POLYMERS

Topic: 2
TYPES OF MOLECULAR WEIGHTS, BIODEGRADABLE POLYMERS, COMMODITY AND ENGINEERING POLYMERS

LONG ANSWER QUESTIONS

1. What is a bio-degradable polymer? Discuss about any two of the biodegradable polymers.

Biodegradable Polymers

The large scale use of synthetic polymers has been based on their relative inertness to environmental process so that degradation reactions leading to any change in the properties of the polymer during the service life of its product does not occur. It is due to this property that management of polymeric waste has become so difficult that use of polymers has created acute environmental problems.

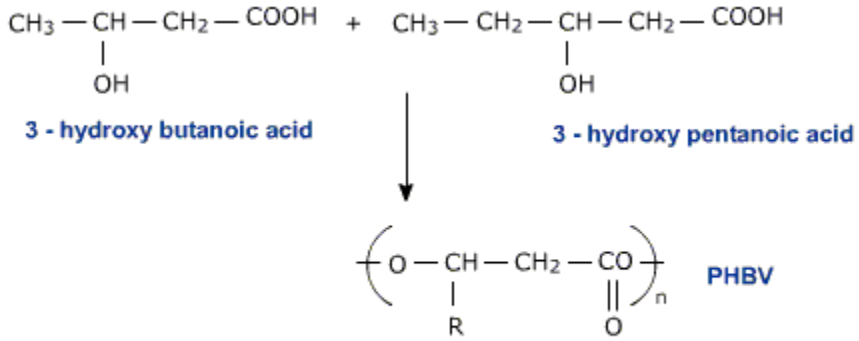
In biological systems, biopolymers degrade mainly by enzymatic hydrolysis and to some extent by oxidation. Biodegradable synthetic polymers have been developed which are safe for use by humans and disposal of polymer waste does not arise.

These synthetic polymers mostly have functional groups prevalent in biopolymers and lipids.

Aliphatic polyesters are one important class of biodegradable polymers as several of them are commercially potential biomaterials.

a) Poly-hydroxybutyrate-co-b-hydroxyvalerate

(PHBV) is a copolymer of 3-hydroxybutanoic acid and 3-hydroxypentanoic acid, in which the monomer units are connected by ester linkages.



R = CH_3, C_2H_5

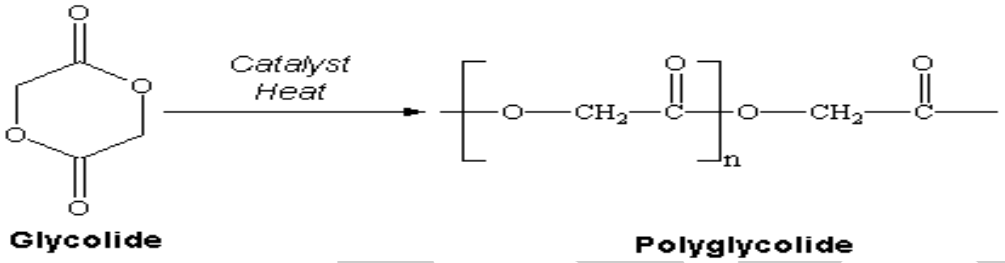
The properties of PHBV vary according to the ratio of both the acids.

3-hydroxybutanoic acid provides stiffness and 3-hydroxypentanoic acid imparts flexibility to the copolymer.

It is used in specialty packaging, orthopaedic devices and even in controlled drug release. When a drug is put into a capsule of PHBV it is released only after the polymer is degraded. PHBV also undergoes bacterial degradation in the environment.

b) Poly (Glycolic acid) and poly lactic acid

Polyglycolide or **Polyglycolic acid** (**PGA**) is a biodegradable, thermoplastic polymer and the simplest linear, aliphatic polyester. It can be prepared starting from glycolic acid by means of poly condensation or ring-opening polymerization. PGA has been known since 1954 as a tough fiber-forming polymer.



Poly (Glycolic Acid) and Poly Lactic Acid are commercially successful biodegradable polymers such as sutures. Dextrin was the first bio absorbable suture made from biodegradable polyesters for post-operative stitches.

2. Explain the molecular weight of polymers.

MOLECULAR WEIGHTS OF POLYMERS:

Molecular weights of polymers expressed in several methods.

(1)Number – Average molecular weight $\bar{M}_n$

(2)Weight – Average molecular weight $\bar{M}_w$

(3)Z – Average molecular weight $\bar{M}_z$

(4)Viscosity – Average molecular weight $\bar{M}_v$

1) <u>Number – Average molecular weight</u> $(\bar{M}_n)$ **:** If N_1, N_2, N_3 are the number of molecules with molecular masses M_1 M_2 M_3 --- respectively. Then

Number – Average molecular mass

$$\bar{M}_n = \frac{N_1M_1 + N_2M_2 + N_3M_3}{N_1 + N_2 + N_3}$$

$$\bar{M}_n = \frac{\sum N_iM_i}{\sum N_i}$$

I**t is determined by**;

- Analysis of end group

- Colligative property like osmotic pressure

2) WEIGHT – AVERAGE MOLECULAR WEIGHT:

If m_1, m_2, m_3 are the masses of species with molecular masses M_1, M_2, M_3 respectively then the weight average molecular weight

$$\bar{m}_w = \frac{m_1M_1 + m_2M_2 + m_3M_3}{m_1 + m_2 + m_3}$$

$$\bar{m}_w = \frac{\sum m_iM_i}{\sum m_i}$$

$$\bar{m}_w = \frac{\sum N_iM_i^2}{\sum N_iM_i}$$

$\bar{M}_w$ can be determined by light scattering and ultracentrifuge method.

3) Polydispersity Index (PDI)

The ratio of weight average molecular mass ($\bar{M}_w$) and Number average mass ($\bar{M}_n$) is called poly dispersity index (PDI)

$$PDI = \frac{\bar{M}_w}{\bar{M}_n}$$

Polymers for which $\bar{M}_w = \bar{M}_n$ are called mono disperse

Most of natural polymers are mono dispersed (PDI is unity). But synthetic polymers or poly dispersed (PDI is greater than unity)

$\bar{M}_w > \bar{M}_n$

4) **z-average molecular weight** : If N_1, N_2, N_3 are the number of molecules with molecular masses M_1 M_2 M_3 --- respectively. Then

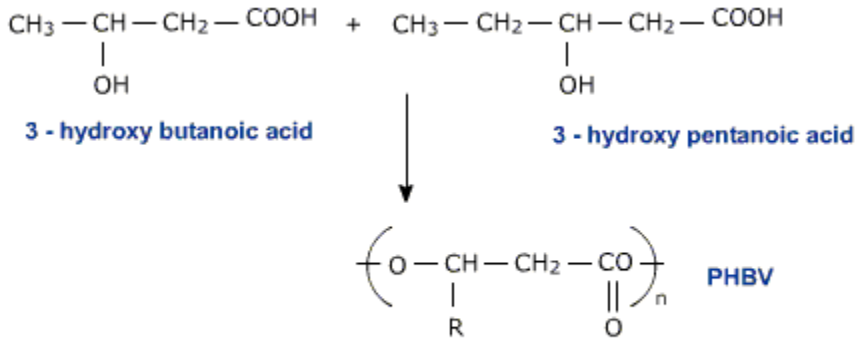
Z – Average molecular mass

$$M_z = \frac{\sum_i N_i M_i^3}{\sum_i N_i M_i^2} = \frac{\sum_i w_i M_i^2}{\sum_i w_i M_i}$$

SHORT ANSWER QUESTIONS

(1) What is PHBV? How it is useful to man?

Ans: Poly-hydroxybutyrate-co-b-hydroxyvalerate : **(PHBV) is a copolymer of 3-hydroxybutanoic acid and 3-hydroxypentanoic acid, in which the monomer units are connected by ester linkages.**



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(2) What is weight average molecular weight?

WEIGHT – AVERAGE MOLECULAR WEIGHT:

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(3) What is number average molecular weight?

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It is determined by;

- Analysis of end group
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(4) What is polydispersity?

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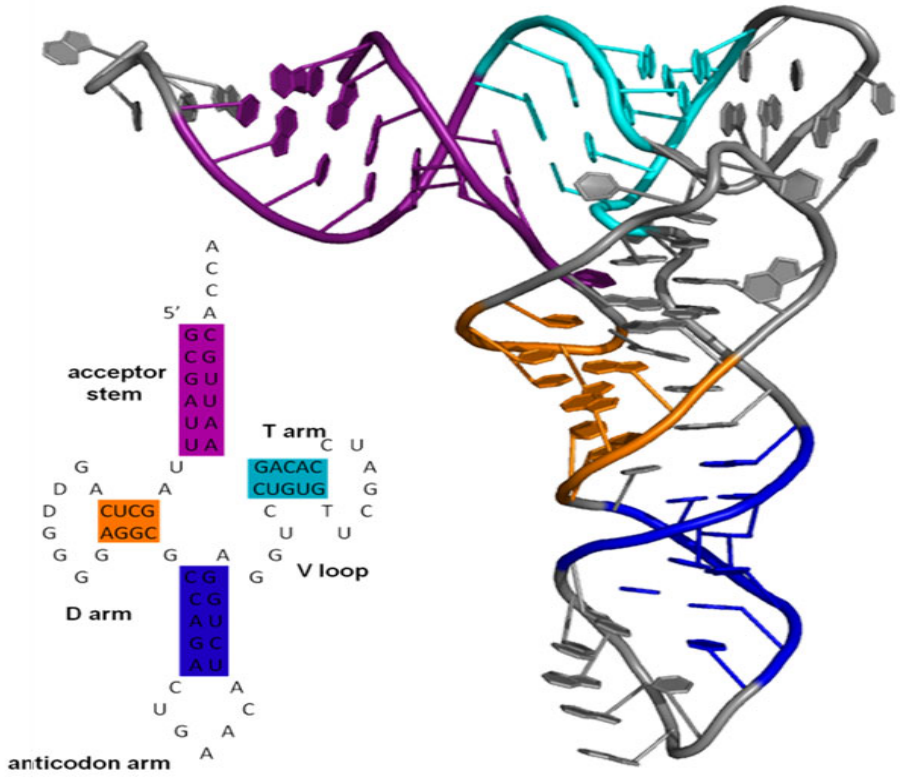
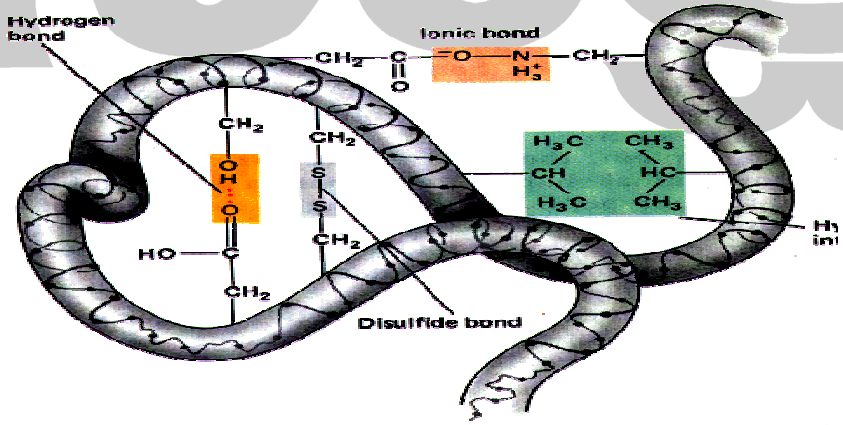
(5) Explain the secondary structure of protein.



Secondary structure is the general three-dimensional form of local segments of biopolymers such as proteins and nucleic acids (DNA/RNA). It does not, however, describe specific atomic positions in three-dimensional space, which are considered to be tertiary structure. Secondary structure is formally defined by the hydrogen bonds of the biopolymer, as observed in an atomic-resolution structure. In proteins, the secondary structure is defined by patterns of hydrogen bonds between backbone amide and carboxyl groups (sidechain-mainchain and sidechain-sidechain hydrogen bonds are irrelevant), where the DSSP definition of a hydrogen bond is used. In nucleic acids, the secondary structure is defined by the hydrogen bonding between the nitrogenous base.

(6) What is the tertiary structure of protein?

Ans: In biochemistry and molecular biology, the **tertiary structure** of a protein or any other macromolecule is its three-dimensional structure, as defined by the atomic coordinates. Proteins and nucleic acids are capable of diverse functions ranging from molecular recognition to catalysis. Such functions require a precise three-dimensional tertiary structure. While such structures are diverse and seemingly complex, they are composed of recurring, easily recognizable tertiary structure motifs that serve as molecular building blocks. Tertiary structure is considered to be largely determined by the biomolecule's primary structure, or the sequence of amino acids or nucleotides of which it is composed. Efforts to predict tertiary structure from the primary structure are known generally as structure prediction



VERY SHORT ANSWER QUESTIONS

(1) What are biodegradable polymers?

Biodegradable polymers are polymers that break down and lose their initial integrity. Biodegradable polymers are used in medical devices to avoid a second operation to remove them, or to gradually release a drug .

(2) What is polyglcolic acid?

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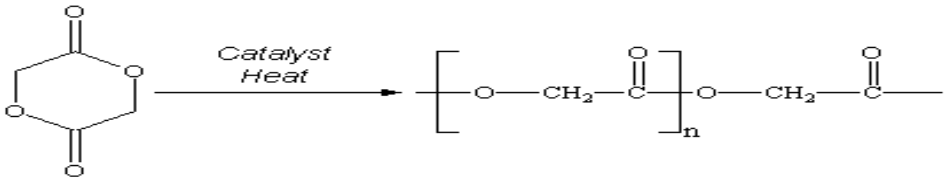

(3) Draw the structure of polylactic acid.

Poly (lactic acid) or **polylactide** (**PLA**) is thermoplastic aliphatic polyester derived from renewable resources, such as corn starch (in the United States), tapioca products (roots, chips or starch mostly in Asia) or sugarcanes (in the rest of world). It can biodegrade under certain conditions, such as the presence of oxygen, and is difficult to recycle.

The name "polylactic acid" is to be used with caution, not complying to standard nomenclatures (such as IUPAC) and potentially leading to ambiguity (PLA is not a polyacid (polyelectrolyte), but rather a polyester)