Influence Of Alkali And Temperature On Fixation And Color Coordinates In Dyeing With Different Reactive Dyes

Abu Naser Md. Ahsanul Haque

Abstract: Influence of alkali and temperature were studied on dyeing of cotton fabric with bi-functional Fluoro Chloro Pyrimidene (FCP), bi-functional Monochlorotriazine-Vinyl Sulphone (MCT-VS) and mono functional Monochlorotriazine (MCT) reactive dyes. For this analysis single joursey knitted fabrics were taken. The selected dyestuffs were Drimarene Yellow K-2R (FCP), Drimarene Red CI-5B (MCT-VS) and Drimarene Navy X-GN (MCT). 1% on the weight of fabric (owf) of each dye was considered for producing 15 single shades by varying the alkali amount and the temperature. Soda ash was used in each dye bath as alkali. As MCT dye is a lower reactive dye, Caustic soda was also added in its dye bath. The post dye liquors and post wash liquors were tested in absorbance spectrophotometer to measure the absorbance of those solutions. Beer-Lambert law was used to get concentration from absorbance and then the fixation% was calculated. The dyed fabric samples were tested in a reflectance spectrophotometer to get the color coordinates (L*, a*, b*, c*, h*). The results show that FCP dye fixation was the best among these three and MCT dye fixation was the least. Alkali increases the fixation of all dyes up to a level and temperature applied here has almost no influence on FCP dyes. MCT-VS dye has a tendency to changing its hue in different alkali amount and temperatures.

Index Terms: Alkali, Temperature, Fixation, Color Coordinates, Spectroscopy, Saturation, Hue.

1 INTRODUCTION

The reaction between reactive dye and cotton fiber cannot be possible in absence of alkali. Amount of alkali is the key factor in fixation of reactive dye. Though water is the competitor for reaction with the dye, but cellulose fiber takes part in the reaction for most of the time. It is because the substantivity of a reactive dye to fiber is much greater than the attraction of it to the water [1]. But all the reactive dyes do not have the same range of substantivity and reactivity. Higher reactivity of a dye can spoil the dyeing due to hydrolysis [2]. Reactive dye gets its reactivity in presence of alkali and it can be increased with higher temperature. Reactivity is compulsory for these dyeing, but for a perfect dyeing it should have a limit. One of the main problems in dyeing with many reactive dyes is their low fixation level, often which is less than 70% of the original dye that reacts with fiber [3]. This results huge dye concentrations in effluent. So a proper utilization of parameters should be understood first before going to the bulk process. Three types of dyes are considered here in this experiment. Drimarene Yellow K-2R is a bi-functional Fluoro Chloro Pyrimidene (FCP) dye which has two different halogen groups, each one responsible for nucleophilic substitution reaction with cotton. The second one, Drimarene Red CI-5B is a hetero bi-functional reactive dye contains both the monochlorotriazine (MCT) and vinyl sulphone (VS) as its reactive group. MCT is responsible for nucleophilic substitution and VS is for addition reaction [4]. The other dye taken here was Drimarene Navy X-GN is a mono-functional monochlorotriazine dye (MCT) and it needs high temperature for its dyeing as it is not so reactive like the others [5].

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Dalal and Desai [6] studied with some bi-functional reactive dyes and found those in medium to good substantivity range. Sultana and Uddin [7] had observed good fixation properties for Drimarine dyes by testing dyed samples in absorbance and reflectance spectroscopy. Several researchers studied on the influence of dyeing parameters on dyeing with reactive dye. Miljkovic *et al* [8], who studied on the effect of dyeing parameter on dyeing with vinyl sulphone dyes, had suggested that a shortening of dyeing time can be effective to get better results. This paper tried to describe the influence of two dyeing parameters, alkali and temperature (who are mainly responsible for dye fixation) on three types of reactive dye. They were compared not only the by the fixation% but also studied with the color coordinates found from reflectance spectroscopy so that results can be obtained from a different viewpoint.

2 Materials and Methods

2.1 Materials and Sample Preparation

For this experiment single jersey scoured-bleached cotton fabric was taken. Fabric was prepared from 26 Ne combed yarn with 2.6 mm stitch length. The Course per inch (CPI) and Wales per inch (WPI) of the fabric were found 42 and 34 respectively and the weight of the fabric was 160 gram per square meter. The spectrophotometers used for the tests are UV 1800 (absorbance spectrophotometer and datacolor 650 (reflectance spectrophotometer. 15 pieces of fabric samples were taken for dyeing, each one weights 5 gram. The samples were divided into three groups for dyeing with three different dyes (5 samples in each group). The first group was named as group Y. It was selected for dyeing with Drimarene Yellow K-2R. The second group was named as group R which was selected for dyeing with Drimarene Red CI-5B. Third group was named as group N and selected for dyeing with Drimarene Navy X-GN. First sample of each group was taken as standard and named as Y1, R1 and N1 respectively. They were dyed with 1% owf (on the weight of fabric). The dyeing recipe followed for the standards are mentioned in Table 1.

TABLE 1
RECIPE FOR DYEING OF STANDARDS

Description	Y1	R1	N1
Dye% owf	1%	1%	1%
Glauber salt	50 g/L	50 g/L	55 g/L
Soda Ash	7.5 g/L	16.2 g/L	5 g/L
Caustic Soda 36°Be (Baume)	---	---	1.10 ml/L
Time	60 minutes	60 minutes	80 minutes
M:L	1: 8	1: 8	1: 8
Temperature	60°C	60°C	85°C

The second sample of group Y was named YA2 and was dyed with the same recipe of Y1 but only the soda ash amount used there was double (15 g/L) of the standard Y1. And the third sample of group Y was dyed with a triple amount of salt (22.5 g/L) than Y1 and named as YA3. For the fourth and fifth sample of Y group only the temperatures were different (65°C and 70°C) and other parameters were same as Y1. They were named as YT2 and YT3 respectively. Thus Y1, YA2 and YA3 were compared for understanding the influence of alkali and Y1, YT2 and YT3 were compared for understanding the influence of temperature. Same procedure was applied for the other two groups R and N and sample RA2, RA3, RT2, RT3 and NA2, NA3, NT2, NT3 were dyed accordingly. The temperatures for the samples NT2 and NT3 were 90°C and 95°C respectively. And both the soda ash and caustic soda amount were doubled and tripled in case of NA2 and NA3.

2.2 Sample Analysis Procedure

The first task was to find out the dye extinction coefficient for each dye. From Beer-Lambert law we get-

$$A(\lambda)= \varepsilon (\lambda) \times l \times c \tag{1}$$

Where, A is the absorbance at the wavelength λ, c is the concentration of the absorbing substance in a solution, l is the length of the light path through the solution and ε is the extinction coefficient at that wavelength λ. From equation (1) we can write-

$$\varepsilon =A/ (c \times l) \tag{2}$$

As the length of the light path through the solution was constant 1 cm for these tests, the dye extinction coefficient was the slope of absorbance vs concentration curve. To draw the curve, different known concentrations were taken for three of the dyes. Their absorbance values were measured in absorbance spectrophotometer and that wavelength was considered where the highest pick of absorbance was observed. The slopes were then calculated by least square method. After calculating the extinction coefficients the post dye liquors were tested in absorbance spectrophotometer (UV 1800) to measure the remaining dye concentration. The fabric samples were washed individually in 500 ml water containing 1 g/L Sandopur SN in 60°C for 10 minutes. Then the fabric was dried in a dryer in 70°C for 30 minutes. The post wash solutions were also tested in UV 1800. A reformed Beer Lambert law was used to calculate the concentration of the liquor.

$$c= A/ (\varepsilon \times l) \tag{3}$$

Where c is the concentration, A is the absorbance, ε is extinction coefficient that was calculated previously and l is the length of light passed through which was 1 cm constant for each test. The fixation percentages of dyes were then calculated by the following formula-

$$F\%= (I-P-Q)/I \tag{4}$$

Where, F is the exhaustion, I is initial concentration of dye liquor and P is the concentration of post dye liquor and Q is the dye concentration in post wash liquor. The results obtained from this calculation for 15 different dye baths are listed in Table 2. The dyed samples were then tested in a reflectance spectrophotometer (datacolor 650) and the L^*, a^* and b^* values were obtained from the instrument. Higher L^* means greater lightness, higher a^* indicates greater redness or lesser greenness and higher b^* indicates greater yellowness or lesser blueness of the shade. The saturation coordinate c^* and coordinate for the hue h^* was calculated from the following formulas-

$$c^* =\sqrt{(a^{*2}+b^{*2})} \tag{5}$$

$$h^*= \tan^{-1}(b^*/a^*) \tag{6}$$

How much the coordinates (L^*, c^* and h^*) varied from the standard was calculated by using the following formula-

$$V\%= (S-R)/R \tag{7}$$

Where, V is the variation, R is the value of a particular coordinate of standard and S is the value of same coordinate of the sample. The results found from these calculations are listed in Table 3.

3 Results and Discussion

3.1 Influence on Fixation

Table 2 shows that Yellow K-2R has greater value of fixation always. The fixation values of Red CI-5B were in between the other two dyes and Navy X-GN had shown the least value of fixation. These are because the FCP dye has higher probable to react with the fiber as it consists of two different halogen groups. A single halogen group in MCT dye was less reactive compared to the others. Fixation% was increasing for the bi-functional dyes up to a level. After that it started to decrease may be because of hydrolysis. In case of MCT dye a higher alkali amount was always decreasing the fixation percentage. Higher temperatures than standard had decreased the fixation of both MCT and MCT-VS dye. But for FCP dye temperature had a very negligible effect which describes the dyes stability in a wide temperature range.

TABLE 2
FIXATION PERCENTAGES OF THE DYES

Drimarene Yellow K-2R	**Y1**	**YA2**	**YA3**	**YT2**	**YT3**
Fixation%	85.3	87.4	86.8	85.4	85.2
Drimarene Red CI-5B	**R1**	**RA2**	**RA3**	**RT2**	**RT3**
Fixation%	81.5	83.5	83.1	80.3	79.8
Drimarene Navy X-GN	**N1**	**NA2**	**NA3**	**NT2**	**NT3**
Fixation%	78.1	74.9	73.2	76.1	74.5

3.2 Influence on Color Coordinates

Figure 1 and Figure 2 has described about the changes that occurred in the color coordinates for different amount of alkali and temperature respectively. Considerable changes were found in hue (*h**) of Red CI-5B which is actually unusual. Saturation can change with parameters but changing in hue is confusing for dyeing. Here hue value of Red CI-5B had increased with the increase of alkali amount and decreased in higher temperatures. And the color coordinates *a** and *b** in Table 3 shows that the value of RA2 and RA3 was reddish yellowish from the standard. On the other hand, value of *a** and *b** for RT2 and RT3 were the opposite color; greenish-bluish. The different criteria of reactivity of MCT and VS group can be a reason behind this because the other dyes had shown as far differences in respect of hue.

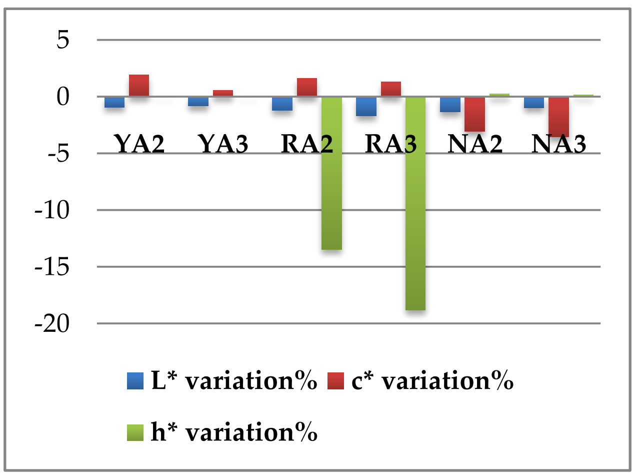

Fig. 1. Influence of alkali to the color coordinates

The saturation (*c**) variation were observed more or less for each dyes especially for different amount of alkali. FCP and MCT-VS dye were saturated more in double alkali amount than the standard. When the alkali amount is tripled, value of *c** were greater than standard but lesser than the doubled amount. In case of MCT dye, value this variation percent was negative which indicates the loss in saturation. Figure 1 also shows that the lightness (*L**) variations were always negative so the shades were darker than the standard in higher alkali concentrations.

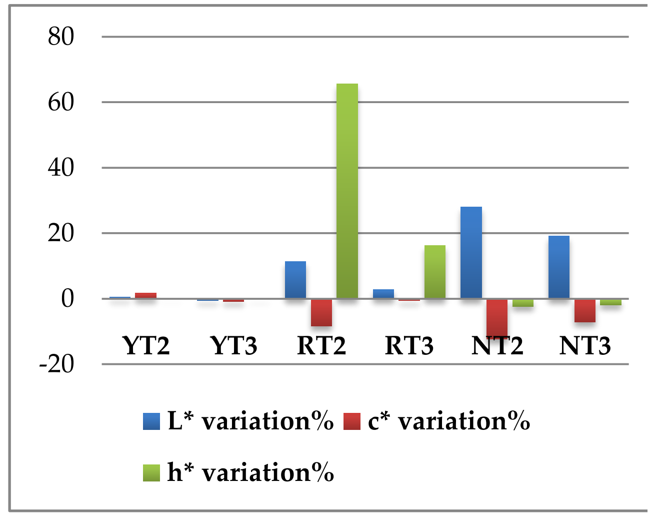

Fig.2. Influence of temperature to the color coordinates

But Figure 2 shows the changes occurred in lightness (*L**) almost positive for all dyes which indicate the shades got lighter in higher temperature. Temperature had affected Navy X-GN most in respect of lightness and also saturation were less for that dye. Red CI-5B the MCT-VS dye was less affected in its saturation and lightness but Yellow K-2R had the least variation in all respect.

TABLE 3
COLOR COORDINATES OF DYED FABRICS

Sample	*L**	*a**	*b**	*c**	*h**
Y1	80.2	20.31	71.80	74.62	0.9983
YA2	79.46	21.24	73.03	76.06	0.9980
YA3	79.55	21.02	72.03	75.03	0.9979
YT2	80.66	19.84	73.21	75.85	0.9988
YT3	79.72	20.67	71.07	74.01	0.9980
R1	51.81	56.21	-4.58	56.40	-0.0813
RA2	51.18	57.17	-4.03	57.31	-0.0704
RA3	50.93	57.02	-3.77	57.14	-0.0661
RT2	57.68	51.21	-6.94	51.68	-0.1355
RT3	53.29	55.79	-5.29	56.08	-0.0948
N1	44.25	-9.89	-19.68	22.03	0.9633
NA2	43.66	-9.45	-19.15	21.35	0.9659
NA3	43.82	-9.46	-19.02	21.24	0.9648
NT2	56.67	-9.61	-16.75	19.31	0.9405
NT3	52.73	-10.01	-17.85	20.47	0.9450

4 Conclusion

Following decisions can be made in conclusion-

- **a)** Fixation order of according to reactive group is FCP>MCT-VS>MCT.
- **b)** Alkali increases the fixation percent up to a certain level for Bi-functional FCP and MCT-VS dye. So an increase in alkali amount in dye bath can decrease the dye loss. But mono-functional MCT dye fixation decreases in higher alkali.
- **c)** Temperature has a negligible effect on FCP dyes. But MCT and MCT-VS dye losses their fixation power with fabric in higher temperatures.
- **d)** All the shades of each dye become darker in higher alkali.

e) Bi-functional MCT-VS dye has a tendency to vary significantly in its hue.

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