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PLASTEC NOTE N24

ENVIRONMENTALLY DEGRADABLE PLASTICS: A REVIEW



FEBRUARY 1973

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ENVIRONMENTALLY DEGRADABLE PLASTICS: A REVIEW

by

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FEBRUARY 1973

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**PLASTICS TECHNICAL EVALUATION CENTER
Picatinny Arsenal, Dover, New Jersey 07801**

FOREWORD

This note contains the paper "Environmentally Degradable Plastics" presented by Mrs. Joan Titus on February 23, 1973 at a Picatinny Arsenal Technical Seminar.

It is being published as an interim report to meet the demand for information in this field. A more comprehensive report on this technology including a complete bibliography is planned by the author at a future date.

Harry E. Pebly, Jr., Director

ABSTRACT

Reviewed are mechanisms for degrading plastics, plastics capable of being degraded, companies and universities engaged in the degradation technology, costs, suggested applications, military problems with degradable plastics and the future outlook for degradable materials. This is an interim report, originally presented at a Picatinny Arsenal Seminar. A more comprehensive report including a complete bibliography will be published later.

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ENVIRONMENTALLY DEGRADABLE PLASTICS

Good morning, Colonel, ladies and gentlemen.

As all of you know, ecology has become the keyword of the sophisticate. It is the "IN THING". It's become the topic of conversation from cocktail parties to Congress. Whole government agencies have developed around it. Thousands of articles have been published on it. It enjoys high priority government and industrial funding and, not to be left behind, the Plastics Industry is concerned with all aspects of it.

According to an Environmental Protection Agency study, plastics account for 3 to 5% of solid waste by weight. This is expected to go to 12% by 1980. In terms of volume this would be much larger because plastics are lighter weight than most other solid wastes. Of the large number of plastics produced in this country, three account for about 90% of the plastics found in municipal waste. They are polyethylene 38%, polyvinyl chloride 31%, and polystyrene 21%.(1)

Plastics can be disposed of by several methods. They are recycling, incineration, land fill, and degradation.

It's this last area that I will speak about today, Degradable Plastics: Plastics which will predictably environmentally decompose to a powder or liquid form and eventually be encompassed in the natural environment. Now, just how do plastics degrade? Well, they can be degraded by three basic mechanisms: biodegradation, solubility and photodegradation. This technology is based on over 20 years research and experience in making plastics more durable — an area in which they were highly criticized in the past, mainly for poor weatherability.

The first class of materials — the biodegradables — are those plastics which, because of their chemical structure, are susceptible to being assimilated by microorganisms such as fungi and bacteria through enzyme action. This mechanism requires heat, oxygen and moisture.

Most naturally occurring polymers such as cellulose and natural rubber are attacked by a variety of fungi and bacteria. However, minor modification of these polymers such as acetylation of cellulose or vulcanization of rubber produce biodegradable resistant materials.(2)

Laboratory and field investigations on synthetic polymer deterioration have shown that some plastics have been attacked by microorganisms. The time span, however, for such deterioration is lengthy and can cover more than a decade. Actually, the filler and additives incorporated in plastics have much to do with the rate of degradation. These chemicals are of lower molecular weight and can act as a source of food for the microorganisms. When

they have been consumed, their loss will result in the loss of the material's elongation, flexibility, and there may be accompanying discoloration and staining.

The almost total resistance of potential waste plastics such as polyethylene, polypropylene, polyvinyl chloride, and polystyrene to biodegradation has led to the modification of their basic structure by specific functional groups to the monomer stage during polymerization. However, this copolymerization approach has been unsuccessful to date in producing completely degradable materials.

In addition to modifying plastics materials via additives and copolymerization, experimental work is being conducted to obtain selected mutants and microorganisms to better degrade plastics. For example, Enzymes Inc. has prepared mutant microorganisms by Cobalt 60, Strontium 90 and 500,000 volt x-ray radiation. These new mutant strains of soil microorganisms show increased capability for degrading the resistant types of synthetic polymers. The use of these specialized bacteria and fungi as inoculants in waste disposal areas may do much to help the problem of degrading waste polymers.(3)

Recently a 14 month study was conducted under the sponsorship of the Environmental Protection Agency which covered the biodegradation of all thermoplastic plastics. It indicated that plastics themselves are pretty immune to enzyme attack. In fact, only the aliphatic polyesters and urethanes derived from aliphatic ester diols and low molecular weight, under 500, unbranched polyethylene derivatives can be assimilated. The next slide shows a 95% weight loss of a 40,000 molecular weight polycaprolactone resin container after a 12 month soil burial test.(1)

CAPROLACTONE POLYESTER

SOIL BURIAL

SMALL CONTAINERS(1)

Months of Burial	Wt. Loss %
0	0
2	12
4	29
6	48
12	95