POLYMERS OR HIGH MPLECULAR WEIGHT COMPOUNDS

Definition:
A polymer is a high molecular weight molecule obtained by combination of single or low molecular weight molecule in presence of application of heat, pressure or catalyst.

ex: $$n\,CH_2 = CH_2 \xrightarrow[\text{Catalyst}]{\text{Heat or pressure}} [-CH_2-CH_2-]_2$$

The process of polymer formation is called polymerization
n the number of molecules participated in the polymerization is called degree of polymerization

Nomenclature:

Homo Polymer: Same monomer participated in the polymerization is called homo polymer

Co Polymer: Two or more monomer participated in the polymerization is called Co polymer

Homo polymer: Same element is repeated in the basic skeleton of polymer is called Homo polymer

Hetro polymer: Different elements are repeated in the basic skeleton of polymer is called Hetro polymer

Iso-tactic polymer: Same orientation of groups around the basic skeleton of the polymer is called iso-tactic polymer

Syndio-tactic polymer: Opposite orientation of groups around the basic skeleton of the polymer is called syndio-tactic polymer

Atactic polymer: Opposite orientation of groups around the basic skeleton of the polymer is called Atactic polymer

Functionality : No. of chain extending sites present in monomer is called functionality

Bi-Functional: Two chain extending sites present in monomer is called Bi-functionality, leads to linear polymer

Tri-Functional: Three chain extending sites present in monomer is called tri-functionality, leads to branched chain polymer

Tetra-Functional: Three chain extending sites present in monomer is called tri-functionality, leads to cross linked polymer

Block co polymer: Different monomeric are groups arranged in basic skeleton is called Block co polymer

Graft co polymer: Different monomeric are groups attached to basic skeleton is called Graft co polymer

Thermoplastics: Polymers undergo softening on heating hardening on cooling

Thermosetting resins: Polymers undergo reversible hardening on heating

Addition polymer: Polymer formed by addition polymerization

Condensed polymer: Polymer formed by condensed polymerization

Types of polymerization:

S.N	Addition polymerization	Condensation polymerization
1	Polymer formed by When monomers undergo addition reaction.	Polymer formed by When monomers undergo condensation reaction.
2	No elimination simple molecule	Elimination of simple condensed molecule
3	Multiple bonds containing monomers under go Addition polymerization	Polar group like -OH, $-NH_2$ containing monomers under go condensed polymerization
4	Polyethylene $n\ CH_2 = CH_2 \longrightarrow [- CH_2 - CH_2 -]_n$	Nylon 6 $n\ H_2N\text{-}(CH_2)_5 - COOH \longrightarrow [- HN\ \text{-}(CH_2)_5 - CO\text{-}]_n$
5	Chain mechanism	Step growth mechanism
6	Molecular weight of a polymer is multiples of no of monomers participated in the polymer	Molecular weight of a polymer is less than multiples of no of monomers participated in the polymer (due to elimination of small molecules)

Plastic:

A high molecular weight organic molecule can be moulded in to any desired shape when subjected to heat, pressure or in the presence of catalyst.

Resin:

it is a important binding material, which form a major part of the plastic, and which actually undergone polymerization and condensation reactions during their preparation

S.N	Thermoplastics	Thermosetting resins
1	The polymer material which soften on heating and harden on cooling	The polymer material which reversibly harden on heating
2	These are Addition polymers, linear polymers	Condensed polymers, cross linked polymers
3.	These can be Reused and reclaimed from wastes	cannot be Reused and reclaimed from wastes
4	Soft and elastic	Hard and brittle
5	PE, PVC,PS etc	Bakelite, epoxy resins etc

Characteristics of polymer structure and properties of polymer

Unique properties of polymers are due to presense of macromolecules with high mol.wt and chain like structure. For each application the requirement of properties are specific and there are number of ways to meet the requirements (mixing polymers with various types of additives, blending two or more polymers, combining polymers with particulate or fibrous materials, developing a new type monomer, polymerising two or monomers together or modifying chemically existing polymers) .

Eg: Mechanical properties of polymers varied over abroad ranges from soft to hard and from brittle to tough.

Polymers are mainly employed in the field of electronics, space technology and medicine.

Macromolecules and polymers:

High molecular mass of macro molecules (masses hundred upto million times) and their structural complexity causes to have specific properties.

Polyethylene(synthetic plastic-molecular mass ranges-tens of thousands to millions) is a polymer consists of a large no.of polyethylene molecules.

Accoring to origin polymers are:

Natural (polysaccharides- basic structural material of plants,protiens- fundemental sructural materials of animals and nucleic acids-carriers of genetic information) and

synthetic polymers (packing materials, synthetic fibers,coating).

Based on general physical properties three types of solid polymers:

Elastomers: Elastomers are rubbers or rubberlike elastic materials.

Thermoplastic polymers: Thermoplastic polymers are hard at room temperature, but on heating become soft and more or less fluid and can be molded.

Thermosetting polymers: Thermosetting polymers can be molded at room temperature or above, but when heated more strongly become hard and infusible

The structural characteristics that are most important to determining the properties of polymers are:

(1) The degree of rigidity of the polymer molecules,

(2) The electrostatic and van der Waals attractive forces between the chains,

(3) The degree to which the chains tend to form crystalline domains, and

(4) The degree of cross-linking between the chains. Of these, cross-linking is perhaps the simplest

A polymer made of a tangle of molecules with long linear chains of atoms. If the intermolecular forces between the chains are small and the material is subjected to pressure, the molecules will tend to move past one another in what is called plastic flow. Such a polymer usually is soluble in solvents that will dissolve short-chain molecules with chemical structures similar to those of the polymer.

If the intermolecular forces between the chains are sufficiently strong to prevent motion of the molecules past one another the polymer will be solid at room temperature, but will usually lose strength and undergo plastic flow when heated. Such a polymer is thermoplastic.

A crosslink is a chemical bond between polymer chains other than at the ends. Crosslinks are extremely important in determining physical properties because they increase the molecular weight and limit the translational motions of the chains with respect to one another. Only two cross-links per polymer chain are required to connect all the polymer molecules in a given sample to produce one gigantic molecule. Only a few cross-links (Figure 29-1) reduce greatly the solubility of a polymer and tend to produce what is called a gel polymer, which, although insoluble, usually will absorb (be swelled by) solvents in which the uncross-linked polymer is soluble. The tendency to absorb solvents decreases as the degree of cross-linking is increased because the chains cannot move enough to allow the solvent molecules to penetrate between the chains.

Thermosetting polymers normally are made from relatively lowmolecular-weight, usually semifluid substances, which when heated in a mold become highly cross-linked, thereby forming hard, infusible, and insoluble products having a three-dimensional network of bonds interconnecting the polymer chains (Figure 29-2).

FORCES BETWEEN POLYMER CHAINS Polymers are produced on an industrial scale primarily, although not exclusively, for use as structural materials. Their physical properties are particularly important in determining their usefulness, be it as rubber tires, sidings for buildings, or solid rocket fuels. Polymers that are not highly cross-linked have properties that depend greatly on the forces that act between the chains. By way of example, consider a polymer such as polyethene which, in a normal commercial sample, will be made up of molecules having 1000 to 2000 CH, groups in continuous chains. Because the material is a mixture of different molecules, it is not expected to crystallize in a conventional way.2 Nonetheless, x-ray diffraction shows polyethene to have very considerable crystalline character, there being regions as large as several hundred angstrom units in length, which have ordered chains of CH, groups oriented with respect to one another like the chains in crystalline low-molecular-weight hydrocarbons. These crystalline regions are called crystallites (Figure 29-3). Between the crystallites of polyethene are amorphous, noncrystalline regions in which the polymer chains are essentially randomly ordered with respect to one another (Figure 29-4). These regions constitute crystal defects

COMPOSITE MATERIALS

Definition

A composite material may be defined as an artificially prepared or natural multiphase material that exhibits a significant proportion of the both the constituent material such as high strength, stiffness and high coefficient of thermal expansion in which the chemically dissimilar phases are separated by distinct interface**.**

Applications of composites

- automobiles industries: Automobile parts like components of engine, spray nozzle, mud guards, tires etc
- Aeronautical applications: structural components like wings, body & stabilizer and fuel of aircraft, rocket amd missiles in military etc
- Marine applications: shaft, hulls, spars and other part of ships
- Safety equipment like helmets
- Sport equipment like tennis rockets, golf sticks, other safety equipment
- Communication Industry like preparation of antennae and electronic circuit boards

Constituents of Composites

Two essential constituents of composites are

1. Matrix phase : It is the continuous body constituent (Dispersion phase) which encloses the composite and gives its bulk form. It may be polymer, metal or ceramic material.

2.Dispersed phase : It is the Structural constituent (Dispersed phase) which determines internal structure of the composite and gives its bulk form. It may be Fiber, Particulate, Flakes or Whiskers

Types of Composites

Based on the dispersed phase in the given matrix of composite they are classified as

A. Fiber reinforced Composite B. Particulate Composite C. Structural Composite

A. Fiber reinforced Composite

- It is Consist of dispersed phase fiber and a continuous or dispersion phase polymer or metal or metal alloy with a bonding agent. The fiber can be employed in the form of continuous length, staples or whiskers.
- Such composites possess high specific strength, specific modulus, stiffness, corrosion resistance and lowers density
- The mechanical characteristics of FRC depend on the following
  1. Properties of fiber
  2. Interfacial bond between fiber and matrix
  3.Fiber length like longer gives continuous, shorter length gives discontinuous or random. Reinforcement efficiency of continuous is higher than short fibers.
  4. Fiber orientation and concentration ie if it is orderly orientation and continuous it is highly anisotropic or discontinuous or random orientation

  Some important types of Fiber reinforced composites are

1. Glass fiber reinforced polymer composite

Fiber glass reinforced composites can be produced by properly incorporating the continuous or discontinuous glass fibers with in a plastic matrix. Polyesters are most commonly used matrix material. most recently nylons are

It is the most popular fiber reinforcement material due to Easily available, easily fabricated, highly economical and which provides stiffness, strength, impact resistance and resistance to corrosion and chemicals.

limitations: they can fuse or melt at high temperatures

Applications: Automobile parts, storage tanks, flourings and plastic pipes etc

2. Carbon fiber reinforced polymer composites

Carbon fibers like (graphite, Grapheens or carbon nanotubes) dispersed in the polymer matrix.

They provide excellent resistance to corrosion, lighter density, and retention of desired properties even at elevated temperatures.

limitations: High cost

Applications: Structural components of air craft like wings and bodies, sport equipment, fishing rods etc.

3. Alumina oxide/ carbon fiber reinforced metal composites:

Fibers of alumina or carbon dispersed in metal or metal alloy matrix which possesses improved specific strength. stiffness, wear resistance**,** creep resistance and resistance to thermal distortion etc

Ex:1. Fiber Al_2O_3 / carbon in a matrix metal alloy find applications in the preparation of components of automobile engines.

2 . Fiber Al_2O_3 /W_2O_3 in a matrix of Ni or Co based alloy find applications in the preparation of components of turbine engines.

B. Particulate Composite

The solid particulates of metal oxides or carbides of varying size and form dispersed in metal , metal alloy, ceramic or polymer liquid matrix.

Particle reinforced composites are further classified into the following two types

1) Large -particulate composites 2) Dispersion strengthened composites

1) Large -particulate composites

Large particle composite used with all the three major types of materials, namely metals, polymer and ceramics.

Example : 1. concrete which is composed of cement matrix and particulates of sand and gravel.

2. Automobile tire in which Carbon black particles dispersed in rubber matrix

3. Ceramic - metal composites which are known as cermets. The most commonly used cermets are

Ex: 1. Al_2O_3 dispersed in Cr matrix possess good strength and good thermal shock resistance.

2. Tungsten carbide(WC) dispersed in Co matrix finds application in preparation of Valves, Spray nozzles and machine parts which require high surface hardness.

2) Dispersion strengthened composites

Very small particles of the range 10-100nm size are used in this which improve strength and hardness.

Metals and Metal alloys may be hardened and strengthened by the uniform dispersion of high volume percent of very hard and inert materials, the strength is achieved due to interactions between particle and dislocations within the matrix. example Thoria-dispersed Nickel

Precipitation hardening: The strength and hardness of some metal alloys may be improved by the formation of extremely small uniformly dispersed particles of a second phase within the original phase matrix with the help of appropriate heat treatment. This process called Precipitate hardening or Age hardening

C. Structural composites

Structural composites are prepared by Compressing the stacking of layers of fiber reinforce composites

These are of two types 1. Laminated composites 2. Sandwich composites.

1. Laminated Composites.

A Laminar composite consists of two-dimensional sheets or panels that have preferred high- strength direction, successive oriented fiber reinforced layers of these are stacked and then cemented together in such a way that the orientation of the high strength varies with each successive layer
Example: Plywood, Copper bottom steel articles

2, Sandwich panels

These usually consist of two strong outer sheets called faces, separated by a layer of less dense material called core which is of lower strength and lower stiffness.
face materials: ply wood, titanium, steel, and aluminum alloy
Core materials: Synthetic rubber, Foamed polymer