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One-Bath One-Step Dyeing of a Polyester/Cotton Blend using the Pad-Dry-Fixation Process

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Abstract
The aim of this research work was to evaluate the one bath dyeing of polyester/cotton blend and to compare the results with those of two bath dyeing. Polyester/cotton (50:50) blend fabrics were studied using dichlorotriazine based reactive dye and compatible disperse dye. The one bath one step method was used to shorten the dyeing process, increase yield and reduce the utility and chemical cost. Trichloroacetic acid (TCAA) was used to provide an acidic and basic medium with a change in temperature. A TCAA/sodium carbonate buffer was also used to obtain the best colour yield. In two bath dyeing disperse dye was fixed on polyester fibre in an acidic medium, whereas reactive dye was fixed on cellulosic fibre in an alkaline medium. In the final stage, the dyed fabric was evaluated by testing the light, washing and rubbing fastness and colour yield strength properties of the dye. The results clearly show that polyester/cotton fabric presents good fastness and colour strength values when the one bath one step dyeing method is used.

Key words: *polyester/cotton, reactive dye, trichloroacetic acid, dyeing.*

Introduction

The acceptance of polyester/cotton blended fabrics is increasing day by day because of their ease of use. The selection of such fibres offers sufficient comfort level due to the different properties of fibres. However the presence of both polyester/cotton components in textile causes difficulties in the dyeing process [1].

Polyester/cotton blends are dyed mainly by either the one-bath two-step or two-bath dyeing methods using suitable dyes and chemicals. The two-bath dyeing methods are relatively long and complicated. The one-bath two-step dyeing procedure is shorter as compared to the two-bath method, but the drawbacks are lower dyeability and poor reproducibility [2 - 4]. Polyester and cotton are dyed under entirely different conditions. Cotton is dyed by employing alkaline conditions at 80 °C and using reactive dyes whereas polyester is dyed using disperse dyes in an acidic medium at 120 °C. This two-bath process, although offering high levels of shade reproducibility, is time consuming, often taking 12 - 14 hours [5].

Different researches are being performed for polyester/cotton blends to dye with the one bath dyeing method using different dyes at acidic or neutral conditions and under different conditions of temperature [6 - 9]. Youssef et al. developed a dyeing method for a polyester/cotton blend using sodium edetate as an alkaline buffering agent. They used some selective mono and bi-functional reactive dyes in combination with alkali stable disperse dyes for the dyeing of the polyester/cotton blend [10]. Meena et al. worked on finding the possibility of making a physical mixture of disperse/reactive dyes and successfully dyed with a physical mixture of dyes by the one-bath one-step dyeing process [11].

The one step dyeing of polyester/cotton blends with disperse/reactive dyes has an advantage over the traditional dyeing process by reducing the dyeing cycle time and utility cost [12]. Due to these advantages an attempt to develop such a process is going on. However, little development has been made on an industrial scale due to the fact that reactive dyeing requires alkaline conditions for dye fixation, whereas disperse dyes need an acidic pH for dyeing [13].

The focus of this study was mainly on the colour strength and the colour fastness properties using the one-bath one-step dyeing process for polyester/cotton blended fabrics and comparing the results with the traditional one-bath two-step process. The one step process is far more efficient in terms of productivity and energy conservation. The present work involves the use of a pH buffer system that would initially provide the acidic pH required for good application of disperse dye on polyester and then, with increasing temperature, produce the alkaline pH required for the fixation of reactive dye on the cotton in the blend. The shade pa-

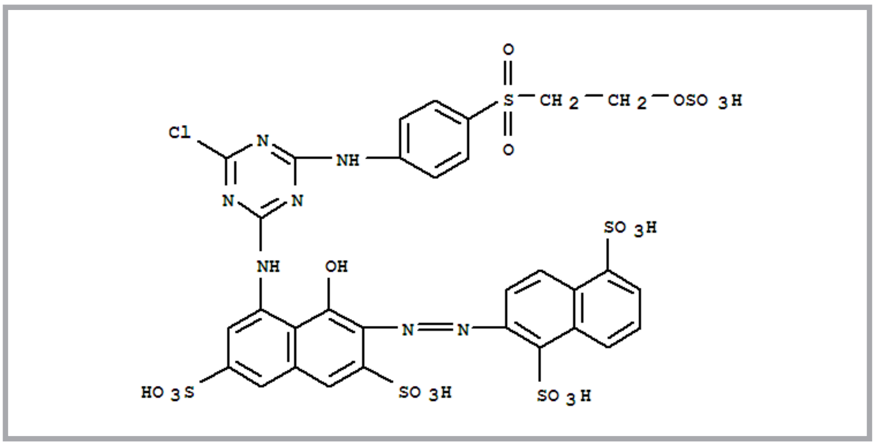

Figure 1. *Dichlorotriazine reactive dye used in the study.*

rameters will be investigated in future studies.

Materials

Fabric

In this study, the fabric used was 2.44 m wide (100 g/m^2) with a polyester/cotton blend ratio of 50 : 50, respectively. This fabric was not subjected to bleaching, mercerising or any of the finishing processes. The ends/cm were 31.5 and the picks/cm - 22. The fabric structure was plain and the warp and weft count - 30/31.

Dyestuffs

Dichlorotriazine based reactive dye (red) was used in this study as shown in ***Figure 1***. The dyestuff was manufactured by Clariant. The commercial name of the reactive dye is Dermarine Red CL-5BN reactive dye (***Figure 1***). Foron Red F-3BS disperse dyes were also used in this study. This disperse dye was of a compatible nature with reactive dye. The disperse dye was used to dye the polyester part of the fabric, whereas the reactive dye was used to dye the cellulosic part of the blend.

Auxiliaries

The following chemicals and auxiliaries were used for dyeing of the polyester/cotton blend with reactive dyes and for the washing-off process:

- Solidokoll 35-P was used as an anti-migrating agent, supplied by Clariant Pakistan
- Eganol Rap was used as a dispersing agent, supplied by Clariant Pakistan
- Acetic acid was used to maintain pH
- Sodium carbonate was used to provide an alkaline medium
- Trichloroacetic acid (TCAA) ($C_2HCl_3O_2$) was used to change the medium from acidic to basic by increasing the temperature.
- Sodium hydrogensulfite was used for reductive clearance
- Hydrogen peroxide was used for oxidative clearance
- Urea was used as a hygroscopic agent with dissolving action in the reactive dye solution
- Sodium chloride
- Sodium bicarbonate

Procedure

The polyester/cotton blend was subjected to dyeing using both the conventional way of dyeing and the dyeing method used in this research. During the conventional process, given as C_1, C_2 and C_3 in ***Scheme 1*** presented below. The dye pad and chemical pad recipes used are given in ***Tables 1*** and ***2***. A pH of 4 - 5 is considered optimum for the application of disperse dye on polyester. Hence when TCAA was used alone, a pH of 4 - 5 could be attained only with a small dosage of TCAA. However, in the presence of sodium carbonate, a much higher concentration of TCAA had to be used to get the initial pH in the range of 4 - 5, which could later on shift towards neutral and alkaline with a rise in the dyeing temperature to facilitate the fixation of the reactive dye on the cotton present in the fabric blend.

In the dye pad recipe, disperse dye Foron red S3BS-343, reactive dye Dermarine red CL5BN-194, anti-migrating agent Solidokol 35-P, dispersing agent Eganol rap, Urea as a hygroscopic agent and Sodium bicarbonate was used to provide an alkaline medium.

In the chemical pad recipe, sodium carbonate and sodium chloride are used to provide an alkaline medium necessary for the fixation of reactive dye.

Dye Pad - Dry 120 °C -
- *Thermosol* 210 °C -
- *Chemical Pad - Steam*
} C_1

Dye Pad - Dry 120 °C -
- *Chemical Pad - Dry* 120 °C -
- *Thermosol* 210 °C
} C_2

Dye Pad - Dry 120 °C -
- *Thermosol* 210 °C -
- *Reductive Clearance* -
- *Dry* 120 °C -
- *Dye Pad - Dry* 120 °C -
- *Chemical Pad - Steam*
} C_3

After the conventional process, the polyester/cotton blend was subjected to dyeing with dye solution using the two kinds of shade recipes following the one bath one step dyeing method presented in ***Scheme 2*** below.

Dye Pad - Dry 120 °C -
- *Thermosol* 210 °C -
- *Reductive / Oxidative Clearance* -
- *Cold washing*

In the first kind of recipe, the amounts of TCAA and sodium carbonate were varied, given in ***Table 3***, whereas in the second recipe variable amounts of TCAA were used with no addition of alkali, as presented in ***Table 4***.

In the dye pad, solutions of disperse and reactive dye, antimigrant, dispersant, urea and TCAA were added. The fabric was padded and dried at 120 °C, and then the dye was cured onto the it in thermosole at 210 °C for one minute.

Table 1. *Dye pad recipe for conventional method.*

Constituents	Amount, g/l
Drimarine Red CL-5B	10
Foron Red F-3BS	10
Solidokol 35-P	10
Eganol rap	10
Urea	100
Sodium bicarbonate	10

Table 2. *Chemical pad recipe for conventional method.*

Constituents	Amount, g/l
Sodium carbonate	6
Sodium chloride	20

Table 3. Shade recipe for fabric dyeing with variable amounts of TCAA and sodium carbonate.

Constituents	Amount, g/l
Dermarine red CL5BN-194	10
Foron red S3BS-343	10
Solidokol 35-P	10
Eganol rap	10
Urea	100
Trichloroacetic acid, variable	5 - 10
Sodium carbonate, variable	1, 1.5, 2

Table 4. Shade recipe for fabric dyeing with variable amounts of TCAA.

Constituents	Amount, g/l
Dermarine red CL5BN-194	10
Foron red S3BS-343	10
Solidokol 35-P	10
Eganol rap	10
Urea	100
Trichloroacetic acid, variable	0.45 - 0.8

The samples were washed with cold water and dipped in hot water at 45 °C for 5 minutes with continuous stirring. One half of each dyed sample was subjected to reductive clearance and the other half to oxidative clearance according to the recipes given in ***Tables 5*** and ***6***. The purpose of mild reducing and oxidising treatments is to remove any unfixed dye from the fabric after the dyeing process. In all industrial dyeing of polyester or polyester/cotton blends, the fabric is usually subjected to a reductive treatment to remove the unfixed disperse dye. In this study, the effectiveness of the reductive post-treatment is compared with a more eco-friendly oxidative treatment for the removal of unfixed dye and resulting colour fastness of the dyed fabric. One of the major causes of the poor colour fastness of dyed fabrics is the ineffective removal of unfixed dye from the dyed fabric after the dyeing process.

During reductive clearance, samples were heated in a boiling solution of sodium hydrogen sulphite, NaOH 36 °Be and washing powder for 15 minutes separately. Then each sample was washed with cold water.

For oxidative clearance, each sample was placed in a boiling solution of hydrogen peroxide 35% and NaOH solution for 15 minutes. Then the samples were washed with cold water.

Measurements

Colour strength

Colour strength values (presented as CV-Sum) of all the dyed samples were evaluated using a spectrophotometer - Macbeth Colour Eye 7000A. The colour value (CV) is a single numerical value related to the amount of light-absorbing materials (i.e. the dye) contained in the fabric sample, and is based on the spectral data. The Colour Value SUM (CV-SUM) is calculated as the sum of K/S values for the sample read across the spectrum for reflectance measurements [14]. The formula used by the spectrophotometer

Table 5. Reductive clearance recipe.

Constituents	Amount
Sodium hydrogensulphite	1 g/l
NaOH 36 °Be	4 ml/l
Washing powder	2 g/l

Table 6. Oxidative clearance recipe.

Constituents	Amount
Hydrogen peroxide 35%	2 ml/l
NaOH solution	To maintain pH 10-11

software for calculating CV-SUM is given in ***Equation 1***:

$$CV_{sum} = \sum [K/S]\lambda \, d\lambda \qquad (1)$$

where, λ is the wavelength within and across the spectrum, and $K/S = \frac{(1 - R)^2}{2R}$, and R is the reflectance at the wavelength of maximum absorption in a decimal form (e.g. 30% R = 0.30 R).

Fastness tests

The samples were subjected to wet and dry crocking tests according to ISO-105X12. Specimens of the size of 5 × 13 cm were used. For dry crocking, each specimen was conditioned for 4 hours at 21 ± 1 °C and a relative humidity of 65 ± 2% by laying each specimen separately on a screen before testing. Wet crocking was performed with a wet white cloth with standard moisture content. Finally the samples were air dried and then conditioned before evaluation.

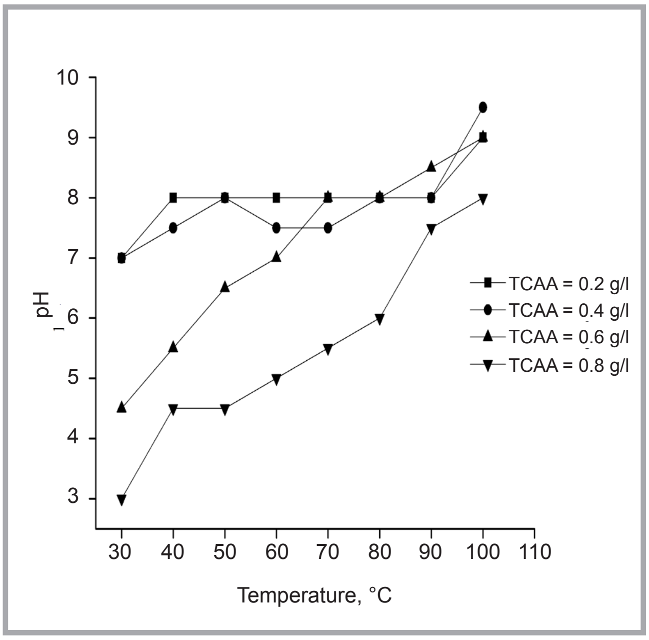

***Figure 2.** pH variation in TCAA solution vs temperature.*

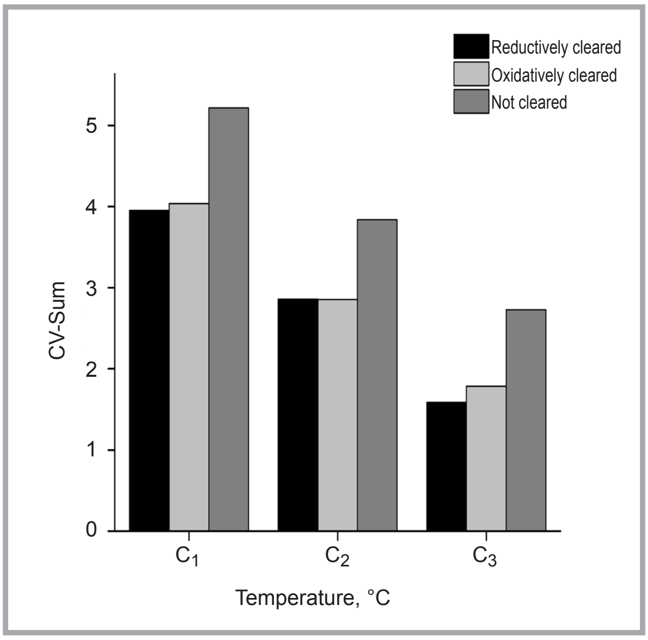

***Figure 3.** Effect of process route on colour values.*

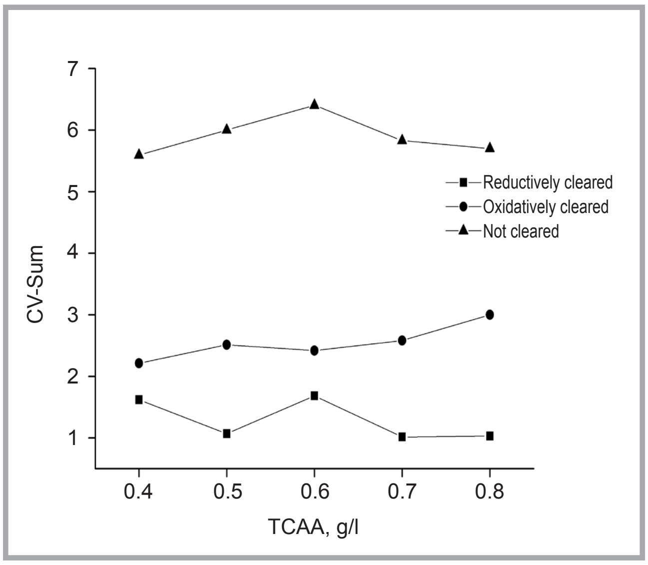

Figure 4. *Effect of TCAA concentration on colour values.*

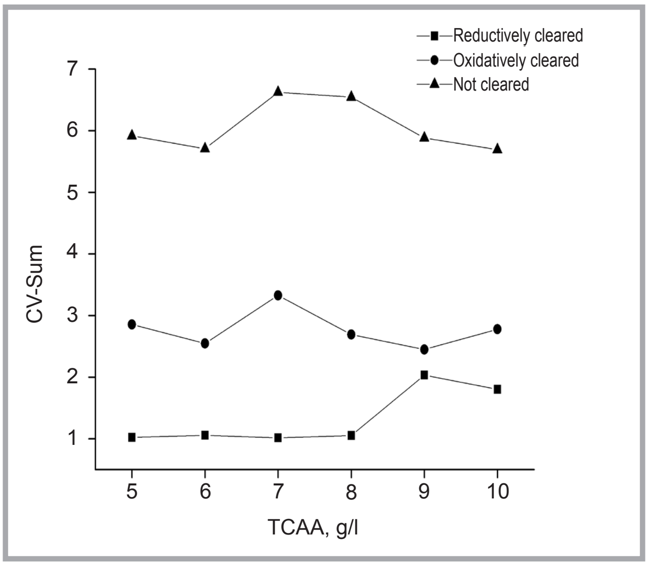

Figure 5. *Effect of TCAA and Na_2CO_3 on colour values when Na_2CO_3=1 g/l.*

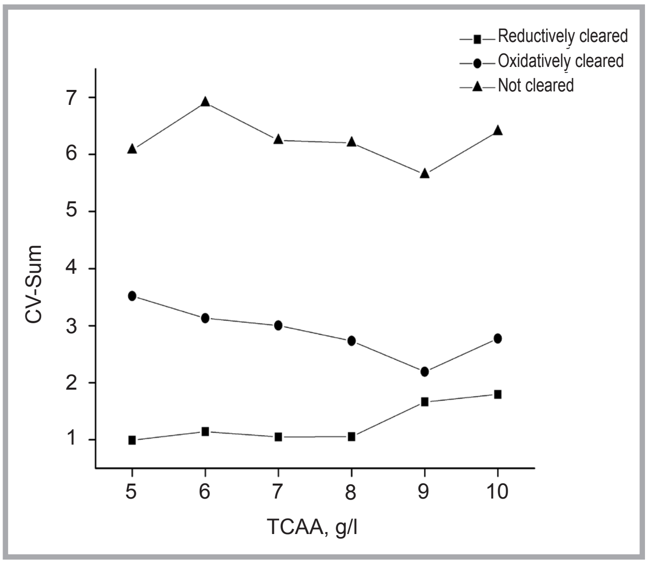

Figure 6. *Effect of TCAA and Na_2CO_3 on colour values when Na_2CO_3=1.5 g/l*

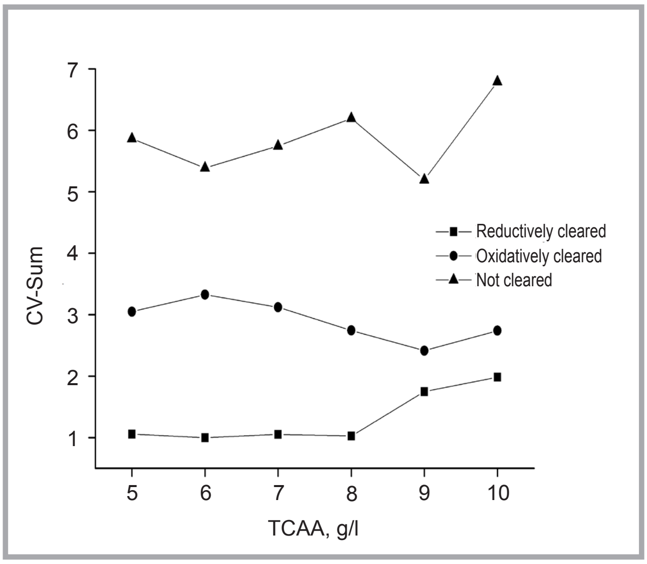

Figure 7. *Effect of TCAA and Na_2CO_3 on colour values when Na_2CO_3=2 g/l.*

The colour fastness to light of the samples was evaluated according to the ISO 105-BO2 method using a Fade-o-meter. The light source was an Xenon Arc lamp. The colour change of the sample was assessed by comparing with the AATCC blue scale.

The washing fastness of the sample was analysed according to the ISO 105 C10 method using a Launder-o-meter, and the samples were compared with the AATCC Grey Scale.

Skeleton test

All reductively cleared samples were subjected to a skeleton test according to the standard, in which one of the fibres in the blended fabric was dissolved in a solvent in order to analyse which part of the sample dye was fixed onto more. Two solvents were used for the Skeleton test. Sulphuric acid was used to dissolve the cotton component in the polyester/cotton blend, whereas m-cresol was utilised to dissolve the polyester component.

Results and discussion

Effect of temperature on the pH variation in TCAA solution

In order to dye the cotton fibre with high reactive dyes, the medium should be acidic to prevent the hydrolysis of the dye; at the same time; there is a need for the alkaline medium during the fixation process. TCAA is found to be effective to achieve this change in pH. The properties of this acid during its dissociation under the effect of temperature are given in ***Figure 2*** (see page 115), from which it can be seen that at low temperature the medium has an acidic pH. While with increased temperature during the fixation process TCAA dissociates and the acidic medium will be converted into alkaline.

Effect of the process route on the colour values of samples dyed by the conventional method

Figure 3 shows the colour values of samples dyed by adopting the conventional process routes given in ***Scheme 1*** as C_1, C_2 and C_3. Here 6 g/l of Na_2CO_3 was used without adding TCAA in the dye recipe.

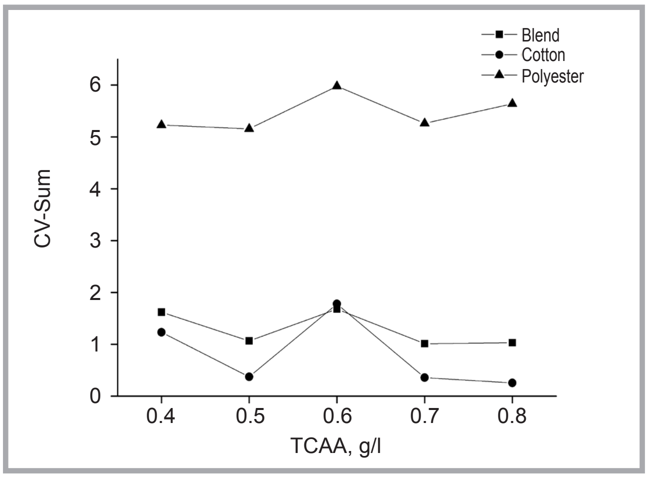

Figure 8. *Effect of TCAA on colour values of cotton/polyester and blend.*

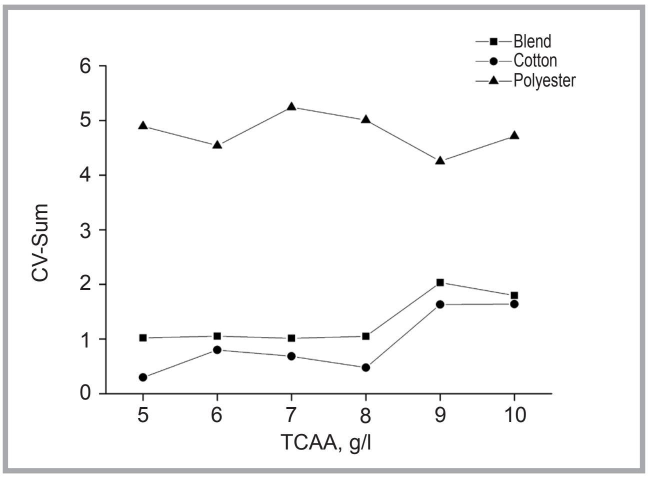

Figure 9. *Effect of TCAA and Na_2CO_3 on colour values of cotton/polyester/blend when Na_2CO_3 = 1 g/l.*

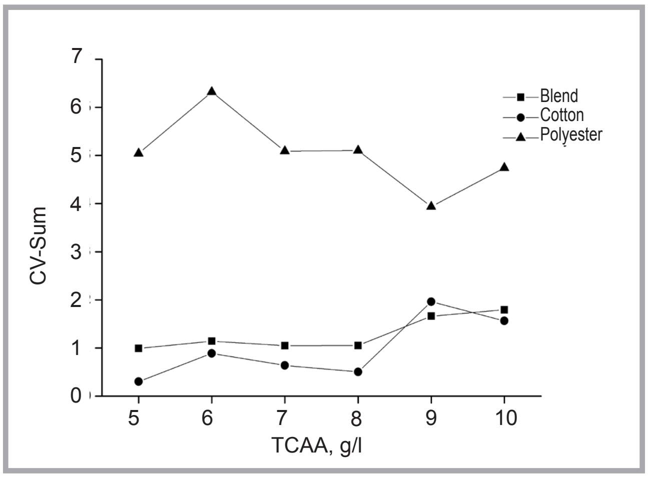

Figure 10. *Effect of TCAA and Na_2CO_3 on colour values of cotton/polyester/blend when Na_2CO_3 = 1.5 g/l.*

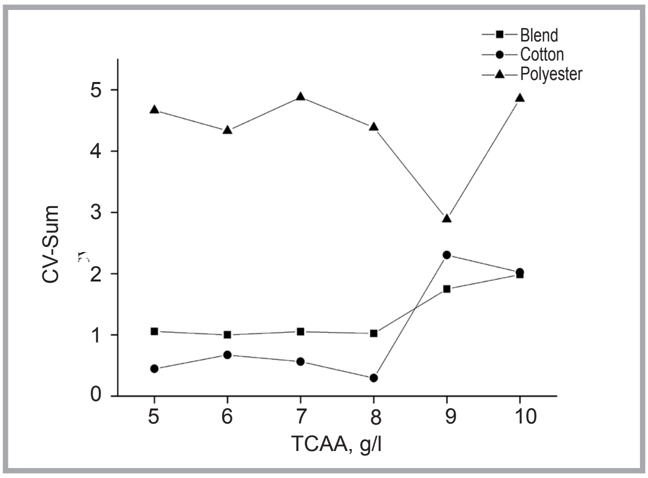

Figure 11. *Effect of TCAA and Na_2CO_3 on colour values of cotton/polyester/blend when Na_2CO_3 = 2 g/l.*

The colour values among the three conventional process routes are best for C_1 for reductively, oxidatively and not cleared samples, given as 3.951, 4.036 and 5.218, respectively. This is because of the fact that disperse dye gets fixed onto the fabric after the thermosole and reactive dye and chemical pad, whereas in the second process route disperse dye is not fixed properly before chemical padding. In C_3, after the application of disperse dye, the fabric was subjected to reductive clearance before the application of reactive dye, which removes a lot of unfixed dye from the fabric, resulting in a lower colour value. With oxidative clearance, a less amount of dye was cleared from the surface of the fabric and adhered strongly, which the treatment also has an impact on colour values;but best results were obtained for samples which are not cleared.

Effect of TCAA concentration on colour values

The effect of TCAA on the colour values of reductively cleared samples was investigated using the one-bath one-step dyeing method, shown in ***Figure 4***. This is the shortest possible cost-effective route. The best colour value of 1.683 was obtained when the concentration of TCAA was 0.6 g/l. TCAA has a dual nature: it shows acidic pH at low temperature, but as the temperature increases up to 100 °C, it displays the basic pH and decomposes to give free radicals, given in ***Equation 2*** [15].

$$CCl3COO\text{-}H+ \quad .CCl3+ CO2 + H+ + e \qquad (2)$$

$$HOH + .CCl3 \quad CHCl3 + OH\text{-}$$

At room temperature the solution was acidic with a pH of 2.55 and tended towards a basic pH at a high temperature of the dyeing bath, as a result of which the pH became 9 at 100 °C. Hence there is no need to use the alkali pad for fixation of the reactive dye. This change in pH with temperature is favourable for the fixation of dye onto the fabric. For 0.7 and 0.8 g/l of TCAA, the pH of solution is 1.52 and 1.2 and colour values are 1.012 and 1.03, respectively. This acidic pH is not suitable for the fixation of reactive dye and the increase in pH is only up to 8 at 100 °C for both these concentrations of TCAA. For oxidatively cleared samples, the best colour value of 2.998 was obtained using 0.8 g/l of TCAA. This result shows that with higher concentrations of TCAA, a strong shade is obtained when the sample is cleared oxidatively. For 0.6 and 0.7 g/l of TCAA, colour values are 2.416 and 2.579. For samples not cleared, all the samples have good colour values, but the best value of 6.40 was obtained for samples dyed using 0.6 g/l of TCAA. These results show that after-treatments have strong effects on the colour values

***Table 7.** Effect of process route on fastness properties of samples dyed by adopting conventional process route[a]; [a] WF, washing fastness; RC, reductively cleared; OC, oxidatively cleared; W*, washing fastness shade change; W**, washing fastness stain on cotton; RF, rubbing fastness; W, wet; D, dry; LF, light fastness*

Samples	WF						RF						LF		
	RC		OC		None		RC		OC		None		RC	OC	None
	W*	W**	W*	W**	W*	W**	W	D	W	D	W	D			
C_1	4	4 - 5	4 - 5	4	4	3	3 - 4	4 - 5	3 - 4	4 - 5	2	3 - 4	4	3 - 4	2
C_2	3 - 4	4 - 5	4	4	3 - 4	4 - 5	3	4 - 5	3	3	2 - 3	4 - 5	4	3	2 - 3
C_3	4	4 - 5	3 - 4	4	3 - 4	3 - 4	4	4 - 5	4	4 - 5	4	4 - 5	4	4	3

***Table 8.** Fastness properties of samples treated with different concentrations of TCAA[a]; [a] WF, washing fastness; RC, reductively cleared; OC, oxidatively cleared; W*, washing fastness shade change; W**, washing fastness stain on cotton; RF, rubbing fastness; W, wet; D, dry; LF, light fastness.*

TCAA, g/l	WF						RF						LF		
	RC		OC		None		RC		OC		None		RC	OC	None
	W*	W**	W*	W**	W*	W**	W	D	W	D	W	D			
0.4	3 - 4	5	3 - 4	3 - 4	1 - 2	3	4	5	3	4 - 5	2	3 - 4	4 - 5	4 - 5	4 - 5
0.5	4	5	3 - 4	2	1 - 2	2	4 - 5	5	3 - 4	4 - 5	2 - 3	4	4 - 5	4 - 5	4 - 5
0.6	3 - 4	5	3 - 4	3 - 4	2	2 - 3	4	4 - 5	3 - 4	4 - 5	2	3 - 4	4 - 5	4 - 5	4 - 5
0.7	3 - 4	3	3 - 4	3	2	2 - 3	3	3 - 4	3 - 4	4	2 - 3	4	4 - 5	4 - 5	4 - 5
0.8	3 - 4	5	3 - 4	3 - 4	1 - 2	2 - 3	4 - 5	5	3	4	2 - 3	3 - 4	4 - 5	4 - 5	4 - 5

***Table 9.** Fastness properties of samples dyed by using different buffer solutions[a]; [a] WF, washing fastness; RC, reductively cleared; OC, oxidatively cleared; W*, washing fastness shade change; W**, washing fastness stain on cotton; RF, rubbing fastness; W, wet; D, dry; LF, light fastness.*

TCAA, g/l	Na_2CO_3, g/l	WF						RF						LF		
		RC		OC		None		RC		OC		None		RC	OC	None
		W*	W**	W*	W**	W*	W**	W	D	W	D	W	D			
5	1	4	4	3 - 4	3 - 4	2 - 3	3	4 - 5	5	2 - 3	4	2 - 3	3 - 4	4 - 5	4 - 5	4 - 5
5	1.5	4	3	3 - 4	3 - 4	2 - 3	2 - 3	4 - 5	5	2 - 3	4	2 - 3	3 - 4	4 - 5	4 - 5	4 - 5
5	2	3 - 4	4	4	2 - 3	2 - 3	2 - 3	4 - 5	5	3 - 4	4 - 5	2 - 3	3 - 4	4 - 5	4 - 5	4 - 5
6	1	3 - 4	4	3 - 4	3	2 - 3	2 - 3	4 - 5	5	3	4	2 - 3	4	4 - 5	4 - 5	4 - 5
6	1.5	3	4 - 5	4	2 - 3	2	2 - 3	4 - 5	5	3	4 - 5	2 - 3	4	4 - 5	4 - 5	4 - 5
6	2	3 - 4	5	3 - 4	3	2 - 3	2	4 - 5	5	2 - 3	4 - 5	2 - 3	3 - 4	4 - 5	4 - 5	4 - 5
7	1	3	5	3 - 4	3	2	2	4 - 5	5	3 - 4	4 - 5	2	4	4 - 5	4 - 5	4 - 5
7	1.5	4	5	4	4	2	1 - 2	4 - 5	5	2 - 3	3 - 4	2 - 3	3 - 4	4 - 5	4 - 5	4 - 5
7	2	4	4	3 - 4	3 - 4	2	2	4 - 5	5	2 - 3	4	3	4 - 5	4 - 5	4 - 5	4 - 5
8	1	4	5	3 - 4	3 - 4	1 - 2	3	5	5	2 - 3	3 - 4	2	3 - 4	4 - 5	4 - 5	4 - 5
8	1.5	3	5	3 - 4	3 - 4	1 - 2	1 - 2	5	5	3 - 4	4 - 5	2 - 3	4	4 - 5	4 - 5	4 - 5
8	2	3 - 4	5	3	3	1 - 2	2 - 3	5	5	3 - 4	4 - 5	2 - 3	4	4 - 5	4 - 5	4 - 5
9	1	3 - 4	4 - 5	3	3 - 4	1 - 2	2 - 3	3 - 4	4 - 5	2 - 3	3 - 4	2 - 3	3 - 4	4 - 5	4 - 5	4 - 5
9	1.5	4	5	3 - 4	2 - 3	1 - 2	3	4 - 5	5	2 - 3	4 - 5	2	3	4 - 5	4 - 5	4 - 5
9	2	4	3 - 4	4	4	1 - 2	2	4 - 5	5	3	4 - 5	2 - 3	3 - 4	4 - 5	4 - 5	4 - 5
10	1	3 - 4	4 - 5	3 - 4	3 - 4	1 - 2	1 - 2	4	4 - 5	2 - 3	3 - 4	2	4	4 - 5	4 - 5	4 - 5
10	1.5	3 - 4	4 - 5	4	3 - 4	1 - 2	2	3 - 4	4 - 5	3 - 4	4 - 5	2	3	4 - 5	4 - 5	4 - 5
10	2	3 - 4	4 - 5	3 - 4	3 - 4	1 - 2	2 - 3	4	4 - 5	4	5	2	3	4 - 5	4 - 5	4 - 5

of samples dyed by following the same process routes.

Effect of TCAA and Na_2CO_3 concentrations on colour values

Figures 5, 6** & **7 show the colour values of samples dyed by one-bath one-step dyeing of a polyester/cotton blend by the dry pad fixation process using different combinations of TCAA and Na_2CO_3.

For reductively cleared samples, the best colour values were obtained for the combination of 8 - 10 g/l of TCAA and 1, 1.5, 2 g/l of Na_2CO_3. In these combinations, the pH of the buffer solution is less acidic, which is favourable for the fixation of reactive dye. For oxidatively cleared samples, all the samples have the best colour values comparable with the standards, but excellent results were obtained with combination of buffer 5 - 7 g/l TCAA and 1 - 2 g/l Na_2CO_3. For oxidatively cleared samples, the best results were obtained because less dye was removed from the surface of the fabric and adhered more strongly. For samples not cleared, all the samples have good colour values, but a combination of 6 - 10 g/l of TCAA and 1 - 2 g/l of Na_2CO_3 gave excellent colour values.

Fastness properties

Table 7 shows the fastness properties of samples dyed by the following the three conventional process routes: C_1, C_2 and C_3. A higher rating in the table of results indicates better colour fastness. Overall the fastness results were better for those samples which were subjected to washing/clearing for the removal of the unfixed dye as compared to those which were not subjected to any treatment. If we compare the fastness results of the samples cleared by reductive and oxidative treatments, the colour fastness of samples subjected to reductive clearing appears to be slightly better as compared to those subjected to the oxidative treatment. However, the results of the oxidatively cleared samples are still in an acceptable range.

Tables 8 and ***9*** show the fastness properties of fabric dyed by varying the concentrations of TCAA and the buffer using the one bath one step dyeing method. It is interesting to note that the light fastness properties of the one-bath one-step process are better as compared to the traditional two-step process. The phenomenon of dye fading with light is entirely different from that of removal of the dye during washing and rubbing. The washing test involves the desorption and dissolution of the unfixed dye in water from the core as well as the surface of the fibres. The rubbing fastness test involves the removal of unfixed dye present on the fabric surface due to physical abrasion, and the light fastness test involves the interaction of electromagnetic light radiation with the colourant and other auxiliaries present on the fabric. Colour fastness results in ***Table 8*** & ***9*** show that in terms of washing and rubbing fastness there are slight variations in the ratings with the change in TCAA and /or sodium carbonate concentrations. Overall colour fastness of the dyed fabric actually depends on the individual fastness properties of disperse and reactive dyes. A better dye fixation would be attained for disperse dyes in the case of a sufficient dyeing time in acidic pH, while a better fixation of the reactive dye would be achieved in the case of a sufficient dyeing time in the neutral to alkaline pH range. Both reductive and oxidative clearing treatments are meant to remove the unfixed dye from the fabric. Slightly better fastness properties of reductively cleared samples indicate that the reductive treatment is a little more efficient in the removal of unfixed dye. However, the efficiency of the oxidative treatment may be enhanced by increasing the concentration of the oxidising agent. Since the reductive clearing process is not environment friendly, it can be replaced by the oxidative method, which is more eco-friendly.

Skeleton test

For the skeleton test of samples dyed using different concentrations of TCAA by following the one bath one step dyeing method with 0.6 g/l of TCAA, both cotton and polyester parts show better colour values as compared to the colour values obtained at other TCAA concentrations. At this concentration TCAA showed a pronounced change in pH with increasing temperature, as given in ***Figure 8***.

Figures 9, 10 & ***11*** show the effect of TCAA and Na_2CO_3 on the colour values of the polyester cotton and blend. For the polyester part, the best colour values are obtained with 1.5 g/l of Na_2CO_3 using different concentrations of TCAA. This combination is suitable for the fixation of dye on the polyester part of the fabric. While for the cotton part the higher concentrations of TCAA in combination with 2 g/l of Na_2CO_3 yield better colour values because in this combination the pH of the medium becomes more alkaline, which is suitable for the fixation of reactive dye on the cotton part of the fabric.

Conclusions

The effect of different concentrations of TCAA and the TCAA/Na_2CO_3 buffer was studied in this research. It was found that oxidatively cleared samples showed high colour strength values and good fastness properties when compared with reductively cleared samples. This shows that after- treatments have impacts on colour values and fastness properties. When compared with conventional process routes, these results show better colour strength values and fastness properties. It can be concluded that one-bath one-step dyeing is very economical, while giving better results than the conventional process route.

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