

# The Anti-Microbial Activity of Metal Complexes Derived from Schiff's Bases

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**Abstract:** *Co(II), Ni(II), Cu(II) complexes of the Schiff base derived from substituted benzaldehyde and m-aminobenzoic acid were synthesized and characterized by elemental analysis, IR, UV-Vis. The IR results demonstrate the bidentate binding mode of the ligand involving azomethine nitrogen and carboxylate oxygen atoms. The antimicrobial activity of the synthesized ligand and its complexes were screened by disc diffusion method. The results show that the metal complexes were found to be more active than the ligand.*

**Keywords:** Schiff's Base, Ligands, Transition Metal Complexes, Anti-Microbial Activity.

## I. INTRODUCTION

There is important applications of Schiff bases ligands and metal complexes in biological, clinical, analytical and industrial area[1].The heterocyclic Schiff base ligands and their metal complexes are more important due to their pharmacological properties[2]. nowadays, they are extensively being used for their promising applications in the treatment of several diseases and also been used as synthetic and analytical reagents [3], Currently researchers take more interest in the study of Schiff bases and their metal complexes due to the synthetic flexibilities and approach of ligands towards transition metal ions [4]. Due to tauto-enol tautomerism ligand show unusual coordination numbers. [5-9].

## 2. Experimental

**2.1. Materials:** The chemicals, metal chloride i.e. Co(II)/Ni(II)/Cu(II) chlorides and solvent was purchased from Thomas Baker, and the solvents were purified by standard methods. Solvents were purified and distilled before use. The metal content present in the complexes was determined by EDTA titration [10-13]

### 2.2. Preparation of Schiff Base Ligand

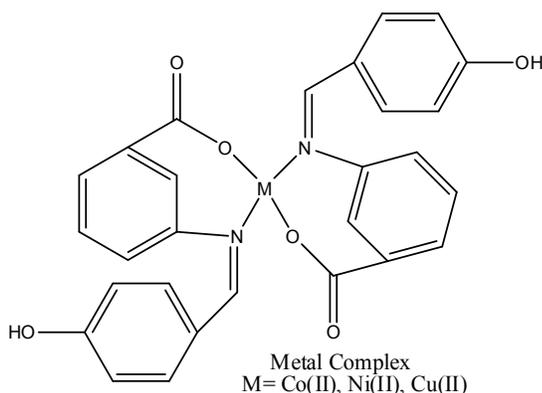
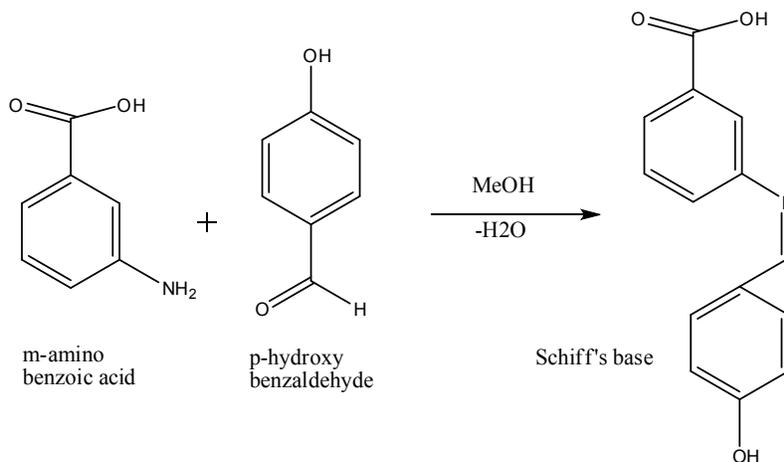
2 mmol solution of m-aminobenzoic acid in methanol, 2 m mol solution of Substituted benzaldehyde in methanol was added drop wise. The above mixture was magnetically stirred and refluxed for about 8 hrs. Then the reaction mixture solvent was evaporated and cooled at room temperature. The crystals were separated out. It was washed with alcohol, ether and recrystallised from ethanol and finally dried under vacuum (yield: 75%).[10-13]

### 2.3. Preparation of Metal Schiff Base Complexes

2 m mol solution of Schiff base ligand dissolved in methanol and 1mmol solution of Co(II),Ni(II),Cu(II) chloride dissolved in methanol was added drop wise. The above mixture was magnetically stirred and refluxed for 1 hr. The obtained complexes were filtered, washed with ethanol and finally dried under vacuum (yield: 73-82%).[10-13]

### 2.4. Physical Measurements

The IR spectra was measured by Nicolet 380 FT-IR spectrometer using KBr pellet having range 4000-400  $\text{cm}^{-1}$ . Electronic spectra also recorded by Perkin Elmer Lambda-25 UV/ VIS spectrometer having range 200-900 nm. Magnetic measurements carried out using Guoy balance at room temperature.[12-16]



### 2.5. Antimicrobial Study

The anti-microbial i.e. antibacterial activity of synthesized Schiff base and their metal complexes was studied by well diffusion method. By dissolving the compounds in DMSO to form 0.001 mol stock solution, and the solutions were serially diluted and check minimum inhibitory concentration (MIC) values ( $\mu\text{g mL}^{-1}$ ). The bacterial stains (*Staphylococcus aureus* and *Escherichia coli*) were incubated for 24 h at 37°C. Streptomycin was used for comparison under similar conditions. Antimicrobial activity studies were performed in triplicate, and the average was taken as the final reading. [12-17]

### III. RESULTS AND DISCUSSION

The analytical data and physical properties of the ligand and metal complexes are listed in Table 1. The Schiff base ligand (L) is soluble in common organic solvents. The resultant Schiff base complexes are soluble in DMF and DMSO and insoluble in other common organic solvents. The analytical data (Table 1) indicate that the metal to ligand ratio is 1:2 for all the complex systems. The molar conductance of all the complexes was measured in DMSO using 10<sup>-3</sup> M solutions at room temperature. The low molar conductivity values of the metal complexes (Table 1) suggest the non-electrolytic nature [12-15,18]

**Table 1:** Analytical data and physical properties of the ligand and metal complexes

Compounds	Empirical formula and colour	Formula weight (g mol <sup>-1</sup> )	Elemental analysis, Calcd. (Found) (%)			$\chi_c$ ( $\Omega^{-1}$ cm <sup>2</sup> mol <sup>-1</sup> )	$\mu_{\text{eff}}$ (BM)
			C	H	N		
L	C <sub>14</sub> H <sub>11</sub> NO <sub>3</sub>	241.234	69.70	4.5918	5.8059	-	-
[CoL2]	C <sub>28</sub> H <sub>20</sub> N <sub>2</sub> O <sub>6</sub> Co	539.387	62.35	3.7338	5.1933	10.2	4.55
[NiL2]	C <sub>28</sub> H <sub>20</sub> N <sub>2</sub> O <sub>6</sub> Ni	539.693	62.31	3.7317	5.1903	9.1	3.20
[CuL2]	C <sub>28</sub> H <sub>20</sub> N <sub>2</sub> O <sub>6</sub> Cu	544	61.82	3.7022	5.1492	9.6	1.86

### 3.1. Infrared Spectra

The IR spectral data of the ligand and its complexes were given in Table 2. The free ligand exhibits IR bands at 3220 cm<sup>-1</sup> v (N–H), 1688 cm<sup>-1</sup> v (C=O), and 1615 cm<sup>-1</sup> v (C=N). The bands at 3455 and 2930 cm<sup>-1</sup> in the free ligand are attributed to the free OH stretching of phenolic moiety [19]. The IR spectrum of the free ligand exhibits a sharp band at 1670 cm<sup>-1</sup> v, due to the azomethine group vibration. On complexation this band was shifted to lower frequency in the 1657–1635 cm<sup>-1</sup> v range indicating the coordination of the azomethine nitrogen atom to the metal ion. [12,13,15] For the free ligand, the observed bands at 1542 and 1356 cm<sup>-1</sup> v can be respectively ascribed to asymmetric carboxylate (COO<sup>-</sup>) and symmetric carboxylate (COO<sup>-</sup>) groups [20]. During complexation these bands were shifted to higher frequency by 5–16 cm<sup>-1</sup> v range indicating the linkage between the metal ion and carboxylate oxygen atom. [12-13,15] The large difference between the asymmetric (COO<sup>-</sup>) and symmetric (COO<sup>-</sup>) value of 200 cm<sup>-1</sup> v indicates the monodentate binding nature of the carboxylate group [20] in the complexes. In the lower frequency region the weak bands observed at 575–553 and 465–415 cm<sup>-1</sup> v have been assigned respectively to the m(M–O) and m(M–N) vibrations [20-24], one can deduce that the ligand binds the metal ion as bidentate fashion (NO). The bonding sites are the azomethine nitrogen and the carboxylate oxygen atoms. In the complexes, the band due to phenolic OH vibrations remained unaltered, suggesting the non involvement of the phenolic proton in the complex formation. [12-13, 25-26]

**Table 2:** Infrared spectral data of ligand and its complexes (cm<sup>-1</sup> v).

Compounds	m(C,N)	as(COO <sup>-</sup> )	ms(COO <sup>-</sup> )	m(M–O)	m(M–N)
L	L 1670	1542	1356	-	-
[CoL2]	1642	1551	1368	560	415
[NiL2]	1657	1567	1375	575	465
[CuL2]	1635	1561	1370	553	458

### 3.2. Electronic Spectra and Magnetic Moment: (in Table 1)

The electronic spectrum of free Schiff base ligand shows a broad band at 348 nm, which is assigned to  $\pi \rightarrow \pi^*$  transition of the C<sub>2</sub>N chromophore. On complexation this band was shifted to lower wavelength region suggesting the coordination of azomethine nitrogen to the central metal ion [18,27]. The Co(II) complex has the magnetic moment value shows Co(II) complex has tetrahedral (4.55 BM) which is in agreement with the reported value for tetrahedral. Ni(II) complexes is tetrahedral its range 3.2–4.1 BM. And Cu (II) complex is monomeric and paramagnetic (1.86 BM) [12-13,15,28-30]

### 3.3. Anti-Microbial Activities

The synthesized transition metal complexes were screened for their antimicrobial activity particularly antibacterial activity and this is done with the help of disc diffusion method. Microorganism like gram positive bacteria Staphylococcus aureus, Gram negative bacteria Escherichia coli. The antimicrobial activity results reveal that the Cu(II) and Co(II) complex have better activity against bacterial strains, the activity of metal complexes as Cu(II) > Co(II) > Ni(II) > L. High activity owing to the metal ions on the normal cell membrane [31]. Due to the combination of polar and non-polar properties permeable into cells and tissues. Also chelation enhances or lowers the biopotency of them. The properties like lipophilicity influence the antimicrobial. The mixed-ligand complexes are more beneficial than free ligands. [12-13, 15-17, 28]

**Table 3:** Minimum inhibitory concentration of the synthesized compounds against the growth of bacteria ( $\mu\text{g/mL}$ )

Compounds	E. coli	S. aureus
L	130	200
[CoL <sub>2</sub> ]	25	20
[NiL <sub>2</sub> ]	40	58
[CuL <sub>2</sub> ]	45	25

#### IV. CONCLUSION

The coordination capabilities of the synthesized Schiff base has been confirmed by complexation reaction with Co(II), Ni(II) ions Cu(II) ions. The newly synthesized schiff's base and their metal complexes are characterized using electronic and infrared spectral data which shows bidentate ligands which co-ordinate through azomethine nitrogen and carboxylate oxygen atoms. Geometry also determined with the help of conductometric, electronic and magnetic studies as Co(II) and Ni(II) complexes have tetrahedral geometry while Cu(II) complex is square planar geometry. The metal complexes show high antimicrobial activity free ligand and the order as Cu(II) > Co(II) > Ni(II) > L.

#### REFERENCES

- [1]. Gupta, K.C., Sutar, A.K., "Catalytic activities of Schiff base transition metal complexes". *Coord. Chem. Rev.* 252 (12–14), 1420–1450. 2008.
- [2]. Budhani, P., Iqbal, S.A., Bhattacharya, S.M.M. "Synthesis, characterization and spectroscopic studies of pyrazinamide metal complexes." *J. Saudi Chem. Soc.* 14, 281–285. 2010.
- [3]. P. V. Bernhardt, P. Chin, P. C. Sharpe, J. Y. C. Wang, and D. R. Richardson, "Novel diaroilhydrazine ligands as iron chelators: coordination chemistry and biological activity," *Journal of Biological Inorganic Chemistry*, vol. 10, no. 7, pp. 761–777. 2005.
- [4]. C. Imrie, P. Engelbrecht, C. Loubser, and C. W. McClelland, "Monosubstituted thermotropic ferrocenes: an overview 1976–1999," *Applied Organometallic Chemistry*, vol. 15, no. 1, pp. 1–15, .2001.)
- [5]. M. Bakir, I. Hassan, T. Johnson et al., "X-ray crystallographic, electrochemical and spectroscopic properties of 2-pyridinio 2- pyridyl ketone phenyl hydrazone chloride hydrate," *Journal of Molecular Structure*, vol. 688, no. 1–3, pp. 213–222. 2004.
- [6]. S. M. Emam, F. A. El-Saied, S. A. Abou El-Enein, and H. A. El-Shater, "Cobalt(II), nickel(II), copper(II), zinc(II) and hafnium(IV) complexes of N-(furan-3-ylmethylene)-2-(4-methoxyphenylamino)acetohydrazide," *Spectrochimica Acta Part A*, vol. 72, no. 2, pp. 291–297. 2009.
- [7]. K. Andjelkovic, G. Jakovljevic, and M. Zlatovic, "Acid–base equilibria of the Zn(II) and Fe(III) complexes with condensation products of 2-acetylpyridine and the dihydrazide of oxalic and malonic acid," *Journal of the Serbian Chemical Society*, vol. 69, pp. 651–660, 2004.
- [8]. P. V. Bernhardt, P. Chin, P. C. Sharpe, J. Y. C. Wang, and D. R. Richardson, "Novel diaroilhydrazine ligands as iron chelators: coordination chemistry and biological activity," *Journal of Biological Inorganic Chemistry*, vol. 10, no. 7, pp. 761–777, 2005.
- [9]. N. Terzioglu and A. G'ursoy, "Synthesis and anticancer evaluation of some new hydrazone derivatives of 2,6-dimethylimidazo[2,1-b][1,3,4]thiadiazole-5-carbohydrazide," *European Journal of Medicinal Chemistry*, vol. 38, no. 7-8, pp. 781–786, 2003.
- [10]. Vogel, A.I., 1978. "A Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis" fourth ed. Longman, London.
- [11]. B. S. Furniss, A. J. Hannaford, and V. Rogers, "Vogel's Textbook of Practical Organic Chemistry", Longman, Inc., New York, NY, USA, 4th edition, 1981.
- [12]. M.S. Nair et al., "Synthesis, characterization, antifungal, antibacterial and DNA cleavage studies of some heterocyclic Schiff base metal complexes.", King Saud University. Production and hosting by Elsevier B.V. 2010
- [13]. C. Anitha, S. Sumathi, P. et al., "Synthesis, Characterization, and Biological Activity of Some Transition Metal Complexes Derived from Novel Hydrazone Azo Schiff Base Ligand." *Hindawi Publishing Corporation International Journal of Inorganic Chemistry*, Article ID 493942, 8 pages. Volume 2011

- [14]. Bauer, A.W., Kirby, W.M.M., Sherris, J.C., Turck, M., "Antibiotic susceptibility testing by a standardized single disc method". *Amer. J. Clin. Pathol.* 45, 493–496. 1966
- [15]. Nayaz Ahmed et.al. "Synthesis, Characterisation, and Biological Evaluation of Zn(II) Complex with Tridentate (NNO Donor) Schiff Base Ligand." Hindawi Publishing Corporation International Journal of Inorganic Chemistry, Article ID 607178, 5 pages. Volume 2015
- [16]. Jitendra N. Boraseet.al., "Design, synthesis and biological evaluation of heterocyclic methyl substituted pyridine Schiff base transition metal complexes.", *SN Applied Sciences* 3:197. (2021)
- [17]. Thierry Y Fonkuiet.al., "Microbial activity of some heterocyclic Schiff bases and metal complexes: A review.", *Tropical Journal of Pharmaceutical Research*; 17 (12): 2507-2518. December 2018
- [18]. W. Walke and Niren E. Kathale., "Synthesis and Characterization of some Metal Complexes prepared from Schiff Base Ligand having Heterocyclic unit", *Journal of Scientific Research*, Volume 65, Issue 6, 2021
- [19]. R. Gup and B. Kirkan, "Synthesis and spectroscopic studies of copper(II) and nickel(II) complexes containing hydrazonic ligands and heterocyclic coligand," *Spectrochimica Acta Part A*, vol. 62, no. 4-5, pp. 1188–1195, 2005.
- [20]. Deacon, G.B., Phillips, R.J., "Relationships between the carbon– oxygen stretching frequencies of carboxylate complexes and the type of carboxylate coordination". *Coord. Chem. Rev.* 33 (3), 227– 250. 1980.
- [21]. Nakamoto, K., "Infrared and Raman Spectra of Inorganic and Coordination Compounds", third ed. John Wiley and Sons. 1978.
- [22]. Shebl, M., "Synthesis, spectral studies, and antimicrobial activity of binary and ternary Cu(II), Ni(II), and Fe(III) complexes of new hexadentate Schiff bases derived from 4,6-diacetylresorcinol and amino acids." *J. Coord. Chem.* 62 (19), 3217–3231. 2009.
- [23]. V. D. Bhatt and A. Ray, "Synthesis, characterization and electrical conductivity of polyesters, polyamides and doped polymers," *Synthetic Metals*, vol. 92, no. 2, pp. 115–120, 1998.
- [24]. D. Prakash, C. Kumar, S. Prakash, A. K. Gupta, and K. R. R. P. Singh, "Synthesis, spectral characterization and antimicrobial studies of some new binuclear complexes of CuI and NiII Schiff base," *Journal of the Indian Chemical Society*, vol. 86, no. 12, pp. 1257–1261, 2009.
- [25]. M. L. HariKumaran Nair and L. Shamlal, "Synthesis, spectral and thermal studies of copper(II) complexes of azo dyes derived from 2,3-dimethyl-1-phenyl-4-amino-5-pyrazolone," *Journal of the Indian Chemical Society*, vol. 86, no. 2, pp. 133–138, 2009.
- [26]. V. Reddy, N. Patil, and B. R. Patel, "Synthesis and characterization of Co(II), Ni(II), and (II) complexes with O,N and S donor ligands," *Journal of Indian Council of Chemists*, vol. 23, no. 2, pp. 1–3, 2006.
- [27]. P. Tharmaraj, D. Kodimunthiri, C. D. Sheela, and C. S. ShanmugaPriya, "Synthesis, spectral characterization, and antimicrobial activity of copper(II), cobalt(II), and nickel(II) complexes of 3-formylchromoniminopropylsilatrane," *Journal of Coordination Chemistry*, vol. 62, no. 13, pp. 2220–2228, 2009.
- [28]. Kettle, S.F.A., *Coordination Compounds*. ELBS, Essex, UK. 1969
- [29]. Cotton, F.A., Wilkinson, G., *Advanced Inorganic Chemistry*. Wiley–Interscience, New York. 1998
- [30]. Parjanya Kumar Shukla et.al., "Significance of Nitrogen Heterocyclic Nuclei in the Search of Pharmacological Active Compounds.", *New Perspective in Agriculture and Human health.*, Researchgate March 2017
- [31]. K. Sadana, Y. Mirza, K. R. Aneja, and O. Prakash, "Hypervalent iodine mediated synthesis of 1-aryl/heteryl-1,2,4-triazolo[4,3-a] pyridines and 1-aryl/heteryl 5-methyl-1,2,4-triazolo[4,3-a]quinolines as antibacterial agents," *European Journal of Medicinal Chemistry*, vol. 38, no. 5, pp. 533–536, 2003.