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Effect of benzophenone and zinc stearate on photodegradation of potato starch based low density polyethylene

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In this research photodegradable blend of Low density polyethylene with starch were prepared. 0/4 mm dumbbell sheets were prepared and exposed to direct sunlight for 3 months. Before and after sunlight exposure mechanical properties of polymers were measured. Benzophenone and zinc stearate were used as a photosensitive and photocatalytic additive. The effects of benzophenone on photodegradation of starch based blends were studied. In these study photodegradation were confirmed by determining carbonyl index and tensile properties. Existences of the carbonyl group indicate the starting of polymer chain degradation. Benzophenone and zinc stearate enhanced the photodegradation of polymer samples.

Keywords: photo degradation, plastic, environment, sunlight, benzophenone

INTRODUCTION

Plastic materials take an important part in modern life. Using these materials has an advantage and disadvantage. Plastic materials have various applications; these materials are the best replacement for wood or metals. Plastic inventions in twenty century change the costumer behaviors. Plastics are light, cheap, and easy to use and have a different usage from industries to medicine. With all benefits plastics has a problem that they remain in the environment for long time and couldn't be degraded by natural agents. Daily plastic waste generation increased. Plastics throw away and caused problems in the environment. Plastic waste one of the source of ocean litters and dangerous for marine creatures [1].

Plastics are resistance to microorganisms. So remain in the nature for many years. Pollutions grow higher and higher, some scientists predict the depletion of fossil fuels in future, then investigation about biodegradable and natural polymers are necessary. Since 1970s many research were done about biodegradable polymers. The first generations of biopolymers were not completely biodegradable they filled up with starch or other biopolymers and after starch degradation they remained in very smaller pieces without noticeable change in polymer chain [1].

Starch has an important role in degradable polymer industries. Starch stored in the plant and has role like fat in animals. Chemical structure of starch has a linear and branches structure: amylase is linear and amylopectin is branched. The ratios of amylase to amylopectin are different in various kind of starch. Because of similarity of linear structure of amylase to synthetic polymers they have a same behavior. Photodegradable plastics have a similar structure to other petroleum base polymers but they have some weak bonds that are break down by sunlight or they have some additive that makes them sensitive to sunlight by adsorb sun rays. UV ray know as an aging and weathering agent. In the absence of oxygen PE are resistant to UV ray, but in presence of oxygen caused the brittleness in polymer matrix [5]. Copolymerization or mixing chromophores material to polymer are the common way to produce photodegradable polymers [7]. Photodegradable plastics react with sunlight and degrade [6]. These polymers could be a good choice for sunny region. If photodegradable polymers throw out in the nature it will be degraded to water and CO2.benzophenon has a various application. Benzophenone could adsorb UV ray and prevent its effect in higher amount. Zinc stearate also has a photo catalytic behavior. In these researches effect of benzophenone and zinc stearate on photo degradability of blend has been studied.

EXPERIMENTAL

Low density polyethylene (LDPE) with commercial grade 0200 prepared from Bandar Imam petrochemical complex, IRAN. Food grade potato 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. Olive oil used as a moisturizer. Benzophenone obtained from Merck Germany. Samples were processed in

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HBI system with 60 rpm in 160°C. Sample sheets (0.4 mm thickness) were prepared by using Hot Mini Press. Samples cut in dumbbell shape and exposed to sunlight for 3 month. The tensile properties were measured by Santam (STM-20) instrument. FTIR test was performed on each sample before and after exposure to sunlight to determine the photo degradability and carbonyl index were calculated.

RESULTS & DISCUSSION

Table 1 shows the climate of Tehran city during summer 2015. Most of days are sunny with low humidity. Believed high temperature with direct sunlight has a positive effect on photodegradation. After 3 month outdoor exposure plastic sheets were brittle.

The carbonyl index of LDPE different samples increased after exposure time (Table 2). Carbonyl index is a good way to identify photodegradation. UV ray caused generation of free radicals that forming carbonyl groups.

Any change in carbonyl index indicated that photodegradation happened [2]. Degradation rate in samples that contain benzophenone increased. Pure LDPE had shown a less sensitivity to sunlight than

Table1. Data of weathering climate at Tehran (summer 2015)

Month	Temperature (°C)	Sunshine hours	Humidity (%)
June	34	>300	20>
July	34	>300	20>
August	35	>300	20>

Table 2. Carbonyl index (CI) of LDPE samples.

Sample	CI (before)	CI (after)
LDPE	1	1.18
LDPE/potato starch	1.8	1.45
LDPE/potato starch/ benzophenone	1.76	1.4
LDPE/potato starch/ benzophenone/zinc stearate	1.14	1.2

Carbonyl index calculated according this equation:
Carbonyl index CI = peak of carbonyl/1465 (I)

Table 3. Mechanical properties of samples before and after exposure to sunlight.

Content of potato starch (%)	Elongation at break (%)		Tensile strength (MPa)	
	Before	After	Before	After
LDPE	286.846	243.321	2.85	2.01
LDPE+ Potato starch	20.74	11.1	2.17	1.26
LDPE+ Potato starch+ benzophenone	19.65	8.72	2.2	0.92
LDPE/Potato starch/benzophenone/zinc stearate	20.31	4.97	3.6	0.51

other samples. Many polymers had been attacked by UV ray and cracked. LDPE are more resistance to UV than PP. samples with starch has more porosity in polymer matrix than pure LDPE so carbonyl index increased [7]. Samples that contain benzophenone are more sensitive than other samples. Benzophenone accelerates the photooxidation. Carbonyl group appeared when the polymer oxidized. Occurrences of carbonyl group identified the polymer chain breakdown [6]. Carbonyl belongs to functional groups that caused the breakdown in polymeric chain.

Mechanical properties of blends measured before and after exposure to sunlight are shown in Table 3. Elongation at break decreased after 3 month outdoor exposure. That's shows all of the blends are sensitive to sunlight, may be zinc content make them photosensitive. All of samples contain benzophenone showed decreased in mechanical properties because in photodegradation carbonyl groups absorb UV rays, free radical cause break down in LDPE linkage [2]. After outdoor exposure polymer sheets are brittle and broken with touching. Photodegradation of samples with benzophenone had a faster degradation. Reduction of elongation at break shown in all samples, UV ray caused the chain scission so make the samples brittle [4]. Zinc stearate has a good effect on photodegradability. It seems combination of zinc stearate and benzophenone enhanced the photodegradability.

CONCLUSION

In this research, effect of benzophenone and zinc stearate on photodegradability of starch based polyethylene has been studied. Benzophenone is a photocatalytic agent and adsorb UV ray and caused the scissoring in polymer chain. According to result samples with amount of benzophenone were shown

more photodegradability behavior than other samples. Zinc stearate has been shown same ability. These polymeric materials are a good choice for environment conservation and decrease the amount of plastic solid waste.

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