

22.07.2022 MACRO MOLECULES:

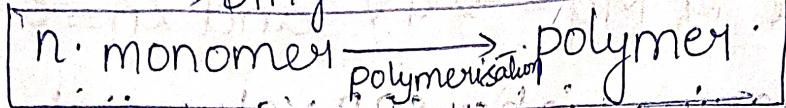
[POLYMERS]

union of many repeating units of same atoms or groups of atoms.

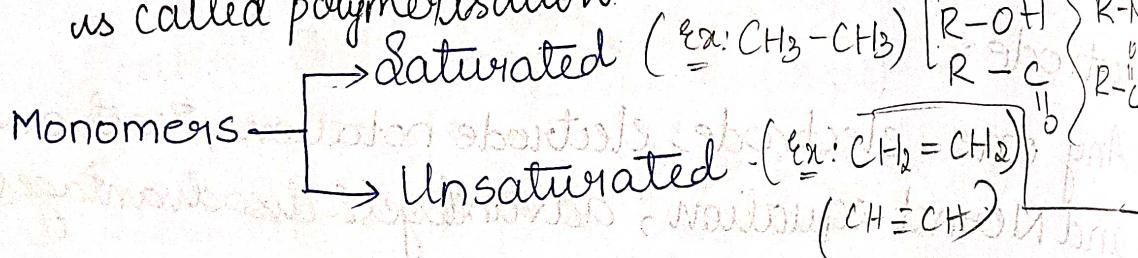
units → repeating units

Single repeating unit of a polymer is called MONOMER.

↳ single



* The process by which a number of monomers are converted into a polymer is called polymerisation.



* Materials used for daily purposes:

- 1) Polymers - light in weight; easily processable
- 2) Metals & alloys - stable at high temp; conductors
- 3) Ceramics - thermally stable; heavy in nature; brittle.

→ Natural Polymers: Jute, Cotton, Silk, natural rubber.

The fibre produced by any plant (or)

- animal is called natural polymer.
- Synthetic Fibre: Rayon, Nylon, polyester, polyethylene
- * Alloys are combination of metals which are mixed to get the desire properties.

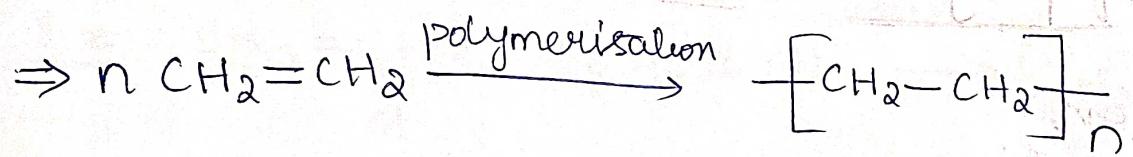
monomers.

- * Unsaturated ~~polymers~~ can be added to /mixed with another to form a co-polymer which have the desired properties.
- * Polymer is a macro molecule which contains many repeating units.

- Classification of Polymers:
- Natural Rubber
 - Synthetic Rubber:
Ex: Bakelite
 - (occurrence)

- * What is the difference b/w manmade & natural polymers?
- Synthetic fibres are advantageous but are non-degradable (not eco-friendly)

* Degree of Polymerisation:



- * Degree of polymerisation is defined as number of repeating units of a polymer.

* Functionality:

→ A molecule can be called a monomer if its functionality is atleast 2.

functionality > 2 : cross linkage polymers,
3D polymers, Network polymers.

functionality: 2 : linear polymers.

* No. of reactive centers or sites in a given molecule ~~are~~ is called functionality.

⇒ Define functionality & explain its effect on the structure of a polymer.

* Classification of polymers based on type of polymerisation:

→ Addition polymers

→ condensation polymers.

→ Types of polymerisation:

* Addition

* Condensation.

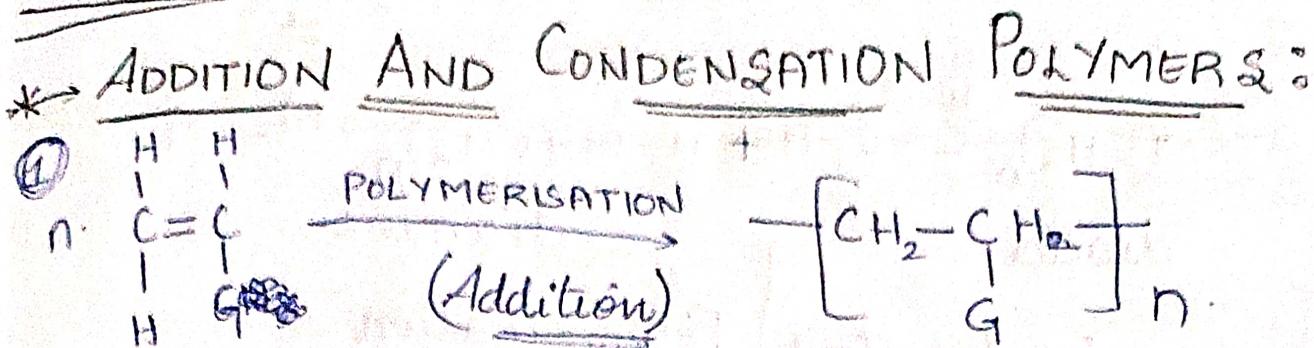
* Classification of co-polymers based on monomers:

→ Homo chain (Homo polymers)

→ Hetero chain (Hetero polymers)

→ co-polymers.

27/07/2022



Monomer

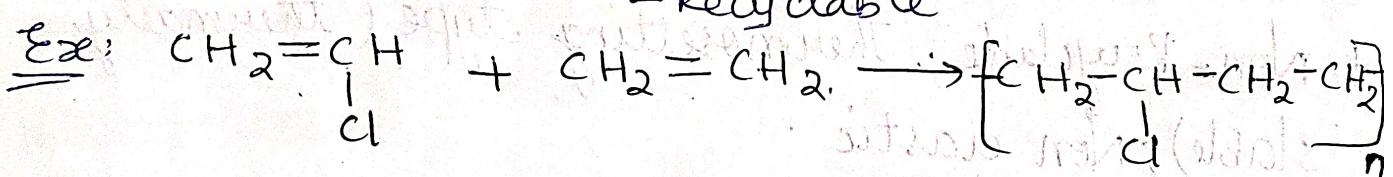
Polymer

- 1) $\text{G} = \text{H}$: Ethene \rightarrow Polyethene.
- 2) $\text{G} = \text{Cl}$: Vinylchloride \rightarrow Poly Vinyl chloride.
- 3) $\text{G} = -\text{CH}_3$: Propene \rightarrow Polypropylene.
- 4) $\text{G} = -\text{C}_6\text{H}_5$: Vinyl benzene
(styrene) \rightarrow Polystyrene.

* The empirical formula of the monomer and polymer is same as well as there is no by product formed ; it is called

Addition polymer.

- Elastic, easily soluble.
- Thermoplastic type
- Recyclable.

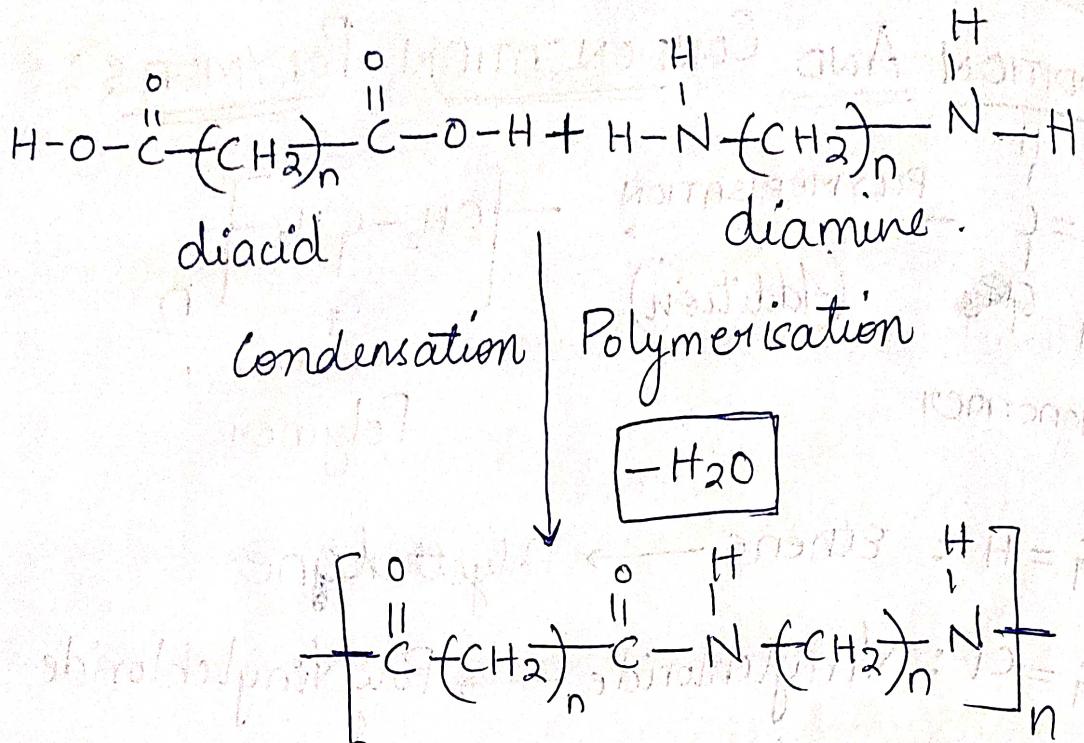


∴ Degree of saturation is reduced by 1.

∴ only unsaturated monomers are used.
and formed polymer is saturated.

* Linear Polymers ; polymer chain is increased in 1 direction

2



- * Proteins contain amide linkage
 - * Monomers must be saturated and the polymer chain is increased in all the directions.
 - * A byproduct is formed.
 - * Polymers formed can be linear as well as branched.
 - * Non-Recyclable; Thermosetting type (thermally stable); Non elastic.
 - * There should be affinity/reactivity towards each other i.e. both the monomers.
 - * List any 5 differences b/w addition & condensation polymerisation / polymers.

Homopolymer and Heteropolymer



Similar atoms

in the backbone
of polymer



C_2H_5
Bottleneck
polymer

* The backbone of the polymer containing similar atoms are called homo^{chain}-polymers.

* The backbone of the polymers containing dissimilar atoms are called hetero^{chain}-polymers.

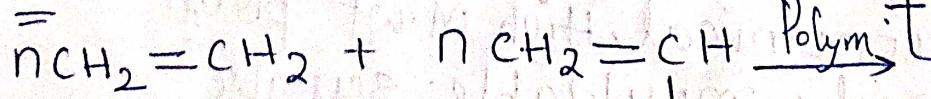
Homo Polymers:

If a polymer is prepared from a single monomer; it is called HOMOPOLYMER

Co-Polymers:

If a polymer is prepared from unsaturated monomers which form homo polymers individually also form a co-polymer when the monomers undergoes polymerisation. (Nylon-6,6) is not a co-polymer.

Ex:



Ethene

Ph
Styrene.

Poly [ethene -co-
styrene]

Types (Co-polymer)

1) $\sim M_1 - M_2 - M_1 - M_2 \sim$
Alternate Co polymer.

2) $\sim M_1 - M_2 - M_2 - M_1 - M_1 - M_2 \sim$
Random Co polymer.

3) $\sim M_1 - M_1 - M_1 - M_1 - M_2 \sim M_2 - M_2 - M_2 \sim$
Block Co-polymer.

4) $\sim M_1 - M_2 - M_1 - M_1 \sim$
 $\quad \quad \quad | \quad |$
 $\quad \quad \quad M_2 \quad M_2$
 $\quad \quad \quad | \quad |$
 $\quad \quad \quad M_2 \quad M_2$
 $\quad \quad \quad | \quad |$
 $\quad \quad \quad M_2 \quad M_2$
Grafted Co-polymer.
ABS: Acrylonitrile
Butadiene
Styrene.

28/07/2022 Classification based on the end applications:

- Plastic: PVC, Polystyrene, Polyethylene etc
- Rubber/ Elastomers: ~~are formaldehyde Latex~~
- Resin: urea formaldehyde, bakelite
- Fibers: Nylon, Polyester; Rayon

→ Plastic:

- light in weight, easily processable
- economical, High M-wt polymer
- easily mouldable; reusable
- Thermally stable

- Resins: - low molecular weight polymers compound.
 - easily hardened; gel like materials to plastics
 - remoulding is not possible; semi solid material
- Rubber / Elastomers (polyisoprene)
 - latex, natural rubber, nitrile rubber, neoprene
 - Automobile tyres, pipes, sealant.
 - cables.

- Fibres:- Highly crystalline in nature
 - High molecular weight; thread like structure
- Eg: Nylon, Dacron, polyester, Teflon.

Elastomers: Polymers which can be elongated from 2 to 10 times of initial length by application of heat or pressure.

- Additives: Polymers of low molecular weights
 - Binders
- Eg: glycols,

Natural binder → bark of the tree

* Glass Transition Temperature:

- List a polymer which is used in our daily life; its chemical composition (structure), name of the monomer, polymer & other filling material + applications of the item, suggest one alternative natural material to replace that particular polymer

Glass Transition Temperature (T_g)

Polymer → Polymer
(Brittle &
hard) (Soft,
rubbery)

- No sharp melting.
 - No fixed molecular mass } poly-dispersed molecule

* The temperature at which a polymer acquires a flexible form is called glass transition temperature (T_g).
 Amorphous, molten, liquid

* This tells us about the given material / polymer.

- * This tells us about the given material / polymer.
- * → Differential Calorimetry : (DSC) → Measurement of T_g .

* Factors effecting T_g value:

→ Molecular Mass

→ Crystallinity

→ Impurities - plasticizers (↑ing plasticity of material)

→ Stereo regularity

→ Side / Branch groups

If n (degree of polymerisation) \uparrow ses; molecular mass \uparrow ses; T_g value \uparrow ses.

mass rises, T_g . After certain rise in molecular mass; the rise in T_g is negligible.

- crystallinity \uparrow ses; $T_g \uparrow$ ses.

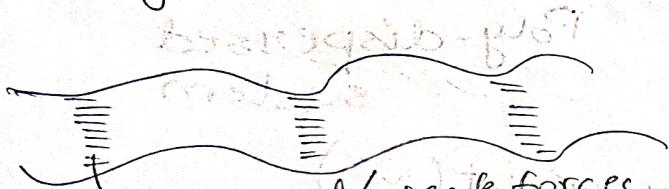
- * plasticizers ↑ ses; T_g ↓ses.
- * More orderly arranged T_g ↑ses
- * If side chain changes; the group nature effects T_g .
- If attractions are more; T_g is more.
(H-bonding)

29/07/2022

* Plastics:

polyethylene, polystyrene
Thermoplastic PVC

- Polymer $\xrightarrow{\Delta}$ soft $\xrightarrow{\Delta}$ char.
- less stable (thermally)
- linear polymers.
(addition polymerisation)
generally.



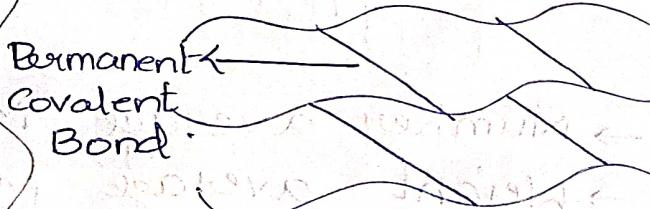
vanderwaal/weak forces
∴ on heating; they form soft bonds.

- Easily soluble in organic solvents.

- Recyclable/Remoulding is possible from polymer granules.

urea formaldehyde,
resins
Thermosetting

- Polymer $\xrightarrow{\Delta}$ excess char.
- more stable.
- crosslinked / branched polymers.
(condensation polymerisation)



- ~~Easily~~ Soluble may be in acids & bases but insoluble in organic solvents.

- Non-Recyclable

GLOBAL

LONG BOAR

* Materials used for making plastic:

→ polymer

→ pigment

→ softened or plasticized

→ filler.

* List any 5 differences b/w thermoplastics & thermosets

* PVC is recyclable, but bakelite is not

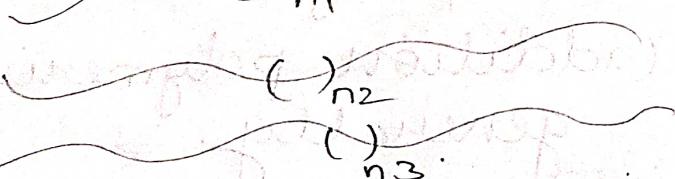
recyclable.

* MOLECULAR WEIGHT OF POLYMER:

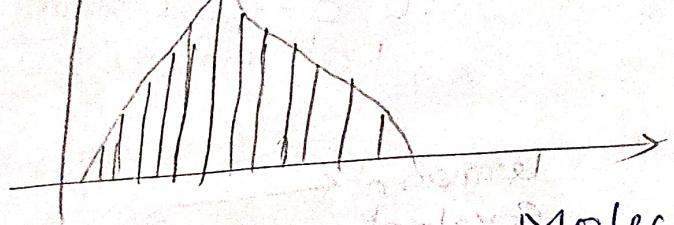
n monomers:

gives $n_1 + n_2 + n_3 + \dots = n$

↓
polymer structure



Poly-dispersed system



Number average Molecular weight (\bar{M}_n)

Weight average Molecular weight (\bar{M}_w)

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

$$\bar{M}_n = \frac{\sum n_i M_i}{\sum n_i}$$

$$\bar{M}_w = W_1 M_1 + W_2 M_2 + \dots$$

$W_1 + W_2 + \dots$

$$\boxed{\bar{M}_w = \frac{\sum W_i M_i}{\sum W_i}}$$

$$\text{if } W = n \times M$$

Gel
Permeation
chromatography
27
32

$$\boxed{\bar{M}_w = \frac{\sum n_i M_i}{\sum n_i M_i}}$$

Q6: $\frac{\bar{M}_w}{M_n} = 1$: Ideal Polymerisation

$$\boxed{\frac{\bar{M}_w}{M_n} > 1}$$

Poly Dispersity Index = $\frac{\bar{M}_w}{M_n} \rightarrow \underline{\text{PDI}}$

n = no. of polymer chains with a particular molar mass.

M = Molar mass of a polymer

w = weight of the polymer chain having a particular molar mass

→ Generally polymers samples molar mass is being determined by GPC technique.

01/08/2022

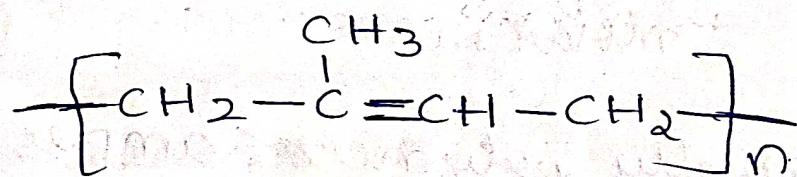
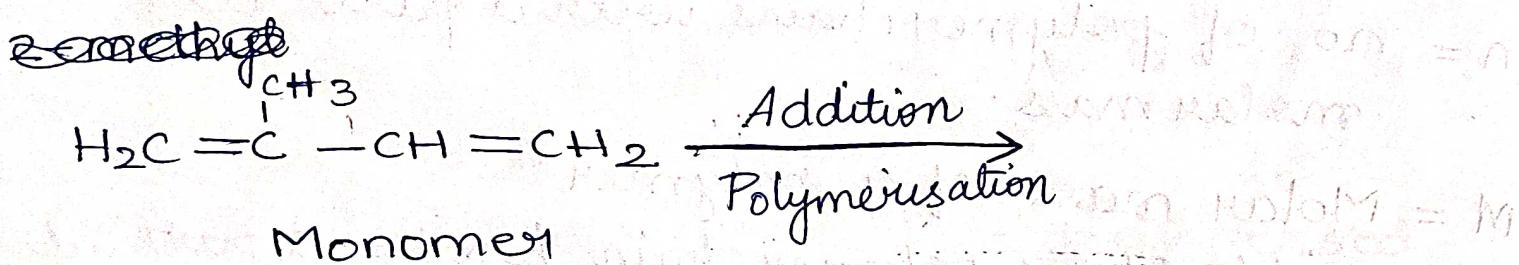
* TYPES OF RUBBER:

- Natural Rubber: Derived from natural plants barks.
- Synthetic Rubber: Rubber prepared in laboratories.

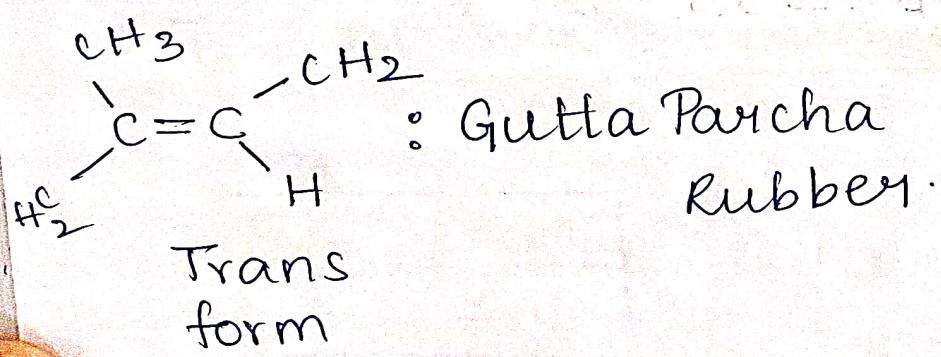
* NATURAL RUBBER:

The trees from which this is obtained are generally grown in tropical regions.

2-Methyl 1,3-Butadiene
(Isoprene)



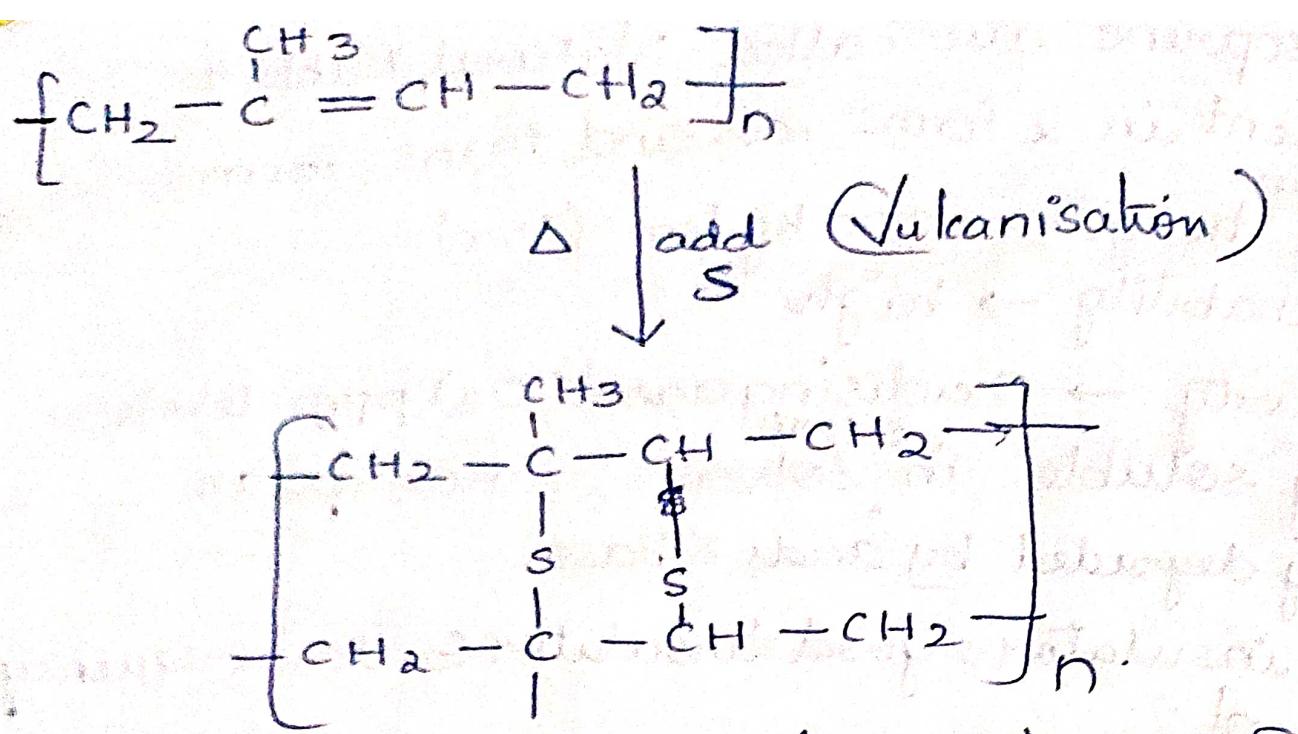
④ Polyisoprene



- * Polyisoprene also called Natural Rubber present in 2 forms cis and trans forms.
- * Properties:
 - Tensile Strength → 200 kg/cm² (low)
 - Stretchability → high
 - Reactivity → Oxidising agent (O₃) ppm levels.
 - Easily soluble in solvents : non-polar.
 - Easily degraded by acids & bases.
 - Poor insulator; good insulator for low frequency current.

- Working temperature [10 - 60 °C].
 - low temp → brittle
- Highly reactive with oxidising agents.
- Swells when comes in contact with water.
- It is permeable to gases.
- Discuss the preparation & properties of natural rubber.
- Suggest a method to improve properties of natural rubber (or) Discuss the chemistry of vulcanisation.

- * Natural rubber has elastic nature due to its coil like structure.
- Vulcanisation is the process of adding sulphur to rubber and heating.



(Cross-linkage Polymer)

Properties of Vulcanised rubber:

- * Tensile Strength : 2000 kg/cm^2 (high)
- * Stretchability : decreases
- * Solubility & reacting with OA decreases.
- * Insulator; tough material.
- * Working temperature : $-10 - 100^\circ \text{C}$

⇒ Swelling property of a polymer have many applications -

- * Vulcanised rubber is not easily soluble in organic solvents, acids & bases.
- * Better insulator than natural rubber.
- * Toughness of natural rubber can be improved by vulcanisation (different quantities of Sulphur).

→ Ebonite Rubber is the toughest natural rubber which contains about 30% of sulphur.

* SYNTHETIC RUBBER:

1) BUNA-S

2) Neoprene Rubber.

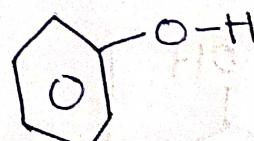
02/08/2022

* BAKELITE: [Phenol - Formaldehyde Resin]

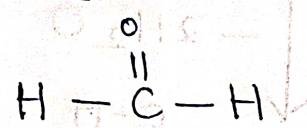
• Thermoset plastic (hard & strong materials)

• cross-linkage polymer. * 40% of

• condensation polymerisation Formaldehyde



Phenol



Formaldehyde

is known as formalin.

* Antiseptic agent used for sterilization

→ Phenol + formaldehyde $\xrightarrow{\text{Rxn. (more)}}$ mono + di + tri

P:F ratio

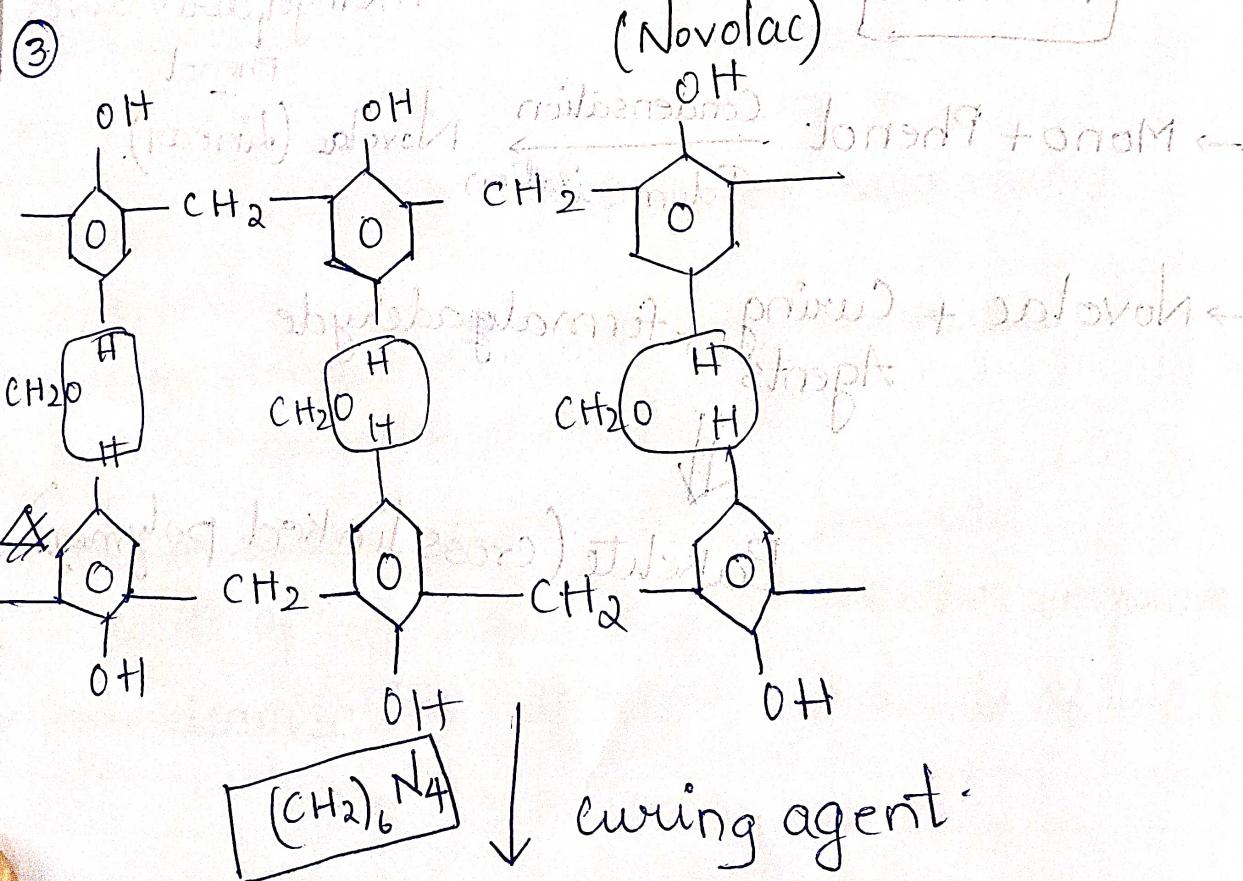
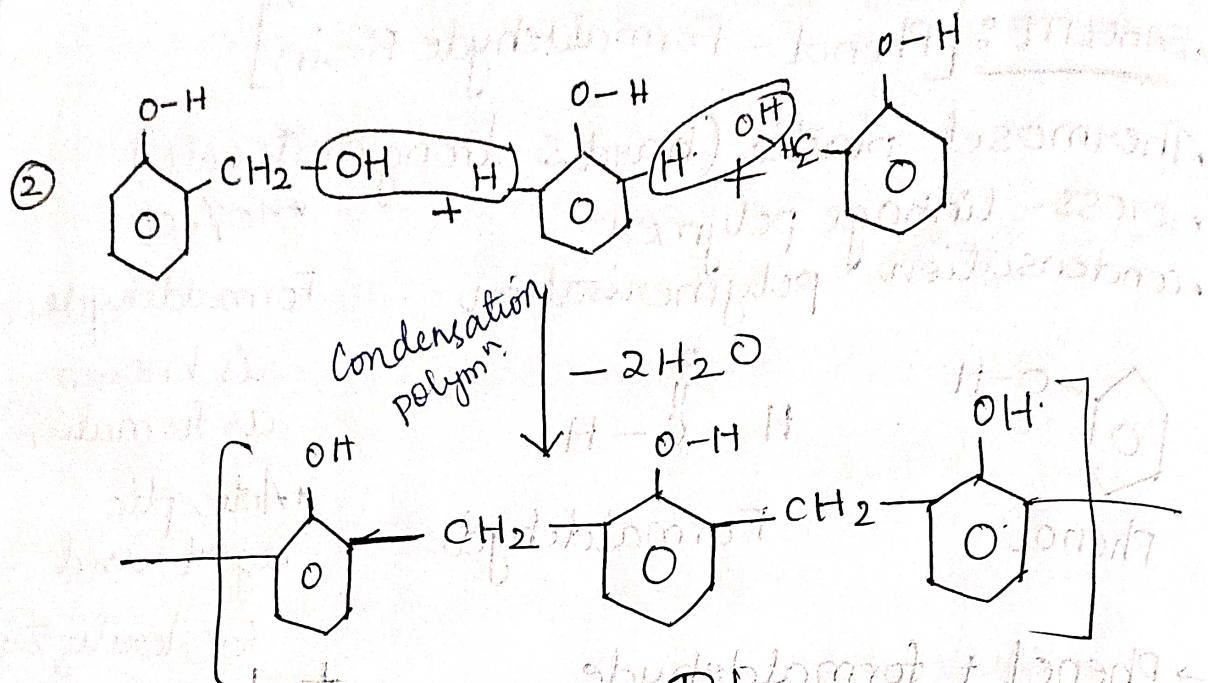
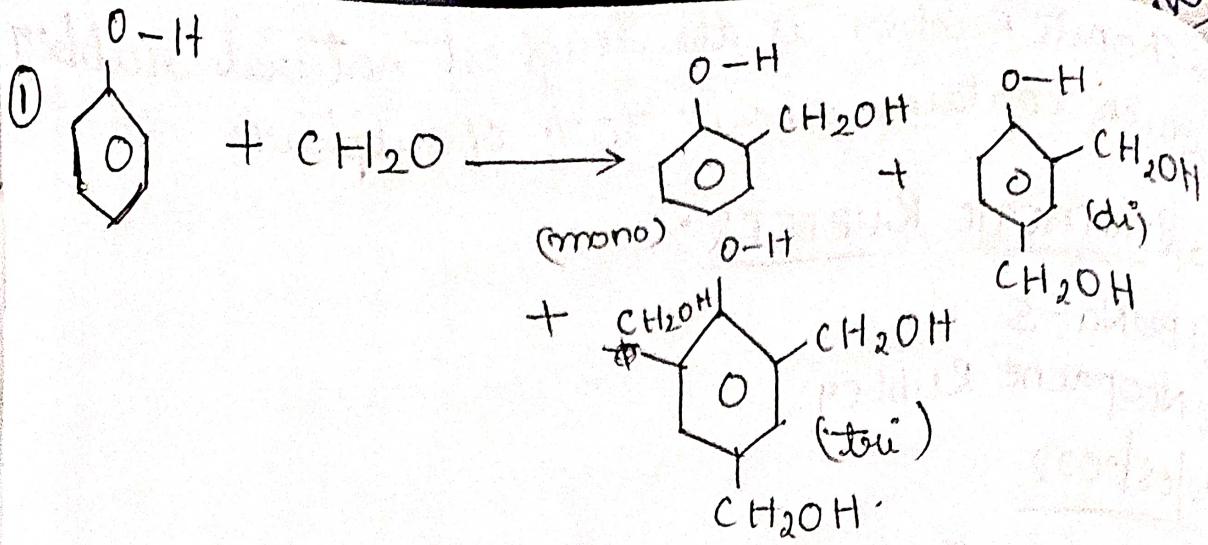
methyl derivatives
phenol

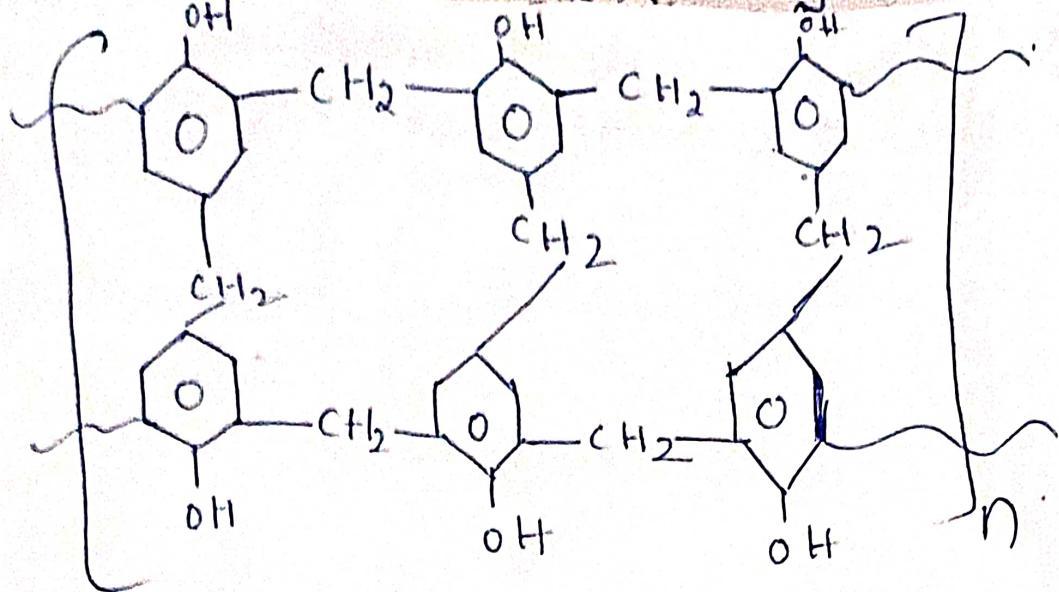
→ Mono + Phenol $\xrightarrow[\text{Polymerisation}]{\text{Condensation}}$ Novolac (Linear).

→ Novolac + Curing Agents + formaldehyde

Bakelite (cross linked polymer).

Strong points





BAKELITE:

- insoluble in organic solvents and acids.
(offers greater resistance to acid).

- Scratch resistance.

- insulator

* Applications :

- Paints industry
- Electronic switches (for high frequency current applications)

- for water purification (ion exchange resins)
 - water softening purpose.

- for electronic gadgets outercase.

- For making lubricants and also grinding wheels in paper & sugar industry.

- Anti-slip coat for scientific equipments.

* Almost all phenol-formaldehyde resins have similar properties.

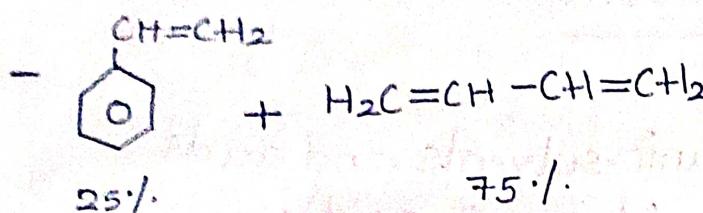
* Discuss the preparation of phenol formaldehyde resin. Mention all properties & applications.

5 03/08/2022

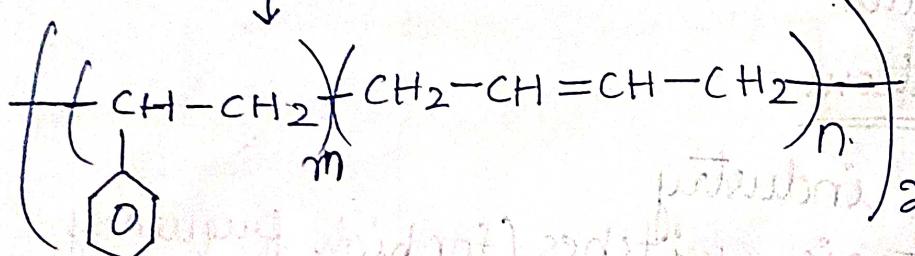
✓ * BuNa-S / SBR : Elastomer

Styrene Butadiene
(Vinyl Benzene) (1,3)

- GR1 rubber



Addition
Polymerisation



Co-polymer:

This polymer can be vulcanised to improve the mechanical property.

- Has mechanically superior properties than natural rubber.

Good insulator to electric current.

Chemically inert and insoluble in organic solvents.

Offer resistance to acids & bases and also aging (fight against UV radiations).

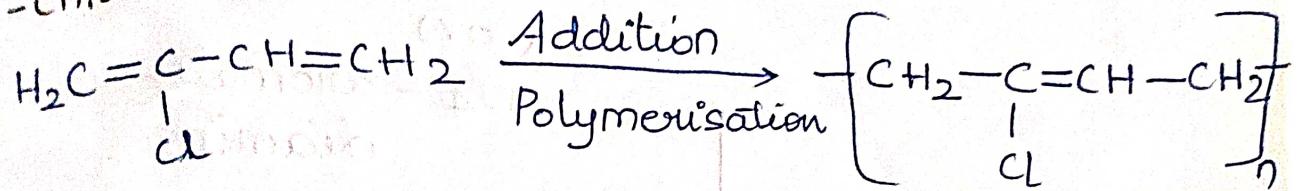
APPLICATIONS:

- Automobile toys
- water proofing agent in construction industry.
- For making foot wear sole.
- can be used as adhesive, pipes, cubes, conveyor belts as a cushioning agents.
- Sports equipments.

* NEOPRENE RUBBER:

- Also known as chloroprene.

2-chloro 1,3-Butadiene:



Monomer:

Neoprene:

Homo-Polymer:

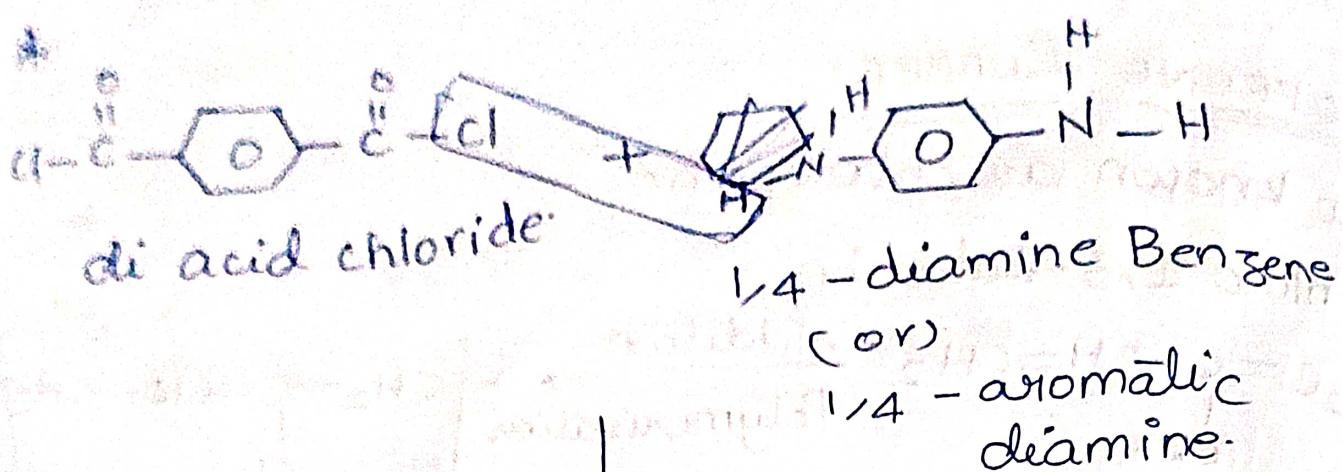
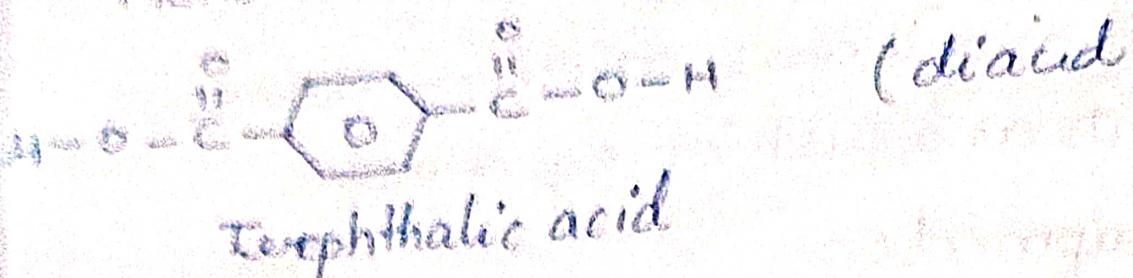
- Due to the presence of chlorine which makes polymer polar; more attractive forces are observed b/w polymer chain that makes this polymer mechanically more strong material.
- It offers high resistance to strong acids & bases.

* APPLICATIONS:

- Good electrical insulator used for transporting acids and corrosive gases.
- As cushioning agent.
- Cables.

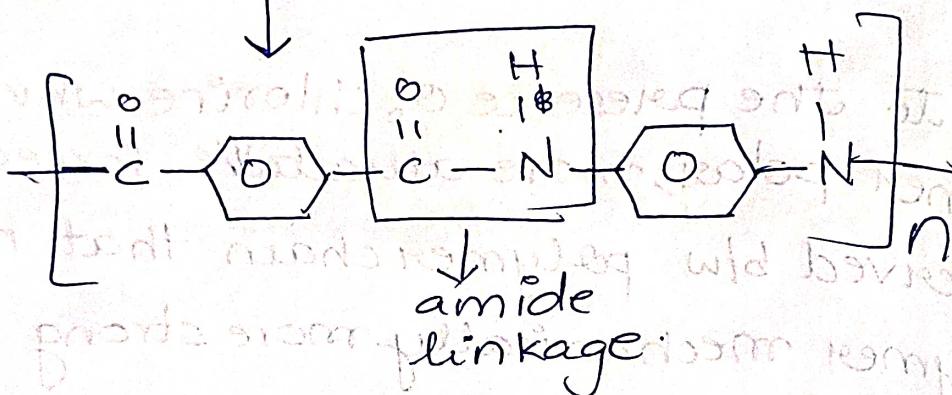
* KEVLAR : [Aramid]

- poly aromatic amide
- Monomer



Condensation
Polymerisation

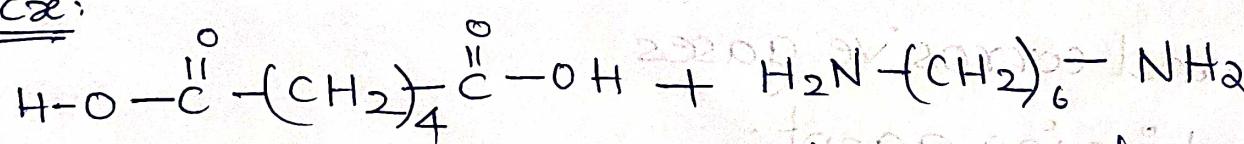
- HCl



Poly aromatic amide

[KEVLAR]

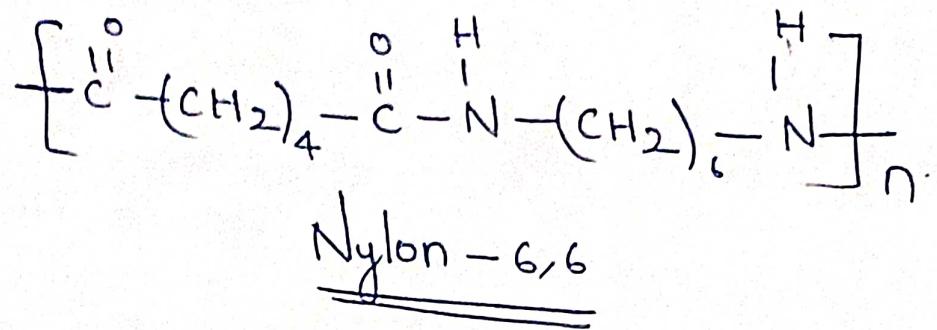
Ex:



Adipic acid

Hexamethylene
diamine

Condensation Polymer



- Kevlar is 5 times stronger than steel and
(eq wt) 10 times stronger than aluminium.

APPLICATIONS:

- Good insulator ; to protect cables.
- Bullet-proof vest/jacket; helmets
- High transmission lines
- Blankets to prevent electric shocks.
- Ropes; fibres; adhesive material.

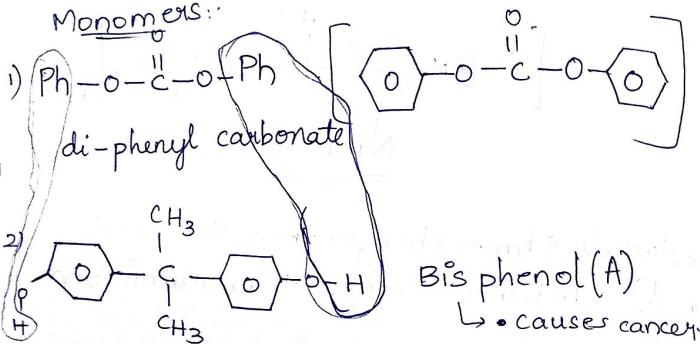
* 6 π electrons given by benzene rings ~~nowhere~~ builds strong intermolecular bonds due to which it is very strong.

Properties:

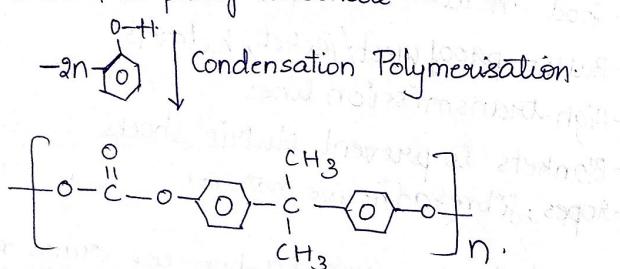
- They have intramolecular forces b/w polymeric chains due π - bonding e⁻s b/w polymer & amide group.
- These attractive forces make this material mechanically tough.
- High performance materials

* POLY CARBONATES: $[CO_3]_n$

Monomers:



* Bis-phenol + di-phenyl carbonate



Properties:

- It's a transparent polymer.
- Very good substitute material for glass.
- Electrical insulator.
- mechanically tough.
- Water repellent.
- Scratch resistance.
- Soluble in some organic solvents & alkalies.

Applications:

- 1) Eye-wear
 - 2) Electrical switches
 - 3) CDs, DVDs.
 - 4) Automobile industry
 - 5) for decoration - head & tail lamps.
 - 6) Storage cans for oils, acids
 - 7) Polycarbonate sheets are used in construction industry
 - 8) Material is very strong due to π es in benzene ring.
- g) Non-degradable and mechanically tough.

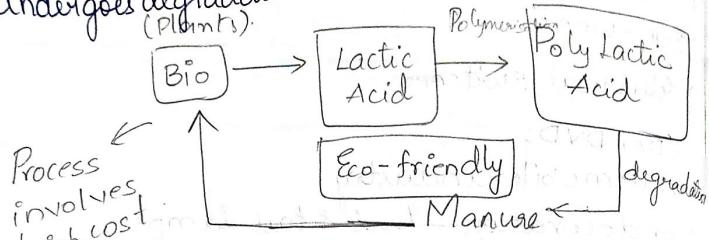
* Bio-degradable Polymers:

ICMR

- Due to disintegration of polymers; a no. of micro-plastics are causing damage to nature.
- But degradation of polymers i.e. formation of CO_x , HO_x , O_2^{Nf} do not cause any damage to nature.
- Starch, wool, silk undergo degradation; but majorly the synthetic polymers undergoes disintegration rather than degradation.
- Poly Lactic Acid (PLA) - synthetic polymer

SIVANIKOLUR

undergoes degradation
(Plants):



Process involves high cost

$\left. \begin{matrix} C-O \\ C-N \\ N-N \\ N-O \end{matrix} \right\}$ If a polymer contains
this types of bonds,
such polymers are biodegradable.

microorganisms \rightarrow soil.
temperature
humidity
pressure $\left\{ \begin{matrix} \text{conditions for} \\ \text{degradation} \end{matrix} \right.$

* Preparation of Poly-lactic acid:

Polystyrene, PVC, Buna-S, nitrile rubber, polypropylene are non-biodegradable polymers. Why?

Which polymers will undergo biodegradability?

* Conversion of polymer having more repeating units to lesser no. of units is ~~not~~ called disintegration which forms micro plastics.

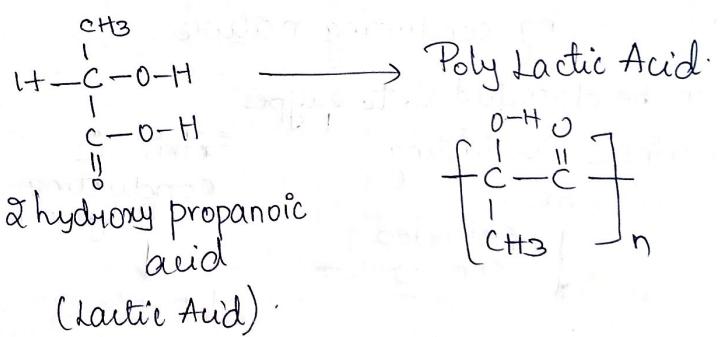
which are more dangerous

* Polymers having bonds like $C=O$, $C-N$, $N-N$, $N-O$, $C-S$ etc are easily breakable bonds. These when in contact with suitable conditions like temp, pH , pressure, humidity, microorganism in soil produces oxidised products like CO_2 , HO_2 , NH_4 derivatives etc.

* These are eco-friendly, less toxic products. This process is called bio-degradation.

Ex: Starch, PLA, peptides, proteins, ~~amino acids~~, cellulose etc.

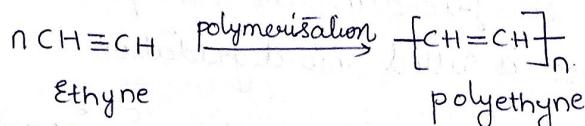
* Poly Lactic Acid : [PLA]



- PLA is mechanically equal to polyethylene & polypropylene but it is costlier 50-100 times
- It should be consumed in limited time after the production

05|08|2022

* CONDUCTING POLYMERS:



Ex: poly thiophene, poly aniline. Conjugated molecule:

* Any polymer having alternating double bonds i.e. conjugation are having conducting nature.

→ Can be classified into 2 types:

Intrinsic Conducting Polymers

Polymers
doping | extended conjugation

Extrinsic
conducting
polymer

Not direct
conducting
polymers,

N-type

P-type.

-ve charge is developed in polymer chain +ve charge is developed in polymer chain

+ve charge
is (flow
developed
in polymer west)
chain

Rather mixing
with other substance
Offer conductance.

Metallic
conducting
polymer

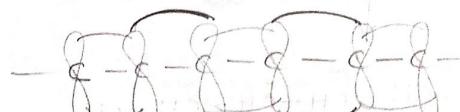
Blended
conducting
polymers

Eq. MO.

* Polymer which conduct electricity is known as conducting polymer.

e.g.: Polyacetylene (Polyethyne)
[Used for ripening purpose]

\Rightarrow Conduction mechanism of Polycrylyne. (Undoped)



This interconversion takes less than 10^{-14} part of a second.

→ In undoped polyacetylene; conduction is due to delocalisation of π - bonding electrons.

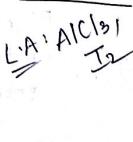
→ After doping: conductance of conducting polymer increases hugely (10^6)

→ After doping; conductance of polyacetylene

is of the order of conductance of metals like copper on weight to weight basis.

polaron

* P-doping: reaction of polymer with Lewis acid; hence polymer gains +ve charge.

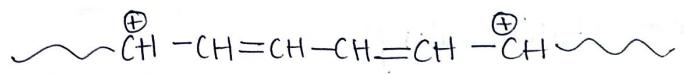
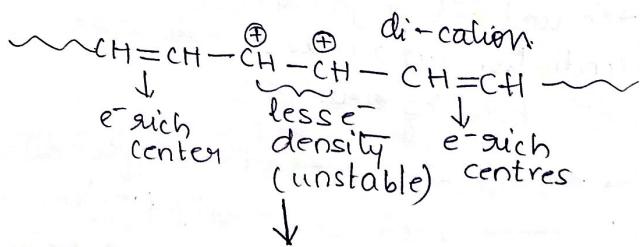
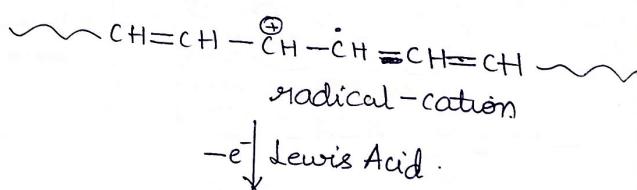
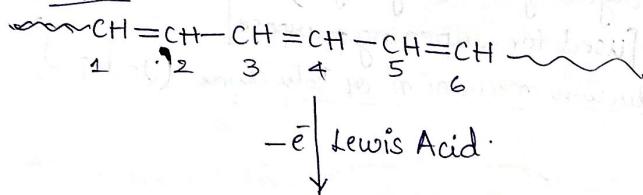


with Lewis acid; hence polymer gains +ve charge.

* n-doping: reaction of polymer with Lewis base; hence polymer gains -ve charge.



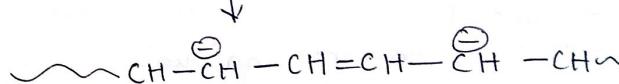
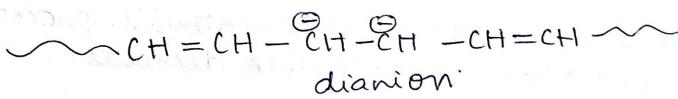
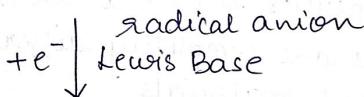
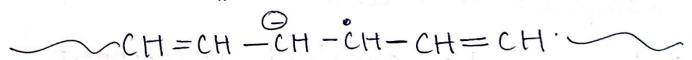
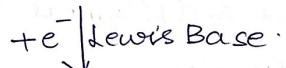
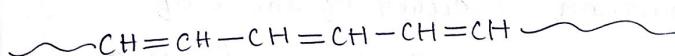
* P-doping:



→ Describe the mechanism of conduction in doped & und.

→ How to improve the conductance of a conducting polymer? Explain its chemistry & mechanism.

Due to the formation of +ve/-ve charge in the chain; e⁻ movement becomes faster & conductance ↑↑



* APPLICATIONS:

→ Display Screens / Devices

→ OLED

→ Photovoltaic Devices (Solar Cell)