



MICROWAVE ASSISTED SYNTHESIS, CHARACTERIZATION AND STUDY OF MICROBIAL ACTIVITIES OF DIOXOMOLYBDENUM(VI) COMPLEX DERIVED FROM SALICYLALDEHYDE AND PHENYL ETHYL AMINE

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Abstract:

The Schiff base ligand *N-Salicylidene-2-phenylethylamine* (SPEA) and its Dioxomolybdenum(VI) complex, MoO_2L_2 , were synthesized by microwave and investigated and characterized by different physicochemical techniques. The infrared spectral data of the mixed Schiff base complexes exhibited chelating behavior between the metal ion and the ligand through the active groups presented in the SPEA such as nitrogen atom of the azomethine and deprotonated oxygen atom of the hydroxyl group. The ligands as well as the complex were assayed for antibacterial activity against some pathogenic bacteria: *Staphylococcus aureus* (gram positive), and *Pseudomonas aeruginosa* (gram negative), using paper disc method and placing the ligands on surface at nutrient agar. The results show that the MoO_2L_2 has higher activities in both lower and higher concentrations against both kind of bacteria *Pseudomonas aeruginosa* respectively as compared to Ligand (SPEA).

KEYWORDS: Antimicrobial activity, Microwave, Molybdenum(VI), Schiff base

Introduction

Coordination compounds are the backbone of modern inorganic and bio-inorganic chemistry and chemical industry. These compounds provide critical insights into the functioning and structures of vital components of biological systems. Coordination compounds also find extensive applications in metallurgical process, analytical and medicinal chemistry [1] Amongst the coordination compounds, Schiff base complexes are of considerable importance and have been known since the mid nineteenth century [2,3]. Metal-complexes of Schiff bases have occupied a central place in the development of coordination chemistry [4].

Chelating ligands containing N and O donor atoms show broad biological activity and are of special interest because of the variety of ways in which they are bonded to metal ions. It is known that the existence of metal ions bonded to biologically active compounds may enhance their activities[5,6]. Schiff base compounds and their complexes play an important application in the area of food and dyes industry, agriculture, polymer, biological sciences as antibacterial and antifungal [7,8]. The medicinal application of metal complexes has been a subject of great interest recently [9]. Apart from the huge success of platinum-based drugs, some other metal compounds such as titanium and ruthenium complexes have shown some potential for

chemotherapy. Copper complexes have indeed demonstrated a wide range of pharmacological activity such as antibacterial, antifungal, antiviral, anticancer and anti-inflammatory activity [10]. Molybdenum complexes of Schiff bases have been investigated because they play an important role not only in the development in coordination chemistry, but also in catalysis, enzymatic reaction, magnetism, molecular architectures [11-13].

Microwave assisted synthesis has now become the new non-conventional method in organic and inorganic synthesis, replacing the conventional reflux and proving to be eco-friendly, clean, and convenient [14]. The use of microwave irradiation as a heat source not only shortens the reaction time but also enhances product yield as well as enhancing the purity by reducing unnecessary side reactions [15]. Microwave-irradiated reactions are done under solvent free or less solvent conditions. There are a few reports on the synthesis of metal complexes by microwave methods [16-18]. Due to the growing interest and pharmacological properties of nitrogen and oxygen containing Schiff base ligands and their metal complexes, a systematic study and biological aspects of the Mo(VI) complexes with Schiff base ligand derived from salicylaldehyde and phenyl ethyl amine have been undertaken. In the present investigation synthesized ligands and their complexes have also been tested *in vitro* for antifungal and antibacterial activity.

EXPERIMENTAL

Materials and Methods

All chemicals, reagents and solvents used in the synthesis of the complex were of analytical grade, while salicylaldehyde, phenylethylamine and ammonium molybdate were obtained from Merck Specialties Private Limited and were used without further purification. MoO₃ was obtained by heating ammonium molybdate. Carbon, hydrogen and Nitrogen analysis were carried out by micro analytical methods. The analysis of metal Molybdenum was carried out by reported method [19]. The molar conductivity of the complexes was measured at room temperature in DMF solvent using digital conductivity meter CMD-650. The infrared spectra over the region 4000-400 cm⁻¹ were carried out applying KBr disc technique using IFS-25 DPUS/IR spectrometer. The electronic spectra were measured in DMF solvent by using a Perkin-Elmer lambda-4β spectrophotometer.

Synthesis of SPEA Schiff's Base Ligand

The Schiff base *N-Salicylidene-2-phenylethylamine* (SPEA) was synthesized as follows: NaOH (0.01 mol; 0.4gm) was dissolved in 30 cm³ of methanol and amino acid (phenylethyl- amine) (0.01 mol; 1.21gm) was added to it. The content was stirred magnetically at room temperature to obtain a homogenous mixture to which 1.05 cm³ of 2-hydroxybenzaldehyde was added in small portions with constant stirring. The reaction mixture was heated in the microwave reactor at 150°C for 5 minutes. A yellowish precipitate was filtered off and washed several times using cold methanol. The precipitate was then dried over anhydrous silica gel. (Yield ≈ 91%) m.p.: 110–114°C. pale yellow solid; molecular formula C₁₅H₁₅ON; IR ν_{max}(cm⁻¹): 1545 (C=N); 1655 (–CH=CH);

Preparation of Metal Complex

MoO₃ 1.44g (1 mmol) was added in 20mL of ethanol and to this a solution of Schiff base ligand SPEA (2 mmol 3.86g in 25mL of ethanol) was added in the presence of 1 mmol of NaOH. The mixture was heated in the microwave reactor at 150°C for 15 minutes. The solid mass (Mo-SPEA complex) so obtained was filtered off, washed several times with ethanol and was finally dried under vacuum. Yield: 87%. m.p.: >280 °C.

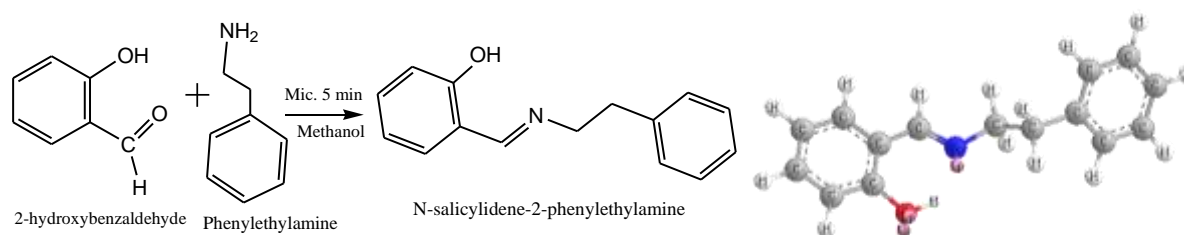


Fig-1: Synthesis and structure of the Schiff base ligand

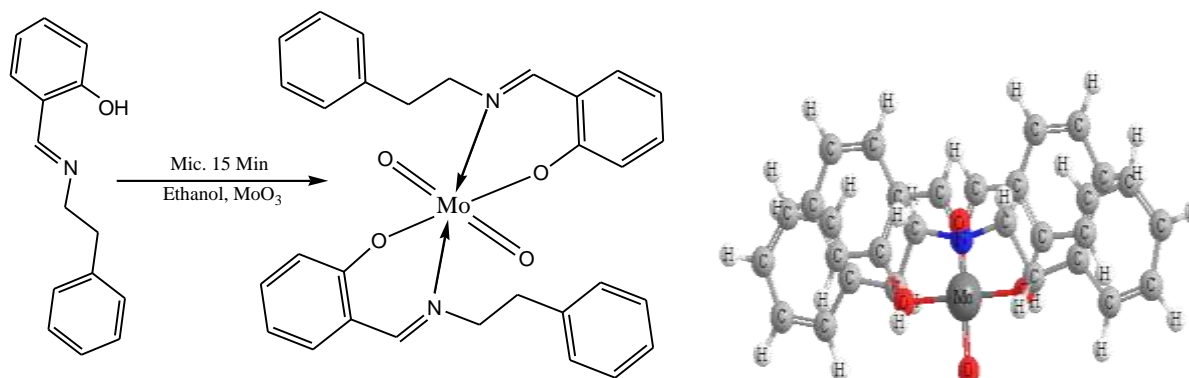


Fig-2: Proposed structure of Molybdenum(VI) – SPEA complex

Table 1: Analytical and Physical data of ligand and complex

Compound	Colour	Mol. Formula	Formula wt. (g mol ⁻¹)	Elemental Analysis Found (Cal)				λ_M Ohm ⁻¹ cm ² mol ⁻¹
				C	H	N	Mo	
SPEA	Light Yellow	C ₁₅ H ₁₅ ON	225.29	79.89 (79.97)	6.78 (6.71)	6.28 (6.22)	----	----
Mo-SPEA complex	Yellow	MoO ₂ (C ₁₅ H ₁₄ ON) ₂	576.50	62.57 (62.50)	4.95 (4.93)	4.89 (4.86)	16.71 (16.64)	38

Conductance measurement

The molar conductivity measurement carried in 10⁻³ M DMF solution for the Mo-SPEA complex was found to be 38 Ohm⁻¹cm²mol⁻¹ which is much less than the value of 70-160 Ohm⁻¹cm²mol⁻¹ obtained for 1:1 electrolyte in this solvent. Thus it can be concluded that the complex in study is undissociated which indicates the non-electrolytic nature of this complex.

Infrared Spectra

The structurally significant IR bands for free ligand and metal-ligand complex are reported in Table 2. The band at 1532 cm⁻¹ observed in the IR spectra of free ligand can be attributed to ν (C=N) stretching vibration, whereas another bands at 3166 cm⁻¹ in the free ligand is attributed to the free OH stretching of phenolic moiety [20]. In the complexes, the band due to phenolic OH vibrations disappeared, indicating deprotonation of the OH group and subsequent coordination of the oxygen to the metal ion. In addition on complexation the band at 1588 cm⁻¹ for the azomethine group in the free ligand was shifted to a lower frequency in the range 1562 cm⁻¹, indicating the coordination of the azomethine nitrogen atom to the metal ion [21]. Further, the spectrum of the complexes shows new bands at 515 and 456 cm⁻¹ which may probably be due to the formation of M–O and M–N bonds, respectively. [22].

Table 2: IR (cm⁻¹) and UV (nm) spectral data

Compound	ν (OH)	ν (C=N)	ν (Mo-O)	ν (Mo-O)	λ_{max}
SPEA	3166	1588	---	----	245, 278, 365
Mo- SPEA complex	----	1562	515	456	239, 332, 529

Electronic spectra

The electronic spectra of compounds were recorded using DMSO as solvent between 200-700nm at room temperature. . The wavelengths values of maximum absorbance are presented in the experimental section, Table 2. The spectra show three bands in the range 245–365 nm. The former spectral range is assigned to π - π^* transitions of the entire p-conjugated system in phenyl and/or phenyl ethyl amine moiety, whereas the bands in the latter range are due to n- π^* transitions of the nonbonding electrons existing on the nitrogen atom of -C=N chromophore. These bands are shifted in the spectra of complex to lower wavelengths indicating the coordination of metal with the ligand. The intense broad band at 529 nm in the spectra of

complex may be due to ligand to metal charge transfer (LMCT) [23]. The tail of this band may obscure other weaker d-d transitions in this wavelength range [24]. The analytical data suggested the stoichiometry of 1:2 (M:L) for the complex.

¹H (proton) NMR spectra

The ¹H (proton) NMR spectral comparison of Ligand SPEA and the diamagnetic Mo(VI) complex using TMS as an internal standard furnishes useful information about the proton environment of ligand and also its mode of ligation in the complex. The spectra of ligand show a sharp singlet peak at δ 8.58 ppm which has been attributed to the presence of azomethine proton (CH = N) and a multiplet within the range of δ 7.1–7.7 ppm for aromatic protons and singlets at δ 3.24 and δ 3.81 for methylene (CH₂) group protons [25]. The hydroxyl group has appeared as a singlet at δ 5.43 ppm. A comparison of ¹H NMR spectrum of Mo(VI) complex of SPEA has shown a slight upfield shift in azomethine signal and appears at δ 8.49 ppm pointing out the involvement of N in coordination [25, 26]. The peaks due to OH group δ = 5.0 ppm in the ligand is found to be absent in the spectra of Mo complex indicating the coordination of ligand through O atom of –OH group via deprotonation [27]. The peaks due to methylene protons and aromatic hydrogen remain almost unchanged in the complex indicating the non-involvement of these groups in coordination.

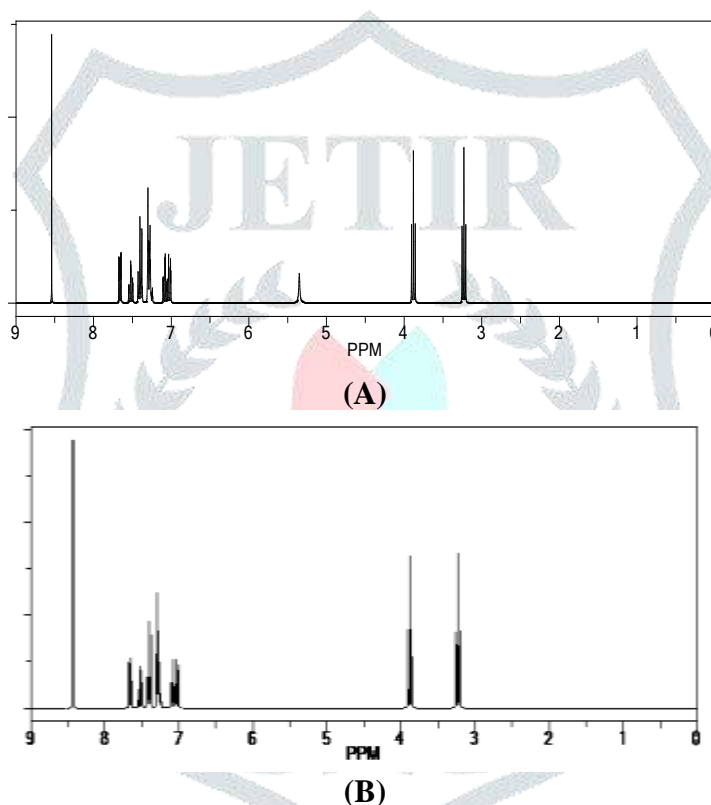


Figure 3. ¹H NMR spectra of (A) SPEA (B) SPEA-Mo Complex.

Antimicrobial Study

The newly synthesized target compounds are assessed for their in vitro antibacterial activity against two Gram-positive bacterial species (*Bacillus subtilis* and *Staphylococcus aureus*), two Gram-negative bacterial species (*Escherichia coli* and *Proteus vulgaris*) and two fungi (*Aspergillus fumigatus* and *Candida albicans*) using the diffusion agar technique. The MIC values calculated for the ligand and its Mo(VI) complex is shown in Table 3. The inhibition zone diameter values obtained for these compounds reveal that the complex shows fairly good activity against all the tested bacterial strains, as compared to ligand or free metal ions. The higher activity of the metal complexes may be owing to the effect of metal ions on the normal cell membrane and can be explained by using overtones concept and chelation theory [28]. The antimicrobial activities are found to increase with increase in concentration of experimental solutions. Metal chelates bear polar and nonpolar properties together; this makes them suitable for permeation to the cells and tissues. In addition, chelation may enhance or suppress the biochemical potential of bioactive organic species. Further, on chelation, metal ion polarity is reduced to a greater extent due to the overlapping of the ligand orbital and partial sharing of positive charge of metal ions with donor groups. Hence, the delocalisation of the π -electrons is increased over the whole chelate sphere which enhances the lipophilicity of the complex. The lipophilic nature of the central metal atom is also increased upon chelation, which subsequently favours the permeation through the lipid layer of the cell membrane [29]. These metal–ligand complex have an

advantage in that the respective bioactivities of the uncoordinated ligands and metal ions are combined which could make them more potent antimicrobial agents.

Table 3: MIC ($\mu\text{g mL}^{-1}$) values of the ligand, free-metal cations and Mo(VI) complex evaluated by minimum inhibitory concentration (MIC)

Compound	Antibacterial activity				Antifungal activity		
	<i>S. aureus</i>	<i>E.coli</i>	<i>P. aeruginosa</i>	<i>B. subtilis</i>	<i>A. niger</i>	<i>C. albicans</i>	<i>R. bataicola</i>
SPEA	95	110	135	90	75	67	79
Free-metal cations	104	135	172	95	87	82	88
Mo- SPEA Complex	25	15	22	16	12	10	27

CONCLUSION

Microwave (MW) irradiation is an efficient and environmentally-benign method to accomplish various inorganic and organic syntheses to afford products in higher yields in shorter reaction periods. In the present studies microwave assisted synthesis and spectroscopic characterization of Mo(VI) complex with a novel bidentate schiff base ligand derived from Salicylaldehyde and phenylethylamine is reported. IR, UV-vis spectra, and magnetic measurements of the ligand and its metal complex confirmed the suggested coordination of the ligand through phenolic oxygen of -OH group, and nitrogen of the azomethine group as bidentate. The newly synthesized metal – ligand complex possesses better antibacterial activity. The process of chelation dominantly affects the biological activity of the complex that is potent against pathogens. Based on these facts, it could be proposed that this novel complex can be better accommodated for antimicrobial applications being more potent antimicrobial agent.

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