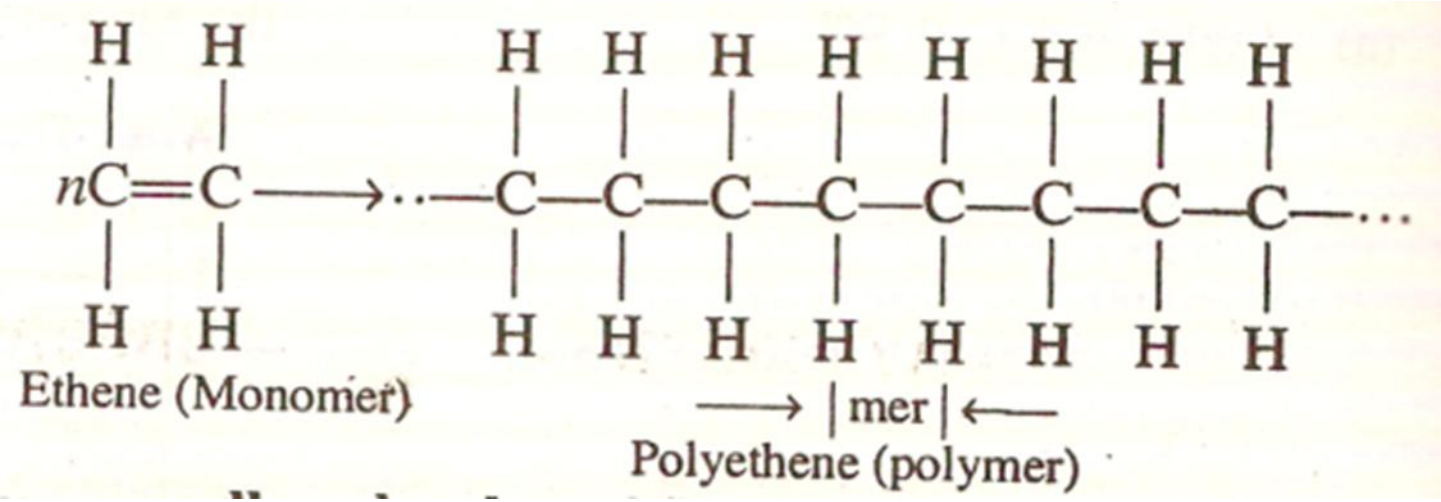
BASIC CONCEPTS OF POLYMERS

Dr. Vandana K. Nair
Assistant Professor
Applied sciences and Humanities
Dronacharya Group of Institutions
Greater Noida, Uttar Pradesh

- Introduction : The word "polymer" is derived from two Greek words, poly (= many) and mer (= parts or units). A polymer is a large molecule which is formed by repeated linking of small molecules called "monomers". Example: Polyethene is a polymer formed- by linking together of a large number of ethene (C_2H_4) molecules



Why to Study Polymers?

Definition of polymers: A polymer is a large molecule of high molecular weight obtained by the chemical interaction of many small molecules of low molecular weight of one or more type. The process of manufacture of a polymer is called the polymerization.

Monomers: Small molecules of low molecular weight, which combine to give a polymer, are called monomers.

Degree of polymerization: The number of monomers used in the process is called degree of polymerization.

Functionality: The total number of functional groups or bonding sites present in a monomer molecule is called the functionality of the monomer.

Characteristics of Polymers :

- Polymeric molecules are very big molecules. They are also known as macromolecules.
- Polymers are semi-crystalline materials. They have both amorphous and crystalline regions. In fact, polymers have regions of crystallinity, called crystallites, embedded in amorphous regions. Crystallites provide strength and hardness and the amorphous regions provide flexibility to the polymeric material.
- Combustible materials.
- Thermal and electrical insulators.
- Show excellent resistance to corrosion.
- Polymers are very light in weight with significant degrees of strength

I. **Based on their sources they are classified into**

1. **Natural polymers**: The polymers, which are obtained from natural sources such as plants and animals, are called natural polymers.
   Egs. Wood, cellulose, Jute, Cotton, Wool, Silk, Proteins, Natural rubber etc.

1. **Synthetic polymers**: The polymers, which are synthesized from simple molecules, are called synthetic polymers.
   Egs: Nylon6,6, PVC, Polystyrene, Teflon, Plexiglass, Polyesters, Polyethylene etc

I. Based on their thermal behaviour thy are classified into

1. **Thermoplastic polymers**: egs: PVC, Polyethylene etc.

2. **Thermosetting polymers**: egs: Bakelite, Urea-Formaldehyde etc.

III. Based on their mechanism of polymerization they are classified into

1. **Addition polymers**: egs: PVC, Polyethylene etc.
2. **Condensation polymers**: egs: Nylon66, Polyester etc.

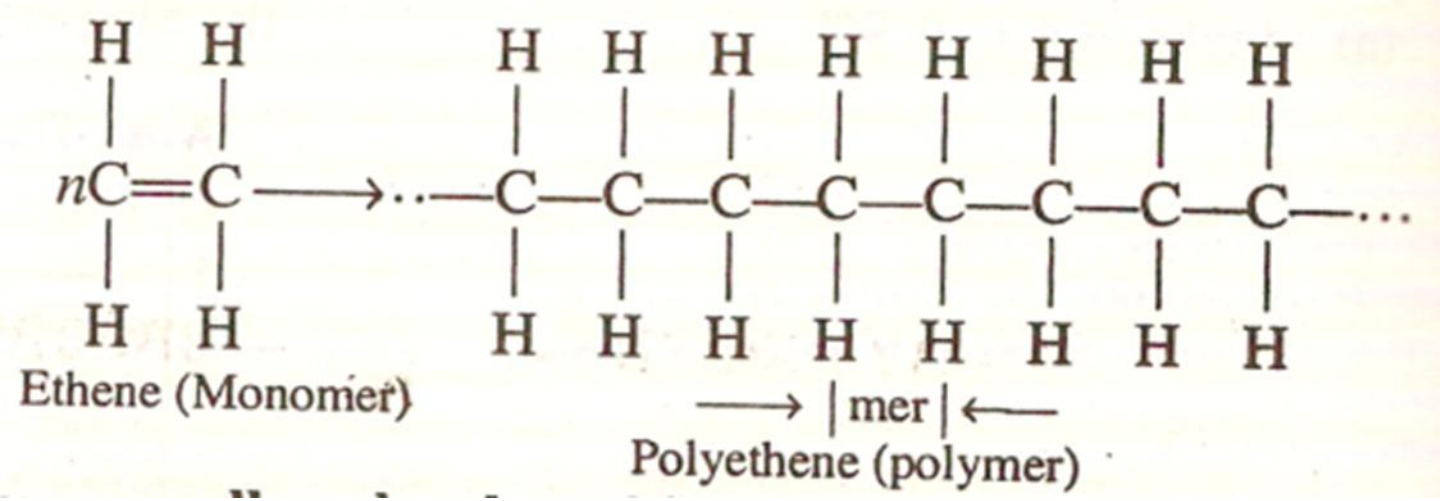
IV. Based on their properties they are classified into

1. **Elastomers** egs; Natural rubber
2. **Fibres** egs: Jute, Wood, Silk etc
3. **Resins** egs: Urea- Formaldehyde, Epoxy resins, Phenol- Formaldehyde etc.
4. **Plastics** egs: Plexiglass, PVC, Teflon etc.

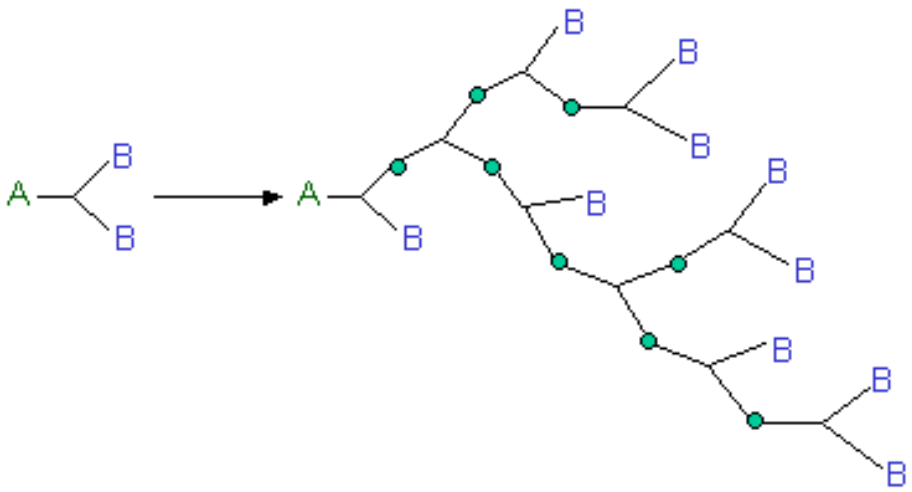
V. Based on the chemical structure

- Linear (Eg; all thermoplastics), branched (eg: polystyrene) and cross-linked polymer (bakalite)

Linear -

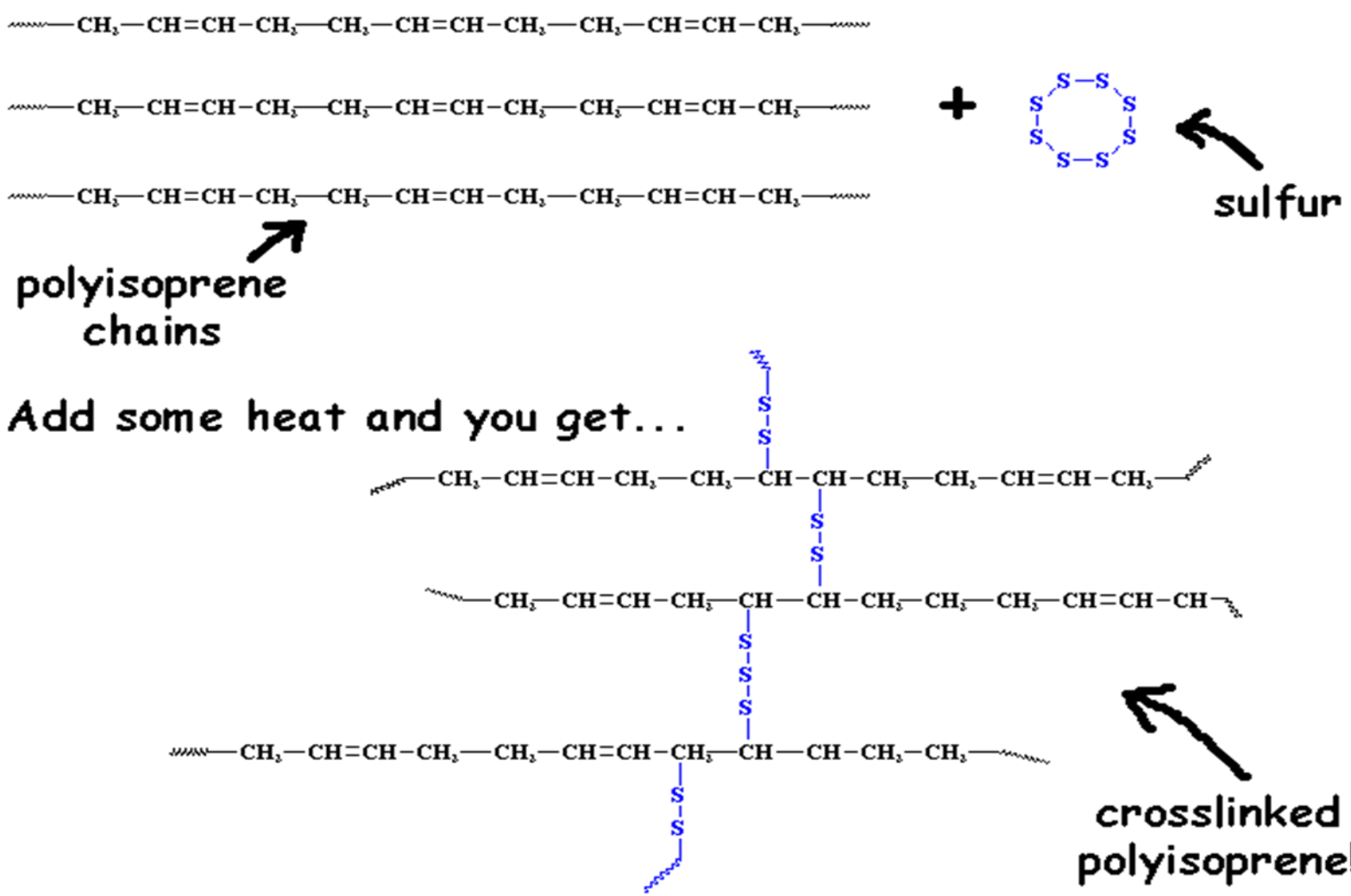


Branched



Eg. Polystyrene, PMMA

Cross linked :a bond that link one polymer chain to another



VI)Based on Tacticity

- The orientation of monomeric units in a polymer molecule can take place in an orderly or disorderly fashion with respect to the main chain. The difference in configuration (**tacticity**) do affect their physical properties.

Isotactic Polymer: All the substituents are located on the same side of the macromolecular backbone.

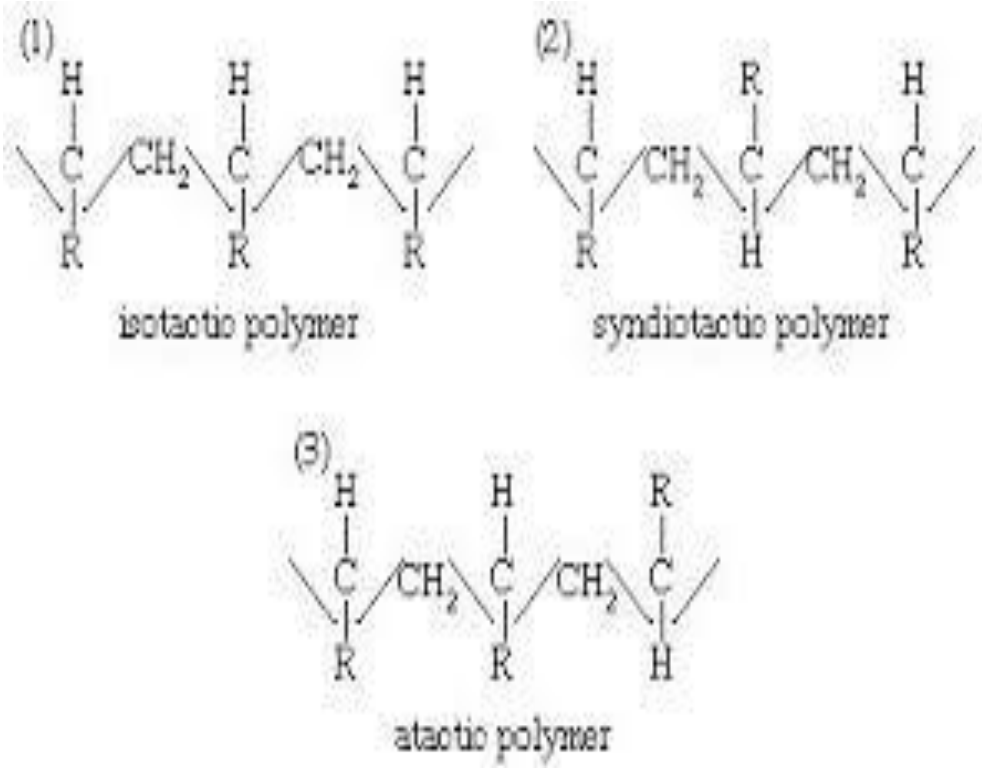
Eg; Polypropylene

SyndiotacticPolymer:The substituents have alternate positions along the chain.

Eg; syndiotactic polystyrene

Atactic Polymer: The substituents are at random around the main chain.

Eg; PVC



Polymerization: Is the process of conversion of low molecular weight substances into high molecular weight substances with or without the elimination of by products such as HCl, H_2O, NH_3 etc.

Types of polymerization:

1.Addition (chain) polymerization: A polymerization reaction in which monomers containing one or more double bonds are linked to each other without the elimination of any by products, usually in the presence of initiators is called addition polymerization.

Egs: 1. Formation of polythene.

Condensation (step) polymerization:

It is brought by linking together different monomers accompanied by the elimination of small molecules like H_2O, HCl, and NH_3.

Egs: 1. Formation of Nylon66

n NH2-(CH2)6-NH2 + n HOOC- (CH2)4- COOH

Hexamethylene diamine Adipic acid

[-NH-(CH2)6-NH-CO-(CH2)4-CO-] n + 2n H2O

Nylon66

Classification Based on structure:

- **Elastomers**: Any rubbery material composed of long chain like molecules, or polymers, that are capable of recovering their original shape after being stretched to great extent.

Eg; Vulcanized Rubber

- Fibres: When a polymer is drawn into long filament like material, whose length is 100 times its diameter, its called fibre.
- e.g., nylon-6,6, cellulose, cotton
-

- Resins:Low moleculat wt.polymers used as adhesives. They can be in the form of liquid or powders.Eg. Phenol formaldehyde, urea formaldehyde
- Plastics: polymers which can be moulded into desired shapes by the application of heat and pressure (Eg. PE, PVC)

Types of Plastics

Classified as thermoplastic and thermosetting

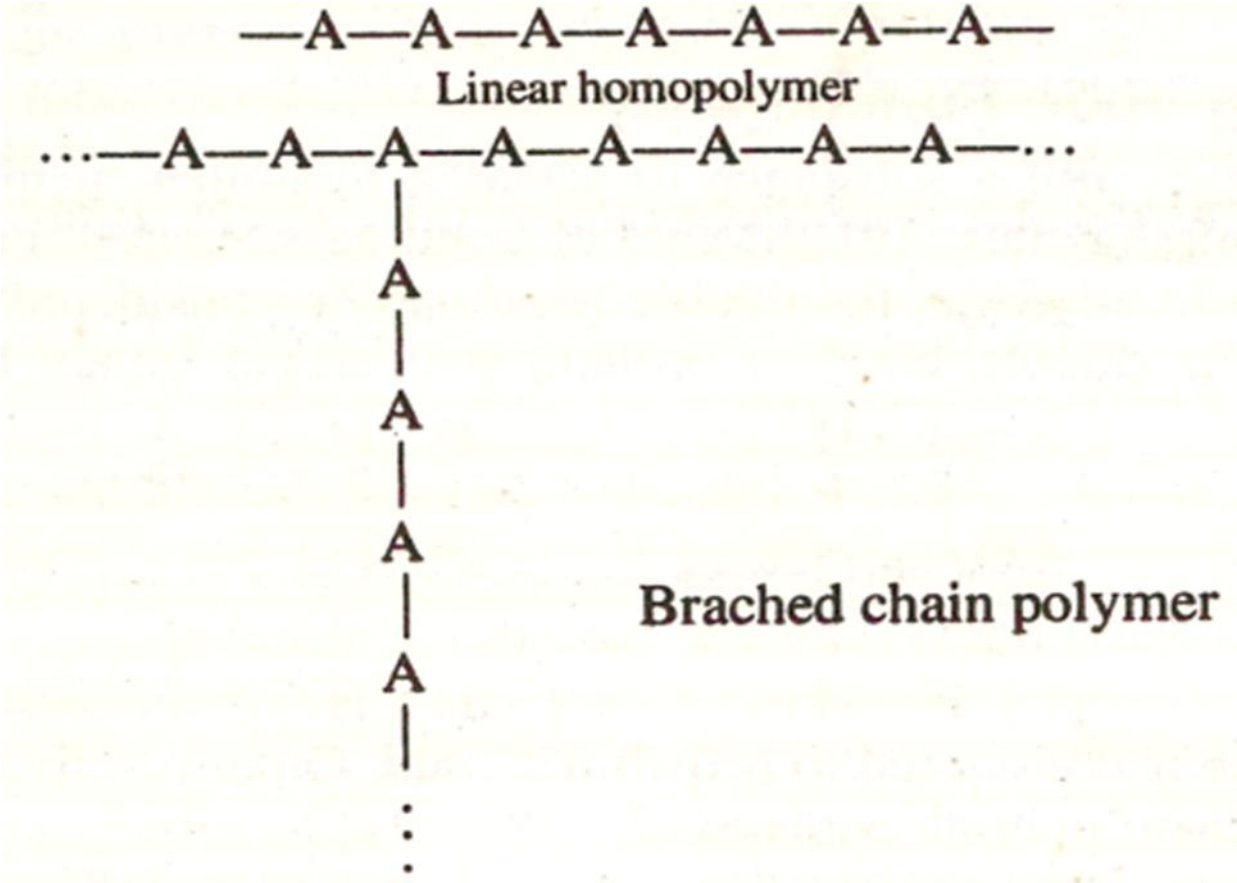
Thermoplastics: Plastics which soften on heating and harden on cooling. They retain their structure when subjected to heat and pressure. Hence they can be remoulded into new shapes without any loss of their physical properties.

Eg: PVC, polyethylene.

Thermosetting plastics: Plastics which get hardened during moulding process and cannot be softened by reheating. They also soften on heating but on standing acquire a cross linked structure which make them stable to heat. Thus they cannot be remoulded into new shapes.
Eg. Phenol formaldehyde resin

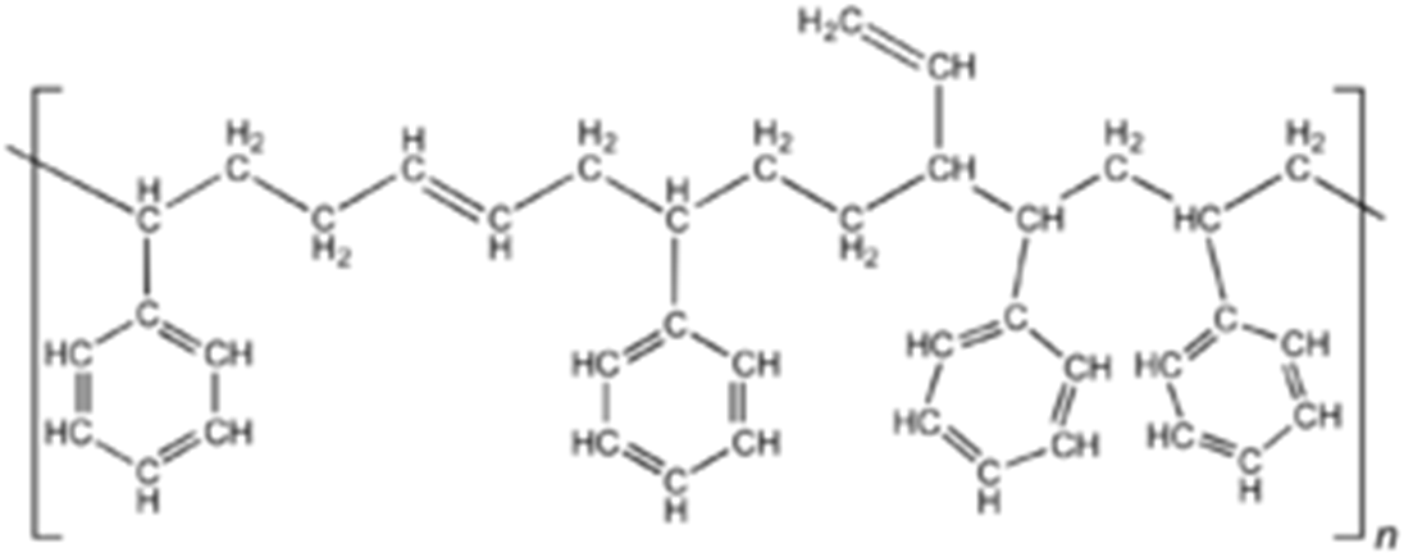
Homopolymers and coplymers

- Polymers formed from the same type of monomers are called homopolymers



Copolymer

- Formed by combining different monomers
- Eg: styrene butadiene copolymer



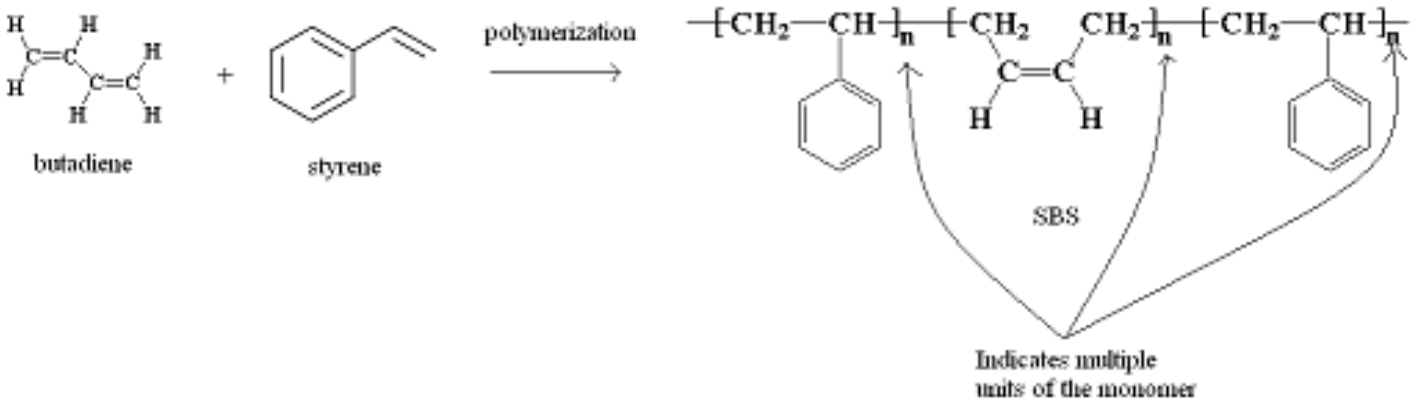
- The chains of co-polymer consist of repeating units derived from each monomer. Following are some common types of co-polymers :

- **(a) Alternating co-polymers**
- **(b) Block co-polymers**
- **(c)Random co-polymers**
- **(d)Graft co-polymers**

Alternating co-polymers

- The different repeating units alternate in each chain. If A and B represent two different units then an alternating co-polymer will be represented as,

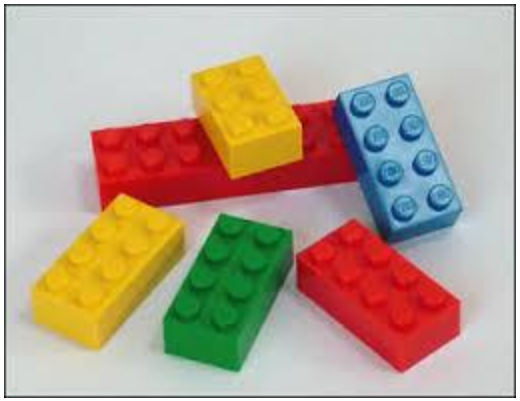
-ABABABAB-



- (b) Random Co-polymers: In this type of copolymers, the different repeating units are not arranged in a systematic manner but are randomly arranged, e.g.

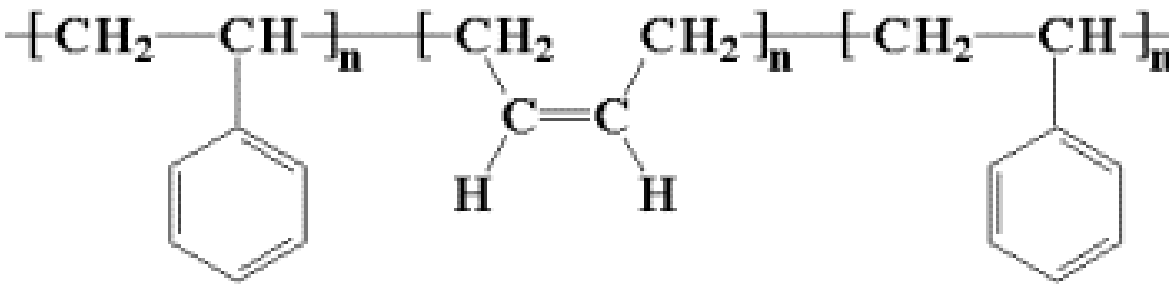
-ABAABABBAAABA-

Eg; commercial copolymers of butadiene and acrylonitrile



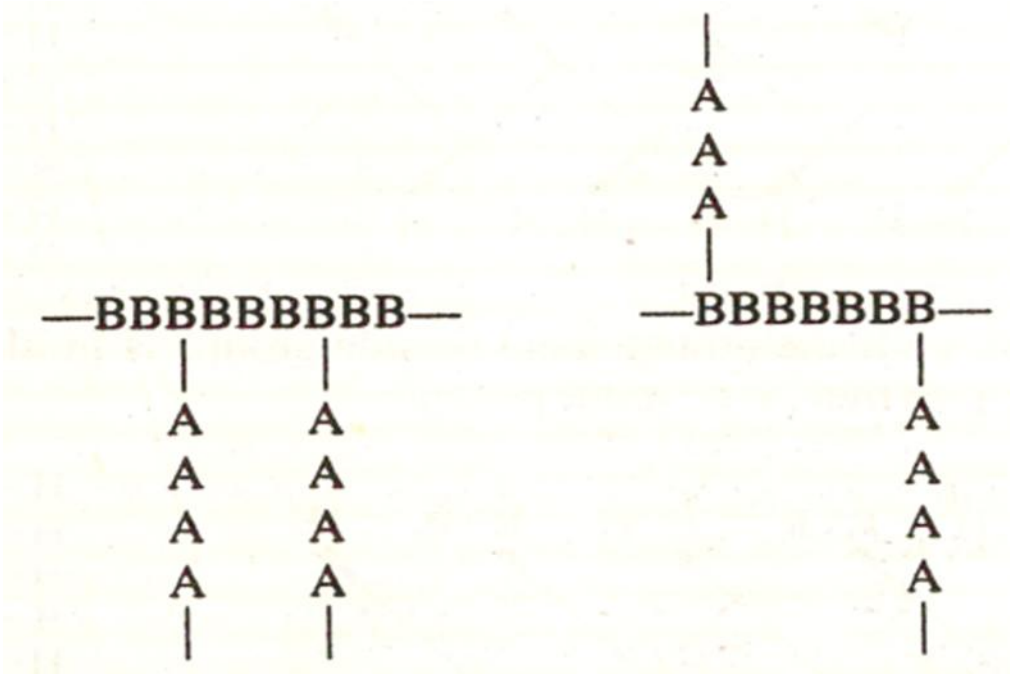
(c) Block Co-polymers: In such co-polymers, block of repeating units of one type alternate with block of another type, e.g. SBS (shoe soul)

-AAAABBBBAAAABBBB-

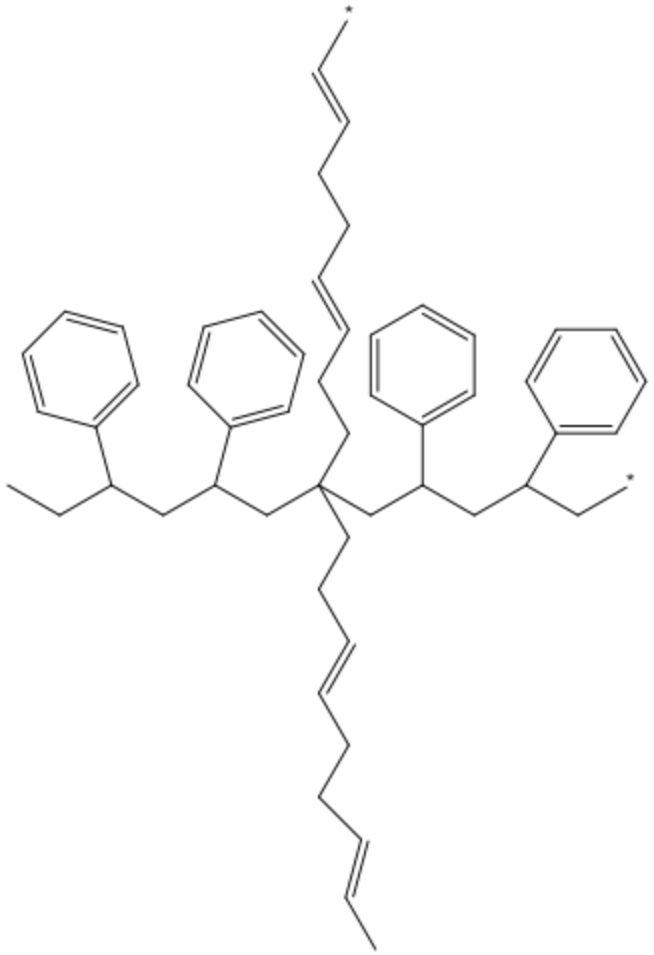


(d) Graft Co-polymers

- In such co-polymers, blocks of one repeating units are attached or grafted to a block of linear polymer, e.g.



- Eg: High impact polystyrene



USE of High impact polystyrene

Difference between Thermoplastics and Thermosetting plastics

Thermoplastics

- Formed by the addition polymerization.
- Soften very readily on heating and stiffen on cooling.(reversible change).
- Can be remoulded.
- Usually soft, weak and less brittle.
- Polymeric chains are held together by weak vander Waal's forces.

Thermosetting

- Formed by condensation polymerization.
- Become stiff and hard on heating, but do not soften on cooling. (irreversible change).
- Can't be remoulded.
- Hard, strong and more brittle.
- Polymeric chains are held together by strong covalent bonds in the forms of cross-links