Eco. Env. & Cons. 29 (4) : 2023; pp. (1820-1823)

ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i04.061

Fabrication and Characterization of Bioplastic films using *Ipomoea batatas*

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(Received 12 May, 2023; Accepted 7 July, 2023)

ABSTRACT

The development of eco-friendly bioplastics is a fascinating and need of the hour. This study aimed to develop bioplastic films using starch extracted from *Ipomoea batatas*. The bioplastic films were fabricated by casting method. The produced bioplastic films were characterized morphologically and chemically by scanning electron microscope and Fourier transform infrared spectroscope. Further, the bioplastic films were assessed for its biodegradability by soil burial method. This study revealed that the developed bioplastic films had notable biodegradability when compared to synthetic polypropylene plastic. In future, the fabricated bioplastics will be evaluated for its mechanical stability, tensile strength and its possible application in commercial purposes.

Key words: *Bioplastic, Biodegradation, Ipomoea batatas, Water solubility*

Introduction

Worldwide, nearly more than 400 million tonnes of polyethylene plastics are produced every year, half of which is intended to be used only once. Of that, less than 10 percent is recycled. An estimated 19-23 million tonnes are dumped in soil, rivers, lakes and seas. Discarded or burnt single-use plastic harms human health, biodiversity and pollutes ecosystem from mountain tops to the ocean floor. The polyethylene plastics approximately take several hundreds of years to deteriorate.

The proportion of plastics in municipal solid waste continues to raise hastily. Polyethylene plastic wastes that are dumped in landfills, get interact with water and form hazardous chemicals. This affects the quality of soil and also drinking water (Emadian *et al.,* 2017). Hence, the government and public sectors are involved in intense research to reduce the use of synthetic plastics and to encourage bioplastics in day-to-day activities.

Biodegradable plastics or bioplastics are made from starch, cellulose, chitosan and protein extracted from renewable sources (Azahari *et al.*, 2011). The bioplastics reduce fossil fuel usage, plastic waste and carbon dioxide emissions. The biodegradability characteristics of bioplastics produce a positive effect in society (Siakeng *et al.,* 2019). The main benefits of the bioplastics are low carbon footprint, low energy costs in manufacturing and reduction in litter with improved compostability.

Approximately 50% of the bioplastics used commercially are prepared from starch. The production of starch-based bioplastics is simple and they are widely used for commercial and packaging applications (Gadhave *et al.,* 2018). The tensile properties of starch are suitable for the production of bioplastics. Along with starch, plasticizers such as glycerol, sor-

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bitol, xylitol, urea, formamide have been widely used for making bioplastic film. The most common plasticizers used inthe preparation of bioplastic film is glycerol. Since it is food grade, edible, safe forconsumption, glycerol is the most commonly used as a plasticizer to produce edible film. Till date bioplastics derived from corn and rice starch have been intensively analysed. Very few reports are reported on bioplastics derived from *Ipomoea batatas*. Hence, in the present study a detailed study have been attempted on bioplastics derived from *Ipomoea batatas.*

Materials and Methods

Isolation of Starch from *Ipomea batatas*

Fresh *Ipomoea batatas* (sweet potatoes) were collected from farmers, washed, peeled off and cut into pieces. The samples were ground in a mortar and pestle using water (1:2 w/v). The thoroughly fine mixture was filtered using muslin cloth and then the filtrate was allowed to settle for 15 min. at room temperature. After that, the supernatant was decanted and the precipitate was collected as wet starch. The wet starch was dried in a hot air oven at 50ºC for 5 hrs. The starch powders were stored in an airtight condition to prevent moisture and contamination for further use (Arikan and Bilgen, 2019).

Fabrication of Bioplastic from *Ipomoea batatas* starch

Sweet potato starch powder (1 g), 0.5g of glycerol and distilled water were added onto a beaker and heated with constant stirring in magnetic stirrer. The mixture was allowed to gelatinize at 70ºC. The resultant starch paste was poured onto a petri plate and dried at 50 ºC. The dried film was peeled off and stored at room temperature (Sadhu *et al.,* 2014).

Morphology of bioplastics

The cross-section morphology of the fabricated bioplastics was observed by a Scanning Electron Microscope (Carel Zeiss – EVO 18). Prior to SEM analysis, the samples were coated with a thin layer of gold (~10 nm) and analyzed at an accelerating voltage of 20 Kv.

Chemical interaction of bioplastics

Intermolecular bonding of bioplastics was evaluated using Fourier Transform Infrared spectroscopy (Thermo Fisher Scientific, Nicolet iS5) in a 4000-400 cm^{-1} wave range with an average of 16 scans for spectrum integration and to collect IR spectra (Abdullah *et al.,* 2019).

Water Solubility

Water solubility ability of the fabricated bioplastics were determined according to method determined by Saberi *et al.*(2017). The bioplastic film samples were cut into 2 cm × 2 cm pieces, dried at 60 °C for 2 h and weighed. The dried pieces of films were immersed in 20 ml of distilled water in a beaker and kept on a rocker for 24 h at room temperature. After 24 h, the films were observed for solubility.

Biodegradability of the bioplastics

Soil burial test was used to determine the biodegradability ability of the fabricated bioplastics by following the procedure of Patkar *et al.* (2020). The fabricated bioplastic films were taken in triplets and commercial biodegradable film were taken as Control 1 and synthetic polyethylene film was taken as Control 2. The films were buried in soil at 10 cm depth to view the natural degradability of the bioplastic film at different intervals of time (0, 5, 10 days). The reduction percentage of the fabricated bioplastic films were determined as per the equation.

$$\% \text{ weight loss} = \frac{W_1 - W_2}{W_1} \times 100$$

W_1 = Original weight of the samples
W_2 = Weight of samples after degradation

Results and Discussion

The fabricated bioplastic films were depicted in Figure 1. Starch obtained from *Ipomoea batatas* is one of the prime material used to make bioplastics. The surface morphology of bioplastic films were observed under SEM. The fabricated bioplastic films revealed few cracks on the surface because of their brittle nature (Fig. 2). The SEM image also has smaller microvoids, but exhibited good integration of plasticizer. Voids and microvoids are caused when hydrogen bonding in long chains of starch breakdown during gelatinization temperatures, leading to infiltration of water molecules into hydroxyl group of starch molecules (Patkar *et al.,* 2020).

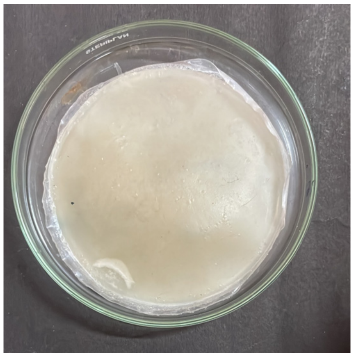

Fig. 1. A smooth, thick and transparent bioplastic film

Bioplastic films developed were examined to identify the functional groups using FT-IR analysis (Fig. 3). The broad peaks at 3000-3600 cm^{-1} were attributed to the hydrogen bonds generated by O-H group interactions of starch and glycerol (plasticizer). Moreover, the peaks around 2885 and 1600 cm^{-1}corresponds to C-H aliphatic and C = O, respectively. The peaks at 1652 and 1023 cm^{-1} represented the C=O and C–O stretching vibrations of glycoside bonds in the starch. The intensity of the peak at 1023 cm^{-1} increased with the integration of glycerol, and the improvement in the –OH stretching vibration at approximately 3269 cm^{-1} suggested the incidence of association (Jiang *et al.*, 2020).

The solubility of the bioplastic films is an indicator of the presence of hydrophilic compounds as the major constituent. Bioplastic films had higher solubility of 70% because of the water absorbing nature. Synthetic polypropylene plastic were very least soluble (2%) because of high levelof intermolecular attractions within the matrix and crosslinking bringing about lower capability to interact with water. Hence, the polypropylene plastic had least solubility in water, while bioplastic films had a notable solubility.

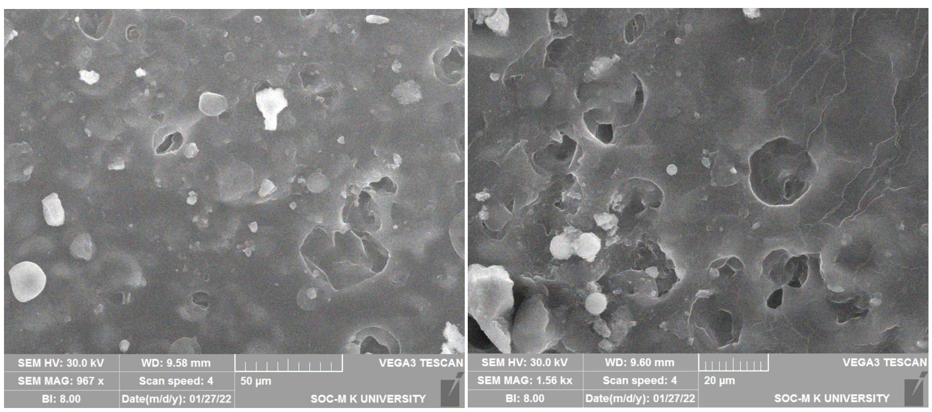

Fig. 2. Surface morphology of bioplastics

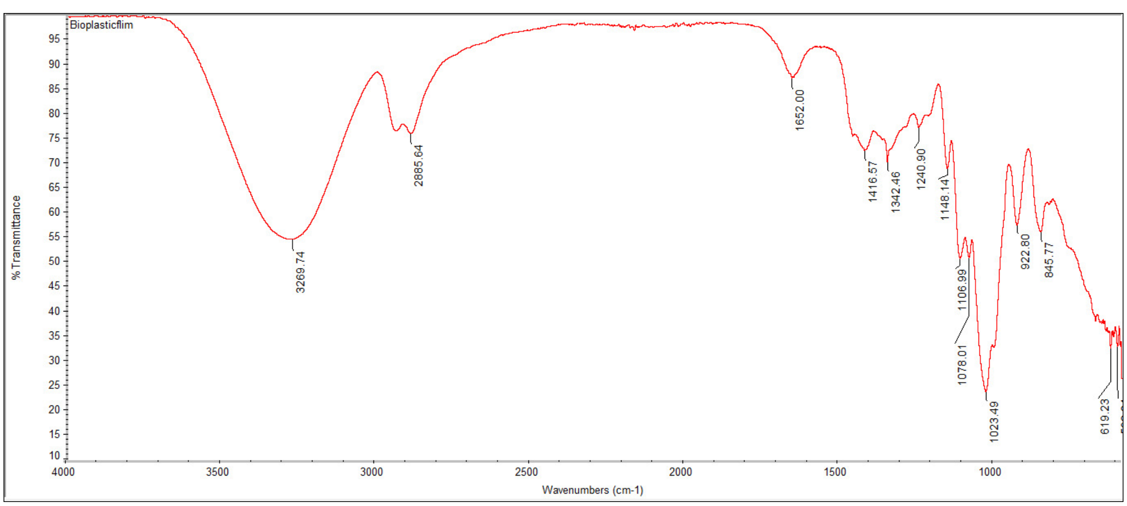

Fig. 3. FTIR spectra of bioplastic films

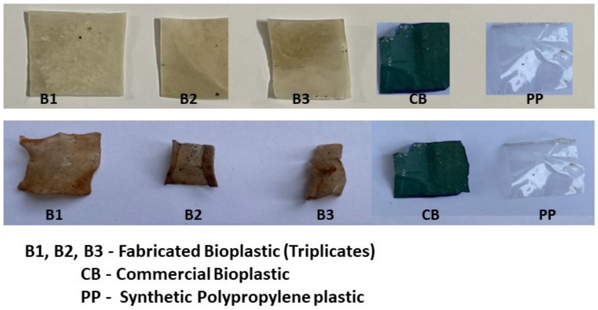

Fig. 4. Biodegradation of bioplastic films by soil burial method

All the soil buried bioplastic samples were taken from the soil at various time intervals. The rate of biodegradation was observed and compared with the synthetic polypropylene. Significant degradation was observed on day 10 in all the bioplastic films. Degradation at 30 % was observed in B1, 28 % in B2, 26 % in film B3, 27 % in commercial bioplastic (CB). On day 20, 62 % of film B1 was degraded while 55 %, 62 % of films B2 and B3 have been degraded respectively. Degradation of all the bioplastic films in soil was almost 80% in 30 days which shows a remarkable degradation period compared to the reports of Carlos *et al.* (2016). No change wasobserved in synthetic polypropylene throughout the study (Fig. 4). This study indicated that starch-based bioplastics have the ability to degrade rapidly when compared to the synthetic plastics (Fig.4). Wahyuningtiyas and Suryanto (2017) established bioplastic from Cassava flour with varying proportions of glycerol from 1 to 3% and evaluated its biodegradation. The mass of bioplastic got reduced within a week, and complete degradation was attained at approximately 12 days of incubation in soil.

This study realizes the utilization of sweet potato as a prime source in fabrication of bioplastics. This study exposed that the fabricated bioplastics had a remarkable bio-degradability in soil. In future studies the mechanical stability of the bioplastics and its possible application in commercial applications will be unravelled.

Conflict of interest

All the co-authors have seen and agree with the contents of manuscript and there is no financial interest to report.

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