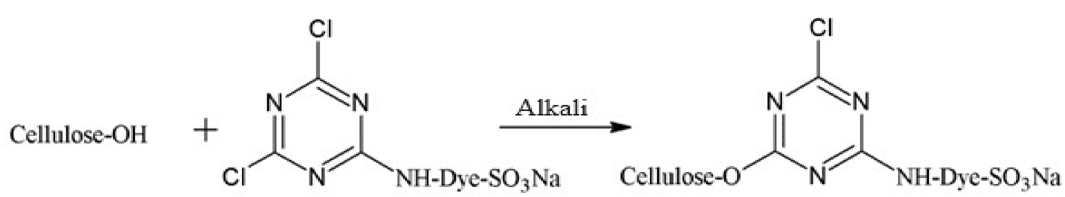
Application

4.1 Application of Reactive dyes

In this chapter the dyes synthesized in chapter II was applied on cotton, silk and wool and several parameters with fastness properties have been examine. The colors were applied using printing, Cold Pad Batch and exhaust dyeing processes. Cellulosic fibres were mostly dyed and printed with reactive class of dyes. Reactive dyestuff is the most widely used for viscose dyeing due to excellent brilliance of shades and outstanding all fastness characteristics [1].

As reactive class of dyes form a covalent link with the textile fibre, they exhibit excellent wet-fastness [2]. Since 1950, reactive dyes have become increasingly popular. To obtain good wet fastness and fixation value, reactive dyes' new structures and fibre modifications were used in the textile industry [3]. In order to create a even depth of colour with colour fastness qualities appropriate for the ultimate application, for getting this additional processing chemical are added during operation in textiles materials [4-5]. The hydroxyl groups of the fibres establish covalent connections with molecules, which gives the dyes a strong resistance to wet conditions [6-7].

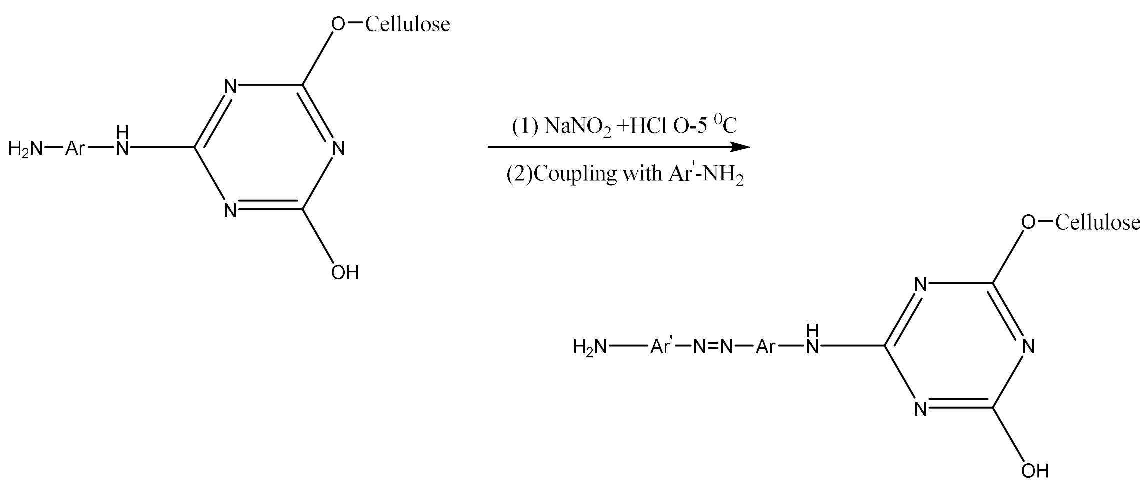


The goal of a triazine dye containing cyanuric chloride residues is interact with cellulose material and form a covalent bonding. Physical adsorption and maybe some hydrogen bonding occur in the neutral solution, Nevertheless, the creation of covalent bonds only occurs after adding alkali to the dye bath. Following are some data that support the idea that chemical union occurs after the addition of alkali [8].

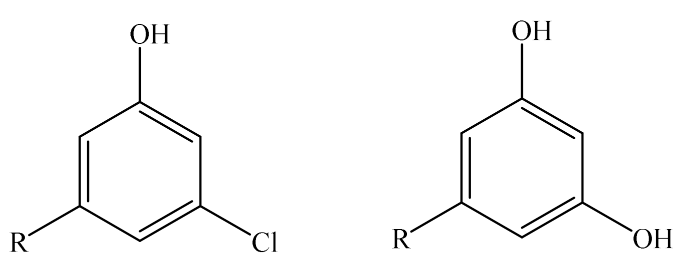
- The colour can be removed before alkali treatment by continuously extracting it with neutral water.
- Following alkali treatment, boiling soap solution could well be generated quickly.

- By boiling azoic or vat dyes in o-chlorophenol, pyridine or chloroform, cellulosic materials coloured with direct dyes can have their colour erased. Procion dyes that have been alkali-fixed, however, do not work like way. The conclusion that follows suggests that a different kind of binding force is at action.
- It is possible to decrease an azo dye to produce a colourless combination of two primary amines.

One part of the synthetic dye molecule stays fixed with the fibre during dyeing process for reactive dyes. The fibre that is produced is colourless. If diazotization and their right coupling component are implemented, the colour is recovered. Similar outcomes can be obtained by repeating the reduction, diazotization, and coupling procedure.



An undesirable interaction between the cyanuric chloride molecule's halogen atoms and water results in either the mono- or di-hydroxy product when the dye is being connected to the cellulose, as shows as below.



4.1.1 Reactive dyes application on Cotton:

Reactive class of dyes performed on cotton textiles material are the main focus of this section. In the process of applying on cotton cloth two method of dyeing process were used Exhaust and cold pad batch. In textiles industries mostly exhaust dyeing method is use, but in application reactive dyes the water consumption is very high so demand that the produced dyes have apply with cold pad batch method. Mostly less water is used and the high fixation is achieved by cold pad batch method.

Reactive dyes when applied to the fabric, there are two steps of process accure one is exhaust and second is fixation, in first step when cotton material treat with water at that time surface anionic charges. The reactive dye in water must be anionic in nature. It is impossible to introduce dye anion to the reactive sites because these two comparable charges resist one another. Salt is added to the substrate's surface in order to diffuse the charges from its surface.

Cation and anion formation in the salt

$$NaCl \longrightarrow Na^{\oplus} + Cl^{\ominus}$$

$$Na_2SO_4 \longrightarrow 2Na^{\oplus} + SO_4^{-2}$$

The cation form of the surface solution.

$$\text{Cell-OH} \longrightarrow \text{Cell-O}^{-} + H^{+}$$

$$\text{Cell-O}^{-} + Na^{+} \longrightarrow \text{Cell-ONa}$$

When the dye anions are neutralised, they easily react with cellulosate anion, which replaces the Na+ cation. The necessity for salt as an exhausting agent is high at this point. Similarly, in the presence of alkali, dye fixation can occur. In dyeing, alkali has two purposes. On the one hand, the addition of alkali increases the synthesis of cellulose anions significantly, and the movement of colour from the fiber's exterior to its interior is still ongoing. The fascinating phenomenon is that the balance is constantly moving since the entering dye reacts instantly.

4.1.1.1 Exhaust dyeing:

Two gram of cotton fabric were dyed in an IR dyeing machine with 2% (owf) dye at a 20:1 ratio of dye liquid to cloth. The fixation of 60°C isothermal procedure was employed using 100 g L^{-1} sodium sulphate and 10 g L^{-1} sodium carbonate. The cotton material (2.0 g) was cleaned in a solution of soap (0.2 g) and water (100 ml) at 50ºC for 10 minutes. The substance was extracted out of the bath, rinsed with water numerous times, compressed, dry, and then processed. Decanting a colour solution into a 250 ml volumetric flask was the next step. After colouring, by applying 2 g/l non-ionic shop for 20–30 minutes at 90–95 °C, the shopping was completed. followed by washing and drying. As shown in Figure:26, the cotton dyeing procedure was carried out.

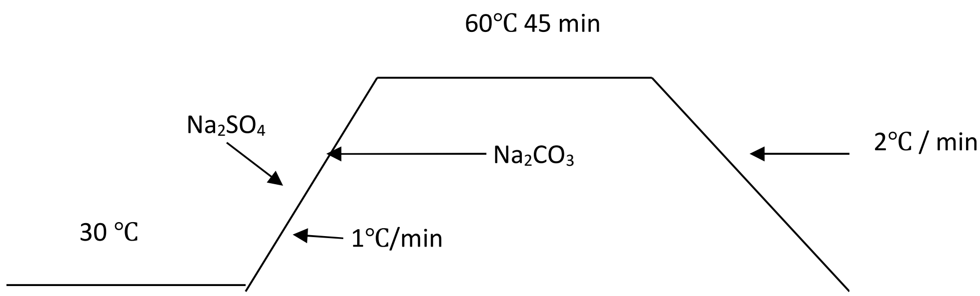


Figure:26 Exhaust dyeing cycles

Mono azo hot brand reactive dyes of series six was dyeing with 100 g/l sodium chloride and 10 g/l sodium carbonate at 80 ºC temperature. The cotton material (2.0 g) was cleaned in a solution of soap (0.2 g) and water (100 ml) at 50 °C for 10 minutes. The material was removed from the bath, washed several times using water, compressed, dried, and then processed. Following exhaust, the fabric was neutralised with acetic acid 1 g L^{-1}, after that fabric washed with 2 g L^{-1} non-ionic shop for 20 to 30 minutes at 95 °C., give cold wash and again hot wash till all unfix colour removed from the fabric. followed by washing and drying. All washed dyed fabric dry in Hot electric oven at temperature 70 °C. after drying the fabric give conditioning at room temperature. Then used this fabric measured on spectrophotometer and for check fastness properties. As shown in Figure:27, the cotton dyeing for hot brand dyes procedure was carried out. For dyeing of hot brand reactive dyes dyeing is started with 30 °C at that time NaCl and Sodium sulphate is added at beginning of dyeing. The heating rate of IR machine is 1 °C per min. at 80 °C dyeing is run for 45 min. after dyeing machine is cooled to room temperature.

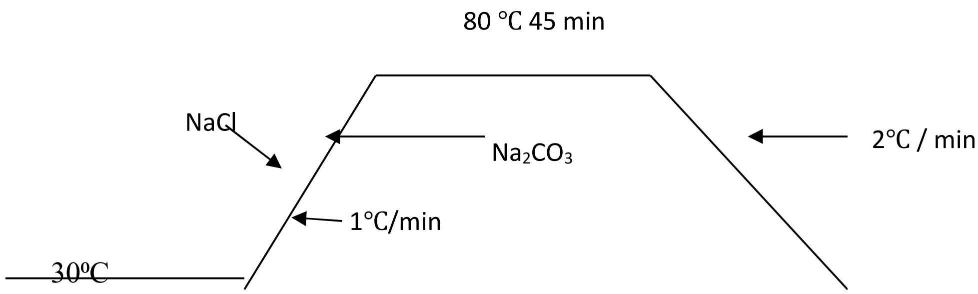


Figure:27 Exhaust dyeing cycles of hot brand dyes

4.1.1.2 Study of Exhaustion and Fixation:

By measuring optical density with the help of a spectrophotometer, the percentage of exhaustion was calculated (Spectrophotometer SS 5100A Premier Colorscan). Then % Exhaustion was calculated using the beginning and final dye solution OD values with use of equation 1 and 2.

$$E = \frac{B_0 - B_1}{B_0} \times 100\% \qquad \text{Equation 1}$$

$$F = \frac{B_0 - B_1 - B_2}{B_0} \times 100\% \qquad \text{Equation 2}$$

Where B_0 = Absorbance Values after dyeing, B_1 = Absorbance Values after dyeing, B_2 = The soaped solution's absorption value

Table 8 displays the findings of the synthetic dye's % of exhaustion readings. Reactive dye's substantivity to fiber is higher than its substantivity to water. The range of substantivity and reactivity of all reactive dyes fluctuates. The exhaustion and fixing of these colors depend on common salt and alkali, therefore salt input to the dye solution prior to alkali addition is necessary. Reactive dyes are given different results at several parameter in this study, all dyes were applied with several conditions.

Dye No	% Exhaustion	% Fixation	Dye No	% Exhaustion	% Fixation	Dye No	% Exhaustion	% Fixation
Z1	98.23	88.45	**Z19**	90.89	89.3	**Z37**	92.9	89.1
Z2	93.34	87.34	**Z20**	89.87	78.23	**Z38**	93.19	82.34
Z3	92.9	89.1	**Z21**	98.23	87.9	**Z39**	96.67	78.67
Z4	93.19	82.34	**Z22**	93.34	88.45	**Z40**	93.65	86.78
Z5	96.67	78.67	**Z23**	92.9	87.34	**Z41**	95.43	88.35
Z6	93.65	86.78	**Z24**	93.19	89.1	**Z42**	92.97	83.56
Z7	95.43	88.35	**Z25**	96.67	82.34	**Z43**	93.52	82.9
Z8	92.97	83.56	**Z26**	93.65	78.67	**Z44**	92.88	78.67
Z9	93.52	82.9	**Z27**	95.43	86.78	**Z45**	93.19	86.78
Z10	92.88	82.33	**Z28**	92.97	88.35	**Z46**	96.67	88.35
Z11	96.67	88.34	**Z29**	93.52	83.56	**Z47**	93.65	83.56
Z12	93.65	87.28	**Z30**	92.88	82.9	**Z48**	95.43	82.9
Z13	95.43	83.43	**Z31**	95.43	82.33	**Z49**	92.97	88.35
Z14	92.97	89.91	**Z32**	92.97	78.67	**Z50**	93.52	83.56
Z15	93.52	88.35	**Z33**	93.52	86.78	**Z51**	98.23	82.9
Z16	92.88	83.56	**Z34**	92.88	89.91	**Z52**	93.34	86.78
Z17	93.34	82.9	**Z35**	93.19	88.35	**Z53**	92.9	88.35
Z18	92.9	82.33	**Z36**	96.67	76.34	**Z54**	97.87	83.56

Table:8 % of Exhaustion and % of Fixation values on cotton fabric

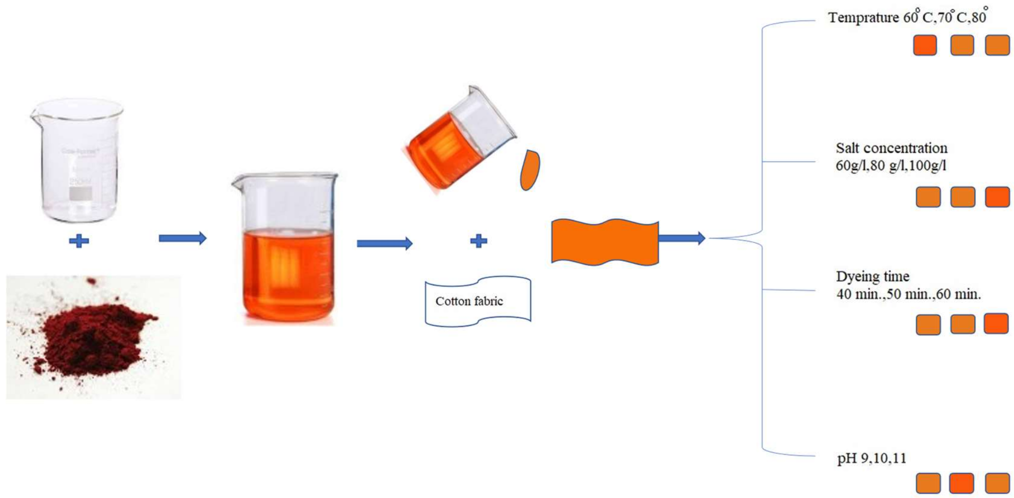


Figure:28 Experimental set up for cotton dyeing

Synthesized dyes of series 1(Reactive dye Z1-Z10) applied on cotton fabric for examination of several parameter like temperature, pH, salt concentration and dyeing time. The Experimental set up of the cotton dyeing method presented in Figure:28.

4.1.1.3 Temperature effects on exhaustion and fixation:

Temperature is a key factor in cotton dyeing to achieve deeper hues and a greater fixation value [9]. Every dyes has a particular exhaustion and fixation rate, which is mostly dependent on the constitution of dye and the dyeing method used [10]. The colouring rate increases with the temperature rises, although the ultimate exhaustion may rise or fall that depend on the dyeing technique. The conclusion of covalent bond development between fibre and dyes in reactive dyes is that cotton's -OH group reacts with dye molecules. With increasing temperature, the initial dyeing rate rises [11]. When the temperature gets higher, the dyeing equilibrium absorbs more heat energy. The relationship involving dye molecules and fiber molecules is more powerful than the interaction between dye molecules and water molecules in solution. Certain dyes had low molecular stability above 70 °C. Molecular stability caused a rise in the exhaustion rate. Depending on the dyes, the temperature of the textile dyeing varies. Figures:29 & 30 demonstrate that the rate of exhaustion and fixation for dyes Z1 to Z10 is higher at 60ºC. For Exhaustion and Fixation, dyeing temperatures above 60ºC were still not recommended. At 60ºC, the Exhaustion and Fixation values for dye Z1-Z10 were higher.

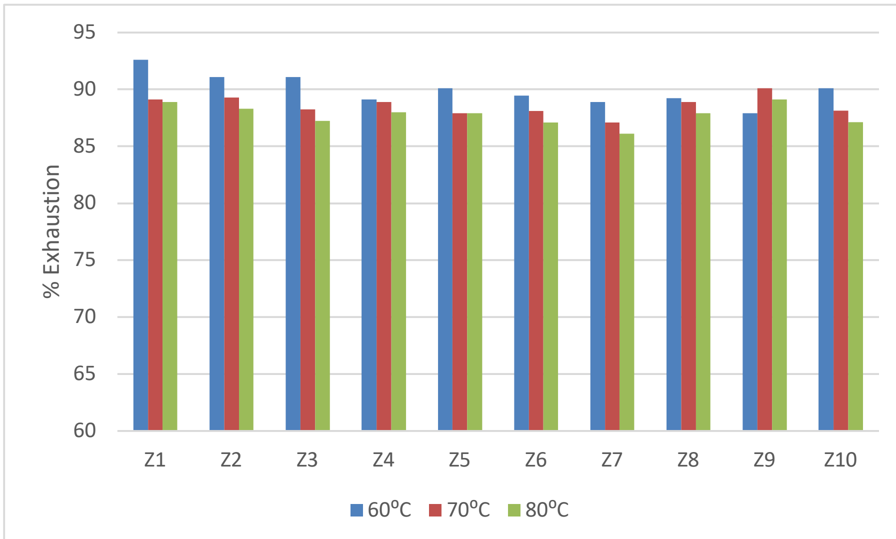


Figure:29 Temperature effect on Exhaustion

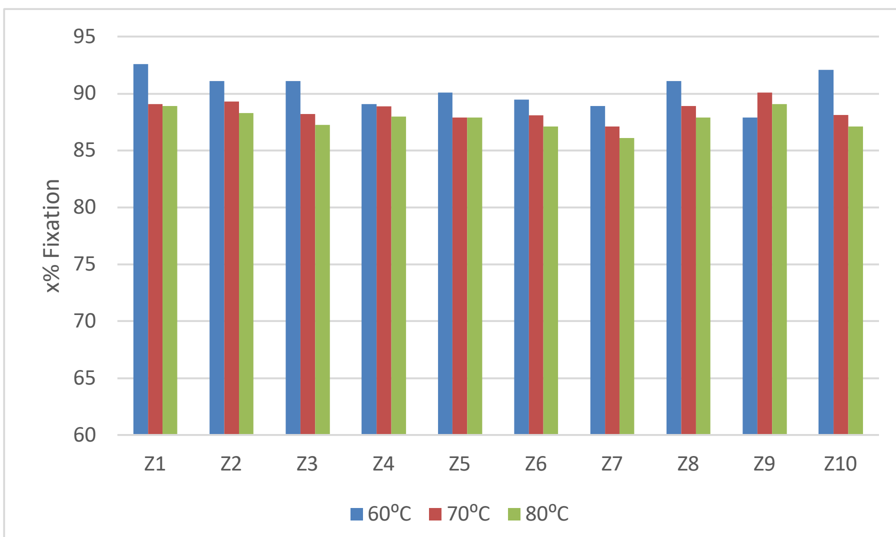


Figure:30 Temperature effect on Fixation

4.1.1.4 Salt concentration effects on exhaustion and fixation:

From an economic and environmental standpoint, exhaustion and fixation needed a great level of expertise. The physical-chemical requirement of using salt and soda in reactive colouring is universal among technicians. In such cases, a catalyst is usually required to aid the colouring activity on the substance. Salt serves as an important catalyst.

In general, salt plays a role in three distinct ways. Initially it drives colour into the material throughout the colouring operation. Second, the usage of salt causes the most dye molecules to be exhausted throughout the colouring process in textiles. Third, it's employed as a solution for the migration, absorption, and fixing of the colouring substance to the polysaccharide material [12]. The textile substrate and dye molecule do not have to have uniform properties in order to mix with one another. Alkalinity is a vital component of the achievement of cellulose fabric dyeing. Electrolytes were utilised in this investigation at concentrations of 60, 80 and 100 g/l. Covalent bond formation is required to add alkali Figure:31&32 shows that when the amount of salt was increased, Moreover, both fixation and exhaustion percentage rate has increased. At 100 g L^{-1}, the rates of synthetic dye fixation and exhaustion were also higher, achieving 93% and above 85%, respectively.

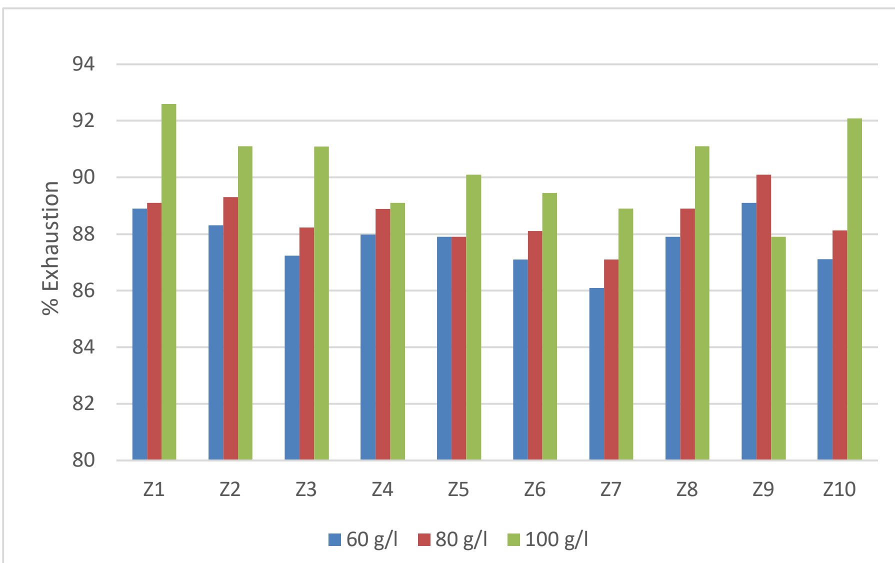


Figure:31 Salt effect on Exhaustion

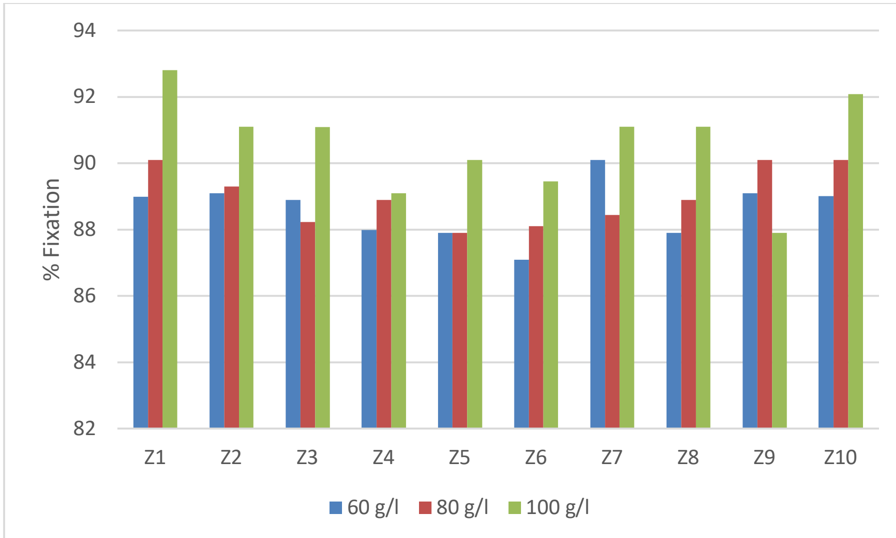


Figure:32 Salt effect on Fixation

4.1.1.5 Dyeing time effects on exhaustion and fixation:

The cotton textiles material was coloured using varied dyeing times for the examination of exhaustion and fixing (40, 50, and 60 min.). A highly reactive dye has a higher likelihood of reacting with fiber, but it also has a high possibility of being hydrolyzed. Cotton's ability to absorb dyes and other colourants is attributed to the polarity of its polymers as well as polymer chain, and also the presents of functional group in dyes structure. Any polar dye molecules will be drawn into the polymer system by this polarity. In actuality, colour molecules that may disperse in water will be absorbed by the cotton polymer. The system to produce a deeper colour on cotton cloth, dyeing time was more important. So, exhaust time and fixing time play major roll. The objective of this research is to produce cotton fabric with a deeper shade. From the experiment the rate of colour migration to cotton fabric peaked after 40 minutes. Exhaustion and fixing rates were higher during the 40-minute dyeing period, as seen in Figure:33 & 34. When compared to 50 and 60 minutes, the fixation rate is at its highest after 40 minutes of dyeing due to the beginning of hydrolysis, which also reduced exhaustion. It is shown that for bi-functional reactive dyes after 40 min. the rate of hydrolysis of dyes was very high. Not only achieved high fixation values of dyes but helps in saving salt, water and alkali to use in dyeing. The covalent bond between dyes and fabric are more stable during 40 minute time.

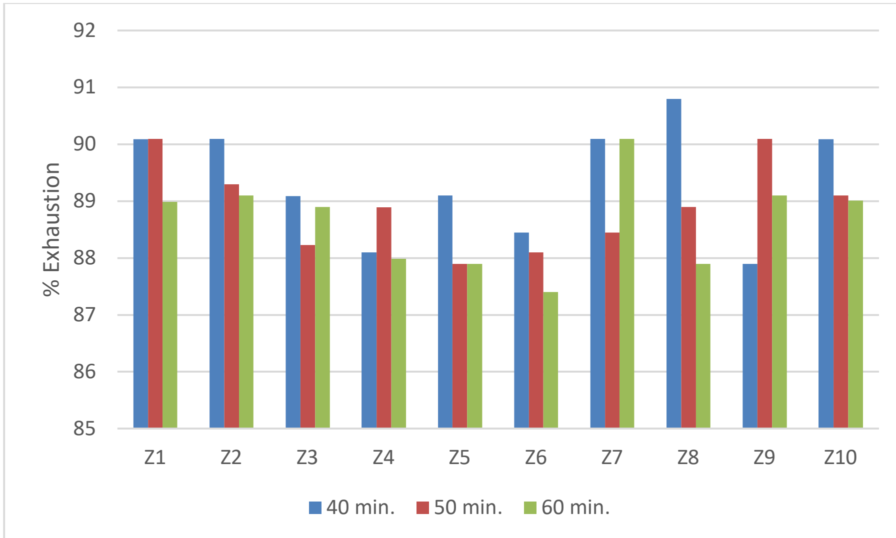


Figure:33 Dyeing time effect on Exhaustion

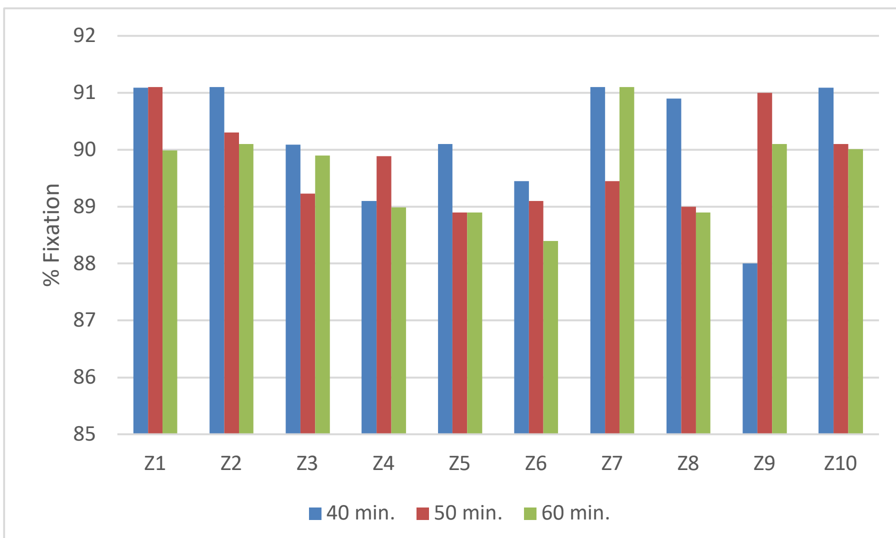


Figure:34 Dyeing time effect on Fixation

4.1.1.6 pH effects on exhaustion and fixation:

Maintaining pH is extremely critical when using reactive dyes on cotton fabric. It was discovered that dyeing temperatures and pH levels rise when the reactivity of the reactive group goes up, and vice versa. The pH of the dye bath has a significant influence on generating increased colour strength in cloth. Alkali media are always required when using reactive dyes. With the exception of pH, all dyeing parameters are the same as above. A dyeing temperature of 60 ºC and a 45 minute dyeing period were utilised. In this experiment, a range of pH (9, 10, and 11) was applied to test the impact on dye exhaustion and fixing rates. Figure: 35 & 30 shows the impact of pH on exhaustion and fixation.

The results indicate that the dyes' exhaustion and fixing rates were higher at pH 10, increasing to above 90% and 93%, respectively.

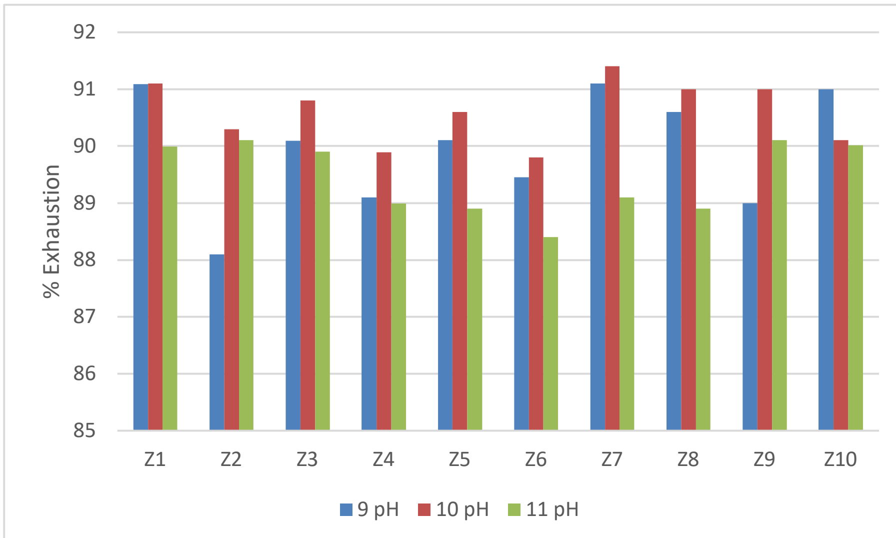


Figure:35 pH effect on Exhaustion

4.1.2 Cold Pad Batch

Reactive dyes that are used in CPB dyeing frequently include one or more vinyl sulphone groups or are bi- or polyfunctional. The CPB technique is relatively easy because all of the steps encompass passing the cloth into the dye bath and squeezing it through the dying padder, followed by batching for a maximum of twelve hours. Many textile workers seeking high output rates find the CPB technique unappealing because of the extended batching period of time [13]. Experimental set up of CPB method explain in Figure:36. First fabric was pad with colour solution with silicate and caustic solution than pass from roller,

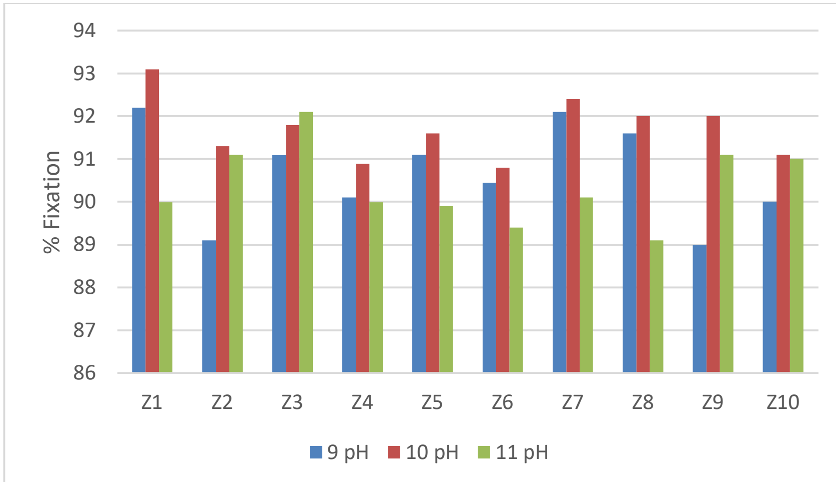


Figure:36 pH effect on Fixation

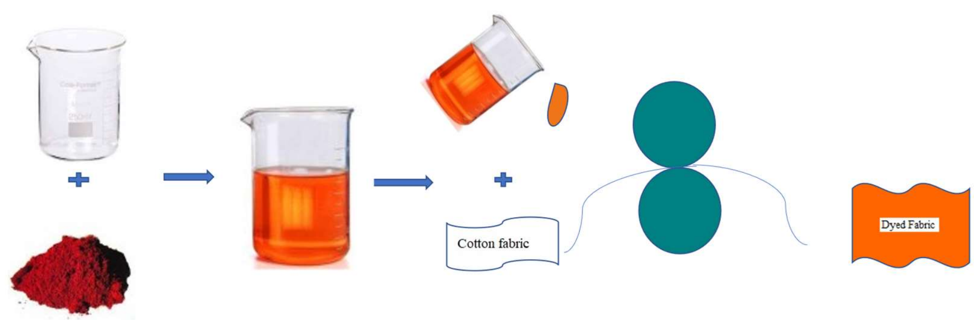


Figure:36 Experimental set up of CPB process

On cotton fabric, series 1 to 4 of synthesised reactive dyes were investigated. Reactive dyes with a 20 g L^{-1} concentration were applied to colour the fabric whenever CPB was applied. For the CPB dyeing technique, horizontal padding mangal was utilized. The fabric was run through a padding mangal where a padding solution and dye were applied. The fabric was run through a padding mangal where a padding solution and dye were injected. The dyed fabric was batch-processed for 16 hours. Sometimes if alkali concentration increased at that time the dwelling time of fabric is reduce. The padding solution for the Cold Pad Batch Dyeing process included, urea (20 g L^{-1}), NaOH 38 Be' (0.5 ml L^{-1}) and sodium silicate 109 ^{0}Tw (50 ml L^{-1}) Each specimen was placed into such a plastic bag pretty quickly. Batches of fabric were kept at room temperature in a dark area. After complete the batching time, the fabric was washed with solution of sodium hexametaphosphate to get remove of any unfixed colours at room temperature, and then the cloth was given a washing treatment with cold water and boiling water. After completed washing treatment the coloured fabric was kept in a drying oven that was set to 60 °C. after drying the dyed fabric were conditioning for four to five hours than Data Colour TM Spectrophotometer was used to evaluate CPB coloured fabric.

On the measurement of cold pad batch cloth with Data Color 400 TM Spectrophotometer, the reflectant values L*, a*, b*, C*, H, and K/S was noted. The following equation 3 was used to compute the dye fixed value of Cold Pad Batch coloured fabric.

$$\%F = \frac{\text{K/S after wash}}{\text{K/S before wash}} \times 100 \qquad \text{Equation 3}$$

Using synthesized reactive dyes(Z1-Z40), it was seen that good fixation and even colouring were accomplished on fabric. All series 1 to 4 dyes showed a fixation of between 85% and 91%. Fixation value in percentage of synthesized dyes were shown in Table: 09. For series I the fixation values shows 85.9% to 91.05% in this series J- acid used as a coupler the phenyl urea presents in triazine ring gives good fixation value as well as good wet fastness properties. The presents of 4-(β-sulfatoethylsulfonyl)aniline gives good affinity of dyes and good fixation values of dyes on fabric. The simplest structure of phenyl urea react with triazine ring gives good fixation of dyes. In remain series also achieved good fixation values. The synthesized dyes have good solubility in water so this behaviour of synthesized dyes have excellent fixation values on cotton fabric.

Dye No	% Fixation	Dye No	% Fixation	Dye No	% Fixation
Z1	89.45	**Z19**	89.04	**Z37**	89.05
Z2	87.34	**Z20**	86.45	**Z38**	86.72
Z3	89.1	**Z21**	87.99	**Z39**	91.04
Z4	85.9	**Z22**	88.45	**Z40**	86.78
Z5	87.79	**Z23**	87.34	**Z41**	88.35
Z6	86.78	**Z24**	89.81	**Z42**	87.66
Z7	88.35	**Z25**	89.89	**Z43**	87.43
Z8	87.12	**Z26**	78.67	**Z44**	85.05
Z9	91.05	**Z27**	86.78	**Z45**	86.78
Z10	87.31	**Z28**	88.35	**Z46**	88.35
Z11	90.12	**Z29**	87.01	**Z47**	88.23
Z12	87.28	**Z30**	85.56	**Z48**	86.47
Z13	85.87	**Z31**	86.12	**Z49**	88.35
Z14	89.91	**Z32**	89.12	**Z50**	91.45
Z15	88.35	**Z33**	86.78	**Z51**	90.32
Z16	86.75	**Z34**	89.91	**Z52**	86.78
Z17	89.23	**Z35**	88.35	**Z53**	88.35
Z18	88.43	**Z36**	91.01	**Z54**	87.67

Table:9 Fixation value by Cold Pad Batch method

Dyes	K/S	L*	a*	b*	C*	H*
Z1	91.02	81.02	14.47	85.17	86.24	81.91
Z2	90.05	81.74	14.3	85.11	86.15	82.02
Z14	87.01	81.71	14.08	84.17	85.19	82.06
Z19	88.85	81.76	14.24	84.38	84.41	82.02
Z25	86.63	81.83	14.13	84.38	85.41	82.05
Z29	86.31	81.79	14.04	84.22	85.24	82.1
Z34	89.35	81.73	14.16	84.84	85.87	82.08
Z42	90.05	81.8	14.23	85.23	86.27	82.07
Z46	88.97	81.64	14.22	84.62	85.66	82.01
Z53	89.65	81.68	14.32	84.79	85.84	81.97

Table:10 Colorimetric (CIELab) data of some selected dyes dyes applied to cotton using the CPB technique

The dyed samples' colorimetric (CIELab) values are listed in Table: 10 With the CPB technique, The synthetic dyes have such a strong compatibility of textiles cotton material. The colour strength (K/S) of each dye for cotton fabric was arranged in the manner shown below.

Z1>Z2>Z42>Z53>Z34>Z46>Z19>Z14>Z25>Z29

Dye Z1 seems to have greatest colour intensity (K/S) value, however dye Z29 has the weakest colour intensity (K/S) value due to high solubility and alkali stability of dye Z1.

4.1.3 Printing

The printing of textiles is a technology used for producing visually appealing, colourful graphics with well-defined borders that are imaginatively grouped into patterns or symbols. Screen printing represents one of the ancient and most adaptable printing processes, in which a screen with mesh is used to transfer ink or dye to the substrate, in this case textiles, to form the design. The thickening ingredient is a vital component of the print paste, specifically in the process of reactive dye printing on cellulosic textiles. Sodium alginate thickening was used as a thickening agent for apply dyes in this method[14].

The print paste was made with sodium alginate thickener and other printing auxiliaries, direct style of printing method was used for print the cotton material. Sodium alginate thickener delivers excellent colour strength with very good fastness characteristics to printed fabric. Reactive Dyes X g KG^{-1}, Thickener 350 g KG^{-1}, Urea 250 g KG^{-1}, water 444 g KG^{-1}, resist salt (sodium 3-nitrobenzenesulfonate) 6 g KG^{-1}, sodium carbonate 15 g KG^{-1} total Print paste was made using 100 g of KG^{-1} [13]. For printing shades, dyes at a concentration of 3% were used, and a print reduction of 1:3 was applied. The print paste was prepared and then applied to cotton fabric via screen printing. After complete the print on cotton goods, the printed cloth was dried in an electric oven at 60 °C before being fixed to a steamer and steamed to 100 ° C for 10 minutes. Non-ionic detergent was used to wash the printed material. Reflectance of printed fabric as measured by a Data Color 400 TM Spectrophotometer.

Measurement of the printed fabric's levelling properties using the colour disparities between each sample at six different locations. UV included condition, D65 illumination, and 10º standard observer were utilised for the measurement. Use of the Kubelka-Munk equation to calculate K/S values. Kubelka and Munk compute the reflectance R of a thick, opaque material with constant K and S using the wavelength and the following relationship[14].

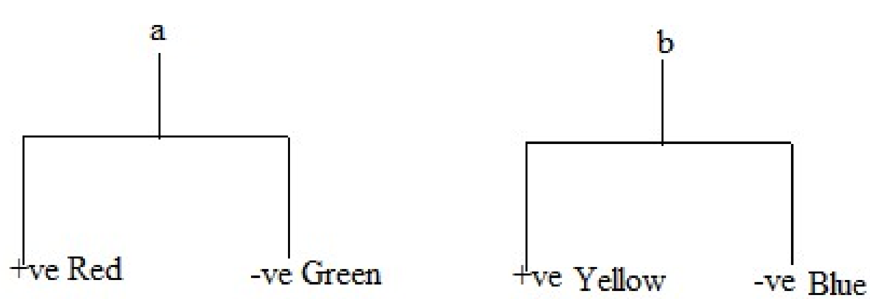
$$\frac{K}{S} = \frac{(1-R)^2}{2R} \qquad \text{Equation 4}$$

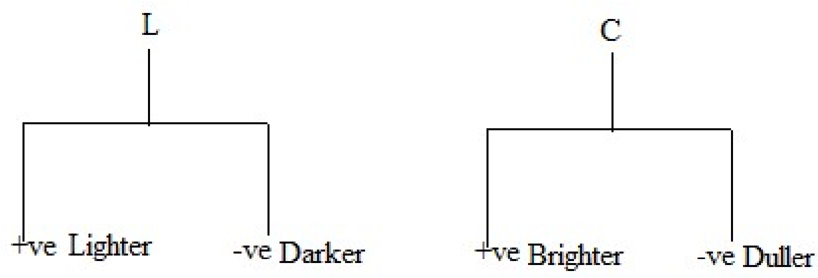
K is the absorbance, S is scattering coefficient and R is percentage of reflectance. According to Kubelka-Munk theory, a sample's optical characteristics can be characterised by two numbers: K, which represents light absorption, and S, which represents light scattering. K is mostly determined by the dyestuff, whereas S is exclusively impacted by the substrate in textiles. As K and S are additive quantities, it is possible to calculate the coefficient of a combination using the K and S values of the individual parts. Since the fibres also absorb light, it is necessary to compensate for their light absorption.

The international committee of colour is called CIE (Commission International Enclarage). The CIE tristimulus values X, Y, and Z quantify colour. These values accurately define the colour, but they do not provide a picture of what the colour will actually look like. CIE Lab colour. The system of colour order is transformed nonlinearly to produce coordinates.

They provide a general concept of what the hue will look like. The international committee of colour is called CIE (Commission International Enclarage). Color is defined in numbers by the CIE tristimulus values X, Y, and Z. These values accurately define the colour, but they do not provide a picture of what the colour will actually look like. L* indicates that lightness between range from 0 to 100; 0 for colour of black and 100 for colour of white), a* is indicates colour values depends on shades of fabric red -green axis [(+) for red, (0) for grey, and (-) for green, and b* is indicate for the yellow -blue axis [(+) for yellow, (0) for grey, and (-) for blue].

When the dominant colour is red (a +ve), the undertone will either be yellow shade (b +ve) or blue (b –ve). Green (a -ve) is the dominant colour, followed by Yellow (b +ve), or Blue (b –ve). Yellow (b +ve) as the primary colour, followed by red (a +ve) or green (a –ve). If preliminary colour is Blue (b –ve) Then red (a +ve) or green (a –ve). When shade is white, grey or black a,b,L and C are represents as below. From this L,a,b,C,H play main roll to display colour value L is represents as lighter and darker of shade. C that is Croma represents as brighter and duller of shades.





All synthetic dyes have their CIELab values evaluated. Table: 11 provides a summary of the selected dyes data.

Dyes	K/S	L*	a*	b*	C*	H*
Z1	89.89	73.56	32	73.37	79.73	67.81
Z7	87.47	73.75	31.85	72.94	79.28	67.69
Z13	86.18	80.66	14.26	83.98	85.05	81.92
Z18	87.31	73.73	31.87	72.87	79.21	67.76
Z25	88.53	73.65	31.95	73.07	79.43	67.78
Z26	8725	81.64	14.24	84.21	85.26	81.98
Z37	88.08	73.6	31.98	72.83	79.22	67.68
Z43	86.97	73.67	31.85	72.64	79.1	68.67
Z48	87.01	77.72	2254	78.67	81.88	75.55
Z53	87.32	76.7	22.63	79	81.94	75.5

Table:11 Colorimetric (CIELab) data of dyes on cotton using the printing process

Figure 37 The graph of K/S values of chosen dyes on cotton fiber with printing process demonstrates that dye Z1 has the highest K/S value and dye Z13 has the lowest K/S value. Also shown in Table:11.

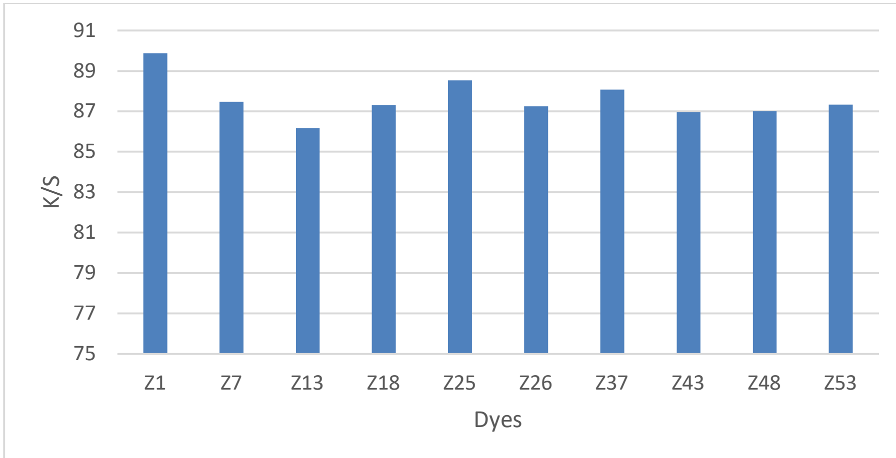


Figure:37 K/S values of printed fabric

Fixation value of selected dyes were examined and shown as under.

Dye No	% Fixation	Dye No	% Fixation	Dye No	% Fixation
Z1	63.23	**Z19**	61.32	**Z37**	62.66
Z2	64.78	**Z20**	69.78	**Z38**	69.78
Z3	62.1	**Z21**	61.32	**Z39**	61.32
Z4	62.66	**Z22**	63.56	**Z40**	63.56
Z5	69.78	**Z23**	62.77	**Z41**	54.43
Z6	61.32	**Z24**	62.66	**Z42**	63.23
Z7	63.56	**Z25**	69.78	**Z43**	64.78
Z8	62.77	**Z26**	61.32	**Z44**	62.1
Z9	58.86	**Z27**	63.56	**Z45**	62.66
Z10	64.02	**Z28**	62.77	**Z46**	69.78
Z11	62.66	**Z29**	63.56	**Z47**	61.32
Z12	69.78	**Z30**	63.23	**Z48**	63.56
Z13	61.32	**Z31**	64.78	**Z49**	62.77

Z14	63.56	**Z32**	62.1	**Z50**	57.89
Z15	62.1	**Z33**	62.66	**Z51**	58.67
Z16	62.66	**Z34**	63.56	**Z52**	58.86
Z17	61.32	**Z35**	58.86	**Z53**	60.71
Z18	63.23	**Z36**	60.23	**Z54**	59.56

Table:12 fixation value of dyes by Printing method

4.2 Antibecterial activity

On an agar plate, the disc diffusion method was employed for testing of the antibacterial activity of series no one synthetic dyes. *Bacillus subtilis* and *Staphylococcus aureus* were utilized as Gram(+) microorganisms. Gram(-) microorganisms *Escherichia coli* and *Pseudomonas aeuroginosa* were utilized[15]. The bacteria were grown for 24 hours at 37^{o} C. The diameter of the Inhibition Zones was determined in millimetres using standard Ampicillin discs, utilizing ampicillin as a positive control, and filter discs immersed with DMSO were used as a negative control. *Meuller-Hinter* agar is used as an agar and is subjected to stringent composition and pH testing. The disc diffusion method considers the agar plate depth to be a significant component [16]. The mixed film samples were sliced into 1 cm diameter pieces and placed into 10 ml of nutrient agar, which was then inoculated with 10 µl of microbe culture. The plates were incubated at 37 ^{o}C for 24 hours after solidification. The diameter of the inhibition zone was then measured.

The disc diffusion method was used to Analyse the produced dyes series no 1, as stated in Table:13.

Inhibition Zone (mm/mg sample) Concentration 2mg/disc				
Sample	**G-**		**G+**	
	Escherichia coli	***Pseudomonas aeruginosa***	***Bacillus subtillis***	***Staphylococcus aureus***
Ampicillin	26	27	27	21
Z1	15	17	16	17
Z2	16	15	17	15
Z3	18	16	15	16
Z4	15	16	17	17
Z5	13	16	18	15
Z6	17	17	15	16
Z7	16	15	17	16
Z8	15	17	15	17
Z9	13	18	16	16
Z10	15	15	16	17

Table:13 Data on the antibacterial properties of reactive dyes Z1 – 10

All components of the Z1–10 have strong antibacterial affinities for two bacterial stains. In comparison to regular *ampicillin*, dye Z3 had exceptional effectiveness against *Escherichia coli*. In comparison to regular ampicillin, dye Z9 shown excellent activity against *pseudomonas*. Z5 Dye demonstrated very good effectiveness against *Bacillus subtillis* as respect to conventional *Ampicillin*. In comparison to ampicillin, dyes Z1, Z4, Z8, and Z10 shown excellent effectiveness against *Staphylococcus aureus*.

4.3 Fastness properties study of cotton dyed fabric

Enhancing the fastness qualities of dyed garments is critical for the desire of customers. The ability of coloured textiles to withstand environmental conditions throughout production, after colouring, and for the duration of their subsequent usable life is a vital necessity. There are various tests for a textile's fastness, each for figuring out how resistant the colour is to a certain agency. It is simple to division these into liquid and non-liquid treatments. The first category includes wet treatments like washing with soap or treating with just water, as well as using bleaching agents, acids, alkalis, and perspiration, including nonaqueous solvent. Other non-liquid treatments include rubbing, exposure to light and gaseous pollutants in the air, and dry tests like ironing. Dimensional stability, wash fastness, and rubbing fastness are important considerations.

4.3.1 Light fastness study:

The use of automated tools called fadeometers to examine the light fastness characteristics of dyed patterns is a common practise. The only light-fastness features of coloured textile materials that must be understood are those that relate to natural daylight. However, it has long been customary to utilize artificial lighting sources for figuring out the light fastness of coloured textiles to figure out the light fastness of coloured fabrics. The Xeno-test machine is a much more effective tool to be used in this manner. Improved testing was conducted for the current investigation using daylight as a light source. Use of common dyed patterns with improving lightfastness qualities is necessary for this. The processes used to create these standard samples are in accordance with the guidelines established by international organisation for standardisation (I.S.O.) [17]. Light fastness ratings for these reference samples range from 8 to 1. the order showing a deterioration in the fastness characteristics.

The eight common dyed patterns and the dyed patterns were placed on cards that were a handy size (about -35 X 10 cm) for the studying. Each dyed pattern had about half of it covered with an opaque cardboard sheet while the other half was left exposed to light. After that, the cards were put into exposure frames that were 45^{o}C tilted so they could be exposed to sunlight. After a specified time frame, the test patterns' exposed and unexposed areas were evaluated. The standard patterns, starting with the first standard pattern, were discovered concurrently with a similar result. Consider a scenario in which the test pattern has not faded but the standard patterns rated 1, 2, and 3 have. The test pattern has clearly faded at the subsequent inspection, while the standard pattern graded as 4 has not faded. The test pattern exhibiting this behaviour is thought to have light fastness in the grade of 3 to 6.

Grade	Assessment
8	Maximum fastness
7	Excellent fastness
6	Very good fastness
5	Good fastness
4	Fair Fastness
3	Moderate fastness
2	Slight fastness
1	Poor fastness

All test patterns' light fastness characteristics were reviewed and assessed using the abovementioned approach. Table:15 presents the results in tabular form.

4.3.2 Wash Fastness Study:

The substantivity and polarity of the dye molecule, as well as the structure of the fibre, affect washing fastness. The following method was used to conduct the investigation. The I. S. O. test was advised to use a soap solution [18]. was created by dissolving soap (5 g) with distilled water (100 ml). The test coloured pattern was then subjected to a 20 ml soap solution treatment for 45 minutes at 50ºC. The test swatches were then taken out of the soap solution bath and washed for 5–10 minutes under cold running water. 50º C was used for drying and pressing the fabric. Gray scale was used to evaluate the pattern's loss of depth in shade [19]. For colour alternation, grades 1 through 5, the following is defined

I.S.O. recommendation, grayscale		
Observation	**Grade**	**Assessment**

Shade not changed	5	Excellent
Extremely little depth loss or alteration	4	Very Good
Appreciable loss or alteration	3	Good
Recognisable loss or alteration	2	Fair
Considerable loss or significant change	1	Poor

By using the abovementioned methodology, all test patterns' wash fastness characteristics were analyses and assessed. Table:18 presents the findings of the dyes D1 through D40 wash fastness investigation.

4.3.3 Rubbing fastness study:

Unwanted colour "crocking" from textile material is problematic and causes a lot of issues during garment finishing and processing as well[20]. There will be unfixed colours remaining on the surface after colouring. Material properties, dye selection/depth of tint, dyeing and printing process all affect rubbing fastness. This test is relevant to all types of textiles produced from fibres, such like yarns and cloths. The samples are secured in the crock meter device, that promotes a standard white piece of cloth (96 X 100-inch cotton fabric long type, starch-free) to rub against the coloured sample with controlled pressure and speed. Both both the dry test and the wet test, white fabric is placed over the rubbing fingers, which are then gently rubbed back and forth for 20 strokes. The grey scaling has been used to assess the colour that transmitted to the white cloth. Greyscale for colour adjustment, comprising defines the following;

Observation	**Grade**	**Assessment**
Undyed materials are not stained by dye	5	Excellent
A minor colour stain on undyed material	4	Very Good
on undyed materials, there is a moderate dye stain	3	Good
Undyed fabrics with a distinctive dye stain	2	Fair

Undyed cloths have a lot of dye stains.	1	Poor

Dye No	Fastness Properties				Dye No	Fastness Properties			
	Light	Wash	Rubbing			Light	Wash	Rubbing	
			Dry	Wet				Dry	Wet
Z1	3	4	4	4	**Z28**	5	5	3	4
Z2	5	5	5	4	**Z29**	5	4	4	3
Z3	6	3	4	5	**Z30**	6	5	3	4
Z4	4	5	5	5	**Z31**	4	3	5	5
Z5	5	4	4	4	**Z32**	5	5	4	4
Z6	6	5	5	3	**Z33**	5	5	3	5
Z7	4	4	3	5	**Z34**	5	4	5	4
Z8	3	5	5	3	**Z35**	6	5	4	5
Z9	3	4	4	3	**Z36**	4	3	4	3
Z10	4	5	4	3	**Z37**	4	5	3	5
Z11	3	3	5	4	**Z38**	6	4	4	3
Z12	3	5	5	4	**Z39**	4	3	5	4
Z13	4	4	4	5	**Z40**	3	3	4	5
Z14	4	4	3	4	**Z41**	3-4	3	5	3
Z15	3	4	5	5	**Z42**	4	5	4	5
Z16	3	5	4	4	**Z43**	4	4	5	4
Z17	4	4	4	5	**Z44**	3	5	3	4
Z18	6	4	4	3	**Z45**	3	5	5	4
Z19	4	4	5	5	**Z46**	4	5	4	5
Z20	5	5	3	4	**Z47**	6	4	4	3
Z21	4	3	5	4	**Z48**	4	5	4	5

Z22	6	5	5	4	**Z49**	3	3	5	3
Z23	4	4	5	4	**Z50**	3	5	4	4
Z24	3	3	3	4	**Z51**	4	4	5	4
Z25	4	3	3	4	**Z52**	6	4	3	3
Z26	4	3	3	5	**Z53**	4	4	5	5
Z27	6	5	5	5	**Z54**	3	4	3	4

Table:14 Fastness Properties of Reactive dyes on cotton fabric

4.3.4 Perspiration Fastness Study:

Perspiration fastness refers to the capacity of coloured cloth to not fade or discolour when perspired. The perspiration fastness test uses artificial perspiration using various acid and alkaline solutions to simulate the sweat scenario when humans wear textiles, and then tests the textiles. ISO 105 E04 test process was used for perspiration fastness evaluation. Perspiration Fastness tester is the machine used to assess Perspiration Fastness. Following is the recipe for Perspiration fastness testing.

Component	**Acidic**	**Alkaline**
L-Histidine mono Hydrochloride	05 Parts	05 Parts
Sodium Chloride	50 Parts	50 Parts
Disodium Hydrogen Orthophospate Dihydrate	22 Parts	25 Parts
Sodium Hydroxide for pH	-	8
Acetic Acid	5.5	-
Distilled Water	X Parts	X Parts
Final Volume	1000 Parts	1000 Parts

The dyed fabric and Multifibre is treated in above mention bath with 30 ^{0}C for 30 minutes. Both treatments given to the fabric Alkaline bath and Acidic bath. After complete the time fabric was removed from bath, after that specimens were placed with used of acrylic plates in pespirometer for four hours at 38 ^{0}C temperature. The specimen and Multifibre were separated and dried at 60 ^{0}C. With using of Grey Scale the assessment of staining on Multifibre was carried out. The Perspiration Fastness of textile materials shows in Table:15.

Dye No	Perspiration Fastness		Dye No	Perspiration Fastness		Dye No	Perspiration Fastness	
	Acidic	Alkaline		Acidic	Alkaline		Acidic	Alkaline
Z1	4	5	**Z19**	5	5	**Z37**	4-5	5
Z2	4	5	**Z20**	5	5	**Z38**	4-5	5
Z3	5	5	**Z21**	4-5	5	**Z39**	4	5
Z4	5	5	**Z22**	4-5	5	**Z40**	4	4-5
Z5	5	5	**Z23**	4	5	**Z41**	4	4-5
Z6	5	5	**Z24**	4	4-5	**Z42**	4	4-5
Z7	5	5	**Z25**	4	4-5	**Z43**	4	4-5
Z8	5	5	**Z26**	4	4-5	**Z44**	4	4-5
Z9	4-5	5	**Z27**	4-5	4-5	**Z45**	4-5	5
Z10	4-5	5	**Z28**	4	4-5	**Z46**	4-5	5
Z11	4	5	**Z29**	4-5	5	**Z47**	4	5
Z12	4	4-5	**Z30**	4-5	5	**Z48**	4	5
Z13	4	4-5	**Z31**	4	5	**Z49**	4	4-5
Z14	4	4-5	**Z32**	4	4-5	**Z50**	4	5
Z15	4	4-5	**Z33**	4	5	**Z51**	4-5	5
Z16	4	4-5	**Z34**	4	5	**Z52**	4	4-5
Z17	4	5	**Z35**	4-5	4-5	**Z53**	4	5
Z18	4	4-5	**Z36**	4	5	**Z54**	4	5

Table:15 The Perspiration fastness characteristics of reactive dyes on cotton fabric

4.3.5 Chlorinated Water Fastness Study:

ISO 105 E03 test method was used for testing of chlorinated water fastness test. This approach is intended to assess any coloured textile substrate's resilience to chlorinated pool water. The test specimen is immersed in a diluted chlorine solution under controlled circumstances of available chlorine concentration, time, and ph. Bellow conditions were used to evaluated chlorinated water fastness.

Active Chlorine Content	20 ppm
pH	7.5
Temperature	27 ^{o}C
M:L Ratio	1:100
Time	1 Hours

Dyed fabric approximately 6×6 and should be weight 5 gm used. 20 ppm chlorinated (sodium hypo chloride) water was used for testing. The prepared specimen was treated in above bath with maintained temperature and time. After complete the cycle, specimen is taken out and dried below 60 ⁰C. The assessment for change of shade is carried out using grey scal. The Chlorine fastness of textiles material shows in Table:16.

Dye No	Chlorine Fastness	Dye No	Chlorine Fastness	Dye No	Chlorine Fastness
Z1	5	**Z19**	5	**Z37**	4-5
Z2	5	**Z20**	5	**Z38**	4-5
Z3	5	**Z21**	4-5	**Z39**	4
Z4	5	**Z22**	4-5	**Z40**	4
Z5	5	**Z23**	4	**Z41**	4
Z6	5	**Z24**	4	**Z42**	4
Z7	5	**Z25**	4	**Z43**	4
Z8	5	**Z26**	4	**Z44**	4
Z9	5	**Z27**	4	**Z45**	4-5
Z10	5	**Z28**	4	**Z46**	4-5
Z11	5	**Z29**	4-5	**Z47**	4
Z12	4-5	**Z30**	4-5	**Z48**	4
Z13	4-5	**Z31**	4	**Z49**	4
Z14	4-5	**Z32**	4	**Z50**	4
Z15	4-5	**Z33**	4	**Z51**	4-5
Z16	4-5	**Z34**	4	**Z52**	4
Z17	4-5	**Z35**	4	**Z53**	4
Z18	4-5	**Z36**	4	**Z54**	4

Table:16 The Chlorine fastness characteristics of reactive dyes on cotton fabric

4.4 Application of Reactive dyes on Silk

Applying reactive dyes on silk has recently attracted more attention. Due to its smooth, delicate lustre and elastic properties, silk is the most excellent natural fibre. It balances durability with beauty, brilliance with cleanliness, and strength with lightness, it was discovered that the pH level has a big influence on the stability of the dye fibre connection between reactive colours and silk. [21,22,23]. The dyeing condition of temperature and time shown in Figure: 33. Reactive dyes when apply to silk fabric gives excellent colour shade. Mostly silk fabric was dyed with acid dyes but reactive dyes also applied on silk fabric. Ready silk fabric was used for dyeing before dyeing the pH of silk fabric was measured that is maintained 3 pH by giving the treatment of diluted Acetic acid (1 g L^{-1}) at 60º C, after achieved pH the silk fabric was squeezed and used for dyeing process.

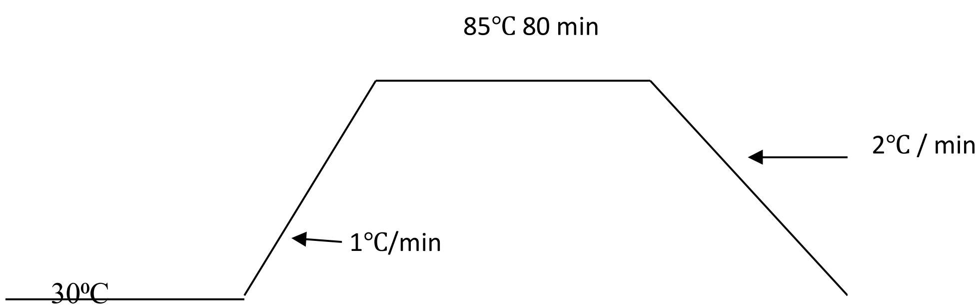


Figure:38 Exhaust dyeing cycles for silk fabric

Applying reactive dyes on silk is covered in this section. 1% depth of shade was dyed with MLR 1:20, Acetic Acid (10% w/v) 3 g L^{-1}, Formic Acid (40% w/v) 1.5 g L^{-1},pH of dye bath adjust 3.0(with use of Acetic acid),Dyeing bath temperature 85ºC, Dyeing time 80 min., The silk material (2.0 g) was cleaned in a solution of soap (0.2 g) and water (100 ml) at 50ºC for 10 minutes. The material was removed from the bath, washed several times using water, compressed, dried, and then processed. after finishing exhaust dyeing process dyed textiles material wash use of hot and cold water, dried in oven at 60º and measured. Exhaustion and fixation value calculated as described method 3.1.2 all values of exhaustion and fixation shown in Table:16.

4.4.1 The light, wash and rubbing fastness characteristics of dyed silk fabric:

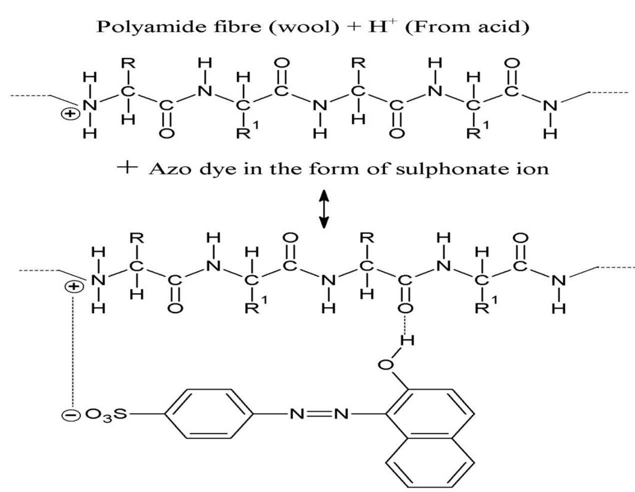
Following the techniques outlined previously for cotton fabric, the light, wash, and rubbing fastness of all the coloured patterns were tested. All testing parameter are same as described in cotton part. The Table: 18 shows the light, wash, and rubbing fastness of silk fabric.

4.4.2 The Perspiration and Chlorine water fastness characteristics of dyed silk fabric:

Following the techniques outlined previously for cotton fabric, the Perspiration and chlorine water fastness of all the coloured patterns were tested. The Table: 19 shows the light, wash, and rubbing fastness of silk fabric. The bi-functional reactive dyes have good wash fastness properties.

4.5 Application of Reactive dyes on Wool

A wide range of dye types can be used to colour wool material, including reactive, metal complex, and acid dyes [24]. In the middle of the 1930, Supramine Orange R, the first reactive wool dye, was created. Under acidic conditions, It interacts with the wool's amino group.. The fact that it was chemically mixed, however, was not known at the time, Although The wash fastness was quite great. In acidic environments, the reactive dyes behave as anionic dyes because they include sulphonic acid groups [25]. Positive sites (-$^{+}NH_2$-) are produced when equilibrium is reached when wool is exposed to a mineral acid solution for a sufficient amount of time. With boosting acid concentration, overall number of such locations in the fibre goes up. It is generally accepted that the sites (- $^{+}NH_2$-) on the fibre and the >C=O group of polyamide fibre's amide repeat unit are both important for retaining the dye molecule at different locations along the polymer chain[26]. The exchanges that are meant to take place in this attachment are shown below.



It makes sense to assume that all of the polyamide's -NH- won't be protonated and that all protonated sites won't have dyes attached to them. The dye anion's sulphonate ion interaction with -NH- will be greater than that of SO_4^{-2} and Cl^{-1} ions. However, because to its high concentration, salt is added would reduce the magnitude of this relationship.

Therefore when it is always required for level the colouring, Furthermore, salt was adding to the acidic dye bath. Nonetheless, the effect of salt addition will favour dyeing rate at neutral pH, even though it will negatively impact dye bath exhaustion at equilibrium. Despite the fact that the speed of dyeing increases as temperature rises, it also minimizes the amount of equilibrium dyeing, as expected [27].

4.5.1 Dyeing of Wool Fabric:

For the application of synthesized reactive dyes on wool fabric first wool fabric was treated with 1 g L^{-1} non ionic soap solution at 80 ºC for ten min. after that fabric was squeezed and dry. It is necessary to give the treatment of Liq. Ammonia (1 g L^{-1} and wetting agent 0.5 g L^{-1}) at 80 ºC for ten min. this wool fabric was then used for dyeing of reactive dyes.

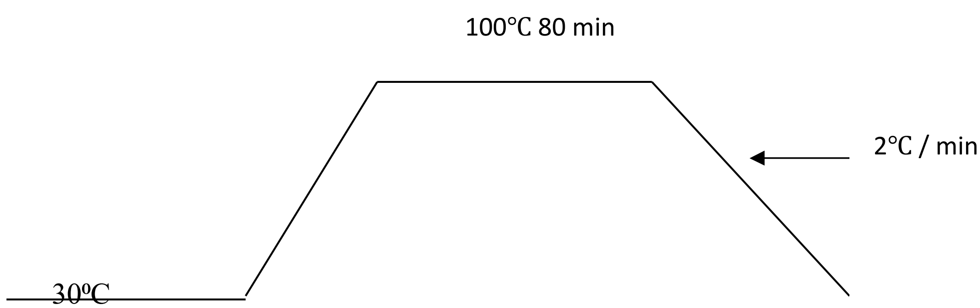


Figure:39 Exhaust dyeing cycles for wool fabric

For dyeing of wool 1% shade dyed with condition Na_2SO_4 (20% w/v) 15 g L^{-1}, CH_3COOH (3% w/v) 10 g L^{-1}, MLR 1:20, dyeing temperature 100 ºC, dyeing time 80 min. pH of dyebath was maintained 3 with use of acetic acid. Heating rate of dyeing was maintained 1º C per minutes. The wool material (2.0 g) was cleaned in a solution of soap (0.2 g), Ammonia solution (0.05%) and water (100 ml) at 50 ^{0}C for 10 minutes. The material was removed from the bath, washed several times using water, compressed, dried, and then processed. After complete the exhaust process the textiles material was wash with normal water after that dry in oven at 60 ºC. The exhaustion value and fixation value were calculated as describe in cotton dyeing section. The exhaustion and fixation value shown in Table: 21. The Figure: 34 shows dyeing condition of wool fabric.

4.5.2 The wash, rubbing and wash fastness characteristics of dyed wool fabric:

Following the processes outlined earlier for cotton fabric, the properties of all the coloured patterns were investigated for light, wash and rubbing fastness. The Table: 22 shows the light, wash and rubbing fastness of textile materials.

4.5.3 The Perspiration and Chlorine water fastness characteristics of dyed wool fabric:

Following the processes outlined earlier for cotton fabric, the properties of all the coloured patterns were investigated for light, wash, and rubbing fastness. The Table: 23 shows the Perspiration and Chlorine water fastness of textile materials.

Dye No	% Exhaustion	% Fixation	Dye No	% Exhaustion	% Fixation	Dye No	% Exhaustion	% Fixation
Z1	90.89	89.3	**Z19**	95.43	83.43	**Z37**	93.9	88.54
Z2	89.87	86.45	**Z20**	92.97	89.91	**Z38**	92.88	82.33
Z3	98.23	87.9	**Z21**	93.52	88.35	**Z39**	96.67	88.34
Z4	93.19	82.34	**Z22**	95.43	88.35	**Z40**	93.65	86.78
Z5	96.67	78.67	**Z23**	92.97	83.56	**Z41**	95.43	88.35
Z6	93.65	86.78	**Z24**	93.52	82.9	**Z42**	92.97	83.56
Z7	95.43	88.35	**Z25**	92.88	82.33	**Z43**	93.52	82.9
Z8	92.97	83.56	**Z26**	96.67	88.34	**Z44**	92.88	78.67
Z9	93.52	82.9	**Z27**	93.65	87.28	**Z45**	93.19	86.78
Z10	92.88	82.33	**Z28**	95.43	83.43	**Z46**	95.43	88.35
Z11	96.67	88.34	**Z29**	92.97	89.91	**Z47**	92.97	83.56

Table:17 % of Exhaustion and % of Fixation values on silk fabric

Dye No	% Exhaustion	% Fixation	Dye No	% Exhaustion	% Fixation	Dye No	% Exhaustion	% Fixation
Z12	93.65	87.28	**Z30**	93.52	88.35	**Z48**	93.52	82.9
Z13	90.89	89.3	**Z31**	92.88	83.56	**Z49**	92.88	82.33
Z14	95.43	83.43	**Z32**	92.97	78.67	**Z50**	96.67	88.34
Z15	92.97	89.91	**Z33**	90.89	89.3	**Z51**	93.65	87.28
Z16	93.52	88.35	**Z34**	89.87	86.45	**Z52**	95.43	83.43
Z17	93.34	82.9	**Z35**	98.23	87.9	**Z53**	93.65	87.28
Z18	93.65	87.28	**Z36**	93.65	87.28	**Z54**	93.52	88.35

Table:17 % of Exhaustion and % of Fixation values on silk fabric

Dye No	Fastness Properties				Dye No	Fastness Properties			
	Light	Wash	Rubbing			Light	Wash	Rubbing	
			Dry	Wet				Dry	Wet
Z1	3	5	5	5	**Z28**	5	5	4	4
Z2	5	5	5	4	**Z29**	4	4	4	3
Z3	6	3	4	5	**Z30**	5	5	3	4
Z4	4	5	5	5	**Z31**	6	3	5	5
Z5	5	4	4	4	**Z32**	4	5	4	4
Z6	6	5	5	3	**Z33**	5	5	3	5
Z7	4	4	3	5	**Z34**	6	4	5	4
Z8	3	5	5	3	**Z35**	6	5	4	5
Z9	4	4	4	3	**Z36**	4	3	4	3
Z10	4	5	4	3	**Z37**	3	5	3	5

Z11	3	3	5	4	**Z38**	3	4	4	3
Z12	4	5	5	4	**Z39**	4	3	5	4
Z13	4	4	4	5	**Z40**	3	3	4	5
Z14	4	4	3	4	**Z41**	3	3	5	3
Z15	3	4	5	5	**Z42**	4	5	4	5
Z16	4	5	4	4	**Z43**	4	4	5	4
Z17	4	4	4	5	**Z44**	3	5	3	4
Z18	6	4	4	3	**Z45**	4	5	5	4
Z19	4	4	5	5	**Z46**	4	5	4	5
Z20	3	5	3	3	**Z47**	6	4	4	3
Z21	3	3	5	4	**Z48**	4	5	4	5
Z22	4	5	5	4	**Z49**	3	3	5	3
Z23	3	4	5	4	**Z50**	3	5	4	4
Z24	3	3	3	4	**Z51**	4	4	5	4
Z25	4	3	3	4	**Z52**	6	4	3	3
Z26	4	3	3	5	**Z53**	4	4	5	5
Z27	6	5	5	5	**Z54**	3	4	3	4

Table:18 Fastness characteristics of reactive dyes on silk fabric

Dye No	**Perspiration Fastness**		**Dye No**	**Perspiration Fastness**		**Dye No**	**Perspiration Fastness**	
	Acidic	**Alkaline**		**Acidic**	**Alkaline**		**Acidic**	**Alkaline**
Z1	4	5	**Z19**	4-5	5	**Z37**	4-5	5
Z2	4	5	**Z20**	5	5	**Z38**	4-5	5
Z3	5	5	**Z21**	4-5	5	**Z39**	4	5
Z4	5	5	**Z22**	4-5	5	**Z40**	4	4-5
Z5	4	5	**Z23**	4-5	5	**Z41**	4	4-5
Z6	4	5	**Z24**	4	4-5	**Z42**	4	4-5

Z7	5	5	**Z25**	4	4-5	**Z43**	4	4-5
Z8	5	4-5	**Z26**	4	4-5	**Z44**	4	4-5
Z9	4-5	5	**Z27**	4-5	4-5	**Z45**	4-5	5
Z10	4-5	5	**Z28**	4	4-5	**Z46**	4-5	5
Z11	4	5	**Z29**	4-5	5	**Z47**	4	5
Z12	4	4-5	**Z30**	4-5	5	**Z48**	4	5
Z13	4	4-5	**Z31**	4	5	**Z49**	4	4.5
Z14	4	4-5	**Z32**	4	4-5	**Z50**	4	5
Z15	4	4-5	**Z33**	4	5	**Z51**	4-5	5
Z16	4	4-5	**Z34**	4	5	**Z52**	4	4-5
Z17	4	4-5	**Z35**	4	4-5	**Z53**	4	5
Z18	4	4-5	**Z36**	4	5	**Z54**	4	5

Table:19 The Perspiration fastness characteristics of reactive dyes on silk fabric

Dye No	Chlorine Fastness	Dye No	Chlorine Fastness	Dye No	Chlorine Fastness
Z1	4-5	**Z19**	5	**Z37**	4-5
Z2	5	**Z20**	5	**Z38**	4-5
Z3	5	**Z21**	4-5	**Z39**	4
Z4	5	**Z22**	4-5	**Z40**	4
Z5	4-5	**Z23**	4	**Z41**	4
Z6	5	**Z24**	4	**Z42**	4
Z7	5	**Z25**	4	**Z43**	4
Z8	5	**Z26**	5	**Z44**	4

Z9	5	**Z27**	4	**Z45**	4-5
Z10	5	**Z28**	4	**Z46**	4-5
Z11	5	**Z29**	4-5	**Z47**	4
Z12	4-5	**Z30**	4-5	**Z48**	4
Z13	4-5	**Z31**	4	**Z49**	4
Z14	4-5	**Z32**	4	**Z50**	4
Z15	4-5	**Z33**	4	**Z51**	4-5
Z16	5	**Z34**	5	**Z52**	4
Z17	4-5	**Z35**	4	**Z53**	5
Z18	4-5	**Z36**	4	**Z54**	4

Table:20 The Chlorine fastness characteristics of reactive dyes on silk fabric

Dye No	% Exhaustion	% Fixation	Dye No	% Exhaustion	% Fixation	Dye No	% Exhaustion	% Fixation
Z1	93.9	88.54	**Z19**	92.88	78.67	**Z37**	93.9	88.54
Z2	92.88	82.33	**Z20**	93.19	86.78	**Z38**	92.88	82.33
Z3	96.67	88.34	**Z21**	95.43	88.35	**Z39**	96.67	88.34
Z4	93.65	86.78	**Z22**	96.67	88.34	**Z40**	93.65	86.78
Z5	95.43	88.35	**Z23**	93.65	87.28	**Z41**	95.43	88.35
Z6	92.97	83.56	**Z24**	90.89	89.3	**Z42**	92.97	83.56
Z7	93.52	82.9	**Z25**	95.43	83.43	**Z43**	93.52	82.9
Z8	92.88	78.67	**Z26**	98.23	87.9	**Z44**	92.88	78.67
Z9	93.19	86.78	**Z27**	93.19	82.34	**Z45**	95.43	83.43

Z10	95.43	88.35	**Z28**	96.67	78.67	**Z46**	92.97	89.91
Z11	96.67	88.34	**Z29**	93.65	86.78	**Z47**	93.52	88.35
Z12	93.65	87.28	**Z30**	95.43	88.35	**Z48**	95.43	88.35
Z13	90.89	89.3	**Z31**	92.97	83.56	**Z49**	92.97	83.56
Z14	95.43	83.43	**Z32**	93.52	82.9	**Z50**	90.89	89.3
Z15	92.97	89.91	**Z33**	92.88	82.33	**Z51**	89.87	86.45
Z16	93.52	88.35	**Z34**	89.87	86.45	**Z52**	98.23	87.9
Z17	93.34	82.9	**Z35**	98.23	87.9	**Z53**	93.19	82.34
Z18	93.65	87.28	**Z36**	93.65	87.28	**Z54**	93.52	88.35

Table:21 % of Exhaustion and % of Fixation values on wool fabric

Dye No	**Fastness Properties**				**Dye No**	**Fastness Properties**			
	Light	**Wash**	**Rubbing**			**Light**	**Wash**	**Rubbing**	
			Dry	**Wet**				**Dry**	**Wet**
Z1	3-4	5	3	4	**Z28**	5	5	3	4
Z2	5	3	5	5	**Z29**	3-4	4	4	3
Z3	6	5	4	4	**Z30**	5	5	3	4
Z4	4	5	3	5	**Z31**	6	3	5	5
Z5	4-5	4	5	4	**Z32**	4	5	4	4
Z6	6	5	4	5	**Z33**	4-5	5	3	5
Z7	4	4	3	5	**Z34**	6	4	5	4
Z8	3	5	5	3	**Z35**	4	5	4	5
Z9	3-4	4	4	3	**Z36**	3	3	4	3
Z10	4	5	4	3	**Z37**	3-4	5	5	4
Z11	3	3	5	4	**Z38**	6	3	4	5

Z12	3-4	5	5	4	**Z39**	4	5	5	5
Z13	4	4	4	5	**Z40**	3	4	4	4
Z14	4	4	3	4	**Z41**	3-4	5	5	3
Z15	3	4	5	5	**Z42**	4	5	4	5
Z16	3-4	5	4	4	**Z43**	4	4	5	4
Z17	4	5	4	5	**Z44**	3	5	3	4
Z18	6	4	4	3	**Z45**	3-4	5	5	4
Z19	3-4	4	5	5	**Z46**	3-4	5	4	5

Dye No	**Fastness Properties**				**Dye No**	**Fastness Properties**			
	Light	**Wash**	**Rubbing**			**Light**	**Wash**	**Rubbing**	
			Dry	**Wet**				**Dry**	**Wet**
Z20	5	5	3	3-4	**Z47**	5	4	4	3
Z21	6	3	5	4	**Z48**	6	5	4	5
Z22	4	5	5	4	**Z49**	4	3	5	3-4
Z23	4-5	4	5	3-4	**Z50**	4-5	5	4	4
Z24	6	3	3	4	**Z51**	6	4	5	4
Z25	4	3	3	3-4	**Z52**	4	4	3	3-4
Z26	3	3	3	5	**Z53**	3	4	5	5
Z27	3-4	5	5	5	**Z54**	3-4	4	3	4

Table:22 The light, washing and rubbing fastness characteristics of wool fabric

Dye No	Perspiration Fastness		Dye No	Perspiration Fastness		Dye No	Perspiration Fastness	
	Acidic	Alkaline		Acidic	Alkaline		Acidic	Alkaline
Z1	4-5	5	**Z19**	4	5	**Z37**	4	5
Z2	4	5	**Z20**	5	5	**Z38**	4.5	5
Z3	5	5	**Z21**	4-5	5	**Z39**	4	5
Z4	5	5	**Z22**	4-5	5	**Z40**	4	4-5
Z5	4	5	**Z23**	4-5	5	**Z41**	4	4-5
Z6	4	5	**Z24**	4	4-5	**Z42**	4	4-5
Z7	4	5	**Z25**	4	4-5	**Z43**	4	5
Z8	5	4-5	**Z26**	4	4-5	**Z44**	4	4-5
Z9	4-5	5	**Z27**	4-5	4-5	**Z45**	4-5	5
Z10	4-5	5	**Z28**	4	4-5	**Z46**	4-5	5
Z11	4	5	**Z29**	4-5	5	**Z47**	4	5
Z12	4	4-5	**Z30**	4-5	5	**Z48**	4	5
Z13	4	4-5	**Z31**	4	5	**Z49**	4	4-5
Z14	4	4-5	**Z32**	4	4-5	**Z50**	4	5
Z15	4	4-5	**Z33**	4	5	**Z51**	4-5	5
Z16	4	4-5	**Z34**	4	5	**Z52**	4	4-5
Z17	4	5	**Z35**	4-5	4-5	**Z53**	4	5
Z18	4	4-5	**Z36**	4	5	**Z54**	4	5

Table:23 The Perspiration fastness characteristics of reactive dyes on wool fabric

Dye No	Chlorine Fastness	Dye No	Chlorine Fastness	Dye No	Chlorine Fastness
Z1	5	**Z19**	4	**Z37**	4-5
Z2	4-5	**Z20**	5	**Z38**	4-5
Z3	5	**Z21**	4-5	**Z39**	4
Z4	5	**Z22**	4-5	**Z40**	4
Z5	4-5	**Z23**	4	**Z41**	4
Z6	5	**Z24**	4	**Z42**	4
Z7	5	**Z25**	4	**Z43**	4

Z8	5	**Z26**	5	**Z44**	4
Z9	4-5	**Z27**	4	**Z45**	4-5
Z10	5	**Z28**	4	**Z46**	4-5
Z11	5	**Z29**	4-5	**Z47**	4
Z12	4-5	**Z30**	4-5	**Z48**	4
Z13	4-5	**Z31**	4	**Z49**	4
Z14	4-5	**Z32**	4	**Z50**	4
Z15	4-5	**Z33**	4	**Z51**	4-5
Z16	5	**Z34**	5	**Z52**	4
Z17	4-5	**Z35**	5	**Z53**	5
Z18	4-5	**Z36**	4	**Z54**	5

Table:24 The Chlorine fastness characteristics of reactive dyes on wool fabric

4.6 Thermogravimetric Analysis

The temperature degradation of dye is affected by a number of factors. TG has a wide range of applications, including evaluating the weight changes of samples during controllable heat processing [28]. However, chemical and analytical information regarding the products during sample weight changes are frequently omitted. Initiators used, termination mechanism, sample size and dimensions, presence of oxygen in the atmosphere or absorbed in the sample or other occluded impurities, decomposition temperatures, heating velocity, rate of removal of volatile substances from the reaction zone, softening and melting points of the dye, and many other factors are all significant [29]. To determine the generalised process, thermal breakdown is carried out in an inert atmosphere using highly pure reactive dye samples in the form of finely separated powder. In the Table:25 shown the temperature characteristics of synthesized dyes. Thermal stability also play main roll in application of reactive dyes.

The thermal stability of reactive dyes is as follows based on an initial breakdown temperature of 150 ^{0}C;

Z42>Z1>Z47>Z9>Z30>Z11>Z6>Z15>Z36>Z18>Z26>Z53

Nearly all reactive dyes deteriorate within one step, approximately 150 ºC is the temperature at which all of the samples start to degrade. With a weight loss of around 1.01-3.85%. Thermogravimetric curves of dyes shown in Figure:40. The table shows that synthesized dyes have good stability, gives excellent fastness properties when apply on wool, silk and cotton fabric.

Dye No	**% Weight loss at various temperature (ºC) from TGA**					
	150	**300**	**450**	**600**	**750**	**900**
Z1	3.89	5.34	10.12	14.23	21.23	28.56
Z6	3.42	6.21	11.23	14.67	21.89	29.45
Z9	3.67	6.12	11.2	15.78	22.6	31.51
Z11	3.44	6.13	11.56	14.34	22.87	35.24
Z15	3.33	7.43	11.67	17.76	25.32	32.12
Z18	3.22	7.34	11.98	16.24	23.67	27.67
Z26	3.11	5.34	12.78	17.34	21.25	33.21
Z30	3.67	6.97	12.54	17.56	25.98	36.87
Z36	3.23	7.12	11.18	15.23	24.67	32.18
Z42	3.9	6.76	12.97	12.28	23.12	38.78
Z47	3.82	7.18	10.76	12.65	22.6	40.34
Z53	2.78	7.01	15.98	17.27	25.9	32.89

Table:25 Temperature (ºC) characteristics of reactive dyes

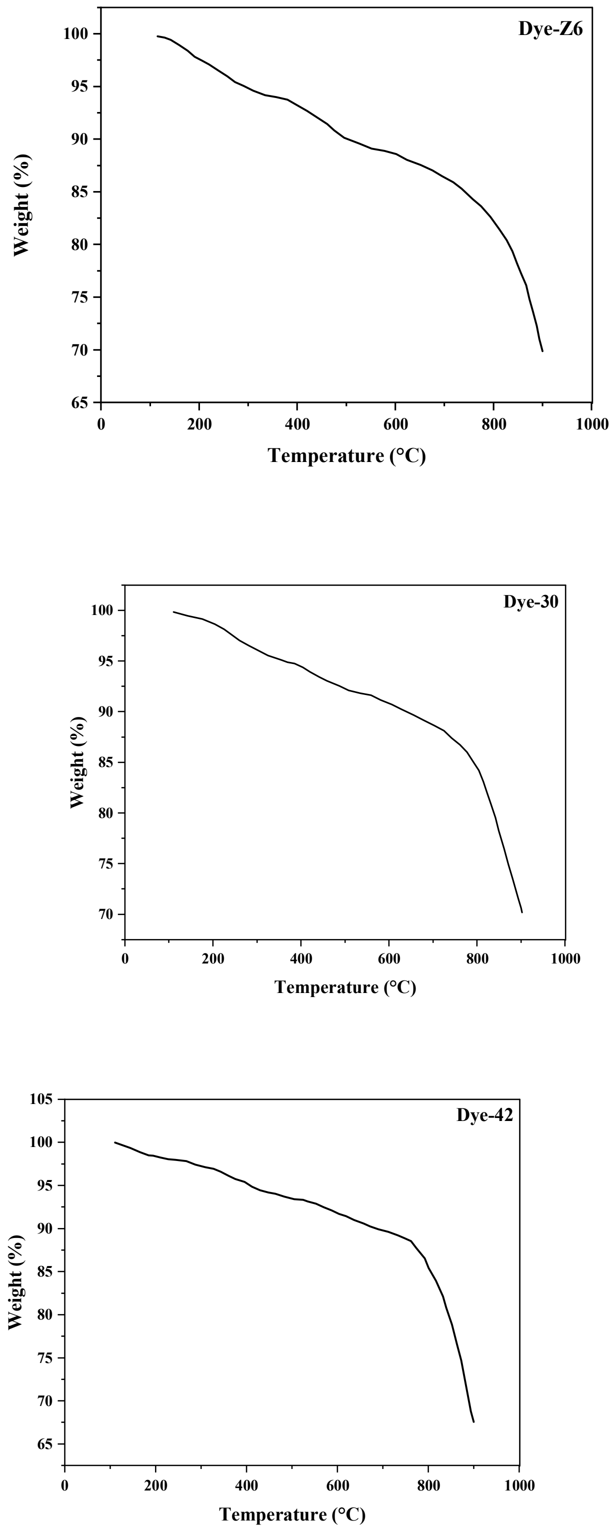


Figure:40 Thermogravimetric curves of dyes

4.7 Moisture content Analysis

Due to hydrolysis is main disadvantage of reactive dyes it is necessary that the dyes have no moisture. The moisture content of all synthesized dyes were measured with Shimadzu makes MOC 63U Moisture analyzer. 4 to 5 grams of synthesized dye kept in moisture Analyzer after reaching maximum temperature reading was noted. The moisture contentment of synthesized dyes were presented in Table:26.

Dye No	Moisture content (%)	Dye No	Moisture content (%)	Dye No	Moisture content (%)
Z1	3.89	**Z19**	3.74	**Z37**	4.56
Z2	4.78	**Z20**	3.84	**Z38**	4.87
Z3	4.67	**Z21**	3.29	**Z39**	3.45
Z4	3.56	**Z22**	3.97	**Z40**	2.54
Z5	4.34	**Z23**	4.67	**Z41**	2.97
Z6	3.98	**Z24**	3.23	**Z42**	2.37
Z7	3.89	**Z25**	2.89	**Z43**	3.39
Z8	3.21	**Z26**	3.78	**Z44**	3.21
Z9	3.23	**Z27**	2.65	**Z45**	2.05
Z10	4.45	**Z28**	2.23	**Z46**	3.31
Z11	4.67	**Z29**	3.22	**Z47**	3.01
Z12	3.9	**Z30**	3.65	**Z48**	2.23
Z13	3.09	**Z31**	3.87	**Z49**	4.42
Z14	3.06	**Z32**	3.9	**Z50**	4.21
Z15	3.78	**Z33**	3.98	**Z51**	3.67
Z16	3.56	**Z34**	3.24	**Z52**	3.62
Z17	4.11	**Z35**	4.02	**Z53**	3.67
Z18	4.29	**Z36**	4.66	**Z54**	3.12

Table:26 Moisture content of reactive dyes

All dyes have 2.0 % to 4.5 % moisture content which is good, above 5.0% moisture causes the hydrolysis of dyes.

4.8 Multifibre staining

It is necessary to test stanning properties of synthesized dyes. Currently several blends fabric is more popular so necessary to check staining on Multifibre. Multifibre staining was carry out with dyeing at 60 ºC for 60 min. used sodium sulphate (50 g L^{-1} sodium sulphate) and sodium carbonate (5 g L^{-1} sodium carbonate) for dye fixation. Multifibre which is made with six different fabric such as Acetate, Cotton, Nylon(PA66), Polyester, Acrylic, wool fibers make SDC. All dyes have good staining properties no staining observed with different fibres some selected dyes multifibre shown in Figure:41. Multifibre staining results shows that synthesized dyes are suitable for all blend fabric like cotton and polyester blend, cotton and wool and many blends. No tinting observed in several blends. All dyes have no tint on several fibers so easy to applied on blend fabric. During the application dyeing with multifibre the pH of dye bath is play main roll and after treatment of fibre is most important. All synthesized dyes were having no staining observed in polyester and acrylic fibers, resulted advisable used in dyeing of polyester cotton blend.

Figure:41 Multifibre staining

4.9 Solubility

Reactive dyes are water soluble dyes hence solubility of reactive dyes class of colour is most important for getting excellent fastness properties. All Synthesis dyes have good solubility between 40 g L^{-1} to 60 g L^{-1}. Solubility test carry out using Whatman Filter Paper no 4 two filter paper into the filter funnel, for 40 g L^{-1} solubility test 2 gm dye sample weight and dissolved in DM water at room temperature on magnetic stirrer with 200 rpm for 15 min after that filter on vacuum pump. Filtration time measured and filter paper dry at room temperature, no residue observed on filter paper and filtration time is within three minutes. All dyes have good solubility [31,32]. Solution stability and salt stability of synthesized dyes were also good for checking of salt stability Sodium Sulphate was used, in this study 40 g L^{-1} to 60 g L^{-1} salt were used.

4.10 Stability of Reactive dyes

Stability of reactive dyes was check at 40 ºC and 50 ºC. Dyes were kept in oven at 40ºC and 50 ºC. for three weeks, after that dyes were removed from oven and one week conditioning at room temperature after that these dyes were check against original sample that is not kept in oven with exhaust method. The exhaust dyeing method was used as same describe in application of reactive dyes section on cotton fabric. After dyeing all fabrics were given all after treatment process that is washing and shopping after complete the all after treatment fabric was measured. Most of synthesized dyes have good stability at 40 ºC but at 50 ºC dyes were not suitable [33]. Selected dyes strength and shade measurement value shown in Table:27. At 50 ºC selected dyes have a high DE value shows that dye was not stable at 50 ºC and also strength about 3% weaker in strength indicate that dyes decreased.

Dye	**Temperature**	**Strength against original sample**	**Residual color Difference (D65 10Deg)**									
			CIE DE*	**CIE DL***	**CIE DC***	**CIE DH***	**CIE Da***	**CIE Db***	**CMC DE**	**CMC DL**	**CMC DC**	**CMC DH**
Z1	40ºC.	98.67%	0.49	0.19	0.38	0.23	0.05	0.44	0.27	0.11	0.11	0.22
	50ºC.	94.45%	1.59	0.97	1.25	0.18	-0.9	0.89	0.63	-0.25	-0.5	0.29

Z12	40ºC.	98.23%	0.47	0.37	0.26	0.14	0.27	0.12	0.11	-0.04	-0.09	-0.03
	50ºC.	95.78%	3.08	2.37	1.92	0.42	1.95	0.28	0.81	-0.35	-0.65	-0.33
Z28	40ºC.	99.34%	1.4	1.16	-0.6	0.52	0.64	0.47	0.23	-0.07	-0.21	-0.07
	50ºC.	97.45%	0.27	0.11	0.1	0.22	0.11	0.21	0.26	0.03	-0.01	0.26
Z34	40ºC.	99.89%	0.33	0.12	0.22	0.22	0.04	0.31	0.29	0.06	0.01	0.28
	50ºC.	93.56%	1.64	0.59	-1.5	0.33	1.16	-1	0.61	-0.41	-0.42	0.16
Z52	40ºC.	99.56%	0.49	0.25	0.35	0.25	0.01	0.43	0.25	0.08	0.13	0.2
	50ºC.	97.09%	0.35	0.14	0.03	0.32	0.24	0.22	0.21	-0.05	0.07	0.19

Table: 27 Strength and shade of selected reactive dyes

Strength of dye Z1 at 40 ºC is 98.67% against original sample result of strength is good and CMC value DE 0.27 result shows that stability of dye Z1 was good, at 50 ºC. strength was 4% weak value of DE was 0.63 its shows that dye is not stable at 50 ºC., Same results are observed in all dyes at 40ºC dye have good stability while at 50 ºC dye shade and strength slightly change.

4.11 Overall Evaluation of Reactive Dyes

The main aim of this study was to synthesis some bi-functional and mono azo hot brand reactive dyes. All synthesized dyes have good percentage yields means conversion of starting material to finished materials all reaction done with good steps. All synthesized dyes were applied on silk, wool and cotton fabric.

4.11.1 Evaluation on Cotton, silk and wool fabric

4.11.1.1 Shade

Dyed fabric of cotton, wool and silk were mounted on shade cards 1 and 2 for cotton 3 and 4 for wool and 5 and 6 for silk. Series I, series II, series III, Series IV, series V and series VI gives orange, golden yellow, red and several red tone colours. In series I as a coupling component J-acid was used gives orange colour, in series II as a coupling component H-acid was used gives red colour, in series III as a coupling component Gamma acid reddish orange, in series IV as a coupling component Orange to reddish brown colour. In series V as a coupling components J- acid, N-methyal -J-acid, N-phenyl-J-acid, K-acid, Peri acid were used gives orange to reddish brown colour. In series VI as a coupling components H-acid, Gamma acid, J-acid, N-phenyl J-acid, K-acid and peri acid gives purple red to marron colures.

4.11.1.2 Dyeing and Printing Properties

All synthesized dyes were applied on Cotton, silk and wool, the fixation value of dye on cotton fabric range between 76% to 89%. The several parameters like temperature effect on exhaustion and fixation, salt concentration effects on exhation and fixation, dyeing time effects on exhaustion and fixation, pH effects on exhaustion and fixation were studied. From the study 60 ^{o}C temperature is more suitable for getting higher fixation value on cotton fabric. 100 g L^{-1} salt concentration gives higher fixation value of dyes. 60 minutes times of dyeing gives highest fixation value of dyes. Dyeing at 10 pH gives best fixation value of dyes on cotton fabric.

Synthesized dyes Z1-47 when applied with cold pad batch method on cotton fabric resulted good colour depth and tone. The dyes were also applied with printing method on cotton fabric gives good fixation value and bright shade it shows that dyes have good interaction and solubility in to fabric. The presents of triazine ring gives good fixation values of dyes. All series of dyes have good colour yield on cotton fabric with printing method. The good penetration of dye in to the fabric gives high levelness of colour.

All dyes applied on silk fabric the range of fixation value was 78% to 93%. achieved. When applied on wool fabric the fixation value were 78% to 89% activated presents of phenyl urea and Vinyl sulphone group have good affinity of dyes resulted excellent fixation values as well as wet fastness properties.

4.11.1.3 Fastness properties

Dyes have good to excellent lightfastness characteristics, good to very good washing fastness properties on cotton, silk and wool. The dyes have good penetration and affinity of the synthesized dyes to the cotton, silk and wool fabric. This is because reactive colors strongly cling to the fabric and have an affinity for it. Good light fastness may be attributed to the conjugated system's better resonance stability and the dye structure within the fabric being converted from a scattered form to an aggregated or crystalline one. Synthesized dyes Z1-Z10 have good antibacterial activity.

4.11.1.4 Thermogravimetric Analysis

The reactive dyes have good heat stability, according to the TGA study data. They can be used in high-tech applications like colour filters because to their excellent thermal stability.

Dyes are tested with multifibre no staing observed on several fibers like wool, acetate, nylon and polyester there for advisable for to be use all kind of fibers. The stability of reactive dyes also evaluated, at 40 ^{0}C stability of dyes gives good results shows that dye have stability at 40 ^{0}C.

4.12 References

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