POLYMERS

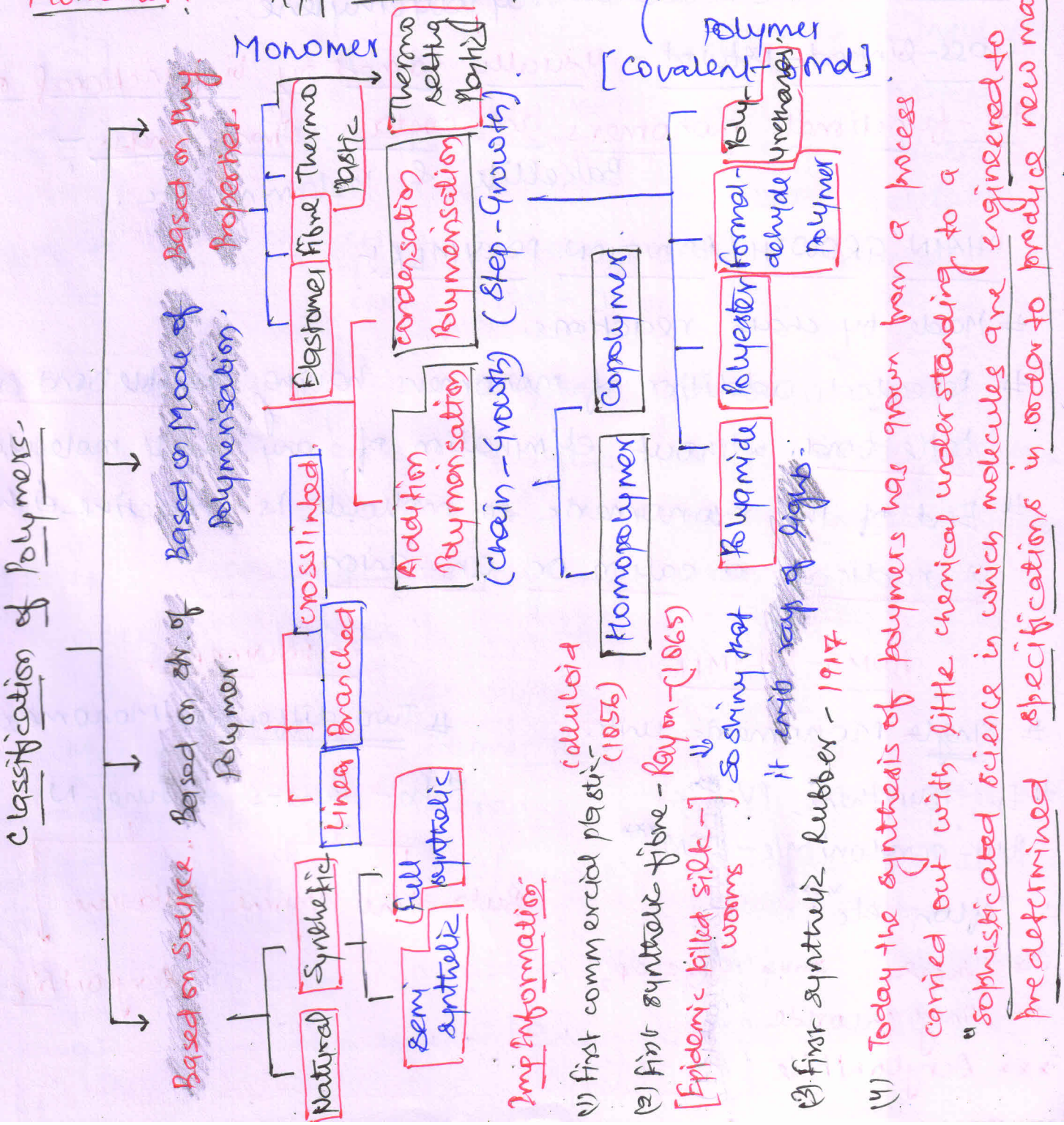
Giant Molecules - with molecular weight ranging from thousands to Millions - 1000 u - 10000000 u.
(Macromolecules)

Huge industrial Importance - photographic film, compact discs, food wrap, Artificial joints, Super Glue, Toys, plastic bottles, Automobile body parts, shoe soles, paints, varnishes etc.

A polymer is a large molecule made by covalent linking together repeating units of small molecules called - Monomer.

$n\,M \xrightarrow{\text{Polymerisation}} -M-M-M-M-M-$

Monomer → Polymer [covalent bond]



Imp Information

1) First commercial plastic (celluloid) (1856)

2) First synthetic fibre - Rayon - (1965)
[Epidemic killed silk-worms] ⇒ so shiny that it was sold as silk.

3) First synthetic Rubber - 1917

4) Today the synthesis of polymers has grown from a process carried out with little chemical understanding to a "sophisticated science in which molecules are engineered to predetermined specifications in order to produce new materials".

COMMON EXAMPLES.

Natural - Made up of cells - Proteins, Polysaccharides, silk, Rubber, wool, starch, cellulose, enzymes, Haemoglobin etc.

Semi-Synthetic - cellulose derivatives - cellulose Nitrate, cellulose Xanthate, cellulose Acetate.

Synthetic Polymers: → Artificial - Man Made.
Polyethylene, Nylon, PVC, Synthetic rubber.

Linear - HDPE High density polyethylene, PVC.

Branched - LDPE - Low density polyethylene.

Cross-linked-Network - Usually formed by bi-functional or tri-functional monomers and contain strong bonds. - Bakelite & Melamine etc.

CHAIN GROWTH / ADDITION POLYMER:

Made by chain reactions.

Repeated addition of monomers having double bond or triple bond, without elimination of any small molecule.

End of the monomeric ~~pp~~ molecule is reacting either a radical, a cation or an anion.

HOMO-POLYMER.

Single Monomeric units.

Ex: Polyethene*, PVC**, Poly-acrylonitrile - PAN***, Teflon etc****

* Ethene **** $CF_2=CF_2$

** Vinyl chloride

*** Acrylonitrile

COPOLYMER.

Two different Monomers.

Ex:- Buna-S & Buna-N.

Buta-diene, Styrene — Buna-S

Butadiene, Acrylonitrile — Buna-N

HOMOPOLYMER.

Monomers	Repeating Unit	Polymer Name.	Uses.
$CH_2=CH_2$	$+CH_2-CH_2+$	Polyethylene	Toys, water bottle, grocery bags.
$CH_2=CH(Cl)$	$+CH_2-CH(Cl)+$	Polyvinyl chloride	shampoo bottle, pipe, flooring etc.
$CH_2=CH-CH_3$	$+CH_2-CH(CH_3)+$	Polypropylene.	Molded caps, indoor outdoor carpeting.
$CH_2=CH(C_6H_5)$	$+CH_2-CH(C_6H_5)+$	Polystyrene.	CD, jackets, hot drink cups, insulation.
$CF_2=CF_2$	$+CF_2-CF_2+$	Poly(tetraflouroethene) (Teflon)	Nonstick surface, liners, cable insulation.
$CH_2=CH(CN)$	$+CH_2-CH(CN)+$	Polyacrylonitrile (PAN – Orlon – Acrilan)	Blankets, apparel, fur.
$CH_2=C(CH_3)(COCH_3)$	$+CH_2-C(CH_3)(COCH_3)+$	Poly(Methyl-methacrylate) Plexiglas – Lucite	lighting fixtures signs, solar panels, skylights
$CH_2=CH(OCCH_3=O)$	$+CH_2-CH(OCCH_3=O)+$	Polyvinyl Acetate	Latex Paints, Adhesives.

COPOLYMER.

Monomers	Polymer Name.	Uses.
$CH_2=CH(Cl)$ + $CH_2=CCl_2$ (vinyl chloride + vinylidene chloride)	Saran	Film for wrapping food.
$CH_2=CH(CN)$ + $CH_2=CH-CH=CH_2$ (Acrylonitrile + Buta-1,3-diene)	SBN / Buna-N	Dishwasher, vacuum cleaner parts.
$CH_2=CH(C_6H_5)$ + $CH_2=CH(CN)$ + $CH_2=CH-CH=CH_2$ (Styrene + Acrylonitrile + Buta-1,3-diene)	ABS	Bumpers, crash helmets, telephones, luggage.

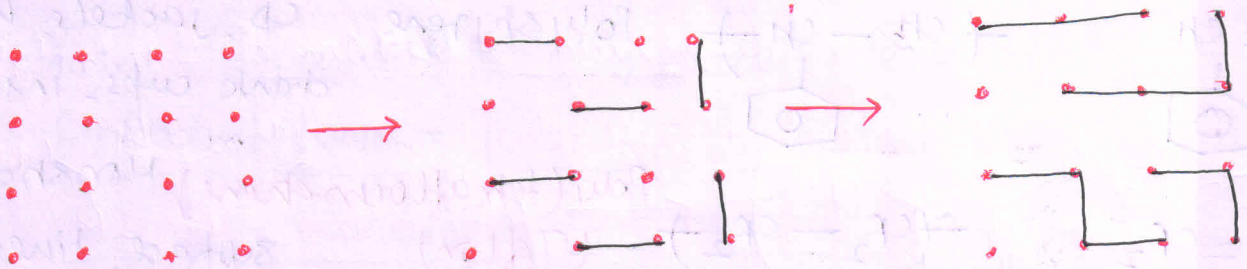
STEP-GROWTH / CONDENSATION POLYMERS:-

Repeated condensation Reaction b/w two different bi-functional or bi-functional monomeric units.

Elimination of small molecules - water, Alcohol, HCl etc.

Monomers. Repeating unit.

Why are they called step-Growth?



0% Reaction 50% Reaction 80% Reaction,

Polyamides

Nylon-6
Nylon-6,6
Nylon-6,10 etc

Polyester

Terylene (Dacron)
Glyptal etc.

formaldehyde-Polymer

Novolac
Bakelite etc.

CLASSIFICATION BASED ON PHY. PROPERTIES.

(i) Elastomers.
weakest IMF
can be stretched.
Buna-S, Buna-N, Neoprene.

(ii) Fibres.
Thread forming solids
High Tensile strength.
H-bond (Stronger).
crystalline nature.
Nylon-66, polyester

(iii) Thermoplastic
linear / slightly branched.
soft ⇌ Hard.
polyethene, PVC etc.

(iii) Thermosetting.
softening & hardening is not possible.
Bakelite, Resin.

order of strength.

Elastomers < Thermoplastic < fibre < Thermosetting

WHY ARE CONDENSATION POLYMERS CALLED STEP-GROWTH?

During the condensation, each step produces a distinct functionalised species and is independent of each other.

Polyamides:- # Amide linkage # ex. of synthetic fibres.
Also called Nylon.

	Polymer Name.	Monomer.	Use.
①	Nylon-6,6	Hexamethylenediamine and Adipic Acid	Sheets, bristles for brushes, Textile etc.

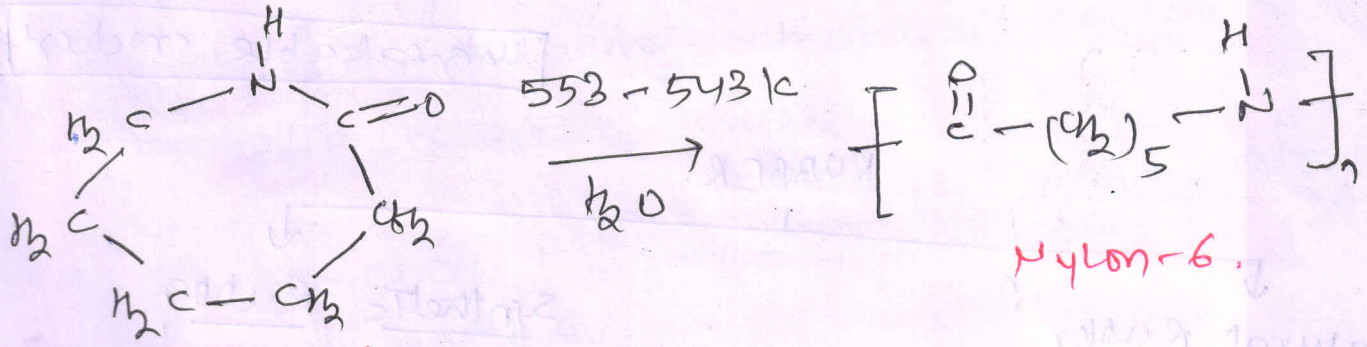
Adipic Acid + Hexamethylenediamine → (553 K, High Pressure)

$$n\,HOOC-(CH_2)_4-COOH + n\,H_2N-(CH_2)_6-NH_2 \rightarrow \left[-NH-(CH_2)_6-NH-C-(CH_2)_4-C- \right]_n$$

Nylon-6,6.

② Nylon-6 — Caprolactam.

Use: Tyre cords, fabrics, ropes.



Caprolactam.

Nylon-6.

Polyester:- # Polycondensation products of dicarboxylic acid & diols.

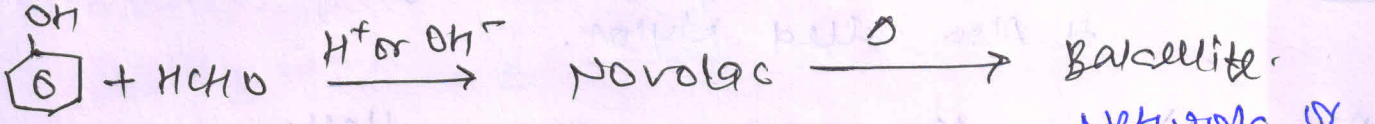
	Polymer	Monomer	Use.
#	Terylene/Dacron.	Ethylene Glycol & Terephthalic Acid.	crease resistant & used in blending with cotton & wool fibres, Helmets etc.

$$n\text{-}HOCH_2-CH_2OH + n\,HOOC-C_6H_4-COOH \rightarrow \left[-OCH_2-CH_2-O-C-C_6H_4-C- \right]_n$$

Terylene/Dacron, Polyester.

Formaldehyde Polymers.

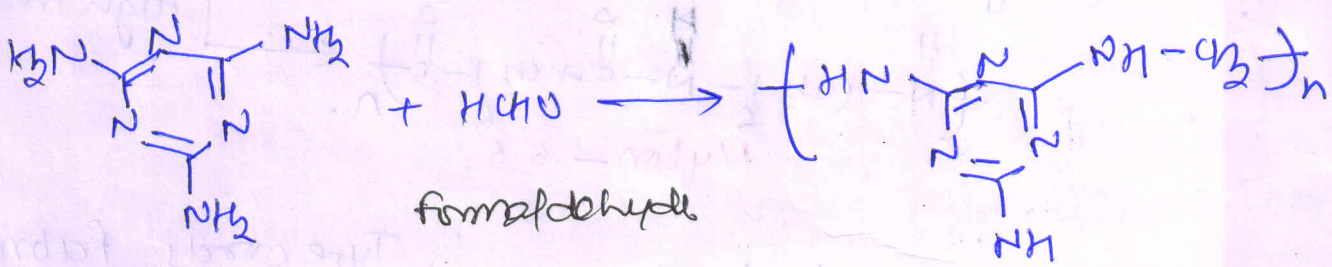
(1) Phenol-formaldehyde polymer:- Monomer - phenol & HCHO (Bakelite Polymers). in Acidic/Basic medium.



linear polymer — Network or cross-linked polymer.

Uses of Bakelite:- combs, electrical switches, utensils etc.

(2) Melamine - formaldehyde polymer:-



Unbreakable crockery.

RUBBER.

Natural Rubber

Elastic Properties.
Manufactured from rubber latex which is a colloidal dispersion of rubber in water.
Latex is found in Bark of Rubber Tree.

Monomer - isoprene. (2-Methyl-1,3-butadiene).
Weak vander Waal's forces.

Synthetic Rubber

More stretchability.
Monomers are. HOMO 1,3-Butadiene. or 1,3-butadiene + other unsaturated polymer.

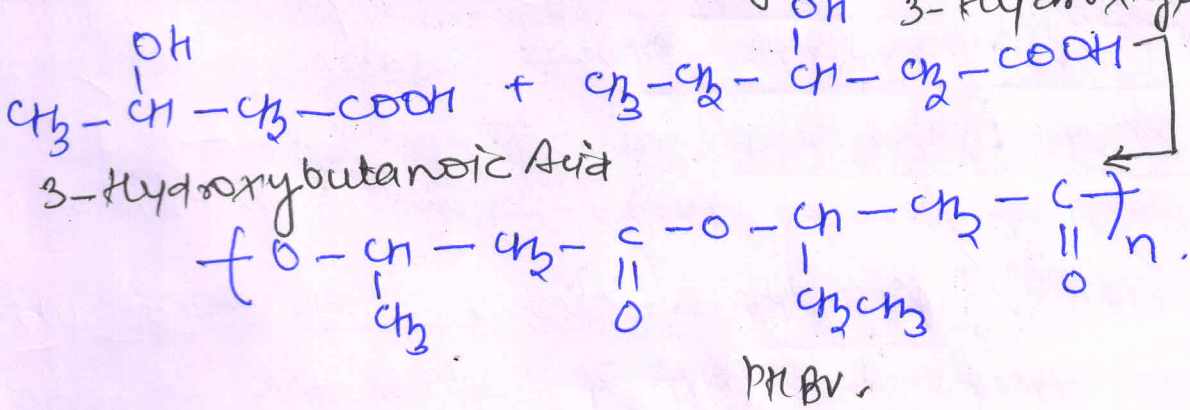
Vulcanisation of Rubber:- In order to improve the strength of natural rubber, it is vulcanised with S b/w 373K to 415K. Sulphur forms cross-links at the reactive sites of double bonds & thus rubber gets stiffened. 5% sulphur is used as a cross-linking agent. Used in Tyres.

Biodegradable Polymers:- Discovered inorder to save environment and contain functional groups similar to the functional groups present in biopolymer.

(1) gmp **Poly β-Hydroxybutyrate-co-β-hydroxy valerate (PHBV) :-**

co-polymerisation of 3-Hydroxybutanoic Acid and 3-Hydroxypentanoic acid.

Speciality packaging, orthopaedic devices & controlled release of drugs.



PHBV.

(2) gmp **Nylon-2-Nylon-6:-** # co-polymer of Glycine & Amino caproic Acid.