SOME STUDIES ON THE PHYSICAL PROPERTIES AND DEGRADABILITY OF TAPIOCA AND CORN STARCH LOW DENSITY POLYETHYLENE BLENDS

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Abstract: Starch based plastics materials have potential to be used in various applications to reduce the use of nonrenewable and nondegradable petroleum based materials. In the present study the compatibility of starch as fillers in low density polyethylene plastic films was evaluated for the purpose of producing degradable plastic films for environmental and agricultural uses. Two different types of starch were used in the study namely: tapioca- and corn-starch. Blends and films at various starch proportions were produced using Twin Screw and Blow Film Extruder respectively. Products were tested for their structural and mechanical properties using DSC, TGA and Tensile Tester. The degradable properties were determined using two methods namely, water absorption test and soil burial test. DSC analysis showed no significant change in the T_m of the blends as compared to the virgin LDPE. Tensile strength decreases with increasing starch content. Water absorption was found to increase with increasing starch content. TGA analysis of LDPE/starch films showed that degradation had occurred in all blends. At least three degradation mechanisms were identified in the blends through TGA analysis. These were assigned to the mass lost due to moisture vaporization, the degradation of the starch and the degradation of the LDPE. Tensile properties and and the starch content decreases after soil burial suggesting that some degree of biodegradation occur.

Keywords: Low Density Polyethylene- Starch blend, Soil Burial Studies, Degradation, Biodegradation

INTRODUCTION

Because plastic does not decompose, the amount of plastic waste in our environments is steadily increasing. Plastic thrown on land can enter into drainage lines and chokes them resulting into floods in cities. Plastics entangle creatures and when eaten may remain in the stomachs, blocking digestion and possibly causing starvation. Our objectives are to improve on the method of production while searching for alternative plastics that may either be photodegradable, semi-biodegradable or fully biodegradable. The present study is the modification of existing material by blending of polyethylene with starch which is indigenous, biodegradable, and renewable material. Starch based plastics materials have potential to be used in various environmental and agricultural applications to reduce the use of nonrenewable non degradable petroleum based materials. Starch is a totally biodegradable polymer. It consists of two major components: amylose, and amylopectin. Both fractions are readily hydrolyzed by amylase and glucosidases. After a starch filled plastic material has been thrown away, microorganisms digest away starch, leaving polyethylene film structure losing its strength and integrity which soon disintegrates.

MATERIALS AND METHODS

Commercial grade Low Density Polyethylene and food grade tapioca and corn starches were used for the experiment. Native dried starch powder was blended with LDPE at different percentage i.e. 10%, 20% and 30% (w/w) to produce films using Twin Screw and Blow Film Extruder. All samples were subjected to 30 days of soil burial test. The blends were characterized by Differential Scanning Calorimetry, Thermogravimetry Analyser and Tensile Testers before and after the soil burial test. Water absorption test on all samples were carried out for 30 days. Soil burial test was extended for 3 months using 20% corn-starch/LDPE films to assess biodegradation of the materials in various environmental conditions.

RESULTS AND DISCUSSIONS

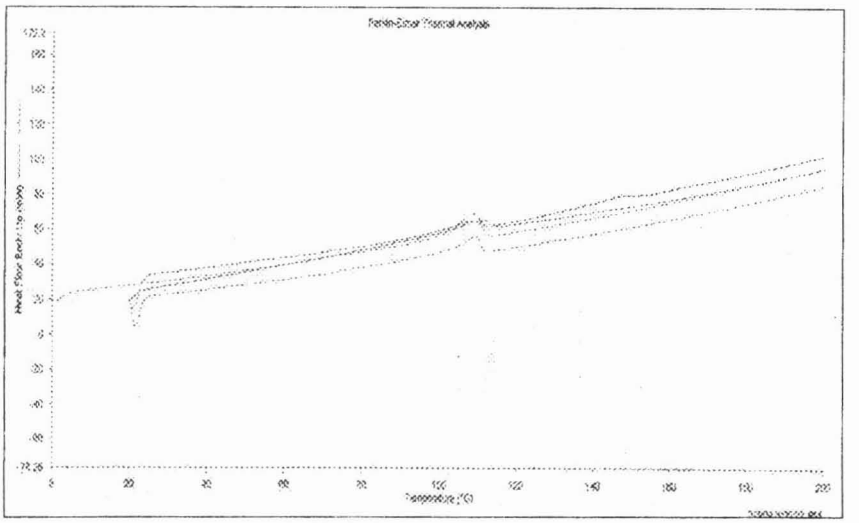

Figure 1: DSC trace of LDPE/corn starch blends

Differential Scanning Calorimetry analysis of the LDPE/tapioca starch blends and LDPE/corn starch blends did not show a significant change compared to the T_m of pure LDPE. Figure 1 showed an example of DSC scans result for corn starch/LDPE blends. This shows that the addition of starch up to 30% into LDPE does not give any effect to the T_m of LDPE. It was observed that the T_m of LDPE remains unchanged after the soil burial test although some samples lost weight.

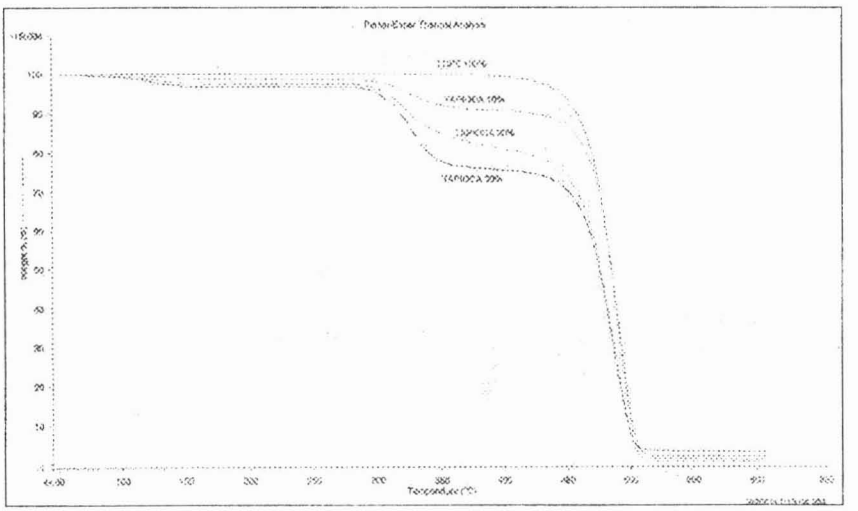

Figure 2: TGA trace of LDPE/tapioca starch blends

TGA thermograms of all LDPE/starch blends show weight losses at three stages. The stages are moisture evaporation at between room temperature and 150°C, starch decomposition at 270 to 350°C and LDPE decomposition at 430 to 520°C as exemplified in Figure 2. After soil burial test thermal degradation behaviour of the blends was unchanged but the starch content were reduced from 25%to 50% of the initial content.

Table 1: Data of Tensile Strength, TGA analysis, and Water Absorption Tests

Sample (w/w)	Tensile Strength (N/mm^2)		Weight Loss by TGA Analysis (%)			Water Absorption (%)	
	Before Burial	After Burial	Moisture	Starch	LDPE	Day 10	Day 30
LDPE (100%)	13.58	13.80	1.41.	8.06.	90.12.	0	0
Tapioca (10%)	9.02	8.99	2.37	16.34	80.01	0.67	0.33
Tapioca (20%)	10.27	9.55	3.27	21.77	71.55	1.96	1.53
Tapioca (30%)	6.86	6.55	1.22.	8.09	89.43	2.80	2.94
Corn (10%)	4.52	3.89	2.30	14.42	80.10	1.92	3.96
Corn (20%)	6.48	5.88	2.45	22.49	72.85	2.15	3.07

Data in Table 1 shows that LDPE/tapioca starch blends have better tensile strength compared to LDPE/corn starch blends. After 30 day soil burial, the tensile strength of all LDPE/tapioca and LDPE/corn starch blends decreases.

Table 2: Degradation of Tapioca (20%)/LDPE buried for 90 days

Environs /Soil type	Weight Loss (%)
Beach/Sand	3.02
Plantation/Red Soil	2.50
Paddy field/Peat soil	2.82
Village/Red soil	2.63
Park/Top soil	1.28
Landfill/Leachate	2.24

Data from soil burial test of 20% tapioca/LDPE indicated losses of between 1.3 to 3.0% in weight (Table 2). Water absorption tests showed that all samples absorb water causing weight increase (Table 1). Under soil burial condition, the increase in moisture content should aid microbial colonization and degradation of starch. This is shown by losses in weight of samples during the burial test which indicate that the biodegradation of the starch component occurred.

Blends and films at various starch proportions have comparable physical properties of pure LDPE. These films were shown to be degraded thermally and have good water absorption properties. Water absorption increased with increasing starch content. Samples buried in soil incur weight losses and decreased tensile strength suggesting that some degree of biodegradation had occurred in all blends. Further studies on the processing methods, extended environmental burial studies and the mechanism of biodegradation are still in progress in our laboratories. Blends of other polymer resin such HDPE, polystyrene and PVA with tapioca, corn, sago and beet starches with and without additives are also being evaluated.

ACKNOWLEDGEMENTS

This project was funded by Institute of Research, Development and Commercialisation, Universiti Teknologi MARA.

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