Applied chemistry

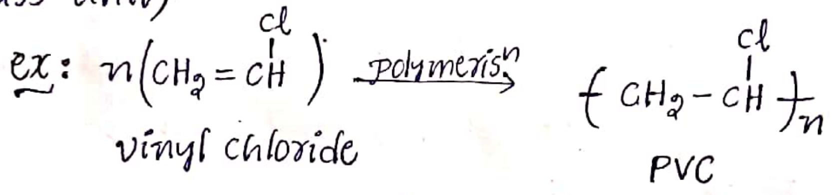
# 1. Polymer Technology

## Introduction:

Polymer is a largest molecule formed by the repeated combination of small molecules (or) units called monomers.

⟹ In a polymer monomers are held together by covalent bonds.

⟹ Molecular weight of polymer lies between 5000 - 200 000 AMU (atomic mass unit).



$$ex: n\left(CH_2=\overset{Cl}{\overset{|}{C}H}\right) \xrightarrow{polymeris^n} \left[ CH_2-\overset{Cl}{\overset{|}{C}H} \right]_n$$

vinyl chloride

PVC

where 'n' is degree of polymerisation.

## Degree of polymerisation:

Number of repeating units in a polymer is known as degree of polymerisation.

## Functionality:

Number of reactive sites in a monomer is called functionality of a monomer.

ex: ethene is bi functional monomer.

## Polymerisation:

It is the chemical reaction at which two or more monomers combined together to form a polymer is known as polymerisation.

$$ex: n(CH_2=CH_2) \xrightarrow{polymerisation} \left[ CH_2-CH_2 \right]_n$$

monomer (ethene)

polymer (polythene)

## Types of polymerisation:

Based upon mechanism polymerisation is four types. They are

1. Addition polymerisation
2. condensation polymerisation
3. Co-polymerisation
4. co-ordination polymerisation (or) Zieglar-natta polymerisation

## Addition polymerisation:

It is the polymerisation reaction at which two or more monomers combined together without elimination of simple molecules is known as addition polymerisation.

ex: polythene, poly vinyl chloride (PVC), Teflon ... etc

⇒ Addition polymerisation is of three types of mechanism

a) free radical mechanism
b) anionic mechanism
c) cationic mechanism.

a) **Free radical mechanism:** It undergoes homolytic clevage mean the bond is shifted towards both sides of the carbon elements.

$$R_2O_2 \xrightarrow[\text{ii) Light, iii) catalyst}]{\text{i) heat,}} 2R^{\cdot} + O_2\uparrow$$

→ It follows three steps. They are

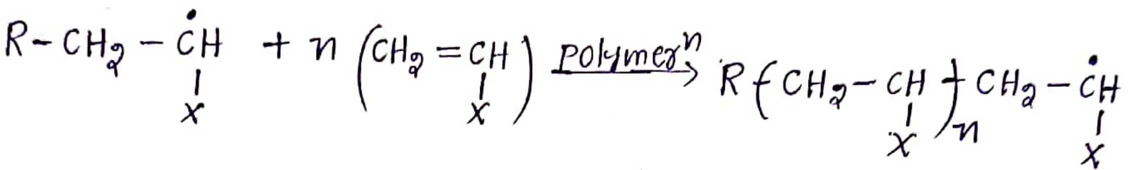
### Initiation step:

$$R^{\bullet} + CH_2 = \underset{X}{CH} \xrightarrow{\text{polymerisali}^n} R-CH_2-\underset{X}{\dot{C}H}$$

monomer radical

### Propogation step:

In this step monomer radical reacts with another monomer for growth the chain.

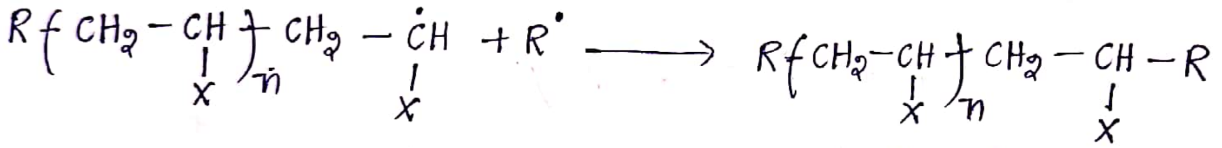


$$R-CH_2-\underset{X}{\dot{C}H} + n\left(CH_2=\underset{X}{CH}\right) \xrightarrow{\text{Polymer}^n} R\left(CH_2-\underset{X}{CH}\right)_n CH_2-\underset{X}{\dot{C}H}$$

"propogated monomer radical"

### Termination step:

In this, The growth of chain is stopped with radical



$$R\left(CH_2-\underset{X}{CH}\right)_n CH_2-\underset{X}{\dot{C}H} + R^{\bullet} \longrightarrow R\left(CH_2-\underset{X}{CH}\right)_n CH_2-\underset{X}{CH}-R$$

dead polymer

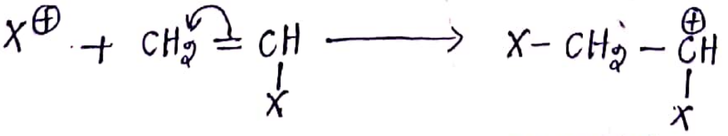
### b) cationic mechanism:

Lewis acids are initiators. The electron pair acceptor (or) electron deficiency molecules acts as Lewis acid.

ex: $AlCl_3$, $BF_3$, $BeCl_2$, $BCl_3$ are positively charged metal ions.

⟹ Lewis acids are denoted as $X^{\oplus}$

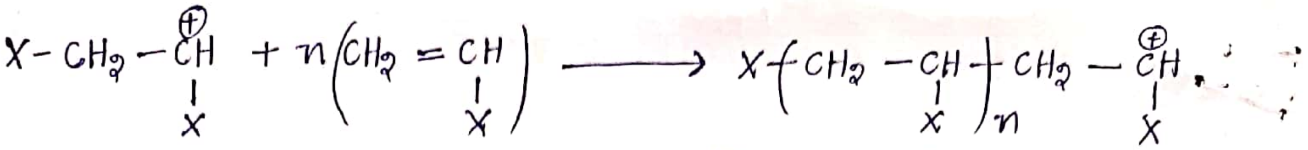
### Initiation step:



$$X^{\oplus} + CH_2 = \underset{X}{CH} \longrightarrow X-CH_2-\underset{X}{\overset{\oplus}{C}H}$$

momer cation

**Propogation step:** In this step monomer cation reacts with another monomer for growth the chain.

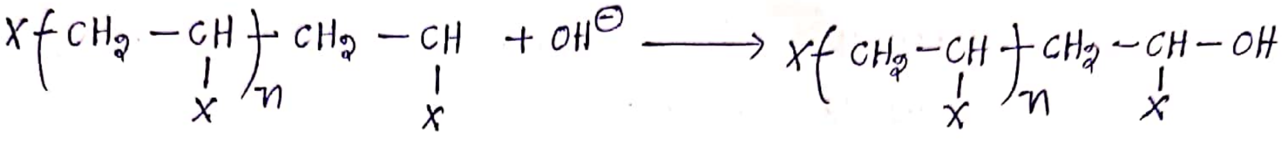


$$X-CH_2-\underset{X}{\overset{\oplus}{C}H} + n\left(CH_2=\underset{X}{CH}\right) \longrightarrow X\left(CH_2-\underset{X}{CH}\right)_n CH_2-\underset{X}{\overset{\oplus}{C}H}$$

Propagated monomer cation

**Termination step:**

In this step the growth of chain is stopped with $OH^-$ ions.



$$X\left(CH_2-\underset{X}{CH}\right)_n CH_2-\underset{X}{CH} + OH^{\ominus} \longrightarrow X\left(CH_2-\underset{X}{CH}\right)_n CH_2-\underset{X}{CH}-OH$$

dead polymer.

### c) Anionic mechanism:

Lewis bases are initiators. The electron pair donar (or) electron efficiency molecules acts as Lewis base.

ex: $NH_3$

⟹ Lewis bases are simple denoted as $y^{\ominus}$

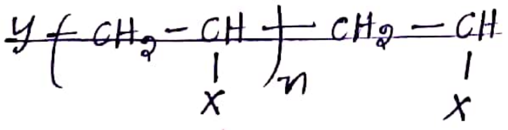
**Initiation step:**

$$y^{\ominus} + CH_2=\underset{X}{CH} \longrightarrow y-CH_2-\underset{X}{\overset{\ominus}{C}H}$$

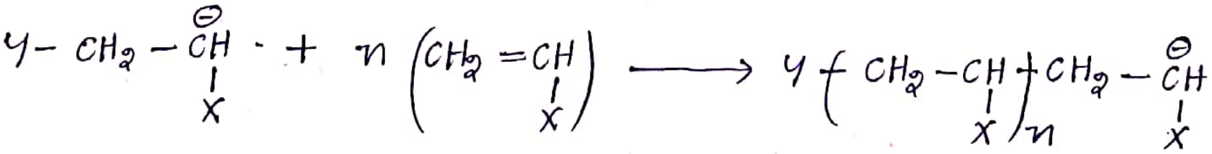
monomer anion

**Propogation step:**

In this step monomer anion reacts with another monomer for growth the chain.



$$\cancel{y\left(CH_2-\underset{X}{CH}\right)_n CH_2-\underset{X}{CH}}$$



$$y-CH_2-\underset{X}{\overset{\ominus}{C}H} + n\left(CH_2=\underset{X}{CH}\right) \longrightarrow y\left(CH_2-\underset{X}{CH}\right)_n CH_2-\underset{X}{\overset{\ominus}{C}H}$$

propogated monomer anion

## Termination step:

$$Y\left(CH_2-\underset{X}{CH}\right)_n CH_2-\underset{X}{\overset{\ominus}{C}H} + H^{\oplus} \longrightarrow Y\left(CH_2-\underset{X}{CH}\right)_n CH_2-\underset{X}{CH}-H$$

dead polymer

## 2. Condensation Polymerisation:

It is a polymerisation reaction at which two or more monomer combined together to form a polymer with elemination of simple molecules like alcohol, water, amonia is known as condensation polymerisation.

ex: bakelite (phenol formaldehye, resin, urea formaldehyde resin).

Flow chart:

Phenol + Formaldehyde

↓ (acid/alkali's)

Mono methylol phenol

↓ (conc $H_2SO_4$)

Novalac (Linear polymer)

$-nH_2O$ ↓ hexamine

bakelite [(cross-link), bulk polymer]

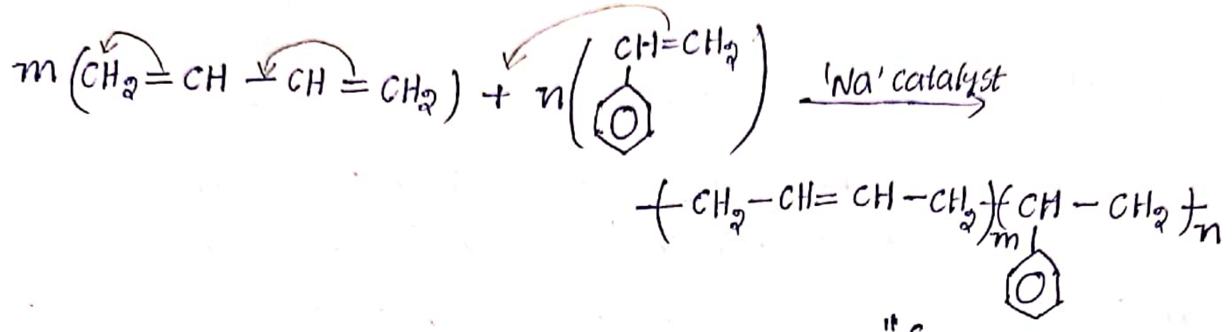
## 3. Co-polymerisation:

It is the polymerisation reaction at which two different monomers combined together to form entirely different polymer is known as co-polymer~~isation~~ and process is called co-polymerisation.

ex: buna-s, buna-N

## Preperation of buna-s:

1,3- butadiene and styrene undergoes co-polymerisation to form buna-s rubber



"buna-s"

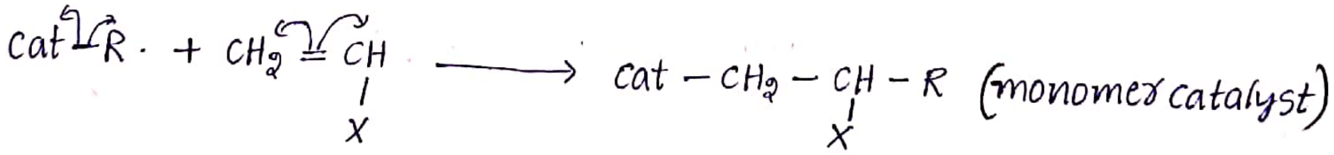
## 4. co-ordination polymerisation : ~~ze~~ (Zieglar-natta) :

In this polymerisation two (or) more momers combined together to form a polymer in the presence of transition metal halide (catalyst) trialkylaluminium (co-~~plas~~ catalyst) is known as co-ordination polymerisation.

ex: $TiCl_3 + AlR_3$ (or) $TiCl_4 + AlR_3$

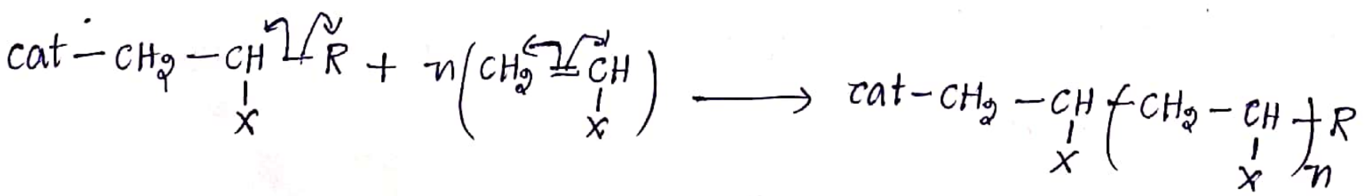
### Mechanism:

Initiation step: catalyst reacts with monomer to form monomer catalyst.



$$\text{cat}-R\cdot + CH_2=\underset{X}{\underset{|}{CH}} \longrightarrow \text{cat}-CH_2-\underset{X}{\underset{|}{CH}}-R \ (\text{monomer catalyst})$$

Propogation step: In this step monomer catalyst reacts with another monomer to growth the chain

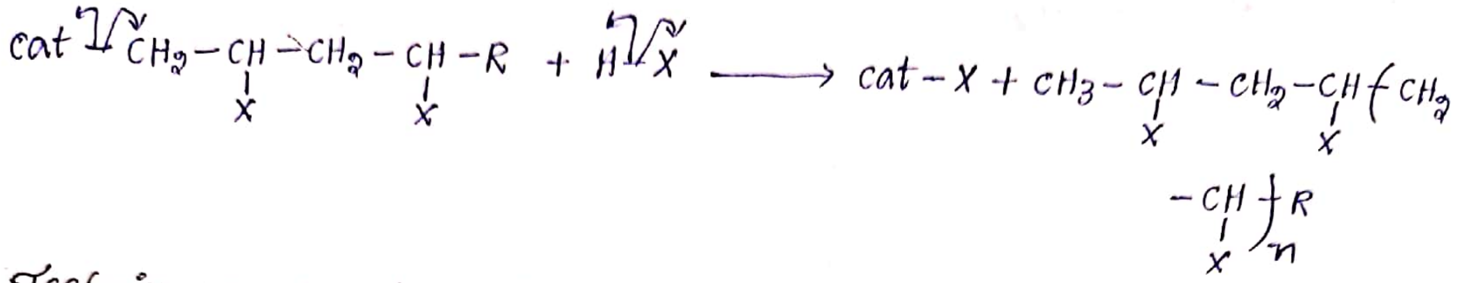


$$\text{cat}-CH_2-\underset{X}{\underset{|}{CH}}-R + n\left(CH_2=\underset{X}{\underset{|}{CH}}\right) \longrightarrow \text{cat}-CH_2-\underset{X}{\underset{|}{CH}}\left(CH_2-\underset{X}{\underset{|}{CH}}\right)_n R$$

"propogated monomer catalyst"

## Termination step:

In this step the growth of chain is stopped with HX (hydrogen halides).

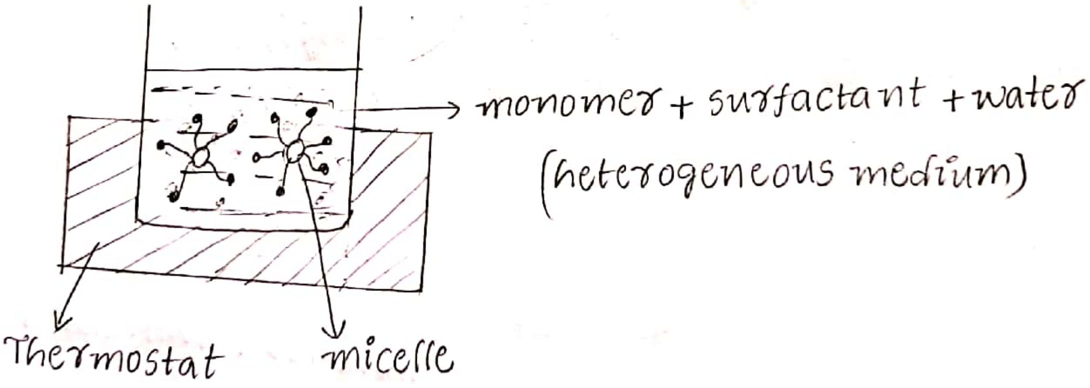


$$\text{cat}^{+}\,\overset{-}{C}H_2-\underset{X}{\underset{|}{CH}}-CH_2-\underset{X}{\underset{|}{CH}}-R + H^{+}X^{-} \longrightarrow \text{cat}-X + CH_3-\underset{X}{\underset{|}{CH}}-CH_2-\underset{X}{\underset{|}{CH}}\left(CH_2-\underset{X}{\underset{|}{CH}}\right)_n R$$

## Techniques of polymerisation:

### 1. Emulsion polymerisation:

On the thermostat take a beaker contains water, monomer is heterogeneous medium, to this add surfactant means emulsifing agent and initiator in the presence of nitrogen at atmosphere, we get polymer. This process is known as emulsion polymerisation.



⇒ here, ∼∼● : hydrophilic end

hydro-phobic end

$$\Longrightarrow \underbrace{\text{monomer} + H_2O}_{\text{heterogeneous medium}} + \text{surfactant} + \text{Initiator} \xrightarrow{N_2 \text{ atmosphere}} \text{polymer}$$

Advantages:

1. The rate of polymerisation is high.
2. Heat can be easily controlled and hence viscosity build up is low.

Disadvantages:

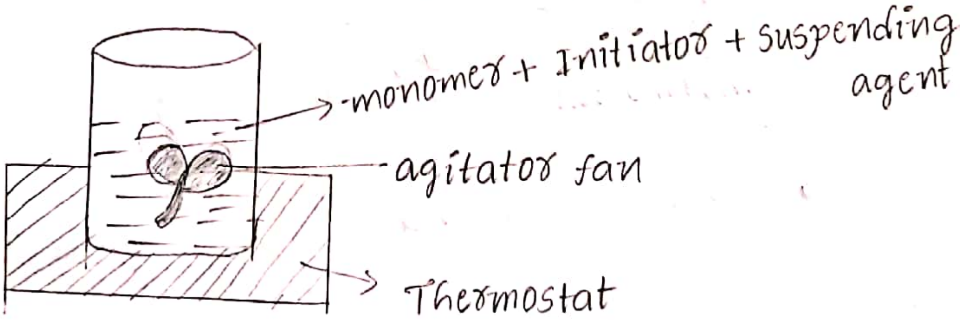
1. Polymer needs purification
2. It is difficult to remove entropped emulsifier and de emulsifier.

Application: emulsion polymerisation is used in largescale production like water based paints, adhesives, plastics etc.

2. Suspension polymerisation:

The monomer is water insoluble monomer to this add suspending agent is agitated at constant temperature in the presence of initiator we get polymer.

⇒ There is agitator fans to mix the suspension to get best polymer beads.



monomer + Initiator + suspending agent ⟶ polymer

Advantages:

1. Since water is used as a solvent. This method is economical.
2. Isolation of product is very easy and the product are very Pure.

Disadvantages:

1. This Method is applicable only for water insoluble monomers.
2. control of particle size is difficult.

Applications:

1. polystyrene beads are used as ion exchange resins.
2. ~~Prep~~ ~~pos~~ ~~sar~~aration of thermacoal sheets for ceiling purpose.

Physical properties of polymers:

1. Crystallinity: The polymers have 60% crystalline, 40% amorphous character, increasing of crystalline character automatically development of strength, hardness brittleness of a polymer.

ex: 1. polythene have highly crystalline in a zig-zig conformation.

2. Polythene have less crystalline in a bulky substituents.

2. Molecular weight:

The strength and hardness will be depends upon molecular weight of polymer.

ex: Less than 1000 — oily visous liquids

1000 — 10,000 — soft, waxy solids.

greater than 10,000 — hard brittle solids
(or)
flexible solids.

3. Solubility:
The polymers are soluble in suitable organic solvents.
ex: eraser soluble in conc. $H_2SO_4$.

4. Effect of heat in polymer:

Polymers on heating gives rubbery state then visco-fluid state then degraded to monomer.

$$\text{Polymers} \xrightarrow{\Delta} \text{rubbery state} \xrightarrow{\Delta} \text{viscofluid state} \xrightarrow{\Delta} \text{degradation of monomer}$$

5. Permeability:
The polymers allows solvent molecules through it, i.e permeability property.

ex: In water, eraser absorbs water molecules and swell in size.

Mechanical properties of polymers:

1. elasticity:
This refers to the ability of material to recover to its initial shape and ~~diver~~ dimension when the applied stress removed.

2. plasticity: The substances which are soften on heating and harden on cooling is known as plasticity.

ex: ~~rubber~~ plastic articles having plasticity nature.

3. **Hardness:** Refers to the ability of a material to surface deformation, indentation (or) abrasion.

4. **strength:** refers to the ability of a material to with stand a gradually applied stress without rupture.

5. **Ductility:** A ductile material undergoes large ~~in~~ irrecoverable deformation before rupture.

6. **brittleness:** A brittle material shatters suddenly without noticeable plastic deformation preceding failures.

**Plastics:** The substance are high molecular weight polymers which exhibits plasticity properties and can be moulded into desirable shape by applying, heat and pressure is called plastics.

ex: polythene, poly vinyl chloride (PVC), polystyrene ...etc.

**Classification of plastics:**

based upon heating the plastics are two types.

1. Thermo plastics (or) Thermo softening plastics
2. Thermo setting plastics (or) Thermo hardening plastics

**Thermo plastics (or) Thermosoftening plastics:**

The plastics which are soften on heating and harden on cooling is known as thermoplastics.

ex: polythene, polyvinyl chloride (PVC).

## Thermo setting plastics (or) Thermohardening plastics:

The plastics which cannot converts into soft state by applying heat (or) pressure once they are in fixed state. ex: bakelite, nylon-6,6.

| Thermoplastics | Thermosetting plastics |
|---|---|
| 1. The plastics which are soften on heating and harden on cooling is known as thermo plastics. | 1. The plastics cannot converts into soft state by appyling heat (or) pressure once they are infixed state. |
| 2. It undergoes additional polymerisation. | 2. It undergoes condensation polymerisation. |
| 3. These are reversible process. | 3. These are irreversible process |
| 4. These are linear shaped polymers. | 4. These are cross-linked polymer |
| 5. These are soluble in organic solvent | 5. These are insoluble in organic solvent |
| 6. These plastics have less vanderwaal's forces. | 6. These plastics have strong ~~co~~ electrostatic force of attraction. |
| 7. In this we ~~have~~ use same monomers. | 7. In this we use different monomers. |
| ex: Polythene, Teflon, PVC | ex: bakelite, nylon-6,6. |

## Advantages of plastics over traditional materials:

1. Light in weight
2. Low cost
3. No corrosion
4. no damage by insects
5. easily maintenance
6. different colours
7. easy for transportation
8. wide range and shape

## Disadvantages:

1. non-biodegrable
2. Increase pollution
3. Spoil the forest
4. Control the fertility of soil
5. risk for aquatic animals.
6. Plastics are soft
7. not suitable for cooking

## Compounding of plastics :-

The process of mixing of raw plastics with special ingredients to develops special properties like tensile strength, colour, quantity ---etc. during moulding is known as Compounding of plastics.

1, **Binders (or) Resins** :- Binder is the major ingredients present in plastic material. Binders hold the other ingredients together.

Ex:- Thermoplastic, Thermosetting plastics.

2, **fillers** :- fillers are cheap organic or inorganic compounds which are added to improve certain properties like hardness, strength, Quantity - -etc.

Ex:- Asbestos, Mica, Silica, Nylon, polyester etc.

3, **Plasticisers** :- plasticisers are freely miscible with plastic material. It increase plasticity and reduce viscosity of plastics.

Ex:- Vegetable oils, camphor, Triphenyl phosphate etc.

4, **Catalysts (or) Accelerators** :- These are used to convert fusible resin into cross limited infusible resin during Moulding operation.

Ex:- $H_2O_2$, ZnO, Ammonia, Benzoyl peroxide etc.

5, **Stabilizers** :- These are added to the plastics to improve thermal stability during Moulding.

Ex:- White lead, Lead silicate, cadmium and Barium Stearates --- etc.

C 6, Fire Retardants :- These are added to plastics to prevent burnings.

Ex:- Mixture of Borax and Boric acid --etc.

7, Colourants :- These are organic and inorganic pigments used to give colour to the plastic article.

Ex:- Barium & Titanium – White
Lead, Iron, Anthraquinones – Yellow
Carbon powder – Black
Azo dyes – Yellow, orange, Red.

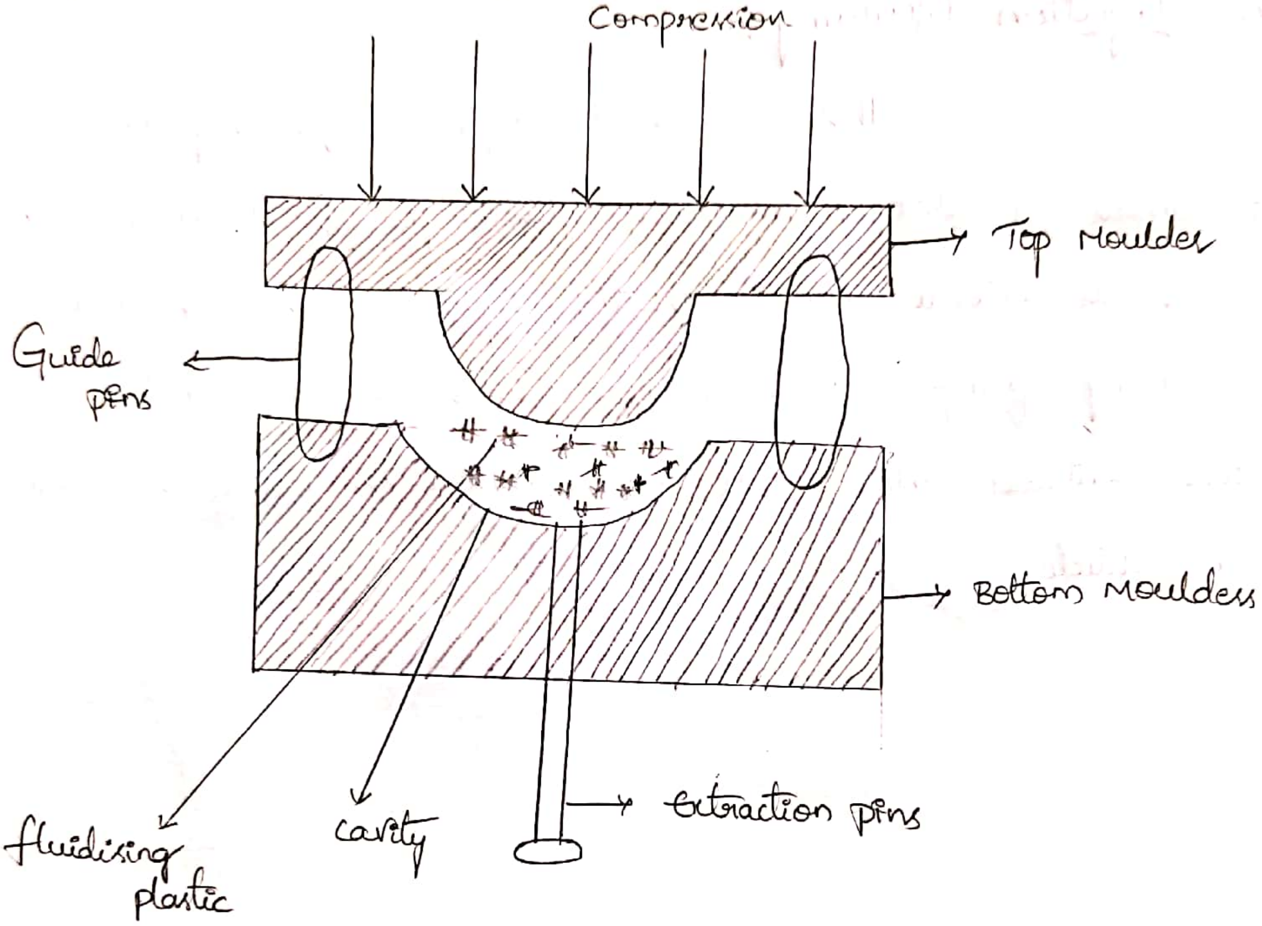
## Fabrication of Plastics (or) Moulding :-

The phenomenon of manufacturing of article from plastic material by applying heat and pressure in a cold moulder is called Moulding.

1, Compression Moulding
2, Injection Moulding
3, Extrusion Moulding
4, Blowing (or) Bubble casting Moulding.

### 1, Compression Moulding :-

Compression moulding is a method applied to both thermoplastics and thermosettings. It consists two half moulders moulders like Upper and Lower moulders. The lower moulder is filled with plastic powder. Then the lower moulder and upper moulder are closed and applied heat and pressure. After cooling the moulder, the plastic powder converted into fluidised plastic and to article, it is taken out from the moulder.



Advantages:-

1, The moulders and machine cost is very low when compared to other moulding methods.

2, In this method we should prepare shape controlled articles.

Disadvantages:-

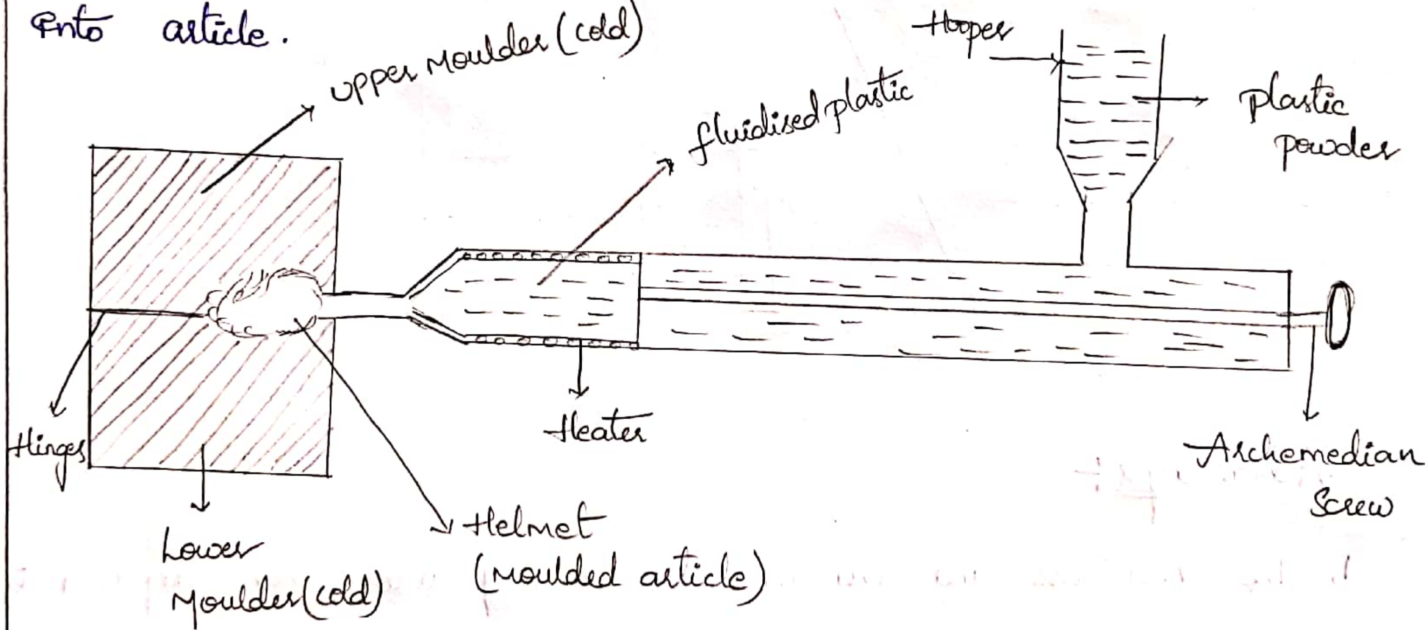
1, In this method we use hydraulic pumps for pressure. These are very high cost.

2, In this moulding maximum we should prepare thermosetting plastics. These are irreversible process.

**Examples:-** Cylindrical shape of articles, Switches, Switch Sockets, Mobile phones pouches, plastic tubs, Umbrella Handles, Burette stoppers.

## 2, Injection Moulding:-

This method is applicable for only thermoplastics. It consists a hooper in which plastic powder is taken. The powder is entered into a heated cylindrical chamber with the help of moving plunger, at nossel the powder is converted into fluidised plastic entered into a cool moulder. Then the plastic is converted into article.



**Advantages:-**

1, In this method we should prepare 90% of plastic articles.

2, It is also shape controlled moulding methods.

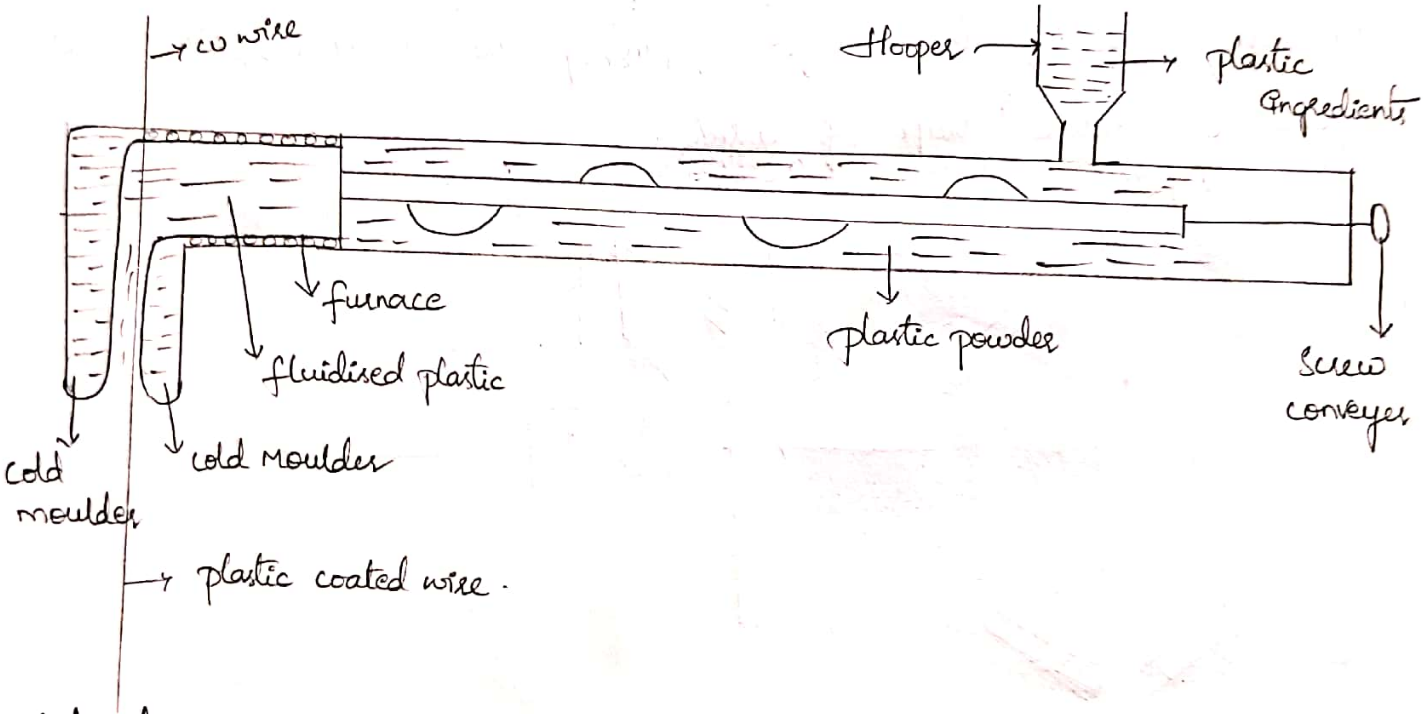
**Disadvantages:-**

Moulders and Moulding Machine is very high cost.

**Examples:-** Helmets, plastic buckets, plastic mugs, cpu exhausting fans.

## 5, Extrusion Moulding :-

This method is applicable for only thermoplastics. It consists a hooper in which plastic powder is taken. The Powdered is entered into a heated cylindrical chamber with the help of moving plunger, at nozzel the powder is converted into fluidised plastic. This fluidised plastic entered into a cool moulder. Then the plastic is converted into article.



### Advantages :-

1, In this method we should prepare long range of articles.

2, The preparation articles have stiffness because of thermosetting character.

### Disadvantages :-

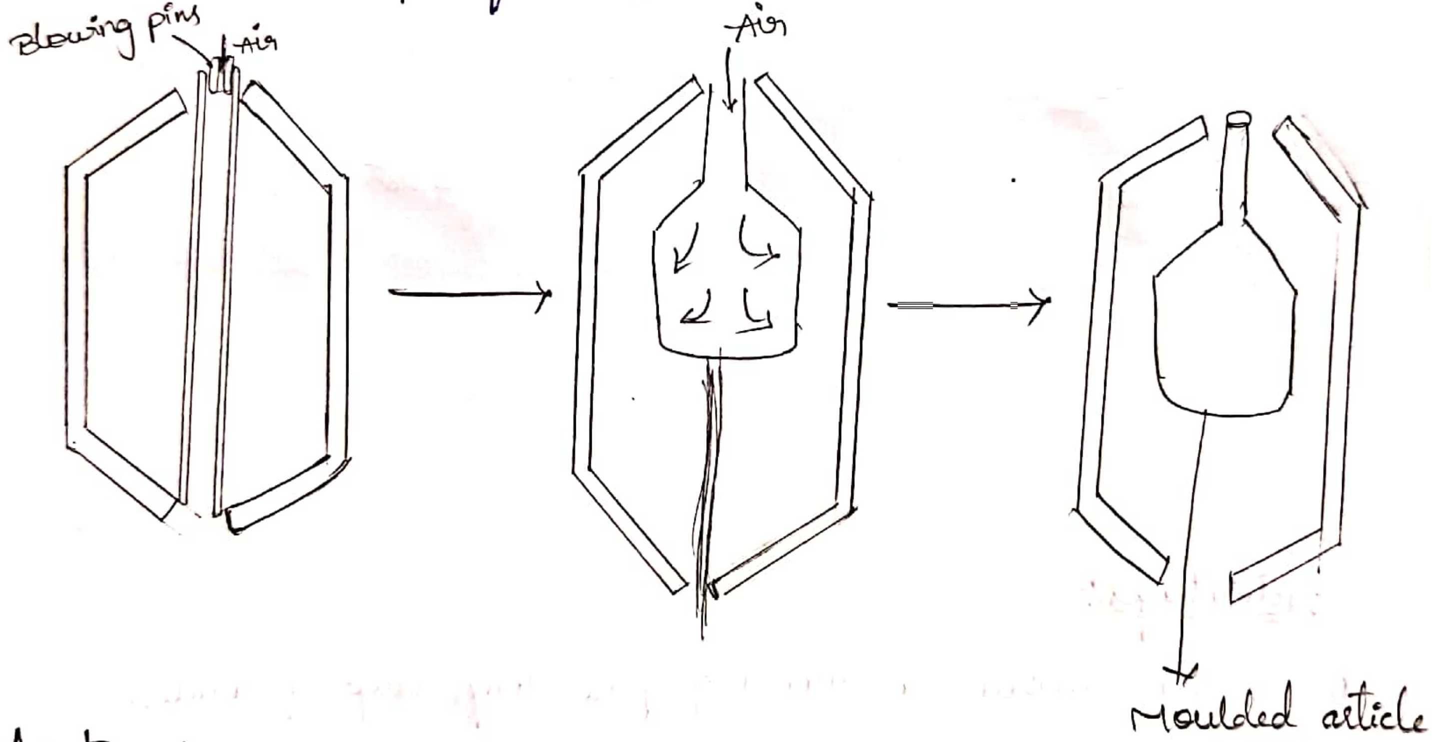
1, The plastic resin expanded to different directions.

2, Thermo-setting plastics are irreversible process.

Examples :- S-shaped chairs, cable wires, Motor tires, tubes, plastic pens, toothpaste tubes - - etc.

4, Blowing (or) Bubble casting moulding:-

The moulding is applicable for thermoplastics, In this moulding hallow shaped articles like bottles, covers, balloons -- etc are fabricated parison is a hot and soft plastics is attached to blowing pins. The pins are placed in between the moulder. Then the moulder is closed and passing compressed air through blowing pins. The parison is expands like a balloon until it touches the interior walls of the moulder. finally, the moulder is cooled and opendable desire shape of article.



Advantages:-

1, High durability, Tensile strength.
2, The moulding machine and moulders are low cost.
3, Electrical resistance property.

Disadvantages:-

The moulded some articles acts as thermoplastic nature and Some articles acts as thermo setting plastic nature.

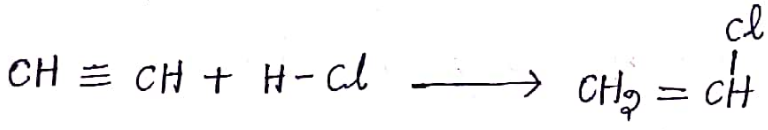
Example:- Hallospherical articles.

**Plastics** :- The polymeric material which have high molecular weight organic polymers which are moulded into desirable shape in the presence of temperature, pressure and catalyst is known as plastics.

1. **Poly vinyl chloride (PVC)** :- (koroseal) Poly vinyl chloride is Prepared by addition polymerisation of vinyl chloride monomer in the presence of benzoyl peroxide (or) hydrogen peroxide ($H_2O_2$) under pressure.

⇒ The acetylene molecule is treated with hydrogen chloride to form monomer. It is the internal rearrangement reaction.

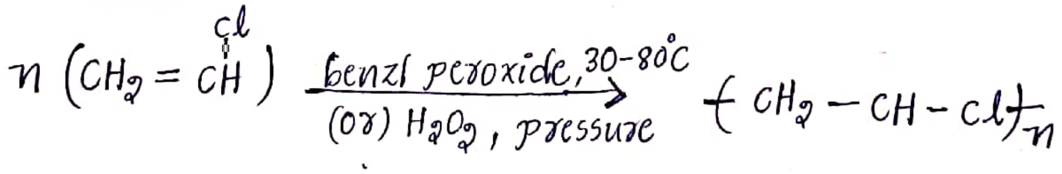
**Monomer preperation** :-



$$CH \equiv CH + H-Cl \longrightarrow CH_2 = \overset{Cl}{\overset{|}{CH}}$$

vinyl chloride

**polymer preperation** :-



$$n\left(CH_2 = \overset{Cl}{\overset{|}{CH}}\right) \xrightarrow[\text{(or) } H_2O_2\text{, pressure}]{\text{benzl peroxide, } 30-80^{\circ}C} \left( CH_2 - CH - Cl \right)_n$$

PVC

**Properties** :-

⇒ PVC is a colourless, non-inflamable material.

⇒ Resistant to atmospheric conditions like $O_2$, $CO_2$ and moisture.

⇒ PVC is strong and brittle

⇒ PVC is not stable to heat and UV radiation.

## Applications :-

1. Injection moulding articles like tool handles, radio, telephone components.

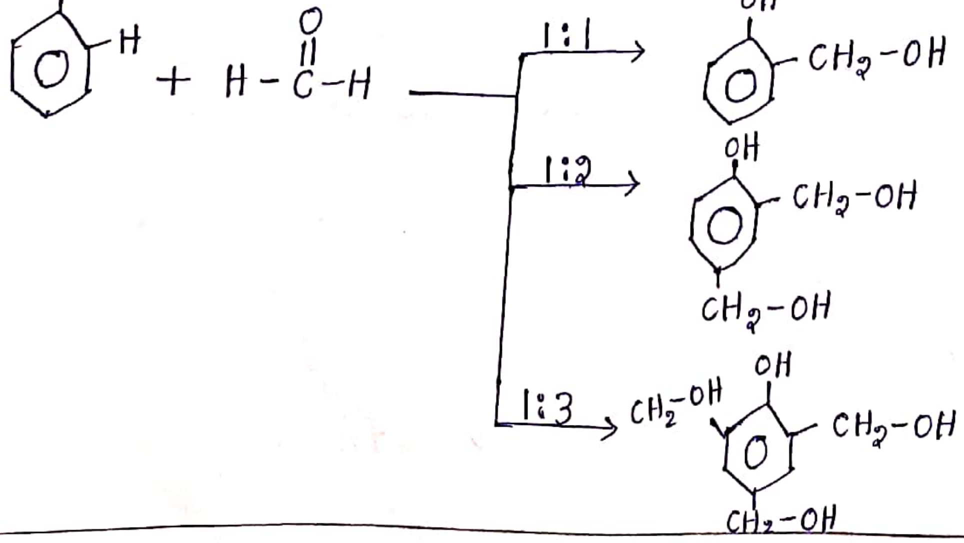
2. Chemical containers and foams used in buildings. camera's and air crafts.

3. Safety helmets, refrigrators components, tyres, cycle and motor cycle mudgaurds.

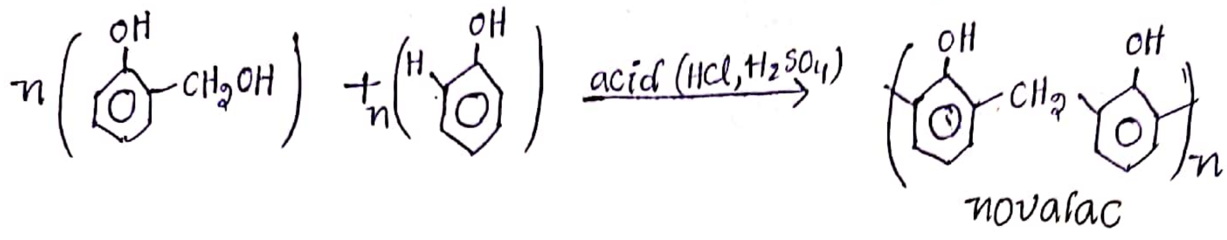
4. Agriculture sector bore pipes, water pipes.

2. **Bakelite** :- bakelite is prepared by condensation polymerisation of phenol and formaldehyde by the elimination of water molecules in the presence of acid, hexamine (hexa methylene tetra amine) in the mechanism novalac formed as a intermediate product which is linear shape thermoplastic polymer. Finally, novalac is converted into bakelite in the elimination of water molecules.

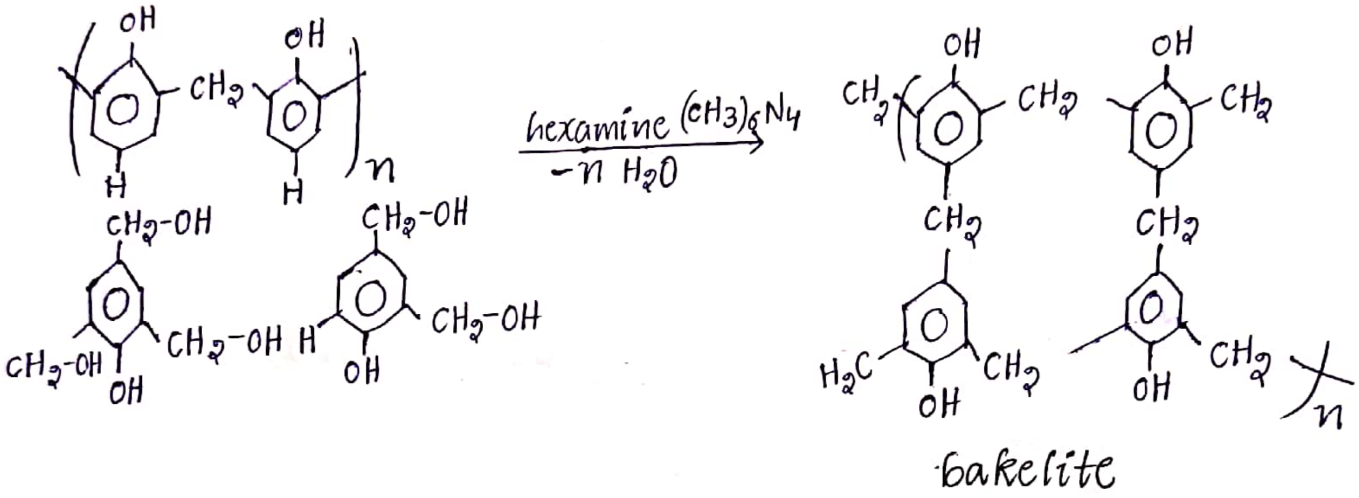
Step-1 : formation of methylol phenol



## Step-2 : formation of novalac (linear polymer) :



## Step-3 : formation of bakelite (phenoplastics) :-



### Properties :-

1. bakelite is hard, rigid and strong.
2. It is a scratch, water resistant polymer.
3. Good anionic exchange resin.
4. Excellent electrical insulators
5. It is very good adhesive and corrosion resistance.

### Applications :-

1. Electrical insulator parts like switches, switch boards, handles etc.
2. Moulded articles like telephone parts, cabinets for radio and television

3. In paints and varnishes.

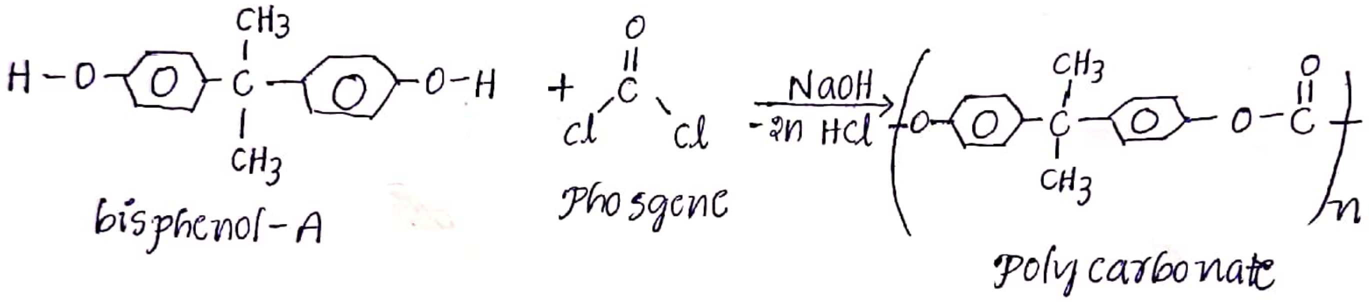
4. as an adhesive for grinding wheels etc.

5. used as anionic exchange resin.

## 3. Poly carbonates:-

It is prepared by condensation polymerisation of bisphenol-A and phosgene monomers in the presence of NaOH as a catalyst.

⟹ Poly carbonate is thermoplastic.



### Properties:-

1. It is durable material with impact resistance, low starch resistance.

2. high transperancy to visible light.

3. Good electrical insulators.

4. It undergo plastic deformation without cracking (or) breaking

### Applications:-

1. electronic components:-

Electrical and telecomunications hard ware and also dielectric in high stability capacitors.

2. Construction materials:

Poly carbonates are used in industry for dome light, flat & curved glazing, sound walls.

3. Storage devices like CD's, DVD's.

4. Laboratory safety goggles, sunglass, computer cases, name plates etc.

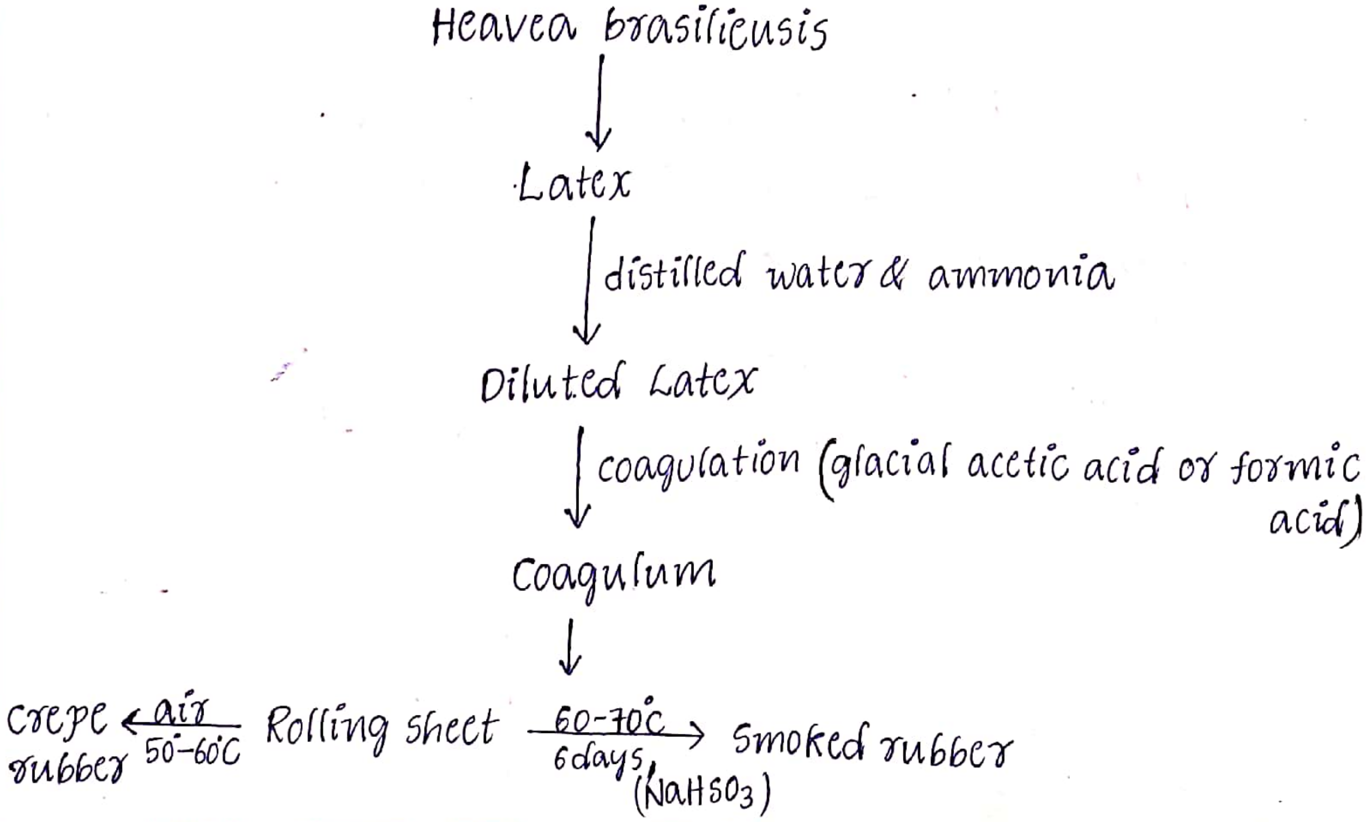
**Rubbers:** A polymeric material which is soft thermoplastic and flexibility is known as "rubber."

(OR)

The polymer having high molecular weight and the capable of regain its original length and shape after release of applied stress is called "rubbers."

**Natural rubber:** The rubber which is obtained from nature (plants) is known as natural rubber.

**Extraction of natural rubber:**

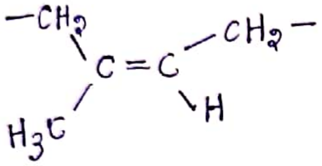


**Preperation of natural rubber:** It is prepared by addition Polymerisation of isoprene (or) 2-methyl 1,3-butadiene.

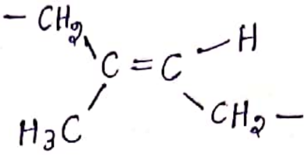
$$n\,(CH_2=\overset{CH_3}{\overset{|}{C}}-CH=CH_2)\xrightarrow[\text{polymerisation}]{\text{addition}}\left(CH_2-\overset{CH_3}{\overset{|}{C}}=CH-CH_2\right)_n$$

natural rubber (or)
cis-poly isoprene.

⇒ Cis-poly isoprene



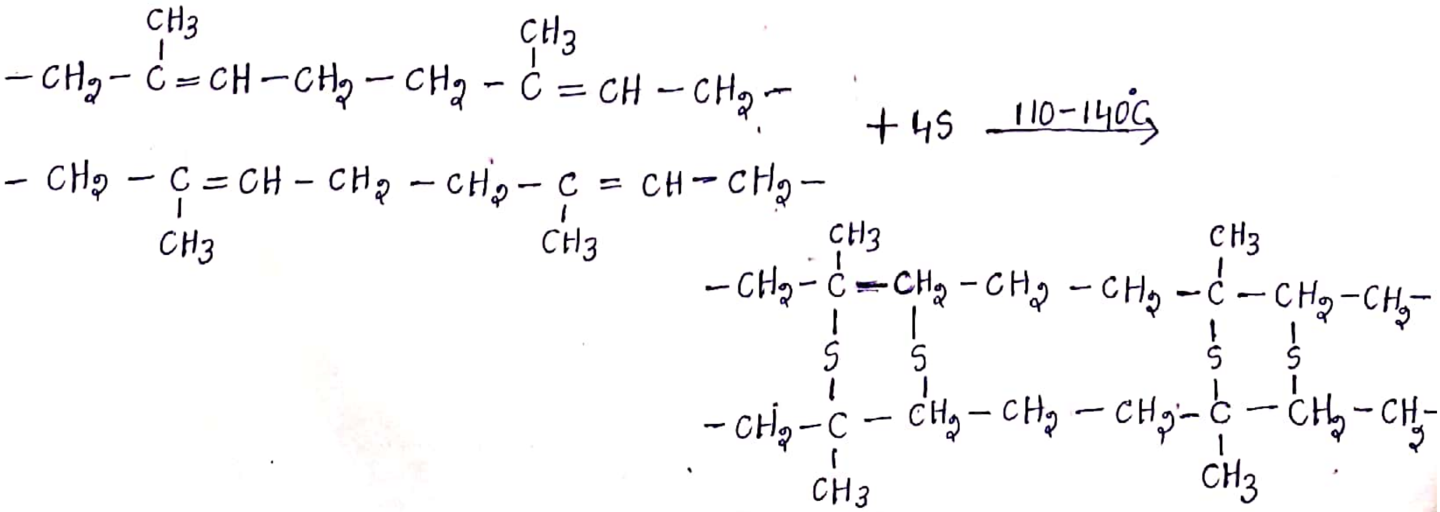
⇒ Trans-poly isoprene (or) gutta percha rubber (came from palageum gutta & dichopsis purcha)



**Properties of natural rubber:**

1. Less tensile strength
2. Less durability
3. Low abrasion resistance
4. Less chemical resistance
5. Low load baring capacity
6. Less oil resistance

**Vulcanisation:** "Charles good year" proposed vulcanisation process in 1839 to overcome the drawbacks of natural rubber with sulphur in the presence of 110-140°C temperature.



### Properties:

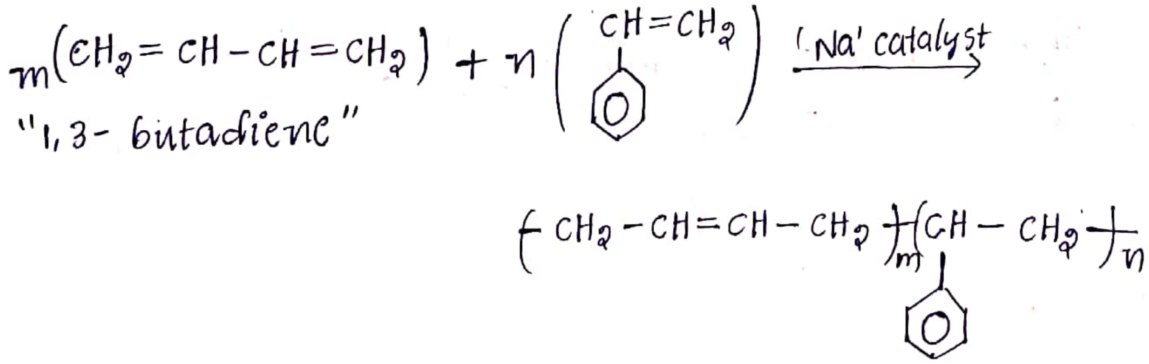
1. high tensile strength
2. high durability
3. high abrasion resistance
4. high chemical resistance
5. high load baring capacity
6. high oil resistance

### Synthetic rubber or elastomers:

A polymeric material which can be stretched atleast twice its original shape but it returns to original position as soon as stretching forces are released.

⇒ Elastomers contains three types of rubbers. they are

1. **Buna-S:** It is prepared by co-polymerisation of 1,3-butadiene and styrene in the presence of sodium as a catalyst. It is also known as GRS (or) ameripole.



"buna-s rubber"

### Properties:

1. It is strong and tough polymer.
2. It is vulcanised by sulphur mono chlorided ($S_2Cl_2$) or sulphur

3. Excellent abrasion resistance.

4. It traces of ozone present in atmosphere.

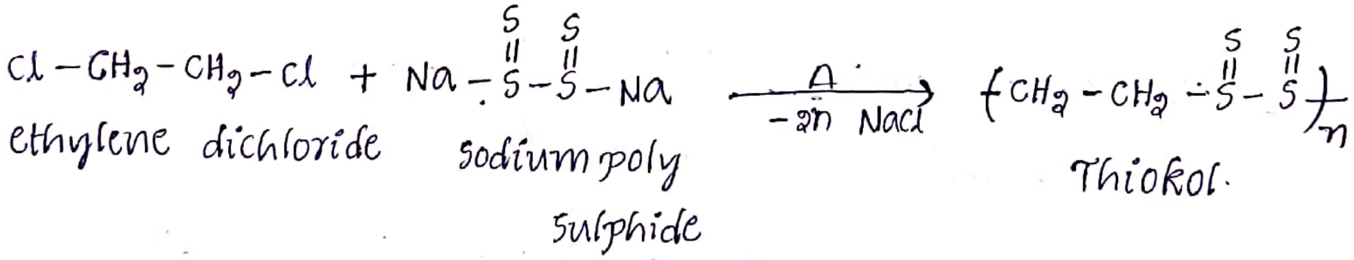
5. High load bearing capacity and resistance.

## Applications :

1. Manufacture of tyres.
2. Foot wear industry for making shoe sales and foot wear component
3. Making wires & cable insulations.
4. Production of floor tiles, tank limings in chemical industries and as adhesive.

2. **Thiokol Rubber:** (government rubber of poly sulphide): It is the co-polymerisation reaction with elemination of simple molecules like Nacl.

⇒ It does not undergoes vulcanisation because of it has excess number of sulphur elements.



$$Cl-CH_2-CH_2-Cl + Na-\overset{\overset{S}{\|}}{S}-\overset{\overset{S}{\|}}{S}-Na \xrightarrow[-2n\ NaCl]{\Delta} \left[ CH_2-CH_2-\overset{\overset{S}{\|}}{S}-\overset{\overset{S}{\|}}{S} \right]_n$$

## Properties :

1. It posses strength & impermeability to gases.
2. This rubber cannot be vulcanised & It cannot form hard rubber.
3. Good resistance to mineral oils, fuels, abrasion, oxygen, solvents, ozone & sunlight.

## Applications :

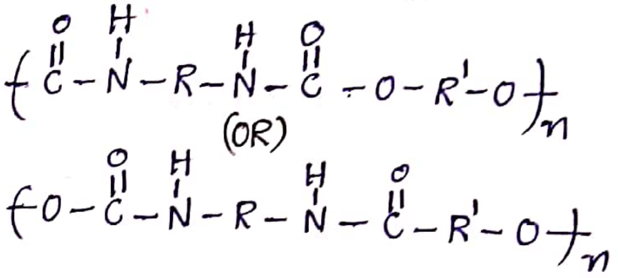
1. used for barrage balloons, life rafts and Jacket which are inflated by $CO_2$.

2. Living hoses for conveying gesolin and oil.

3. Making gasvets and seals for privting rolls

3. **Poly urethanes :** (Poly iso cyanide rubber): It is prepared by rearrangement of co-polymerisation reaction. Momomers are di-iso cyanide and di-ol in the presence of catalyst (tri ethylene diamine) and surfactant (silicone oils)

$$O=C=N^{\ominus}-R-N=C=O + H-O-R'-O-H \xrightarrow[\text{silicone oils}]{TEDA}$$



$$\left( \overset{O}{\overset{\|}{C}} - \overset{H}{\overset{|}{N}} - R - \overset{H}{\overset{|}{N}} - \overset{O}{\overset{\|}{C}} - O - R' - O \right)_n$$

(OR)

$$\left( O - \overset{O}{\overset{\|}{C}} - \overset{H}{\overset{|}{N}} - R - \overset{H}{\overset{|}{N}} - \overset{O}{\overset{\|}{C}} - R' - O \right)_n$$

## Properties :

1. It posses excellent hardness, tensile strength, impact resistance, abrasion and tear resistance

2. Resistance to heat, moisture, gases, chemicals, oils, solvents etc.,

3. Adsorption of heavy metals and colouring agents.

4. It possess high load bearing capacity & flexibility.

## Application :

1. Refrigeration, freezers, furniture and bedding.

2. Foot wear, automotives, coatings and adhesives.

3. Elastomer and sealants.

4. Purification of water and sevage water for adsorption of colouring matter & heavy metals.

## Fibre rein forced plastics (FRP's):

The reinforcing of plastic matrix with high strength of fibre materials like sand, silica, lime stone, glass, carbon etc is known as "fibre reinforced plastics".

### Components of ~~P~~ FRP's :

1. Plastic matrix
2. Fibre material

### Plastic matrix :

⇒ The plastic material used in FRP's is called "matrix"

⇒ The purpose of plastic matrix is to form body and state of the FRP's.

ex: Thermo plastic matrix (polythene, PVC)

Thermo setting matrix (bakelite, urea formaldehyde resin, nylon-6,6)

## Fiber material:

The purpose of fiber materials to develops special properties like tensile strength, durability, ductility all resistance is known as fiber material.

ex: sand, silica, limestone, folic acid, carbonfiber.

## Classification of FRP's:

FRP's is classified into three types based on mixing of fiber material.

1. Glass FRP's
2. aramide (or) bullet proof FRP's
3. carbon FRP's

## Glass FRP's:

Glass FRP's is prepared by mixing of sand, limestone folic acid and minior ~~io~~ ingredients. The mixture is heated it melts about 1200°C. The molten glass is passed through fine holes in a platinum plate. Glass threads (or) needles are obtained these are cooled, gathered and finally we get FRP's.

Plastic matrix + sand, lime stone, folicacid

$\Delta \downarrow 1200^\circ C$

Molten FRP's

$\downarrow$ pour

platinum plate

$\downarrow$

glass threads ⟶ Glass FRP's

### Properties :

1. It has high tensile strength
2. Long durability
3. corrosion resistant
4. electrical resistant

### Applications :

⇒ These are used in making of automobiles glasses, storage tanks, fuel tanks ... etc.

### Aramide (or) bullet proof FRP's :

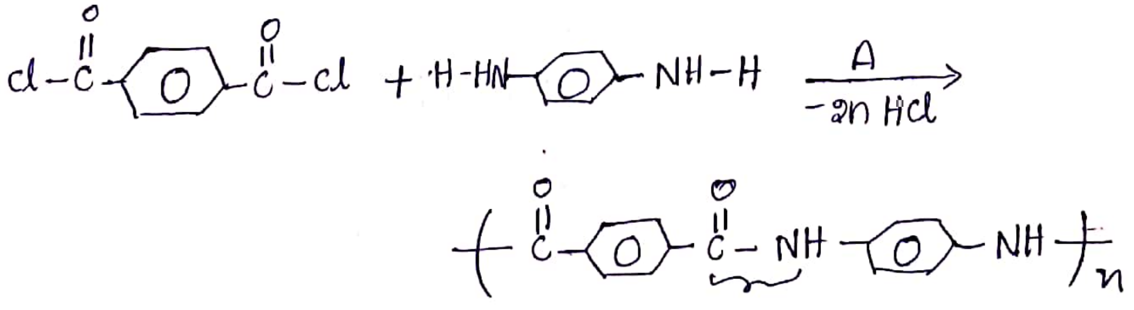
Aramide means aromatic polyamide.

⇒ These are two types

1. kevlar FRP's
2. Nomax FRP's

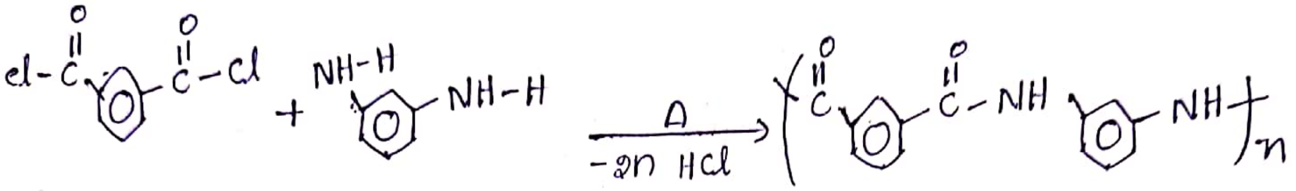
### kevlar FRP's :

It is prepared by condensation polymerisation of Para pthalallyl chloride and para phenylene diamine in the presence of temperature, our elimination molecule is HCl.



Kevlar FRP's

**Nomax FRP'S:** It is prepared by condensation polymerisation of meta thalallyl chloride and meta phenylene diamine in the presence of temperature, our elimination is HCl.



nomax FRP'S

**Properties:**

1. It is very strong
2. It has high heat stability and flexibility
3. chemical resistance
4. corrosion resistance
5. Thermal resistance

**Applications:**

1. It is used in space crafts, aeroplanes and circuit industry.
2. It is used to make car parts (tyres, break)
3. It is used to make helmets, bullet proof, glasses.
4. It is used in gaskets.

**Carbon FRP's:** The plastic matrix combined with carbon fibre to form carbon FRP's.

ex: decorative articles, roof designing of houses

**Properties:**

1. high strength and stiffness
2. Good mechanical strength & chemical resistance.

## Applications :

1. used in vehicles, satellites.
2. used in industrial machinary.

## Bio degradable polymers :

Generally polymers are non-biodegradable but some of the polymers are degraded in the presence of micro organisms is known as bio degradable polymers.

## Controlling factors of degradation :

1. Percentage of crystalinity in polymers.
2. Molecular weight of polymer.
3. Hydrophobicity of polymer.
4. environment surrounding of polymer.

⇒ There are two types of biodegradable polymer.

1. naturally occuring bio-degradable polymer.
2. Synthasised bio-degradable polymer.

## Naturally occuring bio-degradable polymer :

There are 4 types of natural biodegradable polymers.

1. Poly sacharides:

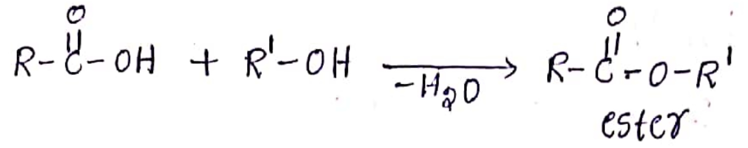
ex: starch, cellulose (green plants)

2. protiens :

ex:- Gelatin, casien (cheese protien)

3. Polyesters:

ex: Poly hydroxy alkanoids

⟹ 

$$R-\overset{O}{\overset{\|}{C}}-OH + R'-OH \xrightarrow[-H_2O]{} \underset{\text{ester}}{R-\overset{O}{\overset{\|}{C}}-O-R'}$$

4. others:

ex: Liguine, shellac, naturalrubber

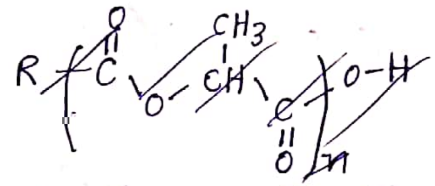
Synthetic biodegrable polymer:

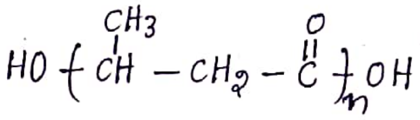
These are many polymers prepared by biological process and these are bio-degradable.

ex: alcohol from molasis, poly latic acids etc.

1. Poly hydroxy alkanoates (PHA): BIOPOL.

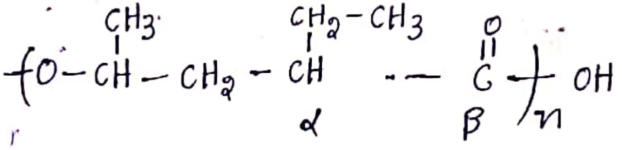
It is used in orthopedic surgeries



1. 

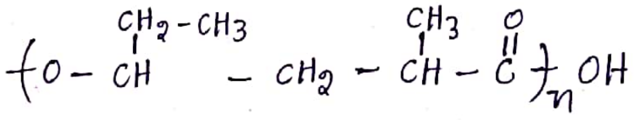
$$HO\left[\overset{CH_3}{\overset{|}{CH}}-CH_2-\overset{O}{\overset{\|}{C}}\right]_n OH$$

Poly 3 hydroxy butyrate.

2. 

$$\left[O-\overset{CH_3}{\overset{|}{CH}}-CH_2-\underset{\alpha}{\overset{CH_2-CH_3}{\overset{|}{CH}}}--\underset{\beta}{\overset{O}{\overset{\|}{C}}}\right]_n OH$$

poly β-hydroxy valrianate.

3. 

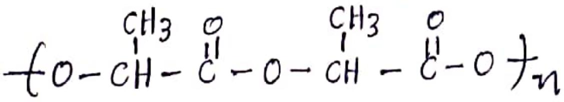
$$\left[O-\overset{CH_2-CH_3}{\overset{|}{CH}}-CH_2-\overset{CH_3}{\overset{|}{CH}}-\overset{O}{\overset{\|}{C}}\right]_n OH$$

poly - hydroxy valarianate

2. poly Latic acid: (Tapioca)

The fermentation of tapioca (or) starch in aerobic condition we get poly Latic acid. (food packing & dippers).

⟹ Tapioca - root part of cassava plant (brazil).



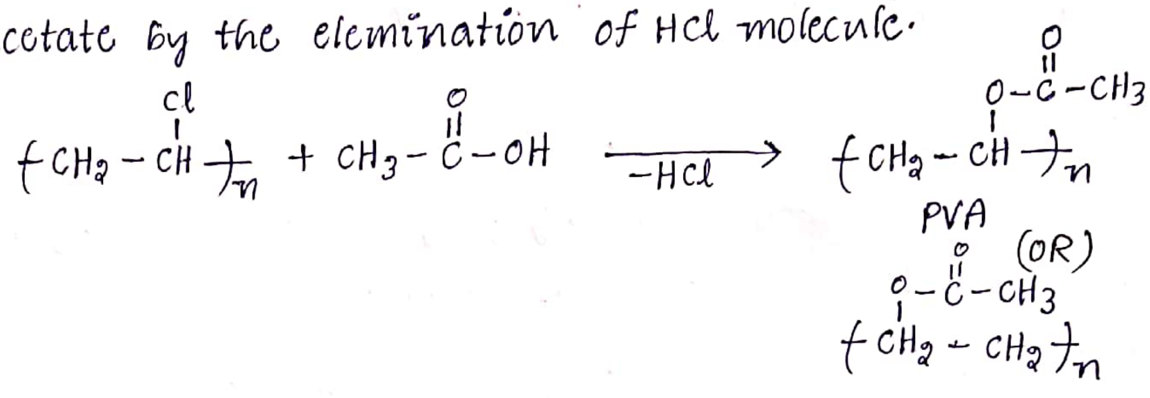
$$-\!\!\left[O-\overset{CH_3}{\overset{|}{CH}}-\overset{O}{\overset{\|}{C}}-O-\overset{CH_3}{\overset{|}{CH}}-\overset{O}{\overset{\|}{C}}-O\right]\!\!-_n$$

Poly Lactide

3. Poly vinyl acetate (PVA):

Fermentation of malasis (or) starch.

⟹ poly vinyl chloride treated with acctic acid to form poly vinyl acetate by the elemination of HCl molecule.



$$-\!\!\left[CH_2-\overset{Cl}{\overset{|}{CH}}\right]\!\!-_n + CH_3-\overset{O}{\overset{\|}{C}}-OH \xrightarrow[-HCl]{} -\!\!\left[CH_2-\overset{O-\overset{O}{\overset{\|}{C}}-CH_3}{\overset{|}{CH}}\right]\!\!-_n$$

PVA

(OR)

$$-\!\!\left[\overset{O-\overset{O}{\overset{\|}{C}}-CH_3}{\overset{|}{CH_2}}-CH_2\right]\!\!-_n$$

PVA.

Applications of biodegradable polymer:

1. These are prepared from natural materials.
2. compostable bats help in the disposcale of the vegetable matter.
3. These are environmentry friendly.
4. The polymers of Land fill by solid waste can be reduced.

Conducting polymer:

Generally polymers are insulators but some of the polymers exhibits slightly conducting property because of conjugated double bonds & doped material is known as conducting polymer.

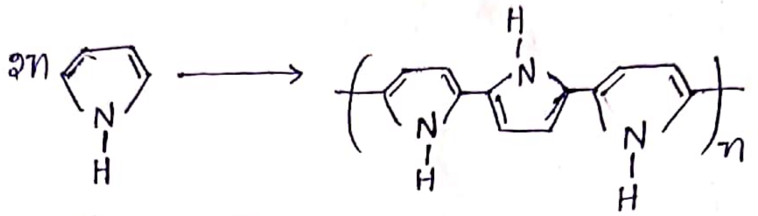
There are two types of conducting polymers.

1. Conjingated conducting polymer
2. Doped conducting polymer

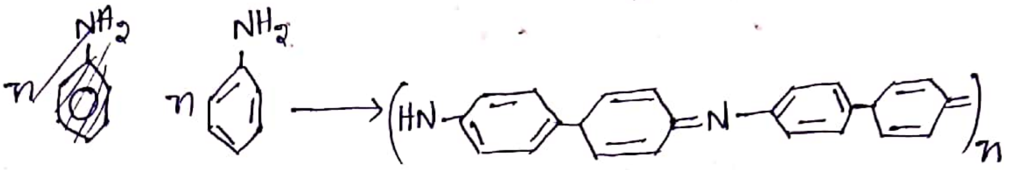
## 1. Conjugated conducting polymers:

Poly acetylene: $n(CH \equiv CH) \longrightarrow [CH=CH]_n$ .

Poly pyrrole:



Poly aniline :



Poly aniline (or) emraldine

## 2. Doped conduction polymer:

It contains two types of doping.

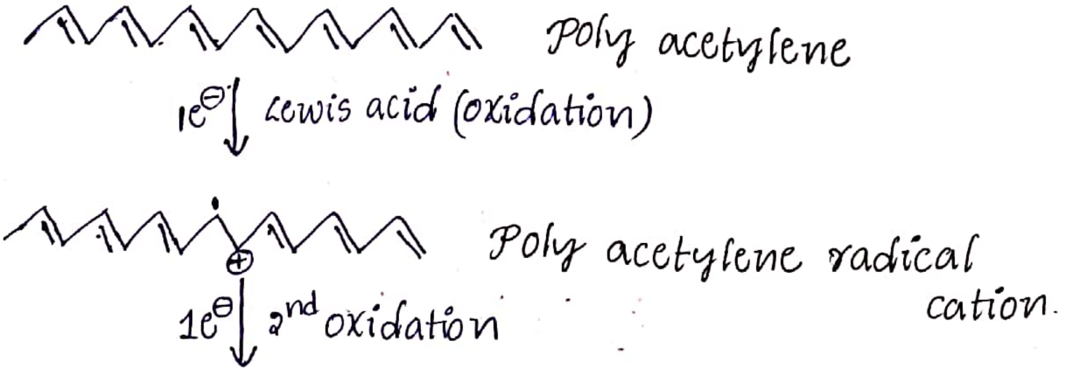
1. P-type doping (or) oxidative doping
2. N-type doping (or) reductive doping

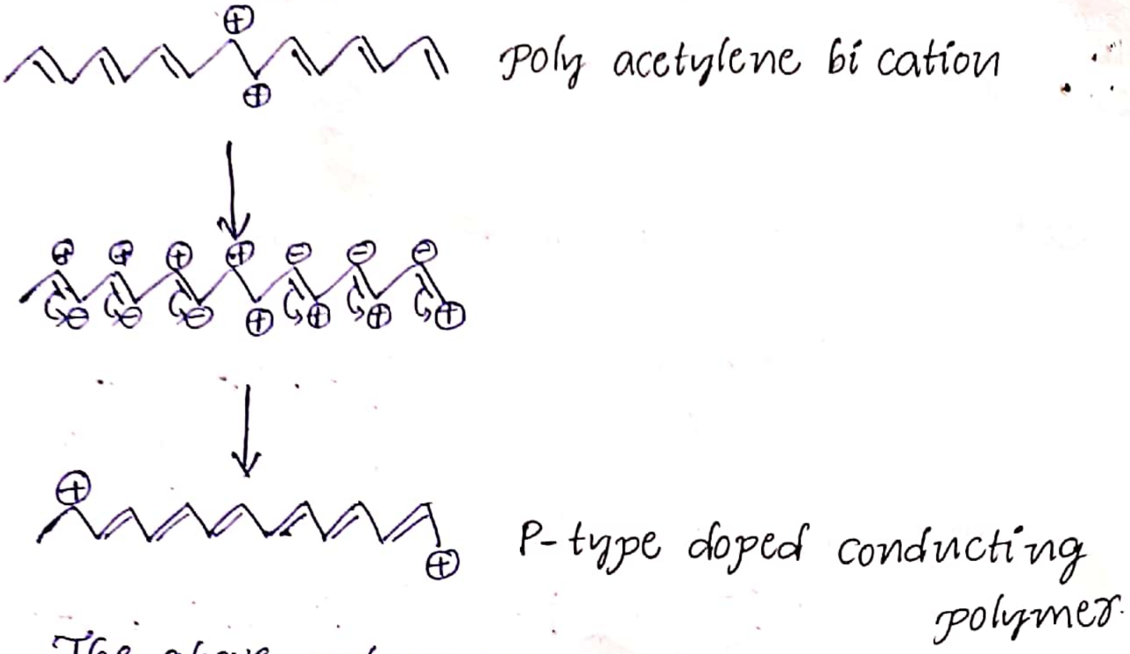
## P-type conducting polymer:

In P-type doping, our doped material is lewis acid. The nature of lewis acid is electron pair acceptor means electron deficiency molecules.

ex: $AlCl_3$, $FeCl_3$, $BF_3$, $BCl_3$ ...

Mechanism:





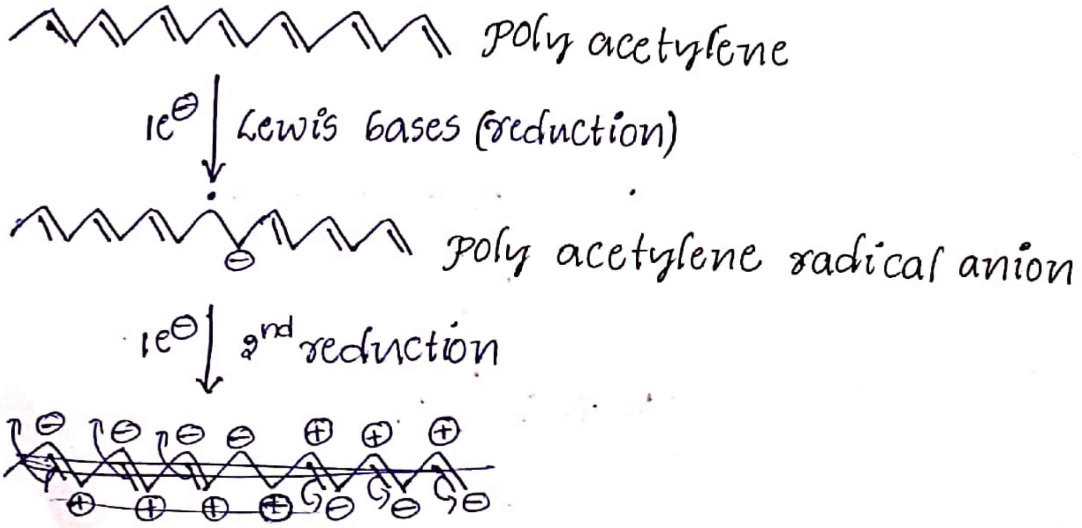
The above polymer the positive charge is moves entire polymer to break the old bonds to forms the new bonds. In which the conducting is due to positive charge. Hence these are called P-type conductivity polymer.

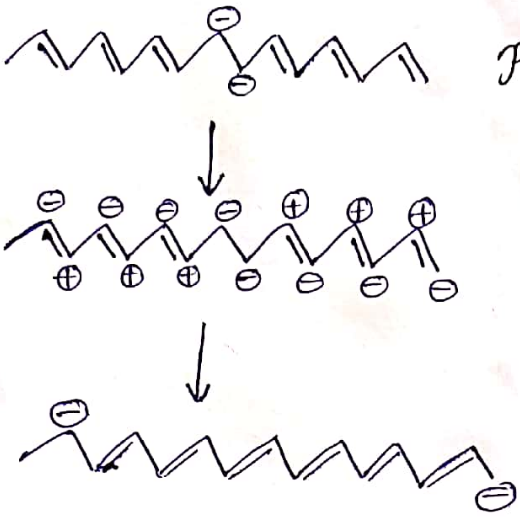
## N-type conducting Polymers:

In N-type dopping our doped material is Lewis bases. The nature of Lewis base is electron pair donar mean electron deficiency molecules.

ex: $NH_3$, $H_2O$, $CN^-$, $ClO_4^-$ . . . . .

## Mechanism:





The above polymer the negative charge moves entire the polymer to break the old bonds to form new bonds, in which the conductivity is due to negative charge. Hence these are called N-type conducting polymer.

prepared by
Sarvepalli. Venkata Rao
M.Sc. B.Ed

# E- Waste and Control methods ÷

* Introduction ÷

Plastics ÷

The Polymeric Materials which have high Molecular weight Organic Polymers which Are Moulded into desirable State In the Presence of temperature, Pressure and Catalyst is known As Plastics.

E- Waste ÷

E-waste (or) electronic waste is created when an electronic Product is discarded AFter the end of Its useful life. The rapid Expansion of technology and the Consumption driven Society results in the creation of a very large Amt of e- Waste In every Minute.

we Can Simply Said that

$$\boxed{\text{Technology} \propto \text{E Plastic waste Consumption}}$$

In 2006, the united State Estimated the Amt of World wide Electronic waste discarded each year to be 50 Million Metric tons

E Plastic waste is not An national Issue. It is an International (or) global Issue.

* Source of E- Waste ÷

The E- waste Can be generated by the All sectors like govt Sector, house hold sector, Private sector

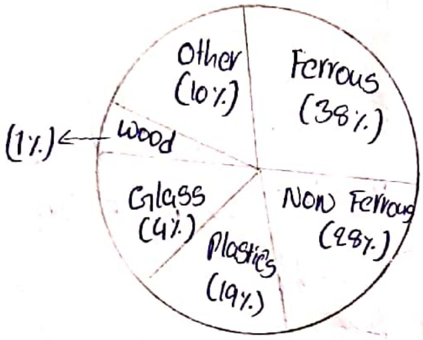
In the Form of
(i) Computers
(ii) Moniters
(iii) Televisions
(iv) Printers
etc

Todays Electronic Gadgets Tomorrow's Electronic waste.

## *Reasons For E-waste :-

- * Advancement to technology
- * changes in Fashion, Style & Status
- * Nearing end of their useful life

## * Components of E-waste :-



## * Effects due to Components of E-waste

| Sl.No | Component | Extract | Effects |
|---|---|---|---|
| 1 | Lead | CRT (Cathode Ray tube) | Anaemia, damage to nervous System |
| 2 | Mercury | Flat screen monitors, | muscle weakness. |
| 3 | PVC (Poly vinyl chloride) | Insulation of wires | respiratory diseases |
| 4 | Bisphenol A | Plastic Components | heart Problems |
| 5 | Poly chlorinated Biphenols | Plastic components. | Damage to the liver |

## * E-Plastic DISPosal :-

→ Plastic waste :-

From key boards, Casing, Plastic hardware components.

→ Printed circuit Board waste :-

From the Circutory boards like Mother board, TV - Internal circuits etc.

## *Control Methods (Recycling of E-Waste)

### * Dis Assembly / dis Mantling ÷

Disassembly is the Systematic removal of components, Parts, a group of Parts or a Subassembly From a Product which is in E-Waste.

### * Upgrading ÷

It Includes comminuting and Separation of Materials using mechanical / Physical and/or Metallurgical Processing. Methods to recover Materials Include refining and other.

### * Material Recovery ÷

The Materials are recovered by recycling facilities. The Plastics, glass, Metals can be recovered by Sorting them before Mixing with other waste.

## * Advantages of Recycling E-waste

- * Asset recovery
- * Reduction of need for land Fills
- * Reduction of Junks
- * Resale and Reuse
- * creation of Jobs

## * Conclusion ÷

→ e-waste is one of the Fastest growing Problem In the world. Hence we Aware of that.

→ Product design by using Safe and most emerging technologies and raw materials, which are environment friendly.

→ Implementing 3R Principle
Reduce - Reuse - Recycle.

# Bio polymer

**Definition:** It is a polymer that is developed from living beings. It is a biodegradable chemical compound that is regarded as the most organic compound in the ecosphere.

The name "Biopolymer" indicates that it is a biodegradable polymer.

## Biopolymer History:

This polymer has been present on earth for billions of years. It is older than synthetic polymers such as plastics.

Ex: 1. protiens 2. Carbohydrates 3. DNA 4. RNA 5. lipids 6. Nucleic acids 7. peptides 8. polysaccharides.

→ DNA biopolymer is the most important of humans

→ The most common biopolymer is cellulose. It is also the most abundant organic compound on this planet.

→ It comprises 33% of all planet component on earth.

## Bio polymer classification:

### Sugar based Biopolymers:

starch or sucrose is used as input for manufacturing poly hydroxi butyrate. sugar based polymers can be produced by blowing, injection, vaccum forming and extrusion. lactic acid polymers are created from milk sugar that is extracted from potatoes. Maize, wheat and sugar beet.

**Starch based Biopolymers:**

Starch acts as a natural polymer and can be obtained from wheat, topica, maize and potatoes. The materials is stored in tissues of plants as one way carbohydrates. It is not present in Animal tissues.

**Biopolymers based on synthetic materials:**

Synthetic compounds that are obtained from Potroleum can also be used for making biodegradable polymers such as aliphatic aromatic copolyesters.

**Cellulose based polymers:**

These are used for packing cigarettes, CDs and confectionary. It is obtained from natural resources like cotton, wood, wheat and corn.

The production of biopolymer may be done either from animal products, or agricultural plants.

**Biopolymer types:**

Thes are prilimarily two types of Biopolymer, one that is obtained from living organisms and another that is produced from renewable resources but require polymerization

**Biopolymer uses:**

1. Biopolymers based on synthetic are used to manufacture substrate mats.
2. Cellulose based Biopolymers, such as cellphone are used as packaging material.
3. These polymers can reduce carbon dioxide levels in the atmospher and also decrease carbon emission.

**Bio Material**:- The substances that has been engineered to interact with biological systems for medical purpose. directly with living cells of our body.

**Bio Medical Polymers**:- The polymers that have been used for medical including preventive medicine, and surgical treatment of diseases.

**Properties**:-

* Non-toxic
* light weight
* Resistance to biochemical attack
* fexibility
* It can be fabricable into desired shape without affecting properties.

## Types of Bio-Medical polymers.

**Natural**:- These are dirived from naturally occuring materials (or) organisms.

These are divided into 3 types on based of chemical structure.

1) **Polysacharides**:- These monosacharides combine together to form a polysacharide.

Ex:- Cellulose, chitin, collagen.

* Cellulose formation:-

Glucose combines to form cellulose

*It is used for Drug delivery, blood purification, wound dressing.

2) Protein → collagen

collagen → protein made of amino acids.

*It is used in cosmetic surgical treatment.

3) Bacterial polyesters → production of medical devices.

Ex:- screws, base fixation, tissue repairs

Properties of Natural Bio-Medical polymers.

- *Cheap to manufacture
- * Non-toxic
- * Highly porous
- * Bio degradable

Biodegradable:- It is Carried Not through thermal oxidation, photolysis (or) radiolysis but through enzymatic or non-enzymatic hydrolysis.

=) Degradation time must match the time required

=) should be Metabolised in the body after fulfilling its purpose.

=) Remain sufficiently strong untill the surrounding tissue has healed.

**Synthetic**:- These are artificially prepared in Industry.

According to properties ~~of~~ these are four types

- * Biostable
- * Bio eradible
- * water soluble
- * others.

**Biostable**:- polymers which are used for long time in place of organs i.e, artificial organs.

Ex:- polyurethane.

**Bio erodiable**:- which serve short term purpose in body and decompose to small molecules that can be metabolized (or) excreted.

**Water Soluble polymers**:- that forms part of plasma or) which functions as macromolecular drug.

**Applications**:- Most widely used are is silicone rubber (Poly dimethyl siloxane)

- * Desirable fexibility
- * inertness to body fluids.
- * non-toxicity

Poly urethane is used in Biostable polymers.

- * Blood filtration.
- * Heart valves
- * vascular tubing

## Artificial Heart:-

In the year 1982, Scientist Robert Jarvik is a person who developed a artifical heart by using Smooth polyurethane.

Nane:- Jarvik 7

1st patient to have artificial heart Barney clock.

* Artifical kidney transplantation by willem kolff.

## ABIO Heart:-

Made of titanium and a plastic to which the blood doesnot stick to its walls.

* walls are fexible made of silicons.
* lifespan is about 5 years
* poly vinyl chloride (pvc) $[CH_2-\overset{Cl}{CH}]_n$

  Manufacture of disposable syringes.
* poly proplene:- Heart valves ; blood filteration.
* poly alkylsophane:- Membrane oxygenater.
* poly Methyl meta acrylale:- (PMMC)

  Contact lense ; dental restoratives

  Facture fixation.

## Advantages:-

* less cost effective.
* Great no. of choice for treatment of diseases

## Disadvantages:-

* shows various problems if used as permanent for body.
* low effectiveness.

## Conclusion:-

Now-a days the medical field is developing rapidly by its wonderful dis coveries. as biomedical Polymers is also are of the great dis coveries by the great ~~scilints~~ scitiests. and still many scitiests are working to make the Biomedical Polymers without any dis advantage and as these Plays a major role in medicine. So everyone should be aware of its usage and may use in a Proper ways.

prepared by

Sarvepalli. Venkata Rao

M.Sc B.Ed