Available online at
www.ijacskros.com

Indian
Journal of Advances in
Chemical Science

Indian Journal of Advances in Chemical Science 1 (4) (2013) 228-235

Synthesis, Characterization, and Antibacterial Activity of the Schiff Base Derived from P-Toluic Hydrazide and o-Vanilin (OVPTH Ligand) and its Mn (II), Co (II), Ni (II) and Cu (II) Complexes

S. Kondaiah*[1], G. Naga Raja Reddy[2], D. Rajesh[2], Jacob Joseph[3]

[1]*Dept of Chemistry, Malla Reddy Engineering College, Hyderabad, India.*
[2]*Dept of Chemistry, Sri Krishnadevaraya University, Anantapur, Andhra Pradesh, India.*
[3]*Aurobindo Pharma Ltd., Vizag, India.*
Received 15th August 2013, Revised 8th September 2013; Accepted 10th September 2013.

ABSTRACT

Metal complexes of a novel Schiff base derived from condensation of p-toluic hydrazide and o-Vanilin are reported and characterized based on elemental analyses, FT-IR, ^{1}H-NMR, UV-Visible, VSM, Molar conductance, ESR Spectroscopy, Powdwe XRD, micro analytical data and also found to be an anti bacterial activity. The magnetic properties of these Mn (II), Co (II), Ni (II) and Cu (II) complexes are 5.20 B.M. 4.93 B.M., 3.2 B.M and 1.63 B.M respectively. This result clearly indicates that the metal complexes of this ligand show octahedral geometry. The IR spectrums of these Schiff base metal complexes shows bands at 1603 cm^{-1}, 1597 cm^{-1}, 1598 cm^{-1}, and 1591 cm^{-1} respectively, which is assigned to (C=N) stretching vibrations, a fundamental feature of azomethine group. The anti bacterial results also indicate that the metal complexes are better antibacterial agents as compared to the Schiff base. All the metal chelates are found to be non-electrolytes.

Key words: *Schiff Base, p-Toluic Hydrazide, o-Vanilin, Anti Bacterial Activity, Characterization.*

1. INTRODUCTION

There is a continuing interest in transition metal complexes of Schiff bases because of the presence of both nitrogen and oxygen donor atoms in the backbones of these ligands, some of these complexes have been exhibit interesting physical and chemical properties and potentially useful biological activities. Schiff base have also been used for analytical purposes in the determination of metal ions, and some Schiff base derivatives [1-2] have been used in the extraction of metal solvents. The applications of such complexes depend to a large extent on their molecular structure. Schiff base ligands are able to coordinate many different metals, and to stabilize them in various oxidation states [2-4]. The Schiff base complexes have been used in catalytic reactions and as models for biological systems. During the past two decades, considerable attention has been paid to the chemistry of the metal complexes of Schiff bases containing nitrogen and other donors. This may be attributed to their stability, biological activity [5-6] and potential applications in many fields such as oxidation catalysis, and electrochemistry. Schiff base ligands have an affinity for transition metals such as Cu, Mn, Co, Ni and Fe. Some of these complexes have been studied in great deal for their various structures, steric effects and their coordination [7] chemistry.

The present paper deals with a new series of metal complexes of Mn (II), Co (II), Ni (II) and Cu (II) with Schiff base ligand (OVPTH) derived from P-Toluic hydrazide and o-Vanilin. These complexes were characterized by elemental analysis, IR, NMR, UV, TG-DTA, and conductivity measurements to determine the mode of bonding, geometry and biological activities of the metal complexes were also studied.

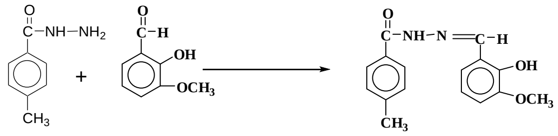
2. EXPERIMENTAL

2.1 Synthesis of p-toluic hydrazide and o-vanilin Schiff base (OVPTH)

Mixture of p-toluic hydrazide (0.01moles) and o-Vanilin (0.01moles) were dissolved in 50 ml methanol and added few drops of Tri ethyl amine. The whole mixture was transferred in to 250 ml round bottom flask. The mixture was refluxed about one and half hour on water bath. When the reaction mixture was allowed to cool light yellow crystals were obtained. The compound was recrystalized from methanol. The %of yield was 85% and melting point of the compound was 180-182 °C. The reagent p-toluic hydrazide and o-Vanilin Schiff base was dissolved in 40ml of 50% methanol and Mn (II), Co (II), Ni (II) and Cu (II) metal ions dissolved in 10ml of distilled water, this compounds mixture was stirred for 6 hours. A

---

*Corresponding Author:
Email:kondareddyseku@gmail.com



Scheme 1

colored precipitate of complex was obtained with good yield. These products were washed several times with hot water and cold methanol to remove unreacted ligand and metal slats respectively. Finally, all these complexes were dried in vacuo over calcium chloride desiccator.

3. RESULTS AND DISCUSSION

3.1. IR & NMR Spectral Studies

IR & NMR data gives further useful information on the structure OVPTH ligand and its metal complexes. IR & NMR spectrum of the free ligand was compared with the spectrum of the metal complexes. The structurally significant IR & NMR Spectral data of free OVPTH ligand and its metal complexes have been reported in table 1&2. The IR & NMR spectras are shown in Fig 1-3.

In NMR spectrum a signal observed at 11.07ppm due to N-H proton in the ligand is shifted to δ 11.25, 11.31ppm respectively for OVPTH-Co and OVPTH-Cu metal complexes. A broad band exhibited at 3330 cm^{-1} in the IR spectrum of the ligand is due to N-H stretching vibration. On complexation [8-9] this band shifted to 3312, 3297, 3310 and 3303cm^{-1} for Mn (II), Co (II), Ni (II) and Cu (II) complexes respectively. The IR spectrum of the ligand has shown a sharp band at 1711 cm^{-1} due to C=O stretching vibration. On complexation this band shifted to 1676, 1678, 1665 and 1670 cm^{-1} for Mn (II), Co (II), Ni (II) and Cu (II) Complexes respectively. These results clearly indicate the formation of complexes. The IR spectra of Mn (II), Co (II), Ni (II) and Cu (II) complexes exhibited broad bands at 3453 cm^{-1}, 3460 cm^{-1}, 3420 cm^{-1} and 3422 cm^{-1} respectively which can be assigned to the OH stretching vibration of the coordinated water molecules [10-11]. These results indicate that the ligand coordinates with the metal ion through the azomethine nitrogen and the oxygen of the deprotonated hydroxyl group.

3.2. UV Spectral studies & Magnetic susceptibility measurements of OVPTH complexes

By UV spectral studies the transition for the ligand occurred at 303 nm. But on complexation with the different metal ions like Mn (II), Co (II), Ni (II) and Cu (II) new bands appeared at 390 nm, 376 nm, 373 nm and 399 nm respectively corresponding to the transitional charge transfer from the ligand to the different metal ions. Bands occurred in the region of 370-395 nm for all complexes are assigned to charge transfer transition (L→M). Based on the results octahedral structure is proposed [12-13] for Mn^{+2}, Co^{+2}, Ni^{+2} and Cu^{+2} complexes. The magnetic moments of the present OVPTH Mn (II), Co (II), Ni (II) and Cu (II) Complexes [14] are 5.20, 4.93, 3.2 and 1.63BM. The magnetic moments of this ranges are suggest octahedral geometry for Mn (II), Co (II), Ni (II) and Cu (II) complexes.

*3.3. Thermal behavior of Mn (II), Co (II), Ni (II) and Cu (II) Metal complexes of OVPT*H

The Thermo gravimetric studies of all the complexes were carried out in air at a heating rate of 10 °C per minute. The thermo analytical data is summarized in Table.3. The thermal decomposition of the complexes proceeds in three stages. The Mn (II), Co (II), Ni (II) and Cu (II) complexes are thermally stable up to 135.32, 130.49, 110.59 and 140 °C respectively. The first stage of decomposition corresponding to endothermic dehydration of complexes by the loss of two water molecules occurs in the temperature range 135-280 °C, 132-233 °C, 110-257 °C and 140-276 °C respectively [15-16]. The intermediates formed are stable up to 310, 313, 284 and 309 °C. The second decomposition with exothermic peak by the loss of ligand moiety occurs in the temperature range 310-553 °C, 313-482 °C, 284-499 °C and 309-592 °C. The solid residues above 611, 520, 560 and 716 °C were identified as Mn, Co, Ni and Cu metal oxides respectively. In all the complexes, the final products are metal oxides.

3.4. ESR Spectral studies of OVPTH-Cu complex

Anisotropic spectra obtained for all complexes in DMF at LNT and representative ESR spectra of RAPPTH-Cu (II) ion complex is presented in Fig.5. In this low temperature spectrum, four peaks of small intensity have been identified which [17-18] are considered to originate from $g_{\parallel}$ component. The G value of present complex is greater than four and suggests that there are no interactions between Copper-Copper centers in DMF medium. The ESR parameters $g_{\parallel}$, $g_{\perp}$, $A_{\parallel}^{*}$ and $A_{\perp}^{*}$ of the complexes and the energies of d-d transitions are used to evaluate the orbital reduction parameters ($K_{\parallel}$, $K_{\perp}$), the bonding parameters (α^2), the dipolar interaction (P). The observed $K_{\parallel} < K_{\perp}$ indicates the presence of out of plane π–bonding. The α^2 value for the present chelate is 0.574. It indicates that the complex has covalent character [19]. This shows an appreciable covalency in the inplane σ bonding. Girdano and Bereman suggested the identification of bonding groups from the values of dipolar term P. The reduction of P values from the free ion value (0.036 cm^{-1}) might be attributable to the strong covalent bonding. The value of P obtained for the present complex is 0.017 cm^{-1} and remain consistent with bonding of Copper ions to oxygen and nitrogen donor atoms respectively. The shape of ESR lines, ESR data together with the electronic spectral data

Table 1. Important IR Spectral bands of OVPTH ligand and its metal complexes.

Compound	OH Water	OH Phenolic	C=N	N-H	C=O	M-O	M-N
OVPTH	-	3215	1645	3330	1711	-	-
OVPTH-Mn	3453	-	1603	3312	1676	600	462
OVPTH-Co	3460	-	1597	3297	1678	597	460
OVPTH-Ni	3420	-	1598	3301	1665	598	465
OVPTH-Cu	3422	-	1591	3303	1670	623	472

Table 2. ^{1}H NMR spectral data of OVPTH ligand and its metal complexes.

Compound	H-C=N	Ar-H	CH_3	OCH_3	Ar-OH	N-H
OVPTH	8.69	6.80-7.86	2.4	3.81	12.04	11.07
OVPTH-Co	8.93	7.01-8.03	2.46	4.02	-	11.25
OVPTH-Cu	8.90	6.82-7.91	2.5	3.82	-	11.31

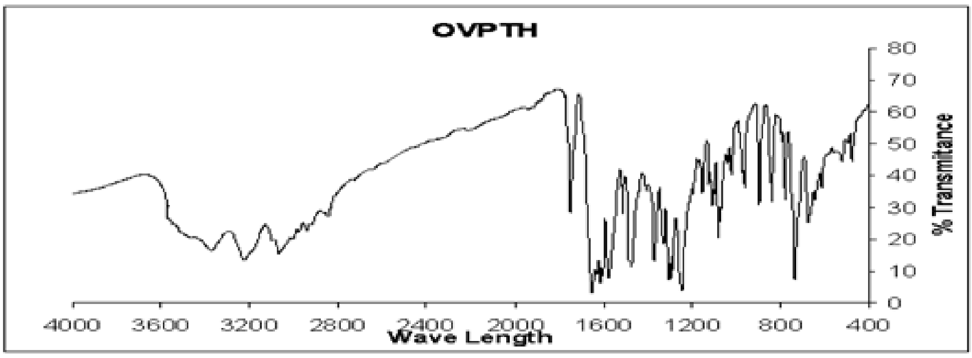


Figure 1. IR spectrum of OVPTH ligand.

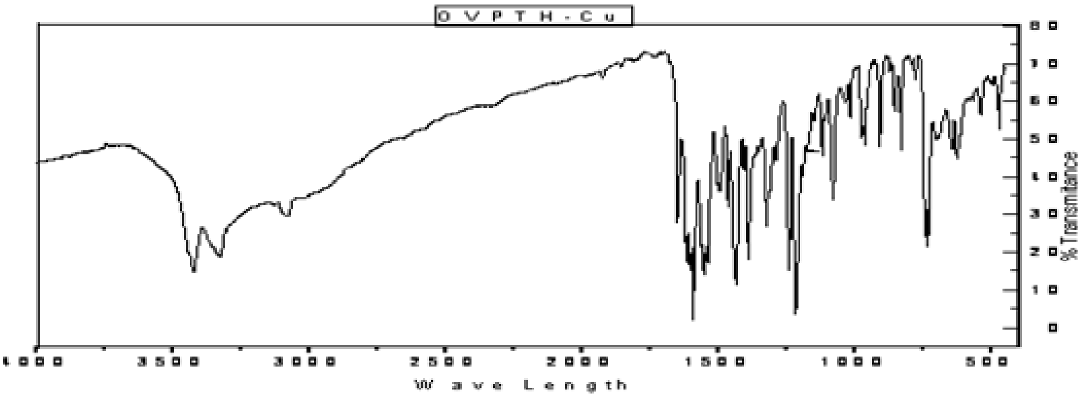


Figure 2. IR spectrum of OVPTH-Cu (II) metal complex.

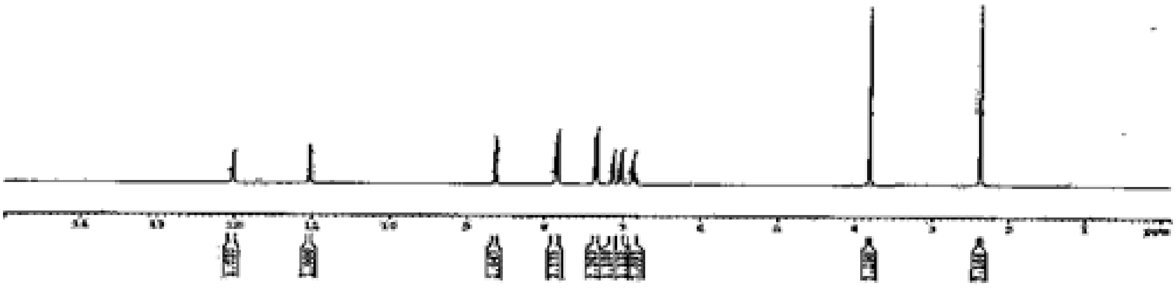


Figure 3. H^1-NMR spectrum of OVPTH ligand.

Table 3. Thermal Analytical Data of the OVPTH Ligand metal complexes.

Complex $X=H_2O$	**Molecular Weight in grams**	**Weight of the complex taken in mgs**	**Stage**	**Temperature range in°C**	**Probable assignment**	**Mass loss (%)**	**Total mass loss (%)**
Mn L_2 2X $L=C_{16}H_{16}O_3N_2$	659.586	7.50	1 2 3	135.32 to 280.15 310.53 to 553.69 Above 611.25	Loss of $2H_2O$ molecules Loss of 2L molecules Corresponds to MnO	5.462 83.241 11.106	88.703
Co L_2 2X $L=C_{16}H_{16}O_3N_2$	663.576	8.00	1 2 3	130.49 to 233.12 313.89 to 482.14 Above 520.34	Loss of $2H_2O$ molecules Loss of 2L molecules Corresponds to CoO	5.429 79.014 14.321	84.443
Ni L_2 2X $L=C_{16}H_{16}O_3N_2$	663.285	7.50	1 2 3	110.59 to 257.27 284.97 to 499.47 Above 560.19	Loss of $2H_2O$ molecules Loss of 2L molecules Corresponds to NiO	5.427 88.124 5.698	93.557
Cu L_2 2X $L=C_{16}H_{16}O_3N_2$	668.102	8.00	1 2 3	140 to 276.54 309.06 to 592.12 Above 716.18	Loss of $2H_2O$ molecules Loss of 2L molecules Corresponds to CuO	5.389 82.210 12.301	87.5

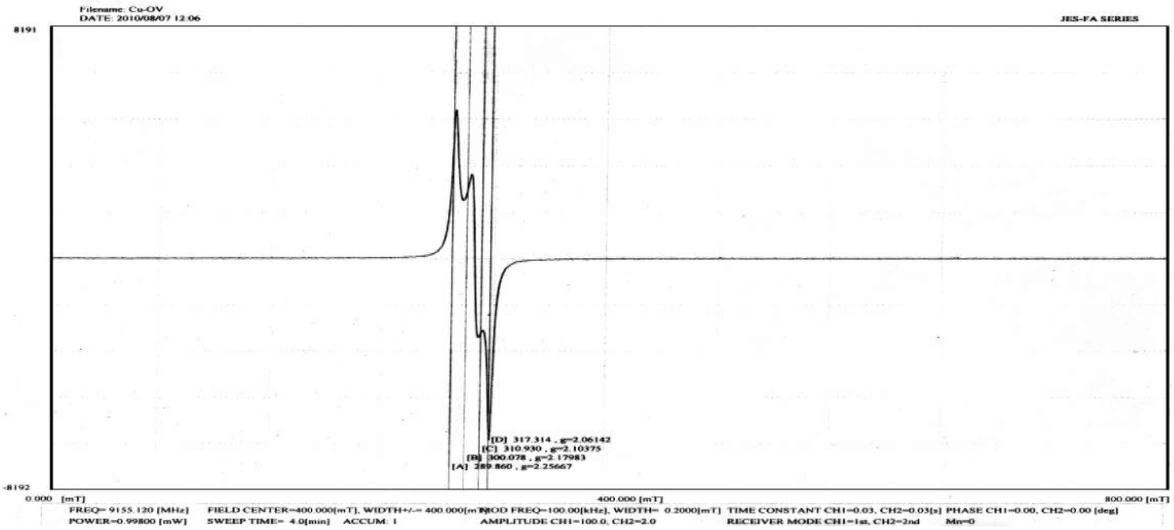


Figure 5. ESR spectrum of OVPTH-Cu (II) metal complex.

suggest an octahedral geometry for OVPTH-Cu complex.

3.5. Molar Conductivity

The molar conductance data of complexes in DMF at10^{-3} are presented in Table 5. The molar conductance values are 4.40, 5.40, 7.00 and 5.20 ohm^{-1} cm^2 mol^{-1} respectively for OVPTH-Mn (II), OVPTH-Co (II), OVPTH-Ni (II) and OVPTH-Cu (II). The complexes are found to be non electrolyte in DMF solution.

3.6. Powder XRD study of OVPTH-Cu Complex

The powder X-ray diffraction data obtained for OVPTH-Cu complex with difractograms using DROL-2 powder diffractometer. Radiation filled by metal foil. The difractograms (15 diffractions) reflects Fig. 6. between 5-75 (2θ) values for Cu complex. Where θ is Brages angle all the main peaks are indicted and calculated values of Miller indices (h k l) along with observed d-specified and reveled intensities are specified in the Fig 3.8a. All the peaks have been indexed 2θ values compared in graph. Comparison values revels that there is good

Table 4. ESR spectral data of OVPTH-Cu complex.

Parameters	OVPTH-Cu
$g_{\|}$	2.21825
$g_{\perp}$	2.05258
g_{ave}	2.10780
G	4.15081
$A_{\|}^{*}$	0.01862
$A_{\perp}^{*}$	0.00434
A_{ave}^{*}	0.0091
d-d	16432
$K_{\|}$	0.614
$K_{\perp}$	0.753
P^{*}	0.017
α^{2}	0.574

agreement between values of 2θ and d-values. The powder x-ray diffraction data showed identical features with very poor crystalinity [20]. The patterns are qualitative and dispersive in intensity of Cu complex. The XRD patterns are used to explain qualitatively the degree of crystalinity. X-ray diffraction data of OVPTH-Cu complex are presented in table.5.

3.7. Anti bacterial activity

The biological activity of the Schiff base ligand and their metal complexes and streptomycin (as a standard compound) were tested against bacteria because bacteria can achieve resistance to antibiotics through biochemical and morphological modifications. The organisms used in the present investigations included *Staphylococcus aureus and Bacillus subtillis* (as gram positive bacteria) *and Pseudomonas aereuginosa* and *Escherichia coli* (as gram negative bacteria). The diffusion agar technique was used to evaluate the antibacterial activity of synthesized ligand and its metal complexes [21-22]. The results of the bacterial screening of the synthesized compounds are recorded in Table 7. The data obtained reflect that the Schiff base ligand shows moderate activity in comparison with *Staphylococcus aureus, Bacillus subtillis* and less active in comparison with *Pseudomonas aereuginosa, Escherichia coli.* Antibacterial activity of all the complexes at low concentration towards gram positive and negative bacteria is not detected or low. The activity of the Schiff base ligand and its metal complexes increases as the concentration increases because it is well known [23-24] fact that concentration plays a vital role in increasing the degree of inhibition. The antibacterial activity results indicate that most of the metal chelates exhibited good to moderate antibacterial activity when compared to Ligand. Among the synthesized metal complexes OVPTH-Cu showed high activity.

4. CONCLUSIONS

The design and synthesis of a new family of bidentate Schiff base ligands for use in octahedral complexes have been successfully demonistrated. In this paper, the coordination chemistry of a Schiff base ligand obtained from the reaction of p-toulic hydrazide and o-vanilin is described Mn (II), Co (II), Ni (II), and Cu (II) complexes have been characterized by spectral and analytical data. The IR&electronic transition data lead to the conclusion that the Mn (II), Co (II), Ni (II), and Cu (II) metal complexes are octahedral in nature and hence the structure of OVPTH Schiff base metal complexes are given in Fig. 7. In all the complexes, the ligand acts as bidentate. The results of in-vitro biocidal activities of the ligand and its metal complexes clearly show antibacterial activity against the tested organisms. On the basis of chelation theory, metal complexes have more biological activity than free ligand. All the metal chelates are found to be non-electrolytes. The present work points to the future work that OVPTH can be exploited as precursor for the synthesis of new complexes and it would be fruitful to obtain complexes with promising antibacterial activity. Further coordination chemistry needs to explore in these chemically rich systems.

Table.5. X-ray Diffraction data of OVPTH-Cu complex.

S.No.	d expt	dCalc	2θ expt	2θ Calc	h k l
1	12.7403	12.7396	6.9235	6.9212	3 1 1
2	10.7611	10.7425	8.2492	8.2361	3 2 0
3	9.4974	9.4862	9.1502	9.1211	3 2 1
4	8.8618	8.8439	9.9831	9.9736	3 3 0
5	6.2993	6.2872	13.9864	13.9647	4 4 2
6	5.6436	5.6326	15.6804	15.6719	5 4 2
7	5.0422	5.0215	17.4826	17.3929	6 4 2
8	4.1829	4.0949	21.1935	21.1736	7 5 3
9	4.0017	3.9976	22.3570	22.3467	7 6 1
10	3.8259	3.8158	23.5902	23.4997	7 6 3
11	3.3973	3.3859	26.3826	26.3615	8 7 4
12	3.1667	3.1548	28.1968	28.1920	9 6 5
13	3.0507	3.0217	29.3102	29.3052	9 8 2
14	2.9033	2.8926	30.7962	30.6989	11 5 5
15	2.7399	2.7147	32.8149	32.8059	10 9 0

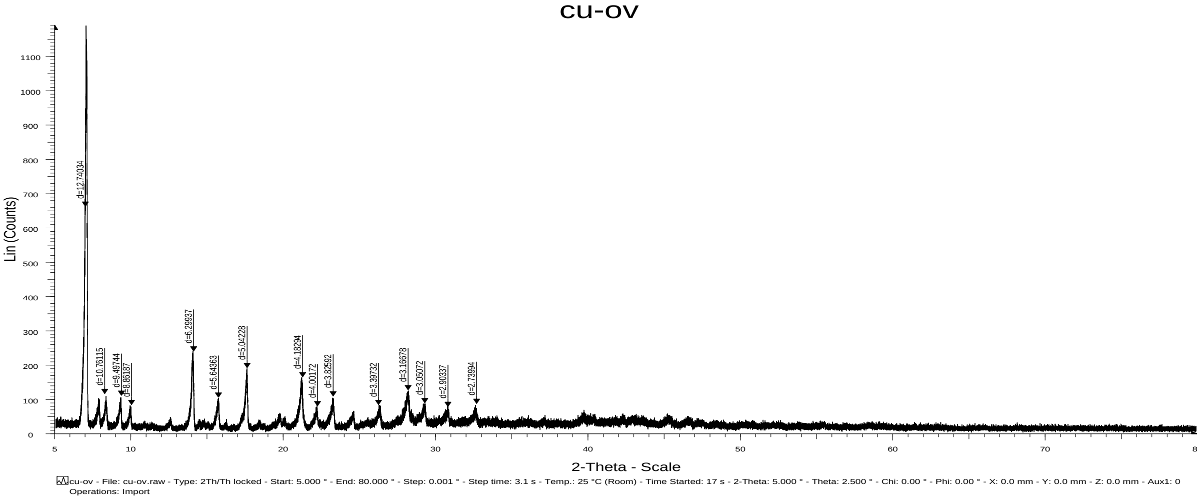


Figure 6. XRD spectrum of OVPTH-Cu (II) metal complex

Table 6. Analytical data of the OVPTH ligand and its metal complexes

Molecular Formula X=H$_2$O	Molecular Weight	Colour	Yield in %	Melting Point in ^{0}C	Elemental analysis							
					Carbon %		Hydrogen %		Nitrogen %		Metal %	
					Calc.	Found	Calc.	Found	Calc.	Found	Calc.	Found
L=$C_{16}H_{16}O_3N_2$	285.33	Light yellow	85	180-182	67.29	66.78	5.60	5.35	9.81	9.52	-	-
[Mn. L_2.2X]	659.586	Light Yellow	72	310-340	58.21	57.52	5.15	4.91	8.49	8.23	8.84	8.54
[Co.L_2.2X]	663.576	Orange yellow	68	290-310	57.86	57.34	5.12	4.75	8.44	8.12	8.88	8.02
[Ni. L_2.2X]	663.285	Green	86	305-325	57.89	57.23	5.13	4.93	8.44	7.91	8.33	7.92
[Cu.L_2.2X]	668.102	Green	75	300-330	57.49	57.21	5.09	4.89	8.38	8.06	9.49	9.13

Table 6. Antibacterial Activity of OVPTH Schiff base Ligand and its metal complexes.

Compound	***Gram positive***						***Gramnegative***					
	Staphylococcus aureus			***Bacillus subtillis***			***Pseudomonas aereuginosa***			***Escherichia coli***		
	5	**2.5**	**1**	**5**	**2.5**	**1**	**5**	**2.5**	**1**	**5**	**2.5**	**1**
L=$C_{16}H_{16}O_3N_2$. (OVPTH)	++	+	**nd**	++	+ +	+	+	+	**nd**	++	+	+
[Mn L_2.]2X. (OVPTH-Mn)	++	++	+	++	++	**nd**	++	++	+	++	+	+
[Co L_2.]2X.(OVPTH-Co)	++	++	**nd**	++	+	+	++	++	+	++	**nd**	**nd**
[Ni L_2.]2X.(OVPTH-Ni)	++	+ +	+	++	+	**nd**	++	++	**nd**	++	+	+
[Cu L_2.]2X. (OVPTH-Cu)	++	++	+	++ +	++	+	++	++	+	++	++	+
Streptomycin(standard)	++	++	++	+++	++	++	++	++	++	++	++	+ +

Inhibition values = 0.1- 0.5cm beyond control = + (less active); inhibition values = 0.6- 1.0cm beyond control = ++ (moderate active); inhibition values = 1.1- 1.5cm beyond control = +++(high active).Concentration in mg/ml. nd:non detected.

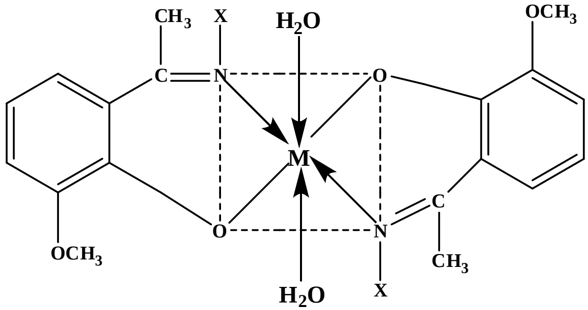


Figure.7. OVPTH metal complexes (M=Cu^{+2}, Co^{+2}, Ni^{+2}, Mn^{+2}).

5. REFERENCES

[1]. Wu Chen, Yuguang Li, Yongming Cui, Xian Zhang, Hai-Liang Zhu, Qingfu Zeng (2010) Synthesis, molecular docking and biological evaluation of Schiff base transition metal complexes as potential urease inhibitors, ***European Journal of Medicinal Chemistry*** **45:** 4473-4478**.**

[2]. Zhong-Lu You, Da-Hua Shi, Chen Xu, Qiang Zhang, Hai-Liang Zhu (2008) Schiff base transition metal complexes as novel inhibitors of xanthine oxidase, ***European Journal of Medicinal Chemistry*, 43:** 862- 871.

[3]. Manjula Patil, Rekha Hunoor, Kalagouda Gudasi (2010), Transition metal complexes of a new hexadentate macroacyclic N_2O_4-donor Schiff base: Inhibitory activity against bacteria and fungi, ***European Journal of Medicinal Chemistry*, 45:** 2981-2986.

[4]. Kiran Singh, Manjeet Singh Barwa, Parikshit Tyagi, (2006) Synthesis, characterization and biological studies of Co(II), Ni(II),Cu(II) and Zn(II) complexes with bidentate Schiff bases derived by heterocyclic ketone. ***European Journal of Medicinal Chemistry*, 41:** 147-153.

[5]. X. Zhong, J. Yi, J. Sun, H.-L. Wei, W.-S. Liu, K.-B. Yu, (2006) Synthesis and crystal structure of some transition metal complexes with a novel bis-Schiff base ligand and their antitumor activities, ***European Journal of Medicinal Chemistry* 41:** 1090-1092.

[6]. Gajendra Kumar, Dharmendra Kumar, Shoma Devi, Rajeev Johari, C.P. Singh (2010) Synthesis, spectral characterization and antimicrobial evaluation of Schiff base Cu (II), Ni (II) and Co (II) complexes, ***European Journal of Medicinal Chemistry*** **45:** 3056-3062.

[7]. Gehad G. Mohamed, M.M. Omar, Amr A. Ibrahim, (2009) Biological activity studies on metal complexes of novel tridentate Schiff base ligand. Spectroscopic and thermal characterization, ***European Journal of Medicinal Chemistry*, 44:** 4801-4812.

[8]. Lotf Ali Saghatforoush, Firoozeh Chalabian, Ali Aminkhani, Ghasem Karimnezhad, Sohrab Ershad, (2009) Synthesis, spectroscopic characterization and antibacterial activity of new cobalt (II) complexes of unsymmetrical tetradentate (OSN2) Schiff base ligands. ***European Journal of Medicinal Chemistry*, 44:** 4490-4495.

[9]. Zeng-Chen Liu, Bao-Dui Wang, Zheng-Yin Yang, Yong Li, Dong-Dong Qin, Tian-Rong Li, (2009) Synthesis, crystal structure, DNA interaction and antioxidant activities of two novel water-soluble Cu(2^+) complexes derivated from 2-oxo-quinoline-3-carbaldehyde Schiff-bases, ***European Journal of Medicinal Chemistry*, 44:** 4477-4484.

[10]. Mehmet Sonmez, Metin Celebi, Ismet Berber, (2010) Synthesis, spectroscopic and biological studies on the new symmetric Schiff base derived from 2,6-diformyl-4-methylphenol with N-aminopyrimidine, ***European Journal of Medicinal Chemistry*, 45:** 1935-1940.

[11]. Adnan S. Abu-Surrah, Kayed A. Abu Safieh, Iman M. Ahmad, Maher Y. Abdalla, Mikdad T. Ayoub, Abdussalam K. Qaroush, Ahmad M. Abu-Mahtheieh,(2010) New palladium(II) complexes bearing pyrazole-based Schiff base ligands: Synthesis, characterization and cytotoxicity**, *European Journal of Medicinal Chemistry*, 45:** 471-475.

[12]. Zeng-Chen Liu, Bao-Dui Wang, Bo Li, Qin Wang, Zheng-Yin Yang, Tian-Rong Li, Yong Li,(2010) Crystal structures, DNA-binding and cytotoxic activities studies of Cu(II) complexes with 2-oxo-quinoline-3-carbaldehyde Schiff-bases, ***European Journal of Medicinal Chemistry*, 45**: 5353-5361**.**

[13]. Gangadhar B. Bagihalli, Prakash Gouda Avaji,Sangamesh A. Patil, Prema S. Badami,(2008) Synthesis, spectral characterization, in vitro antibacterial, antifungal and cytotoxic activities of Co(II), Ni(II) and Cu(II) complexes with 1,2,4-triazole Schiff bases, ***European Journal of Medicinal Chemistry*, 43:** 2639-2649.

[14]. Ajaykumar Kulkarni, Sangamesh A. Patil, Prema S. Badami,(2009) Synthesis, characterization, DNA cleavage and in vitro antimicrobial studies of La(III), Th(IV) and VO(IV) complexes with Schiff bases of coumarin derivatives, ***European Journal of Medicinal Chemistry*, 44:** 2904-2912.

[15]. Rodica Olar, Mihaela Badea, Dana Marinescu, Mariana-Carmen Chifiriuc, Coralia Bleotu, Maria Nicoleta Grecu, Emilia-Elena Iorgulescu, Veronica Lazar, (2010) N,N-dimethylbiguanide complexes displaying low cytotoxicity as potential large

spectrum antimicrobial agents, ***European Journal of Medicinal Chemistry*, 45:** 3027-3034.

[16]. Ayed S. Al-Shihri, (2004) Synthesis, characterization and thermal analysis of some new transition metal complexes of a polydentate Schiff base, ***Spectrochimica Acta Part A*, 60:** 1189-1192.

[17]. Chun Jin, Weibin Fan, Yinjuan Jia, Binbin Fan, Jinghong Maa, Ruifeng Li, (2006) Encapsulation of transition metal tetrahydro-Schiff base complexes in zeolite Y and their catalytic properties for the oxidation of cycloalkanes, ***Journal of Molecular Catalysis A: Chemical*, 249:** 23-30.

[18]. Z.H. Abd El-Wahab, M.R. El-Sarrag, (2004) Derivatives of phosphate Schiff base transition metal complexes: synthesis, studies and biological activity, ***Spectrochimica Acta Part A*, 60:** 271-277.

[19]. Chi-Ming Che, Jie-Sheng Huang, (2003) Metal complexes of chiral binaphthyl Schiff-base ligands and their application in stereoselective organic transformations, ***Coordination Chemistry Reviews*, 242:** 97-113.

[20]. Ramana N., Sobha S., Thamaraichelvan A., (2011) A novel bioactive tyramine derived Schiff base and its transition metal complexes as selective DNA binding agents, ***Spectrochimica Acta Part A*, 78:** 888-898.

[21]. K.C. Gupta, Alekha Kumar Sutar (2008) Catalytic activities of Schiff base transition metal complexes, ***Coordination Chemistry Reviews*, 252:** 1420-1450.

[22]. Adel A.A. Emara, Azza A.A. Abou-Hussen, (2006) Spectroscopic studies of bimetallic complexes derived from tridentate or tetradentate Schiff bases of some di- and tri-valent transition metals ,***Spectrochimica Acta Part A*, 64:**1010-1024

[23]. Anacona, AR., Johan Calvo, Ovidio A. Almanza, (2013) Synthesis, spectroscopic, and magnetic studies of mono- and polynuclear Schiff base metal complexes containing salicylidene-cefotaxime ligand, ***International Journal of Inorganic Chemistry, Article ID108740, 7***

[24]. Matangi Sunitha, Pragathi Jogi, Bathini Ushaiah, C. Gyana Kumari Synthesis, (2012) Characterization and antimicrobial activity of transition metal complexes of schiff base ligand derived from 3-ethoxy salicylaldehyde and 2-(2-aminophenyl) 1-h-benzimidazole, ***E-Journal of Chemistry* 9*:*** 2516-2523.

****Biographical Sketch***

Dr.S.Kondaiah *obtained his M.Sc., Organic Chemistry from Srikrishnadevaraya University, Anantapur, Andhra Pradesh, India. He received his Ph.D. in Analytical Chemistry from Srikrishnadevaraya University, Anantapur, Andhra Pradesh, India. His research interests include synthesis and characterization of Schiff Base Metal Complexes and Spectrophotometric determination of antibiotics like Cephalosporins and Tetracyclines. Currently, he is an Associate Professor of Chemistry at Malla Reddy Engineering College, Maisammaguda, via-Dhulapally, Secunderbad, Andrapradesh, India.*