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Research Article

# Effects of Dyeing Parameters on Color Strength and Fastness Properties of Cotton Knitted Fabric Dyed with Direct Dyes

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***Abstract***

*The dyeing parameters can affect the properties of a dyed sample to a great extent. The effect of dyeing parameters such as salt concentration, soda concentration, temperature and time on color strength and fastness properties of cotton knitted fabric dyed with direct dyes were studied in this work. Cotton knitted fabric was dyed varying one parameter and keeping the other parameters same in exhaust dyeing method. It was repeated for every parameter. The effects of variation in dyeing parameters have been assessed by color fastness to rubbing, color fastness to wash and color strength (K/S). The samples were tested according to ISO standards. From the results it was observed that K/S increases with the increases of salt, soda, temperature and time. No significant change in colorfastness to wash (change in color) for dyeing parameters variation was observed. Dyeing parameters have a little effect on the color fastness to wash (color staining) and rubbing.*

***Keywords:*** *Cotton knitted fabric, Dyeing parameters, Direct dyes, Color strength and Color fastness.*

## 1. Introduction

Direct dyes have inherent substantivity for cotton and other cellulosic fibres, are anionic in nature and are generally applied from an aqueous dye bath in the presence of an electrolyte such as NaCl or $Na_2SO_4$ (Waheed S. *et al, 2002*). Most of the direct dyes are relatively inexpensive and are available in a full range of hues. The main drawback of direct dyes is their poor to moderate color fastness to washing.

There is no denying of the fact that, use of knitted fabric has been rapidly increasing in world wide. Both men & women feel comfortable wearing knitted fabric for their shape fitting properties, softer handle, bulkier nature and high extension at low tension compared to woven fabric (Mahbub et al, 2014).

In this research, 100% cotton plain single jersey knitted fabric and direct dyes have been used. Dyeing parameters such as salt concentration, alkali concentration, temperature and time have been varied to find out the effects on color strength (K/S) and color fastness properties of cotton knitted fabric dyed with direct dyes and also to find out the optimum range of direct dyeing condition. After knitting, samples were dyed by direct dyes. At first, only salt has been varied keeping others parameter same. Simultaneously alkali, temperature and time have been varied keeping the others parameter same. After dyeing, color strength (K/S) was measured of all samples by Kubelka-Munk's theory (MA T. *et al, 1987*; Wyszecky G. *et al, 1982*).

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Color fastness to washing and color fastness to rubbing were evaluated for all samples by ISO 105 C06 and ISO 105 X 12 methods respectively.

## 2. Materials and method

### *2.1 Material*

Knitting

For this research, 100% Cotton Single Jersey Knitted fabric GSM (Gram Per Square Meter) about 180 was prepared without any knitting faults. Stitch length of the sample fabric was 2.80 mm and yarn count 30Ne.

### Dyes and chemicals

- Direct dyes
- Leveling Agent
- Alkali: Soda Ash ($Na_2CO_3$)
- Gluaber Salt
- Soaping Agent

### Dyeing process

Scoured and bleached sample (5 gm) was dyed with direct red dyes for 1% shade. IR laboratory dyeing machine was used for the variation of concentration of salt, concentration of soda, time and temperature throughout this research.

At first marked 10 dyeing pots for the samples. Add required amount of water, leveling agent, salt, soda, dye and fabric sample in that pots. Then the marked pots were set into IR machine at $40^0$C. Temperature was gradually raised from $40^0$c to $100^0$C. The machine was continued 60 minutes at $100^0$C, finally machine was cooled from $100^0$c to $40^0$c and drain.

After drain, dyed fabric was washed with distilled water at room temperature, Soaping with 2 g/l soaping agent at $90^0$C for 10 minutes, then samples were washed with distilled water at room temperature and Drying.

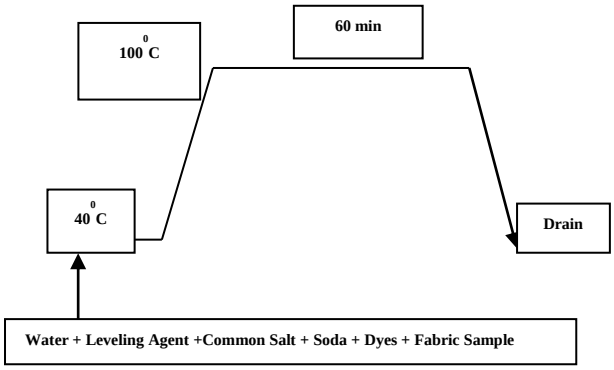


**Figure 1:** Conventional exhaust dyeing curve.

### *2.2 Methods*

In this research, the effect of variation in dyeing parameters on cotton knitted fabric dyed with direct dye had been shown. The following dyeing parameters have been varied.

- Salt concentration
- Alkali concentration
- Temperature
- Time

**Variations in salt, soda, temperature and time**

| Variation in recipe | | | |
|---|---|---|---|
| **Salt (g/l)** | **Soda (g/l)** | **Temperature ($^0$C)** | **Time (min)** |
| 0 | 0 | 60 | 30 |
| 5 | 1 | 65 | 35 |
| 10 | 2 | 70 | 40 |
| 15 | 3 | 75 | 45 |
| 20 | 4 | 80 | 50 |
| 25 | 5 | 85 | 55 |
| 30 | 6 | 90 | 60 |
| 35 | 7 | 95 | 65 |
| 40 | 8 | 100 | 70 |
| 45 | 9 | 105 | 75 |
| 50 | 10 | 110 | 80 |

The standard recipe that was used here: Salt 15 g/l, Soda 5 g/l, Temperature $100^0$c and Time 60min. When one parameter change others are constant and that is occurred consequently.

Color strength

Color strength means a measure of the ability of a dye to impart color to other material. Color strength (K/S) is measured by light absorption in the visible region of the spectrum according to Kubelka-Munk's theory.

In this research, to measure color strength (K/S), a simplified form of the Kubelka-Munk's equation relating the absorption and scattering coefficients and the concentrations of the colorants in the sample with its overall reflectance had been used.

$$K/S = \{K_t + \sum(K_iC_i)\} / \{S_t + \sum(S_iC_i)\} = (1-R_\infty)^2 / 2R_\infty$$

Where K and S are the respective values of the absorption and scattering co-efficient of the various dyes and of the undyed textile materials. $C_i$ is the concentration of each colorant. $R_\infty$ is the reflectance of a sample of the fabric that is sufficiently thick to prevent light transmission through it.

**Color fastness**

The following color fastness test was done for our research work

- Color fastness to wash (Method: ISO 105 C06)
- Color fastness to rubbing (Method: ISO 105 X12)

**3. Results and Discussion**

All the tests were performed in the standard testing atmosphere i.e. 65±2% R.H. and $20^0$C.

*K/S analysis for salt variation*

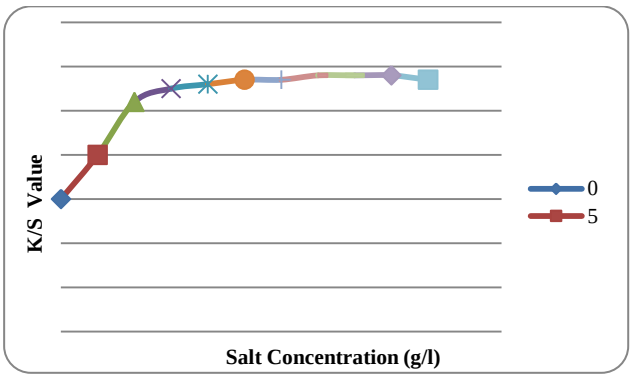


**Figure 2:** Graphical representation of K/S value for Salt variation

The above figure indicates that color strength increases with the increase of salt concentration due to more dyes adhering to the fiber. The color strength increases very quickly at lower salt concentration then it increase slowly and show better color strength from around salt concentration 10 g/l.

***K/S analysis for Soda ($Na_2CO_3$) variation***

Figure 3 indicates that color strength increases with the increase of soda concentration due to more dyes adhering to the fiber. The color strength increases very quickly at lower soda concentration then it increase slowly and final becomes stable at around soda concentration 10 g/l.

**Table 1**: Color fastness to wash for salt concentration variation

| Salt Concentration (g/l) | Change in color | Color Staining on Multi Fiber | | | | | |
|---|---|---|---|---|---|---|---|
| | | Wool | Acrylic | Polyester | Nylon | Cotton | Acetate |
| 0 | 4 | 4-5 | 5 | 5 | 4-5 | 2-3 | 4 |
| 5 | 4 | 4-5 | 5 | 5 | 5 | 2 | 4 |
| 10 | 3-4 | 4-5 | 5 | 5 | 4 | 2 | 4 |
| 15 | 3-4 | 5 | 4 | 5 | 4-5 | 2 | 4 |
| 20 | 3-4 | 4-5 | 4 | 5 | 4-5 | 2 | 4 |
| 25 | 3 | 4-5 | 4 | 5 | 5 | 2 | 4 |
| 30 | 3 | 4-5 | 4 | 5 | 4 | 2 | 4 |
| 35 | 3 | 4-5 | 5 | 5 | 4-5 | 2 | 4 |
| 40 | 2-3 | 4-5 | 4-5 | 5 | 4 | 2 | 4 |
| 45 | 2-3 | 4-5 | 4-5 | 5 | 4-5 | 2 | 4 |
| 50 | 2 | 4-5 | 4-5 | 5 | 4-5 | 2 | 4 |

**Table 2**: Color fastness to wash for alkali concentration variation

| Alkali Concentration (g/l) | Change in color | Color Staining on Multi Fiber | | | | | |
|---|---|---|---|---|---|---|---|
| | | Wool | Acrylic | Polyester | Nylon | Cotton | Acetate |
| 0 | 4 | 4-5 | 4-5 | 5 | 4 | 3 | 4 |
| 1 | 4 | 4-5 | 4-5 | 5 | 4 | 3 | 4 |
| 2 | 4 | 4-5 | 4-5 | 5 | 4-5 | 2-3 | 4 |
| 3 | 3-4 | 5 | 4 | 5 | 4 | 2-3 | 4 |
| 4 | 3-4 | 4-5 | 4-5 | 5 | 4-5 | 2-3 | 4 |
| 5 | 3-4 | 4-5 | 4-5 | 5 | 5 | 2-3 | 4 |
| 6 | 3-4 | 5 | 4 | 5 | 4-5 | 2 | 4 |
| 7 | 3 | 4-5 | 4-5 | 5 | 5 | 2 | 4 |
| 8 | 3 | 5 | 4 | 5 | 4-5 | 2 | 4 |
| 9 | 2-3 | 4-5 | 4-5 | 5 | 4-5 | 2 | 4 |
| 10 | 2-3 | 4-5 | 4-5 | 5 | 4-5 | 2 | 3 |

**Table 3**: Color fastness to wash for temperature variation

| Dyeing Temperature | Change in color | Color Staining on Multi Fiber | | | | | |
|---|---|---|---|---|---|---|---|
| | | Wool | Acrylic | Polyester | Nylon | Cotton | Acetate |
| 60 | 3-4 | 4 | 4-5 | 5 | 4-5 | 2-3 | 4 |
| 65 | 3-4 | 4 | 4-5 | 5 | 4-5 | 2-3 | 4 |
| 70 | 3-4 | 4 | 4 | 5 | 4-5 | 2-3 | 4 |
| 75 | 3-4 | 4-5 | 5 | 5 | 4-5 | 2-3 | 4 |
| 80 | 3 | 4-5 | 4-5 | 5 | 4 | 3 | 4 |
| 85 | 3 | 4 | 5 | 5 | 4-5 | 3 | 4 |
| 90 | 3 | 4 | 4-5 | 5 | 4 | 3 | 4 |
| 95 | 3 | 4 | 5 | 5 | 4 | 3 | 4 |
| 100 | 3 | 4-5 | 45 | 5 | 4-5 | 3 | 4 |
| 105 | 2-3 | 4-5 | 4-5 | 5 | 4-5 | 2-3 | 4 |
| 110 | 2-3 | 4-5 | 4-5 | 5 | 4-5 | 2-3 | 4 |

**Table 4:** Color fastness to wash for time variation

| Dyeing Time (min) | Change in color | Color Staining on Multi Fiber | | | | | |
|---|---|---|---|---|---|---|---|
| | | Wool | Acrylic | Polyester | Nylon | Cotton | Acetate |
| 30 | 4 | 4 | 4-5 | 5 | 4-5 | 2-3 | 4 |
| 35 | 4 | 4-5 | 4-5 | 5 | 5 | 2-3 | 4 |
| 40 | 4 | 5 | 4 | 5 | 5 | 2-3 | 4 |
| 45 | 4 | 4-5 | 5 | 5 | 4-5 | 2-3 | 4 |
| 50 | 3-4 | 4-5 | 4-5 | 5 | 4 | 3 | 4 |
| 55 | 3-4 | 4 | 5 | 5 | 4-5 | 3 | 4 |
| 60 | 3-4 | 4-5 | 4-5 | 5 | 4 | 3 | 4 |
| 65 | 3 | 4 | 5 | 5 | 5 | 3 | 4-5 |
| 70 | 3 | 4-5 | 45 | 5 | 4-5 | 2-3 | 4 |
| 75 | 2-3 | 4-5 | 4-5 | 5 | 4-5 | 2-3 | 4 |
| 80 | 2-3 | 4-5 | 4-5 | 5 | 4-5 | 2-3 | 4 |

**Comparison results of different rubbing fastness for salt, soda, temperature and time variation**

**Table 5:** Comparison results of different rubbing fastness

| Salt variation | | | Soda variation | | | Temperature variation | | | Time variation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Salt (g/l) | Dry Rubbing | Wet Rubbing | Soda (g/l) | Dry Rubbing | Wet Rubbing | Temp. ($^0$C) | Dry Rubbing | Wet Rubbing | Time (min) | Dry Rubbing | Wet Rubbing |
| 0 | 5 | 4 | 0 | 5 | 4 | 60 | 4 | 3 | 30 | 3-4 | 3 |
| 5 | 4-5 | 3-4 | 1 | 4-5 | 4 | 65 | 4 | 3 | 35 | 3-4 | 3 |
| 10 | 4-5 | 3-4 | 2 | 4-5 | 3-4 | 70 | 4 | 3 | 40 | 3-4 | 3 |
| 15 | 4 | 3 | 3 | 4 | 3-4 | 75 | 4 | 3-4 | 45 | 3-4 | 3 |
| 20 | 4 | 3 | 4 | 4 | 3-4 | 80 | 4 | 3-4 | 50 | 4 | 3-4 |
| 25 | 4 | 3 | 5 | 4 | 3-4 | 85 | 4-5 | 3-4 | 55 | 4 | 3-4 |
| 30 | 4 | 3 | 6 | 4 | 3-4 | 90 | 4-5 | 3-4 | 60 | 4 | 3-4 |
| 35 | 4 | 3 | 7 | 4 | 3-4 | 95 | 4-5 | 3-4 | 65 | 4 | 3-4 |
| 40 | 4 | 3 | 8 | 4 | 3-4 | 100 | 4-5 | 3-4 | 70 | 3-4 | 3 |
| 45 | 4 | 3 | 9 | 4 | 3 | 105 | 4 | 3 | 75 | 3-4 | 3 |
| 50 | 4 | 3 | 10 | 4 | 3 | 110 | 4 | 3 | 80 | 3-4 | 3 |

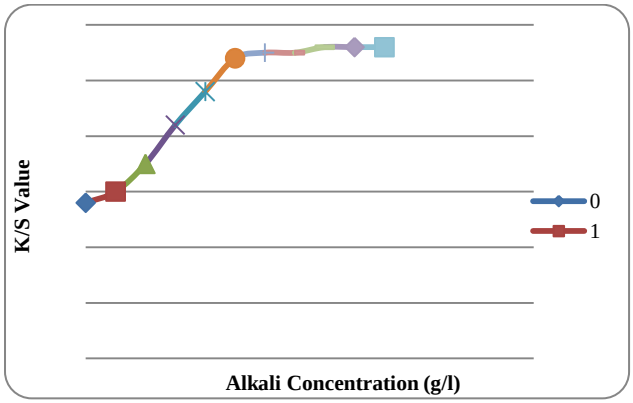


**Figure 3:** Graphical representation of K/S value for Alkali variation.

*K/S analysis for temperature variation*

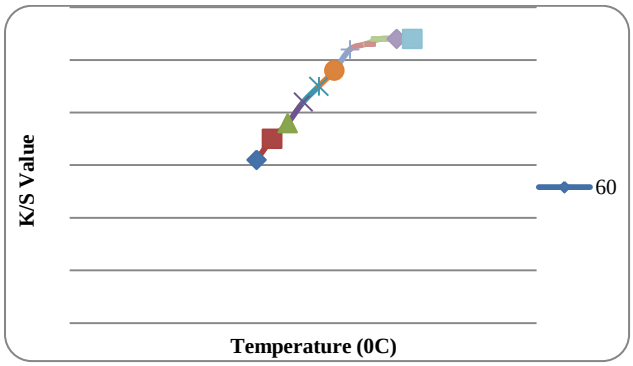


**Figure 4:** Graphical representation of K/S value for Temperature variation.

The above figure indicates that color strength increases with the increase of temperature due to more dyes absorption. The color strength increases very quickly upto 100$^0$c temperature and then finally becomes stable at around soda concentration 100$^0$c temperature.

*K/S analysis for time variation*

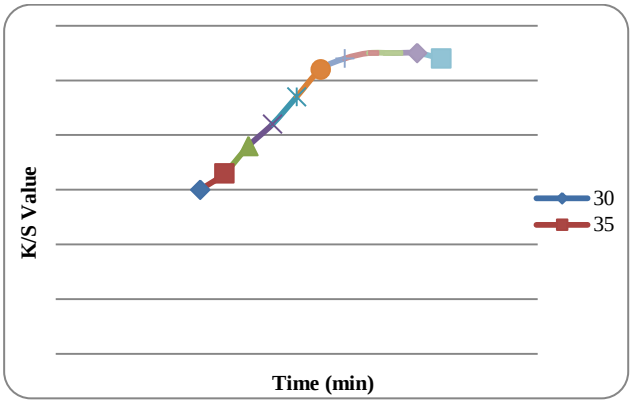


**Figure 5**: Graphical representation of K/S value for Time variation

The above figure indicates that color strength increases with the increase of time. The color strength increases very quickly at lowest time, then it increase slowly and finally becomes stable at 60 min.

*Results of color fastness to wash*

The results of color fastness to wash for salt, soda, temperature and time variations are shown in table 1-4. It is shown from the tables that color fastness to wash for direct dyes for different variations are very poor to moderate.

Table 5 shows the results of different rubbing fastness for salt, soda, temperature and time variation. It is seen from the results that overall rubbing fastness are poor to moderate but dry rubbing fastness is comparatively better than wet rubbing fastness.

## Conclusion

Effects of some dyeing parameters in case of dyeing cotton knitted fabric with direct dyes have been studied in this work. Variations in dyeing parameters can alter the color strength and fastness properties of the dyed fabric. So dyeing parameters should be selected in such a way that they could result in better color strength and optimum

fastness properties. In this research, it was found that for 1% shade of direct dye, salt concentration, alkali concentration, temperature and time should be around 15g/l, 5g/l, $100^0$c and 60 minute respectively.

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