Molecular Weight and Thermal Properties of Biopolymer

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Abstract
In his paper the degradation study of polylactic acid in soil at room temperature was studied to know the effect of microorganism present in domestic compost. Reduction in molecular weight studied by by Gel Permeation Chromatrography (GPC) from 75000 to 22400. Differential Scanning Calorimetry (DSC) was investigated. Through the investigation by DSC showed changes in melting temperature from 171 degree centigrade to 162 degree centigrade which confirmed decrease in crystalline nature and degradation of polylactic acid. Scanning Electron Microscopy (SEM) results showed that formation of small pores on the surface of Polylactic acid (PLA) which supports GPC, DSC data for degradation of PLA.

Keywords- Melting Temperature, TGA, DSC Molecular weight.

INTRODUCTION

The microbial degradation of poly(-lactide), PLA in the soils has been focused. To enclose the part of microorganism in a real process of biodegradation and to understand surface morphology, decrease in molecular weights and thermal properties were examined. The tests were performed in soil i.e. in compost room temperature.

The in vitro degradation characteristics of microporous PCL and inulin/PCL materials in PBS at 37 ^{0}C have been monitored over 45 months. Microporous PCL demonstrated zero weight loss, minor changes in molecular weight characteristics.1

PLA and PCL nanocomposites have been prepared by adding 5 wt% of a sepiolite (SEPS9) and degraded in compost, leading to effective degradation. PLA and PLA/SEPS9 seem to be mainly degraded by a bulk mechanism, showing a significant level of polymer degradation, however the presence of SEPS9 particles partially delays the degradation probably due to a preventing effect of these particles on polymer chain mobility and/or PLA/enzymes miscibility. PCL and PCL/SEPS9 showed a preferential surface mechanism of degradation.[2] PLA undergoes

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PLA nanocomposites based on organically modified montmorillonites at 5% w/w loading were prepared by melt blending using an internal mixer and then degraded in commercial compost. The addition of nanoclay was found to increase the PLA degradation rate, especially for the highest dispersed clay in the polymer matrix. Biodegradation by microorganisms isolated from the compost

showed the bacterium Bacillus licheniformis as one of the responsible for PLA biodegradation in compost. It was also found that clays can influence the polymer bacterial degradation depending on their chemical structure and affinity of the bacterium towards the clay.[3] In order to improve PLA degradation, different layered silicate nanoclays has been added montmorillonites and fluorohectorites, without or with organic modifiers. Environment that contains a natural mixture of fungi and bacteria. Biodegradation studies of the biocomposites have been investigated in medium through morphological and weight loss studies.[4] The degradability of linear low-density polyethylene and poly(L-lactic acid) blend films under controlled composting conditions has been investigated according to modified aerobic standard test method.[5] PLA and thermoplastic starch blends with compatibilizer have been studied the biodegradation in the soil burial test The rate of biodegradation of the blends decreases with an increase in the content of compatibilizer.[6]
The in vitro degradation characteristics of microporous PCL and inulin/PCL materials in PBS at 37 ^{0}C have been monitored over 45 months. Microporous PCL demonstrated zero weight loss, minor changes in molecular weight characteristics.

Materials and Experimental Methods:
PLA (Mw=75000), (Prepared in our Lab), Domestic soil containing compost.

Experimental Methods:
Biodegradation test: Biodegradation was studied using domestic compost. The compost was made of dried leaves trees, soil from farm, and waste of cattle. The compost was kept wet during test. The PLA film was made using polymer hot press at 100 0C. The dimensions of the film were 1 cm x 1 cm and thickness was 0.1mm. The film was kept in contact with the compost. Film was removed at different interval of time for characterization
Differential scanning calorimetric (DSC) measurements were made on a Perkin-Elmer thermal analyzer model DSC-Q10 in a nitrogen atmosphere. The measurements were run from –40 to 250 0C at a heating rate of 10 0C/ min and a cooling rate of 100 0C/ min.
SEM was taken on a gold-coated surface of polymer sample after careful washing and drying by using a Leica Cambridge Stereo scan Model 440.

Result and Discussion:
Biodegradation Study: It has been observed that after 10 days there is a decrease in molecular weight of polymer matrix. This is due to the hydrolytic degradation of PLA matrix which gave lower molecular weights PLA chain. The molecular weight decreased from 75000 to 63700 within 10 days with lowering in melting point by 6 0C as shown in table 1. The changes in surface morphology of PLA shown in fig.2
SEM: Thus at different interval of times i. e. 10 days, 20 days and 48 days the change in molecular weight (Table 1) , surface morphology (fig.2), melting temperature (fig. 1) occured. This is due to hydrolytic scission of ester group into an acid and an alcohol and thus low molecular weight polymer matrix converting into CO_2 and H_2O.

Table1: Molecular weight and melting temperature of PLA after degradation

Polymer	Biodegradation Time (Days)	Mw	Tm (0C)
Pure PLA	0	75000	171
PLA-1	10	63700	165
PLA-2	20	36000	162
PLA-3	48	22400	162

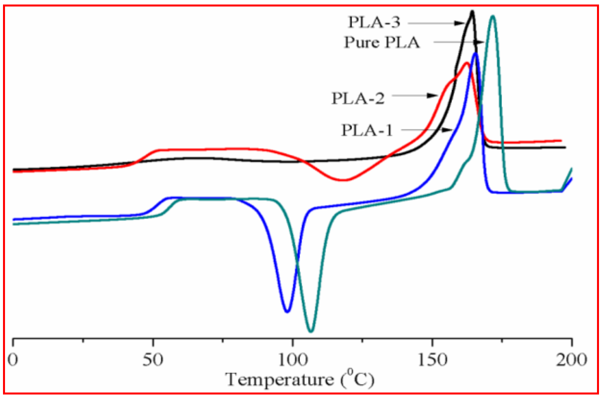

Fig.1 DSC thermograms of PLA and degraded PLA.

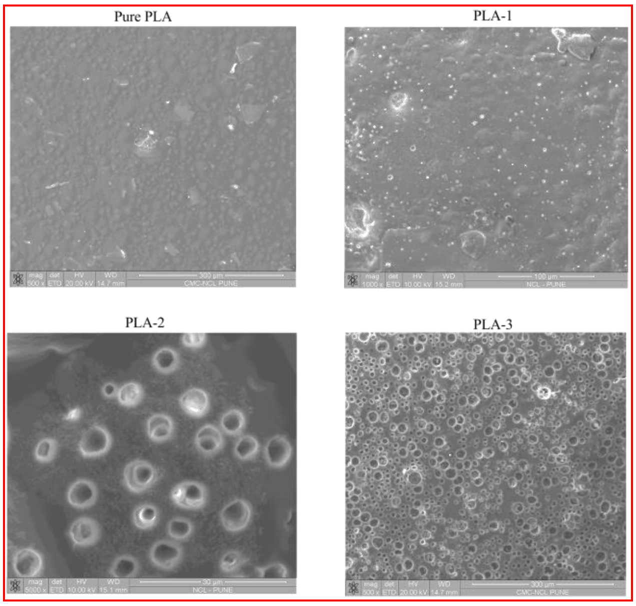

Fig. 2 Surface morphology of PLA before degradation (Pure PLA) and after degradation (PLA-1 to PLA-3).

DSC: Melting temperature of PLA also turned from 171 to 162 ^{0}C as shown by dsc thermogram shown in fig 1.

CONCLUSIONS

Bacterial study showed good evident of killing bacteria in presence of drug inside the nanofibers. The biodegradable test was also performed. The degradation occured hydrolytically followed by enzymatically. The presence of bacteria is responsible for biodegradation converting PLA film to CO_2 and H_2O. PLA is an insulating polymer. Decrease in molecular weight is confirmed by DSC study.

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REFERENCES

1. Coombes, A. G. A.; Rizzi, S. C.; Williamson, M.; Barralet, J. E.; Downes,S.; Wallace, W. A. Biomaterials 2004, 25, 315-325.
2. Dhabliya, D. (2021a). AODV Routing Protocol Implementation: Implications for Cybersecurity. In Intelligent and Reliable Engineering Systems (pp. 144–148). CRC Press.
3. Dhabliya, D. (2021c). Designing a Routing Protocol towards Enhancing System Network Lifetime. In Intelligent and Reliable Engineering Systems (pp. 160–163). CRC Press.
4. Dhabliya, D. (2021b). Blockchain Technology and Its Growing Role in the Internet of Things. In Intelligent and Reliable Engineering Systems (pp. 156–159). CRC Press.
5. Fukushima, K.; Tabuani, D.; Abbate, C.; Arena,M.; Ferreri, L. Polymer
6. Fukushima, K.; Abbate, C.; Tabuani, D.; Gennari, M.; Camino, G. Polymer Degradation and Stability 2009, 94, 1646-1655.
7. Jandas, P. J.; Mohanty, S.; Nayak, S. K. Journalof Polymers and the Environment 2012, 20, 583-595.
8. Q. Y.; Jiang, L.; Shi, R.; Zhang, L. Q. Progress in Polymer Science 2012, 37, 715-765.
9. Swierz-Motysia, B.; Jeziorska, R.; Szadkowska, A.; Piotrowska, M.Polimery 2011, 56, 271-280.

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