Metal Complexation Studies of 1-(4-Carboxy-3-hydroxy-4-phenyl amino methyl) benzotriazole

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Abstract: Aminomethylation of benzotriazole was carried out by treating benzotriazole with formaldehyde and 4-aminosalicylic acid. The resultant compound was designed as 1-(4-carboxy-3-hydroxy-4-phenyl amino methyl) benzotriazole. The transition metal complex of Cu^{2+} , Co^{2+} , Ni^{2+} , Mn^{2+} and Zn^{2+} of 1-(4-carboxy-3-hydroxy-4-phenyl amino methyl) benzotriazole have been prepared. Elemental analysis, spectral studies, magnetic moment determination, molar conductivity measurement and microbial activity of 1-(4-carboxy-3-hydroxy-4-phenyl amino methyl) benzotriazole and its metal complexes were carried out.

Keywords: Benzotriazole, 4-Aminosalicylic acid, Metal complexes, Spectral studies, Magnetic moment, Antibacterial and Antifungal activity.

Introduction

One of the heterocyclic compound say 1-(*H*)-benzotriazole is found as an important heterocyclic compound. It's prime application is as corrosion inhibitors for copper or copper alloys^{1,2}. Ciba Geigy has introduced benzotriazole derivative under the trade name Trinvin-p³. It is applied as an UV light absorber for stabilizing plastics and other organic materials against discoloration determination³. It is also employed as photographic emulsion stabilizer⁴. In the peptide synthesis it acts in form of an active ester⁵. The area in which the Mannich reaction of benzotriazole and 4-amino salicylic acid (*i.e.* ligand) having metal gripping group has not been reported. Hence, it was thought to undertake such work. With this view, the present communication describes the synthesis and characterization of benzotriazole 4-aminosalicylic acid clubbed molecule and its metal complexes. The work is illustrated in Scheme 1.

Experimental

Benzotriazole was prepared by method reported in literature⁶. *p*-aminosalicylic acid (PAS) (*i.e.* 4-aminosalicylic acid) was obtained from local dealer. All other chemicals used were of analytical grade.

Synthesis of 1-(4-carboxy-3-hydroxy-4-phenyl amino methyl) benzotriazole

A mixture of 1-*H* benzotriazole (0.02 mole), formaldehyde (0.02 mole) and 4-aminosalicylic acid (PAS) was (0.02 mole) in ethanol (70 mL) was heated under reflux for 4 h. Subsequently ethanol was distilled off and the lump mass obtained. It was triturated with petroleum ether (40-60°C). The solid designated as HL was isolated and dried in air. Yield was 73%. It's m.p was 165 °C. (uncorrected).

Scheme 1*Elemental analysis*C₁₄H₁₂N₄O₃ (284 g/mol)

	C%	H%	N%
Calculated:	59.15	4.22	19.71
Found:	59.01	4.09	19.69

IR Features:	1485-1522 cm ⁻¹	Benzotriazole ring
	3032, 1502, 1600 cm ⁻¹	Aromatic
	1683 cm ⁻¹	CO of COOH
	3200-3600 cm ⁻¹	OH

	3400 cm ⁻¹	Sec NH
	2850, 2920 cm ⁻¹	CH ₂
NMR	7.1-7.7 ppm	Multiplet aromatic
(DMSO)	2.57 ppm (2H)	Singlet CH ₂
	10.0 ppm (1H)	Singlet (COOH)
	3.9 ppm (1H)	Singlet (OH)

Synthesis of metal complexes of HL

Formation of HL metal complexes

The Cu²⁺, Co²⁺, Ni²⁺, Mn²⁺ and Zn²⁺ metal ion complexes of HL have been prepared in a similar manner. The procedure is as follow.

To a solution of HL (0.1 mole) in ethanol-acetone (1:1) mixture (150 mL), 0.1 N KOH solution was added drop wise with stirring. The pasty precipitates were obtained at neutral pH. These were dissolved by addition of water up to clear solution. It was diluted to 250 mL of the stock solution (which contains 0.01 mL HL) was added drop wise to the solution of metal salt (0.005 mole for divalent metal ions and 0.0033 mole for Fe³⁺ ion) in water at room temperature. Sodium acetate or ammonia was added up to complete precipitation. The precipitation was digested on water bath at 80 °C for 2 h. The digested precipitates of complex were filtered washed with water and air dried. It was amorphous powder. Yield was almost quantitative. The details are given in Table 1.

Measurements

The elemental analysis for C, H and N were carried out on elemental analyzer. IR spectra of HL and its metal complexes were scanned on a Nicolet 760 FTIR spectrophotometer in KBr. The metal content of the metal chelate were performed by decomposing a weighed amount of each metal complexes followed by EDTA titration as reported in literature⁷. Magnetic susceptibility measurement of all the metal complex was carried out at room temperature by the Gouy method. Mercury tetrathiocyanatocobaltate(II) Hg[Co(NCS)₄] was used as a calibrant. The diffused reflectance spectra of solid metal complex were recorded on a Backman DK Spectrophotometer with a solid reflectance attachment, MgO was employed as the reflectance compound. The electrical conductivity of all the complexes was measure in CH₃CN at 10⁻³ M concentration.

Antifungal activity

The fungicidal activity of all the compounds was studied at 1000 ppm concentration *in vitro*. Plant pathogenic organisms listed in Table 3 were used. The antifungal activity of all the samples was measured by cup plate method⁸. Each of the plant pathogenic strains on a potato dextrose agar (PDA) medium contained potato 200 g, dextrose 20 g, agar 20 g, and water 1 litre, 5 days old culture were employed. The compounds to be tested were suspended (1000 ppm) in a PDA medium and autoclaved for 15 min at 15 atm pressure. These medium were poured into sterile petri plate and the organisms were incubated after cooling the petri plated. The percentage inhabitation for fungi was calculated after 5 days using the formula give below.

$$\text{Percentage of Inhibition: } \frac{100(X-Y)}{X}$$

Where, X: Area of colony in control plate

Y: Area of colony in test plate

The fungicidal activity all compounds are shown in Table 3.

Table 1. Analytical data of the metal chelates of HL.

Compound	Emperical Formula	MW. Cal g/mole	Yield %	Elemental Analysis							
				C%		H%		N%		M%	
				Calcd	Found	Calcd	Found	Calcd	Found	Calcd	Found
HL	C ₁₄ H ₁₂ N ₄ O ₃	284	60	59.15	59.00	4.22	4.10	19.71	9.60	-----	-----
[CuHL (H ₂ O) ₂]	C ₂₈ H ₂₂ N ₈ O ₆ Cu ²⁺ 2(H ₂ O)	665.54	55	50.48	50.40	3.90	3.90	16.82	16.80	9.54	9.50
[CoHL (H ₂ O) ₂]	C ₂₈ H ₂₂ N ₈ O ₆ Co ²⁺ 2(H ₂ O)	660.93	58	50.83	50.70	3.93	3.90	16.94	16.90	8.91	8.80
[NiHL (H ₂ O) ₂]	C ₂₈ H ₂₂ N ₈ O ₆ Ni ²⁺ 2(H ₂ O)	660.69	59	50.85	50.00	3.93	3.80	16.95	16.90	8.88	8.70
[MnHL (H ₂ O) ₂]	C ₂₈ H ₂₂ N ₈ O ₆ Mn ²⁺ 2(H ₂ O)	656.93	56	51.14	51.10	3.95	3.85	17.04	17.00	8.36	8.30
[ZnHL (H ₂ O) ₂]	C ₂₈ H ₂₂ N ₈ O ₆ Zn ²⁺ 2(H ₂ O)	667.39	57	50.34	50.00	3.89	3.80	16.78	16.70	9.79	9.69

Table 2. Magnetic moment & reflectance data of the metal complexes.

Complex	Magnetic Moment μ_{ef} , B.M	Absorption band, cm ⁻¹	Transitions
Cu-HL	1.95	22288	C.T
		15630	${}^2\text{B}_{1g} \rightarrow {}^2\text{A}_{1g}$
Ni-HL	3.82	20535	${}^3\text{A}_{2g} \rightarrow {}^3\text{T}_{1g}(\text{P})$
		14677	${}^3\text{A}_{1g} \rightarrow {}^3\text{T}_{1g}(\text{F})$
Co-HI	4.42	26740	${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{2g}(\text{F})$
		15688	${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{A}_{2g}$
Mn-HL	4.86	8995	${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{2g}(\text{P})$
		24445	${}^6\text{A}_{1g} \rightarrow {}^4\text{T}_{1g}(4\text{Eg})$
Zn-HL	Diamagnetic	18333	${}^6\text{A}_{1g} \rightarrow {}^4\text{T}_{2g}(4\text{G})$
		16850	${}^6\text{A}_{1g} \rightarrow {}^4\text{T}_{1g}(4\text{G})$
Zn-HL	Diamagnetic	-----	-----

Table 3. Antifungal activity of ligand HL and its metal complexes.

Sample	Zone of inhibition of fungus at 1000 ppm, %				
	PE	BT	N	T	RN
(HL)-Mn ²⁺	64	71	70	71	70
(HL)-Co ²⁺	73	72	73	75	73
(HL)-Ni ²⁺	70	77	75	79	74
(HL)-Cu ²⁺	73	78	77	82	75
(HL)-Zn ²⁺	68	77	71	77	71
HL	61	61	62	64	65

PE=*Penicillium expansum*, BT=*Botrydepladia thiobromine*, N=*Nigrospra sp.*
 T= *Trichothesium sp.* RN= *Rhizopus nigricans*

Results and Discussion

The parent ligand HL was an amorphous yellow powdered, soluble in various solvents like dioxane, DMSO and DMF. The results of elemental analysis of the ligand are reported in Table 1. They are consistent with the predicted structure as shown in Scheme 1 the ligand was synthesized as shown in the Scheme 1.

Examination of IR spectrum (not shown) of HL reveals that a broad band of phenolic hydroxyl stretching is observed at 3200-3600 cm⁻¹ as well as additional absorption bands at 3030 cm⁻¹, 1500 and 1600 are characteristics of the salicylic acid^{9,10}. The strong bands at 1680 cm⁻¹ for C=O and band at 3400 for sec. NH. The NMR data (shown in experimental part) also confirm the structure of HL.

The metal complex of HL with the metal ions Cu²⁺, Co²⁺, Ni²⁺, Mn²⁺ and Zn²⁺ vary in colours. On the basis of the proposed structure as shown in scheme 1, the molecular formula of the HL ligand is C₁₄H₁₂N₄O₃ which upon complexation coordinates with one central metal atom at four coordination sites and with two water molecules. Therefore the general molecular formula of the resulting metal complex is [C₂₈H₂₂N₈O₆] M 2(H₂O) for divalent metal ions. This has been confirmed by results of elemental analysis of all the five metal chelates and their parent ligand. The data of elemental analysis reported in Table 1 are in arrangement with the calculated values of C, H and N based on the above mentioned molecular formula of parent ligand as well as metal complex.

Inspection of IR Spectra (not shown) of metal complexes reveals that all the spectra are identical in all respects. The comparison of IR spectrum of the parent ligand HL with that of its each metal complex has revealed certain characteristics differences.

One of the significant differences to be expected between the IR spectrum of the parent ligand and its metal complex is the presence of more broadened bands in the region of 3200-3600 cm⁻¹ for the metal complex as the oxygen of the O-H group of the ligands forms a coordination bond with the metal ions⁹⁻¹¹. This is explained by the fact that water molecules might have strongly absorbed to the metal chelates sample during their formation.

Another noticeable difference is that the bands due to the COO⁻ anion at 1600 cm⁻¹ in the IR spectrum of the each metal complex. The band at 1400 cm⁻¹ in the IR spectrum of HL assigned to in plane OH determination⁹⁻¹¹ is shifted towards higher frequency in the spectra of the metal complex due to the formation of metal oxygen bonds. This has been further confirmed by a weak bands at 1105 cm⁻¹ corresponding to C-O-M stretching⁹⁻¹¹. Thus all of these characteristics features of the IR studies suggested the structure of the metal complex as shown in Scheme 1.

Examination of data of the metal content in each compound revealed a 1:2 metal:ligand (M:L) stoichiometry in all of the complex of divalent metal ions. Magnetic moment (μ_{eff}) of each of the metal complex is given in Table 2. Examination of these data reveals that all complexes other than that of Zn^{2+} are paramagnetic while those of Zn^{2+} are diamagnetic.

The diffuse electronic spectrum of the $[\text{CuHL}(\text{H}_2\text{O})_2]$ metal complex shows broad bands at 15630 and 22288 cm^{-1} due to the ${}^2\text{B}_{1g} \rightarrow {}^2\text{A}_{1g}$ transition and charge transfer, respectively suggesting a distorted octahedral structure¹²⁻¹⁴ for the $[\text{CuHL}(\text{H}_2\text{O})_2]$ complex. Which is further confirmed by the higher value of μ_{eff} of the $[\text{CuHL}(\text{H}_2\text{O})_2]$ complex. The $[\text{NiHL}(\text{H}_2\text{O})_2]$ complex gave two absorption bands at 14677, 20535 corresponding to ${}^3\text{A}_{2g} \rightarrow {}^3\text{T}_{1g}(\text{P})$ and ${}^3\text{A}_{1g} \rightarrow {}^3\text{T}_{1g}(\text{F})$ transitions. $[\text{CoHL}(\text{H}_2\text{O})_2]$ complex gave three absorption bands at 15688, 26740 cm^{-1} . Thus absorption bands at 26740, 15688 and 8995 cm^{-1} corresponding to ${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{2g}(\text{F})$, ${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{A}_{2g}$, ${}^4\text{T}_{1g}(\text{F}) \rightarrow {}^4\text{T}_{2g}(\text{P})$ the diffuse, reflectance spectra and the value of the magnetic moments (μ_{eff}) indicate an octahedral configuration for the $[\text{NiHL}(\text{H}_2\text{O})_2]$ and $[\text{CoHL}(\text{H}_2\text{O})_2]$ complex. The spectra of $[\text{MnHL}(\text{H}_2\text{O})_2]$ shows weak bands at 16850, 18333 and 24445 cm^{-1} assigned to the transitions ${}^6\text{A}_{1g} \rightarrow {}^4\text{T}_{1g}(4\text{G})$, ${}^6\text{A}_{1g} \rightarrow {}^4\text{T}_{2g}(4\text{G})$ and ${}^6\text{A}_{1g} \rightarrow {}^4\text{T}_{1g}(4\text{Eg})$ respectively suggesting an octahedral structure for the $[\text{MnHL}(\text{H}_2\text{O})_2]$ chelate. As the spectrum of the $[\text{ZnHL}(\text{H}_2\text{O})_2]$ is not well resolved, it is not interpreted but its μ_{eff} value shows that it is diamagnetic as expected.

The antifungal activity of all the compounds measured for various plant pathogens. Inspection of the result shown in Table 3 indicates that all compounds are good toxic for fungi. Out of all the compounds copper chelates is more toxic than other. These compounds almost inhibit the fungi about 70%. Hence produced metal chelates can be employed as garden fungicides. Further work in the direction is in progress.

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