

MORPHOLOGICAL AND MECHANICAL PROPERTIES OF PINEAPPLE-GLASS FIBERS/ PP COMPOSITES

J. M. Resende^{1*}, D. R. Mulinari¹

¹MEMAT, Centro Universitário de Volta Redonda/UniFOA – Av. Paulo Erlei Alves Abrantes, 1325

Três Poços –27260-540, Volta Redonda/RJ, Brazil

^{1*}jm.resende@yahoo.com.br

Keywords: Pineapple Crown fibers; Hybrid Composites; Mechanical Properties; Morphological Properties

Abstract

In the work, the effect the chemical modification on morphological and mechanical properties of pineapple crown-glass fibers/polypropylene (PP) composites was studied. Pineapple fibers were modified with sodium hydroxide solution 1 % m/v. Furthermore, pineapple crown (2.5 wt/ wt %) and glass (2.5 wt/ wt %) fibres were mixed with the polymeric matrice (PP) in a thermokinetic mixer. After the mixture, composites were dried, ground in mill and placed in an injector camera according to ASTM D-6110 specification. It was evaluated composites reinforced with glass fibers and composites reinforced with modified pineapple crown fibers as well. The modification of fibers was evaluated by scanning electron microscopy and infrared spectroscopy techniques. Results revealed that the treatment proposed on fibres surface improved the impact strength of hybrid composites.

1 Introduction

New technologies have been developed aimed at the reduction of environmental impacts, such as the replacement of non-renewable materials for renewable. Consequently, the use of natural fibers increased as reinforcement in polymer matrixes. In addition, the mixture of these two materials offer synergetic characteristic for structural and non-structural applications [1].

Some disadvantages, such as incompatibility between fibers and polymer matrix and tendency of formation of agglomerates during processing, reduce the use of natural fiber as reinforcement. An alternative to minimize this problem is the hybridization process, involving natural and synthetic fibers [2].

Natural fibers have on its surface extractives with hydrophilic characteristics, incompatible with the hydrophobic polymer matrix. However, for that natural fibers and polymer matrix act is necessary a contact between them, because the interfacial region is responsible for the transfer of mechanics solicitation of matrix for reinforcement [3]. Of this form, various treatments have been used in order to improve compatibly of natural fibers [4-6]. In this work

it was used the treatment with the immersion of pineapple crown fibers in alkaline solution of sodium hydroxide 1% w/v at 25 °C. This treatment causes the defibrillation fibers, in other words, transformation of fibers in microfibrils, with greater roughness and without natural impurities [7].

The morphology and chemical structure of modified material was evaluated by technique of scanning electron microscopy (SEM) and Fourier Transformed Infrared (FTIR).

Figure 1 presents the micrograph of fibers *in nature* and modified.

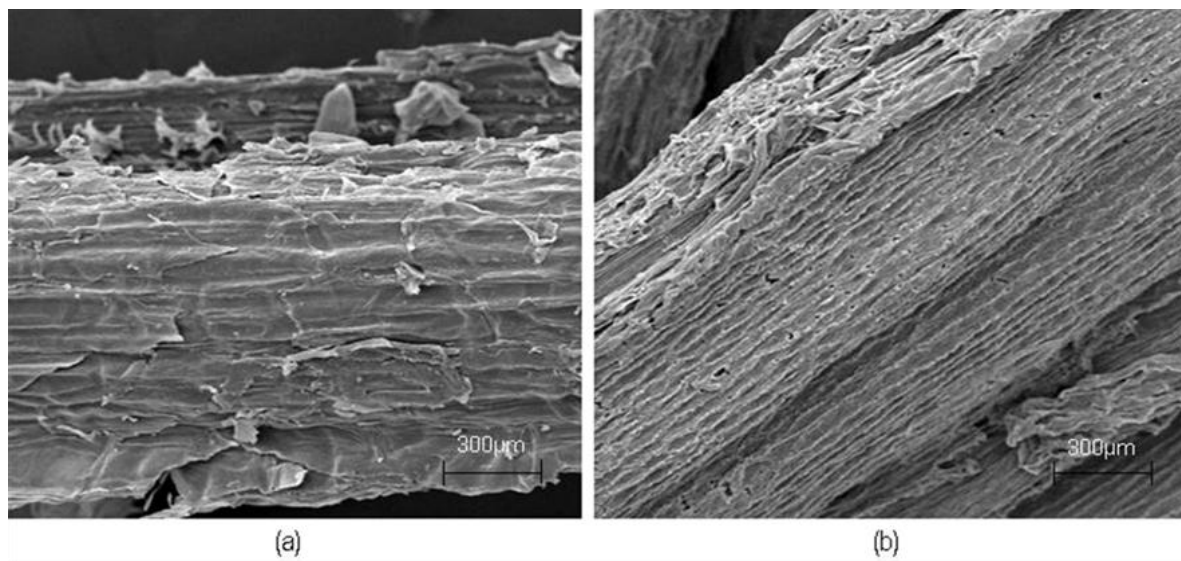


Figure 1. SEM of the fibers in nature (a) and modified (b).

Analysing the fibers in nature (Figure 1a) evidences a large amount of extractives. After the treatment on pineapple crown fibers was observed the removal of these extractives on surface fibers. It was verified also that with the elimination of superficial layer the contact area for exposition of fibrils (reentrance) and globular marks (salience) increased. As a consequence, it was observed an increase in the roughness of fibers, which contributes with the increase of the adhesion between fibers and matrix.

Infrared spectra of pineapple crown fibers in nature and modified are displayed in Figure 2. The most visible differences between the spectra of pineapple crown fibers in nature and modified are the modifications of the signal at 3300 , 2885 and 1732 cm^{-1} , characteristics of the stretching of symmetrical OH groups, CH groups and stretching of unconjugated CO groups present in polysaccharides and xylans. Considering the first region, the ratio between intensity of the C–H stretching band (2900 cm^{-1}) is lower in the spectrum of the material modified than that observed for the in nature. On the other hand, at the second region it may be observed modifications, especially in the ratio between the intensities of the C=O stretching band (1730 cm^{-1}).

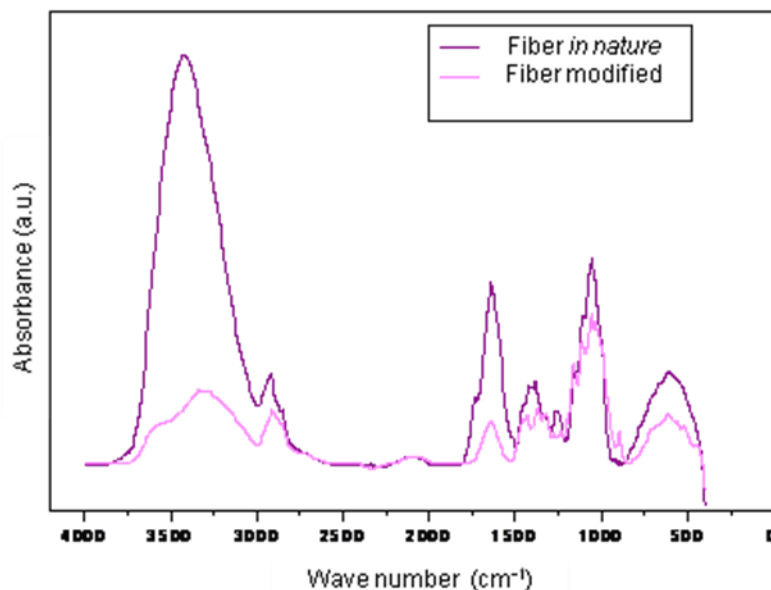


Figure 2. FTIR spectra of the fibers.

Furthermore, pineapple crown modified (2.5 wt/wt%) and glass (2.5 wt/wt%) fibers were mixed with the polymeric matrix (PP) in a thermokinetic mixer, with speed rate maintained at 5250 rpm, in which fibers were responsible for 5 wt% in the composition (hybrid composites).

Table 1 presents the interaction between fiber and matrix during the mixture process obtained by impact tests, which depends fiber/matrix interface.

MATERIALS	ABSORBED ENERGY (J)	IMPACT STRENGTH (KJ.m ⁻²)
PP pure	6.0 ± 0.6	36.0 ± 1.1
CV	11.3 ± 2.3	74.9 ± 15.3
CA	6.8 ± 0.96	43.05 ± 6.2
CH	8.0 ± 2.0	51.3 ± 12.7

Table 1. Mechanical properties obtained of the materials (CV –glass fibers composites; CA – pineapple crown fibers composites; CH – hybrid composites)

Composites reinforced with glass fibers presented higher average values impact strength when compared to the composites reinforced with pineapple crown fibers and the hybrid composites. However, the hybrid composites showed energy absorbed and resistance to impact intermediate when compared to other composites.

The surface of the fractures was examined by scanning electron microscopy technique (SEM), as can be evidenced in Figure 3.

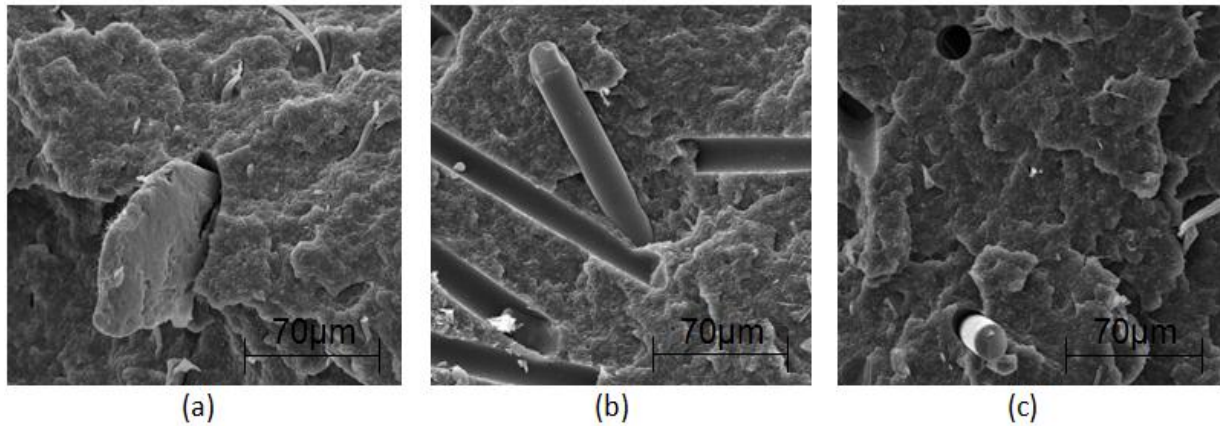


Figure 3. SEM of the fractures. (a) Pineapple fibers composite; (b) Glass fibers composite; (c) Hybrid composite.

Figure 3 showed the fractured region after impact t bonding tests, where it was verified fibers distribution in the matrix, fibers fractured in the matrix and pull out fibers, characterizing mechanism of fragile fracture. It was also observed energy dissipation during the frictional process mechanics. Sipião et al [8] observed behavior similar.

The moisture absorption test, carried out in accordance with ASTM D570. Moisture absorption in composites with natural fibers leads to degradation of the fibers-matrix interfacial region, creating poor stress transfer efficiencies and resulting in a reduction of mechanical and dimensional properties [9]. Figure 4 evidences moisture absorption in materials.

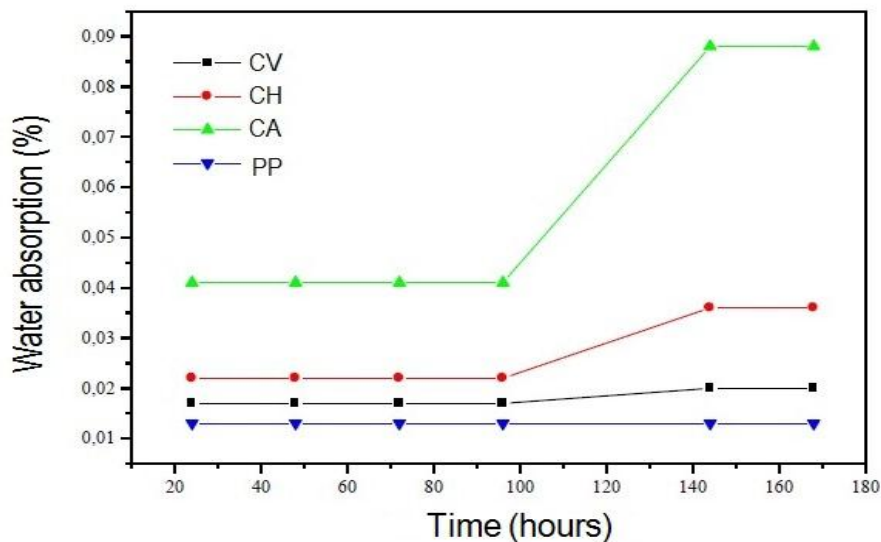


Figure 4. Water absorption of the materials (CV –glass fibers composites; CA – pineapple crown fibers composites; CH – hybrid composites).

Analyzing the results presented in Figure 4, it wasn't observed significant variation. This fact can be explained by good fiber/matrix interaction. The hybridization was efficient to reduce

the water absorption of composite. The hybrid composite proved a promising replacement for composites of fiberglass, even in applications with contact with water.

2 Materials and testing methods

The methodology developed in this work was optimized to evaluate the feasibility of technical-scientific proposal.

For the manufacture of composite fibers were used from the pineapple crown fibers, glass fibers and polypropylene.

Pineapple fibers were extracted from crown and dried at 80 °C for 24 h. After being ground in a mill and sieved. To remove the soluble extractives and to facilitate adhesion between fibers and matrix, the in nature pineapple fibers from crown were modified by pre-treatment with alkaline solution 1% (w/v) at 25 °C. Furthermore the fibers were filtered in a vacuum filter and fibers were washed with distilled water until neutral pH. Then, fibers were dried in an oven at 100 °C for 24 h.

The polypropylene (PP) used is indicated for injection molded parts because it has excellent mechanical strength and high impact resistance.

The fibers from the crown of the pineapple *in nature* and modified were characterized by techniques of scanning electron microscopy (SEM) and infrared Spectroscopy (FTIR).

2.1. Scanning Electron Microscopy (SEM)

The micrographics were obtained on a JEOL scanning electron microscope, JSM5310 with tungsten filament operating at 10 kV, using secondary electrons in order to obtain information about the morphology and composition of the fibers and the fractures.

2.2. X-Ray Diffractograms (FTIR)

For the purpose of evaluating the modification performed into the fibers after treatment was conducted analysis of infrared spectroscopy. The analyses were performed a spectrophotometer Spectrun GX 4000 to 400 cm⁻¹ with 64 scans.

2.3. Composites preparation

Firstly, fibers were dried in an oven at 50° C by 3 hours. The PP was also dry the same temperature, but by 1 hour. Pineapple crown (2.5 wt/wt%) and glass (2.5 wt/wt%) fibres were mixed with the polymeric matrice (PP) in a thermokinetic mixer, with speed rate maintained at 5250 rpm, in which fibres were responsible for 5 wt% in the composition (hybrid composites). After the mixture, composites were dried and ground in mill, model RONE.

Furthermore, composites were placed in an injector camera at 165 °C and 2 °C. min⁻¹ heating rate. The melted material was injected in a required dimensions pre-warm mold (165 °C) to obtain impact specimen (ASTM 6110). The composite milled dried were injected into the mold containing cavities with specific dimensions for mechanical tests, using an Injector Jasot 300/130.

Also were prepared polypropylene composite reinforced with 5% of glass fibers and polypropylene composites reinforced with 5% of fibers from pineapple crown for comparison. Composites obtained are listed in table 2.

<i>Materials</i>	<i>Type of reinforcement</i>	<i>Amount of PP (% wt/wt)</i>	<i>Amount of reinforcement (pineapple) (% wt/wt)</i>	<i>Amount of reinforcement (glass) (% wt/wt)</i>
CH	Glass fibers / Pineapple fibers	95	2.5	2.5
CV	Glass fibers	95	--	5
CA	Pineapple fibers	95	5	--

Table 2. Composites description

2.3. Impact test

The impact tests of treated pineapple fibers reinforced PP composites were determined using a Pantec machine (model PS30). Five specimens were analyzed, with dimensions in agreement with the ASTM D 6110 standard: 12 mm with, 63.5 mm length and 12 mm thickness [10]. It was evaluate the absorbed energy and impact strength.

2.4. Water Absorption Tests

Effects of water absorption on composites were investigated in accordance to ASTM D570 [11]. The percentage of water absorption in the composites was canceled by the difference between the samples immersed in water and the dry samples, using the following equation (1).

$$\Delta M(\%) = \frac{M_f - M_i}{M_i} \quad (1)$$

where $\Delta m(\%)$ is moisture uptake, and M_f and M_i are the mass of the specimen after and before immersion, respectively.

References

- [1] John, M. J.; Thomas, S. Biofibres and biocomposites. *Carbohydrate Polymers*, **v.71**, pp.343-364, 2008.
- [2] Acharya, S. K.; Mishra, P.; Mehar, S. K. Effect of surface treatment on the mechanical properties of bagass fiber reinforced polymer composite. *Bioresource*, **v.6(3)**, pp. 3155-3165, 2011.
- [3] Brugnago, R. J.; Satyanarayana, K. G.; Wypych, F.; Ramos, L. P. The effect of steam explosion on the production of sugarcane bagasse/polyester composites. *Composites: Part A*, **v. 42**, 364-370, 2011.
- [4] Oliveira, T. A.; Teixeira, A.; Mulinari, D. R.; Goulart, S. A. S. Avaliação do uso de agente compatibilizante no comportamento mecânico dos compósitos PEBD reforçados com Fibras de Coco Verde. *Cadernos UniFOA*, **v.14**, pp. 11-17, 2010.

- [5] Florentino, W. M.; Brandão, A. T.; Miléo, P. C.; Goulart, S. A. S.; Mulinari, D. R. Biocompósitos de poliuretano reforçados com fibras de coco verde. *Cadernos UniFOA*, v. **17**, pp. 23-28, 2011.
- [6] Resende, J. M.; Oliveira, F. L.; Mulinari, D. R. Avaliação de compósitos híbridos para aplicação na engenharia. *Cadernos UniFOA*, v. **15**, pp. 11-18, 2011.
- [7] Carvalho, K. C. C.; Mulinari, D. R.; Voorwald, H. J. C.; Cioffi, M. O. H. Chemical modification effect on the mechanical properties of hips/ coconut fiber composites. *BioResources*, v.**5**(2), pp. 1143-1155, 2010.
- [8] Sipião, B. L. L.; Paiva, R. L. M.; Goulart, S. A. S.; Mulinari, D. R. Effect of chemical modification on mechanical behaviour of polypropylene reinforced pineapple crown fibers composites. *Procedia Engineering*, v.**10**, pp. 2028-2033, 2011.
- [9] Mulinari, D. R.; Voorwald, H. J. C.; Cioffi, M. O. H.; Da Silva, M. L. C. P.; Rocha, G. J. M. Surface modification of sugarcane bagasse cellulose and its effect on mechanical and absorption properties of sugarcane bagasse cellulose/HDPE composites. *Bioresource*, v. **5**, pp.661-671, 2010.
- [10] AMERICAN SOCIETY FOR TESTING AND MATERIALS. **ASTM D 570**: Standard Test Method for Water Absorption of Plastics. United States of America, 2005.
- [11] AMERICAN SOCIETY FOR TESTING AND MATERIALS. **ASTM D 6110**: Standard Test Method for Determining the Charpy Impact Resistance of Notched Specimens of Plastics. United States of America, 2006.