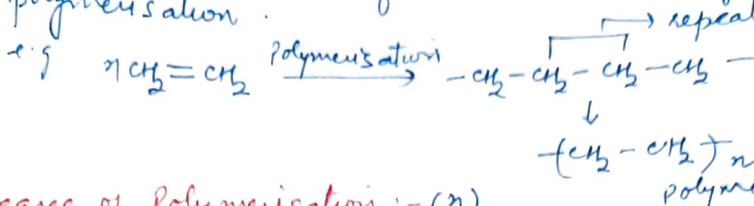


## POLYMERS

Poly  $\Rightarrow$  many, meros  $\Rightarrow$  parts or units  
 large no. of simple repeating units. <sup>their</sup> structures of consists of:  
 from low mol. wt. simple compound known as monomer and  
 the process of conversion of monomer into polymer is known  
 as polymerisation.



### Degree of Polymerisation : $-(n)$

The no. of monomers combined to form polymer is known  
 as degree of polymerisation, denoted by  $n$ .

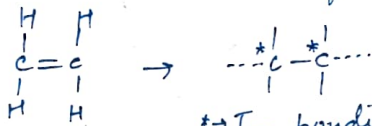
$$n = \frac{M}{m}$$

where  $M \rightarrow$  mol. wt. of polymer  
 $m \rightarrow$  mol. wt. of monomer

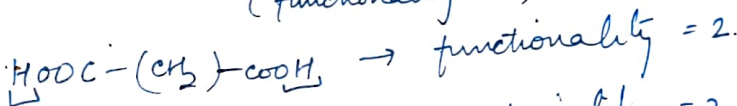
Therefore, molecular wt. of polymer depends upon the degree of  
 polymerisation.

Functionality :- The no. of bonding sites present in a monomer,  
 is known as its functionality.

e.g.  $\text{CH}_2=\text{CH}_2$  When double bond breaks, there are two active  
 sites or bonding sites at which bonding may take place  
 and hence it is a bifunctional monomer.



$\rightarrow$  Two bonding sites  
 (functionality = 2)



Bifunctional monomers form  $\rightarrow$  linear polymers

Trifunction + Bifunctional monomers form  $\rightarrow$  branched polymers

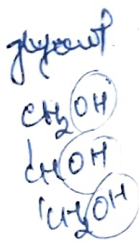
Trifunction + Bifunctional monomers form  $\rightarrow$  cross-linked polymers

polyfunctional form  $\rightarrow$  cross-linked polymers

For a substance to act as a monomer, it must be at least  
 bifunctional in nature, i.e. it must have at least two  
 bonding sites or reactive sites.

Therefore,  $\text{CH}_3\text{COOH}$ ,  $\text{C}_2\text{H}_5\text{OH}$  etc. can not act  
 as monomers as they are monofunctional  
 not bifunctional.

Why all simple organic compds can not act as monomers  
 during polymerisation?



## CLASSIFICATION OF POLYMERS

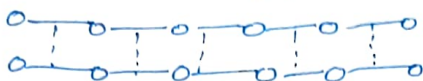
[A] Depending upon the structure of polymer:- 3 types

(i) Linear chain, (ii) Branched chain, (iii) Cross-linked

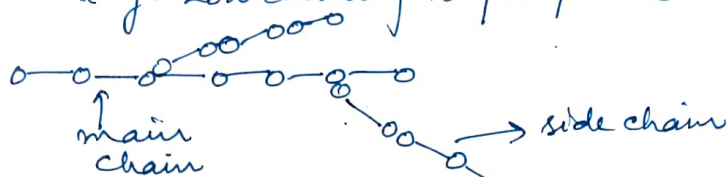
LINEAR CHAIN POLYMERS:- In which monomers are joined like links in chain. They have high density, high tensile strength and high M.P. because of well packed structure.

e.g. Polyethylene, Nylons etc.

o—o monomer structure

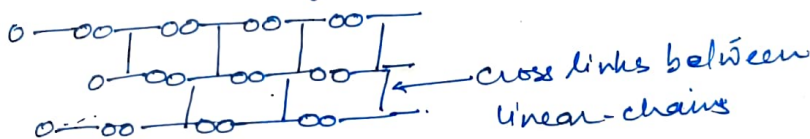


BRANCHED CHAIN POLYMERS:- Polymers having side chains or branches in addition to main chain. Branching hinders tight packing in comparison to the linear chain polymers. They have lesser density and tensile strength & lower M.P. as compared to linear chain polymers. e.g. Low density Polyethylene (LDPE), starch etc.



NETWORK / CROSS-LINKED POLYMERS:-

In which monomers are cross-linked together in all the three dimensions to form 3D-network type of structure. Generally, they are obtained by polyfunctional monomers. They are hard, brittle and rigid because of cross-linking. e.g. Bakelite



DEPENDING UPON THE STEREOCHEMISTRY OR TACTICITY:-

Alkenes are of type  $H_2C=CHZ$  may undergo polymerisation to form polymer  $[H_2C-CHZ]_n$  in which <sup>may</sup> gives any of the three types of polymers.

"The difference in the configuration of polymer is known as tacticity." Depending upon the tacticity, polymers are of 3-types - (i) Isotactic, (ii) Syndiotactic, (iii) Atactic

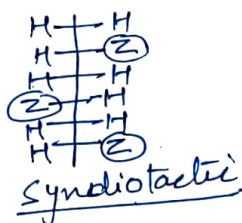
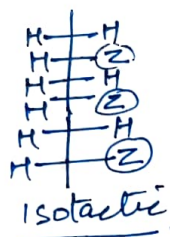


ISOTACTIC :- Polymer in which all the functional gps (Z) are on the same side of the main carbon chain.  
e.g. Cis-polyisoprene, ~~polypropylene~~ [same priority/gp on same side of double bond]

Isotactic polymers are hard and have higher m.p., & higher density ~~than others~~ due to linear chain structure, devoid of branching, therefore have well packed structure. They are superior than atactic & syndiotactic.

SYNDIOTACTIC :- If functional gps are on the alternate side of main chain. e.g. Gutta Percha (Trans-polyisoprene).

ATACTIC :- If functional gps are arranged randomly. e.g. polypropylene. They have low m.p., lesser density, soft and elastic & are inferior than isotactic.



[C] ON THE BASIS OF TYPE OF MONOMERS :- Two types -

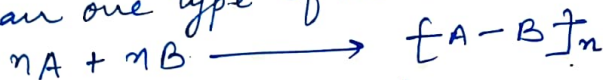
(i) Homopolymer

(ii) Copolymer

HOMOPOLYMER :- A polymer formed by the polymerisation of one type of monomer. e.g. Polyethylene, PMMA, PVC etc.



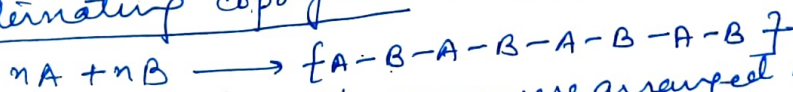
COPOLYMER :- Polymer formed by the polymerisation of more than one type of monomer.



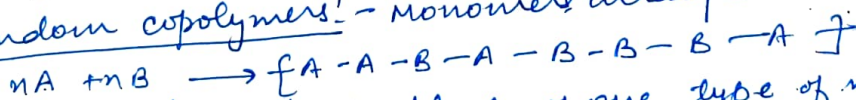
e.g. Nylon 6, 6, Terylene etc.

Depending upon the arrangement of A & B in copolymer, chain copolymers may be of following types -

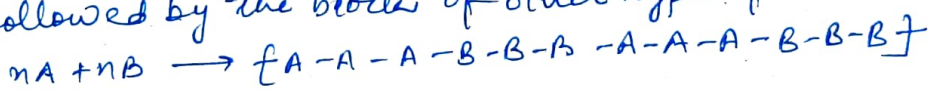
(i) Alternating copolymers :- monomers arranged alternatively



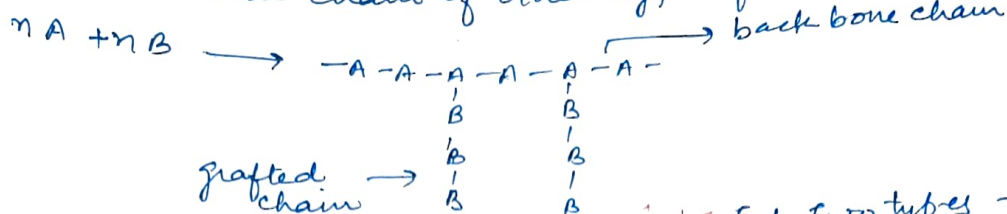
(ii) Random copolymers :- Monomers arranged randomly.



(iii) Block copolymers :- One block of one type of monomer is followed by the block of other type of monomer.



(iv) Graft-copolymers:- One type of monomer chain is grafted on the backbone chain of other type of monomer.



[D] On the basis of mode of Synthesis:- Fyt Two types -

(i) Addition Polymers (ii) Condensation

ADDITION POLYMERS:- Which are formed by the polymerisation of monomers without elimination of atoms/gps. Here, the molecular formula of the repeating unit is exactly same as that of the starting monomer. Also known as chain growth polymers and generally take place in presence of initiator. Its mechanism involves three steps -

→ chain initiation by initiator,

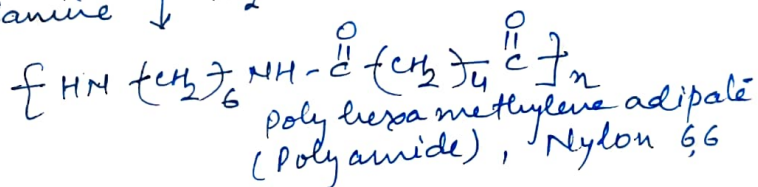
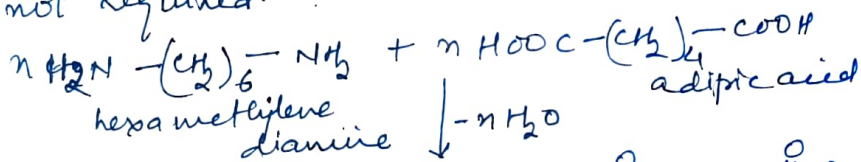
→ chain propagation,

→ chain termination. e.g.  $n \text{CH}_2=\text{CH} \begin{array}{c} \text{C}_6\text{H}_5 \\ | \end{array} \longrightarrow \left[ \text{CH}_2-\text{CH} \begin{array}{c} \text{C}_6\text{H}_5 \\ | \end{array} \right]_n$

styrene polystyrene

CONDENSATION POLYMERS:-

Polymers which are formed by the polymerisation of monomers with elimination of small molecules like  $\text{NH}_3$ ,  $\text{H}_2\text{O}$ , etc. Generally they are formed by the polymerisation of different types of monomers and are also known as step-growth polymers. Initiators are not required.



Conditions for Condensation Polymerisation:-

- ① Generally more than one type of monomers are used.
- ② having different functional groups <sup>polymerise</sup> so that elimination of any small molecule may take place. e.g. Nylon 6,6 <sup>condensation</sup>
- ② If a single monomer is required (for e.g. in Nylon-6, only Amino caproic acid is required), it must contain at least two different functional gps.  $-\text{NH}_2$  gp  $-\text{COOH}$  gp



[E] Based on Action of heat on polymers! - Two types -

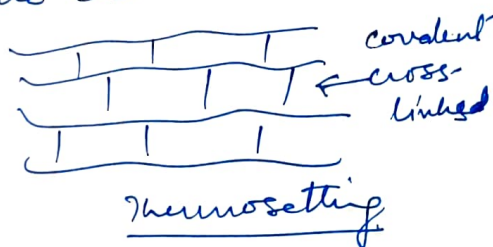
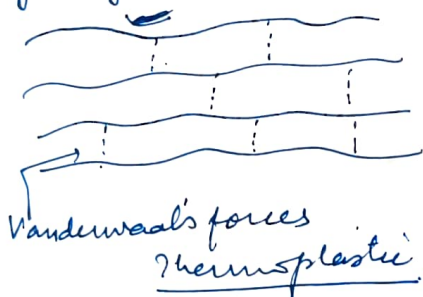
(i) Thermoplastic, (ii) Thermosetting

THERMOPLASTIC POLYMERS! - Thermoplastics are the polymers which get softer on heating and hardened on cooling without or with very little change in their properties. Therefore, they can be remoulded or reprocessed. Generally, they are linear chain polymers (without cross-linking) and different chains are held together by weak Vanderwaal's forces of attraction.

e.g. ~~LDPE~~; PE, PVC, Nylons, PTFE etc.

THERMOSETTING POLYMERS! - Thermosets are polymers which once hardened can not be softened again. They are permanent setting polymers. Such polymers during moulding acquire 3-D cross-linked st. with predominantly strong co-valent bonds. Once they are ~~not~~ moulded, can not be softened again or reprocessed. On heating they undergo hardening because of taking place of any left over polymerisation, later on charring takes place. Generally they are hard, rigid and brittle.

e.g. polyester, bakelite, melamine etc.



[F] on the basis of origin! - Two types -

(i) Natural & (ii) Synthetic

NATURAL! - e.g. starch, cellulose, proteins etc.

SYNTHETIC! - (man-made) - PVC, PE, NYLONS etc.