COMPATIBILITY TESTING OF REACTIVE DYES

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Abstract: *The present work deals with the ways of testing the compatibility of reactive dyes with cotton in different textile industries in Bangladesh. This report includes three laboratory trials that were carried out for three different reactive dyes to check the compatibility for use in a dye recipe on cotton knitted goods. In this study, Spectrophotometric analysis was conducted and the fixation of each dye was determined by using computer colour matching system. The results found from different industries were analysed and discussed. This testing can be used as a tool for selecting good quality dyes as well as to reduce dyeing cost and hazard. Finally few recommendations are highlighted to overcome the problem of selecting better quality dyes for cotton goods in textile industries in Bangladesh.*

INTRODUCTION

Fabric dyeing usually requires three basic dyes in a mixture to achieve the desired hue and shade. Dyes with similar reactive groups and same exhaustion properties will be said to be compatible with each other and are ideal for use in such mixtures. Selecting compatible dyes is a part of ensuring an optimum dyeing recipe which will most efficiently utilize the dye, produce optimal dyeing results and will reduce the number of chemicals that enter the wastewater. So, checking the compatibility of dyes is a key way to minimize the amount of dyes used as well as ensuring the matching of the specific shade. Basic theory of testing of the compatibility of reactive dyes is available in different text books[1] on textile dyeing. By testing the compatibility of dyes the costs of dyeing can be reduced and the level of productivity can be increased because of less time wasted in trying to get the correct shade. This work was carried out for three different reactive dyes to check their compatibility in a dyeing recipe. In this method, Spectrophotometric analysis[2] was conducted and the fixation of each dye was determined by using computer colour matching system.

EXPERIMENTAL PROCEDURE

Three tests were carried out in two different industries. The list of materials used in these tests is given below:

1. Knitted Cotton Fabric (at least 12 pieces: 5g of each)
2. Remazol Yellow RR
3. Remazol Red RR
4. Remazol Blue RR
5. Drimarine Yellow CL2R
6. Drimarine Red CL5B
7. Drimarine Blue CL2RL
8. Scanning absorbance spectrophotometer
9. Volumetric flasks (e.g. 50ml, 100ml, 250ml)
10. Pipettes (eg. 1ml, 5ml, 10ml, 25ml)
11. Beakers (eg. 100ml, 250ml)
12. Soda ash
13. Glauber salt
14. Washing agent
15. Acetic acid

The spectrophotometric analysis[2] puts emphasis on the exhaustion characteristics of any single dye for a particular shade. There were three steps as follows:

a. Measuring the extinction coefficient of the three single dye for a particular shade
b. Measuring the concentration at different stage of dyeing using the dyes of that specific shade
c. Measuring the colour strength before and after washing and finding out the fixation.

Measurement of extinction coefficient for a single reactive dye: Firstly, 0.1% stock solution of a single dye was prepared by dissolving out 1.000g of dye, diluted up to 1000 ml in a volumetric flask. A number of dye solutions of different concentrations were prepared by taking a certain quantity of the stock solution. These solutions were measured in a calibrated absorbance spectrophotometer (model: HACH DR 2500) to obtain an absorbance value for each, which were used to plot an absorbance curve and to calculate the extinction coefficient. A sample of a solution of known concentration was then placed in the spectrophotometer and absorbance values of a range of wavelength were produced. The absorbance value at the peak (λ_{max}) was recorded. This was repeated for at least three other dilutions of the same dye keeping the wavelength same. For example, if λ_{max} is 597 nm for the first sample then all readings were taken at 597 nm.

Measurement of concentration and exhaustion of different reactive dyes: The measured extinction coefficients were used to calculate the concentration of those dyes used in the lab dyeing. To do this, twelve lab dyeing tubes were used. Four tubes were used for each dye of the proposed dye recipe (i.e. four tubes for dye 1; four tubes for dye 2; and four tubes for dye 3). The laboratory dyeing protocol normally used by the dye house was followed; the only exception being that the dyes were not mixed. 5ml sample was taken from tubes containing dye 1, dye 2 and dye 3. These three samples were diluted to a suitable concentration so that they can be analysed using the spectrophotometer to determine the absorbance. A suitable concentration is one where 5ml of sample is diluted to 250ml solution. Lab dyeing was conducted according to the dyeing profile shown in fig. 1.

After 20 minutes another three samples of 5 ml were taken from each of the three dyes and analysed using the spectrophotometer to determine the absorbance. The same procedure is repeated after the addition of soda ash, 20 minutes after the addition of soda ash and at the end of the dyeing.

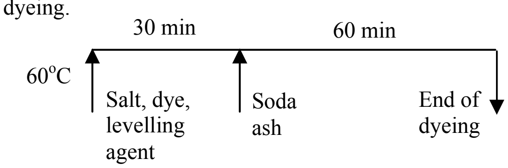

Figure 1: Dyeing profile for testing the compatibility of reactive dyes

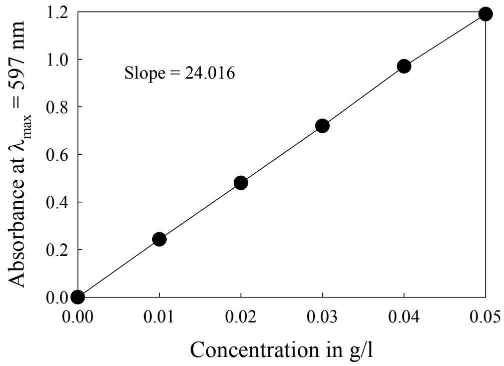

Figure 2: An example of a calibration curve

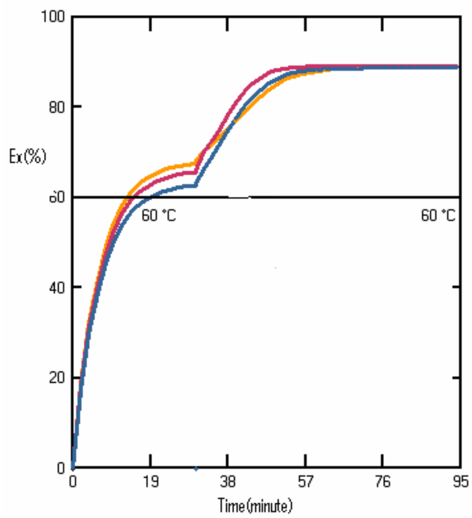

Figure 3: Example of Exhaustion curves characteristics for three compatible reactive dyes

CALCULATION

Extinction coefficient

The data of concentration and absorbance at a particular wavelength are used to draw the calibration curve shown in fig. 2. The slope of the curve (here 24.016) is the extinction coefficient for this dye, at this particular wavelength of 597nm. The extinction coefficients can be used to estimate the concentration of those dyes used in the lab dyeing.

Concentration and Exhaustion

The following equation was used to calculate the concentration.

$A = \epsilon cl$ (1)

Where,

A = absorbance,

ϵ = extinction coefficient

c = concentration of the dye and

l = path length of the cell, which is normally 1cm.

The concentrations of dye in the dye bath were used to calculate the exhaustion (%E) at each stage of dyeing for each dye. For example the exhaustion after stage one is given by, $E_1\% = (C_0 - C_1)*100/C_0$, where, C_0 = Concentration at the initial stage and C_1 = Concentration after 20 minutes of dyeing. Similarly, the exhaustion after stage two is given by, $E_2\% = (C_0 - C_2)*100/C_0$, where, C_2 = Concentration after 40 minutes of dyeing. Thus, E_3, E_4, etc. i.e., the exhaustion at different stages of dyeing can be calculated to plot the exhaustion curve as shown in Fig. 3.

Using the above method the exhaustion data of each dye against time was recorded and then the exhaustion curve characteristics of the three dyes of a particular shade was plotted. This was done three times in two different industries for two different groups of dyes.

Fixation measurement through Colour strength

Fixation of the dye into the fibre was measured using computer colour matching system, which is commonly used in textile dyeing factories to match the shade of sample fabrics with test dyeing. It can also be used to calculate how efficient the dyeing recipe was for fixing the dye to the fabric and thereby giving an estimation of how much dye is being wasted. The colour matching software can measure the colour strength on the fabric and then the fixation can be calculated for any single dye. To determine the fixation, the dyed fabric was cut into two pieces at the end of dyeing and one piece was left in the open air. The other piece was treated in an aqueous solution containing 5g/l washing agent and 2.5 g/l Na_2CO_3, using 50:1 or 40:1 liquor ratio at 98^0C for 30 min. Washing treatment for another 30 minutes with fresh solution was carried out unless colour bleeding occurs. The sample was rinsed thoroughly in cold water and left to dry in the open air.

Each fabric sample was folded so that there are four layers of material. The sample was placed in the colour matching equipment and four different reflectance measurements were made on one side of the fabric. These four reflectances are averaged to calculate the colour strength (K/S). Alternatively, K/S can be measured directly from some measuring equipment. The fixation can then be calculated as,

$$(\%)\ F = \frac{K_2/S_2}{K_1/S_1} \times 100\%$$

Where, K_1/S_1 and K_2/S_2 are respectively the colour strengths of the unwashed and washed dyed samples. These data only gave an approximate fixation value as there are hydrolysed as well as unfixed dyes present in the fabric which can not be washed off. It can however be assumed that the real value will not be much different from this approximate value.

RESULTS

The extinction coefficients and fixation of different reactive dyes are given in Table 1 whereas the extinction coefficient and fixation of different dyes of Drimarine group are given in Table 2.

Table 1: Extinction coefficient and Fixation of the three dyes of Remazol group

Name of dyes	Extinction coefficient	Fixation at 1st test
Yellow RR	31.56	64.198
Red RR	51.76	91.892
Blue RR	43.31	77.477

Table 2: Extinction coefficient and Fixation of three dyes of Drimarine group

Name of dyes	Extinction coefficient	Fixation
Yellow CL2R	42.47	97.85
Red CL5B	42.67	94.71
Blue CL2RL	38.22	93.49

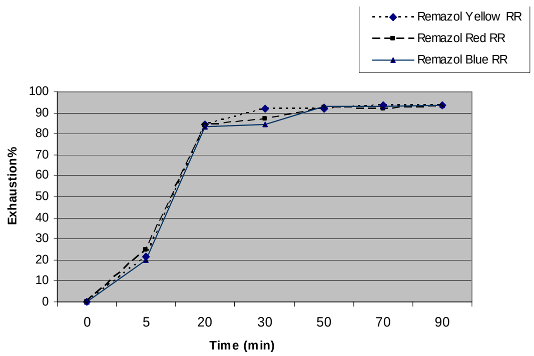

Figure 4: Exhaustion curves of the Remazol dyes (1st test).

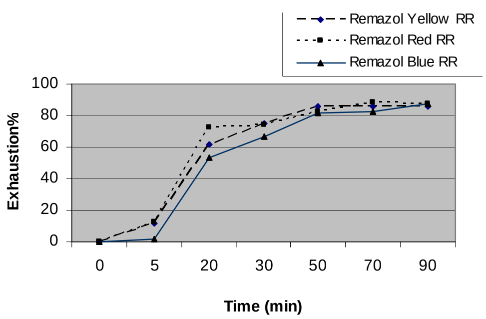

Figure 5: Exhaustion curves of the Remazol dyes (2nd test).

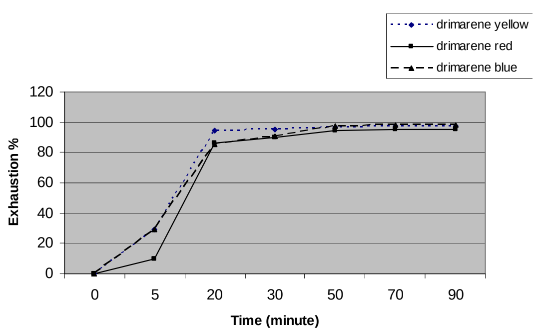

Figure 6: Exhaustion curves of the Drimarine dyes.

DISCUSSIONS

It is seen from Table 1, that the extinction coefficients of Remazol dyes are different from each other. The extinction coefficient of the Remazol Red RR is quite higher (51.76) than the other two dyes. But Table 2 shows that the extinction coefficients of three dyes of Drimarine group are almost similar to each other. Table 1 shows that, the fixation of Remazol Red RR is quite high i.e. 91%, whereas the fixation of Yellow and Blue were 64% and 77%, respectively. It implies that Remazol Red RR was not compatible with the other two dyes. It to be noted that the actual value of fixation would be less than this as the applied method can measure only how much dye is onto the fabric rather than how much dye is fixed onto the fabric.

Now from figure 4, it is seen that the exhaustion values were quite high and the exhaustion curves are showing that the three curves have not been built up in a similar fashion. The exhaustion curve of the red dye was built up in a slightly different way than the other two. It was found that the initial uptakes of the dyes were very high and it was more than 80 %. It can be assumed that it might be because of the high salt concentration, about 65g/litre and the high initial pH, i.e. 9 before dyeing. So a second test (figure 5) with the same dyes was carried out with lower salt concentration and it was about 30g/litre. At that time it was found that the initial uptake was only 60%, which is normal. The initial pH was found to be 7 after the addition of 1-2 drop of acetic acid (5%). Assessing the exhaustion curves of figure 4, it can be said that the dyes were not that much compatible to each other.

From table 2, it is seen that the extinction coefficients of Drimariine dyes were not very much different from each other. The reason behind that might be that the dyes are from same reactive group (hetero bifunctional). It is also seen that the fixation values for these three dyes are quite high, not less than 90 %. But it should be noted that it is the value of how much dye is onto the fabric which includes hydrolysed, un-reacted and un- fixed dyes. It is seen that the fixation values of these three dyes are almost similar to each other.

In figure 6, it is found that their exhaustion values are quite high and the three exhaustion curves seem to have been built up on a similar fashion. Though, their rates of fixation are not same, the equilibrium point for the three curves are quite same. It is found that the initial uptakes of the dyes were very high and it is more than 80%. It may be due to very high concentration of salt solution.

It should be noted that the exhaustion curves should overlay or superimpose on each other to be compatible. If the exhaustion curves do not superimpose on each other; it means that one dye exhausts more quickly than the other dye(s) and thus exhaustion will not be the same for all the three dyes. If the exhaustion is not similar for the three dyes then one cannot say that the dyes are compatible. Thus from figure 6, it can be concluded that the dyes are almost compatible to each other.

CONCLUSION

Dyeing industry should find out the compatibility of all dyes before use. This can be achieved by collecting reliable information from the dye supplier, or ideally by checking the compatibility of each dye at least once. When selecting compatible dyes, the dye manager should consider the full cost of the dyeing process and not just the cost of the dyes. A recipe using compatible dyes may be slightly more expensive in terms of the price of the dye but may be less costly when the overall cost of the dyeing process is considered.

While checking the compatibility of reactive dyes, less amount of salt should be used other wise initial uptake of the dye will be higher than the usual. It means the maximum exhaustion will occur within the first 30 minutes and hence it can hamper the uniform fixation of dyes.

Colour strength should be measured to get the approximate value of fixation. This is extremely useful as the fixation tells how much dye is fixing to the fabric and how much is being wasted. The dye supplier should be able to provide the industries with a figure (or range) for optimal fixation.

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