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EFFECT OF SOIL BURIAL ON PROPERTIES OF POLYPROPYLENE (PP)/ PLASTICIZED POTATO STARCH (PPS) BLENDS

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ABSTRACT

The effect of potato starch on the mechanical properties and biodegradability of polypropylene was investigated using the soil burial test method. Polypropylene and plasticized potato starch with and without compatibilizer were produced through melt blending for soil burial that lasted for 90 days. The results showed that tensile properties of the various PP blends decreased progressively with the increase in starch content and burial time for PP/PPS blends. Similarly, tensile properties of PP/PCPS blends followed the same trend but with less decrease in tensile properties than PP/PPS blend due to compatibilizing effect of maleic anhydride-graft-polypropylene which offered an improved interfacial adhesion between starch and matrix. The tensile properties however, for both PP/PPS and PP/PCPS decreased with increased in starch content and burial period.

KEYWORDS: *Plasticized potato starch, polypropylene, soil burial, mechanical properties, compatibilizer.*

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I. INTRODUCTION

Most inert polymers are considered to be resistant to microbial attack. Their biodegradability depends on various physical and chemical properties. (Chandra and Rustgi, 1998). Solid waste from these materials is a major contributor to environmental pollution as it takes up quite great number of years to degrade. Studies are being conducted to prepare new thermoplastic materials (Averous et al, 2000), composed of blends of synthetic polymer with material polymer, that are degraded more easily when discarded in the environment (Tzankova-Dintcheva et al, 2002). This approach has received a reasonable amount of attention for possible applications in the waste disposal of plastics. The blend looses its integrity, disintegrates and disappears when attacked by microbes in the waste disposal environment if the biodegradable component is present in sufficient amounts. Again, the concept has gained advantage in blends of minor amounts of natural botanical resources with inert polymer in which the later constitutes the continuous phase and the blend can be melt processed to form films or plastics with inert polymer- like properties.

The original application of starch was found in the food industry (Jobling, 2004). However, starch has also been recognized as a potential functional raw material in many other applications (Jobling,2004; Averous, 2004; Bastioli, 2001). Starch is the most attractive candidate of the renewable resources because of its low lost, availability throughout the year and potential for mass production from renewable resources (Guohua et al, 2006; Tang et al, 2007; Yun et al, 2008). Plasticized Starch (PS) can be obtained by an adequate combination of pressure, temperature and shear conditions in the presence of water and/or other plasticizers (Jobling, 2004; Nashed et al, 2003; Aichholzer and Fritz, 1998). Here, water and glycerol were used as plasticizers for the processing of starch. The application of plasticized starch is limited by the inherent susceptibility to the thermo-mechanical degradation. In order to circumvent this problem, starch can be plasticized in combination with different synthetic polymers to satisfy a broad range of performance requirements of market needs (Pranamuda, 1996; Mani and Bhattacharya, 2001; Lorcks, 1998; Bastioli, 1998). Besides improving the biodegradable capacity of the microorganisms, the type of starch used in the production of polymeric blends can interfere directly in the properties of the polymer (Gomes et al, 2004), and plastic material with different mechanical properties is believed to be produced with a mixture of a conventional plastic and biodegradable polymer (Rosen and Schway, 1980).

The overall objective of the study was to investigate the biodegradation potential of different levels of starch on PP/PPS blends. Tensile test was used to determine the changes of tensile properties of the exposed and unexposed blends.

II. EXPERIMENT MATERIALS

Potato starch was got from potato tubers obtained from National Root Crop Research Institute (NRCRI) Umudike, Nigeria according to the method adopted by Integrated Cassava Project (ICP) of the Federal Ministry of Agriculture and Rural Development, Nigeria. It has a particle size of 0.075mm.Granules of polypropylene (PP), with melting temperature of 165˚C and MFI of 70g/10min were obtained from Exxon Mobil Ltd. Maleic anhydride-graft-polypropylene (MA-g-PP) was obtained from Sigma-Aldrich Corporation with melting point of 156˚C and density of 0.934 g/cm^3. Glycerol was used as obtained from Ajax chemicals.

Preparation of Plasticized Potato Starch

Plasticized Potato Starch (PPS) was prepared from potato starch using a high speed laboratory- mixer according to the method of St-Pierre et al (1997). Mixing conditions of starch, water, and glycerol was at 70˚C and 50 rpm. The PPS obtained was oven dried at 90˚C for 12 h to reduce its moisture content (MC).

Polypropylene/PPS Blends Preparation

Polypropylene compounds with plasticized potato starch (PPS) were melt-blended in an injection machine at a temperature of 160-190˚C and a screw speed of 50 rpm to obtain PP/PPS composites. The PPS contents were 0, 10, 20, 30, 40, and 50 wt. % in the blends. Maleic anhydride-graft-polypropylene (MA-g-PP) was used as a compatibilizer at 10 wt. % based on the potato starch content. The liquid melt was injected into a mould to obtain sample sheets. These sheets were oven dried for 24 h at 70˚C and then stored in a desiccator.

Soil Burial Test

To examine the biodegradability of the PP/potato starch blends, soil burial test was carried out on a laboratory scale. Dumbbell shaped specimens of definite sizes were cut from each of the blends. Moist soil was placed into plastic containers with tiny holes was perforated at the bottom and on the body of the container to increase air, and water circulation. The test was carried outside the room and lasted for 90 days. The specimens were buried in the soil at a depth of 10 cm from the surface and thus subjected to the action of microorganisms in which soil is their major habitant. After the test, the blend samples were removed, washed with distilled water and dried in an oven at 70˚C for 24 h and then kept in a desiccator.

Tensile Properties

Tensile tests were carried out for the exposed specimens with a universal testing machine Instron 3366, according to ASTM D638. Dumbbell shape specimens of 3 mm thickness were cut from the moulded samples. The test was performed at a cross-head speed of 5 mm/min at 25±3˚C. Five specimens were used to obtain the average values for tensile strength, elongation at break and Young's modulus.

III. RESULTS AND DISCUSSION

Tensile Properties

Different polypropylene/potato starch compositions were prepared by varying the amount of starch with constant plasticizer and compatibilizer content. Reduction in the tensile properties of the resulting polymer blends is reported as an undesirable effect of the addition of starch to polymers. Blends flexibility enhancement, strong intermolecular and intramolecular interactions between starch molecules and matrix of the polymer can be obtained with the incorporation of plasticizer to the starch so that starch has been plasticized resulting in less brittle and more homogenous mixture.

The effect of soil burial tests on the tensile properties of blends of polypropylene/plasticized potato starch (PP/PPS) and polypropylene/plasticized compatibilized potato starch (PP/PCPS) that were exposed to simple soil environment for the periods of 30, 60 and 90 days are shown in Figures 1-3. Tensile strength, elongation at break and Young's modulus exhibited an induction period when the starch content is less than 20% and decreased afterward with a higher rate as the starch content and burial time increased. With the increasing of starch content, it is expected that the filler-filler interactions predominate over filler-matrix interactions and crack propagation was enhanced which resulted in the decreased tensile strength, elongation at break and Young's modulus. The moisture absorbing characteristics and interfacial bonding effect of potato starch, considered as a defect, decrease the tensile properties of the blends which promote soil microorganisms' consumption of starch and create pits and voids in the PP blends.

The effect of maleic anhydride- graft-polypropylene (MA-g-PP) on polypropylene/ potato starch blends was investigated to evaluate the changes in tensile properties over the test duration. In general, it was observed that for all compatibilized blends the decrease in tensile strength, elongation at break and Young's modulus was less than the uncompatibilized blends (Figures 1-3). Similar observation was seen on calculated percent decrease in tensile strength, elongation at break and Young's modulus of the polypropylene/potato starch blends after biodegradation (Tables 1-3). The addition of MA-g-PP showed a positive effect to reduce the percent decrease in tensile properties. This reduction on addition of MA-g-PP may be ascribed to good adhesion and compatibility between polypropylene matrix and potato starch. The compatibilizer provides polar acid-based interactions and can react with hydroxyl group of the natural filler covalently (Rowell et al, 1999) thus forming ester linkages (Yang et al, 2006). However, all the blends with and without compatibilizer showed a reduction in tensile properties with increase in starch content as burial progressed.

IV. CONCLUSIONS

The results from the tensile test after exposure to soil burial test indicated that the PP/PCPS blends showed higher tensile properties due to good interfacial adhesion between the PP and PS. However, both blends exhibited a decline in the investigated properties with the increase in the soil burial time and increase in PS content for all the blends. So, potato starch filled polypropylenes degrade by loss of structural integrity and this renders them advantageous in terms of environmental protection.

List of Graphs

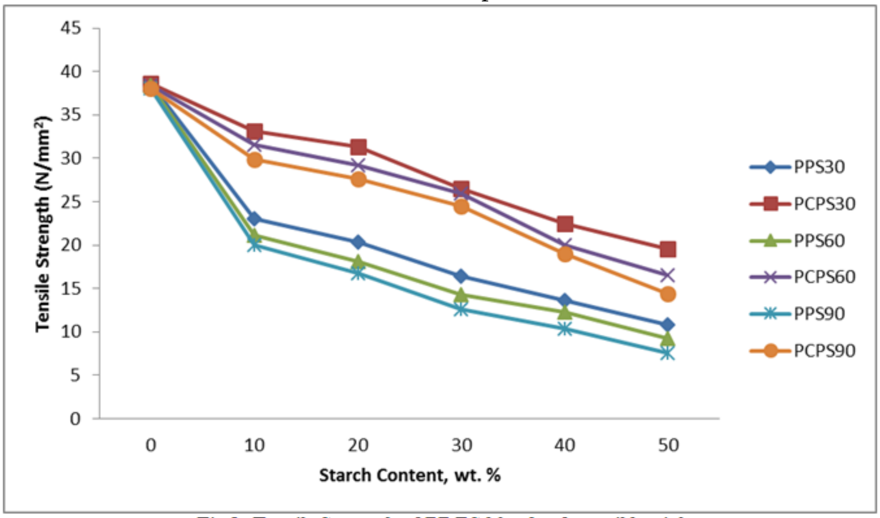

Fig 1: Tensile Strength of PP/PS blends after soil burial

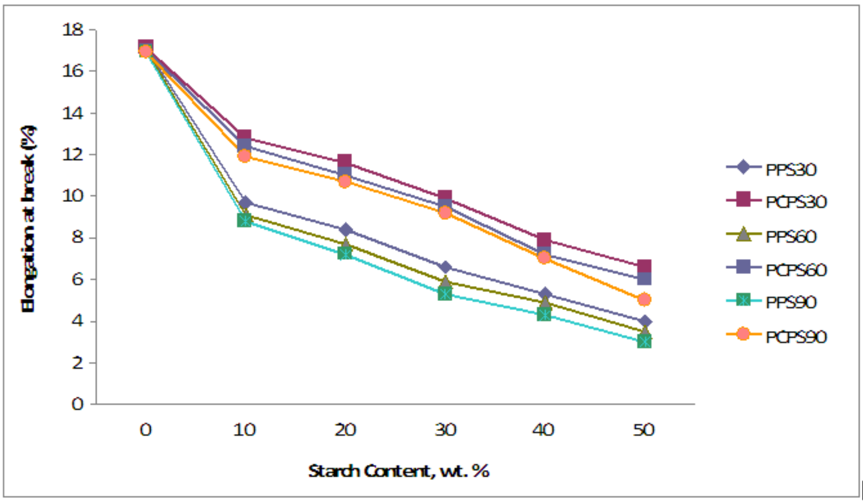

Fig 2: Elongation at Break of PP/PS blends after soil burial

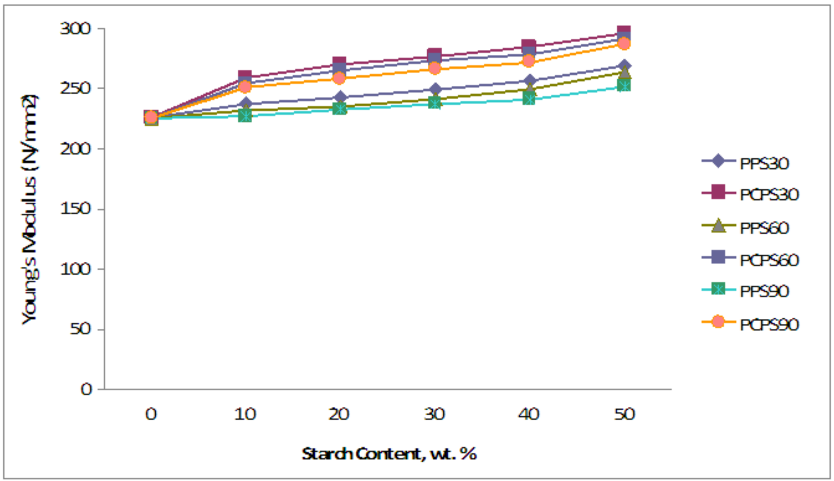

Fig 3: Young's Modulus of PP/PS blends after soil burial

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Table 1: Percent Decrease in Tensile Strength of PP/PS Blends after Biodegradation

Starch contents (wt. %)	% loss in tensile strength after 30 days		% loss in tensile strength after 60 days		% loss in tensile strength after 90 days	
	PPS	PCPS	PPS	PCPS	PPS	PCPS
0	0.66	0.66	1.44	1.44	2.05	2.05
10	10.58	5.31	13.10	8.63	16.78	13.66
20	12.62	6.08	14.33	11.44	19.15	16.13
30	11.97	7.85	17.06	12.56	22.23	18.48
40	13.39	9.23	18.15	14.27	25.04	21.75
50	14.04	11.08	19.80	16.92	29.36	24.17

Table 2: Percent Decrease in Elongation at Break of PP/PS Blends after Biodegradation

Starch contents (wt. %)	% loss in elongation at break after 30 days		% loss in elongation at break after 60 days		% loss in elongation at break after 90 days	
	PPS	PCPS	PPS	PCPS	PPS	PCPS
0	0.58a	0.58	1.16	1.16	1.74	1.74
10	2.02	1.40	5.13	3.02	8.53	6.34
20	5.62	3.83	7.66	6.44	10.16	9.06
30	9.59	7.94	11.48	9.83	13.22	12.10
40	7.02	5.81	12.07	10.45	15.08	13.22
50	10.37	8.69	14.25	12.24	17.14	15.16

Table 3: Percent Decrease in Young's modulus of PP/PS Blends after Biodegradation

Starch contents (wt. %)	% loss in Young's modulus after 30 days		% loss in Young's modulus after 60 days		% loss in Young's modulus after 90 days	
	PPS	PCPS	PPS	PCPS	PPS	PCPS
0	1.21	1.21	1.53	1.53	1.86	1.86
10	3.03	2.56	4.47	3.24	7.35	5.52
20	4.95	3.40	6.32	5.68	9.64	7.71
30	6.14	5.27	8.14	7.06	11.28	10.44
40	7.84	5.74	9.65	8.39	12.96	11.33
50	9.22	6.43	11.38	9.87	14.52	12.95

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