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A Theoretic Study of degradable polymers

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Abstract: Synthetic polymers are important in many branches of industry, for example in the packaging industry. However, they also have an undesirable influence on the environment and cause problems with waste deposition and utilization. Thus, there is a tendency to substitute such polymers with polymers that undergo biodegradable processes. With the increasing market demand, interest in polymers have got a strong and decisive boost towards development on natural materials such as starch. This theoretic study briefly covers major concerns about the natural and synthetic biodegradable polymers (Bioplastic), their types, and biomedical applications.

Keywords: Biodegradation, biopolymer, plastics, bioplastics.

1. Introduction

The plastics industry started looking for alter- native sources of raw materials in the last few decades, and considerable interest is shown in natural, renewable solutions.[1] Bio-based polymers, those polymers which are produced form renewable sources and biomassmay replace the fossil products have many environmental benefits like decreased in pollution. Although the term ‘‘biopolymer’’ is used in several different ways depending on the application area, the generally accepted definition covers polymers that belong to the above mentioned categories, i.e. are either renewable- based, biodegradable or both. Now a days biodegradable polymers are preferred over nondegradable biobased polymers. In future the more stable and non degradable biopolymers will be used [6].

2. Overview of Degradation

Polymer Degradation is the process which deteriorates polymer properties or their outward appearance. Polymers released in to the environment undergoes three types of degradation types of polymer degradation Physical degradation, Chemical degradation and Biological degradation The rates of physical and chemical degradation are faster than environment degradation.

2.1. Physical Degradation

Physical degradation is takes place in the presence of heat of light. It is of two types Thermal degradation and Photo degradation.

2.2. Thermal Degradation

In this polymer has been heated at very high temperatue at which the polymeric chain undergoes the depolymerisation and fragmentation. [2]-[3] The rate and extent of degradation may be monitored by different physico-chemical analysis of byproducts. In thermooxidative degradation the polymeric backbone started to break down on increase the temperature. The above methods are mainly used for recycling of inert polymers.

2.3. Photo Degradation

It is the photo –initiated oxidation. Primary effect of light is the generation of free radicals. It has relatively little effect on the propagating steps of the radical chain reactions. To absorb energy (hν) chromophoric groups must be present. The absorbed radiation will be attenuated as it passes through the polymer and the reaction will be concentrated on the surface layers – skin effect. Ketones are formed by processing at severe conditions and are formed by photolysis of hydroperoxides. Photodegradation is fast when chromophoric groups like C=O are present. This can be used to facilitate easy degradation of plastic materials. There are three main types of degradation through sunlight

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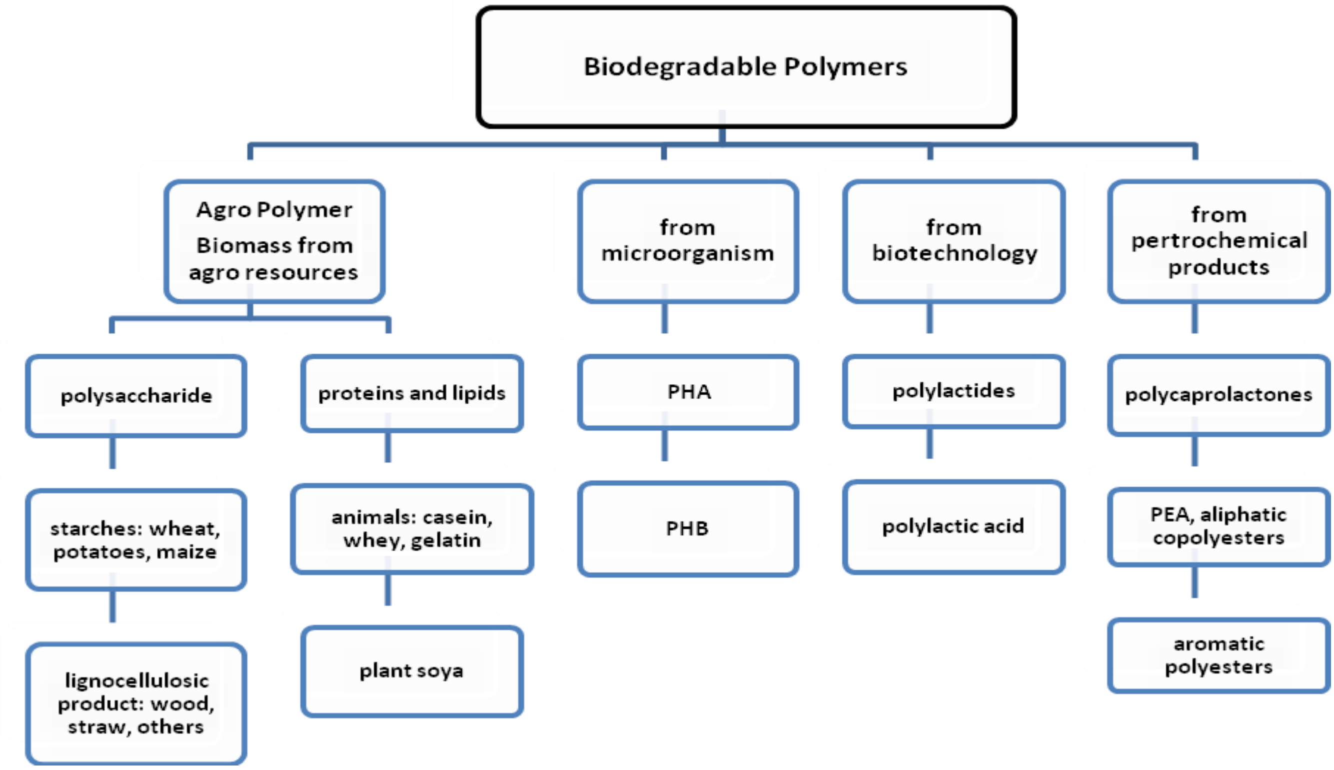

Figure 1: Classification of biodegradable Polymer

• **Photolysis** - absorption as a result of the inherent polymeric structure results in chemistry causing changes in the molecular structure;

• **Photo-oxidation** initiated by photolysis reactions of the polymer itself;

• **Photo-oxidation** initiated by impurities not part of the inherent polymer structure.

2.4. Chemical Degradation

When depolymerisation takes place in presence of any chemical then it is called as chemical degradation of polymers.

2.5. Biodegradation

Biodegradation is the degradation of an organic material caused by biological activity, mainly micro-organisms' enzymatic action. This leads to a significant change in the material chemical structure. The end-products are carbon dioxide, new biomass and water (in the presence of oxygen: aerobia) or methane (oxygen absent: anaerobia). Various steps involved in biodegradation are: a direct enzymatic degradation or oxidative break down followed by metabolization of small fragments of polytmeric chain known as indirect biodegradation.[4] Figure 1 shows the Classification of biodegradable Polymers.

3. Biodegradable Polymer

There are two types of polymer which undergoes biodegradation

- Biopolymers
- Bioplastics

3.1. Biopolymers

Those macromolecules synthesised by living organism are called biopolymers. Some of these are DNA, RNA, proteins, lipid, carbohydrates having specialised role and they also provide structural integrity in biological system.

On the basis of functional group these are classified as polypeptide (proteins), polysaccharides (carbohydrates) or polyphenols. Most of the biopolymers are extracted from biomass. Figure 2 shows the sources of biopolymer.

3.2. Bioplastics

Biodegradable synthetic polymers with modern eco-friendly technologies, biodegradable plastics or bioplastics have been developed from natural products. Unlike synthetic polyethylene non-degradable plastics such as polyethylene (PE), polypropylene (PP), poly(ethylene terephthalate) (PET) and polystyrene (PS). that are derived from petroleum products, bioplastics are produced from renewable biomass sources such as vegetable extracts, sugar cane, food starch, agricultural by-products, organic minerals these natural

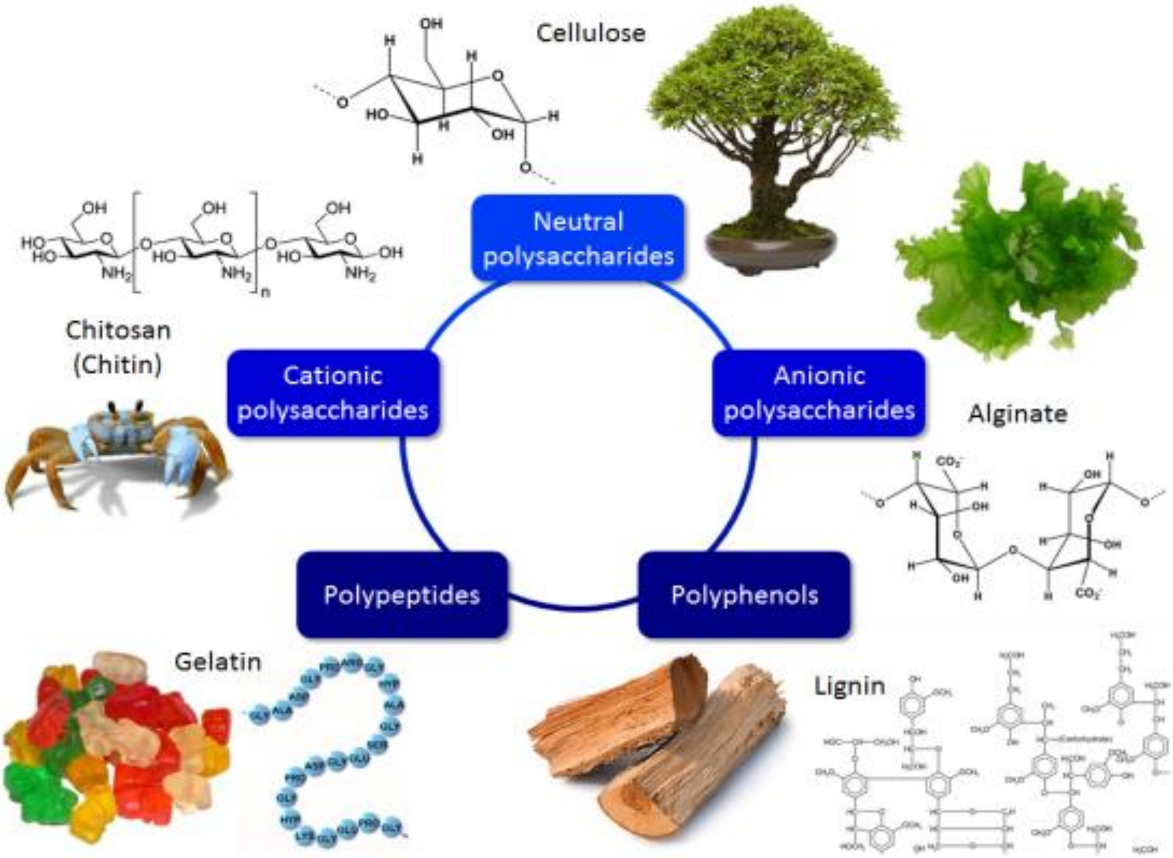

Figure 1: Sources of biopolymers

polymers are also called as biopolymers.[5] Main bioplolymers are polysaccharide-based materials, studies have also been conducted on addition or blends of protein-based materials into polymers. Polyethylene (PE) polypropylene (PP) is non-degradable plastics and hydrophobic due to its hydrocarbon structure. Therefore, it is naturally incompatible with the hydrophilic starch and soya powder. As such, various compatiblizers have been used to improve the interfacial adhesion between PE and polysaccharides or protein based natural polymer[4].

Starch-based bioplastics can be manufactured from either raw or modified starch (e.g. thermoplastic starch or TPS) or from the fermentation of starch-derived sugars (e.g. polylactic acid or PLA). Common starch sources include maize, wheat, potatoes and cassava. Starch is the most attractive candidate of the renewable resources because of its low lost, availability throughout the year and potential for mass production from renewable resources The process of addition of some hydrophilic molecule with inert plastics is backbone is called grafting. Grafting also enhance the biodegradability of Polymers.

Cellulose based Bioplastics are prepared by the chemical modifications in plant cellulose like wood pulp hemp and cotton .these materials are mainly contains cellulose acetate(CA).Plant proteins(zein) and by- products of paper industry (lignin) also used in the making of Bioplastics.[7]

4. Applications of Biodegradable Polymer

Now a days most of the Bioplastics are use in packaging like bottels, film, loosefills and cartons. These are also used in making trash bags, in grocery stores for packing fresh vegetables, fruits, salads, various bakery products,. Bioplastics are also used in waste collection bags, carrier bags, mulch-film and food serviceware such as cutler, minor automotive parts and electronics housings.

Starch-based bioplastics (such as TPS) are used to manufacture food serviceware. Starch mixed with crude oil-based polymers is used for carrier bags. Extruded starch can substitute for expanded polystyrene loosefill packaging. Starch sugar fermentation products such as polylactic acid (PLA) are used in cold drinks cups and bottles, food packaging film and containers, carpets and clothing. PLA can also be used to manufacture CDs and electronics casings.

Polycaprolactum(PCL) is easy to process and with a very short degradation time. It is not used for food application but if mixed with starch it is possible to obtain a good bio-degradable material at a low price, used for trash bags. PET is commonly used for eating utensils (like fork, knife, spoon, dishes and so on) and bottles but it costs twice as much than commercial ones (Salt, 2002). DuPont (Tennessee) produce the PET/hy- dro-biodegradable polyester under the trade name of Bio- max, exported in all over the world.

Polyethylenes (LDPE,HDPE,UHMWPE,) Polyurethanes, Polymethylmethacrylate, Polysulfone, Delrin are used in orthopedics, artificial tendons, catheters, vascular grafts, facial and soft tissue reconstruction. HDPE used as pharmaceutical bottles, fabrics, bags, pouches, tubes etc.

Polymethylmethacrylate (PMMA, lucite, acrylic, plexiglas) in acrylics used in dental restorations, membrane for dialysis, ocular lenses, contact lenses, bone cements. Polyvinylchloride (PVC) used as blood and solution bags, packaging, IV sets, dialysis devices, catheter, bottles, cannulae [6].

Polyurethanes used in tubing, vascular grafts, pacemaker lead insulation, heart assist balloon pumps. Polyanhydrides have been investigated in controlled release devices for drugs treating eyes disorder. They have been used as chemotherapeutic agents, local anesthetics, anticoagulants, neuro-active drugs and anticancer agents [7].

PHB has the advantageous property of being degraded in D-3-hydroxybutyrate, a natural constituent of human blood. As a consequence, PHB is suitable for biomedical applications. It is used in drug carriers and tissue engineering scaffolds [8]. Composites in CFRC, self reinforced, hybrids uses in Orthopedics, scaffolds. Hydrogels in cellulose, acrylic co-polymers uses in drug delivery, vitreous implants, wound healing. Polyglycolic Acid, Polylactic acid, polyesters uses in sutures, drug delivery, in-growth and tissue engineering.[9]

4. Conclusion

Biodegradable polymer shows very hig demand and growth in last decades due to the ecofriendly nature and health benefits. Biodegradable polymers have received much more attention in the last decades due their potential applications in the fields related to environmental protection and the maintenance of physical health. The future outlook for development in the field of biopolymers materials is promising. To provide added value to biodegradable polymers, some advanced technologies have been applied. They include active packaging technology and natural fiber reinforcements. Recently different studies have been reported concerning the use of nanoclay with biodegradable polymers, especially with starch and aliphatic polyesters. Nano-biocomposites or bio-nanocomposites are under investigation. Using biodegradable polymers in many fields of industry, instead of synthetic materials, may significantly help protect the natural environment.

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