

Preparation, Characterization and Antibacterial Studies of Schiff Base Derivatives with 4-Bromo-2,6-Dimethylaniline and Study their Complexes with Some Transition Metal Ions

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ABSTRACT

New complexes of some transition metal ions [Cr(III), Cu(II) and Zn(II)] with prepared ligand 2-(((4-(1-((4-bromo-2,6-dimethylphenyl)imino)ethyl)phenyl)imino)methyl)phenol were synthesized. The new complexes' structures were characterized by elemental microanalysis (CHN), Fourier transforms infrared (FTIR), ultraviolet-visible (UV-visible) spectra, thermal gravimetric analysis-differential thermal gravimetric, flame atomic absorption, molar conductivity, magnetic susceptibility measurement, and mass spectra. According to the obtained data, the probable coordination geometries of these complexes were suggested as octahedral. All complexes were found to be non-electrolyte.

Keywords: Non-electrolyte, Transition metal ions.

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INTRODUCTION

Schiff bases have been known since 1864 by Hugo Schiff.¹ A Schiff base or Schiff's base is a type of chemical compounds containing a carbon-nitrogen double bond as a functional group, where the nitrogen atom connected to aryl group or alkyl group (R) but not hydrogen, where R stand for a phenyl or alkyl group which makes the Schiff base a stable imine. The Schiff bases are generally prepared by condensation of primary amines (-NH₂) with active carbonyl compounds like aldehydes and ketones (>C=O). They are also known as imines and azomethine.² This kind of ligands is able to coordinate with metal ions through the imine nitrogen and another group, usually linked to the aldehyde and there is a wide use of these metal complexes as catalysts.³ Schiff bases are considered as a very important class of organic compounds, having wide applications in many biological aspects, proteins, visual pigments, enzymic aldolization and decarboxylation reactions. Moreover, some Schiff bases and their metal complexes exhibit antibiotic, antitumor, anticancer, antibacterial, antifungal, corrosion inhibition, anti-inflammatory, antimalarial, antiviral activity, anti-HIV,⁴ determination of atrazine,⁵ synthesis of pesticides,⁶ thermal behavior,⁷ antioxidant,⁸ catalysts in polymer,⁹ electronic structure,¹⁰ dyes industry,¹¹ antifertility,¹² and enzymatic agents.¹³ An interesting application of Schiff bases is their use as

an effective corrosion inhibitor, which is based on their ability to form a monolayer on the surface to be protected spontaneously.

EXPERIMENTAL

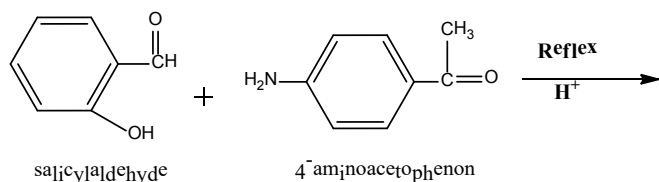
Material and Reagent

The chemicals used included 4-bromo-2,6-dimethylaniline (Fluka), 4-aminoacetophenone (Merck), salicylaldehyde (Sigma- Aldrich), CuCl₂.2H₂O (Merck), CrCl₃.6H₂O (BDH), ZnCl₂ (BDH). The organic solvents which were used included ethanol 95% (BDH), DMSO (BDH), and Petroleum ether (30-60°C) (Fluka).

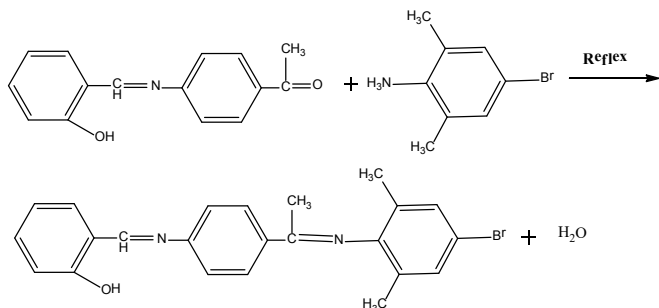
Synthesis of Ligand

4-aminoacetophenone (1 mmole), (0.14 g), was dissolved in absolute ethanol (12 mL) then 5 drops of glacial acetic acid were added. Salicylaldehyde (15 mL), (0.13 g) was added to the solution of 4-aminoacetophenone. The mixture was heated under reflux at a temperature of 75°C for 12 hours. During this period, a violet solid compound was formed, which was washed with ethanol to remove unreacted materials and dried in oven under 70°C shown in the following equation:

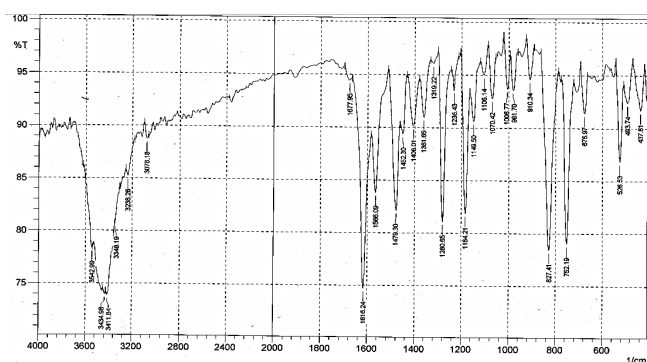
Step 2: Mixing (1 mmole), (0.26 g), from the derivative recorded above with 1 mmole, 12g from 4-bromo-2,6-dimethylaniline in 30 mL ethanol absolute. The mixture was heated under reflux at temperature 80°C for 6 hours then let the



Scheme 1: Preparation of Ligand Step 1



Scheme 2: Preparation of Ligand Step 2

Figure 1: FTIR spectrum of the ligand (L₁)

mixture to cool until the solid precipitate is filtered, washed by absolute ethanol, and dried to get pure violet crystals as shown in the following equation:

Preparation of Complexes

A solution of 0.786 g and 0.001 mol of the ligand (L) in 10 mL of absolute ethanol was added dropwise to warm solution (0.001mol) of metal salts (0.34 g, 0.532 g and 0.272 g for CrCl₃.6H₂O, CuCl₂.2H₂O and ZnCl₂ respectively) dissolved in 15 mL absolute ethanol and the mixture was refluxed for 4–8 hours. Colored crystalline compounds were formed, and products were filtered, washed with ethanol and dried.

RESULT AND DISCUSSION

Microanalysis

The importance of preparing Schiff base compounds arises from their versatility as starting materials for the synthesis of many compounds. The structures of the prepared Schiff base with its metal ion complexes, were identified by CHN (Table 1), FTIR (Table 2), UV-Vis (Table 3), ¹H-NMR (Table 4) ¹³C-NMR (Table 5),

FTIR Spectra

Characterization of the synthesized ligand (L₁)

The FTIR spectrum of the ligand (L₁) showed an abroad band at range 3220–3450 cm⁻¹ region which was assigned to phenolic –OH group of salicylaldehyde moiety.²⁰⁻²² The band of (C=N) imine group was appeared at 1568 cm⁻¹.²¹ Other band has appeared at 1240 cm⁻¹ which was assigned to ν C-O.²³ The FT-IR spectrum of this ligand was shown in Figure 1.

Characterization of the complexes (C₁-C₃)

The FTIR of the complexes (C₁-C₃) showed shift of OH group to lower frequency in the complexes appeared at (3350, 3332 and 3370) cm⁻¹ for (C₁-C₃) complexes respectively. The spectrum of the complex (C₁) was exhibited characteristic

Table 1: Physical properties and analytical data for ligand (L₁) and their ions complexes

Comp	M.Wt g.mol ⁻¹	Yield%	Color	MP (°C)	Micro elemental analysis calc. (Found)				
					C%	H%	N%	M %	Cl %
L ₁	421.33	74	Pall-Yellow	100-104	65.27 (64.94)	3.32 (3.17)	7.21 (7.14)	-----	-----
C ₁	596.33	85	Dark-Brown	140-143	45.52 (44.91)	3.82 (4.12)	4.86 (4.71)	11.37 (10.96)	12.90 (12.48)
C ₂	590.87	79	Dark- Green	91-95	39.28 (38.56)	4.59 (4.26)	4.74 (4.03)	7.78 (7.10)	17.15 (16.78)
C ₃	592.71	82	Pall- Yellow	140Dec	49.28 (48.77)	4.76 (4.22)	4.57 (4.18)	18.85 (18.39)	11.89 (11.09)

Table 2: Characteris infrared absorption bands of the ligand (L₁) and their metal ion complexes

Comp	ν (OH)	ν (C=N)	ν (C-O)	ν (M-N)	ν (M-O)	ν (M-Cl)
L ₁	3400	1568	1240	-----	-----	-----
C ₁	3350	1540	1260	541	495	350
C ₂	3332	1545	1269	516	489	341
C ₃	3370	1535	1258	508	474	358

Table 3: Electronic spectra, spectra parameters, molar conductance, magnetic susceptibility and suggested stereochemical of the ligands (L_1 and L_2) and their metal ion complexes

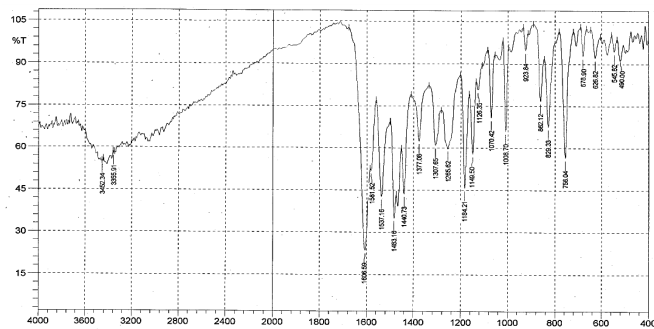
Comp.	Wavelength λ (nm)	Wave no. $\bar{\nu}$ (cm^{-1})	Assignment	Suggested Geometry
L_1	322	31055	$\pi \rightarrow \pi^*$
C_1 Cr(III)	890 508 409	10204 19685 24449	${}^4A_{2g} \rightarrow [{}^4T_{2g}, {}^4E_g]$ ${}^4A_{2g} \rightarrow {}^4T_{1g}(F)$	Octahedral
C_2 Cu(II)	519	19267	${}^2B_{1g} \rightarrow {}^2B_{2g}$	Distorted octahedral
C_3 Zn(II)	455	21978	C.T (M \rightarrow L)	Octahedral

Table 4: ${}^1\text{H-NMR}$ data of the ligand (L) and the metal ion complexes

Compounds	O-H	N=CH	C-H aromatic	H_2O	CH_3 proton
L	13.24	8.69	6.88-7.57	-----	1.68
C_1	13.66	8.63	6.68-8.04	3.51	1.82
C_2	13.19	9.06	6.67-8.01	3.52	1.43
C_3	13.36	8.99	6.67-7.60	3.64	1.86

Table 5: ${}^{13}\text{C-NMR}$ data of ligands (L) and some of the metal ion complexes

Compounds	HC=N	C-O	C-N	C-H aromatic	CH_3 proton
L	165.49	151.37	149.53	113.89-	15.16
C_1	167.41	152.53	154.23	112.72	15.68
C_2	165.85	153.82	149.45	107.71	15.69
C_3	163.31	154.27	149.92	112.22	15.93

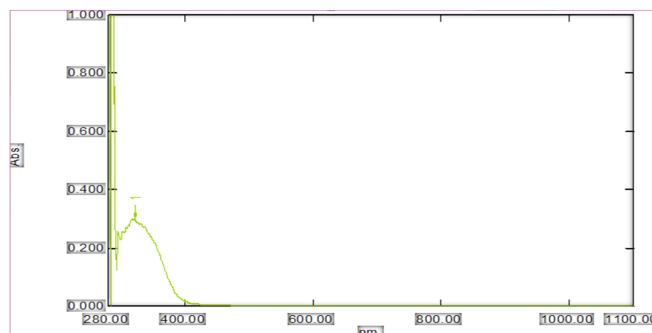
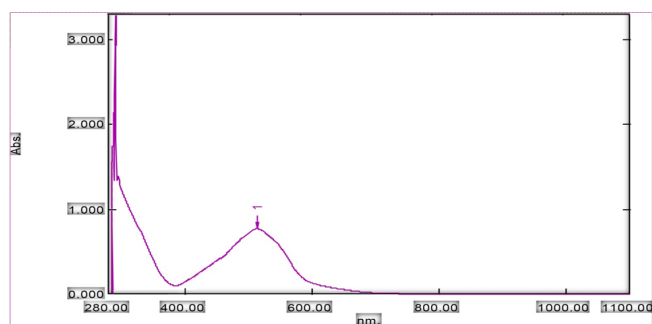
**Figure 2:** FTIR spectrum of the complex (C_2)

band of either lattice water appeared at (3395 cm^{-1}) assigned to ν (OH) or coordinated appeared at ($800\text{--}860 \text{ cm}^{-1}$ and ($3350\text{--}3450 \text{ cm}^{-1}$) assigned to ν (H_2O) of complexes (C_2 and C_3).²⁴ Azomethine group shifted to the lower frequency in the complexes appeared at (1540 , 1545 and 1535 cm^{-1}) for ($C_1\text{--}C_3$) complexes respectively.²⁵ ν (C-O) group appeared at (1260 , 1269 and 1258 cm^{-1}) for ($C_1\text{--}C_3$) complexes, respectively. These complexes' FTIR spectral data were shown in Figures 1 and 2 and Table 2.

Electronic spectra (UV-Visible)

Electronic spectra of the ligand (L_1) and their complexes

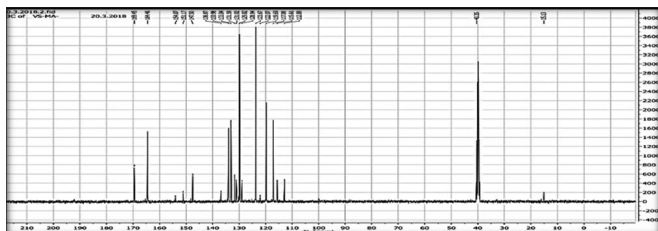
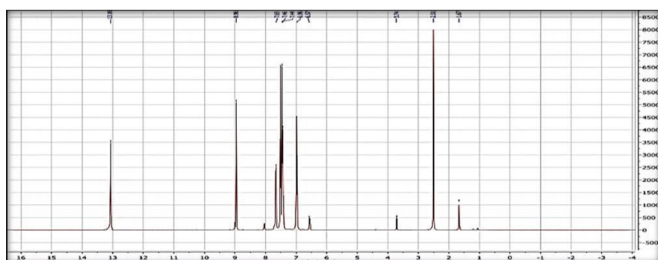
The electronic absorption data of the ligand (L_1) and their metal ion complexes (10^{-4}M) were recorded in DMSO at room temperature, and they were shown in Table 3, while their spectra were shown in Figures 3 and 4. The electronic spectrum of the ligand (L_1) exhibits one band (322 nm , 31055 cm^{-1}) due to

**Figure 3:** UV-Vis spectrum of the ligand (L_1)**Figure 4:** UV-Vis spectrum of the complex (C_2)

($\pi \rightarrow \pi^*$) transition.^{26,27} The complex (C_2) exhibited one band observed at (519 nm , 19267 cm^{-1}), this band assigned to the transition (${}^2B_{1g} \rightarrow {}^2B_{2g}$). The complex (C_1) was showed three bands observed at (895 nm , 11173 cm^{-1}), (510 nm , 19607 cm^{-1}) and (411 nm , 24330 cm^{-1}) respectively. These bands may be

Table 6: Inhibition zones measured in (mm) of DMSO, ciprofloxacin and complex

	Inhibition-zone (mm) <i>Escherichia coli</i>	Inhibition -zone (mm) <i>Pseudomonas aeruginosa</i>	Inhibition zone (mm) <i>Staphylococcus aureus</i>	Inhibition zone (mm) <i>Bacillus subtilis</i>
DMSO	----	----	----	----
L ₁	19.5	25.7	17.15	14.23
C ₁	41.5	27.8	23.7	29.9
C ₂	33.1	26.7	32.3	11.6
C ₃	----	----	51.6	45

**Figure 5:** ¹³C-nuclear magnetic resonance spectrum of ligand (L₁)**Figure 6:** ¹H-nuclear magnetic resonance spectrum of C₃ complex

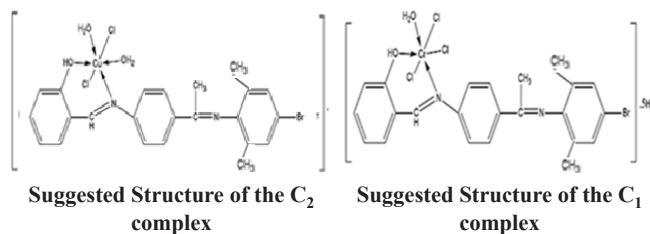
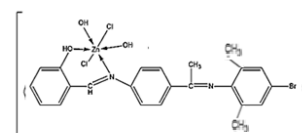
assigned to the transitions (${}^4A_{2g} \rightarrow [{}^4T_{2g}, {}^4E_g]$), ${}^4A_{2g} \rightarrow {}^4T_{2g}$ and (${}^4A_{2g} \rightarrow {}^4T_{1g}(F)$) respectively [28, 29]. The electronic spectrum of complex (C₃), was showed no d-d transition as it belongs to (d¹⁰). This complex's ultraviolet-visible spectrum appeared in (455 nm, 21978cm⁻¹) due to charge transfer from (M→L). Octahedral geometry has been proposed for all the complexes.

¹H-NMR/and ¹³C-NMR spectra

The ligand was characterized by ¹H-NMR and ¹³C-NMR spectroscopic methods, in addition of all complexes using Dimethyl Sulfoxide (DMSO) d⁶ as a solvent.¹⁷ The ¹H-NMR and ¹³C-NMR spectra results were listed in Tables 4 and 5, where Figures 5 and 6 shown The ¹H-NMR and ¹³C-NMR spectra for ligand and C₃ complex.

In vitro Antibacterial Activity

The antibacterial activities of all complexes were screened against test bacteria namely; *Staphylococcus aureus*, *Bacillus subtilis* (Gram+), *Escherichia coli* and *Pseudomonas aeruginosa* (Gram-). Agar, (well-diffusion method) was used to determine the activity.¹⁸ Borer of 0.6 mm diameter was used, the concentration of all complexes is 10⁻³M using DMSO was a solvent and used as a control gram-negative ciprofloxacin was used as a control gram-positive. The solvent DMSO showed no activity against the tested bacteria, while some of prepared complexes showed very good results. Table 6 shows the inhibition zones of the solvent and the prepared complexes. The inhibition zones were measured in (mm) and

**Suggested Structure of the C₂ complex****Suggested Structure of the C₁ complex****Suggested Structure of the C₃ complex**

compared to the inhibition zone of broad-spectrum antibiotics. All complexes showed no activity against the gram-negative bacterium *E. coli*, which can cause disease; for example, enterotoxigenic strains produce toxins in the gut, resulting in a typically in diarrhea.²⁸ C₃ Complex showed activity against the gram-positive bacterium positive *Staphylococcus aureus* and *Bacillus subtilis*. This bacterium is known for its resistance to most developed antibiotics and is the major case of many health issues and infections.¹⁸ The gram-negative *E. coli* and *P. aeruginosa* showed activity. Complexes (C₁ and C₂) showed activity against the gram-positive and gram-negative bacterium. Many factors were reported to control the biological activities of metal complexes.¹⁹ Type of ligand, type of metal, a charge of complex, transition series, metal ion configuration, and geometry of metal complex are affected on biological activity.³⁰

CONCLUSION

In this study, the prepared compounds represent a new group of dentate ligands exhibiting good complex properties. The presence of two donor atoms in this ligand may give various polynuclear metal complexes. In all complexes, ligand's coordination to the metal ions took place through the nitrogen atom of azomethine and oxygen groups. All complexes found to be octahedral geometry around metal ions. All complexes were tested against various bacteria some complexes gave good result another were found not active.

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