ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

# Synthesis and Characterization of 2-( (7-hydroxy-5-methoxy-2-methyl-4-oxo-4H-chromen-6-yl) methylene )hydrazine-1-carbothioamide Metal Complexes and their Investigation as Antibacterial and Antifungal Agents.

**Ahmed MA El-Seidy**[a,b,*] **, Mohamad ME Shakdofa** [a, c]**, and Hanan A Mousa**[a.]

[a] Inorganic Chemistry Department, National Research Centre, P.O. 12622 Dokki, Giza, Egypt
[b] Chemistry Department, Faculty of Science, The Imam Muhammad bin Saud Islamic University, PO Box 5701, Riyadh 11432, Saudi Arabia.
[c] Department of Chemistry, Faculty of Science and Arts, Khulais, University of Jeddah, Saudi Arabia

## ABSTRACT

A novel ligand $H_4L$, 2-((7-hydroxy-5-methoxy-2-methyl-4-oxo-4H-chromen-6-yl)methylene) hydrazine-1-carbothioamide was synthesized and was used to synthesis new Cu(II), VO(II), Co(II), Mn(II), Ni(II) and Zn(II) complexes. Structures were determined using analytical and spectroscopic methods including NMR, IR, UV–vis and ESR. The results showed that the ligand has low to moderate activity, while Metal complexes were moderately active, except for Zn complex, which showed the maximum activity.

**Keywords:** Antibacterial, Antifungal, IR, Schiff base, Metal Complexes.

***Corresponding author***

## INTRODUCTION

Schiff base ligands gain their importance from their ability to coordinate to metal with various oxidation state, their low-cost, their synthetic flexibility, selectivity and their ease of synthesis [1]. Many Schiff bases metal complexes have been reported to possess antifungal, antitumor and anticancer activities [2, 3]. Ligands possessing nitrogen and sulfur attracted special attention because their complexes have superior properties such as semiconducting behavior and molecular magnetism [4, 5]. The catalytic activities of this class of compounds, especially those complexes with O, N and S donor atoms, were also investigated in homogeneous and heterogeneous catalysis. These catalytic reactions include olefins hydrogenation, amino groups transformation and alcohols oxidation [6, 7]. These complexes are used also in toxic metal collecting and metal corrosion inhibitions in acidic media [8]. Many zinc, cobalt, copper and Ni(II) complexes showed potent antibacterial, anticancer and antifungal drugs [9]. The biological activity of many drugs increased on coordination with metals. In current work, we report the synthesis and characterization of $H_4L$ and its complexes and their pharmacological screening.

## MATERIALS

All of the used reagents were of the best grade and were used without further purification.

### Experimental

The ligands and its metal complexes were analyzed for C, H, N, S, Cl and metal contents at the Microanalytical Laboratory, Faculty of Science, Cairo University, Egypt**.** Analytical and physical data of the ligands and their metal complexes are reported. IR spectra of the ligands and their metal complexes were measured using KBr discs with a Jasco FT/IR 300E Fourier transform infrared spectrophotometer covering the range 400-4000 $cm^{-1}$ and in the 500-100 $cm^{-1}$ region using polyethylene-sandwiched Nujol mulls on a Perkin Elmer FT-IR 1650 spectrophotometer. Electronic spectra of the ligands and their complexes were obtained in Nujol mulls using a Shimadzu UV–240 UV–Vis recording spectrophotometer. Magnetic susceptibilities were measured at 25°C by the Gouy method using mercuric tetrathiocyanatocobaltate(II) as the magnetic susceptibility standard. Diamagnetic corrections were estimated from Pascal's constant [10]. $^1H$ and $^{13}C$ NMR spectra were obtained on Brucker Avance 600-DRX spectrometers. Chemical shifts (ppm) are reported relative to TMS. The magnetic moments were calculated from the equation: $\mu_{\text{eff.}} = 2.84\sqrt{\chi_{M}^{\text{corr}}.T}$. ESR measurements of solid complexes at room temperature were made using a Varian E-109 spectrophotometer, with DPPH as a standard material.

### The ligand, $H_4L$

3 drops of glacial acetic acid were added to the hot (78° C) methanol solution (150 mL) of 7-hydroxy-5-methoxy-2-methyl-4-oxo-4H-chromene-6-carbaldehyde (2.57 g, 10.97 mmol) and reflux for 5 m, then hot (60° C) methanol solution (80 mL) of hydrazinecarbothioamide (1.00 g, 10.97 mmol) was added slowly over 10 mine with stirring. The solvent was then evaporated to 110 mL. The ligand was filtered off, washed with methanol and dried in oven (60° C) for 4 h. then in a vacuum desiccator over $P_4O_{10}$ (2.45 g, 74% yield), Figure 1. UV: 274, 280, 286, 312, 318, 324, 336, 343, 349, 400, 456. 1H NMR (600 MHz, DMSO): δ = 11.46 (s, 1H, H(25)), 10.55 (s, 1H, H(22)), 8.54 (s, 1H, H(34)), 8.22 and 7.99 (s, 1H, H(23) and s, 1H, H(24)), 6.75 (s, 1H, H(33)), 6.00 (s, 1H, H(32)), 3.75 (s, 3H, H(26-28)) and 2.25 (s, 3H, H(29-31)). 13C NMR (600 MHz, DMSO): 178.11 C(2), 175.46 C(9), 164.62 C(11), 161.08 C(13), 153.67 C(15), 141.76 C(6), 111.50 C(10), 111.29 C(8), 111.18 C(12), 100.67 C(14), 63.55 C(19) and 19.76 C(21). IR (KBr): (OH) 3284 (s), (NH/NH2) 3151-2998 (s), (C=N) 1652 (s), (C=O) 1630 (s), (C-O) 1219 (m), (N-N) 1110 (m), (C=S) 1056 (m). Elemental analysis for C13H13N3O4S (307.32): Found (calcd) %C 50.89 (50.81), %H 4.37 (4.26), %N 13.72 (13.67), %S 10.39 (10.43).

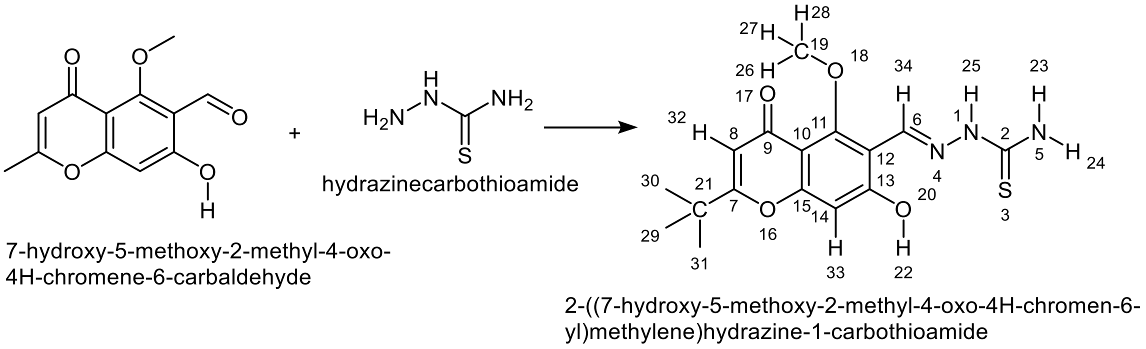


**Figure 1: Preparation of the ligand $H_4L$**

**Metal complexes**

**$[H_3LCu(H_2O)_2(CH_3COO)].H_2O$, complex 2:**

Hot (60° C) methanol solution (50 mL) of $Cu(CH_3COO)_2.H_2O$ (0.32 g, 1.63 mmol) was dropwise added with stirring over 20 m. to hot ethanol (70° C) solution (70 mL) of $H_4L$ (0.50 g, 1.63 mmol) and reflux for 3.0 h. The solvent was evaporated to 80 mL then the precipitate was filtered off, washed with methanol and dried in oven (60 °C) for 4 h. then in a vacuum desiccator over $P_4O_{10}$ (0.62 g, 79% yield). Conductance $\Lambda_m$: 12 $\Omega^{-1}cm^2mol^{-1}$. UV-Vis (Nujol mul (nm)): $\lambda$ = 296, 314, 340, 400, 426, 520, 606 nm. Magnetic moments: 1.99 B.M. ESR: $g_\parallel$ = 2.27, $g_\perp$= 2.049, $g_{iso}$= 2.122, G= 5.732, $g_\parallel/A_\parallel$= 174. IR (KBr): $\nu(H_2O)$ 3371-3309 (s), $\nu(NH/NH_2)$ 3153-2967 (s), $\nu$(C=N) 1642 (m), $\nu$(C=O) 1630 (s), $\nu$(C-O) 1231 (m), v(N-N) 1122 (m), $\nu$(C=S) 1045 (w), $v_{asym.}(COO^-)$ 1339 $cm^{-1}$, $v_{sym.}(COO^-)$ 1551 $cm^{-1}$, $\nu$(M-N) 439, $\nu$(M-O) 561. TGA (found (Calc., temp.): 1 $H_2O$ 3.79 (3.73, 86 °C), 2 $H_2O$ 7.60 (7.46, 137 °C), 1 $CH_3COOH$ 12.19 (12.43, 310 °C), CuO 16.36 (16.47, 490 °C). Elemental analysis for $C_{15}H_{21}CuN_3O_9S$ (482.95): Found (calcd) %C 30.23 (37.31), %H 4.44 (4.38), %N 8.81 (8.70), %Cu 13.22 (13.16), %S 6.53 (6.64).

**$[H_4LCu(H_2O)Cl_2].2H_2O$, complex 3:**

Hot (60° C) methanol solution (45 mL) of $CuCl_2.2H_2O$ (0.31 g, 1.79 mmol) was dropwise added with stirring over 20 m. to hot ethanol (70° C) solution (70 mL) of $H_4L$ (0.55 g, 1.79 mmol) and reflux for 2.5 h. A few drops of trimethyl amine were added to allow precipitation. The solvent was evaporated to 75 mL then and the precipitate was filtered off, washed with methanol and dried in oven (50 °C) for 2 h. then in a vacuum desiccator over $P_4O_{10}$ (0.56 g, 68% yield). Conductance $\Lambda_m$: 22 $\Omega^{-1}cm^2mol^{-1}$. UV-Vis (Nujol mul (nm)): $\lambda$ = 295, 312, 333, 362, 388, 400, 410, 540, 612 nm. Magnetic moments: 1.95 B.M. ESR: $g_\parallel$ = 2.25, $g_\perp$= 2.054, $g_{iso}$= 2.119, G= 4.79, $g_\parallel/A_\parallel$= 181. IR (KBr): $\nu(H_2O)$ 3390-3350 (s), $\nu$(OH) 3260 (br), $\nu(NH/NH_2)$ 3160-3000 (s), $\nu$(C=N) 1635 (m), $\nu$(C=O) 1629 (s), $\nu$(C=S) 1028 (w), $\nu$(C-O) 1235 (m), v(N-N) 1124 (m), $\nu$(M-N) 441, $\nu$(M-O) 556, , v(M-Cl) 334. TGA (found (Calc., temp.): 2 $H_2O$ 7.67 (7.8, 79 °C), **1** $H_2O$ 4.00 (3.92, 137 °C), 2 Cl atom 15.54 (15.42, 230 °C), CuO 17.24 (17.30, 510 °C). Elemental analysis for $C_{13}H_{15}Cl_2CuN_3O_5S$ (459.79): Found (calcd) %C 33.81 (33.96), %H 3.45 (3.29), %N 9.08 (9.14), %Cl 15.57 (15.42), %Cu 13.94 (13.82), %S 6.88 (6.97).

**$[H_4LCd(H_2O)(CH_3COO)_2].3H_2O$, complex 4:**

Hot (60° C) methanol solution (60 mL) of $Cd(CH_3COO)_2\cdot 2H_2O$ (0.39 g, 1.46 mmol) was dropwise added with stirring over 25 m. to hot ethanol (70° C) solution (65 mL) of $H_4L$ (0.45 g, 1.46 mmol) and reflux for 3.0 h. The solvent was evaporated to 75 mL then and the precipitate was filtered off, washed with methanol and dried in oven (40 °C) for 1 h. then in a vacuum desiccator over $P_4O_{10}$ (0.69 g, 77% yield). Conductance $\Lambda_m$: 17 $\Omega^{-1}cm^2mol^{-1}$. UV-Vis (Nujol mul (nm)): $\lambda$ = 261, 303, 385, 398, 595 nm. IR (KBr): $\nu(H_2O)$ 3460-3340 (s), $\nu$(OH) 3272 (br), $\nu(NH/NH_2)$ 3148-2928 (s), $\nu$(OH) 3272 (m), $\nu$(C=N) 1636 (sh), $\nu$(C=O) 1628 (s), $\nu$(C-O) 1225 (m), v(N-N) 1119 (m), $\nu$(C=S) 1020 (w), $v_{asym.}(COO^-)$ 1342 $cm^{-1}$, $v_{sym.}(COO^-)$ 1553 $cm^{-1}$, v(M-N) 437, v(M-O) 571. TGA (found (Calc., temp.): 3 $H_2O$ 8.69 (8.86, 89 °C), 1 H2O 3.01 (2.95, 141 °C), 2 $CH_3COOH$ 19.77 (19.69, 310 °C), CdO 21.19 (21.05, 550 °C). Elemental analysis for $C_{17}H_{27}CdN_3O_{12}S$ (609.88): Found (calcd) %C 33.39 (33.48), %H 4.27 (4.46), %N 6.73 (6.89), %S 5.19 (5.26).

**[$H_3LCo(H_2O)(CH_3COO)$].3$H_2O$, complex 5:**

Hot (60° C) methanol solution (80 mL) of $Co(CH_3COO)_2.4H_2O$ (0.49 g, 1.95 mmol) was dropwise added with stirring over 30 m. to hot ethanol (70° C) solution (85 mL) of $H_4L$ (0.60 g, 1.95 mmol) and reflux for 3.0 h. The solvent was evaporated to 90 mL then and the precipitate was filtered off, washed with methanol and dried in oven (40 °C) for 1 h. then in a vacuum desiccator over $P_4O_{10}$ (0.69 g, 77% yield). Conductance $_m$: 9 $^{-1}$cm$^2$mol$^{-1}$. UV-Vis (Nujol mul (nm)):  = 264, 296, 332, 400, 406, 424, 512, 854 nm. Magnetic moments: 4.81 B.M. IR (KBr): ($H_2O$) 3470-3345 (s), ($NH/NH_2$) 3191-3010 (s), (C=N) 1647 (m), (C=O) 1631 (s), (C=S) 1027(w), $\nu_{asym.}(COO^-)$ 1344 cm$^{-1}$, $\nu_{sym.}(COO^-)$ 1556, (C-O) 1230 (m), ν(N-N) 1124 (m), ν(M-N) 435, ν(M-O) 557. TGA (found (Calc., temp.): 2 $H_2O$ 7.15 (7.26, 86 °C), 2 $H_2O$ 7.32 (7.26, 156 °C), 1 $CH_3COOH$ 12.21 (12.09, 301 °C), CoO 15.24 (15.09, 575 °C). Elemental analysis for $C_{15}H_{23}CoN_3O_{10}S$ (496.35): Found (calcd) %C 36.21 (36.30), %H 4.60 (4.67), %N 8.56 (8.47), %Co 11.69 (11.87), %S 6.52 (6.46).

**[$H_3LMn(H_2O)_2(CH_3COO)$].2$H_2O$, complex 6:**

Hot (60° C) methanol solution (45 mL) of $Mn(CH_3COO)_2\cdot 4H_2O$ (0.38 g, 1.56 mmol) was dropwise added with stirring over 20 m. to hot ethanol (70° C) solution (67 mL) of $H_4L$ (0.48 g, 1.56 mmol) and reflux for 3.0 h. The solvent was evaporated to 80 mL then and the precipitate was filtered off, washed with methanol and dried in oven (60 °C) for 3 h. then in a vacuum desiccator over $P_4O_{10}$ (0.58 g, 75% yield). Conductance $_m$: 15 $^{-1}$cm$^2$mol$^{-1}$. UV-Vis (Nujol mul (nm)):  = 292, 362, 376, 444, 462, 550 nm. Magnetic moments: 5.09 B.M. IR (KBr): ($H_2O$) 3355-3332 (s), ($NH/NH_2$) 3180-2937 (s), (C=N) 1649 (m), (C=O) 1630 (s), (C=S) 1018 (w), $\nu_{asym.}(COO^-)$ 1334 cm$^{-1}$, $\nu_{sym.}(COO^-)$ 1547 cm$^{-1}$, (C-O) 1227 (m), ν(N-N) 1117 (m), ν(M-N) 450, ν(M-O) 563. TGA (found (Calc., temp.): 2 $H_2O$ 7.41 (7.32, 77 °C), 2 $H_2O$ 7.23 (7.32, 144 °C), 1 $CH_3COOH$ 12.34 (12.20, 294), MnO 14.53 (14.41, 490 °C). Elemental analysis for $C_{15}H_{23}MnN_3O_{10}S$ (492.36): Found (calcd) %C 36.41 (36.59), %H 4.82 (4.71), %N 8.67 (8.53), %Mn 11.00 (11.16), %S 6.39 (6.51).

**[$H_4LNi(H_2O)_2(CH_3COO)_2$].$H_2O$, complex 7:**

Hot (60° C) methanol solution (60 mL) of $Ni(CH_3COO)_2.4H_2O$ (0.43 g, 1.72 mmol) was dropwise added with stirring over 20 m. to hot ethanol (75° C) solution (75 mL) of $H_4L$ (0.53 g, 1.72 mmol) and reflux for 3.0 h. The solvent was evaporated to 90 mL then and the precipitate was filtered off, washed with methanol and dried in oven (80 °C) for 3 h. then in a vacuum desiccator over $P_4O_{10}$ (0.74 g, 83% yield). Conductance $_m$: 11 $^{-1}$cm$^2$mol$^{-1}$. UV-Vis (Nujol mul (nm)):  = 268, 296, 306, 310, 388, 400, 562, 815 nm. Magnetic moments: 3.14 B.M. IR (KBr): ($H_2O$) 3456-3370 (s), (OH) 3285 (s), ($NH/NH_2$) 3180-2928 (s), (C=N) 1649 (m), (C=O) 1630 (s), (C-O) 1220 (m), ν(N-N) 1124 (m), (C=S) 1019 (w), $\nu_{asym.}(COO^-)$ 1339 cm$^{-1}$, $\nu_{sym.}(COO^-)$ 1553 cm$^{-1}$, ν(M-N) 451, ν(M-O) 548. TGA (found (Calc., temp.): 1 $H_2O$ 3.52 (3.46, 80 °C), 2 $H_2O$ 6.81 (6.93, 135 °C), 2 $CH_3COOH$ 22.97 (23.09, 308 °C), 1 NiO 14.51 (14.36, 540 °C). Elemental analysis for $C_{17}H_{25}N_3NiO_{11}S$ (538.15): Found (calcd) %C 38.07 (37.94), %H 4.57 (4.68), %N 7.68 (7.81), %Ni 10.87 (10.91), %S 6.03 (5.96).

**[$H_4LV(O)(H_2O)$].$H_2O.SO_4$ , complex 8:**

Hot (60° C) methanol solution (48 mL) of $VOSO_4.H_2O$ (0.29 g, 1.59 mmol) was dropwise added with stirring over 20 m. to hot ethanol (60° C) solution (67 mL) of $H_4L$ (0.49 g, 1.59 mmol) and reflux for 3.0 h. The solvent was evaporated to 85 mL then and the precipitate was filtered off, washed with methanol and dried in oven (70 °C) for 3 h. then in a vacuum desiccator over $P_4O_{10}$ (0.52 g, 64% yield). Conductance $_m$: 115 $^{-1}$cm$^2$mol$^{-1}$. UV-Vis (Nujol mul (nm)):  = 290, 296, 300, 340, 348, 356, 386, 530, 798 nm. Magnetic moments: 1.74 B.M. IR (KBr): ($H_2O$) 3433-3313 (br), (OH) 3270 (br), ($NH/NH_2$) 3150-2982 (s), (C=N) 1647 (m), (C=O) 1630 (s), (C-O) 1238 (m), ν(N-N) 1119 (m), (C=S) 1026 (w), ν(V=O) 980(m), ($SO_4$) 1425(m), 617(m) , ν(M-N) 460, ν(M-O) 568. TGA (found (Calc., temp.): 1 $H_2O$ 3.42 (3.57, 78 °C), 1 $H_2O$ 3.70 (3.57, 143 °C), 1 sulphuric acid 19.29 (19.41, 300 °C), $V_2O_5$ 18.13 (18.00, 600 °C). Elemental analysis for $C_{13}H_{17}N_3O_{11}S2V$ (506.35): Found (calcd) %C 30.77 (30.84), %H 3.21 (3.38), %N 8.43 (8.30), %S 12.79 (12.66).

**[$H_3LZn(H_2O)_2(CH_3COO)$].3$H_2O$, complex 9:**

Hot (60° C) methanol solution (63 mL) of $Zn(CH_3COO)_2.2H_2O$ (0.37 g, 1.69 mmol) was dropwise added with stirring over 20 m. to hot ethanol (60° C) solution (71 mL) of $H_4L$ (0.52 g, 1.69 mmol) and reflux for 3.0 h. The solvent was evaporated to 80 mL then and the precipitate was filtered off, washed with methanol and dried in oven (40 °C) for 2 h. then in a vacuum desiccator over $P_4O_{10}$ (0.60 g, 68% yield). Conductance $_m$: 14 $^{-1}$cm$^2$mol$^{-1}$. UV-Vis (Nujol mul (nm)):  = 262, 295, 342, 380, 393 nm. IR (KBr): ($H_2O$) 3460-3341 (s), (NH/$NH_2$) 3182-2931 (s), (C=N) 1645 (m), (C=O) 1631 (s), (C-O) 1236 (m), ν(N-N) 1120 (m), (C=S) 1028 (w), $\nu_{asym.}$($COO^-$) 1351 cm$^{-1}$, $\nu_{sym.}$($COO^-$) 1564 cm$^{-1}$, ν(M-N) 462, ν(M-O) 581. TGA (found (Calc., temp.): 3 $H_2O$ 10.49 (10.38, 87 °C), 2 $H_2O$ 7.03 (6.92, 145 °C), 1 $CH_3COOH$ 11.44 (11.53, 320 °C), 1 ZnO 15.51 (15.63, 515 °C). Elemental analysis for $C_{15}H_{25}N_3O_{11}SZn$ (520.82): Found (calcd) %C 34.41 (34.59), %H 5.02 (4.84), %N 8.19 (8.07), %Zn 12.38 (12.55), %S 6.01 (6.16).

### In-vitro Antibacterial and Antifungal Activities

Antibacterial activity of the ligand and its metal complexes were tested against the bacterial species Staphylococcus aureus, Escherichia coli, Klebsiella pneumaniae, Proteus vulgaris and Pseudomonas aeruginosa by Kirby Bauer Disc diffusion method [11]. The ligands and complexes were also tested against the fungal species Aspergillus niger, Rhizopus stolonifer, Aspergillus flavus, Rhizoctonia bataicola and Candida albicans, cultured on potato dextrose agar medium and also performed by the disc diffusion method. Amikacin, Ofloxacin and Ciprofloxacin were used as the standard antibacterial agents whereas Nystatin was used in the technique as the standard antifungal agent. The test organisms were grown on nutrient agar medium in petri plates. The compounds were prepared in DMSO and soaked in filter paper disc of 5 mm diameter and 1 mm thickness. The discs were placed on the previously seeded plates and incubated at 37°C and the diameter of inhibition zone [12] around each disc was measured after 24 h for bacteria and 72 h for fungi.

## RESULTS AND DISCUSSION

All results were with agreement to the suggested structures Figure 2.

### Infrared spectra:

IR spectra of the prepared compounds were recorded and compared to confirm the proposed structures. Ligand behaved either as tri- or bidentate. In all complexes the signals of C=N and C=S were shifted to lower wave number (3-16 cm$^{-1}$ and 11-38 cm$^{-1}$, respectively) with an intensity decrease, indicating coordination to the central metal [13-15]. The shift of hydroxyl signal to lower wave number (12-20) in complexes 3, 4 and 8 accompanied by a decrease in intensity may be due to the coordination of the oxygen group to the central metal [16]. The monobasic nature of the ligand in case of complexes 2, 5-6 and 8-9 may be supported by the disappearance of the hydroxyl signal. In the later cases the ligand behaved in a monobasic tridentate fashion, while in the former cases it behaved as a neutral tridentate ligand. In case of complex 7, the hydroxyl signal almost retained its original position indicating the uncoordinated nature of bond. In this case the ligand behaved in a neutral bidentate fashion. The signals appearing in the 435-462 cm$^{-1}$ and 548-581 cm$^{-1}$ ranges may be due to (M-N) and (M-O) respectively [17, 18]. All complexes showed bands in the 3371-3309 cm$^{-1}$ region, which may be due to the presence of water molecules. The weak signal at 334 cm$^{-1}$ in the spectra of complex 3 may be attributed to ν(M-Cl) [19]. The spectrum of Complex 5 showed two bands at 1430 and 622 cm$^{-1}$ characteristics for the uncoordinated sulfato group [20]. The signals for (N-N) and (C-O) were shifted to higher energy which farther more support the C=N nitrogen and hydroxyl oxygen coordination to the central metal [21]. The spectra of complexes 2, 4-7 and 9 showed signals in 1547-1564 and 1334-1351 cm$^{-1}$ ranges, corresponds to $\nu_{sym.}$($COO^-$) and $\nu_{asym.}$($COO^-$), respectively with  > 210 with a characteristic band for monodentate acetate at 750 cm$^{-1}$ assigned for (COO) [20]. In the spectrum of vanadyle complex, the signal at 980 cm$^{-1}$ is assigned to ν(V=O) [22].

### Molar conductivity

The molar-conductance of all complexes, except complex 8, are in the range known for non-electrolytes. The molar-conductance of complex 8 was 115 Ω$^{-1}$ cm$^2$ mol$^{-1}$indicating its electrolyte in nature [23].

### Electronic spectra

All copper complexes showed bands in 606-612 and 520-540 nm region, and magnetic moments between 1.95-1.99 B.M. which indicate a tetragonal distorted octahedral geometry. These bands assignable to

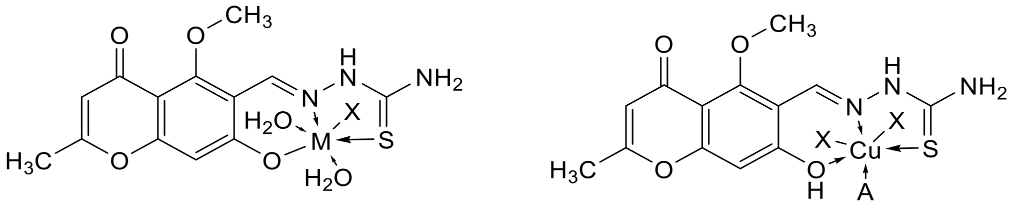
$^2B_{1g}\rightarrow{}^2E_g$ and $^2B_{1g}\rightarrow{}^2B_{2g}$ transitions, respectively [24-26]. Complex 5, showed to bands at 854 and 512 nm with a magnetic moment of 4.81 B.M. Theses bands may be attributed to $^4T_{1g}(F)\rightarrow{}^4T_{2g}(F)$ and $^4T_{1g}(F)\rightarrow{}^4T_{1g}(P)$ transitions in an octahedral geometry [27-29]. Mn(II) complex showed broad bands at 550 nm and magnetic moments of 4.09 B.M, which may indicate a high-spin $3d^5$ octahedral geometry [30]. Complex 8 showed two bands at 530 and 798 nm and a magnetic moment of 1.74 B.M. Theses transitions may be assigned to $^2B_2\rightarrow{}^2B_1$ and $^2B_2\rightarrow{}^3E$ transitions, respectively [31, 32]. The octahedral geometry of the Ni complex is supported by the d–d transitions at 562 and 815 nm assignable to $^3A_{2g}(F)\rightarrow{}^3T_{1g}(F)$ ($\upsilon_2$) and $^3A_{2g}(F)\rightarrow{}^3T_{2g}(F)$ ($\upsilon_1$) spin allowed electronic transitions and also the effective magnetic moment value (314 BM) [33, 34].

## ESR

The ESR spectra were carried out for the solid samples at room temperature. All copper complexes showed $g_{||} > g_{\perp}$, indicating a $^2B_1(d_{x2-y2})$ ground state. The value of $g_{||}$ may give information about environment surrounding copper metal. If this value is less than 2.3, the character around the metal is covalent. The value of $g_{||}$ is greater than 2.3 in all complexes, which suggests ionic characters around central metal. G value is used as indicator for exchange interaction between copper centers. The presence of Cu-Cu interaction is indicated by G value less than 4. In all copper samples the G values exceed 4, indicating the absence of copper–copper interactions [35]. All complexes showed $g||/A||$ ratio with values more than 150 indicating tetragonal geometry around metal center [36].

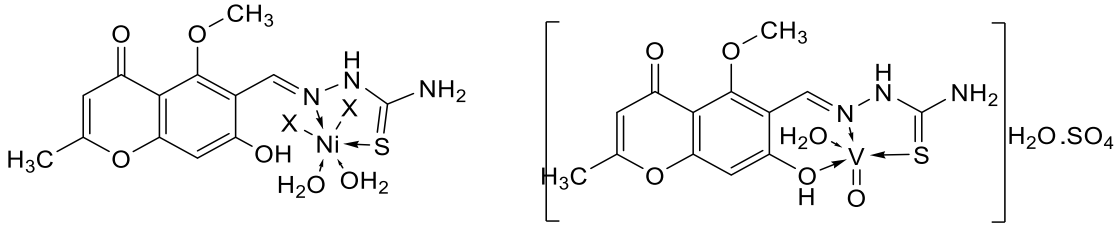
## Thermal Analysis of Metal Complexes

TGA was measured in the temperature 20–800 °C range. In all complexes the first step was the removal of lattice water, followed by losing coordinated water, losing of the anion then the organic constituents leaving the metal oxides.



Complex 2: $[H_3LCu(H_2O)_2(CH_3COO)].H_2O$, M = Cu, X = $CH_3COO$
Complex 6: $[H_3LMn(H_2O)_2(CH_3COO)].2H_2O$, M = Mn, X = $CH_3COO$
Complex 9: $[H_3LZn(H_2O)_2(CH_3COO)].3H_2O$, M = Zn, X = $CH_3COO$
Complex 5: $[H_3LCo(H_2O)_2(CH_3COO)].2H_2O$, M = Co, X = $CH_3COO$

Complex 3: $[H_4LCu(H_2O)Cl_2].2H_2O$; M = Cu, X = Cl
Complex 4: $[H_4LCd(H_2O)(CH_3COO)_2].3H_2O$, M = Ni, X = $CH_3COO$



Complex 7:$[H_4LNi(H_2O)_2(CH_3COO)_2].H_2O$, X= $CH_3COO$

Complex 8:$[H_3LV(O)(H_2O)].H_2O.SO_4$

**Figure 2: The proposed structures of metal complexes of the ligand $H_4L$**

## Antibacterial and Antifungal Screening

The in vitro biological screening effects were performed by disc diffusion method. The biological activities of all synthesized compounds were investigated against some bacterial and fungal species, table 1 and 2. The results showed that the ligand has low to moderate activity. Metal complexes were moderately active, except for Zn complex, which showed the maximum activity. The fact that the complex under study showed higher activity than their parent ligand may be explained on the basis of Overtone's concept and Tweedy's Chelation theory [37]. Metal complexes showed reactivates exceeding that of parent ligand and comparable to that obtained from standard drugs. Nickel and zinc complexes gave the best results which in some cases exceeded that of standard drugs. Complexes showed higher reactivates against bacteria that fungi.

**Table 1. Antibacterial activity of Schiff base ligands and their complexes**

| Compound | Gram positive bacteria | | | Gram negative bacteria | |
|---|---|---|---|---|---|
| | S. aureus | K. pneumaniae | P. vulgaris | E. coli | P. aeruginosa |
| H4L | + | + | + | + | + |
| [H3LCu(H2O)2(CH3COO)].H2O | ++ | + | + | + | + |
| [H4LCu(H2O)Cl2].2H2O | ++ | ++ | ++ | ++ | + |
| [H4LCd(H2O)(CH3COO)2].3H2O | ++ | ++ | ++ | ++ | + |
| [H3LCo(H2O)(CH3COO)].3H2O | ++ | ++ | ++ | ++ | ++ |
| [H3LMn(H2O)2(CH3COO)].2H2O | ++ | ++ | ++ | ++ | ++ |
| [H4LNi(H2O)2(CH3COO)2].H2O | ++ | +++ | +++ | +++ | ++ |
| [H3LV(O)(H2O)].H2O.SO4 | + | ++ | ++ | + | + |
| [H3LZn(H2O)2(CH3COO)].3H2O | ++ | +++ | ++ | +++ | ++ |
| Amikacina | ++ | ++ | +++ | +++ | ++ |
| Ofloxacina | ++ | ++ | ++ | ++ | + |
| Ciprofloxacina | ++ | ++ | ++ | +++ | ++ |

Inhibition values = 0.1~0.5 cm beyond control = + (less active); inhibition values = 0.6~1.0 cm beyond control =+ + (moderate active); inhibition values = 1.1~1.5 cm beyond control = +++ (highly active). [a] Standards.

**Table 2. Antifungal activity of Schiff base ligands and their complexes**

| Compound | A. niger | R. stolonifer | A. flavus | R. bataicola | C. albicans |
|---|---|---|---|---|---|
| $H_4L$ | + | ++ | + | + | + |
| $[H_3LCu(H_2O)_2(CH_3COO)].H_2O$ | ++ | ++ | ++ | + | + |
| $[H_4LCu(H_2O)Cl_2].2H_2O$ | + | ++ | ++ | + | + |
| $[H_4LCd(H_2O)(CH_3COO)_2].3H_2O$ | ++ | ++ | ++ | ++ | + |
| $[H_3LCo(H_2O)(CH_3COO)].3H_2O$ | ++ | ++ | ++ | ++ | ++ |
| $[H_3LMn(H_2O)_2(CH_3COO)].2H_2O$ | + | ++ | + | ++ | + |
| $[H_4LNi(H_2O)_2(CH_3COO)_2].H_2O$ | +++ | ++ | ++ | ++ | ++ |
| $[H_3LV(O)(H_2O)].H_2O.SO_4$ | ++ | ++ | + | ++ | + |
| $[H_3LZn(H_2O)_2(CH_3COO)].3H_2O$ | ++ | ++ | ++ | ++ | ++ |
| Nystatin[a] | ++ | +++ | ++ | ++ | +++ |

Inhibition values = 0.1~0.5 cm beyond control = + (less active); inhibition values = 0.6~1.0 cm beyond control = ++ (moderate active); inhibition values = 1.1~1.5 cm beyond control = +++ (highly active).

## CONCLUSION

All results indicated the tridentate nature of the ligand, except for complex 7, in which the ligand behaved as bidentate nature. The ligand behaved as natural or monobasic ligand with the deprotonation of the hydroxyl oxygen. The absence of any signal regarding SH group indicate that the ligand was present in the thioketone form. The geometries for complexes were either square pyramidal or octahedral. The results showed that the ligand has low to moderate activity, while Metal complexes were moderately active, except for Zn complex, which showed the maximum activity.

## REFERENCES

[1] M Shakir, A Abbasi, AU Khan, Khan SN. Spectrochim Acta, Part A 2011; 78: 29-35.

[2] El-Seidy AMA. Synth React Inorg Met-Org Chem 2015; 45: 437-446.

[3] AMA El-Seidy, E El-Zahany, AS Barakat, NS Youssef, SA Galal, Drweesh SA. Synth React Inorg Met-Org Chem 2013; 43: 46-56.

[4] A Kobayashi, E Fujiwara, Kobayashi H. Chem Rev 2004; 104: 5243-5264.

[5] N Robertson, Cronin L. Coord. Chem Rev 2002; 227: 93-127.

[6] S Bhunia, Koner S. Polyhedron 2011, 30: 1857-1864.

[7] D Ramakrishna, BR Bhat, Karvembu R. Catal Commun 2010; 11: 498-501.

[8] M Behpour, S Ghoreishi, N Soltani, M Salavati-Niasari, M Hamadanian, Gandomi A. Corros Sci 2008; 50: 2172-2181.

[9] M Bharty, R Dani, P Nath, A Bharti, N Singh, O Prakash, RK Singh, Butcher R. Polyhedron 2015; 98: 84-95.

[10] TM Salama, AH Ahmed, El-Bahy ZM. Microporous Mesoporous Mater 2006; 89: 251-259.

[11] DJ Blazevic, MH Koepcke, Matsen JM Am. J Clin Pathol 1972; 57: 592-597.

[12] MB Ferrari, S Capacchi, G Pelosi, G Reffo, P Tarasconi, R Albertini, S Pinelli, Lunghi P. Inorg Chim Acta 1999; 286: 134-141.

[13] K Balasubramanian, K Parameswari, V Chinnusamy, R Prabhakaran, Natarajan K. Spectrochim Acta, Part A 2006; 65: 678-683.

[14] KN Kumar, Ramesh R. Polyhedron 2005; 24: 1885-1892.

[15] H Kawabata, K Omura, T Uchida, Katsuki T. Chem Asian J 2007; 2: 248-256.

[16] S Kannan, RameshR. Polyhedron 2006; 25: 3095-3103.

[17] J M Fernndez-G, P Tepal-Snchez, Hernndez-Ortega S. J Mol Struct 2006; 787: 1-7.

[18] A Majumder, GM Rosair, A Mallick, N Chattopadhyay, Mitra S. Polyhedron 2006; 25: 1753-1762.

[19] K Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds, John Wiley & Sons, Inc., 2008, pp. 149–354.

[20] S Chandra, Gupta LK. Spectrochim Acta, Part A 2005; 61: 2549-2554.

[21] E Keskiolu, AB Gndzalp, S Cete, F Hamurcu, Erk B. Spectrochim Acta, Part A 2008; 70: 634-640.

[22] C Cai, Chen X. Spectrochim Acta, Part A 2008; 69: 592-598.

[23] A Golcu, M Tumer, H Demirelli, Wheatley RA. Inorg Chim Acta 2005; 358: 1785-1797.

[24] S Chandra, Sangeetika Spectrochim Acta, Part A 2004; 60: 2153-2162.

[25] S Chattopadhyay, MS Ray, MG Drew, A Figuerola, C Diaz, Ghosh A. Polyhedron 2006; 25: 2241-2253.

[26] Abou-Melha KS. Spectrochim Acta, Part A 2008; 70: 162-170.

[27] SI Mostafa, S Ikeda, Ohtani B. J Mol Catal A Chem Chemical 2005; 225: 181-188.

[28] K Singh, MS Barwa, Tyagi P. Eur J Med Chem2006; 41: 147-153.

[29] M Shakir, Y Azim, H-T-N Chishti, Parveen S. Spectrochim Acta, Part A 2006; 65: 490-496.

[30] A Majumder, GM Rosair, A Mallick, N Chattopadhyay, Mitra S. Polyhedron 2006; 25: 1753-1762.

[31] UB Gangadharmath, SM Annigeri, AD Naik, VK Revankar, Mahale VB. J Mol Struct 2001; 572: 61-71.

[32] TB Demirci, Y Köseoğlu, S Güner, Ülküseven B. Cent Eur J Chem 2006; 4: 149-159.

[33] GG Mohamed, M Omar, Hindy AM. Spectrochim Acta, Part A 2005; 62: 1140-1150.

[34] M Neelakantan, F Rusalraj, J Dharmaraja, S Johnsonraja, T Jeyakumar, Pillai MS. Spectrochim Acta, Part A 2008; 71: 1599-1609.

[35] NM Shauib, A-ZA Elassar, El-Dissouky A. Spectrochim Acta, Part A 2006; 63: 714-722.

[36] PA Vigato, Tamburini S. Coord Chem Rev 2004; 248: 1717-2128.

[37] N Dharmaraj, P Viswanathamurthi, Natarajan K. Transition Met Chem 2001; 26: 105-109.