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Biodegradation of plastic film based on starch

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ABSTRACT
The concern with the accumulation of synthetic plastics in the environment is one of the reasons for the increasing interest in the development of biodegradable films. Among raw materials from renewable sources, starch is one of the most promising. In order to evaluate biodegradable films obtained from native starches (rice), these were prepared by casting method with the addition of plasticizers (glycerol and sorbitol).This study examined the influence of glycerol and sorbitol as plasticizer on the biodegradability properties of a film of starch. Biodegradation of starch films was evaluated in different types of soil (sand and garden soil) .weight loss significant levels were obtained in quite short periods of incubation. The results indicated that the G-SF was the most biodegradable film in the garden soil.In addition, the starch films were exposed to two bacterial strains and degradation was visually studied.
KEYWORDS: *bacteria, biodegradation, glycerol, soil burial, sorbitol, starch.*

1. INTRODUCTION

Up to date, the packaging industry heavily depends on crude oil for the production of petroleum base plastics [1]. Plastics have been widely utilized as packaging materials due to their good barrier properties, outstanding mechanical performance and so on [2]. However, the non-biodegradable nature of petroleum based plastics has led to enormous environmental pollution. Hence, the growing environmental awareness throughout the world has attracted the development of environmentally friendly plastic materials which are biodegradable and from renewable sources [3]. There has been increasing importance in biodegradable films made from biopolymers. Biodegradation is a natural process by which organic chemicals in the environment are converted to simpler compounds, mineralized and redistributed through elemental cycles such as: the carbon, nitrogen and sulphur cycles. Biodegradation can only occur within the biosphere, as microorganisms play a central role in the biodegradation process [4]. Particular attention has been given in the recent years for the development of biodegradable polymers from renewable resources, especially for packaging and disposable applications to maintain sustainable development of economically and ecologically attractive technology, towards greener environment [5]. Among these biopolymer, starch is one of the promising materials because of its large availability, low cost, renewable resources and inherent biodegradability [6]. Starch and its major components, amylose and amylopectin, are biopolymers, which are attractive raw materials for use as barrier in packaging materials. Starch often used in industrial foods. They have been used to produce biodegradable films to partially or entirely replace plastic polymers because of its low cost and renewability [7].

Starch based films are reported to have good oxygen and carbon dioxide barrier properties which are relevant for effective packaging. On the other hand, they have drawbacks in mechanical and water vapor permeability properties. In addition, native starches are brittle and not processable. Therefore, plasticizers are generally added to native starch to overcome brittleness as well as improve flexibility and workability. The most commonly used plasticizers for starch based films are polyols including glycerol, sorbitol etc. Many researchers studied the effect of various polyols on the properties of starch films derived from different sources [8–15].

This study aim the preparation of a plasticized starch movie with glycerol or sorbitol, First of all we isolated then to test bacterial strains capable of degrading the polymer. Secondly we made a film biodegradation rate of evaluation in soil.

2. EXPERIMENTAL SECTION

2.1. Films Preparation.

The starch-based films were formed using the casting method as described below: Introducing into a beaker 2.5 g of corn starch, 2 ml glycerol (50% by volume) or sorbitol 0.2 g, 3 ml solution of hydrochloric acid 0.1 M and 25 ml of distilled water. The solution is placed on a hot plate (set at 90 ° C) for 15 minutes so that the solution is not boiling. At halftime, add 1 ml of 0.1 M sodium hydroxide neutralized with 2 ml of 0.1 M NaOH remaining to reduce the viscosity of the mixture. Pour the solution into a petri dish spreading. Allow to dry at room temperature for three days. This results in two plastic films (starch glycerol G-SF and starch sorbitol S-SF).

2.2. Preparation of bacterial suspensions.

The Gram negative bacteria (Pseudomonas Aeruginosa) and Gram positive (Staphylococcus Aureus) were cultured on Petri dishes containing the king and A respectively Chapman agar and incubated for 24 hours, to get a young culture bacteria. From these boxes and using a platinum loop several well-isolated colonies are removed and placed in 50 ml of sterile distilled water, the bacterial suspension is homogenized for 24 h. this suspension is used for the bacterial growth test.

2.3. Preparation of the bacterial growth.

Polymer samples were cut into a square of 1.5 x 1.5 cm, and then disinfected with ethanol for 30 min and rinsing with sterile distilled water and then dried. Two bacterial suspensions (Pseudomonas Aeruginosa and Staphylococcus Aureus) were cultivated on the mediums King A and Chapman respectively in the Petri dish in sterile condition. The films are then deposited in the center of each box. The assembly (nutrient medium - polymers - bacterial suspension) was incubated at 37 ° C for 1 to 5 days.

2.4 Biodegradation of starch film by weight method.

The medium used for the degradation of starch film was composed of: KH_2PO_4: 0.35 g; Na_2HPO_4: 1.825g; NaCl: 0.015g; (NH_4) $2SO_4$: 0.244 g; $CaCl_2$. $2H_2O$: 0,0198g; $MgSO_4$ $.7H_2O$: 0.0614 g; microelements: $FeCl_2$ $4H_2O$: 0.032g; glucose; 0.5g; yeast extract: 1 g; in 1000 ml of distilled water, the medium pH is adjusted to 7. In the bottle containing 45 ml of MS medium with 5 ml of bacterial suspension was added as a source of inoculum and starch films which were cut into small pieces (about 1 cm each 1x), disinfected in ethanol and dried for 15 minutes. The medium was then incubated at 30 ° C at different time intervals. The particles of the films were washed with sterile distilled water dried and weighed. The dry weight of polymer recovered from the culture media were weighed at weekly intervals (ie, day 7, day 14, day 21 and day 28) for recognition of the biodegradation rate.

2.5 Soil burial method.

Polymeric films (G-SF or S-SF) of about 1.0 x 1.0 cm were buried in pots containing approximately 1500 g of various types of soil (sand and garden soil). The moisture content of the soil was maintained by adding water. The pots were incubated at room temperature (about 13 ° C). The weights of all samples were taken at regular intervals of time (7 days) to verify any weight loss.

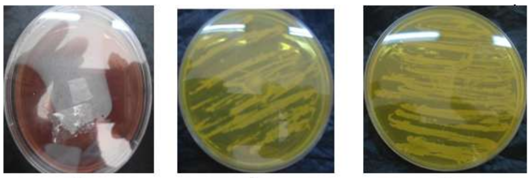
The total weight loss percentage was calculated as follows:

$$Weight\ loss\ \% = \frac{Initial\ weight - Final\ weight\ \times 100}{Initial\ weight}$$

3. RESULTS SECTION

3.1 Exposure bacteria.

Examination of different Petri dishes after 24 hours of incubation, reveled strong growth bacteria (S. Aureus) and (P. Aeruginosa) on the surface of the films, confirming that the starch films are the only source of carbon for microorganisms As shown in Figure 2 (b) portion of the glass are spot appeared on the sample surface, which indicate bacterial invasion. This phenomenon is even more pronounced after 3 days of incubation.



a b c

Figure 1. (a) Before the growth of S. Aureus, (b) after growth of S. Aureus on G-SF, (c) following growth of S. Aureus on S-SF.

a b c

Figure 2. (a) Before the growth of P. Aeruginosa, (b) after growth of P. Aeruginosaon G-SF (c) following growth of P. Aeruginosa on S-SF.

3.2.Soil degradation

Figure 3 and 4 shows the degradation of the G-SF and S-SF movies in both soils, so the soil environment contains different types of microorganisms. It is found that the polymer undergoes more than 50% degradation in 14 days for G-SF movie buried in the garden soil, but this weight loss is less marked for the film buried in the sand, confirming that soil microorganisms attack the polymeric tapes. First, the microorganisms are attracted to the starch content in the mixtures, and then the microorganisms consume the starch in the polymer matrix causing a break in the polymer chain.

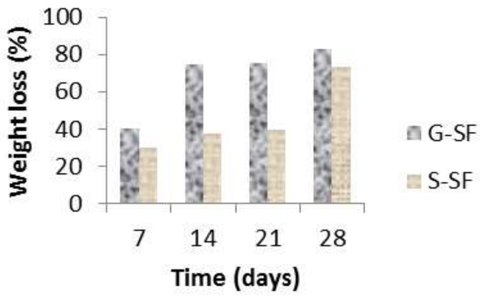


Figure 3. Weight loss (%) of the films starch buried in the soil after different incubation periods.

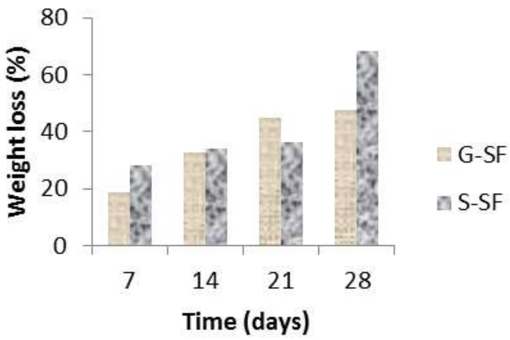


Figure 4. Weight loss (%) of the films starch buried in the sand after different incubation periods.

3.3. Biodegradation of starch film by weight method.

The results of the degradation of the starch films after exposure to cultures of P. aeruginosa and S. aureus is shown in

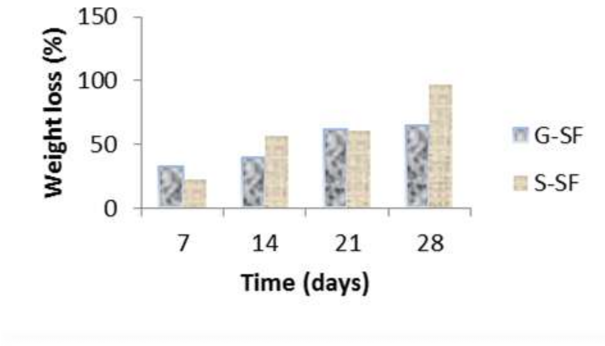


Figure 5. Weight loss (%) of the two films of starch with P.aeruginosa strain.

Figures 5 and 6 note that the maximum weight loss was observed for the film G- SF incubated with the Gram negative bacterium P. aeruginosa, which reached a value of 96.90% after 28 days. This phenomenon is less marked for the Gram positive bacterium S. aureus. The weight loss of starch films can be attributed to the breakdown of the carbon skeleton due to enzymatic degradation by these bacteria.

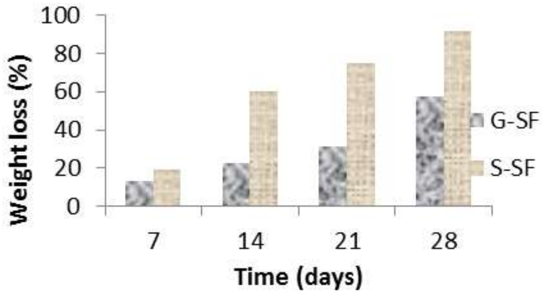


Figure 6. Weight loss (%) of the two films of starch with S. aureus strain

4. CONCLUSIONS

Many different strains of bacteria are involved in the degradation of plastics; the most common of the genus Pseudomonas. Biodegradation of plastic materials by bacteria can be more effective by changing the factors that govern the process. He promises a reduction of plastic pollution in the future. Strains which have been isolated belongs to the Gram-negative group of bacteria (Pseudomonas Aeruginosa) and gram positive (Staphylococcus Aureus). The various tests degradations effects during this study showed that the strain P. aeruginosa have higher rates of degradation of the starch films. The results of this study demonstrate that the plasticized starch film with sorbitol has a higher biodegradation rate.

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