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Bio-based plastic a way for reduce municipal solid waste

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Abstract

There are many ways to reduce plastic waste in the environment. Bio-based plastic could be a best solution for sustainable environment. In this article bio-based plastic were prepared. Potato starch and corn starch as a biopolymer blending with polyethylene. Samples buried into soil for eight months and put in aerated sludge tank for 2 month. Weights lose of sampled after removing from degradation environment indicates a biodegradation rate. FTIR spectra before and after exposure to aerated sludge was done, Through FTIR spectroscopy, the biodegradability rate and reduction in some of the existing bonds in polymer before and after placing the samples inside aerated sludge tank is exhibited and the consumption of polymer by microorganisms is also revealed. Compare SEM before and after soil burial confirm biodegradability of compounds in the natural environment because polymer matrix consume by soil microorganisms.

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Keywords: biodegradation; solid waste; starch;soil degradation; activated sludge

1. Introduction

Plastics have a special place in modern life because they are inexpensive, flexible and had lightweight. With all advantage of plastic materials, they remain in the environment. Long time is need for biodegradation of synthetic polymers [1]. Landfills filled of plastic materials because microorganisms don't have necessary enzymes for degraded those Today public trends are seen in the used of

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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, Chitin and chitosan is applied as an important way to accelerated polymer degradation [5, 6]. In recent years, biodegradable polymers have attracted special attention of researchers with respect to reducing the volume of solid wastes. Biodegradable polymers are materials that could be converted to natural compounds such as water, CO2, methane and other biological components by means of microorganisms such as fungi, bacteria, algae and other natural agents [2].Most of the biodegradable polymers were developed by blending petroleum based polymers such as Low Density Polyethylene (LDPE) with natural biodegradable materials. This method not only conserves the environment, petroleum reservoirs and landscapes, but also decreases CO2 production and presents a green solution in a sustainable development [3].

Study on starch-based synthetic polymers began in 1970s when environmental issues attracted attention .Starch is an abundant, biodegradable, capable of recycling and inexpensive natural polymer which is obtainable from many botanical sources. Starch is composed of two parts: amylose and amylopectin whose percentages are different in various kinds. On the contrary to amylose, amylopectin is branched and forms the water soluble part of the starch. The proportion of amylose to amylopectin affects the manufacturing process and properties of the final product.

Low density polyethylene is employed in packaging industry, in production of bags, bottles and many other items as well as being used in composites with other materials [4, 5].

Weight loss is a common method to measure the rate of biodegradation. Due to the long time required for a polymer sample to degrade in soil, weight loss in an aerated sludge tank, rich in microorganisms is considered as an accelerated method for studying the biodegradability of the samples [6]. Moreover, FTIR spectroscopy of the samples reveals the rate of degradation of the existing bonds of the compound after exposure to aerated sludge environment.

2. Experimental part

For this study two samples were prepared and used in the experimentations Low Density Polyethylene was supplied from Bandar Imam petrochemical complex, IRAN, in the form of the granule and trade name as LLDPE 0200. Potato and corn starch obtain from alvand Co., IRAN. The amount of corn starch and potato starch are 20% and blends were processed in Haake Reomixer 3000 (GmbH) with 60 rpm in 160°C. Sample sheets (0.4 mm thickness) were prepared by using Hot Mini Press. The aerated sludge system consisted of semi-batch tanks equipped with aeration devises supplying dissolved oxygen to a suspension of microorganisms in water. The volume of tank was 9 liters, half filled with settled urban sewage and half filled with normal tap water. Two samples cut in 4 cm×1.5 cm and weighed accurately.. Nutrients such as a carbon source (sugar), nitrogen (urea) and phosphorus (ammonium phosphate) were added to the aerated sludge tank to ensure microorganism growth. Furthermore, to control the nutrient and dissolved oxygen content and the growth of the microorganisms, volatile suspended solids (VSS) tests were employed regularly. The PH and temperature of the tanks were held in the range of 7.5± 1 and 26± 1 ◦C, respectively. The supplied air ensured adequate mixing and prevented the formation of a two phase mixture due to settlement of the solids.

Fourier transform spectroscopy: In order to confirm the sample biodegradability in aerated sludge tank, FTIR tests were performed on each sample before and after placing it in the aerated sludge tank. The tests were performed using equinox 55 made by Bruker at 23 degrees centigrade. The tests were run according to ASTM E 1252-07 and the samples were scanned at 4 cm-1 resolution

Scanning electron microscope: surface of blends was observed by Oxford Instruments INKA Penta FET×3 scanning electron microscope at voltage 20 KV. Samples fractured in liquid nitrogen, then sputter coated with gold.

3. Result and discussion

In figures 1 and 2 the FTIR spectra for low density polyethylene with corn starch and another sample with low density polyethylene/potato starch are shown respectively, before and after degradation in aerated sludge. As can be seen, the peak which falls in the range of 1400-1550 confirms the existence of C-H groups. On the other hand in all 4 spectra the peak which falls in the range of 1730-1750 confirms the existence of Carbonyl groups. The different peak which falls around 1465cm-1 appears for both samples and is related to C= H bonds. The reduction of this peak after exposure to aerated sludge suggests carbon consumption by microorganisms [7] has taken place. The reduction in the peaks of the

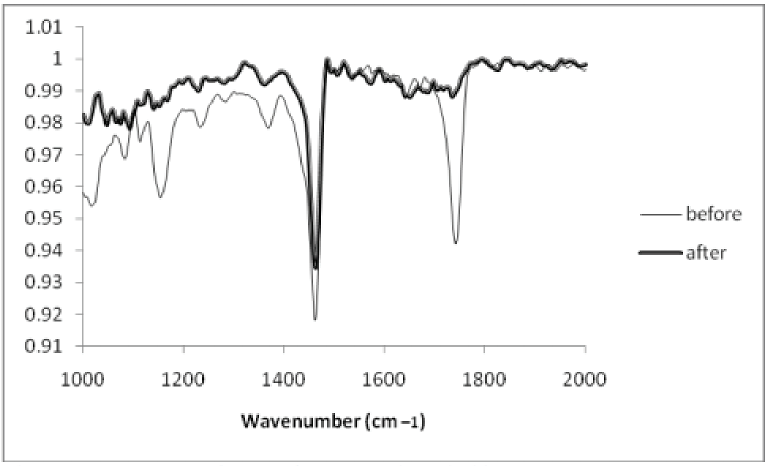

Fig.1. FTIR spectra of corn starch based LDPE compound before and after exposure to aerated sludge.

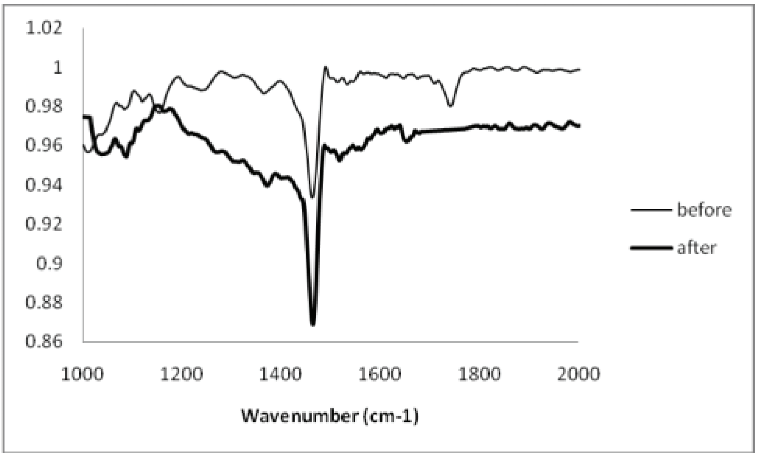

Fig.2. FTIR spectra of samples potato starch based LDPE compound before and after exposure to aerated sludge

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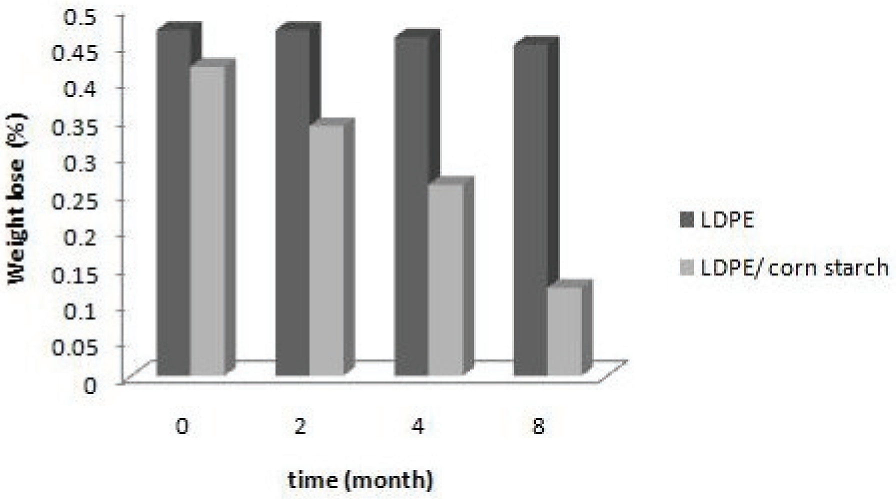


Fig. 3. Weights lose of corn starch /LDPE samples after soil burial

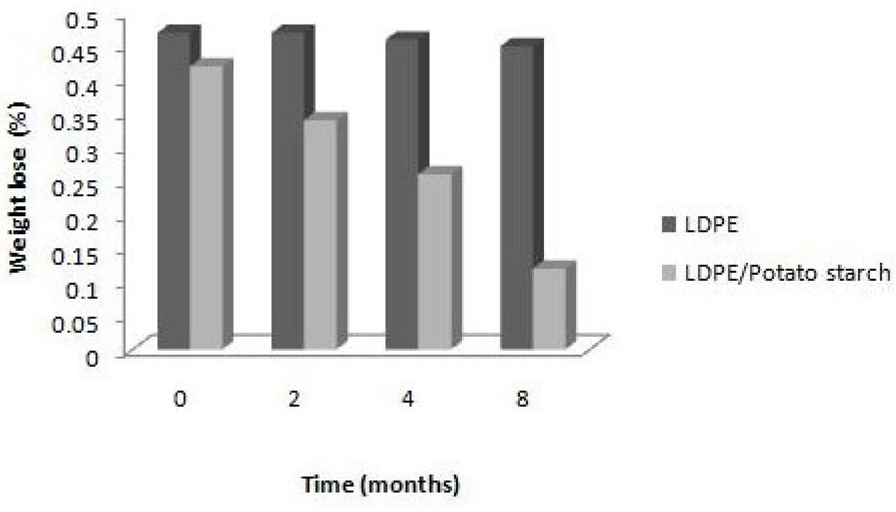


Fig. 4. Weights lose of potato starch /LDPE samples after soil burial

range 1730-1740 also shows the reduction of Carbonyl groups or amine groups. Amine and O-H groups are derived from starch, respectively. Any reduction in this range suggests biodegradation of starch which means these materials have been consumed by microorganisms present in aerated sludge tank. Figure 3 and figure 4 show the biodegradation in soil during 8 months. Weight lose in soil assume as a biodegradation rate in landfill other natural degradation environment. The degradation process is based on the polymers ‘environment and their application. It’s 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. Several mechanisms are involved in the degradation of polymers, one of them is a microbial degradation in which microorganisms such as fungi or bacteria consume the materials. The degradation process is based on the polymers ‘environment and their application. It’s 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 [8].

Figure 3. Shown a degradation of pure LDPE and LDPE/Corn starch blend into the soil for 8 months. Figure 4 shown the weights lose of LDPE and potato starch based LDPE during soil burial. Plastic strips buried in soil consisted of compost and garden soil. Soil environment contain a different kind of microorganism and macro organisms. Weight loses of polymer strips in the soil could be assumed as an indicator of biodegradation in the landfills or natural environment. Soil microorganisms attacked the polymer strips. First of all, microorganisms attracted to the corn starch content of blends. Microorganisms consumed 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 starch- degradation of starch caused a fracture in the polymer matrix and biodegradation of LDPE. Maleic anhydride improved compatibility between non-polar LDPE and polar starches. The potential of soil biodegradation is calculated by the following equation:

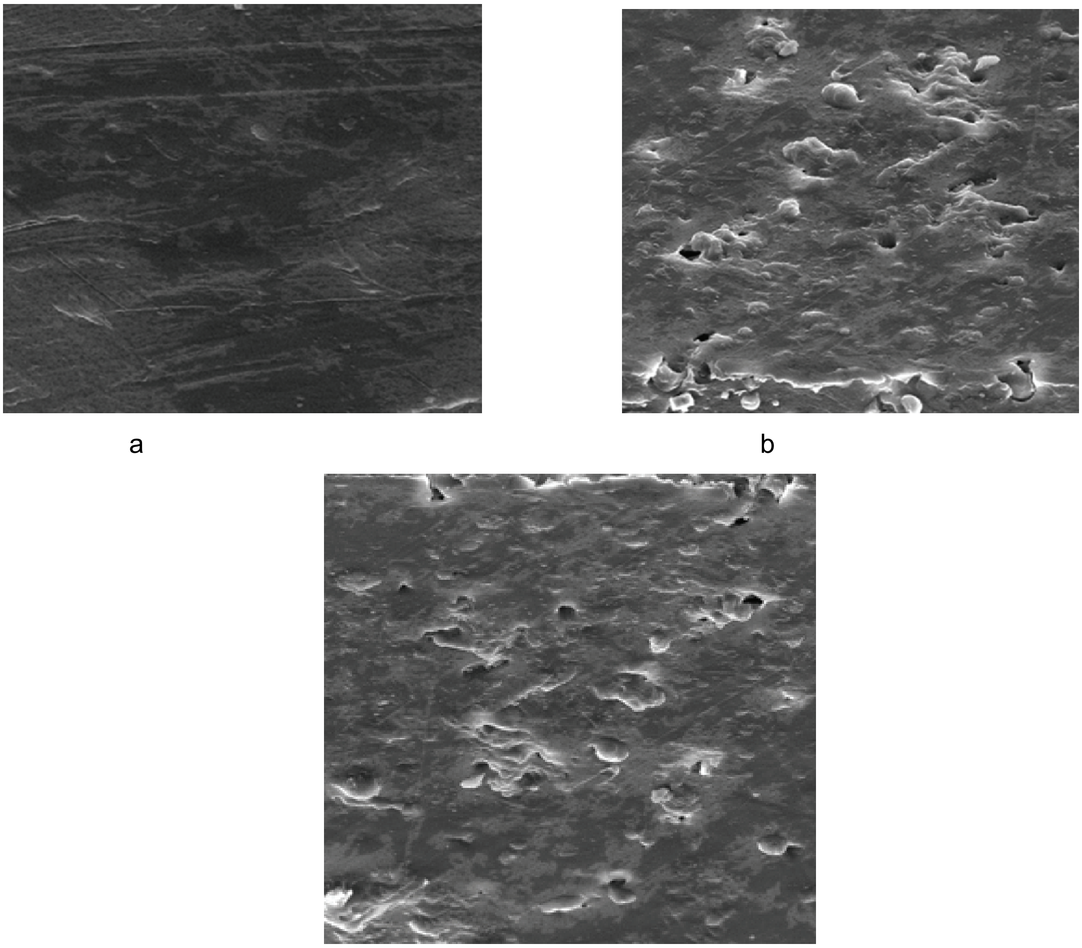
$$\text{Soil biodegradation } (\%) = [(W - W0) / W0] \times 100 \qquad (1)$$

Here W is a secondary weight of sample and W0 is a primary weight of sample. According to figure 3 and 4 pure LDPE doesn’t show any weight lose during the testing time. With increasing the amount of starch (corn or potato) the biodegradability enhanced. Samples with 40% starch shows the highest degrees of weight lose. Its obvious passing more time in soil lead to more weight loses. Soil microorganism is attacking the samples.

Figure 5 show SEM scanning micrograph for samples (a) pure LDPE (b) LDPE/corn starch and (c) LDPE/ potato starch after 8 months soil burial. According to Figure (5) on samples with starch content some holes appeared on the surface of LDPE/starch sheets. These holes indicated the rate of biodegradation and confirmed the starch removal by biological function. Bores show the area that attacked by microorganisms. Starch used as a main source of Carbone and nitrogen by fungi and mould. Starch molecules bonded to LDPE chain so consuming starch by microorganisms cause a fraction in polymer matrix and eventually degradation of polymer. More holes appeared in the polymer matrix lead to high biodegradation rate. According to SEM micrograph potato starch degradation rate more than corn starch degradation in soil environment.

4. Conclusion

In this article Low Density Polyethylene blended with potato starch and corn starch. maleic anhydride used as a compatibilizer to make a bond between starch and LDPE. For ensure biodegradability of blends some tests was done. Soil burial and domestic sludge was the biodegradation environment. Weights lose of samples after 8 months soil burial and SEM confirm the biodegradability of samples. After exposure to sludge FTIR test done to compare adsorption bond before and after biodegradation. All of test confirm that samples are biodegradable in natural environment and could be used for reduce municipal solid waste.



a b

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Fig. 5. SEM scanning micrograph for samples (a) pure LDPE (b) LDPE/corn starch and (c) LDPE/ potato starch after 8 months soil burial.

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