

**SRI Y.N. COLLEGE (AUTONOMOUS) NARSAPUR,  
W.G.Dt.**

**DEPARTMENT OF CHEMISTRY**



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**STUDY PROJECT  
ON  
POLYMERS  
BY**

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## Polymers and their properties:

Polymers are formed by polymerization of monomers. A polymer is chemically described by its degree of polymerisation, molar mass distribution, tacticity, copolymer distribution, the degree of branching, by its end-groups, crosslinks, crystallinity and thermal properties such as its glass transition temperature and melting temperature. Polymers in solution have special characteristics with respect to solubility, viscosity and gelation.

Schematically polymers are subdivided into biopolymers and synthetic polymers according to their origin. Each one of these classes of compounds can be subdivided into more specific categories in relationship to their use, properties and physicochemical characteristics.

The biochemistry and industrial chemistry are disciplines that are interested in the study of the chemistry of polymers.

- Biopolymers: These are produced by living organisms:
  - 
  - Structural proteins: as collagen, keratin, elastin.
  - Functional proteins: as enzymes, hormones.
  - Structural polysaccharides: as cellulose, chitin.
  - Reserve polysaccharides: starch, glycogen.
  - Nucleic acids: DNA, RNA.
- Synthetic polymers: these polymers are used for plastics, synthetic fibers, paints, building materials, furniture, mechanical parts and adhesives. These are divided into:

- - Thermoplastic polymers such as polyethylene, teflon, polystyrene, polypropylene, polyester, polyurethane, Poly(methyl methacrylate), vinyl chloride, nylon, rayon, cellulose, silicon, glass fiber, among others.
  - Thermoset plastics: vulcanized rubber, bakelite, Kevlar, polyepoxide.

## History:

The work of Henri Braconnot in 1777 and the work of Christian Schönbein in 1846 led to the discovery of nitrocellulose, which, when treated with camphor produced celluloid. Dissolved in ether or acetone, it is collodion, used as a wound dressing since the U.S. Civil War. Cellulose acetate was first prepared in 1865. In 1834, Friedrich Ludersdorf and Nathaniel Hayward independently discovered that adding sulfur to raw natural rubber (polyisoprene) helped prevent the material from becoming sticky. In 1844 Charles Goodyear received a U.S. patent for vulcanizing rubber with sulfur and heat. Thomas Hancock had received a patent for the same process in the UK the year before.

In 1884 Hilaire de Chardonnet started the first artificial fiber plant based on regenerated cellulose, or viscose rayon, as a substitute for silk, but it was very flammable.<sup>[4]</sup> In 1907 Leo Baekeland invented the first synthetic polymer, a thermosetting phenol-formaldehyde resin called Bakelite. Around the same time, Hermann Leuchs reported the synthesis of N-carboxyanhydrides and their high molecular weight products upon reaction with nucleophiles, but stopped short of referring to these as polymers, possibly due to



the strong views espoused by Emil Fischer, his direct supervisor, denying the possibility of any covalent molecule exceeding 6,000 daltons.<sup>[5]</sup> Cellophane was invented in 1908 by Jocques Brandenberger who squirted sheets of viscose rayon into an acid bath.<sup>[6]</sup>

In 1922 Hermann Staudinger (of Worms, Germany 1881-1965) was the first to propose that polymers consisted of long chains of atoms held together by covalent bonds. He also proposed to name these compounds macromolecules. Before that, scientists believed that polymers were clusters of small molecules (called colloids), without definite molecular weights, held together by an unknown force. Staudinger received the Nobel Prize in Chemistry in 1953. Wallace Carothers invented the first synthetic rubber called neoprene in 1931, the first polyester, and went on to invent nylon, a true silk replacement, in 1935. Paul Flory was awarded the Nobel Prize in Chemistry in 1974 for his work on polymer random coil configurations in solution in the 1950s. Stephanie Kwolek developed an aramid, or aromatic nylon named Kevlar, patented in 1966.

There are now a large number of commercial polymers, including composite materials such as carbon fiber-epoxy, polystyrene-polybutadiene (HIPS), acrylonitrile-butadiene-styrene (ABS), and other such materials that combine the best properties of their various components, including polymers designed to work at high temperatures in automobile engines.

In spite of the great importance of the polymer industry, it took a long time before universities introduced teaching and research programs in polymer chemistry. An "Institut fur Makromolekulare Chemie was founded in 1940 in Freiburg, Germany under the direction of Hermann Staudinger. In America a "Polymer Research Institute" (PRI) was established in 1941 by Herman Mark at the Polytechnic

Institute of Brooklyn (now Polytechnic Institute of NYU). Several hundred graduates of PRI played an important role in the US polymer industry and academia. Other PRI's were founded in 1961 by Richard S. Stein at the University of Massachusetts, Amherst, in 1967 by Eric Baer at Case Western Reserve University, in 1982 at The University of Southern Mississippi, and in 1988 at the University of Akron.

### **Biopolymers vs Synthetic polymers:**

A major defining difference between **biopolymers** and other polymers can be found in their structures. All polymers are made of repetitive units called monomers. Biopolymers often have a well-defined structure, though this is not a defining characteristic (example: ligno-cellulose): The exact chemical composition and the sequence in which these units are arranged is called the primary structure, in the case of proteins. Many biopolymers spontaneously fold into characteristic compact shapes (see also "protein folding" as well as secondary structure and tertiary structure), which determine their biological functions and depend in a complicated way on their primary structures. Structural biology is the study of the structural properties of the biopolymers. In contrast most **synthetic polymers** have much simpler and more random (or stochastic) structures. This fact leads to a molecular mass distribution that is missing in biopolymers. In fact, as their synthesis is controlled by a template directed process in most in vivo systems all biopolymers of a type (say one specific protein) are all alike: they all contain the similar sequences and numbers of monomers and thus all have the same mass. This phenomenon is called monodispersity in contrast to the polydispersity encountered in synthetic polymers.