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Synthesis, characterization and antimicrobial Studies of (N'^{1}E, N'^{6}E)-N'^{1}, N'^{6}-bis((2-hydroxyquinolin-3-yl)methylene)adipohydrazide

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ABSTRACT

The Cu(II), Co(II), Ni(II), Zn(II), Cd(II), Hg(II), and Mn(II)complexes of Schiff base (N'^{1}E,N'^{6}E)-N'^{1},N'^{6}-bis((2-hydroxyquinolin-3-yl)methylene)adipohydrazide has been synthesized and characterized by various spectral techniques. The complexes were prepared by reacting the ligand and metal chloride of Cu(II), Co(II), Ni(II), Zn(II), Cd(II), Hg(II), and Mn(II) in ethanol to get a series of mononuclear complexes. The complexes were characterized by CHN analysis, conductivity measurements, magnetic susceptibility, IR, NMR, ESR, UV-Vis and X-ray powder diffraction studies. By these spectral studies it is found that Cu(II), Co(II), Ni(II), Zn(II), Cd(II) Hg(II) and Mn(II) complexes have exhibited octahedral geometry. The ligand and its metal complexes have been screened for their antimicrobial activities. The prepared ligand shows low activity and its metal complexes shows moderate to good activity.

Key words: Quinoline, Schiff base, spectral studies, metal complexes and antimicrobial activity

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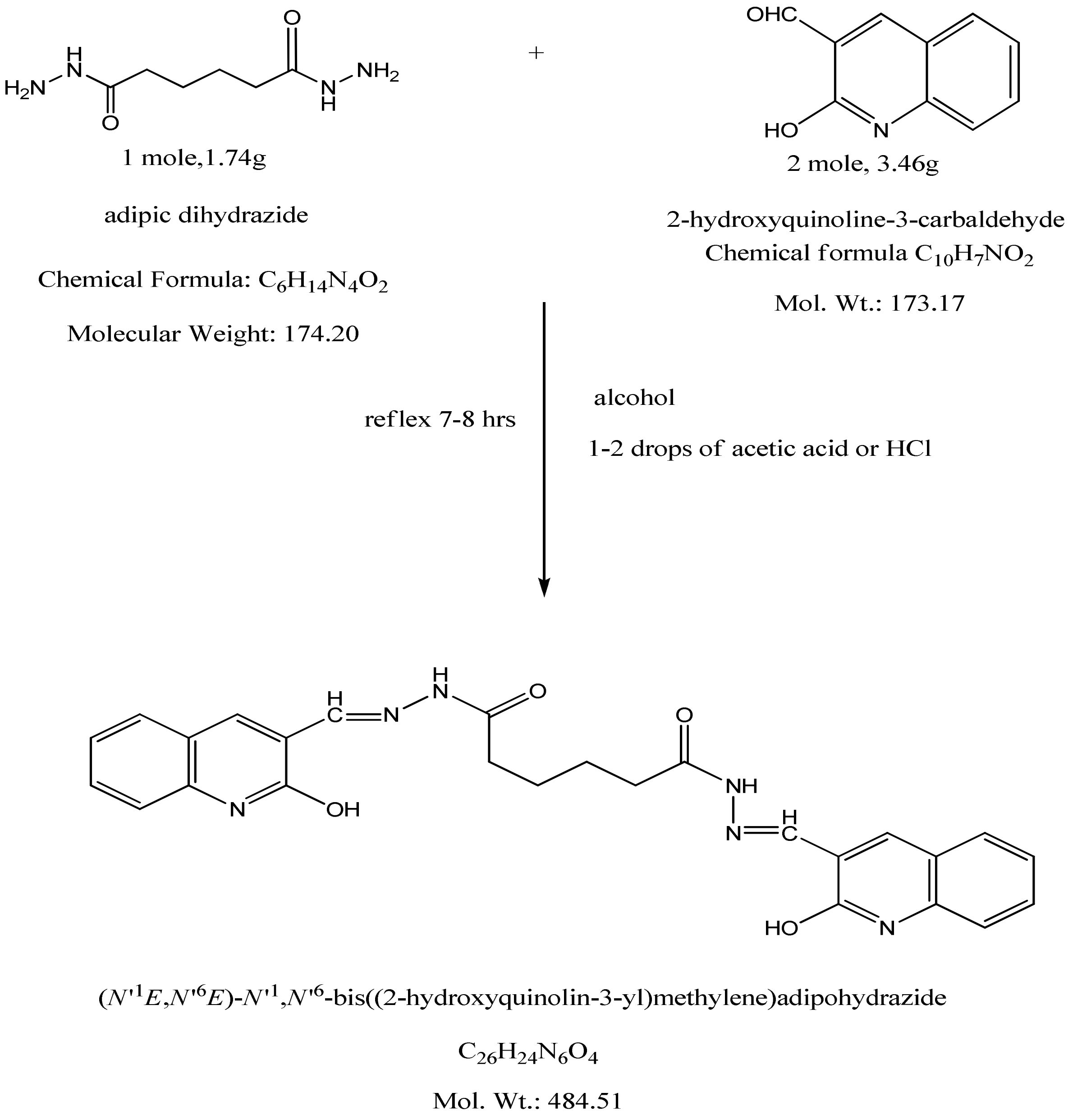
INTRODUCTION

The importance of quinoline and its annealed derivatives is well recognized by synthetic and biological chemist [1,2]. Compounds possessing this ring system have wide applications as drugs and pharmaceuticals [3]. Quinolines, also known as L-azanaphthalene, 1-benzaine or benzo(b) pyridine is an aromatic nitrogen compound characterized by a double ring structure contains benzene fused to pyridine at two adjacent carbon. The chemical formula for quinoline (C_9H_7N) and it has a molecular weight of 129.15g/mol. quinoline family compounds are widely used as a parent compound to make drugs (especially antimalarial medicine), fungicides, biocides, alkaloids,dyes,rubber, chemicals, flavoring agents, antiseptic and antipyretic. Quinolines, 2-methylqunoline is used as antimalarial and preparing other antimalarial drugs. Quinoline derivatives have been reported for anti-inflammatory[4], anti-bacterial[5-7], antifungal[8,9] antiallergy[10], antidepressant[11], antiasthmatic[12], antimalarial[13-15], antiviral[16,17], antitumor[18], neurolepticactivity[19], antihypertensive[20,21], cytotoxic[22-24], antihistamine[25] Our work is concerned with complexation in aqueous- organic solvents attract study researchers participation of the organic component. As a continuation of studies concerning the effect of acid hydrazides [26-28], we examined in this study the complexing properties of adipic acid hydrazide ion aqueous-ethanol solutions. The main goals of this study were describing the complexation of Cu(II), Co(II), Ni(II), Zn(II), Cd(II), Hg(II) and Mn(II) with ligand and revealing the effects of the central metal-ion.



1 mole,1.74g

adipic dihydrazide

Chemical Formula: $C_6H_{14}N_4O_2$

Molecular Weight: 174.20

2 mole, 3.46g

2-hydroxyquinoline-3-carbaldehyde

Chemical formula $C_{10}H_7NO_2$

Mol. Wt.: 173.17

(*N'*^{1}*E*,*N'*^{6}*E*)-*N'*^{1},*N'*^{6}-bis((2-hydroxyquinolin-3-yl)methylene)adipohydrazide

$C_{26}H_{24}N_6O_4$

Mol. Wt.: 484.51

scheme

MATERIALS AND METHODS

Preparation of ligand:
(N'^{1}E, N'^{6}E)-N'^{1}, N'^{6}-bis((2-hydroxyquinolin-3-yl)methylene)adipohydrazide

The Schiff base ligand were prepared by condensation of adipic dihydrazide(1 mole, 1.74g) and 2-hydroxyquinoline-3-carbaldehyde (2mole, 3.46g) in ethanol (30ml) was refluxed on water bath for 5-6 hours in presence of few drops of acetic acid. The reaction mixture was cooled to room temperature, the separated Schiff base were filtered and washed with hot alcohol and recrystalized from alcohol to get a pure sample. The purity of Schiff base was checked by TLC. Yield: 75%, MP; 270°C, Mol. Wt. = 484.51

Preparation of metal complexes

A solution of 0.01mole of metal chloride in ethanol was mixed with the ethanolic solution of 0.01 mole of ligand and refluxed for 3-4 hours on water both to get clear solution. 0.5gm of excess sodium acetate was added to the reaction mixture to adjust the pH 7-8 of the solution. The reaction mixture was further, refluxed for 2 hours more. The resulting mixture was decomposed by pouring into a 100ml of distilled water with constant stirring. The suspended solid complex was allowed to settle and collected by filtration, washed with sufficient quantity of distilled water and then with little hot ethanol to apparent dryness and dried in a vacuum over anhydrous calcium chloride in a desiccator. (Yield, 55-75%)

Physical Measurements

Infrared spectra of the ligand and its metal complexes in KBr pellets were recorded in the spectral range 3800 – 350 cm^{-1} with Perkin Elmer Spectrum One FT-IR Spectrometer.^{1}H-NMR Spectra were recorded on AMX–4000 NMR Spectrometer, using TMS as internal standard and DMSO as a solvent. The Electronic Spectra were recorded on an Elico-SL-164 Double BEAM UV-Visible Spectrophotometer in the range of 200–1200nm in DMF. X-ray powder diffraction was recorded at department of physics, Gulbarga University, Gulbarga. Magnetic susceptibility measurements were recorded on Guoy balance method. The Conductance measurements were made on an ELICO-CM-82-conductivity bridge.

RESULTS AND DISCUSSION

Nature and Stoichiometry

All the complexes are colored in nature and were sparingly soluble in common organic solvents but soluble in DMF, DMSO and acetonitrile. The analytical data indicates that the complexes are agree well with 1:1 metal to ligand stiochiometry for Cu(II), Co(II), Ni(II) Zn(II), Cd(II) Hg(II) and Mn(II). The stoichiometry of all the complexes was confirmed by spectrophotometric method. The observed molar conductance values measures in DMF solution fall in the range 12–20 Ohm^{-1} cm^{2}mol^{1}(Table 1). These observed values of the molar conductance are well within the expected range for non-electrolytic nature [29]. The physical characterization data of all the compounds has been summarized in Table 1.

Infrared Spectra

The significant IR bands for the ligand (N'^{1}E,N'^{6}E)-N'^{1},N'^{6}-bis((2-hydroxyquinolin-3-yl)methylene)adipohydrazide as well as for its metal complexes and their tentative assignments are complied and represented Table 2. The broad band observed at 3433 cm^{-1} in the IR spectra of the ligand assigned to $\nu_{(OH)}$, which were found to have disappeared in all their respective complexes, there by indicating the involvement of phenolic oxygen is bonding with metal ions through deprotonation. The band $\nu_{(NH)}$ observed at 3173 cm^{-1} in ligand and complexes $\nu_{(NH)}$ observed at 3173-3198 cm^{-1} respectively. A strong sharp band observed at 1664 cm^{-1} is assigned to adipic hydrazide ring $\nu_{(C=O)}$ which was shifted to 15-48 cm^{-1} in all complexes, indicates the involvement of adipic hydrazide ring carboxyl in complexation with metal ion, the band at 1594 cm^{-1} is assigned to the azomethine $\nu_{(C=N)}$ group, lowering of $\nu_{(C=N)}$ 10-40cm^{-1} in the complexes as compared to its ligand, is due to reduction of double bond character carbon-nitrogen bond of the azomethine group[30]. The band observed at 1203 cm^{-1}, of the ligand is attributed to phenolic $\nu_{(C–O)}$ in view of previous observations [31]. This band is shifted to higher frequency and is found in the region 1203-1268 cm^{-1} (1-65cm^{-1}) for the complexes. Thus the low frequency skeletal vibrations due to $\nu_{(M-O)}$ and $\nu_{(M-N)}$ stretching provide direct evidence for complexation. In the present investigation the bands in the 550-568 cm^{-1} region for $\nu_{(M-O)}$ and 470 -496 cm^{-1} region for $\nu_{(M-N)}$ vibration respectively.

Magnetic movement and Electronic spectra of the complexes

Copper(II) complex

The complexes having temperature independent magnetic moments in the range of 1.74-2.2 B.M. agreeable to the spin only value. These complexes are mononuclear having no major spin-spin interactions; however no compromise can be set between the magnitude of the distortion and other variable factors. The Cu(II) complexes with this behavior indicate marked spin-exchange and strong coupling interaction between Cu(II) atoms. As the spin only value for a single unpaired electron is 1.72 B.M. The slight excess over this value for the Cu(II) complexes can be attributed to spin orbital coupling. The observed magnetic moment values for the present Cu(II) complexes is 1.90 B.M[32]. This value is expected for one electron system and is in the normal range of Cu(II) complex system. As the spin only values for a single unpaired electron is 1.72 B.M. The slight excess over this value found for the

Cu(II) complex can be attributed to spin orbital coupling. In view of the above observations the magnetic moment values for the present Cu(II) complexes, suggest the distorted octahedral geometry around Cu(II) ions.

Table 1. Analytical, magnetic susceptibility, molar conductance of the ligand and its metal complexes

Ligand / Complex	Mol. Wt.	M.P (°C)	Yield (%)	Found /Calculated (%)				μ_{eff} B.M.	Molar conductance Ohm^{-1} cm^2 mol^{-1}
				M	C	H	N		
$C_{26}H_{24}N_6O_4$	484.51	270	75	-	64.45 (48.62)	4.99 (3.45)	17.35 (13.08)	-	-
$C_{26}H_{22}CuN_6O_4$	546.04	317	65	11.64 (11.70)	57.19 (57.15)	4.06 (4.10)	15.39 (15.42)	1.90	16
$C_{26}H_{22}CoN_6O_4$	541.40	320	68	10.88 (10.78)	57.68 (57.66)	4.10 (4.18)	15.52 (15.55)	4.79	18
$C_{26}H_{22}$ NiN_6O_4	541.18	315	65	10.85 (10.90)	57.70 (57.65)	4.10 (4.18)	15.52 (15.50)	2.91	16
$C_{26}H_{22}MnN_6O_4$	537.43	325	65	10.22 (10.27)	58.11 (58.25)	4.13 (4.20)	15.64 (15.70)	5.70	17
$C_{26}H_{22}CdN_6O_4$	594.90	335	70	18.90 (18.93)	52.49 (52.55)	3.73 (3.68)	14.13 (14.17)	Diamagnetic	18
$C_{26}H_{22}HgN_6O_4$	683.08	350	68	29.37 (29.40)	45.72 (45.65)	3.25 (3.20)	12.30 (12.38)	Diamagnetic	15
$C_{26}H_{22}ZnN_6O_4$	547.88	317	70	11.94 (11.90)	57.00 (57.25)	4.05 (4.10)	15.34 (15.40)	Diamagnetic	17

Table 2. IR Spectral data of the ligand and its metal complexes (cm^{-1})

Ligand / complex	ν_{OH}	ν_{NH}	$\nu_{C=0}$	$\nu_{C=N}$	ν_{C-O}	ν_{M-O}	ν_{M-N}
$C_{26}H_{24}N_6O_4$	3433	3173	1664	1594	1201	-	-
$C_{26}H_{22}CuN_6O_4$	-	3185	1618	1560	1236	552	472
$C_{26}H_{22}CoN_6O_4$	-	3198	1616	1565	1262	562	496
$C_{26}H_{22}N_6NiO_4$	-	3176	1645	1570	1265	568	480
$C_{26}H_{22}$ MnN_6O_4	-	3195	1648	1574	1264	555	465
$C_{26}H_{22}CdN_6O_4$	-	3192	1635	1564	1230	550	460
$C_{26}H_{22}HgN_6O_4$	-	3196	1644	1555	1228	556	470
$C_{26}H_{22}ZnN_6O_4$	-	3194	1650	1560	1262	553	475

Electronic spectra of Cu(II) complexes exhibit a broad, low intensity shoulder band. The ^2E_g and $^2T_{2g}$ states of octahedral Cu(II) ion (d^9) split under the influence of the tetragonal distortion and the distortion can be such as to cause the three transition viz., $^2B_{1g} \rightarrow {}^2B_{2g}$, $^2B_{1g} \rightarrow {}^2E_g$ and $^2B_{1g} \rightarrow {}^2A_{1g}$, to remain unresolved in the spectra. It is concluded that all three transition lie within the single broad band in the region 25400 – 31000 cm^{-1}, have been assigned to charge transfer bands from ligand to metal. The observation favor distorted octahedral geometry around Cu(II) complexes. A broad asymmetric band in the region 13495-16605 cm^{-1}, the symmetry being on the lower energy side[33]. The broadness of the band may be due to dynamic John-Teller distortion. The band maxima observed for the present Cu(II) complexes is at 12105-16675 cm^{-1}, 12416-16537 cm^{-1} and 12500 – 16380 cm^{-1} suggest that the complex displays coordination number six. In addition, we have observed a high intensity band around 15165cm^{-1} that can be attributed to the ligand-metal charge transfer transition.

Cobalt(II) complex

In octahedral Co(II) complexes the ground state is $^4T_{1g}$ and a large orbital contribution to the magnetic moment values for various Co(II) complexes are in the range 4.11-4.71 B.M. and 4.60-5.18 B.M. for tetrahedral and octahedral complexes respectively. In present investigation the observed magnetic moment values is in the range 4.79 B.M[34], which indicates octahedral geometry for these Co(II) complexes. This is due to partial quenching of orbital contribution to the magnetic moment. Electronic spectra of Co(II) complex exhibits three bands in the region 9624 - 10350cm^{-1}, 16504 - 18385cm^{-1} and 24844 - 26954 cm^{-1} due to the transition. $^4T_{1g}(F) \rightarrow {}^4T_{2g}(F)$; ν_1 = 9624 - 10350cm^{-1}, $^4T_1g(F) \rightarrow {}^4A_{2g}(F)$; ν_2 = 16504 - 18385cm^{-1} and $^4T_{1g}(F) \rightarrow {}^4T_{1g}(P)$; ν_3 = 24844 - 26954cm^{-1}. These transitions suggest octahedral geometry. The region at 25650 - 26870 cm^{-1} refers to the charge transfer band. These transitions suggest octahedral geometry for the Co(II) complexes. These assignments are in good agreement with the reported values [35].

Nickel(II) complex

Ni(II) complexes exhibits the magnetic moment value of 2.91 which are well within the range of expected value for octahedral geometry around the central metal ion. Electronic spectra of Ni(II) complexes in octahedral coordination is $^3A_{2g}$, the Ni(II) complexes show three transition in an octahedral field, *viz.*,$^3A_{2g}(F) \rightarrow {}^3T_{2g}(F)$; $\nu_1 = 7483 - 8300$cm^{-1}, $^3A_{2g}(F) \rightarrow {}^3T_{1g}(F)$; $\nu_2 = 16620 - 17200$cm^{-1}$^{3}A_{2g}(F) \rightarrow {}^3T_{1g}(P)$; $\nu_3 = 24730 - 25900$cm^{-1}. The observed transition bands lie well within in the range of reported values. There values indicate considerable covalent character and support the octahedral geometry for the Ni(II) complex[36].

Manganese(II) complex

The observed magnetic moment values for Mn(II) complex of the ligand is in the range 5.70 B.M. The electronic spectra of Mn(II) complex shows three transition, which corresponds to the following transitions,$^6A_{1g} \rightarrow {}^4T_{1g}(4G)$; $\nu_1 = 15630 - 16600$cm^{-1}, $^6A_{1g} \rightarrow {}^4E_g(4D)$; $\nu_2 = 17540-18600$cm^{-1}, $^6A_{1g} \rightarrow {}^4T_{1g}(4D)$; $\nu_3 = 21750 - 22800$cm^{-1} These values indicate considerable covalent character and support the octahedral geometry[37]. Hence under the present study octahedral geometry is suggested for Mn(II) complex.

Table 3. Electronic spectral data of ligand field parameters of Cu(II), Co(II), Ni(II) and Mn(II) metal complexes

Complexes	ν_1(cm^{-1})	ν_2(cm^{-1})	ν_3(cm^{-1})	Dq (cm^{-1})	B^1	β	β%	ν_2/ν_1	ν_3/ν_2	LFSE k cal mol^{-1}
$C_{26}H_{22}CuN_6O_4$	12105 – 16675			1534	-	-	-	-	-	25.48
$C_{26}H_{22}CoN_6O_4$	9820	16504	24844	938	833	0.98	15.56	1.68	1.46	14.54
$C_{26}H_{22}Ni\ N_6O_4$	7483	16620	24730	915	842	0.88	19.96	1.34	1.59	32.88
$C_{26}H_{22}MnN_6O_4$	15630	17540	21750	940	871	0.79	22.44	1.25	1.37	14.53

^{1}H NMR Spectra

Spectrum of ^{1}HNMR is DMSO-d_6 solvent used. In ligand (N'^{1}E,N'^{6}E)-N'^{1},N'^{6}-bis((2-hydroxyquinolin-3-yl)methylene)adipohydrazide showed the sharp peak at δ 9.5 (S, 2H) due to OH at 2-position of phenyl ring of 2-hydroxyquinoline-3-carbaldehydee moiety has resonated, but in the case of Zn(II) complex which has been disappeared indicating the involvement of phenolic oxygen in the coordination *via*, deprotonation[38,39]. A single large peak showed at δ 3.4 (S, 3H, CH_3) due to protons of the azomethine group in ligand but in case of Zn(II) complex the peak observed at δ 2.4 (S, 3H, CH_3)[40]. The Twelve aromatic protons due to quinoline and phenyl rings have resonated in region δ 7.1 - 7.8 (m, 12H, Ar-H) as a multiplet, in Zn (II) complex the twelve aromatic protons have been observed in the region δ 7.0-8.8 (m, 12H, Ar-H) as a multiplet. The Zn(II) complex suggests coordination of the phenolic OH with metal ion.

ESR spectrum

The ESR spectrum of the powder Cu(II) complex was recorded at room temperature using DPPH as a standard showed a broadened feature without hyperfine splitting due to the dipolar interaction from the ESR spectrum of a set of magnetic parameter $g_{\parallel} = 2.0554$, $g_{\perp} = 2.0341$. The observed ESR spectrum is characteristic of distorted octahedral geometry g value averaged to over all directions and G which is measure of extent of exchange interaction between metal ion have been calculated. In present case the value of G was found to be 4.0376. according to Hathway, If G value if grater then 4, the spin exchange interaction is negligible where as G value is less than 4 indicate considerable interaction between metal ions in solid complex clearly indicate that Cu(II) ion in the complex is mononuclear nature of the complex.

Table 4: ESR data of the Cu(II) complex

Complex	$g_{\parallel}$	$g_{\perp}$	g_{av}	g_{iso}	G
$C_{26}H_{22}CuN_6O_4$	2.0554	2.0341	2.04867	2.3849	4.0376

X-ray powder diffraction studies

X-ray powder diffraction pattern for Cu(II) complex has characterized with a view to find the type of crystal system the XRD data given the table the diffractogram of Cu(II) complex consists of ten reflections in the range of 10.93-22.25 (2θ value) with maxima at 2θ =15.94A^o The interplanar spacing(d)has been calculated from the position of intense peaks using Bragg's equation $n\lambda = 2d\sin\theta$, $\lambda = 1.5406$ ^{0}A The observed and calculated values of d are quite consistent (Table 4). The unit cell calculations have been carried out for the cubic system, the set of $h^2 + k^2 + l^2$ values of the complex were found to be 1, 2 and 4 which corresponds to the planes and absence of forbidden number its confirms the cubic symmetry from the above results the unit cell constants for cubic system were found to be a=b=c =8.8514 ^{0}A for the Cu(II) complex of the ligand the complex showed broad peak indicates amorphous nature [41,42].

Table 4. X- ray powder diffraction data of Cu(II) complex.

2θ	**θ**	**sinθ**	**Sin^{2}θ**	**h^2+k^2+l^2 (a)**	**h^2+k^2+l^2 (b)**	**h k l**	**d-spacing**		**Relative intensity (%)**	**a (A°)**
							Cal.	**Abs.**		
10.93	5.46	0.0951	0.0090	1	1	1 0 0	8.346	8.332	64.84	8.3546
14.66	7.33	0.1275	0.0162	2.173	2	1 1 0	5.661	5.675	44.61	8.0032
15.94	7.97	0.1386	0.0192	2.275	2	1 1 0	5.542	5.536	100	8.8514
16.18	8.09	0.1407	0.0197	2.319	2	1 1 0	5.484	5.473	57.25	8.7625
16.88	8.44	0.1467	0.0215	2.507	2	1 1 0	5.278	5.277	47.55	8.4636
21.80	10.90	0.1890	0.0357	4.203	4	2 0 0	4.073	4.380	51.84	8.1638
20.33	10.18	0.1767	0.0312	3.644	4	2 0 0	4.365	4.368	52.32	8.7479
22.60	11.30	0.1959	0.0383	4.116	4	2 0 0	4.116	4.114	55.61	8.2357
21.77	10.84	0.1880	0.0353	4.175	4	2 0 0	4.088	4.085	56.76	8.1851
22.25	11.13	0.1930	0.0372	4.368	4	2 0 0	3.992	3.994	61.73	8.0115

Antibacterial activity

The antibacterial activity results revealed that the ligand and its complexes shown weak to good activity (Table 5). The ligand and its Cu(II), Hg(II), Ni(II) complexes shows weakly active with the zone of inhibition 10-13 mm against the both organisms when compared to the standard drug streptomycin. The Mn(II), Co(II), Cd(II) shows active and moderate activity as compared to its ligand with zone of inhibition 15-17 mm and 18-20 when compared to the standard drug streptomycin[43,44].

Table 5. Antimicrobial activity of the ligand and its metal complexes

Sl. No.	**Compound**	Antibacterial Activity Zone of inhibition (in mm)		Antifungal Activity Zone of inhibition (in mm)	
		E.Coli	***S.aureus***	***A.niger***	***A.flavus***
1.	$C_{26}H_{24}N_6O_4$	09	08	08	10
2.	$C_{26}H_{22}CuN_6O_4$	10	11	15	12
3.	$C_{26}H_{22}CoN_6O_4$	14	13	14	13
4.	$C_{26}H_{22}Ni\ N_6O_4$	12	15	17	15
5.	$C_{26}H_{22}MnN_6O_4$	15	13	20	19
6.	$C_{26}H_{22}\ Zn\ N_6O_4$	20	19	16	17
7.	$C_{26}H_{22}CdN_6O_4$	16	15	18	16
8.	$C_{26}H_{22}HgN_6O_4$	13	14	19	18
9.	Streptomycin	24	23	--	--
10.	Chlotrimazole	--	--	25	26
11.	DMF (Control)	0	0	0	0
12.	Bore size	08	08	08	08

Antifungal Activity

The antifungal activity, results revealed that the ligand and its Cu(II), Co(II), Ni(II), Zn(II), Cd(II),Hg(II) and Mn(II) complexes have exhibited weak to good activity (Table 5). The ligand and its Co(II) and Hg(II) complexes shows weak activity with zone of inhibition, the Cu(II), Ni(II), Mn(II), Zn(II) and Cd(II), shows moderate activity as compared to its ligand with the zone of inhibition 15-17mm, to good activity with the zone of inhibition of 18-20mm when compared to the standard drug chlotrimazole[45,46].

CONCLUSTION

In present studies, our efforts have been to synthesize some new compounds. These synthesized compounds have been characterized by various spectral analyses. The elemental analysis , magnetic susceptibility, electronic spectra, IR, ^{1}H NMR, ESR spectra and X-ray data observations projects the following structures for these complexes where in Cu(II), Co(II), Ni(II), Zn(II), Cd(II), Hg(II) and Mn(II) are exhibit six coordinated octahedral geometry.

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