15 Introduction to Polymer Chemistry

Quick Review

➢ **Classification of polymers:**

Based on source or origin

Natural polymers
From nature
e.g. Plants
From animal sources
e.g. Cotton, Linen, Silk, etc.

Synthetic polymers
Artificially prepared by polymerization of one monomer or copolymerisation of two or more monomers.
e.g. Nylon, Teflon, etc.

Semi-synthetic polymers or regenerated fibres
Derived from naturally occurring polymers by chemical modifications.
e.g. Acetate rayon, viscose rayon, cellulose nitrate, etc.

- Fibres — e.g. Nylon
- Synthetic rubbers — e.g. Buna-S
- Plastics — e.g. Bakelite

Based on the structure

Linear or straight chain polymers
- Monomer molecules are joined together in linear arrangement.
- Obtained from bifunctional monomers or alkenes

e.g. PVC, HDPE, etc.

Branched chain polymers
- Have long chains with the side chains or branches of different lengths.
- Obtained from monomers with side chains or 3 functional groups .

e.g. LDPE, Polypropylene, etc.

Network or cross-linked polymers
- Have linear chain polymers which are cross-linked by covalent bonds leading to 3D network like structure.
- Obtained from polyfunctional monomers.

e.g. Melamine, Bakelite, etc.

Based on the polymerization process

Addition or chain growth polymers

Formed by direct addition of repeated monomers without the elimination of small molecules.
e.g. PAN, Teflon, etc.

Condensation or step growth polymers

Formed by the condensation of two or more than two bifunctional monomers (or polyfunctional monomers) with the elimination of small molecules like H_2O, CH_3OH, HCl, NH_3.
e.g. Terylene, Nylon 6, etc.

Ring opening polymers

Formed by addition of monomers (cyclic compounds) to growing chain molecules without elimination of small molecules like H_2O, CH_3OH, etc.
e.g. ε-caprolactum.

Based on the intermolecular forces

Elastomers

Elastic in character like rubber due to van der Waals forces and few crosslinks.
e.g. Vulcanized rubber, buna-S, neoprene, etc.

Thermoplastic polymers

Softened easily on repeated heating and hardened when cooled with little change in their properties.
e.g. Polystyrene, PVC, etc.

Fibres

Have strong intermolecular forces (hydrogen bonds or dipole-dipole interactions) between the chains resulting in high tensile strength.
e.g. terylene, nylon 6,6, etc.

Thermosetting polymers

Infusible solids with highly cross-linked or heavily branched structure due to strong covalent bonds and undergo permanent change on heating. **e.g.** melamine, bakelite, etc.

Homopolymers

Polymers containing only one type of repeating unit.
e.g. Nylon 6, PAN, etc.

Based on type of different monomers

Copolymers

Polymers containing two or more types of repeating unit.
e.g. Buna-S, Buna-N, etc.

Biodegradable polymers

Polymers affected by microbes.
e.g. PHBV, Nylon 2-nylon 6, etc.

Based on biodegradability

Non-biodegradable polymers

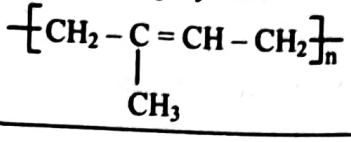
Polymers not affected by microbes.
e.g. Nylon 6,6, Terylene, etc.

➢ **Some important polymers:**

Natural rubber

Monomer: Isoprene — Polymer: Polyisoprene

Structure of polymer:

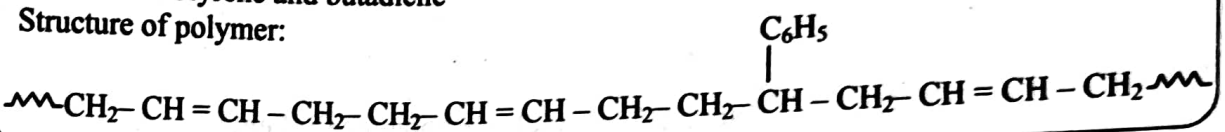


Synthetic rubbers

Buna-S

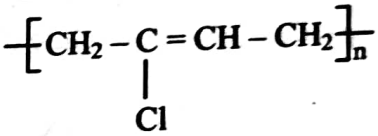
Monomers: Styrene and butadiene

Structure of polymer:



Neoprene

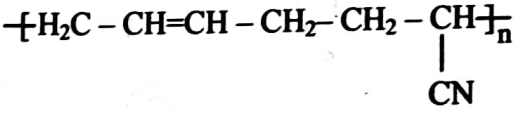
Monomer: Chloroprene — Structure of polymer:



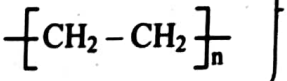
Buna-N

Monomer: Acrylonitrile and butadiene

Structure of polymer:



Polythene



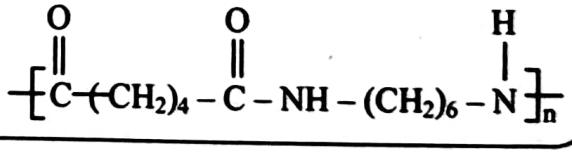
- LDP → Branched polymer
- HDP → Linear polymer

Polyamides (Nylon)

Nylon 6,6

Monomers: Adipic acid and hexamethylenediamine

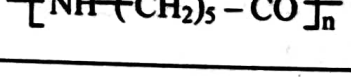
Structure of polymer:



Nylon 6

Monomer: ∈-Caprolactum

Structure of polymer:

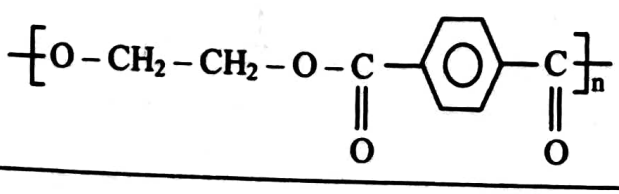


Polyesters

Terylene (Dacron)

Monomers: Ethylene glycol and terephthalic acid

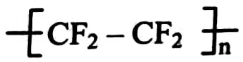
Structure of polymer:



➢ **Other common polymers:**

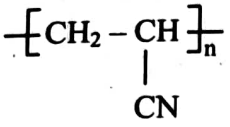
Teflon

Monomer:
Tetrafluoroethylene
Structure of polymer:



Polyacrylonitrile

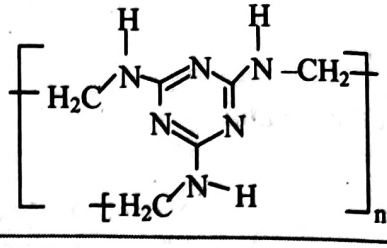
Monomer:
Acrylonitrile
Structure of polymer:



Melamine-formaldehyde polymer (Melamine)

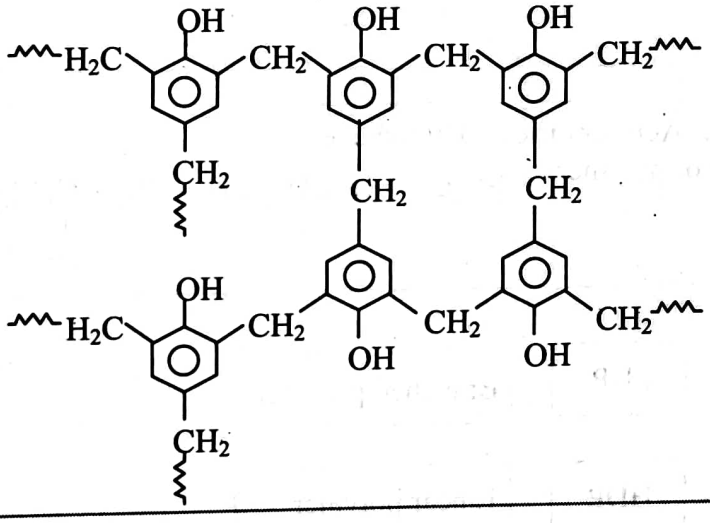
Monomers: Melamine and formaldehyde

Structure of polymer:



Phenol-formaldehyde polymer (Bakelite)

Monomers: Phenol and formaldehyde
Structure of polymer:

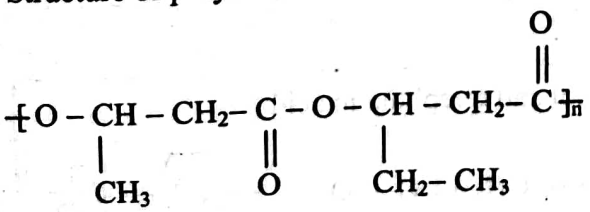


➢ **Biodegradable polymers:**

Biodegradable polymers

PHBV

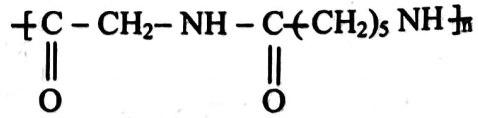
Monomers:
β-Hydroxybutyric acid (3-hydroxybutanoic acid) and
β-Hydroxyvaleric acid (3-hydroxypentanoic acid).
Structure of polymer:



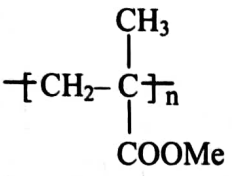
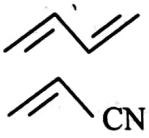
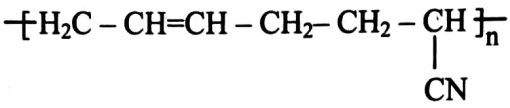
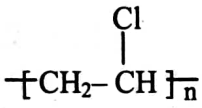
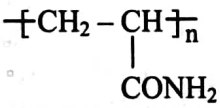
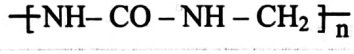
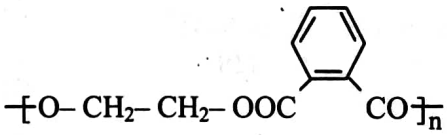
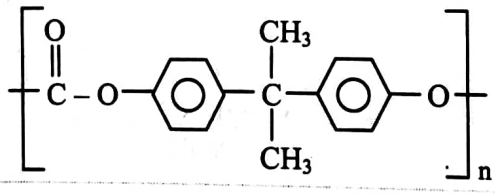
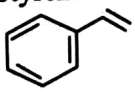
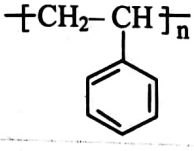
Nylon 2-nylon 6

Monomers:
Glycine and ε-amino caproic acid

Structure of polymer:



Some commercially important polymers:

Trade name	Monomer	Polymer structure	Applications
Perspex/acrylic glass	Methyl methacrylate 		lenses, paint, security barrier, LCD screen, shatter resistant glass
Buna-N	Butadiene and acrylonitrile 		adhesives, rubber belts, shoe soles, O-rings, gaskets
PVC (polyvinyl chloride)	vinyl chloride 		water pipes, rain coats, flooring
Polyacrylamide	acrylamide 		Polyacrylamide gel used in electrophoresis
Urea-formaldehyde resin	a. urea b. formaldehyde		unbreakable dinner ware, decorative laminates
Glyptal	a. ethylene glycol b. phthalic acid		paints and lacquers
Polycarbonate	a. bisphenol b. phosgene		electrical and telecommunication hardware, food grade plastic containers
Thermocol (made from air-filled thin walled beads of polystyrene)	Styrene 		non-biodegradable, styrene can leach when heated. Therefore, it is banned.