



Synthesis, Characterization and Study of Microbiological Activity of Ni(II) Complex with, 2-(5-Bromo-2-Oxindolin-3-Ylidene)-1-Hydrazinecarbothioamide

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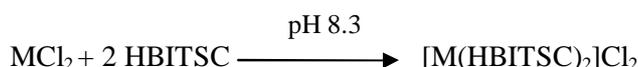
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ABSTRACT

A Schiff base ligand, [2-(5-Bromo-2-Oxindolin-3-ylidene)-1-HydrazineCarbothioamide], [HBITSC] was synthesized from 5-Bromoisatin and thiosemicarbazide. By using this ligand its complex with Ni (II) has been synthesized. The metal complex formed is dark brown coloured solid. Techniques such as electronic spectra, elemental analysis, molar conductance; IR and NMR spectroscopy were used for characterization. The bidentate Schiff base ligand undergoes coordination through azomethine nitrogen and thioketo sulphur to the metal ion. Electronic spectral analysis study reveals tetrahedral geometry of complex. The molar conductivity data of complex confirms its non-electrolytic nature. On the basis of above studies, it is concluded that complex has tetrahedral geometry and two ligands get coordinated to Nickel atom through thioketo sulphur and azomethine nitrogen. The microbiological activity of ligand and Nickel complex has been studied.

Graphical Abstract



Keywords: HBITSC, Metal complex, Bidentate, Microbiological activity.

INTRODUCTION

Schiff bases complexes of metals, with ligands, containing nitrogen and other donor atoms are found to have an important application in the field of coordination chemistry [1-6]. Large number of Schiff bases and the Ni metal complexes are used as catalyst. Many of them have been found to possess important biological activity [7-12]. In trace analysis of some metal cations, Schiff bases are also used as an efficient reagent [13-15].

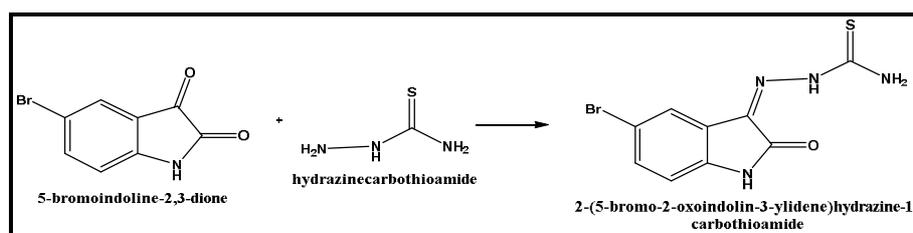
In the present study, a Schiff base ligand, [2-(5-Bromo-2-Oxindolin-3-ylidene)-1-Hydrazine Carbothioamide], [HBITSC] was synthesized from 5-Bromoisatin with thiosemicarbazide. By using

this ligand its complex with Ni(II) has been synthesized and characterized by elemental analysis, molar conductivity measurement, electronic, IR and NMR spectrum to determine the mode of bonding and geometry. The microbiological activities of the ligand and its metal complex we have also studied in the present work.

MATERIALS AND METHODS

Instrumentation: An element analyzer CHNO model flash EA 1112 series was used to determine percentage compositions of the elements (C, H, N, O) of the compound. To record electronic Spectrum of complex ELICO SL-159 UV-Vis Spectrophotometer was used. The Infrared spectra of ligand and complex of Ni(II)-HBITSC were recorded on SHIMADZU IR Affinity 1S. Melting point of ligand and its Ni(II)-HBITSC complex were recorded. ELICO SL-303 model was used to record molar conductivity and measurement was made using methanol as the solvent. All Chemicals and reagents were purchased from SD-Fine Chemicals (INDIA) and used without any further purification

Synthesis of [HBITSC] that is 2-(5-Bromo-2-Oxindolin-3-ylidene)-1-Hydrazinecarbothioamide : By refluxing 1:1 ethanolic solution of 5-Bromoisatin and thiosemicarbazide for 4-5 h Schiff base ligand [HBITSC] was synthesized. Refluxed solution on cooling formed, a sharp yellow crystalline product, which was collected by filtration. The yield was 80% as per the procedure recommended by Vogel, 1978 [16]. A crude HBITSC was recrystallized using aqueous ethanol and then characterized by elemental and spectral analysis.



Scheme 1. Synthesis of 2-(5-Bromo-2-Oxindolin-3-ylidene)-1-Hydrazinecarbothioamide.

Preparation of nickel complex with Schiff base ligand (HBITSC): A solution of ligand HBITSC was prepared in dimethyl formamide. It is then mixed with aqueous solution of hydrated Nickel chloride in molar ratio of 1:2 the pH was maintained at pH 8.3. The reaction mixture was refluxed on boiling water bath for 2-3 h. Dark brown colored Nickel (II) complex was separated out, which was filtered on cooling and washed with water and was recrystallized. Purified product was dried in vacuum desiccator over anhydrous CaCl₂ the yield was 60-70%.

Biological studies: Ni (II)-HBITSC complex stock solution was prepared by dissolving 20 mg of compound in methanol and the volume was made up to 10 mL with same solvent. The stock solution of 2000 ppm of each compound was prepared on active ingredient basis and was kept at room temperature till used. To determine antibacterial and antifungal activity of ligand and its complex cup plate method was used. Sterile Sabourauds agar and Mueller Hinton agar plates were seeded with 1 mL of 24 h old, 0.1 absorbance have taken for fungal and bacteria test cultures respectively. 50 μ L of compounds to be tested were added to the wells punched in the above media. The incubation temperature was 37°C/R.T and kept for 48 h. The inhibition zone around the wells was measured in millimeters.

RESULTS AND DISCUSSION

The Ni(II)-HBITSC complex is stable at room temperature and has brown colour The Ni(II)-HBITSC complex exhibits 1:2 [Ni(II): ligand] stoichiometry.

Table 1. The Analytical and physical data of ligand and Ni(II) complex is recorded

Compounds (Colour)	Mol. Weight	M.P. °C	% Elemental Analysis Found (Calculated)							
			C	H	N	Br	O	S	Cl	M
HBITSC (Yellow)	299.64	278	36.42 (36.1)	2.46 (2.67)	18.5 (18.72)	26.71 (26.70)	4.99 (5.2)	10.92 (10.60)	-	-
[Ni(HBITSC) ₂]Cl ₂	727.99	257	29.18 (29.67)	2.020 (2.19)	15.40 (15.38)	21.896 (21.95)	4.01 (4.39)	8.69 (8.79)	9.73 (9.75)	8.89 (7.84)

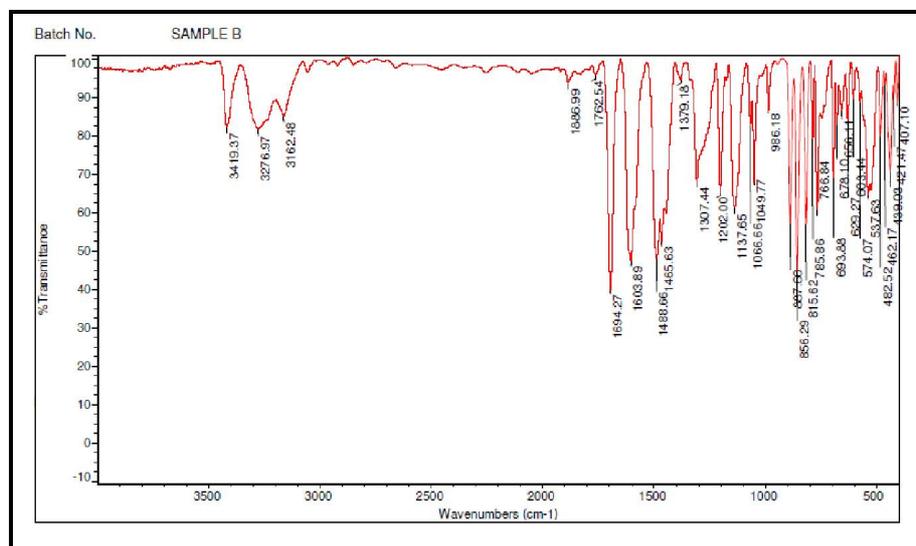
Infrared spectral analysis: The important functional groups in the compound can be identified using IR spectrum. The comparison of Infrared spectrum of the ligand and Ni(II) complex is summarized in table-2. Figure 1 and figure 2 are IR spectra of ligand and Ni(II) complex (Figure 1 and 2).

A broad band at 1603.9 cm^{-1} , is observed in IR spectra. Which is due to $\nu(\text{C}=\text{N})$ stretching of azomethine group [17]. Which is shifted to higher regions, 1614.0 cm^{-1} for Ni(II) complex. Shift in this band confirms the coordination of azomethine nitrogen to metal atom on complexation [18]. This was because of the donation of electron density from Nitrogen to metal.

At 856.29 cm^{-1} the strong bond is observed in ligands is due to the $(\text{C}=\text{S})$ stretching vibration. In metal complex it is shifted towards lower frequency 853 cm^{-1} indicating the coordination of thioketo sulphur to metal atom [19].

Table 2. The Important IR bands of Ligand and Ni Metal Complexes

Compound	$\nu(\text{C}=\text{N})$ cm^{-1}	$\nu(\text{C}=\text{S})$ stretching cm^{-1}	$\nu(\text{M}-\text{N})$ cm^{-1}	$\nu(\text{M}-\text{S})$ cm^{-1}
HBITSC	1603.9	856.29	-	-
[Ni(HBITSC) ₂]Cl ₂	1614.0	853	598	438

**Figure 1.** IR Spectra of ligand.

A new band is observed at 438 cm^{-1} which is because of stretching frequencies of $\nu(\text{M}-\text{S})$. One more band is observed at 598 cm^{-1} which is because of the stretching frequencies $\nu(\text{M}-\text{N})$ respectively [18-20], this new bands between $400\text{-}600\text{ cm}^{-1}$ region in the complex, which were absent in the spectrum of ligand.

Therefore, from above IR spectra it is concluded that ligand behaves as bidentate ligand and coordinated to metal ion via azomethine (N) and thioketo sulphur.

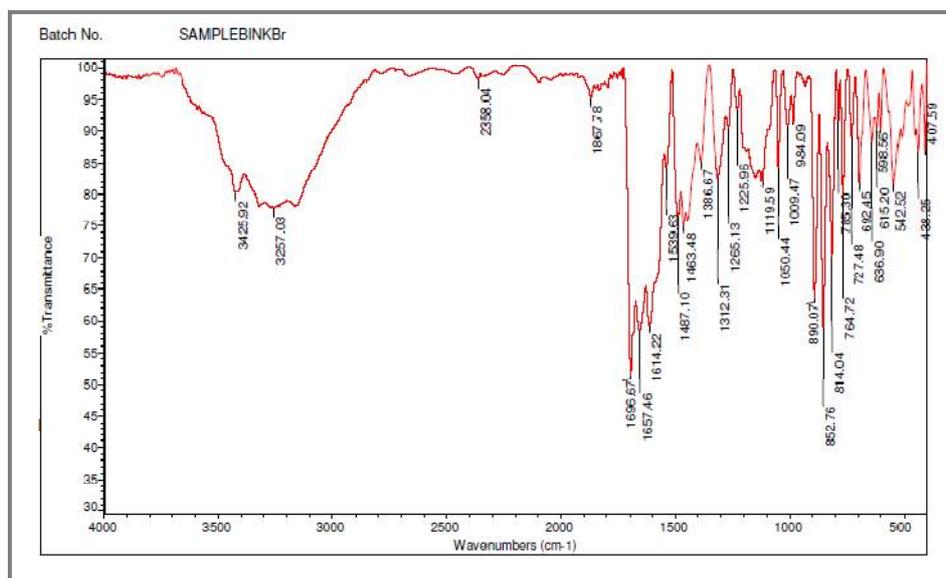


Figure 2. IR Spectra of Ni(II) Complex.

Electronic spectra of complex: In UV-Visible electromagnetic radiation, the transitions are associated with the electronic energy levels of the compound under investigation. The electronic structures are extremely varied because the transition metal ions occur in a variety of structural environments. Using UV-Visible spectroscopy, the electronic structures have been identified. From the electronic spectra, the nature of ligand field around the metal ion and the geometry of complex have been deduced. For the Ni(II) complex [20]. The band at 19607.00 cm^{-1} can be assigned to tetrahedral geometry.

Molar conductance: Using an ELICO conductivity meter (cell constant 1.0 cm^{-1}) the molar conductance values of 0.001 M solution of Ni(II) complex in methanol was measured at room temperature ($32.20 \text{ Ohm}^{-1} \text{ cm}^2 \text{ mol}^{-1}$) by comparing with known molar conductivities [20-21]. The non-electrolytic nature of the Ni-HBITSC complex is concluded.

^1H NMR: Using ^1H NMR spectra, coordination of thiosemicarbazones in the Ni(II)-HBITSC complexes are further confirmed (Table 3). The deprotonation of N-H group proton does not occur as the proton peaks of N-H group at δ 11.35 ppm and δ 12.25 ppm in complex remains same as in the ligand, it also suggests keto form of the ligands [22]. The multiplet as strong band in the region 6.87-7.88 ppm were assign to aromatic ring protons, which is also shifted downfield in the complex [22].

Table 3. NMR spectral data (δ , ppm) of HBITSC and the Ni-HBITSC complex

Compound	$\delta(\text{N-H})$	$\delta(\text{N-H})$	$\delta(\text{Ar-H})$
HBITSC	12.25	11.35	6.87-7.88
$[\text{Ni}(\text{HBITSC})_2]\text{Cl}_2$	12.25	11.35	6.91-7.92

Proposed structure of complexes: The results obtained by spectroscopic study and micro-analytical technique clearly indicates that the ligand [HBITSC] forms stable coordination compound with the Ni(II), On the basis of the above experimental evidence the probable structure of the complex under study is as shown in figure 3.

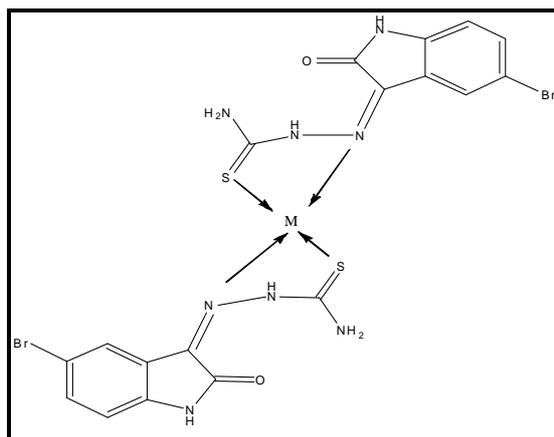


Figure 3. Proposed structure of Metal-Ligand Complex.

Antibacterial and antifungal activity: Antibacterial activity was studied by using Schiff base ligand HBITSC and its Ni(II)-HBITSC complex gram positive bacteria (*staphylococcus aureus*), gram negative bacteria (*Escherichia coli* and *Klebsiella pneumonia*) were used [23-26]. Antifungal activity was studied against (*Candida albicans*) by cup plate method [27]. The results of the biological activity of the metal complexes are as follows.

When comparative study of the inhibition zone of ligand and the Ni HBITSC complexes was done it indicated that free ligand has less antibacterial and antifungal activity than that of the Ni(II)-HBITSC chelate (Table 4). The increase in the biological activity of Ni(II)-HBITSC chelate was found due to the effect of Ni(II) on the chelate which could be explained on the basis of overtones concept and chelation theory. Due to partial sharing of positive charges of Ni(II) with donor group and orbital overlap of ligand and metal, polarity of Ni(II) get reduced on chelation. As a result of this delocalization of electrons over the whole chelate ring, lipophilicity of the complex get enhanced. This increased lipophilicity [28-31]. Enhances the penetration of the complex into lipid membrane and thus blocks the metal sites on enzymes of microorganism. The activity was compared with zone of inhibition was measured in millimeters.

Table 4. Zone of inhibition of growth in millimeters after 48 hours of incubation

Complexes	Cultures			
	S.a	E.c	K.p	C.a.
HBITSC	12	08	10	13
[Ni(HBITSC) ₂ Cl ₂]	20	17	12	18

APPLICATION

On the basis of the results obtained from microbiological studies the complex can be used as an antibacterial and antifungal agent.

CONCLUSION

The results and data obtained from the above study leads to the conclusion that Schiff base ligand 2-(5-Bromo -2-Oxoindolin-3-ylidene)-1-HydrazineCarbothioamide, [HBITSC] is a very good bidentate complexing agent and forms stable complex with Ni(II). Analytical data of complex is in good agreement with its molecular formula. There is no involvement of proton of N-H group but there is involvement of azomethine(N), thioketo(S) of the bidentate Schiff base to the Ni(II) and this was confirmed by comparing electronic, IR and NMR spectral data of the ligand with that of its Ni(II)-HBITSC complex. New band at 438 cm⁻¹ is due to (M-S) and 598 cm⁻¹ is due to ν(M-N) in the IR

spectra of Ni(II) complex further leads to conclusive evidence of the coordination of these Schiff-base with Ni(II). The results obtained from electronic spectra is used for assigning the geometry of complex of Ni(II) with HBITSC was proposed to be tetrahedral in nature. On the basis of these findings the structures have been proposed for the complex which is in good agreement with theoretical consideration (Figure 3). When comparative study of the inhibition zone of ligand and the Ni HBITSC complexes was done it indicated that Ni(II)-HBITSC chelate has more antibacterial and antifungal activity than that of the free ligand (Table 4).

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