POLYMERS

1. INTRODUCTION

A polymer may be defined as a high molecular weight compound formed by the combination of a large number of one or more types of small molecular weight compounds.

The small unit(s) of which polymer is made is (are) known as monomer.

The polymerisation may be defined as a chemical combination of a number of similar or different molecules to form a single large molecule.

A polymer which is obtained from only one type of monomer molecules is known as homopolymer. Example: polythene, PVC, PAN, teflon, Buna rubber etc.

A polymer which is obtained from more than one type of monomer is known as a co-polymer. For example: Buna-S, Dacron, Nylon-66, Bakelite etc.

2. CLASSIFICATION

2.1 Origin (Source)

2.1.1 Natural Polymers

These are of natural origin or these are found in plants and animals. Natural polymers also called as biopolymers.

Example Proteins (Polymers of amino acids), Polysaccharides (Polymers of mono saccharides), rubber (Polymers of isoprene) silk, wool, starch, cellulose, enzymes, natural rubber, haemoglobin etc.

2.1.2 Synthetic Polymers

These are artificial polymers. For example Polythene, nylon, PVC, bakelite, dacron.

2.1.3 Semi-Synthetic Polymers

Natural polymers modified according to human needs.

Examples Nitro cellulose, cellulose acetate, cellulose xanthate, etc.

2.2 Synthesis

2.2.1 Addition Polymers

These are polymers formed by the addition together of the molecules of the monomers to form a large molecule without elimination of any thing.

The process of the formation of addition polymers is called addition polymerisation.

Example–1

$$\underset{\text{Ethene}}{nCH_2{=}CH_2} \xrightarrow{\text{Polymerisation}} \underset{\text{Polythene}}{[-CH_2-CH_2-]_n}$$

2.2.2 Condensation Polymers

Condensation polymers are formed by the combination of monomers with the elimination of simple molecules such as water or alcohol. This process is called condensation polymerisation. Proteins, starch, cellulose etc. are the example of natural condensation polymers.

Two main synthetic polymers of condensation types are polyesters (Terylene or dacron) and polyamides (Nylon-66).

2.3 Mechanism

2.3.1 Chain Growth Polymerization

These polymers are formed by the successive addition of monomer units to the growing chain having a reactive intermediate (Free radical, carbocation or carbanion). Chain growth polymerisation is an important reaction of alkenes and conjugated dienes.

Polythene, polypropylene, teflon, PVC, polystyrene are some examples of chain growth polymers.

2.3.2 Step Growth Polymerization

These polymers are formed through a series of independent steps. Each step involves the condensation between two monomers leading to the formation of smaller polymer.

e.g. Nylon, terylene, bakelite etc.

2.4 Structure

2.4.1 Linear Polymers

These consist of extremely long chains of atoms and are also called one dimensional polymers. Examples - Polyethylene, PVC, Nylon, Polyester.

2.4.2 Three-Dimensional Polymers

Those polymers in which chains are cross linked to give a three dimensional network are called three dimensional polymers. Example - Bakelite.

2.5 Molecular Forces

2.5.1 Elastomers

These are the polymers having very weak intermolecular forces of attraction between polymer chains.

Elastomers posseses elastic character.

Vulcanised rubber is very important example of an elastomer.

2.5.2 Fibres

These are the polymers which have bit strong intermolecular forces such as hydrogen bonding. Ex. Nylon - 6, 6, Nylon-6, 10, Terylene.

Nylon - 6, 6 is obtained by condensation polymerisation of hexamethylene diamine (six carbon) and adipic acid (a dibasic acid having six carbon).

$$nHOOC(CH_2)_4COOH + nH_2N(CH_2)_6NH_2 \xrightarrow{\text{high pressure}} \underset{\text{Nylon-6, 6}}{[\!-\!OC(CH_2)_4CONH(CH_2)_6NH\!-\!]_n}$$

Nylon-6, 10 is obtained by condensation polymerisation of hexamethylene diamine (6C) and sebasic acid (10C).

Terylene (Dacron, teron, cronar, mylar) is a polyester fibre made by the esterification of terephthalic acid with ethylene glycol.

2.5.3 Thermoplastics

A thermo plastic polymer is one which softens on heating and becomes hard on cooling. Polyethylene, polypropylene, polystyrene are the example of thermo plastics.

2.5.4 Thermo Setting Polymers or Resin

A thermo setting polymer becomes hard on heating. Bakelite, Aniline aldehyde resin, urea formaldehyde polymer.

3. MONOMERS AND POLYMERS

S.N.	Monomer	Polymer	Type of Polymers
1.	$CH_2{=}CH_2$ (Ethylene)	Poly ethene	Addition polymer
2.	$CH_2{=}CHCH_3$ (Propylene)	Poly propylene or koylene	Addition homo polymer
3.	$CH_2{=}CHCl$ (Vinyl chloride)	Polyvinyl chloride (PVC)	Homopolymer, chain growth
4.	$CH_2{=}CH{-}C_6H_5$ (Styrene)	Polystyrene (styron)	Addition homo polymer, linear chain
5.	$CH_2{=}CH{-}CN$ (Acrylonitrile)	Polyacrylonitrile (PAN) or Orlon	Addition homopolymer
6.	$CH_2{=}CH{-}CH{=}CH_2$ (1,3 Butadiene)	BUNA rubbers	Addition copolymer
7.	$CH_2{=}CHOCOCH_3$ (Vinyl acetate)	Poly vinyl acetate (PVA)	Addition homopolymer
8.	$CF_2{=}CF_2$ (Tetrafluoro ethylene)	Teflon	Chain growth homopolymer (Nonstick cookwares)
9.	$CH_2{=}C(CH_3){-}CH{=}CH_2$ (Isoprene)	Natural Rubber	Addition homopolymer
10.	$CH_2{=}C(Cl){-}CH{=}CH_2$ (Chloroprene)	Neoprene (Artificial Rubber)	Addition homopolymer
11.	Ethylene Glycol + dimethyl terephthalate	Terylene or Dacron (Polyester)	Copolymer, step growth
12.	Hexamethylene diamine + adipic acid	Nylon-6,6 (Polyamide)	Copolymer, step growth linear
13.	Formaldehyde + urea	Urea formaldehyde resin	Copolymer, step growth
14.	Formaldehyde + Phenol	Bakelite	Copolymer, step growth thermo setting polymer
15.	Maleic anhydride + methylene glycol	Alkyl plastic	
16.	Methyl methacrylate	Poly methyl meth acrylate (PMMA)	Addition homopolymer
17.	Ethylene Glycol + Phthalic acid	Glyptal	Copolymer, linear step growth, thermo plastic
18.	Melamine + formaldehyde	Melamine formaldehyde resin	Copolymer, step growth thermosetting polymer
19.	Hexamethylene diamine + sebasic acid	Nylon - 6,10	Copolymer, step growth linear
20.	6-Aminohexanoic acid	Nylon - 6	Homopolymer, step growth linear

CHEMISTRY IN EVERYDAY LIFE

1. MEDICINE OR DRUGS

Chemical substances helping to a human body or an animal either for treatment of diseases or to reduce suffering from pain are called medicine or drug.

The treatment of disease by chemical compound which destroy the micro organism without attacking the tissue of the human body is known as chemotherapy, and the compounds used are called chemotherapeutic agent.

Various type of medicinal compounds are.

1.1 Antiseptics

Which prevent or destroy the growth of the harmful micro organism, common antiseptics are - Dettol, Savlon, Cetavelon, acriflavin, iodine, methylene blue, mercurochrome & $KMnO_4$.

Dettol is a mixture of chloroxylenol and terpineol. Its dilute solution is used to clean wounds.

Bithional - It is added to soap to impart antiseptic properties.

1.2 Disinfectants

The chemical compounds capable of completely destroying the micro organism are termed as disinfectants. These are toxic to living tissues.

These are utilized for sterilization of floor, toilets instruments & cloths.

eg. 1% solution of phenol is disinfectant while 0.2% solution of phenol is antiseptic.

1.3 Analgesics

The substances which are used to get relief from pain. These are of two types :

(a) Narcotics or habit forming drugs

(b) Non-narcotics

(a) Narcotics : These are alkaloids and mostly opium products, causes sleep and unconciousness when taken in higher doses.

e.g. Morphine, codeine, heroine

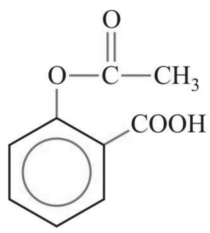
(b) Non-narcotics : Analgesics belonging to this category are effective antipyretics also.

e.g. Aspirin & novalgin, Ibuprofen, Naproxen.

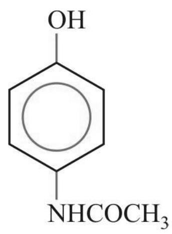
1.4 Antipyretics

To bring down the body temp. in high fever are called antipyretics.

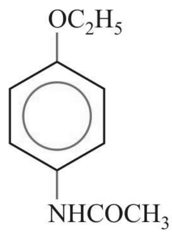
Example–1



Aspirin



Paracetamol



Phenacetin

1.5 Antimalarials

To bring down the body temperature during malarial fever.

e.g. Quinine, Chloroquine, Paraquine and Primaquine etc.

1.6 Tranquilizers

The chemical substances which act on the central nervous system and has a calming effect. Since these are used for mental diseases so are known as psycotherapeutic drugs.

They are of two types -

(a) Sedative or hypnotics (b) Mood elevators

(a) Sedative : Reduce nervous tension and promote relaxation. e.g. Reserpine, barbituric acid and its derivatives as luminal & seconal.

(b) Mood elevators or Antidepressants : A drug used for treatment of highly depressed patient, who has lost his confidence.

e.g. Benzedrine (amphetamine)

1.7 Anaesthetics

These are chemical substances helping for producing general or local insensibility to pain and other sensation. These are of two types (a) General (b) Local

(a) General - Produce unconciousness and are given at the time of major surgical operations.

e.g. Gaseous form – Nitrous oxide, ethylene, cyclopropane etc.

Liquid form – Chloroform, divinyl ether and sodium pentothal etc.

(b) Local anaesthetics : Produce loss of sensation on a small portion of the body. It is used for minor operations.

e.g. Jelly form – Oxylocain

Spray form – Ethyl chloride

Injection form – Procain

1.8 Antibiotics

The chemical substances produced from some micro organism (fungi, bacteria or mold) and are used to inhibit the growth of other micro organism.

These are effective in the treatment of infections diseases.

e.g. Penicillin - It is highly effective drug for pneumonia, Bronchitis, abcesses, sore throat etc.

Synthetic antibiotics are Streptomycin - (Tuberculosis),

Chloromycetin - (Typhoid, Meningitis, Pneumonia, diarrhoea, dysentary etc.)

Tetracyclins - (Acute fever, trachoma, dysentery & urinary tract infection)

1.9 Sulpha Drugs

Having great antibacterial powers. These are a group of drugs which are derivatives of sulphanilamide.

Other sulpha drugs are -

(a) Sulphathiazole - Mainly used in severe infections.

(b) Sulpha guanidine - Used in bacillary dysentery

(c) Sulpha pyridine - Used in pneumonia

(d) Sulpha diazine - Used in dysentery, urinary infection and respiratory infection.

2. ROCKET PROPELLANTS

2.1 Introduction

In order to provide sufficient push to the rocket satellites to enter into the space, some chemical fuels are used, which are termed as rocket propellants.

A propellant is a combination of two compounds i.e.

(a) An explosive compound called fuel

(b) Oxidiser

A chemical compound should satisfy the following conditions to function as propellant -

1. The burning of fuel should not leave any ash.
2. The burning of fuel should produce a large volume of gases/g of fuel.
3. The combustion should proceed at a fast rate.

2.2 Classification

Depending upon physical state of fuel and oxidiser, the propellants are of three types

(a) Solid propellants

(b) Liquid propellants

(c) Hybrid propellants

2.2.1 Solid Propellants

In which fuel and oxidiser both are solid. These are of two types

(I) Composite propellant : It contains polymeric binder as fuel and ammonium perchlorate as oxidiser.

Fuel - Polyurethane or polybutadiene,

Oxidiser - Ammonium perchlorate

(II) Double base propellant : It consists of nitro cellulose and nitroglycerine

Disadvantage of solid propellant

Once they ignite, they burn with a predetermined rate.

These do not have the start and stop capability.

2.2.2 Liquid Propellants

These are of two types :

(I) Monoliquid propellant : when a single liquid acts as fuel and oxidiser.

eg. Nitromethane, Methyl nitrate, H_2O_2 etc.

(II) Biliquid propellant : It comprises a liquid fuel and a liquid oxidiser e.g. Fuel – Kerosene, alcohol, hydrazine, monomethyl hydrazine (MMH) or liquid hydrogen.

Oxidiser – Liquid oxygen, nitrogen tetraoxide (N_2O_4) or nitrous acid.

Advantages :

(I) These provide higher thrust than solid propellants.

(II) The thrust can be controlled by switching on and off the flow of liquid propellant.

2.2.3 Hybrid Propella nts

These consist of a solid fuel and a liquid oxidizer. e.g.

Fuel – Acrylic rubber

Oxidiser – Liquid N_2O_4

2.3 Specific Impulse (I_s

The superiority and performance of a propellant is expressed in terms of specific impulse (I_s).

$$I_s = \sqrt{\frac{T}{M}}$$

Where T = Flame temperature, M = average molecular mass.

Thus the performance of rocket propellant will be better if flame temperature is higher and the average mass of the product gas is lower.

3. DYES

3.1 Introduction

Dyes are coloured substances which can be applied in solution or dispersion to a substrate such as textile fibres (cotton, wool, silk, polyester, nylon), paper, leather, hair, fur, plastic material etc. giving it a coloured appearance.

If a compound absorbs light in the visible region, its colour will be that of the reflected light, i.e. complementary to that absorbed. For example, if a dye absorbs blue colour, it will appear yellow which is the complementary colour of blue.

Auxochromes are groups which themselves do not absorb light (i.e. are not chromophores) but deepen the colour when introduced into the coloured compounds, i.e., OH, NH_2, Cl, CO_2H etc.

3.2 Classification

3.2.1 Source

(i) Natural dyes are obtained from plants. For example, alizarin, indigo etc.

(ii) Synthetic dyes are prepared in the laboratory. For example, martius yellow, malachite green, orange-I, orange-II, congo red, aniline yellow etc.

3.2.2 Constitution

(i) Nitro dyes : martius yellow

(ii) Azo dyes : aniline yellow, methyl orange, orange-I, congo red etc.

(iii) Triphenylmethane dyes : malachite green, magneta

(iv) Indigoid dyes : Indigo, indigosol

(v) Anthraquinone dyes : alizarin

(vi) Phthalein dyes : phenolphthalein

3.2.3 Application

(A) Acid Dyes

Acid dyes are sodium salts of azo dyes containing sulphonic acid or carboxylic acid groups, e.g. orange-I, orange-II, congo red, methyl orange and methyl red. These dyes do not have any affinity for cotton but are used to dye wool, silk, polyurethane fibres. The affinity of acid dyes for nylon is higher than that for other types because polycaprolactam fibres contain a higher proportion of free amino groups.

(B) Basic Dyes

Basic dyes are the salts of azo and triphenylmethane dyes containing amino groups as auxochromes, e.g., aniline yellow, butter yellow, malachite green and chrysoidine G. These dyes are applied in their soluble acid solutions and get attached to the anionic sites present on the fabrics. Such dyes are used to dye polyesters and reinforced nylons.

(C) Direct Dyes

Direct dyes are water soluble dyes which are directly applied to the fabric from an aqueous solution. These dyes are most useful for fabrics which can form H-bonds such as cotton, wool, silk, rayon and nylon. Some example of direct dyes are : congo red and martius yellow.

(D) Fibre Reactive

Fibre reactive dyes attach themselves to the fibre by an irreversible chemical reaction. Therefore, their dyeing is fast and colour is retained for a longtime. These dyes contain a reactive group which combines directly with the hydroxyl or amino group of the fibre (cotton, wool, silk). Dyes which are derivatives of 2, 4-dichloro-1, 3, 5-triazine are important examples of fibre reactive dyes.

(E) Insoluble Azo Dyes

Insoluble azo dyes constitute about 60% of the total dyes used. These are obtained by coupling of phenols, naphthols, aminophenols adsorbed on the surface of a fabric with a polyurethanes, polyacrylonitriles and leather. Azo dyes can also be used to dye foodstuffs, cosmetics, drugs, biological strains such as indicators etc. However, because of their toxic nature, these dyes are no longer permitted to dye foodstuffs.

(F) Ingrain Dyes

Ingrain dyes are water insoluble azo dyes which are produced in situ on the surface of the fabric by means of coupling reactions. e.g. para red.

(G) Vat Dyes

Vat dyes are insoluble dyes which are first reduced to colourless soluble form (leuco compound) in large vats with a reducing agent such as alkaline sodium hydrosulphite and applied to the fabric and then oxidised to the insoluble coloured form by exposure to air or some oxidising agent such as chromic acid or perboric acid, e.g., indigo. Indigosol O, on the other hand, is readily fibre with formation of indigo. It is especially suitable for wool.

(H) Mordant Dyes

Mordant dyes are applied to the fabric after treating them with a metal ion (mordant) which acts as a binding agent between the dye and the fabric. Depending upon the metal ion used, the same dye can give different colours. Thus, alizarin gives a rose red (turkey red) colour with Al^{+3} ions and blue colour with Ba^{2+} ions. These dyes are especially used for dyeing wool.

4. CHEMICALS IN FOOD

4.1 Food additives

All those chemicals which are added to food to improve its keeping qualities, appearance, taste, odour and nutritive or food value are called food additives.

These include preservatives, flavouring agents, artificial sweeteners, dyes, antioxidants, fortifiers, emulsifiers and antifoaming agents.

4.1.1 Antioxidants

Chemicals which are used to prevent oxidation of fats in processed foods such as potato chips, biscuits, breakfast cereals, crackers etc. are called antioxidants. In fact, they are more reactive towards oxygen that the material they are protecting. They also reduce the rate of involvement of free radicals in the ageing process. The two most familiar antioxidants used are butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA).

4.1.2 Artificial sweetening agents

Sucrose and fructose are the most widely used natural sweetners. Since they add to our calorie-intake and promote tooth decay, therefore, many people use artificial sweeteners. For example, saccharin, aspartame, alitame, sucralose, cyclamate and L-glucose.

(i) Saccharin is used in form of its sodium or calcium salt which is highly soluble in water. It is not biodegradable and hence does not have calorific value of food. It is primarily used as a sweetening agent by diabetic patients and by those who need to control intake of calories.

(ii) Aspartame : It is the methyl ester of the dipeptide derived from phenylalanine and aspartic acid. Therefore, it is used as a sugar substitute in cold foods and soft drinks.

(iii) Alitame : Although it is similar to aspartame but is more stable than aspartame.

(iv) Sucralose is trichloro derivative of sucrose. It neither provides calories nor causes tooth decay.

(v) Cyclamate : It is N-cyclohexylsulphamate.

(vi) L-Glucose : Like D-sugars, L-sugars are also sweet in taste but do not provide any energy since our body does not have the enzymes for their metabolism.

4.1.3 Preservatives

Chemical substances which are used to protect food against bacteria, yeasts and moulds are called preservatives. The most commonly used preservative is sodium benzoate. Another well known preservative is sodium or potassium metabisulphite which is used in jams, squashes, pickles etc. Its preservative action is due to SO_2 which dissolves in water to form sulphurous acid which inhibits the growth of yeasts, moulds and bacteria. Salts of propionic acid and sorbic acid are also used as preservatives.

4.1.4 Edible colours

Colours are added to thousands of food items to improve their appearance although they do not have any nutritive or food value. These are essentially dyes which may be either synthetic or natural. The synthetic edible colours are azo dyes which are harmful for young children and asthma patients. The most important synthetic dye is tetrazine which is shown to be harmful. Natural edible colours such as annatto, caramel, carotene and saffron are, however, safe. Some inorganic salts have also been used. For example, iron oxide is used to impart red colour and titanium dioxide is used to intensify whiteness.

5. DETERGENTS

5.1 Soaps

Soaps are sodium or potassium salts of higher fatty acids such as lauric acid, ($C_{11}H_{23}COOH$), myristic acid ($C_{13}H_{27}COOH$), palmitic acid ($C_{15}H_{31}COOH$), stearic acid ($C_{17}H_{35}COOH$), oleic acid ($C_{17}H_{33}COOH$), linoleic acid ($C_{17}H_{31}COOH$) and linolenic acid ($C_{17}H_{29}COOH$).

Soaps are 100% biodegradable, i.e., microorganisms present in sewage water completely oxidise them to CO_2. As a result, soaps do not create any water pollution problem. However, they have two disadvantages :

(i) Soaps cannot be used in hard water since calcium and magnesium ions present in hard water produce curdy white precipitates of calcium and magnesium soaps.

(ii) Soaps cannot be used in acidic solutions since acids precipitate the insoluble free fatty acids which adhere to the fabrics and hence prevent the process of dyeing.

5.2 Synthetic detergents

Synthetic detergents, on the other hand, are generally sodium salts of alkyl hydrogen sulphates of long chain alcohols or alkylbenzene sulphonates. Unlike soaps, detergents can be used even in hard water since like sodium or potassium salts, their calcium and magnesium salts are soluble in water. However, unlike soaps, synthetic detergents are not completely biodegradable and hence cause water-pollution. Synthetic detergents are of the following three types :

(a) Anionic detergents : These are so named because a large part of their molecules are anions. These are of two types :

(i) Sodium alkyl sulphate : These are obtained from long chain alcohols by treatment with conc. H_2SO_4 followed by neutralization with NaOH. For example,

$$\underset{\text{n-Lauryl alcohol}}{C_{11}H_{23}CH_2OH} \xrightarrow[(-H_2O)]{\text{Conc. } H_2SO_4} \underset{\text{n-Lauryl hydrogen sulphate}}{C_{11}H_{23}CH_2OSO_2H}$$

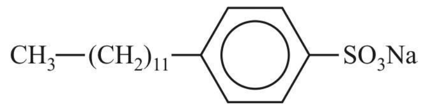
$$\downarrow \text{NaOH } (-H_2O)$$

$$\underset{\text{Sodium lauryl sulphate}}{C_{11}H_{23}CH_2OSO_2Na}$$

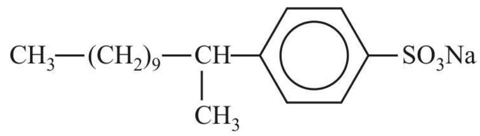
These sodium alkyl sulphates are 100% biodegradable.

(ii) Alkylbenzene sulphonates (ABS) : These are obtained by F.C. alkylation of benzene with long chain alkyl halide or an alkene or an alcohol followed by sulphonation and neutralization with NaOH. The most widely used domestic detergent is the sodium dodecylbenzenesulphonate (SDS).

Another important example is sodium 2-dodecylbenzenesulphonate :



Sod. dodecylbenzenesulphonate



Sod. 2-dodecylbenzenesulphonate

These detergents are also effective in slightly acidic solutions since they form the corresponding alkyl hydrogen sulphates which are soluble materials whereas soaps react with acidic solutions to form insoluble fatty acids.

(b) Cationic detergents : These are quaternary ammonium salts (chlorides, bromides, acetates etc.) containing one or more long chain alkyl groups. Being more expensive than the anionic detergents, they find limited use. Such detergents, however, possess germicidal properties and hence are used quite extensively as germicides, e.g., cetyltrimethylammonium chloride $[CH_3(CH_2)_{15}\overset{\oplus}{N}(CH_3)_3]Cl^{\ominus}$.

(c) Non-ionic detergents : These are esters of high molecular mass obtained by reaction between polyethylene glycol and stearic acid.

These may also be obtained from long chain alcohols by treatment with excess of ethylene oxide in presence of a base.

5.3 Detergent pollution

Detergents having branched hydrocarbon chains cause pollution in rivers and other waterways. The reason being that side chains stop bacteria from attacking and breaking the chains. This results in slow degradation of detergent molecule leading to their accummulation.