PREPARATION OF BIODEGRADABLE COMPOSITE WITH PALM HEART AGROINDUSTRY WASTE BIOMASS

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Abstract. *Peach palm (Bactris gasipaes) is a multi-purpose palm tree, mainly utilized for food industry (fruits and palm core), being important cash income for smallholders. During the production process the palm core large amount of waste is generated and this can cause environmental problems. As a way to reuse the waste from peach palm agroindustry the aim this work was to produce biodegradable composites using different proportions (50, 55 e 60%) of peach palm residues (external sheaths) incorporated with polyurethane foam obtained from vegetable oils. Residues will be collected, dried in an oven at 65-70º C for 72 h, cut into small lengths on a Wiley mill and sifted through a mesh 35(500 µm). Then, incorporated with polyurethane rigid foam derived from vegetable oil. Both the raw materials and their composites will be characterized. Composites produced from the residues of the palm heart agroindustry have adequate thermo-mechanical characteristics, being a water-resistant and thermo-stable material.*

1. INTRODUCTION

The development of eco-friendly materials obtained from sustainable processes has been a necessity to minimize environmental problems in the world, mainly due to the growing awareness about global warming, waste management issue and dwindling fossil resources. Bio-composites can be one of the alternatives to achieve sustainability for being a material where at least one constituent is bio-based, generally are used fibers from agroindustry residues or wood processing.

Natural fibers have economic advantages compared to synthetic fibers in addition to being biodegradable, renewable, abundantly available and lightweight [1]. The social benefits are associated with the fact that many of the regions that produce natural fibers are in areas with fragile economic conditions or degraded environments [2, 3]. How is the case of the Paraná Coast (Brazil), considered one of the Brazilian producing poles of peach palm which features one of the smallest human development index (HDI) (HDI lower than the Brazilian average of 0,754). The production of peach palm in these regions is destined mainly for the extraction of palm hearts.

During the production process the palm hearts, parts, such as of stipe, leaves, and, sheaths are discarded. Some of this material remains at the harvesting, but large amounts become waste without suitable use and this can cause environmental problems. The use of agro-industrial wastes as raw materials can help to add income to smallholders through the commercialization of products obtained from composites (e.g. craft products), also reduce the pollution load from the environment generated by improper disposal of waste, contribute to food security and poverty alleviation.

Some efforts have been made in order to find applications for waste from palm heart agroindustry including the development of composites with polymers matrices from both the renewable and non-renewable resources. Studies indicate the potential composites formed for natural fiber reinforced polyurethane foam promoting high quality, mainly regarding the mechanical, acoustical and heat insulation properties [4, 5, 6].

As a way of to find an environmentally friendly destination for peach palm residues, the aim of this work is at preparation and characterization of composites of heart-of-peach palm sheath residues with polyurethane foam obtained from vegetable oils.

2. MATERIALS AND METHODS

Residues were collected from agroindustry in Paranaense Coast to produce the composites, after were dried in an oven at 65-70°C for 72 h, cut into small lengths on a Wiley mill and sifted through a mesh 35 (500 µm). Different proportions of the residue (50, 55 and 60%) were incorporated with the polymer. Were used two-component polyurethane rigid foam derived from vegetable oil of Kehl brand, reference KT1106, in pre-polymer: polyol ratio 1:1, a total of 120 g (residue + polymer polyurethane foam) was used to each sample. The pressing will be done in a hot press at approximately 60 ºC for 25 minutes with a pressure of 6MPa, each composite had a nominal dimension of 140 mm X 140 mm X 4 mm. After composites preparation and before to measure the mechanical properties, the samples were conditioned in a desiccator.

2.1. Water absorption test

The effect of water absorption on composites was investigated by following ASTM D 570-98. Five samples of each different type of composite were prepared for the testing of thickness swelling and water absorption. All samples were oven dried at 60°C for 24 h. After oven drying, the samples were cooled in decissators over granulated silica.

The test was conducted by immersing the composites in a deionized water bath for different time durations. After immersion for 2 h, the specimens were taken out from the water and all surface water removed with a clean dry cloth. The specimens were weighed regularly and measured the thickness from 24 hours. The specimens were weighed to accuracy of 0,1 mg.

2.2. Thermogravimetric Analysis (TGA) and Dynamic Mechanical Analysis (DMA)

TGA tests were performed in a Setaram equipment—SetSys Evolution model. Samples (4 to 6 mg) were heated from 30°C to 600°C at a constant heating rate of 10°C min^{-1} under a nitrogen flow rate of 50 ml min^{-}1. The mass (TG) were determined.

Dynamic mechanical analysis (DMA) was performed with a rectangular measuring system using a single cantilever. Rectangular samples were cut from the original composite to the size of 35 mm x 15 mm x 4 mm. The samples were measured using a TA Q800 instrument to obtain the curves of storage modulus (E0) and loss factor (tan d) at the fixed frequency of 1 Hz.

3. RESULTS AND DISCUSSION

3.1. Water absorption

Water absorption is one characteristic of composites that determine their end use aplications [7]. Table 1 depict the percentages of the water uptake and swelling for the composites after 24 h of immersion, which vary proportion of the peach palm residue (PPR) and polyurethane (PU). All composites showed the same behavior regarding water absorption. The natural fibers showed hydrophilic characteristic, so exhibit poor resistance to moisture.

Table 1. Thickness swelling and water absorption the composites after 24 h of the exposure to distilled water

Formulation of composites	Thickness swelling		Water absorption	
	mean (%)	standard deviation	mean (%)	standard deviation
PPR 50/ PU50	1.07a	0.24	8,41 a	2.51
PPR 55/ PU45	1.00 a	0.45	9,57 a	2.01
PPR 60/ PU40	0.80 a	0.39	13,45 a	2.94
PPR 0/ PU100	0.85 a	11.97	12,68 a	14.58

Means followed by the same letters area not statistically different ($p > 0.05$).

Likewise, there was no significant difference between the different compositions of composites for a variable thickness swelling. Despite the high change in mass caused by water absorption, the thickness of the materials remained stable, with an average maximum increase of 1.07%, suggesting that the water was not absorbed by the fibers, but by the empty cells from the foam, not affecting significantly the physical characteristic of the composites.

This can also be corroborated through the analysis of water absorption by PPR 0 / PU100. The expansion of the pure polymer occurs of forms different concerning composites, once there are no fibers as an obstacle for expansion, favoring the creation of cells capable of absorbing water, but which, on the other hand, do not change the thickness of the material. This characteristic was also analyzed by [8].

The figure 1 shows the storage module curves of the composites consisting of only by polyurethane (PPRO_PU100) and, composite with 50, 55 e 60% of the peach palm residue (PPR50_PU50, PPR55_PU45 and PPR60_PU40, respectively).

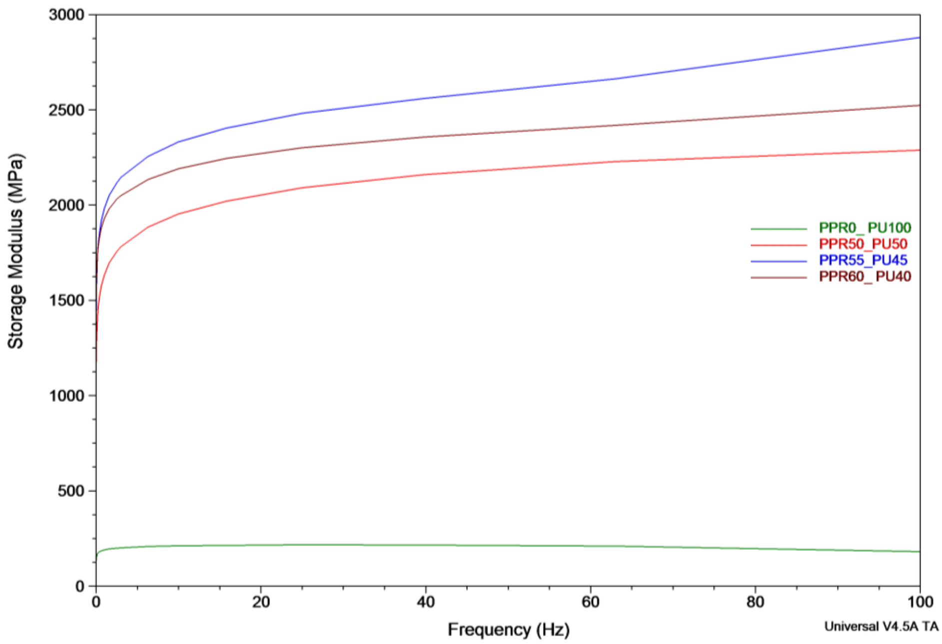

Figure 1 - Storage modulus of composite with polyurethane and different proportions (50, 55 e 60%) of peach palm residues

There are numerous factors that influence the results of the DMA analysis in composites, such as matrix type (resin thermoplastic or rigid), the amount of fiber incorporated into the matrix, the length of the fibers, their form of dispersion and the interaction / adhesion between the fiber and the matrix [8]. The composite formed only by polyurethane demonstrated a storage module practically constant, when compared with the other samples.

The incorporation of the peach palm fiber promoted an increase in the storage module with an increase in frequency, mainly of the composite formed by 55% residue, which presented the greatest increase of up to 2875 MPa at 100 Hz.

3.2. Thermal gravimetric analysis (TGA)

Figure 2 shows mass loss curves of Polyurethane composites with pupunha fibers. It can be observed from Figure 2 (comparison of TGA of composites) that the events of loss of mass of composites present a similar behavior, differing as to the temperature at which they occur. The composite with a lower amount of Polyurethane (40%) presented a higher thermal resistance, with a lower rate of loss of mass from temperatures of 300 °C compared to the others. The composite with the lowest thermal resistance was the one with the highest amount of Polyurethane (50%). The thermal behavior of the composite can be explained as the combination of the thermal behavior of its components, being that the material present in greater quantity can cause greater influence on the thermal behavior [9].

On Figure 2 it can be observed the occurrence of a thermal event between 60 °C and 150 °C that can be influenced by the loss of sample water and decomposition of substances present on the fiber surface. From 150 °C to 400 °C there is a loss of mass that may be related to the degradation of cellulose, hemicellulose and lignin of the fiber and to the decomposition of urethane bonds and rigid segments of polyurethane. From 400°C to 550 °C there is degradation of fiber lignin and flexible segments of polyurethane. The remaining mass after the temperature of 550 °C can be identified as firing residues. These behaviors were also observed by [10,11,12].

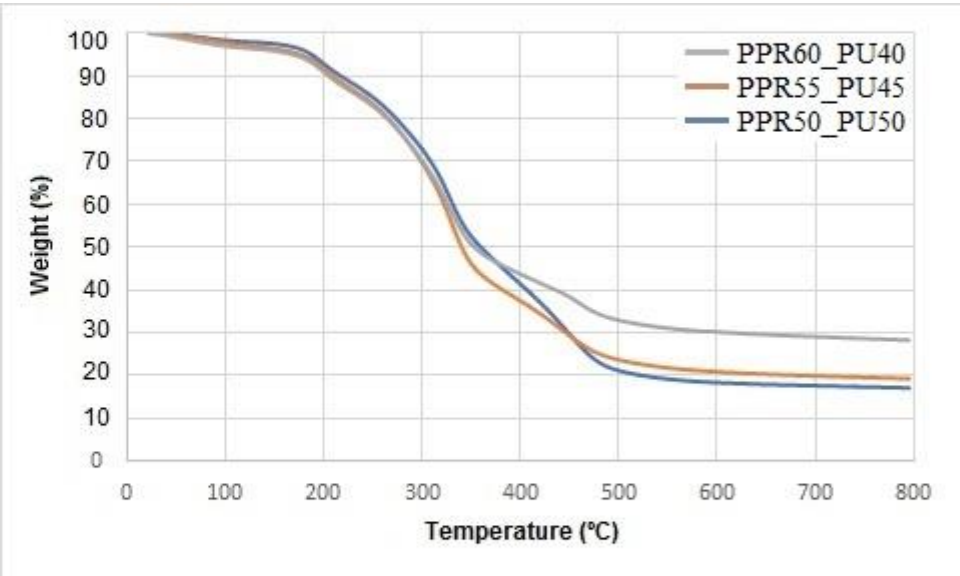

Figure 2 - Thermogravimetric Analysis (TGA) of composite with polyurethane and different proportions (50, 55 e 60%) of peach palm residues.

It is expected that pure polyurethane presents lower thermal resistance [12], a fact that is observed in the curves of mass loss of composites (Figure 2), in which it is possible to verify that composites with a higher proportion of polyurethane had higher mass loss compared to composites with 40% polyurethane.

4. CONCLUSION

The pupunha fiber acted as reinforcement in polyurethane foam composites derived from vegetable oils, increasing the modulus of elasticity. The absorption of water occurs because it is a composite from foam, but this does not significantly change the thickness of the same, being, therefore, a material that can be used in areas susceptible to humidity. The thermal stability of composites, especially at temperatures below 100ºC suggests that the material is stable at room temperature. Thus, it can be concluded that composites can be used as craft materials, among others.
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