Utilization of Waste Banana Peel for Synthesis of Biopolymeric Film

Htun Htun Naing[1], Htay Htay Shwe[2], Ni Ni Pe[3], Yazar Tun[4]

Abstract

Biopolymeric films are made from renewable resources, such as potatoes, soy, corn, yam, sugarcane, wheat, and vegetable oil. The aim of this research is to prepare biopolymeric film from a combination of waste materials. In this study, extraction of starch from chosen tuber with high content of starch namely tapioca has been used as co-biopolymer for biopolymeric film. The physico-mechanical properties such as thickness, tensile strength, elongation at break, tear strength, and thermal properties of the product were determined and analyzed using Fourier Transform Infrared (FT-IR) and Thermogrivimetry-Differential Thermal Analysis (TG-DTA) and Scanning Electron Microscopy (SEM). The FT-IR spectra of the product displayed the presence of O-H, C-H, C=C and C-O absorption peaks, which indicate the formation of biopolymeric film. The TG-DTA results showed that 30% weight loss was occurred at 485.89 °C for biopolymeric film. The highly biodegradability of biopolymeric film was proven using soil burial test, which was observed in 12 days' duration. These biopolymeric films have exhibited good thermal and mechanical properties with high biodegradability, solubility and make them a suitable alternative for the existing conventional plastics.

Keywords: Biopolymeric film, biodegradability, FT-IR, TG-DTA, SEM

Introduction

Plastics have become an indispensible part of our everyday-life and so versatile in their usage. They cannot be completely avoided. However, they have become a major threat to the environment contributing to a major part of the land pollution [1]. Plastics account for 25% of the total volume of landfills. The plastics produced in excess and discarded here and there are deposited as a landfill and are degraded very slowly. Hence, they remain in the landfills for hundreds or even thousands of years [2].

Plastics made from petroleum have many drawbacks. It needs a large amount of energy in the production process. Besides, it took years to degrade, and at the same time, it caused serious hazards to the environment [3][4]. In order to shift to sustainable pathways, the development of biodegradable products has increased for years and it continues to be the area that attracts scientists to involve with new green materials and improvement ideas [5][6]. Renewable natural polymer resources such as starches were one of the most attractive materials because of its inherent biodegradability, ready availability and low cost [7][8].

Starch is one of the major sources in the development of biodegradable bioplastic. Many previous studies have been conducted by using starch as a natural biopolymer. One of the most common waste forms of starch is the banana peels. Banana peels consists high sources of starch, which is about 18.5% [9]. As banana peels ripen, the glucose level increases. However, if the peels are too ripe, the starch

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will be converted into glucose while the least ripened peels, becomes too firm although high in starch molecules [10]. Therefore, banana peels can be suggested as a suitable source for the manufacturing of biopolymeric film or bioplastics. Previous studies also focused only on the potential of banana peels in forming starch-based plastic film. Even though several studies have been done using cellulose as natural reinforced filler in starch-based films [11], yet in this study, a new derivative was prepared by combining starches from two different sources. Therefore, this study aims to investigate the physico-mechanical properties of biopolymeric films, to determine the biodegradability and to characterize the films in term of functional group, morphology and thermal properties. The study also intended to show the bioplastic film from combination of organic waste that has potentials to become alternative resources in plastic making industries, to reduce the amount of discarded organic wastes and to contribute to waste-to-wealth industry development in Myanmar.

Materials and Method

Sample Collection

Banana and tapioca were purchased from Yadanabon market, Mandalay.

Extraction of Cassava Starch

About 100 g of tapioca and 100 mL of distilled water were grinded in blender and then 100 mL of distilled water was added at grinded next times. The water was decanted and was dried leaving the starch behind.

Figure 1. Tapioca and cassava starch

Qualitative Tests for Cassava Starch

Preparation of iodine solution

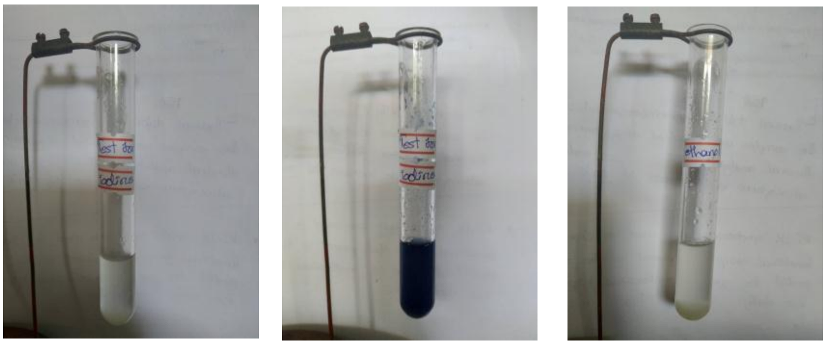
Potassium iodide 10 g was dissolved in about 30 mL of distilled water. Iodine 5 g was added and heated gently with constant mixing until iodine was dissolved. It was diluted to 100 mL with distilled water.

Iodine solution test

2 mL of starch solution was taken and placed in the test tube. 2-3 drops of iodine solution was added into starch solution. Dark blue color was changed and starch was present.

Alcohol test

An equal volume of ethanol and starch solution were taken and placed in the test tube. A few-minutes later, starch was precipitated from solution and starch was present.



Starch Solution Iodine Test Ethanol Test

Figure 2. Identification for starch

Preparation of Banana Peels

The peels of banana were removed from the fresh by using a stainless knife. Approximately 100 g of peels were dipped in 100 mL of acetic acid for 30 min, it was boiled with 250 mL of water in the beaker for 30 min and dried at room temperature for 30 min. The water was decanted off and the peels were left to dry 30 min at room temperature. The peels were then placed in a clean beaker.

Preparation of Biopolymeric Film

The peels of banana were grinded using the blender. 25 mL of the paste was placed in a 250 mL beaker. 3 mL of 0.5 M HCl was added and the mixture was stirred using a spatula. Then 2 mL of 1% glycerol solution was added and the mixture was stirred. A 3 mL of 1% cassava starch was then added as co-biopolymer and the mixture was stirred again. Then, a 3 mL of 0.5 M NaOH was added to the mixture and stirred. The mixture was poured into a mould and dried at room temperature about 3 days [12].

Figure 3. Biopolymeric film of banana peel

Determination of Solubility of Biopolymeric film

0.02 g of biopolymeric film and 20 mL of distilled water were put into the beaker. The solubility of water of biopolymeric film was investigated at various time intervals (60-300 mins).

Figure 4. Solubility test of biopolymeric film

Biodegradation Test (Soil Burial Test)

The biodegradability of the prepared biopolymeric films was carried out by soil burial test. Biodegradation of the prepared films were determined daily from 1 to 12 days.

Figure 5. Biodegradation of biopolymeric films

Determination of Physico-mechanical Properties

Physico-mechanical parameters of biopolymeric film were determined such as thickness, tensile strength, elongation at break and tear strength were tested at Development Centre of Rubber Technology, Yangon.

Determination of Functional Groups

FT-IR spectroscopy was used to characterize the functional group that present in the biopolymeric film to predict the type of synthesized biopolymeric film in this study. FT-IR was determined at Department of Chemistry, University of Monywa.

Determination of Thermal Stability

Thermal stability of the biopolymeric film was studied using thermal analyzer SDT-600 under nitrogen atmosphere rate increased of 20°C/min. Thermogravimetry-

Differential Thermal Analysis was determined at Department of Chemistry, University of Mandalay.

Determination of Surface Morphology

The morphology of the biopolymeric film was examined by Scanning Electron Microscopy at University Research Centre, Yangon.

Results and discussion

Determination of Solubility of Biopolymeric Film

The solubilities of biopolymeric film in water were investigated at various time intervals (60 to 300 mins) and results are shown in Table 1.

Table 1. Results of Solubility of Biopolymeric Film

	Banana film	1 hour	2 hours	3 hours	4 hours	5 hours
Weight of sample (g)	0.200	0.188	0.180	0.171	0.152	0.133
Weight loss (g)	0	0.012	0.020	0.029	0.048	0.067

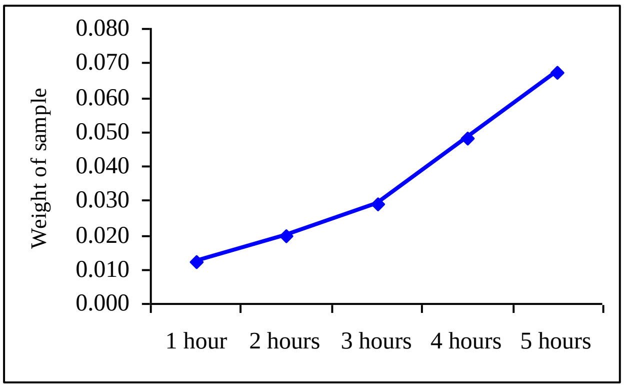


Figure 6. Solubility in water of biopolymeric film

Biodegradation of Biopolymeric Film

From soil burial test, the weight loss and degradation of biopolymeric film were determined. They indicated the amount of degradation in natural environment by action of microorganisms. The starch content is consumed by soil microorganisms. Soil fracture the polymer chain thus cause the biodegradation.

Table 2. Results of Biodegradation of Biopolymeric Film

	1 Day	3 Days	6 Days	9 Days	12 Days
Banana Biopolymeric Film					Completely degraded

Physico-mechanical Properties of Biopolymeric Film

The results of physico-mechanical properties of biopolymeric film were tabulated in Table 3.

Table 3. Results of Physico-mechanical Properties

Thickness (mm)	Tensile strength (MPa)	Elongation at break (%)	Tear strength (kN/m)
0.20	2.0	10	5.0

FT-IR Assignments of Biopolymeric Film

The infrared spectrum of biopolymeric film was carried out by FT-IR instrument at Department of Chemistry, University of Monywa. The result obtained was illustrated in Figure 7.

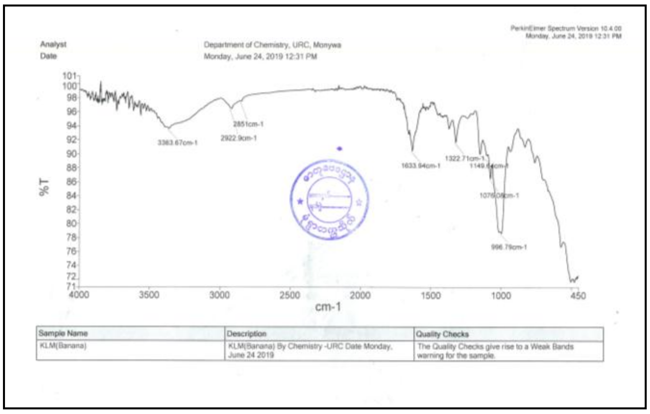


Figure 7. FT-IR spectrum of biopolymeric film

The FT-IR spectrum of biopolymeric film, it could be seen that the characteristic peaks of biopolymeric film were O–H stretching peaks at 3363.67, C–H stretching peaks at 2922.90, C=C stretching peaks at 1633.94 and C–O stretching peaks at 1076.08 cm^{-1}.

Thermal Analysis Data of Biopolymeric Film

Thermal stability of the biopolymeric film was studied using thermal analyzer SDT-600 and results data were listed in Table 4.

Table 4. Thermal Analysis Data of Biopolymeric Film

Temperature range (°C)	Weight loss (%)	Peak nature	Remark
30-60	13.7	A small endothermic peak at 60.35 °C	Loss of surface water and lower molecular weight compounds of film
60-350	80	A small exothermic peak at 342.15 °C	Complete evaporation of plasticizer
350-490	30	An exothermic peak at 485.89 °C	Complete degradation of polymer film

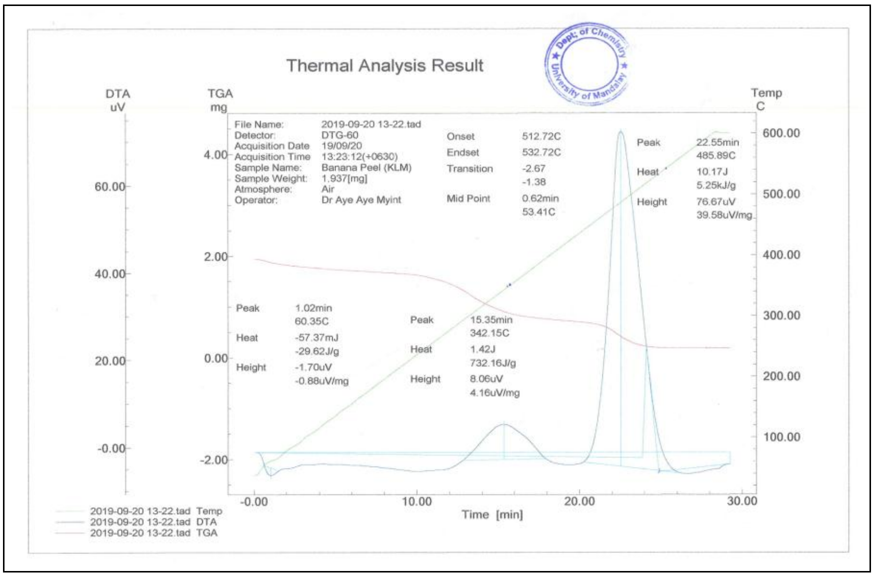


Figure 8. TG-DTA assignment of biopolymeric film

Scanning Electron Microscopy (SEM)

Surface morphology of biopolymeric film was visualized using scanning electron microscope under normal atmospheric conditions. The sample was analysed in SEM at high vacuum in varying magnifications.

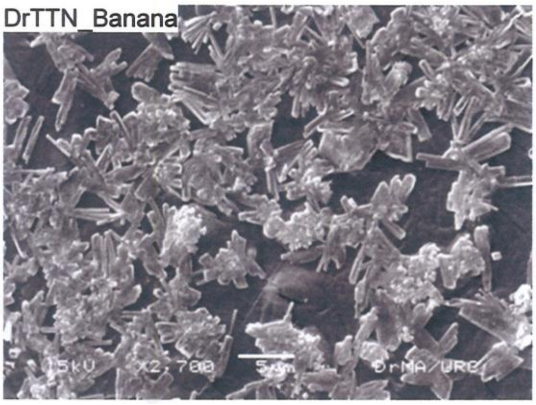


Figure 9. SEM image of biopolymeric film

Conclusion

The biopolymeric films from the composite of banana peel and cassava starch were successfully formed. The physical and chemical characteristics of the biopolymeric film produced indicate their prospective uses as replacement for petroleum-based non-biodegradable plastics which are causing environmental hazards. Water solubility is a useful property as the material may be useful for drug delivery systems, provided, the material can be sterilized. The characterization of functional group by FT-IR analysis indicated that biopolymeric film with 1% cassava starch are comparable with the control bioplastic film and to the previously developed starch-based bioplastic such as corn and potato as most of the major peaks were identified. The biopolymeric films produced from banana peels had potential application to be used as food packaging because it can enhance the food quality and at the same time can protect the environment. More applications of biopolymeric film to replace polythene bags can be ensured by imparting waterproofing ability and increased tensile strength. Since these biopolymeric films are made out of natural wastes, their applications in medical field are very prospective as they may tend to cause less allergies as compared to chemical based plastics. Thus, new formulations can be developed in the future to achieve the standard biopolymeric film (bioplastic) requirements. This research can be performed for reducing the environmental plastic pollution.

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