

SYNTHESIS AND CHARACTERISATION OF Fe (III) COMPLEXES OF MONOBASIC TRIDENTE (SO O' DONOR) AND TETRADENTATE (SO O'N DONOR) LIGANDS

K.P.Srivastava^{*,1} and Ali Akbar²

¹Ganga Singh College, J.P.University, Chapra-841301, Bihar

²Department of Chemistry, K.K.College of Engineering and Management, Bihar Sharif, Nalanda, Bihar

*E-mail: gscdrkpsritprn@gmail.com

ABSTRACT

The ligands α -mercaptobenzacetohydroxamic acid (MBAHA-H) and 2-amino- α -mercapto-benzacetohydroxamic acid (AMBAHA-H) and their different mixed ligand novel complexes with Fe (III) having specific formulae have been synthesized and characterized by elemental analyses, magnetic and conductance measurements, IR and electronic spectral studies. The ligands were found to behave as monobasic tridentate (SO'O donor) and tetradentate (SO' ON donor) manner respectively. All the synthesized Fe (III) complexes were non-electrolyte with magnetic moment ranging from 5.91 to 6.00 BM. The structural assessment of the complexes has been carried out based on spectral studies (electronic and infrared) and molar conductivity values. All the complexes were found to be of octahedral geometry.

Keywords: Hydroxamic acids, polydentate ligands, octahedral complexes, magnetic moment.

©2013 RASAYAN. All rights reserved

INTRODUCTION

Though iron is the fourth most abundant metal in the earth's crust, it is a necessary trace element found in nearly all living organisms and important to many biological processes like photosynthesis, electron transfer in respiration, enzymes involving nitrate and nitrite reduction, N₂ fixation by nitrogenase enzyme, oxygen activation, oxygen transport in the body and detoxification of reactive oxygen species¹⁻³. It is required for a variety of functions like reduction of oxygen for synthesis of ATP, reduction of ribotide precursor of DNA, formation of heme and other essential purposes. Iron is thus an essential nutrient for the growth of microorganisms like bacteria and fungi.

Hydroxamic acids are versatile reagents for organic and inorganic analyses⁴. Their derivatives are biochemically highly active and find applications in medicinal use⁵. The sulphur containing derivatives of hydroxamic acid have aroused considerable interests over decades⁶. Despite the ligational potentiality associated with sulphur derivatives of hydroxamic acid, the studies made on the metal complexes of these ligands are limited. The study of coordination compounds of sulphur donor ligands is of biochemical interests due to their carcinostatic (anticancer), antibacterial and antifungal activities⁷. Sulphur donor compounds are expected to be the most effective anticancer agents as they usually confer lipid solubility on the metal complex. The sulphur donor ligands have also been widely used as agro-chemicals and favorable environmental degradation.

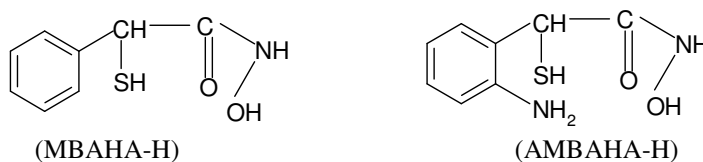


Fig.-1: Structure of ligands

In continuation⁸⁻¹³ of our work on the complexes with the mentioned ligands, we report here the synthesis and structural characterization of two new ligands, 2-amino- α -mercaptobenzacetohydroxamic acid (AMBAHA-H) and α -mercapto benzacetohydroxamic acid, (MBAHA-H) (Figure-1) and their complexes with Fe (III).

EXPERIMENTAL

Materials

All the chemicals and reagents used were of Analar grade. Anhydrous grade alcohols, DMF, and DMSO were obtained from Fischer scientific. 2-aminobenzhydroxamic acid was obtained from Aldrich (USA). The metal chlorides/acetates used were of BDH AR grade in the present investigation. All reactions and experimental manipulations were carried out at appropriate temperature.

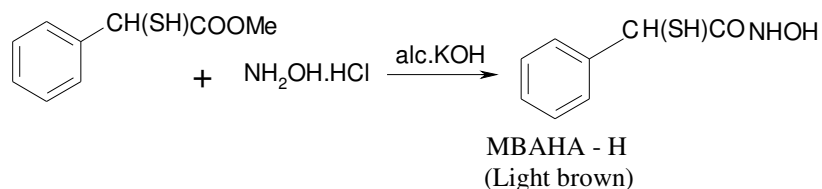
Physico chemical measurements

Elemental analysis (C, H, S and N) of ligands and complexes was carried out in micro analytical laboratory on Carl-Ebra 1106 elemental analyzer. Metal in the complexes was estimated following standard procedure¹⁴. The molar conductance measurements were carried out for the 10^{-3} M solutions of complexes in DMSO solvent at 300K using a Systronics direct reading digital Conductivity Bridge-304 with a dip type cell. The magnetic measurements of the complexes at 300K were made by Gouy magnetic balance using Hg [Co (NCS)₄] as calibrant. The measured susceptibilities were corrected for diamagnetic susceptibility of the ligand. The IR spectra of ligand and the complexes as nujal-mull smears were recorded in the region 4000-200 cm^{-1} on a Perkin-Elmer 577 spectrophotometer. The electronic spectra of the complexes were recorded on Systronics UV-Visible spectrophotometer Type -119 PC based ($\lambda = 200$ -1000 nm and band width 2 nm) using ethanol as the solvent.

Synthesis of Ligand [MBAHA-H = L-H]

The ligand MPA-H was prepared the method reported by Y. Inoue and H.Yukawa¹⁵. One mole of KOH (56.10 g) dissolved in 140 ml of methanol was added to a solution of 0.67 moles of hydroxylamine hydrochloride (46.7 g) in methanol. Both solutions were mixed together keeping the temperature range at 35-40°C. The mixture was left in ice-bath for five minutes ensuring the complete precipitation of KCl. Then 0.35 moles of α -mercaptophenyl acetate was added in portions constant shaking and after the addition is complete the solution was filtered immediately through suction. The residue in funnel was washed with little methanol. The filtrate was kept in Erlenmeyer flask for 48 hours. Crystals of potassium salt of the acid were filtered, washed with a little absolute alcohol and dried in air.

About half of the yield was mixed with 80 ml 1.25N acetic acid and stirred while heating until a clear solution was obtained. The solution was allowed to cool at room temperature and finally chilled in ice-bath. The ligand, MBAHA-H, was separated out as light brown crystals. The melting point (decomposition point) was recorded and found to be 186-188°C. The stoichiometry of the synthesis reaction is represented in the form of equation as-

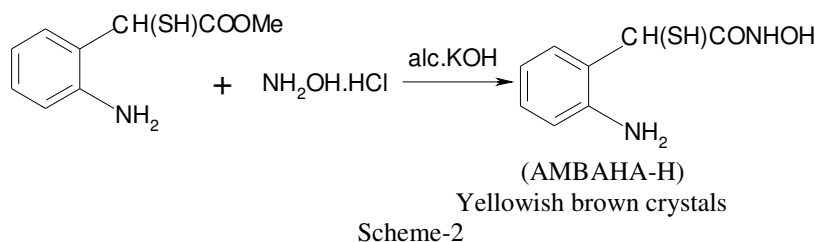


Scheme-1

Synthesis of Ligand [AMBAHA-H = L'H]

This was also prepared by the method described above. The alkaline solution of hydroxylamine was prepared as above mixing the methanolic solutions of KOH and hydroxylamine hydrochloride. The solution of 0.175 mole of 2-amino α -mercaptophenyl acetate in methanol was added to it to get the potassium salt of the acid. The free acid was obtained by treating the potassium salt with acetic acid.

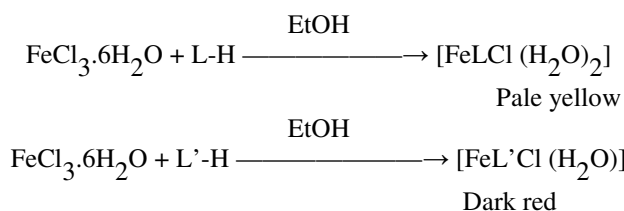
Yellowish brown crystals of the ligand were obtained. The melting point (decomposition point) was recorded and found to be 198-199°C. The formation of ligand can be represented by the following chemical equation-



Synthesis of Complexes

(A) Synthesis of Complexes of Type $[MLX.H_2O]$ and $[ML'X]$ Where, $X = Cl$.

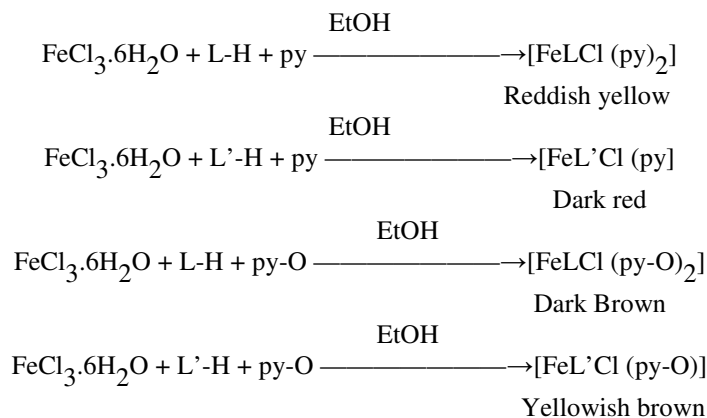
About 0.041 moles of metal chloride were dissolved in 40 ml of distilled water and added to an aqueous ethanolic solution of the ligand (0.40 moles in 35 ml water) slowly with constant shaking. The different colored heavy precipitate was separated out. It was filtered, washed with distilled water until free from chloride and dried at 140-145°C.



Scheme-3

(B) Synthesis of Complexes of Type $[MLXB_2]$ and $[ML'XB]$ (Where, $X = Cl$ and $B = \text{Pyridine} (-py)$ and $\text{Pyridine-N-oxide} (-py-O)$)

Aqueous ethanolic metal salt solution (0.021 moles in 40 ml of aq. ethanol) was mixed with ethanolic solution of the ligand (0.02 moles in 50 ml) and warmed with base on water-bath. It was further digested for a few minutes and the precipitate was filtered. It was washed with water several times and then with ethanol. It was dried at room temperature. Complexes with other bases were prepared similarly. The complexes obtained were collected for analysis and characterization.



Scheme-4

RESULTS AND DISCUSSION

Physico-chemical Characterizations and Geometrical Configuration of the Complexes

Fe (III) salt reacts with MBAHA – H and AMBAHA – H ligands in 1:1 molar ratio in alcoholic medium to afford dark reddish/brown complexes. The ligand and its complexes are stable at room temperature and are non-hygroscopic. The ligands were soluble in common polar organic solvents, such as ethanol, methanol, and chloroform but partially soluble in hexane. The complexes were relatively well soluble in DMF and DMSO. The synthesized ligand and its complexes were characterized by elemental analysis, spectra, and molar conductivity measurements. The geometry of the newly synthesized compounds has been elucidated based on their elemental analysis, molar conductivity and spectral data.

Elemental Analysis

The stoichiometry of the ligands and their complexes were confirmed by their elemental analysis. The metal / ligand ratio was found to be 1:1 has been arrived at by estimating the metal and nitrogen and sulphur contents of the complexes. Elemental analysis of ligands and their Fe (III) complexes show good agreement with the proposed structures of the ligands and their complexes (Table-1).

Table -1: Analytical Table of Iron (III) Complexes

Complex	%M Cal. (Found)	%S Cal. (Found)	%N Cal. (Found)	%Cl Cal. (Found)
[FeLCl(H ₂ O) ₂] 2H ₂ O	16.22 (16.34)	9.29 (9.31)	4.06 (4.10)	10.31 (10.45)
[FeLCl(py) ₂]	12.97 (12.95)	7.41 (7.45)	9.76 (9.80)	8.25 (9.80)
[FeLCl (py-O) ₂]	12.07 (12.06)	6.92 (6.90)	9.08 (9.10)	7.67 (7.70)
[FeL'Cl(H ₂ O)]2H ₂ O	15.54 (15.60)	8.90 (8.85)	7.97 (7.95)	9.87 (9.90)
[FeL'Cl(py)]	15.24 (15.25)	8.73 (8.72)	11.46 (11.52)	9.69 (9.75)
[FeL'Cl (py-O)]	14.60 (14.57)	8.36 (8.40)	10.98 (10.95)	9.28 (9.25)

Molar conductance measurements

The molar conductance values (17-22 ohm⁻¹cm²mol⁻¹) of the complexes which were determined in DMSO solvent indicate that the complexes under study are non-electrolytic in nature¹⁶ (Table-2).

Table -2: Physical Properties of Iron (III) Complexes

Complexes	Mol. Weight (in amu)	Mol. Conductance (in Ω ⁻¹ cm ² mol ⁻¹)	μ _{eff} (in B.M.)
[FeLCl (H ₂ O) ₂] 2H ₂ O	354.85	21.54	5.91
[FeLCl (py) ₂]	431.35	21.57	5.92
[FeLCl (py-O) ₂]	463.35	18.90	5.94
[FeL'Cl (H ₂ O)]H ₂ O	351.85	21.75	5.97
[FeL'Cl (py)]	367.35	19.69	5.99
[FeL'Cl (py-O)]	383.35	17.76	6.00

Magnetic Susceptibility Measurements

The observed magnetic moments of Fe (III) complexes of MBAHA-H and AMBAHA-H are given in table-2. The observed values of magnetic moment for Fe (III) complexes are generally diagnostic of the coordination about the metal ion. The magnetic measurements on the complexes reported herein show that all were paramagnetic and have three unpaired electrons indicating high-spin octahedral stereochemistry¹⁷. For the present complexes these values lay in the range 5.91 to 6.00 B.M. and are being independent of temperature.

IR Spectral Studies

The structural possibilities of the complexes depend upon the mode of coordination of the ligands. The IR spectral studies are quite useful on determining the mode coordination of ligands. On critically examining the position and direction of the shifts of the frequencies of the ligands in the complexes, as compared to their positions in the Free State, the mode of coordination can be suggested for all the investigated complexes.

The IR spectral studies show that the ligand MBAHA-H acts as mono negative tri dentate (SOO' donor) ligand but AMBAHA-H acts as mono negative tetra dentate (SOO'N donor) ligand. The ligand MBAHA-H coordinating with metals through thioalcoholic S, carbonyl O and hydroxamic O atoms respectively [Figure-1] and the ligand AMBAHA-H coordinating with metals through thioalcoholic S, carbonyl O hydroxamic O atoms and primary amino N atoms respectively [Figure-2]. The main infrared bands and their assignments are presented here in table-3.

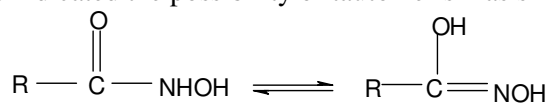
Table-3: Important I.R. Bands of Ligands and Fe (III) Complexes

Compounds	I. R. Bands (in cm ⁻¹)						
	N-H	O-H	C=O	SH	M-O	M-N	M-S
MBAHA-H	3265	2880	1650	2560	-	-	-
AMBAHA-H	3275	2870	1660	2570	-	-	-
[FeLCl(H ₂ O) ₂] 2H ₂ O	3265	2865	1630	-	500	-	270
[FeLCl(py) ₂]	3250	2860	1635	-	480	-	275
[FeLCl(py-O) ₂]	3235	2865	1630	-	490	-	270
[FeL'Cl(H ₂ O)]2H ₂ O	3230	2865	1625	-	500	315	275
[FeL'Cl(py)]	3230	2860	1630	-	490	310	270
[FeL'Cl(py-O)]	3235	2865	1635	-	495	300	275

Vibrations Due To MBAHA -H Moiety

The absorption bands in the region 3280-3260 cm⁻¹ in the free ligands are assigned to NH-stretching frequencies. The band at 3265 cm⁻¹ due to ν(N-H) mode remained intact in the complexes indicating the non-participation of N-H of MBAHA-H group in coordination.

The infrared spectra of the ligand showed a medium intensity band at 2560 cm⁻¹ for ν(S-H) mode. Absence if this band in the complexes indicated the destruction of the S-H bonding followed by complexation of S after deprotonation¹⁸. This was further supported by a downward shift in ν(C-S) by 10-20 cm⁻¹ in the complexes and the appearance of new low intensity bands at 280-270 cm⁻¹ due to M-S stretching vibrations. The appearance of medium intensity band in the region 2700-2400 cm⁻¹ in the infrared spectra of free ligand indicated the possibility of tautomerism as shown below-



Scheme-5

The $\nu(\text{C}=\text{S})$ stretch shifted to lower frequency in the complexes by $45\text{--}30\text{ cm}^{-1}$, suggesting involvement of O of $(\text{C}=\text{O})$ in coordination. This was further supported by the appearance of low intensity bands at $490\text{--}470\text{ cm}^{-1}$ in the spectra of complexes due to the $\nu(\text{M}\text{--}\text{O})$ stretch.

The $\nu(\text{O}\text{--}\text{H})$ stretch shifted to lower frequency in the complexes by $25\text{--}15\text{ cm}^{-1}$ suggesting coordination of ligand through O-H group with metal cations.

It was observed the additional bands in the regions $480\text{--}435\text{ cm}^{-1}$ and $355\text{--}290\text{ cm}^{-1}$ in the complexes which are assigned to $\nu(\text{M}\text{--}\text{O})$ and $\nu(\text{M}\text{--}\text{S})$ stretching vibrational modes respectively.

Further, it was observed that $\nu(\text{M}\text{--}\text{O})$ frequency shifted downward with increasing mass of the metals. The study and comparison of infrared spectra of the free ligand MBAHA-H and its complexes with selected common bivalent transition metals imply that the ligand behaves as a uninegative tridentate (SOO donor) ligand and the metal ion are connected through carbonyl O, hydroxamic O and thioalcoholic S atom.

Vibrations Due to AMBAHA-H Moiety

The ability to locate the various group frequencies corresponding to typical linkage in the investigated AMBAHA-H ligand and in its synthesized complexes is not so easy. Although there have been many attempts to assign empirically a few I.R. bands of metal complexes of AMBAHA-H, no complete assignments of their I.R. spectra have been available.

The infrared spectra of the ligand AMBAHA-H in Free State showed a medium intensity band at 2570 cm^{-1} for $\nu(\text{S}\text{--}\text{H})$ vibration. Absence of this band in its complexes with investigated bivalent transition metals indicates the destruction of the S-H bonding followed by complexation of S with metal after deprotonation. This is further supported by a downward shift in $\nu(\text{C}\text{--}\text{S})$ modes by $30\text{--}15\text{ cm}^{-1}$ in the investigated complexes and the disappearance of a new low intensity band at $300\text{--}275\text{ cm}^{-1}$ due to M-S vibrations. The band at 3275 cm^{-1} due to $\nu(\text{N}\text{--}\text{H})$ mode remains intact in complexes indicating the non-participation of N-H of hydroxamic acid group in coordination.

Further, the I.R. spectra of the metal complexes of AMBAHA-H ligand show the band attributed to $\nu(\text{NH}_2)$ of the coordinated amino group, which appeared at $\Delta\nu > 50\text{ cm}^{-1}$ than in the spectrum of free ligand.

The $\nu(\text{C}=\text{O})$ stretch shifts to lower frequency in the complexes by $30\text{--}15\text{ cm}^{-1}$ suggesting involvement of carbonyl oxygen atom in coordination. This is further supported by the appearance of new low intensity bands around $500\text{--}450\text{ cm}^{-1}$ in the spectra of investigated complexes due to the $\nu(\text{M}\text{--}\text{O})$ stretch.

The $\nu(\text{O}\text{--}\text{H})$ stretch of hydroxamic group shifts to lower frequency in the investigated complexes by $30\text{--}20\text{ cm}^{-1}$ suggesting coordination of AMBAHA-H through O atom of O-H group with metals. The comparison with the infrared spectra of the ligand, the investigated complexes show new bands in the far infrared regions, $500\text{--}450$, $400\text{--}350$ and $300\text{--}275\text{ cm}^{-1}$ assignable to M-O, M-N, and M-S stretching vibrations respectively. The above discussions clearly indicate that the ligand AMBAHA-H serves as a uninegative tetra dentate (SO'ON donor) in all the investigated complexes coordinating through the carbonyl oxygen, hydroxamic oxygen, thioalcoholic sulphur and amino nitrogen atoms with Fe^{3+} in the investigated complexes¹⁹.

The $\nu(\text{M}\text{--}\text{Cl})$ has been assigned in $250\text{--}215\text{ cm}^{-1}$ regions in the present studies. The infrared spectra of metal complexes with pyridine (-py) and pyridine-N-oxide (-py-O-) have been studied extensively. Upon complex formation, the pyridine vibrations in the high frequency region ($650\text{--}420\text{ cm}^{-1}$) are shifted to higher frequencies ($290\text{--}230\text{ cm}^{-1}$) for the investigated metal complexes. The N=O stretching band of pyridine N-oxide (1265 cm^{-1}) is shifted by $70\text{--}30\text{ cm}^{-1}$ to a lower frequency upon complexation. The infrared spectra of investigated metal complexes exhibited characteristic bands due to coordination of water molecules around $490\text{--}310\text{ cm}^{-1}$.

Electronic Spectral Studies

The study of magnetic and electronic spectra data is quite informative in characterizing the geometry of the complexes. The UV-visible spectrum of the ligands and their complexes were recorded in DMSO

solution. The d^5 - configuration of a free ion has a 6S term as its ground term and there are no other terms of sextet multiplicity.

The investigated Fe (III) complexes present a unique case of electronic spectra rich in bands, some of which are sharp and the others broad. Since all the transitions are from sextet to quartet, they are spin-forbidden. Also, since they are g to g transitions, they are also Laporte forbidden. Despite the facts these are doubly forbidden, these have many bands with interesting features due to charge transfer bands²⁰. However, in several spin equilibrium systems, the high spin ($S = 5/2$) form has been characterized by transition at 555-500 nm and the low-spin ($S = 1/2$) form by transition at 714-625 nm²⁰⁻²². From the spectral study of the Fe(III) complexes it can be seen that all of them exhibit one band at 508–568 nm which can be assigned to ${}^6A_{1g} \rightarrow {}^4T_{1g}$ transition characteristic of octahedral structure^{20,23}. The broad intense and poorly resolved bands between 320-450 nm may be assigned to LMCT or MLCT²⁴. The high intensity band below 320 nm is of ligand origin assignable to intra-ligand $n - \pi^* / \pi - \pi^*$ transition²⁵.

On the basis of the forgoing evidences, the proposed octahedral geometry i.e., O_h symmetry for the complexes is presented in figures-2 and 3.

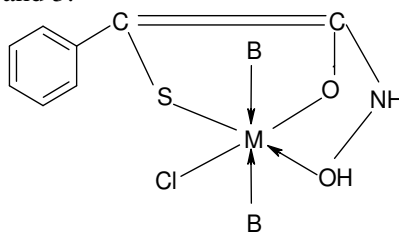


Fig.-2: Proposed octahedral structure complexes of Fe (III) with MBAHA-H ligand
(B = Monodentate secondary ligands)

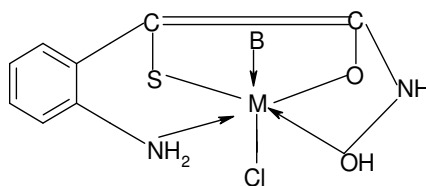


Fig.-3: Proposed octahedral structure complexes of Fe (III) with AMBAHA-H ligand
(B = Monodentate secondary ligands)

CONCLUSIONS

The elemental analysis, molar conductance measurements, infrared and electronic spectra of the iron (III) complexes explains the ligating property of the investigated ligands as well as the stereochemistry of their corresponding complexes. The molar conductance measurements of the complexes show the non-electrolytic systems. The IR spectral studies show that the ligand MBAHA-H acts as mono negative tri dentate (SOO' donor) ligand but AMBAHA-H acts as mono negative tetra dentate (SOO'N donor) ligand. The ligand MBAHA-H coordinating with metals through thioalcoholic S, carbonyl O and hydroxamic O atoms respectively and the ligand AMBAHA-H coordinating with metals through thioalcoholic S, carbonyl O hydroxamic O atoms and primary amino N atoms respectively. The electronic spectra exhibit octahedral geometry for all of the iron (III) complexes.

REFERENCES

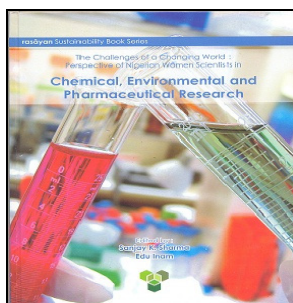
1. I. Bertini *et al.* *Bioinorganic Chemistry*, USB, CA, (1994).
2. B.Krautler and C.Kratky, *Angew.Chem.Int.Ed. Engl.*, **35**, 167,(1996).
3. R.E.P.Winpenny *et al.*, *Chem.Comm.*,653,(1997).

4. Y. K. Agrawal, *Russ. Chem. Rev.*, **48**, 1773, (1979).
5. Y. K. Agrawal, *Rev. Anal. Chem.*, **4**, 274, (1980).
6. Satpathy *et al.* *Acta. Chim. Hung.*, **125**, 527, (1998).
7. B. T. Thaker and B. V. Patel, *Thermochim. Acta.*, **129**, 161, (1988).
8. K. P. Srivastava and N. K. Ojha, *Orient J. Chem.*, **22**, 441, (2006).
9. K. P. Srivastava and N. K. Ojha, *Asian J. Chem.*, **19**(1), 385, (2007).
10. K.P. Srivastava and N.K. Ojha *Int. J. Chem. Sci.*, **5**(3), 2248, (2008).
11. K.P. Srivastava, *et al.*, *Int. J. Chem.Tech. Res.* **1**(1), 71, (2009).
12. K.P. Srivastava and Ali Akbar, *Int. J. Chem. Sci.* (accepted) (2013).
13. K.P. Srivastava and Ali Akbar, *Orient. J. Chem.* (accepted) (2013).
14. A. I. Vogel, *A Textbook of Quantitative Inorganic Analysis*, 6th edn. Wiley NY (1996).
15. Y.Inoue and H.Yukawa, *J.Agr.Chem. Soc. (Japan)*, **16**, 604, (1940).
16. S. L. Livingstone, *Inorg. Chem. Acta.*, **5**, 119 (1971).
17. W. J. Geary, *Coord. Chem. Rev.*, **7**, 81 (1971).
18. K.Nakamoto, *Infrared and Raman Spectra of Inorganic and Coordination Compounds*, John Wiley and Sons, NY (1997).
19. Ali Akbar, *Ph.D. Thesis*, J.P.University, Chapra, Bihar (2011).
20. S.Sarkar and K.Dey, *Spectrochim. Acta Part A*, **62**, 383, (2005).
21. Y.Maeda, N. Tsutsumi and Y.Yakashima, *Inorg. Chem.*, **23**, 2440, (1984).
22. M. Gaber, R.M.Issa, M.M.Ghoniem and K.Y. El-Baradie, *Egypt. J. Chem.*, **34**, 107, (1991).
23. Sk.H.Rahman, H.Chowdhury, D.Bose,R.Ghosh, C.H. Hung andB.K.Ghosh, *Polyhedron*, **24**, 1755, (2005).
24. M. I. Davies, A. M. Orville, F. Neese, J. M. Zaleski, J. D. Lipscomb and E. I. Solomon, *J. Am. Chem.Soc.*, **124** 602, (2002).
25. N.T.Madha, P.K. Radhakrishnan, M.Grunert, P.Weinberger and W. Linert, *Thermochim. Acta*, **407**, 73, (2003).

[RJC-1021/2013]

Absolutely FREE*

[For New life Members]



The Challenges of a Changing World: Perspective of Nigerian Women Scientists in Chemical, Environmental and Pharmaceutical Research

[ISBN: 978-81-921149-0-3]

Print Price: Rs. 990/- only

Be a Proud Life Member of RASĀYAN J. Chem.

Life Membership for Individuals: Rs.8000/- for Indians and USD 1000 for others.

Life Membership for Institutional: Rs.10000/- for Indians and USD 1500 for others.

BENEFITS OF LIFEMEMBERSHIP:

1. You will receive the journal and all its special issues regularly lifelong.
2. If you are a LIFE MEMBER, you need not to pay subscription fee every time for publication of your paper in RJC.
3. You'll be a Reviewer for RJC manuscripts of your Field Interest and we'll publish your name in our journal.
4. You will be exempted from Registration Fee of any National or International future events (i.e. workshop, seminars, Conferences etc.) organized by RJC.
5. You may be elected as Editorial Member of RJC (Note: It'll depend upon your publication and scientific achievements).
6. New Life members shall have a **BOOK*** absolutely **FREE** from RJC with Complements.

For being a **Life Membership**, just mail to editor-in-Chief with your detailed Resume.

Correspondence address:

23 'Anukampa', Janakpuri, Opp. Heerapura Power Stn., Ajmer Road, Jaipur-302024 (India)
E-mail : rasayanjournal@gmail.com ; Phone : 0141-2810628(Off.), 07597925412(Mob.)