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Studies on Environmental Burdens in Reactive Dyeing of Cotton Fabric Pretreated with Cationic Agent

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Abstract

In this research, Pretreatment of cotton fibre using fixative agents before dyeing is investigated for environmental burdens. The dyed fibres were tested for fastness properties and found to be acceptable for light, wash and rub fastness. Three reactive dyes namely Procion H Yellow, Leva fix rose and FN blue dyes were used to dye the cotton fabric. Albafix WFF which is a fixative agent was used for pretreatment. The effluent of dye bath after the treatment were analyzed for BOD, COD and TDS for assessing the environmental burdens. Change in colour and staining were investigated. Wash fastness, Rub fastness and light fastness were studied for both dyeing process of pretreatment with Albafix WFF and without pretreatment. The fibres were dyed with and without pretreatment for comparison. The results show the use of pretreatment considerably reduces the BOD, COD and TDS while achieving the acceptable levels of wash fastness, Rub fastness and light fastness. The dyeing was carried out under optimal conditions which was arrived by trial and error and found to be 70^0C and 20% concentration

Keywords: Pretreatment, cotton fibre , dyeing , Albafix WFF Process

INTRODUCTION

Cotton is a fibre obtained from the seeds of the cotton plant. It is well known for utilization in textile industries and the use of cotton for fabric dates back to prehistoric times. Cotton dyeing is the process of imparting colour to the fibre by using natural or synthetic dyes. In order to avoid the environmental effects due to reactive dyeing pretreatment of cotton is often carried out.

For enhancing the dyeability of different fibres chemical and enzymes such as keratin etc have been added during pretreatment of fibre just before the dyeing process. Arju et al (2015) discussed a new technique for reactive dye uptake by jute fabrics. They used mixture of Albafix Wff (poly – diallyl dimethyl ammonium chloride) and sodium hydroxide to improve the dyeability of jute fibre.

Kantouch et al (2012), have studied the effect of pretreatment of wool fabric with keratin on its dyeability with acid and reactive dyes and showed enhanced dyeability with acid and reactive dyes. Bhuiyan et al (2014) studied the cationization of cotton fibre using Chitosan and its effect on dyeability. They confirm that the cationization resulted in higher absorption of reactive dye. Acharya et al (2014) have studied the Chemical cationization of cotton fabric for improved dye uptake using (3-chloro-2-hydroxylpropyl) trimethyl-ammonium chloride (CHPTAC)

Effects of dyeing process parameters were studied for different fibres suh as Nylon, Wool, Silk, acrylic and cotton by Arora and Rastogi (2012)using natural dyes extracted from Arnebia nobilis Rech.f Shahin (2015) studied the Influence of Cationization on the Dyeing Performance of Cotton Fabrics with Direct Dyes and conclude that dyeability of cotton is increased achieving good colour strength with less quantity of dye used thus reducing the environmental impacts. Pretreatment of cotton by cationization before dyeing will reduce the environmental impacts of dyeing of cotton using reactive dyes. Role of reactive dye and chemicals on mechanical properties of jute (Arju et al, 2013)

S. Rattanaphani et al (2007) have conducted studies on lac dyeing with different concentrations on cotton pretreated with chitosan. The pretreatment experiments have significantly improved the dye uptake on the cotton compared to the lac dyeing without doing pretreatment.

S.M. Burkinshaw et al (2000) studied the use of pretreatment of cotton with dendrimers and suggests that colour strength of the cotton can be enhanced by the pretreatment. A.A. Haroun and H.F. Mansour, presented that cationisation of leather and wool improves the depth of the obtained prints as well as washing and light fastness properties. The reactive dyes are the best for cotton dyeing due its wide range of application and better fastness properties. However, all the reactive dyeing systems require huge amount of electrolyte and alkali to exhaust and fix the dye respectively. These electrolytes are neither exhausted nor destroyed and hence remain in the dye bath after dyeing. Even with the use of salt in the normal dyeing systems only 60-65 % dye utilization is attainable.

Thanikachalam @ al (2017,2018), have indicated to prepare the sample methods with weight ratio and volume ratio.

In this work, an attempt has been made to optimize the process, conditions required to cationize the cotton with Albafix WFF cationizing agent. Also the influence of process variables on the cationization efficiency is studied.

MATERIALS AND METHODS

Material

In this research work the following materials were used for dyeing experiments.

Fabric:

100% grey cotton fabric was used in the work and its warp and weft counts are 40. The properties namely ends per inch EPI, Pichs per inch (PPI), Grams per square meter(GSM), Warp and Weft counts of the cotton fabric is shown in the Table 1.

Table 1. Properties of cotton fabric

Fabric	EPI	PPI	GSM	WARP COUNT	WEFT COUNT	THICKNESS (mm)
Grey cotton	92	88	115	40	40	0.18

DYES AND CHEMICALS

Vinyl sulphone reactive dyes supplied by M/s Colourtex namely Levafix rose dyes, Procion H yellow and FN blue dyes were used throughout this research work. ALBAFIX WFF (a Polyamino Chlorohydrins Quaternary Ammonium Compound) from Alba Specialty chemicals was used as a cationic fixing agent.other chemical used in this work are Sodium Hydroxide,Sodium Chloride, Sodium Carbonate, Sodium Silicate, Acetic acid, Sulphuric acid and Hydrogen peroxide of laboratory grade along with a commercial non- ionic wetting agent and a desizing enzyme.

PREPARATION OF FABRIC:

Desizing:

The grey fabric was desized using 2% enzyme. The process is carried out under acidic condition in the temperature range of 60-70°C for 4 hours in a laboratory dyebath. The enzyme was deactivated by boiling at 95°C for 30 minutes and the degraded starch products were thoroughly washed out.

Scouring:

The fabric was scoured using the above recipe in a laboratory dyebath at boiling temperature for 2 hours. Then the fabric was given a hot wash and a cold wash.

Bleaching:

The fabric was bleached with hydrogen peroxide 2 times by volume of fabric at 85-95°C in dyebath at pH 10.5-10.8 buffed with sodium hydroxide and stabilized with sodium silicate for 2 hours. Then the fabric was given a wash, neutralized with 0.5% sulphuric acid and washed thoroughly.

CONVENTIONAL DYEING:

The bleached fabric was dyed with vinyl sulphone reactive dyes for 2% shade. The laboratory- dyeing machine Rota dyer with the liquor ratio of 1:30 was used throughout this work. The fabric was introduced at room temperature. 1 g/l non-ionic surfactant (Alcox 200), dye solution and half of 50 g/l salt were added and the temperature was raised to 60oC in 30 minutes. Remaining salt was added and the dyeing was continued at 60oC for another 30 minutes. Then 2 g/l NaOH and 10 g/l soda ash were added in the bath and the dyeing was continued for another 45 minutes. The fabric was rinsed at 50oC for 3 times for 20 minutes each, neutralized with 2.5 g/l acetic acid for 30 minutes and hot soaped at 60oC for 30 minutes.

CATIONIZATION OF COTTON FABRIC:

Design matrix for Cationization Pretreatment

1. 1. Concentration of Albafix WFF used are - 1% , 2% and 3% (On Weight of the Fabric)
2. Temperature of treatment bath-50-70 oC
3. Concentration of soda ash –5-15 g/l

Cotton fabric was cationized using the exhaust method. Cationization was carried out in a laboratory dyebath with a Material: Liquor ratio of 1:30.Cationization was carried out with varying concentration of Albafix WFF, concentration of soda ash and the temperature as given in the design matrix to find out the optimum conditions for cationization treatment. Cationization was carried out with the above temperature for 2 hour. Then Sodium carbonate was added to raise the pH to 9 and continued for another 2 hour. Then the fabric was neutralized and washed thoroughly.

DYEING OF CATIONIZED COTTON:

The cationized fabric was dyed in dye bath with Material: Liquor Ratio of 1:30 using vinyl sulphone reactive dyes with I g/l non- ionic wetting agent. The fabric was introduced and the temperature was raised at the rate of 1°C per minute to 60°C and the dyeing was continued for further 45 minutes at this temperature. Then the fabric was soaped with 5 g/l soap and 1 g/l Soda ash at 60 oC for 30 minutes. No salt and no alkali were added during dyeing.

TESTING OF WASH FASTNESS:

The dyed samples were tested ar per ISO Test No.3(1S:764-1979) for wash fastness. A specimen of 10 X4 cm was sandwiched between a cotton fabric and sample fabric and sewn along all four sides to form a composite specimen. Washing solution containing 5g/l soap and 2g/l sodium carbonate was taken in the Landro Meter with a liquor ratio of 1:50. The specimen was treated for 30 minutes at 60+2°C at the speed of 40 revolutions per minute. The specimen was removed and rinsed twice in cold water. The stitch was opened on three sides and dried in shadow.

The change in color and degree of staining was evaluated using geometric grey scales.

TESTING OF RUBBING FASTNESS:

IS: 766-1956 method was followed to measure the rubbing fastness. For dry rubbing, a specimen of 14 X5 cm was mounted on the crock meter. Undyed bleach cloth was mounted on the tip of the finger. The crock meter was operated to rub the specimen in a straight line along a track of 10cm long for 10 times in 10 seconds with a downward force of 900 g.

For wet rubbing, the undyed bleach cloth was soaked in water to have 100% expression and mounted on the tip of the finger. After rubbing, the degree of staining on the un dyed fabric was evaluated using grey scales.

TESTING OF LIGHT FASTNESS (IS: 2454-1967)

The fabric sample of 1 X 4.5 cm was exposed to UV lamp of light fastness tester along with standard blue wool samples (with ratings from 1 to 8) with an opaque cover across the middle third of them. Frequently the cover was lifted noted the color change. When the color change was just perceived, the standard blue wool with the similar color change was noted and the preliminary light fastness rating was assessed. The exposure was continued until the contrast between the exposed and un exposed areas was equal to grey scale rating; 4. Then the second one third of the test specimen was covered with opaque cover and the exposure was continued until the contrast equals grey scale rating 3.

The rating of the blue wool standard showing the similar change of sample after exposure was the light fastness rating of the sample.

TESTING OF EFFLUENT:

Determination of BOD:

BOD (Biological Oxygen Demand) is a measure of the polluting efficiency of water. Oxygen is demanded in effluent for the oxidation of inorganic and organic matter. Demand of oxygen by the organic matter is known as BOD. The BOD is defined as the amount of oxygen required to carry out the biological decomposition of dissolved solids under aerobic conditions at standard temperature.

In a 500 ml BOD bottle, 5 ml sample, 1 ml each of four standard buffer solutions (phosphate buffer, magnesium sulphate buffer, calcium chloride buffer and ferric chloride buffer), 1 ml seed (domestic waste water) were taken and diluted with distilled water. The dissolved oxygen was found immediately (Blank-A) by iodimetric titration. Another sample was prepared as above and incubated at 27 oC for 3 days and then the dissolved oxygen was found (sample value-B)

$$\text{B.O.D in mg/l} = (A - B) \times \text{dilution factor}$$

Determination of C.O.D:

COD is a measure of the oxygen required to oxidize unstable materials in a sample by means of dichromate in an acid solution. It was determined as followed. 20 ml of sample and 10 ml of acidified potassium dichromate solution O.25N, one pinch of mercuric sulphate and 1 glass bead were taken. 30 ml of COD acid (4g silver sulphate in 1 liter of concentrated H2SO4) was added through condenser in an ice bath. The mixture was placed in a COD digestion apparatus for 2 hours at 1500C. It was taken out, rinsed and cooled in ice bath. 3 drops of Ferroin indicator was added and titrated against 0.1N ferrous ammonium sulphate (FAS). End point was reached when the solution appeared wine red. The same procedure was repeated for blank.

Determination of T.D.S:

The Total Dissolved Solids in the effluent was determined as per the formula given below. 100 ml of filtered effluent was taken in a pre-weighed evaporating dish. The effluent was evaporated and the residue was weighed.

$$\text{TDS} = [\,(A-B) * 1000] / \text{ml of sample}$$

A= Weight of Evaporating Dish + Residue

B= Weight of the Evaporating Dish

RESULT OF COLOUR FASTNESS

WASHING FASTNESS RESULT RATING FOR NORMAL DYEING PROCESS

Table: 3.1 Result of washing fastness test in normal dyeing process

S.NO	Procion H yellow		Levafix Rose		FN Blue	
	Change in Colour	Change in Stained	Change in Colour	Change in Stained	Change in Colour	Change in Stained
1% of yellow	4	3-4	3	3-4	3	4-5
2% of rose	3	3-4	4	4-5	4	3-4
3% of blue	4	4	4	3-4	4	4

RUBBING FASTNESS RESULT RATING FOR NORMAL DYEING PROCESS

Table 3.2: Result of rubbing fastness test in normal dyeing process

S.NO	Procion H yellow		Levafix Rose		FN Blue	
	DRY RUB	WET RUB	DRY RUB	WET RUB	DRY RUB	WET RUB
1% of yellow	4	3-4	3	3	3-4	4
2% of rose	3-4	3	4	4	4	3-4
3% of blue	4	4	5	3-4	4	4

LIGHT FASTNESS RESULT RATING FOR NORMAL DYEING PROCESS

Table: 3.3 Result of light fastness test in normal dyeing process

S.NO	Procion H yellow		Levafix Rose		FN Blue	
	Change in Colour	Change in Stained	Change in Colour	Change in Stained	Change in Colour	Change in Stained
1% of yellow	3	4	4-5	4	3-4	4
2% of rose	3-4	3-4	4	4-5	5	3
3% of blue	5	4	3-4	3	3-4	3-4

RESULT OF CATIONIC AGENT OF COLOUR FASTNESS TEST

WASHING FASTNESS RESULT RATING FOR CATIONIC DYEING PROCESS

Table 3.4: Result of washing fastness test in cationic dyeing process

S.NO	Procion H yellow		Levafix Rose		F N Blue	
	Change in Change in	Colour Stained	Change in Change in	Colour Stained	Change in Change in	Colour Stained
1% of yellow	4-5	3-4	3-4	4	3	4-5
2% of rose	4	4	4-5	5	5	4
3% of blue	4	4-5	5	3-4	4	5

RUBBING FASTNESS RESULT RATING FOR CATIONIC DYEING PROCESS

Table 3.5: Result of rubbing fastness test in cationic dyeing process

S.NO	Procion H yellow		Levafix Rose		FN Blue	
	DRY RUB	WET RUB	DRY RUB	WET RUB	DRY RUB	WET RUB
1% of yellow	4	4	4	4	4	5
2% of rose	5	3	5	5	4	3-4
3% of blue	4-5	5	5	4	5	4

LIGHT FASTNESS RESULT RATING FOR CATIONIC DYEING PROCESS

Table 3.6: Result of light fastness test in cationic dyeing process

S.NO	Procion H yellow		Levafix Rose		FN Blue	
	Change in Colour	Change in Stained	Change in Colour	Change in Stained	Change in Colour	Change in Stained
1% of yellow	5	4	5	4	3-4	4
2% of rose	4	4	4	4-5	4	3-4
3% of blue	3-4	5	3-4	4	4	4

RESULT OF TENSILE STRENGTH TESTER

RESULT OF TENSILE STRENGTH TESTER FOR PROCION H YELLOW DYE FABRIC

Table 3.7: Result of tensile strength test for Procion H yellow dye fabric

Tensile strength in Kg				
	Normal dye fabric		Cationic dye fabric	
S.No	Warp way	Weft way	Warp way	Weft way
1	14.2	6.8	15.4	7.8
2	14.4	8.2	15.6	7.2
3	12.8	4.8	14.3	6.1
Avg,	13.08	6.6	15.1	7.1

RESULT OF TENSILE STRENGTH TESTER FOR LEVAFIX ROSE DYE FABRIC

Table 3.8: Result of tensile strength test for Levafix rose dye fabric

Tensile strength in Kg				
	Normal dye fabric		Cationic dye fabric	
S.No	Warp way	Weft way	Warp way	Weft way
1	14.4	5.4	16.4	6.9
2	14.9	6.2	13.9	7.5
3	11.8	3.8	13.7	5.1
Avg,	13.28	4.7	14.6	6.5

RESULT OF TENSILE STRENGTH TESTER FOR FN BLUE DYE FABRIC

Table 3.9: Result of tensile strength test for FN blue dye fabric

Tensile strength in Kg				
	Normal dye fabric		Cationic dye fabric	
S.No	Warp way	Weft way	Warp way	Weft way
1	13.2	7.8	15.4	8.9
2	15.4	6.0	13.8	7.5
3	14.8	5.6	14.7	6.1
Avg,	14.2	6.1	14.8	7.5

EFFECT ON COLOUR FASTNESS TEST

The wash, rubb and light fastness of normal reactive dyeing in cotton fabric is some result rates on very fine good and more result rates on good. The rate of Grey scales for staining and colouring – 5-excellent, 4- very fine, 3-fine, 2-poor, 1-very poor

The average rates for change in colour and staining is 3-4 for all shades of normal dyeing. So the rates of end result normal reactive process sample colour fastness is 3-4 means poor or good.

RESULT OF BIOCHEMICAL OXYGEN DEMAND

Table: 3.10 Result of BOD

S.NO	DIFFERENT DYE STUFF WITH SHADE %	Result of B.O.D (mg/l) Normal Dyeing process	Result of B.O.D (mg/l) Cationic Dyeing process
1	Procion H yellow-1% 0f dye stuff	548.40	76
2	Levafix rose-1% 0f dye stuff	356.10	64.10
3	FN blue dye-1% 0f dye stuff	495.70	69.4

RESULT OF CHEMICAL OXYGEN DEMAND

Table: 3.11 Result of COD

S.NO	DIFFERENT DYE STUFF WITH SHADE %	Result of C.O.D (mg/l) Normal Dyeing process	Result of C.O.D (mg/l) Cationic Dyeing process
1	Procion H yellow-1% 0f dye stuff	1408	267.6
2	Levafix rose-1% 0f dye stuff	1546.10	359.4
3	FN blue dye-1% 0f dye stuff	1495.70	297.9

RESULT OF TOTAL DISSOLVED SOLIDS

Table 3.12 Result of TDS

S.NO	DIFFERENT DYE STUFF WITH SHADE %	Result of T.D.S (mg/l) Normal Dyeing process	Result of T.D.S (mg/l) Cationic Dyeing process
1	Procion H yellow-1% 0f dye stuff	15200	2265
2	Levafix rose-1% 0f dye stuff	15465.10	2659
3	FN blue dye-1% 0f dye stuff	15350	2387.9

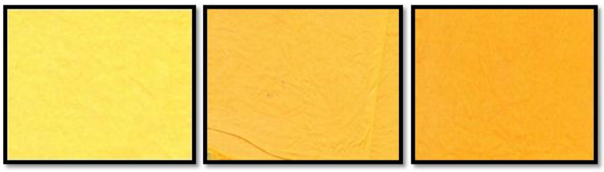
EFFECT OF CATIONIZATION ON ENVIRONMENT

EFFCT ON EFFLUENT LOAD:

The effluent analysis results shown in Table 3.4 clearly depicts that the process with Albafix WFF produces effluent with an effluent load is more of less equal to the norms prescribed by the Pollution Control Board. Hence the dyeing effluent need not be sent to the effluent treatment plant which reduces the needs of plant capacity and the investment. It leads to a substantial reduction in the dyeing cost. But, in normal dyeing process produces more effluents. The effluent of cationized cotton dyeing method poses lesser loads than that of conventional dyeing. It is because of no addition of salt and alkali in the dye bath. The water effluent consists of negligible effluent load due to the maximum fixation of dye through cationization .The most beneficial part of the cationization technique is the reduction of TDS in the effluent as this cannot be removed from the effluent easily, which is capital intensive and cost consuming treatments like Reverse Osmosis, Nano filtration, Ion Exchange etc. cost can be avoided by pre treatment using ALBAFIX WFF . There is a very good scope for the reuse of dye bath water as it contains nohydrolyzed dye and no consumed orconverted auxiliaries. However, it needs to be verified by further research

Effect of Fastness Properties:

3.8.3 Cationic Agent Dyeing of Cotton Fabric with Different Dye Shade Percentage of Dyestuff



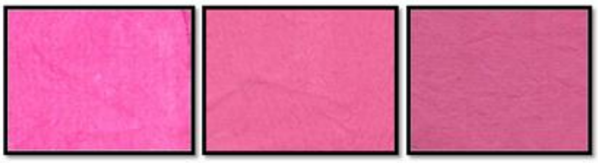
1% shade dye stuff 2% shade dye stuff 3% shade dye stuff

Figure: 1 DYE STUFF OF PROCION H YELLOW COLOUR SAMPLE

The fatness properties of pre treated sample are achieved same as that of conventional dyeing with out pre treatment

1% shade dye stuff 2% shade dye stuff 3% shade dye stuff

Figure 2: DYE STUFF OF FN BLUE COLOUR SAMPLE



1% shade dye stuff 2% shade dye stuff 3% shade dye stuff

Figure 3: DYE STUFF OF LEVAFIX ROSE COLOUR SAMPLE

CONCLUSIONS

In this research work, the ALBAFIX WFF cationizing agent was selected for the pre-treating process. The application of this agent to the cotton material before dyeing is a novel concept. At present this ALBAFIX WFF agent is used as fixing agent after dyeing. Another important activity of this work is to analyze the impact of the process cationization using ALBAFIX WFF beforedyeing on the environmental pollution.

The following are the conclusions derived from this research work:

Optimization of the cationization process parameters has been derived. The results shows that 20% concentration of ALBAFIX WFF agent at 70oC Temperature with 10 g/l of soda ash are the optimized process parameters at which the results shows the better color strength and maximum total dye utilization.

Totally three different reactive color of each three shades of cotton samples has been produced and the dyed fabric characteristics have been studied and compared with normal dyeing process.

The washing and rubbing fastness of cationized cotton are equal to that of normal dyeing. The light fastness is slightly reduced in some dyes.

The B.O.D, C.O.D and T.D.S values of Albafix WFF Process pollutant is much lower (80% reduced) than normal process pollutant. The process pollutant treated with ALBAFIX WFF is very closer to that of Pollution Control Board's standards.

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