Green Polymer Chemistry

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Abstract*:*Green chemistry is an area of chemistry and chemical engineering focused on the designing of products and processes that minimize the use and generation of hazardous substances. Whereas environmental chemistry focuses on the effect of polluting chemicals on nature, green chemistry focuses on technological approaches to preventing pollution and reducing consumption of non-renewable resources.One of the most important branch is Green polymer chemistry

Natural polymers, biomass conversion in biorefineries and chemical carbon dioxide fixation are teamed up with highly effective tailoring, processing and recycling of polymers. “Green monomers” from biorefineries, and “renewable oil”, gained from plastics' and bio wastes, render synthetic polymers renewable without impairing their property profiles and recycling. In context of biofuel production, limitations of the green economy concepts are clearly visible. Dreams and reality of “green polymers” are highlighted.

Key Words*: monomer, polymer, natural polymer, addition polymer, condensation polymer, green polymer,Synthetic polymer, Degradation polymer, Biodegradable polymer.*

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I. INTRODUCTION:

Lifeon Earth has been started with the formation of polymers. Polymer technology has green routes. In both natural and man-made technologies, polymers play a important role as macromolecular materials. Polymerization processes, polymer superstructures, and processing technologies. Without polymers, modern life would be impossible because polymers secure the high quality of life and serve as pacemakers for modern technologies. During the early days of polymer sciences and engineering, almost all materials were based exclusively upon chemically modified biopolymers. Among polymers, sugar-based cellulose, which is the major component of biomass, wood, and cotton, represents the most abundant organic compound produced by living organisms. In biological cells and biotechnology labs, the incorporation of 20 amino acids is precisely controlled, producing polypeptides such as spider silk, wool, enzymes, insulin, and a great variety of other synthetic proteins for industrial and biomedical applications.

During the 20th Century, a great variety of synthetic polymers became available on the industrial scale. Strong technology base is petrochemistry. Exploitation of oil and gas as fossil raw materials for the chemical industry and polymer production greatly improved cost-effectiveness and simplified manufacturing of macromolecular materials. new recycling technologies enabled effective reuse of polymer products that had completed their first lifecycle. Polymer wastes thus became a valuable source of raw materials and energy. In today's highly efficient industrial polymerization processes, polymers are tailored to be stiff, soft, rubbery, conducting or insulating, optically transparent or opaque, permeable or impermeable, stable or (bio)degradable. Prominent examples of polymer applications include food and medical packaging materials, lightweight engineering plastics in the automotive and aerospace industries, damage-tolerant construction materials for modern architecture, high-strength fibers for textiles and composite materials, printed circuit boards and photo resists for microelectronics, solvent-free coatings for corrosion protection, adhesives, and new materials for biomedical applications such as wound dressing, membranes for artificial kidneys and water purification, dental fillings, drug delivery systems, artificial hearts, and implants. Plastics have become essential components of virtually any kind of consumer product that meets the highly diversified demands.

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POLYMER:

'Polymer' comes from the Greek, meaning 'many parts.' A polymer is a long molecule consisting of many identical or similar building blocks linked by covalent bonds - like how a train consists of a chain of cars. Most large molecules, or macromolecules, are polymers. The repeating units that serve as the building blocks of a polymer are small molecules called monomers.

Polymers are of two types:

1)Natural polymer:Natural polymer contains DNA and Proteins etc.

2)Synthetic polymer: Synthetic polymers contains polystyrene, polyvinyl chloride (PVC)etc

Synthetic polymers are produced by following methods

Polymerization: Chemical process by which monomers are linked to form polymer is called as polymerisation, there are two types.

1) Addition polymerization

2) Condensation polymerization.

1) Addition Polymerization:
Polymerization that occurs through the coupling of monomers using their multiple bonds is called addition polymerization. The simplest example involves the formation of polyethylene from ethylene molecules. In this reaction, the double bond in each ethylene molecule opens up, and two of the electrons originally in this bond are used to form new carbon-carbon single bonds with two other ethylene molecules.

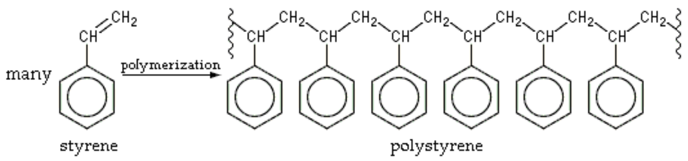
Addition reaction:

(i) $n CH_2 = CH_2 \rightarrow -(CH_2\text{-}CH_2)_n$
Ethylene → Polyethylene or polyethene

(ii) $n CH_2 = CH(CH_3) \rightarrow -(CH_2\text{-}CH(CH_3))_n$
Propylene → Polypropylene

(iii) $n CH_2 = CH(CN) \rightarrow -(CH_2\text{-}CH(CN))_n$
Acrylonitrile → Orlon

(iv) $n CH_2 = CH(Cl) \rightarrow -(CH_2\text{-}CH(Cl))_n$
Vinyl chloride → Poly vinyl chloride (PVC)



Some common commercial addition polymers are:

- Polyethylene - films, packaging, bottles
- Polypropylene - kitchenware, fibers, appliances
- Polyvinyl chloride - pipe fittings, clear film for meat packaging

2) Condensation Polymerization:
The chemical mechanism that cells use to make and break polymers are basically the same in all cases. Monomers are connected by a reaction in which two molecules are covalently bonded to each other through loss of a water molecule; this is called a condensation polymerization because the lost molecule is water. When a bond forms between two monomers, each monomer contributes part of the water molecule that is lost, one molecule provides a hydroxyl group, while the other provides hydrogen.

Natural polymer:
Naturally occurring polymers are silk, wool, DNA, cellulose and proteins. Natural rubber, starch,ribonucleicacid (RNA), cellulose and chitosan

1) Polynucleotides, which are chains of nucleotides.
2) Polyamides, which are chains of proteins.
3) Polysaccharides, which are chains of sugars.

Need for Biodegradable polymers:

1) Polymerhas become an essential part of our daily life. Which is having numerous advantages, it finds that its use in every field.

2) But these polymer products account for approx.150 million tons of non biodegradable waste every year.

3) Such large amount of waste leads to various problems, not to mention, a general lack of cleanliness in the neighbourhood.

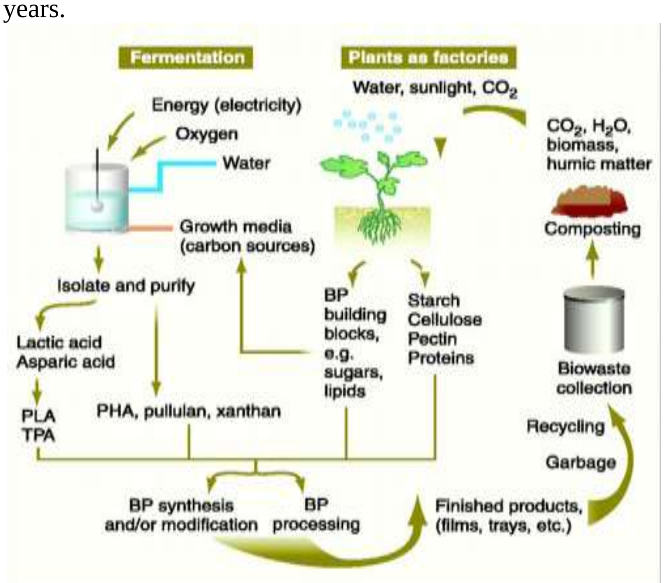
THE DIFFERENCE BETWEEN DEGRADABLE AND BIODEGRADABLE POLYMER:

Degradable Polymer: The word “degradable” just means that something breaks down. Technically, all plastic is degradable plastic. We can add an additive to normal, petroleum-based plastic that will make it become brittle and crumble in sunlight.this is referred to as making “photodegradable” plastic. Other additives can be put into plastic that will make plastic break down by oxidation: this is referred to as making “oxo-degradable plastic.”
These methods will make the bulk of the plastic appear to disappear; however, the small piece that is produced by this effect is still small pieces of plastic. Nothing has changed. Over a matter of years, it is possible for the pieces to become small enough to be assimilated by microorganisms, but there is still a lot of research that needs to be done to verify how long this might take. In the mean time, they are just very small pieces of plastic.
So be cautious when you see a plastic product that advertises that it is “degradable” but not “biodegradable” or “compostable,” because this is nothing special. The plastic material does not “return to the earth” in any real way.

Biodegradable Polymer: When something is biodegradable, it means it is degradable, but it also means something more: it means that it can be broken down by the metabolism by micro-organisms. When a plastic is biodegradable, it can be digested, so that the carbon atoms in the chains of the polymer are broken apart and can actually participate in the creation of other organic molecules. They can be processed by, and become part of, organic living things. This returns them to nature in a very real sense: they become part of the carbon cycle of the ecology of the earth.
Only bioplastic will biodegrade within any reasonable timescale. Petroleum-based plastic that simply breaks down into a fine sand or small pieces still cannot be digested by microorganisms. Perhaps over the time-span of many years, the pieces may get so small that they can be digested by microorganisms. This is currently the focus of a great deal of research and debate, as different groups try to establish how quickly oxo-degradable plastics can be reduced to a form where they are actually biodegradable.

It is also important to note that even some plastics that are made from renewable resources are processed in a way that makes them non-biodegradable. They are still "degradable" but they do not return to the earth, and cannot be processed by microorganisms. That is why the difference between biodegradable plastics, and non-biodegradable plastics, is so important.

Compostable Plastic. When something is compostable, it means that it biodegrades, but it also means something more: it will degrade within a certain amount of time, under certain conditions. For many types of bioplastic, it's possible to say that it will break down "eventually", but if you seal it in an air-tight room, it could take thousands of years.



Cyclic pathway of biodegradable polymer life cycle

Cyclic Process of bio degradable polymer:

Engineering new materials like biodegradable polymers can be a long-term solution for eliminating plastics from landfills. Biodegradable polymers, as the name suggests, are meant to degrade upon disposal with the help of microorganisms .The above diagram shows depicting the life cycle of biodegradable polymers. Starch and cellulose, called biopolymers because they are produced by plants, are extracted and blended with synthetic polymers to produce biodegradable polymers. By varying the amount of starch, cellulose, and synthetic polymers in the mixture, different plastic properties can be achieved. Once processed it can be used for many applications such as packing foam, toothbrush handles, adhesive tape backing, and films.

Upon reaching the municipal waste center they can be sent to bio-waste collection or compost sites where theycan be properly degraded by microorganisms to form carbon dioxide, water, biomass, and humic matter, all of which serve as nutrients for plant life. With the addition of sunlight, plants can grow and produce another batch of biodegradable polymers, repeating the cycle.

Another way to create Biodegradable polymer is the production of polyesters by the bacterial fermentation of sugars and lipids extracted from plants. These biodegradable polymers can be modified with synthetic or natural polymers like starch and cellulose to make other products like shampoo bottles, packaging, fibers, trash bags, and cutlery It provide a long-term solution for replacing hazardous non-degradable plastics in landfills that potentially release toxic compounds and adversely affect human and wildlife health, but they are still under debate for wide use.

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