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Effect of Enzymatic Bio-scouring on Cotton: Properties and Improvement of Dye-Ability by Reactive Dye

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This study especially focused on scouring of cotton knit fabric. Factors which affect enzymatic scouring such as pH, temperature, chelating agents, wetting agents, emulsifying agents, auxiliaries, *etc.* were evaluated to establish optimal conditions. In order to investigate the effect of enzymatic scouring on cotton properties, fabric weight loss, damage on fiber surface and dye-ability of enzymatic scoured knit fabric was compared with alkaline scoured fabric. Furthermore, the difference in dyeing behaviour between enzymatic scoured and alkaline scoured fabric was examined with dye-O-meter.

Key Words: Cotton, Scouring, Enzyme, Dye-ability, K/S value.

INTRODUCTION

Scouring of cotton is the process that removes natural impurities including waxes, pectins and proteins[1]. The removal of these impurities has carried out by boiling with sodium hydroxide. The traditional alkaline scouring process considered as a pollutive process because it consumes large quantity of water, energy and release alkaline effluent. In addition, the treated fabrics are damaged by chemical, thereby gives harsh hand[2]. Therefore, many researches on the replacement of alkaline to enzymes in cotton scouring have attempted in order to reduce fabric damage and environmental concerns[3-5]. Enzymatic scouring has been investigated over the past decade and accelerated last few years due to the development of alkaline pectinases. With the results of intense research, industrial application of enzymatic scouring has begun recently.

It is hoped that the research presented in this paper will contribute to understanding the effect of enzymatic scouring. The experiments were carried out in optimal conditions that were established from a previous work[6] and followings were investigated. First, enzymatically scoured cotton properties such as the weight loss, absorption property, rate of dye up-take, K/S value, degree of surface damage on the fibers and the softness of fabrics were compared with properties of conventional alkaline scoured fabrics. Second, in the view of environmental concern, water (wastewater) and energy consumption and required chemicals for both enzymatic and alkaline scouring were considered.

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EXPERIMENTAL

Scouring: Knitted fabric (60 cotton count, medium weight) and other auxiliaries such as scouring agent, wetting agent, chelating agent and lubricant obtained from W company in Korea were used for the experiments. Bioprep 3000L enzyme was supplied by NOVO-Korea, Seoul, Korea. The amount of enzyme and auxiliaries for the enzymatic and alkaline scouring was summarized in Table-1. The scouring process was carried as shown in Fig. 1. The treated fabrics were washed, dried and conditioned for 24 h prior to the measurement of the weight loss and absorption rate. For the fabric water absorbency test, gravimetric absorbency testing system (GATS) was used. The damage on the fiber was examined using a scanning electron microscope and the softness was measured on a Kawabata evaluation system for fabric (KES-F).

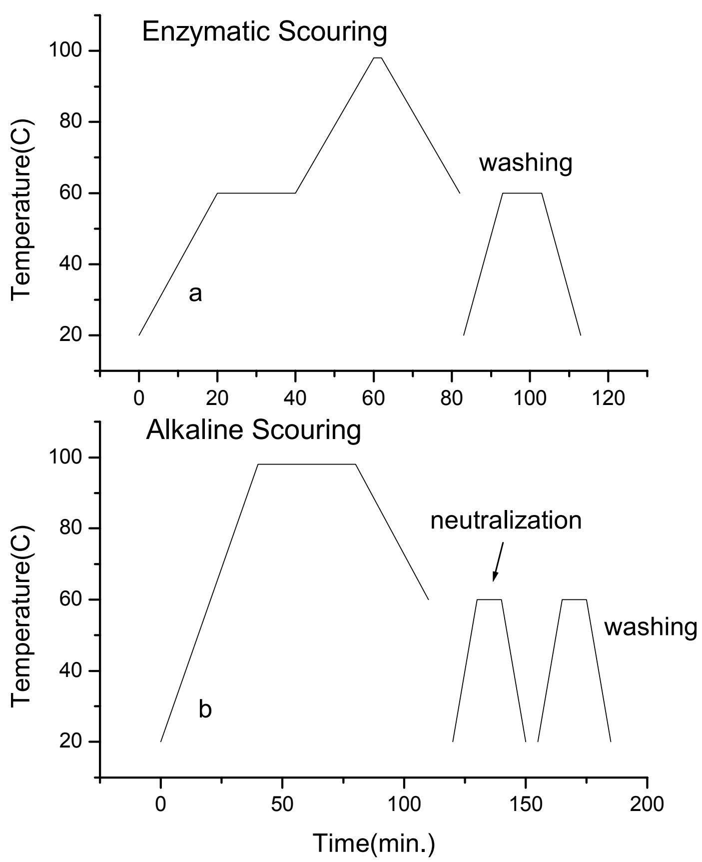


Fig. 1. Alkaline and enzymatic scouring process (a) Water (40:1), wetting a. 0.2 % owf, chelating a. 0.5 % owb, lubricant 0.2 % owf, enzyme 0.1 % owf (b) Water (40:1), scouring agent 0.5 owf, chelating a. 0.5 % owb, lubricant 0.5 % owf, Na_2CO_3 2.4 % owb

TABLE-1
ENZYME AND AUXILIARIES FOR SCOURING (g/10 g OF FABRIC)

Process	Material	Enzymatic scouring	Alkaline scouring
Scouring	Chelating agent	0.03	0.05
	Scouring agent	–	0.04
	Sodium carbonate	–	0.30
	Wetting agent	0.02	–
	Enzyme	0.02	–
	Lubricant	0.03	0.05
	Water	200	200
Washing	HCOOH	-	0.03
	Water	200	400

Dyeing: Dyeing of enzymatically scoured fabrics was performed with three different ways. First, scoured fabrics were washed and dyeing was performed in a new bath (two-step scouring-dyeing). Second, dyeing was performed without washing after the scouring liquor has drained (continuous scouring-dyeing). Third, dyeing was performed using the scouring liquor in the same bath (one-step scouring-dyeing).

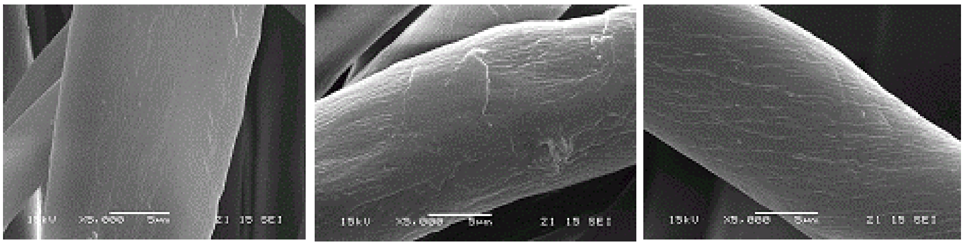
Alkaline and enzymatically treated fabrics were dyed at a 40:1 liquor ratio in IR dyeing machine. The dyes used were reactive yellow CRG, reactive red C2BL and reactive blue CR. Fabrics were introduced into separate dye baths containing 0.5 % owf dye and 40 g/L sodium sulfate at *ca.* 65 ºC. Sodium carbonate (20 g/L) was added into the baths after 15 min and the dyeing was continued for 45 min followed by thoroughly washing and drying. K/S values of dyed fabrics were measured on a Macbeth Coloreye 3100. In order to measure the rate of dye uptake, dyeing was carried in a dye-O-meter as dyeing protocol described above.

RESULTS AND DISCUSSION

Cotton properties: The weight loss of enzymatically treated fabrics was lower than that of alkaline scoured (Table-2). It was expected because while alkali attacks cellulose as well as impurities on the surface of fiber, enzyme used in the experiment only degrades pectin. Therefore, cellulose in the enzymatically treated fabric was not damaged by the treatment. This result can be confirmed by SEM pictures (Fig. 2). In the pictures, the alkaline scoured fiber showed a rough surface, but enzyme treated fiber showed a smooth surface.

TABLE-2
WEIGHT LOSS (%) OF TREATED FABRICS

Trial	Enzymatic scouring	Alkaline scouring
1	3.2	4.3
2	3.0	4.5
3	3.2	4.1
4	3.1	4.3
5	3.1	4.1
Average	3.1	4.3



Raw cotton Alkaline scoured Enzyme treated

Fig. 2. Surface of cotton fiber

Since alkaline scoured fibers are damaged and have a rough surface, the alkaline scoured fabrics were expected to give harsh hand. In order to measure the softness of fabric, KES-F was used. In this experiment, only MIU (coefficient of friction) and SMD (geometrical roughness) in the surface property were measured. In both values, small number indicates greater softness. The test results from KES-F showed that the enzymatic treated fabrics are softer than alkaline scoured fabrics. The test results of these two characteristic values for treated fabrics are summarized in Table-3.

TABLE-3
SOFTNESS OF TREATED FABRICS

Characteristic values	Treatment	Warp	Weft	Mean
MIU	Alkaline	0.206	0.244	0.225
	Enzyme	0.211	0.204	0.216
SMD	Alkaline	1.990	8.673	5.327
	Enzyme	1.826	6.202	4.016

The water absorbency of enzymatically treated fabric was almost the same as that of alkaline scoured for early stage of measurements (until 5 s). However, it was greater by increasing the testing time (Fig. 3). With this result, it is assumed that the total amount of water absorption is higher for the enzymatically scoured fabric compared to the alkaline scoured fabric even if the water drop test gives the same result.

As the results show (Fig. 4), K/S values of enzymatic scoured fabrics are higher than that of alkaline scoured fabrics for all three colours. Among the enzymatic scouring processes, one-step scouring-dyeing produced the highest K/S values in case of yellow and blue colour and two-step scouring scouring-dyeing produced the highest K/S values in red colour. Continuous scouring-dyeing produced the lowest K/S values in case of all three colours.

As observed in Fig. 5, there is not much difference on the rate of dye up-take in case of red and blue between alkaline scoured and enzymatic scoured fabrics. However, the rate of dye up-take of yellow on alkaline scoured fabric was much less than

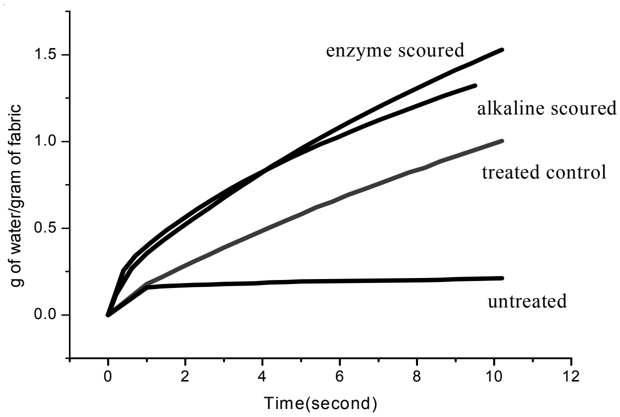
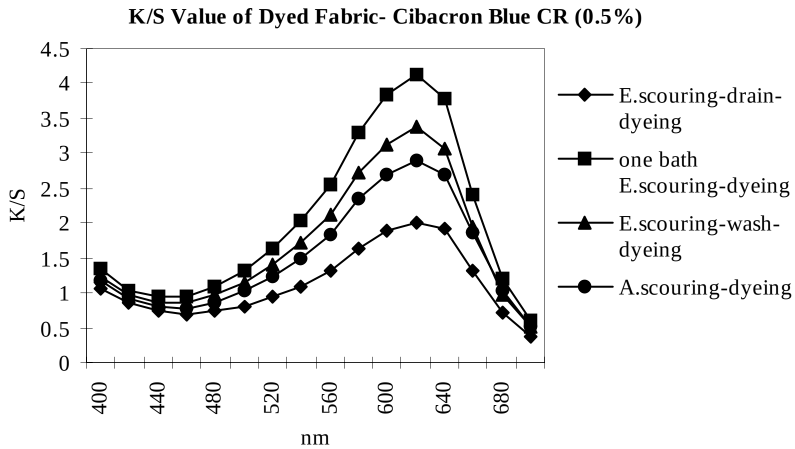
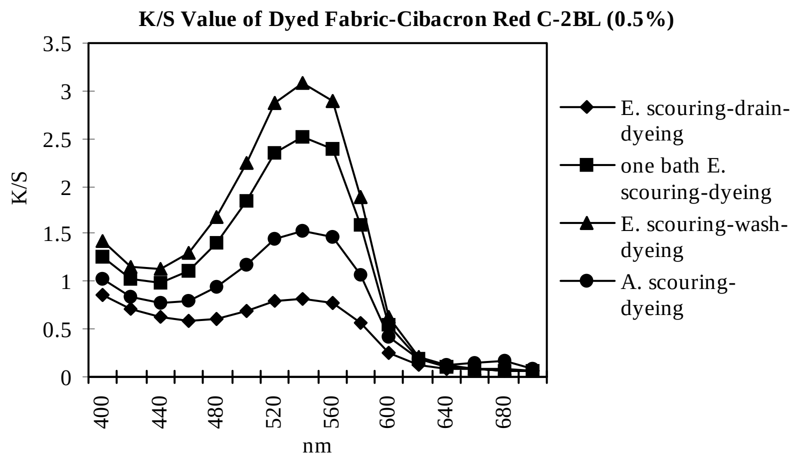


Fig. 3. Water absorbency of treated fabric





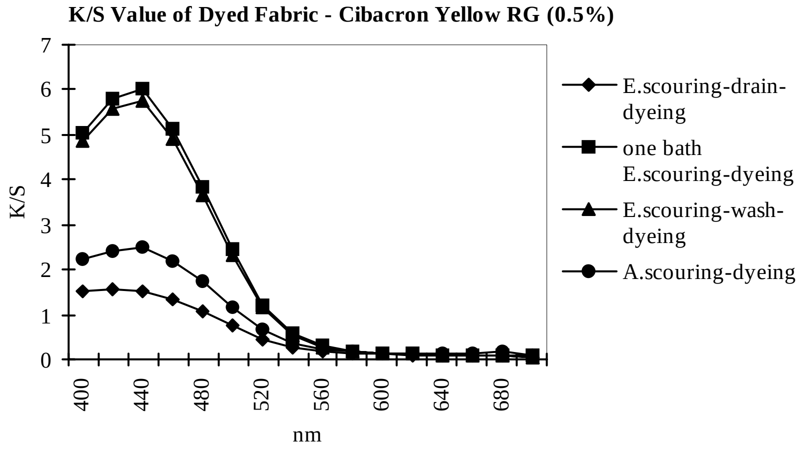


Fig. 4. K/S Values of dyed fabrics

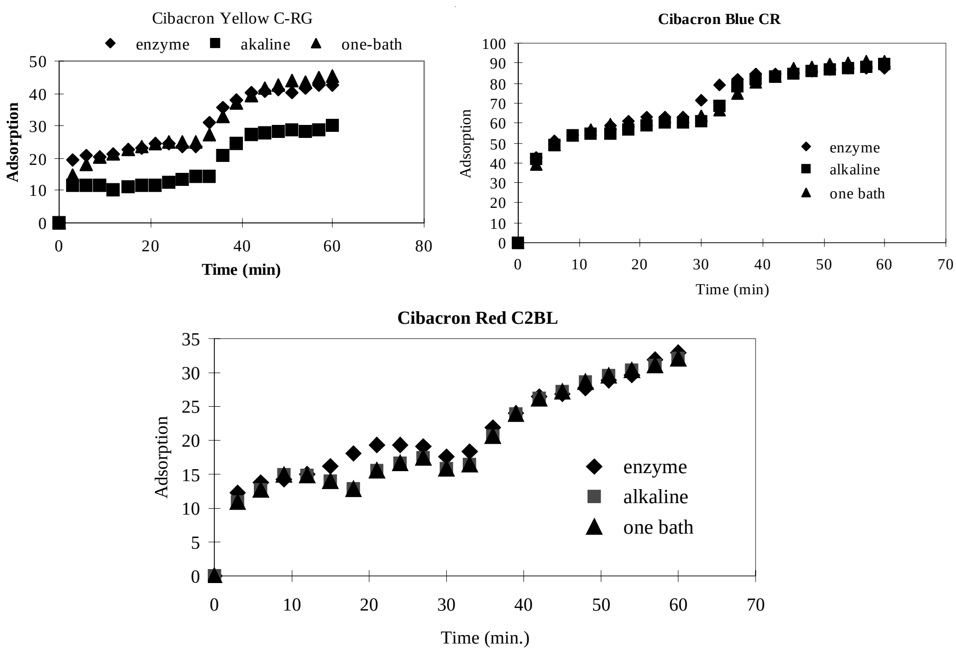


Fig. 5. Rate of dye up-take for the scoured fabrics

enzymatic scoured fabrics. This results imply that the high K/S values of enzyme scoured fabric was not due to high concentration of dyes on the fabric because the concentration of dye should be the same for both pretreated fabrics. One reasonable explanation could be that the enzymatically scoured fabric has darker shade than alkaline scoured fabric. In fact, enzymatic scouring did not remove the natural cotton colour as much as the alkaline scouring did. It could be the major advantage or the opposite of enzymatic scouring.

Environmental concerns: The amount of waste water as well as water consumption used for enzymatic scouring is much less than alkaline scouring process. While the alkaline scouring is carried in alkaline condition, neutralization with an acid and through washing should be applied. The reaction liquor of enzymatic scouring is neutral, neutralization of the liquor or further washing would not be needed. In addition, dyeing can be completed in the scoured liquor for dark shades.

The employed energy for the enzymatic scouring is also less than the alkaline scouring because lower temperature is required for the enzymatic scouring than the alkaline scouring. According to calculation based on the price of power in Korea, the energy cost for the enzymatic scouring is 55 to 90 % of alkaline scouring. The short treatment time of enzymatic scouring could contribute a big portion for the low energy consumption.

The chemicals such as sodium carbonate, acid and lubricant used for alkaline scouring are not needed for the enzymatic scouring. As mentioned earlier, alkali or acid is not required for the enzymatic scouring. A lubricant may not be necessarily needed since the several trials of enzymatic scouring without lubricant resulted softer hand of treated fabric than the alkaline scouring with lubricant.

Conclusion

The influence of enzymatic scouring on cotton properties was examined in this work. From the investigation, it is shown that the most characteristic properties of enzymatic scoured fabric were improved compared to the alkaline scoured fabric. With enzymatic scouring, weight loss of fabric and surface damage on the fibers were reduced. In addition, enzymatically scoured fabric showed high water absorbency and give better softness. Required amount of dye for dyeing fabric with the same shade of colour could be reduced because higher K/S values can be achieved with the same amount of dye on the fabric. For the environmental point of view, enzymatic scouring definitely dominates over alkaline scouring.

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