UNIT-II POLYMERS

Polymer → "A polymer is a long molecule formed by joining together of thousands of small molecules units by chemical bonds." Due to their large size they are also sometimes called as macromolecules.

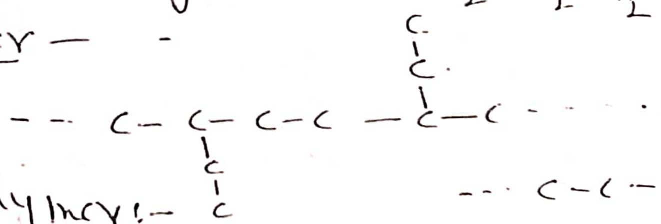
The chemical process leading to the formation of polymer is known as polymerisation and the number of monomeric units contained in a molecule is known as degree of polymerisation.

Polymer
- Homo polymer
- Co-polymer

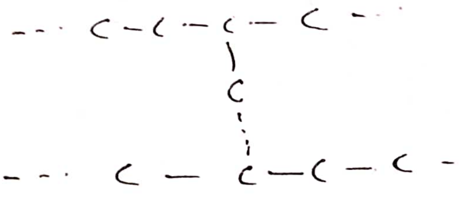
The monomeric unit may combine with each other into macromolecule to form polymer of linear, branched or cross linked structure.

(i) Linear polymer - e.g. Polythene ..... $CH_2-CH_2-CH_2-CH_2$.....

(ii) Branched Polymer -



(iii) Cross linked polymer:-



Classification of polymers :-

(A) (i) Natural Polymer (ii) Synthetic polymer

(B) On the basis of chemical composition:- They are classified into three types

(i) organic polymer (PVC, Polythene etc)
(ii) Hetero organic polymer (Polysiloxanes, Polytitoxanes etc)
(iii) Inorganic Polymer - (Glass, Silicon rubber etc.)

(C) Depending upon mode of Synthesis:— Two types
(i) Addition polymer (ii) condensation polymer

(D) Depending upon force in b/w polymer chain ②
(i) Elastomer or Rubber (ii) Fibre
(iii) Thermoplastic (PVC, Polystyrene etc) (iv) The·
(iv) Thermosetting - Bakelite, alkyl resins, urea-formaldehyde

Mechanism of addition polymerisation:—

① Free radical mechanism:— It takes place in ③ steps

i) Initiation step:— $C_6H_5-\overset{O}{\overset{\|}{C}}-\ddot{O}-\ddot{O}-\overset{O}{\overset{\|}{C}}-C_6H_5 \rightarrow 2\,C_6H_5-\overset{O}{\overset{\|}{C}}-\dot{O}$

(Benzoyl Peroxide) Benzoyl Peroxide $\boxed{\text{or}}$ Peroxide $\rightarrow 2R^{\bullet}$

$\dot{R} + M$ (Monomer) $\longrightarrow R-\dot{M}$ $\left\{\text{or } \dot{R} + CH_2=\underset{G}{\underset{|}{CH}} \longrightarrow R-CH_2-\underset{G}{\underset{|}{\dot{C}H}}\right\}$

ii) Propagation step:—

$R-\dot{M}+M \longrightarrow R.M-\dot{M} \ggg R\{M\}_n\dot{M}$ (I)

or $R-CH_2-\underset{G}{\underset{|}{\dot{C}H}}+CH_2=\underset{G}{\underset{|}{CH}} \longrightarrow R-CH_2-\underset{G}{\underset{|}{CH}}-CH_2-\underset{G}{\underset{|}{\dot{C}H}}$

$R\left(CH_2-\underset{G}{\underset{|}{CH}}\right)_n CH_2-\underset{G}{\underset{|}{\dot{C}H}}$ (II) $\longleftarrow$

iii) Chain Termination step:— The above free radical (II) may be changed into an inactive polymer molecule by two modes

(A) By the combination of above two free radicals.

$R\left(CH_2-\underset{G}{\underset{|}{CH}}\right)_n-CH_2-\underset{G}{\underset{|}{\dot{C}H}} + \underset{G}{\underset{|}{\dot{C}H}}-CH_2-\left(\underset{G}{\underset{|}{CH}}-CH_2\right)_n R$

$\downarrow$

$R\left(CH_2-\underset{G}{\underset{|}{CH}}\right)_n CH_2-\underset{G}{\underset{|}{CH}}-\underset{G}{\underset{|}{CH}}-CH_2\left(\underset{G}{\underset{|}{CH}}-CH_2\right)_n R$

(B) By disproportionation reaction:—

$\sim CH_2-\underset{G}{\underset{|}{\dot{C}H}} + \sim CH_2-\underset{G}{\underset{|}{\dot{C}H}}$

$\downarrow$

$\sim CH=\underset{G}{\underset{|}{CH}} + \sim CH_2-\underset{G}{\underset{|}{CH_2}}$

Mechanism of Ionic Polymerisation :- It is of two types

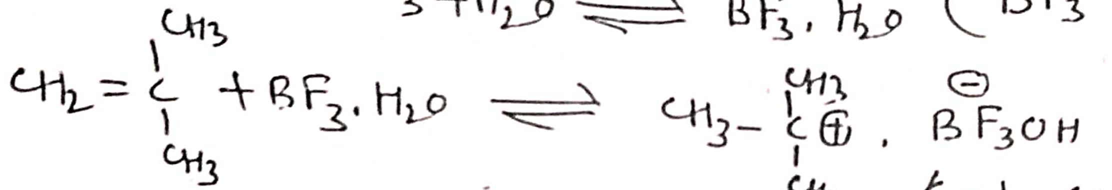
(A) Cationic Polymerisation - (Polymerisation of isobutylene) (3)

(B) Anionic Polymerisation -

Cationic Polymerisation

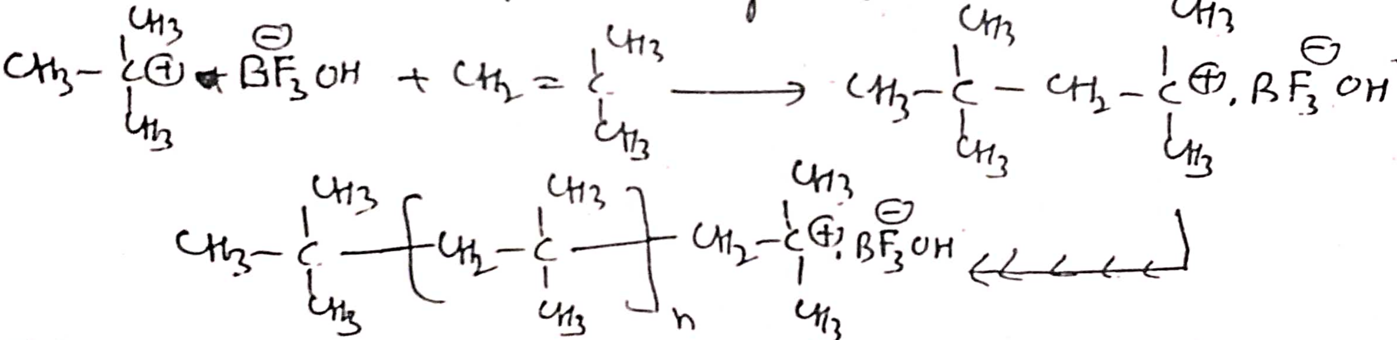
(i) Chain Initiation :- Protonation of alkene to form carbocation.

$$BF_3 + H_2O \rightleftharpoons BF_3 . H_2O$$ (BF_3 is a Lewis Acid)

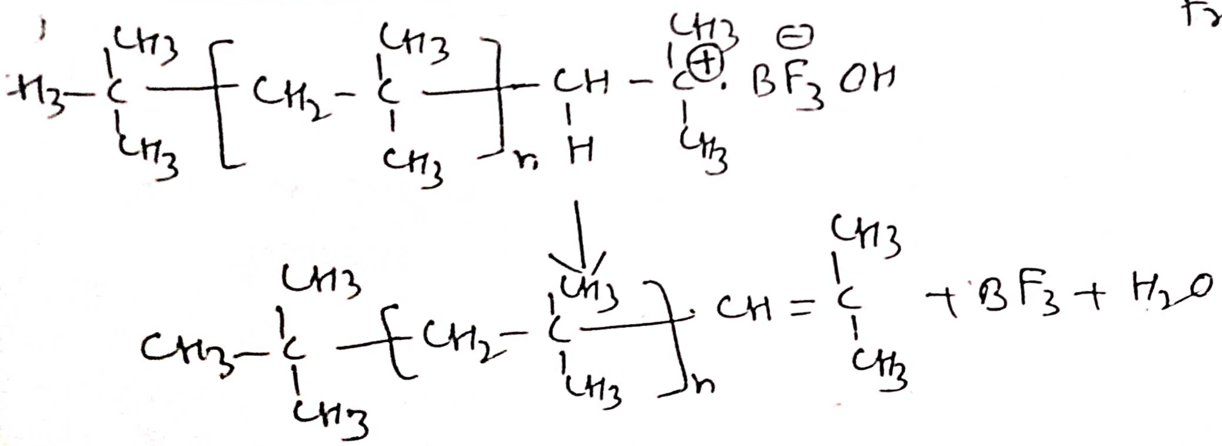


(Carbocation adduct)

(ii) Chain Propagation :- Addition of Carbocation with other monomers to form a big carbocation



(iii) Chain termination → It takes place via proton transfer

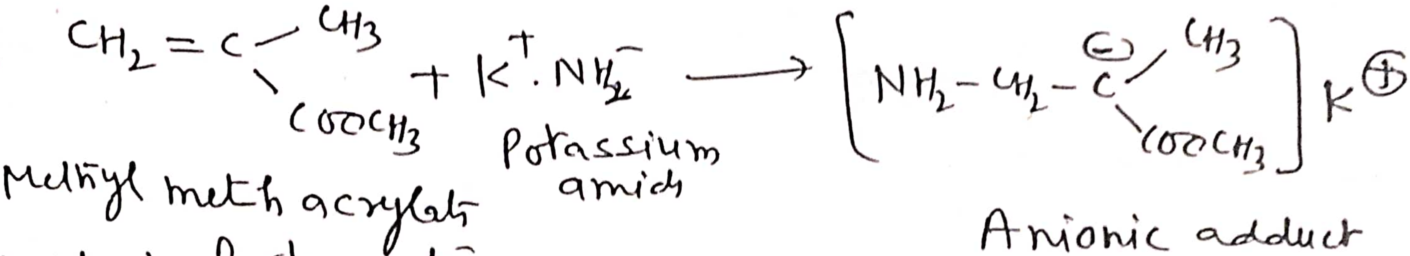


Note → The Cationic Polymerisation may take place in presence of H_2SO_4, $AlCl_3$ or $BF_3 + H_2O$ etc

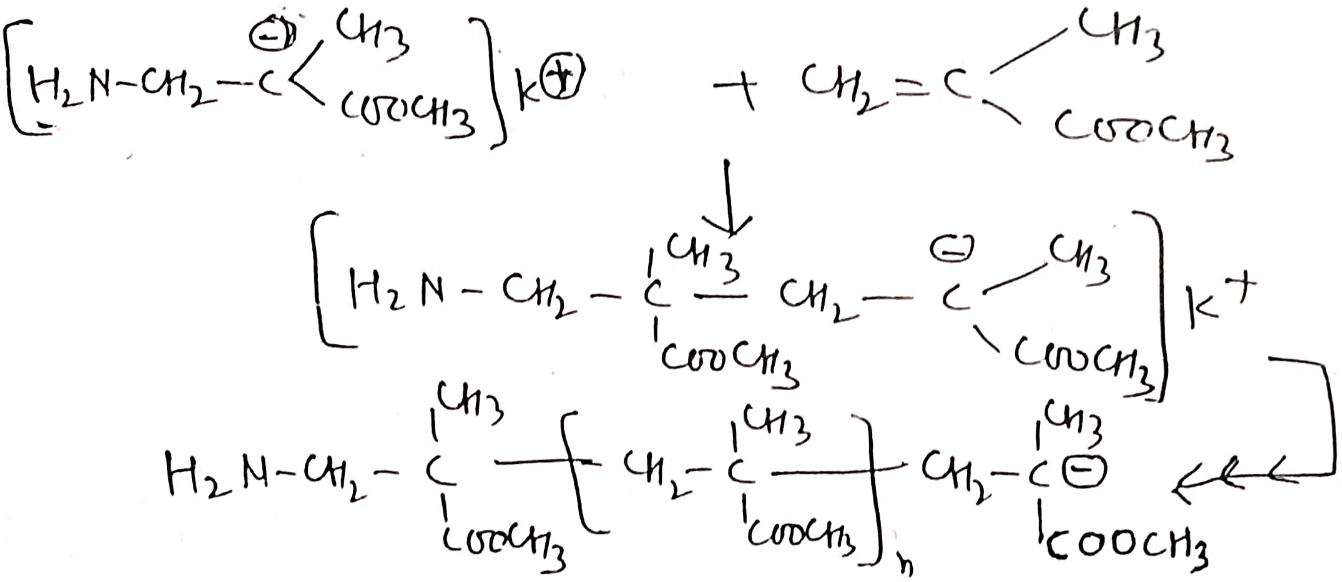
Mechanism of Anionic Polymerisation :-

Monomers with electron - attracting substituents (such as $-CN$, $-COOCH_3$, NO_2 etc.) undergo anionic polymerisation in the presence of Na or KNH_2 or K, n-Butyl lithium, ethyl sodium etc.

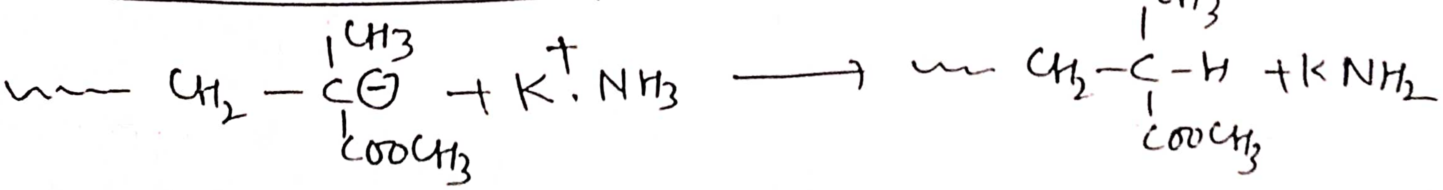
(i) Chain Initiation -



ii) Chain Propagation



(iii) Chain Termination



5. Mechanism of condensation Polymerisation

Consider the esterification reactions as follows:-

(i) When both the monomers contain monofunctional group:-

Then reaction will stop after formation of monoester

$$RCO\boxed{OH + H}OR' \longrightarrow \underset{\text{Monoester}}{RCOOR'} + H_2O$$

$RCOOR' \longrightarrow$ ✗ No further reaction

(ii) When one monomer is bifunctional and other monofunctional:-

Then reaction will stop after formation of diester

$$RCO\boxed{OH + H}O-R'-OH \longrightarrow RCOOR'-OH + H_2O$$

$$RCOOR'-OH \xrightarrow{R.COOH} RCOOR'-OOCR \text{ (Diester)}$$

No further reaction ✗ $\longleftarrow RCOOR'-OOCR$

(iii) When both the monomers contain bifunctional group:-

Then polyester will be formed as shown below

$$HO-R'-O\boxed{H + HO}OC-R-COOH$$

$$\downarrow -H_2O$$

$$HO-R'-OOC-RCOOH$$

$$\xrightarrow{R\begin{smallmatrix}COOH\\COOH\end{smallmatrix}} HOOCRCOOR'OOC-RCOOH$$

$$\xrightarrow{R'\begin{smallmatrix}OH\\OH\end{smallmatrix}} HO-R'-OOC-RCOOR'OH$$

$$HOOCRCOOR'OOC-RCOOH \xrightarrow{+R'\begin{smallmatrix}OH\\OH\end{smallmatrix}} HO-R'-OOC-RCOOR'OOCRCOOH$$

$$HO-R'-OOC-RCOOR'OH \xrightarrow{+R\begin{smallmatrix}COOH\\COOH\end{smallmatrix}} HO-R'-OOC-RCOOR'OOCRCOOH$$

and so on till

Polyester is formed

Q.1 In a particular sample of a polymer 100 molecules have molecular mass 10^3 each, 200 molecules have mol. wr. 10^4 each and 200 molecules have mol. wr. 10^5 each. Calculate the number average and mass average molecular mass.

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Ans We know that number average molecular mass ($\bar{M}_n$) is calculated by the formula

$$\bar{M}_n = \frac{\Sigma n_1 M_1}{\Sigma n_1} = \frac{100 \times 10^3 + 200 \times 10^4 + 200 \times 10^5}{100 + 200 + 200}$$

$= 44200$ gm/mole Ans

We also know that mass average molecular mass ($\bar{M}_w$) is calculated by the eqn.

$$\bar{M}_w = \frac{\Sigma n_1 M_1^2}{\Sigma n_1 M_1}$$

$$= \frac{100 * (10^3)^2 + 200 (10^4)^2 + 200 (10^5)^2}{100 \times 10^3 + 200 \times 10^4 + 200 \times 10^5}$$

$= 91407$ gm/mole Ans

Q2 Equal weights of polymer molecules with $M_1 = 10,000$ gm mol^{-1} and $M_2 = 100,000$ gm mol^{-1} are mixed. Calculate $\overline{M}_n$ and $\overline{M}_w$. (2)

Ans Suppose that w gms of each polymers are mixed. Then

$$n_1 = \frac{w}{M_1} = \frac{w}{10,000}$$

and

$$n_2 = \frac{w}{M_2} = \frac{w}{100,000}$$

we know that

$$\overline{M}_n = \frac{n_1 M_1 + n_2 M_2}{n_1 + n_2}$$

$$= \frac{\frac{w}{10,000} \times 10,000 + \frac{w}{100,000} \times 100,000}{\frac{w}{10,000} + \frac{w}{100,000}}$$

$$= 18181.8 \text{ gm mol}^{-1}$$ Ans

$$\overline{M}_w = \frac{n_1 M_1^2 + n_2 M_2^2}{n_1 M_1 + n_2 M_2}$$

$$= \frac{\frac{w}{10,000}(10000)^2 + \frac{w}{100,000}(100,000)^2}{\frac{w}{10,000} \times 10,000 + \frac{w}{100,000} \times 100,000}$$

$$= 55000 \text{ gm mol}^{-1}$$ Ans

Q3 28 gms of ethylene was polymerised by free radical polymerization process and average degree of polymerization was found to be 1000. Calculate

(i) The no. of molecules of ethene in original sample

(ii) The no. of molecules of polyethylene produced

Ans (i) Mol. wt. of ethylene (C_2H_4) = 24+4 = 28

28 gm ethylene = 1 Mole ethylene = 6.023×10^{23} molecules

Ans

(ii)

$$\text{No. of Polythene molecules produced} = \frac{\text{No. of ethylene molecules}}{\text{Degree of polymerization}}$$

$$= \frac{6.023 \times 10^{23}}{1000}$$

$$= 6.023 \times 10^{20} \text{ Molecules}$$

Ans

Q.4 In a polymer sample, 30% molecules have (9)
molecular weight 20,000, 40% have molecular mass 30,000 and rest 30% have 60,000. Calculate $\overline{M}_w$ and $\overline{M}_n$.

Ans We know that

$$\overline{M}_w = \frac{n_1 M_1^2 + n_2 M_2^2 + n_3 M_3^2}{n_1 M_1 + n_2 M_2 + n_3 M_3}$$

$$= \frac{30(20,000)^2 + 40(30,000)^2 + 30(60,000)^2}{30 \times 20,000 + 40 \times 30,000 + 30 \times 60000}$$

$$= 4.33 \times 10^4 \text{ gm mol}^{-1}$$ Ans

We also know that

$$\overline{M}_n = \frac{n_1 M_1 + n_2 M_2 + n_3 M_3}{n_1 + n_2 + n_3}$$

$$= \frac{30 \times 20,000 + 40 \times 30000 + 30 \times 60000}{30 + 40 + 30}$$

$$= 36,000 \text{ gm mol}^{-1}$$ Ans

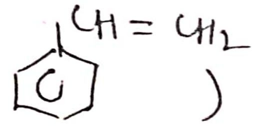
11-PMYS

Q.5 216 gms of 1,3-butadiene is copolymerized with 104 gms of Styrene. Determine the formula of copolymer.

Ans –

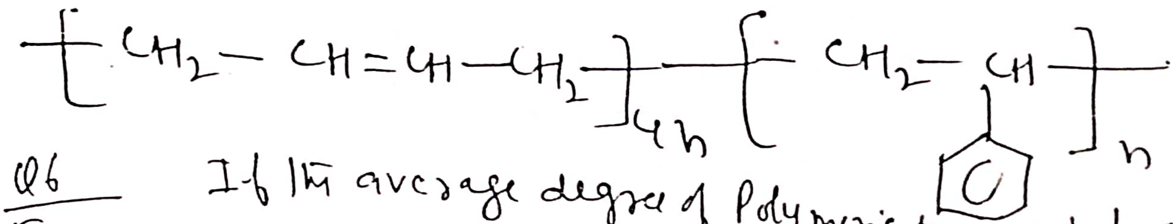
Mol. wr. of 1,3-butadiene $(CH_2=CH-CH=CH_2) = 54$

$\therefore$ Moles of butadiene in copolymer $= \frac{216}{54} = 4$

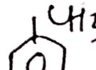
Mol. wr. of Styrene () $= 96+8 = 104$

$\therefore$ Moles of Styrene in copolymer $= \frac{104}{104} = 1$

Hence the molecular formula of copolymer will be



Q6 If the average degree of Polymerisation of polystyrene is 10^5, calculate its average molecular weight

Ans Mol. wr. of styrene  or $C_6H_5-CH_3 = 104$

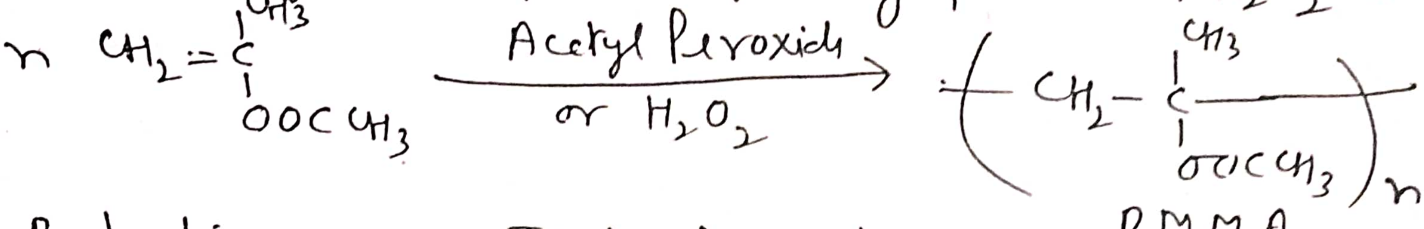
Average mol. wr. = degree of Polymerisation × Mol. wr

$= 10^5 \times 104 = 10.4 \times 10^6$ Ans

Prepn., Properties and Uses of Polymers

① PMMA (Polymethyl meth acrylate) or Lucite or Plexiglass or acrylite Perspex

Prepn. → It is prepared by the polymerisation of Methyl-meth acrylate in presence of acetyl peroxide or H_2O_2 as catalyst.



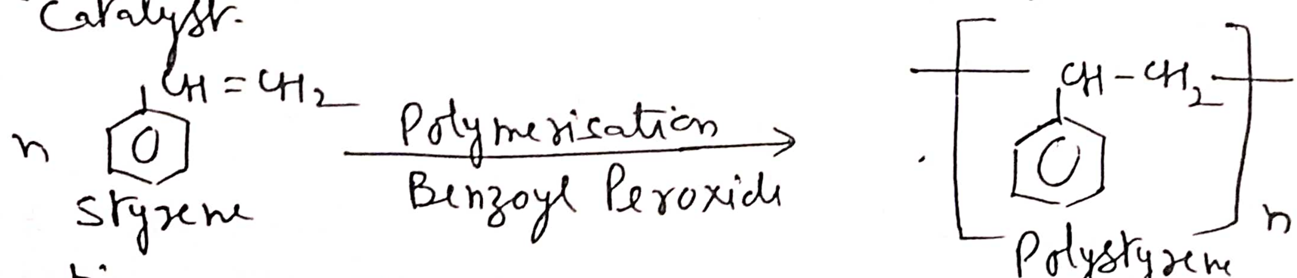
PMMA

Properties — · It is hard, transparent, thermoplastic, colourless with high optical transparency.

Uses — It is used in making lenses, domes, skylight, aircraft window, plastic jewellary, Protective coatings and dome shape covers of solar collectors (i.e Solar heater)

② Polystyrene :—

Prepn. :— It is prepared by the free radical polymerisation of styrene in presence of Benzoyl peroxide as catalyst.

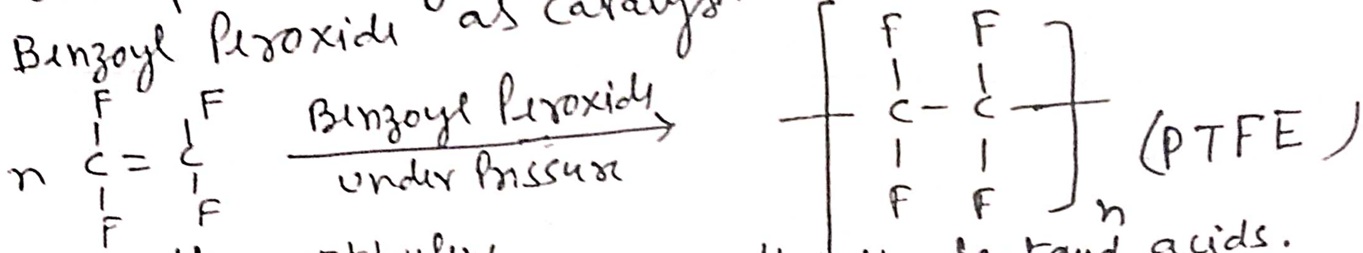


Properties → It has good optical property. It is transparent polymer and allow high transmission of all wavelength.

Uses :— It is used for making toys, combs, ceiling tiles, lining material for refrigerators, TV cabinets, audio — casette, containers of talcum powder etc.

(3) Teflon or Poly tetra fluoro ethylene (. . .)

Prepn. :- It is prepared by the polymerisation of Tetra fluoro-ethylene under pressure in presence of Benzoyl Peroxide as catalyst.



Tetra fluoro Ethylene

It is not affected by heat and acids.

Props — Due to the presence of highly electronegative fluorine atoms, there are very strong attractive forces between different chains. These strong forces are responsible for its

(i) High density (2.1 to 2.3 gm/c.c.)
(ii) Electrical Insulation property
(iii) Excellent toughness and heat resistance
(iv) It has non-adhesive characteristics.

Uses — It is used for making non-stick utensils, wire and cable insulation, its fibres are used to form belts, filter cloths etc., for making gaskets, for carrying chemical carrying pipes, for making non-lubricating bearings etc.

(4) Neoprene :-

It is prepared by the polymerisation of chloroprene (2-Chloro-1,3-Butadiene)

$$n\, CH_2 = \underset{Cl}{\underset{|}{C}} - CH = CH_2 \xrightarrow{\text{Polymerisation}} \left[CH_2 - \underset{Cl}{\underset{|}{C}} = CH - CH_2 \right]_n$$

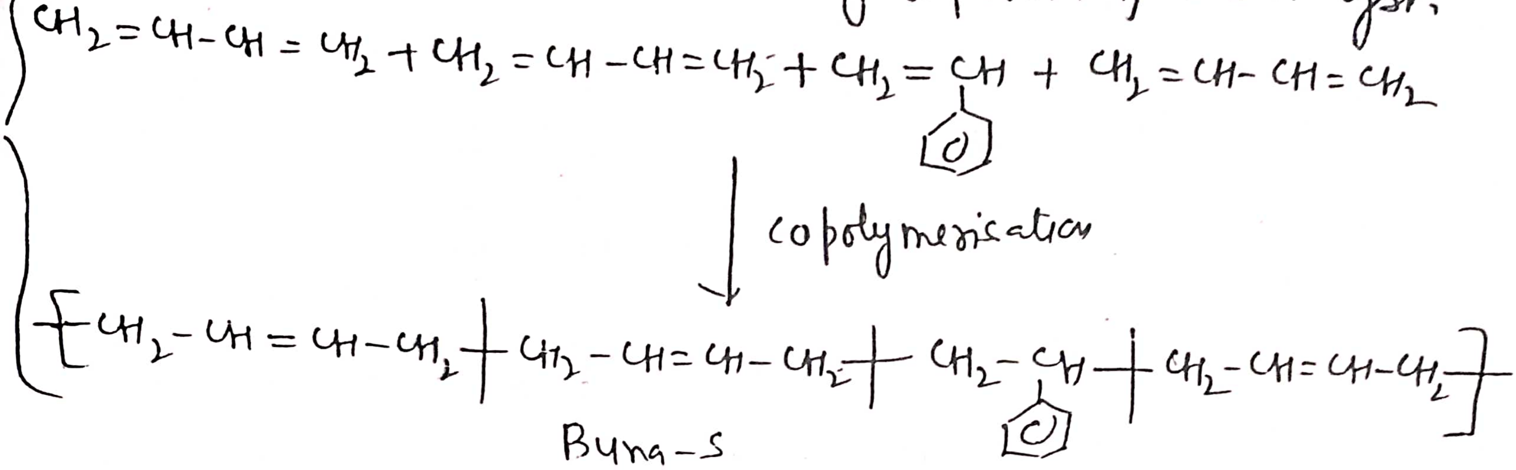
(Chloroprene) (Neoprene)

Properties → It is highly resistance to vegetables and mineral oils & is soluble in organic solvents

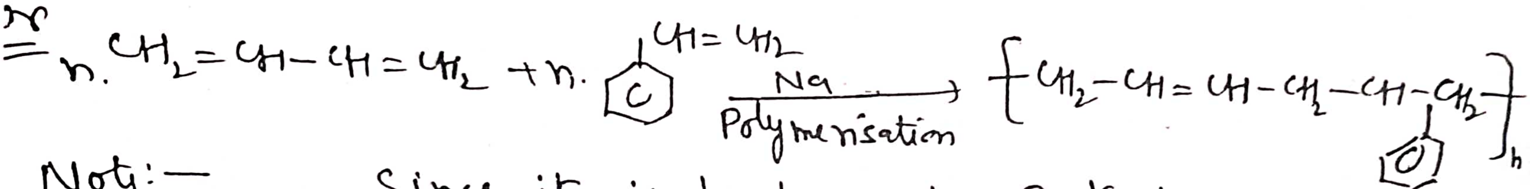
Uses → It is used for making Hoses, gaskets, tubes for carrying corrosive gases and oils, sponges etc.

(i) Buna-S → or SBR or GR-S or Styrene Rubber

Prepn → It is prepared by the polymerisation of Butadiene (75%) and styrene (25%) in an emulsion system at 50°C in presence of cumene hydroperoxide/Na as catalyst.



or



Note:— Since it is prepared by Butadiene and styrene in presence of Sodium (Na), so it is called as Buna-S.

Properties — (i) It possesses high abrasion, losses resistance and high load bearing capacity.

(ii) The weatherability of SBR is better than natural rubber

(iii) It swells in oils and solvents

(iv) It gets easily oxidized in presence of traces of ozone present in the atmosphere.

Uses! — ① It is used for making automobile tyres, hoses, Belt, rubber soles, floor tiles, carpets, tank linings etc. It is also widely used for electrical insulation of wires and cables! etc

NOTE — GR-S means Government Rubber Styrene

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⑥ Buna-N or Nitrile Rubber or NBR or GRA

Prepn.:- It is prepared by the copolymerisation of 1,3 butadiene and acrylonitrile (vinyl cyanide) in an emulsion system

$$n\, CH_2=CH-CH=CH_2 + n\cdot CH_2=CH-CN$$

1,3-Butadiene — Acrylonitrile

$$\downarrow \text{copolymerisation}$$

$$\left[CH_2-CH=CH-CH_2-CH_2-\underset{\underset{CN}{|}}{CH} \right]_n$$

Buna-N

Properties –

① Due to the presence of cyano group, the nitrile rubber is less resistance to alkali than natural rubber.

② It possesses excellent resistance to heat, sunlight, acids and salts.

③ It has good tensile strength and abrasion resistance.

Uses:– ① It is used for making fuel tanks, creaming equipments, gasoline hoses, Gaskets, insulation of wires and Cables, high attitude aircraft components etc

② It can also be used as blend component in tyre manufacture.

⑦ Nylon-6 or PERLON :–

Prepn:– It is prepared by the polymerisation of caprolactam which is prepared from Amino caproic acid.

$$n\, H_2N(CH_2)_5-\overset{O}{\overset{\|}{C}}-OH \xrightarrow[-H_2O]{\text{self condensation}} (CH_2)_5 \langle \begin{matrix} N-H \\ | \\ C=O \end{matrix} \quad \text{(Caprolactam)}$$

$$\left[HN-(CH_2)_5-\overset{O}{\overset{\|}{C}} \right]_n \xleftarrow{\text{Polymerisation}} \text{Caprolactam}$$

Nylon-6

Note → It is called as Nylon-6 because it contains 6 carbon atoms.

(5) Props of Nylons :— ① Nylons are characterized by a combination of high strength, elasticity, toughness and abrasion resistance. (15)

② They have very good moisture resistance

③ The molecular chains of nylons are held together to each other by hydrogen bonds having linear structure, hence permits side-by-side alignment.

④ They are very flexible and retain their original shape after use.

Uses :— It is used for the manufacture of tyre cords, fabrics, ropes etc.

(8) Nylon - 66

Prepn. → It is prepared by the condensation polymerisation between adipic acid (C = 6) and hexamethylenediamine (C = 6) as follows -

$$n\ HOOC(CH_2)_4CO\boxed{OH + n\ H}NH(CH_2)_6NHH \xrightarrow[\text{Polymerisation}]{-nH_2O} \left[\overset{O}{\overset{\|}{C}} - (CH_2)_4 - \overset{O}{\overset{\|}{C}} - NH(CH_2)_6 - NH \right]_n$$

Nylon - 66

Since both the monomers contains 6 carbon atoms each, ∴ it is called as Nylon - 66

Props → See above as in Nylon-6

Uses — ① It is used for making brushes, fibre, bristles, carpets, elastic hosiery etc

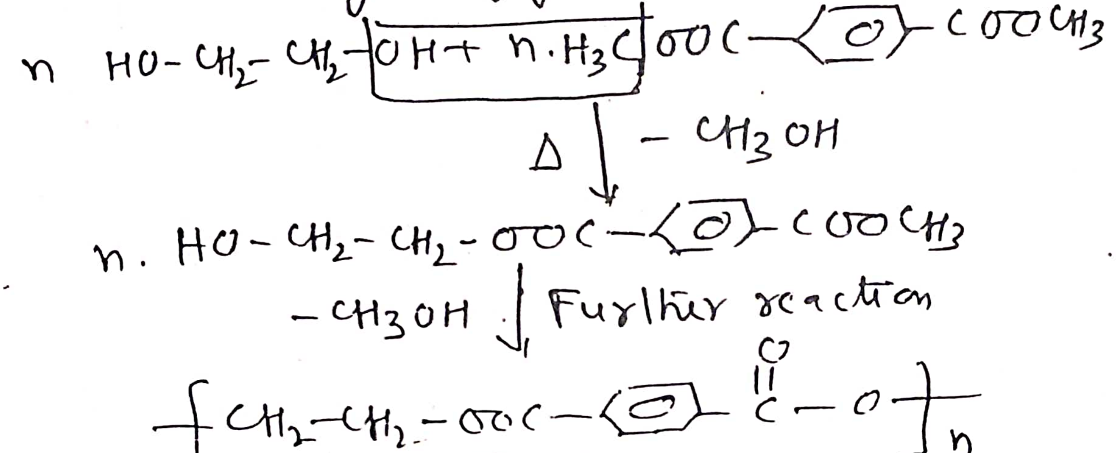
② It is used in automobile tyre cords, ropes, threads, cords having high tenacity and good elasticity.

③ It is used for making nylon bearings, and gears whose performance is good and need little or no lubrication

④ It is also used for making rollers, slides and door latches.

(9) Terylene or Decron or Polyester or Polyethylene terephthalate (PET) :—

Prepn → It is prepared by heating dimethyl-terephthalate and ethylene glycol (or by heating terephthalic acid and ethylene glycol) in basic medium



PET or Terylene

Props. :— ① It is resistant to heat and moisture

2) It has good mechanical strength upto 175°C

3) It is resistant to almost all kinds of insect attacks

4) It can be dyed at 100°C or in presence of carrier.

5) The nylon fibres has good wrinkle resistance due to good elasticity.

Uses :— ① It is mostly used for making synthetic fibres, seat belts, film etc

② It is mixed with cotton ~~and~~ to prepare terycott.

③ Due to its high dielectric strength, they are used for electrical insulation.

④ It is used for making magnetic recording tapes.

Note → In England it is called as Terylene while in USA it is called as Decron.

2) **Polylactic acid → or PLA →**

It is prepared by the polymerisation of lactic acid although lactic acid can not be polymerised to useful product since in each polymerisation reaction one molecule of H_2O is generated.

$$n\ HO-\underset{\underset{H}{|}}{\overset{\overset{CH_3}{|}}{C}}-COOH \xrightarrow{-nH_2O} \left[O-\underset{\underset{H}{|}}{\overset{\overset{CH_3}{|}}{C}}-\overset{\overset{O}{\|}}{C} \right]_n$$

Lactic Acid   PLA

Properties → Due to chiral nature of lactic acid, several distinct forms of polylactic acid are found e.g.

i) **Poly-L-lactide (PLLA)** :- The melting temp. of PLLA can be increased to 40°C - 50°C and its heat deflection temp. can be increased approx. from 60°C to 190°C by physically blending the polymer with PDLA.

ii) **Poly-D-lactide (PDLA)** :- It acts as a nucleating agents.

Biodegradation of PDLA is slower than PLLA due to higher crystallinity of PDLA. PDLA has the useful property of being optically transparent.

Uses of PLA :- ① It is used in number of biodegradable applications such as sutures (or stitches), stents, dialysis media and drug delivery devices.

② Due to its biodegradable nature, it is used in the preparation of bioplastics (which is useful for food packaging and disposable table ware.

(11) Poly β hydroxy Butyrate (PHB) :-

Prepn. → It is prepared by fermentation of sugars (sucrose, glucose and lactose) by micro-organisms (like Alcaligenes entrophus or Bacillus megaterium) is response to conditions of physiological stress. It has following structure -

$$n.\ HO-\overset{CH_3}{\overset{|}{C}H}-CH_2-\overset{O}{\overset{||}{C}}-OH \xrightarrow{-nH_2O} \left[O-\overset{CH_3}{\overset{|}{C}H}-CH_2-\overset{O}{\overset{||}{C}}\right]_n$$

(β-Hydroxy Butric Acid) (PHB)

Properties — ① It shows high degree of crystallinity, high m.pt. 180'c and is rapidly biodegradable.

② It possesses good oxygen permeability.

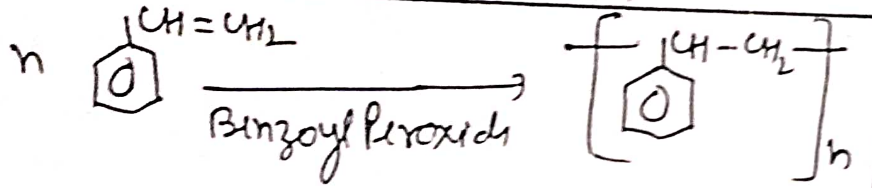
③ It is good resistance to UV light but poor resistance to acid and base.

④ It is insoluble in water but soluble in chloroform and other chlorinated hydrocarbons.

Uses - ① In the manufacture of bottles, bags, wrapping film and disposable nappies etc

② It is used for packing of food

③ It is used for preparing controlled drug-release carriers due to its biodegradable and optical activity prop.

No	Monomer + Prepn.	Polymer	Props.	Uses
1.	$n\,CH_2=C(CH_3)(COOCH_3) \xrightarrow[\text{Peroxide or } H_2O_2]{\text{Acetyl-}} \left[CH_2-C(CH_3)(COOCH_3) \right]_n$	PMMA (Poly methyl meth acrylate)	Amorphous, colourless, Transparent, high optical clarity	Making lenses, domes, skylights, aircraft windows, Protective coating
2.		Polystyrene	Transparent polymer with good optical Property	For making toys, comb, ceiling-tiles, lining material for refrigerators, TV Cabinets
3	$n\,CF_2=CF_2 \xrightarrow[\text{Peroxide}]{\text{Benzoyl-}} \left[CF_2-CF_2 \right]_n$	Teflon or Poly tetra-fluoroethylene (PTFE)	High density, Electrical Insulation prop., Excellent toughness, Heat resistance	Making non-sticking utensils, wire, gaskets, its fibres are used to form belts etc
4.	$n\,CH_2=C(Cl)-CH=CH_2 \xrightarrow{\text{Polymerisation}} \left[CH_2-C(Cl)=CH-CH_2 \right]_n$ Chloroprene or 2-Chloro-1,3-Butadiene	Neoprene (GR-M)	Highly resistance to vegetable and mineral oils, Soluble in organic Solvents	Making hoses, gaskets, sponges, tube for carrying corrosive gases and oils etc

S.No	Monomer + Rxn.	Polymer	Props.	Uses
5.	$n.CH_2=CH-CH=CH_2 + n.\ C_6H_5-CH=CH_2$ (styrene) $\xrightarrow[\text{Na}]{\text{Polymerisation}}$ $\left[CH_2-CH=CH-CH_2-CH(C_6H_5)-CH_2 \right]_n$	Buna-S or SBR or GR-S or Styrene Butadiene Rubber Government Rubber Styrene	Posses high abrasion, high load bearing capacity, Swells in oils and Solvents, oxidised in presence of traces of ozone	For making automobile tyres, hoses, Belts, rubber soles, Floor tiles, Carpets, electrical insulation of wires and Cables etc
6.	$n.\ CH_2=CH-CH=CH_2 + n.\ CH_2=CH-CN$ 1,3-Butadiene, Acrylo nitrile $\downarrow$ $\left[CH_2-CH=CH-CH_2-CH_2-CH(CN) \right]_n$	Buna-N or Nitrile Rubber or NBR or GRA NBR → Nitrile Butadiene Rubber GRA → Government Rubber acrylonitrile	Less resistance to alkali than natural rubber, resistance to heat, sunlight, acids + Salts.	For making Fuel tanks, gasoline hoses, Gaskets, insulation of wires + Cables, Blend component in tyre manufacture
7.	$n\ H_2N(CH_2)_5-C(=O)-OH$ (From caprolactam) $\downarrow$ $(CH_2)_5 < NH-C(=O)$ Caprolactam $\downarrow$ $\left[HN-(CH_2)_5-C(=O) \right]_n$ (Nylon-6)	Nylon-6 or Perlon	High Strength, elasticity, toughness very flexible + retain their original Shape after use	For Manufacture of tyre cords, Fabrics, ropes, etc

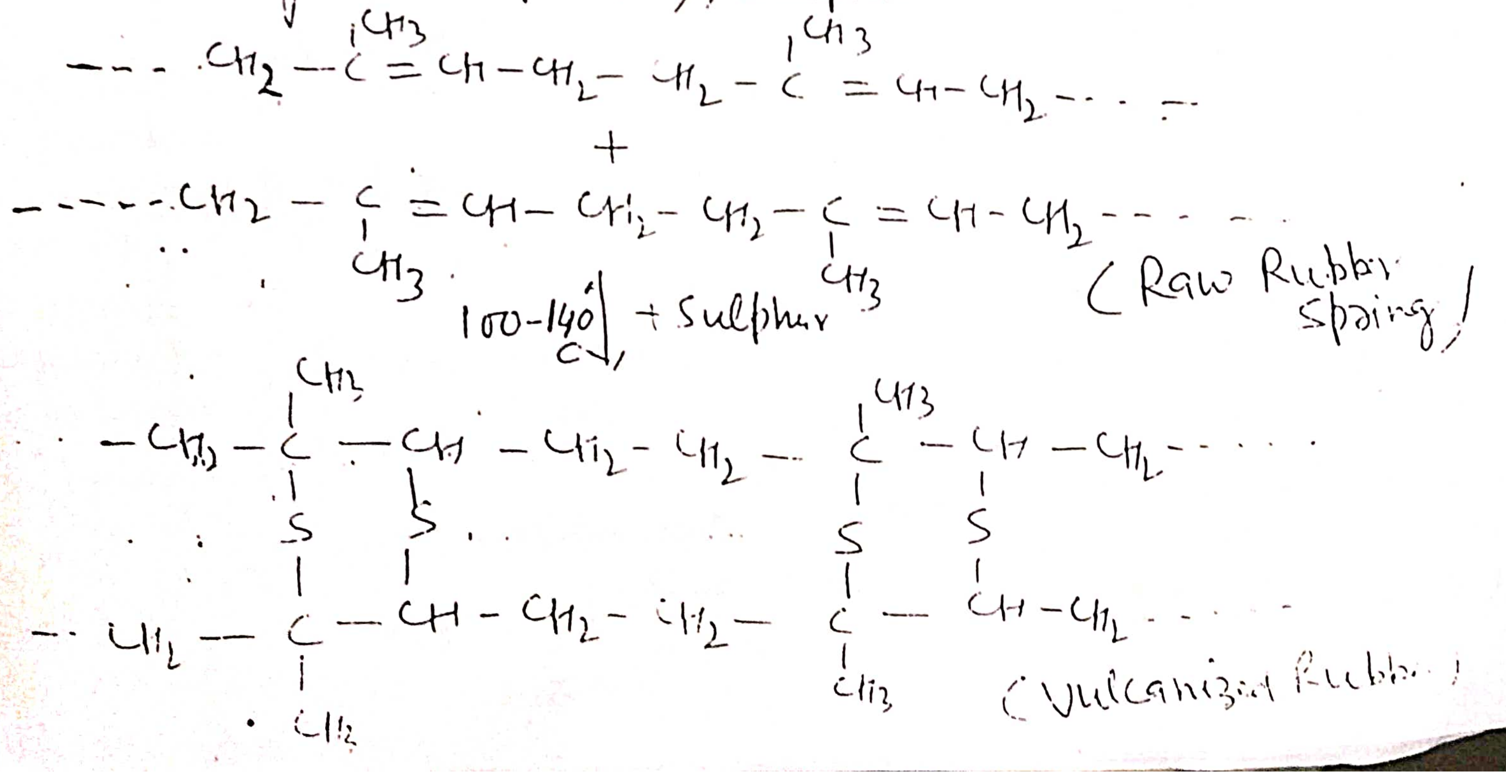
N	Monomer + Prepn.	Polymer	Props.	Uses
8.	$n\ HOOC(CH_2)_4COOH + n.\ H_2N(CH_2)_6NH_2$ Adipic Acid $\downarrow$ Polymerisation $\left[\overset{O}{\overset{\Vert}{C}}-(CH_2)_4-\overset{O}{\overset{\Vert}{C}}-NH(CH_2)_6-NH \right]_n$	Nylon-66	Same as of Nylon-6	For making brushes, bristles, fibre, Carpets, elastic-hosiery, tyre cord, ropes, threads, Nylon bearing and gears, door latch etc
9.	$n\ HO-CH_2CH_2\boxed{OH + nH_3C}OOC-C_6H_4-COOCH_3$ $\downarrow -CH_3OH$ $n.\ HO-CH_2CH_2-OOC-C_6H_4-COOCH_3$ $\downarrow -CH_3OH$ $\left[CH_2-CH_2-OOC-C_6H_4-\overset{O}{\overset{\Vert}{C}}-O \right]_n$	Terylene (In U.K) or Decron (In USA) or PET	Resistant to heat and moisture, good wrinkle resistance, good mechanical strength upto 175°C, can be dyed at 100°C	For making Fibre, Seat belts and Sails, film, Terycott, electric insulation for wires & Cables
10.	$n\ HO-\overset{CH_3}{\overset{\vert}{C}}H-COOH$ (Lactic Acid) Polymerisation $\downarrow - nH_2O$ $\left[O-\overset{CH_3}{\overset{\vert}{C}}H-\overset{O}{\overset{\Vert}{C}} \right]_n$ PLA	PLA Polylactic acid	It is optically transparent	In no. of biodegradable applications such as Stent, dialysis, drug delivery device, bioplastic, sutures (or Stitches) etc

Monomer + Prepn.	Polymer	Props.	Uses
11. Prepared by fermentation of sugars by micro-organisms like Alcaligenes entrophus or Bacillus megaterium $\left[O - \underset{\substack{\vert \\ CH_3}}{CH} - CH_2 - \overset{\substack{O \\ \Vert}}{C} - \right]_n$ (β-Hydroxy Butric Acid)	Polyhydroxy-Butyrate (PHB)	High m.pt., rapidly biodegradable, good resistance to UV light, Poor resistance to acid and base. Insoluble in water and soluble in chloroform and other chlorinated hydrocarbons	For packing of food, manufacturing of bottles, bags, wrapping film, disposable nappies For preparing controlled drug release carriers

Vulcanization of Rubber :— Charles Goodyear in 1839

The raw rubber is of little use as such because it has low tensile strength, poor resistance to abrasion, possesses elasticity only over a limited range of temp. does not resume its original shape after being extended and becomes softer, more plastic and sticky on heating and brittle on cooling.

All the above undesirable properties may be removed by vulcanization process. The heating of raw rubber with sulphur at 100–140°C is called as vulcanization. The added sulphur combines chemically at the double bonds of different rubber springs. Thus we can say that vulcanization serves to stiffen the material by a sort of ~~as~~ anchoring and consequently, preventing intermolecular movement of rubber springs. The extent of stiffness of vulcanized rubber depends on the amount of sulphur added e.g. tyre rubber contains 3–5% sulphur while battery case rubber may contain upto 30% sulphur



Difference b/w Thermoplastic and Thermo Setting

No	Thermoplastic	Thermosetting
1)	Formed by addition polymerization only	① Formed by condensation polymerisation
②	It consists of long chain linear polymers with negligible cross links	② It has three dimensional network structure.
3)	They are usually soft, weak and less brittle	③ They are usually hard, strong and more brittle.
4)	They can be reused (remoulded) in the desired shape	④ They can not be remoulded.
5)	They can be reclaimed from wastes	⑤ They can not be reclaimed from wastes
6)	They are usually soluble in organic solvents	⑥ They are insoluble in organic solvents

Difference b/w Addition and Condensation polymerisation

Addition Polymerisation	Condensation polymerisation
They are formed by addition of repeated units of monomer	① They are formed by the elimination of simple molecules like H_2O, NH_3 etc
The mol. wt. of polymer is multiple mol. wr. of monomer	② The mol. wr. of polymer is not multiple mol. wr. of monomer
Higher molecular mass polymer is formed	③ Polymer molecular mass rises steadily throughout the reaction
Longer reaction times have a little effect on mol. wr. but gives higher yields	④ Longer reaction times gives high mol. wr. polymer

Write a note on Tacticity, Isostatic, atactic and Syndiotactic polymers

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Tacticity :- The orientation of ~~mono~~ monomeric units in polymer molecule can take place in an orderly or disorderly fashion with respect to the main chain is called as Tacticity. The difference in tacticity (configuration) affect their physical properties.

1) **Isostatic :-** If the substituent group (R) is on same side of carbon backbone then the polymer is called as Isostatic as shown in figure ①.

2) **Atactic :-** If the substituent group (R) is at random around the carbon backbone then the polymer is called as Atactic polymer as shown in Fig ②.

3) **Syndiotactic →** If the substituent group (R) is arranged alternately around the carbon back bone chain then it is called as syndiotactic polymer as shown in fig ③.

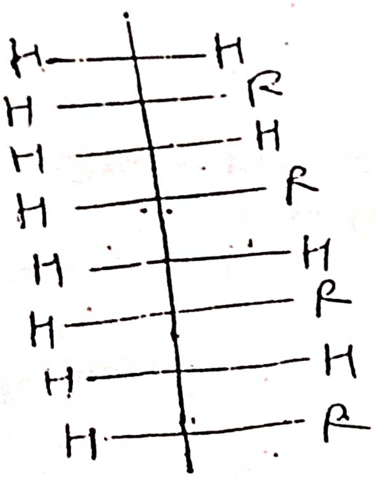

Fig-① (Isostatic)

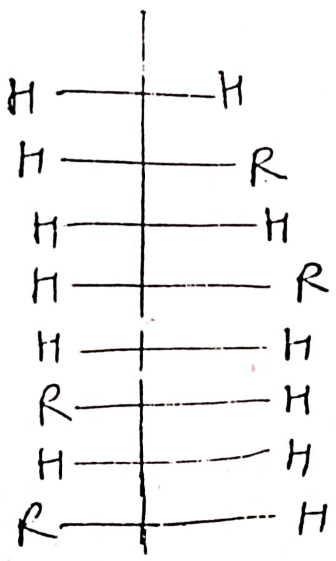

Fig-② (Atactic)

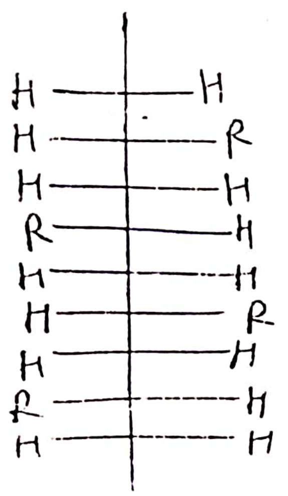

Fig ③ (Syndiotactic)