Research Paper

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Chemistry

Study of Biodegradable Polymers And Its Environmental Impacts

KEYWORDS: Biodegradable, polymers, environment, microorganisms, recycling, microbially-grown plastics.

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ABSTRACT

The world is facing today a very important issue of Global Warming and one of the most significant contribution in increasing Global Warming is plastic. Non biodegradable plastics cannot be broken down by the environmental agents like air, sunlight, water or ground soil substances. They produce a large amount of Carbon dioxide which leads to global temperature rise. They also emit toxic pollutants over a long period of time as they remain on earth for infinite time. In contrast, Biopolymers are long chain compounds made up of long chain subunits which can be broken down by environmental agents like air, sunlight, water or action of living organisms. Biodegradable plastics undergo degradation from the action of naturally occurring microorganisms- bacteria, fungi, algae. Most non renewable plastics are generally petroleum-based while renewable resource plastics include polymers grown from microbes. Extraordinary progress has occurred in development of practical processes and products made from polymers such as starch, cellulose and lactic acid. Biopolymers containing starch and/or cellulose fibers appear to be the most likely to experience continued growth in usage. Compostable plastics undergo biodegradation to yield carbon dioxide, water, inorganic compounds and biomass leaving no visually toxic residues. There are infinite areas where biopolymers may find use. Biopolymers are disposed in landfill environments, in the hope that necessary microorganisms will be present, as the soil is inoculated with them but this may not always be the case. Microbially grown plastics is a novel scientifically sound idea, but the required infrastructure for commercial expansion is still costly and inconvenient to develop. In spite of all this the complete substitution of petroleum-based feedstock plastics with biodegradable ones would lead to a balanced CO_2 level in the atmosphere thereby reducing Global Warming.

INTRODUCTION:

Non-biodegradable waste is a type of waste that can not be broken down into its base compounds by micro-organisms, air, moisture or soil in a reasonable amount of time. Non-biodegradable waste is an environmental concern, as it threatens to overwhelm landfills and create disposal problems. These products have a longer-lasting effect on the environment. plastic bags add tonnes of carbon emissions (CO2) into the air annually, which is the harmful gas causing extreme weather changes, a global temperature increase, the loss of ecosystems and potentially high long-term exposure to air, light and water can cause synthetic materials like plastic to emit toxic pollutants. Plastic materials in dumping sites sink in harmful chemicals into groundwater and pollute water supplies. Biodegradable waste includes any organic matter in waste which can be broken down into carbon dioxide, water, methane or simple organic molecules by micro-organisms and other living things using composting, aerobic digestion, anaerobic digestion or similar processes.

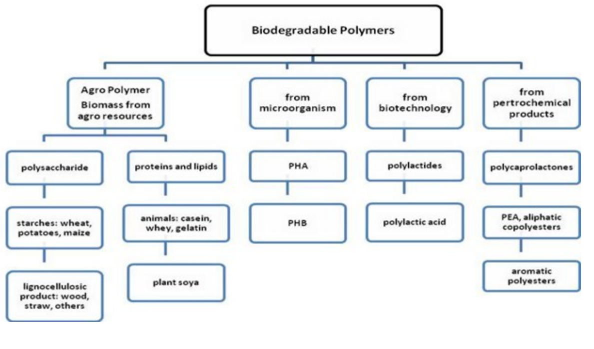
TYPES OF BIODEGRADABLE POLYMERS:

The different types of biodegradable polymers are

1) Natural Biopolymers : These polymers are very common in nature .For e.g. :cellulose, starch, protein
2) Biosynthetic polymers : For e.g. polyhydroxy butarate
3) Synthetic Biopolymers : For e.g. polylactic acid

Biodegradable Polymers can also be classified as shown in table-1

Table-1



METHODS OF BIODEGRADATION:

Biodegradation is the process of converting polymer material into harmless, simple gaseous products by the action of enzyme, microorganisms and water. Biodegradable polymers degrade as a result of natural biological processes eliminating need to create a disposal system which can harm to our environment.The breakdown of polymer materials may occur by microbial action, photodegradation, or chemical degradation. All these three methods are classified under biodegradation, as the end products are stable and found in nature. Many biopolymers are designed to be discarded in landfills, composts, or soil. The materials will be broken down, provided that the required microorganisms are present. Normal soil bacteria and water are generally all that is required, adding to the appeal of microbially reduced plastics (Selin 2002). Polymers which are based on naturally grown materials (such as starch or flax fiber) are susceptible to degradation by microorganisms. The material may or may not decompose more rapidly under aerobic conditions, depending on the formulation used, and the microorganisms required. The microbes digest the starch, leaving behind a porous, spongelike structure with a high interfacial area, and low structural strength. When the starch component has been depleted, the polymer matrix begins to be degraded by an enzymatic attack. Each reaction results in the scission of a molecule, slowly reducing the weight of the matrix until the entire material has been digested (Shetty et al. 1990).

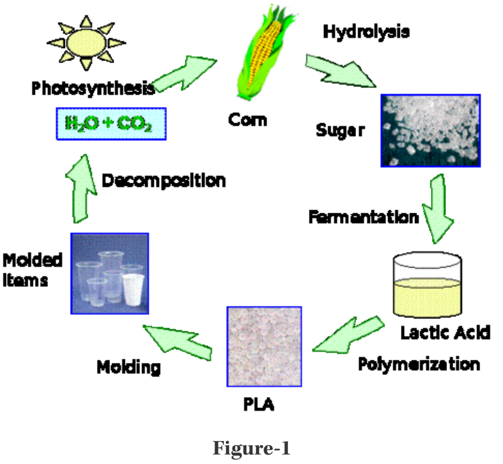


Figure-1

ENVIRONMENTAL IMPACTS:

Recycling of plastic materials is encouraged and well advertised, but attempts at expanding this effort have been less than effective. Recycling must be recognized as a disposal technique, not a final goal for material development.Compostable plastics undergo biological degradation during composting to yield carbon dioxide, water, inorganic compounds, and biomass at a rate consistent with other known compostable materials, and leave no toxic residues (ASTM 1996). Many of the biodegradable plastic materials discussed thus far were designed to be compostable. For instance, the purpose of designing disposable plastic cutlery and plates is that they can be thrown into a compost heap with leftover food. The requirements of biopolymers to be included in industrial composters are complete biodegradation and disintegration, and that there be no effect on compost quality as a result of biopolymer degradation (Wilde and Boelens 1998).As an added benefit,(Nakasaki et al.(2000) concluded that odor emissions from compost piles are reduced when biodegradable plastic is included in the mix. Ammonia is produced by the decomposition of compost. The degradation of biodegradable plastics produces acidic intermediates, which neutralize the ammonia content, thus reducing odor problems.

Bioplastics are designed to biodegrade. Such bioplastics can break down in either aerobic or anaerobic environment depending on how they are manufactured.

$$\text{Cpolymer} + O_2 \rightarrow \text{Cresidue} + \text{Cbiomass} + CO_2 + H_2O$$
$$\text{Cpolymer} \rightarrow \text{Cresidue} + \text{Cbiomass} + CO_2 + CH_4 + H_2O$$

Biodegradable are environmentally friendly as their production results in emission of less CO2 which is thought to cause global warming.

ADVANTAGES AND APPLICATIONS:

Compost derived from bioplastics increases the soil organic content as well as water and nutrient retention thereby improving aeration in soil and promoting plant growth and health. Starch based bioplastics have shown to degrade 10 to 20 times quicker than conventional plastics. Compared to conventional plastics derived from petroleum, bio based polymers have more diverse stereochemistry and architecture of side chains which enables research scientists to customize the properties of packaging materials. Biodegradable plastics has wide application in medical field. Polymer system are used in gene therapy. It is used for ocular , tissue engineering, orthopeadic, skin adhesives and surgical glues. It acts as a drug system for therapeutic agents such as anti tumor, anti psychotic and anti inflammatory agents. Many biomaterials especially heart valve replacement and blood vessels are made of biopolymers like Dacron, Teflon and Poluurethane.

FUTURE SCOPE:

There is room for growth and expansion in many areas of the biodegradable plastic industry. Carbon dioxide emissions from the formation and disposal of conventional plastics are reaching epic levels. The complete substitution of petroleum-based feedstock plastics by renewable resource-based feedstocknes would lead to a balanced carbon dioxide level in the atmosphere (Dahlke et al. 1998). Standards organizations such as the ASTM and ISO have published methods for material tests on biodegradable plastic materials.The nature of natural materials requires different considerations than those for synthetic materials. The biopolymer industry has a positive future, driven mainly by the environmental benefits of using renewable resource feedstock sources. The ultimate goal for those working in development is to find a material with optimum technical performance, and full biodegradability. Figure-2 and Figure-3 show global production capacity of bioplastics and global consumption of biodegradable polymers.

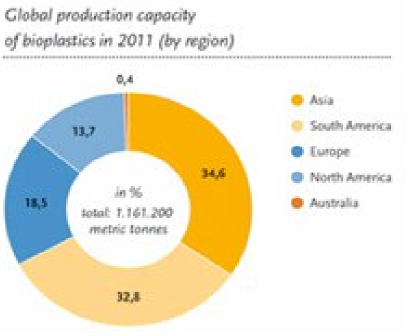


Figure-2

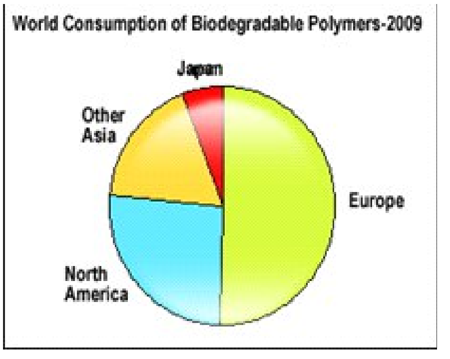


Figure-3

CONCLUSION:

There are limitless number of areas such as agriculture, automotives, medicine, and packaging which require environmentally friendly polymers. The disposal methods may be tailored to industry specifications .Environmental responsibility is constantly increasing in importance to both consumers and industry. Biopolymers limit carbon dioxide emissions thereby reducing the increasing threat of Global Warming. Biodegradable plastics containing starch and/or cellulose fibres appear to be the most likely to experience continual growth in usage. Microbially grown plastics are scientifically sound, and a novel idea, but the infrastructure needed to commercially expand their use is still costly, and inconvenient to develop. Synthetic plastics are a more economically feasible choice than biodegradable ones, society's current views on environmental responsibility make this an ideal time for further growth of biopolymers.