



SYNTHESIS, SPECTRAL CHARACTERIZATION AND BIOLOGICAL ACTIVITIES OF Cu(II) COMPLEX WITH SCHIFF'S BASE LIGAND DERIVED FROM PHENYLACETYLUREA AND SALICYLALDEHYDE

P. DURAI RAJ^{a*}, T. MARUTHAVANAN^b, S. MANJUNATHAN^c, R. GOVINDHARAJU^d and T. RAMACHANDRAMOORTHY^e

^aDepartment of Chemistry, Excel Engineering College, Pallakkapalayam Sankari West (P.O.), KOMARPALAYAM – 637303, Dist.: Namakkal (T.N.) INDIA

^bDepartment of Chemistry, Sona College of Technology, SALEM – 636 005 (T.N.) INDIA

^cDepartment of Chemistry, Government Arts College, Ponneri, CHENNAI – 601204 (T.N.) INDIA

^dDepartment of Chemistry, Government Arts College, ARIYALUR – 621713 (T.N.) INDIA

^ePG & Research Department of Chemistry, Bishop Heber College (Autonomous), TIRUCHIRAPPALLI – 620017 (T.N.) INDIA

ABSTRACT

A new copper(II) complex of Schiff's base derived from phenylacetylurea condensed with salicylaldehyde (SBPS) and thiocyanate ion was synthesized by using microwave irradiation. Microwave synthesis gives high yield of the complex within a short time. The molecular formula and the probable geometry of the complex had been deduced from elemental analysis, electrical conductivity, magnetic susceptibility, infra red, electronic and EPR spectra. The molar conductance value indicates that the Cu(II) complex is a non-electrolyte. The FT-IR spectra show that SBPS and thiocyanate ion are coordinated to the metal ion in a monodentate manner. The covalency character of the complex was indicated by the EPR spectrum. The geometry of the complex was found to be tetragonally distorted octahedral. The antibacterial and antifungal activities of the free ligand SBPS and their Cu(II) complex were studied against the microorganisms, *viz.*, *E. coli*, *Klebsiella Pneumonia*, *P. aeurginosa*, *S. aureus*, *Bacillus cereus*, *Aspergillusflavus*, *Aspergillusniger*, *Aspergillusoryzae*, *Aspergillussojae* and *Candida albicans*, using agar - well diffusion method. The complex shows moderate activity against the bacteria and enhanced activity against the fungi as compared to the free ligands.

Key words: Copper(II) complex, Schiff's base, Thiocyanate ion, Antibacterial and antifungal.

*Author for correspondence; E-mail: duraiu@ymail.com, drt_maruthavanan@yahoo.co.in, manasu2k@yahoo.co.in, argovindh@gmail.com, chemtr@yahoo.co.in

INTRODUCTION

In recent trend there is an enhanced interest in the synthesis of transition metal containing Schiff's base. Schiff's base has several applications in biological, clinical and analytical fields¹ owing to their enhanced biological and pharmaceutical activities. Schiff's bases have attracted many research workers². Schiff's base complexes are used important in many important catalytic reactions³. They are also used in the di-oxygen uptake and oxidative catalyst^{4,5}. In the present work, the Schiff's base derived from phenylacetylurea and Salicylaldehyde by condensation is used as primary ligand for the preparation of complex. The prepared complex is characterized by the physico-chemical and spectral studies.

EXPERIMENTAL

Materials and methods

Phenylacetylurea, potassium thiocyanate and copper nitrate were purchased from Alfa Aaser Company and used as such. The organic solvents used, *viz.*, DMSO, DMF, methanol, ethanol were of AnalaR grade and used as such without further purification.

Preparation of Schiff's base

The Schiff's base (primary ligand) was prepared by refluxing an ethanolic solution of required mole ratios of phenylacetylurea with salicylaldehyde in the presence of NaOH, for more than an hour. It was recrystallized in ethanol.

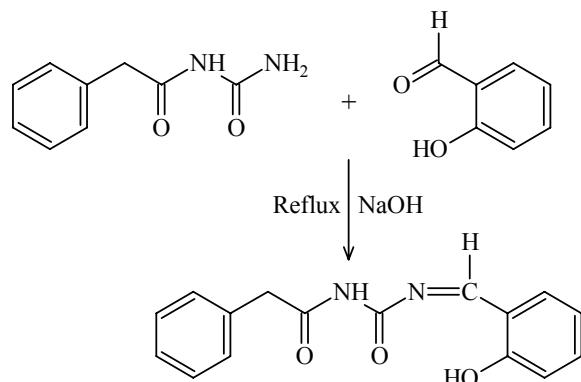


Fig. 1: Schiff's base of phenylacetylurea with Salicylaldehyde (SBPS)

Instrumentations

CHN elemental analyses were performed using Thermo Finnegan make, Flash EA1112 Series CHNS(O) analyzer. The electrical conductivity measurement was carried out

using 10^{-3} M solution of the metal complex in acetonitrile with systronic conductivity Bridge (model number-304) at 30°C. The UV spectrum of the Cu(II) complex was recorded on Varian, Cary 5000 model UV spectrophotometer. Infrared spectra for the complex and the ligands were recorded on a Perkin Elmer, spectrum RX-I, FT-IR spectrometer in KBr discs at room temperature. The Far-IR spectrum of the complex was recorded by Bruker 3000, FT-IR spectrometer. JES FA 200 model Spectrometer was used to record the EPR spectrum. The antibacterial and antifungal activities of the ligands SBPS and thiocyanate (using potassium thiocyanate) and their complex were done by agar- well diffusion method.

Synthesis of copper complex

2.27 g (8.24 mmol) of SBPS in ethanol and 1.05 g (8.27 mmol) of potassium thiocyanate in ethanol were added to copper nitrate 1.00 g (4.13 mmol) in methanol followed by microwave irradiation for a few seconds after each addition by using IFB 25 BG-1S model microwave oven. The resulting precipitate was filtered, washed with 1:1 ethanol: water mixture and dried under vacuum. A yellowish green coloured complex was obtained with the yield of 72%.

Pharmacology

Antimicrobial activity

The copper complex and the ligands were tested for *in vitro* antimicrobial activity by the well diffusion method⁶ using agar nutrient as the medium. The antibacterial and the antifungal activities of the ligand and the copper complex were evaluated by well diffusion method against the strains, cultured on potato dextrose agar as medium. The stock solution

(10^{-2} M) was prepared by dissolving the compounds in DMSO and the solutions were serially diluted to find Minimum Inhibitory Concentration values. According to the typical procedure⁷ a well was made on the agar medium inoculated with the microorganisms. The well was filled with the test solution using a micropipette and the plate was incubated for 24 hrs for bacteria and 72 hrs for fungi at 35°C. At the end of the period, the diameter of inhibition zones formed on the medium were evaluated in millimeters (mm).

RESULTS AND DISCUSSION

Elemental analysis and metal estimation

The elemental analysis and metal estimation of the complex lead to the formula [M(SBPS)₂(SCN)₂]. The percentages of carbon, hydrogen, nitrogen and copper in the complex were found to be 52.74 (52.73), 3.64 (3.67), 10.85 (10.83) and 8.20 (8.16),

respectively. The experimental data are in good agreement with the theoretical values (given in the parentheses).

Molar conductance

The molar conductance of 10^{-3} M solution of $[\text{Cu}(\text{SBPS})_2(\text{SCN})_2]$ in acetonitrile was found to be $81.03\ (\Omega^{-1}\text{cm}^2\text{mol}^{-1})$ indicating its non electrolyte⁸ nature.

Electronic spectra

For $[\text{Cu}(\text{SBPS})_2(\text{SCN})_2]$ the λ_{\max} values at 545 nm ($18348\ \text{cm}^{-1}$), 406 nm ($24630\ \text{cm}^{-1}$) and 249 nm ($40160\ \text{cm}^{-1}$) corresponding to ${}^2\text{E}_g \leftarrow {}^2\text{B}_{1g}$, ${}^2\text{B}_{2g} \leftarrow {}^2\text{B}_{1g}$ and ${}^2\text{A}_{1g} \leftarrow {}^2\text{B}_{1g}$ transitions suggest the tetragonally distorted octahedral geometry⁹. The magnetic moments value (1.79 BM) is consistent with the presence of one unpaired electron. This value lies above the spin-only value of 1.76 BM, probably due to the mixing of ground state with excited states through spin-orbit coupling¹⁰. The reported μ_{eff} values are in the range of 1.75-2.20 BM^{11,12}. These facts confirm the tetragonally distorted octahedral geometry for the copper complex.

FT-IR spectra

The IR spectrum of the pure ligand shows the characteristic frequencies as follows: the band at $3388\ \text{cm}^{-1}$ indicates the $\nu(\text{N-H})$ stretching frequency of primary amine, at $1668\ \text{cm}^{-1}$ indicates symmetric stretching frequency and at $1622\ \text{cm}^{-1}$ the asymmetric stretching frequency of $\nu(\text{N-H})$ in secondary amine. The $\nu(\text{C=O})$ stretching frequency of the ligand is observed at $1475\ \text{cm}^{-1}$. In the Cu(II) complex, $\nu(\text{N-H})$ is shifted to $1656\ \text{cm}^{-1}$ and the symmetry stretching frequency at ($1622\ \text{cm}^{-1}$) is shifted to $1605\ \text{cm}^{-1}$, which confirms the entry of ligands into the coordination sphere. In addition to that, the value at $2072\ \text{cm}^{-1}$ indicates the presence of SCN^- in the coordination sphere of the complex^{13,14}.

Far-IR Spectra

In the Far-IR spectrum of the complex, the frequency at $448.5\ \text{cm}^{-1}$ corresponds to Cu-N (imido nitrogen) bond¹⁵ and at $342.2\ \text{cm}^{-1}$ indicates the Cu-N (from thiocyanate) bond¹⁶. Thus, it is confirmed.

EPR spectrum

The X-band EPR spectrum of DMSO solution of the Cu(II) complex at 77 K (LNT) (Fig. 3) provides useful information about the metal ion environment. The spin Hamiltonian parameters of the complex were calculated and summarized in Table 1.

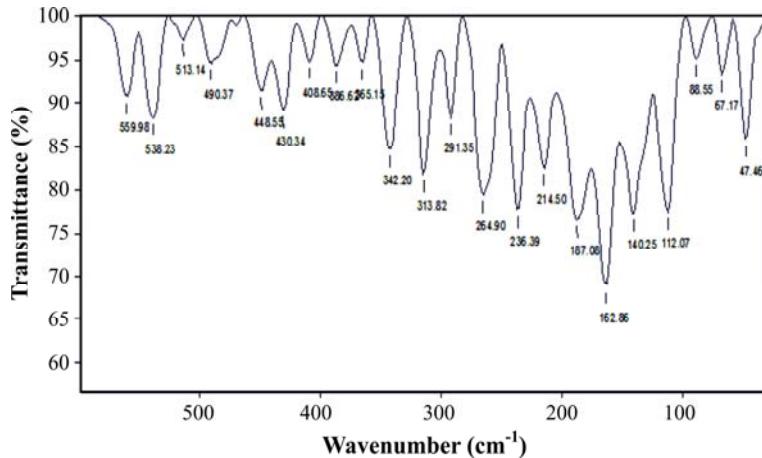


Fig. 2: Far-IR-spectrum of Cu(II) complex

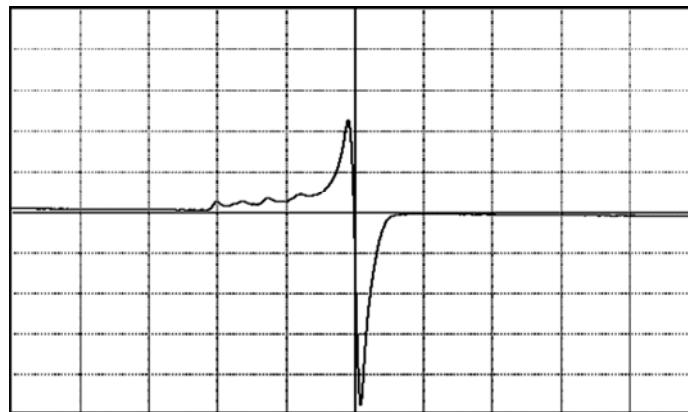


Fig. 3: EPR -spectrum of Cu(II) complex

Table 1: Spin Hamiltonian parameters of Cu(II) complex of (SBPS) and SCN at 300 and 77 K

Complex	Spin Hamiltonian parameters					
	\mathbf{g}_{\parallel}	\mathbf{g}_{\perp}	\mathbf{g}_{av}	\mathbf{G}	$\mathbf{A}_{\parallel} \cdot 10^{-4} \text{ cm}^{-1}$	α^2
[Cu(SBPS) ₂ (SCN) ₂]	2.3869	2.2750	0.4304	0.7220	177.62	0.4304

The spectrum shows four well resolved peaks in the low field region and one intense peak in the high field region. The g-tensor value of the copper complex can be used to derive the ground state. In octahedral complexes, the unpaired electron lies in the $d_{x^2-y^2}$ orbital¹⁷. For this complex, the observed g-tensor values are $g_{\parallel} = 2.3869 > g_{\perp} = 2.2750 > 2.0023$,

which suggest that this complex has an octahedral geometry and the ground state is ${}^2\text{B}_{1g}$. The EPR parameters of the complex coincide well with the related systems which confirm that the complex has an octahedral geometry and it is axially symmetric. In the EPR spectra, the g-values are related with the exchange interaction coupling constant G by the expression¹⁸.

$$G = g_{||} - 2:0023/g_{\perp} - 2.0023$$

According to Hathaway¹⁹, if G value is greater than four, the exchange interaction is negligible because the local tetragonal axes are aligned parallel or are slightly misaligned. If its value is less than four, the exchange interaction is considerable and the local tetragonal axes are misaligned. For the present Cu(II)complex, G = 0.7220 indicating considerable exchange interaction in the complex.

The g_{av} and the covalent in-plane σ -bonding (α^2) parameters are calculated according to the following equation²⁰,

$$g_{av} = 1/3[g_{||} + 2g_{\perp}]$$

$$\alpha^2\text{Cu} = (A_{\square}/0.036) + g_{||} - 2.0023 + 3/7(g_{\perp} - 2.0023) + 0.04$$

The α^2 value less than 1.0 indicates the presence of considerable covalent character associated with the metal-ligand bond^{21,22}.

Biological activity

Antibacterial activity

The antibacterial activities of the copper complex and SBPS were evaluated against the bacteria *E. coli*, *Klebsiella Pneumonia*, *P. aeruginosa*, *S. aureus*, *Bacillus cereus*, *Aspergillusflavus*, *Aspergillusniger*, *Aspergillusoryzae*, *Aspergillussojae* and *Candida albicans* at MIC concentration using agar-well diffusion method. The complex shows moderate activity against the tested microbes. The antibacterial activities of the free ligand and the complex are as shown in Table 2.

Table 2: Antibacterial activities of [Cu(SBPS)₂(SCN)₂] complex zone of inhibition(mm)

S. No.	Ligand/Complex	Zone of inhibition (mm)				
		<i>S.aureus</i>	<i>Bacillus cereus</i>	<i>E. coli</i>	<i>P. aeruginonosa</i>	<i>Kelebsiella</i>
1	SBPS	6	10	10	6	5
2	[Cu(SBPS) ₂ (SCN) ₂]	14	18	17	18	10

Antifungal activity

The antifungal activities of the copper complex and SBPS were evaluated against the *Aspergillusflavus*, *Aspergillusniger*, *Aspergillusoryzae*, *Aspergillussojae* and *Candida albicans* at various concentrations and compared with the antifungal activities of all the complexes, which are lower than those of flukonazole (standard).The complex shows enhanced activity against the tested fungus. The antifungal activities of the free ligand and the complex are as shown in Table 3.

Table 3: Antifungal activities of $[\text{Cu}(\text{SBPS})_2(\text{SCN})_2]$ complex (Diameter of zone of inhibition in mm)

S. No.	Fungus	Concentration		
		$100 \mu\text{g mL}^{-1}$	$200 \mu\text{g mL}^{-1}$	$400 \mu\text{g mL}^{-1}$
1	<i>Aspergillusflavus</i>	7	12	20
2	<i>Aspergillusniger</i>	8	15	24
3	<i>Aspergillusoryzae</i>	0	9	19
4	<i>Aspergillussojae</i>	9	15	26
5	<i>Candida albicans</i>	8	17	29

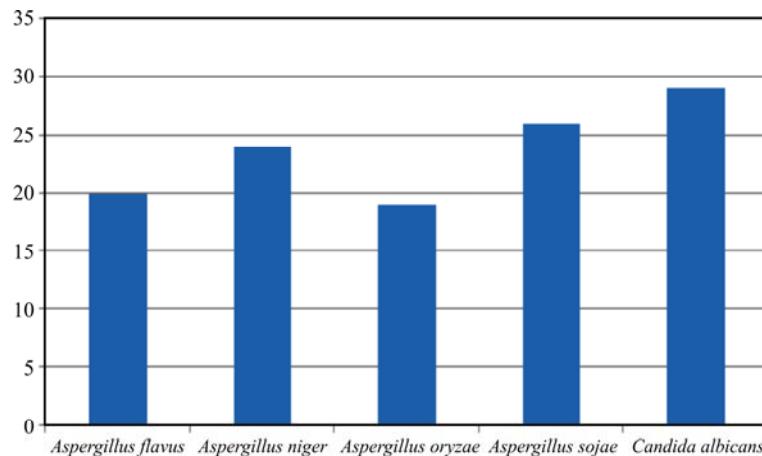


Fig. 4: Zone of inhibition (in mm) Antifungal effects of the $[\text{Cu}(\text{SBPS})_2(\text{SCN})_2]$ complex

CONCLUSION

In the present study, our efforts were to synthesize and characterize a new Cu(II) metal complex with SBPS and thiocyanate ion as ligands. The new complex was synthesized

using microwave irradiation (Green synthesis). The synthesized complex was characterized by various chemical and spectral analyses. Based on the analytical, electrical conductance, spectral and magnetic moment data, tetragonally distorted octahedral geometry had been suggested for the Cu(II) complex. The antibacterial and the antifungal activities of the ligand were compared with the Cu(II) complex. The complex showed moderate activity against the bacteria and enhanced activity against the fungi.

ACKNOWLEDGEMENT

The authors are thankful to the Head, SAIF, IIT and the Director, STIC, Cochin for providing the spectral data collection. The authors also thank the Management and the Principals of Sona College of Technology, Salem and Dr. Navalr Nedunchezhiyan College of Engineering, Tholudur for permitting them to carry out this work.

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Revised : 19.06.2016

Accepted : 21.06.2016