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Studies on the Polyethylene (PE) Degradation Behavior of Seemakkai Seeds Grinding Powder (SGP)

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Abstract

The performance of the SGP on the accelerated UV light of polyethylene (PE) was evaluated by degradation behavior in the mechanical properties. The 5, 10 and 15% were mixed with SGP at various concentrations by using melt blending and then film preparation 53-57 micron thickness by using sheet film process at 105-190 rpm. The analysis was showed that PE with 10% SGP has greater degradation when compared to that of 5 and 15% UV exposure of SGP in the specified hour UV exposure. The photodegraded film when subjected to the ASTMD5338 standard biodegradation compost at 58 °C was monitored, the percentage of biodegradation reveal that 24 % at the end of 60 days.

Keywords: Polyethylene; Seemakkai Seeds Grinding Powder (SGP); Degradation

Introduction

Pollutants composed of plastic garbage and packaging waste have been removed from the environment using three approaches. The first proposal is to store the waste in landfills. However, due to prompt population growth and the limited number of landfills, this proposal only transfers the problem to future generations [1,2]. Plastic garbage and packaging waste represents 20–30% of the total volume of solid waste contained in landfills because in addition to the vast amount of waste generated, plastic waste is pervicacious and remains deposited in these landfills for long periods of time [3]. The second proposal can be subdivided into two distinct parts: waste incineration plastics and a call for the recycling of specific plastics [2,4]. The incineration of plastic waste often results in a significant release of carbon dioxide and other gases. The recycling process includes removing the plastic residue, separating plastic into categories according to type, and washing, drying, grinding and reprocessing the plastic waste [2]. Thus, recycling is an expensive process, and the quality of the recycled plastic is lower than that of the primary material [1-3]. The final proposal is the development of biodegradable plastics packaging.

Biodegradable plastics can be unwinded into three groups according to their origin: (a) bacterial polymers that can be formed by a bacterial biofilm or by microbial fermentation, (b) polymers that are derived from plants and (c) chemically synthesized polymers [3]. Biodegradable polymers derived from renewable sources, such as plants or microorganisms, are ecologically maintainable because they are not assembled in the environment for long periods of time and they are degraded or mineralized by microorganisms. However, these polymers contain some physicochemical properties that restrict their use [5]. Biodegradable plastics that are synthesized by chemical modifications may be divided into two groups: (a) those obtained by the degradation of chemical structures by the direct action of enzymes, such as amylase and cellulase, and (b) those that are made degradable by the action of one or various physic-chemical processes, for example, hydrolysis, photolysis or pyrolysis [4,5].

The polymers of the second subgroup are designated as Oxo-biodegradable polymers due to the presence of the pro-oxidant or pro-degrading additives [1,5]. The pro-oxidant modified additive is incorporated into the polymer chain and represents approximately 1-5% of the polymer molecular weight [5]. These pro-oxidants additives are based on combinations of metal ions of similar stability and oxidation number, for example, Co^{+2}/Co^{+3}, Mn^{+2}/Mn^{+3}, Fe^{+2}/Fe^{+3} and TiO_2 [4,5]. The pro-oxidant additives that is submerge in the polymer chain accelerates the photo and thermal oxidation [4]. Thus, when these residues are exposed to UV or high temperatures, they are degraded by the formation of free radicals that react with atmospheric oxygen, leading to polymer chain scission and the production of low molecular weight compounds, such as carboxylic acids, alcohols and ketones [6]. These compounds are then assimilated by microorganisms [4].

In contrast to most synthetic polymers that are derived from petroleum, biodegradable polymers, when discarded in the environment, may initially be cleaved from the polymer chain by non-enzymatic processes, such as photolysis and chemical hydrolysis, and subsequently degraded by enzymes produced by algae, bacteria or fungi [7]. These biodegradable polymers can be converted to carbon dioxide, methane, water, biomass, humus and other substances. Therefore, the aim of this study was to evaluate the capacity of Postreatus to degrade Oxo-biodegradable plastic and to form mushrooms in this waste. In the project experiment, on the aerobic microbial degradation of PE with SGP additives. In photo-biodegradable systems, biodegradation occurs only after an initial photo degradation stage. Degradation of the polymer is triggered by UV light and assisted by the presence of UV sensitizers in the polymer. The polymer is initially converted to low molecular weight material and then converted to carbon dioxide and water by bacterial action. Most of the literature only considers photo degradation studies. In this study, the SGP additive phodegradation and it subjected to biodegradation analysis using the standard of ASTM D 5338 [8-12].

Experimental

The PE used in this project work was obtained from Reliance Industries pvt Ltd, India. The homopolymers PE film grade 24FS040 having a melt flow index of 2.4g/10 min. Seemakkai seeds grinding powder (SGP) was purchased from local area market in Chennai (koyambedu) used for the study of photo degradation, the SGP were melting blended with PE at 3 different formulations 5, 10 and 15% respectively in twin screw extruder. The pellet produced were subsequently dried and subjected to sheet film process of 58 micron thickness.

The 5, 10 and 15% were mixed with SGP at various concentrations by using melt blending and then film preparation 53-58 micron thickness by using sheet film process at 105-190 rpm using the instrument HAAKE RHEOCARD. The tensile tests were performed according to ASTM D 882 using universal testing machine (UTM) LLOYD Instrument Ltd. UK at room temperature. The gauge length was set as 50 mm. All the SGP with blended samples were subjected to photo- degradation studies as per ASTM D 5208 using Atlas UV Weather-o-meter.

Results and Discussion

Mechanical Properties

On blending with PE at three different ratios 5, 10 and 15%, SGP causes the UV degradation of PE film. The tensile strength and elongation values of the films, before and after exposure samples UV samples are given in Table 1. It is evident that tensile strength of PE increases with the incorporation of SGP due to SGP-PE highly interactive to the polymer so the tensile strength slightly increases. However on exposure of the blended samples for the specified hours (96h) on QUV radiation, there was a considerable decrease in the tensile strength and elongation of the samples due to SGP additives. In the case of the test sample containing 10% SGP, the deterioration in properties was observed from 12.00 MPa to 6.20 MPa (i.e. 40% degradation) for 96 hours. It was observed that with the increase of SGP, the rate of photosensitive degradation decreases, which is probably due to more agglomeration at higher percentage SGP in PE and cross linking to the polymer when compared to 10% SGP-PE.

S. No	Sample Identification	UV Exposure Time	Tensile strength		% Elongation At Break	
			Machine Direction (MD)	Transverse Direction (TD)	Machine Direction (MD)	Transverse Direction (TD)
1	PE Virgin	0 h	12	11.2	324.9	453.44
2	PE Virgin	96 h	10.5	9.3	300.4	420.8
3	PE- 5% SGP	0 h	13	14	328.2	463
4	PE-5% SGP	96 h	11	10	226	405
5	PE-10% SGP	0 h	15	15.3	332.5	470.8
6	PE-10% SGP	96 h	6.2	7	58.4	39.7
7	PE-15% SGP	0 h	12.9	11	330	460
8	PE- 15% SGP	96 h	9.58	9	58	36

Table 1: Tensile strength of the PE- SGP film before and after exposure under UV exposure

The Biodegradation Test (ASTMD 5338)

The photo degradation product (after the UV exposure for the specified 96 hours) when the subject to ASTMD 5338 standard compost condition at 58 °C, The bio degradation is results at 24% at the end of 60 days.

Conclusion

In this study we have used 10% SGP additive enough as a good photodegradable additive but higher concentration increase the SGP additive more agglomeration, the 10% additive the photo degraded film which makes PE more susceptible to microbial attack. The microbial degradation was observed as per ASTM D 5338, the percentage of biodegradation is 24% in the 60 days.

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