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Original Research Article

Synthesis, Spectroscopic Characterization and Pharmacological Significance of Schiff Base Complex

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Abstract: The Schiff base ligand and the Metal complex have been characterized by elemental analysis IR, UV-visible, NMR, conductivity measurements. The Molar conductance of Mn(II) complex showed non-electrolyte in nature. The spectroscopic data of metal complex indicated that the metal ion is complexed with azomethine nitrogen and the complex exhibit octahedral arrangements. The entire complex exhibited more antimicrobial than ligand Further the metal complex screened for cytotoxic studies against a panel of human cancer lines.

Keywords: Synthesis, Spectra, Antimicrobial, cytotoxicity.

INTRODUCTION

Metal complex of Schiff base played a central role in the development of coordination chemistry [1-6]. A novel Schiff base ligand derived from 2-thiophenyl glyoxal-2'-aminophenol and its metal complex with its metal acetate was prepared, spectral and Biological properties were investigated. Schiff bases are regarded as ''privileged ligands''. Due to their ability to form complexes with a wide range of transition metal ions yielding stable and strongly colored metal complexes. In recent years a great deal of interest in the Schiff base transition metal complexes have been used extensively examined due to their diverse biological properties antifungal, antibacterial, anti-inflammatory, antitumor and greater DNA binding ability. A large number of Schiff bases and their complexes have been studied for their interesting and important properties e.g. their ability to reversibly bind oxygen, catalytic activity in hydrogenation of olefins and transfer of an amino group photochromic properties. The high affinity for the chelation of the Schiff bases towards the transition metal ions is utilized in preparing their solid complexes. In the present paper transition metal complex with Mn (II) ion was synthesized with Schiff base ligand 2-thiophenyl glyoxal-2'-aminophenol. The coordination behavior of the ligand towards transition metal ion was fully investigated by various spectral techniques. Biological properties of the complex were evaluated by antimicrobial and cytotoxic studies.

MATERIALS AND METHODS

All the chemicals used were of A.R grade and the solvents were dried and distilled before use according to a standard procedure. C, H, N was analyzed on carlo- Erba microanalyzer Model 1106 Metal content was estimated by standard procedures [7]. IR spectra were recorded in the range 4000 cm^{-1} - 100 cm^{-1} with a Bruker IFS66V in KBr and Polyethylene medium for all complexes. The Molar conductance of the complex in DMF (10^{-3}M) solution was measured at $27+3^0$C with an Elico Model Conductivity meter. Electronic spectra of the complex was recorded on varian cary- 5E UV- visible spectrophotometer NMR spectra was recorded on Bruker 300 Hz spectrophotometer using DMSO d_6 as solvent. Chemical Shifts are reported in ppm relative to tetramethyl silane using the solvent as internal reference. The Magnetic moment measurement were made on a Gouy Balance at room temperature using Hg [Co $(SCN)_4$] as the calibrant.

The Schiff base ligand and its complex were investigated for antibacterial and antifungal activities against staphylococcus aureus and streptococcus

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pneumoniae as gram positive bacteria and Escherichia coli and Pseudomonas areuginosa as gram negative and the Fungi Candida albicans and as Aspergillus niger by using disc agar diffusion method.

The antibiotic chloramphenicol and tetracycline were used as standard reference in the case of Gram-negative and Gram-positive bacterial species, whereas clotrimazole was used as standard reference for fungal species incubation time for 36h at 27^0C in the case of bacteria and for 48h at 24^0C in the case of fungi. After incubation period zone of inhibition were measured.

Further the synthesized metal complex has been evaluated for their cytotoxic activity against a panel of different human cancer cell lines by using MTT (3-(4)5- dimethyl thiazole-2-yl)2,5- di phenyl tetrazolium bromide) assay.

Synthesis of metal complex

An ethanolic solution of ligand 2- thiophenyl glyoxal -2'-aminophenol was prepared by dissolving $4x10^{-3}$ M ligand in 60 mL ethanol added to 30-40 mL ethanolic solution of $2x10^{-3}$ M Mn(OAC)$_{2.}$ 4H$_2$O in round bottom flask. The resulting solution was refluxed over a water bath for about 2 hrs, and cooled. The separated coloured product was filtered throughsuction, washed with ethanol followed by ether and dried in Vacuuo over anhydrous CaCl$_2$

Yield: Mn $[C_{12}H_8O_2NS]_2$ 73%

RESULT AND DISCUSSION

Table-1: Physical and analytical data of synthesized compounds

S. No.	Compound	Molecular Formula	Color	% Analysis Found/ Calculated C	H	N	M	MP (^{O}C) / DT	Molar Conductance $((\Omega)ohm^{-1}cm^2mol^{-1}$
1.	Ligand	$C_{12}H_9O_2NS$	Dark Brown	60.40 (60.23)	3.63 (3.47)	5.56 (5.41)	-	187-190	-
2.	Metal Complex	$Mn[C_{12}H_8O_2NS]_2$	Pale Brown	54.17 (54.27)	2.63 (2.78)	4.64 (4.87)	10.39 (10.25)	302	9.02

IR Spectral Studies

Infrared spectra of free ligand showed a sharp band in the region of 1600-1580 cm^{-1} which may be attributed due to the stretching vibration of azomethine group (>C=N). This band is shifted towards lower frequency region in the spectra of metal complex suggesting thereby the participation of imine nitrogen in complexation A strong band in the region 1700cm^{-1} has been observed in the IR spectra of ligand which in due to the presence of stretching vibration of carbonyl group (>C=O) coordination through this carbonyl oxygen to the central metal ion is confirmed by a negative Schiff in this frequency in the spectra of corresponding metal complexes [8-10].

IR spectra of ligand showed a band of medium intensity in the region of 3520-3400 cm^{-1} due to the –OH stretching vibration of free- CO$_2$H group coordination of ligand as a consequence of deprotonation of – CO$_2$H group is evident by the disappearance of the above band in the IR spectra of respective metal complex. Furthermore the asymmetrical and symmetrical vibrations of COO$^-$ group appear at 1580-1545 cm^{-1} and 1338-1330 cm^{-1} $\Delta\upsilon$(as-s) value 200-204 cm^{-1} indicates the coordination through unidentate carboxylate group. Some New bands appeared in the IR spectra of metal complex in the region of 540 cm^{-1} 438 cm^{-1} and 330 cm^{-1} are probably due to formation of M-O, M-N and M-S respectively.

Electronic and NMR spectral Studies

The Mn (II) complex displayed the weak absorbtion bands at 15300,17200, 27390 and 38800 cm^{-1}.

These spectral bands are assigned as the $^6A_{1g}\rightarrow{}^4T_{1g}$(G) (ν_1), $^6A_{1g}\rightarrow{}^4E_g$(D) (ν_2) $^6A_{1g}\rightarrow{}^4T_{1g}$ (P) (ν_3) and $^6A_{1g}\rightarrow{}^4E_g$ (G) (ν_4) respectively [11-16]. These bands are both Laporte and Spin-forbidden. The Magnetic moment of Mn (II) complex is 5.24 B.M. suggesting octahedral geometry and d^{2}sp^3 hybridization. ^{1}H NMR spectra of free Schiff base the signals were appeared in the range of 8.10 - 8.24 ppm due to (HC=N) proton however in the spectra of Mn(II) complex the signals were observed in the upfield region of 8.20 – 8.32 ppm supporting the coordination of iminonitrogen atom to Mn (II) while the free ligand NMR spectra has a characteristic NMR signal for carboxyl group proton proton in the 10.15-10.90 ppm range, the disappearance of this signal in the ^{1}H NMR spectra of metal complexes indicating the involvement of Carboxylate ion oxygen in chelation through deprotonation. There is no appreciable change in the Peak position corresponding to NH and aromatic proton. The $_{13}$C NMR signals for the metal complex of Mn (II) ion is assigned by the comparison with the spectra of corresponding free Schiff base ligand. A down field shift of CH=N group in the range of 170.4-175.3 ppm and for carboxyl carbon coo ion in the range of 191.3 – 194.6 ppm. The NMR spectra of complexes indicates that the ligand coordinates through both the nitrogen atom of CH=N and the oxygen of COO$^-$ ion [17].

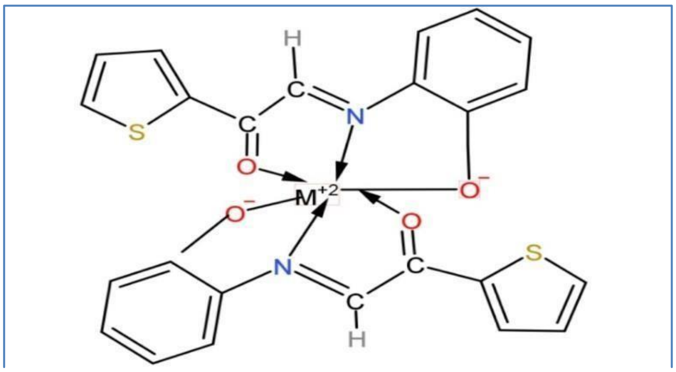

Fig-1: Structure of Complex

Table-2: Antimicrobial activities of Ligand and Metal complexes inhibition zone in mm concentration 100 μg/mL

Test Compound	Gram-positive		Gram- negative		Fungi	
	S. aureus	S. pneumoniae	E. coli	P. areuginosa	C. albicans	A. niger
Tetracycline	27	25	--	--	--	--
Chloramphenicol	--	--	30	28	--	--
Clotrimazole	--	--	--	--	22	23
$C_{12}H_9O_2NS$	10	12	12	12	08	10
Mn $[C_{12}H_8O_2NS]_2$	11	14	16	17	14	10

The result of antimicrobial activity of the ligand and its metal complex indicate that complex showed more activity and the ligand has less activity against microorganism. Metal chelate bear polar and non-polar properties together this makes them suitable for permeation to the cells and tissues. In addition, chelation may enhance or suppress the bio-chemical potential of bioactive organic species. Changing hydrophilicity and lipophilicity probably leads to bringing down. The solubility and permeability barriers of cell further lipophilicity which control the rate of entry of molecules into the cell in modified by coordination so the metal complexes can become more active than free ligand. Chelation considerably reduces the polarity of the Metal ion because of particular sharing of its positive charge with donor groups and possible electron delocalization over the whole chelate ring as a result the lipophilicity of Metal complexes enhances the Penetration of the complexes into lipid membranes and blocking of the Metal binding sides in the enzymes of microorganisms. These complexes also disturb the respiration process of the cell and thus block the synthesis of the Proteins that restricts further growth of the organism [21-23].

Cytotoxic Studies

Table 3: Half Maximum inhibitory concentration of synthesized Metal complexes IC_{50}(a) values expressed in μM

Compound	BT-549$^{(b)}$	SKOV-3$^{(c)}$	HCT-116
Mn$[C_{12}H_8O_2NS]_2$	8.24	9.46	10.20
Doxorubicin	1.73	1.12	1.01

(a) 50% inhibitory concentration values are an average of these individual experiments
(b) Breast cancer
(c) Ovarian
(d) Colon

Preliminary screening of the synthesized metal complex was carried out for its cytotoxic activity against a panel of selected human cancer cell lines such as BT-549(Breast), SKOV-3 (ovarian) and HCT-116 (Colon) by using MTT assay [24-35]. The result of this cytotoxic testing expressed as IC_{50} values are summarized in Table.5 Doxorubicin was used as a positive control. Mn(II) complex was found to be effective in all the cell lines examined [27-30],The higher activity of Manganese complex may be attributed to the function as a competitive inhibitor of hemoxygenese which is produced in large amounts in solid tumors in humans and animal tumor thus the complex has the capacity to reduce the energy status in tumors as well as to enhance tumor hypoxia which also influences its antitumor activity probably through Manganese biomolecule interaction.

CONCLUSION

Schiff base and its Mn(II) complex were prepared and characterized using the micro-analytical, conductance spectral analysis which reveal that ligand coordinating through the azomethine nitrogen and carbonyl oxygen atoms. The geometry of the complex is assigned as octahedral. The complex is biologically active and showed enhanced antimicrobial activity compared to the free ligand. Synthesized metal complex was also found to be effective in all the human cancer cell lines.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

1. Gulcan, M., Özdemir, S., Dündar, A., Ispir, E., & Kurtoğlu, M. (2014). Mononuclear Complexes Based on Pyrimidine Ring Azo Schiff-Base Ligand: Synthesis, Characterization, Antioxidant, Antibacterial, and Thermal Investigations. *Zeitschrift für anorganische und allgemeine Chemie*, *640*(8-9), 1754-1762.
2. Nair, M. S., Arish, D., & Joseyphus, R. S. (2012). Synthesis, characterization, antifungal, antibacterial and DNA cleavage studies of some heterocyclic Schiff base metal complexes. *Journal of Saudi Chemical Society*, *16*(1), 83-88.
3. Al Zoubi, W., Al-Hamdani, A. A. S., & Kaseem, M. (2016). Synthesis and antioxidant activities of Schiff bases and their complexes: a review. *Applied Organometallic Chemistry*, *30*(10), 810-817.
4. Lindoy, L. F. (1971). Metal-ion control in the synthesis of Schiff base complexes. *Quarterly Reviews, Chemical Society*, *25*(3), 379-391.
5. Yamada, S. (1966). Recent aspects of the stereochemistry of schiff-base-metal complexes. *Coordination Chemistry Reviews*, *1*(4), 415-437.
6. Kumar, S., Dhar, D. N., & Saxena, P. N. (2009). Applications of metal complexes of Schiff bases-A review.
7. Vogal, A.I. (1989). Text Book of Practical organic chemistry, fifth ed. Longman, London.
8. Nakamoto, K. (1997). Infrared and Raman spectra of Inorganic and coordination compounds New York Wiley 3^{rd} edn.
9. Thankmony, M., & Mohaman, K. (2007). Indian J. Chem; A(46), 249
10. Thomas, M., Nair, M.K., & Radha Krishan, R.K. (1995). Synth. React Inorg Met- org. chem, 25, 471.
11. Lever, A.B.P. (1968). Inorganic electronic spectroscopy New york Elsevier 2^{nd} edn.
12. Farmer, R.L., & Urbach, F.L. (1974). Inorg Chem, 13, 587
13. Tas, E., Aslanoglu, M., Kilic, A., & Kara, Z.J. (2006). Coord Chem, *59*(8), 861-862
14. Sathyanaryana, E.N. Electronic university press limited India;2001
15. Quraishy, A., & Ahmad, S.J. (2005). Ind Chem. Soc, *82*(6), 553-554
16. Zhou, Y. L., Zeng, M. H., Wei, L. Q., Li, B. W., & Kurmoo, M. (2010). Traditional and microwave-assisted solvothermal synthesis and surface modification of Co7 brucite disk clusters and their magnetic properties. *Chemistry of Materials*, *22*(14), 4295-4303.
17. Linington, R. G., Williams, P. G., & MacMillan, J. B. (2015). *Problems in organic structure determination: A practical approach to NMR spectroscopy*. CRC Press.
18. Winder, C.V., Wax, J., & welfare, J. (1965). Pharmacol Exp. Therop, 140,442.
19. Freeman, P.C., Goudie, A.C., Mangan, F.R., & Thomson, M.J. (1976). Pharm. Pharmacol, 28,285
20. Sorenson, J.R. (1976). J. Med Chem; 19, 135
21. Gross, DC and De Vay, SC Physicald Plant Pathol;1977 11, 13
22. Sonmez, M; Metin, C and Berber, I E. U. J. Med. Chem;2010 45, 1935
23. Kurtomg, Lu; Dagdelen, M and Torg, MM Trans. Met Chem; 2006 31, 382
24. Mueller,H; Kassack,MU and Wiese,M comparison of the usefulness of the MTT,ATP and calcein assays to predict the potency of cytotoxic agents in various human cancer cell lines Journal of Biomolecular screening;2004.**9** (6),506-515
25. Mosmann,T Rapid Colorimetric assay for cellular growth and survival: application to proliferation and cytotoxicity assays Journal of Immunological Methods;1983 **65** (1-2), 55-63
26. Nastasă, C., Vodnar, D. C., Ionuţ, I., Stana, A., Benedec, D., Tamaian, R., ... & Tiperciuc, B. (2018). Antibacterial evaluation and virtual screening of new thiazolyl-triazole Schiff bases as potential DNA-gyrase inhibitors. *International journal of molecular sciences*, *19*(1), 222.
27. Singh, A. P., Kaushik, N. K., Verma, A. K., Hundal, G., & Gupta, R. (2009). Synthesis, structure and biological activity of copper (II) complexes of 4-(2-pyridylmethyl)-1, 7-dimethyl-1, 4, 7-triazonane-2, 6-dione and 4-(2-pyridylethyl)-1, 7-dimethyl-1, 4, 7-triazonane-2, 6-dione. *European journal of medicinal chemistry*, *44*(4), 1607-1614.
28. Verma, A.K., Bansal, S., Singh, J., Tiwari, R.K., Kasi Sankar, V., Tandon, V., & Chandra, R. (2006). Bio org. Med Chem.,14, 6733
29. Zheng, L.W., Wub, L.L., Zhao, B.X., Dong, W.L., & Miao. (1957). Jy Bio Org. Med Chem; 17.
30. Shen, J., Liu, M., Xu, J., Sun, B., Xu, H., & Zhang, W. (2019). ARL15 overexpression attenuates high glucose-induced impairment of insulin signaling and oxidative stress in human umbilical vein endothelial cells. *Life sciences*, *220*, 127-135.
31. Rey, N.A., Neves, A., & Silva, P.P. (2009). Journal of Inorganic Biochemistry, *103* (10), 1323-1330.
32. Hu, W., & Kavanagh, J.J. (2003). The Lancet Oncology, *4*(12),721-729.
33. Mosmann, T. (1983). Journal of Immunological Methods, *65*(1-2),55-63.
34. Degli, E.M. (2001). Methods in Cell Biology, Academic Press.
35. Lehrer, S.S. (1971). Biochemistry, *10*(17),3254-3263.

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