TENSILE STRENGTH OF POLYESTER COMPOSITES REINFORCED WITH PALF*

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Abstract
The environmental concern is creating pressure for the substitution of high energy consumption materials for natural and sustainable ones. Compared to synthetic fibers, natural fibers have shown advantages in technical aspects such as flexibility and toughness. So there is a growing worldwide interest in the use of these fibers. PALF extracted from pineapple leaves, presents some significant characteristic, but until now only few studies on PALF were performed. This work aims to make the analysis of the tensile strength of polyester composites reinforced with PALF. The fibers were incorporated into the polyester matrix with volume fraction from 0 to 30%. After fracture the specimens were analyzed by a SEM (scanning electron microscope).
Keywords: Polyester composites; Mechanical behavior; PALF; Fracture analysis.

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1 INTRODUCTION

In the last century, synthetic fibers such as nylon, carbon, aramid and glass fibers gained interest owing to superior strength and precise dimensional control. Natural fibers were then replaced by synthetics in many fields such as textiles, sports goods and appliances. In particular, research works have disclosed the potential advantages associated with the use of lignocellulosic fibers as the reinforcing phase in polymer composites [1-2]. In addition to environmental benefits the lignocellulosic fibers present economic advantages, such as worldwide abundance and comparatively low costs as well as some technical properties associated with flexibility and toughness, which contribute to the performance of automobile components fabricated with natural fibers composites [3-4].
Even review works on the application of natural fibers in composites [5-6] fail to report on PALF. Since the heterogeneous characteristics of lignocellulosic fibers is a limitation for their use in composites, the present work carried analysis of mechanical behavior on tensile strength of composites of polyester reinforced with PALF.

2 EXPERIMENTAL PROCEDURE

PALF were selected randomly to serve as reinforcement to an polyester matrix. These fibers, with diameter varying from 0.09 to 0.30mm, were laid down inside silicone dog bone-shaped molds with distinct volume fractions up to 30%. The fibers were continuously aligned along the 35 mm length of the mold, coinciding with the tensile axis. The still fluid polyester resin was poured onto the fibers. The already processed composites were allowed to undergo an initial cure at room temperature for 24 hours. For each volume fraction of PALF, more than 10 specimens were fabricated.
Each specimen was tested at 25 ± 2°C in a model 5582 Instron machine at a strain rate of 3×10^{-3} s^{-1}. Samples cut from the fracture tip of representative specimens were coated with gold prior to microscopy work using a Shimadzu SSX-550 scanning electron microscope.

3 RESULTS AND DISCUSSION

Typical tensions versus elongation curves for each specimen with the respective volume fraction of PALF were obtained. These curves were directly recorded from the Instron machine data acquisition system. With this was constructed the Tab. 1 that shows the values for the tensile strength, elastic modulus and total tensile strain for the different composites investigated.

Table 1. Tensile properties for polyester composites reinforced with PALF.

Volume fraction of PALF fiber (%)	*Tensile Strength (MPa)*	*Elastic Modulus (GPa)*	*Total Deformation (%)*
0	28.99 ± 6.58	0.83 ± 0.23	3.66 ± 1.20
10	53.68 ± 10.88	1.31 ± 0.59	5.44 ± 2.84
20	85.54 ± 10.62	1.71 ± 0.26	5.17 ± 0.68
30	119.84 ± 10.59	1.83 ± 0.31	6.95 ± 0.91

Based on table 1 results, Figure 1 presents composites mechanical propreties with the volume fraction of PALF.

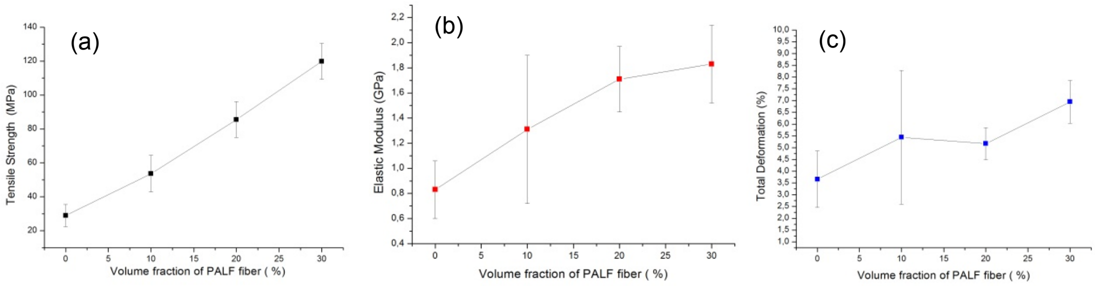

Figure 1. Variation of the tensile strength (a), elastic modulus (b) and the total deformation (c) with the volume fraction of PALF reinforcing polyester composites.

As shown in Figure 1(b), the incorporation of PALF significantly increases the elastic modulus, but it appears to maintain constant with fiber incorporation above 20%, with a value around 1.4 GPa. It is also possible to verify that the incorporation of PALF decreases the maximum elongation of the composites. This can be associated with the behavior of the fibers, which is not able to elongate as much as the polyester matrix. Therefore, their incorporation tends to decrease the elongation capacity of the material. Figure 2 shows typical SEM fractographs of a 30% volume fraction of PALF composites. With lower magnification, Figure 2(a), the fracture surface display evidence of broken fibers sticking out of the polyester matrix.

Figure 2. Microstructure of composite with 30% vol. of fibers: (a) 100X and (b) 700X.

However, a few holes in the surface of Figure 2(a) could also indicate a low fiber/matrix interfacial resistance, as indeed happens in lignocellulosic fibers reinforcing polyester matrices. In this respect, Figure 2(b) with higher magnification shows a crack alongside a PALF beginning to detach it from the polyester matrix. Therefore, although PALF could improve the strength of polyester composites, the weak adhesion between the fiber and the composite matrix is still an important limitation to further increase in the mechanical strength and stiffness.

4 CONCLUSIONS

Selected PALF significantly improve the strength of polyester matrix composites. This improvement corresponds basically to a linear increase up to 30% in volume of fiber and surpasses the flexural results with similar composites.

The elastic modulus of the polyester composites is also increased with the volume fraction of PALF, while the maximum tensile strength does not appreciably changes.

SEM analysis indicates that PALF act as effective reinforcement for the brittle polyester matrix despite the weak fiber/matrix interface. In fact, the same fibers are well adhered to the polyester matrix but evidence of fiber pullout from the matrix indicates a relatively low interfacial shear stress. This is an important limitation for further composite improvement.

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