MECHANICAL BEHAVIOUR OF THE PP COMPOSITES REINFORCED WITH PALM FIBERS

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Abstract

In the work, mechanical properties of palm fibers/polypropylene (PP) composites were studied. To enhance the adhesion between fibers and matrix a coupling agent of maleic anhydride grafted polypropylene (MAPP) was applied. These fibers were mixed with the polymeric matrix (PP) and coupling agent (MAPP) in a thermokinetic mixer, in which fibers were responsible for 5 wt% in the composition. After the mixture, composites were dried, ground in mill and placed in an injector camera according to ASTM D-6110 specification. Specimens were tested in impact mode. The thermal behavior was also evaluated. Results showed the addition MAPP in composites presented increase mechanical and thermal properties.

1 Introduction

Natural fiber reinforced composite is an emerging area in polymer science due to reduction of environmental impacts, such as the replacement of non-renewable materials for renewable. 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. Others processing problems are caused, such as limited processing temperature range, bacterial degradation, dimensional instability because of the water absorption, inconsistent mechanical properties, and processing difficulties [2-5].

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 [6-9]. Of this form, various treatments and compatibilizers have been used in order to improve adhesion between fiber and matrix resulting in the enhancement of the mechanical properties of the composites. In this work, maleic anhydride grafted polypropylene (MAPP) was used as an effective compatibilizer for palm fibers/PP composites with objective to improve mechanical and thermal properties.

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 palm fibers, polypropylene and MAPP Epolene.

Palm fibers were dried at 80 ^{o}C for 24 h. After being ground in a mill and sieved. The polypropylene (PP) from BRASKEN used is indicated for injection molded parts because it has excellent mechanical strength and high impact resistance.

The palm fibers 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 of the fibers.

2.2. Infrared Spectroscopy (FTIR)

To evaluate the chemical structure the fibers 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. Palm fibers (5 wt/wt%) were mixed with polypropylene (94 wt/wt%) and MAPP (1 wt/wt%) in a thermokinetic mixer, with speed rate maintained at 5250 rpm, in which fibers were responsible for 5 wt% in the composition. After the mixture, composites were dried and ground in mill. Furthermore, composites were placed in an injector camera at 165 ^{o}C and 2 ^{o}C. min^{-1} heating rate. The melted material was injected in a required dimensions pre-warm mold (165 ^{o}C) to obtain impact specimen (ASTM D6110). The composite milled dried were injected into the mold containing cavities with specific dimensions for mechanical tests. Also were prepared polypropylene composite reinforced with palm fibers (5 wt/wt%) and polypropylene (95 wt/wt%) for comparison. Composites obtained are listed in table 1.

Materials	*Type of reinforcement*	*Amount of PP (% wt/wt)*	*Amount of reinforcement (palm fibers) (% wt/wt)*	*Amount of MAPP (% wt/wt)*
CPS	Palm fibers	95	5	--
CPC	Palm fibers	94	5	1

Table 1. Composites description (CPS – *palm fibers/polypropylene (PP) composites* without MAPP; CPC – *palm fibers/polypropylene (PP) composites* with MAPP)

2.4. Impact test

The impact tests of 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.

2.5. Thermogravimetric Analysis (TGA)

Samples used for the thermogravimetric analysis were cut from the mixture materials in order to have a weight of 10 mg. Furthemore specimens were dried in an oven for 1 h at 100 ^oC. TGA was carried out using a SHIMADZU (TGA-50) instrument, in N_2 atmosphere at 10 ^oC min^{-1} heating rate, from 30 to 650 ^oC.

3. Results

The morphology and chemical structure palm fibers were evaluated by technique of scanning electron microscopy (SEM) and Fourier Transformed Infrared (FTIR).

Figure 1 presents the micrograph of palm fibers *in nature*.

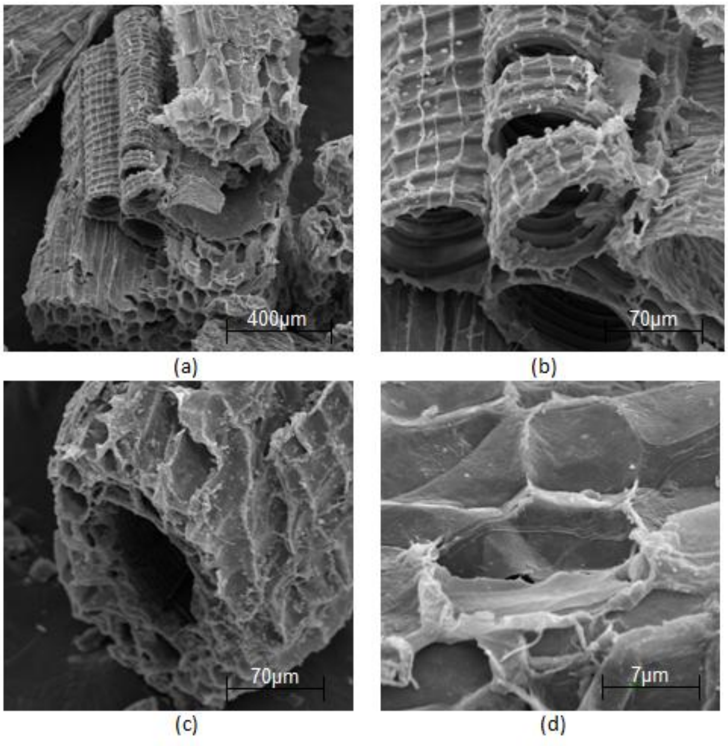


Figure 1. SEM of the palm fibers *in nature* at different magnifications (a, b, c and d).

Analysing the palm fibers *in nature* evidences a layer of substances that may include pectin, lignin, and others extractives. From longitudinal observation, the palm fibers showed a kind of cilyndric element in their inner parts (Fig. 1A and 1B). On the other hand, the fiber surfaces were not extremely smooth, being covered with nodes and irregular stripes. It is also possible to observe in Figure 1C and 1D a superficial layer of parenchyma cells, which contributes for increase of the adhesion between fibers and matrix.

An infrared spectrum of palm fibers in nature is displayed in Figure 2.

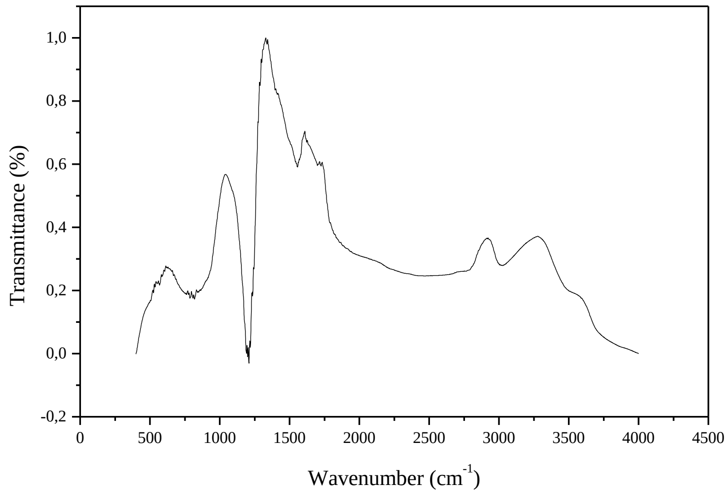


Figure 2. FTIR spectra of the palm fibers.

The main FTIR spectra can be the Table 2. This table summarizes higher bands observed in the FTIR spectrum of palm and their assignments to chemical group vibrations and molecules.

Wavenumber (cm^{-1})	***Vibration***	***Source***
3300	O-H linked shearing	Polysaccharides
2885	C-H symmetrical stretching	Polysaccharides
1732	C=O unconjugated stretching	Xylanes
1335	C-O aromatic ring	Cellulose
1162	C-O-C asymmetrical stretching	Cellulose

Table 2. *Infrared main transitions for palm fibers*

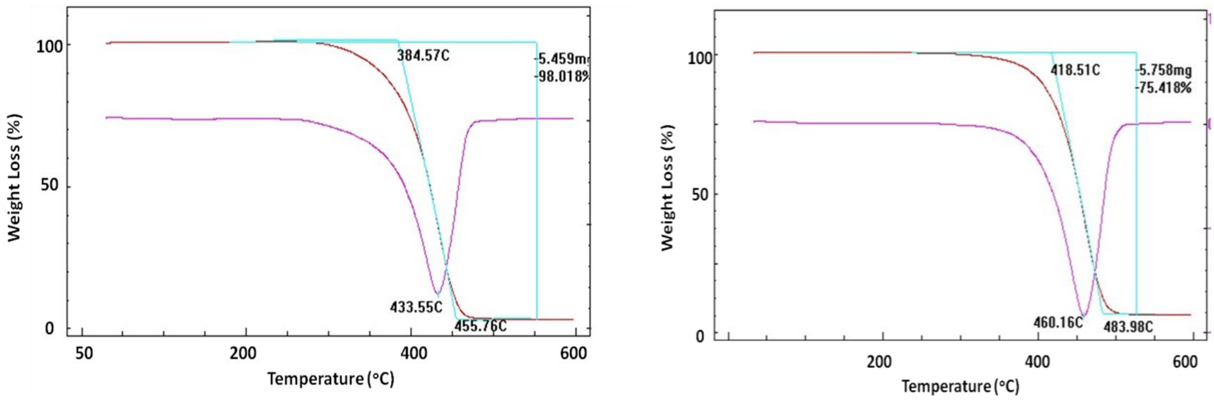
Table 3 presents the interaction between fiber and matrix during the mixture process obtained by impact tests, which depends fiber/matrix interface.

MATERIALS	**IMPACT STRENGHT ($KJ.m^{-2}$)**
PP pure	44.0 ± 0.5
CPS	45.9 ± 0.1
CPC	48.0 ± 0.2

Table 3. Mechanical properties obtained of the materials (CPS – *palm fibers/polypropylene (PP) composites* without MAPP; CPC – *palm fibers/polypropylene (PP) composites* with MAPP)

Composites compatibilized with MAPP Epolene presented higher average values impact strength when compared to the composites without addition of MAPP. This fact occurred due to adhesion between fibers and matrix. However, composites without addition of MAPP presented higher average values impact strength when compared to the PP pure.

TGA curves confirmed these results (Figure 3).



(a) (b)

Figure 3. TGA curves of the materials (a) *palm fibers/polypropylene (PP) composites* without MAPP; (b) *palm fibers/polypropylene (PP) composites* with MAPP

Analyzing the curves it was observed composites compatibilized presented intermediary thermal stability between fibers and matrix, showing synergistic interactions when compared to the composites without addition of MAPP. From the TGA curves it is possible to observe the starting of composites weight loss at 380 ^{o}C.

Thus, it was confirmed that the addition MAPP in composites improve mechanical and thermal properties.

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