STUDY OF THE POTENTIAL USE OF ROYAL PALM FIBERS IN HDPE MATRIX

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Abstract
The objective of this work was investigating one method to applied this fibers in polymeric composites. The King Palm Fibers were treated with alkaline solution of sodium hydroxide and mixed with high density polyethylene (HDPE). Techniques such as Scanning electron microscopy (SEM), X-ray diffraction (XRD) and Thermal analysis (TGA) were used to characterize the effect of treatment on fibers. Furthermore it was evaluated the performance of modified palm fibers as reinforcement in HDPE for tensile tests. Results revealed that the treatment increased made in fibers improve the tensile modulus and resistance of composites when compared with pure polymer.

1 Introduction

1.1 Energy, sustainability and renewable raw material

Actually, the environmental impacts and energetic questions are the principal questions of humanity. The development of biofuels was an important step in the use of biomass as a renewable source of energy. However, not even the natural process is free of residues accumulation in the end of the production process.

These inappropriatly disposed residues could be used for noble purposes and at the same time contribute for the reduction of pollution caused by the population in our planet.
The rational use of nonrenewable raw material and the development of technologies and products that incorporate biomass are important alternatives on pollution control, this would make possible a new sustainable production model.

On the other hand, widespread use and commercialization of plastic materials have created severe environmental, economic, social and political problems. The availability of landfill space has decreased rapidly and the cost of landfilling plastic wastes has increased enormously. To alleviate these problems, plastic recycling is becoming a priority in most waste management program [1], but this is not the only solution, the application of lignocellulosic fibers to reinforce thermoplastics and thermosets polymers are an example of technology to be incorporated in several industrial sectors around the world.

Adding natural fibers in polymeric materials has been the aim of several researches in order to develop new products with high quality compared to products based on synthetic materials.

Polymeric composites present characteristics like low density, higher specific stiffness and strength, [2], low energy cost, positive contribution to global carbon budget, greater deformability, combustibility, ease of recyclability, good thermal and insulation properties, less abrasiveness and others many advantages wen compare with pure polymers or other composites based on synthetic materials [2-3].

1.2 The raw material

Palm trees are the most common species of tropical forests and have important features that ensure the sustainable development of agricultural and horticultural systems. These features are due to the variability of shapes, structures, communities of palm trees and various products they offer.

The interest on the cultivation of these species of plant has increased significantly due to its indisputable landscape, where palms are of immense ecological and economic importance [4]. Archontophoenix alexandrae, commonly known as King Palm, is a species of the family Aracaceae originally from Queensland, Australia, tropical region with altitude below 1100 m. The climate required to cultivate this species can be hot and humid. This plant adapts to various soil types, like very sandy soils or with high clay content, also, they tolerate low pH [5].

The plants of this species form a very dense root system, which makes it very important to prevent erosion of river banks. The A. alexandrae produces heart-of-palm of noble type, with higher quality and superior flavor compared to other species of palm. The harvesting of palm heart is made after a period of 4 years [6].

However, a lot of residue is generated from this cultivation [6]. For each extracted palm, approximately 400g of commercial palm-heart are harvested, which stands for 10-20% of the palm's total mass. The residue constitutes 80-90% of the total palm weight, with some variation depending on species [5]. The residues from king palm constitute mainly of leaves and leaf sheathes (Figure 1). Some quantity of this highly cellulosic material is currently used as boiler fuel, in the preparation of fertilizers or as mulching material whereas major portion is left in mill premises itself. When left in field, these waste materials create great environmental problems [9]. Several studies are seeking to add value to this raw material produced from the extraction of palm-heart, applying it in other ways.

The stem of some species of palm tree is composed of plastic material such as fiber, protein and polysaccharides (cellulose), which gives them their shape, nutritional and material that fills the interior of cells such as sugar and starch. Previous studies used the leaves and leaf sheaths in production of flour and its characterization showed interesting results, especially regarding a fiber and minerals based diet [6].

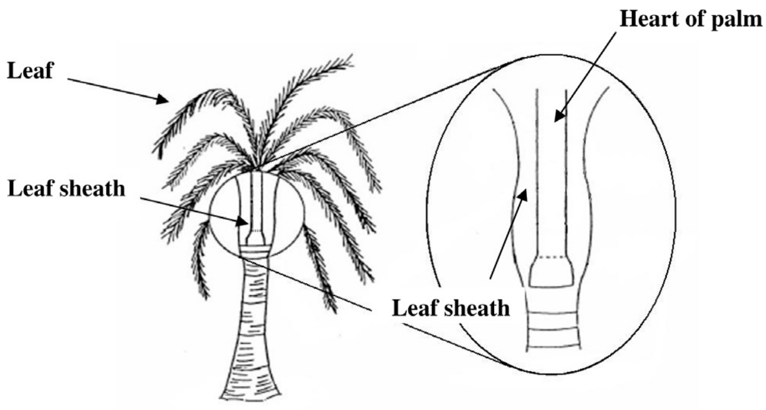

Figure 1. Schematic of the residues from palms: Leaves and leaf sheath. Simas et al.(2010).

Other studies attest more applications to these fibers, for example, filtration with palm fibers could be a potential technology for tertiary wastewater treatment as it provides a "green engineering solution" [8]. Kriker et al. examines four types of palm surface fibers and determines their mechanical and physical properties to apply this row material on structures of concrete [9].

And in the middle of these researches to apply such waste in a sustainable way, we can mention the use in polymeric composites, particularly in the automobile industry, where they are used to improve mechanical performance by reducing cost and weight of components.

2 Materials and testing methods

To obtain cellulosic fibrils, the fibers *in nature* should be treated. The treatment methods assist in removal soluble extractives and facilitate adhesion between fibers and matrix. Some parameters must be observed in the pretreated process. The fibers must be separated into different sizes in order to obtain the best possible use of their aspect ratio, because of this, the fibers are separated through sieves of 20 and 40 mesh. Then, fibers are immersed in alkaline solution of sodium (NaOH) at concentrations of 1% (w/v) for one hour. After being treated for such time, fibers were exhaustively washed with distilled water and filtered in vacuum filter to reach the neutral pH. Then, fibers were dried in an oven at 80ºC for 24 hours.

Physical and chemical structures of the palm fibers were evaluated by X-ray diffraction technique, scanning electron microscopy (SEM).

Examination of the untreated fibers shows a large amount of debris adhering to the surface of the fiber bundles (Figure 2).

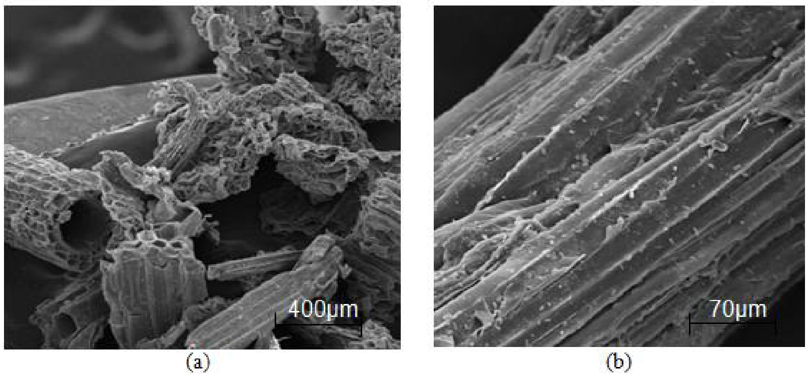

Figure 2 - SEM of untreated palm fibers.

After the treatment on palm fibers it was observed the removal of ashes on fibers surface (Figure 3). It was also verified the elimination of superficial layer, increasing the contact area of exposition of fibrils (reentrance) and globular marks (salience). As a consequence, it was observed an increase in the roughness of fibers, which can increase of the adhesion between fibers and matrix.

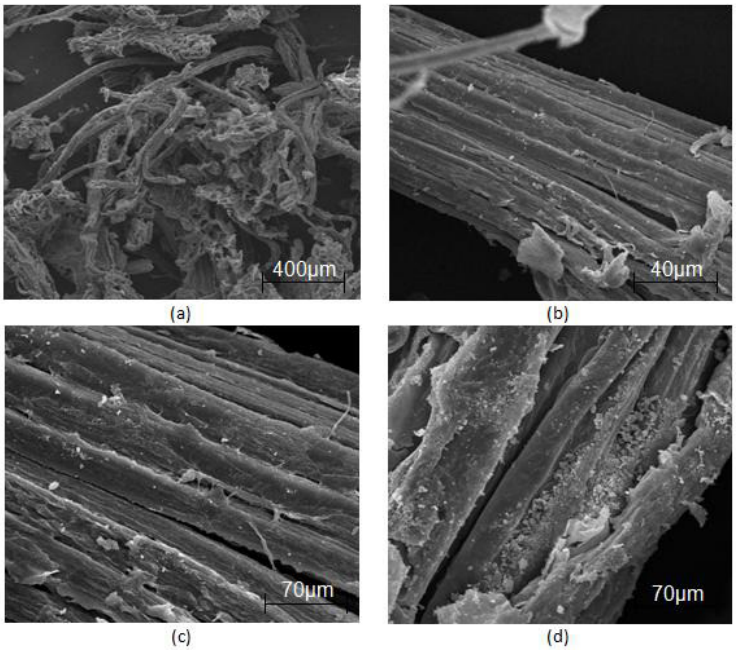

Figure 3 - SEM of palm fibers pretreated.

X-ray diffraction peaks (Figure 4) for the material can be attributed to crystallinity scattering, whereas the diffuse background can be attributed to disordered regions. According to this method, fibers showed 29% of crystallinity.

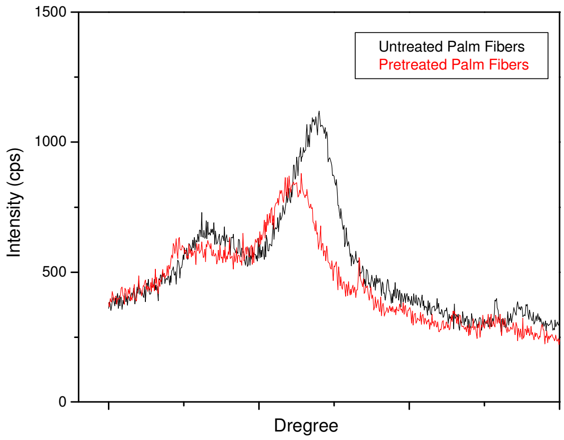

Figure 4 - X-ray diffraction of palm fibers.

Spectroscopy of infrared help analyzing the morphology, the crystal structure and connections of the effective stretching vibration of materials.

Figure 5 shows infrared spectra of palm fibers. The most visible differences between the spectra of in nature and pre-treated palm fibers are the modifications of the signal at 2885 cm-

1 and 1732 cm-1, characteristics of the stretching of symmetrical 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 pre-treated palm fibers than observed for the in nature palm fibers. 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).

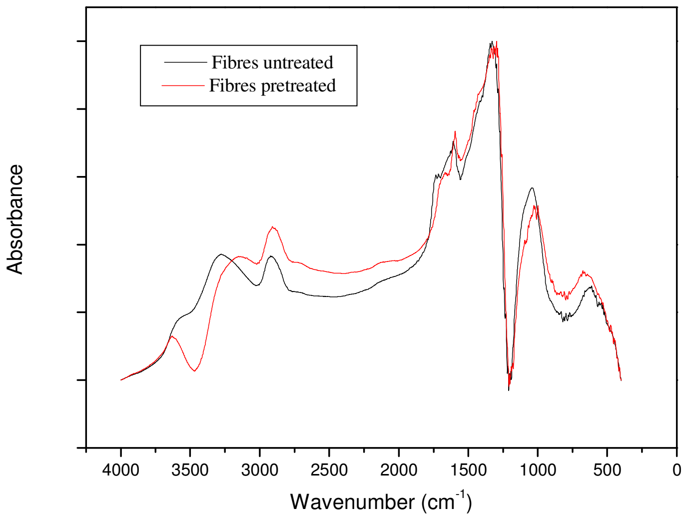

Figure 5. FTIR spectra of palm fibers pretreated and untreated.

Mechanical properties of studied composites reinforced with pre-treated fibers are summarized in Table 1. Composites showed distinct mechanical properties, indicating that the pretreatment affects the fibers-matrix interaction compared to the pure polymer (HDPE). However, the amount of added reinforcement contributes to variation of the tensile modulus.

Samples	Tensile Strenght (MPa)	Tensile Modulus (MPa)
HDPE	15.70 ± 1.10	732.45 ± 90.60
Palm Fiber 5%/HDPE composite	23.51 ± 0.10	979.02 ± 37.75
Palm Fiber 10%/HDPE composite	23.34 ± 0.43	1229.25 ± 34.66

Table 1. Mechanical properties of Palm Fibers Pre-treated/Polyethylene composites.

Composites showed an increase of 32.75% in the tensile strength and 40.41% in the tensile modulus compared to the pure polymer (HDPE). In this case, the higher strength and Young's modulus of fibers have effectively contributed to mechanical properties improvement of the composite, due to a good fibers and matrix interfacial bond. It is interesting to notice that, despite of the considerable discrepancies on tensile behavior of the composites, flexural properties are slightly different, which means higher compared to those of HDPE. This result may reflect a better fibers-matrix interaction under the compressive stresses developed in part of the transverse section of the specimens during bending for whatever the surface condition of the fibers.

This research can help in projects aimed at applying natural fibers in materials engineering. The results show an improvement in the composite when compared with pure polymer and they are lighter and nonabrasive these represent a potential savings to the productive sector. Taking as its point of view the environmental issue, the material falls in reducing the generation of pollutants, better provision for inputs from other processes and better biodegradability of polymeric materials.

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