



Screen Printing on Silk Fabric using Natural Dye and Natural Thickening Agent

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Abstract

The trials were under taken to screen print silk fabric with *Butea monosperma* flower dye extract using natural thickening against i.e. cassia seed gum and mango kernel gum with two mordant. Copper Sulphate and Ferrous Sulphate was selected for the experiments. The screen printed samples were studied for color fastness properties and CIE LAB values. Results of silk screen printed samples with both the mordant exhibited very good to excellent results fastness rating for light, washing, rubbing and perspirations. The results revealed that silk fabric can successfully screen printed with natural dye and natural thickening agents.

Keywords: *Butea monosperma*; Natural thickening agents; International Commission of illumination (CIE); Mordants

Introduction

Silk is naturally occurring protein fiber produced by the worm and has potentially used as textile material for over five thousand years. This delicate filament fiber is well known for its sheen, texture, water absorbency, dye affinity, thermal tolerances along with insulation properties [1]. Silk fiber contains $-NH_2$ and $-COOH$ groups at either ends of its chemical structure due to which it can be dyed with acid dyes, reactive dyes, metal complex dyes etc.

Printing is a form of dyeing in which the color is applied to specified area. The resulting multicolored patterns have attractive and artistic effects which enhance the value of fabric. To resist the coloring matter to the design area, it is pasted with thickening agent which may be natural or synthetic polymer. Plant products are attractive alternatives to synthetic products because of biocompatibility, low toxicity, environmental "friendliness" and low price compared to synthetic products. Natural products are also generally non-polluting renewable sources for the sustainable supply. Cassia seed gum and Mango kernel gum has been taped to explore as a source of natural thickening agent for sustainable development. The present paper deals with preparation of thickening agent from Cassia seed gum and mango kernel gum and investigating their suitability as thickening agent in screen printing on silk fabric using *Butea monosperma* flower dye extract with two different mordants and testing its CIE Color coordinates and color fastness towards light, washing, rubbing and perspiration.

Material and Methods

Fabric

Plain white silk fabric was purchased from market. Scouring was done in order to remove the impurities from the fabric. Fabric was boiled for 45 min. in a solution containing 2 grams of nonionic detergent and one gram of NaOH per liter of water. After this by kneading and squeezing the samples were rinsed in tap water and sun dried.

Pretreatment of fabric

The fabric was pretreated with 20 percent of myrobalan (*Terminalia chebula*) solution for 24 hours maintaining the 1:20 MLR (material to liquor ratio) the fabric was squeezed in both warp and weft direction and sun dried. The side exposed to sunlight was darker and was used for printing.

Dyes and mordents

Butea monosperma flowers were used as a dye source. Aqueous method was used for dye extraction. 100 gram of dye extract was reduced to 5 gm. by boiling. Two mordants were used: Copper Sulphate -5% and Ferrous Sulphate -3%.

Thickening agents

Cassia seed gum and Mango kernel gum.

Preparation of printing paste

It was prepared by mixing 2 gm. of cassia seed gum or 1.5 gm. of mango kernel powder in 15-20 ml of water. Then this paste was kept aside for 10-15 min. 80-85 ml of water was added and the paste was boiled till the desired thickness was obtained. Selected concentration of mordant and dye concentrate was added to the paste. This paste was kept aside and used for printing.

Printing technique

All the printing paste were applied to the fabric through screen printing technique. The printing process consist of forcing a various print paste through the open areas of the screen with a flexible, synthetic rubber, squeegee. The rubber blade, which is contained in a wooden or metal support, is drawn steadily across the screen at a constant angle and pressure. The pressures exerted must be as similar as possible.

After treatment and fixation

Printed samples were treated with Alum. Anonymous [2] proposed Alum for its low environmental toxicity. Fixation was done by steaming at 125°C for 30 min.

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Measurement of fastness properties

Color fastness test to light, washing crocking or rubbing was carried out in fad-o-meter, launder-o-meter and crock-o-meter respectively and fastness was rated as per rating given in Grey scale [3].

Evaluation of CIE lab coordinates

Color value of the sample was analysed on the basis of $L^*a^*b^*$ values using reflectance spectra through (color eye 3100) Macbeth UV spectrophotometer. The L^* value is a measure of lightness and darkness of the color while to define the color on a two dimensional chromatic space of green-red axis and blue-yellow axis, a^* and b^* values were evaluated

Results and Discussion

In order to compare the effect of two thickening agent .Silk fabric was printed with natural dye extracted from *Butea monosperma* with two different mordant. The CIE values and their corresponding fastness grades were evaluated.

Evaluation of color coordinator of printed sample

During printing process, *Butea monosperma* dye extract was used to provide color. Generally it is assumed that color will change according to textile material and printing process. But in natural dyes this expectation is somewhat high and especially in dyeing processes the effect of mordant type is of great importance for the shade of the color. Samanta and Agarwal [4] two mordant namely copper sulphate and ferrous sulphate are used with two thickening agents.

L^* values of the sample relates to brightness. Since the L^* values of both the mordants of Mango Kernel gum is nearly similar. The L^* value is less which shows darkness of printed sample. Greater L^* values may be due to more extent of dye mordant complex formation, since the dye was only in print paste. The extent this dye transfer from the print to interior of the fabric which contain mordant thickening agent a dye and type of mechanism involved in formation of dye mordant complex. The whole complex is transferred during steaming. Different type of mordant and dye resulted in different shades and tones of screen printed silk fabric. It is indicated by CIE color coordinate results.

The a^* value indicates redness or greenness and b^* value indicates yellowness and blueness. From the table it can be seen that a^* values were negative for $FeSO_4$ mordanted printed samples with both thickening agents, $CuSO_4$ mordanted samples it was positive with both thickening paste. Negative a^* value indicates greenness in the screen printed samples. While positive b^* value indicates yellowness in the screen printed samples. Screen printed samples were yellowish green (Table 1 and Figure 1).

Screen Printed Samples

Fastness properties of printed samples

Light fastness properties of printed samples: When the dye or pigment is imparted on the fabric it is expected to have certain

Thickening agent	Mordant	Color obtained	CIE Color Coordinates		
			L^*	a^*	b^*
Mango kernel	$FeSO_4$	Olive green	49.73	-2.42	13.25
	$CuSO_4$	Mehndi green	61.83	3.57	42.16
Cassia seed	$FeSO_4$	Bottle green	47.28	-2.62	11.87
	$CuSO_4$	Green gold	69.93	0.196	30.33

Table 1: Effect of thickening on color strength of screen printed silk fabric.

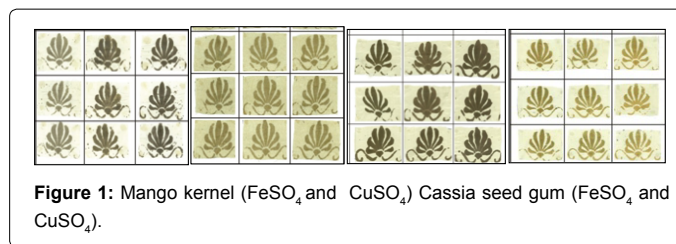


Figure 1: Mango kernel ($FeSO_4$ and $CuSO_4$) Cassia seed gum ($FeSO_4$ and $CuSO_4$).

properties, thus the colored fabric is exposed to sunlight during its use, and the dye should not fade or change its color. During the exposure of colored fabric to crock or sunlight in the presence of air (oxygen or moisture) the color absorbs some portion of sunlight. The light fastness properties of printed fabric with two different thickening agents and mordants are good to excellent which shows that dyes are stable to photo degradation and printing paste interaction is good. Light fastness of printed fabric is influenced by chemical, physical state and concentration of dye, nature of the fibers and mordant type [5] (Tables 2 and 3).

Rubbing fastness properties of printed samples: Screen printed samples were evaluated for rubbing fastness. The extent of rubbing may be influenced by the moisture, as many textiles transfers more color when wet the dry rubbing fastness was slightly better than wet rubbing fastness. Rubbing fastness grades of dry rubbing are found very good to excellent but for wet rubbing fastness it is very good. This shows that majority of dye is fixed well on fibers and surface residual dye is minimal. The CIE color coordinates also confirm the results.

Wash fastness properties of printed samples: Washing fastness grades for color change for both mordant and thickening agents was 5 and color staining was observed between 4/5 to 5 for all the samples. Washing fastness grades clearly reveals that very slight color change was observed with both the mordants, very slight color staining was seen on cotton and wool fabric. The superior washing property of colorant may be due to the kinetics and thermodynamic effects of the metal complex formation [6] (Table 4).

Perspiration fastness properties of printed samples: Almost all screen printed silk sample showed good performance during acidic and alkaline perspiration test (Table 5).

As L^* values decreased during acidic perspiration test while it increased during alkaline perspiration test. Slight color staining was observed. Color of screen printed fabric becomes lighter in case of alkaline medium with mango kernel gum, while shade becomes darker with mango kernel gum in acidic medium with $FeSO_4$ mordant. L value of printing paste prepared with cassia seed gum and $FeSO_4$ mordant with acidic and alkaline medium was found nearly same.

There was slight color staining for both the treated samples on both the sides with both the thickening agents. The good color fastness properties might be attributed to benzene ring and conjugated system present in dye which makes firm bonding with modified fabric upon exposure to agencies heat, light and rubbing resistance [6].

Conclusion

It is evident from the results that silk fabric can be successfully screen printed with Mango kernel and Cassia seed gum with Ferrous Sulphate and Copper Sulphate and *Butea monosperma* dye extract. The color fastness properties of screen printed samples towards sunlight, washing, rubbing and perspiration were found good to very good.

Thickening agent	Mordant	CIE Color Coordinates						Light fastness grades	
		L*		a*		b*		C	E
		C	E	C	E	C	E		
Mango Kernel Gum	FeSO ₄	32.94	33.07	0.78	0.53	7.76	7.07	7	5
	CuSO ₄	53.60	54.26	0.41	0.35	22.37	22.66	7	6
Cassia Seed gum	CuSO ₄	53.20	58.34	-.60	.41	16.93	21.18	7	5
	FeSO ₄	41.68	29.21	-.48	0.53	16.87	14.322	7	4

(C = Control, E = Exposed, Rating 1-poor, 2-fair, 3-moderate, 4-good, 5-better, 6-very good, 7- best and 8-excellent)

Table 2: CIE Color Coordinates and Light fastness grades of Silk Screen printed fabric.

Thickening agent	Mordant	CIE Color Coordinates						Rubbing fastness grade			
		L*		a*		b*		CC		CS	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Mango Kernel Gum	FeSO ₄	16.029	42.25	-0.23	-1.30	16.09	13.36	5	5	5	4
	CuSO ₄	54.17	59.52	4.52	6.53	46.05	52.00	5	5	5	4
Cassia Seed gum	FeSO ₄	30.86	40.07	1.27	1.53	7.47	9.64	5	4/5	5	4
	CuSO ₄	57.47	63.56	3.44	1.43	41.76	36.90	5	4/5	4/5	4

Table 3: CIE Color Coordinates and Rubbing fastness grades of Silk Screen printed fabric.

Thickening agent	Mordant	CIE Color Coordinates			Washing fastness grade		
		L*	a*	b*	CC	CS	
						W	C
Mango Kernel Gum	FeSO ₄	46.46	-1.72	10.01	5	4/5	4/5
	CuSO ₄	31.22	-0.78	10.21	4	5	4/5
Cassia Seed gum	FeSO ₄	39.56	-1.4	8.79	4	4/5	4/5
	CuSO ₄	56.25	1.2	16.70	4	4/5	4/5

CC = Color Change, CS = Color staining, W = wool, C = Cotton

Table 4: CIE Color Coordinates and Washing fastness grades of Silk Screen printed fabric.

Thickening agent	Mordant	CIE Color Coordinates						Prespire-0 –meter grade						
		L*		a*		b*		CC		CS				
		Acidic	Alkaline	Acidic	Alkaline	Acidic	Alkaline	Acidic	Alkaline	W		C		
Mango Gum	FeSO ₄	13.76	52.43	3.78	0.82	12.90	11.68	3	4	4	4	4	4	3/4
	CuSO ₄	63.05	80.55	4.9	-0.86	35.19	29.75	4	4	4	5	5	5	3/4
Cassia Seed gum	FeSO ₄	49.69	49.35	3.82	2.43	12.92	24.0	5	5	5	4	5	5	4
	CuSO ₄	52.47	68.9	4.93	1.66	29.76	33.45	4/5	4	5	4	4/5	4/5	3/4

(CC = Color Change, CS = Color staining, W = wool, C = cotton, Rating 1-poor, 2-fair, 3-good, 4-very good and 5-excellent)

Table 5: CIE Color Coordinates and Prespire-o –meter grades of Silk Screen printed fabric.

Hence, the commercial trials of natural thickening agent with natural dye using screen printing is very much possible, giving all round performance properties.

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