

ENGINEERING MATERIALS

PART-A SHORT QUESTIONS WITH SOLUTIONS

Q1. Define monomer and polymer with examples.

Answer :

Monomer

A monomer is a small molecule that undergoes polymerization to produce polymer. It has low molecular weight.

Examples

Ethene, styrene, etc.

Polymer

A polymer is a large molecule that is formed by repeated linking of small molecules (i.e., monomers) using covalent bonds. It has high molecular weight.

Examples

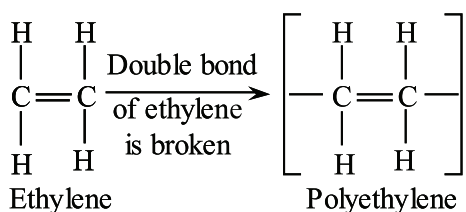
Polythene, polystyrene, etc.

Q2. Explain the functionality of monomer.

Answer :

Functionality is defined as the number of active bonding sites that a monomer holds.

Example, when ethylene double bond is broken, two new active single bonds are formed as shown in figure below.



Figure

Thus, the functionality of ethylene is 2.

Based on the functionality, polymer structures contain bifunctional monomer or trifunctional monomers or Network/3-dimensional polymers.

Q3. What is meant by degree of polymerization?

Answer :

The number of repeating units present in a polymer chain is known as the “degree of polymerization”. There may be many number of monomer molecules that are linked together in a single polymer molecule.

$$\text{Degree of polymerization} = \frac{N_o}{N} = \frac{M}{M_o}$$

Where,

N_o - Number of monomer molecules before polymerization

N - Number of molecules after polymerization

M - Molecular weight of polymer

M_o - Molecular weight of monomer.

Number of repeated units estimate the length of the polymer chain.

Q4. Write short notes on thermoplastics.

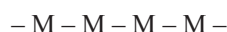
Answer :

The plastic material that becomes soft when heated and hard when cooled is termed as thermoplastic. These materials are heated below their decomposition temperature to give them new shape and dimension.

Example

Cellulose acetate, nylon, polyethylene etc.

In thermoplastics, the polymers are linearly arranged and held together by weak Vander Wall forces as shown in figure.



Where,

M - Monomer.

Q5. Explain about thermosetting plastics.

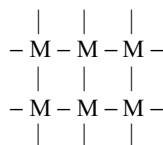
Answer :

The plastic materials that become hard on heating and cannot be softened again, even on applying heat are termed as thermosetting plastics. These plastics cannot be reshaped, once they are moulded into a required shape.

Example

Bakelite, silicones and polyester.

In thermosetting plastics, the polymers are arranged in the form of cross links and held together by strong covalent bonds as shown below.



Where,

M - Monomer.

Q6. Give one example each for addition and condensation polymers.

June/July-17, Q7

OR

Define addition and condensation polymers with suitable examples.

Answer :

(i) Addition Polymers

Polymers containing same composition of repeat unit and monomers can be defined as addition polymers.

Examples

Polystyrene, Polythelene, Teflon etc.

(ii) Condensation Polymers

Polymers in which the atoms of repeat unit are less when compared to that of corresponding monomers can be defined as condensation polymers.

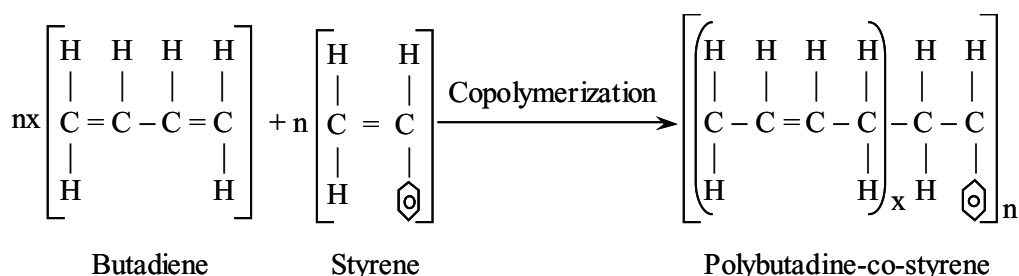
Examples

Nylon, Polyesters, Phenol-farmaldehyde resin etc.

Q7. What is co-polymerization?**Answer :**

Copolymerization is defined as a process in which two or more different monomer species undergo combined polymerization to produce polymers.

The polymers which exhibit the phenomenon of copolymerization are called as copolymers. These are high molecular weight compounds.

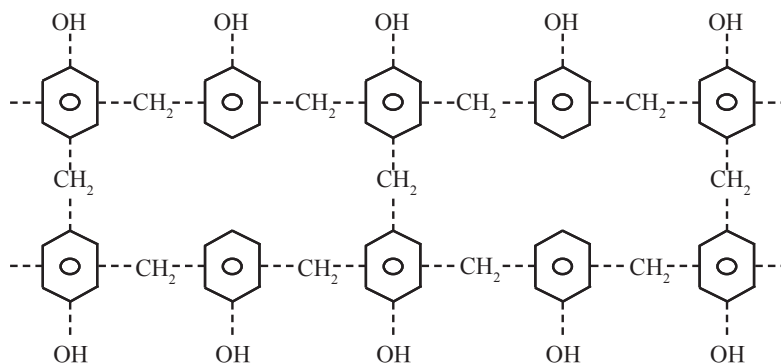
Example**Q8. PVC is soft and flexible, whereas bakelite is hard and brittle. Explain.****Answer :**

PVC is soft and flexible. Its softness is obtained by adding plasticizers like dioctyl phthalate, dibutyl phthalate and tricresyl phosphate. Due to its softness and flexibility, it is used for coating of wires, electrical insulation, making tubes etc.

But, during moulding of novolac, hexamethylene tetramine is added, which provides formaldehyde. This formaldehyde converts the soluble and fusible novolac into hard and brittle bakelite of cross-linked structure.

Q9. Write the structure of bakelite.**Answer :**

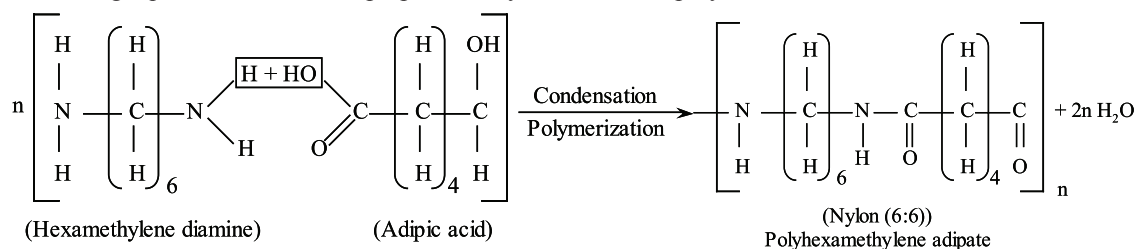
The structure of bakelite is illustrated in figure below.

**Figure : Structure of Bakelite****Q10. Give the reaction for the preparation of Nylon 6.6 from its monomers.****Answer :**

May/June-18, Q7

The condensation polymerization of adipic acid with hexamethylene diamine gives Nylon 6:6.

The following equation describes its preparation by condensation polymerization.

**Figure**

Q11. What are elastomers? Give examples.**Answer :**

Elastomer is vulcanizable rubber like polymer that can be stretched atleast twice its length. As soon as the force is released, synthetic rubber retains its original length and dimensions. It is also called as synthetic rubber or artificial rubber. The molecules arranged in this polymer are in the form of zig-zag or spring shaped chain.

Examples

Silicone rubber, Polysulfide rubber, Buna-S rubber, Buna-N rubber, Butyl rubber, GR-N rubber, Chloro sulphorated polyethylene rubber etc.

Q12. Give one example each for natural and synthetic polymers.

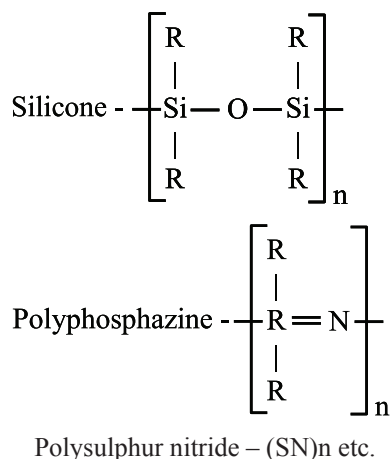
Dec.-16, Q8

OR**Differentiate between natural and synthetic polymers.****Answer :**

Natural Polymer		Synthetic Polymer	
1.	Based on origin, polymers may be natural polymers.	1.	They are man made polymers.
2.	Natural polymers occur in nature, they cannot be prepared.	2.	They are prepared from natural polymers.
3.	Examples are starch, cellulose, proteins, nucleic acids, natural rubber etc.	3.	Examples are polyethylene, polypropylene polystyrene, PVC, bakelite, nylon etc.

Q13. What are inorganic polymers?**Answer :**

Inorganic polymers are giant molecules containing atoms (except carbon) linked by covalent bonds.

Examples**Q14. What are conducting polymers? Give examples.**

May/June-18, Q8

OR**What is conducting polymer? Give two examples.****Answer :**

June-14, Q8

Conducting Polymers

The polymers which conduct electricity are known as conducting polymers. There are four different types of conducting polymers. They are,

- (i) Intrinsically conducting polymer
- (ii) Doped conducting polymer
- (iii) Extrinsically conducting polymer
- (iv) Coordination conducting polymer.

Examples

Polyacetylene, Polypyrrole, Polythiophene, Polyaniline, Polysulphur nitride etc.

Q15. Mention the applications of polyacetylene.**Answer :****Applications of Polyacetylene**

1. Polyacetylene is used as passive and active electrode in electronic devices.
2. It is used in high power density rechargeable batteries.
3. It is used in the fabrication of (p-n junction) diodes.
4. It has a potential application in solar energy conversion.
5. It is used in non-linear optics and micro electronics.

Q16. What are biodegradable polymers?**Answer :**

Biodegradable plastic components are obtained from renewable raw materials and abundant agricultural/animal resources such as cellulose, starch, collagen, casein etc. These plastics decompose in natural environment over a period of time if exposed to sun and air. Large scale use of these would help in preserving nonrenewable resources like petroleum, natural gas and coal and contribute to the problem of waste management. Biodegradation of plastics can be achieved by enabling microorganisms in the environment to metabolize the molecular structure of plastic films to produce an inert humus like material that is less harmful to the environment.

PART-B

ESSAY QUESTIONS WITH SOLUTIONS

3.1 POLYMERS

3.1.1 Basics of Terms Polymers: Monomer and its Functionality, Polymers and Degree of Polymerization. Classification of Polymers – Thermoplastics & Thermosetting Resins

Q17. Give the classification of polymers.

Answer :

Classification of Polymers

Polymers can be classified as,

- (i) Natural and synthetic polymers
- (ii) Addition and condensation polymers
- (iii) Organic and inorganic polymers
- (iv) Thermoplastic and thermosetting polymers

(i) Natural and Synthetic Polymers

Natural polymers available naturally in animals and plants.

Example : Starch, cellulose, proteins, nucleic acids etc.

Synthetic polymers are man - made polymers.

Example : Polyethylene, polypropylene, nylon, bakelite etc

(ii) Addition and Condensation Polymers

For answer refer Unit - IV, Q4

(iii) Organic and Inorganic Polymers

Polymers whose back bone structure is made of carbon atoms are called as Organic polymers.

Polymers having back bone structure of non-metals are called as Inorganic polymers.

(iv) Thermoplastic and Thermosetting Polymers

The plastic material that becomes soft when heated and hard when cooled is termed as thermoplastic.

Example : Cellulose acetate, nylon, polyethylene etc.

The plastic material that becomes hard on heating and cannot be softened again, even on applying heat is termed as thermosetting plastics.

Example: Bakelite, silicones, polyester etc.

Q18. Differentiate between thermoplastic and thermosetting polymers.

(June/July-17, Q14(b) | Dec.-16, Q14(b))

OR

Write the differences between thermoplastics and thermosetting resins.

April-16, Q17(a)

OR

Give the differences between thermosets and thermoplastics.

June-14, Q14(a)

OR

Differentiate between thermoplastics and thermosetting resins.

June-13, Q7

OR

Bring out the differences between thermoplastics and thermosetting resins.

Jan-13, Q14(a)

Answer :

The differences between thermoplastics and thermosetting plastics are,

Thermoplastics		Thermosetting Plastics	
1.	Thermoplastics are defined as the plastics which becomes soft, when heated and hard when cooled. Example: Polyethylene, Nylon etc.	1.	Thermosetting plastics are defined as the plastics which becomes hard on heating and cannot be softened by applying heat. Example: Bakelite, Polyester etc.
2.	These are processed by addition polymerization.	2.	These are processed by condensation polymerization
3.	They are long chain linear polymers.	3.	They are branched or cross-linked polymers.
4.	Chemical changes does not occur on repeated heating and cooling.	4.	Chemical changes occur on heating.
5.	These plastics undergo purely physical process.	5.	These plastics undergo physical as well as chemical process.
6.	Waste thermoplastics can be recovered.	6.	Waste thermosetting plastics cannot be recovered.
7.	These plastics can be processed by heating.	7.	These plastics cannot be processed by heating.
8.	Plasticity of these plastics is reversible.	8.	Plasticity of these plastics is irreversible.
9.	These are soft, weak and less brittle.	9.	These are hard, strong and more brittle.
10.	Polymers of these plastics are linearly linked in shape.	10.	Polymers of these plastics are cross linked in shape.
11.	Molecular weight of the polymers is less.	11.	Molecular weight of the polymers is high.
12.	The neighbouring chains in the polymer are held together by weak Vander-Walls forces.	12.	The neighbouring chains in the polymer are held together by strong covalent bonds.
13.	These are soluble in organic solvents.	13.	These are insoluble in organic solvents.

3.1.2 Types of Polymerization (i) Addition (ii) Condensation (iii) Co-polymerization. Mechanism of Free Radical Polymerization

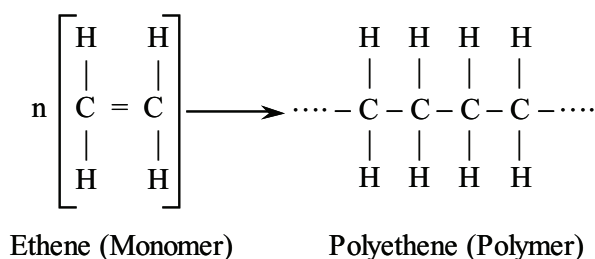
Q19. What is polymerization? Explain the different types of polymerization with examples.

Answer :

Polymerization

Polymerization is a process of combining or linking monomers to produce polymers.

Example



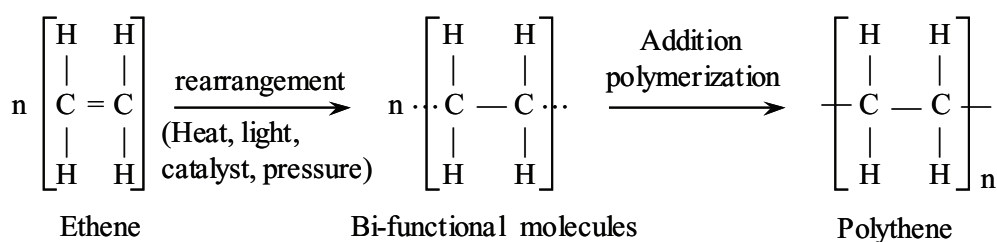
Types of Polymerization

Basically there are three types of polymerizations. They are,

1. Addition polymerization
2. Condensation polymerization
3. Copolymerization.

1. Addition Polymerization

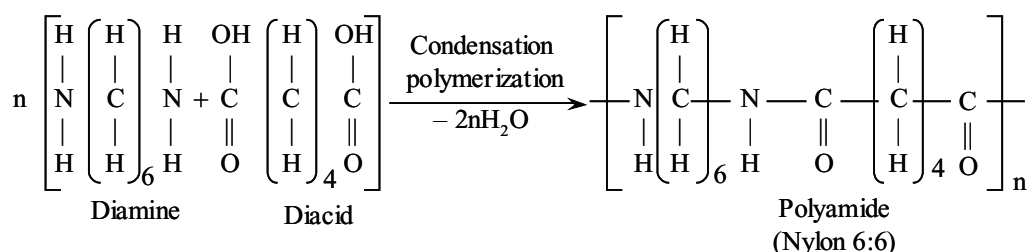
Addition polymerization can be defined as a process in which multiple molecules of monomer, having one or more double bonds combine to form polymers without losing any molecule. It is also called as chain-growth polymerization as the monomer molecules continuously add up to form polymers.

Example

Bifunctional molecules are formed by intermolecular arrangement of the double bonds between the monomer molecules. The double covalent bonds between the monomers can be broken by applying light, heat, catalyst or pressure.

2. Condensation Polymerization

Condensation polymerization can be defined as a process in which multiple monomers of polar group combine to form high molecular weight polymers by losing molecules like water, HCl etc. It is also called as step-growth polymerization as the monomer molecules add up in stepwise manner to form polymers.

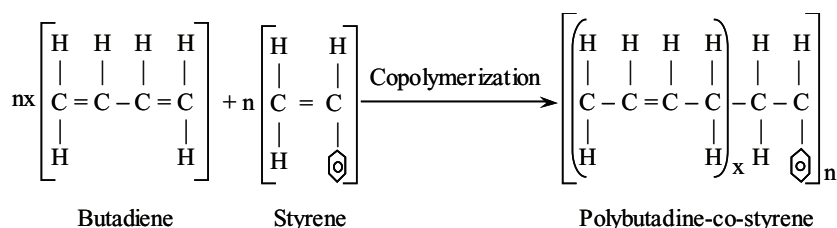
Example

In condensation polymerization when the monomers contain three functional groups, then the polymer is in cross linked structure.

3. Copolymerization

Copolymerization is defined as a process in which two or more different monomer species undergo combined polymerization to produce polymers.

The polymers which exhibit the phenomenon of copolymerization are called as copolymers. These are high molecular weight compounds.

Example**Q20. Distinguish between addition and condensation polymerization.****Answer :****Differences between Addition and Condensation Polymerization**

S.No	Addition Polymerization	S. No	Condensation Polymerization
1.	Addition polymerization is defined as a process in which two or more molecules of same monomer are combined to produce a polymer without removing the molecules. Example: Polymerization of ethylene to give polyethylene.	1.	Condensation polymerization is defined as a process in which two or more monomers are combined to produce a high molecular weight polymer by removing the simple molecules. Example: Formation of phenol formaldehyde.

S.No	Addition Polymerization	S. No	Condensation Polymerization
2.	This polymerization is applicable to the monomers, which contain double bonds.	2.	This polymerization is applicable to the monomers, which contain reactive functional groups.
3.	In this process, monomers are added to the growing chain.	3.	In this process, the reaction takes place in step wise manner of adding monomers.
4.	It is also called as chain-growth polymerization.	4.	It is also called as step-growth polymerization.
5.	The rate of overall reaction is fast.	5.	The rate of overall reaction is slow.
6.	Free radical initiators i.e., lewis acids and bases are used as catalysts.	6.	Mineral acids and bases are used as catalysts.
7.	This process involves a free radical or cationic or anionic mechanisms.	7.	This process involves the condensation reactions like ether formation, esterification etc.
8.	Dead polymers are formed at the end of the reaction.	8.	Active polymers are formed since the terminal end of the chain is active.
9.	High molecular mass polymer is formed only once.	9.	Polymer molecular mass rises steadily throughout the reaction.
10.	Mostly thermoplastics are formed by this process.	10.	Thermosetting plastics are formed by this process.
11.	Example: Polyethylene, Poly Vinyl Chloride (PVC).	11.	Example: Bakelite, Silicones.

Q21. Explain the mechanism of addition polymerization.

Answer :

Mechanism of Addition Polymerization

Addition polymerization can be carried out by using any of the following mechanisms,

1. Free radical polymerization mechanism
2. Cationic mechanism of polymerization
3. Anionic mechanism of polymerization
4. Co-ordination polymerization.

Free Radical Polymerization Mechanism

Free radical polymerization mechanism involves the formation of free radicals as the active centres which is illustrated in three steps.

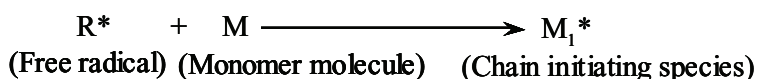
(i) Initiation Step

In the initiation step, an initiator undergoes homolytic dissociation and produces two highly reactive unpaired electrons called as initiator fragments or free radicals,



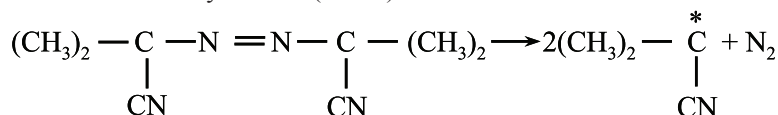
i.e., (Initiator) (Free Radical)

These unpaired electrons are highly reactive. They react with the monomer molecule to produce chain initiating species.



Example

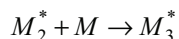
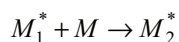
Azo – bis – isobutyronitrile (AIBN)



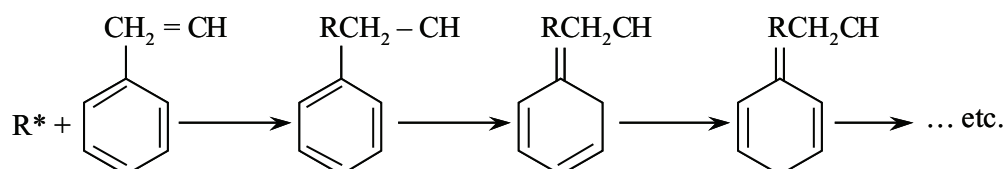
(ii) Chain Propagation Step

In this step, the monomer molecules add up continuously with the chain initiating species in large number to keep producing new free radicals. This process continues until all the monomers are consumed or it is terminated. Hence, the growth of the chain initiating species increases.

i.e.,



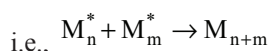
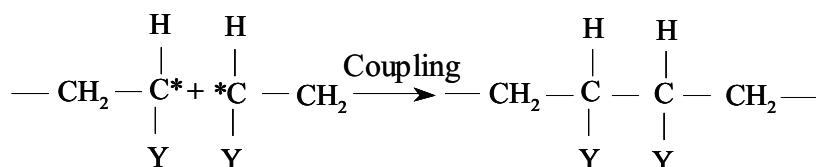
In general, $M_n^* + M \rightarrow M_{n+1}^*$

Example**(iii) Termination Step**

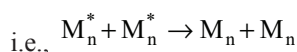
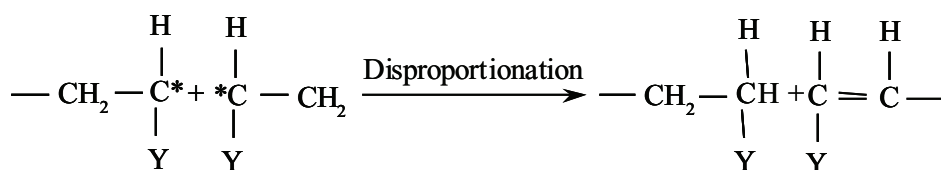
In this step, chain propagation is stopped to isolate medium chain polymers from long chain polymers. This termination can be done by either 'coupling mode' or 'disproportionation mode'.

(a) Coupling Mode

In this mode two growing radical chains are combined to form a saturated macromolecule

**Example****(b) Disproportionation Mode**

In this mode a hydrogen atom is transferred from one growing chain to another chain. This stops the reaction as the first growing chain is left with zero unpaired electrons.

**Example****2. Cationic Mechanism of Polymerization**

In cationic polymerization, strong photonic acid is used as initiator and water, methanol acts as co-catalysts.

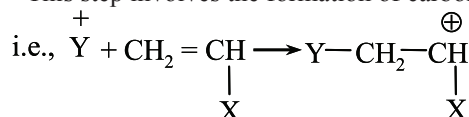
Example

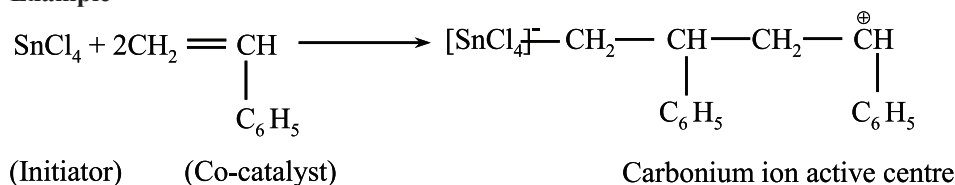
Styrene, iso butylene etc.

This mechanism involves formation of carbonium ion which is illustrated in the following steps,

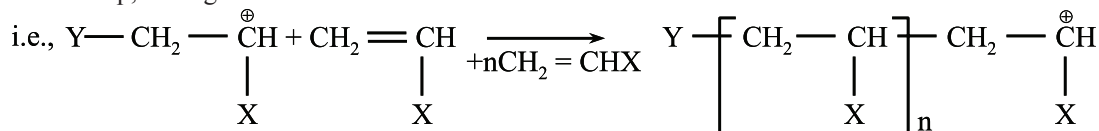
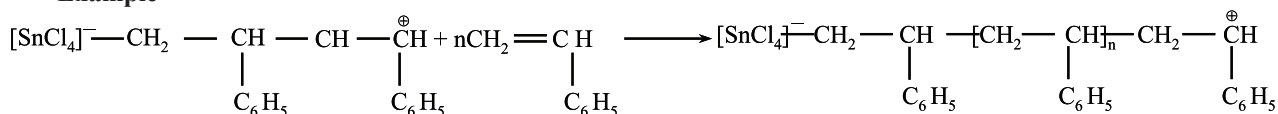
(i) Initiation Step

This step involves the formation of carbonium ion active centre i.e.,

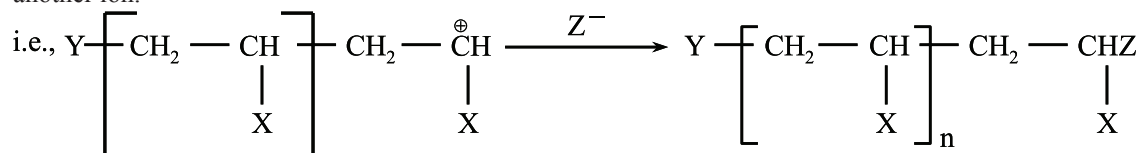
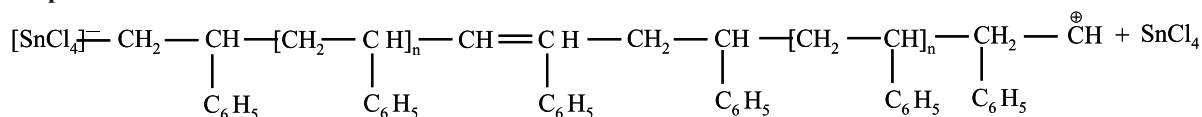


Example**(ii) Propagation Step**

In this step, the regenerated carbonium ions react with monomer molecules

**Example****(iii) Termination Step**

In this step, the cationic polymerization gets terminated when a carbonium ion of growing polymer collides with another ion.

**Example****3. Anionic Mechanism of Polymerization**

In anionic polymerization, anion reacts with the λ -electron pair of monomer.

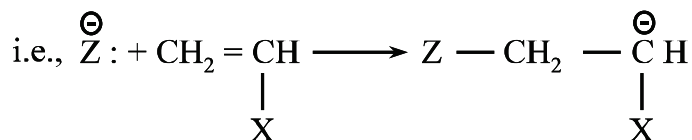
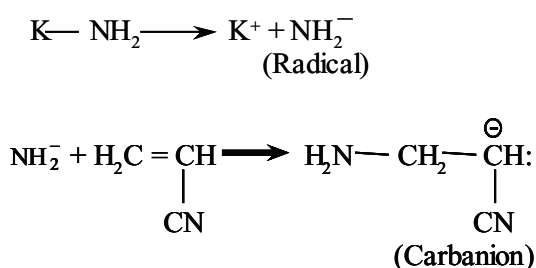
Example

Methylmethacrylate, α -methyl acrylonitrile etc.

In this mechanism, electropositive initiators polymerize the monomers containing electro negative substituents which is illustrated in the following steps,

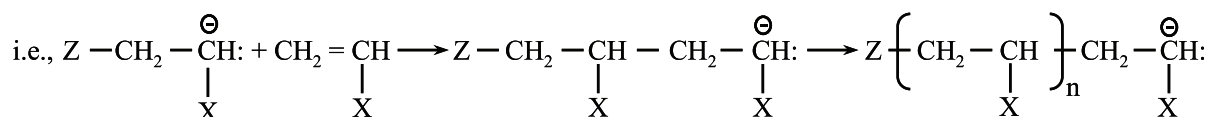
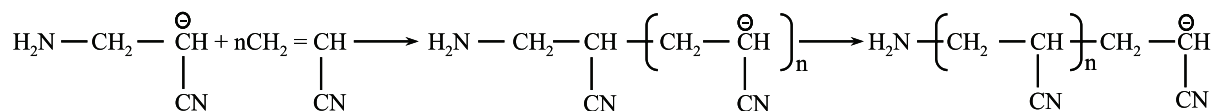
(i) Initiation Step

In this step, an anion produced by initiator combines with the monomer molecule and produces carbanion active centre.

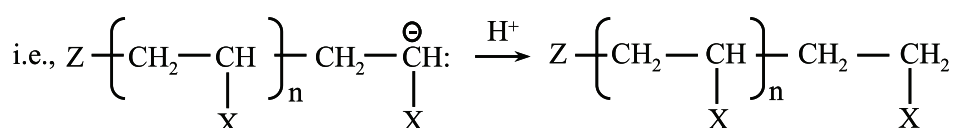
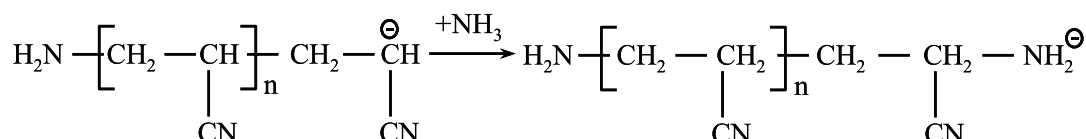
**Example**

(ii) Propagation Step

The carbanion attacks the second monomer molecule and moves the λ -electron pair in opposite direction to the end of the molecule. This increases the growth of chain,

**Example****(iii) Termination Step**

In this step, the anionic polymerization gets terminated by adding impurities or by consuming all the monomers,

**Example****4. Co-ordination Polymerization**

In co-ordination polymerization, stereospecific polymerization can be carried out by the combination of a transition halide and organo-metallic compounds. The mechanism of co-ordination polymerization is illustrated in following steps,

(i) Initiation Step

In this step, the monomer combines with a complex catalyst to produce an active centre i.e., co-ordinate polymer.

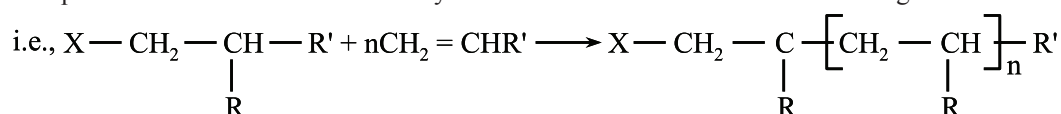


Where,

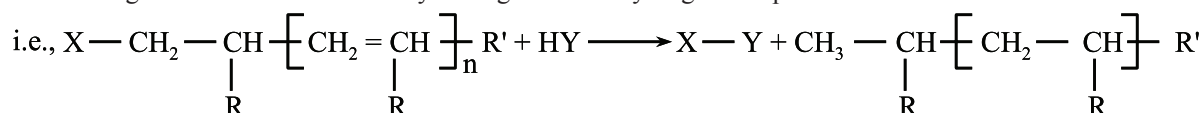
X – Catalyst, R – Radical

(ii) Propagation Step

The produced active centre continuously reacts with the monomers to increase the growth of chain.

**(iii) Termination Step**

The chain growth can be terminated by adding an active hydrogen compound.

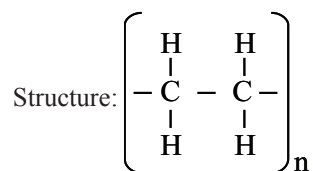


Q22. Write the structure of four addition polymers and four condensation polymers with their respective monomers.

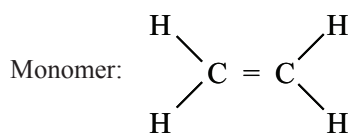
Answer :

Addition Polymers**1. Polyethylene**

The structure and monomer of polyethylene are shown below,



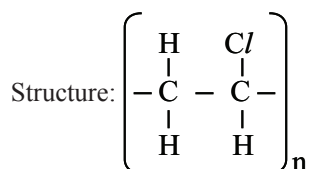
(Polyethylene)



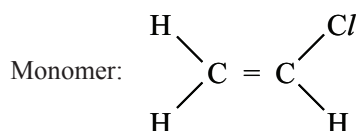
(Ethylene)

2. Poly Vinyl Chloride

The structure and monomer of polyvinyl chloride are shown below,



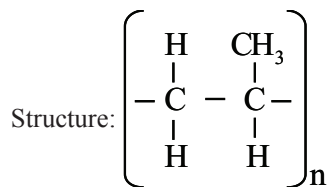
(Poly Vinyl Chloride)



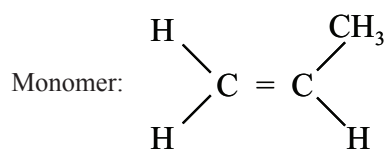
(Vinyl Chloride)

3. Poly Propylene

The structure and monomer of polypropylene are shown below,



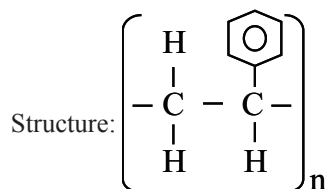
(Polypropylene)



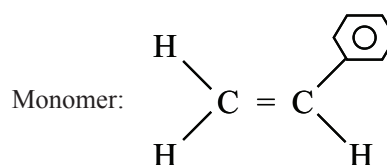
(Propylene)

4. Polystyrene

The structure and monomer of polystyrene are shown below,



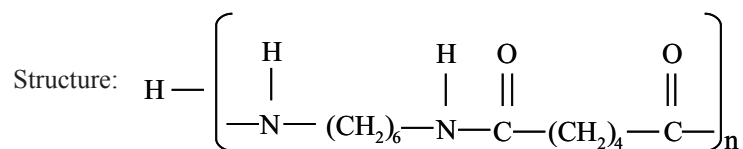
(Polystyrene) or (Poly Vinyl Benzene)



(Styrene) or (Vinyl Benzene)

Condensation Polymers**1. Nylon 6 : 6 (Polyhexamethylene Adipamide)**

The structure and monomer of nylon 6:6 are shown below,



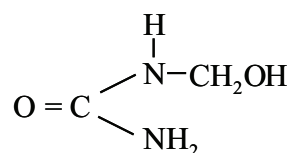
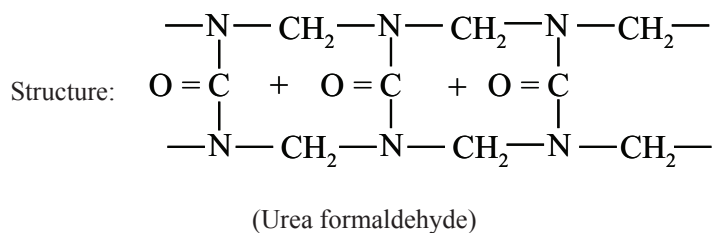
(Polyhexamethylene adipamide) or (Nylon 6:6)

Monomers: $\text{HOOC}(\text{CH}_2)_4\text{COOH} + \text{H}_2\text{N}(\text{CH}_2)_6\text{NH}_2$
(By elimination of H_2O molecule).

(Hexa methylene adipamide)

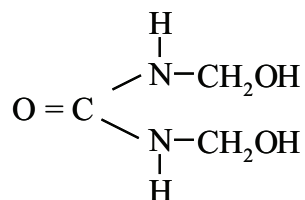
2. Urea Formaldehyde

The structure and monomer of urea formaldehyde are shown below,



(Monomethylol Urea)

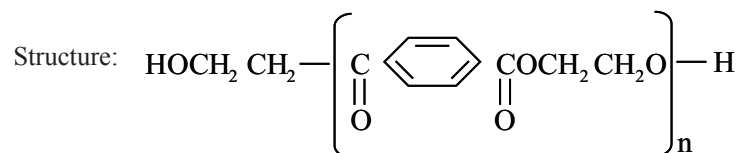
Monomer:



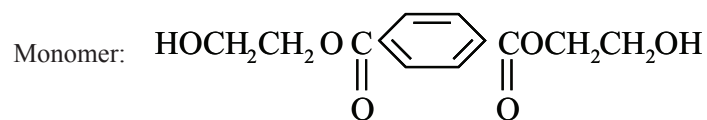
(Dimethylol Urea)

3. Decoran (or) Terylene

The structure and monomer of terylene are shown below,



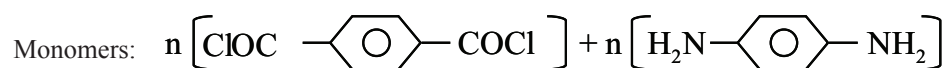
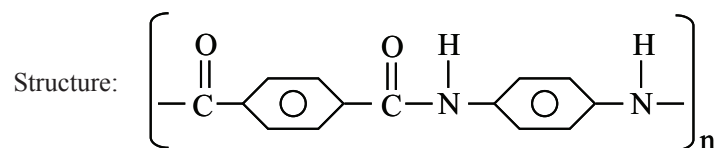
(Diglycol terephthalate) or (Terylene)



(Terephthalic acid)

4. Kevlar

The structure and monomer of Kevlar are shown below,



3.1.3 Preparation, Properties and Uses of the Following Polymers: Plastics – PVC and Bakelite, Fibers – Nylon 6:6 and Kevlar, Elastomers – Buna – S, Butyl and Silicon Rubbers

Q23. What are plastics? List out their properties.

Answer :

Plastics are the materials that show the property of plasticity and can be moulded into any desired shape and dimensions by the application of heat and pressure. Plastics having variety of properties that are used in present applications. The properties are low thermal and electrical conductivity that are easy to fabricate, and has low specific gravity etc. They can be fabricated in large number of colours and it can be used for decorative purposes. They can also be used to produce complicated shapes and accurate dimensions at low costs by moulding process. Plastics are generally used for making automobile parts, goggles, telephones, electrical instruments, optical instruments, household appliances etc. They have high wear resistance properties and can be used for making gears, bearings etc.

Example : Bakelite and Teflon.

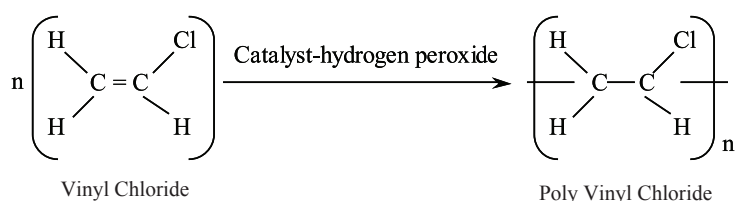
Properties

1. High resistance to corrosion and abrasion.
2. Plastics possess good thermal and electrical insulation properties.
3. Plastic have good shock absorption capacity.
4. Low thermal coefficient of expansion.
5. Light in weight and easily workable.
6. Good dimensional stability.
7. Good strength and excellent in finish.
8. Fabrication and Maintenance cost is low.

Q24. Describe the preparation, properties and uses of PVC.

Answer :

Poly Vinyl Chloride (PVC) is a thermoplastic. It is obtained by addition polymerization of vinyl chloride in the presence of small quantities of hydrogen peroxide at a given pressure.



Properties

1. It is colourless, odourless, non-inflammable.
2. It is tasteless and chemically inert powder.
3. It is resistant to light, atmospheric oxygen, alkalies and inorganic acids.
4. Pure PVC is brittle in nature.
5. Pure PVC possess high softening point, greater stiffness and rigidity.
6. It has good electrical properties.
7. It is abrasion resistant and impermeable to gases.

Uses

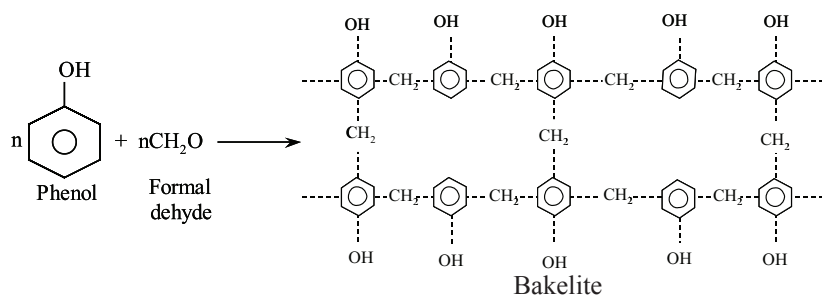
1. It is used for tank-linings, light fitting, safety helmets etc.
2. It is used for making sheets to protect the appliances.
3. It is used for tyres, oil pipes, hot and cold water pipes, motor cycle mud guard and processing vessels.
4. It is used for household applications like bottles, refrigerator components etc.

Q25. Write the preparation, properties and engineering applications of Bakelite.**Answer :**

Dec.-16,Q14(a)

Bakelite is one of the most important thermosetting resins named after an American chemist Bakeland. It is also called as phenol-formaldehyde resin. Bakelite is prepared by condensation polymerization of phenol and formaldehyde, in presence of acidic or basic catalyst. In condensation polymerization, the monomers, ortho 'o' and para 'p' positions of hydroxyl methyl phenols are formed which then reacts to form novolac.

During polymerization process, hexamethylene tetramine $(CH_2)_6N_4$ are added in the alkaline conditions to the phenol and formaldehyde. This makes the novolac as hard and infusible polymer.

**Figure: Bakelite****Uses**

1. Bakelite is used for manufacturing of bearings, which are used in rolling mills and paper industry.
2. It is used as adhesive or binder for grinding wheels.
3. It is used as constituent in paint and varnish manufacturing process.
4. Bakelite is used for making heater handles, switchboards, switches etc.
5. It is also used in making moulded parts like telephone cabinets etc.

Q26. What are fibers? List out their properties.**Answer :****Polymer Fibers**

Polymer fiber is a subset of man-made fiber, which is prepared by using synthetic chemicals. These synthetic polymer fibers are formed with regular structures in order to tightly pack the polymer chains.

Example

PET, Nylon, Fiber-reinforced Plastic (FRP).

Characteristics of Polymer Fiber

The important characteristics of a synthetic polymer fiber are,

- (i) Synthetic polymer fibers give good strength to the filaments.
- (ii) Some of these polymers exhibit good resistance towards hydrocarbon solvents and moisture.
Example: Polyethylene terephthalate.
- (iii) These fibers have good mechanical strength and impact resistance.
Example: Fiber-reinforced plastic.
- (iv) The polymer fibers also possess good abrasion resistance and high temperature stability. The polymer fibers are used in preparing filaments for ropes, bristles for toothbrushes, films and tyre-cords.
Example: Nylon 6:6.

Q27. Explain the preparation, properties and applications of Nylon-6, 6.**Answer :**

June/July-17, Q14(a)

Preparation of Nylon 6:6

For answer refer Unit-3, Q10.

Properties of Nylon

1. These are horn like projection, whitish and translucent polymers.
2. They possess high melting point of 160 to 240°C.
3. Possess good abrasion-resistance and high temperature stability.
4. They are soluble in phenol and formic acid.
5. These are insoluble in organic solvents such as methylated spirit, benzene and acetone.

Uses

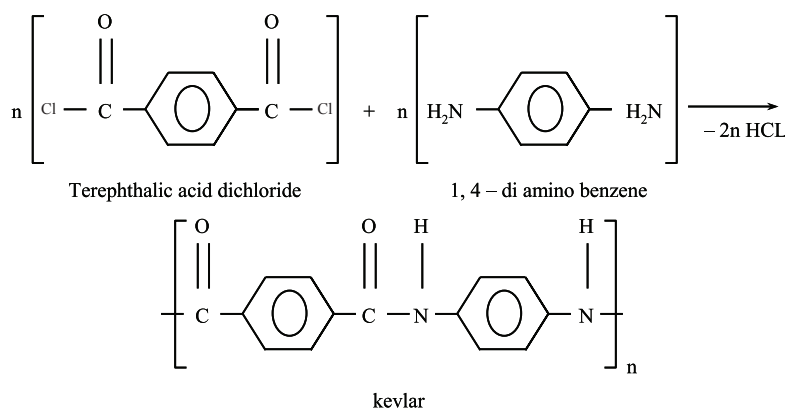
1. Nylon 6:6 is used for making socks, ladies hoses, carpets, undergarments, dresses, etc.
2. These are used for making filaments for ropes, bristles for toothbrushes, films and tyre-cords, etc.

Q28. Explain the method of preparation, properties and applications of kevlar.**Answer :**

Kevlar is also known as aramid polymer (or) aromatic poly amide.

Preparation

Terephthalic acid dichloride and 1, 4 – diamino benzene are subjected to the condensation polymerization and produce kevlar.

**Properties**

1. Kevlar is a very stiff or rigid polymer.
2. It is very strong due to stronger inter molecular forces between neighbouring chains.
3. It possesses high heat stability.

Applications

1. Kevlar is a well-known component of personal armor, such as combat helmets, ballistic face masks and ballistic vests.
2. Kevlar is used to manufacture gloves, sleeves, jackets, chaps and other articles of clothing designed to protect users from cuts, abrasions and heat.
3. Kevlar is very popular material used for racing canoes.
4. Kevlar is used as an inner lining for some bicycle tires to prevent punctures.
5. Kevlar has also been found to have useful acoustic properties for loudspeaker cones, specifically for bass and midrange drive units.
6. Kevlar is also used as a material on marching snare drums. It allows an extremely high amount of tension, resulting in a cleaner sound.
7. Kevlar is used in the wood wind reeds of fibracell.

Q29. What are elastomers? List out their properties.**Answer :****Elastomers**

For answer refer Unit-3, Q11.

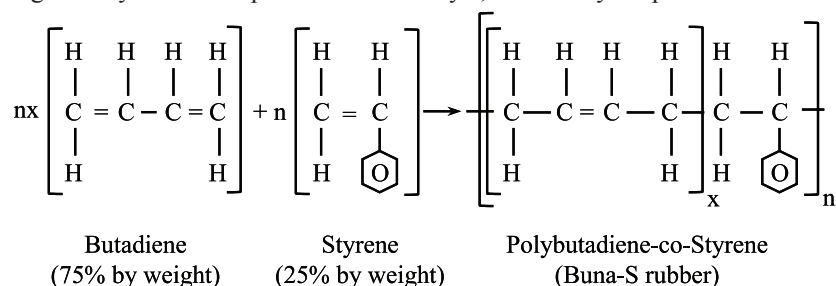
Properties of Elastomers

1. Rapid extensibility to great elongations.
2. Resistance to water, bases and dilute acids.
3. High resiliency.
4. Resistance to abrasion.
5. Low thermal and electrical conductivity.
6. High strength and stiffness.

Q30. Write the preparation and properties of Buna - S rubber.**Answer :**

Jan.-16, Q13(a)(ii)

Buna-S rubber is also called as styrene rubber or GR-S rubber. It is obtained by copolymerization of 75% by weight of butadiene and 25% by weight of styrene in the presence of a catalyst, cumene hydro peroxide.

**Properties**

1. It has high load-bearing capacity and resilience.
2. It has low oxidation resistance i.e., readily oxidizes in the presence of traces of ozone.
3. It has high abrasion resistance.
4. It requires less sulphur during vulcanization.
5. When placed in oil and solvents, Buna-s-rubber swells.

Applications

1. It is used for the manufacture of gaskets, wires, cable insulations.
2. It is used to prepare floor tiles, motor tyres, foot wear components, shoe soles etc.
3. It is used as tank-lining, adhesive, carpet backing etc.

Q31. Write the preparation, properties and uses of,

- (i) Bakelite
- (ii) Buna-S

Answer :

May/June-18, Q13(a)

(i) Bakelite

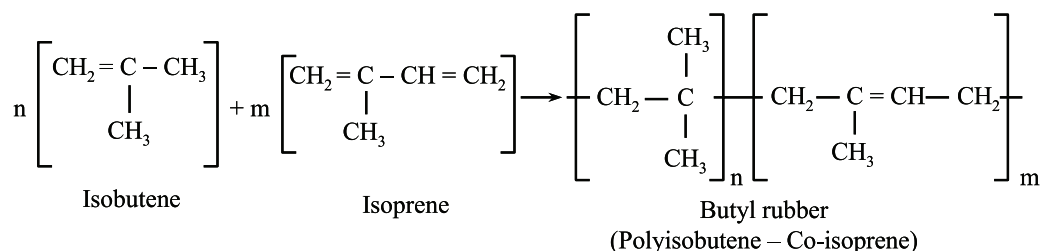
For answer refer Unit-3, Q25.

(ii) Buna-S

For answer refer Unit-3, Q30.

Q32. Explain the properties and applications of Butyl rubber.**Answer :**

Butyl rubber is also called as GR-I rubber. It is obtained by copolymerization of isobutene and small amounts of isoprene (5%). The resultant rubber is vulcanized.



Properties

1. It has good electrical insulation properties.
2. It is soluble in hydrogen solvents.
3. It is highly resistant to ageing, chemicals, polar solvents, heat etc.
4. It provides low permeability to gases and air.
5. Due to very low unsaturation, it cannot be hardened.

Applications

1. It is used for manufacturing automobile parts and tubes.
2. It is used for insulation of wires and cables.
3. It is used in making hoses, conveyor, belts etc.

Q33. Write preparation, properties and uses of

- (i) PVC and
- (ii) Butyl rubber.

June-13, Q14(a)

Answer :

- (i) PVC

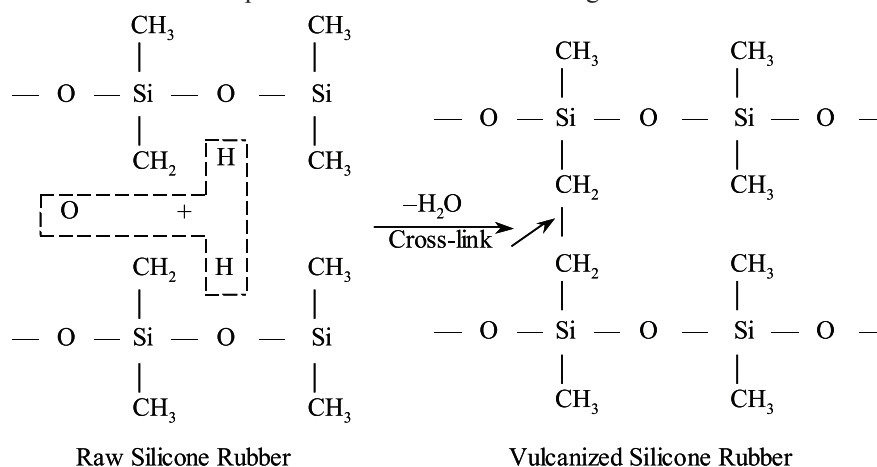
For answer refer Unit-3, Q24.

- (ii) Butyl Rubber

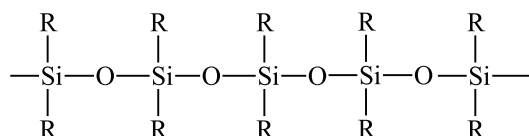
For answer refer Unit-3, Q32.

Q34. Write a note on silicone rubber.**Answer :**

Silicone rubbers are produced by polymerization of dimethyl silicone hydroxide. Silicone rubbers are obtained by mixing or milling together high molecular weight linear dimethyl silicone polymers with an inorganic fillers like finely divided silicone dioxide, TiO₂, ZnO, Iron oxide etc., and a vulcanizing agent such as benzoyl peroxide. Peroxide causes the formation of dimethyl bridge of cross-link between methyl groups of adjacent chains. These rubbers have good resistance to prolonged exposure to sunlight, boiling water, dilute acids, weathering, most common oils and alkalies. These rubbers remain flexible even at minimum temperatures like – 90°C and maximum temperature of 260°C and used in fighter aircrafts.

**Q35. Why are silicones called inorganic polymers? Discuss the synthesis of linear chain silicones.****Answer :**

Silicones contain a network or chain (i.e., backbone chain) of alternate silicone and oxygen atoms based on the repeating unit — (R₂SiO)_n.

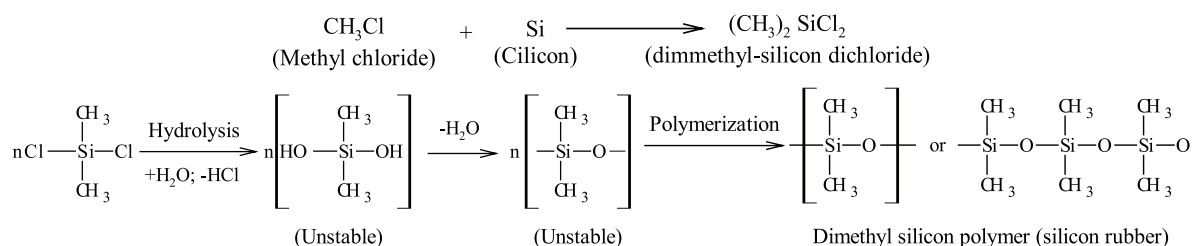


Silicons are considered as organic polymers as the backbone chain does not contain carbon atoms.

When different organic groups of atoms get attached to the backbone, different kinds of silicones are formed. For example, if — CH₃ (methyl) groups attach to the silicon atoms, the polymer is called polydimethyl siloxane.

Synthesis of Linear Chain Silicones

Methyl chloride reacts with silicon to produce dimethyl-silicon dichloride. This reaction product is distilled and then polymerized using hydrolysis carefully.

Reactions**3.2 CONDUCTING POLYMERS****3.2.1 Introduction, Classification and Mechanism of Conduction in Poly-acetylene, Applications of Conducting Polymers**

Q36. What are conducting polymers? Discuss the applications of conducting polymers. June/July-15, Q13(b)

OR

Write the applications of conducting polymers.

Dec.-16, Q7

(Refer Only Applications)

OR

Discuss the applications of conducting polymers.

Jan-16, Q13(b)

(Refer Only Applications)

OR

Write any three applications of conducting polymers.

June-13, Q17(c)

(Refer Only Applications)

OR

Write a short note on applications of conducting polymers.

Jan-13, Q8

(Refer Only Applications)

Answer :

Conducting Polymers

For answer refer Unit-4, Q9.

Applications

1. Conducting polymers are used in the manufacture of analytical sensors. These sensors are used for pH, NH₃ (ammonia) and sulphur dioxide.
2. In the preparation of ion exchangers for the balanced control release of drugs especially in cancer therapy.
3. They are also used in optical filters and batteries.
4. They are used as electro chromic materials which change their colour reversibly in the electrochemical processes.

Q37. Write a note extrinsic conducting polymers.

May/June-18, Q17(a)

OR

Write a note on intrinsic conducting polymers.

June/July-17, Q17(a)

OR

Discuss the classification of conducting polymers.

May/June-12, Q14(b)

Answer :

Classification of Conducting Polymers**(a) Intrinsically Conducting Polymer (ICP)**

Intrinsically conducting polymers contain conjugated π -electron in its backbone or associated group that increases the conductivity of the polymer. Conjugate π -electrons are excited in the presence of electric field, and are transported to the solid polymer. The orbitals overlap over the entire backbone to form valence and conduction bands in polymer molecule. Therefore, electrical conduction occurs only after thermal activation of electrons. This allows to attain enough energy to jump the gap and reach lower levels of conduction band.

Examples: Polyacetylene polymers, poly p-phenylene, polyquinoline, poly-m-phenylene sulphide etc.,

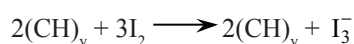
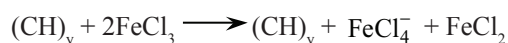
(b) Doping Conducting Polymer

Doping conducting polymers are produced when charge transfer substance is applied to a polymer in a gas or liquid. These can be oxidized or reduced easily due to their low ionization, conductivity and high electron affinity. Its conductivity can be increased by producing positive or negative charges on its backbone using oxidation or reduction techniques. Doping is of two types. They are,

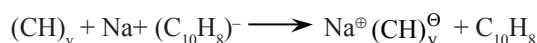
- (i) p-doping
- (ii) n-doping.

(i) p-doping

p-doping is a process in which an intrinsically conducting polymer is treated with Lewis acid. The polymer undergoes oxidation process, leaving a positive charge on the backbone of the polymer. Some of the p-dopants are Br_2 , Ar, F_5 , I_2 etc.

Example**(ii) n-doping**

n-doping is a process in which an intrinsically conducting polymer is treated with Lewis base. The polymer undergoes reduction process, leaving negative charge on the backbone of the polymer. Some of the n-dopants are Ca, Na, Li, FeCl_3 etc.,

Example**(c) Extrinsically Conducting Polymers**

In extrinsically conducting polymers, conductivity occurs due to an externally added substance. These are of two types.

- (i) Conductive element filled polymer
- (ii) Blended conducting polymer.

(i) Conductive Element Filled Polymer

Conductive element filled polymer is a polymer or resin that is filled with a conducting material like metal oxides, carbon black, metal oxides, metallic fibres etc. The polymer binds the conducting elements together in the solid. These polymers are low in cost, light in weight, strong, mechanically durable easily processable into varied forms and shapes. They have a good bulk conductivity.

(ii) Blended Conducting Polymer

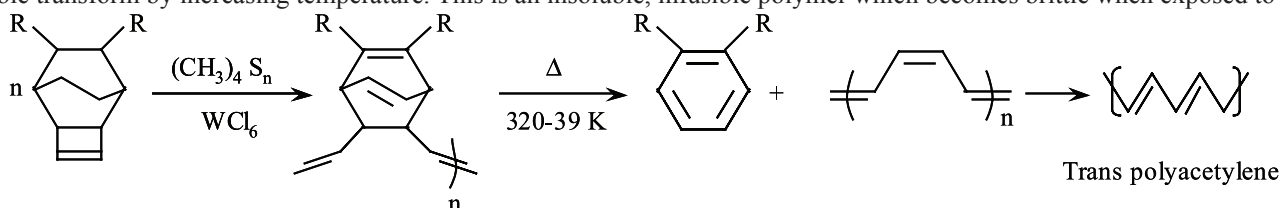
Blended conducting polymer is formed when a conventional polymer is blended with conduction polymer by a physical or chemical change. These polymers have better mechanical, physical and chemical properties. They are easy to process.

(d) Coordination Conducting Polymer

Coordination conducting polymer is an inorganic complex polymer which is formed when a metal atom combines with a polydentate ligand. These polymers show corrosion characteristics inspite of possessing a low degree of polymerization. These are being used widely due to their light weight, good mechanical properties and easy to process capability.

Q38. Explain the preparation of polyacetylene.**Answer :**

Polyacetylene is prepared by polymerization of acetylene with Ziegler catalysts. It is in cis form and can be changed to stable transform by increasing temperature. This is an insoluble, infusible polymer which becomes brittle when exposed to air.



Doping of polyacetylene will increase its conductivity to a great extent. Example: p-doping agents like AgF_5 , I_2 , Br_2 or HClO_4 increase the conductivity of polyacetylene. When its film is exposed to dry ammonia it forms a polymer with a conductivity of 10^3 S/cm .

Q39. Explain the mechanism of conduction in polyacetylene.

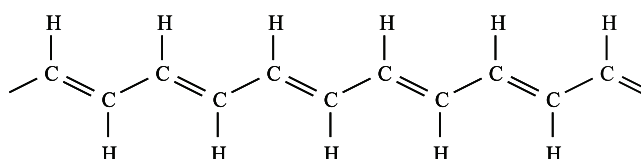
Answer :

April-16, Q6

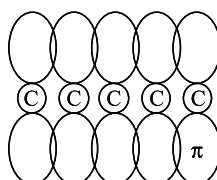
Polyacetylene is a conjugated polymer with the simplest chemical structure. When polyacetylene is treated with Ziegler-Matta catalysts a high temperature and stability oriented polyacetylene is obtained. This is an insoluble, infusible and brittle (when exposed to air) polymer whose conductivity can be increased by doping.

Conduction in Polyacetylene

The chemical structure of polyacetylene is given below.



$(\text{CH}_2)_n$ is a semiconducting polyacetylene with a carbon-carbon backbone structure as shown in figure.



The localized electrons in ' s ' bonds which form the backbone of the polymer chain are responsible for mechanical properties, whereas the delocalized electrons in the π -bonds along the chain are responsible for electrical and optical properties. The σ bonds totally fill the low lying energy bands that have a higher energy gap than π -bond electrons. Before the passage of current, the electrons can flow along the molecule and remove or insert one or more electrons into it. When an electric field is applied the electrons with π -bonds move with the molecular chain. The conductivity of the polymer is limited due to the electron jump from one molecule to another. Therefore, the chains are to be packed in an ordered row.

3.3 BIODEGRADABLE POLYMERS

3.3.1 Introduction, Preparation, Properties and Applications of Polylactic Acid

Q40. Explain the term biodegradable polymers with its applications and properties.

Answer :

Biodegradable

For answer refer Unit-3, Q16.

Biodegradation occurs in two ways i.e., aerobically (with oxygen) or anaerobically (without O_2). It can be measured either through the amount of O_2 consumed by aerobic microbes or amount of CO_2 produced by them or through the amount of methane or alloy produced by anaerobic microbes.

Types of Biodegradable

Based on polymers there are two types of biodegradable plastics. They are,

1. Hydro-biodegradable Plastics (HBP)

HBP undergoes chemical degradation through hydrolysis more quickly. It is highly expensive as it is made with current plastic processing unit.

2. Oxo-biodegradable Plastics (OBP)

OBP undergoes chemical degradation through oxidation very slowly. It is less expensive as it is made from corn, wheat, sugarcane and fossils.

Properties

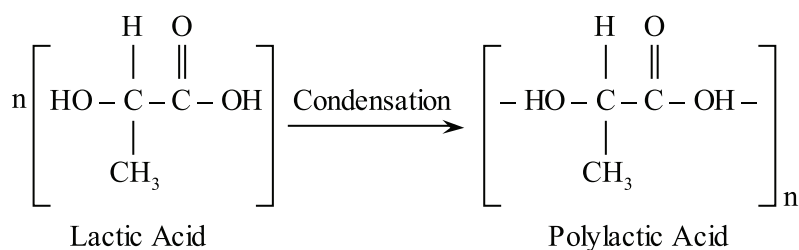
- (a) Biodegradable polymers are non-toxic.
- (b) They possess control rate of degradation.
- (c) They have good mechanical integrity until degradation.

Applications

- (a) Biopolymers are mainly used in medical devices.
- (b) They find vast acceptance in drug delivery systems.
- (c) Dental devices and orthopedic fixation devices are made using biodegradable polymers.
- (d) They are used in tissue engineering, sutures and controlled drug release.

Q41. Explain the preparation, properties and uses of Polylactic acid.**Answer :****Preparation**

The microbiological synthesis of lactic acid and then undergoing polycondensation by evaporating water produces polylactic acid.



Polylactic acid can also be obtained by polymerization of cyclic dimer of lactic acid.

Properties

1. It is a biodegradable thermoplastic aliphatic polyester.
2. It provides good tensile strength.
3. It is brittle
4. It is a low impact resistance material
5. It has low melt viscosity.

Uses

1. It is used in biomedical materials and environment friendly materials.
2. It is used in food packaging, feminine hygiene products.
3. It is used in disposable table ware etc.