

Synthesis, Spectral Characterization and Application of Some Thio-azo Dyes

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In this study, some substituted azo compounds containing thio-urea, -NH(C=S)NH- and azo -N=N- groups, (1) [N,N'-bis(4-phenylazophenylene)thiourea] (bppt), (2) [N,N'-bis(4-(4'-sodiumsulfophenylazo)phenylene)]thiourea, (bspt), (3) 4-(4'-aminophenyleneazo)-5-hydroxy-2,7-naphthalene disulfonic acid disodium salt, (ahns), (4) N,N'-bis-[4-(8-hydroxy-3,6-disulfodisodium-1-naphthylazo)phenylene]thiourea, (bhnt) were synthesized by the reaction of some aromatic amines and CS₂ in EtOH. The thio-azo-dyes, (1) (bppt), (2) (bspt), (3) (ahns) and (4) (bhnt) have been characterized by the use of spectroscopic techniques such as infrared, UV-Visible, proton nuclear magnetic resonance and analytical methods. The dyeing properties and fastness of these dyes were investigated by applying them onto cotton and wool fibers. The applications on wool fibers were carried out by the use of direct and mordant dyeing methods and the applications on cotton fabric were made by direct and printing methods.

Key Words: Azo dyes, Synthesis, Thiourea, Dye application.

INTRODUCTION

Azo dyes, which are aromatic compounds with one or more -N=N- groups, constitute the largest class of synthetic dyes used in commercial applications. Azo dyes show generally red to blue colour with high extinction coefficient in comparison with aniline-based azo dyes. Today more than 2000 different azo dyes are currently being used in the industries such as textiles, leather, plastics, cosmetics and food for the dyeing of various materials. Aromatic azo compounds represent the dominant class of synthetic colourants¹. They are extensively used for dyeing fabrics and as colourants in printing. There is also interest in their biochemical applications, because of their ability to bind to proteins^{2,3}. Azo dyes incorporating 'pushpull' donor acceptor aryl rings are of much commercial importance for the dyeing of textiles⁴ and some exhibit second- or third-order non-linear optical properties^{5,6}. They have been receiving much attention and have been widely used in many practical applications such as colouring

fibers⁷, photoelectronic applications⁸, printing systems^{9,10}, optical storage technology^{11,12}, textile dyes¹³⁻¹⁵ as well as in many biological reactions¹⁶⁻¹⁸ and in analytical chemistry^{19,21}.

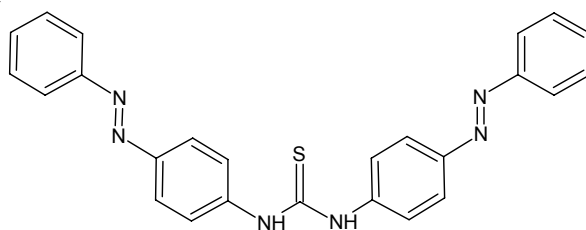


Fig. 1. Proposed structure of **1** (bppt)

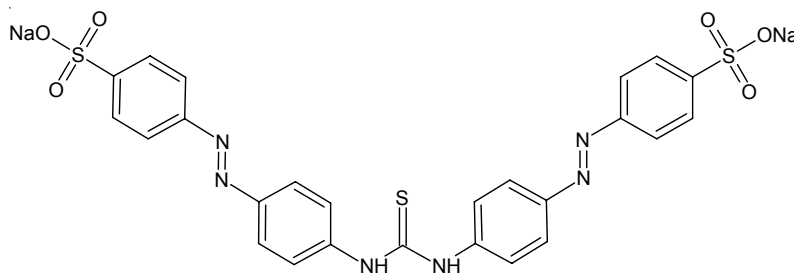


Fig. 2. Proposed structure of **2** (bspt)

Azo dyes which have a prominent place in synthetic dyes have a 70 % share in world textile markets. They are also used in diversified fields such as food, pharmaceutical, cosmetics, photography industries. It is possible to obtain large numbers of dyes with high absorption values in the visible region by attaching the compounds containing azo chromophore group (-N=N-) to aromatic rings such as benzene and naphthalene. As a result, azo group is employed in many dye classes such as direct, acid, disperse, azoic, reactive and metal complex. The metal complexes of azo compound are dyes with good fastness values. There are numerous studies in literature related to their synthesis and properties²³⁻²⁷. Some of the literatures carried out in the last decade are as follows: Hamam *et al.*²⁸ carried out solvatochromic studies on 2-[(2-hydroxyphenylazo)-4,5-diphenylimidazole. Tijima *et al.*²⁹ investigated the tautomeric behaviour of CI Acid Red 138 azo compound. Zhen and Tian³⁰ studied the effect of the structure upon the conductivity of *ortho*-hydroxyazo dyes. Adams *et al.*³¹ investigated two Cu(II)-azo complexes. Chao *et al.*³² examined the-effect of perflourbutamido group upon the colour, dyeability and fastness of 2-(*p*-alkyl)phenylazo-1-naphthol. Again Hanna investigated the complexation of *p*-chlorphenylazo-R-acid with Pd(II)³³.

The synthesis of thiourea containing groups was first carried out by Meyer and Sundmacher in 1879. This study was restricted with the determination of *m*-aminophenol for the time being but latter it was found that these types of compounds could be used as resinous paints in industry^{34,35}. Starting from 1990s the number of studies related with the use of thiourea containing dyes showed an increase and these dyes with good fastness values were applied to cotton, silk and wool. Diphenyl thiourea which is the basis of all these compounds are used in sulphide dyeing. The thiourea is also used with vat dyes and in the photo-stabilization of wool dyes. In addition to their dyeing features the compounds with thiourea structure were found to possess antibacterial properties. Thiourea has found many applications in industry, agriculture and other areas of chemistry. It is widely used in the rubber industry as accelerators, in photography as fixing agents and to remove stains from negatives and in agriculture as fungicides, herbicides and rodenticides. The use of an aqueous solution of thiourea as a leaching agent for gold has been widely reported in the literature. Serin and Bekaroglu³⁶ studied 1,3-diphenyl-2-thio-4,5-*amphi-bis*hydroxyimine-1,2,4,5-tetrahydroimidazoline and elucidated its structure.

In previous studies³⁷⁻³⁹, the synthesis and characterization and some properties of various novel dyes containing azo chromophore group for some textile fibres were investigated. Based on the mentioned properties for dyes, herein the syntheses, spectroscopic studies as well as dye properties of new thio-azo derivative dyes, **(1)** [N,N'-*bis*(4-phenylazophenylene)thiourea] (bppt), **(2)** [N,N'-*bis*(4-(4'-sodiumsulphophenylazo)phenylene)]thiourea, (bspt), **(3)** 4-(4'-aminophenyleneazo)-5-hydroxy-2,7-naphthalene disulfonic acid disodium salt, (ahns), **(4)** N,N'-*bis*-[4-(8-hydroxy-3,6-disulfodisodium-1-naphthylazo)phenylene]thiourea, (bhnt) are reported. These dyes were applied to various fabrics in order to determine their fastness values. The structures of the synthesized thio-azo dyes **(1)** (bppt), **(2)** (bspt), **(3)** (ahns), **(4)** (bhnt) are given in Figs. 1-3.

EXPERIMENTAL

Aniline, *p*-aminoazobenzene, sulfonic acid, mineral acids and CS₂ were obtained from Merck. The solvents were supplied commercially. All solvents were reagent grade and purified according to the standard procedure. All chemicals used in syntheses were of reagent grade and used without further purification.

The elemental analyses (C, H, N) were determined in the TUBITAK laboratory (Center of Science and Technology Research of Turkey). The IR spectrum (KBr disc) was recorded in the 4000-400 cm⁻¹ range on a Shimadzu 8300 FT-IR spectrometer. The electronic spectra were obtained using DMF on a Shimadzu UV-160 A spectrophotometer. ¹H NMR spectrum

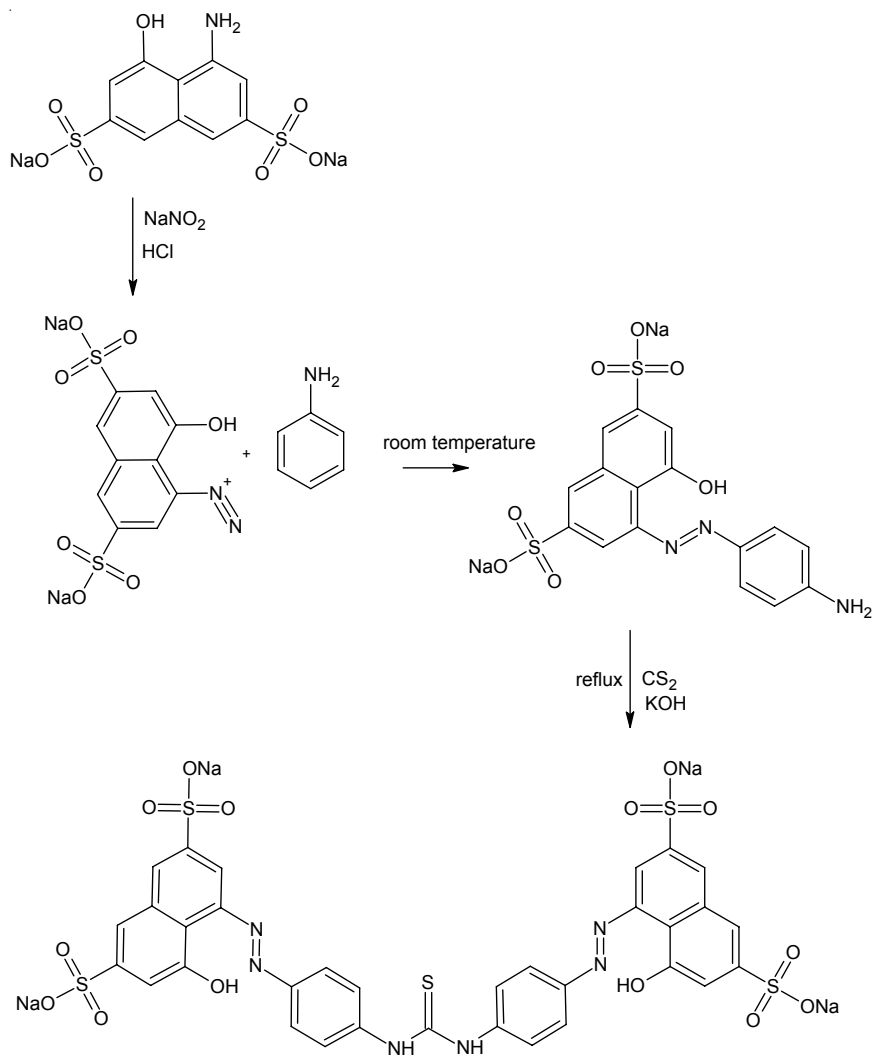


Fig. 3. Synthesis reaction of (3) 4-(4'-aminophenylazo)-5-hydroxy-2,7-naphthalene disulfonic acid disodium salt (ahns) and (4) *N,N'*-bis-[4-(8-hydroxy-3,6-disulfodisodium-1-naphthylazo)phenylene]thiourea (bhnt)

was recorded on a Bruker GmbH 300 MHz FT-NMR spectrometer. Melting points were obtained with an Electrothermal LDT 9200 apparatus in open capillaries.

Synthesis of [N,N'-bis(4-phenylazophenylene)thiourea], bppt (1): *p*-Aminoazobenzene (3.94 g, 20 mmol) was dissolved in CS_2 (0.76 g, 0.60 mL, 10 mmol) and EtOH (10 mL) in a 250 mL round bottom flask fixed

with a long refluxer. The solution was refluxed for 5 h in a water bath. The yellow precipitate formed at the end of this period. The excess CS₂ and EtOH were removed in a rotary evaporator. The residue was washed with water and filtered through a Gouch filter. The product was insoluble in water but soluble in benzene, DMSO, DMF and CCl₄. The final yield was 3.40 (78%). IR (KBr, ν_{\max} , cm⁻¹): 3296 (Ar-NH), 3038 (Ar), 1537 (-N=N-), 1323 (C=S). ¹H NMR (DMSO, ppm) δ : 7.75 (d, 4 H, Ar-H), 7.20 (d, 4 H, Ar-H), 7.50 (d, 4 H, Ar-H), 4.40 (t, 6 H, Ar-H), 2.6 (s, -NH-C:S-). UV-Vis (DMF, nm, ϵ): 510 (28.10³).

Synthesis of [N-N'-bis(4-(4'-sodiumsulfohenylazo) phenylene)]-thiourea, bspt (2): The azo dye (spb) was synthesized according to the known method. 4-Aminobenzenesulfonic acid (1.73 g) was dissolved in distilled water (50 mL) by the addition of Na₂CO₃ (0.6 g). The temperature was decreased to 5 °C by the help of a cryostat. The diazotization was carried out with dropwise addition of NaNO₂ solution (0.7 g) after the addition of HCl (3 mL). The white coloured solution was stirred at 5 °C for 1 h. The termination of the diazotization process was checked with starch-iodine paper.

Aniline (0.93 g, 10 mmol, 0.91 mL) was added to the sulfonic acid diazonium salt in dropwise manner at -5 °C. The solution was stirred for 3 h. The temperature was gradually brought to the room conditions during this period. The product was washed with ether. The yield was 2.19 g (73%). The light pink coloured final product was highly soluble in water, DMF and DMSO, sparingly soluble in EtOH and insoluble in Et₂O. m.p. > 250 °C.

The spb (5.98 g, 20 mmol) was dissolved in EtOH (50 mL) by heating. KOH (0.1 g) was added to shorten the reaction time. CS₂ (5 mL) was added in dropwise manner and the resulting solution was refluxed for 8 h. A yellow coloured precipitate was formed at the end of 3 h. The excess alcohol and CS₂ was removed with rotary evaporator. The product was filtered, dried and recrystallized from EtOH. The yield was 5.63 g (88 %). IR (KBr, ν_{\max} , cm⁻¹): 3340 (N-H), 3020 (ArH), 1440 (-N=N-), 1115 (C=S). ¹H NMR (DMSO, ppm) δ : 7.70 (d, 4 H, Ar-H), 7.25 (d, 4 H, Ar-H), 7.15 (d, 4 H, Ar-H), 6.55 (d, 4 H, Ar-H), 4 (s, N-H), 2.3 (s, -SH-). UV-Vis (water, nm, ϵ): 540 (22 × 10³).

Synthesis of 4-(4'-aminophenyleneazo)-5-hydroxy-2,7-naphthalene disulfonic acid disodium salt, ahns (3): H-acid monosodium salt (100%, 6.82 g) and water (8 mL) was mixed in a beaker and the pH was brought to 7 by adding Na₂CO₃ (1.2 g). The temperature was brought down to 14 °C with ice after the addition of HCl (5 mL). The diazotization process was carried out by the dropwise addition of NaNO₂ (1.4 g). The termination of the diazotization process was checked by starch-iodine paper.

The diazonium salt of H-Acid (1.86 g, 1.76 mL, 20 mmol) was added to aniline at 14 °C by constant stirring in 2 h. The stirring was continued for 4 h. The yield of dark violet coloured final product was 8.2 g (87 %) the final product was highly soluble in water, sparingly soluble in EtOH and not soluble in CCl₄ and Et₂O. IR (KBr, ν_{\max} , cm⁻¹): 3454 (-OH), 3286 (N-H), 3040 (Ar-CH), 1498 (-N=N-), 1047 (C-N). ¹H NMR (*d*⁶-DMSO) δ : 3.5 (s, -NH₂), 6.60 (m, naphth-H), -7.45 (s, naphth-H), 7.65 (d, Ar-CH), 7.75 (d, Ar-CH), 15.5 (s, OH). UV-Vis (water, nm, ϵ): 415 (49 × 10³).

Synthesis of N,N'-bis-[4-(8-hydroxy-3,6-disulfodisodium-1-naphthylazo)-phenylene]thiourea, bhnt (4): 9.34 g (20 mmol) (4) was dissolved in alcohol:water mixture (1:5, 50 mL). The solution was placed in 250 mL flask. The solution was boiled after the addition of KOH (1.64 g) and CS₂ (0.76 g, 10 mmol, 0.60 mL). A brown coloured precipitate was formed after 8 h reflux. The excess water, alcohol and CS₂ were removed with rotary evaporator. The product was dried in vacuum oven, then it was washed with Et₂O. The final product was highly soluble in water, DMF and DMSO but not soluble in Et₂O, benzene and carbon tetrachloride. The yield was 6.71 g (69 %). IR (KBr, ν_{\max} , cm⁻¹): 3411 (-OH), 3250 (N-H), 3045 (Ar-CH), 1495 (C=S), 1043 (C-N). ¹H NMR (*d*⁶-DMSO, ppm) δ : 2 (s, -SH), 6.60 (m, naphth-H), -7.45 (s, naphth-H), 7.65 (d, Ar-CH), 7.75 (d, Ar-CH), 8.5 (s, N-H), 15.05 (s, OH), UV-Vis (water, nm, ϵ): 523 (48 × 10³).

Dyeing procedures:

Dyeing methods of (2) bspt and (4) bhnt (water soluble dyes)

Wool: The dye solution was prepared by dissolving 0.4 g of the dye (2) bspt and (4) bhnt in water (50 mL) at room temperature. This solution was applied to the fabric by using two different methods as follows: (1) direct dyeing method (2) bottom mordant method.

In direct dyeing method, 0.5 g of wool was treated with a wetter and kept in a dye bath at room temperature for 16 h. The dyed wool was washed with water, then it was subjected to basic washing processes and finally dried at room temperature.

In bottom mordant process, K₂Cr₂O₇ and CuSO₄·5H₂O, Zn(CH₃COO)₂·H₂O, Co(CH₃COO)₂·4H₂O and NiCl₂·6H₂O were used. A 1 % mordant solution was prepared and the wool fibers were treated with this solution at 50 °C for 0.5 h. The fibers were removed from the mordant bath and kept at water bath for 4 h. The fibers were subjected to water and basic washing and then neutralization processes and dried at room temperature.

Cotton: The cotton fabric, treated with 5 % wetter for 10 min at 40 °C, was dyed with 5 % dye solution for 1 h at 90 °C. The fabric was removed from the washing bath after being kept there for 1 h washed with cold water, soap, hot water and cold water again.

Dyeing methods of dye (1) bppt

Wool: (1) bppt dye (0.4 g) was dissolved in water (100 mL) by adjusting the pH value at 4 with acetic acid. 0.5 g of wool was kept in dyeing bath for 1 h. Then the wool fibers were washed with water and neutralized with basic washing. The fibers were subjected to resistance test against the case that they would be damaged due to acidic dyeing process. They were also evaluated as regards to their use in weaving process.

Printing method of (1) (bppt) to cotton: 1000 g printing paste was prepared x g synthetic setter, y g binder and z g dye. The pH was buffered to pH 8 during the printing process with ammonia. The fixation process was carried out at 180 °C after the printing process.

RESULTS AND DISCUSSION

In this study, new -N=N- and C=S containing dyes were prepared by interacting the azo compounds, obtained with the coupling of aniline diazonium salt solution to aniline and H-acid diazonium salt to aniline and sulfonic acid, with CS₂ in EtOH containing media. The synthetic route of (4) (bhnt) azo dye is given in Fig. 3. The new dyes were characterized by the use of ¹H NMR, IR, UV-Visible spectra, elemental analysis data. These compounds were applied to wool fibers by the use of direct dyeing and upper mordant methods. Different mordant were used in upper mordant method. The dyes which were soluble in water were applied to cotton fabric by direct dyeing or printing techniques. The fastness values of these samples were examined.

The elemental analyses data of the compounds are given in Table-1. The experimental elemental analysis results of thio-azo dyes are in good compliance with the theoretical calculations.

UV-Visible spectra: The electronic spectra of the thio-azo compounds, were recorded in 10⁻⁵ M DMF at room temperature. The data of the compounds are given in experimental section. The UV-Visible 10⁻⁵ M DMF solution of (1) (bppt) azo dye revealed absorption bands at 235, 257, 375 and 510 nm. These values are due to red shift $\pi \rightarrow \pi^*$ transition of E₂ band as the result of -C=S and -N=N- groups²². The $n \rightarrow \sigma^*$, $\pi \rightarrow \pi^*$ and $n \rightarrow \pi^*$ transitions of C=S bond in thiocarbonyl compounds are observed at 50 and 360 and 320 nm, respectively. The maximum absorption band observed at 510 nm is due to conjugation in the structure. The UV-Vis spectrum of (2) (bspt) dye in water reveals band located at 245, 250 and 360 nm which belong to red shift of E₂ band appeared as a result of benzene and sulfo groups, -N=N- and C=S groups, respectively. The medium intensity absorption band observed at 540 nm stems from the conjugation in the structure. The UV-Visible spectrum of (3) (ahns), dye taken in 10⁻⁵ M water revealed an absorption band at 227 nm belonging to $\pi \rightarrow \pi^*$ of the

TABLE-1
SOME ANALYTICAL DATA OF THE INVESTIGATED DYES,
(1) bppt, (2) bspt, (3) ahns, (4) bhnt

Dye	m.f. (colour)	m.w. (g/mol)	Yield (%) / m.p. (°C)	Found (calcd.) %			
				C	H	N	S
(1) (bppt)	C ₂₅ H ₂₀ N ₆ S (Yellow)	436	78 (214)	68.81 (68.40)	4.59 (4.48)	19.27 (18.76)	7.33 (7.65)
(2) (bspt)	C ₁₆ H ₁₂ N ₃ O ₇ S ₂ Na ₂ (Violet)	445	87 (>350)	43.14 (43.00)	2.70 (2.69)	9.44 (9.93)	14.38 (14.48)
(3) (ahns)	C ₁₆ H ₁₁ N ₆ O ₇ S ₂ Na ₂ (Brown)	932	69 (>350)	42.49 (41.87)	2.36 (2.16)	9.01 (8.81)	17.16 (17.02)
(4) (bhnt)	C ₃₃ H ₂₀ N ₆ O ₁₄ S ₅ Na ₄ (Yellow)	640	88 (>350)	46.88 (46.52)	2.81 (2.76)	13.13 (13.68)	15.00 (15.51)

benzene ring and an absorption band at 356 nm coming from $n \rightarrow \pi^*$ transition -N=N- group. Apart from these the absorption band which appears at the visible region at 415 nm is the indication of the colouring feature. When the UV-Visible and IR spectra of (4) (bhnt) and (3) (ahns), dyes are compared one can see that in there is C=S absorption band at 367 nm in the UV-Vis spectrum and C=S stretching band in the IR spectrum of (4) (bhnt) which do not appear in the spectra of (3) (ahns). The UV-Visible absorption bands of (4) (bhnt) dye are as follows benzene ring at 238 nm, -N=N- at 370 nm and C=S at 367 nm. Since (4) (bhnt) is a coloured compound it gives a medium intensity peak at 523 nm.

In the IR spectra of (1) (bppt) dye, the aromatic -NH appeared at 3296 cm^{-1} , the aromatic C-H stretching bands were observed at 3038 cm^{-1} ; -N=N- band is seen at 1537 cm^{-1} and the bands originate from -N=N- were observed at 1323 cm^{-1} . The band belonging to C=S bond is reported to appear at 1300-1165 cm^{-1} in literature. The experimental elemental analysis results are in good compliance with the theoretically calculated values. Some of the elemental analyses data of the all thio-azo type dyes are tabulated in Table-1 and electronic spectral data are given in the experimental section.

IR data of (3) (ahns), indicates the Ar-NH₂ (3286 cm^{-1}), Ar-OH (3454 cm^{-1}), -N=N- (1498 cm^{-1}) and C-N (1047 cm^{-1}).

IR spectrum of (4) (bhnt) dye gives important clues about its structure. The broad band observed at 3411 cm^{-1} is due to OH group and the bands observed at 3250 and 1495 cm^{-1} are stretching bands belong to Ar-NH and C=S groups, respectively.

Also, the Ar-NH₂ peak observed in the IR spectrum of (3) (ahns) and disappear in the IR spectrum of (4) (bhnt) is another indication of the validity of the proposed structure.

The IR spectrum of (2) (bspt) gives important diagnostic bands such as Ar-NH at 3340 cm^{-1} , Ar-CH at 3020 cm^{-1} , C=S at 1115 cm^{-1} and -N=N- 1440 cm^{-1} .

^1H NMR spectra: The (3) (ahns) azo dye obtained by the coupling reaction of 1-amino-8-naphthol-3,6-disulfonic acid (H-acid) to aniline after being diazotized, was characterized by using UV-Visible, IR, elemental analysis and ^1H NMR techniques. Looking at ^1H NMR data of (3) (ahns) one can see that the singlet peak at 3.5 ppm belongs to the NH_2 and the peak at 6.6-7.55 ppm is due to protons in naphthalene ring. The peak observed at 15.5 ppm is due to the fact that the structure was in azo hydrazone tautomerism. The elemental analysis data of (3) (ahns) are in good accordance with the theoretical values. The aromatic C-H peaks observed at 6.5-8.5 ppm, aromatic N-H peak at 8.5 ppm and naph-OH peaks at 14.5 ppm in the ^1H NMR spectrum of (4) (bhnt) verify the proposed structure. The elemental analysis data are also in good accordance with the theoretically calculated values. Also the Ar-H peaks at 7.6 and 8 ppm, Ar-NH peaks at 10.5 ppm and the singlet peak at 2.6 ppm belonging to $-(\text{NH})_2\text{C}=\text{S}$ in ^1H NMR data of (1) (bppt) dye show the validity of the proposed structure²³. ^1H NMR of (2) (bspt) azo dye also verifies the validity of the proposed structure. ^1H NMR data were evaluated as follows: the singlet at 4 ppm is due to Ar-NH, the multiplet at 6.5-7 ppm is result of aromatic C-H and the singlet at 2.3 ppm is due to S-H resulted from the tautomerism of the structure. The tautomeric forms of (4) (bhnt) azo dye are depicted in Fig. 4. The elemental analysis data also comply well with theoretical calculations. The possible tautomeric structures of (4) (bhnt), one of the thio-azo structure dyes synthesized in this study, are given in Fig. 4.

Dyeing properties: The dyeing results of (1) (bppt), (2) (bspt), (3) (ahns) and (4) (bhnt) dyes are tabulated in Table-3.

The azo compounds (3) (ahns) dye was applied to wool fibers, its dyeing properties were investigated and its light fastness value was determined. As a result of the direct application of the dye to wool fibers and the colour value was found as $\text{Y}_{30}\text{M}_{70}\text{C}_{40}$ according to European Colour Scale.

The water soluble (4) (bhnt) azo dye was applied to wool and cotton fabrics for fastness tests. The dye was applied to wool fibers with the use of direct and mordant techniques and dye gave the colour value $\text{Y}_{80}\text{M}_{60}\text{C}_{50}$ according to European Colour Scale. The corresponding value was found as $\text{Y}_{40}\text{M}_{30}\text{C}_{20}$ in cotton fabric after the application of the dye by the use of pigment printing method. The fastness evaluation results showed that (4) (bhnt) dye have suitable properties for the use in textile industry.

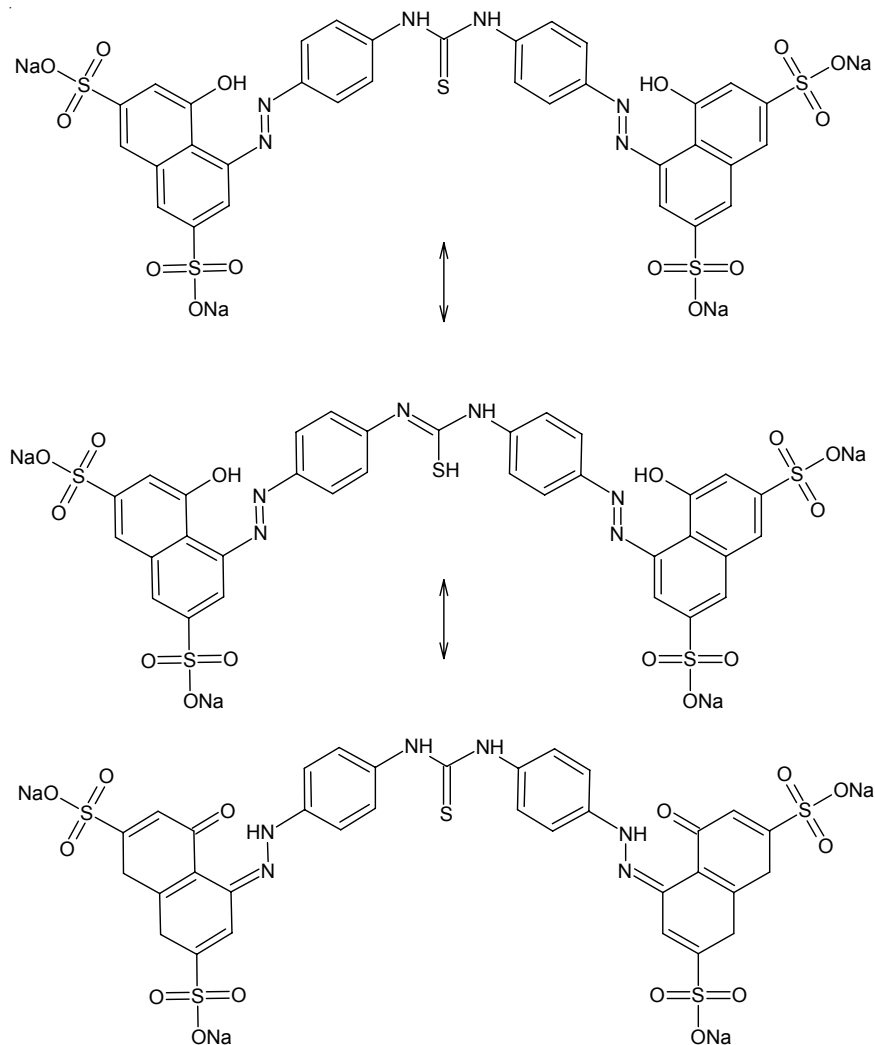


Fig. 4. Three tautomeric forms of (4) (bhnt) azo-thio dye

The colour values of (1) (bppt) dye in accordance with the European Colour Scale were found as $Y_{30}M_{00}C_{00}$ for cotton and $Y_{60}M_{60}C_{00}$ for wool. The (1) (bppt) dye insoluble in water was applied to cotton fibers by the use of printing method and the wool fiber after being dissolved in acetic acid medium at pH value of 4. The resistance of the wool fibers was checked after the application of the dye in acidic medium. The wool fibers were not damaged in slightly acidic media and their resistance was observed to change a little.

TABLE-2
SHADES AND FASTNESS PROPERTIES OF SYNTHESIZED DYES

Dyes	Colour fastness	Staining	Change shade						Test method
			Acetate	Cotton	Nylon 6.6	Polyester	Acrylic	Wool	
bppt	Washing	3/4	2/3	4/5	2	4/5	4	3/4	CB1 BS EN 105 C06
	Water	3/4	3	4	2	4/5	4	3/4	CB2 BS EN ISO 105 E01
	Perspiration (acid)	4	3	4	2	4/5	4	3/4	CB4 BS EN ISO 105 E01
	Perspiration (alk.)	4	3	3/4	2	4/5	4	3/4	CB4 BS EN ISO 105 E01
	Rubbing (dry)	4/5	-	-	-	-	-	-	CB3 BS EN ISO 105X12
	Rubbing (wet)	4/5	-	-	-	-	-	-	CB3 BS EN ISO 105X12
	Light	4+	-	-	-	-	-	-	CB5 BS EN 10105 B02
	Light	4	4/5	3/4	4	4/5	4	4/5	CB1 BS EN 105 C06
bhnt	Washing	4	4/5	4	3/4	4/5	4	3	CB2 BS EN ISO 105 E01
	Water	4	4	3/4	3/4	4/5	4	3	CB4 BS EN ISO 105 E01
	Perspiration (acid)	4	4	3/4	3	3/4	3/4	2/3	CB4 BS EN ISO 105 E01
	Perspiration (alk.)	4	3/4	2/3	-	-	-	-	CB3 BS EN ISO 105X12
	Rubbing (dry)	4/5	-	-	-	-	-	-	CB3 BS EN ISO 105X12
	Rubbing (wet)	4	-	-	-	-	-	-	CB3 BS EN ISO 105X12
	Light	4	2/3	4/5	2	4/5	4	3/4	CB1 BS EN 105 C06
	Light	4	3	4	3/4	4/5	4	4	CB1 BS EN 105 C06
bpsf	Washing	3/4	3	4	2	4/5	4	3/4	CB2 BS EN ISO 105 E01
	Water	3/4	4/5	4	2	4/5	4	3/4	CB4 BS EN ISO 105 E01
	Perspiration (acid)	4	4	4	3/4	4	4/5	3/4	CB4 BS EN ISO 105 E01
	Perspiration (alk.)	4	4	3/4	2	3	4	3	CB4 BS EN ISO 105 E01
	Rubbing (dry)	4/5	-	-	-	-	-	-	CB3 BS EN ISO 105X12
	Rubbing (wet)	4	-	-	-	-	-	-	CB3 BS EN ISO 105X12
	Light	4	2/3	4/5	2	4/5	4	3/4	CB1 BS EN 105 C06
	Light	4	3	4	3/4	4/5	4	4	CB1 BS EN 105 C06
ahns	Washing	3/4	3	4	2	4/5	4	3/4	CB2 BS EN ISO 105 E01
	Water	3/4	4/5	4	2	4/5	4	3/4	CB4 BS EN ISO 105 E01
	Perspiration (acid)	4	4	4	3/4	4	4/5	3/4	CB4 BS EN ISO 105 E01
	Perspiration (alk.)	4	4	3/4	2	3	4	3	CB4 BS EN ISO 105 E01
	Rubbing (dry)	4/5	-	-	-	-	-	-	CB3 BS EN ISO 105X12
	Rubbing (wet)	4	-	-	-	-	-	-	CB3 BS EN ISO 105X12
	Light	4	-	-	-	-	-	-	CB5 BS EN 10105 B02
	Light	4	-	-	-	-	-	-	CB5 BS EN 10105 B02

Rating scale = 1 (lowest) to 8 (highest) for light fastness and 1 to 5 for washing, perspiration, rubbing and sublimation fastness.

TABLE-3
APPLICATION AND COLOURS OF THE DYES TO WOOL AND
COTTON FIBRES

Dyes	Dyeing method	Fibre	(European colour scale)
bbpt	Direct	Wool	Y ₆₀ M ₆₀ C ₀₀
bbpt	Printing	Cotton	Y ₃₀ M ₀₀ C ₀₀
ahns	Direct	Wool	Y ₃₀ M ₇₀ C ₄₀
ahns	Direct	Cotton	Y ₂₀ M ₂₀ C ₂₀
ahns	Mordant (K ₂ Cr ₂ O ₇)	Wool	Y ₄₀ M ₅₀ C ₄₀
bhnt	Direct	Wool	Y ₈₀ M ₆₀ C ₅₀
bhnt	Mordant (K ₂ Cr ₂ O ₇)	Wool	Y ₄₀ M ₄₀ C ₁₀
bhnt	Mordant (CuSO ₄ .5H ₂ O)	Wool	Y ₅₀ M ₃₀ C ₆₀
bhnt	Mordant [Zn(CH ₃ COO) ₂]	Wool	Y ₅₀ M ₃₀ C ₁₀
bhnt	Mordant [Co(CH ₃ COO) ₂]	Wool	Y ₈₀ M ₆₀ C ₆₀
bhnt	Mordant [NiCl ₂ .6H ₂ O]	Wool	Y ₆₀ M ₄₀ C ₄₀
bhnt	Direct	Cotton	Y ₁₀ M ₁₀ C ₁₀
bhnt	Printing	Cotton	Y ₄₀ M ₃₀ C ₂₀
bspt	Direct	Wool	Y ₉₀ M ₄₀ C ₀₀
bspt	Mordant (K ₂ Cr ₂ O ₇)	Wool	Y ₆₀ M ₂₀ C ₂₀
bspt	Mordant (CuSO ₄ .5H ₂ O)	Wool	Y ₇₀ M ₀₀ C ₀₀
bspt	Mordant [Zn(CH ₃ COO) ₂]	Wool	Y ₅₀ M ₀₀ C ₀₀
bspt	Mordant [Co(CH ₃ COO) ₂]	Wool	Y ₆₀ M ₃₀ C ₅₀
bspt	Mordant [NiCl ₂ .6H ₂ O]	Wool	Y ₈₀ M ₀₀ C ₀₀

The fastness properties of (1) (bppt) dye were examined in order to evaluate its usability in the textile sector. The data obtained show that the properties of the dye as regards to light, perspiration and washing fastness values were suitable for textile industry.

The application of (2) (bspt) azo dye to wool fibers was carried out by the use of direct and mordant dyeing techniques. The results were evaluated according to European colour scale. The colour value of the dye as a result of direct application method was found as Y₉₀M₄₀C₀₀. The other fastness evaluations are tabulated in Table-3.

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