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BENDING TEST IN EPOXY COMPOSITES REINFORCED WITH CONTINUOUS AND ALIGNED PALF FIBERS*

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Abstract
In the context of changing culture, the society is increasingly looking for environmentally friendly materials, the natural fibers appear as an option to substitute the synthetic. Among these natural fibers, the PALF fiber may be considered an option, but there is limited information about the flexural strength of epoxy composites incorporated with PALF fibers. Therefore, the objective of this work was to investigate the mechanical properties in bending tests of epoxy composites incorporated with up to 30% in volume of PALF fibers. The results showed that the PALF fiber increase the flexural strength of polymer composites.
Keywords: PALF fibers; Bending test; Natural fibers.

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1 INTRODUCTION

In the search for environmentally friendly materials, the natural fibers extracted from cellulose-containing are been investigated to replace the synthetic ones in polymer composites. They are abundant, renewable, biodegradable, recyclable and above all, neutral with respect to carbon dioxide emission, associated with global warming and greenhouse effect. They are considered an environmentally correct alternative to replace, non recyclable, energy-intensive and including more expensive synthetic fibers [1-3], like the glass fiber. Previous works demonstrate that the incorporation of lignocellulosic fibers in polymeric matrix gives rise to composites with mechanical resistance directly proportional of the fiber content [4-5], where these fibers act as reinforcement for matrix due to their high mechanical properties. Therefore, this study aim to evaluate the tensile properties of epoxy matrix composites reinforced with continuous and aligned PALF fibers.

2 MATERIALS AND METHODS

The basic material used in this work was the PALF fiber supplied by Desigan Natural Fibers and a diglycidyl ether of the bisphenol A (DGEBA) epoxy resin and TETA hardener (trietylene tetramine) was used as matrix. One hundred PALF fibers shown in figure 1 are randomly selected from the bundle, the equivalent diameter corresponding to the average between the larger and smaller (90º rotation) cross section dimensions at five locations for each fiber, was measured in a profile projector Nikon 6C. Figure 2 presents histogram corresponding to the distribution of diameter of the as-received PALF fibers. The equivalent diameter of each fiber was actually the average value obtained by 10 different measurements performed in a profile projector at five distinct locations (two with 90º rotation at each location).

Figure 1. A smail bundle of PALF fibers.

The histogram in Figure 2 reveals a relatively large variation in the diameter, which is a consequence of the non-uniform physical characteristics of a

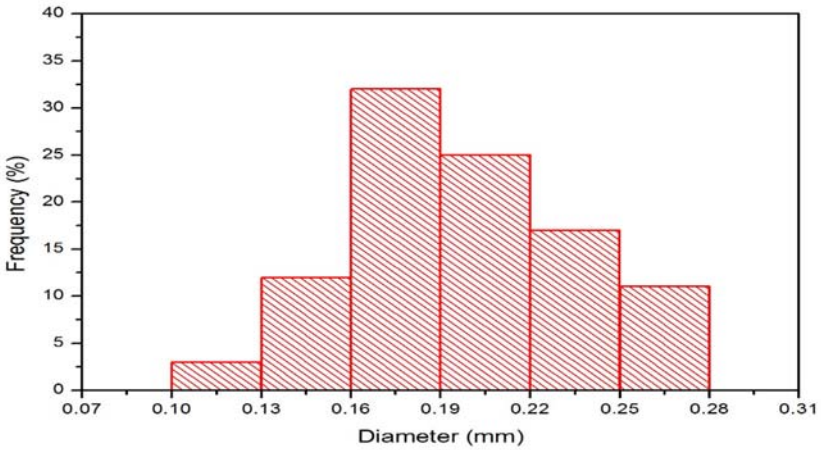

Figure 2. Histogram for the distribution of diameter's PALF fibers.

lignocellulosic fiber [1,3,5-8]. It should be noticed that the diameter range was 0.10-0.28 mm with an average of 0.20 mm. The still fluid epoxy resin was poured onto the fibers and pressured in the mold up to 2 tons, creating the composites plates for each volume fraction. The already processed composites plates were allowed to undergo an cure at room temperature for 24 hours. Each plate corresponding to a given amount of fiber was then cut into 6 specimens with 122 x 25 x 7 mm. These specimens were three points bend-tested in a model 5582 Instron machine with capacity of 100 kN, with a span-to-depth ratio of 9 at a constant speed of 10^{-4} m/s.

3 RESULTS AND DISCUSSION

A typical flexural force *vs.* deflection curve obtained from the machine acquisition data program are show in Figure 3. In this figure it should be noticed that the flexural curve for the PALF fiber reinforced composite specimens display limited plastic deformation. Indeed, after the first linear elastic part of the curves in Figure 3, a drop associated with the rupture occurs gradually, followed by some sharps, indicating that maybe some fibers were been pulled out of the composite, and after this, they were getting fixed again in the matrix, rising the resistance for a short time.

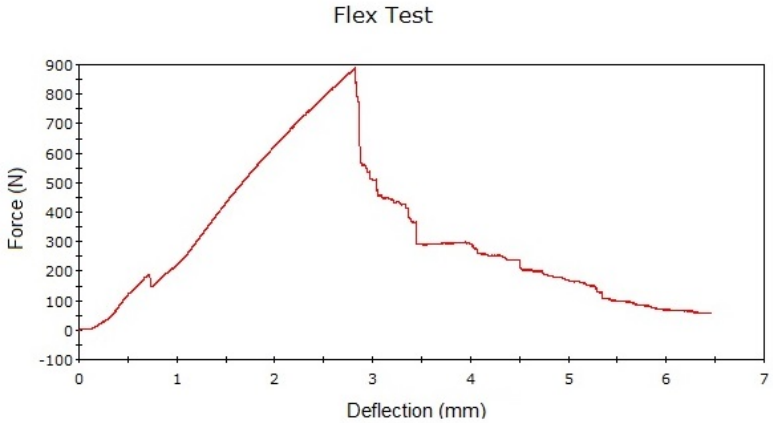

Figure 3. Typical force *vs.* deflection curve for flexural test of epoxy composite with 30 % of volume fraction of PALF fibers.

The flexural strength (maximum bend stress) was calculated for each amount of fiber from curves such as the ones shown in Figure 3. Table 1 presents the flexural strength and the corresponding volume fraction of fiber. It is important to note that the flexural strength tends to increase with the amount of fibers incorporated to the composite.

Table 1. Flexural results for the epoxy composites reinforced with PALF fibers

Volume Fraction of fibers (%)	*Flexural Strength (MPa)*
0	48.71 ± 4.90
10	56.27 ±9.31
20	78.31 ± 3.54
30	84.97 ± 7.39

A curve of variation of flexural strength with the volume fraction of PALF fibers are made of from the results in the table 1 and presented in the Figure 4. Some comments about this curve should be made. Within the error bars, the flexural strength are continuous, in a linear way, with the volume fraction of incorporated PALF fibers.

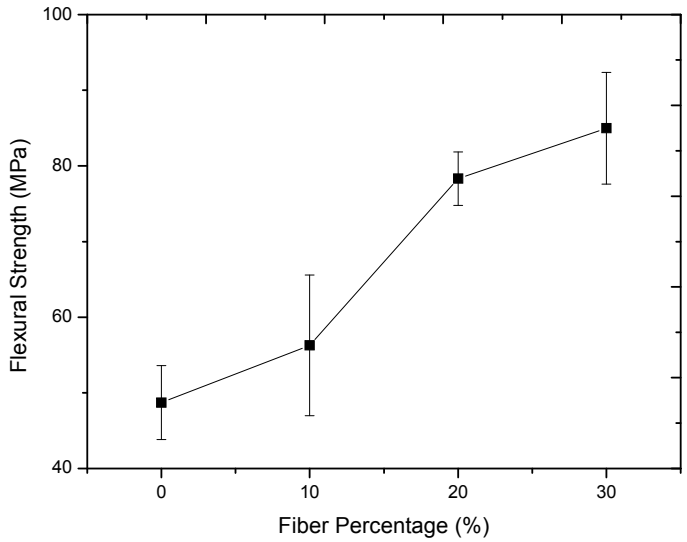

Figure 4. Variation of flexural strength with the PALF fiber percentage.

It is relevant to emphasized that continuous and aligned PALF fiber improve the flexural strength of the composite in any volume fraction. This improvement shows a continuous line and can be considered as a linear growing in the flexural strength within the error bars. With lower amounts of fibers, the cracks propagations occurs transversally through the brittle epoxy matrix with limited interference of the relativity fewer PALF fibers. On the other hand, above 20% in volume fractions, cracks are effectively arrested by the PALF fiber what causes the participation of the stronger fibers in the rupture mechanism, which contributes to a higher strength of the composites.

4 CONCLUSIONS

- Epoxy matrix composites reinforced with continuous and aligned PALF fibers show an improvement in the strength as compared to the pure epoxy matrix.
- Samples above 10% of PALF fibers did not completely brake. This occurs because of the poor interface between the PALF fiber and the epoxy matrix.
- The fracture was displaced to the fiber/matrix interface, what increased the energy to completely rupture of the specimens.

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