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Isolation, Characterization and Antimicrobial activity of Imipramine-Cobalt (II) Complexes

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A series of seven new coordination compounds of Co(II) with imipramine hydrochloride (IPH) has been isolated in non-aqueous media. The new complexes are characterized by thermal analysis, IR, electronic spectra, magnetic moments and conductivity measurements. The IR data suggest that IPH acts as a bidentate ligand. On the basis of spectral data, an octahedral structure is proposed. Thermogravimetric studies indicate the presence of water molecule in the complex. The molar conductance value shows the non-electrolytic nature of the complexes. These complexes exhibit enhanced antimicrobial activity compared to that of free ligand.

INTRODUCTION

Imipramine hydrochloride (IPH) is an important psychotropic drug which contains a coordinating atom in its structure. Its complexation property has been seldom explored except that with copper.[1] Due to the presence of tertiary nitrogen in it, IPH acts as an active donor especially for coordination with biometal like cobalt. The present communication reports on the isolation of Co(II) complexes with IPH and their IR, electronic, TGA and magnetic moments data.

EXPERIMENTAL

All the chemicals and solvents used were of AR grade. The ligand IPH received as a gift sample from Sun Pharmaceutical industries was used as such.

JASCO model UVIDEC-610 spectrophotometer was used for recording electronic spectra. Infrared spectral measurements of ligand and the complexes were recorded on Hitachi model 297 spectrometer in the 4000–250 cm^{-1} region using nujol/ KBr discs. Dupont 9900 computer/thermal analyser with 951 TG module thermobalance was used for recording thermogravimetric curves in the atmosphere of air at a heating rate of 6°C min^{-1} with 5 nm min^{-1} chart speed. The magnetic moments of the complexes were determined at room temperature with Gouy balance using $Hg[Co(SCN)_4]$ as calibrant. Conductivity measurements have been done for the complexes in DMF (1.0×10^{-4} M) using Equiptronics digital conductivity meter model No. EQ-DCM-P. The melting points of the complexes were determined using Thomas Hoover capillary melting point apparatus. The elemental analysis were recorded at Department of Chemical Technology, University of Bombay, Bombay. The chloride and the metal analysis were carried out as usual by the literature methods.[2,3]

Synthesis of the complexes

The complexes were isolated by mixing ethanolic solution of metal ions (50 mL) with ligand (50 mL) in 1 : 1 mole ratio and heated for about 3 h. It was concentrated over a hot water bath and on cooling, a bluish coloured solid was formed which was washed with cold ethanol, then with ether and dried in vacuum desiccator.

RESULTS AND DISCUSSION

The analytical data has confirmed the molecular formula of the complexes as presented in Table-1. On calculation the molecular formulae of the new complexes are found to be $CoIPHX_2 \cdot 2H_2O$ (where $X^- = Cl^-$, Br^-, NO_3^-, SO_4^{2-}, ClO_4^- or CH_3COO^-). The complexes are soluble in most of the organic solvents such as DMF, DMSO and acetonitrile etc. The molar conductance values as measured in DMF at 10^{-4} M for these complexes fall in the range 14.12–28.01 mhos $cm^2 mol^{-1}$ indicating non-electrolytic behaviour, due to charge neutralization of metal ion with an anionic ligand.

The electronic spectra show ligand field transition in the range 14,365–14,402 cm^{-1} which is assigned to $^4T_{1g} \rightarrow {}^4T_{2g}$ under octahedral approximations. The visible absorption spectrum at 14,836 cm^{-1} which is assigned to $^4T_{1g} \rightarrow {}^4A_{2g}(F)$ and $^4T_{1g} \rightarrow {}^4T_{1g}(P)$ transitions is due to the band at 16,404 cm^{-1} respectively. These bands characterize octahedral ligand field around the cobalt ion.[4] The more intense band at 37,537 cm^{-1} is charge transfer band. The crystal field splitting energy (10 Dq) value calculated for these complexes is in agreement with the value obtained for known octahedral cobalt(II) complexes.[5,6]

The magnetic moments of the complexes calculated from corrected magnetic susceptibility are given in Table-1. The magnetic moment values of Co(II) complexes found to be in the range 4.42–5.16 BM also suggest an octahedral geometry.[7] The magnetic susceptibility of thiocyanato cobalt(II) complex (4.23 BM) indicates tetrahedral geometry.[8, 9]

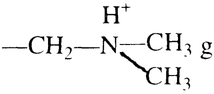
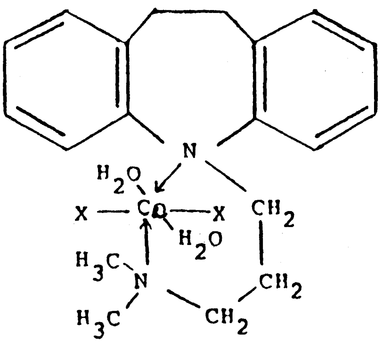
The IR spectra of free ligand and its complex revealed that IPH acts as a bidentate ligand by coordinating through its heterocyclic nitrogen atom and the tertiary nitrogen atom in the side chain.[1] The literature survey reveals[10] that the ion —R_3NH^+ combined with X^- (where X^- is the halogen) present in the molecules of many phenothiazine drugs gives rise to a broad band generally between 2500–2300 cm^{-1}. In this case a broad band between 2650–2400 cm^{-1} was observed in the IR spectra of the ligand corresponding to  $—CH_2—\overset{H^+}{N}(CH_3)—CH_3$ group combined with Cl^- ion.[11] But in the IR spectrum of the complex this band has totally disappeared showing thereby nitrogen of the side chain to be the site of interaction. It is reported in the literature[12, 13] that a sharp peak ranging from 2835–2810 cm^{-1} corresponds to the heterocyclic nitrogen attached with alkyl group. The band at 2890–2850 cm^{-1} in the free ligand is assigned to the heterocyclic nitrogen attached with alkyl group. The peak has totally disappeared in IR spectra of all the complexes showing thereby the heterocyclic nitrogen attached with alkyl group is also the site of interaction. A new band in the region 3300–3200 cm^{-1} is due to ν(OH) vibration of coordinated water molecule. The new bands at 440–425 cm^{-1}, 365–340 cm^{-1} are assigned to ν(Co—N) and ν(Co—X) respectively[14].

TABLE-1
CHARACTERIZATION OF THE METAL COMPLEXES

Complex	Found (Calcd)%				ΛM mhos cm^2 mol^{-1}	μ_{eff} (B.M.)
	C	H	N	Co		
$[Co(C_{19}H_{24}N_2)(H_2O)_2Cl_2]$	51.09 (51.13)	5.20 (5.87)	5.91 (6.29)	13.58 (13.20)	16.83	4.81
$[Co(C_{19}H_{24}N_2)(H_2O)_2Br_2]$	41.91 (42.64)	4.91 (5.27)	5.02 (5.23)	10.81 (11.01)	28.01	5.01
$[Co(C_{19}H_{24}N_2)(H_2O)_2(NO_3)_2]$	46.01 (45.69)	5.89 (5.65)	11.93 (11.29)	12.08 (11.80)	14.19	4.19
$[Co(C_{19}H_{24}N_2)(H_2O)_2(ClO_4)_2]$	40.52 (39.73)	5.30 (4.91)	5.58 (4.87)	9.85 (10.26)	17.06	5.13
$[Co(C_{19}H_{24}N_2)(H_2O)_2(CH_3COO)_2]$	45.94 (46.24)	5.61 (4.91)	6.83 (5.67)	12.08 (11.94)	19.97	4.90
$[Co(C_{19}H_{24}N_2)(H_2O)_2SO_4]$	47.73 (48.40)	6.89 (5.98)	5.01 (5.94)	11.98 (12.50)	19.12	5.15
$[Co(C_{19}H_{24}N_2)(SCN)_2]$	54.19 (55.37)	4.98 (5.31)	11.91 (12.30)	13.91 (12.93)	23.06	4.23

Thermal decomposition of few new Co(II) complexes was carried out to observe the thermal behaviour and to determine the decomposition temperature of the complexes. TGA of the complex demonstrated that two coordinated water molecules escape at the temperature range 185–199°C except Co(II) thiocyanato complex. The expulsion of water from the complex in the above temperature range indicates that they are present inside coordination sphere.[15] Above 250°C these complexes decompose rapidly due to less thermally stable organic moiety. The complexes undergo complete decomposition in the region 788–812°C and the TG curve complexes stoichiometry of 1 : 1 (metal : ligand). All these complexes are anhydrous and are thermally stable.

On the basis of chemical analysis and various physico-chemical studies, we tentatively propose the six-coordinated structure of the Co-IPH complex having octahedral structure as shown in the figure:



Antimicrobial activity

The antifungal and antibacterial activity of the ligand and its Co(II) complexes (0.1 and 0.2% per test) were checked by employing the tested fungi and bacteria *viz.*, *Alternaria alternata, Aspergillus flavus, Escherichia coli** and *Staphylococcus aureus** following cup diffusion techniques.[16]

All plates were run in triplicate. The inhibition zones were measured and mean in millimetres was recorded. The data in Table-2 indicate the ligand, *i.e.*, IPH was not able to inhibit the growth of all the above fungi and bacteria. Better activities of the complexes as compared to free ligand could also be understood in terms of the chelation theory,[8] which explains that a decrease in polarizability of the metal could enhance the lipophilicity of the complexes.

TABLE-2
PERCENTAGE INHIBITION OF FUNGICIDAL AND BACTERIAL GROWTH

Compound	*A. alternata*		*A. flavus*		*E. coli**		*S. aureus**	
	0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.2
$C_{19}H_{24}H_2$	30.13	38.20	28.41	37.25	25.21	31.63	26.01	33.15
$[Co(C_{19}H_{24}N_2)(H_2O)_2Cl_2]$	54.64	67.16	47.13	54.19	38.,23	48.45	38.02	45.61
$[Co(C_{19}H_{24}N_2)(H_2O)_2Br_2]$	48.13	55.25	48..08	51.63	35.91	42.61	36.58	44.15
$[Co(C_{19}H_{24}N_2)(H_2O)_2SO_4]$	58.41	69.70	55.51	58.47	41.27	49.51	42.13	53.02

*Bacterial growth

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