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The Potential of Natural Waste (Corn Husk) for Production of Environmental Friendly Biodegradable Film for Seedling

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***Abstract*—**The use of plastic materials in agriculture causes serious hazards to the environment. The introduction of biodegradable materials, which can be disposed directly into the soil can be one possible solution to this problem. In the present research results of experimental tests carried out on biodegradable film fabricated from natural waste (corn husk) are presented. The film was characterized by Fourier transform infrared spectroscopy (FTIR), differential scanning calorimeter (DSC), thermal gravimetric analysis (TGA) and atomic force microscope (AFM) observation. The film is shown to be readily degraded within 7-9 months under controlled soil conditions, indicating a high biodegradability rate. The film fabricated was use to produce biodegradable pot (BioPot) for seedlings plantation. The introduction and the expanding use of biodegradable materials represent a really promising alternative for enhancing sustainable and environmentally friendly agricultural activities.

***Keywords*—**Environment, waste, plastic, biodegradable.

I. Introduction

ROBUST agricultural growth and productivity increases are crucial to sustain economic development. Seeds are very important to establish plantation for agriculture. The implication was that the use of improved seedling quality would have major impact on survival and subsequent growth in the field which lead to greater in agriculture production. Polybags made from plastic are normally used for seedlings. Polybag system is not good for growing any kind of seedling because they can lead to damage the root system. Another alternative for seedling is by using paperpots but they have low mechanical properties and durability. The agricultural activities uses a lot of plastic, to the point that there is a name for the use of plastic products in agriculture: plasticulture. Plasticulture is a multi-billion dollar industry worldwide, and it is growing at a rapid pace.

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The conventional agricultural plastic films used are low density polyethylene (LDPE), high density polyethylene (HDPE), poly(vinyl chloride), polybutylene or copolymers of ethylene with vinyl acetate [1]. A major negative consequence of this expanding use of plastics for agriculture activities is related to handling the plastic wastes and the associated environmental impact as only a small percentage of the constantly rising amount of agricultural plastic waste is currently recycled. A large portion of plastic waste is left on the field where they may have pesticide residue on them, burnt uncontrollably by the farmers releasing harmful substances with the associated obvious negative consequences to the environment [2].

Furthermore, burying of these materials in the agricultural land, a practice unfortunately followed by many farmers represents an imminent threat for an irreversible soil contamination and possibly for the safety of the food produced in such fields [3]. The reasons for these environmentally dangerous practices are the lack of cost efficient systematic disposal techniques available to the growers and the high labour cost for the proper collection of the plastic films following the end of the cultivation [4].

The modern agricultural sector generates great amounts of wastes, which represent a tremendous threat to the environment. The plants wastes can be recycled as source of natural fiber to fabricate biodegradable films. Natural fibers are getting the attention as a reinforcing agent in both thermoplastic and thermoset matrices. Starch is a renewable source that commonly used to fabricate biodegradable film since it is inexpensive, widely available and relatively easy to handle [5]-[6]. Biodegradable films can be disposed directly into the soil or into a composting system at the end of their lifetime [7]-[8].

In an effort to cope up with the severe and continuously growing agricultural plastic waste problem, biodegradable film was fabricate using natural waste (corn husk) as reinforcing agent and the film fabricated was used to produce biodegradable pot (BioPot) that can be used for seedlings plantation. The increasing interest in the use biodegradable pot in agriculture industries aims providing a better micro environment for seeds plantation.

II. METHODOLOGY

A. Film Preparation

An alkaline treatment was applied on cornhusk. The cornhusk was cleaned and then soaked in a concentrated 17.5% w/w sodium hydroxide (NaOH) solution. After 2 hours treated cornhusk was washed with distilled water. The pre-treated pulp was hydrolyzed by 1 M of hydrochloric acid (HCl) at 80 ± 5°C for 2 hours and then washed with distilled water repeatedly. The pulp was treated once more with the 2% w/w of NaOH solution at 80 ± 5°C for 2 hours. The alkali treated pulp was washed several times with distilled water until the pH of the fiber suspension became neutral before being dried at room temperature.

Fig. 1 Corn husk for film preparation

Fig. 2 Chemical treatment of corn husk

The solution was prepared by mechanically stirring chitosan, acetic acid and corn husk pulp. Additive also added to the solution and stirred until the solution became homogeneous. The resulting solution was degassed for several hours. Then the solution was poured onto the glass plate and casted using casting knife and leaved it at ambient temperature and humidity for two days. After the film is completely dried, the film then been peeled off from the glass plate.

B. Film Characterization

The film fabricated was characterized by atomic force microscope (AFM), Fourier transform infrared (FTIR), differential scanning calorimeter (DSC), and thermo gravimetric analysis (TGA).

For AFM analysis, the surface morphology (2D and 3D topographic images) and roughness analysis of the film in scan area of 2 μm × 2 μm was characterized using atomic force microscope model Shimadzu SPM 9500J2.

Fourier transform infrared spectroscopy (FTIR) identifies chemical bonds in a molecule by producing an infrared absorption spectrum. The FTIR generates an infrared spectral scan of samples that absorb infrared light. FTIR spectra was recorded between 400 and 4000 cm^{-1} with a piece of film 2 cm in diameter. Spectral output was recorded in absorbance as a function of wave number.

Thermo gravimetric analysis (TGA) was performed to study the degradation characteristic of the fibers of the film fabricated. Thermal stability of the biodegradable film was determined using TGA Q500 series Thermo gravimetric analyzer (TA Instruments) with a heating rate of 10 °C/min in a nitrogen environment. It has a weighing capacity 10 mg to 20 mg and final temperature 600°C.

Differential scanning calorimetry (DSC) identifies the melting temperature of the film. The thermal properties of the film with a weight about 10mg to 20 mg was performed by a DSC Q1000 series (TA Instrument) under nitrogen atmosphere, with a flow capacity of 25 ml/min from 20 to 300 °C at a heating rate of 10 °C/min.

The biodegradability of corn husk composite film was observed by buried the film in the controlled soil condition. The fabricated film was used to produce biodegradable pot (BioPot) that has been used for seedling.

III. RESULTS AND DISCUSSION

Corn husk composite biodegradable film fabricated from blend of natural waste, starch, chitosan and additive is presented in Fig. 1.

Fig. 3 Corn husk composite biodegradable film

Atomic force microscopy is a characterization technique, which presents very high possibilities of application in the field of microscopy observation and characterization of various surfaces [9]. 2D and 3D AFM images of the biodegradable film were shown in Fig. 4 and 5 respectively. The nodules are seen as bright high peaks whereas the pores are seen as dark depressions.

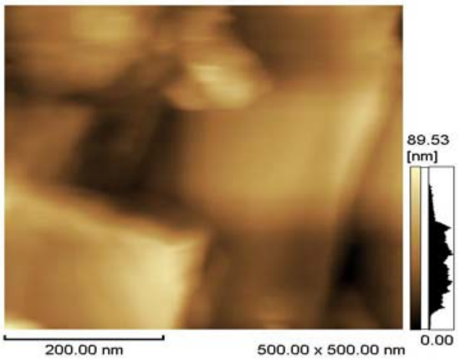

Fig. 4 2D AFM topographic image

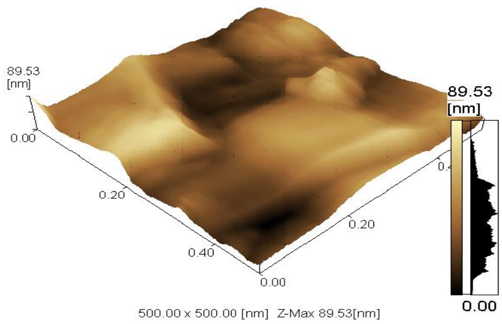

Fig. 5 3D AFM topographic image

From Fig. 4 and 5 were clearly showed that the morphology of the surface of biodegradable film fabricated. It is observed that the nodules are merged forming nodules aggregate. The surface roughness parameter of the biodegradable film fabricated was presented in Table 1. The results showed that the film has smooth and compact surface showing the miscibility and compatibility of each component in the film.

TABLE I THE SURFACE ROUGHNESS OF THE CORN HUSK COMPOSITE BIODEGRADABLE FILM

Roughness Parameter	Value
Ra	13.483
Ry	86.717
Rz	34.234
Rms	16.053

FTIR spectroscopy was used to determine the interactions between the chemical used to produce the film. The infrared spectra of corn husk composite biodegradable film are shown in Table 2.

TABLE II SOME IMPORTANT INFRARED REGIONS THAT WERE ANALYZED FROM THE FILM

IR regions (cm^{-1})	Functional group	Corn husk Composite film
3600 -3000	Aliphatic and aromatic	Present
3000-2850	Aliphatic	Present
1740-1660	Aldehyde and ketone	Present

The broad band of corn husk composite biodegradable film at 3350 cm was the O-H stretching. The peak at 2908.04 cm corresponded to the C-H stretching, while a small peak at 1670.77 cm was due to the C=O stretching (amide I). When several components are mixed, the physical blends versus chemical interactions are affected by changes in the characteristic spectra peaks [10]. In the spectrum of corn husk composite biodegradable film, the amino group peak of chitosan shifted from 1541.15 to 1670.77.96 cm. This phenomenon pointed out that interactions were present between the hydroxyl group of rice starch and the amino group of chitosan [11]-[12].

The thermo gravimetric analysis is used to determine the weight loss of the material as it is heated [13]. The film was run for thermal gravimetric analysis and the result was shown in Fig. 6 and Table 3.

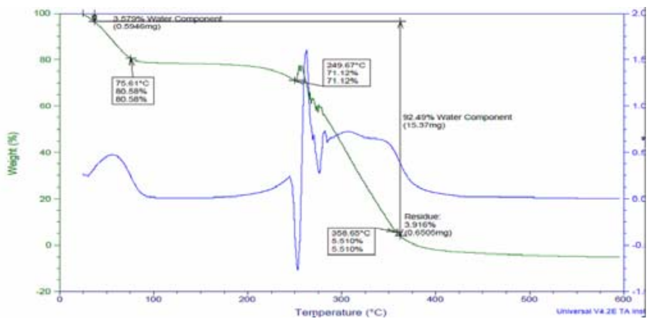

Fig. 6 TG curve of corn husk composite biodegradable film

The initial weight loss of all samples at approximately 100 °C due to the evaporation of water, while the weight loss in the second range 220°C corresponded to a complex process including the dehydration and depolymerization. From the TG curve result show that the corn husk film is stable up to 248°C with a maximum rate of decomposition occurring at 249.67 °C.

TABLE III THE OXIDATION TEMPERATURE, ASH, WATER CONTENT AND ONSET TEMPERATURE OF THE FILM

Film sample	Oxidation temperature (°C)	Ash (%)	Water (%)	Onset Temperature (°C)
Corn husk composite film	249.67	3.916	3.579	240

To further understand the structure and interaction between the components, DSC study of the film was performed and the result was shown in Fig. and Table 4.

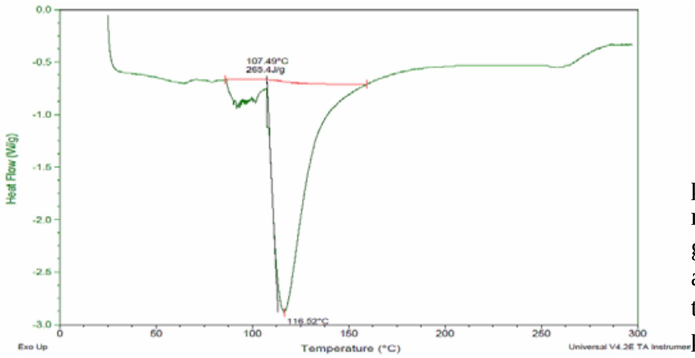

Fig. 7 DSC curve of corn husk composite biodegradable film

TABLE IV GLASS TRANSITION AND MELTING TEMPERATURES OF THE FILM

Film sample	Glass transition, T_g (°C)	Melting Temperature, T_m (°C)
Corn husk composite film	24	116.52

Corn husk composite biodegradable film has been shown to have a glass transition temperature at 24 °C. The results also showed that the corn husk film has melting point at 116.52 °C.

Currently, no official standard method was established in determining biodegradability of the film produced. In order to get biodegradability, the enzyme method, the microbiological method and the soil burial method can be used [14]. In this study, an experiment was set up for biodegradation testing under controlled soil conditions. The loss of weight of corn husk composite biodegradable film monitored by means of sample collected from the soil at regular time interval. The corn husk film was buried in the soil and the sample was removed for evaluation at 1 month interval. The evolution of the degradation in soil of the biodegradable film during the experimental period of under controlled soil conditions was shown in Fig 8. From this figure, it can be seen that with the increase of degradable time, the compactness of corn husk films was destroyed. The film was shown to degrade within a period of 7-9 months. The film achieves 100% degradation at 270 days.

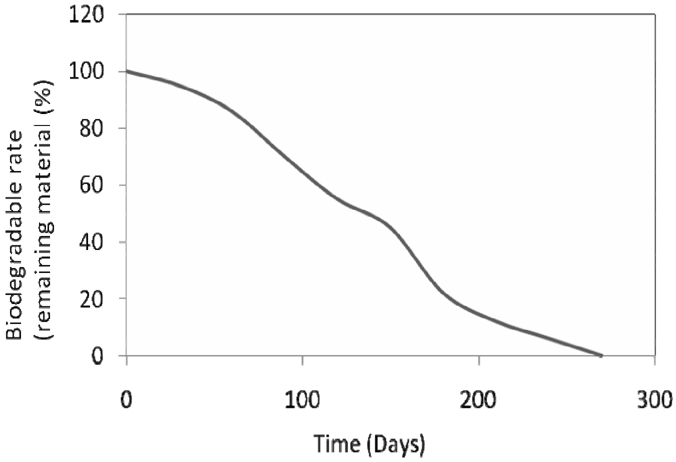

Fig. 8 Biodegradability of corn husk composite biodegradable film

The corn husk biodegradable film fabricated was used to produce biodegradable pot (BioPot) for seedling and the results was shown in Fig. 8. It can be seen that the seedling grow healthily. When this Biopots decompose, it release water and carbon dioxide without leaching harmful chemicals into the air or soil. The environmental benefits of biodegradable pots are considerable. BioPot can be planted where there is no need to remove seedlings from pots. This encourages root growth while the BioPot decomposes.

Fig. 9 BioPot from corn husk composite film

The breakdown of biodegradable pots can introduce excessive moisture and increase acid levels in an industrial hot compost. Biodegradable pots produce from corn husk film offer earth friendly options to overcome environmental problem cause by plasticulture activities.

IV. Conclusion

Corn husk composite biodegradable film was prepared by solution mixing. These results from AFM, TGA and DSC analysis exhibit the properties of the corn husk film fabricated. The biodegradability shows that the 100% composting achieved at 270 days. The BioPot produce from corn husk composite biodegradable film is suitable to be used for seedling because it can give a plant a more comfortable growing condition and also protect the environment.

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