

Synthesis, Spectral Characterization and Microbial Studies On Metal (II) Complexes with Methoxy Benzofuran Methoxy phenylthiosemicarbazide Derivative

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Abstract:

The complexes of the type $MLCl_2$, where $M = Co(II), Cu(II), Ni(II), Zn(II), Cd(II), Mn(II), Fe(III)$ and $Hg(II)$ and L is the methoxythiosemicarbazide ligand derived from reaction between 3-methoxybenzofuran-2-carboxyhydrazide and methoxyphenylisothiocyanate (MeOBMeOSCH). All the complexes were characterized on the bases of elemental analysis, conductance, magnetic susceptibility measurements, UV-Vis, IR, ^1H NMR, ESR spectra studies and X-ray data studies. Thiosemicarbazide ligand behaves as bidentate by coordinating through the oxygen of the carbonyl group and the nitrogen of the hydrazide residue. Based on the results, we have proposed the probable structures for all the metal complexes. Both the ligands and their complexes have been screened for their fungicidal and bactericidal activities

Keywords: methoxybenzofuran methoxythiosemicarbazides, metal complexes, spectral studies and microbial activities.

1. Introduction

Thiosemicarbazides and thiosemicarbazones have gained special attention due to their activity against protozoa¹, influenza², small-pox³, malaria, cancer⁴ and tuberculosis. As a ligand they provide three potential donor sites viz, O, N and S and form complexes with various metal ions. Owing to the wide range of microbial properties^{5,6} of their thiosemicarbazides and thiosemicarbazones and their ability to form chelates with metal ions, in the present study, we report the synthesis and characterization of $Cu(II), Co(II), Ni(II), Zn(II), Cd(II), Hg(II), Mn(II)$ and $Fe(III)$ metal complexes with the thiosemicarbazide ligands derived from reaction between 3-methoxybenzofuran-2-carboxyhydrazide and methoxyphenylisothiocyanate. All the complexes have been characterized by Elemental analysis, Conductance, Magnetic Susceptibility measurements, UV-Vis, IR, ^1H NMR, ESR spectral studies and X-ray data studies.

Experimental

All the chemicals used were of Analytical Grade. The compound methoxybenzophthofuran-2-carboxyhydrazide was prepared by the literature method⁷. The metal and chloride contents are determined as per Vogel's procedure⁸. The nitrogen content was estimated micro-analytically.

Preparation of 3-methoxybenzophthofuran-2-carboxy-[phenyl] methoxythiosemicarbazide [MeOBMeOSCH]

The methoxyphenylisothiocyanate (0.5 mole) in alcohol (10 cm³) was added to an ethanolic (20 cm³) solution of 3-methoxybenzofuran-2-carboxyhydrazide (1.7 g, 0.5 mole). The reaction mixture was boiled under reflux water bath for about 3-4 hours. The solid thiosemicarbazide ligand starts separating out after few minutes. The reaction mixture was cooled room temperature; product was filtered out and washed successively with alcohol. The compound was recrystallized from alcohol and dried in vacuum over fused CaCl₂.

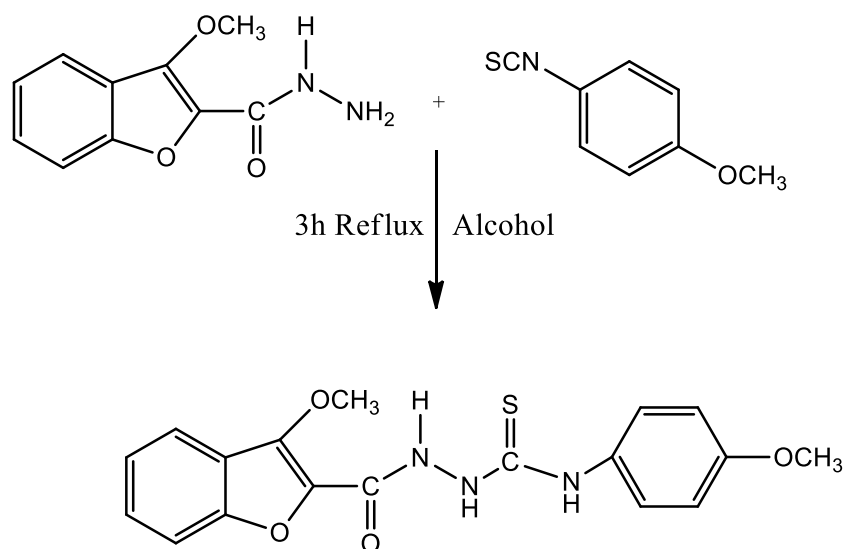
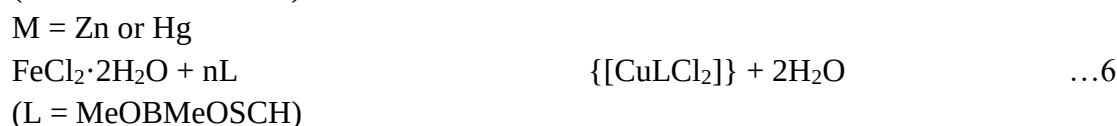
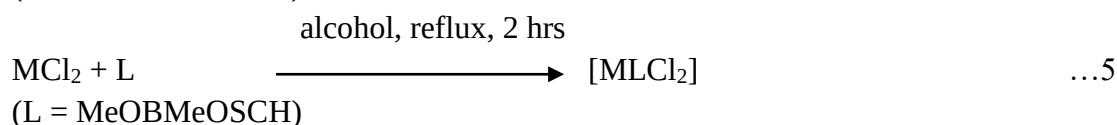
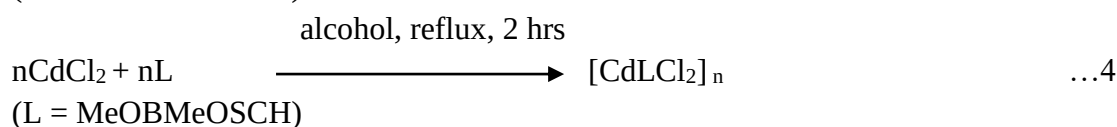
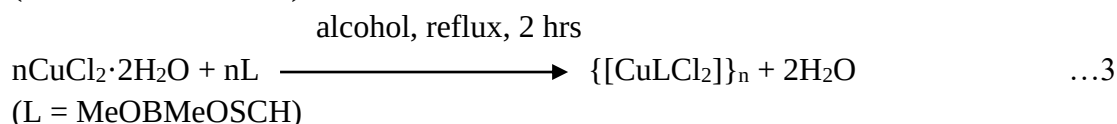
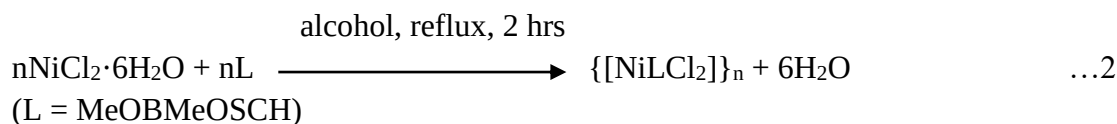
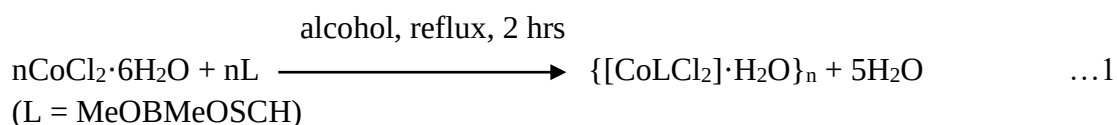


Figure-I

[Mol. formula – C₁₈H₁₇O₄N₃S, M.P. = 185⁰C, yield 85% and Mol. Wt. 371]

Preparation of Complexes

Metal complexes were prepared by adding the aqueous solution of metal(II) chlorides(0.1mole, 20 cm³) to thiosemicarbazide ligand (1.55 g MeOBCPT, 0.1mole) in alcohol(50 cm³) with vigorous stirring. The complexes were not separated immediately, the reaction mixture was boiled under reflux on a water bath for about 2 hours, during which complexes started separating out. The reaction solution was concentrated and cooled to room temperature. The crystalline light colored complexes were filtered, washed with water and alcohol to remove the un-reacted salts and ligands. All the complexes were dried in open air and kept in vacuum desiccator. The formation of the complexes may be represented by the following equations



Physical measurements

All the complexes were analyzed for their metal content, following the standard procedures⁸. Sulphur and chloride contents were determined as BaSO₄ and AgCl₂, respectively. The magnetic susceptibility measurements were made at room temperature on a Gouy balance using Hg[Co(NCS)₄] as the calibrate. Electronic spectra of the Cu(II), Co(II) and Ni(II) complexes in DMF (10⁻³ M) solution were recorded using a Hitachi 150-20 model spectrophotometer in the range of 200-1100 nm. IR spectra of the ligands and their complexes were recorded in KBr pallets on Perkin Elmer-783 model IR spectrometer in the range of 4000-350 cm⁻¹ and Impact 410 Nicolet FT-IR spectrometer in the range of 4000-250 cm⁻¹. The proton magnetic resonance spectra of ligands and few complexes were recorded on a Brucker 300 MHz at IISc Bangalore and Bracker A.C. 300 F at USA, NMR spectrometer using TMS as an internal standard and DMSO-d₆ were used as solvents. The electron spin resonance spectra of Cu(II) complexes in polycrystalline state (powder spectra) were recorded on Varian E-4X-band ESR spectrometer using tetracyanoethylene (TCNE) free radical as 'g' marker (g=2.0036) at room temperature. The X-ray spectra were recorded on Phillips PW 3710 diffractometer attached to a digitized computer along with graphical assembly using CuK α radiation source. The X-ray tube was operated at 25KV/20mA. The sample was scanned in the 2 θ range from 0-80°C at a scanning speed of 2 θ /min.

The antimicrobial activities of the compounds synthesized in the present investigation were screened for their antibacterial and antifungal activities by agar cup plate technique⁹. These bacterial species namely Escherichia coli, Pseudomonas and Bacillus and three fungal species Aspergillus Niger, Aspergillus fumigatus and Aspergillus flavons procured from the Department of Microbiology, Gulbarga University, Gulbarga were used in the present study. DMF was used as the solvent and it has

been well established as an inert solvent with negligible antimicrobial activity. The experiments were conducted in triplicate and the average activity is reported

2. Results and Discussions

Analytical data for the complexes indicate 1:1 stoichiometry for all the complexes (**Table-I**). All the complexes possess high melting points and are stable towards air and are partially or insoluble in common organic solvents and soluble in DMF, DMSO and Pyridine. The molar conductance of the complexes fall in the range of 11.193-19.109 $\Omega^{-1} \text{ cm}^2 \text{ mole}^{-1}$ in DMF (10^{-3}M) solution. The values are too low to account for any electrolytic behaviors of the complexes¹⁰.

The observed magnetic moment values for Co[MeOBMeOSCH] complexes are 4.68 B. M., have been used as a criterion to determine the type of geometry around the metal ions, these values suggests an octahedral geometry for Co(II) complexes¹¹. The magnetic moment values for Ni(II) complexes 3.34 B.M., for MeOBMeOSCH ligand, suggests the hexa-coordinated Ni(II) ions¹². The effective magnetic value for Cu [MeOBMeOSCH] complexes are 1.97 B.M., suggests, the distorted octahedral geometry.

Electronic Spectra

The electronic spectra of Co(II) complexes show two bands at 13250 cm^{-1} , 19240 cm^{-1} for [MeOBMeOSCH], these bands are assigned to $^4\text{T}_{1g}(\text{F}) \rightarrow ^3\text{A}_{2g}(\text{F})(\nu_2)$ and $^4\text{T}_{1g}(\text{F}) \rightarrow ^4\text{T}_{2g}(\text{F})(\nu_3)$ transitions, respectively, in an octahedral environment^{13,14}. The band ν_1 could not be observed due to the limited range of the instrument; however, ν_1 8025 cm^{-1} would be calculated using band-fitting procedures¹⁵. The octahedral geometry¹⁶ is further supported by the values of ligand field parameters like, Dq, B', β , $\beta\%$ and LFSE. All these values are given in the Table-II. The reduction in Racah parameter value from the free ion value (971) suggests measure of covalent character of M-L bond.

The hexa-coordinated light green colored Ni[MeOBMeOSCH] complexes exhibit two bands at 16951 cm^{-1} and 26045 cm^{-1} respectively assignable to $^3\text{A}_{2g} \rightarrow ^3\text{T}_{1g}(\text{F})(\nu_2)$ and $^3\text{A}_{2g} \rightarrow ^3\text{T}_{1g}(\text{P})(\nu_3)$ transitions, respectively, in view of their octahedral geometry (13). This is further supported by ligand field parameters like Dq, B', β , $\beta\%$, ratio $(\nu_2) / (\nu_1)$ and LFSE values shown in (**Table-II**).

The Cu(II) complexes shows broad asymmetric band in the region 16896-12410 cm^{-1} . The broadness of the band may be due to dynamic Jahn-Teller distortion¹⁷. These observations suggest that complexes have distorted octahedral structures.

¹H NMR spectra

The ¹H NMR spectrum of MeOBMeOSCH ligand and their Cd(II) and Hg(II) complexes in DMSO-d₆ solvents were recorded. The three signals at, $\delta(10.14, 10.21)$, $\delta(9.82, 9.93)$ and $\delta(9.76, 9.83)$ ppm, due to ¹NH, ²NH and ⁴NH protons of amide, hydrazine and thioamide functions respectively. The signal appeared at $\delta(3.41)$ and $\delta(3.49)$ due to the two methoxy proton present. Nine aromatic proton

have resonated in the region $\delta(7.02-7.98)$ (m, 9H) and Eight aromatic proton present in the region $\delta(7.14-7.87)$ (m, 8H) as a multiplet respectively.

The signals due to ^2NH proton are shifted down field in the spectra of Cd(II) and Hg(II) complexes and the signals due to ^1NH proton shows a small down field shift thereby indicating the coordination of ligands through the oxygen of CONH and nitrogen of ^2NH groups to the metal ions. The methoxy proton and aromatic region are disturbing its ligands signals it indicates the coordination of ligands takes place in the metals.

Infrared spectra

The thiosemicarbazide ligand [MeOBMeOSCH] exhibits the three bands at 3348, 3281 and 3076 cm^{-1} assigned to $\nu(^4\text{NH})$; $\nu(^2\text{NH})$ and $\nu(^1\text{NH})$ respectively, in view of the earlier reports^{18,19}. In the spectra of the complexes the bands due to $\nu(^4\text{NH})$ shifts to higher wave number side by about 10-25 cm^{-1} or it remains unaltered indicating non-involvement of nitrogen of (^4NH) group in coordination with metal ions. The band due to $\nu(^2\text{NH})$ shifts to lower wave number side by about 20-35 cm^{-1} in all the complexes and becomes weak in the complexes suggesting the coordination of the nitrogen of (^2NH) group.

The weak bands observed in the regions 2775-2840 cm^{-1} are assigned to stretching vibrations of intra-molecular hydrogen bonding between -CO and ^2NH group²⁰. The absence of any band above 3500 cm^{-1} due to $\nu(\text{OH})$ stretch and 2650-2450 cm^{-1} due to $\nu(\text{SH})$ stretch suggests that ligand exists in thioketo form.

The strong band observed²¹ at 1649 cm^{-1} in free ligand are assigned to $\nu(\text{CO})$ stretching vibrations. This band shifts to lower wave number side by about 30-52 cm^{-1} in all the metal complexes. This suggests the coordination of oxygen with metal ions. The positive shift of $\nu(\text{N-N})$ stretch observed at 974 cm^{-1} in free ligand by 10-25 cm^{-1} in the complexes, thereby, showing the coordination of the one of the nitrogen atom of the hydrazinic moiety in bonding²².

The thioketo $\nu(\text{C=S})$ band observed at 745, cm^{-1} shows no shift in the metal complexes compared with the free ligands, this shows sulphur atom of (C=S) group has not been taken part in the coordination. The thio-amide²³ bands observed at 1532 ; 1351; 1084, and 752, cm^{-1} due to amide I, II, III and IV respectively, remain unaltered or do not show considerable change in the complexes suggesting the non-involvement of (C=S) group in bonding with metal ions.

In the far infrared spectra of the complexes the bands observed in the region 544-511, cm^{-1} can be assigned to $\nu(\text{M-O})$ stretching vibrations and bands in the region 488-422, 447-496 cm^{-1} to $\nu(\text{M-N})$ stretching vibrations in all the complexes²⁴.

In the case of polymeric complexes $\nu(\text{M-Cl})$ stretch terminal and $\nu(\text{M-Cl})$ stretch bridging are assigned in the region 416-343, cm^{-1} and 362-287, 364-226 cm^{-1} respectively, in view of previous reports²⁵, in Co(II), Cu(II), Ni(II) and Cd(II) complexes. In Hg(II) and Zn(II) complexes $\nu(\text{M-Cl})$ stretch is assigned in the region 362-324, 364-326 cm^{-1} in view of their monomeric /diameric structures. All assignments in (Table- III)

ESR spectra

The ESR spectrum of Cu(II) complex of ligands [MeOBMeOSCH] in solid polycrystalline state have been scanned at room temperature. These Cu(II) complexes showed medium broad signals with of $g_{\parallel} = 2.2675$ and $g_{\perp} = 2.1272$ respectively. The g_{av} values of the complexes have been calculated and shown in **(Table-IV)**. The obtained g_{av} values for the Cu(II) complexes are 2.1748 for MeOBMeOSCH ligand respectively. The 'g' values indicate that the free electron is predominantly in $d_{x^2-y^2}$ orbital of Cu(II). The 'G' values are less than 4 and it indicates anti ferromagnetic coupling interaction between the metal ions.

The sample Cu[MeOBMeOSCH] show the spectra having asymmetric bands with two 'g' values, $g_{\parallel} > g_{\perp}$. The trend $g_{\parallel} > g_{\perp} > g_e$ (2.0036) observed for these complexes indicating that, the unpaired electron lies predominantly in the $d_{x^2-y^2}$ orbital with the possibility of some mixing of d_{z^2} , because of low symmetry²⁶.

The bonding coefficients parameter K, $K_{\parallel}$, $K_{\perp}$, α^2 , β^2 and degree of covalency K_o^2 have been calculated which is the residential time of an unpaired electron on a Cu(II) ion, and the value of $g_{\parallel}$ (<2.3) confirm the covalent nature of the complexes^{27,28}.

X-ray Diffraction Studies of Co[MeOBMeOSCH] complex

The powder X-ray diffraction pattern for the Co[MeOBMeOSCH] complex were shows eleven reflections in the range of $5-80^\circ$ (2θ) arising from the diffraction of X-rays by planes of complex. The inter planar spacing (d) values have been calculated from the position of intense peaks by using Bragg's relation. The calculated spacing together with relative intensities with respect to most intense peaks has been recorded in **Table-V**. The 2θ values with maximum intensity of the peak for the cobalt complex were found to be 5.784° (2θ) which corresponds to $d=15.437 \text{ \AA}$. The 2θ values for the prominent peaks and the experimental values of $\sin^2\theta$ / common factor are recorded for each peak. From the table, experimental d-spacing values are in good agreement with the calculated values. The unit cell calculations have been done for cubic symmetry of the compound. The set of $(h^2+k^2+l^2)$ values of the complex were found to be 1, 2, 5, 7, 10, 11, 14, 18, 22, 25 and 26 which corresponds to the planes and the absence of forbidden numbers confirms the cubic symmetry. From the above results the unit cell constants for cubic system were found to be $a = b = c = 15.540 \text{ \AA}$ for the Co(II) complex.

Biological activity

The microbial activity results show that the compounds exhibit antimicrobial properties and it is important to note that the metal complexes exhibit more inhibitory effects than the parent ligands, the values are given in **(Table-VI)**. The increase in the antibacterial and antifungal activity of the metal complexes is due to the presence of metal ions in the compounds. The increased activity of the metal chelates can be explained on the bases of chelation theory²⁹. It is known that chelation tends to make the ligand act as more powerful and potent bactericidal agents, thus killing more of the bacteria than the ligand. It is observed that, in a complex, the positive charge of the metal is partially shared with donor atoms present in the ligand and there may be π -electron delocalization over the whole chelating³⁰. The

complexes exhibited enhanced activities, which is due to the synergistic effect that increases the lipophilicity of the complexes. Chelation decreases the polarity of the metal ion which further leads to the enhancement of lipophilicity of the complex. Since the microorganism cell is surrounded by lipid membrane which favors the passage of lipid soluble materials, increased lipophilicities allows the penetration of the complex into, and through sites of the microorganisms. There are other factors which also increase the activity, which are solubility, conductivity and bond length between the metal and ligand.

Antibacterial and antifungal screening data clearly to the following conclusion

1. The metal complexes are slightly more toxic than their parent ligand against tested microorganisms under identical experimental conditions.
2. The Microbial activity results indicate that the activity of Cu(II), Fe(III) and Zn(II) complexes show better activity than that of Co(II), Ni(II), Mn(II), and Cd(II) complexes.
3. The Microbial activity results clearly show that the inhibition of fungal growth increases with increasing the concentration of the complexes.

3. Conclusion

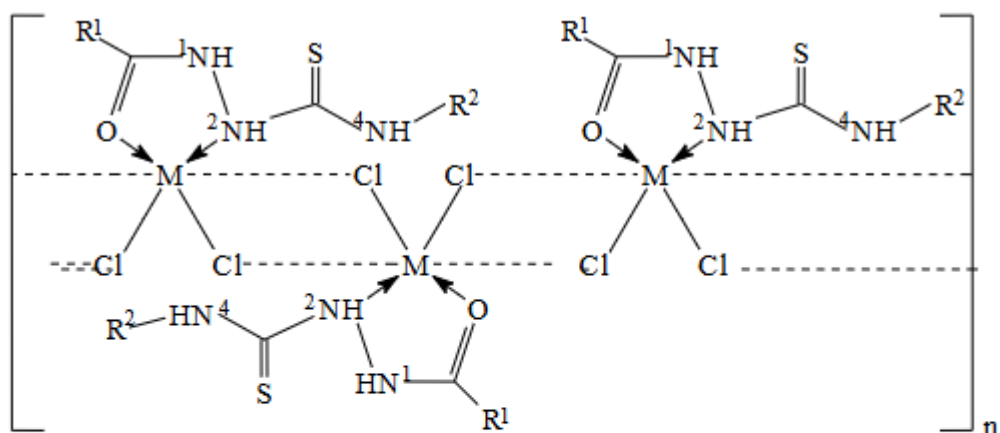
The ligand [MeOBMeOSCH] acts as a neutral bidentate, coordinating through the amide-O and ²NH nitrogen of the thiosemicarbazide function. All the complexes are isolated in solid state, possess 1:1 (M: L) stoichiometry.

On the basis elemental analysis, electronic spectra, magnetic susceptibility, IR, NMR and ESR spectral data, we suggest the following probable geometries to all the complexes.

1. For Cu(II), Co(II), Ni(II) and Cd(II) chloride bridged polymeric octahedral structure.
2. For Zn(II) and Hg(II) complexes monomeric/dimeric tetrahedral structures.

4. Acknowledgement

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M = Cu(II), Co(II), Ni(II) or Cd(II)

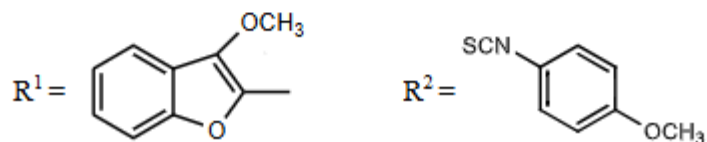
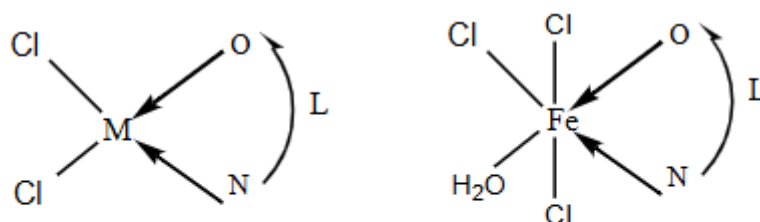


FIGURE-II Suggested structures of the complexes



M = Cd(II), Zn(II) or Hg(II)

FIGURE-III Suggested structures of the complexes

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Table-I
Physical, Analytical data, Magnetic Susceptibility and Molar Conductance data of
MeOBMeOSCH ligand and its complexes

Compound	Molecular Formula	Mol. Wt.	MP °C	Yield %	Elemental analysis (%)					μ_{eff} B.M.	Molar conductance Λ ohm ⁻¹ cm ² mole ⁻¹
					Found / (Calculated)						
					M	C	H	N	Cl		
[MeOBMeOSCH] [C ₁₁ H ₁₇ O ₄ N ₃ S] [371]	[Co(C ₁₁ H ₁₇ N ₃ O ₄ S ₁)Cl ₂]	500.24	>300	85	11.860 (11.789)	43.300 (43.220)	3.300 (3.223)	8.450 (8.400)	14.208 (14.170)	4.68	16.674
	[Ni(C ₁₁ H ₁₇ N ₃ O ₄ S ₁)Cl ₂]	500.00	298	84	11.833 (11.740)	43.366 (43.243)	3.289 (3.230)	8.566 (8.400)	14.210 (14.180)	3.34	14.026
	[Cu(C ₁₁ H ₁₇ N ₃ O ₄ S ₁)Cl ₂]	504.0	>295	80	12.600 (12.590)	42.525 (42.820)	3.200 (3.190)	8.150 (8.320)	14.205 (14.040)	1.97	11.193
	[Zn(C ₁₁ H ₁₇ N ₃ O ₄ S ₁)Cl ₂]	509.69	286	79	13.254 (13.695)	42.605 (42.670)	3.256 (3.180)	8.306 (8.290)	13.980 (13.990)	--	17.254
	[Cd(C ₁₁ H ₁₇ N ₃ O ₄ S ₁)Cl ₂]	553.72	300	86	20.405 (20.300)	39.144 (39.044)	2.980 (2.910)	7.670 (7.590)	12.899 (12.810)	--	15.262
	[Hg(C ₁₁ H ₁₇ N ₃ O ₄ S ₁)Cl ₂]	641.90	>303	81	31.304 (31.250)	33.704 (33.680)	2.600 (2.510)	6.602 (6.550)	11.120 (11.055)	--	16.978
	[Mn(C ₁₁ H ₁₇ N ₃ O ₄ S ₁)Cl ₂]	496.25	298	75	11.120 (11.077)	43.660 (43.570)	3.340 (3.255)	8.503 (8.476)	14.340 (14.290)	5.63	13.787
	[Fe(C ₁₁ H ₁₇ N ₃ O ₄ S ₁)Cl ₂].H ₂ O	515.17	299	74	10.903 (10.845)	41.999 (41.970)	3.605 (3.520)	8.200 (8.168)	13.800 (13.760)	5.97	19.109

Table- II
Electronic Spectral data and Ligand field parameter of the Co(II), Ni(II),Cu(II) Fe(III) and
Mn(II) Complexes with Thiosemicarbazide in DMF (10⁻³M) solution.

Ligand	Complexes	Transition in cm ⁻¹				Dq cm ⁻¹	B ¹ cm ⁻¹	β	$\beta\%$	ν_2/ν_1	L.F.S.E kcal
		ν_1^*	ν_2	ν_3	ν_4						
[MeOBMeOSCH]	[Co(C ₁₁ H ₁₇ N ₃ O ₄ S ₁)Cl ₂]	8025	13250	19240	--	695	895	0.9225	07.722	1.454	11.81
	[Ni(C ₁₁ H ₁₇ N ₃ O ₄ S ₁)Cl ₂]	10815	16951	26045	--	1085	1083	0.6766	32.304	1.533	37.04
	[Cu(C ₁₁ H ₁₇ N ₃ O ₄ S ₁)Cl ₂]	12410 – 16896				1466	1468	--	--	--	25.06
	[Fe(C ₁₁ H ₁₇ N ₃ O ₄ S ₁)Cl ₂].H ₂ O	16335	20410	24880	--	--	--	--	--	--	--
	[Mn(C ₁₁ H ₁₇ N ₃ O ₄ S ₁)Cl ₂]	17238	23698	27779	33128	--	--	--	--	--	--

* Calculated values

Table- III
Infrared Spectra of the Thiosemicarbazide base of ligand [MeOBMeOSCH] and its Complexes

Ligand/ Complexes	ν^4_{NH} sym stretch	ν^2_{NH} sym stretch	ν^1_{NH} sym stretch	ν_{N-N}	$\nu_{C=O}$	ν_{M-O}	$\nu_{(M-N)}$	$\nu_{(M-Cl)_t}$	$\nu_{(M-Cl)_b}$	$\nu_{(M-Cl)}$
[MeOBMeOSC]	3348	3281	3076	974	1649	--	--	--	--	--
Cu	3354	3255	3078	1021	1613	511	463	416	362	--
Co	3356	3253	3082	1015	1607	515	447	362	296	--
Ni	3363	3257	3079	998	1596	531	468	383	296	--
Zn	3368	3245	3084	1034	1618	544	422	--	--	337
Cd	3364	3259	3079	1035	1616	532	433	--	--	326
Hg	3374	3256	3074	1023	1605	534	428	--	--	353
Mn	3361	3259	3079	1009	1606	543	422	343	287	364
Fe	3370	3255	3074	1034	1612	547	488	--	--	--

Table-IV
ESR spectral data of Cu(II) complexes.

Complex	$g_{ }$	$g_{\perp}$	g_{av}	$A_{ } \times 10^{-4} (cm^{-1})$	$g_{ } / A_{ }$	α^2	G
[Cu(C ₁₅ H ₁₆ N ₃ O ₄ S ₁)Cl ₂]	2.2675	2.1272	2.1748	190.585	117	0.8504	2.108

Bonding Coefficient Parameter for the Cu(II), Complexes with Thiosemicarbazide.

Complexes	$A_{iso} 1 \times 10^{-4} cm^{-1}$	$K_{ }$	$K_{\perp}$	K	β^2	α	K_o^2
[Cu(C ₁₅ H ₁₆ N ₃ O ₄ S ₁)Cl ₂]	127.142	0.6538	0.5901	0.4202	1.8450	0.2310	0.4215

Table-V
Powder X-ray diffraction data of Co(II) complex of the Ligand [MeOBMeOSCH]

Peak No.	2 θ	θ	Sin θ	Sin θ^2	$h^2+k^2+l^2$	h k l	$\frac{d}{\text{Calc. Obs.}}$		Intensity	a in Å
1	5.69531	2.84766	0.04968	0.00247	1	1 0 0	15.50508	15.50508	19.49	16.63
2	7.78845	3.89423	0.06791	0.00461	2	1 1 0	11.34216	11.34216	54.81	16.63
3	11.40289	5.70144	0.09934	0.00987	5	2 1 0	7.7538	7.7538	49.29	16.63
4	14.43785	7.21892	0.12566	0.01579	7	---	6.12999	6.12999	30.82	16.63
5	17.05353	8.52676	0.14827	0.02198	10	3 1 0	5.1952	5.1952	22.48	16.63
6	18.0304	9.0152	0.1567	0.02455	11	3 1 1	4.91587	4.91587	61.15	16.63
7	19.76616	9.88308	0.17164	0.02946	14	3 2 1	4.48793	4.48793	15.93	16.63
8	22.77078	11.38539	0.19741	0.03897	18	4 1 1	3.90208	3.90208	39.18	16.63
9	25.26503	12.63252	0.2187	0.04783	22	3 3 2	3.52222	3.52222	100.00	16.63
10	26.87552	13.43776	0.23239	0.054	25	5 0 0	3.3147	3.3147	70.12	16.63
11	27.13857	13.56929	0.23462	0.05505	26	5 1 0	3.28317	3.28317	96.38	16.63

Table -VI
Antibacterial and antifungal activity results of ligands and their metal complexes

Complexes/Compounds	Zone of inhibition (mm)					
	Bacteria			Fungi		
	<i>E. coli</i>	<i>S. aureus</i>	<i>Bacillus subtilis</i>	<i>A. flavus</i>	<i>A. niger</i>	<i>A. fumigatus</i>
MeOBMeOSCH	14	14	14	15	14	14
Cu(MeOBMeOSCH)	15	14	15	13	13	15
Co(MeOBMeOSCH)	14	13	14	11	13	14
Ni(MeOBMeOSCH)	15	12	12	13	15	14
Zn(MeOBMeOSCH)	12	14	14	16	13	14
Cd(MeOBMeOSCH)	12	13	16	16	13	15
Mn(MeOBMeOSCH)	12	16	17	15	12	17
Fe(MeOBMeOSCH)	18	15	16	14	16	18
Streptomycin	22	20	--	--	22	20
Nystatine	--	--	21	20	--	--
Control (DMF)	08	08	04	04	08	08