EFFECT OF CAUSTICIZATION ON COLOUR STRENGTH (*K/S*) OF REACTIVE DYED LYOCELL FABRIC

Shamshad Ali [1], Awais Khatri [1], Mazhar H Peerzada[1,2], Aijaz Ahmed [1]

e-mail: shamshad.ali@faculty.muet.edu.pk

[1]Department of Textile Engineering, Mehran University of Engineering and Technology, Jamshoro.

[2]Department of Textiles and Paper, School of Materials, University of Manchester, UK

ABSTRACT: *The casticization of lyocell, a regenerated cellulose, fabric was studied to determine its effect on dyeing results. The fabric was dyed with direct dyes after casticization for that purpose. Monographs were taken on Scanning Electron Microscope (SEM) to decipher the surface morphology of causticized lyocell fabric in comparison with untreated lyocell fabric. Owing to fibrillation of lyocell; its dyeing is challenging when viewed against other regenerated cellulosics. Frosty look is usually obtained for dark hues such as black, navy and brown. In this research work, lyocell woven fabric was pre-treated with sodium hydroxide (NaOH) at varying concentrations by pad-batch method. The causticized lyocell fabric was then dyed with monochloro-triazine (MCT), vinyl-suphone (VS) and MCT / VS based reactive dyes by exhaust, continuous (pad-dry-cure) and pad-batch methods. The causticization process resulted reduction in fabric whiteness, similar fabric absorbency and increased fabric stiffness comparing to the untreated fabric. When dyed, the causticized lyocell fabric gave higher colour strength (K/S); and un-level shade appearance in most cases when compared with untreated lyocell fabric. However, pad-batch dyeing resulted an evenly dyed fabric.*

*Keywords**:** causticization, regenerated cellulose lyocell, fibrillation, reactive dyes*

INTRODUCTION

Lyocell is a biodegradable and absorbent regenerated cellulosic fibre [1]. It is a solvent spun fibre manufactured by dissolving the wood pulp into an aqueous solution of N-methylmorpholine-N-oxide monohydrate [2, 3]. Lyocell and viscose fibres have similar empirical formulae but different super molecular structure; e.g. molecular orientation, degree of crystallinity, crystalline and amorphous dimensions and the shape and size of voids; resulting in very different technical properties [4, 5].

Lyocell fibres are more crystalline (80%) in comparison with other regenerated cellulosic fibres, such as modal (49%) and viscose (41%) [6].

Due to abrasion in wet condition, a single lyocell fibre splits into micro-fibres of less than 1-4 microns in diameter. This occurrence is known as *fibrillation*. The fibrils are transparent giving either frosty or pilled appearance to finished fabric [1].

It is observed that higher colour strength is achievable in the reactive dyeing of lyocell compared with cotton using same amount of dye [7]. Lyocell can be dyed with vat, direct and reactive dyes. It was discovered that reactive dyes having two or three reactive groups can crosslink lyocell fibre and thereby prevent or inhibit fibrillation of the fibre. The dyeing with Procion Orange H-ER, a bis-MCT dye, to reduce fibrillation has been reported [1, 8].

Lyocell fibres swell laterally about 30% upon moisture sorption and over 200% in NaOH relative to dry diameter. It is revealed that the splitting tendency of lyocell fibres increases with increasing sodium hydroxide concentration, in a sodium hydroxide treatment. Fibrils on the surface of lyocell fibres are stripped in causticization process, thus fibre smoothens and swells; reducing pilling and improving colour strength [9, 10].

This paper presents results of an investigation on the the characterization of sodium hydroxide (NaOH) in causticization processes, and its influence on the reactive dyeing of lyocell fabric by exhaust, pad-dry-cure and pad-batch methods.

EXPERIMENTAL

Materials: 100% lyocell twill woven fabric was used in the study. The specifications of fabric are given in Table 1.

Table 1. Specifications of Lyocell Fabric

Parameters	Results
Ends / Inch	128
Picks / Inch	78
Fabric Weight	157
Warp Count	30
Weft Count	30
CIE Whiteness	61

The fabric was washed with boil water for 2 minutes to remove any impurities on the fabric.

Three commercial reactive dyes were selected for the study. Procion Dark Blue HEXL (monochloro-triazine, MCT) and Remazol Blue RGB (vinyl-suphone, VS) were received from Dystar Pakistan and Drimarene Blue CL-BR (MCT / VS) was supplied by Clariant Pakistan.

Sodium hydroxide (36^{o}Be), acetic acid, urea, sodium chloride and sodium carbonate were of Analar grade. Drimagen E2R (anionic levelling agent, aromatic polyether sulphonate) Ladipur RSK (anionic detergent, based on polycarboxylic acid) were received from Clariant Pakistan. Thermacol MIN (migration inhibitor, based on solution of an acrylic copolymer) was supplied by Huntsman Pakistan. Deionized water was used for casticization and dyeing processes.

Methods:

Pad-batch Causticization: Lyocell fabric was padded with sodium hydroxide (5^{o}Be, 8^{o}Be and 11^{o}Be) at 70% pick-up. The fabric was then batched for 15 minutes in a polyethene bag followed by washing.

Reactive dyeing by exhaust method: The dyeing was done at liquor to good ratio of 15:1. The recipe was: 1%, 2% and 3% o.m.f. reactive dye, 2 g/l Drimagen E2R, 60 g/l sodium chloride and 10 g/l sodium carbonate. Dye exhaustion was carried out at 40°C for 20 minutes and dye fixation was done at 60°C for 60 minutes.

Reactive dyeing by pad-dry-cure method: The lyocell fabric was padded with 10 g/l, 20 g/l and 30 g/l reactive dye, 2 g/l Drimagen E2R, 15 g/l Thermacol MIN, 15 g/l sodium carbonate and 100 g/l urea. The pick-up was 70%. The fabric was dried in hot air at 120°C for 90 seconds followed by curing at 160°C for 90 seconds.

Reactive dyeing by pad-batch method: The lyocell fabric was padded with 10 g/l, 20 g/l and 30 g/l reactive dye, 2 g/l Drimagen E2R, 20 g/l sodium hydroxide (36°Be), 30 g/l sodium carbonate and 50 g/l urea. The pick-up and dwell time were 70% and 17 hours respectively.

After dyeing process each sample was washed as: cold wash, hot wash, soaping-off using 2 g/l Landipur RSK, hot wash, neutralization with acetic acid, and finally cold wash.

Testing and Analysis: The samples were conditioned at 65% relative humidity and 20°C temperature for 24 hours before testing. Degree of whiteness expressed as CIE Whiteness was evaluated on reflectance spectrophotometer (Macbeth CE7000A). Surface morphology of fabrics was analysed by scanning electron microscopy, SEM, (JSM 6490 LV JEOL Japan). Reflectance spectrophotometer (Macbeth CE7000A) was used for the measurement of colour strength (*K/S*) of lyocell dyed fabric.

RESULTS AND DISCUSSION

Analysis of Untreated and Causticized Samples: In order to comprehend the effectiveness of causticization process on lyocell fabric, causticized samples by pad-batch method were examined by scanning electron microscopy.

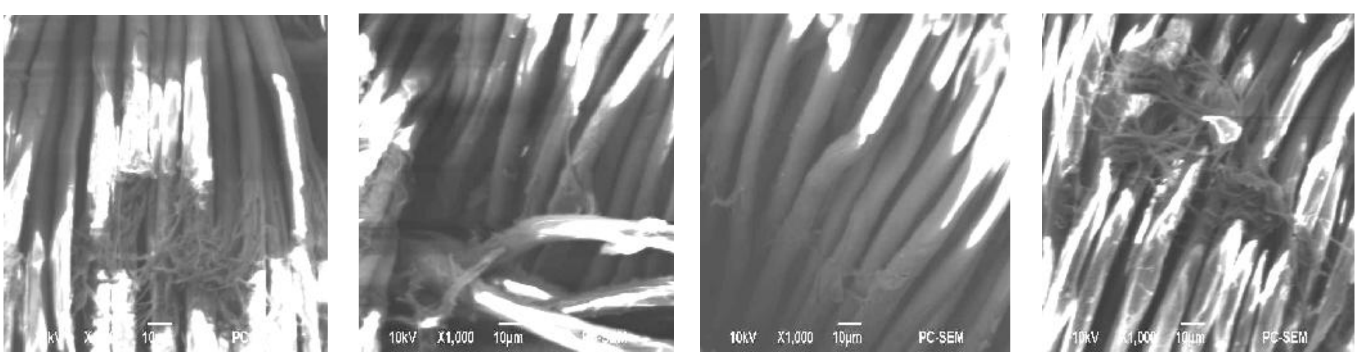
Figs. 1 (a) to 1 (d) show micrographs of untreated and treated lyocell fibres taken at a magnification of 1000. The micrographs show the arrangement of lyocell fibres in the yarns within woven fabric structure. The fibres are relatively parallel on which bunch of fibrils was there. It was demonstrated that during causticization; cross-section of lyocell fibre became spherical and swollen at 8°Be NaOH concentration [Fig. 1(c)]. However, lyocell fibres looked collapse inside at 11°Be NaOH concentration [Fig. 1(d)].

Effect of sodium hydroxide concentration on colour strength (exhaust dyeing method): Procion Dark Blue HEXL and Drimarene Blue CL-BR dyes were used for exhaust dyeing. It is clear from Figs. 2 and 3 that causticized samples after reactive dyeing; gave more colour strength than untreated sample. As concentration of sodium hydroxide raised from 5°Be to 8°Be there was a corresponding increase in colour strength. However, at 11°Be concentration a reduction in colour depth was observed. Fabrics dyed with Drimarene Blue CL-BR showed higher colour strength than fabrics dyed with Procion Dark Blue HEXL. The dyed samples were un-even in appearance without any mark. Mechanical agitations and crease formation in lyocell fabric may be the factors responsible for shade variation and marks irrespective of different reactive dyes used during dyeing process.

Pad-Dry-Cure Method (0-11°Be NaOH)

Effect of Sodium Hydroxide Concentration on Colour Strength (pad-dry-cure dyeing method): Procion Dark Blue HEXL and Drimarene Blue CL-BR were used for pad-dry-bake dyeing. It is clear from Figs. 4 and 5 show that causticized samples after reactive dyeing gave more colour strength than untreated sample. As concentration of sodium hydroxide raised from 5°Be to 8°Be there was a corresponding increase in colour strength. However, at 11°Be concentration a reduction in colour strength was achieved. Fabrics dyed with Drimarene Blue CL-BR showed higher colour strength than fabrics dyed with Procion Dark Blue HEXL. The dyed samples were un-even in appearance without any mark. Mechanical agitations and crease formation in lyocell fabric may be the factors responsible for shade variation and marks irrespective of different reactive dyes used during dyeing process

Effect of sodium hydroxide concentration on colour strength by (pad-batch dyeing method): Remazol Blue RGB and Drimarene Blue CL-BR were used for pad-batch dyeing. Figs. 6 and 7 reveal that at a given concentration of NaOH, the colour strength increased simultaneously with the rise in the dye concentration. However, with the increase in the concentration of NaOH, the colour strength raised from 5°Be to 8°Be followed by a reduction at 11°Be. Fabrics dyed with Remazol Blue RGB showed higher colour strength than fabrics dyed with Drimarene Blue CL-BR. The dyed samples showed evenness in appearance with no marks.



(a) (b) (c) (d)

Fig. 1: Surface Morphology of (a) Un-treated lyocell, (b) Causticized Lyocell at 5°Be, (c) Causticized Lyocell at 8°Be, (d) Causticized Lyocell at 11°Be

.

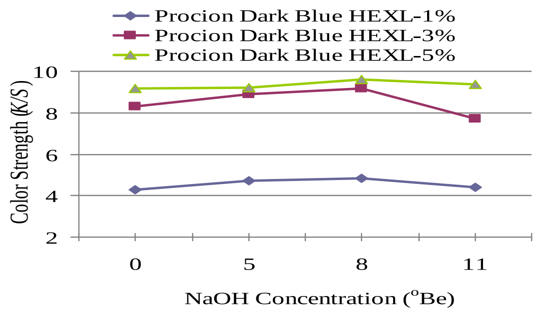


Fig. 2: Colour Strength of Lyocell Fabric Dyed – Exhaust Method (0-11°be NaOH)

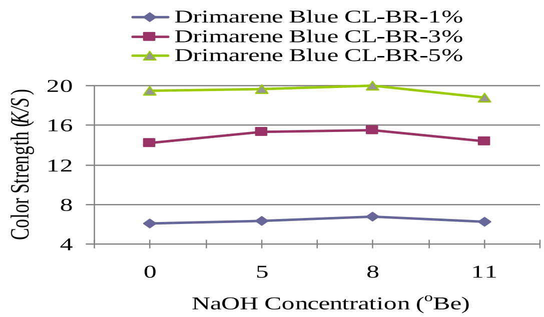


Fig. 3: Colour Strength of Lyocell Fabric Dyed – Exhaust Method (0-11°Be NaOH)

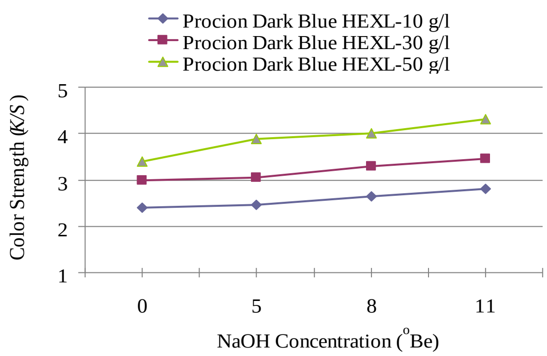


Fig. 4: Colour Strength of Lyocell Fabric Dyed - Pad-Dry-Cure Method (0-11°Be NaOH)

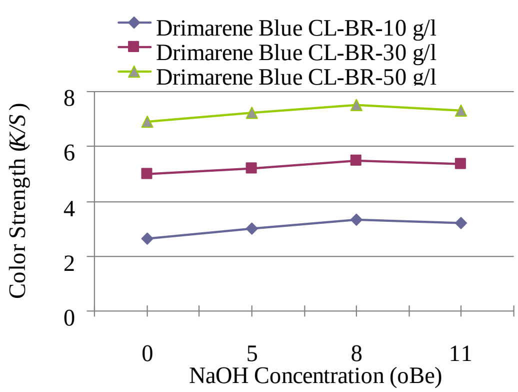


Fig. 5: Colour Strength of Lyocell Fabric Dyed –

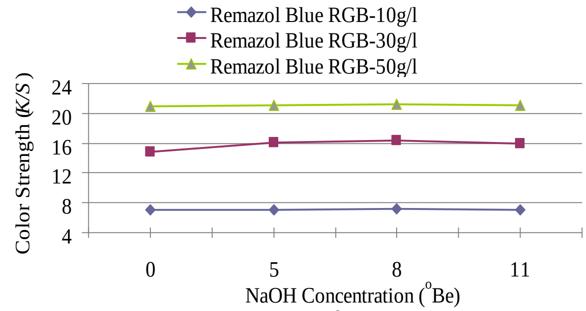


Fig. 6: Colour Strength of Lyocell Fabric Dyed by Pad-Batc h Method (0-11°Be NaOH)

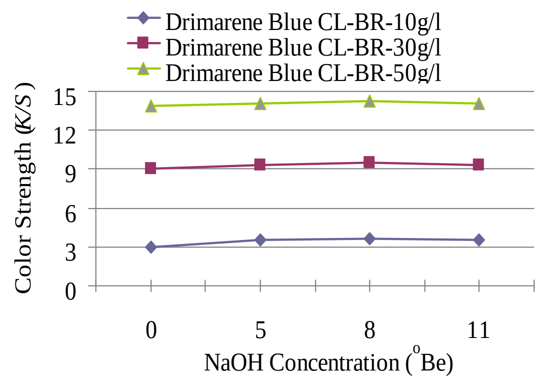


Fig. 7: Colour Strength of Lyocell Fabric Dyed by Pad-Batch Method (0-11°Be NaOH)

In other words, the problem of shade un-evenness was not observed when pad-batch dyeing method was employed. This may be due to very less mechanical action/agitation during the process. And, it can be comprehended that open-width processing and absence of fabric abrasion is essential for level dyeing.

CONCLUSIONS

It was revealed that causticized lyocell fabrics have inferior CIE whiteness, more stiffness and similar absorbency in comparison with untreated lyocell fabric.

It was investigated that after causticization process; colour strength (*K/S*) of reactive dyed lyocell fabrics have improved, and un-even shade appearance was noticed in most cases. However, that problem was not observed with pad-batch dyeing method.

ACKNOWLEDGEMENTS

Authors are thankful to Mr. Kamran Khatri Clariant Pakistan, Mr. Faisal Ansari, Popular Fabrics Private Limited Pakistan and Mr. Noor Ahmed Sanbhal ITTM Pakistan; for their profound help and support in this work.

REFERENCES

[1] P. W. MBE, *Regenerated Cellulose Fibres*, First ed.: Woodhead Publishing Limited UK, 2001.

[2] R Ibbett, *et al.*, "Protection of lyocell fibers against fibrillation; mechanism for the poor crosslinking performance of reactive dyes on lyocell fibers and influence of a colourless crosslinking agent as co-

applicant.," *Coloration Technology*, vol. 125, pp. 123-131, 2009.

[3] A. P. Manian, *et al.*, "The influence of alkali pretreatments in lyocell resin finishing – Fiber structure," *Carbohydrate Polymers,* vol. 71, pp. 664-671, 2008.

[4] I Bates, *et al.*, "Protection of of lyocell against fibrillation. Part 1: Design, synthesis and application of novel crosslinking agents.," *Coloration Technology*, vol. 122, pp. 270-276, 2006.

[5] S Kaenthong, *et al.*, "Accessability of man-made cellulosic fibers. Part1: Exhaust application of reactive dyes to never-dried lyocell, viscose and modal fibers," *Coloration Technology*, vol. 121, pp. 45-48, 2005.

[6] Parikshit Goswami, *et al.*, "Effect of sodium hydroxide pretrement on the optical and structural properities of lyocell.," *European Polymer Journal,* vol. 45, pp. 455-465, 2009.

[7] Ahmad Wassim Kaimouz, *et al.*, "The inkjet printing process for lyocell and cotton fibers. Part 1: The significance of pre-treatment chemicals and their relationship with colour strength, absorbed dye fixation and ink penetration.," *Dyes and Pigments,* vol. 84, pp. 79-87, 2010.

[8] D A S Phillips, *et al.*, "Influence of dichloro-s-triazinyl reactive dyes on the fibrillation propensity of lyocell fibres," *Coloration Technology*, vol. 124, pp. 173-179, 2008.

[9] M. I. Bahtiyari, *et al.*, "Causticizing of viscose fabircs," *Journal of Textile and Apparel, Technology and Management*, vol. 6, pp. 1-7, Spring 2009.

[10] U. Syed and R. H. Wardman, "Assessment of uniformity of fibre coloration in Tencel woven fabrics dyed using reactive dyes," *Coloration Technology*, vol. 127, pp. 418-425, 2011.