National Journal of Advanced Research
www.multidisciplinaryarticle.in
ISSN: 2455-216X
Received: 09-02-2024, Accepted: 03-03-2024, Published: 26-03-2024
Volume 10, Issue 1, 2024, Page No. 9-13

Sem microscopic and ftir examination of plastic bottle waste degradation using bakery yeast

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Abstract
The large quantity and persistence of PET (poly (ethylene terephthalate) plastic wastes in the environment may disturb the weak ecological balance of the earth. Eco friendly technologies need to be devised to solve this problem. In the present study usage of bakery yeast inoculated with PET bottle plastic in laboratory conditions for period of one month after that bioflim formation was analysis by SEM. The observation of present study reveal appearance of cluster and mass colonization of Bakery yeast on surface of PET plastics when compared control PET flakes. FTIR spectral analysis depict that new (2625 cm^{-1} C-H bond stretching and 1036 cm^{-1} C-O bond stretching) functional group is appeared in yeast inoculate PET flakes when compared untreated ones.

Keywords: Bakery yeast. PET bottle plastic, FTIR, SEM

Introduction

Polyester (Poly (ethylene terephthalate), PET fibers are used in a great number of application areas such as apparel, home furnishing and interior textiles, hygiene and medical textiles [1]. Polyethylene terephthalate (PET) is widely used in multiple application such as fibers, films etc. The presence of PET in municipal solid waste has been increasing, and it causes plastic waste disposal problem as consumption increases dramatically. But recycling is a complex process as the materials are degraded during normal usage and by the recycling process [2]. These materials, due to high molecular weight and hydrophobicity, are resistant to environmental factors and after usage they become burdensome ballast to the environment [3]. The abundant accumulation of PET waste is of environmental concern due to its non-biodegradability, which is a major obstacle for disposal of PET by conventional methods such as land filling and incineration. The microbial biodegradation of plastic is a widely accepted option and is still underway for its enhanced efficiency [4]. There is growing interest in non-degradable synthetic polymer biodegradation using effective microorganisms [5]. Polymers that undergo a controlled biological degradation by micro-organisms have become of remarkable interest during the last years [6]**.** Recently several microorganisms have been reported to produce polyester degrading enzymes. The microbial species associated with the degrading materials were identified as bacteria (*Pseudomonas, Streptococcus, Staphylococcus, Micrococcus* and *Moraxella),* fungi (*Aspergillus niger, Aspergillus glaucus*), *Actinomycetes sp*., and *Saccharomonospora genus* [7]. In the present study used bakery yeast to biodegradation of PET plastics in laboratory conditions, further biodegradation was confirmed by FTIR analysis and SEM analysis.

Material and Methods

Purchased PET bottles were cut into small flakes. Then the PET flakes were washed with 70 % ethanol and again washed with distilled water and finally the samples were kept in at 45 ^{o}C for drying. Then the samples were directly inoculated into PDA broth medium containing Bakery Yeast. Medium were kept in orbital shaker for a period of one month at room temperature with 120 rpm.

1. FTIR Spectroscopic analysis of bacterial degradation of PET flakes

Fourier transform infrared (FT-IR) measurements were carried out with a Perkin Elmer Spectrum two (Version 10.03.09) in the range of 4000-400 cm^{-1}. FT-IR spectra were recorded at a resolution of 2 cm^{-1} and at an accumulation of 32 scans.

2. Scanning Electron Microscopy

Scanning electron microscope (SEM) (VEGA3 TESCAN) was used to determine the changes on the surface of PET flakes and colonization of Microorganisms. Control and yeast treated samples are generally sputter-coated with gold or some metal ions before SEM examination. Analysis was carried out using low vacuum 0.68 Torr mode, 10 to 30 kv at different magnification 6.13 kx to 500 kx and LFD (large field Detector) [8].

Result and Discussion

The SEM images of Yeast untreated PET indicate no yeast colonization on the surface of PET flakes (Plate -1). Cluster of yeast colonization was evinced in the SEM images of yeast treated PET when compared to the control (No Yeast treated PET). partially agrees with that of partially agrees with that of Atefeh Esmaeili *et al.*, (2013) who have also evinced colonisation of mixed culture of fungi

(*Lysinibacillus xylanilyticus* and *Aspergillus niger*) on PET flake surface, when incubated in soil inoculated with *Lysinibacillus xylanilyticus* and *Aspergillus niger* for a period of 126 days in the SEM image [9]. The adherence of the microorganisms to the polymeric surface is fundamental for biodegradation to take place [10]. Raaman *et al.,* (2012) have reported that the control polyethylene strips treated with *Aspergillus niger* and *Aspergillus japonicus* showed appreciable surface corrosion, folding and cracks in the SEM images and have attributed it due to fungal extracellular metabolites and fungal enzymes [11]. Sowmya *et al.,* (2014) have confirmed through Electron microscopic studies that the formation of holes and disappearances of PE structure on inoculation with *Chaetomium globosum* in MSM for a period 3 months [12].

FTIR spectra of control PET flakes have been displayed in Fig-1. Appearance of peaks have been noticed at 3916 cm^{-1} to 3056 cm^{-1} has been attributed to O-H bond stretching, 2968 cm^{-1} to 2282 cm^{-1} has been recognized to C-H bond stretching (Methylene Groups) and 2100 cm^{-1},1613 cm^{-1}, 1577 cm^{-1}, 1505 cm^{-1}has been attributed to C=C, C-C bond stretching (Benzene ring) and 1956 cm^{-1}, 1726 cm^{-1}, 1154 to indicated C=O bond stretching (Ether group),and 973 cm^{-1},873 cm^{-1},793 cm^{-1} cm^{-1},730 cm^{-1} to attributed to C-H bond stretching. Appearance of new peaks have been noticed at 2625 cm^{-1} and 1412 cm^{-1} to C-H bond stretching, 1036 cm^{-1} (C-O bond stretching) when compared to the control. Agrees with that Umamaheswari (2013a) have reported that inoculation of PET flakes in soil, sewage and cowdung, FTIR spectral analysis reveal C-H and C=C bond stretching. Except in PET flakes in cowdung, PET inoculation in soil and sewage elicited C=O bond stretching. PS powder inoculated in soil, sewage and cowdung underwent degradation which in reflected in the FTIR spectral analysis (C-O, bond stretching). Furthermore, PS powder on inoculation with sewage elicited C-H and C=C bond stretching, while in cowdung it resulted in O-H, C=O and C=C bond stretching. PS flakes when buried in soil, sewage and cowdung exhibited C=C bond stretching. In addition, O-H, C-H, C=O bond stretching was evident in PS flakes buried in cowdung. Thus fungal species (*Aspergillus sp., Penicillium sp. and Fusarium* sp) could be used as a biological agents to degrade PET and PS foam [13].

shift in absorption bands have been noticed from 2100 to 2106, 1726 to 1747, 1154 to 1172 were registered in bakery Yeast treated PET flake agrees with that of Weng *et al.,* (2013) who have also reported similar shift in absorption peak of C=O stretching vibration (from 1735 to 1759 cm^{-1}) in the FTIR spectra of PHA (Polyhydroxyalkanoate) buried in 20 or 40 cm of soil. Further, they noticed shift in absorption peak of C=O stretching vibration from 1749 to 1758 cm^{-1} after burial in 20 cm of soil for a period of 4 month [14].

Table 1: Band assignment of FTIR spectra of Control PET flakes and inoculated with bakery Yeast for a period of one months

Control PER Wave Number (cm^{-1})	Functional Group	Yeast Inoculated PET Wave Number (cm^{-1})	Functional Group
3916	O-H	3916	O-H
3804	O-H	3804	O-H
3757	O-H	3757	O-H
3554	O-H	3554	O-H
3431	O-H	3431	O-H
3336	O-H	3337	O-H
3300	O-H	3300	O-H
3229	O-H	3229	O-H
3056	O-H	3058	O-H
2968	C-H	2968	C-H
2906	C-H	2906	C-H
2806	C-H	2806	C-H
		2625	C-H
2539	C-H	2540	C-H
2389	C-H	2388	C-H
2282	C-H	2282	C-H
2100	C=C	2106	C=C
1956	C=O	1956	C=O
1726	C=O	1747	C=O
1613	C-C	1615	C-C
1577	C-C	1577	C-C
1505	C-C	1505	C-C
1443	C-H	1447	C-H
		1412	C-H
1330	C-H		
1154	C-O	1172	C-O
		1036	C-O
973	C-H	973	C-H
873	C-H	872	C-H
793	C-H	794	C-H
730	C-H	730	C-H

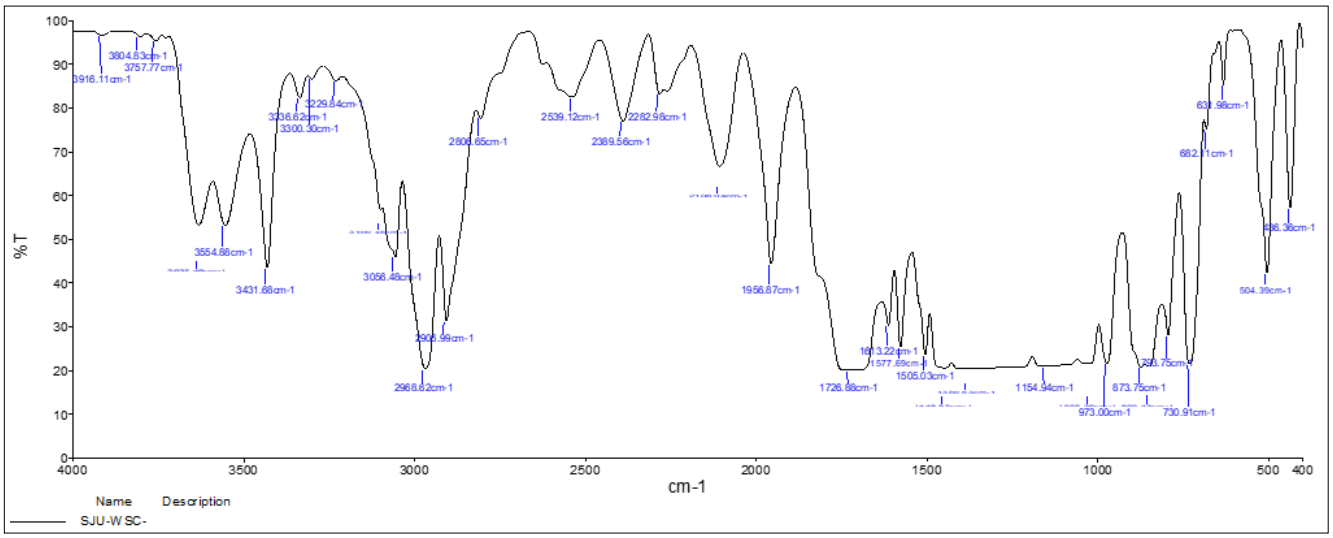


Fig 1: FTIR spectra of Control PET flakes

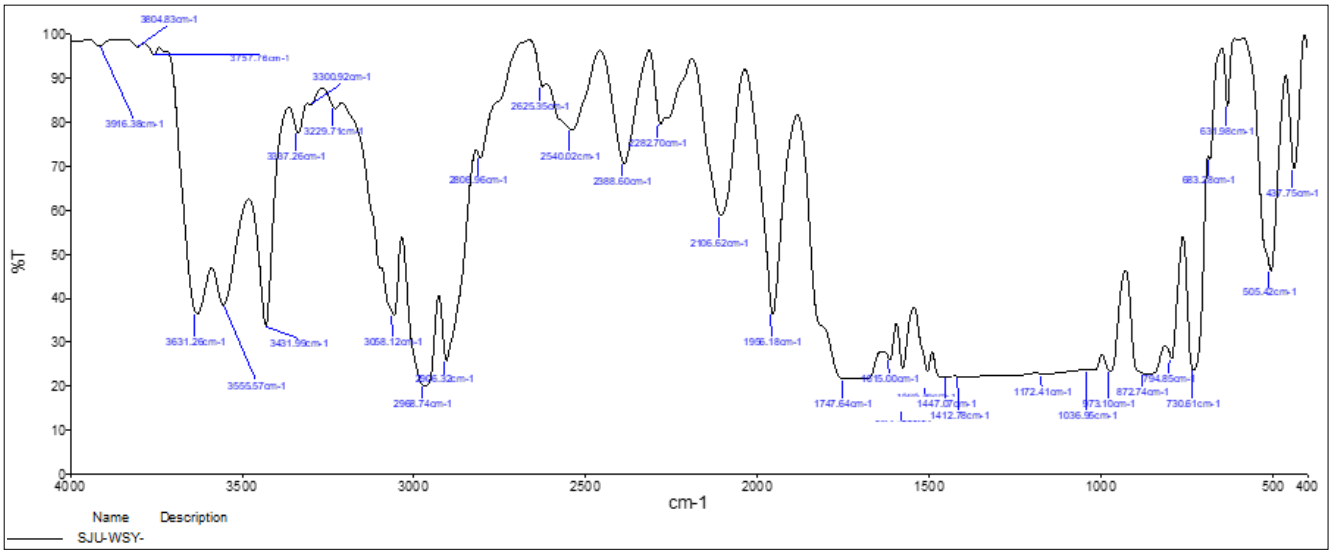
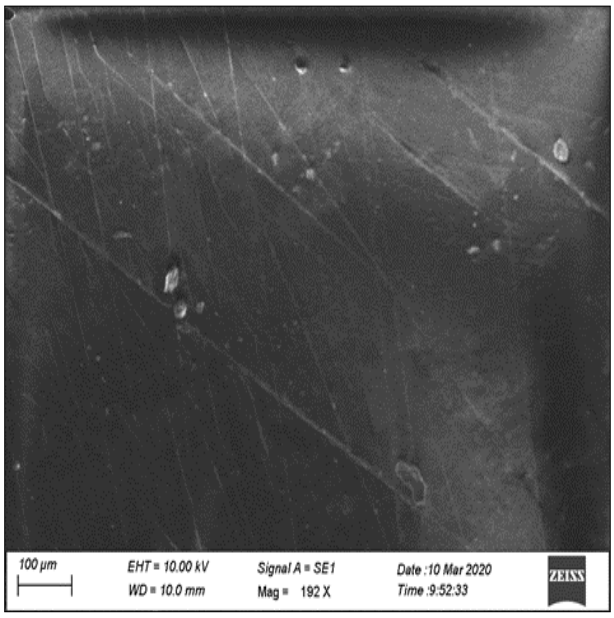
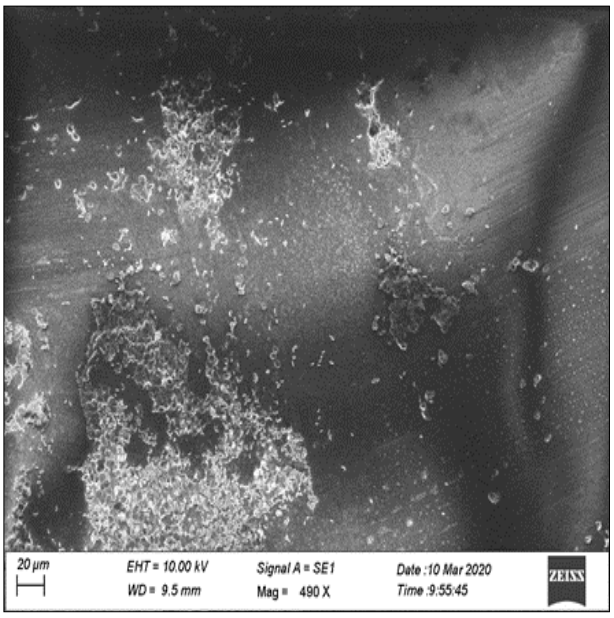


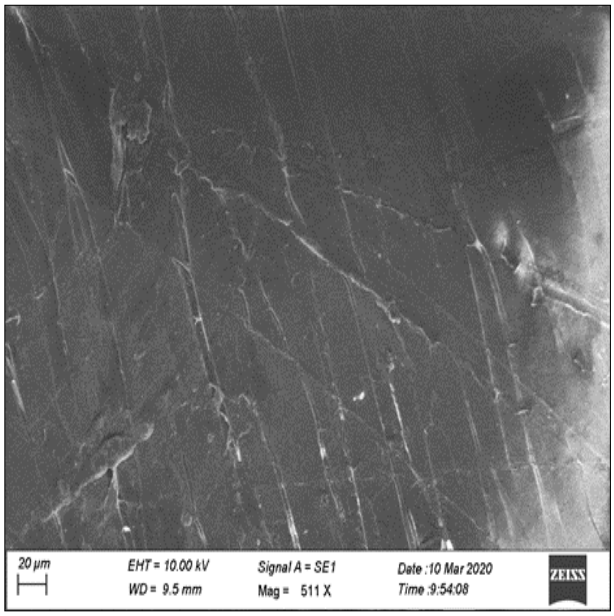
Fig 2: FTIR spectra of Yeast treated PET flakes in laboratory conditions for a period 4 months



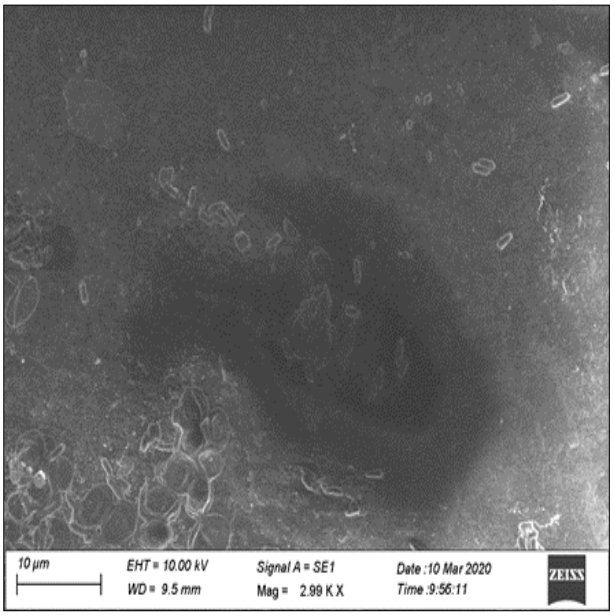
Control PET flakes



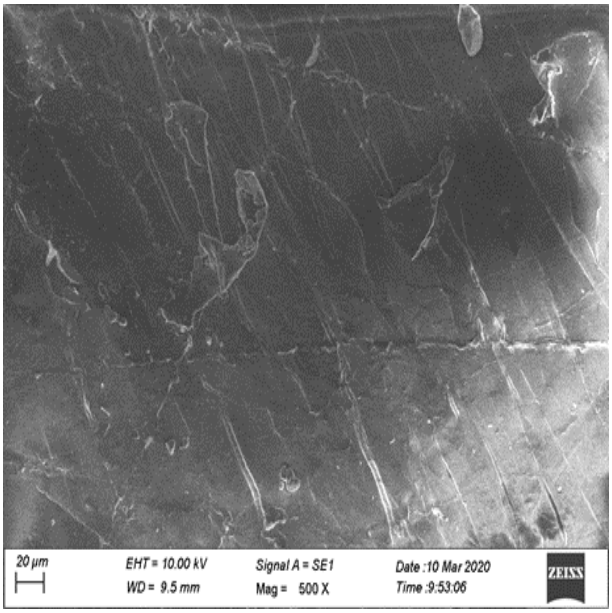
Yeast treated PET flakes



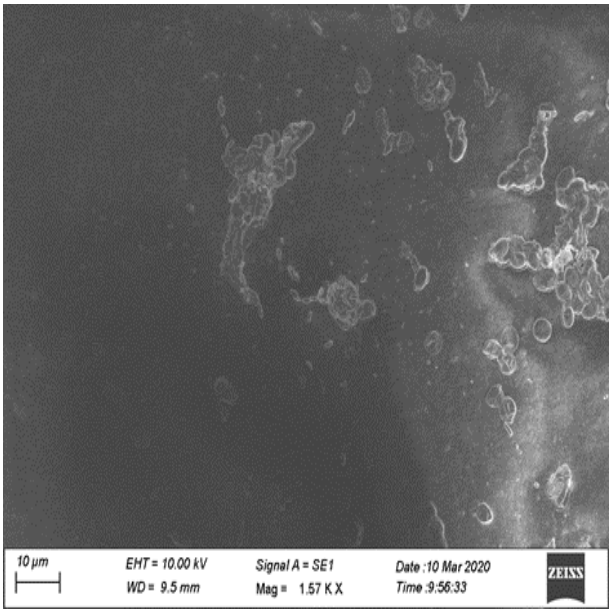
Control PET flakes



Yeast treated PET flakes



Control PET flakes



Yeast treated PET flakes

Plat 1: SEM image of control and Yeast treated PET flakes

Conclusions

PET plastic were inoculated with bakery yeast in laboratory conditions. These treated samples elicited significant changes on the surfaces of PET flaks as evident from the SEM images. This study indicates that the bakery yeast is able to adhere to the PET surface and could accelerate the PET degradation process.

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