

Unit-18

Chemistry in the Service of Mankind (10TH)

 **NEB Syllabus - 4 teaching hours**

Polymers

Addition and condensation polymers

Elastomers and fibres

Natural and synthetic polymers

Some synthetic polymers (Polythene, PVC, Teflon, Polystyrene, Nylon, Bakelite)



Dyes

Introduction

Types of dyes on the basis of structure and method of application

Drugs

Characteristics of drugs

Natural and synthetic drugs



Classification of some common drugs

Habit forming drugs and drug addiction

Pesticides

Introduction to insecticides, herbicides and fungicides

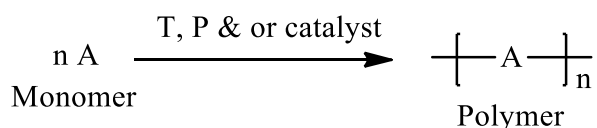
Polymer

The word polymer is made up of two Greek words;

Poly = many & meros = parts

Definition

The Giant molecules (**macromolecules**) with high molecular mass which is made up of large number of smaller **repeating units (monomer)** are called **polymers**.



Monomer

The smaller repeating unit (subunits) which combines to give polymer is known as monomer.

Polymerization

The process of formation of polymer from monomer under suitable condition of temperature, pressure and / or catalyst is called **polymerization**.

Polymer may be linear, branched or cross link.

Classification of Polymers

[A] On the basis of its source of origin:

1) Natural polymers

The polymers formed naturally by living things (i.e. plants and animals) are called **natural polymers**.

Examples:

- a) Polysaccharides: Starch & cellulose are polymer of glucose monomer.
- b) Proteins (e.g., enzymes, wool, silk etc.) are polymers of α -amino acids monomers.
- c) Nucleic acid: DNA & RNA are polymers of deoxyribonucleotide monomer & ribonucleotide monomer respectively.
- d) Natural rubber (Polyisoprene): Polymers of isoprene (2-methyl-1,3-butadiene) monomer.

2) Synthetic polymers

The polymers synthesized or prepared in laboratory or in chemical industry are called synthetic polymers.

Examples:

- a) Polyethene: Polymer of ethene monomer
- b) Polyvinyl chloride (PVC): Polymer of vinyl chloride (Chloroethene) monomer.
- c) Polystyrene: Polymer of styrene (2-phenyl ethene) monomer.
- d) Polytetrafluoroethene (PTFE or Teflon): Polymers of tetrafluoroethene monomer.

- e) Nylon-6,6: Polymer of hexamethylene diamine (Hexane-1,6-diamine) & adipic acid (Hexane-1,6-dioic acid) monomers.
f) Bakelite: Polymer of phenol and formaldehyde monomers.

[B] On the basis of nature / types of monomers:

1) Homopolymers

The polymers formed by combining only one type of monomer units are called *homopolymers*.

Examples:

- a) Polyethene
- b) Polyvinyl chloride (PVC)
- c) Polystyrene
- d) Polytetrafluoroethene (PTFE or Teflon)

2) Copolymers

The polymers formed by combining more than one type of monomer units are called *copolymers*.

Examples:

- a) Nylon 6, 6
- b) Bakelite
- c) Terylene or Dacron (Polyester): Polymer of benzene-1,4-dicarboxylic acid (Terephthalic acid) and Ethane-1,2-diol (ethylene glycol) monomer units.

[C] On the basis of Synthesis:

1) Addition polymers or chain growth polymers

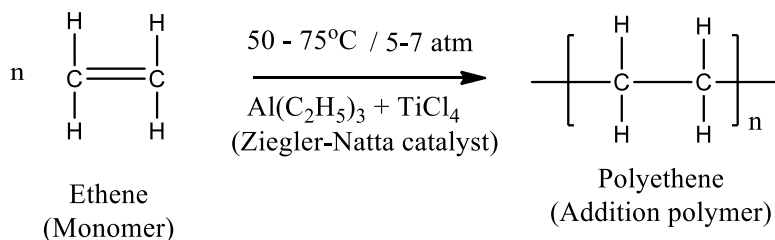
The polymers formed by combining monomer units without elimination of any molecules are called **addition polymers**. And, the process is known as **addition polymerization**.

Monomer units are usually unsaturated compounds.

Formed in single step reaction.

Examples:

- a) Polyethene
- b) Polyvinyl chloride (PVC)
- c) Polystyrene
- d) Polytetrafluoroethene (PTFE or Teflon)
- e) Benzene



2) Condensation polymers or step growth polymers

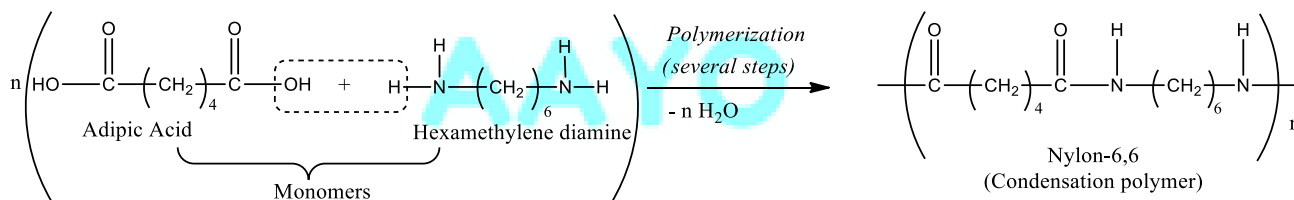
The polymers formed by combining monomer units with the elimination of smaller molecules like H_2O , NH_3 , HCl , etc. are called **condensation polymers**. And the process is known as **condensation polymerization**.

Monomer units are usually two or more with different functional groups.

Formed in stepwise reaction.

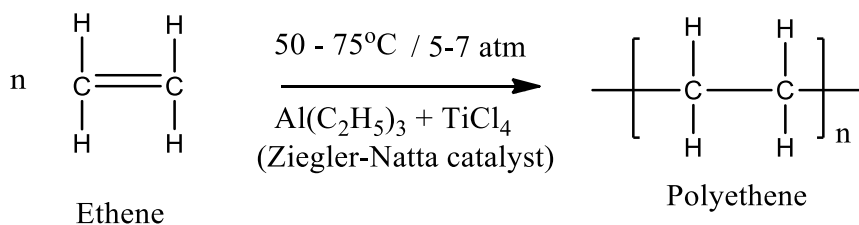
Examples:

- a) Nylon-6,6
- b) Bakelite
- c) Terylene or Darcon (Polyester)



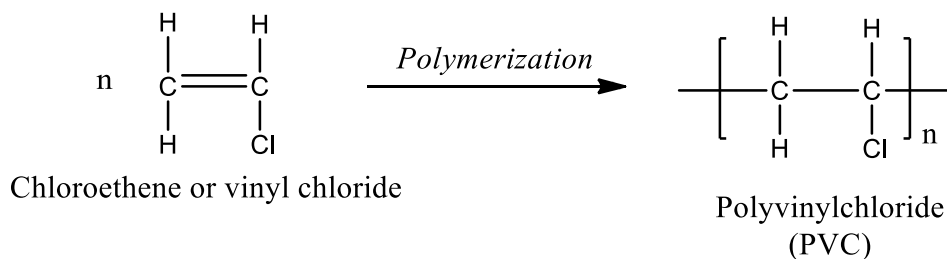
Preparation of Polymers & their Uses

1) Polyethene (thermoplastic)



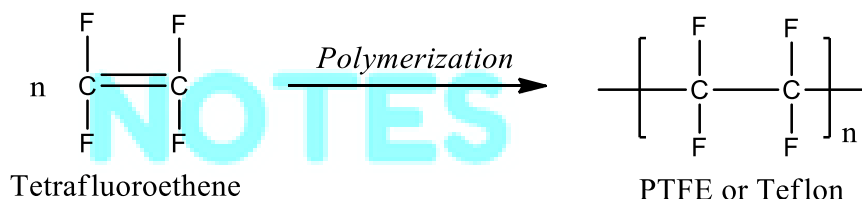
It is used to prepare house wares like Buckets, Dustbins, carpet backing, packaging materials, cable insulations, etc.

2) Polyvinyl chloride (PVC)



It is used to make pipes & fittings, carpets, containers, window & door frames, CD-DVD, cable or wire insulations, blood bags, etc.

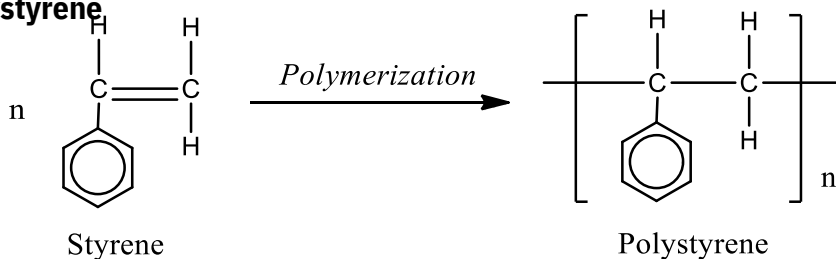
3) Polytetrafluoroethylene or PTFE or Teflon



It is used as non-sticky coatings for cooking utensils (frying pans).

Used in manufacture of waterproof clothes, insulations of electrical items, gaskets, valves, handles for pressure cookers, pans, etc.

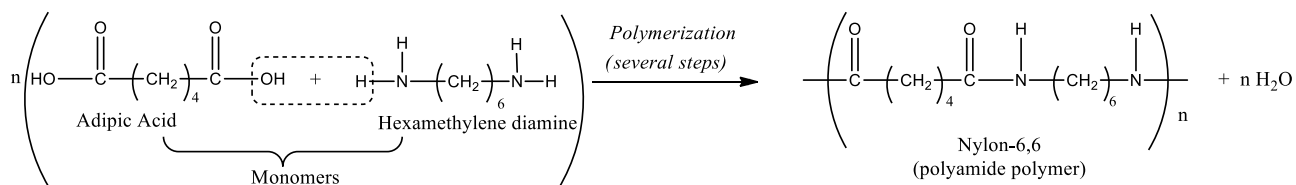
4) Polystyrene



Used to make rigid trays and containers, disposable eating utensils, foamed cups, plates and bowls.

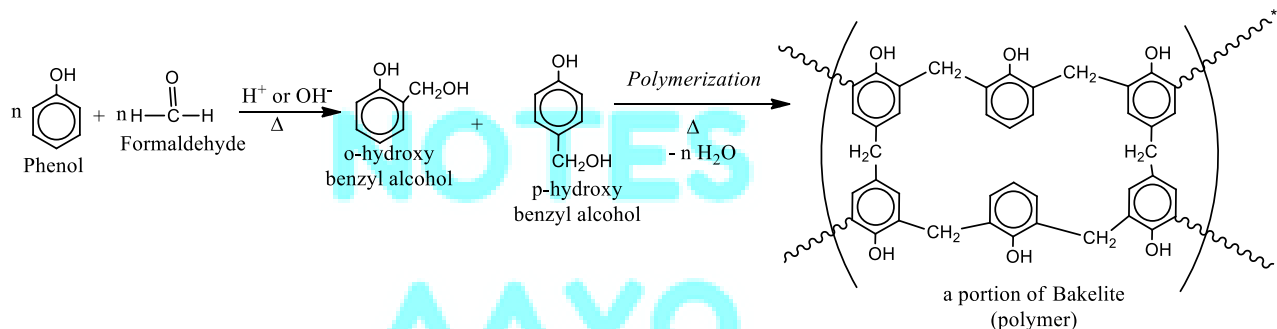
When combined with various colorants, additives or other plastics, polystyrene is used to make appliances, electronics, automobile parts, toys, gardening pots and equipment and more.

5) Nylon-6,6



It is used to make ropes & the nylon ropes which are used in rock climbing, mountain climbing, parachutes, etc.

6) Bakelite (Thermosetting plastic)



It is thermosetting plastic & used to make electrical switches, holders, multi plugs, pressure cooker & frying pan handles, etc.

Elastomers

The polymers that have viscosity as well as elasticity are known as elastomers. Rubber-like solids with elastic properties are called elastomers.

In elastomers, the Polymer chains are held together by relatively weak intermolecular bonds, which permit the polymers to stretch.

An elastomer is a material with the mechanical property that it can undergo much more elastic deformation under stress than most materials and still return to its previous size without permanent deformation.

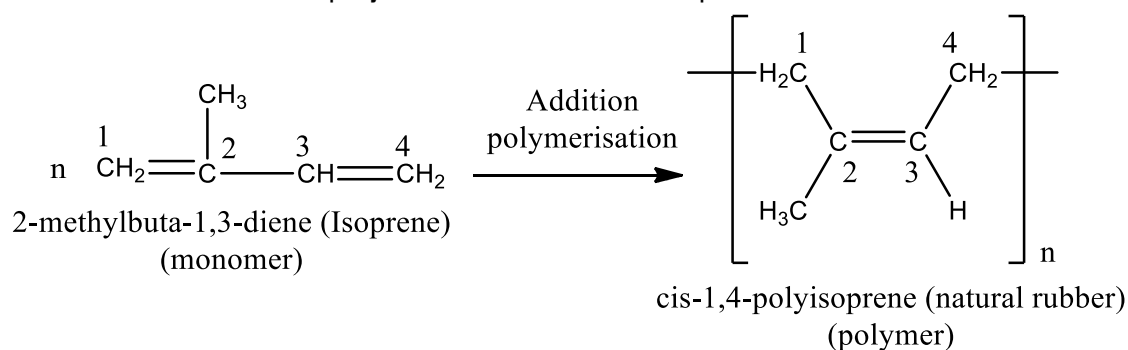
Natural Elastomers(rubber):

The elastomers which can be extracted from natural resources are called natural elastomers. Rubber is harvested mainly in the form of the latex from the rubber tree (*Hevea brasiliensis*).

Example

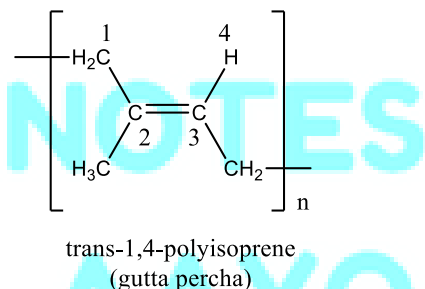
Polyisoprene rubber is chemically cis-1,4-polyisoprene which rubber is also called natural (NR).

The natural rubber is addition polymer of monomer unit isoprene.



NOTE:

trans-1,4-polyisoprene is also called gutta-percha (**Gutta-percha** is a tree of the genus *Palaquium* in the family Sapotaceae).

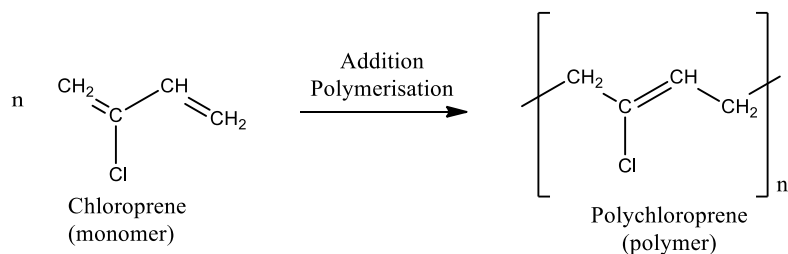


Synthetic Elastomers(rubber):

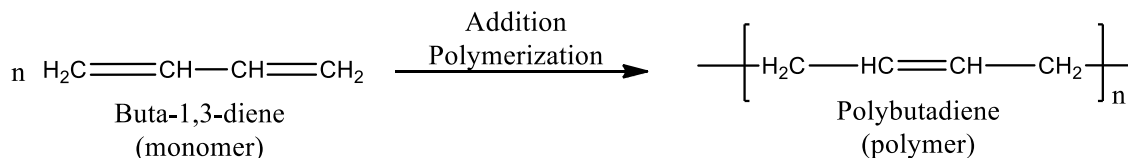
The elastomers which are artificially produced in industry from different chemical compounds are called synthetic elastomers. Synthetic rubber serves as a substitute for natural rubber in many cases, especially when improved material properties are required.

Example:

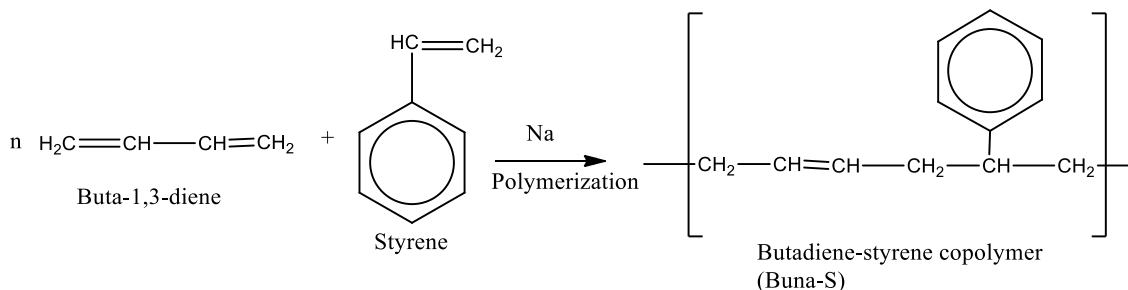
Neoprene (also polychloroprene) is a family of synthetic rubbers that are produced by addition polymerization of chloroprene monomer unit.



Polybutadiene [butadiene rubber BR] is a synthetic rubber. Polybutadiene rubber is a polymer formed from the addition polymerization of the monomer 1,3-butadiene.



Other synthetic elastomer (rubber) includes **Buna-S (SBR)** is a **copolymer of 1,3-butadiene and styrene**. It is obtained by polymerization of 1,3-Butadiene and styrene in the ratio 3:1 in the presence of sodium. In Buna - S, Bu stands for butadiene, Na for sodium and S for styrene.

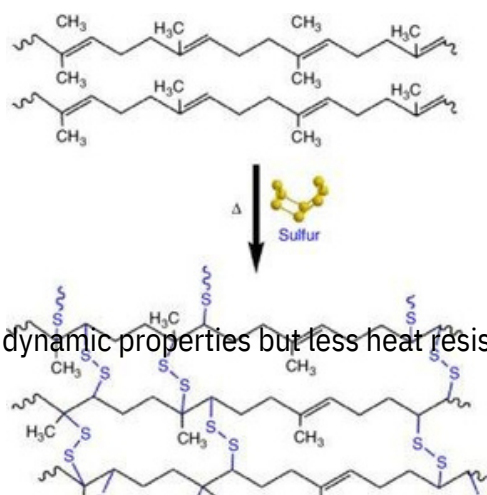


Vulcanization

Vulcanization is a **chemical process in which the rubber is heated with sulphur, accelerator and activator at 140–160°C**. The process involves the formation of cross-links between long rubber molecules so as to achieve improved elasticity, resilience, tensile strength, viscosity, hardness and weather resistance.

The word vulcanization is derived from Vulcan, the Roman god of fire and forge.

The main polymers subjected to sulfur vulcanization are polyisoprene (natural rubber) and styrene-butadiene rubber (SBR), which are used for most street-vehicle tires.



dynamic properties but less heat resistance.

During vulcanization, some of these C-H bonds are replaced by chains of sulfur atoms that link with a cure site of another polymer chain. These bridges contain between one and several atoms. The number of sulfur atoms in the crosslink strongly influences the physical properties of the final rubber article. Short crosslinks give the rubber better heat resistance. Crosslinks with higher number of sulfur atoms give the rubber good

Fibres

The polymers that form **thread-like structures that are thin, long, and flexible strands**. The two main sources of Fibres are plants and animals.

Natural Fibres

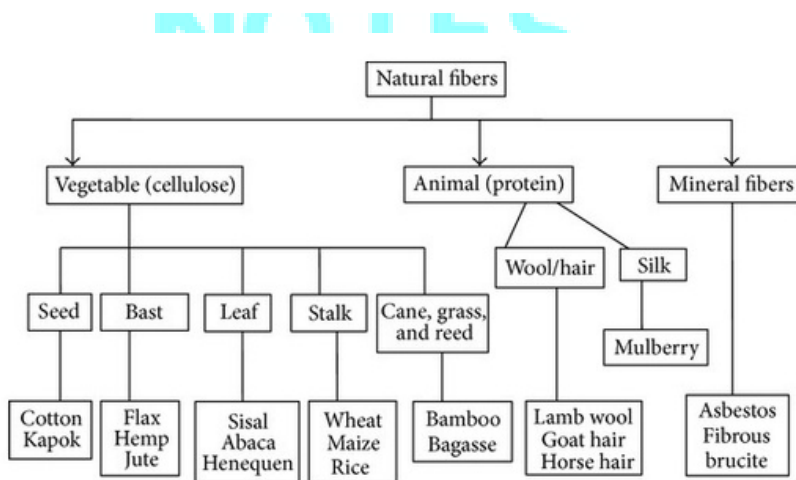
The Fibres obtained naturally from both plants and animals are termed as the Natural Fibres. These Fibres are hair-like raw material directly obtainable from different plants and animals.

Plant Fibres: Cotton and jute are examples of plant-based fibres. Plant Fibres come from a variety of sources, including bamboo, coconut trees, flax seeds, Cannabis sativa plant species, vegetable fibres, cellulose-based, straw, Nettle, Ramie, wood, and cereals.

Animal Fibres: Wool and silk are two examples of animal-derived fibers. Animal Fibres are made up entirely of proteins and the animals' protective epidermal coating for example silk, wool/hair.

Animal fibres come from sheep, camels, cashmere and mohair goats, rabbits, yak, silkworms.

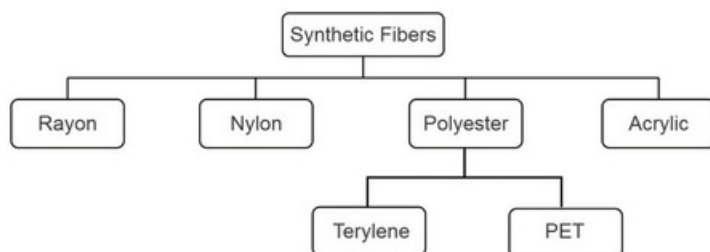
Mineral Fibres: Mineral fibres are inorganic minerals formed into fibers. Asbestos is one example. These fibers are employed in industrial applications because they are fire and acid resistant.



Synthetic Fibres

These fibres are created artificially by humans in businesses where polymers are manufactured to make garments using basic chemicals.

Polymers are macromolecules formed by linking tiny, repetitive components together. Synthetic fibres are best represented by Rayon and Nylon. Acrylic, polyester, and acetate are among the others.

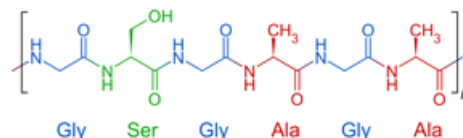
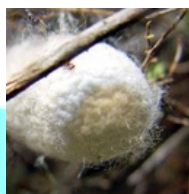


Some examples of natural and artificial fibres:

Silk

Silk is a protein fiber that may be woven into textiles in many ways. Silk is made up mostly of fibroin, a protein fiber generated by some insect larvae in order to build cocoons. The most well-known silk comes from the cocoons of *Bombyx mori* larvae raised in captivity (sericulture).

Element of silk fiber	Amount%
Fibroin	75
Ash of silk fibroin	0.5
Sericin	22.5
Fat & Wax	1.5
Mineral Salt	0.5
Total	100



Silk's glossy look is due to the triangular prism-like structure of the silk fiber, which allows silk material to refract incoming light at different angles, generating various hues.

Rayon

Rayon is a man-made fiber created from regenerated cellulose found in natural sources such as wood and agricultural goods. The molecular structure is identical to that of cellulose. Viscose is the other name for it.

Uses of Fibres

1. It is used to make ropes & the nylon ropes are used in rock climbing, mountain climbing, parachutes.
2. An artificial textile fibre made from a polyester, used to make light, crease-resistant clothing, bed linen, and sails.

Drugs

The term drug is derived from French word „**Droque**’ which means “dry herb”

Definition

The chemical substances used in prevention, diagnosis and treatment of different types of diseases are called drugs or medicines.

According to WHO: “A drug is defined as any product (substance) that is used to modify or explore physiological system or pathological states for the benefit of recipient.”

The process of treating diseases by using chemicals (drugs) is called chemotherapy

Father of chemotherapy- **Paul Ehrlich**

Characteristics of Drugs

A good drug has following characteristics;

1. It must be non-toxic to the recipient.
2. It should have minimum side effects.
3. It should be highly effective.
4. The action of drug should be localized at the site where it is desired to act.
5. It should not make the host cell resistant to the drug after its use for a long time.

Classification of drugs

A) On the basis of source of origin:

Natural and Synthetic drugs

Natural drugs

The chemical substance which is obtained from plants, animals, microorganisms, etc. that is used in the treatment of various diseases are called natural drugs.

Example: Penicillin, Atropine, Morphine, etc.

Synthetic drugs

The chemical substance which is synthesized in the laboratory by using different chemicals that is used in the treatment of various diseases are called natural drugs.

Example: Paracetamol, chloramphenicol, etc.

B) On the basis of mode of action / therapeutic actions:

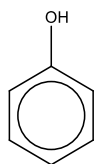
1. Chemotherapeutic drugs: Used to treat infectious disease caused by microorganisms. Used to treat bacterial, viral, protozoal, malarial infections, etc.

2. Pharmacodynamic drugs: Used to treat disease caused by functional disorder or degradation of body not by microorganisms. Used to treat anemia, cancer, diabetes, depressions, cardiovascular disorders, etc.

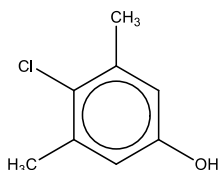
Examples of Chemotherapeutic drugs

1. Antiseptics:

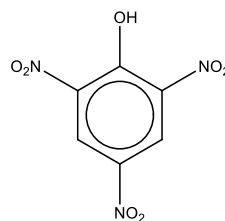
Inhibit growth of microorganism either by inhibiting their reproduction or by causing their death but safe to host cell.



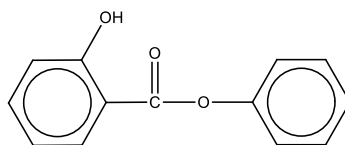
Phenol



Chloro-m-xyleneol



Picric acid



Phenyl salicylate
(Salol)

Other example of antiseptics:

Tincture of Iodine ($I_2 + KI$ dissolved in C_2H_5OH)

Iodoform CHI_3

Dettol – alcoholic solution of chloro-m-xyleneol and terpene.

2. Disinfectant:

Similar to antiseptics but harmful to host cell so apply to inanimate objects such as floor, instruments swimming pools.

Examples:

Cl_2 – sterilization of swimming pool

SO_2 – used in bakery

3. Antibiotics:

Chemical substances produced by various micro-organisms (can be synthesized in lab) which kills or inhibits the growth of bacteria are called antibiotics.

Examples: Penicillin, streptomycin, chloramphenicol, tetracyclines, erythromycin, etc.

t

sPenicillin – 1 antibiotic, discovered by Alexander Fleming in 1928.

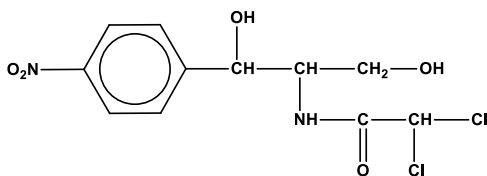
Broad spectrum antibiotics Narrow spectrum antibiotics

1. Effective against a wide range of

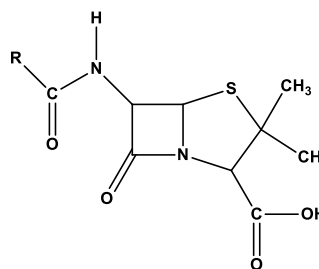
1. Effective against a few microorganisms

microorganisms

2. Example: Chloramphenicol 2. Example: Penicillin, streptomycin



Structure of Chloramphenicol



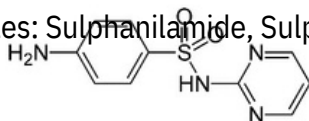
Structure of penicillin

4. Sulpha-drugs:

These drugs are synthetic which acts as antibiotics (i.e. kills or inhibits the growth of bacteria) having antibacterial property are called sulpha-drugs.

These are not derived from microorganisms but are chemically synthesized.

Examples: Sulphanilamide, Sulphadiazine, Sulphaguanidine, etc.



Sulfadiazine

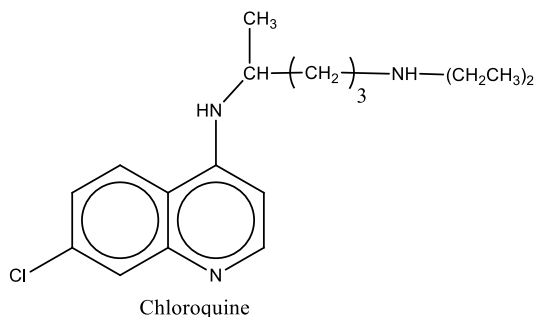
Sulphadiazine is an antibiotic used to treat the urinary tract infections.

5. Antimalarial

Used against malarial agent *Plasmodium*.

Malaria causes shivering and fever. Also causes weakness with side effects in liver and also causes anemia.

Example of antimalarial drugs: **Chloroquine, Primaquine, Guinine**, etc.



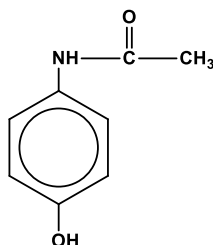
Chloroquine

Examples of Pharmacodynamic drugs

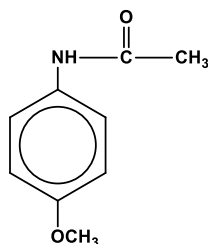
1. Antipyretics:

Used to lower body temperature in fever.

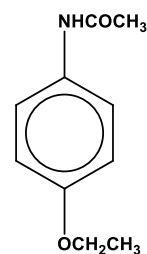
Examples: Paracetamol, Methacetin, Phenacetin, Aspirin, etc.



p- Acetamidophenol
(Paracetamol)



Methacetin

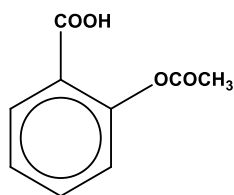


Phenacetin

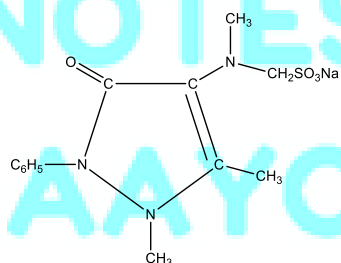
2. Analgesics:

Used to relieve pain without loss of consciousness.

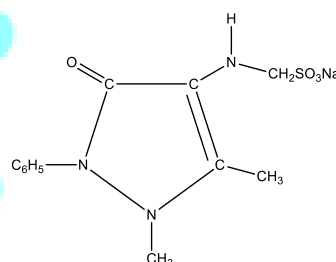
Examples: Aspirin, Novalgin, Melubrin, Phenacetin, Brufane, etc.



Acetylsalicylic acid
(Aspirin)



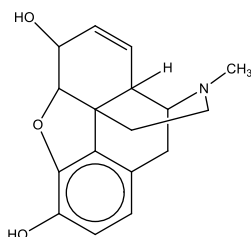
Novalgin



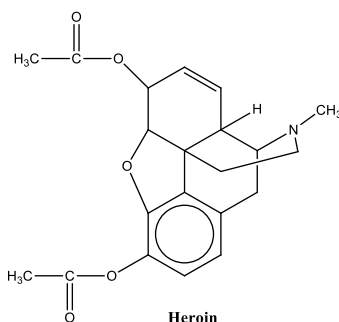
Melubrin

Types of Analgesic drugs

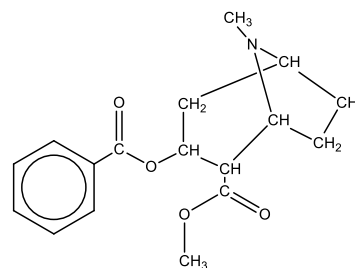
Narcotics drugs	Non-Narcotics drugs
1. Habit forming drugs responsible for drug addictions	1. Not habit-forming drugs
2. Example: Morphine, Heroin, Cocaine, codeine, etc.	2. Example: Aspirin, Novalgin, etc.



Morphine



Heroin



Cocaine

3. Anesthetic

Used to bring about the loss sensation for certain period of time. This drug has made surgery a more comfortable experience for patients.

Examples:

$\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$ (diethyl ether)

$\text{CH}_2=\text{CH}_2$ (ethene)

N_2O (Dinitrogen monoxide)

CHCl_3 (Chloroform)

4. Antacids

Used to neutralize excess acid in gastric juice.

Examples: NaHCO_3 , $\text{Al}(\text{OH})_3$, $\text{Mg}(\text{OH})_2$, anhydrous Na_2CO_3

“ENO” = mixture of NaHCO_3 , anhydrous Na_2CO_3 citric acid and flavoring agents

5. Tranquilizers

Used for the treatment of mental diseases. These chemicals affect the CNS and may induce sleep to the patients. It is also called psycho-therapeutic drugs.

Examples: Barbituric acid, Luminal, Seconal, Equanil, etc.

NOTES

Barbituric acid

6. Sedative: A drug taken for its calming or sleep-inducing effect.

Example: Diazepam

7. Antidepressant: A drug used to treat major depressive disorder, some anxiety disorders

Example: Fluoxetine

8. Hypnotic or soporific drugs, commonly known as **sleeping pills**, are a class of **psychoactive drugs** whose primary function is to induce sleep.

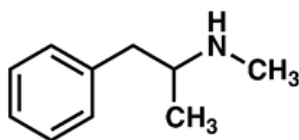
Example: cloroqualone

9. Psychedelic drugs are a class of hallucinogenic drugs whose primary effect is to trigger non-ordinary states of consciousness (known as psychedelic experiences or "trips")

Examples: **Lysergic acid diethylamide (LSD)**, ***N*, *N*-Dimethyltryptamine (DMT or *N*, *N*-DMT)**

NOTE:

Methamphetamine (contracted from ***N*-methylamphetamine**) or **meth** is a potent central nervous system (CNS) stimulant that is mainly used as a recreational drug and less commonly as a second-line treatment for attention deficit hyperactivity disorder and obesity.



Drug Addiction

Compulsive desire and dependence on illegal drugs despite of negative consequences.

Effects in human behavior- mood swings, depression, anxiety, violence, hallucinations, confusion, decrease in pleasure in everyday life

Creates many physical, psychological, physiological, effects leading to serious problems in individuals' life, in family & Society

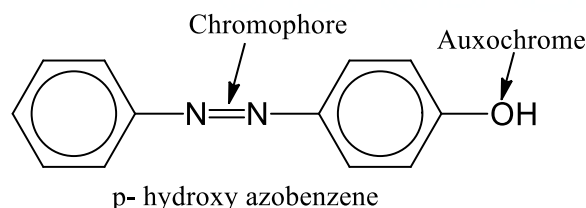
Can be treated by rehabilitation techniques in rehab centers.

Dyes

Dyes are chemical chemicals that are used to give color to fabrics, foods, and other items in order to beautify and distinguish them. They have the ability to adhere to fabrics/objects indefinitely and are resistant to water, soap, light, acid, and alkalies.

Characteristics of dyes:

1. Dyes should have suitable color, capable of being fixed to fabrics to which it is applied, resistant to water, acids, alkalis and detergents.
2. The unsaturated groups such as $-N=N-$, $-O-N=O$, $>C=O$, etc. is responsible for the color of dye and are called **chromophores**
3. Substances having such chromophore groups are called **chromogens** & dyes are chromogens.
4. Some groups are responsible for enhancing the color of dyes & are called **auxochrome**.



Classification

A) On the basis of source of origin

Natural Dyes

The coloured matters that are obtained or extracted from plant and animal sources (like coloured flowers, roots, barks, leaves, fungi, lichens) are called natural dyes.

Example: Indigo (derived from leaves of *Indigofera species*) also called blue-green dye.

Alizarin also called red dyes (extracted from madder root)

Heena (extracted from Heena plant), etc.

Synthetic Dyes

The dyes which are synthesized/prepared in lab or industry from aromatic compounds (like benzene) is called synthetic dyes.

In 1771, the **first** synthetic dye, **Picric acid** (2,4,6-trinitrophenol) was prepared by Woulfe.

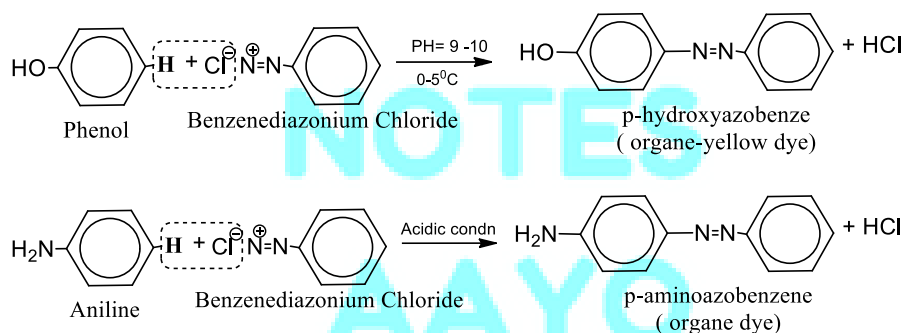
Example: Phenolphthalein, p-hydroxyazobenzene, p-aminoazobenzene, picric acid, methyl orange, etc.

B) On the basis of Structure:

1. Azo dyes:

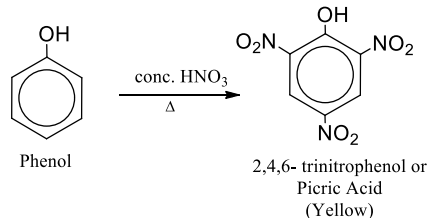
Dyes containing azo ($-N=N-$) functional groups as the primary chromophore are commonly called azo dyes. The common auxochromes are $-NH_2$, $-NR_2$, $-OH$, $-SO_3H$, etc.

Azo dyes like p-hydroxy azobenzene & p-aminoazobenzene can be prepared by coupling reactions.

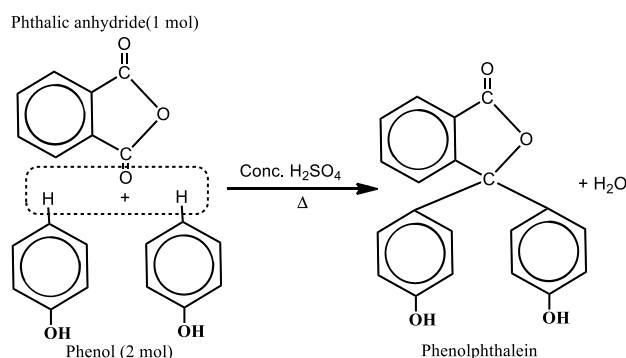


2. Nitro dyes:

Dyes containing $-NO_2$ and $-NO$ group as the primary chromophores.



3. Phthalein dyes:



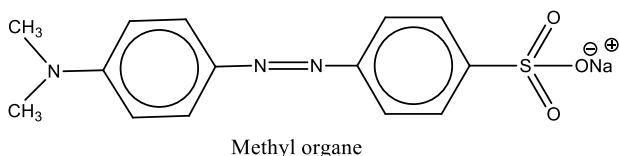
Phenolphthalein is used as an acid base indicator.

B) On the basis of Method of application:

1. Acid dyes

These are **azo dyes** and are characterized by the salts of sulphonic or carboxylic acids. These are usually applied to wool, silk and nylon and have no affinity for cotton.

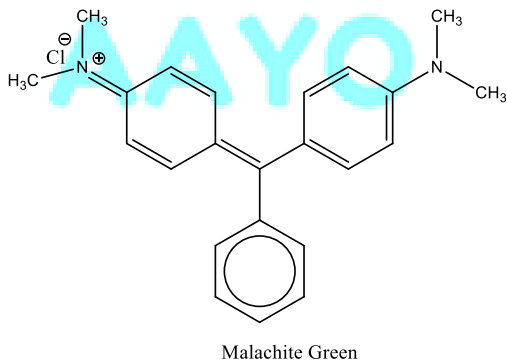
Example: Methyl orange (azo dye)



2. Basic dyes

These dyes contain Amino group in unsubstituted (-NH₂) or Substituted form (-NR₂) as **chromophore** (colour bearing group) or **auxochrome** (colour enhancing group). These form water-soluble cations in an acid solution which then react with anionic sites present on the fabrics and thus get attached to them. These are used to dye modified nylons, polyesters, paper, leather, wool, cotton.

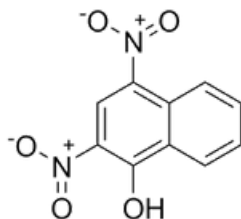
For example: Malachite green, Aniline yellow, etc.



3. Direct dyes

These also belong to the class of **azo dyes** and are used to dye the fabrics directly by placing it in an aqueous solution of the dye. These are suitable for those fabrics which can form H-bonds with the dyes. These are used to dye wool, silk, nylon, rayon and cotton.

Example: Martius Yellow & Congo Red.



Martius Yellow

4. Disperse dyes

These are water-insoluble dyes which are dispersed in reagents like Phenol, Cresol etc. before applying to synthetic fibres. These are used to dye nylon, polyesters and polyacrylonitrile.

For example: Celliton Fast Blue B

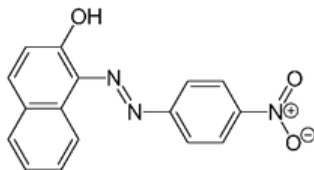
5. Fiber Reactive dyes

These dyes contain a reactive group which combines directly with the hydroxyl or Amino group of the fibres. Because of the irreversible chemical reaction; the colour is fast and has a long life. These are used to dye nylon, wool and silk.

6. Insoluble Azo dyes (Ingrain dyes)

These dyes are directly synthesized on the surface of the fibres. The fabric to be colored is soaked in an alkaline solution of Phenol or Naphthol and is then treated with a solution of diazotized amine to produce azo dye on the surface of the fabric. The colour imparted by such dyes is not very fast. These are used to dye nylon, cotton, silk, polyester etc.

Example: Para red

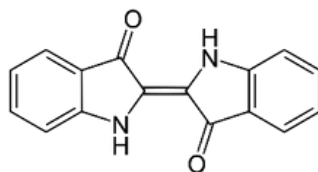


Para -red

7. Vat dyes

These are insoluble dyes which are first reduced to a colourless **leuco compounds** in wooden vats by alkaline reducing agents like sodium hyposulphite and then applied to the fabric. After some time, the fabric is exposed to air or an oxidizing agent to get insoluble colored dye on the fabric. These are used to dye cotton fibres.

Example: Indigo

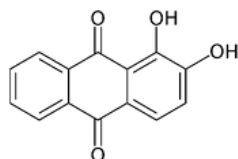


Indigo

8. Mordant dyes

These dyes do not dye a fabric directly but require a mordant which act as the binding agent between the dye and fabric. For acid dyes, the mordant is a metal hydroxide while for basic dyes it is Tannic acid. The mordant gets attached to the fabric and then interacts with the dye forming an insoluble colored complex, called Lake. Depending upon mordant used, dyes give different colors.

Example: Alizarin (a mordant dye) gives a red colour with **Al** and **Sn** salts, blue colour with **Ba**, brownish-red with **Cr** mordant and black-violet with **Fe** mordant.



Alizarin

Pesticides

Chemicals used to control or to kill pests that are harmful to human beings or in agriculture are called commonly called pesticides.

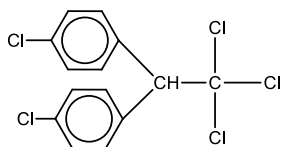
Chronologically the use of pesticides in Nepal is

- Organochlorine -1950s,
- Organophosphate- 1960s,
- Carbamates-1970s
- synthetic pyrethroids-1980s

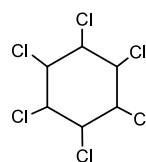
1. Insecticides:

Chemicals used to control or to kill insects.

Organochlorine insecticides:

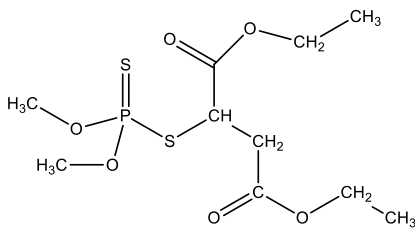


Dichlorodiphenyltrichloroethane
(DDT)



Benzene hexachloride
(BHC or Gammexene or Lindane or 666)

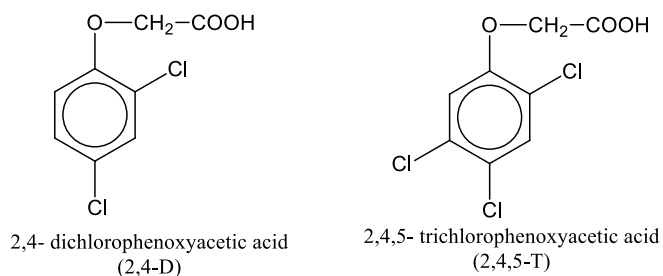
Organophosphorus insecticides:



Malathion

2. Weedicides or herbicides

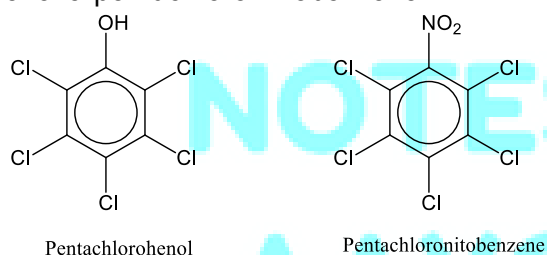
Chemicals used to control or to control and kill the unwanted weeds or herbs.



3. Fungicides:

Chemicals used to control and kill the fungi.

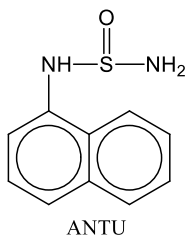
Examples: CuSO₄ solution, Aluminum phosphide (ALP) Bordeaux mixture (Mixture of CuSO₄ and CaO), Cl₃C-NO₂ (Chloropicrin)
Pentachlorophenol & pentachloronitrobenzene



4. Rodenticides

Chemicals used to control or to control and rodents (like rats).

ClCH₂COONa (Sodium monochloroacetate), Zinc phosphide (Zn₃P₂), Alpha naphthylthiourea (ANTU)

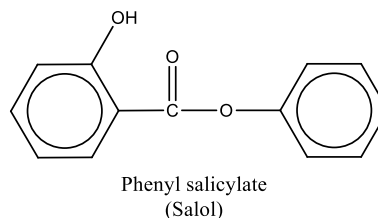
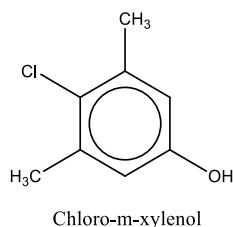


5. Germicides:

Chemicals used to control and kill the microorganisms

There are two broad classifications of germicides: antiseptics and disinfectants.

Examples: 8% formaldehyde, 10–20% stabilized hydrogen peroxide, 70–90% alcohol, 0.1–0.5% chlorine, phenolic compounds (chloro-m-xyleneol, salol etc).



Pesticides and environmental pollution

Pesticides are also the causative agents for air, water, soil pollutions

Some side effects on plants and animals of pesticide pollution:

- Egg shell thinning in birds,
- Interact with vertebrate immune systems,
- Thyroid disruption properties in rodents, birds, amphibians and fish,
- Impaired metabolic functions such as thermoregulation, water and/or food intake and behavior, impaired development, reduced reproduction and hatching success in vertebrates, carcinogens,
- High honey bee worker mortality due to homing failure, reduced nitrogen fixation and thus reduced crop yields
- In humans, Skin irritation to birth defects, tumors, genetic changes, blood and nerve disorders, endocrine disruption, coma or death.

NOTES
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