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Synthesis and Reactivity in Inorganic and Metal-Organic Chemistry

Publication details, including instructions for authors and subscription information: <u>http://www.tandfonline.com/loi/lsrt19</u>

Synthesis and characterization of Mixed-Ligand Complexes of Cu(II), Ni(II), Co(II), Zn(II), Sm(III), and U(VI)O₂, with a Schiff Base Derived from the Sulfa Drug Sulfamerazine and 2,2'-Bipyridine

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To cite this article: R. C. Maurya , P. Patel & S. Rajput (2003) Synthesis and characterization of Mixed-Ligand Complexes of Cu(II), Ni(II), Co(II), Zn(II), Sm(III), and U(VI)O₂, with a Schiff Base Derived from the Sulfa Drug Sulfamerazine and 2,2[']-Bipyridine, Synthesis and Reactivity in Inorganic and Metal-Organic Chemistry, 33:5, 801-816, DOI: <u>10.1081/</u><u>SIM-120021647</u>

To link to this article: http://dx.doi.org/10.1081/SIM-120021647

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SYNTHESIS AND REACTIVITY IN INORGANIC AND METAL-ORGANIC CHEMISTRY Vol. 33, No. 5, pp. 801–816, 2003

Synthesis and Characterization of Mixed-Ligand Complexes of Cu(II), Ni(II), Co(II), Zn(II), Sm(III), and U(VI)O₂, with a Schiff Base Derived from the Sulfa Drug Sulfamerazine and 2,2'-Bipyridine

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ABSTRACT

A new series of novel mixed-ligand complexes of Cu(II), Ni(II), Co(II), Zn(II), Sm(III) and U(VI)O₂ with the Schiff base derived from salicylaldehyde and the sulfa drug sulfamerazine, [N-(salicylidene)-sulfamerazine] (LH) and the heterocyclic base 2,2'-bipyridine (bpy) have been synthesized and characterized by IR, NMR, diffuse reflectance spectra and magnetic, thermal, and molar conductance measurements. The coordination by the azomethine nitrogen is inferred by the downfield shifting of the -CH=N- signal in the NMR spectra and the shift of v(C=N) to lower frequencies by 15–40 cm⁻¹ in the IR spectra upon complexation.

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DOI: 10.1081/SIM-120021647 Copyright © 2003 by Marcel Dekker, Inc. 0094-5714 (Print); 1532-2440 (Online) www.dekker.com

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Conductance measurements confirm the non-electrolytic nature of these complexes. The presence of lattice and coordinated water molecules are indicated by thermograms of the complexes. The general compositions of the complexes were found to be $[M(L)(bpy)(OAc)(H_2O)]$ (where M = Cu(II), Ni(II), Co(II) or Zn(II) and HOAc = acetic acid) and $[Sm(L)(bpy)(OAc)_2(H_2O) \cdot 2H_2O]$ and $[UO_2(L)(bpy)(OAc)(H_2O) \cdot H_2O]$.

Key Words: Schiff base; Sulfa drug; Sulfamerazine; Bipyridine; Cu(II); Ni(II); Co(II); Zn(II); Sm(III); U(VI)O₂ mixed ligand complexes.

INTRODUCTION

A large number of mixed-ligand complexes involving heterocyclic bases such as pyridine, 2,2'-bipyridine, *o*-phenanthroline, etc. were reported by many workers^[1-3] due to their bio-inorganic applications and thermal stability. Studies of formation constants of mixed-ligand systems [M(A)(L'), where A = 2,2'-bipyridine or 2,2'-bipyridylamine and L' = amino acids have been carried out by earlier workers.^[4-7] Schilt and Fritsch^[8] prepared a series of neutral, mixed-ligand complexes of the type (M(B)₂(NCS)₂], where M = Fe(II), Co(II), Ni(II), Cu(II) or Zn(II) and B = a heterocyclic base. Dutta and De^[9] isolated solid, mixed-ligand complexes of copper(II) containing 2,2'-bipyridine as primary ligand and glycine or alanine as secondary ligands. A new series of eight mixed-ligand complexes of Cu(II), and Co(II) with Schiff bases, viz., 2-hydroxybenzalidene-anthranilic acid or 2-hydroxybenzalidene-2-aminothiophenol and 2- or 3-pyrazoline-5-one derivatives have been reported by Maurya et al.^[10]

Chaturvedi et al. reported potentiometric and biocidal studies of some mixed-ligand complexes of transition metals with N-pyridylanthranillic acid and some bidentate ligands.^[11] Complexes of thorium(IV) with heterocyclic bases were reported by Manhas et al.^[12] Copper(II) and zinc(II) complexes of some bisheterocycles, viz., 2-[[5-substituted-1,3,4-oxadiazole-2-yl)-thio]-methyl]-1H-benzimidazole, 2-[[5-substituted-4-amino1,2,4-triazol-3-yl)-thio]methyl]-1H-benzimidazole and 2-[[5-substituted-1,3,4-thiadiazole-2-yl)-thio]methyl]-1H-benzimidazole as fungicides have been studied by Mishra et al.^[13] It appears that the heterocycles, which have been observed to be least biologically active, showed enhanced activities upon complexation.

EXPERIMENTAL

Materials

Salicylaldehyde, 2,2'-bipyridine, sulfamerazine (Sisco Chem. Industry, Bombay), Cu(OOCCH₃)₂·H₂O, Ni(OOCCH₃)₂·4H₂O, Co(OOCCH₃)₂·4H₂O,

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 $Zn(OOCCH_3)_2 \cdot 2H_2O$ and $UO_2(OOCCH_3)_2 \cdot 2H_2O$ (E. Merck); and Sm-(OOCCH₃)₃· $3H_2O$ (Indian Rare Earth Ltd.), DMF (Sisco), ethanol and other solvents of A.R. grade were used as received.

Synthesis of Schiff Base Ligand

A hot ethanolic solution (20 mL) of salicylaldehyde (50 mmol, 6.100 g, 5.32 mL) was added to a hot methanolic solution (25 mL) of sulfamerazine (50 mmol, 13.215 g). This mixture was then refluxed on a water bath for 4-5 h. A coloured solid mass separated out on cooling which was filtered, washed several times with ethanol, diethyl ether and, subsequently, dried over solid CaCl₂ in a desiccator. The purity of the ligand was checked by TLC. The ligand is insoluble in non-polar solvents, viz., acetone, alcohol, and benzene and soluble in polar solvents like DMF and DMSO. Yield, 14.7 g (80%).

Synthesis of Mixed-Ligand Complexes

A solution of the Schiff base ligand (5 mmol, 1.840 g) in the minimum quantity (~30 mL) of DMF was mixed with a solution of 2,2'bipyridine (5 mmol, 0.780 g) in 20 mL ethanol. The resulting solution was refluxed with stirring on a magnetic stirrer equipped with heater for 2 h. Subsequently, an ethanolic solution (~40 mL) of the metal acetate (5 mmol) [0.995 g of Cu(OOCCH₃)₂·H₂O; 1.244 g of Ni(OOCCH₃)₂·4H₂O; 1.100 g of Zn(OOCCH₃)₂·2H₂O; 1.245 g of Co(OOCCH₃)₂·4H₂O; 1.906 g of Sm(OOCCH₃)₃·3H₂O or 2.120 g of UO₂(OOCCH₃)₂·2H₂O] was added drop-wise with stirring and the mixture was refluxed for 4 h on a heating mantle. The bright-coloured mixed-ligand complexes separated out on cooling, were filtered by suction, washed with ethanol and diethyl ether and dried in vacuo over anhydrous CaCl₂. The yields of the complexes were 60–70% with respect to ligand.

RESULTS AND DISCUSSION

Composition and Characterization of the Ligand

The sulfa drug based Schiff base ligand [N-(salicylidene)-sulfamerazine] (LH) was prepared as shown in Figure 1.

The composition of the ligand is consistent with the microanalytical data (Table 1). The ¹H NMR spectrum of LH is given in Figure 2, along with the assignments of the various protons. The formation of this Schiff base ligand is revealed by the appearance of the azomethine proton (-CH=N-) signal at 8.96 ppm.^[14] This is further supported by the appearance of a band for v(C=N)(azomethine)^[15] at 1590 cm⁻¹ in the IR



N-(salicylidene)-sulfamerazine (LH)

Figure 1. Synthesis of the Schiff base ligand.

spectrum of the ligand. The ligand also exhibits a signal for the phenolic (OH) proton at 12.55 ppm and NH proton at 11.81 ppm.^[16] The aromatic proton signals appear as a multiplet at 6.90 to 8.33 ppm.

Composition and Characterization of the Metal Complexes

The mixed-ligand metal complexes of LH and 2,2'-bipyridine were prepared according to the following equations:

$$\begin{array}{l} M(OOCCH_3)_2 \cdot nH_2O + LH + bpy \\ \xrightarrow{\text{Ethanol}-DMF}_{\text{Reflux}} & +[M(L)(bpy)(OAc)(H_2O)] + (n-1)H_2O + CH_3COOH \end{array} \tag{1}$$

Where, M = Cu(II), n = 1 (1); Ni(II), n = 4 (2); Co(II), n = 4 (3); Zn(II), n = 2 (4)

 $Sm(OOCCH_3)_3 \cdot 3H_2O + LH + bpy$

$$\frac{\text{Ethanol-DMF}}{\text{Reflux}} [\text{Sm}(L)(\text{bpy})(\text{OAc})_2(\text{H}_2\text{O}) \cdot 2\text{H}_2\text{O} (\textbf{5}) \text{CH}_3\text{COOH} (2)]$$

$$UO_2(OOCCH_3)_2 \cdot 2H_2O + LH + bpy$$
(3)

$$\frac{\text{Ethanol-DMF}}{\text{Reflux}} \quad [\text{UO}_2(L)(\text{bpy})(\text{OAc})(\text{H}_2\text{O})] \cdot \text{H}_2\text{O} \text{ (6) CH}_3\text{COOH}$$

| Complexes | of | Sulfamerazine |
|-----------|----|---------------|
|-----------|----|---------------|

| | | | I able 1. FIIJS | ical cnaracteri | sucs and | microan | alyucal c | lata of LH and 1 | the mixe | d-ligand c | omplexes | | |
|---|-----------|--------------|--|---------------------|---------------|--------------|-----------|----------------------------|-------------------|------------------|----------------|------------------|------------------|
| | | | Compound | | Deco. | | | | | | Found (| calc.), % | |
| | Sr. no | | (empirical formula) (F. W.) | Color | temp. (°C) | Yield (%) | C.N. | μ _{eff} (B.M.) | Λ_{M}^{a} | C | Н | z | М |
| | 1 | | LH (C ₁₈ H ₁₆ N ₄ O ₃) (368) | Orangish- vellow | 285 | 80 | I | I | I | 58.12 (58.47) | 4.55 (4.33) | 15.49 (15.15) | I |
| | (I) | () | [Cu(L)(bpy)(OAc)(H ₂ O)] (C ₃₀ H ₂₈ CuN ₆ O ₆ S) (663 54) | Green- gold | 300 | 65 | 9 | 1.80 | 10.7 | 54.01 (54.12) | 4.16 (4.20) | 12.43 (12.62) | 9.41 (9.55) |
| | (2) | 5) | (Data):24) [Ni(L)(bpy)(OAc)(H ₂ O)] (C ₃₀ H ₂₈ NiN ₆ O ₆ S) (658.69) | Terracotta | 320 | 68 | 9 | 3.13 | 8.2 | 54.42 (54.51) | 3.99 (4.24) | 12.58 (12.72) | 8.64 (8.89) |
| | (3) | 3) | $[Co(L)(bpy)(OAc)(H_2O)] (C_{30}H_{28}CoN_6O_6S) (658.93) (658.93)$ | Yellow gold | 310 | 70 | 9 | 4.91 | 11.8 | 54.23 (54.49) | 4.01 (4.23) | 12.68 (12.71) | 8.75 (8.92) |
| | (4) | 4 | [Zn(L)(bpy)(OAc)(H ₂ O)] (C ₃₀ H ₂₈ N ₆ O ₆ SZn) (665.39) | Lemon yellow | 320 | 64 | 9 | Diamagnetic | 10.2 | 53.86 (53.97) | 4.02 (4.19) | 12.47 (12.59) | 9.63 (9.80) |
| | (2) | (i) | [Sm(L)(bpy)(OAc) ₂ - (H ₂ O)]-2H ₂ O (C ₃₂ H ₃₅ N ₆ O ₁₀ SmS) (845.36) | Olive Green | 340 | 60 | 2 | 1.67 | 10.6 | 45.01 (45.33) | 3.98 (4.13) | 9.62 (9.91) | 17.21 (17.75) |
| 270 N | 9 | 9 | [UO ₂ (L)(bpy)(OAc)- (H ₂ O)]·H ₂ O (C ₃₀ H ₃₀ N ₆ O ₉ SU) (888.02) | Reddish brown | 320 | 68 | × | Diamagnetic | 9.8 | 40.15 (40.46) | 3.03 (3.37) | 9.28 (9.44) | 26.57 (26.75) |
| Marcel Dekker, Inc. Iadison Avenue, New York, New York 10016 | | Ohm. | ⁻¹ cm ² mole ⁻¹ . | | | | | | | | | | |



Figure 2. ¹H NMR spectrum of the Schiff base ligand HL.

Some physical properties such as melting points, % yields, colours, etc. of the complexes are given in Table 1. The complexes were characterized by the following physical studies.

Infrared Spectra

The important IR spectral bands of the Schiff base ligand LH and its metal complexes are given in Table 2. The ligand LH contains five potential donor sites: 1) the phenolic oxygen, 2) the azomethine nitrogen, 3) the sulfonamide oxygen, 4) the sulfonamide nitrogen and 5) the ring nitrogen. In the IR spectrum of this ligand a sharp band observed at 1590 cm⁻¹ is assigned to the v(C=N)^[15] mode of the Schiff base and medium-broad bands observed at 3540 and 3030 cm⁻¹ are due to v(O–H) phenolic and v(NH) stretching, respectively.^[17] Evidence of nitrogen bonding of the azomethine (C=N) group to the central metal ion stems from the shift of the v(C=N) frequency to lower frequencies by 15–40 cm⁻¹ in all of the

| | Table 2. | Important IR | spectral data (| cm^{-1}) of LH | and its mix | ted-ligand | netal comp | lexes with | bpy. | |
|------------|--|----------------------|------------------------|----------------------------|-------------|------------|-----------------|--------------------|-------------|---------------------------------|
| Sr. no. | Compound | v(O-H) (phenolic) | v(C=N) (azomethine) | v(C-O) (phenolic) | v(M-O) | v(M-N) | v(O-H) water | v(N-H) | v(=N-) | Hetero- cyclic base (bpy) |
| Ξ | LH | 3540 br | 1550 s 1550 s | 1480 m 1450 m | - 540 w | | - 3460 br | 3030 br 3060 br | - 1505 m | - 150 w |
| 9 3 | [Cu(L)(0P3)- (OAc)(H ₂ O)] [Ni(L)(bpv)- | | 1560 s | 1460 m | 510 w | 405 w | 3380 br | 3080 br | 1590 s | 445 w |
| <u>(</u>) | (OAc)(H ₂ O)] [Co(L)(bpy)- | I | 1560 s | 1465 m | 520 w | 420 w | 3380 br | 3070 br | 1585 m | 460 w |
| (| (OAc)(H ₂ O)] [Zn(L)(bpy)- | I | 1560 s | 1440 m | 520 w | 420 w | 3360 br | 3020 br | 1577 m | 465 w |
| 3 | (OAc)(H ₂ O)] [Sm(L)(bpy)(OAc) ₂ - | I | 1550 s | 1450 m | 560 w | 440 w | 3380 br | 3050 br | 1595 s | 460 w |
| 9 | (H ₂ O)]·2H ₂ O [UO ₂ (L)(bpy)(OAc)- | I | 1575 s | 1450 m | 520 w | 410 w | 3450 br | 3050 br | 1590 s | 440 w |
| | (H_2O) J \cdot H_2O | | | | | | | | | |

complexes.^[18] This is further confirmed by the appearance of new bands at $405-440 \text{ cm}^{-1}$ due to the $v(M-N)^{[19]}$ band.

The coordination through the phenolic oxygen after deprotonation is revealed by the disappearance of the v(OH) phenolic band at 3540 cm^{-1} and the appearance of a band due to v(C-O) phenolic at much lower frequencies $(1440-1465 \text{ cm}^{-1})^{[20]}$ in all the complexes as compared to that of the ligand at 1480 cm⁻¹. This is further confirmed by the appearance of a new nonligand band at 510–560 cm⁻¹ due to $v(M-O)^{[20]}$ in all the complexes. The bands in the ligand due to $v_{as}(SO_2)$ and $v_s(SO_2)$ appear at 1340 and 1155 cm⁻¹, respectively. These remain almost unchanged in the complexes, indicating that this group is not participating in coordination.^[21] This is supported by the unchanged v(S-N) and v(C-S) modes appearing at 965 cm^{-1} and 845 cm^{-1} , respectively, in the ligand after complexation.^[22] The band due to v(=N-) ring appearing at 1565 cm⁻¹ in the Schiff base, does not show any appreciable change in the complexes. In some complexes this mode seems to be merged with the v(C=N) azomethine band, which is indicated by the appearance of a broad band in this region. This suggests that the ring nitrogens of the ligand are not taking part in coordination.^[23] In all the complexes the lattice/coordinated^[24] water molecules are indicated by the appearance of a broad band in the region 3350-3460 cm⁻¹. The coordination of an acetato group in all the complexes is indicated by the appearance of two new bands in the regions 1606-1660 and 1320-1360 cm^{-1} assignable to $v_{as}(COO)$ and $v_s(COO)$ modes, respectively. The value of $\Delta v = v_{as}(COO) - v_s(COO) = 286 - 300 \text{ cm}^{-1}$ suggests the unidentate coordination of the acetato group.^[25] In the uranium complex (6) two additional sharp bands are observed at 940 and 820 cm⁻¹, which are assigned to $v_{as}(UO_2)$ and $v_s(UO_2)$ modes, respectively. This observation suggests that the O=U=O moiety is virtually linear in this complex.^[26] The IR spectra of all the complexes show a change in the ring (=N-) nitrogen frequencies of the 2,2'-bipyridine (bpy). The bands in bpy at 1570 and 415 cm⁻¹ have shifted to higher frequencies at 1577–1595 cm⁻¹ and 440–465 cm⁻¹, respectively, in all the complexes. This suggests that both nitrogens of bipy are coordinated to the metal ion.^[27] A new band in the region 210-250 cm⁻¹ due to v(M-N) of bpy further confirms its bidentate coordination to the metal centre.

Conductance Measurements

The observed molar conductances ($\Lambda_{\rm M} = 8.2-11.8 \text{ ohm}^{-1}\text{cm}^2 \text{ mole}^{-1}$) of all the complexes in 10^{-3} M DMF solutions are given in Table 1. This suggests the non-electrolytic nature of these complexes.^[28]

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Magnetic Susceptibility Measurements

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The room temperature magnetic moment values of the complexes are given in Table 1. The magnetic moment value of 1.80 B.M. measured for the copper complex (1) lies in the range expected for a d⁹ system, which contains one unpaired electron with octahedral geometry.^[29] The measured value of 3.13 B.M. for the nickel complex (2) suggests octahedral geometry for this complex.^[30] The observed magnetic moment of 4.91 B.M. is consistent with a high-spin octahedral cobalt(II) complex.^[30] The room temperature magnetic moment value (1.67 B.M.) of the samarium complex (5) is consistent with the presence of five unpaired electrons and indicates only slight participation of 4f electrons in bonding.^[31] The Zn(II) and $UO_2(VI)$ complexes were found to be diamagnetic as expected.

¹H NMR Spectra

Proton NMR spectra of the ligand LH (Figure 2) and the [Zn(L)- $(bpy)(OAc)(H_2O)$ complex (Figure 3) were recorded in DMSO-d₆. The absence of the phenolic (OH) proton signal (at 12.55 ppm in the ligand



¹H NMR spectrum of $[Zn(L)(bpy)(OAc)(H_2O)]$ (4). Figure 3.

LH) in the Zn complex indicates the coordination by phenolic oxygen to the metal ion after deprotonation.^[37] The coordination of the azomethine nitrogen is inferred by the downfield shifting of the -CH=N- proton signal from 8.96 ppm in the ligand to 9.8 ppm in the complex.^[16] The aromatic proton signals and $-CH_3$ proton signal are seen at 6.8–8.4 ppm and 2.32 ppm, respectively. The ¹H NMR spectra of these two compounds, along with the assignment of proton signals, are given in Figures 2 and 3.

Electronic Spectra

The diffuse reflectance spectra of a few representative compounds were recorded in the wave length range 260 to 800 nm. Compound (2) exhibits five absorption maxima (Figure 4) at 274, 314, 338, 406 and 545 nm. The first three absorption maxima are most probably due to $n \rightarrow \sigma^*$, $\pi \rightarrow \pi^*$ and $n \rightarrow \pi^*$ intraligand transitions, respectively. Considering the high intensity of the fourth band at 406 nm, it may be assigned as ligand \rightarrow metal charge transfer transition The last absorption maximum at 545 nm is due to a d-d transition assignable to ${}^{3}A_{2g}(F) \rightarrow {}^{3}T_{1g}(F)$. This suggests an octahedral^[32] stereochemistry around the nickel(II) ion. The diffuse reflectance spectrum of compound (6) displays three spectral bands at 265, 342 and 480 nm. These are assigned to $\pi \rightarrow \pi^*$ and $n \rightarrow \pi^*$ and ${}^{1}\sum_{g}{}^{+} \rightarrow {}^{3}\pi_{u}$ transitions,^[33] respectively. The last one of the transition is typical of the O=U=O symmetric stretching frequency of the first excited state.^[3] The diffuse reflectance spectrum (Figure 4) of the Sm(III) complex



Figure 4. Diffuse reflectance spectrum of [Ni(L)(bpy)(OAc)(H₂O)] (2).

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(5) displays three absorption bands in the visible region at 505, 692 and 716 nm. These are assigned to ${}^{6}\text{H}_{5/2} \rightarrow {}^{4}\text{F}_{9/2}$, ${}^{6}\text{H}_{5/2} \rightarrow {}^{6}\text{P}_{5/2}$, ${}^{6}\text{H}_{5/2} \rightarrow {}^{4}\text{I}_{13/2}$, respectively.^[34]

Thermogravimetric Analysis

The TG curves of two representative compounds, [Sm(L)(bpy)(OAc)₂-(H₂O)·2H₂O and [UO₂(L)(bpy)(OAc)(H₂O)·H₂O, were recorded in the temperature range from ambient to 810 °C at a heating rate of 15 °C /min. The TG curve of the compound (5) shows a first weight loss at 116 °C of 4.0% (calc. 4.1%) corresponding to two lattice water molecules.^[35] The second weight loss at 142 °C was observed to be 2.5% (calc. 2.2%) corresponding to the elimination of one coordinated water molecule.^[36] The dehydrated compound is stable up to 322 °C and shows a sudden weight loss of 34% (calc. 34.5%), which may be due to removal of two acetato groups and one 2,2'-bipyridine molecule in the temperature range 322-390 °C. At subsequent higher temperatures the TG curve consists of greatly overlapped decomposition steps which prevent the accurate correlation of these steps with the proper decomposition products. The TG curve of complex (6) shows a first weight loss of 2.0% (calc. 2.02%) at 110 °C due to elimination of one lattice water^[35] molecule. It shows a further weight loss of 2.4% (calc. 2.6%) at 143 °C corresponding to removal of one coordinated water^[36] molecule. The third weight loss of 7.0% (calc. 6.9%) was observed at 290 °C and may be due to loss of one acetato group from the coordination sphere. The fourth weight loss of



M = Cu(II) (1), Ni(II) (2), Co(II) (3), Zn(II) (4), OAc = CH₃COO

Figure 5. Suggested structure of [M(L)(bpy)(OAc)(H₂O)].

20% (calc. 19.6%) in the temperature range 290-416 °C may be due to the elimination of one bpy molecule. The following equations represent these processes:

$$[UO_{2}(L)(bpy)(OAc)(H_{2}O) \cdot H_{2}O \xrightarrow[-H_{2}O]{110 °C} [UO_{2}(L)(bpy)(OAc)(H_{2}O)]$$

$$(4)$$

$$[\mathrm{UO}_{2}(\mathrm{L})(\mathrm{bpy})(\mathrm{OAc})(\mathrm{H}_{2}\mathrm{O})] \xrightarrow[-\mathrm{H}_{2}\mathrm{O}]{} [\mathrm{UO}_{2}(\mathrm{L})(\mathrm{bpy})(\mathrm{OAc})]$$
(5)

$$[UO_2(L)(bpy)(OAc)] \xrightarrow[-OAc]{290 °C} [UO_2(L)(bpy)]$$
(6)

$$[\mathrm{UO}_{2}(\mathrm{L})(\mathrm{bpy})(\mathrm{OAc})] \xrightarrow[-\mathrm{bpy}]{290-416\ ^{\circ}\mathrm{C}} [\mathrm{UO}_{2}(\mathrm{L})]$$

$$(7)$$

CONCLUSIONS

From the satisfactory analytical data, magnetic studies, conductance measurements, thermal and various spectral studies it is concluded that the metal: ligand stoichiometric ratio is 1:1 in all the complexes. The general compositions of the transition metal complexes are $[M(L)(bipy)-(OAc)(H_2O)$ (where M = Cu(II), Ni(II), Co(II) or Zn(II) and OAc = CH_3-COO) and the complexes derived from the inner transition metals have the composition $[Sm(L)(bipy)(OAc)_2(H_2O)\cdot 2H_2O]$ and $[UO_2(L)(bipy)-(OAc)(H_2O)\cdot H_2O]$. The overall spectral studies indicate that the Schiff



Figure 6. Suggested structure of $[Sm(L)(bpy)(OAc)_2(H_2O)] \cdot 2H_2O$ (5).

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Figure 7. Suggested structure of $[UO_2(L)(bpy)(OAc)(H_2O)] \cdot H_2O$ (6).

base ligand behaves in a monobasic bidentate (O,N) manner. The proposed structures of the synthesized complexes are shown in Figures 5, 6 and 7.

ACKNOWLEDGMENTS

The authors are thankful to Professor S. D. Tripathi, Vice-Chancellor of this University, for encouragement, and Professor K. K. Mishra, Head, Department of Chemistry, for laboratory facilities and helpful discussions. Analytical facilities provided by the Central Drug Research Institute, Lucknow, India, and the Regional Sophisticated Instrumentation Centre, Indian Institute of Technology, Chennai, India, are gratefully acknowledged.

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Received August 17, 1998 Accepted January 31, 2003 Referee I: F. T. Greenaway Referee II: R. A. Faltynek

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