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THE EFFECT OF 1, 2, 3, 4 BUTANETETRACARBOXYLIC ACID AND TIO_2 TREATMENT COTTON ON UV PROTECTION

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Abstract: *Cotton fabrics are modified chemically to add durable press properties. For that, the textile material is treated with crosslinking agents in combination with an appropriate catalyst. Polycarboxylic acids in combination with inorganic phosphorus-containing salts have proven to be one of the most effective formaldehyde-free system capable of imparting durable press properties to cotton fabrics. In this work the 1,2,3,4 butanetetracarboxylic acid (BTCA) and sodium hypophosphite NaH2PO2 . H2O (SHP) were used to treat cotton fabric in order to get easy care properties. In adittion, we study the behauviour of BTCA as bonding agent for particles without any affinity for the cellulosic fibres. This research focuses on determining the influence of BTCA on the TiO_2 nanoparticles loss of the fabrics during washing treatments and the difference of UV protection using or not using BTCA as a linking agent in the treatment. The scanning electron microscopy was used to verify the presence of the TiO_2 on the cotton fabric before and after the launderings. We conclude that with BTCA, more TiO_2 nanoparticles remain on the fabric surface. It was shown that the UV protection of treated fabric using BTCA as a binder is lower than treated fabric only with TiO_2 nanoparticles.*

Key words: *easy care, BTCA, TiO_2, linking agent, UPF.*

1. INTRODUCTION

Cellulosic fibres are characterized by good properties which generate comfort to the users who are wearing these type of fabrics. However, during their use and maintenance, these fabrics show high capacity shrinkage, wrinkling and little wrinkle recovery. These properties are not desirable and are removed by applying crosslinkers to the fibre. So far, the most widely used product is the dimetildihidroxietilenurea (DMDHEU) [1], whose main disadvantage is the release of formaldehyde, a product that is considered a carcinogen.

Currently some new products are under study. They are supposed to be environmentally friendly and from the point of view of human health they should be formaldehyde free. The polycarboxylic acids are gaining importance in this field being studied in some papers [2-4]. Recent investigations indicate that these products can be used not only as crosslinking agents [5] but as bonding agents for certain substances with no affinity for the cellulosic fibres too [6].

In this study, carboxylic acid was used to bind TiO_2 nanoparticles to cotton fabric in order to provide new properties to the fabric and give easy care effects as well. The functionality provided by the particles to the fabric was characterized using specific techniques in order to test the properties to evaluate. The level of protection against UV radiation was analyzed by measuring the transition at different wavelength [7].

2. EXPERIMENTAL

We used a 100% cotton fabric with the weight of 210 gr/m^2. These fabrics samples were impregnated with solutions containing 2 g/L TiO2 nanoparticles P25 (Degussa) and one sample 80 g/L of 1,2,3,4-butane-tetracarboxilyc acid (BTCA) was used as a linking agent and 40 g/L sodium hypophosphite monohydrate ($NaH_2PO_2 \cdot H_2O$) (SHP), which was used as catalyst for the reaction of cellulose with BTCA. The samples were treated by padding and we obtain between 80-85 % pick-up. After that, samples were crosslinked following the procedure of dry crosslinking, drying at 85ºC, and crosslinking at 180ºC during 2 min.

Treated samples were washed by following UNE EN ISO 6330 method no. 2A, 10 cycles of washes were carried out.

To verify the existece of silica particles on the fiber surface, treated samples were observed with a scanning electron microscope FEI model Phenom (Fei, Oregon, USA). Prior to sample observation, samples were covered with a gold–palladium alloy in a Sputter Coater EMITECHmod. SC7620 (QuorumTechnologiesLtd, EastSussex, UK). Samples were then examined with suitable accelerating voltage and magnification.

The method used to evaluate was described by the authors Campos et al [7]. This method is based on a UV-lamp that irradiates on the fabric at 312 and 365 nm, which belongs to UVB and UVA radiation respectively. The UPF can be calculated by equation:

$$UPF = \frac{E(312) \cdot \varepsilon(312) \cdot \ \Delta(\lambda) + E(365) \cdot \varepsilon(365) \cdot \Delta(\lambda)}{E(312) \cdot \varepsilon(312) \cdot T(312) \ \cdot \Delta(\lambda) + E(365) \cdot \varepsilon(365) \cdot T(365) \cdot \Delta(\lambda)} \quad \textbf{(1)}$$

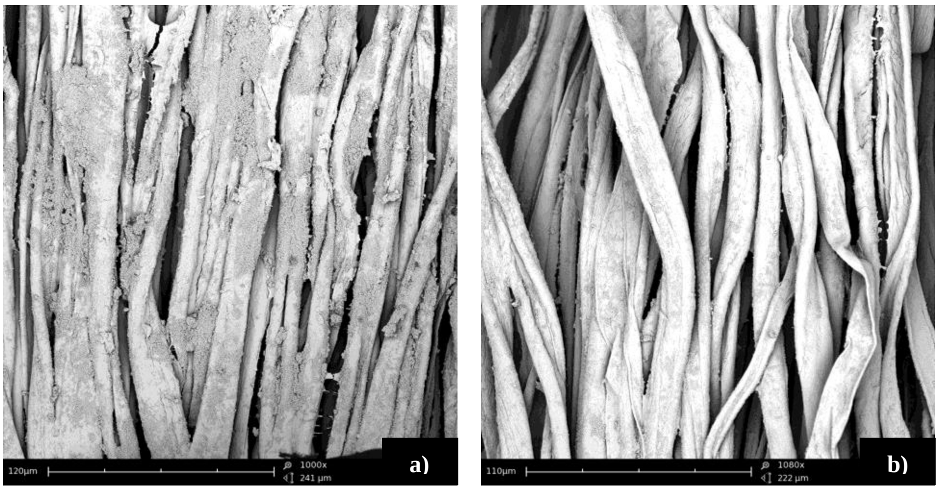
The equation for determining the UPF by this method only works on two specific wavelengths such as 312nm (UVB) and 365nm (UVA). It works only at these two wavelengths because it is considered to represent optimally ultraviolet radiation.

3. RESULTS AND DISCUSS

To check the presence of the particles on the surface cotton fiber, some images from SEM were taken from the fabrics that have been studied in this work. In Figure 1, we can observe the TiO_2 treated samples using or not using BTCA and these fabrics after 10 laundries.

Unwashed fabric | Washed fabric (10 times)

Without BTCA



With BTCA

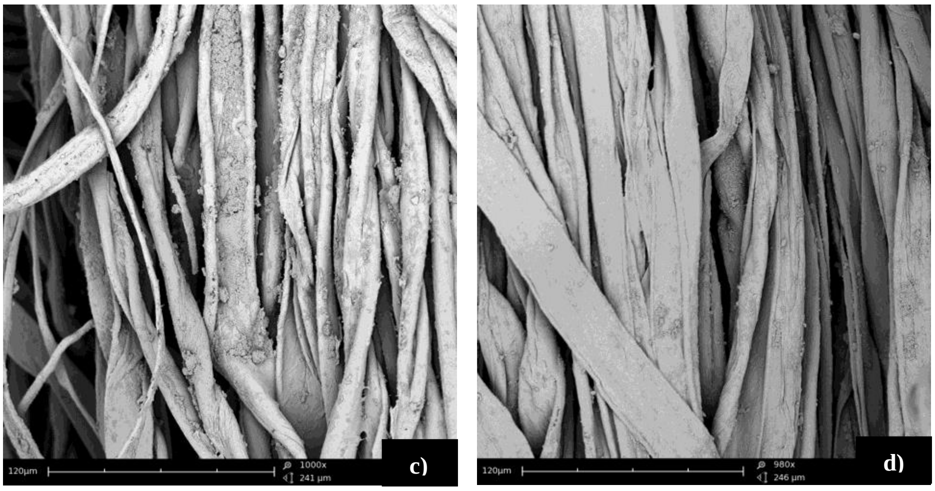


Fig. 1: *SEM images of the treated samples, before and after 10 washes.*

After 10 washing cycles, we can observe the presence of particles on the fabric in both cases, but it seems that when we used BTCA as a linking agent in the treatment bath together with TiO_2 nanoparticles, the quantity of nanoparticules is slightly higher, although the difference is not significant. To verify this behaviour, specific techniques, like particles counter or scanning electron microscopy with energy dispersive X-ray spectroscopy, should be used.

The measurements of the UVA and UVB and the result of the UPF calculated on these two values are provided in table 1. To compare the effect of both treatments conducted on the UV protection, we analyze the untreated fabric too.

Table 1: *UVA, UVB and UPF results*

	UVA (312 nm)	*UVB (365 nm)*	*UPF*
Co-210	0,25	0,11	**1,54**
TiO_2	0,06	0,00	**302,89**
TiO_2 + BTCA	0,05	0,00	**263,22**

The results of UV protection of both treated fabric show higher UV protection than in untreated sample. According to AS/NZ 4399:1996 standard, it has to be considered that the analysed fabric has an acceptable UV protection from UPF 15 value, the fabric is though to have good protection between the range of 25 to 39 and excellent when values are over 40. Thus it should be high lighted that treated samples give UV protection to cotton fabrics, being it excellent in both cases. When the fabric is treated using BTCA, then the UPF is lower than the treatment without this agent.

4. CONCLUSIONS

We can conclude that there is not evidence about the bind effect of the BTCA between cotton fibres and TiO2 nanoparticles, as if we compare the SEM images of the treated fabric after 10 laundries, both fabrics have nanoparticles on the surface fibers. On the other hand, BTCA blocks the

UV protective action characteristic of TiO_2. Despite that, both treatments show high UV protection.

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