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Optimization of Discharge Printing Recipe on Cotton Fabric Dyed with Eco-Friendly Reactive Dye

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ABSTRACT

Decorating fabrics by dyeing and printing are very ancient arts, which in modern time have received considerable help from science and have shared in the forward surge of technology. Printing, a method of ornamentation employed first by ancient Indians and Egyptians, can be broadly classified on the basis of methods and styles. Textile printing is the process of applying colour to the fabric in a definite pattern or design. It may be regarded as a specialized technique of dyeing. The main idea of printing is to deliberate and control application of dye to exactly defined location on the fabric leaving the rest of the fabric essentially unaffected. In dyeing, colour is applied in the form of solution, whereas in printing, colour is applied in the form of a printing paste of the dye and thickener.

1. Introduction

Decorating fabrics by dyeing and printing are very ancient arts, which in modern time have received considerable help from science and have shared in the forward surge of technology. Printing, a method of ornamentation employed first by ancient Indians and Egyptians, can be broadly classified on the basis of methods and styles. Textile printing is the process of applying colour to the fabric in a definite pattern or design. It may be regarded as a specialized technique of dyeing. The main idea of printing is to deliberate and control application of dye to exactly defined location on the fabric leaving the rest of the fabric essentially unaffected. In dyeing, colour is applied in the form of solution, whereas in printing, colour is applied in the form of a printing paste of the dye and thickener.

Discharge printing is one of the printing style in which the printing operation takes place on a previously dyed fabric often called the 'ground' shade. The dyes used for the ground shade have to be carefully selected so that by applying a suitable print paste the dyed fabric will be permanently decolourised locally giving a 'white' discharge patterned effect. Discharge printing has the ability to make bright, opaque designs on the dark fabrics with a soft hand. Discharge style brings the patterns on the fabric by the chemical destruction of the original dye in the printed areas. Keeping in mind these facts in the present study an attempt was made to optimize the discharge printing recipe by optimising concentration of dye and discharging agent, for cotton fabric dyed with eco- friendly reactive dye and to assess the physical and colour fastness properties of printed samples.

2. Materials and Methods

Collection of raw materials: Reactive dye was used for the printing of cotton fabric as this dye is eco-friendly, easily dischargeable and has good affinity for cellulose fabric and is easy to discharge.

Pre- treatments of the fabrics

Before dyeing, the cotton fabric was desized and scoured to make the fabric free from starch and to make it free from impurities. The following recipes given by **Shenai (1990)** was used for desizing of fabric.

Sodium hydroxide	= 1g/litre
Detergent	= 2g/litre
M: L	= 1:30

Before dyeing, the entire length of fabric was soaked overnight in water to remove the natural impurities that may hinder the subsequent operation of dyeing and printing. The detergent and sodium hydroxide were added in a required amount of soft water as per the material liquor ratio (MLR) of 1:30. The fabric was dipped into the solution and boiled for 1 to 2 hours with occasional stirring. Then it was washed and rinsed thoroughly. Afterwards, the fabric was partially dried in shade and then ironed when half wet. The fabric finally was readied for dyeing.

Optimization of thickener concentration

Gum tragacanth was used as a thickener agent with five concentrations i.e. 15g, 20g, 25g, 30g and 35g. The paste for each concentration was prepared separately. For this the required amount of gum tragacanth powder was taken in a beaker. Small amount of water was added to make thick and uniform paste. After that the rest of the water was added to make the volume up to 100ml. The paste was kept overnight i.e. approximately 15-18 hours. After that in each beaker 2 percent dye and 10g Rongalite C was added to prepare printing paste. The samples were printed with each printing paste and kept for ten minutes. Each sample was then steamed for 5 minutes in a steamer at 100°C-102°C finally the samples were subjected to light rinsing to remove the thickener residual chemicals. The

samples were evaluated visually for the selection of one best concentration of thickener.

Optimization of dye concentration

Scoured fabric was dyed with reactive dye using the recipe given by **Shenai (2003).**

Reactive dye	= 1, 2, 3, 4, % (o.w.f)
Urea	= 50 % (o.w.f)
Glauber's salt	= 10 % (o.w.f)
Sodium carbonate	= 10 % (o.w.f)

The required amount of dye was mixed with a little amount of water to make a paste. Lukewarm water was added in the paste maintaining the material to liquor ratio 1:30. Urea and glauber's salt were added in this solution at 50°C and it was kept for boiling at 100°C. The fabric was added and kept for stirring for 10 minutes. Then sodium carbonate was added in the dye bath and dyeing was further carried out for half an hour. When the dye bath reached to the boiling point, the fabric was removed from the dye liquor and rinsed thoroughly in running water. Then the fabric was left to dry in shade. One best concentration of dye was selected on the basis of visual evaluation and colour fastness of dyed samples.

Optimization of concentration of Rangolit C

For the preparation of discharge printing paste by using Rongalite C a discharging agent the following recipe as given by **Shenai (2003)** was used.

Rongalite C	= 5, 10, 15, 20g
Gum Tragacanth (paste form)	= 50g
Zinc Oxide	= 10g
Egg Albumin	= 5g

The paste was prepared by mixing all the ingredients well and then the paste was printed on the cloth dyed with easily dischargeable reactive dyes by using screen printing technique. The printed fabric was kept for drying for ten minutes. It was then steamed for 5minutes in a steamer at 100-102°C. Finally the sample was subjected to light rinsing to remove the thickener and the residual chemicals and dyes decomposition product. The best concentration of Rongalite C was selected on the basis of clarity of design (sharpness and neatness), and whiteness index.

Physical testing of printed samples: Printed samples were tested and evaluated for various physical testing including:

Fabric thickness test:	ISI (IS 7702-1975)
Fabric stiffness test:	ISI (IS: 6490-1971)
Crease recovery test:	ISI (IS: 4681- 1968)
Fabric drape test:	ISI (IS: 8358-1968)

Computer Colour Matching: **Maulik (2006)**

Colour fastness of Printed sample: All the printed samples were subjected to various colour fastness properties including:

Colourfastness to light:	ISI (IS: 686- 1957)
Colourfastness to washing:	ISI (IS: 3361-1979)
Colourfastness to crocking:	ISI (IS: 766- 1956)
Colourfastness to perspiration:	ISI (IS 971-1956)

Visual evaluation of printed samples

To select the best sample of discharge printing with optimized concentration of discharging agent and dye concentration samples were evaluated visually by a panel of 30 judges including 10 staffs member and 20 students. The attributes assigned for evaluation were depth of shade, evenness of dye, clarity of design and overall appearance. Five point scales was used for the evaluation score. One, two, three, four and five were assigned for poor, fair, good, very good and excellent, respectively.

3. Results and Discussions

Optimized concentration of thickener

Gum tragacanth with various concentrations i.e. 15g, 20g, 25g, 30g and 35g were taken separately for preparation of discharging paste for applying on cotton samples that were already dyed with 2 per cent reactive dye. All the samples were discharged with these pastes and visual evaluated to select the best concentration of gum tracagant for preparation of discharging paste. The results are reported in Table 1. It was found that printed sample with 25g thickener was selected as best for reactive dye.

Table 1 Visual evaluation score of discharge printed samples (dyed with 2% reactive dye) for selection of concentration of gum tragacanth.

Gum tragacanth concentration(gm)	Average score
15g	3.25
20g	2.99
*25g	3.54
30g	2.95
35g	3.12

**Selected thickener concentration*

Twenty five grams concentration of gum tragacanth was selected as best for discharging the samples, because by using this concentration, gum tragacanth dissolves completely in water, giving a thick smooth paste. It enables the paste to remain on the surface of the fabric and yet fill in between the warp and filling yarn. It also produces smooth and sharp prints.

Optimized concentration of dye

Dye solutions for each dye concentration i.e. 1, 2, 3, 4 per cent were prepared separately using standardized recipe. The cotton samples were dyed with each solution and printed with discharge paste prepared by optimized concentration of gum tragacanth and evaluated visually and for colour fastness for selection of best dye concentration and results are reported in Table 2. It was found that sample dyed with 3 per cent reactive dye was selected as best for 25g gum tragacanth as dye concentration affect the evenness of dye on the printed samples. 3 per cent reactive dye was selected as best on the basis of scores obtained by visual evaluation, also the depth of shade was highest with this concentration.

Table 2: Visual evaluation score of printed samples for the selection of dye concentration

Thickener used	Dye concentrations (%)	Average score
Gum tragacanth (25g)	1%	3
	2%	3.5
	***3%**	**4**
	4%	3.8

**Selected dye concentration*

Optimized concentration of Rongalite C (discharging agent)

Rongalite C with various concentration i.e. 5g, 10g, 15g, and 20 g were taken separately for preparation of discharge printing paste for cotton samples. All the samples were subjected to visual evaluation to select the best concentration of Rongalite C for eco-friendly reactive dye. The results are reported in Table 3. It is evident from the table that the maximum average for Rongalite C concentration was scored by 20g. Hence it was selected as best for discharged printing on cotton fabric.

Table 3 Visual evaluation score of printed samples for the selection of conc. of Rongalite C.

Dye concentrations (%)	Rongalite C concentrations (gm)	Average score
3%	5g	3.06
	10g	3.6
	15g	3.5
	***20g**	**4**

**Selected Rongalite C concentration*

Physical properties of printed cotton fabric

Thickness of printed samples

It is evident from the table 3 that the thickness of discharge printing samples ranges from 0.33mm to 0.35mm with an average of 0.33mm. It was found that sample discharged with 20gm of Rongalite C concentration showed less thickness value i.e. 0.33mm, whereas sample discharged with 15g Rongalite C concentration showed maximum thickness value of 0.35mm. While comparing with other samples discharged with different concentrations of Rongalite C, it was observed that sample discharged with 20g Rongalite C showed better thickness value. This may be due to the accumulation of thickener and Rongalite C on the surface of the fabric.

Drapability of printed samples:

It was found that the drape coefficient of the discharged printed samples was ranged from 0.33 to 0.34 in all concentrations of Rongalite C. Samples discharged with 20g and 15g Rongalite C showed the minimum (0.33) drape coefficient whereas sample discharged with 5g and 10g Rongalite C showed maximum (0.34) drape coefficient. With the increase of Rongalite C concentration the drape coefficient of the fabric decrease and the fabric showed high drapability which is desirable property for apparels (Table 4).

Table 4: Various physical properties of discharged printed samples.

Reactive Dye concentration (%)	Rongalite C concentration (g)	Thickness (mm)	Drape coefficient	Stiffness (cm)		Colour Strength (K/S Value)	Crease recovery (angle)	
				Warp	Weft		Warp	Weft
3%	5g	0.33	0.34	3	2.7	1.94	92°	86°
	10g	0.34	0.34	2.92	2.94	1.93	90°	88°
	15g	0.35	0.33	2.9	2.68	1.95	93°	89°
	*20g	0.33	0.33	2.92	2.68	1.98	94°	92°

Stiffness of printed samples:

The stiffness of fabric was determined by measuring blending length of the samples both in warp and weft direction and the result are reported in Table 4. It was observed from the table that all samples discharged with different concentrations of Rongalite C showed similar bending length i.e. 2.9 cmto 3 cm in warp direction and 2.68cm to 2.94cm in weft direction. It was observed that bending length of all samples discharged with different concentrations of Rongalite C was more in warp direction than in weft direction.

Colour strength value of printed samples:

The K/S values were measured for all the discharge printed samples and the results are reported in Table 4. It is evident from the table that K/S value of all the printed samples was different with different concentration of Rongalite C. It was observed from the table that K/S value of samples discharged with 20g Rongalite C scored the highest value of 1.98 followed by sample printed with 15g Rongalite C (1.95) and the lowest value of 1.93 was scored by 10g Rongalite C.

Crease recovery of printed samples:

All printed samples were subjected to crease recovery test and the results are reported in Table 4. It is evident from the table that all samples discharge with different concentration of Rongalite C showed high crease recovery in warp direction. It was observed from the table that samples discharge with 20gRongalite C showed highest angle in warp direction (94°) and(88°) in weft direction, whereas samples discharge with 5g Rongalite C showed less angle in warp direction (92°) and (86°) in weft direction. With the increase of Rongalite C concentration crease recovery angle also increased.

Colour fastness of printed cotton fabric:

All the printed samples were subjected to various colour fastness testing such as light, washing, crocking and perspiration and the results are reported in Table 5.

Light fastness of printed samples:

This test measures the resistance to fading of dye or printed textiles when exposed to daylight. It is evident from the table that light fastness of all the samples dyed with all dye

concentrations and printed with gum tragacanth showed excellent (7) colourfastness against sunlight.

Washing fastness of printed samples:

For colour fastness of washing the samples were rated on the basis of change in colour as well as degree of staining on adjacent cotton fabric. Table 5 clearly reveals that the printed samples showed changes in colour between 4 to 5 i.e. slightly to negligible while the colour staining of the adjacent cotton fabric was found to be noticeable to slight (3 - 4).

In case of sample printed with 1 per cent reactive dye concentration, change of colour and colour staining was found to be good (4). Samples printed with 2 per cent reactive dye concentration showed minimum (4/5) change in colour, similarly staining on the adjacent cotton sample was also found to be slight (4). However 3 per cent reactive dye concentration showed negligible (5) change in colour and slight staining (4) on the adjacent cotton sample. The colour change of sample printed with 4 per cent dye concentration was found to be slightly to negligible (4/5) and staining on the adjacent cotton sample was found to be noticeable to slightly stained (3/4). From the overall readings, it was found that 3 per cent reactive dye showed best results compared to other concentrations. Further increase in concentration of dye showed heavy staining on adjacent cotton samples.

Perspiration fastness of printing samples

All the cotton samples printed with different dye concentrations were rated for colour fastness to perspiration for both acidic and alkaline, with respect to change in colour and degree of staining on cotton and the results are reported in Table 5.

From the table it was observed that 3 per cent reactive dye concentration showed good (4) to excellent (5) results for change in colour and colour staining on the adjacent cotton fabric in alkaline perspiration solution whereas in acidic perspiration solution it showed excellent (5) change in colour and in colour staining of the adjacent cotton samples. In case of samples dyed with 1 per cent dye concentration, colour change and colour staining was found to be good (4) in alkaline perspiration solution and in acidic solution it was found to be moderate (4/5) change in colour and slightly staining on the adjacent cotton sample.

It was found that between the two perspiration solutions, the results of acid perspiration solution were better than the alkaline perspiration. Also the staining on cotton fabric was found to be less for acidic perspiration solution than alkaline perspiration solution. While comparing the various dye concentrations for reactive dye using gum tragacanth it was found that 3 per cent dye concentration showed good results as compared to 1, 2 and 4 per cent.

Crocking fastness of printing samples

All the printed samples were rated for colour fastness to crocking in both wet and dry conditions with respect to change in colour and staining on cotton test sample. The results are reported in Table 5. It is evident from the table that in case of change in colour, samples printed with various dye concentration showed excellent (5) fastness in dry crocking and fair (3/4) to excellent in wet crocking. In case of staining on adjacent cotton, it was observed that all the dyes concentrations showed slightly (4/5) to negligible (5) colour staining in dry crocking fastness however in case of wet crocking there was noticeable (3/4) to negligible (4/5) staining on cotton samples. While comparing various dye concentrations using gum tragacanth it was found that the crocking fastness results of all the printed samples were good.

4. Conclusion

It is concluded that 25g concentration of gum tragacanth and 3 per cent concentration of reactive dye with 20g Rongalite C produced best results in terms of clarity in design, and colourfastness properties. The standardised discharge printing recipe may be commercialize for the production of various utility articles as the used of gum tragacanth is safe because it is a natural thickener; it does not caused any health hazards. The discharge printing recipe can be optimized for other fabrics such as silk and other synthetic fabric.

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Discharge printed prepared Articles