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ENVIRONMENTAL FRIENDLY MATERIALS : TODAY'S DOMINANT NEED

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ABSTRACT

The paper critically discusses and analyses the philosophy of developing and using general purpose and industrial environmental friendly materials for a variety of applications.

INTRODUCTION

There is a general feeling that plastics/ man made polymeric materials are not environmental friendly as is summed by the observation " the garbage tide is rising; land fills reach capacity but the trash keeps piling up with the plastics accounting for 10-15% of it ". However, in reality the state of affairs may be contrary to what is generally precieved. As a matter of fact materials which contribute to the environmental pollution are not the only culprits; in fact materials which require more energy and consume large amount of natural resources also fall under the category of ' non-eco friendly materials'. It is begining to be believed that plastics deliver much more with less resources namely water, energy etc. and are mostly made by processes which do not discharge bad effluents.

Reverting back to the universal problem of solid waste generation by industry and end consumers, it will not be out of place to state that plastics, owing to their immense popularity in all spheres of our lives, are contributing in no small a measure to the problem of its disposal. Most solutions being offered today include:

- a combination of recycling, landfilling, incineration (with or without power generation) ,
- source reduction and
- material substitution

to name a few. Degradable plastics however should be considered as a viable solution to the abovesaid problem, recycling waste materials being the other option worthy of attention. Firm indications are emerging that these are the useful technological options for the future.

WHAT IS ECO- FRIENDLY ?

Paper and paper products consume a large volume of water and chemicals for their processing and the resulting effluent problems are severe. Besides, paper unless coated with polymeric materials (e.g. wax) can not withstand wet conditions - a bane of region with a tropical climate. Also paper making consumes considerable energy. Environmental degradation has unquestionably occured due to pulp manufacturing activities as commercial forestry, on a large scale, is still something not extensively practiced. Is' nt it surprising that we still consider paper as an eco-friendly material. On the other hand without the use of plastics for packaging, all types of food articles from salted products to sweets, fruits and vegetables would perish as also the precious conventional packaging material, namely wood, thereby resulting in deforestation, poor monsoon, global warming etc. In fact most plastics, except PVC , can be easily burnt and 40 to 50% of the energy required to make them can thus be recovered.

In short , in our opinion, materials which do not burden the natural resources for their manufacture /production should be considered as eco- friendly without any bias against plastics. Once this is accepted the major problem remaining to be resolved is whether they can be made degradable?

DEGRADABLE PLASTICS

Plastics are chemical compounds with a long ,strong chain of carbon and hydrogen atoms. Accordingly, a degradable plastic is one that degrades into the basic constituents i.e. carbon and hydrogen. Degradable plastics could be defined as those materials which are easily assimilated into the environment without hazardous consequences. Such plastics may broadly be classified as Bio-Degradable and Photo-Degradable.

Photo degradable plastics decompose when exposed to sunlight. This is usually achieved either by addition of photosensitive species that catalyze the breaking of polymer chains or by using metal salts. Photodegradation is achieved by one metal complex while another metal complex simultaneously acts as a metal ion deactiviting compound. These plastics are mainly composed of polyethylene, whose bonds disintegrate when exposed to light, especially ultra violet light. Two major hurdles associated with these plastics are : (i) timing & rate of their degradation is greatly affected by soils and weather patterns and thus is hard to predict. (ii) While photo-degradable plastics disintegrate, microorganisms do not consume their component parts and thus a combination of photo and bio- degradable additives is advocated.

A number of recent articles [1,2] reflect the resurgence of interest n bio-degradable polymers/ plastics. Bio-degradable plastics decompose entirely when submerged or buried. These plastics can be grouped into (i) those which are designed to be directly susceptible to natural biological system and (ii) those with additives designed to cause both macro fracturing of the resin with which they are blended as well as accelerate oxidative breakdown that breaks the molecular chain and permits direct metabolization by microbes when disposed in environments rich in them.

Taking into consideration the cost factor the apporach which is generally followed is based on designing a product which can be combined with a commodity thermoplastic polymer to make a processable and functional plastic article that will degrade in the appropriate environment.

An apporach in designing degradable polymers has been to use destructured or gelatinized starch. Du Pont has developed a plastic in which polyethylene is bound with starch, a favorite food of most micro organisms. But as in the case of photo- degradable plastics the polyethylene components survive after they have been broken down. Polyester- based materials, such as polylactic acid (PLA) and the micro biologically- produced combination of polyhydroxybutyrate and polyhydroxy valerate (PHB/PHV) are bio- degradable polymers but they also have processing limitations and production costs are very high.

One of the first degradable plastics was developed by ICI, UK and commercialized under the brand name of BIOPOL in April 1990 [3]. It decomposes into carbon dioxide and water in just a few weeks. Conventional plastics are synthesized from petroleum but BIOPOL consists of polyhydroxybutyrate (PHB) a natural substance synthesized by microorganisms found in soil. Microorganisms use PHB to store energy in much the same way that animals use fat or plants use starch.

P.E.Ecostar International, New York have developed a family of plastic additives which can be used with LLDPE, LDPE, HDPE, PP (homopolymer and copolymer) and PS. These additives generally include directly bio- degradable components blended with timed degradants for the polyolefins. They are used at 10 to 25% level [4].

RECYCLABLE MATERIALS

Due to change in the living pattern of mankind the amount of municipal solid waste is increasing every year resulting in landfill sites. Keeping this in view ecologists have started giving preference to such alternative materials which can be recycled or reprocessed. Some countries have even enacted legislations to meet this requirement and for preserving the environment. Bureau of Indian Standards

(BIS) has assigned specific symbols to be marked on items that are reprocessable and environmental friendly [5,6]. Sri Ram Test House has been working towards improvement of the quality of reprocessed materials [7]. Researchers around the world have been striving to develope reprocessable and bio- degradable materials both for daily use and specific applications.

'WASHI' a traditional hand made paper composed largely from bark of the plants in the Mullberry family has been used successfully by the Tokyo Institute of Technology, Daifuku Seishi Co.Ltd and Ashai Engineering Corporation Ltd. to develop a bicycle with frames which are recyclable and bio- degradable [8]. In order to make 'washi' stronger than usual, the fibers were aligned in the same direction and bleaching was cut to a third. Next the paper was cut into 2mm X 1.0 M long strips which were twisted to form washi threads. These threads were then combined with epoxy resin, layered onto an iron core and heated in a hardening furnace. When the resin had set, the iron core was removed and a strong light washi pipe was left. Work on further improvement of its strength is already in progress.

Mazda car's developmental model the HR-X2 uses recyclable, high strength plastics reinforced with liquid crystal polyster fibers. The design of the car is such that sorting of different types of materials for recycling is very convenient [9].

SUBSTITUTE MATERIALS

Electrically operated vechiles are in the process of replacing the conventional automobiles since they are environmental friendly, however the basic hinderence in their development is that they need storage batteries which are non eco-friendly. Most secondary (rechargable) batteries use lead acid or Ni- Cd reactions; since they are toxic in nature and need special handling for disposal, they are not optimal from an environmental stand point. Polymer batteries which use conductive polymers for their electrodes provide an attractive alternative. Because they contain no heavy metals they are non toxic to the environment and provide a reliable source of energy. Polyacenic semiconductor (PAS) were developed by Kanebo as conductive polymers combining safety and performance [10]. PAS is made by subjecting phenolic resin to a heat reaction in an inert gas environment. As reaction progresses a molecular structure resembling that of graphite builds up - a layering of aromatic rings in which hexagonal carbon atoms connect with one another. What makes the structure valuable are the 'gaps' between the molecules. This 'gapped' structure can be easily doped i.e. small amount of impurities can be added to the semi conductor through ion injection or similar methods in order to achieve the required electrical characteristics. As a result PAS batteries have relatively large capacity for storing electric charge. They are rechargeable and excel in the three basic measures of battery performance: voltage, capacity and smal internal resistance. At present only small PAS cells are commercially available but research is in progress towards development of lithium - PAS batteries with higher capacity.

A measure of dealing with the global warming is removal of excess carbon dioxide from atmosphere. However, since CO2 represents just 0.04% of the total atmosphere it is difficult to deal with such a low concentration artificially. One of the most effective ways of retrieving CO2 is to use the absorption capacity of natural eco-system. Corals rely on the photosynthetic products produced by the symbiotic algae living inside them. These algae are tiny single celled organisms but dynamic photosynthesizers, converting large quantities of CO2 into organic matter which is consumed by fishes, crustaceans and corals themselves. Corals produce more organic matter per unit area than any other ecosystem on land or sea, out producing even the tropical rain forests. Ideally, for every square meter of coral reef, four kilograms of CO2 goes into production of organic carbon and calcium carbonate.

The Geological Survey of Japan is working towards creation of 'Coral Reef Eco- factory' for maximum fixation of CO2 [11]. Unlike other methods of CO2 fixing, coral reef eco-factory results in no additional energy for fixation and no concern for chemicals or ill effect on environment. In tropical coral reef areas this technology will lead to 10% fixation of the total CO2 released by human activities. Thereby presenting an eco friendly material for the future.

CONCLUSIONS

Starting from the basics of what is environmental friendly, the paper sets about to describe and analyse the materials of the future which are environmental friendly. Due emphasis has also been laid on recyclable and substitute materials. The critique could prove useful in arriving at an objective assessment of the material's scenario of the present and the future. As has been said time and again that ' earth is not our inheritance but we are mearly it's custodians for the future generation' we can do justic only by reprocessing our wastes and using eco friendly materials to conserve the gifts that mother nature has given us.

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