How to improve dyeing and antimicrobial properties of cotton materials
Verbesserungsmöglichkelten von färberischen-und antimikrobiellen eigenschaften auf baumwolle

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1. Introduction

Nowadays, textile materials are expected to provide many additional functions. In this perspective, chemical functional treatment is the most convenient process in textile manufacturing to bring in new performance and functions to regular textile fabrics, and contributes significantly in added values to the final textile products.

Generally speaking, most functional finishing technologies employed in textile treatments are directly incorporating functional agents to textiles that impart special properties to final product. The present challenge is to face the textile functionalization as a global process, with balance of the different properties of the materials such as dyeability, fastness properties, antimicrobial characteristics, for instance. So as to achieve this, an integration of the novel finish processes on the currently widely employed chemical finishing processes will be required.

The amination of the cellulosic fibres was been extensively studied to overcome many of environmental problems associated to the dyeing process. The change on the fibre surface charge facilitates the dye fixation, minimising dye effluent discharge and removing or reduce the salt consumption. On the other hand, it has for some time recognized that cationic surfactants bear antimicrobial activity. In terms of structure-activity, their activity is due to the cationic site in addition to the lipophilic component of the surfactant.

In the present work, some specific amino compounds were linked to the cotton fabrics on a process that can impart at the same time dyeability and durable antimicrobial properties. The process was monitored on-line in a prototype dyeing system since the addition of cationic agents will influence dye uptake. Different dyeing conditions were tested with direct dyes, with and without salt, until the exhaustion curve was at least equivalent to the standard dyeing curve in the presence of salt. The problem in the past with projects that involved measurement of exhaustion was the time that was consumed with the measuring of the exhaustion accurately, with all the steps involved: extraction and dilution of samples manually, drawing of the calibration curves, drawing of the exhaustion curves. With the development of an instrument as a PhD project, that does all this automatically and with great accuracy, it was possible to speed up all the process and observe the evolution of the curves on-line or afterwards (while other tasks were being done). It was possible to find out quickly the best concentration of the cationic agent to be used, for example. This was found to be a very useful tool and is already planned for further research experiments involving the study of exhaustion curves.

2. Materials and Methods

2.1 Materials

Desized, scoured and bleached cotton (100%) was purchased from Lameirinho S.A (Portugal).

3-Chloro-2-hydroxypropyltrimrthylammonium chloride (CHTAC), 1,4-diazabicyclo[2,2,2] octane (DABCO) and ethyl acetate was supplied by Aldrich (Germany) and used in analar grade.

Sirius Blue FGG (C.I Direct 225) was obtained from Dystar (Portugal) and was used as received.

2.2 Synthesis of monocationic salt (MS)

The synthesis of MS was performed as described by Cohen et al. (2000).

The product yield obtained was 60%. The synthesized product was characterized by NMR and FTIR spectroscopy.

2.3 Modification of cellulosic fabric

The cotton fabrics were modified with monocationic salt (MS) and quaternary ammonium salt (CHTAC).

The cotton modification processes adopted was intended to evaluate the effect of different application methods.

In Pad-Batch application method the textile material was immersed in the aqueous solution containing 10 and 50 g/L of MS or 5 and 10 g/L CHTAC and padded to give a wet pick up of 80-90% and 70% respectively. After that, the samples were sealed in plastic for 24hours. Then it was rinsed several times with water and dried at room temperature.

In the exhaustion method it was applied 15% (w.o.f) of MS or CHTAC (60% solution), 2.75 g/L of sodium hydroxide with 1:20 liquor ratio.

2.4 Antimicrobial activity of modified materials

Antibacterial activity of the materials samples was evaluated according to AATCC 100 (1999) test method, AATCC 147 test method (1998) and AATCC 30 test method (1999).

NF EN 1040 - (1997) e NF EN 1275 - (1997).

2.6 Dyeing tests

The dyeing tests were conduced on SIMCOR system (Figure 1) with on line control of the dyeing process.

Figure 1- SIMCOR system

All dyeing tests used 1% direct dye Sirius Blue FGG (C.I Direct 225) on weight of fabric was applied, 1:30 liquor ratio, using isothermal (95ºC) and gradient temperature dyeing processes (Figures 2 and 3 respectively). The electrolyte, Sodium sulphate (20g/L) was added at the beginning in the standard samples dyeing and no electrolyte was added for modifying samples dyeing.

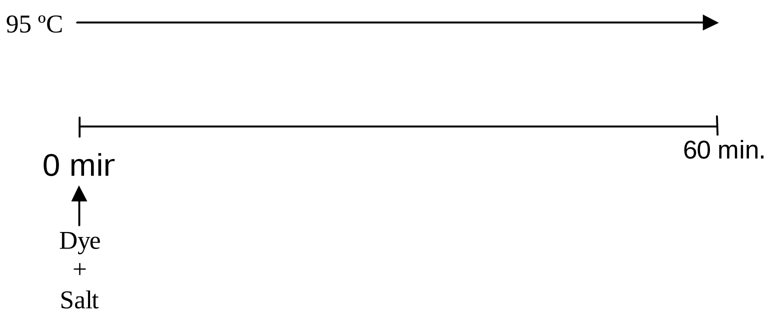

Figure 2- Dyeing Process

3. Results and Discussion

3.1 Antimicrobial characterization of modified cotton fabrics

The antimicrobial activity of modified fabrics was evaluated using AATCC standard test methods.

Table 1- The antibacterial activity of the modified samples according to AATCC 147 test method.

Sample	Method	CCMI 335[a] Wm (mm)	CCMI 446[b] Wm (mm)	Activity
Standard cellulose	-	0	0	negative
Cellulose modified with 10 g/L CHTAC	pad-batch	0	0	negative
Cellulose modified with 15% (w.o.f) CHTAC	exhaustion	0	0	negative
A Cellulose modified with 15% (w.o.f) MS	exhaustion	5.3	0.45	positive
Cellulose modified with 10 g/L MS	pad-batch	4.75	1.2	positive

[a] Gram + Staphylococcus aureus; [b]Gram - Klebsiella pneumoniae; CCMI- Culture Collection of Industrial Microorganisms

Table 1 shows the antibacterial results according to AATCC test method 140. All modified samples with MS showed activity against Gram+ (Staphylococcus aureus) and Gram- (Klebsiella pneumoniae) bacterias. The samples treated with CHTAC are ineffective in terms of antimicrobial activity even for concentrations as high as 90 g/L.

3.2 Dyeing results

In Figure 3 was present the dyeing results of modified samples with a direct dye Sirius Blue FGG (C.I Direct 225). As was foreseeable no exhaustion was observed in case of standard sample dyeing without salt.

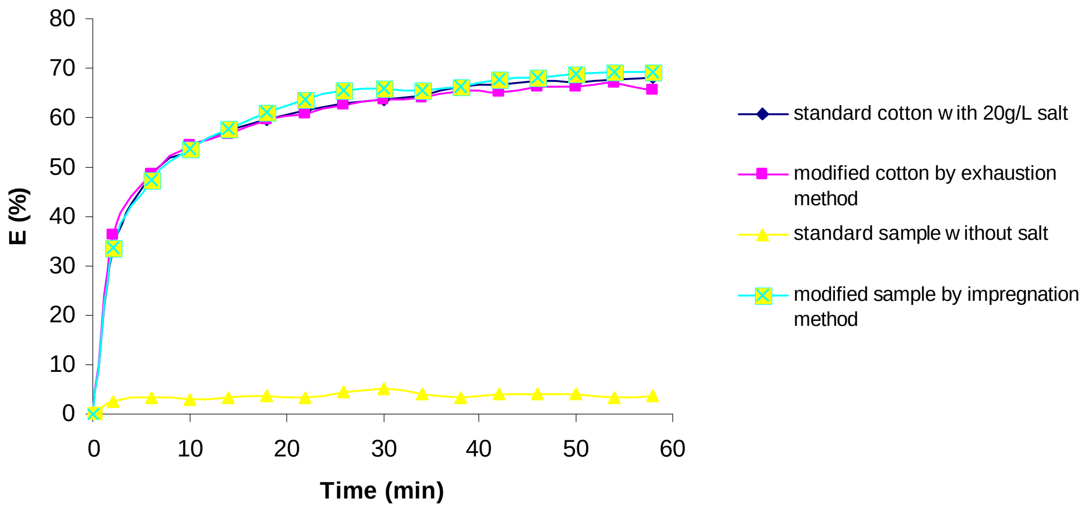

Figure 3- Exhaustion profiles for MS-cotton modified material with direct dye Sirius Blue FGG (C.I Direct 225)

However, similar exhaustion profiles were obtained for modified cotton with MS independent of modifying method used (pad-batch and exhaustion processes).

In the case of samples modified with CHTAC (figure 4), the impregnation process allows us to achieve 97% of exhaustion in relation to the 68% obtained with exhaustion method. In this case, no difference was observed in terms of final exhaustion obtained when we compare traditional dyeing process that use 20g/L of salt and new exhaustion method without salt and with cationised material. But the dyeing profile of exhaustion curves is different. However, gradual addition of salt in the conventional process allows us to obtain similar exhaustion profile curves.

In fact, the cationisation of cotton was confirmed by the exhaustion profile of modified cotton without salt.

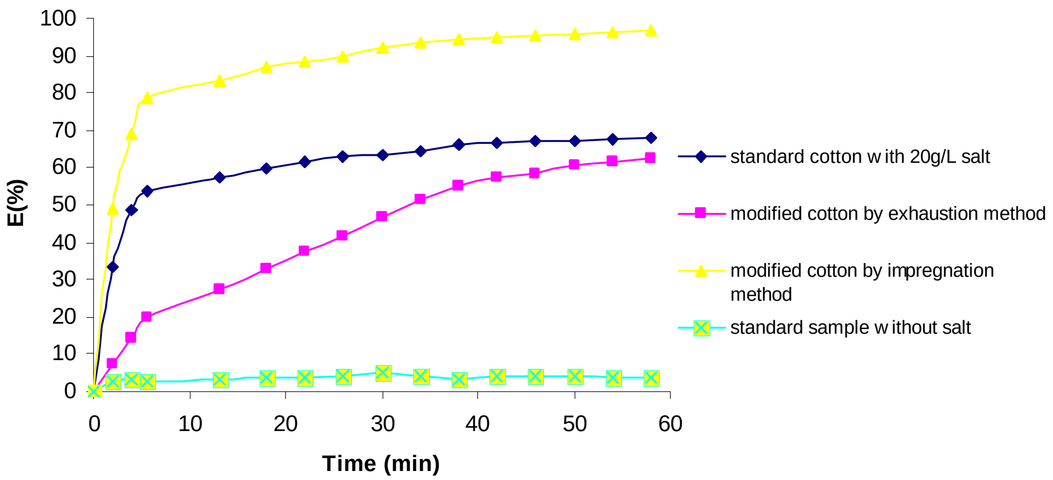

Figure 4- Exhaustion profiles for CHTAC-cotton modified material with direct dye Sirius Blue FGG (C.I Direct 225)

The chemical modification efficiency was evaluated in terms of MS used and it was found that the best results were obtained with 15% w.o.f of MS (Figure 5).

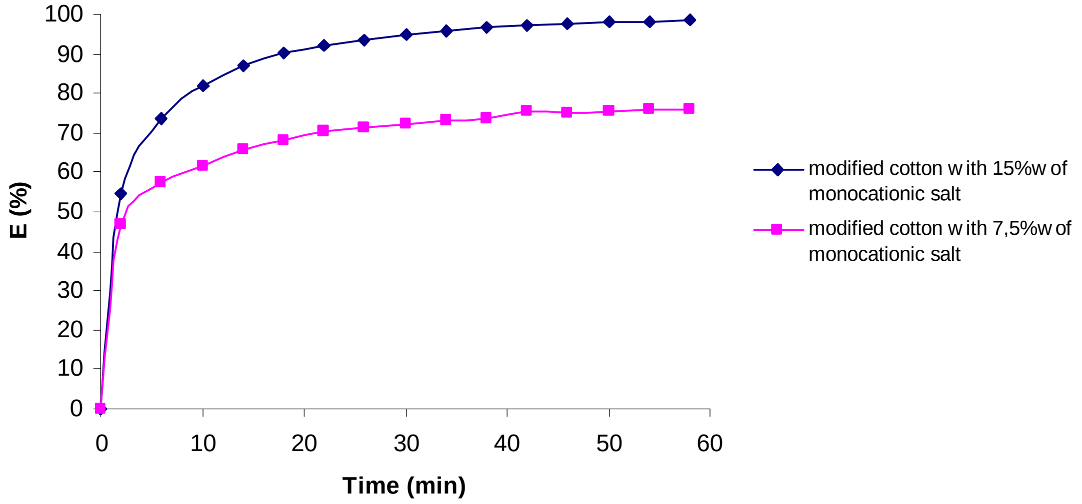

Figure 5- Effects of the MS concentration in the pad-batch dyeing exhaustion profiles

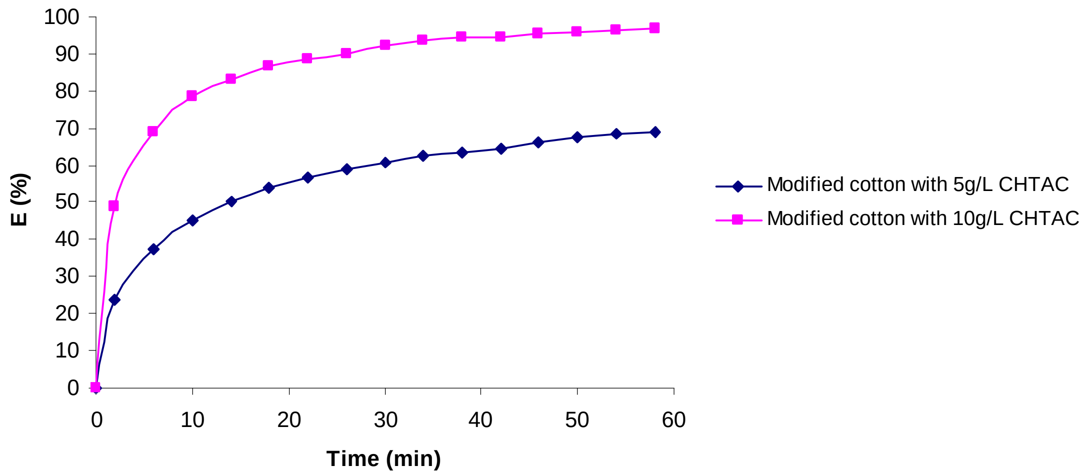

Figure 6- Effect of the CHTAC concentration in the pad-batch dyeing exhaustion profiles

In the case of CHTAC modifying process, the best cationisation results were obtained with 10g/L (Figure 6). After this concentration, problems of hue change were observed.

4. Conclusions

CHTAC has a significant influence in terms of dyeability of cotton but no antimicrobial active action was observed in treated fabrics.

MS can impart antimicrobial proprieties to cotton textile fabrics and improve at same time the dyeing exhaustion profile with direct dyes.

The obtained results with MS-cotton modifying and the technical simplicity of the application process suggest that this may be a method for production of future textile multifunctional fabrics.

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