CHEMISTRY IN SERVICE TO MANKIND

Chemical that are used most commonly by human beings directly or indirectly to make their life easier, sophisticated, healthier etc. are known as **chemicals in service to mankind.** Preparation, properties and uses of these chemicals are studied as **chemistry in service to mankind.**

Out of many classes of organic compounds, some important compounds which are widely used in service to mankind are:

1. Polymers
2. Dyes
3. Drugs
4. pesticides
5. fertilizers

1. Polymers

- A **polymer** is defined as a **high molecular weight** compound formed by combination of large number of same or different kinds of small molecules (monomers).
- The **small molecules** from which large polymers are formed are called **monomers.**
- The process of formation of a large polymer by combination of large number of monomer unit is called **polymerization.**

$$n\ \text{Monomer} \xrightarrow{polymerization} \text{Polymer}$$

CLASSIFICATION OF POLYMERS

On the basis of monomer unit.

A. Homopolymers: The polymers which are made up of **only one type of monomer** unit are called **homopolymers**. Examples: polyethene, polystyrene, Teflon, PVC etc.

If A is a monomer unit then homopolymers are generally represented as, -A-A-A-A-A-A-A-A-

B. Copolymers: The polymers which are made up of **more than one type of monomers** are called **copolymers**. The monomers may be arranged in definite pattern or in a random manner. Example: Bakelite, Nylon-6,6 etc.

If A and B are monomer units then copolymers are generally represented as, -A-B-A-B-A-B-A-B- Or -A-A-A-A-B-B-B-A-A-A-

TYPES OF POLYMERS ON THE BASIS OF MODE OF POLYMERIZATION

1. **Addition polymers/chain polymers:** The polymers which are formed by **addition reaction of monomer** units without elimination of small molecules are known as addition polymers. Monomers containing **double or triple bond** most commonly undergo addition polymerization. Example: Polyethene, Polystyrene, Polyvinyl chloride, Teflon etc.
2. **Condensation polymers/step growth polymers:** The polymers which are formed by **condensation reaction** of two **different kind monomers** with the elimination of small molecules like H_2O, HCl, NH_3 is known as condensation polymers. Example: Bakelite, Dacron, Nylon-6,6 etc.

TYPES OF POLYMERS ON THE BASIS OF THEIR BEHAVIOR ON HEATING

All types of synthetic polymers are commonly known as **plastics.** On the basis of behavior of polymers on heating, polymers are classified into two types, they are:

1. **Thermoplastics:** The polymers which **become soft on heating** and can be **moulded** into different shapes are called thermoplastic polymers or simply thermoplastics. Most of the thermoplastics are formed by **addition polymerization**. Example: polyethene, polystyrene, PVC etc.
2. **Thermosetting plastics:** The polymers which **do not become soft** on heating and **cannot be moulded** into different shapes are called thermosetting plastics. Most of these plastics are formed by **condensation polymerization** forming cross linked polymers. Example: Bakelite, epoxy resin etc.

Classification based on origin

1. **Natural polymers**: The polymers which are synthesized or **produced naturally** by **plants and animals** are called **natural polymers.** Example: protein, carbohydrates, nucleic acid, natural rubber etc.

a. **Starch:** It is a linear polymer of **α -glucose**. It is formed as main food reserve of plant. Its formula is $(C_6H_{10}O_5)_n$

b. **Cellulose:** It is a linear polymer of **β -glucose**. It is main structural component of plants. Its formula is $(C_6H_{10}O_5)_n$

c. **Proteins:** Proteins are the polymers of **amino acids**. They are structural and functional component of animal body.

d. **Nucleic acids:** They are long thread like polymer of **nucleotides**. Each nucleotide unit is composed of three components; pentose sugar, nitrogen bases and phosphate.

e. **Natural rubber:** It is a polymer of **isoprene** (**2-methyl-1,3-butadiene**). They occurs as latex in the bark of tree.

2. Synthetic polymers: The polymers which are **prepared in laboratory** or **manufacture in industry** are called synthetic polymers. They are non-biodegradable as they cannot be broken down into simpler form. Example: polyethene, PVC, polystyrene, Teflon, bakelite, nylon-6,6 etc.

Preparation and uses of some common synthetic polymers:

A. Polyethene: It is the polymer formed by polymerization of large number of ethene (monomer) molecules. It is prepared by heating ethene at about 250°C and 1500 atmospheric pressure in presence of **organic peroxide** as a catalyst

$$n CH_2=CH_2 \xrightarrow{250^\circ C/1500 atm, R_2O_2} (-CH_2-CH_2-)_n$$

ethene (monomer) — polyethene (polymer)

Uses: It is used for making plastic bags, pipes, buckets, bottles, dustbins, toys etc.

High density polyethene (HDP) is prepared by passing ethene at 50°C and 6-7 atmospheric pressure in presence of **Zeigler-Natta catalyst (triethyl aluminium and titanium chloride)**. It is stronger than low density polyethene and withstand high temperature. It is used for making tanks, pipes, bottles, toys etc.

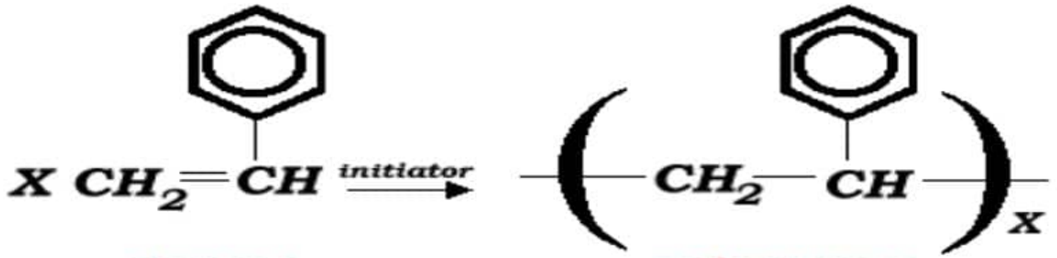
B. Polyvinyl chloride (PVC): It is the polymer formed by polymerization of **vinyl chloride (CH_2=CHCl)**. It is prepared by heating vinyl chloride in presence of benzoyl peroxide.

$$nCH_2{=}CHCl \xrightarrow{\Delta,\ benzoyl\ peroxide} (\text{-}CH_2\text{-}CHCl\text{-})_n$$

Vinyl chloride (monomer) — Polyvinyl chloride (polymer)

Uses: It is used in manufacture of **artificial leather, floor covering, table cloths, raincoats, handbags, pipes and fittings** etc.

C. Polystyrene: It is the polymer formed by polymerization of styrene or phenyl ethene. It is prepared by heating the styrene in presence of organic peroxide (benzoyl peroxide).



styrene — polystyrene

Uses of polystyrene: It is used to make soft drink bottle, disposal cups, foams, packing for delicate materials etc.

D. Teflon (PTFE): It is the polymer formed by polymerization of tetrafluoroethene. It is also called polytetrafluoroethene (PTFE).

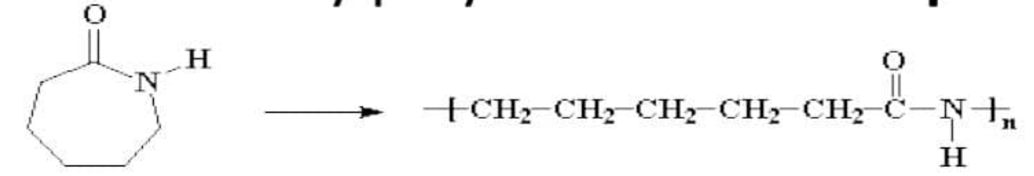
It is prepared by heating tetrafluoroethene in presence of ferrous sulphate and hydrogen peroxide as catalyst. It is an extremely inert polymer, so resistant to heat, acids and alkalies.

$$nCF_2{=}CF_2 \xrightarrow{FeSO_4/H_2O_2} (\text{-}CF_2\text{-}CF_2\text{-})_n$$

Uses: It is used in making gaskets, valves, non stick pans and cooking wares etc.

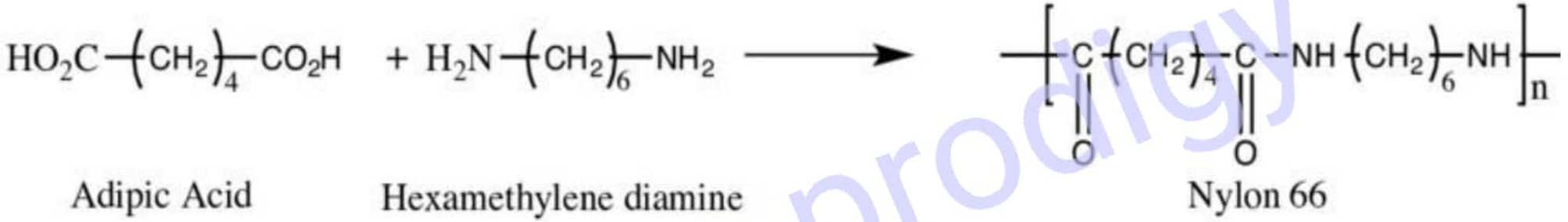
E. Nylon: It is a polyamide polymer containing amid linkage in the polymeric chain. Nylon-6 and Nylon-6,6 is most commonly used nylon.

Nylon-6 is manufactured by polymerization of **caprolactam (cyclic amide)**.



ε-caprolactam nylon 6

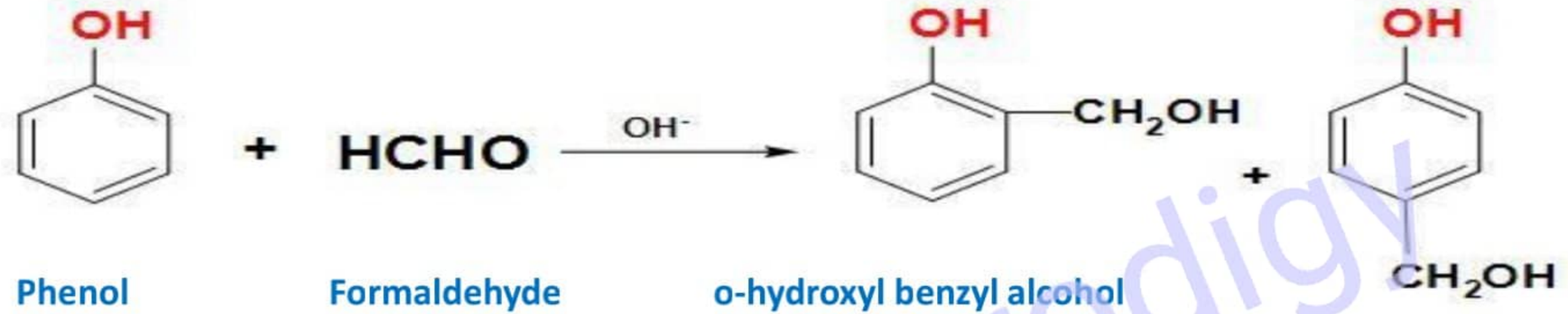
Nylon-6,6 is manufactured by condensation polymerization of two monomers 1,6-diaminohexane and hexane-1,6-dioic acid (adipic acid).



Uses: Nylon is mainly used for making mountain climbing ropes, parachute rope, fishing net, cords, tennis rackets, automobile tubes etc.

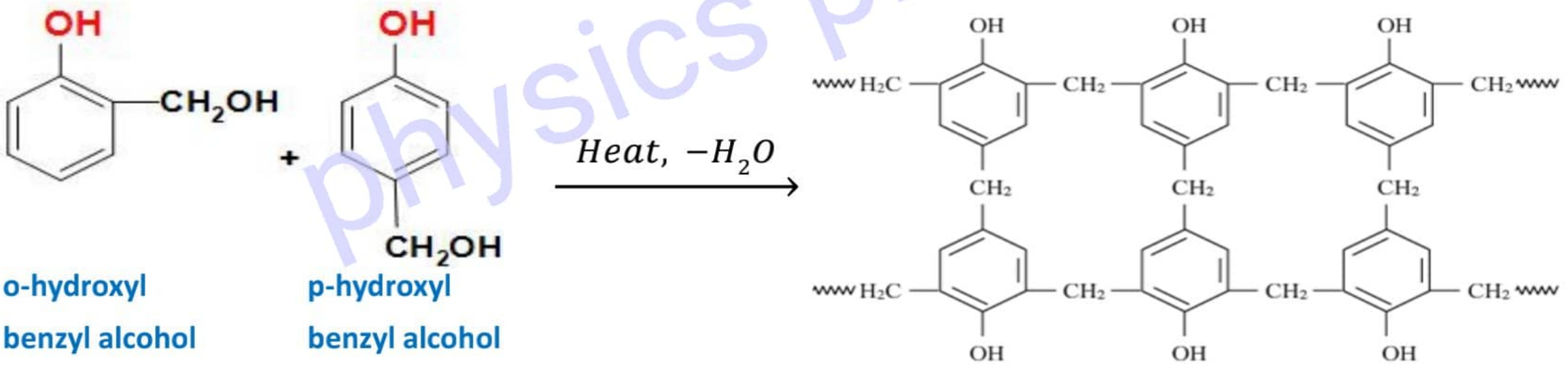
F. Bakelite: It is a polymer formed by condensation polymerization of two monomers **formaldehyde and phenol.**

When phenol is heated with aqueous formaldehyde solution in presence of alkali as a catalyst, **o-hydroxyl benzyl alcohol** and **p-hydroxyl benzyl alcohol** are formed as intermediate product which further undergo polymerization and form hard, insoluble product called bakelite.



Phenol Formaldehyde o-hydroxyl benzyl alcohol

p-hydroxyl benzyl alcohol



o-hydroxyl benzyl alcohol p-hydroxyl benzyl alcohol

Bakelite

Uses of bakelite: Electric switch, combs, handles of cooking utensils , etc

Dyes

The **coloured substances** or compounds which are **used for imparting colour to textile, silk, wool, foodstuff, leather** etc. are known as dyes.

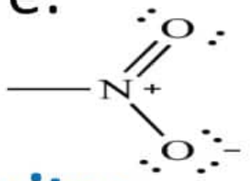
Characteristics of dyes: **All coloured** substances are **not necessarily dye**. A coloured substance is classified as a dye if it has following characteristic features:

1. It must have **suitable colour.**
2. It should **get fixed on the material** from its solution directly or with the help of mordant.
3. Once fixed to the fabric, it **should be resistant to water, air, dilute acids and alkalis** etc.
4. It should **not undergo fading on washing, drying, heating** etc.

Structural component of a dye: Colour of dye is closely related to structure of dye molecules. Generally a dye consist of following **three components**:

a. Chromophores: The part of a **dye containing multiple bonds** (unsaturated groups) due to which dye appears coloured are called **chromophore.**

Some most common **chromophores** are:

-N=N- -N=O  >C=O

azo **nitroso** **nitro** **carbonyl**

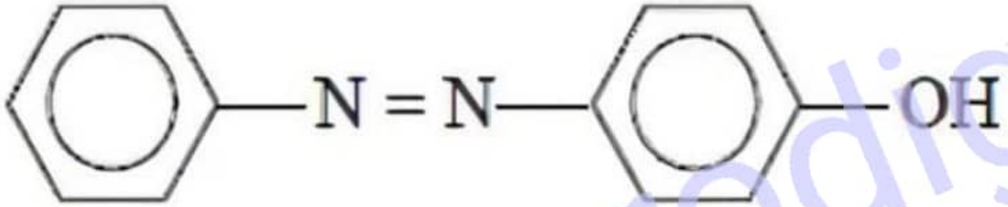
b. Chromogen: The **compound containing chromophore unit** is known as Chromogen.

c. Auxochrome: The **functional group** which do not produce colour themselves but when present along with chromophore **increase the intensity of colour of dye** is known as auxochrome.

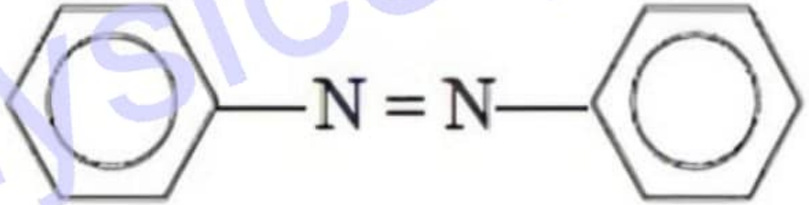
Auxochrome not only intensify the colour of the dye but **also help to attach the dye to fabric** or food stuffs.

Examples: -OH, $-SO_3H$, -COOH, $-NH_2$, -NHR, -OR etc.

Example of dye with all **three components**:



P-hydroxyaxobenzene (red coloured dye)

(a) azobenzene,  is the chromogen

(b) diazo group, – N = N – is the chromophore

(c) hydroxyl group, –OH is auxochrome

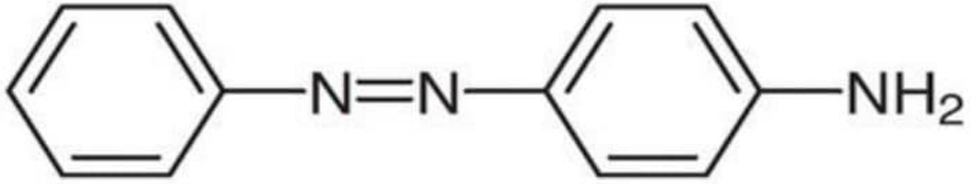
CLASSIFICATION OF DYE

1. On the basis of structure:

On the basis of **types of chromophore unit** present, dyes are classified as follows:

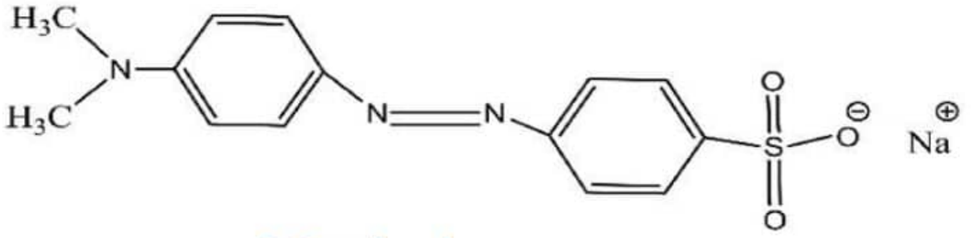
1. **Azo dyes:** The dyes containing **azo group (-N=N-)** joined to aromatic ring as a chromophore unit is called azo dyes. Example:

p-hydroxy azobenzene



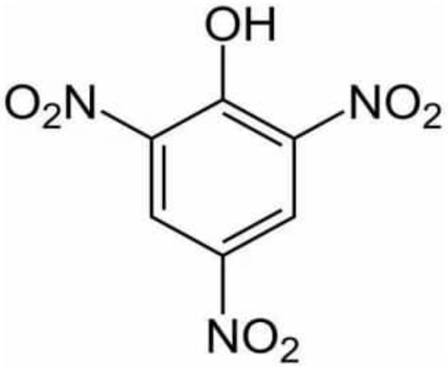
p-aminoazobenzene

(orange red dye)



Methyl orange

2. Nitro dyes: The dyes containing **nitro group (-NO_2)** as a chromophore unit is known as nitro dyes. Example: picric acid, martius yellow



Picric acid

3. Phthalein dye: The dye containing **Phthalein group as a chromophore unit** is known as Phthalein dye. Example: phenolphthalein. It is used as an indicator in acid base titration.

4. Indigo dye: Indio dye is an organic compound containing distinctive blue colour. Example, indigo. It is mainly used for making printing ink.

5. Triphenyl methane dye: Example: malachite green. It is used for dying silk, leather etc.

Type of dyes on the basis of mode of application

On the basis of **mode of application**, dyes are of following types

1. **Direct dyes:** The dyes which are used for colouring the object **directly in their hot aqueous solution** are called **direct dyes**. These stick to the fabrics by hydrogen bonding. Example martius yellow, congo red, napthol, methyl red, etc.
2. **Vat dyes:** These are **water insoluble dyes** which are **reduced to colourless water soluble compound** on treating with sodium bisulphite. The **fabrics are then dipped** into the solution of reduced colourless compound and **then exposed to air or other oxidizing agents**. On oxidation, the dye get converted back into the insoluble oxidized forms and thus provide colour to the fabric. Example: indigo
3. **Mordant dyes:** These dyes do not dye the fabric directly but **get fixed to the fabric with the help of metal ions like Al, Cr, Fe etc.** These metal ions are called **mordant.** The mordant form insoluble coordinate complex between the fabric and the dye. Example: alizarin give rose red colour with aluminium and blue colour with barium.

4. Disperse dye: Disperse dye are **insoluble in water** but get dispersed in water in **colloidal form**. When **fabric is immersed** in colloidal solution of dye, the **dye particles get absorbed** in fabric and **give proper colour** to the fabric. These dyes are used for dying synthetic fibres like nylons, polyesters etc.

5. Developed dyes: The **dyes formed on the surface of fabric by the reaction of precursors**. After their formation, these dyes are attached to the fabric. Colouring with azo dyes are done by this method. In this, the fabric is immersed in the solution of the coupling reagents like phenol or aniline and diazonium salt.

Drugs

The word **drug** is derived from the French word ‘drogue’ which means **dry herbs.** The chemicals which are used to cure, prevent and diagnose disease in man and animal are known as drugs.

The process of treating disease by using drugs is known as chemotherapy.

Characteristics of drugs:

1. The **action** of drug should be **localized** at the site where it is desired to act.
2. It should be **efficient in less amount.**
3. It should have **minimum side effect.**
4. It should be **non toxic.**
5. It should **not make the host cell resistant** to the drug after its use for a long time.

Example: **paracetamol, aspirin, penicillin, streptomycin** etc.

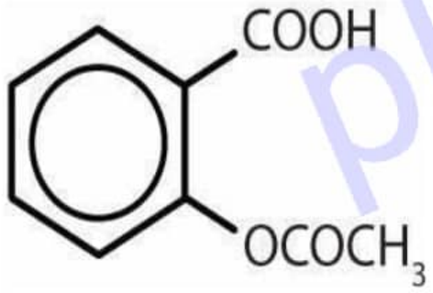
Based on the **sources**, drugs are classified into two types:

1. **Natural drugs:** The drugs which are **obtained from plants and animals** are called natural drugs. **Ayurvedic medicine**, derived directly from plants, animals and minerals are a form of natural or crude drugs containing little amount of active ingredient. Example: **Neem, Garlic, Turmeric, Bakaino, Jatamasi, Panchaule etc**. have been used for thousands of years and are natural drugs.
2. **Synthetic drugs:** The drugs which are **man made or synthesized in the laboratory or in industry** in the form of tablet, capsule etc. are known as synthetic drugs. These synthetic drugs are collectively known as **allopathic medicines**. Example: paracetamol, aspirin, chloramphenicol, streptomycin etc.

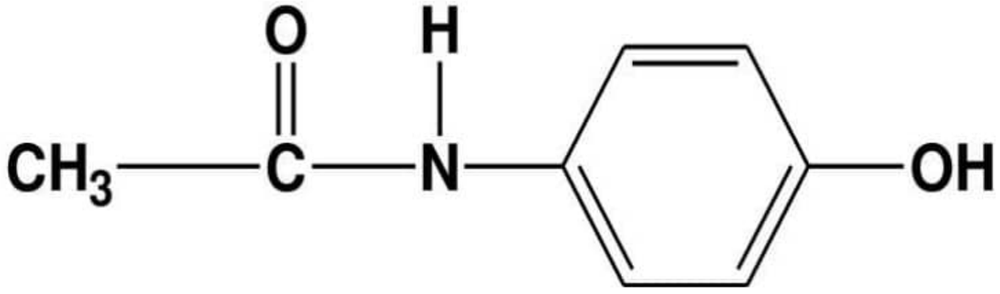
Some common synthetic drugs and their uses

Based on their action against pathogens or physiological effects, synthetic drugs are classified as follows:

1. **Antipyretis**: The drugs which are used extensively to **reduce the body temperature** to normal in case of high fever are called **antipyretics**. These drugs **cause sweating** in the body and thus cool the body of patients. Example: aspirin, paracetamol, antipyrine, analgin etc.



Aspirin



Paracetamol

2. Analgesics: The drugs which are used to **reduce pain** in body of patient without the loss of consciousness is known as analgesics. Analgesics are also known as pain killer. Example: **aspirin, brufin, novalgin, morphin, heroin** etc.

3. Antibiotics: The chemical substances produced by micro-organism (like bacteria, fungi etc.) that either **inhibit the growth or kill the pathogens** (other micro-organism) are called antibiotics. Example: **ampicillin, amoxicillin, penicillin** etc.

The range of micro-organism which an antibiotic can attack is known as **spectrum**. The antibiotic which can kill or inhibit **large variety of micro-organism** is known as **broad spectrum antibiotic**. Example: chloroamphenicol, tetracycline, streptomycine etc.

The antibiotics which are **very specific** and kill or inhibit only **few kind** of **micro-organism** is known as **narrow spectrum antibiotics.** Example: penicillin, vancomycin etc.

4. Sulpha drugs: A type of synthetic drugs that are **synthesized from sulphanilamides** is called **sulpha drugs.** They are mostly **used to treat bacterial infections and diabetes**. Example: sulphaguanidine, sulphadiozine etc.

5. Antiseptics and disinfectants: The drugs which are used to **kill or inhibit the growth of micro-organism** is known as **antiseptics.** They are mostly used to prevent the infection of wound **with out harming the living tissue**. Example: iodine, detol, iodoform solution, 0.2% phenol etc.

The chemical substance which are used to **kill micro-organisms** but **cannot** be **applied on living tissue** is known as **disinfectants.** Example: chlorine water, 1% phenol

6. Anesthetics: The chemical substance that produce the loss of sensation to the whole body or to a part of the body is known as anesthetics. These drugs are generally used to facilitate surgery.

a. **Local anesthetics:** The drugs that produce **loss of sensation in a particular area** of a body are known as **local anesthetics**. Example: ethyl chloride, novocaine etc.

b. **General anesthetics:** The drugs that produce **loss of consciousness of whole body** are known as **general anesthetics**. Eg. Morphine, procaine, pathedine etc.

Drug addiction and its effect: Drug addiction is a **dependence of a person on some drugs** (generally those having narcotic actions) despite the negative consequences. The excessive use of **narcotic (sleep inducing) drugs** like cocaine, morphine, hashish, alcohols, heroin etc. make someone quickly an addict. The **continuous use** of these drugs makes the person **habitual** to such drugs and their scarcity makes the person mentally and physically sick.

These narcotic drugs, on one hand, **provide false happiness and physical and mental relief** to the users and on the other hand, they cause severe physiological problems like respiratory depression, constipation, nausea, vomiting etc.

The addiction may lead to negative consequences to one's personal life and to society. Some of the direct consequences are:

1. Addiction is not just a habit but it **is a sort of disease**.
2. Drug addiction makes a person compulsion to take drugs, increase its dose and make dependence on it.
3. It causes **loss of wealth, health and social reputation**.

For the **prevention** of drug abuse or addiction, **rules and regulation should be strictly implemented** and youths and their parents should be well educated and informed. For the **treatment** of drug addiction, patient should be **taken to rehabilitation centers** and given proper.

Pesticides

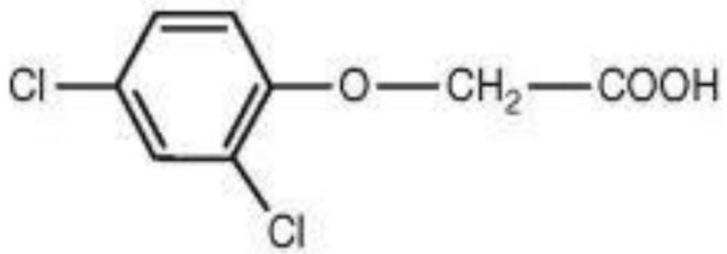
The **chemicals** which are which are used for **controlling or killing pests** are called pesticides. **Pests** are any creature (insects or animals or micro-organism) that harm crops.

Classification on the basis of **type of pest**:

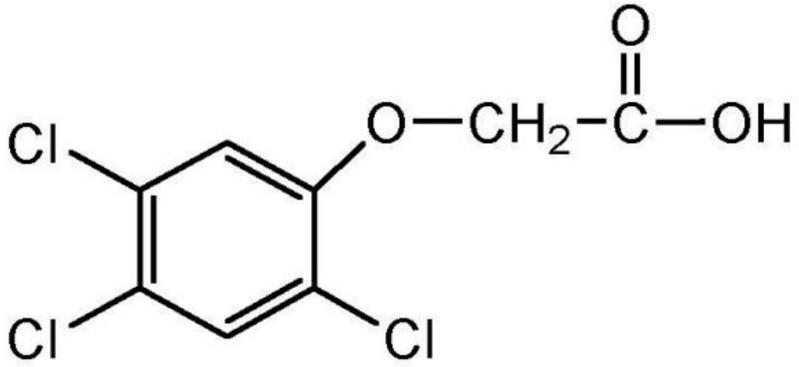
Pesticides are classified into three types on the basis of types of pest.

1. **Insecticides:** The pesticides that are used to **kill or control insects** are called insecticides. Chlorinated hydrocarbons are most commonly used as insecticides. Example: Dichlorodiphenyl trichloroethane **(DDT),** dichlorodiphenyl ethenedichloride **(DDE**), benzene hexachloride **(BHC),** aldrin, pentachlorophenol tec.
2. **Fungicides:** The pesticides which are used to either **kill or inhibit the growth of fungi** are called fungicides. Some commonly used fungicides are **blue vitriol**, **aluminium phosphide**, **chloropicrin (CCl_3NO_2),** pentachlorophenol etc.

3. Herbicides or weedicides: The pesticides which are used to **kill herbs or weeds** (undesired plants) are called herbicides. Some commonly used herbicides are **2,4-D (2,4-dichlorophenoxy acetic acid), 2,4,5-T (2,4,5-trichlorophenoxy acetic acid), atrazine diuron** etc.



2,4-dichlorophenoxy acetic acid



2,4,5-trichlorophenoxy acetic acid

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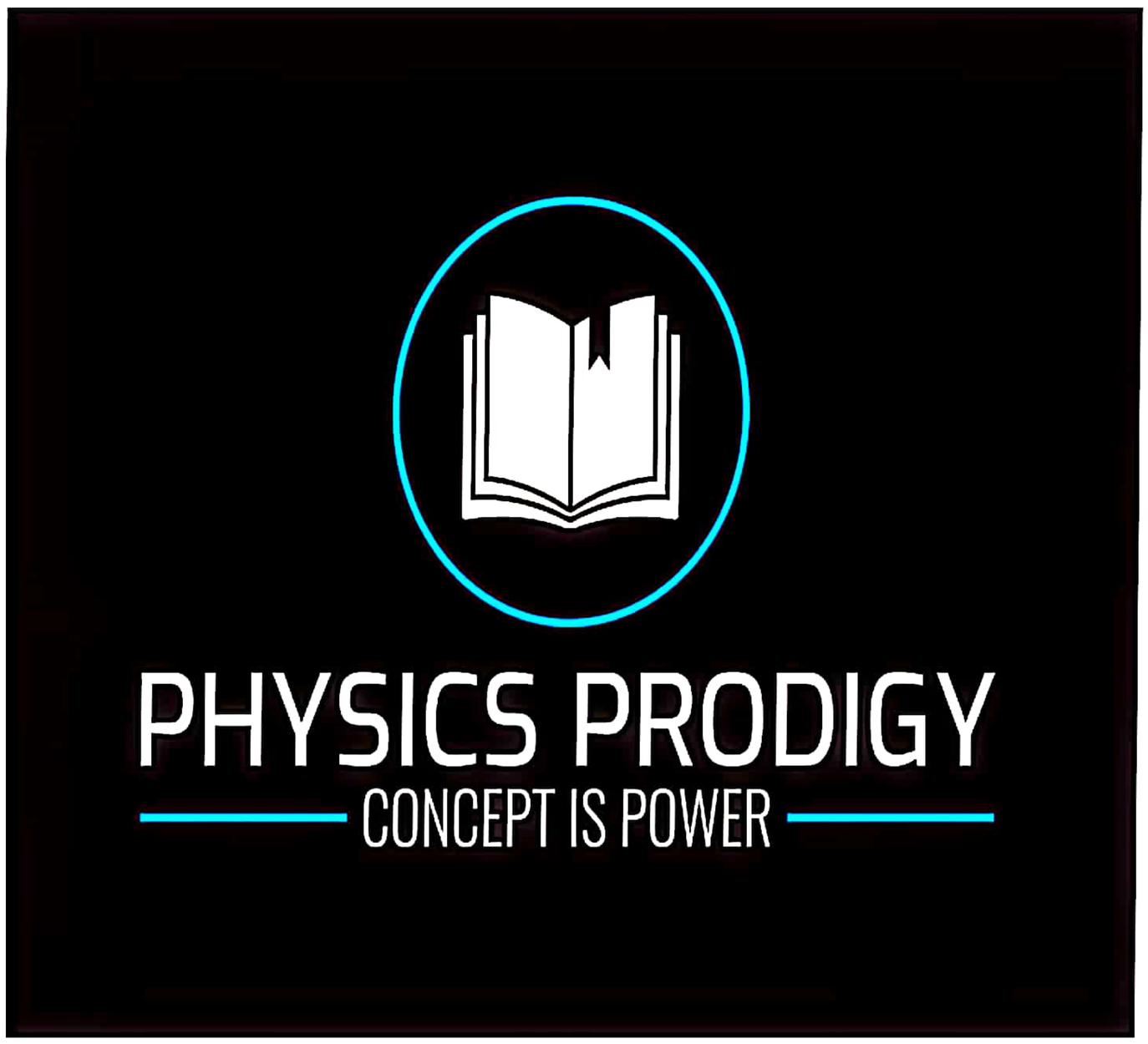

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