

Polymer Chemistry

Polymer :- Polymer is a macro molecule.

macro molecule = Huge molecule.

poly = Several ; mer = molecule or unit.

Below 20 micros plastic is harmful.

Milk packet - 40 micros.

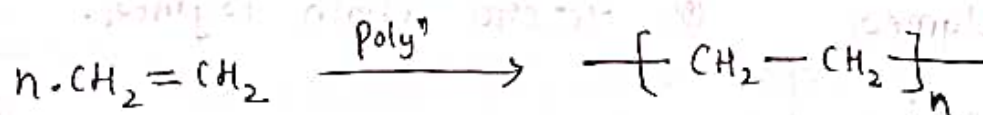
Polymerisation :-

The several number of monomers (small molecules) are combined together to form a polymer the process is called "polymerisation".

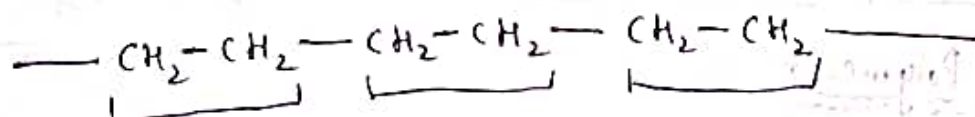
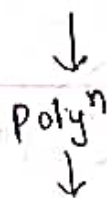
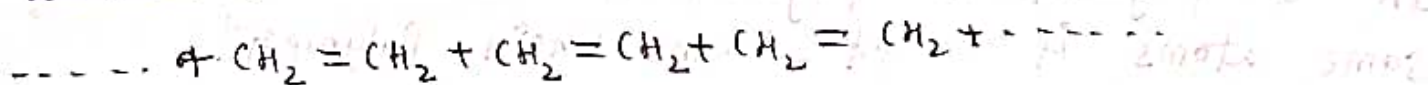
Degree of Polymerisation :-

The number of monomers are involved in a polymerisation is called "Degree of polymerisation".

It is denoted by 'n'.



Mechanism :-



monomer

Polyethylene (or) $\left[\text{CH}_2 - \text{CH}_2 \right]_n$

Monomer :- Repeating unit in a polymer is called monomer.

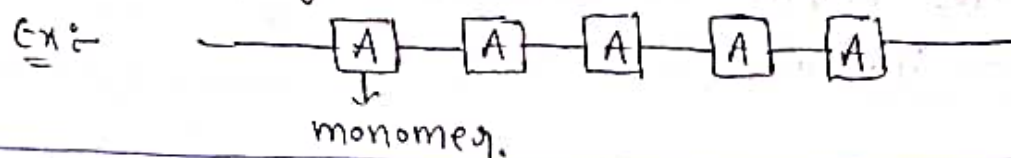
Types of Polymers:-

Based on the nature of monomers:-

- (i) Homo Polymers (ii) Co-Polymers.

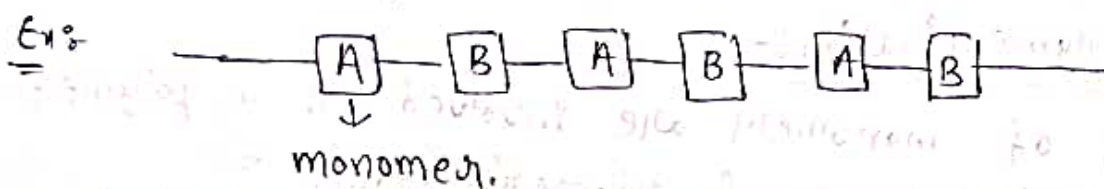
Homo Polymers:-

A polymer is made up of same monomers is called "Homo polymers".



Co-Polymers:-

A polymer is made up of different monomers is called "Co-polymers".

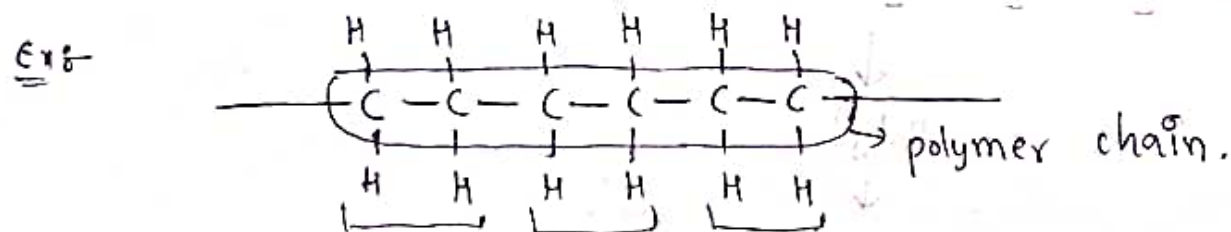


Based on the nature of polymer chain:-

- (i) Homo Chain Polymer (ii) Hetero Chain Polymer.

Homo Chain Polymer:-

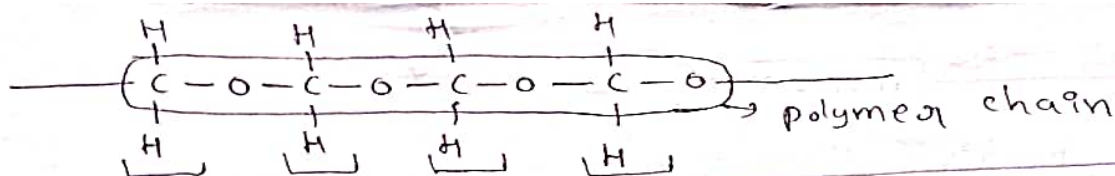
In a polymer the polymer chain is made up of same atoms is called "Homo Chain Polymer".



Hetero Chain Polymer:-

In a polymer the polymer chain is made up of different atoms is called "Hetero Chain Polymer".

Ex:-



Based on the structure of polymers:-

- (i) Linear polymers (Soft Polymers)
- (ii) Cross Linkage Polymers (Hard Polymers)

Linear Polymers:-

The linear polymers are soft due to the presence of weak van der Waals forces of attraction between individual polymer chains.



Ex:- Polyethylene, PVC.

weak van der Waals forces of attraction.

Cross Linked Polymers:-

The cross linked polymers are hard, due to the presence of strong covalent bonds between the individual polymer chains.



strong covalent Bond.

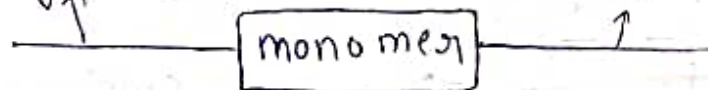
Ex:- Bakelite

Functionality:-

The number of bonding sites around to the monomer is called "Functionality of monomer".

Bonding site

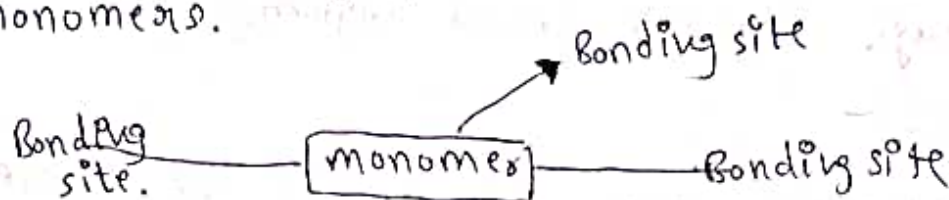
Bonding site



No of bonding sites = 2

Functionality = 2 [Bi functional monomer]

Note: The linear polymers are prepared by bifunctional monomers.



No of Bonding sites = 3.

Functionality = 3 [Tri-functional monomers]

Note: The cross linked polymers are prepared by tri functional monomers.

Tacticity:

The arrangement of functional groups around to the polymer chain is called tacticity of a polymer.

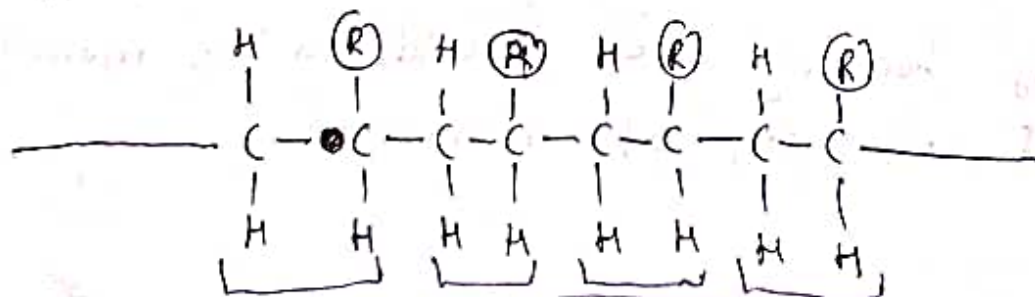
The polymers are classified into three types based on the tacticity.

(i) Isotactic Polymers (ii) Syndiotactic polymers.

(iii) Atactic Polymers.

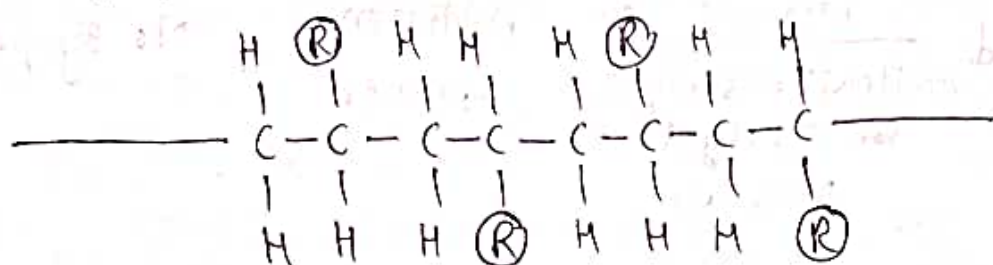
Isotactic Polymers: Iso = same

In Isotactic polymers all the functional groups are arranged same side to the polymer chain (Top side or bottom side).



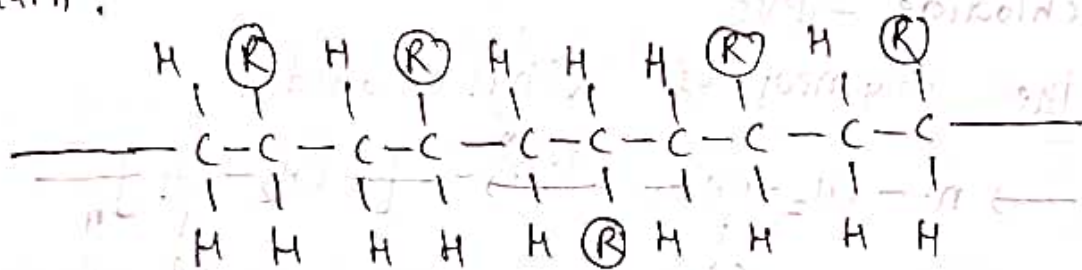
Syndiotactic Polymers:- syndio = alternative

In syndiotactic polymers all the functional groups are arranged in the alternative positions around to the polymer chain.



Atactic Polymers:- atactic = random (zig zag).

In atactic polymers all the functional groups are arranged in random positions around to the polymer chain.



Types of Polymerisation:-

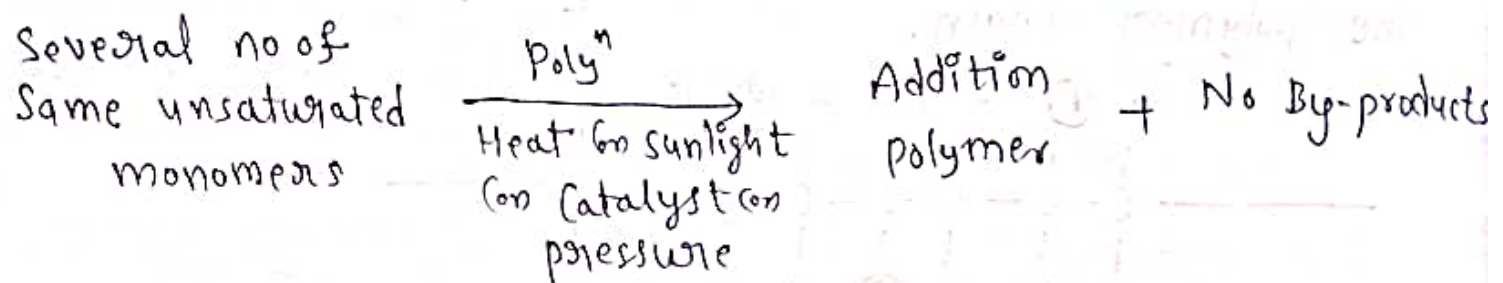
- (i) Addition polymerisation or Chain growth polyⁿ.
- (ii) Condensation polymerisation
- (iii) Co-polymerisation.
- (iv) Co-ordination polymerisation.

Addition Polymerisation:-

Several number of same unsaturated ($=$ or \equiv) monomers on polymerisation (polyⁿ) in the presence of heat or sun light or catalyst or pressure to form addition polymers without elimination of any by-products, the process is called addition polyⁿ.

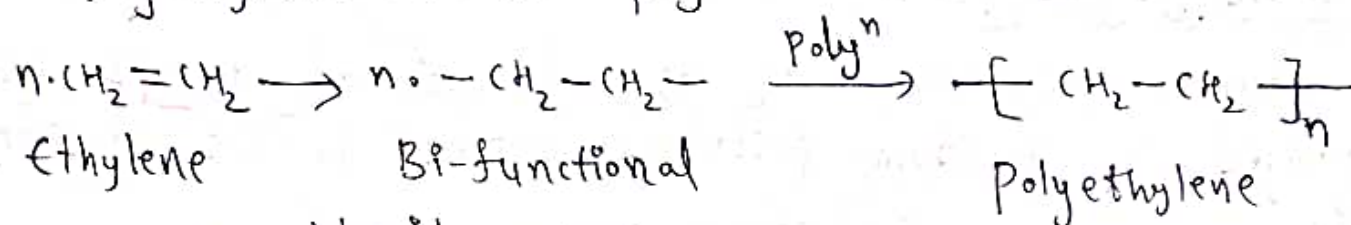
The polyⁿ proceeds through chain growth mechanism so it is also called chain growth polymerisation.

In addition polyⁿ the linear polymers are prepared.



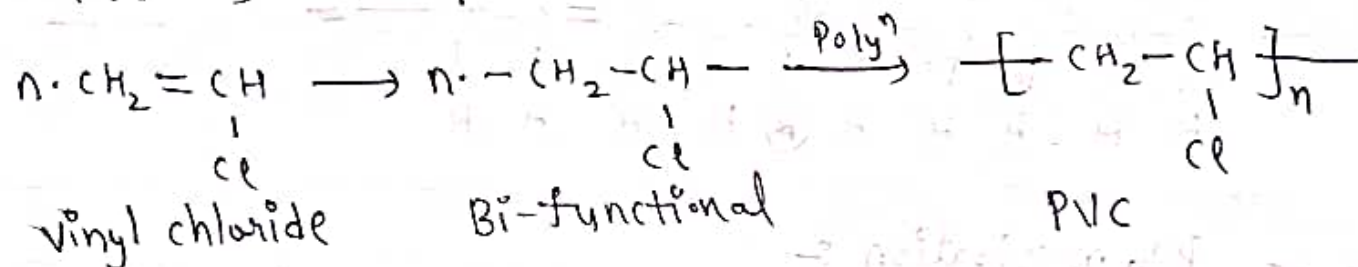
Ex: (i) Poly ethylene

Poly ethylene is the polymer of ethylene.



(ii) Poly vinyl chloride - PVC

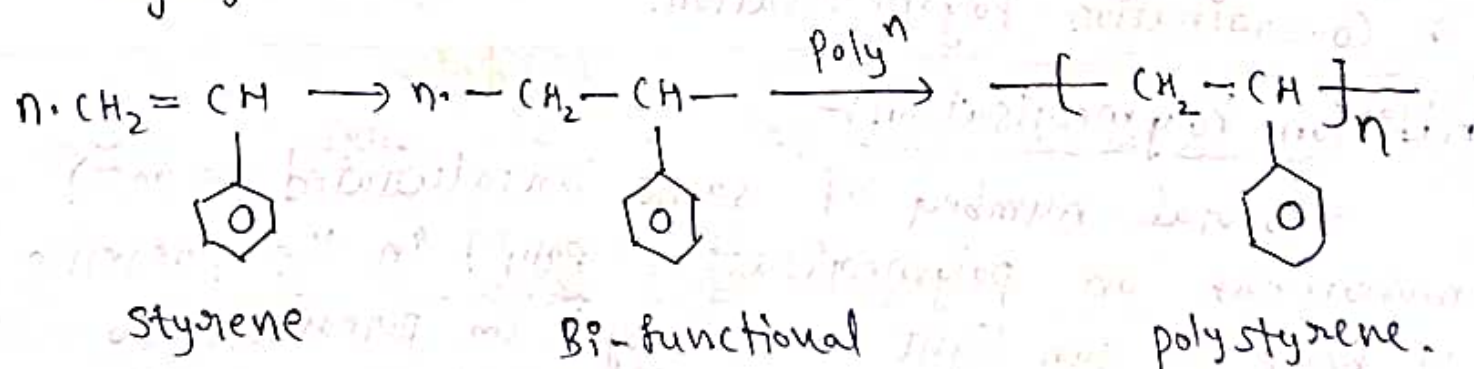
PVC is the polymer of vinyl chloride.



↓ $\text{CH}_2 = \text{CH} \text{---}$ → this is vinyl group.

(iii) Polystyrene.

Polystyrene is the polymer of styrene.

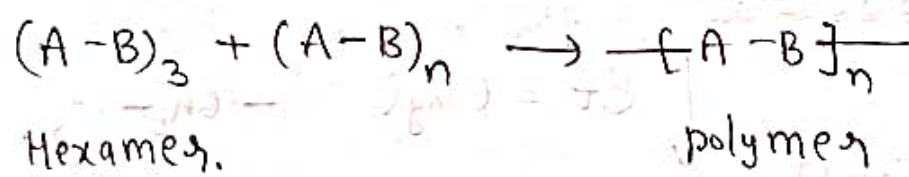
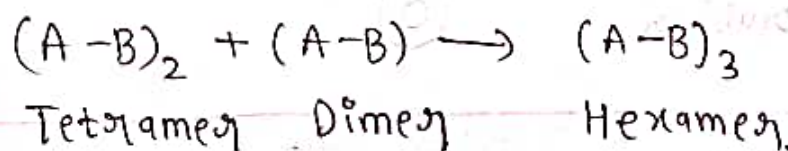
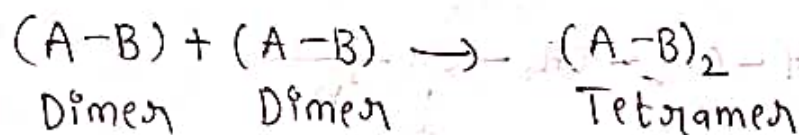
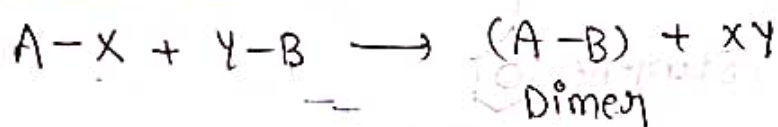


Condensation Polymerisation:-

Several number of same or different monomers having two or more functional groups on polyⁿ in the presence of heat to form condensation polymers with the elimination of by-products, the process is called condensation polyⁿ. The polyⁿ proceeds through step growth mechanism so it is also called step growth polymerisation.

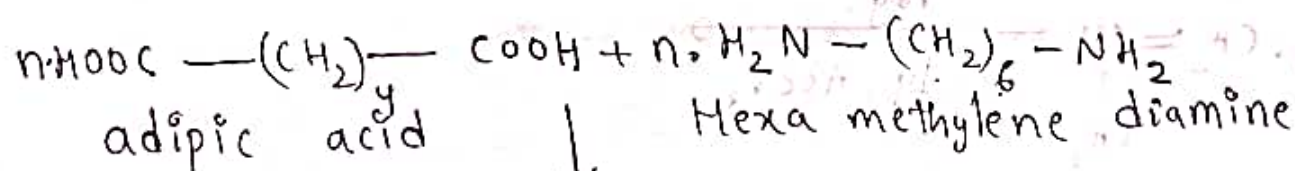
The cross linked polymers are prepared by condensation poly.

Mechanism:-

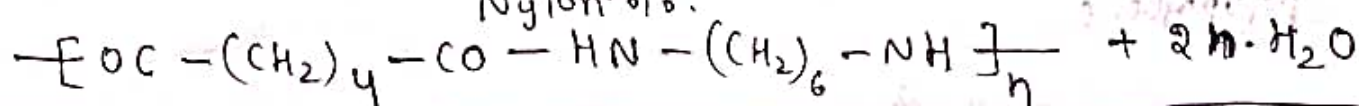


Exo: Nylon-6,6.

Nylon - 6,6 is the polymer of adipic acid and hexa methylene diamine.



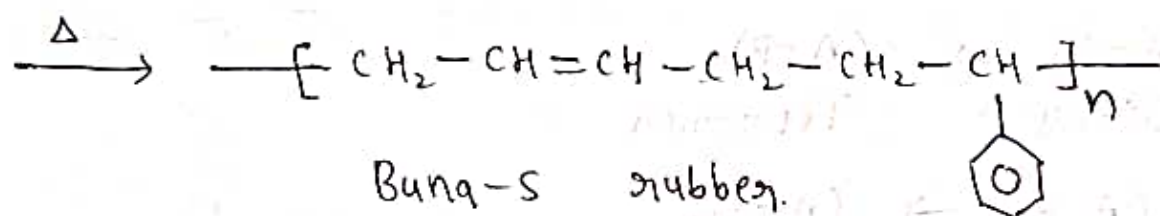
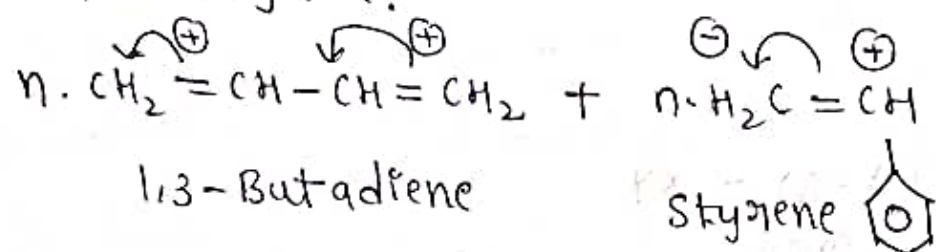
Nylon-6,6.



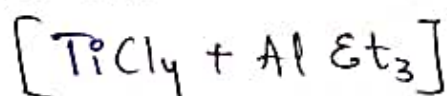
Co-Polymerisation:- Several number of different unsaturated monomers on polyⁿ in the presence of heat to form co-polymers without elimination of any by-products, the process is called co-polymerisation. The rubbery polymers are prepared by co-polyⁿ.

Ex:- Buna-S rubber.

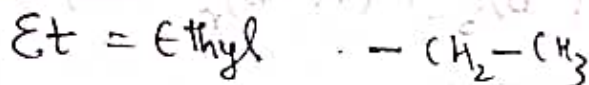
Buna-S rubber is the polymer of 1,3-Butadiene and styrene.



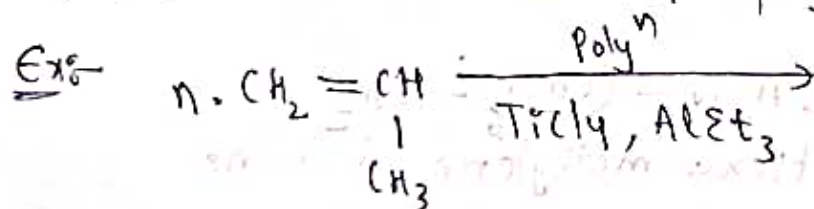
Co-ordination Polymerisation:-



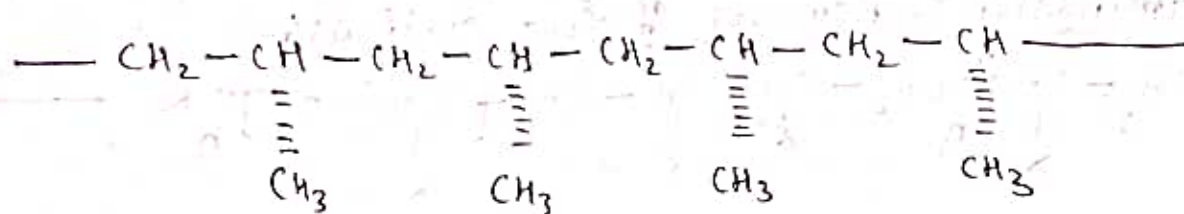
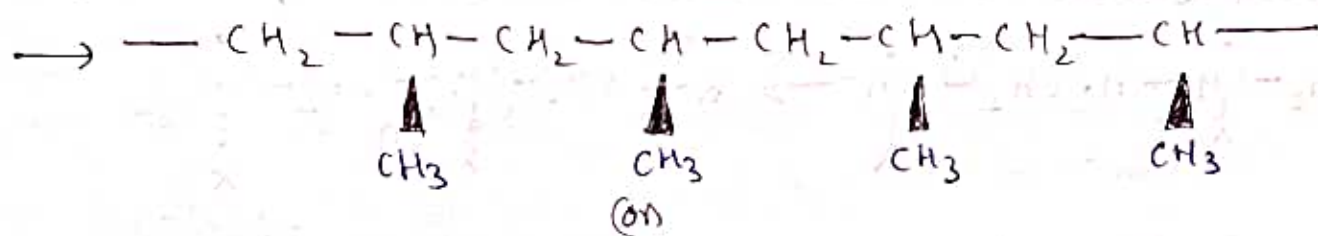
Ziegler-Natta Catalyst.



Several number of unsaturated monomers on polyⁿ in the presence of Ziegler-Natta catalyst to form stereo isomer polymers.



polypropylene



Stereo-Isomeric Polymers

Mechanism of addition polymerisation:-

Addition polyⁿ mechanism is classified into three types based on the active centres.
[Free radicals, Cations, Anions].

(i) Free Radical Addition polyⁿ mechanism.

(ii) Cationic Addition polyⁿ mechanism.

(iii) Anionic Addition polyⁿ mechanism.

The addition polyⁿ mechanisms proceeds by the following three steps.

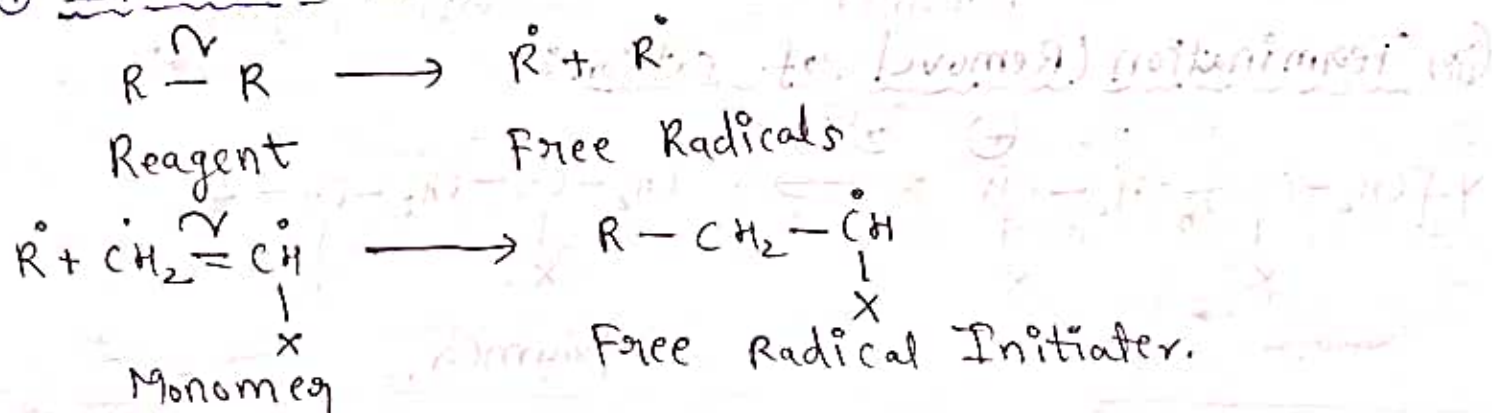
(a) Initiation (Formation of active centre).

(b) Propagation (Growth of polymer chain).

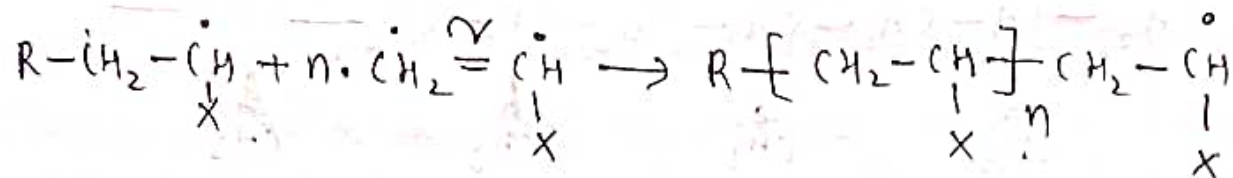
(c) Termination (Removal of active centre).

(i) Free Radical Addition polyⁿ mechanism:-

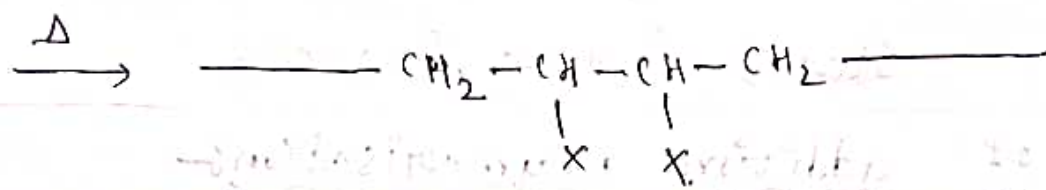
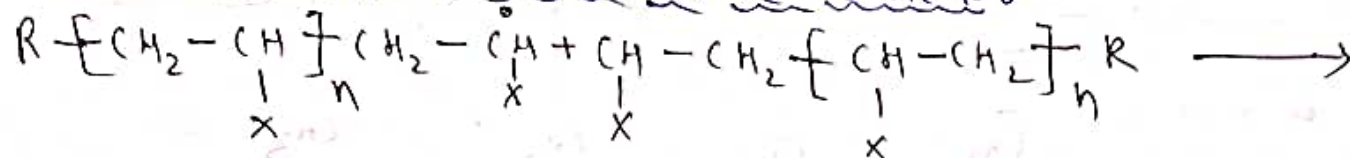
(a) Initiation (Formation of free radical) :-



(i) Propagation (Growth of polymer chain):-

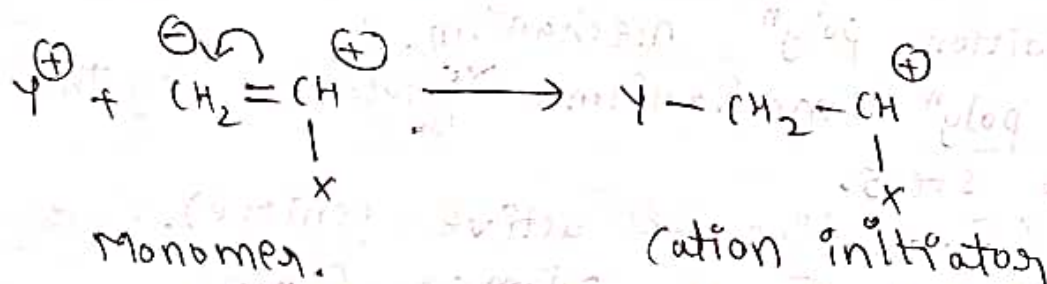
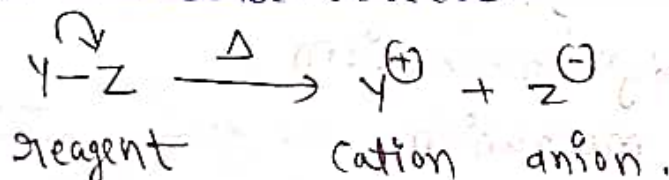


(ii) Termination:- (Removal of free radicals) Free radical polymer.

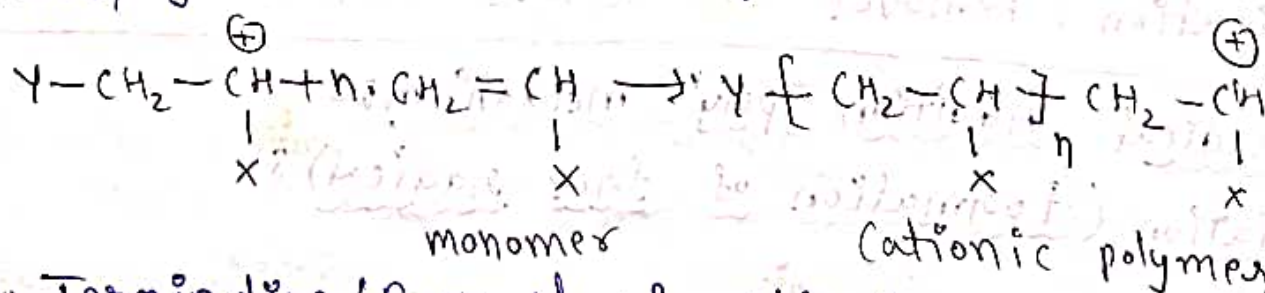


Cationic Addition polyⁿ Mechanism:-

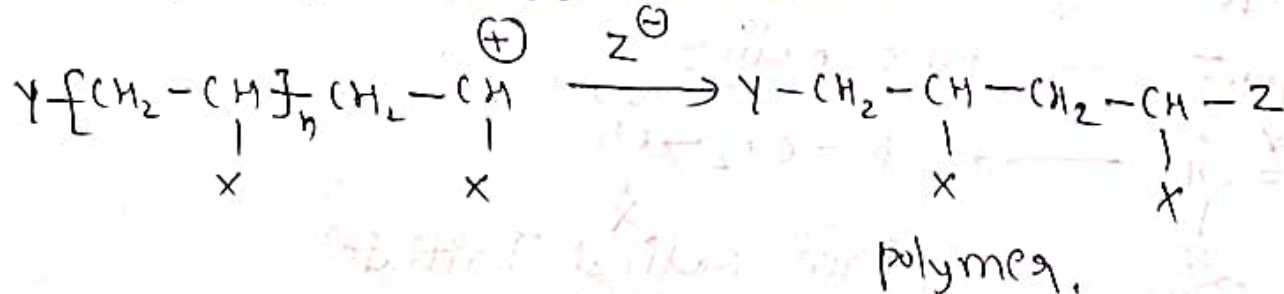
(i) Initiation (Formation of cation):-



(ii) Propagation (Growth of polymer chain):-

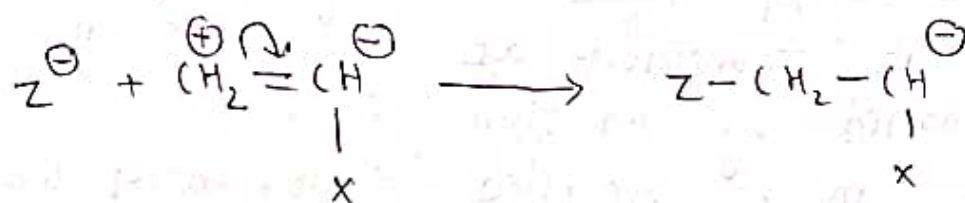
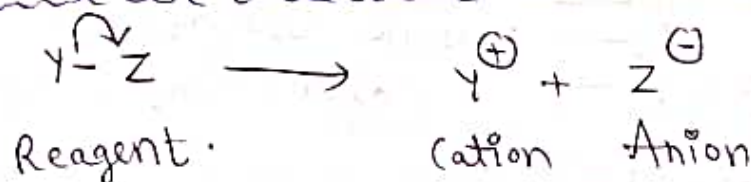


(iii) Termination (Removal of cation):-



Anionic Addition Polymerisation mechanism:-

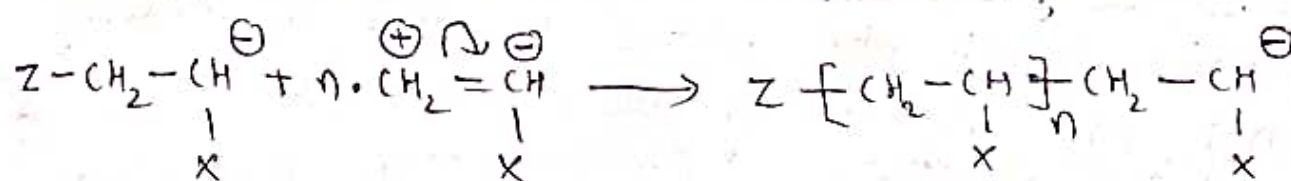
(i) Initiation (Formation of anion):-



Monomer

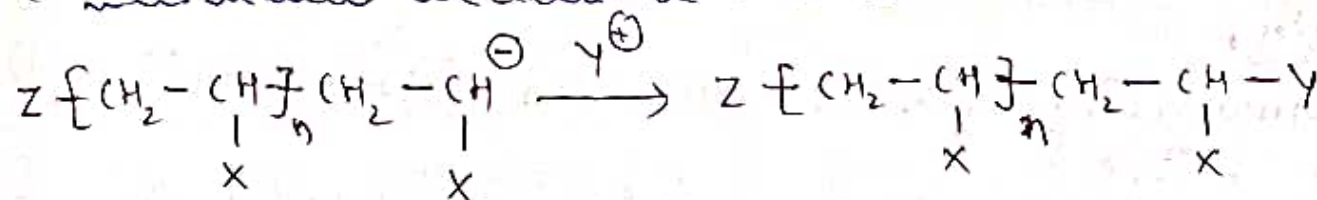
Anionic Initiator.

(ii) Propagation (Growth of polymer chain):-



Anionic Polymer.

(iii) Termination (Removal of Anions):-



polymer.

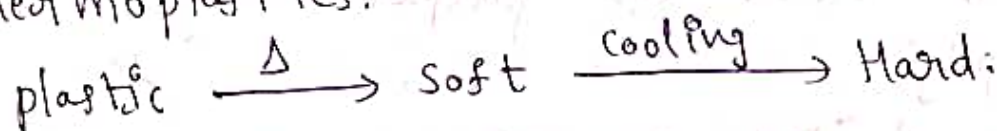
Plastics:- The plastics are classified into 2 types

Thermoplastics:-

(i) Thermoplastics

(ii) Thermosetting plastics.

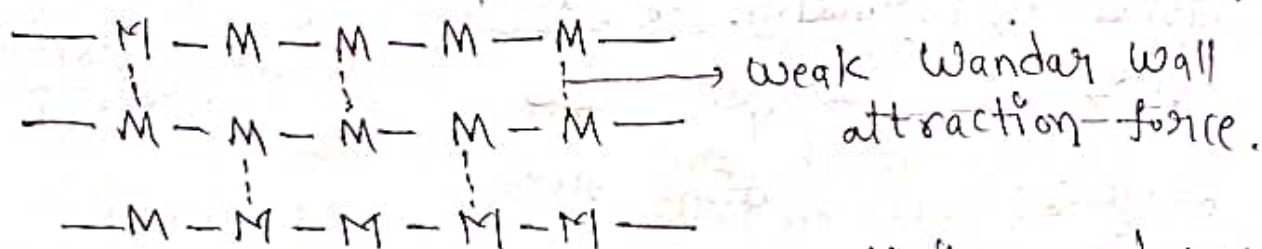
The plastics which become soft on heating and they become hard on cooling are known as thermoplastics.



Properties:-

- ① Thermoplastics are soft, weak and less brittle.
- ② The individual polymer chains are held together

by weak wanda wall attraction forces,



- ③ Thermoplastics are considered as linear polymers which are prepared by addition polyⁿ.
- ④ Thermoplastics can be recycled from their waste.
ex: PVC, Polythene.

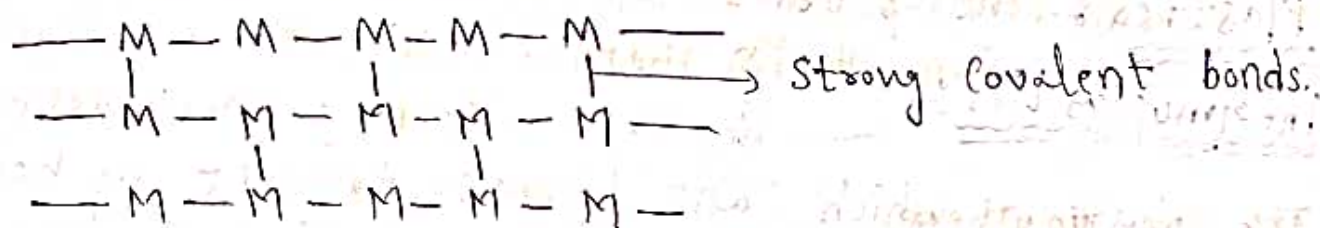
① Thermosetting plastics:-

The plastics which are become to hard on heating but not soft on cooling are known as thermosetting plastics.

Plastic $\xrightarrow{\Delta}$ Hard.

Properties:-

- ① Thermosetting plastics are hard, strong and more brittle.
- ② The individual polymer chains are held together by strong covalent bonds.



- ③ Thermosetting plastics are considered as cross linked polymers which are prepared by condensation polyⁿ.
- ④ Thermosetting plastics can not be recycled from their waste.
ex: Bakelite.

Q:- Write the difference between thermoplastics and thermo setting plastics.

Sol:- Thermoplastics

① The plastics which are become to soft on heating and they become to hard on cooling are known as thermoplastics.

② Thermoplastics are soft, weak and less brittle.

③ The individual polymer chains are held together by weak van der Waals attraction forces.

④ Thermoplastics are considered as linear polymers which are prepared by addition polymerisation.

⑤ Thermoplastics can be recycled from their waste.

ex:- PVC, Polythene

Thermosetting plastics

① The plastics which are become to hard on heating but not soft on cooling are known as thermosetting plastics.

② Thermosetting plastics are hard, strong and more brittle.

③ The individual polymer chains are held together by strong covalent bonds.

④ Thermosetting plastics are considered as cross linked polymers by condensation polymerisation (which are prepared).

⑤ Thermosetting plastics can not be recycled from their waste.

ex:- Bakelite.

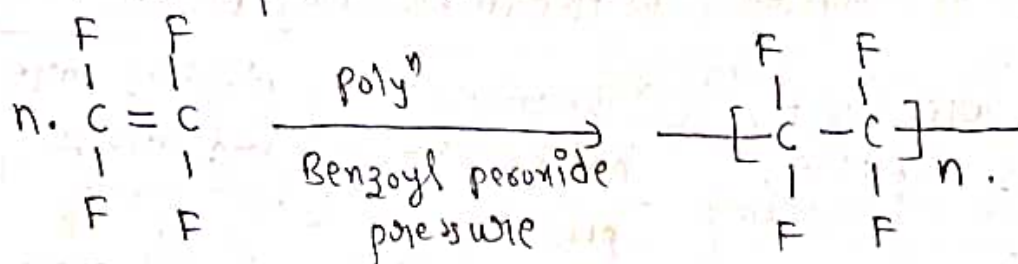
Teflon:-

Q. Write preparation, properties and uses of Teflon.

Sol: Polytetra Fluoro Ethylene = Teflon.

Preparation:-

Teflon is prepared by the polyⁿ of tetra fluoro ethylene in the presence of benzoyl peroxide as catalyst under pressure.

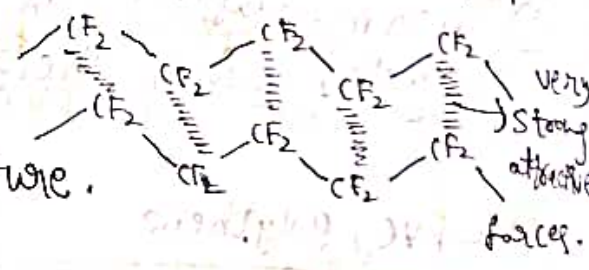


(Tetra Fluoro Ethylene)

(poly-Tetra Fluoro Ethylene)

Properties:-

- (i) The teflon structure is similar like polyethylene. But, the property are not similar.
 - (ii) The strong attractive forces present between individual polymer chains of teflon due to the presence of highly electro negative fluorine atoms.
 - (iii) The strong attractive forces makes the teflon molecule as the following
- (a) Extreme toughness
 - (b) Very high softening temperature.
 - (c) High Chemical resistance.



Uses:-

- (i) The teflon is used for making gasket wires and chemical carrying pipes.
- (ii) The teflon is used for making non-stick cook ware.
- (iii) Teflon is used for making stop-corks of burettes.

(iv) Teflon is used for making electrical insulating wires.

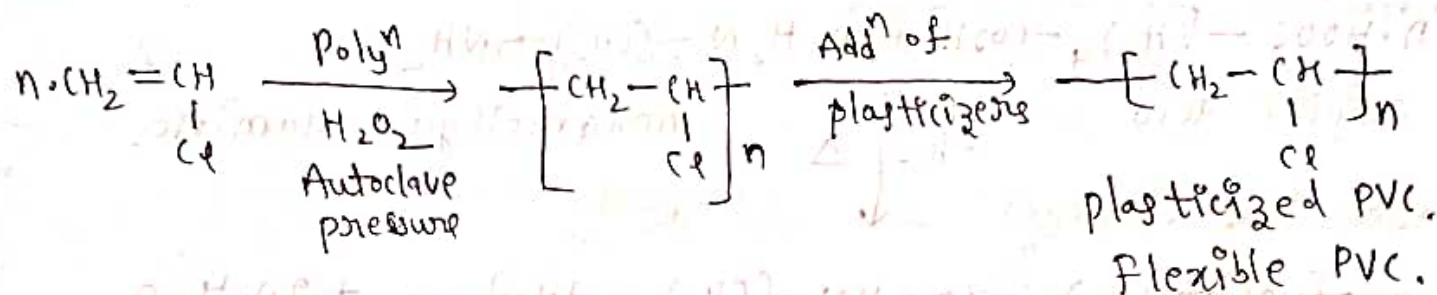
PVC:-

Q. Write the preparation and uses of PVC?

Sol:- PVC = Poly Vinyl Chloride.

Preparation:-

The PVC is prepared by the polyⁿ of Vinyl chloride in the presence of hydrogen peroxide (H_2O_2) as catalyst under pressure in an autoclave.



Properties:-

- (i) PVC is colourless, odourless powder.
- (ii) PVC is a non-inflammable and highly chemical inert compound.
- (iii) PVC exhibits two forms as follows

(a) unplasticized PVC

(b) plasticized PVC.

Uses:-

Unplasticized PVC:-

- (i) The unplasticized PVC is used for making refrigerator components, bottles, toys, ATM cards, window frames, PVC pipes etc.

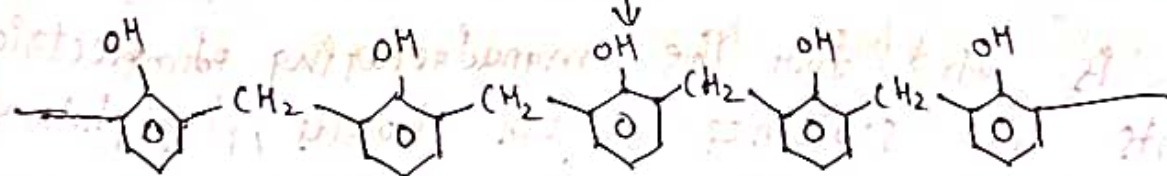
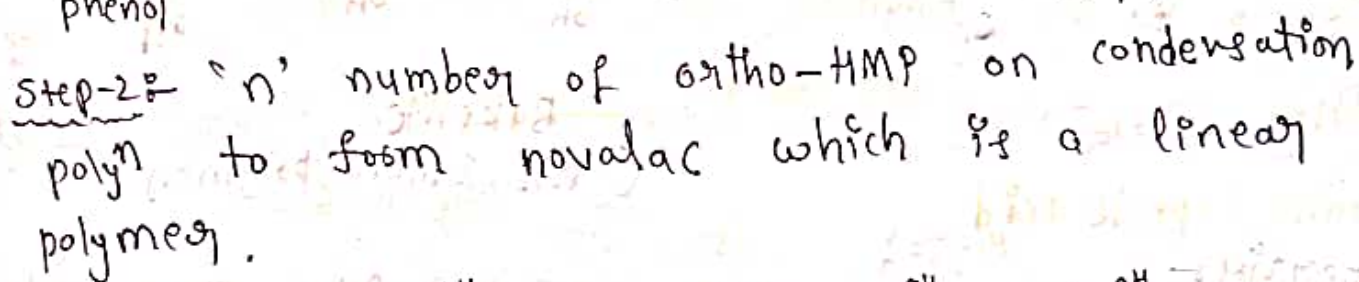
Plasticized PVC:-

- (i) Plasticized PVC is used for making table cloths, insulating cables, carpets, rain coats, tank linings etc.

Nylon-6: It is used for making moulded materials for gears and bearings.

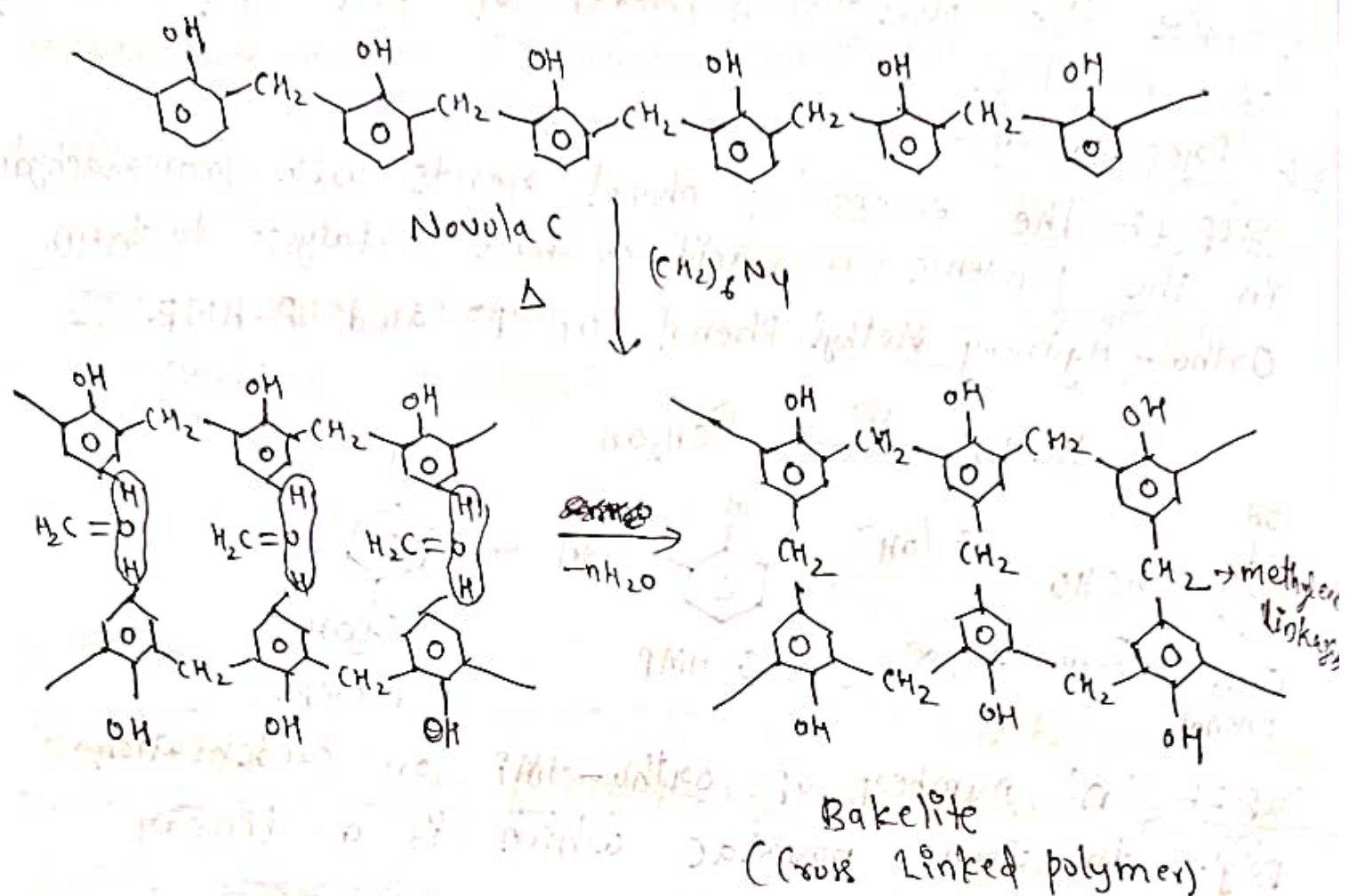
Q. Write the preparation, properties and uses (applications) of bakelite.

Preparation:-
Step-1:- The excess of phenol reacts with formaldehyde in the presence of acid or base catalyst to form Ortho-Hydroxy Methyl Phenol (OHMP) and P-HMP.



Novolac
(Linear polymer)

Step-3: Novolac is heated in the presence of hexamethylene tetra amine which provides formaldehyde which are formed between polymer chains as methylene linkages. The methylene linkages makes the novolac polymer hard and rigid which is known as "Bakelite".



Properties

- (i) Bakelite is a ~~hard~~ hard, rigid and infusible cross linked polymer.
- (ii) Bakelite has good insulating capacity.

Uses

- (i) Bakelite is used for the manufacturing of electrical equipments like switches, switch boards, plugs, holders etc.
- (ii) It is used for making TV, refrigerator components.
- (iii) It is used in paints and varnishes.
- (iv) It is used as a cation exchange resin in water softening process.

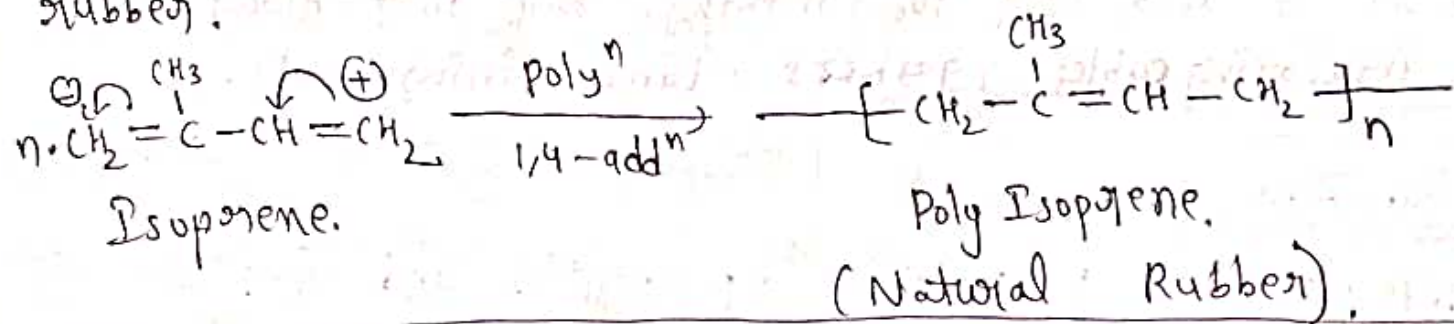
Elastomers (Rubbers) :-

Rubber is available in two types.

(i) Natural Rubber, (ii) Synthetic Rubber.

Natural Rubber :-

The 'n' number of isoprene on polyⁿ by 1,4-addition to form poly Isoprene, which is known as natural rubber.



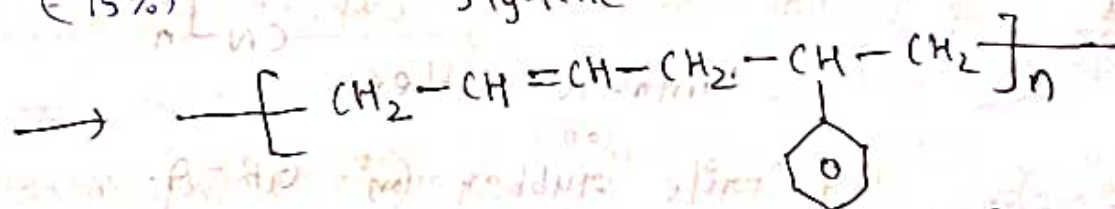
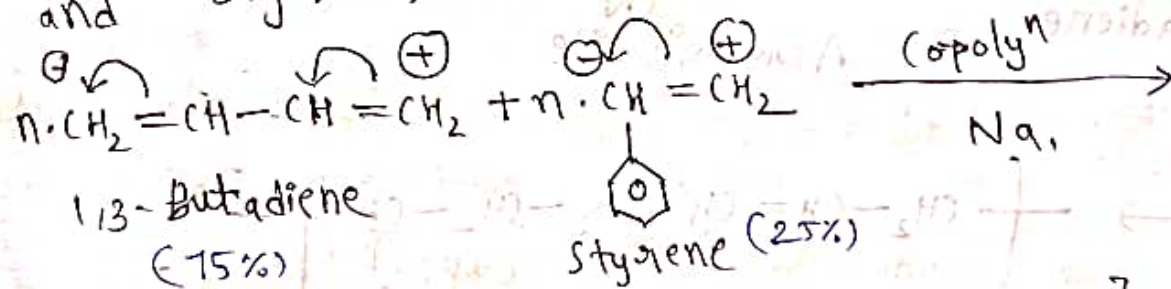
Synthetic Rubber :-

Buna-S Rubber :-

Q. Write the preparation, properties and uses of Buna-S rubber?

Preparation :-

Buna-S rubber is the polymer of 1,3-butadiene (75%) and styrene (25%).



Buna-S (or) GR-S (or) SBR.

Properties :-

(i) Buna-S rubber has high load bearing capacity.

(ii) It has abrasion resistance.

- (iii) It swells in oils and organic solvents.
- (iv) It oxidises in presence of ozone.
- (v) It is vulcanized in the same way as natural rubber.

Uses:-

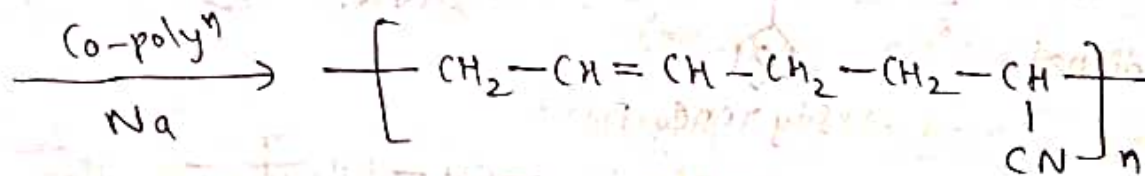
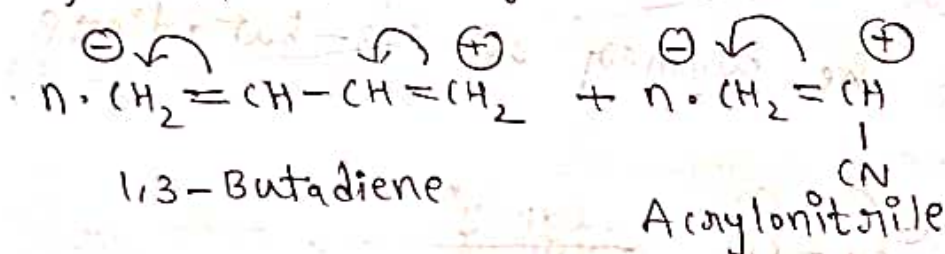
- (i) Buna-S rubber is mainly used for manufacturing of tyres.
- (ii) It is also used for making shoe soles, floor tiles, insulating cables, gaskets, tank linings etc.

Buna-N Rubber:-

Q. Write the preparation, properties and uses of Buna-N rubber?

Ans:- Preparation:-

Buna-N rubber is prepared by the copolymerisation of 1,3-Butadiene and acrylonitrile in the presence of 'Na' as catalyst.



Buna-N rubber

(or)
Nitrile rubber (or) GR-A.

Properties:-

- (i) Buna-N rubber has oil resistance, heat resistance and abrasion resistance.
- ↓ abrasion ಎಂಬ ಪದ Rough & Tough ಗೆ ಅನುಸಾರ.

- (ii) It has acid, salt resistance but attacked by alkalis (bases) due to presence of $-CN$ group.
- (iii) It is vulcanized in the same way as natural rubber.

Uses:-

- (i) Buna-N rubber is used for making auto-mobile parts, air craft components, conveyor belts, hoses, printing rollers, tank linings. etc.

Conducting Polymers:-

Q. Write a note on conducting polymers? Or Types of conducting polymers?

Ans: The ~~poly~~ polymers are the poor conductors of electricity due to very large band gap (Energy gap).

A few number of polymers possess the conductance because they can reduce their band gap as low as $0.5 - 1 \text{ eV}$, those polymers are called conducting polymers.

Types of conducting polymers:-

- (i) π conjugated conducting polymers
- (ii) Doped conducting polymers.

π conjugated conducting polymers:-

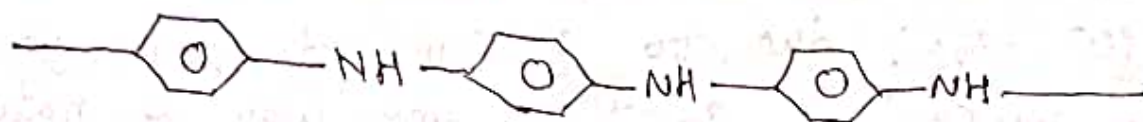
The π conjugated conducting polymers possess the conductance is due to the delocalization of π -conjugated electrons on the backbone of the entire polymer which makes the polymer as conductor.

Ex- (i)



polyacetylene.

(iv)



polyaniline

The π -conjugated conducting polymers possess less conductivity which is not sufficient for various applications.

Doped Conducting Polymers:-

The conductivity of π -conjugated conducting polymers can be increased by creating +ve & -ve charges on the back bone of polymer by oxidation & reduction, the process is called doping and the polymers are called doped conducting polymers.

p-doping:- The process of creating +ve charges on the back bone of polymer by oxidation is known as p-doping.

n-doping:- The process of creating -ve charges on the back bone of the polymer by reduction is known as n-doping.

Applications:- The conducting polymers are used
(i) In solar cells, (ii) In transistors, (iii) In LEDs,
(iv) In telecommunication, (v) In display of mobiles, TVs etc.

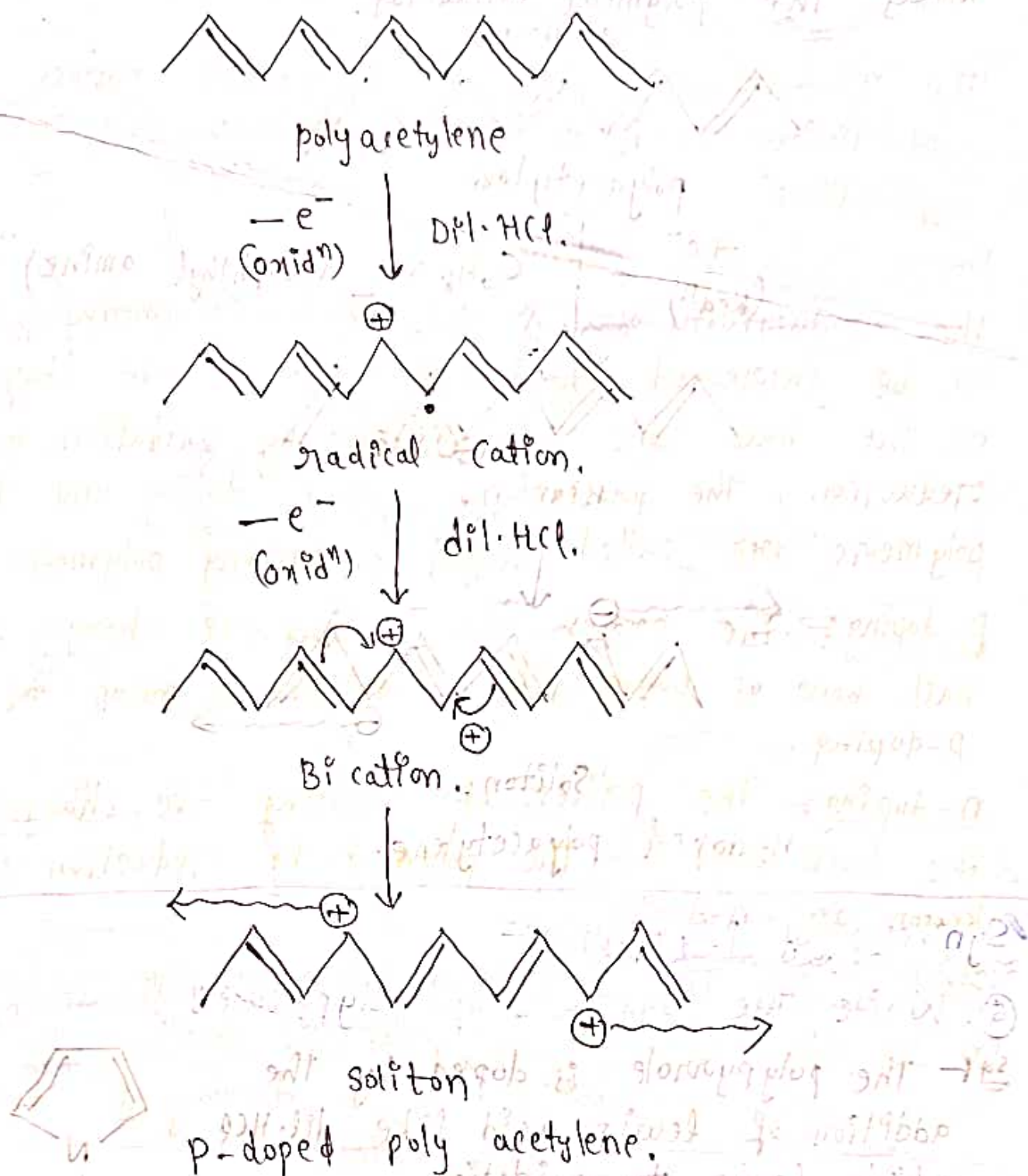
Q. Write the synthesis of polyacetylene.

Ans. p-doping:-

The polyacetylene is doped by the addition of Lewis acid like dil. HCl which leads to oxidation.

In 1st oxidation forming radical cation and in 2nd oxidation forming Bication.

The +ve charges are moving away from each other known as soliton. which make the polymer conductor.



n-doping

The polyacetylene is doped by the addition of lewis base like naphthyl amine ($C_{10}H_8NH_2$) which leads to reduction.

In 1st reduction forming radical anion and in 2nd reduction forming di-anion.

The $-ve$ charges on the polymer back bone moving away from each other known as soliton, which makes the polymer conductor.



polyacetylene

$+e^-$
(Redⁿ)

$C_{10}H_8NH_2$ (Naphthyl amine)



Bianion.



Soliton.

n-doped polyacetylene.

Synthesis of Polypyrrole

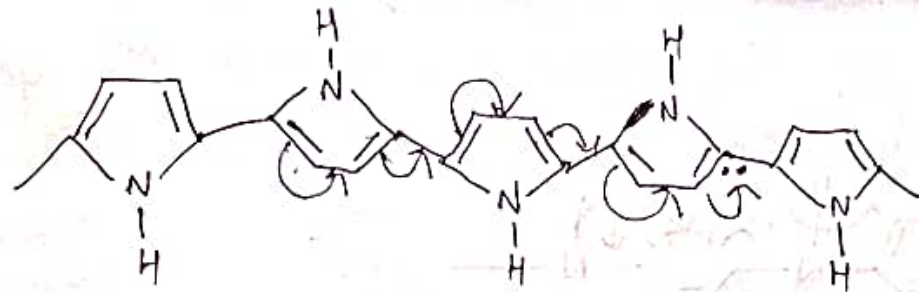
Q. Write the synthesis of polypyrrole?

Ans. The polypyrrole is doped by the addition of Lewis acid like $dil. HCl$ which leads to oxidation.

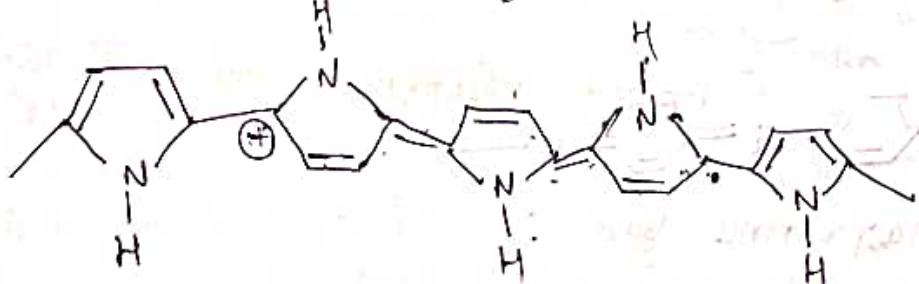
In 1st oxidation forming radical cation, and In 2nd oxidation forming bication.

The $+ve$ charges on the back bone of the polypyrrole moving away from each other known as soliton which is responsible for conduction.

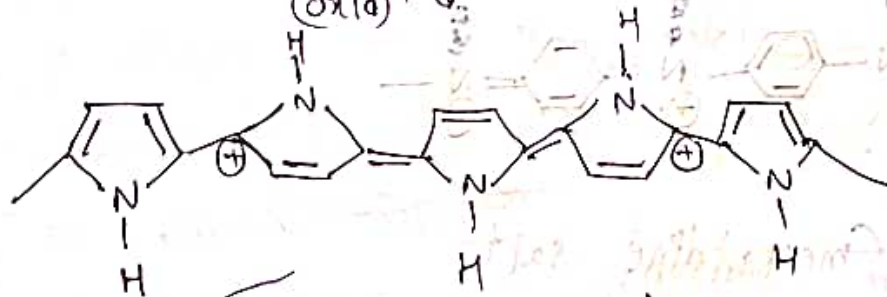
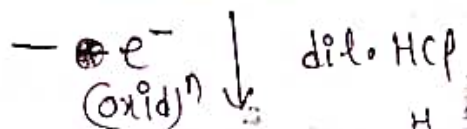




poly pyrrole

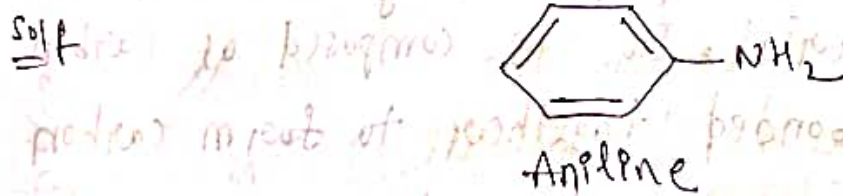


Radical Cation.



Bication,

Q. Write the synthesis of polyaniline.



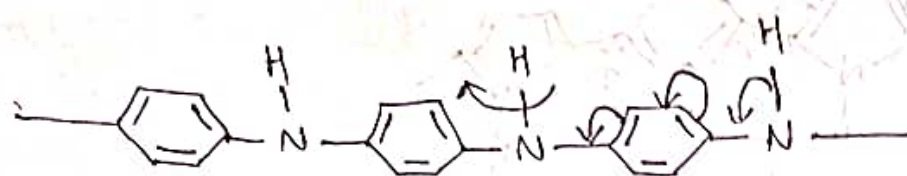
The polyaniline is doped by the addition of Lewis acid like dil. HCl which leads to oxidation.

In 1st oxidation forming emeraldine base and

In 2nd oxidation forming emeraldine salt.

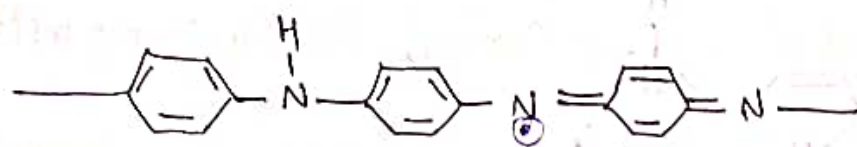
The +ve charges on the polyaniline moving away from each other, known as soliton, which is responsible

for conduction.



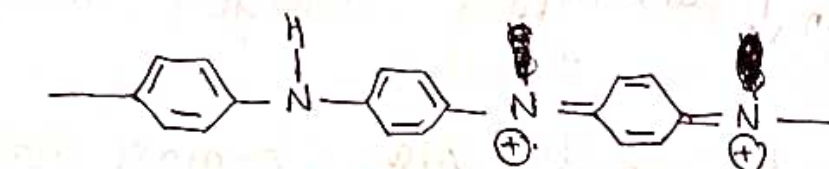
polyaniline

(Oxid)ⁿ ↓ dil. HCl.



Emeraldine Base

(Oxid)ⁿ ↓ dil. HCl



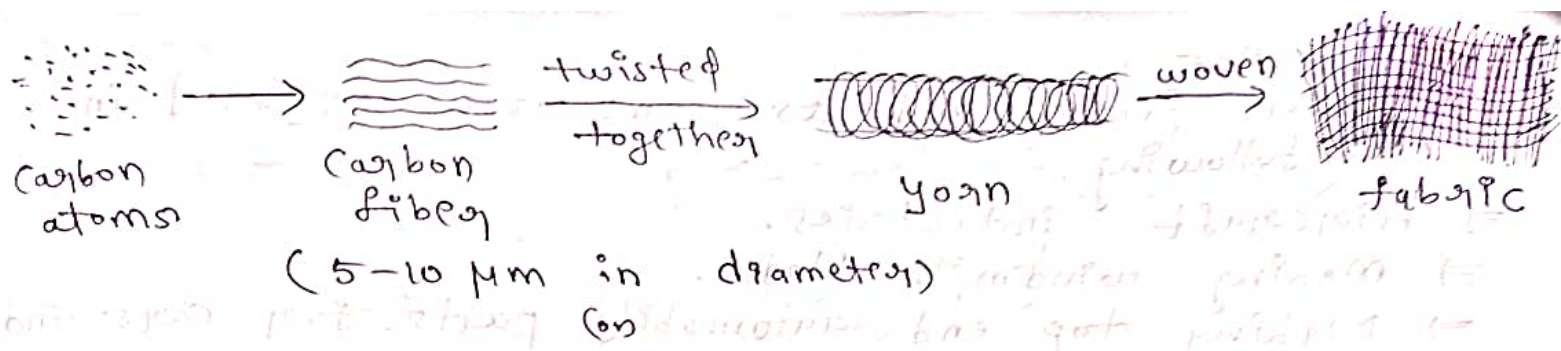
Emeraldine salt

Carbon Fibers:-

Q. Write a note on carbon fibers:-

sol:- Carbon fiber is a super strong material and light weight material. It is composed of carbon atoms which are bonded together to form carbon fibers. The thousands of carbon fibers twisted together to form yarn which are woven into fabric.

The carbon fibers are mixed with other components to form carbon fiber composites.



Carbon fibres + components \rightarrow Carbon fibre composites.

(i) Carbon fibres about 5 to 10 μm in diameter.
 (ii) Carbon fibres are composed of 90% of carbon atoms.

(iii) Carbon fibre is five times stronger than steel and 2 times lighter than steel.

(iv) Carbon fibre is thinner than human hair (100 times thinner).

(v) Carbon fibres are synthesized mainly from the PAN. (polyacrylonitrile) method. Alternatively synthesized from rayon method or petroleum pitch method.

Properties:

- (i) Carbon fibre has high tensile strength and high stiffness.
- (ii) It has low thermal expansion.
- (iii) It has high chemical resistance.
- (iv) It is a light weight material.
- (v) It is a super strong material.

Applications:

(i) Carbon fiber and its composites are used in the following.

⇒ Aircraft industries.

⇒ Making windmill blades.

⇒ Making top end automobile parts, for cars and bikes.

⇒ Making light weight badminton rackets, golf sticks.

⇒ Used in building and construction purpose.