1st ICDI International Conference on Design and Innovation

2012 PROCEEDINGS

SUSTAINABLE GROUND

07 08 Nov. 2012

Processing and Characterization of Durian Skin Fibers Composites: Mechanical Properties

CONTACT INFORMATION
Mohd Romainor Manshor
romainor@gmail.com
Hazleen Anuar
Nur Aimi Mohd Nasir
Ahmad Fitrie Mohd Ithnin
Mohammad Rejaul Kaiser
Department of Manufacturing and Materials Engineering, Faculty of Engineering, International Islamic University Malaysia (IIUM), Malaysia.

Wan Nazri Wan Busu
Food Technology Research Center, Malaysian Agricultural Research and Development Institute (MARDI), 43400 Serdang, Malaysia.

Abstract
Durian skin fibers are the newly explored fiber as reinforcement for thermoset and thermoplastic to produce composites products. This paper presents the effect of fiber loading on mechanical behaviors of DSF reinforced composites. Biocomposites of poly(lactic acid) (PLA) reinforced with durian skin fibers (DSF) were prepared by melt compounding using twin-screw extruder and an injection molder. The mechanical properties including tensile properties and flexural properties of the composites increased with the increasing fiber content. The results show that the properties of composites are better when the content of the DSF is 30%. At fiber loading 30%, the composites can get the best mechanical properties.
Keywords: Durian skin fiber, biocomposites, natural fiber, mechanical properties.

1. Introduction

In recent years, great progress was achieved in the development of biodegradable products on the basis of agricultural raw materials. A wide variety of natural biodegradable polymers like collagen, gelatin, and chitosan etc. and synthetic biodegradable polymers like polylactic acid (PLA), polyglycolic acid (PGA) and their copolymers etc. have been investigated recently for broad applications.

PLA is a commercially available biopolymer. It is a biodegredable thermoplastic polyester produced from L-and D-lactic acid, which is derived from the fermantation of corn starch[1]. Their physical and chemical properties can be easily modified to achieve desirable mechanical and degradation characteristics [1]. Therefore, PLA can be a potential structural material. The properties of PLA are determined by the weight ratio of the two lactic molecules. PLA can therefore vary from being an amorphous polymer to being a semi or highly crystalline material[2]. PLA is the one of the few biopolymers available today which have similar properties as fossil fuel based commodity plastics. However PLA softens at lower temperatures compared to equivalent petroleum based polymers[3]. A low softening temperature results in a lower temperature of use of material, which in turn will limit the number of application of the material. Preparation of nano composites has been considered a promising method to increase the softening temperature of biopolymers[4,5].

In Malaysia, the uses of plant fibre reinforced composites have been increasingly studied recently. With increasing concern regarding environmental issues, scientists are seriously looking at natural fibres (plant fibre) as alternative to replace man-made fibres [6]. Current local researchers are using fibre from palm oil, rice husk and kenaf as filler for use in thermoplastic matrix composites. Among fillers, natural fibre has many advantages, including low density, little damage during processing, little requirements on processing equipment, bio-degradability, high stiffness and relatively low price [7]. Durian skin fibers are the newly explored fiber as reinforcement for thermoset and thermoplastic to produce composite products. It is important to understand their physical and mechanical properties so that it be can used in appropiate and variety of applications [8]. Different percentage of DSF was used to improve the tensile strength and ductility. So in order to optimize the properties of biocomposite, a comprehensive study on the physical characteristics of PLA/DSF composite is necessary.

2. Materials and methods

Materials and processing

Durian skins were obtained from local market. The freshly skins were washed thoroughly with tap water to remove any adhering particles and dusk. After that, the skins were chopped and ground, and dried in an oven at 80°C for 12 h. Next, dried durian skins were hammermilled and the dried skins were screened by siever over a screen size of 1mm of Durian skin fibres (DSF). Polylactic acid (PLA) (grade 3051D) produced by NatureWorks®, China was used. Its specific gravity and melting temperature as well as glass transition temperature were recorded at 0.998 g/cm3, 152.3 °C and 57-61°C, respectively.

Fibre surface treatments

Pre-dried DSF were soaked with 4 wt% of sodium hydroxide (NAOH) (Sigma Aldrich) solution for 3 hours at ambient temperature followed by washing with distilled water until neutralization. The DSF were then dried by dryer for 24 hours at 50 °C, followed by oven dried at 80 °C for another 24 hours.

Compounding process

In this study, different loading of DSF were investigated. Dried PLA (80°C, 24h) were compounded with treated DSF (10, 20 and 30 wt %) fibre) in a Thermo Hakke twin screw extruder. After compounding, the composites were pelletized and went for injection molding by using BATTENFELD HM 600/850 injection molding machine.

Characterization

The tensile and flexural test was performed by using a computer controlled universal testing machine (LLOYD) as per ASTM D-790 test method.

3. Results and discussion

Tensile strengths and modulus

Figure 1 and 2 summarizes the average tensile strengths (MPa) and tensile modulus of each sample of the PLA/DSF with corresponding standard deviation. The tensile strengths slightly improve with increased fiber content with the exception of the pure PLA. The tensile strength of PLA when reinforced with 10% DSF is 44.26 Mpa and reached the highest at 30% fibre loading with the value is 51.43 Mpa. When the fibre loading were 40%, the strength went down to 42.61 Mpa. From the data it has been observed the the composites with reinforced 30% DSF can withstand maximun load before failure. The increase in strength is associated with a strong bond interface between PLA and the fiber, which also causes increased stress transfer efficiency. The decrease in tensile strength at 40% DSF because the dissipation of fibre in PLA matrix become bad [9].In contrast to tensile modulus, figure 2 show that the modulus decreased as the fibre content increase with the exception of the 40% due to that the addition of the natural fiber limits the mobility of the polymer matrix. Then when the more the 30% fibres were added, the tensile modulus of composites decreases due to the bad dispersion of fiber in the PLA.

Figure 1. Effect of DSF loading on the tensile strength (MPa) of PLA/DSF composites.

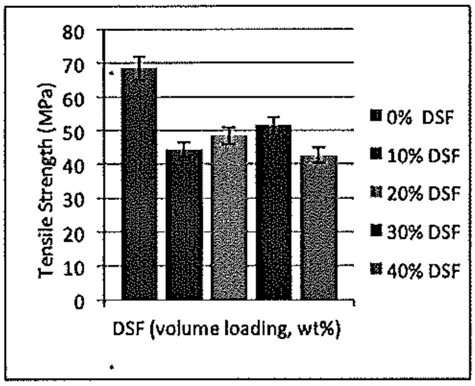
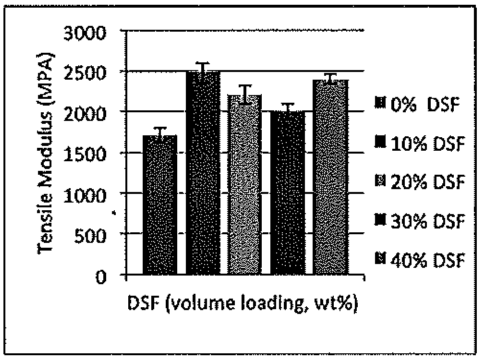


Figure 2. Effect of DSF loading on the tensile modulus (MPa) of PLA/DSF composites.



Flexural strength and modulus

Figure 3 and 4 shows the flexural properties of PLA/DSF based composites. From the data, the flexural strength of the composites increases compared with the increased of DSF into PLA matrix due to the addition of fibre and an efficient stress transfer between PLA and DSF [10]. When the content of fibers is over 30%, the flexural strength of composites decreases due to the bad dispersion in the matrix. The flexural modulus showed in contrast. The average of flexural modulus decreased with increased fibre content, a trend similar to tensile modulu properties. This may suggest that the increase of fibre attributed to the increased of fibre defect and the fibre ends[10].

Figure 3. Effect of DSF loading on the flexural strength (MPa) of PLA/DSF composites.

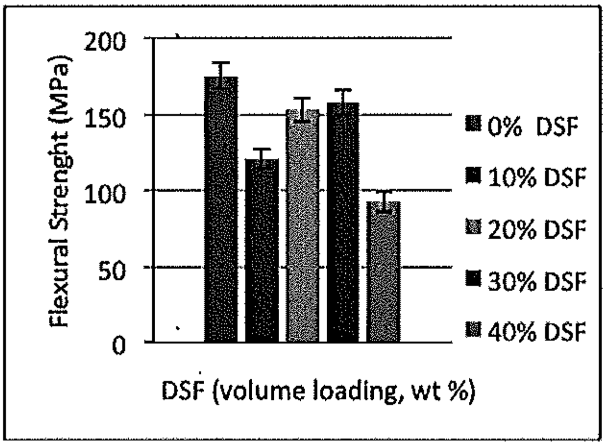
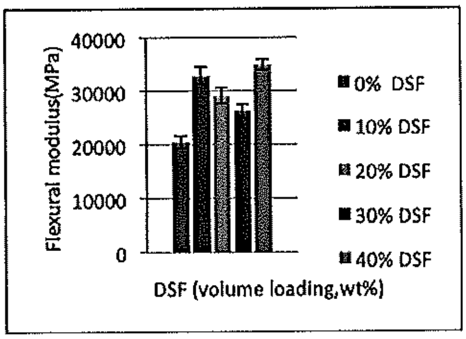


Figure 4. Effect of DSF loading on the flexural modulus (MPa) of PLA/DSF composites.



4. Conclusions

It is well known that the mechanical strength of natural fiber composites is essentially controlled by the interfacial bonding between the fibre and matrix. In this study, DSF have been used as filler and PLA was used as a matrix. As a result, the optimum fiber loading for DSF into PLA is at 30%. When the fiber increased over 30%, the tensile and flexural properties were drop significantly.

References

[1] Cheung, Hoi-yan Karen, (2009). Development of a silkworm silk fiber-reinforced polylactic acid bio composite, Hong Kong Polytechnic University.

[2] Zanetti M, Gamingo G, Thomann R, Malhupt R. Synthesis and thermal behaviour of layered silicate. EVA nanocomposites. Polymer 2001;42(10):4501-7.

[3] Okamoto M, Morita S, Taguchi H, Kim YH, Kotaka T, Tateyama H. et al. Synthesis and structure of smeetic clay/poly(methyl methacrylate) and clay/polystyrene nanocomposites via insitu intercalative polymerization. Polymer 2000;4(10):3887-90

[4] Yao KJ, Song M, Hourstn DJ, Luo DZ, Polymer/layered clay nanocomposites: 2-polyurethane nanocomposites. Polymer 2002;43(3):1017-20

[5] Pluta M, Galaski A, Alexandre M,Paul M.A, Dubois P. Polylactide/montmorillonite nanocomposites and microcomposites prepared by melt blending: structure and some physical properties. J Appl Polym Sci 2002;86(6):1407-506.

[6] Abdul Khalil H. Ismail, (2001). Effect of acetylation and coupling agent treatments upon biological degradation of plant fibre reinforced polyester composites, Polymer Testing, No. 20, pg 65-75.

[7] J.K Sameni, S.H. Ahmad, S. Zakaria, (2004). Effect of MAPE on the mechanical properties of rubber wood fibre/ thermoplastic natural rubber composites, Advances in Polymer Technology, Vol.23, No. 1, pg 18-23.

[8] Narendra Reddy and Yiqi Yang. Structure and properties of high quality natural cellulose fibers from cornstalks. Polymer 46 (2005) 5494–5500.

[9] DAVID P, TOM L A, WALTHER B P, LOTTE N. Biodegradable composites based on L-polylactide and jute fibres [J]. Compos Sci Technol, 2003, 63: 1287-1296.

[10] Sawpan, M.A., Pickering, K.L., Fernyhough, A., Flexural properties of hemp fibre reinforced polylactide and undaturated polyester composites, Composites: Part A (2011).