WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 6.805
Volume 5, Issue 11, 1078-1086. Research Article ISSN 2277– 7105

SYNTHESIS AND CHARACTERIZATION OF MIXED IGAND COMPLEXES OF O, N AND S DONAR LIGANDS

P. R. Shirode*[1], R. K. Agrawal[1] and P. M. Yeole[2]

[1]Department of Chemistry, Pratap College, Amalner, India.
[2]Centre for P.G. Research in Chemistry, R.L. College, Parola, Dist. Jalgaon North Maharashtra University, Jalgaon (Maharashtra), India.

Article Received on
05 Sept. 2016,

Revised on 26 Sept. 2016,
Accepted on 16 Oct. 2016

DOI: 10.20959/wjpr201611-7260

***Corresponding Author**
P. R. Shirode
Department of Chemistry,
Pratap College, Amalner,
India.

ABSTRACT

The mixed ligand complexes of the type $[ML_1L_2]Cl_2$. Where M=Cr(III), Mn(II), Co(II),Ni(II) and Cu(II) with L_1=Pyruvic acid thiosemicarbazone L_2= Cyclohexanone semicarbazone have been synthesized, by the reactions of metal chlorides with two different semicarbazones in 1:1:1 molar ratios. The resulting products have been characterized on the basis of elemental analysis, magnetic measurement, IR and Electronic spectra, conductivity measurement, thermal analysis, antimicrobial activities. The metal complexes show ratio 1:1:1 with metal, ligand L_1 and ligand L_2.The ligands are bonded through oxygen and nitrogen and sulphur to metal ion.

KEYWORDS: Mixed ligand, Pyruvic acid thiosemicarbazone, cyclohexanone semicarbazone, transition metals.

INTRODUCTION

Semicarbazones, thiosemicarbazones and their derivatives have aroused much interest in recent times due to their versatility and their interesting pharmacological properties as antibacterial, antifungal[1-4] antivirial, antiamoebic, antimalarial, antitumor, anticonvulsant.[5-6], antiinflammatory, antineoplastic and corrosive inhibitory activities.[7] The chemistry of semicarbazones and thiosemicarbazones has been extremely active and extensively investigated because of these chemotherapeutic and anti-corrosive activities. Secondly, the ease of preparation, diversity in geometrical configurations also added to their valuable applications. As is the case in many structure-activity relationship studies, modifications of the parent molecular structure with various active substituents at the different positions of the moiety and the type of metal ion incorporated in the complex.[8-11] significantly alter the configuration and properties. These alterations often times are done to enhance the therapeutic potency and efficiencies as drugs. Though understanding the exact mechanism of the antimicrobial activities of these drugs are yet to be completely ascertained, presently some evidences exist of a correlation between hypophilicity (i.e ease of transport across cell membrane) and the degree of antimicrobial activity in an organism[12]

Objectives and scope of the present work

There has been considerable interest in the studies of thiosemicarbazones due to their coordination modes when bound to metals. The wide applications and structural diversity of metal complexes of thiosemicarbazones encouraged us to synthesize the tridentate ONS donor semicarbazones and their metal complexes. Due to good chelating ability, the present work is mainly concerned on the studies of two novel semicarbazones, pyruvic acidthio semicarbazone [L_1] and cyclohexanone semicarbazone [L_2]. The compositions of these semicarbazones were determined by the CHNS analyses. For the characterization of these compounds we have used IR and UV spectral studies. We have synthesized manganese(II), cobalt(II), nickel(II) and copper(II) complexes of these semicarbazones, in the ratio 1:1:1 with metal:ligand L_1:ligand L_2. These complexes were characterized by various spectroscopic techniques, magnetic and conductivity studies, biological activities.

MATERIALS AND METHODS

The compounds pyruvic acid, benzaldehyde and semicarbazide hydrochloride and chlorides of Fe(III)used were of E MEARK, BDH analytical grade. The amount of metal is determined complex metrically by EDTA suitable indicator metal ions. Carbon, hydrogen , nitrogen and sulpher analysis were carried from SAIF, Mumbai. Specific conductance were measured at room temperature in DMF by a Systronics direct reading 304conductivity meter using a glass conductivity cell having a cell constant.IR spectra were taken on JASCO 6600 FTIR SPECTROPHOTOMETER and JASCO - 670 -UV SPECTROPHOTOMETER from Central Research Laboratory, Pratap College, Amalner.. Thermo gravimetric analysis were performed on STA 6000 from Department of Physics, Pratap College, Amalner. Microbial activities were carried out from PG Department of Microbiology, Pratap College, Amalner.

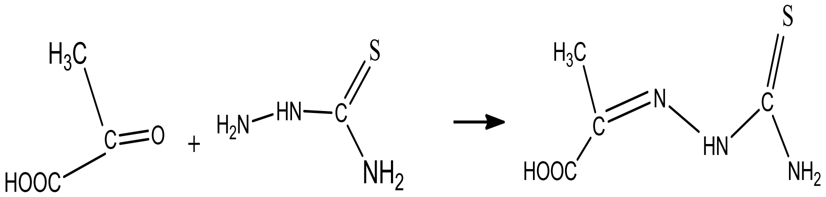
Synthesis of Ligands

Ligands L_1 and L_2were prepared. The methods of their preparation are given below.

Ligand: L_1

PYRUVIC ACID THIOSEMICARBAZONE (PYTSC)

One mmole of pyruvic acid was added drop wise to the 20ml. methanolic solution of thiosemicarbazide (1mmole) with constant stirring. The reaction mixture was heated with reflux condenser for four hours. Then the reaction mixture is cooled to ambient temperature in a crushed ice. A light brown crystalline solid was formed. The product is filtered, washed and recrystallized from methanol, dried and melting point was recorded.



Ligand: L_2

Dissolved 2 gm. of semicarbazide of hydrochloride &3 gm. of crystallized sodium acetate in about in about 25-30ml distilled water hard glass test tube to this solution add 1ml of cyclohexanone and shake well .If the mixture is turbid then add 1:1 ethyl alcohol until a clear solution is obtained. Than heat this reaction mixture in water bath for 10 minutes. Then cool this solution & transfer into a beaker containing crashed ice. White crystals of the semicarbazone derivative are separate out from the solution. Filter the crystals & recrystallized from ethyl alcohol,dry and then melting point and yield is recorded .

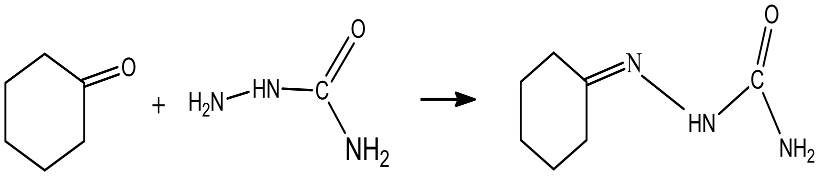


Table I: Physical properties of ligands.

Name of the ligand	Symbol	Colour and nature	Method purification.	M.P. ^{0}c	Mol. wt	Molecular formula
Pyruvic acid thiosemicarbazone	PYTSC	Light brown crystals	Recrystallization from methanol	186 (185)	161	$C_4H_7N_3O_2S_1$
Cyclohexanone semicarbazone	CYSC	White Crystals	Crystallized from aq.Ethanol	167 (167)	155	$C_7H_{13}N_3O$

Synthesis of Mixed ligand Complexes of Transition Metals$[M(L_1)_1(L_2)_1(H_2O)_1]Cl_2$

where L_1= PYTSC and L_2=,CYSC

To 20 ml ethanalic solution of 0.01M metal chloride a mixture of 20 ml ethanalic solution of0.01M cyclohexanone semicarbazone and 20 ml 0.01M pyruvic acid thiosemicarbazone ligands were added with continuous stiring in a water bath .Then the reaction mixture is refluxed with water condenser for four to five hours. Then P^H of the reaction mixture was raised to 7.5 to 8.00 by adding 5% NaOH solution drop wise with constant stirring. The p^H was measured with the help of the p^H paper. Stirring was continued for another half an hour. The coloured precipitate of the complex separates out from the solution. The complex is filtered and dried under IR lamp. By using similar procedure other complexes were prepared by mixing metal salt solutions with pyruvic thiosemicarbazone and cyclohexanone semicarbazone in the ratio 1:1:1. In this way other complexes are prepared.

Experimental Analytical Technique

The compounds pyruvic acid, cyclohexanone, semicarbazide hydrochloride and metal chlorides used were of analytical grade The amount of metal present determined volumetrically by EDTA using double burette technique for optimum utilization of reagents. Indicator Erich Rome Black T was used for Mn(II) and Mg, ammonium thiocynate for Fe(III), xylenol orange for Co(II) and mureoxide for Ni(II) and Cu(II). Carbon, hydrogen and nitrogen analysis were carried from SAIF, Mumbai. Specific conductance were measured at room temperature in DMF by a Systronics direct reading 304 conductivity meter using a glass conductivity cell having a cell constant L_1 and L_2. IR spectra of the complexes were recorded on Perkin Elmer FTIR instrument using KBr pellets in the region 400-4000 cm^{-1} from Department of Physics, Pratap College, Amalner. The spectral data of complexes is shown in annexure A. Electronic spectra of complexes were recorded on Systronics UV-VISIBLE Spectrophotometer in the Department of Chemistry,, Pratap College, Amalner. The spectral data of complexes is shown in annexure B. Thermo gravimetric analysis was carried out on SHIMAdZU STA 6000. Antimicrobial activities are determined by using three microbial nutrients.

RESULT AND DISCUSSION

The reactions of metal chlorides with pyruvic acid thiosemicarbazone and cyclohaxanone semicarbazones in the 1:1:1 molar ratio results in the formation mixed ligand complexes.

The resulting complexes were having different colours as given in the table II., They are insoluble in chloroform, carbon tetrachloride, methanol, ethanol but soluble in DMF. The properties of complexes are indicated in table II. The TLC of the mixed ligand complexes exhibit single spots with R_f values being intermediate of the two corresponding symmetrical bis-complexes indicating that these are mixed ligand complexes rather than a mixture of two corresponding bis-complexes. From the magnetic moments these complexes show octahedral geometry.

The conductance's of the complexes are very low (29.04-71.0Ω^{-1}cm^{2}mol^{-1}) indicating their non-electrolyte nature. In the IR spectra of the mixed ligand complexes the bands at 1601-1621cm^{-1}may be assigned to the symmetric and asymmetric v(C=N) vibrations. A strong band in the region 1689-1787cm^{-1}are due to v(C=O) groups. On complex formation, the position of these bands is shifted toward lower side as compared to the metal free ligand. This indicates that the coordination takes place through the nitrogen and oxygen atom of the(C=N) and (C=O) groups. A broad band appears in the region at 3629-3718cm^{-1} be attributed to the coordinated water molecule.

The reflectance spectrum of Cr(III) complex exhibit three transitions at 12224,21762 and 30769 cm^{-1} due to the $^4A_{2g}(F) \rightarrow {}^4T_{2g}(F)$,$^4A_{2g}(F) \rightarrow {}^4T_{1g}(F)$ and $^4A_{2g}(F) \rightarrow {}^4T_{1g}$ (P) transitions, respectively, suggesting an octahedral geometry around the Cr(III) ion.

The reflectance spectrum of the Mn(II)-complex **4** showed a series of bands in the range 11600,19607,26315 and 32417 cm^{-1}. These bands are both Laporte and spin-forbidden. However, due to instantaneous distortion of the octahedral structures around the metal cation, weak bands sometimes do appear.[18,20] The magnetic moment of the complex is 4.39 B. M. and indicates antiferromagnetic interaction between the adjacent metal cations.

The electronic spectrum of Fe(III) complex displays three bands at 12345, 17391and 22222 cm^{-1} assignable to $^6A_{1g}(S) \rightarrow {}^4T_{1g}(G)$,$^6A_{1g}(S) \rightarrow {}^4T_{2g}(G)$ and $^6A_{1g}(S) \rightarrow {}^4E_g$,$^4A_{1g}(G)$ transition.

The $\mu_{eff.}$ value measured for the Co(II)-complex is 4.116 B.M, indicating octahedral geometry of the Co(II) ion in the complex. The reflectance spectrum of the complex showed a band at 11547,14947 and 21008 cm^{-1} besides the ligand absorptions for transitions would be due to a $^4T_{1g} \rightarrow {}^4A_{2g}(F)$, $^4T_1g(F) \rightarrow {}^4T_1g$ (P) and $^4T_1g(F) \rightarrow {}^4T_2g$ (F)[19,20], indicating an octahedral configuration around Co(II) ions.[18,20]

The reflectance spectrum of the mononuclear Ni(II) complex showed a broad and main absorption band at 8495 cm^{-1} and a shoulder at 16583 cm^{-1}. The main band may be due to $^3A_{2g}(F) \rightarrow {}^3T_{1g}(P)$ electronic transition of Ni(II) in an octahedral geometry. The $^3A_{2g}(F)$

$\rightarrow {}^3T_{1g}$(P) transition may be overlapped by the ligand absorption bands which appeared at 26315 cm^{-1}.[18] The third transition due to $^3A_{2g}$(F) $\rightarrow {}^3T_{2g}$ is out of the range of the spectrophotometer used. This indicates that the Ni(II) ion coordinated to $(N_2)_2$ sites in an octahedral geometry.[18] The Ni(II) ion completes its hexa-coordination sphere with two water molecules. The third transition due to $^3A_{2g}$(F) $\rightarrow {}^3T_{1g}$(P) would be outside the scale of the spectrophotometer used. The magnetic moment of the complex is 3.165 B.M. which agrees well with the known values for Ni(II) complexes in octahedral geometry.

The observed magnetic moment of the Cu(II) complex is 2.1 B.M., which confirms the octahedral structure of this complex. Electronic spectrum of the copper(II) complex displays bands at 13736,19531 and 26737 cm^{-1}. First two bands may be assigned to the transitions: $^2B_{1g} \rightarrow {}^2A_{1g}$ ($dx^2 - y^2 \rightarrow dz^2$) ($\nu_1$), $^2B_{1g} \rightarrow {}^2B_{2g}$ ($dx^2 - y^2 \rightarrow dzy$) ($\nu_2$), respectively and third band (ν_3)may be due to charge transfer.

ANTIMICROBIAL ACTIVITY OF THE LIGAND AND ITS COMPLEXES

The Cr(III) complex is found to show good activity against*S. Aureus*. All the metal complexes were more potent bactericides and fungicides than the ligand. Fe(III),Co(II) and Mn(II) complexes were much less bacterial activity than the Cu(II) and Ni(II) complex while Mn(II) complex shows superior antifungal activity compare to other complexes. It can be seen that the highest Antibacterial activity of Cu(II) complex against the bacterium B. subtilis (3.125 µg/ml). On the other hand, Mn(II) complex showed the best activity towards fungi against A. niger (3.125 µg/ml). There was a marked increase in the bacterial and fungi activities of the Cu(II) and Mn(II) complexes respectively, as compared with the free ligand and other complexes under test, which is in agreement with the antifungal and antibacterial properties of a range of Cu(II) and Mn (II) complexes evaluated against several pathogenic fungi and bacteria.

Table: 2. Elemental analyses data of the complexes

Ligand/ Complex	**Colour**	**Mole. Wt.**	**%Yield of Compd.**	**% of metal**	**% of C**	**% of N**	**% of H**	**% of S**
Cr[$(PYTSC)_1$ $(CYSC)_1(H_20)_1$]	Gray green	491.49	62.0	11.47 (11.99)	26.85 (26.98)	17.09 (17.15	4.09 (4.06	6.51 (6.55)
Mn[$(PYTSC)_1$ $(CYSC)_1(H_20)_1$]	Brown	458.43	65.5	13.07 (13.45)	28.79 (28.12)	18.32 (18.21)	4.36 (4.35)	6.98 6.94
Fe[$(PYTSC)_1$ $(CYSC)_1(H_20)_1$]	Redish brown	496.35	69.6	12.23 (12.04)	26.59 (27.01)	16.92 (17.07)	4.02 (4.04)	6.45 6.46
Co[$(PYTSC)_1$	Red	463.93	63.2	12.65	28.45	18.10	4.31	6.89

$(CYSC)_1(H_20)_1]$				(12.91)	(28.90)	18.21)	(4.33)	6.87
$Ni[(PYTSC)_1$ $(CYSC)_1(H_20)_1]$	Yellowish green	463.69	67.45	12.56 (12.34)	28.45 28.39)	18.11 (18.02)	4.31 (4.29)	6.90 6.85
$Cu[(PYTSC)_1$ $(CYSC)_1(H_20)_1]$	Pale Yellow	468.54	62.23	13.55 (13.07)	28.17 (28.23)	17.92 (17.85)	4.26 (4.24)	6.82 6.84

Table: 3. IR spectra (cm-1) bands of the parent and mixed ligand transition metal complexes

Ligand/ Complex	**ν_{OH} from H_2O**	**ν COOH**	**ν(C=O)**	**ν(C=N)**	**ν(C-o)**	**V (C=S)**	**V (M-N)**	**ν M-S**
CYSC		-	1734	1601	1241	-		
PYTSC		2361	1699	1605	1248	855		
$Cr[(PYTSC)_1(CYSC)_1$ $(H_20)_1]$	3629	2358	1774	1615	122	724	657	481
$Mn[(PYTSC)_1(CYSC)_1$ $(H_20)_1]$	3724	2360	1787	1615	1222	730	647	530
$Fe[(PYTSC)_1(CYSC)_1$ $(H_20)_1]$	3720	2360	1749	1621	1215	862	672	487
$Co[(PYTSC)_1(CYSC)_1$ $(H_20)_1]$	3731	2360	1689	1617	1216	865	550	478
$Ni[(PYTSC)_1(CYSC)_1$ $(H_20)_1]$	3738	2358	1697	1614	1231	855	521	485
$Cu[(PYTSC)_1(CYSC)_1$ $(H_20)_1]$	3720	2358	1736	1614	1227	836	669	499

Table: 4 Magnetic moment and molar conductance values of the complexes.

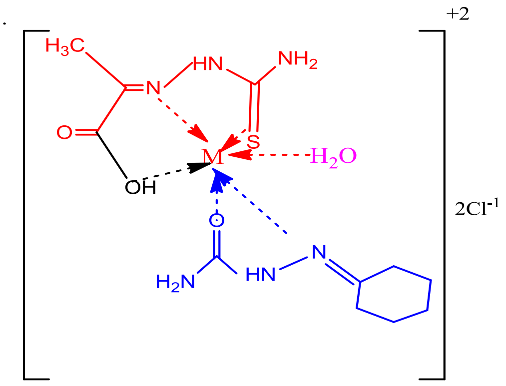
Ligand/ Complex	**Magnetic moment in B.M.**	**cond.Ω^{-1} cm^{-2} mol^{-1} at 29 ^{0} C**	**cond.Ω^{-1} cm^2 mol^{-1} at 39 ^{0} C**
$Cr[(PYTSC)_1(CYSC)_1(H_20)_1]$	4.490	61.258	63.622
$Mn[(PYTSC)_1(CYSC)_1(H_20)_1]$	4.343	25.524	29.084
$Fe[(PYTSC)_1(CYSC)_1(H_20)_1]$	5.085	27.266	29.647
$Co[(PYTSC)_1 (CYSC)_1(H_20)_1]$	4.116	40.25	51.700
$Ni[(PYTSC)_1 (CYSC)_1(H_20)_1]$	3.165	65.23	50.23
$Cu[(PYTSC)_1 (CYSC)_1(H_20)_1]$	2.190	15.62	70.21

Table: 5. Electronic spectra

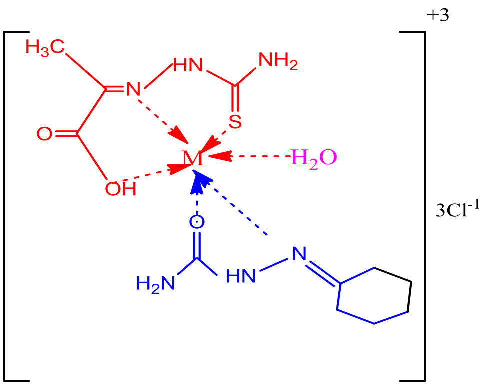
S.No.	**Name of the Complex**	**ν_1**	**ν_2**	**ν_3**
1	$Cr[(PYTSC)_1(CYSC)_1(H_20)_1]$	12224	21762	30769
2	$Mn[(PYTSC)_1(CYSC)_1(H_20)_1]$	11600	19607	26315
3	$Fe[(PYTSC)_1(CYSC)_1(H_20)_1]$	12345	17391	22222
4	$Co[(PYTSC)_1(CYSC)_1(H_20)_1]$	11547	14947	21008
5	$Ni[(PYTSC)_1 (CYSC)_1(H_20)_1]$	8495	16583	26315
6	$Cu[(PYTSC)_1$ $(CYSC)_1(H_20)_1]$	13736	19531	26737

Table: 6 Thermodynamic properties of complexes

Name of the Complex	**Temp.^{0}C**	**% Mass Loss Found**	**DSC peak in ^{0}C**	**Endo/Exo ΔH in J g-1**
$Cr[(PYTSC)_1(CYSC)_1(H_20)_1]$	70-200 201-350	4.790 21.425	428.61	-1008.53
$Mn[(PYTSC)_1(CYSC)_1(H_20)_1]$	70-240 241-400	4.680 36.341	293.60	-393.307
$Fe[(PYTSC)_1(CYSC)_1(H_20)_1]$	70-200 201-400	3.521 17.680	231.68	-2569.96
$Co[(PYTSC)_1(CYSC)_1(H_2O)_1]$	70-180 181-400	2.560 27.460	375.14	-1353.94
$Ni[(PYTSC)_1(CYSC)_1(H_2O)_1]$	70-140 141-347	2.940 10.670	420.67	-826.45
$Cu[(PYTSC)_1(CYSC)_1(H_20)_1]$	50-120 121-280	3.430 15.240	243.39	-8355.27



$[M(CYSC)_1(PYTSC)_1(H_2O)_1]Cl_2$



$[M(CYSC)_1(PYTSC)_1(H_2O)_1]Cl_3$

From all these invistagation the structure of complexes are as given below

ACKNOWLEDGEMENT

I am grateful to Principal, Pratap College, Amalner and the Head Chemistry Department Pratap college, Amalner for laboratory facilities. I am also thankful to the Head Physics Department Pratap College, Amalner for Electronic spectra and IR spectra and Head, SAIF, IIT Mumbai for elemental analysis.

REFERENCES

1. Farrell N, *Coord Chem Rev*., 2002; 232(1-2): 1-4. DOI:10.1016/S0010-8545(02)00100-5
2. West D X, Padhye S B and Sonawane P B, Structure and Bonding Springer-Verlag: New York, 1991; 76: 1.
3. Cerecetto H and Gonzalez M, *Curr Topics Med Chem*., 2002; 2: 1185. 1192 Chem Sci Trans., 2014; 3(3): 1186-1192.
4. Beraldo H and Gambino D, *Mini Rev Med Chem*., 2004; 4: 159-165.

5. Pandeya S N and Dimmock J R, *Pharmazie*, 1993; 48(9): 659-666.
6. Warren J D, Ronald T H and Woodward D L, *J Med Chem*., 1977; 20(11): 1520-1521; DOI:10.1021/jm00221a034
7. Sogni P, Yang S, Pilette C, Moreau R, Gadano A, Avenard G, Bloy and Lebrec C D, *Eur J Pharmacol*., 1998; 344(1): 37-43; DOI:10.1016/S0014-2999(97)01567-7
8. Singh A, Dharkarey R and Saxena G C, *J Indian Chem Soc*., 1996; 73: 339.
9. Anderson R J, Cloudsdale I S, Lamoreaux R J, Schaefer K and Harr J, US Patent 6, 2000; 110: 869.
10. Copping L G, Kerry J C, Watkins T I, Wllis R J and Bryan H, US Patent 1983; 4: 394-387.
11. Pandeya S N, Aggarwal N and Jain J S, *Pharmazie*, 1999; 54(4): 300-302.
12. Patole J, Dutta S, Padhye S and Sinn E, *Inorg Chim Acta*, 2001; 318(1-2): 207-211. DOI:10.1016/S0020-1693(01)00416-9
13. Atalay T and Akgemci E G, *Tr J Chem*., 1998; 22 123-128.
14. Kolb V M, Stupar J W, Janota T E and Duax W L, *J Org Chem*., 1989; 54(10): 2341-2346; DOI:10.1021/jo00271a019
15. Basuli F, Ruff M, Pierpont C G and Bhattacharya S, *Inorg Chem*., 1998; 37(23): 6113-6116; DOI:10.1021/ic980424i
16. R.N. Prasad, Jindal, R.P. Sharma. Curr. Sci., 1984; 53: 1128.
17. Denisa MÂNZU, Ticuţa NEGREANU-PÎRJOL, Florina DUMITRU, Mihaela ALEXIE, Cornelia GURANU.P.B. Sci. Bull., Series B, 2009; 71: Iss. 2.
18. Abdul Salam A.K. Abdul Rahman Diala, Jour, 2009; 39.
19. R.N. Prasad, M.Jindal, M.Jain..J.Ind. Chem. Soc., 1990; 67: 874.
20. GN MUKHERJEE AND ANSUMAN DAS., Proc. Indian Acad. Sci.(Chem. Sci.), June 2002; 114(3): 163-174
21. S. Chandra, K.B. Pandeya and R.P.SinghJ.Inorg.Nucl.Chem., 1977; 39: 2079.
22. P.R.SHIRODE and P.M.YEOLE *Chem. Sci. Trans*., 2014; 3(3): 1186-1192
23. R.N.Prasad, K.M.Sharma, Anjali Agrawal.J.Ind.Chem.Soc.,85(2008)36-41
24. K.N.Thimmaiah, W.D.Lloyd, G.T.Chandrappa, Inorg. Chim. Acta., 1985; 106: 81.