## 3. Classification based on chemical nature:

*(i) Inorganic compounds:* The inorganic compounds having insecticidal property are divided into arsenicals, fluorides and other inorganic compounds.

### a. *Arsenicals*

*Lead arsenate:* $PbHAsO_4$ (acid orthoarsenate), $Pb_4(PbOh)(A_sO_4)$ (basic orthoarsenate). It was used for the first time by Moulton for the control of gypsy moth in the year 1892. It is available in two forms, acid orthoarsenate and basic orthoarsenate. The acid form is more effective and is widely used against insects having chewing type of mouth parts. It is stomach poison with a little contact action.

*Calcium Arsenate:* It is a white powder. The commercial formulation consists of tricalcium arsenate $[Ca(A_sO_4)_2]$ and calcium arsenate $(CaHA_sO_4)$. It is formulated as 25% dust. On storage the percentage of water soluble arsenic increases hence the product stored for a period of more than one year should not be used. It is a stomach poison and is very effective against leaf eating insects.

Other arsenicals are white arsenic or arsenic trioxide $(As_2O_3)$, paris green $(CH_3COO)2Cu.3Cu\ (As.O_2)_2$ etc.

b. *Fluorides:*

*Sodium fluoride:* (NaF). It is a white powder used in preparation of baits against chewing insects. It is highly phytotoxic.

*Sodium Fluoaluminate:* ($Na_3AlF_6$). In naturally occurring mineral cryolite, it is found upto the extent of 98 per cent, but can also be manufactured synthetically. It is relatively less toxic to mammals.

c. *Other inorganic compounds:*

*Sulphur:* It has strong acaricidal and fungicidal action and is formulated as dust and wettable powder. It may also serve as diluent for some insecticidal dusts. It is nontoxic to mammals. Lime sulphur is the aqueous solution of calcium polysulphide which was used for the control of San Jose scale.

*Zinc Phosphide:* It is a grey powder with garliky odour and is used mainly as rodenticide. However, it is also used as a bait for mole crickets in the fields.

*(ii) Organic compounds:* The organic compounds having insecticidal properties are divided into hydrocarbon oils, compounds of animal origin and compounds of plant origin.

(a) *Hydrocarbon oils:*

Petroleum (mineral) oils and coal–tar oils are the oils which are used for insect control. In these oils the presence of the unsaturated compound makes them phytotoxic. These unsaturated compounds when treated with strong sulphuric acid leave unsulfonatable residue (U.R.), the percentage of which indicates the purity of the oil. Based on the U.R. rating, two types of oils are recognised, summer oil with U.R. rating 90–96% and dormant oil with U.R. rating 50–90%.

(b) *Compounds of animal origin:*

Spiders and insects are the common sources for extracting insecticidal venoms. The venom glands of spiders, salivary glands of hemipterous insects, poison glands of hymenopterous insects are generally exploited to obtain insecticidal poi ons. The salivary secretation of *Platymeris* causes failure of heart in cockroaches. Venoms of ants, bees and social wasps have proved as toxic as DDT to a large number of insects such as house fly, termites, rice weevil etc. The product which is obtained from the blood and accessory glands of the male genitalia of several species of meloid beetles is a poison known as 'cantharidin'. This poison although does not harm many species of insects but brings

about appreciable mortality to several insect pests such as fern beetle (*Phyllopertha horticola*), silk worm (*Bombyx mori*), stick insect (*Carausius morosus*) etc. Nereistoxin (NTX) was isolated from a marine annelid, *Lumbrinereis heteropoda* by Nitta in 1934 but its insecticidal properties were discovered by Sakai (1964). Nereistoxin reduces the amount of Ach released from the presynapses and also has inhibitory effect on Ach receptors.

Another compound Dithiothreitol (DTT) is an effective inhibitor of Ach receptors. Because of its structural similarity with nereistoxin, it is presumed that nereistoxin is reduced to DTT which attacks the receptors. A number of related compounds now have been synthesized and are available commercially. Cartap, 1,3–bis (carbamoylthio)–2–(N,N–dimethylamino) propane hydrochloride, is an effective insecticide formulated as 2% dust, 50% WP and 2,5 and 10% granules. It is marketed under the trade name Padan and is very effective against rice stem borer and cabbage diamond–back moth.

c. *Compounds of plant origin:*

*Pyrethrum:* It was used as insecticide for the first time in 1800. It was introduced in Europe in 1828 and in U.S.A. in 1876. It is prepared from the flowers of *Chrysanthemum cinereriaefolium* and *C. coccineum* but the former is the chief source. Chrysanthemum production is maximum in Kenya. The crop is also grown in Japan and Iran. The active ingredients of pyrethrum are four esters, pyrethrin I, pyrethrin II, cinerin I and cinerin II. The esters are derived from two acids (chrysanthemic acid and pyrethric acid) and two alcohols (cinerolone and pyrethrolone).

Pyrethrolone + chrysanthemic acid = pyrethrin I
Pyrethrolone + pyrethric acid = pyrethrin II
Cinerolone + chrysanthemic acid = cinerin I
Cinerolone + pyrethric acid = cinerin II

It is a viscous liquid insoluble in water but soluble in organic solvents. It is highly unstable in the presence of light, moisture and air. Stored products lose 20% of their potency in one year. It has powerful contact action with rapid knock down.

Seasamin, sesamolin and piperonyl butoxide are known to synergize the action of pyrethrum. It is exempted from tolerance limit and is

permitted on food packages by Food and Drug Administration in U.S.A.

Allethrin, dimethrin, barthrin and resmethrin are synthetic analogues of pyrethrum.

*Nicotine:* $C_{10}H_{14}N_2$: It is isolated from atleast 18 species of tobacco plants among which *Nicotiana tabacum* and *N. rustica* are most common. Mention of tobacco extract as insecticide dates back to 1690. (cf. Irwin Schmeltz, 1971). As an insecticide it was first used in 1763 in France and the pure alkaloid was isolated in 1828 by Posselt and Reimann. It was synthesized in 1904 and appeared in the market in 1910 under the name 'Black Leaf 40'. Which was the aqueous solution of nicotine sulfate containing 40% nicotine. It is a colourless, odourless liquid with a boiling point 247°C. On exposure to air, it darkens, becomes viscous and develops disagreeable smell. It is miscible with water below 60°C and soluble in organic solvents. Nicotine does not leave any harmful residue on treated surface. It is highly toxic to mammals. The oral $LD_{50}$ for rats is 50–60 mg/kg.

In addition to nicotine which comprises 97% of the alkaloid content, anabasine and nornicotine are the only other alkaloids of insecticidal importance found in tobacco. Anabasine which is also called neonicotine is obtained from new twigs of *Anabasis aphylla* and nornicotine from *Duboisia hopwoodii.*

*Rotenone:* $C_{23}H_{22}O_6$. Plants containing rotenone have been used as fish poison for many centuries but the active chemical ingredient was isolated by Geoffroy in 1882 and named nicoulene. Nagai Rotenone isolated an identical substance from derris and named rotenone in 1902. Economically rotenone is obtained from the roots of *Derris elliptica* and *Derris malaccensis* belonging to the family Leguminosae. It is white to yellowish white solid substance having melting point 143°C. It is insoluble in water but soluble in polar solvents. It is not photo and thermo-stable and the toxicity is lost after 2-3 days of summer exposure. The mammalian toxicity varies greatly with the animal species, method of administration and type of formulation. The acute oral $LD_{50}$ of crystalline rotenone to rat is 132 mg/kg, to rabbit 3000 mg/kg and to guinea pigs 60 mg/kg. It is highly toxic to fishes.