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The effect of fiber length on the mechanical properties of pineapple leaf (PALF) fiber reinforced PLA biocomposites

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ABSTRACT – This research work investigates the effect of fiber length on the mechanical performance of the pineapple leaf fiber (PALF) reinforced poly lactic acid (PLA) biocomposites. Two types of composite systems are considered, these being the short (fiber length of 30 mm) and continuous long pineapple leaf fiber (fiber length greater than 100 mm) reinforced composites. The corresponding fabrication routes are melt-mixing and compression molding via film stacking, respectively. The test samples with nominal thickness of 3 mm were cut to size and subjected to flexural testing via three-point bending set-up, as per ASTM D790. As expected, the continuous long pineapple leaf fiber reinforced composites exhibit greater flexural strength and modulus, with flexural strength and modulus being 30% and 45% than those of the short fiber reinforced composites. These preliminary findings reveal the effect of fiber length on the overall performance of the composites studied.

1. INTRODUCTION

Natural fiber reinforced PLA composites are purely bio-based material with a promising mechanical properties profile in comparison to non-renewable petroleum based products. Nonetheless, this type of material is brittle and has relatively low tensile strength and impact properties in comparison to that of the non-renewable petroleum based polymer [1]. The mechanical properties of such composites depend on the type of fiber used and its homogenization to the matrix. Among the key governing factors that affect the mechanical properties are (i) the content of cellulose in the fiber, (ii) fiber orientation (iii) fiber length and fiber diameter [1].To-date, majority of research studies have focused on physical and mechanical characterization of short-fiber reinforced PLA-based biocomposites with the fiber length of approximately 30 mm or less [2-8].

Thus, this research work aims to contribute in the understanding of influence of the fiber architecture in terms of fiber length on the mechanical properties of the PLA degradable biocomposites, which can provide rigorous input in designing new composite materials (green composites) as a substitute to existing non-renewable petroleum-based products in automotive industry. However, this research paper is focus on the preliminary results obtained from a series of experimental work on the mechanical properties of the biocomposites, using the continuous long fiber as the reinforcement for the plain PLA matrix material.

2. METHODOLOGY

2.1 Raw materials

The biocomposites are fabricated from poly lactic acid (PLA) matrix, supplied by Natureworks (6100D) and pineapple leaf fiber as reinforcement, supplied by Macrocom (M) Sdn Bhd. For this study, all of the test samples are fabricated using an optimum fiber loading, which is at 30 wt. % as reported in the literature [7]. To aid in wetting of the fiber and matrix in the composites, the pineapple leaf fibers were pre-treated using NaOH solution and dried prior to fabrication process. In addition, PLA pellets were also oven dried in the oven at temperature of 60°C for a minimum of 8 hours before proceeding with the fabrication process.

2.2 Fabrication process

There are two types of composites considered for this study; these being the short fiber PALF reinforced PLA biocomposites and the continuous long PALF fiber reinforced PLA biocomposites, with the fiber length of 30 mm and greater than 100 mm for the short and long fiber reinforced composites, respectively.

2.2.1 Short fiber reinforced composites

The short fiber reinforced biocomposites were prepared using a two-step processing. First, the raw materials underwent melt-mixing process using a ThermoHaake machine to form a composites blend. Following these, the composites blend was compression molded to size using a Hot Press machine to produce test samples with nominal thickness of 3 mm each for mechanical characterization.

2.2.2 Continuous long fiber reinforced composites

Continuous long fiber reinforced composites were prepared using a two-step processing, with fiber length and loading of >100 mm each and 30 wt. %. First, the plain PLA material was compression molded into thin films having nominal thickness of 1 mm each. The cured PLA thin films were then stacked together in between the continuous long pineapple leaf fibers using hand lamination and subjected to applied pressure and temperature using a Hot Press machine. The final nominal thickness of the test samples is approximately 3 mm each.

2.3 Mechanical characterization

A flexural test, using a three-point bending set-up was considered to characterize the flexural properties of both types of biocomposites. According to ASTM D790, specimens with dimension of 74 mm x 12 mm x 3 mm were considered. The test samples were then placed on two supports and load were applied.

3. RESULTS AND DISCUSSION

Preliminary results following flexural tests on the PALF reinforced PLA biocomposites as well as data from the literature on PALF reinforced PP composites [7] are listed in Table 1. The continuous long PALF fiber reinforced PLA composites exhibit much greater flexural strength (>30%) and modulus (> 45%) than those of the short fiber reinforced composites of the same fiber loading (30 wt. %). Moreover, these values are also compatible or superior (flexural modulus) to those of the reinforced PP composites [7] of similar fiber loading.

Table 1 Flexural properties of PALF reinforced composites.

Sample	Flexural strength	Flexural Modulus
Short fiber reinforced composites		
PALF reinforced PLA composites	33.6±4.8	2.2 ±0.2
PALF reinforced PP composites [7]	34.8	2.6
Continuous long fiber reinforced composites		
PALF reinforced PLA composites	44.4±15.4	3.17±0.2
PALF reinforced PP composites [7]	68.0	1.94

4. CONCLUSION

In conclusion, the preliminary results following flexural tests on the short and continuous long PALF fiber reinforced PLA biocomposites were assessed as a function of fiber length. As expected, the continuous long fiber exhibit better mechanical properties in comparison to those of the short fiber, demonstrating the effect of fiber length in the mechanical performance of a composite system. However, further works in this area are required to fully characterize the composites behavior under various loading conditions such as tensile, compression and impact as well as other characterization such as physical and thermal properties to provide an insight into the behavior of PALF reinforced PLA biocomposites.

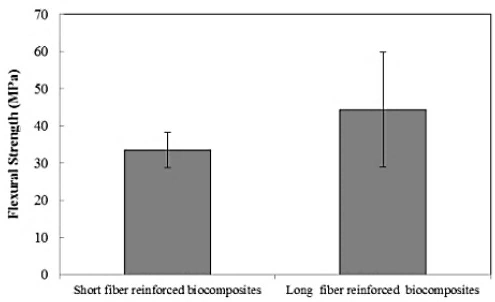

Figure 1 Flexural strength values for the short PALF fiber and continuous long PALF fiber reinforced PLA biocomposites.

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