Q 1 Define the terms:

i. Monomer

Monomer (Greek: mono-one and mers-part):
The repeating (basic) unit of fibre which combines to give a polymer are called monomers.

(ii) Polymer (Greek: poly-many, and mers-part):
Polymers are compounds of very light molecular masses formed by combination of large number of smaller repeating units called monomer.
Polymers are very large molecules having high molecular mass \((10^3 \text{ to } 10^7 u)\) and are also called macromolecules.

(iii) Polymerisation:
A process of conversion of monomers into polymers is called polymerization OR
Polymerisation is a process in which a large number of simple and small molecules called monomers are allowed to undergo an addition or condensation reaction.

Example:
\[
n.\text{CH}_2=\text{CH}_2 \xrightarrow{\text{Polymerization}} (\text{CH}_2=\text{CH}_2)_n\]

Polyethene

Classification of Polymers

Polymers are classified in a numbers of

(i) Classification based upon availability.
(ii) Classification based upon structure
(iii) Classification based upon polymerization and
(iv) Classification based upon molecules

Classification based upon Source

Depending upon the source from are obtained, polymers are broadly divided following three classes:

1. Natural polymers and
2. Semi-synthetic polymers

1. Natural polymers:
Polymers found in nature, i.e., in animals and plants natural polymers. Proteins which make our body, nucleic acids which control here molecular level, cellulose which provides clothing and shelter and rubber which is making various articles daily use are all polymers.

2. Semi-synthetic polymers:
These are the derived from naturally occurring polymers chemical modifications. For example, cellulose acetylation with acetic anhydrido in present conc. \(H_2SO_4\) gives cellulose diacetate which for making threads of acetate rayon and materials like films, glasses, etc. Vulcanized which is superior to natural rubber is extend used for making types. Gun cotton which is trinitrate is used for making tyres. Gun cotton which is trinitrate is used for making explosives and less powders.
3. Synthetic polymers: A large number of made polymers are extensively used in daily well as in industry. These include fibres (polyester) plastics (polythene, polypropene bers (neoprene, polystyrene), etc.

Classification based on the structure of polymers

These polymers are further classified into three types.

A) Liner polymers: They are made up of long continuous chains without any excess attachments (branches). The repeating units are joined together to form a long chain. e.g. polythene, PVC

\[
\begin{align*}
n & \quad CH_2 \\
\text{ethene} & \quad \rightarrow CH_2-CH_2 \rightarrow [CH_2-CH_2]_n \\
\text{polythene} & \\
\end{align*}
\]

\[
\begin{align*}
nCH_2=CH-CI & \text{ Polymerisation} \rightarrow CH_2-CH-CH_2- \rightarrow [CH_2-CH]_n \\
vinyliclorid & \quad \rightarrow \text{PVC} \\
\end{align*}
\]

B) Branched polymers: these polymers consist of chain structure having one main chain of molecules with smaller chains as branches of main chain. They have low density.

e.g. polypropylene having methyl groups as branches

\[
\begin{align*}
n & \quad CH_3-CH=CH_2 \\
\text{propylene} & \quad CH_3-CH_2 \rightarrow [CH_3-CH_2]_n \\
\text{polypropylene} & \\
\end{align*}
\]

C) Network or cross-linked polymers: Linking of chain polymers by strong covalent bonds leads to network like structure. They are also called cross-linked structure due to cross linking.

e.g. melamine, Bakelite, vulcanization of rubber, etc.
Classification based on polymerization process

These are of two types as given below:

A) **Addition polymers**: The monomers are alkene and the polymers are formed by chain growth polymerisation. The addition polymers contain all the atoms of monomers.

e.g. orlon, Teflon, PVC, polythene, etc.

B) **Condensation polymers**: These polymers are formed by combination of two monomers by elimination of a small molecule like water or methyl alcohol. There are ester or amide linkages in the polymer. The reaction between two or more monomers is stepwise.

dimerisation to form dimers, tetramer...................and so on.

(Examples: nylon, polyester, etc are explained ahead in detail)

Classification based on molecular forces

The properties of polymers depend on molecular forces. Molecular forces bind polymer chains either by hydrogen bonds or by Vander Waal’s forces. These forces are called intermolecular forces. Polymers are further classified as follow.

A) Elastomers: When polymer is stressed, the polymer chain stretches, but due to cross linked tearing is prevented. When the strain is relieved the chain returns to its original position. Thus polymers show elasticity and are called elastomers. They are soft and stretchy and are used in making rubber bands. e.g. neoprene, vulcanized rubber.

B) Fibers: Strong intermolecular forces in fibers of polymers are due to hydrogen bonding. These polymers possess high tensile strength and are used in textile industries, strong ropes, tyre cords, etc. Polymer chains form fibers by hydrogen bonding.
C) Thermoplastic polymers:

Their properties are in between elastomers and fibers. These polymers are called thermoplastic as on heating they become soft and on cooling become hard. Hence these polymers can be remoulded and recycled. They are either linear or branched chain polymers e.g. polythene, polystyrene, PVC, etc. PVC is used as synthetic leather.

D) Thermosetting polymers: These do not become soft on heating under pressure, hence cannot be remoulded and recycled. These are cross linked polymers and cannot be reused. E.g. Bakelite.

---

**Difference between Thermoplastic and Thermosetting plastic**

**Thermoplastic polymers**

1. These soften and melt on heating.
2. These can be remoulded recast and reshaped.
3. These are less brittle and soluble in some organic solvents.
4. These are formed by addition polymerisation.
5. These have usually linear structures.
Ex. Polyethylene, PVC, teflon.

**Thermosetting polymers**

1. These do not soften on heating but rather become hard in case prolonged heating is done these start burning.
2. These can not be remoulded or reshaped.
3. These are more brittle and insoluble in organic solvents.
4. These are formed by condensation polymerisation.
5. These have three dimensional cross linked structures.
Ex. Bakelite, urea, formaldehyde, resin.
Classification based on growth polymerisation: These are classified into two types-

a) These are addition polymerse and the polymerisation process involves the addition at the reactive end of the growing chain across the double bond, e.g. polythene. Many alkene undergo growth chain polymerisation when treated with suitable initiators in small quantity.

b) Condensation polymers are called step growth polymers, any pair of monomer molecules react to give a step in the condensation reaction like dimer, tetramer, etc. e.g. Dacron

Q.2 Write a short note on copolymers or copolymerization?

Ans Copolymerization

When two or more different monomers are allowed to polymerize together, the product formed is called a copolymer and the process is called copolymerization.

A copolymer can be made not only by chain growth polymerization. It contains a large number of units of each monomer used in the same polymeric chain. For example, copolymerization of mixture of 1, 3-butadiene and styrene-butadiene copolymer commonly called as styrene butadiene rubber (SBR) or Buna–S. In Buna–S, Bu stands for butadiene, na for sodium which is the polymerizing agent and S stands for styrene.

Composition of copolymers

In general, the composition of the copolymer depends not only upon the proportion of the monomers but also upon their relative reactivity, Some monomers as such do not polymerize at all but undergo copolymerization. For example, maleic anhydride does not polymerization with styrene in a highly symmetrical manner to form styrene-maleic anhydride copolymer.

Properties and uses of copolymers. The properties of copolymers are usually quite different from those of homopolymers derived from each of the combining monomers. Actually, copolymers have better physical and mechanical properties. Copolymerization is similar to alloying in metallurgy. Just like alloys, various copolymers can be synthesized having desired properties. For example, polystyrene is an homopolymer of styrene. It is a good electrical insulator and can be moulded into toys, combs, radio and television parts. In contrast, SBR or Buna-S is a copolymer of styrene and butadiene. It is very tough and is a good substitute for natural rubber. It possesses high abrasion resistance, high load bearing capacity and is used for the manufacture of automobile tyres. It is also used for making floor tiles, footwear components, cable insulation, etc.

Types of Polymerization

Depending upon the mode of polymerization mainly occurs by the following methods :

1. Addition polymerization or chain growth polymerization.
2. Condensation polymerization or step growth polymerization.
1. Addition Polymerization or Chain Growth Polymerization:

Addition polymerization involves successive addition of monomer units to the growing carrying a reactive intermediate such as a free carbocation or a carbonion.

This type of polymerization is also called chain growth polymerization because it takes in stages leading to increase in chain length of each stage produces a reactive intermediate for in the next stage of growth of the chain. Depending upon the nature of the reactive species involves addition polymerization occurs by the following three mechanisms:

(i) Free radical addition polymerization
(ii) Cationic polymerization
(iii) Anionic polymerization

However, here we shall discuss only free radical addition polymerization. For cationic and anionic polymerization refer to ‘Competition Focus’ on pages 15/37-15/38.

Free radical addition polymerization: A variety of unsaturated compounds such as alkenes, alkadienes, and their derivatives readily undergo polymerization in presence of a radical initiator (radical generating catalyst) such as dioxygen, benzoyl peroxide, acetyl peroxide, etc. For example, polymerization of ethane is carried out at high temperatures (350-570K) and at high pressures (1000-2000 atm) in presence of dioxygen or a small amount of benzoyl peroxide as radical initiator.

These initiator molecules readily decompose on mild heating to form initiator free radicals. For example, benzoyl peroxide on heating produces phenyl initiator free radicals.

The phenyl free radical thus formed adds to the double bond of ethane molecule (monomer) to form a new and larger free radical. This is called chain initiating step.

The new and large free radical (I) produced in the chain initiating step reacts with another molecule of ethane to form another bigger sized radical. Repitition of this sequence with new and bigger radicals carries the reaction forward. This step is called chain propagating step.

Ultimately, the growing free radical chain gets terminated by reactions which consume these free radicals either by combination (Step 1) or by disproportion (Step 2). These are called chain terminating steps.

The entire sequence of steps governing the free radical polymerization of ethene to form polythene is depicted below:

1) Chain initiating steps:

\[
\begin{align*}
\ce{C6H5 + C2H4 &<-> C6H5 + C2H4} \\
\text{(Monomer)} &\quad \text{Polythene (Product)}
\end{align*}
\]
2) Chain propagating steps:

\[ C_6H_5 - CH_2 - \cdot CH_2 + CH_2 = CH_2 \rightarrow C_6H_5 - CH_2 - CH_2 - CH_2 - \cdot CH_2 \]

Here

\[ C_6H_5 -(CH_2 - CH_2)_n - CH_2 - \cdot CH_2 \]

Bigger free radical (II)

3) Chain terminating steps:

Step 1. By combination of free radicals (II):

\[ C_2H_5 \quad (CH_2 \quad CH_2) \_ CH_2 - \cdot CH_2 + CH_2 - CH_2 \rightarrow [CH_2 - CH_2]_n \rightarrow C_6H_5 \]

II

\[ C_6H_5 -(CH_2 - CH_2)_n - CH_2 \quad CH_2 \quad CH_2 -(CH_2 - CH_2)_n \rightarrow C_6H_5 \]

Polyethylene (Polymer)

Step 2. By disproportionation of free radicals.

\[ C_2H_5 \quad (CH_2 \quad CH_2) \_ CH_2 - \cdot CH_2 + C_4H_9 \quad (CH_2 \quad CH_2) \_ CH_3 - \cdot CH_2 \rightarrow \text{Disproportionation} \]

II

\[ C_6H_5 -(CH_2 - CH_2)_n - CH_2 \quad CH_3 + C_4H_9 - (CH_2 - CH_2)_n \rightarrow CH = CH_3 \]

Polyethylene (Polymer)  Polyethylene (Polymer)

2. Condensation polymerization or Step Growth Polymerization:

If two reacting molecules have one functional group each, the reaction stops after one step. For example, acetic acid reacts with ethyl alcohol to form ethyl acetate in one step:

\[ CH_3 \quad C \quad OH + HO \quad CH_2 CH_3 \rightarrow CH_3 \quad C \quad OCH_2 CH_3 + H_2 O \]

Acetic acid  Ethyl alcohol  Ethyl alcohol

If, however, one of the reacting molecules has two functional groups and the other has one functional group, i.e. acetic acid and ethylene glycol, the reaction stops after two steps:
However, when both the reactants are bifunctional, i.e. have two functional groups each they undergo a series of condensations in a stepwise manner with the loss of simple molecules like water, alcohol, etc. at each step leading ultimately to the formation of a high molecular mass condensation polymer.

Write Difference between Addition and condensation polymerization

<table>
<thead>
<tr>
<th>Addition Polymers</th>
<th>Condensation Polymers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formed by addition reaction.</td>
<td>Formed by condensation process with elimination of small molecules like H2O.</td>
</tr>
<tr>
<td>Molecular mass is a whole number multiple of the monomer.</td>
<td>Molecular mass is not whole number multiple of the monomer units.</td>
</tr>
<tr>
<td>Generally involve one monomer unit.</td>
<td>Generally involve more than one monomer unit.</td>
</tr>
<tr>
<td>Monomers are unsaturated molecules.</td>
<td>Monomer units must have two active functional groups.</td>
</tr>
<tr>
<td>They are generally chain growth polymers.</td>
<td>They are generally step growth polymers.</td>
</tr>
</tbody>
</table>

Q 3 Explain Nylon- 6,6 and give its preparation.

Ans:

(i) Nylon-66 was the first synthetic fibre prepared in laboratory.

(ii) It is a polyamide fibre it contains amide linkage & CO – NH –

(iii) It is a hetero- polymer (co- polymer) because it is obtained from two different monomer (hexamethylene diamine and adipic acid).

(iv) It is called as Nylon- 6,6 because the two raw materials from which it is prepared contain six carbon atoms each.

Starting materials:
The starting materials used for preparation of Nylon-6,6 are:

(i) Hexamethylene diamine \( H_2N - (CH_2)_6 - NH_2 \) and

(ii) Adipic acid

\[
\begin{align*}
\text{CH}_3 & \quad \text{C} \quad \text{O} \quad \text{OH} + \text{HO} \quad \text{CH}_2\text{CH}_2 \quad \text{OH} \rightarrow \text{CH}_3 \quad \text{C} \quad \text{OCH}_2\text{CH}_2 \quad \text{OH} + \text{H}_2\text{O} \\
\text{Acetic acid} & \quad \text{(monofunctional)} \\
\text{Ethylene glycol} & \quad \text{(Bifunctional)}
\end{align*}
\]

\[
\begin{align*}
\text{CH}_3 & \quad \text{C} \quad \text{CH} \quad \text{CH} \quad \text{CH} \quad \text{CH} \quad \text{C} \quad \text{O} \quad \text{CH}_2\text{CH}_2 \quad \text{OH} + \text{H}_2\text{O} \\
\text{CH}_3 & \quad \text{C} \quad \text{OCH}_2\text{CH}_2 \quad \text{OH} + \text{H}_2\text{O}
\end{align*}
\]
Preparation:
(i) Preparation of monomer (nylon salt)
(a) Equimolecular aqueous solutions of monomers, hexamethylene diamine and adipic acid are mixed together. The \(-\text{COOH}\) group of one monomer reacts with amino group of another monomer to form a salt hexamethylene diaminium adipate known as byline salt.

(ii) Preparation of liquid polymer (polymerization of monomer):
Sufficient amount of nylon salt is placed in a closed vessel containing nitrogen gas to prevent oxidation. Salt on heating upto 553 K polymerizes to Nylon-6,6 polymer.

During polymerization, the amino group reacts with \(-\text{COOH}\) group to form amide linkage by elimination of water. Thus the monomers are linked through amide bonds and it is a condensation polymer. Nylon-6,6 is a linear and polyamide polymer.

(iii) Spinning of polymer:
Molten mass of Nylon-6,6 polymer is placed in spinnerest and forced under pressure through fine pores into a closed chamber in which hot air blow is passed, extruded solution solidifies to fine filaments of Nylon-6,6

Q. 4 How is Nylon-6 prepared? Why is it so called?
Explain Nylon-6 or Perlon-L and give its preparation.

Ans:
(i) Polyamide fibres contain amide linkage \((-\text{CO} - \text{NH} -)\) in the chain.
(ii) Nylon-6 is also called as perlon-L (in Germany) or polycaprolactum.
(iii) It is a homopolymer as it contains only one monomer
(iv) It is called as Nylon-6, because the monomer \((\varepsilon - \text {caprolactum})\) from which it is prepared contains six carbon atoms.

Starting materials:
Nylon-6 is prepared from a monomer, \(\varepsilon - \text {caprolactum}\) (monomer). The monomer is obtained from \(\omega - \text {amino caproic acid}\).
Polymerisation of \(\varepsilon - \text {caprolactum}\):
\(\varepsilon - \text {Caprolactum} is seven membered amide (cyclic amides are known as lactums).\)
Sufficient amount of monomer, \(\varepsilon - \text {caprolactum} is placed in closed vessel and heated upto 533 K in inert atmosphere of nitrogen to prevent oxidation.
It undergoes addition polymerization to form Nylon-6. It is a linear polyamide, homopolymer. It also called Perlon-L or polycaprolactum.
\[ e\text{-caprolactum} \text{, (monomer)} \]

**Nylon-6** → It is a linear polyamide, it is also called parlon-L polycapropactum

**Q.5 What are the uses of the following?**

(i) **Nylon-6,6 or Nylon-6 or polyamide fibres**

(ii) **Terylene.**

**Ans:**

(i) **Nylon-6,6 or Nylon-6 or polyamide fibres:**
   (a) Nylons are used in the preparation of textile industries—shirting, sarees shawls bed covers, etc.
   (b) Nylons bristles are used in the preparation of tooth brush, hair brush, shaving brush etc.
   (c) Nylon sutures are used for stitching during surgical operations.
   (d) Nylons are used in the preparation of ropes, fishing nets etc.
   (e) Nylons are used in the preparation of motor tyres (Tyre cords).
   (f) Due to their chemical resistance, they are also used in paints and coatings in industry.

(ii) **Terylene:**
   (a) Since they are wrinkle free, no ironing is required and as they dry quickly, they are extensively used in textile manufacture.
   (b) It is blended with cotton to form terycot and blended with wool to form terywool.
   (c) It is used in fishing nets, ropes, conveyor belts, parachute fabric and balloons due to their high tensile strength.
   (d) Used to make filter cloth due to chemical inertness.
   (e) Terylene fibres are used in magnetic tape recorders as they are tear resistance.
   (f) These fibres are also used as reinforcement materials in tyres.

**Q.6 If glycerol is polymerized with dimethyl terephthalate, what will be the structure of the repeating unit in the polymer formed?**

**Ans:**

\[ \text{glycerol} \rightarrow \text{DMT} \rightarrow \text{polymer} \]

\[ \text{O-O-C} \left( \text{CH}_2 - \text{CH}_2 \right) \text{O-O-C} \text{OH} \]

\[ \text{OH} - \text{CH}_2 - \text{CH}_2 - \text{OH} + 2 \text{OH} \]

\[ \rightarrow \left( \text{monomer} \right) \]
Q.7 Give preparation of following polymers:
   i) Phenol formaldehyde polymer (Bakelite)
   ii) Urea formaldehyde polymer
   iii) Formaldehyde melamine polymer (Melamine)

Ans. i) Phenol formaldehyde polymer (Bakelite):
Monomers of Bakelite are formaldehyde and phenol.
Linear polymer of phenol formaldehyde is called Novolac.

Overall reaction for the formation of Novolac can be written as,

\[
\begin{align*}
\text{formaldehyde} + \text{phenol} & \rightarrow \text{Novolac} \\
\end{align*}
\]

Molecules of phenols are joined by \(-CH_2-\) linkage at ortho or pera positions.
Cross linked three dimensional space network solid is called as Bakelite.

Structure of Bakelite:
ii) Urea formaldehyde polymer: it is moulded plastic.

\[
\text{H}_2\text{C}=\text{O} + \text{H}_2\text{N} - \text{C} - \text{NH}_2 \rightarrow \text{HO} - \text{CH}_2 - \text{N} - \text{C} - \text{NH}_3
\]

Formaldehyde  \[\text{NH}_3\]  Urea

\[
\text{HO} - \text{CH}_2 - \text{N} - \text{C} - \text{NH}_2 - \text{CH}_2 - \text{OH} \xrightarrow{\text{CH}_2\text{O}} \text{O} = \text{C}
\]

Intermediate

\[
\text{CH}_2 - \text{O}
\]

\[
\text{N} - \text{C} - \text{N}
\]

\[
\text{CH}_2
\]

\[
\text{Urea formaldehyde polymer}
\]

iii) formaldehyde melamine polymer (Melamine) it is used for making crockeries.

\[
\text{NH}_3 \quad \text{NH}_3
\]

\[
\text{N} - \text{C} - \text{N}
\]

\[
\text{NH}_3 \quad \text{NH}_3
\]

\[
\text{N} - \text{C} - \text{N}
\]

\[
\text{CH}_2 - \text{O}
\]

Melamine polymer

Natural Rubber

It is obtained from rubber tree as a latex, in the form of colloidal suspension. It is a linear polymer of isoprene, 2-methyl-1, 3-butadiene. Natural rubber is cis-1, 4-polyisoprene. It has long flexible chains, weak intermolecular forces and exhibits elastic properties.

\[
\text{CH}_3
\]

\[
\text{CH}_2 \text{C} - \text{C} - \text{CH}_2
\]

\[
\text{H}_3\text{C}
\]

Natural Rubber

\[
\text{CH}_3
\]

\[
\text{CH}_2 = \text{C} - \text{CH} = \text{CH}_2
\]

2-Methyl-1, 3-butadiene (isoprene)

The trans-1, 4-polyisoprene occurs naturally as Gutta-Oerrega, which has zigzag chains sitting in one another. It is non-elastic and crystalline.
**Vulcanization of Rubber**

Natural rubber is soft, sticky and has less tensile strength. To make the natural rubber more strong, tough and elastic it is vulcanized. Charles Goodyear discovered the process of converting natural rubber to more strong and elastic form and called the process vulcanization. Natural rubber is mixed with 3 to 5% sulphur and heated at 100-150° C, it forms cross linking of cis-1, 4 polypropene chains through disulphide bonds, (\(-\text{S-S}-\)). Wide range of physical properties of rubber can be obtained by controlling the amount of sulphur in the process of vulcanization. Rubber made with 20-30% sulphur is hard, 3 to 10% sulphur is a little harder and is used in making tyres. Low sulphur rubber is made with 1 to 3% of sulphur and is used in making rubber bands. Structure of vulcanized rubber is given under cross linked polymers.

**Preparation of Synthetic Rubbers**

There are many different formulations of synthetic rubbers. Preparation of some synthetic rubbers is given below.

A) Buna-S or styrene butadiene rubber (SBR): It is a copolymer of styrene and 1,3-butadiene. It is used in making inner tubes for tyres, motors, bubble gums, etc.

B) Buna-N: It is a copolymer of acrylonitrile and 1,3 butadiene. It is used in making soles of the shoes, adhesives, tank lining, oil seals, etc. (1,3-diene). It is superior to natural rubber and resistant to chemical action. It is used in the manufacture of chemical containers, conveyor belts, gaskets etc.

C) Neoprene rubber: The monomer used is chloroprene (2-chlorobuta-1, 3-diene). It is superior to natural rubber and resistant to chemical action. It is used in the manufacture of chemical containers, conveyor belts, gaskets etc.
D) Butyl rubber: It is a copolymer of isobutylene and isoprene. The mixture of the two monomers when heated at about 100° C in presence of anhydrous aluminium chloride as a catalyst and methyl chloride as a solvent, polymerises to form butyl rubber.

\[
\begin{align*}
\text{CH}_3 & \quad n \text{CH}_2 = C \quad + \quad n\text{CH}_2 = C - CH = CH_2 \xrightarrow{\text{AlCl}_3, \Delta} \\
\text{CH}_3 & \quad \text{Butyl rubber}
\end{align*}
\]

It is used for making inner-tubes of tyres and motors.

**Nonbiodegradable and Biodegradable Polymers**

After a certain period of time the natural polymers degrade on their own but synthetic polymers do not. These are nonbiodegradable polymers and are resistant to environmental degradation processes and are accumulated as solid waste materials. Hence efforts were made to synthesise biodegradable polymers to avoid environmental problems. Some biodegradable polymers are given below:

A) PHBV Polymer (polyhydroxy butyrate-co-β-hydroxy valerate)
It is a copolymer. The monomers used are 3-hydroxy butanoic acid and 3-hydroxy pentanoic acid. It has an ester linkage.

B) Dextran
It is polyglycollic acid-polyactic acid polymer. The monomers used are glycolic acid and lactic acid. It is a copolymer and has ester linkage.
C) Nylon- 2- nylon-6

It is a copolymer and contains polyamide linkages. It is obtained by condensation polymerisation of the monomers, glycine and \( \epsilon \)-amino caproic acid.

\[
\text{glycine} \quad \epsilon \text{amino caproic acid} \quad \text{Nylon-2-nylon-6}
\]

Biodegradable polymers are used as orthopaedic devices, implants, sutures and rug release matrices. They are degraded by bacteria in the environment.

Q.8 \textit{Explain the preparation of terylene or Dacron or polyester fibres OR}

\textit{What happen when ethylene glycol and DMT are heated at 503K in vacuum?}

Ans:
(i) Terylene is a polyester type of fibre also called as Dacron in USA.
(ii) It is a heteropolymer of co-polymer.
(iii) It is also known as Orlon polyester fibre as it contains ester linkage \(-\text{COO}–\)

Starting materials:
It is prepared from ethylene glycol and dimethyl terephthalate (DMT)

\textbf{Preparation:}

1. Preparation of monomer:

   Dimethyl terephthalate and ethylene glycol are mixed together in the ratio 1:2 and the mixture is heated at 503K in pressure of catalyst zinc acetate and \( \text{Sb}_2\text{O}_3 \) in a closed vessel. Transesterification takes place with formation of dihydroxy diethyl terephthalate and elimination of methanol.
2. **Polymerization of monomer:**

   A suitable amount of dihydroxy diethyl terephthalate is heated at $553\,\text{K}$ in vacuum for 3-4 hours. A terylene polymer if formed with partial elimination of ethylene glycol, hence it is condensation polymer.

   It is also known as polyethylene terephthalate. Terylene is linear, polyester polymer

   **Reaction:**

   \[
   \begin{align*}
   \text{HO-CH}_2-\text{CH}_2-\text{O-C-OC-CH}_2-\text{CH}_2-\text{OH} & \quad \text{553 K, vacuum} \\
   \text{CH}_2-\text{CH}_2-\text{O-C-OC-CH}_2-\text{CH}_2-\text{OH} \quad \text{terylene} & \quad + \text{nHO-CH}_2-\text{CH}_2-\text{OH} \quad \text{ethylene glycol}
   \end{align*}
   \]

   The repeating unit in terylene is $-\text{CH}_2-\text{CH}_2-\text{O-C-OC-CH}_2-\text{CH}_2-\text{OH}$

   The repeating units in Terylene are linked by $-\text{CO-CH}_2-\text{ester linkage}$

   Spinning of the polymer

   Terylene polymer is melted and placed in spinnert and then forced under pressure into a closed chamber in which hot air blow is passed solution solidifies in the form of thin fine filaments or melt is cast on rotating wheel to obtain films.
BOARD QUESTIONS

1. Write the chemical reaction to prepare novolac polymer. (March 2013)

2. Explain the following terms: (a) Homopolymers (b) Elastomers. (March 2013)

3. How are polymers classified on the basis of polymerization process? (Oct 2013)

4. Write the structure of ‘melamine’ (Oct 2013)

5. What are thermoplastic polymers? (March 2014)

6. Write names and chemical formulae of monomers used in preparing Buna-S (March 2014)

7. How is nylon 6,6 prepared? Write any Two uses of Terylene (Oct 2014)

8. Explain with examples: branched and linear polymers. (March 2015)

9. What are biodegradable and non-biodegradable polymers?

   Write one example of each (March 2015)

10. Write the reactions involved in the preparation of

    (a) Teflon     (b) Orlon     (c) PVC (Oct 2015)

11. Write the reaction for the preparation of nylon-6. (March 2016)

12. How are polythene and neoprene prepared? (March 2016)