ENZYMATIC ASSISTED COLORING OF COTTON FABRICS

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The project aims a new treatment based on modification of cotton fibre for improving the dyeability of cellulosic fabric with the reactive dye and reducing effluent discharge. The project is focused to examine the performance of enzyme and its coloring ability using reactive dyes. The overall test results of color fastness values showed excellent ratings except a significant drop in light fastness and moderate increase in CIELAB and K/S values for enzymatic colored sample compared to the conventional colored sample. The effluent load of enzymatic colored sample is significantly reduced compared to the conventional colored sample. The project enhances the possibility of using enzyme as an alternative source for the salt in coloring the cotton fabrics.

Keywords: cellulose, color fastness, effluent, reactive dyes, oxidizing and reducing agents.

INTRODUCTION

Many studies have been devoted for improving the substantivity of cotton for reactive dyes, thus diminishing or eliminating the amount of electrolyte required and increasing the efficiency of the dye fiber reaction. However, none to the date has achieved significant commercial success, since all suffer from one or more disadvantages, such as significantly reduced light fastness, unsatisfactory dye fixation efficiency or poor wet fastness, marked change in hue, limited suitability of the treatment for different kinds of reactive dyes, unpleasant odors released during application and ring dyeing. [3, 4] .The objective of our study is to develop a new technique that minimizes the problems cited above.

In the last few years various patents were reported on coloration of protein fibre a using laccase [5] .However, dyeing of cellulose fabrics has not been reported so far, except for a patent application that claims in general the dyeing of the whole range of natural and synthetic fibers without specific examples for cellulose fibers [6]. The main difficulty consists in the lack of substantivity of the enzymatically generated dyes towards the cellulose substrate [7,8]. Hence this research offered to develop a cellulase mediated dyeing process for cotton fabric.

AIM OF THE PROJECT

- To achieve by the normal dyeing process using enzyme as an alternative source for the salt.
- To reduce the effluent discharge in the dyeing process.
- To protect it from environmental issues.

PROBLEM DEFINITION

- In the dyeing process salt is added as an exhausting agent which substantially increase the water hardness, pollution load and also the above water cannot be easily removed in the subsequent effluent treatment process.
- Since the utilization and water requirement is high in dyeing process it gives a serious issue regarding the environmental pollution.

SOLUTION FOR PROBLEM

- In our work, enzyme is used as an alternative for the salt in the dyeing process and thus reducing the issue of water hardness in the effluent treatment process.

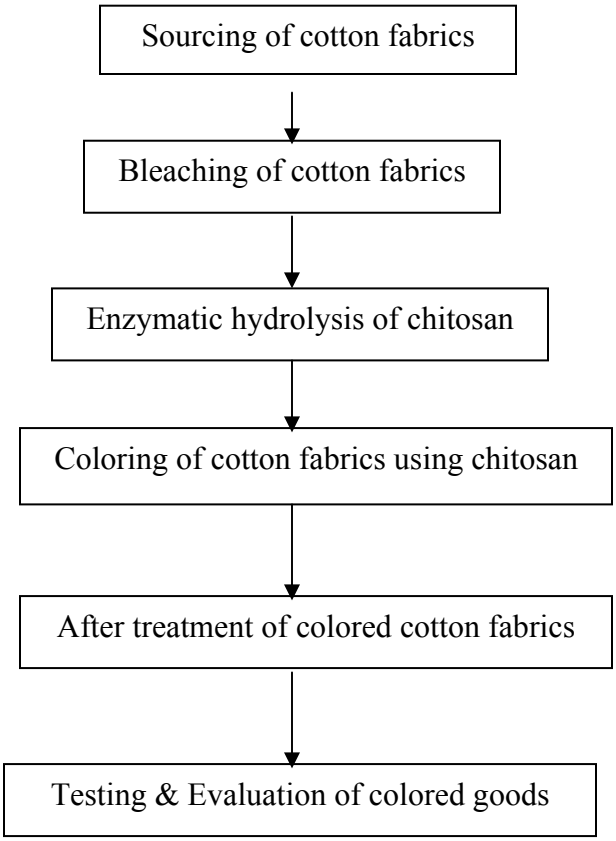
MATERIALS & METHODS

Scoured 100% cotton fabric sourced from the textile mills was used as the substrate throughout. The dyes, chemicals and enzymes used are listed in Table 1. All chemicals were used without further purification.

Table 1: Chemicals used in this work

Chemical Name	Function
Sodium carbonate	Fixing agent
Sodium hydroxide	Fixing agent
TRO	Non ionic wetting agent
H_2O_2	Bleaching agent
Sodium silicate	Stabilizer
Chitosan (chitosan E)	Biopolymer
Acetic acid	pH controlling agent
cellulase	Enzyme
Formic acid	Oxidizing agent
Oxalic acid	Reducing agent
Soap solution	After treatment
Reactive dyes	Dyeing

WORK METHODOLOGY



TESTING PROCEDURE

The resultant fabric was tested and analyzed the color fastness of the dyed fabrics was evaluated following establishing test procedures : ISO 105 C06 A2S:1994 – Color fastness to domestic and commercial washing (Grey scale 1-5); ISO 105 X12:2001 – color fastness to rubbing (Grey scale 1-5); ISO 105 E04:1994 – color fastness to perspiration (Grey scale 1-5); AATCC -16(Option 5): 2004 – color fastness to artificial light: Xenon arc fading lamp test (Blue scale 1-8); ISO 105 D01 : 1993 (Solvent perchloroethylene) – color fastness to dry cleaning

(Grey scale 1-5); ISO 975:88 – color fastness to sublimation (Grey scale 1-5)

The spectral values of the dyed samples were samples compared with the white samples (standard) and ΔE (CIE 2000) values determined using a Minolta 508 spectrophotometer with Macbeth match view software (X-Rite, USA) in D65 daylight. The color difference (ΔE) was calculated according to Eqn 1.

$$\Delta E = (\Delta L^2 + \Delta a^2 + \Delta b^2)^{1/2}$$

The effluent load was analyzed according to the standards of the examination of water for pollution control and the waste water characteristics were determined.

All the test results were compared with the conventionally colored samples and evaluated

RESULTS & DISCUSSIONS

TESTING

1. Fastness Properties

The cotton material was dyed using enzymatic dyeing method by many trials using the proposed procedures in different ways. The values are compared with similar normal dyeing method (adding salt and alkali) applied on the cotton fabric with that of the the same dyed using enzymatic dyeing technique and it was observed that the results were closer to those obtained using conventional method of normal dyeing.

Testing Methods	Normal dyeing	Enzymatic dyeing
Washing fastness	2	3
Rubbing fastness	3	3-4
Light fastness test	1-2	1.0
Perspiration fastness Acid	2	3
Alkali	2	3-4

Sublimation fastness	4-5	4-5
Dry cleaning fastness	2-3	3-4

From the above observation, conventional dyed sample and enzymatic dyed sample were compared and it was found that enzymatic dyed sample showed better ratings compared to that of the conventional dyed samples.

2. Effluent Load Analysis

Textile effluents are generally colored and have high hardness BOD, COD and total dissolved solids (TDS), Total suspended solids(TSS), total hardness(TH), and p^H, color hazard are tested for specific procedures with equipment.

- Effluent loads were analysed in both normal dyeing liquor and enzyme dyeing liquor for comparison.

	EFFLUENTS LOAD ANALYSIS		
EFFLUENTS	**Normal water**	**Normal dyeing**	**Enzymatic dyeing**
P^H	7.40	10.30	2.30
TDS(ppm)	123	41495	8229
TH(ppm)	40	5000	3000
TSS(ppm)	8	886	92
COD(ppm)	16	7200	6800
BOD(ppm)	73	6	186
Color (hazan units)	1	26250	23000

From the above test results, our new proposed dyeing method (enzymatic dyeing) had highly reduced the effluent load compared to conventional dyeing process.

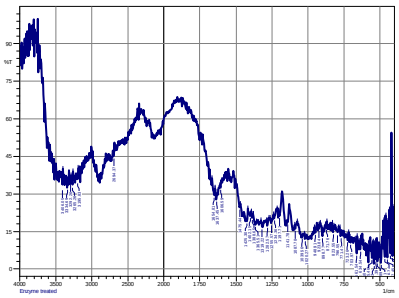
3. Color Difference Evaluation Result (ΔE)

Material	Method	Normal dyeing	Enzymatic dyeing
Cotton	(ΔE)	0.8	0.4

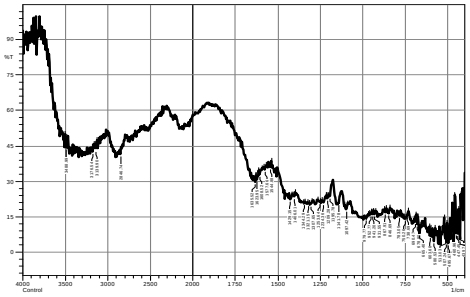
4. Color Strength value result (K/S)

Material	Method	Enzymatic dyeing
Cotton	(K/S)	1.694

FTIR TEST



ENZYMATIC DYEING



NORMAL DYEING

5. Computer color matching analysis

- Color difference between the standard sample and dyed sample under D65 illumination, 10 degree observer is given below

Material	Method	Normal dyeing	Enzymatic dyeing
Cotton	**(ΔE)**	**0.8**	**0.4**

CONCLUSION

The study of this new treatment based on modification of cotton fibre for improving the dyeability of cellulosic fabric with the reactive dye and reducing effluent discharge is found to be more effective than the conventional coloring of cotton fabrics. Compared to the conventional coloring method for cellulose, the enzymatic coloring has significant advantages such as catalytic amount of biodegradable oxidants (enzymes) and dye precursors, coupled to considerable savings in energy coming from the moderate treatment temperature. This project concludes that modified substrates can be colored more efficiently showing a considerable improvement in dyeability, color fastness, CIELAB & K/S values and considerable reduction in the effluent load compared to conventional coloring process.

FUTURE SCOPE

The project is aimed to achieve conventional dyeing process using enzyme as an alternative source for the salt. The results are compared with that of the conventional dyeing process and sounds better, as well as effluent load is also gradually reduced. This method paves a platform for the wet processing sector and can be implemented in the industry to bring out a new revolution in the wet processing mills.

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ENZYMATIC COLORED SAMPLE