



Influence of Cationization of Cotton on Reactive Dyeing

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ABSTRACT

Cationization of cotton is emerging as an effective tool that solves the environmental problems associated with dyeing of cotton with anionic dyes. In this research work, the cationizing efficiency of cationizing agent CIBAFIX WFF was estimated and it was found to be a better one than compared with normal or existing method of reactive dyeing of cotton. The influence of process conditions like concentration of cationizing agent, concentration of alkali and temperature of cationization bath on the color strength (K/S) and Total dye utilization percentage (T%) were analyzed and these process conditions are optimized. The optimized process conditions gives better K/S values and T% than the normal reactive dyeing of cotton. The effect of cationization on color strength and color fastness of various reactive dyes was found and cationization shows higher increase in lighter shades and lesser increase in dark shades than normal cotton dyeing. The impact on the environmental pollution and the dyed fabric quality were ascertained and compared with the existing dyeing system and the cationized cotton gives very less (nearly zero) environmental pollution. The cationized cotton shows similar kind of fabric quality as like normal dyeing of cotton. Cationization of cotton with cibafix WFF was found to be a successful and commercially viable process, since it is found to be cheaper than the normal dyeing process.

Keywords: Cationization, Cotton, Reactive Dyes, Cibafix WFF, Color Strength, % Exhaustion

INTRODUCTION:

The fiber reactive dyes are known as the best for cotton for 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. All the above, only 60-65% dye utilization is attainable even with the use of salt in the normal dyeing systems.

When alkalinity is introduced in the bath in order to facilitate the formation of covalent bond between the fiber and the functional groups of the reactive dye, the

only 60-65% dye utilization is attainable even with the use of salt in the normal dyeing systems.

When alkalinity is introduced in the bath in order to facilitate the formation of covalent bond between the fiber and the functional groups of the reactive dye, the abundance of hydroxyl ions causes significant hydrolysis of reactive dyes. Those hydrolyzed dyes are called 'dead' dyes as they have no affinity towards cotton and hence remains in the dye bath, deposition of the same on the fiber significantly lower the fastness properties, that calls on severe wash-offs.

Reactive dyeing thus pollutes the environment ²⁸ by discharging highly colored reactive dye bath and higher electrolyte concentration.

Higher electrolyte concentration in the effluents causes worst effects such as

- Impairing the delicate biochemistry of aquatic organism
- Destructive attack on concrete pipes if sodium sulphate is used as electrolyte due to the formation of alumino-sulphato complexes which swell and crack concretes with considerable alumina content.
- Evolution of hydrogen sulphide gas under anaerobic conditions when sodium sulphate is used as the electrolyte.
- Dissolution of such sulphides and subsequent bacterial oxidation to the harmful sulphuric acid.

OPTIONS FOR REDUCTION OF SALT:

- Shifting from exhaust to pad batch dyeing.
- Shifting from high liquor ratio to low liquor ratio machines.
- Recycling the salt contaminated dye bath after eliminating the hydrolyzed dye.
- Molecular engineering of reactive

dyes to have high affinity and good wash off properties.

- Molecular modification of fiber to have greater affinity and attraction towards anionic dyes.

The last option totally eliminates the salt and reduces the alkali considerably that leads to

- Reduction of colorant in the effluent.
- Lower COD (Chemical Oxygen Demand), BOD (Biological Oxygen Demand), TDS (Total Dissolved solvents) and no AOX (Absorbable Organic Halogens) in the effluent.
- Reduced number of wash offs and elimination of neutralizing.
- Reduced effluent volume.
- Increased productivity due to reduced dyeing time.
- Increased dye utilization.
- Reduced cost of dyeing and cost of effluent treatment.
- Possibility to create one bath dyeing of polyester/cotton blends.

Numerous processes 1 - 27 have been proposed from the early 1930's to improve the substantivity of anionic dyes for cellulose by introducing cationic sites in the fiber.

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In this research work, an attempt has been made to optimize the process conditions required to cat ionize the cotton with Cibafix WFF²⁹ cationizing agent and to critically analyze the influence of process variables on the cationization efficiency.

2.0.MATERIALS AND METHODS:

2.1 MATERIALS:

In this research work the following materials were used throughout.

2.1.1 Fabric:

100% grey cotton fabric was used in this

work and its warp and weft counts are 40s and its ends per inch and pick per inch is 72 & 52 respectively.

2.1.2 Chemicals:

CIBAFIX WFF (a Polyamino Chlorohydrin Quaternary Ammonium Compound) from Ciba Specialty chemicals was used as a cationic fixing agent. Sodium Hydroxide, Sodium chloride, Sodium carbonate, Sodium silicate, Acetic acid, Sulphuric acid and Hydrogen peroxide of laboratory grade were also used along with a commercial non-ionic wetting agent (Alphox200 of, ICL), a desizing enzyme Baysalex, Vinyl sulphone reactive dyes supplied by *MI's Colourtex* and CIBA FN dyes and Procion H and M dyes were used throughout this research work.

2.2 PREPARATION OF FABRIC:

2.2.1 Desizing:

The grey fabric was desized using 2% enzyme under slightly acidic pH at 60-70°C for 2 hours in a laboratory Jigger. The enzyme was deactivated by boiling at 95°C for 30 minutes and the degraded starch products were thoroughly washed out.

2.2.2 Scouring:

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

Recipe for scouring of the fabric (On Weight of the Fabric):

NaOH	- 3%
Na ₂ CO ₃	- 2%
Non-ionic wetting agent	- 0.5%

2.2.3 Bleaching:

The fabric was bleached with 2 volumes of hydrogen peroxide at 85-95°C in jigger 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.

2.3 CONVENTIONAL DYEING:

The bleached fabric was dyed with vinyl sulphone reactive dyes (Corozol Blue HR) for 2% shade. The laboratory-dyeing machine Rota dyer with the liquor ratio of 1:20 was used throughout this work. The fabric was entered 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 60°C in 30 minutes. Remaining salt was added and the dyeing was continued at 60°C 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 50°C for 3 times for 20 minutes each, neutralized with 2.5 g/l acetic acid for 30 minutes and hot soaped at 60°C for 30 minutes.

2.4 CATIONIZATION OF COTTON FABRIC:

Design matrix for Cationization Pretreatment

1. Concentration of Cibafix WFF -10, 20,30 % (On Weight of the Fabric)
2. Temperature of treatment bath-30, 50,70 °C
3. Concentration of soda ash --5,10,15 g/l

Cotton fabric was cationized using the exhaust method. Cationization was carried out in a laboratory Rota dyeing machine with a Material: Liquor ratio of 1:20. Cationization was carried out with varying concentration of cibafix, 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 1/2 hour. Then, Sodium carbonate was added to raise the pH to 9 and continued for

another 1/2 hour. Then the fabric was neutralized and washed thoroughly.

2.5 DYEING OF CATIONIZED COTTON:

The cationized fabric was dyed in Rota dyer with Material: Liquor Ratio of 1:20 using vinyl sulphone reactive dyes with 1 g/l non-ionic wetting agent (Alphox 200 of ICL). 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 °C for 30 minutes. No salt and no alkali were added during dyeing.

2.6 TESTING OF EXHAUSTION (% E):

The optical density of the dye solution before and after the dyeing was measured using BOUCH-Lamp UV-Visible spectrophotometer at the maximum wavelength of absorbency (λ max). Before measuring the absorbency, the wavelength of maximum absorbency (λ max) was determined for each dye by using the calibration standard solutions. For the calibration standard solutions, a dye stock solution of 0.5g/l was prepared. By pipetting 0.1 ml - 2.0ml of this stock solution and diluting to 50ml, 15 different calibration standard solutions were prepared. The concentrations of the calibration standard solutions ranged from 0.001 g/l to 0.02g/l. For measuring the absorbency of the dye baths, each initial dye bath was diluted to 5mg/l. Some of the equilibrium dye baths were also diluted depending on the final color of the equilibrium dye bath. This was done to keep the absorbency under 2AU.

The dye bath exhaustion percentage (%E) was calculated using Eqn-2.1

$$\%E = \frac{(A_0 - A_1)}{A_0} \times 100 \quad (2.1)$$

Where A_0 and A_1 are the absorbencies at maximum wavelength (λ max) of dye originally in the dye bath and of residual dye after dyeing respectively.

2.7 TESTING OF COLOUR STRENGTH (K/S):

The reflectance values at all wavelengths were measured by using JAYPACK COMPUTER COLOR MATCHING SYSTEM with X 4000 Spectrophotometer. The reflectance (R) value of dyed cloth at the maximum wavelength of absorbency (λ max) is found and the K/S is calculated using the built -in software of the computer color matching system. Kubelka Munk equation given in equ-2.2

$$K/S = \frac{(1-R)^2}{2R} \quad (2.2)$$

2.8 DETERMINATION OF FIXATION (%F)

The percentage of dye fixation (%F) was calculated using Eqn-2.3

$$\%F = \frac{(K/S)_b}{(K/S)_a} \times 100 \quad (2.3)$$

Where K/S is the color yield with the values before soaping (b) and after soaping (a).

2.9 DETERMINATION OF TOTAL DYE UTILISATION (% T):

The Total Dye Utilization percentage (%T) was calculated using Eqn-2.4

$$\%T = \frac{ExF}{100} \quad (2.4)$$

2.10 TESTING OF WASH FASTNESS:

ISO Test No.3 (IS:764-1979) method was followed for wash fastness. A specimen of 10 X 4 cm was sandwiched between a cotton fabric and viscose fabric and sewn along all four sides to form a composite specimen. Washing solution containing 5 g/l soap and 2 g/l sodium carbonate was taken in the Landro Meter with a liquor ratio of 1:50. The specimen was treated for 30 minutes at $60 \pm 2^\circ\text{C}$ 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.

2.11 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 undyed fabric was evaluated using grey scales.

2.12 TESTING OF LIGHT FASTNESS (IS: 2454-1967)

The fabric sample of 1 X 4.5 cm was exposed to MBT 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 unexposed 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.

2.13 DETERMINATION OF FLEXURAL RIGIDITY (IS: 6490-1971):

Rectangular sample of 2.5 X 20cm in warp way and weft way was cut. After conditioning, the sample was placed on the stiffness tester and moved until the fabric coincides with the indicator mark at 41.5° angle. The length to which the specimen moved was noted. The bending length and flexural rigidity was calculated by the formula following:

1. Bending length

$$C=L/2$$

Where L= Mean length of over hanging in cm

2. Flexural rigidity

$$G= W \times (L/3)^3 \text{ mg-cm}$$

Where W= Weight per square cm in mg

3. Overall Rigidity

$$G_o = v G_w + G_f$$

Where G_w = warp way flexural rigidity

G_f = weft way flexural rigidity

2.14 DETERMINATION OF TEARING STRENGTH:

Ballistic tear test was done in warp way and weft way. The work done to tear 1" and 4"

length of fabric was measured using a ballistic tear tester.

Tearing strength in lb = 1/6 (W4-W1)
 Where W1 =mean strength through 1"
 W4= Mean strength through 4"

2.15 DETERMINATION OF CREASE RECOVERY:

The crease recovery angle was determined using Shirley crease recovery tester. The fabric (2x1 cm) was placed in between two glass plates and 2kg weight was put on the top of the glass plate for 1 minute. Then the sample was placed on the clamp and WRA was measured by rotating the dial of the instrument after allowing to recover for a minute.

2.16 TESTING OF EFFLUENT:

2.16.1 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°C for 3 days and then the dissolved oxygen was found (sample value-B)

B.O.D in mg/l = (A - B) X dilution factor

2.16.2 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 0.25N, 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 150°C. 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.

$$COD = \frac{(\text{Blank value} - \text{sample value}) \times N \text{ of FAS} \times 8 \times 1000 \times \text{dilution factor}}{\text{Volume of the sample}}$$

2.16.3 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.

$$T.D.S = \frac{\text{Weight of residue} \times 1000}{\text{Volume of effluent}} \text{ ppm}$$

3.0.RESULTS AND DISCUSSIONS:

3.1 CATIONIZATION WITH CIBAFIX WFF:

3.1.1 Effect of Concentration of CIBAFIX WFF:

Effect of concentration of Cibafix WFF was calculated based on color strength and total dye utilization percentage of the sample and the values are given in Table 3.1.

To evaluate the effect of concentration of Cibafix WFF, the cationization was done by varying the concentration of Cibafix, temperature and concentration of soda ash and these samples are plotted against K/S values for graphical representation in Fig.3.1. and T% in Fig.3.2.

There is no significant increase in K/S value and T% from 10g/l to 30g/l of

Cibafix WFF. So it is inferred that the effect of Cibafix WFF contributes only very less amount and it also be represented that the cationizing efficiency solely depends on the temperature rather than its quantity in the bath. From the Figs.1&2, the optimum concentration for cationization is 20g/l because the sample 15 gives high K/S and T% value.

Table 3.1 Experimental Design for Cibafix WFF

Sample No.	Conc. of Ciba Fix WFF	Temperature	Conc. Of Soda ash	K/S	E%	F%	T%
1	10	30	5	6.124	60.0	74.5	44.7
2	10	50	5	10.358	90.5	80.6	72.9
3	10	70	5	10.820	90.9	81.0	73.63
4	10	30	10	6.602	60.1	74.8	45.0
5	10	50	10	10.224	89.2	79.6	71.0
6	10	70	10	11.320	91.2	88.6	80.8
7	10	30	15	6.987	62.1	76.0	47.2
8	10	50	15	10.911	87.4	87.4	76.4
9	10	70	15	11.859	91.8	88.9	81.6
10	20	30	5	7.139	61.4	76.7	47.1
11	20	50	5	12.114	94.9	89.0	84.46
12	20	70	5	12.035	94.8	89.9	85.22
13	20	30	10	7.790	94.1	90.8	85.5
14	20	50	10	12.690	94.1	90.8	85.5
15	20	70	10	12.987	95.1	90.4	85.9
16	20	30	15	7.543	67.1	78.1	52.4
17	20	50	15	12.725	94.8	90.4	85.69
18	20	70	15	13.001	94.3	91.1	85.9
19	30	30	5	7.925	68.2	78.5	53.53
20	30	50	5	11.315	94.0	85.9	80.8
21	30	70	5	11.957	94.5	91.2	86.18
22	30	30	10	8.499	75.7	78.1	59.1
23	30	50	10	12.710	96.5	90.9	87.7
24	30	70	10	12.253	96.2	90.8	87.4
25	30	30	15	9.112	78.1	79.2	61.85
26	30	50	15	11.180	88.9	89.0	79.1
27	30	70	15	13.011	96.8	91.3	88.37

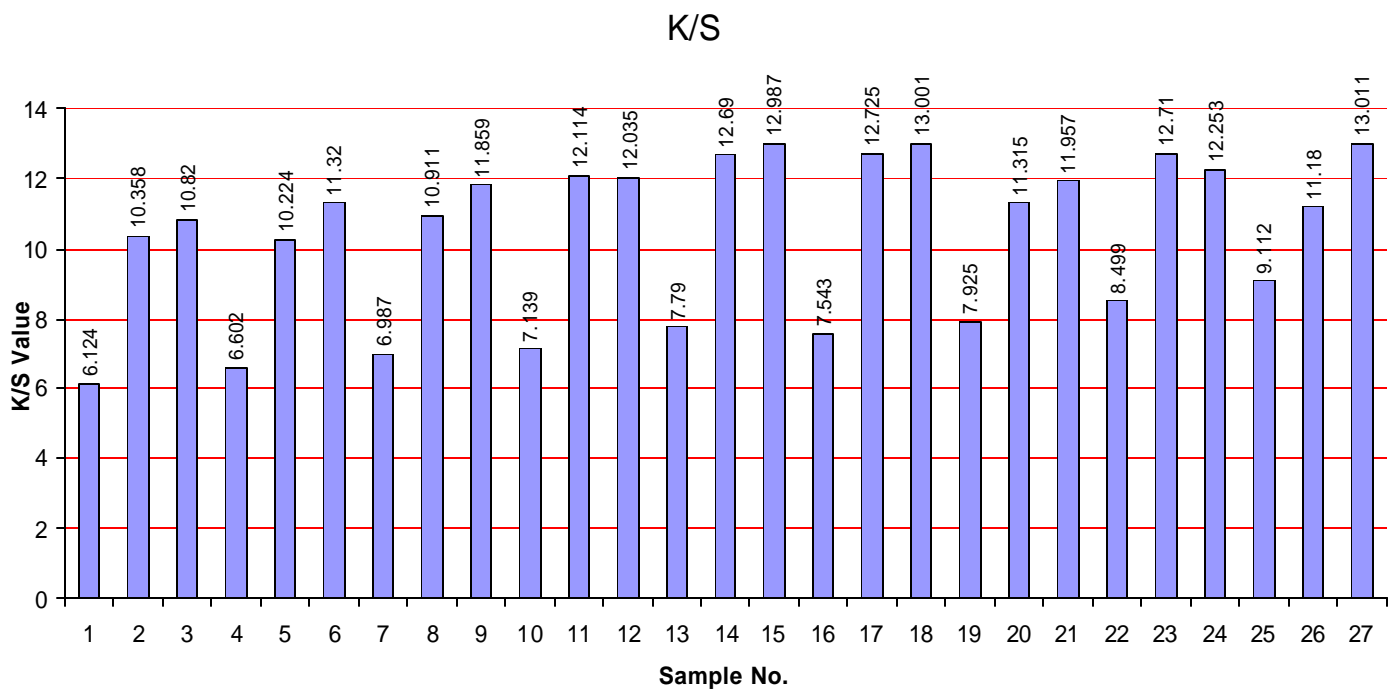


Figure 3.1 K/S values for different combinations of samples

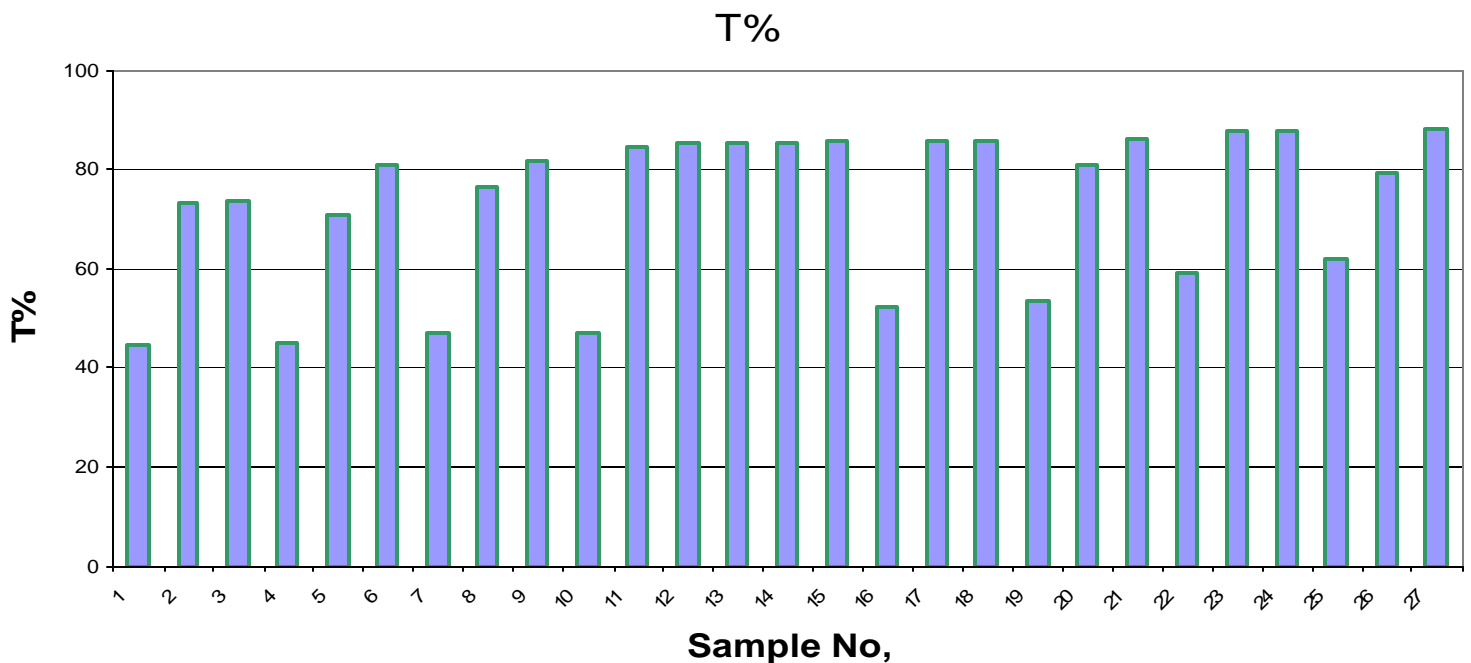


Figure 3.2 T% Values for different combinations of samples

3.1.2 Effect of Temperature:

From the Table 3.1, it can be concluded that the temperature is the prime factor that greatly influences the T%, which may be due to the increased rate of

penetration of cationizing agent into the vicinity of the substrate. As in every other molecule, the increase in temperature increases the molecular vibrations both in fiber and in the agent, which induces favorable sorption kinetics. Hence, at higher

temperature, even lesser quantity of the agent may be available for the fiber, as they would have fully utilized. The optimum temperature for cationization is found to be 70°C.

3.1.3 Effect of Soda Ash Concentration:

The soda ash is playing a little role that can be seen from the Table 3.1. It serves as an aid in keeping the Cibafix WFF in stable

form at higher temperatures. Hence, it does not make any big impact on T% after 10 g/l.

3.2 EFFECT OF CATIONIZATION ON COLOUR STRENGTH:

The optimized recipes were taken and the bulk trials were carried out in laboratory winch dyeing machine with M: L ratio of 1:20. The color buildup in terms of exhaustion and fixation is given in Table-3.2

Table 3.2 Color build up of different dyeing systems

PROCESS	EXHAUSTION %	FIXATION %	TOTAL DYE UTILIZATION %	K/S AFTER SOAPING-COROZOL BLUE HR
CONVENTIONAL	76	85	64.6	7.012
CIBAFIX	99.31	92.26	91.68	12.352

The exhaustion of Corezol Blue HR is above 99% that leaves the dye bath nearly colorless, about 23% more than that of normal dyeing. Fixation is also increased 7-9%. The reason for this is there is no chance for hydrolysis of dyes. The Total dye utilization ratio is increased 91.5% in CIBAFIX process. Hence, the cationized dyeing can save approximately 30 % dye.

The similar trend exists in other dyes also, some of which are tabulated in Table 3.3 in terms of its K/S value before soaping for varying depth of shades. Color strength of the sample is varied between the dyes to dyes is due to different dye chemistry of the dye. However, for all the dyes, higher color strength for light shades than in dark shades. This may be probably due to insufficient number of cationic sites in the fiber to accommodate those larger quantities of dyes.

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Table 3.3 K/S values before soaping for varying depth of shades

DYE	Max. wave length	NORMAL %		CIBAFIX	
		SHADE	KIS	K/S	%OF NORMAL
COROZO L BLUE HR (Vinyl sulphone)	590 nm	0.5	2.516	5.862	233
		1.0	5.215	10.552	170
		2.0	8.385	13.499	161
		4.0	13.561	16.569	122
CIBA RED FN- 3G	510nm	0.5	3.083	9.557	310
		1.0	6.212	13.045	248
		2.0	9.291	16.537	178
		4.0	13.135	17.206	131
PROCIO N GOLDEN YELLOW- H5G	420nm	0.5	3.721	7.258	195
		1.0	5.568	9.865	177
		2.0	7.752	10.968	141
		4.0	9.611	11.682	121
PROCIO N VIOLET- C4R	550 nm	0.5	1.695	4.084	241
		1.0	3.493	6.147	176
		2.0	5.244	8.331	159
		4.0	7.533	10.621	141
PROCIO N ORANGE M2R	500 nm	0.5	2.721	5.986	220
		1.0	6.253	8.629	138
		2.0	10.213	11.438	112
		4.0	13.303	14.36	108
PROCIO N RED M5B	550 nm	0.5	2.963	6.987	235
		1.0	5.221	9.865	177
		2.0	8.596	12.698	148
		4.0	13.012	16.354	125
CIBA YELLOW- 3G	430nm	0.5	1.474	5.660	385
		1.0	3.758	8.415	224
		2.0	6.153	10.521	171
		4.0	8.605	12.39	144

3.3 EFFECT OF CATIONIZATION ON COLOUR FASTNESS:

3.3.1 Wash Fastness:

Table 3.4 Wash Fastness for Different Dyes

Dye	Wash fastness			
	Change in color		Staining	
	Normal dyed	Cibafix WFF	Normal dyed	Cibafix WFF
Corozol Blue HR	5	5	4-5	5
Ciba Red FN-3G	5	5	5	5
Procion Golden Yellow-H5G	5	5	5	5
Procion Violet- C4R	5	4-5	5	5
Procion Orange M2R	5	5	5	5
Procion Red M5B	5	4-5	4-5	4
Ciba Yellow-3G	5	5	5	5

Table - 3.5 Rubbing Fastness for Different Dyes

Dye	Rubbing fastness			
	Dry		Wet	
	Normal dyed	Cibafix WFF	Normal dyed	Cibafix WFF
Corozol Blue HR	5	5	4-5	5
Ciba Red FN-3G	5	4-5	4-5	4-5
Procion Golden Yellow-H5G	5	5	5	5
Procion Violet- C4R	5	5	5	5
Procion Orange M2R	5	5	5	4-5
Procion Red M5B	5	4-5	4	4
Ciba Yellow-3G	5	5	5	5

The table 3.4 shows the wash fastness rating for normal dyed and cationized dyed fabric dyed with different dyes. It shows that there is not much difference between the normal dyed fabric and cationized dyed fabric. It may be due to the formation of strong ionic bond between the fiber and dye as it is equally good of the covalent bond that normally linking the dye and fiber.

3.3.2 Rubbing Fastness:

The table 3.5 shows the rubbing fastness rating for normal dyed and cationized dyed fabric dyed with different dyes. The table tells there is not much difference between the normal dyed fabric and cationized dyed fabric. It may be due to the formation of strong ionic bond between the fiber and dye and there is no hydrolyzed dye is fixed in the fabric.

Table - 3.6 Light Fastness for Different Dyes

Dye	Light fastness	
	Normal dyed	Cibafix WFF
Corozol Blue HR	7	6-7
Ciba Red FN-3G	7	6-7
Procion Golden Yellow-H5G	6	5-6
Procion Violet- C4R	7	6
Procion Orange M2R	7	6
Procion Red M5B	7	6-7
Ciba Yellow-3G	6	5-6

3.3.3 Light Fastness:

The table 3.6 shows the light fastness rating for normal dyed and cationized dyed fabric dyed with different dyes. The light fastness rating is slightly reduced in some dyes, about half to one point, as reported by various researchers

previously. The presence of an aliphatic molecule between the dye and fiber may be disturbing the stable electronic configuration of dye that leads to the shifting of electrons to the higher energy state and subsequent disintegration of dye by the photons of light rays.

Table 3.7 Effluent content

Particulars	Conventional	Cibafix	TNPCB Standards
B.O.D in mg/l	485	55	30
C.O.D in mg/l	1408	267.6	250
T.D.S in ppm	15200	2265	2100

3.4 EFFECT OF CATIONIZATION ON ENVIRONMENT:

3.4.1 EFFECT ON EFFLUENT LOAD:

The effluent analysis results shown in Table 3.6 clearly depicts that the process with Cibafix WFF produces effluent with an effluent load is more or 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 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 wash water effluent consists of negligible effluent load as 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 can not be removed from the effluent easily, which need capital intensive and cost consuming treatments like Reverse Osmosis, Nano filtration, Ion Exchange etc.

3.4.2 EFFECT ON VOLUME OF EFFLUENT DISCHARGE:

The fabric is in pure neutral state and contains very less quantity of unfixed dye and hydrolyzed dye. Hence, the neutralizing and subsequent acid washing treatments can be eliminated. One soaping is sufficient to remove those surfaces deposited dyes and hence at least three baths can be reduced. A substantial reduction in the requirement of water and their treatment

cost can be expected. There is a very good scope for the reuse of dye bath water as it contains no hydrolyzed dye and no consumed or converted auxiliaries. However, it needs to be verified by further research.

3.5 EFFECT OF CATIONIZATION ON FABRIC QUALITY:

3.5.1 EFFECT ON TEARING STRENGTH:

It was reported in some of the previous researches that the strength of the fabric is slightly reduced due to the reduction in the number of inter molecular H-bonds by cross linking of molecule by the cationic reactants. But in this case, there is no such significant reduction caused.

Table 3.8 Tearing strength in lbs

Particulars	Conventional	Cibafix
warp way	1.833	1.732
weft way	2.333	2.238

Cationization occurs mainly at methyl hydroxyl groups of cotton cellulose i.e. at C₆ and not breaking the intermolecular H-

bonds. This hypothesis is very well proved by the fact that the strength is not affected, which is shown in Table-3.8.

3.5.2 EFFECT ON FLEXURAL RIGIDITY:

Table 3.9 Flexural rigidity

Particulars	Conventional	Cibafix
warp way in mg-cm	1.51	1.64
Weft way in mg-cm	0.637	0.614
Overall FR in mg-cm	1.638	1.751

It is evident from the Table 3.9, the flexural rigidity of fabric is not affected by the incorporation of cations in the cellulose.

It may be due to the incorporation of a low molecular weight agent, which might not have cross-linked the cellulose molecule.

3.5.3 EFFECT ON CREASE RECOVERY ANGLE:

From the Table 3.10, it is evident that the wrinkle recovery angle of conventional dyed and cationized cotton does not reflect any major variation. Hence, it can be

concluded that the incorporation of amine groups in the cotton cellulose molecule does not affect the wrinkling behavior of cotton.

Table 3.10 Crease recovery angle

Particulars	Conventional	Cibafix
WRA* in warp way	149	145.8
WRA* in weft way	143.2	137.6

*Wrinkle recovery angle

4.0 CONCLUSIONS:

In this research work, the CIBAFIX 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 CIBAFIX WFF agent is used as fixing agent after dyeing.

Another important activity of this project work is to analyze the impact of the novel process (cationization using CIBAFIX WFF before dyeing) 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 CIBAFIX WFF agent at 70°C Temperature with 10 g/l of soda ash are the optimized process parameters at which the results shows the better color strength value (K/S value 12.987) and maximum total dye utilization (T value 95.1%).
- The influence of Temperature and the concentration on K/S and T%

value are predominating than pH value of the bath.

- Totally seven different reactive color of each four shades of cotton samples has been produced and the dyed fabric characteristics have been studied and compared with normal dyeing process.
- The increase in color strength is much larger in light shades (250% to 300%) than in dark shades (120-180%)
- 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 CIBAFIX Process pollutant is much lower (80% reduced) than normal process pollutant. CIBAFIX WFF process pollutant is very closer to that of Pollution Control Board's standards.

In the case of developing countries, where scare in natural recourses such as water, thermal energy and high capital investment/ processing cost in effluent treatment, this novel technique (cationization using CIBAFIX WFF before dyeing) solves the above said problems. The practical implementation of this novel

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process at M/S. SSM Processing mills, Komarapalayam, Taminadu, India immediately after completing this project work proves the techno economic beneficial value of this project work.

REFERENCES:

1. Balland, "Epoxypropyl ammonium salt and boric acid assisted dyeing process" US patent number 4,072,464, Feb 1978
2. Bhattacharya. S.D. et al, "A novel technique of cotton dyeing with reactive dyes at neutral pH". Indian Journal of Fiber and Textile Research, Dec-2001, pp418,
3. Burkinshaw et al, "Modification of cotton to improve its dyeability. Part-2. Pretreating cotton with a Thiourea derivative of polyamide - epichlorohydrin resins", JSDC, p307, 106(1990)
4. Burkinshaw .et al, Modification of cotton to improve its dyeability. Part-1. Pretreating cotton with polyamide - epichlorohydrin resins. JSDC, P391, 105(1989)
5. Chen. KM .et al, New cationic agents for improving the dyeability of cellulose fibers. Part-2- Pretreating cotton with polyepichlorohydrin-amine polymers for improving dyeability with reactive dyes. JSDC, P153, 109(1993)
6. Chen. KM .et al, New cationic agents for improving the dyeability of cellulose fibers. Part-1 Pretreating cotton with polyepichlorohydrin-amine polymers for improving dyeability with direct dyes, JSDC, P389, 108(1993)
7. Dr. Fred L. Cook, Salt Requirements put pressure on wet processing plants, Textile World, p83, Aug-1994.
8. Eugene J. Blanchard et al, Dyeable durable press cationic cotton, Colourage, p55, Annual 1999
9. Gohl. E.P.G and Vilensky. L.D, Textile Science, CBS Publishers & Distributors, New Delhi.1999
10. Harper. J, Dyeability of crosslinked cationic cotton fibers. 1987 International Technical paper competition, Textile Chemist and Colorist. P25. 20(1988)
11. Jang. J et al, investigation of improved dyeability of cationized cotton via photografting with UV active cationic monomers, Coloration Technology, p139, 117(2001)
12. Kamel. Metal, Dyeing of cationized cotton with acid dyes, JSDC, p101, vol-114, March 1998.
13. Lewis and Mcilroy, Modification of cotton cellulose with NicotinyI Thio glycollate, Dyes and Pigments, p69, 1997(35)
14. Lewis. D.M, New possibilities to improve cellulosic fiber dyeing process with fiber-reactive systems By JSDC, P357, 109(1993)
15. Lewis. D.M .et al, Improved cellulose dyeability by Chemical modification of the fiber. Textile Chemist and Colorist, p23, 21 (1989)
16. Lewis. D.M and Lei. X.P, New methods for improving the dyeability of cellulose fibers with reactive dyes ,JSDC, p103, 107 (1991)
17. Lewis. D.M and Lei. X.P, Modification of cotton to improve its dyeability. Part-3-Polyamide-

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- epichlorohydrin resins and their ethylenediamine reaction products, JSDC, p353, Volume-106, Nov-1990
18. Lewis. D.M, Improved cellulose dyeability by Chemical modification of the fiber. AATCC International conference and exhibit of papers, Atlanta, p257, 1992
 19. Magda M. Kamel, Adsorption rates of cationized cotton towards acid dyes, Journal of Textile Assn., p287, Mar 2003
 20. Mehmel Kanic and Peter J. Hauser, Printing of cationized cotton with reactive dyes Coloration Technology, p300, 118(2002)
 21. Palithorpe. T .et al, A new method for improving the dyeability of cotton with reactive dyes, Textile Research Journal, p440, 69(6)1999
 22. Peter J. Hauser, Reducing pollution and energy requirements in cotton dyeing, Textile Chemist and colorist, p44, Vol-32(6), June 2000.
 23. Peter J.Huaser & Adam H . Tabba ,Improving the environmental and economic aspects of cotton dyeing using a cationized cotton., Coloration Technology, p282,117(2001)
 24. Reda M.E.I. Shishtawy and S.H.Nassar ,Cationic pretreatment of cotton fabric for anionic dye and pigment printing with better fastness properties, Coloration Technology, p115. 118(2002)
 25. Seong -il Eom .et al, Improving the dyeability of natural colorants on cotton by cationization, Indian Journal of Fiber and Textile Research, p425, Dec-2001
 26. Yiqi Yang .et al , An Unusual application of a usual cross linking agent Dyeing Trimethylolmelamine pretreated cotton without added salt ,Textile Research Journal P433, 64(8)1994
 27. Yousef. Y.A, Direct dyeing of cotton fabrics pre-treated with cationizing agents, JSDC vol-116, Oct-2000 p317.
 28. Sekar. N, Reactive -cellulose fibers for no-salt dyeing -a conceptual development towards redressal of environmental issues in reactive dyeing: An update, colourage, p29, June1999
 29. Technical data sheet CIBA WFF, CIBA specialty chemicals.

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