DEVELOPMENTS IN PREPARATION AND DYEING OF CORONA DISCHARGED CELLULOSIC MATERIALS

N. Carneiro[1]; A.P. Souto[1]; C. Nogueira[1]; M. J. Rios [1]; A. Madureira[1]; F. Fernandes [2]; P. Dias [2]

[1]University of Minho, Textile Engineering Department, 4800-058 Guimarães, Portugal

[2] CITEVE – Technological Centre for the Textile and Garment in Portugal

Abstract

The preparation and dyeing of cellulosic fabrics has important problems such as uniformity of aspect, cleaning efficiency, level of bleaching, conformity and fastness of colours, and ecological impact.
Combination of preparation processes can give optimal solutions, regarding economy and ecology, especially if superior quality items are achieved in final products. In fact, high standards concerning whiteness, starch removal and hidrophilicity are considered a good basis for levelled, cleaner and intense dyeings. A better white basis, excellent hidrophilicity and enough removal of impurities are obtained if desizing is omitted and a CORONA discharge is made over dry grey material.
Exhaustion dyeings with different classes of direct dyes show similar behaviour concerning the positive influence of the discharge in the intensity of colours and their fastness. Good penetration of dyes in coronised cotton materials is assured and consequently a good fastness is obtained.

Key-words: CORONA discharge; direct dyeing, cotton; bleaching; desizing.

1. INTRODUCTION

Cotton materials force dyers and finishers to adopt aggressive cleaning processes in order to remove natural and added impurities responsible for the major part of problems in the wet textile processing.
The influence of these impurities are diverse, but are mainly related to their hidrophilicity, to the yellowness and to the bad aspect they give to the final product. The study of mechanisms for the influence of a CORONA discharge in the cuticle of cotton demonstrates that physical and chemical changes co-exist being responsible for hidrophilization of the fibre and increase in reactive potential of the surface (Souto et al.,1996).
Coloration of incompletely prepared materials is normally very difficult and the final colour can be affected showing colour coordinates far way from expected.
All the factors improving cleaning efficiency and dyeing quality are considered as an important up-grade in ecological and economical competitiveness. Hidrophilicity, starch removal and whiteness degree are compared for different options, being CORONA treatment found as a powerful means for hidrophilisation and improvement of preparation quality (Carneiro et al., 1999, 2004).
Exhaustion dyeings with different classes of direct dyes show similar behaviour concerning the positive influence of the discharge in the intensity of colours and their fastness (Carneiro et al., 2001).

Tests with A, B and C direct dyes were made in order to evaluate the possibility of replacement of enzymatic desizing by CORONA discharge in the preparation of cotton fabrics which means substantial savings at several levels of the finishing process.

2. METHODS

2.1. Substrate

- 100% raw cotton fabric, plain weave, with starch sizing (8% o.w.f), and the following characteristics: weight per square meter – 172,6 g/m^2; thickness – 0,48 mm; number of yarns/cm - 18 (warp) and 15 (weft); yarn count – 30,6 tex (warp) and 76,2 tex (weft).

2.2. Equipments

- **CORONA**
  The discharge was made in a SOFTAL laboratorial prototype model "Lisboa", composed by a ceramic electrode and a counter electrode with silicon coating, where the width of treatment is 50 cm. The following conditions were used: power of discharge - 1,53 kW; velocity of the fabric - 2,4m/min; variable number of passages.
- **Long-bath equipment**
  A laboratorial machine, model IBELUS IL-720, Labelus, with IR heating has been used.
- **Reflexion spectrophotometer**
  The model Spectroflash 600 plus from Datacolor has been used for the evaluation of whiteness degree and colour coordinates of bleached and dyed samples, respectively.

2.3. Processes

- **Pad-batch desizing**
  Lufibrol E: 3 mL/L, Enzilase U-50: 3 mL/, Kieralon ED 835
  Temperature: 80ºC, Batch: 6 hours, Pick-up: 60%-65
  Washings: water (98ºC); water (95ºC); water (60ºC); cold water.
- **Long-bath bleaching**
  3mL/L NaOH (48%), 0,4 mL/L Kieralon ED 835, 0,3mL/L Sequestrator S, 2 mL/L H_2O_2 50 %
  liquor ratio – 1/10
  Initial temperature = 20 ºC
  Final temperature = 100 ºC
  Heating gradient = 3 ºC/ minute
  Duration = 30 minutes
  Washings: water (90ºC) during 10 minutes; water (70ºC) during 10 minutes; cold water until neutral pH.
- **Exhaustion dyeing with direct dyes**
  Saturn Blue L3R 300% (class A)- C.I. Direct Blue 67 – 0,5%
  Solophenyl Blue GL 250 % (class B)- C.I. Direct Blue 71 – 0,1%
  Sirius Supra Scarlet BN (class C)- C.I. Direct Red 95 – 0,25%
  Liquor ratio -1/10
  Washings: water (40ºC) during 10 minutes; cold water

Table 1 – Dyeing processes and auxiliaries (recommended methods)

	Initial temperature (ºC)	Final temperature (ºC)	Heating gradient (ºC/min)	Duration (min)
Dye A	20	95	3	50
Dye B	50	90	1,5	60
Dye C	20	85	3	60

Auxiliaries	Na_2CO_3 (%)	NaCl (%)
Dye A	1	4
Dye B	-	3
Dye C	0,5	3

2.4. Quality control

- **Starch's degree**
  Starch's degree was tested with a solution of iode/potassium iodide and measured using the TEGEWA scale.
- **Hidrophilicity**
  Time of water drop absorption was measured according to the principles of the norm: AATCC-39-1980.
- **Whiteness degree**
  Whiteness degree was evaluated using Berger formula. Twenty readings with aleatory distribution for the calculation of uniformity were made in the entire surface of the sample. The coefficient of variation was calculated.

3. RESULTS

3.1. Competitive tests between discharged and non-discharged samples

- Preparation of grey 100% cotton fabric, with 8% starch sizing, is made using procedures adapted from industrial practice, which include a long bath alkaline oxidative treatment with hydrogen peroxide. In this case a previous CORONA discharge is made. Another preparation procedure is compared with this in which pad-batch enzymatic desizing is individualised followed by the same bleaching treatment.
- The CORONA discharge, at different dosages (2508 and 5016 w.min/m^2, is made in a laboratorial prototype working with air, in normal conditions of pressure and temperature. The treatment is carried continuously with a chosen velocity for the movement of the fabric between the system formed by the electrode and the counter-electrode.
- Competitive dyeings, with direct dyes belonging to A and C class, were made using recipes and suitable processes indicated by manufacturers for each case.

The quality of the preparation has been assessed by means of whiteness (W), quantity of starch (S) and hidrophilicity (H) measurements. The coefficient of variation (CV%) has been evaluated for whiteness and hydrophilicity. The colorimetric K/S values were measured in dyed samples as well as the correspondent coefficient of variation.

Table 2 – Quality control of preparation and dyeing for competitive tests

Dye A	Enzymatic desizing and bleaching (CV%)	CORONA (2508 w.min/m^2) and bleaching (CV%)
W – Berger	51,1 (1,1)	55,30 (1,3)
S - Tegewa scale	8	6
H - seconds	1,2 (28,0)	0,5 (8,2)
K/S	2,9 (2,5)	3,1 (2,2)

Dye C	Enzymatic desizing and bleaching (CV%)	CORONA (2508 w.min/m^2) and bleaching (CV%)
W – Berger	56,0 (1,2)	61,9 (1,2)
S - Tegewa scale	8	7
H - seconds	1,6 (16,0)	0,6 (8,7)
K/S	2,9 (2,4)	3,2 (2,7)

Dye A	Enzymatic desizing and bleaching (CV%)	CORONA (5016 w.min/m^2) and bleaching (CV%)
W – Berger	54,5 (1,3)	60,8 (1,0)
S - Tegewa scale	8	6/7
H - seconds	1,9 (33,9)	0,6 (5,9)
K/S	2,6 (2,2)	2,7 (2,0)

Dye C	Enzymatic desizing and bleaching (CV%)	CORONA (5016 w.min/m^2) and bleaching (CV%)
W – Berger	58,9 (1,1)	60,8 (1,0)
S - Tegewa scale	8	6/7
H - seconds	1,0 (24,4)	0,6 (6,9)
K/S	3,1 (3, 8)	3,2 (2,9)

3.2. Non-competitive tests

Enzymatic and bleaching operations (with previous CORONA discharge at 7524 w.min/m^2) were made in accordance to the methods and processes of the competitive tests, using individual treatments for each sample.
Non-competitive dyeings with A, B and C direct dyes were made using the same recipes as presented before.

Table 3 – Quality control of preparation and dyeing for non-competitive tests

Dye A	Enzymatic desizing and bleaching (CV%)	CORONA (7524 w.min/m^2) and bleaching (CV%)
W – Berger	58,5 (0,8)	61,3 (1,0)
S - Tegewa scale	8	7
H - seconds	1,9 (36,9)	0,6 (9,1)
K/S	2,1 (3,0)	3,1 (2,2)

Dye B	Enzymatic desizing and bleaching (CV%)	CORONA (7524 w.min/m^2) and bleaching (CV%)
W – Berger	57,9 (1,0)	61,7 (1,2)
S - Tegewa scale	8	7
H - seconds	1,6 (34,9)	0,6 (7,8)
K/S	1,0 (6,6)	1,0 (2,3)

Dye C	Enzymatic desizing and bleaching (CV%)	CORONA (7524 w.min/m^2) and bleaching (CV%)
W – Berger	59,9 (1,0)	62,4 (1,4)
S - Tegewa scale	8	6/7
H - seconds	0,7 (21,6)	0,5 (8,3)
K/S	3,1 (2,6)	3,4 (2,9)

Table 4 – Colorimetric evaluation of dyed samples

Dye A	L*	a*	b*	C*	h
Enzymatic desizing, bleaching and dyeing	55,72	-1,58	-26,95	27,00	266,64
CORONA (7524 w.min/m^2), bleaching and dyeing	51,03	-1,30	-27,36	29,34	267,47

Dye B	**L***	**a***	**b***	**C***	**h**
Enzymatic desizing, bleaching and dyeing	66,12	-5,03	-19,47	20,11	255,51
CORONA (7524 w.min/m²), bleaching and dyeing	65,80	-4,94	-19,99	20,60	256,11

Dye B	**L***	**a***	**b***	**C***	**h**
Enzymatic desizing, bleaching and dyeing	59,52	47,19	12,44	48,81	14,76
CORONA (7524 w.min/m²), bleaching and dyeing	58,37	48,14	13,21	49,92	15,35

Table 5 – Washing fastness of dyed samples- staining of cotton (ISO CO6 – A1S method)

	Staining (CO)
Dyeing for competitive tests	
Dye A - Enzymatic desizing and bleaching	3
Dye A - CORONA (2508 w.min/m²) and bleaching	3/4
Dye C - Enzymatic desizing and bleaching	4
Dye C - CORONA (2508 w.min/m²) and bleaching	4
Dye A - Enzymatic desizing and bleaching	4
Dye A - CORONA (5016 w.min/m²) and bleaching	4
Dye C - Enzymatic desizing and bleaching	4
Dye C - CORONA (5016 w.min/m²) and bleaching	3/4
Dyeing for non-competitive tests	
Dye A - Enzymatic desizing and bleaching	4
Dye A - CORONA (7524 w.min/m²) and bleaching	4
Dye B - Enzymatic desizing and bleaching	5
Dye B - CORONA (7524 w.min/m²) and bleaching	5
Dye C - Enzymatic desizing and bleaching	3/4
Dye C - CORONA (7524 w.min/m²) and bleaching	3/4

Note: No noticeable change in colour has been detected between each pair of dyed samples.

Either in competitive or in non-competitive procedures, results show important improvements for whiteness and hidroplility when CORONA is added as a pre-treatment to bleaching. Concerning starch removal, enzymatic desizing is naturally more effective, but recent results (Carneiro et al., 2004) show that CORONA discharge is able to induce starch decomposition if a more intense oxidative treatment is made afterwards. In fact, hydrogen peroxide concentration must be raised if complete starch removal is needed in the absence of enzymatic desizing. In the referred work CORONA gives a better result for starch removal up to three points in Tegewa scale when comparing to the isolated oxidative bleaching operation.
The increase in CORONA dosage is not directly related to an increase in the effects obtained, which means that with minimal intensity of discharge important up-grade in preparation can be reached.
Dyeings obtained for A, B, and C dyes in competitive and non-competitive tests prove that in every case the integration of the CORONA discharge before bleaching is advantageous, giving more intense and cleaner colours with little deviation in hue.
Concerning the washing fastness of dyed samples the values are similar for samples dyed with previous desizing and bleaching and for the ones where desizing has been replaced by a CORONA discharge.

4. CONCLUSIONS

The replacement of enzymatic desizing by a CORONA discharge in grey cotton fabrics is possible and better results are obtained in preparation and dyeing. Overall benefits include hidrophilicity, starch

removal and whiteness extended to more intense and fast colours in dyeing. The economical and ecological impact is obvious and a good contribution is given to pollution reduction in the source, this is, during the wet processing of the fabric.
An industrial CORONA machine for the preparation of cotton fabrics is being implemented and complete evaluation of impact is expected (Patent, 2004).

5. REFERENCES

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ADITIONAL DATA ABOUT AUTHORS

Prof. Drª. Noémia Carneiro, Associated Professor, University of Minho, Textile Engineering Department, 4800-058 Guimarães, Portugal, E-mail: noemiac@det.uminho.pt, Tel: +351 253 510288, Fax: +351 253 510293