Lecture 41

Polymer Chemistry

Polymers are substances whose molecules have high molar masses and are composed of a large number of repeating units. There are both naturally occurring and synthetic polymers. Among naturally occurring polymers are proteins, starches, cellulose, and latex. Synthetic polymers are produced commercially on a very large scale and have a wide range of properties and uses. The materials commonly called plastics are all synthetic polymers.

Terminologies about Polymers:

Monomer:

It is a molecule with low molecular weight that may bind chemically to other molecules to form a polymer. The process by which monomers combine end to end to form a polymer is called polymerization.

Oligomer:
In chemistry, an oligomer is a molecular complex that consists of a few monomer units.

Copolymer:

When two different types of monomers are joined in the same polymer chain, the polymer is called a copolymer.

Random copolymer:

In a random copolymer, the two monomers may follow in any order:

—A—A—B—A—B—B—A—B—A—A—B—B—B—A—

random copolymer

Alternating copolymer:

These are copolymer with regular alternating A and B units.

Block copolymer:

In a block copolymer, all of one type of monomer is grouped together, and all of the other is grouped together. A block copolymer can be thought of as two homopolymers joined together at the ends.

—A—A—A—A—A—A—A—B—B—B—B—B—B—B—

block copolymer

Naturally Occurring Polymer:

Natural polymers occur in nature and can be extracted. They are often water-based. Examples of naturally occurring polymers are silk, wool, DNA, wood, cotton, leather cellulose and proteins. The cellular structure of wood endows it with high strength to weight ratio. Rubber consists of polymers of the major organic compound isoprene. Cotton is made up of cellulose, a linear polymer of D-glucose units. The cellulose content of cotton fiber is 90%. Wool is a protein fibre. Its monomer units are amino acids. Leather is made from animal skin is made of a polymer called collagen. Silk is a natural protein fiber formed from amino acids.

Chemical Foundation:

Most polymers are hydrocarbons i.e. made up of C and H which may be saturated hydrocarbons each carbon is bonded to four other atoms or unsaturated hydrocarbons Each carbon is bonded to 1 to 3 other atoms.

Free Radical Polymerization:

Free radical polymerization is a method of polymerization by which a polymer forms by the successive addition of free radical building blocks. Free radicals can be formed via a number of different mechanisms usually involving separate initiator molecules. Following its generation, the initiating free radical adds (nonradical) monomer units, thereby growing the polymer chain. Each polymer molecules grows by addition of monomer to a terminal free-radical reactive site known as active center. After each addition the free radical is transferred to the chain end. Chain polymerization is characterized by four distinct stages.

Three Stages in Polymerization:

Initiation:

Initiation is the first step of the polymerization process. During initiation, an active center is created from which a polymer chain is generated. Not all monomers are susceptible to all types of initiators. Radical initiation works best on the carbon-carbon double bond of vinyl monomers and the carbon-oxygen double bond in aldehydes and ketones.

Propagation:

During polymerization, a polymer spends most of its time in increasing its chain length, or propagating.

Termination:

Chain termination will occur unless the reaction is completely free of contaminants. In this case, the polymerization is considered to be a living polymerization because propagation can continue if more monomer is added to the reaction.

Range of Polymers:

Traditionally, the industry has produced two main types of synthetic polymer plastics and rubbers. A plastic is a material that can change its shape; so many things can be made of plastic. There are many types of plastic. Some can be shaped only when they are freshly made; then they become hard.
Rubbers are flexible, low modulus materials which exhibit long-range elasticity. The most common properties of rubber are its elasticity, resistance to water and its use as an electrical insulator. When raw rubber is heated, it becomes sticky, and when it is in colder temperatures, it tends to break, just like the synthetic variety.

Plastics are further subdivided into two types:

1. Thermoplastics
2. Thermosets

Thermoplastics:

A thermoplastic is a material, usually a plastic polymer, which becomes soft when heated and hard when cooled. Thermoplastic materials can be cooled and heated several times. They can be recycled. When thermoplastics are heated, they melt to a liquid. They also freeze to a glassy state when cooled enough. Some types of thermoplastic that are commonly produced today are polypropylene, polyethylene, polyvinylchloride, polystyrene, polyethylenetheraphthalate and polycarbonate.

Thermosets:

Thermoset, or thermosetting, plastics are synthetic materials that strengthen during being heated, but cannot be successfully remolded or reheated after their initial heat-forming. Thermosetting plastics, however, have a number of advantages. Unlike thermoplastics, they retain their strength and shape even when heated. This makes thermosetting plastics well-suited to the production of permanent components and large, solid shapes. Additionally, these components have excellent strength attributes and will not become weaker when the temperature increases. Examples of thermoset plastic materials include epoxy, phenolic resins and unsaturated polyester resins.

References:
http://www.plasticseurope.org/what-is-plastic/types-of-plastics-11148/thermoplastics.aspx
http://www.thomasnet.com/about/thermoset-plastics-61020277.html
http://chemed.chem.purdue.edu/genchem/topicreview/bp/1polymer/types.html
http://www.britannica.com/topic/industrial-polymers-468698