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Improving LDPE degradation by using Ferrous itaconate additives

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Abstract

The most stubborn pollutant threat to the environment is the plastic wastes. The plastic waste is very resistant to the biodegradability factor and hence they keep on accumulating in the landfills and the dump yards increasing the level of environmental pollution to its extent. Modification of the plastics by blending with proper additives has shown the propitious way of enhancing the microbial attack and plastic waste management. In this frame of work the Ferrous itaconate additives were synthesized and were infused into Polyethylene (PE) . Ferrous itaconate infused polyethylene were subsequently processed to produce films of 50-60 μ m thickness. The synthesis of proposed Ferrous itaconate additive was done and their performance index was measured. Infused polyethylene films were tested for their photo light attack and biotic attack for checking the biodegradability using accelerated UV/sunlight. The changes in the mechanical properties like Tensile strength and Elongation at break were analysed for Ferrous itaconate infused polyethylene in transverse direction (TD) and machine direction (MD). The percentage of biodegradation of the photo degraded film was analyzed by ASTMD 5988-96 and ASTMD 5338-98.

Keywords: Ferrous Itaconate, Tensile strength, LDPE, biodegradation

1. Introduction

In highly populated cities the sight of overflowing garbage and unbearable stretch coming from it is a usual scenario. The solid waste generated in the world is estimated to be over one million bags every minute which is a big threat to the environment. Of the total bags 7%-10% of plastic waste accumulation contributes as the main factor in degrading the landfill in the environment. This degradation takes place at the rate of 500 billion tons per year. It was surveyed that minimal about 3% of entire plastic waste are

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being treated and recycled [1,2]. Plastic wastes have an instinctive property of strong resistance to chemicals which becomes the main reason for plastic accumulation in the environment. Secondly the minimal usage time is also a prime factor for the buildup of the plastic wastes [3,4].The extreme height of stability of the plastic wastes in ecology causes high grade of degradation of environmental parameters. Many research works are done to get effective methods for the degradation of plastic but still a concrete solution has not been developed other than developing plastics which can be biodegradable. This can be accomplished by the modification of plastics with some additives which can enhance the property of biodegradation by microorganisms [5,6]. Different polymers exhibits different properties and they react differently with nature. Study of nature of blending of different polymers with environment can give a significant solution for plastic waste management. The use of this material is mainly for food packaging, disposable bags and for agricultural utilities. The environmental degradation of these plastics is a very slow synergistic process consisting of initial photo and thermo oxidation followed by the biological activity of micro organisms [7,8]. Different biochemical factors affect the inhered polymer properties like temperature, moisture in polymer, air humidity pH and solar energy.

The proposed frame of work is centralized on the refinement of property of biodegradation of polyethylene (PE) and PolyPropelyne containing the synthesized pro-oxidant combined with bioactive additives. The bioactive additives that are used in this study are ferrous Itaconate. The additive loadings are upto 5wt% for Low density polyethylene (LDPE).

2. Material and method

The materials used for the synthesis of Ferrous sulphate and itaconic acid

Haake Poly Lab –OS

LDPE were blended with Ferrous itaconate photo and biodegradable additives (1%, 3% and 5%) by using Haake polylab-OS, Thermo Scientific, Germany. The temperature range was maintained at 105-190°C for the blending process and the rotation of screw was maintained at a rotational speed of 75-135 rpm. The film was prepared by using film die for all the three percentages of additives. The thickness of the films was maintained as 50 microns by controlling the speed of the nip rollers and output rate.

Photo degradation

The photodegradation studies of blended LDPE with Ferrous itaconate were done using Q Lab- UV Weather-O-meter. UV irradiation and condensation test cycles were done for the samples and degradation phenomena was assessed using 25 mm width films.

Test Method	-	ASTM D 5208
Exposure Range	-	313 nm UV -B
Film Dimensions	-	50 micron thickness, 27.5cm X 2.5cm
Duration of Exposure -		144 hrs as per standard

Mechanical properties

Mechanical properties (Tensile Strength ASTM D 882)

LDPE with Ferrous Itaconate

Tensile properties of films of virgin LDPE films with prooxidant bioactive Ferrouw itaconate additive have been evaluated. This evaluation was done before UV exposure and even after UV exposure. The tensile tests were done according to ASTM D 882, using Universal Testing Machine (UTM), Lloyd Instrument Ltd, and UK. The specimen dimensions were maintained at 150 x 23 x 0.050 for the tensile tests. The tests were carried out at a cross head speed of 500mm/min and gauge length of 50mm. The tensile properties of films in both machine directions as well as in transverse direction were evaluated.

Compost Biodegradation

The degree and rate of aerobic biodegradation of plastic materials was tested using ASTMD 5338 under a controlled composting environment in laboratory scale. Inoculums that were derived from compost from municipal solid waste were used on the test samples. The main parameter for aerobic composting is temperature, aeration and humidity which were monitored and controlled. The rate of degradation is monitored as well. This test method is designed to be applicable to all plastic materials.

3. Result Discussion

The tensile strength, elongation at break of LDPE films having Ferrous Itaconate additive are presented in Table 1. The incorporation of ferrous itaconate up to 5 wt%, decrease the tensile strength as an extensive effect of additive on LDPE. After the UV exposure for 52 hrs there is no much change in the mechanical properties. But after the UV exposure for 102 hrs there was a significant reduction in mechanical properties which which clearly presume that there was photodegradation of LDPE in the presence of Ferrous itaconate additives.

Table 1 The mechanical properties of Ferrous itaconate with LDPE

SNO	Sample Details	Tensile strength (Kgf/cm^2)		Elongation (%)	
		MD	TD	MD	TD
1	LDPE	23.00	18.00	223.00	354.00
2	LDPE for 220 Quv	24.00	19.10	228.00	368.00
3	1% Fe itaconate beforeUV	19.00	16.00	197.00	300.00
4	3% Fe itaconate beforeUV	18.00	15.00	153.00	264.00
5	5% Fe itaconate beforeUV	17.00	14.00	111.00	217.00
6	1% Fe itaconate after UV	15.00	13.00	18.50	37.00
7	3% Fe itaconate after UV	13.00	10.85	16.90	26.20
8	5% Fe itaconate after UV	11.0	10.00	4.00	20.22

The biodegradation test (ASTM D 5338)

The prooxidant bioactive additives act as photodegradable agents as well as biodegradable agents as it has been synthesized from Ferrous itaconate additive. The biodegradation results show that the biodegradation of the photodegraded film of LDPE with Ferrous itaconate film fragments (under accelerated UV for the specified hours) occurs progressively and up to 25% at the end of 90 days when extrapolated to 100% for the cellulose. It can be seen from the Figure 1 that the films with higher photodegradation i.e., which contain higher amount of additive show higher percentage of biodegradation

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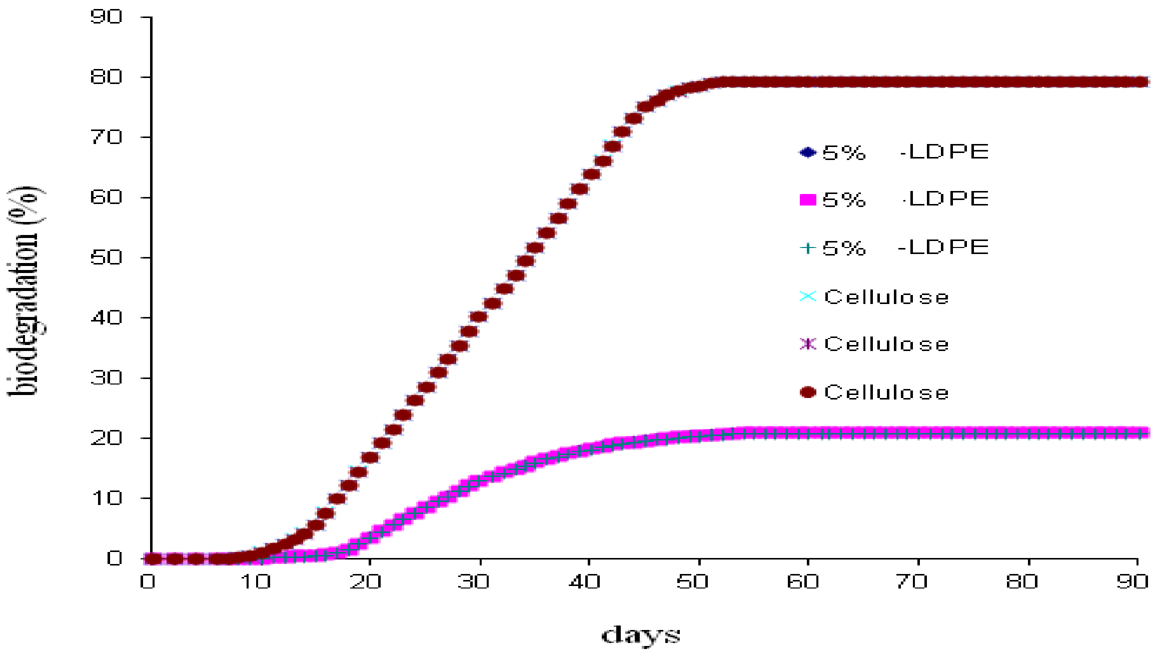

Figure 1 The percentage of biodegradation for LDPE with Ferrous itaconate

Conclusion

These additives have been incorporated into polyolefins LDPE using Hakke film extruder. An optimum additive loading of 5 wt% for LDPE, these additives accelerated the photodegradation of LDPE films of 50 micron thickness and reached almost 100% degradation causing complete embrittement of the film within 2-5 days under accelerated conditions. The photodegraded film fragments subjected to biodegradation by standard composting test method (ASTMD 5338), 25% biodegradation for a period of 90 days.

References

1. Abrusci, C., Pablos, J.L., Corrales, T., Lopez-Marin, J., Marin, I. and Catalina, F. "Biodegradation of photo-degraded mulching films based on polyethylene's and stearate of calcium and iron as prooxidant additives", International Bio deterioration and Biodegradation, Vol. 65, pp. 451-459, 2011.
2. Bravo, A. and Hotchkiss, J. H. "Identification of volatile compounds resulting from the thermal oxidation of polyethylene", J. Appl. Polym. Sci. Vol.47, No.10, pp.1741-1748, 1993.
3. Hakkarainen, M. and Albertsson, A-C. "Environment degradation of polyethylene", Advan. Poly. Sci., Vol. 169, pp.177–199, 2004.
4. Ojeda, T., Freitas, A., Dalmolin, E., Dal Pizzol, M., Vignol, L., Melnik, J., Jacques, R., Bento, F. and Camargo, F. "Abiotic and biotic degradation of Oxo-biodegradable foamed polystyrene" Poly. Degrad. Stab., Vol.94, pp. 2128-2133, 2009.
5. J.H.Song,R.J.Murphy,R.Narayan "Biodegradable and compostable alternatives to conventional plastics" Philosophical transactions B,2009 Jul 27; 364(1526): 2127–2139.
6. Kale.G,Kijchaven.T,Auras.R,Rubino.M "Compostability of bioplastic packaging materials: an overview" Macromolecular Bioscience 2007 Mar 8;7(3):255-77.
7. Stephan Kubowicz and Andy M. Booth," Biodegradability of Plastics: Challenges and Misconceptions " *Environmental Science & Technology* **2017** *51* (21), 12058-12060
DOI: 10.1021/acs.est.7b04051
8. Emilio Delgado , William Aperador Chaparro, Juan Carrillo León "Effects of Incorporation of Additives in the Mechanical Properties of Films of Linear Low-Density Polyethylene" TECCIENCIA, Vol. 12 No. 23, 51-59, 2017