



## Studies on Dyeing Performance of Novel Acid Azo Dyes and Mordent Acid Azo Dyes Based on 2,4-Dihydroxybenzophenone

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**Abstract:** Novel acid azo and mordent acid azo dyes have been prepared by the coupling of diazo solution of different aminonaphthol sulphonic acids and aromatic amino acids with 2,4-dihydroxybenzophenone. The resultant dyes were characterized by elemental analysis as well as IR and <sup>1</sup>H NMR spectral studies. The UV-visible spectral data have also been discussed in terms of structure property relationship. The dyeing assessments of all the dyes were evaluated on wool and silk textile fibers. The dyeing of chrome pretreated wool and silk have also been monitored. The result shows that better hue was obtained on mordented fiber. Results of bactericidal studies of chrome pretreated fibers revealed that the toxicity of mordented dyes against bacteria is fairly good. Dyeing on wool and silk fibers resulted in yellowish pink to reddish brown colourations having excellent light fastness and washing fastness.

**Keywords:** Acid azo dyes, Chrome dyes, Light fastness, Washing fastness.

### Introduction

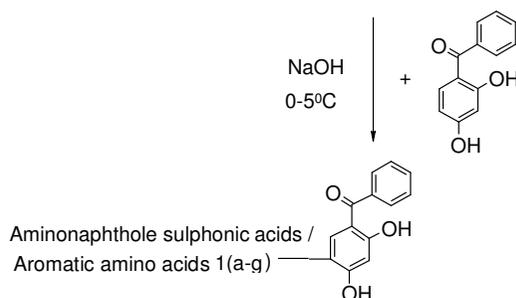
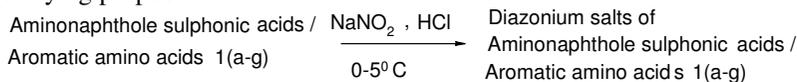
Whilst phenols are well established intermediates for the synthesis of various commercial dyes<sup>1-6</sup>, they are marketed in the form of azo disperse, azo-acid dyes *etc.* All of these dyes having phenolic motif, containing hydroxyl group as an auxochrome group. Such auxochromic(-OH) and chromophoric(C=O) group containing compound *i.e.* 2, 4-dihydroxybenzophenone has shown wide applications as a polymer additives<sup>7-9</sup>. It is an excellent UV absorber, which prevents the photo degradability of most of vinyl polymers<sup>10-12</sup>.

The area in which the acid azo dyes and mordent azo dyes formation based on this compound has not been developed except of few patents<sup>13-16</sup>.

The formation of dyes based on this compound may yield the dyes with good hue properties. Hence, in continuation of our earlier work<sup>17</sup>, it was thought interesting to explore the field of acid azo dyes based on 2,4-dihydroxybenzophenone. Thus, the present communication comprises the synthesis, characterizations and dyeing performance of novel acid azo and mordent acid azo dyes based on 2,4-dihydroxybenzophenone.

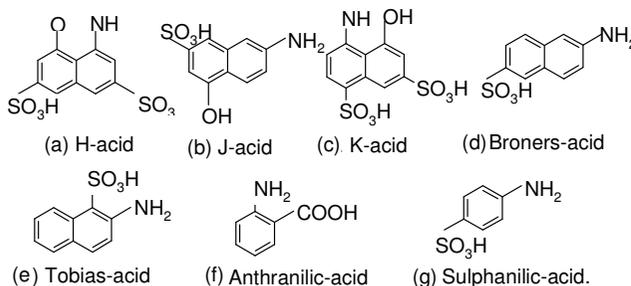
## Experimental

All the chemicals used were of analytical grade and were further purified as and when required. The aminonaphthol sulphonic acids and aromatic amino acids listed in Scheme 1 were used for diazotization. Wool and silk fibers were gifted by Color Tax (Pvt) Ltd, Surat. Melting points were determined by open capillary method and are uncorrected. The visible absorption spectra were measured on a Carl Zeiss UV/VIS Specord spectrometer, and elemental analysis was carried out on Perkin Elmer CHNS/O Analyzer 2400 Series II. Infrared spectra were recorded in KBr pellets on a Perkin-Elmer Spectrum GX FT-IR model, proton NMR spectra were recorded on Hitachi R-1500 in DMSO-D<sub>6</sub> solvent and TLC (Thin layer chromatography) was run on a aluminum sheets precoated with silica gel 60 F<sub>245</sub>, (Merck, Germany) using methanol-water-acetic acid (12:3:7) solvent system. Colour spot was visualized by UV chamber. HTHP dyeing machine (model-LL) was used for dyeing purpose.



**Scheme 1** . Synthesis of 2,4-dihydroxybenzophenone based dyes (D<sub>1</sub>-D<sub>7</sub>)

Aminonaphthole sulphonic acids and Aromatic amino acids 1(a-g) are as under:



## Synthesis of acid azo dyes

### *Diazotization*

Diazotization of various aminonaphthol sulphonic acid and aromatic amino acid 1(a-g) (Scheme 1) was carried out by the method reported in literature<sup>18,19</sup>.

Accordingly each of the aminonaphthol sulphonic acids and aromatic amino acids 1(a-g) ( $3.19 \times 10^{-3}$  kg, 0.01 mol) was mixed with HCl ( $2.5 \times 10^{-5}$  m<sup>3</sup>, 37%) in a mortar, transferred to a 3-neck round bottom flask, and additional HCl ( $2.0 \times 10^{-5}$  m<sup>3</sup>, 37 %) was added. To the resultant suspension, crushed ice ( $25 \times 10^{-3}$  kg) and NaNO<sub>2</sub> ( $2.5 \times 10^{-5}$  m<sup>3</sup>, 4N) were added. Diazotization was carried out over 0.5 h at 5 °C with constant stirring.

### *Coupling procedure*

The coupling of above mentioned diazotized aminonaphthol sulphonic acid and aromatic amino acid 1(a-g) was carried out in the similar manner. The general procedure followed is given below:

2,4-Dihydroxybenzophenone ( $2.15 \times 10^{-3}$  kg, 0.01 mol) was dissolved in sodium hydroxide ( $1.2 \times 10^{-5}$  m<sup>3</sup>, 0.01 mol) solution. The clear solution was cooled in ice-bath and diazonium solution of aminonaphthol sulphonic acid and aromatic amino acid 1 (a-g) was added drop wise over a period of 30 min with vigorous stirring. The pH was maintained between 2.0 to 3.0 by simultaneous addition of 10 % w/v sodium carbonate solution. Stirring was continued for 2 h, allowing the temperature rise to ambient. The dyes was then filtered off and dissolved in distilled water after that acid azo dyes were obtained by evaporation procedure, and it was dried at room temperature. The dyes were designated as acid azo dye (D<sub>1-7</sub>) and were recrystallised in acetone.

### *Acid azo dyeing method*

Dyeing of wool and silk fiber, is convenient at 90<sup>0</sup>–130<sup>0</sup>C and at high pressure (165.6 kpa - 207 kpa) in the laboratory. A model glycerin-bath high-temperature beaker and HTHP (model-LL) dyeing machine was used. For this purpose a paste of finely powdered acid azo dye ( $6 \times 10^{-5}$  kg) was prepared with dispersing agent dodamol ( $9 \times 10^{-5}$  kg), wetting agent Tween-80 ( $6 \times 10^{-6}$  kg) and water ( $2 \times 10^{-6}$  m<sup>3</sup>) in a ball mill. To this paste, water ( $9.9 \times 10^{-5}$  m<sup>3</sup>) was added with stirring and the pH was adjusted to 2.0 – 4.0 using acetic acid, the previously mentioned dye suspension ( $1 \times 10^{-4}$  m<sup>3</sup>) was added to a beaker provided with a lid and a screw cap. Before closing the lid and lightening the metal cap over the beaker a wetted pattern of wool and silk fiber was rolled in to the beaker, and then placed vertically on the rotatory carrier inside the tank and the clamp plate was firmly tightened.

The rotatory carrier was then allowed to rotate in the glycerin-bath and the temperature was raised to 90 °C at the rate of 2 °C/min. The dyeing was continued for 1 h under pressure. After cooling for 1 h, the beaker was removed from the bath and washed with distilled water. The dyed pattern was thoroughly washed with cold water and dried at room temperature.

### *Mordent dyeing method*

The dye pattern of wool and silk fibers obtained from the above mentioned process was treated with potassium dichromate solution equal to half of the weight of dye and it was allowed to roll into the beaker and again, the beaker was then placed vertically on the rotatory carrier inside the tank and the dyeing was continued for 1 h under the pressure. After cooling for 1 h, the beaker was removed from the bath and washed with cold distilled water. The dyed pattern was thoroughly washed with warm water and air dried at room temperature.

**Characteristic data of acid azo dyes***1-[2,4-Dihydroxy-5-(8-hydroxynaphthylazo-3,6-disulphonic acid)phenyl]-1-phenylmethanone (D<sub>1</sub>)*

Calculated for C<sub>23</sub>H<sub>14</sub>O<sub>10</sub>N<sub>2</sub>S<sub>2</sub>: M. wt.: 542, % yield: 81, m. p.: 136-140°C, R<sub>f</sub> value: 0.82; C, 50.92 %; H, 2.58 %; N, 5.16 %; S, 11.83 %. Found: C, 50.88 %; H, 2.52 %; N, 5.11 %; S, 11.80 %. IR : 3463 cm<sup>-1</sup> (-OH); 3072 cm<sup>-1</sup> (=CH, aromatic); 1628 cm<sup>-1</sup> (C=O, diaryl); 1521 cm<sup>-1</sup> (N=N); 1520 cm<sup>-1</sup> (for naphthalene substitution); 1481 cm<sup>-1</sup> (C=C, aromatic); 1333 cm<sup>-1</sup> (C-N); 1101 cm<sup>-1</sup> (C-O); 1030 cm<sup>-1</sup>, 650 cm<sup>-1</sup> (for sulphonic acid); 732 cm<sup>-1</sup>, 584 cm<sup>-1</sup>, 481 cm<sup>-1</sup> (for substituted benzene). <sup>1</sup>H-NMR: 7.2-7.4 δ (Ar-H, multiplet), 5.4 δ (Ar-OH, singlet), 8.0 δ (-SO<sub>3</sub>H, singlet, 1H).

*1-[2,4-Dihydroxy-5-(4-hydroxynaphthylazo-6-sulphonic acid)phenyl]-1-phenylmethanone (D<sub>2</sub>)*

Calculated for C<sub>23</sub>H<sub>15</sub>O<sub>7</sub>N<sub>2</sub>S: M. wt.: 463, % yield: 78, m. p.: 140-144°C, R<sub>f</sub> value: 0.80; C, 59.61 %; H, 3.23 %; N, 6.04 %; S, 6.92 %. Found: C, 59.58 %; H, 3.19 %; N, 6.01 %; S, 6.88 %. IR : 3450 cm<sup>-1</sup> (-OH); 3082 cm<sup>-1</sup> (=CH, aromatic); 1624 cm<sup>-1</sup> (C=O, diaryl); 1540 cm<sup>-1</sup> (for naphthalene substitution); 1522 cm<sup>-1</sup> (N=N); 1490 cm<sup>-1</sup> (C=C, aromatic); 1345 cm<sup>-1</sup> (C-N); 1101 cm<sup>-1</sup> (C-O); 1032 cm<sup>-1</sup>, 653 cm<sup>-1</sup> (for sulphonic acid); 744 cm<sup>-1</sup>, 564 cm<sup>-1</sup>, 478 cm<sup>-1</sup> (for substituted benzene). <sup>1</sup>H-NMR: 7.2-7.5 δ (Ar-H, multiplet), 6.3 δ (Ar-OH, singlet), 8.2 δ (-SO<sub>3</sub>H, singlet, 1H).

*1-[2,4-Dihydroxy-5-(8-hydroxynaphthylazo-4,6-disulphonic acid)phenyl]-1-phenylmethanone (D<sub>3</sub>)*

Calculated for C<sub>23</sub>H<sub>14</sub>O<sub>10</sub>N<sub>2</sub>S<sub>2</sub>: M. wt.: 542, % yield: 82, m. p.: 141-146°C, R<sub>f</sub> value: 0.85; C, 50.91 %; H, 2.58 %; N, 5.16 %; S, 11.83 %. Found: C, 50.87 %; H, 2.53 %; N, 5.10 %; S, 11.80 %. IR : 3481 cm<sup>-1</sup> (-OH); 3070 cm<sup>-1</sup> (=CH, aromatic); 1632 cm<sup>-1</sup> (C=O, diaryl); 1542 cm<sup>-1</sup> (N=N); 1525 cm<sup>-1</sup> (for naphthalene substitution); 1483 cm<sup>-1</sup> (C=C, aromatic); 1337 cm<sup>-1</sup> (C-N); 1103 cm<sup>-1</sup> (C-O); 1029 cm<sup>-1</sup>, 650 cm<sup>-1</sup> (for sulphonic acid); 737 cm<sup>-1</sup>, 562 cm<sup>-1</sup>, 472 cm<sup>-1</sup> (for substituted benzene). <sup>1</sup>H-NMR: 7.1-7.3 δ (Ar-H, multiplet), 5.5 δ (Ar-OH, singlet), 7.9 δ (-SO<sub>3</sub>H, singlet, 1H).

*1-[2,4-Dihydroxy-5-(naphthylazo-5-sulphonic acid)phenyl]-1-phenylmethanone (D<sub>4</sub>)*

Calculated for C<sub>23</sub>H<sub>15</sub>O<sub>6</sub>N<sub>2</sub>S: M. wt.: 447, % yield: 85, m. p.: 138-142°C, R<sub>f</sub> value: 0.87; C, 61.74 %; H, 3.35 %; N, 6.26 %; S, 7.17 %. Found: C, 61.70 %; H, 3.31 %; N, 6.22 %; S, 7.14 %. IR : 3633 cm<sup>-1</sup> (-OH); 3080 cm<sup>-1</sup> (=CH, aromatic); 1652 cm<sup>-1</sup> (C=O, diaryl); 1560 cm<sup>-1</sup> (for naphthalene substitution); 1532 cm<sup>-1</sup> (N=N); 1473 cm<sup>-1</sup> (C=C, aromatic); 1338 cm<sup>-1</sup> (C-N); 1104 cm<sup>-1</sup> (C-O); 1032 cm<sup>-1</sup>, 653 cm<sup>-1</sup> (for sulphonic acid); 782 cm<sup>-1</sup>, 741 cm<sup>-1</sup>, 583 cm<sup>-1</sup>, 485 cm<sup>-1</sup> (for substituted benzene). <sup>1</sup>H-NMR: 7.2-7.4 δ (Ar-H, multiplet), 6.10 δ (Ar-OH, singlet), 8.1 δ (-SO<sub>3</sub>H, singlet, 1H).

*1-[2,4-Dihydroxy-5-(naphthylazo-8-sulphonic acid)phenyl]-1-phenylmethanone (D<sub>5</sub>)*

Calculated for C<sub>23</sub>H<sub>15</sub>O<sub>6</sub>N<sub>2</sub>S: M. wt.: 447, % yield: 86, m. p.: 140-144°C, R<sub>f</sub> value: 0.86; C, 61.74 %; H, 3.35 %; N, 6.26 %; S, 7.17 %. Found: C, 61.70 %; H, 3.32 %; N, 6.23 %; S, 7.13 %. IR : 3580 cm<sup>-1</sup> (-OH, phenolic); 3070 cm<sup>-1</sup> (=CH, aromatic); 1621 cm<sup>-1</sup> (C=O, diaryl); 1575 cm<sup>-1</sup> (for naphthalene substitution); 1531 cm<sup>-1</sup> (N = N); 1482 cm<sup>-1</sup> (C=C, aromatic); 1463 cm<sup>-1</sup> (C-N); 1338 cm<sup>-1</sup> (C-O); 1034 cm<sup>-1</sup>, 650 cm<sup>-1</sup> (for sulphonic acid); 1103 cm<sup>-1</sup>, 732 cm<sup>-1</sup>, 574 cm<sup>-1</sup>, 473 cm<sup>-1</sup> (for substituted benzene). <sup>1</sup>H-NMR: 7.1-7.5 δ (Ar-H, multiplet), 6.3 δ (Ar-OH, singlet), 8.2 δ (-SO<sub>3</sub>H, singlet, 1H).

*1-[2,4-Dihydroxy-5-(phenylazo-2-carboxylic acid)phenyl]-1-phenylmethanone (D<sub>6</sub>)*

Calculated for C<sub>20</sub>H<sub>13</sub>O<sub>5</sub>N<sub>2</sub>: M. wt.: 361, % yield: 80, m. p.: 145-148°C, R<sub>f</sub> value: 0.83; C, 66.48 %; H, 3.60 %; N, 7.75 %. Found: C, 66.43 %; H, 3.58 %; N, 7.71 %. IR : 3430 cm<sup>-1</sup>

(-OH, phenolic); 3540  $\text{cm}^{-1}$  (-OH, acidic); 3062  $\text{cm}^{-1}$  (=CH, aromatic); 1634  $\text{cm}^{-1}$  (C=O, diaryl); 1678  $\text{cm}^{-1}$  (C=O, carboxylic acid); 1581  $\text{cm}^{-1}$  (N=N); 1483  $\text{cm}^{-1}$  (C=C, aromatic); 1352  $\text{cm}^{-1}$  (C-N); 1103  $\text{cm}^{-1}$  (C-O); 1100  $\text{cm}^{-1}$ , 850  $\text{cm}^{-1}$  (for carboxylic acid); 783  $\text{cm}^{-1}$ , 741  $\text{cm}^{-1}$ , 583  $\text{cm}^{-1}$ , 482  $\text{cm}^{-1}$  (for substituted benzene).  $^1\text{H-NMR}$ : 7.1-7.5  $\delta$  (Ar-H, multiplet), 5.5  $\delta$  (Ar-OH, singlet), 10.9  $\delta$  (-COOH, singlet, 1H).

*1-[2,4 -Dihydroxy -5-(phenylazo-4-sulphonic acid)phenyl]-1-phenylmethanone (D<sub>7</sub>)*

Calculated for  $\text{C}_{19}\text{H}_{13}\text{O}_6\text{N}_2\text{S}$ : M. wt.: 397, % yield: 83, m. p.: 150-154 $^{\circ}\text{C}$ , R<sub>f</sub> value: 0.85; C, 57.43 %; H, 3.27 %; N, 7.05 %; S, 8.07 %. Found: C, 57.39 %; H, 3.23 %; N, 7.01 %; S, 8.04 %. IR : 3590  $\text{cm}^{-1}$  (-OH); 3063  $\text{cm}^{-1}$  (=CH, aromatic); 1632  $\text{cm}^{-1}$  (C=O, diaryl); 1533  $\text{cm}^{-1}$  (N=N); 1471  $\text{cm}^{-1}$  (C=C, aromatic); 1324  $\text{cm}^{-1}$  (C-N); 1103  $\text{cm}^{-1}$  (C-O); 1031  $\text{cm}^{-1}$ , 652  $\text{cm}^{-1}$  (for sulphonic acid); 780  $\text{cm}^{-1}$ , 744  $\text{cm}^{-1}$ , 586  $\text{cm}^{-1}$ , 475  $\text{cm}^{-1}$  (for substituted benzene).  $^1\text{H-NMR}$ : 7.2-7.4  $\delta$  (Ar-H, multiplet), 6.1  $\delta$  (Ar-OH, singlet), 7.9  $\delta$  (-SO<sub>3</sub>H, singlet, 1H).

*Determination of the percentage exhaustion and fixation*

The dye bath percentage exhaustion and fixation of the dyed fabric was determined according to the known method<sup>20</sup> and is shown in Table 1.

**Table 1.** Absorption maxima ( $\lambda_{\text{max}}$ ), intensities (log  $\epsilon$ ), exhaustion (E) and fixation (F) of acid azo dyes on wool and silk.

Dyes No.	Absorption maxima $\lambda_{\text{max}}$ /nm in DMF	Intensities log $\epsilon$	Acid azo dyeing on wool		Acid azo dyeing on silk	
			%E	%F	%E	%F
D <sub>1</sub>	465	4.60	80	89	72	90
D <sub>2</sub>	445	4.36	75	94	75	87
D <sub>3</sub>	450	4.45	72	90	80	92
D <sub>4</sub>	435	4.27	85	89	76	88
D <sub>5</sub>	430	4.20	74	86	82	91
D <sub>6</sub>	420	4.18	71	88	75	89
D <sub>7</sub>	422	4.21	85	92	78	90

*Fastness property*

The fastness to light, sublimation and perspiration of dye pattern was assessed according to British standard: 1006-1978 and the wash fastness test according to Indian standard: IS: 765-1979. The rubbing fastness was tested by using Crock meter (Atlas) AATCC-1961, shown in Table 2 to 5.

**Table 2.** Results of acid azo dyeing and various fastness properties of dyes on wool.

Dyes No.	Color shades on wool	Light fastness	Washing fastness	Perspiration fastness		Sublimation fastness	Rubbing fastness	
				Acid	Alkaline		Dry	Wet
D <sub>1</sub>	Pinkish blue	5	5	4	5	4	4	4
D <sub>2</sub>	Pinkish blue	5	4	5	4	4	4	4
D <sub>3</sub>	Reddish brown	5	5	5	5	5	5	4
D <sub>4</sub>	Yellowish pink	4	5	4	5	4	4	3
D <sub>5</sub>	Chocolate brown	4	4	5	5	4	5	4
D <sub>6</sub>	Red	5	5	5	5	5	4	3
D <sub>7</sub>	Red	5	4	5	5	4	5	4

**Table 3.** Results of acid azo dyeing and various fastness properties of dyes on silk.

Dyes No.	Color shades on silk	Light fastness	Wash fastness	Perspiration fastness		Sublimation fastness	Rubbing fastness	
				Acid	Alkaline		Dry	Wet
D <sub>1</sub>	Pinkish blue	5	4	4	5	5	4	3-4
D <sub>2</sub>	Pinkish blue	5	4	5	4	4	4	3
D <sub>3</sub>	Reddish brown	4	4	4	5	5	4	4
D <sub>4</sub>	Yellowish pink	4	4	4	4	4	4	3-4
D <sub>5</sub>	Chocolate brown	5	5	4	4	4	5	4
D <sub>6</sub>	Red	5	4	4	4	5	4	4
D <sub>7</sub>	Red	5	4	4	4	5	5	3-4

**Table 4.** Results of mordent acid azo dyeing and various fastness properties of dyes on wool.

Dyes No.	Color shades on wool	Light fastness	Washing fastness	Perspiration fastness		Sublimation fastness	Rubbing fastness	
				Acid	Alkaline		Dry	Wet
D <sub>1</sub>	Pinkish blue	5	5	4	5	5	5	4
D <sub>2</sub>	Pinkish blue	5	5	5	4	5	4	4
D <sub>3</sub>	Reddish brown	5	5	5	5	5	5	4
D <sub>4</sub>	Yellowish pink	5	5	5	5	5	5	4
D <sub>5</sub>	Chocolate brown	5	4	5	5	4	5	4
D <sub>6</sub>	Red	5	5	5	5	5	4	4
D <sub>7</sub>	Red	5	5	5	5	5	5	4

**Table 5.** Results of mordent acid azo dyeing and various fastness properties of dyes on silk.

Dyes No.	Color shades on silk	Light fastness	Wash fastness	Perspiration		Sublimation	Rubbing	
				Acid	Alkaline		fastness	Dry
D <sub>1</sub>	Pinkish blue	5	5	4	5	5	5	4
D <sub>2</sub>	Pinkish blue	5	5	5	4	5	4	4
D <sub>3</sub>	Reddish brown	5	5	5	5	5	5	4
D <sub>4</sub>	Yellowish pink	5	5	5	5	5	5	4
D <sub>5</sub>	Chocolate brown	5	4	5	5	4	5	4
D <sub>6</sub>	Red	5	5	5	5	5	4	4
D <sub>7</sub>	Red	5	5	5	5	5	5	4

## Results and discussion

### *Physical properties of dyes*

All the dyes are obtained as crystal powder ranging from yellowish pink to pinkish blue in colours. The purity of the dyes were checked by TLC using methanol-water-acetic acid (12:3:7) solvent system. The TLC results show that only single spot observed for each dye. The purified dyes have melting point measured by open capillary tube. The melting points were uncorrected.

The results of elemental analysis content of each dyes are consistent with the predicted structure as shown in Scheme 1. The number of azo group is almost one for each dye. The nitrogen content and number of azo group for each dye are co-related with each other. The IR spectrum of each dye comprises the important features of aromatic, azo, hydroxyl and keto groups. The  $^1\text{H}$  NMR spectra of all the diazo compounds based on 2,4-dihydroxybenzophenone shows an important signals at their respective positions confirmed the structures of various dyes as shown in Scheme 1.

The visible absorption spectroscopic properties of dyes were recorded in double distilled water. The absorption maxima ( $\lambda_{\text{max}}$ ) of all the dyes fall into the range of 422-465 nm in water, as shown in Table 1. The value of the logarithm of molar extinction coefficient ( $\log \epsilon$ ) of all the dyes were in the range of 4.21 – 4.60, consistent with their high intensity of absorption.

Moreover, the presence of electron donating or electron attracting groups did not bring about any marked increase or decreased in  $\lambda_{\text{max}}$  in the visible region and that  $\log \epsilon$  remained nearly constant. However, electron attracting substituents like  $-\text{SO}_3\text{H}$  and  $-\text{COOH}$  in the substituent group of the coupler increase polarizability, and will results in bathochromic shifts. This leads to decrease in energy between the highest occupied molecular orbital and lowest unoccupied molecular orbital and thus  $\pi \rightarrow \pi^*$  electronic transition takes place at lower frequency photon, resulting in the bathochromic shift of the visible absorption band.

#### *Dyeing properties of dyes*

The acid azo dyes were applied at 2% depth on wool and silk fabric respectively. Their dyeing properties are given in Table 2 to Table 5. These dyes gave a wide range of colours varying from yellowish pink to pinkish blue shades with good levelness, brightness and depth on the fabrics. The variation in the shades of the dye fabric results from both the nature and position of the substituent present on the diazotized compound. The dyeing showed an excellent fastness to light, with very good to excellent fastness to washing, perspiration and sublimation, however it shows poor rubbing fastness.

A remarkable degree of levelness after washing is observed. This may be attributed to good penetration and affinity of the dye molecule in to fiber structure. The most prominent features of these dyes is that, the dye patterns treated with Cr (III) salt solution afford excellent shining shade of dyes. This might be due to the chrome complex formation on fiber matrix. The bacterial activities of chrome complexes of dyes were monitored against the plant pathogens. The results show that these dyes are inhibiting the bacteria about 70 to 80% and are shown in Table 6. The dye pattern of chrome treated dye may be affordable for human body.

**Table 6.** Antibacterial activity of acid azo chrome dyes (D<sub>1</sub>-D<sub>7</sub>).

Dyes No.	Organism			
	<i>E. coli</i>	<i>S. aureus</i>	<i>S. typhi</i>	<i>B. subtilis</i>
D <sub>1</sub>	+++	++	++	++
D <sub>2</sub>	+	+	+	+
D <sub>3</sub>	+++	++	++	++
D <sub>4</sub>	+	+	+	+
D <sub>5</sub>	+	+	+	+
D <sub>6</sub>	++	++	+	++
D <sub>7</sub>	+++	+++	++	++

(Diameter of inhibition zone in mm; concentration 100  $\mu\text{g}/\text{mL}$ )

(-) = inactive (10 mm and less); (+) = weakly active (11-15 mm);

(++) = moderately active (16-20 mm); (+++) = highly active (21 mm and above).

## Conclusions

Produced acid azo dyes have good fastness to light, sublimation and perspiration but show poor rubbing fastness properties. The nature of the substituent in the coupling components has a little influence on the visible absorption and shade of the dyeing. Comparison of above two dyes reveals that mordent acid azo dyes have better shades than acid azo dyes.

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