e. *Organophosphorus compounds:*

The organic chemistry of phosphorus goes back to 1820 when Lassaigne first studied the reaction of alcohol with phosphoric acid. In 1854 Clermont prepared tetraethyl pyrophosphate (TEPP), but its insecticidal properties were not discovered until 1939. Saunders at Cambridge and Schrader at Germany discovered several pesticides during second world war but the world was not aware of these discoveries until their publication in 1947; the reason being that organophosphorus compounds of very high mammalian toxicity were developed for military use. In the post war period the compounds having high insecticidal and low mammalian toxicity were developed.

The organophosphorus insecticides constitute the most important class of present day pesticides. They are widely used against plant pests and ecto- and endo-parasites of domestic animals. The advantages of using organophosphorus insecticides are:

High insecticidal and acaricidal activity.
Wide spectrum action.
Low persistence and break-down into harmless products.
Systemic action of a number of compounds.
Rapid metabolism in vertebrates; do not accumulate in their bodies.
Low dose per unit area.

Organophosphorus insecticides are considered as derivatives of the corresponding acids and are classified as follows:

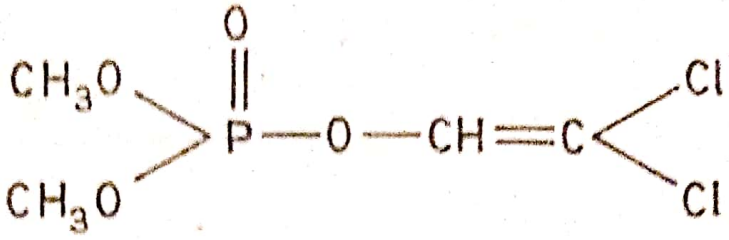
e1 Derivatives of phosphorus acid
e2 Derivatives of thiophosphorus acid
e3 Derivatives of phosphoric acid
e4 Derivatives of thiophosphoric acid
e5 Derivatives of dithiophosphoric acid
e6 Derivatives of pyrophosphoric acid
e7 Derivatives of phosphonic acid.

Derivatives of (e1) and (e2) group have weak insecticidal and acaricidal activity but high herbicidal activity.

e3. Derivatives of phosphoric acid:

The insecticidal and acaricidal activity of the compound increases with a transformation from phosphite to phosphate i.e. from derivatives of phosphorus to phosphoric acid.

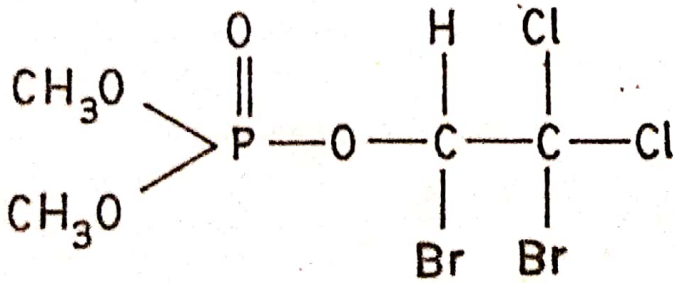
DDVP: dimethyl dichlorovinyl phosphate (dichlorvos); $C_4H_7O_4Cl_2P$: The compound was introduced by Ciba in 1951. It is a colourless pleasant smelling liquid with boiling point 74°C at 1 mm of Hg. It is highly soluble in most of the organic solvents. In water its solubility is about 1%. It is hydrolysed slowly in neutral and acid medium but in alkaline medium it gets hydrolysed rapidly.



Dichlorvos

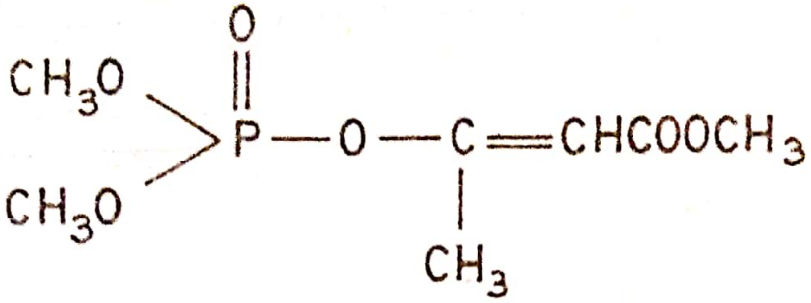
In water it is hydrolysed in 20 to 25 minutes at 70°C. The hydrolysed products are dimethyl phosphoric acid and dichloroacetaldehyde. The former is harmless and the latter rapidly decomposes and evaporates hence no residue remains on the treated surface. Therefore, it can be used on all crops until shortly before harvest. It is highly toxic to bees. It is marketed as 100 EC under the trade name Nuvan.

Nalad: 1,2-dibromo-2,2-dichloroethyl dimethyl phosphate; $C_4H_7Br_2Cl_2P$: The pure material is white crystalline with melting point 25°C at 0.5 mm of Hg. It is insoluble in water but highly soluble in aromatic solvents. It is an active insecticide having some fungicidal effect. It was introduced by Chevorn chemical company under the trade name Dibrom.



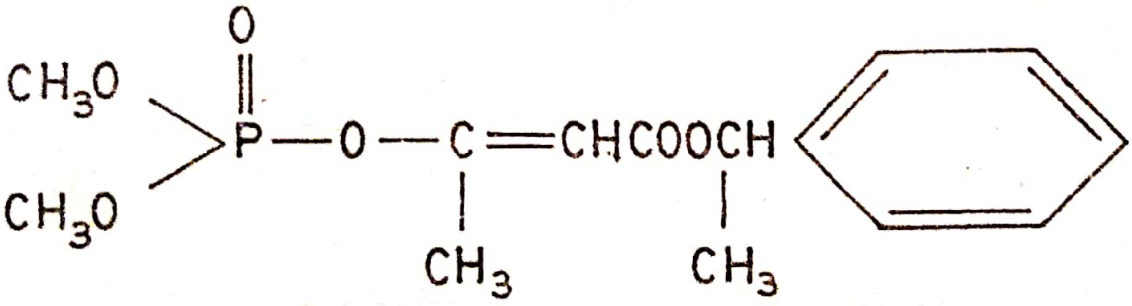
Nalad

Mevinphos: 2-methoxycarbonyl-1-methylvinyl dimethyl phosphate; $C_7H_{13}O_6P$: Its insecticidal properties were first described by Corey and his associates in 1953. It is colourless liquid highly soluble in water, acetone and benzene. It is a systemic insecticide with powerful contact and fumigant action. It occurs in two forms cis- and trans-isomer. The insecticidal activity is due to cis-isomer which constitutes 60% of the product. It is broken down in plants rapidly (90% in 0.8 to 4 days). It was first introduced by Shell under the trade name Phosdrin.



Mevinphos

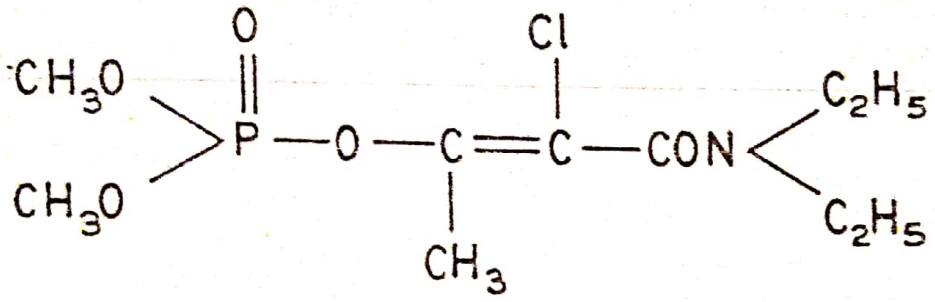
Crotoxyphos: dimethyl cis-1 methyl 2-(1-phenylethoxy carbonyl vinyl phosphate; $C_{14}H_{19}O_6P$: Wiedenbach and Younger described the insecticidal properties in the year 1962. It is a colourless liquid with boiling point 135°C at 0.03 mm of Hg. It is readily miscible with xylene but the solubility in water is about 0.1%. Half life in water is 35 hours. It is used for the control of external parasite on livestock. It was introduced by Shell under the trade name Ciodrin.



Crotoxyphos

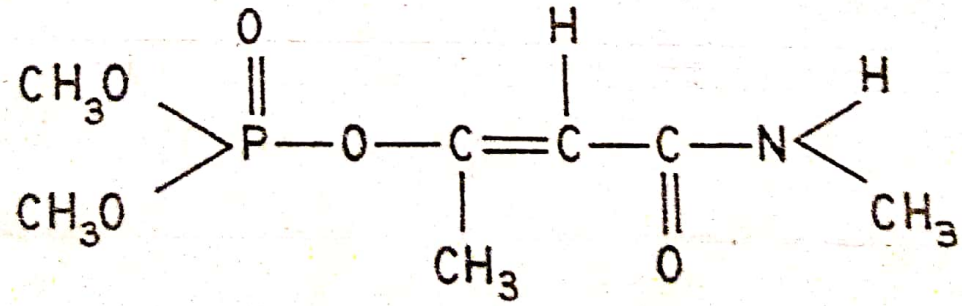
Phosphamidon: 2-chloro-2 diethyl carbamoyl-1 methylvinyl dimethyl phosphate; $C_{10}H_{19}O_5ClP$: It was first synthesized by Beriger in 1955 but its insecticidal properties were discovered by Bachmann and Meierhaus in 1956. Pure form is colourless liquid highly soluble in water, alcohol, and acetone with boiling point 70°C at 0.01 mm of Hg. The technical grade is dark brown and commercial product is bright violet due to addition of a dye. It contains two isomers alpha and beta in the ratio of 3:7. The insecticidal properties are due to beta isomer. It is a systemic and contact insecticide with low contact action. It is less toxic to fishes but highly toxic to bees. It is hydrolysed to desethylphos-

phamidon which is as toxic as phosphamidon. In plants desethylphosphamidon is rapidly broken down to non-insecticidal compounds like monochloroacetone, ethylamine and CO_2. It is marketed under the trade name Dimecron as soluble concentrate.



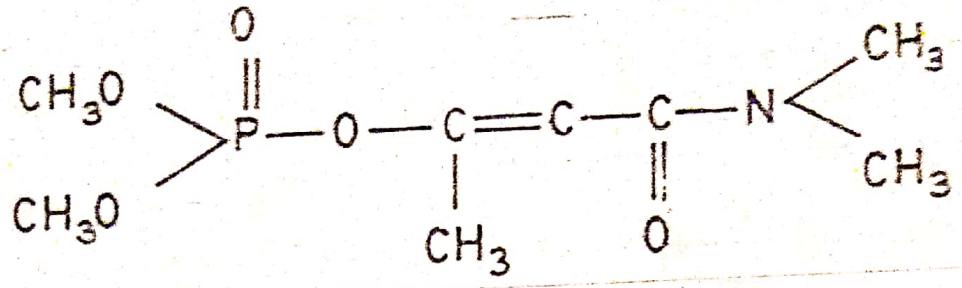
Phosphamidon

Monocrotophos: dimethyl-cis-1-methyl-2 methylcarbamoylvinyl phosphate; $C_7H_{14}O_5NP$: It is colourless, crystalline solid with mild smell, miscible in water, acetone and alcohol. It is a systemic insecticide with stomach and contact action. It is highly toxic to bees but at normal rate of application less toxic to fishes. It is hydrolysed in plants and animals to non-insecticidal product but oxidative product hydroxymethyl amide is as toxic as partent compound. It is marked under the name Nuvacron, Azodrin, Monocil.



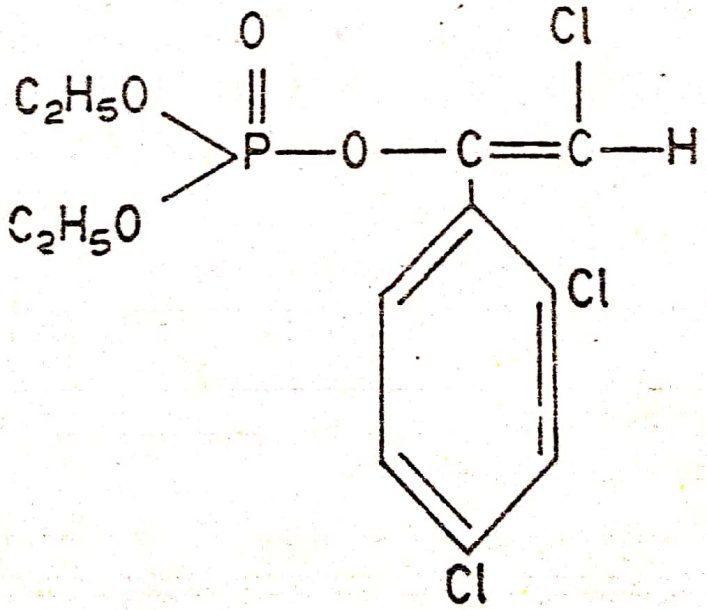
Monocrotophos

Dicrotophos: dimethyl-cis-2 dimethylcarbamoyl-1 methylvinyl phosphate; $C_8H_{16}O_5NP$: It is brown to yellow liquid miscible with water, acetone and alcohol. It is an effective systemic insecticide with stomach and contact action. It is toxic to bees but relatively safer to natural enemies. It is hydrolysed rapidly in alkaline medium. It is marketed under the trade name, Bidrin, Carbicorn as soluble concentrate.



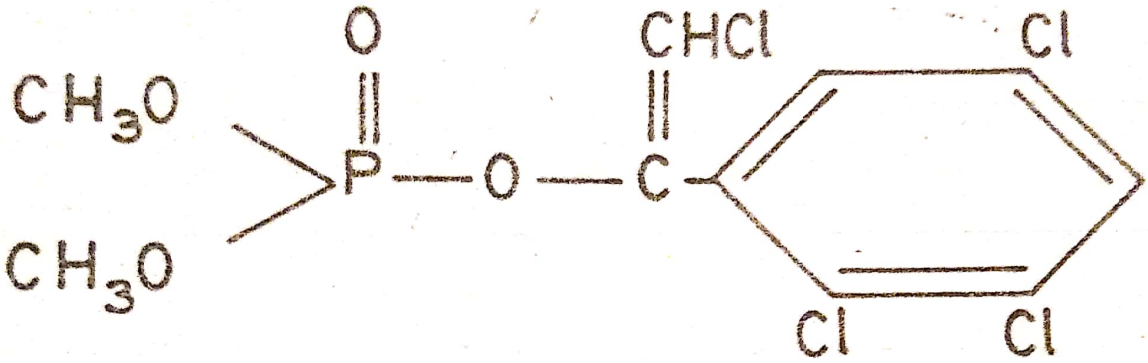
Dicrotophos

Chlorfenvinphos: 2-chloro-1-(2,4 dichlorophenyl) vinyl diethyl phosphate; $C_{12}H_{14}O_4Cl_3P$: The insecticidal properties were described by Chamberlain and his associates in 1962. It is an amber colour oily liquid slightly soluble in water (145 mg/l at 20°C) but readily soluble in organic solvents. It is a contact insecticide and does not leave any harmful residues on treated surface at normal dosages. It is marketed under the trade name, Birlane, Sapecorn.



Chlorfenvinphos

Tetrachlorvinphos: 2-chloro-1(2,4,5 trichlorophenyl) vinyl dimethyl phosphate; $C_{10}H_9O_4Cl_4P$: It is a white crystalline solid with melting point 97-98°C having low solubility in common organic solvents and practically insoluble in water. It is a contact insecticide. On foliage and in soil it is hydrolysed at P-O-C bond to give initially trichlorophenacyl chloride and desmethyl gardona. The former then breaks down to give several 'eight carbon' non-insecticidal compounds. It is marketed under the name Gardona.



Tetrachlorvinphos