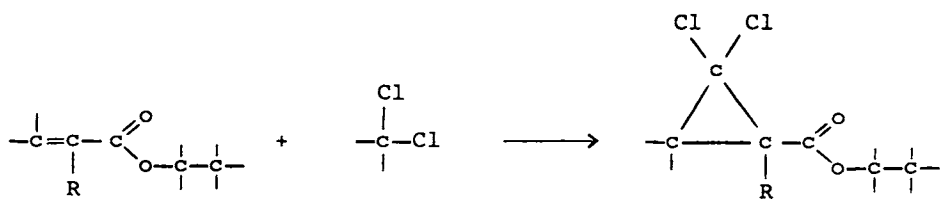
The synthesis of the acid depends upon the nature of  $R_1$ .

Basically there are 3 main routes to the acid :

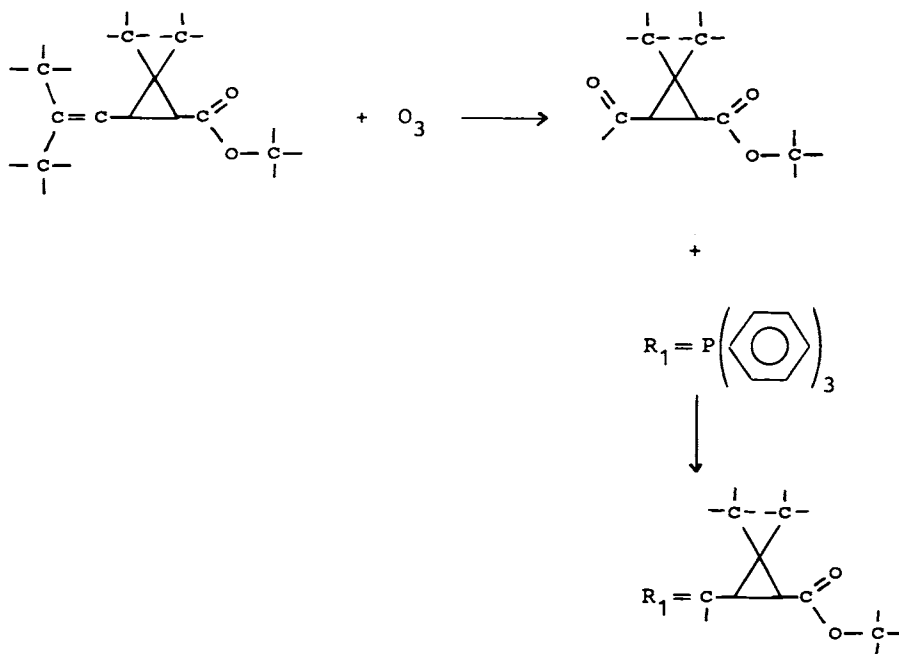


$R_1$  then receiving ( or not ) further transformation.

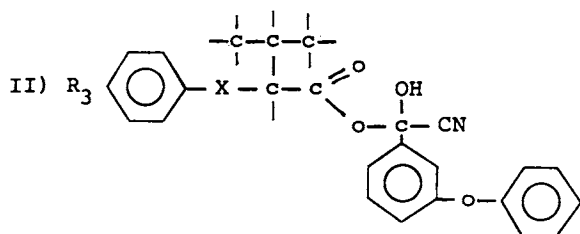
ii) formation of the cyclopropyl ring by reaction between an aliphatic acrylic acid ester and methylene chloride



- iii) Ozonolysis of a crysanthemic acid ester followed by reaction of the carbonyl compound with a triphenyl phosphine derivative



The main products are acrinathrin, cycloprothrin, cyfluthrin, cyhalothrin, cypermethrin, cyphenothrin, deltamethrin, fenpropathrin, permethrin, phenothrin, tralomethrin

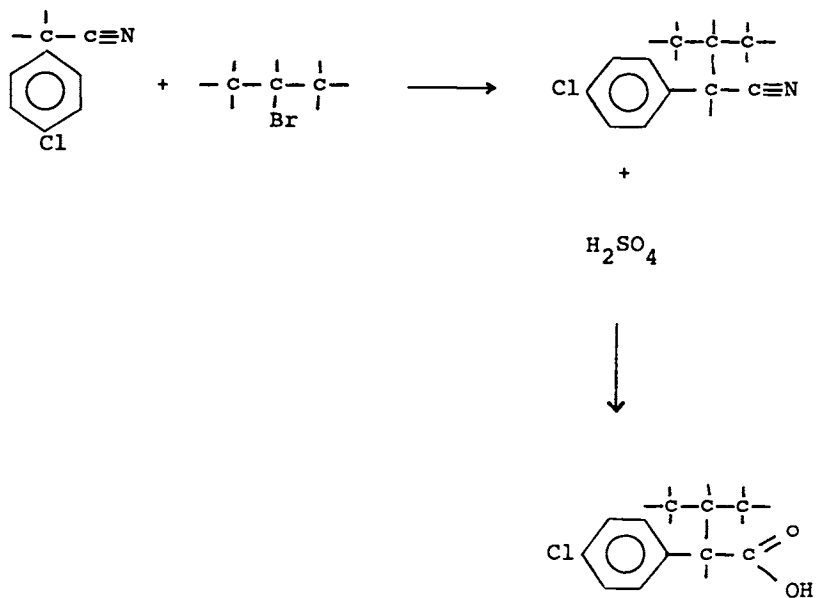


The structure consists of an acid nucleus and m.phenoxy cyano benzyl alcohol.

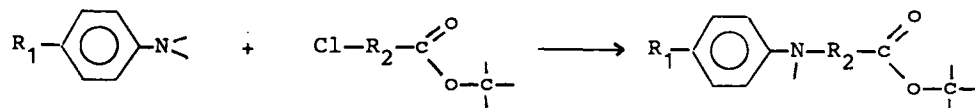
The main products with this structure are fenvalerate, esfenvalerate, flucythrinate and fluvalinate all of which do not have a crysanthemic acid derivate.

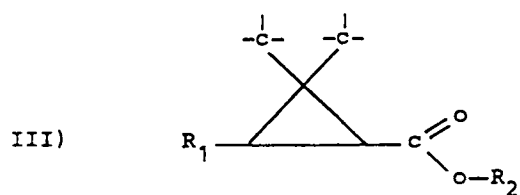
Once again there are 2 basic routes to the acid :

- i) Tacking on the isopropyl radical to a nitrile followed by hydrolysis for example:



- ii) Reacting an amine with a chloro acid ester





The structure consists of a crysanthemic acid nucleus and an alcohol other than PCBA.

This is the case of allethrin, bifenthrin, bioresmethrin, prallethrin, resmethrin, tefluthrin, tetramethrin.

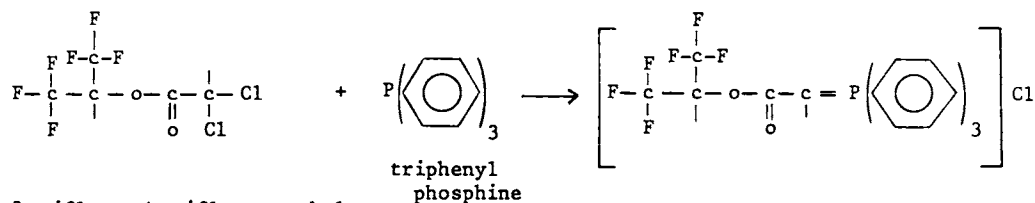
## Acrinathrin

Uses: acaricide, insecticide, citrus, cotton, fruit, soyabeans, tobacco, vegetables

Trade names: Rufast (Roussel-Uclaf)

Type: pyrethroid

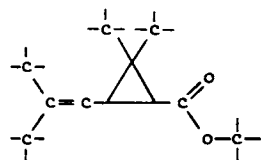
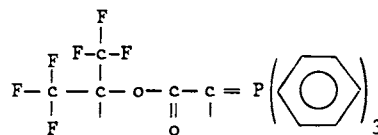
Synthesis:



2 trifluoro 1 trifluoro methyl  
ethoxy carbonyl carbon dichloride

(2 trifluoro 1 trifluoro methyl  
ethyl dichloro acetate)

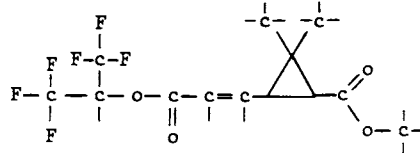
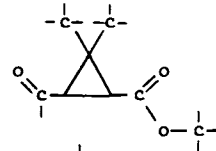
+  
NH<sub>3</sub>



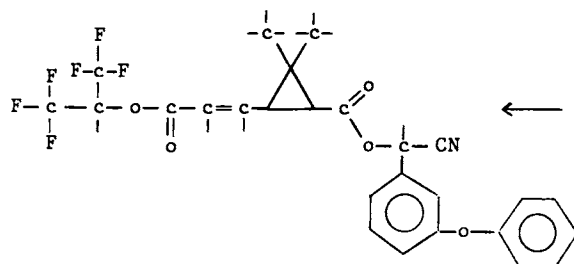
chrysanthemic acid

+ O<sub>3</sub>

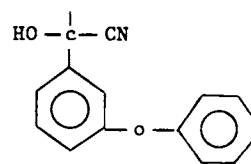
→



+



acrinathrin



PCBA

(see cypermethrin)



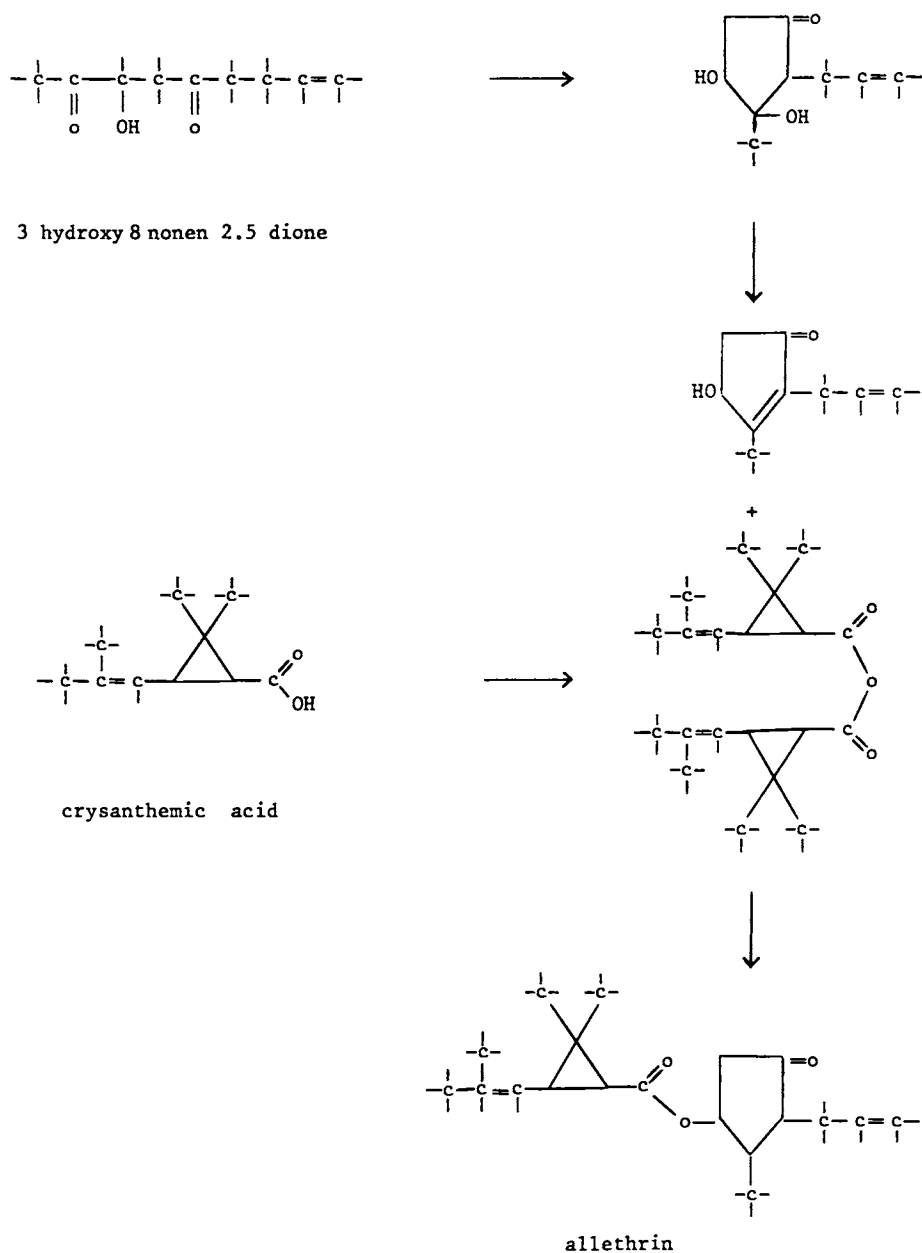
## Allethrin

Uses: insecticide, household

Trade names: Pyonamin (Sumitomo)

Type: pyrethroid

Synthesis:



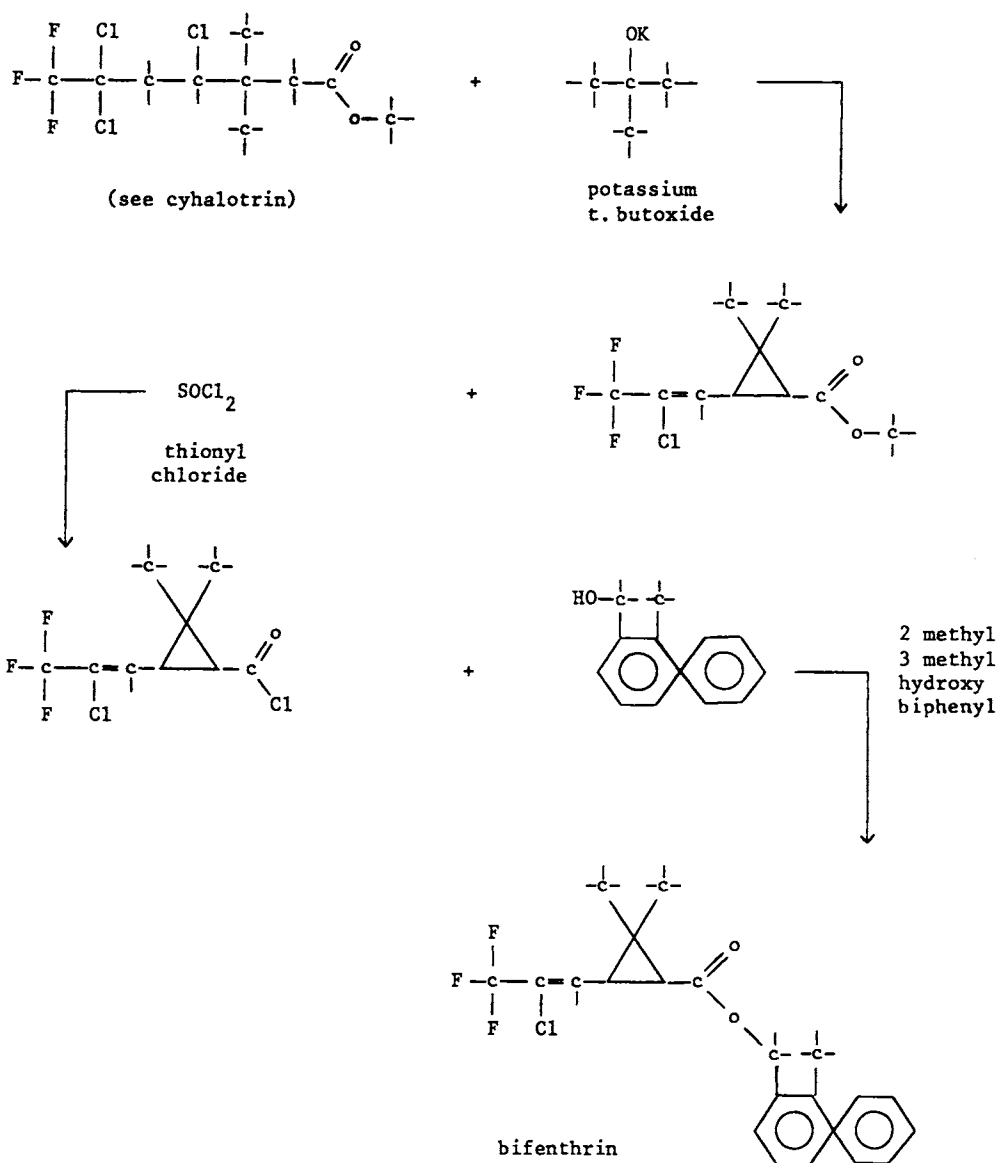
## Bifenthrin

Uses: insecticide, cereals, citrus, cotton, fruit, vegetables

Trade names: Brigade, Talstar (FMC)

Type: pyrethroid

Synthesis:



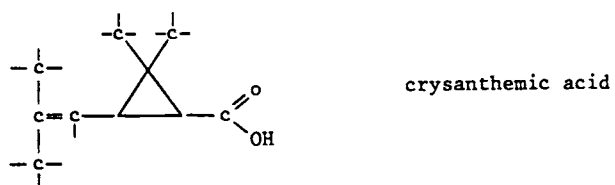
## Bioresmethrin

Uses: insecticide, household, public health

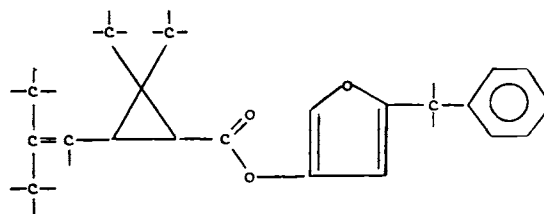
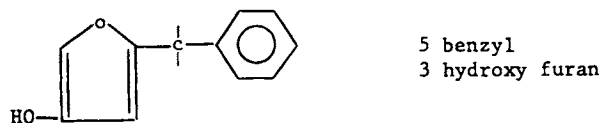
Trade names: Resbuthrin (Wellcome), Chryson Forte (Sumitomo)

Type: pyrethroid

Synthesis:



+



bioresmethrin

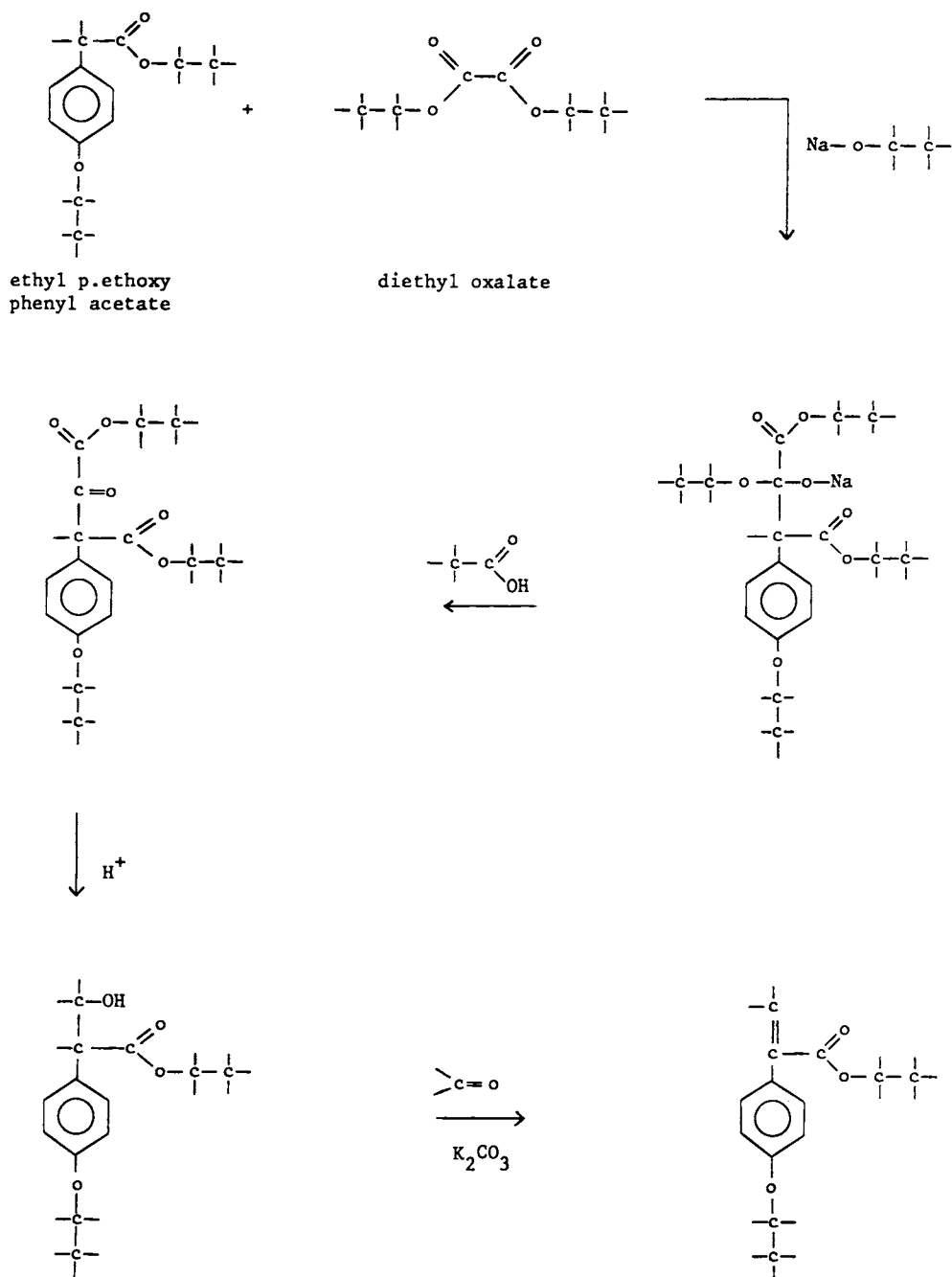
## Cycloprothrin

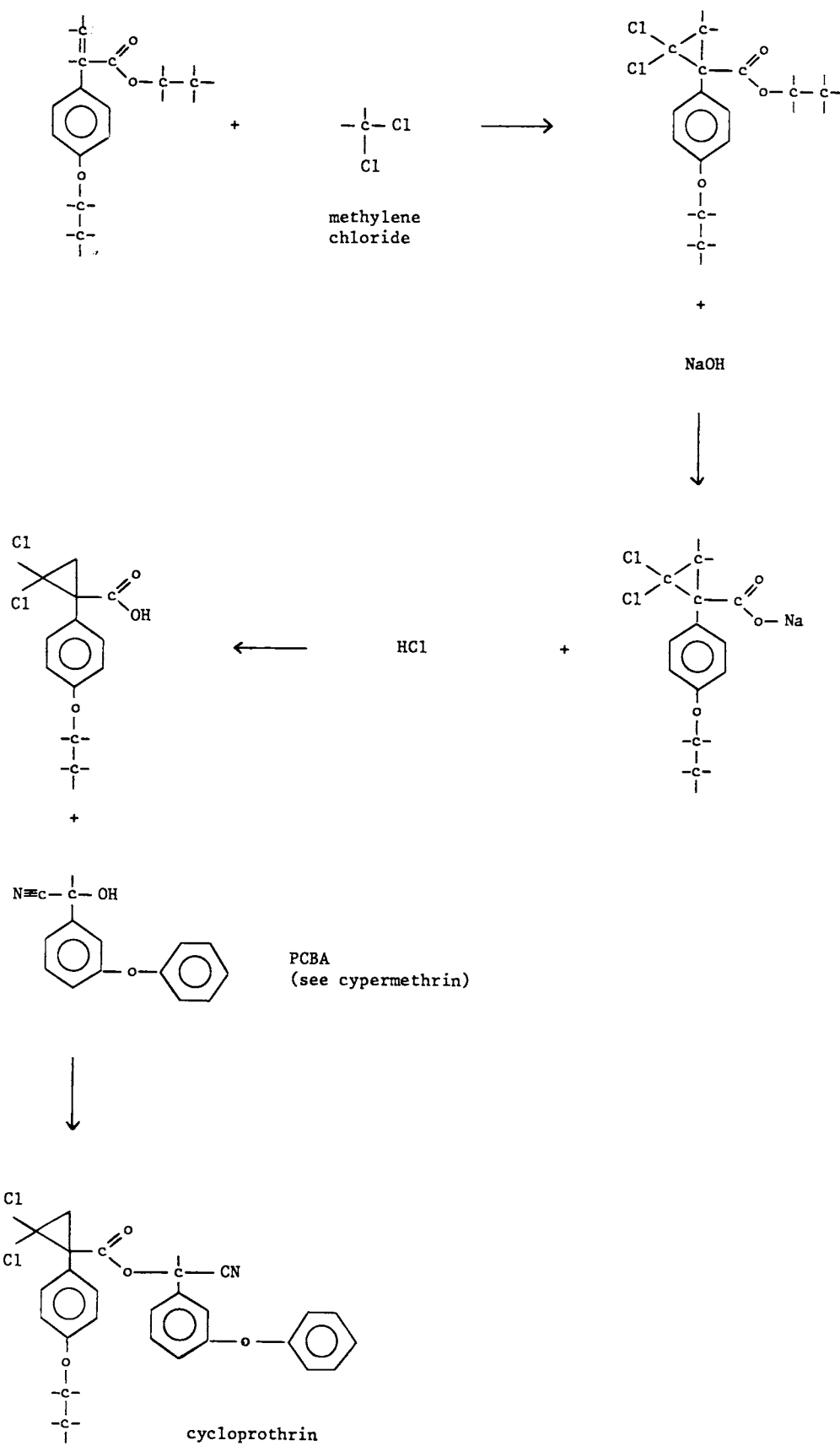
Uses: insecticide, rice

Trade names: Cyclosal (Nippon)

Type: pyrethroid

Synthesis:





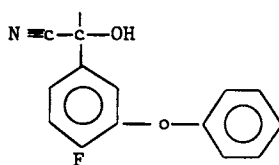
## Cyfluthrin

Uses: insecticide, cotton, cereals, fruit, vegetables

Trade names: Baythroid, Responsar, Solfac (Bayer)

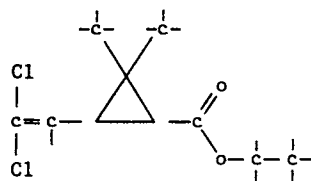
Type: pyrethroid

Synthesis:

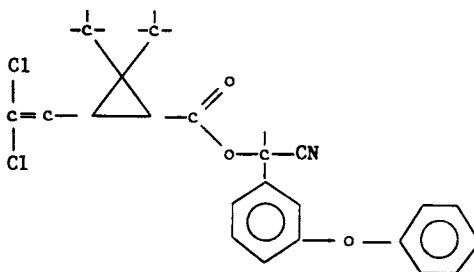


m.phenoxy  
p.fluoro  
α cyano  
benzyl alcohol  
(as PCBA with 3 bromo 4 fluoro  
toluene - see cypermethrin)

+



DV  
acid ester  
(see cypermethrin)



cyfluthrin

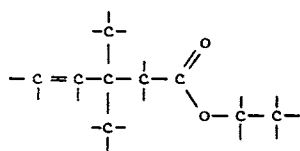
## Cyhalothrin

Uses: insecticide, cattle, sheep

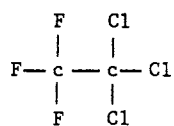
Trade names: Grenade (ICI)

Type: pyrethroid

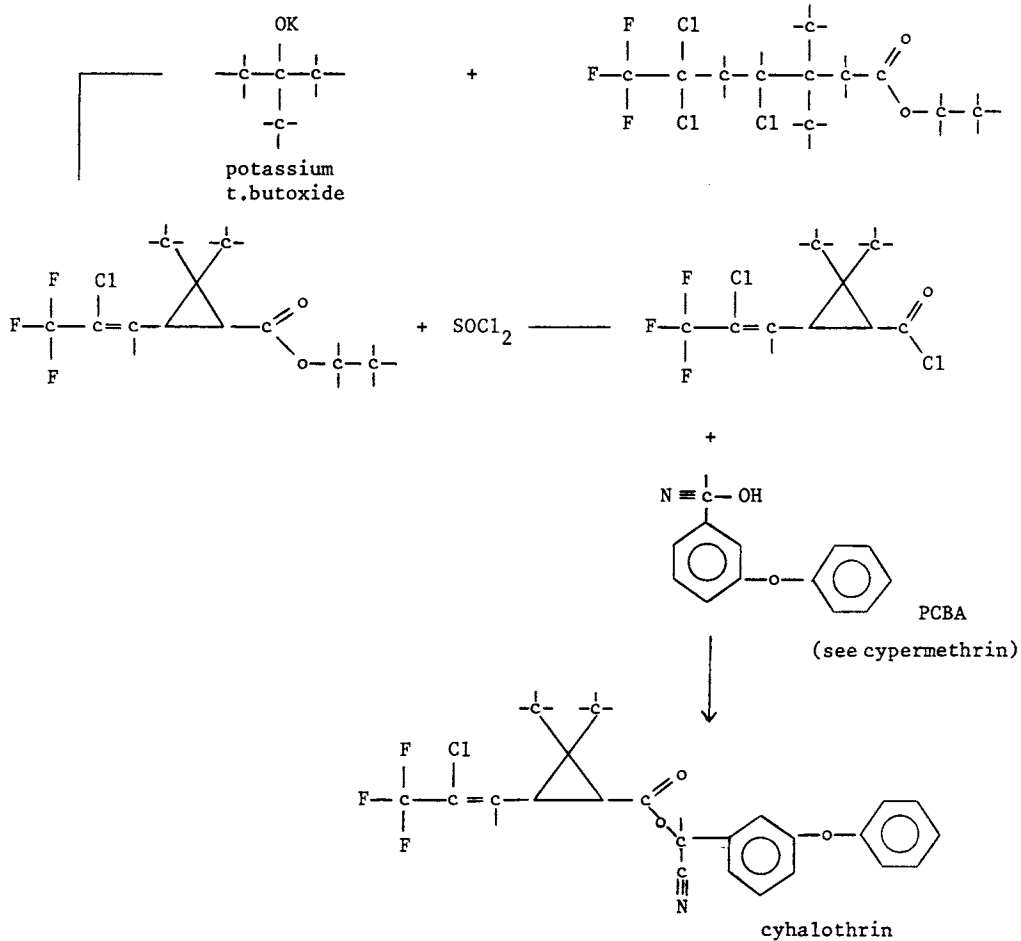
Synthesis:



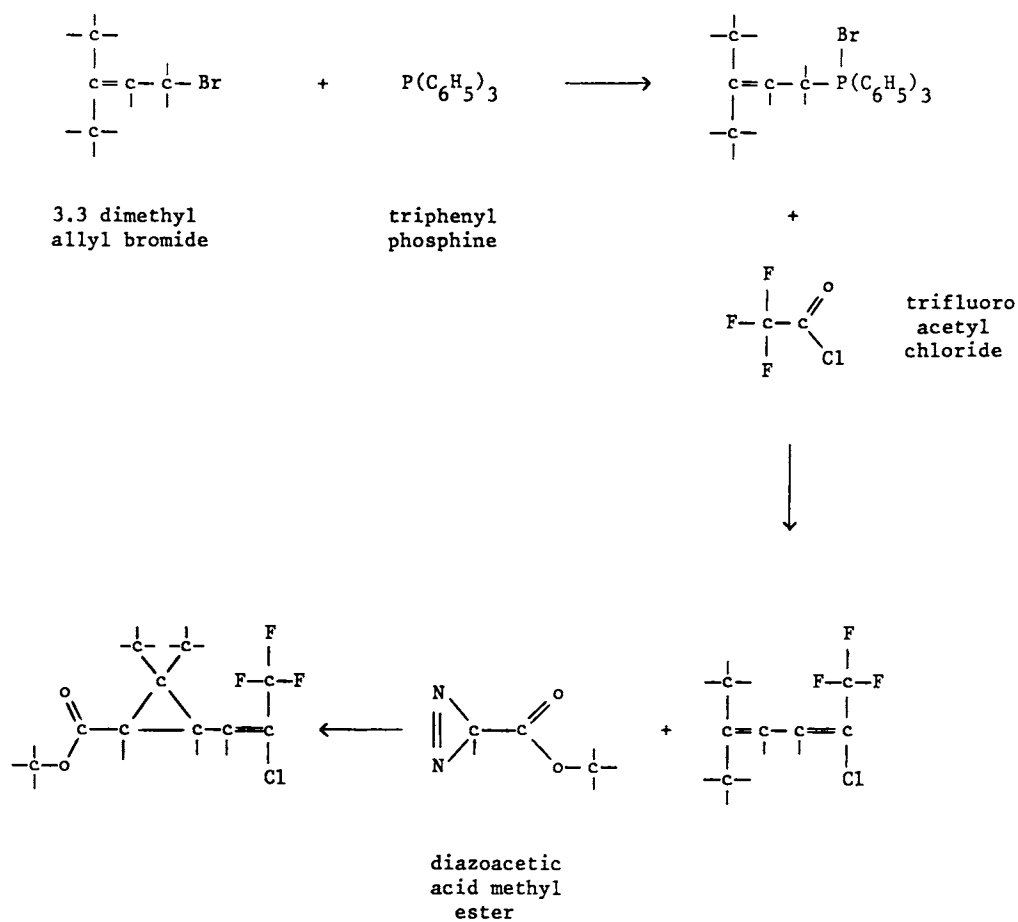
(see cypermethrin)



1.1.1 trichloro  
2.2.2 trifluoro  
ethane

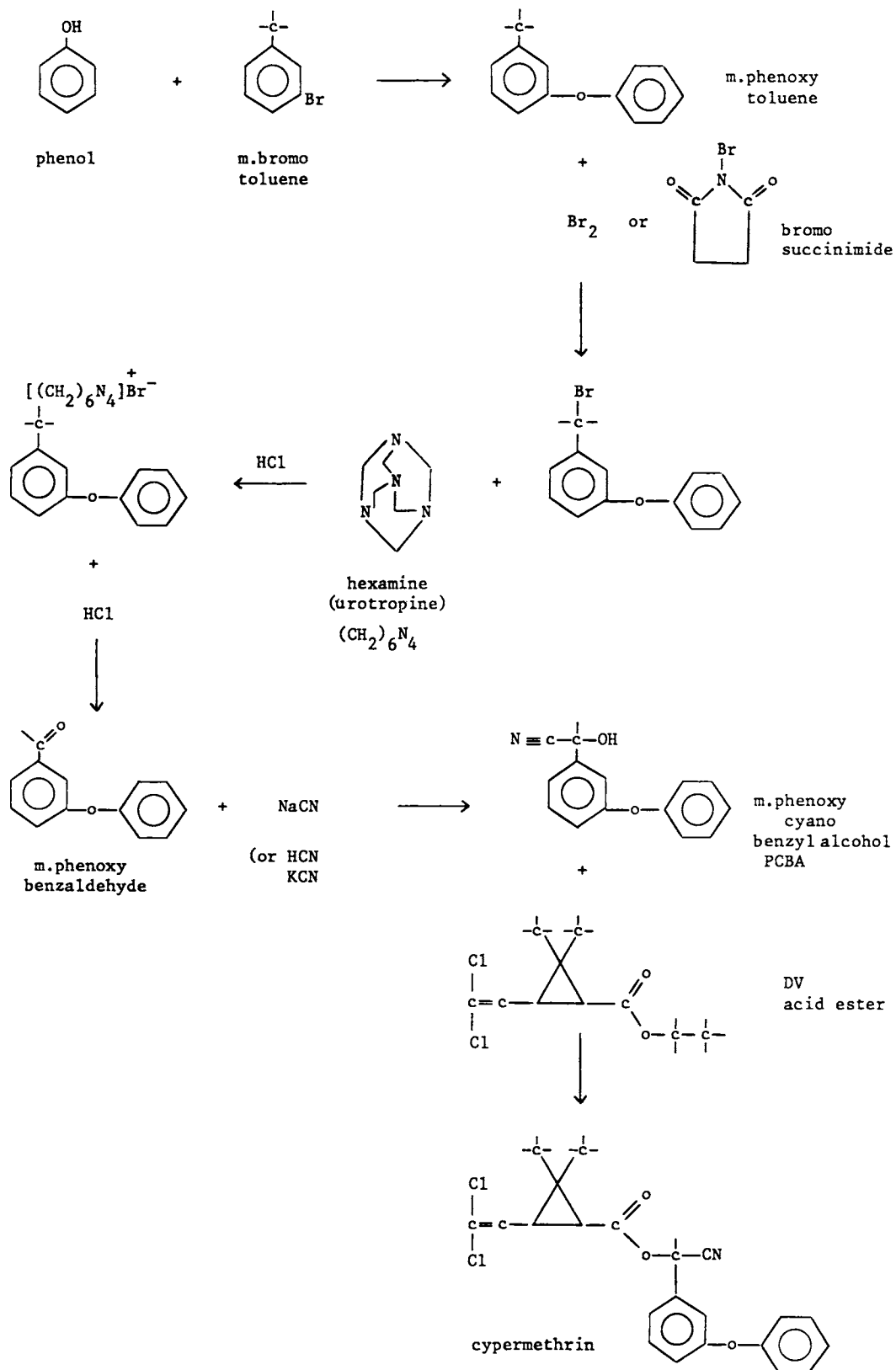


alternate route :

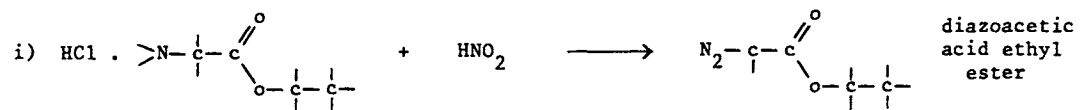








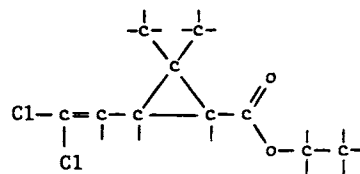
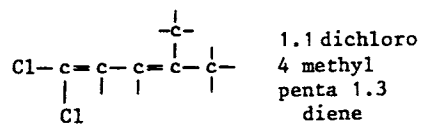
alternate routes :

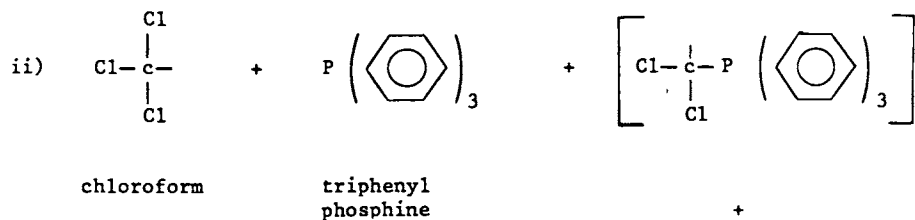


glycine ester  
hydrochloride

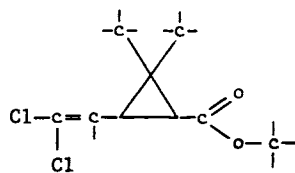
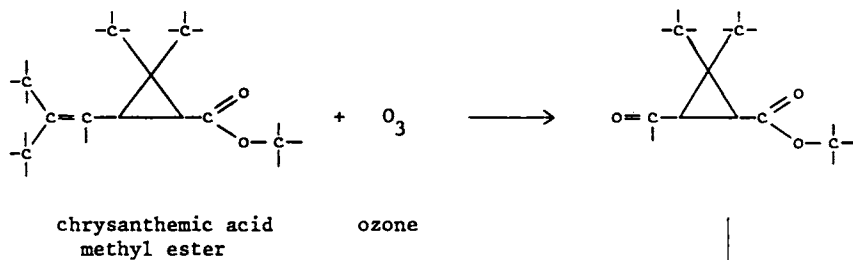
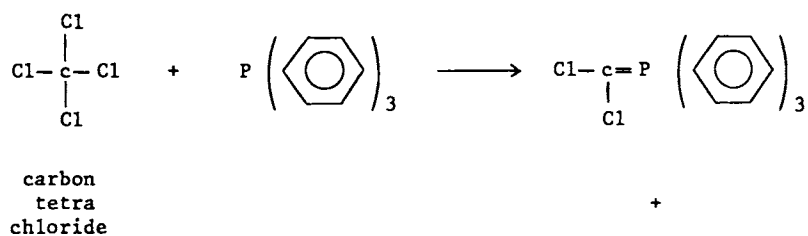
nitrous  
acid

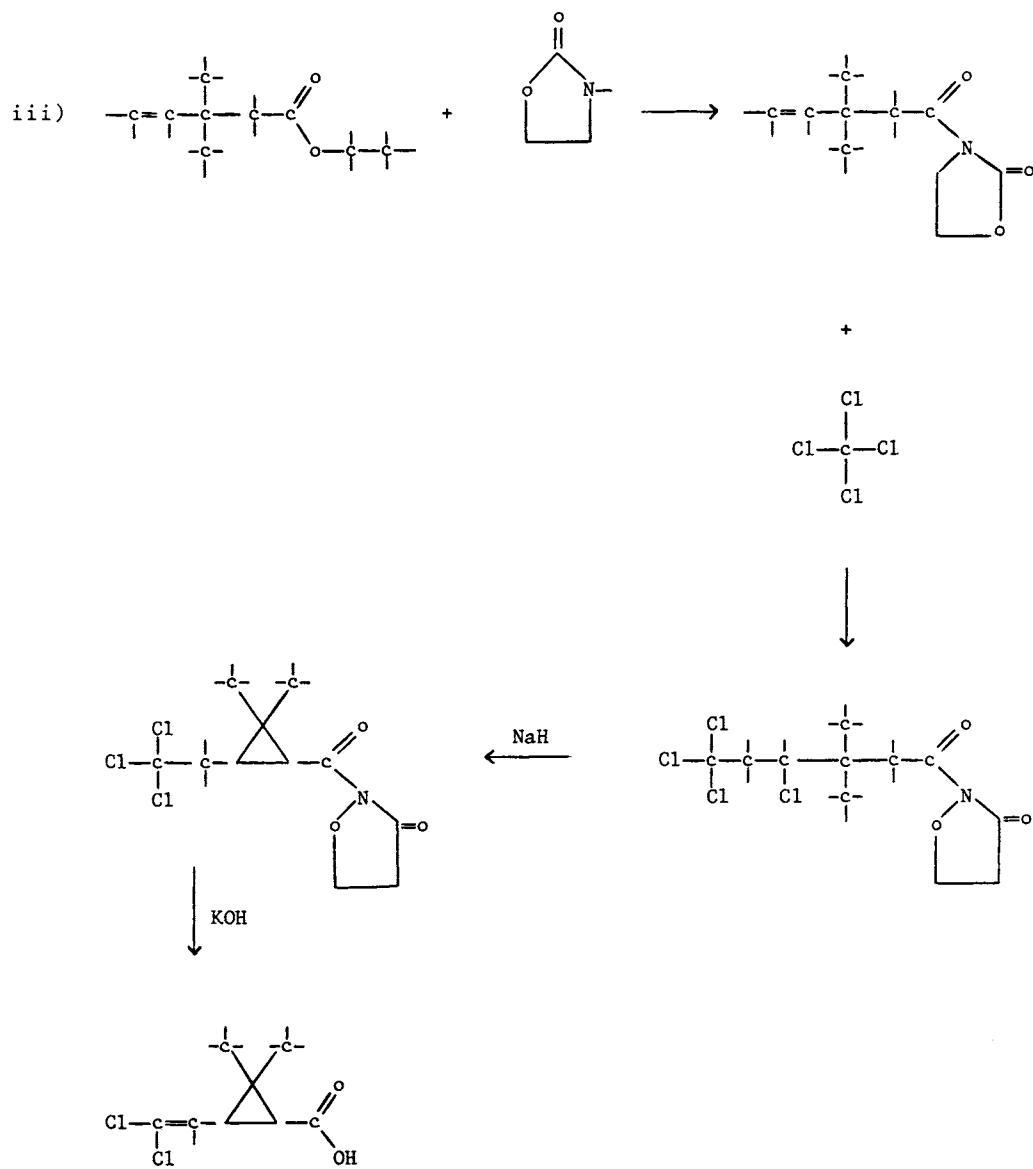
+





OR

 $\text{NH}_3$ 



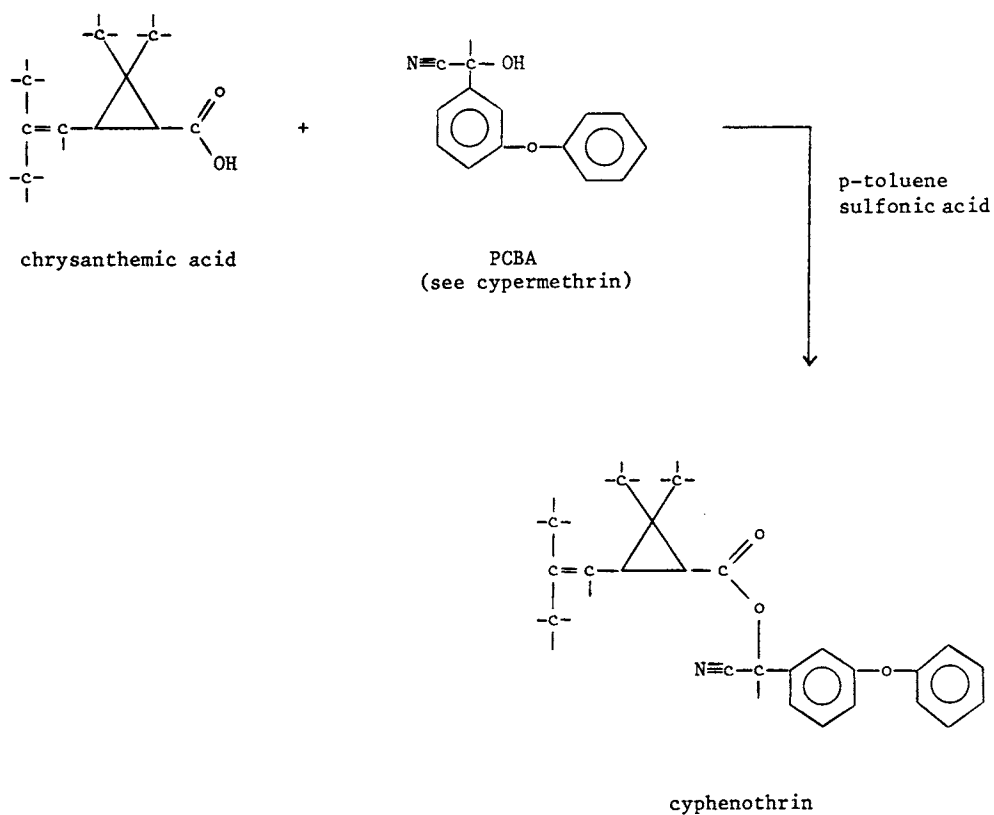
## Cyphenothrin

Uses: insecticide, public health, households, wood, fabric

Trade names: Gokilaht (Sumitomo)

Type: pyrethroid

Synthesis:



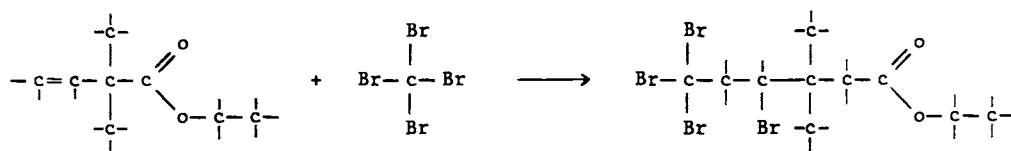
## Deltamethrin

Uses: insecticide, cereals, cotton, citrus, maize, soyabeans, vegetables

Trade names: Decis (Roussel Uclaf)

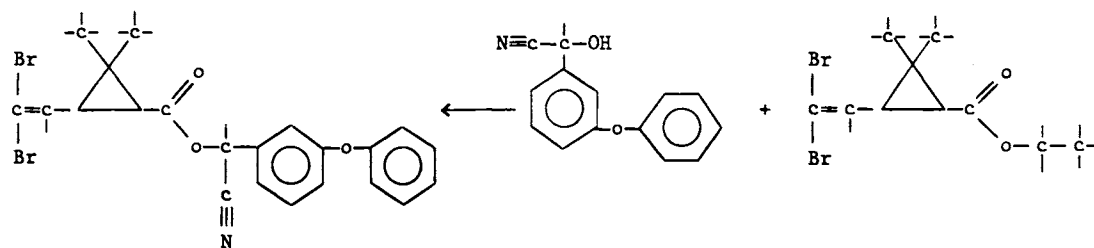
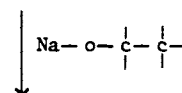
Type: pyrethroid

**Synthesis:**



(see cypermethrin)

carbon tetra  
bromide



deltamethrin

PCBA  
(see cypermethrin)

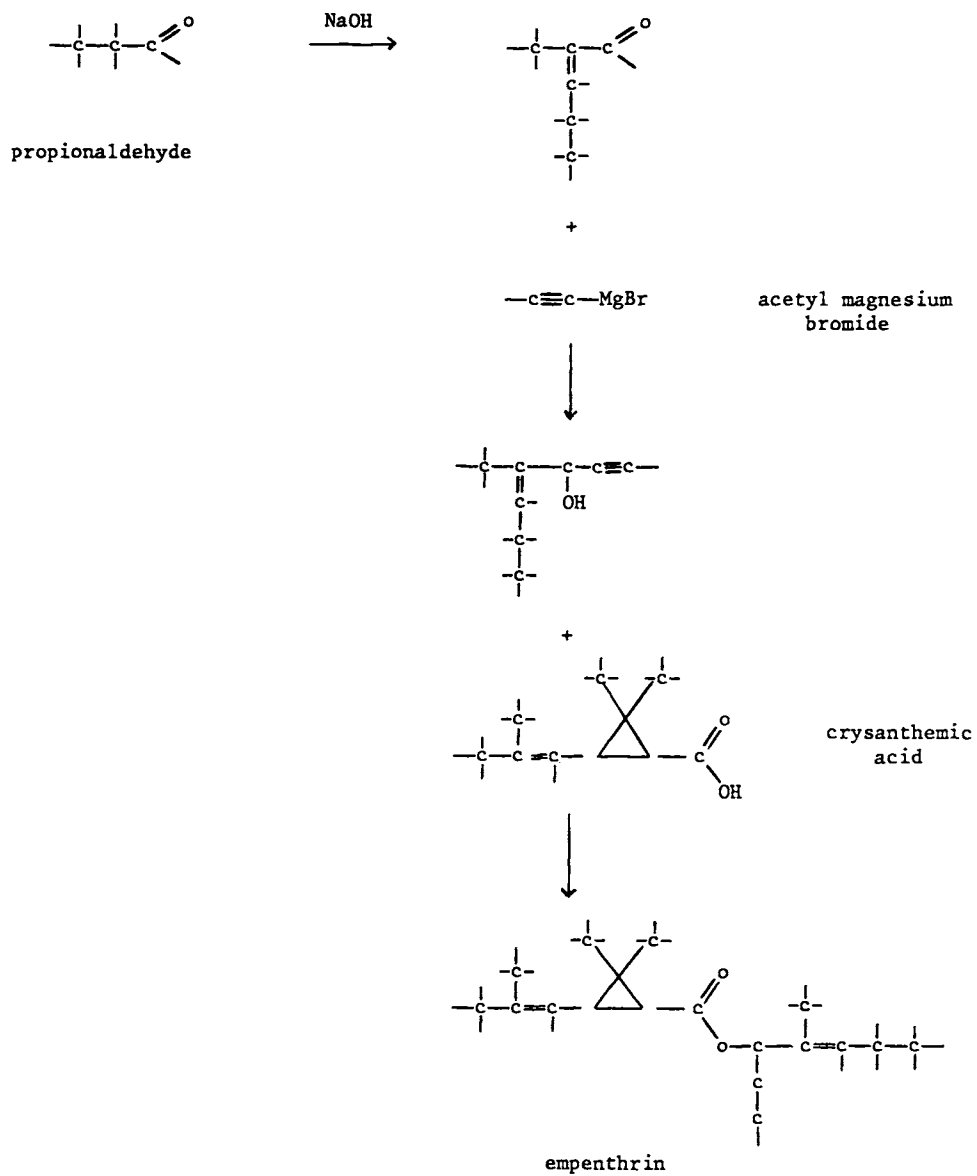
## Empenthrin

Uses: insecticide, house holds pests

Trade names: Vaporthrin (Sumitomo)

Type: pyrethroid

Synthesis:





## Esfenvalerate

Uses: insecticide, cotton, fruit, vegetables

Trade names: Sumialpha, Sumialfa (Sumitomo), Asana (Dupont)

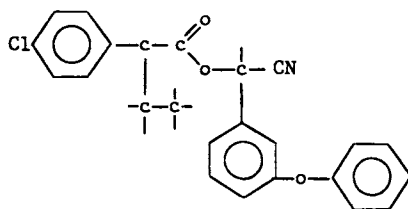
Type: pyrethroid

Synthesis:

( see fenvalerate )

use  $\begin{array}{c} | & | \\ -C- & C- \\ | & | \end{array} Br$  instead of isopropyl bromide

ethyl bromide



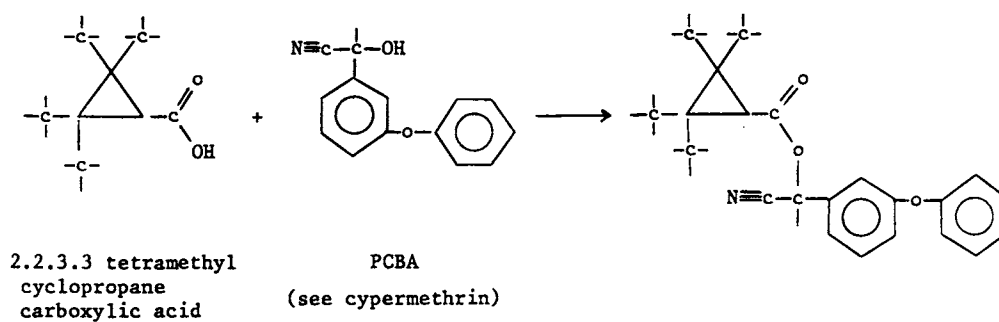
## Fenpropathrin

Uses: insecticide, cotton, grapes, fruit, vegetables

Trade names: Rody, Danitol, Meothrin (Sumitomo), Herald (Shell)

Type: pyrethroid

Synthesis:



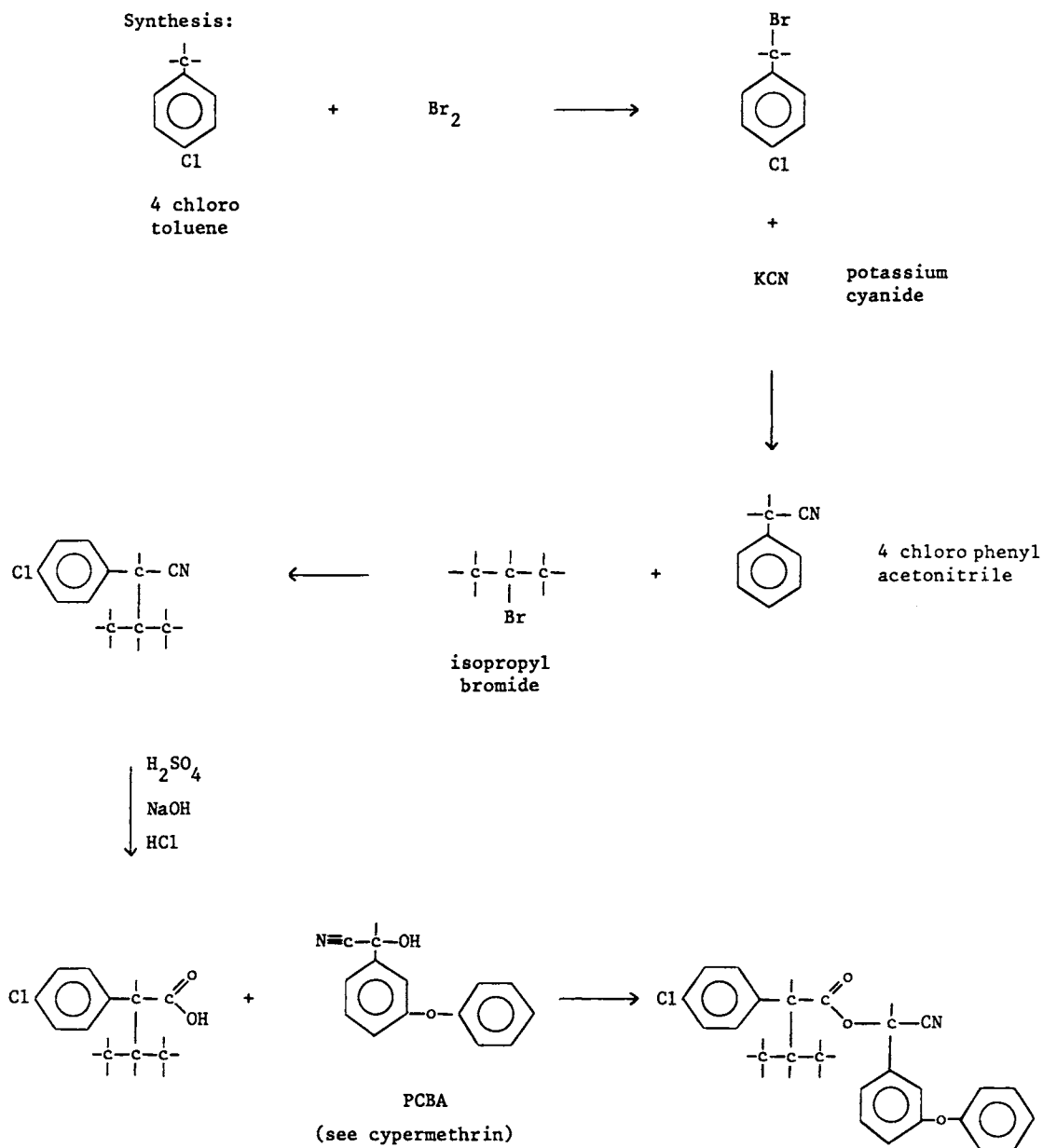
## Fenvalerate

Uses: insecticide, cereals, cotton, maize, potatoes, grapes, fruits, vegetables

Trade names: Sumicidin (Sumitomo), Belmark (Shell), Pydrin (Dupont)

Type: pyrethroid

Synthesis:



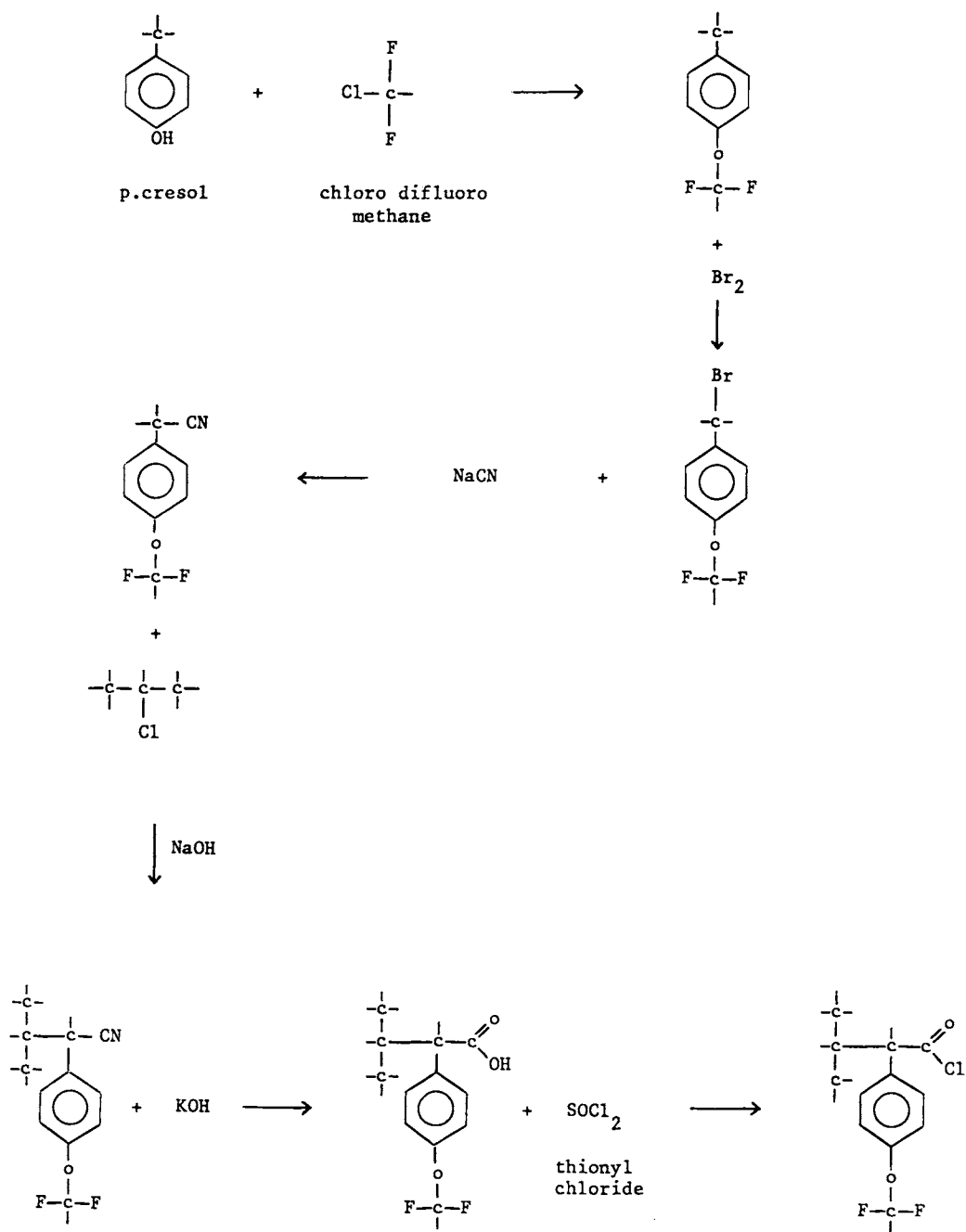
## Flucythrinate

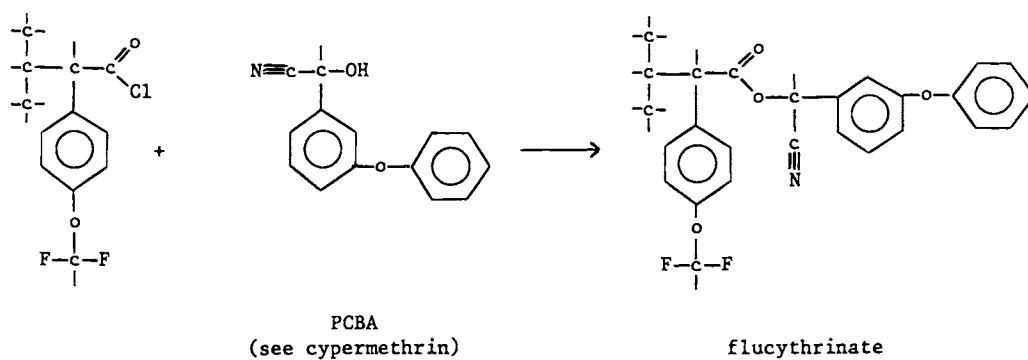
Uses: insecticide, cotton, maize, potatoes, soyabeans, fruits, sugar beet, tobacco, vegetables

Trade names: Cybolt, Cythrin, Pay-off (Cyanamid)

Type: pyrethroid

**Synthesis:**





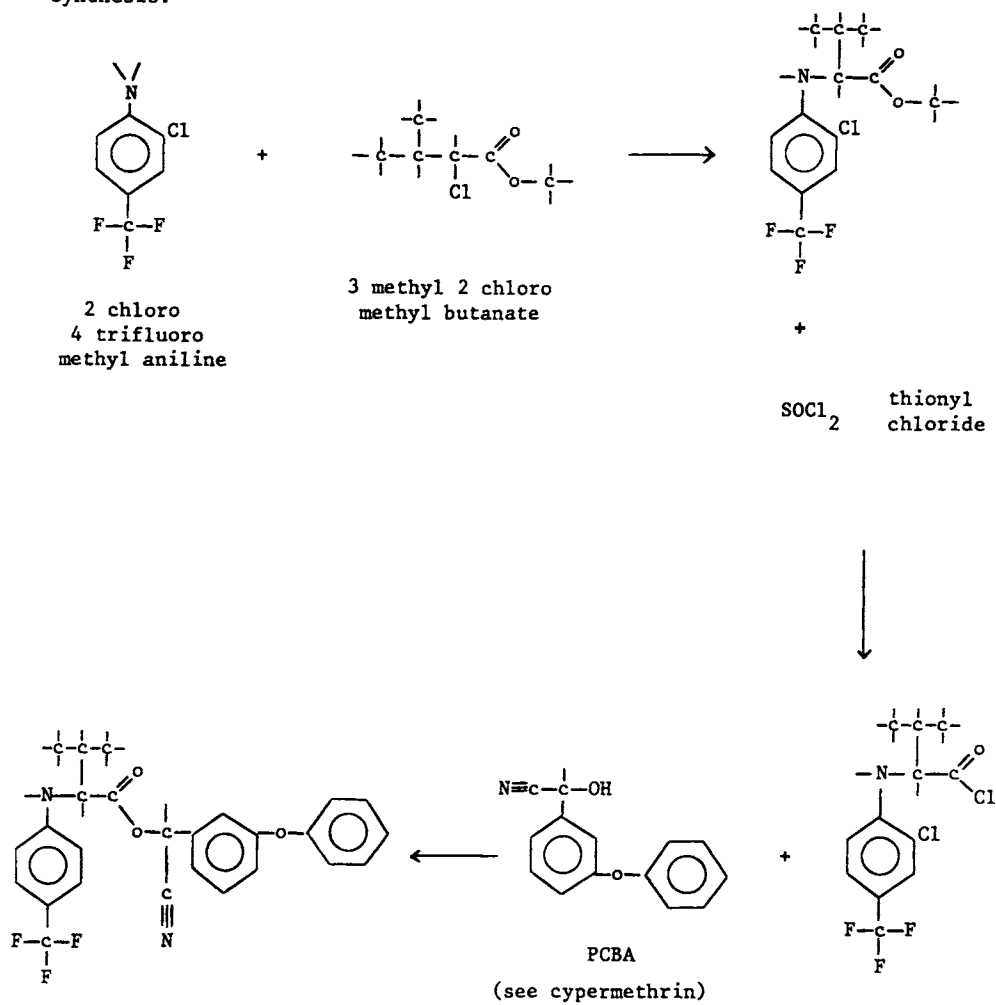
## Fluvalinate

Uses: insecticide, cotton, fruit trees, trees, vegetables

Trade names: Maurik, Klartan, Apistan (Sandoz)

Type: pyrethroid

Synthesis:



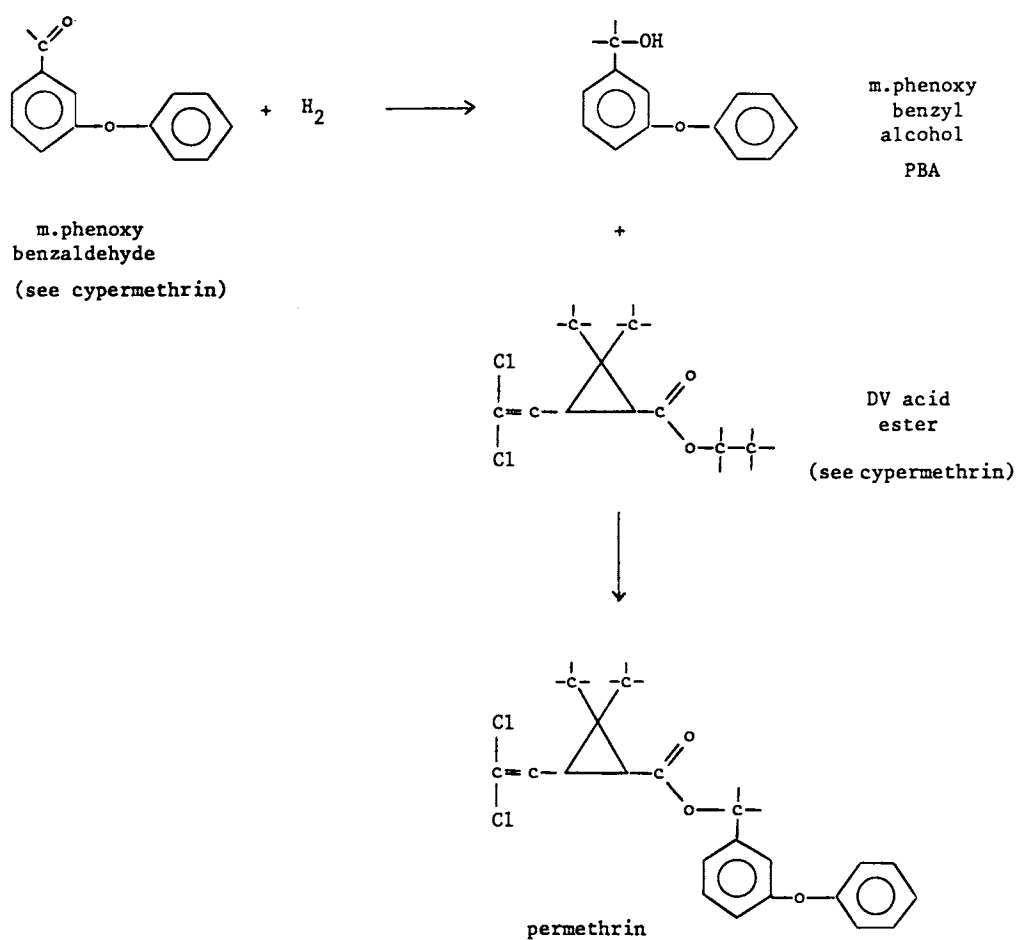
## Permethrin

Uses: insecticide, tobacco, fruit, cotton, household, animals

Trade names: Ambush, Perthrine, Picket (ICI), Pounce (FMC)

Type: pyrethroid

Synthesis:



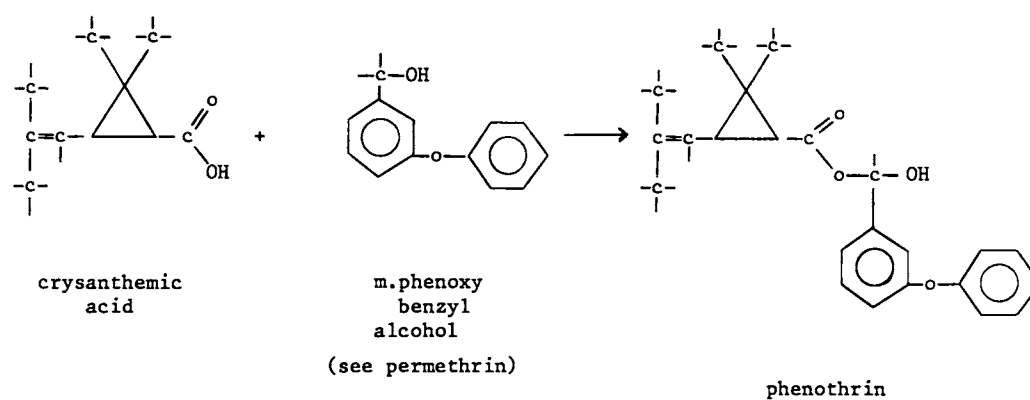
## Phenothrin

Uses: insecticide, public health, stored grain

Trade names: Sumithrin (Sumitomo)

Type: pyrethroid

Synthesis:





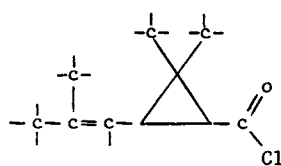
## Prallethrin

Uses: insecticide, public health

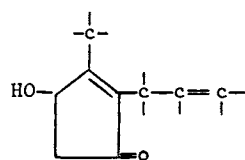
Trade names: Etoc (Sumitomo)

Type: pyrethroid

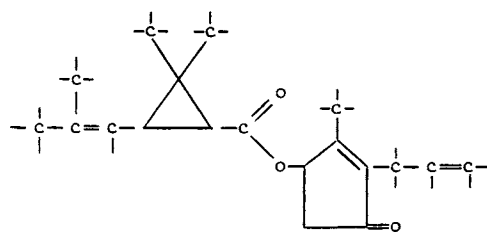
Synthesis:



chrysanthemic  
acid chloride



2 allyl  
3 methyl, 4 hydroxy  
cyclopentrin 2 ene 1 one



prallethrin

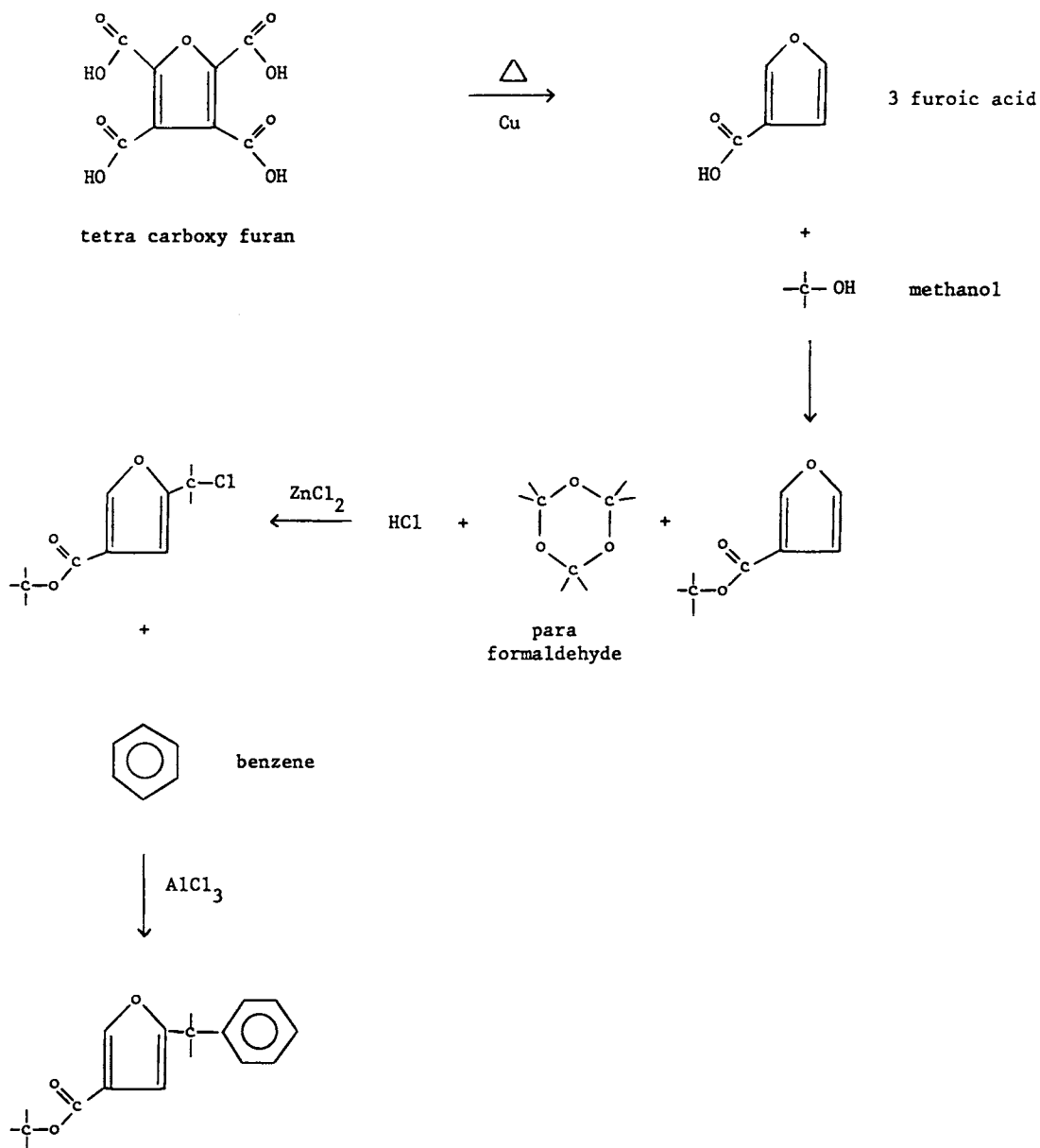
## Resmethrin

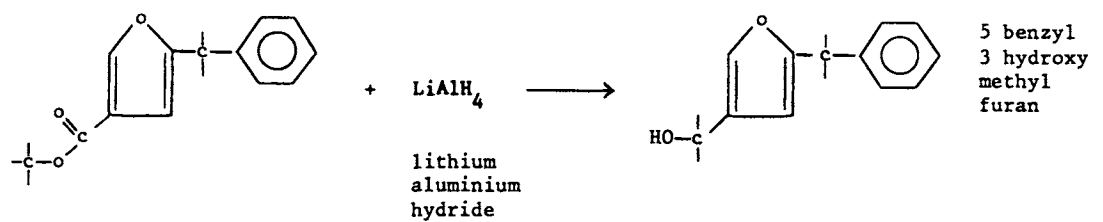
Uses: insecticide, household, public health

Trade names: Chryson (Sumitomo)

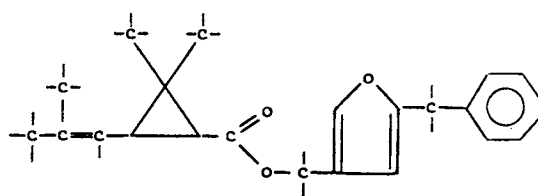
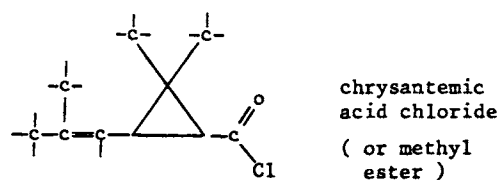
Type: pyrethroid

Synthesis:



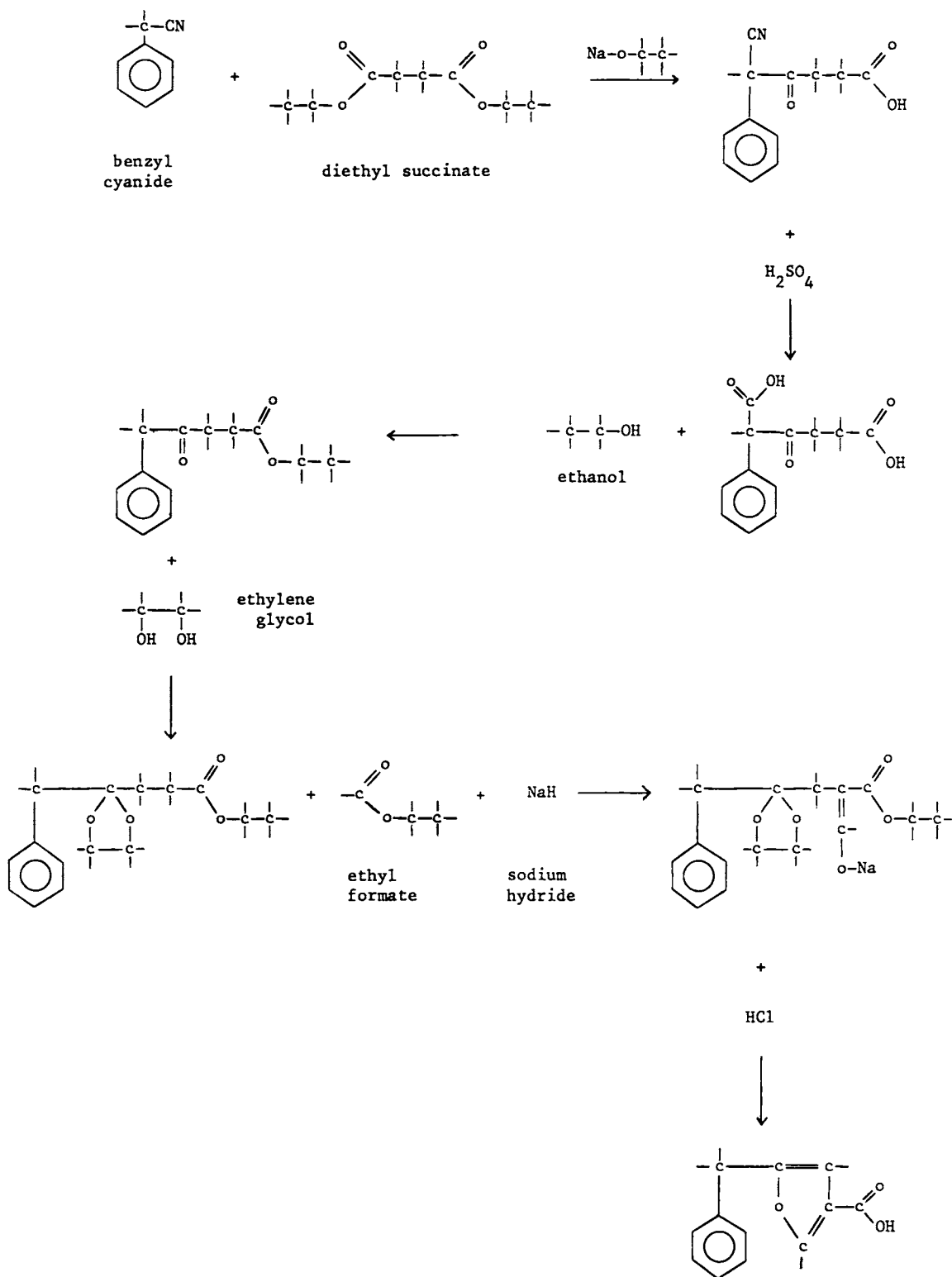


+



resmethrin

alternate route :



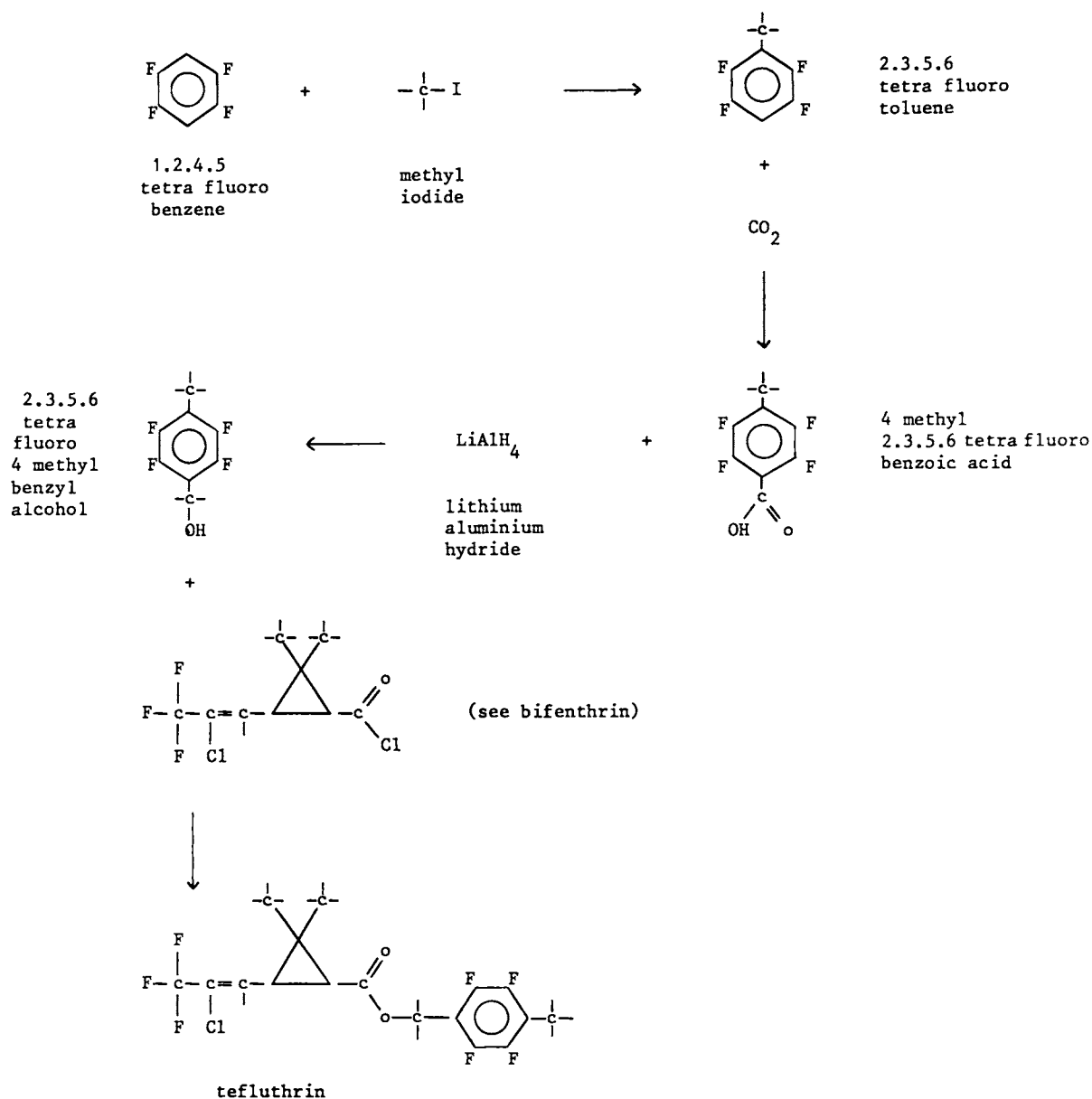
## Tefluthrin

Uses: insecticide, maize, sugar beet

Trade names: Force, Forza (ICI)

Type: pyrethroid

Synthesis:



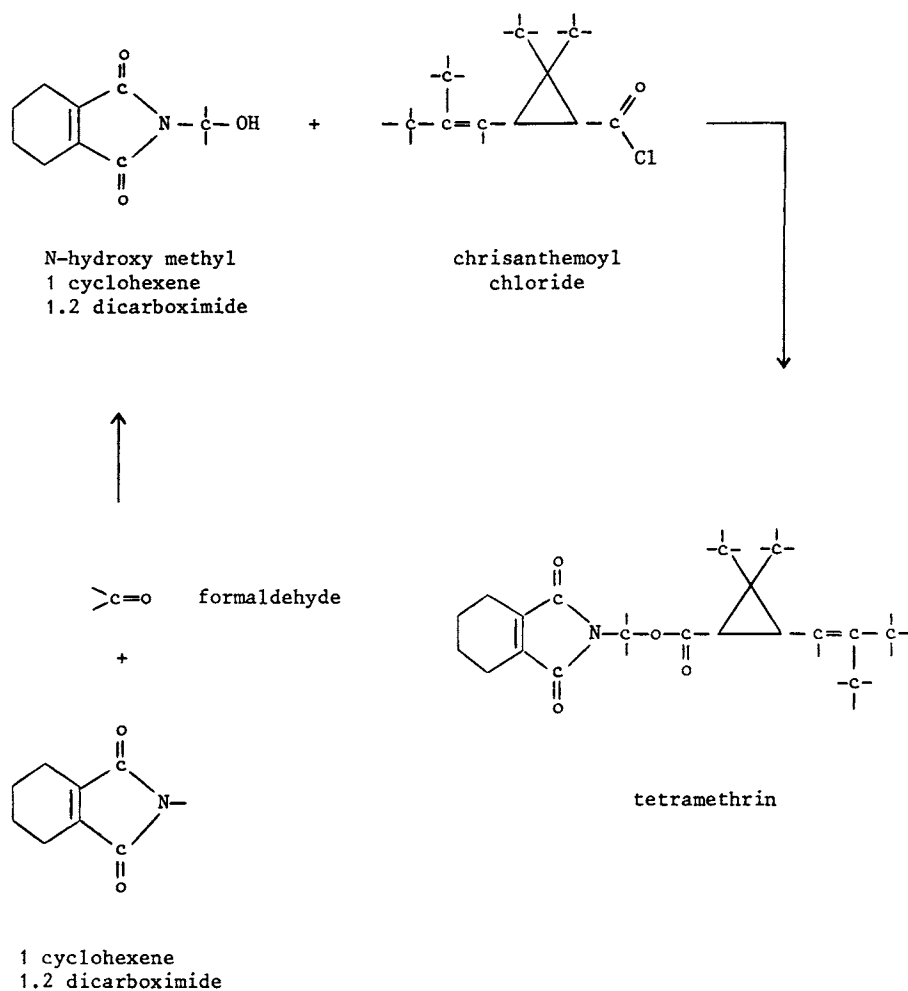
## Tetramethrin

Uses: insecticide, public health

Trade names: Neo Pynamin (Sumitomo)

Type: pyrethroid

Synthesis:



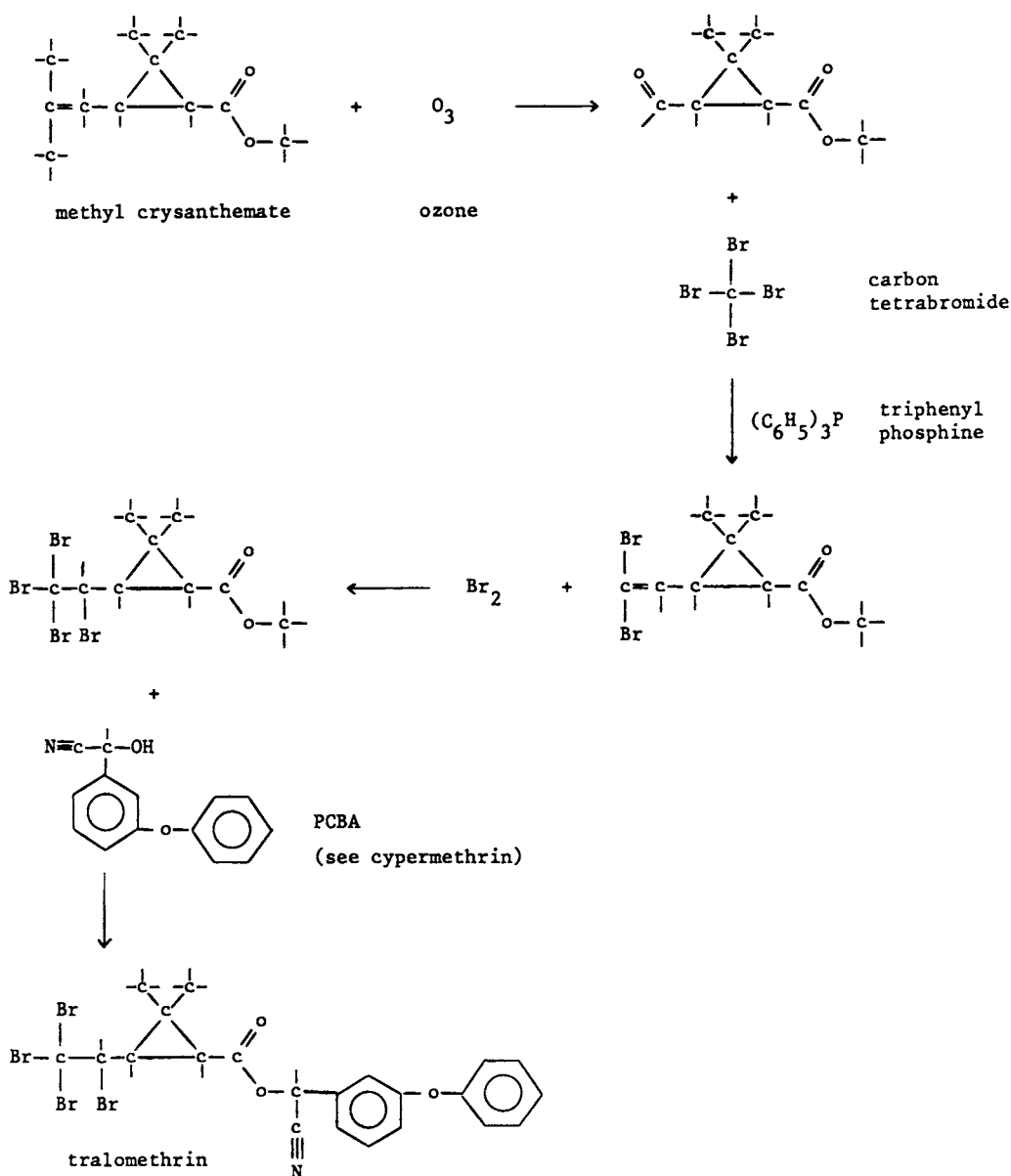
## Tralomethrin

Uses: insecticide, cereals, coffee, cotton, maize, rice, tobacco, fruit, vegetable

Trade names: Scout (Roussel Uclaf), Tralate, Tracker (Dupont)

Type: pyrethroid

Synthesis:



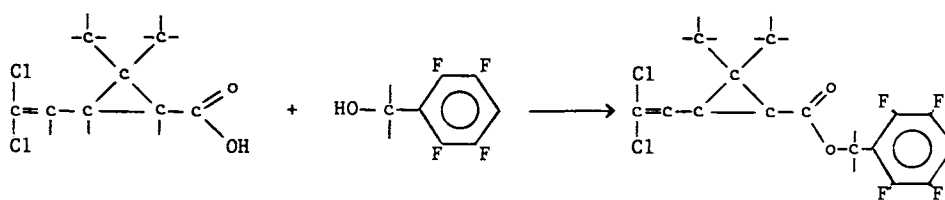
## Transfluthrin

Uses: insecticide, mosquitoes, flies, cockroaches

Trade names: Baygon, Bayothrin (Bayer)

Type: pyrethroid

Synthesis:



DV acid  
see cypermethrin

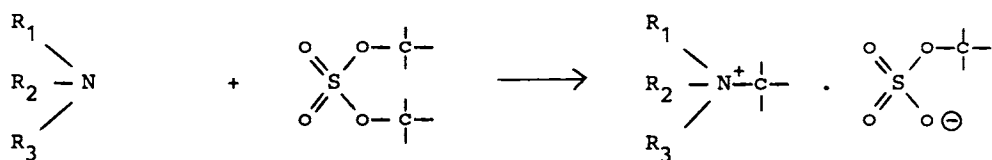
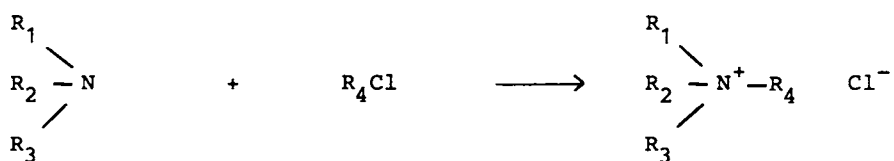
2,3,5,6 tetrafluoro  
benzyl alcohol

transfluthrin

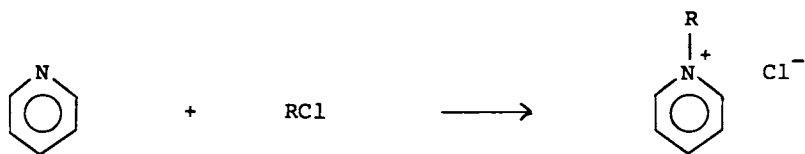


# QUATERNARY AMMONIUM

The synthesis route is by reaction between a tertiary amine and an alkyl halide or dimethyl sulfate



The tertiary amine can be aromatic such as a pyridine, piperidine, pyrazole, etc.



## Chlormequat

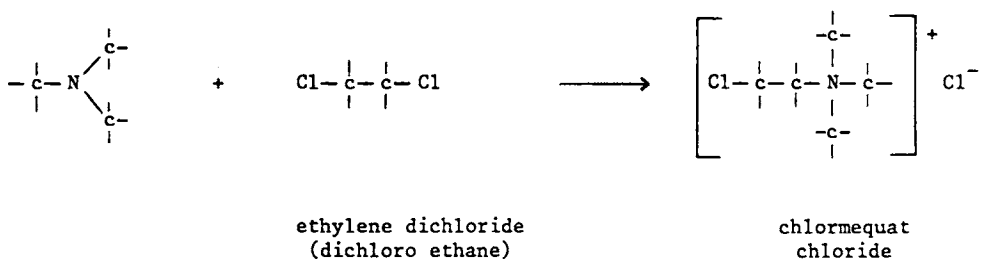
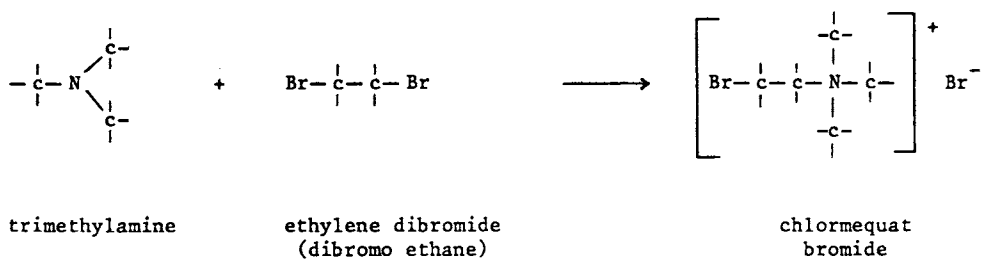
BROMIDE  
CHLORIDE

Uses: growth regulator, oats, rye, wheat

Trade names: Cycocel (Cyanamid)

Type: quaternary ammonium

### Synthesis:



## QUINONES

Naphthoquinone pesticides are synthesized either starting from naphthalene via chlorination and oxidation, or starting from naphthoquinone by chlorination.

These 2 basic routes are illustrated for dichlone.

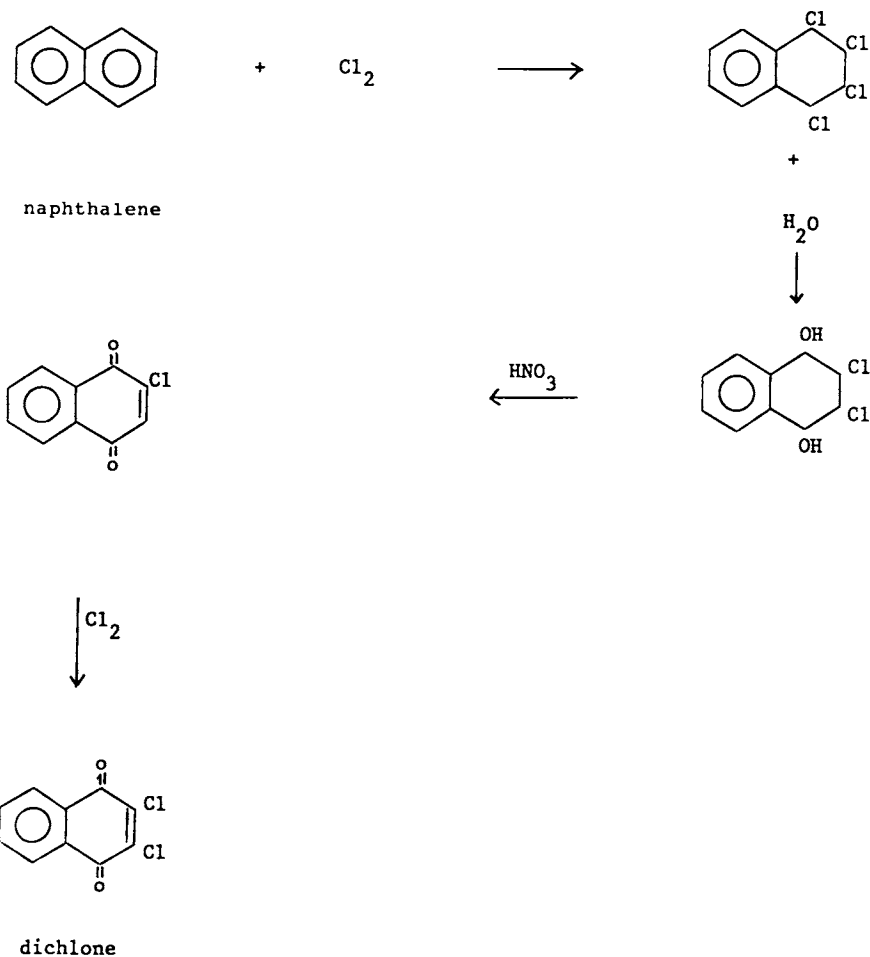
## Dichlone

Uses: fungicide, fruit

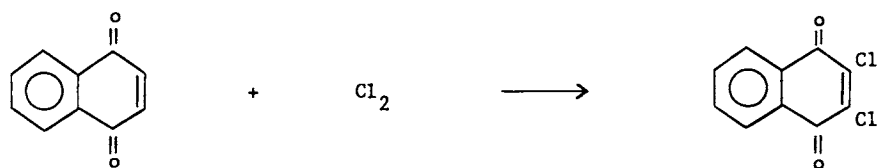
Trade names: Phygon (Uniroyal), Kolo (FMC)

Type: quinone

Synthesis:



alternate route :



1.4 naphtho quinone

dichlorone

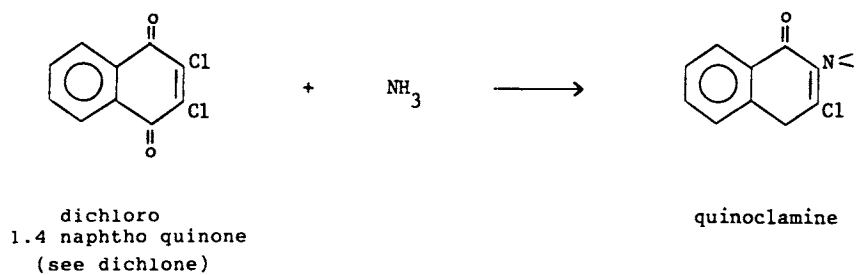
## Quinoclamine

Uses: herbicide, algicide, rice

Trade names: Mogeton (Agro Kanesho)

Type: quinone

Synthesis:



# SILANES

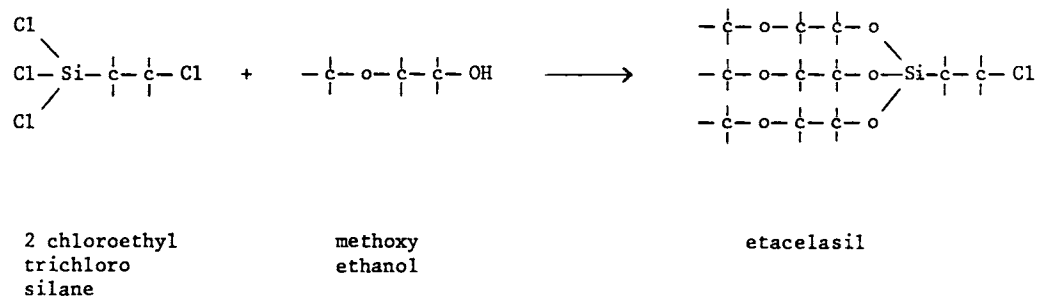
## Etacelasil

Uses: growth regulator, olives

Trade names: Alisol (Ciba)

Type: silane

Synthesis:



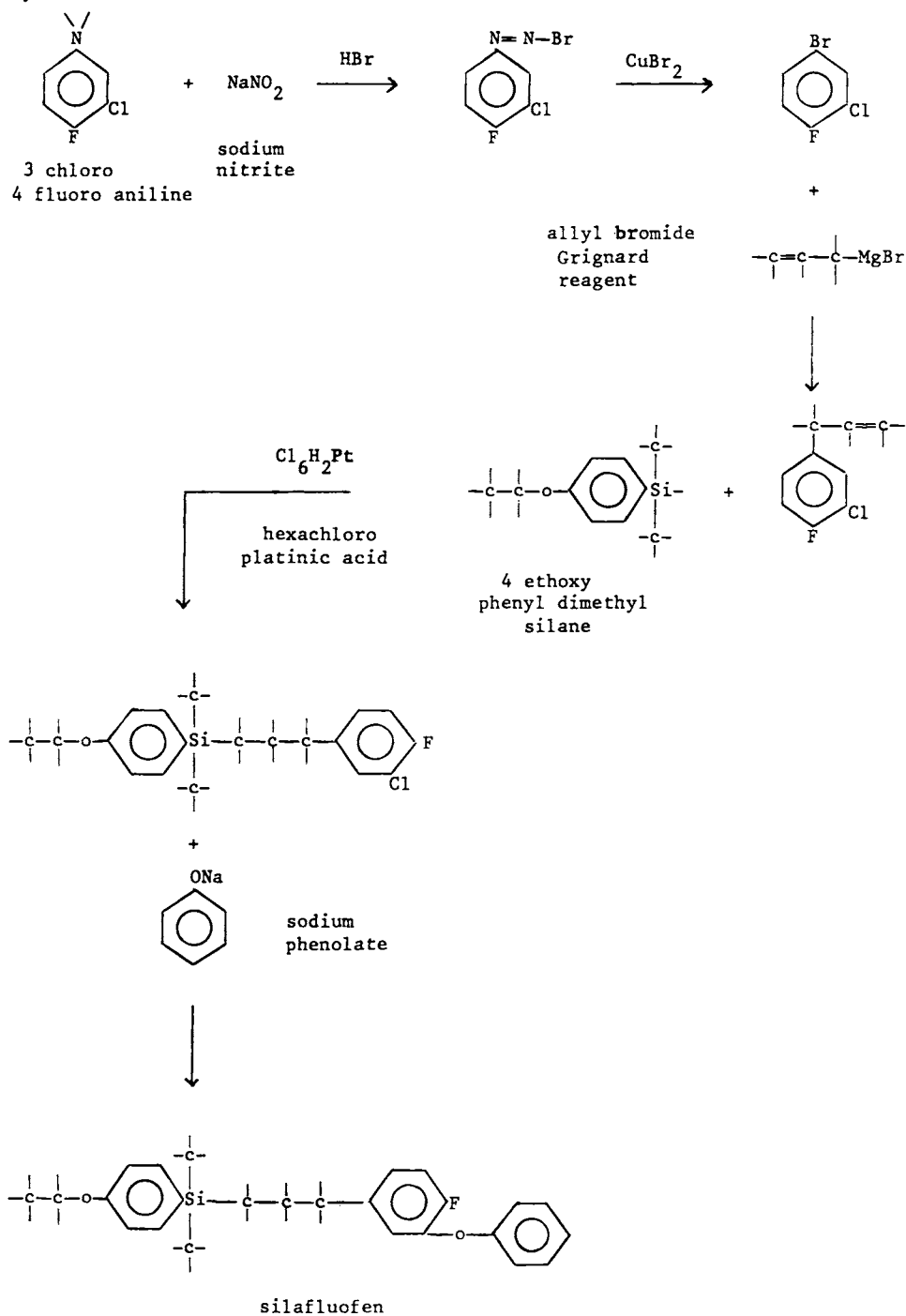
## Silafluofen

Uses: insecticide, lepidoptera and others

Trade names: Joker, Silatop (AgrEvo)

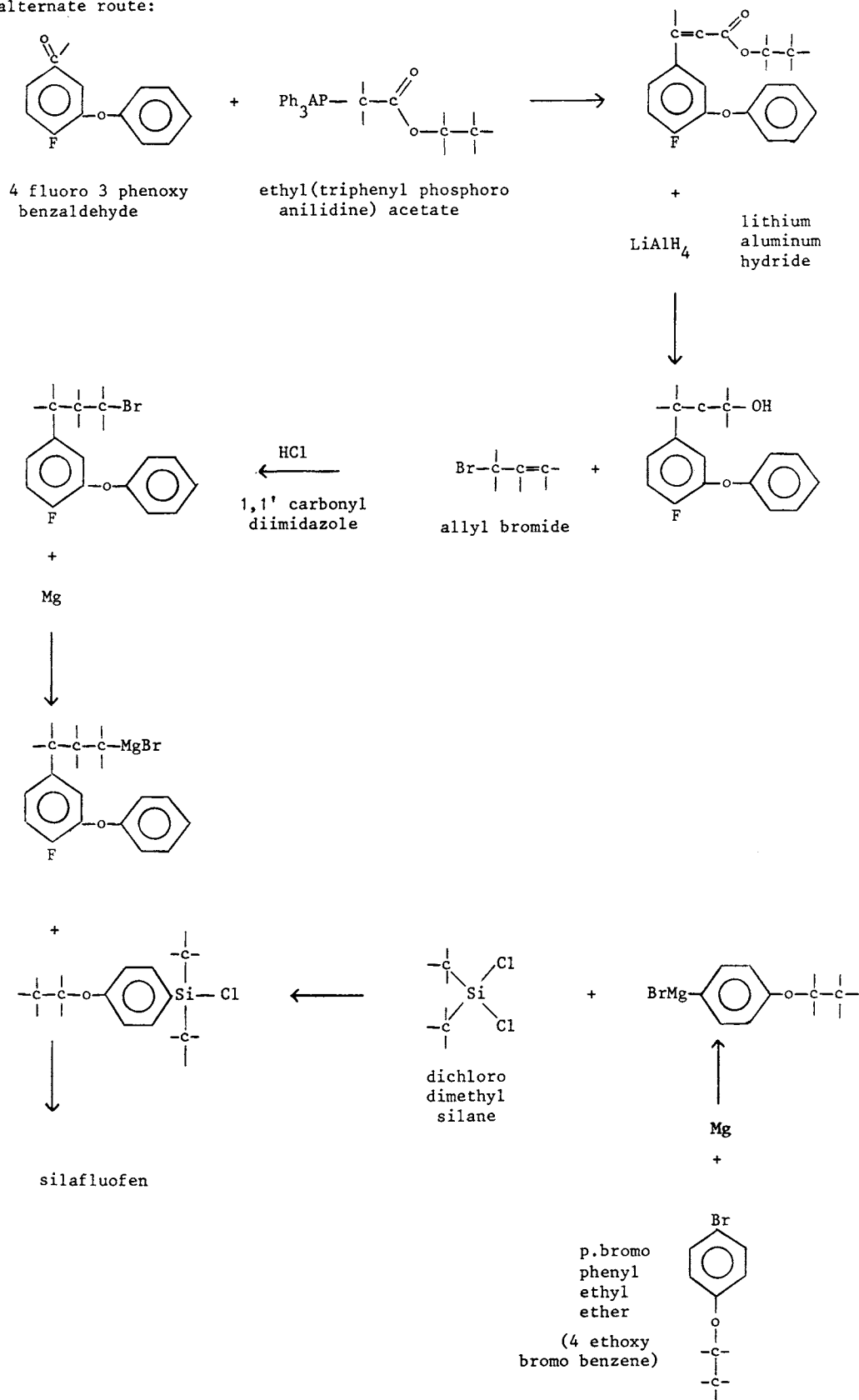
Type: silane, phenyl ether

Synthesis:

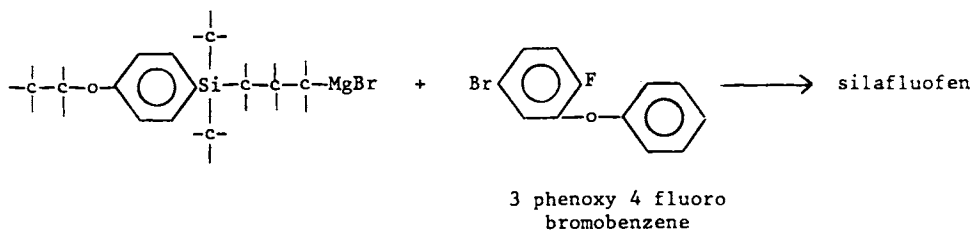




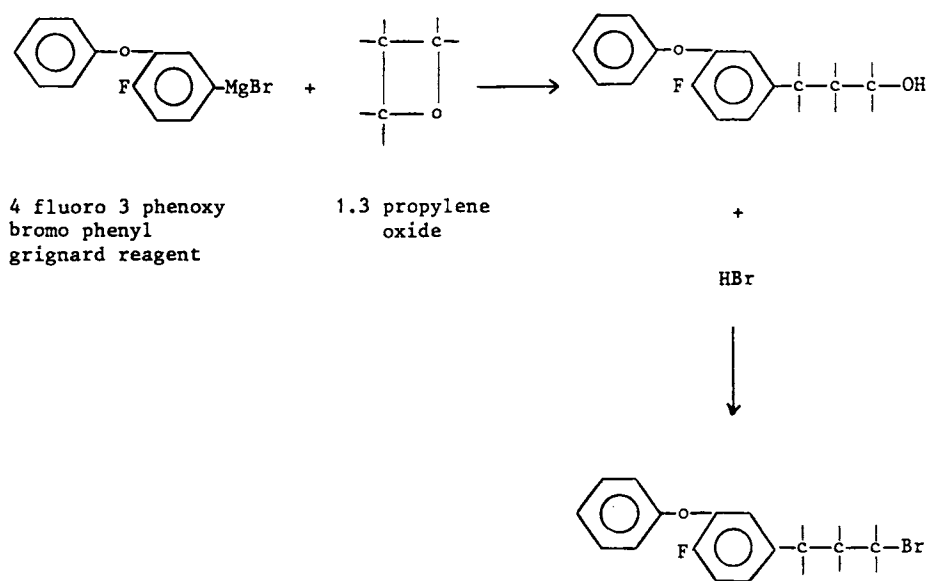
alternate route:



alternate route :



alternate route :



# SUGAR DERIVATIVES

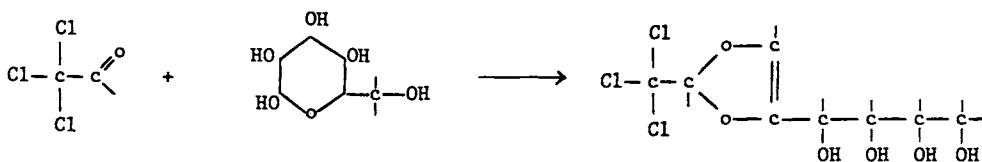
## Chloralose

Uses: rodenticide

Trade names: (Jewin-Joffe)

Type: glucose derivate

Synthesis:



chloral

glucose

chloralose

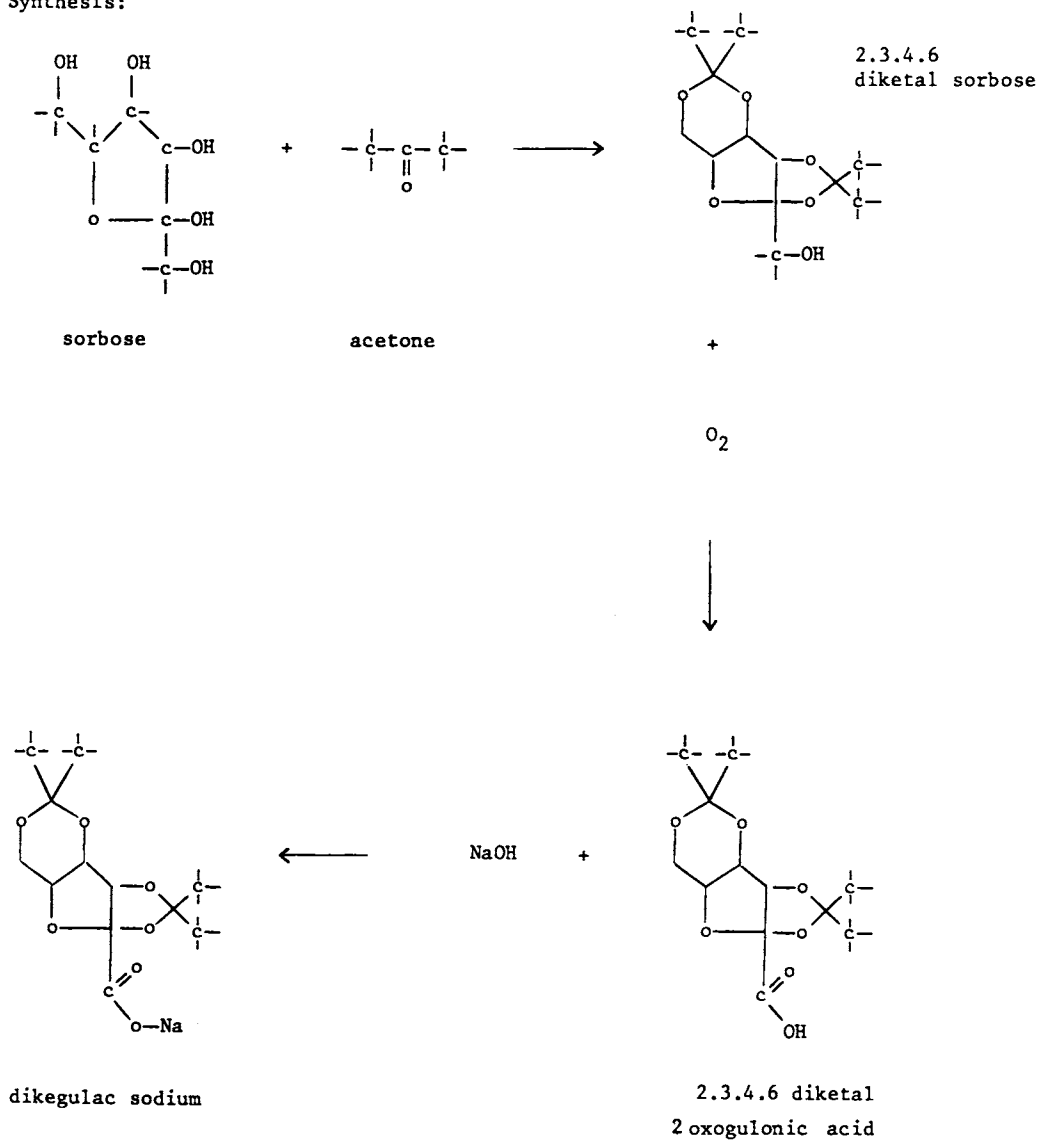
## Dikegulac-Sodium

Uses: growth regulator, hedges, ornamentals

Trade names: Atrinal (Ciba)

Type: sorbose

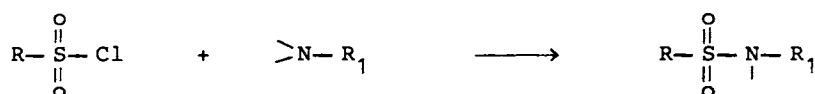
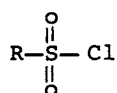
Synthesis:



# SULFONAMIDES

## SULFAMATES

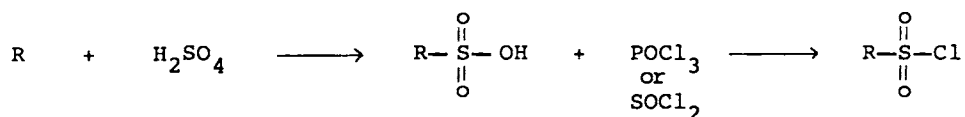
Sulfonamides are obtained by reaction between an alkyl sulfonyl chloride and an amine or ammonia



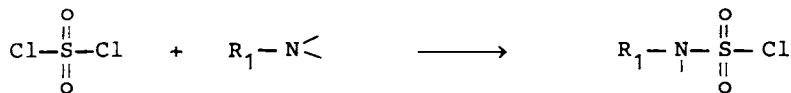
The alkyl sulfonyl chloride is usually synthesized using chlorosulfonic acid



Sulfonation followed by chlorination also leads to a chlorosulfone



Sulfonamides are also obtained by reaction between sulfuryl chloride or methane sulfonic acid and an amine or ammonia



In addition to the sulfonamides listed in the index, all sulfonyl ureas also contain the sulfonamide moiety.

Sulfamates are prepared by reaction between an alkyl sulfamoyl chloride and an OH or ONa group.

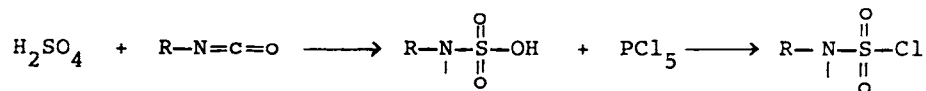


The sulfamoyl chloride may be obtained by the following routes:

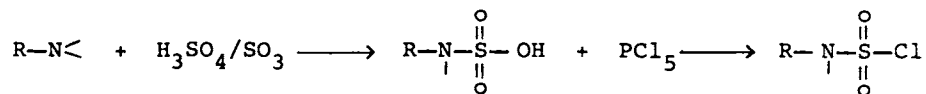
- reaction between chlorosulfonic acid and an amine



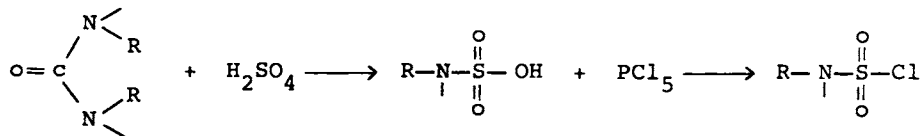
- sulfonation of an isocyanate followed by chlorination



- sulfonation of an amine followed by chlorination



- sulfonation of a urea followed by chlorination



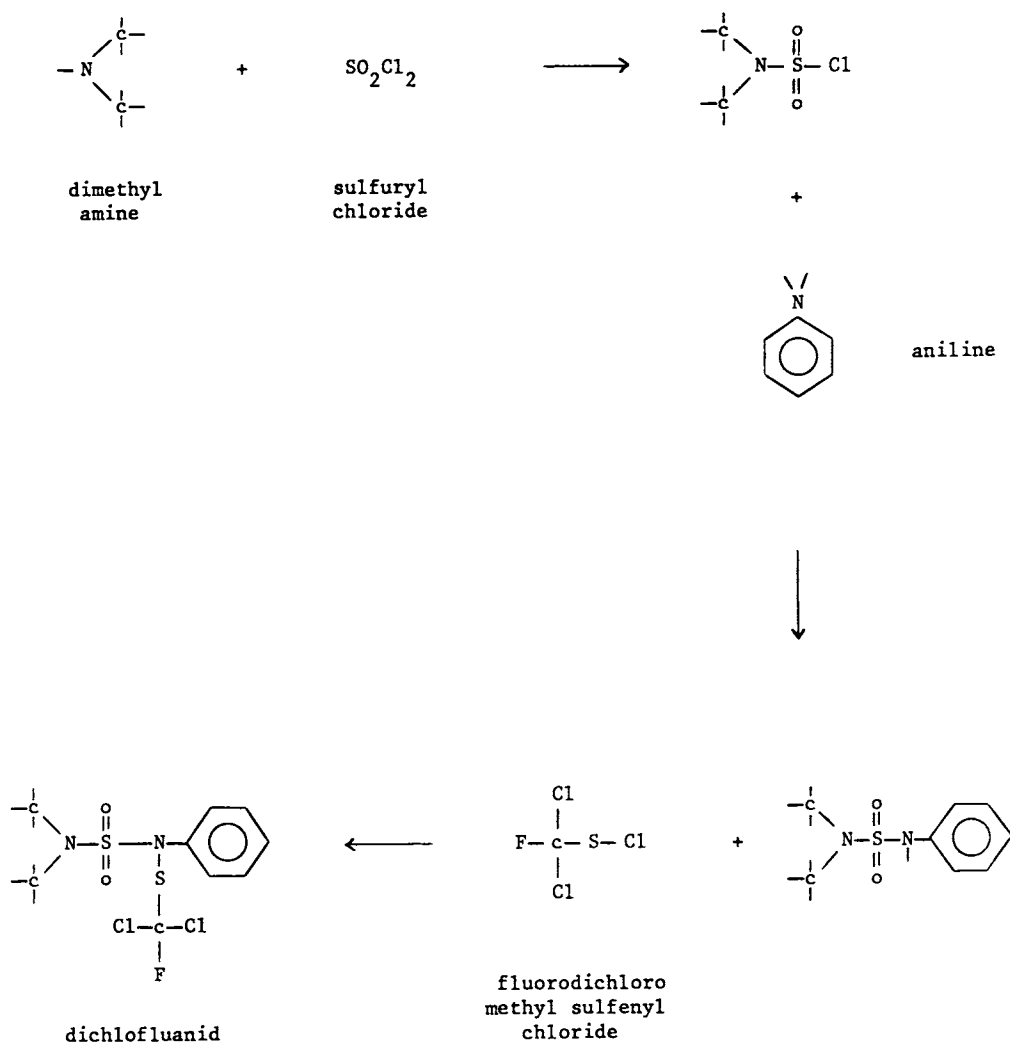
## Dichlofluanid

Uses: fungicide, fruit, timber

Trade names: Euparen, Elvaron (Bayer)

Type: sulfonamide

Synthesis:



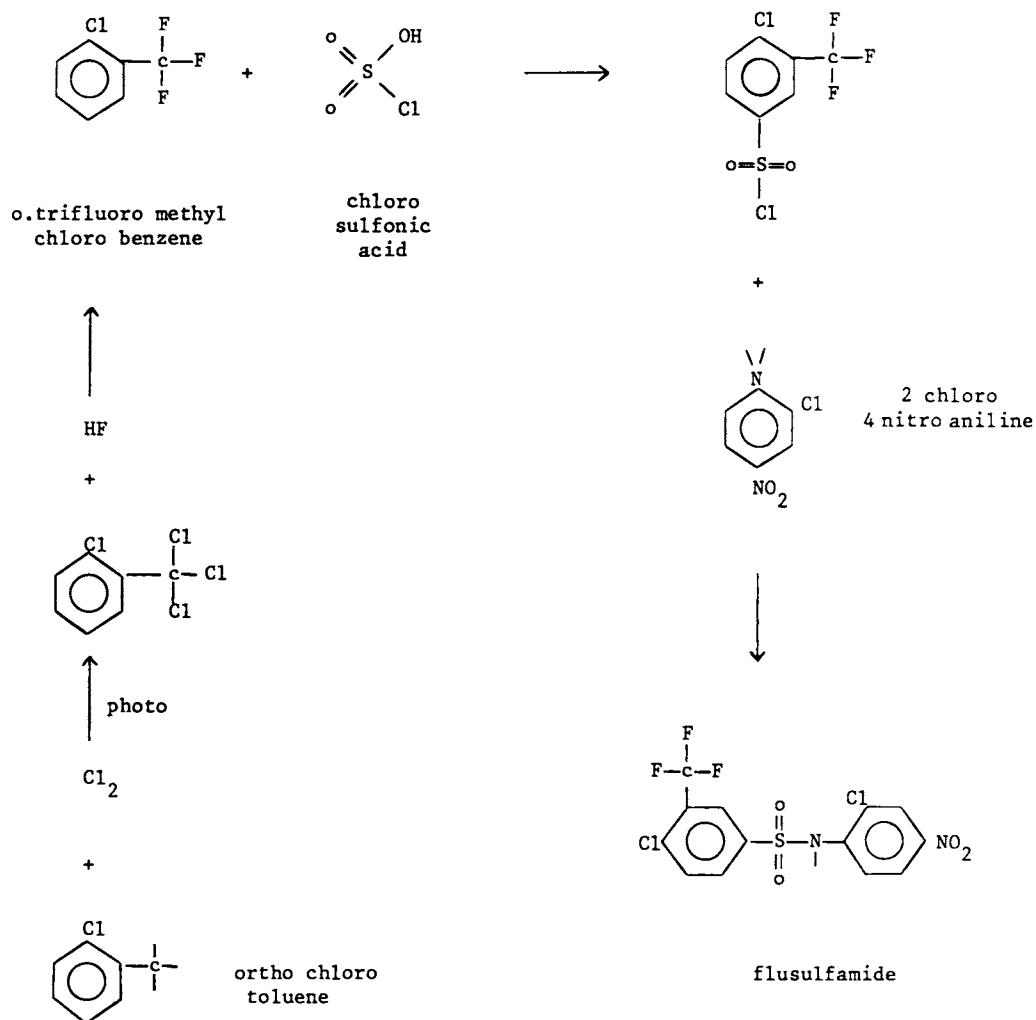
## Flusulfamide

Uses: fungicide, sugar beet

Trade names: Nebijin (Mitsui)

Type: sulfonamide

Synthesis:





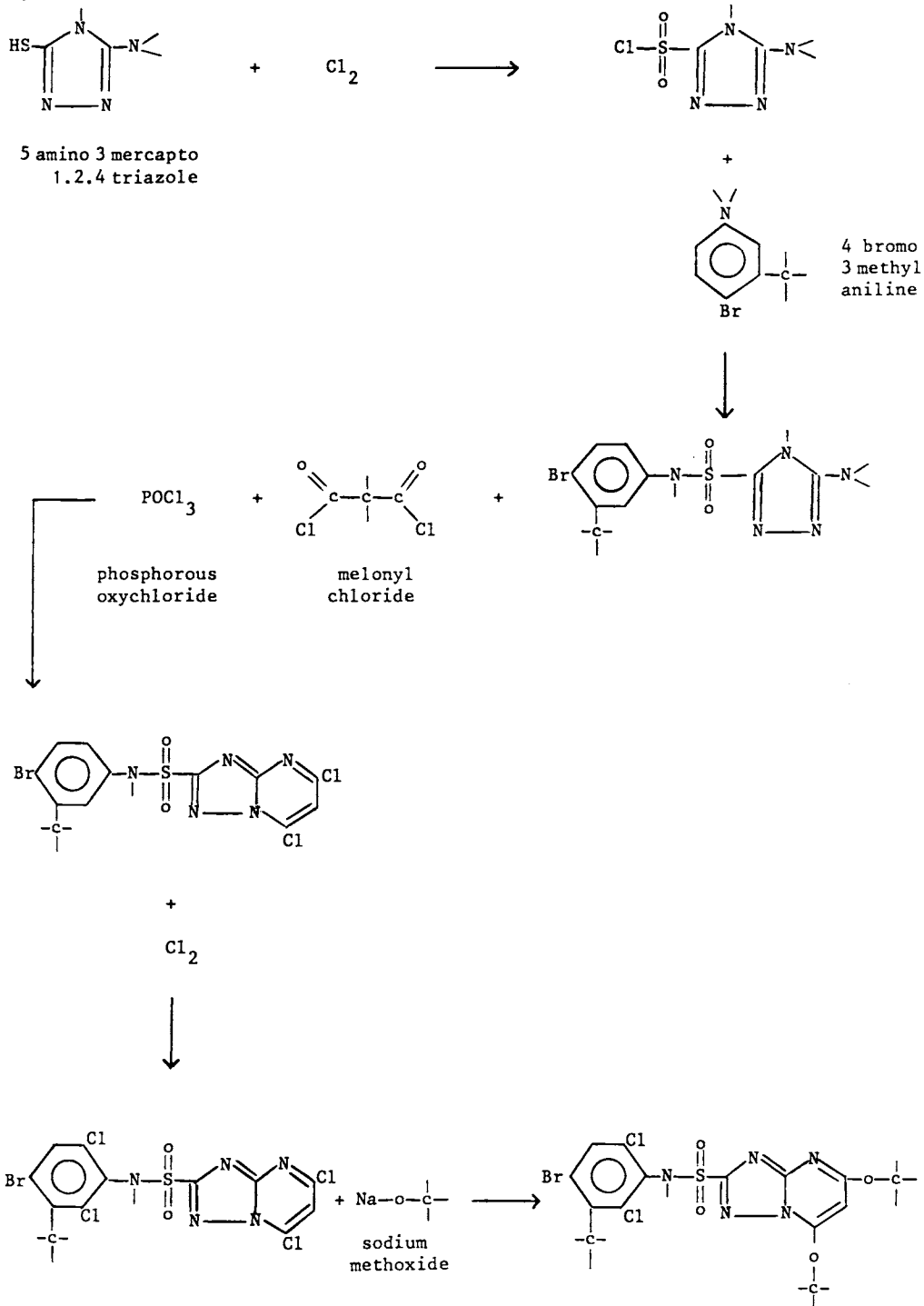
## Metosulam

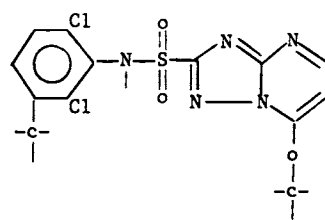
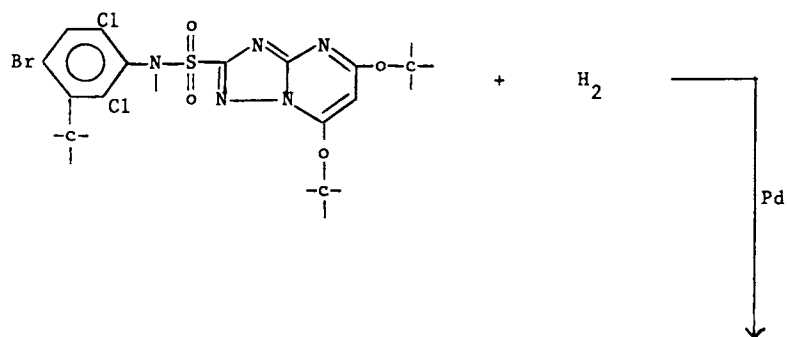
Uses: herbicide, wheat, cereals

Trade names: Pronto (Dow Elanco)

Type: sulfonamide, triazole, pyrimidine

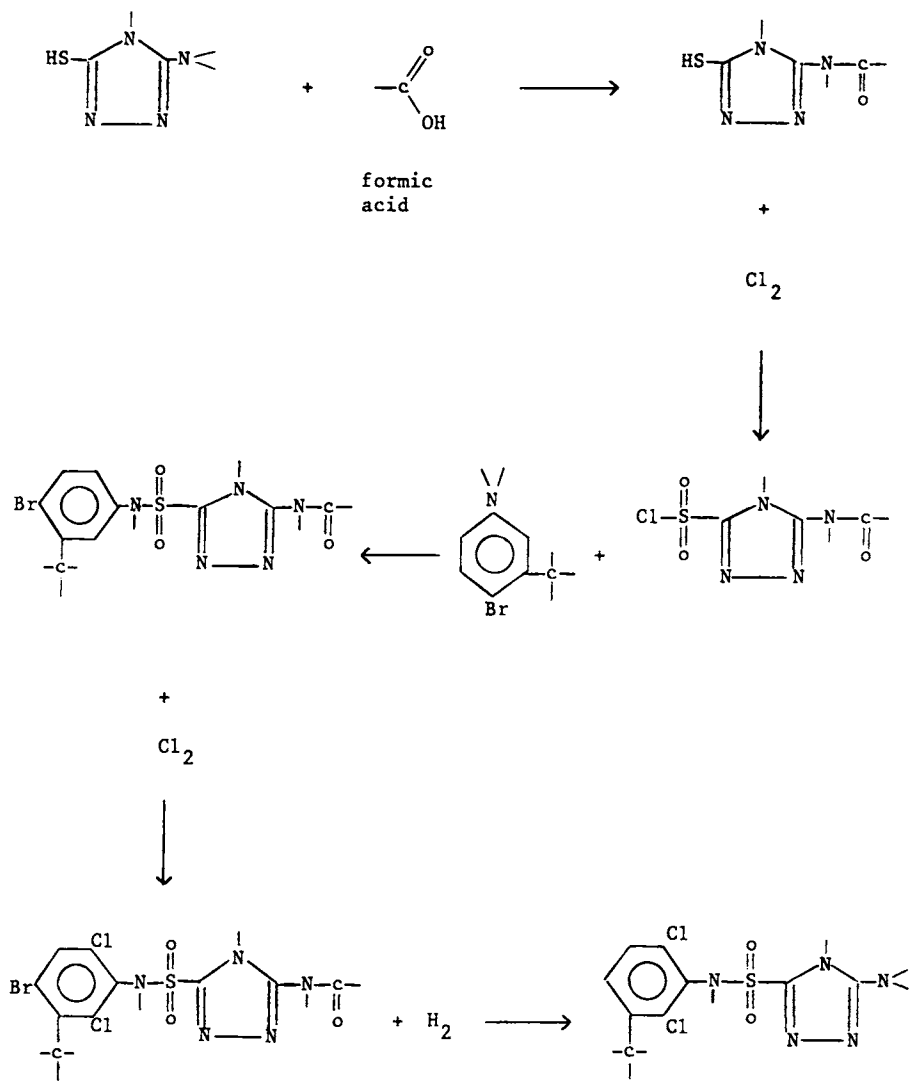
Synthesis:





metosulam

alternate route :



followed by condensation with melonyl dichloride in the presence of phosphorous oxychloride, and reaction with sodium methoxide as in the other route.

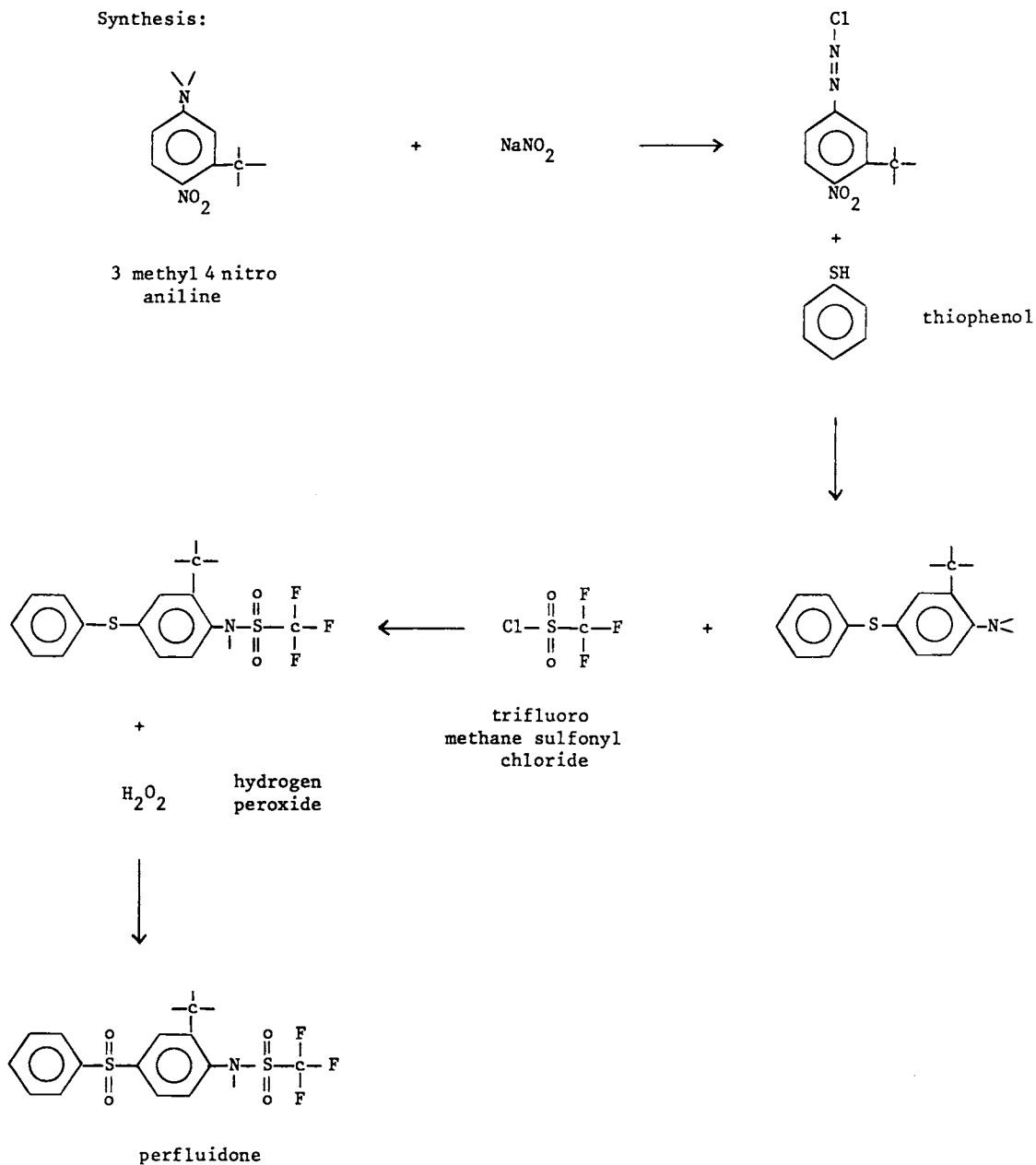
## Perfluidone

Uses: herbicide, cotton, tobacco, turf, sugarcane, rice, ground nuts

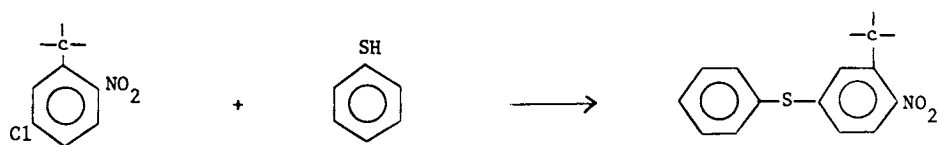
Trade names: Destun (3M)

Type: sulfonamide, sulfone

Synthesis:



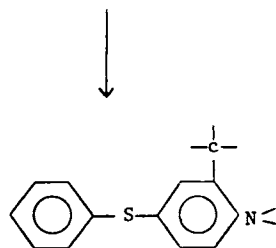
alternate route :



2 nitro  
5 chloro  
toluene

+

H<sub>2</sub>



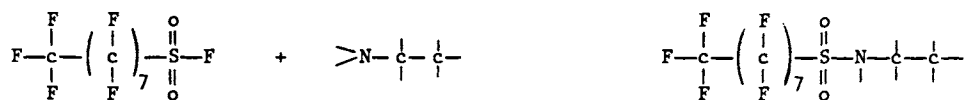
## Sulfluramid

Uses: insecticide, household

Trade names: Finitron, Mirex (Griffin)

Type: sulfonamide

Synthesis:



perfluoro octane  
sulfonyl fluoride

ethyl  
amine

sulfluramid

## Tolyfluanid

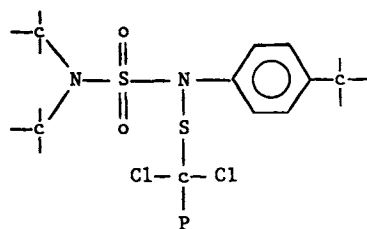
Uses: fungicide, fruit

Trade names: Euparen M (Bayer)

Type: sulfonamide

Synthesis:

Same as for dichlofluanid using p.toluidine instead of aniline



tolyfluanid

## SULFONATES—SULFONES—SULFITES

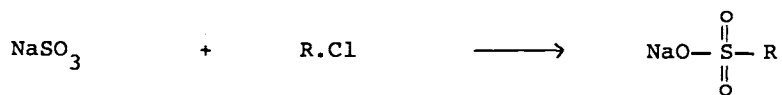
Sulfonate, sulfone and sulfite functions usually play a secondary role in pesticide activity. Thus many pesticides with these functions have also another main function which gives the molecule its characteristic activity.

### Sulfonates

$\begin{array}{c} \text{O} \\ || \\ -\text{S}-\text{O}- \\ || \\ \text{O} \end{array}$ 
 are synthesized by reaction between an alkyl sulfonyl chloride (see sulfonamides) and ROH



An unusual route is by reaction between sodium sulfite and R-Cl



Sulfonic acids are obtained by direct sulfonation

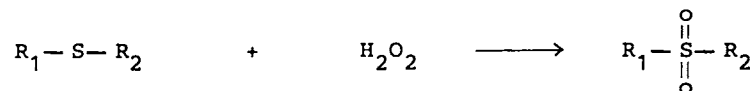




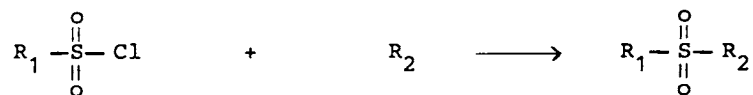
Sulfones

$\begin{array}{c} \text{O} \\ || \\ -\text{S}- \\ || \\ \text{O} \end{array}$ 
 are obtained by the following routes:

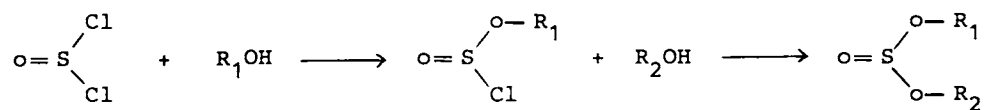
- oxidation of a sulfide by  $\text{H}_2\text{O}_2$  or peracetic acid



- reaction between an alkyl sulfonyl chloride and a hydrocarbon

Sulfites

$\begin{array}{c} \text{O}^- \\ \diagup \\ \text{O}=\text{S} \\ \diagdown \\ \text{O}^- \end{array}$ 
 are obtained by the action of thionyl chloride on ROH



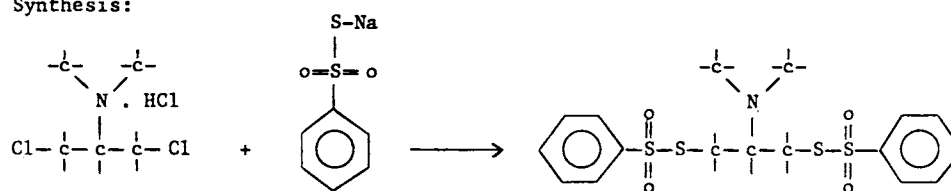
## Bensultap

Uses: insecticide, potatoes, rice, cereals

Trade names: Bancol, Victenon, ZZ-Doricida (Takeda)

Type: thiosulfonate

Synthesis:



2 dimethyl amino  
1,3 dichloro propane  
hydrochloride

sodium  
phenyl  
thiosulfonate

bensultap

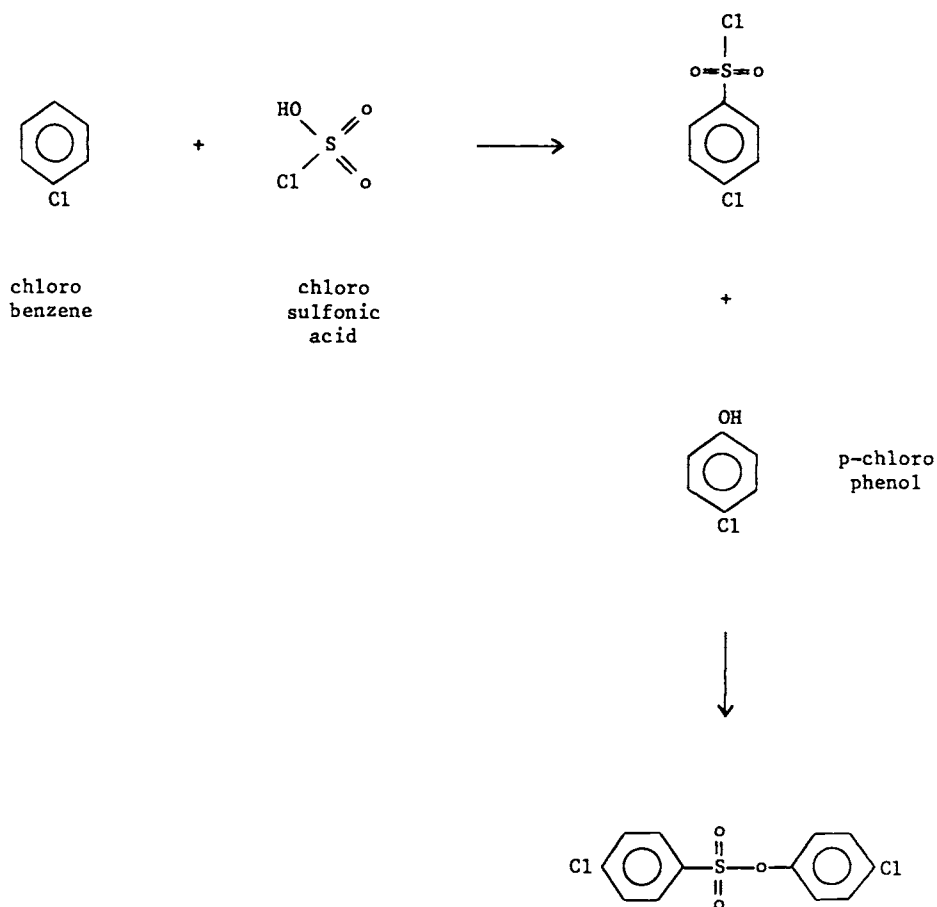
## Chlorfenson

Uses: acaricide, citrus, vines, nuts, cotton, vegetables

Trade names: Ovex (FMC), Orotran (Dow), Sappiran (Nippon)

Type: sulfonate

Synthesis:



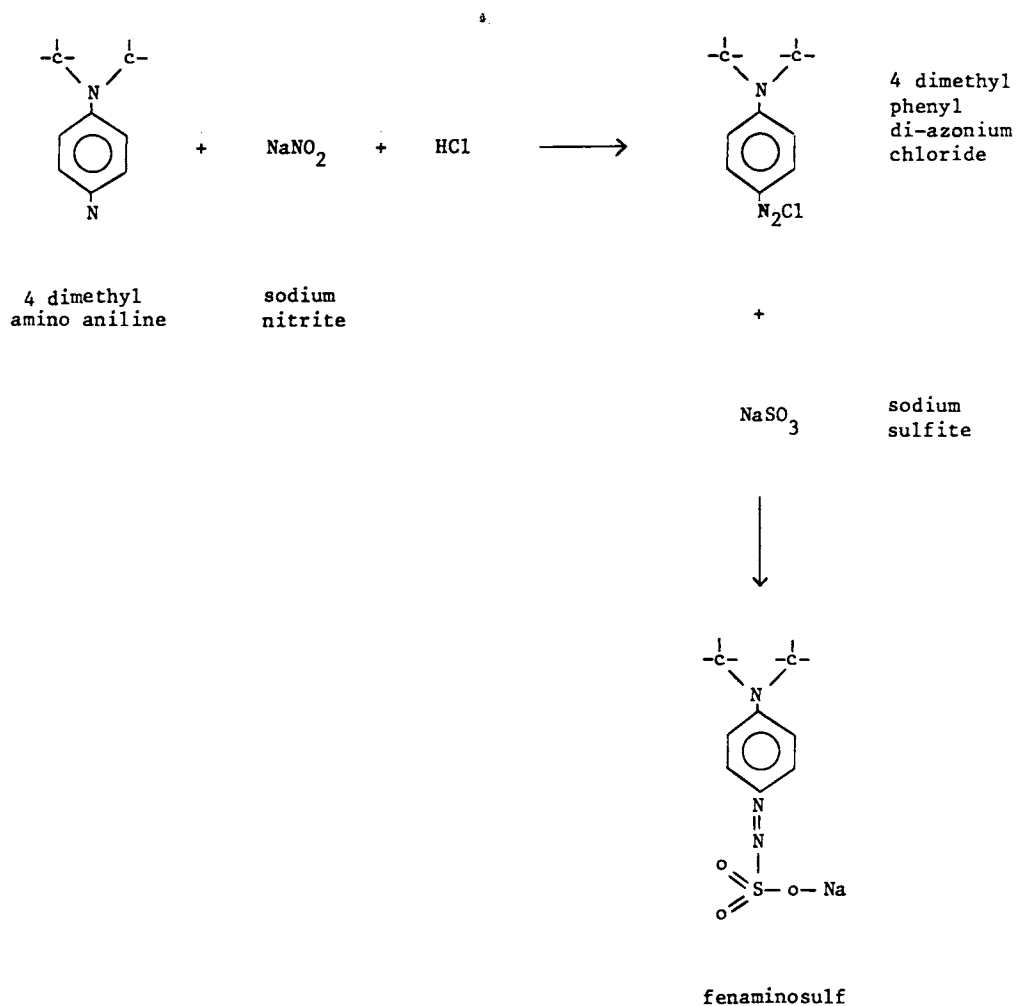
## Fenaminosulf

Uses: fungicide, cotton, maize, sorghum, sugarcane, beet, cucumbers

Trade names: Lesan (Bayer)

Type: diazosulfonate

Synthesis:



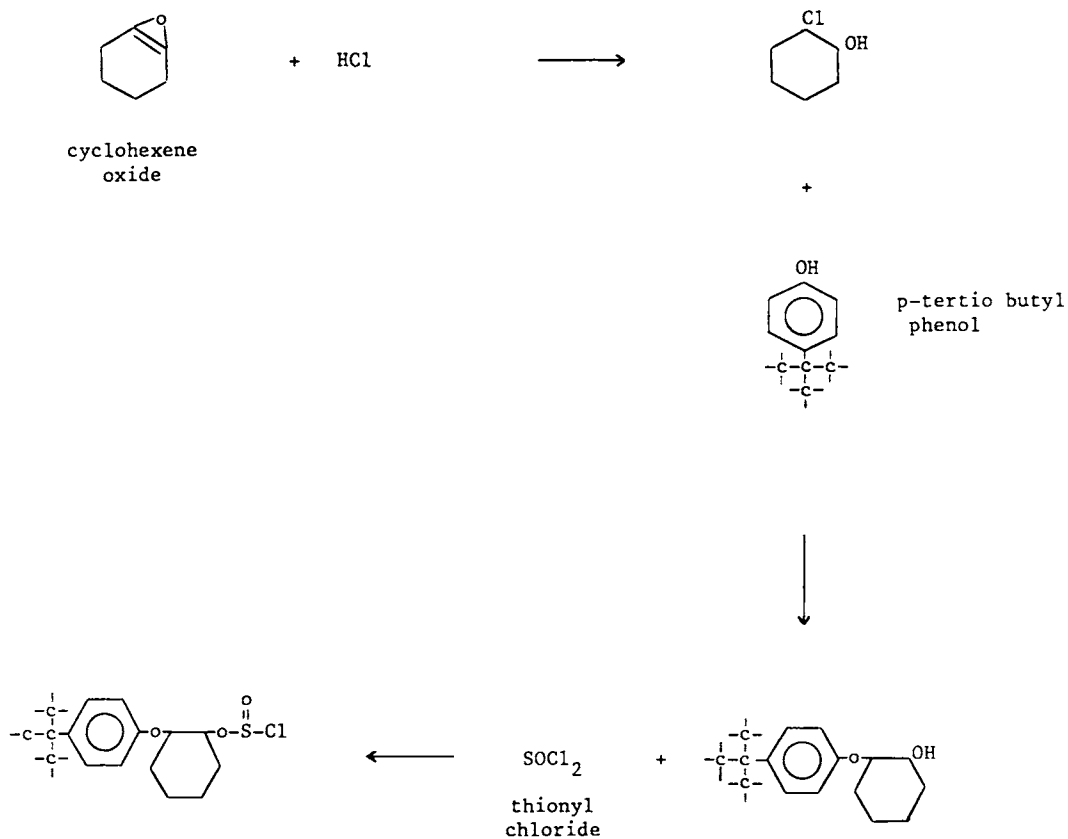
## Propargite

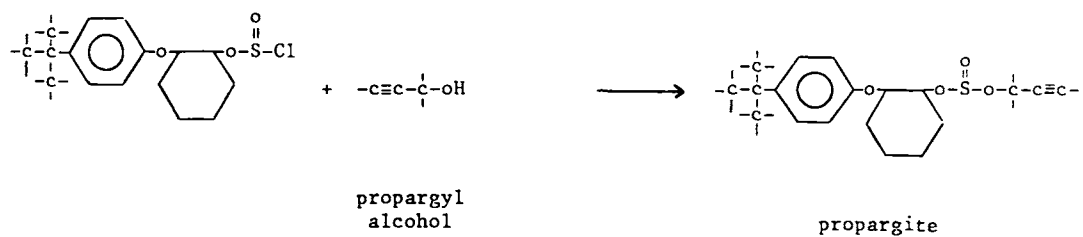
Uses : acaricide, fruits, maize, soyabean, tomatoes, nuts, cotton, also corn.  
alfafa, vegetables

Trade names : Uniroyal (Omite)

Type: sulfite

Synthesis:





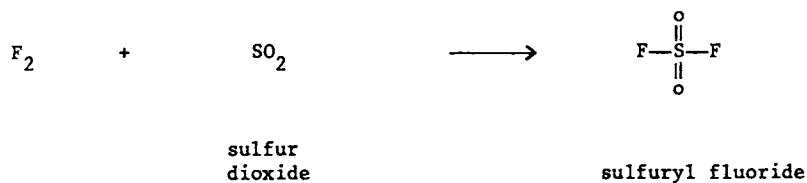
## Sulfuryl Fluoride

Uses: fumigant insecticide, structures, vehicles, wood products

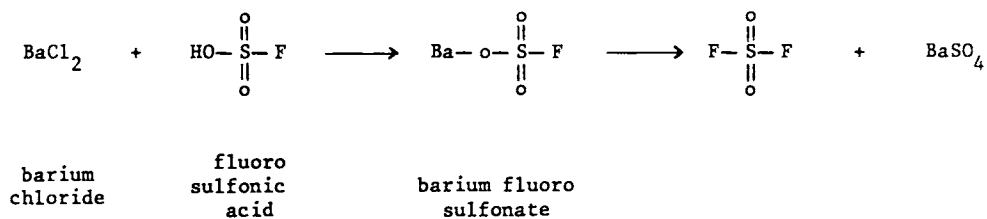
Trade names: Vibane (Dow Elanco)

Type: sulfone

Synthesis:



alternate route :



## OTHER TYPES

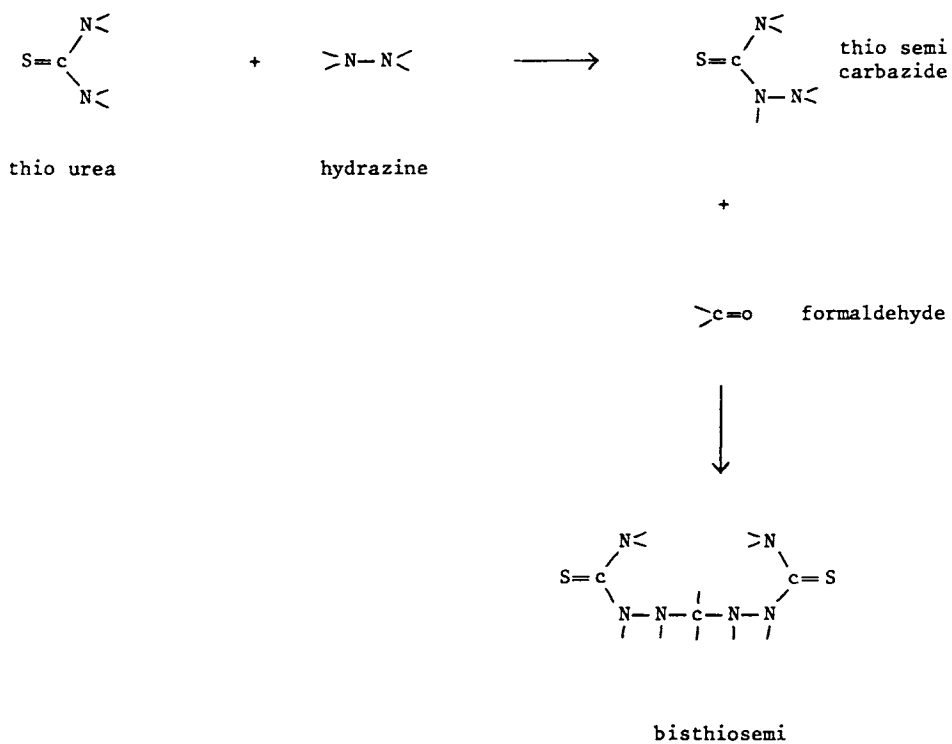
### Bisthiosemi

Uses: rodenticide

Trade names: Kayanex (Nippon)

Type: thiosemicarbazide

Synthesis:





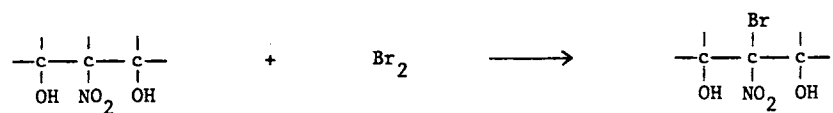
## Bronopol

Uses: bacteriostat, cotton, cooling towers

Trade names: Bronotak (Schering), Bronocot (ICI)

Type: nitrodiol

Synthesis:



nitropropane  
1,3 diol

bronopol

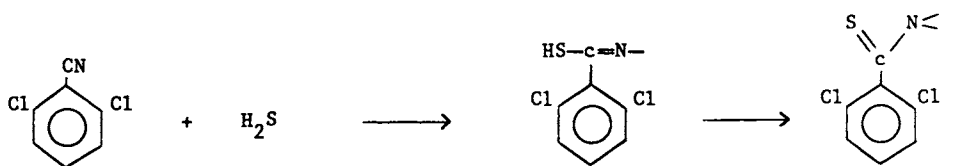
## Chlorthiamid

Uses: herbicide, fruit, olives, citrus, shrubs

Trade names: Prefix (Shell)

Type: thioamide

Synthesis:



2,6 dichloro  
benzonitrile

chlorthiamid

(2,6 dichloro  
phenyl cyanide)

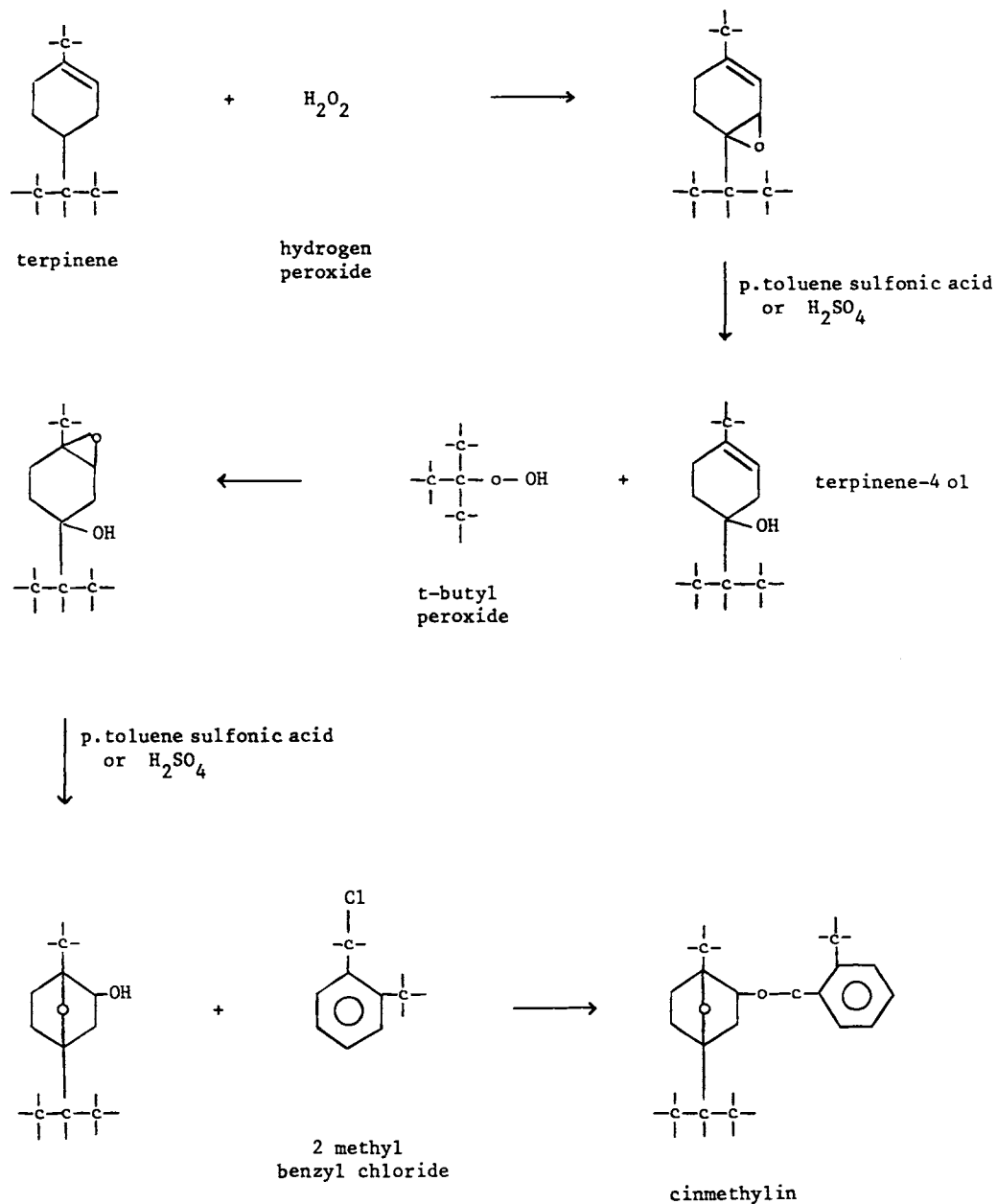
## Cinmethylin

Uses: herbicide, rice

Trade names: Argold (Shell), Cinch (Dupont)

Type: epoxy

### Synthesis



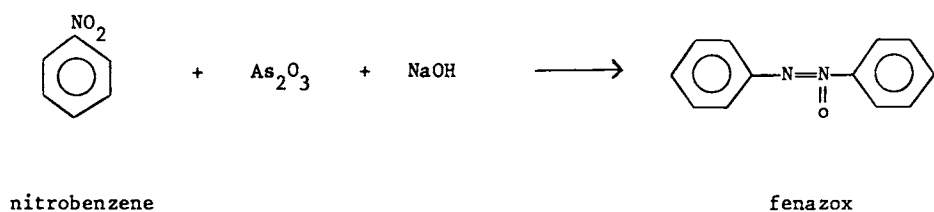
## Fenazox

Uses: acaricide, insecticide, fruit trees, soya beans, vine, vegetables

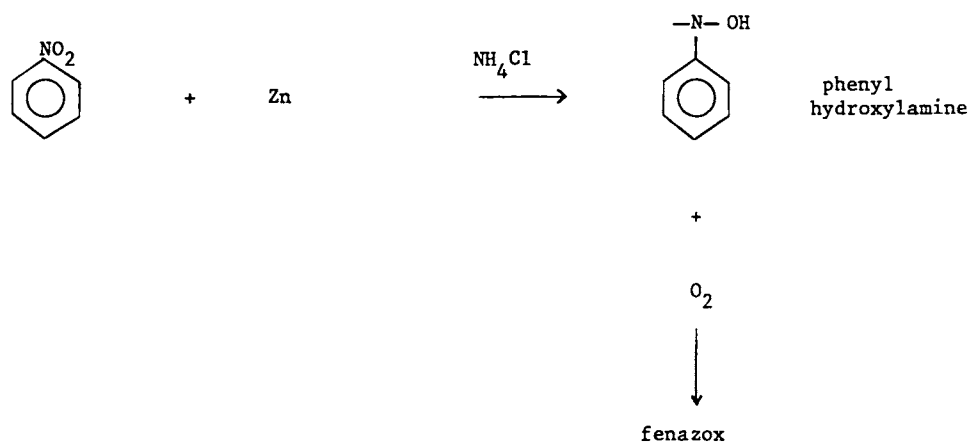
Trade names: Fentoxan (Fahlberg)

Type: azoxy

Synthesis:



alternate route :



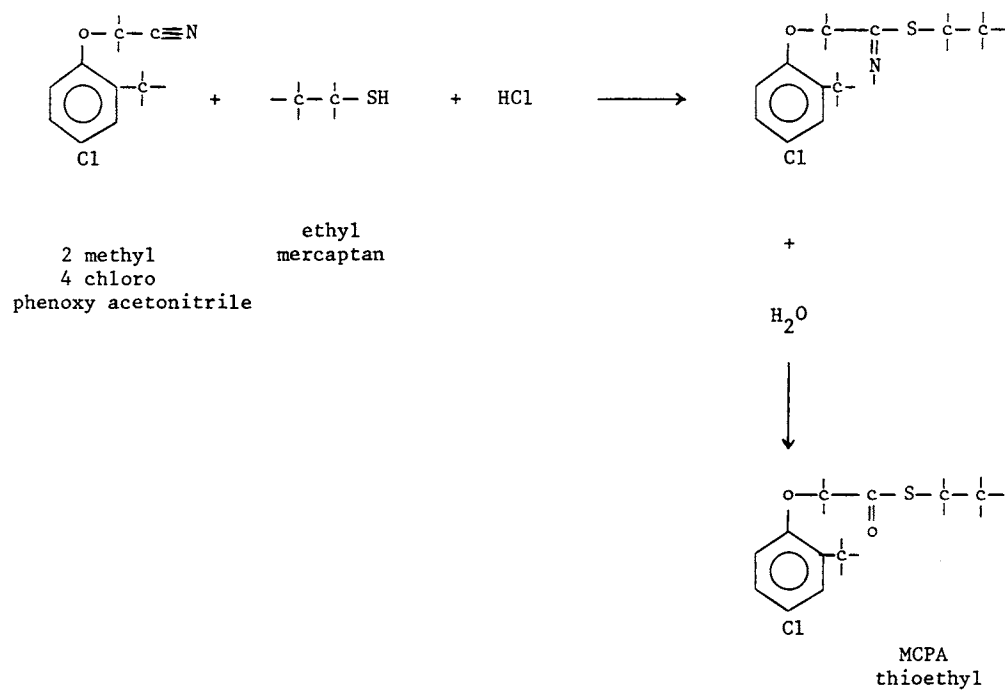
## MCPA-Thioethyl

Uses: herbicide, rice, wheat

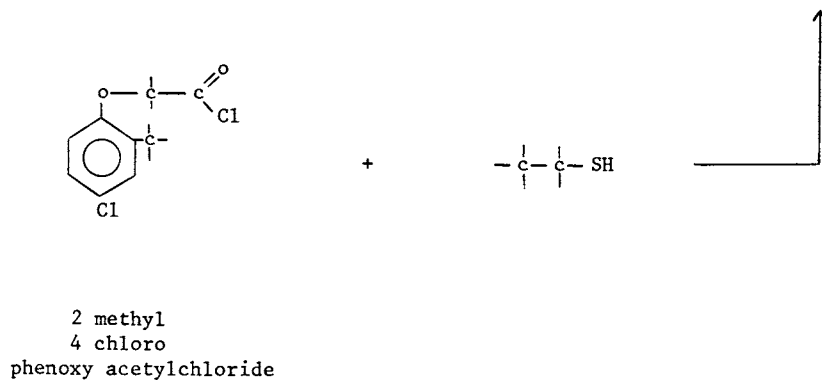
Trade names: Zero One, Herbit (Hokko)

Type: thioate

Synthesis:



alternate route :



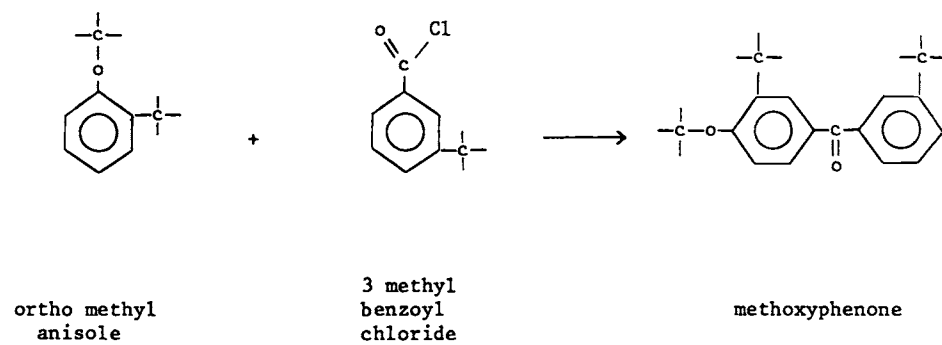
## Methoxyphenone

Uses: herbicide, rice, vegetables

Trade names: Kayametone (Nippon)

Type: phenyl ketone

Synthesis:



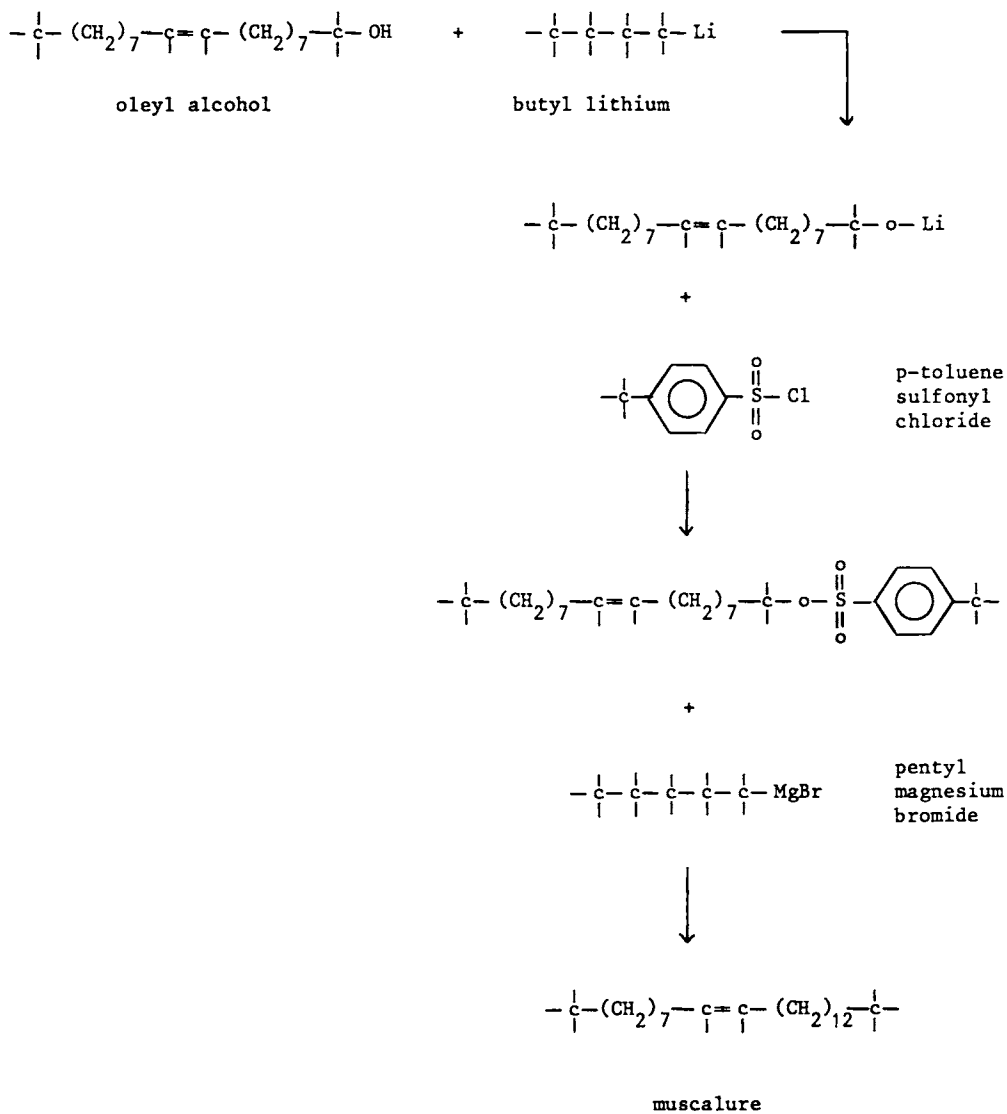
## Muscalure

Uses: insect pheromone, flies

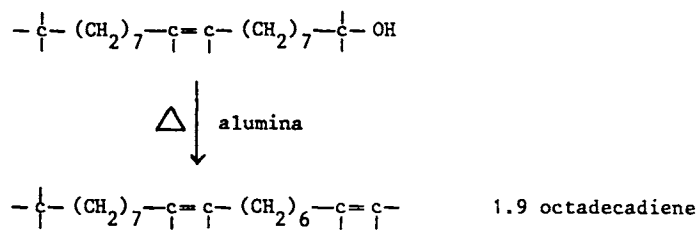
Trade names: Muscamone (Sandoz)

Type: cis-olefin

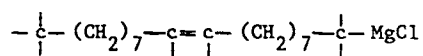
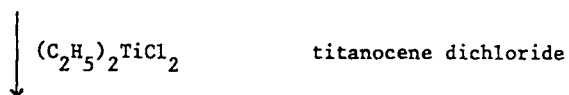
**Synthesis:**



alternate route :



+



+



muscalure



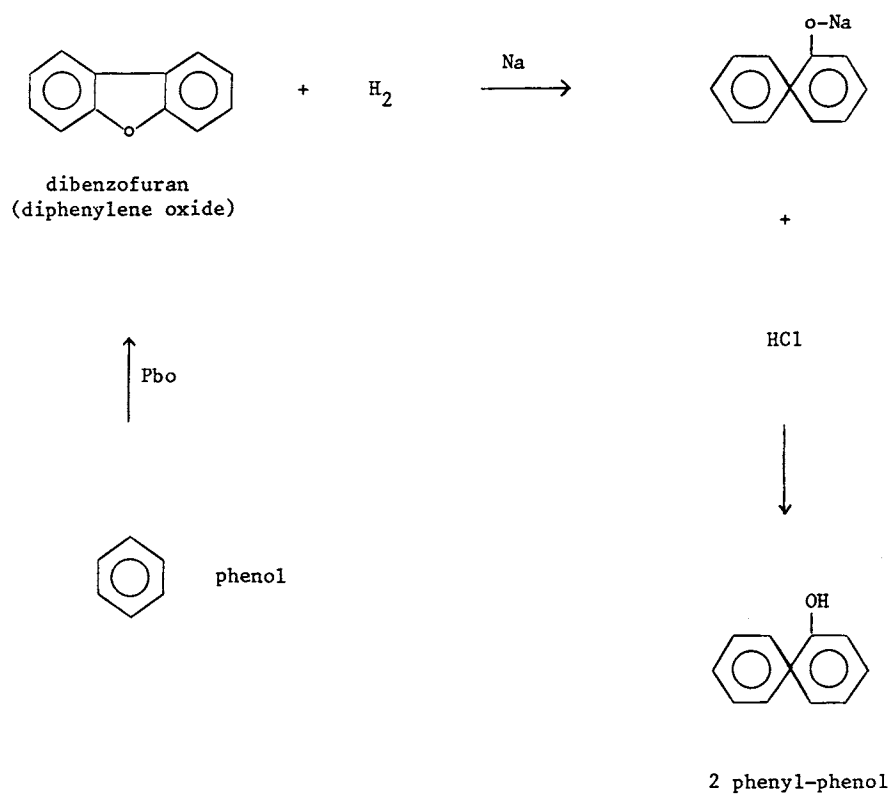
## 2 Phenyl-Phenol

Uses: fungicide, apple trees, seed, wrappers

Trade names:

Type: diphenyl

Synthesis:



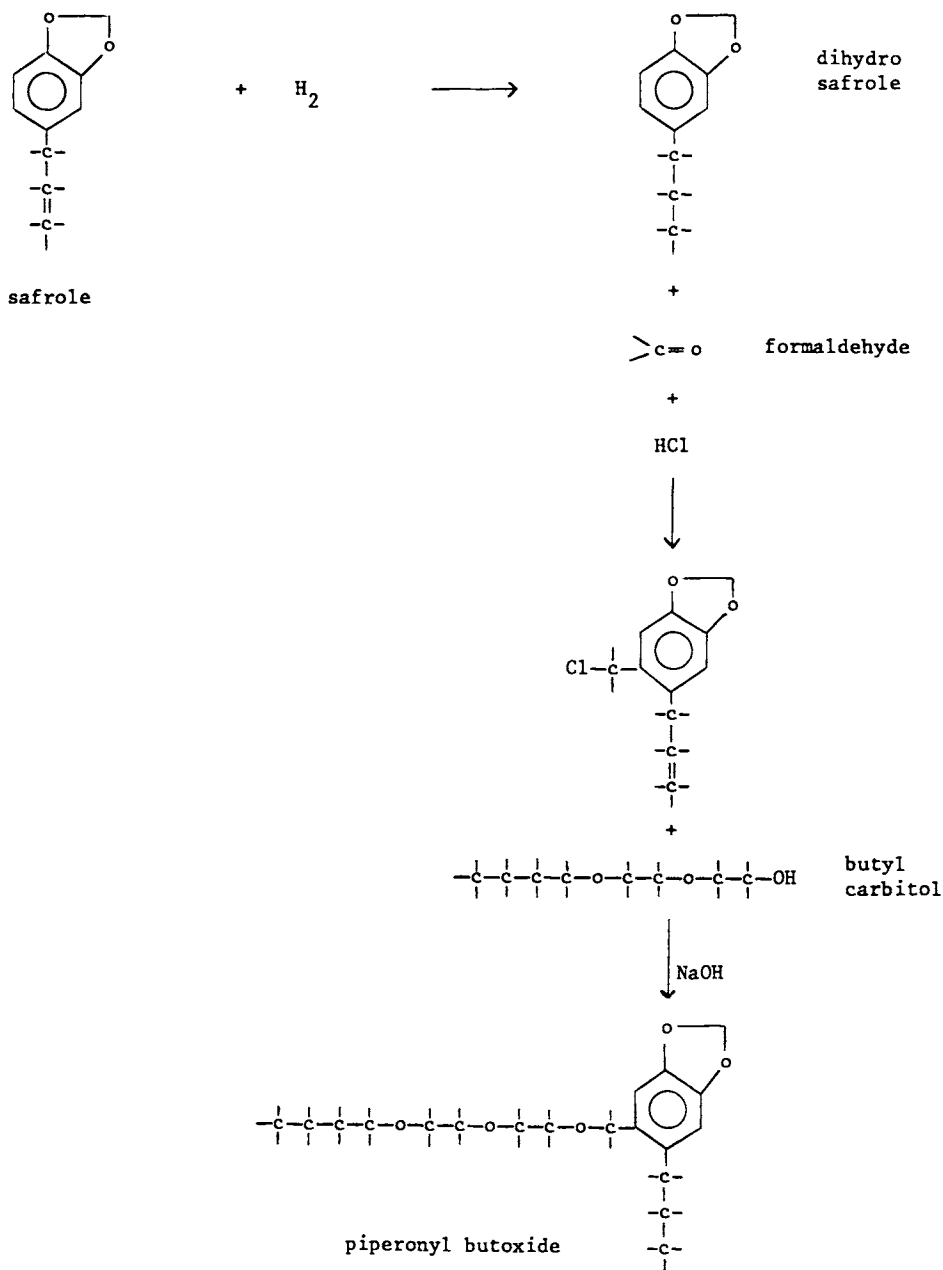
## Piperonyl Butoxide

Uses: insecticide, synergist for pyrethroids

Trade names:

Type: benzodioxole

Synthesis:



# APPENDIX I

## GENERIC NAMES

See PREFACE: *How to Use This Handbook*

Acephate: phosphoro organic, phosphoro amido thioate	Bensulide: phosphoro organic, phosphoro dithioate, sulfonamide
Acetochlor: amide	Bensultap: thiosulfonate
Acifluorfen-sodium: phenyl ether	Bentazone: heterocyclic nitrogen, thiadiazinone
Aclonifen: phenyl ether	Benthioncarb: see Thiobencarb
Acrinathrin: pyrethroid	Benzamizole: see Isoxaben
Alachlor: amide	Benzofenap: heterocyclic nitrogen, pyrazole
Alanycarb: oxime amide	Benzoximate: oxime
Aldicarb: oxime amide	Benzoylprop-ethyl: amide
Aldoxycarb: oxime amide	Benzthiazuron: heterocyclic nitrogen, benzothiazole, urea
Aldrin: halogenated hydrocarbon	BHC: see Lindane
Allethrin: pyrethroid	Bifenox: phenyl ether
Allidochlor: amide	Bifenthrin: pyrethroid
Alloxydim: oxime	Binapacryl: dinitrophenol derivative
Ametryn: heterocyclic nitrogen, triazine	Bioresmethrin: pyrethroid
Amidosulfuron: sulfonyl urea	Bisthiosemi: (other) thiosemicarbazide
Aminocarb: carbamate	Bitertanol: heterocyclic nitrogen, triazole
Amitraz: amidine	Brodifacoum: coumarin
Amitrole: heterocyclic nitrogen, triazole	Bromacil: heterocyclic nitrogen, pyrimidinedione
Ampropylfos: phosphoro organic, phosphonic acid	Bromadiolone: coumarin
Ancymidol: heterocyclic nitrogen, pyrimidine	Bromethalin: dinitroaniline
Anilazine: heterocyclic nitrogen, triazine	Bromobutide: amide
Anilofos: phosphoro organic, phosphoro dithioate	Bromofenoxim: oxime
ANTU: thiourea	Bromophos: phosphoro organic, phosphoro thioate
Asulam: carbamate, sulfonamide	Bromopropylate: halogenated aromatic carboxylic acid
Atrazine: heterocyclic nitrogen, triazine	Bromoxynil: halogenated aromatic
Azaconazole: heterocyclic nitrogen, triazole	Bromuconazole: heterocyclic nitrogen, triazole, furan
Azamethiphos: oxazole, phosphoro organic, phosphoro thioate, pyridine	Bronopol: (other) nitrodiol
Azinphos-ethyl: benzotriazine, phosphoro organic, phosphoro dithioate	Bupirimate: heterocyclic nitrogen, pyrimidine, sulfamate
Azinphos-methyl: benzotriazine, phosphoro organic, phosphoro dithioate	Buprofezin: heterocyclic nitrogen, thiadiazinone
Aziprotryne: heterocyclic nitrogen, triazine	Butachlor: amide
Azocyclotin: organo tin, triazole	Butamifos: phosphoro organic, phosphoro amido thioate
Barban: carbamate	Butenachlor: amide
Benalaxyl: amide	Buthiobate: heterocyclic nitrogen, pyridine
Benazolin: heterocyclic nitrogen, benzothiazoline, carboxylic acid	Butocarboxim: oxime amide, sulfone
Bendiocarb: carbamate	Butoxycarboxim: oxime amide
Benefin: see Benfluralin	Butralin: dinitroaniline
Benfluralin: dinitroaniline	Butylate: thiocarbamate
Benfuracarb: carbamate, benzofuran	Cacodylic acid: organo arsenic
Benfuresate: benzofuran, sulfonate	Cadusafos: phosphoro organic, phosphoro dithioate
Benodanil: amide	Camphechlor: chlorinated hydrocarbon
Benomyl: heterocyclic nitrogen, benzimidazole, carbamate	Captafol: heterocyclic nitrogen, indoleione
Benoxacor: heterocyclic nitrogen, benzoxazine, amide	Captan: heterocyclic nitrogen, indoleione
Bensulfuron-methyl: sulfonyl urea	Carbaryl: carbamate

- Carbendazim: carbamate, benzimidazole  
 Carbetamide: carbamate  
 Carbofuran: carbamate, benzofuran  
 Carbophenothion: phosphoro organic, phosphoro dithioate  
 Carbosulfan: carbamate, benzofuran  
 Carboxin: oxathiin, amide  
 Cartap: thiocarbamate  
 CDAA: see Allidochlor  
 Chinomethionat: dithiin, heterocyclic nitrogen, quinoxaline  
 Chlomethoxyfen: phenyl ether  
 Chloralose: sugar derivate  
 Chloramben: halogenated aromatic, carboxylic acid  
 Chlorbromuron: urea  
 Chlorbufam: carbamate  
 Chlordane: halogenated hydrocarbon  
 Chlordimeform: amidine  
 Chloretoxyfos: phosphoro organic, phosphorothioate  
 Chlorfenac: halogenated aromatic acid  
 Chlorfenson: sulfonate  
 Chlorfenvinfos: phosphoro organic, phosphoro ester  
 Chlorfluazuron: urea  
 Chlorflurecol-methyl: see Chlorflurenol-methyl  
 Chlorflurenol-methyl: carboxylic acid  
 Chloridazon: heterocyclic nitrogen, pyridazinone  
 Chlorimuron: sulfonyl urea  
 Chlormephos: phosphoro organic, phosphoro dithioate  
 Chlormequat chloride: quaternary ammonium  
 Chlornitrofen: phenyl ether  
 Chlorobenzilate: halogenated aromatic acid  
 Chloromethiuron: thiourea  
 Chloroneb: halogenated aromatic  
 Chlorophacinone: indiane dione  
 Chloropicrin: halogenated hydrocarbon  
 Chloropropylate: halogenated aromatic acid  
 Chlorothalonil: halogenated aromatic  
 Chlorotoluron: urea  
 Chloroxuron: urea, phenyl ether  
 Chlorphonium chloride: phosphoro organic, phosphonate  
 Chlorphoxim: phosphoro organic, phosphoro thioate, oxime  
 Chlorpropham: carbamate  
 Chlorpyrifos: phosphoro organic, phosphoro thioate, pyridine  
 Chlorsulfuron: sulfonyl urea  
 Chlorthal-dimethyl: halogenated aromatic acid  
 Chlorthiamid: (other) thioamide  
 Chlozolate: heterocyclic nitrogen, oxazolidine dione  
 Cinmethylin: (other) epoxy  
 Cinosulfuron: sulfonyl urea  
 CIPC: see Chlopropham  
 Clethodim: oxime  
 Clodinafop: phenoxy carboxylic acid, phenyl ether, pyridine  
 Cloethocarb: carbamate  
 Clofentezine: heterocyclic nitrogen, tetrazine  
 Clomazone: heterocyclic nitrogen, oxazolidinone  
 Clomeprop: phenoxy carboxylic acid derivate, amide  
 Cloprop: phenoxy carboxylic acid  
 Clopyralid: heterocyclic nitrogen, pyridine  
 Cloquintocet: heterocyclic nitrogen, quinoline  
 Cloxyfonac: phenoxy carboxylic acid  
 Coumachlor: coumarin  
 Coumaphos: phosphoro organic, phosphoro thioate, coumarin  
 Coumatetralyl: coumarin  
 3-CPA: phenoxy carboxylic acid  
 4-CPA: phenoxy carboxylic acid  
 Crimidine: heterocyclic nitrogen, pyrimidine  
 Crotoxyfos: phosphoro organic, phosphate ester  
 Cyanazine: heterocyclic nitrogen, triazine  
 Cyanofenphos: phosphoro organic, phosphoro thioate  
 Cyanophos: phosphoro organic, phosphoro thioate  
 Cycloate: thiocarbamate  
 Cycloprothrin: pyrethroid  
 Cycloxydim: oxime, thiopyran  
 Cyfluthrin: pyrethroid  
 Cyhalothrin: pyrethroid  
 Cyhexatin: organo tin  
 Cymoxanil: urea, oxime  
 Cypermethrin: pyrethroid  
 Cyphenothrin: pyrethroid  
 Cyprazine: heterocyclic nitrogen, triazine  
 Cyproconazole: heterocyclic nitrogen, triazole  
 Cyprofuram: amide, furanone  
 Cyromazine: heterocyclic nitrogen, triazine  
 2,4-D: phenoxy carboxylic acid  
 Daimuron: urea  
 Dalapon-sodium: halogenated aliphatic acid  
 Daminozide: hydrazide, carboxylic acid  
 Dazomet: heterocyclic nitrogen, thiadiazine  
 2,4-DB: phenoxy carboxylic acid  
 DBCP: see Dibromochloro propane  
 DCNA: see Dicloran  
 DDT: halogenated hydrocarbon  
 Deltamethrin: pyrethroid  
 Demeton-s-methyl: phosphoro organic, phosphoro thioate  
 Demeton-s-methyl sulphon: phosphoro organic, phosphoro thioate  
 Desmedipham: carbamate  
 Desmetryn: heterocyclic nitrogen, triazine  
 Diafenthiuron: thiourea  
 Dialifos: phosphoro organic, phosphoro dithioate  
 Diallate: thiocarbamate

- Diazinon: heterocyclic nitrogen, pyrimidine, phosphoro thioate  
 Dibromochloro propane: chlorinated hydrocarbon  
 Dicamba: halogenated aromatic acid  
 Dichlobenil: halogenated aromatic  
 Dichlofenthion: phosphoro organic, phosphoro thioate  
 Dichlofluanid: sulfonamide  
 Dichlone: quinone  
 Dichlormid: amide  
 Dichlorophen: halogenated aromatic  
 1,3-Dichloropropene: halogenated hydrocarbon  
 Dichlorprop: phenoxy carboxylic acid  
 Dichlorvos: phosphoro organic, phosphate ester  
 Dichlozolate: see Chlozolate  
 Diclobutrazol: heterocyclic nitrogen, triazole  
 Diclofop-methyl: phenoxy carboxylic acid  
 Diclomezine: heterocyclic nitrogen, pyridazine  
 Dicloran: halogenated aromatic  
 Dicofol: halogenated hydrocarbon  
 Dicrotophos: phosphoro organic, phosphate ester, amide  
 Dieldrin: halogenated hydrocarbon  
 Dienochlor: halogenated hydrocarbon  
 Diethyl-ethyl: amide  
 Diethofencarb: carbamate  
 Diethyltoluamide: amide  
 Difenacoum: coumarin  
 Difenconazole: heterocyclic nitrogen, triazole  
 Difenoxuron: urea, phenyl ether  
 Difenzoquat methyl sulphate: heterocyclic nitrogen, pyrazole, quaternary ammonium  
 Difethialone: coumarin (similar)  
 Diflubenzuron: urea  
 Diflufenican: amide, pyridine  
 Dikegulac-sodium: (other) sorbose derivative  
 Dimefuron: oxadiazolone, urea  
 Dimepiperate: thiocarbamate, piperidine  
 Dimethachlor: amide  
 Dimethametryn: heterocyclic nitrogen, triazine  
 Dimethazone: see Clomazone  
 Dimethenamid: heterocyclic sulfur, thiophene, amide  
 Dimethipin: heterocyclic sulfur, dithiin, sulfone  
 Dimethirimol: heterocyclic nitrogen, pyrimidine  
 Dimethoate: phosphoro organic, phosphoro dithioate, amide  
 Dimethomorph: heterocyclic nitrogen, morpholine  
 Dimethylarsinic acid: see Cacodylic acid  
 Dimethylvinphos: see Tetrachlorvinphos  
 Diniconazole: heterocyclic nitrogen, triazole  
 Dinitramine: dinitroaniline  
 Dinobuton: dinitrophenol derivative  
 Dinocap: dinitrophenol derivative  
 Dinoseb: dinitrophenol  
 Dinoseb acetate: dinitrophenol derivative  
 Dinoterb: dinitrophenol  
 Diofenolan: phenyl ether  
 Dioxabenzofos: phosphoro organic, phosphoro thioate  
 Dioxacarb: carbamate  
 Dioxathion: phosphoro organic, phosphoro dithioate  
 Diphacinone: indanedione  
 Diphenamid: amide  
 Dipropetryn: heterocyclic nitrogen, triazine  
 Dipyrithione: disulfide, heterocyclic nitrogen pyridine  
 Diquat dibromide: heterocyclic nitrogen, pyrazine, quaternary ammonium  
 Disulfoton: phosphoro organic, phosphoro dithioate  
 Ditalimfos: phosphoro organic, phosphoro amidodithioate  
 Dithianon: heterocyclic sulfur, dithiin, quinone  
 Dithiopyr: heterocyclic nitrogen, pyridine  
 Diuron: urea  
 DNOC: dinitrophenol  
 Dodemorph acetate: heterocyclic nitrogen, morpholine  
 Dodine: guanidine  
 Drazoxolon: heterocyclic nitrogen, isoxazolone  
 DSMA: organo arsenic  
 Ebufos: see Cadusafos  
 Edifenphos: phosphoro organic, phosphoro dithioate  
 Eglazine: heterocyclic nitrogen, triazine  
 Empenthrin: pyrethroid  
 Endosulfan: halogenated hydrocarbon  
 Endothal: carboxylic acid  
 Endrin: halogenated hydrocarbon  
 EPN: phosphoro organic, phosphoro thioate  
 EPTC: thiocarbamate  
 Esfenvalerate: see Fenvalerate  
 Esprocarb: thiocarbamate  
 Etacelasil: silane  
 Etaconazole: heterocyclic nitrogen, triazole  
 Ethalfuralin: dinitroaniline  
 Ethametsulfuron: sulfonyl urea  
 Ethephon: phosphoro organic, phosphonic acid  
 Ethidimuron: urea, thiadiazole, sulfone  
 Ethiofencarb: carbamate  
 Ethion: phosphoro organic, phosphoro dithioate  
 Ethirimol: heterocyclic nitrogen, pyrimidine  
 Ethofumesate: benzofuran, sulfonate  
 Ethoprop (Ethoprophos): phosphoro organic, phosphoro dithioate  
 Ethoxyquin: heterocyclic nitrogen, quinoline  
 Ethylchlozate: heterocyclic nitrogen, indazole  
 Etofenprox: phenyl ether  
 Etridiazole: heterocyclic nitrogen, thiadiazole  
 Etrimfos: phosphoro organic, phosphoro thioate  
 EXD: disulfide

Famphur: phosphoro organic, phosphoro thioate, sulfonamide  
 Fenaminosulf: sulfonate  
 Fenamiphos: phosphoro organic, phosphoro amidate  
 Fenarimol: heterocyclic nitrogen, pyrimidine  
 Fenazaquin: heterocyclic nitrogen, quinazoline  
 Fenazox: (other) azoxy  
 Fenbuconazole: triazole  
 Fenbutatin oxide: organo tin  
 Fenchlorazole: heterocyclic nitrogen, triazole  
 Fenclorim: heterocyclic nitrogen, pyrimidine  
 Fenfuram: amide, furan  
 Fenitropan: aromatic carboxylic acid  
 Fenitrothion: phosphoro organic, phosphoro thioate  
 Fenobucarb: carbamate  
 Fenoprop: phenoxy carboxylic acid  
 Fenothiocarb: thiocarbamate  
 Fenoxaprop-ethyl: phenoxy carboxylic acid, heterocyclic nitrogen, benzoxazole  
 Fenoxycarb: carbamate, phenyl ether  
 Fencpiclonil: heterocyclic nitrogen, pyrrole  
 Fenpropathrin: pyrethroid  
 Fenpropidin: heterocyclic nitrogen, piperidine  
 Fenpropimorph: heterocyclic nitrogen, morpholine  
 Fenpyroximate: heterocyclic nitrogen, pyrazole  
 Fensulfothion: phosphoro organic, phosphoro thioate  
 Fenthion: phosphoro organic, phosphoro thioate  
 Fentin acetate: organo tin  
 Fentin hydroxide: organo tin  
 Fenuron: urea  
 Fenvalerate: pyrethroid  
 Ferbam: dithiocarbamate  
 Ferimzone: heterocyclic nitrogen, pyrimidine  
 Fipronil: heterocyclic nitrogen, pyrazole  
 Flamprop-m-isopropyl: amide  
 Flamprop-methyl: amide  
 Flazasulfuron: sulfonyl urea  
 Flocoumafen: coumarin  
 Fluazifop-butyl: phenoxy carboxylic acid, pyridine  
 Fluazifop-p-butyl: phenoxy carboxylic acid, pyridine  
 Fluazinam: dinitroaniline  
 Fluazuron: urea, heterocyclic nitrogen, pyridine  
 Flubenzimine: heterocyclic nitrogen, thiazolidine  
 Fluchloralin: dinitroaniline  
 Flucofuron: urea  
 Flucycloxuron: urea  
 Flucythrinate: pyrethroid  
 Fludioxonil: heterocyclic nitrogen, pyrrole  
 Flufenoxuron: urea, phenyl ether  
 Flumetralin: dinitroaniline  
 Flumetsulam: heterocyclic nitrogen, pyrimidine, triazole, sulfonamide  
 Flumiclorac: heterocyclic nitrogen, indole  
 Flumioxazin: heterocyclic nitrogen, benzoxazine: indole

Fluometuron: urea  
 Fluoroacetamide: amide  
 Fluoroglycofen-ethyl: phenyl ether  
 Fluoromide: heterocyclic nitrogen, pyrrole  
 Fluoronitrofen: phenyl ether  
 Fluotrimazole: heterocyclic nitrogen, triazole  
 Flupoxam: heterocyclic nitrogen, triazole  
 Flupropadine: heterocyclic nitrogen, piperidine  
 Flupropanate: halogenated aliphatic acid  
 Flurazole: heterocyclic nitrogen, thiazole  
 Flurenol: carboxylic acid  
 Fluridone: heterocyclic nitrogen, pyridone  
 Flurochloridone: heterocyclic nitrogen, pyrrolidinone  
 Fluroxypyr: heterocyclic nitrogen, pyridine  
 Flurprimidol: heterocyclic nitrogen, pyrimidine  
 Flurtamone: furanone  
 Flusilazole: heterocyclic nitrogen, triazole  
 Flusulfamide: sulfonamide  
 Flutolanil: amide  
 Flutriafol: heterocyclic nitrogen, triazole  
 Fluvalinate: pyrethroid  
 Fluxofenim: oxime  
 Folpet: heterocyclic nitrogen, indoleione  
 Fomesafen: amide, phenyl ether, sulfonamide  
 Fonofos: phosphoro organic, phosphoro dithioate  
 Forchlorfenuron: urea, pyridine  
 Formetanate hydrochloride: carbamate, amidine  
 Formothion: phosphoro organic, phosphoro dithioate, amide  
 Fosamine-ammonium: phosphoro organic, phosphonate  
 Fosetyl-aluminium: phosphoro organic, phosphonate  
 Fosmethilan: phosphoro organic, phosphoro dithioate, amide  
 Fosthiazate: phosphoro organic, phosphono thioate, thiazolidinone  
 Fuberidazole: heterocyclic nitrogen, benzimidazole  
 Furalaxyl: amide  
 Furathiocarb: carbamate, benzofuran  
 Furconazole: heterocyclic nitrogen, triazole, furan  
 Furilazole: heterocyclic nitrogen, oxazolidine, furan  
 Furmecyclox: furan, carboxamide  
 Furyloxyfen: phenyl ether, furan  
 Glufosinate: phosphinate  
 Glyodin: heterocyclic nitrogen, imidazoline  
 Glyphosate: phosphoro organic, phosphonate  
 Guazatine: guanidine  
 Halfenprox: phenyl ether  
 Halosulfuron: sulfonyl urea, heterocyclic nitrogen, pyrazole  
 Haloxyfop: phenoxy carboxylic acid, pyridine  
 HCH: see Lindane

- Heptachlor: halogenated hydrocarbon  
 Heptenophos: phosphoro organic, phosphate ester  
 Heptopargil: oxime  
 Hexachlorobenzene: halogenated aromatic  
 Hexaconazole: heterocyclic nitrogen, triazole  
 Hexaflumuron: urea  
 Hexazinone: heterocyclic nitrogen, triazine  
 Hexythiazox: thiazolidine, amide  
 Hydramethylnon: heterocyclic nitrogen, pyrimidine  
 Hydroprene: dienedodecanoate  
 8-Hydroxyquinoline sulphate: heterocyclic nitrogen, quinoline  
 Hymexazol: heterocyclic nitrogen, isoxazole
- Imazalil: heterocyclic nitrogen, imidazole  
 Imazamethabenz-methyl: heterocyclic nitrogen, imidazolidinone  
 Imazapyr: heterocyclic nitrogen, imidazolidinone, pyridine  
 Imazaquin: heterocyclic nitrogen, imidazolidinone, quinoline  
 Imazethapyr: heterocyclic nitrogen, imidazolidinone  
 Imazosulfuron: sulfonyl urea  
 Imibenconazole: heterocyclic nitrogen, triazole  
 Imidacloprid: heterocyclic nitrogen, imidazolidine, pyridine  
 Iminoctadine: guanidine  
 Inabenfide: amide, pyridine  
 Indol-3-ylacetic acid: heterocyclic nitrogen, indole  
 4-Indol-3-ylbutyric acid: heterocyclic nitrogen, indole  
 Iodofenphos: phosphoro organic, phosphorothioate  
 Ioxynil: halogenated aromatic  
 Ipconazole: triazole  
 Iprobenfos: phosphoro organic, phosphoro dithioate  
 Iprodione: heterocyclic nitrogen, imidazolidinone  
 IPSP: phosphoro organic, phosphoro dithioate  
 Isazofos: phosphoro organic, phosphorothioate, triazole  
 Isocarbamid: amide, imidazolidinone  
 Isufenphos: phosphoro organic, phosphoro amido thioate  
 Isoprocarb: carbamate  
 Isopropalin: dinitroaniline  
 Isoprothiolane: dithiin  
 Isoproturon: urea  
 Isouron: heterocyclic nitrogen, isoxazole, urea  
 Isoxaben: heterocyclic nitrogen, isoxazole, amide  
 Isoxapyrifop: heterocyclic nitrogen, azolidine  
 Isoxathion: phosphoro organic, phosphoro thioate, isoxazole  
 Iodenphos: see Iodofenphos  
 Jodfenphos: see Iodofenphos
- Karbutilate: urea, carbamate
- Lactofen: phenyl ether  
 Lenacil: heterocyclic nitrogen, pyrimidinedione  
 Lindane: halogenated hydrocarbon  
 Linuron: urea  
 Lufenuron: urea
- Malathion: phosphoro organic, phosphoro dithioate  
 Maleic hydrazide: heterocyclic nitrogen, pyridazinedione  
 Mancozeb: dithiocarbamate  
 Maneb: dithiocarbamate  
 MCPA: phenoxy carboxylic acid  
 MCPA-Thioethyl: (other) thioate  
 MCPB: phenoxy carboxylic acid  
 Mecarbam: phosphoro organic, phosphoro dithioate, carbamate  
 Mecoprop: phenoxy carboxylic acid  
 Mefenacet: heterocyclic nitrogen, benzothiazole, amide  
 Mefluidide: amide, sulfonamide  
 Mepanipyrim: heterocyclic nitrogen, pyrimidine  
 Mephosfolan: phosphoro organic, phosphoro amido thioate  
 Mepiquat chloride: heterocyclic nitrogen, piperidine, quaternary ammonium  
 Mepronil: amide  
 Merphos: phosphoro organic, phosphoro tri thioite  
 Metalaxyl: amide  
 Metam: dithiocarbamate  
 Metamitron: heterocyclic nitrogen, triazine  
 Metazachlor: amide, pyrazole  
 Metconazole: heterocyclic nitrogen, triazole  
 Methabenzthiazuron: urea, benzothiazole  
 Methacrifos: phosphoro organic, phosphoro thioate  
 Metham-sodium: see Metam  
 Methamidophos: phosphoro organic, phosphoro amido thioate  
 Methasulfocarb: thiocarbamate, sulfonate  
 Methazole: heterocyclic nitrogen, oxadiazolone, urea  
 Methfuroxam: amide, furan  
 Methidathion: thiadiazolone, phosphoro organic, phosphoro, dithioate  
 Methiocarb: carbamate  
 Methomyl: oxime amide  
 Methoprene: dienedodecanoate  
 Methoprotlyne: heterocyclic nitrogen, triazine  
 Methoxychlor: halogenated aromatic  
 Methoxyethylmercury acetate: organo mercurics  
 Methoxyphenone: (other) benzophenone  
 Methyl arsonic acid: see MSMA  
 Methyl bromide: halogenated hydrocarbon  
 Methylidymron: urea

Metiram: see Zineb  
 Metobenzuron: urea  
 Metobromuron: urea  
 Metolachlor: amide  
 Metolcarb: carbamate  
 Metosulam: sulfonamide, heterocyclic nitrogen, triazole, pyrimidine  
 Metoxuron: urea  
 Metribuzin: heterocyclic nitrogen, triazine  
 Metsulfovax: heterocyclic nitrogen thiazole, amide  
 Metsulfuron-methyl: sulfonyl urea  
 Mevinphos: phosphoro organic, phosphate ester  
 Mexacarbate: carbamate  
 Mirex: halogenated hydrocarbon  
 Molinate: thiocarbamate  
 Monalide: amide  
 Monocrotophos: phosphoro organic, phosphate ester, amide  
 Monolinuron: urea  
 Monuron: urea  
 MSMA: organo arsenics  
 Muscalure: (other) cis olefin  
 Myclobutanil: heterocyclic nitrogen, triazole

Nabam: dithiocarbamate  
 Naled: phosphoro organic, phosphoro ester  
 1-Naphthylacetamide: amide  
 1-Naphthylacetic acid: aromatic carboxylic acid  
 2-Naphthylloxy acetic acid: phenoxy carboxylic acid  
 Naproanilide: amide  
 Napropamide: amide  
 Naptalam: amide  
 Neburon: urea  
 Niclosamide: amide  
 Nicosulfuron: sulfonyl urea  
 Nipyraclofen: heterocyclic nitrogen, pyrazole  
 Nitalin: dinitroaniline  
 Nitrapyrin: heterocyclic nitrogen, pyridine  
 Nitrofen: phenyl ether  
 Nitrothal-isopropyl: aromatic carboxylic acid  
 Norbormide: heterocyclic nitrogen, pyridine  
 Norflurazon: heterocyclic nitrogen, pyridazinone  
 Nuairimol: heterocyclic nitrogen, pyrimidine

Oethilnolone: heterocyclic nitrogen, triazolone  
 Ofurace: amide, furanone  
 Omethoate: phosphoro organic, phosphoro thioate, amide  
 Orbencarb: thiocarbamate  
 Oryzalin: dinitroaniline, sulfonamide  
 Ovex: see Chlorfenson  
 Oxabetrinil: oxime  
 Oxadiazon: heterocyclic nitrogen, oxadiazolone  
 Oxadixyl: oxazolidine, amide

Oxamyl: oxime amide  
 Oxine-copper: heterocyclic nitrogen, quinoline  
 Oxolinic acid: heterocyclic nitrogen, quinoline  
 Oxycarboxin: oxathiin, amide, sulfone  
 Oxydemeton-methyl: phosphoro organic, phosphoro thioate  
 Oxyfluorfen: phenyl ether

Paclobutrazol: heterocyclic nitrogen, triazole, see Diclobutrazol  
 Paraquat dichloride: heterocyclic nitrogen, pyridine, quaternary ammonium  
 Parathion: phosphoro organic, phosphoro thioate  
 PCNB: see Quintozene  
 Pebulate: thiocarbamate  
 Pefurazolate: heterocyclic nitrogen, imidazole, furan  
 Penconazole: heterocyclic nitrogen, triazole  
 Pencycuron: urea  
 Pendimethalin: dinitro aniline  
 Pentachlorophenol: halogenated aromatic  
 Pentanochlor: amide  
 Perfluidone: sulfonamide  
 Permethrin: pyrethroid  
 Phenisopham: carbamate  
 Phenmedipham: carbamate  
 Phenothrin: pyrethroid  
 Phenthoate: phosphoro organic, phosphoro dithioate  
 Phenylmercury acetate: organic mercury  
 2-Phenylphenol: (other) diphenyl  
 Phorate: phosphoro organic, phosphoro dithioate  
 Phosalone: phosphoro organic, phosphoro dithioate, benzoxazole  
 Phosdiphen: phosphoro organic, phosphate  
 Phosfolan: imino-dithiolane, phosphoro organic, phosphoro amidate  
 Phosmet: phosphoro organic, phosphoro dithioate  
 Phosphamidon: phosphoro organic, phosphate ester, amide  
 Phoxim: oxime, phosphoro organic, phosphorothioate  
 Picloram: heterocyclic nitrogen, pyridine  
 Pindone: indanedione  
 Piperonyl butoxide: (other) benzadioxole  
 Piperophos: phosphoro organic, phosphoro dithioate, piperidine  
 Piproctanyl Bromide: heterocyclic nitrogen, piperidine, quaternary ammonium  
 Pirimicarb: carbamate, pyrimidine  
 Pirimiphos-ethyl: pyrimidine, phosphoro organic, phosphoro thioate  
 Pirimiphos-methyl: pyrimidine, phosphoro organic, phosphoro thioate  
 Plifenate: halogenated aromatic acid  
 Prallethrin: pyrethroid  
 Pretilachlor: amide, see Dimethachlor



Primisulfuron: sulfonyl urea  
 Probenazole: heterocyclic nitrogen, benzothiazole  
 Prochloraz: heterocyclic nitrogen, imidazole  
 Procyazine: heterocyclic nitrogen, triazine  
 Procymidone: heterocyclic nitrogen, pyrrolidinedione  
 Prodiamine: dinitroaniline  
 Profenofos: phosphoro organic, phosphoro thioate  
 Profluralin: dinitroaniline  
 Proglinazine: heterocyclic nitrogen, triazine  
 Prohexadione: hexanedione carboxylic acid  
 Promacyl: carbamate  
 Promecarb: carbamate  
 Prometon: heterocyclic nitrogen, triazine  
 Prometryn: heterocyclic nitrogen, triazine  
 Pronamide: amide  
 Propachlor: amide  
 Propamocarb: carbamate  
 Propanil: amide  
 Propaphos: phosphoro organic, phosphate ester  
 Propaquizafop: heterocyclic nitrogen, quinoxaline  
 Propargite: sulfite  
 Propazine: heterocyclic nitrogen, triazine  
 Propetamphos: phosphoro organic, phosphoro amido thioate  
 Propham: carbamate  
 Propiconazole: heterocyclic nitrogen, triazole  
 Propineb: dithiocarbamate  
 Propisochlor: amide  
 Propoxur: carbamate  
 Propyzamide: see Pronamide  
 Prosulfocarb: thiocarbamate  
 Prosulfuron: sulfonyl urea  
 Prothiocarb: thiocarbamate  
 Prothiofos: phosphoro organic, phosphoro dithioate  
 Prothoate: phosphoro organic, phosphoro dithioate, amide  
 Pymetrozine: heterocyclic nitrogen, triazine, pyridine  
 Pyraclofos: pyrazole, phosphoro organic, phosphoro thioate  
 Pyrazolate: heterocyclic nitrogen, pyrazole  
 Pyrazophos: phosphoro organic, phosphoro thioate, pyrazole, pyrimidine  
 Pyrazosulfuron: sulfonyl-urea  
 Pyrazoxyfen: heterocyclic nitrogen, pyrazole  
 Pyributicarb: thiocarbamate, pyridine  
 Pyridaben: heterocyclic nitrogen, pyridazinone  
 Pyridafenthion: phosphoro organic, phosphoro thioate, pyridazine  
 Pyridate: heterocyclic nitrogen, pyridazine  
 Pyrifenox: oxime, pyridine  
 Pyrimethanil: heterocyclic nitrogen, pyrimidine  
 Pyriproxifen: phenyl-ether, pyridine  
 Pyriothiobac-sodium: heterocyclic nitrogen, pyrimidine

Pyroquilon: heterocyclic nitrogen, quinoline, pyrrole  
 Quinalphos: quinoxaline, phosphoric organic, phosphorothioate  
 Quinclorac: heterocyclic nitrogen, quinoline  
 Quinmerac: heterocyclic nitrogen, quinoline  
 Quinoclamine: quinone  
 Quinomethionate: see Chinomethionat  
 Quintozene: halogenated aromatic  
 Quizalofop: phenoxy carboxylic acid, quinoxaline  
 Resmethrin: pyrethroid  
 Rimsulfuron: sulfonyl urea  
 Secbumeton: heterocyclic nitrogen, triazine  
 Sethoxydim: oxime  
 Siduron: urea  
 Silafluofen: silane, phenyl ether  
 Simazine: heterocyclic nitrogen, triazine  
 Simetryn: heterocyclic nitrogen, triazine  
 Sulcofuron: urea, phenyl ether  
 Sulfentrazone: heterocyclic nitrogen, triazole, sulfonamide  
 Sulfluramid: sulfonamide  
 Sulfometuron: sulfonyl urea  
 Sulfotep: phosphoro organic, thiopyrophosphate  
 Sulfuryl fluoride: sulfone  
 Sulprofos: phosphoro organic, phosphoro dithioate  
 2,4,5-T: phenoxy carboxylic acid  
 2,3,6-TBA: halogenated aromatic acid  
 TCA: halogenated aliphatic acid  
 Tebuconazole: heterocyclic nitrogen, triazole  
 Tebufenozide: hydrazide  
 Tebufenpyrad: heterocyclic nitrogen, pyrazole, amide  
 Tebutam: amide  
 Tebuthiuron: thiadiazole, heterocyclic nitrogen, urea  
 Tecloftalam: amide  
 Tecnazene: halogenated aromatic  
 Teflubenzuron: urea  
 Tefluthrin: pyrethroid  
 Temephos: phosphoro organic, phosphoro thioate  
 TEPP: phosphoro organic, pyrophosphate  
 Terbacil: heterocyclic nitrogen, pyrimidinedione  
 Terbufos: phosphoro organic, phosphoro dithioate  
 Terbumeton: heterocyclic nitrogen, triazine  
 Terbutylazine: heterocyclic nitrogen, triazine  
 Terbutryn: heterocyclic nitrogen, triazine  
 Tetrachlorophthalide: halogenated aromatic  
 Tetrachlorvinphos: phosphoro organic, phosphate ester  
 Tetraconazole: heterocyclic nitrogen, triazole

Tetradifon: halogenated aromatic, sulfone  
 Tetramethrin: pyrethroid  
 Tetrasul: halogenated aromatic  
 o,o,o',o'-Tetrapropyl dithiopyrophosphate: phosphoro organic, thiopyrophosphate  
 Thenylchlor: amide, heterocyclic sulfur, thiophene  
 Thiabendazole: heterocyclic nitrogen, benzimidazole, thiazole  
 Thiameturon: see Thifensulfuron  
 Thiazafuron: heterocyclic nitrogen, thiadiazole, urea  
 Thiazopyr: heterocyclic nitrogen, thiazole, pyridine  
 Thicyofen: heterocyclic sulfur, thiophene  
 Thidiazuron: thiadiazole, urea  
 Thifensulfuron: sulfonyl urea  
 Thifluzamide: heterocyclic nitrogen, thiazole, amide  
 Thiobencarb: thiocarbamate  
 Thiocyclam: heterocyclic sulfur, trithiane  
 Thiodicarb: oxime amide  
 Thiofanox: oxime amide  
 Thiometon: phosphoro organic, phosphorodithioate  
 Thiophanate: thiourea, carbamate  
 Thiophanate-methyl: thiourea, carbamate  
 Thiram: dithiocarbamate, disulfide  
 Tiocarbazil: thiocarbamate  
 Tioclorim: pyrimidine  
 Tolclofos-methyl: phosphoro organic, phosphorothioate  
 Tolyfluanid: sulfonamide  
 Toxaphene: see Camphechlor  
 Tralkoxydim: oxime  
 Tralomethrin: pyrethroid  
 Transfluthrin: pyrethroid  
 Triadimefon: heterocyclic nitrogen, triazole  
 Triadimenol: heterocyclic nitrogen, triazole  
 Triallate: thiocarbamate, see Diallate  
 Triapenthenol: heterocyclic nitrogen, triazole, see Diniconazole  
 Triasulfuron: sulfonyl urea  
 Triazamate: heterocyclic nitrogen, triazole

Triazophos: phosphoro organic, phosphorothioate, triazole  
 Triazoxide: heterocyclic nitrogen, triazine  
 Tribenuron: sulfonyl urea  
 SSS-Tributyl phosphorotrithioate: phosphoro organic, phosphoro trithioate  
 Trichlamide: amide  
 Trichlorfon: phosphoro organic, phosphonate  
 Trichloronat: phosphoro organic, phosphonothioate  
 Triclopyr: heterocyclic nitrogen, pyridine  
 Tricyclazole: triazole, heterocyclic nitrogen, benzothiazole  
 Tridemorph: heterocyclic nitrogen, morpholine  
 Tridiphane: halogenated aromatic, oxirane  
 Trietazine: heterocyclic nitrogen, triazine  
 Triflumizole: heterocyclic nitrogen, imidazole  
 Triflumuron: urea  
 Trifluralin: dinitroaniline  
 Triflusaluron: sulfonyl urea  
 Triforine: amide, heterocyclic nitrogen, piperazine  
 Trimethacarb: carbamate  
 Trinexapac: hexanedione carboxylic acid  
 Triticonazole: heterocyclic nitrogen, triazole  
  
 Uniconazole: heterocyclic nitrogen, triazole, see Diniconazole  
  
 Vamidothion: phosphoro organic, phosphorothioate, amide  
 Vernolate: thiocarbamate  
 Vinclozolin: heterocyclic nitrogen, oxazolidinedione  
  
 Warfarin: coumarin  
  
 XMC: carbamate, see Xylylcarb  
 Xylylcarb: carbamate  
  
 Zineb: dithiocarbamate  
 Ziram: dithiocarbamate

# APPENDIX II

## TRADE NAMES

*See PREFACE: How to Use This Handbook*

Aatrex: atrazine  
Aazomate: benzoximate  
Abat: temephos  
Abate: temephos  
Abathion: temephos  
Acaraben: chlorobenzilate  
Acarol: bromopropylate  
Acarstin: cyhexatin  
Acatak: fluazuron  
Accelerate: endothal  
Accent: nicosulfuron  
Acclaim: fenoxaprop-ethyl  
Accothion: fenitrothion  
Achieve: tralkoxydim  
Acricid: binapacryl  
Acrobat: dimethomorph  
Acryptan: folpet  
Actellic: pirimiphos  
Actril: ioxylin  
Actril M: mecoprop  
Admire: imidacloprid  
Afalon: linuron  
Afilene: butocarboxim  
Afix: formothion  
Afugan: pyrazophos  
Agil: propaquizafop  
Agreen: pyrazosulfuron  
Agrimet: phorate  
Agrisil: trichloronat  
Agritox: trichloronat  
Agrosan: phenylmercury acetate  
Agroxone: MCPA  
Akar: chlorobenzilate  
Alanap: naptalam  
Alar: daminozide  
Albrass: propachlor  
Alden: piproctanyl bromide  
Aldrex: aldrin  
Aldrite: aldrin  
Alegro: phenmedipham  
Alfacron: azamethiphos  
Alette: fosetyl-aluminum  
Allie: metsulfuron  
Allisan: dicloran  
Ally: metsulfuron  
Alon: isoproturon  
Alsol: etacelasil  
Alto, Altemi: cyproconazole  
Altosid: methoprene

Altozar: hydroprene  
Alsystin: triflumuron  
Amaze: isofenphos  
Amber: triasulfuron  
Ambox: binapacryl  
Ambro: hydramethylnon  
Ambush: permethrin  
Ambush C: cypermethrin  
Amchem 64-50: 3 CPA  
Amexine: butralin  
Amiben: chloramben  
Amid-Thin: 1-naphthylacetamide  
Andalin: flucycloxuron  
Animert: tetrasul  
Anniverse: halfenprox  
Ansar 8100: MSMA  
Ansar: DSMA  
Anten: flurenol  
Anthio: formothion  
Antinonin: DNOC  
Antiphen: dichlorophen  
Antor: diethatyl-ethyl  
Antracol: propineb  
Anvil: hexaconazole  
Apache: cadusafos  
Apachlor: chlorfenvinphos  
Aphidan: IPSP  
Aphox: pirimicarb  
Apite: furiloxifen  
Apollo: clofentezine  
Appa: ampropylfos  
Applaud: buprofezin  
Apron: metalaxyl  
Aquazine: simazine  
Arasan: thiram  
Arelon: isoproturon  
Aresin: monolinuron  
Arest: ancymidol  
Aretit: dinoseb acetate  
Argold: cinmethylin  
Arozin: anilofos  
Arrivo: cypermethrin  
Arsenal: imazapyr  
Arsonate: MSMA  
Asana: esfenvalerate  
Aspon: o,o,o,o tetrapropyl dithiopyrophosphate  
Assert: imazamethabenz-methyl  
Assure: quizalofop-ethyl

Asulox: asulam  
 Asuntol: coumaphos  
 Atabron: chlorflurazuron  
 Atemi: cyproconazole  
 Atgard: dichlorvos  
 Atrimmec: dikegulac  
 Atrinal: dikegulac-sodium  
 Avadex: di-allate  
 Avadex BW: tri-allate  
 Avenge: difenzoquat  
 Aware: diofenolan  
 Azodrin: monocrotophos  
 Aztec: triazamate

Balan: benfluralin  
 Bandren: aclonifen  
 Bandur: aclonifen  
 Bancol: bensultap  
 Banvel: dicamba  
 Baraki: difethialone  
 Baronat: triapenthenol  
 Barricade: prodiamine  
 Basagran: bentazone/dichlorprop  
 Basalin: fluchloralin  
 Basamid: dazomet  
 Basanite: dinoseb  
 Basfapon: dalapon-sodium  
 Basitac: mepronil  
 Bassa: fenobucarb  
 Basta: glufosinate  
 Basudin: diazinon  
 Bavistin: carbendazim  
 Baycarb: fenobucarb  
 Baycid: fenthion  
 Baycor: bitertanol  
 Baygon: propoxur  
 Baygon: transfluthrin  
 Baygon MEB: plifenate  
 Bayleton: triadimefon  
 Baylucid: niclosamide  
 Bayluscide: niclosamide  
 Bayrusil: quinalphos  
 Bayothrin: transfluthrin  
 Baytan: triadimenol  
 Baytex: fenthion  
 Baythion: phoxim  
 Baythion C: chlorphoxim  
 Baythroid: cyfluthrin  
 Beacon: primisulfuron  
 Beam: tricyclazole  
 Befran: iminoctadine  
 Belmark: fenvalerate  
 Bellmac Straight: MCPB  
 Benchmark: flurtamone

Benit: etaconazole  
 Benlate: benomyl  
 Beosit: endosulfan  
 Beret: fenpiclonil  
 Betanal AM: desmedipham  
 Betanal: phenmedipham  
 Betanex: desmedipham  
 Betapal: 2 naphthyloxy acetic acid  
 Betasan: bensulide  
 Biallor: cyproconazole  
 Bialor: cyproconazole  
 Bideron: prothiofos  
 Bidrin: dicrotophos  
 Bilobran: monocrotophos  
 Bim: tricyclazole  
 BIPC: chlorbufam  
 Birgin: propham  
 Birlane: chlorfenvinphos  
 Bladafum: sulfotep  
 Bladan: parathion  
 Bladan M: parathion-methyl  
 Bladex: cyanazine  
 Blascide: tricyclazole  
 Blattanex: propoxur  
 Blazer: acifluorfen-sodium  
 Bloc: fenarimol  
 BNine: daminozide  
 Boa-Ana: famphur  
 Bolero: thiobencarb  
 Bolls-Eye: dimethylarsinic acid  
 Bolstar: sulprofos  
 Boltage: pyraclofos  
 Bonalan: benfluralin  
 Bonzi: paclobutrazol  
 Botran: dicloran  
 Botriflex: quintozone  
 Boxer: prosulfocarb  
 Bravo: chlorothalonil  
 Brestan: fentin acetate  
 Brestan Flow: fentin hydroxide  
 Brigade: bifenthrin  
 Broad Strike: flumetsulam  
 Brominal: bromoxynil  
 Bronocot: bronopol  
 Bronotak: bronopol  
 Bronok: trietazine  
 Broot: trimethacarb  
 Bucril: bromoxynil  
 Bueno: MSMA  
 Buster: glufosinate  
 Butisan S: metazachlor  
 Butox: deltamethrin

Caden: cartap

Caid: chlorophacinone	Coratop: pyroquilon
Caliber: simazine	Corbel: fenpropimorph
Caldon: dinoseb	Cornox: benazolin
Calirus: benodanil	Cornox M: MCPA
Calixin: tridemorph	Cornox: dichlorprop
Camogran: fumeqyclox	Corsair: permethrin
Caparol: prometryn	Cotofor: dipropetryn
Caragard: terbumeton	Cotoran: fluometuron
Caramba: metconazole	Counter: terbufos
Carbamult: promecab	Cremart: butamifos
Carbicron: dicotophos	Croneton: ethiofencarb
Carbyne: barban	Cropotex: flubenzimine
Caryne: barban	Crotthane: dinocap
Carzol: formetanate hydrochloride	Cryptonol: 8-hydroxyquinoline sulfate
Cascade: flufenoxuron	Cultar: paclobutrazol
Casoron: dichlobenil	Curacron: profenofos
Castrix: crimidine	Curamil: pyrazophos
CeCeCe: chlormequat	Curaterr: carbofuran
Cela W524: triforine	Curbiset: chlorflurenol-methyl
Celest: fludioxonil	Curzate: cymoxanil
Celio: clodinafop	Cutless: flurprimidol
Celio: cloquintocet	Cyalane: phosfolan
Cente: clomeprop	Cyanox: cyanophos
Cercobin M: thiophanate-methyl	Cybolt: flucythrinate
Ceresol: phenylmercury	Cyclodan: endosulfan
Cerone: ethephon	Cyclosal: cycloprothrin
Certrol: ioxynil	Cycocel: chlormequat chloride
Cethion: ethion	Cycosin: thiophanate-methyl
Challenge: acionifen	Cygon: dimethoate
Chess: pymetrozine	Cylan: phosfolan
Chinosol: 8-hydroxyquinoline sulfate	Cymbush: cypermethrin
Chlormite: chloropropylate	Cymperator: cypermethrin
Chryson: resmethrin	Cyolan: phosfolan
Chryson Forte: bioresmethrin	Cyolane: phosfolan
Cidial: phenthoate	Cyperal: benfuresate
Cinch: cinmethlyn	Cyprene: halfenprox
Ciodrin: crotoxypfos	Cyprex: dodine
CIPC: chlorpropham	Cytel: fenitrothion
Citrazon: benzoximate	Cythion: malathion
Clarosan: terbutryn	Cythrion: flucythrinate
Classic: chlorimuron	Cytrolane: mephosfolan
Clermait: azocyclotin	
Clipper: paclobutrazol	Dacamox: thiofanox
Clout: alloxym	Daconate: MSMA
Cobex: dinitramine	Daconil: chlorothalonil
Cobra: lactofen	Dacthal: chlorthal-dimethyl
Combat: hydramethylnon	Dalacide: dalapon
Command: clomazone	Damfin: methacrifos
Commando: flamprop-M-isopropyl	Danitol: fenpropathrin
Comodor: tebutam	Danitron: fenpyroximate
Compete: fluoroglycofen	Dapacryl: binapacryl
Concep II: oxabetrinil	Dasanit: fensulfothion
Concep III: fluxofenim	Deadline: bromadiolone
Confidor: imidacloprid	Debantic: tetrachlorvinphos
Consult: hexaflumuron	Deccoquin: ethoxyquin
Contraven: terbufos	Decis: deltamethrin
Coopex: permethrin	

Dedevap: dichlorvos  
 DEF 6: S,S,S-tributyl phosphorotrithioate  
 DEF Defoliant: S,S,S-tributyl phosphorotrithioate  
 Defi: prosulfocarb  
 Deflor: metoxuron  
 Delan: dithianon  
 Delnav: dioxathion  
 Delsene: carbendazim  
 Deltanet: furathiocarb  
 Deltic: dioxathion  
 Demosan: chloroneb  
 Denmert: buthiobate  
 Derosal: carbendazim  
 Desmel: propiconazole  
 Desormone: 2,4 D  
 Dessin: dinobuton  
 Destun: perfluidone  
 Devrinol: napropamide  
 Dextrone X: paraquat dichloride  
 Diazitol: diazinon  
 Dibrom: naled  
 Dicarzol: formetanate hydrochloride  
 Diconal: phenisopham  
 Dicoprime: bromofenoxim  
 Dicuran: chlorotoluron  
 Dieldrite: dieldrin  
 Difolatan: captafol  
 Dimecron: phosphamidon  
 Dimenson: dithiopyr  
 Dimepax: dimethametryn  
 Dimilin: diflubenzuron  
 Diphacin: diphacinone  
 Dipofene: chloromethiuron  
 Dipterex: trichlorfon  
 Direx: diuron  
 Dirimal: oryzalin  
 Disyston: disulfoton  
 Dithane D-14: nabam  
 Dithane M-22: maneb  
 Dithane M-45: mancozeb  
 Dithane Z-78: zineb  
 Dithiosystox: disulfoton  
 Domark: tetraconazole  
 Dorado: pyrifenoxy  
 Dorlone: 1,3-dichloropropene  
 Dorochlor: chloropicrin  
 Dosanex: metoxuron  
 Dotan: chlormephos  
 Dowco 199: ditalimfos  
 Dowco 356: tridiphane  
 Dowfume: methyl bromide  
 Dowcide EC7: pentachlorophenol  
 Dowcide G: pentachlorophenol  
 Dowpon: dalapon-sodium

Dozer: fenuron  
 Drat: chlorophacinone  
 Drawin: butocarboxim  
 Draza: methiocarb  
 Drepamon: tiocarbazil  
 Dropp: thidiazuron  
 Dual: metolachlor, benoxacor  
 Duplosan: mecoprop  
 Dursban: chlorpyrifos  
 Duter: fentin hydroxide  
 Dybar: fenuron  
 Dyfonate: fonofos  
 Dylox: trichlorfon  
 Dymid: diphenamid  
 Dynone: prothiocarb  
 Dyrene: anilazine

E-605: parathion  
 Ebufos: cadusafos  
 Ekalin: quinalphos  
 Ekalux: quinalphos  
 Ekamet: etrimfos  
 Ekatina: thiometon  
 Ekkusugoni: chlormethoxyfen  
 Ektafos: dicrotophos  
 Elancolan: trifluralin  
 Elite: tebuconazole  
 Elocron: dioxacarb  
 Elsan: phenthoate  
 Elvaron: dichlofluanid  
 Embark: mefluidide  
 Embutox: 2,4 DB  
 Eminent: tetraconazole  
 Endaven: benzoylprop-ethyl  
 Endosan: binapacryl  
 Endrex: endrin  
 Enide: diphenamid  
 Entex: fenthion  
 Eptam/Eradicane: EPTC  
 Erbotan: thiazfluron  
 Esgram: paraquat dichloride  
 Etazine: secbumeton  
 Etheverse: ethephon  
 Ethiol: ethion  
 Ethrel: ethephon  
 Etoc: prallethrin  
 Etrofolan: isoprocarb  
 Euparen: dichlofluanid  
 Euparen M: tolyfluanid  
 Evik: ametryn  
 Evisect: thiocyclam  
 Evisekt: thiocyclam  
 Evital: norflurazon  
 Exagama: lindane  
 Exceed: prosulfuron

Exotherm-Termil: chlorothalonil  
Express: tribenuron

Fac: prothoate  
Facet: quinclorac  
Famid: dioxacarb  
Fan: endosulfan  
Faneron: bromofenoxim  
Far-Go: tri-allate  
Farmil: ditalimfos  
Fecundal: imazalil  
Fenac: chlorfenac  
Fenatrol: chlorfenac  
Fentoxan: fenazox  
Fermate: ferbam  
Fernasan: thiram  
Fernex: pirimiphos-ethyl  
Fervin: alloxydim  
Fervinal: sethoxydim  
Ficam: bendiocarb  
Fiesta: quinmerac  
Figaron: ethylchlozate  
Finale: glufosinate  
Finaven: difenzoquat  
Finitron: sulfluramid  
Flectron: cypermethrin  
Flex: fomesafen  
Flexidor: isoxaben  
Florel: ethephon  
Focus: cycloxydim  
Folar: terbutylazine  
Folbex: chlorobenzilate  
Folex: merphos  
Folicur: tebuconazole  
Folidol M: parathion-methyl  
Folimat: omethoate  
Folithion: fenitrothion  
Folosan: quintozone, tecnazene  
Folpan: folpet  
Fongarene: pyroquilon  
Fongarid: furalaxyl  
Fongoren: pyroquilon  
Force: tefluthrin  
Fortress: chloretoxyfos  
Fortrol: cyanazine  
Forum: dimethomorph  
Forza: tefluthrin  
Forfeno: parathion  
Frap: difethialone  
Frenock: flupropanate  
Frontier: dimethenamid  
Frowncide: fluazinam  
Fruitone: cloprop  
Fruitone N: naphthyl acetic acid  
Fruitone N: 1-naphthylacetic acid  
Fruitone T: fenoprop

Frumin AL: disulfoton  
Fuji-one: isoprothiolane  
Fuji-grass: esprocarb  
Fuklasin: ziram  
Fumazone: DBCP  
Fundal: chlordimeform  
Fungaflor imazalil  
Fungazil: imazalil  
Furadan: carbofuran  
Furore: fenoxaprop-ethyl  
Fusarex: tecnazene  
Fusilade: fluazifop-butyl  
  
Galben: benalaxyl  
Galecron: chlordimeform  
Gallant: haloxyfop-ethoxyethyl  
Gallogama: lindane  
Gammalin: lindane  
Gammexane: lindane  
Gardona: tetrachlorvinphos  
Gardoprim: terbutylazine  
Garlon: triclopyr  
Garrathion: carbophenothion  
Garvox: bendiocarb  
Gatnon: benzthiazuron  
Gaucha: imidacloprid  
Gebutox: dinoseb  
Gencor: hydroprene  
Gesagram: prometon  
Gesagard: prometryn  
Gesamil: propazine  
Gesapax: ametryn  
Gesaprim: atrazine  
Gesaran: methoprottryne  
Gesarol: DDT  
Gesatop: simazine  
Geysar: difeconazole  
Glean: chlorsulfuron  
Glyodex: glyodin  
Glyoxide: glyodin  
Goal: oxyfluorfen  
Gokilaht: cyphenotrin  
Goltix: metamitron  
Graminon: isoproturon  
Gramoxone: paraquat dichloride  
Granit: bromuconazole  
Granurex: neburon  
Grasp: tralkoxydim  
Gratil: amidosulfuron  
Grenade: cyhalothrin  
Guerasol: DDT  
Guthion: azinphos-ethyl  
Gusathion: azinphos-ethyl  
Gy-bon: simetryn  
  
Harmony: thifensulfuron

Harness: acetochlor  
 Harvade: dimethipin  
 Hataclean: trichlamide  
 Healthied: pefurazoate  
 Helothion: sulprofos  
 Herald: fenpropathrin  
 Herbadox: pendimethalin  
 Herbit: MCPA-thioethyl  
 Herbogil: dinoterb  
 Hinochloa: mefenacet  
 Hinosan: edifenphos  
 Hoegrass: diclofop-methyl  
 Hoelon: diclofop-methyl  
 Horizon: tebuconazole  
 Hostaquick: heptenophos  
 Hostathion: triazophos  
 Hyvar X: bromacil

Ignite: glufosinate  
 Igran: terbutryn  
 Illoxan: diclofop-methyl  
 Imidan: phosmet  
 Impact: flutriafol  
 Imperator: cypermethrin  
 Insegar: fenoxycarb  
 Iso-Cornox: mecoprop  
 Isotox: lindane  
 Isoxyl: isouron  
 Ivosit: dinoseb acetate

Javelin: diflufenican  
 Joker: silafluofen

Karathane: dinocap  
 Karmex: diuron  
 Karphos: isoxathion  
 Kayabest: methasulfocarb  
 Kayametone: methoxyphenone  
 Kayanex: bithiosemi  
 Kayaphos: propaphos  
 Kelthane: dicofol  
 Kemate: anilazine  
 Kenopel: guazatine  
 Kerb: propyzamide  
 Keropur: benazolin  
 Kilval: vamidothion  
 Kitazin: iprobenfos  
 Klartan: fluvalinate  
 Klerat: brodifacoum  
 Kloben: neburon  
 Kolo: dichlone  
 Krenite: fosamine  
 Kumulan: nitrothal  
 Kuron: fenoprop  
 Kurosal: fenoprop  
 Kusagard: alloxymdim

Lance: cloethocarb  
 Landrin: trimethacarb  
 Lanirat: bromadiolone  
 Lannate: methomyl  
 Lanray: orbencarb  
 Laptran: ditalimfos  
 Larvadex: cyromazine  
 Larvin: thiodicarb  
 Laser: cycloxydim  
 Lasso: alachlor  
 Lebaycid: fenthion  
 Legurame: carbetamide  
 Lentagran: pyridate  
 Lesan: fenaminosulf  
 Lexone: metribuzin  
 Limbolid: heptopargil  
 Lindafor: lindane  
 Lindagranox: lindane  
 Lindamul: lindane  
 Lindaterra: lindane  
 Liphadione: chlorophacinone  
 Lironion: difenoxuron  
 Logran: triasulfuron  
 Londax: bensulfuron  
 Lontrel: clopyralid  
 Lorox: linuron  
 Lorsban: chlorpyrifos  
 Lynx: tebuconazole

Machete: butachlor  
 Magister: fenazaquin  
 Maki: bromadiolone  
 Malix: endosulfan  
 Maloran: chlorbromuron  
 Manage: imibenconazole  
 Manzate 200: mancozeb  
 Manzate: maneb  
 Marathon: prodiamine  
 Mariate: methoxycor  
 Marshal: carbosulfan  
 Masai: tebufenpyrad  
 Matacil: aminocarb  
 Mataven: flamprop methyl  
 Match: lufenuron  
 Mavrik: fluvalinate  
 Maxforce: hydramethylnon  
 Mediben: dicamba  
 Melprex: dodine  
 Meltatox: dodemorph acetate  
 Meobal: xylylcarb  
 Meothrin: fenpropathrin  
 Merpelan AZ: isocarbamid  
 Mertect: thiabendazole  
 Mesamate: MSMA  
 Mesoranil: aziprotryne



Mesurol: methiocarb  
 Metacide: parathion  
 Metacrate: metolcarb  
 Metadelphene: diethyl toluamide  
 Metaisosystoxulfon: demeton-S-methyl sulphone  
 Metasystemox: oxydemeton-methyl  
 Metasystemox R: oxydemeton-methyl  
 Metasystox: demeton-S-methyl  
 Metasystox R: oxydemeton-methyl  
 Methavin: methomyl  
 MG-06: eglinazine  
 MH-30: maleic hydrazide  
 Milagro: nicosulfuron  
 Milban: ziram  
 Milban: dodemorph acetate  
 Mil-Col: drazoxolon  
 Milcurb: dimethirimol  
 Mildothane: thiophanate-methyl  
 Milgo: ethirimol  
 Millie: ditalimfos  
 Milogard: propazine  
 Mimic: tebufenozide  
 Mipcin: isoprocarb  
 Miral: isazofos  
 Mirex: sulfluramid  
 Missile: pyrazophos  
 Mist-o-matic: phenyl mercury acetate  
 Mitac: amitraz  
 Mitacid: cyhexatin  
 Mitin FF: sulcofuron  
 Mitin N: flucofuron  
 MO: chlornitrofen  
 MO 500: fluoronitrofen  
 Mobilawn: diclofenthion  
 Mocap: ethoprophos  
 Moddus: trinexapac  
 Modown: bifenox  
 Mogeton: quinoclamine  
 Monceren: pencycuron  
 Moncut: flutalonil  
 Monguard: diclomezine  
 Monitor: methamidophos  
 Morestan: chinomethionat  
 Morfotox: mecarbam  
 Morocide: binapacryl  
 Morrocid: binapacryl  
 MTO 460: phosdiphen  
 Multiprop: chlorflurenol methyl  
 Murfotox: mecarbam  
 Murox: nuarimol  
 Muscamone: muscalure  
 Muster: ethametsulfuron  
 Mylone: dazomet  
 Mylone: ioxynil

Mythos: pyrimethanil  
 Nabu: sethoxydim  
 Nebijin: flusulfamide  
 Neguvon: trichlorfen  
 Nelpon: tridiphane  
 Nemacur: fenamiphos  
 Nemagon: DBCP  
 Nemathorin: fosthiazate  
 Neobyne: barban  
 Neocid: DDT  
 Neo-Pynamin: tetramethrin  
 Neoron: bromopropylate  
 Neotox: TEPP  
 Neporex: cyromazine  
 Nexion: bromophos  
 Nifos: TEPP  
 Nimrod: bupirimate  
 Niran: parathion  
 Nissorun: hexythiazox  
 Nogos: dichlorvos  
 Nomolt: teflubenzuron  
 Nortron: ethofumesate  
 N-Serve: nitrapyrin  
 Nudrin: methomyl  
 Nustar: flusilazole  
 Nuvacron: monocrotophos  
 Nuvan: bromopropylate  
 Nuvanol N: iodofenphos  
 Octachlor: chlordan  
 Octalene: aldrin  
 Octalox: dieldrin  
 Ofnak: pyridafenthion  
 Oftanol: isofenphos  
 Ofunack: pyridafenthion  
 Olymp: flusilazole  
 Omadine: dipyrithione  
 Omexan: bromophos  
 Omite: propargite  
 Oncol: benfuracarb  
 Ordram: molinate  
 Orion: alanycarb  
 Ornaline: vinclozolin  
 Orthene: acephate  
 Ortho 20615: ofurace  
 Orthocide: captan  
 Ortus: fenpyroximate  
 Oryzaemate: probenazole  
 Oryzemate: probenazole  
 Osadan: fenbutatin oxide  
 Osbac: fenobucarb  
 Oust: sulfometuron  
 Outflank: permethrin  
 Outfox: cyprazine

Ovex: chlorfenson  
Ovotran: chlorfenson

Paarlan: isopropalin  
Padan: cartap  
Paicer: pyrazoxyfen  
Pallinal: nitrothal  
Pancil-T: octhiline  
Panocon: fenothiocarb  
Panocrine: guazatine  
Panogen: methoxy ethyl mercury acetate  
Panoram: fenfuram  
Panoram D-31: dieldrin  
Papthion: phenthoate  
Parlay: paclobutrazol  
Patap: cartap  
Parzate: nabam  
Parzate: zineb  
Patoran: metobromuron  
Patrol: fenpropidin  
Pay-Off: flucythrinate  
Peak: prosulfuron  
Pegasus: diafenthion  
Penta: pentachlorophenol  
Pentac: dienochlor  
Perfekthion: dimethoate  
Perflan: tebuthiuron  
Perizin: coumaphos  
Permit: halosulfuron  
Peropal: azocyclotin  
Persulon: fluotrimazole  
Perthrine: permethrin  
Phaltan: folpet  
Pharorid: methoprene  
Phenacide: camphechlor  
Phenatox: camphechlor  
Phenotan: dinoseb acetate  
Phosdrin: mevinphos  
Phosfleur: chlorphonium  
Phosfon: chlorphonium chloride  
Phygon: dichlone  
Phyomone: 1-naphthylacetic acid  
Phytar: dimethylarsinic acid  
Phytosol: trichloronat  
Picket: permethrin  
Picrin 80: chloropicrin  
Pilot: quizalofop-ethyl  
Pirimor: pirimicarb  
Pival: pindone  
Pivalyn: pindone  
Pivot: imazethapyr  
Pix: mepiquat chloride  
Planavin: nitalin  
Planete: hexaconazole  
Plant Pin: butoxycarboxim  
Plantvax: oxycarboxim  
Plictran: cyhexatin

Plondrel: ditalimfos  
Poast: sethoxydim  
Polo: diafenthion  
Polyram: metiram  
Pomarsol: thiram  
Potablan: monalide  
Pounce: permethrin  
Pradone: dimefuron  
Pramitol: prometon  
Prebane: terbutryn  
Precor: methoprene  
Prefar: bensulide  
Prefix: chlorthiamid  
Pregard: profluralin  
Prevenol: chlorpropham  
Previcur: prothiocarb  
Previcur N: propamocarb hydrochloride  
Pride: fluridone  
Primetol: prometon  
Prime: flumetralin  
Primicid: pirimiphos  
Primo: trinexapac  
Princep: simazine  
Probe: methazole  
Promet: furathiocarb  
Promicide: promacyl  
Pronto: metosulam  
Prophos: ethoprop  
Proponit: propisochlor  
Provax: metsulfovax  
Provenol: chlorpropham  
Prowl: pendimethalin  
Prunit: uniconazole  
PSP-204: IPSP  
Puma: fexoxaprop  
Punch: flusilazole  
Pursuit: imazethapyr  
Pydrin: fenvalerate  
Pynamin: allethrin  
Pyramin: chloridazon  
Pyranica: tebufenpyrad

Quartz: diflufenican  
Quick: chlorophacinone  
Quinolate: oxine-copper

Rabon: tretachlorvinphos  
Racer: fluorchloridone  
Racumin: coumatetralyl  
Radapon: dalapon-sodium  
Radar: propiconazole  
Ramik: diphacinone  
Ramrod: propachlor  
Rancho: mefenacet  
Randex: allidochlor  
Rangado: dimethylvinphos  
Ratak: brodifacoum/difenacoum

Raticate: norbormide  
 Ratilan: coumachlor  
 Raviac: chlorophacinone  
 Raxil: tebuconazole  
 Real: triticonazole  
 Reducymol: ancymidol  
 Reflex: fomesafen  
 Regent: fipronil  
 Reglone: diquat dibromide  
 Reldan: chlorpyrifos methyl  
 Remtal: trietazine  
 Resbuthrin: bioresmethrin  
 Resisan: dicloran  
 Resource: flumiclorac  
 Responsar: cyfluthrin  
 Rhizopon: indol-3-ylacetic acid  
 Rhodocide: ethion  
 Rico: anilofos  
 Ridomil: metalaxyl  
 Rifit: pretilachlor  
 Rilof: piperophos  
 Rimidin: fenarimol  
 Ripcord: cypermethrin  
 Rizolex: tolclofos-methyl  
 Ro-Neet: cycloate  
 Rodewood: azaconazole  
 Rodex: fluoroacetamide  
 Rody: fenpropathrin  
 Rogue: propanil  
 Rondo: pyrifenoxy  
 Ronilan: vinclozolin  
 Ronstar: oxadiazon  
 Rootone: 1-naphthylacetic acid  
 Rootone F: indol butyric acid  
 Rospin: chloropropylate  
 Roundup: glyphosate  
 Rovral: iprodione  
 Roxion: dimethoate  
 Rubigan: fenarimol  
 Rufast: acrinathrin  
 Rugby: cadusafos  
 Ryzelan: oryzalin

Safari: triflurosulfuron  
 Safetray: azaconazole  
 Safrotin: propetamphos  
 Saga: tralomethrin  
 Salithion: dioxabenzofos  
 Salvo: dazomet  
 Sanbird: pyrazolinate  
 Sancap: dipropetryn  
 Sandofan: oxadixyl  
 Sanmite: pyridaben  
 Santobrite: pentachlorophenol  
 Sanvex: cartap  
 Sapecron: chlorfenvinphos  
 Sappiran: chlorfenson  
 Saprol: triforine

Satisfar: etrimfos  
 Saturn: thiobencarb  
 Scala: pyrimethanyl  
 Scepter: imazequin  
 Score: difenconazole  
 Scout: tralomethrin  
 Screen: flurazole  
 Seedox: bendiocarb  
 Selecron: profenofos  
 Select: clethodim  
 Semeron: desmetryn  
 Semevin: thiodicarb  
 Sencor: metribuzin  
 Sencoral: metribuzin  
 Seradix: 4 indol 3yl butyric acid  
 Serinal: chlozolate  
 Seritard: inabenzide  
 Setoff: cinosulfuron  
 Sevin: carbaryl  
 Shibagen: flazasulfuron  
 Shiragen: tecloftalam  
 Shirahagen: tecloftalam  
 Shiran: fluazinam  
 Shogun: propaquizafop  
 Showrone: daimuron  
 Shoxin: norbormide  
 Sibatito: imazosulfuron  
 Silatop: silafluofen  
 Silvaur: tebuconazole  
 Sinbar: terbacil  
 Sirbon: halfenprox  
 Sirius: pyrazosulfuron  
 Siofex: forchlorfenuron  
 Siofit: fenclorim  
 Solan: pentanochlor  
 Solfac: cyfluthrin  
 Solicam: norflurazon  
 Solvirex: disulfoton  
 Sonalan: ethalfluralin  
 Sonalen: ethalfluralin  
 Sonar: fluridone  
 Sonax: etaconazole  
 Sorilan: fenpropadin  
 Sparticide: fluoromide  
 Spike: tebuthiuron  
 Splendor: tralkoxydim  
 Sportak: prochloraz  
 Spotless: diniconazole  
 Stacker: methylmymron  
 Stam: propanil  
 Stampede: propanil  
 Standak: aldoxycarb  
 Staple: pyriothioac-sodium  
 Starane: fluroxypyr  
 Starner: oxolynic acid  
 Steladone: chlorfenvinphos  
 Stemtrol: piproctanyl bromide

Stockade: cypermethrin/permethrin  
 Stomp: pendimethalin  
 Stopscald: ethoxyquin  
 Storite: thiabendazole  
 Storm: flocoumafen  
 Stratagem: flocoumafen  
 Stratos: cycloxdim  
 Subitex: dinoseb  
 Suffix: benzoylprop-ethyl  
 Suffix BW: flamprop-M-isopropyl  
 Sulfasan: EXD  
 Sumagic: uniconazole  
 Sumi-alfa: esfenvalerate  
 Sumi-alpha: esfenvalerate  
 Sumi-eight: diniconazole  
 Sumicidin: fenvalerate  
 Sumico: diethofencarb  
 Sumiherb: bromobutide  
 Sumilarv: pyriproxifen  
 Sumilex: procymidone  
 Sumisclex: procymidone  
 Sumisoya: flumioxazin  
 Sumithion: fenitrothion  
 Sumithrin: phenothrin  
 Super-Barnon: flamprop-M-isopropyl  
 SuperCaid: bromadiolone  
 Super-Mosstox: dichlorophen  
 Superarsonate: MSMA  
 Supona: chlorfenvinphos  
 Supracide: methidathion  
 Surcopur: propanil  
 Surpass: acetochlor  
 Surecide: cyanofenphos  
 Surflan: oryzalin  
 Sutan: butylate  
 Synexus: flupoxam  
 Systhane: myclobutanil

Tachigaren: hymexazol  
 Tackle: acifluorfen-sodium  
 Tairel: benalaxyl  
 Takeoff: imazosulfuron  
 Taktic: amitraz  
 Talcord: permethrin  
 Talon: brodifacoum  
 Talstar: bifenthrin  
 Tamaron: methamidophos  
 Tamex: butralin  
 Tandem: tridiphane  
 Tandex: karbutilate  
 Taredan: cadusafos  
 Targa: quizalofop-ethyl  
 Task: dichlorvos  
 Techlead: ipconazole  
 Tecto: thiabendazole  
 Tedion: tetradifon

Telar: chlorsulfuron  
 Tell: primisulfuron  
 Telone: 1,3-dichloropropene  
 Telvar: monuron  
 Temik: aldicarb  
 Tenoran: chloroxuron  
 Teridox: dimethachlor  
 Tern: fenpropidin  
 Terraclor: quintozone  
 Terracur P: fensulfothion  
 Terratop: isocarbamid  
 Terrazole: etridiazole  
 Tersan: thiram  
 Tetron: TEPP  
 Thifor: endosulfan  
 Thimet: phorate  
 Thimul: endosulfan  
 Thiobel: cartap  
 Thiodan: endosulfan  
 Thiophos: parathion  
 Tiezene: zineb  
 Tiguvon: fenthion  
 Tillam: pebulate  
 Tilt: propiconazole  
 Titus: rimsulfuron  
 Tok: nitrofen  
 Tokkom: nitrofen  
 Tokuthion: prothiofos  
 Tolban: profluralin  
 Tolkan: isoproturon  
 Tomathrel: ethephon  
 Tomatlane: cloxyfonac  
 Tomorin: coumachlor  
 Topas: penconazole  
 Topik: clodinafop  
 Topik: cloquintocet  
 Topsin M: thiophanate-methyl  
 Torak: dialifos  
 Tordon: picloram  
 Torque: fenbutatin oxide  
 Totril: ioxynil  
 Toxakil: camphechlor  
 Tracker: tralomethrin  
 Tralate: tralomethrin  
 Tralox: tralomethrin  
 Tramet: ethofumesate  
 Trans-Vert: MSMA  
 Trebon: ethofenprox  
 Treflan: trifluralin  
 Tribunil: methabenzthiazuron  
 Trifmine: triflumizole  
 Trifocide: DNOC  
 Trifungol: ferbam  
 Trigard: cyromazine  
 Trimidal: nuarimol  
 Triminol: nuarimol

Trithion: carbophenothion  
 Tritisan: quintozene  
 Trivax: methfuroxam  
 Trophy: acetochlor  
 Tropotox: MCPB  
 Trueno: hexaflumuron  
 Trysben: 2,3,6 TBA  
 Tsumacide: metolcarb  
 Tubotin: fentin hydroxide  
 Tugon: trichlorfon  
 Tupersan: siduron

Ultracide: methidathion  
 Unden: propoxur  
 Undene: propoxur  
 Uribest: naproanilide  
 Urox: monuron  
 Ustilan: ethidimuron

Vangard: etaconazole  
 Vapam: metham-sodium  
 Vapona: dichlorvos  
 Vapotone: TEPP  
 Vaporthrin: empethrin  
 Vectra: bromuconazole  
 Vegetox: cartap  
 Velpar: hexazinone  
 Velsicol 104: dicamba  
 Vendex: fenbutatin oxide  
 Venturol: dodine  
 Venzar: lenacil  
 Verdict: haloxyfop  
 Verdinal: phenisopham  
 Vernam: vernolate

Vetrazine: cyromazine  
 Victenon: bensultap  
 Vigil: diclobutrazol  
 Vikane: sulfuryl fluoride  
 Vinicur: cyprofuram  
 Vincit: flutriafol  
 Vitavax: carboxin  
 Volaton: phoxim  
 Volparox: fenitropan  
 Voltage: pyraclofos  
 Voronit: fuberidazole  
 VPM: metham-sodium  
 Vydate: oxamyl

Warbax: famphur  
 Warbexol: famphur  
 Weedazol: amitrole  
 Weedex: simazine  
 Weedone: 2,4,5-T  
 Whip: fenoxaprop-ethyl  
 Wypout: barban

Xyligen: furmecyclox

Yaltox: carbofuran  
 Yukamate: dimepiperate

Zectran: mexacarbate  
 Zellek: haloxyfop-ethoxyethyl  
 Zerlate: ziram  
 Zero One: MCPA-thioethyl  
 Zolone: phosalone  
 Zorial: norflurazon  
 ZZ-Doricida: bensultap

# APPENDIX III

## RAW MATERIALS AND INTERMEDIATES

*See PREFACE: How to Use This Handbook*

Many intermediates are listed under the main function. For example:

chloroformates	pyridines
coumarin derivatives	pyrimidines
diazonium chloride compounds	pyrroles
esters (see the corresponding acid)	quinolines
guanidines	quinoxalines
hydrazines	silanes
isocyanates	sulfenyl chlorides
isoxazoles	sulfonamides
mercaptans	sulfonium ions
oxadiazoles	sulfonyl chlorides
piperidines	thiadiazoles
pyridazines	thiophenes
pyridazines	triazines

Example:	butyl mercaptan	see	mercaptan butyl
	ethyl aceto acetate	see	aceto acetic acid
	methyl benzoate	see	benzoic acid
	dimethyl hydrazine	see	hydrazine dimethyl
	methyl thio pseudo urea	see	pseudo urea
	methyl sulfonyl chloride	see	sulfonyl chloride (methyl)

– di, tri are listed in alphabetical order

Example:	dichloroaniline	see	<u>d</u> ichloroaniline
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–ortho, meta, para, secondary, tertiary, are not considered in alphabetical order.

Example:	tertiary butyl	see	<u>b</u> under butyl
	orthodichlorobenzene	see	<u>d</u> under o- <u>d</u> ichlorobenzene

The synthesis of intermediaries marked with an asterisk is described in the previous section, or in the synthesis of the corresponding pesticide.

The first word is the raw material/intermediate, and the products follow after the colon.

Acetaldehyde: alanycarb, fluxofenim, methomyl, nitrapyrin, sulfentrazone

Acetamide malonic acid: glufosinate

Acetanilide\*: asulam

Acetic acid: dodine, fentin, glyodin, phenyl mercury acetate, see acetyl chloride chloro acetic acid

Acetic anhydride: acephate, fluoro chloridone, plifenate

Aceto acetaldehyde: flumetsulam

Aceto acetanilide\*: carboxin, metsulfovax, oxycarboxin

Aceto acetic acid\*: benzofenap, bromacil, carboxin, coumaphos, crotoxypfos, diazinon, dithiopyr, drazoxolon, fenfuram, flurazole, furnecyclox, hymexazol, imazaquin, methfuroxam, mevinphos, oxycarboxin, phosphamidon, pirimiphos, propetamphos, pyrazolate, terbacil

Acetoin: methfuroxam

Acetone: alloxymid, bendiocarb, coumachlor, cyanazine, dikegulac-sodium, ethoxyquin, furilazole, hydramethylnon, metobenzuron, procyazine, pronamide, propaquizafop, sethoxidim, tralkoxydim, warfarin

Acetone cyanohydrin\*: cyanazine, procyazine

Acetone oxime: propaquizafop

Acetonitrile: alanycarb, benzamizole, chlorsulfuron, etridazol, flurazole, isoxaben, methomyl, metsulfovax, metsulfuron, thicyofen, thifensulfuron, triasulfuron, see TOA

Acetonyl succinic acid: prohexadione

Acetophenone\*: difenzoquat, pyrazoxyfen

Acetophenone 2,4 dichloro: see dichloro acetophenone

Acetyl acetone\*: sulfmeturon

Acetyl chloride: acephate, azaconazole, chlorfenvinphos, cyhalotrin, dimethomorph, dinoseb acetate, fenitropan, fluxofenim, furconazole, mefluidide, propiconazole

Acetyl chloride (dichloro): see dichloro

Acetyl chloride phenyl carbinol: bromadiolone

Acetylene: aldrin, 2,4 DB

Acetyl hydrazine\*: metamitron

Acetylide (sodium): pronamide

Acetyl magnesium bromide: empenithrin

Acetyl morpholine\*: dimethomorph

Acetyloxy propionaldehyde: furmecyclox

Acrolein: 8 hydroxy quinoline sulfate

Acrylic acid: propaquizafop

Acryloyl chloride: propaquizafop

Acrylonitrile: fenpiclonil, fludioxonil, nipyraclufen

Aldrin: dieldrin, endrin

Allyl bromide: bromuconazole, fluorochloridone, piproctanyl, silafluofen

Allyl chloride\*: DBCP, dichloropropene, imizalil, probenazole

2 Allyl, 3 methyl, 4 hydroxy cyclopent 2 ene 1 one: prallethrin

Alumina: fosetyl aluminum

Aluminum isopropylate: bromadiolone

Aluminum nitrate: fosetyl aluminum

o-Amino benzaldehyde: imazaquin

2 Amino 6 chloro benzoic acid: pyriithiobac

2 Amino benzothiazole\*: benzthiazuron

2 Amino 5 chloro cinnamic acid: ethylchlozate

2 Amino 5 chloro toluene: chlordinform, chloromethiuron

2 Amino 4 chloro phenol: cloquintocet

p-Amino 2,6 dichloro phenol\*: chlorfluazuron

4 Amino 2,2 difluoro benzodioxol: fludioxonil

2 Amino 2,3 dimethyl butyramide: imazamethabenz, imazapyr, imazaquin, imazethapyr

5 Amino 2,4 dimethyl aniline: mefluidide

Amino guanidine\*: amitrole

Amino isobutyronitrile: cyanazine

m-Amino phenol\*: desmedipham, formetanate, karbutilate, mepronil, phenisopham, phenmedipham

o-Amino phenol\*: 8 hydroxyquinoline sulfate, phosalone, triasulfuron

m-Amino toluene\*: phenmedipham

o-Amino toluene\*: siduron

p-Amino toluene\*: daimuron, dymron

4 Amino xylenol: mexacarbate

Ammonium chloride: dichlobenil

Ammonium dithiocarbamate: thiabendazole

Ammonium thiocyanate: antu

Aniline: benodanil, bromethalin, carbetamide, carboxin, clomeprop, desmedipham, dichlofluanid, fenfuram,

- fenpiclonil, fenuron, forchlorfenuron, metobromuron, metsulfovax, methfuroxam, naproanilide, oxycarboxin, pencycuron, propham, siduron, thidiazuron
- Aniline derivatives: see methyl, dimethyl, trifluoro, etc.
- Anisole\*: chlomethoxyfen, diclofop, methoxychlor, see bromoanisole
- Anthranilic acid\*: bentazon, fenazaquin
- Antimony trifluoride: flurprimidol
- Arsenic trioxide: cacodylic acid, DSMA, MSMA
- Arsenious oxide: fenasox
- Atrazine: ametryn
- Barium chloride: sulfuryl chloride
- Barium fluoro sulfonate: sulfuryl chloride
- Bensultap: thiocyclam
- Benzalacetone\*: warfarin
- Benzaldehyde\*: diclobutrazol, difenzoquat, diniconazole, diphenamid, warfarin, see chlorobenzaldehyde, dichloro benzaldehyde
- Benzamidine: fenclorim
- Benzazimide: azinphosmethyl
- Benzene: carbophenothion, diphacinone, fluotrimazole, hexachlorobenzene, lindane, phenylmercury acetate, resmethrin
- Benzene chloride: see Chlorobenzene
- Benzene sulfonyl chloride\*: bensulide
- Benzil (4.4 dichloro): chlorbenzilate
- Benzimidazole\*: carbendazim
- Benzoic acid\*: benodanil, benzoximate, benzoylprop ethyl, bifenox, chloramben, clofentezine, dimethomorph, flampop isopropyl, flampop methyl, oxabetrinil, phoxim, pronamide, 2.3.6 TBA, triflumuron, see benzoyl chloride, see chlorobenzoic acid, see dichlorobenzoic, see iodo benzoic acid
- Benzoin (4.4 dichloro): chlorbenzilate
- Benzol thiosulfonic acid: bensultap
- Benzotrifluoride: fluometuron
- Benzonitrile\*: fenclorim
- Benzoquinone: chloraneb, ethofumesate
- Benzothiazole: benzthiazuron, metabenzthiazuron
- Benzoxazine (2.3. dihydro 3 methyl): benoxacor
- Benzoxazole (2 mercapto, 6 chloro): fenoxaprop
- Benzoxazolone: phosalone
- Benzoyl chloride\*: see benzoic acid
- Benzoyl cyanide\*: metamitron, oxabetrinil
- N Benzoyl glycine: see hippuric acid
- Benzyl alcohol: flurazole
- Benzylamine\*: methyldymron
- Benzyl bromide\*: cinosulfuron, hexythiazox
- Benzyl chloride: tebutam
- Benzyl cyanide\*: fenbuconazole, resmethrin
- 5 Benzyl 3 hydroxy furan: bioresmethrin
- 5 Benzyl 3 hydroxy methyl furan: resmethrin
- N benzyl N isopropyl amine: tebutam
- 2.2. Bipyridil: diquat
- Bornan 2 one: heptopargil
- Bromo acetic acid methyl ester: flumiclorac
- p.Bromo aniline: metobromuron
- p.Bromo anisole: benfuresate, diclofop, flurprimidol
- Bromo benzene: chlorbromuron, fonofos
- $\alpha$  Bromo t.butyl acetylchloride: bromobutide
- Bromo chloromethane: chlormephos



Bromo cyclohexane: azocyclotin, cyhexatin  
 Bromoethane: furconazole  
 3 Bromo 4 fluorotoluene: cyfluthrin  
 2 Bromo 1 methoxy propane: metolachlor  
 4 Bromo 3 methyl aniline: metosulam  
 4 Bromo methylbenzoic acid isobutyl ester: fenpyroximate  
 p Bromo nitro benzene: chlorbromuron  
 4 Bromophenol: silafluofen  
 $\alpha$  Bromo  $\alpha$  phenyl acetone: diphacinone  
 Bromo pinacolone\*: diclobutrazol, triadimefon  
 Bromo propane: penconazole  
 Bromo propionic acid: diclofop-methyl, furalaxyl, metalaxyl, naproanilide, napropamide, see chloro propionic acid  
 1 Bromo 2 propyne: flupropadine  
 Bromo succinimide\*: quinmerac  
 m. Bromotoluene: see PCBA  
 p Bromo trichloro methoxy benzene: flurprimidol  
 p Bromo trifluoro methoxy benzene: flurprimidol  
 Butadiene: captafol, captan  
 1.2 Butane diol: etaconazole  
 Butanoic acid: cycloxidim  
 n-Butanol: butachlor, fluazifop, furathiocarb, piperonyl butoxide  
 2 Butene diol 1.4: endosulfan  
 2 Butenol: butenachlor  
 Butocarboxim: butoxycarboxim  
 t-Butyl acetyl chloride: bromobutide  
 t-Butyl alcohol: bifenthrin, cyhalothrin, tefluthrin  
 n Butyl amine\*: benfluralin, benomyl  
 sec Butyl amine: bromacil, sebumeton  
 t Butyl amine: diafenthuron, glyphosate, karbutilate, nicosulfuron, rimsulfuron, terbumeton, terbutryne, terbutylazine  
 p-tert Butyl benzaldehyde: fenpropidin, fenpropimorph  
 p-tert Butyl benzylamine: tebufenpyrad  
 p-tert Butyl benzyl chloride: pyridaben  
 Butyl bromide: buthiobate  
 Butyl carbitol\*: piperonyl butoxide  
 t-Butyl dimethyl silylamine: triflusulfuron  
 2 Butyl ethyl aceto acetate: dimethirimol, ethirimol  
 Butyl ethyl amine: benefin, benfluralin, pebulate  
 Butyl lithium: fenarimol, hexaconazole, muscalure  
 Butyl magnesium chloride: muscalure  
 t-Butyl methyl ketone: see pinacolone  
 o-sec Butyl phenol: dinobuton, dinoseb, fenobucarb  
 m-tert Butyl phenol: pyributicarb  
 o-tert Butyl phenol: dinoterb  
 p-tert Butyl phenol\*: butralin, propargite  
 2(p-tert Butyl phenyl)ethanol: fenazaquin  
 1.4 Butyne diol\*: barban, chloridazon, norflurazon, pyridaben  
 (iso) Butyraldehyde: ethofumesate  
 $\delta$  Butyrolactone\*: 2,4 DB, 4 indol 3 yl butyric acid, MCPB  
 Butyric acid: perfurazoate, see butyryl chloride  
 Butyryl chloride: alloxidim, cycloxidim, fosmethilan, promacyl, sethoxydim  
  
 Camphene: camphechlor (toxaphene)  
 Capryl phenol: dinocap  
 Carbendazim: benomyl

Carbofuran: benfuracarb

Carbon dioxide: dicamba, tefluthrin

Carbon disulfide: captan, dazomet, dithianon, EXD, ferbam, folpet, hexythiazox, isoprothiolane, mancozeb, maneb, metam, methidathion, nabam, propineb, tebuthiuron, thicyofen, thiram, zineb, ziram

Carbon monoxide: fenuron

Carbon oxy sulfide: see carbonyl sulfide

Carbon tetrabromide: deltamethrin, tralomethrin

Carbon tetrachloride: cypermethrin, permethrin, tridiphane

Carbonyl sulfide: diallate, fenothiocarb, hexythiazox, orbencarb, thiobencarb, triallate

Carboxin: oxycarboxin

2 Carboxy 5 t.butyl isoxazole: isouron

Catechol\*: carbofuran, cloetocarb, dimethomorph, oxolinic acid, propoxur

CDMA: alachlor, butachlor

Chloroacetic acid\*: benazolin, cloquintocet, cloxyfonac, 4 CPA, cymoxanil, 2,4 D, diethatyl, fenchlorazole, flumioxazin, fluoroglycofen, fluoxypyr, glyphosate, indol 3 yl acetic acid, MCPA, naphthoxy acetic acid, naphthylacetamide, naphthylxy acetic acid, 2 naphthylxy acetic acid, 2,4,5 T, triazamate, see chloro acetylchloride

Chloral\*: chloretoxyfos, chloralose, DDT, dichlorvos, dicofol, methoxychlor, naled, plifenate, trichlamide, trichlorfon, triforine

Chlordane: heptachlor

Chlordene: chlordane

Chlorine cyanide: see cyanogen chloride

Chloro acetaldehyde: nipyraclufen, oxabetrinil

Chloro acetone: pymetrozine

Chloro acetonitrile: thicyofen

Chloro acetyl chloride: acetochlor, alachlor, allidochlor, anilofos, butachlor, butenachlor, CDAA, diethatyl, dimethachlor, dimethenamid, dimethoate, flutriafol, formothion, hexaconazole, mecarbam, metalaxyl, metazachlor, ofurace, omethoate, oxadixyl, piperophos, pretilachlor, propachlor, propaquizafop, propisochlor, prothoate, pyrifenoxy, thenylchlor, triflumizole, see dichloro acetyl chloride

Chloro acetyl morpholine: dimethomorph

2 Chloro acrylonitrile: nipyraclufen, thifensulfuron

1 Chloro 3 allyl oxyamine: clethodim

6 Chloro amino benzoic acid\*: pyriothiobac

5 Chloro meta amino phenol: fluazuron

2 Chloro 4 amino toluene\*: chlorotoluron, pentanochlor

m-Chloro aniline: barban, chlorbufam, chlorpropham, cyprofuram, flutalonil

o-Chloro aniline\*: anilazine, chlorsulfuron, drazoxolon

p-Chloro aniline\*: chloroxuron, difenoxuron, diflubenzuron, monalide, monolinuron, monuron, pyraclofos

2 p.Chloro aniline, phenyl ketone: inabenfide

m-Chloro anisole: chlomethoxyfen

6 Chloro anthranilic acid: pyriothiobac

p-Chloro benzal acetone\*: coumachlor

o-Chloro benzaldehyde\*: dimethazone

p-Chloro benzaldehyde\* chlorobenzilate, chloropropilate, coumachlor, paclobutrazol, triticonazole, uniconazole

Chloro benzene: chlorfenson, chlorophacinone, DDT, dicofol, EPN, ethoxyquin, fenarimol, fentin, fluxofenim, nitrofen, pyriproxifen, tetradifon

o-Chloro benzene diazonium chloride: drazoxolon

2 Chloro benzene sulfonamide: chlorsulfuron

3 Chloro 1,2 benziso thiazole 1,1 dioxide: probenazole

2 Chloro benzoic acid\*: triflumuron

3 Chloro benzoic acid: acifluorfen

2 Chloro 4 fluoro phenol: flumiclorac

2 Chloro 4 fluoro 5 nitrophenol: flumiclorac

1 Chloro 2 methoxy ethylene: cloetocarb

- 3 Chloro benzoic acid\*: bifenox, fluoroglycofen, fomesafen
- 2 Chloro benzoyl chloride: chlorphoxim, clofentezine, fenarimol
- 4 Chloro benzoyl chloride\*: dimethomorph
- 2 Chloro benzoyl cyanide\*: chlorphoxim
- 2 Chloro benzyl bromide: orbencarb
- p.Chloro benzyl chloride\*: ipconazole, metconazole, paclobutrazol, pencycuron, thiobencarb
- 2 Chloro 4 bromophenol\*: profenofos
- 1 Chlorobutane: myclobutanil
- 2 Chloro 3 butanone: butocarboxim, dimethipin
- Chloro t.butyl phenol: fenbutatin
- 2 Chloro butyric acid: pefurazoate
- 3 Chloro  $\delta$  butyrolactone: cyprofuram, ofurace
- 4 Chloro butyronitrile: MCPB
- Chloro carbonyl sulfenyl chloride: flurazole
- 1 Chloro 2 (4 Chloro phenyl) ethane: fenbuconazole
- 4 Chloro o-cresol: see 2 methyl 4 chloro phenol
- p.Chloro cumene: isopropalin
- Chloro cyclohexane: cyhexatin
- Chloro difluoro methane: flucythrinate, sulfentrazone
- 4 Chloro 2,6 diisopropyl aniline: diafenthuron
- 3 Chloro 2,2 dimethyl propionic acid: dimethazone
- 7 Chloro 3,8 dimethyl quinoline: quinmerac
- 1 Chloro 2,4 dinitro benzene\*: bromofenoxim
- 4 Chloro 3,5 dinitrobenzoic acid: benfluralin, trifluralin
- Chloroethanol: oxadixyl, vamidothion
- 2 Chloro ethyl amine: fenoxycarb
- Chloro ethyl propyl amine: fluchloralin
- 2 Chloro ethyl p.toluyl sulfonate: triasulfuron
- 3 Chloro 4 fluoroaniline: flamprop isopropyl, flamprop methyl, silafluofen
- 2 Chloro 6 fluoro benzaldehyde: pyriothion
- 3 Chloro 4 fluoro benzaldehyde: silafluofen
- p.Chloro fluoro benzene: flusilazole
- 2 Chloro 6 fluoro benzyl chloride: flumetralin
- Chloroform: cypermethrin
- Chloroformates—
  - Butyl: furathiocarb
  - 2 Sec butyl phenyl: fenobucarb
  - 2 Chloroethyl: oxadixyl
  - Ethyl: ampropylfos, chlorsulfuron, desmedipham, fenoxycarb, linuron, methazole, metsulfuron, sulfometuron, tribenuron
  - Ethyl thio: butylate, cycloate, EPTC, molinate
  - Isopropyl: chlorpropham, diethofencarb, dinobuton, phenisopham, propham
  - Methyl: asulam, benomyl, carbendazim, flumiclorac, fosamine ammonium, hexazinone, phenmedipham, pyrazosulfuron, thiophanate, triflurosulfuron
  - Phenyl: amidosulfuron, buprofezin, flazasulfuron, imazosulfuron, nicosulfuron, prosulfuron, pyrazosulfuron, rimsulfuron, thidiazuron
  - Propyl: propanocarb
  - Propyl thio: pebulate, vernolate
- p-Chloro N-isopropyl aniline: anilofos
- 6 Chloro 2 mercapto benzoic acid\*: pyriothion
- 2 Chloro 6 mercapto benzonitrile\*: pyriothion
- N.Chloro methylaniline: buprofezin
- 2 Chloro N methyl acetamide: benfuracarb, omethoate
- 3 Chloro methyl benzamide: azinphos methyl

- 2 Chloro methyl benzoic acid, methyl ester\*: bensulfuron
- 3 Chloro methyl diphenyl ether: halfenprox
- Chloro methyl (dichloro) methyl silane: flusilazole
- Chloro methyl ethyl ether: acetochlor
- Chloro methyl ethyl sulfide: phorate
- 2 Chloro methyl phenol: ethiofencarb
- Chloro methyl phosphonic acid: glyphosate
- 7 Chloro 8 methyl quinoline: quinclorac
- 2 Chloro methyl trichloro silane: etacelasil
- 3 Chloro 4 methoxy aniline: metoxuron
- 1 Chloro 2 methoxy ethylene: cloetocarb
- N Chloro methylphthalimide: phosmet
- 2 Chloro nicotinic acid: dimethipin, nicosulfuron
- 2 Chloro 4 nitro aniline: flusulfamide, niclosamide
- 3 Chloro 4 nitro aniline: dimefuron
- 4 Chloro 6 nitro aniline\*: propaquizafop
- 3 Chloro 6 nitro anisole: chlomethoxyfen
- 3 Chloro 4 nitro isothiazole: nypyraclufen
- 2 Chloro nitrobenzene\*: nitralin
- 4 Chloro nitro benzene\*: diclofop, ethoxyquin, fluoronitrofen, metobenzuron, nitrofen, tetradifon, tetrasul
- 3 Chloro 6 nitro benzoic acid\*: acifluorfen, bifenox, fluoroglycifen, fomesafen
- 2 Chloro 5 nitro benzyl chloride: flupoxam
- 4 Chloro 3 nitro methyl sulfone: nitralin
- 5 Chloro meta nitro phenol: fluazuron
- 2 Chloro 4 nitro toluene\*: chlorotoluron
- 3 Chloro 6 nitro toluene\*: bifenox, fomesafen, lactofen, perfluidone
- m-Chloro perbenzoic acid: fipronil, rimsulfuron
- m-Chlorophenol: cloprop, 3 CPA, oxyfluorfen
- p-Chloro phenol\*: clodinafop, chloroxuron, 4 CPA, dichlorphen, difeconazole, difenoxuron, fenoxycarb, triadimefon, triadimenol
- 4 Chloro phenyl acetonitrile: myclobutanil
- 1 (4 Chloro phenyl) 2 cyclopropyl propanone 1: cyproconazole
- 1 (4 Chloro phenyl) 4.4 dimethyl 3 pentanone: tebuconazole
- 2-Chlorophenyl 4 fluorophenyl ketone: nuarimol
- o. Chloro phenyl magnesium bromide: fenarimol
- p. Chloro phenyl magnesium bromide: fenarimol
- 2 Chloro phenyl methyl thiourea: methabenzthiazuron
- 2 Chloro phenyl thiourea: see Thiourea
- α Chloro propionic acid\*: benalaxyl, benzoylprop, clodinafop, clomeprop, cloprop, 3 CPA, dalapon, dichlorprop, fenoprop, fenoxaprop, flamprop isopropyl, flamprop methyl, fluazifop, haloxyfop, isoxapyrifop, mecoprop, napronamide, quizalofop, quizalofop-ethyl, see propionic acid
- β Chloro propionyl chloride: pyroquilon
- Chloro pyruvic acid\*: pyraclofos, thiabendazole
- 5 Chloro salycilic acid: niclosamide
- 6 Chloro salycilic acid: pyriithiobac
- Chloro sulfonic acid: asulam, bentazon, carbophenotion, chlorfenson, famphur, flusulfamide, hexachlorobenzene, imazosulfuron, prosulfuron, tetradifon
- 3 Chloro tetra hydro furan 2 one: see 3 Chloro δ butyrolactone
- Chloro thiophenol: carbophenothion
- m-Chloro toluene: bifenox
- o-Chloro toluene: flusulfamide
- p-Chloro toluene\*: benefin, benfluralin, esfenvalerate, fenvalerate, fluchloralin, ethalfluralin, thiobencarb, trifluralin
- 2 Chloro 4 trifluoromethyl aniline: fluvalinate
- 2 Chloro 3 trifluoromethyl aniline: flucofuron

2 Chloro 4 trifluoromethyl aniline: triflumizole  
 m-Chloro trifluoromethyl benzene: bromethalin  
 o-Chloro trifluoromethyl benzene: flusulfamide  
 p-Chloro trifluoromethyl benzene: see PCTF  
 2 Chloro 4 trifluoromethyl phenol: fluoroglycofen, furyloxyfen  
 Chrysanthemic acid: acrinathrin, allethrin, bioresmethrin, cypermethrin, cyphenothrin, empenthrin, phenothrin, prallethrin, resmethrin, tetramethrin, tralomethrin  
 Copper chloride: tetradifon, tetrasul, thicyofen  
 Copper sulfate: oxime copper  
 Copper cyanide: 2.3.6 TBA  
 Coumarin\*: coumaphos  
 Coumarin (3 carbethoxy 4 hydroxy): coumachlor  
 Coumarin (3 chloro 4 methyl 7 hydroxy)\*: coumaphos  
 Coumarin (4 hydroxy): brodifacoum, bromadiolone, coumatetralyl, difenacoum, flocoumafen, warfarin  
 Coumarin (4 methyl 7 hydroxy)\*: coumaphos  
 m-Cresol: acifluorfen, clomeprop, metolcarb  
 o-Cresol: DNOC, MCDA, MCPB, mecoprop  
 p-Cresol: fluoroglycofen, fomesafen, flucythrinate, furyloxyfen, lactofen  
 Crotonaldehyde\*: sethoxidim  
 Crotonyl chloride: dinocap  
 Cumene: isopropalin, isoproturon  
 Cumidine: see p.Isopropylaniline  
 Cuprous cyanide: Dichlobenil  
 Cyanamide: benomyl, chloresulfuron, dodine, hexazinone, iminoctadine, metsulfuron, thifensulfuron, triesulfuron  
 Cyano acetamide: fenpiclonil  
 Cyanoacetic acid\*: cymoxanil, fenpiclonil  
 Cyanate: see Potassium, see Sodium  
 Cyano aceto nitrile: thicyofen  
 Cyanoborohydride: dimethazone  
 Cyanogen bromide: imidacloprid  
 Cyanogen chloride: benomyl, mephosfolan, phosfolan  
 Cyanophenol: cyanofenphos, cyanophos  
 Cyanuric chloride: ametryn, anilazine, atrazine, aziprotryne, benomyl, cinosulfuron, cyanazine, cyprazine, cyromazine, desmetryn, dimethametryn, dipropetryn, eglinazine, methoprotetryn, procyazine, proglinazine, prometon, prometryn, propazine, sec bumeton, simazine, simetryn, terbumeton, terbütryn, terbutylazine, triazines (see sulfonyl ureas), trietazine  
 Cyclododecylamine: dodemorph  
 1 Cyclohexene 1.2 dicarboximide: tetramethrin  
 Cyclohexene oxide: propargite  
 Cyclohexyl aldehyde: triapenthenol  
 Cyclohexyl amine\*: hexazinone, hexythiazox  
 Cyclohexyl hydroxylamine: furmecyclox  
 Cyclohexyl magnesium bromide: cyhexatin  
 Cyclohexyl magnesium chloride: cyhexatin  
 Cyclohexyl urea: lenacil  
 Cyclopentadiene: aldrin, chlordane, dienochlor, endosulfan, heptachlor, mirex, norbormide  
 2 Cyclopentanone 1 carboxylic acid: lenacil  
 Cyclopentylamine: pencycuron  
 Cyclopropane carboxylic acid chloride\*: cyprofuram, profluralin, trinexapac  
 Cyclopropylamine: cyprazine, cyromazine, procyazine  
 Cyclopropyl p.chloro phenyl ketone: flucycloxuron  
 DCPI\* (3.4 dichloro phenyl isocyanate): diuron, linuron, neburon, sulcofuron  
 DDT: dicofol

Demeton: oxydemeton methyl

Demeton-S-methyl: demeton-S-methyl sulfone

DEPA\* (diethyl phosphoro dithioic acid): carbophenothion, chlormephos, dialifos, dioxathion, disulfoton, ethion, fonofos, mecarbam, phorate, phosalone, prothoate, terbufos

DEPCT\* (diethyl phosphoro chlorido thioate): chlorphoxim, chlorpyrifos, coumaphos, demeton, diazinon, dichlofenthion, ditalimfos, ethyl parathion, fensulfothion, isazofos, isoxathion, mephosfolan, phoxim, pirimiphos, pyrazophos, pyridafenthion, quinalphos, sulfotep, triazophos

Diallyl amine: allidochlor, dichlormid

Di(8 amino octyl) amine: iminoctadine

Diazoacetic acid: cyhalothrin, cypermethrin

Diazomethane\*: chloroneb

Diazonium chloride (o amino phenol): triasulfuron

Diazonium chloride (o-chloro benzene): drazoxolon

Diazonium chloride (p-chloro benzene): pyraclofos

Diazonium chloride (4 dimethyl amino phenyl): fenaminosulf

Dibenzofuran: 2 phenyl phenol

Dibromobenzilic acid: bromopropylate

Dibromoethane: see Ethylene dibromide

Dibromo isocyanuric acid: bromethalin

Dibromo methane: see Methylene bromide

1.8 Dibromo octane: guazatine

Dibromoformaldoxine: hymexazol

Di-sec-butylamine: tiocarbazil

N-t-butyl-N-isopropyl thiourea: buprofezin

Dichlorfos: naled

Dichloroacetic acid: quinalphos

2.4 Dichloroacetophenone: azaconazole, chlorfenvinphos, etaconazole, propiconazole

Dichloroacetylchloride: benoxacor, chlorfenvinphos, dichlormid, fluorochloridone, furilazole, tetrachlorvinphos

2.3 Dichloroaniline: tecloftalam

2.4 Dichloroaniline: fenchlorazole, sulfentrazone

2.5 Dichloroaniline: sulcofuron

2.6 Dichloroaniline: dichlobenil

3.4 Dichloroaniline 3.4 DCA)\*: benzoyl prop-ethyl, diethofencarb, diuron, linuron, neburon, propanil, sulcofuron

3.5 Dichloroaniline: chlozolate, iprodione, procymidone, vinclozolin

3.5 Dichloro anthranilic acid: dicamba

2.3 Dichloro benzaldehyde: fenciclonil

2.4 Dichloro benzaldehyde: diclobutrazol, diniconazole

2.6 Dichloro benzaldehyde\*: dichlobenil

m.Dichlorobenzene: azaconazole, chlorfenvinphos, difeconazole, furconazole, hexaconazole, propiconazole, pyrifeno

o.Dichlorobenzene: chlorsulfuron, plifenate, see 3,4 Dichloroaniline

p.Dichlorobenzene: anilofos

4,4 Dichlorobenzil: chlorbenzilate, chloropropylate

3,4 Dichlorobenzyl chloride: chlorphonium chloride

4,4 Dichlorobenzilic acid: chlorbenzilate, chloropropylate

2,4 Dichloro benzoic acid\*: diclobutrazol, hexaconazole, penconazole, pyrifeno

2,6 Dichloro benzoic acid: dichlobenil

3,4 Dichloro benzoic acid: piperalin

3,5 Dichloro benzoic acid: pronamide

3.5 Dichloro benzoic acid: dicamba

4.4 Dichlorobenzoin: chlorbenzilate, chloropropylate

2.6 Dichlorobenzonitrile: chlorthiamid, pyriothiac

3.7 Dichloro benzotriazine 1 oxide: triazoxide

2.4 Dichloro benzotrifluoride: dinitramine, prodiamine

- 2.4 Dichloro benzoyl chloride: pyrazolate, pyrazoxyfen
- 2.5 Dichloro benzoyl chloride: chloramben
- 2.6 Dichloro benzoyl chloride: dichlobenil
- 2.4 Dichloro benzyl bromide: penconazole
- 3.4 Dichloro benzyl chloride: chlorphonium chloride
- 2.4 Dichloro benzyl chloride: diclobutrazol, penconazole
- 7.7 Dichloro bicyclohepten 2 one 6: heptenphos
- 3.6 Dichloro 5 bromo 2 hydroxy benzyl alcohol: dicamba
- 3.6 Dichloro 5 bromo 2 methoxy benzyl alcohol: dicamba
- 2.5 Dichloro 4 bromo phenol: bromophos
- 1.4 Dichlorobutane: fenothiocarb
- 2.3 Dichloro cinnamic nitrile\*: fenciclonil
- 3.5 Dichloro 2,4 difluoro aniline: teflubenzuron
- 3.5 Dichloro 2,4 difluoronitro benzene: teflubenzuron
- 2.4 Dichloro dinitro benzo trifluoride prodiamine
- Dichlorofluoromethyl sulfenyl chloride: dichlofluanid, tolyfluanid
- 2.4 Dichloro 6 fluoro phenol: fluoronitrofen
- 3.5 Dichloro 4 hydroxy aniline: chlorfluazuron
- 2.5 Dichloro 4 iodo phenol: iodofenphos
- Dichloro isopropoxy phenyl hydrazine: oxadiazon
- Dichloro maleic anhydride: fluoramide
- 2.4 Dichloro 3 methyl benzoyl chloride: benzofenap
- 1.1 Dichloro 1 methyl penta 1.3 diene: cypermethrin
- 2.4 Dichloro 3 methyl phenol: clomeprop
- 2.6 Dichloro 4 methyl phenol\*: tolclofos
- 2.3 Dichloro 1.4 naptho quinone: dithianon, quinoclamine
- 3.4 Dichloro nitrobenzene\*: methazole
- 2.4 Dichlorophenol\*: bifenox, chlomethoxyfen, 2,4 D, 2,4 DB, dichlofenthion, dichlorprop, diclofop, diclofop-methyl, nitrofen, phosdiphen, prothiofos
- 2.5 Dichloro phenol\*: dicamba
- 4(2.4 Dichloro phenoxy) phenol: diclofop-methyl
- 2.4 Dichloro phenyl acetate: penconazole
- 2.4 Dichloro phenyl acetonitrile: penconazole
- 2.4 Dichloro phenyl, diethylamino acetonitrile: pyrifenox
- 2.4 Dichloro phenyl hydroxylamine\*: methazole
- α 2.4 Dichloro phenyl B hydroxy methyl propanoate: tetraconazole
- 3.4 Dichloro phenyl isocyanate: see DCPI
- 2(3.5 Dichloro phenyl) 4,4,4 trichloro 1 butene: tridiphane
- 1.3 Dichloro propene: clethodim
- 2.4 Dichloro propyl benzoate: penconazole
- 1.3 Dichloro propyl dimethylamine: cartap
- 2.6 Dichloro quinoxaline: propaquizafop
- 2.5 Dichloro 4(1.1.2.2 tetrafluoro ethoxy) aniline: hexaflumuron
- 3.5 Dichlorotoluene: tridiphane
- 2.6 Dichloro 4 trifluoro methyl aniline: fipronil, nipyraclufen
- 1.2 Dichloro 4 trifluoro methyl benzene: flufenoxuron
- 1.2 Dicyanodimercapto ethylene: dithianon
- 2.3 Dicyano propionic acid ethyl ester: fipronil
- Dicycloheptadiene: aldrin
- Diethylamine: diethylolamide, dinitramine, famphur, phosphamidon, napropamide, orbencarb, thiobencarb, trietazine
- 2.6. Diethylaniline: alachlor, butachlor, butenachlor, diethatyl, pretilachlor
- Diethylethoxymethylene malonate: oxolonic acid
- Diethyl 3 ethoxy 2 methyl 2 propanyl phosphonate: hydroprene
- Diethyl ethyl phosphonate: fonofos

Diethyl 4 isopropiloxy carbonyl 2 methyl 2 propenyl phosphonate: methoprene

Diethyl ketone: pendimethalin

Diethyl maleate: malathion

Diethyl malonate: see Malonic acid

Diethyl phosphatechloroester: phosfolan

Diethyl phosphite\*: demeton-S-ethyl, demeton-S-methyl, fosetyl aluminum, glyphosate, penconazole

Diethyl phosphoro chloridate\*: phosfolan, TEPP

Diethyl phosphoro chloridothioate: see DEPCT

Diethyl phosphoro dithioic acid: see DEPA

Diethyl phthalate: pindone

Diethyl sulfate: chlorobenzilate, dipropetryn

2.4 Difluoro aniline: diflufenican

2.6 Difluoro aniline: flumetsulam

2.6 Difluoro benzamide (benzoylamide): chlorfluazuron, diflubenzuron, flucycloxuron, flufenoxuron, lufenuron

2.6 Difluoro benzoic acid: chlorfluazuron, difluobenzuron, flucycloxuron, flufenoxuron, hexaflumuron, teflubenzuron

Difluoro dibromo methane: halfenprox

Difluoromethane: primisulfuron

2.6 Difluoro phenyl cyanide: fluazuron

2.3. Dihydro 3 methylbenzoxazine: benoxacor

Dihydropyrane: pyriproxifen

Dihydro safrole: piperonyl butoxide

2.6 Dihydroxy benzoic acid: isoxaben

3.5. Dihydroxy benzoic acid\*: trinexapac

Di-isobutylamine: butylate

Di-isopropanol amine: fenpropimorph

Di-isopropylamine: diallate, triallate

Di-isopropylaniline: diafenthuron

2.6. Di-isopropyl 4 bromo aniline: diafenthuron

Diisopropyl phosphorochlorido thioate: see DIPCT

Diketal sorbose: dikegulac-sodium

Diketene\*: carboxin, dicrotophos, hymexazol, metsulfovax, monocrotophos, oxycarboxin, phosphamidon, propaquizafop

Dimethoxy acetic acid: propaquizafop

Dimethoxy acetic anhydride: oxadizyl

o-Dimethoxy benzene: dimethomorph

p-Dimethoxy benzene: chloroneb

Dimethoxymethane: phorate

2.2 Dimethoxy propane\*: bendiocarb

3.3 Dimethyl acrylic acid: binapacryl

3.3 Dimethyl allyl bromide: cyhalotrin

Dimethylamine: chlordimeform, chloromethiuron, chloroxuron, chlorotoluron, crimidine, dichlofluanid, dicrotophos, difenoxuron, dimefuron, dimethirimol, diphenamid, diuron, fenothiocarb, fenuron, ferbam, fluometuron, hexazinone, isoproturon, karbutilate, metoxuron, metribuzin, monuron, nicosulfuron, oxamyl, pirimicarb, pyriothiobac, thiram, tolyfluanid, triazamate, ziram

4 Dimethyl amino aniline: fenaminosulf

2 Dimethyl amino 1,3 dichloro propane: bensultap, thiocyclam

N-N'-Dimethylamino dimethyl aluminum: nicosulfuron

2 Dimethyl amino 1,3 Dithiobenzyl propane: thiocyclam

4 Dimethyl amino 3 methyl phenol: aminocarb

3.5 Dimethyl 4 amino phenol: mexacarbate

2.4. Dimethyl aniline: amitraze

2.6. Dimethyl aniline: benalaxyl, dimethachlor, furalaxyl, metalaxyl, metazachlor, ofurace, thenylchlor

2.3. Dimethyl benzoic acid: imazamethabenz

3.5 Dimethyl benzoyl chlorid2e: tebufenozide



$\alpha$   $\alpha$  Dimethyl benzyl amine: bromobutide, daimuron, methylmymron  
 $\alpha$   $\alpha$  Dimethyl benzyl chloride: bromobutide, daimuron, methylmymron  
 3.3 Dimethyl butanone: see Pinacolone  
 2.2 Dimethyl 5 methyl carboxylic acid cyclopentanone: metconazole  
 Dimethyl chloro methyl acetyl chloride: dimethazone  
 5.5 Dimethyl cyclohexane 1.3 dione: metconazole  
 2.2 Dimethyl cyclopentanone\*: triticonazole  
 1.3 Dimethyl cyclopropane dicarboxylic acid anhydride: procymidone  
 Dimethyl formamide: chlordinform, formetanate  
 2.2 Dimethyl-3(2.2 dichloro vinyl) cyclopropane carboxylic acid (or ester): see DV acid  
 Dimethyl guanidine sulfate: dimethirimol, pirimicarb  
 o-N-Dimethyl hydroxylamine\*: linuron, metobromuron, monolinuron  
 3.7 Dimethyl 7 methoxy 1 octanal: methoprene  
 3.6 Dimethyl 4 methyl thiophenol: methiocarb  
 2.6 Dimethyl morpholine\*: fenpropimorph  
 3.7 Dimethyl octanal: hydroprene  
 3.3 Dimethyl 2oxo cyclopentane methyl carboxylate: metconazole  
 2.2 Dimethyl 4 pentenoic acid chloride: triticonazole  
 Dimethyl phosphite\*: demeton-S-methyl, demeton-S-methyl sulfone, oxydemeton, trichlorfon  
 Dimethyl phosphoro chlorido thioate: see DMPCT  
 Dimethyl phosphoro dithioic acid: see DMPA  
 Dimethyl phosphoro thioic acid: omethoate, vamidothion  
 Dimethyl phthalate: chlorophacinone, diphacinone  
 N-N-Dimethyl propanediamine: prothiocarb  
 2.2 Dimethyl propionic acid: tebuthiuron  
 1.2 Dimethyl propylamine: dimethametryn  
 3 Dimethyl propylamine propamocarb  
 Dimethyl sulfamoyl chloride: bupirimate  
 Dimethylsulfate: acephate, bromothalin, carbendazim, cymoxanil, dicamba, difenzoquat, flurtamone, furmecyclox, hexazinone, linuron, methamidophos, metobenzuron, mexacarbate  
 Dimethyl sulfoxide: hexaconazole  
 Dimethyl sulfide: hexaconazole, tebuconazole  
 2.2 Dimethyl valeryl chloride: monalide  
 2.4 Dinitro 6 sec.butyl phenol: dinobuton  
 3.4 Dinitro chloro benzene: furyloxyfen  
 3.5 Dinitro 4 chloro benzo trifluoride: profluralin  
 2.6 Dinitro 3 chloro 4 trifluoro methyl aniline: fluazinam  
 2.6 Dinitro 3 chloro 4 trifluoro methyl chloro benzene: fluazinam  
 2.6 Dinitro 4 trifluoromethyl chloro benzene: see DTFB  
 Dinoseb: binapacryl, dinoseb acetate  
 Dioxane\*: dioxathion  
 DIPA\*: IPSP  
 DIPCT\*: iprobenfos  
 Diphenyl: brodifacoum, bromadiolone, difenacoum, difethialone  
 $\alpha$   $\alpha$  Diphenyl acetone\*: diphacinone  
 p-Diphenyl bromide: brodifacoum, bromadiolone, difethialone  
 Diphenyl carbonate: prosulfuron  
 Diphenylene oxide: see Dibenzofuran  
 N-N' Diphenyl thiourea\*: flubenzimine  
 Diphenyl urea\*: fenuron  
 Di-n-propylamine: CDAA, EPTC, isopropalin, nitratin, oryzalin, prodiamine, propalin, prosulfocarb, trifluralin, vernolate  
 Dipropylchloride phosphate: propaphos  
 Dipropyl dithio phosphoric acid: piperophos

Dithiodioctyl propionamide: othilinone

DMPA\* dimethyl phosphoro dithioic acid: anilofos, azamethiphos, azinphosmethyl, dimethoate, formothion, fosmethilan, malathion, methidathion, phentoate, phosmet, thiometon

DMPCT\* dimethyl phosphoro chlorido thioate: acephate, bromophos, cyanophos, etrimfos, famphur, fenthion, fenitrothion, iodofenphos, metacrifos, methamidophos, methyl parathion, pirimiphos, temephos, tolclofos

Dodecyl amine chloride: dodine

Dodecyl chloride: dodine

Dodecyl dimethyl sulfonium methyl sulfate: cyproconazole

DSMA: cacodylic acid

DTFB 2.5 dinitro 4 trifluoro methyl chlorobenzene: benfluralin, butralin, ethalfluralin, fluchloralin, flumetralin, profluralin, trifluralin

DV acid: cypermethrin, permethrin, transluthrin

Ethane dithiol: dimethiin, phosfolan

Ethane sulfonyl chloride: benfuresate

Ethanol amine\*: bensulide

Ethirimol: bupirimate

Ethoxyamine\*: alloxidim, sethoxidim, tralkoxydine

Ethoxy ammonium chloride: cycloxadim

4 Ethoxy benzyl cyanide: etofenprox

4 Ethoxy bromo benzene: silafluofen

p. Ethoxy phenyl acetic acid\*: cycloprothrin

Ethyl aceto acetate: see Aceto acetic acid

Ethyl amine: ametryn, atrazine, carbetamide, cyanazine, cymoxanil, dimethametryn, eglinazine, flumetralin, propetamphos, sebumeton, simazine, simetryn, sulfuramid, terbumeton, terbutylazine, trietazine

N-Ethyl aniline: phenisopham

4 Ethyl benzoyl chloride: tebufenozide

Ethyl bromide: esfenvalerate

Ethyl butyl amine: see Butyl ethyl amine

o-Ethyl sec butylamino thiono phosphoro acid chloride: butamifos

Ethyl carbamate\*: ampropylfos

Ethyl chloride: fonofos, oxyfluorfen, trichloronat

Ethyl chloroacetate: see Chloro acetic acid

Ethyl 3 chloro 2.6 dimethoxy benzohydroxamate: benzoximate

Ethyl (2 chloro 6 fluoro benzyl) amine: flumetralin

S-ethyl chlorothioformate: prothiocarb

Ethyl cyclohexyl amine: cycloate

Ethyl, 1.2 dimethyl propyl amine: esprocarb

Ethyl disulfide: rimsulfuron

Ethylene: methoxy ethyl mercury acetate

o-Ethyl ethyl phosphoro chlorido thionate\*: fonofos, trichloronat

Ethylene diamine: glyodin, imidacloprid, mancozeb, maneb, nabam, zineb

Ethylene dibromide: chlormequat, diquat, isoprothiolane, glufosinate, prochloraz

Ethylene dichloride: chlormequat

Ethylene glycol\*: azaconazole, dioxacarb, fluxofenim, glyphosate, oxabetrinil, resmethrin

Ethylene glycol methyl ether: cinosulfuron

Ethylene oxide: ethephon, demeton-S-methyl, demeton-S-methyl sulfone, oxydemeton, piperonyl butoxide, propaquizafos

Ethyl p.ethoxy phenyl acetate\*: cycloprothrin

Ethyl formate: fluridone

Ethyl glycinate: glyphosate

Ethyl guanidine: ethirimol

Ethyl imido acetate: see TOA

Ethyl iodide: oxolinic acid, thicyofen

Ethyl mercapto ethyl thiocyanate: demeton-S-ethyl, demeton-S-methyl, demeton-S-methyl sulfone, oxydemeton  
 Ethyl methallyl amine: ethalfluralin  
 2 Ethyl 6 methyl aniline: acetochlor, metolachlor, propisochlor  
 Ethyl phenyl acetate\*: flurtamone  
 Ethyl phenyl ketone: hexythiazox  
 o-Ethyl phenyl phosphono chlorido thioate: cyanofenphos  
 Ethyl phosphoro dichloridate\*: edifenphos, isofenphos  
 Ethyl stearate: glyodin  
 2 Ethyl thio ethanol: thiometon  
 2 Ethyl thio ethyl chloride\*: disulfoton, thiometon  
 2 Ethyl thiomethyl phenol: ethiofencarb  
 Ethyl urea\*: cymoxanil  
 Ethyl xanthic acid: pyriithiobac  
  
 Ferric sulfate: ferbam  
 Fluorene: chlorfluorenenol, flurenol  
 Fluorenone: chlorfluorenenol, flurenol  
 Fluoro acetyl chloride: fluoroacetamide  
 o-Fluoro aniline: flumetsulam  
 p-Fluoro aniline: fluoromide  
 Fluoro benzene: flutriafol  
 2 Fluoro  $\beta$  chloro acetophenone: see 2 Fluoro phenacyl chloride  
 4 Fluoro 2 chloro benzophenone: see 2 Chloro phenyl 4 fluoro phenyl ketone  
 Fluoro dichloro methyl sulfenyl chloride: dichlorofluanid  
 2 Fluoro 4 hydroxy aniline: flufenoxuron  
 o-Fluoro iodo benzene: flutriafol  
 p-Fluorolithio benzene: flusilazole  
 3 Fluoro phenol: flumioxazin  
 4 Fluoro phenacyl chloride: flutriafol  
 3 Fluoro phenyl cyanide: acifluorfen  
 2 Fluorophenyl, 4 fluorophenyl, ketone: flutriafol  
 Fluoro sulfonic acid: sulfuryl fluoride  
 Formaldehyde: acetochlor, alachlor, azamethiphos, azinphosmethyl, bithiosemi, butachlor, butenachlor, carbophenothion, dazomet, 2,4 D B, dichlorphen, glyphosate, IPSP, oxolinic acid, penconazole, phorate, phosalone, phosmet, piperonyl, butoxide, tetramethrin  
 Formamide: fenazaquin, triforine  
 Formanilide: mepanipyrim, pyrimethanil  
 Formic acid: amitrole, chlordimeform, dicofol, fenpropidin, fenpropimorph, fluridone, formothion, metosulam, propiconazole, resmethrin, tricyclazole  
 2 Furaldehyde: furilazole  
 Furan\*: endothal  
 Furfural: fuberidazole  
 Furfuryl amine: pefurazoate  
 2 Furoic acid\*: furalaxyl  
 3 Furoic acid: resmethrin  
  
 Geraniol: piproctanil  
 Glucose: chloralose  
 Glycerine: cloquintocet, diofenolan, 8 hydroxy quinoline sulfate  
 Glycine\*: cypermethrin, eglazine, glyphosate, 8-hydroxy quinoline sulfate, iprodione, proglinazine  
 Glycoaldehyde\*: fenfuram  
 Glycolide: indol-3 ylacetic acid  
 Glyoxylic acid\*: oxamyl  
 Guanidine\*: amitrole, bensulfuron, chlorimuron, flazasulfuron, nicosulfuron, pirimiphos, primisulfuron,

pyrazosulfuron, sulfmeturon

Guanidine (amino)\*: amitrole

Guanidine (diethyl)\*: pirimiphos

Guanidine (dimethyl) sulfate\*: dimethirimol

Guanidine (ethyl)\*: ethirimol

Guanidine nitrate\*: amitrole

Guanidine sulfate: amitrole

Hexachlorocyclohexane: hexachlorobenzene, tecnazene

Hexachlorocyclopentadiene: aldrin, chlordane, dieldrin, dienochlor, endosulfan, endrin, mirex

Hexachloroparaxylene: chlorthal

Hexachloro platinic acid: silafluofen

Hexafluoro acetic anhydride: thiazafluron

1.1.2.3.3.3 Hexafluoro propoxy 2.5 dichloro 4 amino benzene: lufenuron

1.1.2.3.3.3 Hexafluoro propoxy 2.5 dichloro benzene: lufenuron

Hexamethylene imine: molinate

Hexamethylene tetramine\*: see Urotropin

Hippuric acid: flupoxam

Hydrazine: bisthiosemi, clethodim, clofentezine, diclomazine, difenzoquat, ferimzone, flupoxam, maleic hydrazide, metamitron, methidathion, metribuzin, pymetrozine, tebutiuron, thiazafluron, triclopyr

Hydrazine (acetyl)\*: metamitron

Hydrazine (tertobutyl): tebufenozide

Hydrazine (p.tertio butyl benzyl): pyridaben

Hydrazine (2.4 dichloro phenyl)\*: sulfentrazone

Hydrazine (dimethyl): daminozide

Hydrazine (2.6 dimethyl phenyl)\*: oxadixyl

Hydrazine (methyl): benzofenap, difenzoquat, pyrazolate, pyrazosulfuron, pyrazoxyfen

Hydrazine (phenyl)\*: chloridazone

Hydrazine (3 trifluoro methyl phenyl): norflurazon

2 Hydrazino 4 methyl benzothiazole: tricyclazole

(Sodium boro) hydride: imizalil

Hydrogen cyanide: chlorfluorecol, diphenamid

Hydrogen peroxide: aldoxycarb, cinmethylin, dieldrin, dimethipin, endrin, ethoprop, fensulfothion, hexaconazole, IPSP, mepanipyrim, oxycarboxin, oxydemeton, perfluidone, tetradifan, thiabendazole, thiocyclam, thiram

Hydroquinone\*: clodinafop, fenoxaprop, fluazifop, haloxyfop, isoxapyrifop, propaquizafop, quizalofop-ethyl

Hydrosafrole: piperonyl butoxide

4 Hydroxy acetophenone: propaquizafop

Hydroxyacetyl chloride: mefenacet

4 Hydroxy benzaldehyde: bromoxynil, ioxynil

4 Hydroxy benzene sulfonic acid: methasulfocarb

3 Hydroxy benzoic acid\*: acifluorfen

4 Hydroxy benzonitrile\*: bromofenoxim, bromoxynil, ioxynil

4 Hydroxy benzothiopyran 2 one: difethialone

o-Hydroxy benzyl alcohol: dioxabenzofos

Hydroxy coumarin: see Coumarin (hydroxy)

2 Hydroxy ethylamine: thiazopyr

Hydroxyethyl ethyl sulfide: demeton-S-methyl, demeton-S-methyl sulfone, disulfoton, oxydemeton

Hydroxylamine (and hydroxylamine hydrochloride or sulfate): alanycarb, benzamizole, benzthiazuron, bromofenoxim, bromoxynil, butocarboxim, chlorbromuron, chlorphoxim, dichlobenil, dimethazone, fenpyroximate, flucycloxuron, fluxofenim, heptopargil, hymexazol, ioxynil, isoxaben, linuron, methabenzthiazuron, methomyl, metobenzuron, oxabetrinil, oxamyl, pendimethalin, phoxim, propaquizafop, pyrifenox, quinclorac, thiodicarb, thiofanox

1 Hydroxy methyl acetophenone: isoxathion

3 Hydroxy methyl 5 benzyl furan: resmethrin

2 Hydroxy methyl 4 chlorophenol: cloxyfonac  
 N-Hydroxy methyl 1 cyclohexene 1.2 dicarboximide: tetramethrin  
 Hydroxy methylene acrylic acid: methacrifos  
 3 Hydroxy 8 nonene 2.5 dione: allethrin  
 p.Hydroxy phenyl acetic acid\*: cycloprothrin  
 3 Hydroxy 5 phenyl isoxazole: isoxathion  
 3 Hydroxy phenyl aceto acetate\*: coumaphos  
 N-Hydroxy phthalimide: clethodim  
 1 Hydroxy propylene oxide: diofenolan  
 4 Hydroxy quinazoline\*: fenazaquin  
 8 Hydroxy quinoline\*: 8 hydroxy quinoline sulfate, oxime copper  
 3 Hydroxy tetra hydro furan: furyloxyfen

Imidazole\*: imizalil, pefurazoate, prochloraz, triazoxide, triflumizole

2 Imidazolidinone\*: isocarbamid

(Ethyl) imido acetate: see TOA

Iminodiacetic acid: glyphosate

Imino diaceto nitrite: glyphosate

2 Imino 3.3 dimethyl butyro nitrile: metribuzin

1H Indazole (3 hydroxy methyl): ethylchlozate

Indole\*: indol-3yl acetic acid, 4 indol-3yl butyric acid

Indoline: pyroquilon

o-iodo benzoic acid: benodanil

Isobutanol: metconazole

Isobutyl amine: isocarbamid

Isobutyl aniline: terbacil

Isobutylene: aldicarb, aldoxycarb, see MBO, see Methallyl chloride

Isobutyraldehyde: ethofumesate

Isobutyronitrile: diazinon, flurprimidol

Isocyanates\*—

p.Bromo phenyl isocyanate: metobromuron

Butyl isocyanate: benomyl, halosulfuron

t.Butyl isocyanate: karbutilate

Chlorophenyl isocyanate: diflubenzuron

Chlorosulfonyl isocyanate: amidosulfuron

Cyclohexyl isocyanate: hexazinone, hexythiazox

3.4 Dichlorophenyl: see DCPI

2.6 Difluoro benzoyl amide: lufenuron

2.6 Difluorobenzoyl isocyanate\*: fluazuron, flucycloxuron, flufenoxuron, lufenuron, teflubenzuron

Dimethyl phenyl methyl isocyanate: dymron, methyl dymron

2 isobutoxy acetyl chloride: flumetsulam

Isopropoxy formaldehyde: propisochlor

Isopropyl: iprodione

Methyl isocyanate: alanycarb, aldicarb, aldoxycarb, aminocarb, bendiocarb, benzthiazuron, butocarboxim, carbaryl, carbendazim, carbofuran, cinosulfuron, dioxacarb, ethidimuron, ethiofencarb, formetanate, furathiocarb, mecarbam, methabenzthiazuron, methasulfocarb, methazole, methiocarb, methomyl, metolcarb, mexacarbate, oxamyl, promacyl, promecarb, propoxur, prosulfuron, tebuthiuron, thiazafluron, thiodicarb, thiofanox, trimethocarb, xylilcarb

Phenyl isocyanate: carbetamide, desmedipham, fenuron, forchlorfenuron, metobromuron, pencycuron, propham, siduron, thidiazuron

Toluylyl sulfonyl methyl: fludioxonil

m.Tolyl: phenmedipham

3 Trifluoromethyl phenyl: fluometuron

Isocyanuric acid: bromethalin

Isonicotinic acid\*: inabenfide

Isophthalic acid: chlorotalonil, nitrothal

Isophthalonitrile: chlorotalonil

Isopropanol: bensulide, bromopropylate, chlorpropham, chlorpropylate, diethofencarb, dinobuton, flamprop isopropyl, isofenphos, isoprothiolane, nitrothal, phenisophan, propham

Isopropyl amine: ametryn, anilofos, aziprotryne, desmetryn, dipropetryn, fenamiphos, glyphosate, iprodione, isofenphos, methoprotryne, proglinazine, prometon, prometryn, propazine, prothoate, tebutam

N-isopropyl aniline\*: propachlor

p.Isopropyl aniline\*: isoproturon

Isopropyl bromide: fenvalerate, mepronil

Isopropyl chloride: fluythrinat

m.Isopropoxy aniline: flutalonil

o.Isopropyl phenol: isoprocarb

Isopropyl salicylate: isofenphos

Isopropyl sulfamoyl chloride: bentazon

Isovaleraldehyde: dithiopyr, thiazopyr

Isoxazole 5 amino-3(1 ethyl 1 methyl) propyl: isoxaben

Isoxazole (3 hydroxy 5 phenyl): isoxathion

Isoxazolidine: isoxapyrifop

1 Isoxalzone (3 methyl): drazoxolon

Lactic acid: carbetamide, lactofen, propaquizafop, pyriproxifen

Maleic anhydride: captafol, captan, endotal, fluoromide, maleic hydrazide

Maleimide\*: norbormide

Manganese sulfate: mancozeb, maneb

Malonic acid\*: alloxym, bensulfuron, brodifacoum, chlorimuron, difenacoum, difethiolone, fenclorim, flazasulfuron, flocoumafen, glufosinate, nicosulfuron, isoprothiolane, oxolinic acid, primisulfuron, pyrazosulfuron, sethoxydim, tralkoxydim

Malonic acid acetamide: glufonisate

Malonic acid dinitrile: thicyofen

Maneb: mancozeb

MBO 3 methyl 2 butene 1 ol: bifenthrin, cyhalothrin, cypermethrin, deltamethrin, permethrin, tefluthrin

Melonic acid: metosulam

Melonyl chloride: metosulam

Mercaptans—

Benzyl: iprobenfos, nicosulfuron, prosulfocarb, pyrazosulfuron, rimsulfuron, tiocarbaryl, triflusulfuron

Butyl: merphos, SSS tributyl phosphoro trithioate

2 Butyl: cadusafos, ebufos, fosthiazate

t.Butyl: terbufos

p.t.Butyl benzyl: pyridaben

p.Chloro benzyl\*: imibenconazole, thiobencarb

α Dimethyl benzyl: dimepiperate

Ethyl: butylate, cycloate, demeton, dipropetryn, EPTC, ethiofencarb, MCPA thioethyl, molinate, phorate, prothiocarb, sethoxidim

Methyl: acephate, alanycarb, aldicarb, aldoxycarb, ametryn, aziprotrine, butocarboxim, desmetryn, dimethametryn, dithiopyr, methomyl, methoprotryne, oxamyl, prometryn, simetryn, terbutryn, thiodicarb, thiofanox

Octyl: pyridate

Perchloro methyl: captan, folpet

n-Propyl: chlorsulfuron, ethoprop, pebulate, profenofos, prothiofos, pyraclofos, sulfoprofos, vernolate

Mercapto benzothiazole\*: benzothiazuron, mefenacet, methabenzthiazuron

2 Mercapto 6 chloro benzoxazole: fenoxaprop

Mercapto ethanol: carboxin, oxycarboxin

- 2 Mercapto ethyl amine: fosthiazate
- 2 Mercapto nicotinic acid: nicosulfuron
- Mercapto propionic acid: vamidothion
- Mercuric acetate: methoxy ethyl mercury acetate, phenyl mercury acetate
- Mercury oxide: methoxy ethyl mercury acetate, phenyl mercury acetate
- Mesityl oxide\*: alloxydine
- Meta: see Parent compound
- Methacrylic acid: dimethenamid
- Metaxylene: chlorotalonil
- Methane sulfonyl chloride\*: ethofumesate, fomesafen, methasulfocarb, penconazole, tetraconazole
- Methomyl: alanycarb, thiodecarb
- Methoxy acetaldehyde: dimethachlor
- Methoxy acetone: metolachlor
- Methoxy acetyl chloride: metalaxyl, oxadixyl
- 1 Methoxy 2 amino propane: dimethenamid
- 4 Methoxy benzoyl cyclo propane: ancymidol
- 7 Methoxy 3.7 dimethyl octanal: methoprene
- Methoxy ethanol\*: etacelasil
- p-Methoxy phenol: difenoxuron, fluazifop, pyriproxifen
- 3 Methoxy n.propylamine: methoprotryne
- 3 Methoxy 1 propyne: furconazole
- Methyl acetoacetate: see Aceto acetic acid
- Methyl aceto acetic acid\*: pirimicarb
- 2 Methyl acetophenone: ferimzone
- 4 Methyl acetophenone: benzofenap
- Methyl allyl chloride: benfuresate, carbofuran
- Methyl amine: alanycarb, aldicarb, aldoxycarb, aminocarb, bendiocarb, benzthiazuron, butocarboxim, carbaryl, carbendazim, carbofuran, cinosulfuron, cloethocarb, dazomet, desmetryn, dimethoate, dioxacarb, ethametsulfuron, ethidimuron, ethiofencarb, fluridone, formethanate, formothion, furathiocarb, isoprocarb, mecarbam, metam, methabenzthiazuron, methasulfocarb, methazole, methiocarb, methonyl, metolcarb, mexacarbate, monocrotophos, norflurazon, omethoate, oxamyl, promacyl, promecarb, propoxur, tebuthiuron, thiazafluron, thiodicarb, thiofanox, trimethocarb, vamidothion, xylilcarb
- N-Methyl aniline: mefenacet
- p-Methyl aniline: see p.toluidine
- o-methyl anisole: methoxyphenone
- 2 Methyl benzoic acid: bensulfuron
- m-Methyl benzoyl chloride: diethyltoluamide, methoxyphenone
- o-Methyl benzoyl chloride: mepronil
- $\alpha$  Methyl benzyl alcohol: crotoxyphos
- 2 Methyl benzyl chloride: cinmethylin
- Methyl bromide: dimethomorph, mepiquat chloride, metribuzin
- Methyl bromo propionate: diclofop methyl
- 3 Methyl butanal: dithiopyr
- 3 Methyl 2 butene 1 ol: see MBO
- Methyl butyl amine: neburon
- Methyl  $\delta$  butyl ketone: see Pinacolone
- 2 Methyl butyric acid: pentanochloro
- Methyl chloride: bensulfuron, cacodylic acid, dicamba, DSMA, flazasulfuron, glufosinate, MSMA, nicosulfuron, paraquat
- 2 Methyl 3 chloro aniline: pyriathiobac
- Methyl chloroformate: see Chloroformates
- 3 Methyl 2 chloro methyl butanoate: fluvalinate
- 2 Methyl 4 chloro phenol\*: MCPB, mecoprop
- 2 Methyl 4 chloro phenoxy acetonitrile: MCPA thioethyl

2 Methyl 4 chloro phenoxy acetyl chloride: MCPA thioethyl  
 Methyl chrysantemate: see Chrysanthemic acid  
 2 Methyl cyclohexyl amine: siduron  
 Methyl dichloroquinoxaline: quinomethionate  
 Methyl diethyl malonate: endonthal  
 Methyl 1,3 dioxolane: fluxofenim  
 Methylene bromide: ethion, fenbuconazole, myclobutanil  
 Methylene chloride: cycloprothrin  
 Methylene chlorobromide: ethion  
 Methylene dioxybenzene: oxolinic acid  
 Methyl 2 ethyl butyrate: isoxaben  
 Methyl ethyl carbamate\*: mecarbam  
 3 Methyl, ethyl 2 oxo cyclopentane carboxilate: ipconazole  
 Methyl formamide: amitraze, formothion  
 N-Methyl formyl 2,6 difluoro benzamide: lufenuron  
 2 Methyl furan carboxylic acid\*: fenfuram  
 2 Methyl 6 ethyl aniline: see 2 Ethyl 6 methyl aniline  
 1 Methyl hexyl alcohol: cloquintocet  
 Methyl hydroxylamine\*: methabenzthiazuron, pyrifenox  
 Methyl iodide: benzamizole, bromethalin, etofenprox, hexaconazole, isoxaben, methamidofos, methoprotetryne, metribuzin, tefluthrin  
 Methyl isocyanate: see Isocyanates  
 3 Methyl 5 isopropyl phenol: promacyl, promecarb  
 o-Methyl isourea\*: chlorsulfuron, iminocadine, metsulfuron, thifensulfuron, triasulfuron  
 Methyl lactate: carbetamide  
 Methyl magnesium chloride: tridiphane  
 Methyl malonic acid: endothal  
 4 Methyl mercapto meta cresol: fenthion  
 4 Methyl mercapto phenol: see 4 methyl thiophenol  
 2 Methyl 3 methyl hydroxy biphenil: bifenthrin  
 3 Methyl 4 nitro phenol: perfluidone  
 3 Methyl 6 nitrophenol: butamifos  
 4 Methyl phenol: see p-Cresol  
 Methyl phenyl carbinol: crotoxypfos  
 Methyl phenyl glyoxalate: metamitron  
 Methyl phosphoro dichlorido thionate: dioxabenzofos  
 5 Methyl phthalic anhydride: imazamethabenz  
 2 Methyl piperidone: piperophos  
 Methyl propynol: chlorbufam  
 Methyl sodium sulfide: dithiopyr  
 α Methyl styrene: bromobutide, daimuron, dymron, methyl dymron  
 p-Methyl sulfinyl phenol: fensulfothion  
 3 Methyl 4 thiomethyl phenol: fenamiphos  
 4 Methyl thiophenol\*: fensulfothion, sulfoprofos  
 Methyl thiopseudo urea: guazatine, hexazinone  
 4 Methyl thiosemi carbazide: thiazafluron  
 Methyl thio urea\*: tebuthiuron, thiazafluron  
 Monobromo benzene: chlorbromuron  
 Monochloro acetic acid: see Chloro acetic acid  
 Morpholine\*: dimethomorph, ethofumesate, nipyraclufen  
 Mucochloric acid\*: chloridazon, norflurazon, pyridaben

Nabam: mancozeb, maneb, zineb

Naphthalene: carbaryl, dichlone, naphthyl acetamide, naphthyl acetic acid



1-Naphthol\*: carbaryl, napropamide  
 2-Naphthol\*: naphthoxy acetic acid, 2 naphthyloxy acetic acid, naproanilide  
 1.4 Naphthoquinone\*: dichlone, dithianon  
 1 Naphthyl acetic acid\*: naphthyl acetamide  
 Naphthyl 1 acetonitrile: Naphthyl acetic acid  
 1-Naphthylamine\*: antu, naptalam  
 Neophyl chloride\*: fenbutatin oxide  
 Nicotinic acid\*: diflufenican  
 p-Nitroaniline\*: DCNA (dicloran)  
 Nitrobenzene: PCNB, fenazox, quintozone  
 4 Nitrobenzyl bromide: flucycloxuron  
 p-Nitrocumene: isoproturon  
 2 Nitroimine imidazolidine: imidacloprid  
 4 Nitrometacresol: fenitrothion  
 Nitromethane: chloropricrin  
 2 Nitro 3 methyl benzoic acid methyl ester: triflurosulfuron  
 o-Nitrophenol\*: carbofuran  
 p-Nitrophenol\*: ethyl parathion, EPN, methyl parathion  
 Nitropane 1.3 diol: bronopol  
 Nitrosyl chloride: aldicarb, aldoxycarb  
 Nitrosyl sulfuric acid: dichlobenil  
 m-Nitrotoluene: fluometuron, fluorchloridone, norfluazuron, phenmedipham  
 p-Nitrotoluene\*: chlortoluron, tolyfluamid  
 Nitrous acid: cypermethrin

1.9 Octadecadiene: muscalure  
 Octamethylene diamine: guazatine  
 2 Octanol: dinocap  
 Octyl acrylamide thiocyanate: othilnone  
 Oleyl alcohol: muscalure  
 Ortho: see Parent compound  
 1.3.4 Oxadiazole (5 trifluoro methyl 2-3H one): pymetrozine  
 Oxalic acid: cycloprothrin  
 Oxime 2 chloro phenyl acetic acid: chlorphoxim  
 Ozone: acrinathrin, cypermethrin, tralomethrin

Para: see Parent compound  
 Paraformaldehyde: metazachlor, triclopyr  
 PBA m-phenoxy benzyl alcohol: see-Phenoxy benzyl alcohol  
 PCBA m-phenoxy cyano benzyl alcohol: acrinathrin, cycloprothrin, cyhalothrin, cypermethrin, cyphenothrin, deltamethrin, esfenvalerate, fenpropathrin, fenvalerate, flucythrinate, fluvalinate, tralomethrin  
 PCBTF para chloro benzotrifluoride: benefin, benfluralin, ethalfluralin, fluchloralin, flumetralin, profluralin, trifluralin  
 Pentachlorobenzene: quintozone  
 2.2.3.3.3 Pentafluoro propanol: flupoxam  
 1.2 Pentanediol: propiconazole  
 3 Pentane amine\*: pendimethalin  
 1 Pentanol: propiconazole  
 3 Pentanol\*: pendimethalin  
 1 Pentene propiconazole  
 4 Pentene 2 ol: pefurazate  
 3 Pentylamine: pendimethalin  
 Pentyl bromide: muscalure  
 Pentyl chloride: hexaconazole  
 Pentyl magnesium bromide: muscalure

- Peracetic acid: aldoxycarb, butoxycarboxim, dieldrin, dipyrithione, endrin, metconazole, tridiphane
- Perfluoro 2.5 diazahexa 2.4 diene: flubenzimine
- Perfluoro octane sulfonyl fluoride: sulfuramid
- Phenacyl chloride\*: see 2 Chloro acetophenone
- Phenanthrenequinone\*: chlorfluorenel, flurenol
- p-Phenitidine\*: ethoxyquin
- Phenol: aclonifen, butralin, cyfluthrin, 2.4 D, diafenthion, dichlorprop, diclofop-methyl, dinocap, famphur, fenothiocarb, fenoxycarb, fenpyroximate, nicosulfuron, nitrofen, pentachlorophenol, 2 phenyl phenol, silafluofen, sulcofuron
- m-Phenoxy benzaldehyde\*: etofenprox, permethrin, see PCBA
- m-Phenoxy benzyl alcohol (PBA): etofenprox, permethrin, phenothrin
- Phenoxy cyanobenzyl alcohol: see PCBA
- 3 Phenoxy 4 fluoro bromo benzene: silafluofen
- p-Phenoxy phenol\*: diofenolan, fenoxycarb, pyriproxifen
- 2 Phenoxy propionic acid: dichlorprop
- Phenyl acetic acid\*: flurtamone
- Phenyl acetone: chlorophacinone
- Phenyl acetonitrile\*: see Benzyl cyanide
- Phenyl acetyl chloride: benalaxyl, brodifacoum, difenacoum, difethialone, flocoumafen
- Phenyl bromo acetic acid\*: phentoate
- o-Phenylene diamine\*: benomyl, carbendazim, fuberidazole, quinalphos, thiabendazole, thiophanate
- Phenyl hydroxylamine\*: fenazox
- 1 Phenyl 2 nitro 1.3 propane diol: fenitropan
- 4 Phenyl phenol\*: bitertanol
- Phenyl thiophosphonyl dichloride: EPN
- 4 Phenyl thio o-toluidine: perfluidone
- Phosgene: alanycarb, aldicarb, aldoxycarb, aminocarb, barban, bendiocarb, benodanil, benomyl, bentazone, bensulfuron, benzthiazuron, bromacil, buprofezin, butocarboxim, butylate, carbaryl, carbendazim, carbetamide, carbofuran, chlorbufam, chlorfluazuron, chlorimuron, chlorotoluron, chloroxuron, chlorpropham, chlorsulfuron, chlozolate, cinosulfuron, cloetocarb, cycloate, daimuron, desmedipham, diethofencarb, difenoxuron, diflubenzuron, dimefuron, dimepiperate, dinobuton, dioxacarb, diuron, EPTC, esprocarb, ethametsulfuron, ethidimuron, ethiofencarb, fenobucarb, fenothiocarb, fenoxycarb, fenuron, flazasulfuron, fluazuron, flucofuron, flucycloxuron, flufenoxuron, fluometuron, fonofos, forchlorfenuron, formetanate, fosamine ammonium, fosthiazate, furathiocarb, halosulfuron, hexaflumuron, hexazinone, hexythiazox, iprodione, isocarbamid, isoprocarb, isotroturon, karbutilate, linuron, lufenuron, mecarbam, methabenzthiazuron, methasulfocarb, methazole, methidathion, methiocarb, methomyl, metobenzuron, metobromuron, metolcarb, metoxuron, metsulfuron-methyl, mexacarbate, molinate, monolinuron, monuron, neburon, nicosulfuron, oxadiazon, oxadixyl, oxamyl, pebulate, pefurazoate, pencycuron, phenisopham, phenmedipham, pirimicarb, primisulfuron, prochloraz, promacyl, promecarb, propamocarb, propham, propoxur, prosulfocarb, prosulfuron, prothiocarb, pyrazosulfuron, pyridate, quinomethionate, siduron, sulcofuron, sulfometuron, tebuthiuron, teflubenzuron, terbacil, thiazafuron, thiadiazuron, trifensulfuron, thiobencarb, thiodicarb, thiophanate, thiophanox, tiocarbamil, triasulfuron, triazamate, tribenuron, triflumuron, triflumizole, trimethocarb, vernolate, vinclozolin, xylilcarb, see also Chloroformates/Isocyanates
- Phosphine: chlorphonium chloride
- Phosphite (sodium diethyl): penconazole
- Phosphites: see Diethyl, Dimethyl
- Phosphonium(methyl triphenyl bromide): ipconazole
- Phosphoric acid: fosetyl aluminum
- Phosphorous acid: fosetyl aluminum, glyphosate
- Phosphorus derivatives: see DEPA, DEPCT, DMPA, DMPCT
- Phosphorus oxychloride: acephate, cadusofos, chlordimephorm, chlorimuron, chlorotalonil, ebufos, edifenphos, ethaprop, fenamiphos, fenclorim, flazasulfuron, flurazole, imazosulfuron, methasulfocarb, metosulam, nicosulfuron, phosdiphen, phosfolan, primisulfuron, profenofos, propaphos, pyrazosulfuron, SSS tributyl phosphorotrithioate, TEPP

Phosphorus pentachloride: bentazon, clofentezine, flurprimidol  
 Phosphorus pentasulfide: bensulide, fonofos, tebuthiuron, tetrapropyl dithiopyrophosphate, thiazopyr, see DEPA, DEPCT, DMPA, DMPCT  
 Phosphorus pentoxide: chlorotalonil, TEPP  
 Phosphorus sulfochloride: see Thiophosphorylchloride  
 Phosphorus tribromide: brodifacoum, difenacoum, fenpropidin, flocoumafen, pyriproxifen  
 Phosphorus trichloride: chloretoxyfos, disulfoton, EPN, ethephon, ethoprop, fonofos, fosamine ammonium, fosetyl aluminium, fosthiazate, glufosinate, glyphosate, isofenphos, merphos, propaphos, sulprofos, SSS-tributyl phosphorotrithioate, trichlorfon, trichloronat  
 Phthalic acid: pindone, tecloftalam  
 Phthalic anhydride: chlorophacinone, diphacinone, folpet, naptalam, phosmet, pindone  
 Phthalimide\*: ditalimfos, folpet, phosmet  
 $\alpha$  Picoline\*: clopyralid, nitrpyrin, picloram  
 $\beta$  Picoline: chlorfluazuron, flazasulfuron, fluazifop, fluazinam, haloxyfop  
 $\delta$  Picoline: inabenfide  
 Picric acid\*: chloropicrin  
 Pinacolone\*: bitertanol, diclobutrazol, diniconazole, metribuzin, paclobutrazol, pindone, thiofanox, triadimenol, triadimefon, triapenthenol, uniconazole  
 Piperazine: triforine  
 Piperidine\*: dimepiperate, fenpropidin, mepiquat, piproctanil  
 Piperidine (4 tert butyl): flupropadine  
 Piperidine (2 methyl): piperophos  
 Pivalic acid\*: tebutam  
 Pivalyl chloride: tebutam  
 Polyphosphoric acid: brodifacoum, difenacoum, flocoumafen  
 Potassium t.butoxide: bifenthrin, cyhalotrin  
 Potassium cyanate: cymoxanil, sulfentrazone  
 Potassium cyanide: chlorphoxim, dichlobenil, esfenvalerate, ethylchlozate, fenvalerate, nipyraclufen, oxabetrinil, penconazole, phoxim, triclopyr, see PCBA  
 Potassium fluoride: teflubenzuron  
 Potassium hydrosulfide: fenothiocarb, methoprotetryne  
 Potassium phthalimide: hexythiazox  
 Potassium thiocyanate: demeton-S-methyl, demeton-S-methyl sulfone, oxydemeton methyl, thiophanate  
 Potassium permanganate: demeton-S-methyl sulfone, pyriothiobac  
 Potassium phthalimide: ditalimfos  
 Promecarb: promacyl  
 Propanal: ampropylfos  
 Propane 1.2 dithiol: mephosfolan  
 n-Propanol: propanophos, triflumizole  
 Propargyl bromide: heptopargil  
 Propargyl chloride: flumioxazin, furconazole  
 Propargylic alcohol\*: flupropadine, furconazole, propargite  
 Propazine: dipropetryn, prometon, prometryn  
 Propinyl chloride: see Propionic acid  
 Propionaldehyde\*: fenpropidin, fenpropimorph, empenthrin  
 Propionic acid\*: benalaxyl, benzoylprop-ethyl, clethodim, clodinafop, clomeprop, cloprop, 2 CPA, dalapon, dichlorprop, diclofop, fenoprop, fenoxaprop, flamprop isopropyl, flamprop methyl, fluazifop, furalaxyl, haloxyfop, isoxapyrifop, mecoprop, metalaxyl, naproanilide, napropamide, prohexadione, propanil, pyroquilon, quizalofop ethyl, tralkoxydim  
 Propoxy acetaldehyde: pretilachlor  
 n-Propylamine: prochloraz, profluralin  
 Propyl alcohol\*: propaphos, tetrapropyldithiopyrophosphate, trichlamide  
 Propyl aldehyde: diofenolan  
 Propyl chloroethyl amine: fluchloralin  
 Propyl dimethylamine: cartap

Propylene: dichloropropene, propoxur  
 Propylene diamine: propineb  
 Propylene glycol: difeconazole  
 1.2 Propylene oxide: dodemorph, tridemorph  
 1.3 Propylene oxide: silafluofen  
 Propyl hydroxyethyl amine: fluchloralin  
 5(Propyl 2 thioethyl)cyclohexane 1.3 dione: clethodim  
 Propyne: hymexazol  
 2 Propyn-1 ol: see Propargylic alcohol  
 Pseudo urea (methyl thio): hexazinone  
 Pyrazole\*: metazachlor  
 Pyrazole (3 chloro,4 carboxy,1 methyl 5 sulfonamide): halosulfuron  
 Pyrazole (1.4 dimethyl,2 chloro, 3 formyl): fenpyroximate  
 Pyrazole (2 methyl, 3 amino, 4 carboxy)\*: pyrazosulfuron  
 Pyrazole (2 methyl,4 carboxy, ethyl ester): pyrazosulfuron  
 Pyrazole (1 methyl,2 ethyl,4 chloro 5 carboxy): tebufenpyrad  
 5 Pyrazolone (1.3 dimethyl)\*: benzofenap, pyrazolate, pyrazoxyfen  
 Pyridazine (1 phenyl 3 hydroxy, 6 oxo): pyridafenthion  
 3 Pyridazinone (2.p.tert.butyl 5 mercapto): pyridaben  
 3 Pyridazinone (2.p.tert.butyl 5 chloro): pyridaben  
 3 Pyridazinone (2.p.tert.butyl 3.5 dichloro): pyridaben  
 Pyridazone (3 phenyl 4 hydroxy 6 chloro): pyridate  
 Pyridine\*: diquat, fluroxypyr, paraquat, triclopyr  
 Pyridine (3 acetic acid)\*: pyrifenoxy  
 Pyridine (3 aldehyde): pymetrozine  
 Pyridine (2 amino): clodinafop  
 Pyridine (2 amino 5 chloro)\*: clodinafop  
 Pyridine (3 amino 2.5 dichloro)\*: clodinafop  
 Pyridine (2 amino 3 hydroxy): azamethiphos  
 Pyridine (2 amino-N-methyl 6 methoxy): pyributicarb  
 Pyridine (4 amino 2,3,5 trichloro 6 fluoro): fluroxypyr  
 Pyridine (2 amino, 3 chloro 5 trifluoro methyl): fluazinam  
 Pyridine (2 benzoyl): norbormide  
 Pyridine (4 tert.butyl): flupropadine  
 Pyridine (3 carboxaldehyde): pyrifenoxy  
 Pyridine (2 carboxylic acid 3 methyl): imazapyr  
 Pyridine (2 carboxylic acid ethyl ester 3 methyl, 6 ethyl): imazethapyr  
 Pyridine (2 chloro): dipyrithione, pyriproxifen  
 Pyridine (2 chloro 4 amino): forchlorfenuron  
 Pyridine (2 chloro 3 amino 5 trifluoro methyl): fluazinam  
 Pyridine (2 chloro 5 chloromethyl): imidacloprid  
 Pyridine (3 chloro 5.6 difluoro): clodinafop  
 Pyridine (2 chloro 5 formyl): imidacloprid  
 Pyridine (3 chloromethyl)\*: pyrifenoxy  
 Pyridine (3 chloro, 5 nitro, 6 hydroxy)\*: clodinafop  
 Pyridine (2 chloro 3 trifluoromethyl): flazasulfuron  
 Pyridine (2.3 dicarboxylic acid): imazapyr  
 Pyridine (2.3 dicarboxylic acid 6 ethyl): imazethapyr  
 Pyridine (2.5 dichloro 3 fluoro)\*: clodinafop  
 Pyridine (2.5 dichloro, 3 nitro)\*: clodinafop  
 Pyridine (5.6 dichloro 3 trifluoro methyl)\*: chlorfluazuron, fluazinam, fluazuron  
 Pyridine (2 fluoro): pyriproxifen, rimsulfuron  
 Pyridine (2 hydroxy): pyriproxifen  
 Pyridine (2 hydroxy, 3 fluoro, 5 chloro): clodinafop

1-2a Pyridine (2 hydroxy imidazol): imazosulfuron  
 Pyridine (3 hydroxymethyl): pyrifenoxy  
 Pyridine (2 methyl): see  $\alpha$  Picoline  
 Pyridine (3 methyl): see  $\beta$  Picoline  
 Pyridine (4 methyl): see  $\delta$  Picoline  
 Pyridine (2,3,5 trichloro): clodinafop, isoxapyrifop  
 Pyridine (2,3,5 trichloro, 6 hydroxy): chlorpyrifos  
 Pyrimidine (2 amino 4,6 dichloro)\*: bensulfuron, chlorimuron, flazasulfuron, nicosulfuron, pyrazosulfuron  
 Pyrimidine (2 amino, 4 chloro, 6 methoxy)\*: chlorimuron  
 Pyrimidine (2 amino 4,6 difluoro methoxy)\*: primisulfuron  
 Pyrimidine (2 amino 4,6 dihydroxy)\*: bensulfuron, flazasulfuron, nicosulfuron, primisulfuron, pyrazosulfuron  
 Pyrimidine (2 amino 4,6 dimethoxy)\*: amidosulfuron, bensulfuron, flazasulfuron, halosulfuron, imazosulfuron, nicosulfuron, pyrazosulfuron, rimsulfuron  
 Pyrimidine (2 amino 4,6 dimethyl)\*: sulfometuron  
 Pyrimidine (5 bromo): ancymidol, fenarimol, flurprimidol, nuarimol  
 Pyrimidine (5 butyl 4 hydroxy 6 methyl 2 methyl thio): methirimol  
 Pyrimidine (2 chloro 4,6 dimethoxy): pyriithiobac  
 Pyrimidine (2 chloro 4,6 dimethyl): ferimzone  
 Pyrimidine (2 chloro 4 methoxy 6 amino): chlorimuron  
 Pyrimidine (2,4 dichloro, 6 methyl)\*: crimidine  
 Pyrimidine (2,4 dihydroxy 6 methyl)\*: crimidine  
 Pyrimidine (4,6 dimethoxy, mercapto): pyriithiobac  
 Pyrimidine (2 dimethyl amino 4 hydroxy 5,6 dimethyl)\*: pirimicarb  
 Pyrimidine (5,5 dimethyl per hydro 2 hydrazide): hydramethylnon  
 Pyrimidine (4,6 dimethyl, 2 methyl sulfonyl): pyrimethanil  
 Pyrimidine (2 ethyl 4 ethoxy 6 hydroxy): etrimfos  
 Pyrimidine 2 hydroxy 5 methyl 6 carbethoxy pyrazole): pyrazophos  
 Pyrimidine (methyl 5 carboxylate): fenarimol  
 Pyrimidine (2 thiomethyl 4 methyl 6 propynil): mepanipyrim  
 Pyrimidine (2,4,6 trichloro, 5 thio methyl): tioclorim  
 Pyrogallol\*: bendiocarb  
 Pyruvic acid\*: pyraclofos, sulfentrazone  
  
 Quinazoline (4 hydroxy)\*: fenazaquin  
 Quinoline (7 chloro 3,8 dimethyl): quinmerac  
 Quinoline (7 chloro 8 methyl): quinclozac  
 Quinoline, 2,3 dicarboxylic acid: imazaquin  
 Quinoxaline\*: quinomethionate, quizalofop-ethyl  
 Quinoxaline (2,6 dichloro)\*: propaquizafop, quizalofop  
 Quinoxaline (6 methyl 2,3 dichloro): chinomethionate  
 Quinoxaline (2 hydroxy)\*: quinalphos  
 Quinoxaline (2 hydroxy, 6 chloro)\*: propaquizafop  
  
 Resorcinol\*: coumaphos, metobenzuron, oxyfluorfen  
  
 Saccharin: clorimuron, ethametsulfuron, metsulfuron-methyl, primisulfuron, sulfometuron, tribenuron  
 Saflor: piperonyl butoxide  
 Salicylic acid\*: isofenphos, niclosamide, trichlamide  
 Salicylaldehyde\*: dioxacarb  
 Silane (2 chloro ethyl trichloro): etacelasil  
 Silane (cyano trimethyl): furilazole  
 Silane (dichloro dimethyl): silafluofen  
 Silane (trichloro): thenylchlor  
 Silane (trimethyl bromide): flumetsulam  
 Silver chloride: mepiquat chloride

- Sodamide (sodium amide)\*: pronamide  
 Sodium acetylde: pronamide  
 Sodium arsenite: cacodylic acid, DBMA, MSMA  
 Sodium azide: aziprotrine  
 Sodium bisulfide: dipyrithione  
 Sodium borohydride: brodifacoum, diclobutrazol, difenacoum, difethialone, diniconazole, fenpropidin, flocoumafen, imidacloprid, imizalil, inabenfide, paclobutrazol, penconazole, triadimenol, uniconazole  
 Sodium butyl mercaptide: see Butyl mercaptan  
 Sodium chlorate: cloroneb  
 Sodium chloro propionate: see Chloro propionic acid  
 Sodium cyanamide: dodine  
 Sodium cyanide: chlorfenac, cyfluthrin, cymoxanil, dithianon, flucythrinate, flupropanate, triclopyr, see PCBA  
 Sodium diethyl phosphite: see Diethyl phosphite  
 Sodium disulfide: pyrihiobac  
 Sodium ethyl mercaptide: see Ethyl mercaptan  
 Sodium hydride: benfuresate, diclobutrazol, pyrihiobac, resmethrin  
 Sodium hydrosulfide: flazasulfuron, quinomethionate  
 Sodium isopropyl oxide: flutalonil  
 Sodium methoxide: benfuresate, chlorimuron, difenoxuron, difenzoquat, prometon, terbumeton  
 Sodium methyl mercaptide: see Methyl mercaptan  
 Sodium methyl thiophenate: see Methyl thiophenol  
 Sodium nitrite: aldicarb, chlorsulfuron, clodinafop, clofentezine, cymoxanil, dichlbenil, diclofop, dimefuron, drazoxolon, ethylchlozate, fenaminosulf, fenchlorazole, fencpiclonil, flupoxam, nipyraclufen, perfluidone, pyraclofos, pyrazosulfuron, pyrihiobac, silafluofen, sulfentrazone, 2,3,6 TBA, tetradifon, tetrasul, thifensulfuron, triasulfuron  
 Sodium phenolate: see Phenol  
 Sodium phenyl thiosulfonate: bensultap, thiocyclam  
 Sodium propyl mercaptide: see Propyl mercaptan  
 Sodium pyrosulfate: pyrihiobac  
 Sodium sulfide: thiobencarb, thiocyclam  
 Sodium sulfite: ethylchlozate, fenaminosulf, sulfentrazone  
 Sodium thiocyanate: cartap  
 Sodium thiosulfate: thiocyclam  
 Sodium 1,2,4 triazole: flusilazole  
 Sorbose: dikegulac-sodium  
 Stearic acid: glyodin  
 Succinic acid: quinmerac, resmethrin  
 Succinic anhydride: daminozide, diclomezine  
 (Isopropyl) sulfamoyl chloride: bentazon  
 o.Sulfamoyl methyl benzoate: chlorimuron  
 Sulfanilamide: flumetsulam  
 Sulfenyl chloride (tetra chloro): captafol  
 Sulfenyl chloride (trichloromethane): etridazol  
 Sulfonamide (chloro): amidosulfuron  
 Sulfonamide (2 chloro benzene): chlorsulfuron  
 Sulfonamide (methane N-methyl): amidosulfuron  
 Sulfonium (trimethyl iodide): hexaconazole, metconazole  
 Sulfonium (trimethyloxo iodide): ipconazole, triticonazole  
 Sulfonyl chloride: ethylchlozate  
 Sulfonyl chloride (methyl) (or methane): ethofumesate, fomesafen, metconazole, sulfentrazone  
 Sulfonyl (trifluoro methane chloride): perfluidone  
 Sulfonyl (trifluoro methyl fluoride): fipronil, mefluidide  
 Sulfoxide (dimethyl): ipconazole, pyrihiobac  
 Sulfur chloride: thiodicarb

Sulfur dichloride: benfuracarb, furathiocarb, thiocyclam, thiodicarb  
 Sulfur dioxide: sulfuryl fluoride, triasulfuron  
 Sulfur tetra fluoride: benfluralin, trifluralin  
 Sulfuryl chloride: carboxin, chlordane, crotoxyphos, dichlofluanid, dicrotophos, flurazole, heptachlor, hexachlorobenzene, metribuzin, metsulfovax, mevinphos, monocrotophos, othilinone, oxycarboxin, phosphamidon, tolyfluanid  
  
 TEP triethyl phosphite: chlorfenvinphos, fonofos, glufosinate  
 Terephthalic acid\*: chlortal, DCPA  
 Terephthalic dichloride: chlortal  
 Terpinene: cimmethylin  
 Terpinene-4 ol: cimmethylin  
 Tetracarboxy furan\*: resmethrin  
 1.2.3.4 Tetrachloro benzene: 2.3.6 TBA  
 1.2.4.5 Tetrachloro benzene: 2.4.5 T, tecnazene  
 Tetrachloro 1.2 bis dichloro methyl benzene: tetrachloro phthalide  
 Tetrachloro isophthalic acid: chlorotalonil  
 2.3.4.5 Tetrachloro nitrobenzene: teflubenzuron  
 1.1.2.3 Tetrachloro propene\*: triallate  
 Tetrachloro sulfenyl chloride: captafol  
 1.2.4.5 Tetra fluoro benzene: tefluthrin  
 2.3.5.6 Tetra fluoro benzyl alcohol: transfluthrin  
 Tetrafluoro ethylene: flupropanate, tetraconazole  
 3.4.5.6 Tetrahydrophthalic anhydride: flumiclorac, flumioxazin  
 1 Tetralol\*: coumatetryl  
 2.2.3.3 Tetramethyl cyclo propane carboxylic acid: fenpropathrin  
 1.2 Thiadiazole (3 amino): thiadiazuron  
 1.3.4 Thiadiazole (2 methyl amino 5 ethyl sulfonyl): ethidimuron  
 3 Thial N octyl propionamide: othilinone  
 Thiazole\*: thiabendazole  
 Thiazole 4 aldehyde\*: thiabendazole  
 Thiazole 4 carboxylic acid\*: thiabendazole  
 Thiazolidine 2 one\*: fosthiazate  
 Thioacetamide: metsulfovax, thifluzamide  
 Thiocarbamic acid\*: metribuzin  
 Thiocarbohydrazide\*: metribuzin  
 Sodium) thiocyanate: cartap  
 1.4 Thiodiphenol\*: thenephos  
 Thioglycolic acid\*: thifensulfuron  
 Thiolactic acid: dimethenamid  
 Thiomethyl phenol\*: propaphos  
 Thionyl chloride: azinphosmethyl, barban, bensulide, benzthiazuron, bifenthrin, butralin, carboxin, cyhalothrin, DCPA, dichlobenil, diflufenican, dimethenamid, diphenamid, dithiopyr, endosulfan, ethylchlozate, fenfuram, fluchloralin, flurazole, fluvalinate, fucythrinate, furmecyclox, inabenfide, isoxaben, naproamide, methabenzthiazuron, methidathion, nicosulfuron, penconazole, piperalin, pronamide, propaquizafop, propargite, pyrifenox, thiazopyr, thifluzamide, triforine, thiodicarb, trichlamide, vamidothion  
 Thiophene (2 carbonyl, 3 methoxy): thenylchlor  
 Thiophene(2 carboxylic acid, 3 sulfonamide): thifensulfuron  
 Thiophen (3 methoxy): thenylchlor  
 Thiophenol\*: carbofenothion, edifenphos, fonofos, perfluidone  
 Thiophenone(2,4 dimethyl tetra hydro 3)\*: dimethenamid  
 Thiophosgene: chloromethiuron, diafenthuiuron, pyributicarb, pyriothibac  
 Thio phosphoryl chloride: isofenphos, propetamphos, prothiofos, sulfoprofos, tolclofos  
 Thio pseudo urea (methyl): hexazinone

Thio pyran 3 cyclo hexane 1.3 dione: cycloxidim

Thio semi carbazide\*: bisthiosemi, triazamate

Thio semi carbazide (4 methyl): thiazafluron

Thiourea: benazolin, bensulfuron, bisthiosemi, carbendazim, dipropetryn, flazasulfuron, flurazole

Thiourea (N.t.butyl,N-isopropyl)\*: buprofezin

Thiourea (2 chlorophenyl): benazolin, benzothiazuron

Thiourea (methyl): tebuthiuron, thiazafluron

Tin tetra chloride: azocyclotin, cyhexatin, fenbutatin, fentin

TMP trimethyl phosphite: chlorfenvinphos, crotoxyphos, dichlorvos, dicrotophos, glyphosate, heptenphos, mevinphos, monocrotophos, naled, phosphamidon, tetrachlorvinphos

TOA triethyl ortho acetate: bifenthrin, cyhalothrin, cypermethrin, deltamethrin, permethrin, tefluthrin

Toluene: bromethalin, chlorbenzilate, chlorotoluron, diclomazine, thiobencarb, see PCBA

p.Toluene sulfonic acid\*: amitraz, pretilachlor, propaquizafop, pyriproxifen, triasulfuron

p.Toluene sulfonic chloride: muscalure, pyrazolate

m.Toluidine\*: phenmedipham

p.Toluidine: daimuron, tolyfluand

Tosyl methyl isocyanide: fenciclonil

1.3.5 Triazine (2 amino 4.6 dimethoxy)\*: cinosulfuron, prosulfuron

1.3.5 Triazine (2 amino 4 methoxy 6 methyl)\*: chlorsulfuron, metsulfuron, thifensulfuron, triasulfuron

1.3.5 Triazine (2 methylamino 4 methoxy 6 methyl): tribenuron

1.3.5 Triazine (2 methylamino 6 ethoxy)\*: ethametsulfuron

1.3.5 Triazine (hexahydro) 1.3.5 tri(2 chloro phenyl): fosmethilan

1.2.4 Triazole\*: azaconazole, azocyclotin, bitertanol, bromuconazole, cyproconazole, diclobutrazol, difeconazole, diniconazole, etaconazole, fenbuconazole, fluotrimazole, flusilazole, flutriafol, furconazole, hexaconazole, imibenconazole, ipconazole, metconazole, myclobutanil, paclobutrazol, penconazole, propiconazole, tebuconazole, tetraconazole, triadimefon, triadimenol, triapenthenol, triticonazole, uniconazole

1.2.4 Triazole (2 amino 5 benzyl thio): flumetsulam

1.2.4 Triazole (5 amino 3 mercapto): metosulam

1.2.4 Triazole (1 isopropyl 3 hydroxy): isazofos

1.2.4 Triazole (1 phenyl 3 hydroxy): triazophos

Tributyl phosphine: chlorphonium chloride

$\alpha$  2.4 Trichloro aceto phenone: bromuconazole

Trichloro acetyl chloride: fenchlorazole

1.2.3 Trichloro benzene: acclonifen

1.2.4 Trichloro benzene\*: dicamba, tetrachlorvinphos, tetradifon

2.3.6 Trichloro benzoic acid: dicamba

2.3.6 Trichloro benzoylchloride: 2.3.6 TBA

Trichloromethyl sulfenyl chloride: etridazol

2.3.4 Trichloronitrobenzene: acclonifen

2.4.5 Trichlorophenol\*: fenoprop, 2.4.5 T, trichloronat

2.4.6 Trichloro phenol\*: prochloraz

1.2.3 Trichloro propylene\*: diallate

3.5.6 Trichloro 2 pyridinol: chlorpyrifos

2,4,5 Trichloro thiophenol: tetradifon, tetrasul

2,3,6 Trichloro toluene: chlorfenac, dicamba, 2,3,6 TBA

1,1,1 Trichloro 2,2,2 trifluoro ethane: bifenthrin, cyhalothrin, tefluthrin

Tridecylamine: tridemorph

Triethyl ortho acetate: see TOA

Triethyl phosphate: TEPP

Triethyl phosphite: see TEP

Triethyl phosphonacetate: dimethomorph

Trifluoro acetic acid: nicosulfuron, thiazfluron

Trifluoroaceto acetic acid: dithiopyr, flurazole, thiazopyr

Trifluoro acetic acid anhydride: thiazfluron



Trifluoroacetonitrile: flurazole  
 Trifluoro acetyl chloride: cyhalothrin, fluxofenin  
 4,4,4 Trifluoro 2 chloro aceto acetic acid ethyl ester: thifluzamide  
 Trifluoroethanol: furconazole, triflusulfuron  
 Trifluoro methane sulfonyl chloride: perfluidone  
 Trifluoro methane sulfonyl fluoride: fipronil, mefluidide  
 4 Trifluoromethoxy aniline: thifluzamide, triflumuron  
 m-Trifluoromethyl aniline\*: fluometuron, fluorochloridone, norflurazon  
 p-Trifluoromethyl,  $\beta$  amino ethyl acrylate: dithiopyr  
 p.Trifluoro methyl benzaldehyde: hydramethylnon  
 4 Trifluoro methyl benzene: acifluorfen, fomesafen  
 3 Trifluoromethyl benzotrichloride: fluotrimazole  
 2 Trifluoromethyl benzoyl chloride: flutalonil  
 2 Trifluoromethyl chloro benzene\*: flusulfamide  
 3.5 Bistrifluoromethyl iodo benzene: flupropadine  
 4 Trifluoromethyl methyloxy benzene: flocoumafen  
 3 Trifluoromethyl phenol\*: diflufenican  
 4 Trifluoromethyl phenol\*: fluoroglycofen, fomesafen, furyloxyfen  
 2(3 Trifluoromethyl phenoxy)nicotinic acid: diflufenican  
 3 Trifluoromethyl, phenyl acetonitrile: flurtamone  
 1(3 Trifluoromethyl phenyl) 3 phenyl acetone: fluridone  
 3.3.3 Trifluoro propyl benzene: prosulfuron  
 Trimethyl acetyl chloride: dimefuron, oxadiazon, triazamate  
 Trimethylamine: chlormequat  
 2.4.6 Trimethyl benzaldehyde\*: traloxymid  
 2.3.5 Trimethyl phenol: trimethocarb  
 3.4.5 Trimethyl phenol: trimethocarb  
 Trimethyl phosphite: see TMP  
 Trinitro phenol: see Picric acid  
 Triphenyl phosphine: acrinathrin, cyhalothrin, cypermethrin, tralomethrin  
 Triphenyl phosphite: ampropylfos  
 Triphenyl tin chloride: fentin acetate, fentin hyroxide

Urea: crimidine, cymoxanil, fenuron, isoproturon, phosalone  
 Urotroprin: cyfluthrin, glyphosate, see PCBA

Veratrole\*: dimethomorph  
 Vinyl phthalimide: dialifos

m.Xylene: chlorotalonil  
 o-Xylene: pendimethalin  
 p.Xylene: chlorthal  
 3.4 Xylenol: xylilcarb  
 3.5 Xylenol: XMC

Zinc nitrate: mancozeb, propineb  
 Zinc sulfate: zineb, ziram

# APPENDIX IV

## SYNTHESIS OF RAW MATERIALS AND INTERMEDIATES

*See PREFACE: How to Use This Handbook*

### INTERMEDIATES

### SYNTHESIS

Acetanilide

Acetic acid (or anhydride) + aniline

Acetoacetanilide

Diketene + aniline

Aceto acetic acid

Hydrolysis of ethylacetoacetate

Acetone cyanohydrin

Acetone + HCN

Acetophenone

- (1) Benzene + acetyl chloride
- (2) Ethyl benzene + O<sub>2</sub>
- (3) By product of phenol production

Acetyl acetone

Ethylacetate + acetone in presence of Na

Acetyl hydrazine

Methyl acetate + hydrazine

Aldol

Condensation of acetaldehyde

Allyl chloride

Chlorination of propene

p.Amino 2.4 dichlorophenol

p.Nitro 2.4 dichlorophenol + H<sub>2</sub>

Amino guanidine

Nitroguanidine + Zn

4 Amino 1 naphthol

1 Naphthol + benzene diazonium chloride followed by sodium hydrosulfite

m.Amino phenol

- (1) Nitrobenzene + oleum → m.nitro phenyl sulfonic acid + H<sub>2</sub> → m.amino sulfonic acid + NaOH → m.amino sodium fenolate + H<sub>2</sub>SO<sub>4</sub>
- (2) Resorcinol + ammonia
- (3) Metaphenylene diamine + NaNO<sub>2</sub> → diazonium salt + HCl/H<sub>2</sub>O

o.Amino phenol

o.Nitrophenol + H<sub>2</sub>

m.Amino toluene

m.Nitrotoluene + H<sub>2</sub>

o.Amino toluene

o.Nitrotoluene + H<sub>2</sub>

p.Amino toluene

p.Nitrotoluene + H<sub>2</sub>

Anisole

Phenol + methyl chloride

Anthranilic acid

- (1) Phthalimide + H<sub>2</sub>
- (2) o.Nitrotoluene + HNO<sub>3</sub> → o.Nitrobenzoic acid + H<sub>2</sub>

**INTERMEDIATES****SYNTHESIS**

Benzalacetone

Benzaldehyde + acetone

Benzaldehyde

- (1) Toluene + O<sub>2</sub>
- (2) Benzylidene chloride + NaOH

Benzene diazonium chloride

Aniline + NaNO<sub>2</sub> + HCl

Benzene sulfonyl chloride

Benzene + chlorosulfonic acid

Benzil

Oxydation of benzoin

Benzimidazole

o-Phenylene diamine + formic acid

Benzoic acid

Toluene + O<sub>2</sub>

Benzoin

Benzaldehyde condensation

Benzonitrile

- (1) Toluene + NH<sub>3</sub>
- (2) Sodium benzene sulfonate + NaCN
- (3) Benzene diazonium chloride + NaCN

Benzoyl chloride

Benzoic acid + thionyl chloride

Benzoyl cyanide

Benzoyl chloride + NaCN

Benzylamine

- (1) Benzaldehyde + NH<sub>3</sub>
- (2) Benzyl chloride + NH<sub>3</sub>

Benzyl chloride

- (1) Toluene + Cl<sub>2</sub>
- (2) Benzyl alcohol + thionyl chloride

Benzyl cyanide

Benzyl chloride + KCN

Benzylidene chloride

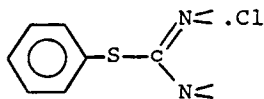
Benzyl chloride + Cl<sub>2</sub>

Benzyl mercaptan

- (1) S-benzyl thiuronium chloride + NaOH
- (2) Benzyl chloride + NaSH

S-Benzyl thiuronium chloride

Benzyl chloride + thiourea



Bromo succinimide

Succinimide + Br<sub>2</sub>

n-Butyl amine

Butanol + NH<sub>3</sub>

Butyl carbitol

Butyl cellosolve + ethylene oxide

Butyl cellosolve

Butanol + ethylene oxide

p.t. Butyl phenol

Phenol + isobutanol

1.4 Butynediol

Acetylene + formaldehyde

**INTERMEDIATES** $\gamma$  Butyrolactone

Catechol (hydro/pyro)

Chloroacetic acid

Chloroacetyl chloride

Chloral

2 Chloro 4 amino toluene

o.Chloroaniline

p.Chloroaniline

o.Chlorobenzaldehyde

p.Chlorobenzaldehyde

m.Chlorobenzoic acid

o.Chlorobenzoic acid

p.Chlorobenzoic acid

o.Chlorobenzoyl cyanide

o.Chlorobenzyl chloride

p.Chlorobenzyl chloride

o.Chlorobenzylidene chloride

p.Chlorobenzylidene chloride

2 Chloro 4 bromophenol

Chloro 2,4 dinitrobenzene

o/p.Chloronitrobenzene

2 Chloro 4 nitrotoluene

Chloroformates

o/p Chloronitrobenzene

3 Chloro 6 nitrobenzoic acid

2 Chloro 4 nitrotoluene

**SYNTHESIS**

Acetylene + formaldehyde

- (1) Phenol +  $\text{H}_2\text{O}_2$
- (2) o/p.Chlorophenol + NaOH +  $\text{H}_2\text{SO}_4$
- (3) o-Dichlorobenzene + NaOH

- (1) Acetic acid +  $\text{Cl}_2$
- (2) Trichloroethylene +  $\text{H}_2\text{SO}_4$

Chloroacetic acid +  $\text{SOCl}_2$ Acetaldehyde +  $\text{Cl}_2$ 2 Chloro 4 nitrotoluene +  $\text{H}_2$ o.Chloronitrobenzene +  $\text{H}_2$ p.Chloronitrobenzene +  $\text{H}_2$ 

o.Chlorobenzylidene chloride + NaOH

p.Chlorobenzylidene chloride + NaOH

Benzoic acid +  $\text{Cl}_2$  +  $\text{AlCl}_3$ o.Chlorotoluene +  $\text{HNO}_3$ p.Chlorotoluene +  $\text{HNO}_3$ 

o.Chlorobenzoyl chloride + KCN

o.Chlorotoluene +  $\text{Cl}_2$ p.Chlorotoluene +  $\text{Cl}_2$ o.Chlorobenzyl chloride +  $\text{Cl}_2$ p.Chlorobenzyl chloride +  $\text{Cl}_2$ o.Chlorophenol +  $\text{Br}_2$ o.Chloronitrobenzene +  $\text{HNO}_3$ Chlorobenzene +  $\text{HNO}_3$ p.Nitrotoluene +  $\text{Cl}_2$ 

Phosgene + alcohol

Chlorobenzene +  $\text{HNO}_3$ m.Chlorobenzoic acid +  $\text{HNO}_3$ p.Nitrotoluene +  $\text{Cl}_2$

**INTERMEDIATES****SYNTHESIS**

3 Chloro 6 nitrotoluene

m.Chlorotoluene +  $\text{HNO}_3$ 

o/p.Chlorophenol

Phenol +  $\text{Cl}_2$ 

p.Chlorophenyl acetic acid

see Phenyl acetic acid

 $\alpha$  Chloropropionic acidPropionic acid +  $\text{Cl}_2$ 

Chloropyruvic acid

Pyruvic acid +  $\text{Cl}_2$ 

o/p/2.4 Dichlorotoluene

Toluene +  $\text{Cl}_2 \rightarrow$  ortho, para +  $\text{Cl}_2 \rightarrow$   
2.4 dichlorotoluene

Coumaric acid

Salicyl aldehyde + acetic anhydride

Coumarin

Cyclization of coumaric acid

Crotonaldehyde

Dehydration of aldol

Cyanoacetic acid

Chloroacetic acid + KCN

Cyclohexyl amine

Aniline +  $\text{H}_2$ 

Cyclopropane carboxylic acid

- (1) Cyclopropane bromide + KCN  $\rightarrow$   
cyclopropane cyanide followed by  
hydrolysis
- (2) Ethylene dibromide + diethyl malonate  $\rightarrow$   
cyclopropane dicarboxylic acid followed by  
saponification and monodecarboxylation via  
heating

3.4 Dichloroaniline

Orthodichlorobenzene +  $\text{HNO}_3 \rightarrow$  followed by hydro-  
genation

DCPI

3.4 Dichloroaniline + phosgene

DEPA

 $\text{P}_2\text{S}_5$  + ethanol

DECPT

DEPA +  $\text{Cl}_2$ 

Diazomethane

Chloroform + hydrazine

Diazonium salts

Amine +  $\text{NaNO}_2$ 

3.4 Dichloroaniline

- (1) p.Chloroaniline +  $\text{HCl}$  +  $\text{AlCl}_3$
- (2) 3.4 Dichloronitrobenzene +  $\text{H}_2$

2.4 Dichlorobenzoic acid

2.4 Dichlorotoluene +  $\text{HNO}_3$ 

2.6 Dichloro 4 methyl phenol

p.Cresol +  $\text{Cl}_2$ 

3.4 Dichloronitrobenzene

o.Dichlorobenzene +  $\text{HNO}_3$ 

2.4 Dichlorophenol

p.Chlorophenol +  $\text{Cl}_2$

**INTERMEDIATES**

Dicyano diamide

Diethanol amine

2.6 Diethyl aniline

Diethylmalonate

N-N-Diphenyl thiourea

Diethyl phosphite

3.5 Dihydroxy benzoic acid

Diketene

2.2 Dimethoxy propane

Dimethyl morpholine

2.6 Dimethyl phenyl hydrazine

Dimethyl phosphite

Dioxane

DIPA

DIPCT

Diphenyl acetone

Diphenyl urea

DMPA

DMPCT

Ethanol amine

Ethoxyamine

p.Ethoxy phenyl acetic acid

Ethyl aceto acetate

N-Ethyl aniline

o/m.Ethyl aniline

Ethyl chloroformate

Ethylene diamine

**SYNTHESIS**

Condensation of cyanamide

Ethylene oxide +  $\text{NH}_3$ 

o.Ethylaniline + ethylene

Cyanoacetic acid + ethanol +  $\text{H}_2\text{SO}_4$ 

Phenyl thiourea + aniline HCl

 $\text{PCl}_3$  + ethanolBenzoic acid +  $\text{H}_2\text{SO}_4 \rightarrow$  3.5 disulfonic benzoic acid  
followed by alkali fusion

see Ketene

Methyl isopropenyl ether + methanol

Propylene oxide + isopropanolamine

see Phenyl hydrazine

 $\text{PCl}_3$  + methanol

Condensation of ethylene glycol

 $\text{P}_2\text{S}_5$  + isopropanolDIPA +  $\text{Cl}_2$ 

1 Bromo 3 phenylacetone + benzene

Phenyl urea + aniline HCl

 $\text{P}_2\text{S}_5$  + methanolDMPA +  $\text{Cl}_2$ Ethylene oxide +  $\text{NH}_3$ 

Hydroxylamine disulfonic acid + ethyl sulfate

p.Chlorophenyl acetic acid + sodium ethoxide

- (1) Diketene + ethanol
- (2) Ethyl acetate + sodium ethoxide

Aniline HCl + ethanol

Aniline + ethylene

Phosgene + ethanol

Ethylene dichloride +  $\text{NH}_3$

**INTERMEDIATES****SYNTHESIS**

Ethylene glycol

Ethylene oxide + H<sub>2</sub>O

2 Ethyl 6 methylaniline

o.methylaniline + ethylene

Ethyl urea

Ethylamine + KOCN

Furan

Furfural + NaOH (oxidation + dicarboxylation)

2 Furoic acid

Furfural + NaOH (acid salt) followed by HCl

Glycine

Chloroacetic acid + NH<sub>3</sub>

Glycoaldehyde

Condensation of formaldehyde

Glyoxal

Ethylene oxide + O<sub>2</sub> (or HNO<sub>3</sub>)

Glyoxilic acid

- (1) Dichloroacetic acid + H<sub>2</sub>O
- (2) Electrochemical reduction of oxalic acid with H<sub>2</sub>

Guaicol

Pyrocatechol + dimethylsulfate

Guanidine

- (1) Chlorine cyanide + NH<sub>3</sub>
- (2) Ammonium thiocyanate + NH<sub>3</sub>
- (3) Thiourea + NH<sub>3</sub>

Guanidine (dimethyl)

Dimethylamine + cyanamide

Guanidine (diethyl)

Diethylamine + cyanamide

Guanidine nitrate

- (1) Guanidine + HNO<sub>3</sub> + H<sub>2</sub>SO<sub>4</sub>
- (2) Dicyanodiamide + (NH<sub>4</sub>)NO<sub>3</sub>

Hexamethylene tetramine

Formaldehyde + NH<sub>3</sub>

Hydroquinone/pyrocatechol

see Catechol

o/p.Hydroxy benzaldehyde

Phenol + chloroform + KOH

4 Hydroxy benzonitrile

4 Hydroxy benzaldehyde + hydroxylamine followed by dehydration

4 Hydroxy coumarin

Cyclization of acetylsalicylic acid

3 Hydroxy phenyl aceto acetate

Aceto acetyl chloride + resorcinol

8 Hydroxy quinoline

o.Amino phenol + glycevol + H<sub>2</sub>SO<sub>4</sub>

Imidazol

Glyoxal + NH<sub>3</sub> + formaldehyde

2 Imidazolidinone

Ethylenediamine + CO<sub>2</sub>

Indole

- (1) Cyclization of o.amino phenyl + acetaldehyde
- (2) Cyclization of N-formyl, o.toluidine
- (3) Cyclization of N-methyl, o.toluidine

## INTERMEDIATES

## Isocyanates

methyl  
ethyl  
phenyl  
etc.

Isonicotinic acid

N.Isopropylaniline

p.Isopropyl aniline

Ketene

Maleic anhydride

Maleimide

Malonic acid

Mercaptobenzothiazole

Mesytil oxide

Methallyl chloride

Methane sulfonic acid

Methane sulfonyl chloride

Methoxy ethanol

Methyl acetoacetic acid

N-Methylaniline

Methyl chloroformate

Methyl hydroxylamine

Methyl isothiocyanate

4 Methyl thiophenol

Methyl thiourea

Morpholine

Mucochloric acid

## SYNTHESIS

Phosgene + amine

methylamine  
ethylamine  
aniline  
etc.

 $\gamma$  Picoline +  $\text{KMnO}_4$ 

(1) Isopropylamine + benzene chloride  
(2) Aniline HCl + isopropanol

p.Nitrocumene +  $\text{H}_2$ 

Cracking of acetic acid

Benzene +  $\text{O}_2$ Maleic anhydride +  $\text{NH}_3$ 

Hydrolysis of diethyl malonate

Aniline +  $\text{CS}_2$  + S

Dehydration of diacetone alcohol

Isobutylene +  $\text{Cl}_2$  $\text{SO}_3$  + Methane

Methane sulfonic acid + thionyl chloride

(1) Ethylene oxide + methanol  
(2) Ethylene glycol + diazomethane

Acetoacetic acid + methyl iodide

Aniline HCl + methanol

Phosgene + methanol

Hydroxylamine + dimethyl sulfate

Methylamine + thiophosgene

4 Toluene sulfonyl chloride + Zn

Methylamine + carbon disulfide  $\rightarrow \text{CH}_3\text{NHCSSNH}_4$  +  
 $\text{Pb}(\text{NO}_3)_2 \rightarrow \text{methyl isothiocyanate} + \text{NH}_3 \rightarrow$   
methylthiourea

Cyclization of diethanolamine

Butyne 1.4 diol +  $\text{Cl}_2$  or furfural +  $\text{Cl}_2$



**INTERMEDIATES****SYNTHESIS**

1 Naphthalene sulfonic acid

Naphthalene +  $\text{H}_2\text{SO}_4$  ( $0^\circ\text{C}$ )

2 Naphthalene sulfonic acid

Naphthalene +  $\text{H}_2\text{SO}_4$  ( $160^\circ\text{C}$ )

1 Naphthol

(1) 1 Naphthaleneamine +  $\text{H}_2\text{SO}_4$  (hydrolysis)  
 (2) 1 Naphthalene sulfonic acid + NaOH

2 Naphthol

2 Naphthalene sulfonic acid + NaOH

1.4 Naphthoquinone

(1) 4 Amino 1 naphthol +  $\text{FeCl}_3$   
 (2) Naphthalene + chromic anhydride

1 Naphthyl acetic acid

Naphthalene + acetic anhydride

1 Naphthylamine

1 Nitronaphthalene +  $\text{H}_2$ 

Neophyl chloride

Benzene + methallyl chloride

Nicotinic acid

Paraldehyde +  $\text{NH}_3 \rightarrow$  2 methyl 5 ethyl pyridine +  $\text{HNO}_3 \rightarrow$   
 2.5 dicarboxy pyridine  $\rightarrow$  nicotinic acid

o/p.Nitroaniline

(1) o/p.Chloronitrobenzene +  $\text{NH}_3$   
 (2) Aniline +  $\text{HNO}_3$

o.Nitrobenzoic acid

o.Nitrotoluene +  $\text{HNO}_3$ 

p.Nitro 2.4 dichlorophenol

2.4 Dichlorophenol +  $\text{HNO}_3$ 

1 Nitronaphthalene

Naphthalene +  $\text{HNO}_3$ 

o/p.Nitrophenol

(1) o.Chloronitrobenzene + NaOH  
 (2) Phenol +  $\text{HNO}_3$

o/p.(m)Nitrotoluene

Toluene +  $\text{HNO}_3$  (+ meta)

Paraldehyde

Condensation of acetaldehyde

Phenacyl chloride

(1) Benzene + chloroacetylchloride  
 (2) Acetophenone +  $\text{Cl}_2$

Phenanthrenequinone

Oxidation of phenanthrene

p.Phenitidine

p.Nitrochlorobenzene + sodium ethylate followed by  
 reduction with hydrogen

m.Phenoxy benzaldehyde

(1) Bromination/hydrolysis of m.phenoxy toluene  
 (2) Reduction of m.phenoxy benzoic acid methyl ester

Phenyl acetic acid

Benzyl cyanide +  $\text{H}_2\text{SO}_4$ 

o/m.Phenylenediamine

(1) o/m Nitroaniline +  $\text{H}_2$   
 (2) o.Dinitrobenzene +  $\text{H}_2$

**INTERMEDIATES**

Phenyl hydrazine

Phenyl hydroxylamine

4 Phenyl phenol

Phenyl urea

Phenyl thiourea

Phthalimide

 $\alpha$  Picoline

Picolines (+ pyridine)

Picric acid

Pinacol

Pinacolone

Piperazine

Pivalic acid

Piperidine

Propargylic alcohol

Propionaldehyde

Propionic acid

n.Propionol

Pyrazole

Pyridine

Pyridine 3 acetic acid

Pyridine (2 benzoyl)

Pyrogallol

**SYNTHESIS**Aniline diazonium chloride +  $\text{Na}_2\text{SO}_3$  + NaOH

Nitrobenzene + Zn

Biphenol + sulfonic acid followed by hydrolysis

Urea + aniline . HCl

Thiourea + aniline . HCl

Phthalic anhydride +  $\text{NH}_3$ Acetaldehyde +  $\text{NH}_3$ Acetaldehyde + formaldehyde +  $\text{NH}_3$ Phenol +  $\text{H}_2\text{SO}_4 \rightarrow$  phenol disulfonic acid followed by nitration

Condensation of acetone

Pinacol +  $\text{H}_2\text{SO}_4$ 

Condensation of ethanolamine

t-Butyl chloride + Mg  $\rightarrow$  Grignard +  $\text{CO}_2$ Pyridine +  $\text{H}_2$ (1) 1,3 Dichloropropene + NaOH  $\rightarrow$  3 chloro 2 propen 1 ol + NaOH

(2) Acetylene + formaldehyde

(1) Propylene oxide +  $\text{H}_2\text{SO}_4$ (2) n.Propanol +  $\text{O}_2$ (3) Allyl alcohol  $\xrightarrow{\Delta}$ n.Propanol +  $\text{O}_2$ 

Ethylene + CO

Diazomethane + acetylene

(1) Acrolein + formaldehyde +  $\text{NH}_3$ (2) Acetaldehyde + formaldehyde +  $\text{NH}_3$  $\beta$  Picoline + benzene lithium  $\rightarrow$   $\beta$  picoline lithium +  $\text{CO}_2$ 2 Benzyl pyridine +  $\text{O}_2$ 

Heating of gallic acid

**INTERMEDIATES****SYNTHESIS**

Pyruvic acid	Tartaric acid + HCl (dehydration)
Quinoxaline	o-Phenylenediamine + glyoxal
Resorcinol	Benzene + $\text{H}_2\text{SO}_4 \rightarrow$ m.benzene disulfonic acid + NaOH
Saccharin	(1) Toluene + chlorosulfonic acid $\rightarrow$ o.toluene sulfonate + $\text{NH}_3 \rightarrow$ o.toluene sulfonamide + $\text{KMnO}_4$ (2) Anthranilic acid + $\text{NaNO}_2 + \text{N}_2\text{S}_2 \rightarrow$ o.sodium benzoate disulfide + methanol + $\text{Cl}_2 \rightarrow$ o.sulfonyl chloride methyl benzoate + $\text{NH}_3$
Salicyl aldehyde	Phenol + chloroform + KOH
Salicylic acid	Phenol + $\text{CO}_2$
Sodamide	$\text{Na} + \text{NH}_3$
Succinimide	Succinic acid + $\text{NH}_3 \rightarrow$ diammonium succinimate followed by heating
Terephthalic acid	Paraxylene + $\text{O}_2$
Tetracarboxy furan	Condensation of ethyl sodio oxalacetate
Tetralol	1 Naphthol + $\text{H}_2$ or Na
1.1.2.3 Tetrachloropropylene	1.2.3 Trichloropropylene + $\text{Cl}_2 \rightarrow$ 1.1.2.2.3 penta chloro-propane $\rightarrow$ NaOH $\rightarrow$ 1.1.2.3 tetrachloropropylene
Thioacetamide	Ammonium acetate + aluminum sulfide Acetonitrile + $\text{H}_2\text{S}$
Thiocarbohydrazide	Thiosemi carbazide + hydrazine
Thiodiphenol	Chlorophenol + $\text{Na}_2\text{S}$ (or $\text{Na}_2\text{S}_2$ or potassium ethyl xanthate)
Thioglycolic acid	(1) Sodium sulfhydrate + sodium chloroacetate (2) Sodium chloroacetate + $\text{Na}_2\text{S} \rightarrow$ thiodim glycolic acid sodium salt <u>electrolysis</u>
4 Thiomethyl phenol	p.Chlorophenol + sodium methyl mercaptide
Thiophenol	Benzene sulfonyl chloride + Zn
Thiosemi carbazide	Thiourea + hydrazine
Thiourea	(1) Fusion of ammonium thiocyanate (2) Cyanamide + $\text{H}_2\text{S}$
Thiourea (N-t.dibutyl, N-isopropyl)	$\text{CS}_2$ + t.Butylamine + isopropylamine
p.Toluene sulfonic acid	Toluene + $\text{H}_2\text{SO}_4$

## INTERMEDIATES

1.2.4 Triazole

1.2.4 Trichlorobenzene

2.4.6 Trichlorophenol

1.2.3 Trichloropropylene

Trifluoro methyl phenol

2.4.6 Trimethyl benzaldehyde

Veratrole

## SYNTHESIS

Formamide + hydrazine

Orthodichlorobenzene +  $\text{Cl}_2$

Phenol + chlorine

Propylene +  $\text{Cl}_2 \rightarrow$  1.2.3 trichloropropane +  $\text{NaOH} \rightarrow$   
 2.3 dichloropropylene +  $\text{Cl}_2 \rightarrow$  1.2.2.3 tetrachloro-  
 propane +  $\text{NaOH} \rightarrow$  1.2.3 trichloropropylene

Chlorine + methyl phenol  $\rightarrow$  trichloromethyl phenol +  $\text{HF}$

Mesitylene +  $\text{CO} + \text{AlCl}_3$

Guaiacol + methyl chloride

# APPENDIX V

## CHEMICAL FUNCTIONS

See PREFACE: How to Use This Handbook

This Appendix lists all products which have the same chemical function. The synthesis route(s) for each product are described under the heading of the main function.

When a product has more than one main chemical function, it is listed under all its functions. However, whenever a function is indicated in parenthesis, this means that this is the function under which the synthesis route of the compound is described in the main text.

### 1. AMIDES AND OTHER



#### AMIDES

acephate (phosphoroamido thioate)	isocarbamid
acetochlor	isoxaben (isoxazole)
alachlor	mefenacet (benzothiazole)
allidochlor	mefluidide
benalaxyl	mepronil
benodanil	metalaxyl
benoxacor (benzoxazine)	metazachlor
benzoylprop-ethyl	methfuroxam
bromobutide	metobenzuron (urea)
butachlor	metolachlor
butenachlor	metsulfovax (thiazole)
carboxin (oxathiin)	monalide
clomeprop (phenoxy carboxylic acid)	monocrotophos (phosphoro ester)
3 CPA (phenoxy carboxylic acid)	1 naphthylacetamide
cyprofuram	naproanilide
dichlormid	napropamide
dicrotophos (phosphate ester)	naptalam
diethatyl-ethyl	niclosamide
diethyl toluamide	ofurace
diflufenican	omethoate (phosphoro thioate)
dimethachlor	oxadixyl (oxazolidine)
dimethenamid (thiophene)	oxycarboxin (oxathiin)
dimethoate (phosphoro dithioate)	pentanochlor
diphenamid	phosphamidon (phosphate ester)
fenfuram	pretilachlor
flamprop-isopropyl	pronamide
flamprop-methyl	propachlor
fluoroacetamide	propanil
flutolanil	propisochlor
fomesafen (phenyl ether)	prothoate (phosphoro dithioate)
formothion (phosphoro dithioate)	tebufenozide (hydrazide)
fosmethilan (phosphoro dithioate)	tebufenpyrad (pyrazole)
furalaxyl	tebutam
hexythiazox (thiazolidine)	techloftalam
inabenfide	thénylchlor

thifluzamide (thiazole)  
 trichlamide  
 triforine  
 vamidothion (phosphoro thioate)

**CARBAMATES**

aminocarb  
 asulam  
 barban  
 bendiocarb  
 benfuracarb  
 benomyl (benzimidazole)  
 carbaryl  
 carbendazim (benzimidazole)  
 carbetamide  
 carbofuran  
 carbosulfan  
 chlorbufam  
 chlorpropham  
 cloethocarb  
 desmedipham  
 diethofencarb  
 dioxacarb  
 ethiofencarb  
 fenobucarb  
 fenoxycarb  
 formetanate  
 furathiocarb  
 isoprocarb  
 karbutilate (urea)  
 mecarbam (phosphoro dithioate)  
 methiocarb  
 metolcarb  
 mexacarbate  
 phenisopham  
 phenmedipham  
 pirimicarb  
 promacyl  
 promecarb  
 propamocarb  
 propham  
 propoxur  
 thiophanate (thiourea)  
 thiophanate-methyl thiourea)  
 trimethacarb  
 xmc-see xylcarb  
 xylcarb

**THIOCARBAMATES**

butylate  
 cartap  
 cycloate  
 diallate  
 dimepiperate  
 EPTC  
 esprocarb  
 fenothiocarb

methasulfocarb  
 molinate  
 orbencarb  
 pebulate  
 prosulfocarb  
 prothiocarb  
 pyributicarb  
 thiobencarb  
 tiocarbazil  
 triallate  
 vernolate

**DITHIOCARBAMATES**

ferbam  
 mancozeb  
 maneb  
 metam  
 nabam  
 propineb  
 thiram  
 zineb  
 ziram

**OXIME AMIDES**

alanycarb  
 aldicarb  
 aldoxycarb  
 butocarboxim  
 butoxycarboxim  
 methomyl  
 oxamyl  
 thiodicarb  
 thiofanox

**OXIMES**

alloxydim  
 benzoximate  
 bromofenoxim  
 chlorphoxim (phosphoro thioate)  
 clethodim  
 cycloxydim  
 cymoxanil (urea)  
 fluxofenim  
 heptopargil  
 oxabetrinil  
 phoxim  
 pyrifenoxy  
 sethoxydim  
 tralkoxydim

**SULFONYL-UREAS**

amidosulfuron  
 bensulfuron  
 chlorimuron  
 chlorsulfuron  
 cinosulfuron  
 ethametsulfuron-methyl  
 flazasulfuron  
 halosulfuron

imazosulfuron  
 metsulfuron-methyl  
 nicosulfuron  
 primisulfuron  
 prosulfuron  
 pyrazosulfuron  
 rimsulfuron  
 sulfometuron  
 thifensulfuron  
 triasulfuron  
 tribenuron  
 triflusulfuron

**THIOUREAS**

antu  
 chloromethiuron  
 diafenthiuron  
 thiophanate-ethyl  
 thiophanate-methyl

**UREAS**

benzthiazuron (benzothiazole)  
 chlorbromuron  
 chlorfluazuron  
 chlorotoluron  
 chloroxuron  
 cymoxanil  
 daimuron  
 difenoxuron  
 diflubenzuron  
 dimefuron (oxadiazolone)  
 diuron  
 ethidimuron  
 fenuron  
 fluazuron  
 flucofuron  
 flucyclofuron  
 flufenoxuron  
 fluometuron  
 forchlorfenuron  
 hexaflumuron  
 isoproturon  
 isouron (isoxazole)  
 karbutilate  
 linuron  
 lufenuron  
 methabenzthiazuron (benzothiazole)  
 methazole (oxadiazolone)  
 methylidymron  
 metobenzuron  
 metobromuron  
 metoxuron  
 monolinuron  
 monuron  
 neburon  
 pencycuron  
 siduron

sulcofuron  
 tebuthiuron (thiadiazole)  
 teflubenzuron  
 thiazafluron (thiadiazole)  
 thidiazuron  
 triflumuron

**2. PHOSPHORO ORGANICS****PHOSPHONATES - PHOSPHINATES -  
PHOSPHONIC ACIDS**

ampropylfos  
 chlorphonium chloride  
 ethephon  
 fosamine-ammonium  
 fosetyl-aluminium  
 glufosinate  
 glyphosate  
 trichlorfon

**PHOSPHONO THIOATES**

cyanofenphos  
 EPN  
 fosthiazate  
 trichloronat

**PHOSPHONO DITHIOATES**

fonofos

**PHOSPHATE ESTERS**

chlorfenvinphos  
 crotoxyphos  
 dichlorvos-DDVP  
 dicrotophos  
 dimethylvinphos  
 heptenophos  
 mevinphos  
 monocrotophos  
 naled  
 phosdiphen  
 phosphamidon  
 propaphos  
 tetrachlorvinphos

**PHOSPHOROAMIDATES**

fenamiphos  
 phosfolan (dithiolane)

**PHOSPHOROTHIOATES**

azamethiphos (oxazole)  
 bromophos  
 chloretoxyfos  
 chlorphoxim  
 chlorpyrifos  
 coumaphos  
 cyanophos  
 demeton-S-methyl  
 demeton-S-methyl sulphon  
 diazinon (pyrimidine)  
 dichlofenthion

dioxabenzofos  
 etrimfos  
 famphur  
 fenitrothion  
 fensulfothion  
 fenthion  
 iodofenphos  
 isazofos  
 isoxathion  
 methacrifos  
 omethoate  
 oxydemeton-methyl  
 parathion  
 phoxim (oxime)  
 pirimiphos-ethyl (pyrimidine)  
 pirimiphos-methyl (pyrimidine)  
 profenofos  
 pyraclofos (pyrazole)  
 pyrazophos  
 pyridafenthion  
 quinalphos (quinoxaline)  
 temephos  
 tolclofos  
 triazophos  
 vamidothion

**PHOSPHORODITHIOATES**

anilofos  
 azinphos-ethyl (triazine)  
 azinphos-methyl (triazine)  
 bensulide  
 cadusafos  
 carbophenothion  
 chlormephos  
 dialifos  
 dimethoate  
 dioxathion  
 disulfoton  
 edifenphos  
 ethion  
 ethoprop  
 formothion  
 fosmethilan  
 iprobenfos  
 IPSP  
 malathion  
 mecarbam  
 methidathion (thiadiazolone)  
 phenthoate  
 phorate  
 phosalone (benzoxazole)  
 phosmet  
 piperophos  
 prothiofos  
 prothoate  
 sulprofos

terbufos  
 thiometon

**PHOSPHOTRITHIOATES**

S,S,S tributyl phosphoro trithioate

**PHOSPHOROAMIDOTHIOATES**

acephate  
 butamifos  
 ditalimfos  
 isofenphos  
 mephosfolan  
 methamidophos  
 propetamphos

**PHOSPHOTRITHIOITES**

merphos

**PYROPHOSPHATES**

TEPP

**THIOPYROPHOSPHATES**

sulfotep  
 O,O,O,O tetrapropyl dithiopyrophosphate

**3. ORGANO ARSENICS, MERCURICS, TINS****ORGANO ARSENICS**

cacodylic acid  
 DSMA  
 MSMA

**ORGANO MERCURICS**

methoxy ethyl mercury acetate  
 phenyl mercury acetate

**ORGANOTINS**

azocyclotin  
 cyhexatin  
 fenbutatin oxide  
 fentin acetate  
 fentin hydroxide

**4. HETEROCYCLIC NITROGEN****BENZIMIDAZOLES**

benomyl  
 carbendazim  
 fuberidazole  
 thiabendazole

**BENZOTHIAZOLES, BENZOTHIAZOLINES, BENZISOTHIAZOLES**

benazolin  
 benzthiazuron  
 mefenacet  
 methabenzthiazuron  
 probenazole  
 tricyclazole (triazole)

**BENZOXAZINES**

benoxacor



flumioxazin

**BENZOXAZOLES, BENZOXAZOLINES,  
BENZOXAZOLINONES, BENZOXAZOLONES**

fenoxaprop (phenoxy carboxylic acid)

phosalone

**IMIDAZOLES**

imazalil

pefurazoate

prochloraz

triazoxide (triazine)

triflumizole

**IMIDAZOLINES, IMIDAZOLIDINES,  
IMIDAZOLIDINONES,IMIDAZOLINONES,**

glyodin

imazamethabenz

imazapyr

imazaquin

imazethapyr

imidacloprid

iprodione

isocarbamid (amide)

**INDAZOLES**

ethylchlozate

**INDOLES, INDOLEDIONES**

captafol

captan

flumiclorac

flumioxazin (benzoxazine)

folpet

indol 3 yl acetic acid

4 indol 3 yl butyric acid

**ISOXAZOLES, ISOXAZOLONES,  
OXAZOLONES**

azamethiphos

drazoxolon

hymexazol

isouron

isoxaben

isoxathion (phosphoro thioate)

**MORPHOLINES**

dimethomorph

dodemorph

fenpropimorph

tridemorph

**OXADIAZOLONES, OXADIAZOLIDINONES**

dimefuron

methazole

oxadiazon

**OXAZOLIDINES, OXAZOLIDINONES,  
OXAZOLIDINEDIONES, OXAZOLES**

chlozolate

clomazone

furilazole

isoxapyrifop

oxadixyl

vinclozolin

**PIPERAZINES**

triforine (amide)

**PIPERIDINES**

dimepiperate (thiocarbamate)

fenpropidin

flupropadine

mepiquat

piperophos (phosphoro dithioate)

piproctanyl

**PYRAZINES**

diquat

**PYRAZOLES**

benzofenap

difenzoquat

fenpyroximate

fipronil

halosulfuron (sulfonyl urea)

metazachlor (amide)

nipyraclufen

pyraclofos

pyrazolate

pyrazophos (phosphoro thioate)

pyrazoxyfen

tebufenpyrad

**PYRIDAZINES, PYRIDAZINONES,  
PYRIDAZINEDIONES**

chloridazon

diclomezine

maleic hydrazide

norflurazon

pyridaben

pyridafenthion (phosphoro thioate)

pyridate

**PYRIDINES**

azamethiphos (oxazole)

buthiobate

clodinafop (phenoxy carboxylic acid)

chlorpyrifos (phosphoro thioate)

clopyralid

diflufenican (amide)

dipyrrithione (disulfide)

dithiopyr

fluaizifop (phenoxy carboxylic acid)

fluaizuron (urea)

fluroxypyr

forchlorfenuron (urea)

haloxyfop (phenoxy carboxylic acid)

imazapyr (imidazolidinone)

imidacloprid (imidazolidine)

inabenfide (amide)

nitrapyrin

norbomide

paraquat  
picloram  
pymetrozine (triazine)  
pyributicarb (thiocarbamate)  
pyrifenoxy (oxime)  
pyriproxifen (phenyl ether)  
thiazopyr (thiazole)  
triclopyr

**PYRIDONES**

fluridone

**PYRIMIDINES**

ancymidol  
bupirimate  
crimidine  
diazinon  
dimethirimol  
ethirimol  
etrimfos (phosphoro thioate)  
fenarimol  
fenclozime  
ferimzone  
flumetsulam  
flurprimidol  
hydramethylnon  
mepanipyrim  
metosulam (sulfonamide)  
nuarimol  
pirimicarb (carbamate)  
pirimiphos-ethyl  
pirimiphos-methyl  
pyrazophos (phosphoro thioate)  
pyrimethanil  
pyrithiobac  
quizalofop (phenoxy carboxylic acid)  
tioclozime  
(see also sulfonyl ureas)

**PYRIMIDINEDIONES**

bromacil  
lenacil  
terbacil

**PYRROLES, PYRROLIDINONES**

fenpiclonil  
fludioxonil  
fluoromide  
flurochloridone  
procymidone  
pyroquilon (quinoline)

**QUINOLINES**

cloquintocet  
ethoxyquin  
8 hydroxy quinoline  
imazaquin (imidazolidinone)  
oxine-copper  
oxolinic acid  
pyroquilon  
quinclorac

quinmerac

**QUINOXALINES, QUINAZOLINES**

chinomethionat (dithiin)  
fenazaquin  
propaquizafop  
quinalphos  
quizalofop (phenoxy carboxylic acid)

**TETRAZINES**

clofentezine

**THIADIAZINES, THIADIAZINONES**

bentazone  
buprofezin  
dazomet

**THIADIAZOLES, THIADIAZOLONES**

ethidimuron (urea)  
etridiazole  
methidathion  
tebuthiuron  
thiazafluron  
thidiazuron (urea)

**THIAZOLES, THIAZOLONES**

flurazole  
metsulfovax  
octhilinone  
thiabendazole (benzimidazole)  
thiazopyr  
thifluzamide

**THIAZOLIDINES**

flubenzimine  
fosthiazate (phosphono thioate)  
hexythiazox

**TRIAZINES FROM CYANURIC CHLORIDE**

ametryn  
anilazine  
atrazine  
aziprotryne  
cyanazine  
cyprazine  
cyromazine  
desmetryn  
dimethametryn  
dipropetryn  
eglinazine  
methoprotetryne  
procymazine  
proglazine  
prometon  
prometryn  
propazine  
sebumeton  
simazine  
simetryn  
terbumeton  
terbuthylazine  
terbutryn

trietazine  
**TRIAZINES NOT DERIVED FROM  
 CYANURIC CHLORIDE, BENZOTRIAZINES**

azinphos-ethyl  
 azinphos-methyl  
 hexazinone  
 metamitron  
 metribuzin  
 pymetrozine  
 triazoxide  
 (see also sulfonyl ureas)

**TRIAZOLES**

amitrole  
 azaconazole  
 azocyclotin (organo tin)  
 bitertanol  
 bromuconazole  
 cyproconazole  
 diclobutrazol  
 difenoconazole  
 diniconazole  
 etaconazole  
 fenbuconazole  
 fenchlorazole  
 flumetsulam (pyrimidine)  
 fluotrimazole  
 flupoxam  
 flusilazole  
 flutriafol  
 furconazole  
 hexaconazole  
 imibenconazole  
 ipconazole  
 isazofos (phosphoro thioate)  
 metconazole  
 metosulam (sulfonamide)  
 myclobutanil  
 paclobutrazol  
 penconazole  
 propiconazole  
 sulfentrazone  
 tebuconazole  
 tetraconazole  
 triadimefon  
 triadimenol  
 triapenthenol  
 triazamate  
 triazophos (phosphoro thioate)  
 tricyclazole  
 triticonazole  
 uniconazole

**5. HETEROCYCLIC SULFUR COM-  
 POUNDS: DITHIINS, OXATHINS, THIO-  
 PHENES, THIOPYRANES, TRITHIANES**

carboxin  
 chinomethionat/quinomethionate  
 cycloxdim (oxime)  
 dimethenamid  
 dimethipin  
 dithianon  
 isoprothiolane  
 oxycarboxin  
 phosfolan  
 thenylchlor (amide)  
 thicyofen  
 thiocyclam

**6. CARBOXYLIC ACIDS**

**AROMATIC CARBOXYLIC ACIDS**

benazolin (benzothiazoline)  
 chlorflurenol - methyl ester  
 endothal  
 fenitropan  
 flurenol  
 naphthylacetic acid  
 nitrothal isopropyl

**PHENOXY CARBOXYLIC ACIDS  
 AND AMIDES**

clodinafop  
 clomeprop  
 cloprop  
 cloxyfonac  
 3 CPA  
 4 CPA  
 2.4 D  
 2.4 DB  
 dichlorprop  
 diclofop-methyl  
 fenoprop  
 fenoxaprop-ethyl  
 fluazifop-butyl  
 haloxyfop-methyl  
 MCPA  
 MCPB  
 mecoprop  
 2 naphthyloxy acetic acid  
 quizalofop ethyl  
 2.4.5 T

**HALOGENATED ALIPHATIC ACIDS**

dalapon

flupropanate

TCA

#### HALOGENATED AROMATIC CARBOXYLIC ACIDS

bromopropylate

chloramben

chlorfenac

chlorobenzilate

chloropropylate

chlorthal dimethyl

dicamba

plifenate

2.3.6 TBA

#### HEXANEDIONE CARBOXYLIC ACIDS

prohexadione

trinexapac

### 7. HALOGENATED HYDROCARBONS

#### HALOGENATED HYDROCARBONS

aldrin

camphechlor (toxaphene)

chlordane

chloropicrin

DDT

(DBCP) dibromochloro propane

1.3 dichloropropene

dicofol

dieldrin (see endrin)

dienochlor

endosulfan

endrin - dieldrin

heptachlor

lindane

methyl bromide

mirex

#### HALOGENATED AROMATICS

bromoxynil

chloroneb

chlorotalonil

dichlobenil

dichlorophen

dicloran - DCNA dichloronitroaniline

hexachlorobenzene

ioxynil

methoxychlor

pentachlorophenol

quintozone

tecnazene

tetrachlorophthalide

tetradifon

tetrasul

tridiphane

### 8. DIVERSE CHEMICAL FUNCTIONS

#### AMIDINES

amitraz

chlordimeform

formetanate (carbamate)

#### BENZOFURANS

benfuracarb (carbamate)

benfuresate

carbofuran (carbamate)

carbosulfan (carbamate)

ethofumesate

furathiocarb (carbamate)

#### COUMARIN AND SIMILAR DERIVED PRODUCTS

brodifacoum

bromadiolone

coumachlor

coumaphos (phosphoro thioate)

coumatetralyl

difenacoum

difethialone

flocoumafen

warfarin

#### DISULFIDES

dipyrrithione

EXD

thiram (dithiocarbamate)

#### DIENEDODECANOATES

hydroprene

methoprene

#### DINITROANILINE HERBICIDES

benfluralin

bromethalin

butralin

dinitramine

ethalfluralin

fluazinam

fluchloralin

flumetralin

isopropalin

nitralin

oryzalin

pendimethalin

prodiamine

profluralin

trifluralin

#### DINITRO PHENOLS AND DERIVATIVES

binapacryl

dinobuton

dinocap

dinoseb

dinoseb acetate

dinoterb

DNOC

**FURANS – FURANONES****– HYDROFURANS**

bromuconazole (triazole)  
 cyprofuram (amide)  
 fenfuram (amide)  
 flurtamone  
 furalaxyl (amide)  
 furconazole (triazole)  
 furilazone (oxazolidine)  
 furnecyclox  
 furyloxyfen (phenyl ether)  
 methfuroxam (amide)  
 ofurace (amide)  
 pefurazoate (imidazole)

**GUANIDINES**

dodine  
 guazatine  
 iminoctadine

**HYDRAZIDES**

daminozide  
 tebufenozide

**INDANEDIONES**

chlorophacinone  
 diphacinone  
 pindone

**PHENYL ETHERS**

acifluorfen  
 aclonifen  
 bifenox  
 chlomethoxyfen  
 chlornitrofen  
 chloroxuron (urea)  
 clodinafop (phenoxy carboxylic acid)  
 diclofop (phenoxy carboxylic acid)  
 difenoxuron (urea)  
 diofenolan  
 etofenprox  
 fenoxycarb (carbamate)  
 flufenoxuron (urea)  
 fluoroglycofen  
 fluoronitrofen  
 fomesafen  
 furyloxyfen  
 halfenprox  
 lactofen  
 nitrofen  
 oxyfluorfen  
 pyriproxifen  
 silafluofen (silane)  
 sulcofuron (urea)

**PYRETHROIDS**

acrinathrin  
 allethrin  
 bifenthrin

bioresmethrin  
 cycloprothrin  
 cyfluthrin  
 cyhalothrin  
 cypermethrin  
 cyphenothrin  
 deltamethrin  
 empenthrin  
 esfenvalerate  
 fenpropathrin  
 fenvalerate  
 flucythrinate  
 fluvalinate  
 permethrin  
 phenothrin  
 prallethrin  
 resmethrin  
 tefluthrin  
 tetramethrin  
 tralomethrin  
 transfluthrin

**QUATERNARY AMMONIUM**

chlormequat  
 difenzoquat (pyrazole)  
 diquat (pyrazine)  
 mepiquat (piperidine)  
 paraquat (pyridine)  
 piproctanil (piperidine)

**QUINONES**

dichlone  
 dithianon (dithiin)  
 quinoclamine

**SILANES**

etacelasil  
 silafluofen

**SUGAR DERIVATIVES**

chloralose  
 dikegulac – sodium

**SULFONAMIDES, SULFAMATES**Sulfonamides

asulam (carbamate)  
 bensulide (phosphoro dithioate)  
 dichlofluanid  
 famphur (phosphoro thioate)  
 flumetsulam (pyrimidine)  
 flusulfamide  
 metosulam

Sulfamates

bupirimate (pyrimidine)  
 fomesafen (phenyl ether)  
 mefluidide (amide)  
 oryzalin (dinitroaniline)  
 perfluidone  
 sulfentrazone (triazole)  
 sulfluramid

tolyfluamid

**SULFONATES, SULFONES,  
SULFITES**

Sulfonates

benfuresate (benzofuran)

bensultap

chlorfenson

ethofumesate (benzofuran)

fenaminosulf

methasulfocarb (thiocarbamate)

pyrazolate (pyrazole)

sulcofuron (urea) – sulfonic acid

Sulfones

aldoxicarb (oxime amide)

butoxicarboxim (oxime amide)

demeton-S-methyl (phosphoro thioate)

dimethipin (dithiin)

ethidimuron (urea)

nitralin (dinitroaniline)

oxycarboxin (oxathiin)

perfluidone (sulfonamide)

sulfuryl fluoride

tetradifon (halogenated aromatic)

Sulfites

endosulfan (chlorinated hydrocarbon)

propargite

**OTHER TYPES**

bisthiosemi

bronopol

chlorthiamid

cinmethylin

fenazox

MCPA-thioethyl

methoxyphenone

muscalure

2 phenyl phenol

piperonyl butoxide

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