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সোনারগাঁও ইউনিভার্সিটি (এসইউ)
WE WILL RISE UP WE WILL SHINE

Department of Textile Engineering

Project On:

Study on Reactive Dyeing of Cotton Fabric using an Ethanol Solvent System.

Course Title: Project Work (Thesis)
Course Code: Tex-441

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The Thesis presented in partial fulfillment of the requirements for the degree of
Bachelor of Science in Textile Engineering

Duration Time: September,2025

LETTER OF APPROVAL

08 September 2025

To The Head,

Department of Textile Engineering.

Sonargaon University (SU).

GP Ja-146, Wireless gate, Mohakhali, Dhaka-1212.

Subject: Approval of Thesis Report of B.Sc. in TE Program.

Dear Sir,

We are just writing to let you know this project report titled as study on,"Reactive Dyeing of Cotton Fabric using an Ethanol Solvent System" has been completed by the students are bearing **Afsarul Pappu ID: TEX2103024002, Ratul Hasan ID: TEX2103024009, Rakib Hossain ID: TEX2103024022, Md. Shobuj Mia ID: TEX2001019062, Md. Yousub Ali ID: TEX1801013035** for final evaluation. The whole report is prepared based on proper Investigation and understanding though critical analysis of empirical data with required belongings. The students were directly involved in their thesis activities and the report becomes vital to spark of many valuable information for the readers.

Therefore, it will highly be appreciated if you kindly accept this thesis report and consider it for final evaluation.

Yours Sincerely

……..

Engr.Mohammad Abdul Baset
Associate Professor & Head
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DECLARATION

We hereby declare that, this Industrial Thesis report has been done by us under the supervision of **Mohammad Abdul Baset**, Assistant Professor & Head Department of Textile Engineering, Sonargaon University. We also declare that neither this industrial attachment report nor any part of this report has been submitted elsewhere for award of any degree.

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DEDICATION

At first we want to dedicate this attachment report to almighty Allah for giving us this opportunity to prove ourselves. Without almighty helps nothing would be possible.

Then we want to dedicate our parents. We love them very much for completing our study they play a vital role to complete this attachment. It's very pleasure for us. Without their help it is impossible for us to complete this attachment. And we also want to dedicate this attachment of our teacher.

ACKNOWLEDGEMENT

At first, we want to thank the almighty Allah for making it possible to complete our industrial attachment program successfully. We are highly delighted to express our regards & gratitude to our supervising teacher Mohammad Abdul Baset (Assistant Professor) for all necessary information for preparing this report.

We also take this opportunity to express our sincerest gratitude to Md. Faruk Hossain, (Laboratory Manager), Md. Mizanur Rahman, (Manager – Admin & HR), Md. Sohel (Dyeing Production Manager), Md. Faisal (Knitting AGM) & Md. Sadakath Hossain (Dyeing Quality AGM) who has allowed us to work in his organization within a congenial atmosphere during the industrial training period.

Thanks goes to Managers of different sections, executives and personnel for their excellent guidance & co-operation during the period of our training.

During the attachment we were scheduled to work with all the departments of M.M. Knitwear Ltd. & M.K. Knitwear Ltd. So, we would like to thank the officials of dyeing, washing, knitting, garments, maintenance & all other departments who gave their valuable time in helping us to achieve our intended goal.

Our deepest appreciation goes to them for their sincere co-operation, support and advice which they have provided us during these two months of training. Our sincere appreciation goes to the entire M.M. Group team for extending their hands of cooperation throughout the training period.

Finally, we would like to acknowledge that we remain responsible for the inadequacies & errors, which may unintentionally remain in the following report.

ABSTRACT

In this study, an ethanol–water mixture is used as a dyeing medium for cotton fabric with reactive dyes without using salt, soda, or any other auxiliary chemicals. After dyeing, several fastness properties were evaluated, including:

Color fastness to wet and dry rubbing
Color fastness to washing
Color fastness to alkaline and acidic perspiration

The results were found to be very similar to those of conventionally dyed samples using water-based systems for reactive dyes. Since ethanol is a green solvent, and the ethanol–water mixture is recyclable, it presents a sustainable alternative to traditional cotton dyeing methods.
This approach is expected to contribute positively toward eco-friendly and sustainable textile processing by reducing the environmental impact associated with water and chemical consumption.

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CHAPTER-01

Introduction

1.1 Introduction:

Among the varied fibers available in nature, cotton has gained much popularity owing to its desirable properties, such as high hygroscopicity and air permeability, as well as being com- for table to wear and easy to dye. [1] Generally, reactive dyes with soluble sulphonate groups are used for the coloration of cotton fibers. However, owing to the dissociation of hydroxyl groups on cotton fibers, slightly negative surface charges are easily produced when cotton comes in contact with water, leading to electrostatic repulsion between the dye and the fibers. [2] Accordingly, huge amounts of salts (30–100 g L−1) such as sodium sulfate (Na 2 SO 4) and sodium chloride (NaCl) are required in dyeing processes to suppress repulsion, thus improving the affinity of the reactive dye towards the fibers. It is common knowledge that discharging the dyeing effluent with high salt content may cause pipeline blockages, dust pollution, and soil saline-alkalization.

Furthermore, as most commercial reactive dyes can only be dissolved in aqueous solution, conventional reactive dyeing of cotton fibers is carried out in water, resulting in high water consumption. [3] Water is widely regarded as the most important natural resource. Owing to the uneven distribution of fresh water, more than two billion people live in highly water-stressed regions and this number is increasing remarkably. According to the investigation of Arivithamani and Fernandez et al., dyeing 1 kg of cotton fabrics consumes 120–200 L of water, 0.8–1.0 kg of salt, and 0.2–0.3 kg of alkali. Therefore, the dyeing process generates chemically complex effluents that are characterized by high salinity, high alkalinity, and a deep color.

Discharge of these effluents causes environ- mental pollution. [4] Although treatment of effluents from dyeing processes can be achieved using various techniques, including membrane filtration, photo catalytic degradation, activated carbon adsorption, and biological treatment, [5] it is difficult to meet environmental discharge requirements using these methods. To alleviate this issue, there has been a steady increase in the demand for methods to enhance the dye ability of cotton fibers with reactive dyes in the absence of electrolytes. In this regard, cat ionization of cotton fibers has received considerable interest in recent decades. [6] However, most cationic agents are synthetic compounds, which may have poor Dura- ability and present safety hazards during application. Furthermore, it seems arduous to reduce the considerable volume of freshwater consumed using this method. While dyeing of cotton with reactive dyes dispersed in supercritical carbon dioxide seems to be an attractive alternative to water- based dyeing, poor shade build-up and high equipment invest-meant are significant drawbacks to this method. [7] Nowadays, solvents are used in large quantities in chemical industry. Sawada and Ueda used a non-aqueous system of Aerosol OT/isooctane for reactive dyeing of cotton fibers. Although excellent exhaustion was obtained in the absence of an electrolyte in this system, the fixation of reactive dyes tended to be poorer than that obtained with conventional dyeing, likely to the negative impact of the ionic head groups of the surfactant on the polarity of water molecules. Hence, a non-ionic reverse micelle consisting of Triton X-100, n-octane, and isooctane was prepared to alleviate this issue. Moreover, Fu et al. investigated the dyeing of cotton in a dye/ decanethiol cycle open siloxane (D5) suspension system. [8] They found that almost all of the reactive dye was absorbed without the addition of salt in the D5 system. It should be noted that a dispersant and a milling process were required to prepare a stable dye suspension paste, which may make recycling of the
D5 system difficult and expensive. In addition, various non-nucleophile organic solvents, such as dimethyl sulfoxide and dimethyl carbonate, have been investigated to facilitate dye sorption and reduce waste in reach- tive dyeing processes. A similar attempt was made to dye cotton fibers with reactive dyes in polar–non-polar systems using acetone as a nonpolar solvent and form amide, dimethyl- form amide, or dimethylacetamide as a non-polar solvent. Although it was possible to achieve 100% exhaustion in this non-nucleophile, polar–non-polar solvent mixtures, comply- cited

purification of the reactive dyes using a solvent–non-solvent method was essential before reactive dyeing. Chlorinated solvents such as trichloroethane, trichloroethylene, and perchloroethylene have also been reported to improve dye absorption to some extent when dyeing textiles. However, owing to the low solubility of the dyes in these chlorinated solvents, a solubilizing agent is generally required. To solve this problem, a two-phase immiscible solvent system comprising water and dichloromethane was investigated for dyeing cotton with a reactive dye. [9] However, the low dyeing levelness of the cotton fibers caused by the immiscibility of water and dichloromethane was a major issue. Such drawbacks have prevented the adoption of such systems in place of the water systems currently in commercial use. 'Green' solvents are defined as solvents that have minimal environmental influence arising from their use in chemical production.[10] As a green solvent, ethanol has the advantages of wide availability, non-toxicity, low boiling point, low molecular weight, low surface tension, low price and strong permeability. Furthermore, it has been shown that ethanol–water mixtures are environmentally favorable compared to pure ethanol. Most importantly, ethanol can be recycled using the azeotropic distillation method, which is considered a mature procedure for producing absolute ethanol from the ethanol–water mixtures. Amato et al. found that the adsorption isotherms of a direct dye on cotton fibers in ethanol–water mixtures were affected by the concentration of ethanol. The dyeing properties of cotton with pigments from an ethanol–water system was determined by Jiang et al. showing that the dyeing depth of cotton fabrics was initially enhanced and then decreased with increasing ethanol content. In another study, Yakubu et al. indicated that the pretreatment of cotton fibers with ethanol had a positive influence on dye uptake. Dyeing of cotton yarns with reactive dyes using ethanol as an auxiliary agent at low content was studied, and an enhancement in the uptake of reactive dyes was observed. This phenomenon was more strongly suggested by the work of Islam, who explored the relationship between low concentrations of ethanol and the uptake of reactive dyes. However, the influence of high contents of ethanol on the dyeing properties of cotton fibers with reactive dyes has not been examined. Therefore, in the present work, a 'green' ethanol–water mixture was proposed for reactive dyeing of cotton fibers to minimize the consumption of salt and water simultaneously. Swelling of cotton fibers with an alkali aqueous solution has been shown to be an effective approach to address the low solubility of alkalis, such as sodium hydroxide and sodium carbonate, in organic solvents. Thus, our new approach incorporates the preselling of cotton fibers with an alkali aqueous solution. Accordingly, cotton fibers were first pretreated with alkali and then dyed in an ethanol–water dye liquor containing a relatively high concentration of ethanol. This study was undertaken with the aim of determining an environmentally friendly method for promoting the exhaustion of reactive dyes on cotton fibers without the addition of salt.

1.2 Objectives

The primary objective of using an ethanol solvent system in reactive dyeing of cotton fabric is to enhance dye fixation efficiency, reduce water consumption, and improve dye uptake and color yield. Specifically, the goals include:

1. Improving Dye-Fiber Interaction: Ethanol can alter the swelling behavior of cotton and the solubility of dyes, promoting better dye penetration and bonding.

2. Enhancing Fixation Rate: The use of ethanol may increase the reaction rate between reactive dyes and cellulose, leading to higher fixation efficiency.

3. Reducing Hydrolysis: Ethanol can suppress the hydrolysis of reactive dyes, ensuring more dye reacts with the fiber rather than being wasted.
4. Lowering Environmental Impact: By reducing water usage and improving dye utilization, the process aims to be more sustainable and eco-friendlier.

5. Exploring Alternative Dyeing Media: Investigate ethanol as a viable alternative to conventional aqueous systems for future industrial applications.

CHAPTER-02

Literature Review

2.1 Reactive Dyes

Reactive dyes are a type of synthetic dye known for forming a strong, covalent bond with fabric fibers, resulting in excellent colorfastness, especially to washing. These dyes are particularly popular for dyeing natural fibers like cotton, wool, and silk.

Key characteristics of reactive dyes:

Covalent Bonding: Unlike dyes that simply adhere to the fabric surface, reactive dyes chemically react with the fiber molecules, creating a permanent bond.

High Colorfastness: The strong covalent bond makes the color very resistant to washing, fading, and other forms of color loss.

Wide Range of Colors: Reactive dyes can produce a vast array of vibrant and deep colors.

Application: They are commonly used in exhaust dyeing, discharge printing, and inkjet printing.

Environmentally Friendly: According to www.dyespigments.net, reactive dyeing is considered more environmentally friendly compared to some older dyeing methods.

How reactive dyes work:

Dyeing Process: The dye is dissolved and applied to the fabric, often under controlled alkaline conditions.

Fixation: The dye molecules react with the fiber, forming a covalent bond.

Washing: Unfixed dye is removed by washing, leaving behind the permanently bonded color.

Examples of reactive dyes and their uses:

Procyon dyes: A well-known brand of reactive dyes, particularly for cotton.

Lanasol dyes: Contain bromo-acrylamide groups and are used for dyeing wool, according to Textile Focus.

Halogen derivatives of heterocyclic nitrogen: These are another type of reactive group used in reactive dyes.

Vinyl sulfone dyes: React with fibers through a nucleophilic addition reaction, according to Textile Learner

2.2 Cotton

Cotton fabric is a natural textile made from fibers of the cotton plant (Gossypium). It is one of the most widely used and oldest known fabrics, prized for its comfort, breathability, and versatility.

Origin of Cotton

Source: Cotton fibers are harvested from the seed hairs of the cotton plant.

Major Producers: India, China, the United States, Pakistan, Brazil, and Uzbekistan.

Properties of Cotton Fabric

Types of Cotton Fabric

Common Weaves and Knits

Care and Maintenance

Washing: Machine washable; use cold or warm water.

Drying: Can shrink with high heat; air drying recommended. Ironing:

Tends to wrinkle; iron on medium to high heat.

Bleaching: Use non-chlorine bleach to avoid fiber damage.

Common Uses of Cotton

Apparel: T-shirts, jeans, shirts, underwear, socks

Home Textiles: Towels, bed sheets, curtains

Industrial: Canvas, tarpaulins, medical gauze

Accessories: Tote bags, hats, bandanas

Environmental Impact

Pros: Natural, renewable, biodegradable

Cons: Conventional cotton uses high water and pesticide levels; choose organic cotton for sustainability

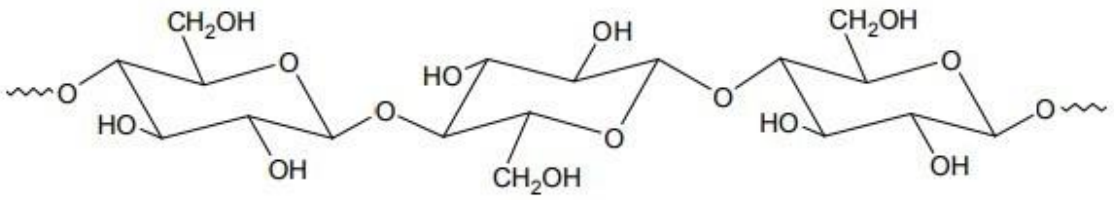


Figure 2.1 Chemical Structure of Cellulose

2.3 Ethanol

1. Fermentation: Produced by the fermentation of sugars by yeast (used in beverages and biofuels).

2. Synthetic: Made from petrochemical feedstocks like ethylene (used in industrial applications).

Chemical Properties

Alcohol Group: Ethanol contains a hydroxyl group (-OH), making it a primary alcohol.

Polarity: It is polar and can form hydrogen bonds, contributing to its solvent power.

Volatility: It evaporates easily at room temperature.

Uses of Ethanol

Industrial and Laboratory Uses

Solvent: For resins, dyes, pharmaceuticals, and cosmetics.

Disinfectant: Used in hand sanitizers and medical wipes.

Fuel: Used as bioethanol in gasoline blends (e.g., E10, E85).

Reagent: Common in chemical synthesis and laboratory protocols.

Preservative: For biological specimens and herbal extracts.

Consumer and Household Uses

Alcoholic Beverages: Ethanol is the type of alcohol found in beer, wine, and spirits.

Perfumes and Colognes: Solvent for fragrance compounds.

Cleaning Products: Found in glass cleaners and antiseptics.

Safety and Hazards

Flammability: Highly flammable; keep away from open flames and heat.

Toxicity: Can cause intoxication, central nervous system depression, and liver damage with chronic exposure.

Irritation: Can irritate skin, eyes, and respiratory tract.

Ingestion of industrial or denatured ethanol (contains additives like methanol) is extremely dangerous and can be fatal.

Environmental Aspects

Biodegradable: Ethanol breaks down naturally in the environment.

Renewable: Bioethanol from crops is considered a renewable energy source.

Emissions: When burned, ethanol produces carbon dioxide and water, similar to other organic fuels.

CHAPTER-03

Materials & Method

3.1 Materials

3.1.1 Fabric

We used 100% cotton single jersey 160 GSM bleached fabric.

3.1.2 Reactive dye

The reactive dye (Remazol Blue RGB, Remazol Red RGB, Remazol Golden-Yellow RGB) was collected from the laboratory of Tosrifa Industries Ltd, Sreepur Gazipur.

3.1.3 Ethanol

We used 90% ethanol instead of water for coloring here.

3.1.4 Cellulose activation

Soda Ash- 20g/l for 2 minutes Soaking & Padding

3.1.5 Recipe for Dyeing:

Ethanol: Water mixture 90:10

Wetting agent : 1 g/L (0.5 CC)

Dye						
Dyes Name	1% Shade		2% Shade		3% Shade	
	%	ML(CC)	%	ML(CC)	%	ML(CC)
Remazol Golden-Yellow RGB	0.25	1.25	0.5	1.25	0.75	1.25
Remazol Red RGB	0.25	1.255	0.5	1.255	0.75	1.255
Remazol Blue RGB	0.5	2.5	1	2.5	1.5	2.5

Table: 3.1 Dyes recipe

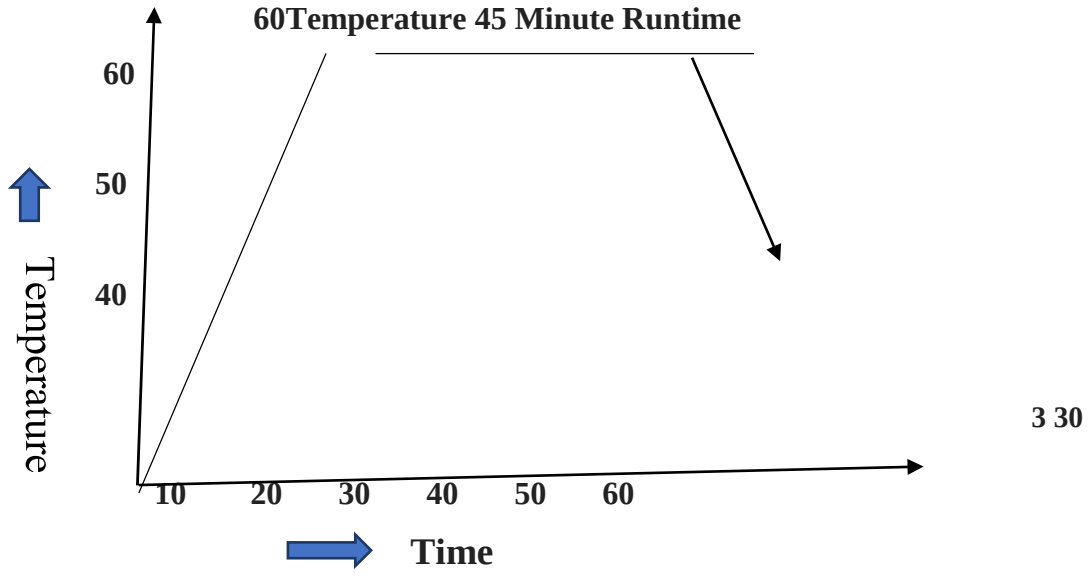
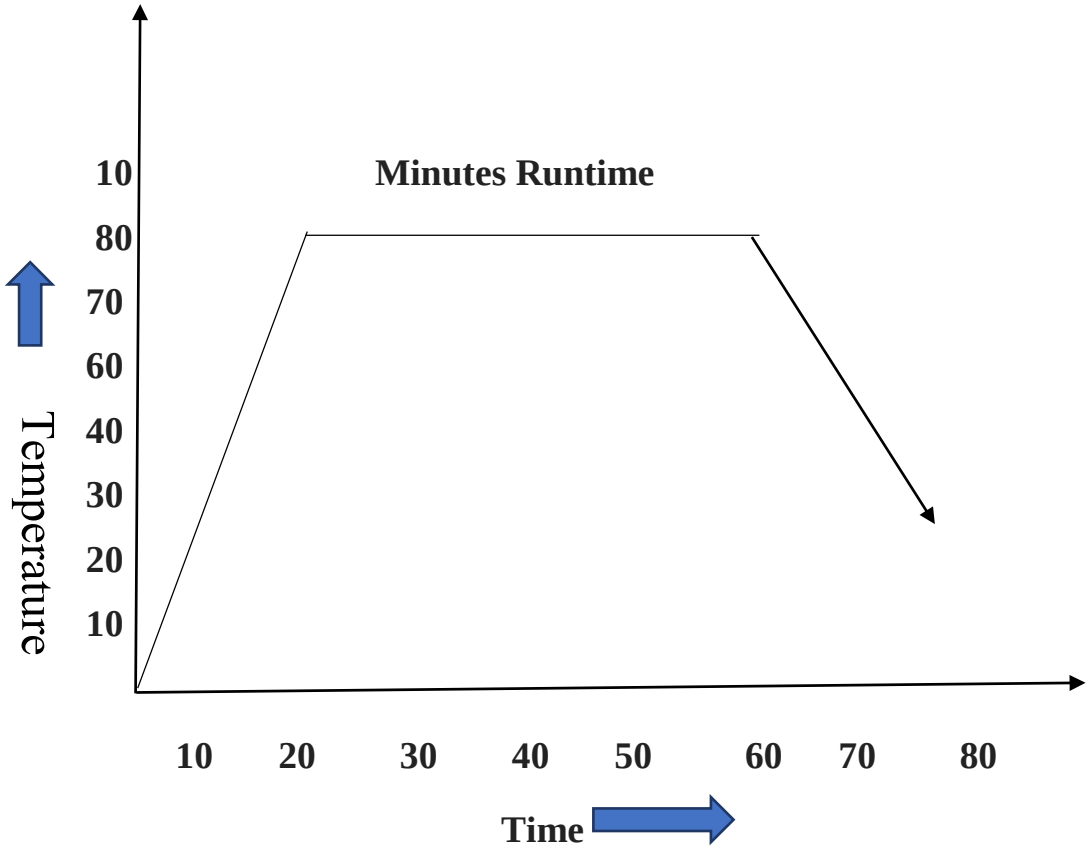


Table: 3.2 Recipe for After Treatment:

Typical Recipe (Per liter of Water)	
Component	Dosage
Hot Water	80°C
Detergent	1-2 g/L
pH	6-7

.



3.1.6 Work Outline

1. Fabric Preparation
De sizing → Scouring → Bleaching (if needed)

Drying



2. Preparation of Dye Solution

Reactive dye + Ethanol (as partial solvent)

Add electrolytes (e.g., NaCl) pH

adjustment with alkali (e.g., Na2CO3)



3. Dye Application

Pad dyeing or Exhaust dyeing method

Maintain ethanol–water ratio

Control temperature (typically 40–60°C)



4. Fixation

Hold time for reaction (e.g., 30–60 min)

Ethanol aids in better dye-fiber interaction



5. After-Treatment

Rinse with cold water

Soap wash (removes unfixed dye)

Final rinse



6. Drying

Remove moisture Final drying under controlled conditions

3.1.7 Apparatus

- Beaker
- Stirrer
- Conical Flux
- Measuring Cylinder
- pH Meter
- Electric Balance
- Scissor
- Thermometer
- Padding Mangle
- Dye Bath
- Shaker Bath
- Drying Machine Curing Machine

3.1.8 Equipment's

Table: 3.3: The following instruments were used for this study

Name of Equipment	Used For
Sample dyeing machine	Spectrophotometer and dyeing
Crock meter	Assessment of colorfastness to rubbing
Grey Scale	Assessment of Color fastness
Gyro wash	Assessment of colorfastness to washing
Incubator	Assessment of color fastness to perspiration & saliva

3.1.9.1 Sample dyeing machine

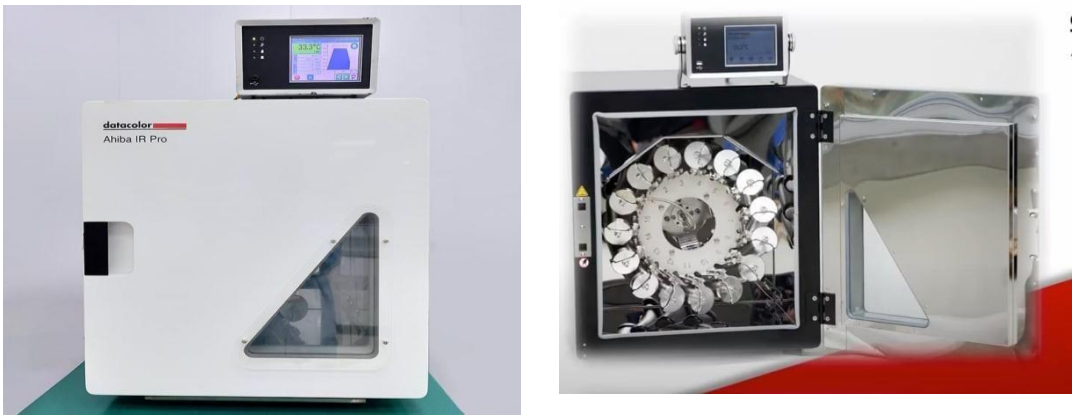


Figure 3.1 Sample dyeing machine

Purpose:
Used for dyeing fabric or yarn samples in a controlled lab setting to:
Test dye recipes, check color fastness, Simulate bulk dyeing results.

Features:
Rotary dyeing system, the circular arrangement allows multiple sample beakers (usually stainless steel) to be dyed simultaneously. Digital control panel, for setting temperature, time, and rotation speed accurately. Stainless steel chamber, for durability and resistance to chemical corrosion. Transparent door panel, for monitoring the dyeing process without interrupting it. Individual beakers/cylinders, often 12–24, each holding small sample fabrics or yarns.

Typical Specs:
Temperature Range, up to 140°C (usually for polyester dyeing with disperse dyes), capacity per beaker: 100–500 mL, heating Medium: Electric or glycol bath, dye Liquor Ratio, low, often 1:5 to 1:20

Applications:
Disperse dyeing (for polyester), reactive dyeing (for cotton) acid dyeing (for wool and nylon)

3.1.9.2 Spectrophotometer

A spectrophotometer is an instrument containing a monochromatic, a device which produces a light beam containing wavelengths in a narrow band

around a selected wavelength, and a means of measuring the ratio of that beam's

intensity as it enters and leaves a cuvette.



Figure 3.2 Spectrophotometer **(**X-rite 78i00)

Here X-rite 78i00 of spectrophotometric series is used for successful color management of printed sample. The L* value is a measure of lightness and darkness of the color while the a* value indicates redness or greenness and b* value indicates yellowness and blueness. Reflectance value (R) of all samples determined between the wavelength 400-700 nm within 10 intervals using Data color 650® Spectrophotometer. Putting these values of R into the Kubelka-Munk theory to find out the color strength (K/S) of each specimen.

Color Strength, $K/S = (1-R)^2/ 2R$Where, R = reflectance at complete opacity, K = absorption coefficient, S = scattering coefficient.

3.1.9.3 Color Fastness to Wash (ISO 105-CO6 A2S)

Assessment of color fastness

1. Changes in the color of the specimen being tested that is color fading.
2. Staining of undyed material which is in contact with the specimen during the test that is bleeding of color.

3.1.9.4 GREY SCALE

Grey scale is an empirical scale containing a series of pairs of neutrally colored chips, showing increasing contrast within pairs.
It is used to assess contrasts between the pairs of patterns visually.
Two types of grey scale -

1. Color change
2. Staining

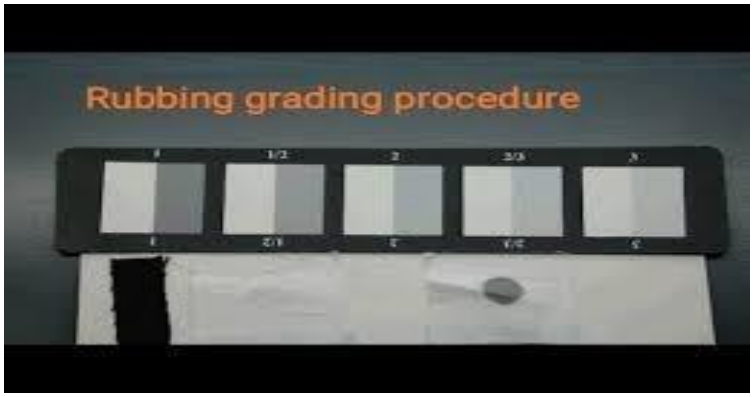


Figure: 3.3 Grey Scale

3.1.9.5 Color Fastness to Washing

Wash fastness of dye cotton were measured as per the ISO 105-C06 respectively. Color fatness to washing means, a specimen of the textile, in contact with one or two specified adjacent fabrics, is mechanically agitated under described conditions of time and temperature in a soap solution, then rinsed and dried. The change in color of the specimen and the staining of the adjacent fabric are assessed with the greyscales. In my personal experience, in case of fastness test color fastness to washing is the first and most important requirements of buyers. There are a number of ISO test for color fastness to washing.

3.1.9.6 Instruments

- Rota wash / Gyro wash m/c
- Stainless Still Ball
- Multi-fiber fabric
- Greyscale
- Sewing machine
- Thermometer
- Cylinder
- Scissor

3.1.9.7 Recipe

ECE phosphate reference detergent (B) 4gm./liter
Sodium Perborate 1gm/liter

3.15.1 Sample Preparation

1. Sample Fabric = 100mm × 40mm
2. Multi fiber fabric = 100mm × 40mm

3.1.9.8 Working Procedure

Collecting the sample and then conditioning for 06 hours. Making a specimen of 100mm × 40mm in size. Sewing the specimen with multi-fiber fabric of same size at one corner, Making the solution of 4gm/liter ECE(B) detergent &1 gm/liter sodium perborate. Putting the specimen with multi-fiber fabric into the solution in Gyro wash m/c Program. A2S Temp.:/40°C Time: 30 min Still ball: 10 pcs. Rinsing with hot water respectively. Squeezing with cold water of the sample is done (Hand Wash). Then drying is done at a temperature in the air not exceeding 60°C The stitching is then broken out except on one of the shorter ends. Measuring the staining and color change by grey scale & make a test report. By the similar way we can observe others color of sample.



Figure 3.4: Gyro wash (For Color Fastness to Washing)

3.1.9.9 For ISO 105-C06 (C2S)

- Total solution(changeable)…… 50ml
- Stainless Still Ball …….... 25 (for hitting)
- Time……. 30min
- Temperature…… 60^0C

3.1.9.10 Color Fastness to Perspiration

The color fastness to perspiration (acid and alkaline) shall be at least level 3-4 (color change and staining). This criterion does not apply to white products, to products that are neither dyed nor printed, to furniture fabrics, curtains or similar textiles intended for interior decoration. A level of 3 is nevertheless allowed when fabrics are both light colored (standard depth < 1/12) and made of silk or of blends with more than 20% silk. This kind of test is specially applied for the sportswear and heavy dresses which are used specially. Normal cloths are also tested by perspiration test. [20]

The garments which come into contact with the body where perspiration is heavy may suffer serious local discoloration. This test is intended to determine the resistance of color of dyed textile to the action of acidic and alkaline perspiration. Before knowing about the Color Fastness to perspiration you must have to know about color fastness to Wash and Color Fastness to Rubbing. Well, now will know about the perspiration matters which effects on Colorfastness.

There are two types of method for color fastness to perspiration test

1. ISO 105-E04 1994 (Acidic and Alkaline perspiration) 2. AATCC 15:2002 (only acid perspiration)

3.1.9.11 Apparatus and Materials

- ➢ Perspiration tester; perspiration or equivalent device.
- ➢ Oven, maintain at 37±2°C, or equivalent device.
- ➢ Multifiber test fabric.
- ➢ Grey scale
- ➢ Standard lighting chamber ➢Acid and Alkali solution ➢Glass or Acrylic plates.

3.1.9.12 Recipe of Acidic and Alkaline Perspiration Test

Table: 3.4 Recipe of Acidic and Alkaline Perspiration

Reagent	Acid	Alkali
L-histidine mono-hydrochloride mono-hydrate	0.5g/l	0.5g/l
sodium chloride	5g/l	5g/l
Sodium dihydrogen ortho phosphate	2.2g/l	2.2g/l
P^H (Adjust with 0.1N NaOH)	5.5	8.0

3.1.9.13 Working Procedure

Where fibers are to be tested, take a mass of the fiber approximately equal to one-half of the combined mass of the adjacent fabrics and either place it between a (100 ± 2) mm × (40 ± 2) mm piece of the multitier fabric and a (100 ± 2) mm × (40 ± 2) mm piece of the non-dye able fabric and sew them along all four sides. Layout the composite specimen in a flat bottom dish and cover with grade 3 water at room temperature. Thoroughly wet out approximately liquor ratio 50:1, and allow it for 30 min. Pour off the solution and wipe the excess liquor off the between two glass plate. Place the composite sample between two resin plate under presser of
12.5± 0.9 KPA /5kg, place the test device in oven at temp 37±2ºC for 4 hours. Open out the specimen, dry by hanging in the air not exceeding 60ºC in contact only at the line of stitching.
After that make a test report with gray scale.
By the similar way we can observe others color of sample.



Figure: 3.5 Incubator & Per spirometer (For Color Fastness to Perspiration)

3.1.9.14 Color Fastness to Rubbing

Rubbing test specifies a method for determining the resistance of the color of textiles of all kind's fabric. The method is applicable to textiles made from all kinds of fibers in the form of yarn or fabric. Two tests may be made, one with a dry rubbing cloth and one with a wet rubbing cloth. Specimens of the textile are rubbed with a dry rubbing cloth and with a wet rubbing cloth. The machine provides two combinations of testing conditions through two alternative sizes of rubbing finger: one for pile fabrics and one for solid color or large print fabrics.
There are two test methods for rubbing fastness.

1. ISO-105-X12
2. AATCC-08

In ISO-105-X12 the wet pickup of rubbing cloth is 100%, while in AATCC-08 the wet pickup of rubbing cloth is 65%.
Determining the resistance of the color of textiles of all kinds, including textile floor coverings and other pile fabrics, to rubbing off and staining other materials. A rectangular rubbing surface with the lead edge rounded measuring 19 mm × 25.4 mm (crock block). Downward force of (9 ± 0.2) N, Track length (104 ± 3) mm Diameter of rubbing finger (16 ± 0.1) mm. Two tests may be made, two with a dry rubbing cloth and two with a wet rubbing cloth on both directions. Two pieces not less than (140 ×50) mm are required for dry rubbing and two for wet rubbing. Two pieces not less than (140 ×50) mm are required for dry rubbing and two for wet rubbing. 10 cycle 10 sec, Condition the specimen and rubbing cloth for at least 4h in an atmosphere of (20 ± 2) ◦C and (65 ± 2) % RH by laying each test specimen and each piece of rubbing cloth separately on a screen or perforated shelf. The moisture picks up percentage for wet rubbing 95% to 100%. [15,16].

3.1.9.15 Working Procedure

3.1.9.15.1 Dry rubbing test:

- The length or with direction of the test specimen should be parallel to the direction in which the rubbing is to be calculated.
- Using the spiral ring clip set a 5cm×5cm square of the white, cotton rubbing test cloth to the finger (peg) of the crock meter. The weave of the test cloth should be parallel to the direction of rubbing.
- Lower the covered finger onto the test sample.
- Make ten (10) complete turn of the crank, at the rate of one turn per second.
- Remove the white rubbing test cloth from the finger and evaluate color transfer using the grey scale for staining under standard lighting. D65 (Artificial daylight).
- One test is done to warp/Wales direction and another for weft/course direction.

3.1.9.15.2 Wet rubbing test:

➢ Repeat the same procedure with the white cotton test cloth wetted in distilled water. Ensure that the rubbing test cloth will be wetted with water to 100% take up. ➢

Air dries the cotton test cloth at the room temperature before evaluation.

➢

After completing the procedure make a test report with gray scale. By the similar way we can observe others color of sample.



Figure 3.6: Crock meter (For Color Fastness to Rubbing) & checking with light box

CHAPTER-04

Results and Discussion

4.1 Color Strength

The color strength value of sample S_2 is higher than all other samples colored with three different sources of Modifier & without modifier. The mostly light shade was achieved for S_3 sample treated with NH_{4Cl} modifier and dark shade of with alum obtained for S_2 sample.

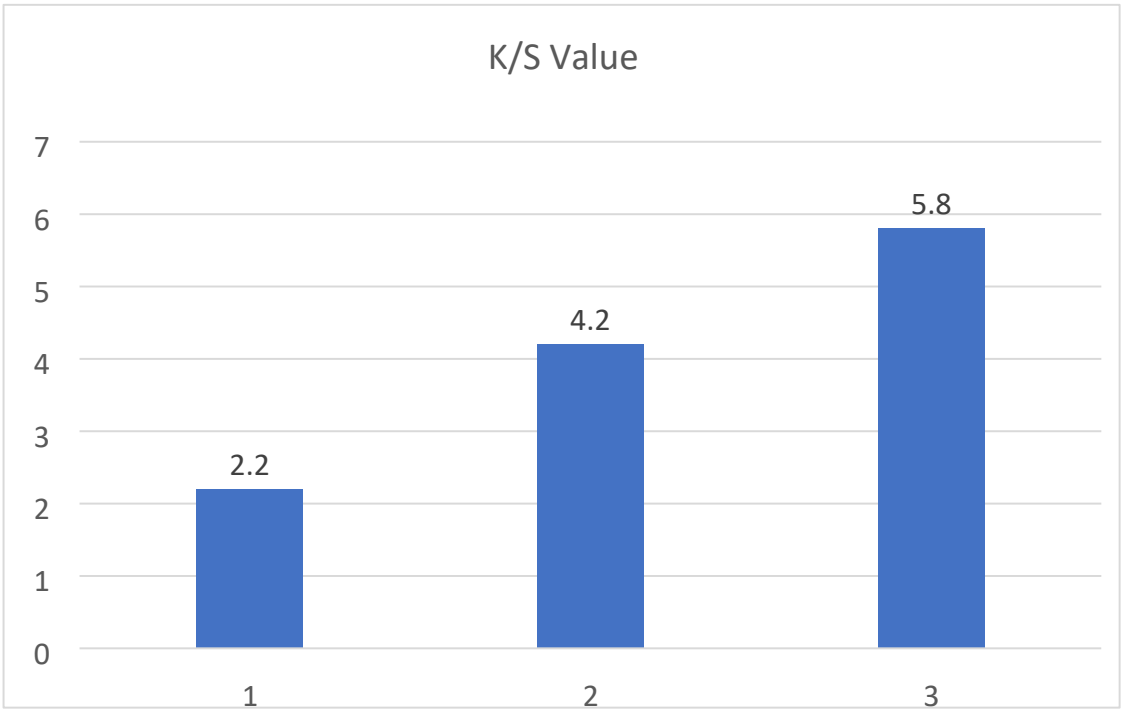


Figure:4.1 Color strength value of dyed sample.

4.2 Color Coordinates

L* values of the sample relate to brightness/lightness. From the TABLE 4.2, it has been found that sample S_2 and S_3 dyed with reactive dyes using NH4Cl as modifier describes

Brighter lighter shade than S_1. D_{65} illuminant. Similarly, for marigold dyes, the value b* of S_1 sample exhibits better depth of blue color than others sample.

Table: 4.1 CIE color coordinates of dyed sample

Sample no.	Illuminant	L*	a*	b*	C*	H
Sample-1% Shade	D65-10	50.18	10.53	-10.31	14.74	315.58
Sample-2% Shade	D65-10	41.5	10.05	-10.51	14.54	313.73
Sample-3% Shade	D65-10	35.88	10.2	-10.62	14.73	313.84

4.3 Test Result of color fastness to wash

In the color fastness to wash test, it has been found that color change rating of S_2 & S_3 was found similar than another sample although the color value of this two sample falls under a lighter Red region. Color staining of S_1 sample defines fair wash fastness rating.

Table: 4.2 Result of color fastness to wash

Fabric type	Color	Color change	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
Dyed fabric cotton s/j treated	Sample-1% Shade	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Sample-2% Shade	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Sample-3% Shade	4-5	4-5	4-5	4-5	4-5	4-5	4-5

4.3 Test Result of Color Fastness to Rubbing

It was a noticeable matter that after dyeing individually by reactive dyestuffs with modifier gave excellent rubbing fastness. Sample S_1, S_2, and S_3 exhibits good to excellent dry rubbing fastness whereas wet rubbing was found fair to good result. With modifier (NH4Cl), sample S_2 & S_3shows excellent dry rubbing performance.

Table: 4.3 rating of color fastness to rubbing test result of all samples

Fabric type	Color	Color change	Dry			Wet		
Dyed fabric cotton s/j treated	Sample-1% Shade	4-5	4-5	4-5	4-5	4	4	4
	Sample-2% Shade	4-5	4-5	4-5	4-5	4	4	4
	Sample-3% Shade	4-5	4-5	4-5	4-5	4	4	4

4.4 Test Result of Color Fastness to Perspiration

In color fastness to perspiration test, a good fastness rating against acid and alkaline perspiration was obtained for S_1, S_2 and S_3 sample. Here sample S3 has shown a poor rating of perspiration fastness.

Table: 4.4 Rating of color fastness to perspiration test result of all dyed samples

Fabric type	Color	Color change	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
Dyed fabric cotton s/j treated	S Sample-1% Shade	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Sample-2% Shade	4-5	4-5	4-5	4-5	4-5	4-5	4-5
	Sample-3% Shade	4-5	4-5	4-5	4-5	4-5	4-5	4-5

4.5 Discussion

The initial observation of differing dye uptake (Sample 1 being significantly darker) contrasts with the nearly identical results from colorfastness tests—specifically perspiration, rubbing, and washing. This discrepancy suggests that the visual differences among the samples are not primarily due to differences in dye fixation or colorfastness, but may be attributable to other factors such as:

Dye type

Dye concentration

Variations in the dyeing process

All three samples (S1, S2, S3) showed good to excellent performance in colorfastness tests, indicating that the ethanol–water dyeing method is effective in fixing dye to the cotton fibers even without the use of salt or other auxiliaries. This result supports the potential of ethanol as a green solvent and highlights its ability to produce results comparable to traditional methods, with added environmental benefits. However, further investigation into specific process parameters (e.g., temperature, pH control, and ethanol concentration) is necessary to optimize and fully understand this novel system.

CHAPTER-05

Conclusions

5.1 Conclusions

Cotton fiber is a vastly used natural textile fiber. For dyeing purposes, reactive and direct dyes are routinely used. However, traditional cotton dyeing processes produce effluents with a high environmental load. Therefore, adopting an alternative dyeing medium that is recyclable can contribute significantly to a sustainable dyeing process.

In this regard, the ethanol–water mixture presents itself as a novel and ecofriendly solvent. In this study, cotton knitted fabric was dyed in both ethanol–water mixtures and conventional water mediums using reactive and direct dyes. Dyeing performances were then evaluated.

Notably, the ethanol–water system did not require the use of salt, soda, or auxiliary chemicals during dyeing. Despite this, the results were very satisfactory, showing similar color fastness and dye uptake as the conventional methods. This suggests that ethanol–water mixtures can be a viable, greener alternative for cotton dyeing.

There remains scope for further analysis, particularly regarding the characterization and treatment of process effluents, which could help establish this as a truly novel and sustainable dyeing approach.

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