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Biopolymers Versus Synthetic Polymers

This paper present an overview of important synthetic and natural polymers with emphasis on polymer structure, the chemistry of polymer formation. an introduction to polymer characterization. The biodegradation process can take place aerobically and anaerobically with or without the presence of light. These factors allow for biodegradation even in landfill conditions which are normally inconducive to any degradation. The sheeting used to make these packages differs significantly from other "degradable plastics" in the market as it does not attempt to replace the current popular materials but instead enhances them by rendering them biodegradable.

Keywords: *polysaccharides, polyesters, polyamides, cutin, suberin*

1. Introduction

The word "polymer" is derived from the Greek roots "poly" and "mer," which mean "many parts." Polymeric substances are composed of many chemical units called monomers, which are joined together into large molecular chains consisting of thousands of atoms. The monomers can be connected in linear chains, branched chains, or more complicated structures, each variety yielding interesting and useful properties. Most polymers are derived from petroleum and are based on the chemistry of carbon, although some polymers have noncarbon-based compounds (e.g., silicones have backbones composed of alternating silicon and oxygen atoms, with organic—carbon-containing—side groups attached to the silicon atoms). The familiar categories of materials called plastics, fibers, rubbers, and adhesives consist of a diverse array of natural and synthetic polymers. It is useful to consider these types of materials together under the general rubric of structural polymers because macroscopic mechanical behavior is at least a part of their function. Compared with classical structural materials like metals, the presents a considerable broading of the term.

2. Natural and synthetic polymers

The Natural Biopolymers it's the Macromolecules produced by living organisms and the Synthetic Biopolymers represents the Macromolecules synthesized with biomolecules. A huge variety of biopolymers, such as ***polysaccharides, polyesters, and polyamides***, are *naturally produced by microorganisms*. These range from viscous solutions to plastics and their physical properties are dependent on the composition and molecular weight of the polymer. The genetic manipulation of microorganisms opens up an enormous potential for the biotechnological production of biopolymers with tailored properties suitable for high-value medical application such as tissue engineering and drug delivery.

Polysaccharides

Natural polysaccharides

Carbohydrates are the main components of plant tissues. There are more carbohydrates on earth than all other organic matter combined. Polysaccharides represents 75% of all matter; Cellulose represents 40% of all matter.

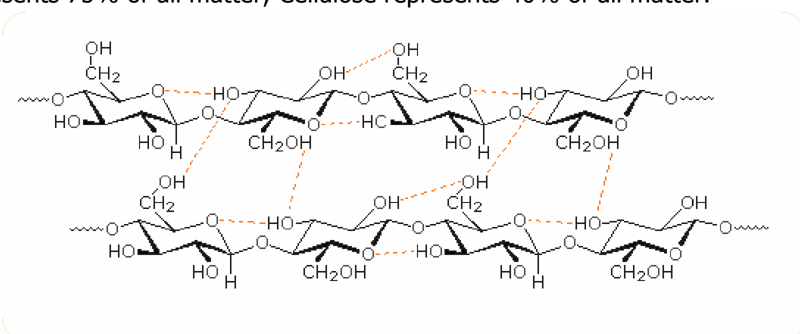

Figure 1. Cellulose , a linar polyglucose joined by β-1-4 bonds. Iner and intramolecular hidrogen bonds.

Synthetic fiber.

The chemical fiber is based on regenerated cellulose, such as rayon and cupro. The synthetic fiber is based on high polymer by organic composition. They can be indicated many kinds of characteristics by mixing with natural materials like pulp, or individually. *Rayon(Viscose, Staple Fiber)* Soft touch, glossy, hygroscopicity, releases water and dyes easily. Also, it is not softened or melted by heat. *Celluloid* is the name of a class of compounds created from nitrocellulose and camphor, plus dyes and other agents. Celluloid is easily molded and shaped, and it was first widely used as an ivory replacement. Celluloid is highly flammable and also easily decomposes, and is no longer widely used. Its most common uses today are the table tennis ball and guitar picks.

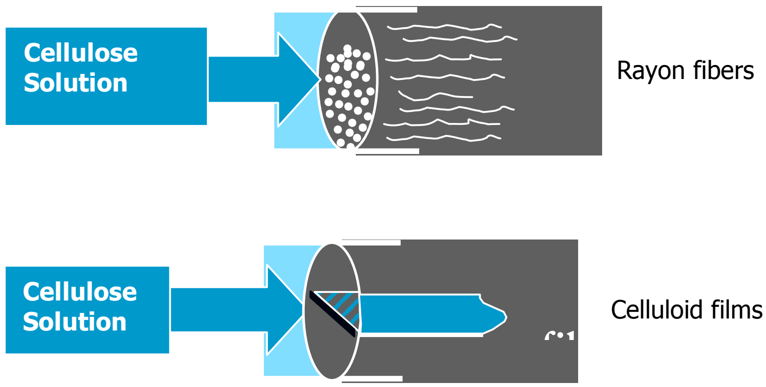

Figure 2. Uses of Regenerated cellulose

Polyesters

Natural polyesters - Biodegradable packaging materials, films, bottles, coated paper with medical applications (surgical sutures, matrix for transport and slow release of drugs, scaffold polymers, fracture fixation materials).

- **PHAs** – Poly(3-HydroxyAlkanoates) - Microbial water-insoluble aliphatic polyesters, optically active.
- **Cutin and Suberin** - Complex Polyesters of aliphatic fatty acids, diacids and hydroxyacids present in "skin" protection tissues of plants. *Cutin* is the most important component of the epidermis of aerial plant tissues. *Suberin* is the most important component of tree stem barks and of roots "skin".

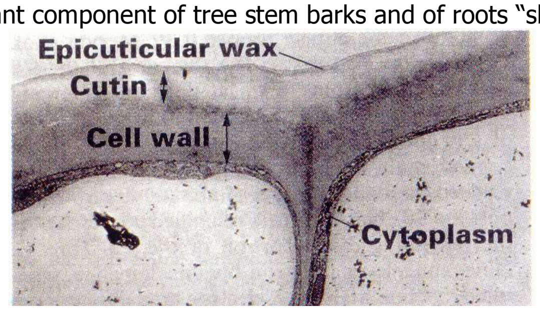

Figure 3. Cutin in the wood cell (Jetter, R., *et al.*, 2000) (X. Fang *et al.*., 2001)

Natural materials are not always better than synthetic materials from an environmental point of view.

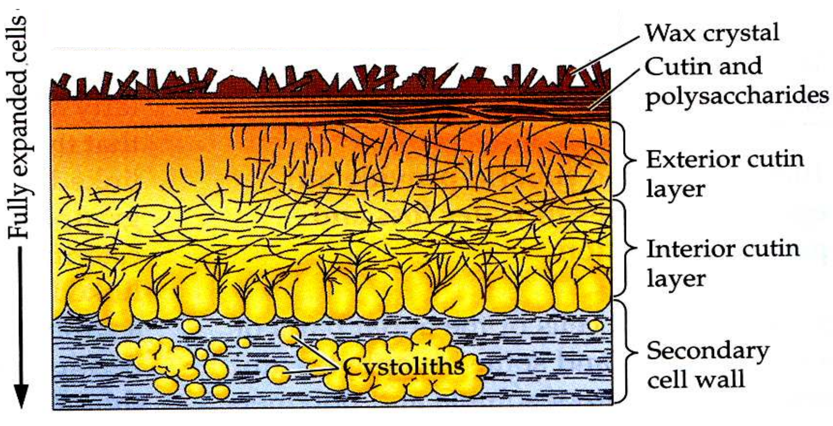

Figure 4. Cutin is the most important component of the epidermis of aerial plant tissues (Buchanan, B. B., *et al.* 2000)

Synthetic polyesters (plastics)

Some polymers are used for many different purposes. A good example is poly(ethylene terephthalate), or PET, which was originally developed as a textile fiber. It is now used in film and tape (virtually all magnetic recording tape is based on PET), as a molding material, and as the matrix for glass-filled composites.
One of its largest uses is for making bottles, especially for soft drinks. PET is also used in blends with other polymers, such as polycarbonate.
The word "plastic" is frequently used loosely as a synonym for "polymer," but the meaning of "polymer'' is based on molecular size while "plastic" is defined in terms of deformability. Plastics are polymeric materials that are formed into a variety of three-dimensional shapes, often by molding or melt extrusion processes.

Figure 5. PET - bottles of **P**oly(**E**thylene **T**erephthalate) Synthetic polyester.

They retain their shape when the deforming forces are removed, unlike some other polymers such as the elastomers, which return to their original shape. Plastics are usually categorized as thermoplastics or thermosets, depending on their thermal processing behavior.

Polyamides

Natural polyamides, proteins

The process of harvesting the silk from the cocoon kills the larvae. Silk has recently come under critism from some animal rights activists who claims that the common practice of boiling silkworms alive in their cocoons is cruel. **Silk** is a natural protein fiber that can be woven into textiles. It is obtained from the cocoon of silkworm larvae reared in captivity (sericulture). The shimmering appearance for which silk is prized comes from the fibers' triangular prism-like structure, which allows silk cloth to refract incoming light at different angles.

Figure 6. Silkworms

In addition to clothing manufacture and other handicrafts, silk is also used for items like parachutes, bicycle tires, comforter filling and artillery gunpowder bags. Early bulletproof vests were also made from silk in the era of blackpowder weapons until roughly World War I. Silk undergoes a special manufacturing process to make it adequate for its use in surgery as non-absorbable sutures.

Chinese doctors have also used it to make prosthetic arteries. Silk cloth is also used as a material to write on. (figure 7)

Synthetic Polyamide

A comparison of fiber production is instructive. The natural fibers cotton and wool make heavy demands on agricultural resources, including land use, fertilizer (from petroleum), and fuel for transportation. Maintenance of clothing made from synthetic fibers requires less hot water. The trade-offs are complicated, but synthetic fibers offer many advantages. A challenge to the use of all materials is posed by their disposal after use. National concern about the use of landfills has resulted in increased emphasis on recycling programs and a reluctance to use "once-through" products that must be sent to landfills. On a volume basis, polymer waste makes up about 20 percent of current landfill input (by weight, the percentage is lower), and methods must be devised to cope with this large and growing problem. Polymers degrade very slowly in landfills, but under typical landfill conditions even paper does not degrade rapidly enough to match the rate at which it enters the landfill.

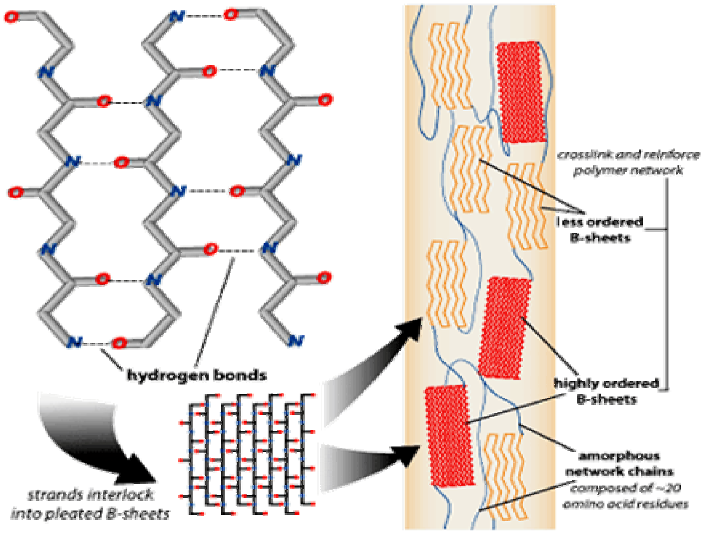

Figure 7. Silk, natural poliamide, product by silkworms.

Although paper and other biodegradable materials degrade much more rapidly under composting conditions, this approach is not generally feasible

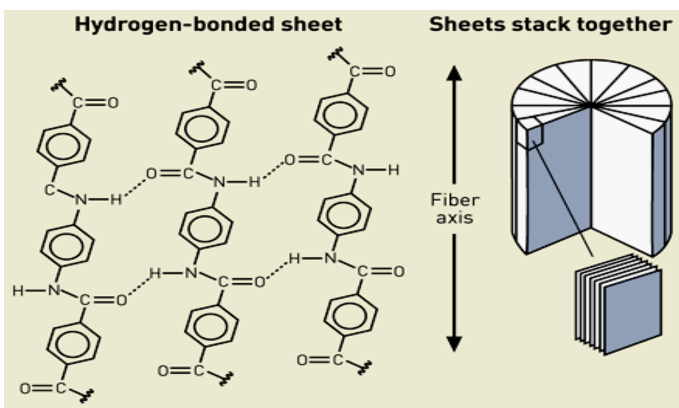

Figure 8. KEVLAR fibers - Synthetic Polyamide

Polymers can be made that are degradable at a more rapid, controlled rate, but these materials are not competitive in cost or in other properties, such as durability.

Recycling of materials is environmentally attractive but in many cases has not proved to be economically viable.

Frequently, products can be made with less expense from raw materials. In part, this observation may reflect our imperfect accounting systems, in which the producer bears no responsibility for the cost of disposal. Manufacturing firms are now moving to design and engineer new products with an eye to the need for recycling at the end of product life. The European automobile industry is a leader in this area, and U.S. automobile manufacturers have formed the Polymer Recycling Consortium to coordinate similiar work.

3. Renewable and not renewable source

Renewable does not mean sustainable, say activists and experts who want to see fewer gigantic dams and more regulation of the use of firewood (source of Mohanty 2004), and incentives for non-conventional sources. The most accessible renewable source currently seems to be geothermal energy, given the high costs still associated with widespread use of solar, wind or wave power, though *biomass* (made from biological waste) is also gaining ground, as are small hydroelectric dams, which are also seen as more sustainable.

Table 1. Biodegradable Polymers vs. Conventional Polymers

Caractheristic of materials	Synthetic polymers	Natural biopolymers
Main Source	Petroleum and Gas	Biomass
Biodegradability	No/Slow	Yes
Structure	stochastic	Well defined
MW distribution	Polydisperse	Monodisperse
Chemical Backbone Structure	Mostly Carbon	Carbon, Oxygen and Nitrogen
conclusions	**NOT renewable source**	**Renewable source Sustainable production**

Biodegradable materials are beginning to be accepted in many countries. These materials are thought to help the environment by reducing waste issues. The two main reasons for using biodegradable materials are, "the growing problem of waste resulting in the shortage of landfill availability and the need for the environmentally responsible use of resources". As the government and many organizations are working to save the environment, there is a definite advantage to making biodegradable plastics more of a reality. Conventional plastics have widespread use in the packaging industry because biodegradable plastics are cost prohibitive. The key, bringing the costs down, is to have numerous companies buy a large sum of biodegradable materials. Laws of supply and demand state that increasing demand will drive costs down. Like conventional plastics, biodegradable plastics must have the same structural and functional qualities, in addition to reacting the same as conventional plastics when used by the consumer. The biodegradable plastics also must be inclined to, "microbial and environmental degradation upon disposal, without any adverse environmental impact"

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