Introduction of Polymers

Polymer : The word ‘polymer’ is the Greek word : poly means many and mer means unit or parts, A Polymer is a large molecule that comprises repeating structural units joined by the covalent bonds.

Monomer : The small molecule or repeating unit or the building block in the structure of polymer is called monomer. To be a monomer , the substance unit should have a functionality of at least two , some compounds have two functionality other have double or triple bonds in the molecule .

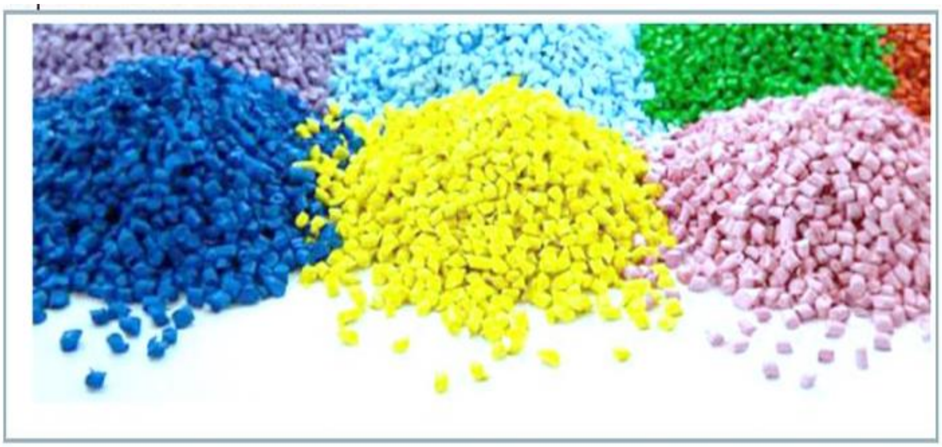
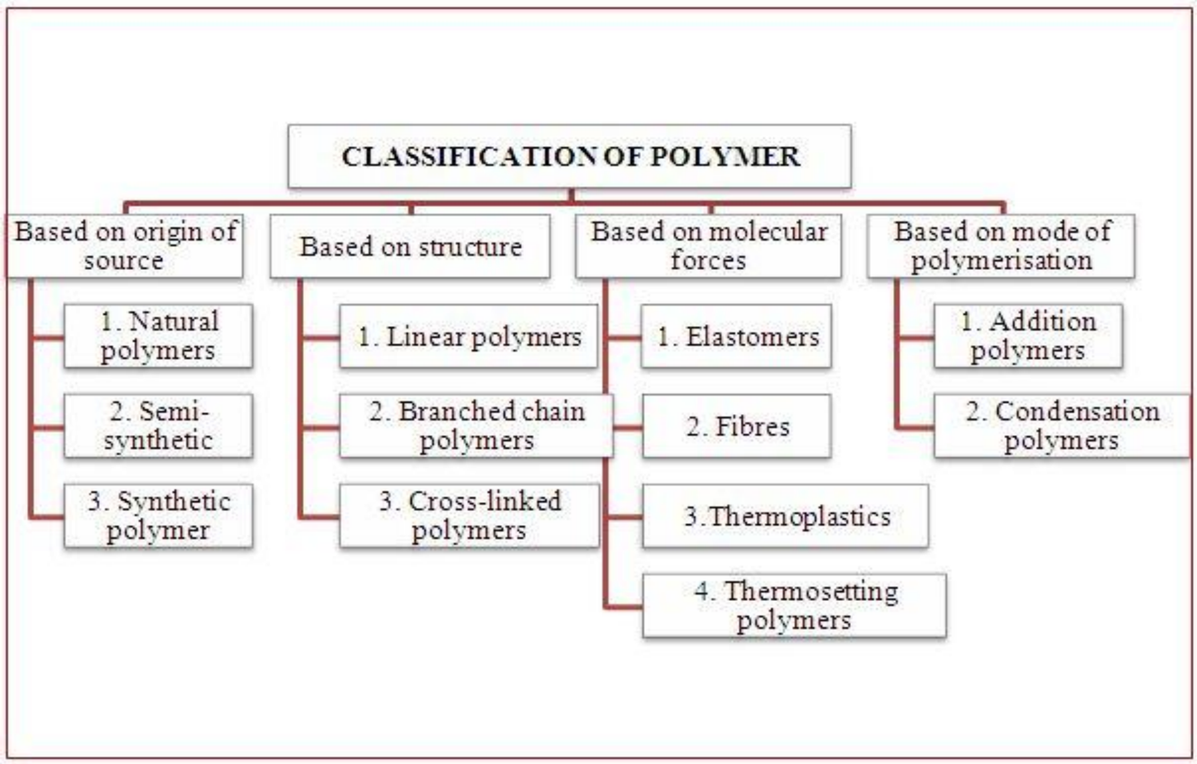


Fig: shows shape of polymer .

Polymerization : it is chemical reaction in which two or more than two molecules of one or more than one substance combine together to form a molecule of high molecular weight.

Degree of Polymerization: Number of monomer or repeating unit(n) in the polymer chain is called degree of polymerization (DP).Degree of polymerization (DP) is used to calculate the average molecular weight of polymer.

Average molecular weight of polymer= DP X Weight of repeating unit.



A- Classification Based on Source Under :

1. Natural polymers: These polymers are found in nature , example plants and animals. Examples are proteins, cellulose, starch, resins and rubber.

2. Semi-synthetic polymers: The polymers obtained by simple chemical treatment of natural polymers to change their physical properties like Starch, silicones

3. Synthetic polymers: The fibres obtained by polymerisation of simple chemical molecules in laboratory are synthetic polymers, ex.. Nylon, polyethene, polystyrene, synthetic rubber, PVC, Teflon…. etc..

B- Classification Based on the structure of polymers :

There are three different types based on the structure of the polymers.

1. Linear polymers on Structure • In these polymers monomers are linked with each other and form a long straight chain.

• These chains has no any side chains, ex. Polyethene, PVC, Nylons, polyesters etc.

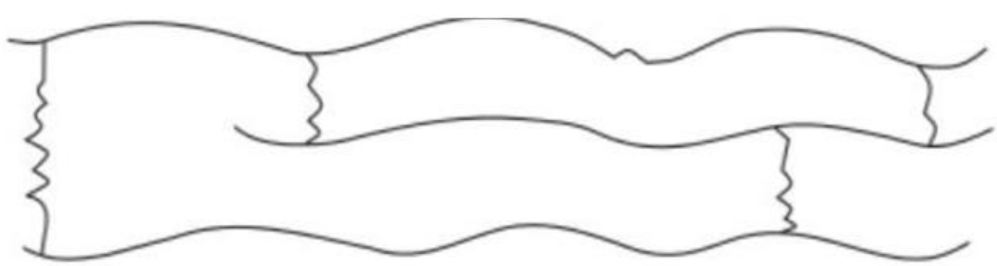
• Their molecules are closely packed and have high density, tensile strength. These are represented as:

2. Branched chain polymers • They have a straight long chain with different side chains.

•Their molecules are irregularly packed hence they have low density, Tensile strength and melting point, ex… polypropylene , amylopectin .

3. Crosslinked or Network polymers : Those polymers in which two linear chains are joined together by covalent bonds and it have three dimensional.

□ Degree of crosslinking is a number of junction point per unit volume.
□ Polymers crosslinking are hard, rigid .and brittle due to their network structure.
□ Polymers Crosslinked do not dissolve in solvents because all the polymer chains are covalently tied together, but they can absorb solvents.
Ex. Bakelite, melamine, formaldehyde resins, vulcanised rubber etc.
These polymers are depicted as follows



C. Classification Based on Mode of Polymerization

Addition Polymerization: In this type, the monomers join together directly without losing any atoms or molecules. The monomers usually have double bonds, and when the reaction starts, these double bonds open up so the monomers can link in a chain. Nothing is eliminated during the process, so the polymer is just a long chain made by adding monomer after monomer.

Condensation Polymerization: In this type, the monomers join by reacting through their functional groups, and every time a bond forms, a small molecule—such as water or HCl—is released. Because a by-product is formed at each step, the chain grows slowly, building the polymer bit by bit as more monomers connect while losing small molecules.

D- Classification Based on Molecular Forces

Elastomers: In elastomers, the molecular forces between the polymer chains are very weak. Because of these weak forces, the chains can stretch easily and return to their original shape when the force is removed. This gives elastomers a rubber-like elasticity.

Fibres: have very strong intermolecular forces, often due to hydrogen bonding or strong polarity. These strong forces keep the chains closely packed and tightly held together, making fibres tough, stiff, and capable of forming strong threads.

Thermoplastics: have moderate intermolecular forces. These forces are not too weak or too strong, which allows the polymer to soften on heating and harden again on cooling. This heating and cooling process can be repeated many times without major chemical change.

Thermosetting Polymers: In thermosetting polymers, strong covalent cross-links are formed between polymer chains. Once these cross-links set during heating, the polymer becomes hard and infusible. After setting, it cannot be melted or reshaped because the network of bonds is permanent.

Composite materials

Composite materials are materials made by combining two or more different substances in such a way that the final material has better properties than each component alone. The components do not dissolve into each other; instead, they stay separate but work together to give improved strength, durability, or lightness.

A composite has two main parts. The matrix is the continuous phase that holds everything together—it can be a polymer, metal, or ceramic. The reinforcement is the stronger, stiffer material added to improve properties; it can be fibers, particles, or flakes. When the reinforcement is mixed into the matrix, the resulting composite becomes stronger, lighter, more heat-resistant, or more flexible depending on the design.

Simple examples include concrete, where cement acts as the matrix and sand/gravel act as reinforcement; fiberglass, where glass fibers reinforce a plastic matrix; and carbon-fiber composites, which are extremely strong and lightweight, used in aircraft, cars, and sports equipment.

Types of Composite Materials

1. Fibre-reinforced composites

These contain strong fibres (like glass, carbon, or aramid) embedded in a matrix such as plastic or metal. The fibres give strength, while the matrix gives shape and protects the fibres. Examples include fiberglass and carbon-fibre composites.

2. Particle-reinforced composites

Here, tiny particles (like metals, ceramics, or carbon black) are spread throughout the matrix. These composites improve hardness, wear resistance, and strength. Examples include concrete and metal-matrix composites with ceramic particles.

3. Laminate composites

These are made by stacking layers (laminae) of different materials. Each layer has different properties, and together they provide high strength and rigidity. Plywood and laminated safety glass are common examples.

Advantages of Composite Materials

1. They are strong but lightweight, making them ideal for vehicles and aircraft.

2. They have high resistance to corrosion, unlike many metals.
3. They can be designed to have specific properties such as high stiffness, flexibility, or heat resistance.
4. They generally have long service life and good fatigue resistance.

Applications of Composite Materials

1. Composite materials are used in many fields:
2. In aerospace, for building aircraft parts like wings and fuselage sections.
3. In automobiles, for lightweight and strong body panels and structural parts.
4. In construction, such as reinforced concrete, roofing sheets, and bridges.
5. In sports equipment, including tennis rackets, bicycles, helmets, and racing car bodies.
6. In marine applications, such as boat hulls and underwater structures, because composites resist water and chemicals.