

EVALUATION OF MECHANICAL PROPERTIES OF FRIENDLY COTTON / NESTRAPOL 455-60 COMPOSITES AFTER SALINE ENVIRONMENTAL CONDITION

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Abstract. In this research paper a comparison between mechanical characteristics of two friendly composites with three and five layers after immersion were evaluated. Five specimens for each composite were immersed in 5 % NaCl aqueous solution for 90 days at room temperature. Three point bending test show that the saline environmental conditions concern the mechanical characteristics between composites and with the increasing number of layers increases and properties.

Keywords: natural fibers, polymers, friendly composites, water absorption, mechanical characteristics

1. Introduction

In our days many composites have been developed with various types of synthetic fibers in order to improve the mechanical properties. Currently, polymers matrix composites reinforced with vegetable fibers have attracted great interest because are environmentally friendly, biodegradable, abundantly available, low cost, excellent mechanical properties like low density, better strength stiffness, Young's modulus, etc. Their various advantages can help to replace neat polymers or glass fiber composites [1-5]. Natural fiber such as cotton fiber in advanced composite materials with polyester resin offer an interesting alternative to petrochemicals products, cotton is mainly used for sports equipment, automotive industries, low load bearing structures, buildings, packaging applications and marine sector [6-9].

In the present study cotton tissues / NESTRAPOL 450-66 unsaturated polyester resin composites with three and five layers were prepared and their 5 % NaCl aqueous solution absorption and flexural properties were studied. After monitoring the immersion for 90 days the mechanical properties of these specimens were tested to determine the effect of the 5% NaCl aqueous solution ageing and even the number of cotton tissue layers.

2. Materials and method

The matrix material used in this research paper was based on commercially NESTRAPOL 455-60 unsaturated polyester resin and the bidirectional cotton tissue. In Figure 1 are presented hand lay-up method applied to obtaining friendly composite plates with three and five layers.

From the cured plates, specimens with three and five layers for bending tests were cut by the electrical fretwork Proxxon. In Figure 2 are

presented the plate model and the specimens with different layers.

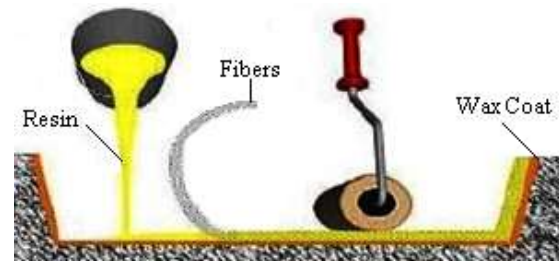


Figure 1. Hand Lay-up process [1]



a)



b)

Figure 2. Eco-composite plate (a) and bending test specimens (b)

3. Synthetic 5% NaCl aqueous solution uptake

Figure 3 shows the specimens for each composite with three and five layers were left to soak in 5 % NaCl aqueous solution for 90 days at room temperature.



Figure 3. Specimens immersed in 5 % NaCl aqueous solution

For 12 days the specimens was weighed with a precise electronic balance, every 24 hours to monitoring the variation of the composite mass and the absorption process was expressed with the relation (1) [11]:

$$\text{Water absorption} = (m_a - m_d)/m_d \times 100\% \quad (1)$$

where m_a is the mass of the sample after exposing to 5 % NaCl aqueous solution and m_d is the mass of dry specimens.

The Figure 4 reports the average of 5 % NaCl aqueous solution uptake of cotton tissue / unsaturated polyester resin specimens with three and five layers for 90 days.

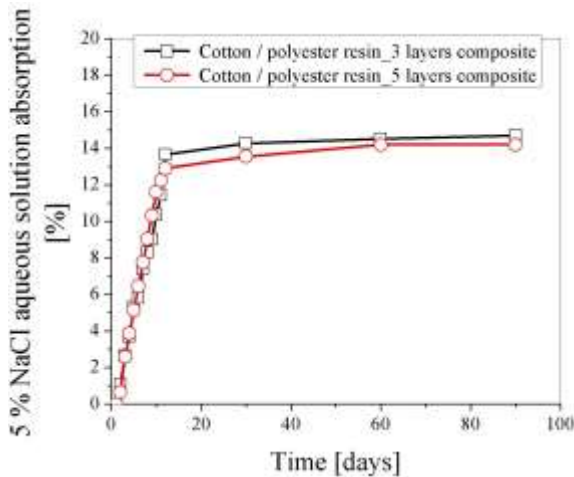


Figure 4. Average uptake of three and five layers specimens

In Figure 4 it is shown that, in the first 12 days the average of absorption report a rapid linear sharp of 13.65 % and 12.9 % corresponding to three and five layers composites, and the equilibrium state shows up after 60 days with 14.7% and 14.19 % of composites with three and five layers respectively.

4. Three point bending test

In Figure 5 are presented the flexural tests were produced by LR5K Lloyd's Instruments, which provides a maximum force $F_{max} = 5$ kN.

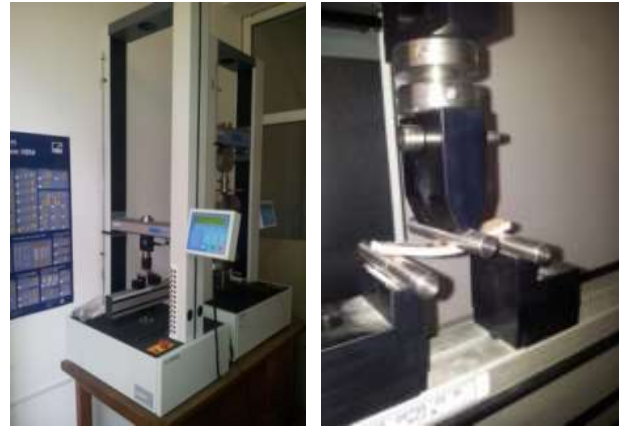


Figure 5. LR5K Lloyd's apparatus

The untreated and treated in 5 % NaCl aqueous solution specimens subjected to three point bending tests with a constant speed of 5 mm/min until fracture. The untreated and treated specimens' dimensions with three layers are presented in Table 1.

Table1. The dimensions of untreated and treated specimens with three layers

Sample no.	Cotton tissue / unsaturated polyester resin specimens with three layers				
	Untreated				
	1	2	3	4	5
L2 [mm]	80	80	80	80	80
b1 [mm]	15	15	15	15	15
h [mm]	1.81	1.56	1.42	1.49	1.56
A [mm ²]	27.15	23.4	21.3	22.35	23.4
Treated 5% NaCl aqueous solution					
	1	2	3	4	5
L2 [mm]	80	80	80	80	80
b1 [mm]	15	15	15	15	15
h [mm]	1.63	1.54	1.51	1.47	1.57
A [mm ²]	24.45	23.1	22.65	22.05	23.55

The untreated and treated specimens' dimensions with five layers are presented in Table 2.

The average of mechanical characteristics of cotton tissue/unsaturated polyester resin composites with three and five layers are presented in Table 3.

The graphs force-deflection is compared between untreated and treated specimens and is presented in Figures 6 and 8, respectively.

The median value compared between untreated and treated specimens shows better values with a maximum load of 0.0168 kN and 0.0658 kN for three and five layers of untreated cotton/polyester resin composites. In the Table 3 and Figures 7 and 9, it shows that the absorption of three and five layers composites decreased the flexural strength, but at the same time shows that the elasticity modulus decreases for three layers composite and

increases for five layers composite. It is evident that the saline environment acts on the polymer matrix by plasticizer and can offer good mechanical characteristics. Flexural test also proved that the cotton/polyester resin composite with five layers

had a higher flexural strength value at 55.74 MPa compared with three layers composite of a value at 48.02 MPa, and for 5 % NaCl aqueous solution treated composites respectively.

Table 2. The dimensions of untreated and treated specimens with five layers

Sample no.	Cotton tissue / unsaturated polyester resin specimens with five layers				
	Untreated				
	1	2	3	4	5
L ₂ [mm]	80	80	80	80	80
b ₁ [mm]	15	15	15	15	15
h [mm]	2.58	2.42	3.16	2.53	3.17
A [mm ²]	38.7	36.3	47.4	37.95	47.55
	Treated 5% NaCl aqueous solution				
	1	2	3	4	5
	L ₂ [mm]	80	80	80	80
b ₁ [mm]	15	15	15	15	15
h [mm]	2.77	2.64	2.88	2.51	2.43
A [mm ²]	41.55	39.6	43.2	37.65	36.45

Table 3. The mechanical characteristics of untreated and treated cotton tissue / unsaturated polyester resin composites with three and five layers

Characteristics	Units	Average values of cotton / unsaturated polyester resin composites			
		Untreated	Treated	Untreated	Treated
		Layers		Layers	
		3	3	5	5
Stiffness	[N/m]	933.5	855.11	5012.2	5074.9
Young's modulus	[MPa]	1208.5	1107	1053.0	1261.5
Maximum Load	[kN]	0.0168	0.0109	0.0658	0.0529
Max. Bending Stress at Max. Load	[MPa]	48.020	31.132	55.743	50.142
Extension at Max. Load	[mm]	27.8	31.0	21.1	28.2
Max. Bending Strain at Max. Load	[-]	0.061	0.068	0.0848	0.107
Load at Break	[kN]	-	-	0.0657	0.0194
Max. Bending Stress at Break	[MPa]	-	-	55.609	18.389
Max. Bending Strain at Break	[-]	-	-	0.0781	0.150

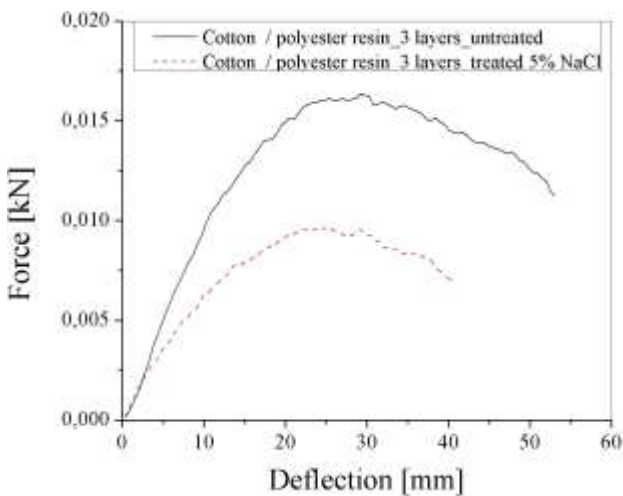


Figure 6. Average values of load-deflection curve of untreated and treated specimens

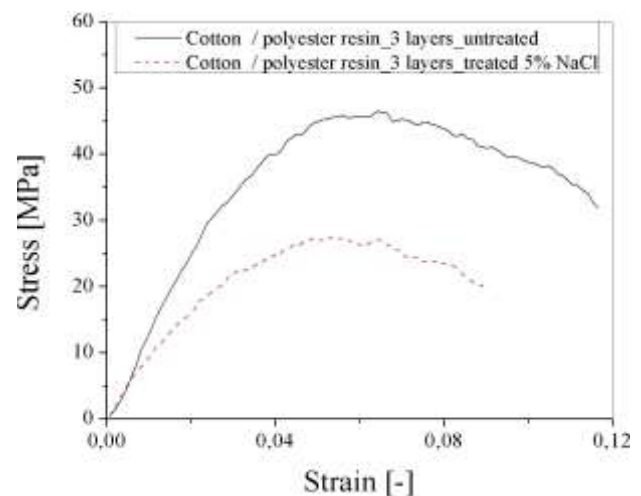


Figure 7. Average values of stress-strain curve of untreated and treated specimens

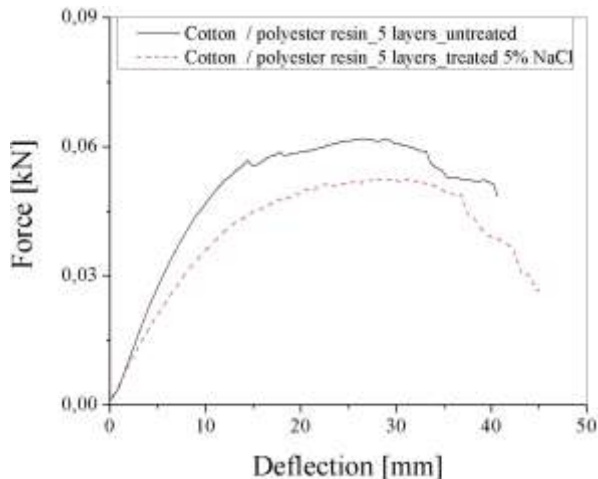


Figure 8. Average values of load-deflection curve of untreated and treated specimens

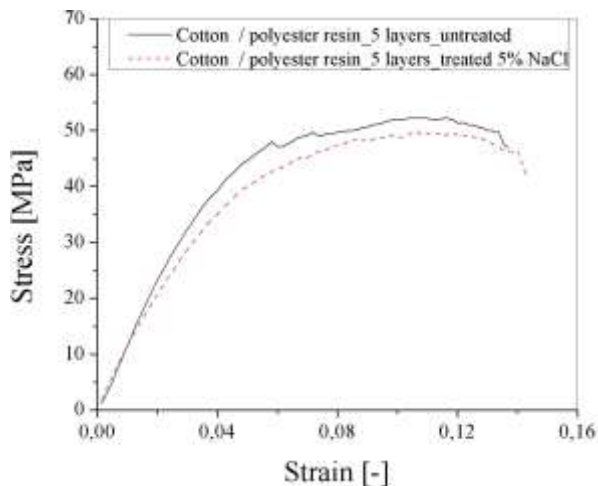


Figure 9. Average values of stress-strain curve of untreated and treated specimens

5. Conclusions

The biodegradable fiber reinforced unsaturated polymer composites with different layers was studied. The three point bending tests were investigated on eco-composite based cotton tissue / unsaturated polyester resin composites. Increasing the number of layers on the composite the mechanical characteristics get increased. The maximum value of flexural strength and elasticity modulus were found at five layers cotton tissue / polyester resin composite. The synthetic saline environment treatment decreases the flexural strength and increase the elasticity modulus by plasticizer effect of matrix composites. The hydrophilic nature of the fiber and the access of capillarity with the aqueous solution increase the absorption percentage.

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