IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 11, March 2025
Impact Factor: 7.67

Antifungal, Antibacterial, and Cytotoxicity Study of Transition Metal Complexes Derived from Novel Quinoline Schiff Base

Vibhute Baliram T.
MTES, Doshi Vakil Arts and G.C.U.B. Science & Commerce College, Goregaon-Raigad, Maharashtra, India
Author for Correspondence: vbtchem@gmail.com

Abstract: *The present study reports the synthesis of a new quinoline Schiff base by condensing 2-hydroxy-6-methoxyquinoline-3-carbaldehyde and Para-methylbenzenesulfonohydrazide. Prepared Schiff base was further used to form metal complexes with copper, cobalt, cadmium, and nickel, metal salts. The structure of the prepared Schiff base and its metal complexes was proved through FTIR, ^{1}H NMR, ^{13}C NMR, ESR, ESI-MS, electronic spectra, elemental analysis, and TGA. Magnetic susceptibility values indicate that Cu(II), Co(II), and Ni(II) complexes were paramagnetic. The molar conductivity values reveal that the prepared compounds are non-electrolytic. The presence of N and O donor atoms in the ligand was confirmed by FTIR data. Further, these compounds were subjected to in vitro Antifungal, Antibacterial, and Cytotoxicity activity. The results showed that most of the prepared compounds exhibited excellent cytotoxicity activity against the human lung cancer cell line (**A-549**) compared to the standard drug paclitaxel. Hence, the present study proposed that all the synthesized Schiff base metal complexes have excellent biological activity and might act as potential anticancer agents.*

Keywords: Metal complexes, ESR, ESI-MS, and Schiff base

I. INTRODUCTION

Schiff bases are significant classes of chemical compounds that coordinate with different metal ions through the azomethine nitrogen. They have been extensively considered because of their wide role in the biological system [1]. The Schiff bases containing ONO donor atoms showed important biological activity, and they help to easily bind with transition and non-transition metal ions [2, 3]. The binding of organic moieties with cobalt, copper, cadmium, and nickel showed good results in the biological field [4]. The presence of the azomethine functional group in the metal complex was found to be important for biological activity. Various azomethines were known to have important anticancer [5], antifungal [6], antibacterial [7], and diuretic activities [8].

The Schiff bases having heterocyclic moieties have been a productive area of research work for a long period, and there is enormous literature on Schiff base complexes containing heterocyclic structures [9]. Among the heterocyclic compounds, the metal complexes derived from quinoline compounds are currently attracting more attention than the Schiff bases derived from other chemical classes; this is because of wide applications of quinoline in biological and pharmaceutical activities such as cytotoxicity [10], antimicrobial [11], antitubercular [12], antioxidant [13] and DNA binding study [14].

In our previous work [15, 16, 17, 18], the ligands, (E)-N'-((2-hydroxyquinolin-3-yl) methylene)-4-methylbenzenesulfonohydrazide, (E)-N'-((2-hydroxy-6-methylquinolin-3-yl) methylene)-4-methylbenzenesulfonohydrazide, (E)-N'-((2-hydroxy-7-methylquinolin-3-yl) methylene)-4-methylbenzenesulfonohydrazide and (E)-N'-((2-hydroxy-7-methoxy lquinolin-3-yl) methylene)-4-methylbenzenesulfonohydrazide were synthesised. These ligands were further used for the preparation of metal complexes with Cu, Ni, Co, and Cd and screened for mycobacterial cytotoxicity, antifungal, antibacterial, and DNA binding studies.

DOI: 10.48175/IJARSCT-26550

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 11, March 2025 Impact Factor: 7.67

In consideration of the above facts, this work is an extension of our work, including the preparation of the new Quinoline Schiff base and its metal complexes. The prepared compounds were subjected to *in vitro* antibacterial, antifungal, and cytotoxicity studies**.**

Experimental section

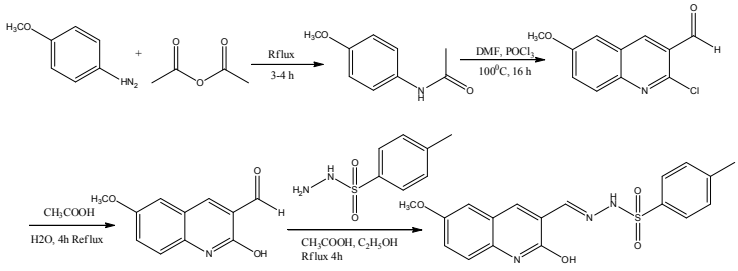
Reagents and instruments

Metal salts, primary aromatic amines, and solvents were purchased from Molychem, Mumbai (India), and Sigma Aldrich chemicals (USA). The chemicals were of analytical grade and used as pure chemicals without further purification.

^{13}C NMR and ^{1}H spectra of the ligand were recorded in d6-DMSO solvent on Bruker Avance 100 MHz and 400 MHz spectrometers, respectively, and tetramethylsilane (TMS) was used as internal standard. FTIR spectra were recorded on a Nicolet iS10, Thermo Scientific, USA spectrophotometer using KBr pellets in the range of 4000–400 cm^{-1}. Electronic spectra were recorded using a Cary 100 UV-Visible spectrophotometer. The magnetic moment was measured by the Gouy method at 25 ^{0}C temperature using the MKl Johnson Matthey model. Thermo gravimetric analysis (TGA) was performed on a Mettler-Toledo instrument at a heating range 20 ^{0}C /min with a temperature range of 25 to 1000 ^{0}C. High-resolution Mass spectra were recorded on a Waters Micromass Q-Tof Micro with electrospray ionization (ESI) and atmospheric pressure chemical ionization (APCI) sources. Molar conductance was measured on a DDS-11C type Conductivity Bridge in DMSO solution at a concentration of 10^{-3} M. The ESR spectrum of Cu (II) complex was performed on a JES-FA200 ESR Spectrometer. CHNS analyses were performed on a FLASH EA 1112 series instrument.

The experimental procedure for the synthesis of the ligand

2-chloro-6-methoxyquinoline-3-carbaldehyde was synthesised from the starting material 4-methoxy aniline by acylation followed by Vilsmeier-Haack reaction as per the reported method [19]. The obtained product was further used for the preparation of 2-hydroxy-6-methoxyquinoline-3-carbaldehyde by refluxing 2-chloro-6-methoxyquinoline-3-carbaldehyde (10 mmol) and H_2O (1 mL) in acetic acid (5 mL) for 4h; then the reaction mass was transferred into ice-cold water. The obtained product was filtered and washed with water. The crude product was purified in hot ethanol to obtain a corresponding pure product, 2-hydroxy-6-methoxyquinoline-3-carbaldehyde, as an intermediate. The obtained intermediate was further used for the formation of the corresponding ligand. A mixture of 2-hydroxy-6-methoxyquinoline-3-carbaldehyde (1 mmol), Para-methylbenzenesulfonohydrazide (1 mmol), and acetic acid (5–10 drops) in ethanol (10 mL) was placed in a round-bottom flask. The mixture was refluxed at 80 °C for 4h. The progress of the reaction was checked by TLC. The reaction mixture was transferred into crushed ice and extracted with ethyl acetate (2 × 15 mL). The organic extracts were washed with brine solution (2 × 15 mL) and dried over anhydrous sodium sulfate. The solvent was evaporated under reduced pressure to afford the corresponding crude compound. The obtained crude compound was recrystallised using ethanol.



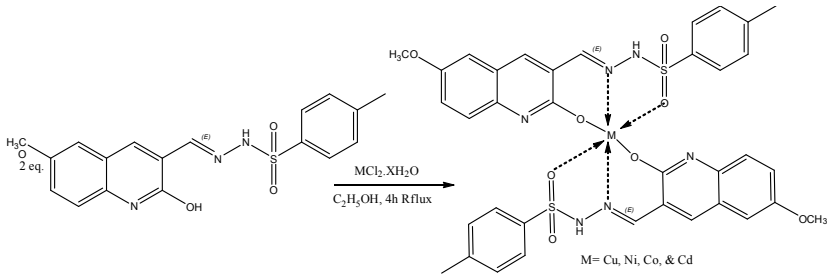
Scheme 1. Synthesis of ligand, (E)-N'-((2-hydroxy-6-methoxyquinolin-3-yl) methylene)-4-methylbenzenesulfonohydrazide.

DOI: 10.48175/IJARSCT-26550

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 11, March 2025
Impact Factor: 7.67

Synthesis of metal complexes

Preparation of metal complexes was performed by adding 25 mL hot ethanolic metal chloride solution (2.5 mmol) to the 25 mL hot ethanolic Schiff base solution (5 mmol) in 2ligand: 1metal proportion. The reaction mixture was stirred for 30 min., and then a few drops of 5% NaOH solution were added to maintain the basic pH of the reaction mixture. For the complete formation of complexes, the reaction mixture was refluxed for 4h. Coloured precipitate complexes were formed. The obtained product was filtered and washed with water and then with ethanol and dried in an oven for 80 min. at 85 °C.



Scheme 2 Synthesis of metal complexes

Biological study

Antibacterial study

The minimum inhibitory concentration (MIC) of the ligand and its metal complexes was carried out by the broth dilution method [20-25]. DMSO used as a diluent served as a negative control test [26]. Two gram-negative bacteria, viz., *Escherichia coli* (MTCC 443) and *Pseudomonas aeuruginosa* (MTCC 1688), and two gram-positive bacteria, viz., *Staphylococcus aureus* (MTCC 96) and *S. pyogenus* (MTCC 442), were tested against prepared compounds with Chloramphenicol and Ampicillin as the standard reference drugs [21]. Serial dilutions of the ligand and its metal complexes were prepared in primary and secondary screening. The control plate with no prepared compounds and drugs was subcultured, spreading evenly over a plate suitable for the growth of selected bacterial pathogens, and kept overnight at 37 °C in the incubator. The MIC of the control bacterial strain was assessed to check the efficacy of the reference drug concentrations. The lowest concentration was recorded as the MIC. The amount of growth from the control plate before incubation was compared. Synthesised compounds were diluted to 2000 µg/mL concentration as a stock solution. In primary screening, 125, 250, and 500 µg/mL concentrations of synthesised compounds were used. The synthesised compounds found active in primary screening were further tested in the second set of dilutions against all selected pathogens. The particles found active in primary screening were diluted similarly to 100, 50, 25, 12.5, 6.250, 3.125, and 1.5625 µg/mL concentrations. The MIC was considered for the dilution showing at least 99% inhibition.

Antifungal study

Antifungal activity of reported compounds was examined with fungal strains *Aspergillus niger* (MTCC 282), *Candida albicans* (MTCC 227), and *A. clavatus* (MTCC 1323) using the agar dilution method [19]. To determine MIC, a stock solution of the synthesised compounds was prepared in DMSO and then incorporated in a specified quantity of sterile molten dextrose agar. Inoculants were prepared by diluting the stock to 100 mL of the nutrient broth in 250 mL sterilised and clean conical flasks. The conical flasks were incubated at 27 °C for 24 h before the experiment. The plates were kept under aseptic conditions to allow the diffusion of the solution properly into the potato-dextrose agar medium. Then, the plates were incubated at 25 °C for 48 h. The highest dilution displaying at least 99% inhibition zone was taken as MIC against Griseofulvin and Nystatin standards. The triplicate analysis was performed to minimise errors.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 11, March 2025
Impact Factor: 7.67

Cytotoxicity

The prepared compounds were studied for their cytotoxicity against the MCF-7 (Human breast cancer) and A-549 (Human Lung cancer) cell lines by using MTT [3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium Bromide] assay. These cells were seeded at a density of approximately 5×10^3 cells per well in a 96-well flat-bottom microtitre plate and maintained at 37 °C overnight in 95% humidity and 5% CO_2. Different concentrations (50, 40, 30, 20, 10, 5 µM) of samples were treated, and the cells were incubated for the next 48 h. Then cells in the wells were washed twice with phosphate buffer saline (PBS), and 20 µL of the MTT [3-(4,5-dimethylthiazol-2-yl)-2,5 2,5-diphenyltetrazolium bromide] staining solution (5 $mgmL^{-1}$ in phosphate buffer saline) was added to each well, and the plate was incubated at 37 °C. After 4 h, 100 µL DMSO was added to each well to dissolve the formant crystals. Absorbance was recorded at 570 nm using a microplate reader**.**

Paclitaxel was used as a standard drug during the activity check. Each reading was performed in three types for each concentration. Results are expressed as mean±standard deviation (n = 3). The percentage cell viability of the cells is calculated using the relation,

% Viability = (Mean OD of test compound/Mean OD of negative control) x 100

Inhibiting cells (%) = 100- Surviving cells.

The IC_{50} was extrapolated from the dose-response curve. The synthesized compound concentration that reduced the viability of cells by 50% (IC_{50}) was calculated by plotting triplicate data points over a concentration range and calculating the values using *GraphPad Prism Ver. 5.1 program.*

II. RESULT AND DISCUSSION

^{1}H NMR of Ligand

(DMSO-d_6, δ ppm): 11.71 (s, 1H, NH), 11.37 (s, 1H, OH), 8.10 (s, 1H, Ar-H), 8.08 (s, 1H, Ar-H), 7.28-7.29 (d, H, Ar–H, J = 7.5 Hz), 7.70 (s, 1H, Ar–C=CH), 7.18-7.15 (d, 1H, Ar–H, J = 8 Hz), 6.98-6.96 (d, 1H, Ar–H, J = 8 Hz), 3.79 (s, 3H, -OCH_3) and 2.30 (s, 3H, –CH_3);

^{13}C NMR of Ligand: (100 MHz, DMSO-d_6, δ ppm): 160.06, 155.77, 143.54, 142.21, 136.51, 134.67, 133.91, 129.67, 127.46, 125.31, 121.02, 119.83, 117.97, 109.26, 56.65, and 21.52.

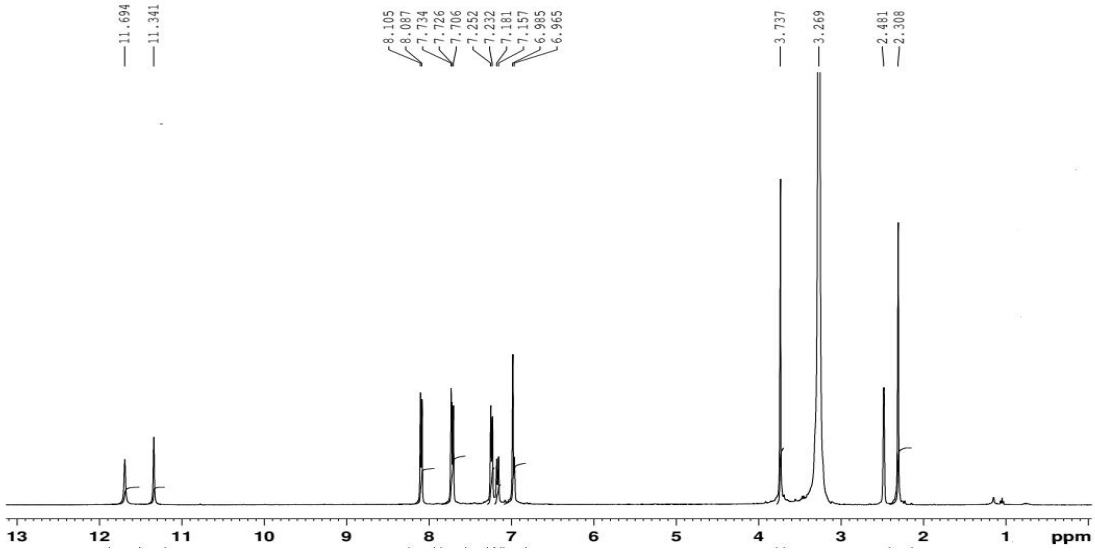


Figure 1 ^{1}H NMR spectrum of ligand

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 11, March 2025
Impact Factor: 7.67

FT-IR spectroscopy

To determine the characteristic vibration bands between ligand and their metal complexes, all the prepared compounds were subjected to FT-IR spectra. The peak observed in the ligand at 1661 cm^{-1} was due to the azomethine ν (C=N) stretching, which was shifted to a lower wave value (1620-1632 cm^{-1}) in the complexes indicating the participation of azomethine nitrogen in coordination with the metal ion (N-M) [27] .The phenolicν (O-M) stretching vibration band is observed at 1352 cm^{-1} in the free ligand. In metal complexes, this band appeared at a lower frequency, 1028-1082 cm^{-1} region, confirming the participation of the phenolic group in complex formation [28]. The vibration bands for the SO_2 group in the free ligand molecule appeared at 1315 and 1185 cm^{-1} ($\nu_{asym}(SO_2)$) and ($\nu_{sym}(SO_2)$), respectively. In the metal complexes, the asymmetric and symmetric bands are shifted to 1217- 1235 and 1112-1123 cm^{-1}, respectively, upon coordinating the central metal ion [28-31]. The additional peaks observed in metal complexes in the range of 459 to 465 cm^{-1} were due to N-M bonding, and 506 to 512 cm^{-1} were due to O-M bonding [32-36]. Details of the peak are given in Table 1.

Table 1 FT-IR stretching frequency of ligands and their metal complexes in cm^{-1}

Compounds	ν C=N	ν C-O	ν N-M	ν O-M	$\nu_{asym}(SO_2)$	$\nu_{sym}(SO_2)$
Ligand	1661	1350	------	-------	1315	1185
Cu-complex	1631	1053	465	508	1221	1114
Ni-complex	1621	1082	465	512	1217	1115
Co-complex	1622	1024	459	506	1235	1123
Cd-complex	1630	1088	464	506	1223	1113

Electronic spectra and magnetic moment

All the prepared complexes were subjected to electronic spectra and magnetic moment. In electronic spectra, the transition bands for ligand were obtained at 322 and 370 nm; this transition is due to π→π* and n→π*, respectively. For metal complexes, these transition bands were shifted to higher wavelengths. For metal complexes (Cu, Ni, Co and Cd), transition bands are observed at 325 and 385, 349, and 396, 347, and 394, 357, and 394 nm, respectively. The shifting of the transition band at longer wavelengths in metal complexes was due to the coordination of the Schiff base with the central metal ion [37].

The magnetic moment for Cu, Ni, and Co was calculated by using the Gouy balance at 25 °C. For the Cu complex, the magnetic moment was observed as 1.80 B.M., which is close to spin only value for the octahedral geometry of copper complexes [38]. The magnetic moment values for Ni and Co complexes were found to be 3.25 and 4.85 B.M., respectively, which is again equal to spin-only values for octahedral geometry for Ni and Co complexes [39, 40]. Details of the magnetic moment values are given in Table 2.

Molar Conductivity:

To determine the electrolytic nature of all complexes, molar conductivity was checked in DMSO solvent at concentrations of 10^{-3} M. The measured conductance values of complexes were in the range of 36–57 Ω^{-1} cm^2 mol^{-1}, representing the non-electrolytic character of the complexes [40]. It is also evidence for the absence of water molecules in the coordination sphere of the complexes [41]. Hence, the complex formed is in the ratio of 2:1(ligand: metal) as shown in Scheme 2 [42]. Details of the values are given in Table 2.

Elemental analysis:

Ligands and their metal complexes were subjected to elemental analysis. Practical calculated values for the elements of ligand and metal complexes were matched with theoretical values. A detail of the values is given in Table 2

Table 2 Physical and analytical data of the ligand and its metal complexes

Compounds	Yield in %	M.P. in °C	λ_m (cm^2 Ω^{-1} mol^{-1})	μ_{eff} (B.M.)	Mol. Wt.	Elemental Composition in %			
						C	N	H	S
Ligand	78	222-224	……	…..	371.41	58.18 (58.21)	11.36 (11.31)	4.45 (4.61)	8.78 (8.63)
Cu-complex	72	280-282	36	1.80	803.35	53.66 (53.76)	10.23 (10.45)	3.87 (4.01)	7.76 (7.97)

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 11, March 2025 Impact Factor: 7.67

Ni-complex	83	>300	38	3.25	799.50	54.07 (54.08)	10.44 (10.51)	3.90 (4.03)	8.20 (8.02)
Co-complex	68	>300	47	4.85	799.74	54.15 (54.07)	10.39 (10.51)	4.13 (4.03)	8.02 (8.03)
Cd-complex	81	>300	57	Dimag-netic	854.22	50.43 (50.68)	9.71 (9.85)	3.66 (3.78)	7.51 (7.52)

ESR Spectra:

An ESR spectrum of the Cu complex was recorded in DMSO solvent at liquid nitrogen temperature (77K). It gives information about the environment around the central metal ion in the complex. The spectrum shows a highly intense band in the higher magnetic field. The hyperfine interaction that occurred for the complex was due to the interface with oxygen and nitrogen nuclei near copper ions [43]. The Hamiltonian parameter was used to calculate the ground state of the Cu complex. Details of the calculated values are given in Table 3. The obtained g -value for the Cu complex is $g_{\parallel}$ 2.225 and $g^{\perp}$ 2.189. The obtained $g_{\parallel}$ and $g^{\perp}$ values are greater than g value for free electron 2.0023, which indicates that the complex is axially symmetrical with dx2-y2 ground state, which is characteristic of octahedral geometry [44].

Table3. ESR spectral data of Cu complex

$g_{\perp}$	$g_{\parallel}$	$g_{avg.}$	G	$\mu_{eff.}$ (BM)
2.189	2.225	2.201	1.192	1.81

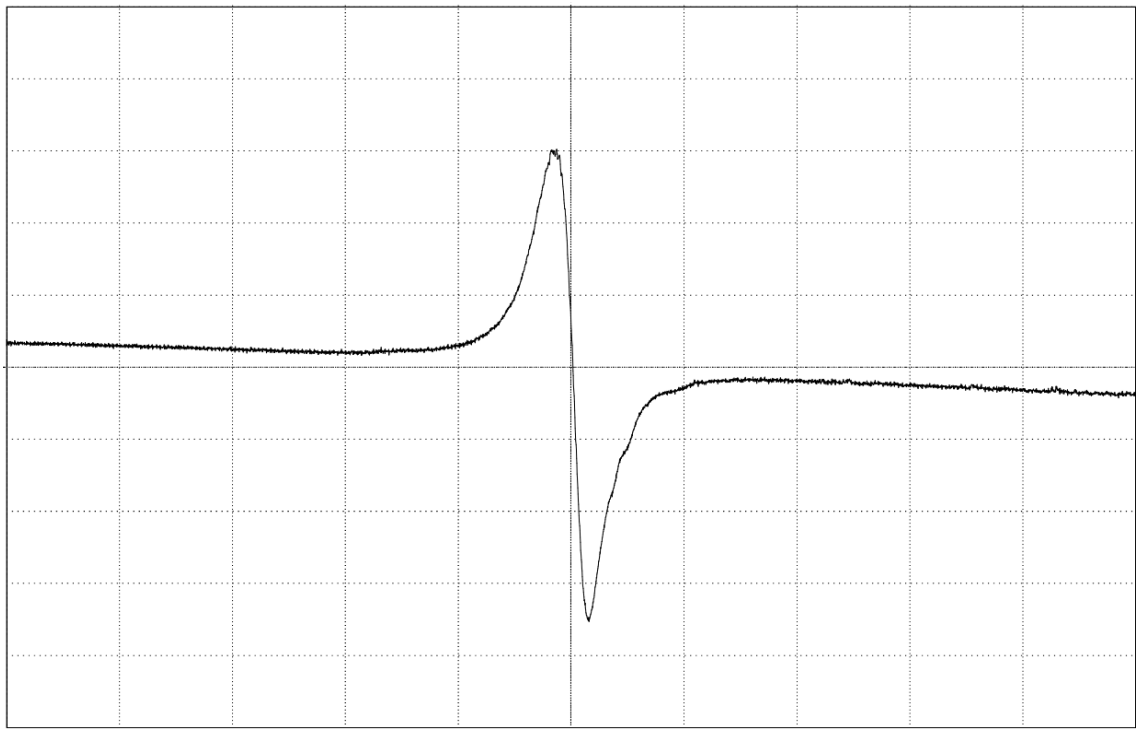


Figure 2: ESR spectrum of Cu-complex

Mass Spectra:

Mass spectra provide important information about the molecular weight of the prepared compounds. The molecular ion peak of the ligand was observed at m/z= 372.04, which exactly matched its calculated molecular weight. In metal

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 11, March 2025
Impact Factor: 7.67

complexes, the highest mass peaks were obtained at m/z= 802.77, 800.84, 800.80, and 855.39 for Cu, Ni, Co, and Cd complexes, respectively. The obtained mass peaks are equal to their corresponding molecular weight. Hence, the obtained mass spectra support the proposed structure of the compounds. All the mass spectra of the prepared compounds are given in the supplementary data file.

TGA:

Thermal analysis was performed to gain significant information about the thermal stability of the prepared metal complexes and decide whether the solvent molecules (if present) are inside or outside the inner coordination sphere of the metal [45–47]. The thermogram of the Cu-complex is shown in Figure 3. Table 4 is summarised with decomposition stages, temperature range, loss of weight (actual and calculated), and assignments of the loss fragments. The representative thermogram of the Cu complex is presented in detail. The thermogram of the Cu complex exhibited two decomposition stages. In stage first, the 35.36% weight loss (calculated 35.00%) was observed between the temperature range 180–460°C, which corresponds to the loss of the toluene side chain of the ligand moiety. In the second stage, 40.48% weight loss was observed (calculated 39.50%) in the temperature range 480–960°C, which represents the loss of quinoline moiety of the coordinated ligand molecule. Lastly, 13.07% residue remains present (calculated 13.25%), which was due to a metal with an organic moiety.

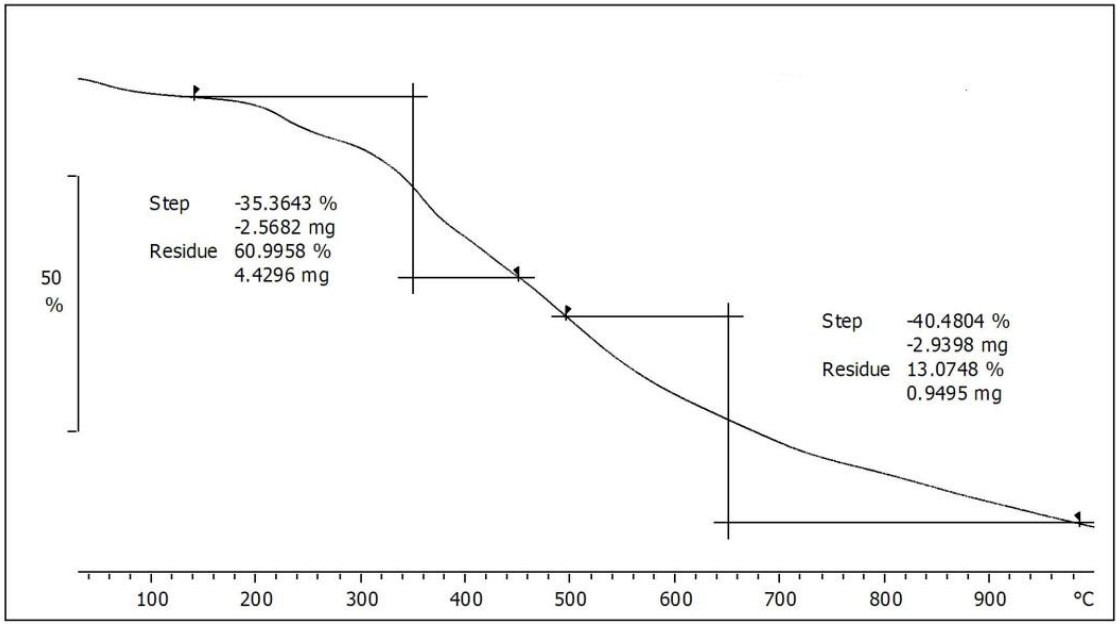


Figure 3 TGA of Cu-complex

Table 4 Stepwise thermal decomposition study of metal complexes

Complex Formula	Decomposition Tem. (^{O}C)	weight loss in %		Assignment
		Obsd	Cald	
$(C_{18}H_{16}N_3O_4S)_2$ Cu	180-480	35.36	35.00	$C_{14}H_{14}O_2S_2$
	480-960	40.48	39.50	$C_{20}H_{14}N_2O_2$
	Residue	13.07	13.25	$C_2H_4O_4Cu$
$(C_{18}H_{16}N_3O_4S)_2$ Ni	180-320	32.53	32.91	$C_{11}H_9N_3O_3S$
	340-580	20.81	21.27	$C_{11}H_8NO$
	620-100	17.11	17.27	$C_7H_8N_2$
	Residue	21.47	22.65	$C_7H_7O_2Ni$

DOI: 10.48175/IJARSCT-26550

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 11, March 2025
Impact Factor: 7.67

$(C_{18}H_{16}N_3O_4S)_2$ Co	140-480 500-1000 Residue	24.55 33.68 32.45	24.90 32.91 31.65	$C_{11}H_9N_3O$ $C_{11}H_9N_3O_3S$ $C_7H_7O_4SCo$
$(C_{18}H_{16}N_3O_4S)_2$ Cd	180-280 300-660 Residue	22.43 29.70 31.23	23.06 28.92 31.01	$C_8H_9N_3O_2S$ $C_{11}H_9N_3O_4$ C_9H_4OCd

***In-vitro* cytotoxicity**

In-vitro cytotoxicity of ligand and its metal complexes was investigated against A-549 (Human Lung cancer) and MCF-7(Human Breast cancer) cell lines, and results are tabulated in Table 5. Paclitaxel was used as the standard drug during the activity check. The ligand and its metal complexes showed inhibition of cell value IC_{50} in the range 43.10-58.47 µM for A-549 and 44.09-61.27 µM for MCF-7 cell lines. The ligand and its metal complexes exhibited higher activity against the A-549 cancer cell line and lower activity in the case of the MCF-7 cancer cell line compared to the standard.

From the obtained results, it was observed that the prepared metal complexes were found to be more active than their corresponding ligand molecule. The order of activity of all prepared compounds against the A-549 cancer cell line is Ni > Cu > Co > Cd-complex > ligand.

Table 5 shows the *in vitro* cytotoxicity data

Sr. No.	**Compound**	**IC_{50} values in µM**	
		A-549	**MCF-7**
1	Ligand	57.47	61.25
2	Cu-complex	45.55	55.49
3	Ni-complex	43.13	44.07
4	Co-complex	54.19	53.07
5	Cd-complex	54.36	46.67
6	Paclitaxel	69.545	30.7

Antibacterial Activity:

Both the ligand and its metal complexes formed from it displayed antibacterial activity against *E. coli, P. aeruginosa, S. aureus,* and *S. pyogenes* with MICs less than 250 µg/ml. Experimental ligand displayed good antibacterial activity with the least MIC (12.5µg/ml) against *P. aeruginosa* than standard chloramphenicol (MIC= 50µg/ml) and ampicillin (MIC= 100 µg/ml). Ni-complex displayed MIC with the highest MIC value for *S. aureus* and *S. pyogenes,* and Cd-complex for *S. aureus*. This was following the antibacterial activity displayed by standard ampicillin for *S. aureus*. Except for Cd and Cu complexes, formed complexes displayed better antibacterial activity than the ligand (MIC=125 µg/ml) for *S. pyogenes*, but not like the standard chloramphenicol (MIC=50 µg/ml). Further, among experimental standards, chloramphenicol (MIC=50µg/ml) displayed better antibacterial activity than ampicillin (MIC=100 and 250 µg/ml).

Table 7 Antibacterial Activity of ligand and its metal complexes [MIC in µg/ml]

Sr. No	**Compound**	***E.Coli***	***P.Aeruginosa***	***S.Aureus***	***S.Pyogenus***
		MTCC 443	**MTCC 1688**	**MTCC 96**	**MTCC 442**
1	Ligand	25.1	12.4	52	127
2	Cu-complex	101	124	62.52	100
3	Ni-complex	126	50.1	252	250
4	Co-complex	62	25.3	100	250
5	Cd-complex	124.9	124	250	100

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 11, March 2025
Impact Factor: 7.67

6	Ampicillin	100	100	250	100
7	Chloramphenicol	50	50	50	50

Antifungal Activity

Both ligand and its metal complexes displayed antifungal activity against *C. albicans, A. niger,* and *A. clavatus* but with moderate activity than experimental standards Nystatin and Griseofulvin (except from *C. albicans*with MIC 500µg/ml). But what was notifying was the antifungal activity of the synthesised Cu-complex, which was found to be the least (MIC=110 µg/ml) than the experimental ligand (MIC=250µg/ml). Further, Cu-complex displayed antifungal activity almost near about to standard Nystatin and Griseofulvin, and thus poses its use as an antibiotic for further use.

Table 8 Antifungal activity of the ligand and its metal complexes [MIC in $mgmL^{-1}$]

Sr. No.	**Compound**	**C. *albicans***	**A. *niger***	**A. *clavatus***
		MTCC 227	**MTCC 282**	**MTCC 1323**
1	Ligand	255	502	510
2	Cu-complex	111	501	1000
3	Ni-complex	501	>1000	>1000
4	Co-complex	502	1000	1000
5	Cd-complex	504	>1000	>1000
6	Griseofulvin	500	100	100
7	Nystatin	100	100	100

III. CONCLUSION

New Quinoline Schiff base and tits metal complexes were prepared and characterised by several analysis techniques. The prepared ligand and its metal complexes were tested for *in vitro* biological activity. The antibacterial screening results showed that the Cu-complex and Co metal complexes possessed good antifungal activity and antibacterial activity, respectively, compared to other metal complexes. Further, *in vitro* cytotoxicity studies showed that all metal complexes have excellent activity toward the human lung cancer cell line (**A-549**), compared to the standard drug Paclitaxel. Hence, it is concluded that prepared compounds possessed excellent cytotoxicity properties and could be used as potential leads for cancer treatment.

Acknowledgement: The authors would like to extend their sincere appreciation to the Department of Chemistry, MTES, Doshi Vakil Arts and G.C.U.B. Science & Commerce College, Goregaon-Raigad (MH), India, for providing a laboratory facility.

Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

[1]. P. A. Vigato and S. Tamburini. The challenge of cyclic and acyclic Schiff bases and related derivatives, Coordination Chemistry Reviews, 248 (2004) 1717–2128

[2]. N. K. Kaushik and A. K. Mishra. Synthesis, characterization and thermal studies of some new organotin (IV) complexes with aniline *N*-thiohydrazide and benzaldehyde aniline *N*-thiohydrazone, Indian Journal of Chemistry *A* 42:11(2003) 2762–2766

[3]. M. S. Saraiva, S. Quintal, F. C. M. Portugal et al. Nitrogen donor ligands bearing N-H groups: effect on catalytic and cytotoxic activity of molybdenum η^3-allyl-dicarbonyl complexes, Journal of Organometallic Chemistry, 693:21-22 (2008) 3411–3418

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 11, March 2025
Impact Factor: 7.67

[4]. N. K. Singh, A. Srivastava, A. Sodhi, and P. Ranjan, "In vitro and in vivo antitumour studies of a new thiosemicarbazide derivative and its complexes with 3D-metal ions, Transition Metal Chemistry, 25:2 (2000) 133–140

[5]. V. E. Kuz'min, A. G. Artemenko, R. N. Lozytska et al. Investigation of anticancer activity of macrocyclic Schiff bases by means of 4D-QSAR based on simplex representation of molecular structure, SAR and QSAR in Environmental Research, 16:3(2005) 219–230

[6]. M. E. Hossain, M. N. Alam, J. Begum et al., "The preparation, characterization, crystal structure and biological activities of some copper(II) complexes of the 2-benzoylpyridine Schiff bases of S-methyl- and S-benzyldithiocarbazate," *Inorganica Chimica Acta*, 249:2(1996) 207–213

[7]. Y. K. Vaghasiya, R. Nair, M. Soni, S. Baluja, and S. Chanda, Synthesis, structural determination and antibacterial activity of compounds derived from vanillin and 4-aminoantipyrine, Journal of the Serbian Chemical Society 69:12(2004) 991–998

[8]. C. T. Supuran, M. Barboiu, C. Luca, E. Pop, M. E. Brewster, and A. Dinculescu, Carbonic anhydrase activators. Part 14. Syntheses of mono and *bis* pyridinium salt derivatives of 2-amino-5-(2-aminoethyl)- and 2-amino-5-(3-aminopropyl)-1,3,4-thiadiazole and their interaction with isozyme II, European Journal of Medicinal Chemistry, 31:7-8(1996) 597–606

[9]. Mallandur BK, Rangaiah G, Harohally NV. Synthesis and antimicrobial activity of Schiff bases derived from 2-chloro quinoline-3-carbaldehyde and its derivatives incorporating 7-methyl-2-propyl-3H-benzoimidazole-5-carboxylic acid hydrazide. Synth Commun. 47:11(2017) 1065–1070

[10]. Yernale NG, Mathada MBH. Synthesis, characterization, antimicrobial, DNA cleavage, and *In-vitro* cytotoxic studies of some metal complexes of Schiff base ligand derived from thiazole and quinoline moiety. Bioinorg Chem Appl. 2014 (2014) 3149-3163

[11]. Althobiti, Hanan A. and Zabin, Sami A.. "New Schiff bases of 2-(quinolin-8-yloxy)acetohydrazide and their Cu(ii), and Zn(ii) metal complexes: their in vitro antimicrobial potentials and in silico physicochemical and pharmacokinetics properties: " *Open Chemistry*, 18:1, (2020), 591-607. https://doi.org/10.1515/chem-2020-0085

[12]. Salve PS, Alegaon SG, Srirram D. Three-component, one-pot synthesis of anthranilamide Schiff bases bearing 4-aminoquinoline moiety as Mycobacterium tuberculosis gyrase inhibitors. Bioorg Med Chem Lett. 27 (2017)1859–66.

[13]. Adeleke, Adesola A., Zamisa, Sizwe J., Islam, Md. S., Olofinsan, Kolawole, Salau, Veronica F., Mocktar, Chunderika, Omondi, Bernard, Quinoline Functionalized Schiff Base Silver (I) Complexes: Interactions with Biomolecules and In Vitro Cytotoxicity, Antioxidant and Antimicrobial Activities, Molecules, 26:5, (2021)1420-3049.

[14]. Vidyavathi G. T., Vinay Kumar B., Aravinda T., Hani U, Cashew nutshell liquid catalyzed green chemistry approach for synthesis of a Schiff base and its divalent metal complexes: molecular docking and DNA reactivity, Nucleosides, Nucleotides & Nucleic Acids, 40:3 (2021)264-287.

[15]. Patil, Sanjay K., Vibhute, Baliram T., Synthesis, characterization, anticancer and DNA photocleavage study of novel quinoline Schiff base and its metal complexes, Arabian Journal of Chemistry, 14:8 (2021, 1878-5352.

[16]. Baliram T. Vibhute, Sanjay K, Patil, Arvind M. Patil. Synthesis, Spectral Characterization and Antitubercular Study of Novel Quinoline Schiff Base and Its Metal Complexes, 11:4 (2021)523-538.

[17]. Vibhute, B., Aghav, B., More, B., Bellamkonda, R., & Patil, S. (2022). Antimicrobial, Cytotoxicity and Molecular Docking Study of New Quinoline Schiff Base and its Metal(II) Complexes. Asian Journal of Chemistry, 34(3), 685–694. https://doi.org/10.14233/ajchem.2022.23301

[18]. Vibhute, B. T., & Ghoti, A. J. (2025). In vitro Antibacterial, Antifungal, Cytotoxicity and Molecular Docking Studies of Transition Metal (II) Complexes Derived from New Quinoline Schiff Base. Asian Journal of Chemistry, 37(2), 266–274. https://doi.org/10.14233/ajchem.2025.32957

[19]. Singh, R. M.; Srivastava, A. Indian J. Chem. 44 (2005)1868.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 11, March 2025
Impact Factor: 7.67

[20]. **A** Rattan, Antimicrobials in laboratory medicine(Churchill B. I. Livingstone, New Delhi, 2000) 85–108

[21]. Wiegand, K. Hilpert, R.E.W. Hancock, Agar and broth dilution methods to determine the minimal inhibitory concentration (MIC) of antimicrobial substances. Nat. Protoc. 3(2008) 163–175

[22]. Z.M. Alvand, H.R. Rajabi, A. Mirzaei, A. Masoumisl, Ultrasonic and microwave assisted extraction as rapid and efficient techniques for plant mediated synthesis of quantum dots: green synthesis, characterization of zinc telluride and comparision study of biological activities. New J. Chem. 43(2019) 15126–15138

[23]. P. Sharma, S. Pant, V. Dave, K. Tak, V. Sadhu, K.R. Reddy, Green synthesis and characterization of copper nanoparticles by Tinospora cardifoliato produce nature friendly copper nano-coated fabric and their antimicrobial evaluation. J. Microbiol. Methods 160 (2019) 107–116

[24]. **A** Misra, S. Jain, D. Kishore, V. Dave, K.R. Reddy, V. Sadhu, J. Dwivedi, S.Sharma, A facile one pot synthesis of novel pyrimidine derivatives of 1,5benzodiazepines via domino reaction and their antibacterial evaluation. J. Microbiol. Methods 163 (2019)105648

[25]. **B** Nagaraja, M.D. Jalageri, Y.M. Puttaiahgowda, K.R. Reddy, A.V. Raghu, A review on various maleic anhydride antimicrobialpolymers. J. Microbiol. Methods 163 (2019) 105650

[26]. H.R. Rajabi, A. Naghiha, M. Kheirizdeh, H. Sadatfaraji, A. Mirzaei, Z.M. Alvand, Microwave assisted extraction as an efficient approach for biosynthesis of zinc oxide nanoparticles: synthesis, characterization and biological properties. Mater. Sci. Eng. C 78 (2017) 1109–1118.

[27]. Muhammad Pervaiz, Ikram Ahmad, Muhammad Yousaf, Shamaila Kirn, Asima Munawar, Zohaib Saeed, Ahmad Adnan, Tahsin Gulzar, Tahseen Kamal, Awais Ahmad, Ayoub Rashid, Synthesis, spectral and antimicrobial studies of amino acid derivative Schiff base metal (Co, Mn, Cu, and Cd) complexes, Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 206 (2019) 642-649

[28]. Natarajan, Raman & Kulandaisamy, A. & Jeyasubramanian, Kadarkaraithangam. Synthesis, spectroscopic characterization, redox, and biological screening studies of some Schiff base transition metal(II) complexes derived from salicylidene-4-aminoantipyrine and 2-aminophenol/2-aminothiophenol. Synthesis and Reactivity in Inorganic and Metal-organic Chemistry – syn. Reactive. Inorg. metal-org. c. 31(2001). 1249-1270.

[29]. Nurþen Sari, Seza Arslan, Elif Loðoðlu and Ýffet Þakiyan. Antibacterial Activites Of Some Newamino Acid-Schiff Bases, Journal of Science, 16 (2003) 283-288

[30]. Mohamed, G., & Abd El-Wahab, Z. Salisaldehyde-2-aminobenzimidazole schiff base complexes of Fe(III), Co(II), Ni(II), Cu(II), Zn(II) and Cd(II), Journal of Thermal Analysis and Calorimetry, 73:1 (2003), 347-359.

[31]. Salameh A.S and Tayim, H.A., Reaction of 2, 5-(Dibenzothiazolin-2-yl)thiophene with Some Metal Ions, Polyhedron2:8 (1983), 829-834.

[32]. Seleem, H.S., El-Shetary, B.A. and Shebl, M.), Synthesis and characterization of a novel series of metallothiocarbohydrazone polymers and their adducts. Heteroatom Chem., 18:1 (2007), 100-107. https://doi.org/10.1002/hc.20239.

[33]. Shebl, Magdy, Khalil and Saied M. E., Synthesis, spectral, X-ray diffraction, antimicrobial studies, and DNA binding properties of binary and ternary complexes of pentadentate N2O3 carbohydrazone ligands, Monatshefte für Chemie - Chemical Monthly 145:1 (2015), 15-33. https://doi.org/10.1007/s00706-014-1302-x

[34]. Shebl, Magdy, Khalil and Saied M. E., Synthesis, spectral, X-ray diffraction, antimicrobial studies, and DNA binding properties of binary and ternary complexes of pentadentate N2O3 carbohydrazone ligands, Monatshefte für Chemie - Chemical Monthly 145:1 (2015), 15-33.https://doi.org/10.1080/00958972.2015.1116688

[35]. Shebl, Magdy, Synthesis, spectral studies, and antimicrobial activity of binary and ternary Cu(II), Ni(II), and Fe(III) complexes of new hexadentate Schiff bases derived from 4,6-diacetylresorcinol and amino acids, Journal of Coordination Chemistry, 62:19 (2009), 3217-3231. https://doi.org/10.1080/00958970903012785

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 11, March 2025
Impact Factor: 7.67

[36]. Shebl, Magdy, Coordination behavior of new bis(tridentate ONO, ONS and ONN) donor hydrazones towards some transition metal ions: Synthesis, spectral, thermal, antimicrobial and antitumor studies Journal of Molecular Structure 1128 (2017), 79-93. https://doi.org/10.1016/j.molstruc.2016.08.056.

[37]. Prateek Tyagi, Sulekh Chandra, B.S. Saraswat. Ni(II) and Zn(II) complexes of 2-(thiophen-2-ylmethylene amino) benzamide: Synthesis, spectroscopic characterization, thermal, DFT and anticancer activities, Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy,134 (2015) 200-209

[38]. Singh, D. P., Kumar, R., Malik, V. and Tyagi, P.,Synthesis and characterization of complexes of Co(II), Ni(II), Cu(II), Zn(II), and Cd(II) with macrocycle 3,4,11,12-tetraoxo-1,2,5,6,9,10,13,14-octaaza-cyclohexadeca-6,8,14,16-tetraene and their biological screening. Transition Metal Chemistry. 32:8 (2007) 1051-1055.

[39]. Rao, T. R. and Prasad, A. Syntheis and spectral studies on 3d metal complexes of mesogenic Schiff base ligands. Part 1. Complexes of N-(4-butylphenyl) salicylaldimine. Synthesis and reactivity in inorganic, metal-organic and nano-metal chemistry. 35:4 (2005) 299-304.

[40]. Greenwood, N. N. and Earnshaw, A.Chemistry of the elements. Heimemann, Oxford, UK 2nd edition. (1997)

[41]. Geary, W.J., The use of conductivity measurements in organic solvents for the characterisation of coordination compounds, Coordination Chemistry Reviews. 7:1 (1971)81-122.

[42]. Savant, V. V.; Patel, C. C. Diphenyl Sulphoxide Complexes of Some Oxo Cations. J. Inorg. Nucl. Chem. 31(1969) 2319–2327.

[43]. Quagliano, J. V.; Fujita, J.; Franz, G.; Phillips, D. J.; Walmsley, J. A.; Tyree, S. Y. The Donor Properties of Pyridine N-Oxide. J. Am. Chem. Soc., 83 (1961) 3770–3773.

[44]. Reddy,T. Ramasubba, Srinivasan,R. ESR and Optical Absorption Studies in Copper Diethyldithiocarbamate. American Institute of Physics. 43(1965)1404–1409.

[45]. Thaker, B. T., Tandel, P. K., Patel, A. S., Vyas, C. J., Jesani M. S. and Patel, D. M.Synthesis and mesomorphic characterization of Cu(II), Ni(II) and Pd(II) complexes with azomethine and chalcone as bridging group. Indian Journal of Chemistry A. 44:2 (2005) 265-270.

[46]. El-Shafiy, H. F.Shebl, Magdy Oxovanadium(IV), cerium(III), thorium(IV) and dioxouranium(VI) complexes of 1-ethyl-4-hydroxy-3-(nitroacetyl)quinolin-2(1H)-one: Synthesis, spectral, thermal, fluorescence, DFT calculations, antimicrobial and antitumor studies, Journal of Molecular Structure, 1156 (2018), 403-417.

[47]. Shebl, Magdy, Synthesis, spectral and magnetic studies of mono- and bi-nuclear metal complexes of a new bis(tridentate NO2) Schiff base ligand derived from 4,6-diacetylresorcinol and ethanolamine. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy.73:2(2009), 313-323. https://doi.org/10.1016/j.saa.2009.02.030

[48]. Shafiy, H.F., Shebl, Magdy, Binuclear oxovanadium(IV), cerium(III) and dioxouranium(VI) nano complexes of a bis(bidentate) ligand: Synthesis, spectroscopic, thermal, DFT calculations and biological studies, Journal of Molecular Structure. 1194(2019), 187-203. https://doi.org/10.1016/j.molstruc.2019.05.063