DEVELOPMENT OF CEMENT- BASED MATRIX COMPOSITES REINFORCED WITH TREATED JUTE FABRICS USING THE POLYMER STYRENE-BUTADIENE

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Abstract

The use of plant fibers for low impact and durable composites development has a well-known importance, since they are biodegradable and low cost. These fibers and their fabrics are used as reinforcement on cement based composites in order to improve their mechanical properties. However, it is important to consider the interface between the natural fibers and the matrix. In the present paper, jute fibers fabric were treated superficially using several styrene-butadiene polymers to promote durability and to increase bonding to a cement based system. A matrix free of calcium hydroxide was used. Jute fabrics were evaluated by mechanical and chemical analysis. Adhesion was evaluated by Pull-out tests.

Keywords: Natural vegetable fiber, Jute, Styrene-Butadiene, Polymer, Composite.

1. INTRODUCTION

Despite the benefits of the use of natural fibers as the ultimate green material option, such as minimizing the use of natural resources and overall lifetime impact, the use of such material is not that simple. In the line of development of materials reinforced with natural fibers, many researchers have been carried out on cementitious and polymeric matrix composites and promising results have been achieved.

Even with results showing an improvement in strength and ductility there still a lack of information about fiber and composite durability.

The impregnation treatment using the styrene-butadiene (SBR) polymer can be an alternative to improve adhesion and promote composite durability, considering that SBR polymer builds a physical and chemical bond to both cellulose and cement based matrix [5]. Therefore, both the partial replacement of cement by metakaulin can promote natural fibers protection mechanisms against alkaline degradation.

In summary, this research objective was to evaluate the mechanical and chemical behaviour of polymer treated jute fabrics regarding the interface with a cement-based matrix.

2. MATERIALS AND METHODS

2.1 Natural jute fabrics and polymer treatments

The Natural jute fabrics used in the present study were obtained from a Brazilian company, located in the city of São Paulo. The average diameter of natural jute fibers was 0.066 mm. Each jute string contained, in average, 12 fibers, and its average diameter was 0.785. Moreover, natural jute fabric contained, in average, 2.7 strings/cm and 3.5 strings/cm, transversely and longitudinally, respectively.

The polymer treatment used in the present study consisted in an impregnation by immersing a fabric of fibers in three different polymers: NTL-271 carboxilated styrene-butadiene polymer (SBR-X), NTL-350 (SBR-1) and L-2108 (SBR-2) its monomers emulsion where the continuous phase is water (See table 1). The jute fibers were placed in a container with the polymer emulsion for 50 minutes. The fibers were then dried in an oven during 24h at 40ºC.

Table 1: Polymers used to treat the Natural jute fabrics

	Styrene content (%)	**pH**	**Surface Tension (dynes/cm)**	**Brookfield Viscosity (cP)**	**Solid content (%)**
SBR-X (NTL-218)	50%	8.5 – 9.5	40 - 50	90 – 200	48 - 50
SBR-1 (NTL-350)	-	11-12	35-45	70	49-51
SBR-2 (L-2108)	21.5-25.5	10.7 – 11.7	55 – 60	43	38-41

2.2 Direct tensile tests (fabric)

Four samples for each treatment and for the natural fabric were crafted for these tests. The treated and natural fabrics were cut in 30 cm x 5 cm (length x width) tapes and a 4 cm silver-tape protection was set at the fabric edges in order to mitigate the fabric displacement during the test, so that, the effective dimensions of the fabric requested in the test were 22 cm x 5 cm (length x width).

The fabric tapes were tested in an Arotec machine with a load cell of 300 kN, at the Department of Engineering at UFLA, at a 1.25 mm/min speed.

2.3 Differential Scanning Calorimetry (fiber)

Fiber samples, extracted from the jute fabrics, weighing 10mg were subjected to a heating rate of 10°C/min until reaching 1000°C in a platinum crucible using 100 ml/min of nitrogen as the purge gas. The DSC tests took place at the Department of Chemistry at UFLA.

2.4 Developed matrix

The cement-based matrix that was used in this project was made using a 20L volume mixer. The design mix adopted was the following one: 1 (cement): 0.8 (metakaulin): 1.2 (fly ash): 1.52 (sand): 0.38 (water). Furthermore, 0.85% (bwc) of Glenium 51 super-plasticizer, acquired from BASF Brazil.

2.5 Pull-out test (string)

Thirteen samples for each treatment and for the natural string were crafted for these tests. Cylindrical samples with internal diameter of ¾ in and 25 mm high were made using the cement-based matrix established before and using PVC tubes with same dimensions as molds. The matrix was inserted in the molds, while the jute strings, extracted from the fabrics, were aligned uprightly at their centers. The pull-out tests were performed at the Department of Food Science at UFLA, using a Stable Micro System Lite Texturometer at 0.3 mm/min speed, after 7 days age.

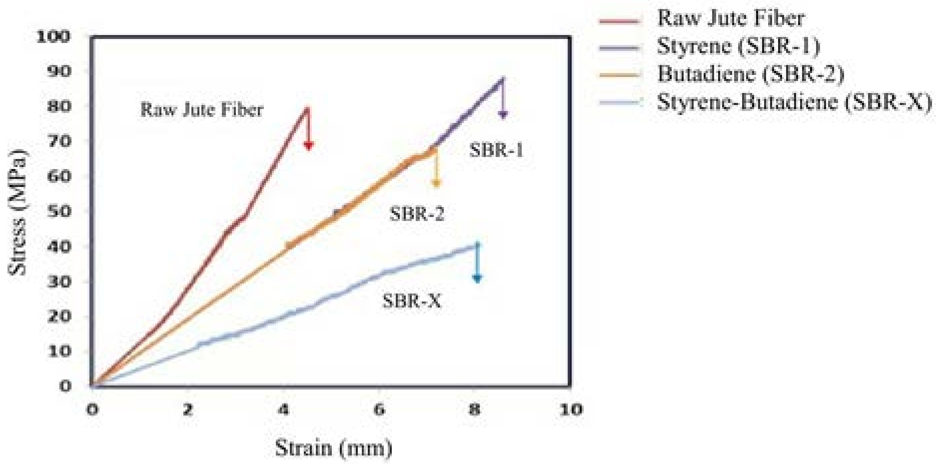
3. RESULTS AND DISCUSSION

3.1 Direct tensile tests (fabric)

The average diameter of natural jute fibers was 0.066 mm. After polymer treatment the average value changed to 0.068, 0.070 and 0.068mm to polymer SBR-1, SBR-2 and SBR-X, respectively. Figure 1 shows the typical curves of raw and treated fabrics subjected to tensile test. According to Figure 1, it is notable that the treated fabrics reached a higher capacity of deformation while requested in the direct tensile test. It is possible to observe that the treatments improved strain capacity in 79.78, 92.22, 63.33 % to SBR-1 SBR-2 and SBR-X, respectively, in comparison to the raw jute.

Moreover, as shown in Figure 1, all treatments decreased stiffness values, in comparison to raw jute. The jute fabrics treated with Styrene and Butadiene achieved similar stiffness values. The Styrene treatment improved the maximum value of the material's strain in 10.70 %, while the others treatments reduced this maximum value, comparing to the natural fabrics (Figure 1).

Figure 1: Typical curves of raw and treated fabrics subjected to tensile test.

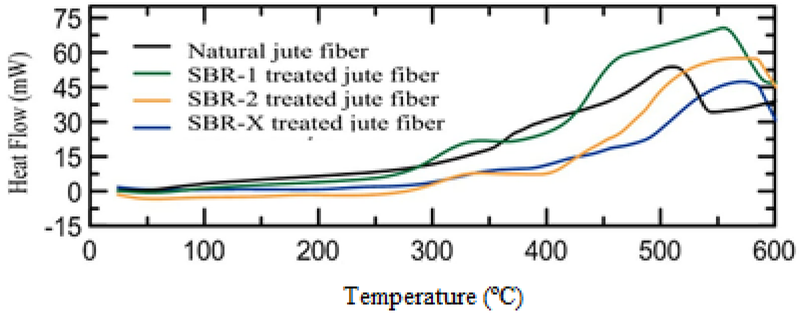


3.2 Differential Scanning Calorimetry tests (fiber)

Figure 2 indicates the thermal evolution of fibers substances degradation events with the temperature.

As shown in figure 2, for all the treatments, cellulose molecules were degraded for temperatures greater than 350 ºC, which is their typical degradation temperature. Thus, it can be deduced that all applied treatments intensified the interaction of cellulose molecules with each other.

Figure 2: Thermal evolution of fibers substances degradation event with the temperature.

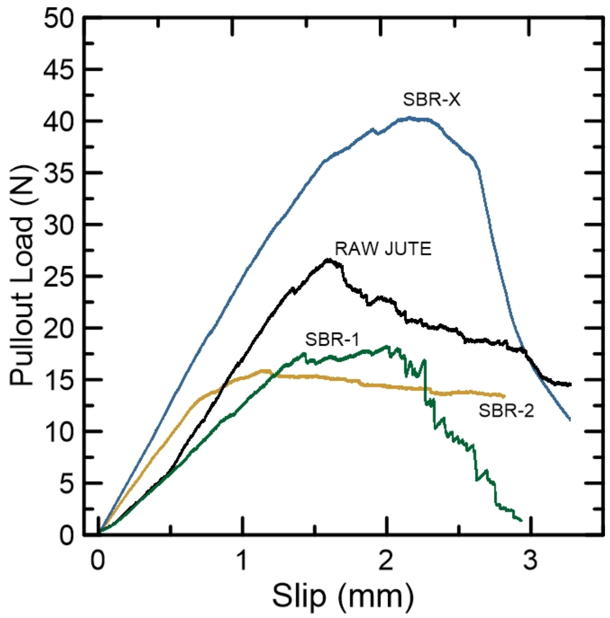


3.3 Pull-out tests (string)

Figure 3 indicates the typical curves of natural and treated jute strings when subjected to the pull-out test.

According to Figure 3, it is notable that the SBR-X treatment increased in 33.63 % the pull-out load of the string, comparing to the natural one. This result indicates that the Styrene-butadiene treatment increases the adhesion between the jute string and the matrix.

Figure 3: Typical curves of natural and treated jute strings subjected to the pull-out test.



4. CONCLUSION

The work in hand investigated the effect of several polymers treatments on jute fibers mechanical and fiber-matrix interface properties. The following conclusions can be drawn from the present research:

- All applied treatments promoted an increase of thermic stability of cellulose;
- After treatment the jute fibers presented an increase of strain capacity;
- SBR-X polymer treatment was more effective on increasing fiber-matrix adhesion.

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