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# Comparative Study of Washing Fastness of Vat and Reactive Dyed Fabric Samples

Iftikhar Ahmad, Nisar Ahmed Jamil and Afshan Athar
Department of Fiber Technology, University of Agriculture, Faisalabad, Pakistan

**Abstract:** Vat and reactive dyes were utilized in continuous dyeing of pure cotton and polyester. Cotton blended fabric samples. Comparative study of their shade matching and washing fastness results revealed that the reactive dyes might be suitable substitutes of vat dyes.

**Keyword**: Washing Fastness, Reactive Dyes, Cotton Blended Fabric

## Introduction

The modern trend in textiles processing involves the use of readymade dyes being available easily. Vat dyes and disperse dyes belong to water insoluble where as reactive dyes fall in the water soluble group. Majority of these dyes have brought a revolution in dyeing technology due to their availability in variety of colours and having excellent colour fastness properties, in addition to the reasonable less prices of the reactive dyes.

There is always a tendency to reduce the processing cost through suitable substitute of the vat dyes due to their remarkable high cost though fastness properties and colour matching is no problem in the vat dyes. Vat dyes are no doubt play excellent role in colour fastness alongwith variety of shades but they are too much expensive that of reactive dyes (Mandrea, 1986), he reported also the savings in dyes and auxiliaries. On the basis of a thorough study on dyestuffs, it is a doctrine that the reactive dyes might be proved as a proper replacement of vat dyes. In the dyeing mode of the reactive dyes the reactive chlorine covalent bonding with fibre structure plays a significant role in their fastness properties and durability.

The present research work was conducted keeping in view the economy of the dyeing materials and process, using vat and reactive dyes and by adopting continuous method. After a number of trials, it resulted in a success to get matching shades in both the types of dyes. The fastness against washing tests were performed for comparative study.

## Materials and Methods

Present research work was carried out at the Quality Control Laboratories of the processing unit of Nishat Mills Ltd. Faisalabad. The material collected and procedures adopted to accomplish the project are as under:

### Material

- Grey fabric 100% cotton, construction 128 x 60/20 x 16.
- Polyester/cotton blend (65:35), construction 20 x 20/96 x 60.
- Commercial vat dye Red 2B, Reactive Red 4B, and Red PB and disperse SGRL were used in the samples dyeing in the following three phases.

**Phase 1**:
Pretreatments were given successively as gas singeing, desizing (using nervanase Rd 4 g/L), scouring and bleaching, caustisizing (with 18 Be° NaOH Sol.), heat setting at 180°C for 2 minutes and resin finishing.

**Phase 2**:
Dyestuffs for sample dyeing:
Recipes for light, medium and dark red shades in vat and reactive dyes were used as follows:

**For 100% Cotton Samples**

| Dye Type | Dyestuff Elements | Recipe for Shade (gms/L) Light Red | Medium Red | Dark Red |
|---|---|---|---|---|
| | Red 2B | 05.00 | 20.00 | 40.00 |
| | Orange G | 50.00 | 02.00 | 04.00 |
| **Vat dye** | Levalin KAM | 02.00 | 02.00 | 02.00 |
| | Cottoclorine | 01.00 | 01.00 | 01.00 |
| | Setamol PN | 02.00 | 02.00 | 02.00 |
| **For developing process** | | | | |
| Caustic Soda (48 Be° 50%) | | 38.00 | 70.00 | 85.00 |
| Sodium Hydrosulphite | | 30.00 | 55.00 | 70.00 |
| Common Salt | | 15.00 | 15.00 | 15.00 |
| | Red P4B | 01.61 | 06.20 | 13.60 |
| | Orange P4R | 00.89 | 04.40 | 11.40 |
| **Reactive Dye** | Sodi. Carb. | 20.00 | 20.00 | 20.00 |
| | Urea | 100.00 | 100.00 | 100.00 |
| | Blue P3R | - | 00.35 | 00.97 |

Note: Quantity of acetic acid and $H_2O_2$ for oxidizing process in all the cases of vat dyeing of pure cotton fabric and PC dyed sample was kept 3.00 ml/L and 5.00 ml/L respectively.

**For PC (65:35) Fabric Samples dyeing (by Single bath process)**

| Dye Type | Dyestuff Elements | Recipe for Shade (gms/L) Light Red | Medium Red | Dark Red |
|---|---|---|---|---|
| | Red SGRL | 01.90 | 10.28 | 18.00 |
| | Blue SE2R | 00.09 | 00.08 | 00.01 |
| | Yellow SRL | 00.09 | 00.13 | 00.65 |
| | Merapan DPE | 02.00 | 02.00 | 02.00 |
| **Disperse-Vat** | Red 2B | 02.67 | 12.20 | 30.00 |
| | Orange G | 00.22 | 00.70 | 01.45 |
| | Levolin KAM | 02.00 | 02.00 | 02.00 |
| | Cottoclorine PN | 01.00 | 01.00 | 01.00 |
| | Setamol BL | 02.00 | 02.00 | 02.00 |
| **For Developing Process** | | | | |
| | Castic Soda (Be°48, 50%) | 38.00 | 70.00 | 80.00 |
| | Sod. Hydrosulph. | 30.00 | 30.00 | 60.00 |
| | NaCl | 15.00 | 15.00 | 15.00 |
| | Red SGRL | 01.90 | 07.30 | 18.00 |
| **Disp.-Reactive** | Blue SE2R | 00.09 | 00.18 | 00.36 |
| (Double bath process) | Yellow SRL | 00.09 | 00.36 | 00.56 |
| | Merapan DPE | 02.00 | 02.00 | 02.00 |
| | Red PB 00.98 | 05.00 | 09.45 | |
| | Orange P4R | 00.32 | 01.27 | 05.25 |
| **Disp.-Reactive** | Sod. Carb. | 20.00 | 20.00 | 20.00 |
| | Urea | 100.00 | 100.00 | 100.00 |
| | Golden Yellow P2R | - | - | 00.40 |
| **For Reduction Clearing** | | | | |
| | Caustic Soda | - | 70.00 | 20.00 |
| | Sod.Hydrosulph. | - | 50.00 | 20.00 |

Procedures for vat and reactive dyeing were adapted as under:
Vat dye solution was prepared according to the above recipe. For proper dissolution the solution was heated. Then the cotton samples were dyed by padding mangle of continuous method at 100 kg/cm$^2$ with 70% pick up. The dyed samples were dried at 120°C for 1.5 minute. Then developing process at 102°C was performed in which NaOH solution acted as solubilizing agent and sodium hydrosulphite as reducing agent. The samples were, then given cold washing and oxidized with $CH_3COOH$ and $H_2O_2$. Again cold washing to the samples and then dried and pressed.
Reactive dyes solution was prepared as per recipe, cotton samples were padded at 100 kg/cm$^2$ with 70% pick up. The dyed samples were then oven dried at 120°C for 1.5 minute. Curing of the dyed samples was performed at 180°C for 15 seconds. Then the samples were hot watched, then cold washing was given before final drying and pressing.

**Phase 3**
**Colour Fastness Test Against Washing**: Two washing fastness tests were recommended by ISO (International Standards Organization). These are $ISO_3$ and $ISO_4$.
$ISO_3$ was fixed for reactive dyes whereas $ISO_4$ was compulsory for vat dyes. The samples were tested for their dye fastness against washing adopting $ISO_3$ and $ISO_4$ method (ISO, 1948). Recipe for washing fastness ($ISO_3$ and $ISO_4$):

| | | |
|---|---|---|
| Detergent | = | 5 g/L |
| Sodium Carbonate | = | 2 g/L |

**Method**
In this test, soaping solution consisting of soap and sodium carbonate was used with the standard ratio of 1:50 i.e. for 1 g of sample, soaping solution required is 50 ml. However, in the present study, each fabric sample for washing fastness weighed 2 g. So, all the samples were dipped in 100 ml soaping solution and were placed in laundrometer at 95°C and 60°C with vat and reactive dyed samples, respectively, for half an hour. Finally, scoring was noted down on grey scale for staining and shade change.

## Results and Discussion

The final results carried out under $ISO_3$ and $ISO_4$ procedures of reactive dyes and vat dyes respectively are being presented as under:

- Grey scale rating for washing fastness for 100% cotton (Red) dyed with reactive and vat dyes in table 1.
- Statistical analysis for washing fastness for 100% cotton against staining in table 1(a) and 1(b).
- Statistical analysis for washing fastness for 10% cotton against shade change table 1(c) and 1(d).
- Grey scale rating for washing fastness for polyester/cotton 65/35 blended fabric samples table 2.
- Statistical analysis for washing fastness for 65/35 PC fabric samples against staining table 2(a) and 2(b).
- Statistical analysis for washing fastness for 65/35 PC fabric sample against shade change table 2(c) and 2(d).

Table 1 shows the scoring rate for cotton with vat and reactive dyes as 4-5 indicating that both the colours produce very good to excellent results for all shades (i.e. light, medium and dark shade).
As regards washing fastness for shade change vat dye is superior to reactive with scoring rate 5. The staining on wool by vat dye is remarkably high and it might be due to high temperature. The findings of Schimidlin (1969) being similar confirm the present results.
According to table 1(a) dyes (reactive vs vat) exhibition significant difference and give same fastness results. Moreover, all the three shades light, medium and dark red show no difference against washing fastness giving excellent results. The interaction between the two factors i.e. dyes and shades is also found non-significant. Very good to excellent results of washing fastness fully collaborates with the previous results reported by Caribman (1975) who stated that cotton is best dyed with vat dyes and provides good colour fastness (Yamada *et al.*, 1973) while dyeing cotton with reactive dyes stated that cotton gives good washing fastness in light and dark shades. Dixit and Doshi (1980) found that carrier such as urea gives increased colour yield in reactive dyeing although their effect varied depending on the method of fixation. Kopach (1984) confirmed high fastness of vat dyes on cotton obtained in this study saying that cotton fabric dyed in light shades with leuco acid vat dye gives a high degree of fastness.
Statistical analysis in table 1(c) for shade change shows significant difference between vat and reactive dyes. Mean values table 1(d) shows that vat dye is superior to reactive dye. While the factor shades and its interaction with dyes both show non-significant difference in fastness behaviour giving all excellent results. Interaction shows that cotton dyed with vat and reactive dyes in light, medium and dark shades gives non-significant difference, showing very good to excellent results in washing fastness as is indicated in table 1.
**Washing Fastness for Polyester/Cotton (65/35) Fabric Samples**: The results related to washing fastness tests carried out with $ISO_3$ and $ISO_4$ have been presented for polyester/cotton dyed fabric in table 2, whereas statistical analysis have been given in table 2(a) and 2(b) against staining fastness and 2(c) and 2(d) for shade change.
Table 2 gives the scoring rates on grey scale PC with disperse vat and disperse reactive dyes show 4-5 mean scoring, indicating that PC dyed with above mentioned dyes yielded very good to excellent results for all three shades, indicating both dyes are equal in their dyeing and washing fastness behaviour. Staining on wool was also prominent which was expected because disperse dyeing at a very high temperature (210°C) yield staining. In case of light shade, on an average, acrylic, polyester, nylon 6,6, bleached unmercerized cotton and secondary cellulose acetate fabrics are highly resistant against vat and reactive dyes giving very good to excellent washing fastness. However, nylon 6,6 and B.U.C. are little bit sensitive to reactive dye. In case of medium and dark shades, acrylic shows excellent fastness with vat dyes scoring 5 as against reactive dyes with scoring rate 4 (very good). For shade change, vat is superior to reactive on an average with the scoring rate 5 table 1.
Table 2(a) presents ANOVA for staining whereas table 2(c) shows the ANOVA for shade change. According to

Table 1(a): ANOVA for washing fastness of 100% pure cotton against staining for red dye

| Source | D.F | S.S | M.S | F. Value | Prob. |
|---|---|---|---|---|---|
| Dyes | 1 | 0.028 | 0.028 | 0.2381 | |
| Shades | 2 | 0.264 | 0.112 | 1.1310 | 0.3361 |
| Dyes x Shades | 2 | 0.264 | 0.112 | 1.1310 | 0.3361 |
| Error | 30 | 3.500 | 0.117 | | |
| Total | 35 | 4.056 | | | |

Table 1(b): Mean values for washing fastness of 100% pure cotton against staining for red dye

| Dyes | Shades | | | |
|---|---|---|---|---|
| | Light | Medium | Dark | Overall |
| Vat | 4.167 | 4.538 | 4.333 | 4.361 |
| Reactive | 4.417 | 4.417 | | 4.417 |
| Overall | 4.292 | 4.500 | | |

Table 1(c): ANOVA for washing fastness of 100% pure cotton against shade change for red dye

| Source | D.F | S. S | M.S | F. Value | Prob. |
|---|---|---|---|---|---|
| Dyes | 1 | 1.125 | 1.125 | 5.4000 | 0.0385* |
| Shades | 2 | 0.000 | 0.000 | 0.0000 | |
| Dyes x Shades | 2 | 0.000 | 0.000 | 0.0000 | |
| Error | 12 | 2.500 | 0.208 | | |
| Total | 17 | 3.625 | | | |

Table 1(d): Mean values for washing fastness of 100% pure cotton against shade change for red dye

| Dyes | Shades | | | |
|---|---|---|---|---|
| | Light | Medium | Dark | Overall |
| Vat | 5.000 | 5.000 | 5.000 | 5.000 |
| Reactive | 4.500 | 4.500 | 4.500 | 4.500 |
| Overall | 4.750 | 4.750 | 4.750 | |

Table 2(a): ANOVA for washing fastness of polyester/cotton blend (65/35) against staining for red dye

| Source | D.F | S.S. | M.S. | F. Value | Prob. |
|---|---|---|---|---|---|
| Dyes | 1 | 0.174 | 0.174 | 1.666 | 0.2066 |
| Shades | 2 | 0.056 | 0.028 | 0.2667 | |
| Dyes x Shades | 2 | 0.056 | 0.028 | 0.2667 | |
| Error | 30 | 3.125 | 0.104 | | |
| Total | 35 | 4.410 | | | |

Table 2(b): Mean values for washing fastness of polyester/cotton blend (65/35) against staining for red dye

| Dyes | Shades | | | |
|---|---|---|---|---|
| | Light | Medium | Dark | Overall |
| Disperse Vat | 4.417 | 4.417 | 4.417 | 4.417 |
| Disp. Reactive | 4.167 | 4.333 | 4.333 | 4.278 |
| Overall | 4.292 | 4.375 | 4.375 | |

Table 2(c): ANOVA for washing fastness of polyester/cotton blend (65/35) against shade change for red dye

| Source | D.f | S. S | M.S | F. Value | Prob. |
|---|---|---|---|---|---|
| Dyes | 1 | 0.500 | 0.500 | 3.0000 | 0.1089 |
| Shades | 2 | 0.250 | 0.125 | 0.7500 | |
| Dyes x Shades | 2 | 0.250 | 0.125 | 0.7500 | |
| Error | 12 | 2.000 | 0.167 | | |
| Total | 17 | 3.000 | | | |

Table 2(d): Mean values for washing fastness of polyester/cotton blend (65/35) against shade change for red dye

| Dyes | Shades | | | |
|---|---|---|---|---|
| | Light | Medium | Dark | Overall |
| Disperse Vat | 5.000 | 4.500 | 5.000 | 4.833 |
| Disp. Reactive | 4.500 | 4.500 | 4.500 | 4.500 |
| Overall | 4.750 | 4.500 | 4.750 | |

table 2(a) both vat and reactive dyes are non-significant giving no difference between each other, with the same fastness against washing. The three shades also produce non-significant difference among their shade fastness property indicating once again very good to excellent performance. Interaction of dyes and shades indicate that both factors (dyes and shades) have maintained their fastness i.e., when they come in combination show no deviation in fastness. Shades in all possible combinations with vat and reactive dyes i.e., light vat, medium vat, dark vat and light reactive, medium reactive and dark reactive, also follow the same line of action against washing fastness giving very good to excellent results.

Statistical analysis given in Table 2(c) for shade change is also non-significant for factor dyes, shades, and their interaction. It means that both the dyes and three shades show no difference between and among themselves. It shows that they have maintained their purity of fastness against washing very good to excellent results achieved in this study fully agree with the previous findings narrated by Abe *et al.* (1974); Nishida *et al.* (1974) and Azeem (1990). They stated that PC fabric (dyed) gives excellent results in washing fastness of the basic conditions that is time, temperature etc. are kept at optimum level. Padhye and Singhi (1981) reported that alkali treatment enhances the dye uptake because with alkali treatment the fibre swells and thus expose more polyester fibres to the dye bath, while Anonymous (1981) stated that washing fastness property of PC blended fabrics by first dyeing the fabric with disperse dye and reactive dye and then by treating with an alkali is improved; thus it confirms the present findings. Finally, it is concluded that vat dyes might be successfully replaced by reactive dyes being almost identical fastness of both and too much lower price of the reactive dyes.

Table 1: Washing fastness performance* of cotton for red dyes

| Colour | Shade | Shade vat $ISO_3$ | Change Reactive $ISO_4$ | STAINING Wool | | Acrylic | | Polyester | | Nylon 6,6 | | B.U.C. | | S.C.A. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Vat | Reac. | Vat | Reac. | Vat | Reac. | Vat | Reac. | Vat | Reac. | Vat | Rea. |
| | Light | 5 | 4-5 | 3 | 4 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 | 4 | 4-5 |
| Red | Medium | 5 | 4-5 | 4 | 4 | 4-5 | 4-5 | 5 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 | 5 | 4-5 |
| | Dark | 5 | 4-5 | 4 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 | 4 | 4-5 | 4-5 | 4 | 4-5 | 4-5 |
| | Average | 5 | 4-5 | 4 | 4 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 |

Table 2: Washing fastness performance* of polyester/cotton blend (65/35) for red dyes

| Colour | Shade | Shade vat $ISO_3$ | Change Reactive $ISO_4$ | STAINING Wool | | Acrylic | | Polyester | | Nylon 6,6 | | B.U.C. | | S.C.A. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Vat | Reac. | Vat | Reac. | Vat | Reac. | Vat | Reac. | Vat | Reac. | Vat | Rea. |
| | Light | 5 | 4-5 | 4 | 4 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 | 3-4 | 4-5 | 4-5 | 4-5 | 4 |
| Red | Medium | 4-5 | 4-5 | 4 | 4-5 | 5 | 4-5 | 4-5 | 4-5 | 4 | 4 | 4-5 | 4-5 | 4-5 | 4 |
| | Dark | 5 | 4-5 | 4 | 4-5 | 5 | 4-5 | 4-5 | 4-5 | 4 | 4 | 4-5 | 4-5 | 4-5 | 4 |
| | Average | 5 | 4-5 | 4 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 | 4-5 | 4 | 4-5 | 4-5 | 4-5 | 4 |

B.U.C. = Bleached unmercerized cotton
S.C.A. = Secondary cellulosic acetate

| **Grey scale for shade change** | | **Grey scale for staining** | |
|---|---|---|---|
| 1 | Poor | 1 | Poor |
| 2 | Fair/Moderate | 2 | Fair/Moderate |
| 3 | Good | 3 | Good |
| 4 | Very good | 4 | Very good |
| 5 | Excellent | 5 | Excellent |

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