



*J. Serb. Chem. Soc.* 74 (8–9) 917–926 (2009)  
JSCS–3887

## Synthesis, characterization, chelation with transition metal ions, and antibacterial and antifungal studies of the 4-[(*E*)-phenyldiazenyl]-2-[(*E*)-(phenylimino)methyl]phenol dye

NURCAN KURTOGLU\*

*Kahramanmaraş Sütçü İmam University, Department of Textile Engineering,  
Avşar campus, 46050, Kahramanmaraş, Turkey*

(Received 26 November 2008, revised 12 January 2009)

**Abstract:** New Ni(II), Cu(II) and Co(II) complexes were synthesized with the bidentate azo-azomethine dye, 4-[(*E*)-phenyldiazenyl]-2-[(*E*)-(phenylimino)methyl]phenol (dmpH), which was prepared by the reaction of 2-hydroxy-5-[(*E*)-phenyldiazenyl]benzaldehyde with aniline in EtOH. The syntheses of the metal chelates of the azo-azomethine dye were realized by the precipitation technique. The synthesized metal complexes were characterized by elemental analysis, molar conductance measurements, as well as infrared and UV-Vis spectral data. Based on these characterizations, the metal complexes of the transition metal ions may be formulated as  $[M(dmp)Cl(H_2O)]$  where  $M = Ni(II), Cu(II)$  and  $Co(II)$ . The metal complexes were formed by the coordination of N and O atoms of the ligand. The molar conductance values of the Ni(II), Cu(II) and Co(II) complexes of the bidentate ligand indicate their non-ionic character. The free ligand and its metal complexes were tested for their *in vitro* antimicrobial properties against eight bacteria: *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Mycobacterium smegmatis*, *Pseudomonas aeruginosa*, *Enterococcus cloacae*, *Bacillus megaterium*, and *Micrococcus luteus*, and three fungi, *Kluyveromyces fragilis*, *Rhodotorula rubra* and *Saccharomyces cerevisiae*, in order to assess their antimicrobial potential. The  $[Ni(dmp)Cl(H_2O)]$  chelate exhibited high activity against all the bacteria and fungi, except *Rhodotorula rubra*.

**Keywords:** azo dye; azo-azomethine; transition metals; spectroscopy; antimicrobial activity.

### INTRODUCTION

Colorants, which include chromophores of dyes usually consisting of C=C, N=N, C=N, and aromatic and heterocyclic rings, containing oxygen, nitrogen or sulfur, have been widely used as dyes owing to their versatility in various fields

\* E-mail: nkurtoglu@ksu.edu.tr

doi: 10.2298/JSC0909917K

and high technologies, including textiles, paper, leather, plastics, biological staining, lasers, liquid crystalline displays, ink-jet printers, and in specialized applications, such as food, drug, cosmetic and photochemical productions.<sup>1-4</sup> Dyes used before the nineteenth century were either of vegetable (*i.e.*, weld, madder, indigo) or animal origin (*i.e.*, cochineal, shellfish) and belonged to various chemical types, such as flavonoids (yellow), anthraquinones (red) and indigoids (blue and violet).<sup>5</sup> These chemical types of anthraquinoid dyes provide the most important red dyes and lakes used in artistic paintings. Synthetic dyes are extensively used in industry and a vast amount of the dyes produced enter the environment as waste material.<sup>6</sup> The main synthetic dye classes include azo, anthraquinone and triarylmethane dyes which constitute more than half of the dyes used in industrial applications. Azo dyes are widely used in the textile industry and are the largest and most versatile group of synthetic organic dyes, with a tremendous number of industrial applications.<sup>7</sup>

Schiff base metal complexes have the ability to reversibly bind oxygen in epoxidation reactions,<sup>8</sup> biological activity,<sup>9,10</sup> catalytic activity in hydrogenation of olefins<sup>11,12</sup> and photochromic properties.<sup>13</sup> Also, Schiff bases can be used in the degradation of organic compounds<sup>14</sup> and in radiopharmaceuticals.<sup>15</sup>

In previous studies, the synthesis and characterization of various bidentate compounds and some of their properties were investigated.<sup>16-20</sup> In this article, because of the importance of azo-azomethine compounds and in continuance of present interest in the syntheses of azo and azomethine compounds, the syntheses, complex formation and characterization using different techniques, in particular the elemental analyses, molar conductivity, infrared and electronic spectroscopy, of 4-[(*E*)-phenyldiazenyl]-2-[(*E*)-(phenylimino)methyl]phenol are reported. The ligand was synthesized by the reaction of 2-hydroxy-5-[(*E*)-phenyldiazenyl]benzaldehyde with aniline in EtOH solution at the boiling point. Its complexing ability with Ni(II), Cu(II) and Co(II) salts was examined. The structure of the metal chelates is proposed.

## EXPERIMENTAL

### *Reagents*

Aniline and salicylaldehyde were purchased from Aldrich. 2-Hydroxy-5-[(*E*)-phenyldiazenyl]benzaldehyde was prepared as described previously.<sup>21-23</sup> NiCl<sub>2</sub>·6H<sub>2</sub>O, CuCl<sub>2</sub>·2H<sub>2</sub>O and CoCl<sub>2</sub>·6H<sub>2</sub>O (Merck) were used as purchased with no additional purification. All solvents were of reagent grade and used without further purification.

### *Physical measurements*

The microanalyses for carbon, hydrogen, nitrogen were performed by the TUBITAK Analyses Center. The proton NMR spectrum of the azo ligand was determined in the İnönü University Laboratories, Malatya, Turkey. The infrared spectra (KBr disc) were recorded in the 4000–400 cm<sup>-1</sup> range on a Shimadzu 8300 FT-IR spectrometer. The electronic spectra were obtained on a Shimadzu 160A UV spectrometer. The melting points were measured with an Electrothermal LDT 9200 apparatus in open capillaries.

*Synthesis of 4-[(E)-phenyldiazenyl]-2-[(E)-(phenylimino)methyl]phenol, dmpH (1)*

The azo-azomethine compound was prepared according to a literature method (Fig. 1).<sup>16</sup> Aniline (0.043 g, 0.5 mmol) and 0.104 g (0.460 mmol) 2-hydroxy-5-[(E)-phenyldiazenyl]-benzaldehyde were dissolved in 75 mL absolute EtOH with a few drops of glacial acetic acid as a catalyst. The solution was refluxed for 5 h and then left at room temperature. After cooling, the azo-azomethine dye was obtained as orange microcrystals. The microcrystals were filtered off, washed with 20 mL of cold absolute EtOH and then dried.

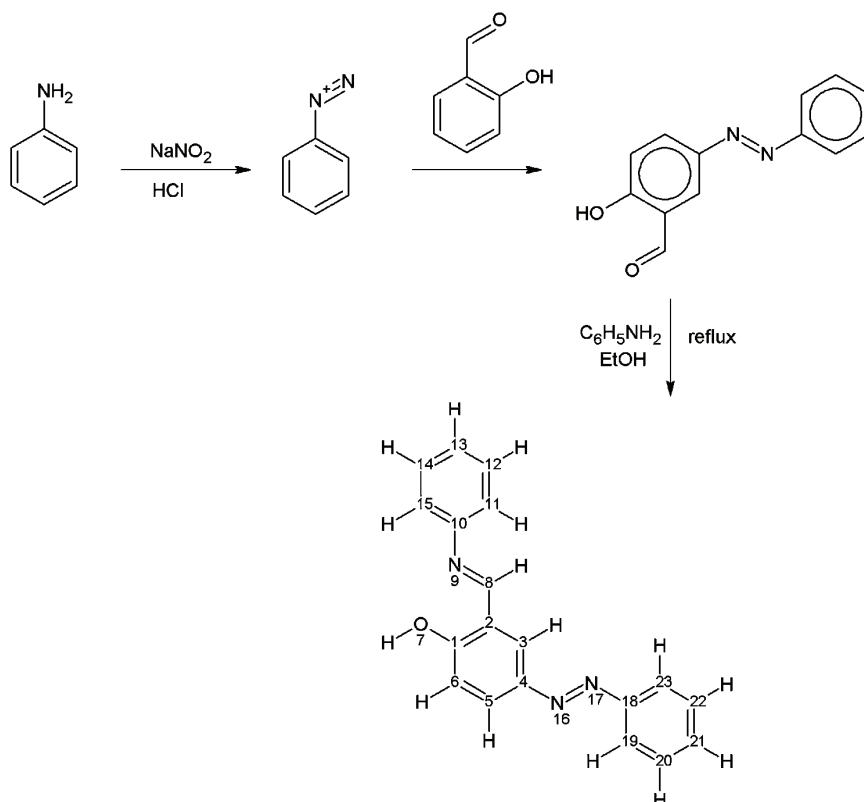


Fig. 1. Preparation of the azo-azomethine dye.

*Synthesis of [Ni(dmp)Cl(H<sub>2</sub>O)] (2)*

A methanolic solution (15 mL) of (0.040 g,  $1.66 \times 10^{-4}$  mol) nickel(II) chloride was added to 15 mL of a clear solution of dmpH (0.050 g,  $1.66 \times 10^{-4}$  mol) in 10 mL MeOH. The resulting mixture was refluxed for 4 h on a water bath. The volume was reduced to half by slow evaporation. After cooling, the red colored complex precipitated out, which was filtered off, washed several times with EtOH and dried *in vacuo*.

*Synthesis of [Co(dmp)Cl(H<sub>2</sub>O)] (3)*

A solution of  $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$  (0.516 g, 0.0200 mmol) in 10 mL of MeOH was added to a magnetically stirred 15 mL MeOH solution containing the ligand (0.653 g, 0.0217 mol) and then refluxed for 2 h. The obtained solution was left at room temperature. The cobalt(II) com-

plex was obtained as a reddish brown precipitate. The product was filtered off, washed with cold EtOH and then dried under vacuum.

#### Synthesis of $[Cu(dmp)Cl(H_2O)]$ (4)

Copper(II) chloride hexahydrate (0.0524 g,  $3.08 \times 10^{-4}$  mol) dissolved in MeOH (10 mL) was added to a hot solution of the azo-azomethine ligand (0.0928 g,  $3.08 \times 10^{-4}$  mol) dissolved in MeOH (20 mL). The pH was adjusted to 5–6 using alcoholic sodium hydroxide (0.010 M). The resulting solution was stirred and heated on a hot plate at 70 °C for 30 min. The volume of the obtained solution was reduced to one-half by evaporation. One day later, a greenish brown colored solid of the complex formed, which was filtered, the solid washed with cold EtOH and Et<sub>2</sub>O and finally dried under vacuum.

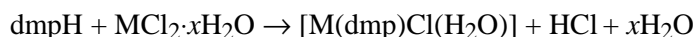
#### Biological studies

The azo-azomethine dye and its metal complexes were evaluated for both their *in vitro* antibacterial activity against *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Mycobacterium smegmatis*, *Pseudomonas aeruginosa*, *Enterococcus cloacae*, *Bacillus megaterium* and *Micrococcus luteus*, and their *in vitro* antifungal activity against *Kluyveromyces fragilis*, *Rhodotorula rubra* and *Saccharomyces cerevisiae* by the disc diffusion method.<sup>24,25</sup>

### RESULTS AND DISCUSSION

#### Synthesis of the coordination compounds

The dye, 4-[(*E*)-phenyldiazenyl]-2-[(*E*)-(phenylimino)methyl]phenol was prepared by reacting aniline with 2-hydroxy-5-[(*E*)-phenyldiazenyl]benzaldehyde, obtained by treating a solution of aniline with salicylaldehyde in EtOH medium with an aqueous solution of NaNO<sub>2</sub> at –5 °C. The structure of the azo-azomethine dye was demonstrated by a combination of analytical, spectroscopic and single crystal X-ray studies. The level of impurity in the product was checked by thin layer chromatography. The single crystal structure of the azo-azomethine ligand has been reported and discussed in a previous paper.<sup>16</sup> In methanolic solution (pH 5–6), the ligand undergoes deprotonation to form 1:1 mononuclear complexes with Ni(II), Co(II) and Cu(II) metal ions:



#### Characterization and analytic data of the ligand and the complexes

4-[(*E*)-phenyldiazenyl]-2-[(*E*)-(phenylimino)methyl]phenol, *dmpH* (I). Yield: 0.12 g (85 %). m.p. 137–138 °C. Anal. Calcd. for C<sub>19</sub>H<sub>15</sub>N<sub>3</sub>O (301.3 g/mol): C, 75.73; H, 5.02; N, 13.94 %; Found: C, 75.64; H, 5.09; N, 13.86. FTIR (KBr, cm<sup>-1</sup>): 3420 (Ar–OH), 3049 (Ar–C–H), 1620 (–CH=N–), 1346 (–N=N–). <sup>1</sup>H-NMR (DMSO-*d*<sub>6</sub>, δ / ppm): 13.87 (1H, s, –OH), 9.17 (1H, s, –CH=N–), 8.32–8.30 (2H, *d*, *J* = 9.1 Hz, Ar–H), 8.04–7.99 (5H, *dd*, *J* = 8.9 Hz, Ar–H), 7.88–7.85 (1H, *d*, *J* = 8.6 Hz, Ar–H), 7.62–7.57 (5H, *m*, Ar–H). UV–Vis (EtOH, λ<sub>max</sub> / nm): 272 (π→π\*, Ar–C=C), 320 (π→π\*, –CH=N–), 333 (π→π\*, –N=N–), 345 (n→π\*, –CH=N–), 452 (n→π\*, –N=N–). UV–Vis (DMF, λ<sub>max</sub> / nm): 277 (π→π\*, Ar–

C=C), 326 ( $\pi \rightarrow \pi^*$ , -CH=N-), 343 ( $\pi \rightarrow \pi^*$ , -N=N-), 360 ( $n \rightarrow \pi^*$ , -CH=N-), 460 ( $n \rightarrow \pi^*$ , -N=N-).  $\Lambda_M = 13 \Omega^{-1} \text{ cm}^2 \text{ mol}^{-1}$ .

[Ni(dmp)Cl(H<sub>2</sub>O)] (2). Yield: 65 %. m.p. 225 °C. Anal. Calcd. for C<sub>19</sub>H<sub>16</sub>ClN<sub>3</sub>NiO<sub>2</sub> (412.50 g/mol): C, 55.32; H, 3.91; N, 10.19 %; Found: C, 55.07; H, 3.69; Cl, 8.44; N, 10.42 %. FTIR (KBr, cm<sup>-1</sup>): 3415  $\nu$ (OH), 3064  $\nu$ (Ar-C-H), 1618  $\nu$ (C=N), 1350  $\nu$ (-N=N-), 941, 569  $\nu$ (Ni-O), 447  $\nu$ (Ni-N). UV-Vis (DMF,  $\lambda_{\text{max}}$  / nm): 229 ( $\pi \rightarrow \pi^*$ ), 279 ( $\pi \rightarrow \pi^*$ ), 347 ( $n \rightarrow \pi^*$ ), 363 ( $n \rightarrow \pi^*$ ), 443 (d $\rightarrow$ d).  $\Lambda_M = 15 \Omega^{-1} \text{ cm}^2 \text{ mol}^{-1}$ .

[Co(dmp)Cl(H<sub>2</sub>O)] (3). Yield: 69 %. m.p. 258 °C. Anal. Calcd. for C<sub>19</sub>H<sub>16</sub>ClCoN<sub>3</sub>O<sub>2</sub> (412.74 g/mol): C, 55.29; H, 3.91; Cl, 8.59; N, 10.18; Co, 14.28 %; Found: C, 55.35; H, 3.68; Cl, 8.71; N, 9.96; Co, 14.07 %. FTIR (KBr, cm<sup>-1</sup>): 3439  $\nu$ (OH), 3039  $\nu$ (Ar-C-H), 1613  $\nu$ (C=N), 1382  $\nu$ (-N=N-), 563  $\nu$ (Co-O), 447  $\nu$ (Co-N). UV-Vis (DMF,  $\lambda_{\text{max}}$  / nm): 235 ( $\pi \rightarrow \pi^*$ ), 293 ( $\pi \rightarrow \pi^*$ ), 346 ( $n \rightarrow \pi^*$ ), 428 ( $n \rightarrow \pi^*$ ), 605 (d $\rightarrow$ d), 669 (d $\rightarrow$ d).  $\Lambda_M = 25 \Omega^{-1} \text{ cm}^2 \text{ mol}^{-1}$ .

[Cu(dmp)Cl(H<sub>2</sub>O)] (4). Yield: 71 %. m.p. >250 °C. Anal. Calcd. for C<sub>19</sub>H<sub>16</sub>ClCuN<sub>3</sub>O<sub>2</sub> (417.35 g/mol): C, 54.68; H, 3.86; Cl, 8.49; N, 10.07; Cu, 15.23 %; Found: C, 54.55; H, 3.74; Cl, 8.27; N, 10.16; Cu, 15.32 %. FTIR (KBr, cm<sup>-1</sup>): 3458  $\nu$ (OH), 3058  $\nu$ (Ar-C-H), 1611  $\nu$ (C=N), 1379  $\nu$ (-N=N-), 530  $\nu$ (Cu-O), 455  $\nu$ (Cu-N). UV-Vis (DMF,  $\lambda_{\text{max}}$  / nm): 234 ( $\pi \rightarrow \pi^*$ ), 274 ( $\pi \rightarrow \pi^*$ ), 352 ( $n \rightarrow \pi^*$ ), 370 ( $n \rightarrow \pi^*$ ), 412 (d $\rightarrow$ d).  $\Lambda_M = 21 \Omega^{-1} \text{ cm}^2 \text{ mol}^{-1}$ .

The structures of the ligand and corresponding complexes were elucidated based on <sup>1</sup>H-NMR, IR and UV-Vis spectra, elemental analysis and molar conductivity. In the complexes, the chloride ions were found to be coordinated to the metal ions as confirmed by the conductivity measurements.

#### Solubility and molar conductance

All of the metal chelates, [Ni(dmp)Cl(H<sub>2</sub>O)], [Cu(dmp)Cl(H<sub>2</sub>O)] and [Co(dmp)Cl(H<sub>2</sub>O)] are stable in air and soluble in DMF and insoluble in water and *n*-hexane. Single crystals of the metal chelates could not be isolated from any organic solution, thus no definite structures can be described. However, the analytical, spectroscopic and conductivity data enabled possible structures to be predicted as shown in Fig. 2. The molar conductance values of the complexes 2–4 in DMF were in the range 15–25  $\Omega^{-1} \text{ cm}^2 \text{ mol}^{-1}$ , indicating that they are non-electrolytes.

#### Elemental analyses

The elemental analysis results of the complexes of the ligand 1 are in good agreement with the theoretical calculations. The data show a 1:1 (M:dmpH) ratio of the complexes with formulae [M(dmp)Cl(H<sub>2</sub>O)].

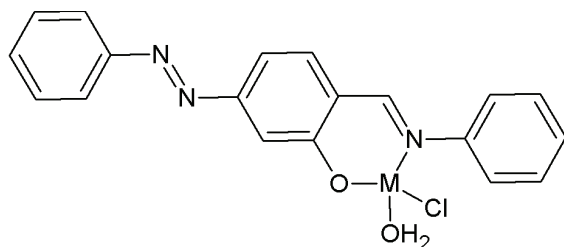


Fig. 2. The proposed general structure of the metal chelates.

### <sup>1</sup>H-NMR spectrum of the ligand

Proton nuclear magnetic resonance spectral analysis was performed for the synthesized dye which provided further evidence for the structural characteristics of the dye. The <sup>1</sup>H-NMR spectrum of the dye showed a signal at  $\delta$  13.87 ppm.<sup>26</sup> This chemical shift can be attributed to hydrogen bonded O–H proton. The aldehyde compound containing an azo group exhibited a peak in its <sup>1</sup>H-NMR spectrum at  $\delta$  10.32 ppm as a singlet belonging to the proton of the –CHO group. However, the aldehyde peak disappeared in the azo-azomethine dye. The proton of the azomethine group appeared at  $\delta$  9.17 ppm as a singlet (Fig. 3). The <sup>1</sup>H-NMR spectrum of the dye showed *d* peaks at  $\delta$  8.32–8.30 ppm (H-3), a *dd* at  $\delta$  8.04–7.99 ppm (H-5) and a *d* at  $\delta$  7.88–7.87 ppm (H-6), which are attributed to phenyl protons, including the –OH group.<sup>22</sup> These results show that the azo-azomethine dye shifts to the enol-imine form. The multiple peaks appearing at  $\delta$  7.62–7.57 ppm are also attributed to aromatic protons.<sup>2</sup>

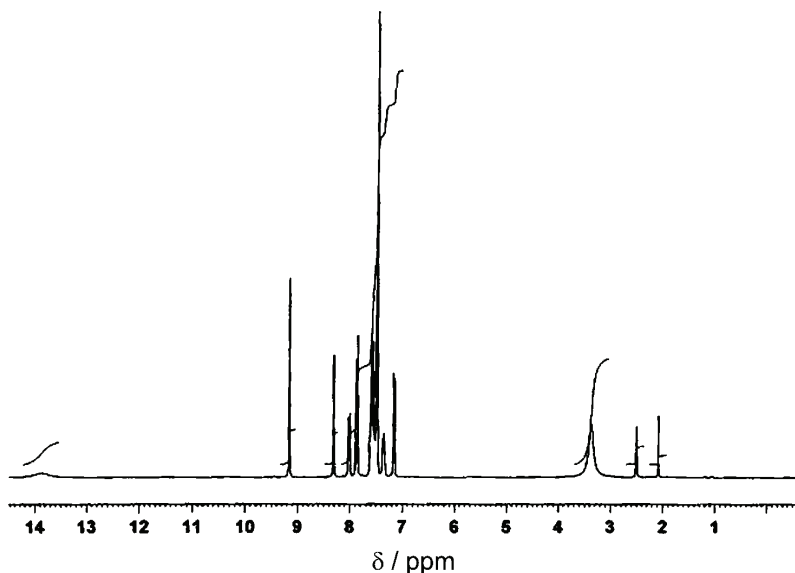


Fig. 3. <sup>1</sup>H-NMR spectrum of the dye.

### IR spectra

The IR spectra of the complexes were studied to characterize their structures. The IR spectra of the dmpH ligand **1** and its metal complexes were taken as KBr pellets.

The ligand spectrum revealed a broad band at  $3420\text{ cm}^{-1}$  corresponding to the vibration of the O–H group present in the structure.<sup>2</sup> The band observed at  $3049\text{ cm}^{-1}$  is due to the presence of aromatic C–H bonds in the structure. Especially, the band observed at  $1620\text{ cm}^{-1}$  indicates the azomethine (–CH=N–) group, which was not present in the starting material but forms in the resulting product as a result of the condensation reaction.<sup>27</sup> This band is shifted in the metal chelates toward lower frequencies because of the coordination of the nitrogen to the metal ion. This fact can be explained by the withdrawing of electrons from nitrogen atom to the metal ion on coordination. The band observed at  $1346\text{ cm}^{-1}$  is an indication of the –N=N– group. The peak at  $3420\text{ cm}^{-1}$  in the spectrum of the ligand corresponding to the OH group was observed at  $3415\text{ cm}^{-1}$  in the spectrum of **2**. The peak observed at  $3064\text{ cm}^{-1}$  is due to the aromatic C–H group in the complex. The peak at  $1618\text{ cm}^{-1}$  is due to C=N. These values are in good accordance with the values cited in the literature. The peak appearing at  $3420\text{ cm}^{-1}$  in the IR spectrum of the ligand corresponding to OH group was observed to appear at  $3439\text{ cm}^{-1}$  in the IR spectrum of **4**. The peak aromatic C–H group was observed at  $3039\text{ cm}^{-1}$ . The peak at  $1613\text{ cm}^{-1}$  corresponds to the vibration mode of the C=N group. The peak appearing at  $3420\text{ cm}^{-1}$  in the spectrum of the ligand, corresponding to the OH group, was observed at  $3458\text{ cm}^{-1}$  in the IR spectrum of **3**. The peak corresponding to the imine group appeared at  $1611\text{ cm}^{-1}$ . The peaks appearing at  $530$  and  $455\text{ cm}^{-1}$  were attributed to the Cu–O and Cu–N groups. In the infrared spectra of the complexes, bands assigned to M–O and M–N were identified between  $569$ – $530\text{ cm}^{-1}$  and  $455$ – $447\text{ cm}^{-1}$ , respectively.<sup>28</sup>

### Electronic spectra

The electronic spectra of the dye and its metal chelates were recorded in both EtOH and DMF between 200 and 800 nm. The room temperature UV–Vis absorption spectrum of the synthesized dye (dmpH) displayed mainly five bands observed within the range 200–800 nm in EtOH and DMF solution. The first band at 272 nm as a shoulder was assigned to the moderate energy  $\pi\rightarrow\pi^*$  transition of the aromatic ring, while the second band at 320 nm is due to the low energy  $\pi\rightarrow\pi^*$  transition of the –CH=N– group.

The peaks belonging to the azomethine group in the spectra of **2**, **3** and **4** coordination compounds were observed at 347, 350, 342 nm, respectively. The bands at 333 in EtOH and 343 nm in DMF were assigned to the  $\pi\rightarrow\pi^*$  transition of the –N=N– azo group. The other bands in EtOH at 345 and 452 nm were due to  $n\rightarrow\pi^*$  transitions of the –CH=N– and –N=N– groups of the dye, respecti-

vely.<sup>29</sup> These transitions were observed at 360 and 460 nm in DMF solutions, respectively. The peaks belonging to the –N=N– group in the spectra of the complexes **2**, **3** and **4** appeared at 363, 389 and 370 nm, respectively. The d–d transition bands in the spectra of the azo-azomethine dye complexes were observed at 412–605 nm. The spectroscopic data obtained in this work agreed well with the results of previous studies.

#### Biological activity

The antibacterial and antifungal activity of the new azo-azomethine chelates were tested by the disc diffusion method. The antibacterial and antifungal activities of the compounds against eight bacteria, namely *E. coli*, *S. aureus*, *K. pneumoniae*, *M. smegmatis*, *P. aeruginosa*, *E. cloacae*, *B. megaterium* and *M. luteus*, and three fungi, namely *K. fragilis*, *R. rubra* and *S. cerevisiae*, are presented in Table I. The results showed that the compound dmpH exhibited high activity against all the tested bacteria and fungi, except for *R. rubra*. The dye, compound **1**, showed the highest effect against *S. aureus* and *K. pneumoniae* among all the tested bacteria and *S. cerevisiae* among all the tested fungi. Compound **2** was quite effective against all the tested bacteria and fungi, with the exception of *R. rubra*, as in the case of compound **1**. However, compound **2** had the highest effect only against one bacterium, namely *S. aureus*, showing an inhibition zone of 22 mm. It is also clear from the data in Table I that compound **3** exhibited high activity against all the tested bacteria and fungi, showing an inhibition zone of 9–15 mm. Compound **4** exhibited moderate activity against all the tested bacteria and fungi, except for *R. rubra*. The copper complex showed the highest effect against *E. coli* and *B. megaterium* among all the tested bacteria and *S. cerevisiae* among all the tested fungi.

TABLE I. Antibacterial and antifungal activities (mm) of the synthesized dye and its complexes

Tested microorganisms	Compound			
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
<i>E. coli</i>	16	15	13	10
<i>S. aureus</i>	20	22	10	8
<i>K. pneumoniae</i>	20	19	12	8
<i>M. smegmatis</i>	15	15	11	7
<i>P. aeruginosa</i>	15	15	9	7
<i>E. cloacae</i>	15	15	12	7
<i>B. megaterium</i>	16	16	11	10
<i>M. luteus</i>	17	16	12	9
<i>K. fragilis</i>	14	15	15	11
<i>R. rubra</i>	0	0	10	0
<i>S. cerevisiae</i>	17	16	12	16



## CONCLUSIONS

In this work, an azo-azomethine dye ligand, 4-[(*E*)-phenyldiazenyl]-2-[(*E*)-(phenylimino)methyl]phenol (dmpH), derived from 2-hydroxy-5-[(*E*)-phenyldiazenyl]benzaldehyde and aniline in EtOH, and some of its transition metal complexes were prepared. The analytical data and spectroscopic studies suggested that the complexes had the general formula of  $[M(dmp)Cl(H_2O)]$ , where M is nickel(II), cobalt(II) or copper(II). The molar conductance measurements of the complexes showed their non-electrolytic nature. According to UV–Vis and IR data, the phenylazo-linked azo-azomethine dye was coordinated to the metal ion through the azomethine nitrogen and oxygen atom of the hydroxyl group in salicylaldehyde.

Based on the above results, the structure of the investigated coordination compounds can be formulated as in Fig. 2. The studied metal chelates exhibited high activity against *S. cerevisiae*.

## ИЗВОД

СИНТЕЗА, КАРАКТЕРИЗАЦИЈА, ХЕЛАЦИЈА ЈОНА ПРЕЛАЗНИХ МЕТАЛА, И АНТИБАКТЕРИЈСКА И АНТИФУНГАЛНА ИСПИТИВАЊА БОЈЕ 4-[(*E*)-ФЕНИЛДИАЗЕНИЛ]-2-[(*E*)-(ФЕНИЛИМИНО)МЕТИЛ]ФЕНОЛА

NURCAN KURTOGLU

*Kahramanmaraş Sütçü İmam University, Department of Textile Engineering,  
Avşar campus, 46050, Kahramanmaraş, Turkey*

Синтетисани су нови комплекси Ni(II), Cu(II) и Co(II) са бидентатном азо-азометинском бојом 4-[(*E*)-фенилдиазенил]-2-[(*E*)-(фенилимино)метил]фенолом (dmpH), добијеном у реакцији 5-[(*E*)-фенилдиазенил]-2-хидроксибензалдехида с анилином у EtOH. Синтезе металних хелата азо-азометинске боје изведене су техником таложења. Синтетисани комплекси су окарактерисани елементалном анализом, мерењем моларне проводљивости и на основу инфрацрвених и UV–Vis спектралних података. На основу ове карактеризације формула металних комплекса јона прелазних метала може бити  $[M(dmp)Cl(H_2O)]$  где је M = Ni(II), Cu(II) и Co(II). Метални комплекси су формирани координовањем N и O атома лиганда. Вредности моларне проводљивости комплекса Ni(II), Cu(II) и Co(II) бидентатног лиганда указују на њихов нејонски карактер. Испитана су антимикуробна својства *in vitro* слободног лиганда и комплекса на осам бактерија: *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Mycobacterium smegmatis*, *Pseudomonas aeruginosa*, *Enterococcus cloacae*, *Bacillus megaterium* и *Micrococcus luteus*, и три гљиве: *Kluyveromyces fragilis*, *Rhodotorula rubra* и *Saccharomyces cerevisiae*, како би се проценио њихов антимикуробни потенцијал. Хелат  $[Ni(dmp)Cl(H_2O)]$  је показао високу активност на све бактерије и гљиве, сем на гљиву *Rhodotorula rubra*.

(Примљено 26. новембра 2008, ревидирано 12. јануара 2009)

## REFERENCES

1. A. T. Peters, H. S. Freeman, *Colour chemistry, the design and synthesis of organic dyes and pigments*, Elsevier App. Sci. Publ., Barking, Essex, UK, 1991, p. 193

2. H. Kocaokutgen, M. Gur, M. S. Soylu, P. Lonneck, *Dyes Pigm.* **67** (2005) 99
3. P. Gregory, *High-technology applications of organic colorants*, Plenum Press, New York, 1991, p. 1
4. S. C. Catino, R. E. Farris, in: *Concise Encyclopedia of Chemical Technology*, M. Grayson, Ed., John Wiley & Sons, New York, 1985, p. 142
5. W. Nowik, *Encyclopedia of separation sciences*, Academic Press, London, 2000, p. 2602
6. H. Zollinger, *Color Chemistry – Synthesis, Properties and Application of Organic Dyes and Pigments*, VCH Publishers, New York, 1987, p. 1436
7. H. Ollgaard, L. Frost, J. Galster, O. C. Hansen, *Survey of azo-colorants in Denmark: consumption, use, health and environmental aspects*, Ministry of Environment and Energy, Denmark and the Danish Environmental Protection Agency, No. **XX**, 1998, p. 147
8. M. S. El-Medani, O. A. M. Ali, R. M. Ramaden, *J. Mol. Struct.* **738** (2005) 171
9. S. Ren, R. Wang, K. Komastu, P. B. Krause, Y. Zyrianov, C. E. McKenna, C. Csipke, Z. A. Tokes, E. J. Lien, *J. Med. Chem.* **45** (2002) 410
10. M. T. H. Tarafder, M. A. Ali, N. Saravana., W. Y. Weng, S. Kumar, N. U. Tsafe, K. A. Crouse, *Transition Met. Chem.* **25** (2000) 295
11. J. Colman, L. S. Hegedu, *Principles and Applications of Organotransition Metal Chemistry*, University Science Book, Herndon, VA, 1980
12. J. Zhan, B. Zhan, J. Liu, W. J. Xu, Z. Wang, *Spectrochim. Acta A* **57** (2001) 149
13. W. Liu, Y. Zou, Y. Li, Y. G. Yao, Q. J. Meng, *Polyhedron* **23** (2004) 849
14. H. Yoon, T. R. Wagler, K. J. O'Connor, C. J. Burrows, *J. Am. Chem. Soc.* **122** (1990) 4568
15. M. A. Green, H. Luo, P. E. Fanwick, *Inorg. Chem.* **37** (1998) 1127
16. M. Aslantaş, N. Kurtoğlu, E. Şahin, M. Kurtoğlu, *Acta Crystallogr., Section E: Struct. Rep. Online* **E63** (2007) O3637
17. M. Kurtoğlu, N. Birbiçer, U. Kimyonşen, S. Serin, *Dyes Pigments* **41** (1999) 141
18. N. Birbiçer, M. Kurtoğlu, S. Serin, *Synth. React. Inorg. Met. Org. Chem.* **29** (1999) 1353
19. N. Kurtoğlu, M. Kurtoğlu, S. Serin, *Synth. React. Inorg. Met. Org. Chem.* **29** (1999) 1779
20. N. Kurtoğlu, D. Şenol, *Asian J. Chem.* **20** (2008) 1986
21. M. S. Refat, I. M. El-Deen, H. K. Ibrahim, S. El-Ghool, *Spectrochim. Acta.* **65** (2006) 1208
22. M. Odabaşoğlu, Ç. Albayrak, R. Özkanca, F. Z.Akyan, P. Lonecke, *J. Mol. Struct.* **840** (2006) 71
23. S. Çakır, E. Biçer, M. Odabaşoğlu, Ç. Albayrak, *J. Braz. Chem. Soc.* **16** (2005) 711
24. C. H. Collins, P. M. Lyne, *Microbial Methods*, University Park Press, Baltimore, 1970, p. 422
25. M. Kurtoglu, E. Ispir, N. Kurtoglu, S. Serin, *Dyes Pigments* **77** (2008) 75
26. K. Nejati, I. Z. Rezvani, *New J. Chem.* **27** (2003) 1665
27. V. P. Singh, P. Gupta, *J. Coord. Chem.* **61** (2008) 1532
28. F. Karipcin, E. Kabalcilar, *Acta Chim. Slov.* **54** (2007) 242
29. H. Karaer, I. E. Gümrükçüoğlu, *Turk. J. Chem.* **23** (1999) 67.