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Synthesis and Characterization of Co(II), Cu(II), Ni(II), Mn(II) and Pb(II) Complexes with 1,3-*bis*[(4-amino-5-mercapto)-1,2,4-triazol-3-yl]benzene

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A series of complexes of Co(II), Cu(II), Ni(II), Mn(II) and Pb(II) with a polydentate ligand,1,3-*bis*[(4-amino-5-mercapto)-1,2,4-triazol-3-yl] benzene, [H_2-(BAMTB)] were synthesized and characterized on the basis of elemental analysis, molar conductance, diffused reflectance, magnetic susceptibility, spectral, thermal and X-ray studies. The antimicrobial and antifungal activity have also been checked. All the complexes are of 1:1 (M:L) stoichiometry. The IR spectra show that the tetradentate ligand coordinating through the SN-NS donor system. Various ESR parameters for the copper complex have been calculated. The complexes are monomeric in nature and non electrolytic in nature. Magnetic moment value indicates diamagnetic nature of Pb(II) complex and paramagnetic nature of Co(II), Cu(II), Ni(II) and Mn(II) complexes. The reflectance spectral data suggest a tetrahedral geometry for Pb(II) complex, an octahedral geometry for Co(II), Ni(II) and Mn(II) complex and a pseudo-tetrahedral geometry for Cu(II) complex. The complexes show high antimicrobial activities as compared with corresponding ligand but complexes do not show any antifungal activity. Diffractogram of present complexes do not show sharp refluxes indicate that they are amorphous in nature.

Key Words: Monomeric, Triazole, Macrocyclic, Isopthalic acid.

INTRODUCTION

According to the chemistry of macrocyclic compounds and their uses, especially those incorporated with heterocyclic nuclei, the therapeutic importance of 4-N-alkyl/aryl/acyl-2*H*-1,2,4-triazoles is well documented[1] and therefore, we thought to use half crown systems as a polydentate ligands for the further studies.

In continuation of our work, it has been observed that the presence of side chains increases the comple xation capacity of the ligands. This will act as a cap, which will increase the effective inclusion of the metal ion in the coordination sphere. Thus, 1,2,4-triazoles are similar compounds with wide acceptance due to their varied uses in industries and medicine. The therapeutic importance of alkyl, aryl and acyl 1,2,4-triazoles is well documented.

Several S-substituted triazoles have shown biological activities against tuberculosis and anticococidal agents in chicken and in cephalosporins as antibacterial[2] agents. Some 1,2,4-triazoles are reported to have good fungicidal activity against *Aspergillus niger*. These compounds are also used in medicine and agriculture, fungicidals, pesticidals, insecticidals, bactericidals and antiinflammatory[3] agents. The presence of the electron pairs on the nitrogen atom makes them utilize as ligands for complexation as well as reagents for efficient metal extractions.

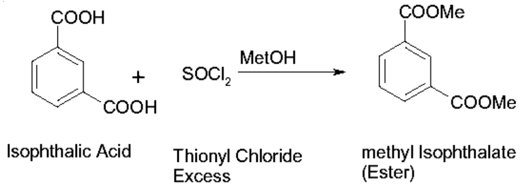
Keeping in view the versatility of these type of compounds, their electronic, spectral, pharmacological and physical and mechanical properties, excellent heat resistance[4] the interaction of 1,3-*bis*[(4-amino-5-mercapto)-1,2,4-triazol-3-yl] benzene with the transition metals such as Co(II), Cu(II), Ni(II), Mn(II) and a non-transition metal Pb(II)were studied. The ligand possess nitrogen and sulphur atoms, which are rich electron donors and hence are utilized to form complexes with these metals. Here, we report here the synthesis and characterization of polydentate ligand derived from fusion of isopthalic acid and hydrazine hydrate and their metal complexes.

EXPERIMENTAL

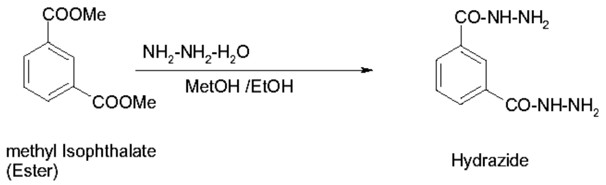
All the chemicals used were of AR grade. Various solvents used were of SD Fine Chemicals and of Merck made. The compounds were analyzed for C, H, N, S contents on Thermo Finnignan elemental analyzer, Model No. Flash EA 1112 Series at SAIF, Mumbai. The metal content in the complexes were determined by Inductively Coupled Plasma Analysis (ICPAES) technique as well as volumetrically by standard procedure[5] .The molar conductance values were measured in DMF (10^{-3}) on an digital conductivity meter. Room temperature magnetic susceptibilities were measured by a Gouy balance using $Hg[Co(SCN)_4]$ as a calibrant. The effective magnetic moments were calculated after diamagnetic correction for ligand components using Pascal's constants[6]. The infrared spectra were recorded on a model 160 Perkin Elmer FTIR spectrophotometer using KBr Pellets. Far IR spectra were recorded on Magna IR 550, make of Nicolet. Reflectance spectra of the solid complexes in the UV-visible spectral region were recorded against $BaSO_4$ as reference in the Jasco 560 solid state UV/Vis spectrophotometer. The ESR spectra of Cu(II) complexes were recorded on an E-112 Varian-E-LINE, electron spin resonance spectrometer at room temperature and low temperature for the samples using TCNE as marker. Thermogravimetric studies (TGA and DTA) of the complexes were made on Perkin-Elmer diamond TG-DTA instrument at SAIF, Mumbai, by recording the change in weight on increasing the temperature from room temperature to 900 ºC in the nitrogen atmosphere. X-Ray diffraction studies for the complexes have been done at SAIF, Mumbai.

The ligand, 1,3-*bis*[(4-amino-5-mercapto)-1,2,4-triazol-3-yl] benzene, abbreviated as H_2-(BAMTB) is prepared by the procedure reported below reaction steps:

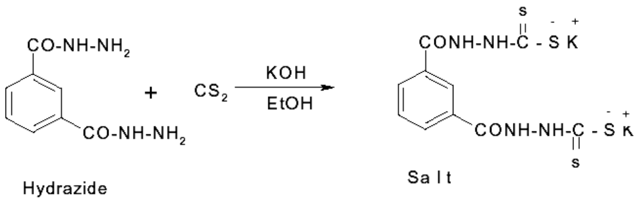
Step-I: Preparation of ester



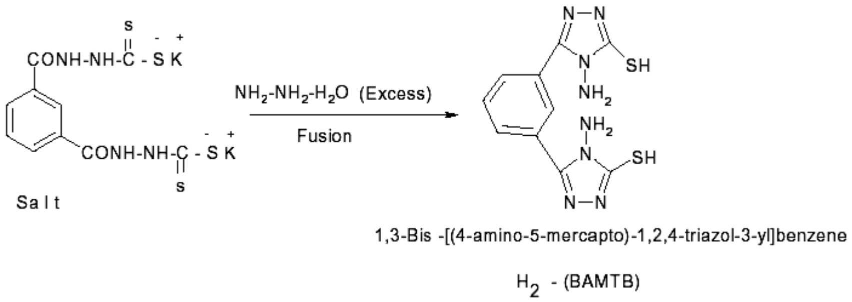
Step-II: Preparation of hydrazide



Step-III: Preparation of salt



Step-IV: Preparation of ligand



Melting point of the ligand = 240 ºC; % Yield of ligand = 84 %.

Preparation of complexes: The ligand (0.03 mol) was suspended in 20 mL DMF. The solution of metal acetate (0.03 mol) was dissolved in 20 mL distilled water which was added to the ligand solution drop wise under stirring. The solid product obtained was stirred for 0.5 h and filtered by suction, washed with distilled water, repeatedly and dried in vacuum.

Biological activities: The antibacterial and antifungal activities of the complexes were screened against some of the bacterial and fungal strains. The Pour plate method was used to assay antibacterial and antifungal activity against *E. coli, S. typhi , S. aureus* and *A. niger*. The solvent used was 0.1 N HCl and the sample concentration was 100-0.1 μg/mL.

Outlay of the Pour plate method: The analysis is carried out in 2 steps: (a) Qualitative analysis: To detect whether the samples are active against specific organisms at ambient conditions. (b) Quantitative analysis: To calculate the minimum inhibitory concentrations (MIC) of the active samples.

Procedure for determination of biological activities: The test compounds have been subjected to *in vitro* screening by pour plate technique against Gram +ve and Gram -ve bacteria *viz.*, *E. coli* ATCC 11108, *S. typhi* ATCC 786, *S. aureus* ATCC 29737 using Himedia Antibiotic No. 8 as the culture medium. This medium is boiled and filtered through an ordinary filter and then further through a Whatmann filter paper. To this filterate agar is added. The medium thus prepared is used for the growth of bacteria after sterilization in an autoclave at 15 lbs/121 ºC/15 min. After sterilization, the medium is mixed with respective cultures (diluted in 0.9 % saline) and poured in sterile petri-dishes. After setting, small bores are made on the plates. 0.1 mL of the sample dilutions are added in these bores and allowed to diffuse for 1 h at 10 ºC then incubated at 37 ºC for 24 h and then examined for the presence or absence of growth of the test organisms. The lowest concentration at which there was no visible growth was taken as an end point known as minimum inhibitory concentration (MIC). Next day the zones of inhibition are measured in mm.

Dilutions: (a) For qualitative test: Concentration of 100 μg/mL is prepared in 0.1 N HCl. (b) For quantitative test: Various concentrations *viz.*, 100, 50, 40, 30, 20, 10, 5, 0.5, 0.25, 0.125, 0.1 *etc.* are prepared in 0.1 N HCl.

Ampicilin and cephalexin were used as standard drugs against Gram +ve and Gram -ve bacteria, respectively and were subjected to similar screening programs. MIC of ampicilin is 0.01 μg/mL against *S. aureus* and that of cephalexin is 1 μg/mL against *S. typhi*.

Measurements of inhibition zones: The zones of inhibition found around each disc were measured by means of calipers.The end point was taken as the complete inhibition of growth as it appeared to the unaided eye. The diameters of zones were recorded and reported as resistant or sensitive to each microbial tested.

The complexes have been tested for their antibacterial activity with the help of Pour plate method results. The results are given by G and NG signs where, G means inhibition zones observed and NG means no inhibition zones observed.

RESULTS AND DISCUSSION

The analytical and physical data of the ligand and metal complexes are presented in Table-1. The ligand is white and the complexes are intensively coloured and thermally stable at least upto 275 ºC. They are insoluble in water and show almost negligible solubility in common organic solvents, though they are more soluble in more polar solvents like DMF and DMSO at room temperature. The analytical data of the metal complexes indicate that the complexes have 1:1 (Metal-Ligand) stoichiometry. The elemental analysis data of the complexes show the presence of the one metal atom for the ligand. Thus, the complexes can be formulated as [ML] where M = Pb(II), Co(II), Cu)(II), Ni(II) and Mn(II); L-represents deprotonated Ligand, *i.e.* H_2-(BAMTB).

The FT-IR Spectra of the complexes were recorded over a range of 4000 to 100 cm^{-1}, so as to account for the metal-ligand vibrational frequencies. The assigned values of the structurally important bands due to ν(C=N), ν(C-S), ν(M-S) and ν(M-N), ν(O-H) are given in (Table-2). These were distinguishable and provided structural features and manner of their bonding with metal ions. Some of the common features of the IR spectra are discussed below.

The IR Spectra of the metal complexes quite complex and it is not possible to assign all the bands without ambiguity However, structurally important bands such as those due to ν(C=N), ν(M-S), ν(M-N) modes are distinguishable and provide important evidence regarding structural features and manner of their bonding with metal ions. Some common feathers of the infrared spectra are note worthy: (1) Prime importance is to be given to the position of azomethine stretching vibrations. This band is difficult to identify due to considerable changes in its environment. Also, if the ligands have (>C=C<) linkage, then the frequencies generally overlap. Literature survey suggests that the ν(C=N) band is reported[7] to occur near 1670 cm^{-1}. For the present ligands the band appears in the range of 1637-1600 cm^{-1} which is attributed to ν(C-N). The ν(C=N) band appeared in the ligand spectrum was seen to be unaffected in the complexes.This shows that azomethine does not participate in the coordination. (2) In addition to the above, the infrared spectra of the ligands also show IR bands due to phenyl ring system in case of the ligand H_2-(BAMTB).The weak bands at around 1600 cm^{-1} and an intense absorption bands between 1581-1546 cm^{-1} are assigned[8] to the aromatic C=C and C-H deformation modes. (3) The strong band due to ν(C-S)[9] observed at 1191 to 1250 cm^{-1} in the spectrum of the ligand was shifted towards lower wave number in the complexes; point out bonding of ligand to metal ion through sulphur. This was further supported

TABLE-1

MAGNETIC, PHYSICAL AND ANALYTICAL DATA FOR METAL COMPLEXES WITH POLYDENTATE LIGAND H_2-(BAMTB)

Sr. no.	Compd. (m.f.)	m.w.	Colour	Yield (%)	Dec. temp. (ºC)	Molar cond.* at 10^{-3} M	Elemental analysis %: Obs. (Calcd.)					μ_{eff} (BM)
							M	C	N	H	S	
Ligand	H_2-(BAMTB)	306.00	White	84	–	–	–	38.548	20.97	4.56	7.1	–
	($C_{10}H_{10}N_8S_2$)						–	(39.21)	(21.32)	(4.57)	(6.24)	
1	[Pb(BAMTB)]	511.20	Pale yellow	87	265	0.044	39.57	24.724	20.788	4.644	10.265	Diamag.
	($C_{10}H_{10}N_8S_2Pb$)						(40.54)	(23.47)	(21.90)	(1.564)	(12.51)	
2	[Co(BAMTB)·$2H_2O$]	398.94	Light brown	86	230	0.270	13.99	33.546	26.980	4.065	11.694	4.6
	($C_{10}H_{10}N_8S_2O_2Co$)						(14.80)	(30.07)	(28.07)	(3.00)	(16.04)	
3	[Cu(BAMTB)]	367.54	Metallic grey	75	265	0.310	17.99	27.173	32.085	3.651	17.680	1.52
	($C_{10}H_{10}N_8S_2Cu$)						(17.31)	(32.64)	(30.47)	(2.176)	(17.41)	
4	[Ni(BAMTB)·$2H_2O$]	398.71	Light green	76	240	0.390	13.87	31.548	28.685	3.934	12.957	2.85
	($C_{10}H_{10}N_8S_2O_2Ni$)						(14.74)	(30.09)	(28.09)	(3.009)	(16.05)	
5	[Mn(BAMTB)·$2H_2O$]	394.94	Cream	86	220	0.054	13.50	33.429	27.824	3.454	12.624	5.50
	($C_{10}H_{12}N_8S_2O_2Mn$)						(13.94)	(30.38)	(28.35)	(3.03)	(16.20)	

*mhos cm^2 mol^{-1} in DMF.

TABLE-2

SELECTIVE IR BANDS (cm^{-1}) OF LIGAND AND COMPLEXES

Sr. no.	Compound	ν(C=N)	ν(C-S)	ν(O-H)	ν(M-S)	ν(M-N)	ν(C-N)
Ligand	H_2-(BAMTB)	1637	1190	–	–	–	1326
1	[Pb(BAMTB)]	1642	1097	3455	579	488	1298
2	[Co(BAMTB)·$2H_2O$]	1642	1128	3419	577	487	1285
3	[Cu(BAMTB)]	1632	1128	3434	577	486	1316
4	[Ni(BAMTB)·$2H_2O$]	1632	1082	3434	570	486	1321
5	[Mn(BAMTB)·$2H_2O$]	1625	1118	3418	591	488	1260

by the appearance of new peaks[10] due to ν(M-S), at around 692 cm^{-1} in the spectra of the complexes. (4) Symmetric stretching frequency ν(C-N) in the spectra of the ligand is found to be shifted to lower wave numbers *i.e.*, 1317-1321 cm^{-1} in the spectra of the complexes confirming coordination through the nitrogen of the ligand. A -ve shift in this vibrational mode indicates coordination through N donar of the ligand. (5) Peaks corresponding to the ν(O-H) stretching[11] was observed in the complexes at around 3461 cm^{-1}. (6) Inference can be made that these were due to the presence of coordinated water molecules, which is generally expected in the cobalt, nickel and manganse complex, to have water molecules coordinated to the metal ion. However, the copper complex exhibited a weak band, which can be attributed to the adsorbed water, which was further supported by thermal studies.

Magnetic measurements: The observed magnetic moment value for the Pb(II)complex at room temperature is diamagnetic. The magnetic moment value for the Co(II) complex is 4.6 BM. Although the μ_{eff} value of high-spin octahedral and tetrahedral cobalt complexes overlap considerably, tetrahedral Co(II) complexes generally have lower μ_{eff} values, often in the range of 4.2-4.5 BM Cu(II) complex has magnetic moment value 1.52 BM shows pseudo tetrahedral geometry, Ni(II) has magnetic moment value 2.82 BM shows an octahedral geometry[12] and Mn(II) complex has magnetic moment value 5.50 BM shows octahedral geometry.

Diffused reflectance spectroscopy: The UV-Vis spectra were recorded in solid state as reflectance spectra. In the present studies, as the ligands were not isolated in free state, the diffuse reflectance spectral data on the constituent ligands has been used to derive useful inferences. The spectrum reveals a strong band at *ca.* 39,000 cm^{-1}, which is attributed to π to π* intra ligand trannsition. The shoulder and a strong absorption band at *ca.* 43,103 and *ca.* 33,784 cm^{-1}, respectively, the latter being due to the deprotonation of the -S-H group in the constituent ligands.

Present Co(II) complex the diffuse reflectance spectrum reveals two peaks at 25,906 and 29,239 cm^{-1} due to charge transfer transitions. Taking into consideration the spectral features expected for an octahedral[13] Co(II) complex which is in support with the magnetic moment values.The other transitions Cu(II) centers.,indicates a pseudo-tetrahedral geometry[14] around the Cu(II) centers which is also supported by ESR spectral studies and magnetic moment values.

The diffuse reflectance spectra for the Ni(II) complex exhibits a strong absorption bands at 26,595 cm^{-1} in case of [Ni(BAMTB)·2H_2O]. On the basis of its position and intensity, it could be assigned to a charge transfer transitions. Ni(II) complex exhibits a hump at 16,393 cm^{-1} indicates a transition at $^3T_{2g} \rightarrow {}^3T_{1g}(F)$. Thus, Ni(II) complex shows an octahedral geometry which is in accord with the transitions and magnetic moment values and also with the spectral data.

TABLE-3
REFLECTANCE SPECTRAL DATA FOR LIGAND AND METAL COMPLEXES

S. no.	Complex	μ_{eff} (BM)	Observed band position		Assignment
			λ (nm)	ν (cm^{-1})	
Ligand	H_2-(BAMTB)	–	342	29240	Charge transfer
			276	36232	Intra-ligand transition
			242	41322	Intra-ligand transition
			232	43103	Intra-ligand transition
1	[Pb(BAMTB)]	Diamag.	600	16666	Charge transfer
			346	28901	Charge transfer
			292	34264	Intra-ligand transition
			272	36764	Intra-ligand transition
			262	38167	Intra-ligand transition
			252	39682	Intra-ligand transition
			246	40650	Intra-ligand transition
			234	42735	Intra-ligand transition
2	[Co(BAMTB)·2H_2O]	3.85	386	25906	Charge transfer
			342	29239	Charge transfer
			328	30487	Intra-ligand transition
			308	32467	Intra-ligand transition
			272	36764	Intra-ligand transition
			262	38168	Intra-ligand transition
			248	32528	Intra-ligand transition
			228	43859	Intra-ligand transition
3	[Cu(BAMTB)]	1.52	350	28571	Charge transfer
			274	36496	Intra-ligand transition
			258	38759	Intra-ligand transition
			252	39682	Intra-ligand transition
			236	42372	Intra-ligand transition
			232	43103	Intra-ligand transition
4	[Ni(BAMTB)·2H_2O]	2.32	610	16393	$^3T_{2g} \rightarrow {}^3T_{1g}(F)$
			376	26595	Charge transfer
			306	32679	Intra-ligand transition
			278	35971	Intra-ligand transition
			260	38461	Intra-ligand transition
			248	40322	Intra-ligand transition
			242	41322	Intra-ligand transition
			230	43478	Intra-ligand transition
			224	44642	Intra-ligand transition
5	[Mn(BAMTB)·2H_2O]	5.50	544	18382	$^6A_{1g} \rightarrow {}^4T_{1g}(G)$
			342	29239	Charge transfer
			270	37037	Intra-ligand transition
			258	38759	Intra-ligand transition
			232	43103	Intra-ligand transition

For high spin octahedral Mn(II) complexes, the *d-d* transitions are both spin and multiplicity forbidden. However, the electronic spectra of these complexes often exhibit a number of bands with very weak intensities with great variation in band widths on account of spin-orbit interactions and are usually due to transitions from $^6A_1$ ground state to various excited quartet states. However, in present reflectance studies, the Mn(II) complexes (Table-3). Intra-ligand transitions in the region 46,650-35,971 cm^{-1}. The charge transfer transitions are observed in the range of 26,041-32,680 cm^{-1}. Also, the band, 18,238 cm^{-1} is due to $^6A_{1g}(S) \rightarrow {}^4T_{1g}(G)$ for the complex. Thus, it is confirmed that Mn(II) complexes possess an octahedral geometry, which is in accordance with the magnetic moment values.

The diffuse reflectance spectra of non-transition Pb(II) complex show intra-ligand and charge transfer transitions. No *d-d* transitions are expected and hence, no absorption bands in the visible region should be observed. Thus, Pb(II) complexes are tetrahedral and diamagnetic in nature.

Thermogravimetric analysis: The thermogravimetric TG curves recorded for the complexes listed in Table-4 shows that all the complexes decomposed on heating to form the product, following a sequence of steps. The complexes of lead, cobalt, copper and nickel showed two steps in the TG prior to the formation of final stable product.

The first mass loss step in each of these complexes initiated at about 150-250 ºC and tapered in the temperature range 300 to 400 ºC. This was followed by other steps involving the major mass loss. The complexes show a clear separation between the first and further steps. The values deduced from the TG curves for the number of constitutional water were found to be two for cobalt, nickel and manganese complex. The presence of constitutional water in complexes of cobalt, nickel and manganese was evident from the IR patterns recorded for these samples.

The IR patterns recorded for the samples prior to thermogravimetric studies did show the presence of water in all the compounds. A sharp -OH frequency band was observed for cobalt, nickel and manganese complex, confirming the presence of water molecule[15] in coordination sphere. However, the copper complex showed a weak band which could be due to the adsorbed water by the complex on exposure to the ambient atmosphere. Hence, the possibility for the elimination of water from the compounds during thermolysis could be well expected.

The loss corresponding to the second steps in complexes resulted in the formation of their oxide from the dried complex, The thermal stability of anhydrous complexes deduced from the TG curves suggest that the temperatures of thermal decomposition of lead, cobalt, copper, nickel and manganese were *ca.* 265, 250, 265, 240 and 220 ºC, respectively.

Differential thermal analysis: Differential thermal analysis (DTA) was done by heating at the programmed heating rate for the samples in inert atmosphere. The temperature was allowed to increase at a rate of 10 ºC min^{-1}. The high decomposition temperature of the chelates indicates that they are thermally quite stable, suggesting stronger metal-ligand bonding and also their polymeric existence. This is further supported by the very low solubility in all the common solvents.

The DTA curves recorded for the samples showed endothermic peak followed by broad exothermic peak for all the complexes. The endothermic peak could be in general be attributed to the loss of water in case of cobalt, nickel and manganese complex, the twin endothermic peak preceding the exothermic peak in the range 200 to 300 ºC could be due to loss of water and partial decomposition of the complex which subsequently merges with the peak caused by the burning of the complex. The peak intensities suggest that the copper complex have adsorbed moisture, where as cobalt, nickel, manganese complexes have coordinated water molecules, which was confirmed by TG and DTA.

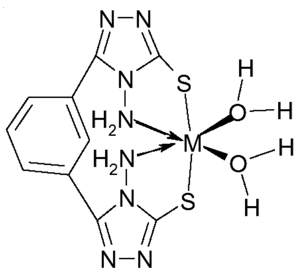
TABLE-4
THERMOANALYTICAL DATA FOR METAL COMPLEXES

Complex	Temp. range (ºC)	Weight loss %		Group/ moiety lost
		Calcd.	Obsr.	
[Pb(BAMTB)]	RT-534	1.220	1.34	-$C_{10}H_8N_8$
	534-900	1.370	1.24	-PbO
[Co(BAMTB)·2H_2O]	RT-230	0.230	0.30	-2H_2O
	230-785	1.910	1.92	-$C_{10}H_8N_8S_2$
	785-900	0.370	0.30	-CoO
[Cu(BAMTB)]	RT-750	1.822	1.83	-$C_{10}H_8N_8S_2$
	750-900	0.380	0.39	-CuO
[Ni(BAMTB)·2H_2O]	RT-240	0.243	0.26	-2H_2O
	240-740	2.060	2.06	-$C_{10}H_8N_8S_2$
	710-900	0.400	0.37	-NiO
[Mn(BAMTB)·2H_2O]	RT-220	0.170	0.18	-2H_2O
	220-850	1.400	1.27	-$C_{10}H_8N_8S_2$
	850-900	0.250	0.32	-MnO

X-Ray studies: X-Ray diffraction technique can be used to determine the crystallinity of the complexes. In present case, each diffractogram is not well resolved into sharp refluxes suggesting amorphous[16] nature for the complexes and hence, lattice parameters can not be obtained.

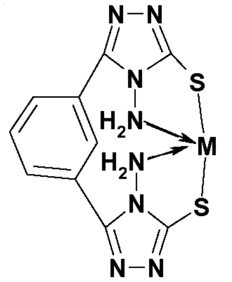
On the basis of the physico-chemical studies, the bonding and structure for the metal complexes may be represented as shown as below:

Complexes of (BAMTB)
Co(II),Ni(II),Mn(II)



M= Co(II), Ni(II), Mn(II)

Complexes of (BAMTB) with
Pb(II),Cu(II)



M= Pb(II), Cu(II)

Biological activities: The results of the Pour plate method shown in the Tables 5 and 6 indicate that the complexes are highly active for the selected organisms. Compared with the standard compound cephalexin,

TABLE-5
QUALITATIVE RESULTS (CONCENTRATION-100 μg/mL)

Sample	No.	Organism			
		E. coli (gram -ve)	*S. typhi* (gram -ve)	*S. aureus* (gram +ve)	*A. niger* (gram +ve)
Ligand	H_2-(BAMTB)	NG	NG	NG	G
1	[Pb(BAMTB)]	NG	NG	NG	G
2	[Co(BAMTB)·$2H_2O$]	NG	NG	NG	G
3	[Cu(BAMTB)]	NG	NG	NG	G
4	[Ni(BAMTB)·$2H_2O$]	NG	NG	NG	G
5	[Mn(BAMTB)·$2H_2O$]	NG	NG	NG	G

NG = No growth – (Inhibition zones observed).
G = Growth – (No inhibition zones observed).

TABLE-6
MINIMUM INHIBITORY CONCENTRATION (MIC) RESULTS

Sr. no.	Sample	*E. coli*		*S. typhi*		*S. aureus*	
		MIC (μg/mL)	Zone (mm)	MIC (μg/mL)	Zone (mm)	MIC (μg/mL)	Zone (mm)
Ligand	H_2-(BAMTB)	1.25	14.20	1.50	12.40	1.25	15.60
1	[Pb(BAMTB)]	1.50	13.20	1.25	11.44	1.25	12.48
2	[Co(BAMTB)·$2H_2O$]	0.50	10.44	0.25	8.68	0.50	10.24
3	[Cu(BAMTB)]	0.25	7.75	0.25	8.06	0.20	8.14
4	[Ni(BAMTB)·$2H_2O$]	1.20	14.22	1.20	12.06	1.24	11.34
5	[Mn(BAMTB)·$2H_2O$]	1.50	13.20	1.00	10.30	1.50	14.80

the present complexes are less active against the respective strains of microorganisms. But, present complexes are highly active as antibacterial agents as compared with the corresponding ligand. The present complexes are not at all active as the antifungal agents.

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