UNIT I: POLYMER TECHNOLOGY

[Polymerisation:- Introduction, methods of polymerization (emulsion and suspension), mechanical properties.

Plastics: Compounding, fabrication (compression, injection, blown film and extrusion), preparation, properties and applications (PVC, polycarbonates and Bakelite), mention some examples of plastic materials used in electronic gadgets, recycling of e-plastic waste (waste towealth).

Elastomers:- Introduction, preparation, properties and applications (Buna S, thiokol and polyurethanes).

Composite materials: Fiber reinforced plastics, conducting polymers, biodegradable polymers, biopolymers, biomedical polymers.

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Introduction:

Polymer: Polymers are large molecules made up of many smaller molecules. 'Poly' means many and 'mer' means units.

Monomers: Small molecules of low molecular weight, which combine to give a polymer, are called monomers.

(mono = one, mer = unit) monomers are joined together through polymerisation to form polymers. A polymer contains hundreds of thousands of monomers.

Homo polymer: a polymer, in which a single type of monomer is used, is called homo polymer.

Examples : Polythene, polystyrene, Polyvinylchloride etc.

Copolymer: A polymer in which the monomers are more than one type is called copolymer (heteropolymer).

Examples : Buna-S is a copolymer of 1,3- butadiene and styrene.
Bakelite is a copolymer of phenol and formaldehyde.

Degree of polymerization:

The number of repeating units (or) monomer units available in the polymer is known as degree of polymerization. Polymers with a high degree of polymersation are called High polymers.

Polymers with low degree of polymerization are called Oligo polymers

Functionality:

The number of bonding sites (or) reactive sites (or) functional groups present in the monomer is called functionality.

When the functionality of monomer is two; it is bifunctional and Linear straight chain polymer is formed.

Examples for bifunctional monomers: a) ethylene b) styrene c) vinyl chloride d) vinyl cyanide.

When the functionality of monomer is three; it is tri-functional and three- dimensional net work polymer is formed.

Ex: phenol, glycerol.

when a trifunctional monomer is mixed in small amounts with a bifunctional monomer, a branched chain polymer is formed.

Classification of polymers: Based on their sources they are classified into;

1)Natural polymers: The polymers, which are obtained from natural sources such as plants and animals, are called natural polymers. Eg: Wood, starch, cellulose, Jute, Cotton, Wool, Silk, Proteins, Natural rubber etc.

2)Synthetic polymers: These are synthesized with the help of chemicals in industries

E.g.: polythene, nylon-6, 6, synthetic rubber etc.

3)Semi synthetic polymers: These are the synthetic derivatives of the natural polymers.

E.g.: Cellulose acetate (Rayon) and cellulose nitrate.

Classification based on structure:

a) Linear Polymers: These polymers consist of long and straight chains.

b) Branched chain polymers: These polymers contain linear chains having some branches.

c) Cross linked polymers (or) 3- dimensional network polymers:

Classification Based on Composition of Polymers: [1] Homopolymer [2] Copolymer

Classification Based on Backbone of the polymer chain: [1] Organic polymer [2] Inorganic Polymers.

A polymer whose backbone chain is essentially made of carbon atoms is termed as organic polymer.

If chain backbone contains no carbon atom is called inorganic polymer. Glass and silicone rubber are examples.

Polymerisation: The process of formation of polymers from respective monomers is termed as Polymerization.

Addition polymerization: During the polymerization process, if the polymer is formed **without loss** of small molecules like water, ammonia etc; then this type of polymerization is called Addition polymerization. It is also known as Chain polymerization. Ex: Polyethylene (PE); Polystyrene (PS); Polyvinylchloride (PVC), Neoprene etc.

Condensation polymerization: During the polymerization process, if the polymer is formed **with loss** of small molecules like water, ammonia etc; then this type of polymerization is called condensation polymerization. It is also known as Step polymerization. Ex: Polycarbonates, Thiokol, Nylon-6,6, Terylene and Bakelite etc.

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- **Write about emulsion polymerization and suspension polymerisation method. Give its advantages. (or) Explain the Methods of Polymerization (or) Technology of Polymerization?**

1) Suspension (Bead or Pearl) polymerization:
This polymerization occurs in heterogeneous system. The water insoluble monomer is suspended in water as tiny droplets by continuous agitation. The droplets are prevented from coalescing by using small quantities of water- soluble polymers such as polyvinyl alcohol or colloids. The polymerization is made to occur in each droplet of the monomer using a catalyst. The reaction mass is heated to initiate the polymerization. After the completion of polymerization pearl like polydispersed polymer mixture is obtained.

Advantages:

1. The viscosity build up of polymer is negligible.
2. Isolation of product is easy as it needs only filtration and washing.
3. High purity products.
4. The process is more economical since water is used.
5. Isolated products need no further purification.
6. Efficient thermal control.

Disadvantages:

1. This method is applicable only for water insoluble monomers.
2. It is difficult to control particle size.

Application: This technique is used for the production of polyvinyl acetate, poly styrene, styrene-divinyl benzene etc.

2) Emulsion polymerization: In this method emulsion of water insoluble monomer and water is prepared and is stabilized by the addition of surface acting agents (surfactants) such as soap. Polymerization is initiated by the addition of water-soluble initiator such as potassium persulphate. After adding the initiator, the system is kept agitated in the absence of oxygen at 70^{o}c.

Mechanism: The surfactant has hydrophilic head and hydrophobic tail. The water- soluble initiator links to the hydrophilic end whereas the monomer is linked to the hydrophobic end. At a little higher concentration it gets dispersed. When the concentration of surfactant exceeds critical micelle concentration (cmc), the soap molecule form micelle (aggregation of 50-100 molecules) oriented with tails inwards and head outwards. Now, an initiator molecule at the polar end diffuses into the micelle to initiate the polymerization process. As the polymerization progresses, there will be depletion in the number of monomers within the micelle. They are replenished by the medium. This continues till the polymer formed is big enough to come out, the process is terminated by combination. The pure polymer is isolated from the emulsion by the addition of de-emulsifier.

Advantages:

1. The rate of polymerization is high.
2. Easy heat control.
3. A very high molecular weight polymer is obtained.

4. Molecular weight control is possible.
5. Viscosity build up is low.

Disadvantages: Polymer needs purification.

Application: This method is used for the production of PVC, Poly vinyl acetate etc.

❖ Explain the Mechanical properties of Polymers?

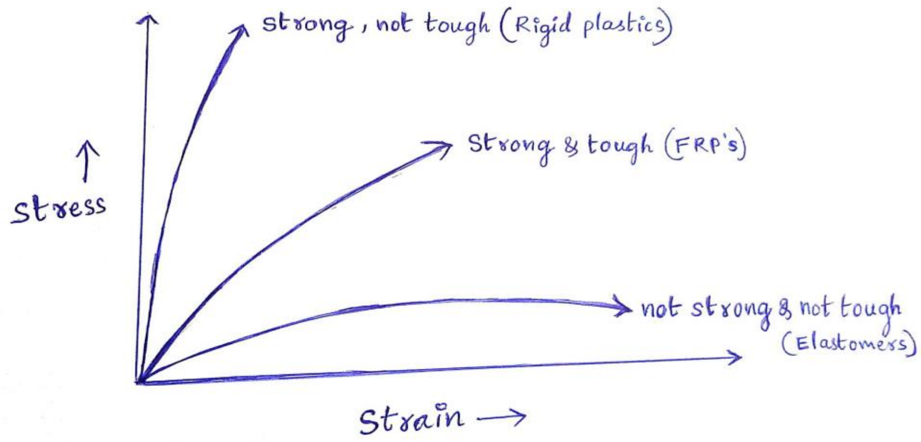
Mechanical properties of Polymers:

- **1.Strength:**
  - ✓ Strength of the polymer depends upon the intermolecular attractive forces.
  - ✓ Greater is the attractive forces; higher is the strength of the polymer.
  - ✓ Strength of the polymer increases with increasing molecular weight of the polymer or increasing polar groups such as –OH, -COOH, -OCH_3, -COOR & -X.
  - ✓ So, the lower molecular weight polymers have less strength, soft and gummy.
  - ✓ In cross linked polymers, the polymer chains are strongly linked to each other by covalent bonds which cause higher strength, toughness, brittleness etc.
  - ✓ Strength of the polymer depends on the shape of the molecule also.
  - ✓ If the shape of the molecule is simple and uniform, polymer molecule has less strength.
  - ✓ Ex: In PVC, large Cl atoms are present on alternative carbon atoms in the polymer.
  - ✓ These Cl atoms and strong attractive forces restrict the movement of molecules in the polymer.
  - ✓ So, PVC is tougher and stronger polymer.
  - ✓ In poly ethylene attractive forces are weak due to simple structure. Thus, PE is weaker than PVC.
- **2.Elastic character:**
  - ✓ Rubber is an elastomer, when applied stress is removed; the polymer gets original shape in case of elastomers.
  - ✓ In an elastomer, polymer chains are randomly arranged, coiled chains with slight cross links.
  - ✓ When the polymer is stretched, the cross links begin to disentangle and straight out.
  - ✓ As a result, chains are regularly arranged which cause hardness, stiffness and crystallinity due to increase of the attractive forces between the chains.
- **3.Plastic deformation:**
  - ✓ This is found in thermoplastics.
  - ✓ In thermoplastics, polymer chains are close to each other with weak attractive forces.
  - ✓ On applying heat or pressure or both, these forces become weak and the polymer chains start moving over each other.
  - ✓ This results in attaining desired shape by passing the material into the mould.
  - ✓ On further cooling, the attractive forces are restabilised and the shape of the material is fixed.
  - ✓ Incase of thermosetting polymers, shape of the plastic material cann't be changed by applying heat or pressure.
  - ✓ Because the polymer chains are strongly held together by strong covalent cross linkages and there is no movement of polymer chains.
- **4.Structure and electrical properties:**
  - ✓ Most of the plastic materials are good insulators.
  - ✓ They are able to withstand to very small current.
  - ✓ The insulating property will breakdown in a sufficiently strong field.
  - ✓ In non polar polymers, only electronic polarization is responsible for dielectric constant.
  - ✓ Dielectric strength is defined as the electric strength which an insulating material can withstand.
  - ✓ In polar polymers, both electronic as well as dipole polarization contribute towards overall dielectric constant.

5.Heat effect on polymers:

- Heat greatly affects the properties of polymers.
- Amorphous polymers do not possess sharp melting points.
- At very low temperature, the amorphous material exists as glassy materials, which have lack of mobility in polymer molecules.
- If the polymer is heated, it eventually becomes soft and flexible.
- This happens only at the glass transition temperature.

MECHANICAL PROPERTIES



PLASTICS:

The word plastic itself comes from the Greek word plasticos, which means to be able to be shaped or moulded by heat.

Advantages of plastics over other traditional materials (like wood, metals, glass etc):

1) Plastics are available in attractive colours.
2) They do not undergo corrosion.
3) They are not affected by insects.
4) They are light in weight
5) They are cheap.
6) They can be moulded into any shape easily.
7) They are chemically inert.
8) They have good abrasion resistance.
9) They are good insulators of heat and electricity.

Disadvantages:

1. Recycling of plastic is a costly process.
2. Plastic undergo biodegradation after long time.
3. Incineration of plastic causes pollution.
4. Plastics are derived from petrochemicals and their production causes environmental pollution.
5. Plastics are low heat resistance and brittle. They undergo deformation at low temperatures.

Differences between Thermo Plastics &Thermo Setting plastics :

S.no	THERMOPLASTIC RESINS	THERMOSET RESINS
1.	These resins become soft on heating and rigid on cooling.	During fabrication process these resins are moulded. Once moulded or shapened, they can not be softened.
2.	Thermoplastic resins are formed by chain polymerisation.	Thermoset resins are formed by step polymerisation.
3.	They can be reshaped.	They cannot be reshaped
4.	These plastics can be reclaimed from waste.	They cannot be reclaimed from waste.
5.	Thermoplastic resins are soft, weak and less brittle.	Thermoset resins are hard, strong and more brittle.
6.	These resins are usually soluble in organic solvents. Eg: Polyethylene, polyvinyl chloride etc.	Due to strong bonds and cross links, they are insoluble in almost all organic solvents. Eg: Bakelite, Nylon etc.

Explain the compounding of plastics with suitable examples?

Definition: "The process of mechanical mixing of various additives with polymers to impart some special properties to the end product is known as compounding of plastics". The additives get incorporated into the polymer to give a homogeneous mixture.

The principal additives used in compounding are; 1) Binders or Resins 2)Plasticizers 3)Fillers 4)Lubricants 5)Activators or accelerators 6)Stabilisers 7)Colourants

1) Binders or Resins:

Resin is the binder which holds the other constituents of the plastics together and it is the major constituent.

The binders used may be natural or synthetic resins with very high molecular mass. They undergo condensation and polymerization during moulding of plastics. The resin gives the desired properties like plasticity and electrical insulating properties to the plastic.

2) Plasticizers:

These are materials which are added to resins to increase their plasticity and flexibility.

commonly used plasticizers are tributyl phosphate, triphenyl phosphate, diiso-octyl phthalate, dibutyl phthalate etc.

3) Fillers:

Fillers are inert materials add to plastic to increase the bulk and there by to reduce the cost of production.

and also to impart certain specific properties to the finished product.

Commonly used fillers are mica, silica, graphite, carbon-black (C-black), chalk, china clay, clay, wood flavour etc.

4) Lubricants:

Lubricants such as oils, waxes, stearates, soaps etc help in easy moulding and give better glossy finish.

Prevent moulded article from sticking to the fabrication equipment.

5) Catalyst or Accelerators:

These are used in the case of thermosettings plastics to accelerate the condensation polymerization to form the linked products.

Examples , benzoyl peroxide, H_2O_2 , metals like Ag, Cu, Pb etc

6) Stabilizers:

- ★ Many plastics undergo thermal (or) photo chemical degradation during their processing (or) when they are put into use.
- ★ Stabilizers protect the plastic from such degradation.
- ★ Natural rubber, PE, esters undergo such degradation.
- ★ Examples : PbO, lead silicate, , lead chromate, stearates of Pb & Ba etc

These are substances added to plastic to improve the thermal stability during moulding.

7)Colourants :

- ★ These are inorganic (or) organic pigments used to impart pleasing colours to the plastic.
- ★ They don't cause any influence on other properties.
- ★ Ex; Carbon black, anthraquinones, azodyes, phthalocyamines, $BaSO_4$, TiO_2, $PbCrO_4$, Fe_2O_3, Zinc chromate ,Organic dyestuff, opaque inorganic pigments.

Methods of Fabrication of plastics: [or] methods of moulding of plastics: [or] Fabrication Techniques:

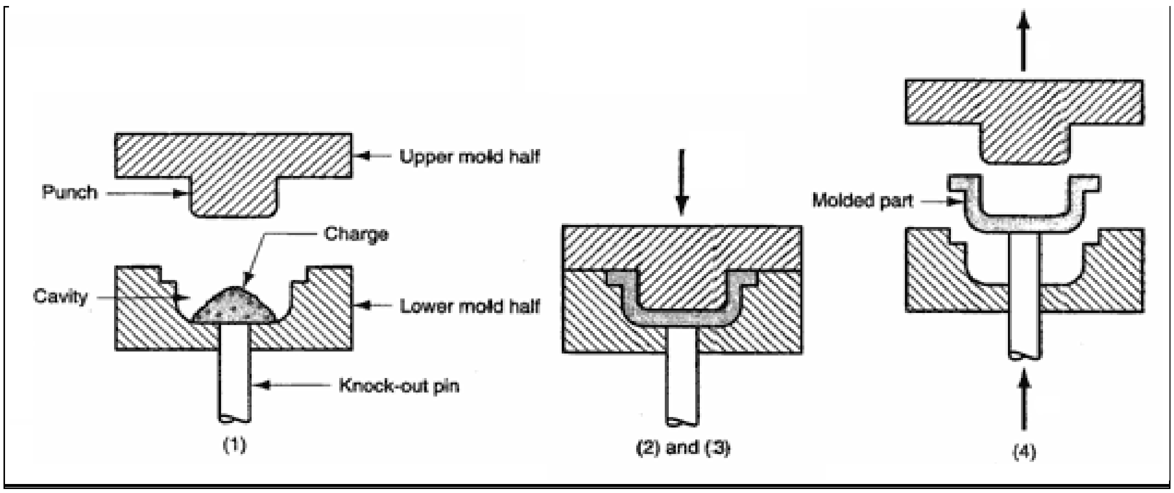
The process of converting the given polymeric material into suitable designs is called moulding.

The different moulding methods used are

a) Compression moulding b) Injection moulding c) Blow film

d) Extrusion moulding

<u>Compression moulding:</u>

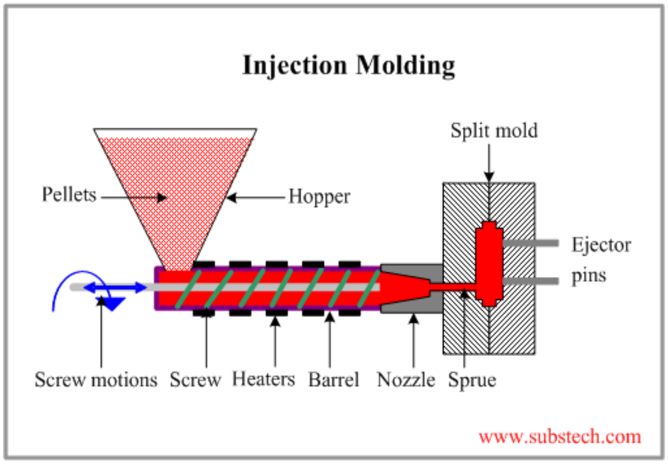


- ❖ Compression moulding method is applied to both thermoplastics and thermosettings plastics.
- ❖ Compression moulding is one of the oldest manufacturing technologies associated with plastics.
- ❖ The mould consists of two halves, the upper half and the lower half.
- ❖ The lower half contains a cavity and the upper half has a projection.
- ❖ The required amount of a compounded mixture is placed in the cavity in the lower half and the mould is closed carefully.
- ❖ The gap between the projected upper half and the cavity in the lower half gives the shape of the moulded article.
- ❖ The time given to polymer to set in the mould is called curing.
- ❖ Curing is done either by heating as in the case of thermosetting or cooling as in the case of thermoplastics.
- ❖ After curing, the moulded article is taken out by opening the mould parts.Now a days fully automatic compression moulding presses are available.

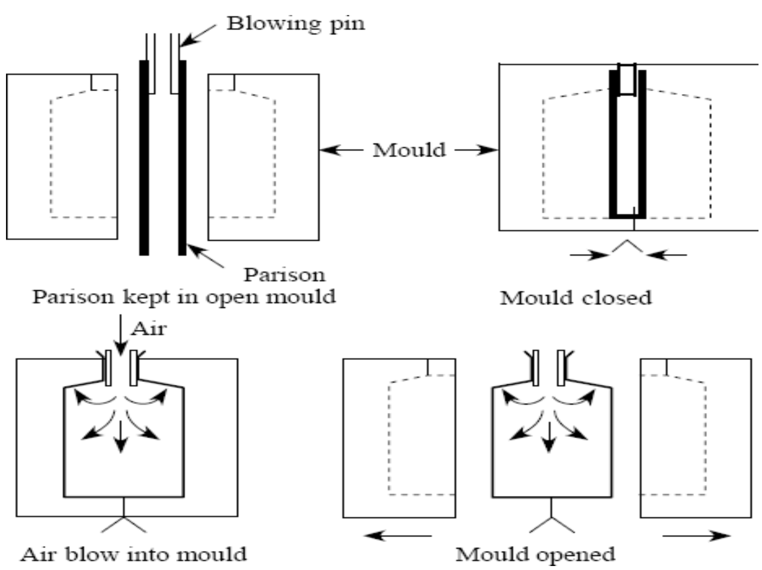
<u>Injection moulding:</u>

- ❖ Injection moulding method is mainly used for thermoplastic resins.
- ❖ This process is one of the most common of all plastics manufacturing processes.
- ❖ The compounded mixture in the form of a powder (or) pellet is fed into the heated cylinder of the injection moulding machine.

- The softened plastic mass in the cylinder is injected at a controlled rate by a screw (or) piston under high pressure into a cold mould.
- Curing of the softened plastic into rigid product occurs during cooling in the mould.
- The mould is opened after sufficient curing to remove the finished product.
- Thermosetting polymer can't be moulded by this method.

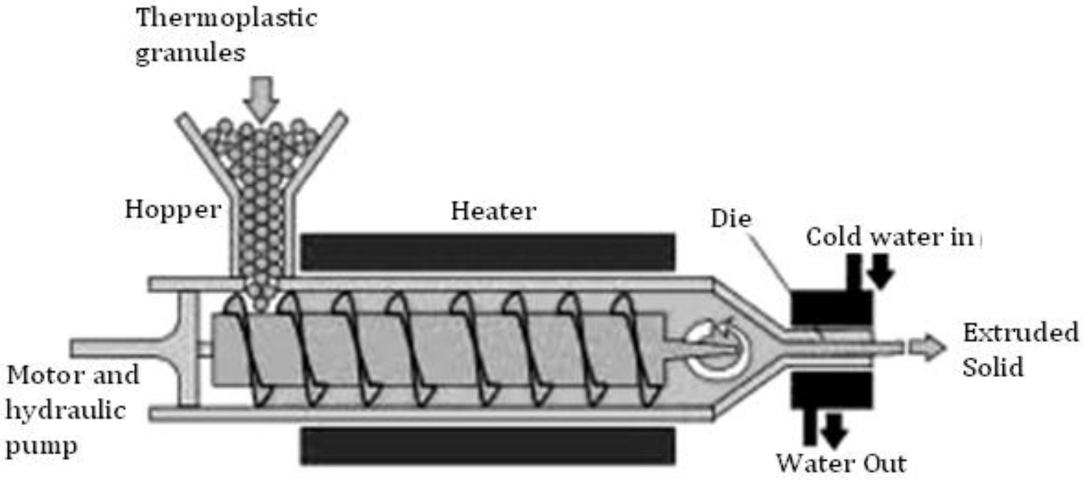


2. Blow Moulding: Blow moulding produces hollow plastic materials like bottles, tubes, tanks and drums. Thermoplastic materials like PVC, polysty- rene, polypropylene can be blow moulded.
In this process a tube is placed inside a two piece hollow mould. One end of the tube is completely closed in heated and simultaneously air is blown to fabricate the product having the shape of mould



Extrusion moulding:

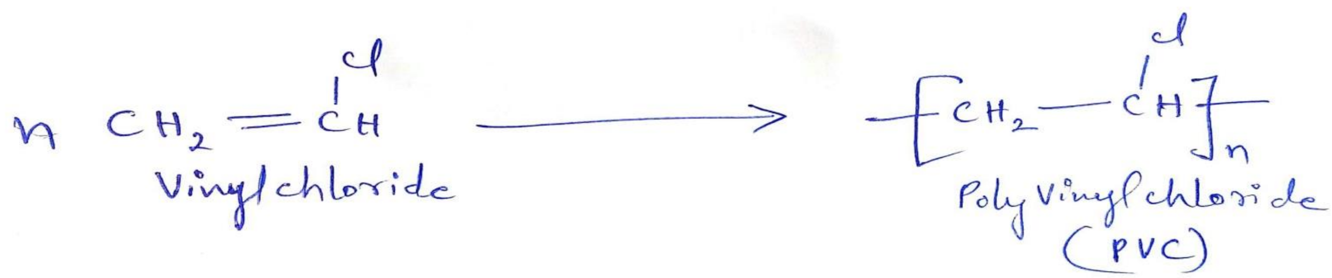
- Extrusion moulding method is used for thermoplastic resins
- This method is used to produce continuous sheets, rods, threads, tubes, cords and cables.
- It is similar to injection moulding.
- Dry plastic material is placed into heated injection chamber.
- At the end of the chamber, the material is forced out of a small ring opening (or) a die in the shape of the desired finished product.
- Extruded out plastic is placed on a moving conveyor belt for uniform cooling.



Write preparation, properties and applications of i) PVC. ii) Polycarbonates. iii)Bakelite.

i)PVC (Poly vinyl chloride):

Preparation: Poly vinyl chloride is produced by heating vinyl chloride in presence of benzyl peroxide or H2O2.



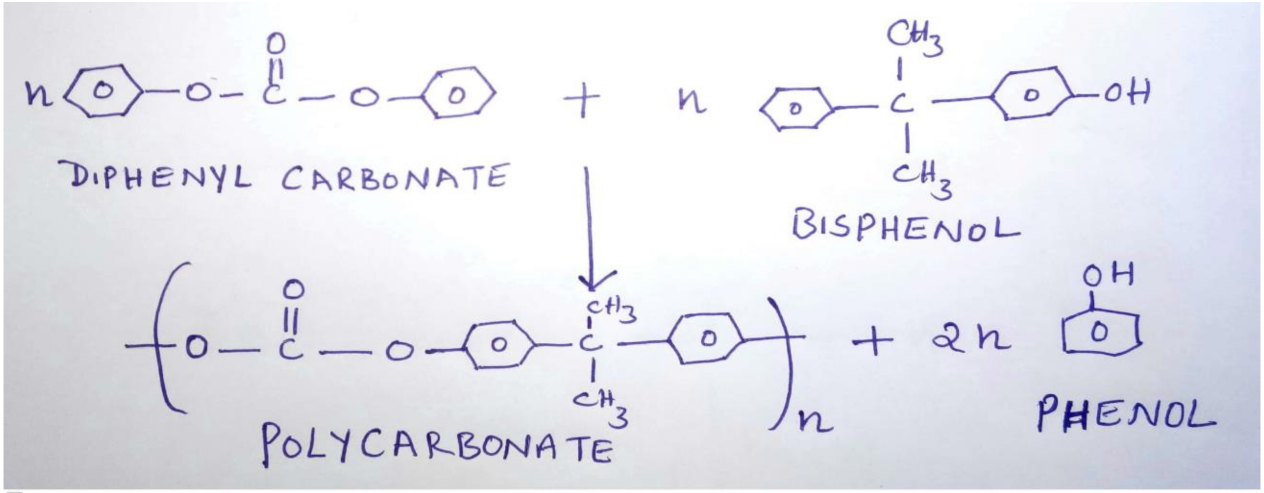
Properties: PVC is colourless, odourless, non-inflammable and chemically inert powder. Pure resin possesses greater stiffness and rigidity compared to poly ethylene. It is brittle in nature.

Applications: or Uses:

1. P.V.C is mainly used as an insulating material.
2. It is used for making table clothes, rain coats, toys, tool handles, radio components, etc.
3. It is used for making pipes, hoses, etc.
4. It is used for making helmets, refrigerator components, etc.
5. It is used in making cycle and automobile parts.

ii) Polycarbonates:

Preparation:



Properties:
1. High melting points
2. Tensile strength and impact resistance.
3. It has excellent mechanical properties.
4. It is soluble in acids and alkali.

Uses: The polymer is used in the manufacture of safety goggles, telephone parts, automobile taillight lenses and unbreakable glazing appliances.

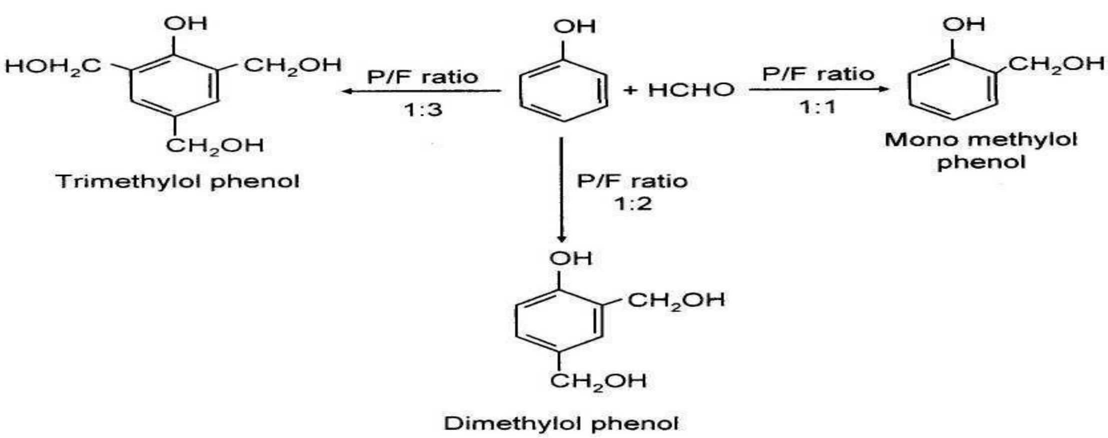
3.Phenol formaldehyde resins or Bakelite :

Bakelite is a condensation polymer of phenol and formaldehyde

Preparation :

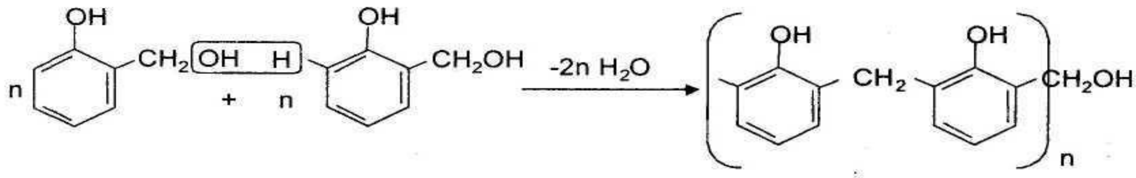
I) stage:

Phenol is made to react with formaldehyde in presence of acid / alkali to produce non - polymeric mono, di, and tri methylol phenols depending on the phenol formaldehyde ratio (P/F ratio)

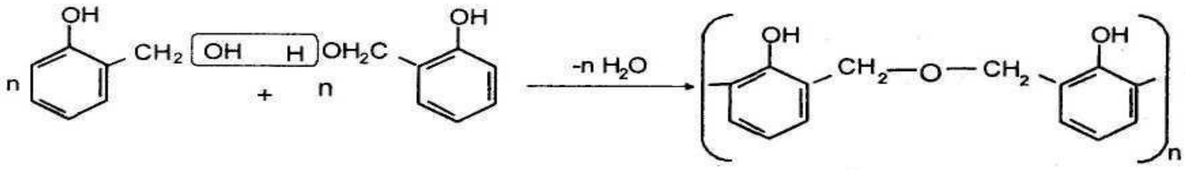


II) Stage:

The mono, di, and tri methylol phenols are heated to produce two types of straight chain resins by condensation of the methylol group with hydrogen atom of benzene ring or another methylol group.

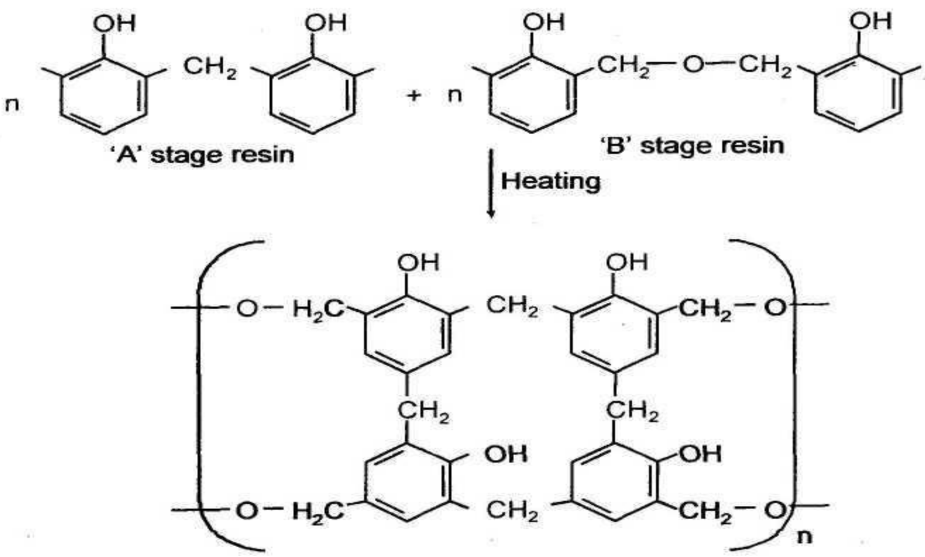


'A' stage resin/resol/Novolac



'B' stage resin/resol/Novolac

<u>III) Stage</u>: This stage of preparation includes heating of 'A' stage resin and 'B' stage resin together, which develops cross linking and bakelite plastic resin is produced.



Bakelite

<u>Properties:</u>

1. Bakelite plastic resin is hard, regid, and strong.
2. It is a scratch resistant and water resistant polymer.
3. Bakelite has got good chemical resistance, resistant to acids, salts and any organic solvents, but it is attacked by alkalis due to the presence of- OH group.
4. It is a good anion exchanging resin, exchanges - OH group with any other anion.
5. Bakelite is an excellent electrical insulator.
6. It is a very good adhesive.
7. Bakelite has very good corrosion resistance, resistant to atmospheric conditions like O2, CO2, moisture, light, U.V.radiation etc.

<u>Engineering applications:</u> Bakelite is used widely.

1. For making electrical insulator parts like switches, switch boards, heater handles etc.
2. For making moulded articles like telephone parts, cabinets for radio and television.
3. For making tarpaulins, wood laminates and glass laminates.
4. As an anion exchanger in water purification by ion exchange method in boilers.
5. As an adhesive (binder) for grinding wheels etc.

6. In paints and varnishes.
7. For making bearings used in propeller shafts, paper industry and rolling mills.

Some examples of plastic materials used in electronic gadgets:

S.No.	Plastic materials	Uses in electronic gadgets
1	Phenol formaldehyde	Fuse boxes, knobs, switches, handles.
2	Polyamide	food processor bearings, adaptors.
3	Polycarbonate	Telephones.
4	Polyethylene	Cable & wire insulation.
5	Polypropylene	Kettles
6	Polystyrene	Refrigerator trays/linings, TV cabinets
7	Polysulphone	Microwave grills
8	Polytetrafluoroethene	Electrical applications.
9	Polyvinyl chloride	Cable and wire insulation, cable trunking.
10	Urea formaldehyde	Fuse boxes, knobs, switches
11	Polymethyl pentane	Circuit boards, microwave grills
12	Acrylonitrile butadiene styrene	Telephone handsets, keyboards, monitors, computer housings

Write a note on recycling of e-plastic waste.

e-plastic waste (electronic plastic waste) includes discarded electrical or electronic divices. Some examples of e plastic waste are ABS (acrylonitrile butadiene styrene), polycarbonate or PVC (polyvinyl chloride), phenol formaldehyde, polyamides etc.E-plastics are an environmental hazard, and have negative effects on human heath.

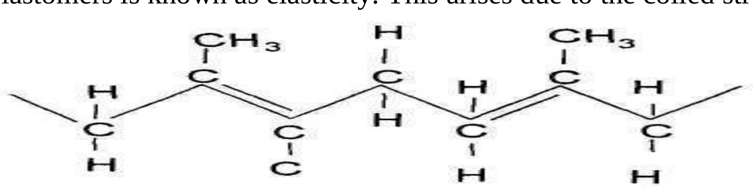
Recycling e-plastics is challenging. This is because most plastics are not truly recycled. Some plastics can be melted down and used to manufacture new items, but most kinds of plastics are not recycled in this way. Instead, many plastic recycling facilities prepare the plastic to be repurposed, or “down-cycled.” For example, a plastic milk bottle cannot be used to manufacture a new plastic milk bottle. Instead, that milk bottle can be processed and “down-cycled” in the manufacturing of plastic lumber. E-plastics are so challenging to recycle because the brominated flame retardants prevent these plastics from being down-cycled. The e-plastics that contain those banned compounds cannot be reused; they must be disposed.

When recycling e-plastics, it is especially crucial to use a certified recycler. To maintain certification, a certified recycler must make sure that, when possible, e-plastics are processed and reintegrated back into the manufacturing process. All un-usable e-plastics, like those with banned brominated flame retardants, must disposed in carefully controlled conditions in a properly equipped facility.

Because e-plastics are so difficult to recycle, a better environmental strategy for this material is to reuse electronics. Reuse slows the production of scrap e-plastics, and mitigates the need for more plastics to be manufactured. If reusing your corporate electronics is not possible within your own company, reselling or donating the equipment allows it to be reused by others.

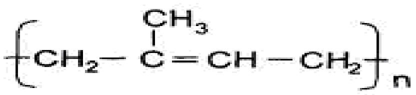
ELASTOMERS:

Definition: Elastomers are high polymers that undergo very long elongation (500 – 1000%) under stress, yet regain original size fully on released of stress. Those rubbers are therefore referred to as elastomers.
The property of elastomers is known as elasticity. This arises due to the coiled structure of elastomers.

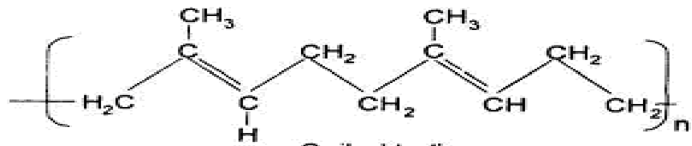


Natural rubber:

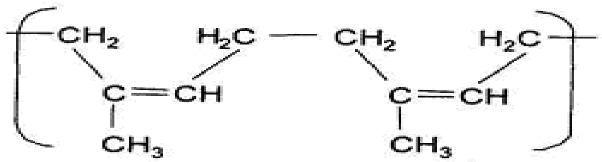
Natural rubber is found in several species of rubber trees grown in tropical countries, of these Hevea brasiliensis is the most important source of natural rubber and the rubber obtained from this is known as “Hevea” rubber. Rubber is stored in the form of white fluid called ‘latex’ behind the bark of the rubber tree.



Isoprene unit of natural rubber



Coiled helix structure of trans-polyisoprene



Structure of Cis-polyisoprene

Natural rubber is a high polymer of isoprene (2-methyl-1,3-butadiene).

Polyisoprene exists in two geometric isomers cis and trans forms.

Natural rubber is soft and has cis-configuration while ‘Guttapercha’ or, ‘Ballata’ has trans configuration.

Write preparation, properties and applications of i) Buna-S ii) Thiokol iii)PolyUrethane.

<u>BUNA-S [or] SBR,[or] GRS) Styrene Butadiene Rubber) gov. regulated styrene rubber or *Ameripol*</u>

BUNA - S is otherwise called styrene rubber or *GRS* (Government Rubber Styrene) or Ameripol.

BUNA - S stands for the composition of the monomers and catalyst.

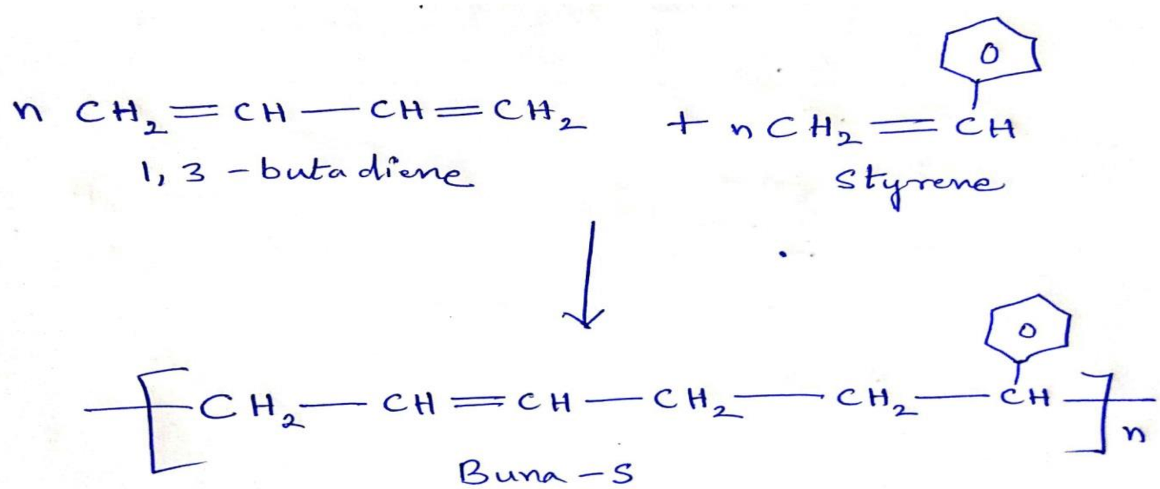
BU stands for Butadiene - monomer

NA stands for Sodium - catalyst

S stands for Styrene - monomer

Buna-S is the most important synthetic rubber it is obtained by the co-polymerization of butadiene and styrene using sodium as a catalyst.

<u>Preparation :</u>



Properties:

1. Styrene rubber is a strong and tough polymer.
2. It is vulcanised by sulphur monochloride (S2CI2) or sulphur.
3. It resembles natural rubber in processing characteristics and quality of finished products.
4. BUNA - S possess excellent abrasion resistance.
5. It is a good electrical insulator.
6. It is resistant to chemicals but swells in oils and attacked by even traces of ozone, present in the atmosphere.
7. Styrene rubber possess high load bearing capacity and resilience.

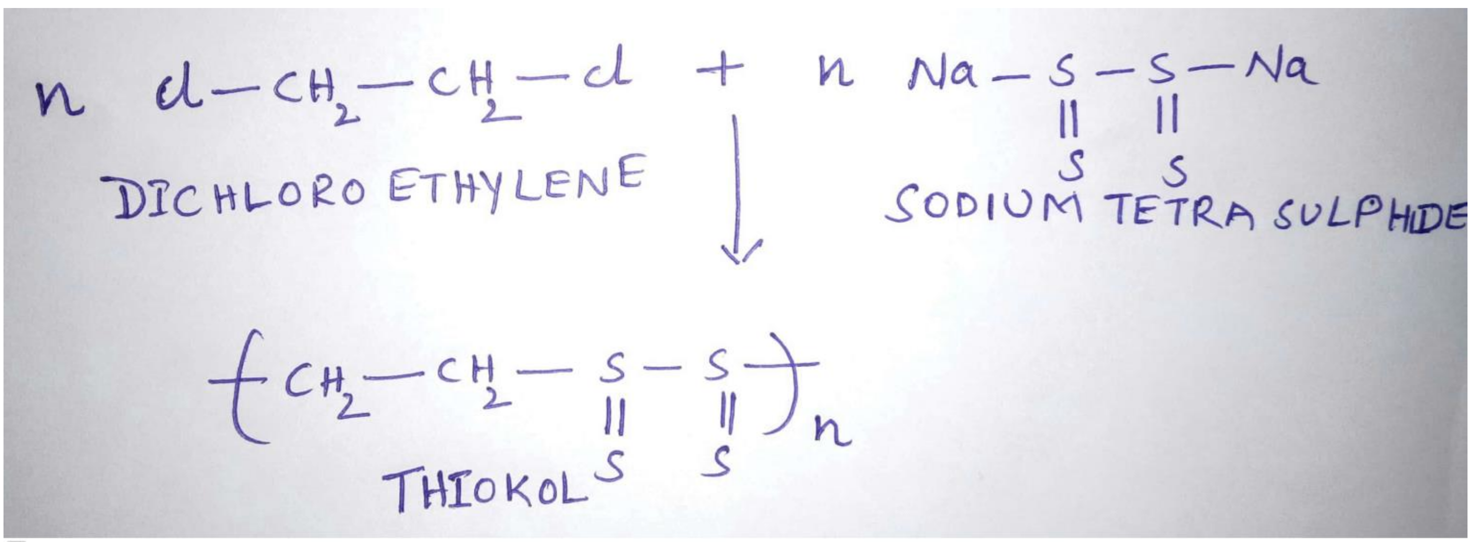
Applications:

1. Major application of styrene rubber is in the manufacture of tyres.
2. It is used in the footwear industry for making shoe soles and footwear components.
3. It is also used for making wires and cable insulations.
4. The other applications of styrene rubber are for the production of floor files, tank linings in chemical industries and as adhesives.

Thiokol (Polysulphide Rubber or GR-P):

Polysulphide rubbers are the condensation product of ethylene dichloride and sodium tetra sulphide.

Preparation :



Properties:

Thiokol rubber possess strength and impermeability to gases.

This rubber cannot be vulcanized and it cannot form hard rubber.

Possess good resistance to mineral oils,fuels,oxygen,solvents,ozone and sunlight.

It is also resistant to the action of petrol lubricants and organic solvents

Applications:

Fabrics coated with thiokol are used for barrage balloons,life rafts and jackets.

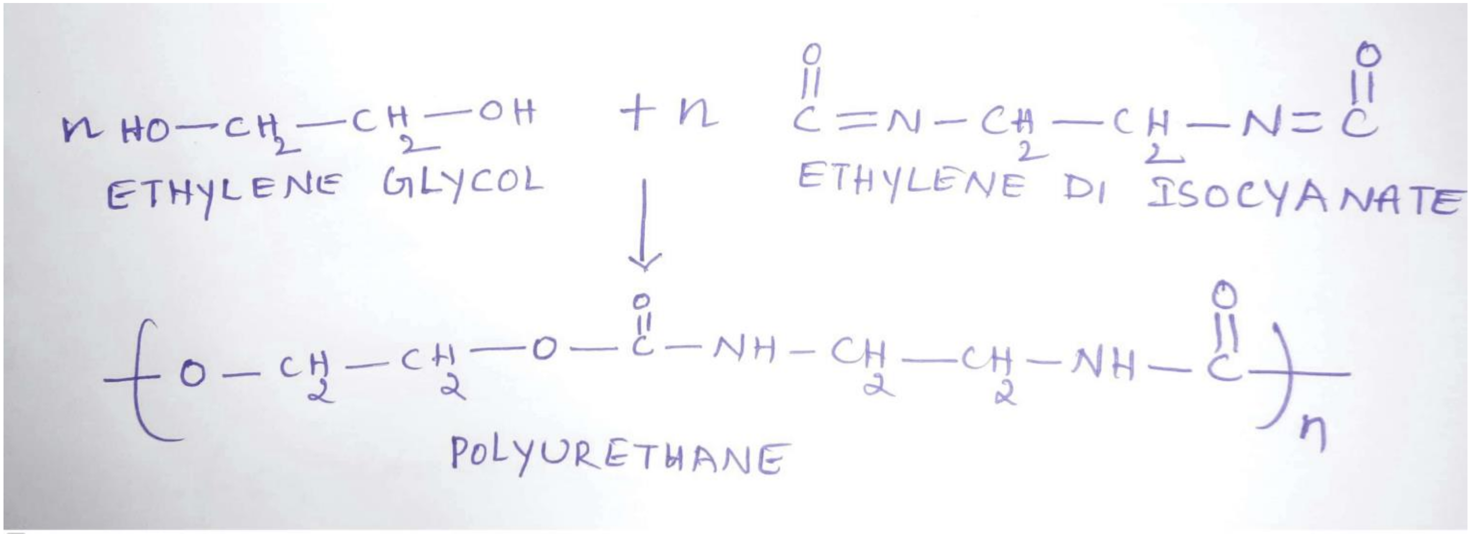
Thiokols are used for lining for canveying gasolin and oil.

Used for making gaskets and seals for printing rolls.

Thiokol mixed with oxidizing agents in used as a fuel in rocket engine.

Polyurethanes:

Preparation :



Polyurethanes are formed by the reaction between diisocyanate and diol
egs: Perlon-U is obtained by the reaction of 1,4-butane diol with 1,6-hexa methylene diisocyanate.

Properties:

1.polyurethanes are less stable than polyamides (nylons) at elevated temperature (because of the presence of additional oxygen in the chain which increases its flexibility,the M.P of polyurethanes is much less than that of the corresponding polyamides.)

2.They are characterized by excellent resistance to abrasion and solvents.

Applications:

1. It is used for floor coating for gymnasium and dance floors where high abrasion resistance is required.
2. Used as surface coatings, films, foams and adhesives.
3. They are used for cushions because of improved strength, lower density and easier fabrication.
4. It is used in lightweight garments and swim suits because of its stretching property.
5. They are used to cast to produce gaskets and seals.

COMPOSITE MATERIALS:

The composite materials are generally made by placing the dissimilar materials together in such a manner that they work as a single mechanical unit. The properties of new materials so produced are
different in kind and scale from those of any constituents. Thus it has became possible to incorporate or alter properties, more than that, introduce a combination of properties like high strength and stiffness at elevated temperatures.

Defintion:

A composite material is a material system consisting of a mixture of two (or) more micro constituents which are mutually insoluble differing in form and composition and forming distinct phases.

Thus using composites it is possible to have such combination of properties like high strength and stiffness, corrosion resistance, and ability to withstand extreme high temperature conditions.

For eg. Wood (a composite of cellulose fibres and lignin cementing materials), rain proof cloth (cloth impregnated with water proof material) and bone (a composite of soft callogen and brittle and hard material apatite).

Fibre Reinforced Plastics(FRP):

Reinforcing a plastic matrix with a high strength fibre material results in the formation of fibre reinforced plastics.

FRP contains two components. 1) Fibre. 2) Matrix.

1)Fibre:

Fibers are used to strengthen thermoplastic compounds.
There are three main types of fibers carbon, glass & Aramid fibers.
They have different properties.
All fibers have generally high stress capacity than the ordinary steel.

2) Matrix:

The plastic material used in FRP is called matrix.
Matrix is a tough and relatively weak plastic that is reinforced by stronger fibers.
Generally thermosetting plastics are used as matrix.
Vinyl esters and epoxy resins are most commonly used matrixes.

Glass fibre - reinforced polymer(GFRP):

Glass fibre + Polymer → GFRP

Glass fibre - reinforced polymer composites employ glass fibres for improving the characteristics of especially polymeric matrices containing nylons, polyesters etc. These composites posses lower densities higher tensile strengths and impact resistance and resistance to corrosion and chemicals.

Applications: Automobile parts, storage tanks transportation industries, plastic pipes etc.,

Carbon fibre - reinforced polymer(CFRP):

Carbon fibre + Polymer → CFRP

Carbon fibre - reinforced polymer composites are employed in situations requiring excellent resistance to corrosion, lighter density retention of properties even at high temperatures.

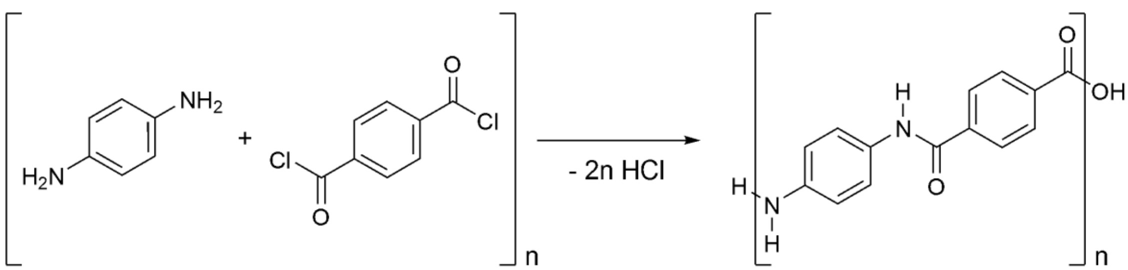
Carbon fiber reinforced composites are very strong and are often stronger than steel but lighter. They are used for making parts of aeroplanes and the space shuttle, tennis rackets and golf clubs, weaving machines, missiles, agricultural etc.

Aramid fiber reinforced plastics [bullet proof plastic]:

- Aramid is a short form of aromatic polyamide.
- Ex: Nomex & Kevlar.
- These are used to make bullet proof vests & bicycle tyres.

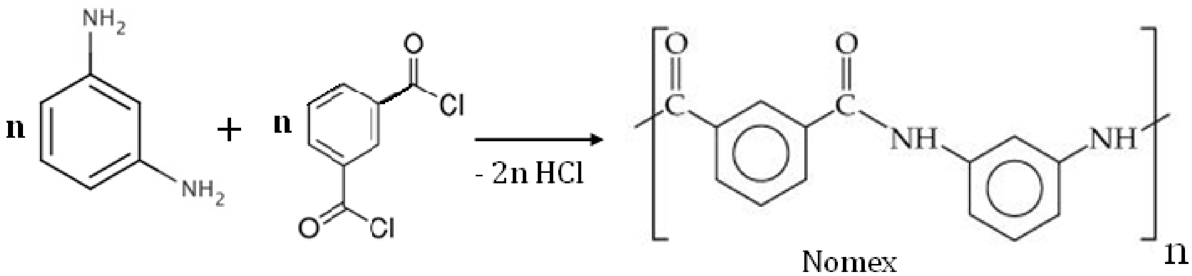
Kevlar:

- It is prepared by condensation polymerization of terephthalic acid chloride & 1,4-diamino benzene.



Nomex:

- This is produced by condensation reaction from the monomers phenylene diamine & isophthaloyl chloride.



Properties:

- ❖ It has higher tensile strength and modulus than fibreglass.
- ❖ It has high chemical inertness.
- ❖ It has very low coefficient of thermal expansion.
- ❖ It has flame resistance and high impact resistance.
- ❖ It has low weight.

Uses:

- ❖ Kevlar fibers are used for structures requiring good stiffness, high abrasion resistance and lightweight.
- ❖ It is used as inner lining for tires to prevent punctures (puncture resistant bicycle tyres).
- ❖ It is used in table tennis, tennis, badminton and squash racquets, cricket bats, hockey sticks.
- ❖ It is used in personal armor such as helmets, ballistic face masks, bullet proof vests etc.
- ❖ It is often used in the field of cryogenics for its low thermal conductivity and high strength.

It is used in boat hulls, helicopter blades etc.

CONDUCTING POLYMERS:

A polymer which conducts electricity is called conducting polymer.

Eg :- Polyaniline, polyacetylene, polypyrrole, etc

They are classified into two types : 1) Intrinsically conducting polymers.
2) Extrinsically conducting polymers

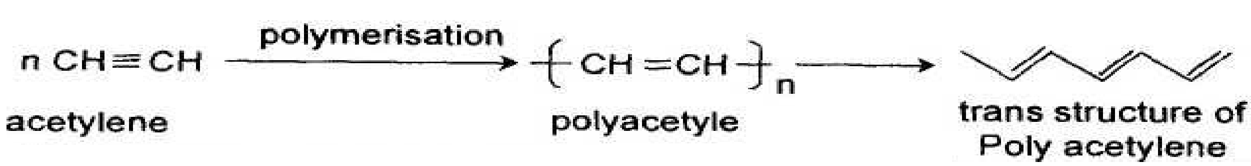
1. Intrinsically conducting polymers:

These have extensive conjugation in the backbone which is responsible for conductance. These polymers can be divided into two :

a) Conducting polymers having conjugated π – electrons in the backbone:

eg :- polyacetylene, polyaniline etc.

These type of polymers have backbones of continuous sp2 hybridized carbon centers. One valence electron on each center resides in a Pz orbital. Overlapping of conjugated π – electrons over the entire backbone results in the formation of valence bonds as well as conduction bands, which extends over the entire polymer molecule. But since the valence band and the conduction band are separated by a significant band gap, conductivity of these polymers is not very high.

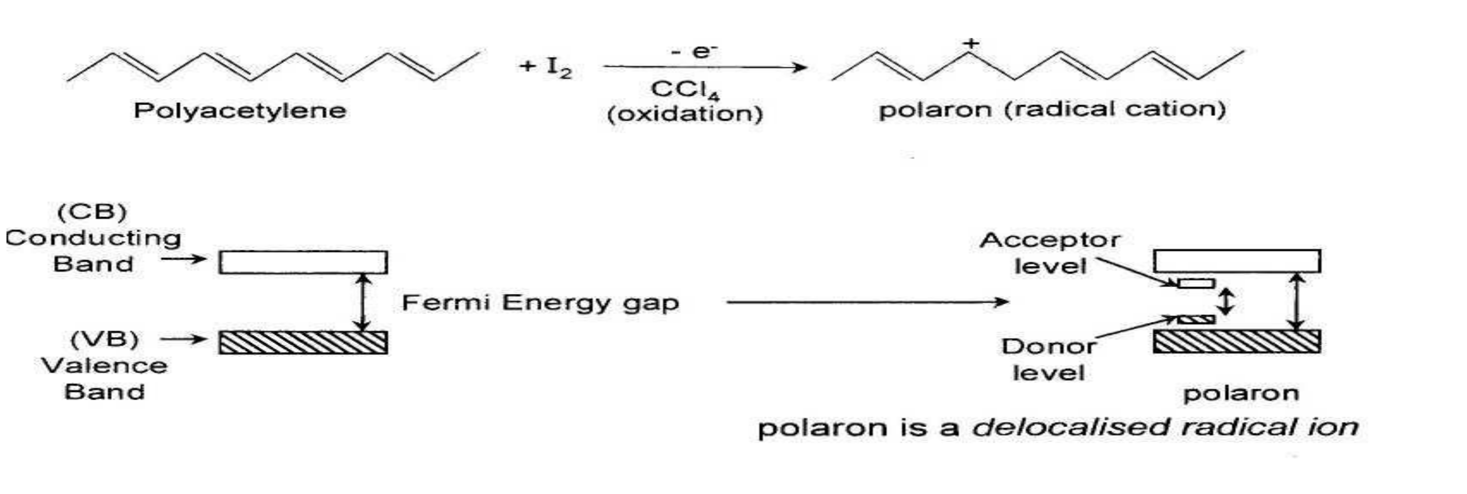


b) Doped conducting polymers:

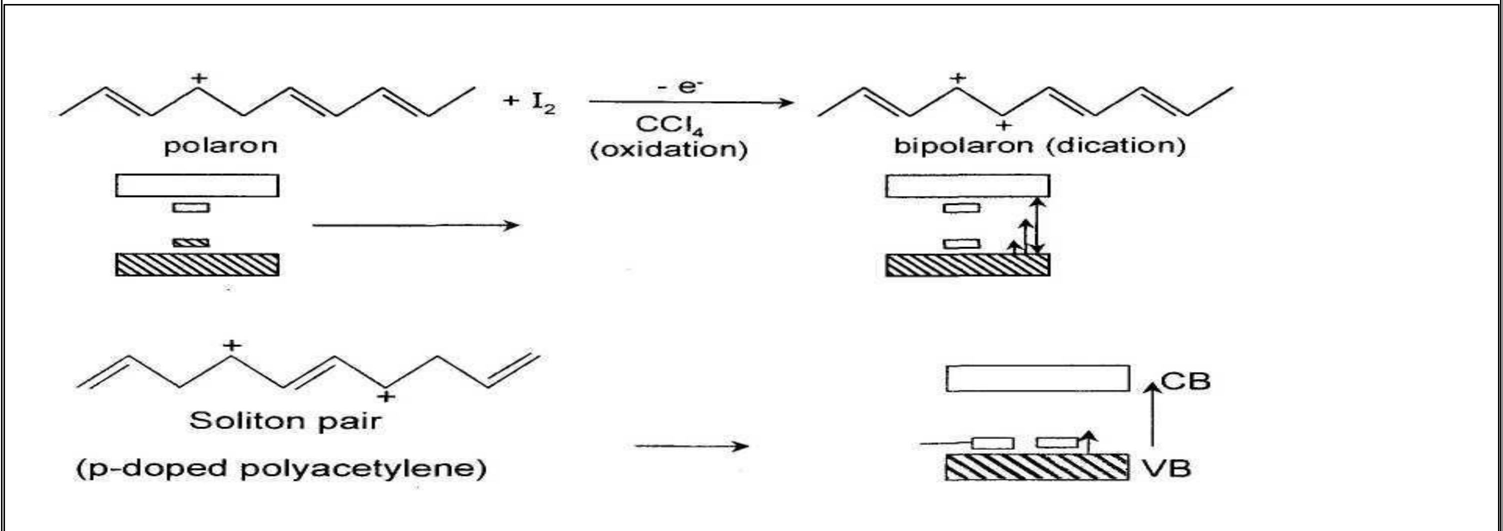
Conductivities of polymers having conjugated π – electrons in the backbone can be increased by creating either +ve or –ve charges on the polymer backbone by oxidation or reduction. This process is called doping.

It can be done in two ways :

i)Oxidative doping (P – doping):
It involves treating the conjugated polymer with a Lewis acid like FeCl3 thereby oxidation takes place and +ve charges are created on the back bone.



ii) Reductive doping (n – doping):
It involves treating the polymer with a Lewis base like RNH2 thereby reduction takes place and -ve charges are created on the polymer back bone.



2.Extrinsically conducting polymers:
Some of the polymers conduct electricity due to externally added ingradients to them. They are of two types.
a) Polymers with conductive elements filled Polymers. b) Blended conducting polymers.

a).Polymers with conductive elements filled:
In these polymers, the polymer acts as a 'binder' and holds the conducting element added so that the polymer becomes a conductor. Examples of conductive elements are carbon black, metallic fibers, metallic oxides etc.
Minimum concentration of conductive element to be added so that the polymer becomes a conductor is called percolation threshold. The conductive elements added to create a conducting path in the polymer.

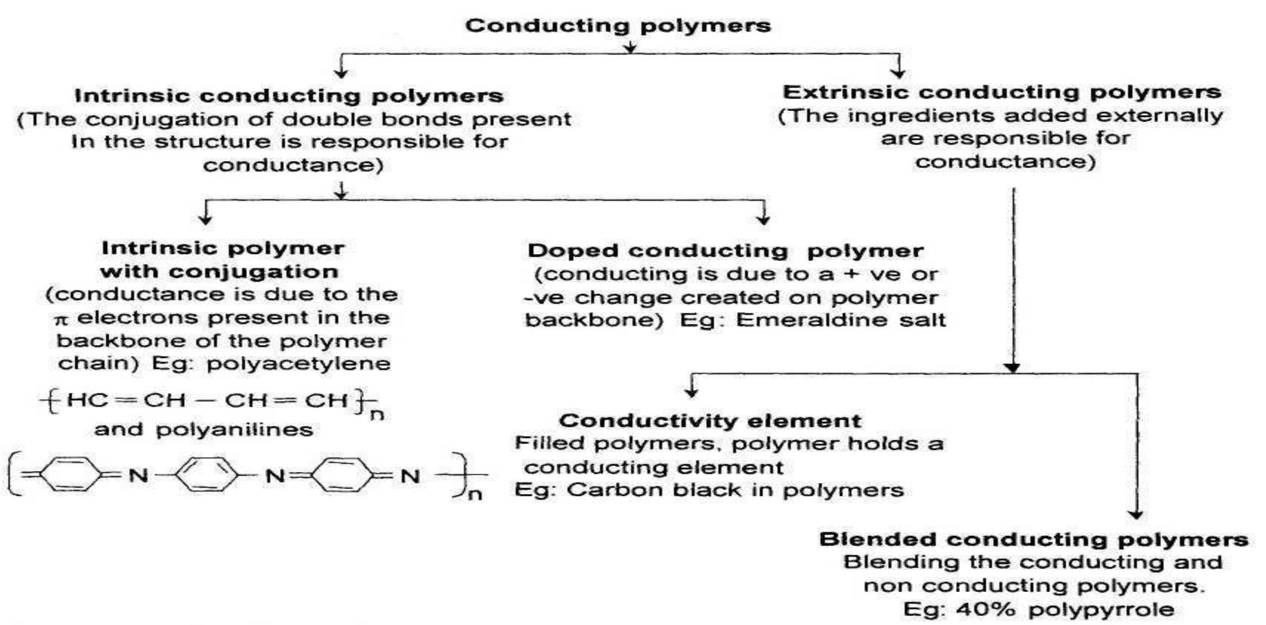
b).Blended conducting polymers:
These polymers are obtained by blending a conventional polymer with a conducting polymer.
The polymer thus obtained has good chemical, physical, electrical properties and mechanical strength.
Ex; 40% pyrrole when blended with a conventional polymer, the combination gives conducting polymer with good impact strength.

Applications of conducting polymers in biomedical devices:

- ★ Conducting polymers are used in preparation of artificial devices like Heart valves, kidneys, and lungs.
- ★ Poly methyl methacrylate is used as bone cement used for some fracture repairs.
- ★ Poly methyl methacrylate is also used for artificial teeth.
- ★ Used in preparation other medical devices include sutures, pins, screws used during surgery on bones, ankles, hands etc.
- ★ They are used to prepare contact lenses which permit O_2 to the eyes. These lenses are called rigid gas permeable lenses (RGP).

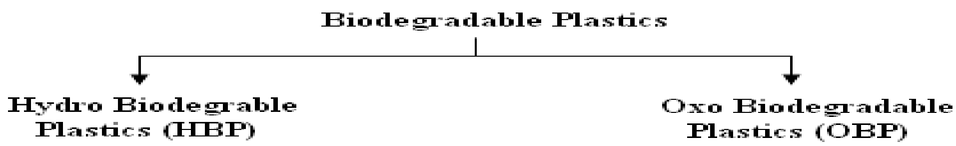
Applications of conducting polymers in electronics:

- They are used in rechargeable batteries.
- They are used in analytical sensors of p^H, O_2, NO_2, SO_2, NH_3 etc.
- Used in photo voltaic cells. Ex; Al/polymer/Au.
- Used in telecommunication systems.
- Used in transistors and diodes.
- Used in solar cells.
- Used as wiring in air crafts and aerospace parts.



Write a note on Biodegradable polymers.

- ♦ Biodegradation is the chemical breakdown of materials by physiological environment.
- ♦ Some polymers undergo degradation when exposed to moisture, heat, oxygen, ozone and micro organism.
- ♦ These agents change the chemical structure of the polymer and lead to change in properties of polymer.
- ♦ Generally materials obtained from plants, animals and other living organism and synthetic materials similar to plant and animal material undergo degradation by microorganism.
- ♦ These organic materials can be degraded either aerobically or anaerobically.
- ♦ During biodegradation, microorganism secrets biosurfactant which facilitates degradation easily.
- ♦ These microorganisms can perform various activities like degradation, transformation or accumulation of compounds like hydrocarbons, poly aromatic hydrocarbons, pharmaceutical substances, radio nucleids and metals.
- ♦ The activity of aerobic bacteria is measured by the amount of O_2 consumed or the amount of CO_2 produced.
- ♦ The activity of anaerobic bacteria is measured by the amount of CH_4 gas produced.



Hydro biodegradable plastics	Oxo biodegradable plastics
➢ They undergo degradation by hydrolysis. ➢ It is rapid process. ➢ End products are H_2O & CO_2. ➢ It is expensive process. ➢ HBP emits CH_4 in anaerobic condition. ➢ HBP can be prepared from corn, wheat, sugar cane etc.	➢ They undergo degradation by oxidation. ➢ It is rather slow process. ➢ End products are H_2O & CO_2. ➢ It is less expensive process. ➢ It does not emit CH_4. It emits only H_2O & CO_2. ➢ OBP can be prepared from byproducts of oil or natural gas.

- Properties:
  - These are non – toxic.
  - They are able to maintain good mechanical integrity until degraded.
  - Capable of controlled rates of degradation.
- Applications:
  - It is used in drug delivery systems.
  - It is used to coat a stent and release drugs in a controlled way.
  - It is used in dental devices and orthopedic fixation devices.
  - Ex: Poly lactic acid, Poly glycolic acid, Poly hydroxyl butyrovelarate (PHBV).

Write a short notes on Biopolymers.

Biopolymers are naturally occuring long chain molecules which are involved in biological changes important for our lives. These polymers are present in living matter.

Biopolymers are classified into four types. They are

a. Carbohydrates
b. Proteins
c. Lipids
d. Nucleic acids.

Carbohydrates:

Carbohydrates are a group of compounds represented by the general formula, $C_x(H_2O)_y$

Carbohydrates are classified into following classes depending upon whether these undergo hydrolysis and if so on the number of products form: Monosaccharides, Disaccharides, Trisaccharides, Oligosaccharides, Polysaccharides.

1) **Monosaccharides** (also known as simple sugars) are the simplest carbohydrates containing 3-7 carbon atoms. A sugar containing: – an aldehyde is known as an aldose – a ketone is known as a ketose.
2) **Disaccharides** :When two monosaccharides are combined together with elimination of a water molecule it is called disaccharide. Monosaccharides are combined by glycosidic bond.
3) **Oligosaccharide**s contain 2-10 monosaccharides bonded together (building block = residue) Example: Sucrose
4) **Polysaccharides**: Polysaccharides are polymerized products of many monosaccharide units.

Proteins:

Proteins are complex nitrogeneous organic compounds of high molecular masses, synthesized by plants and animals, which on hydrolysis yield amino acids. Proteins are essential for the growth and maintenance of life.

Role of proteins:

1) They serve as fuel to yield energy.

2) They help in maintenance of fluid-balance.
3) They are responsible for functional characteristics.
4) They help in the formation of haemoglobin,chromosomes, etc.

Lipids:

Lipids are a heterogeneous group of organic compounds, whih are essential constituents of all plants and animal cells. They may be defined as the group of naturally occurring substances of the higher fatty acids.

Types of lipids: Fats and oils, waxes, phospholipids, Glycolipids, Steroids.

Role of lipids:

1) They act as structural components of cell membranes.
2) They act as transport forms of various metabolic fuels.
3) They fecilitate the absorption of the fat soluble vitamins.(such as vitamin A,D,E and K).
4) Their presence in tissues of animals serve as good heat insulators and shock-absorbers.

Nucleic acids:

A nucleic acid is a polymer in which the monomer units are nucleotides. There are two Types of Nucleic Acids:

1) **DNA: Deoxyribonucleic Acid**: Found within cell nucleus for storing and transfering of genetic information that are passed from one cell to other during cell division
2) **RNA: Ribonucleic Acid**: Occurs in all parts of cell serving the primary function is to synthesize the proteins needed for cell functions.

Nucleic acids are the carriers of genetic information. In all living organisms, the hereditary information is stored in deoxyribonucleic acid (DNA), which is a molecule formed by the repetition of nucleotides (making DNA a polymer). There are four different nucleotides in DNA, which form a universal code for hereditary information. Ribonucleic acid (RNA), the other kind of nucleic acid, is a related molecule to DNA. It is also a polymer of four nucleotides, three of which are the same as in DNA while the fourth one is slightly different. It has many functions in cells, notably acting as the intermediate between DNA and proteins. Some viruses even store their genome in the form of an RNA molecule rather than DNA

Write a note on Biomedical polymers.

Biomedical polymers are the materials that can be implanted in the body to provide special functions or in diagnostic, surgical and various therapeutic applications without causing adverse effect on blood and other tissues. They are tailor-made or modified at will suit specific body functions.

Polymers used for medical application should be biocompatible. It should possess the following characteristics.

1) It should have purity and reproducibility.
2) It should have optimum physical and chemical properties.
3) It should be fabricated into any desired shape without being degraded.
4) It should be sterilized easily.
5) Biopolymers that come in contact with blood and tissues should not damage cellular elements of blood, enzymes and protein.
6) They should not produce toxic and allergic reactions.
7) They should not deplete electrolytes present in the body.

Biomedical uses of polymers:

Applications of biomedical polymers in medicine are given below.

S.No	Polymer	Applications
1	Polyurethane	Heart valves, blood filters, artificial hearts, vascular tubes, etc.
2	Polyvinyl chloride (PVC)	Disposable syringes, etc.
3	Polypropylene	Heart valves, blood filters, etc.
4	Polyethylene	Disposable syringes, etc.
5	Polymethyl methacrylate	Contact lenses, dental restoratives etc
6	Silicone rubber	Heart valves, drain tubes etc.

Long answer type questions:

1) What is Polymerization? Explain types of polymerisation with examples.(Addition & condensation polymerisation)
2) Explain Emulsion and Suspension polymerization techniques. (or) Explain the methods of polymerisation.(or) Write a brief account on techniques of polymerisation.
3) Write a brief account on mechanical properties of polymers?
4) Explain Compounding of plastics with suitable examples. (or) What is compounding of plastics? What are the additives added to the resins before moulding them?
5) Differentiate between thermo plastics & thermosetting plastics. Give two examples for each type ?
6) Describe with neat sketches, the following moulding techniques of plastics (or) fabrication of plastics.
   a) Compression moulding. **b)** Injection moulding **c)** Extrusion moulding. **d)** Blown film.
7) Write preparation, properties and applications of i) PVC. ii) Polycarbonates. iii)Bakelite.
8) Mention some examples of plastic materials used in electronic gadgets.
9) Explain about recycling of e-plastic waste.
10) Write preparation, properties and applications of i) Buna-S ii) Thiokol iii) Poly Urethane.
11) What are composite materials. Explain about bullet proof plastics.
12) Write a note on Fibre reinforced plastics (FRP).
13) Write a note on conducting polymers with examples.
14) Expain about Biodegradable plastic materials.
15) Write a note on Biopolymers.
16) Write a note on Bio-medical polymers.