Indian Journal of Fibre & Textile Research
Vol. 47, June 2022, pp. 242-245

Short Communications

Combined wet pretreatments of cotton with enzymes

Arun K Patra[a], Shivani Gupta & Alka Ali

Department of Textile Chemistry, U P Textile Technology Institute, Kanpur 208 001, India

Received 21 June 2021; revised received and accepted 3 September 2021

An improvisation of enzymatic wet processing has been done by combining desizing and scouring treatment of cotton under benign conditions. The merit in this attempt lies in saving energy, time, water and importantly environment. The feasibility of this process is studied by evaluating the weight loss, absorbency and Tegewa rating. Concurrently, separate preparatory processes are also carried out and evaluated for comparison purpose. Further, to ensure the effectiveness of the combined process, peroxide bleaching of the enzyme-treated samples are carried out. The whiteness so obtained for single bath desize-scour fabrics is found to be comparable to that of separate bath processed fabrics, measured in terms of whiteness and yellowness indices. The samples later dyed also show similar results.

Keywords: Bioscouring, Cotton, Desizing, Enzyme, Pectinase, Wet processing, Whiteness

There is an increasing concern for two cardinal aspects in wet processing of textiles. One is the share of energy cost in the total production cost, which has spiralled in the last few decades after the oil shocks. Other one is the carbon footprints of textile manufacturing processes, adversely affecting the environment. Both the issues can be addressed by low energy consuming, chemicals-free enzymatic processing. In fact, enzymes are making significant inroads in textile processing and are likely to substitute the conventional chemical processing soon, given the thrust on eco-friendly sustainable treatments. Enzymatic desizing although an established process and widely followed for bulk production, bioscouring is yet to gain industrial acceptance. However, scouring with pectinase enzyme has been found to be quite effective and proven to be a good alternative to conventional high temperature alkaline scouring[1-3].

Bioscouring of cotton using alkaline pectinase and its compatibility with peracetic acid bleaching for a one-step process has been studied and successfully carried out with reasonable success[4]. The enzyme formulation containing pectinase often has cellulase along with it or in some cases xylanase[5, 6].

The enzymatic desizing and bioscouring have usually been two separate processes, the former requiring slightly acidic *p*H and the latter at conditions based on the enzyme used. These treatments usually done in moderate temperature, and ensure saving in energy. Also, the harsh chemicals used in conventional scouring are completely avoided here thus making the process environment friendly, generating easily manageable effluent. Amylase used in desizing acts on starch, the main constituent of sizing chemicals, while the pectinase in enzyme scouring acts on pectins, the naturally present binding material in cotton, thus loosening up the fats and waxes from the fibre matrix. In the present work, a further improvement in enzymatic pretreatment is studied by combining desizing and scouring so as to decrease the process time and water consumption. Herein, suitable amylase and pectinase are chosen, as their operating pH and temperatures are in the same range. This gives the opportunity to have a single bath desizing and scouring treatment. The fabric coming out is thus ready to bleach.

Experimental

Greige plain woven cotton fabric, having EPI 60 & PPI 50, warp & weft 20^s Ne, weight 154 gsm and tensile strength 31.86 kgf, was used for this study. The enzymes employed were amylase for desizing and pectinase based product for scouring, both procured from Novozymes. The various ingredients used were Lenetol HPLF Premium (non-ionic detergent) from Croda and LR (laboratory range) grade chemicals such as acetic acid, soda ash, common salt, hydrogen peroxide (50%) and EDTA (Ethylenediamine tetraacetic acid). Reactive dye Coracion Blue HEGN of Colourtex was applied to evaluate efficacy of the pretreatment.

The desizer was fixed at three different levels (0.5%, 0.75% and 1%), while the scouring enzyme was used at the concentrations of 0.4, 0.7 and 1%, and they were applied from single bath at all possible combinations to see the effect. Treatment

[a] Corresponding author.
E-mail: arunkpatra1@gmail.com

was given at neutral *p*H with 60°C temperature for 1 h in presence of 1% wetting agent. The prescribed operating range for the amylase enzyme was *p*H 6-7 and temperature 50-70°C, while that of scourzyme was 6-9 *p*H and 50-60°C temperature Hence, a common rationalized condition was chosen for the combined process. The sample numbering and corresponding enzyme concentrations are given in Table 1.

After this, the bath temperature was raised to 95°C and run for 30 min at that temperature. At this temperature, the pectinase and amylase enzymes get deactivated and the fats and oils present in cotton are also removed. All the treatments are given in an IR (Infrared) Dyeing machine at an MLR of 1:20. For comparison purpose, the same conditions were maintained for separate bath desizing and scouring as well. Then, all the eighteen samples were bleached with hydrogen peroxide in separate pots of the IR machine with recipe and condition given below:

Hydrogen peroxide (30% strength) : 2%
Non-ionic detergent : 0.5%
Sodium silicate :1%
EDTA : 0.1%
Conditions :Temperature 85°C, time 90 min and *p*H 10-11

The bleached fabrics were given thorough hot wash, cold wash followed by neutralization with acetic acid. The oven dried samples were then dyed with reactive dye as per the dyeing profile given in Fig. 1. Wetting agent (0.5%) was added as an auxiliary, while common salt and soda ash were used for exhaustion and fixation respectively to dye with Coracion Blue HEGN at 0.5% shade.

Test Methods

The samples were checked using a Tegewa scale to ensure efficient size removal. Absorbency of the fabric was tested using AATCC Test method 79 by dropping water on fabric and recording the wetting time with a stop watch[7]. The weight loss on desizing and scouring due to removal of added and natural impurities was evaluated using the following simple calculation:

$$\text{Weight loss \%} = \frac{(\text{Weight before scouring} - \text{Weight after scouring})}{\text{Weight before scouring}} \times 100$$

The fabric samples then bleached were tested for quantitative measurement in terms of whiteness index and yellowness index in a CM-2600d Konica Minolta portable spectrophotometer. This was done to check if the combined process has any adverse effect on subsequent bleaching. Further, the samples were dyed to see the effect on colouration and using the same device, colour strength in terms of K / S (coefficient of absorption/coefficient of scattering) as well as colour difference dE between the single bath and the separate bath desize-scour ones were measured. Colour strength was determined using the Kubelka-Munk equation.

Table 1 — Enzyme concentration for one bath desize-scour process

Sample No.	Amylase, %	Pectinase, %
1	0.5	0.4
2	0.5	0.7
3	0.5	1.0
4	0.75	0.4
5	0.75	0.7
6	0.75	1.0
7	1.0	0.4
8	1.0	0.7
9	1.0	1.0

Results and Discussion

The test results of pretreated samples for process efficiency are shown in Table 2. The results are quite good and similar for both single bath and double bath treatments. The desizing efficiency is checked by iodine spotting and then rating the result using a Tegewa scale. The rating is in the range of 6-8 showing total effectiveness of the process. The weight loss values as given in the table are quite significant, indicating removal of both added and natural impurities serving the purposes of desizing and scouring respectively. Also, the absorbency time of all the samples being less than two seconds, the purpose of making the fabric hydrophilic is achieved as absorbency of ≤3 seconds is considered a measure of successful scouring. The results of all the three tests for combined process are found on similar lines as that of separate enzymatic processes. On the contrary

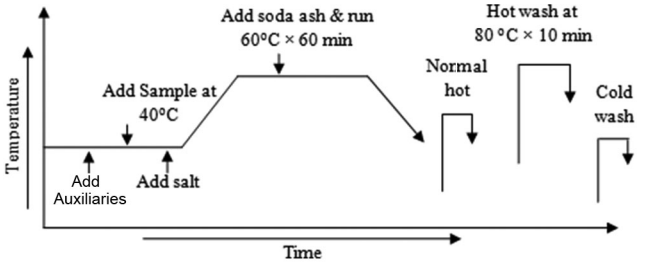

Fig. 1 — Dyeing profile for the reactive colour application on bleached samples

Table 2 — Test results of two bath and one-bath desize scour

Sample No.	Double bath			Single bath		
	Tegewa rating	Weight loss, %	Absorbency time, s	Tegewa rating	Weight loss, %	Absorbency time, s
1	6	8.07	< 2	6	8.09	< 2
2	6-7	8.24	< 2	6-7	8.91	< 2
3	6-7	9.02	< 2	6-7	9.09	< 2
4	7	8.38	< 2	7	8.36	< 2
5	7	9.29	< 2	7	9.09	< 2
6	8	9.48	< 2	8	9.14	< 2
7	7	9.22	< 2	7	8.96	< 2
8	7-8	9.47	< 2	7	9.17	< 2
9	8	9.92	< 2	8	9.30	< 2

Table 3 — Whiteness of bleached samples desized and scoured in double bath and single bath

Sample No.	Bleaching indices for separate bath desizing and scouring			Bleaching indices for single bath desizing and scouring		
	CIE whiteness	Hunter whiteness	Yellowness - E313	CIE whiteness	Hunter whiteness	Yellowness- E313
1	56.46	75.02	8.51	58.40	76.30	6.96
2	60.36	77.67	6.03	62.34	78.41	6.79
3	61.62	78.35	5.85	62.10	78.96	6.82
4	56.80	75.10	8.69	61.54	78.01	6.83
5	58.32	76.52	6.59	60.81	77.54	7.16
6	56.44	74.93	8.69	61.45	78.00	6.74
7	60.47	77.79	5.89	61.47	78.01	6.73
8	61.21	77.87	6.79	61.61	78.06	6.55
9	60.69	77.30	7.24	61.70	78.17	6.61

in separate processes, it is more time consuming, with requirement of larger amount of water and machine occupancy. This indicates that the enzymes are independent of each other and don't get affected in presence of the other. Being very specific in action, the amylase acts on amylose, the starch present in size only, while pectinase removes pectins, the natural gluing matter from the substrate. The subsequent heating up the bath after the treatment, deactivates both the enzymes and at the same time removes the fats and waxes bound by pectin on to the primary wall of the cotton fibre, thus completing the scouring process.

Effect of Bleaching

In usual sequence of wet processing, both sets of scoured fabric samples are chemical bleached with hydrogen peroxide under prescribed condition as already mentioned. The bleached samples when spectrophotmetrically measured for whiteness (both CIE and Hunter) and yellowness as per E 313 standards, the CIE whiteness is found invariably lower than Hunter Whiteness for the samples (Table 3). High whiteness indices are accompanied by corresponding low yellowness indices. Quite importantly, the values obtained for fabrics treated in combined processes are found similar to that of the two bath desize and scoured ones. This shows that the single bath desize-scour treatment has absolutely no negative influence on bleaching.

Table 4 — Dyeing results of enzyme pretreated and bleached samples

Sample No.	Colour strength (K/S)		Colour difference (dE)
	Two bath	One bath	
1	1.705	1.730	0.56
2	1.954	1.946	0.44
3	1.682	1.723	0.60
4	1.685	1.660	0.43
5	1.763	1.701	0.74
6	1.645	1.696	0.62
7	1.614	1.635	0.54
8	1.773	1.792	0.43
9	1.756	1.756	0.22

Effect on Dyeing

The cotton samples were further dyed with reactive dye at 0.5% shade to once again validate the pretreatment process. After dyeing, the colour strengths measured in computer colour matching system in terms of K / S values are given in Table 4. Other than that the colour difference between the corresponding samples of one bath and two bath processes is also measured. The colour depth obtained for the samples is almost on the same range with minimal colour difference values between the combined and separate bath desized scoured

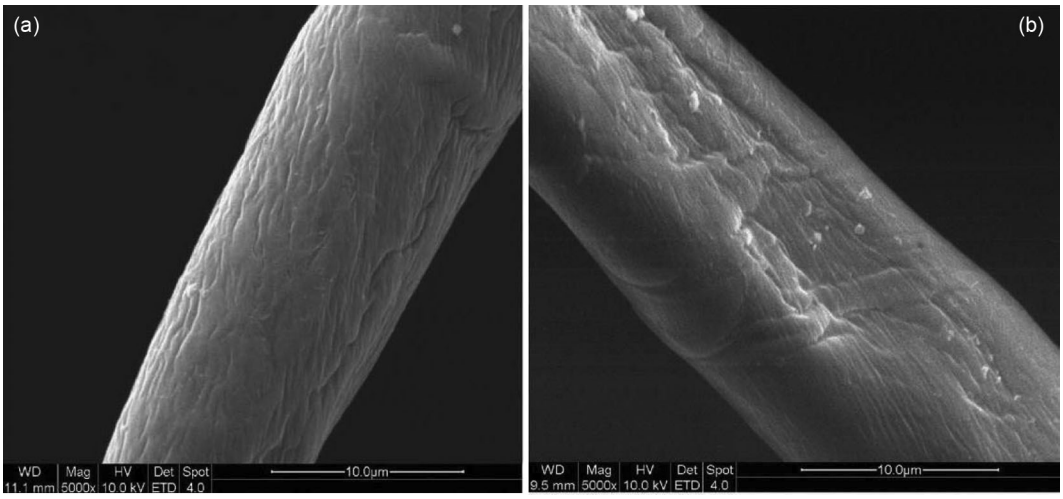

Fig. 2 — SEM images of enzyme pretreated fabrics (resolution × 5000) (a) single bath and (b) separate bath

fabric. Thus, there is absolutely no problem in the proposed process all the way up to dyeing, where absorbency and whiteness of the fabric matters to get the desired shade.

Scanning Electron Micrographs

The harmless effect of the enzymatic treatment is amply evident in the scanning electron micrographs (Fig. 2). There are no damages observed on the surface by either of the enzyme treatments, thus giving a smooth appearance. Also there is no visual difference between the separate and the combined desized scoured fabrics.

The attempted process is therefore a shorter process without compromising quality. All possible evaluations till colouration show that the combined desize-scour using enzymes is no way inferior to separate enzyme desize and bioscour. So, the environment friendly bioprocessing of textiles which is being vouched for is further improved in terms of economy and ecology by this proposed method.

References

1 Singh A, Varghese L M, Battan B, Patra A K, Mandhan R P & Mahajan R, *Environmental Science and Pollution Research* (Springer Berlin Heidelberg, Germany), December 2019.

2 Anis P & Eren H A, *AATCC Rev*, 2 (2002) 22.

3 Cavac-Paulo A & Gubitz G M, Catalysis and Processing, in *Textile Processing with Enzymes* (Woodhead Publishing Limited, Cambridge, England), 2003, 86.

4 Shafie A E, Fouda M M G & Hashem M, *Carbohydrate Polym*, 78 (2009) 302.

5 Patra A K, *Text Asia*, 34 (9) (2003) 46.

6 Patra A K, Mahish S S & Chakraborty J N, *Indian J Fibre Text Res*, 38(2) (2013)150.

7 *AATCC Technical Manual*, Vol.83 (American Association of Textile Chemists and Colorists), 2008.