

## Module - III

### Polymers

Polymer: polymers can be defined as the large molecule (macro molecular) formed by the linkage of small molecules of called monomers.

In greek language poly means many & mer means units.

e.g. poly ethylene.

Monomer: Thus the repeated unit of polymer is called monomer.

- The number of repeating units in a polymer chain is called degree of polymerization (n).

### Classification:

Classification of Polymers based on source of availability.

#### (a) Natural polymers:

They occur naturally and are found in plants and animals. For example proteins, starch, cellulose, and rubber.

#### (b) Semi-synthetic polymers:

They are derived from naturally occurring polymers and undergo further chemical modification.

Ex: Cellulose nitrate

#### (c) Synthetic polymers:

These are man-made polymers

Ex: nylon - 6, 6, Polyethers etc.

→ Based on the structure of monomeric chain  
linear polymers

The structure of polymers containing long and straight chains fall into this category. PVC, i.e. poly-vinyl chloride is largely used for making pipes and electric Ex:- PVC (poly vinyl chloride)

Branched - Chain Polymers:

When linear chains of a polymer form branches then such polymers are called as branched chain polymers Ex:- Low density polyethylene (LDPE).

Cross-linked Polymers:

They are composed of bifunctional and trifunctional monomers.

Classification based on polymerization

a) Addition polymerization:

Ex: poly ethane, Teflon, polyvinyl chloride (PVC)

b) Condensation polymerization:

Ex: Nylon - 6, 6,

→ Classification of Based on Monomers.

a) H homopolymer:

Ex: polyethene

(b) Hetero or Heteropolymer or co-polymer.

Ex: nylon 6, 6.

## Classification of Polymers Based on Molecular Force

(a) Elastomer:

Ex: Rubber

(b) Fibers:

Ex: nylon-6,6

(c) Thermoplastic

Ex: polyvinyl chloride

(d) Thermosetting polymers:

Ex: phenolics, epoxies, and silicones

Q) 18/11/23.

g. Phenolics, Epoxies, and silicones.

\* Difference b/w Condensation & addition polymerisation

Condensation Polymerisation

1. It is also known as step growth polymerisation
2. It takes place in monomers having reactive functional group

Addition Polymerisation

1. It is also known as chain growth polymerization
2. It takes place only in monomers having multiple bonds

- 3. It takes place with elimination of simple molecule like  $H_2O$ ,  $NH_3$ ,  $HCl$  etc.
- 4. Repeat units of monomers are different.
- 5. The polymer is formed in gradual steps.
- 6. The molecular mass of polymer increases throughout the reaction.
- 7. Product obtained may be thermosetting/thermoplastic.
- 8. Eg: Bakelite, Polyester, polyamides etc.
- 9. There are cross-linked chain polymers.
- 10. These are high stable polymers.
- 3. It takes place without elimination of simple molecule.
- 4. Repeat units & monomers are same.
- 5. Reaction is fast and Polymer is formed at once.
- 6. There is very little change in the molecular throughout the reaction.
- 7. Product obtained are Thermoplastics.
- 8. Eg: Polyethylene, PVC, Poly Styrene.
- 9. These are linear & branched chain polymers.
- 10. These are less stable polymers.

Plastics: plastic is a substance that can be easily formed or moulded into a desired shape.

• Plastic can be formed in a desired shape by the effect of mechanical force & heat.

#### Advantages of plastic:

1. Low fabrication cost, low thermal & electrical conductivities, high resistance to corrosion & solvent.

2. Plastics reduce noise & vibration in machines.

(29) Difference b/w Thermoplastic & Thermosetting polymers

#### Thermoplastic

1. These are produced by additional polymerization.

#### Thermosetting

2. These are produced by condensation polymerization.

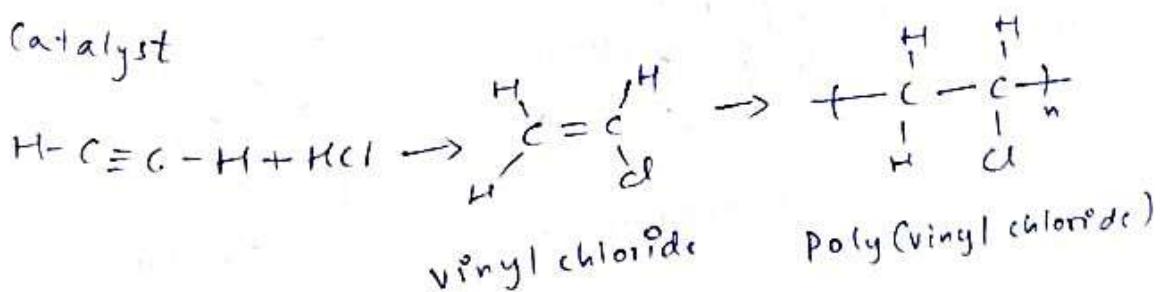
- 2. The resins are made of long chains attached by weak van der waal's force of attraction
  - 3. On heating they soften & on cooling become stiff. Chemical nature won't change.
  - 4. They can be remoulded.
  - 5. Scrap (waste product) can be used.
  - 6. The resins are soft, weak and less brittle.
  - 7. They are easily soluble in some organic substances.
  - 8. Eg:- PVC, Polyethylene etc.
  - 9. Contain long chain polymer with no cross linkage.
  - 2. The resins have three dimensional network structure connected bonds.
  - 3. On heating they become stiff & hard. No change on cooling. Chemical nature changes.
  - 4. They cannot be remoulded bcoz once set means they <sup>are</sup> permanently set.
  - 5. Scrap cannot be used.
  - 6. The resins are usually hard, strong, tough & more brittle.
  - 7. Resins are not soluble in organic solvents.
  - 8. Eg:- Nylon, Bakelite etc.
  - 9. They have 3D network structure.

## 1) Poly vinyl chloride (PVC)

## Preparation:

The monomer used for the manufacture of PVC is vinyl chloride. Vinyl chloride is prepared by treating acetylene with HCl at 60-80°C and in presence of a metal oxide.

## Catalyst



## Properties and uses :-

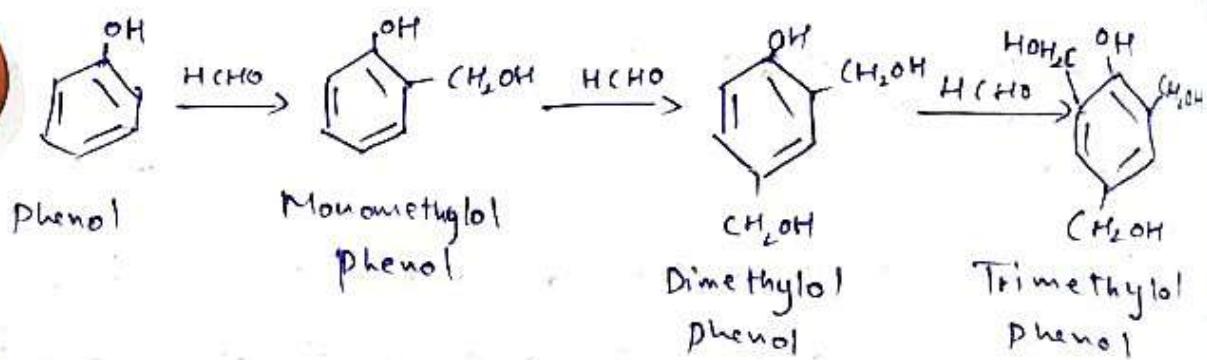
Step 2

- Rigid PVC: (unplasticized PVC) - It is chemically inert & non-inflammable powder having a high softening point of 140°.
- This PVC is used for making safety helmets, refrigerators, components, tyres, cycles & motor cycle mud guards.
- Plasticizers PVC: It is produced by mixing plasticizers like diisobutyl phthalate with PVC resin uniformly.
- It is used for making rain coats, table-cloths, handbags, curtains & electrical insulators, radio, T.V. components, All purpose shoes for beach wear.

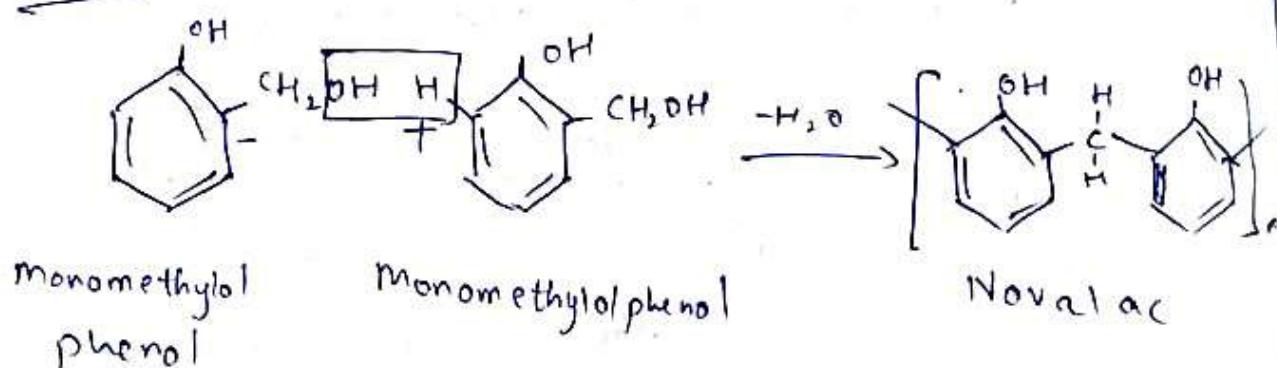
## (2) Bakelite :-

### Preparation:

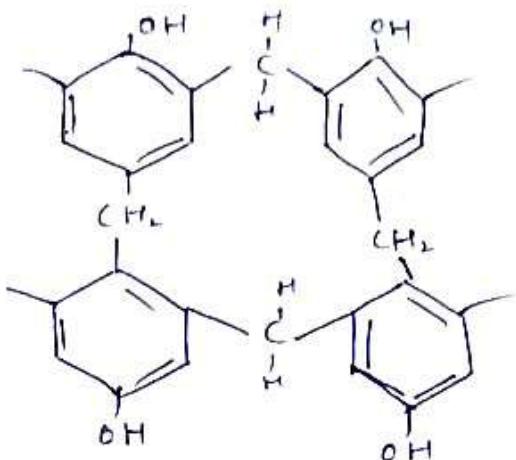
Step 1: Bakelite is the commercial name for the polymer obtained by the polymerization of Phenol & formaldehyde.



Step 2:



Step 3: When novolac resin is further heated in presence of HCHO producer i.e hexamethylenediamine (crossing agent) a cross linked polymer Bakelite can be obtained.



Bakelite.

### Properties of Bakelite:

1. It can be quickly molded.
2. Bakelite moldings are heat-resistant and scratch-resistant.
3. They are also resistant to several destructive solvents.

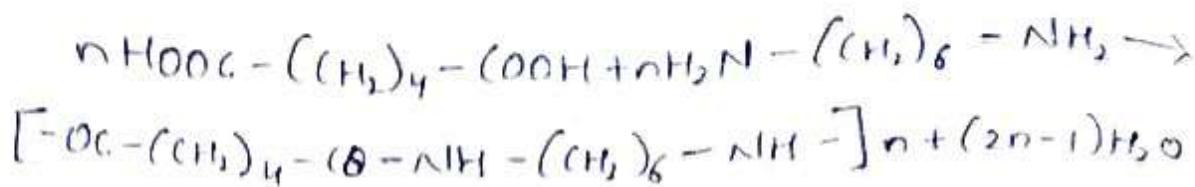
### Uses:

1. It is used for making electric insulator parts like switches, plugs, switch boards etc.
2. for making moulded articles like telephone parts cabinet of radio and television.
3. As an anion exchanger in water purification by ion exchange method in boilers.

### (3) Nylon-6,6

#### Preparation:

It is prepared by condensation polymerization of adipic acid and hexamethylene diamine in the absence of air.



### Properties:

1. High mechanical strength
2. High toughness, stiffness & hardness
3. Good electrical insulating properties
4. No resistance to UV rays
5. Light weight and sometimes used in place of metals

### Uses or Application:

1. The major application is in textile industry
2. Flexible Tubings for conveying petrol etc. are made from nylon.
3. Nylon 6 is used for making Tie cords

## Elastomers - Processing Of Natural rubbers:

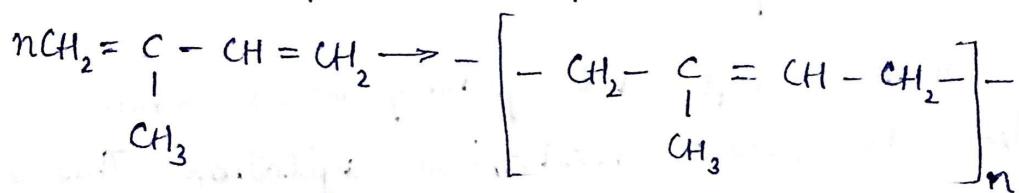
### Introduction:

Rubbers also known as elastomers, they are high polymers, which have elastic properties in excess of 300%.

### Natural rubber:

Natural rubber is a high molecular weight hydrocarbon polymer represented by the formula  $(C_5H_8)_x$

It is obtained from a milk emulsion called latex by tapping the bark of the tree "Hevea Brasiliensis". It is a polymer of isoprene units.



Isoprene

Natural rubber

[2-methyl butadiene]

[poly isoprene]

→ The polymer chain of natural rubber is made of 2000 to 3000 monomer units.

### Processing Of natural rubber:

- By cutting the bark of rubber tree the milky colloidal rubber milk is obtained.
- The main constituent of rubber latex is 25-45% of rubber and the remaining are water, protein and resinous materials.

- The rubber latex is coagulated by using 5% acetic acid and made in to sheets
- The rubber sheets are cured under mild heat and then subjected to further processing.

### Stage 2: Crepe rubber:

- To the rubber latex a small amount of sodium bisulphite is added to bleach the colour and feed in to roller which produce 1mm or more thickness sheets which are dried in air at about 40-50°C.
- The dried thin sheet of rubber are known as "smoked crepe rubber".

### Mastication: → step-3:

Rubber becomes soft and gummy mass when subjected to severe mechanical agitation. This is known as mastication.

- Mastication followed by the addition of certain chemical (compounding) which is carried out on roll mills or internal mixers
- After mastication is complete, the rubber mix is prepared for Vulcanization

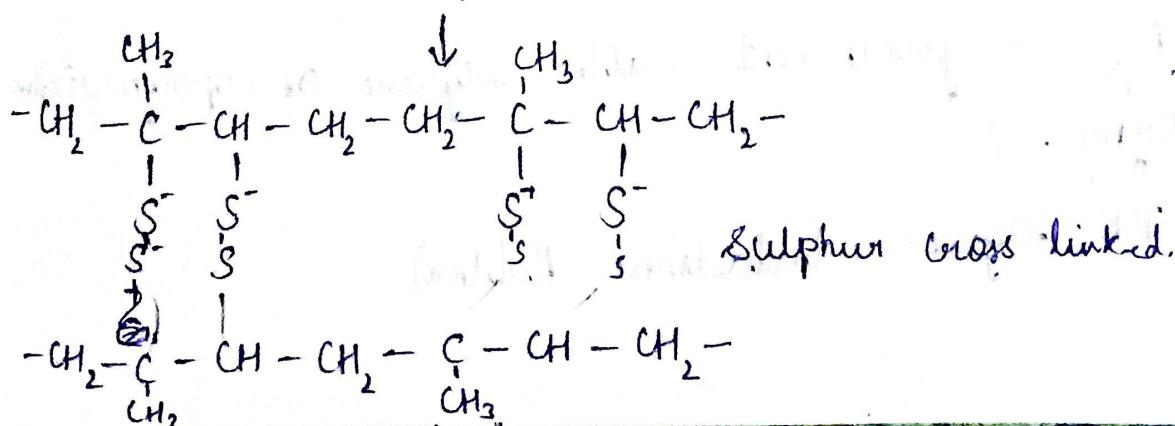
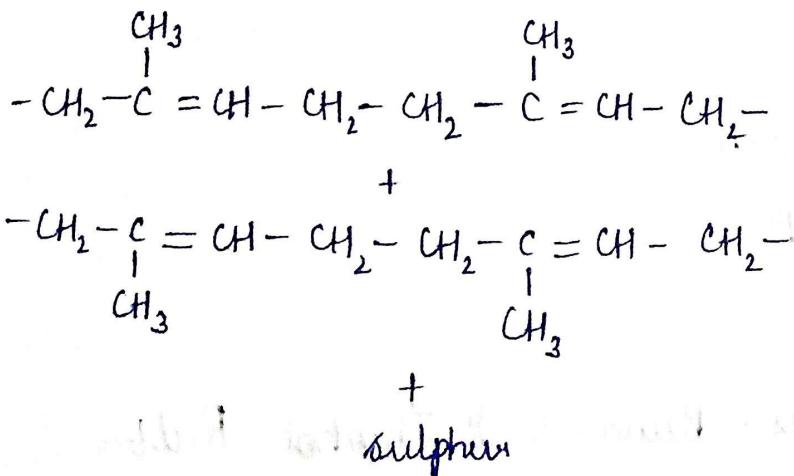
### Drawbacks of Natural Rubber:

- Soft and gummy in summer. [temp rises]
- hard and brightened in winter [temp down]
- It is easily react with all chemicals

## Vulcanization:

Vulcanization process discovered by Charles Goodyear in 1839. It consists of heating the raw rubber at  $100-140^{\circ}\text{C}$ . with sulphur <sup>and zinc</sup>.

- The <sup>combine</sup> chemically at the double bonds of different rubber sprung and provides cross linking between the chains.
  - This cross linking during vulcanization brings about a stiffening of rubber by anchoring and consequently preventing intermolecular movement of rubber springs
  - The amount of stiff sulphur added determines the extent of stiffness of vulcanized rubber.
  - For eg: ~~which~~ ordinary rubber (say for battery use) may contain as much as 30% sulphur.



## Advantages:

- The tensile strength increase
- To vulcanized rubber has excellent resilience
- It has only slight thickness
- It has low elasticity
- It is resistance to organic solvents like  $C_{Cl_4}$ , Benzene petrol etc.
- It has better resistance to moisture, Oxidation and abrasion.

## Applications:

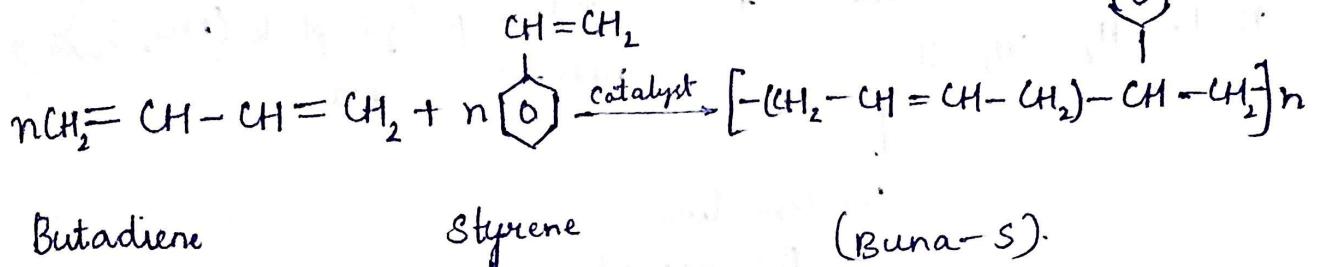
- Rubber hoses
- Shoe soles.
- Toys.
- Erasers.
- Conveyor belts.
- Shock absorbers
- Rubber - lined tanks
- Vibration dampers.
- Insulation.

## Synthetic Rubbers - Buna-S & Styrol Rubber

- ① GRS → government rubber styrene or copolymerization  
    ↑(or)  
    Buna - S
- ② SBR (styrene butadiene rubber).

## Preparation of Buna-S

It is a random copolymer formed by the emulsion polymerization of a mixture of 1.3 butadiene and styrene in the presence of peroxide catalyst at  $5^{\circ}\text{C}$  and therefore the product is called as cold rubber.



## Properties Of Burn-s

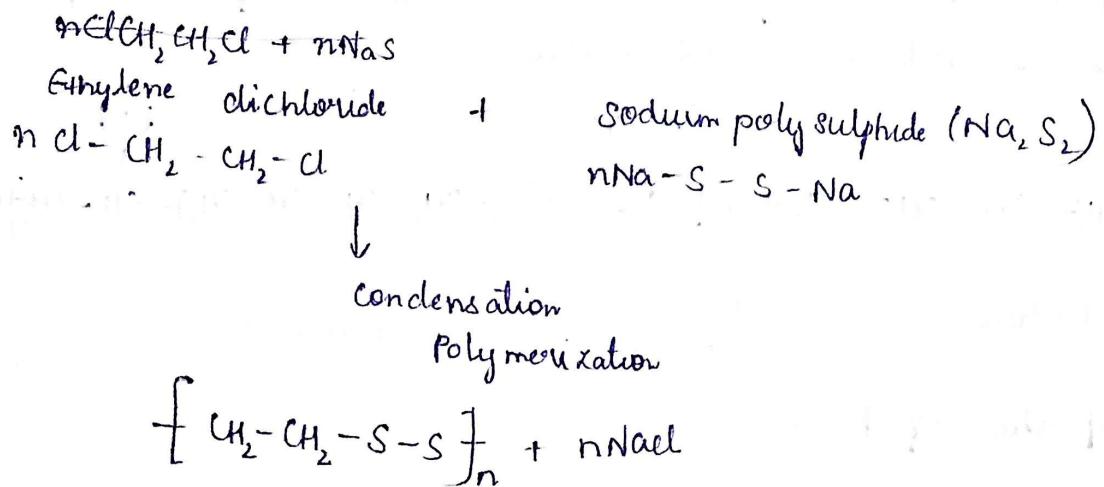
- It is a strong & tough polymer.
  - The rubber var. It is a good electrical insulator
  - It possess excellent abrasion resistance.
  - It posses high load bearing capacity and resilience.

## Applications Of Buena - S:

- Major application of styrene rubber is in manufacture of tyres
  - It is used in foot wear industry for making shoe soles and footwear components
  - It is also for making wires and cable insulators
  - It is also used for the production of floor tiles, tank linings in chemical industries

## Preparation Of Thiokol rubber or polysulphide rubber.

Thiokol is prepared by the condensation polymerization of sodium poly sulphide ( $\text{Na}_2\text{S}_x$ ) and ethylene dichloride ( $\text{ClCH}_2\text{CH}_2\text{Cl}$ )



## Properties Of Thiokol rubber

- It is resistant to the action of oxygen and ozone
- It is also resistant to the action of petrol, lubricants and organic solvents
- Thiokol's outstanding resistance to swelling by organic solvents but benzene and its derivatives cause some swelling.
- Thiokol films are impermeable to gases to a large extent

## Applications of Thiokol rubber.

- Fabrics coated with thiokol are used for barrage balloons
- It is mainly used as solid propellant fuel

for rocket  
 → It is a cable line  
 → It is a Biodegradable  
Definition:  
 \* Biodegrading  
 being  
 of box  
 degradation  
 Introduct  
 \* Those  
 action  
 bacteria  
 The base  
 \* Fine pr  
 \* Capable  
 \* until  
 degrad  
 Types:  
 (a) Natur  
 \* There  
 biodegr  
 (i) polysac  
 ed.

Uses: for rocket

- It is also used for making gaskets, hoses, cable linings, tank linings etc.
- It is also used for painting walls.

### Biodegradable polymers:

#### Definition:

\* Biodegradability is defined as the ability of being chemical transformation by enzymatic action of bacteria which are capable of further degradation.

#### Introduction:

\* Those polymers which degrade for by enzymatic action of naturally occurring micro organisms and bacteria are called biodegradable polymers.

The basic requirements of biodegradable polymers.

- \* The production of non-toxic products
- \* Capable of maintaining good mechanical integrity until degradation and controlled rates of degradation.

#### Types:

(a) Naturally occurring Biodegradable polymers.

\* There are four groups of naturally occurring biodegradable polymers.

(i) polysaccharides.

Ex: Starch and Cellulose

(2) proteins

Ex: Gelatin, Casein, silk, wool.

(3) polyesters

Ex: polyhydroxy alcanoates

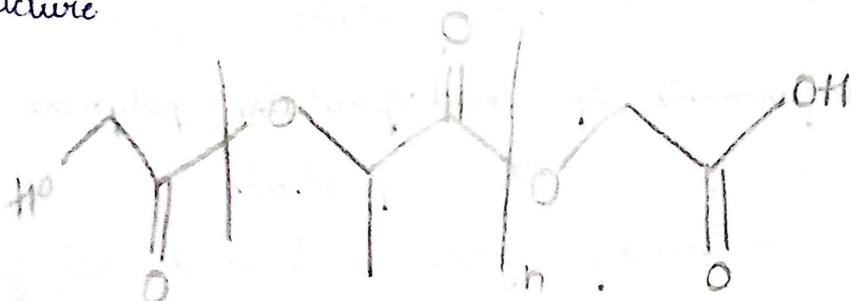
(4) others

Ex: lignin, Shellac, natural rubber etc.

(b) Synthetic biodegradable polymers:

i) Poly lactic acid / Poly actide (PLA):

This is a biodegradable thermoplastic Polyester belonging to the class of poly hydroxy alcanoates. derived from renewable sources such as starch, tapioca or, sugar cane, possess the following structure



Polyacetic acid / polyactide (PLA)

Properties:

- \* The glass transition temp of PLA is 60-65°C
- \* PLA posses melting point 173-178°C.
- \* PLA is chiral compound existing as polyacetic acid (PLLA)

## Applications

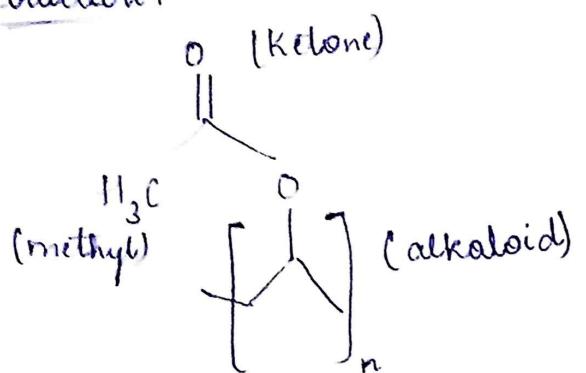
- \* PLA is widely used for making medical implants like anchor, screws, pins, mesh etc
  - \* For making compostable packing material, disposable garments, food packing etc

## 2) poly Vinyl acetate (PVA):

## Polymer Preparation

Polyvinyl acetate is a water soluble and biodegradable polymer, possessing excellent mechanical properties and compatibility with starch.

## Structure:



## Properties.

- \* It belongs to the class of Vinyl polymers
  - \* It is water soluble
  - \* possess excellent mechanical properties
  - \* It is compatible with starch i.e. starch mole can be introduced into the backbone for quick biodegradability.

### Application:

- \* polyvinyl acetate is used in food industry as a packing material, food storage and catering, mailing.