VIVEKANANDA COLLEGE THAKURPUKUR KOLKATA-700063

NAAC ACCREDITED ‘A’ GRADE

Topic: PESTICIDE CHEMISTRY (L1,L2,L3,L4 & L5)

Course Title: SEC-B
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SKILL ENHANCEMENT COURSES

SEC-B [SEMESTER 4]

SEC-4 PESTICIDE CHEMISTRY

CONTENTS

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes:Organochlorines(DDT, Gammexene,); Organophosphates (Malathion, Parathion); Carbamates (Carbofuranand carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).

GENERAL INTRODUCTION TO PESTICIDES

Since historical time , there were continuous efforts by man to produce food for the ever growing world's population . In spite of the rapid technological development , still the end has not justified the means in the area of food production . The report of World Health Organisation indicated that a third of the population of the world suffers from hunger and malnutrition. This is because agriculture production faces some problems emanating from invasion by **pests** , weeds, microbial infections, etc.

Pests : A pest is a destructive plant or animal which directly or indirectly affects to humans or human concerns including crops, livestock and forestry. Pests can be birds, mammals (Rats, Mice, Rabbits etc) , arthropods (Grasshoppers, ants, silverfish, flies, beetles, cloth moths etc) , ectoparasites (ticks and mites) , nematodes, gastropods, fungi, weeds etc.

Pest Control : It is the regulation or management of a species defined as a pest. Pest control measures may be performed as part of an integrated pest management strategy. Various methods of pests control include, cultural control, biological control, chemical control etc.

Target : It is the pest against which a particular pesticide or a pest control method is applied. For Example, Marathion (Pesticide) is used to control mosquitoes , therefore, mosquito is the target.

Pesticide : (Pest = damage causing organism and cide= killer) . The term pesticide refers to toxic/ poisonous chemicals which are used directly or indirectly against pests or insects in orders to eradicate or control such pests. Pesticidal compounds are often used in the control of pests and diseases of plants and to control microorganisms and other microbes that disturbs the growth and productivity in plants . They are generally known to be toxic. Pesticide include : Insecticides, Herbicides, Rodenticides, Bacteriocides, Nematocides , Fungicides, etc.

Natural and Synthetic Pesticides

Natural Pesticides: Those pesticides which are obtained from plants or animals (bacteria or fungi) are known as natural pesticides. The root stems, leaves or flowers may be finely grounded and used as such. In some cases active part is extracted from plant and used either alone or with other toxicants and auxiliary materials. Examples of some natural pesticides are : Nicotine, Pyrithrines, rotenones, allethenes, etc.

Synthetic Pesticides: Those pesticides which are obtained by using chemicals are known as synthetic pesticides. They are also known as manmade pesticides. They have very harmful effects too, but because of their effectiveness and cheaper rates, they are much common in use. For example, DDT, Aldrin, Dieldrin, Malathion, Parathion, Alachlor ,Butachlor etc.

Pesticide Residue: It refers to the pesticides that may remain on or in food after they are applied to food crops. The maximum allowable levels of these residues in foods are often stipulated by regulatory bodies in many countries . Exposure of the general population to these residues most commonly occurs through consumption of treated food sources, or being in close contact to areas treated with pestisides such as farms or lawns.

Many of these chemical residues , especially derivatives of chlorinated pesticides, exhibit bioaccumulation which could build-up to harmful levels in the body as well as in the environment.

BENEFITS AND HARMFUL EFEECTS OF PESTICIDES

Benefits

1. According to a report of World Health Organisation the one- third of the population of the world suffer from hunger and malnutrition. This is because agriculture production faces some problems emanating from invasion by pests , weeds , microbial infections , etc. Pests equally attack stored grains , tubers, to the extent that they cause a lot of damage. A complete elimination of the problem above was achieved through by integrated pests management.

2. Pesticides are used in grocery stores and food storage facilities to manage rodents and insects that infest food such as grain.

3. Pesticides are used to control organisms that are considered to be harmful for human beings . For example , they are used to kill mosquitoes that can transmit potentially deadly diseases like West Nile Virus , yellow fever and malaria.

4. They can also kill bees, wasps or ants that can cause allergic reactions. Insecticides can protect animals from illness that can be caused by parasites such as fleas.

5. Herbicides can be caused to clear roadside weeds , trees and brush.

6. Herbicides are commonly applied in ponds and lakes to control algae and plants such as water grasses that can interfere with activities like swimming and fishing and cause the water to look or smell unpleasant.

7. Uncontrolled pests such as termites and mold can damage structures such as furniture and houses . Pesticides can be used to control their population also.

Each use of a pesticide carries some associated risk. Proper pesticide use decrease these associated risks to a level deemed acceptable by pesticide regulatory agencies.

Adverse Effects:

These effects can be studied under following two headings :

(a) Health Effects

1. Pesticide exposure can cause a variety of adverse health effects, ranging from simple irritation of the skin and eyes to more serve effects such as cancer.

2. The use of excessive pesticides can affect the nervous system and mimick hormones.

3. Pesticide exposure can also affect reproductive system of animals and can cause reproductive problems.

4. Pesticides may cause acute and delayed health effects in people who are exposed to them.

5. Non- Hodgkin lymphoma and leukemia showed positive associations with pesticide exposure.

6. There is substantial evidence of association between organophosphate insecticide exposure and neurobehavioral alterations. Limited evidence also exists for other negative outcomes from pesticide exposure including neurological , birth defects and fetal death.

7. Owing to inadequate regulation and safety precaution , 99% of pesticide related deaths occur in developing countries that account for only 25% of pesticide usage.

(b) Environmental effects

Pesticide use raises a number of effects on environment . Over 98 % of sprayed insecticides and 95% of herbicides reach a destination other than their target species (Pests). That is , they go into the air, water and soil.

2. Pesticide drift occurs when pesticides suspended in the air as particles are carried by wind to other areas, potentially contaminating them.

3. Pesticides are one of the causes of water pollution and some pesticide are persistent organic pollutants and contribute to soil contamination.

4. The use of pesticides reduces biodiversity , contributes to pollinator decline , destroys habitat (especially for birds) and threatens endangered species .

5. Pests can develop a resistance to the pesticide (pesticide resistance) , necessitating a new pesticide . Alternatively a greater dose of the pesticide can be used to counteract the resistance, although this will cause a worsening of the ambient pollution problem.

6. Global distillation is the process whereby pesticides are transported from warmer to colder regions of the Earth , in particular the Poles and mountain tops. Pesticides that evaporate into the atmosphere at relatively high temperature can be carried considerable distance (thousands of kilometres) by the wind to an area of lower temperature , where they condense and are carried back to the ground in rain or snow and hence affects environment.

In order to reduce negative impacts , it is desirable that pesticides be degradable or at least quickly deactivated in the environment . Such loss of activity or toxicity of pesticides is due to both innate chemical properties of the compounds and environmental processes or conditions.

CHANGING CONCEPTS OF PESTICIDES:

After 1940, the use of synthetic chemical pesticides remained the major tactics in pest control. When properly used they provide an efficient, fast, reliable and cost-effective means of pest control. Until 1962, pesticide use in agriculture and public health was indiscriminate. Only after the publication of “Silent Spring” by Rachel Carson in 1962 people’s awareness towards the ill effects of pesticides increased. The drawbacks most often cited with injudicious and indiscriminate use of pesticides include development of pest resistance to pesticides, destruction of natural enemies, poisoning of man and animals, environmental pollution, minor pest assuming major status and increasing costs etc. Then a change in the attitude of policy planners of pesticide use, researchers, pesticide manufacturers and users of pesticides was observed. In addition to the conceptual shift concerning pesticide use and manufacture, the selection and extent of pesticide use in pest management is strongly influenced by a host of multifarious factors. These factors exert unseen positive or negative pressures on the need for pesticides in agricultural and health situations, the selection and availability of specific compounds and the extent to which they are used. Recognition of these factors is critical to an understanding of the changes in pesticide use in the tropics. Several international actions have been undertaken on pesticide use in developing countries. Such policies and legislation are aimed at improved pesticide management, a practice that can help avoid pesticide misuse and the possible loss of a valuable and badly needed pest control tactic in the third world. Food and Agricultural Organization (FAO)/ World Health Organization (WHO) established the Codex Alimentarius Commission in 1963 to harmonize international pesticide residue standards through legislation that affect shipment of food item. The commission established Maximum Residue Limits (MRL) for food coming into international trade. These are offered to participating countries for acceptance.

Similarly, an International Code of Conduct on the distribution and use of pesticides was developed by the FAO conference in its 23rd session in 1985. Besides, the member countries have their own regulatory infrastructures for pesticides.

In India, the Directorate of Plant Protection, Quarantine and Storage organization was set up in 1946 under the Ministry of Agriculture, Government of India, which was later, shifted to Faridabad in 1968. This organization looks after the registration, banning, quality testing and setting up laws for pesticide use. Besides, some other laws enforced by Government of India to prevent environmental pollution are Environment Protection Act, 1968, Water (Prevention and Control of Pollution) Act, 1974 and Water Cess Act, 1977. As of this time, over 40 pesticides are included on the suspended, cancelled and restricted use list by Government of India. Clearly, the outright banning or cancellation of pesticide registrations, particularly those in use for many years can have significant, but hopefully beneficial impact on pest management programmes.

STRUCTURE - ACTIVITY RELATIONSHIP(SAR)

The structure-activity relationship(SAR) is the relationship between the chemical or 3D structure of a molecule and its biological activity. The analysis of SAR enables the determination of the chemical group responsible for evoking a target biological effect in the organism. This allows modification of the effect or the potency of a bioactive compound(typically a drug) by changing its chemical structure. Medicinal chemists use the techniques of chemical synthesis to insert new chemical groups into the biomedical compound and test the modifications for their biological effects.

Examples: Two pesticides of interest , molinate and dieldrin, have been shown to cause neurotoxicity in humans, but their mechanisms of toxicity are still unknown. In order to better understand how exposure to these chemicals can cause toxicity , the structure -activity relationship (SAR) was defined to determine how specific changes to the structure of each pesticide affects the toxicity profiles of each of these compounds . Results of this study demonstrated that oxidation of molinate to molinate sulphoxide ,and then further to molinate sulphone , a more potent inhibitor of aldehyde dehydrogenase. The sulphone metabolite is capable of covalently modifying the active site cysteine residue of aldehyde dehydrogenase, accounting for the observed enzyme inhibition. These results indicate that the compound responsible for the toxicity from molinate exposure is not the parent compound , but rather one of the sulphoxidation metabolites. When the SAR of dieldrin was investigated with respect to a Parkinson's disease model, it was determined that the compounds that were previously found to be the least potent insecticides were the most toxic with respect to dopaminergic cells. Each of the compounds tested was observed to disrupt dopamine metabolism in accordance with their toxicity profiles in dopaminergic cells. In combination, these results implicate important structural features responsible for the toxicity with respect to a Parkinson's disease . This information is critical for the development of new pesticides and will be important to increase the selective toxicity for insects. This can lead to the development of safer , more effective pesticides that will be essential for future environmental and human health.

The Structure- Activity Relationship (SAR) , is a rapidly growing field of research in chemistry and biology . Some areas of the application of SAR include the design of more active and less toxic agricultural products (Martin 1978) . Basically , a SAR analysis consists of comparison between experimental values by mathematical variance analysis (e.g. regression analysis , discriminant analysis, factorial analysis and pattern recognition techniques) and a selection of the best correlation values . The best- fitted correlations are then used to develop a mathematical expression to estimate end-values from known substances to unknown substances. When performing a SAR analysis , it is assumed that the chemical or biological response produced by a substance (usually an organic compound) is a direct function of its chemical structure , and that the same substance will always produce the same response , under a given set of experimental conditions . However , chemical structure cannot be dealt directly . Instead quantities, usually of a numerical nature , which are derived from and represent the chemical structures, are used . These quantities are called molecular descriptors . The molecular descriptors are of various types :

(a) Fragments (e.g. counts of atoms , bonds of various types , ring atoms, molecular weight)

(b) Topological (e.g. molecular connectivity, molecular symmetry)

(c) Geometrical (e.g. molecular surface area and volume)

(d) Physico- chemical (e.g. molar refraction) or substructural (e.g. topological)

(e) Physico- chemical properties of substructures as embedded in the structure .

The more relevant to the chemical and to the observed responses the molecular descriptors become , the more exact the approximation will be and the more valid and useful the relationship will be . Based on the work already performed on these initial analyses , this report uses the most promising descriptors. As most of the preliminary work has been done on simpler molecules , an evaluation at this stage may result in a less promising result.

Today , the most promising technique for estimating the toxicity of pollutants is QSAR. However , it should be noted that QSARs should be applied within its recognised limits of applicability, e.g. validity within a certain range of parameters(Kow- values, pH , etc.), certain groups of chemicals (carbamates, phenylureas, triazines, etc). or mode of action . SAR is based on the knowledge that substances with a similar (analogous) chemical structure may have the same biological activity . SAR is a qualitative comparison of the structure of chemical compounds and their effects in the biological system. From this evaluation of the influence of the chemical structure on the biological system , combined with experience in how changes in the chemical structure affect the magnitude and type of biological effect , unknown toxic effects to the biological system of unknown compounds with related chemically structure are predicted.

However , it has been found reasonable to perform such an analysis to assess the current stage of the use of QSARs on pesticides. The fast development in models (i.e . mathematical expressions) has resulted in a constant rewriting to include the most recent relationships during the processing of this report . The inclusion of QSAR in the formal EU technical guidance document on risk assessment (TGD 1996) has made it imperative to present a report on QSARs and pesticides at this stage. For pesticides, the comprehensive data requirements demanded for authorisation normally mean that sufficient data requirements demanded for authorisation normally mean that sufficient data for a risk assessment are present. This is not the case for the additives , impurities and substances used in the formulation of the pesticide product and usually not the case for the degradation or transformation products from biocidal active substances. The research devoted to develop reliable estimation procedures for the toxicity of environmental pollutants may therefore have a potential in estimating the needed data for the groups of substances.

This method was refined to build mathematical relationships between the chemical structure and biological activity , known as quantitative structure - activity relationships (QSAR). A related term is structure affinity relationship (SAFIR).

Factors affecting the environmental fate and behaviour of a chemical

(i) Water solubility

(ii) Adsorption to soil and sediments

(iii) Volatilisation

(iv) Biotic and abiotic degradation

(v) Bioaccumulation

Quantitative knowledge of these processes enables chemists to standardise the concentrations of a certain chemical substance in the different environmental compartments (soil, air, water and sediment). An approach towards the toxicity of a compound with regard to environmental risk assessment would be to determine a "safe level", a concentration at or below which , no organism or only a certain percentage of organisms in an ecosystem would be affected by the compound . For pesticides , the comprehensive data requirements demanded for authorisation normally mean that sufficient data for a risk assessment are present . This is not the case for the additives , impurities and substance used in the formulation of the pesticide product and usually not the case for the degradation or transformation products from biocidal active substances. The research devoted to develop reliable estimation procedures for the toxicity of environmental pollutants may therefore have a potential in estimating the needed data for the groups of substances.

ORGANOCHLORINES (DDT & Gammexene)

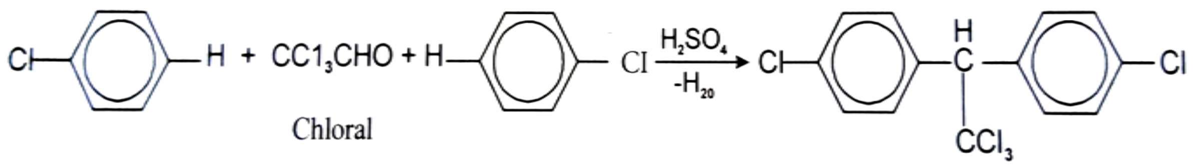
Organochlorine pesticides are chlorinated hydrocarbons which are used extensively from the 1940s through the 1960s in agriculture and mosquito control . Representative compounds in this group include DDT, methoxychlor , dieldrin, chlodrane, toxaphene, mirex, kepone, lindane and benzene hexachloride. As neurotoxicants, many organochlorine pesticides were banned, although a few are still for use all over the world.

DDT(Dichloro- Diphenyl- Trichloro Ethane)

DDT was first prepared by O. Zeidler, a German Ph.D student in 1874. Its insecticidal properties were , however, discovered by a swiss chemist, Paul Muller in 1939.

Synthesis

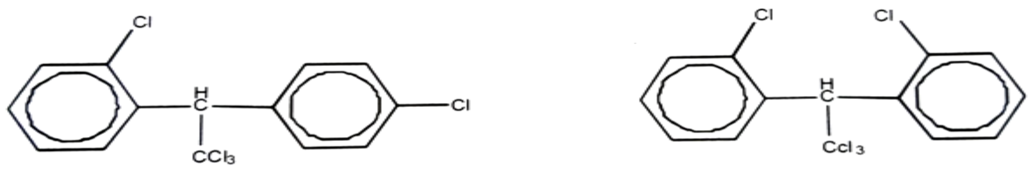
DDT in manufactured by exothermic condensation of chlorobenzene (2-4parts), with chloral (1part), at about in presence of oleum or 99% sulphuric acid (10 parts). Chloral and chlorobenzene   are condensed in a glass lined reactor in presence of 90- 100 % conc.H_2SO_4. The reaction takes 5-6 hours , and the temperature is maintained at 15-30^0 C , by external cooling . The external cooling is done by means of brine or steam coils . The spent acid is withdrawn and the crude DDT is removed from the top , washed with water several times and then neutralised with soda ash.



p-p′-Isomer of DDT

The mixture of DDT and unreacted chlorobenzene is then conveyed to a dryer, where steam melts the DDT and distils any unreacted chlorobenzene , overhead. The molten DDT is then passed to casting pans and practically pure product , thus obtained is pulverized for the market.

Actually the commercial DDT is a mixture of a various isomers in which the para isomer : 2, 2- bis (p- chlorophenyl) - 1, 1 , trochloroethane is present in 70% , the ortho - para 10-15 percent , and the rest being related compounds and impurities.

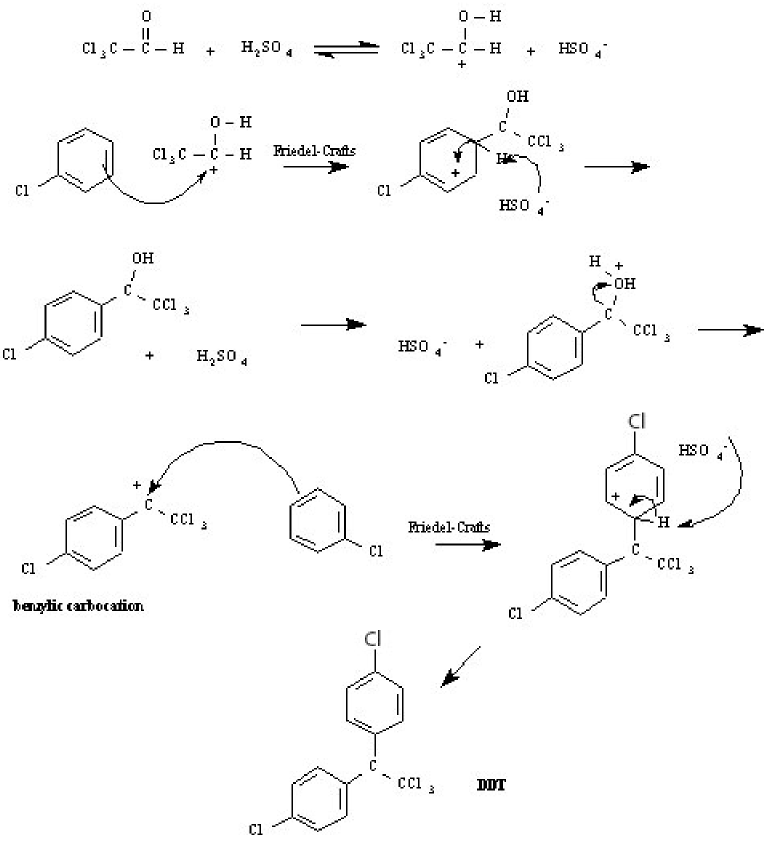


O-*p*′-Isomer of DDT

O-o′-Isomer of DDT

DDT is generally used as a dust contaning 5-10 % emulsions having 25% of the material and also as aerosols.

Mechanism:



Technical Manufacturing of DDT

In industries , DDT is produced by the reaction between monochlorobenzene with chloral in the presence of Oleum as catalyst.

Monochlorobenzene + Chloral → DDT+ H_2O

Therefore , to prepare DDT , first we need to prepare Chloral and purify it to the highest standered. It can be done in following ways : Chloral is prepared by first forming chloral hydrate using chlorination of benzene route.

1. In the process technology, we first discuss the process technology of chloral which is an important ingredient.

2. Dry chlorine is first absorbed into ethanol at room temperature conditions . In this process , the alcohol turns to a syrupy fluid. The operation occurs in a chlorination tank which produces chloral hydrate and HCL.

$4Cl_2 + C_2H_5OH + H_2O \rightarrow Cl_2CCH(OH)_2 + 5HCl$

3. Then chloral hydrate is allowed to distill in the presence of sulphuric acid which dessicates the chloral hydrate to chloral .

4. From the chlorination tank , HCL is seperated by using partial condencer. The uncondencible HCL is sent for gas recovery using scrubbing. The liquid stream from the partial condenser is sent back to the chlorinator.

5. The condensate from the chlorination tank is sent to a still , where distillation is facilitated in the presence of sulphuric acid which acts as a dessicant. Eventually, the still is operated at high temperature and for this purpose , steam is used for heating purpose . To control the operation , cooling water is also circulated in the jacket , as chloral hydrate conversion to chloral is a sensitive reaction.

6. After the reaction , the batch still produce the waste acid as a product at the bottom and the clear chloral liquid at the top along with the vant gases.

7. Eventually chloral is treated with lime to remove dissolved acidic impurities .

8. The purified crude chloral is further sent to distillation in another still remove chloral hydrate present in the stream. Therefore, the second distillation unit is also operated in the presence of $H_2 SO_4$. Vapours released during this step(from the partial condenser) are sent to the vent scrubber.

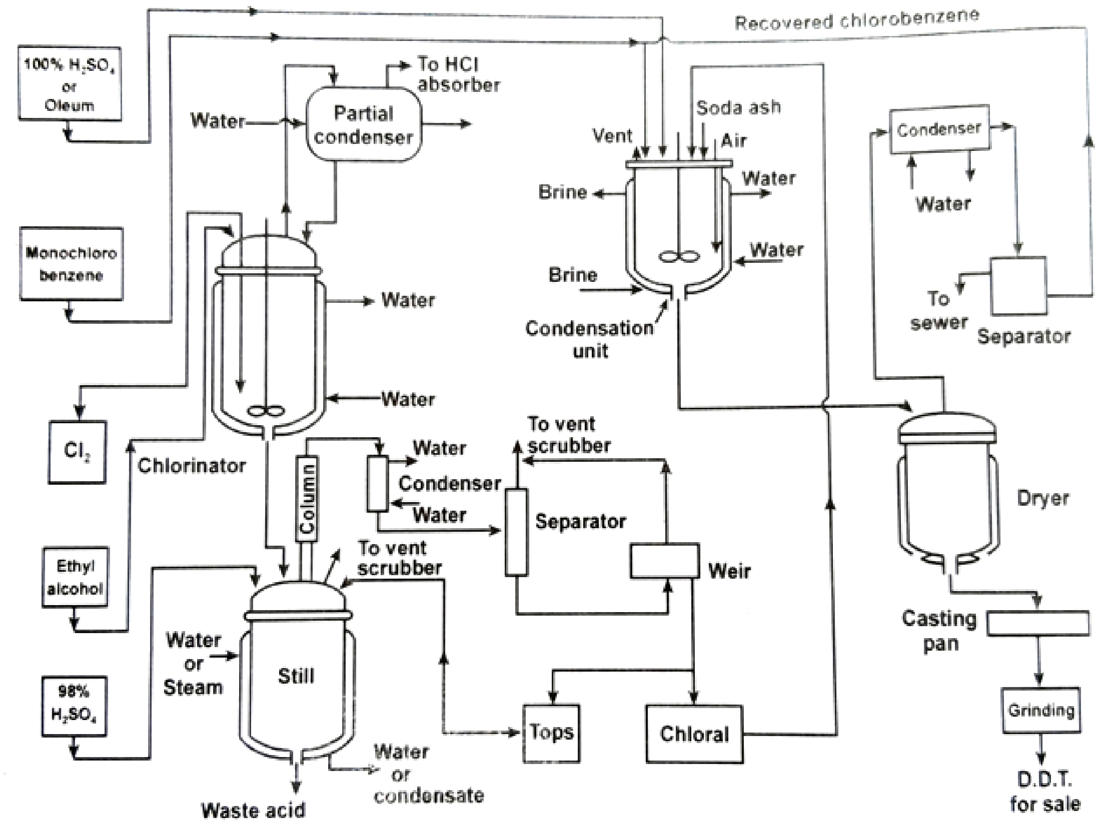
9. Eventually , chloral is produced from the distillation unit and chloral hydrate is recycled back to the chloral hydrate converter to chloral.

10. To manufacture DDT , purified chloral , monochlorobenzene, oleum are allowed to enter the DDT condensation unit.

11. After condensation, the organic layer and spent acid are withdrawn. The organic layer consists of DDT and monochlorobenzene. This is first neutralised with soda ash.

12. After reaction, the organic layer is sent to a dryer where the vapours generated from dryer enter a total condenser followed with gravity settling separator. The gravity settling unit separates monochlorobenzene from other organic impurities . The monochlorobenzene is recycled back to the condensation unit that is meant for preparing the DDT.

13. The Dryer produces DDT powder which is sent for casting / pelletisation process to obtain the DDT in either flakes or in pellets for sale.



Uses

1. DDT was used extensively during World War II by the Allies to control the insect vectors of typhus − nearly eliminating the disease in many parts of Europe .

2. DDT has broad spectrum insecticidal activities , killing variety of insects.

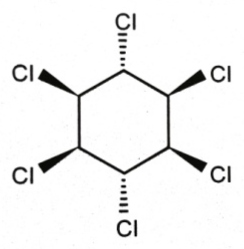
3. It is specifically used against mosquito - transmitting malarial parasites .

4. It is used against flies that transmit typhoid.

5. DDT is mainly used as a pesticide. DDT was the first of the modern insecticides . However , the use of this chemical has been restricted to some degree due to its harmful ill effects and development of resistance in insects and pest as reported in mosquitoes.

Gammaxene or Lindane

Lindane is chemically 1, 2, 3, 4, 5, 6 hexachlorocyclohexane (HCH). It is also known as γ-hexachlorocyclohexane , gammaxene, Gammallin and popularly called as benzene hexachloride (BHC).



Lindane (Gamma isomer)

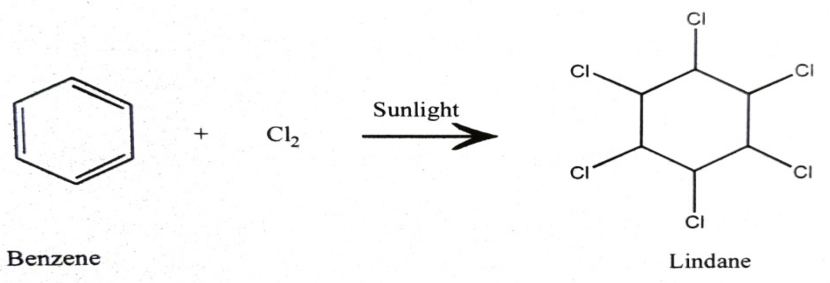
It is an important insecticide which exists in a number of stereoisomer's, the γ(gamma) being the most toxic. The commercial sample possesses 5 main isomers. The percentage of each of the isomer in the commercial HCH is alpha(55-70%), beta(5-14%), gamma(10-13%), delta(6-8%), epsilon(3-4%).

The mode of action of HCH is similar to that of DDT. The size and shape of HCH is responsible for the activity. Amongst all the isomers only γ-isomer fits snugly in the pores of nerve membrane to impart insecticidal activity.

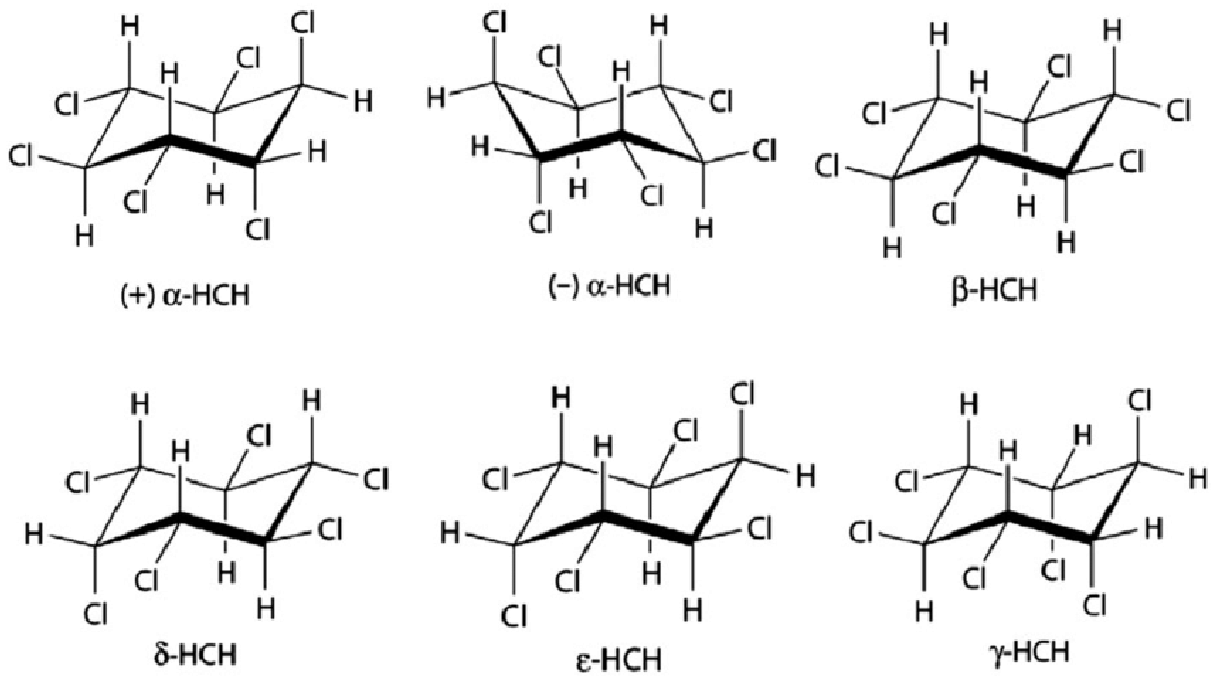
The analytical methods of estimation of HCH are volumetric, colorimetric and Gas-Liquid Chromatography (GLC) using the electron capture detector.

Synthesis

Lindane is prepared by the chlorination of benzene in presence of sunlight. The reaction appears simple , but results in formation of five different isomers .



The product is a mixture of five out of eight possible isomers of which the physiologically active isomers does not exceed 18% . The amount and formation of γ-isomer has been found to increase in presence of some substances such as sulphur, selenium, tellurium, nitrotoluenes , dialkyl peroxy dicarbonates etc. Excess of benzene is used in order to keep the products in solution and to continue the reaction under homogeneous conditions. The reaction can also be carried out in presence of γ-radiation or fluroine (elemental) instead of UV radiation.



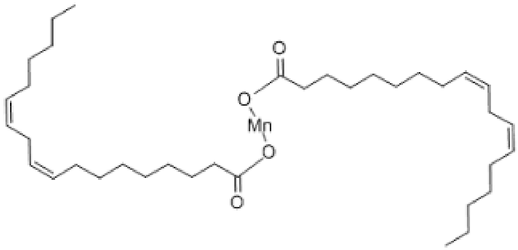
Technical Manufacture

The manufacture can be carried out by batch process or by continuous process . In batch process technical grade benzene and chlorine are reacted in a lead lined vessel provided with cooling arrangements. Mercury vapour lamp is used as UV source . The temperature is kept between 15-20^0 C and pressure is maintained slightly above atmospheric pressure , in order to minimize the loss of benzene . The reaction is continued till the HCH concentration attain 12-15 % . The excess of chlorine is air blown and the mother liquor is concentrated and finally fractionally crystallised to isolate the biologically active γ-isomer.

In continuous process chlorination is carried out in a glass lined pipe chlorinator in the central tube of which benzene is taken and UV source is two 40 watt fluorescent lamps . The temperature is 40 - 60^0 C and pressure is atmospheric . The chlorination is continued till the concentration of BHC reaches 13 - 14.5 % . The chlorinated liquor is concentrated at 85 - 88^0 C till it becomes saturated in γ- isomers and almost all the γ- and β - isomers are crystallised out. The crystals are separated by filtration and the filtrate or mother liquor is subject to steam distillation .

The molten residue in the vessel is cooled to get lumps of crude BHC containing 25% of the γ-isomer . The isomer is then extracted by solvent extraction using hexane - nitromethane solvent mixture. The ground solid is then deodorised by treatment with oleum or agitation in air with $CaCO_3$, MnO_2, **kaolin and manganese linoleate** . γ-Isomer of BHC is more soluble than other in most organic solvents.

NB: Kaolin clay or China clay is the most gentle among all the other types of clays used in skin care. The name **"Kaolin"** originates from "**Kaoling,"** a hill in China from where this clay was first obtained or mined. In China, this clay is mostly used for making porcelain and also as a medicine for treating diarrhea. Kaolin clay is white and has a very soft texture. It is rich in "**Kaolinite,"** a type of mineral.



MANGANESE LINOLEATE

Uses

1. It is used for the control of lice , fleas , ticks, and mange in barns and in and around other farm or agricultural structures.

[Fleas: Flea, the common name for the order Siphonaptera, includes 2,500 species of small flightless insects that survive as external parasites of mammals and birds.

Ticks: Ticks are eight-legged parasites that bite your dog to drink their blood.

Mange: Mange is a type of skin disease caused by parasitic mites. Because mites also infect plants, birds, and reptiles, the term "mange", suggesting poor condition of the hairy coat due to the infection, is sometimes reserved only for pathological mite-infestation of nonhuman mammals.

Barn: A barn is an agricultural building usually on farms and used for various purposes.]

 Mange	 Ticks	 Lice infestations on cattle

2. It may also be used by professional pet care personnel for control of fleas and ticks on dogs.

3. Agriculturally , lindane is registered for use as a seed treatment for a wide variety of crops to control moths , beetle and flies and to deter birds.

4. Lindane may be applied by the home gardener for control of fleas and ticks on dogs and in areas occupied by dogs .

5. It is also used to control boring and leaf mining insects on apples , cherries, peaches, azaleas, rhododendrons and a variety of shrubs and trees. It may be applied as a foliar spray or as a soil drench under these plants.

ORGANOPHOSPHATES (Malathion & Parathion)

The use of organophosphate and carbamate compounds (Figure 1) as insecticides began in the 1930s and has increased markedly since many organochlorine insecticides were banned in the 1970s. In contrast to organochlorine insecticides, organophosphate and carbamate insecticides degrade rapidly in the environment and do not accumulate or concentrate in the food chain. Thus, organophosphate and carbamate insecticides have less potential for chronic health effects or environmental contamination than do organochlorine insecticides and pose less risk to consumers of food products. However, organophosphate and carbamate compounds have a greater potential for acute toxicity in humans than do chlorinated compounds. Even among the organophosphate or carbamate pesticides, however, a wide spectrum of potency exists. As insects develop greater resistance, the trend is to use more potent, and consequently, more lipid-soluble and longer-lasting insecticides.

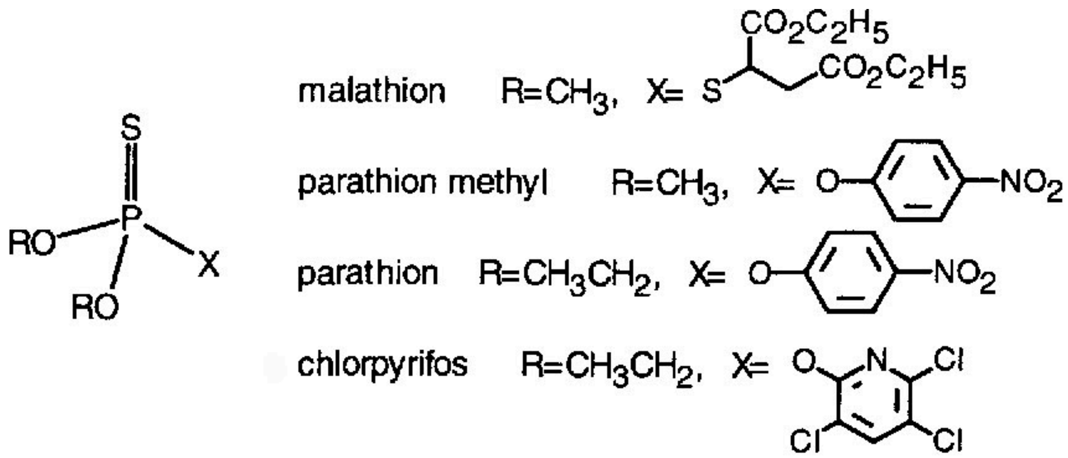
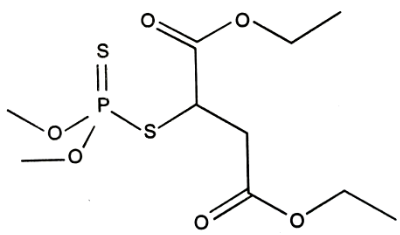


Figure 1. General chemical structure of organophosphate

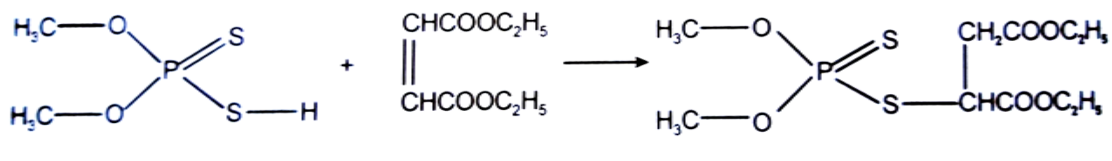
Malathion

Malathion is a clear colorless liquid in its pure form. The technical-grade, which is most often used, is a clear amber liquid. It has a skunk or garlic-like odor. It has a low solubility in water.



Technical Manufacture (Synthesis)

Malathion is typically manufactured using a condensation reaction (at 70-80 °C) of O,O-dimethyl phosphorodithioic acid and diethyl maleate or diethyl fumarate in the presence of hydroquinone.



The feed materials for malathion manufacture are O,O-dimethyl phosphorodithioic acid and diethyl maleate or fumarate. An antipolymerization agent such as hydroquinone may be added to the reaction mixture to inhibit polymerization of the maleate or fumarate compound under reaction conditions. This reaction is preferably carried out at temperatures within the range of 20 deg to 150 °C. This reaction is preferably carried out at atmospheric pressure. The reaction is preferably carried out in a solvent such as the low molecular weight aliphatic monohydric alcohols, ketones, aliphatic esters, aromatic hydrocarbons or trialkyl phosphates. A stirred, jacketed reactor of conventional design may be used. After cooling, the reaction mixture may be taken up in benzene. It is then washed with 10% Na_2CO_3 and with water. The organic layer is dried over anhydrous Na_2SO_4, filtered and concentrated in vacuo to give the final product as residue.

As many as 14 impurities have been identified in technical-grade malathion. The identities of the impurities and their percent (w/w) in technical grade malathion were found to be as follows: S-1,2-ethyl-O,S-dimethyl phosphorodithioate (isomalathion; 0.2%), S-1,2-bis(ethoxycarbonyl)-ethyl-O,O-dimethyl phosphorothioate (malaxon; 0.1%), diethylfumarate (DEF; 0.9%), O,S,S-trimethyl phosphorodithioate (0.003-

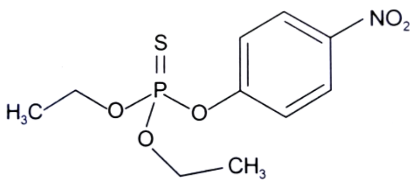
1.2%), O,O,S-trimethyl phosphorothioate (0.04%), O,O,S-trimethyl phosphorodithioate (1.2%), O,O,O-trimethyl phosphorothioate (0.45%), diethylhydroxysuccinate (0.05%), ethyl nitrite (0.03%), diethyl mercaptosuccinate (0.15%), diethyl methylthiosuccinate (1.0%), O,O-dimethylphosphorothioate (0.05%), diethyl ethylthiosuccinate (0.1%), and sulfuric acid (0.05%). **Technical grade malathion may contain malaoxon, isomalathion, or other organophosphates as impurities. These compounds inactivate carboxylesterases, thus increasing malathion toxicity by decreasing the hydrolysis of the drug and increasing the amount of the drug that is oxidized to malaoxon.**

Uses

Malathion is used to kill insects on farm crops and in gardens, to treat lice on humans, and to treat fleas on pets. Malathion is also used to kill mosquitos and Mediterranean fruit flies on (medflies) in large outdoor areas. Malathion is a synthetic phosphorous compound and cholinesterase inhibitor that is strictly used as a topical pediculicide. Malathion exerts its action on the nervous system of the lice by irreversibly inhibiting the activity of cholinesterase, thereby allowing acetylcholine to accumulate at cholinergic synapses and enhancing cholinergic receptor stimulation. This eventually leads to the head lice's death.

Parathion

Parathion, also called **parathion-ethyl** or **diethyl parathion** and locally known as "**Folidol**", is an organophosphate insecticide and acaricide. It was originally developed by IG Farben in the 1940s. It is highly toxic to non-target organisms, including humans, so its use has been banned or restricted in most countries. The basic structure is shared by parathion methyl.



When pure, parathion is a white crystalline solid. It is commonly distributed as a brown liquid that smells of rotting eggs or garlic. The insecticide is somewhat stable, although it darkens when exposed to sunlight.

Technical Manufacture/ Industrial synthesis

Parathion is synthesized from diethyl dithiophosphoric acid $(C_2H_5O)_2PS_2H$ by chlorination to generate diethylthiophosphoryl chloride ($(C_2H_5O)_2P(S)Cl$), and then the chloride is treated with sodium 4-nitrophenolate (the sodium salt of 4-nitrophenol).

$$2(C_2H_5O)_2P(S)SH + 3Cl_2 \rightarrow 2(C_2H_5O)_2P(S)Cl + S_2Cl_2 + 2HCl$$

$$[(C_2H_5O)_2P(S)Cl + NaOC_6H_4NO_2 \rightarrow (C_2H_5O)_2P(S)OC_6H_4NO_2 + NaCl]$$

Uses

Parathion is a broad spectrum, organophosphate pesticide used to control many insects and mites . It has non-systemic, contact, stomach and fumigant actions . It has a wide range of applications on many crops against numerous insect species .

Parathion, an organic phosphorus compound well known as an insecticide that is extremely toxic to humans. The compound acts in mammals, as in insects, as a cholinesterase inhibitor (cholinesterase being the enzyme that controls the normal functioning of the nervous system), causing death by inducing respiratory failure. The specific antidote for poisoning by parathion and other organophosphorus insecticides is atropine. Parathion and similar insecticides must be handled with great care because the substance is toxic if swallowed, inhaled, or absorbed through the skin. Parathion may be rendered nontoxic by application of an alkaline solution.

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