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ORIGINAL RESEARCH

Chromium(III), Cobalt(III) and Iron(III) Complexes of NNS Chelating Thiosemicarbazone Ligands: Spectroscopic and Biological Studies

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ABSTRACT

Thiosemicarbazones (TSCs) have been emerged as influential category of N,S-donor ligands with an extended time due to structural divergence, donor effectiveness and biological applications. Nitrogen possessing marginal feature can bind with hard-soft transition metal ions while sulphur favours coordination with ions of soft metals. A new series of transition metal complexes of Chromium(lll), Cobalt(III) and Iron(lll) derivatives have been isolated from tthiosemicarbazone ligandsupon reacting with diacetyl-α-monoxime and unsubstituted/substituted thiosemicarbazone. The synthesized ligands and complexes were distinguished through physical investigations along with spectral investigation (UV-Vis, IR and ^{1}H NMR). The obtained input illustrates that these complexes have composition of $[M(LH)_2]Cl\cdot 3H_2O$ type and octahedral geometry around central metal ion with N/ S donor atoms. The ligands are of uni-negative tridentate nature. The synthesized trivalent metal complexes appear to be 1:1 electrolyte. In addition, biological studies have been carried out in vitro for investigated compounds.

KEY WORDS: Biological activity, Diacetyl-α-monoxime, Metal chelates, Spectral analysis, Thiosemicarbazone,

INTRODUCTION

Bioinorganic chemistry can extend an inventive approach to a large number of issues in the biomedical domain, allowing to exploit the properties of metal ions in synergy with organic ligands (Carcelli *et al*., 2020). Thiosemicarbazones or N-imino thiourea, $R_2C=N-NH-C(=S)-NH_2$ are organic ligands commonly synthesized by the condensation process of carbonyl compounds with unsubstituted and/or substituted thiosemicarbazide under ambient conditions. These are Schiff base compounds or derivatives of merged soft and hard N,S-chelating ligands (Mukherjee *et al*., 2016). Hence, it is possible to change their lipophilic properties (Süleymanoglu *et al*., 2019), chelating ability, steric hinderance and synergistic effect on the biological activity (Chudzik-Rzad *et al*., 2020). The appealing coordination chemistry of thiosemicarbazones or thiosemicarbazide derivatives is due to their differing reaction opportunities permitting the synthesis of abundance of new organic compounds. They hold imine bonds (-N=CH-) (Matsa *et al*., 2019) which makes them advantageous in biotic synthesis for transfer hydrogenation (Barrozo *et al*., 2021), oxidation (Castillo *et al*., 2023), reduction (Dutta *et al*., 2002), condensation reactions (Nickisch *et al*., 2022) and can act as homogenous catalyst (Priyarega *et al*., 2022), antioxidant (Yakan *et al*., 2020) and organic corrosion inhibitor (Bimoussa *et al*., 2022).

TSCs can align as a electroneutral bidentate N,S-chelate or ordinarily as negatively charged bidentate N,S-chelate upon proton removal of the nitrogen of azomethine group. TSC ligand design can be adapted to incorporate supplementary heteroatom enlarging its denticity from two to three, regularly in form of NNS or ONS chelates (Muleta *et al*., 2019). This behaviour shows notable coordination selectivity with steadiness to the heterogeneity of metal ions. Hence, their capability to form divergent complexes with transition metal ions fabricates them more relevant in applied and foundational research as ligand-metal ion

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Table 1: Physical properties and analytical data of ligands and metal complexes

Compound/ Empirical formula	Formula Weight(gmol^{-1})	Yield (%)	Colour	Decom. Temp.(^{0}C)	Analysis found (Calculated) % C	H	N	O	S	Br	Cl	M	$\mu_{eff.}$
$AMTH_2$/ $C_5H_{10}N_4OS$	174.20	67.8	Off white	200	34.44 (34.42)	5.74 (5.72)	32.15 (32.14)	9.19 (9.17)	18.37 (18.34)	-	-	-	-
$AMCPTH_2$/ $C_{11}H_{13}N_4OSCl$	284.77	47.4	Light brown	190	46.40 (46.38)	4.60 (4.58)	19.67 (19.66)	5.62 (5.61)	11.26 (11.24)	-	12.45 (12.44)	-	-
$AMBPTH_2$/ $C_{11}H_{13}N_4OSBr$	329.21	56.2	Cream	205	40.13 (40.09)	3.98 (3.97)	17.02 (17.01)	4.86 (4.84)	9.74 (9.73)	24.27 (24.26)	-	-	-
$AMMPTH_2$/ $C_{15}H_{12}N_2OS$	264.35	32.6	Dark cream	200	54.53 (54.50)	6.10 (6.08)	21.19 (21.18)	6.05 (6.03)	12.13 (12.12)	-	-	-	-
$[Cr(AMTH)_2]Cl\cdot 3H_2O$/ $C_{10}H_{24}N_8O_5S_2ClCr$	487.92	44.3	Cream	<260	24.62 (24.59)	4.96 (4.95)	22.97 (22.96)	16.40 (16.39)	13.14 (13.12)	-	7.27 (7.26)	10.66 (10.65)	3.97
$[Cr(AMCPTH)_2]Cl\cdot 3H_2O$/ $C_{22}H_{30}N_8O_5S_2Cl_3Cr$	709.00	47.5	Light brown	<240	37.27 (37.26)	4.26 (4.25)	15.80 (15.79)	11.28 (11.27)	9.05 (9.04)	-	15.00 (14.97)	7.33 (7.32)	3.95
$[Cr(AMBPTH)_2]Cl\cdot 3H_2O$/ $C_{22}H_{30}N_8O_5S_2Br_2ClCr$	797.90	56.2	Brown	<255	33.12 (33.11)	3.80 (3.78)	14.04 (14.01)	10.03 (10.02)	8.04 (8.03)	20.03 (20.02)	4.44 (4.42)	6.52 (6.51)	3.93
$[Cr(AMMPTH)_2]Cl\cdot 3H_2O$/ $C_{24}H_{36}N_8O_5S_2ClCr$	668.17	66.0	Brown	<245	43.14 (43.12)	5.43 (5.41)	16.77 (16.75)	11.97 (11.96)	9.60 (9.59)	-	5.31 (5.30)	7.78 (7.76)	3.85
$[Co(AMTH)_2]Cl\cdot 3H_2O$/ $C_{10}H_{24}N_8O_5S_2ClCo$	494.86	39	Light brown	<280	24.27 (24.26)	4.89 (4.87)	22.64 (22.62)	16.17 (16.16)	12.96 (12.95)	-	7.16 (7.14)	11.91 (11.90)	Dia.
$[Co(AMCPTH)_2]Cl\cdot 3H_2O$/ $C_{22}H_{30}N_8O_5S_2Cl_3Co$	715.95	42	Brown	<270	36.91 (36.88)	4.22 (4.21)	15.65 (15.64)	11.17 (11.16)	8.96 (8.95)	-	14.86 (14.85)	7.33 (7.31)	Dia.
$[Co(AMBPTH)_2]Cl\cdot 3H_2O$/ $C_{22}H_{30}N_8O_5S_2Br_2ClCo$	804.84	64	Dark brown	<275	32.83 (32.82)	3.76 (3.75)	13.92 (13.91)	9.94 (9.93)	7.97 (7.96)	19.85 (19.83)	4.40 (4.39)	7.32 (7.29)	Dia.
$[Co(AMMPTH)_2]Cl\cdot 3H_2O$/ $C_{24}H_{36}N_8O_5S_2ClCo$	675.11	58.3	Brown	<265	42.70 (42.69)	5.37 (5.36)	16.60 (16.58)	11.85 (11.84)	9.50 (9.49)	-	5.25 (5.23)	8.73 (8.72)	Dia.
$[Fe(AMTH)_2]Cl\cdot 3H_2O$/ $C_{10}H_{24}N_8O_5S_2ClFe$	491.77	37.4	Light brown	<250	24.42 (24.40)	4.92 (4.91)	22.79 (22.78)	16.27 (16.26)	13.04 (13.01)		7.21 (7.19)	11.36 (11.35)	5.23
$[Fe(AMCPTH)_2]Cl\cdot 3H_2O$/ $C_{22}H_{30}N_8O_5S_2Cl_3Fe$	712.85	55.9	Greenish brown	<245	37.07 (37.06)	4.24 (4.21)	15.72 (15.71)	11.22 (11.20)	9.00 (8.99)	-	14.92 (14.91)	7.83 (7.82)	5.29
$[Fe(AMBPTH)_2]Cl\cdot 3H_2O$/8 $C_{22}H_{30}N_8O_5S_2Br_2ClFe$	01.75	86	Dark green	<270	32.96 (32.95)	3.77 (3.75)	13.98 (13.97)	9.98 (9.97)	7.99 (7.97)	19.93 (19.92)	4.42 (4.41)	6.97 (6.96)	5.38
$[Fe(AMMPTH)_2]Cl\cdot 3H_2O$/ $C_{24}H_{36}N_8O_5S_2ClFe$	672.02	73.8	Brown	<255	42.89 (42.86)	5.40 (5.39)	16.67 (16.65)	11.90 (11.89)	9.54 (9.53)	-	5.27 (5.26)	8.31 (8.29)	5.31

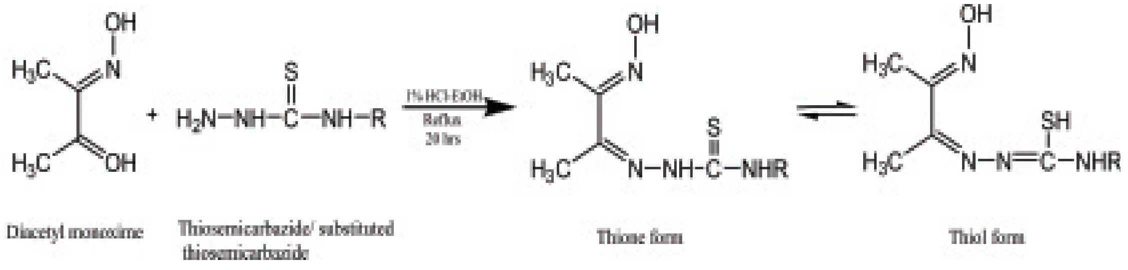

Fig.1. Synthesis route of ligands R= H(AMTH$_2$); 4-ClC$_6$H$_4$(AMCPTH$_2$); 4-BrC$_6$H$_4$(AMBPTH$_2$); 4-CH$_3$C$_6$H$_4$(AMMPTH$_2$)

coordination has been explored to be useful in amplifying the drug value. TSCs have been the centre of interest of biologists and chemists due to their widespread pharmacological effects. They can act as antibacterial (Govender *et al.*, 2019), antifungal (Bajaj *et al.*, 2021), antidiabetic (Gul *et al.*, 2024), antimalarial (Matsa *et al.*, 2019), antiviral (Arslan *et al.*, 2021), antiprotozoal (Gonzalez *et al.*, 2021), antitubercular (Sharma *et al.*, 2020) and herbicidal (Yun *et al.*, 2020). One of most encouraging areas in which these exemplary metal complexes are being refined is their usage as potent anticancer agents (King *et al.*, 2017; Shakya *et al.*, 2020). The compounds have a broad clinical antitumor (Ghiasi *et al.*, 2023) spectrum with potency in variety of tumors such as pancreatic, non-small cell lung, prostate, cervical and bladder cancer.

Thiosemicarbazones obtained from diacetyl-α-monoxime, hold both thione and oxime segments and thus they direct to impressive functional and structural characteristics. The present investigation is oriented towards synthesis of thiosemicarbazones obtained from diacetyl-α-monoxime with unsubstituted/ substituted thiosemicarbazide and their Cr(lll), Co(III) and Fe(III) complexes and their spectral characterization.

MATERIALS AND METHODS

The chemicals, used in the investigation were procured from trade sources and utilized as received without any purification. Diacetyl-α-monoxime and thiosemicarbazide were purchased from Sigma Aldrich. 4-(4-Chlorophenyl)-3-thiosemicarbazide, 4-(4-bromophenyl)-3-thiosemicarbazide and 4-(4-methylphenyl)-3-thiosemicarbazide were synthesized according to the literature method (Kazakov *et al.*, 1961). Iron trichloride hexahydrate (FeCl$_3$·6H$_2$O)and chromium trichloride hexahydrate (CrCl$_3$·6H$_2$O) were purchased from SD Fine Chemicals Ltd. (Mumbai). Each of the used organic solvents was of reagent grade.

Elemental (carbon, hydrogen and nitrogen) analysis

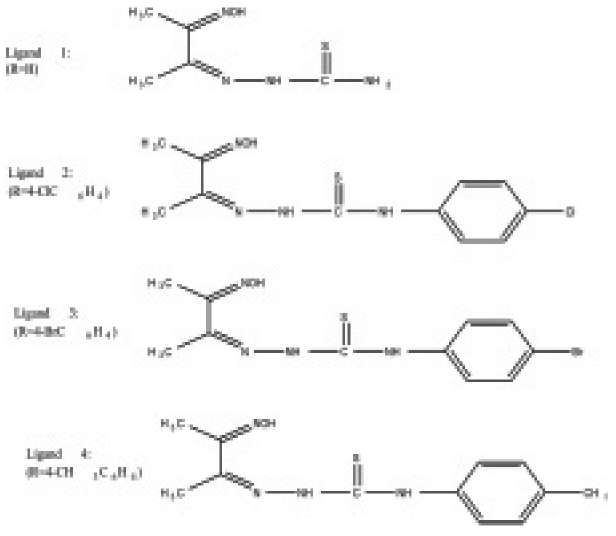

Fig.2. Structure of ligands

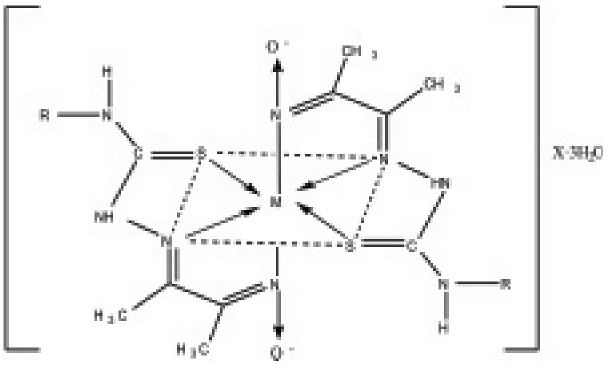

Fig. 3: Structure of octahedral metal complexes,X=Cl and R= H(AMTH$_2$); 4-ClC$_6$H$_4$(AMCPTH$_2$); 4-BrC$_6$H$_4$(AMBPTH$_2$); 4-CH$_3$C$_6$H$_4$(AMMPTH$_2$)

Table 2: Infrared spectral data (cm^{-1}) of ligands and its complexes

Compounds	ν(O-H) oxime	ν(N-H)	ν(C=N) imine	ν(C=N) oxime	ν(C=S)	ν(N-O)	ν(M-S)	ν(M-N)
AMTH$_2$	3410	3295, 3140	1595	1596	1016	937	-	-
AMCPTH$_2$	3298	3231, 3100	1526	1590	1015	940	-	-
AMBPTH$_2$	3345	3250, 3155	1575	1580	1020	950	-	-
AMMPTH$_2$	3365	3240, 3160	1525	1585	1022	960	-	-
$[Cr(AMTH)_2]Cl\cdot 3H_2O$	-	3295, 3155	1575	1585	986	912	370	490
$[Cr(AMCPTH)_2]Cl\cdot 3H_2O$	-	3250, 3115	1501	1574	985	920	345	498
$[Cr(AMBPTH)_2]Cl\cdot 3H_2O$	-	3265, 3180	1540	1565	992	928	360	492
$[Cr(AMMPTH)_2]Cl\cdot 3H_2O$	-	3245, 3165	1505	1560	996	940	365	501
$[Co(AMTH)_2]Cl\cdot 3H_2O$	-	3255, 3145	1565	1566	990	915	330	510
$[Co(AMCPTH)_2]Cl\cdot 3H_2O$	-	3250, 3170	1506	1580	987	910	350	505
$[Co(AMBPTH)_2]Cl\cdot 3H_2O$	-	3260, 3120	1550	1562	995	925	355	510
$[Co(AMMPTH)_2]Cl\cdot 3H_2O$	-	3245, 3160	1500	1565	993	930	370	495
$[Fe(AMTH)_2]Cl\cdot 3H_2O$	-	3265, 3130	1570	1581	990	917	363	500
$[Fe(AMCPTH)_2]Cl\cdot 3H_2O$	-	3270, 3150	1515	1570	992	919	335	490
$[Fe(AMBPTH)_2]Cl\cdot 3H_2O$	-	3290, 3180	1560	1566	990	930	340	495
$[Fe(AMMPTH)_2]Cl\cdot 3H_2O$	-	3260, 3140	1507	1575	995	933	360	505

of the ligands and complexes was carried out using Carlo Erba 1108 elemental analyzer at SAIF, CDRI, Lucknow. Fe and Cr were approximated gravimetrically by precipitating them. Sulphur was assessed gravimetrically in form of $BaSO_4$. The IR spectra of ligands along with complexes were set down using KBr pellets on Shimadzu 8201 PC spectrophotometer inside limit of 4000-200 cm^{-1}. Perkin Elmer Lambda 15 UV/VIS spectrophotometer was used to note down electronic spectra in solvent DMF or DMSO. ^{1}H NMR spectra of prepared ligands were recorded in DMSO-d$_6$ at 90 MHz. Beckman conductivity bridge model RC-18A was used to take electrical conductance measurements in DMF or nitrobenzene at room temperature. Gouy's method was employed to obtain magnetic measurements using $Hg[Co(NCS)_4]$ as calibrant at room temperature . Ambassador melting point apparatus was used to record melting point utilizing capillaries.

Synthesis of ligands

The ligands were synthesized in two steps. First step includes preparation of 4-substituted thiosemicarbazide according to the literature. In second step, thiosemicarbazone ligands were synthesized by mixing equal molar proportions of diacetyl-α-monoxime and the preferred thiosemicarbazide in EtOH, adding up 1% HCl-EtOH (50 ml), followed by refluxing for 20 hours. The obtained solution was kept overnight and separated by filtration, washed a number of times with hot water and small quantity of methanol followed by hexane and desiccated *in vacuo* over calcium chloride. The synthetic route and structure of ligands are given in Fig.1 and Fig.2, respectively.

Preparation of Cr(III), Co(III) and Fe(III) complexes with ligands AMTH$_2$/ AMCPTH$_2$/ AMBPTH$_2$/ AMMPTH$_2$

The synthesis of metal complexes was done by allowing metal salt to react with ligand in 1:2 molar ratio. The freshly prepared, magnetically stirred methanolic solution (0.005 mol, 30 cm^3) each of $CrCl_3\cdot 6H_2O$ (1.33 g)/ $CoCl_2\cdot 6H_2O$ (1.19 g) or $FeCl_3\cdot 6H_2O$ (1.35 g) was added drop by drop to solution of 0.01 mole each of AMTH$_2$ (1.74 g)/ AMCPTH$_2$ (2.85 g)/ AMBPTH$_2$ (3.29 g) or AMMPTH$_2$ (2.64 g) in 20 cm^3 of methanol over a spell of 20 min. The synthesis of Co(III) complexes includes addition of H_2O_2 (0.005 mol, 30%) after the addition of ligand to metal salt solution. The color of the solution modified and stirring was continued for 10 hours at 45^{0}C. The coloured precipitate was filtered first, then washed with ethanol (2 x 5 cm^3), cold water (2 x 5 cm^3) and ultimately with diethyl ether and desiccated in vacuo.

Purification of $[M(LH)_2]Cl{\cdot}3H_2O$ (M=Cr, Co or Fe)

The metal complexes were processed by placing them on a column in a minimum volume of methyl alcohol (1:2) (ca. 100 cm^3). Ethanol/water was used to pass through the chromatography column to wash out the product. Metal complexes were recovered conveniently by lowering volume under vacuo. The columns used for chromatography were having 2 cm of inner diameter loaded using alumina (Acros).

RESULTS AND DISCUSSION

In methanolic solution, ligands and metal solutions react to form desired metal complexes. The analytical data and spectroscopic studies hold up the proposed structure of ligands and metal chelates. Ligands are solvable in THF, DMSO and DMF while the metal complexes are easily soluble in DMSO and DMF. The precipitous complexes are coloured microcrystalline powder. Conductivity measurements in ethanol indicated the electrolytic (1:1) nature of complexes. The analytical and physical properties data of thiosemicarbazone ligands and complexes are listed in Table 1.

Magnetic moment and electronic spectra

Magnetic susceptibility studies were executed on powdered metal complexes at room temperature. Data of magnetic moment is summarized in Table 1. The effective magnetic moment (μ_{eff}) values (Lewis *et al.*, 1960) for Cr(III) complexes were found in the range 3.85-3.97 BM in good agreement with the theoretical spin only value (μ_{eff} =3.87 BM) for $Cr^{3+}(d^3)$ system which recommend an octahedron around transition metal ion. Magnetic moment values for Fe(III) complexes (5.23-5.38 BM) are lesser than expected values corresponding to high spin (5.9 BM). The Co(III) complexes are diamagnetic as predicted for a low spin d^6 system (S=0) corresponding to $t_{2g}{}^6$ configuration in octahedral environment (Sharma *et al.*, 2018).

The electronic spectra of Fe(III) metal complexes show intense absorbance at range of 26,080-25,170 cm^{-1}, consorted by an intensive Q band (Sharma *et al.,* 2008) and can be attributed to intraligand transitions. Due to greater oxidizing power of Fe(III), the d-d bands in region 25,000-18,160 cm^{-1} are not found. The colour of complexes is confirmed by appearance of short charge transfer absorption bands which are one or more in number. The electronic absorption spectra of Co(III) complexes show two spin allowed transitions which are at 17,220-18,130 and 24,290-24,500 cm^{-1}. These bands are formed due to $^1A_{1g}\rightarrow{}^1T_{1g}$ and $^1A_{1g}\rightarrow{}^1T_{2g}$ d-d transition (Jeremiæ *et al.*, 2019). The Cr(III) metal complexes reveal d-d transitions show spin allowed transitions $^4A_{2g}\rightarrow{}^4T_{1g}(P)$, $^4A_{2g}\rightarrow{}^4T_{1g}(F)$, $^4A_2\rightarrow{}^4T_{2g}(F)$ and in range of 25150-32550, 21000-24400 and 16200-18600 cm^{-1} respectively in order of their increasing energy.

Table 3: ^1H NMR spectral data(δ, ppm) of the ligands and their Co(III) complexes

Compounds	-NHR	N-H (imine)	O-H (oxime)
$AMTH_2$	4.95	9.62	10.07
$AMCPTH_2$	4.93	9.87	10.05
$AMBPTH_2$	5.11	9.71	10.12
$AMMPTH_2$	5.20	9.55	10.15
$[Co(AMTH)_2]Cl$	4.87	9.61	-
$[Co(AMCPTH)_2]Cl$	4.80	9.85	-
$[Co(AMBPTH)_2]Cl$	4.98	9.73	-
$[Co(AMMPTH)_2]Cl$	4.85	9.62	-

Table 4: Antibacterial activities of the ligands and its complexes

Compounds	Antibacterial activity Zone of inhibition (mm)		
	E.Coli	*S.aureus*	*P.aeruginosa*
Erythromycin	12.66	17.68	15.09
$AMTH_2$	18.12	21.97	17.38
$AMCPTH_2$	20.23	19.45	18.47
$AMBPTH_2$	19.36	18.98	21.65
$AMMPTH_2$	14.28	21.07	19.04
$[Cr(AMTH)_2]Cl{\cdot}3H_2O$	13.54	16.09	24.07
$[Cr(AMCPTH)_2]Cl{\cdot}3H_2O$	16.73	23.19	26.76
$[Cr(AMBPTH)_2]Cl{\cdot}3H_2O$	20.44	27.84	25.86
$[Cr(AMMPTH)_2]Cl{\cdot}3H_2O$	17.29	18.90	18.82
$[Co(AMTH)_2]Cl{\cdot}3H_2O$	18.28	16.73	26.45
$[Co(AMCPTH)_2]Cl{\cdot}3H_2O$	23.83	22.47	27.57
$[Co(AMBPTH)_2]Cl{\cdot}3H_2O$	17.19	19.76	15.29
$[Co(AMMPTH)_2]Cl{\cdot}3H_2O$	15.34	32.04	29.64
$[Fe(AMTH)_2]Cl{\cdot}3H_2O$	24.62	23.83	31.04
$[Fe(AMCPTH)_2]Cl{\cdot}3H_2O$	19.75	25.38	28.61
$[Fe(AMBPTH)_2]Cl{\cdot}3H_2O$	21.09	31.64	30.37
$[Fe(AMMPTH)_2]Cl{\cdot}3H_2O$	20.11	20.52	23.76

IR spectra

Different effective IR bands for establishing coordination of thiosemicarbazone ligands and metal complexes are arranged in Table 2. In spite of fact that thiosemicarbazones can demonstrate thiol-thione tautomerism because of existence of -NH-C=S (thioamide) group, the non-appearance of the ν(S-H) frequency band near 2560 cm^{-1} specifies its presence in solid state as thione form (Casas *et al.,* 1993). The presence of band at 3298-3410 cm^{-1} is allotted to ν(O-H) stretching frequency. A wide band in region 3100-3295 cm^{-1} emerging from overlapping of stretching vibrations of molecules of lattice water with ν(N-H) of ligands are remarked generally in metal complexes. A prominent band of nitrogen of imine group ν(C=N) in the ligand near about at 1525-1595 cm^{-1} is transferred upon binding with metal to lower frequencies by 20-35 cm^{-1}. In these metal complexes, involvement of ν(C=N) of oxime part is confirmed by shift of 10-30 cm^{-1} of thiosemicarbazone band around 1590 cm^{-1}. A prominent band near at 1020 cm^{-1} in spectra of ligands is ascertained to ν(C=S) which again shifts by 30 cm^{-1} in spectra of metal complexes indicating coordination through sulfur. A band near to 960 cm^{-1} caused by ν(N-O) in all free standing oxime ligands shifts to lesser frequency by 20-25 cm^{-1} in the spectra of metal complexes. The other bands at low frequency, assigned to ν(M-N) and ν(M-S) are obtained at 490-510 cm^{-1} and 330-370 cm^{-1} range respectively. In this way, IR spectral study affirms that thiosemicarbazones are neutral tridentate ligands, coordinating with metal ion through S of thioketo group and N,N of two azomethine entities.

^{1}H NMR spectra

The ^{1}H NMR spectra of thiosemicarbazone ligands and their Co(III) complexes have been recorded in DMSO-d_6 and are consolidated in Table 3. The following conclusions can be drawn on comparing the spectra of ligands and their complexes:

a) The signals at δ 9.55-9.81 ppm in the spectral data of thione form of ligands are assignable to the N-H proton. The downfield shift for all Co(III) metal complexes indicates coordination via amide form of the ligands.

b) O-H proton of oxime moiety provides signal at δ 10.05-10.15 ppm in spectra of ligands which vanishes in spectra of the corresponding complexes suggesting removal of proton.

c) Strong signals of NHR at δ 4.80-5.20 and CH at δ 6.25-6.50 can be obtained at the same place in ligands along with their complexes.

Biological Screening

The data of results of antibacterial activity of TSCs and their metal complexes have been compared with standard drug Erythromycin and compiled in Table 4. The synthesized ligands and metal complexes show inhibitory activity against tested bacteria. The antibacterial activities were carried out against *E. coli*, *S. aureus* and *P. aeruginosa*. The cultures were prepared at optimum temperature and in growth medium free from other pathogens using vital nutrients.

It is evident that the activity changes after complexation and it can be concluded that some complexes are more potent than the corresponding ligands. Therefore, based on elemental analysis, molar conductance results and spectral data, the following structure of metal complex can be proposed (Fig.3).

CONCLUSION

Tridentate NNS donor thiosemicarbazone ligands coordinate to Chromium(III), Cobalt(III) and Iron(III) to form metal chelates of type$[M(LH)_2]Cl\cdot3H_2O$. The compounds have been segregated and designated by various physiochemical data. The structure of metal complexes disclosed that NNS donor sets of ligand fragments form a distorted configuration at metal ions.

Biological screening reveals that all the ligands show greater antibacterial activity than the reference compounds and except $[CrAMTH_2]Cl\cdot3H_2O$, all the complexes are also having high potency toward the tested bacteria than the used standard Erythromycin.

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