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Studies on Degradation of Poly Vinyl Chloride (PVC) by Soil Mycoflora

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ABSTRACT *Lack of degradability and the closing of landfill sites as well as growing water and land pollution problems have led to concern about plastics. With the excessive use of plastics and increasing pressure being placed on capacities available for plastic waste disposal, awareness of the waste problem and its impact on the environment has awakened new interest in the area of biodegradation of polymers. Fungi, isolated from plastic buried in soil, were subjected to growth in a medium containing plastic as the sole carbon source. The increase in fresh weight of the fungi and weight loss of plastic material in the medium after regular time intervals is evident that the fungi are utilizing plastic as the carbon source. SEM image reveals reduction in particle size of material.*

Introduction

Plastic materials are strong, light-weight, and durable and thus are widely used in food, clothing, shelter, transportation, construction, medical and recreation industries (Orhan and Buyukgungor, 2000)[1]. More than 40 million tons of plastics are produced every year (Yang et al., 2007)[2]. However, because of its xenobiotic origin and recalcitrant nature, its biodegradation is problematic and it accumulates at a rate of 25 million tons per year (Orhan and Buyukgungor, 2000)[1]. Plastic is a common term used to include all sorts of polythene (polyethylene), polyvinyl chloride (PVC) and many other related polymeric materials. Plastics possess a number of key characteristics including inertness, flexibility and low production costs that have led to their application in many areas of human life. But the problem that neutralizes all these attributes in their recalcitrance, i.e., they cannot be degraded easily by nature. Certain species of fungi are the engines of the process of decomposition. These are particularly efficient at degrading the major plant polymers, cellulose and lignin, but they also decompose a huge array of other organic molecules including waxes, rubber, feathers, insect cuticles, and animal flesh . Some fungal members are shown their activity on plastic material[3]. The speed at which the decomposition occurs called the "rate of decomposition", depends on the temperature, moisture and chemical composition of the organic matter. The oxygen level is another important factor, since fungi require oxygen for growth. In low oxygen environments, fungal growth is slow resulting in decrease in the decomposition process.

Recent research works have shown that most of the constituents of plastics can be degraded by microbes and the film plastics can be treated by microbial systems. Acrylonitrile fibres are attacked by species of *Aspergillus, Penicillium, Stachybotrys, and Nigrespora*. polycaprolactone is degraded by species of fungal genera like *Aspergillus, Penicillium and Chaetomium*. Degradation of the substrate is achieved through depolymerisation process by the use of polymerized vinyl acetate or ethylene copolymer. *Pullularia pullulans* can degrade polycaprolactone and other aliphatic polyesters. N-alkenes, alkenes and other aliphatic hydrocarbons are readily utilized by yeasts and fungi. Since a wide variety of fungi grow and degrade plastics and their polymers, only they have to be upgraded[4].

It has been recently shown that the members of order Xylariales belonging to class Ascomycetae such as *Xylaria* also grow on the plastic strips (as a source of carbon)[5] besides the species of *Aspergillus* and *Penicillium*. Microorganism for biological decomposition of polythene and plastics are isolated and tested for their ability in in-vivo and in-vitro condition by P. Nayak et.al.[6].

Till today most of research work has been carried out in field of bioremediation for plastic, but most of workers concentrated towards microbial remediation and the powerful scavengers, fungal members are yet ignored.

Materials and Methods

Different types of plastic material were cut in to pieces. Each piece was buried for about two months during which the moisture was maintained in soil to ensure fungal growth[7]. After two months periods, these plastic pieces were removed. Each type of plastic material was washed separately with sterilized distilled water after removal of excess of soil artifact. Distilled water containing fungal spores after the plastic sheet wash, was inoculated separately on special sterilized synthetic medium.

Preparation of Medium (SM)

Constitutions of medium in 1000 ml distilled water (K_2HPO_4, 1 g; KH_2PO_4, 0.2 g; NaCl, 1g; $CaCl_2.2H_2O$, 0.002 g; $(NH_4)_2SO$, 1 g; $MgSO_4.7H_2O$, 0.5 g; $CuSO_4.5H_2O$, 0.001 g; $ZnSO_4.7H_2O$,0.001 g; $MnSO_4.H_2O$, 0.001 g and $FeSO_4.7H_2O$, 0.01 g. and 100 mg of polymer source[8].

Screening and Identification

After aseptically inoculation, SM was incubated at 37°C temperature for one week. From third day, mycelium grows on SM in plates. In first set about 15 fungal forms were observed.

All these 15 strain were tested repeatedly for their plastic degrading ability by using Polyvenylchloride. Out of these 15 forms, five forms have been found to be more active. All these five forms with extensive network of fungal hyphae were observed under light microscope. On the basis of microscopic examination and morphologic characteristics, the fungal strain was identified. Authentication has been done by Agharkar Research Institute, Pune. These forms have been confirmed as species of genus *Chrysonelia, Aspergillus, Penicillium*.

Measurement of Plastic Degradation

Weight difference

The degrading ability of fungi is tested in laboratory by different methods. The tested samples were checked by calculating weight difference between before and after treatment of sample. These weight differences noted separately for

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different fungal species which reveal activity differences of different species

Physical test-
Particle size and surface changed were analyzed and tested by SEM technique from SAIF IIT, Pawai, Mumbai.

FTIR Test
Fourier Transform Infrared Spectroscopy analysis was used for detecting the formation of new functional groups or changes in the amount of existing functional groups

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Result and Discussion
The present study deals with the isolation of polyethylene degrading fungi and to test their ability for plastic degradation in laboratory condition. PVC is used as plastic material. Fungal organisms with the ability to degrade polyvinylchloride were isolated in synthetic medium supplemented with PVC powder and these organisms were used for degradation study. Several methods are employed to monitor the biodegradation of the polymers. Colonization study with the fungi showed a result of visible decrease in the polymer weight of fungus after 04 to 12 week incubation. The difference in before and after treatment weight of polymers by respective fungi species are given in table no.1.1 This data reveals the highest degradation potential is by *Aspergillus flavus Link.* and least by *Chrysonilia setophila (Mont) Arx.*

Fungal strains found colonized on the surface of plastic material causing some physical changes that will be evident in our study by image of Scanning electron microscope. The particle size of PVC material is 100 nanometer, which brought in to more fine particles by breakage if polymer molecules.

The treated PVC sample was studied under FTIR. The study reveals area of peak at wavelength 2918 was broad and greater in treated as compared to the original spectrum; while a small peak (2966.06) appeared original was not present in sample. The peak at wavelength 1634 (C=C stretching) in sample was sharp and larger as compared to the original. Similarly the small peak 1898, 2023, 2150 found only in treated sample. (corresponding to C=O strech) disappeared in the sample spectrum,. IR Spectrum of original polymer and treated polymer reveals that there could be structural changes in the molecule. The absorption frequencies and peak intensities are different in the two spectrums which confirmed the original molecule is consumed by the fungus species. Biodegradation of PVC brought some structural changes in the FTIR spectra of the polymer [9].

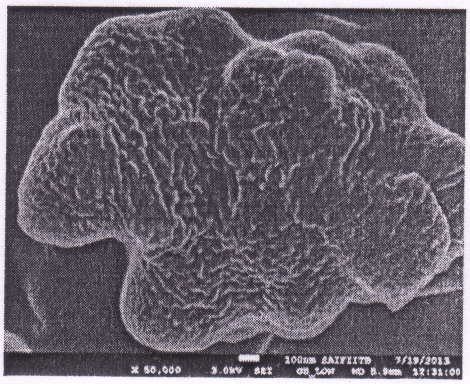
Sturm test was commonly employed for evaluation of the biodegradability of polymer materials. The CO_2 evolution test gave a valid data about the degradation rate. From the present study it can be concluded that fungal isolates are able to grow on minimal medium with plastic as a sole carbon source. Hydrophobic nature of plastic material acts as substratum for fungi which colonized the surface of the PVC material. Production of CO_2 during modified Sturm test indicates positive degradability test for the PVC and this test have given fulfillment to the objective of this study. Sturm test have been used for the measurement of CO2 in gaseous form release during degradation of polymer.

Conclusion
Soil and sewage sludge contain microorganisms (fungi) that are able to bring about some degradation of synthetic polymers. All the fungal isolates showing adherence and growth on the polymer surface indicated their ability to utilize PVC as a source of nutrient (Carbon). Production of carbon dioxide during the Sturm test indicated positive degradability test for the PVC material. The changes in the peaks of the FTIR spectra of the test samples as compared to control, is an indication of breakdown of plastics (PVC) as a result of fungal treatment.

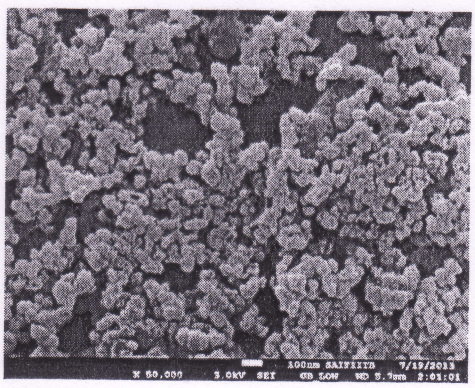
Table no. 1.1
List of isolated fungal species with their plastic degradation activity

Sr. No.	Name of fungus	Weight loss of polymer In gm PVC	ARI Accession No.
1	Aspergillus versicolor gr.	0.210	2812
2	Aspergillus niger gr.	0.241	2814
3	Aspergillus flavus Link.	0.419	2813
4	Chrysonilia setophila (Mont) Arx.	0.145	2815
5	Penicillium sp.	0.182	Sps.not confirm

Scanning Electron Image Compared

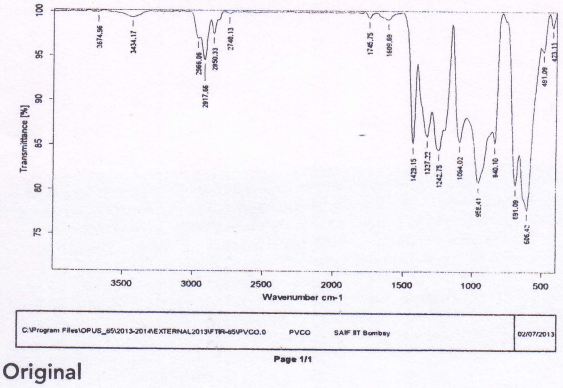


Original

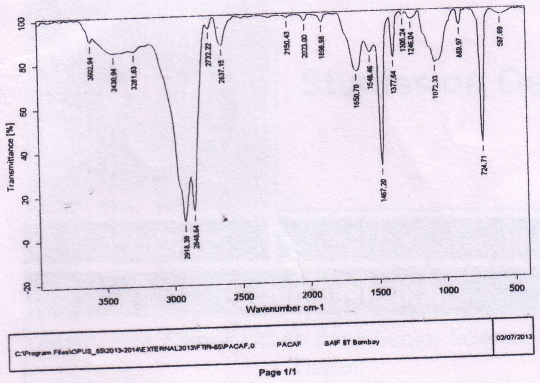


After Treatment

Result for Original and Treated PVC Sample



Original



After Treatment

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