THE INFLUENCE OF SALINITY TREATMENT ON THERMO - MECHANICAL PROPERTIES OF SUSTAINABLE JUTE TISSUE/NESTRAPOL 455-60 COMPOSITE

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Abstract: *Unsaturated polyester resin and jute tissue are combined to obtain a sustainable composite. In the present research paper, some aspects about the thermomechanical properties after immersion in aqueous solution with 5 % NaCl for 3 months at room temperature are presented. Thermo-gravimetric analysis (TGA) and three point bending test were used to study the thermal decomposition behavior and to determinate some aspects concerning the characteristics of this composite.*

Keywords: *natural fibres, unsaturated polyester resin, bending test, thermal analysis*

1. INTRODUCTION

Recently, with growing pressure on the word's resources, as well as concerns about disposal of the synthetics fiber the strict environmental regulations have forced the composite industry to replace the conventional materials such as glass fiber or carbon fiber with an alternatively eco - friendly reinforcements such as natural fibers [1,2]. Natural fibers are undergoing a high-tech revolution that could see them in applications such as boat hulls, bath tubs, archery bows, some plane parts, automotive, aerospace, rail sectors, etc. [3, 4, 5]. In this sense jute is one of the most well-known natural fibers used because is eco-friendly, low cost, versatile in textile fields and has moderate mechanical properties [6]. Polymer matrices are most commonly used because of cost efficient, easy of fabricating complex parts with less tooling cost and also having excellent room temperature properties when compared to other matrices [7]. The saline medium and climatic conditions, affect in time the thermo-mechanical properties of eco-composites. Within the frame of this work thermal ageing and flexural tests are carried out on untreated composite samples and treated in aqueous solution with 5 % NaCl.

2. EXPERIMENTAL DETAILS AND RESULTS

2.1. Material and method

Commercial jute fabric and Nestrapol 455-60 unsaturated polyester resin were performed by hand lay-up method to obtain natural composite plate with 3 layers (Figure 1). In Figure 2 are presented ten specimens were left drying several days to obtain the optimum mechanical properties.

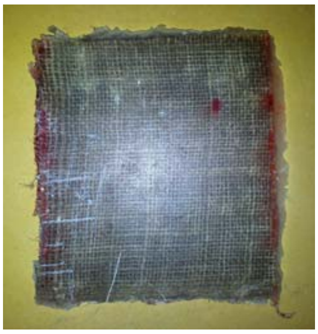

Fig. 1. Jute fabric/resin composite plate

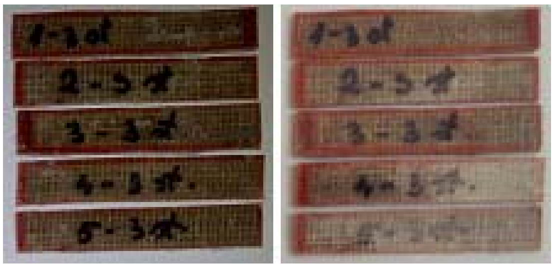

Fig. 2. Jute fabric/ resin composite specimens

2.2. Water uptake

In this study synthetic aqueous solution with 5 % NaCl was performed on the jute fabric and unsaturated polyester resin composite for 3 months. Periodically the 5 samples were weighted with a precise electronic balance, for 12 days every 24 hours, for monitoring the variation of the sample mass during the ageing process.The absorption process was expressed with the relation (1) [8]:

$$Water\ uptake = (P_w - P_o/P_o) * 100\ [\%] \quad (1)$$

where: P_w - is the wet weight;
P_o - is the dry weight of the specimen

Figure 3 reports the median water uptake of 5 jute/unsaturated polyester resin samples for 3 months.

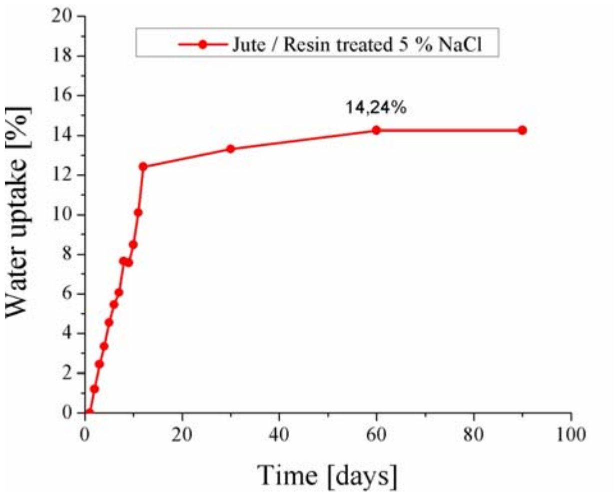

Fig. 3. Median water uptake (%) for jute/resin composite

Median uptake of aqueous solution with 5 % NaCl is shown in Figure 1.
The curve present a rapid gain of aqueous solution in the first 12 days and the absorption becomes slower and static in time.

The equilibrium state of the composite can be seen after 60 days, with an absorption to 14, 24 %.

2.3. Simultaneous TG / DTA analysis

A *STA 449 F3 JUPITER* thermogravimetric analyzer instrument was used to analyze the thermal decomposition of the untreated and treated 5%NaCl jute/unsaturated polyester composite. Sample weights of around 15 mg were heated from room temperature up to 600 ºC. The heating rate is 10 ºC/min under nitrogen atmosphere at a gas flow rate of 20 ml/min as the purge gas to determine the residual limited to thermal stability results associated with mass loss with temperature. The TG / DTA analyses of jute fabric/resin composite are shown in Figure 2.
In Figure 4, the comparative TG / DTA curves for untreated and treated samples are plotted and the degradation occurs with increasing temperature. Three stages of thermal degradation can be observed.
In the 1st stage mass loss occurs in range of room temperature to 170 ^{o}C with composite dehydratation. The 2nd stage of mass loss occurs at ~ 265 ^{o}C with exothermic peak of T_{onset} = 217 ^{o}C corresponding to decomposition of chemical compounds of matrix and some constituents of jute fiber.
In the 3rd stage the major mass loss can be observed between 355 ^{o}C to 420 ^{o}C. In this temperature range the untreated and treated composites reported a mass loss of 53,70 % and 58,56 % respectively. It is evident that the treated sample is stable compared with untreated sample and the differents of residual mass between samples are caused by the present of salt crystals, retained after water evaporation.

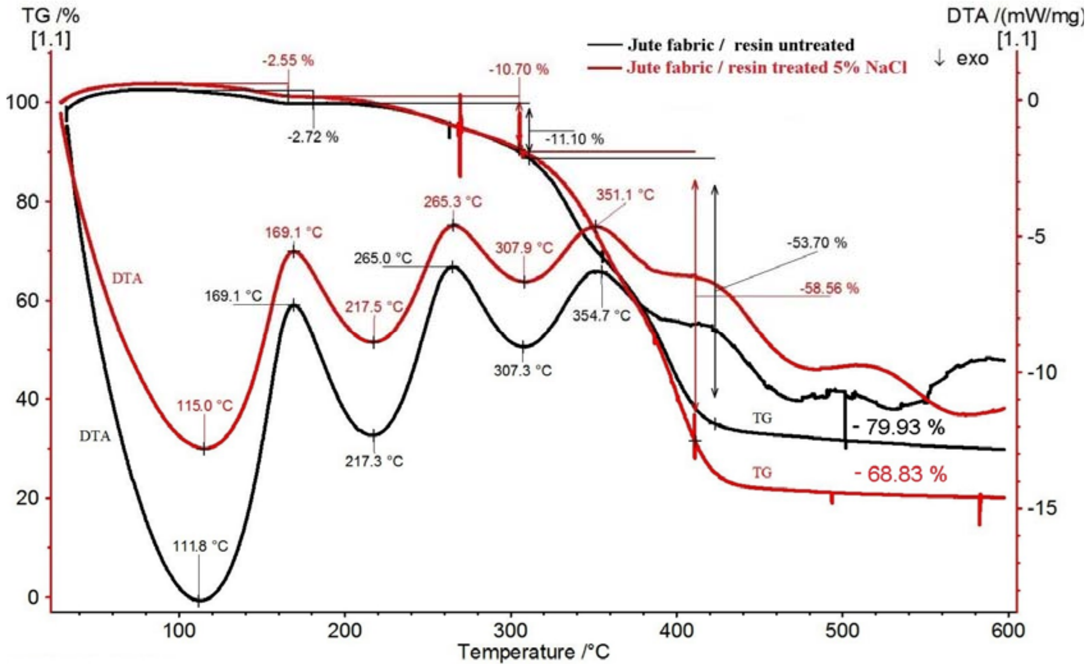

Fig. 4. TG/DTA curves of untreated and treated jute fabric /unsaturated polyester composites

2.4. Three- point bending test

In Figure 5, are presented the LR5K Lloyd's apparatus which provides a maximum force F_{max} = 5 kN. In the Table 1 are presented ten specimens with exact dimension corresponding to untreated and treated composites and tested in horizontal position by applying a down warded load at the mid-length with a constant speed of 5 mm/min.

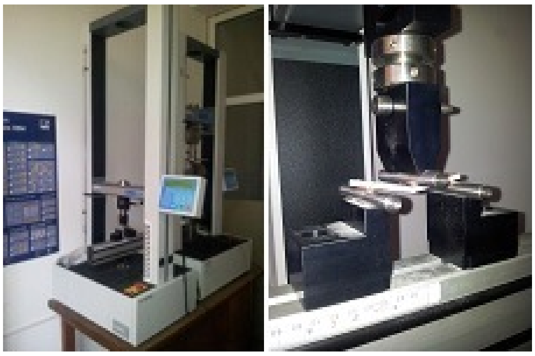

Fig. 5. LR5K Lloyd's apparatus

Table 1. The dimensions of untreated and treated jute fabric/resin samples

Jute fabric/Unsaturated polyester resin composites					
Samples	Untreated				
	1	2	3	4	5
L_2 [mm]	80	80	80	80	80
b_1 [mm]	15	15	15	15	15
h [mm]	3.02	3,50	3,16	3,37	3,39
A [mm^2]	45,3	52,5	47,4	50,5	50,8
Samples	Treated 5% NaCl				
	1	2	3	4	5
L_2 [mm]	80	80	80	80	80
b_1 [mm]	15	15	15	15	15
h [mm]	3,34	3,17	3,08	3,41	3,22
A [mm^2]	50,1	47,55	46,2	51,15	48,3

Table 2. The mechanical properties of untreated and treated jute fabric/resin composites

Characteristics	*Units*	*Median values of jute fabric /resin*	
		Untreated	Treated 5% NaCl
Stiffness	[N/m]	7775,9	7575,3
Young's Modulus	[MPa]	1258,3	771,94
Maximun Load	[kN]	0,0561	0,0519
Max. Bending Stress at Max. Load	[MPa]	39,91	27,13
Extension at Max. Load	[mm]	14,6	15,4
Max. Bending Strain at Maximum Load	[-]	0,0642	0,0790
Load at Break	[kN]	0,01264	0,05135

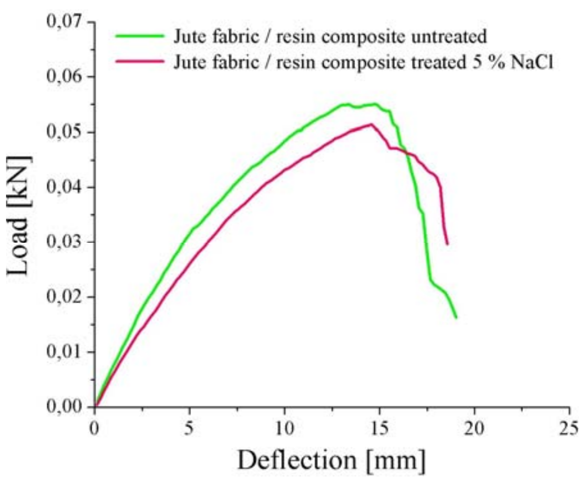

Fig. 6. Median load - deflection curves of untreated and treated jute fabric / resin composites

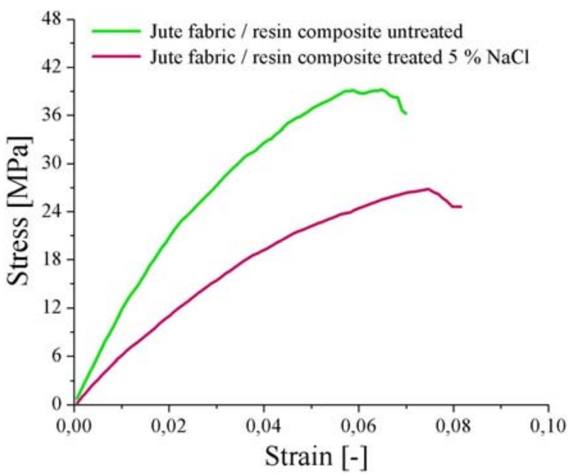

Fig. 7. Median stress-strain curves of untreated and treated jute fabric / resin composites

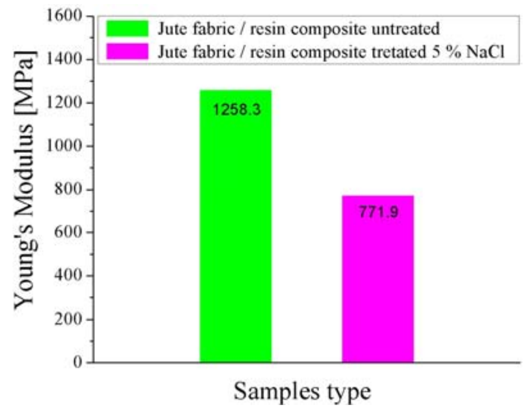

Fig. 8. Median Young's Modulus of untreated and treated jute fabric / resin composites

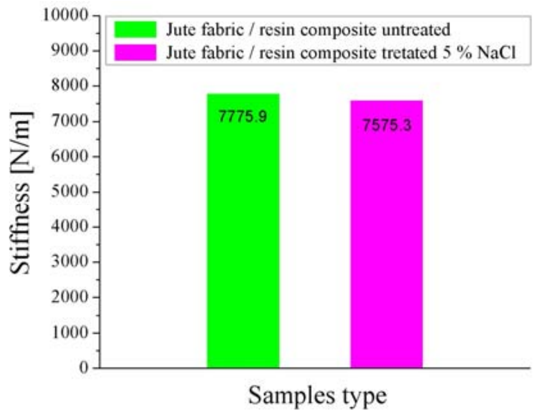

Fig. 9. Median Stiffness of untreated and treated treated jute fabric / resin composites

The influence of 5 % NaCl aqueous solution on flexural properties of jute fabric reinforced polyester resin composite is shown in Table 2. Figure 6 shows the load-deflection curves of the untreated and treated jute fabric/resin composites. From the figure, it can be seen that the value of maximum load decrease after immersion from 0, 0561 kN to 0, 0519 kN. Figure 7 shows the stress -strain curves for untreated and treated samples. The untreated dispalyed the highest value 39.91 MPa while the treated jute fabric/resin composite showed the lowest 27.13 MPa. Figure 8 shows the Young's Modulus obtained by median value of stress-strain. The flexural modulus shows an decrease from 1258.3 MPa to 771.9 MPa, after 5 % NaCl aqueous solution immersion for three months. Figure 9 shows a comparison between stiffness and reported that after salt treatment the value decrease from 7775.9 N/m to7575.4 N/m.

3. CONCLUSIONS

The immersion of composites in 5% NaCl aqueous solution reported appearance of hydro-dilatation process, resulting interfacial debonding between fiber and matrix and finally decreasing the mechanical characteristics.

It is possible to reduce the water absorption by through chemical treatment having possibility to remove some constituents of cell wall for a good adhesion between fiber and matrix. Good wetting of the fiber by matrix and adequate fiber-matrix bonding can decrease the rate and amount of water absorbed in the interphasical region of composite [9]. From TG/DTA results it was reported that the sample treated in 5 % NaCl aqueous solution is more stable between room temperature up to 200 ^{o}C than untreated sample and after 200 ^{o}C the treated sample becomes instable.

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