A Comparative Study on Dyeing Behavior of Modified Rajshahi Silk Fabric with Reactive Orange 14, Direct Yellow 29 and Mordant Blue 9 Dyes

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Abstract

Improved multi-voltine variety of Rajshahi silk fabric was dyed with Reactive Orange 14, Direct Yellow 29 and Mordant Blue 9 dyes. The color of silk fabric becomes even and bright when it was dyed with 1.5% Reactive Orange 14, 2.0% Direct Yellow 29 and Mordant Blue 9 dyes for dyeing 50-60 minutes at 80-100°C temperature.

Reactive Orange 14 and Direct Yellow 29 exhibit better color fastness than Mordant Blue 9 under the exposure of sunlight in air and also washing with soap solution.

Key words: Rajshahi silk fabric, dyeing, colorfastness.

Introduction

Silk fabric originates from the silk worm as a continuous protein filament that closely resembles artificial and synthetic fabrics. It has been used as a textile material for centuries due to its super lustre, feel and tensile strength. Although silk fabric bears a glorious and prehistoric background, it renders to improve its textile performances to meet the renewable demands of the 21st century. In this century, the synthetic rival products with their captivating features throw challenges towards silk, threatening its prestigious position in the textile market.

In recent times, attempts have been made to improve properties of silk such as crease recovery, wash and wear properties, anti-photoyellowing, water and oil staining resistance, dye ability and colorfastness. In this work, investigation will be made on dye ability and colorfastness properties of Rajshahi silk. To utilize silk in a better way, it is an urgent need to make the fabric attractive by dyeing as well as by improving its colorfastness.

If a textile material is dyed to enhance its pleasing appearance, the color must withstand under exposure in light, weather, moisture washing, etc., for a certain limit. It is also expected that the dyeing should be level1. In the dyeing process, two important factors are to be considered: (i) migration of coloring matters from the aqueous medium on to the textile fabric under the conditions that will result in a uniform distribution of dye on the fabric and (ii) fixation or affinity of dye particles on to the fabric backbone so that it becomes stable towards washing, exposure to light, weather, moisture, etc.2.

In this project, a comparative study of colorfastness and loss of tenacity of modified dyed silk fabric was observed after exposure to sunlight in air. Optimum dyeing conditions were also selected for economic dyeing.

Materials and Methods

Materials

As a material for investigations, improved multi-voltine variety of mulberry silk fabric was collected from Bangladesh Sericulture Research and Training Institute (BSR and TI), Rajshahi, Bangladesh. Reagent grade sodium carbonate (99.5%), methyl alcohol, sulphuric acid (98%), ammonia solution (25%), sodium hydroxide (98%); Reactive Orange 14 and Direct Yellow 29 dyes were purchased from Sigma (USA), tannic acid, aluminium sulphate [(Al2(SO4)3.24H2O)] (98%) and glacial acetic acid (99.7%) from Merck (Germany), and wheel soap from Uniliver Bangladesh Ltd.

Methods

Degumming of Silk fabric: Silk fabric was degummed by the optimum degumming method3.

Selection of modifying condition:

To select the modifier for Reactive Orange 14, Direct Yellow 29 and Mordant Blue 9 dyestuffs, three modifying baths (30% CH3COOH; 30% CH3COOH and 10% tannic acid; 30% CH3COOH and 20% tannic acid) were prepared and heated at 70◦C temperature for 20 min.

The non-modified and five modified fabrics were then dyed with 2% dye at 85◦C for 60 min for each of the dyes. Colorfastness tests of these dyed fabrics were conducted washing with soap so¬lution and after 7 days exposure in sunlight in air. The modifying condition, which gave best colorfastness, was selected for modifying the silk fabric4.

Selection of optimum dyeing conditions

To select optimum dyeing conditions of modified silk fabric, concentration of dye and electrolyte, dyeing time and temperature were selected accordingly. The percentage of dye absorption was calculated with the spectrophotometric analysis5.

a. Selection of dye concentration: Six dye baths were pre¬pared with 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0% dye on the basis of weight of modified silk fabric, and the dyeing was carried out at 85 C for 60 min. The electrolyte con¬centration was 10%, and the fabric–liquor ratio was 1:50. The concentration of dye that gave the silk fabric even and maximum shade was selected for dyeing.
b. Selection of electrolyte concentration: Eight dye baths were prepared with 0, 3, 5, 7, 9, 11, 13 and 15% aluminium sulphate as electrolyte. The fabric was then dyed with selected concentration of dye, and the dyeing temperature and fabric–liquor ratio were same as above. The electrolyte concentration that gave the maximum absorption of dye by fabric was selected for dyeing.
c. Selection of dyeing time: Seven dye baths, each containing selected dye concentration and electrolyte concentration, were prepared, and the fabric was dyed at varying times as 30, 40, 50, 60, 70 and 80 min. The minimum dyeing time at which the maximum dye absorption was obtained was selected for dyeing.
d. Selection of dyeing temperature: Each of seven dye baths containing selected concentration of dye and electrolyte was prepared. Then fabrics were dyed at the selected time by varying temperature as 50, 60, 70, 80, 90 and 100°C. The lowest temperature at which maximum ab¬sorption was obtained was selected as dyeing temperature.

Calculation of the quantities of dye and electrolyte from stock solution:

To calculate the quantities of dye and electrolyte, the fol¬lowing formula was used 6.

$$\text{Stock solution required (mL)} = \frac{W \times P}{C}$$

Where W is weight (in grams) of fabric sample to be dyed, P percentage of dye and electrolyte to be used (expressed on the basis of the weight of fabric) and C Concentration of stock solution.

Colorfastness Test

Colorfastness test was carried out of the dyed silk fabrics. The specimens were exposed under the sun for 250 h without protecting from weathering. After every 50 h, the fastness was assessed by the 'Grey Scale7 for assessing change in color' Comparing with the control '5' Colorfastness to washing with soap solution, spotting with acids8 and alkalis9 was measured with the Grey Scale.

Results and discussion

Modification

Table -I: Effect of modifiers on dyeing of Rajshahi silk with reactive dyes (Reactive Orange 14a)

Expt. No	Modification Conditions	Color and fastness grade Control	Color and fastness grade after 7-day exposure to sunlight in air	Colorfastness grade after washing with soap solution at 70°C for 30 min
1	Modified with 30% CH3COOH, 70°C, 20 min.	Bright Orange 5	3	2-3
2	Modified with 30% CH3COOH, 10% tannic acid, 70°C, 20 min.	Orange 5	4	2-3
3	Modified with 30% CH3COOH, 20% tannic acid, 70°C, 20 min.	Bright Orange 5	4-5	3-4

Other dyes (Direct Yellow 29 and Mordant Blue 9) also showed better colorfastness on exposure to sunlight in air and washing with soap solution at the same modifying condition no. 3. Dyeing condition: 2% dye at 80 °C for 60 min.

Table 1 presents the effect of modifiers on the colorfastness of the dyed silk fabrics. The three modified dyed fabrics were tested for colorfastness after 7-day exposure to sunlight in air and after washing with soap solution (70°C for 30 min). The silk fabric exhibits best colorfastness when modification was made with 30% acetic acid and 20% tannic acid mixture (condition no. 3). Under this condition, the fabric became more acidic and thus enabled easier fixation of Reactive, Direct and Mordant dyes on the fabric. Dyes combined with tannic acid to form an insoluble prod¬uct and increased the wet fastness of the dyes10.

Dyeing

The fabric modified with 30% acetic acid and 20% tannic acid was dyed with Reactive Orange 14, Direct Yellow 29 and Mordant Blue 9. The dye uptake depends on the concentration of dye, concen¬tration of electrolyte, dyeing time and temperature of the dye bath; therefore, an attempt was made to determine the optimum dyeing conditions for making the process more economic11.

Table-II: Selected optimum dyeing conditions of different dyes

Dyeing conditions	Used dyes		
	Reactive orange 14	Direct yellow 29	Direct blue 9
Dye Conc. (%)	1.5	2	2
Electrolyte Conc. (%)	5	0	0
Dyeing Time (min.)	50	60	50
Dyeing Temperature (°C)	80	100	100

Effect of sunlight on the tenacity of dyed Silk fabric12:

Table-III: Effect of sunlight on the tenacity of silk fabric dyed with reactive, direct and mordant dyes

Exposure time, hr	Loss in Tenacity, %		
	Reactive orange 14	Direct yellow 29	Mordant blue 9
50	5.38	25.46	2.45
100	12.50	34.56	5.68
150	23.45	42.86	10.36
200	33.34	48.32	16.61
250	38.42	58.72	21.43

Table-III shows the effect of sunlight on the tenac¬ity of dyed silk fabrics after 250 hr exposure to sunlight in air. The loss in tenacity silk fabric dyed with Mordant Blue 9 is comparatively low (21.43%) than others. The order of tenacity losses of dyed silk fabrics are as follows: Mordant Blue 9> Reactive Orange 14> Direct Yellow 29.

Table-IV: Effect of sunlight on the colorfastness of raw, degummed and dyed silk fabric.

Exposure period (hr)	Fastness Grade and Color		
	Reactive Orange 14	Direct Yellow 29	Mordant Blue 9
00	5 (Orange)	5 (Yellow)	5 (Pink)
50	5	4-5	5
100	4-5	4-5	4-5
150	4-5	4-5	4
200	4-5	4	4
250	4-5	4	3-4

Effect of sunlight on the colorfastness of the dyed silk fabrics:

Table-IV shows the color change of dyed silk fabrics with Reactive Orange 14, Direct Yellow 29 and Mordant Blue 9 dyes under 250 hr exposure in sun¬light. The very slight color change occurred for the silk fabric dyed with Reactive Orange 14. The order of colorfastness of dyed silk fabrics is as follows: Reactive Orange 14> Direct Yellow 29> Mordant Blue 9.

Table 4 that the colorfastness of the dyed silk with reactive, direct dyes is good. Silk dyed with Reactive Orange 14 and Direct

Yellow 29 exhibits better colorfastness than that of Mordant Blue 9 dyes.ase of Table 5 Effect of washing with soap solution on the colorfastness of dyed silk fabric.

Table-V: Effect of washing with soap solution on the colorfastness of dyed silk fabrics.

Washing temp., (°C)	Fastness Grade and Color		
	Reactive Orange 14	Direct Yellow 29	Mordant Blue 9
Unwashed	5 (Orange)	5 (Yellow)	5 (Pink)
40	5	5	4
70	4-5	4-5	3
100	4	4	3

Table-V shows that among the dyes used, Reactive Orange 14 and Direct Yellow 29 withstand their color on silk to a great extent on washing with soap solution. The wash fastness depends on the physical and chemical properties of the dye and fabric and their interac¬tion. The more interaction the better is the wash fastness. It is also seen that the wash fastness decreases with the increase of washing temperature and it is due to the in¬creasing trends of dissolution of the dye particles from the fabric surface.

Table-VI: Effect of acids and alkalis on the colorfastness of dyed silk fabrics.

Chemicals	Fastness Grade and Color		
	Reactive Orange 14	Direct Yellow 29	Mordant Blue 9
Unspotted	5 (Bright Orange)	5 (Bright Yellow)	5 (Pink)
Sulfuric acid	5	5	5
Acetic acid	5	5	5 (Shade increase)
Tartaric acid	5	5	5
Sodium hydroxide	4	4	Blue
Sodium carbonate	4-5 (Shade increase)	5	Blue
Ammonium hydroxide	5	5	5

Table -VI shows the colorfastness to spotting with acids and alkalis of the dyed silk with Reactive Direct and Mordant dyes. The dyes ex¬hibit better colorfastness to spotting with organic acids and weak alkalis. But silk undergoes degradation when spotted with strong alkalis (e.g., NaOH, Na2CO3). At the same time, the auxochrome and chro-mophore groups of dye mole-cules react with alkali and result in the change of color of dyed silk.

Conclusion

Modification of Rajshahi silk with acetic acid and tannic acid showed better colorfastness properties of dyed silk with Reactive and Direct dyes. The best result was obtained with 30% acetic acid and 20% tannic acid. Among the dyes used, Reactive Orange 14, and Direct Yellow 29 showed good colorfastness properties on exposure to sunlight in air. The colorfastness tests to spotting of dyed silk with sodium hydroxide and sodium carbon-ate give unsatisfactory results by changing color, whereas acetic acid, tartaric acid and ammonium hydroxide give satisfactory results in most of the cases.

References:

1. Cockett, S. R. and Hilton, K. A. (1961); Dyeing of cellulosic fabric and related processes, Leonard Hill (Books) Ltd., London, p. 31-36.
2. Edward Lynn, J. and Press, J. Y. (1961); Advances in Textile Processing, Vol. 1, Textile Book Publishers, Inc., New York, p. 335- 342.
3. Sheikh, M.R.K. Uzzal Kumar Saha and Zakiya Yasmin (2005); Modification of Silk with Vinyl Monomers: Effect of Acrylic Acid and Acrylamide on Rajshahi Silk, The Pakistan Textile Journal, Vol. 11, p. 58-63.
4. Mathews, J. M. (1920); Application of Dyestuffs, John Willey and sons, Inc., New York, p. 1-2, 34-56, 85-97.
5. Farouqui, F.I., Sheikh, M.R.K., Hossain, M.I. and Saha, S.K. (1997); Selection of optimum dyeing conditions in dyeing jute fiber with reactive dyes and their color fastness proper-ties. Indian Journal of Chemical Technology, Vol. 4, p.185.
6. Charles, H. G. (1974); A Laboratory Course in Dyeing, 3rd ed., The Society o f Dyers and Colorsts, Bradford Yorkshire, England, pp. 54-58, 79.
7. Grey Scale for assessing change in color' (International Standard, British Standards Institution).
8. International Standard Organization, 105-E05-1978 (E). Textiles-Tests for Colorfastness. E 05 Colorfastness to Spotting: Acid.
9. International Standard Organization, 105-E06-1978 (E). Textiles-Tests for Colorfastness. E 06 Colorfastness to Spotting: Alkali.
10. Tortman, E. R. (1975); Textile fiber to fabrics, McGraw Hill Publishing, Co, New York, p. 392.
11. Sheikh, M. R.K., Farouqui, F.I., Poly Rani Modak, Md. Asadul Hoque and Zakiya Yasmin (2006); Dyeing of Rajshahi Silk with Basic Dyes: Effect of modification. The Journal of Textile Institute, Vol. 97 (4), p. 295.
12. International Standard Organization, 5081-1977 (E), Textile-Woven Fabrics. Determination of Breaking Strength and Elongation (Strip Method). ◆