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RESEARCH ARTICLE

Synthesis, Characterization and Bioactivity Study of Mixed-ligand Complexes with Some Metal ions for new dithiocarbamate, 8-Hydroxyl quinolone

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Abstract

A series of [M(Q)(L)] (where M=Co(II),Ni(II) ,Cu(II), Zn(ll),Cd(ll) and Pd(II) , Q=8-hydroxylquinoline and L= dithiocarbamate ligand) complexes have been prepared. The new dithiocarbamate compound was characterized using elemental analyses, FT-IR, UV-VIS spectroscopy magnetic moments, ^{1}H and ^{13}C NMR for ligands, thermal gravimetric analysis (TGA), differential thermal gravimetric (DTG). The antibacterial activities of synthesized compound were studied against *Esherichia Coli*, *Staphylococcus aureus*, *Proteus mirabilis* and *Pseudomons aerugino*, for antifungal activity against *Candida albicans* and *Candida tropicalis*

Keywords: *Mixed ligand complexes, Dithiocarbamate, Spectral dat.*

Introduction

ß-enaminone is an unsaturated compound derived by the condensation of an aldehyde or a ketone with a secondary amine [1]. These compound are constitute a powerful class of significant intermediates which are versatile for various chemical transformations, especially for heterocyclic compounds synthesis [2]. They have been used for the preparation of various important antibacterial [3], anticonvulsant [4], anti inflammatory [5] and antitumour agents [6].

They are also important precursors for the synthesis of azo compounds [7], 3-amino sugar derivatives [8], hexahydroazulenes [9], ß-amino ketones [10] and indolizidine alkaloids [11]. They are versatile synthetic intermediates that combine the ambident electrophilicity of enones with the ambident nucleophilicity of enamines. They are typical push-pull systems in which the amine group pushes and the carbonyl pulls electron density.

The carbonyl group, conjugated with the enamine moiety, gives this system enough stability to be easily prepared, isolated and stored under atmospheric conditions at room temperature [12]. The conventional method for the synthesis of enaminones is the

azeotropic removal of water by refluxing an amine with 1, 3-diketone in an aromatic solvent [13].

Various modified synthetic pathways have been reported in literature such as the addition of metallic esters or amide enolates to nitriles [14], tosyl imines [15] or imidoyl halides. Dithiocarbamates (dtcs) represent a class of compounds that were evaluated in different applications due to their ability to stabilize specific stereochemistry in their complexes [16, 17].These species are organosulfur ligands which form stable complexes with metals [18].

There are two types of dithiocarbamates are mono- and dithiocarbamates. The two are formed depending on the nature of amines used during the synthesis of the compound [19]. Mixed ligand complexes also play an important role in the biological field [20]. So that a large number of mixed ligand complexes with various transition metals are known [21, 23]. In this paper, an attempt has been made to synthesize a new mixed ligand

DTC ligand and its complexes. The spectral analysis and bacterial activity of complex have been evaluated.

Experimental

Martial's

Chemicals and solvents supplied by B.D.H, Merck and Fluke were used without further purification.

Instruments

Melting points for prepared complexes were measured by electro thermal (Stuart melting point apparatus).IR- spectra were taken on a (a Biotic 600) FT-IR spectrophotometer in the range 4000-400 cm^{-1}. With samples as discs. UV-Vis spectra were recorded on (Shimadzu UV-160 A) Ultra Violet– Visible spectrophotometer. Elemental analysis (C.H.N) was (EURO3000 Single), Conductivities were measured for 10^{-3}M of complexes in DMSO at 25°C using (Digits conductivity meter WTW, 720), Metal contents complexes were determined by atomic absorption (A.A) technique using Atomic Absorption spectrophotometer-5000, Perkin-Elmer.

Electrical conductivity measurements of the complexes were recorder at 25ºC for 10^{-3} $mole.L^{-1}$ solution of the samples in DMSO by using (conductivity meter, model 4070), Thermogravimetric analysis (TGA) was carried out using STA PT-1000 Linseis company /Germany.

The ^{1}H and ^{13}C-NMR spectra were measured by Bruker, model ultra-shield at 300 and 75 MHz in ppm (δ), respectively. DMSO was used as a solvent with TMS as an internal standard, Mass spectra for ligands were obtained by Electrospray (ES) mass spectroscopy on Shimadzu GC-Mass QPA-2013 spectrometer. The preparations of free ligands were achieved by two steps Scheme (1) [24].

Synthesis of Free Ligand [K-L]

The preparation of free ligand was achieved by two steps scheme (1) [25]

Step 1

Preparation of 4-((5, 5-dimethyl-3-oxocyclohex-1-en-1-yl) amino) benzenesulfonamide (Precursors [H-P])

Dimedone (1g,7.13mmole) was was dissolved in absolute ethanol (20ml) and heated up to 40 ºC, and then sulphanilamide (1.22 g, 7.13 mmol) was added portion-wise with stirring, To the solution few drops of glacial acetic acid was added, The mixture was allowed to continuous stirring until complete dissolution and formation of yellow color solution. Then resulting solution was refluxed for (9) hrs until the light brown precipitate was observed, The reaction mixture was allowed to cool at room temperature, A dark yellow solid was formed which then filtered, washed by dry benzene (5mL), and dried at room temperature, Weight (1.59g) yield (71.8%), m.p (136-138) °C.

Step 2

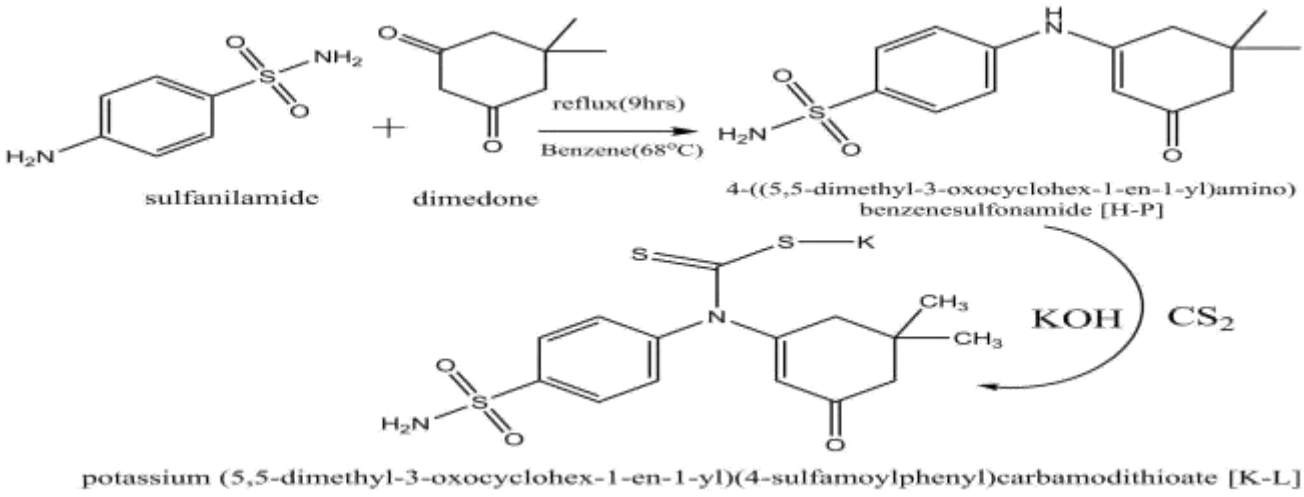
Synthesis of Potassium (5, 5-dimethyl-3-oxocyclohex-1-en-1-yl) (4-sulfamoylphenyl) Carbamodithioate (ligand [K-L])

To a solution of [H-P] (1 g, 2.44mmol) in 10 mL of absolute ethanol was added an excess of potassium hydroxides (0.13 g, 2.44mmol) dissolved in absolute ethanol (5mL). The mixture stirring at room temperature for 30 min., then the solution was cooled at an ice bath, and then a solution of pure carbon disulfide (0.185 g, 2.44mmol) was added dropwise with stirring.

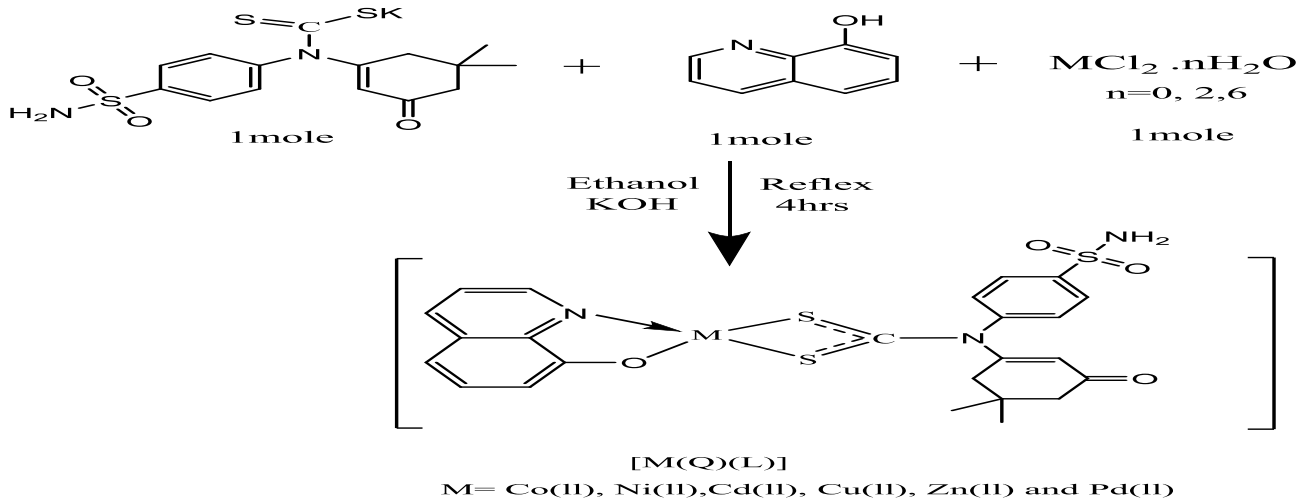
The mixture was allowed to stir at 0 °C for 4 h; the yellow solution was allowed at room temperature and was then evaporated until precipitation of the yellow solid was complete. The yellow solid was then collected by filtration, and then recrystallized from methanol, washed with diethylether (10ml) twice. The formation of the potassium dithiocarbamate salt was obtained as a Pale mustard, m.p= 202-204 ºC. Weight (0.86g), Yield (65.9%).

Synthesis of [K-L] Complexes

The complexes were prepared from the reaction of the ligand K-L and 8-hydroxy quinoline with metal chloride salts in (1:1:1) mole ratio heated under reflux in ethanol, potassium hydroxide was used as a base to produce pure complexes, where isolated in moderate yield, Scheme (2) shows that. Where MII= Co, Ni, Cd, Cu, Zn and Pd.



Scheme 1: Synthetic route for ligand [K-L]



Scheme 2: Synthesis route of [M (Q) (L)] complexes

Results and Discussion

The complexes are solid; stable in air condition and are soluble in the common organic solvents. The molar conductance measurements of complexes in DMSO solution lie in the range (16.3-7.4) ohm^{-1}.cm^2.mol^{-1}, indicating their non-electrolyte behavior. The analytical and some physical properties of complexes are listed in Table 1.

IR- Spectroscopy

The assignment of the infrared spectra bands of ligand [K-L] and its complexes are listed in Table (2). FTIR spectrum of [K-L] exhibits bands at 3329 and 3199 cm^{-1} due to υ_{as} (NH_2) and υ_s(NH_2) stretching band respectively [26]. Band related to ν(C=O) is observed at 1610 cm^{-1} and band observed at 1429 cm^{-1} is related to ν(C=C) mode of aromatic system [27]. The bands at 3064 cm^{-1} and 2954, 2868 cm^{-1} attributed to the υ(C–H) aromatic and υ(C–H) aliphatic stretching vibration respectively [28]. Bands at 1325 And 1159 cm^{-1} that resulted from the stretching of the υas (S=O) and υs (S=O) groups [29]. The new band at 1452 cm-1 can be attributed to ν(C-N) stretching of (N-CS_2) moiety [30, 32]. The spectrum reveals two new bands at 1047 and 974 cm^{-1} that attributed to ν_{as}(CS_2) and ν_s(CS_2), respectively [33]. Indicating an anisobidentate chelation approach of the ligand to the metal atoms [34, 35].The spectrums of prepared complexes have shown some new bands at (517-580) and (420-496) cm^{-1} due to the formation of ν (M- N) and ν (M-O) bands respectively [36].

^{1}H-NMR Spectrum for the Ligand K-L

The ^{1}H-NMR spectrum for ligand [K-L] shown in Figure (1). The signals in the aromatic region are multiple chemical shifts at range (δ =7.77 ppm) are assigned to protons of ($C_{3,7}$-H) and of ($C_{4,6}$-H) of aromatic rings [37]. The chemical shift at (δ= 2.01 ppm) is assigned to the (C_{12}-H) of protons for CH_2 group [38]. The signal at chemical shift (δ =7.02 ppm) is assigned to the protons of (N-H) amine group of (S-NH_2) [39]. The chemical shift at (δ =1.00 ppm) refer to the ($C_{16,15}$-H) proton of CH_3 groups [40]. The signal at chemical shift at (δ =5.21 ppm) is assigned to

the proton of the (C_{10}-H) for the aliphatic ring [41]. The chemical shift at (δ=2.5) is assigned to DMSO solvent. The chemical shift at (δ= 2.33 ppm) is assigned to the (C_{14}-H) protons of the CH_2 groups [42]. The results are summarized in Table (3).

^{13}C-NMR Spectrum for the Ligand [K-L]

The ^{13}C-NMR spectrum in DMSO-d^6 solvent for ligand [K-L] is depicted in Figure (2). The formation of the free ligand has revealed by detecting signal at δ=189.90 ppm, which can be attributed to carbon atom C_{17} for(C-S) of dithiocarbamate group [43]. The carbon atoms (C_{15} and C_{16}) of CH_3 groups resonated with the chemical shifts at δ=27.57ppm [44].Signals at (δ=32.66) ppm assigned to (C_{13}) atom [45]. The carbon atoms (C_{14}) of CH_2 group resonated with the chemical shift at (δ = 43.41) ppm [46]. Also the carbon atoms (C_{12}) of CH_2 group resonated with the chemical shift at (δ = 50.78 ppm [47]. The carbon atom (C_{10}) of CH group with the chemical shifts at δ=96.61 ppm [48]. The resonances at 126.64, 122.11ppm attribute to ($C_{3,\ 7}$ and $C_{4,\ 6}$) of aromatic ring [49]. Signals at (δ=144.63ppm assigned to (C_2) of aromatic ring [50].

The carbon atoms (C_{11}) of C=O group resonated with the chemical shift at (δ=194.43ppm) [51]. Chemical shift related to (C_5) of aromatic ring is detected at δ= 143.40 ppm [52]. The Chemical shift of C_9 moiety appears as expected downfield at δ=161.63 ppm [53]. The results are summarized in Table (4).

The Mass Spectrum of ligand [K-L]

The mass spectrum of ligand [K-L] is depicted in Figure (3). The spectrum reveals successive fragments related to ligand structure with the appropriate isotope distribution pattern. The for molecular ion peak for the free ligand is observed at m/z^+ = 409.7 $[M+H]^+$ (38%) for $[C_{15}H_{18}KN_2O_3S_3]^+$; requires = 409.6 . Other peaks detected at m/z^+= 294.2 (100%), 230.2 (24%), 215.7(28%) and 173.6 (21%) correspond to $[C_{14}H_{17}N_2O_3S]^+$, $[C_{14}H_{17}N_2O]^+$, $[C_{14}H_{16}NO]^+$ and $[C_{12}H_{14}N]^+$ respectively. The fragmentation pattern of [K-L^1] tabulated in Table (5).

Electronic Spectra Data and Magnetic Susceptibility

The UV-Vis spectrum of [K-L] in DMSO solution shows three absorption peaks at (268 nm =37313cm^{-1}; ε_{max}= 745 $molar^{-1}$ cm^{-1}, 281 nm =35587cm^{-1}; ε_{max}=637 $molar^{-1}$ cm^{-1}) assigned to π → π* and (314 nm =31847 cm^{-1}; ε_{max}=1814 $molar^{-1}$ cm^{-1}) assigned to n→π* transitions [54, 55]. The electronic spectra of the complexes exhibited bands at 267-322 nm associated to the ligand field π→π* and n→π* transitions. Bands at 321-417 nm attributed to the charge transfer transitions(CT) in ligand complexes[56].The Co(II) complex shows peak in the d-d region at (488 nm) may due to $^4A_{2(F)}\rightarrow{}^4T_{1(p)}$ transition. These peaks are characteristic for tetrahedral structure around Co atom.

The μ_{eff} value of 4.21 B.M for Co-complex indicates a four coordinate complex with a tetrahedral arrangement about metal centre [57]. The [Ni(Q)(L)] complex exhibits a peak in the d-d region at (640 nm) assigned to $^3T_{1(F)}\rightarrow{}^3T_{1(P)}$ transition, indicating the tetrahedral environment of the ligand surrounding Ni(II) in the complex The μ_{eff} value of 3.89 B.M for Co-complex indicates a fourcoordinate complex with a tetrahedral arrangement about metal centre[58].Band in the [Cu(Q)(L)] spectrum at (806 nm) attributed to d-d transition type $^2B_1g\rightarrow{}^2Eg$ transition confirming square planar geometry about Cu atom.

The magnetic moment value of 2.01 B.M for Cu^{II} complex confirms the square planar geometry around Cu (II) ion [59]. The electronic spectra of the [Zn(Q) (L)] and [Cd(Q) (L)] complexes exhibited peaks (267, 284, 322, 394)and (268, 284, 322, 410) nm respectively which were assigned to the intra-ligand field and charge transfer transitions, no d-d transitions are expected for d^{10} Zn(II) and Cd(II) complexes[60,61]. The spectrum of the [Pd(Q)(L)] complex showed two peaks in the (d-d) region at 636 and 763 nm assigned to $^1A_{1g}\rightarrow{}^1A_{2g}$ and $^1A_{1g}\rightarrow{}^1B_{1g}$,respectively, indicating square planar geometry about Pd atom[62].The electronic data, molar conductance and magnetic moment measurements of K-L complexes with their assignments are listed in (Table 6).

Thermal Analysis

One complex was chosen from all complexes for thermal analysis curve [Cu (Q) (L)] complex described in Figure (4) that revealed the complex is stable up to 100°C in Argon atmosphere. It is decomposed in one step.

The Peak observed at 100-644°C attributed to the loss of (NH_2+CS_2+ Ph-NH +$C_8H_{10}O$) fragment, (obs. = 9.523 mg, 52.909%; calc. = 9.556 mg, 53.092%).The final residue of the compound is related to the ($CuC_9H_5NO_3S$) calc. = 8.443 mg, 46.908%. %. Peaks at 144.1 ºC and 209.7 ºC are measured by the DSC analysis. The peak at 144.1ºC refers to endothermic decomposition process, while peak at 209.7 ºC refers to exothermic decomposition process. The endothermic may signify the metal-ligand bond breaking and the exothermic may indicate combustion of the organic ligand in argon atmosphere .Thermal decomposition data for this complex is summarizing in Table (7).

Bacterial Activity

The ligand and its metal complexes were tested for their antimicrobial activity towards four bacterial species (Escherichia coli, Staphylococcus aureus, Proteus mirabilis, and Pseudomonas aeruginosa) .These compounds were dissolved in DMSO, which showed no activity against any bacterial strains [63]. Incubation period for bacteria was 24 hours. The measured of inhibition zones against the growth of different microorganisms are listed in Tables (3) The synthesized ligand [K-L], and its complexes shows zone of inhibition 12-24 mm in diameter for Escherichia coli where as Staphylococcus aureus exhibit zone of inhibition 15-27 mm in diameter and Proteus mirabilis exhibit zone of inhibition 13-21 mm in diameter,, and Pseudomonas aeruginosa shows zone of inhibition 10-20 mm in diameter. More of complexes found to be actually more active towards tested bacterial strains, compared with the free ligands, indicating complex formation improves antimicrobial activity.

This could be related to the chelation effects that allow the involvement or partially sharing of the positive charge of the metal ion in complexes by the donor atoms present in the ligand. And there may be the π-electron delocalisation over the entire chelate ring that increases the lipophilic character of the metal chelate system. This will favour its permeation through lipid layer of the cell membranes [64, 65]. See Figure (5).

Fungi Activity

The synthesized ligand and its metal complexes have been tested against two types of fungi (Candida albicans and Candida tropicalis). The measured of inhibition zones against the growth of different fungi are listed in Tables (9). The tested complexes have potential as antifungal agents due to increase of inhibition zones against the growth of different Fungi. The complexes showed greater activity than the ligands alone [66] See Figure (6).

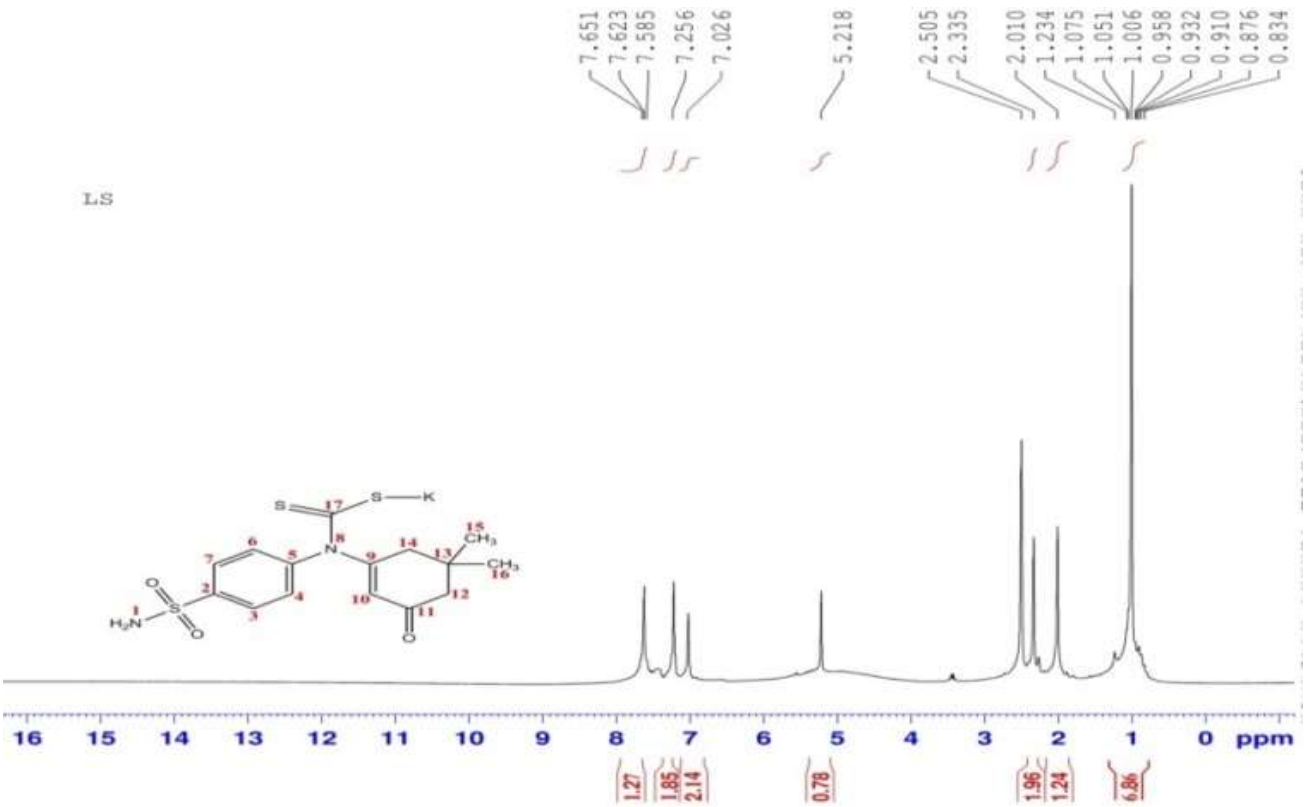


Figure 1: ^{1}H-NMR spectrum of ligand [K-L] in DMSO-d^6

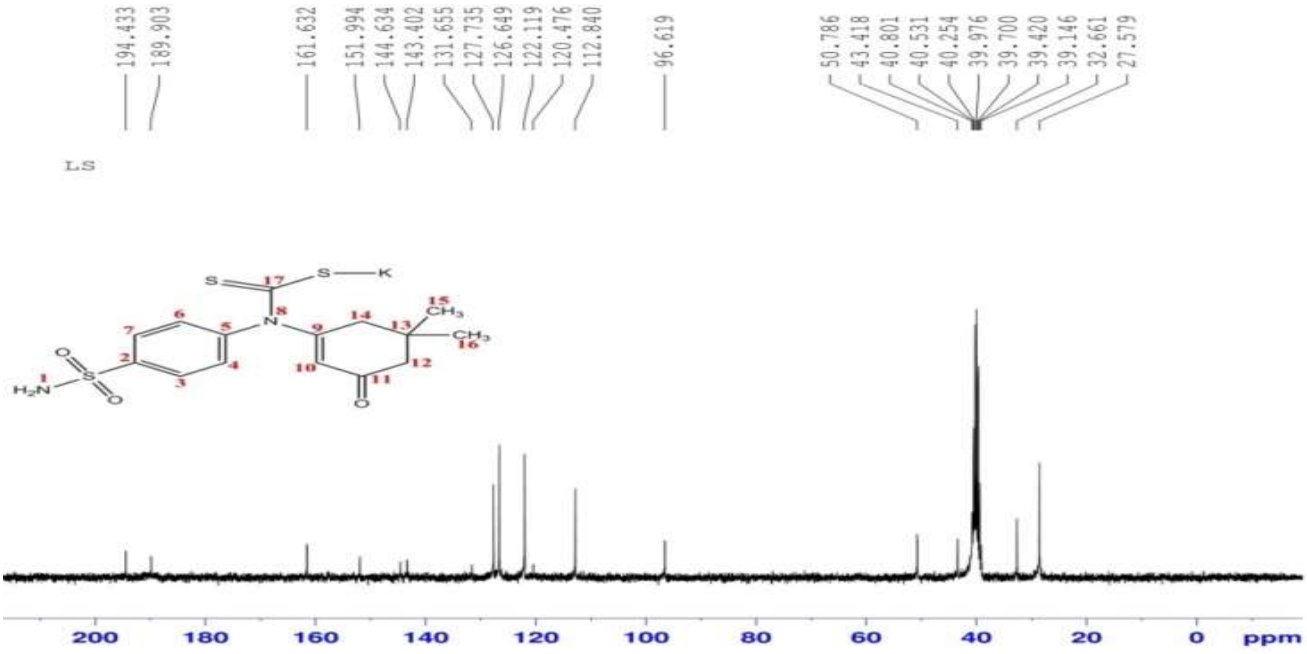


Figure 2:^{13}C-NMR spectrum for the ligand [K-L] in DMSO-d^6

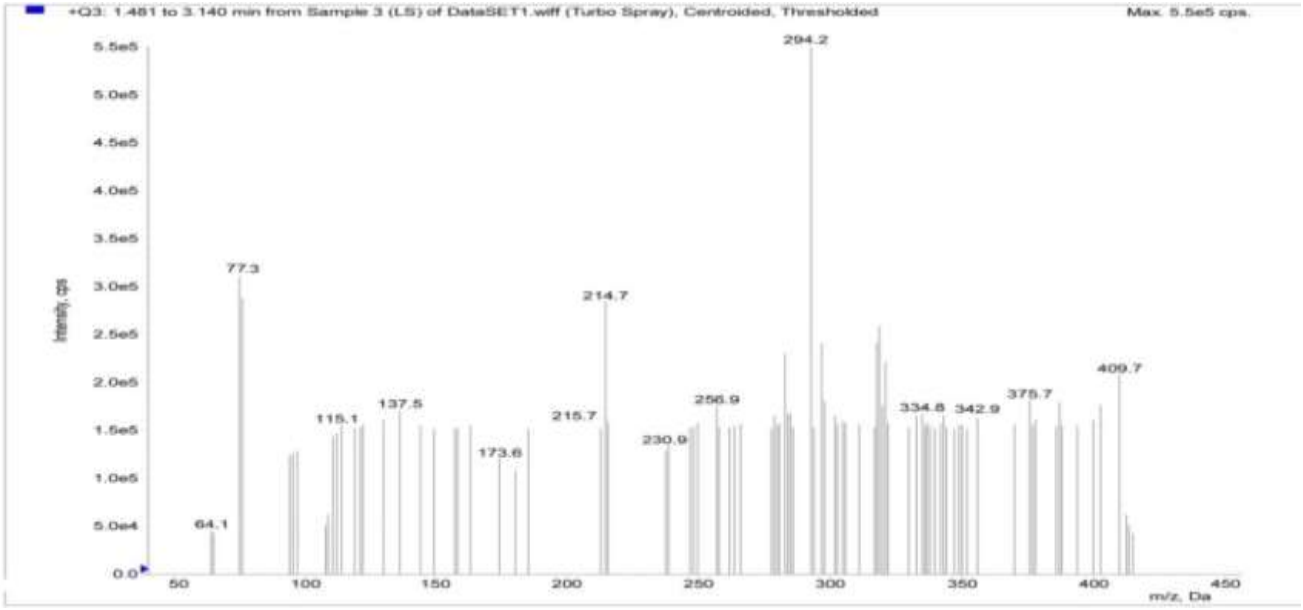


Figure 3: ES (+) mass spectrum of [K-L]

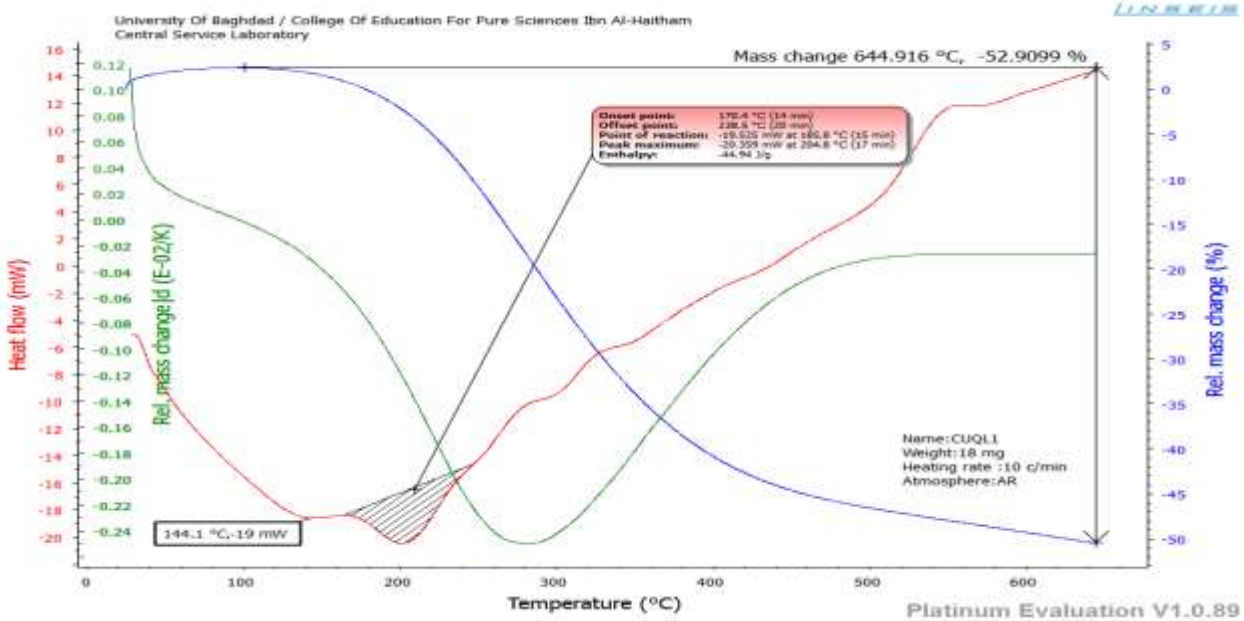


Figure 4: (TGA) for [Cu (L) (Q)] complex in Argon atmosphere

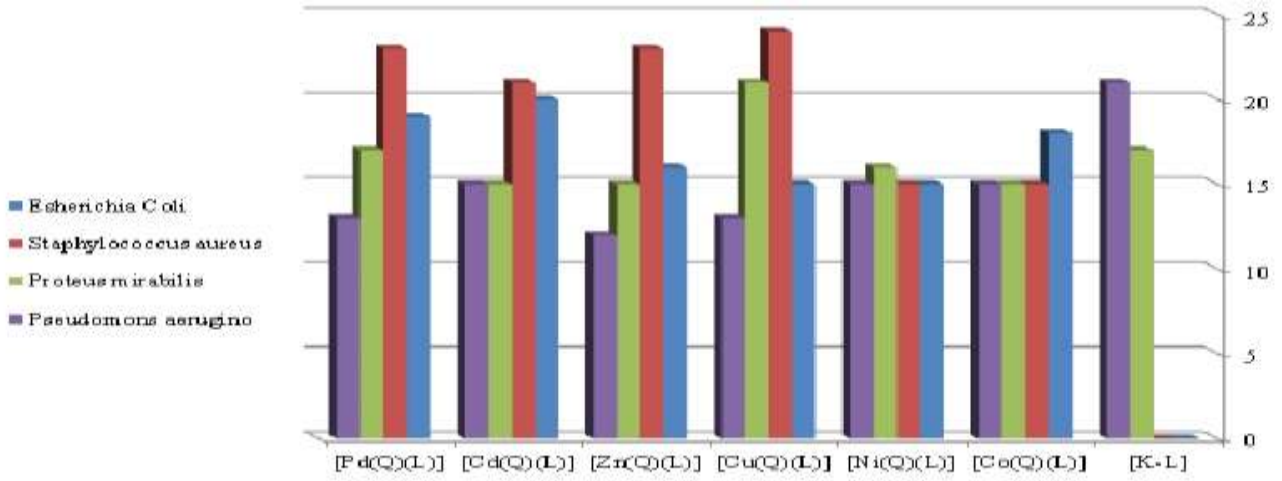


Figure 5: Evolution of diameter zone (mm) of inhibition of [K-L] and its complexes against the growth of Esherichia Coli, Staphylococcus aureus, Proteus mirabilis and Pseudomons aerugino

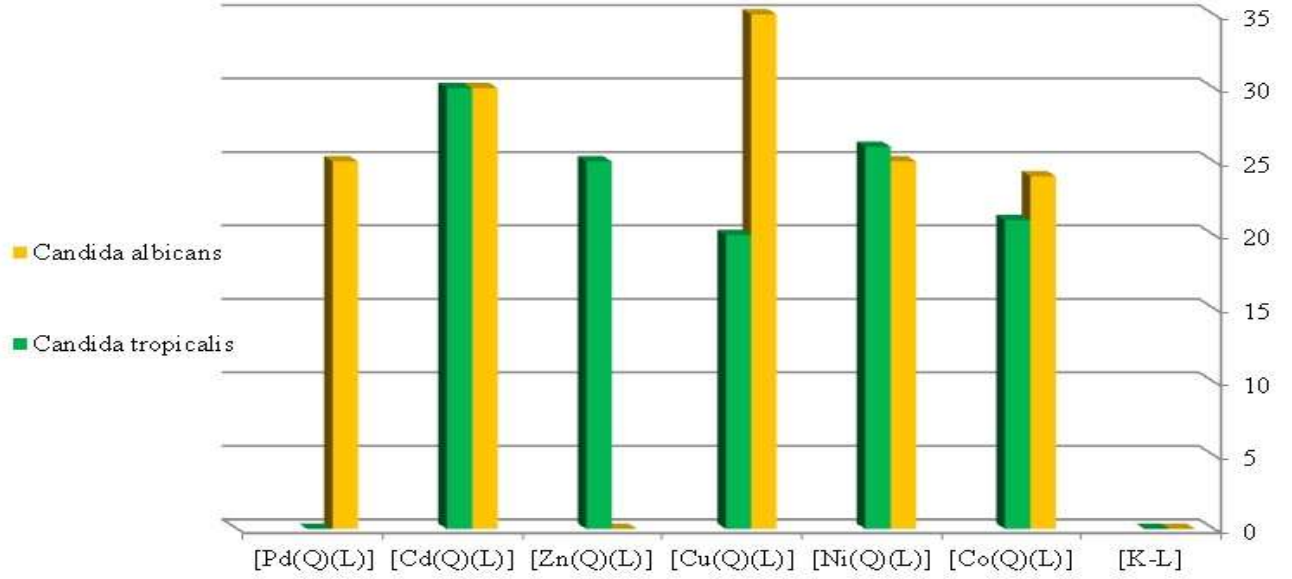


Figure 6: Evolution of diameter zone (mm) of inhibition of [K-L] and its complexes against the growth of Candida albicans and Candida tropicalis

Table 1: Colours, yields, melting points and (C, H, N, S) analysis, values for ligand and their complexes

No.	Empirical formula	M.wt g/mol.	Yield %	Color	m.p. °C	Microanalysis found, (Calc.) %				
						Metal	C	H	N	S
[K-L]	$C_{15}H_{17}N_2O_3S_3K$	408.60	65.90	Pale mustard	202-204	-	43.36 (44.09)	3.76 (4.19)	7.04 (6.86)	23.08 (23.54)
[Co(Q)(L)]	$[CoC_{24}H_{23}N_3O_4S_3]$	572.58	68.27	Dark green	254*	9.47 (10.29)	50.11 (50.34)	4.02 (4.05)	7.27 (7.34)	16.94 (16.80)
[Ni(Q)(L)]	$[NiC_{24}H_{23}N_3O_4S_3]$	572.34	57.04	Pale green	242*	10.13 (10.26)	50.28 (50.37)	3.93 (4.05)	7.27 (7.34)	15.97 (16.80)
[Cu(Q)(L)]	$[CuC_{24}H_{23}N_3O_4S_3]$	577.19	58.94	Pale brown	202-204	10.39 (11.01)	49.89 (49.94)	3.93 (4.02)	7.22 (7.28)	16.58 (16.66)
[Zn(Q)(L)]	$[ZnC_{24}H_{23}N_3O_4S_3]$	579.06	66.46	Pale yellow	232-234	10.82 (11.29)	49.70 (49.78)	3.92 (4.00)	7.19 (7.26)	16.36 (16.61)
[Cd(Q)(L)]	$[CdC_{24}H_{23}N_3O_4S_3]$	626.06	69.50	Yellow	256*	17.77 (17.96)	46.41 (46.04)	3.33 (3.70)	7.43 (6.71)	14.61 (15.36)
[Pd(Q)(L)]	$[PdC_{24}H_{23}N_3O_4S_3]$	620.07	65.78	Dark brown	196-198	16.60 (17.16)	46.12 (46.49)	3.37 (3.74)	7.50 (6.78)	14.76 (15.51)

*= Decomposed, (calc.) = Calculated

Table 2: FTIR spectral data (wave number) cm^{-1} of ligand and their complexes

Compound	υ(C-H) arom.	υ(C-H) alip.	$\upsilon_{as}(NH_2)$ $\upsilon_{s}(NH_2)$ sulfone	υ(C=O)	υ(C=C)	υ(C-N)	υ(N-CS_2)	υas(CS_2) υs(CS_2)	υ(M-N)	υ(M-O)
KL[1]	3064	2954, 2868	3329 3199	1610	1529	1255	1452	1047 974	-	-
8-HQ	3049	-	-	-	1500	-	-	-	-	-
[Co(Q)(L)]	3072	2954, 2873	3329 3248	1608	1527	1265	1466	1036 937	519	451

[Ni(Q)(L)]	3063	2954, 2870	3329 3225	1608	1529	1263	1466	1051 993	517	420
[Cu(Q)(L)]	3064	2954, 2868	3329 3253	1610	1529	1267	1468	1050 963	517	426
[Zn(Q)(L)]	3066	2954, 2871	3327 3205	1608	1529	1267	1466	1039 1001	519	449
[Cd(Q)(L)]	3068	2954, 2866	3329 3209	1606	1529	1265	1464	1016 992	519	496
[Pd(Q)(L)]	3062	2960	3363 3249	1597	1527	1265	1495	1014 914	580	467

Table 3: ^{1}H-NMR spectral data the ligand [K-L]

Assignment	[K-L] δ (ppm)
(N-H) of (S-NH_2)	7.02
(C-H) of $C_{3,7}$-H aromatic group	7.651
(C-H) of $C_{6,4}$-H aromatic group	7.25
(C-H) of C_{10} for CH group	5.21
(C-H) of C_{15}, C_{16} for CH_3 group	1.00
(C-H) of C_{12} for CH_2 group	2.01
(C-H) of C_{14} for CH_2 group	2.33
DMSO solvent	2.505

Table 4: ^{13}C-NMR data for the ligand [K-L]

Assignment	[K-L] δ (ppm)
C_2 for C aromatic ring	144.63
C_5 for C aromatic ring	143.40
$C_{3,7}$-H aromatic group	126.64
$C_{6,4}$-H aromatic group	122.11
C_{10} for CH group	96.61
C_{15}, C_{16} for CH_3 group	27. 57
C_{12} for CH_2 group	50.78
C_{14} for CH_2 group	43.41
C_9 for C dimedone	161.63
C_{11} for C=O dimrdone	194.43
C_{13} for C dimedone	32.66
C_{17} for S=C-S of dithiocarbamate group	189.90

Table 5: EI-Mass data of the ligand [K-L]

Fragment	Mass/charge (m/z)	Relative abundance (%)
$[M+H]^+ = [C_{15}H_{18}KN_2O_3S_3]^+$	409.7	38
$[C_{14}H_{17}N_2O_3S]^+$	294.2	100
$[C_{14}H_{17}N_2O]^{+\cdot}$	230.2	24
$[C_{14}H_{16}NO]^{+\cdot}$	215.7	28
$[C_{12}H_{14}N]^+$	173.6	21
$[C_6H_5]^+$	77.3	56
$[CS_2K]^{+\cdot}$	115.1	28
$[SO_2]^{+\cdot}$	64.1	9

Table 6: Electronic spectra data of ligand and complexes in DMSO solutions, molar conductance, magnetic moment and Suggested structure

Complexes	Wavenumber		ε_{max} molar^{-1} cm^{-1}	Assignment	Λ_m (ohm^{-1}.cm^2.mol^{-1})	$\mu_{eff.}$ B.M. exp.	Suggested structure
	Nm	Cm^{-1}					
[Co(Q)(L)]	268	37313	1589	L.F	16.30	4.21	T.d
	287	34843	1023	L.F			
	318	31446	2282	L.F			
	417	23980	295	C.T			
	488	20491	156	$^4A_2 \rightarrow {}^4T_{1(P)}$			
[Ni(Q)(L)]	268	37313	1683	L.F	14.68	3.89	T.d
	285	35087	731	L.F			
	320	31250	2194	L.F			
	401	24937	224	C.T			
	640	15625	35	$^3T_{1(F)} \rightarrow {}^3T_1(P)$			
[Cu(Q)(L)]	268	37313	1706	L.F	10.86	1.82	S.p
	284	35211	1030	L.F			
	319	31347	2169	L.F			
	397	25188	345	C.T			
	806	12406	61	$^2T_2 \rightarrow {}^2Eg$			
[Zn(Q)(L)]	267	37453	1555	L.F	7.60	Diamagnetic	T.d
	284	35211	618	L.F			
	322	31055	1979	L.F			
	394	25380	173	C.T			
[Cd(Q)(L)]	268	37313	1308	L.F	7.40	Diamagnetic	T.d

	284 322	35211 31055	701 1976	L.F			
	410	24390	123	C.T			
[Pd(Q)(L)]	269 287	37174 34843	1494 1249	L.F L.F	15.72	Diamagnetic	S.p
	321	31152	1771	C.T			
	636 763	15723 13106	52 62	$^1A_{1g} \rightarrow {}^1Eg$ $^1A_{1g} \rightarrow {}^1B_{1g}$			

Table 7: TGA data for [Cu (L^1) (Q)] complex

Comp.	Stable up to(°C)	step	Dec. Temp. Initial-Final (°C)	DTG Temp. (°C)	Wt. of mass loss (calc)- found Wt. of mass loss (calc)- found %	Nature of DSC peak and temp. °C
[Cu(Q)(L)]	100	1	100-644	144	(9.556)-9.523 (53.092)- 52.909	endothermic 144.1
		residue	644≤	-	(8.443)-8.623 (46.908)-47.909	exothermic 209.7

Table 8: Bacterial activity of ligand [K-L] and its complexes

Complexes	Escherichia Coli	Staphylococcus aureus	*Proteus mirabilis*	Pseudomons aerugino
[K-L]	-	-	17D	21D
[Co(Q)(L)]	18	15	15	15
[Ni(Q)(L)]	15	15	16	15
[Cu(Q)(L)]	15	24	21	13
[Zn(Q)(L)]	16	23	15	12
[Cd(Q)(L)]	20	21	15	15
[Pd(Q)(L)]	19	23	17	13

D= diluted

Table 9: Fungi activity of [K-L] and their mixed-ligand complexes

Complexes	*Candida albicans*	*Candida tropicalis*
[K-L]	-	-
[Co(Q)(L)]	24	21
[Ni(Q)(L)]	25	26
[Cu(Q)(L)]	35	20
[Zn(Q)(L)]	-	25
[Cd(Q)(L)]	30	30
[Pd(Q)(L)]	25	-

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