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MECHANICAL PROPERTIES OF RECYCLED COTTON NONWOVEN USING CHITOSAN AND ACRYLIC RESIN AS A BINDER

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Abstract: *Nowadays, people are concerned with the use of natural products and the environment problems that some waste and chemicals products can cause. For this reason many researchers are developing new products or manufactures which use recycled materials in order to reuse waste and studying the possibility of replacing resins or synthetic materials with natural and biodegradable materials. The textile sector is making a big effort in order to carry out changes that improve the care of the enriroment.*

The aim of this work is the use of recycled fibres to produce nonwovens. To achieve the binding of the fibers a synthetic, acrylic resin, and natural resin, chitosan, are used. Chitosan is the N-deacetylated derivative of chitin. Chitin is the most abundant natural amino polysaccharide and is estimated to be produced annually almost as much as cellulose. It has become of great interest not only as an underutilized resource, but also as a new functional material of high potential in various fields due to its antimicrobial properties.

To study the behavior of nonwovens obtained using different binders and the possibility of using chitosan as a binder to produce nonwoven fabrics, flexural rigidity and tensile tests are carried out.

Key words: *strength, reused fibers, fabric, natural polymer.*

1. INTRODUCTION

Nowadays, there is a clear concern to stop the environmental deterioration, which is reflected in the increase of proposals that through their development allow to create a conciseness and humanization with the preservation of the natural environment. This has opened the possibilities of developing products that, based on fomenting this ideology under mercantile criteria, when purchased, used and discarded, decrease the impact on the diversity of ecosystems.

The present work focuses on the development of nonwovens of recycled cotton fibers using as a binder two types of resins, a biodegradable resin, chitosan, and a synthetic one, acrylic. The influence of using different binders of different nature is analyzed by comparing the characteristics of each of the nonwovens obtained. For this, the flexural rigidity, the tensile strength and the elongation percentage are analyzed.

Chitosan is a natural polymer, whose chemical structure is composed of a poly [β- (1-4) -2-amio-2-deoxy-D-glucopyranose] bond, obtained from the chitin alkaline deacetylation, a substance extracted from crustaceans and molluscs exoskeleton. Its molecular weight depends on the conditions in which the deacetylation takes place, but it is usually greater than 100kD [1].

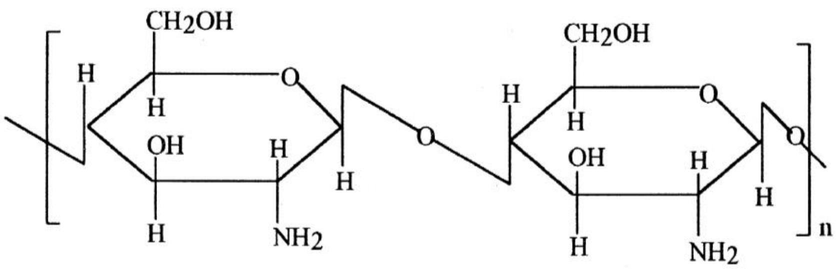

Fig. 1: *Chitosan chemical structure [2]*

Coming from a natural waste, quitosan is biodegradable and biocompatible, it also has antimicrobial properties, an aspect that has positioned it as a substance of great interest in various sectors, such as textile, because when applied it transfers this functionality being anti-allergenic and preventing infectious diseases [3].

Different applications of chitosan in fabrics are studied, for example W. Lox et al. [4] studied the improvement of the traction resistance in cotton fabrics treated with chitosan by padding system. This biopolymer is wide used as biomordant in dyeing process using natural dyes, due to textile fibers do not show any affinity to natural dyes, like Eisenia Bicyclis extraction [5]. K. Kaliyamoorthi et al. decribed a new method of union dyeing cotton and nylon fabric using chitosan nanoparticles and acid dyes, the results showed that the cotton/nylon sample treated with 0.3% of chitosan nanoparticles had higher K/S values, washing, and crocking fastness. Also observed, dyed fabric had antibacterial potential due to the antibacterial property of chitosan [6].

The objective of this study is to develop a nonwoven from recycled cotton fibers and chitosan, and on the other hand to use acrylic resin as binders, to study its influence on the behavior of the material, considering that cotton is composed of a 83% cellulose and that it is possible to increase the mechanical properties of the resulting samples [7].

2. EXPERIMENTAL

This section presents the characteristics of the textile fiber used and the resins applied as a binder, as well as the different methods and tests carried out to determine the behavior of the resulting nonwovens.

2.1 Materials

As it is mentioned previously, the fiber used for the constitution of nonwovens is 100% recycled cotton. The fibers from which the substrates were formed are shown in figure 2, it can be seen that in addition to fibers, contains a certain number of yarn.

As binders, medium molecular weight chitosan supplied by Aldrich and STK-100 acrylic resin supplied by Color-Center, S.A. were used.

Fig. 2: *100% recycled cotton fibers and yarns.*

2.2 Methods

Regenerated fibers characterization

To determine the fiber length and weight, the Duble Sorter tester (Suntex Weeb Duplex) is used, examining 75 mg. of matter, analyzing it by length interval.

Recycled cotton nonwoven

In this section the non-woven formation process is described, it is sprayied a solution of 80 g/L of both chitosan and Center STK / 100 acrylic resin, using 5 gr. of fiber as base material of each nonwoven.

The fiber web is placed in an area of 20x10cm and 40g / L of binder is sprayed and distributed by pressure along the surface of the sample. It is is subjected to drying at 100 ° C for a period of 20 minutes. Subsequently, the remaining 40 g/L of resin is sprayed on the obverse. This process applies to both binders separately.

The following image shows examples of the nonwovens obtained by each binder:

Fig. 3: *Nonwovens obtained according to the type of binder*

Nonwovens characterization

To determine the flexural stiffness of both types of binder, it is carried out a test following UNE 40-392-79 standard, which refers to the process to determine the degree of rigidity that a fabric presents.

The process to know the tensile strength of nonwovens is carried out by the Zwick / Roell Z005 dynamometer under the UNE-EN ISO 9073-18: 2008 standard, which specifies a procedure to determine the strength and the percentage of elongation to breakage of non-woven materials by the grip tensile test.

For both tests, the guidelines described in the mentioned standards were followed, except for the dimensions of the specimens (50 mm x Y mm) that had to be adapted to those of the equipment with which the non-wovens were obtained.

3. RESULTS

3.1 Regenerated fibers characterization

As a result of the regenerated cotton fibers characterization, the results are presented according to the fiber length interval in table 1.

Table 1: *Fiber length and weight per interval*

LENGTH INTERVAL OF FIBER			NUMBER OF FIBERS FOR EACH LENGTH INTERVAL	% FIBERS FOR EACH LENGTH INTERVAL
46,10	-	39,75	7	0,11
39,75	-	33,40	44	0,66
33,40	-	27,05	159	2,40
27,05	-	20,70	452	6,84
20,70	-	14,35	942	14,24
14,35	-	8,00	2.157	32,63
8,00	-	0,00	2.850	43,12
			6.610	**100,0**

The properties of the fiber are determined from the analysis of the results shown in Table 1, also integrating a disintegration test to know the amount of fiber and yarn contained in 100 mg of matter:

Table 2: *100% recycled cotton fiber length properties*

Composition	EL (mm)	Average (mm)	MODA (mm)	% Short fiber	% Yarn
100% CO	25,26	15,52	4	79	46,20%

As can be seen in table 2, the percentage of short fiber is 79% with an average length of 15,52 mm and a major dimension of 4 mm, considering that for every 100 mg of fiber, an average of 46,20% of yarn was obtained.

3.2 Nonwovens characterization

In order to evaluate and compare the composition and properties of each of the resulting nonwovens, the flexural rigidity, tensile strength and percentage of elongation are analyzed according to the specified standard.

As a result of the flexural rigidity test, the different behavior of the samples tested is notorious, since those in which the chitosan was applied have a high rigidity that it has not been possible to test, contrary to those that were made by integrating the acrylic resin, as shown in the following figure:

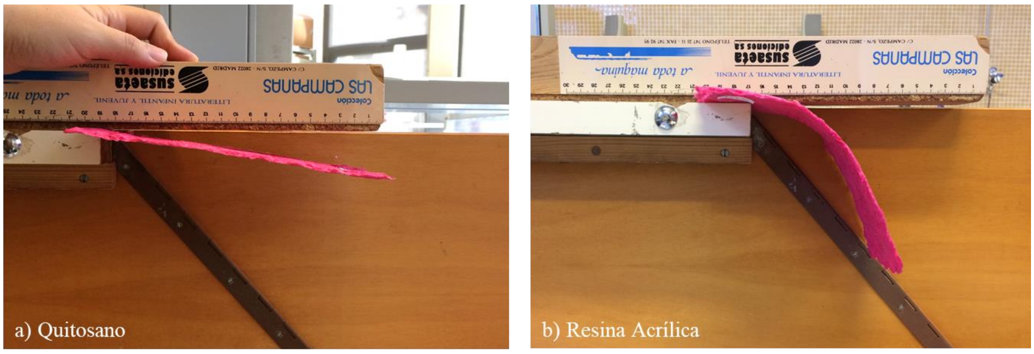

Fig. 4: *Flexural rigidity comparation by binder*

To obtain the tensile strength and percentage of elongation of each of the samples, they are subjected to the test with the dynamometer and the following results are obtained:

Table 3: *Tensile strength by binder*

	Type of binder	Tensile strength FH (N)	% Elongation εH%
100% recycled cotton	Chitosan	68,66	0,76
	Acrylic resin	13,0475	10,0575

As it is seen in Table 3, the samples to which chitosan was applied have a high tensile strength but low percentage of elongation, breaking in shear in some cases. On the other hand, those that contain acrylic resin, have low resistance but a considerable percentage of elongation.

4. CONCLUSIONS

With the present study it has been possible to develop an analysis on the influence of chitosan and acrylic resin in a nonwoven made of 100% recycled cotton. The first binder generates a biodegradable and antimicrobial nonwoven with high flexural rigidity and high mechanical strength but does not have elongation properties, while the synthetic resin provides a high index of flexion and good elongation, however, the resistance does not provide good tensile properties.

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