BIOLOGICAL STUDIES OF SOME NOVEL TRANSITION METAL COMPLEXES WITH SCHIFF BASE

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ABSTRACT

Schiff bases and their coordination complexes have acquired great significance in the field of inorganic research mainly because of their biological activity. Antibacterial, antifungal and antitumour activities are reported (Xinde Zhu, 2002) for these compounds. In the present study, the Schiff base derived from 2-hydroxybenzaldehyde and 2-aminophenol are used for preparing complexes of selected transition metal salts. The complexes were prepared by mixing equimolar quantities of the Schiff base and the transition metal salts, $MX_n\cdot mH_2O$ where $M= \text{Co, Ni, Cu and Zn, } X=\text{NO}_3^-, \text{ClO}_4^-, \text{and Cl}$. Characterizations of the complexes were done by metal analysis, elemental analysis, conductivity measurements in non aqueous solvents, IR and Electronic spectral analysis. Biological activity was checked against the bacteria Escherichia Coli and Bacillus subtilis by disc diffusion method. The Schiff base and the complexes were found to be active against both the bacteria. But some complexes showed more activity than the Schiff base indicating the effect of metal coordination in inhibiting bacterial growth.

Key words: Schiff base, Ligand, 2-hydroxybenzilidene-2-aminophenol, Antibacterial activity studies.

1.INTRODUCTION

Schiff bases have been extensively used in the study of structure and bonding in coordination complexes. Schiff base of 2-hydroxybenzaldehyde with different aromatic amines have been studied in particular for the past few years (Hankare and Chawan, 2003), due to the exclusive biological activity shown by their complexes. The present study concentrates on the Schiff base derived from 2-hydroxybenzaldehyde and 2-aminophenol and a few complexes with transition metals. All the compounds synthesized were characterized and tested for their antibacterial activities against E. Coli and B. Subtilis.

2.MATERIALS AND METHODS

All the chemicals used were of A.R. grade. 2-hydroxybenzaldehyde is used after purification by distillation. The transition metal salts were prepared from the respective carbonates by reacting with 60% corresponding mineral acid and then crystallizing by evaporation over a steam bath.

Synthesis of Schiff base: 2-hydroxybenzilidene 2-aminophenol

2-aminophenol (0.109g, 1mmol) in 20ml ethanol is mixed with 2-hydroxybenzaldehyde (0.122g, 1mmol) in 20ml ethanol. The mixture was refluxed for 4 hours on a boiling water bath, cooled and kept overnight. Orange red needles were formed, which was filtered, washed with 50% ethanol and dried in a dedicator over anhydrous $\text{CaCl}_2$ and recrystallised from ethanol.

Synthesis of complexes

To the refluxing solution of the Schiff base, 2-hydroxybenzilidene 2-aminophenol (0.11g, 0.5 mm) in 30ml ethanol, 0.5mM solution of the transition metal salt $MX_n\cdot mH_2O$ where $M=\text{Co(II), Ni(II), Cu(II), Zn(II)}$ and $X=\text{ClO}_4^-, \text{NO}_3^-, \text{Cl}$, added drop by drop and then refluxed the mixture for 2 hours, concentrated and kept overnight. The precipitate formed is filtered, washed with ethanol and ether. Dried in a vacuum desiccator over anhydrous $\text{CaCl}_2$ and recrystallised from ethanol.

Analytical methods

The melting points were determined on a Thosniwal melting point apparatus. The Schiff base and the complexes were analyzed for carbon, hydrogen and nitrogen content on a Heraeus CHN rapid analyzer. The metals were determined gravimetrically as oxides. Molar conductance in DMF, ethanol and nitrobenzene in $10^{-3}$M solutions were measured at room temperature (Singh, 2003) using an ELICO CM–180 conductivity meter with a dip type cell of platinum electrodes (Cell constant = 0.986). The chloride content was determined by Volhard method and perchlorate analysis done by first reducing to the chloride and then by Volhard method (Indrasenan and Jayasankar, 1990). The IR spectrum

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of the complexes were recorded in the range 400-4000 cm\(^{-1}\) on a Schimadzu IR 470 spectrophotometer in KBr discs. The electronic spectra in ethanol solution (10\(^{-3}\)M) were recorded in the range 200-900 nm on a Schimadzu UV-160 A spectrometer.

**Antibacterial activity**

Antibacterial studies were conducted against *E. Coli* and *B. Subtilis* by disc diffusion method (Powar, 1986; Mukherjee, 1983). Nutrient Agar was used as the cultural medium. Agar medium was prepared in distilled water and poured into sterilized Petri dishes. Inoculation was done with the help of a platinum wire loop. The ligand /complex (0.003g) was dissolved in 1ml DMSO. Blotting paper discs (3mm) diameter were dipped in the solution. Dried in an incubator and then applied on the bacteria grown in agar plates. The plates were inverted and kept in an incubator set at 37°C for 24 hours. The zone of inhibition around the disc was measured in mm. The percentage of inhibition was calculated (Raman, 2006; Izmail, 2002).

**3. RESULTS AND DISCUSSION**

The elemental analysis data and some physical properties of the ligand and its complexes are given in Table:1. The ligand is soluble in most common organic solvents such as ethanol, acetone, dichlorobenzene, acetonitrile, Hexane, DMF and DMSO. The complexes were insoluble in water, but soluble in some organic solvents like ethanol, DMF and DMSO. The molar conductance data of the complexes is given in Table:2. The following observations are concluded from the comparison of the IR spectra of ligand and metal complexes.

**IR Spectra**

The important IR frequencies of the ligand and its complexes along with their assignments are reported in Table:3. The bending vibrations of –OH group. The down shift of azomethine stretching frequency in all the complexes provided evidence in support of the involvement of azomethine nitrogen in coordination to the metal atom (Muraleedharan Nair and Radhakrishnan, 1995). Similarly, a weak band in the far IR region near 600 cm\(^{-1}\) attributed to \(\gamma(M-N)\) was observed for all the complexes (Rao, 2002), which was not found in the spectra of ligands. The broad band corresponding to –OH stretching shifted downfield in complexes suggesting coordination through oxygen. In zinc perchlorate and copper perchlorate complexes, the OH band disappeared suggesting coordination through oxygen after deprotonation and the absence of coordinated water molecules, thus ML\(_2\) structure of the complexes (Min Zao, 2002). In all other cases, the IR data support ML structure of complexes (Manimekalai and Mahendran, 2003). In cobalt perchlorate complex, two distinguishable peaks around 1100cm\(^{-1}\) is obtained characteristic of the coordinated perchlorate stretching vibrations (Muraleedharan Nair and Radhakrishnan, 1995). The IR spectrum of [CuL\(_2\)] is given in Figure 1.2.

**Electronic spectra**

The electronic spectra of the complexes were recorded in the solution state. The spectrum of all Co(II) complexes exhibited three bands (Figure 1.1) which may be assigned as \(^4T_{1g}(F)\rightarrow ^4T_{2g}(F) (\gamma=9500 cm^{-1}), ^4T_{1g}(F)\rightarrow ^2A_{1g}(F) (\gamma=1800 cm^{-1})\) and \(^4T_{1g}(F)\rightarrow ^2T_{2g}(P) (\gamma=1900 cm^{-1})\) (Maurya, 2002). The Ni(II) complexes exhibit crystal field transitions at 10550 cm\(^{-1}\), 17391 cm\(^{-1}\) and 25000 cm\(^{-1}\), which can be the allowed transitions \(^3A_{2g}(F)\rightarrow ^3T_{2g}(F) (\gamma_1), ^3A_{2g}(F)\rightarrow ^3T_{1g}(F) (\gamma_2)\) and \(^3A_{2g}(F)\rightarrow ^3T_{1g}(P)(\gamma_3)\) (Kazunori Sakata, 1990; Huheey, 2000). The third spin allowed transition is observed as a shoulder. The Cu(II) complexes displayed a broad band centred at 15000 cm\(^{-1}\) which is an envelope of the transitions. Because in Cu(II) complex, the Jahn Teller effect removes the degeneracy of the d– orbitals resulting tetragonal distortion and splitting of \(E_g\) and \(T_{2g}\) levels into \(B_{1g}, A_{1g}\) and \(E_g\) levels(Maurya, 2003). Thus the observed spectral properties of Cu(II) complexes are due to the weakly distorted octahedral geometry of the complex.

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Antibacterial studies

The results of biological studies were reproduced in Table 4. The ligand and the metal complexes showed variable activity against the bacterial stains of E. Coli and B. Subtilis (Patel, 2003). The Schiff base 2-hydroxybenzilidene-2-aminophenol showed moderate activity against the bacteria. But comparing to the ligand, almost all metal complexes exhibited enhanced activity (Thangadurai, 2002). Especially the complexes of the type \([M(H_2L)(H_2O)]X_2\) showed the maximum inhibition and among the complexes formed from different metals, copper(II) complexes were found to be most effective in inhibiting the bacterial growth.

4. Conclusion

The analytical results showed that the ligand 2-hydroxy benzilidene-2-aminophenol formed both ML and ML₂ type complexes and the anions from the metal salts played a prominent role in directing the complex formation towards ML or ML₂ type. Ni(II), Cu(II) and Zn(II) perchlorate salts directed the formation of ML₂ complexes, while the chloride salts preferred ML type. All the nitrato salts and Co(II) salts stabilized MLX₂ type complexes where \(X=\text{NO}_3, \text{ClO}_4, \text{Cl}^-\). The structure of the Schiff base and the complexes are given in Figure 1.3 to Figure 1.7.

The molar conductance data provided valuable support for the above inference. The cobalt perchlorate complex exhibited anomaly forming MLX₂ type complex with the anion coordinating to the metal inside the coordination sphere which is firmly supported by the IR data. The biological studies provided valuable information regarding the variation in antimicrobial activity of a Schiff base when coordinated to different transition metals.

5. ACKNOWLEDGEMENT

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### Table 3: IR SPECTRAL DATA

<table>
<thead>
<tr>
<th>( \gamma (\text{NO}_2) )</th>
<th>( \gamma (\text{C=O}) )</th>
<th>( \gamma (\text{C-O}) )</th>
<th>( \gamma (\text{S-N}) )</th>
<th>( \gamma (\text{C=C}) )</th>
<th>( \gamma (\text{C=NH}) )</th>
<th>( \gamma (\text{C=CH}) )</th>
<th>( \gamma (\text{C-H}) )</th>
<th>( \text{H-L} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1307 m</td>
<td>1485 s</td>
<td>1461 s</td>
<td>1631 s</td>
<td>3047 m</td>
<td>3452 m</td>
<td>1527 s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>462 w 624 w</td>
<td>1292 (ds15)</td>
<td>1473 s (ds12)</td>
<td>1442 s</td>
<td>1612 s (ds19)</td>
<td>3058 w (us11)</td>
<td>3448 w, (ds4)</td>
<td>1542 w, (us15)</td>
<td>[Co(H₂L)(H₂O)₂] Cl₂</td>
</tr>
<tr>
<td>1153 m 1107 s</td>
<td>467 w 624 w</td>
<td>1288 s (ds19)</td>
<td>1473 s, (ds12)</td>
<td>1442 s, (ds19)</td>
<td>1612 s (ds19)</td>
<td>3062 w (us15)</td>
<td>3448 w, (ds4)</td>
<td>1542 w, (us15)</td>
</tr>
<tr>
<td>1382.8s</td>
<td>460 w 538 w</td>
<td>1263 s (ds44)</td>
<td>1467 s, (ds18)</td>
<td>1438 s, (ds23)</td>
<td>1602 s (ds29)</td>
<td>3020 w (ds27)</td>
<td>3352 m, (ds100)</td>
<td>1583 w, (us56)</td>
</tr>
<tr>
<td>420 w 617 m</td>
<td>1296 s (ds11)</td>
<td>1465 s (ds20)</td>
<td>1620 s (ds11)</td>
<td>3058 w (us11)</td>
<td>3402 m, (ds50)</td>
<td>1546 m, (ds19)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>412 w 617 m</td>
<td>1296 s (ds11)</td>
<td>1460 s (ds20)</td>
<td>1620 s (ds11)</td>
<td>3058 w (us11)</td>
<td>1531 m, (us4)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1382.8s</td>
<td>486 w 560 w</td>
<td>1296 s (ds11)</td>
<td>1467 s (ds18)</td>
<td>1618 s (ds13)</td>
<td>3055 w (us8)</td>
<td>3452 m</td>
<td></td>
<td></td>
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<td>480 w 600 w</td>
<td>1296 s (ds11)</td>
<td>1460 s (ds20)</td>
<td>1612 s (ds19)</td>
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<td>3402 m, (ds50)</td>
<td>1531 m, (us4)</td>
<td></td>
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<tr>
<td>486 w 605 w</td>
<td>1296 s (ds11)</td>
<td>1458 s (ds20)</td>
<td>1612 s (ds19)</td>
<td>3055 w (us8)</td>
<td>-</td>
<td>1531 m, (us4)</td>
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<tr>
<td>1382.8s</td>
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<td>1298 s (ds9)</td>
<td>1469 s, (ds16)</td>
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<td>1612 s (ds19)</td>
<td>3055 w (us8)</td>
<td>-</td>
<td>1531 m, (us4)</td>
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<tr>
<td>450 w 609 m</td>
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<td>1469 s, (ds16)</td>
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<td>1612 s (ds19)</td>
<td>3055 w (us8)</td>
<td>3479 m, (us27)</td>
<td>1585 s, (us58)</td>
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### Table 4: ANTIBACTERIAL ACTIVITIES

<table>
<thead>
<tr>
<th>Compound</th>
<th>E.Coli</th>
<th>B.Subtilis</th>
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<tbody>
<tr>
<td></td>
<td>Activity</td>
<td>Percentage of inhibition %</td>
</tr>
<tr>
<td>DMSO</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>H₂L</td>
<td>++</td>
<td>12</td>
</tr>
<tr>
<td>[Co(H₂L)(H₂O)₂] Cl₂</td>
<td>+++</td>
<td>24</td>
</tr>
<tr>
<td>[Co(H₂L)(H₂O)₂] Cl₂</td>
<td>+++</td>
<td>24</td>
</tr>
<tr>
<td>[Co(H₂L)(H₂O)₂(NO₃)₂]</td>
<td>+++</td>
<td>24</td>
</tr>
<tr>
<td>[NiL(H₂O)₂]</td>
<td>+++</td>
<td>16</td>
</tr>
<tr>
<td>[NiL₂]</td>
<td>++</td>
<td>13</td>
</tr>
<tr>
<td>[NiL(H₂O)₂(NO₃)₂]</td>
<td>+++</td>
<td>19</td>
</tr>
<tr>
<td>[CuL(H₂O)₂]</td>
<td>+</td>
<td>10</td>
</tr>
<tr>
<td>[CuL₂]</td>
<td>++</td>
<td>12</td>
</tr>
<tr>
<td>[Cu(H₂L)(H₂O)₂(NO₃)₂]</td>
<td>+++</td>
<td>24</td>
</tr>
<tr>
<td>[ZnL(H₂O)₂]</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>[ZnL₂]</td>
<td>++</td>
<td>14</td>
</tr>
<tr>
<td>[Zn(H₂L)(H₂O)₂(NO₃)₂]</td>
<td>+++</td>
<td>22</td>
</tr>
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</table>

**Percentage of Inhibition:**
- Below 5mm = (-)
- 5mm-10mm = (+)
- 10mm-15mm = (++)
- 15mm-20mm = (+++)

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Figure 1.1 Spectrum of [Co(H₂L)(H₂O)₂]Cl₂

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Figure 1.2 IR Spectrum of [CuL₂]

Figure 1.3 Structure of 2-hydroxybenzimidene-2-aminophenol

Figure 1.4 Structure of [M(H₂O)₃] where M=Ni, Cu and Zn

Figure 1.5 Structure of [ML₂] where M= Ni, Cu and Zn

Figure 1.6 Structure of [M(H₂L)(H₂O)ₓ]X₂, where M= Co, Ni, Cu and Zn; X= -NO₃ and -Cl

Figure 1.7 Structure of [Co(H₂L)(H₂O)(ClO₄)₂]
REFERENCES


Xinde Zhu et al., Synthesis, structure and biological activities of the o,o'-diethylphosphohydrazonothionato and complexes with Ni(II), Cu(II) and Zn(II), Synthesis and Reactivity in Inorganic and Metal-organic Chemistry, 32(3), 2002, 475-487.