

## Synthesis and Biological Activities of Nickel(II), Copper(II) and Zinc(II) Complexes of S-Alkyl dithiocarbamate

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Complexes of S-alkyl dithiocarbamate with transition metal ions, viz., Ni(II), Cu(II) and Zn(II) have been prepared and characterized by infrared, <sup>1</sup>H NMR, UV-Vis, elemental analysis and conductivity measurement. All of the synthesized compounds are biologically active and screened for their antibacterial and antifungal activities which are found to exhibit moderate to significant biological activities.

**Key Words:** Synthesis, Schiff base complexes, Antimicrobial activity.

### INTRODUCTION

Metal dithiocarbamate complexes involving nitrogen-sulphur donor ligands are of considerable interest due to their potential biological activity<sup>1</sup> and practical applications in the fields of pharmaceutical and agricultural industries<sup>2,3</sup>. Dithiocarbamates exhibit significant antifungal, antiprotozoal, antibacterial and anticancer activity<sup>4,6</sup>. Recently, as *in vitro* insulinomimetic potential of these compounds has been established<sup>7</sup>. Carcinostatic activities have been found for metal complexes of dithiocarbamic acid and the Schiff base derived from S-methyl ester<sup>2</sup>. We report herein the synthesis and characterization of a new ligand having NS donor atoms and its complexes with Ni(II), Cu(II) and Zn(II) ions and describe their potential as antibacterial and antifungal agents.

### EXPERIMENTAL

All the chemical and reagent used were of reagent grade and used with out any further purification. The IR spectra of ligand and its complexes in DMSO were recorded on a Perkin-Elmer 283 spectrophotometer in the 4000-400 cm<sup>-1</sup> region. Electronic absorption spectra were obtained on a Spectrascan UV-2700, using a prepared dimethyl sulphoxide solution in the 200-1100 nm region. The <sup>1</sup>H NMR spectral analysis were performed on a Bruker advance 400 spectrophotometer using TMS as an internal standard.

Elemental analysis of the ligand and complexes were carried out in Microanalytical laboratory, CDRI Lucknow on Elemental Vario EL III Carlo Erba 1108 elemental analyzer. Molar conductance measurements were carried out for the 10<sup>-3</sup> M solution

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of the complexes in DMF solvent at 298 K using Decibel DB1011. Purity of the compounds was checked on TLC using silica gel-G. Melting points were determined in open capillaries and are uncorrected.

**Synthesis of ligand:** A solution of S-methyl dithiocarbazate (0.1 mol) in absolute ethanol (40 mL) was added to an equimolar solution of 4-methoxy acetophenone in 50 mL of the same solvent. The solution was heated on a steam bath for 2-3 h and then cooled to 0 °C in an ice bath. Precipitated Schiff base were filtered, washed and recrystallized with ethanol and dried at room temperature. m.p. 170 °C, yield 65 %, Anal. (%) Found: N, 11.10; S, 25.28 %. Calcd. for C<sub>11</sub>H<sub>14</sub>N<sub>2</sub>OS<sub>2</sub>: N, 11.02; S, 25.20 %.

**General method for synthesis of metal complexes:** The Schiff base (0.002 mmol) and metal salt (0.001) Ni(OAc)<sub>2</sub>, Cu(OAc)<sub>2</sub>.H<sub>2</sub>O, Zn(OAc)<sub>2</sub> was dissolved in ethanol (20 mL) and content were refluxed for 3-5 h on water bath. The mixture was then cooled in an ice bath and the product were filtered with suction, washed with ethanol and dried in desiccator over anhydrous silica gel. The coloured solid are obtained and are mostly soluble in common organic solvents, DMSO and DMF.

## RESULTS AND DISCUSSION

The elemental analysis data of the ligand and its complexes are given in Table-1. The data indicates the formation of 1:2 [M:L] ratio of the formulae of [M(pmasme)<sub>2</sub>] [M = Ni<sup>2+</sup>, Cu<sup>2+</sup>, Zn<sup>2+</sup>]. The molar conductances of the complexes in DMF indicate that they are essentially non-electrolyte in this solvent. The non-electrolytic nature of the complexes indicates that the ligand is coordinated as a uninegatively charged anion.

TABLE-1  
ANALYTICAL DATA AND PHYSICAL PROPERTIES OF  
THE SCHIFF BASE AND ITS COMPLEXES

Compd. No.	Compounds <sup>a</sup> (colour)	Yield (%) / m.p. (°C)	Molar conductance <sup>b</sup>	Analytical data <sup>c</sup>	
				N	S
<b>2a</b>	Hpmasme (Yellow)	70 (156)	–	11.10 (11.02)	25.28 (25.20)
<b>3a</b>	[Ni(pmasme) <sub>2</sub> ] (Deep green)	62 (200)	7.0	9.88 (9.91)	21.49 (22.68)
<b>3b</b>	[Cu(pmasme) <sub>2</sub> ] (Green)	58 (157)	26.0	9.80 (9.83)	21.84 (22.48)
<b>3c</b>	[Zn(pmasme) <sub>2</sub> ] (Light yellow)	56 (164)	46.0	9.76 (9.81)	22.48 (22.42)

<sup>a</sup>Hpmasme anionic form of the Schiff base of S-methyldithiocarbazate with 4-methoxy acetophenone. <sup>b</sup>Molar conductance of approximately 10<sup>-3</sup> M solutions in DMF (ohm<sup>-1</sup> cm<sup>2</sup> mol<sup>-1</sup>). <sup>c</sup>Calculated values are given in parenthesis.

4-Methoxy acetophenone Schiff base of S-methyl dithiocarbazate has the -N(H)C(S) (thioamide) function and therefore, in principle, it can exhibit thione (Fig. 1a) and thiol (Fig. 1b) tautomerism. However, its IR spectrum in KBr does not exhibit any

$\nu(\text{S-H})$  band at *ca.* 2700, but displays a medium intensity band at  $2840\text{ cm}^{-1}$  attributable to the  $\nu(\text{N-H})$  of the thione form. This is strong evidence that, like other Schiff bases of S-alkyldithiocarbazates, it also remains as the thione tautomer in the solid state. But when it is dissolved in ethanol and a metal [Ni(II), Cu(II), Zn(II)] salt is added to the solution, it quickly converts to the thiol form with the concomitant formation of a metal(II) complex of the deprotonated thiolate form of the Schiff base.

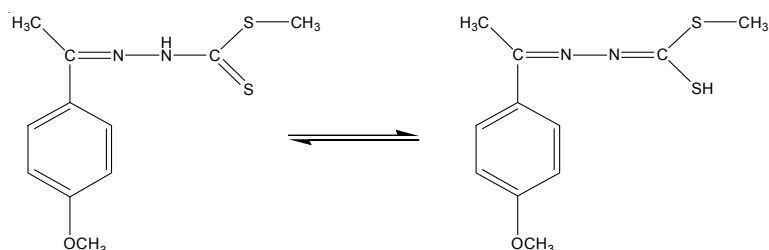


Fig. 1. Hpmasme: (a) thione form and (b) thiol form

The  $^1\text{H}$  NMR spectra of the Schiff bases in  $\text{DMSO-}d_6$  does not show any signal at 4.0 ppm due to the  $-\text{S-H}$  proton, indicating that in DMSO, it remains in their thione form. Thiosemicarbazones, which are closely related to Hpmasme, have been found to coordinate to metal ions in both the protonated thione form<sup>8</sup> and the deprotonated thiolate form<sup>9</sup>. There are examples of metal complexes in which both the protonated thione and the deprotonated thiolate forms of a thiosemicarbazone ligand are present in the same complex<sup>10</sup>. However Schiff bases derived from S-alkyl esters of dithiocarbazic acid invariably deprotonate while coordinating with metal ions yielding complexes containing only the thiolate form of the ligand. So far, there has not been a single example of a metal-dithiocarbazate complex in which a thione tautomer has been found to be coordinated to a metal ion.

The IR bands of Schiff base and its complexes are summarized in Table-2. A comparison of the IR spectrum of the ligand with those of its complexes shows that the broad and weak band at  $2840\text{ cm}^{-1}$  attributable to  $\nu(\text{N-H})$ , is not present in the spectra of the complexes indicating that the ligand is coordinated in its deprotonated form. In the past, evidence of coordination of thiosemicarbazone and dithiocarbazate ligands to metal ions via the azomethine nitrogen atom was based on shifting of the azomethine  $\text{C}=\text{N}$  band of the free ligand from higher to lower wave numbers in the spectra of metal complexes<sup>11</sup>. However, shifting of this band to both higher<sup>12</sup> and lower<sup>13</sup> wave numbers have been reported. Since the  $\nu(\text{C}=\text{N})$  band is expected to couple with other bands, the shifting of this band will be dependent on how much it is in combination with other bands. In the IR spectra of the present complexes, the  $\nu(\text{C}=\text{N})$  band is not shifted but the  $\nu(\text{N-N})$  band of the free ligand shifts considerably to higher wave numbers supporting coordination *via* the azomethine nitrogen atom<sup>14</sup>.

TABLE-2  
SPECTRAL DATA OF SCHIFF BASE AND THEIR COMPLEXES

Compd. No.	Compounds	IR absorption bands (cm <sup>-1</sup> )					UV-Vis (nm)
		v(C=N)	v(N-H)	v(C=S)	v(C-O)	v(N-N)	
<b>2a</b>	Hpmasme	1601	2840	1282	1058	1058	356, 385
<b>3a</b>	[Ni(pmasme) <sub>2</sub> ]	1603	–	–	1057	1177	430
<b>3b</b>	[Cu(pmasme) <sub>2</sub> ]	1604	–	–	1056	1179	429, 605
<b>3c</b>	[Zn(pmasme) <sub>2</sub> ]	1605	–	–	1058	1176	450

The sharp v(C=S) bands at 1282 cm<sup>-1</sup> for ligands were also not observed in the metal complexes, thus supporting the suggestion of coordination through the thione sulphur and from the IR studies a band v(C-O) at 1058 cm<sup>-1</sup> due to methoxy group remains unchanged in all the complexes, suggesting non participation of methoxy group in coordination with central metal ion.

Electronic spectral data are given in Table-2. The Schiff base spectral data exhibit a band in the 356-385 nm range, due to the π-π transition within the azomethine group, affected by the intramolecular charge transfer within the ligand molecule. The electronic spectra of the Schiff base complexes under investigation do not resemble the free Schiff base, which is the supporting evidences for complex formation. The electronic spectrum of the Ni(II) complex exhibited absorption band at 430 nm which are assigned to <sup>2</sup>B<sub>1g</sub>→<sup>2</sup>E<sub>1g</sub> transition, a square planar geometry has been suggested<sup>15</sup>. The Cu(II) complex displays two bands at 429, 605 nm attributed to the <sup>2</sup>B<sub>1g</sub>→<sup>2</sup>A<sub>1g</sub> and <sup>2</sup>B<sub>1g</sub>→<sup>2</sup>E<sub>1g</sub> transitions (d-d), suggesting square planar geometry.

Zinc(II) ion is flexible with respect to the number of ligand it can adopt in the coordination sphere. Analytical data and molar conductance values of the zinc(II) complexes adequately support their formulation as in Table-2. A tetrahedral geometry has been presumed for the zinc complexes. It has been reported that tetrahedral geometry is the most preferred structure for such a four coordinated zinc(II) complexes.

From the foregoing observations, the suggested chemical structures for the prepared Schiff base complexes under investigation are given in Fig. 2.

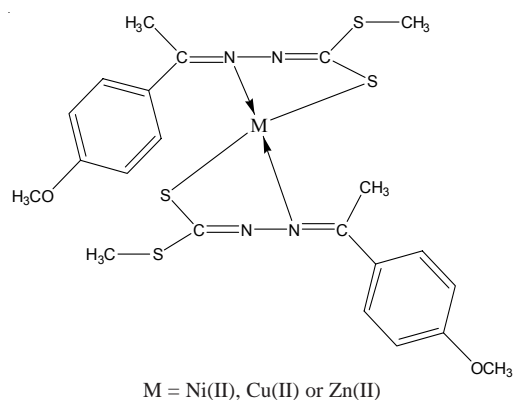


Fig. 2. Proposed structures of the metal complexes

**Antimicrobial activity:** The antibacterial activities were tested by disc diffusion method at 30 µg/mL concentration and ampicillin and tetracycline was used as a reference compound. *E. coli*, *S. aureus*, *Pseudomonas* species and *S. albus* used as the bacterial test organisms. All the new complexes were also screened for antifungal activity against *Aspergillus niger*, *Alternaria alternata* and *Candida* species at concentration of 50 µg/mL using subroad and dextrose agar media, Amphotericin B disc were used as the standard drugs. **3b** and **3c** complexes have shown moderate activity against bacteria, **3b** complex have also shown significant activity against *Aspergillus niger* and *Candida* species. **3a** exhibit very little activity against these organisms.

#### ACKNOWLEDGEMENTS

The authors are thankful to Principal Bipin Bihari P.G. Science College, Jhansi for providing research facilities. Authors are also grateful to Directors, C.D.R.I. Lucknow for elemental analysis, D.R.D.E. Gwalior for spectral studies and Birla Institute of Medical and Research, Gwalior for biological activities.

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