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FLEXURAL STRENGHT OF THE SURGACANE BAGASSE FIBERS MODIFIED FOR MERCERIZATION REINFORCED POLYPROPYLENE

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Abstract. A*ctually has been studied natural fibers as reinforcement for polymers, due to advantages natural fibers present when reinforced in polymeric matrix, such as low cost and low density. These fibers reinforced polymeric matrix can be applied in the building and construction industry and the automobile industry. However , these fibers present certain drawbacks, such as the incompatibility between fibers and polymer matrices, tendency to form aggregates during processing and poor resistance to moisture. Because of this, several treatments and modifications are made to improve compatibility. In this work, the effect of modification in the sugarcane bagasse fibers/ PP composites was evaluated on flexural and impact strenght. Fibers were modified with sodium hydroxide solution 1 % m/v at 25 ^{o}C. Furthermore, fibers were mixed with the polymeric matrix (PP) in a thermokinetic mixer, in which fibers were responsible for 5 to 30 wt% in the composition. After the mixture, composites were dried, ground in mill and placed in an injector camera.. Scanning Electron Microscopy (SEM) and thermogravimetry (TGA) were used to analyze the modification on fibers structure. Results showed that, the addition of modified fibers in the pure PP presented better result when compared to the pure polymer.*

Keywords: *Composites, Interfacial bonding, Sugarcane bagasse, Flexural strength*

1. INTRODUCTION

Nowadays, the developments of natural fibers reinforced polymer composites have been much studied (Corrales *et al*., 2007, De Rosa *et al*., 2010, Mulinari *et al*., 2009). Natural fibers have diverse origins, such as wood, cellulose, cotton, sugarcane bagasse, bamboo, straw of cereals and vegetables (e.g., flax, jute, hemp, sisal, rame, and sugarcane bagasse) (De Rosa *et al*., 2010, Xie *et al*., 2010). Because of this, extensive studies on preparation and properties of thermosetting and thermoplastic composites reinforced with natural fibers, which can replace the conventional carbon fiber and glass fiber have been reported (Bakare *et al*., 2010).

Compared to other mechanical properties, the characterization of fracture polymers and composites are still in at infant stage (Nair *et al*., 201; Wong *et al*., 2010). The natural fibers present several advantages compared with conventional fibers (glass or carbon) such as abundance, low cost, biodegradability, flexibility during processing and less machine wear resulting health hazards minimum, low density, proportion of desirable fiber and relatively high modulus and flexural strength. The natural fibers also are important to facilitate its disposal by incineration or composting options that are not possible with most industrial fibers. Another important fact is that to address these fibers contains in its structure and atmospheric carbon dioxide are less embodied energy compared to industrially produced glass fibers (Stael *et al*., 2001; Xie *et al*. 2010)**.**

The automotive industries have demonstrated an interest in use of the natural fibers reinforced composites, in order to reduce vehicle weight. The automotive companies have already shifted from steel to aluminum and now are shifting from aluminum to fiber reinforced composites for some applications. This has led to predictions that in the near future plastics and polymer composites will comprise approximately 15% of total automobile weight (Zampolini *et al.*, 2007).

The processing of a polymeric matrix composite does not necessarily involve high pressures and temperatures. Normally, it is simpler and less expensive than the treatment of other matrices. With the growing global energy crisis and the current environmental problems, much research aimed at the production and use of agricultural products and derivatives as a source of fibers for reinforcing polymeric matrices for composites was perfomed (Ramires *et al*., 2010).

Coupling agents and fiber - and / or chemical treatment of the matrix are suggested in the literature to intensify the fiber - matrix adhesion and reduce the overall water uptake of natural composites (Meggiato *et al*., 2010). Then the objective of this work was to study the mechanical properties sugarcane bagasse fibers modified for mercerization reinforced polypropylene composites.

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2. EXPERIMENTAL

2.1. Chemical modification surgarcane bagasse fibers

To remove the soluble extractives and to facilitate adhesion between fibers and matrix, the sugarcane bagasse fibers were modified by pre-treatment with alkaline solution 1% (w/v). Furthermore the fibers were filtered and washed with distilled water until neutral pH. Then, fibers were dried in an oven at 100 ^{o}C for 24 h.

2.2. Characterization of the fibers

The effects of the modification conducted in the fibers were characterized by techniques scanning electron microscope (SEM) and thermogravimetry (TGA). The samples to be observed under the SEM were mounted on conductive adhesive tape, sputter coated with gold and observed in the SEM using a voltage of 15 kV using JEOL JSM5310 model. Thermogravimetry (TGA) technique was used to analyze the thermal stability of fibers modified and unmodified. The thermal behavior of each dried samples (~10 mg) was determined, using a TGA 50 series thermogravimetric analyzer (SHIMADZU), across a temperature range of 30- 550 ^{o}C, at a heating rate of 10 ^{o}C.min^{-1}, in a nitrogen atmosphere.

2.4. Composites preparation

The sugarcane bagasse fibers modified were mixed with the PP in a thermokinetic mixer with speed rate maintained at 5250 rpm, in which fibers were responsible for 5 to 30 wt% in the composition. After the mixture, composites were dried and ground in mill. The composites were placed in an injector camera at 165ºC and 2 ºC min^{-1} heating rate in a required dimension pre-warm mold with specific dimensions for impact specimens. The flexural tests of sugarcane bagasse fibers modified for mercerization reinforced PP composites were determined using an EMIC DL2000 universal testing machine. Five specimens were analyzed, with dimensions in agreement with the ASTM D 790 standard with 2 mm.min^{-1} crosshead speed. It was evaluate the flexural strength and modulus. Also it was conducted impact test in the composites, which it was determined using a Pantec machine (model PS30). Five specimens were analyzed, with dimensions in agreement with the ASTM D 6110 standard. It was evaluate the absorbed energy and impact strength.

3. RESULTS

SEM provides an excellent technique for examining the surface morphology of sugarcane bagasse unmodified and modified. The morphology of fibers unmodified can be observed in Fig. 1. These fibers show a superficial layer with high percentage of extractives.

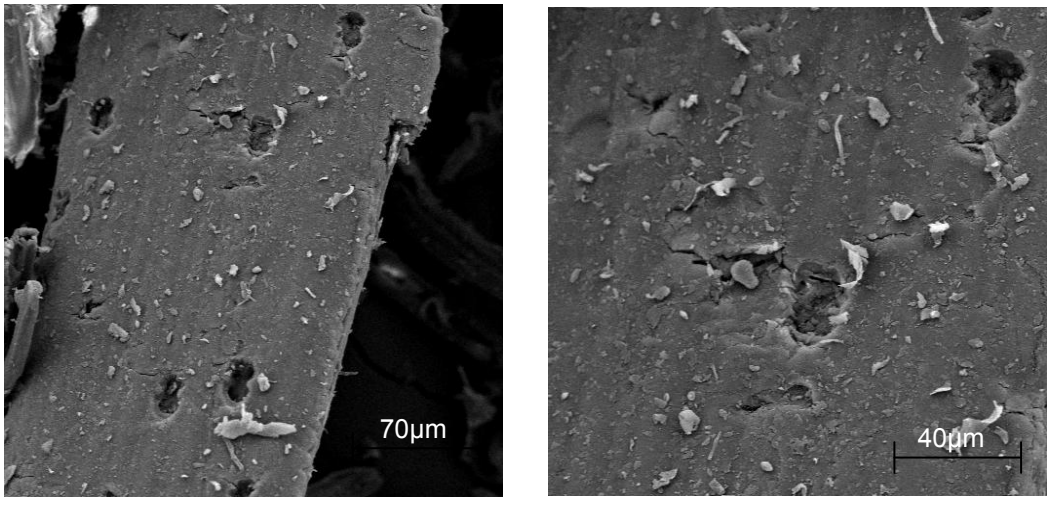

Figure 1. Morphology of sugarcane bagasse fibers *in nature*: (A) 500X; (B) 1000X.

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After the treatment on fibers unmodified it is observed the removal of the extractives on surface fibers. This image can be observed in Fig.2. It is 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 is observed an increase in the roughness of fibers, which contributes with the increase of the adhesion between fiber and matrix.

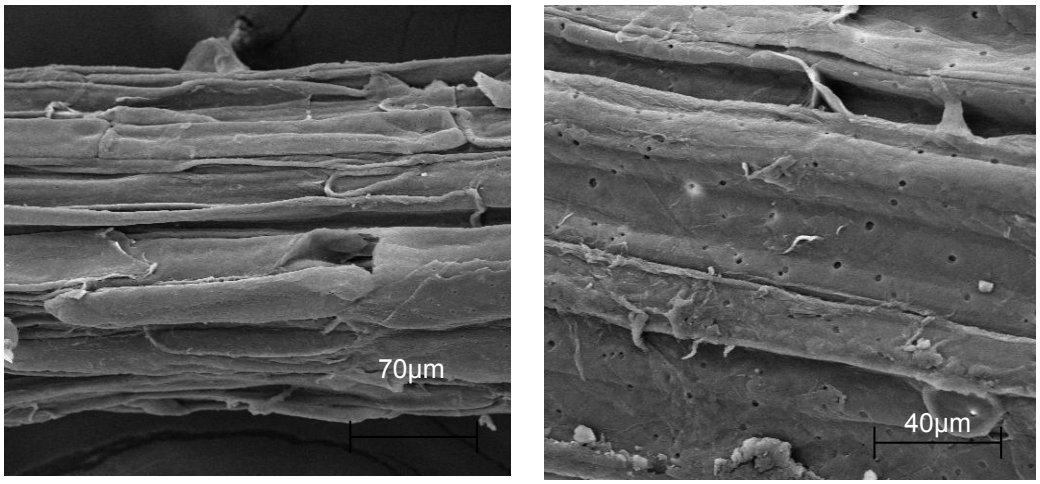

Figure 2. Morphology of sugarcane bagasse fibers modified: (A) 500X; (B) 1000X; (B) 5000X; (B) 20000X.

Figures 3 and 4 show TGA curves of modified and unmodified sugarcane bagasse fibers. From the TGA curves it is possible to observe the starting of modified and unmodified sugarcane bagasse fibers weight loss at 100 ^{o}C. This corresponds to the vaporisation and removal of bound water in the samples. The next weight loss of the modified and unmodified sugarcane bagasse fibers is attributed to thermal degradation of fibers.

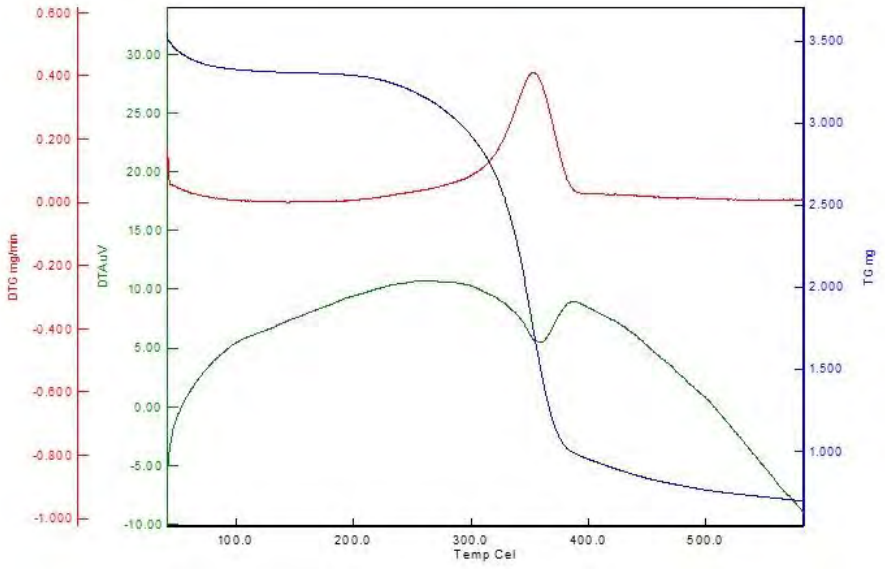

Figure 3. TGA curves of sugarcane bagasse fibers unmodified.

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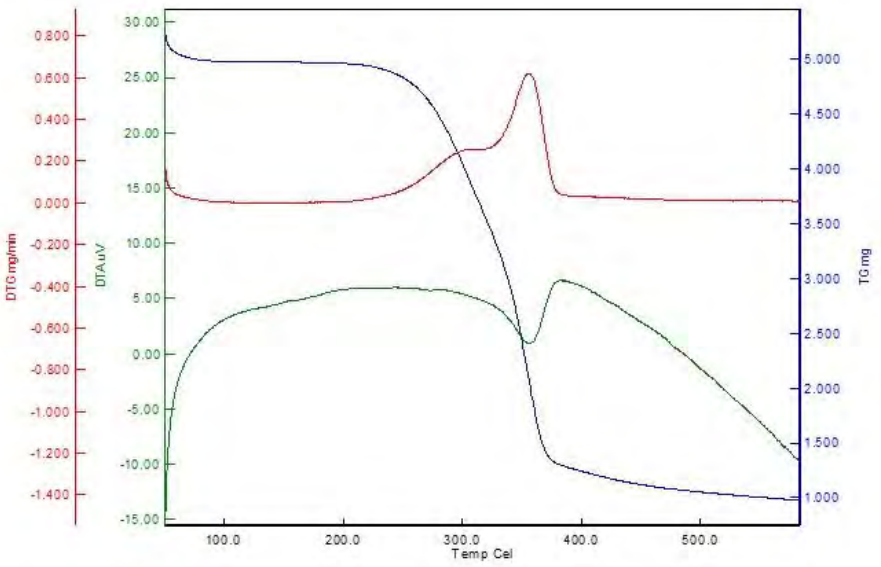

Figure 4. TGA curves of sugarcane bagasse fibers modified.

Table 1 shows the weight loss and degradation temperature peak of modified and unmodified sugarcane bagasse fibers.

Table 1. Thermal properties of the materials.

Samples	Weight loss (%)						Degradation temperature (°C)
	100 °C	200 °C	300 °C	400 °C	500 °C	580 °C	
SB Unmodified	7.9	8.2	25.2	77.1	80.6	81.9	237
SBF Modified	13.1	14.8	16.3	78.4	81.7	84.5	250

Analyzing Table 1, it is observed that modified sugaracane bagasse fibers present higher thermal stability than the unmodified sugarcane bagasse fibers. This occurs in the temperature range of 220 to 300°C. After 380°C, the residual is due to decomposition of samples.

Mechanical properties of the composite and pure polyester are summarized in Table 2. The amount of added reinforcement contributes to variation of the flexural modulus. Fibers insertion can contribute to the modulus increase, because the Young's modulus of the fibers is higher than the thermoplastic modulus. However, to obtain a significant increase, a good interfacial bond between fiber and matrix is necessary.

Table 2. Mechanical properties of the materials.

Materials	Flexural strength (MPa)	Flexural modulus (MPa)
PP	50.9 ± 0.4	1069 ± 35.0
SB5%	60.6 ±1.1	1480.0 ± 71.6
SB10%	57.1 ± 1.5	1532.0 ± 85.1
SB20%	55.4 ± 2.5	1703.0 ± 158.3
SB30%	53.7 ± 5.1	1821.0 ± 299.7

Reinforcement in wt%.

Sugarcane bagasse fibers modified/polypropylene composites presented higher flexural strength and modulus results compared to pure polypropylene. This occurred due to good interaction between fibers and matrix. Fibers insertion can contribute to the modulus increase, which exhibited an increase of 70%, compared to the pure polypropylene.

Results obtained in the impact tests also presented same behavior. Table 3 presents the interaction between fiber and matrix during the mixture process obtained by impact tests, which depends fiber/matrix interface.

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Composites presented high average values impact strength when compared to the pure polypropylene. It was observed an increase of 46% impact strength. This fact can be explained by interfacial bonding between fibers–matrix.

Table 3. Impact strength of the materials.

Materials	Impact strength ($KJ.m^{-2}$)
PP	42.6 ± 13.2
SB5%	54.9 ± 14.8
SB10%	44.8 ± 11.4
SB20%	57.8 ± 24.5
SB30%	62.4 ± 30.7

Reinforcement in wt%.

4. CONCLUSION

The feasibility of utilizing the agro-residue as alternative reinforcement in thermoplastics was studied. Chemical modification of sugarcane bagasse fibers was studied to demonstrate the effect of modification on the mechanical properties of the composites and to study the practicability of processing these agro-residue with thermoplastics. The modification of fibers with alkaline solution was successfully accomplished and it was verified that effectively improves the flexural strength and modulus in comparison to the polymer pure, exhibiting an increase of 70% in the flexural modulus. In the impact test also was observed an improve the impact strength of the composites when comparison to the polymer pure, exhibiting an increase of 46% in the impact strength.

5. ACKNOWLEDGEMENTS

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