WORKSHOP ON BIODEGRADABLE POLYMERS

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The high per capita consumption of plastics in the developed countries has led to an acute solid waste disposal problem. This has intensified the search for three kinds of solutions:

- Reduce the usage of plastic products in single use/ throwaway applications;
- Recycle plastic waste material;
- Make the plastic bio or environmentally degradable.

The growth of this sector of the industry is propelled by both consumer activism and legislative/regulatory actions. It is expected that by 2005, 15 % of all post consumer plastic waste in the United States will be biodegradable compared to 1 % at the present time. Also, the US will account for 85 % of the potential environmentally degradable plastics market with Canada accounting for the balance. Major application areas are films (garbage bags, grocery sacks, merchandise bags, diaper back sheets), and disposable polystyrene beverage containers and food containers.

Conventional plastics, used in the above applications, can be made environmentally degradable by blending with modified corn, potato or rice starch. Micro-organisms will readily digest the starch, weakening and breaking down the plastic article. The remaining plastic fragments can be made to photodegrade (by use of suitable additives) or break down oxidatively, if buried. Environmentally degradable LLDPE/ LDPE polymers are commercially available from companies such as Archer Daniels (USA), St. Lawrence Starch (Canada). Ampacet (USA), Porvair Ltd., (UK). A biodegradable polyamide has recently been introduced by Novamont, Italy, in the commercial market. However, starch-based products can cost about 25% more to produce.

Incorporation of photodegradable additives is an alternative approach to the elimination of solid waste problems. Companies such as Plastigone Technologies, Rhone Poulenc, Ecoplastics and Princeton Polymer Laboratories produce additives for blending into plastics. Large resin producers like Dow, DuPont and Union Carbide produce polyethylene copolymers with 1% carbon monoxide for use in photodegradable film applications. However, photodegradable products cannot be disposed of in landfills where penetration of light is not easy.

BIOTECHNOLOGICAL MATERIAL

The other approach to environmentally degradable plastic is to synthesise a new polymer, which is intrinsically biodegradable on account of its structure and chemical composition. Examples are poly(hydroxy butyrate), poly(lactides), poly(glycolides), hydrolysed poly (vinylene carbonate), polyanhydrides, poly(amino acids). Some of these polymers or precursors can be biologically derived (e.g. PHB, lactic acid etc.) or even chemically synthesised. In general, such polymers are more expensive. For example PHB, tradenamed Biopol by ICI, costs over 30 US dollars per kg today. However, such polymers find valuable applications in areas such as controlled and targeted drug delivery systems, injectible parenteral drugs, implantable biomaterials, synthetic surgical sutures, biologically active synthetic polymer drugs, etc.

Fermentation derived lactic acid is becoming a commercially significant new monomer. Major new capacities for poly(lactic acid) are now coming up in the USA (Cargill, Cornagro, Chronopac). It is believed that poly(lactic acid) may stand

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the best chance of becoming the first truly biodegradable material with commodity markets and offer an economically viable replacement for polyethylene.

The use of biotechnology in polymer materials is not restricted only to biodegradable materials. Increasing attention is being given to aspects of microbial and enzymatic synthesis of polymers and monomers. The derived polymers may or may not be biodegradable. Examples are synthesis of phenol-formaldehyde type resins and oligopolycarbonate by enzymatic processes and a single step process for the conversion of biphenyl to 4,4'-dihydroxybiphenyl, a valuable intermediate for polymer synthesis, using a monooxygenase enzyme from the fungus Aspergillis.

Use of recombinant DNA methodologies to produce polymers and silk-like fibres have been recently described. The feasibility of producing non-clinical products by the use of recombinant DNA has been established. However, further R&D will be required to determine the economics of such products and processes.

In the Indian context, future options with regard to the application of environmentally degradable polymers must be weighed against issues such as recycling/reuse and cost. It will be at least another decade before environmentally degradable materials are available at a cost which will make it a potent and viable alternative to the commodity polymers of today.

Another factor in the Indian environment which makes bio-degradable polymers difficult to live with, is the vibrant recycling industry. Industry estimates that 50 to 60 % of the products in the Indian market come from recycling. In fact, more advanced countries like the USA are now actively encouraging the recycling industry as a viable solution for both waste disposal and extending the value of the non-renewable resource, namely oil.

Although, the Indian recycling industry is far from being technologically advanced or sophisticated, there is little doubt that it is very efficient. It is also a significant source of employment for the urban poor. Besides providing economically useful products from recyclates for the weaker sections of society, India also has one of the lowest per capita consumption of polymers.

ENVIRONMENT-FRIENDLINESS

The coexistence of environmentally degradable materials in the environment with non-degradable material is a principal concern and threat to the recyling industry. For if the degradable materials find their way into materials to be recycled, they could seriously compromise the quality of the products made from recycled plastics. Widespread use of degradables therefore poses a serious threat to the plastics recycling industry.

This however, does not preclude the use of environmentally degradable plastics in niche applications. These include feminine hygiene products, medical disposables, marine applications, agricultural mulch film, pre-packaged pesticides and so on.