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Biodegradable plastics: Green option for tackling plastic pollution

The biodegradable polymers could be an alternative to the conventional plastic materials. These polymers being biodegradable can be disposed off in safe and ecologically sound manner, through disposal processes (waste management) like composting, soil application, and biological wastewater treatment. Bio-based and biodegradable plastics can form the basis for environmentally preferable, sustainable alternative to current materials which are exclusively based on petroleum feed stocks. These bio-based materials offer value in the sustainability/ life-cycle equation by being a part of the biological carbon cycle and as well are a green option for tackling the plastic pollution.

Your full article (between 500 to 5000 words) - - Do check for grammatical errors or spelling mistakes

Biodegradable plastics: Green option for tackling plastic pollution

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Introduction:

Today's consumer driven society demands huge plastics for the manufacture of millions of products. Packaging materials largely contribute to the high demand of plastics. Our fast paced life styles demands convenience and single serving, pre-packaged foods also. The manufacturer of cost effective packaging that adequately protects the products is made possible by plastics only. There are three major forms of plastic that contribute to plastic pollution: micro-plastics as well as mega and macro-plastics. Mega and micro-plastics have accumulated in highest densities in the Northern Hemisphere, concentrated around urban centers and water fronts. The polyethylene based plastics are slow to degrade. Plastic pollution can unfavorably affect lands, waterways and oceans. Living organisms, particularly marine animals, can also be affected through entanglement, direct ingestion of plastic waste, or through exposure to chemicals within plastics that cause interruptions in biological functions.

Humans are also affected by plastic pollution, such as through the disruption of the thyroid hormone axis or hormone levels. Plastic reduction efforts have occurred in some areas in attempts to reduce plastic consumption and pollution and promote plastic recycling. Apart from the plastic recycling, biodegradable plastic is one of the most attracting options for reducing the plastic pollution.

What are synthetic plastics?

Literally and also in the language of science "plastics" simply describe the property of being able to form or mold. When we use the term plastic we tend to think of hydrocarbon plastic which is used in the manufacture of just about of everything of the daily life from kitchen ware to organ implants. Generally we know about plastic as a chemically polyethylene.

What are bio degradable plastics?

Bio + Degradable

Biological means Degradation

Biodegradable plastics are a plastic which will degrade by the action of naturally occurring microorganisms, such as bacteria, fungi, etc. over a period of time. Generally they have no toxic residues and produced from naturally occurring renewable source.

Basic difference between the two:

Synthetic plastic is produced from nonrenewable and synthetic polymers, mainly from petrochemicals. But Bioplastic are produced from the renewable and natural polymers.

Past history about the synthetic plastics in the last 50 years:

Approximately 200 billion pound of plastics produced worldwide every year. This equates about 40 pounds of plastic per person per year. Between (30-42) % plastics produced is used for packaging purpose. The plastic produced, of that more than 60 billion ton are thrown away in the ocean every year. Not only that, the oil that is used as well as the oil required for the energy, 6-8% is consumed for plastic production. Although this is a small percentage, over time the petroleum used to make plastic may contribute to the depletion of fossil fuels. The rate of the consumption also influence to the overall price hike, also contributing to the recent price rise in the petroleum product.

Back ground behind the concept of biodegradable plastics:

Advance technology in the petrochemical polymers has brought many benefits to mankind, however it have become more evident that the ecosystem is considerably and damaged as a result of non degradable materials like synthetic plastic. The environmental impact of persistent plastic waste is growing more global concern and there is limitation of alternative disposal methods. Incineration may generate toxic air pollutant and satisfactory land fill sites are

also limited. Another most important aspect that the petroleum resources are finite and are becoming limited also. One study has revealed that at the rate of recent use of petrochemicals may lead full worlds petroleum resources exhausted. So it has become the important and basic need to alternative resources of the plastic. More to this the burning pollution problem of plastic pollution is also another trigger for this alternative initiative of biodegradable plastic concept.

Main principle behind the new emerging concept:

The synthetic plastic is polymer of ethylene (polythene). Actually the synthetic plastic produced from crude oil, a non renewable resource. This type of polymer chain can also found in nature, for example this polymer chain is available in cellulose, lignin, starch etc. So here the basic idea is to exploit these biological polymers to produce biodegradable plastics.

As natural polymer contains oxygen and nitrogen, these oxygen and nitrogen in the polymer permit the easy biodegradation through different microorganisms.

Possible source for production of biodegradable plastic: There are several natural biopolymers present. As for example: Corn starch, Potato starch, Tapioca starch, Used paper waste, Milk whey, Forest derived renewable bi-product, etc.

These renewable sources as well as huge amount of wastes containing the bio-polymers are also abundant. Now if they are commercially converted to biodegradable plastics, the cost of production can be reduced as well waste can also be managed in a better way.

Research on biodegradable plastics

However researches are going on to come out more cost efficient production techniques of bioplastics. Following are some of the examples of those findings.

a) Optimum substrate and product concentration ratio: A balanced ratio of these two can foster the inter cellular accumulation PHA (polyhydroxy alkanoic acid) and also give the highest production.

b) Duration of the fermentation time: This plays a pivotal role in case of polymer yield. A compromise has to be determined between increasing the polymer producing biomass with the culture time. Generally PHA yield decreases after sometimes of broth nutrient depletion. Different culture time length and relevant harvest shows marked difference in PHA production.

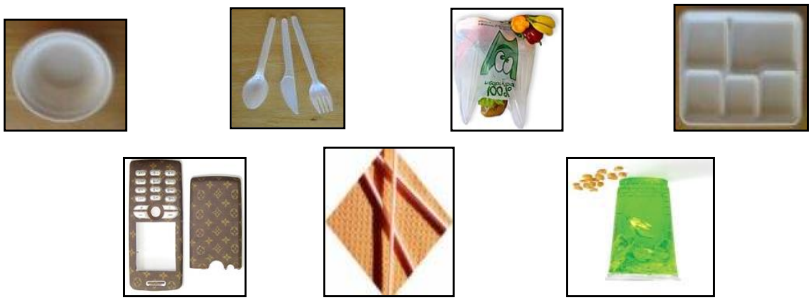
c) Modification of the production recipe: It may lead most cost effective bioplastic production. Researches is also going on the genetic engineering applied to the selected microorganism that holding greater potential for high yield of polymer

Normal *E. coli*

Genetically modified *E.coli*

Products which can be produced from bioplastics:

Different ecofreindly plastic material can be produced from bioplastics such as: Biodegradable film, Biodegradable bag, Biodegradable sheet, Dish-ware-cutlery-dinner ware, Knife-fork-spoon plate, etc.



Main ingradients for biodegradable plastics:

The main ingredients of biodegradable plastic polymer are

PHA - Poly Hydroxy Alkanoates.

PHH – Poly Hydroxy Hexanoate.

PLA - Poly Lactic acid.

PBS - Poly Butylene Succinate.

PBAT – Poly Butylene Adipate or Terephthlate.

AAC - Aliphatic Aromatic Co-polyesters

PHB –polyhydroxybutyrate

PHV – polyhydroxyvalerate

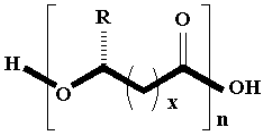
PCL - polycaprolactone

PBSA - polybutylene succinate adipate

PET - polyethylene terephthalate

PTMAT- polymethylene adipate/terephthalate

Structure of PHA:



R=C or H chain up to 30 C long

X=1 to 3 more carbon

n=100-30000

Biodegradable plastics from different natural and renewable sources:

a) **Biodegradable plastics from waste paper:**

A govt. affiliated research institute has developed a technology to produce bioplastics from waste and used paper. Actually in this new technology, fiber from the used paper is first dissolved in to sugar by using enzymes. Then such simple sugar if fed to microorganism whose gene has been modified to produce succinic acid which is used for further processing to bioplastic material. From this succinic acid bioplastics are produce.

Properties:

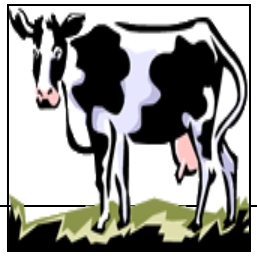
1) This plastic material degraded by microorganism completely within 6 weeks.

2) Softer, can be traced more easily than lactic acid plastics

2) As because waste material is used, so the cost of the plastic produced become about $2.5 per Kg. But cost of synthetic plastic $4 per kg. So it may compete with synthetic plastic market (Ref.: Research institute of innovative technology for the earth, RITE).

b) Biodegradable plastics made from whey:

PHA can be manufactured by feeding the bacteria glucose as a source of food material. However in the year 2000, PHA plastic production cost was 10 times more than the conventional plastics as because glucose at that time was used as substrate. So most of this expense was due to high cost of glucose. Now if we replace this glucose with a cheaper sugar found in whey, could make biodegradable plastics of lower cost.



Generally whey was considered the liquid part of the milk that separates from the curd at the beginning of the cheese making process. In the past whey was considered as waste material. It was difficult to dispose to the environment as because it also contains salt.

c) Bioplastic from corn:

Advantage of using corn is that here waste corn is generally used that is not consumed. Corn plastic: you can drink coffee out of it, put groceries in it, wear it and even hang ten on it on a corn plastic surfboard. Most important, you can turn corn into plastic and avoid dependency on petroleum. Much like corn ethanol, corn plastic allows us to make a comparable product out of a renewable resource, as opposed to oil reserves that will one day run dry. While normal plastic has a nasty habit of sticking around for centuries after disposal, corn plastic boasts the ability to biodegrade in mere months. Moreover, should you choose to burn it, you don't have to worry about creating toxic fumes.

Properties:

1) Not water-resistant

2) No toxic material is produced

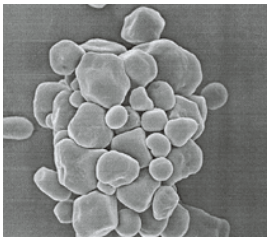
3) Fully biodegradable and compostable

4) Lower combustion calorie with that of petroleum based plastics

5) Good compatibility with the other biodegradable plastic material like PLA, PLC, etc

Ecofrindly plastic film from potato starch:

Plastic made up of potato starch is a promising material for packaging. It has excellent oxygen barrier properties and in some case can replace aluminum. So it can be used for protecting oxygen sensitive foods.



Biodegradable plastic from synthetic plastic:

The microbes, special strain of soil bacterium *Pseudomonus putida* can convert polystyrene foam-commonly known as Styrofoam (synthetic plastic material). The steps of degradation are as follows:

Polystyrene

(pyrolysis in the absence of O2)

↓

Styrene oil

↓

Fed to *Pseudomonas putida*

↓

Converted to PHA

↓

From PHA biodegradable plastic

Forest derived renewable bi-products to produce bioplastics:

Different wood material and their bi-products can be used in the production of the biodegradable plastics that have potential to replace conventional, environmentally recalcitrant, petroleum based plastics.

Environment for Biodegradation:

The bioplastics will not degrade either they come to contact with water or soil along with an environment which contain microorganism in it. However following are the most optimum site (environment) for degradation.

a. Compost pit
b. Wild in nature (aerobic degradation)
c. Soil (aerobic and anaerobic)
d. Land fill (anaerobic)

End product of biodegradation:

End product of biodegradation of bioplastics is not toxic at all. Generally 60-80 days are required for complete degradation.

a) CO_2 and water is produced during aerobic biodegradation
b) CO_2, H_2O, CH_4 is produced in case of anaerobic degradation

   One negative consequence about this is, we are adding more green house gases in the environment.

Enhancement of biodegradation of the plastics:

It can be achieved by:

a) Addition of biodegradable compound in to the synthetic polymer
b) Addition of extra nutrient for the microorganism
c) Ensuring a good access of enzyme in to a polymer structure
d) Addition of initiator of hydrolysis to the polymer

Photodegradable plastic:

This are the biodegradable plastics in which we incorporate some light sensitive chemical additives of copolymers for the purpose of weakening of bonds in the presence of sunlight. Photodegradable plastics are designed to become weak and brittle when exposed to sunlight for prolonged period. Here, photosensitizer are used includes diketones ferrocene derivatives and carbonyl contating species. These plastics degrade in to two-stage process:

a. with the UV light initially breaking of the bond leaving more brittle and lower molecular weight compounds
b. this again attacked by microorganisms and physical stress

Future promising sector:

Scientists are searching cheaper alternatives to plastic. Some plastic alternatives are: graphite, fiberglass, carbon fiber, graphene, carbon nanotubes, diamond, aerogel, carbon nanofoam, cellulose soybean plastic (bioplastic), and other carbon-based non-petroleum materials. Some of these alternatives are too expensive or not malleable enough, but can be used in some plastic applications. Some are many times strong enough like plastic, but crack if made thin like cellophane. The most promising alternatives to plastic are graphene, carbon nanotube, and carbon nanofoam. All three of these are made of nanocarbons, products of the new nanotechnology. Nanocarbons are very cheap, 100 times stronger than steel, slicker than Teflon, light weight and can be made very thin, made to stretch and built into any shape all the things plastic can do. In addition, nanocarbon manufacturing is low to non polluting. Already bowling balls, golf balls, sports equipment, and water-proof cotton balls have been made of nanocarbons.

Price and future:

One of the great appeals of plastics has been their low price, as compared to other materials. However, in recent years the cost of plastics has been rising dramatically. The cause of the increase is the sharply rising cost of petroleum, the raw material that is chemically altered to form commercial plastics. As the cost of plastic hinges on the cost of petroleum, so petroleum prices continues to rise and

so will the cost of plastic. In 2004, the higher price of plastic drove a number of plastic toy manufacturers out of business.

At present, the cost of biodegradable plastics is 2- 10 times more than conventional plastics. As per the available data, the current price trend of Oxo/Photo-degradable plastics (Based on Polyethylene material) and Biodegradable plastics for film applications (copolyester based) are given below:-

(i) Oxo/Photo Degradable plastics film / bags – Rs.90 – 120 per kg (depending upon prices of polyethylene & additive, which are variable and as per the global trend of polymer pricing.)

(ii) (ii) Biodegradable plastics film / bags - Rs.400 – 500 per kg.

So, if we replace the substrate with low cost sugar source, the production cost of biodegradable plastics can also compete with the synthetic plastic market. Here is the challenge for the upcoming research in this line.

Target should be focused towards:

For PHA based plastic production to be economically competitive, they must be produced on a large-scale and from an inexpensive raw material. However following points are to be taken care of for cost effective bioplastics production.

1) PHA production should be economically competitive.

2) Must be produced in a large scale.

3) Searching for inexpensive source of raw materials.

4) More alternative source should be identified.

5) Searching for more efficient microorganisms.

6) Production of genetically modified strains.

7) Awareness about the environment among the people should be grown.

Conclusion:

To tackle the ever increasing price of the petroleum, shift towards the concept of biodegradable plastic is the best way. Ever increasing pollution mainly White pollution, which is due to conventional plastics that we are using can also be tackled with the help of this concept. More to this, use of renewable source don't create pressure on the nonrenewable sources. Biodegradable plastics lead no toxic substances to the environment. Only we have to concentrate to our research on the cheaper substrate source to reduce the cost of production. To maintain a sustainable Ecosystem around you, me

and wild life we have to change our practices towards biodegradable plastics. So, it is the best alternative way to detoxify our world from whatever plastics we have dumped till date.

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