



Studies on synthesis, characterization and solvatochromic effect of novel tris(heteroaryl)bisazo dyes for dyeing polyester fabric

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ABSTRACT

In the present communication novel tris(heteroaryl)bisazo dyes were synthesized by the coupling of various heterocyclic diazonium salt with 1-ethyl-6-hydroxy-4-methyl-2-oxo-5-((4-phenylthiazol-2-yl)diazenyl)-1,2-dihydropyridine-3-carbonitrile. The later compound was synthesized by a new procedure for the synthesis of well known azo pyridone dyes from 2-cyano-N-ethylacetamide, ethyl-3-oxobutanoate and 4-aryl-2-aminothiazole. Structural confirmation of all the synthesized compounds have been accomplished by UV-Visible, FT-IR, ¹H-NMR, ¹³C-NMR and mass spectroscopic techniques. Solvent effects on the visible absorption spectra of the dyes were evaluated. The color of the dyes is discussed with respect to the nature of the heterocyclic ring and substituent present therein. All these dyes were applied as disperse dyes on to polyester fabrics and their fastness properties were evaluated.

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Introduction

The synthetic azo compounds are very important in the fields of dyes, pigments, and advanced materials [1]. It has been known for many years that azo compounds are the most widely used class of dyes owing to their versatile application in various fields such as dyeing of textile fibers, coloring of different materials, colored plastics and polymers, biological-medical studies, and advanced applications in organic synthesis [2-4]. However, a recent trend has seen the introduction of an increasing number of heterocycles as dye precursors and nowhere has the impact been felt more than in azo dyes [5]. Azo dyes from synthesized heterocyclic coupling components have been investigated for the production of bright and strong color shades ranging from yellow to brown on synthetic fabrics. These results have led commercial products to replace the conventional azobenzene disperse dyes [6]. There are some reports of azo dye derivatives of heterocycles such as pyridone, pyrazolone, and thiophene [7-12]. Pyridone as coupling components have been shown to be important colorants for various dyes in industrial applications. Furthermore, N-substituted pyridone azo disperse dyes show good colour strength, luminous colors and excellent light fastness [13]. In addition, pyridones are found to be used widely in textile industry for the preparing azo and azamethine dyes [14,15]. The visible absorption wavelength of these dyes are generally in the yellow to orange range due to poorly delocalized electrons in the heterocyclic ring; however, some of these dyes show more deeper color strength and shades such as red or violet or brown [3,5,8]. On the other hand, the use of heteroaromatic amines as diazo components in the generation of disperse dyes having essentially color-deepening effect is well established [7,9,10]. Heterocyclic azo compounds tend to be more strongly affected by solvents than azobenzene based dyes. This is a consequence of the increased polarity of the system, especially in the excited state. Much attention has also been given towards bisazo and polyazo dyes as dyeing materials in the recent years to increase their dye ability on fabrics [16]. In

addition to that there are several reports regarding bisazomethine (bisanil) dyes in which imine group formed by Schiff reaction of aromatic aldehyde with aromatic amine [17,18]. The crystal structures and properties of some bisazomethine dyes have been studied [19,20]. However, there are no reports regarding bis-azo tris(heterocyclic) disperse dyes based on 1-alkyl-6-hydroxy-4-methyl-2-oxo-5-(aryldiazenyl)-1,2-dihydropyridine-3-carbonitrile and the dyes in which both bisazo and tris(heterocyclic) chromophoric groups lie in a single molecular framework.

Thus in the present study some new bis(heteroaryl) azopyridone dyes were coupled with various diazotized heterocyclic amines at 5-position of 2-amino-4-phenylthiazole and made tris(heteroaryl) bisazo dyes and their applications as disperse dyes for dyeing polyester fabrics. The synthetic route of these dyes is presented in Scheme 1, as shown below.

Experimental

¹H-NMR and ¹³C-NMR spectra were recorded in DMSO-d₆ solutions on a BRUKER 400-MHz spectrometer, and chemical shifts were expressed as part per million (ppm; δ values) against tetramethylsilane as internal reference (TMS). The Infrared spectra (ν, cm⁻¹) were obtained with a Perkin-Elmer 1650 FT-IR spectrometer in KBr pellets. Mass spectra (MS) were recorded on EI +Q1 MSLMR UPLR. Elemental analyses were performed on a ECS 4010 Elemental Combustion System, and the results were within the accepted range (±0.40) of the calculated values. All melting points were determined on an Electro-thermal IA 9100 apparatus and are uncorrected.

Material

All the required reagents and solvents were of the commercial quality and purchased from Merck, Fluka and localize companies.

1-ethyl-6-hydroxy-4-methyl-5-((4-(3-nitrophenyl)thiazol-2-yl)diazenyl)-2-oxo-1,2-dihydro pyridine-3-carbonitrile 3

4-(4-arylphenyl)thiazol-2-amine 1 (2.21gm, 0.01mole) was dissolved in freshly prepared cool nitrosyl sulphuric acid (0.01) solution as per reported method [21,22] and rapidly cooled

in an ice bath to 0-5°C. Before the diazotization ends, the sulphamic acid (0.5mg) was added to the solution of diazonium salt in order to remove excess nitrite ion. At the same time solution of ethyl acetoacetate (0.01 mol) in 30 ml of ethanol, sodium acetate (3.0g) was added. The mixture was cooled to 0 °C then a cooled solution of diazonium salt in water (4.2 ml) was added under stirring. The stirring was continued for one hour after which the solid product 2 were collected, washed with water and ethanol, and dried in air. The obtained product (0.01 mol), potassium hydroxide (0.017 mol) and 2-cyano-Nethylacetamide (0.02 mol) were dissolved in 15 ml of acetone and mixture was refluxed for 5 h. The resulting mixture was acidified using dilute HCl, and the solid product was collected by filtration and washed with water and acetone. The obtained products were purified recrystallized from acetone to give 3a and 3b.

1-ethyl-6-hydroxy-4-methyl-2-oxo-5-((4-phenyl-5-(thiazol-2-yl)diazenyl)thiazol-2-yl) diazenyl)-1,2-dihydropyridine-3-carbonitrile 4a-l and 5a-l

1-ethyl-6-hydroxy-4-methyl-2-oxo-5-((4-arylthiazol-2-yl)diazenyl)-1,2-dihydropyridine-3-carbonitrile 3a,3b (2.36gm, 0.01mole) as coupling component were dissolved in water and added solid sodium acetate till solution become clear. It was cooled at 0-5°C and then diazonium salt solution of various heterocyclic amines were added into 2-pyridone solution by drop wise with constant stirring. The temperature was maintained at 0-5°C during this addition. The pH 6-7 of the mixture was adjusted by adding 40% aq. Sodium hydroxide. The resultant dyes were filtered, washed with water and air-dried then purified by column chromatography technique.

Dyeing of polyester fabric and dyeing properties

Dyeing procedure

1% (Avolan IS) dispersing agent, kept at a liquor ratio of 20:1. The process was started at 60°C; the temp. was then raised to 130°C over 30 min and maintained for 1 hr. Fabric was taken out after cooling, and treated with 2% sodium bisulphate, 2% sodium hydroxide, and 0.1% dispersing agent (Avolan IS) at 70°C for 30 min. Finally, the fabric was rinsed and dried at 60°C.

Color fastness tests

Fastness to washing

A specimen of dyed polyester fabric was stitched between two pieces of undyed cotton fabric, all of equal length, and washed at 50°C for 30 min. The staining on the undyed adjacent fabric was assessed according to the following gray scale: 1-Poor, 2-Fair, 3-Moderate, 4-Good, 5-Excellent. (Table 4)

Fastness to perspiration

The samples were prepared by stitching a piece of dyed polyester fabric between two pieces of undyed cotton fabric, all of equal length, and immersed in the acid or alkaline solution for 30 min. The staining on the undyed adjacent fabric was assessed according to the following gray scale: 1-Poor, 2-Fair, 3-Moderate, 4-Fair, 5-Excellent. The acid solution (pH=3.5) contains sodium chloride (10 g/ml), lactic acid (1g/ml), disodium orthophosphate (1 g/ml) and histidine monohydrochloride (0.25 g/ml). The alkaline solution (pH=8) contains sodium chloride (10 g/ml), ammonium chloride (4g/ml), disodium orthophosphate (1 g/ml) and histidine monohydrochloride (0.25g/ml).(Table 4)

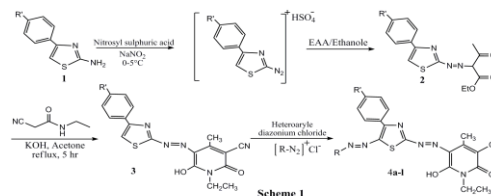
Fastness to rubbing

The dyed polyester fabric was placed on the base of the Crockmeter, so that it rested flatly on the abrasive cloth with its

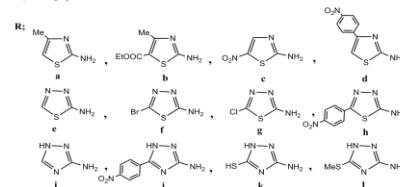
long dimension in the direction of rubbing. A square of white testing cloth was allowed to slide on the tested fabric back and twenty fourth times by making ten complete turns of the Crank. For the wet rubbing test, the testing squares were thoroughly immersed in distilled water. The rest of the procedure was same as in the dry test. The staining on the testing cloth was assessed according to the gray scale : 1-poor, 2-Fair, 3-Moderate, 4-Good, 5-Excellent. (Table 4)

Fastness to sublimation

Sublimation fastness was measured with an iron tester (Yasuda N138). The samples were prepared by stitching a piece of dyed polyester fabric between two pieces of undyed polyester, all of equal length, and then treated at 180°C and 210°C every 1 min. Any staining on the undyed adjacent fabric or change in one was assessed according to the following gray scale: 1-Poor, 2-Fair, 3-Moderate, 4-Good, 7-Excellent. (Table 4)



Where R': -NO₂, -Cl



Results and discussion

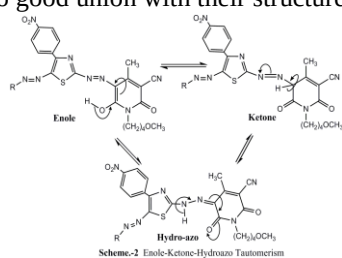
Preparation of tris(heteroaryl) bisazo dyes 4a-l and 5a-l

Scheme 1 represents the synthetic route for preparation of tris(heteroaryl) bisazo dyes. The diazo components, 4-aryl-2-aminothiazole 1, used as starting materials. As shown in Scheme 1, two derivatives of bis(heteroaryl) monoazo dyes 3a and 3b, based on 4-aryl-2-aminothiazoles as diazo components, were prepared by using EEA and 2-cyano-N-ethylacetamide. The diazo component of various heterocyclic amines were diazotized using nitrosyl sulfuric acid at 0-5 °C. Before the end of diazotization, the sulphamic acid was added to a diazonium salt solution to remove excess nitrite ions; the diazonium salt solution was then added to an aqueous diluted sodium hydroxide solution of coupling components 3a and 3b. To complete the coupling reaction, the pH value of the mixture was adjusted about 5 to 6 by adding 40% ammonia solution, which promoted the precipitation of two series of tris(heteroaryl) bis-azo dyes 4a-l and 5a-l and were then filtered, washed and air-dried.

Analysis of ¹H-NMR and ¹³C-NMR

The ¹H-NMR spectrum analysis of the tris(heteroaryl) bisazo dyes 4a-l and 5a-l are summarized in Table 2, which reveals that the diazo coupling of the intermediates 3a and 3b causes the -CH of dyes 4a-l and 5a-l to be replaced by an azo heteroaryl ring. The symmetric hydrogen of benzene ring shows two doublets for all dyes at around δ 7.87 (d, J = 9.0 Hz) and δ 8.29 (d, J = 9.0 Hz) ppm. Also the ¹H-NMR spectra of all the dyes exhibited a signal near δ 14.13–14.19 ppm. This signal corresponds to the imine N-H proton resonance of the hydrazone form. These results are in agreement with the data obtained for hydrazone form with N-H peaks in the range of δ 15.1–15.6 ppm [23]. The tautomerism is shown in Scheme 2. The triplet-quartet pair around δ 1.09 (t, J=7.4Hz, 3H, CH₃) and

δ 3.95 (q, $J=7.4\text{Hz}$, 2H, CH_2) correspond to ethyl group. The ^{13}C -NMR spectral data of all the dyes are summarized in Table 2, which are also good union with their structures.



Analysis of FT-IR

The FT-IR spectra of all the dyes shows two absorption bands at 1360, 1536 cm^{-1} indicates the presence of $-\text{NO}_2$ group. Also all the spectra exhibited a broad N-H hydrazone band in the region 3434–3457 cm^{-1} which suggests that these compounds dominantly exist in the solid state in the hydrazone tautomeric form which was also confirmed by ^1H -NMR. The infrared spectra of all synthesized dyes showed two intense carbonyl bands at about 1648 and 1690 cm^{-1} , which were assigned to the diketohydrazone form. The other ν_{max} values at 3095–3044 cm^{-1} (aromatic CH) and 2973–2915 cm^{-1} (aliphatic CH) were also recorded.

Mass spectra

Besides, the structure of the compound was well confirmed by its mass spectral studies. Mass spectra of compound 4a, 4h, 5c and 5j gave molecular ion peak at m/z 535 ($M+1$), m/z 643 ($M+1$), m/z 555 ($M+1$) and m/z 615 ($M+1$) corresponding to molecular formula $\text{C}_{22}\text{H}_{17}\text{N}_9\text{O}_4\text{S}_2$, $\text{C}_{26}\text{H}_{17}\text{N}_{11}\text{O}_6\text{S}_2$, $\text{C}_{21}\text{H}_{14}\text{ClN}_9\text{O}_4\text{S}_2$ and $\text{C}_{26}\text{H}_{18}\text{ClN}_{11}\text{O}_4\text{S}$ respectively. The elemental analysis are also good agreement with structure data, presented in Table 1.

Visible absorption spectra

The visible absorption spectra of all the synthesized compounds were recorded in different solvent system such as DMF, Methanol, Acetone and Chloroform and their data are shown in Table 3. The solvatochromic properties of these dyes were systematically investigated in different solvents with different polarities [24].

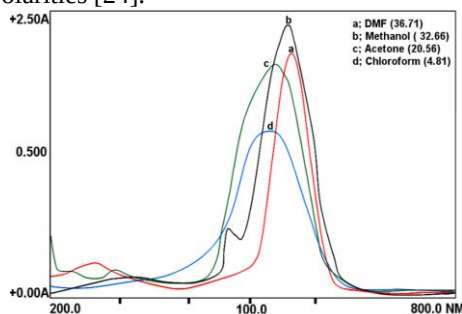


Figure. 1 UV overlap of 4d in various solvents

The visible absorption maxima of these dyes are very clearly depend on the polarities of solvents and increase with increase in polarities of solvents in the order: Chloroform < Acetone < Methanol < DMF. The influences on the visible absorption maxima of dyes 4a-l and 5a-l by substituent at the ring position of coupling components have been evaluated. As shown in Table 3, it was found that substituent such as the ethyl group at the 1-position of pyridone ring had only a slight influence on the absorption maxima. The absorption maxima of dyes 4a-l show good bathochromic shift in compared to dyes 5a-l. Replacement of DMF by solvents of lower polarities which are

methanol (32.60), acetone (20.56) and chloroform (4.18) [25], led to a hypsochromic shift of absorption maxima.

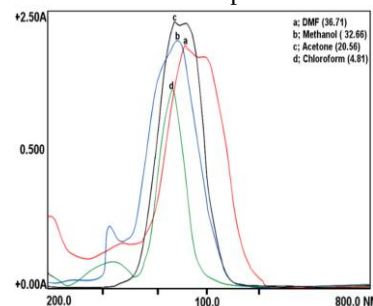


Figure 2 UV overlap of 5i in various solvents

In methanol solvent system the hydrogen bonding may be possible with dye molecules but from results as shown in Table 3 we can see that there is no significant effect of H-bonding on the electronic spectra. The $\Delta\lambda_{\text{max}}$ values of these dyes shifted in the range of 10 to 48 nm in solvents with different polarities. The effect of substitution on the phenyl ring of the diazo component and also effect of heterocyclic ring of the another diazo component as well as two azo group of coupling component on the visible absorption spectrum and the color intensity was also investigated. The wavelength of maximum absorption, (λ_{max}) of the dyes ranges from 434 to 523 nm in chloroform. Change in λ_{max} value can be brought about by varying the substituent in the phenyl ring and heterocyclic ring of diazo components. As expected, the incorporation of an electron withdrawing group at any carbon of the phenyl diazo component moiety was found to give rise in bathochromic shift.

Thus, the introduction of another azo group resulted in a shift of λ_{max} to longer wavelength. As expected from magnitude of the appropriate field and resonance components of the substituent effect [26,27], other dyes followed a similar pattern. Introduction of azo group at the 5-position of thiazole with strong electron withdrawing group provided much more bathochromic effect; thus the most bathochromic dyes were prepared. Introduction of another azo group also introduce one more heterocyclic ring which is also responsible for good bathochromic shift because heterocyclic ring contain hetero atom such as S and N. The strong electron attracting capacity of the heterocyclic residue result in the large bathochromic shift and the increase λ_{max} in these dyes, which are indicative of delocalization within an electron rich π - system. In order to bring about a bathochromic shift, a negative group strategically placed in the diazo compound which allows a greater electronic displacement is necessary. It has been suggested [28] that the increased diene character of the ring may be responsible for the large colour shifts observed. The bathochromicity of heterocyclic dyes is not attributable to a contribution of the 3d atomic orbitals of the heteroatom of the heterocyclic ring [29]. The dyes no. 4c, 4d, 4h, 4j have two $-\text{NO}_2$ group which is strongly electro withdrawing group and it shows most bathochromic shift. Dyes no. 5c, 5d, 5h, 5j have one $-\text{NO}_2$ group and one $-\text{Cl}$ group and both are electro withdrawing group so these dyes also shows good bathochromicity in compared to dyes no. (4-5)a, (4-5)b, (4-5)e, (4-5)i, (4-5)k, (4-5)l. Dyes (4-5)f are also shows good bathochromic shift because two $-\text{Cl}$ group are present. In addition dyes (4-5)g have one $-\text{Cl}$ group and one $-\text{Br}$ group and both are highly electro withdrawing group so it cause good bathochromic shift. So we can say that in order to bring bathochromic shift, electro withdrawing group is

strategically to be placed in diazo compound which allows a greater electronic displacement.

Dyeing characterization on polyester fabric

For some time an effort has been made to replace certain anthraquinone disperse dyes by new dyes often derived from heteroaryl compounds to improve the properties. Useful dyes in this respect are derived from 2-aminothiazole, 2-amino-1,3,4-thiadiazole and 2-aminotriazole as diazonium components and pyridone as coupling components. Thus tris(heteroaryl) bisazo dyes 4a-l and 5a-l were synthesized to assess their dyeing properties and performance. All these dyes were used for dyeing polyester fabric at 2% (w/w) shades as dispersed dyes. Their dyeing properties are summarized in Table 4 that shows wide range of shades varying from Yellowish orange to Maroon to Brown with excellent brightness, levelness and depth of fabric. Variation in the shades of the dyed fabric results from both the nature and position of the substituent present on the diazo component. The dyed fabrics have well to excellent sublimation fastness. A remarkable degree of levelness and brightness after washing indicates good penetration and excellent affinity of these dyes to the fabric.

Colour properties of the dyes on polyester fabric

The dyes when applied to polyester fabric under high temperature dyeing condition furnished Yellowish orange to Maroon to Brown shades. There appears to be general correlation between the hues of dyeing on polyester with the absorption characteristics in solution. Dyeing on the fabric is also affected by substitution of phenyl ring of diazo component. In contrast to negligible effect of 4-substituents on color than azo group with substituted phenyl ring at 5-position of thiazole ring. In these dyes there are two azo groups present with strongly electron withdrawing and a polar group. So, it shows deep Yellow to Maroon to Brown shades.

Fastness properties of the dyed polyester fabric

The fastness ratings are summarized in Table 4. In general they are good to excellent for fabrics which had been subjected to the reduction clearing stage. However when the reduction clearing was omitted, marginally worse staining was observed. This indicates that reduction clearing is important for these dyeing. As these dyes are characteristically hydroscopic and high fastness ratings. The dyes bearing nitro function, either in the diazo or coupling component, also displayed marginally fastness. Although in all the cases light fastness was good as shown in Table 4, the light fastness of the dyes on polyester fabric is significantly affected by the nature of the substituents in the diazonium components which are contain strongly electron withdrawing (nitro, bromo or chloro) and highly polar group were marginally superior to the other, again emphasizing the importance of appropriate substituents. In most cases, the best light fastness was obtained by the dyes containing a nitro group in the diazonium component. The nitro group increases the polarity of the dyes which may link them more strongly to the fabric and it opens an extra way for the energy dissipation after light absorption which decreases the chance for photobleaching. Attempts are in hand to improve the light fastness properties of these dyes. Dry heat fastness property was determined and is as shown in Table 4; generally fastness to heat was moderate to good, consistent with the presence of polar groups on the chromophores. Only a few of these dyes have moderate to poor rubbing fastness (dry and wet) and this may be attributed to inadequate diffusion of the dye molecules into the

fabric. Same thing was observed in rubbing fastness which is shown in Table 4.

Conclusion

This article describe the synthesis of some novel tris(heterocyclic) based bisazo disperse dyes by using various heteroaryl amines as diazo components and 2-azopyridone-4-phenyl thiazole as coupling component. The solvatochromic behavior and substituent effect in various solvents were evaluated. The results indicated that these dyes were strongly dependent on solvents and show generally bathochromic shifts as the polarity of solvents were increased. The washing fastness property is good whereas the light fastness property is also considerable due to incorporation of electron withdrawing substituent, to be a correlation between the color strength of the dyes in solution and on polyester fabric.

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Table 1 Physiochemical parameters for dye derivatives 4a-l, 5a-l

Comp.	M.P (°C)	Yield (%)	Molecular Formula	Mole. Weight	Elemental Analysis. Found (Calc.)			
					C (%)	H (%)	N (%)	S (%)
3a	212-214	72	C18H14N6O4S	410.41	52.68(52.64)	3.44(3.45)	20.48(20.49)	7.81(7.83)
3b	209-211	76	C18H14ClN5O2S	399.85	54.07(54.09)	3.53(3.55)	17.51(17.53)	8.02(8.05)
4a	221-222	68	C22H17N9O4S2	535.56	49.34(49.36)	3.20(3.21)	23.54(23.56)	11.97(11.98)
4b	208-209	72	C25H21N9O6S2	607.62	49.42(49.41)	3.48(3.47)	20.75(20.76)	10.55(10.56)
4c	211-213	76	C21H14N10O6S2	566.53	44.52(44.50)	2.49(2.48)	24.72(24.73)	11.32(11.33)
4d	218-219	69	C27H18N10O6S2	642.63	50.46(50.48)	2.82(2.83)	21.80(21.82)	9.98(9.97)
4e	234-235	71	C20H14N10O4S2	522.52	45.97(45.95)	2.70(2.72)	26.81(26.84)	12.27(12.28)
4f	237-238	68	C20H13BrN10O4S2	601.42	39.94(39.95)	2.18(2.19)	23.29(23.30)	10.66(10.67)
4g	236-238	70	C20H13ClN10O4S2	556.03	43.13(43.15)	2.35(2.36)	25.15(25.17)	11.51(11.53)
4h	241-243	65	C26H17N11O6S2	643.08	48.52(48.53)	2.66(2.69)	23.94(23.95)	9.96(9.95)
4i	223-225	78	C20H15N11O4S	505.47	47.52(47.53)	2.99(2.98)	30.48(30.49)	6.34(6.35)
4j	227-228	75	C26H18N12O6S	626.56	49.84(49.86)	2.90(2.92)	26.83(26.85)	5.13(5.13)
4k	232-233	72	C20H15N11O4S2	537.53	44.69(44.67)	2.81(2.82)	28.66(28.67)	11.93(11.94)
4l	229-232	67	C21H17N11O4S2	551.56	45.73(45.71)	3.11(3.12)	27.93(27.94)	11.63(11.65)
5a	243-245	65	C22H17ClN8O2S2	525.01	50.33(50.31)	3.26(3.27)	21.34(21.35)	12.22(12.23)
5b	241-244	72	C25H21ClN8O4S2	597.07	50.29(50.30)	3.55(3.56)	18.77(18.76)	10.74(10.76)
5c	251-252	72	C21H14ClN9O4S2	555.98	45.37(45.38)	2.54(2.56)	22.67(22.68)	11.53(11.51)
5d	249-252	69	C27H18ClN9O4S2	632.07	51.31(51.32)	2.87(2.88)	19.94(19.93)	10.15(10.17)
5e	247-248	74	C20H14ClN9O2S2	511.97	46.92(46.93)	2.76(2.78)	24.62(24.63)	12.53(12.56)
5f	253-255	73	C20H13BrClN9O2S2	590.86	40.65(40.66)	2.22(2.25)	21.33(21.35)	10.85(10.86)
5g	244-248	77	C20H13Cl2N9O2S2	546.41	43.96(43.98)	2.40(2.43)	23.07(23.09)	11.74(11.73)
5h	254-256	73	C26H17ClN10O4S2	633.06	49.33(49.35)	2.71(2.73)	22.13(22.15)	10.13(10.14)
5i	248-249	65	C20H15ClN10O2S	494.92	48.54(48.56)	3.05(3.03)	28.30(28.32)	6.48(6.49)
5j	257-258	71	C26H18ClN11O4S	616.01	50.69(50.68)	2.95(2.97)	25.01(25.03)	5.21(5.23)
5k	252-253	66	C20H15ClN10O2S2	526.98	45.58(45.59)	2.87(2.88)	26.58(26.60)	12.17(12.19)
5l	255-257	70	C21H17ClN10O2S2	541.01	46.62(46.63)	3.17(3.72)	25.89(25.87)	11.85(11.87)

Table 2 ¹H-NMR, ¹³C-NMR and IR spectral data of synthesized dye molecules

Comp.	¹ H NMR : δ (ppm)	¹³ C NMR : δ (ppm)	IR (KBr) : ν cm ⁻¹
3a	1.11 (t, J = 7.2 Hz, 3H, CH ₃), 2.52 (s, 3H, CH ₃), 3.79 (q, J = 7.2 Hz, 2H, CH ₂), 6.10 (s, 1H, thiazol), 7.58 (d, J = 8.6 Hz, 2H, Ar-H), 7.87 (d, J = 8.6 Hz, 2H, Ar-H), 15.13 (1H, s, N-H hydrazone)	12.37, 16.42, 36.08, 111.20, 117.46, 120.72, 128.78, 128.89, 129.32, 137.24, 146.83, 147.00, 147.36, 155.47, 154.28, 158.40, 161.43, 166.07	1364 [NO ₂ sym. Str.], 1528 [NO ₂ asym. Str.], 1619 [C=C], 2217 [CN], 1652, 1682 [CO], 3441 [NH, hydrazo], 1621 [N ₂]
3b	1.13 (t, J = 7.2 Hz, 3H, CH ₃), 2.48 (s, 3H, CH ₃), 3.74 (q, J = 7.2 Hz, 2H, CH ₂), 6.12 (s, 1H, thiazol), 7.27 (d, J = 8.6 Hz, 2H, Ar-H), 7.49 (d, J = 8.6 Hz, 2H, Ar-H), 15.07 (1H, s, N-H hydrazone)	12.67, 17.32, 37.18, 112.04, 117.40, 120.79, 128.92, 129.10, 129.46, 137.62, 146.97, 147.15, 147.28, 155.53, 154.24, 158.44, 161.51, 166.15	1617 [C=C], 2221 [CN], 1650, 1676 [CO], 3452 [NH, hydrazo], 1611 [N ₂]
4a	1.09 (t, J = 7.4 Hz, 3H, CH ₃), 2.44 (s, 3H, CH ₃), 2.56 (s, 3H, CH ₃), 3.95 (q, J = 7.4 Hz, 2H, CH ₂), 6.10 (s, 1H, thiazol), 7.84 (d, J = 9.0 Hz, 2H, Ar-H), 8.32 (d, J = 9.0 Hz, 2H, Ar-H), 15.13 (1H, s, N-H hydrazone)	10.84, 13.23, 16.80, 35.86, 106.26, 115.62, 118.70, 124.72, 126.86, 128.47, 138.42, 139.46, 146.83, 147.23, 147.52, 154.52, 156.42, 158.08, 160.27, 165.00	1358 [NO ₂ sym. Str.], 1534 [NO ₂ asym. Str.], 1612 [C=C], 2213 [CN], 1648, 1689 [CO], 3447 [NH, hydrazo], 1638 [N ₂]
4b	1.12 (t, J = 7.4 Hz, 3H, CH ₃), 1.35 (t, J = 8 Hz, 3H, CH ₃), 2.46 (s, 3H, CH ₃), 2.58 (s, 3H, CH ₃), 3.97 (q, J = 7.4 Hz, 2H, CH ₂), 4.27 (q, J = 8 Hz, 2H, CH ₂), 7.86 (d, J = 9.0 Hz, 2H, Ar-H), 8.30 (d, J = 9.0 Hz, 2H, Ar-H), 15.16 (1H, s, N-H hydrazone)	10.80, 13.28, 14.62, 16.92, 35.79, 38.42, 106.20, 115.74, 118.78, 124.70, 126.84, 128.45, 138.44, 139.48, 146.86, 147.27, 147.54, 154.50, 156.45, 158.12, 160.30, 165.23	1361 [NO ₂ sym. Str.], 1535 [NO ₂ asym. Str.], 1616 [C=C], 2217 [CN], 1652, 1693 [CO], 1726 [CO, ester], 3449 [NH, hydrazo], 1646 [N ₂]
4c	1.10 (t, J = 7.4 Hz, 3H, CH ₃), 2.59 (s, 3H, CH ₃), 3.96 (q, J = 7.4 Hz, 2H, CH ₂), 6.12 (s, 1H, thiazol), 7.87 (d, J = 9.0 Hz, 2H, Ar-H), 8.29 (d, J = 9.0 Hz, 2H, Ar-H), 15.15 (1H, s, N-H hydrazone)	10.78, 13.18, 35.91, 106.30, 115.60, 118.72, 124.76, 126.78, 128.49, 138.45, 139.49, 145.83, 146.98, 147.68, 154.08, 156.34, 158.12, 160.32, 166.48	1367 [NO ₂ sym. Str.], 1539 [NO ₂ asym. Str.], 1614 [C=C], 2215 [CN], 1656, 1685 [CO], 3452 [NH, hydrazo], 1640 [N ₂]
4d	1.08 (t, J = 7.4 Hz, 3H, CH ₃), 2.60 (s, 3H, CH ₃), 3.98 (q, J = 7.4 Hz, 2H, CH ₂), 6.10 (s, 1H, thiazol), 7.88 (d, J = 9.0 Hz, 4H, Ar-H), 8.33 (d, J = 9.0 Hz, 4H, Ar-H), 15.17 (1H, s, N-H hydrazone)	10.72, 13.17, 36.12, 106.02, 115.40, 118.62, 124.82, 125.84, 126.47, 127.09, 128.66, 132.42, 138.58, 139.61, 147.05, 147.36, 147.68, 154.27, 156.24, 158.13, 160.42, 167.07	1358 [NO ₂ sym. Str.], 1530 [NO ₂ asym. Str.], 1617 [C=C], 2212 [CN], 1650, 1687 [CO], 3450 [NH, hydrazo], 1648 [N ₂]
4e	1.12 (t, J = 7.4 Hz, 3H, CH ₃), 2.54 (s, 3H, CH ₃), 3.95 (q, J = 7.4 Hz, 2H, CH ₂), 6.13 (s, 1H, thiazol), 7.84 (d, J = 9.0 Hz, 2H, Ar-H), 8.31 (d, J = 9.0 Hz, 2H, Ar-H), 15.14 (1H, s, N-H hydrazone)	11.23, 13.83, 36.14, 106.78, 114.82, 118.06, 125.42, 127.06, 128.04, 140.37, 146.46, 147.62, 147.15, 154.24, 156.72, 158.56, 160.82, 164.93	1364 [NO ₂ sym. Str.], 1536 [NO ₂ asym. Str.], 1608 [C=C], 2211 [CN], 1658, 1694 [CO], 3443 [NH, hydrazo], 1644 [N ₂]
4f	(DMSO) : δ 1.10 (t, J = 7.4 Hz, 3H, CH ₃), 2.61 (s, 3H, CH ₃), 3.97 (q, J = 7.4 Hz, 2H, CH ₂), 7.89 (d, J = 9.0 Hz, 2H, Ar-H), 8.27 (d, J = 9.0 Hz, 2H, Ar-H), 15.18 (1H, s, N-H hydrazone)	10.96, 15.20, 17.18, 35.41, 106.68, 115.50, 118.36, 124.52, 127.16, 128.82, 142.84, 145.82, 147.90, 147.06, 154.72, 156.74, 158.63, 160.72, 165.65	1075 [C-Br], 1357 [NO ₂ sym. Str.], 1539 [NO ₂ asym. Str.], 2220 [CN], 1646, 1683 [CO], 3442 [NH, hydrazo], 1636 [N ₂]
4g	1.12 (t, J = 7.4 Hz, 3H, CH ₃), 2.57 (s, 3H, CH ₃), 3.93 (q, J = 7.4 Hz, 2H, CH ₂), 7.85 (d, J = 9.0 Hz, 2H, Ar-H), 8.32 (d, J = 9.0 Hz, 2H, Ar-H), 15.17 (1H, s, N-H hydrazone)	11.23, 13.57, 35.70, 107.32, 114.84, 118.37, 124.92, 126.45, 128.64, 142.52, 145.80, 146.76, 147.26, 154.47, 157.29, 158.40, 160.72, 166.73	1086 [C-Cl], 1363 [NO ₂ sym.], 1538 [NO ₂ asym.], 1617 [C=C], 2216 [CN], 1652, 1687 [CO], 3440 [NH, hydrazo], 1642 [N ₂]
4h	1.13 (t, J = 7.4 Hz, 3H, CH ₃), 2.60 (s, 3H, CH ₃), 3.94 (q, J = 7.4 Hz, 2H, CH ₂), 7.87 (d, J = 9.0 Hz, 4H, Ar-H), 8.30 (d, J = 9.0 Hz, 4H, Ar-H), 15.15 (1H, s, N-H hydrazone)	10.70, 13.32, 36.62, 106.64, 115.72, 118.07, 124.26, 125.24, 126.73, 127.38, 128.68, 132.60, 143.27, 146.78, 147.62, 147.46, 154.35, 156.50, 158.72, 160.50, 167.14	1354 [NO ₂ sym. Str.], 1535 [NO ₂ asym. Str.], 1613 [C=C], 2217 [CN], 1642, 1687 [CO], 3446 [NH, hydrazo], 1637 [N ₂]
4i	1.09 (t, J = 7.4 Hz, 3H, CH ₃), 2.58 (s, 3H, CH ₃), 3.96 (q, J = 7.4 Hz, 2H, CH ₂), 6.77 (d, 1H, triazol), 7.86 (d, J = 9.0 Hz, 2H, Ar-H), 8.30 (d, J = 9.0 Hz, 2H, Ar-H), 12.34 (d, J = 4.6 Hz, 1H, NH triazol), 15.16 (1H, s, N-H hydrazone)	10.90, 13.57, 35.67, 106.48, 115.78, 118.82, 123.43, 126.94, 128.52, 139.37, 146.74, 147.34, 147.60, 154.05, 156.61, 158.24, 160.52, 166.24	1360 [NO ₂ sym. Str.], 1539 [NO ₂ asym. Str.], 1612 [C=C], 2220 [CN], 1638, 1686 [CO], 3439 [NH, hydrazo], 1646 [N ₂]
4j	1.11 (t, J = 7.4 Hz, 3H, CH ₃), 2.56 (s, 3H, CH ₃), 3.99 (q, J = 7.4 Hz, 2H, CH ₂), 7.84 (d, J = 9.0 Hz, 4H, Ar-H), 8.32 (d, J = 9.0 Hz, 4H, Ar-H), 12.30 (d, J = 4.6 Hz, 1H, NH triazol), 15.17 (1H, s, N-H hydrazone)	10.92, 13.12, 16.74, 35.84, 108.17, 115.25, 118.60, 123.84, 126.62, 127.72, 128.78, 131.57, 136.60, 138.28, 142.70, 146.38, 147.68, 147.34, 154.30, 156.63, 158.40, 160.62, 165.48	1356 [NO ₂ sym. Str.], 1534 [NO ₂ asym. Str.], 1607 [C=C], 2212 [CN], 1645, 1682 [CO], 3440 [NH, hydrazo], 1637 [N ₂]
4k	1.12 (t, J = 7.4 Hz, 3H, CH ₃), 2.54 (s, 3H, CH ₃), 3.97 (q, J = 7.4 Hz, 2H, CH ₂), 4.46 (s, H, SH), 7.87 (d, J = 9.0 Hz, 2H, Ar-H), 8.29 (d, J = 9.0 Hz, 2H, Ar-H), 12.34 (d, J = 4.6 Hz, 1H, NH triazol), 15.13 (1H, s, N-H hydrazone)	10.78, 13.48, 35.70, 106.62, 115.82, 118.43, 124.24, 126.59, 128.49, 142.44, 145.73, 146.57, 147.60, 154.42, 156.56, 158.82, 160.63, 166.05	1362 [NO ₂ sym. Str.], 1537 [NO ₂ asym. Str.], 1614 [C=C], 2218 [CN], 2568 [SH], 1646, 1690 [CO], 3447 [NH, hydrazo], 1642 [N ₂]

4l	1.10 (t, $J=7.4\text{Hz}$, 3H, CH ₃), 2.57 (s, 3H,CH ₃), 3.98 (q, $J=7.4\text{Hz}$, 2H, CH ₂), 2.72 (s, 3H,SCH ₃), 7.84 (d, $J=9.0\text{Hz}$, 2H, Ar-H), 8.28 (d, $J=9.0\text{Hz}$, 2H, Ar-H), 12.35 (d, $J=4.6\text{Hz}$, 1H, NH riazol), 15.13 (1H, s, N-H hydrazone)	12.02, 14.17, 36.53, 42.28, 106.49, 115.62, 118.37, 124.56, 126.50, 128.48, 143.29, 147.69, 147.73, 154.44, 156.57, 158.40, 160.63, 167.43	1356 [NO ₂ sym. Str.], 1539 [NO ₂ asym. Str.], 1615 [C=C], 2219 [CN], 2872 [S-CH ₃] 1653, 1694 [CO], 3443 [NH, hydrazo], 1647 [N ₂]
5a	1.11 (t, $J=7.4\text{Hz}$, 3H, CH ₃), 2.45 (s, 3H,CH ₃), 2.56 (s, 3H, CH ₃), 3.94 (q, $J=7.4\text{Hz}$, 2H, CH ₂), 6.09 (s, 1H, thiazol), 7.80 (d, $J=9.0\text{Hz}$, 2H, Ar-H), 8.26 (d, $J=9.0\text{ Hz}$, 2H, Ar-H), 15.15 (1H, s, N-H hydrazone)	10.76, 13.26, 16.81, 35.86, 106.22, 115.60, 118.64, 124.77, 126.92, 128.52, 138.26, 139.40, 146.76, 147.17, 147.46, 154.56, 156.48, 158.12, 160.22, 165.00	1082 [C-Cl], 1609 [C=C], 2219 [CN], 1642, 1689 [CO], 3442 [NH, hydrazo], 1639 [N ₂]
5b	1.10 (t, $J=7.4\text{Hz}$, 3H, CH ₃), 1.36 (t, $J=8\text{Hz}$, 3H, CH ₃), 2.45 (s, 3H, CH ₃), 2.57 (s, 3H,CH ₃), 3.97 (q, $J=7.4\text{Hz}$, 2H, CH ₂), 4.28 (q, $J=8\text{Hz}$, 2H, CH ₂), 7.79 (d, $J=9.0\text{Hz}$, 2H, Ar-H), 8.24 (d, $J=9.0\text{ Hz}$, 2H, Ar-H), 15.17 (1H, s, N-H hydrazone)	10.85, 13.23, 14.60, 16.98, 35.72, 38.48, 106.28, 115.78, 118.72, 124.63, 126.75, 128.40, 138.41, 139.42, 146.74, 147.21, 147.43, 154.58, 156.43, 158.18, 160.38, 165.20	1083 [C-Cl], 1615 [C=C], 2218 [CN], 1639, 1687 [CO], 1722 [CO, ester] 3448 [NH, hydrazo], 1643 [N ₂],
5c	1.12 (t, $J=7.4\text{Hz}$, 3H, CH ₃), 2.58 (s, 3H,CH ₃), 3.94 (q, $J=7.4\text{Hz}$, 2H, CH ₂), 6.10 (s, 1H,thiazol), 7.82 (d, $J=9.0\text{Hz}$, 2H, Ar-H), 8.24 (d, $J=9.0\text{Hz}$, 2H, Ar-H), 15.15 (1H, s, N-H hydrazone)	10.48, 13.22, 35.92, 106.37, 115.66, 118.64, 124.72, 126.74, 128.43, 138.41, 139.43, 145.80, 146.69, 147.69, 154.13, 156.37, 158.18, 160.32, 166.42	1086 [C-Cl], 1364 [NO ₂ sym. Str.], 1542 [NO ₂ asym. Str.], 1611 [C=C], 2213 [CN], 1650, 1686 [CO], 3450 [NH, ydrazo], 1642 [N ₂]
5d	1.10 (t, $J=7.4\text{Hz}$, 3H, CH ₃), 2.59 (s, 3H,CH ₃), 3.97 (q, $J=7.4\text{Hz}$, 2H, CH ₂), 6.09 (s, 1H,thiazol), 7.83 (d, $J=9.0\text{Hz}$, 4H, Ar-H), 8.26 (d, $J=9.0\text{Hz}$, 4H, Ar-H), 15.13 (1H, s, N-H hydrazone)	10.78, 13.20, 36.23, 106.13, 115.36, 118.49, 124.76, 125.79, 126.42, 127.11, 128.69, 132.47, 138.51, 139.66, 147.09, 147.32, 147.62, 154.32, 156.28, 158.21, 160.52, 167.13	1081 [C-Cl], 1359 [NO ₂ sym. Str.], 1532 [NO ₂ asym. Str.], 1619 [C=C], 2212 [CN], 1646, 1696 [CO], 3446 [NH, hydrazo], 1644 [N ₂],
5e	1.13 (t, $J=7.4\text{Hz}$, 3H, CH ₃), 2.55 (s, 3H,CH ₃), 3.95 (q, $J=7.4\text{Hz}$, 2H, CH ₂), 6.11 (s, 1H,thiazol), 7.80 (d, $J=9.0\text{Hz}$, 2H, Ar-H), 8.22 (d, $J=9.0\text{Hz}$, 2H, Ar-H), 15.13 (1H, s, N-H hydrazone)	11.34, 13.75, 36.18, 106.77, 114.74, 118.20, 125.48, 127.16, 128.12, 140.33, 146.42, 147.67, 147.21, 154.18, 156.67, 158.48, 160.73, 164.90	1084 [C-Cl], 1612 [C=C], 2213 [CN], 1637, 1685 [CO], 3439 [NH, hydrazo], 1642 [N ₂]
5f	1.10 (t, $J=7.4\text{Hz}$, 3H, CH ₃), 2.59 (s, 3H,CH ₃), 3.94 (q, $J=7.4\text{Hz}$, 2H, CH ₂), 7.83 (d, $J=9.0\text{Hz}$, 2H, Ar-H), 8.20 (d, $J=9.0\text{ Hz}$, 2H, Ar-H), 15.16 (1H, s, N-H hydrazone)	10.86, 15.14, 17.12, 35.45, 106.57, 115.62, 118.38, 124.54, 127.34, 128.92, 142.80, 145.76, 147.79, 147.23, 154.57, 156.64, 158.46, 160.47, 165.73	1087 [C-Cl], 2217 [CN], 1642, 1686 [CO], 3440 [NH,hydrazo], 1638 [N ₂]
5g	1.09 (t, $J=7.4\text{Hz}$, 3H, CH ₃), 2.56 (s, 3H,CH ₃), 3.91 (q, $J=7.4\text{Hz}$, 2H, CH ₂), 7.79 (d, $J=9.0\text{Hz}$, 2H, Ar-H), 8.24 (d, $J=9.0\text{ Hz}$, 2H, Ar-H), 15.19 (1H, s, N-H hydrazone)	11.14, 13.42, 35.56, 107.23, 114.74, 118.30, 124.76, 126.42, 128.60, 142.22, 145.53, 146.82, 147.34, 154.54, 157.32, 158.47, 160.63, 166.78	1082 [C-Cl], 1619 [C=C], 2214 [CN], 1651, 1691 [CO], 3439 [NH, hydrazo], 1643 [N ₂],
5h	1.12 (t, $J=7.4\text{Hz}$, 3H, CH ₃), 2.61 (s, 3H,CH ₃), 3.92 (q, $J=7.4\text{Hz}$, 2H, CH ₂), 7.82 (d, $J=9.0\text{Hz}$, 4H, Ar-H), 8.19 (d, $J=9.0\text{ Hz}$, 4H, Ar-H), 15.15 (1H, s, N-H hydrazone)	10.76, 13.45, 36.68, 106.72, 115.82, 118.12, 124.57, 125.18, 126.65, 128.60, 132.58, 143.30, 146.72, 147.72, 147.50, 154.39, 156.57, 158.76, 160.42, 167.26	1086 [C-Cl], 1354 [NO ₂ sym. Str.], 1535 [NO ₂ asym. Str.], 1613 [C=C], 2217 [CN], 1649, 1694 [CO], 3446 [NH, ydrazo], 1637 [N ₂]
5i	1.08 (t, $J=7.4\text{Hz}$, 3H, CH ₃), 2.59 (s, 3H,CH ₃), 3.94 (q, $J=7.4\text{Hz}$, 2H, CH ₂), 6.77 (d, 1H, triazol), 7.86 (d, $J=9.0\text{Hz}$, 2H, Ar-H), 8.30 (d, $J=9.0\text{ Hz}$, 2H, Ar-H), 12.34 (d, $J=4.6\text{Hz}$, 1H, NH triazol), 15.16 (1H, s, N-H hydrazone)	10.93, 13.60, 35.69, 106.52, 115.72, 118.80, 123.47, 126.86, 128.42, 139.30, 146.67, 147.28, 147.52, 154.12, 156.46, 158.42, 160.38, 166.47	1080 [C-Cl], 1614 [C=C], 2221 [CN], 1639, 1686 [CO], 3442 [NH, hydrazo], 1648 [N ₂],
5j	1.10 (t, $J=7.4\text{Hz}$, 3H, CH ₃), 2.56 (s, 3H,CH ₃), 3.97 (q, $J=7.4\text{Hz}$, 2H, CH ₂), 7.78 (d, $J=9.0\text{Hz}$, 4H, Ar-H), 8.26 (d, $J=9.0\text{ Hz}$, 4H, Ar-H), 12.28 (d, $J=4.6\text{Hz}$, 1H, NH triazol), 15.19 (1H, s, N-H hydrazone)	10.87, 13.34, 16.78, 35.90, 108.34, 115.38, 118.57, 123.92, 126.38, 127.67, 128.54, 131.50, 136.56, 138.24, 142.67, 146.35, 147.70, 147.37, 154.34, 156.67, 158.60, 160.54, 165.62	1084 [C-Cl], 1352 [NO ₂ sym. Str.], 1532 [NO ₂ asym. Str.], 1609 [C=C], 2215 [CN], 1647, 1693 [CO], 3444 [NH, ydrazo], 1640 [N ₂]
5k	1.09 (t, $J=7.4\text{Hz}$, 3H, CH ₃), 2.56 (s, 3H,CH ₃), 3.96 (q, $J=7.4\text{Hz}$, 2H, CH ₂), 4.43 (s, H, SH), 7.80 (d, $J=9.0\text{Hz}$, 2H, Ar-H), 8.23 (d, $J=9.0\text{ Hz}$, 2H, Ar-H), 12.30 (d, $J=4.6\text{Hz}$, 1H, NH triazol), 15.16 (1H, s, N-H hydrazone)	10.73, 13.43, 35.75, 106.56, 115.80, 118.46, 124.27, 126.57, 128.45, 142.42, 145.75, 146.59, 147.65, 154.38, 156.50, 158.68, 160.60, 166.07	1086 [C-Cl], 1610 [C=C], 2214 [CN], 2564 [SH], 1637, 1687 [CO], 3449 [NH, hydrazo], 1643 [N ₂]
5l	1.11 (t, $J=7.4\text{Hz}$, 3H, CH ₃), 2.59 (s, 3H,CH ₃), 3.94 (q, $J=7.4\text{Hz}$, 2H, CH ₂), 2.70 (s, 3H,SCH ₃), 7.77 (d, $J=9.0\text{Hz}$, 2H, Ar-H), 8.21 (d, $J=9.0\text{Hz}$, 2H, Ar-H), 12.26 (d, $J=4.6\text{Hz}$, 1H, NH riazol), 15.14 (1H, s, N-H hydrazone)	12.05, 14.19, 36.55, 42.30, 106.52, 115.67, 118.34, 124.57, 126.53, 128.46, 143.27, 147.65, 147.75, 154.40, 156.54, 158.44, 160.60, 167.39	1080 [C-Cl], 1616 [C=C], 2217 [CN], 2874 [S-CH ₃] 1640, 1691 [CO], 3440 [NH, hydrazo], 1649 [N ₂]

Table 3 Visible absorption spectra and spectra shifts in various solvents for dyes 4a-l, 5a-l

Dyes	Color on polyester	DMF(36.71) λ_{max}	MeOH (32.66)		Acetone(20.56)		Chloroform(4.81)	
			λ_{max}	$\Delta\lambda_{\text{max}}$	λ_{max}	$\Delta\lambda_{\text{max}}$	λ_{max}	$\Delta\lambda_{\text{max}}$
4a	Red	487	473	19	467	25	455	37
4b	Bright Red	492	469	18	462	25	453	39
4c	Brown	563	545	18	523	40	515	48
4d	Dark Brown	568	554	14	530	38	523	45
4e	Dark Orange	476	464	12	457	19	453	23
4f	Reddish Violet	498	479	19	471	27	461	37
4g	Violet	502	485	17	479	23	465	37
4h	Dark Maroon	538	520	18	509	29	500	38
4i	Orange	469	451	18	447	22	443	26
4j	Maroon	518	493	25	484	34	478	40
4k	Reddish Orange	482	466	16	459	23	449	33
4l	Orange	472	458	14	452	20	446	26
5a	Light Red	479	467	12	462	17	457	22
5b	Red	487	463	24	458	29	452	35
5c	Light Brown	551	541	10	517	34	503	48
5d	Brown	556	545	11	520	36	510	46
5e	Orange	469	458	11	450	19	438	31
5f	Red	487	474	13	467	20	455	32
5g	Reddish Violet	496	477	19	470	26	456	40
5h	Dark Maroon	528	511	17	504	24	494	34
5i	Yellowish Orange	460	442	18	437	23	430	30
5j	Light Maroon	507	481	26	472	35	461	46
5k	Orange	474	460	14	454	20	442	32
5l	Orange	467	451	16	442	25	434	33

Table 4 Fastness Properties of the Dyes derivatives 4a-l, 5a-l

Dye	Washing	Perspiration		Rubbing		Sublimation Fastness			Light (40h)
		Acid	Alkali	Dry	Wet	Change in tone	Staining 180°C	Staining 210°C	
4a	4-5	4	4-5	4-5	4-5	4-5	4-5	3-4	4-5
4b	4-5	4-5	4-5	4-5	4-5	4	4	4-5	4-5
4c	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	5
4d	4-5	4-5	4-5	3-4	4-5	4	4	4-5	5
4e	4-5	4-5	4-5	3-4	4	4-5	4-5	4	4-5
4f	4-5	4	4	4-5	4-5	4-5	4-5	4-5	4-5
4g	4-5	4-5	4-5	4-5	4-5	4-5	3-4	4-5	5
4h	4-5	4	4-5	4	4	4-5	3-4	4-5	5
4i	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4
4j	4-5	4	4-5	4-5	4	4-5	4-5	3-4	5
4k	4-5	4	4-5	3-4	4-5	4-5	4	4-5	4
4l	4-5	4-5	4-5	3	3-4	4	4	4	5
5a	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	4
5b	4-5	4	4	4-5	4-5	4-5	4-5	4	4-5
5c	4-5	4-5	4-5	4-5	4	4-5	4-5	3	5
5d	4-5	4-5	4-5	4-5	4	4-5	4-5	4-5	5
5e	4-5	4-5	4	4-5	4-5	4-5	4	4	4
5f	4-5	4	4-5	4	4-5	4	4	3-4	4-5
5g	4-5	4	4-5	4-5	4	4-5	4-5	4-5	4-5
5h	4-5	4-5	4-5	4-5	4-5	4-5	4-5	3-4	5
5i	4-5	4-5	4-5	4-5	4-5	4-5	4	3-4	4
5j	4-5	4-5	4-5	3-4	4	4-5	4-5	4-5	5
5k	4-5	4	4-5	4-5	4	4-5	4-5	4-5	4-5
5l	4-5	4-5	4-5	4-5	4-5	4	4-5	4-5	4-5