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MORPHOLOGICAL AND PHYSICS ASPECTS, AND TENSILE MECHANICAL PROPERTIES OF *MIRITI* FIBERS FOR REINFORCED COMPOSITES[1]

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Summary

In this work studies on miriti fibers (*Mauritia flexuosa* L.) are conducted with the purpose of examining their potential use for reinforced polymeric composites. Attributes such as diameter dimensions, shape of the cross section, microstructure and surface morphology, and mechanical properties of the fiber are investigated. Diameter average dimensions are studied from cross-section images obtained by SEM. Mechanical properties were determined by tensile tests accordance to ASTM 3379 standard on single fibers specimens. A range of results was obtained for diameter dimensions and the morphology of the cross section of fibers indicated various shapes, and images from SEM exibt the singular microstructure of miriti fiber. The tensile mechanical properties show also a variety of results, characteristic of natural fibers, but the results are similar to other natural fibers used in industry.

Key-words: Vegetable fibers, Tensile tests, Green composites.

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1. INTRODUCTION

Plant fibers or ligno-cellulosic fibers are a type of natural fiber and can be distinguished according to their origin in the structure of the plant, in: (i) fiber fruits such as coconut and *açai*, (ii) stem fibers such as flax, jute, kenaf, (iii) leaf fibers such as sisal and *curauá*, and (iv) seed fibers such as cotton [(1)].

All ligno-cellulosic fibers consist primarily of cellulose fibrils in amorphous matrix of lignin [(2)] and it is therefore considered as natural composites, where the celullose is the crystalline portion that allows plants to withstand internal and external efforts, and lignin, which provides sufficient flexibility to allow the cell expansion during plant growth [(3)].

The industrial use of vegetable fibers is relatively recent and a major boost in this area of research was given to the top of environmental concerns, particularly in European countries, where laws have been applied that force the automobile industry to gradually replace the man-made fiber plant [(4,5,6)]. Nowadays new discoveries have been made on the fibers that have already been used in industry as well as the discovery of new fiber plant with potential for industrial application [(7,8,9,10)]. In an attempt to find answers to the plant evolution, many researchers began to study the structure of plants and concluded that macroscopic properties are mainly due to the arrangement of the fibrils in the fiber, meaning that the micro scale is relevant to approaches of biomechanical aspects [(3)].

This paper presents a study on *miriti* fibers, from the palm of *buritizeiro* whose botanical name is Mauritia flexuosa L. [(11)], which is a typical specie that grows in Amazonian region. This specie is very important to some amazonian populations because its fruit provides eating, materials for building and handicrafts [(12)].

2. MATERIALS AND METHODS

Miriti fibers used in this study were obtained from the petiole of the Mauritia flexuosa L. palm (Fig. 1). The petioles were carefully collected from palms in a ranch in state of Pará, and the fibers were extracted manually with a small knife.

Figure 1: Petiole of the palm (left) and *miriti* fibers (right).

2.1. Density of the fiber

The density of *miriti* fiber was determined according to ASTM D792. During the procedure, an initial volume (V_i) was taken of a beker with deionized water.

Then a sample of fiber of known mass was added, and the final volume (V_f) was measured. The volume of fiber (V_F) was then determined by the difference between V_f and V_i, which was used in the equation below to determine the density of the *miriri* fiber.

$$D_F = M_F / V_F$$

2.2. Average diameter

The study of the average diameter was made from images of the cross section of fibers taken by the scanning electron microscopy (SEM). In this method, each specimen was sectioned at 3 points and they were mounted in appropriate support where images of cross section were made. Each specimen provided three images of cross-section, and measures were taken by each image, resulting in the average diameter of the fiber. A sample of 50 randomly selected specimens were used.

2.3. Surface Morphological analysis and microstructure

The surface morphological and microstructure analysis, and morphology of the cross section of *miriti* fiber was conducted using the scanning electron microscopy (SEM) technique. For the analysis of the fiber microstructure, samples were cracked on liquid nitrogen in order to exposure brittle fracture.

2.4. Mechanical test

The mechanical characteristics of *miriti* fiber were determined under tensile loading, and the specimens were prepared in accordance to ASTM D3379 standard. Tests were conducted on the Universal EMIC equipament, in a cross-head speed of 5 mm / min., on room temperature of 21℃ and 75% of relative humidity. A sample of 50 specimens of fibers selected randomly was tested, and then mean values of strength and modulus fiber were obtained.

3. RESULTS AND DISCUSSION

The value obtained for the density of *miriti* fiber was 0.886 g/cm^3, less than water value, consistent with the microstructure of the material which contains many voids. This value is better than some values of other fibers used in industry (5), which can provide good specific properties as reinforcement in a polimeric composite.

Figure 2 shows the distribution of mean diameters of *miriti* fibers where we can observe a wide variation in results, which is characteristic of vegetable materials. The majority of the values lies in the range from 0,300 to 0,400mm, a result that is greater than some fibers used in industry (13,14,15).

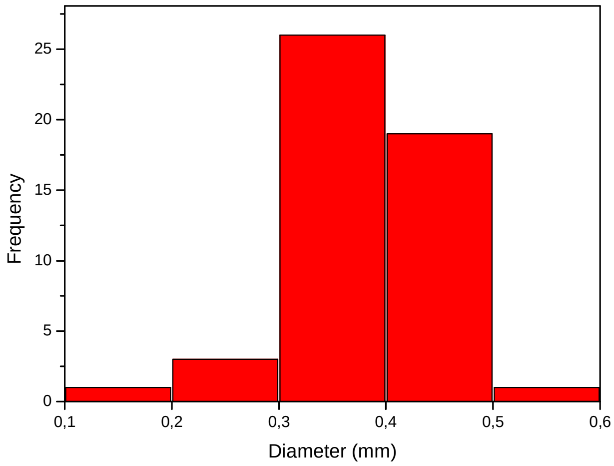

Figure 2: Distribution of mean diameter of *miriti* fibers.

In the study of the morphology of the fiber, many peculiar characteristics were observed on the surface, which can be the result of the extraction method of *miriti* fiber. Brands of deformation are visible in images of fig. 3, as well as the regular alignment of the fibrils, characteristic that may affect the mechanical properties of *miriti* fiber, due to the directionality of the material.

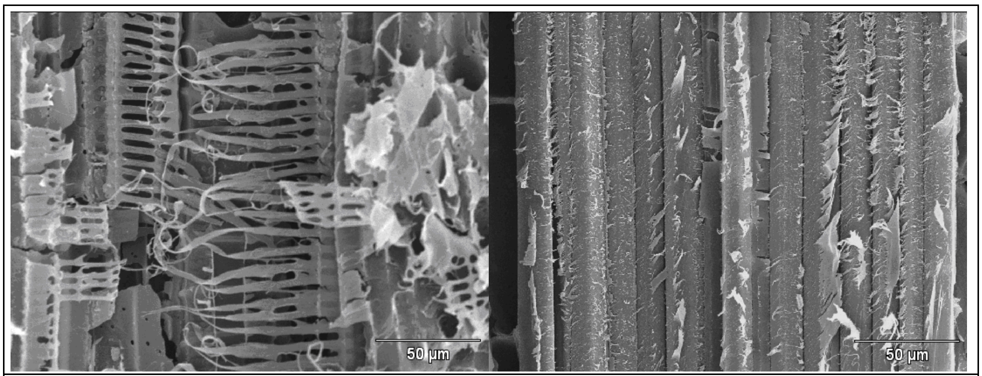

Figure 3: Surface morphology of the fiber: (a) deformation brands; (b) deformation and alignment of the fibrils.

The alignment of the fibrils is also present in image of fiber cross-section (fig. 4.a.), as well as the presence of the lumen in each fibril (fig.4.b, c, d), and the hexagonal shape of fibrils (fig.4.d). The existence of a type of membrane that seems to hold the fibers is shown in detail in fig.4.d, and is indicated with blue arrows. In the same figure we can observe that the spaces among larger fibrils cross-section are filled up by smaller fibrils cross-section. This arrangement can also influence favorably the mechanical properties.

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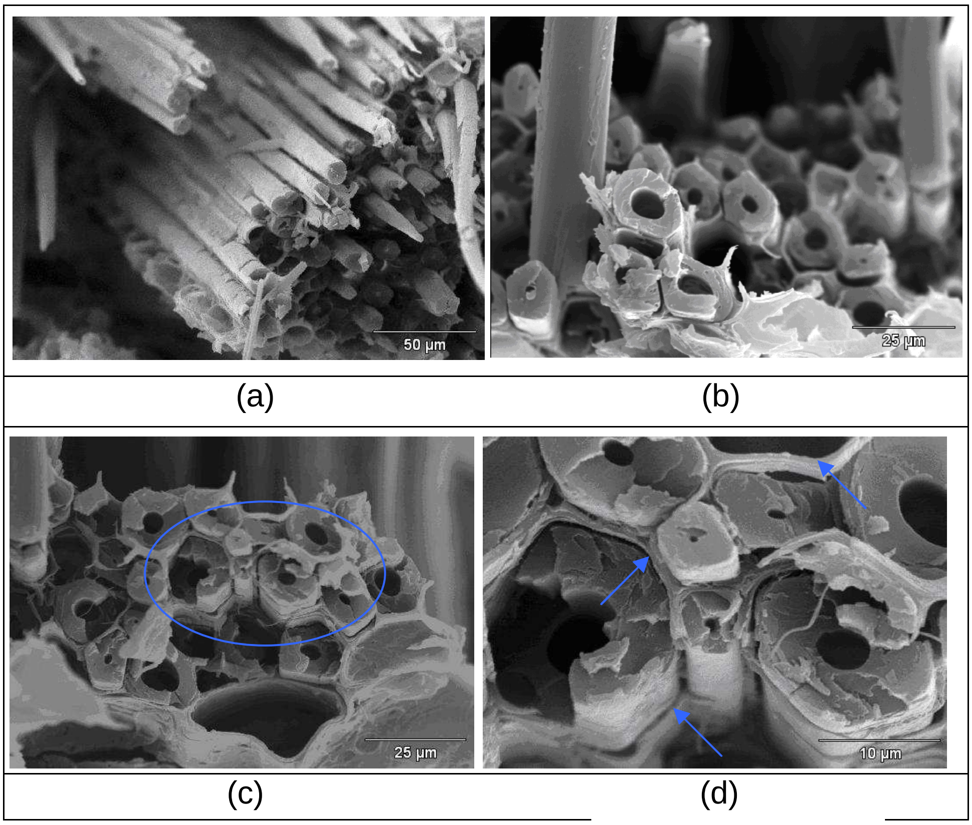

Figure 4: Microstructure morphology of *miriti* fiber: (a) alignment of the fibrils; (b) and (c) lumen of the fibrils; (d) hexagonal shape of fibrils.

Figure 5 shows the morphology of cross-section of *miriti* fiber, feature that can also cause the wide variation on mechanical properties, as shown in figure 6.

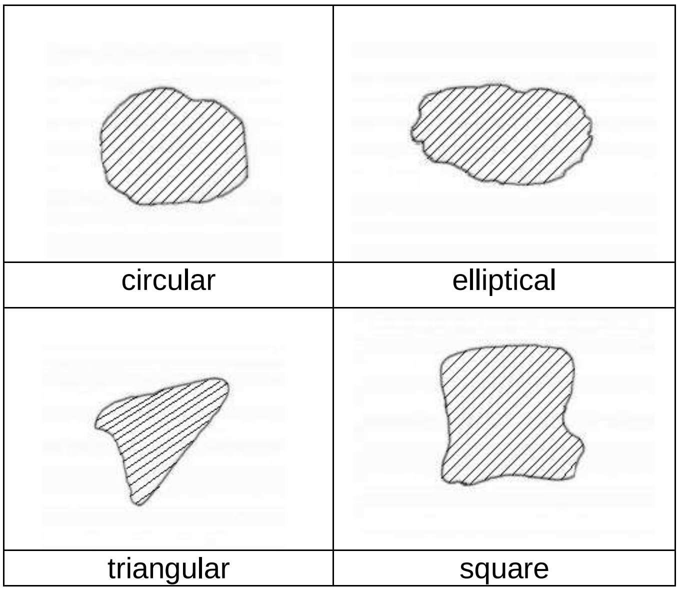

Figure 5: Wide variation on morphology of cross-section of *miriti* fiber.

The singular arrangement of fibrils and its directionality, unidirectionally oriented on *miriti* fiber, as well as the presence of lumen in each fibril, can be responsible for good mechanical properties and low density, respectively. Results of physical characteristics and tensile tests of *miriti* fiber are listed in table 1. A range of diameter values were selected from fig.2 and a mean of these values were taken for tensile tests.

Table 1

Physical-mechanical properties of *miriti* fiber.

Fiber	Diameter (mm)	Density (g/cm^3)	Tensile Strenght (MPa)	Elastic Modulus (GPa)
Miriti	0,300-0,400	0,886	492,74 ± 102,29	24,87 ± 5,37

The typical mechanical behaviour of *miriti* fiber under tensile tests are shown in fig.6, which indicated some variation in mechanical performance.

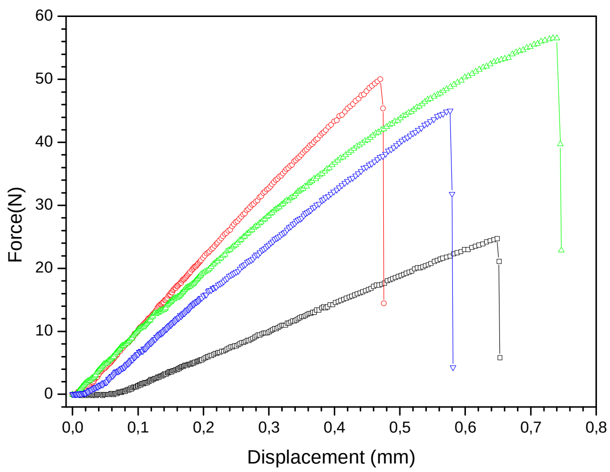

Figure 6: Typical curves of force versus displacement of *miriti* fiber under tensile tests.

The variability of the mechanical properties of raw vegetables have been a search object of many authors [(9,14)], and it is an aspect that limits the industrial use of vegetable fibers.

4. CONCLUSIONS

- The results of mean diameter obtained by measures made in SEM technique indicated a wide variation on *miriti* fiber diameter;
- The microstructure surface of *miriti* fiber showed brand of plastic deformation which can be due to the extraction method;
- The analysis of the microstructure showed details such as the alignment of fibrils, the lumen presented in each fibril, and a type of membrane that seems to hold the fibers;
- The good properties of *miriti* fibers are probably due to the alignment of fibrils and their arrangement, their low density;
- The *miriti* fibers have compatible properties to be used as reinforcement in composites.

5. REFERENCES

1. **MUELLER, D.H.; KROBJILOWSKI, A**. New Discovery in the Properties of Composites Reinforced with Natural Fibers. *J. Ind. Text*., v.33, p.110-130, 2003

2. **RAO, K.M.M., RAO, K.M.** Extraction and tensile properties of natural fibers: Vakka, date and bamboo. *Composites structures*, v.77, p.288-295, 2007.

3. **BURGET, I.,** Exploring the micromechanical design of plant cell walls. *American Journal of Botany*, v.93, p.1391-1401, 2006.

4. **KAMATH, G. S. BHAT,G. S., PARIKH, D.V., MUELLER, D.** Cotton Fiber Nonwovens For Automotive. Composites**,** *INJ Spring* 2005.

5. **BLEDZKI, A.K., FARUK, O., SPERBER, V.E.** Cars from Bio-Fibres. Macromol. *Mater. Eng,.* v. 291, p.449–457, 2006.

6. **ZAH, R.; HISCHIER, R.; LEÃO, A.L.; BRAUN, I**. Curauá fibers in the automobile industry – a sustainable assessment. ***Journal of Clener Production***, v. 15, p.1032-1040, 2007.

7. **SATYANARAYANA, K.G.; GUIMARÃES, J.L.; WYPYCH, F**. Studies on lignocellulosic fibers of Brazil. Part I: Source, production, morphology, properties and applications. *Composites: Part A*, v.38, p.1694–1709, 2007.

8. **D`ALMEIDA, J.R.M.; AQUINO, R.C.M.P.; MONTEIRO, S.N**. Tensile mechanical properties, morphological aspects and chemical characterization of piassava (Attalea funifera) fibers. *Composites: Part A,* v.37, p.1473–1479, 2006

9. **CHARLET, ET AL.,** Characteristics of Herme`s flax fibres as a function of their location in the stem and properties of the derived unidirectional composites. *Composites: Part A,* v. 38, p.1912–1921, 2007.

10. **SGRICCIA, N., HAWLEY, M.C., MISRA, M.** Characterization of natural fiber surfaces and natural fiber composites. *Composites: Part A,* v.39, 1632–1637, 2008.

11. **VALENTE, R.M.; ALMEIDA, S.S**. As palmeiras de Caxiuanã. Belém: *Museu Paraense Emílio Goeldi*, 2001.54f.

12. **VILHENA-POTYGUARA, R.C.** Panorama sobre as pesquisas em anatomia de órgãos vegetativos das palmae (arecaceae). In: *54° CONGRESSO NACIONAL DE BOTÂNICA*, 2003, Belém. Anais …Belém: Museu Paraense Emilio Goeldi, 2003. p. 246-247.

13. **PRASAD, A.V.R., RAO, K.M., NAGASRINIVASULU, G.** *Mechanical properties of banana empty fruit bunch fibre reinforced polyester composites. Indiana Journal of Fibre & Textile Research*, V.34, p. 162-167, 2009.

14. **ANDERSONS, K.; SPARNINS, E.; JOFFE, R., WALLSTROM, L**. Strength distribution of elementary flax fibres. ***Composites science and Technology,*** v. 65, p.693-702, 2005.

15. **HERRERA-FRANCO, P.J., VALADEZ-GONZALEZ., A.** Mechanical properties of continuous natural fibre-reinforced polymer composites. ***Composites: Part A,*** v. 35, p. 339–345, 2004.

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