NC STATE UNIVERSITY

COLLEGE OF Textiles NC STATE UNIVERSITY

JTATM
Journal of Textile and Apparel, Technology and Management

Volume 6, Issue 1, Spring2009

CAUSTICIZING OF VISCOSE FABRICS

M. İ. Bahtiyari, K. Duran, A. E. Körlü, M. Bahar, A. Özerdem, S. Perincek
Ege University, Department of Textile Engineering, Izmir, Turkey
aysegul.ekmekci@ege.edu.tr

ABSTRACT

Viscose treatment needs high care and know-how. Because viscose fabrics are more susceptible to the chemical processes. In this study, causticizing which is generally found to be dangerous in the pretreatment of viscose fabrics was applied to viscose fabrics. It was found that the usage of caustic-soda in pretreatment of viscose fabrics ensured considerable advantages in terms of pilling degree and color efficiency in textile printing and dyeing. After causticizing the surface of the fabrics became smoother, fuzzy of the fabric decreased and the crystallinity of the fabric increased. In addition, performing a causticizing before dyeing and printing with reactive dyestuffs caused an increase in the color efficiency.

Keywords: Causticizing, reactive dyestuff, dyeing, printing, viscose, pilling, FTIR

1. INTRODUCTION

The demand for viscose fibers is increasing day by day because of their natural origin and high comfort in wear. Thanks to the recent production techniques, today it is possible to provide all kinds of usage expectations by the regenerated cellulose fibers. Unfortunately, some problems such as high fibrillation/pilling tendency, low repeatability and low uniformity after dyeing and printing can occur during processing of viscose fabrics. [1, 2, 14, 18].

Cellulases are used to remove the fuzz or pills on the fiber or fabric surface for a long time. There are a lot of studies on the use of cellulases and some other parameters affected the bio-polishing [3-13]. But the pilling and fuzz of the viscose fabric's surface did not decrease sufficiently with commercial cellulases [14, 15]. Moreover, causticizing process has been seen to restrict the pilling problem of viscose fabrics. It was reported that fibrils on the surface of the fibers are stripped, solved by causticizing, thus fiber smoothens and swells. Swollen fibers cause the fabric to gain more compact structure, thus reduce pilling formation [14, 16].

Besides the increase in the swelling tendency, with the aid of causticizing process, color efficiency of the fabric significantly increases in the further printing and dyeing processes. Since dye uptake of the viscose fabric increases and dyeing becomes more even after the treatment with 4-6 % caustic-soda, it is recommended to apply 6-8 Bé caustic-soda. But this increase in color efficiency in the printing of viscose materials caused by causticizing changes according to the dyestuff used and the darkness of the print [2, 17, 18].

On the other hand, it is well known that any kind of textile pretreatment conventionally used in practice influences the fiber fine structure. Smole et. al. investigated the effect of bleaching and causticizing processes on the crystallinity of the regenerated fabrics. They reported that among these pretreatment processes, changes in fine structures were especially pronounced after treating the fibers with NaOH due to the chemical changes caused by causticizing. [2, 18-20].

Because of all these benefits, a systematic research was carried out in order to discuss the general idea that causticizing process is harmful for viscose fabrics during pretreatment.

2. EXPERIMENT

For the experiments, 30/1 single jersey Lycra/viscose knitted fabric with 310 g/m^2 weight was used in accordance with the test plan (Figure 1).

All pretreatment and dyeing processes were realized on an overflow machine with a capacity of 50 kg and a stenter. Fabrics were printed at 20 m/min at 3 bars of pressure on a J. Zimmer MDK laboratory-type printing machine with 70 Nr PES gauze and a doctor blade 8 mm in diameter in laboratory conditions (Figure 2, Table 1).

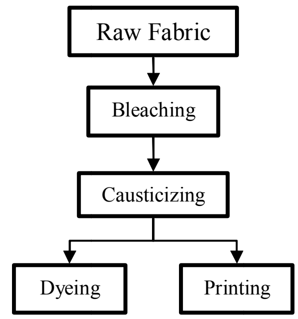


Figure 1. Test plan used for the pretreatment, dyeing and printing of viscose fabric

Then, printed fabrics were dried in a laboratory type drying machine (Rapid) at 100 ^{0}C for 3 minutes and fixed on a laboratory type steamer (Mathis) at 102 ^{0}C for 10 minutes. Afterwards, washing-off was performed for both dyed and printed fabrics with cold water then a hot rinsing was performed it was repeated till the rinsing water will be clean and finally a cold rinsing was managed. During the treatment processes, soft mill water (permutit-water) was used.

Table 1. Process Conditions

Bleaching	Causticizing	Dyeing		Printing	
		Dyestuff	Procion HE-XL	Impregnation with urea	Printing paste*
1 g/l Anticreasing agent	70.7 g/l NaOH	%	2.613 Gelb	150 g/l urea	Dyestuff (Cibacron)
1 g/l Metal complexing agent			1.259 Crimson	AF = 75 %	Yellow P-2RN 10 g
1 g/l Wetting agent			2.43 Marine		Red P 4B 5 g
0.2 g/l Stabilizer					Blue P 3R 10 g
4.0 g/l H_2O_2 (50%)					Urea 150 g
4.0 g/l Na_2CO_3	35 0C,15 min				Alginate (SMT % 4) 600 g
	LR 1/15				Ludigol 10 g
85 ^{0}C, 30 min LR 1/15		NaCl (g/l)	65		$NaHCO_3$ 30 g
		Na_2CO_3 (g/l)	20		Water/Paste ~ g
		L.R 1/15			------------ 1000 g
*For all printing processes, viscosity of the printing paste has been measured by Brookfield RVT viscosimeter using number 5 spindle at 20 Rpm speed and 60 poise viscosity has been considered as the basis.					

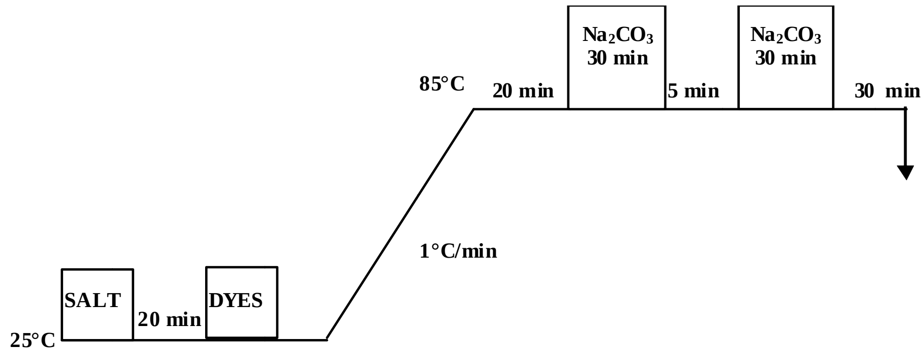


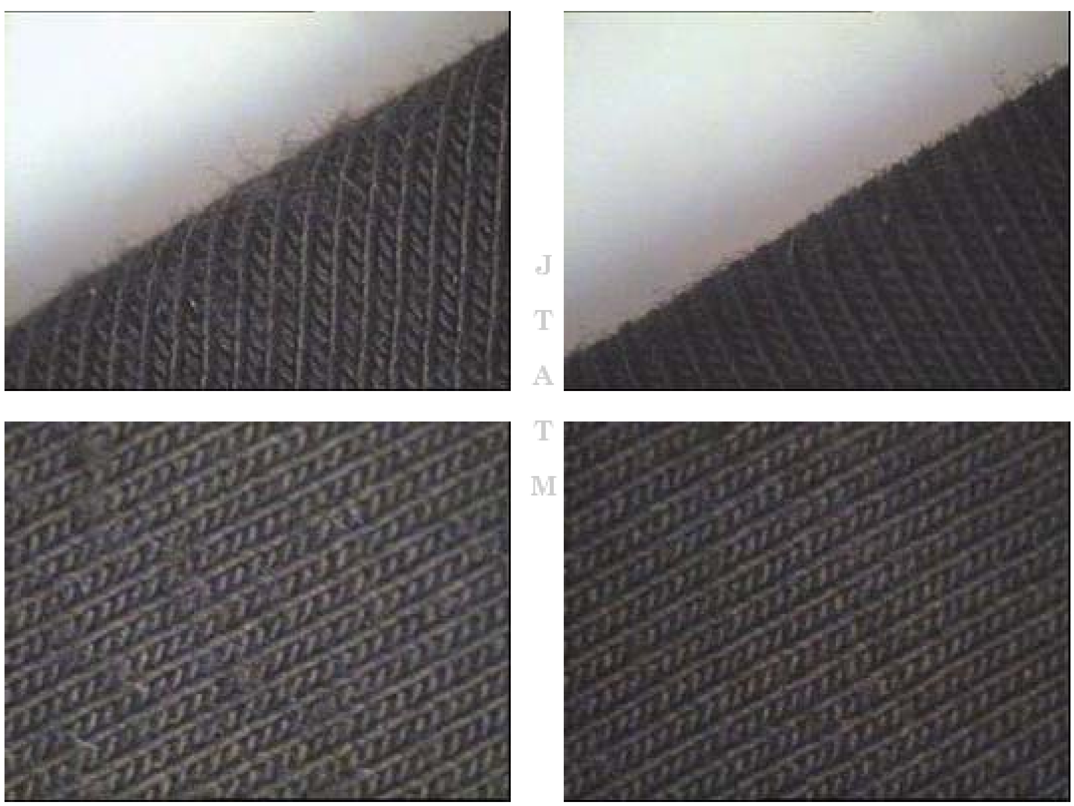
Figure 2. Dyeing Process

In order to evaluate the results obtained, pilling tests were realized according to the ASTM 3512 and K/S values of dyed and printed fabrics were determined with a Minolta CM 3600d Model Spectralphotometer. Surface modification was evaluated by taking fabric photographs on Motic trade mark microprojection device.

Moreover, strength loss was measured on James J Heal bursting strength measurement device (7.5 cm² area and 30.5 mm diaphragm diameter) and FT-IR analysis of fabrics was carried out with Perkin Elmer Spectrum 100.

3. RESULTS AND DISCUSSION

3.1. Pilling Values



Not Causticized & Dyed Fabric   Causticized & Dyed Fabric

Figure 3. Microscopic views of causticized and not causticized fabrics after dyeing

In order to evaluate pilling values of end product, the pilling test was carried out for both causticized and not causticized and then dyed fabrics. As a result, it was seen that the causticized one had better pilling value. While the pilling value of not causticized & dyed fabric was 3, it was 4 if a causticizing was carried out. This decrease in the pilling tendency is significant since the commercial cellulases could not solve this problem properly in viscose based fabrics yet [14].

Photographs of fabrics after pilling test were taken on Motic trade mark microprojection device with 10x magnification in order to confirm the pilling test results. As a result, it was clearly seen from the Figure 3 that the causticizing process has decreased the fuzz of the surface significantly.

3.2. Bursting Strength Losses

The strength loss is also another parameter affects the usage of the product, because of this bleached and bleached & causticized fabrics' bursting strength losses were evaluated after dyeing. It was found that causticizing did not affect the bursting strength of the fabric. The bleached viscose fabric had 366 kPa of bursting strength; which was 359.3 kPa when a causticizing was performed after bleaching. So it can be easily told that causticizing (mentioned in Table 1) causes inconsiderable bursting strength loss. This term was claimed in literature too [2].

3.2. Color Efficiency After Dyeing

Table 2. Color efficiencies of causticized and not causticized fabrics after dyeing

	K/S
Not Causticized Dyed Fabric	23.28
Causticized Dyed Fabric	33.17

It is well-known that the impregnation of fabrics with diluted caustic-soda solution has a positive effect on the dyeing properties of cellulosic fabrics [17]. Beyond the general application of caustic-soda, in this study the viscose fabric treated with caustic-soda in high concentrations in an exhaustion machine. The results in Table 2 show the K/S values of causticized and not causticized fabrics which were dyed in the same bath. It was found that performing a causticizing before dyeing increases the color efficiency too much. For instance, when the K/S value of not causticized dyed fabric was 23.28, it increased to 33.17 with the causticizing before dyeing. This increase (nearly 40 %) can provide the dyeing with low dye or low salt consumption. This is why it is important ecologically aspects.

3.3. Color Efficiency After Printing

On the other hand, causticized and not causticized fabrics were printed too. It was found that the color efficiencies of the printed samples increased significantly as a result of such a pre-process (causticizing) before printing.

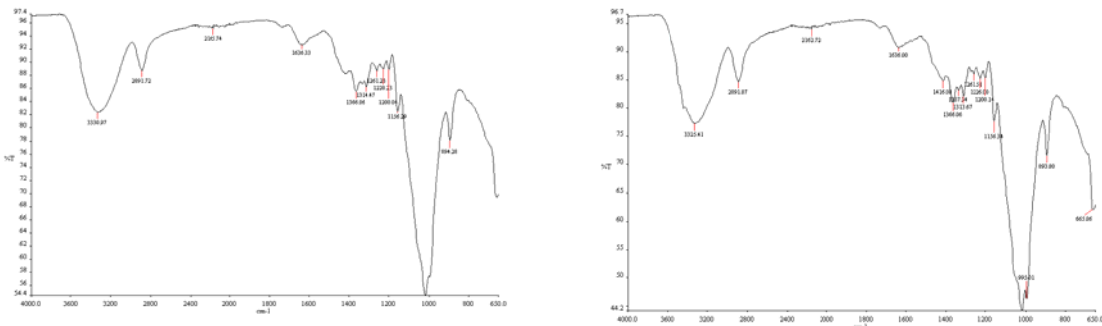
Table 3. Color efficiencies of causticized and not causticized fabrics after printing

	K/S
Not Causticized Printed Fabric	9.79
Causticized Printed Fabric	17.69

In other words, performing causticizing process before printing increased the color efficiency from 9.79 to 17.69 (nearly 80 %). It is thought that the main reason of this incredible increase is the swelling of fibers with caustic-soda treatment which causes higher dye uptake.

3.4 FT-IR Analysis

Spectral study of greige and treated viscose fabric was examined to investigate the changes in crystalline and amorphous region caused by caustic treatment. Also, IR results throw light on the cause of an improvement of dyeability and printability of treated viscose fabric. The infrared spectra are shown in Figure 4. Table 4 shows the most significant bands that were studied and analyzed, and their corresponding assignment [20,21].



a **b**

Figure 4. Infrared spectra of greige (**a**) and treated viscose fabric (**b**)

Table 4. Characteristic absorption bands of regenerated cellulose fibers [20]

Wavenumber (cm^{-1})	Assignment
3326	-OH stretching
2890	-CH stretching
1650	-OH of water absorbed from cellulose
1420	CH_2 symmetric bending
1365	C-H bending
1336	C-OH in plane bending
1316	CH_2 wagging
1278	C-H bending
1235	C-OH in plane bending
1227	C-OH in plane bending
1200	OH in plane bending
1155	C-O-C asymmetric stretching
894	Group C_1 frequency

In the literature, it is well known that caustic treatment causes structural changes at regenerated cellulose fibers [20]. Studying the intensity and shape evolution of infrared absorbance bands at 1400-1200 cm^{-1} is mostly preferred to define structural changes.

The absence of an appreciable band at 1430 and at 1111 cm^{-1} indicates that crystalline cellulose I is practically non-existent in the regenerated cellulose fibers. Bands at 1336 and 1316 cm^{-1} show significant differences in their absorbances. The 1316 cm^{-1} band assigned to crystalline cellulose is much more intense in the treated viscose fabric than in the greige fabric (Figure 4). As a result, IR spectrum of treated viscose fabric showed that caustic treatment improved crystallinity degree of viscose fabric.

4. CONCLUSIONS

In this paper causticizing process was determined by comparing the pilling degree and the color values of the printed and dyed fabrics. It was found that in order to achieve a high color efficiency of the dyeing and printing, causticizing must be performed. Moreover, during causticizing, since fibers has swollen and got smoother, the pilling tendency of fabrics was reduced too. Thus, it is possible to say causticizing is the most important process that directly influences the structure properties of fibers, dyeability and printability features of fibers. In other words, performing a causticizing process before dyeing or printing increased the K/S value of samples fairly. Meanwhile, no significant strength loss was measured and it becomes more crystalline so more stabile against the subsequent treatment processes.

In the view of ecologically and economically aspects, performing a caustizing process can be readily recommended because it ensures to achieve demanded color efficiency with the use of lower dyestuff.

5. REFERENCES

[1] Ciechañska D., Struszczyk H., Miettinen-Oinonen A., Strobin G., 2002, "Enzymatic Treatment of Viscose Fibres Based Woven Fabric", *Fibres & Textiles in Eastern Europe*, October/December, pp. 60- 63.

[2] Özgüney A. T., Tarakçıoğlu I., Körlü A. E., Özerdem A., Bahtiyari M.İ., 2005, "Effects Of Different Pretreatment Processes On Viscose Fabrics In Different Types And Properties", *The Journal of The Textile Institute*, Vol. 96, No 5 pp. 319-327.

[3] Cavaco-Paulo, A., 1998, "Mechanism of cellulase action in textile processes", *Carbohydrate Polymers*, Vol. 37, pp. 273-277.

[4] Eriksson, K.-E., Cavaco-Paulo, A. 1998, "Processing textile fibers with enxymes: An overview:Enzyme Applications in Fiber Processing", *ACS Symposium*, Washington DC,. pp. 180-189.

[5] Cavaco-Paulo A., Almeida L., 1996, "Cellulase Activities And Finishing Effects", *Textile Chemist and Colorist*, Vol. 28, pp.28-32.

[6] Cavaco-Paulo A, Luís de A., 1994, "Cellulase hydrolysis of cotton cellulose: the effects of mechanical action, enzyme concentration and dyed substrates", *Biocatalysis*, Vol. 10, pp. 353-360.

[7] Heikinheimo L., Miettinen-Oinonen A., Cavaco-Paulo A. Buchert J., 2003, "Effect of Purified Trichoderma Reesei Cellulases on Formation of Cotton Powder from Cotton Fabric", *Journal of Applied Polymer Science*, Vol. 90, pp. 1917–1922.

[8] Sarkar A.K., Etters J.N., 2001, "Kinetics of the enzymatic hydrolysis of cellulose", *AATCC Review*, Vol. 3, pp. 48-52.

[9] Morgado, J. Cavaco-Paulo, A. Rousselle, M.-A, 2000, "Enzymatic Treatment of Lyocell-Clarification of Depilling Mechanisms", *Textile Research Journal*, Vol. 70, No 8, pp. 696-699.

[10] Heikinheimo L., Buchert J., Miettinen-Oinonen A., Suominen P., 2000, "Treating Denim Fabrics with Trichoderma Reesei Cellulases", *Textile Research Journal*, Vol. 70, No 11, pp.969-973.

[11] Cortez J.M., Ellis J., Bishop D.P., 2001, "Cellulase finishing of woven, cotton fabrics in jet and winch machines", *Journal of Biotechnology*, Vol. 89, pp.239–245.

[12] Ibrahim N. A., Fahmy H. M., Hassan T. M., Mohamed, Z. E., 2005, "Effect of cellulase treatment on the extent of post-finishing and dyeing of cotton fabrics", *Journal of Materials Processing Technology*, Vol.160, Issue 1, pp.99-106.

[13] Cavaco-Paulo A., Almeida L., Bishop D., 1998, "Hydrolysis of Cotton Cellulose by Engineered Cellulases from Trichoderma Reesei", *Textile Research Journal*, Vol. 68, pp. 273-80.

[14] Bahtiyari, M. İ., 2005"Preventing Pilling Problem With Different Type Of Enzymes In Viscose Fabrics And Comparing The Obtained Effects", MSc Dissertation, Ege University..

[15] Körlü A.E., Taralp A., Duran K., Sezerman U., Bayram G., Bahtiyari M.İ., 2005, "Effect of Crosslinked and Commercial Cellulases on Bio-polishing of Viscose Based Knitted Fabrics", *World Textile Conference 5th Autex Conference*, Portoroz Slovenia,. pp.584-589.

[16] Bahtiyari M. İ., Duran K., Körlü A. E., 2007, "The Effect of Causticizing Processes on the Pilling Values of Viscose Fabrics", *AATCC Review*, April, pp. 40-45.

[17] Rouette, K., 1995, "Lexikon für Textilveredlung", Lauman-Ferlag, Dülmen, pp. 2390-2396.

[18] Bahar, M. 2006, "A Research About the Effect of Sulphur in Regenerated Cellulosic Fibers to Colour Exchange in Hot Dyeing and Cold Dyeing", MSc Dissertation, Ege University.

[19] Smole, M. S., Persin, Z., Kreze, T., Kleinschek, K. S., Ribitsch, V., Neumayer, S., 2003, "X-ray Study of Pre-treated Regenerated Cellulose Fibers" *Materials Research Innovations*, Vol. **7**, No 5, pp. 275-282.

[20] X. Colom, F. Carrillo, 2002, "Crystallinity changes in lyocell and viscose-type fibers by caustic treatment", *European Polymer Journal,* Vol. 38, pp. 2225–2230.

[21] F. Carrillo, X. Colom, J.J. Sunol, J. Saurina, 2004, "Structural FTIR analysis and thermal characterisation of lyocell and viscose-type fibers", *European Polymer Journal*, Vol. 40, pp. 2229–2234.