Journal of Global Biosciences
Vol. 3(3), 2014, pp. 681-685
ISSN 2320-1355
http://mutagens.co.in

CAN A STARCH BASED PLASTIC BE AN OPTION OF ENVIRONMENTAL FRIENDLY PLASTIC?

Mehta, Varda[1], Marjadi Darshan[2] and Dharaiya Nishith[1]

[1]Department of Life sciences,
Hemchandracharya North Gujarat University, Patan.
[2]Shree Ramkrishna Institute for Computer Education and Applied Sciences,
Surat.

Abstract

Bio-Plastic are a form of plastic derived from renewable biomass source such as vegetable fats, oils and cornstarch, pea starch or micro biota. Thermo starch Plastic currently represents the most widely used bio-plastic pure starch possesses the characteristics of being able to absorb humidity and thus is it being used for the production of drug capsule in pharmaceutical sector. Bio-plastic can be made from a compound Polyhydroxyalkanotes (PHA) and Polyhydxoxybutyrate (PHB) was synthesized from acetyl Co-A. For the production of starch based plastic, glycerol was added for the gelatinization of starch during thermal processing. Check their degradability with microbial *Spp* in MMSB medium during this study. This starch based plastic can be used in Medical, Agriculture and food packing.

Key words: *Biodegradable plastic, Sorbitol, Starch, Gelatinization, Staphylococcus*.

INTRODUCTION

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 [1]. Among these biopolymer, Starch is a cheap biopolymer that is totally biodegradable, ultimately up to carbon dioxide and water. Starch is used as a natural food-ingredient and is a main energy provider in the human diet starch consist amylase and amylopectine (Figure 1). Starch is one of the promising materials because of its large availability, low cost, renewable resources and inherent biodegradability [2]. Bio Plastic Starch (BPS) is an amorphous or semi-crystalline polymeric material composed of gelatinized or destructurized starch containing one or a mixture of plasticizer [3]. Various plasticizer and additives had evaluated for the gelatinization of starch during thermal processing. Among the plasticizers, water is the most commonly used in the thermal processing of starch based polymers. BPS containing only water alone however, results in poor mechanical properties such as the brittleness due to the fast retro gradation (re crystallization). Therefore, other non-volatile plasticizers are investigated to improve the processing ability and product properties of the BPS such as, glycerol, glycol, sorbitol, sugars, urea, formamide, acetamide, ethylenebisformamide, ethanolamine and citric acid [4].

Biodegradable polymer during their usage must have same mechanical properties like synthetic polymers. However, they are finally degradable to low molecular weight compounds such as H_2O and CO_2 but they are nontoxic by products in living microorganisms [5]. Microbial plastics could be degraded into simpler form such as CO_2 or water by microbial activities. Bacteria and fungi are attracted to polyethylene starch based blend [6]. Microorganisms break the polymeric chain and consume materials through aerobic and anaerobic process. Low density polyethylene was used in huge scale for package and production of bags, composites and agricultural mulches [7, 8].

Microorganisms secrete a variety of enzymes into the soil water, which begin the breakdown of the polymers. Two types of enzymes are involved in the process, namely intracellular and extracellular depolymerases. Exoenzymes from the microorganism's first breakdown the complex polymers giving short chains or monomers that are small enough to permeate through the cell walls to be utilized as carbon and energy sources. The process is known as depolymerization. When the end product is carbon dioxide, water or methane, then the process is known as mineralization [9]. Microorganisms catabolized the end chain of polyethylene. Polyethylene is the hydrophobic polymer with high molecular weight; degradation of polyethylene takes a hundred years in nature [10]. In food packaging section, starch based plastic is most considered and widely accepted. Plastic that contained starch did not have a negative effect on quality of food or other packed materials [7]. Also, starch based plastic did not have a negative effect on the environment and also reduced the green house effect [11]. Synthetic plastic takes a long time to degrade in nature. The use of starch as a biodegradable agent accelerated the time of degradation in the environment.

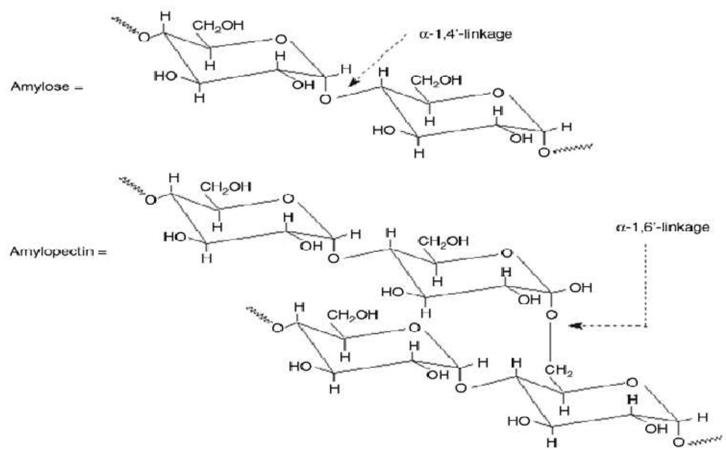

Figure 1. Molecular Structure of Starch

This study was carried out to investigate the potentials of starch as natural source for the production of BPS and to optimize the process condition of the starch plasticized with glycerol, and also to check its degradation through microbial activity in soil.

MATERIALS AND METHODS

Film Preparation

A starch based film was formed using casting method as described below. A control film, without lauric acid or chitosan was formed using mixtures of starch (5.0 g), glycerol (2 ml) and water (60 ml). A control film was prepared by adding glycerol (half amount of the starch) and gelatin was added based on the percentage of starch. The solution was mixed by gentle stirring with a magnetic stir bar until starch dissolved. The solution was then homogenized for about 15 min. with addition of slow heating. Stirring and heating were ended when the solution reaches at temperature of about 80-95 ºC and also added food dye for the development of color. 10 ml of the film forming solution was pipetted and spread evenly into a petri dish bottom (100x 15 mm) and allowed to air-dry at room temperature overnight. After three days at room temperature the starch based plastic film was ready for further use [9].

Preparation of bacterial growth

Flat parts of polymer samples were cut into a square of 1.5 cm and placed on the surface of the nutrient agar in the petri dish. *Staphylococcus epidermidis* [12] 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 paraffin film with dimensions of 4 × 4 cm was placed on it and was then incubated at humidity greater than 90% at 30 °C temperature for 72 hours [9].

Microbial degradation of Starch based plastic

The starch based plastic film was tested for its degradation by *Staphylococcus epidcermidis* in MMSB (modified mineral salt basal) medium $(NH_4)2HPO_4$ (1.1 g), K_2HPO_4 (3.7 g), 0.1 M $MgSO_4$ (10 ml) and 1.0 ml of Microelement Solution, containing $FeSO_4.7H_2O$ (2.789), $MnCl_2.4H_2O$ (1.989), $COSO_4.7H_2O$ (2.819), $CaCl_2.2H_2O$ (0.179) $ZnSO_4.7H_2O$ (0.299) in 1 L of 1N HCl [13]. 0.12 g or 1.5 cm plastic was cut and placed in to flask containing MMSB medium, incubated on shaker for 150 rpm for three days. The degradation was tested by percentage weight loss in the medium using the formula

ISSN 2320-1355

(i) below [14]. The similar method has been used to test the degradation of synthetic plastic, commercially available in market and the results of all above tests were recorded [9].

Degradability test

The BPS film produced was checked for its degradability in soil and the microorganisms were isolated from the same soil. The isolates were grown on MMSB medium and were checked for degradation capacity of BPS produced in the experiment.

The starch based films (BPS) were also being experimented under the same conditions for comparison purposes. The duplicate test pieces were retrieved from the medium, washed in sterile distilled water, dried for 24 hours at room temperature, and weighed. The degradation of these films was calculated conventionally in terms of percentage using the following formula (i) [14].

…. (i)

RESULTS

Biodegradable plastics combine the utility of plastics (lightweight, resistance, relative low cost) with the ability to biodegrade. Among the different types of biodegradable plastics, starch based plastics (BPS) constitute about 50% of the bioplastics market [9]. Thermoplastic starch, such as plastic material, currently represents the most important and widely used bioplastic. Flexibiliser and plasticizer such as sorbitol and glycerin are added to the starch. By varying the amounts of these additives, the characteristic of the material can be tailored to specific needs.

Starch contains two polymer amylose and amylopectin. Amylase is a long straight-chained polymer and useful as it gives strength to the plastic. Amylopectin is branched polymer. When starch is dried from an aqueous solution it forms a film due to hydrogen bonding between the chains of amylose and amylopectin. However, the amylopectin inhibits the formation of the film, as it makes the plastic brittle [11].

Film Preparation:

A starch based plastic has been produced in 24 hrs at the laboratory scale using glycerol on aluminum foil (Figure 2). This thermoplastic starch is known as a bio-plastic starch (BPS) [15]. BPS is a semi crystalline polymeric material composed of gelatinized or destructurised starch containing mixture of plasticizers like glycerol. Therefore other non-volatile plasticizers like glycerol are investigated to improve the processing ability and the product properties as starch based plastic.

Figure: 2 Observation of Starch based plastic film on 1st day (a) and after 48 hrs (b)

Microbial degradation of starch based plastic

A pure culture of *S. epidermidis* start growing in MMSB media after 72 hours which can be easily visualized by the increase in turbidity of MMSB medium. As illustrated in Figure 3, the clear media turn to turbid after 72 hours of inoculation of the microorganism. The microbial activities were further checked by spectroscopic observation at the interval of 24 hours, increase in optical density indicates the microbial growth of *S. epidermidis* inoculated in the medium (Figure 4).

ISSN 2320-1355

Small pieces of BPS of 0.12 g weight were converted into fine powder of 0.5 g weight in MMSB media containing pure culture of *S. epidermidis* after 72 hours showing 58% degradation of starch based plastic (Figure 5). Table 1 depicts the comparison of BPS and polythene based plastic with respect to their degradation by *S. epidermidis* in MMSB medium after 72 hours. Table shows that significant degradation of BPS (58%) compared to the polythene based plastic (18%).

Figure 3: Change in the turbidity of the medium showing microbial

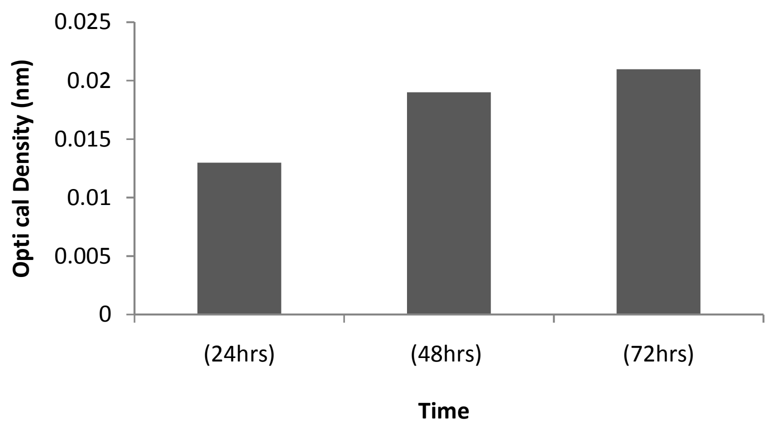

Figure 4: Optical density of MSB media indicating microbial degradation

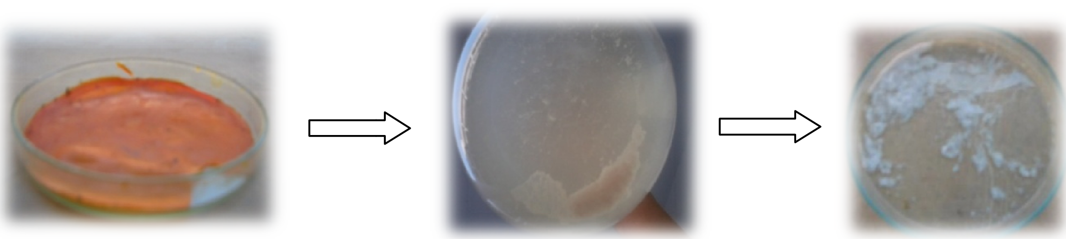

Figure: 5 Degradation of starch based plastic in 72 hrs by isolated microorganisms

Table 1: Degradation of plastics after 72 hours of incubation

	Initial Weight	Final Weight (after 72 hrs)	Results
Starch based plastic	0.12g	0.05 g	58.33%
Polythene plastic	0.38g	0.31g	18.38%

CONCLUSION

This starch based plastic films exhibit physical characteristics similar to synthetic polymers [11]. The produced plastic film was tested for their bio degradability through microorganism isolated from contaminated soil and was compared with that of the synthetic plastic. The results revealed 58% degradation in starch based plastic by soil microorganism while partial degradation was observed in synthetic plastic.

ACKNOWLEDGEMENTS

The authors are thankful to the Head, Department of Life Sciences, HNG University for necessary laboratory facilities and permission to carryout research work.

REFERENCES

1. Schlemmer, D., Angelica, R. S. and Sales, M. J. A., 2010, Morphological and Thermo mechanical Characterization of Thermoplastic Starch/ Montmorillonite Nanaocomposites. Composite Structures, 92: 2066-2070.
2. Shi, R., Zhang, Z., Liu, Q., Han, Y., Zhang, L., Chen, D. and Tian, W., 2007, Characterization of CitricAcid/Glycerol Co-Plasticized Thermoplastic Starch Prepared by Melt Blending, Carbohydrate Polymers,69: 748-755.
3. Liu, H., Xie, F., Yu, L., Chen, L. and Li, L., 2009, Thermal Processing of Starch-Based Polymers. Progress in Polymer Science , 34: 1348-1368.
4. Zuraida, A., Yusliza, Y., Anuar, H. and Mohd Khairul Muhaimin, R., 2012, The effect of water and citric acid on sago starch bio-plastics, International Food Research Journal, 19(2), 715-719.
5. Mehdi Borghei, Abdolreza Karbassi, Shahrzad khoramnejadian1, Abdolrasoul Oromiehie and Amir hossein Javid,2010, Microbial biodegradable potato starch based low density polyethylene, African Journal of Biotechnology, 9(26), pp. 4075-4080,
6. Rutkowska M, Heimowska A, Krasowska K, Janik H. 2002, Biodegradability of Polyethylene Starch Blends In Sea Water. Pol. J.Environ Stud, 11(3): 267-274.
7. Raj B, Sankar U, 2004, LLDPE/Starch blend films for food packaging applications. Adv. Polymer Technol, 23(1): 32-45.
8. Wang S, Yu J, Yu J, 2005,Compatible thermoplastic starch/polyethylene blends by one-step reactive extrusion; Polym. Int. 54: 279-285.
9. Mehta V., 2013, Production and evaluation of Microbial Plastic for its degradation capability. M.Sc. Dissertation, Hemchancharya North Gujarat University, Patan, ,72 pp.
10. Labuzek S, Nowak B, Pajak J, 2004, The Susceptibility of Polyethylene Modified with Bionolle to Biodegradation by Filamentous Fungi; Pol.J. Environ. Stud. 13(1): 59-68.
11. Bastioli C,2001,Global status of the production of biobased packaging. Starch/Stärke., 53: 351-355.
12. Darshan Marjadi , 2011,"Production of microbial plastic by Microorganism from oil contaminated site and its Biotechnological application".Ph.D., Thesis, Hemchandracharya North Gujarat University, Patan.,191 Pp,
13. Darshan Marjadi and Nishith Dharaiya., 2010 ,Screening of edible oil contaminated soil for polyhydroxyalkanoates producing bacterial strains, IUP Journal of life sciences, IV (4), 37-43.
14. Saw-Peng Yew, Hui-Ying Tang and Kumar Sudesh., 2010, Photo catalytic activity and biodegradation of polyhydroxybutyrate films containing titanium dioxide,Polymer Degradation and Stability, 91: 1800e180.
15. Corradini, C., Carvalho, A.J.F., Antonio, A., Jose, A.M. and Luiz, H.C., 2007, Preparation and characterization of thermoplastic starch/zein blends. Materials Research, 10 (3): 227-231.