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Short Communications

Padding technique for natural dyeing

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The dye extracted from palas flower petals has been used on cotton fabric and a comparative study is carried out for conventional exhaust dyeing against the pad dyeing. For these two methods, combination of experiments has been conducted for three typical mordanting methods with four different mordants. In conventional dyeing method, at three different temperatures (60˚, 80˚ and 100˚C), more uneven dyeing is observed. Hence, to overcome this problem, padding method is tried for 5, 15 and 30 min steaming time. The *K/S* values show that, 80˚C is the optimum temperature for exhaust method, while for padding method, 15 min is the optimum time of steaming. Out of all experiment combinations, ferrous sulfate with pre-mordanting method gives excellent depth of shade. *K/S* value for the conventional exhaust dyeing is 7.45, while it is 9.15 for padding with significantly improved fastness ratings as compared to conventional technique. Thus, it is inferred that the innovative padding method is significantly superior to conventional exhaust method. The added advantage of pad method lies in significant time as well as energy saving.

Keywords: Cotton fabric, Dyeing, Mordanting, Natural dyes, Padding technique

The natural dyes are being used for coloration of textiles from ancient times till the nineteenth century. As the names suggest, natural dyes are the colorants derived from natural resources, like plants, animals and minerals. It has been found that people around the world have their own natural dyeing traditions to utilize natural resources available in the particular regions[1]. The common sources of natural dyes include (i) plant parts such as leaves, flowers, fruits, seeds, barks and roots, (ii) Prussian blue, red ochre and ultramarine blue from mineral origin, and (iii) lac cochineal and kermes from animal origin[2]. Plants, minerals and animals that are processed to produce a dye are known as dyestuff. Dyes are extracted from original dyestuff, usually in a heated water bath[3].

One of the major drawbacks of natural dyes is the poor affinity towards textile substrate under application. The concept of mordanting is found the remedy to improve dye affinity and the depth of shade as well[4]. Thus, natural dyes are made suitable to apply on cotton by mordanting. In the technique of mordanting, fabric is first treated with metal mordants, such as alum, tannic acid, copper sulphate, and ferrous sulphate, at warm condition for about half an hour. It ensures penetration of ions into interior of fibres. After application of mordant evenly on fabric, the mordanted fabric is immersed in natural dye extract where the dye and the mordant mutually interact and consequently coloring compounds are generated *in situ* in the fibres.

Using exhaust method of cotton dyeing with natural dyes, an uneven distribution of mordants takes place mostly. It is because of the dye's lack of affinity towards cotton. Moreover, during immersing of mordanted fabric into dye liquor, mordant from fabric gets migrated towards fabric surface or in solution and may change it's orientation within the fabric. It leads to development of an uneven shade after dyeing. This particular problem of uneven shades is more common with different combinations of dye and mordants.

One of the significant drawbacks of natural dyes is the poor wet fastness of dyed cotton. This is due to the fact that the dyed cotton loses its color in wet condition. This phenomenon is the consequence of breaking of coordinate bonds and thereby loss of color from the substrate. It adversely affects the depth of shade.

To overcome these drawbacks of natural dyes and dyeing, a novel concept of pad dyeing method is developed. In this method, the material is initially padded with mordants and then padded with extracted dye solution. After this process, the shade development is carried out in a steamer.

Experimental

In this study, 120 × 68 (EPI × PPI) plain woven, scoured and bleached 100% cotton fabric having

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156 g/m^2 was used for the experiments. Both warp and weft yarns were of 40^s count. The dyeing was carried out using both traditional exhaust method and pad dyeing method with natural dye "Palas" (*Butea monosperma*) and four different mordants, namely alum, tannic acid, copper sulphate and ferrous sulphate. Besides the variation in mordants, the comparative study was also conducted for the three mordanting techniques, such as premordanting, post mordanting and the simultaneous mordanting. Considering temperature as the main parameter in exhaust dyeing and comparing depth of colored fabric, the optimum temperature was decided. In case of the innovative padding technique, considering steaming time as the main parameter and comparing depth of colored fabric, the optimum time was decided.

Extraction of Dye

From a plant based dyestuff, flower petals of palas (*Buteamonosperma* Plant*)*, dye was extracted by soxhlet extraction. Firstly the dry palas (*Buteamonosperma*) petal mass was converted into powder form. 5 gm powder was put into the filter paper bag. The bag was placed in an extraction chamber, which was suspended above a flask containing 200 ml water as a solvent. The flask was heated to carry out solvent evaporation and the vapours moved up into the condenser where it was converted into a liquid that trickled into the extraction chamber containing the sample. When the level of liquid in the chamber rose to top of the siphon tube, the liquid contents of the chamber got siphoned into the flask. At the end of the process, after 8 cycles, the extraction of color from material gets stopped and pure water is circulated in this process[5]. This stage is an indicator of complete extraction of the colorant matter from the dyestuff with 4% yield.

Dyeing of Cotton

Exhaust Method

In exhaust dyeing method, premordanting, post-mordanting and simultaneous mordanting processes were carried out. Dyed samples were washed thoroughly and dried. The comparative study was conducted for four different mordants and three different mordanting methods, as discussed hereunder:

(i) Premordanting – In premordanting method, the cotton fabric was first treated separately with alum, tannic acid, ferrous sulphate and copper sulphate as mordant at 60˚C for 30 min. After this process, the fabric was dyed with the extracted solution by keeping material-to-liquor ratio 1: 20. The dyeing process was carried out at 60˚, 80˚ and 100˚C with the Rota dyer machine. Dyeing was carried out for 30 min duration. After the development of color shade on the fabric, fabric was removed, washed and dried.

(ii) Simultaneous mordanting – In this method, the mordanting and dyeing was carried out simultaneously in a Rota dyer machine at 60˚, 80˚ and 100˚C. Dyeing was carried out for 30 min by keeping material-to-liquor ratio 1:20. After the development of color shade, the dyed fabric was removed from the machine, washed and dried.

(iii) Postordanting – In this method, the cotton material was first dyed at 60˚, 80˚ and 100˚C by keeping material-to-liquor ratio 1:20 for 30 min and then treated with the mordants at 60˚C for 30 min. After the development of color shade, the treated fabric was removed from the machine, washed and dried.

Pad Dyeing Method

In pad dyeing method, pre-mordanting, postmordanting and the simultaneous mordanting processes were also carried out. The application of dye was done in a steamer at 100˚C and various time periods (5, 15 and 30 min). Finally, dyed samples were washed thoroughly and dried. Mordanting was carried out as per the following process:

(i) Premordanting – In this method, cotton fabric was padded with mordants and followed by padding with an extracted dye solution by keeping expression 100% in both the steps viz mordanting and dyeing. After the padding, for shade development, samples were steamed for 5, 15 and 30 min duration respectively. After the development of the shade, dyed fabric was removed, washed and dried.

(ii) Simultaneous mordanting – In this method, mordanting and dyeing was carried out simultaneously by padding method, keeping expression 100%. After this process, for the shade development, the samples were steamed for 5, 15 and 30 min duration respectively. After the development of the shade, dyed fabric was removed, washed and dried.

(iii) Postmordanting – In postmordanting method, fabric was first padded with dye solution and shade development was carried out in the steamer for 5, 15 and 30 min respectively. After this process, the dye

treated samples were padded with mordants. Finally the dyed fabric was washed and dried.

Results and Discussion

In exhaust dyeing method, an uneven distribution of mordants is observed because they do not have affinity towards cotton. We observe more uneven shades with some combination of dye mordant at 60˚, 80˚ and 100˚C. To overcome this problem, we innovatively implemented padding method with some combination of dye mordant for 5, 15 and 30 min duration time in curing of dyeing. Based on *K/S* values of dyed fabric for all the mordants – mordanting techniques, the optimum performance is observed for the two dyeing techniques. We find the optimum results at 80˚C temperature for exhaust method, while in case of padding method the optimum time for steaming is found to be 15 min. Besides qualitative improvement in dyeing, the additional advantage of the padding technique lies in time and energy saving as well. The results obtained from these two dyeing methods with different mordants-mordanting combination are discussed hereunder (Table 1).

In premordanting method, we find that the depth of shade in terms of *K/S* value is more in padding method as compared to that in exhaust method, showing the improving trend for different mordants as alum < tannic < copper sulphate < ferrous sulphate. In terms of wash and rub fastness test, padding method is better than exhaust method.

In case of simultaneous method, the depth of shade is almost the same for both exhaust and padding method with darker shade for ferrous sulphate mordant as compared to the other mordants. Wash and rub fastness ratings are nearly same for both exhaust and padding method; alum showing poor result than other mordanting agent.

For postmordanting process, as regards *K/S* values, the depth of shade is less than in premordanting, but better than in simultaneous mordanting method. Wash fastness results are almost the same for both exhaust and padding method, while the rub fastness in case of padding method is better than in exhaust method.

Figure 1 depicts that the padding method of dyeing is far superior over the exhaust method of dyeing. This may be due to enhanced and even migration of colorant on to the fabric during padding technique of dyeing. This is confirmed from the higher *K/S* values of the dyed fabric by the new technique as compared to the exhaust technique.

The padding method shows development of an even shade of the dye on cotton. In proposed padding technique, the depth of shade is significantly found better than that in the exhaust method. The pad dyeing technique also saves the energy as well as time as compared to exhaust method of dyeing. The padding method for dyeing of cotton using natural dye extract is therefore found to be promising one for obtaining even shades on the substrate to be colored. This gives rise to sustainable development through the use of

Table 1 — K/S and fastness rating

Mordant	Method	Exhaust method (80°C)				Padding method (15 min)			
		K/S	Wash fastness	Rub fastness		*K/S*	Wash fastness	Rub fastness	
				Dry	Wet			Dry	Wet
Alum	Premordanting	2.46	1-2	3-4	3	3.7	1-2	4-5	3
	Simultaneous mordanting	1.39	1-2	3	2-3	1.31	1-2	3	2-3
	Postmordanting	1.46	1 – 2	3	3	1.89	1-2	4-5	4
Tannic	Premordanting	3.09	2	4	2-3	3.79	2-3	4-5	3
	Simultaneous mordanting	1.77	2-3	4	3	1.8	2-3	3-4	3
	Postmordanting	2	2-3	3-4	4	1.98	2-3	4-5	4
Copper sulphate	Premordanting	4.5	2-3	3-4	3	6.34	3	5	3
	Simultaneous mordanting	1.5	3	4	3	1.82	3	4	3-4
	Postmordanting	1.85	2	4-5	3-4	1.9	2	5	3-4
Ferrous sulphate	Premordanting	7.45	2-3	3-4	3	9.15	3-4	5	3-4
	Simultaneous mordanting	1.89	3	4	3-4	1.92	2-3	4-5	3-4
	Postmordanting	3.34	2	4-5	3-4	3.77	2-3	4-5	4

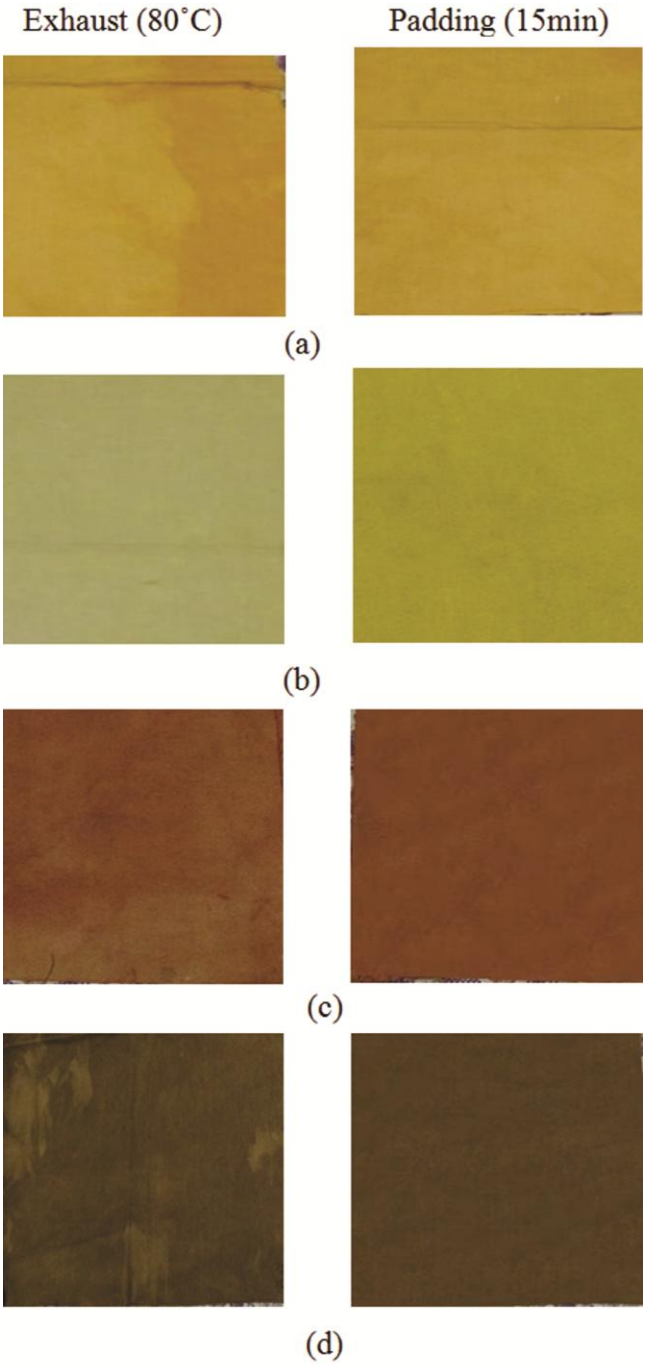

Fig. 1 — Dyeing quality comparison of exhaust method against padding technique for (a) alum, (b) tannic acid, (c) copper sulphate, and (d) ferrous sulphate

natural dyes making them viable alternate for their counterparts.

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