WATER ABSORPTION STUDY IN COMPOSITES OF EPOXY MATRIX USING AS REINFORCEMENT FIBER: SISAL NATURAL, ACETYLATED AND MODIFIED WITH ALUMINIUM OXIDE HYDRATED

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Abstract

Due to its eminent environmental concern, purely synthetic materials are being increasingly discouraged for application as dispersed phase in polymer matrix composites. Considering its mechanical properties, an ecological alternative for it is the use of Sisal fiber (Agave sisalana) as reinforcement. However, by reason of its hydrophilic nature, there is a necessity to improve the characteristics of the fiber in terms of decreased water absorption capacity, increased mechanical strength and improved thermal stability. The possible improvements currently studied are the surface modifications of plant fibers through physical and chemical treatments. This work has the objective of presenting two surface treatments of sisal fiber: acetylation and modification with hydrated aluminum oxide ($Al_2O_3.nH_2O$), which is called hybrid. The fibers were characterized by Fourier transform infrared spectroscopy (FTIR). The presence of 0.72% (w/w) aluminum was observed by using dispersive energy spectrometry (EDS) attached to a scanning electron microscope. The manual rolling process was used to prepare the composites. Tests of water absorption in the composites showed a decrease in 33% when the acetylated fiber was used as reinforcement and 28% when using the hybrid.

1. INTRODUCTION

Generally, a composite can be considered as any multiphase material that exhibits a significant proportion of properties of both constituent phases. For the biocomposites, at least one of the phases has organic origin[1][2]. Currently, there is a high demand for new materials that combine simplicity in production, high quality standard, large scale supply and low manufacturing cost. Additionally, with the growing environmental concern with residues and product lifetime, the use of pure synthetic materials in both matrices and reinforcements has been increasingly discouraged on the many engineering applications[3]. The sisal fiber (Agave Sisalana) stands out as a dispersed phase in biocomposites, due to its availability and mechanical resistance. Usually when the fiber is hydrophilic, surface treatments are used to improve interfacial adhesion and consequently there is a significant increase in the mechanical properties of the material[4]. Acetylation is a chemical modification technique that decreases the hydrophilic tendency of natural fibers. The hydroxyl groups present in the hemicellulose or lignin constituting the sisal fibers are partially replaced by the acetyl functional group present in the acetic acid, thus it forms an ester. This type of modification shows a notable improvement in interfacial bonds, promoting changes in mechanical properties[5][6][7]. The hydrated aluminum oxide ($Al_2O_3.nH_2O$) is the inorganic component most used as flame retardant when applied to polymers[8]. As the temperature rises, the hydrated alumina oxide decomposes endothermally (about 220 ° C with an endothermic reaction of 1.17 KJ g -1). It absorbs energy and releases nonflammable water that dilutes combustible gases [9]. Group work has shown promising results regarding the thermal stability of lignocellulosic fibers treated with hydrated aluminum oxide[7][10][11]. Besides the optimization of mechanical and thermal properties, surface treatments of natural fibers seek to minimize water absorption[6]. The aim of the present work was to evaluate the amount of water absorption in epoxy matrix composites reinforced with modified sisal fiber through two surface treatments: acetylation and modification with hydrated aluminum oxide ($Al_2O_3.nH_2O$).

2. METHODOLOGY AND CHARACTERIZATION

First of all, the sisal fibers, which were bought from Sisalsul, were subjected to attack with 80% (v / v) acetic acid for 20 min at 120ºC whilst stirring, promoting their acetylation. In a second stage the acetylated fibers were placed in a reactor, where metal aluminum was solubilized in a solution of KOH (0.2 mol L^{-1}). Then, H_2SO_4 solution (1 mol L^{-1}) was added until pH ~ 9 for the precipitation of the hydrated aluminum oxide. The fibers were washed and dried at room temperature until constant weight. At that point The natural, acetylated and hybrid fibers were analyzed using Fourier Transform Infrared Spectroscopy (FTIR) techniques and scanning electron microscopy attached to a dispersive energy spectrometer (EDS). For this work three composites were prepared, one with natural sisal fiber as reinforcement, the second with acetylated fiber and the third with the hybrid. The conformation of the composite begins with the preparation of the reinforcement, which is the organization of the fibers in a continuous and parallel pattern. After preparation of the reinforcement, a blend of Araldite LY 1564 epoxy resin with Aradur 2963 hardener was added to the fibers at a ratio of 5.8 g of blend: 1g of fiber, using the manual laminating technique. After 24 hours the composites were submitted to the water absorption test according to ASTM D570. For this test, a pre-weighed 5cm x 5cm specimen was immersed in deionized water at 23 ° C (± 2). After 2h the specimens were dried and weighed. The tests were repeated every 24 hours until a significant mass variation was not observed. The test was done in triplicate.

3. RESULTS

Figure 1 shows the FTIR spectrum of the natural, acetylated and hybrid fibers. An axial strain C = O of ester is observed at 1740 cm-1, confirming the occurred esterification in the sisal fiber. It should be noted that the hybrid does not exhibit this vibration, that indicates a modification in the ester function of the structure. Figure 2 shows the results of the water absorption test between (a) natural, acetylated and hybrid fibers and (b) their respective composites. The test allows to say that the fibers maintained a different behavior and the treatment promoted significant changes in the capacity of absorption. Even though it was observed to increase in the fiber's water capacity after the treatment with aluminum oxide, the test with the composites shows a decrease of 33% and 28% for those that used the reinforced fibers acetylated and hybrid, respectively.

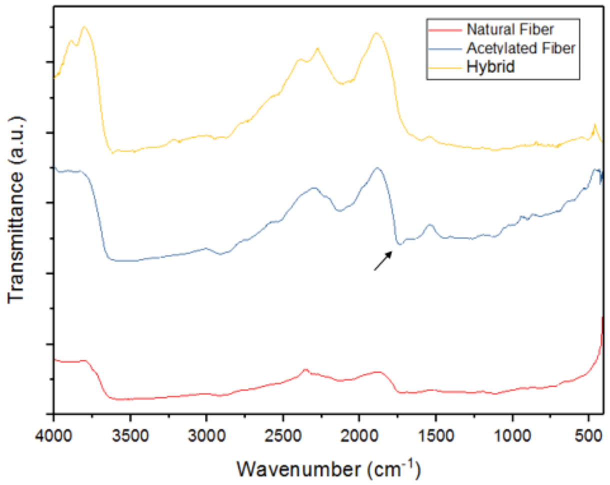

Figure 1 - FTIR spectre natural fiber, acetylated and hybrid

(a) (b)

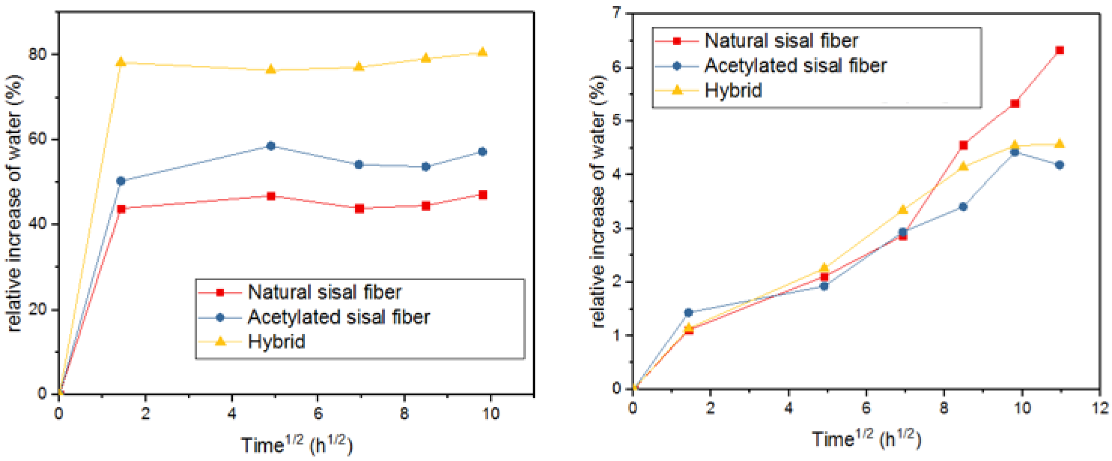

Figura 2 –water absorption (a) natural fiber, acetylated and hybrid (b) epoxy matrix composites with natural fiber, acetylated and hybrid

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4. CONCLUSION

Esterification was verified by FTIR and generation of the hybrid by EDS. The treatments performed on the fiber promoted changes, resulting in a decrease in the water absorption capacity of the epoxy matrix composites studied.

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