

Pineapple Peel Fiber based Biocomposites for Green Packaging

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Abstract

In this research, pineapple peel fiber (PAPF) based low density polyethylene (LDPE) biocomposites for green packaging was studied. The PAPF was first being treated with alkali before compounded with LDPE. Then, the mixture was compounded using twin screw extruder and the test samples were prepared using hot press machine. The compatibility of the PAPF as biocomposites was observed through the characterization and biodegradation analysis. Melt flow index (MFI) analysis was conducted to determine the process ability of the biocomposites. As the fiber loading in the biocomposites increases, the MFI values were decreased. The amount of water absorption was increased with the increases of PAPF loading due to the higher cellulose content. The biocomposites was buried in the soil for a month for biodegradation analysis and the highest PAPF/LDPE loading biocomposites degraded the most.

Keywords. Pineapple peel fiber, biocomposite, green packaging, injection moulding

1 Introduction

The annual world production of polymer materials was around 150 million tons in 1996 [1] and the current global consumption of plastics is more than 200 million tones, with an annual grow of approximately 5% [2]. Packaging waste is a major contributor of municipal solid waste (MSW) and disposed of by landfill [3]. Landfilling disposal may result in the generation of greenhouse gases and takes up. It also may contaminate land that could be used in the future. The rapid increase in production and consumption of plastics has led to the serious plastic waste problem, besides landfill depletion because of the plastic waste high volume to weight ratio and resistance to degradation [1]. Natural fibers reinforced composites will form new class of materials which poses a significant improvement in properties without sacrificing the desirable properties. The biocomposites also contains biodegradable components from waste for biodegradability and cost effectiveness. Pineapple peel fiber (PAPF) shows significant role as cheap, exhibiting superior properties and environmental friendly biocomposite as a reinforcement fiber. Pineapple leaf fiber (PALF) exhibit high specific strength and stiffness due to the high cellulose content which is 70-80% and relatively low microfibrillar angle. Due to its excellent mechanical properties, PALF have a high reinforcing efficiency for application in polyester, low density polyethylene (LDPE) and biodegradable plastic composites. There are also some limitations encounters in the PALF biocomposites due to an inadequate bonding between PALF and hydrophobic matrix. PALF biocomposites also has high susceptibility to water absorption, particularly at elevated temperatures [4]. Blending PAPF with LDPE will increase the mechanical properties of the composites as they have satisfactorily high specific strength and modulus light weight. However, increasing percentage of PAPF composition in the blend will introduce to the lower mechanical properties. The usage of suitable compatibilizer can reduce the incompatibility and increase the

mechanical properties of the blend. In this study, LLDPE-g-MA will be utilized as compatibilizer to improve the strength and the mechanical properties of the blend PAPP and LDPE. The cooking oil were added as a function of processing aids. In addition, the PAPP were treated with alkali and peroxide to modify the fiber surface.

2 Methods

The pineapple peel fiber was supplied by Lee Pineapple Co. (Pte.) Ltd. LDPE was supplied by Titan Polyethylene (M) Sdn. Bhd. The PAPP was treated with alkali treatment, NaOH to improve the adhesion between fiber and matrix and mixed with the Linear low-density polyethylene-grafted maleic anhydride (LLDPE-g-MA) and cooking oil. The fiber was immersed in 0.5% NaOH solution for half an hour before being washed several times with cold water and finally with acidified water, HCl 0.1 N. Then, the fiber was dried in an air oven at 60°C for 24 hours. PAPP based biocomposites were dried in the oven at 80°C for 24 hours to eliminate moisture content. LDPE, PAPP and compatibilizer were mixed manually. First, the LDPE was well mixed with the plasticizer. Then, PAPP and compatibilizer were added into the mixture and were mixed again. The compounding of PAPP biocomposites were done using SINO PSM 30 co-rotating twin screw extruder in the feed, compression, metering and die zone with suitable temperature (150°C, 155°C, 165°C, 165°C, 150°C, and 140°C) and formulations were listed in Table 1. The pre-mix PAPP biocomposite were fed to feed hopper into the feed section of the barrel. The biocomposites were melted and mixed in various shearing by shearing action of the screw at speed 80 rpm. Then, continuous strands were formed through the die when the composites passed through the die zone. The biocomposites were pelletized using pelletizer machine.

Water absorption test were carried out to determine the resistance ability of the samples in the water. The samples were first being dried at 50°C in an oven for 24 hours and immediately weighed. According to ASTM D570, the samples of thickness 3.00 ± 0.05 mm were entirely immersed in a container of distilled water. At specified interval, each sample was removed from the water container, wiped with a clean cloth, and consequently weighed. The weight gains of the samples were recorded and the percentages of weight gain, M_t were determined by equation 1.;

$$M_t (\%) = \frac{(W_w - W_d)}{W_d} \times 100$$

where,

$$\begin{aligned} W_d &= \text{Initial weight samples} \\ W_w &= \text{Weight of samples after exposure to water absorption} \end{aligned}$$

The samples were buried in the soil for about a month in a preparation box and the initial weight of the samples were recorded. On the testing day, the samples were wiped cleanly, and then will be dried in the oven at 60°C for 24 hours. The final weights of the samples were recorded and the percentages of weight loss were calculated using the following equation 2.;

$$\text{Weight loss } (\%) = \frac{(W_o - W_s)}{W_o} \times 100$$

where,

$$\begin{aligned} W_o &= \text{Initial weight of the samples} \\ W_s &= \text{Final weight of the samples} \end{aligned}$$

Table 1. Formulations of PAPP based biocomposites

Samples	LDPE, (%)	PAPP, (%)	Plasticizer, (%)	LLDPE-g-MA, (%)
LDPE	100	-	-	-
LDPE/PAPP:50/50	35	50	5	10
LDPE/PAPP:60/40	45	40	5	10
LDPE/PAPP:70/30	55	30	5	10
LDPE/PAPP:80/20	65	20	5	10
LDPE/PAPP:90/10	75	10	5	10

3 Results and Discussion

Water Absorption Test. Water absorption test is important to determine the water absorptivity of the biocomposites during certain period. The abundant of cellulose content when used to reinforced hydrophobic matrices; the result is a very poor interface and poor resistance to moisture absorption. Cellulosics fiber is difficult to dissolve because of their high crystallinity but they tend to retain liquids in the interfibrillar space. Based on Figure 1, the amount of water absorption increased with the increases of PAPF loading due to the higher cellulose content. The LDPE/PAPF with 50% PAPF composition shows the highest increment in the weight due to the higher water absorption. The percentage of weight gained for 50% PAPF loading was 7.6%. The 10% of fiber loading shows no significant changes in their weight compared to the others. The treated PAPF reduced the water absorption because of better interfacial bonding. To promote the adhesion between the fiber and the matrix, chemical treatment or modifications are considered. Chemicals activate the hydroxyl groups or introduce new moieties that can effectively interlock with the matrix [5]. Alkali treatment has two effects on the fiber which are increasing the surface roughness resulting in better mechanical interlocking; and increasing the amount of cellulose exposed on the fiber surface, thus increasing the number of possible reaction sites. Alkali treatment also reduces the polarity of the PAPF which increased the crystallinity and reduced the sorption capacity of the fiber. The chemically modified LDPE/PAPF exhibited a reduction in water uptake.

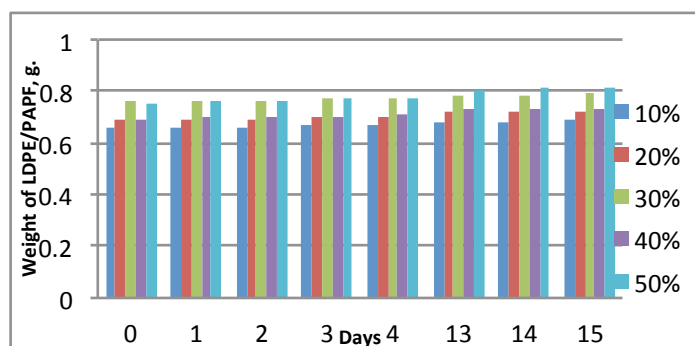


Figure 1. Weight gained of PAPF based biocomposites with various fiber contents

Melt Flow Analysis. Table 2 shows that the MFI values for LDPE/PAPF decreased as the fiber loading increased. The decreasing of MFI values indicates the decreasing in the flow ability of the biocomposites. The decreasing in the MFI values also indicates the increasing of the viscosity of the biocomposites. The viscosity of the system increased with fiber loading due to an increased hindrance to the flow. Addition of bonding agents increases the viscosity of PAPF biocomposites due to the increased fiber-matrix interaction. The mechanical interlocking between fiber and matrix was increased due to the removal of the waxy material present on the surface of the fiber [6].

Table 2. Melt flow index of PAPF based biocomposites

Samples	Composition	MFI value (g/10 min)
LDPE	100	4.78
LDPE/PAPF	90/10	6.92
LDPE/PAPF	80/20	5.10
LDPE/PAPF	70/30	2.89
LDPE/PAPF	60/40	0.90
LDPE/PAPF	50/50	0.60

Soil Burial Test. Figure 2 presents the weight changes of the biocomposites after being buried in the soil for specified periods. There were no significant decreased in the biocomposites weight for PAPF loading of 10%, 20%, 30% and 40% but 50% PAPF loading shows the opposites. The percentage of weight loss for 50% PAPF loading was 3.5%. This shows that the higher PAPF loading expected to have the higher weight loss after soil burial. The alkali treated PAPF biocomposites inhibits biodegradation of LDPE/PAPF in the soil. The interface between the fiber and the matrix and the fiber volume fraction affects the biodegradation of biocomposites in the soil [6].

4 Conclusion

The study on the effect of PAPF loading shows that the alkali treatment of the PAPF will affect the characteristics, mechanical and thermal analysis of the biocomposites. The improved fiber-matrix interaction increased the viscosity of LDPE/PAPF thus decreased the MFI values. The flow behavior of LDPE/PAPF decreased as the PAPF loading increased. The increased in PAPF loading increased the amount of water uptake due to the abundance of cellulose in PAPF. However, the large amount of water uptake can be hindered by treating the PAPF. The reinforcement of LDPE and PAPF also shows the biodegradable characteristics as the LDPE/PAPF reduced weight after being buried in the soil for a month. PAPF biocomposites can be a new alternative for green packaging purpose as it is stronger, stiffer and more degradable besides can reduce the cost.

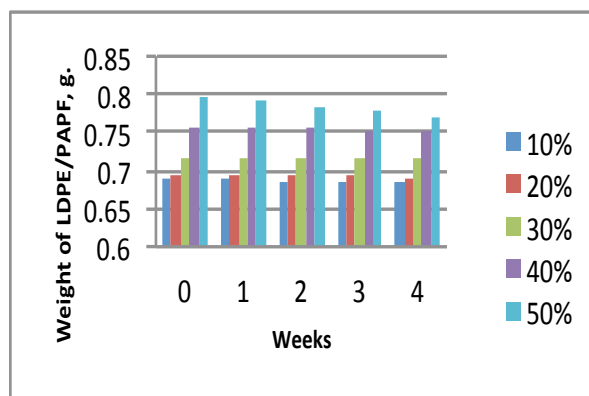


Figure 2. Weight loss of PAPF based biocomposites with various contents of fiber

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