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TENSILE STRENGTH OF POLYESTER COMPOSITES REINFORCED WITH FIQUE FIBERS

Giulio Rodrigues Altoé, Pedro Amoy Netto[1], Maria Carolina Andrade Teles[1], Glenio Daniel[1], Frederico Muylaert Margem[1], Sergio Neves Monteiro[2].

1 State University of the Northern Rio de Janeiro, UENF, Advanced Materials Laboratory, LAMAV; Av. Alberto Lamego, 2000, 28013-602, Campos dos Goytacazes, Brazil
2 Instituto Militar de Engenharia , IME, Praça Gen. Tibúrcio, nº80 Urca, Rio de Janeiro - RJ, 22290-270
giulioaltoe@gmail.com

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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. Fique fiber extracted from fique plant, presents some significant characteristic, but until now only few studies on fique fiber were performed. This work aims to make the analysis of the tensile strength of polyester composites reinforced with fique fibers. 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).

Introduction

The interest of this research is to develop composites with polyester resin matrix reinforced with continuous and aligned fique fibers, for applications in various industries, including construction and automotive industry. Conflicts related to the use of non-renewable forms of energy are increasing the interest to enter the market to replace natural materials, synthetic materials synthetics have a higher power consumption in its manufacture [1-4].

Therefore, applications of natural lignocellulosic fibers obtained from cellulose-based plants are receiving increased attention as an alternative to replace more environmentally correct non-recyclable materials, energy intensive and glass fiber composites in [5-6].

The use of composites reinforced with natural fibers is a reflection of the concerns with environmental issues such as pollution caused by waste that is not biodegradable or cannot be incinerated and climate change due to CO_2 emissions associated with the processes of intensive energy and also motivates this work to develop self-sustaining, since natural fibers generate a source of income, especially in developing countries, where most originate, encouraging the cultivation of non-food agriculture [7-9]. Additionally, it is worth also remembering that these fibers come from renewable sources, in addition to being abundant, inexpensive and have a relevant set of mechanical properties [10].

Then, in order to have a composite rigid enough to compete with conventional products such as sheets of wood, only a limited percentage of fique fiber can be incorporated in the polymeric matrix [11-13]. This means that the final cost of the composite would more depending on its processing and polymer resin used as matrix. Therefore, the aim of this work was to study the mechanical properties of polyester matrix composites reinforced with continuous fibers and lined with fique.

Experimental Procedure

Composites were prepared with distinct volume fractions, up to 30%, of fique fibers incorporated into a commercial unsaturated polyester resin, already mixed with 0.5 wt% of methyl-ethyl-ketone. The as-received fique fibers were first cleaned in water and then dried at 60º C for 24 hours. Tensile specimens for each composite was fabricated by laying down the fique fibers in a flat and open dog-bone shaped silicone mold with 5.8 x 4.5 mm of reduced cross section and 35 mm of gage length of the specimen, which corresponds to the tensile axis. Still fluid polyester resin already mixed with the hardener was poured onto the fique fibers inside the mold and allowed to cure for 24 hours at room temperature.

A total of seven composite specimens were prepared for a given volume fraction of fique fiber. Each specimen was tensile tested in a model 5582 universal Instron machine at an acclimatized 25º C and a strain rate of 1.0 mm/s. The fracture surface of some representative specimens was attached to a metallic support by a conducting carbon tape and then coated with platinum to be analyzed by scanning electron microscopy, SEM, in a model SSX-550 Shimadzu microscope operating with secondary electron at an accelerating voltage of 15 kV.

Results and Discussion

Examples of tensile load vs. elongation curves for distinct volume fraction composite specimens are shown in Figure 1.

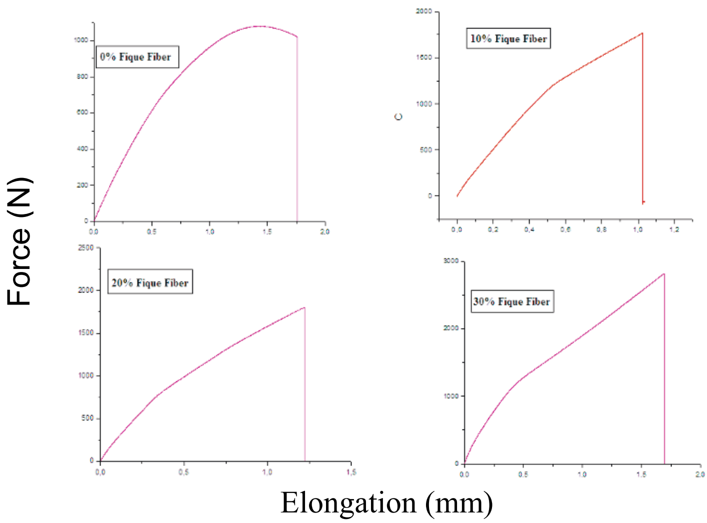

Figure 1. Tensile load vs. elongation curves for polyester composites of volume fraction of fique fibers

Figure 2 depicts the macro aspects of typical tensile ruptured specimens for each volume fraction of fique fiber incorporated into polyester composites.

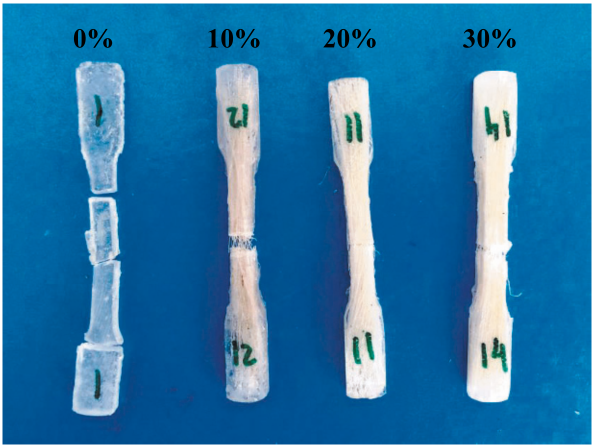

Figure 2. Typical tensile ruptured specimens of polyester composites with different volume fraction of continuous and aligned fique fiber

Based on the results of the tensile load vs. elongation curves, such as the ones shown in Fig 1, the tensile strength, elastic modulus and the total deformation were evaluated. Table 1 presents the average value of these tensile properties for the distinct volume fraction incorporated into polyester composite.

Table 1. Tensile properties of the polyester composites incorporated with continuous and aligned fique fibers

Volume Fraction of fique fiber (%)	Tensile Strength (MPa)	Elastic Modulus (GPa)	Total Deformation (%)
0	27.72 ± 7,22	0.31 ± 0.12	3.33 ± 2.80
10	32.98 ± 3.36	0.28 ± 0.23	7.30 ± 1.81
20	47.54 ± 6.42	0.68 ± 0.24	6.91 ± 1.31
30	61.65 ± 6.76	0.72 ± 0.11	8.88 ± 1.12

Figure 3 plots the variation of the tensile strength, elastic modulus and total deformation, presented in Table 1 for polyester composites, with the volume fraction of fique fibers.

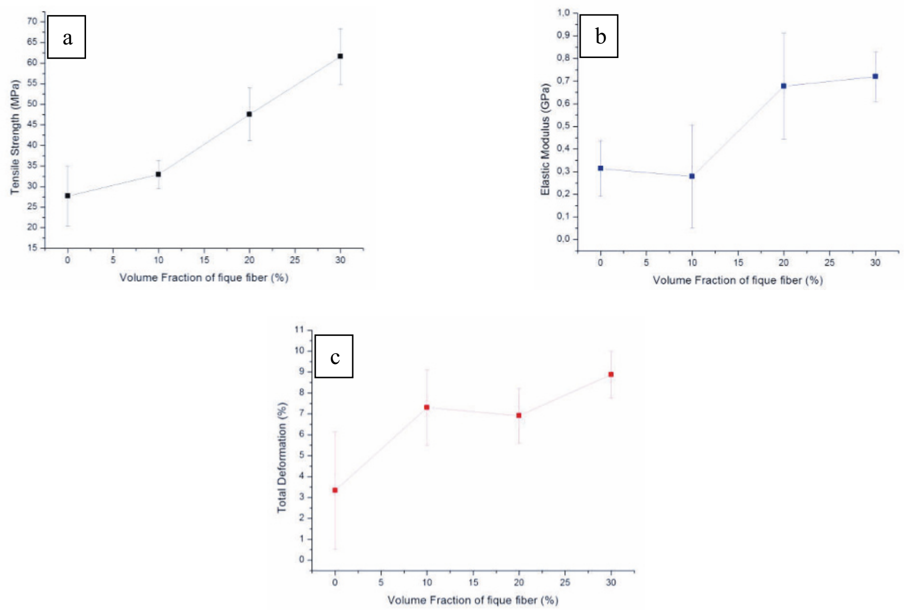

Figure 3. Variation of the tensile strength (a) and elastic modulus (b) and total deformation (c) with the volume fraction of fique fibers in polyester composites.

An important result to be mentioned in Fig. 3 is that, as the percentage of fique fiber increases, the tensile strength, elastic modulus and total deformation in a nearly linear relationship, although the elastic modulus practically do not vary between 0 and 10%.

Figure 4 shows with different magnifications the typical SEM fractographs of tensile ruptured specimens corresponding to polyester composite incorporated with a volume fraction of 30% of fique fibers.

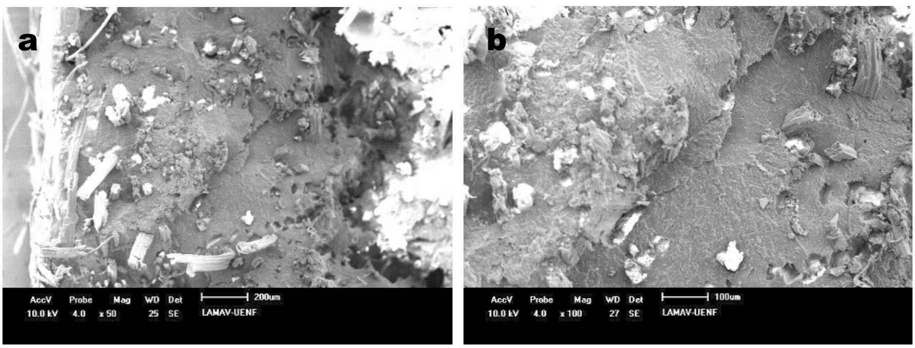

Figure 4. SEM fractographs of a polyester composite with 30% of volume fraction of fique fibers: (a) 50x and (b) 100x

The fracture analysis of representative tensile ruptured specimens was performed by microscopic (SEM) observations. Figure 4 shows typical SEM fractographs of a 30% volume fraction of fique fiber reinforced polyester composite. With lower magnification, Fig 4(a), the fracture surface display evidence of broken fibers sticking out of the polyester matrix. Apparently, these fibers are well adhered to the matrix, which justifies the significant improvement on the composites strength and stiffness with increasing amount of fibers up to 30%, as shown in Fig. 3.

Is notable the crack propagation is blocked by the fique fibers, opening a space between the fiber and the matrix, changing the crack propagation direction to transversal ones. Even after of polyester matrix fracture the fibers continue resisting to tensile effort, because this behavior the composite find higher resistance values in correlation with pure matrix and could explain the no homogeneous fracture on composites with higher fique fibers incorporation as seen in Fig 2.

Conclusions

- The incorporation of continuous and aligned fique fibers increases the tensile strength and stiffness of polyester matrix composites.
- The macro and microstructures indicates that the fique fiber acts as effective barrier to the propagation of the brittle break in the polyester matrix, being of great importance for the improvement of the mechanical properties of the composite**.**

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