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# Preparation, characterisation and biological activity of some metal complexes derived from new dithiocarbamate of heterocyclic ligand

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#### Abstract

In this study, synthesised new ligand: potassium 2,2'-(quinoxaline-2,3diyl)bis(1-phenylhydrazinecarbodithioate) (L). The ligand synthesised by reacting  $N^{I}$ , $N^{2}$ -dip-tolyloxalamide as the starting material with CS<sub>2</sub> and KOH to add the CS<sub>2</sub> group and then with phenylendiammine to achieve (L). The ligand used in the synthesis of complexes with (Co<sup>II</sup>, Ni<sup>II</sup> and Cd<sup>II</sup>). The new ligand and its complexes characterised by FT-IR, UV-Vis, <sup>1</sup>H, <sup>13</sup>C-NMR, Mass spectroscopy, and elemental analysis, in addition to the above techniques were using magnetic moment, atomic absorption, chloride content, and melting point to describe the metal complexes.

Key words: hydrazinecarbodithioate ligand, dithiocarbamate, metal complexes and biological activity.

# 1. Introduction

The chemistry of dithiocarbamates has achieve more attention in last years, due to their variable ability of coordination modes and strong ability to coordination to many groups [1] and transition metal ions [2]. The dithiocarbamates derivatives had great attention due to their biological activity [3] such as antitumor [4], antibacterial [5], and antifungal [6]. The dithiocarbamates had application in supramolecular chemistry [7], and science of materials [8].

The multi-dithiocarbamates ligands with additional donor atoms [9] used to construction of high nuclearity aggregates, some of their show good molecular recognition function neutral and anionic species [10,11].

Dithiocarbamates (DTC) may form complexes with most elements, resulting in the stabilization of a wide range of transition metal ion oxidation states such as Fe(IV), Ni(IV), Cu(III), and Au(III) [12]. This is due to electron delocalization on the NCS<sub>2</sub> group [13]. The uniqueness of these complexes derives from their well-defined architecture and abundance of metal-centered electrochemistry [14]. Dithiocarbamates (DTC) have piqued the interest of researchers due to their easy to synthesis and the fact that the ligand's small interatomic distance between two sulfur atoms confers higher affinity between ligands and metal catalysts. Because of their greater affinity for metal ions, dithiocarbamates block enzymes, making them physiologically significant compounds [15]. Dithiocarbamates (DTC) can be linked to metal ions in a number of ways, such as as unidentate, bidentate, chelating, or bridging ligands [16]. Because like supramolecular structures macrocycles, cages, catenanes. and nanodimentional assemblies may be produced through the ability of varied combination with metal ions, they can be helpful tectons for the production of assemblies capable of selectively enclosing guest molecules [17]. Disulfur can be bidentately linked to metal ions in all dithiocarbamates. Dithiocarbamates (DTC) exhibit a variety of characteristics, including unusual redox, magnetic, and photochemical capabilities [18]. Diethyl dithiocarbamate salts have potential use in chronic alcoholic treatment, such as (disulfiram), which promotes alcohol intolerance by inhibiting the acetyl-dehyde dehydrogenase enzyme [19]. The employment of alkyl dithiocarbamates ligand to synthesize conducting infinite coordination polymers and also to outstanding conductivity, it lacks in optical characteristics concurrently crucial for optoelectronic devices

[20]. Dithiocarbamates (DTC) can stabilize macrocyclic structures and have a high Possibility of binding charged adsorbed species.

### 2. Experiential

**2.1 Review and meta - analysis**: All chemicals were purchased commercially (Aldrich) and used in their natural state. Prior to usage, all solvents in the synthesis were distilled from the appropriate drying agent.

**2.2 Analyses of elements:** (C, H, and N) performed using a Heraeus apparatus (Vario EL). Shimadzu 8400 S FTIR solar spectrum scale was used for capture IR spectra as KBr and CsI discs ranging from 4000-400 and 4000-300 cm<sup>-1</sup>. At 25°C, an electronic spectra from 200-1100 nm for 10-3 M results in DMSO were analyzed using a Shimadzu 1800 solar spectrum scale. A Jeol 400 MHz spectroscopy was used to acquire <sup>1</sup>H- <sup>13</sup>C-NMR spectra in DMSO–d<sup>6</sup> solution and tetramethylsilane (TMS) as an inner standardization. Electro-thermal Stuart melting point, uncorrected.

The melting points were determined using SMP40 capillary melting point apparatus. Metals were identified using a Shimadzu (A.A) 680 G atomic absorption spectrophotometer. The chloride content was measured using a 686-Titrp processor-665Dosimat-Metrohm Swiss using a potentiometer titration method. At room temperature, a magnetic susceptibility balance was utilized to measure magnetic moments and a PW 9526 digital conductivity meter was used to evaluate conductivity in DMSO solutions (Catalyst Technology Division of Johnson Matthey).

# 3. Synthesis

3.1 method for planning:

<u>Preparation of N'1,N'2-diphenyloxalohydrazide(A)</u>. A mixture of phenyl hydrazine (10g, 2 mmol) and oxalyl chloride (5.92g, 1 mmol) in benzene as solvent stirred below 0°C for 4 hsr. The white solid product collected, cleaned with ether, and dried. Recrystallised from a combination of benzene and ethanole. M.p=117 Yield 11.30g, 45%

<u>Preparation of potassium 2,2'-oxalylbis(1-phenylhydrazine-1-carbodithioate)(B)</u>. N'1,N'2-diphenyloxalohydrazide(A) (3g, 1 mmol) dissolved in THF and (2.5g, 4 mmol) of KOH in 10 ml of water, and then (2.54g, 3 mmol) CS<sub>2</sub> added in portions while cooling and vigorously stirring, with the temperature kept below 0 °C. The brown product then separated, dried, and recrystallised from 1: 1 methanol-water.m.p=153 °C, Yield (2.95g, 53 percent )

3.2.1 Synthesis of potassium quinoxaline-2,3-diylbis(p-tolylcarbamodithioate)(L) [21]

Ligand was synthesised using a modified technique from the literature. A mixture (2g, 1 mmol) of 2,2'-oxalylbis(1-phenylhydrazine-1of carbodithioate)(**B**)was added to O-phenylen diammine (0.666g, 1 mo) the raw material was purified out, and the pure desired brown product was recrystallized from 1.76 g yield (50 percent ). After being mixed in a combination of 50 mL of (35 mL of THF and 15 mL of ethanol and 0.05 mmol of 4-methylbenzenesulfonic acid were heated at 80 °C. Infrared radiation (KBr, cm<sup>-1</sup>): ν(NH) 3298, δ(NH)1591, ν(C=N) 1668, ν(C=S) 1065, ν(C-S) 877, 1315. <sup>1</sup>H NMR (300 MHz, DMSO-d<sub>6</sub>):  $\delta$  = 4.430 (2H, NH), 6.283-6.291 (2H, C<sub>5</sub>, C<sub>19</sub>),7.352-7.360 (4H, C<sub>3</sub>, C<sub>7</sub>, C<sub>17</sub>, C<sub>21</sub>), 7.483-7.491 (4H, C<sub>4</sub>, C<sub>6</sub>, C<sub>18</sub>, C<sub>20</sub>), 8.391-8.399 (2H, C<sub>11</sub>, C<sub>12</sub>), 9.015 (2H, C<sub>10</sub>, C<sub>13</sub>); <sup>13</sup>C NMR (DMSO-d6, TMS): δ =118.833 (C<sub>5, 19</sub>), 126.050 (C<sub>3, 7, 11, 12, 17, 21</sub>), 127.379 (C<sub>10, 13</sub>), 128.423 (C<sub>4, 6, 18</sub>) <sub>20</sub>), 141.291 (C<sub>9, 14</sub>), 143.170 (C<sub>2, 16</sub>), 170.412 (C<sub>8, 15</sub>), 191.725 (C<sub>1, 22</sub>). The spectrum of mass for L revealed numerous peaks that corresponded to the molecule's sequential fragmentations. The peak seen at m/z 570.6 (6 percent) (M)<sup>+</sup> is assigned to ligand's molecular ion peak. Other notable peaks in the spectrum were monitored at m/z 492.4 (9 percent), which appear the ligand's molecular ion peak losing [M-2K]<sup>+</sup>, another peak detected at 416.7 (47 percent), which refers to losing [M- 2K+CS<sub>2</sub>]<sup>+</sup>, another peak detected at 235.3 (7 percent), which refers to losing [M- 2K+CS<sub>2</sub>+NHNPhCS<sub>2</sub>]<sup>+</sup>, and the last peak detected at 130.2 (8 percent) which refers to the losing [M-2K+CS<sub>2</sub>+(NH)<sub>2(</sub>NPh)<sub>2</sub>CS<sub>2</sub>]<sup>+</sup> fragments, respectively

#### 3.3 Synthesis of complexes

The complexes were produced by reacting L (1 mmol) with in ethanol and THF (30 mL), then adding a solution of MClx.nH<sub>2</sub>O (1 mmol) in water with [M=Co, n=6, Ni, n=6, and Cd, n=2, x=2] (5 mL). The solid that separated after 15 hours of agitation was filtered, washed with methanol, and dried. The elemental analytical complexes' statistics, coloring, and yields presented in (Table 1).

<sup>1</sup>H NMR of CdL (300 MHz, DMSO-d<sub>6</sub>):  $\delta = 3.783$  (2H, NH), 7.627 (2H, C<sub>5</sub>, C<sub>19</sub>), 7.688 (4H, C<sub>3</sub>, C<sub>7</sub>, C<sub>17</sub>, C<sub>21</sub>), 8.176 (4H, C<sub>4</sub>, C<sub>6</sub>, C<sub>18</sub>, C<sub>20</sub>), 8.198 (2H, C<sub>11</sub>, C<sub>12</sub>), 8.852 (2H, C<sub>10</sub>, C<sub>13</sub>); <sup>13</sup>C NMR (DMSO-d6, TMS):  $\delta = 118.961$  (C<sub>5, 19</sub>), 125.973 (C<sub>3, 7, 11, 12, 17, 21</sub>), 137.626 (C<sub>10, 13</sub>), 137.974 (C<sub>4, 6, 18, 20</sub>), 143.925 (C<sub>9, 14</sub>), 144.196 (C<sub>2, 16</sub>), 163.672(C<sub>8, 15</sub>), 190.719 (C<sub>1, 22</sub>). CdL mass spectrum revealed a slew of peaks that matched to the molecule's a series of small fragments. The first peak reveal at m/z 1212.3 (26 percent) (M+2)<sup>+</sup> which refer to molecular ion of the CdL complex. Other distinct peaks in the spectrum were found at m/z 947.47 (26 percent), which corresponds to the ligand's molecular ion peak disappearing [M-(2CS<sub>2</sub>+Cd)]+, while peak at 841.3 (26 percent) refers to lose

 $[M-(2CS_2+Cd)]+(2CS_2+Cd)+(C_6H_5NHNH)]^+$ , other peak detected at 734.9 (24) %) refer to losing  $[M-(2CS_2+Cd)_2+(C_6H_5NHNH)_2]^+$ , other peak detected at 499.96 (100%)assigned the losing [Mto  $(2CS_2+Cd)_2+(C_6H_5NHNH)_2+(C_{13}H_{11}N_4)]^+$ , the most recent peak discovered at 234.9 (100%)allocate to the lose [M- $(2CS_2+Cd)_2+(C_6H_5NHNH)_2+(C_{13}H_{11}N_4)+(2CS_2+Cd)]^+$  fragments, respectively.

#### 4. Discussion of the findings

4.1. Chemistry

The ligand L was obtained in good yield by reacting (2g, 1 mmol) of 2,2'oxalylbis(1-phenylhydrazine-1-carbodithioate)(B) with O-phenylen diammine (0.666 g, 1 mmo) and 0.05 mmol of 4-methylbenzenesulfonic acid dissolved in a mixture of 50 mL (35 mL of THF and 15 mL of ethanol) for 10 hours at 80 °C, then filtering off the crude product (L) was achieved (Scheme 1), the ligand have a CS<sub>2</sub> group that may be coordinated to metal ions as bidentate lidand. The ligand was characterised using elements (Table 1), infrared (Table2), UV-Vis (Tablet 3), mass, and <sup>1</sup>H, <sup>13</sup>C NMR spectroscopy are all used in this study. The complexes were achieved from the reaction (1 mmol of ligand with 1 mmol of metal chloride Co<sup>(II)</sup>, Ni<sup>(II)</sup>, and Cd<sup>(II)</sup> in the presence THF and ethanol) from the stirrer. The neutral complexes [23] with the general formula  $[M(L)]_2$  were synthesised (where  $M = Co^{(II)}$ ,  $Ni^{(II)}$ , and  $Cd^{(II)}$ , (Scheme 1). The complexes are air-stable solids that are soluble in DMF and DMSO but not in other organic solvents. The complexes' coordination geometries were deduced from their spectra. The results of the analysis (Table 1) support the provided formula. The ligands' and complexes' most significant infrared bands have been collected, as well as their assignments.



potassium 2,2'-(quinoxaline-2,3-diyl)bis(1phenylhydrazine-1-carbodithioate)

Figure 1 depicts the general architectures of the ligand

Compound	Colour	Yield (%) m.p			Found (Calcd.) (%)				$\Lambda_{\rm M}({\rm cm}^2\Omega^{-1}{\rm mol}^{-1})$
				М	С	Н	N	Cl	_
$L^1$	brown	78	207-209	-	45.93	2.47	14.35	-	-
					(46.29)	(2.83)	(14.72)		
$[\mathrm{Co}^{\mathrm{II}}(\mathrm{L})]_2$	brown	64	302*	10.38 (10.68)	47.51 (47.90)	2.67 (2.92)	14.87 (15.24)	-	17.21
$[Ni^{II}(L)]_2$	green	61	290*	10.27	47.38 (47.92)	2.61 (2.92)	14.76 (15.24)	-	13.97
$[Cd^{II}(L)]_2$	Pale Yellow	58	311	18.23 (18.58)	43.34 (43.67)	(2.39 (2.67)	13.58 (13.89)	-	18.67

Table: 1 shows the colors, yields, elemental analyses, and molar conductance values.

#### (Calculated), Decomposed

**4.2 IR and NMR Spectra:** The important infrared bands for the precursor 1 Fig(1) showed band at 3305 and 3236 cm<sup>-1</sup> attributed to v(NH) for amide and amine group[22], the appearance of these two new bands refer to change chloro atom in phenyl hydrazine in the reaction. The band at 1583 is ascribed to v(NH)

for the amide and amine group. Only two bands are seen in the spectrum, suggesting that the two v(NH) are not similar. The amide group's v(C=O) is responsible for the band at 1674. Compound B has bands at 3294 and 1599 that are attributed to v(NH) and  $\delta$ (NH), respectively. The deprotination of (N-H) and the insertion of the CS<sub>2</sub> group are shown by the disappearance of v(NH) of amine. The v(C=O) and v(C-N) groups can be assigned to the bands at 1666 and 1236, respectively. The bands of v(C=S) and v(C-S) are responsible for the new bands in the spectrum at 1047 and 1344, 874, respectively[23].

The spectrum of the ligand, Fig.(2) show bands at 3298 and 1591 due to v(NH) and  $\delta(NH)$ . The bands at 1065 and 1315, 877, may be assigned to v(C=S) and v (C-S), respectively. At 1668, the band of v(C=O) was disappeared, and a new band attributed to v(C=N) of the aromatic ring emerged, referring to the creation of the ligand.

The ligand and their complexes' main infrared bands, as well as their assignments, are listed in (Table 2). Due to complex formation, the IR spectra of the complexes revealed L bands with appropriate shifts and M-S frequencies (Table 2). In free ligand, the vas(NH) vibration at 3298 cm<sup>-1</sup> did not disappear in complexes. This band was shifted and appeared at 3300-3388 cm<sup>-1</sup>, corresponding to the absence of the amine group alone (NH) in Figs.(3-5). The (NH) group includes the bands at 1583-1603. The bands at 1653-1660 for ligand may be due to v(C=N) in the complexes. These bands are small shifted because are not represented in complexes. The change in v(C=S) and v(C-S) occurred at 1047-1057, 866-877, and 1306-1308 in ligand, suggesting sulfur ion coordination [24]. At lower frequencies, the complexes displayed bands in the 374-381 cm<sup>-1</sup>, which may be ascribed to v(M-S) in ligand.



Fig: 1 IR spectrum of Precursor 1



Fig: 2 IR spectrum of L



Fig: 3 IR spectrum of CoL







Fig: 5 IR spectrum of CdL

<sup>1</sup>H NMR of L Fig.(6) show chemical shift s at 4.430 (2H, NH), 6.283-6.291 (2H, C<sub>5</sub>, C<sub>19</sub>),7.352-7.360 (4H, C<sub>3</sub>, C<sub>7</sub>, C<sub>17</sub>, C<sub>21</sub>), 7.483-7.491 (4H, C<sub>4</sub>, C<sub>6</sub>, C<sub>18</sub>, C<sub>20</sub>), 8.391-8.399 (2H, C<sub>11</sub>, C<sub>12</sub>), 9.015 (2H, C<sub>10</sub>, C<sub>13</sub>); <sup>13</sup>C NMR (DMSO-d6, TMS), Fig(7):  $\delta = 118.833$  (C<sub>5, 19</sub>), 126.050 (C<sub>3, 7, 11, 12, 17, 21</sub>), 127.379 (C<sub>10, 13</sub>), 128.423 (C<sub>4, 6, 18, 20</sub>), 141.291 (C<sub>9, 14</sub>), 143.170 (C<sub>2, 16</sub>), 170.412 (C<sub>8, 15</sub>), 191.725 (C<sub>1, 22</sub>).

<sup>1</sup>H NMR of CdL, Fig.(8), (300 MHz, DMSO-d<sub>6</sub>):  $\delta = 3.783$  (2H, NH), 7.627 (2H, C<sub>5</sub>, C<sub>19</sub>), 7.688 (4H, C<sub>3</sub>, C<sub>7</sub>, C<sub>17</sub>, C<sub>21</sub>), 8.176 (4H, C<sub>4</sub>, C<sub>6</sub>, C<sub>18</sub>, C<sub>20</sub>), 8.198 (2H, C<sub>11</sub>, C<sub>12</sub>), 8.852 (2H, C<sub>10</sub>, C<sub>13</sub>); <sup>13</sup>C NMR (DMSO-d<sub>6</sub>, TMS), Fig(9):  $\delta = 118.961$  (C<sub>5</sub>, 19), 125.973 (C<sub>3</sub>, 7, 11, 12, 17, 21), 137.626 (C<sub>10</sub>, 13), 137.974 (C<sub>4</sub>, 6, 18, 20), 143.925 (C<sub>9</sub>, 14), 144.196 (C<sub>2</sub>, 16), 163.672(C<sub>8</sub>, 15), 190.719 (C<sub>1</sub>, 22).



Fig: 6<sup>1</sup>HNMR spectrum of L



Fig: 7<sup>13</sup>C-HNMR spectrum of L



Fig: 8 <sup>1</sup>HNMR spectrum of CdL



Fig: 9<sup>13</sup>C-HNMR spectrum of CdL

#### 4.3 Mass spectrum

The mass spectrum of L Fig(10) exhibited numerous peaks owing to sequential molecule fragmentations. The top tip seen at m/z 570.6 (6 percent)  $(M)^+$  is ligand's molecular ion tip Other notable tips in the spectrum were observed at m/z 492.4 (9 percent), This indicates the ligand's molecular ion peak loss [M-2K]+, another peak detected at 416.7 (47 percent), which refers to

losing  $[M- 2K+CS_2]+$ , another peak detected at 235.3 (7 percent), which refers to losing  $[M- 2K+CS_2+NHNPhCS_2]+$ , and the last peak detected at 130.2 (8 percent) which refers (Figure SI 10 (Supplemental Information)).

Because of the molecule's successive fragmentations, the mass spectrum of CdL (Fig. 11) showed many peaks. The top tip reveal at m/z 1212.3 (10 percent)  $(M+2)^+$  is the molecular ion tip of the CdL complex. Other distinct peaks in the spectra were identified at m/z 947.47 (14%), indicating that the ligand's molecular ion peak loses  $[M-(2CS_2+Cd)]^+$ , and another peak detected at 841.3 (12%), indicating that the ligand loses  $[M-(2CS_2+Cd)]^+$ , other peak detected at 734.9 (24 %) refer to losing  $[M-(2CS_2+Cd)+(C_6H_5NHNH)_2]^+$ , another peak 499.96 allocated discovered at (100%)to the losing [M-The  $(2CS_2+Cd)+(C_6H_5NHNH)_2+(C_{13}H_{11}N_4)]^+$ losing [M-(2CS2+Cd)+(C6H5NHNH)2+(C13H11N4)+(2CS2+Cd)]+ fragments, respectively, are allocated to the final peak identified at 234.9 (8 percent) (Figure SI 11 (Supporting Information)).



Fig: 10 Mass spectrum of L



Fig: 11 Mass spectrum of CdL

Comp	oound	ν(O-H)	ν (N-H)	v <sub>as</sub> (C=O) Or v <sub>as</sub> (C=N)	v(C-N))	v(C-O)	v(C=S)	v(C-S) v(	M-S)
A		33	05,3236 1583	1674	1250	-	-	_	-
В		32	.94, 1599	1666	1236	-	1047	874, 1377	-
L	-	32	98, 1591	1668	1240	-	1055	877,1315	-
$[\mathrm{Co}^{\mathrm{II}}(\mathrm{L})_2]$	-	33	00, 1587	1653	1250	-	1057	866, 1308	381
$[Ni^{II}(L)]_2$	-	330	07, 1603	1653	1238	-	1039	814, 1306	374
$[Cd^{II}(L)]_2$	-	330	03, 1583	1660	1238	-	1047	867, 1306	376

Table 2 shows the compounds IR frequencies (cm<sup>-1</sup>).

#### 4.4 Electronic spectra, magnetic moments, and conductivity measurements

Strong absorption peaks at 250, 262, and 316 nm for L are attributed to  $\pi \rightarrow \pi^*$ ,  $n \rightarrow \pi^*$ , and CT transitions in the UV–Vis spectrum of ligand. In Co, Ni, and Cd complexes, the electronic spectra exhibited various degrees of hypsochromic shift of bands associated to the intra-ligand\* transition (Table 3). Spectra of Co and Ni complexes show bands associated with the (CT) transition (Table 3) [25, 26]. The d–d bands in the spectrum of the Co(II) complex, as

seen in Fig(12), can be attributed to a spin forbidden transition in a tetrahedral geometry [25]. This complex's magnetic moment is indicative of a high spin tatrahedral structure. Tetrahedral assignment is consistent with Co(II) complexes [27]. The diamagnetic Ni(II) complex Fig(13) suggests a square planar shape [28-31]. This complexes electronic spectrum corresponded to this assignment. This complex's magnetic moment is indicative of a diamagnetic square planar structure. The intra-ligand\* bands in the spectrum of the Cd(II) complex (Fig. 14) were ascribed to intra-ligand\* [26]. Tetrahedral coordination is more common in metals. The magnetic moment of this compound is diamagnetic, as is usual for a tetrahedral structure.



Fig: 12 UV-Vis spectrum of CoL



Fig: 13 UV-Vis spectrum of NiL



Fig: 14 UV-Vis spectrum of CdL

Table 3: The m	nagnetic moment and	ultraviolet-vis spectral	data In	<b>DMF</b> solutions
	0	<b>.</b>		

Compound	μ <sub>eff</sub> (BM) Posit (per atom)	ion of the band ( $\lambda$ nm)	Coefficient of extinction $\varepsilon_{max}(dm^3 mol^{-1}cm^{-1})$	Assignments
	2.77	207	170	*
$[\operatorname{Co}^{(n)}(L)]_2$	3.67	287	460	$\pi  ightarrow \pi$
		378	113	CT
		618	33	${}^{4}A_{2} \xrightarrow{(F)} \rightarrow {}^{4}T_{1} \xrightarrow{(P)}$
		668	31	${}^{4}A_{2}^{(F)} \rightarrow {}^{4}T_{1}^{(P)}$
$[Ni^{(II)}(L)]_2$	diamagnetic	263	100	$\pi  ightarrow \pi^{*}$
	C	334	2970	CT
		382	1300	$^{1}A_{1}g \rightarrow ^{1}B_{1}g^{)}$
		514	31	$^{1}A_{1}g \rightarrow ^{1}B_{2}g$
$[Cd^{(II)}(L)]_2$	Diamagnetic	270	1574	$\pi  ightarrow \pi^{*}$
				345



Where  $M = Co^{II}$ ,  $Ni^{II}$  and  $Cd^{II}$ 

Scheme 2: Synthesis route of ligand and the proposed complexes.

### **5. Biological Activity**

#### **5.1 Bacterial Activity**

The antibacterial properties of the dithiocarbamate ligand and its metal complexes were tested against four bacterial species: E. coli, Pseudomonas aeruginosa (G), Staphylococcus aureus, and Bacillus stubtilis (G+). Separate studies employing DMSO solutions alone revealed that no bacterial strains were affected, indicating DMSO's role in biological screening [29].

The impact of the produced compounds on bacterial strains is depicted in Table (4), which also shows the zones of inhibition against the development of diverse microorganisms. Table (4) shows that the discovered complexes are possibly more active against specific bacterial strains than the free ligand, implying that complexation boosts antimicrobial efficacy.

This could be explained by the chelate effect, wherein the donor atoms in ligands share a portion of the metal's positive charge in compounds, and there may be electron delocalization over the whole chelate ring, enhancing the lipophilicity of the metal chelate system. This will make it easier for it to permeate the lipid layer of cell membranes [26]. An inhibitory technique was used to test the biological activity of the ligand and their complexes against four different harmful bacteria and fungi [28]. Gram positive (G+) bacteria included Bacillus subtilis and Staphylococcus aureus, whereas gram negative (G-) bacteria included Psedomonas aeruginosa and Escherichia coli (G-). This is done to see how effective they are in fighting bacteria and how much growth they can prevent. The role of (DMSO) in biological activity was clarified by separate studies using (DMSO) solutions alone, which showed no impact in the presence of bacterial strains. The measured areas of inhibition against the development of various microorganisms are shown in Table (4). As a result of this, the following key points emerge.

# **5.2 Fungi Activity**

The Schiff-base ligand and its metal complexes have antifungal action against two types for fungi have been identified (Trichomoniasis and Candida ). Table 4 shows fungi activity data with tested drugs (4). Metal complexes for ligand have no antifungal effect against any type of fungus.

Compound	Inhibition zones (mm)						
	Bacter	Fungi species					
	Bacil	Sta.	Ech	Pse.	Can	Tro	
	•						
[L]	15	12	7	9	-	5	
$[\operatorname{Co}^{\mathrm{II}}(\mathrm{L})]_2$	19	18	15	18	8	11	
$[\mathrm{Ni}^{\mathrm{II}}(\mathrm{L})]_2$	17	13	12	22	5	9	
$[\mathrm{Cd}^{\mathrm{II}}(\mathrm{L})]_2$	14	8	19	24	7	4	

Table (4): The biological evaluation of ligand and its complexes.

# 6. Conclusion

In this work, the synthesis and coordination chemistry of certain complexes that are generated by the reaction of (A) with *O*-phenylen diammine to provide potassium 2,2'-(quinoxaline-2,3-diyl)bis(1-phenylhydrazinecarbodithioate) (L), which reacted with metal ions in THF and ethanol mixture. Physico-chemical and spectroscopic methods were used to establish the complexes' bonding mechanism and overall structure.

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