Physical properties of amino acids :-

(i) Non-volatile, crystalline solid having high melting point

(ii) Highly water soluble & insoluble in non-polar solvents

(iii) pH of soln is neutral

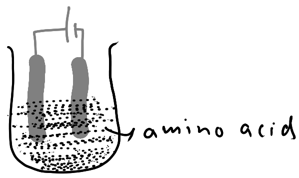
(iv) Behaves like soln of substance having high dipole moment.

(v) Ka and Kb are ridiculously low for -COOH and -NH2 groups.

All above properties are due to dipolar ion / zwitter ion

$R-\underset{\overset{|}{\oplus NH_3}}{CH}-COO^{\ominus}$ Dipolar ion / zwitter ion

Iso-electric point (pI) :- At a certain H^+ ion (pH = pI), the dipolar ion exists as a neutral and doesn't migrate to either electrode ie no net movement / migration the pH is called iso-electric point.



At iso-electric point, [cation] = [Anion]

$$\left[R-\underset{\overset{|}{^+NH_3}}{CH}-COOH\right] = \left[R-\underset{\overset{|}{NH_2}}{CH}-COO^-\right]$$

$$\underset{(\text{cation})}{R-\underset{\overset{|}{\oplus NH_3}}{CH}-COOH} \rightleftharpoons \underset{\text{Dipolar ion (DI)}}{R-\underset{\overset{|}{\oplus NH_3}}{CH}-COO^-} + H^+ \; ; \; ka_1 \text{ of } -COOH$$

$$ka_1 = \frac{[DI][H^+]}{[\text{cation}]} \Rightarrow [\text{cation}] = \frac{[DI][H^+]}{ka_1} \quad \text{— (1)}$$

$$\underset{(DI)}{R-\underset{\overset{|}{\oplus NH_3}}{CH}-COO^-} \rightleftharpoons \underset{(\text{Anion})}{R-\underset{\overset{|}{NH_2}}{CH}-COO^-} + H^+ \; ; \; ka_2 \text{ of } -\overset{+}{N}H_3$$

$$ka_2 = \frac{[\text{Anion}][H^+]}{[DI]} \Rightarrow [\text{Anion}] = \frac{ka_2 \cdot [DI]}{[H^+]} \quad \text{— (ii)}$$

At iso-electric point, [cation] = [anion]

$$\therefore \frac{[DI][H^+]}{ka_1} = \frac{ka_2 [DI]}{[H^+]}$$

$$[H^+]^2 = ka_1 \times ka_2$$

$$[H^+] = (ka_1 \times ka_2)^{1/2}$$

$$-\log[H^+] = \frac{1}{2}\left[-\log ka_1 + (-\log ka_2)\right]$$

$$\boxed{pH = pI = \frac{pka_1 + pka_2}{2}}$$

eg: $CH_3-CH(\overset{\oplus}{N}H_3)-COOH$ ($pka = 2.34$; $\overset{\oplus}{N}H_3$ $pka = 9.69$)

$$\therefore pI = \frac{2.34 + 9.69}{2} = 6.02$$

NOTE: ① If an amino acid has 2nd ionisable $-\overset{+}{N}H_3$ or $-COOH$ group, its pI is equal to the average of the pka values of similar ionisable group.

eg: $HOOC-(CH_2)_4-CH(\overset{\oplus}{N}H_3)-COOH$ ($pka = 2.19$); $HOOC$ $pka = (4.25)$; $\overset{\oplus}{N}H_3$ ($pka = 9.67$)

$$pI = \frac{2.19 + 4.25}{2} = 3.22 \ \text{Ans}$$

(ii) If pH of solⁿ > pI ⇒ amino acid exists as anion

< ———————— cation

Peptide Bond / Linkage:- Acid amide bond is formed by the rxn between $-COOH$ of one amino acid with $-NH_2$ of other amino acid.

$H_2N-CH_2-\overset{O}{\overset{||}{C}}-OH + H-NH-CH(CH_3)-NH_2 \longrightarrow H_2N-CH_2-\overset{O}{\overset{||}{C}}-NH-CH(CH_3)-NH_2$

Glycine (Gly or G) — Alanine (Ala / A) — Peptide Bond

G-A (Gly-Ala)

Note: It is customarily to write $-NH_2$ at the extreme left and $-COOH$ at the extreme right.

glycine + alanine ⟶ 4 different possible products (2 self + 2 cross products)

$H_2N-CH_2-\overset{O}{\overset{||}{C}}-OH + H-NH-CH_2-COOH$ (G) $\xrightarrow{}$ $H_2N-CH_2-\overset{O}{\overset{||}{C}}-NH-CH_2-COOH$

G (glycine), H_3O^+, G-G

called dipeptide because it is formed by the rxn of two amino acids

If a third amino acid combines to a dipeptide, the product is called tripeptide

fourth ———————— tripeptide, ———————— tetrapeptide and so on:-

when no. of amino acid > 10 then product is called polypeptide

Polymer

Large molecules formed by combining small repeating units (monomer) is called polymer.

Types of Polymer —
- Homopolymer (having only one type of monomer)
- copolymer (having more than one type of monomer)

Examples

(I) Homopolymer :-

(a) polythene : $n(CH_2=CH_2)$ ⟶ $[CH_2-CH_2]_n$

ethene (monomer) ⟶ Polythene

(b) Teflon : $n(CF_2=CF_2)$ ⟶ $[CF_2-CF_2]_n$

Tetrafluoroethene ⟶ Teflon - used in non-sticky utensil

(c) Polyacrylonitrile (PAN) : $n(CH_2=\underset{CN}{\underset{|}{CH}})$ ⟶ $[CH_2-\underset{CN}{\underset{|}{CH}}]_n$

Acrylonitrile or vinyl cyanide ⟶ PAN

(d) Polyvinyl chloride (PVC) : $n(CH_2=\underset{Cl}{\underset{|}{CH}})$ ⟶ $[CH_2-\underset{Cl}{\underset{|}{CH}}]_n$

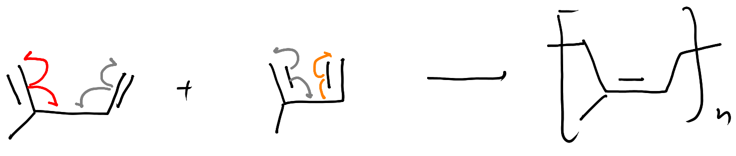
vinyl chloride ⟶ PVC

(e) Natural Rubber :-

monomer - isoprene (common name)

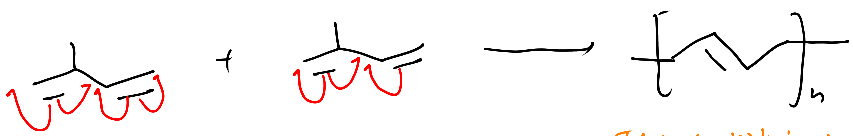
$CH_2=\underset{CH_3}{\underset{|}{C}}-CH=CH_2$ IUPAC : 2-methylbuta-1,3-diene

Case I : cis-form



cis-polyisoprene (natural rubber)

Case II : Trans-form

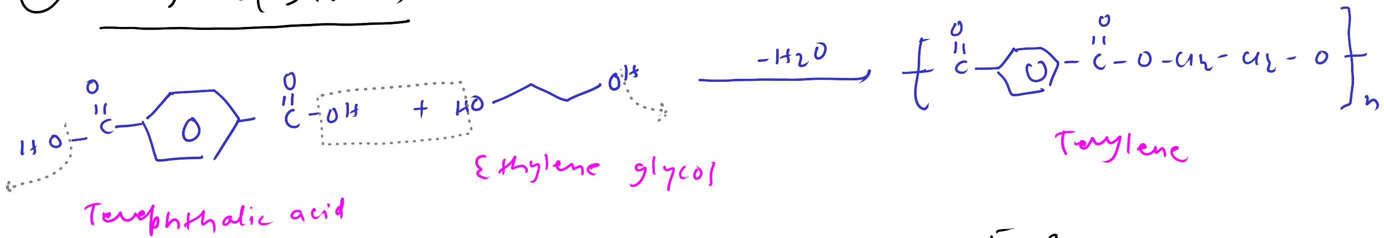


Trans-polyisoprebene

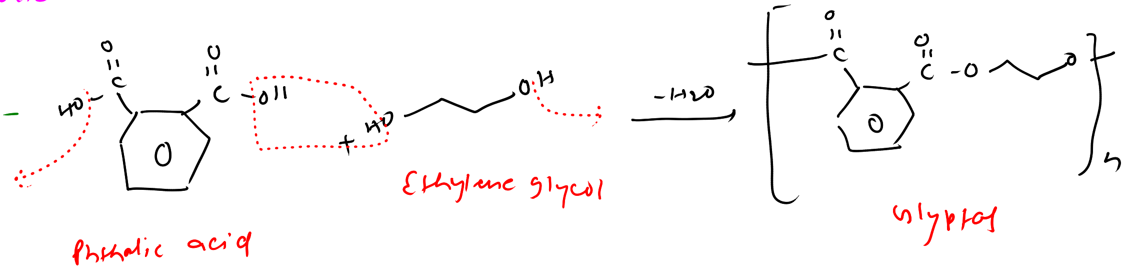
gutta-purcha - used in filling teeth

II Copolymers :-

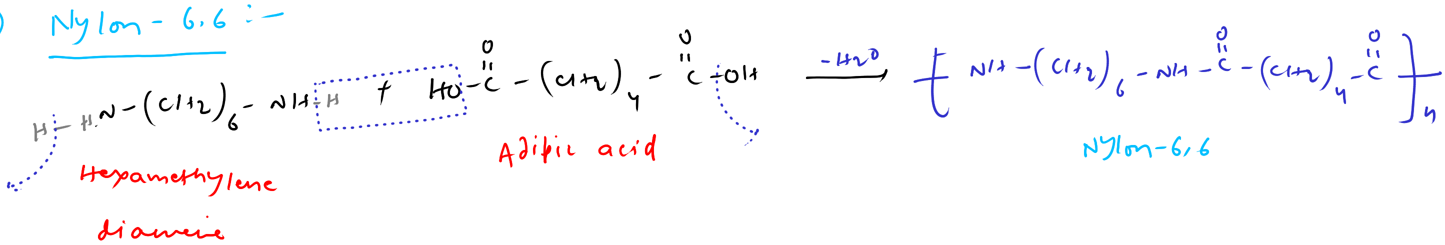
(a) Terylene (Dacron) :-



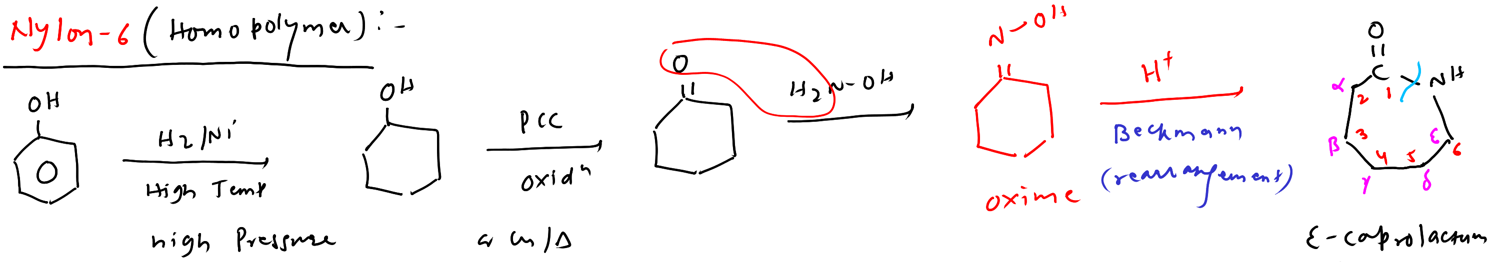
(b) Glyptal :-



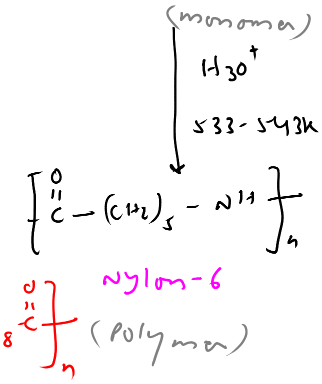
(c) Nylon - 6,6 :-



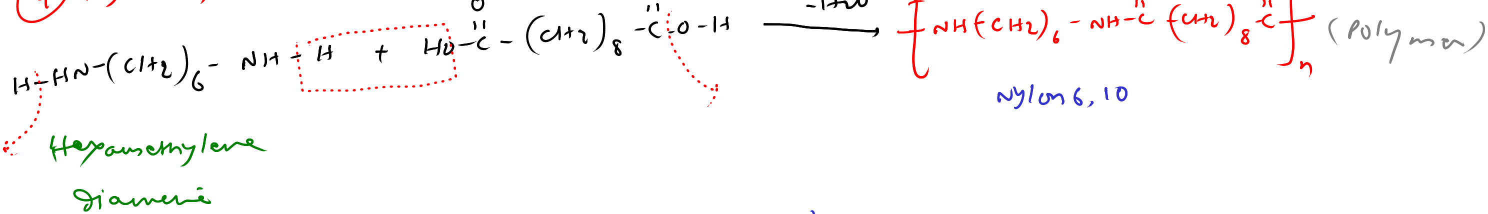
Nylon-6 (Homopolymer) :-



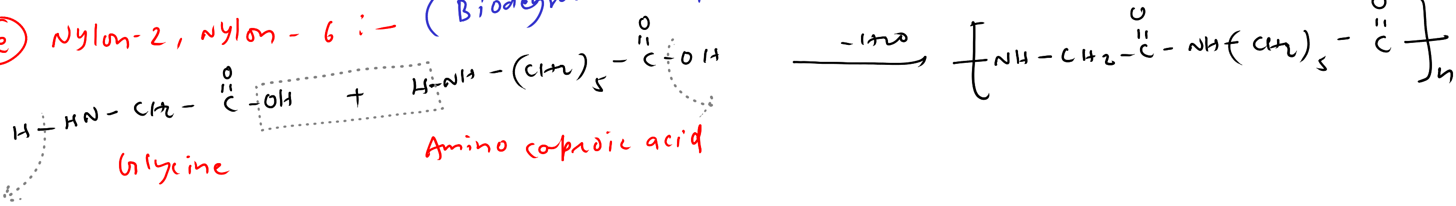
Nylon-6 is used in making tyre cords, fabric and ropes



(d) Nylon 6, 10 :-

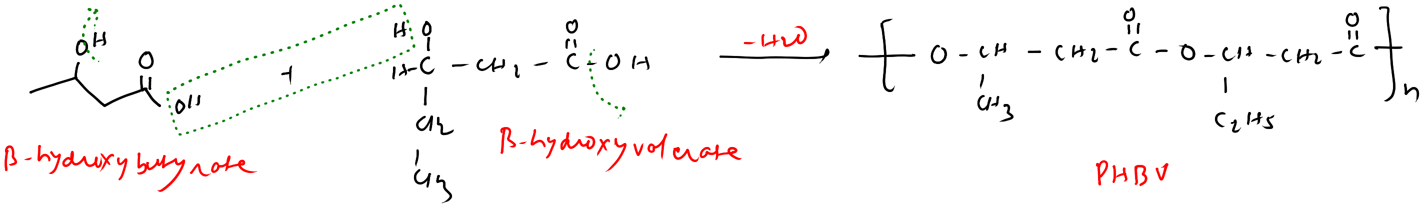


(e) Nylon-2, Nylon - 6 :- (Biodegradable polymer)



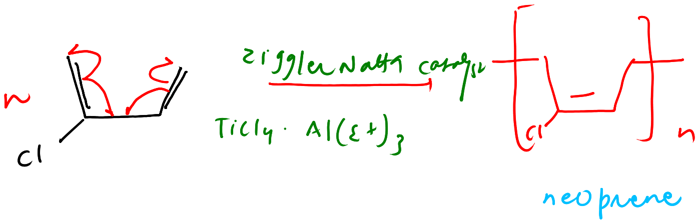
PHBV (biodegradable polymer) :-

Poly - β - hydroxybutyrate - co - β - hydroxyvalerate



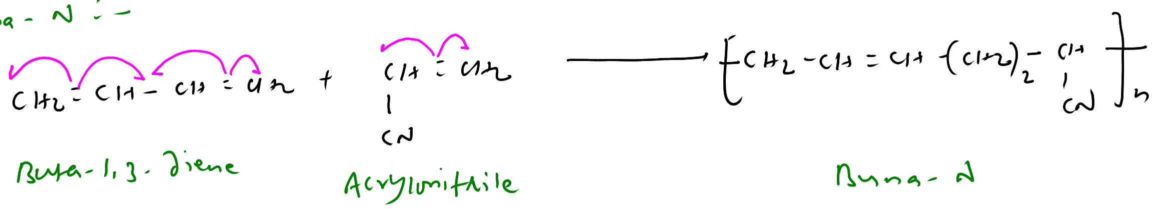
Synthetic Polymer :-

(i) Neoprene :-

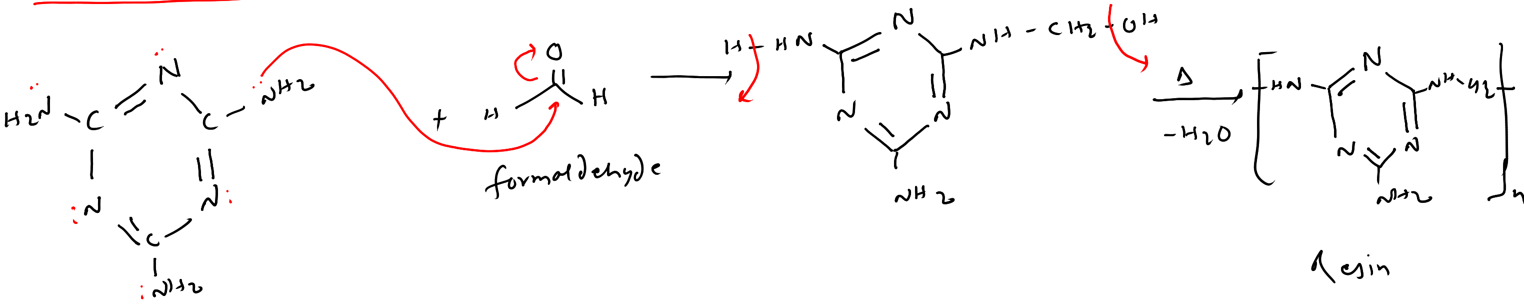


(ii) Buna-S (Butadiene - Styrene rubber) :-

(iii) Buna-N :-



- Melamine - formaldehyde Resin :-



(melamine) - Aromatic

total 6 lone pair of e's

Classification of Polymers :

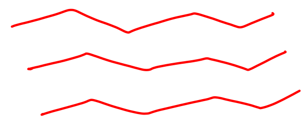
Based on Source

- Natural (By plants/animal)
- Semi-synthetic: Raw material natural but made in lab
- Synthetic: made in lab by chemicals; eg : polythene, nylon, bakelite

eg polythene, Nylon, bakelite)

Based on structure

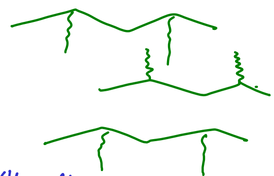
(I) Linear polymer :-



- High Packing
- High density, high m.pt, high tensile strength

eg : HDP (or HDPE) = high density polythene

(II) Branched polymer :-



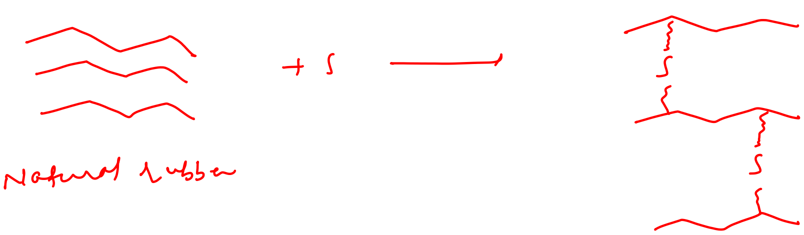
- low packing
- low density, low m.pt low strength

LDP (LDPE) = low density polythene

(III) Cross-linked Polymer :- Made by bifunctional and trifunctional monomers

- Having strong covalent bond in cross linking between linear chains

eg:- bakelite, vulcanised rubber (used in making tyre)

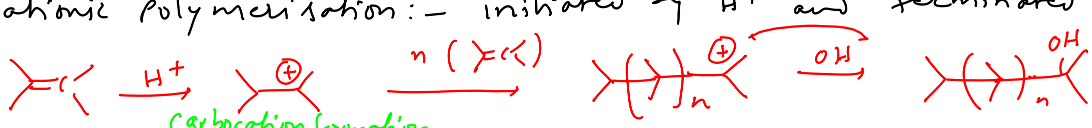


strength of rubber ↑

(III) Based on mode of polymerisation

Addition Polymer (chain growth polymer)	condensation Polymer (step growth polymer)
• cationic polymerisation	• Removal of small molecule like H_2O, NH_3, ROH etc
• Aneonic "	
• free radical "	eg. Nylon, Terylene, Bakelite

(A) cationic Polymerisation :- initiated by H^+ and terminated by base



(B) Anionic polymerisation :- initiated by OH^- and terminated by H^+

(C) Free radical polymerisation :-

Step I: $Ph-\overset{O}{\overset{\|}{C}}-O-O-\overset{O}{\overset{\|}{C}}-Ph \xrightarrow{h\nu} 2\,Ph-\underset{O}{\underset{\|}{C}}-\dot{O} \longrightarrow Ph\cdot + CO_2\uparrow$

(Benzoyl peroxide)

Step II: $Ph\cdot + CH_2=CH_2 \longrightarrow Ph-CH_2-\dot{C}H_2 \xrightarrow{n(CH_2=CH_2)} Ph-(CH_2-CH_2)_n-\dot{C}H_2$

Step III: $2\,Ph-(CH_2-CH_2)_n-\dot{C}H_2 \longrightarrow Ph-(CH_2)_{n'}-Ph$

(IV) Based on force of attraction: (H-bonding, Ester, Amide, sulphide linkage, Vander waal's force of attraction)

(A) Elastomer :- (rubber like properties)

- weakest force of attraction (having few branching and cross-links)

eg : neoprene, Buna-S, Buna-N etc

(B) Fibres : (Linear Polymer) ⇒ strongest force of attraction

- high tensile strength, eg. Nylon, Terylene/Dacron etc

(C) thermoplastic (moderate force of attraction) - Also called reversible polymer

Hard at low temp

soft at high temp

can be moulded into any shape

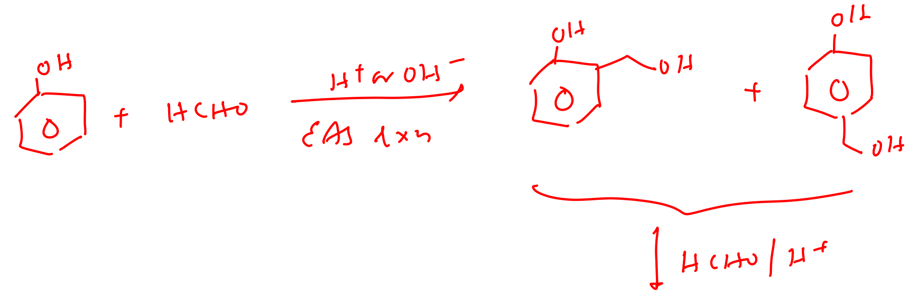
eg. polythene, polyester, PVC etc

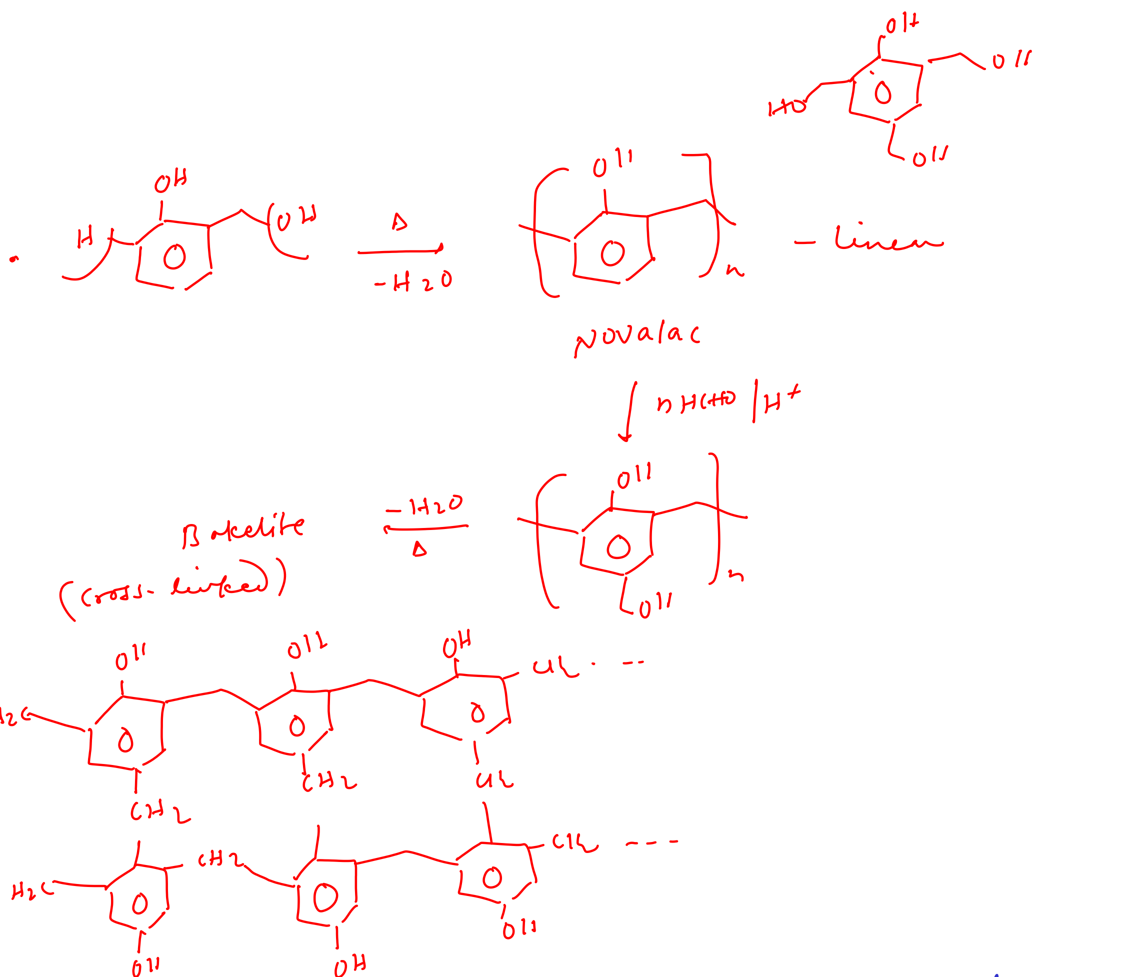
(D) Thermosetting Plastic (Irreversible polymer)

- once heated, get permanent shape

eg. bakelite, melamine-formaldehyde resin

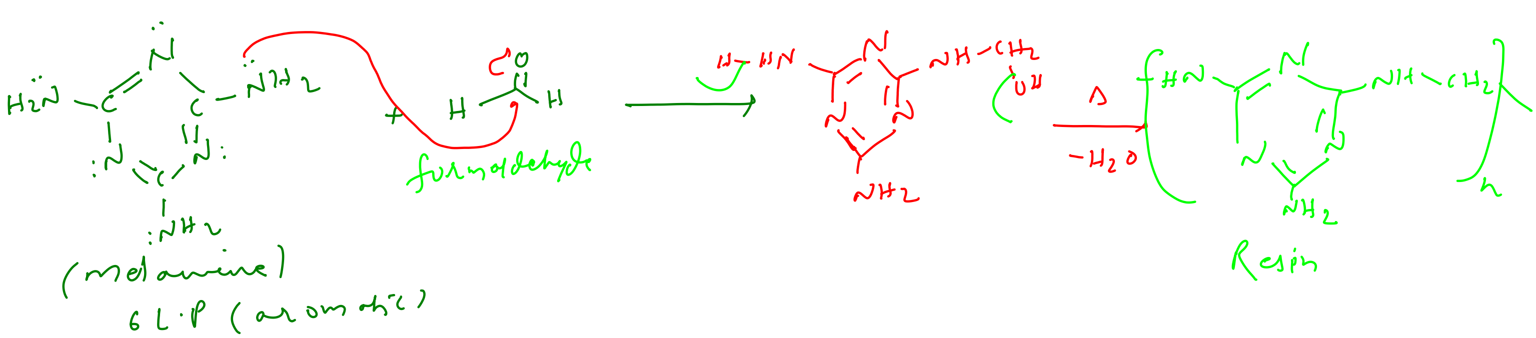
Bakelite





Bakelite is used as making combs, phonograph records, electrical switches and handles of various utensils.

Melamine-formaldehyde Resin :-



Mulliken's Test: of NO_2 group

A little of the sample is dissolved in 2ml alcohol and is reduced with Zn/NH_4Cl or $CaCl_2$ solution and Zn dust by boiling for 5 mins. It is then filtered, cooled and heated with (NH_4OH + $AgNO_3$) and heated in a water bath; white to grey and then black ppt formation confirms the presence of nitro group.

$$R\text{-}NO_2 + 4[H] \xrightarrow[\text{or } NH_4Cl\ \text{soln}]{Zn} R\text{-}NHOH + H_2O$$

or

The presence of nitro group also be detected by reducing the compound with Sn/HCl and then conducting the carbyl amine test.

$$R\text{-}NO_2 \xrightarrow{Sn/HCl} R\text{-}NH_2$$

$$R\text{-}NH_2 + CHCl_3 + 3KOH \longrightarrow R\text{-}\overset{+}{N}\equiv\overset{-}{C} + 3KCl + 3H_2O$$

Alkyl isocyanide (foul smelling)