LESSON 9 PLASTICS

STRUCTURE

9.1 Plastics

Hardly a product on the market today does not have some component made of polymers. Although the word *plastic is* a commonly used synonym for polymers, plastics are one of numerous polymeric materials and have extremely large molecules. Consumer and industrial products made of polymers include food and beverage containers, packaging, signs, house wares, medical devices, toys, appliances, gears, automobile bodies etc. Today, plastics play a dominant role both for industry and domestic applications because of their excellent properties and other merits. These are: high specific strength, hardness and stiffness, good corrosion resistance, good electrical and thermal insulating properties, low coefficient of friction, good vibration and damping capabilities, ease of fabrication, low weight, resistance to most chemicals and cheap compared to other metals or alloys on volume basis.

India is apparently flooded with plastic products, but when compared to the industrially advanced countries, the picture looks totally different. You may be surprised to know that per capita consumption of plastic in our country was only 0.67 kg/year during 1991, whereas in West Germany it was 73 kg/year during 1988. In a developing country like ours, plastics are a boon. They can help in raising the living standards by providing cheap and durable products. In the west, plastics have already replaced many ferrous and non-ferrous metals and other conventional materials in a big way. In some of these countries, production of plastics has already surpassed the production of metals like zinc. Even in India, the usage of plastic items is having a steady growth. A survey conducted in 1991 has indicated that domestic consumption of plastics was only 700,000 tones per annum and a forecast has indicated that it is likely to cross 3 million tones by 2000.

Though plastics are very useful for us, they have a great nescience value. They cause pollution in more than one way and are very dangerous for the environment. We must ensure that the plastics are used correctly such that do not spoil our environment.

Typical products made from plastics include wall tiles, lenses, washbasins, typewriters, gears, TV housings, furniture, brief cases etc. In fact, the applications are limited only by one’s imagination.

The word plastic is derived from the Greek word *Plastikos,* meaning it can be moulded and shaped. The term ‘plastics’ usually refers to a large and varied group of synthetic materials, which are solid in finished form, but at some stage in their

processing, they are fluid enough to be shaped by application of heat and pressure. Plastics may be defined as materials made up of long chain molecules based on carbon and hydrogen. In general, the term *'plastic'* is applied to all materials capable of being moulded or modeled. Modern usage of this word has changed its meaning into a large group of synthetic organic materials that become plastic by the application of heat and are capable of being formed into shapes under pressure. Plastics can be machined, cast, formed or joined to get desired shapes with ease, which is an important advantage over metals.

Polymers do not have a specific melting point, but they undergo a distinct change in their mechanical behavior across a narrow range of temperature. At low temperatures, they are hard, rigid, brittle, and glassy and at high temperatures, they are rubbery or leathery. The temperature at which this transition occurs is called the *glass transition temperature*.

Plastics are derived from two sources – natural and synthetic. The plastics available as such are called '*natural resins'*. Natural resins are exudations from various plants and animals. Rosin from pine trees and shellac from certain insects are examples of natural resins. The plastics that are prepared artificially by chemical processes are called '*synthetic resins'*. Urea, phenol formaldehyde, polystyrene, nylon etc. are the examples of synthetic resins.

Polymers are long chain molecules (also called macromolecules or giant molecules), which are formed by polymerization, i.e. by linking and cross-linking of different monomers. A monomer is the basic building block of polymers. The word 'mer' indicates the smallest repetitive unit, similar to the term unit cell used in connection with crystal structures of metals. The term *polymer* means many mers or units, generally repeated hundreds or thousands of times in a chain like structure. An ethylene molecule, shown in Figure 16.1, is a simple monomer consisting of carbon and hydrogen atoms.

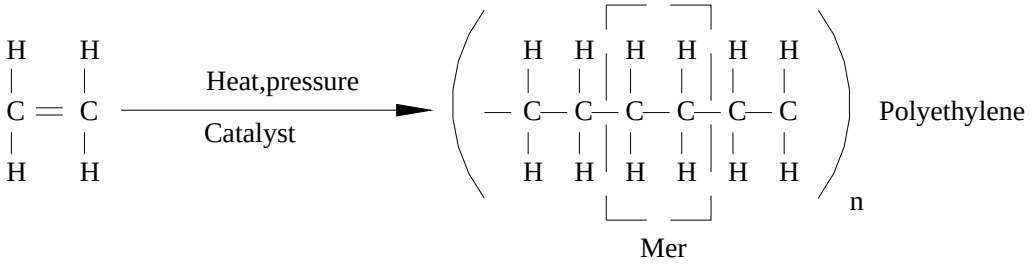

Figure 1: Basic structure of polymer molecules

Polymerization processes are complex. Although there are many variations, two basic polymerization processes are condensation and addition polymerization.

In condensation polymerization, polymers are produced by the formation of bonds between two types of reacting mers. One characteristic of this reaction is that reaction by-products such as water are condensed out hence the term condensation. This process is also known as step-growth or step-reaction polymerization because polymer molecule grows step by step until all of one reactant is consumed.

In addition, polymerization, also known as chain growth or chain-reaction polymerization, bonding takes place without reaction by-products. It is called chain-reaction because of the high rate at which long molecules form simultaneously, usually within a few seconds. This rate is much higher than that for condensation polymerization.

9.2 TYPES OF PLASTICS

Plastics may be broadly classified under two categories:

1. Thermosetting plastics, and
2. Thermoplastic plastics.

9.2.1 Thermosetting Plastics

Thermosetting plastics are formed to shape with heat, with or without pressure, resulting in a product that is permanently hard. The heat first softens the material, but, as additional heat or special chemicals are added, the plastic is hardened by the chemical change known as *polymerization* and cannot be re-softened. The more they are heated, the harder they get. They will burn, crack, and char, but they will not melt or soften. During polymerization, the network is completed and the shape of the part is permanently set. The reaction is irreversible. Hence, these plastics cannot be recycled. We can compare the effect of temperature on a thermosetting plastic to baking a cake or boiling an egg. Once the cake is baked and cooled, or the egg boiled and cooled, reheating it will not change it. The major structural characteristic of thermosets is that the polymer chains are bonded to each other by strong covalent bonds in contrast to weaker secondary bonds that prevail in thermoplastics. Thermosetting plastics are hard and relatively brittle substances. They have greater thermal stability than thermoplastics and exhibit greater resistance to creep. Typical examples are epoxy, polyester etc.

Processes used for thermosetting plastics include compression or transfer moulding.

Typical examples of the products made by thermosetting plastics include switchboards, chairs etc.

9.2.2 Thermoplastic Plastics

For certain polymers as the temperature is raised above the glass-transition temperature or melting point we find that it becomes easier to form or mould them into desired shapes. If we then cool the polymer, it returns to its original hardness and strength. In other words, the process is reversible. Polymers that exhibit this property are known as *thermoplastics*. These plastics can be reused and recycled simply by melting and remolding them. Obviously, these plastics cannot be used at high temperatures. Hence, to make handle of frying pan thermoplastics will not be a better choice. These plastics are known by the commercial name *T-plasts*. Typical examples are acrylic, polyethylene etc.

Typical examples of the products made by thermoplastics include refill and body of pen, carry bags etc. Few products such as dustbins, water tanks can be made from either thermosetting plastics or thermoplastic plastics. Large size dustbins are made from thermosets; where as small size dustbins are made from thermoplastics. Similarly, large size water tanks are made from thermosets, because, thermoplastic plastics have less load carrying capacity. In addition, for thermosetting plastics, fibers can be reinforced to increase its load carrying capacity and hence they are preferred for water storage tanks of larger capacity. These plastics are commercially known as *T-sets.*

Thermoplastic materials are processed by injection or blow moulding, extrusion etc.