Polymers

Polymers : A substance of high molecular mass formed by combination of large number of simple molecules called monomers.

Monomers : Unit of polymers are called monomers.

Polymerisation : Process of formation of polymers from monomers.

$$\boxed{\text{Monomers}} \xrightarrow{\text{Polymerisation}} \boxed{\text{Polymers}}$$

Homopolymer : When monomer units are identical.
Eg. Polyethylene, PVC, polythene etc.

Copolymer (Mixed polymer) : When monomer units are different.
Eg. Nylon-6,6

Classification of polymers :-

(i) Based upon origin :-

(a) Natural polymers : Polymers which occur in nature mostly in plants and animals.
Eg. Cellulose, protein etc.

(b) Synthetic polymers :- Polymers which are prepared in laboratory
Eg. Nylon, PVC etc.

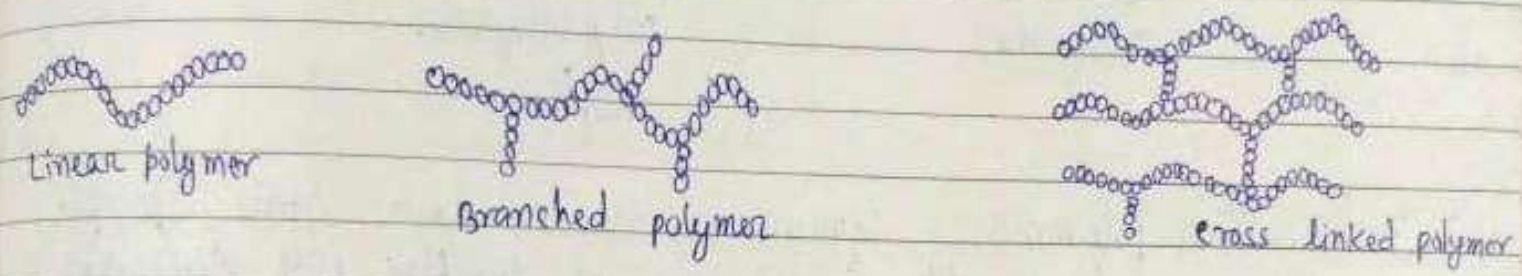
(c) Semi-synthetic polymers :- These are obtained from natural polymers by subjecting them to some chemical processes.
Eg. Rayon, Vulcanised rubber.

(ii) Based upon structure :-

(a) Linear chain polymers : Monomers are linked to one another to form long linear chains.
Eg. Nylon, PVC etc.

(b) Branched chain polymers : Monomers are linked to form long chains which have also side chains.
Eg. Starch, glycogens etc.

(c) Cross-linked polymers :- Monomers are linked together to form three dimentional network like structure.
Eg. Bakelite etc.



(iii) Classification based upon nature of molecular forces :-

(a) Elastomers : They have weakest intermolecular forces. Elasticity can be increased by introducing some cross links.
Eg. Buna-S, Buna-N, neoprene etc.

(b) Fibres :- These are thread-like polymers and can be woven into fabrics.
Eg. Nylon-6,6.

(c) Thermoplastics : They can be cast into different shapes by using suitable moulds. They have weak Vander Waals' forces acting in the various chain.
Eg Polyethene.

(d) Thermosetting plastics :- These polymers when heated, they become hard and infusible due to the cross linking between the polymer chains.
Eg. Bakelite, melamine-formaldehyde etc.

(iv) Classification based upon mode of synthesis :-

(a) Addition polymers :- Monomer units are unsaturated in nature and repeatedly added to form long chains without the elimination of any by-product molecules.

eg. Formation of polythene.

$$n\,CH_2 = CH_2 \xrightarrow{\text{Polymerisation}} \left[CH_2 - CH_2\right]_n$$

Ethylene → Polyethylene or polythene

(b) Condensation polymers :- Monomer units have some specific functional groups react together with elimination of simple molecules like water, ammonia etc.

Eg. $HO-CH_2-CH_2-OH + HO-C(=O)-C_6H_4-C(=O)-OH \xrightarrow{-H_2O} HO-CH_2-CH_2-O-C(=O)-C_6H_4-C(=O)-$

Some important synthetic polymers :-

1. Addition polymers :-

a. Polyethylene: It is polymer of ethylene and these are of two types

(i) Low density polyethylene : When ethylene is heated to a temperature of 350 to 570K under high pressure of about 2000 atmosphere and some traces of peroxide then it gives Low density polyethene (polyethylene).

$$n\,CH_2 = CH_2 \xrightarrow[350 - 370\,K]{1000 - 2000\ atm.} \left(CH_2 - CH_2\right)_n$$

Ethene → Polyethene

Properties :- It is low density polyethene, it is also bad conductor of electricity, chemically inert, tough to use.

use : (i) for insulating wires

(ii) in toys, bottles and flexible pipes.

(ii) High density polyethene (HDP): Under 333 - 343K and 6-7 atm pressure and in presence of Zeiglar Natta catalyst (triethyl aluminium and titanium tetrachloride), ethene gives HDP.

$$\underset{\text{Ethene}}{n\,CH_2=CH_2} \xrightarrow[\substack{333-343K \\ 6-7\ atm}]{\text{Zeiglar Natta Catalyst}} \underset{\text{HDP}}{\left(CH_2-CH_2\right)_n}$$

Properties: It is low density polyethene, quite inert, tougher and harder.

Uses: in storing chemicals, buckets, dustbins, bottles, pipes etc.

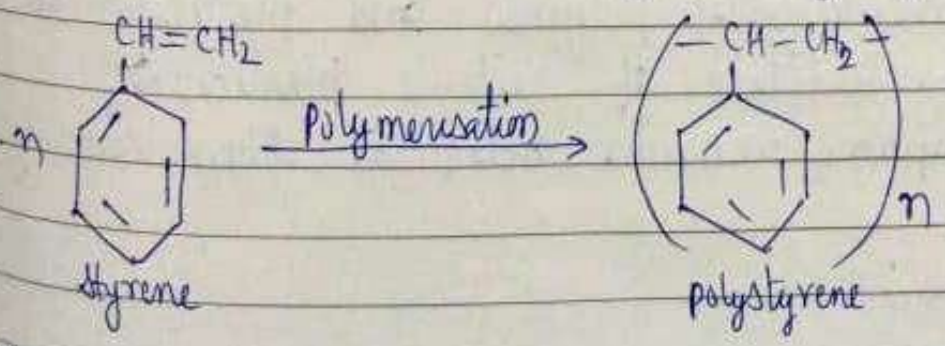
(iii) Polypropylene :- Propylene dissolved in n-hexane containing a small amount of triethyl aluminium at 373 K and 10 atm pressure.

$$n\,\underset{\underset{CH_3}{|}}{CH}=CH_2 \xrightarrow[373K,\ 10\ atm]{(C_2H_5)_3Al} \left(\underset{\underset{CH_3}{|}}{CH}-CH_2\right)_n$$

Properties: It is harder and tougher than polyethene.

Uses: making seat covers, carpet fibres, ropes etc.

(iv) Polystyrene: It is formed by heating styrene in presence of peroxide.



Properties :- It is transparent thermoplastic materials and floats over water.

Uses :- making toys, combs, TV cabinets, making tiles.

eg. $n\,HO-CH_2-CH_2-OH + HO-C(=O)-C_6H_4-C(=O)-OH + HO-CH_2-CH_2-OH$

$\downarrow$

$\therefore \left(O-CH_2-CH_2-O-C(=O)-C_6H_4-C(=O)-O-CH_2-CH_2-O\right)_n + n\,H_2O$

Decron

Properties :- Its fibres are quite strong and durable. It can also blended with wool and cotton.

Uses :- Variety of cloth such as terycot, terywool and terysilk.

(ii) Glyptal : It is polymer of ethylene glycol and phthalic acid.

$n\,HO-CH_2-CH_2-OH + n$ (phthalic acid, HOOC, COOH) $\longrightarrow$ $-O-CH_2-CH_2-O-C(=O)-C_6H_4-C(=O)-$ $+ n\,H_2O$

Ethylene glycol phthalic acid Glyptal

Properties :- It is suitable organic solvents.
Uses : in paints, lacquers, cement etc.

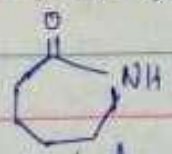
(iii) Nylon-66 :- It is polymer of adipic acid and hexamethylene diamine. Each monomer consists of 6 carbon atoms.

$n\,H_2N-(CH_2)_6-NH_2 + n\,HOOC-(CH_2)_4-COOH \longrightarrow -HN(CH_2)_6-NH-C(=O)-(CH_2)_4-C(=O)-$

hexamethylene diamine adipic acid Nylon 66

Properties :- Bristles of tooth brushes, due to its fibrous nature
Uses : climbing ropes, socks, sweaters etc.

(iv) Nylon-6 : It is polymer of caprolactum.



$\xrightarrow{H_2O}$ $NH_2-(CH_2)_5-COOH \xrightarrow{heat} \left(HN-(CH_2)_5-C(=O)-\right)_n$

Caprolactum Nylon-6

(d) Orlon (Poly acrylo nitrile): It is formed in presence of peroxide.

$$n\,CH_2 = \underset{\underset{CN}{|}}{CH} \xrightarrow{\text{Polymerisation}} \left(CH_2 - \underset{\underset{CN}{|}}{CH} \right)_n$$

Properties:- Fibres are resistance to stains, quite hard and fibrous.
Uses :- Synthetic carpets, blankets, sweaters and bathing suits.

(e) Teflon :- It is polymer of tetrafluoroethylene in presence of acetyl peroxide.

$$n\,CF_2 = CF_2 \longrightarrow \left(CF_2 - CF_2 \right)_n$$

tetrafluoroethylene

Properties :- very hard and tough, resistant towards heat, acids and bases, bad conductor of electricity.
Uses :- making seals and gaskets, non stick surfaces of cooking pans.

(f) PVC (Poly Vinyl chloride) :- It is polymer of Vinyl chloride.

$$n\,CH_2 = \underset{\underset{Cl}{|}}{CH} \xrightarrow{\text{Polymerisation}} \left(CH_2 - \underset{\underset{Cl}{|}}{CH} \right)_n$$

Vinyl chloride PVC

Properties :- It is thermoplastic polymer and plasticity can be increased by addition of suitable plasticizer.
Uses :- pipes, gramophone records, artificial floor covering.

Condensation polymers :-

(i) Terylene (Dacron): It is polymer of ethylene glycol and terephthalic acid formed under condition of 450K temperature and mixture of zinc acetate and antimony trioxide.

Natural Rubber :- It is polymer of isoprene and its polymer is also called polyisoprene.

$$n\, CH_2 = \overset{CH_3}{\overset{|}{C}} - CH = CH_2 \xrightarrow{\text{Polymerisation}} \left(CH_2 - \overset{CH_3}{\overset{|}{C}} = CH - CH_2 \right)_n$$

Natural rubber.

Vulcanisation of Rubber :- To make more useful and elastic, under high temperature of 335 K sulphur is mixed and this process is called Vulcanisation.

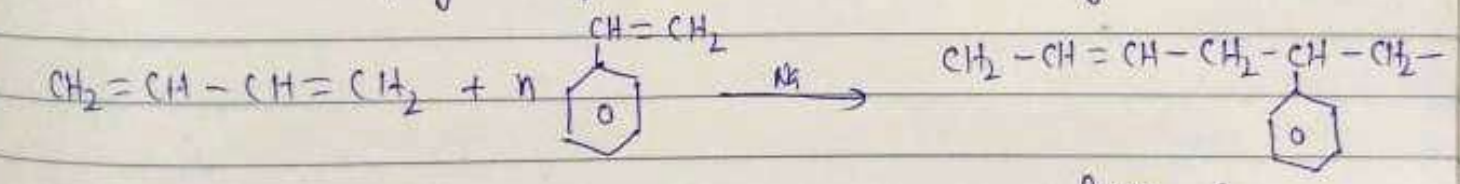
Synthetic rubber :- It is polymer of chloroprene and also known as neoprene.

$$n\, CH_2 = \underset{Cl}{\underset{|}{C}} - CH = CH_2 \xrightarrow{\text{Polymerisation}} \left(CH_2 - \underset{Cl}{\underset{|}{C}} = CH - CH_2 - \right)_n$$

Chloroprene — Neoprene.

- Resistant to oils, gasoline and other solvents.
- It is used in Containers for storing petrol, oil and other solvents.

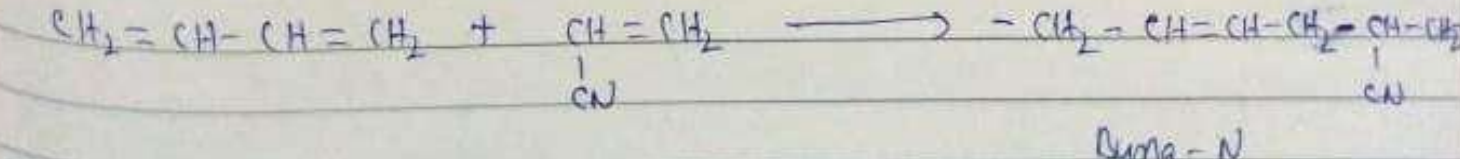
Buna - S : It is polymer of 1,3-butadiene and styrene.



Buna - S

Properties : quite tough, less tensile than natural rubber.
Uses : Making tyres of automobiles, rubber soles, belts etc.

Buna - N : Polymer of Buta-diene and acrylonitrile.

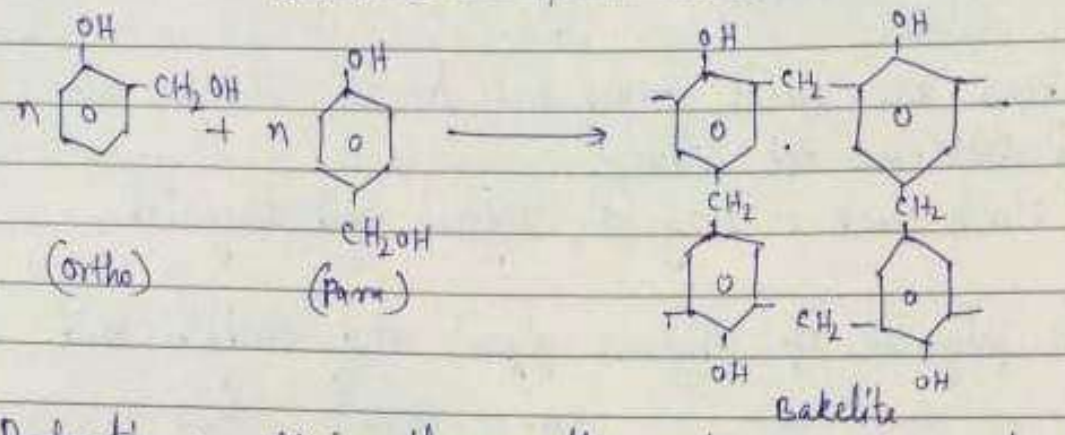


Buna - N

Properties :- Resistant to action of petrol lubricating oil and organic solvent.
Uses : Oil seals, tank lining.

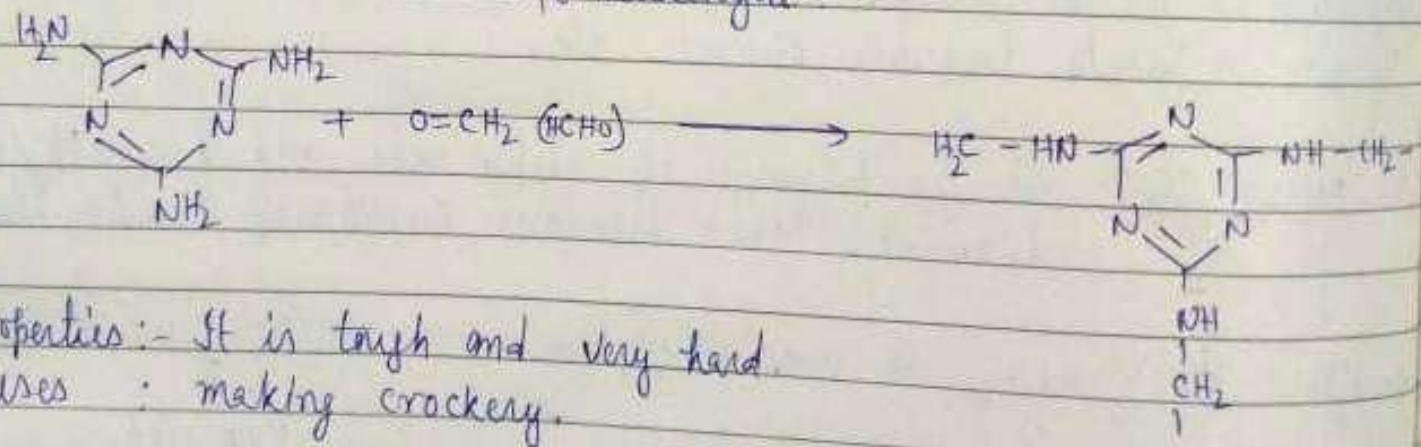
Properties :- It is hard and crystalline.
Uses : It is used in ropes, tyre cords, fabrics etc.

(v) Bakelite : o-hydroxymethyl phenol and p-hydroxymethyl phenol may condense to form bakelite.



Properties :- It is thermosetting polymer. It is hard and tough.
Uses :- Combs, fountain pens, electrical goods etc.

(vi) Melamine formaldehyde resin :- Polymer of hetrocyclic triamine and formaldehyde :



Properties :- It is tough and very hard.
Uses : making crockery.

(vii) Urea formaldehyde resin : Polymer of urea and formaldehyde

It is used in laminated sheets and also in plastic moulds.

Biopolymers :- Polymers present in biological systems in plants and animals. Eg. starch, nucleic acid etc.

Biodegradable polymers :- Some synthetic polymers can decompose or hydrolyse in the presence of different enzymes are biodegradable polymers.

Eg. β-hydroxy butanoic acid.