Algal Bioplastics

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Introduction

Bioplastics or organic plastics are a form of plastics derived from renewable biomass sources such as vegetable oil, corn starch, pea starch unlike fossil-fuel plastics derived from petroleum. Bioplastics provide the twin advantages of conservation of fossil resources and reduction in CO_2 emissions, which make them an important innovation of sustainable development.

Algae serve as an excellent feedstock for plastic production owing to its many advantages such as high yield and the ability to grow in a range of environments. Algae bioplastics mainly evolved as a byproduct of algae biofuel production, where companies were exploring alternative sources of revenues along with those from biofuels. In addition, the use of algae opens up the possibility of utilizing carbon, neutralizing greenhouse gas emissions from factories or power plants.

Algae based plastics have been a recent trend in the era of bioplastics compared to traditional methods of utilizing feedstocks of corn and potatoes as plastics. While algae-based plastics are in their infancy, once they are into commercialization they are likely to find applications in a wide range of industries.

Types of Algal Bioplastics

Bioplastics are plastics manufactured using biopolymers derived from two routes:

- ✓ *Biopolymers from living organism* – these are typically made from cellulose, soy protein and starch.
- ✓ *Polymerizable Molecules* – these are typically made from lactic acid and triglycerides, wherein these molecules come from renewable natural resources, and can be polymerized to be used in the manufacture of biodegradable plastics.

Source: http://www.biobasics.gc.ca/english/View.asp?x=790#top

The various plastics that can be made from algae feedstock include:

1. *Hybrid Plastics*
   - These plastics are made by adding denatured algae biomass to petroleum based plastics like polyurethane and polyethylene as fillers. It thus decreases the amount of petroleum used per unit of plastic, and often provides these plastics with very desirable properties including biodegradability.
   - Filamentous green algae of the order Cladophorales are claimed to be well suited for use in hybrids.

2. *Cellulose-based Plastics*
   - The oldest forms of Bioplastics, first made over a century ago, are a cheap and low quality family of plastics that are derived from cellulose, a naturally occurring bio-polymer of glucose.
   - For some strains of algae, 30% of the biomass produced after extraction of algal oil is known to contain cellulose. These strains are thus ideally suited to be feedstocks for cellulose-based bioplastics.

3. *Poly-Lactic Acid (PLA)*
   - Lactic acid is usually produced by fermentation of feedstocks and it is polymerized to produce polylactic acid.
   - Lactic acid and its polymer poly-lactic acid (PLA) are already used as a biodegradable alternative and are believed to be economically viable alternatives on a large scale in the future.
   - Lactic acid can be produced by bacterial fermentation of algal biomass.

4. *Bio-Polyethylene*

   - The monomer used in the production of polyethylene is ethylene, which is easily produced from ethanol, by a chemical reaction called cracking.
   - The ethanol is presently derived from natural gas or petroleum; however it can also be derived from bacterial digestion of algal biomass, or directly from algae.
   - However, it is not economically feasible since algae derived ethanol is much costlier than petroleum derived ethanol.

While the above types of plastics from algae are technically feasible, their economic (cost) feasibility is still being worked out.

Companies in the field of Algae Bioplastics Research

1. **Petro Sun** is on the verge of utilizing its algae oil produced in the farm to bioplastics research. Their primary objective of exploring bioplastics is to complement algae biofuel production.

2. **Dow Chemicals** announced its partnership with **Algenol Biofuels** to build a pilot plant, which will use algae to convert carbon dioxide emissions into ethanol. Ethanol obtained would be used as one of the ingredients for Dow plastics. Dow plastics are quite interested in producing ethanol because they believe ethanol can replace fossil fuels in the production of ethylene, a feedstock for many plastics.

   Source**:** http://www.treehugger.com/files/2009/07/dow-chemical-partners-algenol-biofuels-pilot-biorefinery.php

3. **Cereplast** has been recently in the news for its compostable bioplastics made from food starches including corn, tapioca, wheat, and potatoes. The company believes that algae-based resins represent the latest advancement in bioplastics technology.

   Cereplast hybrid plastic is made by binding algae materials with oil-based polyolefins.

   The company has plans of producing 100% algae based bioplastic in future.

   Source: http://www.designnews.com/article/457262-Algae_Biomass_Could_be_Central_to_New_Plastics_Compounds.php

4. **Soley Biotechnology Institute** produces bioplastic from Spirulina dregs. The company utilizes this dreg which is left as byproduct when extracting useful products from Spirulina.

   Source: http://www.soley.cn/bioplastic.html

Future Trends

- Algae bioplastics can be commercialized in the future if they can negate the technical problems they posses. According to Cereplast, the company will launch its new 'Cereplast Algae Plastics' in the market by the end of 2010. But the plastics they produce contain only 50% algae. Plastics that comprise material derived 100% from algae are still not a reality and require innovative developments.

- The use of biotechnology techniques can play a key role in conducting the feasibility and sustainability studies in algae bioplastics. Fermentation and genetic engineering can take the lead in using novel techniques to make algae bioplastics commercially viable.

- The plastics market is worth more than $400 billion and has grown at an average of 3.5% per year over the last two decades. But the contribution made by the bioplastics is meager. The key reason for the minor contribution is its high cost. The good news is that significant R&D investments are made into bioplastics by many companies especially in Europe, and these efforts are likely to result in significant cost reductions. Such cost reductions for bioplastics in general are expected to make algae-based bioplastics more viable as well.

Source: http://www.plaxica.com/Plaxica/Market.html

Conclusion

Algae bioplastics can play a vital role as an environment friendly, biodegradable alternative compared to conventional plastics.

Algae based biofuels are often quoted as the only plausible biofuel solution to the world's oil crisis. But the economic viability of algae fuels is still in doubt. Exploring the production of non-fuel products such as bioplastics could play a major role in shaping the economics and viability of algal biofuel solutions.

The technology routes for the production of algae based bioplastics are still under the research phase, and are far from commercialization. It is hoped that the significant advances made in the bioplastics industry in general will benefit algal bioplastics industry as well and will make algae bioplastics a reality in the not-too-distant future.