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Microbial biodegradation of corn starch based polyethylene

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ABSTRACT

In this paper biodegradation of starch based polyethylene were studid. Starch used as a biopolymer to make polyethylene biodegradable. Corn starch selected from various kind of starch. Degradation of starch based Low Density Polyethylene has been investigated in soil rich in microorganisms for 8 months. Biodegradable blends exposed to 8 different kinds of fungi and Pseudomonas aeruginosa84th day's. The biodegradability is determined by two ways: first, comparing differences in the weight change of two samples, Second test for biodegradation is by examination of FTIR spectroscopy. Through FTIR spectroscopy, the biodegradability rate and reduction in some of the existing bonds in polymer before and after exposure to mould growth is exhibited and the consumption of polymer by microorganisms is also revealed. In addition, corn starch based LDPE exposed to 8 different kinds of fungi and the degradation studied as a visual.

KEYWORDS

Soil;
Biodegradable;
Pseudomonas aeruginosa;
Starch;
Biopolymer;
Mould growth.

INTRODUCTION

Plastic material have important role in modern life. Plastics waste could be seen everywhere, because they remain in the environment for decades[1]. Low density polyethylene is employed in packaging industries and production of bags, composites and agricultural mulches. Microorganism catabolized the end chain of polyethylene. Polyethylene is the hydrophobic polymer with high molecular weight, and then degradation of polyethylene takes a hundred years in the nature. LDPE have a kind of carbon –Carbon linkage that microorganisms couldn't degraded it easily.

Study on the starch based synthetic polymers has begun from 1970s. There is a special attention to use starch as biodegradable filler. Starch is an abundant, biodegradable, recycling and inexpensive natural polymer obtainable from many botanical sources. Starch obtained from difference source like corn, rice, tapioca, banana, wheat and potato. Corn starch composed of two polymers: amylase and amylopectin. These polymers are formed from repeating D- Glucose unit that connected together. Today public trends are seen in the used of biodegradable plastics and environment conservation. Used biodegradable plastic is a best way to solve the solid waste problem. Blending synthetic polymers with natural polymers such as Starch, Cellulose, Lignin, and Chitin is applied as an important way to accelerated polymer degradation. Usage of starch based polymers has a benefit for environment conservation, because they reduce an exploitation of the non-renewable resource.

Biodegradation occurs when microorganism such as bacteria or fungi consumes polymer in an aerobic or anaerobic environment. Output of degradation process includes: Carbon dioxide, methane and other natural products. The degradation process is based on the polymers 'environment and their application. It is better to estimate the biodegradability characteristics of the plastic materials under natural condition where the waste plastic materials are exposed under the natural biological process in the nature.

Starch is an inexpensive materials used as a biodegradable additive. Starch is abundant, biodegradable and renewable, so appropriate for blending with synthetic polymers. In food packaging section starch based plastic most considered. Plastic containing starch didn't have a negative effect on quality of food or other packed materials. Starch based plastic didn't have a negative effect on the environment and reduce the green house effect. Synthetic plastic needs a long time to degradation in nature. Used starch as a biodegradable agent accelarated the time of the biodegradation.

In this article biodegradable blend of corn starch and Low Density Polyethylene (LDPE) was prepared.

MATERIAL AND METHOD

Low Density Polyethylene (LDPE) with commercial grade 0200 prepared from Bandar Imam petrochemical complex, IRAN. Food grade corn starch obtained from Alvand co. IRAN. Glycerol with food grade belongs to Merck co. Germany. Polyethylene grafted maleic anhydride (PE-g-Ma) produces in Karankin Co., IRAN.

Starches powder plasticized with 25wt% glycerol at 180°c for 10 minute. Samples were processed in HBI system (Haake Buchler Company from UK) with 60 rpm in 160°C. Sample sheets (0.4 mm thickness) were prepared by using Hot Mini Press.

The suspension prepared in distilled water with 0.05% dioctyl sodium sulphosuccinate. Spore solution was put in sterile Petri dish. The polymer samples immerse into suspension. Then transferred to another sterile Petri dish and incubated in humidity greater than 90% and 30° C for 84 days. According to standards 8 kind of mould species included Aspergillus niger, Aspegillus terreus, Aureobasidium pullulans, Poecilomyces variotii, Penicillium funiculosum, Penicillium ochrochloron, Scopulariopsis brevicaulis, Trichoderma viride used for test.

Samples also exposure to Pseudomonas aeroginosa, then incubated in humidity greater than 90% and 30° C for 84 days.

Soil degradation Samples cut in strip shape and buried into soil for 8 months. Soil was a combination of Pseudomonas aeruginosa, garden soil, leaf soil, compost, and humus with bird fertilizer. FTIR test was performed on each sample before and after soil burial to confirm the biodegradability in soil environment.

RESULT AND DISCUSSION

Figure 1. shown a degradation of LDPE and LDPE/ corn starch into the soil. Microorganisms attracted to the corn starch content of blends. Microorganisms consumed corn starch in the polymer matrix and caused a fractured in the LDPE chain. Because of the existence of maleic anhydride – that made a chemical bond between LDPE and corn starch- degradation of corn starch caused a fracture in the polymer matrix and biodegradation of LDPE.

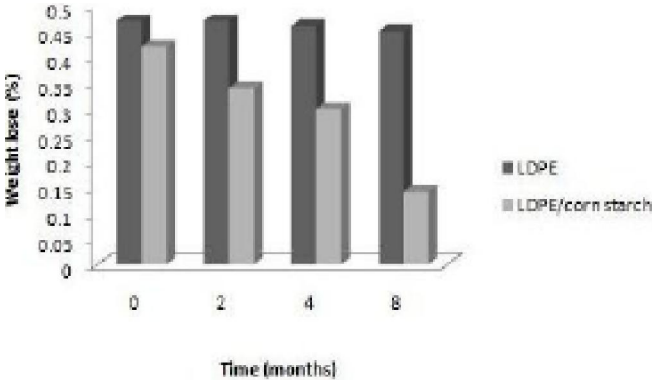

Figure 1 : Degradation of LDPE and LDPE/corn starch into the soil.

Before and after a degradation test by bacteria, polymer samples weighted. TABLE 1 shows the percentages of polymer weight lose during degradation by Pseudomonas aeroginosa. According pure LDPE had a little weight lose. The weight lose could be attributed to biodegradation by Pseudomonas aeroginosa, because in Carbon free media Pseudomonas aeroginosa could degrades Low Density

polyethylene. LDPE/ corn starch show significant weights lose. It's determined that corn starches were the only source of Carbon for microorganisms.

TABLE 1 : Weight change of corn starch based LDPE after 84th day's exposure to Pseudomonas.

Samples	Weight lose (%)
LDPE	0.43
LDPE/ corn starch	2.02

After 20 days of sample incubation 20% of Petri dishes covered by fungi growth. Samples colonized by mould about 50% in the middle of the incubation period.

Fungi colonized on corn starch/LDPE surface over 80% at the end of incubation. After 84-days incubations, LDPE strips didn't exhibit any colour change or mould growth, That It shown in Figure 2. Genus Penicillum could decompose hazardous materials and plastics. Genus Aspergillus is described as a decomposer of polyethylene, DDT and starches[2, 3]. Corn starch in polymer matrix had a digestible link for mould and fungi. Microorganisms recognized the Corn starch carbon link as a nutrient source. Consumption of polar hydrophilic starch caused fracture in the polymer chain.

Figure 2 : Visual fungal growth on LDPE/ corn starch blend after 84th day's incubation.

TABLE 2 : Visual examination of LDPE/ Potato starch blends during incubation.

Cultivation time (days)	LDPE	LDPE/ Corn starch
20	0	2
40	0	3
84	0	3

0= no growth apparent under a nominal magnification of approximately 50×; 2= growth plainly visible to the naked eye, but covers less than 25% of the test surface; 3= growth plainly visible to the naked eye and covering more than 25% of the test surface

Fourier transform spectroscopy (FTIR) confirmed the biodegradation in soil environment. Figure 3 showed the FTIR spectroscopy before and after degradation in soil. FTIR exhibit some change in LDPE/corn starch after degradation in soil. The highest decrease in spectrum observed at 1700 cm^{-1} derived from Carbonyl groups of corn starches. This reduction confirmed the degradation LDPE/corn starch in soil. Maleic anhydride improved compatibility between non-polar LDPE and polar corn starches[2]. Absorption band between (1081 cm^{-1} – 1156 cm^{-1}) derived from C-O-H stretching bond. Reduction 1070 – 1200 cm^{-1} belongs to alcohol absorption band and indicated of fast degradation rate of Carbon chain[3].

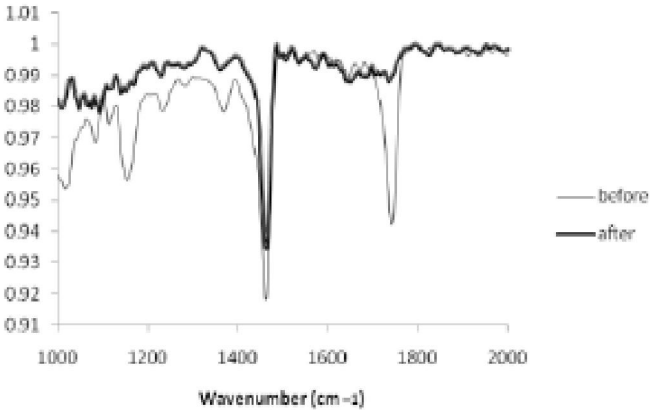

Figure 3 : FTIR spectra of corn starch based LDPE compound before and after exposure to mould growth.

CONCLUSION

Corn starch/LDPE weight loss and FTIR test after soil burial simulated as biodegradation in landfills. Microbial degradation in laboratory by 8 kinds of fungi and exposure to Pseudomonas aeroginosa were done and approved the microbial degradability of corn starch based LDPE. Consumption of corn starch as a biodegradable agent initiates the biodegradation process. According to this research corn starch based Low Density Polyethylene was a microbial biodegradable polymer.

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