Unit- 15

Polymers

Polymer → are the macromolecules formed by repeating of large no. of simple molecules. These simple molecules are known as monomers. Thus polymers are the monomer macromolecules formed by largeed no. of monomers.

Diff. b/w macromolecules & polymer
→ All the polymers are macromolecules but all the macromolecules are not polymer

Polymerisation → The process of converting monomers into polymer is known as polymerisation.

Classification of polymers →

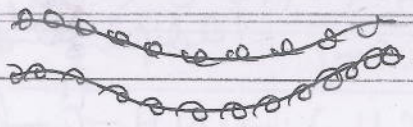
A) Based upon their sources/origin → we have two types of polymers

(1) Natural polymer → are the polymers which are obtained from the nature. For eg:→ starch, cellulose etc.

(2) Synthetic polymer → are the man made polymers. They are prepared in the labs. eg → Nylon 66, Terylene etc.

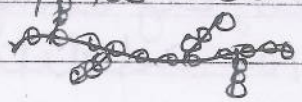
B) Based upon the molecular structure → we have three types of polymers →

(1) Linear chain polymer → The polymers in which monomer units are linked in such a way to form the linear chain are known as linear chain polymers.

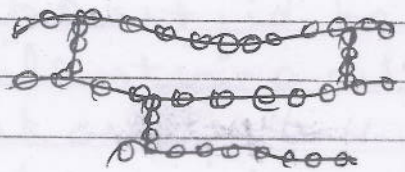


eg → Nylon, polyesters etc.

(2) Branched chain polymer → The polymer in which monomer units are linked in such as way to form a branched chain are known as branched chain polymers.
eg → Starch, low density polythene.



(3) Crossed linked polymer → The polymer in which the monomers are linked in such as way to form crossed linked structure are known as crossed linked polymers.



eg → Glyptal, Bakelite.

(C) Based upon the nature of monomer → we have two types of polymers
(1) Homopolymers → A polymer which is formed by only one type of monomer are known as homopolymers.
eg → Polythene

$$n(CH_2=CH_2) \xrightarrow{\text{Polymerisation}} \underset{\text{(Polythene)}}{\left(CH_2-CH_2\right)_n}$$

(2) Copolymer → A polymer which is formed by more than one type of monomer are known as copolymers.
eg → Nylon 66 → Nylon 66 is a copolymer

of hexamethylene diamine and adipic acid

$$n H_2N-(CH_2)_6-NH_2 + nHO-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-OH \xrightarrow{-nH_2O}$$

(Hexamethylene diamine) (adipic acid)

$$\left(NH-(CH_2)_6-NH-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-\right)_n$$

(Nylon 66)

(D) Based upon the mode of synthesis → we have two types of polymers

(1) Additional polymer → A polymer which is formed by simple addition of monomers is known as additional polymer.

eg → polythene

$$n CH_2=CH_2 \xrightarrow{\text{Polymerisation}} \left(CH_2-CH_2\right)_n$$

Polythene

(2) Condensation polymers → A polymer which is formed by the addition of monomers along with elimination of some simple molecules such as water is known as condensation polymers.

eg → $n H_2N(CH_2)_6-NH_2 + nHO-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-OH$

$$\rightarrow \left(NH(CH_2)_6-NH-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}-\right)_n$$

Nylon 66

(E) Based upon the nature of molecular forces → we have three types of polymers →

(1) Elastomers → Are the polymers in which there are weak intermolecular forces b/w the monomers. These molecules

behave like a rubber. eg ⇒ Natural rubb

(2) Fibres → In fibre there are strongest molecular forces b/w the monomers. eg ⇒ Nylon 66, Terylene.

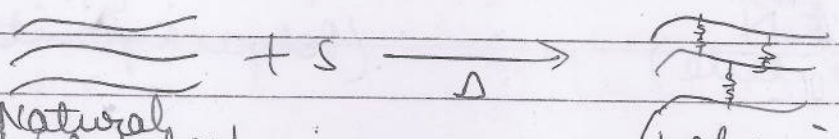
(3) Thermoplastic → These are the polymer in which there are molecular forces stronger than elastomers and weaker than fibres. Thus they have intermole cular forces b/w elastomers and fibre

Difference b/w thermoplastic and thermo setting plastic →

thermoplastics become soft on heating and hard on cooling with little change in properties. eg ⇒ Teflon, polystyren

thermosetting plastic → These are the polymer which undergo permanent change on heating. On heating they become extensive crossed linked and become hard. eg ⇒ Bakelite.

* vulcanisation → The tential strength an elasticity of the natural rubber can be increased by heating it with sulphur. This process of heating natural rubber with sulphur to ~~heat~~ increase its tential strength and elasticity is known as vulcanisation.



The rubber formed after vulcanisation is known as

vulcanised rubber.

Some important polymers :-

(A) Polyenes →

⇒ Polythene → ethene on polymerisation forms polythene.

$$nCH_2=CH_2 \xrightarrow{\text{Polymerisation}} \underset{\text{Polythene}}{(CH_2-CH_2)_n}$$

ethene

⇒ Poly vinyl chloride (PVC) → vinyl chloride on polymerisation forms a polymer known as poly vinyl chloride (PVC).

$$nCH_2=\underset{Cl}{\underset{|}{CH}} \xrightarrow{\text{Polymerisation}} \underset{\text{(PVC)}}{(CH_2-\underset{Cl}{\underset{|}{CH}})_n}$$

(vinyl chloride)

⇒ Polystyrene → styrene on polymerisation forms a polymer known as polystyrene

$$nCH_2=\underset{C_6H_5}{\underset{|}{CH}} \xrightarrow{\text{Polymerisation}} \underset{\text{(Polystyrene)}}{(CH_2-\underset{C_6H_5}{\underset{|}{CH}})_n}$$

(Styrene)

⇒ Polyacrylonitrile (PAN)/orlon/acrilon → Acrylonitrile on polymerisation forms a polymer known as polyacrylonitrile

$$nCH_2=\underset{CN}{\underset{|}{CH}} \xrightarrow{\text{Polymerisation}} \underset{\text{(Polyacrylonitrile)}}{(CH_2-\underset{CN}{\underset{|}{CH}})_n}$$

(Acrylonitrile)

⇒ Polytetra flouro ethylene (PTFE)/Te
→ Tetra flouro ethylene on polymerisa
forms a polymer which as tetra flubro
ethylene or teflon.

$$n CF_2=CF_2 \xrightarrow{\text{Polymerisation}} \left(CF_2-CF_2\right)_n$$

(TFE) (PTFE or Teflon)

(B) Polydienes :⇒

⇒ Natural rubber → The monomer o
natural rubber is isoprene (2methyl
buta diene). Isoprene on polymeris
tion forms a polymer which as natural
rubber.

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

(Isoprene) (Natural rubb

⇒ synthetic rubber → There are fol
types of synthetic rubber. The mono
of Neoprene (Synthetic rubber) is Chlor
(2chloro 1,3 buta diene). Chloroprene o
polymerisation gives polymer which as Neopr

$$n CH_2=\underset{Cl}{\overset{|}{C}}-CH=CH_2 \xrightarrow{\text{Polymerisation}} \left(CH_2-\underset{Cl}{\overset{|}{C}}=CH-CH\right.$$

(Chloroprene) (Neoprene)

⇒ Buna S → is a copolymer of but 1,3
diene and Styrene.

$n\,CH_2=CH-CH=CH_2 + n\,CH_2=\underset{C_6H_5}{CH}$ (Polymerisation)

(but 1,3 diene) (Styrene)

$$\left(CH_2-CH=CH-CH_2-CH_2-\underset{C_6H_5}{CH}\right)_n$$

(Buna S)

⇒ Buna N → is a copolymer of but 1,3 diene and acrylonitrile.

$n\,CH_2=CH-CH=CH_2 + n\,CH_2=\underset{CN}{CH}$ (Polymerisation)

(but 1,3 diene) (acrylonitrile)

$$\left(CH_2-CH=CH-CH_2-CH_2-\underset{CN}{CH}\right)_n$$

(Buna N)

(C) Polyesters →

⇒ Terylene / Dacron → Terylene or a Dacron is a copolymer of ethylene glycol and terephthalic acid

$n\,OH-CH_2-CH_2-OH + n\,HOOC-C_6H_4-COOH \xrightarrow[-n\,H_2O]{\text{Polymerisation}}$

(ethylene glycol) (terephthalic acid)

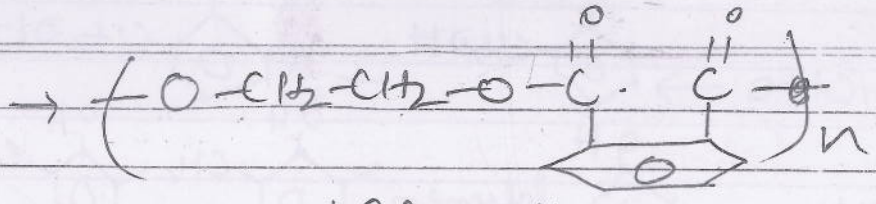
$$\left(O-CH_2-CH_2-O-\overset{O}{\overset{\|}{C}}-C_6H_4-\overset{O}{\overset{\|}{C}}\right)_n$$

(Terylene)

⇒ Glyptol → is a copolymer of ethylene glycol and phthalic acid

$n\,OH-CH_2-CH_2-OH + n\,HO-\overset{O}{\overset{\|}{C}}-C_6H_4-\overset{O}{\overset{\|}{C}}-OH \xrightarrow[-n\,H_2O]{\text{Polymerisation}}$

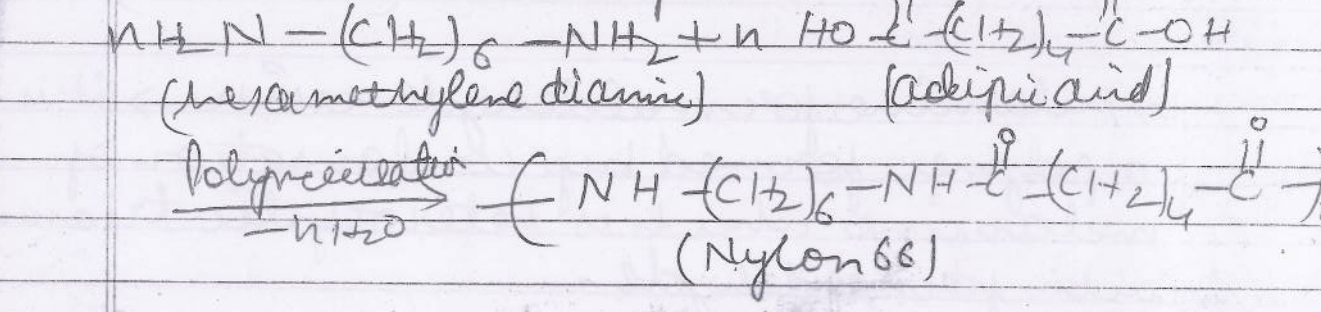
(ethylene glycol) (Phthalic Acid)



(Glyptal)

(D) Polyamides →

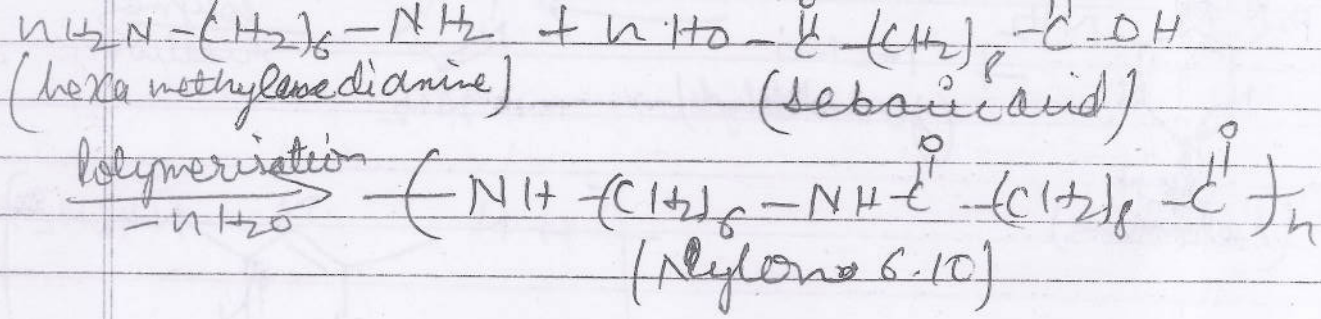
⇒ Nylon 66 → is a copolymer of hexa methylene diamine and adipic acid.



(hexamethylene diamine) (adipic acid)

(Nylon 66)

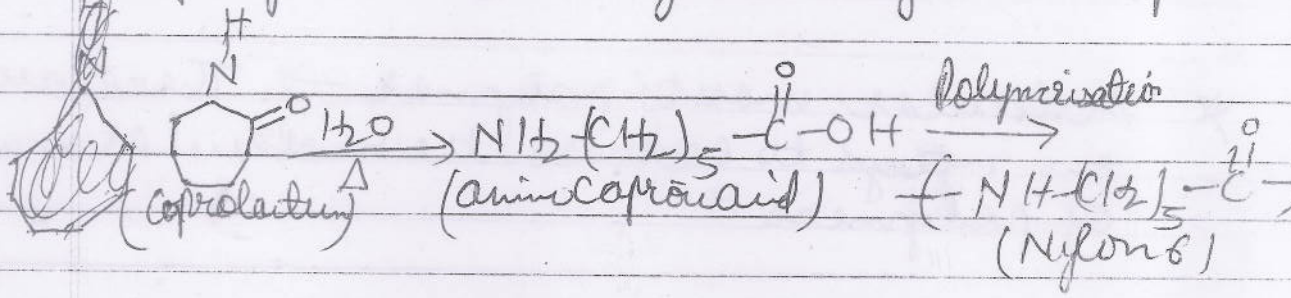
⇒ Nylon 6-10 → is a copolymer of hexa methylene diamine and sebacic acid



(hexa methylene diamine) (sebacic acid)

(Nylon 6-10)

⇒ Nylon 6 → is a polymer of caprolactum when aqueous sol. of caprolactum is heated it gives amino caproic acid and this on polymerisation gives Nylon 6 as product

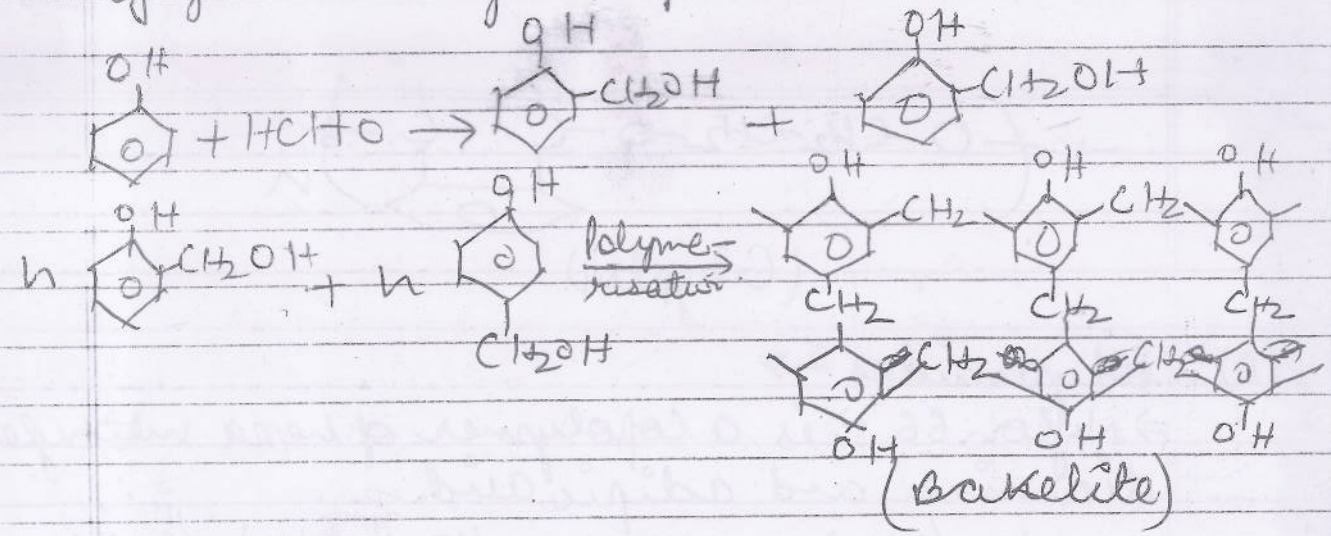


(caprolactum) (amino caproic acid)

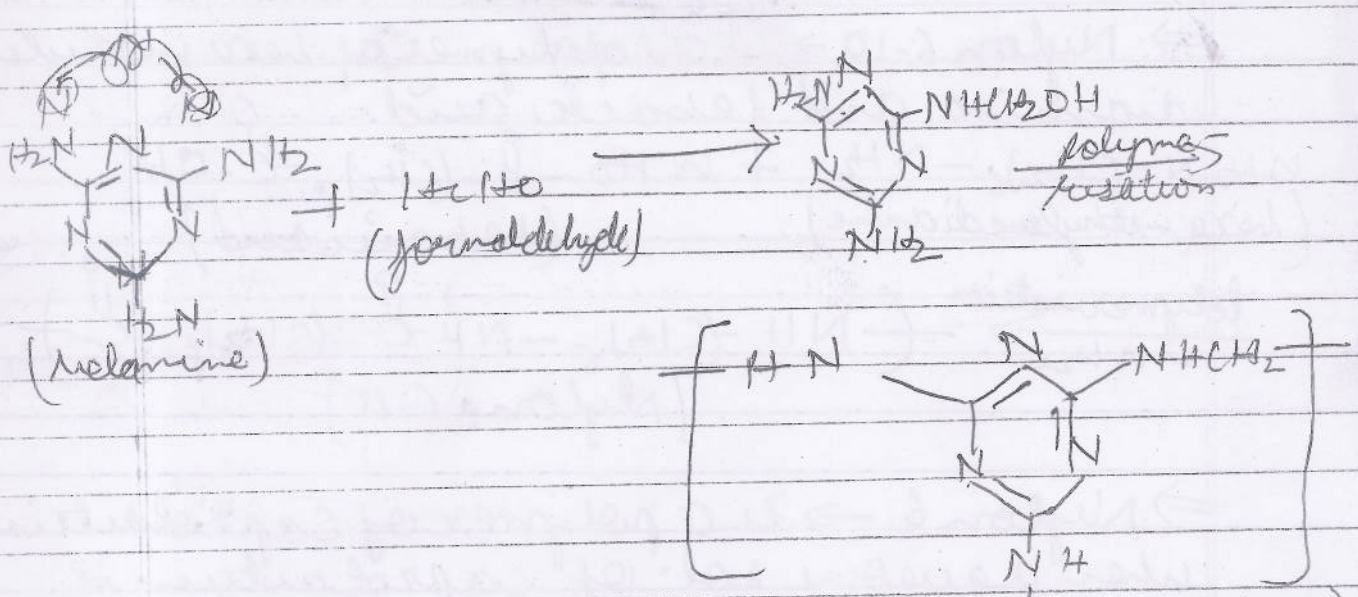
(Nylon 6)

(E) Formaldehyde resin / Bakelite → is a polym

of formaldehyde & phenol -



⇒ melamine formaldehyde resin → It is a polymer formed by condensation of melamine which is heterocyclic triamine with formaldehyde.



** Molecular mass of polymer → There are two ways to express the molecular mass of polymers :-

1) weight average molecular mass ($\bar{M}_w$)
2) Number average molecular mass ($\bar{M}_N$)

weight average molecular mass → If N_1 be the no. of monomer having M.M M_1 & N_2 be the monomers having M.M M_2 & N_3 be the no. of monomers having M.M M_3 & so on then weight average molecular mass

$$\bar{M}_w = \frac{N_1M_1^2 + N_2M_2^2 + N_3M_3^2 + \cdots}{N_1M_1 + N_2M_2 + N_3M_3 + \cdots}$$

$$\bar{M}_w = \frac{\sum N_i M_i^2}{N_i M_i}$$

Number average molecular mass → If N_1 be the no. of monomers having M.M M_1 & N_2 be the no. of monomers having M.M M_2 & N_3 be the no. of monomer having M.M M_3 & so on then no. average molecular mass

$$\bar{M}_N = \frac{N_1M_1 + N_2M_2 + N_3M_3 + \cdots}{N_1 + N_2 + N_3 + \cdots}$$

$$\bar{M}_N = \frac{\sum N_i M_i}{\sum N_i}$$

PDI (Poly dispersity index) → It is the ratio of weight average M.M to the no. average M.M. Mathematically → $PDI = \frac{\bar{M}_w}{\bar{M}_N}$

Biodegradable polymers → These are the polymers which are decomposed by micro-organism & they do not causes any serious effects on the environment. These polymers are environment friendly polymers.
eg → PHBV (Poly hydroxy butyrate hydroxy valerate)