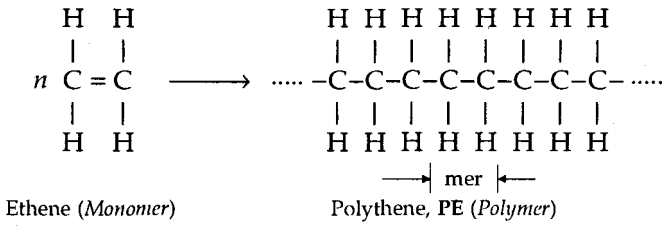
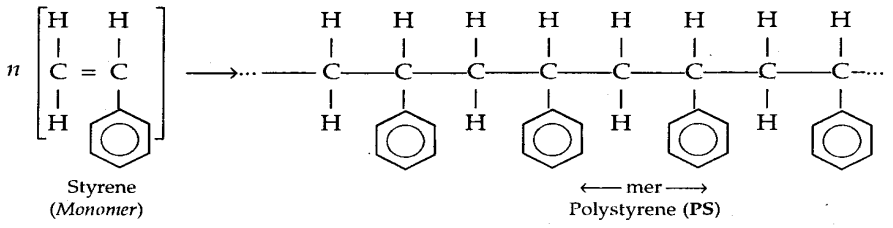
Polymers: Polymers' (Greek poly - many; mers - units or parts) is 'macromolecules' built-up by the linking together of a large number of small molecules. The repeat units in a polymer chain are linked through strong covalent bonds.

Example: Polythene is a polymer formed by linking together of a large number of ethylene (C_2H_4) molecules.



Monomers: Small molecules which combine with each other to form polymer molecules are termed monomers; and the "repeat unit" in a polymer is called mer. Monomers are often called building blocks of polymer chain. The essential requirement of a small molecule to qualify as a monomer is the possession of at least two bonding sites (Bifunctional).



Polymerization: The fundamental chemical process by which the low molecular weight molecules are converted into high molecular weight molecule, with elimination of small molecules like water, ammonia, alcohol etc. or without such elimination is called the polymerization.

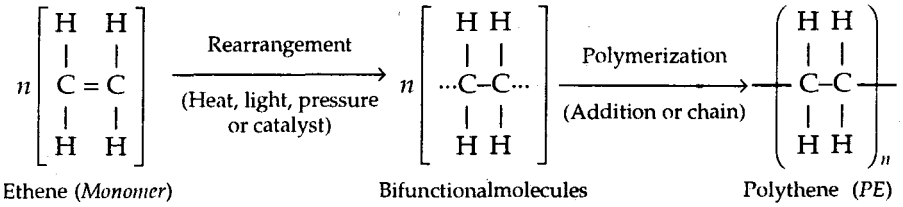
Degree of polymerization (DP): The number of repeating units (n) in polymer chain is known as the "degree of polymerization" (DP). There may be hundreds or thousands or tens of thousands or more monomer molecules linked together in a polymer molecule. Most of the polymers, usually, fall into the 5,000—200,000 molecular mass range.

Functionality: The total number of bonding sites or reaction sites present in a monomer molecule is called the functionality of the monomer. Depending on the number of bonding sites, the monomers are called bifunctional, trifunctional and polyfunctional.

S. No	Name of The Monomer	Molecular Formula	Functionality
1	Vinyl chloride	CH_2= CHCl	02
2	Ethylene glycol	HO-CH_2-CH_2-OH	02

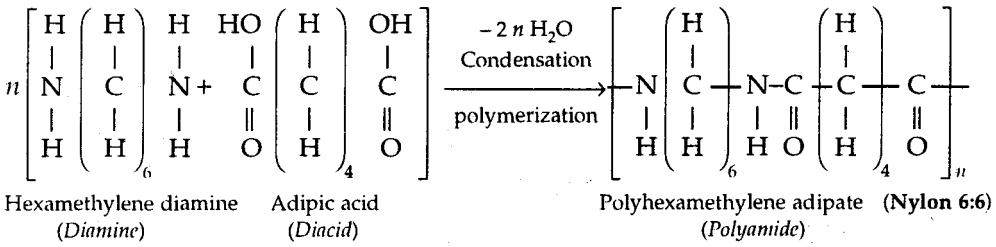
Addition or chain growth polymerization: The fundamental chemical process by which the low molecular weight molecules are converted into high molecular weight molecule, without the elimination any small molecules like water, ammonia, ethyl alcohol etc. is called the addition polymerization. A chain polymerization is a reaction that yields a polymer product which is the exact multiple of monomers.

Ex: Polyethylene



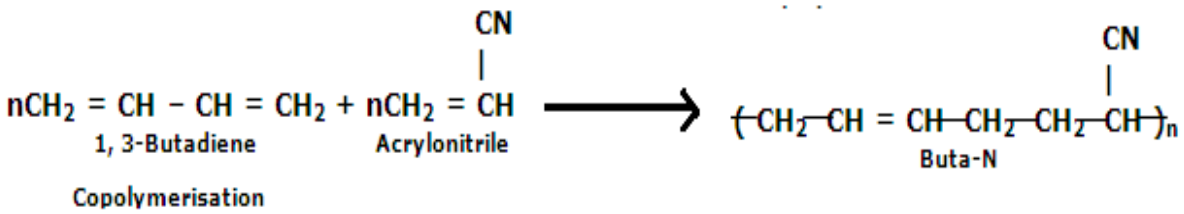
Condensation or step growth polymerization: The fundamental chemical process by which the low molecular weight molecules are converted into high molecular weight molecule with the elimination any small molecules like water, ammonia, ethyl alcohol etc. is called condensation or step growth polymerization.

Example: Nylon 6:6



Copolymerization: The processes of simultaneous addition polymerization of two are more different types of olefininic monomers are called copolymerization.

Ex: Nitrile Rubber or Buna-N Rubber: It is prepared by copolymerization of butadiene and Acrylonitrile



Difference between addition and condensation polymerization:

S. No	Addition Polymerization	Condensation Polymerization
1	It is also known as chain growth polymerization	It is also known as step growth Polymerization
2	The polymerization takes place by self addition of monomers	It is due to slow step wise condensation of the functional groups
2	It takes place only in monomers having multiple bonds	It takes place in monomers having reactive functional groups
3	It takes place without elimination of simpler molecule	It takes place with elimination of simple molecule like H_2O, NH_3, HCl etc
4	High molecular weight polymer is formed soon.	The molecular weight of polymer increases steadily throughout the reaction
5	The product obtained by this Polymerization is thermoplastic.	The product obtained in the polymerization may be either thermoplastic or thermosetting
6	Reaction initiated by initiator(catalyst)	Reaction initiated by heat
7	Reaction proceeds in fast manner	Reaction proceeds comparatively slow.
8	Polyethylene, polystyrene, polypropylene, polyvinyl chloride etc. are its examples	Bakelite, urea formaldehyde resin, epoxy resins, etc. are its examples

PLASTICS

Plastics: Plastics are high molecular weight organic Polymers which can be moulded into desired stable shapes by the application of heat and pressure. (Or) Plastics are high molecular weight organic polymers which exhibit the property of plasticity. i.e. ability to get deformed or 'to undergo change of shape under pressure.

Properties of plastics: In recent years, plastics have attained great importance in every walk of our life, due to their certain unique properties like:

1. Light in weight and have low specific gravity varies from 1 to 2.4.
2. Highly resistant to corrosion.
3. Moulded in to any desired shape.
4. Easy workability, low fabrication cost and low maintenance cost.
5. Shining and glassy surfaces.
6. Good shock-absorption capacity.
7. Good thermal and electrical insulators.
8. Low thermal expansion coefficient.
9. Do not absorb water
10. Some plastics have high tensile strength
11. Can be made transparent or opaque, brittle, malleable or elastic, hard or soft.
12. Can be obtained any desired colour.

Types of plastics: Plastics are classified into two types:

1. Thermoplastics
2. Thermosetting

Thermoplastics: Plastics which are soften on heating and harden on cooling are known as thermoplastics.

Characteristics:

1) These are formed by addition polymerization.

2) These are linear polymers without any cross linking.

3) The plasticity of these plastics is reversible.

4) These are weak, soft and less brittle.

5) Polymeric chains are held together by weak vander Waals (intermolecular) forces.

6) These can be reclaimed from the waste.

7) These are soluble in some organic solvents.

$$-M-M-M-M-M-M-\ (M = \text{Monomer})$$

Thermosetting: The polymers which undergo chemical changes and cross linking on heating and become permanently hard, rigid and infusible are called thermosetting.

Characteristics:

1) These are formed by condensation polymerization

2) These are three dimensional cross linked polymers.

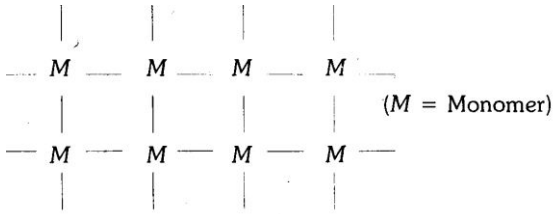
3) The plasticity of these plastics is irreversible

4) These are strong, hard and more brittle.

5) Polymeric chains are held together by strong covalent bonds in the form of cross links.

6) These cannot be reclaimed from waste

7) These are insoluble in almost all organic solvents.

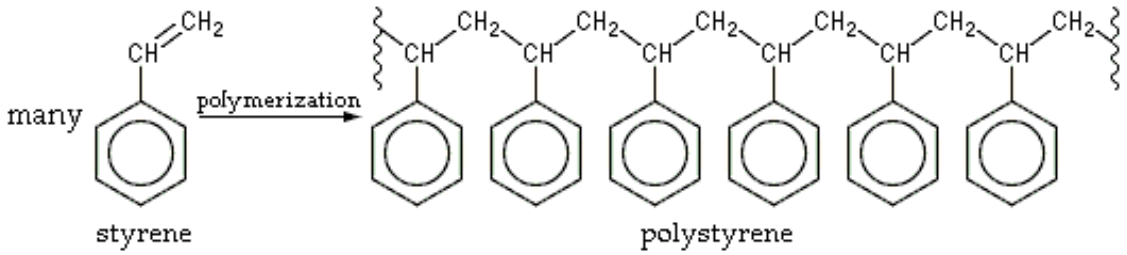


S. No	Thermoplastics	Thermosetting
1	They soften on heating and harden on cooling	Become permanently hard, rigid and infusible product on further heating
2	They are formed by addition polymerization.	They are formed by condensation polymerization.
3	They undergo reversible changes on	They undergo irreversible changes on the

	the application of heat.	application of heat.
4	They can be reshaped and reused.	They cannot be reshaped and reused.
5	They are soft and flexible.	They are hard, rigid and infusible.
6	They have linear structure.	They have three dimensional
7	There is no change in chemical composition and structure during moulding process.	They undergo chemical changes such as further polymerization and cross linking during molding process.
8	They swell or dissolve in organic solvents.	They neither dissolve nor swell in organic solvents.
9	They can be reclaimed from waste.	They cannot be reclaimed from waste.
10	Examples Polyethylene, Polypropylene, Polystyrene, Polyvinyl chloride, Teflon, Plexiglass	Examples Phenol - Formaldehyde resin (PF) Urea - Formaldehyde resin (UF) Melamine - Formaldehyde resin (MF), Epoxy resins.

Poly styrene (PS):

Preparation: Polystyrene is prepared by polymerization of styrene (dissolved in ethyl benzene) in presence of benzoyl peroxide catalyst.



Properties:

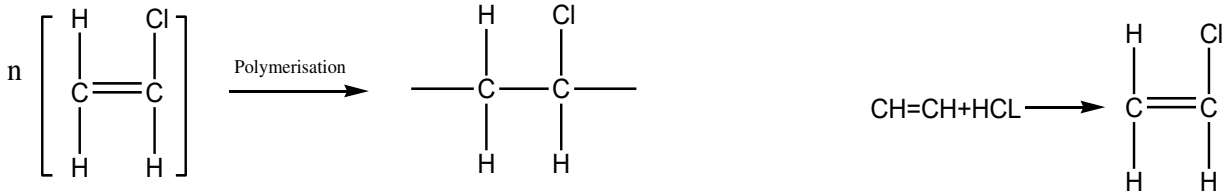
- Polystyrene is transparent, light weight, good light stable, excellent moisture resistant material.
- It can be nitrated by fuming nitric acid and sulphonated by conc. H_2SO_4.
- It is highly electric insulating, highly resistant to acids and good-chemical resistant too.

Applications:

- Used in moulding of articles like toys, combs, buttons and buckles, radio and television parts, refrigerator parts, battery cases etc.

Poly vinyl chloride (PVC):

Preparation: Heating a water emulsion of vinyl chloride in presence of a small amount of benzyl peroxide (or) hydrogen peroxide in auto clave under pressure.



Vinyl chloride is prepared by treating acetylene at 1 to 1.5 atmospheres with hydrogen chloride at 60- 80 ^{O}C in presence of metal chloride as catalyst.

Properties:

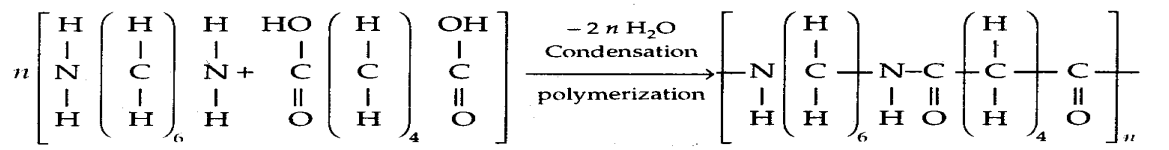
1. PVC is colourless, odour less, non-inflammable and chemically inert powder.
2. Resistant to light, atmospheric oxygen.
3. Resistant to acids and alkalis
4. But soluble in hot chlorinated hydrocarbons.
5. High softening point(148 ^{O}C)
6. Greater stiffness and rigidity compared to polyethylene, but is brittle.

Applications:

1. It is used for making sheets, which are employed for tank-linings, light-fittings, safety helmets.
2. Refrigerator components.
3. Cycle and motor cycle mud guards.
4. Packing rain coats, table cloths & curtains.
5. Electrical insulation like covering of electrical cables.
6. Chemical containers, Conveyor belts etc.

Nylon-6, 6:

Preparation: It is synthesized by poly condensation of hexa methylene di amine and adipic acid. Equivalent amounts of hexa methylene di amine and adipic acid are combined with water in a reactor. This is crystallized to make nylon salt, an ammonium/carboxylate mixture. The nylon salt goes into a reaction vessel where polymerization process takes place either in batches or continuously.



Hexamethylene diamine (*Diamine*) Adipic acid (*Diacid*) Polyhexamethylene adipate (*Polyamide*) **(Nylon 6:6)**

Properties:

1. High mechanical strength, stiffness, hardness and toughness.
2. High mechanical damping ability.
3. Good sliding properties.
4. Excellent wear resistance
5. Good electrical insulating properties

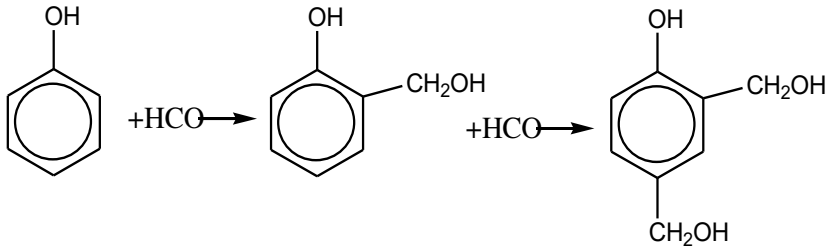
Applications:

1. It is used in fibres for textiles and carpets and molded parts.
2. It has broad use in auto applications; these include "under the hood" parts such as radiator end tanks, rocker covers, air intake manifolds, and oil pans.
3. Other applications include electro-insulating elements, pipes, profiles, various machine parts, zip ties, conveyor belts, hoses, polymer-framed weapons, and the outer layer of turnout blankets. Also a popular guitar nut material

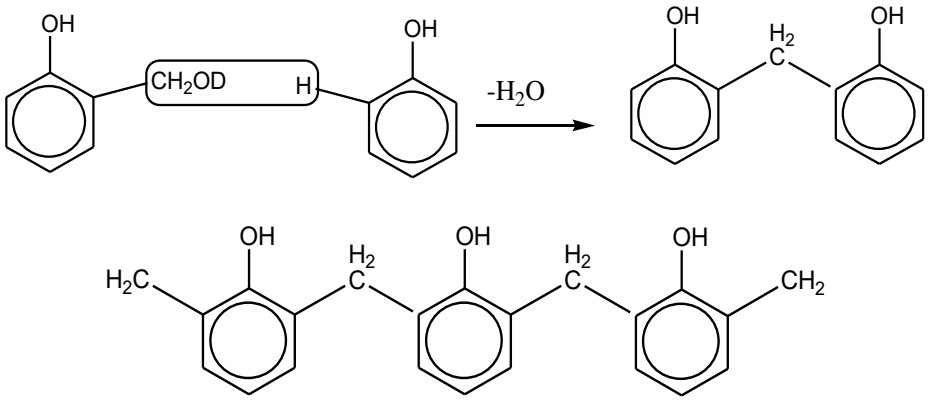
Phenol formaldehyde resin (or) Bakelite:

Preparation: These are condensation products of phenol and formaldehyde. Most important member of this class is Bakelite. It is prepared by the condensing phenol with formaldehyde in

presence of acid or alkaline catalyst. Phenol and formaldehyde react to form methylol derivatives which act as monomers for subsequent polymerization.

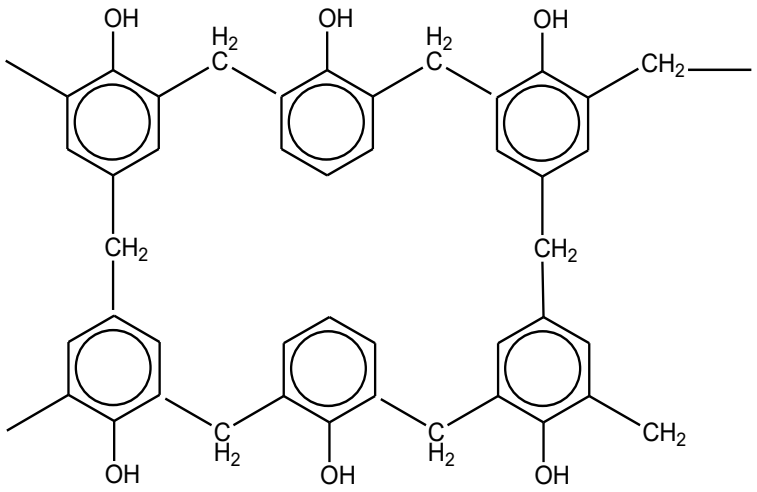


The ortho hydroxy methyl phenol reacts with phenol to form NOVALAC linear polymer. The formed novalac polymer is linear and also it is fusible and soluble



Novalac

In moulding hexamethylene tetraamine is added. It provides the soluble and fusible novalac converts into hard, infusible and insoluble solid cross linked structure (Bakelite).The following is the structure of bakelite.



Bakelite

Properties:

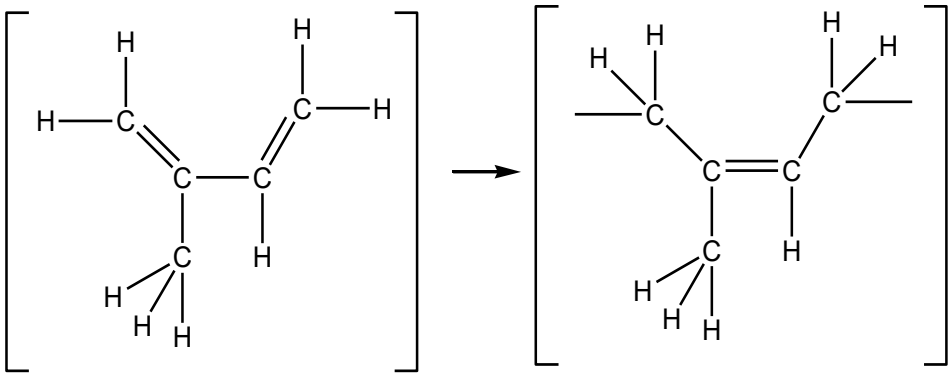
1. Phenolic resins are hard, rigid and strong material
2. Excellant chemical, heat and moisture resistance
3. It is attacked by alkalis, because of free hydroxyl groups present in the structure.

Applications:

1. Making electrical insulator parts like domestic plugs and switches.
2. Making moulding articles like Radio and T.V.cabinets
3. In paints and varnishes
4. It is used as a anion exchanger.

RUBBERS

Introduction: Rubbers are high polymers, which have elastic properties in excess of 300 percent. An elastomeric molecule is not straight chained, but in the form of a coil and consequently it can be stretched like a spring. Natural rubber is consists of basic material latex, which is a disperson of isoprene. During the treatment, these isoprene molecules polymerize to form long coiled chains of cis- poly isoprene.

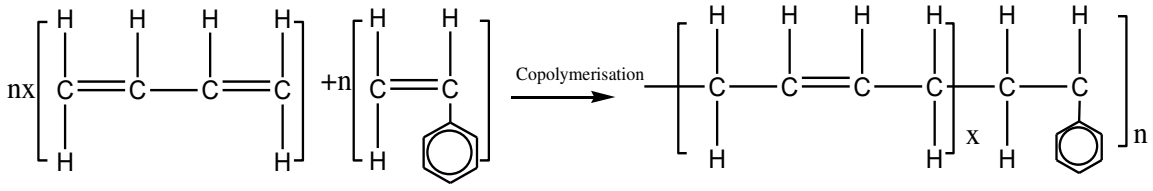


Preparation, Properties and applications of Buna-S, Buna-N

Buna-S rubber or Styrene rubber or GR-S

Preparation: It is a synthetic rubber.

It is produced by copolymerization of butadiene (about 75% by weight) and styrene (25% by weight)



Properties:

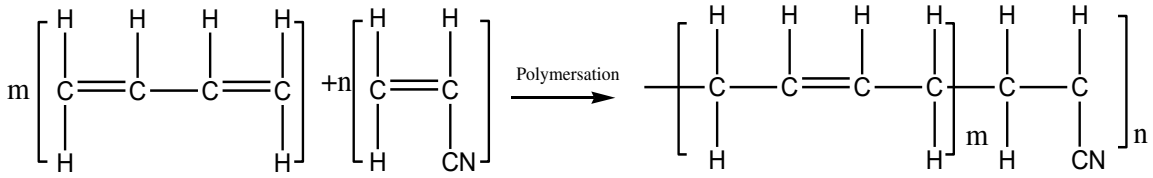
1. It possesses high abrasion resistance
2. High load bearing capacity
3. But it readily gets oxidized, especially in presence of traces of ozone present in the atmosphere.
4. It swells in oils and solvents
5. It can be vulcanized by using sulphur

Applications:

1. Manufacture of motor tyres
2. Floor tiles, shoe soles, gaskets, foot wear components.
3. Wire and cable insulation
4. Tank lining etc.

Buna-N rubber or Nitrile Rubber or GR-A

Preparation: It is a copolymer of butadiene and acrylonitrile



Properties:

1. Excellent resistance to heat, sunlight, oils, acids and salts
2. Less resistant to alkalis, because of the presence of cyno groups
3. Vulcanized nitrile rubber is more resistant to heat

Applications:

For making

1. Conveyor belt
2. Tank linings
3. Gasket
4. Printing rollers
5. Auto mobile parts etc.

Thiokol Rubber/Poly sulphide rubber/ GR-P:

It is prepared from the polymerization of di chloro ethane and sodium poly sulphide.

$$n[Cl\text{-}CH_2\text{-}CH_2\text{-}Cl] + n[Na_2S_4] \rightarrow [\text{-}CH_2\text{-}CH_2\text{-}S\text{-}S\text{-}S\text{-}S\text{-}]_n$$

Di chloro ethane Sodium poly sulfide Thiokol

Properties:

1. It is resistant to oxygen and ozone
2. It is resistant to petrol, diesel, kerosene
3. It do not swell in organic solvents
4. It has low tensile strength
5. It smells bad

Applications:

1. Thiokol mixed with oxidizing agents used as rocket fuel.
2. It is used as engine gaskets
3. It is used to store oils and solvents
4. It is used in tank lining