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Study on Discharge Printing of cotton fabric using Catalase Peroxidase Enzyme

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A B S T R A C T

This study was under taken to optimize the variables of discharge printing of cotton fabric. Four variables of printing process namely pH, enzyme concentration, temperature and steaming time were optimized. Printed samples were visually evaluated by panel of judges on the basis of whiteness of the motifs and sharpness of the outline of the motifs. All the testing were assessed after optimization of printing variables. It was found the best discharge print on cotton fabric was obtained by catalase enzyme as a discharging agent. It was assed that optimum amount of pH was 7, enzyme concentration was 120g/kg at 70˚C within 40 min of steaming time. .This work has been done to avoid Sodium sulphoxylate formaldehyde which has been successfully replaced by Catalase enzymes in discharge printing.

K E Y W O R D S

Catalase peroxidase | discharge printing | cotton | reactive dye | Hand screen

C I T A T I O N

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Introduction

Printing is use to add color in localized area only. Printing allows for great design flexibility and relatively inexpensive pattern fabric. Pattern can be achieved with printing that is not possible with any other method. Dyed fabric can be printed after referred to as over printing (Kadolph, 1999).

Printing applications by screen printing are of great importance with the increased concernment of small lot production and fashion related products due to the severe competitive conditions of the textile industry. Discharge printing method is one of the popular techniques in these application due to the aesthetic attractiveness. Discharging agents are used to obtain discharge printing. The compounds used to destroy the ground shade are called discharging agent. Discharging agent cannot be used alone on fabric so thickening agents are also used in printing. Discharge printing is usually done on dark back ground. Discharge style can be obtained by applying some chemical reagents to a desired pattern and predetermined area to remove ground color. Discharge printing with enzymes has good demand in the market, but no suitable method has yet been established till date. Sodium sulphoxylate formaldehyde is the strongest reducing agent commonly used for discharge printing, but it is not well accepted due to the nature of the compound liberating formaldehyde that causes pollution in the environment while steaming.

Enzymes are widely used in the textile industry because it operates under mild conditions of temperature and pH, it replaces non-selective chemicals. Enzymes are specific *i.e.* they control only one particular chemical change. Enzymatic discharging printing carried out with Phenol oxidizing enzymes such as Peroxidase with hydrogen peroxide by selectively discharged reactive dyes from the cotton fabric at selected areas creating a printed surface.

The project work is based on finding out an effect of enzymatic discharge printing on cotton fabric.

Reactive dyes are extensively used in textile industries worldwide for dyeing of cotton fiber, mainly because of characteristics such as better dyeing processing, bright colors and reducing the energy consumption. The dyes are adsorbed on cellulose by covalent bonding (Paul *et al*., 2013).

Materials and methods

Materials

Plain woven cotton fabric having thread count of 38 warps and 43 wefts per inch was used as the substrate for dyeing and enzymatic discharge printing. The parameters of cotton fabric are given in Table 1.

Fabric	Fabric count		Thickness	Weave
100% Cotton	Warp	Weft	0.30	Plain weave
	38	43		

Table 1: Parameters of cotton fabric

Dyes and chemicals

The following chemicals were used for dyeing and enzymatic discharge printing on the cotton fabric. The details of the dye and the chemicals used are given in Table 2.

S. No.	Dye and chemicals	Functions
1.	Reactive Brown	Dyeing
2.	Glauber Salt	Exhaustion agent
3.	Sodium Carbonate (Na_2CO_3)	Fixing agent
4.	Guar gum	Thickner
5.	Catalase Enzymes	Discharging agent
6.	Zinc Oxide	Thickening agent
7.	Egg albumin	Fixing agent

Table 2: Functions of the dye and chemicals used

Methods

Dyeing

Dye paste was prepared with wetting agent. The dye bath was set at 40˚C with the dye. The fabric was put into a dye bath and worked for 10 minutes. The temperature of dye bath is raised to 50˚C and first instalment of sodium chloride was added. After 10 minutes' temperature was raised till at 60˚C and second instalment of sodium chloride was added. After 10 minute, the temperature of the dye bath was maintained to 40˚C -60˚C and third instalment of sodium chloride was added. After 10 minutes temperature was raised till to 75˚C and fourth installment of sodium chloride and first installment of sodium carbonate was added. After 10 minutes at 80˚C second installment of sodium carbonate was added. After 30 minute at boiling third instalment of sodium carbonate was added. After it, fabric was rinsed and dry at room temperature (Shenai, 1999). The process conditions for dyeing are given in Table 3.

S. No.	Specification	Amount
1.	Dye Percentage (%)	9
2.	Material Liquor Ratio	1:30
3.	Dyeing temperature	40˚C to boiling
4.	Glauber's salt	60gpl
5.	Na_2CO_3	20gpl
6.	pH	10-11
7.	Time of dyeing	80 min
8.	Fixation time	20 min
9.	Wetting agent	For preparing paste

Table 3: Process conditions for dyeing

Discharge printing

The cotton samples were printed with a printing paste using a hand screen printing technique according to the recipe below (white discharge printing):

Printing Recipe

- Catalase Peroxidase: 100, 110, 120, 130 and 140 g/kg
- Guar gum: 20 g
- Egg albumin: 5 g
- Zinc oxide: 10 g
- Water: as per requirement

The printed cotton samples were allowed to dry at ambient conditions and were left at oven for 60 minutes at 70˚C.

Steaming

After the sample was died, it was rolled along with the paper and grey fabric then tied it with thread to avoid the water to enter inside the sample and it was placed on steamer. Steaming was for 40 mins.

Washing

Samples removed from the steamer were untied and laid flat on the bed for 5 mins and then samples were thoroughly rinsed in clean water for 1-2 mins then the samples were allowed to dry and then ironed.

Testing Methodology

After the printing on samples, enzymatic printed on the samples were collected and tested for the following experiments using standard test methods. The testing methods and instruments used are given in Table 4.

S. No	Property	Standards	Instrument used
1.	Tearing strength	ASTM	Elemdrorf tearing tester
2.	Stiffness testing	IS 6490: 1971	Fabric Stiffness tester
3.	Crease recovery		Shirley Crease Recovery tester
4.	Color fastness to rubbing	AATCC	Crockmeter

Table 4: Testing methods and instruments used

Results and discussion

The catalase peroxidase enzyme was used in this study instead of a toxic reducing agent, *i.e.* formaldehyde sulphoxylate, which can release formaldehyde, known to be human carcinogen, under a variety of conditions. The effect of enzyme concentration, pH, temperature and steaming time on white discharge printing performance was studied. Different testing was used in this study which was considered to evaluate the efficiency of the discharging effect of catalase peroxidase under various conditions. Various parameter was studied in this project to optimize enzyme activity, pH, temperature and steaming time in discharge printing.

Optimize the effect of pH

Fabric sample were printed with five different pH value. Weighted mean score obtained by each sample is given in Table 5.

Fabric	pH Value	Weighted Mean Score	Rank
Cotton	**7***	**4.26***	**I**
	7.5	3.83	IV
	8	3.86	III
	8.5	3.90	II
	9	3.40	V

*selected pH

Table 5: Effect of pH

Table 5 indicates that sample printed with Catalase enzyme with pH 7 obtained highest weighted mean score *i.e.* 4.26 whereas sample printed with printing paste having value of pH 7.5 obtained mean score is 3.83, pH 8 is 3.86, pH 8.5 is 3.90, and pH 9 is 3.40 respectively. Print was found to be most sharpness of outline and whiteness of the outline of the motifs among all the printed sample, when it was printed with pH 7. Therefore, pH 7 was selected as most suitable pH for carrying out further experiments.

Optimize the effect of Enzyme concentration

Fabric sample were printed with printing paste having five different concentration of Catalase enzyme *i.e.* 100,110, 120, 130 and 140g/kg. Weighted Mean score obtained by each printed sample given in Table 6. Further, Table 6 indicates that sample printed with Catalase enzyme with 120g/kg obtained highest weighted mean score *i.e.* 4.13 whereas remaining sample printed with printing paste having enzyme concentration 100/kg obtained mean score is 3.53, 110g/kg is 3.66, 130g/kg is 3.83 and 140g/kg is 3.60 respectively.

Fabric	Enzyme concentration (g/kg)	Weighted Mean Score	Rank
Cotton	100	3.53	V
	110	3.66	III
	120*	**4.13***	**I**
	130	3.83	II
	140	3.60	IV

*selected enzyme concentration

Table 6: Effect of enzyme concentration

Sharpness of outline of motifs and whiteness of motifs was found to be most clear among all the printed samples. When it was printed with enzyme concentration 120g/kg. Therefore, 120g/kg concentration of enzyme was selected as optimum enzyme concentration for carrying out further experiments.

Optimize the effect of Temperature

Fabric sample were printed with the enzymatic white paste, after printing the sample were subjected to drying at different temperature *i.e.* 60˚C, 70˚C, 80˚C, 90˚C and 100˚C. Weighted Mean score obtained by each printed sample given in Table 7.

Fabric	Temperature	Weighted Mean Score	Rank
Cotton	60˚C	3.36	IV
	70˚C*	**4.03***	**I**
	80˚C	3.83	III
	90˚C	3.93	II
	100˚C	3.30	V

*selected drying temperature

Table 7: Effect of temperature

It can be observed in the Table 7 that, the temperature 70˚C obtained highest Weighted Mean Score *i.e.* 4.03 whereas sample drying at temperature 60˚C is 3.36, 80˚C is 3.83, 90˚C is 3.93 and 100˚C is 3.30 respectively. Prints was found to be most sharp outline of the motifs and whiteness of the motifs among all the printed sample, when it was drying at temperature 70˚C. The above observation indicates that 70˚C is the optimum temperature.

Optimize the effect of steaming time

Fabric sample were subjected to steaming process for various intervals of time *i.e.* 30min, 40min, 45min, 50min and 60min in order to determine the optimum steaming time. Weighted mean score obtained by each printed sample given in Table 8.

Fabric	Steaming time	Weighted Mean Score	Rank
Cotton	30min	3.40	IV
	40min*	**3.90***	**I**
	45min	3.30	V
	50min	3.83	II
	60min	3.53	III

*selected steaming time

Table 8: Effect of steaming time

It can be observed in the Table 8 that, the steaming time 40min obtained Weighted mean score *i.e.* 3.90 whereas sample printed with printing paste having steaming time 30min is 3.40, 45min is 3.30, 50min is 3.83 and 60min is 3.53 respectively. Print was found to be most sharp outline of the motifs and whiteness of the motifs among all the printed sample, when it was steamed at 40 min. The above observation indicates that 40min is the optimum steaming time.

Tearing strength

The printed sample were tested using Elemdrorf tearing tester; the results of these tests on the fabric tearing strength value (warp and weft) of the samples are given in Table 9.

S. No.	Sample code	Mean Tearing Strength		Loss or gain over original sample	
		Warp	Weft	Warp	Weft
1.	COS	53.2	81.4	0.0	0.0
2.	CDS	47.7	65.5	-5.5	-15.9
3.	CEPS	45.3	60.7	-7.9	-20.7

*COS – Cotton original sample; *CDS – Cotton dyed sample; *CEPS – Cotton enzymatic printed sample

Table 9: Tearing strength result - warp and weft

Stiffness

The printed sample were tested using Fabric Stiffness tester; the results of these tests on the fabric stiffness value (warp and weft) of the samples are given in Table 10.

S. No.	Sample	Mean Stiffness		Loss or gain over original sample	
		Warp	Weft	Warp	Weft
1.	COS	1.92	2.64	0.0	0.0
2.	CDS	1.24	1.62	-0.68	-1.02
3.	CEPS	1.21	1.32	-0.71	-1.32

Table 10. Stiffness test result-warp and weft

Crease recovery

The printed sample were tested using Shirley Crease Recovery tester; the results of these tests on the fabric crease recovery value (warp and weft) of the samples are given in Table 11.

Conclusion

Discharge printing is a method where the pattern is produced by the chemical destruction of the dye in printed areas. The discharging agents used can be oxidizing or reducing agents, acids, alkalis and various salts. But, most important methods of discharging are based on sulphhoxylates formaldehyde.

S. No.	Sample	Mean Crease recovery		Loss or gain over original sample	
		Warp	Weft	Warp	Weft
1.	COS	103˚	118.2˚	0.0	0.0
2.	CDS	100.4˚	109.2˚	-2.6	-9
3.	CEPS	98˚	104˚	-5˚	-14.4˚

Table 11. Crease recovery result – warp and weft

The optimum conditions for using the Catalase enzyme (peroxidase) formulation were found to be pH is 7, temperature is 60˚C, enzyme concentration is 120 g/kg and steaming time is 40 min. Other samples require steaming to get the optimum result. It is also observed that the fabrics are kept in air for 1 hour after discharge printing, discharge effects become pronounced without steaming. This is another achievement of the work for them who have no proper steaming infrastructure and it is having also a fuel saving aspect.

By using the peroxidase enzyme discharge printing method, the following advantages were observed: -

- Elimination of formaldehyde
- Energy saving
- Environmentally friendly
- Reduction of strength loss

This study aims at using Catalase enzyme to replace the sulphoxylates formaldehyde. A study on discharge printing of cotton fabric using Catalase enzymes is discussed and evaluated and it is observed that discharge paste of Catalase enzyme is better. It can be replaced instead of paste containing hazardous sulphoxylates formaldehyde.

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