

**Research Article****Copper(II) Complexes of a Phthalimide Mannich Base (2-dimethylaminomethyl)isoindoline-1,3-dione: Synthesis and Spectral, Thermal and Electrochemical Studies**M.Yosuva Suvaikin<sup>1\*</sup>, A.Sabastiyam<sup>2</sup>, C.Kalaivanan<sup>3</sup> and C.Muthukumar<sup>4</sup><sup>1</sup>Department of Chemistry, Urumu Dhanalakshmi College, Tiruchirappalli-620019, India<sup>2</sup>Department of Chemistry, Shivani Engineering College, Tiruchirappalli-620009, India<sup>3</sup>Department of Chemistry, Mahendra College of Engineering, Salem – 636106, India<sup>4</sup>Department of Chemistry, JJ College of Arts and Science, Pudukkottai-622022, India**Abstract**

The coordination chemistry of Mannich bases has been a subject of investigation by many researchers. Mannich bases possess a wide range of pharmacological uses viz. antibacterial, antifungal, antimalarial, cytotoxic etc. activities. In the present study the Mannich base 2-(dimethylaminomethyl)isoindoline-1,3-dione and its complexes with copper(II) have been synthesized and characterized. Their structures have been established on the basis of analytical, magnetic, conductance, IR, electronic and EPR spectral data. 2-(Dimethylaminomethyl)-isoindoline-1,3-dione (DMID) is found to act as a neutral bi-dentate ligand coordinating to the metal ion through a carbonyl oxygen and tertiary amino nitrogen atoms. The non-electrolytic nature of the

complexes is evidenced by their low molar conductance values. On the basis of magnetic moments, electronic and EPR spectral data, the chloro and nitrate Cu<sup>II</sup> complexes are assigned an octahedral stereochemistry. The bromo and sulphato complexes are assigned pseudo tetrahedral geometry. The TG and DTA studies on the chloro and bromo complexes were undertaken. Electrochemical studies on the chloro complex of Cu<sup>II</sup> show a reversible one electron redox process. The peak current ratios  $i_{pa}/i_{pc}$  are greater than unity indicating that the electron transfer is not followed by a chemical reaction.

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**Keywords:** Mannich Base, metal complexes, geometry, thermal analysis, electrochemical study**Introduction**

Chemistry of Mannich bases and their metal complexes has become a subject of great interest due to their versatile applications [1,2]. These Mannich base complexes possess several biological properties and pharmaceutical applications [3]. Metal ion complexes of Mannich bases have been studied extensively in the recent years due to their selectivity and sensitivity towards biologically important metal ions [4-9]. Cyclic imides possess a structural feature – CO-N(R)-CO- and an imide ring which help them to be biologically active and pharmaceutically useful. Phthalimides have received much attention due to their antibacterial, antifungal, analgesic, antitumour, anxiolytic and anti HIV-1 activities [10-13]. When phthalimide is subjected to Mannich condensation, it yields Mannich bases which may display more potent biological activities [14-17] and pharmaceutical uses. In view of these facts and in continuation of our earlier work [18, 19] on Mannich base complexes, we report herein the synthesis, spectral characterization, thermal and electrochemical studies on copper(II) complexes with 2-(dimethylaminomethyl)isoindoline-1,3-dione.

**Experimental****Materials and Reagents**

Reagents used such as formaldehyde, dimethylamine, phthalimide, various metal salts, other reagents and solvents were used analytical grade Merck products. They were used as such without further purification. Elemental (C, H, N)

analyses were performed using Carlo Erba 1108 CH analyzer and Coleman N analyzer. The molar conductivities of the metal complexes were measured in  $\sim 10^{-3}$  M DMF solutions at room temperature using Systronics direct reading conductivity meter 304. Infrared spectra of the synthesized compounds were recorded on a Perkin Elmer 337 FT-IR spectrophotometer in the form of KBr pellets. The UV-visible absorption spectra of the compounds were recorded on a Perkin Elmer EZ 301 spectrophotometer. Both  $^1\text{H}$  NMR and  $^{13}\text{C}$  NMR spectra were recorded on a JEOL GSX-400 spectrometer employing TMS as internal reference and DMSO- $d_6$  as solvent at ambient temperature. The mass spectral study of the ligand was carried out using JEOL D-300 (EI) mass spectrometer. EPR spectra were recorded with a JEOL JES-TE5 100 EPR spectrometer using polycrystalline DPPH as a standard. Electrochemical behaviour of the chloro complex was recorded on a CH instrument, U.S.A, Model 111 A- Electrochemical analyzer. Simultaneous TG/DTA patterns were recorded on a Perkin Elmer, Diamond TG/DTA Thermal analyzer. Magnetic susceptibility measurements were carried out using a Gouy magnetic balance at room temperature.  $\text{Hg}[\text{Co}(\text{SCN})_4]$  was used as a standard and diamagnetic corrections were made with Pascal's constants [20]. Wet chemical analyses for metal ions and anions (chloride, bromide and sulphate) were performed using standard methods. Nitrate was not estimated separately.

### *Synthesis of 2-(Dimethylaminomethyl) isoindoline-1,3-dione (DMID)*

2-(Dimethylaminomethyl)isoindoline-1,3-dione (DMID) is commonly known as N-(dimethylaminomethyl)phthalimide. It was synthesized by the Mannich condensation reaction of phthalimide, formaldehyde and dimethylamine at room temperature. The details of synthesis of DMID are provided elsewhere [18].

### *Synthesis of Metal Complexes*

An ethanolic solution of the Mannich base ligand DMID (0.01mol) was added to a hot ethanolic solution of the metal salt (0.01mol) taken in a 100mL beaker with constant stirring. The content of the beaker was digested on a boiling water bath for an hour. The solid product thrown out in each case was filtered, washed with ethanol and dried under vacuum in a desiccator. The metal complexes thus obtained were preserved in a vacuum desiccator.

## **Results and Discussion**

Based on analytical and spectral data, the structure of the ligand DMID has been confirmed. The analytical and spectral data obtained for the ligand are already reported by Sabastiyani and Yosuva Suvaikin [18] as given below.

**Analysis:** calculated for  $\text{C}_{11}\text{H}_{12}\text{N}_2\text{O}_2$ : C 64.70, H 5.88, N 13.72 %, Found: C 64.60, H 5.96, N 13.59 %, **FT-IR** (KBr,  $\text{cm}^{-1}$ ): 2943, 2837(C-H), 1768, 1713 (C=O), 1393, 1313 (C-N), 1158, 1089 (C-N-C);  **$^1\text{H}$  NMR** (DMSO- $d_6$ ,  $\delta$ ppm): 2.20 (s, 6H,  $\text{N}(\text{CH}_3)_2$ ), 4.39 (s, 2H, N- $\text{CH}_2$ -N), 7.89-7.40 (m, 4H, aromatic);  **$^{13}\text{C}$  NMR** (DMSO- $d_6$ ,  $\delta$ ppm): 42.37 - 39.21(m, 2C,  $\text{N}(\text{CH}_3)_2$ ), 59.89 (s, 1C, N- $\text{CH}_2$ -N), 123.12 (m, 4C, aromatic), 134.48 -131.48 (m, 2C, aromatic bridgehead), 168.86 (s, 2C, C=O); **Mass** (m/z): 203.98 ( $\text{M}^+$  peak).

### *Characterization of Metal Complexes*

The analytical and molar conductance data of the copper (II) complexes of DMID are provided in **Table 1**. The analytical and conductance data [18] indicate that all the metal complexes synthesized are non-electrolytes. The non-electrolytic nature of the metal complexes suggests that the anions of the salts have coordinated to the metal ions.

### *Infrared Spectra*

The characteristic IR absorption bands of the  $\text{Cu}^{\text{II}}$  complexes have been compared with those of the free ligand DMID (**Table 2**) in order to get meaningful information regarding the bonding sites. In the ligand spectrum, the infrared bands observed at 1768 and  $1713\text{cm}^{-1}$  are assigned to  $\nu_{\text{CO}}$  of phthalimide moiety [21, 22]. But in the IR spectra of  $\text{Cu}^{\text{II}}$  complexes the band at  $1713\text{cm}^{-1}$  has split into two bands one at a higher position and another at a lower position

indicating the coordination of one of the two carbonyl oxygens to the  $\text{Cu}^{\text{II}}$  ion. The binding of carbonyl oxygen to the  $\text{Cu}^{\text{II}}$  ion has also been confirmed by the appearance of bands due to  $\nu_{\text{MO}}$  in the far IR region at  $556 - 528\text{cm}^{-1}$ .

**Table 1** Analytical and molar conductance data for the  $\text{Cu}^{\text{II}}$  Complexes

Compound	% Analysis Found (Calculated)					$\Lambda_{\text{M}} \text{ohm}^{-1} \text{cm}^2 \text{mol}^{-1}$
	C	H	N	M	Anion	
$\text{CuCl}_2 \cdot \text{DMID} \cdot 2\text{H}_2\text{O}$	35.28 (35.24)	4.61 (4.66)	7.42 (7.47)	46.95 (16.97)	18.99 (18.96)	22
$2\text{CuBr}_2 \cdot \text{DMID}$	21.63 (21.61)	1.99 (1.96)	4.59 (4.59)	20.85 (20.81)	45.54 (45.52)	26
$\text{Cu}(\text{NO}_3)_2 \cdot 2\text{DMID}$	44.30 (44.33)	4.08 (4.03)	14.12 (14.10)	16.01 (16.06)	--- (20.82)	18
$\text{CuSO}_4 \cdot \text{DMID}$	36.34 (36.31)	3.32 (3.30)	7.67 (7.70)	17.49 (17.48)	26.44 (26.41)	34

The ligand DMID exhibits vibrational absorption bands at  $1158$  and  $1089\text{cm}^{-1}$  which are assigned to  $\nu_{\text{CNC}}$  of the dimethylamino moiety. These bands have shifted to lower region ( $1149 - 1049\text{cm}^{-1}$ ) in the complexes indicating the coordination of the tertiary amino nitrogen atom to the  $\text{Cu}^{\text{II}}$  ion. The appearance of bands due to  $\nu_{\text{MN}}$  in the far IR region  $452 - 430\text{cm}^{-1}$  is also indication of metal-nitrogen bonding in the  $\text{Cu}^{\text{II}}$  complexes. Though the coordination of aliphatic tertiary amino nitrogen is not sterically favoured, the high electron density available on tertiary amino nitrogen favours its coordination to a metal ion when there is a possibility for chelation.

The  $\text{Cu}^{\text{II}}$  nitrate complex has shown IR absorptions in the three regions at  $1465(\nu_5)$ ,  $1384(\nu_1)$  and  $1052\text{cm}^{-1}(\nu_2)$  suggesting unidentate nitrate coordination. But the  $\text{Cu}^{\text{II}}$  sulphate complex absorbs at  $1149$ ,  $1107\text{cm}^{-1}(\nu_3)$ ;  $715$ ,  $639$ ,  $613\text{cm}^{-1}(\nu_4)$ ; at  $885(\nu_1)$  and at  $554(\nu_2)$  suggesting chelating bidentate coordination. In the case of metal chloro complexes, observation of absorptions at  $360 - 340\text{cm}^{-1}$  points to the binding of chloro group to the metal ion.

**Table 2** Infrared Spectral data of DMID and its  $\text{Cu}^{\text{II}}$  Complexes

Compounds	$\nu_{\text{C=O}}$	$\nu_{\text{C=N}}$	$\nu_{\text{C-N-C}}$	$\nu_{\text{M-O}}$	$\nu_{\text{M-N}}$	$\nu_{\text{M-X}}$
DMID( $\text{C}_{11}\text{H}_{12}\text{N}_2\text{O}_2$ )	1768, 1713	1393, 1313	1158, 1089	--	--	--
$\text{CuCl}_2 \cdot \text{DMID} \cdot 2\text{H}_2\text{O}$	1634	1395	1103	556	439	342
$2\text{CuBr}_2 \cdot \text{DMID}$	1745, 1633, 1607	1383	1137, 1087, 1049	528	442	317
$\text{Cu}(\text{NO}_3)_2 \cdot 2\text{DMID}$	1731, 1602	1383	1143, 1087, 1052	542	430	--
$\text{CuSO}_4 \cdot \text{DMID}$	1730, 1631	1384	1149, 1108	554	452	--

### Electronic Spectral and Magnetic data

The colours, magnetic moments and electronic spectral data of the  $\text{Cu}^{\text{II}}$  complexes are summarized in **Table 3**. The electronic spectra of chloro and nitrate  $\text{Cu}^{\text{II}}$  complexes display absorption bands in the regions  $9152 - 9176$ ,  $12866 - 10096$ ,  $15395 - 14970$  and  $\sim 25000\text{cm}^{-1}$ , which may be assigned to  ${}^2\text{B}_{1g} \rightarrow {}^2\text{A}_{1g}$ ,  ${}^2\text{B}_{1g} \rightarrow {}^2\text{B}_{2g}$ ,  ${}^2\text{E}_g \rightarrow {}^2\text{T}_{2g}$  and charge transfer transitions respectively. These indicate distorted octahedral geometry of chloro and nitrate complexes of  $\text{Cu}^{\text{II}}$  ion. The magnetic moment values (1.80 and 1.93 BM) are also supportive of the octahedral symmetry. A very high  $\mu_{\text{eff}}$  value for the sulphate complex of  $\text{Cu}^{\text{II}}$  (2.09 BM) suggests pseudo-tetrahedral stereochemistry of  $\text{Cu}^{\text{II}}$  sulphate complex and a very low  $\mu_{\text{eff}}$  value for the  $\text{Cu}^{\text{II}}$  bromo complex (0.79 BM) which is much lower than the spin only value is attributed to anti-ferromagnetic[23-25] interaction between the two  $\text{Cu}^{\text{II}}$  ions and suggest the pseudo-tetrahedral geometry.

### Electron Paramagnetic Resonance Study

The EPR spectrum of the bromo complex of Cu<sup>II</sup> shows one intense absorption band in the high field region and is isotropic due to tumbling motion of the molecules. The hyperfine splitting has been lost due to intermolecular interactions or due to spin exchange interactions. The  $g_{\parallel} > g_{\perp} > 2.0023$  suggesting that the unpaired electron lies predominantly in the  $d_x^2-d_y^2$  orbital and the  $g_{\parallel}$  values of these complexes are less than 2.30 indicating the covalent[26-27] nature of the metal-ligand bonding (**Table 4**). The axial symmetry parameter  $G$  which is a measure of interaction between the metal centres in the crystalline solid is less than 4 for chloro, nitrate and sulphato complexes of Cu<sup>II</sup> indicating considerable coupling and appreciable misalignment of the tetragonal axes leading to exchange interaction of free electron between copper centres in the solid state [28].

**Table 3** Electronic Spectral data and Magnetic Moment Values of Complexes

Compound	Colour & Magnetic Moment (B.M)	Coordination Environment	Absorption maxima (cm <sup>-1</sup> )	Transition Assignment	LFSE (kcal mol <sup>-1</sup> )
CuCl <sub>2</sub> .DMID.2H <sub>2</sub> O	Dark green (1.80)	[CuO <sub>3</sub> NCl <sub>2</sub> ]	9152 12866 15395 25460	<sup>2</sup> B <sub>1g</sub> → <sup>2</sup> A <sub>1g</sub> <sup>2</sup> B <sub>1g</sub> → <sup>2</sup> B <sub>2g</sub> <sup>2</sup> E <sub>g</sub> → <sup>2</sup> T <sub>2g</sub> CT	26.39
2CuBr <sub>2</sub> .DMID	Greenish blue (0.79)	[CuOBr <sub>2</sub> Cu] [CuNBr <sub>2</sub> Cu]	8868 10096 12195 31624	<sup>2</sup> B <sub>1g</sub> → <sup>2</sup> A <sub>1g</sub> <sup>2</sup> B <sub>1g</sub> → <sup>2</sup> B <sub>2g</sub> <sup>2</sup> E <sub>g</sub> → <sup>2</sup> T <sub>2g</sub> CT	13.93
Cu(NO <sub>3</sub> ) <sub>2</sub> .2DMID	Parrot green (1.93)	[CuO <sub>4</sub> N <sub>2</sub> ]	9176 12854 14970 26075	<sup>2</sup> B <sub>1g</sub> → <sup>2</sup> A <sub>1g</sub> <sup>2</sup> B <sub>1g</sub> → <sup>2</sup> B <sub>2g</sub> <sup>2</sup> E <sub>g</sub> → <sup>2</sup> T <sub>2g</sub> CT	25.66
CuSO <sub>4</sub> .DMID	Apple green (2.09)	[CuO <sub>3</sub> N]	8422 10081 11793 28660	<sup>2</sup> B <sub>1g</sub> → <sup>2</sup> A <sub>1g</sub> <sup>2</sup> B <sub>1g</sub> → <sup>2</sup> B <sub>2g</sub> <sup>2</sup> E <sub>g</sub> → <sup>2</sup> T <sub>2g</sub> CT	20.21

**Table 4** EPR Spectral Parameters for Cu<sup>II</sup> Complexes of DMID at RT and LNT

Complex	$g_{\parallel}$	$g_{\perp}$	$g_{av}$	$G$	$g_{iso}$
CuCl <sub>2</sub> .DMID.2H <sub>2</sub> O(RT)	2.264	2.199	2.221	1.329	--
2CuBr <sub>2</sub> .DMID (LNT)	--	--	--	--	2.074
Cu(NO <sub>3</sub> ) <sub>2</sub> .2DMID(RT)	2.247	2.183	2.205	1.354	--
Cu(NO <sub>3</sub> ) <sub>2</sub> .2DMID(LNT)	2.264	2.104	2.157	2.582	--
CuSO <sub>4</sub> .DMID(LNT)	2.256	2.105	2.155	2.495	--

### Thermal Study

Thermal studies (TG/DTA) (**Table 5**) have been carried out to understand the thermal stabilities and thermal decomposition patterns of the halo complexes. The TG/DTG and TG/DTA patterns of CuCl<sub>2</sub>.DMID.2H<sub>2</sub>O are shown as representative cases in **Figure 1a and 1b**. The ligand DMID is a thermally stable compound. It undergoes rapid decomposition and weight loss with two different rates as shown by the DTG peaks centered at 179 and 216.5°C and

also the exothermic DTA peak found at 180.80°C indicating the breaking of bonds and decomposition of the ligand molecule.

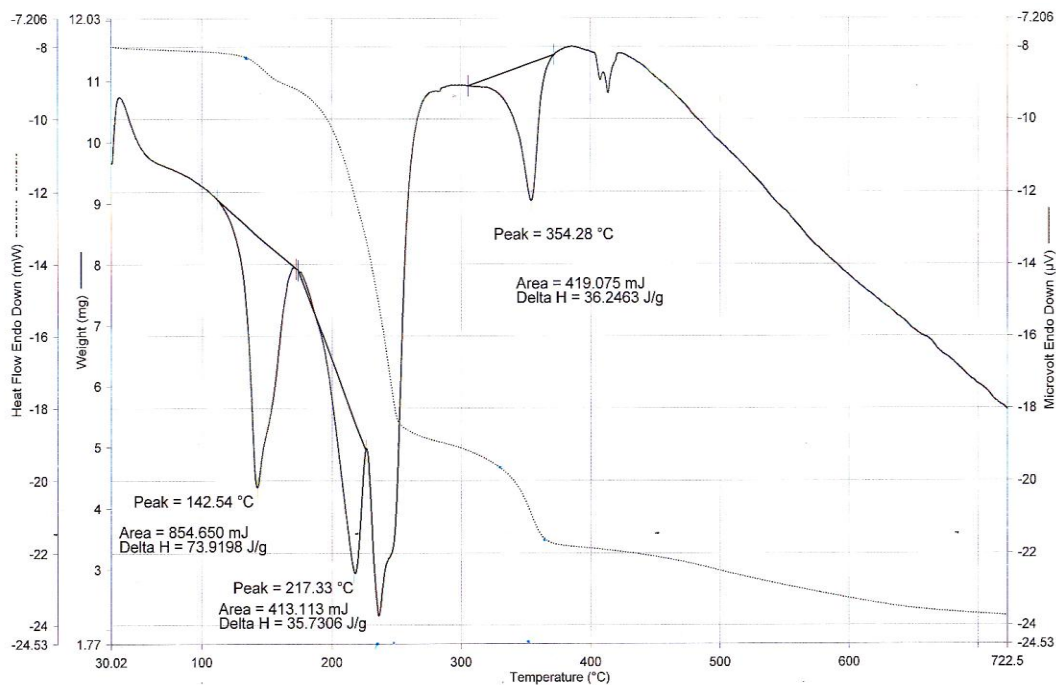


Figure 1a. TG/DTA Pattern of  $\text{CuCl}_2 \cdot \text{DMID} \cdot 2\text{H}_2\text{O}$

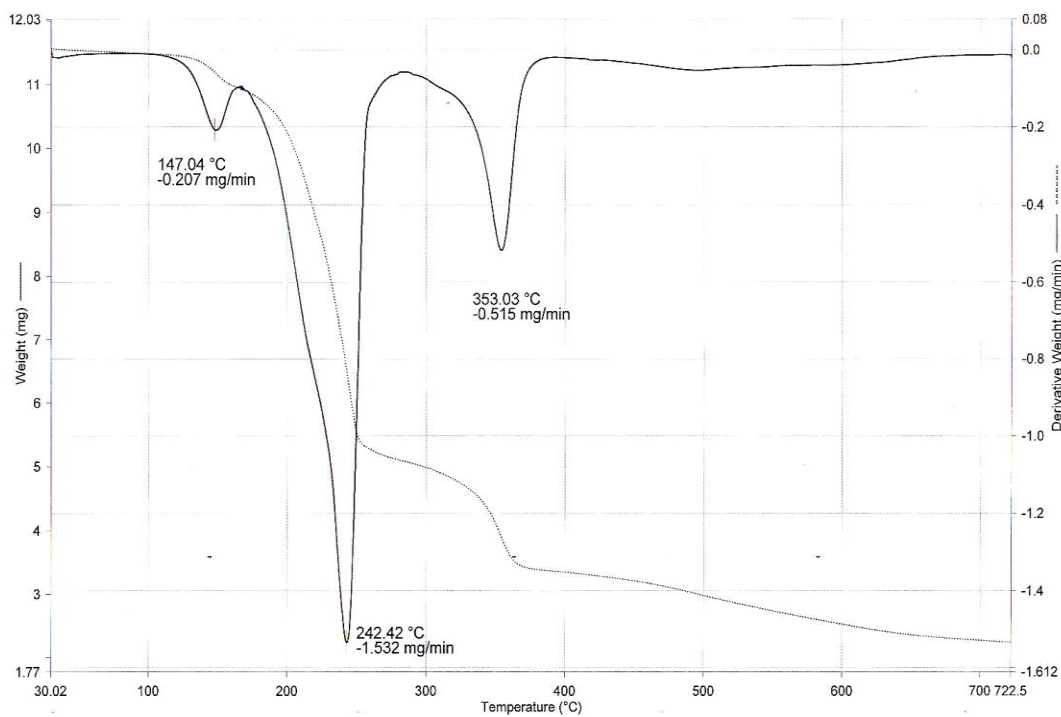


Figure 1b. TG/DTG Pattern of  $\text{CuCl}_2 \cdot \text{DMID} \cdot 2\text{H}_2\text{O}$

The  $\text{CuCl}_2 \cdot \text{DMID} \cdot 2\text{H}_2\text{O}$  complex is stable upto  $130^\circ\text{C}$ . An endotherm observed at  $142.5^\circ\text{C}$  shows the loss of coordinated water to give the anhydrous complex. Decomposition of the anhydrous complex occurs in the range  $165-250^\circ\text{C}$  which involves the elimination of ligand DMID to form an intermediate  $\text{CuCl}_2$ . When heated in the range  $340-360^\circ\text{C}$ , the  $\text{CuCl}_2$  decomposes to form the final residue  $\text{CuO}$ . The conversion of  $\text{CuCl}_2$  into  $\text{CuO}$  is evidenced by an endothermic DTA peak found at  $354.3^\circ\text{C}$ . Thus the chloro complex shows a three stage thermal decomposition.

The  $2\text{CuBr}_2 \cdot \text{DMID}$  complex is stable upto  $169.4^\circ\text{C}$ . The weight loss in the ranges  $170-210^\circ\text{C}$  signifies the loss of the organic ligand DMID to produce an intermediate of  $\text{CuBr}_2$ . The elimination of the ligand is also evidenced by the endothermic DTA peak at  $205.8^\circ\text{C}$ . The  $\text{CuBr}_2$  intermediate undergoes a slow decomposition above  $500^\circ\text{C}$  to form the final residue  $\text{CuO}$ .

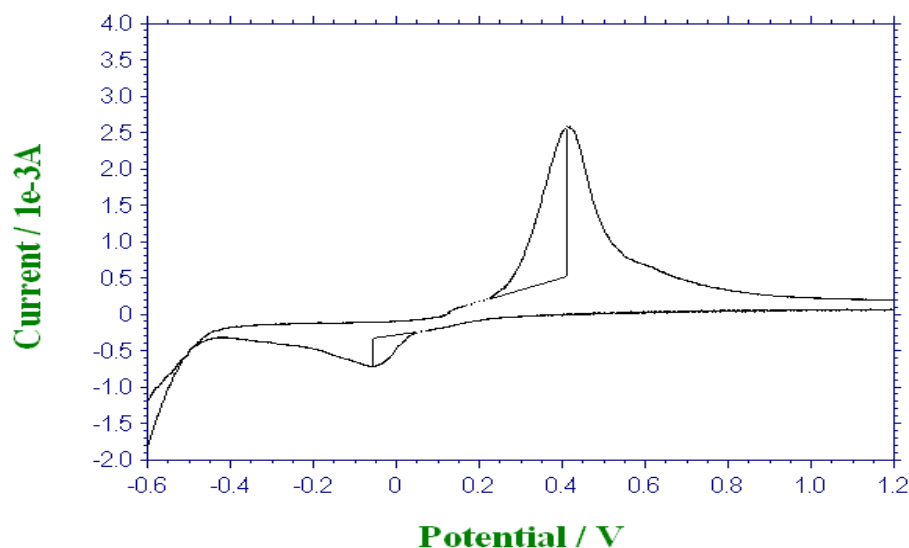
**Table 5** TG/DTG/DTA Data for DMID and its  $\text{Cu}^{\text{II}}$  Complexes

Compound	Stable upto ( $^\circ\text{C}$ )	Stage	Decomposition Temperature		Nature of Transformation/ Intermediate Formed % mass found(Calc.)	Nature of DTA peak and Temp. ( $^\circ\text{C}$ )	DTG peak Temp. ( $^\circ\text{C}$ )	
			Initial ( $^\circ\text{C}$ )	Final ( $^\circ\text{C}$ )				
DMID	133.8	I	-	-	Phase transformation	51.44 Endo	-	
			-	-	Melting point	77.77 Endo	-	
			134	220	Decomposition of the organic ligand DMID. No final residue	180.08 Exo	179.0 216.5	
$\text{CuCl}_2 \cdot \text{DMID} \cdot 2\text{H}_2\text{O}$	130.0	I	130	165	Loss of coordinated water to form the anhydrous complex	142.54 Endo	147.04	
			165	250	Elimination of organic ligand to form $\text{CuCl}_2$ as intermediate	93.1(91.46) 42.0(37.0)	217.33 Endo 240.0 Endo	242.42
			340	360	Decomposition of $\text{CuCl}_2$ to form $\text{CuO}$	29.0(27.6) 354.3 Endo	353.0	
$2\text{CuBr}_2 \cdot \text{DMID}$	170	I	170	260	Loss of organic ligand to form $\text{CuBr}_2$ as an intermediate	205.76 Endo	204.1 252.29	
			380	700	Conversion of $\text{CuBr}_2$ into $\text{CuO}$	23.8(24.4)	- 396.13	

Exo = exothermic, Endo = endothermic, Temp = Temperature

### Electrochemical Studies on $\text{CuCl}_2 \cdot \text{DMID} \cdot \text{H}_2\text{O}$

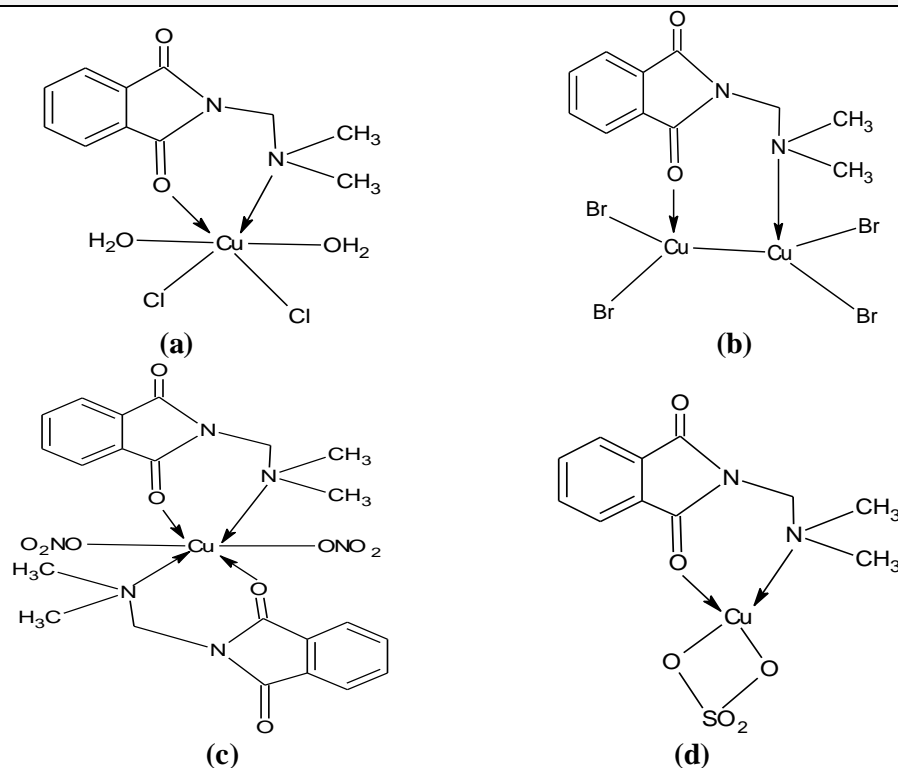
The cyclic voltammograms of  $\text{CuCl}_2 \cdot \text{DMID} \cdot 2\text{H}_2\text{O}$  have been measured at different scan rates (50, 250 and  $500\text{mVs}^{-1}$ ). The typical voltammogram of  $\text{CuCl}_2 \cdot \text{DMID} \cdot 2\text{H}_2\text{O}$  at scan rate  $250\text{mVs}^{-1}$  is shown in **Figure 2**. The redox properties are listed in **Table 6**. At the scan rates of 50, 250 and  $500\text{mVs}^{-1}$  the voltammograms feature the reduction of copper(II) to copper(I) at cathodic peak potentials of  $-0.0037$ ,  $-0.0553$  and  $-0.0874\text{V}$  respectively versus  $\text{Ag}/\text{Ag}^+$ . The separations between the anodic and cathodic peak potentials ( $\Delta E_p$ ) are 39, 47, 48mV at 50, 250 and  $500\text{mVs}^{-1}$  respectively. The number of electrons transferred in the redox process for the reversible couple is determined using



**Figure 2** Cyclic Voltammogram of  $\text{CuCl}_2 \cdot \text{DMID} \cdot 2\text{H}_2\text{O}$  at the Scan Rate of  $250 \text{ mVs}^{-1}$

**Table 6** Redox Properties of  $\text{CuCl}_2 \cdot \text{DMID} \cdot 2\text{H}_2\text{O}$  at Various Scan Rates

Scan rate	$E_{pa}$ (V)	$E_{pc}$ (V)	$\Delta E_p$ (mV)	$E_{1/2}$ (V)	$i_{pa}$ ( $\mu\text{A}$ )	$i_{pc}$ ( $\mu\text{A}$ )	$i_{pa}/i_{pc}$
50	0.3862	-0.0037	39	0.1912	1330	212.3	6.265
250	0.4145	-0.0553	47	0.1796	2607	694.7	3.753
500	0.3922	-0.0874	48	0.1524	2218	670.1	3.310



**Figure 3** Proposed Structures of Complexes (a)  $\text{CuCl}_2 \cdot \text{DMID} \cdot 2\text{H}_2\text{O}$ , (b)  $2\text{CuBr}_2 \cdot \text{DMID}$ , (c)  $\text{Cu}(\text{NO}_3)_2 \cdot 2\text{DMID}$ , (d)  $\text{CuSO}_4 \cdot \text{DMID}$

the relationship  $\Delta E_p = 0.059/n$ . The values of  $\Delta E_p$  indicate reversible one-electron redox process. The voltammetric  $E_{1/2}$  values (or the formal  $E^0$ ) taken as the average of  $E_{pc}$  and  $E_{pa}$  at the scan rates of 50, 250, 500  $mVs^{-1}$  are 0.1912, 0.1796 and 0.1524V respectively indicating that the present complex can not undergo easy reduction at a more positive potential as the better  $\sigma$ -donating ability of the chelating (N,O) Mannich base DMID would tend to stabilize copper(II) ion in the complex. The peak current ratios  $i_{pa}/i_{pc}$  are greater than unity at all the scan rates (50, 250 and 500  $mVs^{-1}$ ) pointing to the fact that EC mechanism is followed.

## Conclusion

The Mannich base ligand (DMID) and its  $Cu^{II}$  metal complexes have been synthesized and characterized by elemental analysis, IR, NMR, electronic, mass and EPR spectra, conductivity and magnetic measurements. The IR studies indicate that the ligand involves in bidentate coordination through the dimethylamino nitrogen atom and one of the two carbonyl oxygen atoms. On the basis of electronic, EPR and magnetic moment data, distorted octahedral geometry is assigned to the chloro and nitrate complexes of  $Cu^{II}$  and pseudo tetrahedral geometry is proposed to the bromo and sulphato complexes of  $Cu^{II}$  (**Figure 3**). The TG/DTA and DTG studies have been undertaken to find out the thermal stability, mode of decomposition, the compositions of the intermediates and the final residues. Electrochemical studies of the chloro complex of  $Cu^{II}$  indicate a reversible one-electron redox process and also show that the present complex can not undergo easy reduction.

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