MASS SPECTROMETRY OF ORGANOPHOSPHORUS COMPOUND

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by

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A C K N O W L E D G E M E N T

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Tariq Mah.

TARIQ MAHMOOD

A B S T R A C T

Chlormephos (S-chloromethyl-O,O-diethyl phosphorothiolothionate) and Oxychlormephos (O-chloromethyl-O,O-diethyl phosphorothiolothionate) were prepared by the interaction of their appropriate salts with chlorobromomethane.

$$(C_2H_5O)_2\overset{S}{\overset{\|}{P}}\text{-SK} + CH_2ClBr \longrightarrow (C_2H_5O)_2\overset{S}{\overset{\|}{P}}\text{-SCH}_2Cl + KBr$$

$$(C_2H_5O)_2\overset{S}{\overset{\|}{P}}\text{-OK} + CH_2ClBr \longrightarrow (C_2H_5O)_2\overset{S}{\overset{\|}{P}}\text{-OCH}_2Cl + KBr$$

These compounds and their intermediates were characterized and identified by using elemental analysis, GLC, IR and mass spectrometry.

The fate of chlormephos and oxygen analogues in soil and in various crops was the main purpose of the present work. As a preliminary to this study however, the stability of these compounds in aqueous medium at various pH were determined. It was found that chlormephos was relatively stable at acid pH but was rapidly degraded in alkaline condition. The oxygen analogue was prepared as this was considered to be a potential metabolites.

The fragmentation patterns were established with the aid of accurate mass measurements and metastable transitions. The mass spectra of these compounds show that most ions arise through hydrogen migration from alkyl ester groups to the phosphorous-oxygen backbone. The compounds have been reported to be potentially used as pesticides and have high physiological and pesticidal activities. Mass spectrometry is employed to provide information of various fragmentations and breakdown products in order to compare them with the various metabolites expected to be formed under the influence of biological, chemical and environmental conditions and to confirm or characterize the identities of the residues of unknown structures.

C O N T E N T S

CHAPTER 1

INTRODUCTION

More intensive agriculture brings with it spreading of pests. Therefore, intensive pest control measures are required.

Pesticides play an essential role in increasing food yields and thereby answering the ever-increasing demand for world food. Their function is to destroy or control organisms that destroy or endanger man's food, health or environment. A particular pesticide is chosen because:

(a) It is effective in controlling the offending organism.

(b) It causes no damage to the crop to which it is applied.

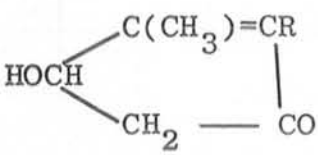
(c) The residue left at harvest is so small as to be of no harm to the consumer.

HISTORICAL

1. There had always been an awareness of the need for control of pests and diseases that have wrought havoc upon man. There are many biblical references to the various plagues, notably the locust insect and corn blast. However, in these early days there were few effective remedies and consequently the early land-worker suffered many losses of food crops with attendant disease and famine. The main problem in the early days of crop protection was the failure to recognize a particular organism which was responsible.

2. The Irish famine in 1845 and 1846 which resulted in the deaths or emigration of millions of people was caused by the failure of the potato crop in that country. A fungus Phytophthora Infestans was responsible for the crop loss. Around the same time the powdery mildew of the vine appeared in Europe. The Colorado Beetle was becoming an important pest. A disaster similar to that of the Irish famine struck parts of the Mississippi valley when masses of grasshoppers destroyed the vegetation and forced the people from their homes. These events marked the introduction of certain Inorganic Chemicals as fungicides, notably sulphur, copper sulphate-Lime mixture, Paris green, i.e. copper aceto-arsenite $(CH_3\ COO)_2\ Cu.3Cu(AsC_2)_2$ and Lead arsenate [1-2]. The dried heads of the flowers Pyrethrum Cinerafolium were recognised as possessing insecticide properties. Their use has since been replaced by that of

extracts which contain the active components having the trivial name pyrethrins [1]. They are esters of two ketonic alcohals and two acids.



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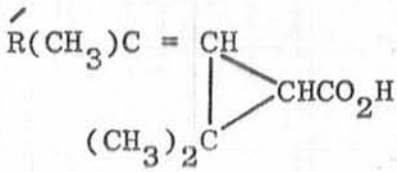


R =$-CH_2$ - CH = CHCH = CH_2

or $-CH_2CH$ = $CHCH_3$

$\acute{R}$ = $-CH_3$

or $-CO_2CH_3$

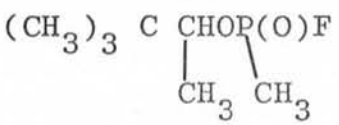
DNOC [3], the common name for 2 - methyl - 4, 6-dinitrophenol was first introduced in 1892 as an insecticide and later in 1932 as a herbicide. It is interesting to note that DDT 1,1,1-trichloro-2,2-di-(4-chlorophenyl) ethane was first synthesised in 1874 but its insecticidal properties were not discovered until 1939 [4].

3. In the early part of the present century the inorganic chemicals, plant extracts such as pyrethrins, nicotine and derris long with certain coal tar products were important in the control of insects. The effectiveness of the compounds could be enhanced by improved formulations and mode of application. The addition of certain compounds which delayed the metabolic detoxication process increased the effectiveness many fold. For example, the addition of

piperonyl butoxide to preparations of pyrethrins greatly enhanced the activity. Such compounds as piperonyl butoxide became known as synergists.

The 1930s saw the beginning of much more constructive approaches to the research for effective synthetic organic pesticides to the research for effective synthetic organic pesticides. The second World War (1939-1945) led to a reduction of supplies of derris and pyrethrum and the discovery of the insecticidal properties of BHC(1,2,3,4,5,6-hexachlorocyclo hexane)[5] and DDT led to their introduction in 1940-41. The herbicidal activity of 2,4-D(2,4-dichloro phenoxyacetic acid) was first described in 1942 [6]. The relief of human suffering and disease made possible by the eradication of insect-borne fevers greatly encouraged wider and more intense research.

Much research was carried out during the war on organophosphorous compounds known as nerve gases. One of the nerve gases, Soman [7] has the structure



Although these compounds were not used in warfare, their properties suggested their use in agriculture, initially as a substitute for nicotine. The first preparation used in

Germany was Bladan whose active component is TEPP (bis-O, O-diethylphosphoric anhydride) [1]. A compound introduced around the same time and discovered by the same persons (Schrader, G. et. al.). was Schradan [1,7,8-] ,

$$(Me_2N)_2PO.O.PO(NM_2e)_2$$

Schrader also developed the compound parathion [1,7-]

$$(EtO)_2P(S)OC_6H_4NO_2$$

but this not introduced until 1947. Since the development of these compounds the range of organophosphorous compounds has greatly increased. Many of these organophosphorous compounds are highly toxic and can kill by inhibiting the enzyme cholinesterase with consequent accumulation of acetylcholine. Acetylcholine is required for the transmission of impulses from nerve endings to muscles. The accumulation of this compound results in disruption of normal nervous activity [7]. The suitability of these compounds as insecticides must obviously, therefore, be dependent on their stability, solubility, vapour pressure and mode of action. As in all cases a pesticide, effective only against a target pest is highly desirable.

Reference has been made to the chlorinated hydrocarbons, the dinitrophenols and organophosphorous compounds. Other groups include organic thiocyanates, carbamates, amines, mercaptans and organometallics, which have been developed since the war.

II. LEGISLATIVE CONSIDERATIONS

4. Pesticides, like virtually every chemical, may effect a physiological change in organisms in the environment including man himself. By environment it is meant the conditions under which the basic needs of an organism is met, viz., air, nutrition and shelter.

By 1916 the use of arsenic compounds was common in many countries [1,2] for the control of certain pests. However, in France an order was made forbidding the use (or sale) of soluble arsenic salts and severely restricted the sale of insoluble arsenic compounds. Earlier, a similar order was made in 1864 forbidding the use of arsenic for pickling of grain or destruction of insects. In the United States during the 1920s a survey of arsenic residue level on certain crops showed that arsenic did not enter into the treated plants and that the surface residue disappeared within 24 days. It was also shown that t o obtain a toxic dose of arsenic at a meal a person would have to eat 28 Cabbages or several 26 gallon barrels of potatoes [9]. These findings and calculations are the earliest examples of residue analyses and safety interval regulations.

In the United Kingdom there exists the Pesticides Safety Precautions Scheme which is entirely voluntary.

Under this scheme manufacturers or distributors undertake to notify the appropriate government departments of their intention to introduce new pesticides or new uses of pesticides into agricultural, horticultural, home garden, or food storage practice in Great Birtain. The company concerned provides all the information needed in order that the departments may advise on the precautionary measures to be taken when the pesticide-containing products are used and not until the recommendations for safe use are made will the product be introduced.

In many other countries there exists legislative control over the use of pesticides. In the United States there exists the Food, Drug and Cosmetic Act of 1938 which was amended and passed by Congress in 1954. This amendment is known as the Miller Amendment.

The Federal Law applies to the whole of the United States but many individual states have their own legislation. In the US a product is first registered under the Federal Insecticide, Fungicide and Rodenticide Act for use on produce to which the Food, Drug and Cosmatics Act applies. Application for a tolerance may then be made (under the Miller Amendment) when the Secretary of Healths, Education and Welfare has been assured of the usefulness of the product.

Many other countries such Canada, Australia, Newzealand and Holland have similar legislative control.

In the USSR the statutory control of pesticides rests with a state commission made up of representatives of the chemical industry and various health and Agricultural Organizations. The commission can prohibit the use of a chemical if the risks to man are too high. In general, compounds having an LD_{50} value (i.e. the median lethal dose) of less than 50 mg/kg and a high cumulative toxicity are banned.

In contrast to the above Schemes a National Corporation in the Republic of China has the complete control over, and is responsible for, the distribution of pesticide and its uses.

Because of the toxic nature of pesticides in general there is a distinct possibility of their being toxic to man. It is, therefore, essential that a complete dossier on the toxicology of the compound in question be prepared. In order to do this LD_{50} values for various species are obtained; other studies such as the dermal and inhalation toxicity are carried out. In order to check on the possible cumulative action various interval feeding studies, e.g. 3 months - 2 years are made. From these better studies data are obtained on such things as carcinogenicity, neurotoxicity and tetratogenicity. The data from the combined studies are used for extrapolation

to individual men or human communities.

There have been few reported instances of ill-effects suffered as a result of consuming food which had been treated with pesticides in the recommended manner. However, the possibility of undetected disorders or morbidity arising from pesticide use can obviously not be ruled out. It is unlikely that an increased incidence of cancer could be attributed to the practice of using pesticides in particular. There is of course the situation where a compound undergoes metabolism in the crop to a compound which may be many times more toxic than its parent. There is, therefore, the very obvious need to develop techniques for determining these possible break-down products as well as their precursors. Should these metabolites form a considerable residue then further toxicological studies on these would be desirable.

III. 5. TYPES OF COMPOUNDS HAVING PESTICIDAL ACTIVITY

5.1. Organochlorine and Other Halogeno Compounds:

The halogen derivatives of aliphatic and alicyclic hydrocarbons are considerably more toxic to insects and micro-organisms than their parent, the toxicity increasing in the order Chloro-, < bromo-, < Iodo alkalanes. Dichloroethane and mixed dichloropropanes are used as fumigants to control pests of stored products and also nematodes in soil. Most halogeno compounds are made by direct halogenati of the suitable starting material. 1,3-Dichloropropene is an important pesticide used for the control of nematodes. Both the cis and trans forms show activity in nematode control. A mixture of cis- and trans- 1,3-dichloropropenes is obtained as a by-product in the production of alkyl chloride by the chlorination of propene.

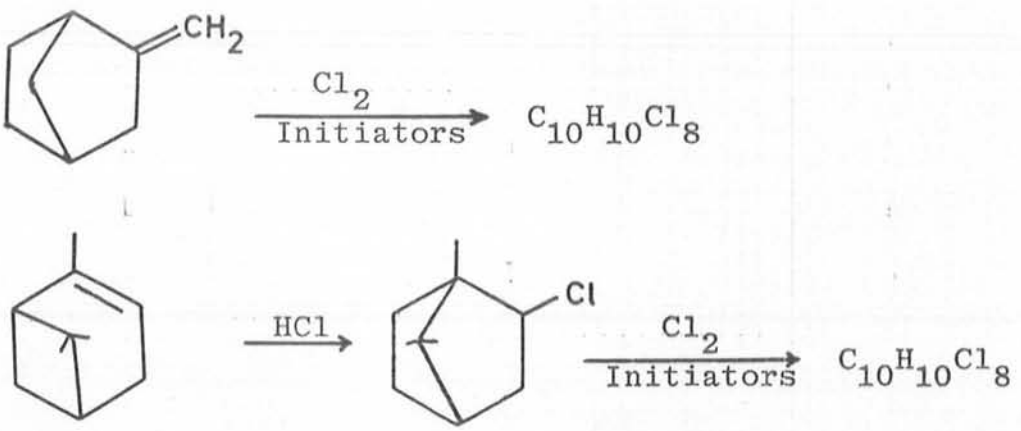
$$CH_3CH = CH_2 + Cl_2 \longrightarrow ClCH_2CH = CH_2 + HCl$$

$$ClCH_2CH = CH_2 + Cl_2 \longrightarrow ClCH_2CH = CHCl + HCl$$

Hexachlorocyclohexane (BHC)[5]is an important insecticide. Eight stereoisomers are known but only one, the γ-isomer, is an active insecticide. The α-, β -, γ -, δ -, and ε- hexachlorocyclohexanes exist in the chair form and the structure of the -isomer is a a a e e e where a and e refer to axial and equatorial bonds respectively. Apart

from the γ-isomer, which has an appreciable fungicidal effect, the remaining isomers are non-toxic to fungi or insects. The main industrial preparation of BHC is by the direct Chlorination of benzene in the presence of initiators such as organic peroxides or γ-radiation. The product contains about 20% of the γ-isomer which is later isolated by a fractional crystallisation process.

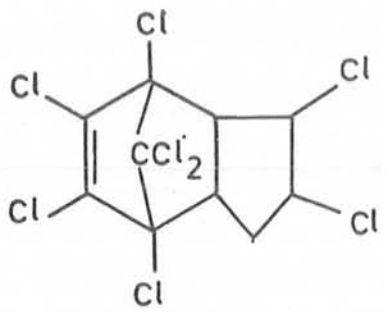
The chlorination products of terpenes such as Camphene, pinene, etc. have been used successfully as pesticides. Thus, the insecticide toxaphene [10] is a polychlorterpene obtained by the chlorination of Camphene.



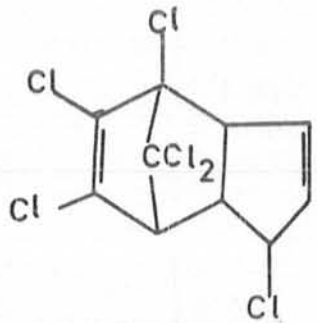
α-pinene bornylchloride.

The polychlorocyclodienes [10] are used in agriculture and in industry. They are derivatives of bi-, tri- and tetra-cyclic hydrocarbons and are obtained by diene synthesis using hexachlorocyclopentadiene as the diene:

Chlordane (2,3,4,5,6,7,8,8-octachloro-4, 7-endo methylene-2, 3,3a,4,7,7a - hexahydroindene) and heptachor are examples.



CHLORDANE



HEPTACHLOR

DDT[4] is probably the best example of a halogen derivative of an aromatic hydrocarbon which is used as an insecticide. The technical grade product is a complex mixture in which the p,p' isomer amounts to around 75%.

It is prepared by condensing chlorobenzene with chloral in the presence of condensing agents such H_2SO_4 or $AlCl_3$.

$$2ClC_6H_5 + CCl_3CHO \xrightarrow[\text{agents}]{\text{Condensing}} (ClC_6H_4)_2CHCCl_3 + H_2O$$

Methoxychlor which is considerably less toxic than DDT is also an effective insecticide. It is prepared by condensation of chloral with anisole in the presence of a condensing agent (e.g. H_2SO_4).

$$2CH_3OC_6H_5 + CCl_3CHO \xrightarrow[\text{agents}]{\text{Condensing}} p,p'\text{-}(CH_3OC_6H_4)_2CHCCl_3$$

5.2. Aliphatic and aromatic nitro Compounds.

The pesticidal activity of the nitro compounds of aliphatic and aromatic series is much higher than that of the hydrocarbons. The introduction of a halogen atom into the molecule further increases the activity.

Chloronitroalkanes can be prepared by direct chlorination of nitroalkanes.

$$RCH_2NO_2 \xrightarrow{Cl_2} RCHClNO_2 + HCl.$$

Chloropicrin CCl_3NO_2 which can be obtained by the oxidative chlorination of picric acid is extremely lachrymatory and is used to control various harmful organisms [2].

Nitrostyrenes are produced by condensing the appropriate aldehyde with nitromethane or its homologues. These, on halogenation, yield highly active bactericides and fungicides.

$$ArCHO + CH_3NO_2 \longrightarrow ArCH = CHNO_2 + H_2O$$

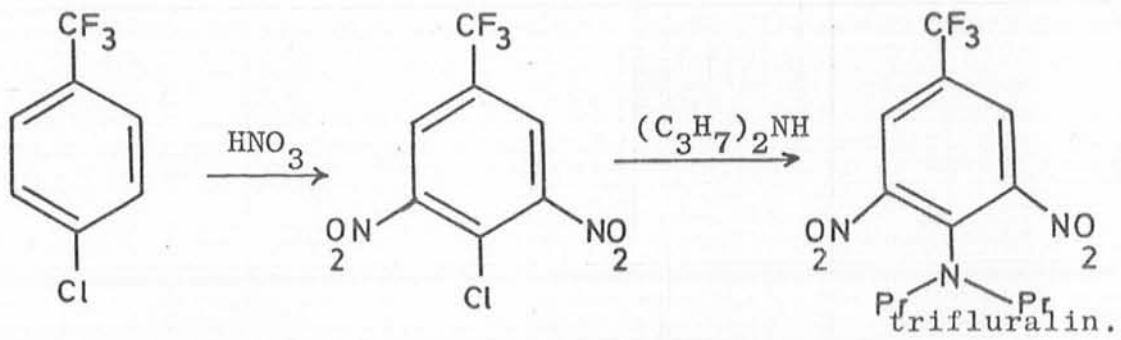
$$ArCH = CHNO_2 \xrightarrow{X_2} ArCHXCHXNO_2 .$$

where X = Cl or Br

Compounds containing nitro groups in the aromatic ring also have pesticidal activity.

5.3. Amines and Salts of quaternary ammonium bases.

Of the aliphatic amines studies di-n-octylamine has been found to be highly active. Aromatic amines tend to be more toxic and the introduction of a halogen atom into the aromatic ring does not affect that toxicity. The diarylamines have generally higher insecticidal activity, and diphenylamine used as a protectant on citrus fruits is a good example. Amines tend to be phytotoxic to most plants and indeed some substituted aromatic amines are potent herbicides, trifluralin being a good example (2,6-dinitro-4-trifluromethyl-N,N-dipropylaniline). This compound is prepared as follows [11]:

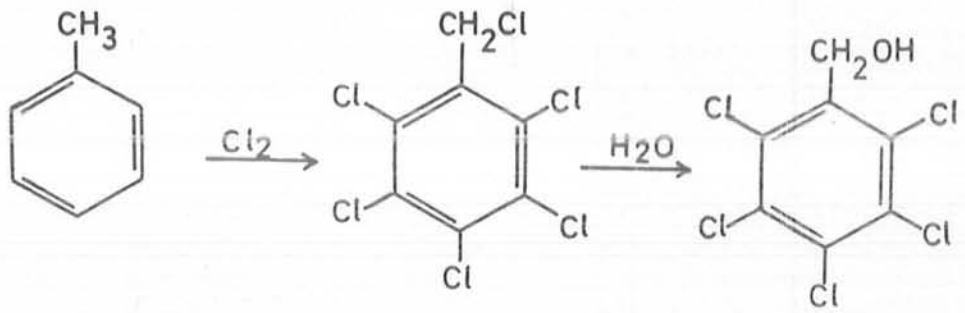


trifluralin.

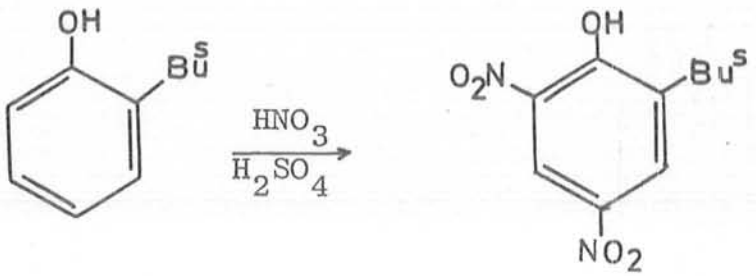
Quaternary ammonium salts possess both germicidal and insecticidal properties. They are, however, phytotoxic in many cases and their use is restricted for disinfection and in animal husbandry.

5.4. Alcohals, phenols and ethers.

Aliphatic alcohals have little pesticidal value although some (undecyl and dodecyl alcohals) do possess fungicidal activity. Some of the higher unsaturated alcohals, e.g. hexadeca-10,12-dienol is a sex attractant which has been isolated from female silkworm moths. Halogenation of alcohals enhances activity Pentachlorobenzyl alcohal, made from the chlorination of toluene followed by hydrolysis, is used to control rice blast.

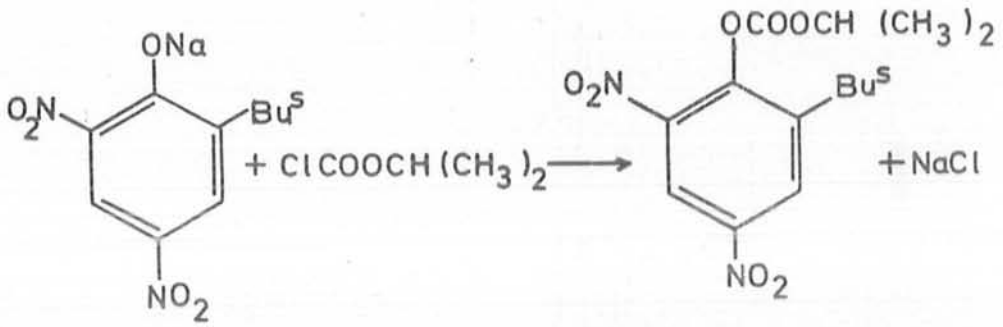


In contrast to the alcohals, phenols exhibit a greater range of physiological activity. They are more powerful insecticides, fungicides, bactericides and herbicides. This pesticidal activity is increased when various substituents are introduced into the aromatic nucleas. The alkyl dinitrophenols are particularly active. An example is 2,4-dinitro-6-s-butylphenol which is very effective as an insecticide. It is prepared by direct nitration of 2-s-butylphenol in the presence of sulphuric acid [11].

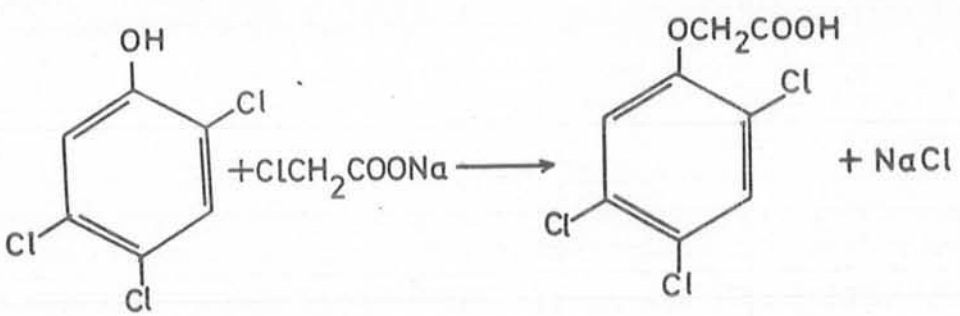


dinoseb.

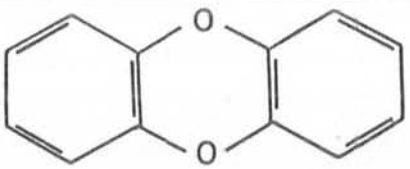
For the control of plant pests certain derivatives of dinoseb are used in preference to the parent. Examples of these are the acetate, and the isopropyl carbonate. The latter derivative (2,4-dinitro-6-s-butylphenyl isopropyl carbonate) is known as dinobuton [12]. It is a non-systemic acaricide and fungicide. Dinobuton is prepared by the condensation of an alkali salt of dinoseb with isopropyl chloroformate.



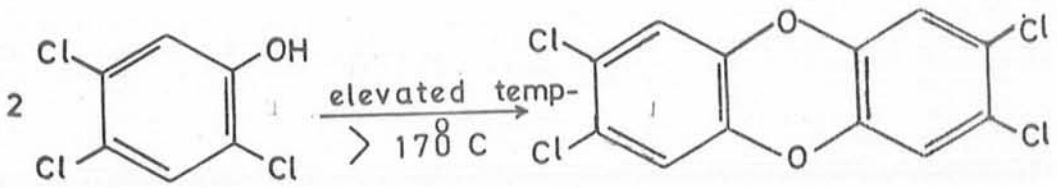
Besides nitrophenols and their derivatives the halophenols and their derivatives are important pesticides. 2,4,5-Trichlorophenol, which is prepared by the alkaline hydrolysis at 160°C of 1,2,4,5-tetrachlorobenzene, is an important fungicide. It is also an intermediate in the preparation of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T)[11] 2,4,5-T is prepared by the interaction of sodium monochloro-acetate and 2,4,5-trichlorophenol.



2,4,5-T is an important herbicide. Both the latter and 2,4,5-trichlorophenol contain very toxic impurities, whose removal is a necessary preliminary to the formulation and sale of the desired active ingredients. These are chlorinated derivatives of dibenzo-P-dioxin.



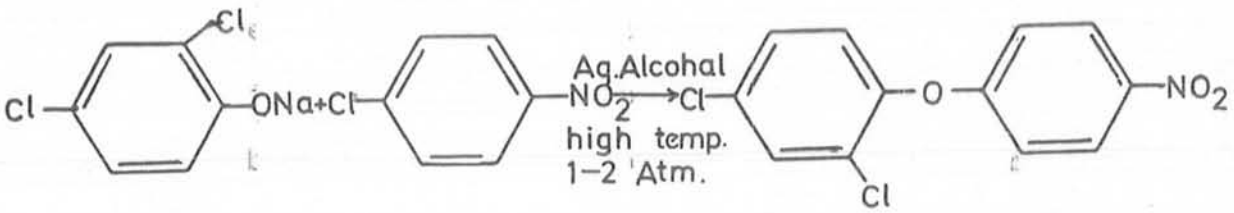
The more important of these is the highly toxic 2,3,7,8-tetrachlorodibenzo-P-dioxin which causes severe acne in man has produced foetal deaths in hamsters at 9.1 Mg/Kg. 13,1 It has also caused severe tetratogenic disorders in the offspring of certain animals which received doses of the compound during pregnancy. The compound arises during the hydrolysis stage of 1,2,4,5-tetrachlorobenzene [15].



The compound is extremely stable to alkali and high temperatures and even to strong oxidizing agents. A limit of less than 0.1 ppm in the product has been imposed on manufacture of 2,4,5-TCP or 2,4,5-T.

2,4-Dichlorophenyl-4-nitrophenyl ether has been used as a herbicide for the control of weeds. It is made

by reacting sodium 2,4-dichlorophenolate with P-nitro-chlorobenzene [11].

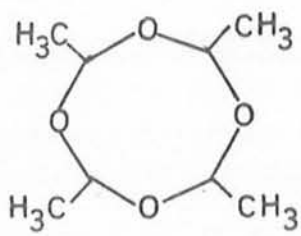


5.5. Aldehydes, acids, ketones.

Formaldehyde is the simplest aldehyde which has also bactericidal and fungicidal properties. Acetaldehyde has no use in agriculture but metaldehyde is a powerful molluscicide especially effective against slugs. It is produced by the polymerisation of acetaldehyde in the presence of a mineral acid.

$$CH_3CHO \xrightarrow{H_3O^+} (CH_3CHO)_n$$

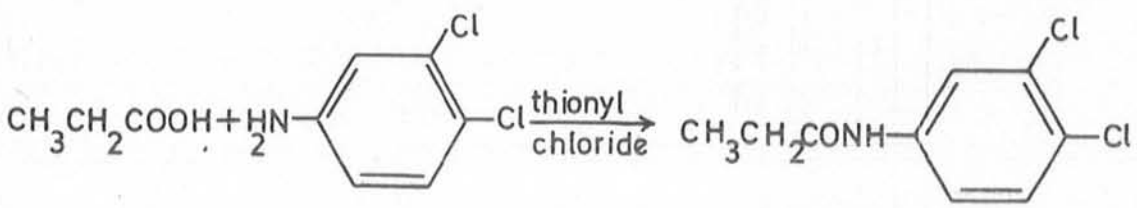
It is thought to be a stereoisomer of the eight-membered ring.



The unsaturated aldehydes have stronger pesticidal effects, acrolcin and crotonic aldehyde being examples of agents used for the control of slime.

Hexachloroacetone has been used for the control of annual and perennial weeds. It is prepared by the direct chlorination of acetone [11]. Substituted aliphatic carboxylic acids e.g. monohaloacetic acid have greater pesticidal activity than the parent acids. In the ω-fluorocarboxylic acid series of formula $F(CH_2)_nCOOH$ it has been shown by Saunders et al. that when n is odd, the compound is highly toxic, whereas if n is even it is nontoxic [16]. The explanation for this is that enzymatic oxidation occurs at the β -carbon atom and produces the toxic fluoroacetic acid in the case where n is odd, where as the non-toxic β propionic acid would be produced if n was even. Further β -oxidation of the latter would lead to CO and HF.

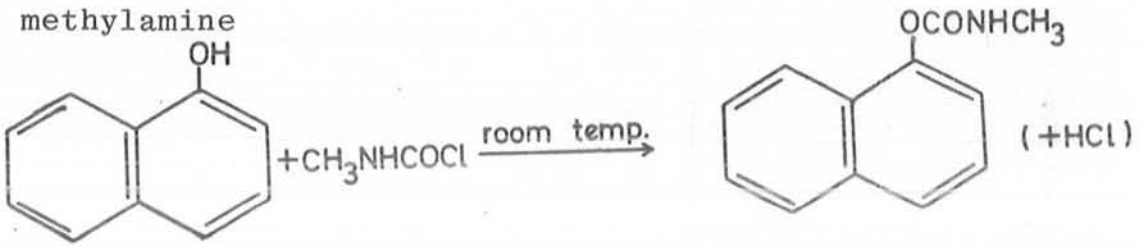
Esterification of carboxylic acids often increases this activity. Unsubstituted amides of alkanecarboxylic acids compare unfavourably with substituted amides. The halogen substituted anilides are especially active, propanil being an example.



3,4-dichloro propionilide

5.6. Derivatives of Carbamic acid.

These derivatives include aryl esters of N-methyl-carbamic acid which are powerful herbicides. N-methyl-carbamates have insecticidal properties and act through their ability to cause cholinesterase depression [17]. 1-Naphthyl-N-methylcarbamate, known as carbaryl is a powerful insecticide. It is made by the reaction of 1-naphthol and methyl isocyanate or of 1-naphthol and Phosgene and methylamine



The intermediate methylcarbamoyl chloride is made by the reaction of phosgene and methylamine at 300°C.

$$CH_3NH_2 + COCl_2 \xrightarrow{300^{\circ}C} CH_3NHCOCl.$$

5.7. Derivatives of thio- and dithio- carbamic acids.

Compounds of this class are mainly herbicides and fungicides, the most effective being the S-alkyl N,N-dialkyl-thiocarbamates. Derivatives of dithiocarbamic acids act as nematicides, the simplest being sodium-N-methyl dithiocarbamat known as methan. This is an important soil sterilant.

Esters of alkyl- and dialkyl- thiocarbamic acid are prepared by reacting the mercaptides of alkali metals, ammonia and amines with carbamoyl chlorides.

$$R_2NC(O)Cl + NaS\acute{R} \longrightarrow R_2NC(O)S\acute{R} + NaCl$$

The simplest derivative of a dialkyl thiocarbamic acid is EPTC, the common name for S-ethyl N,N- di-n- propylthiocarbamate, and is a pre-emergent herbicide. It can be made by the reaction of ethyl mercaptan and di-n-propylcarbamoyl chloride.

The salts of methyl-, dimethyl-, and ethylenebis (dithiocarbamic)acids are used to control various plant diseases and they are prepared as follows:

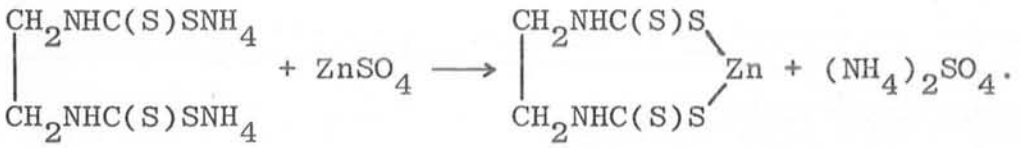
$$R_2NH + NaOH + CS_2 \longrightarrow R_2NC(S)SNa + H_2O$$

$$2\ R_2NC(S)SNa + ZnSO_4 \longrightarrow \left[R_2NC(S)S\right]_2Zn + Na_2SO_4$$

Diammonium ethylenebis dithiocarbamate is made thus:

$$\begin{array}{l} CH_2NH_2 \\ | \\ CH_2NH_2 \end{array} + 2CS_2 + 2NH_3 \longrightarrow \begin{array}{l} CH_2NHC(S)SNH_4 \\ | \\ CH_2NHC(S)SNH_4 \end{array}$$

From this salt, the fungicide, Zineb is produced.



Zineb

This salt is only sparingly soluble in water.

5.8. Urea and thiourea derivatives.

These exhibit only fungicidal and herbicidal properties and are an important and useful group of compounds. The trialkylureas have been shown to be active in inhibiting growths of weeds. They are made by reacting isocyanates with amines.

$$RNCO + R'_2NH \longrightarrow R'_2NC(O)NHR$$

R or R may be replaced by an aryl or substituted aryl group, e.g.

$$ArNCO + R_2NH \longrightarrow ArNHCONHR_2.$$

when Ar = Phenyl and R = methyl, the compound is fenuron which is an active root herbicide used to control annual vegetation [11].

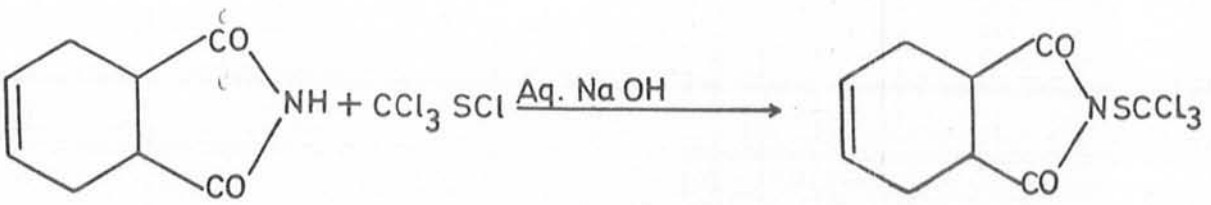
The thio analogues of these aryldialkyl ureas are less active as herbicides and more toxic to mammals.

5.9. Mercaptans, sulphides and their derivatives.

The lower members (up to C_4) of the aliphatic mercaptan series are effective against some insects. Above C_4 the activity decreases. The introduction of halogen substitutents into the nucleus of aronatic mercaptans increases the acaricidal effects. Aromatic sulphones are also acaricidally active.

Trichloromethylsulphenyl chloride, CCl_3SCl, which is highly toxic is an intermediate for the synthesis of trichloromethylthioimides of various acids that have fungicidal properties.

N-trichloromethylthiotetrahydrophthalimide [11] (captan) is a broad spectrum protective fungicide which is produced by the reaction of tetrahydrophthalimide in aqueous alkali with trichloromethylsulphenyl chloride



5.10. Derivatives of hydrazine and azo compounds.

Substituted hydrazines, especially of the aromatic series, show strong pesticidal activity. Azobenzene, which has miticidal activity, is prepared by the controlled

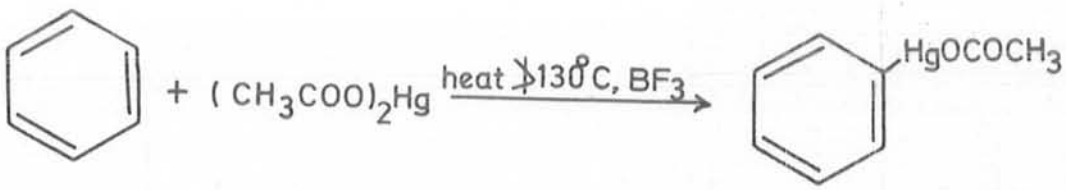
reduction of nitrobenzene [11].

$$2C_6H_5NO_2 + 8[H] \xrightarrow[MeOH]{Zn/NaOH} C_6H_5.N = N.C_6H_5$$

5.11. Organometallic Compounds.

5.11.1 Organomercury Compounds.

The main use for organomercury compounds is as seed dressings. The insecticidal properties are negligible. Aromatic mercury compounds have fungicidal, disinfectant and herbicidal properties. Phenyl mercury derivatives can be prepared by direct treatment of benzene with mercury (II) acetate or other mercury (II) salts.



5.11.2 Organotin Compounds.

Tin (II) or tin (IV) chlorides do not possess fungicidal properties. However, replacement of the chlorine atoms in tin (IV) chloride by alkyl or aryl radicals results in greatly increased activity. The activity rises on substitution with R or Ar but tetraalkyl- or tetraaryltin compounds do not possess fungicidal properties.

The preparation of these compounds involves the reaction of tetra(R)(Ar) tin with the halides or other salts of tin (IV):

$$3R_4Sn + SnCl_4 \xrightarrow{heat} 4R_3SnCl$$

$$R_3SnCl + KOH \longrightarrow R_3SnOH + KCl$$

$$R_3SnOH + HAC \longrightarrow R_3SnAC + H_2O$$

$$4RMgX + SnX_4 \longrightarrow R_4Sn + 4MgX_2$$

5.11.3 Organoarsenic Compounds.

These compounds generally have fungicidal properties though some possess herbicidal activity in addition. The fungicidal activity of the alkylarsines decreases with increase in molecular weights. Because the compounds are highly toxic, and in cases irritant to the respiratory passages, their use is limited. Cacodylic acid has been used for the pre-emergent control of weeds on pestures and as a desiccant [11]. Its preparation involves the following route.

$$4\ CH_3\ COOK + As_2O_3 \xrightarrow[\text{distillation}]{\text{dry}} \left[(CH_3)_2As\right]_2 O + \begin{matrix} 2K_2CO_3 \\ 2CO_2 \end{matrix}$$

$$\left[(CH_3)_2As\right]_2 O + H_2O + \left[O\right] \longrightarrow 2(CH_3)_2\ \underset{\underset{O}{\|}}{AsOH}$$

Cacodylic acid

5.12. Organophosphorous Compounds.

This is an important group whose members exhibit a vast spectrum of pesticidal activity and include insecticides, herbicides and defoliants. Mention has been made earlier of Schradan [1,7,8], parathion [1,7], and TEPP [1]. Since the introduction of these compounds many others, including dimethoate [18], malathion [11] and mecarbam [19]have appeared on the market. In most cases the organophosphorous compounds are considered as derivatives of the corresponding acids (or phosphine), or the sulphur analogues of these acids.

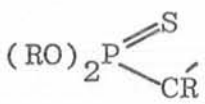
Derivatives of phosphorous acid generally have weak insecticidal activity, whereas they and their thio analogues do possess high herbicidal properties. This latter activity increases with an increase in the number of carbon atoms in the aliphatic ester radical.

The insecticidal and acaricidal activity of phosphoric acid derivatives and their sulphur analogues is far superior to that of phosphites. Certain aliphatic halogen-containing esters of phosphoric acid are used in agriculture. An example is O,O.dimethyl O-2,2-dichloro-vinyl phosphate (dichlorves, DDVP) [11] which may be prepared as follows:

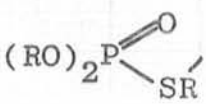
$$(CH_3O)_3P + CCl_3CHO \xrightarrow{\text{benzene}} (CH_3O)_2P(O)OCH_2 =\cdot CCl_2 + CH_3Cl$$

This compound adds on bromine at the double bond of the dichlorovinyl group and the product, naled, (1,2-dibromo-2, 2-dichloroethyl dimethyl phosphate) is a powerful insecticide with some fungicidal activity.

If one of the oxygen atom is replaced by sulphur, then the resulting thiophosphoric acid derivatives are less toxic to animals although still retaining their insecticidal and acaricidal activity. These derivatives may have either a thiono (I) or thiolo (II) structure depending on the preparation

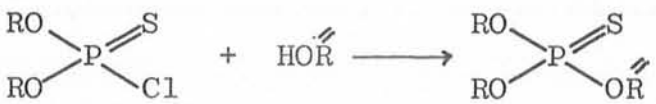


(I)

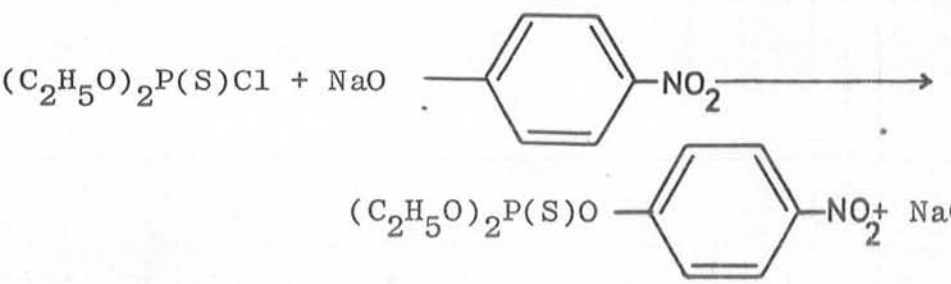


(II)

The principal method used for making thiophosphate involves:



Parathion is prepared as follows:



The reaction is carried out in chlorobenzene. At 100°C parathion is gradually converted into its thiolo-isomer [17].

In addition to the thiophosphoric acid derivatives, those of dithiophosphoric trithiophosphoric acids find many uses as pesticides. In most cases the toxicity of these derivatives is less than that of their thiophosphoric counterparts. They are also more stable, and consequently have longer periods of activity in the field. The principal methods for making these derivatives are as follows:

(i) $(RO)_2P(S)SNa + ClCH_2\acute{R} \longrightarrow (RO)_2P(S)SCH_2\acute{R} + NaCl$

(ii) $(RO)_2P(S)SH + \begin{matrix} CH\acute{R} \\ \| \\ CH\acute{R} \end{matrix} \longrightarrow (RO)_2P(S)SCH\acute{R}$ with $CH_2\acute{R}$ below

e.g. malathion is prepared as follows:

$$(CH_3O)_2P(S)SH + \begin{matrix} CHCOOC_2H_5 \\ \| \\ CHCOOC_2H_5 \end{matrix} \xrightarrow[\text{solvent}]{\text{base}} (CH_3)_2P(S)SCHCOOC_2H_5 \text{ with } CH_2COOC_2H_5 \text{ below}$$

Dimethoate is produced by the reaction of salts of O,O-dimethyl dithiophosphoric acid with N-methyl chloroacetamide.

$$(MeO)_2P(S)SK + ClCH_2CONHCH_3 \longrightarrow (MeO)_2P(S)SCH_2CONHCH_3 + KCl$$

Mecarbam, S-(N-ethoxycarbonyl-N-methylcarbamoylmethyl) diethyl phosphorothiolothionate is similarly produced by the reaction of a salt of O,O-diethyldithiophosphoric acid (DETA) with N-Chloroacetyl-N-methyl ethylcarbamate in the presence of a base:

$$(EtO)_2P(S)SK + ClCH_2CON(CH_3)COOC_2H_5 \longrightarrow$$

$$(EtO)_2P(S)SCH_2CON(CH_3)COOC_2H_5 + KCl$$

IV. PESTICIDES - THEIR MODES OF ACTION

In general a pesticide may kill an organism by a physical or a chemical effect or by both. Examples of the former effect are provided by fumigants and organic solvents, which are thought to act by a process which disrupt the physical properties of lipid biophase. Silica aerogels are other examples which can absorb cuticular grease with subsequent desication. Physical toxicants are recognised for their lack of specificity and, normally, low order of toxicity.

Of more interest are those compounds which kill chemically by reacting with a specific body component. These reactions may involve definite convalent bond formation such as the carbamylation or the phosphorylation of cholinesterase. Other processes may involve forces such as ionic, or hydrogen bonding. In most instances, however, many processes are thought to be involved.

6.1 HERBICIDES.

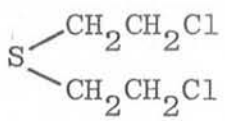
These fall into two catagories - the inorganic and organic herbicides. Little is known about the mode of action of the former which include such compounds as ammonium sulphamate, ammonium thiocyanate, copper sulphate, sodium chloride, sodium chlorate, and sulphuric acid.

In the case of salts of heavy metals it is considered that enzyme inactivation occurs and in some cases plasmolysis of cells. In the case of sodium chlorate it appears that reduction to hypochlorite takes place [20]. The enzymes responsible for this reduction are thought to be those also involved in the reduction of nitrate. More is known about the mode of action of the organic herbicides[21]The organic herbicides include the phenoxy-acetic acids, substituted ureas, carbamates, triazines, and bipyridylium quaternary salts.

The phenoxyacetic acids are known as auxin herbicides. An auxin is a substance which promotes growth along the longitudinal axis when applied to shoots of plants which have lost their own growth - promoting substances, i.e. indole auxins. 2,4-Dichlorophenoxyacetic acid is an example of an artificial auxin which is highly persistent and capable of upsetting the normal growth of the plant with resulting stoppage of cell-division and failure of the roots to take up salts and water. The urea herbicides, the triazines and the bipyridylium quaternary salts act by upsetting the photosynthetic processes involving electron flow and energy exchange.[20,21].

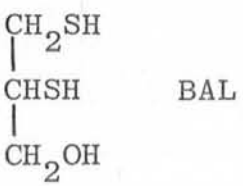
6.2 INSECTICIDES.

The complex set of symptoms observed in poisoning may often be traced to a single reaction with a body component. In 1931 Sir Rudolph Peters introduced the phrase "biochemical lesion" when he showed that thiamine-deficient pigeons had brains with an inability to oxidise pyruvate because the thiamine was needed as a Co- factor[22]. He showed that biochemical lesions occurred in arsenical and sulphur mustard poisoning cases, both of which involve reaction with sulphydryl groups. From this concept was developed an antidote for the vesicant action of sulphur mustard [23].



Sulphur mustard.

The antidote was the compound:



BAL

which could react with sulphur mustard.

As a result of Sir Rudolph Peters' work, the biochemical basis of fluoroacetate poisoning was discovered. The fluoroacetate undergoes conversion to its fluoroacetyl coenzyme A derivative [16].

$$FCH_2COOH \longrightarrow FCH_2COSCOA \qquad (I)$$

This product reacts with oxalacetate to give fluorocitrate.

$$FCH_2COSCoA + O{=}C(COOH)CH_2CO_2H \longrightarrow FCO_2H\,HOCCO_2H\,CH_2\,CO_2H \qquad (II)$$

Fluorocitric acid.

Compound (II) inhibits the enzyme aconitase whose function is to metabolise citric acid (in the krebs' cycle). The result is that citrates accumulate in tissues especially of the heart and kidneys and may be the cause death by disrupting energy-producing reactions or by lowering calcium levels at vital areas. Peters termed this process "Lethal synthesis."

In the case of fluoroacetamide poisoning it is assumed that the same mechanism applies after the hydrolysis to fluoroacetic acid. Organophosphorous compounds kill animals, both vertebrates and invertebrates by inhibiting

the enzyme cholinesterase [17]. The function of the latter is the hydrolysis of the product of nerve functioning (acetylcholine) to harmless compounds, viz., choline and acetic acid. When the enzyme suffers inhibition there results an accumulation of acetyl choline at nerve endings with subsequent disruption of nervous activity.

$$(CH_3)_3N^+CH_2CH_2OC(O)CH_3 \xrightarrow{ChE} (CH_3)_3N^+CH_2CH_2OH + CH_3COOH$$

Ch.E = Chloline - esterase.

It is considered that an -OH group of the serine molecule in the cholinesterase attacks an organophosphate. The serine involved is at the active site of cholinesterase. The overall reaction for a compound of type $(RO)_2P(O)X$, where X is the leaving group, is thought to be a phosphorylation.

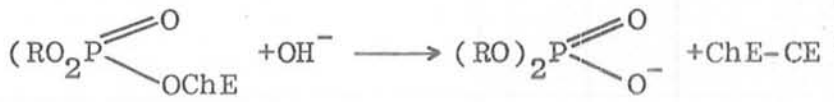
$$Ch\text{-}E\text{-}OH + (RO)_2P(O)X \longrightarrow (RO)_2P(O)OChE + HX$$

Many organophosphates are latent inhibitors of cholinesterase and must undergo some change before they become active, e.g.

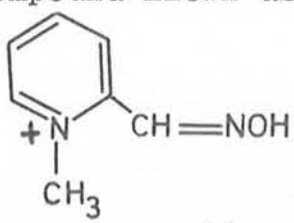
$$\gtrless P(S)- \longrightarrow \gtrless P(O)-$$

This process is often referred to as an oxidation although O'Brien prefers the term desulphuration since no change in the oxidation state of P occurs. Other types of activation processes include hydroxylation, hydrolysis, and oxidation. These reactions are used to effect a more potent in vitro inhibitor for analytical purposes.

The hydrolysis of the phosphorylated enzyme is important in cases of poisoning the reaction being as follows:



The regeneration of inhibited cholinesterase is a slow process. Nucleophilic agents have been tested and used as antidotes, e.g., oximes were found to accelerate the regeneration of cholinesterase. One of these is the compound known as 2-PAM.



2-PAM(R=N-OH)

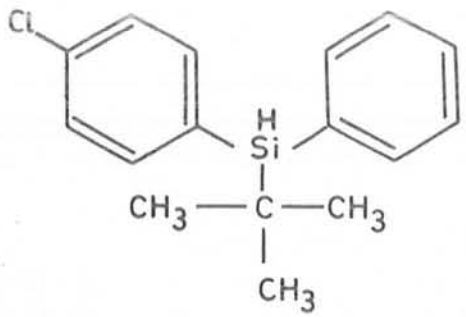
The regeneration process is thought to involve the reaction

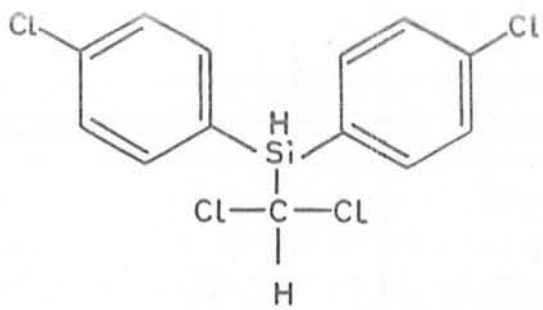
$$(RO)_2P(O)OChE + R = NOH \longrightarrow ChEOH + R = N\text{-}OP(O)(RO)_2$$

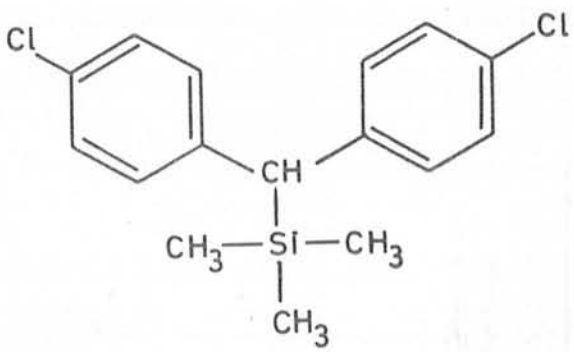
Less is known about the modes of action of organochlorine compounds. It is agreed that the primary effect is on the

nervous system, both in vertebrates and invertebrates. The symptoms of poisoning include tremors, hyperexcitability, convulsions and ataxia.

Recently, Fahmy et al synthesised a series of silicon-containing analogues of DDT and evaluated their insecticidal activity [24]. Their aim was to obtain more potent, biodegradable insecticides. In all, [20] silicon analogues were prepared and were found to be ineffective against houseflies. The structures of some of these compounds are as follows:







Theinactivity of these and other silicon compounds was considered to be due to steric effects resulting in a "poor fit" at the site of action. The DDT receptor site is considered to be a flexible one which can accommodate molecules of various dimensions as long as the overall size of the molecule does not deviate substantially from that of DDT. Compounds possessing the same geometry as that of DDT but which fall outside the range of maximum interaction because of their overall size (i.e., smaller or larger) are unlikely to be toxic. The organosilicon analogues fall into this catagory.

Finally, mention must be made of the ability of organisms, particularly mites and insects, to develop resistance to toxicants. The resistance process is a complex one involving many biochemical processes and genetic factors[25]. To overcome this problem, use is made of compounds that delay the special detoxication processes or of compounds that enhance the activity of the toxicant.

V. 7. PRINCIPLES OF RESIDUE ANALYSIS

There are essentially four stages involved in the experiment to test the residual nature of a pesticide on a crop. These include the field experiment, sampling, extraction and clean-up, and, finally, the measurement of the residue.

7.1. The field experiment.

The residue chemist is not formally involved at this stage of the experiment and it is assumed that the optimum physical nature of the formulation, methods of application and the nature of the experimental design are properly worked out prior to starting the field experiment.

7.2. Sampling.

The procedures for sampling crops will obviously vary and will depend on the type and maturity of the crop. The importance of obtaining a valid, representative sample cannot be over-emphasized. A representative sample is necessarily a random one where every unit in the experimental design has an equal chance of being selected for the test. The final accuracy of and validity of the residue data obtained will be related to and dependant on the accuracy of sampling [26,27,28].

7.3. Extraction and Clean-up.

Once a suitable size sample for analysis is obtained - normally by processes involving shredding, slicing, quarterning, etc. It is subjected to solvent extraction. The solvent chosen will depend on the nature of the pesticide but should be capable of removing all the pesticide residue with a minimum of extraneous materials. The solvent should also in no way lead to any interference in the subsequent determination stage. Because of the large volumes generally involved in the extraction the solvent should be of low toxic hazard to the operator.

The actual extraction procedure involves maceration or homogenisation of the crop (100 g) with the extraction solvent (usually 2 ml per 1 g of sample) in the presence of a dehydrating agent such as anhydrous sodium sulphate. The extraction procedure is normally repeated two or three times. Each extract is filtered through a suitable filter and concentrated to a volume suitable for the subsequent clean-up procedures. The concentration of the extract is performed at a low temperature to avoid loss or decomposition of the pesticide or its metabolites.. A suitable apparatus for this is the rotary-film evaporator. The clean-up procedures employed may involve the following processes:

(i) Solvent Partition.

This involves the principle that some pesticides are partitioned into one phase of two immiscible solvents whilst the co-extracted biological materials remain in the other phase. An example of two "immiscible" solvents are hexane and acetonitrile.

Beroza et al have carried out much work on 'P' values and have employed these values for confirming the identity of pesticides [29]. The 'P' value is defined as the fraction of the total solute that distributes itself in the non-polar (usually upper) phase of an equivolume solvent pair.

(ii) Oxidation:

This is a useful procedure employed either (a) when the compound to be determined is stable to oxidation but the co-extracted materials are not or (b) when the compound to be determined can itself be oxidised to a species, e.g., a phosphate or other inorganic compound, which can then be determined. Thus acid $KMnO_4$ solution is used for the destruction of plant co-extractives prior to the determination of dinobuton [30]. The procedure involves the heterogenous benzene/aqueous $KMnO_4$ system.

(iii) Reduction.

Sulphur dioxide passed into a methanol solution of a plant extract is sometimes used to destroy plant pigments.

(iv) Steam distillation.

Some compounds are easily separable from plant materials by steam distillation.

(v) Chromatography.

By far the most common and useful techniques for clean-up involve some form of chromatography. The Chromatographic separation can be achieved where the material to be isolated exhibits a selective adsorption onto the adsorbent. The converse situation also applies. Some of the common adsorbents used include the aluminas (acids, basic or neutral), diatomaceous earths, silicic acid. The adsorbents can be either used in an activated or de-activated form. Activation is usually achieved by heating, whilst de-activation may involve the addition of water. Apart from column chromatographic techniques other processes involve thin-layer, paper, liquid, or gel-filtration chromatography. Gas-liquid chromatography is seldom used for preliminary clean-up but only in the final stages of the analysis.

(vi) Freezing techniques.

Many fats and waxes, co-extracted from the plant material, are insoluble in acetone at low temperatures. This principle afford a useful clean-up for some pesticides and involves temperatures of around -80°C.

7.4. The analytical measurement of the pesticide.

As a necessary preliminary to developing an analytical method for determining the pesticide residue, the chemical and physical nature of the pure pesticide specimen must be fully investigated. Many tools and techniques are available for measuring the pesticide residue. These include spectrophotometry, gas-liquid, and thin-layer chromatography, enzyme inhibition, neutron activation, and bio-assay. By far the most common techniques are those involving spectrophotometry, and gas-liquid chromatography.

7.4.1. Spectrophotometric methods.

These methods include use of absorptions in the ultraviolet, visible, and infrared regions. In all cases a clean-up is required in order to ensure no interference from other compounds. The pesticide may be measured directly, or, after conversion to a derivative.

7.4.2. Gas-liquid Chromatography.

In residue analysis, gas-chromatographs are employed which are fitted with selective or specific detectors. These detectors include electron capture, alkali-flame ionisation, flame photometric, and micro wave plasma detectors. By far the most versatile are the electron capture and alkali flame ionisation detectors.

The electron capture is useful for detecting compounds having electron attracting groups or atoms such as the organochlorine compounds. Hydrocarbons do not respond. The detector consists of a radio-active β-emitter positioned in such a way that the eluted compounds from the column are capable of making maximum contact with the electrons. The compounds capture some of these electrons with resulting subsequent decrease in the standing current. The detector is capable of detecting 10^{-12} g (picogran = pg) of some compounds.

The alkali flame ionisation (AFID) detector is basically a modification of the conventional flame ionization detector [31]. An alkali halide, e.g., NaBr or CsBr pellet is positioned over the hydrogen flame. Compounds containing phosphorous or halogen are selectively detected although by altering the geometry of the detector. only phosphorous-containing compounds are detected.

The mechanism is not fully understood but it is generally accepted that in an ionic atmosphere, such as that created under the AFID conditions, compounds containing P or halogen atoms can form more stable complex ions which are amenable to collection on the electrode. Quantities in the order 10^{-11} of some organophosphorous detectors are capable of being detected. By employing RbBr in place of Cs or Na halides nitrogen-containing compounds can be detected [32].

7.4.3. Enzyme inhibition methods.

These are not very specific but are nevertheless very sensitive methods of analyses. An example is the use of the enzyme acetylcholinesterase. This enzyme is inhibited by many organo-phosphorous compounds, thus measurement of the inhibitory activity of acetylcholinesterase can be used to measure the concentration of the inhibitor , since some organophosphorous compounds phosphorylate the acetylcholinesterase and render it inactive.

$$CH_3CO_2CH_2CH_2N^+(CH_3)_3 + H_2O \xrightarrow[\text{sterase}]{\text{Acetylcholine-}} CH_3CO_2H + HOCH_2CH_2N^+(CH_3)_3$$

Choline

Acetylcholinesterase + organophosphorous compound ⟶

phosphorylated acetylcholinesterase

(inactive)

The amount of acetic acid liberated in a given time is a measure of the enzyme activity which varies inversely with the concentration of the inhibitor. The acetic acid is measured in terms of a change in P^H, in the presence of a standard buffer, over a definite time period. The method is capable of detecting 10^{-6} - 10^{-8} g of some inhibitors (depending on the potency of the inhibitor).

CHAPTER 2

CHAPTER II

DISCUSSION

8. Virtually all pesticides undergo some alteration as a result of environmental or biological influence. Knowledge of their fate in plants, soil, and water, affords data for determining the potential hazards to man. The environmental effects include those due to the action of soil, water, atmospheric oxygen, and light. Degradations resulting from biological influence take place both in animals and plants. The degradation of a pesticide in soil may result from hydrolysis in the presence or absence of light, or from microbiological metabolism by bacteria or fungi. Active surfaces of soil particles may also be responsible in some cases.

In the biological system, plant or animal, degradation of a pesticide occurs as a result of many processes. These include non-enzymic reactions involving hydrolysis, isomerisation or oxidation. Other reactions, which result in degradation of the pesticide, take place as a consequence of enzyme action. The enzymes responsible, phosphatases, carboxyesterases, amine-oxidases and hydrolases.

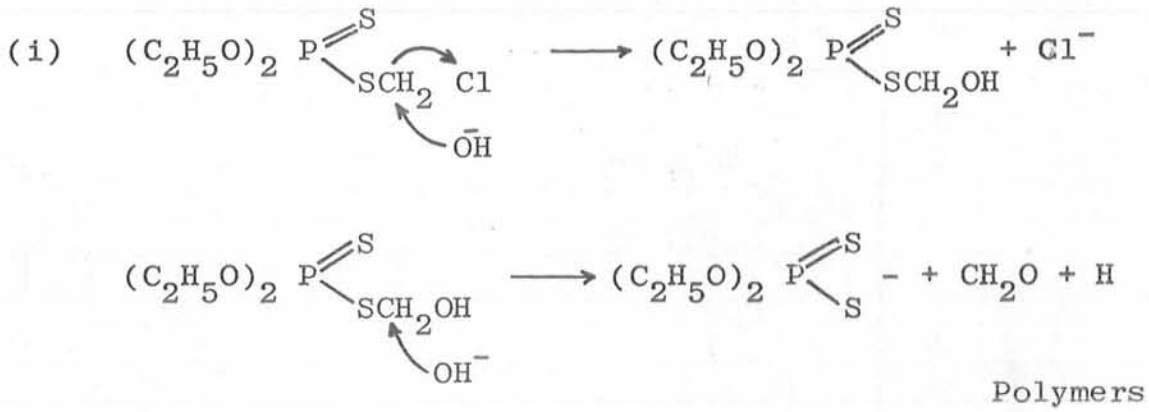
Apart from the degradative metabolism the process resulting in more toxic products also occurs and is termed as activative metabolism, e.g., P=S ⟶ P=O conversion. Other processes involved, include alkylation, and dealkylatio reductions and conjugations. The latter are, in fact, bio-syntheses resulting from the coupling of the pesticide or its metabolite with some agent within the biological system. For example, glucuronic acid readily forms conjugates, as a result of enzyme catalysis, with compounds containing for example the hydroxyl, phenolic or amino group. In general, the conjugates are hydrophilic compounds which are biologically inactive.

Chlormephos (S-chloromethyl O,O-diethyl phosphorothiolothionate) has been used solely as soil insecticide.[33] It is active against wireworms, rootworms and other soil pests which cause serious damage to crops by feeding on their roots and shoots. Such pests can be controlled by the use of chlorinated hydrocarbons such as dieldrin or BHC but these compounds are highly persistent in the soil and hence their use is undesirable.

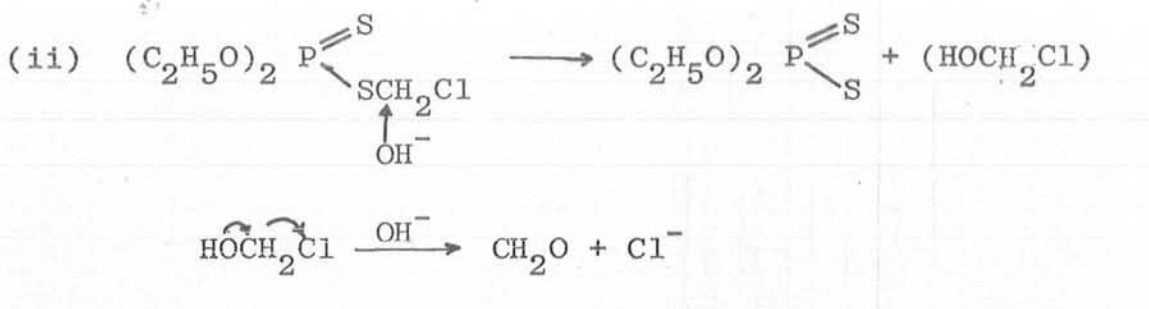
9. HYDROLYSIS OF CHLORMEPHOS

In aqueous acid solution ($pH_{2.2}$) Chloromphos was stable for 100 hours whereas at pH10 it had degraded by 60% in 7 hours, and was totally degraded in 24 hours.

The main product of alkaline hydrolysis was O,O-diethyldithiophosphoric acid (DETA). This means that fission of the S-C bond in the molecule occurs and possible routes of hydrolysis are:-

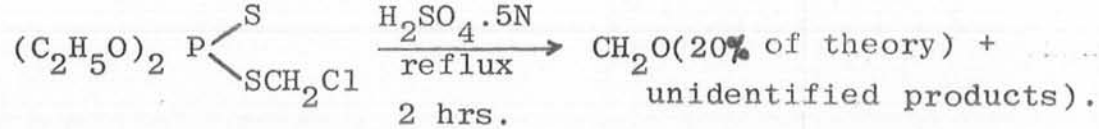


Polymers



Polymers

Under acid hydrolysis and reflux conditions chlormephos yielded formaldhyde which was identified using 2-hydrazinobenzo thiazole. The maximum yield of formaldehyde was obtained when an aqueous acid solution (5M sulphuric acid) of Chlormephos was heated under reflux for two hours.



The hydrolysis also produced other unidentified products, some of which had a strong characteristic smell of sulphur compounds. This method was considered unreliable as a means of determining chlormephos residues.

10. Preparation of Oxygen analogue of Chlormephos

This compound was prepared by the method described by T.W. MASTIN [34], but with slightest modification which include a purification step employing aqueous potassium carbonate. The compound was found to decompose at room temperature and was therefore stored at $-9^{o}C$.

$$(C_2H_5O)_2P((O)SK + CH_2ClBr \longrightarrow (C_2H_5O)_2P(O)SCH_2Cl + KBr$$

The possibility of mixed products being produced due to resonance were considered, but spectral examination indicate the presence of mixed products, possibly of thiol ester. Pure compound of thiol was not available for comparative study.

10.1 Preparation of Chlormephos

This compound was prepared by the method described in the literature[34]. O,O Diethyl-thionophosphori acid potassium salt was treated with Chlorobromomethane.

The residue left after filtration was extracted with ether.

$$C_2H_5OH + P_2S_5 \longrightarrow (C_2H_5O)_2\ P(S)SH$$

$$(C_2H_5O)_2P(S)SH + KOH \longrightarrow (C_2H_5O)_2P(S)SK$$

$$(C_2H_5O)_2P(S)SK + CH_2ClBr \longrightarrow (C_2H_5O)_2P(S)SCH_2Cl + KB$$

Purity of Chlormephos was determined by GLC and IR-Spectroscopy.

10.2 Preparation of O,O, Diethylthionophosphoric Acid Potassium salt

O,O - Diethylthiono phosphoric acid Potassium salt, $(C_2H_5O)_2\ P(O)SK$ was obtained by the method described in the experimental section. The product obtained by this method indicate that this compound melts at 191°C. The reaction proceed as under.

$$PSCl_3 + 3C_2H_5OH \xrightarrow{3C_2H_5ONa} (C_2H_5O)_3PS + 3NaCl$$

$$(C_2H_5O)_3PS + KOH \longrightarrow (C_2H_5O)_2P(O)SK + C_2H_5OH$$

The preparation of O,O, Diethylthiono phosphoric acid described below was not considered because of the low yield

of the compound.

$$(RO)_2PSCl + KOH \longrightarrow (RO)_2P(O)SK$$

10.3 Preparation of O,O - Diethylthiolthionophosphate

Fused phosphorous pentasulphide was refluxed in ethyl alcohal for several hrs. $C_2H_5OP(S)SH$ so produced was treated with potassium hydroxide solution, the mechanism showed the complete replacement of hydrogen by potassium ions to form a white crystalline salt of $(C_2H_5O)_2P(S)SK$.

II. 11. MASS SPECTRA OF ORGANO PHOSPHORUS PESTICIDES.

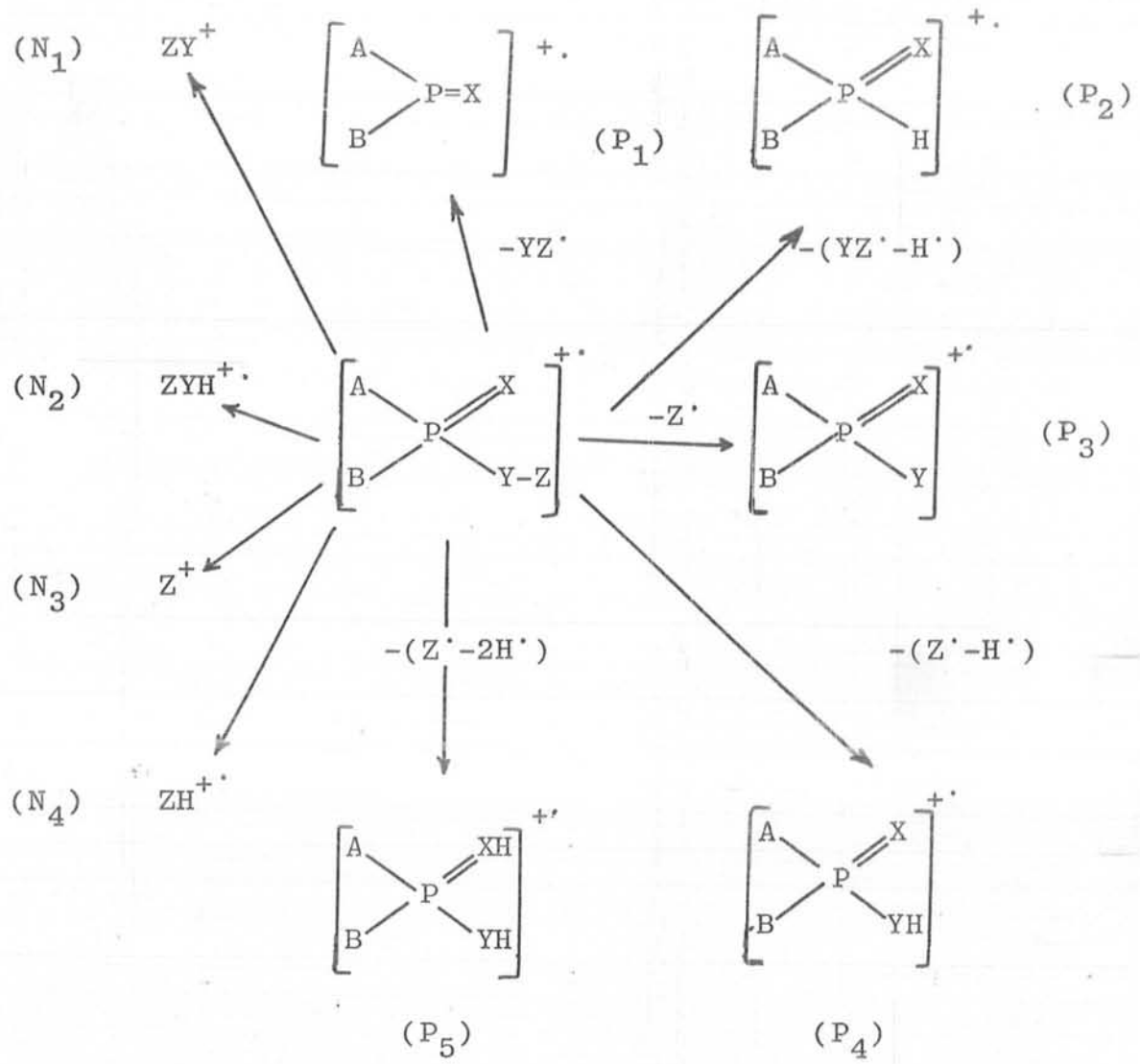
The general typesof fragmentations observed in these compounds, are restricted to compounds possessing the $R^1R^2P(X)YR^3$ structure (X=O,S; Y=O,S). These spectra have been included along with the published spectra of OP esters to provide future basic information, to elucidate with specific examples points discussed to provide a more valid standard for comparison. The OP esters whose mass spectra are reported in this work were identified by NMR and in manycases by elemental analysis and chromatographically.

11.1 Intensity of the molecular radical ion.

The presence of clearly defined molecular radical ion (M^+) is obviously of prime importance in identification structure determination and isotopic composition for certain thermally unstable OP esters of low vapour pressure, it is difficult to obtain clearly defined molecular radical ion, example includes dialkylated OP esters. A thermally dependent rearrangement under mass spectral conditions is observed, in many instances. This type of rearrangement to give apparent molecular radicals of higher m/e values than that of the compound was investigated in number of cases.

Higher intensities M+1 or M-1 ions in the spectra of several OP esters may lead to a false identification of the molecular radical ion. These ions, however, are easily distinguished from the true molecular radical ion which must have an even numbered molecular weight, unless, the compound contain an odd number of nitrogen atoms. M+1 ions are intense in the spectra of OP acids but M+1 ion intensities are, in general depends on the sample pressure in the ion source.

Compounds with large alkyl substituents may fragment in a larger number of energetically favourable ways. Consequently the intensity of the molecular radical ion as the number of energetically favourable fragments increases, is observed in the mass spectra of OP esters.



11.2 Mass spectra of OP esters - General discussion

The molecular radical ion provides molecular weight or the molecular formula of a compound depending on the instrument, a knowledge of mass spectral fragmentation can be of great use in assigning structures to unknown OP esters.

The general principles that are used in the interpretation of the spectra of OP acids and ester many of the "principles" are admittedly simple and empirical but nontheless are useful. For example, the principle that suitable ion will be intense explains the high intensity of the ion at m/e 77 ($C_6H_5^+$) in the mass spectra of aryl compounds.

Many of the ions formed from the molecular radical ion in the spectra of OP acids and esters are of the types outlined in the scheme 1.

The relative intensity of a given ion is largely governed by FOUR factors:-

(i) Stability i.e. energy of formation of the observed ion,

(ii) The stability of the uncharged fragment formed,

(iii) The stability of the parent ion (possibly but not necessarily the molecular radical ion), to fragment by other pathways.

(iv) The ability of the ion formed to fragment by other pattern.

The example listed below (A-G) are extensive, but they provide rational explanations for the occurance of many of the ions observed in the spectra of likely OP residue.

A. If the fragmentation of two or more ions of types N_1 -N_4 is possible, the ion that most delocalizes the positive charge will predominate. The predominance of aromatic or conjugated ions over aliphatic ions may be reserved when electron withdrawing substituents are present on an aromatic ring. In these cases the proportion of the ion current borne by phosphorus containing ions increases. The proportion of the ion current borne by aromatic ions corelated within the short series of diethyl and dimethyl substituted aryl phosphorothioates.

(substituents are H, CH_3O, CH_3, NO_2)

B. Rearrangement from ions of type (RO - P(= X) - YR^+ R- P(=X) -YR^+ and R - P (=X) - R^+, (X, Y = O, S) to give ion of type ROR^+ , $RR^{+\cdot}$ and Polycylic aromatic ions formed by loss of H· are more pronounced when R and R are aryl or highly conjugated alkyl.

Rearrangement to give phenolic ions are observed in the spectra of Phenylphosphonic acid. The expected relative intensity decreases in this process apparently caused by the electron withdrawing properties of Br should be noted.

C. If hydrogen transfer is possible, i.e., from alkyl group other than methyl or alkyl, intense ions are formed containing the maximum number of P - OH bonds. This has been explained in terms of the strength of the P - OH bonds. The ions m/e 99 $P(OH)_4^+$, m/e 127 $C_2H_5OP(CH_3)^+$. These are intense ions in the spectrum of triethyl phosphate. The energies of formation of these ions (H_f) are -44, -69, and -84, Kcal/mol. respectively. Represented examples of ions that maximize the number of P-OH bonds alongwith structures that do and do not yield these ions are presented.

The tendency to maximize P-OH bonds is a useful aid in the interpretation of mass spectra. As obtained below:-

The presence of ions m/e 65 $P(OH)_2^+$, m/e 81 $O=P(OH)_2^+$, m/e 83 $HP(OH)_3^+$, m/e 97 $S=P(OH)_2^+$, m/e 97 $CH_3\ P(CH_3)^+$ and m/e 99 $P(OH)_4^+$, with appropriate intensities of other ions were also noted. In petroleum addatives the presence of an intense ion at m/e 99 $P(OH)_4^+$, is indicative of the presence of trialkyl Phosphates, other than methyl phosphates. The mode of origin of this ion as indicated by metastable ions is presented in scheme 2.

$(C_2H_5O)_3\ P{=}O^{+\cdot}$ $\xrightarrow[m^*]{-C_2H_3}$ $(C_2H_5O)_2\ P^+(OH)_2$ $\xrightarrow[m^*]{-C_2H_4}$ $C_2H_5OP^+(OH$

$M^{+\cdot}$ m/e 182, 26% m/e 155, 68% m/e 127

$C_2H_5OP^+(OH)_3$ $\xrightarrow[m^*]{-C_2H_4}$ $P^+(OH)_4$ $\xrightarrow[m^*]{-H_2O}$ $OP^+(OH)_2$

m/e 127 m/e 99, 100% m/e 81, 78%.

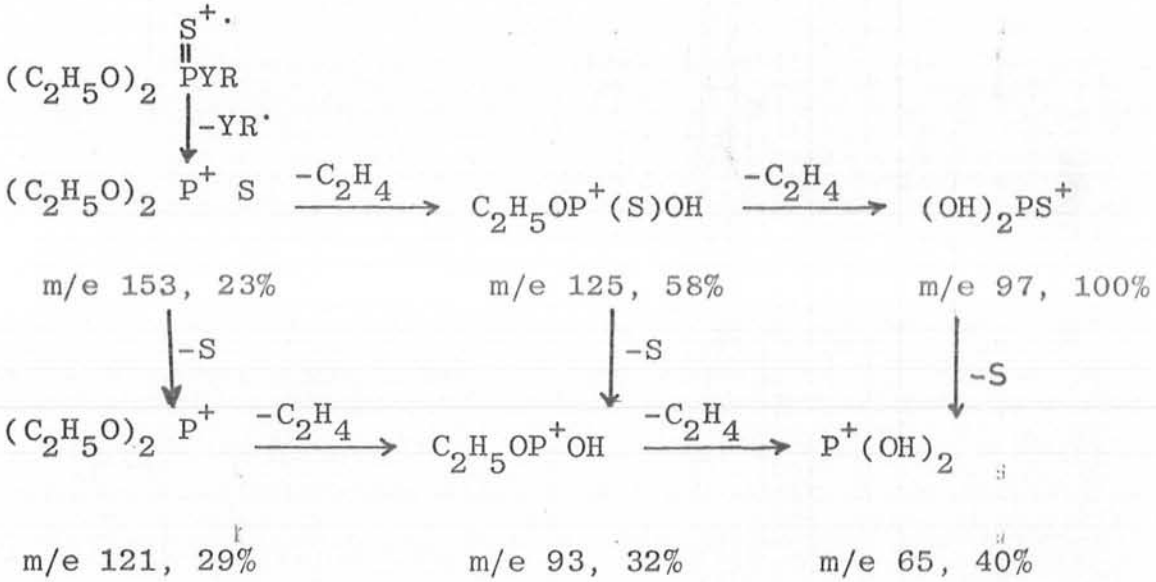
The other ions that contain P-OH bonds outlined can also be rationalized as being formed through ions of type P_5, followed by successive loss of olefine from alkoxy groups and alkyl groups from Phosphorus-Carbon bond fission with or without proton transfer.

Maximization of P-OH bonds is also useful in structure elucidation from a study of ions at high molecular weight. Loss of ethylene from the molecular radical ions is preferred to loss of $C_2H_3^{\cdot}$ from the stand point of the stability of the fragment, eliminated in these cases when loss of C_nH_{2n-1} give rise to more intense ions than loss of C_nH_{2n}, the compound contains the $P\text{-}OC_nH_{2n+1}$ and nearly always the $P(O)\text{-}OC_nH_{2n+1}$ group. The reverse is not true thus the lossof m/e 27 (C_2H_3) is more intense than the loss of m/e 28 (C_2H_4) in the spectrum of O,O-dimethylchloromethyl-phosphonate but less intense in the spectrum of O,O-diethyl-iodomethyl phosphonate. Examples where fission from the molecular ion occurs with double proton transfer.

The tendency to maximize the number of P-OH bonds is also apparent in the spectra of biological phosphate esters.

Similarly the presence of an intense ion at m/e 97 $S=P^{+}(OH)_2$ is indicative of dialkyl Phosphorothionate. An intense ion at m/e 97 ($S=P^{+}(OH)_2$ is not found in the

spectra of dialkyl S-aryl phosphorothiolates or in methyl esters. The likely mechanism for the formation of this and other phosphorus containing ions observed in the spectra of dialkyl Phosphorothionates is shown in scheme 3. The ion intensities are taken from the spectrum of dioxidation. The ratio of intensities of the ions at m/e 125 m/e 97 is typical



Likely mechanism for formation of P-containing ions.

D. Fission of a P-OCH_3 bond is usually accompanied by hydrogen transfer to phosphorus bonding to the elimination of CH_2O (m/e 30) rather than the less stable CH_3O , loss of CH_3O (m/e 31) is held to rise by a two step loss of H· and CH_2O. The derived ion m/e 109 $(CH_3O)_2\ PO^+$ fragments to the ion m/e 79. CH_3OPOH^+ by loss of CH_2O. This transition i.e. loss of CH_2O from derived ions is observed.

Successive loss of sulphur and CH_2O from the derived ion m/e 125 $(CH_3O)_2PS^+$ account for the ions m/e 93 $(CH_3O)_2P^+$ and m/e 63 CH_3OPH^+ in the spectra of dimethyl phosphorothionate fragments by loss of SCH_2 rather than OCH_2 to give the ion m/e 79 (CH_3OPOH^+).

The present evidence that despite the lower bond energy of P-S compared to P-O, the activation energy for loss of CH_2O is lower than that for the loss of CH_2S. The predominance of loss of CH_2S is explained by a much higher frequency factor involved in the transition complex for the loss of CH_2S.

E. Derived ions containing the group P-XC_2H_5 (X=O,S) fragment by loss of C_2H_4 rather than by loss of $C_2H_5^{\cdot}$, $C_2H_3^{\cdot}$ or $C_2H_4O^{\cdot}$ (m/e 44) except in those cases outlined above. Scheme 2 and 3 present examples of this fragmentation ion persued by loss of m/e 28 and 56 from the molecular radical ion or derived ions (rather than 27, 29, or 44) are noticeably in the spectra of diethyl phosphorothionates.

F. Molecular radical or derived ions containing the RS-P(O)-OR group fragment by P-S rather than by P-O bond by fission. This process may be accompanied by hydrogen transfer to phosphorus in analogy with the loss of CH_2O from methyl esters or $CH_3S^{\cdot}$ may be lost obtains intense fragments are observed that correspond to the loss of both $C_nH_{2n}S$ and $C_nH_{2n+1}S^{\cdot}$. As discussed P-O-C_2H_5 groups

predominately fragment to ethylene plus a phosphorus containing ion. In contrast, P-S-C_2H_5 group fragment by P-S fission to lose C_2H_4S and $C_2H_5S^{\cdot}$. The few reported examples of the mass spectra.

G. Ions that may be rationalized as being formed by the loss of sulphur especially from derived even electron species, are common in the spectra of thionates. The corresponding loss of oxygen in P=O compounds is not recorded.

H. Only occasionally can an intense phosphorus-containing ion be rationalized by P-N bond fission in the mass spectra of phosphor- and phosphonamidates, even though the P-N bond is intermediate in strength between P-S and P-O bonds, examples of P-N fission are seen to be limited.

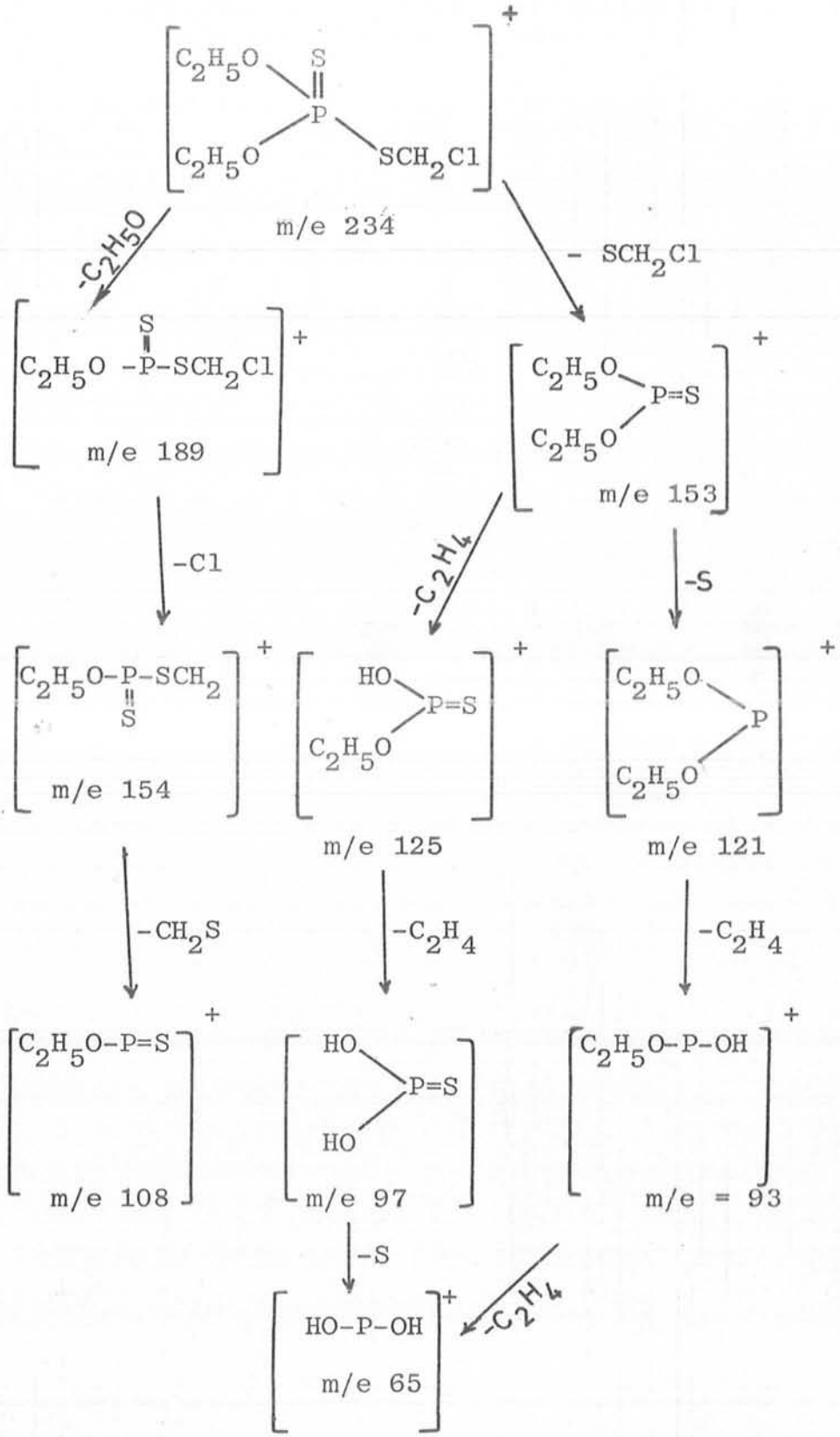
11.3 Mass Spectra of Chlormephos

Mass Spectral data can be employed to confirm or characterise the identity of residues of unknown structure. When coupled with gas Chromatography the mass spectrometer can provide an excellent tool for the analysis of complex mixtures. The mass spectra of the above compounds were recorded, firstly for molecular weight determination, and for confirmation of structure in

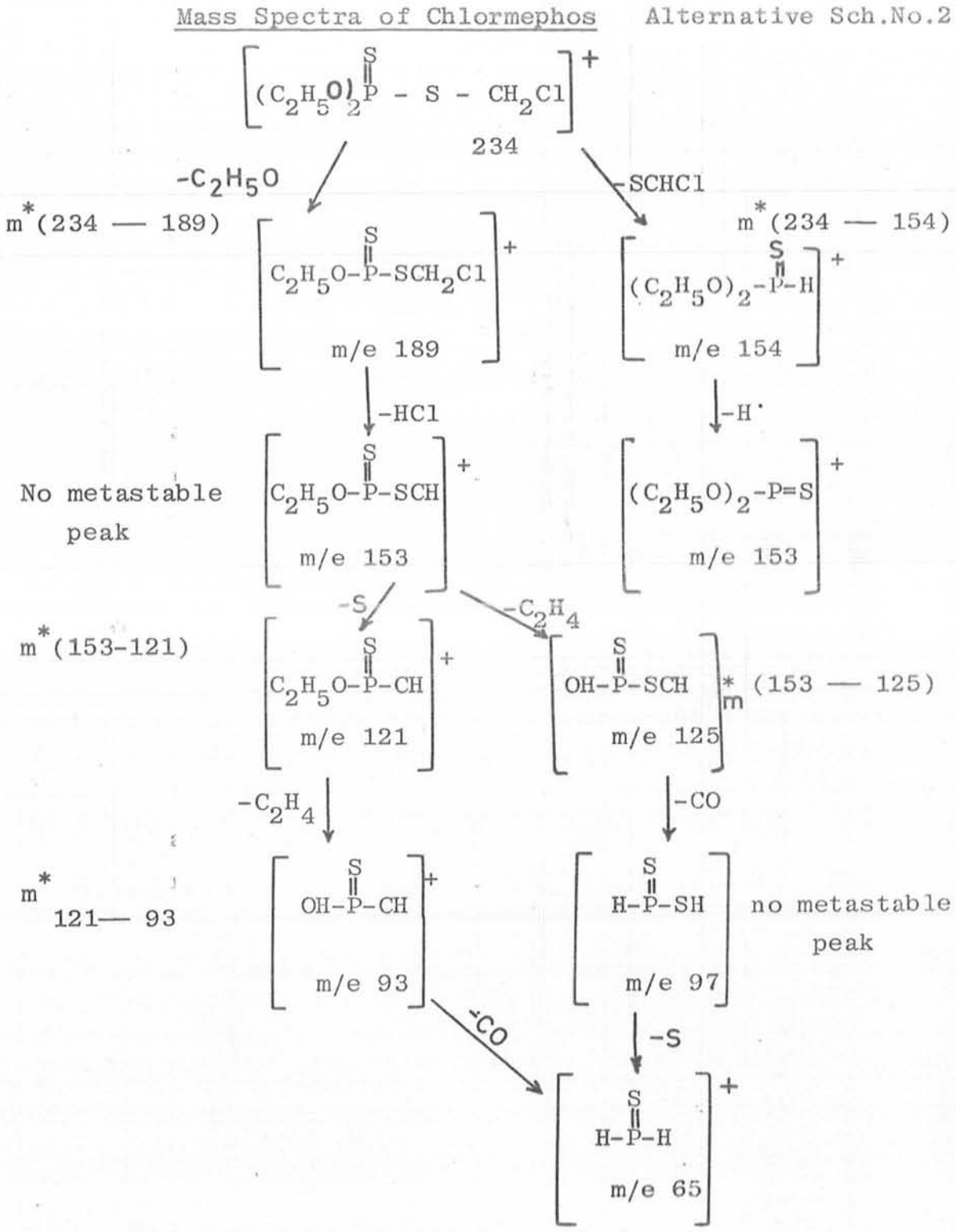
conjunction with elemental analysis and P^{31}nmr. All the compounds gave a molecular ion, followed by similar fragmentation patterns discribed above for the related phosphorothiolothionates.

This compound gave strong peaks at m/e 234, 154, 125, 121, 97, 93, and 65. Metastable ions were observed at m^{*} 152. 6, 234- 189 ; 102.1, 153 - 125 ; 101.3, 234 - 154 ; 95.6, 153 - 121 ; 71.4, 21 - 93 ; and 45.4, 93 -- 65 .

The M-45 and M-28 peaks which are characteristic of ethylesters were recorded. However, these were extremely weak when compared to the base peak at 121. A peak of similar intensity for M-35 was also recorded. On the basis of these findings the following fragmentations pattern for chlormephos is proposed.



11.3.1 Fragmentation Scheme for Chlormephos.

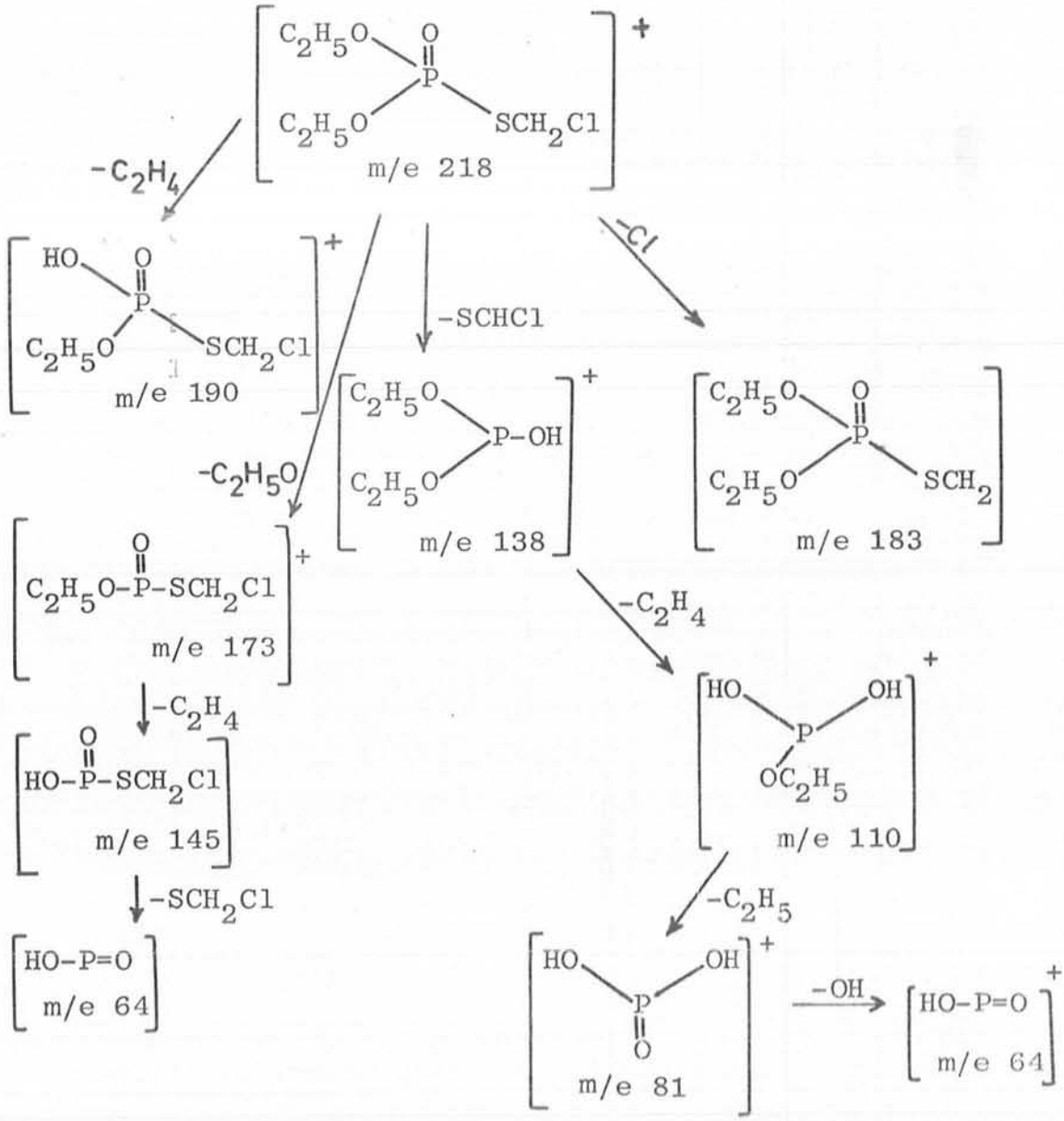


11.3.2 Fragmentation Scheme for Chlormephos - m^* (93— 65)

11.4 Oxychlormephos

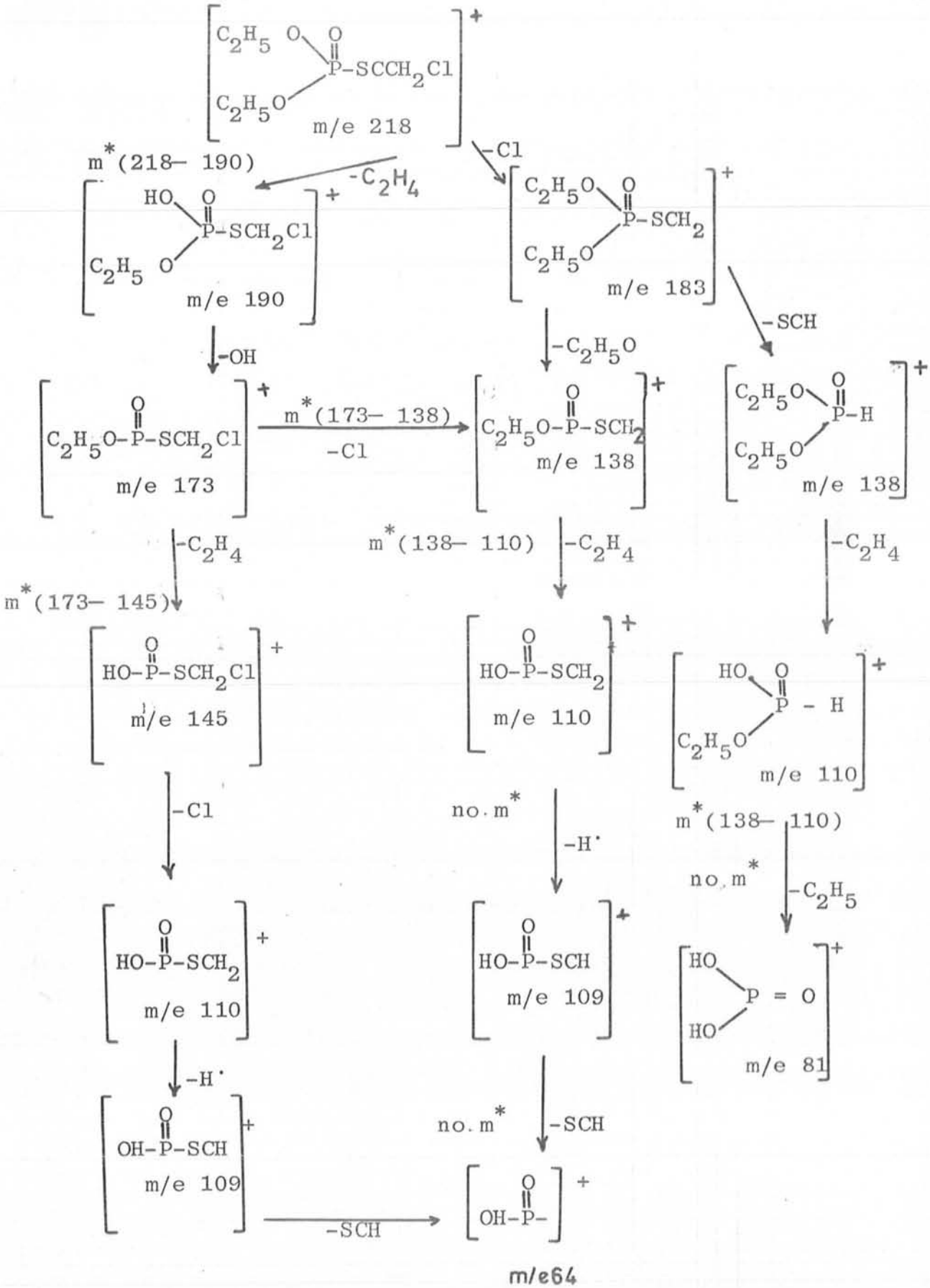
This compound gave intense peaks at m/e 183, 138, 110, 109, 108, 81, and 64. The peak at 138 is thought to arise from migration of the hydrogen of the methylene group to the phosphorus oxygen (P=O). Metastable peaks were observed at m^* 165.6, 218-- 190 ; 131.5 ; 121.5, 173-- 145 88.8; 87.6, 138--110 and 86.8.

The following fragmentation scheme is proposed:



11.4.1 Fragmentation Scheme of Oxychlormephos

Mass Spectra of Oxychlormephos Alternative Sch.No.2

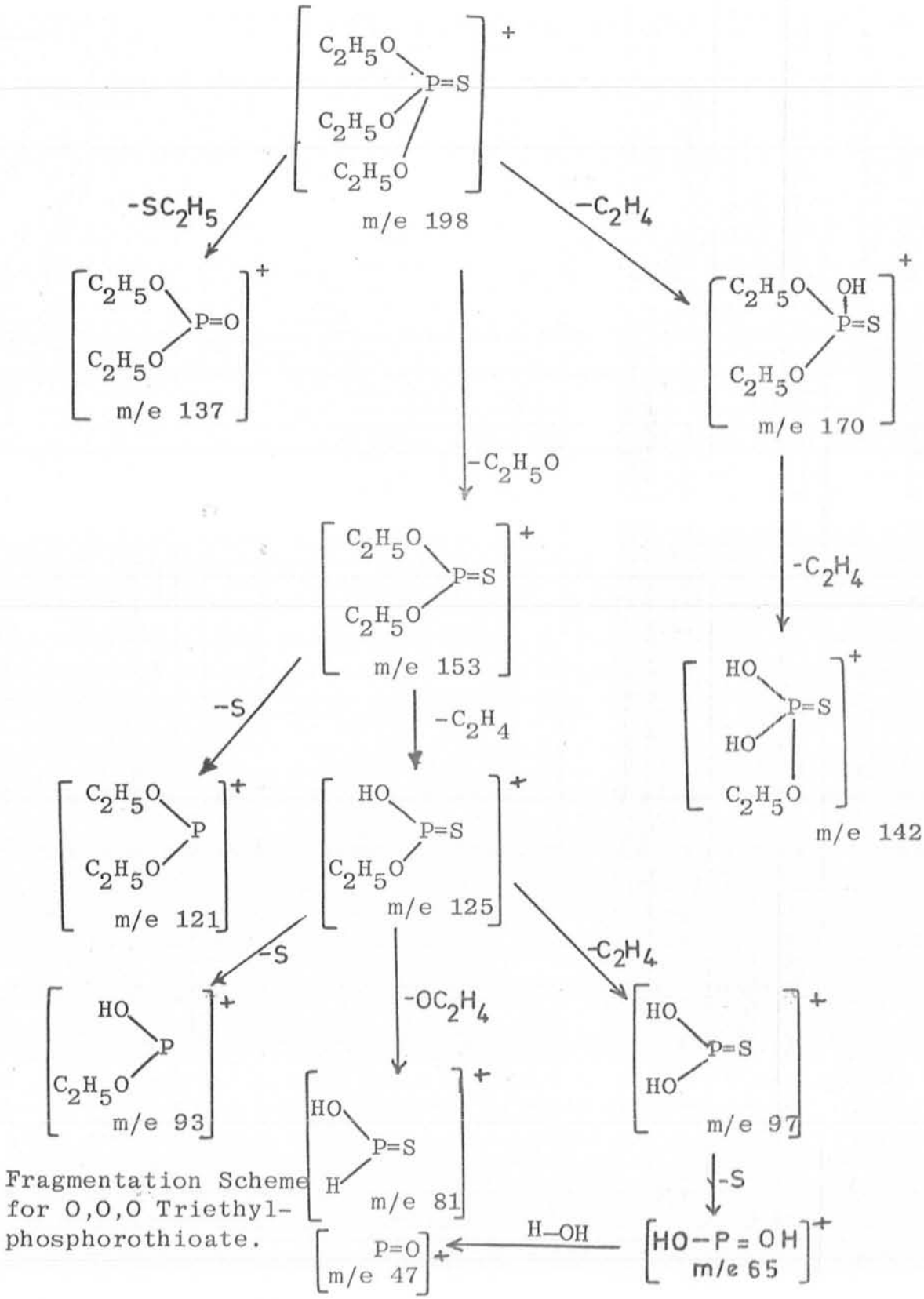


11.4.2 Fragmentation Scheme for Oxychlormephos

11.5 O,O,O,-triethyl phosphorothioate

This compound gave intense peaks at m/e 198, 142, 125, 121, 97, 93, 81, 65.

The following fragmentation scheme is proposed:



Fragmentation Scheme for O,O,O Triethyl-phosphorothioate.

CHAPTER 3

CHAPTER III

12. APPARATUS, REAGENTS AND STARTING MATERIALS

12.1 GAS CHROMATOGRAPH:

A pye 104 Model 154 is thermal gas Chromatograph fitted with a thermionic detector was used. The columns consisted of 3'x1/4" o,d or a 5'1/4" o.d. glass tubing packed with 8% silicone fluid. The carrier gas was nitrogen (Oxygen-free) at 35 ml/min flow rate. The flow rates of the air and hydrogen, and the position of the caesium bromide tip were adjusted to give optimum sensitivity and response to the phosphorous containing compounds. Temperatures ($0^{o}C$) even, 200; injected part $210^{o}C$.

12.2 THIN LAYER CHROMATOGRAPHY

Plates, 20x20 cm, coated with silica gel 60 I-254, 0.25 mm layer thickness, supplied by Merck. The developing solvent was hexane (75), acetone (25) Vol. %.

The R_f values calculated are as follows:

Chlormephos $R_f = 0.57$

Oxychlormephos $R_f = 0.34$

12.3 CHROMATOGRAPHIC COLUMNS

A glass tube, 50 cm long, 2.1 cm i.d. fitted with a tap at the lower end and a ground glass joint B24 at the upper end to which is attached a 100 ml vessel serving as a reservoir.

12.3.1 SINTERED GLASS BUCHNER FUNNEL

10 cm diameter, porosity 3.

12.3.2 VACUUM ROTARY FILM EVAPORATOR

Vacuum rotary film evaporater type 350.

12.4 SPECTROMETRS

Infra-red spectrophotometer SP1000 PYE UNICAM . This spectrophotometer was used for recording IR Spectra for the finger prints.

12.4.1 MASS SPECTROMETER

Mass Spectra were obtained using a CH-5 instrument at 70 eV, and accelerating Voltage of 8 KV, with the ionisation chamber at 200^{o}C. Puresamples were introduced with a direct insertion probe. The mass distribution of the molecular-Ion peak was calculated by binomial expansion method. The following isotope abundances were used in the calculations:

Cl^{35}, 24.47; Cl^{37}, 75.53%

13. REAGENTS

All the solvents used throughout the experiments were AR grade, except in the case of dichloromethane, ethyl alcohol, acetone.

13.1 CHROMATOGRAPHIC ADSORBENTS

ALUMINA - Woelm grade I, acid, neutral or basic. Other grades were obtained by adding an appropriate amount of water according to the instructions.

FLORISIL - 60/100 mesh, used as supplied by Bromhead and Denison or, after addition of water.

CELITE - Hyflo, super-cell, Johns-Manwille.

SILICIC ACID - 100 mesh, Mallinckrodt reagent 2847.

FLORISIL CONTAINING ORTHOPHASPHORIC ACID - This adsorbent was prepared by adding a solution of H_3PO_4 (40 ml) in methanol (60 ml) to a slurry of florisil (360 g) in methanol (200 ml). The mixture was shaken and allowed to stand for 5 minutes. The excess methanol was removed under reduced pressure until a free-flowing solid was obtained. The solid was heated in vacuo at 95°C for 1 hr. and then for 5 hrs.

at atmospheric pressure and finally, sieved, collecting the 60/100 mesh fractions.

CHARCOAL - Darco G60.

SODIUM SULPHATE - Anhydrous powder, neutral cotton wool - absorbent (BP) grade.

14. ANALYTICAL TECHNIQUES

14.1 (a) CHLORINE - Chlorine was determined using a modification of the stephon method 52.

14.2 (b) MIXED HALOGENS - Halogens were determined Potentiometrically as halides after hydrolysis with water or aqueous Potassium hydroxide followed by acidification with nitric acid. Titration with standard Silver nitrate solution was carried out. Sample resistant to hydrolysis were fused with Sodium Peroxide in Pan bomb, or were oxidized in an atmosphere of pure Oxygen in contact with a little aqueous Potassium hydroxide The solutions were then acidified and titrated Potentiometrically.

14.3 (c) PHOSPHOROUS - Phosphorous was determined by the method of kitson and Mellon, which involved oxidising the sample with perchl ric acid and determining the phosphate as a molybdovanado phosphoric acid comple

15. PURIFICATION OF THE STARTING MATERIAL

15.1 PURIFICATION AND DRYING OF DICHLOROMETHANE (CH_2Cl_2)

The commercially available dichloromethane purified by washing with 5 percent sodium carbonate solution, followed by water, dried over anhydrous calcium chloride, and then fractionated. The fraction, b.p. 40-41°C was collected. The sample purified and dried by the above process is then treated with calcium hydride and left for a week so that the dichloromethane is separated from the water. We get calcium hydroxide and hydrogen. The methylene chloride was then distilled and $Ca(OH)_2$ left as a solid. The methylene chloride obtained by this process was free from water.

15.2 PURIFICATION AND DRYING OF ACETONE $(CH_3)_2CO$

Acetone was purified by refluxing it with successive small quantities of potassium permanganate until the violet colour persists. It is then dried with anhydrous calcium sulphate, filtered from the desicant and fractionated.

The acetone obtained is treated with sodium Iodide to get ($NaI_3, 3CH_3HO$) which decomposes on gentle heating and is particularly well adapted for the preparation of pure and super dry acetone. One hundred grams of finely powdered sodium iodide are dissolved under reflux in 440 g. of boiling acetone and the solution is cooled in a mixture of ice and sodium chloride to -8°C. The crystals are filtered off, and

quickly transfered to a dry distilling flash, connected to an efficient condenser and to a receiver cooled in ice, upon gentl warming, the acetone distils rapidly. The pure and dry acetone coming at b.p. 56°C/760 mm.

15.3 PURIFICATION AND DRYING OF ETHYL ALCOHOL (C_2H_5OH)

The commercial ethyl alcohol was kept for 15 days with calcium oxide. It was then distilled and the fraction was collected at 81°C.

The alcohol from first step was treated with magnesium metal and then added iodine and refluxed for 5 hrs. Then the rest of the distilled alcohol from first step was added to the magnesium ethoxide obtained from magnesium metal, iodine and ethyl alcohol. Ethyl alcohol was refluxed in the presence of magnesium ethoxide so the water present reacted with the magnesium ethoxide. The mixture was distilled at b.p. 79°C. and was further treated with sodium metal and fraction was collected at b.p. 78°C.

16. SYNTHESIS

16.1 PREPARATION OF SODIUM POLYSULPHIDE (Na_2S_5)

Technically available sodium monosulphide, $Na_2S.9H_2O$ (120.1 g., 0.5 mol.) was dehydrated by using fusion technique. Anhydrous sodium monosulphide, Na_2S (78.04 g., 0.5 mol) and sulphur (128.26 g., 4.00 mol.) was mixed and heated at 1400°C. The polysulphide Na_2S_5 (206.2 g.) was recovered. (Found: Na, 22.28; S, 77.57; Calc. for Na_2S_5: Na, 22.29; S, 77.7%).

16.2 PREPARATION OF PHOSPHOROUS THIOCHLORIDE ($PSCl_3$)

(i) Phosphorous trichloride, PCl_3 (39.4 g., 4.4 mol.) was added dropwise to sodium polysulphide, Na_2S_5 (14.8 g., 0.14 mol.). The mixture was refluxed for 4 hrs. The mixture was filtered off and the filtrate recovered was distilled at 124-125°C contain $PSCl_3$, (37.69 g., 96.3%) (Found: P, 17.55; S, 18.24; Calc. for $PSCl_3$; P, 18.28, S, 18.92%).

(ii) Phosphorous trichloride, PCl_3 (315 g., 2.3 mol.) was treated with calcium sulphide (3.9 g., 0.05 mol.) and sulphur (74 g., 2.3 mol.), the mixture was refluxed for 4 hrs. The distillate recovered at 123-125°C as $PSCl_3$, (86.8 g., 22.3%) (Found: P, 17.1; S, 17.23; Calc. for $PSCl_3$: P, 18.28; S, 18.9%).

(iii) Phosphorous trichloride, PCl_3, (315 g., 2.3 mol.) was added dropwise to a mixture of barium sulphide (3.9 g., 0.027 mol.) and sulphur (74 g., 2.3 mol.). The mixture was then refluxed for 4 hrs., product was filtered off. Filtrate was redistilled at 123-125°C and the product recovered as

$PSCl_3$ (54.5 g., 14%) (Found: P, 16.57; S, 16.66; Calc. for $PSCl_3$: P, 18.28; S, 18.92%).

16.3 PREPARATION OF TRIETHYL THIONOPHOSPHATE $(C_2H_5O)_3PS$

Thiophosphoryl chloride, $PSCl_3$ (67 g., 0.5 mol.) was added dropwise to a well cooled sodium ethoxide solution (from 1.5 g - atom of sodium and 500 ml. of ethanol). After stirring for 4 hrs. the sodium chloride was filtered off and washed with absolute alcohal.

The alcohal solution was concentrated under vacuum and 500 ml. of benzene was added. This solution was then washed with water dried and concentrated. The whitish yellow residue was fractionated through three feet column. The product coming over at 105 - 106°C (20 mm.) weighed (69 g.). The yield was 70% of the theoretical amount, (Found: P, 14.70; S, 16.40; Calc. for $C_6H_{15}O_3PS$: P, 15.65; S, 16.60%).

16.4 PREPARATION OF O,O, DIETHYLTHIONOPHOSPHORIC ACID POTASSIUM SALT $(C_2H_5O)_2P(O)SK$

Triethyl thionophosphate, $(C_2H_5O)_3PS$,(39.6 g., 0.15 mol.) was added to 200 ml. of absolute alcohal containing potassium hydroxide (11.76 g., 0.16 - 0.2 mol.). After a 6 hrs. reflux, the reaction mixture was filtered off and the filtrate was concentrated to one third of the original volume.

From the colled solution the product separated as fine white needles, melting point 197°C. The yield was (15 g., or 73.7%) of the theoretical amount. (Found: S, 15.30 P, 15.51; K, 10.62 Calc. for $C_4H_{10}O_3PSK$: P, 14.89; S, 15.39).

16.5 PREPARATION OF CHLOROBROMOMETHANE (CH_2ClBr)

Aluminum powder (13.49 g., 0.5 mol.) was treated dichloromethane (250 ml.) and the mixture was stirred continuously with dropwise addition of liquid bromine (119.85 g., 0.75 mol.), the reaction was vigorous and it was proceeded under a cold state. The reaction products were refluxed for 3 hrs. The residue was transferred to another fask for distillation, chlorobromomethane formed was redistilled at 68°C. product recovered as chlorobromomethane (49.5 g., 75.8%) of the theoretical amount. (Found: Cl, 26.47; Br, 60.73; Calc. for CH_2Cl Br: Cl, 27.40; Br, 61.77%).

16.6 PREPARATION OF OXYGEN ANALOGUE OF CHLORMEPHOS $(C_2H_5O)_2P(O)-SCH_2Cl$

Potassium diethyl phosphonothionate, $(C_2H_5O)_2P(O)$ SK (9.9 g., 0.05 mol.) was suspended in acetone (100 ml.). Bromochloromethane, CH_2ClBr (12.3 g., 0.1 mol.) was added and the mixture heated under reflux for 7 hrs. The precipitate of Potassium bromide (5.7 g.) was filtered off and clear filtrate evaporated on a rotary film evaporator.

The residue was redissolved in ether (100 ml.) and this solution was washed with a saturated solution of sodium chloride containing potassium carbonate (Ca 1%). The ether wa removed under pressure to leave colourless oily material of Oxygen analogue of chlormephos (6.4 g., 59%) (Found: Cl, 16.1 P, 13.8; Calc. for $C_5H_{12}O_3$ ClPS: Cl,16.2; P, 14.2%).

16.7 PREPARATION OF PHOSPHOROUS PENTASULPHIDE (P_2S_5)

Phosphorus (red) powder (30.97 g., 0.1 mol.) was homogenously mixed with powdered sulphur (80.15 g., 2.5 mol.) and heated at 400°C in sealed tube to fuse the products. The P_2S_5 (111g.) 99%.recovered was analysed. (Found: S, 72.13; Calc. for P_2S_5: S, 72.12; P, 27.87%).

16.8 PREPARATION OF POTASSIUM O,O -DIETHYL THIOLTHIONOPHOSPHATE $(C_2H_5O)_2P(S)SK$

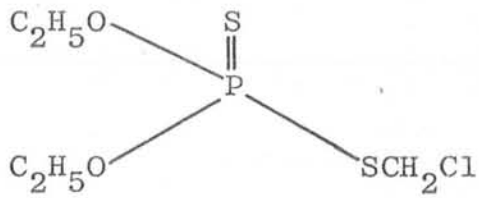
Ethyl alcohol (500 ml.) was added to Phosphorus Pentasulphide P_2S_5(30 g., 0.14 mol.), before the product was isolated Potassium hydroxide (7.57 g., 0.14 mol.) was added and mixture was refluxed for 6 hrs., the reaction mixture was filtered off and filtrate was concentrated to one third of the original volume. The crystalline product (31.27 g., 51.67%) was isolated in a cold state. (Found: S, 26.93; P, 12.96; K, 17.12; Calc. for $C_4H_{10}O_2$ PS_2K: P, 13.8; K, 17.44; S, 27.63%).

16.9 PREPARATION OF CHLORMEPHOS $(C_2H_5O)_2P(S)SCH_2Cl$

Potassium O,O, - Diethyl thiolthionophosphate $(C_2H_5O)_2$ P(S) SK; (11.21 g., 0.05 mol.) was suspended in acetone (100 ml.). Bromochloromethane (12.3 g., 0.1 mol.) was added dropwise and the mixture was heated under reflux for 7 hrs. The precipitate of potassium bromide was filtered off and clear filtrate was evaporated on a rotary film evaporator. The residue was redissolved in ether (100 ml.) and this solution was washed with a saturated solution of sodium chloride containing potassiun carbonate (Ca 1%). The ether was removed under vacuum to leave colourless liquid of chlormephos (7.4 g., 63.08%). (Found: Cl, 14.80; P, 12.82; S, 26.78; Calc. for $C_5H_{12}O_2PS_2Cl$: Cl, 15.11; P, 13.20; S, 27.34

17. MASS SPECTRUM OF CHLORMEPHOS

17.1 Table - 1



M. Wt. = 234 Temp. 180°C

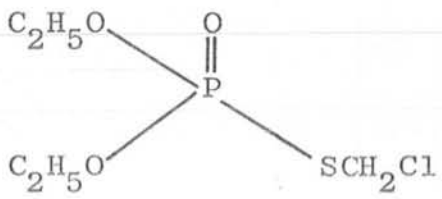
m/e	R.I. %	m/e	R.I. %
234	80.0	121	100
154	93.8	109	20.7
153	26.2	97	95.4
129	18.5	93	53.1
125	46.2	65	53.8
		47	24.6

R.I. = Relative Intensity

Metastable ions observed at m^* 152.6; 102.1; 101.3; 95.6; 71.4; and 45.4

17.2 MASS SPECTRUM OF OXYCHLORMEPHOS

Table - 2



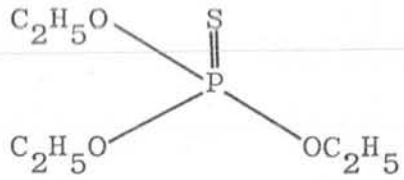
M.Wt. = 218 Temp. 180°C

m/e	R.I. %	m/e	R.I. %
218	2.5	110	100
190	5.0	109	43.7
183	1.8	108	78.9
173	1.9	81	41.3
145	8.1	64	71.0
138	45.6	49	36.4

Metastable ions observed at m^* 165.6; 131.5; 121.5; 88.8; 87.6 & 86.8.

17.3 MASS SPECTRUM OF TRIETHYL THIONOPHOSPHATE

Table - 3



M.Wt. 198.

m/e	R.I. %	m/e	R.I. %
198	83	121	100
170	21.8	97	72.4
153	10.2	93	88
142	23.2	81	33.5
137	9.6	65	74.5
125	22.3	47	15

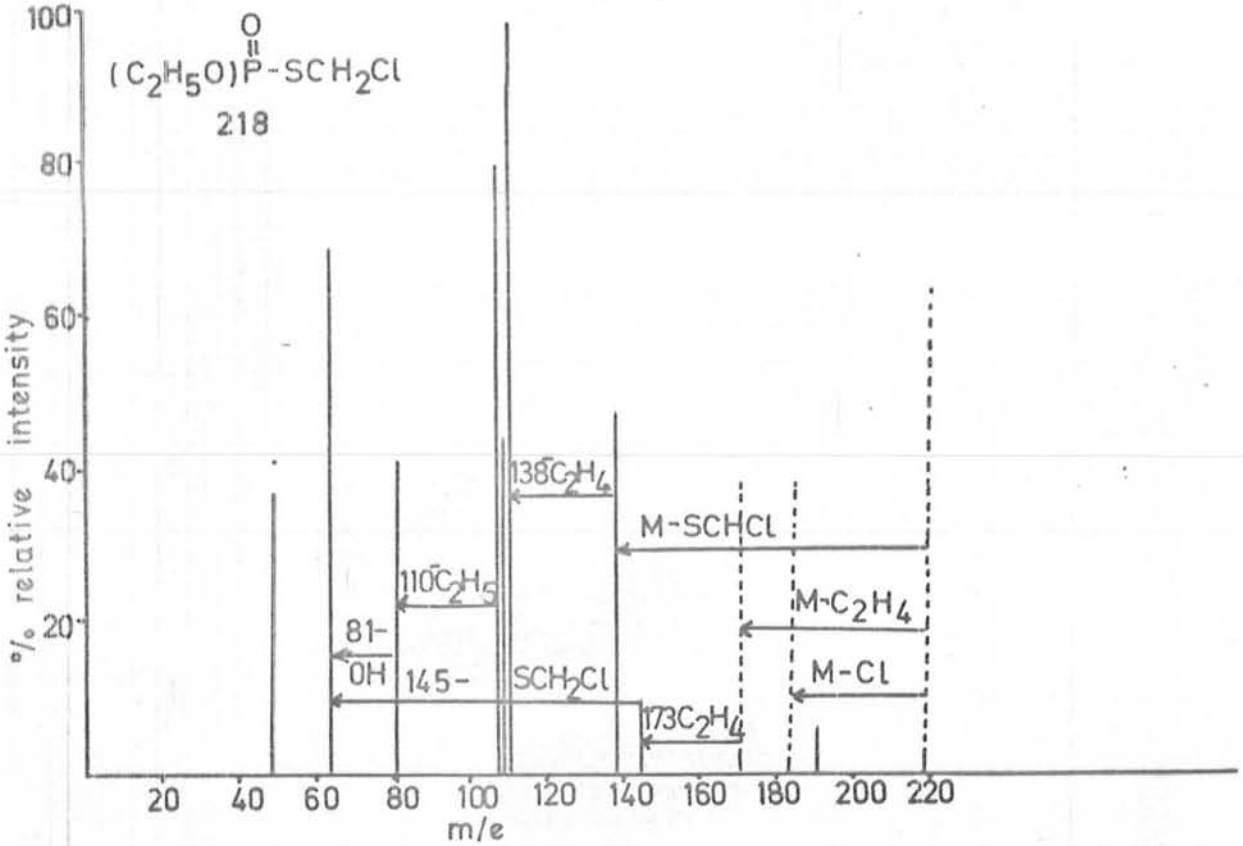


FIG: 2 Oxychlormephos 18.1

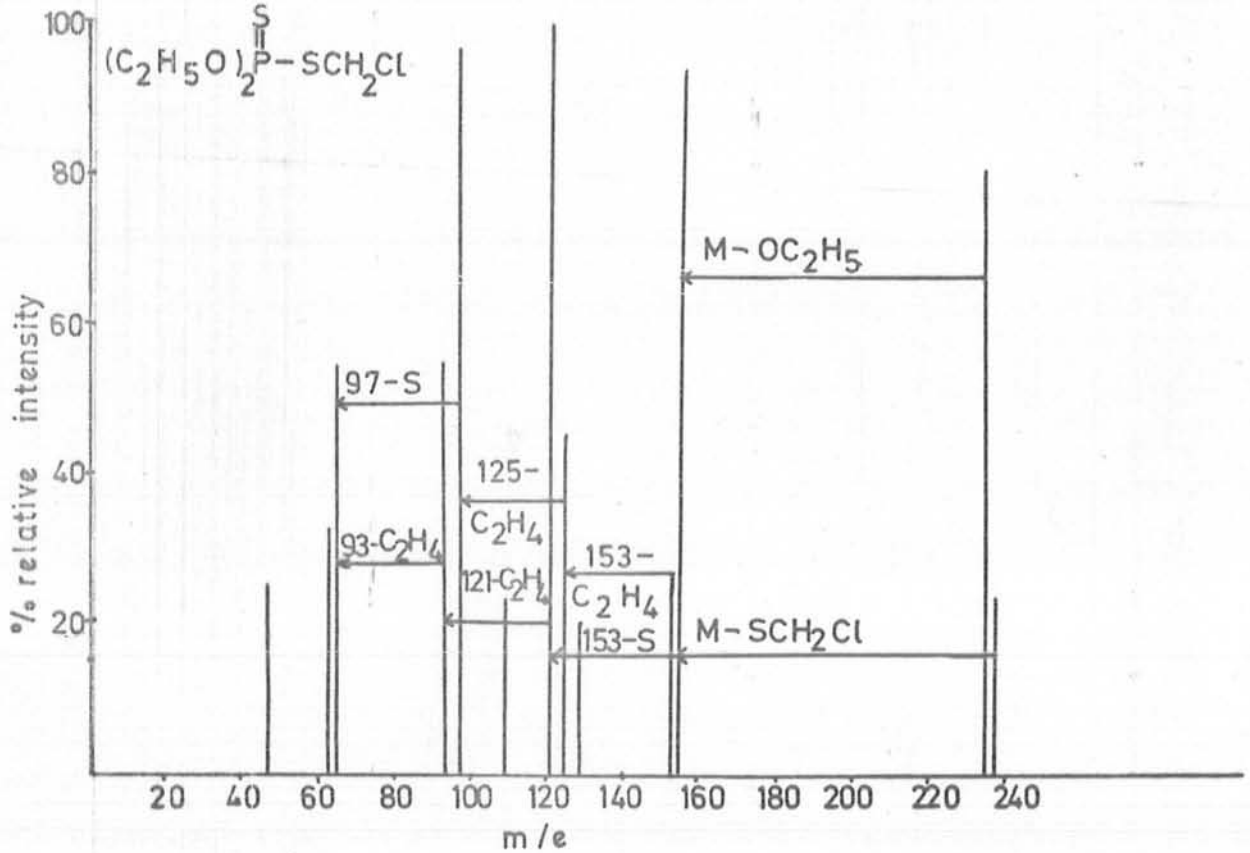


FIG: 3 18.2 Chlormephos

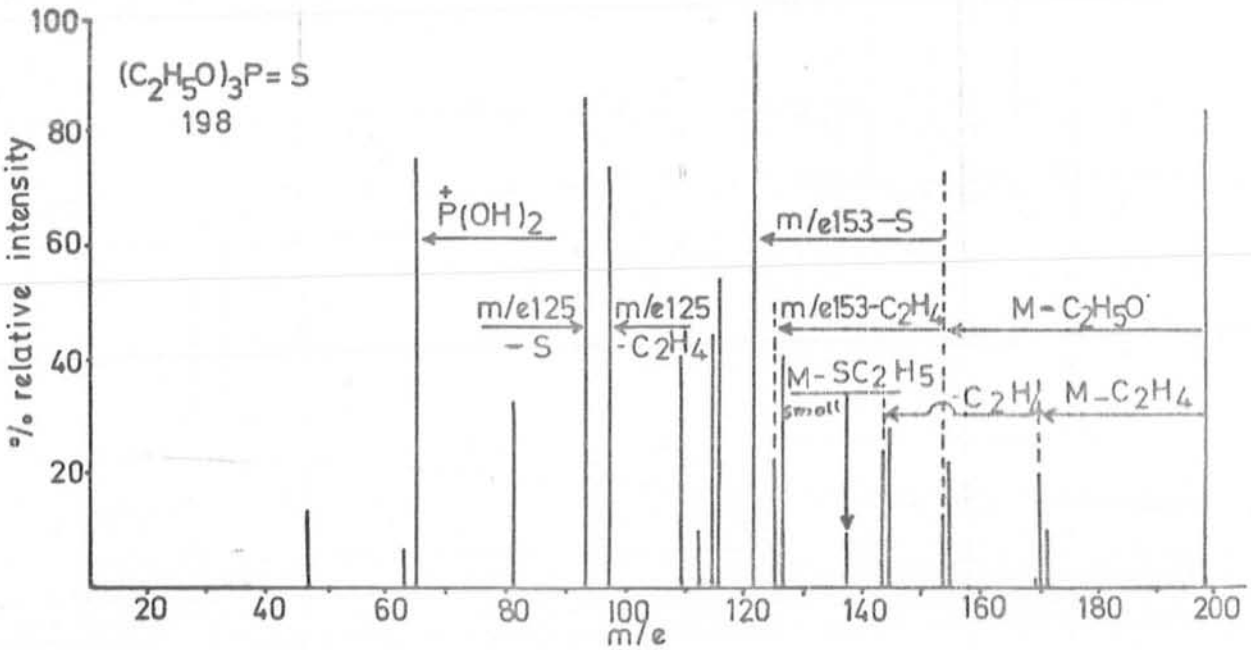


FIG: 4 18.3 Triethyl thionophosphate

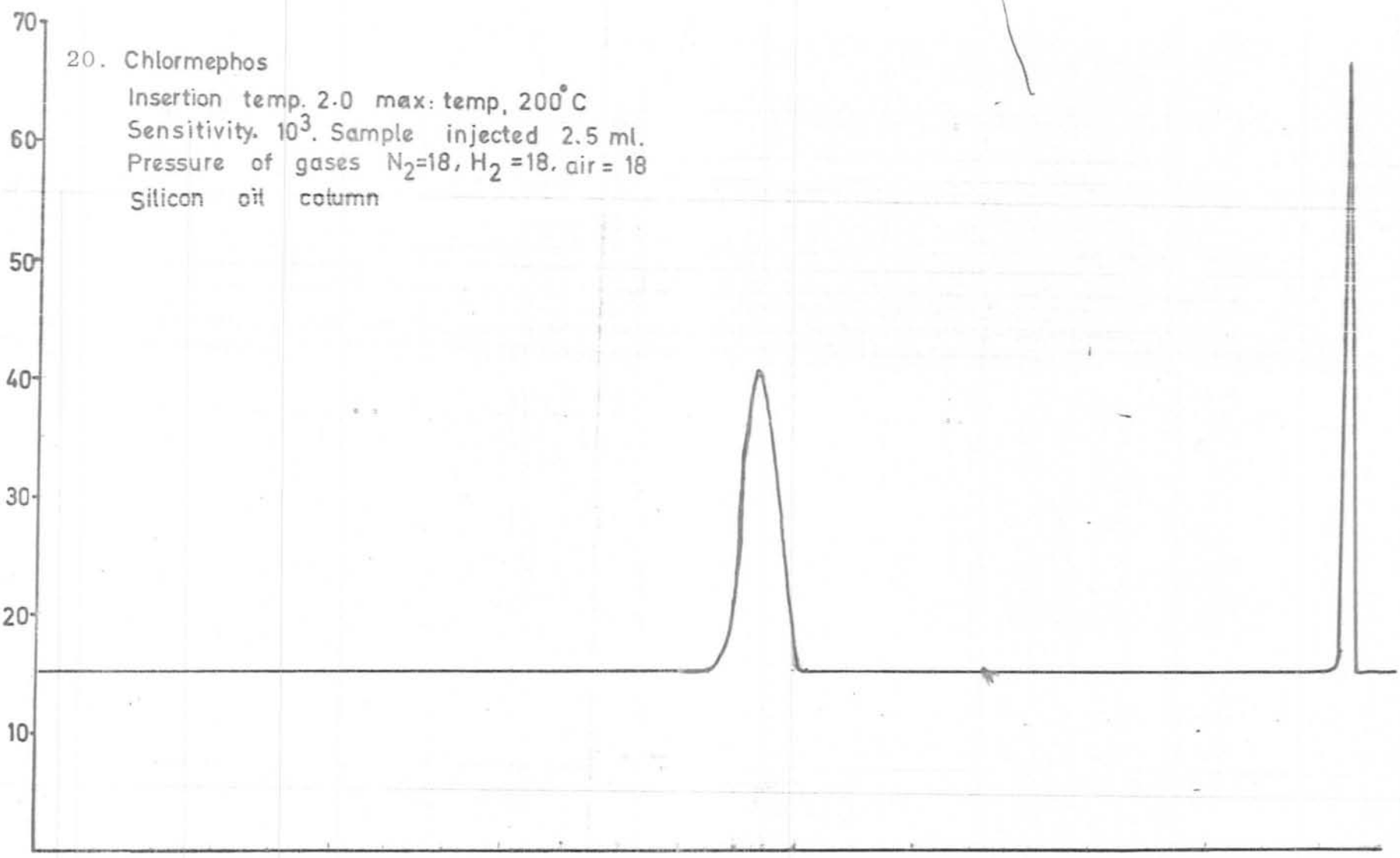
19. PHOSPHATE ROCK

Phosphate rock was collected in the form of a gray solid (pebbles) from Abbottabad area. This material was washed and dried. It was then crushed to a fine powder. The quantitative estimation of this material indicate the presence of Phosphorous 5.7%. The other contents of the rock are tabulated in Table - 4.

S.No.	Contents	%age.
1.	Fe^{+++}	4.36
2.	Ca^{++}	31.17
3.	Mg^{++}	1.552
4.	Na^{+}	0.267
5.	Mn^{++}	0.226
6.	CO_3^{--}	0.5126
7.	SO_4^{--}	2.522
8.	PO_4^{---}	17.656
9.	SiO_2	40.525

20. Chlormephos

Insertion temp. 2·0 max: temp, 200°C
Sensitivity. 10^3. Sample injected 2.5 ml.
Pressure of gases N_2=18, H_2 =18, air = 18
Silicon oil column



REFERENCES

1. Martin, H., The Scientific Principles of Crop Protection, Edward Arnold (Publishers), London 4th Ed. (1959).
2. Frear, D.E.H., Chemistry of Insecticides and Fungicides, Chapman and Hall, London (1943).
3. Wain, R.L., Ann. appl. Biol., (1942), 29, 301-308.
4. West, T.F. and Campbell G.A., DDT and Newer Persistent Insecticides, Chapman and Hall, London (1950).
5. Slade, R.E., Chemy. Ind., (1945), 314.
6. Zimmerman, P.W. and Hitchcock, A.E., Contr. Boyce Thampson Inst., (1942), 12, 321.
7. O'Brien, R.D., Toxic Phosphorous Esters, Academic Press, New York (1960).
8. Pianka, M., J. appl. Chem., (1955), 5, 109-120.
9. Bates, J.A.R., Chemy. Ind., (1968), 1324-1332.
10. Metcalf, R.L., Organic Insecticides, Interscience, New York (1955).
11. Pesticide Manual (ed. Martin, H.) issued by the British Crop Protection Council (2nd ed. 1971).
12. Pianka, M. and Smith, C.B.F., Chemy. Ind. (1965), 1216.

13. Higginbotham, G.R., et al., Nature (1968), 220, 702.

14. Nature (1970), 226, 309-311.

15. Elvidge, D.H., Analyst (1971), 96, 721-727.

16. Saunders, B.C., Phosphorous and Eluorine, Cambridge University Press (1957).

17. O'Brien, R.D., Insecticides, Action and metabolism, Academic Press, New York, (1967).

18. Hoegberg, E.I. and Cassady, J.T., J. Amer. Chem. Soc., (1951), 73, 557-559.

19. Pianka, M., Chemy. Ind. (1961), 324.

20. The Physiology and Biochemistry of Herbicides (ed. Audus, L.J.), Academic Press, New York, (1964).

21. Crafts, A.S., The Chemistry and Mode of Action of Herbicides, Interscience, New York (1961).

22. Garvilescu, N. and Peters, R.A., Biochem. J. (1931), 25, 1397.

23. Peters, R.A., Proc. Roy. Soc., London (1952), B139, 143.

24. Fahmy, M.A.H., et al., J. Agr. Food Chem., (1973), 21, 585-591.

25. Busvine, J.R., PANS (1971), 17, 2, 135-146.

26. Lykken, L. et al., J. Agric. Food Chem., (1957), 5, 501.

27. Quackenbush, F.W. and Rund, R.C., J.A.O.A.C. (1967), 50, 997.

28. Bates, J.A.R., Chemy. Ind., (1964), 1591.

29. Beroza, M. and Bowman, M.C., Anal. Chem., (1965), 37, 291-292.

30. Crossley, H. and Lynch, V.P., J. Sci. Fd. Agric., (1968), 19, 57-59.

31. Giuffrida, L., J.A.O.A.C. (1964), 47, 293-300.

32. Aue, W.A., et al., J. of G.C., (1967), 381-382.

33. B.P. 1258922, December, 1971.

34. J.Am.Chem. Soc. 67, 1662-4, (1945).