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Synthesis and Biological Activity and Thermal Analysis of Sulfaquinoxaline Mixed Metal Complexes

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ABSTRACT

New mixed sulfaquinoxaline metal complexes were synthised by reacting sulfanomide ligand with transition metals which were as chlorides (Cr(III), Mn(II), Co(II), Cu(II), Hg(II), Fe(III), Zn(II), Cd(II), Ni(II)). The nine mixed complexes of sulfaquinoxaline is prepared by reflux method and determined by CHN analysis and IR. The results of IR spectral data showed that the binding of metals to the sulfonamidic nitrogen, oxygen of sulfone group and nitrogen of amino group .The geometries of all complexes are octahedral and that proved by magnetic measurements and spectral data. The thermogravimetric analysis (TGA) of mixed metal sulfaquinoxaline complexes and DTA that used to determine thermodynamic parameters of the thermal decomposition steps, Ea, ΔH*and ΔS* are carried out from ambient temperature to 700°C in inert nitrogen atmosphere.

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Introduction

Sulfonamides are the first antimicrobial agent used for eliminating a wide range of infections in human and other animal systems. Sulfaquinoxaline (Figure1) is one of sulfonamide family which used in veterinary medicine, meats, and in poultry industries [1-5]. Mixed metal complexes of sulfaquinoxaline is not reported in the literature and therefore, authors made and attempt to prepare mixed metal complexes of title compounds using routine reflux method and determined by spectroscopic and thermal analysis (DTA and TGA).

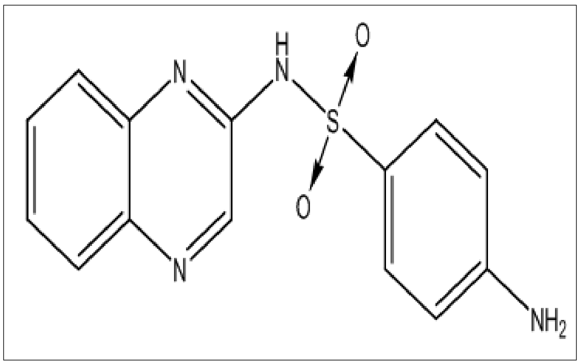


Figure 1: Sulfaquinoxaline (HL)

Experimental Procedure

Sulfaquinoxaline solution was applied to bidistilled water and the inorganic salts [Cr(III), Mn(II), Fe(III), Co(II), Ni(II), Cu(II), Zn(II), Cd(II) and Hg(II)] dissolved as chlorides in 40 mL ethanol getting nine mixed metal-ligand(sulfaquinoxaline)complexes. The molar quantity of metals chloride were mixed together as [Cu(II) and Co(II)],[Cu(II) and Zn(II)],[Cr(III) and Cd(II)],[Fe(III) and Mn(II)],[Hg(II) and Ni(II)],[Hg(II) and Fe(III)],[Cd(II) and Fe(III)],[Hg(II) and Zn(II)], each mixture of them was applied with constant stirring to the measured ligand quantity using specific mole ratios (M:M:L). Then the reaction mixture was refluxed for about 5 min then left over-night, the precipitates were formed, filtered and washed several times with a mixture of EtOH-H_2O and dried desiccator over anhydrous $CaCl_2$, the analytical results given in Tables (1) are determined by normal methods [6].

Table 1: Elemental Analysis, m.p., Formula, Stoichiometries and Color of Mixed Sulfaquinoxaline Complexes

Complexes	Color	Calculated/(Found)%					
		C	H	N	S	M	Cl
$[CrCd_2(HL)_2(H_2O)_2 (Cl)_5]$	Green	36.73 (36.95)	3.08 (3.02)	11.95 (11.90)	6.84 (6.80)	19.69 (19.52)	12.61 (12.73)
$[Mn Fe_2 (HL) Cl_4(OH)_2 (H_2O)_6]$	Brown	22.39 (22.36)	3.49 (3.52)	7.46 (7.52)	4.27 (4.32)	22.19 (22.17)	18.88 (18.82)
$[FeHg(HL)_2Cl_5(H_2O)_2]$	Dark brown	31.42 (31.47)	2.64 (2.72)	10.47 (10.41)	5.99 (5.02)	23.96 (23.87)	16.56 (16.66)
$[CoCu_2(HL)Cl_4(H_2O)_8]$	Green	21.77 (21.72)	3.65 (3.60)	7.25 (7.15)	4.15 (4.11)	24.09 (24.05)	18.36 (18.40)
$[NiZn(HL)Cl_4 (H_2O)_3]$	Green	36.53 (36.41)	3.28 (3.26)	12.7 (12.12)	6.97 (6.93)	13.48 (13.38)	15.40 (15.30)
$[Cu Zn_2 (HL)_3Cl_4 (H_2O)_4]$	Green	38.53 (38.51)	3.39 (3.35)	12.84 (12.81)	7.35 (7.31)	14.84 (14.89)	10.83 (10.75)
$[Zn Hg(HL)_2 Cl_4(H_2O)_3]$	Pale orange	31.65 (31.42)	2.85 (2.81)	10.55 (10.41)	6.03 (6.05)	25.03 (25.14)	13.35 (13.23)
$[Cd_2 Fe (HL)_3Cl_5(H_2O)_2]$	Brown	36.16 (36.10)	2.89 (2.81)	12.05 (12.02)	6.89 (6.85)	20.12 (20.03)	12.71 (12.62)
$[Hg Ni (HL) Cl_4(H_2O)_4]$	White	21.74 (21.72)	2.61 (2.55)	7.24 (7.21)	4.14 (4.15)	33.52 (33.45)	18.33 (18.29)

All the Complexes have m.p > 300º C

Measurements

The chloride content of complexes was determined by using the familiar Volhard method [7]. IR spectra of the sulfaquinoxaline and their mixed metal complexes were evaluated by Perkin Elmer spectrophotometer, Model 1430 with a range of 200-4000 cm^{-1}. Nujol mull spectra was used to determine spectra of sulfaquinoxaline and the solid mixed complexes by using Unicam UV/Vis spectrometer. Faraday's method were used to determine the magnetic measurements at room temperature (25 C).The reflection spectrometer operating was used to calculate ESR spectra at (9.1–9.8) GHZ in a cylindrical resonance cavity with modulation of 100 KHZ and by contrast with DPPH signal g values were determined. The differential thermal analysis (DTA) and thermogravimetric analysis (TGA) for sulfaquinoxaline and its mixed complexes were reported on Shimadzu DTA/TGA-60 thermal analyzer with heating rate 20°C/min under flow rate 20 ml/min of nitrogen atmosphere. The ligand was been applied by using Hyperchem. computer software using PM3 semi-empirical and Molecular Mechanics Force Field (MM+). Sulfaquinoxaline biological activity and its mixed metal complexes were examined against 5 microorganisms representing different categories of microbials.

Result and Discussion

Sulfaquinoxaline mixed metal complexes give broad bands in the 3315 – 3480cm^{-1} region in all prepared complexes suggesting coordination with water which obtained from IR spectra of sulfaquinoxaline and its mixed complexes, Table (2). There was a metal-oxygen bands at 410 cm^{-1} region [8]which indicate that there were coordinated water in these complexes. The bands appear between (3360-3437) and (3420-3576) cm^{-1} are due to νas(NH$_2$) and νsy(NH2) stretching vibrations of the amino (–NH$_2$) group for complexes but for sulfaquinoxaline the band appear between 3318 and 3356 cm^{-1} due to νas(NH$_2$) and νsy(NH$_2$) stretching vibrations of the amino (–NH$_2$) group this shifting suggest that coordination occurred through nitrogen of amino group. The sharp band around 1350cm^{-1} is assigned to SO$_2$ stretching vibration of sulfaquinoxaline at but for metal complexes is shifted to (1414-1416) cm- range that suggesting that ligand coordination with metals through oxygen of sulfone group. The band of sulfonamidic NH group sulfaquinoxaline appears at 3192cm^{-1} while for complexes appears at (3240-3361cm^{-1}) range for, this large shifting mean that there is metal ligand coordination occurred through nitrogen of secondary amino group. The narrow band appeared at 1308cm^{-1} is assigned to C-N stretching vibration of spectrum of sulfaquinoxaline while for mixed complexes is correspond to (1307-1315cm^{-1}) that meaning that there is no shifting occurred in the band and so no metal ligand coordination occurred. The peak at 1637cm-corresponding to stretching vibration of C=N of sulfaquinoxaline but the complexes show this band at (1637-1642cm-) range so the shifting is not significant so there is no metal ligand coordination.. The sharp band appears at 2942cm-of CH stretching vibration of the spectrum of sulfaquinoxaline but for mixed complexes appears at (2920-2955) cm- range. The absorption band at 1598cm- is assigned to phenyl bending vibration of sulfaquinoxaline while for complexes appears at (1592-1594) cm^{-1} range.

Electronic Spectral and Magnetic Studies

The pale green electronic absorption spectra of copper-cobalt complex $[CoCu_2(HL)Cl_4(H_2O)_8]$ gave three bands at 302, 365 and 795 nm, Table (3). The nature of geometry is octahedral due to charge transfer of bands which are assigned to $^2Eg \rightarrow {}^2T_{2g}$ (D) transition and $^4T_{1g}(F) \rightarrow {}^4T_{2g}(P)$ transition. The octahedral geometry around the Cu (II) ions is determined by ESR data while the visible d-d electronic spectral band at 725 nm may probably be due to octahedral spatial configuration around Co (II). At room temperature the μeff value is of 6.51, that suggested the octahedral geometry of complex. The electronic pale green absorption spectra of copper-zinc complex $[Cu Zn_2 (HL)_3Cl_4 (H_2O)_4]$ showed three bands at 285, 343 and 781 nm, Table(3).These values mean that the complex has octahedral geometry as result of 2Eg → 2T2g (D) transition for copper and no d-d transition could be observed due to the d10- configuration of zinc so it,s geometry like that of copper. The bands obtained by electronic absorption spectra of iron-cadmium complex $[Cd_2 Fe(HL)_3Cl_5(H_2O)_2]$ are of values 293, 338 and 359 nm, Table(3).Due to CT ($t_{2g} \rightarrow \pi^*$) and CT ($\pi \rightarrow e_g$), Iron bands were appeared and no d-d transition could be observed due to the d10- configuration of cadmium (suggesting that it,s geometry will similar to that of cadmium).The presence of octahedral geometry is suggested by μeff value that equal 4.56. Iron-manganese complex [Mn Fe2 (HL) $Cl_4(OH)_2$ $(H_2O)_6$] showed three bands by electronic absorption spectra with values 293, 333 and 364 nm, Table(3).The appearance of octahedral geometry due to Due to CT ($t_{2g} \rightarrow \pi^*$) and CT ($\pi \rightarrow e_g$) of iron due to π - π* the first band appear while the second one is assigned to 6A1g→4A1g , while the third is due to $^6A_{1g} \rightarrow {}^4T_{2g}$ transition[9-10]. with magnetic moment value equal to 4.89 typified the existence of the complex in Oh geometry for complex. The electronic absorption spectra of iron-mercury complex[$FeHg(HL_2)Cl_5(H_2O)_2$] appeared three bands at 280, 329 and 355 nm, Table(4-5), Figure(2,6).Iron bands appeared due to CT ($t_{2g} \rightarrow \pi^*$) and CT ($\pi \rightarrow e_g$) which assigned that the geometry is octahedral while mercury has no d-d transition could be observed due to the d10- configuration so it,s geometry cannot be determined by ultraviolet-visible spectra and suggested that it similar to that of iron , So in general the geometry of complex is octahedral and with magnetic moment value equal to 4.32 B.M. The geometry of complex [Hg Ni (HL) Cl4$(H_2O)_4$] octahedral because the three bands showed by electronic absorption spectra have values 288, 347 and 363 nm, Table (3). The geometry is assigned to ^{4}T1g(F) → $^4T_{2g}$(P) transition of nickel but mercury cannot be determined by UV-VIS spectra as it has no d-d transition could be observed due to the d10- configuration so expected to be as nickel. Its room temperature μeff value of 2.44, typified the existence of Oh configuration. There are three bands obtained by electronic absorption spectra of zinc-mercury complex [ZnHg $(HL)_2$ $Cl_4(H_2O)_3$] of 288, 314 and 347 nm, Table (3). Both of Zn(II) and Hg(II) has no d-d transition could be observed due to the d10- configuration and cannot be determined by ultra-visible spectra and as a result the suggested geometry is octahedral like other complexes. The electronic absorption spectra of nickel-zinc complex [NiZn (HL)Cl_4 $(H_2O)_3$] gave three bands at 291, 320 and 360 nm, Table (3). The geometry of complex is octahedral due to $^3T_1(F) \rightarrow {}^3T_1(P)$ transition of nickel and zinc is suggested as nickel as it has no d-d transition could be observed due to the d^{10}- configuration (not determined by UV-VIS spectra). Its room temperature μeff value of 2.44, typified the existence of Oh configuration. The electronic absorption spectra of chromium-cadmium complex [$CrCd_2(HL)_2(H_2O)_2$ $(Cl)_5$] showed bands at 285, 309 and 479 nm which assigned to octahedral geometry as result of $^4A_{2g} \rightarrow {}^4T_{2g}$ (F), $^4A_{2g} \rightarrow {}^4T_{1g}$(F) and $^4A_{2g} \rightarrow {}^4T_{1g}$(p) transitions for chromium but cadmium cannot be determined by spectra because it has no d-d transition could be observed due to the d^{10}- configuration so considered like chromium, Table(3). The octahedral geometry is suggested through Its room temperature μeff value of 6.40 B.M.

Table 2: Fundamental Infrared Bands (Cm^{-1}) of Sulfaquinoxaline and its Mixed Metal Complexes

Compound	νNH 2^O amine	ν (O=S=O)	ν(NH) 1^O amine sym	ν(NH) 1^Oamine asym	ν (C-N)	ν (C=N)	ν(CH) stretch	ν(NH) 1^Oamine bend
Sulfaquinoxaline	3192	1350	3318	3356	1308	1637	2942	1598
[$CrCd_2(HL)_2(H_2O)_2$ $(Cl)_5$]	3240	1416	3361	3439	1313	1640	2905	1592
[Mn Fe_2 (HL) $Cl_4(OH)_2$ $(H_2O)_6$]	3240	1416	3360	3420	1313	1638	2920	1592
[Cd_2 Fe $(HL)_3Cl_5(H_2O)_2$]	3075	1414	3360	3420	1310	1638	2920	1594
[$CoCu_2(HL)Cl_4(H_2O)_8$]	3075	1416	3360	3440	1313	1639	2955	1592
[Hg Ni (HL) $Cl_4(H_2O)_4$]	-	1414	3361	3430	1311	1638	2937	1594
[Cu Zn_2 $(HL)_3Cl_4$ $(H_2O)_4$]	3075	1412	3360	3440	1312	1639	2916	1594
[Zn $Hg(HL)_2$ $Cl_4(H_2O)_3$]	3254	1412	3360	3439	1311	1639	2937	1593
[NiZn(HL)Cl_4 $(H_2O)_3$]	-	1416	3360	3450	1313	1640	2920	1592
[$FeHg(HL_2)Cl_5(H_2O)_2$]	3075	1414	3361	3436	1311	1637	2937	1594

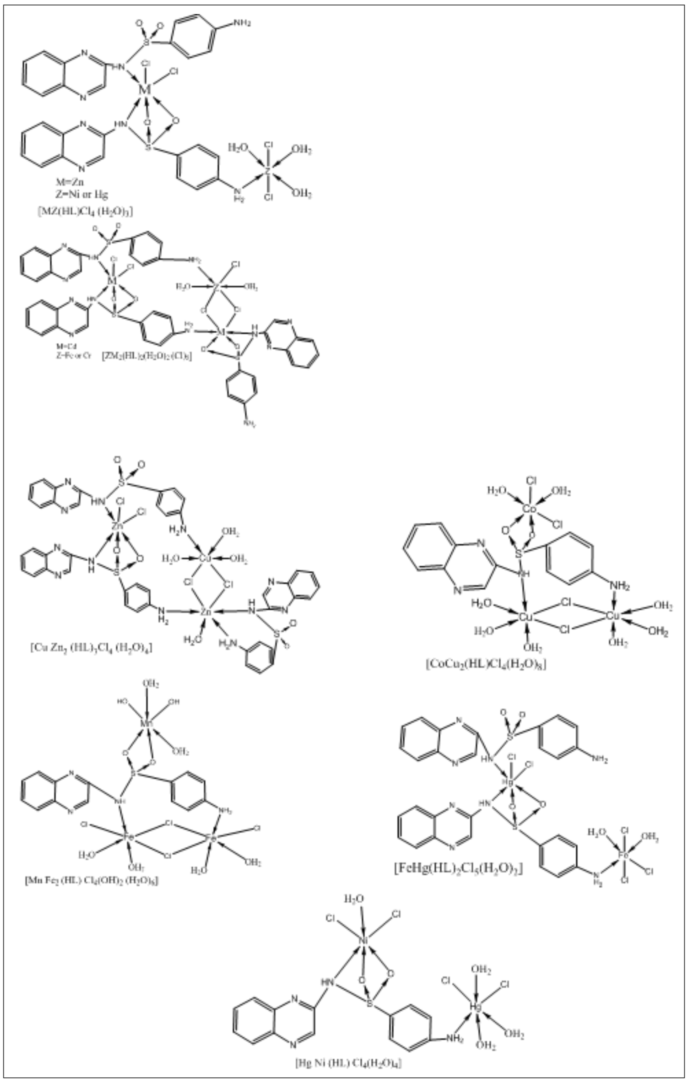


Figure 2: Proposed Structures of Sulfaquinoxaline Complexes

Table 3: Nujol Mull Electronic Absorption Spectra λ_{max} (nm), Room Temperature Effective Magnetic Moment Values (μ_{eff} 298°K) and Geometries Of Sulfaquinoxaline Mixed Metal Complexes

Complex	λ_{max} (nm)	μ_{eff}	Geometry
$[HgNi(HL)Cl_4(H_2O)_4]$	288, 347, 363	2.44	O_h
$[CoCu_2(HL)Cl_5(H_2O)_7]$	302, 365, 795	6.51	O_h
$[ZnHg(L)_2Cl_2(H_2O)_2]$	288, 314, 347	Diamagnetic	O_h
$[CrCd_2(L)_2(H_2O)_2 (Cl)_3]$	285, 309, 492	6.40	O_h
$[NiZn(HL)Cl_4(H_2O)_3]$	291, 320, 360	2.44	O_h
$[FeHg(HL)_2Cl_5(H_2O)_2]$	280, 329, 355	4.32	O_h
$[Mn Fe_2 (HL) Cl_6 (H_2O)_5]$	293, 333, 364	4.89	O_h
$[Cd_2Fe(HL)_2Cl_5(H_2O)_2]$	293, 333, 364	4.56	O_h
$[Cu Zn_2 (HL)_3Cl_2 (H_2O)_4]$	285, 343,781	1.62	O_h

The groups that have the highest charges of sulfaquinoxaline are oxygen of sulfonyl group and nitrogen of both primary and secondary amine and so coordination occurred through those groups, charge density of sulfaquinoxaline atoms is calculated from hyper-chem program, Figure (3).

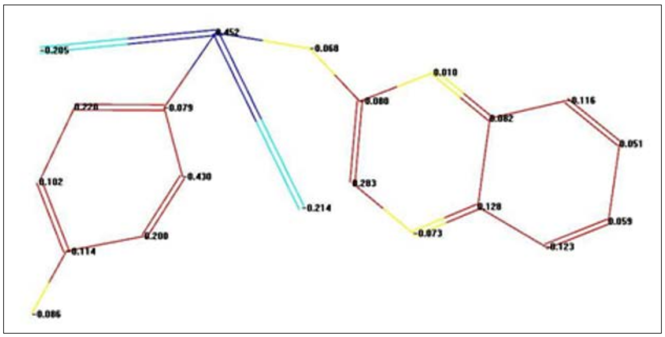


Figure 3: Charge density of sulfaquinoxaline

Electron Spin Resonance of Cobalt Copper Complex

The room temperature polycrystalline X-band ESR spectral pattern of $[CoCu_2(HL)Cl_5(H_2O)_7]$ complex, figure (4) is isotropic nature with g_s= 2.15 and value of A= 130. The presence of ESR signals at g<4 may assign the spin-spin interaction between the Cu and Co atoms show the diametric nature of complex.

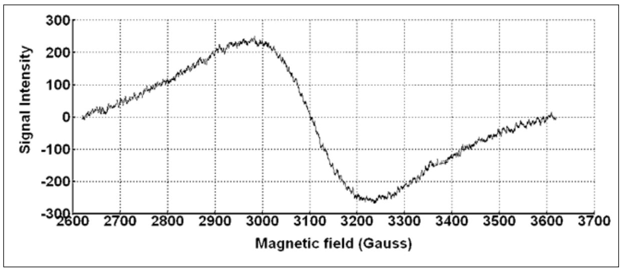


Figure 4: ESR of Cobalt Copper Sulfaquinoxaline Complex

Result and Discussion

Biological Activity

There were five microorganisms which involved {two Gram-positive (*Staphylococcus Aureas* ATCC6538P and Bacillus subtilis ATCC19659), two Gram negative (Escherischia coli ATCC8739 strain and Pseudomonas aeruginosa ATCC9027) bacteria and (Candida albicans as fungi) are used to study biological activity of sulfaquinoxaline and its complexes, in this study there are five complexes of different mixed metal ions are used and two different broadly antibiotics (Ciprofloxacin and Clotrimazole) are used as references (Table 4).

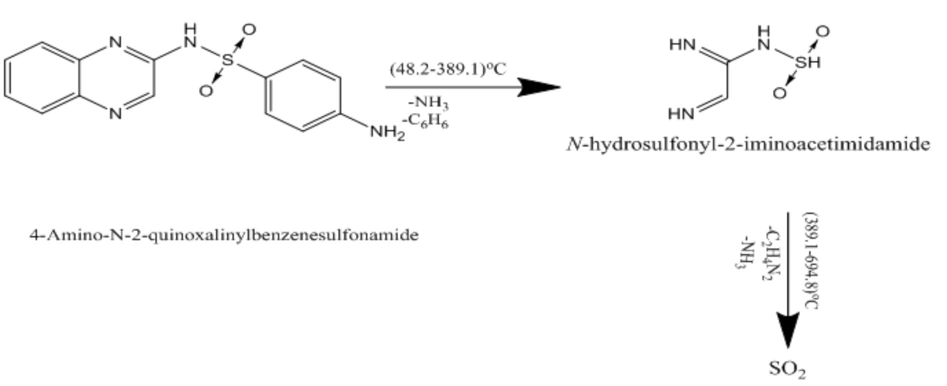
From the data we conclude that. All investigated compounds showed higher activity for Staphyllococcus aureus except $[Mn Fe_2 (HL) Cl_4(OH)_2 (H_2O)_6]$ which showed similar activity to it. The activities for all compounds are similar to Candida albicans, Escherischia coli, Pseudomonas aeruginosa, and Bacillus subtilis except $[Zn Hg(HL)_2 Cl_4(H_2O)_3]$ that has higher activity to Escherischia coli and Bacillus subtilis which meant that presence of mercury affect on the activity of zinc in the complex.The activity of free ligands have lower activity than most of metal complexes, the increased activity of metal chelates could be discussed deponding on the bases of overtone's concept and chelation theory [11-12]. As result of chelation, the polarity of metal ion is decreased to a larger extent due to the overlap of the ligand orbital and partial sharing of the positive charge of the metal ion with the donor groups which lead to raising the delocalization of p- and d-electrons over the whole chelate and enhances the lipophilicity of the complex. The cell is surrounded by the lipid membrane that itscell permeability prefers the passage of only lipid soluble materials deponding on that liposolubility is an important factor that controls antimicrobial activity.

Table 4: The Antibacterial Activity of The Free Ligands and its Complexes Against Some Reference Strains Expressed in Absolute Activity (AU)

complexes	Candida albicans		Escherischia coli		Pseudomonas aeruginosa		Staphyllococcus aureus		Bacillus subtilis	
	Blank	Cpd	Blank	Cpd	Blank	Cpd	Blank	Cpd	Blank	Cpd
Sulfaquinoxaline	9	9	9	9	9	9	9	9	9	9
[Cu Zn_2 $(HL)_3Cl_4$ $(H_2O)_4$]	9	9	9	9	9	9	9	14	9	9
[Zn Hg$(HL)_2$ $Cl_4(H_2O)_3$]	9	9	16	9	9	9	9	23	9	17
[[NiZn(HL)Cl_4 $(H_2O)_3$]	9	9	9	9	9	9	9	16	9	9
[Mn Fe_2 (HL) $Cl_4(OH)_2$ $(H_2O)_6$]	9	9	9	9	9	9	9	9	9	9
[$CoCu_2(HL)Cl_4(H_2O)_8$]	9	9	9	9	9	9	9	25	9	9
Ciprofloxacin (reference)	-	-	9	30	9	30	9	30	10	30
Clotrimazole (reference)	9	18	-	-	-	-	-	-	-	-

Thermal Analysis

Masoud et al. has reported the thermal behavior of some biologically active compounds [13-19]. The thermograms (TGA) has been used to determine thermal decomposition of ligand and its investigated compounds, Decomposition occurred in two steps in the range of 50-700°C for sulfaquinoxaline. The first step of decomposition starts at 48°C and ends at 389.1°C with a corresponding weight loss 60.8%, DTA showed endothermic effect in this step. The last step of decomposition is observed at 389-684°C with a corresponding weight loss 17.90% that accompanied by exothermic effect from DTA curve.(Figure5,6), (Table 5,6)



Scheme(1):Thermolysis of sulfaquinoxaline

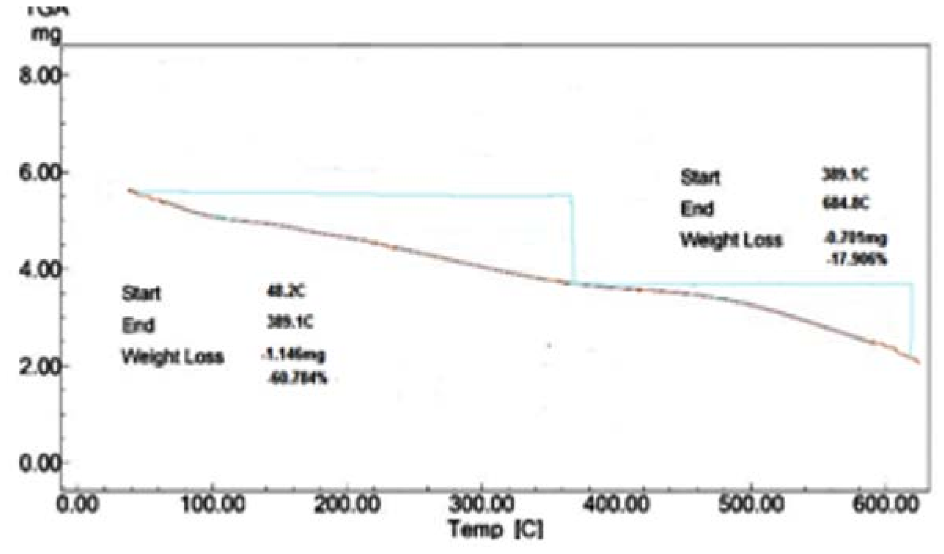


Figure (5):TGA of sulfaquinoxaline ligand

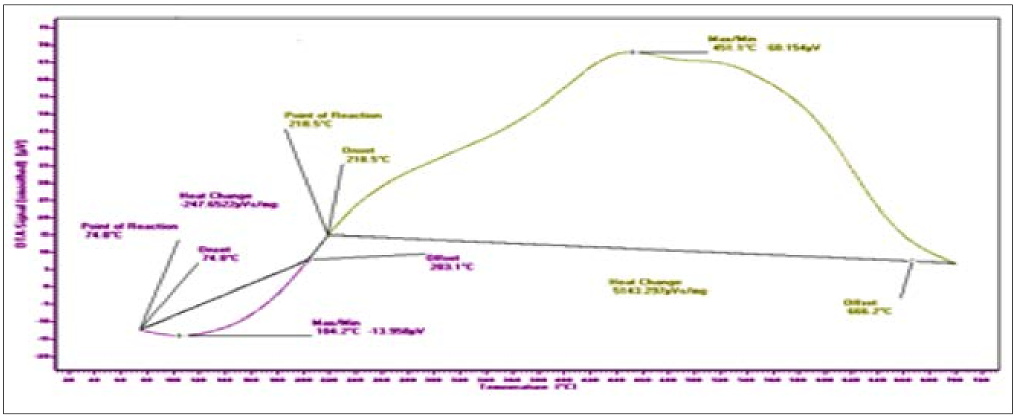


Figure 6: DTA of sulfaquinoxaline ligand

Table 5: DTA Analysis of Sulfaquinoxaline and its Mixed Complexes

Complex	Type	Tm (°C)	Ea kJ mol^{-1}	n	am	DS# kJ K^{-1} mol^{-1}	DH# kJ mol-1	103 Z S^{-1}
Sulfaquinoxaline	Endo	104.2	3.38	1.99	0.50	-0.30	-31.41	0.004
	Exo	451.1	22.64	1.28	0.59	-0.31	-139.8	0.006
[$CoCu_2(HL)Cl_5(H_2O)_7$]	Endo	90.5	2.86	1.87	0.51	-0.30	-27.19	0.004
	Exo	332	21.57	1.03	0.63	-0.31	-101.35	0.008
	Exo	555.8	27.38	1.22	0.59	-0.31	-173.34	0.006
[Cd_2 $Fe(HL_2)$ $Cl_5(H_2O)_2$]	Endo	82.6	11.43	1.99	0.50	-0.29	-23.74	0.017
	Exo	519.1	63.59	1.20	0.60	-0.30	-157.67	0.015
[$FeHg(HL)_2Cl_5(H_2O)_2$]	Endo	92.1	12.98	1.66	0.54	-0.29	-26.54	0.017
	Exo	462.3	49.35	1.40	0.57	-0.30	-140.50	0.013
[$NiZn(HL)Cl_4$ $(H_2O)_3$]	Endo	133	6.12	1.99	0.50	-0.30	-39.97	0.006
	Exo	570	83.05	1.15	0.60	-0.30	-172.75	0.018

Table 6:TGA of Sulfaquinoxaline and its Mixed Complexes

Complex	Temp. (°C) TGA	Wt. Loss %		Assignment
		Calc	Found	
Sulfaquinoxaline	48.2-389.1°C	59.60	60.87	Elimination ofNH_3 and $2C_6H_6$
	389.1-684.6 °C	17.20	17.71	Elimination of $C_2H_4N_2$ and NH_3
[$CoCu_2(HL)Cl_5(H_2O)_7$]	20.26 -87.13 °C	18.89	18.91	Elimination of$7H_2O$
	87.13-131.62 °C	6.65	6.61	Elimination of C_6H_6 and 2HCl
	131.62-232.07 °C	10.02	9.96	Elimination ofC_6H_7N and $C_2H_4N_2$
	232.07-321.04 °C	2.89	2.86	Elimination of NH_3 and S
[$FeHg(HL)_2Cl_5(H_2O)_2$]	20.97-97.07 °C	18.32	18.36	Loss of $4H_2O$, 8HCl and $2NH_3$
	97.07-149.14 °C	3.18	3.17	Loss of $4C_6H_6$ and 2HCl
	149.14-230.68 °C	3.49	3.55	Loss of $4C_6H_6$ and $2NH_3$
	230.68-334.82 °C	4.38	4.36	Loss of $4C_2H_4N_2$ and $2NH_3$
	334.82-458.42 °C	3.25	3.28	Loss of $2NH_3$,3SO and S
[Cd_2 $Fe(HL_2)$ $Cl_5(H_2O)_2$]	25.98-84.51°C	25.93	25.90	Elimination of $2H_2O$,$3C_6H_6$ and3HCl
	84.51-230.27°C	5.34	5.29	Elimination of 4NH3,2C2H4N2 and2 HCl
	230.27-377.37°C	21.21	21.25	Loss of $2NH_3$, $3C_6H_6$, 2S and SO
[$NiZn(HL)Cl_4$ $(H_2O)_3$]	20.24-105.05 °C	13.87	13.90	Loss of $3H_2O$ and 2HCl
	105.05-217.93 °C	12.62	12.64	Elimination of 2HCl and $2C_6H_7N$
	217.93-362.62 °C	11.98	12.003	Elimination of $2C_8H_6N_2$ and NH_3
	362.62-475.50 °C	2.65	2.61	Loss of 2SO and NH_3

In case of [NiZn $(HL)Cl_4$ $(H_2O)_3$] complex, (Table 5,6) (Figure7,8), there is no weight loss up to 20.24°C. The decomposition occurred in 4 steps, the first step of decomposition starts at 20.24°C and ends at 105.05°C with a corresponding weight loss 15.62%. The second step of decomposition occurred at (105.05-217.93)°C range with 12.63% weight loss. In case of third stage the decomposition starts at217.93°C and ends at 362.62°C with a weight loss 12.003%. In the last step the weight loss was of 2.61% from decomposition at(362.62-475.50)°C range . The DTA data showed two peaks at 133 and 570°C first one is endothermic and second is with exothermic effect.

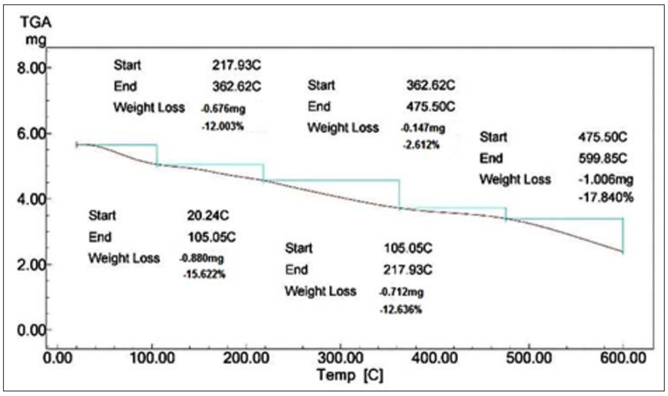


Figure 7: TGA of Ni-Zn Sulfaquinoxaline Complex

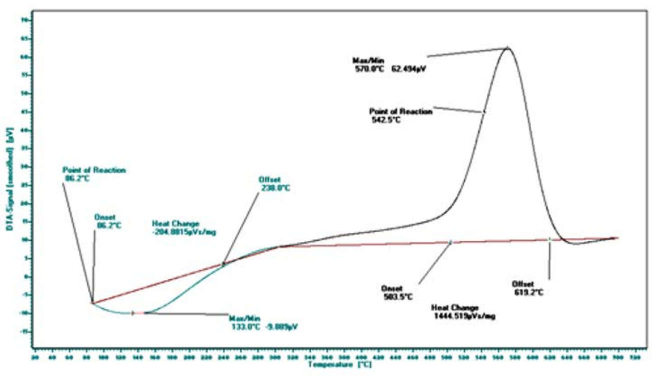
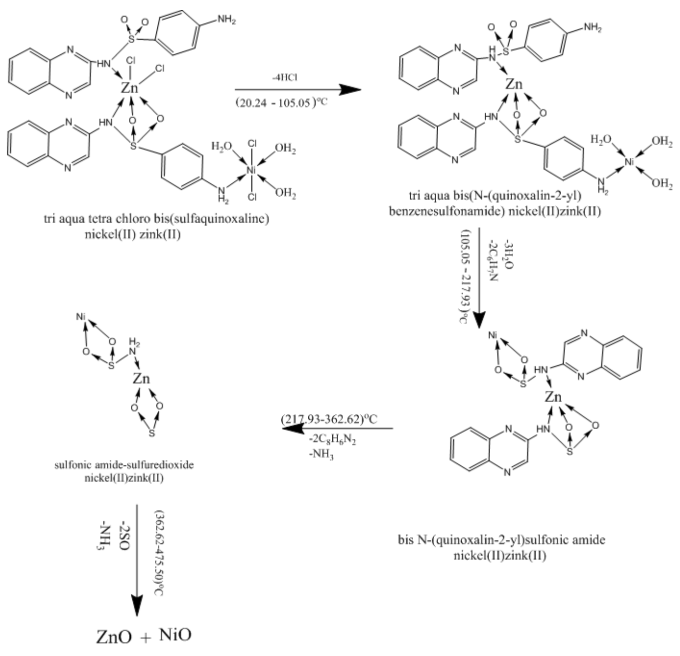


Figure 8: DTA of Ni-Zn Sulfaquinoxaline Complex

In case of [Cd_2Fe $(HL)_3Cl_5(H_2O)_2$] complex, (Figure9,10), (Table5,6), there is no weight loss up to 25.98°C.TGA curve showed that the decomposition occured 3 steps. In the first step the decomposition starts at 25.98°C and ends at 84.51°C with a coressponding weight loss 25.89%. The decomposition in second step include 5.48% weight loss and occurred at (84.51-230.27) oC. In case of last step the decomposition starts at 229.70°C and ends at 377.73°C with acorresponding weight loss 21.25. The DTA data gave two peaks at 82.6 and 519.1°C first one is endothermic and second is with exothermic effect.



scheme(2): Thermolysis of[$NiZn(HL)_2Cl_3$ $(H_2O)_5$]

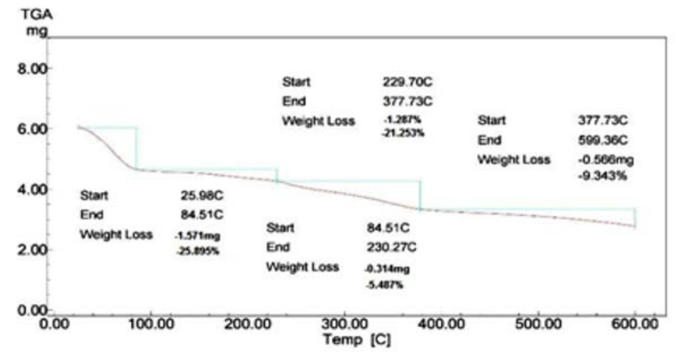


Figure 9: TGA of Fe-Cd Sulfaquinoxaline Complex

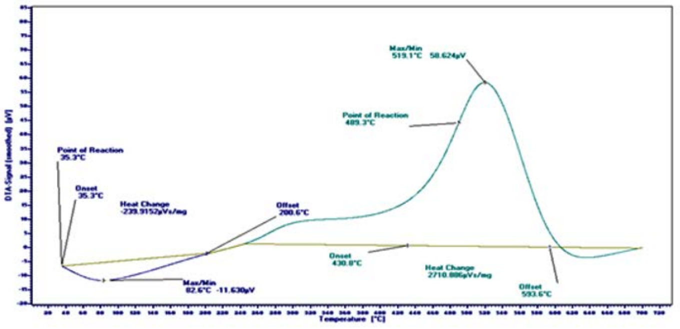
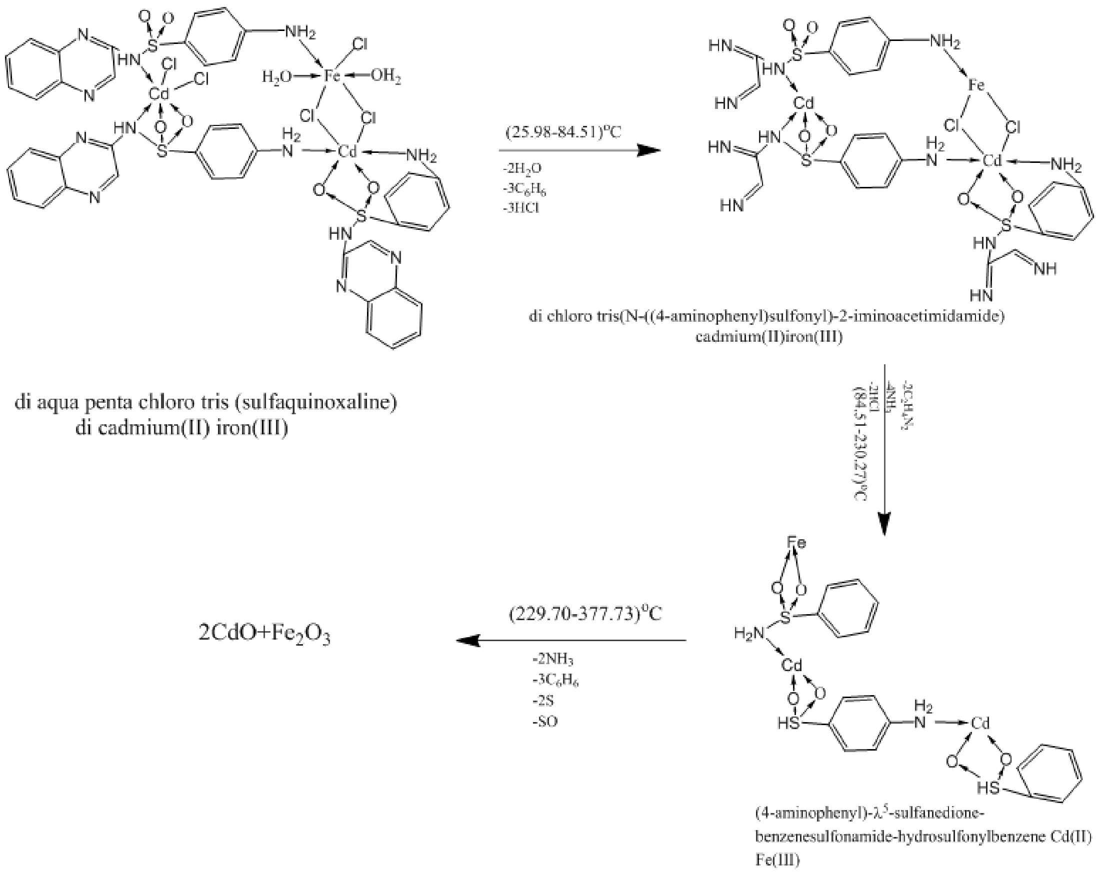


Figure 10: DTA of Fe-Cd Sulfaquinoxaline Complexes



Scheme (3): Thermolysis of $[Cd_2\ Fe\ (HL)_2\ Cl_5(H2O)_2]$

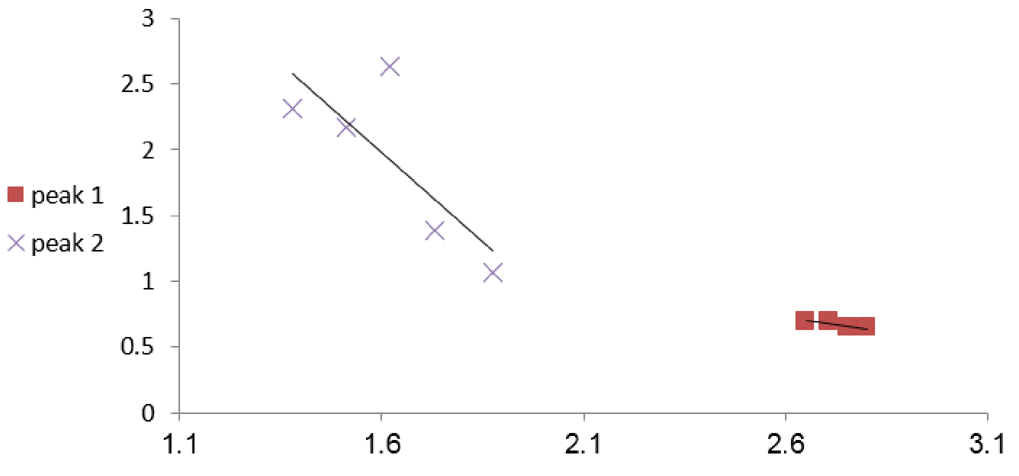


Figure 11: lnΔT against 103/T Relation for Sulfaquinoxaline Ligand

Conclusion

Different spectroscopic methods are used to analyze the prepared mixed metals complexes of sulfaquinoxaline and its Stoichiometries are different. Nujol and ESR spectra are used to confirm geometry which are Oh geometry for all mixed complexes have. Sulfaquinoxaline has different sites available for coordination which carries more electronegative charges and hyper chem. program discuss these results. The thermal decomposition of the complexes ended with the formation of metal oxides as a final product. The activity of sulfaquinoxaline complexes are higher than industrial sulfaquinoxaline for Staphyllococcus aureus except $[Mn\ Fe_2\ (HL)\ Cl_4(OH)_2\ (H_2O)_6]$ complex. $[Zn\ Hg(HL)_2\ C_{14}(H_2O)_3]$ has higher activity to Escherischia coli and Bacillus subtilis than sulfaquinoxaline while the other complexes has similar activity.

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