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The Effect of Weight Per Square Meter of Cotton Fabrics on Durable Press Finishing with 1, 2, 3, 4 Butanetetracarboxylic Acid

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Abstract. Cellulosic fibres, like cotton, are characterized by good properties. However, during their use and maintenance, textiles made with these fibres show high capacity of shrinkage, wrinkling and little wrinkle recovery. In order to solve this behaviour, cotton fabrics are treated applying crosslinkers agents in combination with an appropriate catalyst. In this study, 1, 2, 3, 4 butanetetracarboxylic acid (BTCA) and a catalyser, sodium hypophosphite NaH2PO2 . H2O (SHP) were used to treat two cotton fabrics in order to get easy care properties. To study the influence of the weight per square meter of the fabrics, weave fabrics with 110 and 210 g/m2 were treated by padding system using 80 g/L of BTCA and 40 g/L of SHP. Once the treatment was applied, the samples were dried at 80ºC and cured at 160ºC, these conditions are necessary to carry out the cross-linking reaction between cellulose and BTCA. Results show that fabric with less weight per square meter has an increase of 20% of free carboxylic groups, however the fabric of higher weight presents an increase of 120%. To calculate the increase in free carboxylic groups, it has been taken into account the number of those groups from the same fabric before the treatment. As a conclusion, we can confirm that modification of properties are achieved more effectively when the treatment of polycarboxylic acids is performed on cellulosic fabrics with higher content of oxycellulose groups and this factor influence is higher than the g/m^2.

INTRODUCTION

The beginning of the production of synthetic fibers dates from the middle of the s. XIX, most of the techniques for its production have been improved and developed over time, but not yet have achieved synthetic fibers with properties similar to those natural.

One of the properties of cotton fibers is its ease of use and its ability to retain moisture and therefore against present a great wrinkling capacity as well as certain degree of shrinkage compared to wet treatments.

These characteristics usually unwanted by the user final can be modified by finishing operations, which are based on applying chemical products in order to create cross-links between cellulosic chains and confer to the treated fabric properties such as dimensional stability and recovery to wrinkling.

Said chemical treatment involves the use of agents of crosslinking, mainly formulated by reagents such as the dimethyloldroxylethylenurea (DMDHEU) which are considerably effective but they can generate carcinogenic formaldehyde [1], but these products have such disadvantages such as reduction of mechanical properties[2], degradation of fiber and especially the release of toxic and irritating vapors from formaldehyde [3] or colour degradation due to yellowing [4]. In order to attack this problem, polycarboxylic acids have been used as alternative to reagents with formaldehyde, being the subject of study of many research papers currently [5-8].

Fabrics can be characterized by its density, which is directly related to the yarn count and determines the weight of the fabric which is usually measured in g/m^2. Density is indicated both by weft and warp, with picks / cm for weft direction and ends / cm for the warp one. The density of the warp is determined by the beam of the loom. The weft

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usually varies over a wider range of values, usually less than the warp density, although this depends on the kind of fabric. What determines to a large extent the density of the plot is the yarn count of the yarns.

Depending on the density that we give to the fabric, we will obtain different qualities of resistance, tightness, weight and tie of the threads. In such a way that the lower the density, the lighter and cooler the fabric will be. The higher the density, the thicker and heavier the fabric will be. It should be noted that the higher the density, the more amount of threads and material the fabric contains and the more compact they are. With a lower density, there are fewer threads and the grip is lighter.

The reaction between butanetetracarboxylic acid (BTCA) and cellulose from cotton takes place in two phases as it can be observed in figure 1. The first one is the anhydre formation from two adjacent carboxyl groups from BTCA. The second phase is the esterification of anhydre form from the pahse 1 and the hydroxyl groups from cellulose.

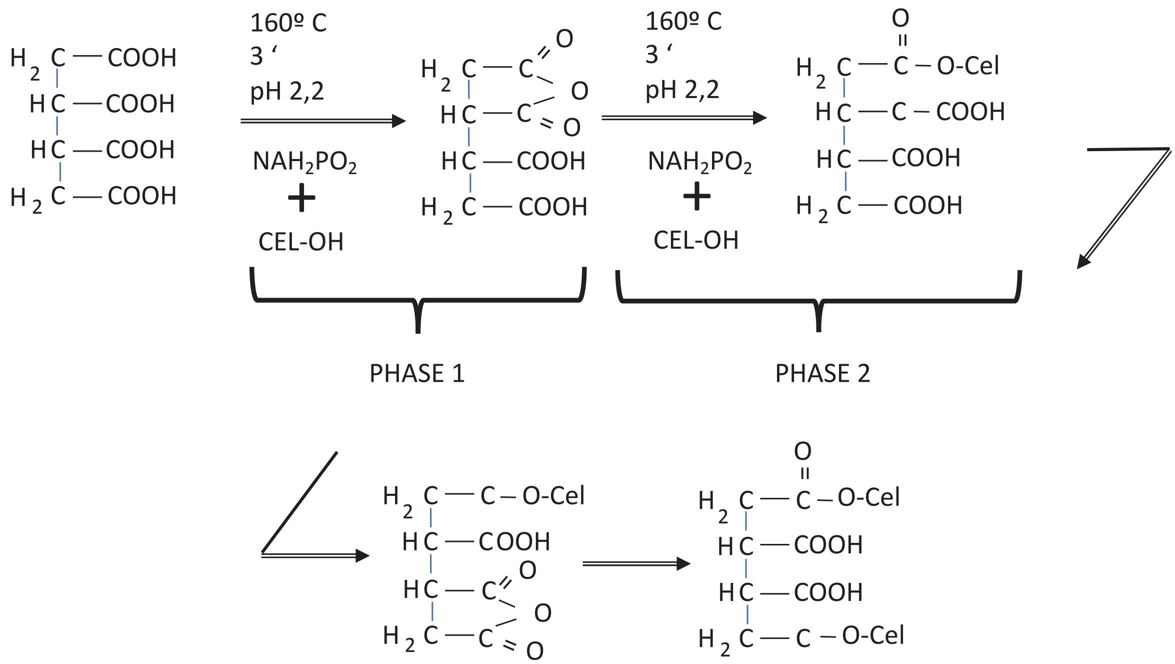

FIGURE 1. Reaction between BTCA and cellulose.

The aim of this study was to determine the influence of the weight per square meter of the fabrics when 1, 2, 3, 4 butanetetracarboxylic acid (BTCA) is applied onto cotton fibres. Fabrics with different g/m^2 have been tested.

MATERIALS AND METHODS

Materials

Two cotton fabrics were tested. Fabrics were comprised of 100 % cotton fibers with a plain wave and 115 g/m^2 or 210 g/m^2 whose references are Co-115 and Co-210 respectively. Both fabrics were chemically bleached in industry.

BTCA was supplied by Alpha Aesar and of NaH_2PO_2 was supplied by Sigma Aldrich. They were used as provided without any modification.

Methods

Application

The formulation used for the treatment was 80 g / L of BTCA and 40 g / L of NaH_2PO_2, after drying at 85ºC, have been cured at 160º C, these parameters being the values that define the optimal formulation that has resulted from the studies carried out in order to avoid yellowing [4]. The first difference observed during the application process is the pick-up obtained in each of the fabrics, since as expected, the higher the grammage, the greater the retention of the bath. Therefore, the Co-115 fabric has 65% pick-up and the Co-210 fabric 80%.

FTIR

Fourier Transmission Infrared spectra (FTIR) were recorded in order to characterize the fabrics surface. An FTIR-4700typeA from JASCO wit ATR accessory was used, 16 spectra were recorded with a 4 cm^{-1}resolution for each sample.

Bending Stiffness

In order to evaluate the behavior of the different tissues before the effects of the treatment using the same formulation for both, the flexural stiffness is studied before and after the treatment. The test procedure has been carried out in accordance with the UNE 40-392-79 standard "Textiles: Flexural rigidity".

RESULTS AND DISCUSSIONS

The spectra of the treated Co-115 and Co-210 fabrics were analyzed in order to be able to compare both fabrics and obtain possible differences in the absorbance bands. Figure 2 shows both spectra of the untreated textile substrates Co-115 and Co-210.

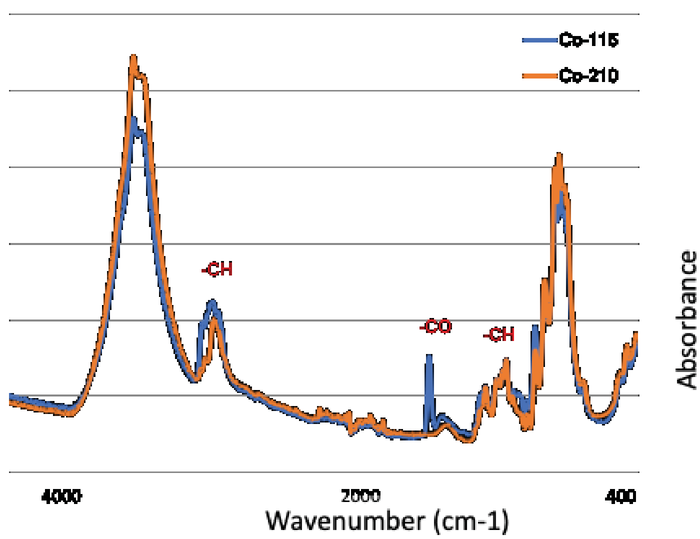

FIGURE 2. Montmorillonite K-10.

Both spectra are very similar, observing a single different absorbance band. The Co-115 tissue shows a very intense peak in band 1729, a band that, on the contrary, is not seen in the spectrum of the Co-210 tissue. This peak located in the 1729 cm-1 band indicates that the cotton fabric has a content of C = O groups characteristic of the ester group. This can be the product of different finishes to which the fabric has been subjected, such as bleaching and bleaching. On the other hand, the Co-210 fabric despite the bleaching process has not evidenced a partial oxidation of the tissue's own cellulose.

The fact that cotton cellulose is not oxidized, and therefore does not show ester groups in the spectrum, can facilitate the crosslinking reaction of cellulose with polycarboxylic acid since cellulose contains a greater number of free hydroxyl groups. This fact is subsequently verified with the analysis of both fabrics treated with BTCA together with the catalyst, dried at 85º C and cured at 160º C. In order to be able to compare objectively, the 1729/1317 ratios of each of them are used together with those obtained from the untreated tissues. Table 1 shows these results together with the % increase in the ratio calculated when comparing the treated samples with the untreated fabric.

TABLE 1. Ratio 1729/1317 of Co-115 and Co-210 treated and untreated fabrics.

Band (cm-1)	Co-115	Co-115 (80BTCA + 40P_160)	Co-210	Co-210 (80BTCA + 40P_160)
1317	0.1448	0.1004	0.1445	0.1464
1725	0.1379	0.1157	0.0497	0.1109
1725/1317	0.9520	1.1526	0.3436	0.7571

As already intuited previously, the results described in table 1 show that the Co-210 fabric shows a greater increase in the ester groups characteristic of the esterification reaction and the carboxylic groups of BTCA acid, obtaining a 120% increase in the Co-210 fabric compared to a 21% increase when treating the Co-115 fabric. This fact must be mainly related to the pick-up of each fabric obtained after the treatment, since the Co-210 cotton fabric retains a greater quantity of bath and consequently a greater quantity of polycarboxylic acids, achieving a much more effective treatment.

Tables 2 and 3 show the results obtained from the flexural stiffness test. The samples are tested in weft and warp direction, thus differing in the direction of the tested fabric. The results shown in mg / cm are the calculation of the arithmetic mean of 5 tests on the face and 5 tests on the underside of the textile, both for warp and weft.

TABLE 2. Flexural stiffness of treated and untreated CO-115

	Co-115		Co-115 (80BTCA + 40P_160)	
	Weft	Warp	Weft	Warp
mg / cm	57.39	80.78	77.70	124.26
% Increase			35.40	53.82

TABLE 3. Flexural stiffness of treated and untreated CO-210

	Co-210		Co-210 (80BTCA + 40P_160)	
	Weft	Warp	Weft	Warp
mg / cm	86.02	311.20	112.55	340.58
% Increase			30.84	9.44

In order to evaluate and compare the improvement in flexural stiffness effect of cellulose crosslinking, the % increase is calculated when comparing the treated and untreated fabric of both tested textiles. With this, a 35% increase in weft and 53% in warp direction is obtained for the 210 g / m^2 fabric and a 31% improvement in weft direction and only a 9% increase in warp direction after treatment with BTCA of the 115 g / m^2 fabric. Therefore, the modification of properties is achieved more effectively when treating higher grammage textile substrates with polycarboxylic acids. These same data are represented in the graph of figure 3.

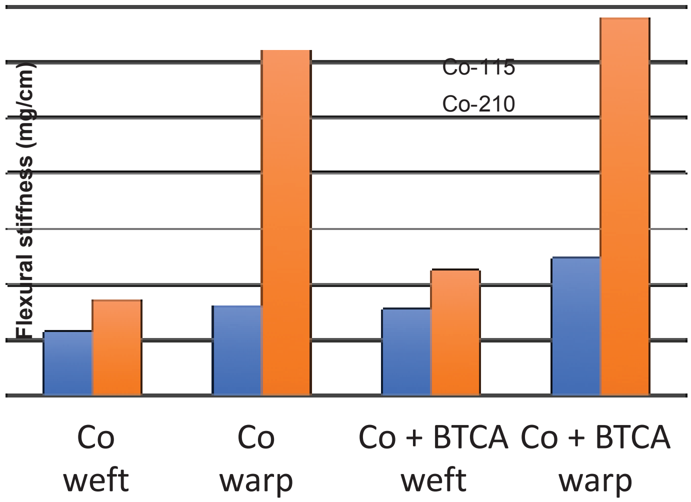

FIGURE 3. Comparison of flexural stiffness of treated and untreated fabrics for different g/m2

As it can be seen from figure 3, initially the untreated fabric Co-210 shows greater flexural stiffness than the textile Co-115, especially in the warp direction. Probably this is due to the fact that initially the warp valuer were considerable high and it is difficult to increase it considerably. The fabric Co-115 showed lower pick-up (65%) than Co-210 (80 %), but higher flexural stiffness, which is directly related with higher values of crosslinking. This can be due to the presence of higher number of oxycellulose in Co-115 as demonstrated previously in figure 2.

The higher values in the increase of Co-115 The presence of oxycellulose in contact with BTCA at 160º C and pH = 2,2 would derive into a reaction not only with the hydroxyl groups from cellulose placed in Carbon 2 (C2, carbon 3 (C3) and Carbon 6 (C6), but a reaction with carboxylic groups from C2 and or C3 in the oxidized cellulose, as well. This means that a reaction such as the one shown in figure 4 must occur. In this reaction, the carboxylic groups generated in the oxycellulose can react with the anhydre form from BTCA, in a esterification reaction. This reaction is considerably likely as the carboxylic groups in C2 and C3 are more accessible than hydroxylic groups for the same carbons, (C2 and C3) [9-11]. Thus, would explain the higher increase in flexural stiffness for Co-115 despite showing less pick up and less fibers to crosslink (g/m^2).

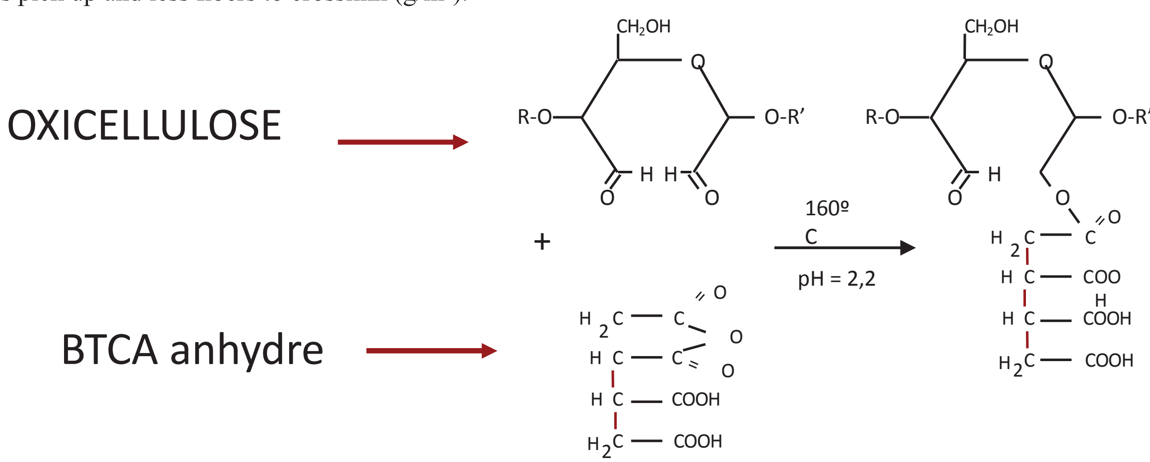

FIGURE 4. Reaction between BTCA and oxycellulose.

CONCLUSIONS

Using the FTIR technique, the degree of crosslinking obtained by applying BTCA on tissues of different weights is compared. Concluding that the Co-210 tissue shows a greater increase in the ester groups characteristic of the esterification reaction and the carboxylic groups of BTCA acid. This fact must be mainly related to the pick-up of each fabric obtained after the treatment, since the Co-210 cotton fabric retains a greater quantity of bath and consequently a greater quantity of polycarboxylic acids, achieving a much more effective treatment. Despite the fact that the Co-115 shows higher number of C = O groups than CO-210, the gramaje is influencing a higher absorption of liquor during the treatment and consequently the yield of crosslinking is higher.

On the other hand, the modification of the properties of the fabric after being treated is greater when the fabric of lower grammage Co-115 is treated, which may be due to the fact that initially the Co-115 textile has lower flexural rigidity than the Co-210 fabric .

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