A

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Faculty	**:**	**Technology & Engineering**
Title of Thesis	**:**	**Synthesis, Characterization and Dyeing Performance of Reactive Dyes**
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Introduction :

Dyes are generally a coloured organic compound or blend that may be used for imparting colour to a substrate such as cloth, paper, plastic or leather. The middle of last century mostly the dyes were obtained from plants or animal sources .Indigo,Tyrian Purple ,Alizarin, Cochineal and Logwood were used as a Natural dyes [1]. In 1771 Picric acid was obtained by Woulfe by treating indigo with nitric acid ,and use dyeing for silk. In 1856 William H. Perkin when preparation of quinine from aniline, accidently obtained black mass in reaction .He isolated a purple water soluble compound that's called purple dye named Mauveine and he applied directly on wool and silk [2]. Reactive dyes are coloured compounds which contain one or two groups capable of forming covalent bond between a carbon or phosphorous atom of the dye ion or molecular and an oxygen, nitrogen or sulphur atom of a hydroxyl, an amino or a mercapto group, respectively of the substract[3]. The first commercial reactive dyes developed by ICI in 1956 named procion M. In Morden synthetic dyestuff reactive dyes are successful class of dyes due to simply application, brilliancy verity of shades, and excellent wet-fastness properties [4-5].

Day by day, the dyes and textiles industry climbs higher and higher. Development in the dyes industry and chemical intermediates are very important for growth of the market. The establishment of reactive dyes is an major milestone in the history of synthetic dyes. Reactive dyes are the only class of dyes which have covalent bond with subtract during dyeing process [6]. In the structure of reactive dyes easily introduced several chromophores, resulted brilliant shades and excellent wet-fastness properties. Bi-functional reactive mostly used in textiles industries because of easy application, bi-functional reactive dyes containing monochlorotriazinyl and vinyl sulphone group as a reactive group [7]. Hot brand reactive dyes are also most popular class of dyes due to less water dyeing [8]. Reactive dyes containing the triazine ring have an electrophilic site that undergoes nucleophilic substitution reaction by reaction with hydroxyl group of cellulose . 80% of chromophores used in reactive dyes are azo chromophores [9].

Summary of Research Work :

The present thesis comprises of five chapters as arranged in following manner.

Chapter 1 – Introduction and literature survey of reactive dyes

Chapter 2 – Experimental work

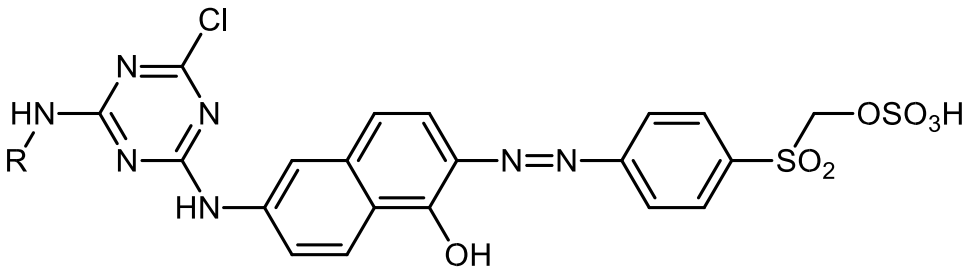
Chapter 3 – Characterization of synthesized dyes

Chapter 4 – Application of Reactive dyes

Chapter 1

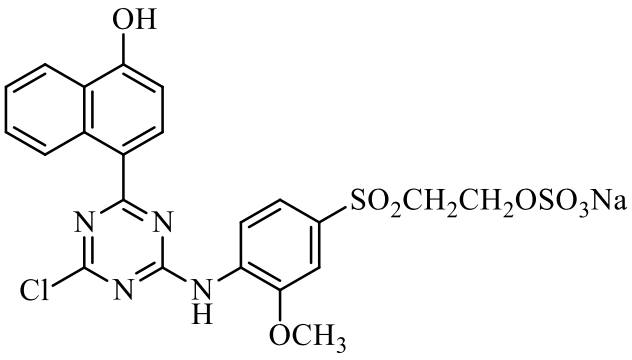
Introduction and Literature survey of Reactive dyes :

Xiong Wei et al.,[10] have been synthesized new hetero-bifunctional reactive dyes by introducing benzene sulfonamide and its derivatives into the triazine ring. All synthesized dyes have excellent light-fastness. 4-(β-sulfatoethysulfonyl) aniline used as the diazo component and cyanuric chloride with benzene sulfonamide and J-acid was used as a coupling component. Introduction of sulfonamide group gives good exhaustion and excellent light fastness.



Structure of dyes prepared by Xiog Wei et al.

Snehal lokandwala et al.,[11] prepared new reactive dyes from Benzothiazole derivatives, all dyes have good fixation value on cotton fabric. M.M. Dalal et al.,[12] have been prepared bifunctional reactive dyes from 2-chloro-4-[4`-(β-sulphatoethyl)-sulphonyl-2-methoxyanilino]-6-4"-hydoxy1"-naphthyl)-s-triazine. The performance of dyeing and all fastness properties of dyes were studied on cotton, silk and wool fabric. Dyes have moderate to good light fastness, good to excellent wash fastness and very good to excellent rubbing fastness.

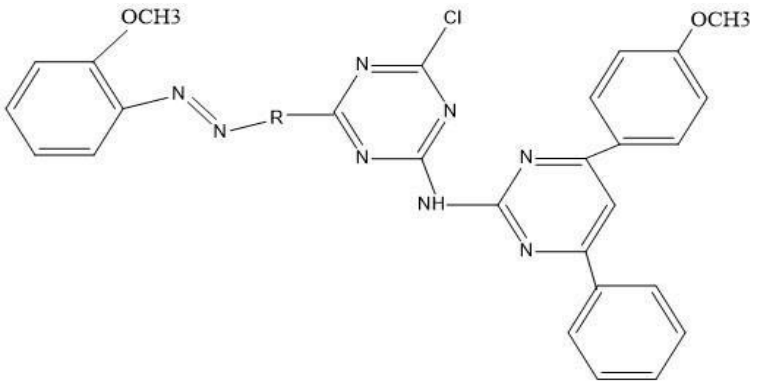


Structure of bi-functional reactive dyes prepared by M.M.Dalal et al.

Lina et al.,[13] studied reactive dyes based on 4,4′-Diaminobenzanilide and apply on various fibres. A series of synthesized dyes have been applied on silk. wool and cotton fibres. Different coupling component were used for synthesized dyes gives yellow to pink shades on fibers. Divyesh R. Patel et al.,[14] have been synthesized some novel bisazo reactive dyes based on 4,4′-methylene-bis-(2methylene-bis(2-methyl-5-nitro aniline). All dyes were characterized by UV-Vis, FTIR, ^{1}H NMR spectroscopic techniques. The exhaustion and fixation of dyes were found to be very good. The dyes have excellent fastness properties. Umme Habibah Siddiqua et al.,[15] have been studied relationship between structures and dyeing properties of reactive dyes for cotton dyeing, six reactive dyes have different numbers and position of functional groups dyed with pad dyeing method. All dyes showed variable strength of colour and fastness properties of cotton fabric. The colour strength and fastness properties of fabric depends upon the functional groups and their positions. Fatma A. Mohamed, Saadia A. Abd EL-Megied et al.,[16]. Synthesized novel monofunctional MCT- dyes based on thiazol moiety, exhaustion, fixation and wet-fastness properties showed higher on cotton fabric. Dyed fabrics antibacterial activity showed very good inhibition for S. *aureus* and E. Coli. Divyesh R. Patel et al.,[17] synthesized monoazo reactive dyes based on quinazolinone, Dyes were synthesized by coupling of diazotized 3-{4-[4-amino -2nitrobenzyl]-3-nitrophenyl}-7-chloro-2-phenylquinazolin-4(3H)-one with several p-chloro anilino cyanurated coupling components. All synthesized dyes have excellent fastness properties and fastness due to presents of triazine ring in dye structure.

Alkesh B. Patel et al.,[18] have been synthesized Monoazo reactive dyes and application study on silk, wool and cotton fibers. All dyes have prepared from diazotized o-anisidine with different 4(4-

methoxyphenyl)-6-phenylpyrimidin-2-yl-amino cyanurated coupling components. Dyes have excellent fastness properties and very good fixation value on silk,wool and cotton fibers.

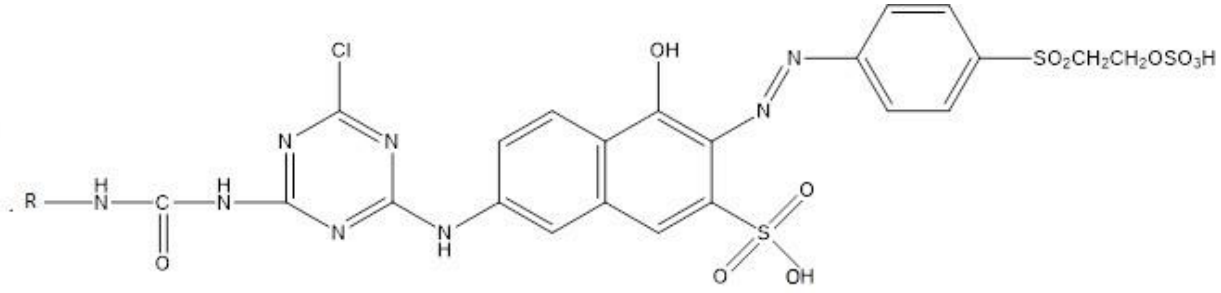


Structure of mono azo reactive dyes prepared by Alkesh B. Patel et al.

Paresh S. Patel et al.,[19] have been prepared some Heteropolyfunction Reactive dyes and their application on silk, wool and cotton fibers.4,4'-Methylene bis(2-carboxy aniline) was tetrazotized and various 4-(ethylsulfurate sulfonyl) anilino cyanurated coupling components gave novel heteropolyfunctional reactive dyes. All synthesized dyes gave violet to yellow shade on cotton,silk and wool fibres. Dyes have excellent fastness properties and fixation value. The presents of striazine group and vinyl sulfone systems show high percentage of exhaustion , fastness properties and fixation values.

Chapter 2

In the series 1 the bi-functional reactive dyes based on following structure were prepared

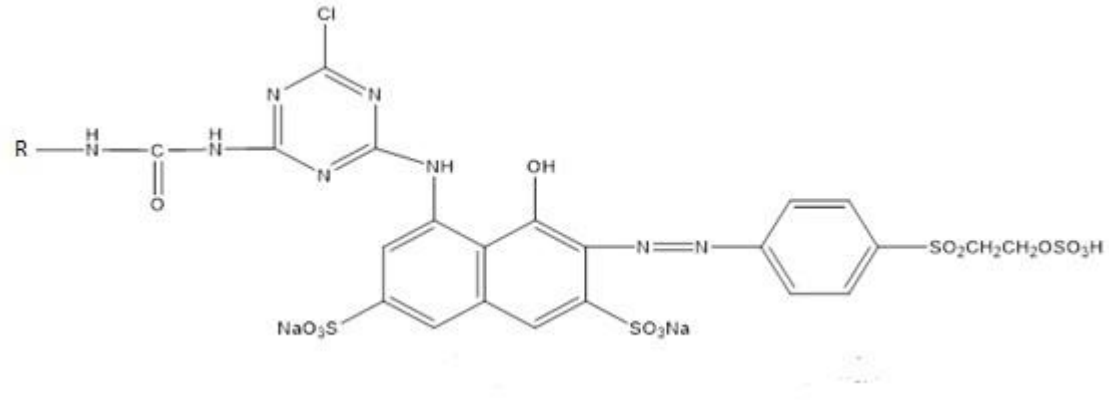


Where R= Phenyl Urea Derivatives

a : Phenyl, f : p-Nitro
b : o-Tolyl g : m- Nitro
c : m-Tolyl h : o-Chloro
d : p-Tolyl i : m Chloro
e : o-Nitro j : p-Methoxy

One mole of 2-amino-5-naphthol-7-sulfonic acid(J-acid) was condensing with one mole of various phenyl urea cynurated coupling component to obtain different reactive dyes. First condensation was carried out with Cyanuric chloride and J-acid at 0-5º C with used with sodium carbonate solution maintained pH neutral. cyanurated J-acid is formed in a clear solution. For second condensation mixture of cyanurated J acid ice cooled well-stirred solution was heated to 45ºC. Phenyl urea was introduced to this mixture slowly, pH was maintained neutral with sodium carbonate solution after complete reaction mixture was used for coupling reaction. 4-(βsulfatoethylsulfonyl)aniline was dissolved in H_2O at pH 6-7 adjust with sodium carbonate solution maintained temperature 0-5ºC. A solution of sodium nitrite was then added to the solution of 4-(βsulfatoethylsulfonyl)aniline. The mixture was then added to a cooled mixture of concentrated hydrochloric acid under stirring. The excess nitrous acid was decomposed with small amount of sulfamic acid. The diazo salt was used for the subsequent reaction. The diazonium salt was added to the coupling reaction mixture at temperature 5-10º C. pH was maintained at 7-8 by adding sodium carbonate. The dye was salted out with addition potassium acetate, filtered and washed with ethanol and dried.

In the series 2 the bi-functional reactive dyes based on following structure were prepared.

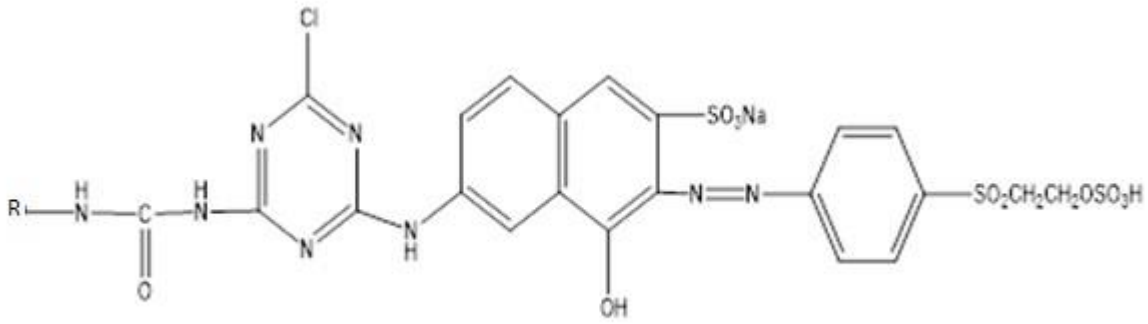


Where R= Phenyl Urea Derivatives

One mole of 8-amino-1-naphthol-3,6-disulfonic acid(H-acid) was condensing with one mole of various phenyl urea cynurated coupling component to obtain different reactive dyes. First condensation was carried out with Cyanuric chloride and J-acid at 0-5º C with used with sodium carbonate solution maintained pH neutral. Cyanurated J-acid is formed in a clear solution. For second condensation mixture of cyanurated H acid ice cooled well-stirred solution was heated to 45ºC. Phenyl urea was introduced to this mixture slowly, pH was maintained neutral with sodium carbonate solution after complete reaction mixture was used for coupling reaction. 4-(βsulfatoethylsulfonyl)aniline was dissolved in H_2O at pH 6-7 adjust with sodium carbonate solution maintained temperature 0-5ºC. A solution of sodium nitrite was then added to the solution of 4-(βsulfatoethylsulfonyl)aniline. The mixture was then added to a cold mixture of concentrated hydrochloric acid under stirring. The excess nitrous acid was decomposed with small amount of sulfamic acid. The diazo salt was used for the subsequent reaction. The diazonium salt was add to the coupling reaction mixture at temperature 5-10º C. pH was maintained at 7-8 by adding sodium

carbonate. The dye was salted out with addition potassium acetate, filtered and washed with ethanol and dried.

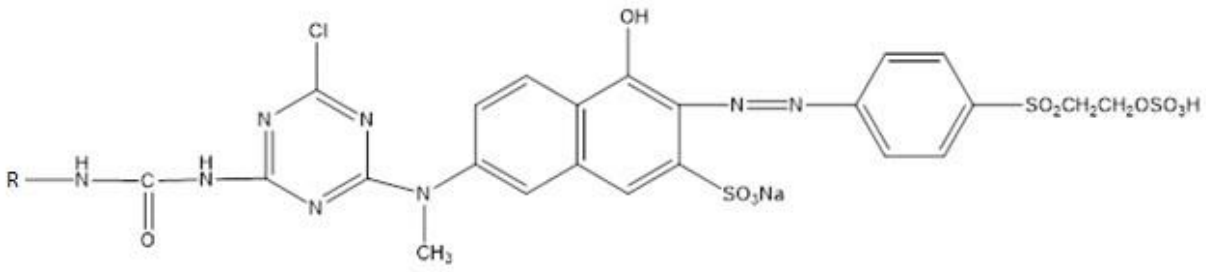
In the series 3 the bi-functional reactive dyes based on following structure were prepared.



Where R= Phenyl Urea Derivatives

For synthesis of above dyes synthesis procedure was same as series 1 and 2 only coupling component changed that a 2-Amino-8-naphthol-6-sulfonic acid Gamma acid.

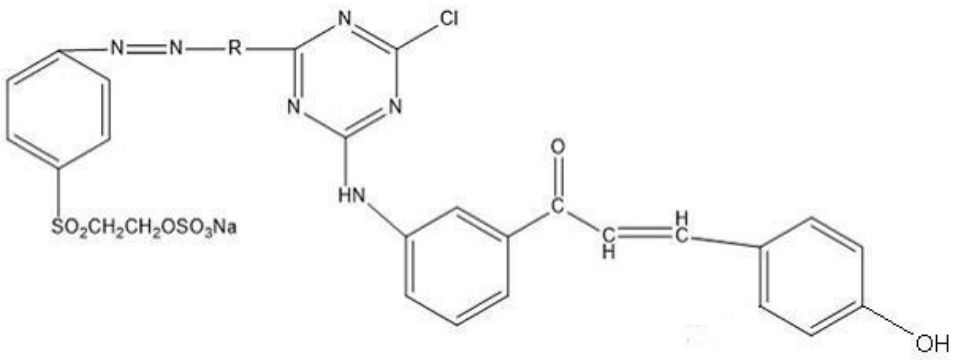
In the series 4 the bi-functional reactive dyes based on following structure were prepared.



Where R= Phenyl Urea Derivatives

For synthesis of above structure synthesis procedure was followed same as series 1 and 2 and coupling component changed as 1- hydroxy-6-(methylamino)-3-naphthalenesulphonic acid(methyl J- acid).

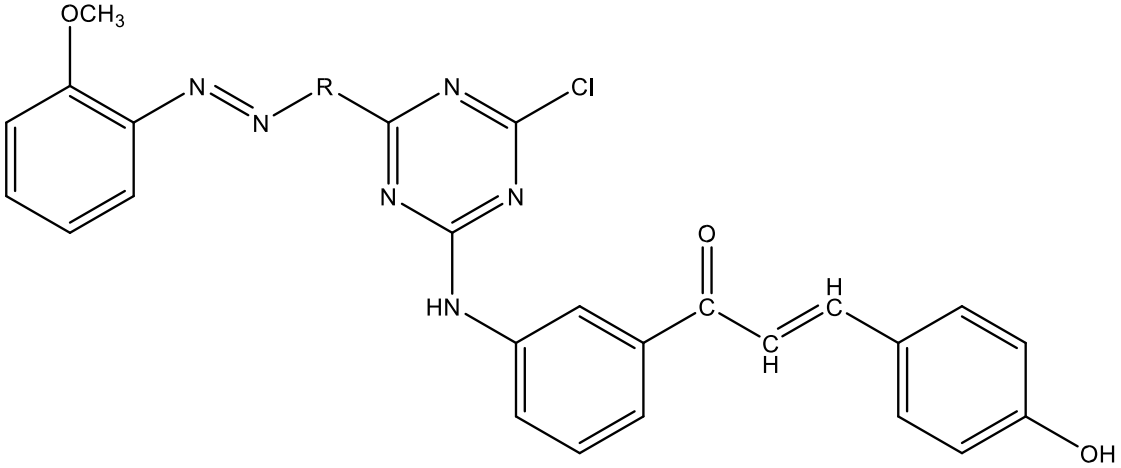
In series 5 the bi-functional reactive based on following structure were prepared.



Where R=H-acid, Gamma acid, J-acid, N-methyl J-acid, N-phenyl J-acid, S-acid, K-acid, Peri acid, Laurent acid, Koch acid.

For inter mediate preparation 4-Amino-4′-hydroxy chalcone was prepared by using 0.1 mole 4Amino acetophenone, 0.1 mole 4-hydroxy benzaldehyde and a few drops of piperidine in ethanol were taken in round bottom flask and refluxed for twelve hours. After complete the reaction mass was poured to ice-water mixture with stirring, solid separated, filtered and crystalized from ethanol. 4-(β-sulfatoethylsulfonyl)aniline used as diazonium component and coupled with cynurated 4-Amino-4′-hydroxy chalcone and different coupling component.

In the series 6 the hot brand reactive dyes based on following structure were prepared.



Where R= H-acid, Gamma acid, J-acid, N-methyl J-acid, N-phenyl J-acid, S-acid, K-acid, Peri acid.

Various mono azo reactive dyes have been prepared from 1—(4-aminophenyl)-3-(2hydroxyphenyl)prop-2-en-1-one cyanurated coupling components such as H-acid, Gamma acid, Jacid, N-methyl J-acid, N-phenyl J-acid, Chicago acid, S-acid, K-acid, Bronner acid, Peri acid.

Chapter 3

In this chapter characterization of synthesized dyes were described. For characterization of reactive dyes following methods were used. **(i) Thin Layer chromatography(TLC):**

In Thin Layer chromatography(TLC) the basic equipment is simple and exorbitant, and time of evolution is short. The fundamental explains for TLC is given by y E. Stahl[20], B. Fried and J. Sherma[21], J. G. Kirchner[22], G. B. Bettol-Marini[23] and K. Macek and I. M. Hais[24].Following solvent were used.

1) ethyl acetate-n-Propanol-water(10+60+30).

2) pyridine-2-Butanol-ammonium hydroxide-ethanol-2-Butanol(20+40+30+10).

(ii) Ultraviolet (UV) and Visible spectroscopy:

The wavelength λmax. was measured on primer spectrophotometer SS 5100 Premier. It is observed that the wavelength λmax. was recorded around 420 to 590 nm of synthesized dyes.

(iii) Infra-Red (IR) Spectra:

The IR spectrum data are used for dyes characterization. On the careful observation of all synthesized dyes it is observed that for -OH stretching vibration found around 3300-3400 CM^{-1},NH_2 stretching vibration found around 3200-3300 cm^{-1}, C-Cl stretching vibration found around 600-800 cm^{-1},N=N stretching vibration found around 1543-1564 cm^{-1}, triazine stretching vibration found around 1498-1499 cm^{-1},C-H stretching vibration found around 2928-2936 cm^{-1},-SO_3Na stretching vibration found around 1035-1260 cm^{-1},C=O stretching vibration found around 16751684 cm^{-1},NO_2 stretching vibration found around 1360-1370 cm^{-1}.

(iv)Nuclear Magnetic Resonance Spectroscopy:

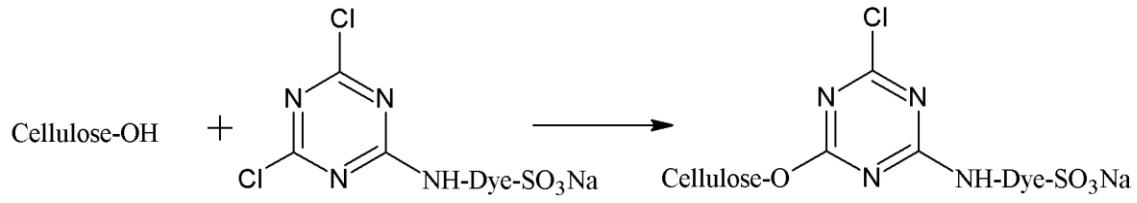
^{1}H NMR spectra was used for dyes characterization, for dyes M1 found 5.72(S, 1H,SO_2CH_2)6.80-7.9(m,13H,Ar-H),8.65(S,1H,SO_3H),9.21(s,1H,OH),9.34-9.66(m,3H,NHCONH,9.21(s,1H,OH),9.34-9.66(m, 3H,NHCONH,NH)δ ppm and others.

(v)Solubility:

Solubility of reactive dyes play main roll of reactive dyes. All synthesized reactive dyes solubility check 40 to 60 g/l dyes have filtered with Whatman filter paper no 4 in vacuum pump. All dyes were filtered > 2 min. and no insoluble or residue observed on filter paper filtration time was also measured.

Chapter 4

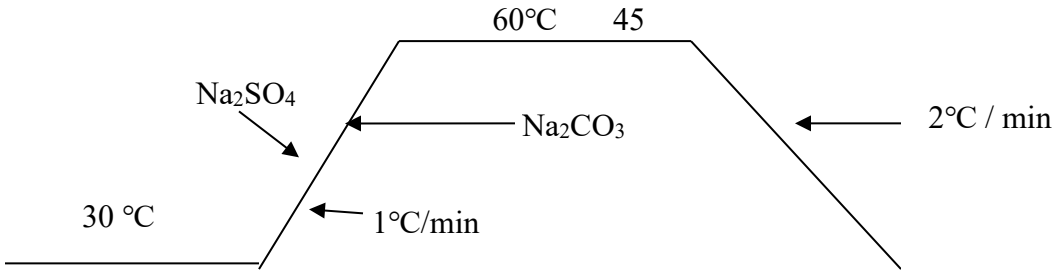
Present chapter deals with application of reactive dyes with different dyeing method applied on silk, wool and cotton fabrics. Triazinyl dyes containing cyanuric chloride are react with cellulose forming covalent bond between dye and cellulose.



(i) study of dyeing properties on Cotton by Exhaust method:

All synthesized dye (series 1 to 7) ware used to the dyeing Cotton,Wool and Silk at 1.0% colour shade. 1.0% Dye concentration provide good fastness properties as well as Exhaustion and Fixation , Current this study 1% applied for dyeing of fabrics. Dyeing Of Cotton with synthesized dyes ware carried out using 2 gm fabric, liquor to goods ratio 1:10 .100 g L^{-1} Na_2SO_4 (Sodium sulphate) and 10 g $L^{-1}$$Na_2CO_3$(Sodium Carbonate) under the fixation of 60℃ isothermal process was used .After dyeing the shopping was carried out using 2 g L^{-1} Non ionic shop at 90-95℃ for 20-30 min and lastly cleaned and dehydrated .The dyeing procedure of cotton was carried as delineated in Figure

Dyeing cycles of dyes for cotton dyeing.



Exhaustion and fixation value of synthesized dyes were calculated from below equations

$$\% \text{ Exhaustion } E = (C_1 - C_2) / C_1 \times 100\% \quad (1)$$

$$\% \text{ Fixation } F=(C_1 - C1 - C3) / C_1 \times 100\% \quad (2)$$

$$\% \text{ Reactivity } R= E / F \times 100\ \% \quad (3)$$

The percentages of dye exhaustion on the cotton fabric range 89-91% and the percentage of fixation on the cotton fabric range 78-88%.

From series one reactive dyes have different position of functional group (meta and para VS) was applied on cotton fabric through Exhaust dyeing. The dyeing parameter like temperature, pH and dyeing time were optimized and dyeing properties were studies. Same dyeing condition all dyes showed variable exhaustion, fixation and fastness properties. The fixation value and fastness properties of fiber correlated with used functional group (position). Dyes have same chromophore only change in VS used (meta and para) , dyes have good fixation(78%) and excellent wet fastness compared to para, same results observed in meta have good fixation 73% and fastness properties compare to para dyes.

(ii) study of dyeing properties on Cotton by Cold Pad Batch method:

Synthesized reactive dyes series 1 to 4 were studied on cotton fabric. In the application of CPB 20 g L^{-1} concentration of reactive dyes were used for dyeing of fabric. Horizontal padding mangal was used for CPB dyeing method. The fabric was passed through padding mangal where the dye with padding solution. The Batching time of dyed fabric was 16 hrs. In Cold Pad Batch Dyeing method Sodium silicate 109º Tw(50 ml L^{-1}) ,Urea (20 g L^{-1})and NaOH 38 Be' (0.5 ml L^{-1}) was used as a padding solution. Each sample was instantly wrapped in plastic bag. Batched fabric were kept in dark room at room temperature. After batching fabric was first washed with Sodium Hexa Meta Phosphate to remove unfix dyes from dyed fabric, after that cold wash and Hot wash given to dyed fabric. After removed all unfix dyes from fabric, the dyed fabric was kept in Oven for dry at 60ºC. Dyed fabric was measured on Data Color 400 TM Spectrophoto meter .The reflectant value L*,a*,b*,C*,H and K/S were recorded on Data Color 400 TM Spectrophotometer. Fixation value of CPB dyed fabric were calculated by below equation

$$\%F = \frac{\text{K/S after wash}}{\text{K/S before wash}} \text{ X } 100 \qquad (3)$$

In the CPB method 20 g L^{-1} concentration of dyes ware used. It was observed that the good fixation and the levelness of dyeing achieved on fabric with synthesized reactive dyes . All dyes of series 1 to 4 had fixation 85 to 91 %.

(iii) Printing Application of Synthesized Dyes on cotton fabric:

Sodium Alginate Thickener was used for preparation of print paste and Direct style of printing was used. Sodium alginate gives good color strength and fastness properties of print fabric. Reactive Dyes X g KG^{-1} ,Thickener 350 g KG^{-1},Urea 250 g KG^{-1},Sodim Carbonate 15 g KG^{1},Rassist Salt 6 g KG^{-1}, Water 444 g KG^{-1} Total 100 g KG^{-1} was used for preparation of print paste.3 % Concentration of dyes were used for printing shade and 1:3 reduction print used for printing .After preparation of Print paste ,the paste was applied on Cotton Fabric with screen printing. After printing fabric printed fabric dry at 60ºC in oven, dried printed fabric fixed on steamer machine for steaming at 102 º C for 10 min.. The printed fabric than Cold wash and hot wash with non ionic detergent. Printed fabric reflectance measured with Data Color 400 TM Spectro photo meter. Levelling properties of printed fabric measured with the colour differences each samples at six separate points. the Absorbance value of dyes was average 64% on cotton fabric. The levelness value of printed fabric was achieved for synthesized dyes. All synthesized liq. dyes from series 1 to 4 applied on cotton fabric by printing method. All dyes have good Absorbance value average 62%.

(iv) Study of Different Parameters on cotton fabric:

Different parameters such as Dyeing temp. (60ºC,70ºC and 80ºC temperature) ,Salt (Na_2SO_4) Concentration (60,80 and 100 $g.L^{-1}$),10 g $L^{-1}Na_2CO_3$ was common for all salt concentration. Dyeing Time (40,50,60 min),pH (9,10 and 11) were used for Exhaustion and Fixation study of synthesized dyes series 1 to 4.

(a) Effect of temperature on Exhaustion and Fixation:

Temperature play main roll for dyeing of cotton to getting higher depth of shades as well as Fixation value.Exhaustion and Fixation rates of every dyes were different and mostly depends upon structure of dyes and Dyeing process used. The temperature of dyeing process rotate from dyes to dyes. Exhaustion and Fixation rate of dyes series 1 to 4 higher at 60ºC.Dyeing temperature above 60ºC was not suitable for Exhaustion and Fixation .

(b) Effects of Salt Concentration on Exhaustion and Fixation:

Economically and Environment point of of View Exhaustion and Fixation required high value of Degree . Alkalinity is strong characteristics for dyeing of cellulose fabric. In this study Electrolytes used with different concentration 60,80 and 100 g L^{-1}. Formation of Covalent bond necessary to

add Alkali ,From Figure 5 it can be seen that we increased amount of salt the percentage rates of Exhaustion and fixation were also increased . Rate of Exhaustion of Synthesized dyes was higher up to 94% at 100 g L^{-1} and also Rate of Exhaustion of Synthesized dyes was higher up to 90% at 100 g L^{-1} .Series 1 dyes (Yellow) shown that high rate of Exhaustion and Fixation compare to Dyes series 2 and series 3.

(c) Effects of Dyeing Time on Exhaustion and Fixation:

The fabric was dyed with different Dyeing Time (40,50,60 min)for the study of Exhaustion and fixation. Dyeing time was more important for getting higher depth of shade on cotton fabric. Purpose of this study to get higher strength of shade on cotton fabric. The migration of dyes to cotton fabric was high in time interval 40 min. Figure 7 shows that Exhaustion and fixation rate was higher in 40 min dyeing time. After 40 min hydrolysis started and decreased the Exhaustion So that 40 min dyeing time gives best Fixation percentage compare to 50 and 60 min..

(d) Effects of pH on Exhaustion and Fixation:

Dyeing of reactive dyes with cotton fabric more important to maintain pH, always alkali media necessary to dyeing with reactive dyes. In this project different pH (9,10,11) was used for effect on exhaustion and fixation rate of dye. All parameter of dyeing ware same as above only difference in pH. Dyeing Temperature 60ºC and dyeing time 45 minutes was used. Effects of pH on exhaustion and fixation is shown in Figure 9. Exhaustion and fixation rate of dyes were higher at pH 10 result shows that at 10 pH exhaustion rate was increased above 93 % and fixation rate above 90% achieved.

(v) study of dyeing properties on wool by Exhaust method:

The synthesized biofunctional reactive dyes (series 1 to4) and hot brand reactive dyes (series 5 to 7)were tested to wool fabric using 2 gm of wool fabric at pH 3-7 with Acetic acid, Sodium sulphate (100 g.L^{-1}) and Sera Gal WUL (Dystar) at Temp 100°C for 60 min. after dyeing of wool fabric washed and dried, The exhaustion value of synthesized dyes on wool fabric was 64-73%,the fixation values of dyes on wool fabric was is 68-80%.

(vi) study of dyeing properties on silk by Exhaust method.

Exhaust dyeing of silk 1.0 % was managed at pH 5 with using Acetic Acid at Temp 90°C. For 60 min, finally washed with water and dried. The exhaustion value of synthesized dyes on wool fabric was 69-70%,the fixation values of dyes on wool fabric was is 71-79%.

(vii) Fastness properties of dyes on Silk, wool and cotton fabric:

Reactive dyes growing rapidly due to have good light fastness properties. Presents of triazin group in dye structure upgrade the fastness properties of dyes . From fastness it can be seen that Fastness properties of synthesized dyes such as Washing ,Light and Rubbing fastness was achieved. Solubility behavior are importance of reactive dyes ,solubility effects on getting all wet fastness as well as fixation of dyes.Dyes have good substantivity with the fabric resulted good fastness properties as well as all application of dyes. Following fastness properties were studied.

(a) Fastness to washing:

The washing fastness of fabric wool, silk and cotton fabric was carried out as per ISO test[25]. Soap as per ISO describe (5 gm) desolved in 100 ml distilled water take 20 ml of this solution and put dyed fabric in it dyeing pot now kept in IR Dyeing machine run with 45 min at 50ºC after that test fabric removed and give treatment of cold wash and after that dry. Fabric was measured as Grey scale and provide rating as per below.

Observation	Grade	Qualitative assessment
Shade unaltered	5	Excellent
Very Slight loss in depth	4	Very Good
Appreciable loss	3	good
Distinct loss	2	Fair
Great Loss	1	Poor

All dyes (series 1 to 6) have very good to good fastness properties on silk, wool and cotton fabric.

(b) Fastness to light:

For the lightfastness of reactive dyes all dyed fabric cut similar size as per describe ISO method and mounted on card , after that card was exposed to light and then exposed to sunlight during some intervals check the observation in shade of fabric. All shades of fabric was measured with

original shade of colour and given rating as per below ratting. All dyes have Very good to good fastness properties.

Grade	Qualitative 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

(c) Fastness of rubbing wet and dry:

For the testing of rubbing wet as well as dry using ATLAS crock meter. The specimen are fastened in the crockmeter apparatus which causes a piece of standard of white cloth (starch free 96×100 cotton fabrics long type) to rub against the colored specimen under controlled condition of pressure and speed. Test was carry out both condition wet and dry after that fabric was compare with Grey Scal and defines as follow. All series of dyes have good to very good rubbing fastness properties.

Observation	Grade	Qualitative assessment
No dye stain on undyed fabrics	5	Excellent
Slight dye stain on undyed fabrics	4	Very good
Moderate dye stain on undyed fabrics	3	Good
Distinct dye stain on undyed fabrics	2	Fair
Very much dye stain on undyed fabrics	1	Poor

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List of Conferences attended:

1. Current Trends and Advances In Chemical Science (NCBKM), Valsad, 2020. Offline. Attended,
2. Application of synthesized bifunctional reactive dyes on wool and silk by exhaust method.
   International Conference on Multidisciplinary Research & Development (ICMRD-21), Akola,March 2021.Virtual Mode.
   Oral presentation
3. Study of Synthesized Bifunctional Reactive dyes by Cold Pad Batch Method.
   International Conference On Innovation Perspectives Psychology and Social Studies (ICIPPS), Akola,April-2021,Virtual Mode.
   Oral presentation.
4. Application of synthesized reactive dyes by Dyeing and Printing method on cotton fabric.
   Indian Council Of Chemists, Surat, April -2021. Virtual Mode.
   Poster presentation.
5. Application of bifunctional reactive dyes by dyeing method on silk and wool fabric.
   International e-conference on Management, Science and Technology (ICMST-Online) May (2021),Coimbatore.
   Oral Presentation.
6. Synthesis of Reactive Dyes and Their application on Silk Fibers with Exhaust.
   International Conference on Recent Advances in Fundamental and Applied Sciences, (RAFASA),2021. Virtual Mode.
   LOVELY PROFESSIONALY University Phagwara (Panjab).
   Oral presentation.

List of Publications :

1. Synthesis of reactive dyes by the introduction of Phenyl Urea derivatives into the triazine ring and their application on different fibers.
   Manoj J.Patel, R.C.Tandel,
   Material Today: Proceeding.(2021),46(15),6459-6464.
2. Dyeing and printing study of synthesized reactive dyes using phenyl urea bifunctional reactive dyes on cotton fabric.
   Manoj J. Patel, R.C.Tandel,
   Material Today: Proceeding(2021),51(1),770-778.
3. Application of reactive dyes by Dyeing and Printing Method on Cotton Fabric and Study of Antibacterial Activity
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4. Trends in the synthesis and application of some reactive dyes- A review Manoj J. Patel, R.C. Tandel ,IJFTR,(Communicated),ID-IJFTR-4080.
5. Synthesis and application of bi-functional reactive dyes and application study on cotton fabric with exhaust technique.
   Manoj J. Patel, R.C.Tandel. Coloration Technology (under review) ,ID-CTE-22-0078.
6. Synthesis of bi-function reactive dyes and their application on different fibers.(under preparation)
   Manoj J. Patel, R.C.Tandel.

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