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Microbial Degradation of Starch Based Polypropylene

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Polypropylene has a special place in plastic industries. Polypropylene like other synthetic plastic doesn't degrade by microorganisms, so remain in the nature and has a harmful effect on environment. Biodegradable plastic could help to solve this problem. In this article biodegradable blend of polypropylene and starch was prepared. Samples with different levels of starch (10% and 20%) were prepared. Pure Polypropylene and starch based samples buried in soil for 6 months and exposure to mould growth. Every two months samples removed from the soil and weight change were measured. Scanning electron microscope (SEM) approved Polypropylene/ starch blend biodegradation. Result approved that Polypropylene / Starch blend are degradable in soil. This method could be used for reduce pollution in the environment. Samples were exposure to Pseudomonas aeruginosa for 84th days. Pseudomonas aeruginosa consumed the polymer and confirmed biodegradability of compound.

Key words: Polypropylene, *Pseudomonas aeruginosa*, Biodegradation.

Nowadays increasing plastic consumption has caused the increase in solid waste. Synthetic polymers are resistant to degradation so they remain in the environment for a long time. Accumulation of plastic waste in the environment caused many problems. Landfills are full of plastic waste and every year we need a new site for waste disposal. Today many ways are used for reduce plastic waste such as source reduction, recycling and biodegradable plastic[1]. Recycling is not a general solution for all plastic materials because some plastics are non recyclable. Biodegradable plastic could be defined as a plastic degraded in the environment and convert to Carbon dioxide, methane and other natural products. They should be degraded in the environment and not have a harmful effect on the nature. Bio based plastic is one of the biodegradable polymer categories. In this method a biodegradable polymer compounds with a synthetic polymer. Natural polymers such as Starch, Cellulose, Lignin, Chitin and chitosan are used for this purpose[2].

Starch is a polysaccharide which consists of amylose and amylopectin. Starch is an inexpensive material used as a biodegradable polymer. Starch is abundant, biodegradable and renewable; so it is appropriate for blending with synthetic polymers[3].

Polypropylene belongs to polyolefin's. Polypropylene is a thermoplastic and used widely in food packaging, composites, pipe, textile, medical instrument, automotive component and so on. Polypropylene was first synthesized by Ziegler and Natta. They used propylene as a monomer[4].

Biodegradable polymers have the same properties as the synthetic polymers but they could be degraded by microorganisms after disposal. Biodegradable polymers widely used in drug delivery systems, food industry, biomaterials, bags, agricultural films, washable paints and lubricants.

Synthetic polymers like Polypropylene (PP) are hydrophobic so microorganism could not attach to their surface and consume them[4].

Many factors are involved in the degradation of polymers, microbial degradation is

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one of the factors in which some microorganisms such as fungi or bacteria consume polymer materials. Estimate the amount of biodegradation required simulation of natural environment where polymer samples exposed to microorganisms.

In this article biodegradable compound of polypropylene prepared. This compound is biodegradable. Biodegradability of this compound test by water absorption, soil degradation and microbial degradation, all of those test proved the starch based Polypropylene is biodegradable.

MATERIALS AND METHODS

Polypropylene with commercial grade 0800 obtains from Bandar imam petrochemical complex, Iran. Starch obtains from Glocosan Co., Iran.

Samples were processed in HBI system (Haake Buchler Company from UK) with 60 rpm in 190°C. Sample sheets (0.4 mm thickness) were prepared by using Hot Mini Press.

Water absorption capacity was carried out by using sheets with size of 3×8 cm^2. Samples were soaked in water and every 24 hours they were weighed. This procedure continued until a constant weight was achieved.

Samples cut in strip with dimensions of 3×8 cm^2 and buried into soil for 6 months. First of all samples weighted and put vertically into soil. Every two months samples removed from the soil and weighted.

Scanning electron microscope (SEM): Surface of samples 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.

Flat parts of polymer samples were cut into a square of 5 × 5 cm and placed on the surface of the nutrient agar in the Petri dish. *Pseudomonas aeruginosa* was cultured on nutrient agar medium in sterile condition. A bacterial suspension was prepared in the physiological saline and then sprayed on the samples. A piece of parafilm with dimensions of 4 × 4 was placed on it and was then incubated in humidity greater than 90 at 30°C for 84 days.

Table 1. Weight lose of samples after exposure to *Pseudomonas aeroginosa*

Samples	Weight lose (%)
PP	0.08
10%starch/PP	1.12
20% starch/PP	1.46

RESULTS AND DISCUSSION

Synthetic polymers don't show any water absorption because they are non- polar and hydrophobic. As shown in Fig. 1, pure polypropylene doesn't show any water absorption, that this was predictable. Natural polymers have a hydrophilic character and tend to absorb water. With increase the amount of starch in compounds, water absorption increases. Starch is a hydrophilic material and polypropylene such other polyolefin's hydrophobic. The ability to absorb water molecules by polymers influences their physicochemical properties and susceptibility to hydrolysis and biodegradation. Plastics are resistant to biological degradation, because microorganism does not have capable enzymes for degrading and utilizing the synthetic polymer. Samples with 20% of starch showed highest water absorption in comparison with other samples.

Compounds buried into soil for 6th months. Every two months samples removed from soil and weighted. Weight changes of samples are shown in Fig. 2. Weight changes are not distinguished until the second month. Sample weight loss was started at the end of the fourth months of test duration. Soil microorganisms need a time to degraded materials. Highest weight loss that is related to compounds that contain 20% starch. 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.

Samples of pure polypropylene don't show weight change in test duration. This condition was seen in other researcher studies[5].

To ensure the destruction of samples in the soil scanning electron microscope (SEM) has been done. Figure 3 show the surface of samples after 6th months of soil burial. Fig. 3 parts (a) belong to pure Polypropylene that doesn't show any surface change after 6th month's soil burial. There is no carbon source on the pure

polypropylene that microorganisms could use it. Fig. 3 part (b) shows the samples that contain starch. Some holes and bores appeared on the surface of this sample. Holes indicated the rate of biodegradation and confirmed the starch removal by microorganisms. Starch used as a Carbone source for soil microorganisms. Starch molecules bonded to PP 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.

Samples incubated with *Pseudomonas aeruginosa* for 84th days. Before and after the degradation test by bacteria, polymer samples were weighted. Table 1 shows the percentages of polymer weight loss during degradation by *P. aeruginosa*. Accordingly, pure PP had a little weight loss. The weight loss could be attributed to biodegradation by *P. aeruginosa*, because

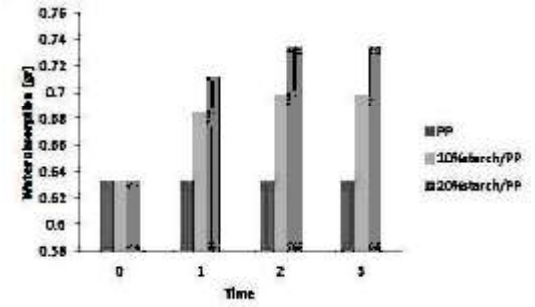

Fig 1. Water absorption of starch/ polypropylene compound

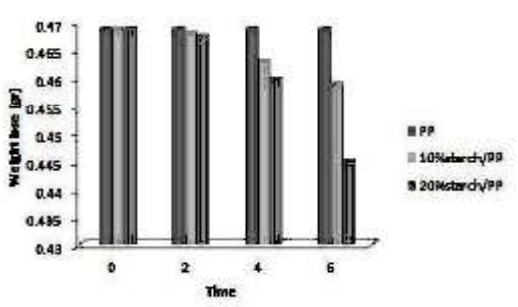

Fig. 2. Weight loses of starch/polypropylene compound

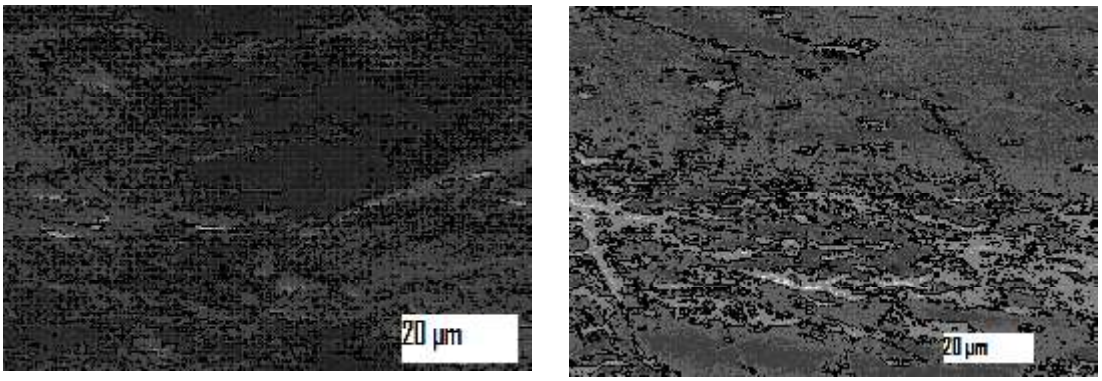

Fig. 3. Scanning electron micrograph (SEM) of (a) pure PP and (b) corn starch/PP after 6th month soil burial

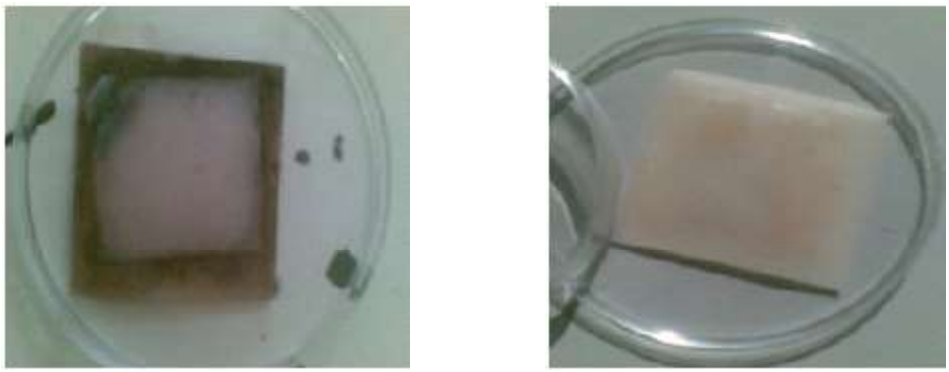

Fig. 4. Degradation of samples after exposure to *Pseudomonas aeroginosa* (a) starch based PP, (b) pure PP

carbon free media could Degrade polypropylene. With increased the amount of starch biodegradation increased.

It was determined that starches were the only source of carbon for microorganisms. As shown in Fig. 4 part (a), black spot appeared on the surface of sample, which indicate the bacterial growth; but pure PP did not show any visible growth.

CONCLUSIONS

In this article starch based polypropylene was prepared. 10% and 20% of starch used to make polypropylene biodegradable. For examine the biodegradability of compounds samples bured in soil for 6 months and after that weightened. The weight lose happens when the polymer consume by microorganisms. Water absorption also shows the biodegradability of blend because synthetic and non-biodegradable polymers are hydrophobic. Pure polypropylene don't show any weight lose during soil burial. Also pure PP doesn't show water absorption. But samples with 10% and 20% of starch show the weight change after soil burial and soaking in water. SEM test confirmed the biodegradation of starch based samples in soil and consumption of starch by microorganisms. Samples are biodegradable by *Pseudomonas aeruginosa*.

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