CHARACTERISTICS OF POLYMERS :-

→ Macromolecules with a repeating unit.
→ Have two types of bonding - strong covalent between monomers and weak vanderwaals forces between polymer chain.
→ Light wt & low density
→ Low tensile strength and stiffness
→ Some have good elasticity (e.g. rubbers)
→ Good thermal and electrical insulation
→ In general they are tailor made materials.
→ Have excellent corrosion resistance.

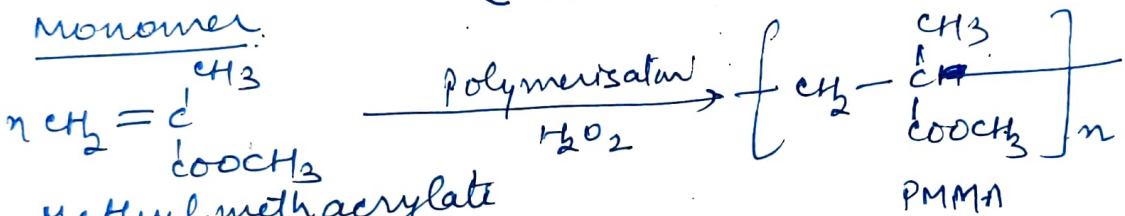
INDIVIDUAL POLYMERS

POLYMETHYLMETHACRYLATES (PMMA)

- Addition polymer
- Homopolymer
- Thermoplastic

It is also known as
- PERSPEX
- PLEXIGLASS
- LUCITE
- [redacted]

Monomer



Methylmethacrylate (MMA)

PMMA

→ Optical clarity is the main feature of this thermoplastic
→ Outstanding shape forming ability.
→ Resistant to sunlight and have ability to transmit light accurately.

Uses:- Used as a substitute for glass as for making-
Lense, prisms, transparent domes etc.
Hard contact lense, artificial eyes, artificial teeth (dentures)
Air craft windows, sign boards
Wind screens, TV screens.

POLY ACRLONITRILE (PAN)

- Addition polymer
- Homopolymer
- Thermoplastic

Monomer: $CH_2 = CH$ (CN) — Vinyl cyanide or Acrylonitrile

$$CH_2 = CH(CN) \xrightarrow[H_2O_2 + FeSO_4]{\text{Polymerisation}} \left\{ CH_2 - CH(CN) \right\}_n$$

PAN.

It is also known as ORLON & ACRILAN

→ It exhibits high tensile strength and good mechanical properties.

→ Presence of highly polar CN gp is responsible for its excellent heat resistant nature.

Uses: - Generally used for making fibres & carpets.
- used for preparation of other polymers like nitrile rubber.

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POLY TETRAFLUORO ETHYLENE (PTFE)

- Addition polymer
- Homopolymer
- Thermoplastic

Monomer

$CF_2 = CF_2$ — Tetrafluoro ethylene

Polymerisation (Benzoyl peroxide) → $\{CF_2 - CF_2\}_n$ PTFE

It is also known as -
TEFLON & ~~FLON~~ FLUON.

imp → Since fluorine is highly electronegative, it leads to very strong attractive forces between the different polymeric chains. This strong attractive force is responsible for the high stiffness, exceptionally high chemical resistance towards chemicals except hot alkalis and hot fluorine.
→ It is resistance to heat (thermally stable) and corrosion
→ Its m.p. is very high
→ It is extremely good electrical & mechanical properties.

Uses:- PTFE is used for non-stick coating particularly for cooking utensils.
For stop-cock of burettes
For making insulating gaskets & valves, cables, wires etc.

FIBRES.

POLYAMIDES

Polyamides are the polymers which are obtained by condensation polymerisation of acids (bifunctional) and amines (bifunctional) and they contain amide linkage i.e. $\{-C(=O)-NH\}$.

$-C(=O)-OH$ (Acid) + $H-N-$ (Amines) $\xrightarrow{-H_2O}$ $\{-C(=O)-NH\}$ Amide.

They are generally distinguished by numbering systems.

NYLON 6

- condensation polymer
- Homopolymer
- Thermoplastic

Monomer

ε-caprolactam

Ring opening & polymerisation → $\{NH(CH_2)_5C(=O)\}_n$ Nylon-6

or

$n\ H_2N(CH_2)_5COOH$ — ε-amino caproic acid

Self condensation → $\{NH(CH_2)_5C(=O)\}_n$ Nylon-6

NYLON 6,6

- Condensation polymer
- Copolymer
- Thermoplastic

Monomers -

$$n\,H_2N-(CH_2)_6-NH_2 + n\,HOOC-(CH_2)_4-COOH \xrightarrow{-2n\,H_2O} \left[NH-(CH_2)_6-NH-\overset{O}{\overset{\|}{C}}-(CH_2)_4-\overset{O}{\overset{\|}{C}}\right]_n$$

Hexamethylene diamine & adipic acid

Nylon 6,6

NYLON 6,10

- Condensation polymer
- Copolymer
- Thermoplastic

Monomers.

$$n\,H_2N(CH_2)_6NH_2 + n\,HOOC(CH_2)_8COOH \xrightarrow{-2n\,H_2O} \left[NH(CH_2)_6NH-\overset{O}{\overset{\|}{C}}-(CH_2)_8-\overset{O}{\overset{\|}{C}}\right]_n$$

Hexamethylene diamine & sebacic acid

Nylon 6,10

→ Nylons have high m.p. & possess high temp. stability.
→ Have good abrasion resistance.
→ Resistant to chemicals.
→ Their mouldings and extrusions have good physical strength.

Uses:- Nylons are used for making fibres for socks, dresses carpets etc.
In making filaments of ropes, bristles for brushes etc.
Used in gears, bearings, rollers, etc. as lubricants (Nylon 6,6)

POLYESTERS :-

Polyesters are the polymers obtained by poly-condensation of acid (bifunctional monomer) and alcohol (bifunctional monomer) containing ester linkage $\left[\overset{O}{\overset{\|}{C}}-O\right]$.

TERYENE

- Condensation polymer
- Copolymer

It is also known as DACRON or PET (polyethylene Terephthalate).

Monomers

$n\ HO(CH_2)_2OH + n\ HOOC-C_6H_4-COOH$

Ethylene glycol — Terephthalic acid

$\xrightarrow[-2nH_2O]{200^\circ C,\ \text{basic catalyst}}$

$-[O(CH_2)_2-O-C(=O)-C_6H_4-C(=O)]_n-$

POLYESTER (TERYLENE)

→ Because of relatively symmetrical structure and presence of polar gps, the polyester is a good fibre forming material. These fibres have high strength stretch resistance and wrinkle resistance (crease resistance).

→ They have high tensile strength.

→ Resistant to organic acids & mineral acids.

Uses:- used for making mixed (blended) cloths with cotton or wool. These blended cloths have superior properties.

- used for making magnetic recording tapes.
- PET is used for making bottles.
- Used for reinforcing material in safety helmets.

ELASTOMERS

An elastomer is a linear polymer which exhibits elasticity and other rubber like properties.

Natural Rubber :- Natural rubber is obtained from 'Latex' which is milky emulsion obtained from bark of Hevea Brasillians (rubber tree).

chemically natural rubber is cis-polyisoprene

Monomer

Isoprene or

2-methyl 1,3-butadiene

$n(CH_2=\underset{CH_3}{\underset{|}{C}}-CH=CH_2) \xrightarrow[\Delta]{\text{Polymerisation}} -[CH_2-\underset{CH_3}{\underset{|}{C}}=CH-CH_2]_n-$

Drawbacks of Natural rubber

→ Raw rubber is weak due to its low tensile strength ($200\ kg/cm^2$)

→ Becomes soft at temp. and too brittle at low temp. i.e. it is plastic in nature. It can be used between $10-60^\circ C$.

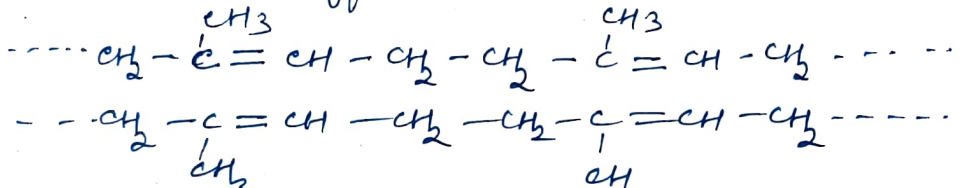
→ It has large water absorption capacity.
→ Swells in organic solvents and gradually disintegrates.
→ It is attacked by oxidizing agents like conc. H_2SO_4 & conc HNO_3.
→ When two fresh surfaces of raw rubber are pressed together they coalesce to form a single piece. This process is known as tackiness. (stickiness)
→ Has less durability due to oxidation in air.
→ Non-resistant to non-polar solvents like- C_6H_6, CCl_4 etc.

Because of these draw backs natural rubber can't be used as such.

Vulcanisation In order to improve the properties of rubber it is vulcanized by heating it with certain chemicals.

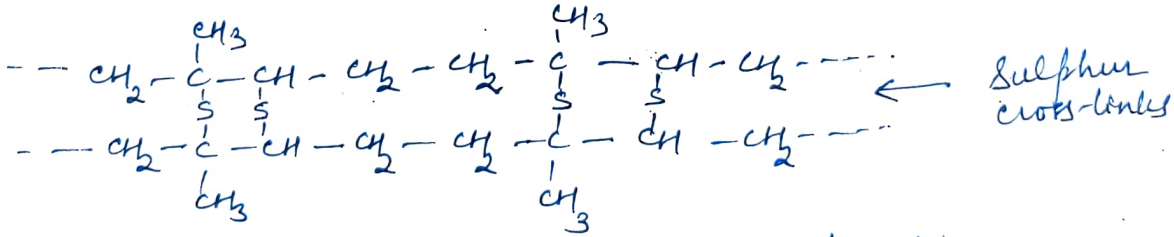
Vulcanisation is the process by which rubber is converted from plastic condition to elastic condition by heating it with certain chemicals like sulphur & sulphur monochloride or H_2S.

Raw rubber is heated with 'S' at 100-140°C. Chemically S adds to the double bonds of different polymeric chains providing cross-linking between them and hence it stiffens the raw rubber.



Chains of raw rubber

Δ/100-140°C/S



Structure of vulcanised rubber

Advantages of Vulcanized rubber

→ Vulcanised rubber has good tensile strength. It can bear load upto 2000 kg/cm².
→ Has greater working temp. range (-40°C - 100°C) as compared to raw rubber.
→ Good ~~abrasion~~ abrasion resistance, chemical resistance, oxidation resistance as compared to natural rubber.
→ ~~It is h~~ It has only slight tackiness and low water absorption capacity.
→ Resistant to organic solvents.

SYNTHTIC RUBBERS

Synthetic rubber is a gp of high polymers which resembles natural rubber in their physical properties. They have superior chemical ~~resistant~~ properties as compared to the natural rubber.

STYRENE RUBBER

[copolymer polymer
Addition polymer

Monomers

(i) Butadiene (ii) Styrene

$$CH_2=CH-CH=CH_2 + CH_2=CH \xrightarrow[\text{(cumene hydroperoxide catalyst)}]{\text{Polym}^n} \left[CH_2-CH=CH-CH_2-CH \right]_n$$

(with benzene ring on the styrene unit)

SBR.
(Styrene Butadiene Rubber)

Also known as
SBR, GR-S & Buna-S

[In Buna-S, words stand for
Bu → Butadiene
Na → Sodium
S → Styrene
GR-S → Government rubber styrene]

→ has high load bearing capacity
→ has high abrasion resistance
→ swells in O_2 ~~+ O_3~~ oils & solvents.

Uses:- Used for making
shoes soles and footwear components
Floor tiles
Wire & cable insulations

NITRILE RUBBER (NBR)

[Copolymer
Addition polymer

Monomers -

(i) 1,3-butadiene $CH_2=CH-CH=CH_2$

(ii) Acrylonitrile (Vinyl cyanide) $CH_2=\underset{\underset{CN}{|}}{CH}$

Polymn → $\left\{CH_2-CH=CH-CH_2-\underset{\underset{CN}{|}}{CH}-CH_2\right\}_n$

Nitrile rubber

Also known as Buna-N, GR-A & NBR.

→ Resistant to heat, sunlight, oils & acids
→ ~~Less resistant to abrasion~~
→ Good abrasion resistance
→ Vulcanised NBR has high temp. resistance.

Uses: - used for making -
- Gasoline hoses because of its excellent resistance to oils.
→ In automobile parts
→ conveyor belts
→ High altitude aircraft components
→ Printing rollers, adhesives.

NEOPRENE: (GR-M)

[Homopolymer
Addition polymer

Monomer

$CH_2=\underset{\underset{Cl}{|}}{C}-CH=CH_2$ → (Polymn, Δ) → $\left\{CH_2-\underset{\underset{Cl}{|}}{C}=CH-CH_2\right\}_n$

2-Chloro, 1,3-butadiene (Chloroprene)

Polymer

Neoprene

Also known as GR-M..

→ The structure of Neoprene is closely related to natural rubber. From the structure it is evident that in neoprene one H-atom is replaced by one Cl-atom. This substitution gives superior resistance to vegetable and mineral oils.
→ It is polar due to Cl, therefore dissolves in polar solvents.
→ Resistant to oxidative degradation.

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Uses of Neoprene:-

→ Used for making gaskets (a flat piece of rubber etc. placed b/w two metal surfaces in a pipe etc. or to prevent leakage), sponges etc.
→ Lining of reaction vessels
→ Tyres prepared by neoprene rubber are superior but due to the higher cost it ~~is~~ can't compete with other polymers.

BUTYL RUBBER (GR-I)

[copolymer
Addition polymer

Monomers

(i) $CH_2=C(CH_3)-CH_3$ — Isobutene

(ii) $CH_2=C(CH_3)-CH=CH_2$ — Isoprene

Polymn

$$\left[CH_2-C(CH_3)_2-CH_2-C(CH_3)=CH-CH_2 \right]_n$$

Butyl rubber.

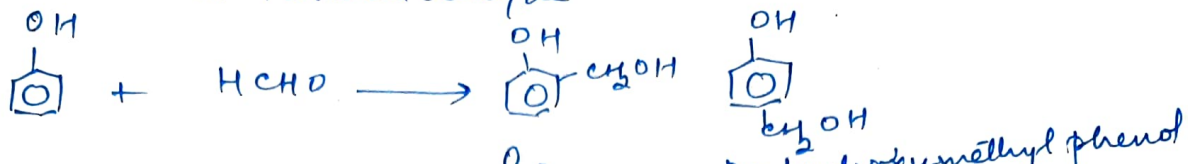
→ Excellent ~~heat~~ resistance to heat, abrasion and ageing.
→ Excellent chemical resistance towards mineral acids.
→ Resistance to oxidation due to low degree of unsaturation.
→ Good electrical insulation property.

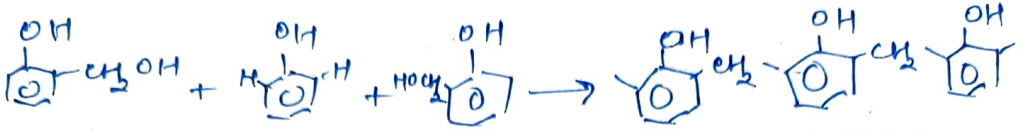
Uses:- used for making -
- cycle & automobile tyres.
- In insulation of high voltage wires & cables.
- tank linings
- making conveyor belts.

BAKELITE [Thermoset] cross-linked polymer.

Monomers (Phenolic-resin) [copolymer
[thermosetting polymer

Phenol & Formaldehyde





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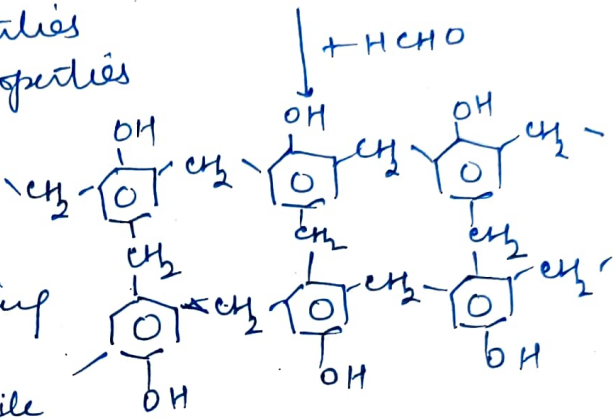

→ have excellent heat resistance
→ have good dielectric properties
→ remarkable adhesive properties and bonding strength.
→ hard, rigid & scratch resistant.

Uses:- Widely used in making
- telephone parts, cabinets for radio, TV & automobile parts.
- electric insulating parts like switches, plugs, switch boards, heater-handles etc.
- used in varnish, paint & protective coatings
- ion-exchange resins for water softening