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Polyester Composites Reinforced with the Highest Strength Curaua Fibers

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Abstract – A statistical evaluation was performed to correlate the mechanical properties and the diameter of curaua fibers. These natural lignocellulosic fibers were found to have a hyperbolic correlation between their ultimate strength and diameter. This permitted to select thinner high strength fibers, with over 1000 MPa, as reinforcement for the strongest polymer composites ever fabricated with these fibers. A structural analysis was conducted by electron microscopy to identify the strengthening mechanism for both, the high performance fiber and their improved polymer composites.

The fibers extracted from the leaves of the curaua (*Ananas erectifolius*), a native plant cultivated in the Amazon region are among the strongest lignocellulosic fibers. It was recently found [1] that the fiber tensile strength varies inversely with its diameter. This result suggested that a substantial increase in the strength of curaua fibers might be attained with even smaller diameters than the investigated ones. Potentially higher strength curaua fibers would allow the fabrication of composites with the highest mechanical resistance. Therefore, the objective of this work was to obtain the strongest possible curaua fibers, by selecting those with smaller diameters to reinforce, in a continuous and aligned way, improved polyester matrix composites.

A statistical evaluation of a random lot of fibers revealed intervals of diameters, measured by profile projector, varying from 30 to 290 μm. These values in diameter are comparable to those previously investigated [1]. For each interval, a great number of fibers were then obtained from the lot to be single-tested and used as reinforcement for polyester composites. The result of tensile tests for the curaua fibers associated with 12 average (middle point) diameter intervals from 40 to 280 μm are shown in Fig. 1. The tensile strength of the curaua fibers, σ_f, sharply increases for smaller diameters, $\mathbf{d_f}$, with a hyperbolic correlation associated with 96% of precision coefficient: $\sigma_f = 59/\mathbf{d_f} + 129$. It should be noted that fibers thinner than 60 μm in diameter present strength above 1000 MPa.

These select strongest curaua fibers were used to fabricate polyester composite specimens, with amounts of up to 30% in volume of fibers, by means of a similar procedure as described elsewhere [2]. Figure 2 shows the flexural strength of these composites as a function of the amount of selected thinner (strongest) fibers. In this figure, corresponding results [2] for similar composites with non-selected curaua fibers are also presented. The flexural resistance of the highest strength selected curaua fiber composites is more than 20% of the non-selected ones. Figure 3 shows the ruptured tips of curaua fibers with distinct diameters. For the smaller diameter, a more uniform fracture is observed, Fig 3(a), involving the fewer filaments that compose the fiber. By contrast, the larger diameter, Fig 3(b), is associated with separated parts constituted by more filaments. Statistically, the thicker fiber has a greater chance to have defects, which favors a mechanism of lower stress rupture beginning at one of its many filaments.

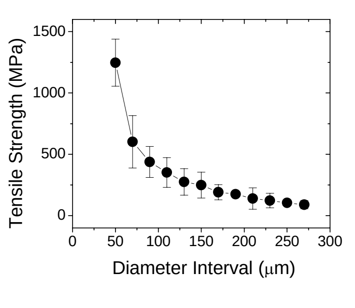

Figure 1: Ultimate tensile stress vs. the curaua fiber diameter.

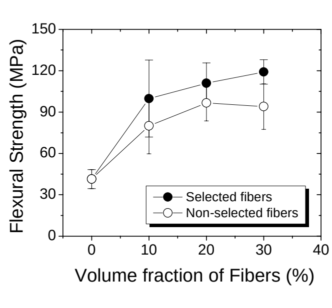

Figure 2: Flexural strength of polyester composites vs. the amount of continuous and aligned curaua fiber

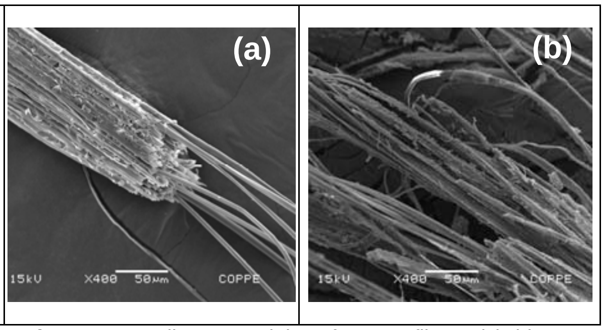

Figure 3: Tensile ruptured tips of curaua fibers: (a) thinner, d=80 μm and (b) thicker, d=120 μm.

References

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