

## Synthesis, Characterization and Biological Studies of 2-[Phenylmethylamino] benzoic acid and Its Complexes with Co (II), Ni (II), Cu (II) and Zn (II)

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**Summary :** 2-[Phenylmethylamino] benzoic acid and its complexes, with Co (II), Ni (II), Cu (II) and Zn (II), have been synthesized and were characterized on the basis of physical, analytical, conductance and spectroscopic data. The ligand and its complexes were been screened for antibacterial activity against different bacterial strains such as *Escherichia coli*, *Staphylococcus aureus* and *Pseudomonas aeruginosa*. These studies demonstrate that the complexes are more antibacterial as compared to the uncomplexed ligand.

### Introduction

Schiff base, derived from an amine and an aldehyde, is an important class of compounds that coordinates to the metal ion through azomethene nitrogen and has been studied extensively [1-3]. During the past decades, there was a great interest in the synthesis and characterization of Schiff base complexes because of their importance as catalysts in many reactions such as carboxylation, hydroformylation, reduction, oxidation and hydrolysis [4-8]. Schiff base complexes have also been studied for their significant antimicrobial activities [9, 10]. Earlier work has shown that some drugs showed increased activity when administered as metal chelates rather than as organic compounds [11-12], and that the coordinating possibility of 2-aminobenzoic acid has been improved by condensing it with benzaldehyde. Dey S. K. *et al.*, [13] have reported on the synthesis and characterization of Schiff base derived from Pyridene-2-carboxaldehyde and anthranilic acid and its complex with copper. Pania S.L *et al.*, [14] have also reported the stabilities of transition metal complexes with Schiff base derived from benzoyl acetone and 2-aminobenzoic acid. Previous studies show that no work has been carried out on the transition metal complexes of the Schiff base derived from 2-aminobenzoic acid and benzaldehyde.

In this paper we describe the synthesis, characterization, and biological studies of transition metal complexes with 2-[Phenylmethylamino] benzoic acid, which is actually a Schiff base ligand derived from the condensation of 2-aminobenzoic

acid and benzaldehyde. This Schiff base ligand acts as a monoanionic bidentate in nature and coordinates to the metal ion through carboxylate (COO-) group and azomethene nitrogen atom. The structure of this Schiff base ligand is given in Fig. 1.

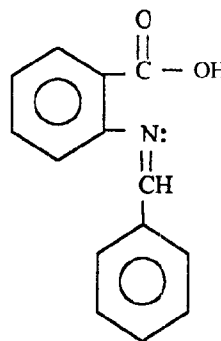


Fig.1: Schiff Base Ligand (LH).

### Result and Discussion

The ligand, 2-[Phenylmethylamino] benzoic acid (Fig. 1) was prepared by reacting equimolar amount of 2-aminobenzoic acid and salicylaldehyde in ethanol. The synthesized ligand was further used to prepare its cobalt, copper, nickel and zinc (II) metal complexes, which were all characterized by IR, UV-Visible, molar conductance, magnetic moment and elemental analysis data. The analytical data along with some physical properties of the ligand and complexes are shown in Table-1. The ligand LH on

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Table-1: Physico-analytical data of metal complexes

| Compound                               | M.P<br>°C              | Color            | Yield<br>% | $\mu_{\text{eff}}$ (B.M) | $\lambda_{\text{m}}$<br>nm |
|--|------------------------|------------------|------------|--------------------------|----------------------------|
| LH                                     | 130                    | Yellow           | 76         | -                        | -                          |
| $[\text{CuL}_2(\text{H}_2\text{O})_2]$ | Above 200<br>decompose | Reddish<br>Brown | 65         | 4.18                     | 11.5                       |
| $[\text{CoL}_2(\text{H}_2\text{O})_2]$ | Above 200<br>decompose | Dark<br>Green    | 62         | 1.86                     | 11.7                       |
| $[\text{NiL}_2(\text{H}_2\text{O})_2]$ | Above 200<br>decompose | Green            | 63         | 3.42                     | 10.6                       |
| $[\text{ZnL}_2(\text{H}_2\text{O})_2]$ | Above 200<br>decompose | white            | 59         | Diamagnetic              | 10.4                       |

Where LH = 2-[Phenylmethylimino] benzoic acid

interaction with Cu (II), Co(II), Ni (II) and Zn (II) chlorides yields complexes corresponding to the general formula  $[\text{ML}_2(\text{H}_2\text{O})_2]$ , as shown in Fig. 2. The analytical data showed the metal to ligand ratio to be 1: 2. All complexes are colored amorphous solid, which decompose without melting. They are insoluble in common organic solvents and only soluble in DMF and DMSO. Molar conductance values of soluble complexes in DMF ( $10^{-3}$  M solution at  $25^\circ\text{C}$ ), indicate lower value, suggesting that they are all non-electrolyte in nature [15].

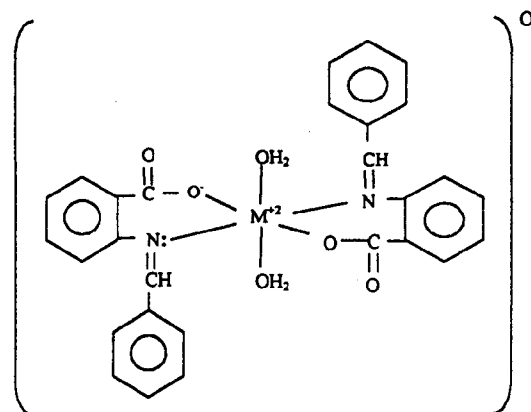


Fig. 2: Proposed structure of metal complexes where M = Co (II), Ni (II), Cu (II) and Zn (II)

### IR Spectra

The bonding of ligand to metal was investigated by comparing the IR Spectra of complexes with that of free ligands. IR Spectra of the ligand LH (Table-2) showed the absence of bands at  $\sim 1733\text{ cm}^{-1}$  and  $3318\text{ cm}^{-1}$  due to the carbonyl  $\nu(\text{C}=\text{O})$  and  $\nu(\text{NH}_2)$  stretching vibrations and presence of a strong new band at  $\sim 1626\text{ cm}^{-1}$  assigned to azomethene  $\nu(\text{HC}=\text{N})$  linkage, showing that amino and aldehyde moieties of the starting material are

Table-2. Spectral Data of Ligand and Metal Complexes

| Compound                               | I.R<br>( $\text{cm}^{-1}$ )                                     | $\lambda_{\text{max}}$<br>( $\text{cm}^{-1}$ ) |
|--|---|--|
| LH                                     | 1626(C=N), 1731 $\nu(\text{COO}^-)$<br>1248 $\nu(\text{COO}^-)$ | 38910, 28328                                   |
| $[\text{CoL}_2(\text{H}_2\text{O})_2]$ | 1616(C=N), 432(M-N)<br>415(M-O), 3395(br-OH)                    | 7279, 17263, 20486, 27175                      |
| $[\text{CuL}_2(\text{H}_2\text{O})_2]$ | 1614(C=N), 432(M-N)<br>415(M-O), 3395(br OH)                    | 16630  |
| $[\text{NiL}_2(\text{H}_2\text{O})_2]$ | 1616(C=N), 432(M-N)<br>415(M-O), 3395(br-OH)                    | 10275, 15742, 26363,<br>30,180                 |
| $[\text{ZnL}_2(\text{H}_2\text{O})_2]$ | 1612(C=N), 432(M-N) 415(M-O)<br>3395(br-OH), 893(-OH)           | 28270  |

Where LH = 2-[Phenylmethylimino]benzoic acid br = broad

absent and have been converted into Schiff base ligand (LH). The comparison of IR Spectra of Schiff base ligand (LH) and its complexes indicate the monoanionic bidentate nature of ligand. The band appearing at  $\sim 1626\text{ cm}^{-1}$  due to azomethene linkage shifted to lower frequency by  $\sim 1-16\text{ cm}^{-1}$  in all the complexes, indicating a participation of azomethene nitrogen in the interaction with metal ion. The band responsible for carboxylic group in ligand LH appeared at  $1731\text{ cm}^{-1}$  and  $1248\text{ cm}^{-1}$  but it disappeared in the spectra of metal complexes, which indicated that carboxylic group took part in complex formation. The disappearance of  $1731\text{ cm}^{-1}$  due to carboxylic acid ( $\text{C}=\text{O}$ ) in the complexes suggested the coordination of carboxylic oxygen after deprotonation. In the spectra of all these complexes, the broad band at  $\sim 3395\text{ cm}^{-1}$  together with new band at  $893\text{ cm}^{-1}$  confirmed the presence of coordinated water [16-17]. The far IR Spectra of these metal complexes (Table-2) exhibited new bands at  $432$  and  $415\text{ cm}^{-1}$ , which are not present in ligands. These were assigned [18-19] to  $\nu(\text{M-N})$  and  $\nu(\text{M-O})$ , thus confirming the bonding of ligand with the metal ions.

### Electronic Absorption Spectra

In the electronic spectra, the cobalt (II) complexes exhibited well-resolved low energy peaks at  $7275\text{ cm}^{-1}$ ,  $17260\text{ cm}^{-1}$  and a strong high energy peak at  $20482\text{ cm}^{-1}$  which were assigned [20] to transition  ${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{2g}(\text{F})$ ,  ${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{A}_{2g}(\text{F})$  and  ${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{2g}(\text{P})$  for a high spin octahedral geometry, whereas the last one which was high intensity band at  $27175\text{ cm}^{-1}$  was assigned to metal charge transfer spectra. The electronic spectra of Ni (II) complexes showed d-d transition in the regions  $10275$ ,  $15742$  and  $26360\text{ cm}^{-1}$ . These are assigned [21] to the transitions  ${}^3\text{A}_{2g}(\text{F}) \rightarrow {}^3\text{T}_{2g}(\text{F})$ ,  ${}^3\text{A}_{2g}(\text{F}) \rightarrow {}^3\text{T}_{1g}(\text{F})$ , and  ${}^3\text{A}_{2g}(\text{F}) \rightarrow {}^3\text{T}_{2g}(\text{P})$ , respectively. These were consistent with well defined octahedral geometry. The high energy band at  $30180\text{ cm}^{-1}$  was assigned to metal charge transfer spectra. The Zn (II)

complex exhibited only a high intensity band at  $28275\text{ cm}^{-1}$  and was assigned to ligand-metal charge transfer spectra. These values support octahedral geometry [22] of metal complexes. In case of Cu (II) complex, a broad band at  $16,630\text{ cm}^{-1}$  was observed which was assigned to  ${}^2E_g-{}^2T_{2g}$  transition, which confirmed its octahedral geometry [19].

#### Magnetic Susceptibility Measurement:

The magnetic moment value 4.18 BM for the solid Co (II) complex suggested [22-23] octahedral environment, indicating three unpaired electrons. The magnetic moment value of Cu (II) complex was 1.86 BM, which suggested distorted octahedral geometry [24-25]. The magnetic moment value of Ni (II) complex 3.42 BM, which showed two unpaired electrons and suggested [23] an octahedral geometry for Ni (II) complex. The zinc complex was found to be diamagnetic as expected for  $d^{10}$  configuration.

#### Antibacterial Studies

The Schiff base ligand (LH) and its transition metal complexes were evaluated for their antibacterial activity against some bacterial strain such as *Escherichia coli*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus* by disc diffusion method [26]. The susceptibility zones were measured in diameter (mm) and results are tabulated in Table-3. These results indicated that the antibacterial activity of metal complexes was greater as compared to uncomplexed ligand. Such enhancement in antibacterial activity can be explained on the basis of Overtone's concept [27] and Tweedy's Chelation Theory [28].

Table-3. Antibacterial Activity Data of Ligand and metal complexes

| Compound                               | Bacterial species |     |     |
|--|-------------------|-----|-----|
|  | a                 | b   | c   |
| LH                                     | ++                | ++  | ++  |
| $[\text{CoL}_2(\text{H}_2\text{O})_2]$ | +++               | ++  | +++ |
| $[\text{CuL}_2(\text{H}_2\text{O})_2]$ | ++++              | +++ | +++ |
| $[\text{NiL}_2(\text{H}_2\text{O})_2]$ | +++               | +++ | ++  |
| $[\text{ZnL}_2(\text{H}_2\text{O})_2]$ | ++                | +++ | ++  |

Where LH = 2-[Phenylmethylamino] benzoic acid

a = *Escherichia coli*, b = *Pseudomonas aeruginosa*,

c = *Staphylococcus aureus*

Inhibition zone diameter (mm) + 0-5 mm ++ 6-10 mm  
+++ 11-15 mm ++++ 16-20 mm

#### Experimental

All the chemicals and solvents used were of analytical grade. The metals (II) were used as

chloride salts. IR Spectra were recorded on a Philips analytical PU 9800 FTIR spectrophotometer. U.V /visible spectra were obtained in DMF on a Hitachi U-2000 double beam spectrophotometer. Molar conductances of the complexes were determined at room temperature using a CMD 750 WPA conductivity meter. Magnetic measurements were carried out on solid complexes using Gouy's method [29]. Melting points were determined on Gallenkamp apparatus. Antibacterial studies were carried out at the Department of Molecular Biology, University of the Punjab, Lahore (Pakistan), using Disc Diffusion method.

#### Synthesis of Ligand LH

The ligand 2-[Phenylmethylamino] benzoic acid was synthesized by the condensation of 2-aminobenzoic acid and salicylaldehyde (1:1 molar ratio), dissolved in ethanol. The resulting reaction mixture was refluxed for 1:30 hour. The yellow solid precipitate of the ligand LH obtained was filtered, washed with distilled water and recrystallized from ethanol; Yield 67 % (m.p.  $130\text{ }^\circ\text{C}$ ).

#### Synthesis of Complexes

The metal complexes were prepared by refluxing an ethanol (10 ml) solution of ligand (0.02 mol) with metal (II) chloride (0.01 mol) in ethanol (10 ml) for 2 hours. The resulting colored solution was cooled at room temperature. The colored precipitates were formed which were filtered, washed with distilled water, ethanol and dried.

#### Antibacterial Studies

Antibacterial activity of the complexes/ ligand was carried out at the Department of Microbiology, University of the Punjab, Lahore. Antibacterial activity against different bacterial strains such as *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* was determined using the paper Disc diffusion method [26].

The nutrient agar medium (Peptone, Beef extract, NaCl and Agar-Agar) and 5 mm diameter paper discs (Whatman No. 1) were used. The compounds were dissolved (30 ug) in DMF (0.01 ml). The filter paper disc was soaked in solutions of ligand as well as complexes, dried and then placed in Petri plates previously seeded with the test organisms. The plates were incubated for 24-30 hrs at  $37\text{ }^\circ\text{C}$  and the inhibition zone around each disc was measured.

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