Synthesis, Characterization and Antibacterial Activities of Ligand Type N_2O_4 Schiff base and its Novel Complexes with Co(II), Ni(II), Cu(II) and Zn(II) ions.

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Abstract

The reaction of 2-amino benzoic acid with 1,2-dichloroethane under reflux in methanol and KOH as a base to gave the precursor [H_4L]. The precursor under reflux and drops of CH_3COOH which reacted with (2mole) from salicycaldehyde in methanol to gave a new type N_2O_4 ligand [H_2L], this ligand was reacted with (MCl_2) Where [M= Co (II), Ni(II), Cu(II) and Zn(II)] in (1:1) ratio at reflux in methanol using KOH as a base, to give complexes of the general formula [M(L)]. All compounds have been characterized by spectroscopic methods [^{1}H NMR (just to the ligand), FTIR, uv-vis, atomic absorption], melting point, conductivity, chloride content, as well as magnetic susceptibility measurements. From the above data, the proposed molecular structure of [Co(L)], [Ni(L)], [Cu(L)] and[Zn(L)] complexes adopting an octahedral about this metal ions. The synthesized ligand, along with their metal complexes were screened for their *in vitro* antibacterial activity against ten local strains of *E. coli* as gram-negative bacteria in addition to ten strains of *Salmonella typhi* and to ten strains of *Acinetobacter baumannii* and Ten gram- positive bacteria utilizing for locally strains of *Staphylococcus aureus*, were tested also using the agar diffusion technique.

Keywords: Schiff base , Complexes .

الخلاصة

تضمن البحث تحضير الليكاند [H_2L] وذلك من مفاعلة ٢- أمينو حامض البنزويك مع ٢,١- داي كلورو أيثان تحت التصعيد الارجاعي في الميثانول وبوجود هيدروكسيد الصوديوم كقاعدة اذ اعطى التفاعل المادة الوسطية[H_4L] ومن خلال تفاعل المادة الوسطية مع ٢ مول من Salicylaldehyde تحت التصعيد الارجاعي في الميثانول وقطرات من CH_3COOH الثلجي ، اذ اعطى التفاعل الليكاند [H_2L] نوع (N_2O_2) ، ثم مفاعلة الليكاند مع بعض العناصر الفلزية باستخدام الميثانول وسطاً للتفاعل وبنسبة (١:١) وبوجود هيدروكسيد البوتاسيوم كقاعدة وتحت التصعيد الأرجاعي , حيث تكونت معقدات جديدة ذوات الصيغة العامة [M(L)] , حيث M= Co(II), Ni(II), Cu(II), and Zn(II). شخصت جميع المركبات بالطرق الطيفية التالية (الاشعة تحت الحمراء والاشعة فوق البنفسجية – المرئية و وطيف الرنين النووي المغناطيسي ^{1}HNMR (فقط لليكاند)) و التحليل الكمي الدقيق للعناصر مع التوصيلية المولارية الكهربائية ومحتوى الكلور ودرجة الانصهار والحساسية المغناطيسية ، من نتائج البحث كان الشكل الفراغي المقترح [Zn(L)],[Co(L)], [Ni(L)], [Cu(L)] ثماني السطوح.درست الفعالية البايولوجية خارج الخلية الحية لليكاند ومعقداته ضد عشر عزلات من ال *E. coli* كبكتريا سالبة لصبغة كرام و عشر عزلات أخرى من ال *Salmonella typhi* وعشر عزلات من *Acinetobacter baumannii* وعشر عزلات من ال *Staphylococcus aureus* كبكتريا موجبة لصبغة كرام حيث جميع الأصناف أختبرت بأستخدام تقنية الحيود.

Introduction

Schiff bases and their coordination compounds have played a great importance in medicine, industry and biochemistry. Schiff bases are characterized by the (-N=CH-) (imine) group which imports in elucidating the mechanism of transamination rasemination reaction in biological (1,2). During the past two decades, considerable attention has been paid to the chemistry of metal complexes containing nitrogen and other donor (3). This may be attributed to their stability, biological activity (4)and potential application in many fields such as oxidation catalysis (5) and electrochemistry (6). We have already drawn attention (7-11) to the strong relationship between metals or their complexes, and antibacterial (12-18), and anticancer (19,20) activities. In 2009 A. Thabit and co-workers reported the synthesis of a Novel ligand type N_2O_2 and its complexes with Co(II), Cu(II), Zn(II), and Cd(II), which have been characterized by spectroscopy and elemental analysis (21). This paper reports the synthesis and characterization of new derived from the reaction of α-amino carboxylic acid with 1,2-dichloroethane in methanol, resulted (precursor)[H_4L], which reacted with salicylaldehyde and its Co(II), Ni(II), Cu(II) and Zn(II) complexes.

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Experimental

Chemicals used were analytical grades; metals were used as chloride salts. The complexes were determined by absorption technique, using Shimadza (A.A) 680 G atomic absorption spectrophotometer. I.R data were recorded as (KBr) disc using a Schimadza 4800 s FTIR spectrophotometer in the range (4000-400) cm^{-1} which measured at the laboratories of Ibn-Sinaa Company. ^{1}H-NMR spectra were recorded in DMSO-d_6 using Burcker 300 MHz spectrometer[1] which measured at Amman - Jordan. (UV-Vis.) spectra were obtained in (MeOH) on a CECIL, CE 2700 spectrophotometer in the range (200-900) nm using quartz cell which measured at the college of Ibn- Al-Haithem. Magnetic measurements were carried out on solid compounds using 6 Bruker B.M. Melting points were recorded on an electro thermal Stuart apparatus and are not corrected. Electrical conductivity measurements of the complexes were recorded at 25C for 10^{-3}M solutions in (MOH) as a solvent using a Wissenchaftilich technique werksttaten, D1820 bweilheimI.F 42 conductivity meter which measured at the college of Ibn- Al-Haithem. The chloride contents for complexes was determined by potentiometric titration method on (686-titro processor-665), Dosinat-metrom Swiss, which measured at the laboratories of Ibn-Sinaa Company. Antibacterial screening was done at laboratories of medical city, Baghdad using agar diffusion technique (22,23). The ligand along with their metal complexes were screened for their *in vitro* antibacterial activity against gram negative bacteria (*E. coli*), gram-positive bacteria (*Staphylococcus aureus*), *Salmonella typhi* and *Acinetobacter baumannii* bacterial strains. The ligand and their complexes have shown varied antibacterial activities against one or more bacterial strains and this activity enhanced on coordination / chelating.

Preparation of the ligand [H_2L]

The ligand was prepared by two **steps**: Step (1): A solution of α-amino carboxylic acid (0.35 g, 2.25 mmole) in methanol (10ml) was added to it dichloroethane (0.2g, 2.23mmole) , (0.2 ml) with KOH (0.18ml) as a base, the mixture was refluxed for 3 hours with stirring. Then the mixture was allowed to cool at room temperature. The resulting a gray solid (precursor) [H_4L] was obtained which filtered off and then washed with ethanol. Yield (37%), (0.25g), mp (245-250 C° dec.). Step (2): A solution of salicalyaldehyde (0.2 g, 1.66mmole), (0.18 ml) in methanol (5 ml) was added to the precursor solution [H_4L] (0.25 g, 0.83 mmole), then (8) drops of CH_3COOH was added slowly to the reaction mixture. The mixture was refluxed for (5 hours) with stirring. The resulting was orange solid of [H_2L] as product was filtered of and then washed with ethanol. Yield (42%), (0.18g), mp (220-226 C° dec.).

Preparation of the ligand [H_2L] with metal ions

(0.15 g, 2.94 mmole) of ligand solution in methanol (10ml), with KOH as a base was added to a solution of (0.07 g, 2.94 mmole) $CoCl_2.6H_2O$ in methanol (10ml), the mixture was refluxed with stirring for (4 hours). The resulting was dark brown solid as product which was filtered of and then washed by water and re-crystallized with ethanol. The complexes [Ni(L)], [Cu(L)] and[Zn(L)], were obtained in a similar method to that mentioned in the preparation of [Co**(**H_2L**)**$_2$] complex described above, (Table1) stated the quantity of starting materials and some physical properties of the prepared complexes.

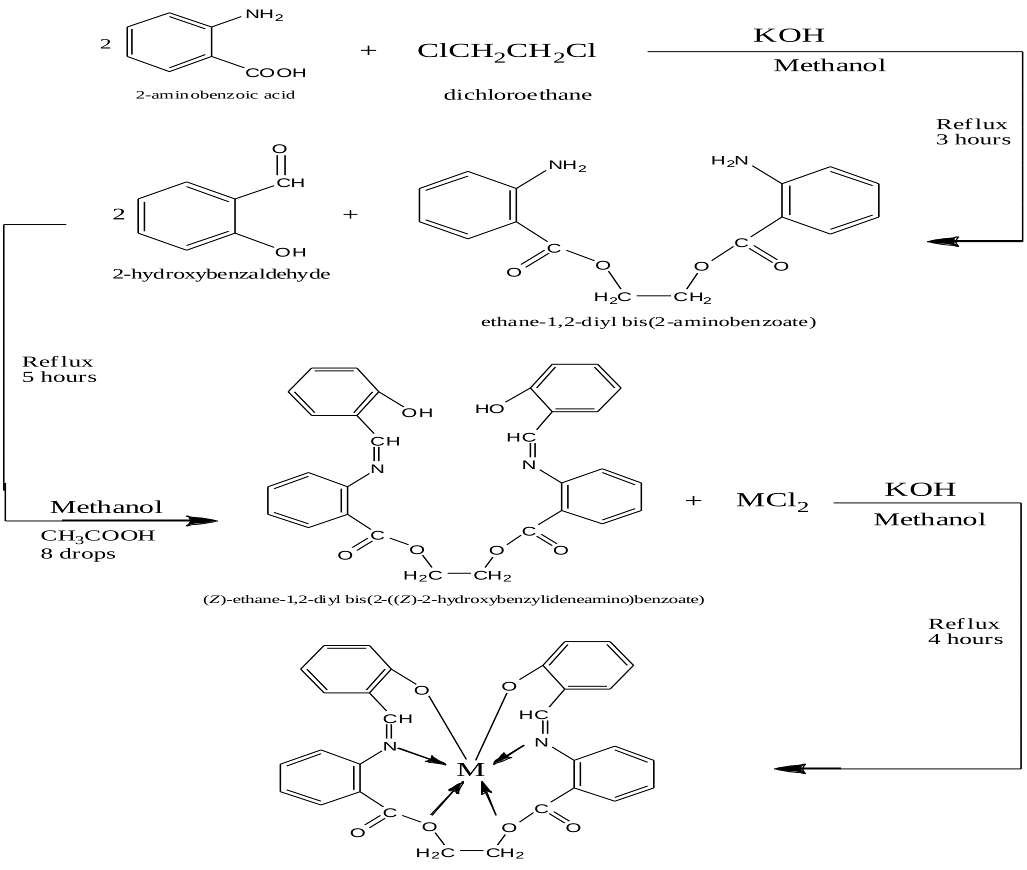
Table 1 : The microanalysis results and some physical properties for the prepared ligand H_2L and its complexes

Compounds	Formula	Colour	M.p(C°)	Yield%	Chloride	Metal	M.wt
H_4L	$C_{16}H_{16}N_2O_4$	Gray	245-250 dec.	37	Nil	-----	300.31
H_2L	$C_{30}H_{24}N_2O_6$	Orange	220-226 dec.	42	Nil	-----	508.52
[Co(L)](1)	$C_{30}H_{22}N_2CoO_6$	Dark brown	230 dec.	60	Nil	10.42 (9.18)	565.44
[Ni(L)](2)	$C_{30}H_{22}N_2NiO_6$	Yellowish green	292 dec.	78	Nil	10.38 (11.18)	565.20
[Cu(L)](3)	$C_{30}H_{22}N_2CuO_6$	Dark green	320 dec.	52	Nil	11.15 (11.37)	570.05
[Zn(L)](4)	$C_{30}H_{22}N_2ZnO_6$	Light green	230 dec.	53	Nil	11.43 (12.44)	571.90

Results and Discussion

Synthesis of the ligand

The ligand [H_2L] was prepared according to the general method shown in Scheme (1). The I.R spectral of the precursor [H_4L] of the ligand [H_2L], is shown in Fig (1), the results were summarized in Table (2) The figure exhibited band at (3329,3379) cm^{-1} which attributed to the stretching vibration of asymmetric and symmetric (N-H) for NH_2 group, also the spectrum was showed bands at (1612)cm^{-1}, (1249) cm^{-1} and (1192) cm^{-1} attributed to υ (C=O) of ester group, υ (C-O) ester group and υ (C-O) phenolic respectively (21,24-27) , By comparing with the I.R spectrum of the ligand [H_2L], Fig (2), Table (2) exhibited bands (3421) cm^{-1}, which can be attributed to υ (O-H) and (disappeared NH_2 groups), also the spectrum showed bands at (1612)cm^{-1}, (1608) cm^{-1}, (1273) cm^{-1} and (1239) cm^{-1} attributed to υ (C=O) ester group, υ (C=N) imine group, υ (C-O) ester group and υ (C-O) phenolic respectively [21,24-27]. The (U.V-Vis) spectra for precursor [H_4L], Fig (3), the results were summarized in Table (3), the figure exhibits two high intense absorption peaks at (248) nm ε_{max} (2532) molar^{-1}cm^{-1}, and (319) nm ε_{max} (2484) molar^{-1}cm^{-1}, which assigned to ($\pi\rightarrow\pi^*$), and ($n\rightarrow\pi^*$) transition respectively [28,29], While The (U.V-Vis) spectrum of the ligand [H_2L] Fig (4), (Table3) exhibits three high intense absorption peaks at (250) nm ε_{max} (2631) molar^{-1}cm^{-1}, (293) nm ε_{max} (2660) molar^{-1}cm^{-1}, and (360) nm ε_{max} (2581) molar^{-1}cm^{-1}, which assigned to ($\pi\rightarrow\pi^*$), ($\pi\rightarrow\pi^*$) and ($n\rightarrow\pi^*$) transition respectively (28,29). The ^1H NMR spectrum of the ligand (H_2L), in DMSO-d^6, Fig (5) shows proton of (O–H) group (ph–OH) which appears as a singlet peak signal at (10.2) ppm. The proton of (C–H) imine group appears as a singlet peak at (8.7) ppm. The multiples signals peaks at the range between (7-8)ppm, are due to aromatic hydrogen of carbon for the benzene ring which bonded with (C=O) carbonyl group, while the multiples signals peaks at the range between (6-7)ppm, are due to aromatic hydrogen of carbon for the benzene ring which bonded with (C=N) imine group, also the spectrum of the ligand appears a triplet peak at (4.7)ppm, which assigned to (-CH_2-) methelene group, as soon as a singlet high peak at (2.5)pmm for the DMSO-d^6 solvent [24,25,30,31].



Where M= Co(II),Ni(II),Cu(II),and Zn(II)

Scheme 1 : The preparation of the ligand [H_2L] and its complexes

Table 2 : Infrared spectral data(wave number ύ) cm^{-1} for the ligand H_2L and its complexes

Compound	**υ(C=N)**	**υ(C=O) ester**	**υ(C-O) ester**	**υ(C-O) phenolic**	**υ(O-H)**	**υ(M-O) phenolic**	**υ(M-O) esteric**	**υ(M-N)**
H_4L	-----	1612	1249	1192	-----	----	-----	-----
H_2L	1608	1612	1273	1239	3421	-----	-----	-----
[Co(L)](1)	1593	1612	1327	1300	-----	505	461	416
[Ni (L)](2)	1593	1612	1327	1300	------	536	440	430
[Cu (L)](3)	1585	1609	1319	1288	------	540	468	428
[Zn (L)](4)	1593	1611	1327	1300	-----	516	459	445

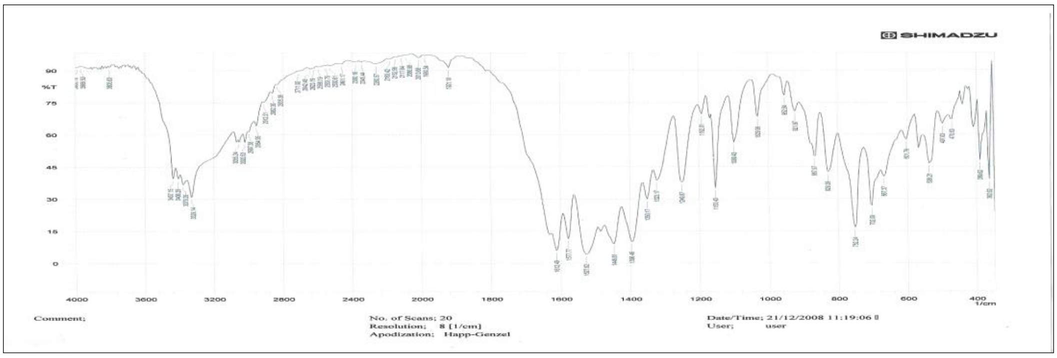


Figure 1: Infrared spectrum of the precursor (H_4L)

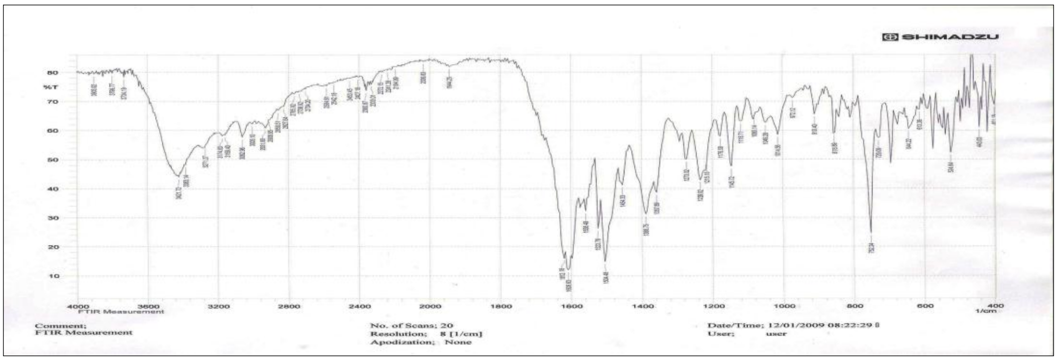


Figure 2 : Infrared spectrum of the ligand (H_2L)

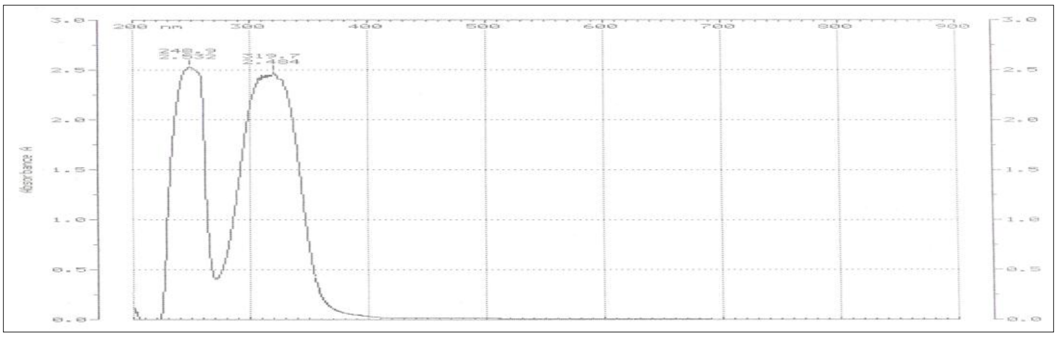


Figure 3 : Electronic spectrum of the precursor (H_4L)

Table 3 : Electronic spectral data for the ligand H_2L and its complexes

Compound	Λ nm	ε_{max} molar^{-1}cm^{-1}	Assignment	Ratio	Molar conductivity S.cm^2.mol^{-1}	Magnetic susceptibility B.M	coordination
H_4L	248.9 319.7	2532 2484	$\pi\rightarrow\pi^*$ $n\rightarrow\pi^*$	-----	------	------	-------
H_2L	250.0 293.6 360.8	2631 2660 2581	$\pi\rightarrow\pi^*$ $\pi\rightarrow\pi^*$ $n\rightarrow\pi^*$	-----	-------	------	------
[Co(L)](1)	248.5 295.6 414.0 629.8	2642 2531 1264 96	Ligand field Ligand field C.T $^4T_{1g(F)}\rightarrow{}^4T_{2g(F)}$	neutral	18.1	3.87 (4.15)	Octahedral
[Ni(L)](2)	245.0 305.3 400.1 580.0	2597 1617 1317 62	Ligand field Ligand field C.T $^3A_{2(g)}\rightarrow{}^3T_{1g\ (p)}$	neutral	14.9	2.83 (3.2)	Octahedral
[Cu(L)](3)	243.5 300.0 406.1 698.9	2608 2551 2636 52	Ligand field Ligand field C.T $^2E\rightarrow{}^2T_2$	neutral	12.46	1.7 (1.9)	Octahedral
[Zn(L)](4)	220.3 289.0 388.5	1483 584 371	Ligand field Ligand field C.T	neutral	13.65	------	Octahedral

C.T= Charge transfer

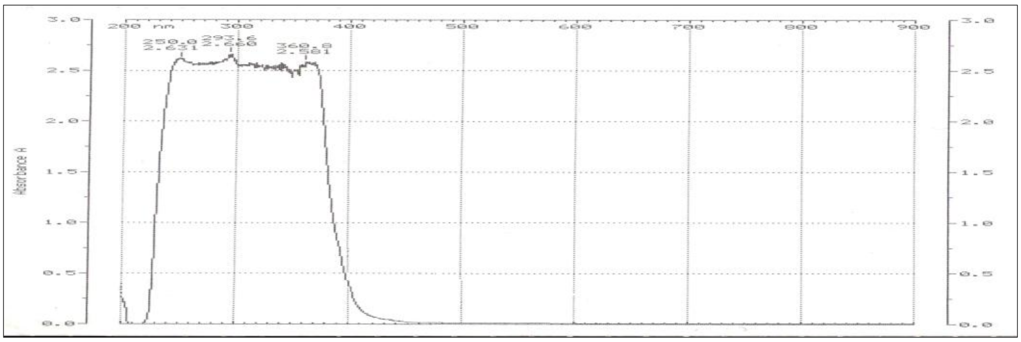


Figure 4: Electronic spectrum of the ligand (H_2L)

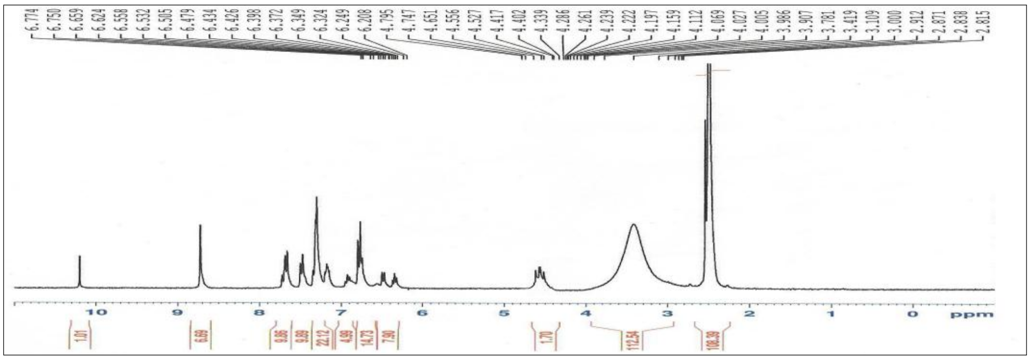


Figure 5: ^{1}H NMR spectrum of the ligand (H_2L)

Synthesis of the complexes

The reaction the of ligand [H_2L] with Co(II), Ni(II), Cu(II) and Zn(II) was carried out in MeOH. These complexes are stable in solution. The analytical and physical data, Table (1) and spectral data, Table (2) and Table (3) are compatible with the suggested structure Scheme (1). The I.R spectra of the complexes [Co(L)](1), [Ni(L)](2), [Cu(L)](3), and [Zn(L)](4). Fig (6) and Fig (7), respectively, the results were summarized in Table (2), the figure exhibited at (1608) cm^{-1} in the free ligand spectrum which assigned to υ (C=N) imine group Shifted to lower frequency and appeared at (1593) cm^{-1}, (1593) cm^{-1}, (1585) cm^{-1} and (1593) cm^{-1} for the complexes (1),(2),(3), and (4) respectively (25-28). These bands were assigned the υ (C=N) stretches of reduced bond order, this can be attributed to the delocalization of metal-electron density into the ligand π-system (HOMO→LUMO) [32,33]. (HOMO=Highest occupied molecular orbital, LUMO= Lowest unoccupied molecular orbital). The phenolic (C-O) stretching vibration appeared at (1239) cm^{-1} in the free ligand was Shifted to higher frequency and appeared at (1300) cm^{-1}, (1300) cm^{-1}, (1288) cm^{-1}, and (1300) cm^{-1} for the complexes (1), (2), (3) and (4) respectively, as well as ester group (C-O) stretching vibration appeared at (1273) cm^{-1} in the free ligand was shifted to higher frequency too, and appeared at (1327) cm^{-1}, (1327) cm^{-1}, (1319) cm^{-1} and (1327) cm^{-1} for the complexes (1), (2), (3) and (4) respectively, all that indicated a linkage between oxygen of phenolic group and oxygen of ester group and the metal (24,32,34). The spectra showed the appearance of bands at (416) cm^{-1}, (430) cm^{-1}, (428) cm^{-1} and (445) cm^{-1} refer to υ (M-N) for complexes (1), (2), (3) and (4) respectively, These bands confirm the coordination of the nitrogen atom to the metal center, while the bands at [(505),(461)] cm^{-1}, [(536),(440)] cm^{-1} and [(540),(468)] cm^{-1} [(516),(459)] cm^{-1}assigned to υ (M-O) of complexes (1),(2),(3), and (4) respectively, Theses bands indicating the phenolic and esteric oxygen in the ligand is involved the coordination with metal ions in complexes [34-37]. The (U.V-Vis) spectra for the complexes are shown in Fig (8) and Fig (9), Table(3), **Complex [Co(L)]:** showed two high intense peak at (248) nm ε_{max} (2642) $molar^{-1}cm^{-1}$ and (295) nm ε_{max} (2531) $molar^{-1}cm^{-1}$ were assigned to the ligand field, while a medium intense peak at (414) nm ε_{max} (1264) $molar^{-1}cm^{-1}$ was assigned to the charge transfer (C.T), a weak broad peak at (629) nm ε_{max} (96) $molar^{-1}cm^{-1}$ was assigned to(d-d)electronic transition ($^4T_{1g(F)}\rightarrow{}^4T_{2g(F)}$) suggesting octrahedral geometry(29). **Complex[Ni(L)]:** showed two high intense absorption peaks at (245) nm ε_{max} (2597) $molar^{-1}cm^{-1}$ and (305) nm ε_{max} (1617) $molar^{-1}cm^{-1}$ are due to the ligand field, another high intense peak at (400) nm ε_{max} (1317) $molar^{-1}cm^{-1}$ was assigned to (C.T), while a weak broad peak at (580)nm ε_{max} (62) $molar^{-1}cm^{-1}$ was assigned to (d-d) electronic transition ($^3A_{2(g)}\rightarrow{}^3T_{1g(p)}$) suggesting octahedral geometry (29). **Complex[Cu(L)]:** showed two high intense absorption peaks at (243) nm ε_{max} (2608) $molar^{-1}cm^{-1}$ and (300) nm ε_{max} (2551) $molar^{-1}cm^{-1}$ are due to the ligand field. a high intense absorption peak at (406) nm ε_{max} (2636) $molar^{-1}cm^{-1}$ was assigned to (C.T), while a weak broad peak at (698) nm ε_{max} (52) $molar^{-1}cm^{-1}$ was assigned to (d-d) electronic transition ($^2E \rightarrow {}^2T_2$) suggesting octahedral geometry(29). **Complex[Zn(L)]**: showed two peaks at (220) nm ε_{max} (1483) $molar^{-1}cm^{-1}$ and (289) nm ε_{max} (584) $molar^{-1}cm^{-1}$ are due to the ligand field. while a weak broad peak at (388) nm ε_{max} (371) $molar^{-1}cm^{-1}$ was assigned to (C.T), the d^{10} configuration of Zn^{II} ion along with the data obtained confirms a octahedral structure around the ion (29). The molar conductance of the complexes in methanol lie in the range(12.46-18.1 $Ohm^{-1}cm^{-2}mol^{-1}$), Table(3), indicting their non-electrolyte having molar ratio of metal:ligand as 1:1 (38). The magnetic moments for the complexes are shown in Table (3) (39).

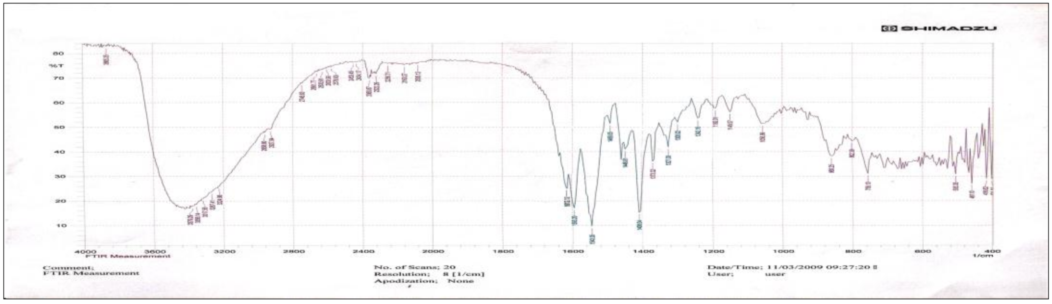


Figure 6: Infrared spectrum of the complex [Co(L)](1)

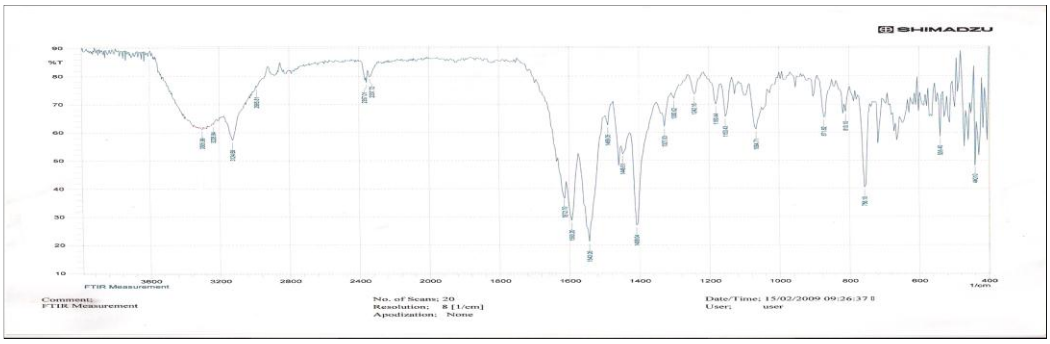


Figure 7: Infrared spectrum of the complex [Ni(L)](2)

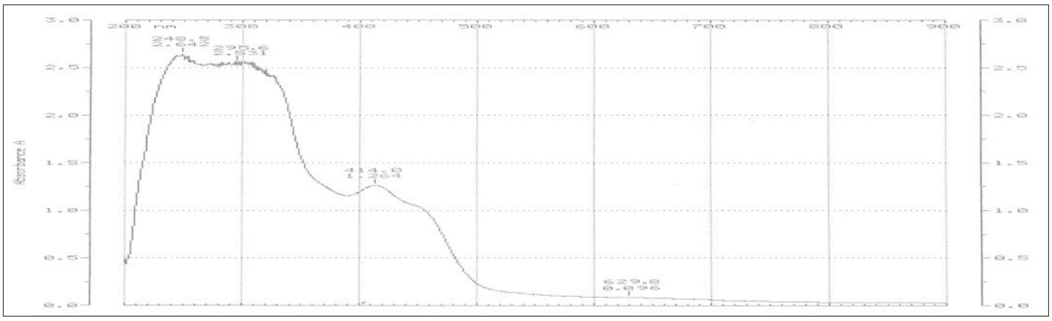


Figure 8: Electronic spectrum of the ligand [Co(L)](1)

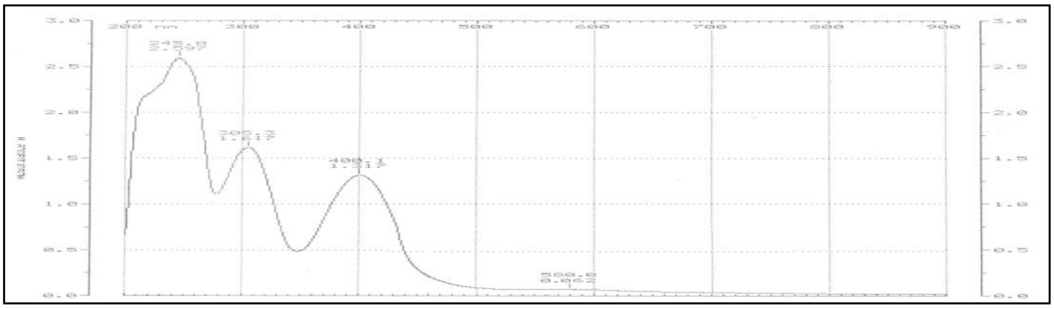


Figure 9: Electronic spectrum of the ligand [Ni(L)](2)

Biological activity

The antibacterial activity of the synthesized ligand [H_2L] and its complexes [Co(L)](1), [Ni(L)](2) , [Cu(L)](3) , and [Zn(L)](4) Table (4, 5, 6 and7), Fig(10 and 11) were tested utilizing the agar diffusion technique (40). The organisms tested were *Staphylococcus aureus , E. collie , Salmonella typhi , and Acinetobacter baumannii*. The agar media (Muller-Hinton agar) were inoculated with test organisms and a solution of the tested compound (100µg/ml) (41), was placed separately in cups (6 mm diameter) in the agar medium. The inhibition zones were measured after 24 hours incubation at 35 °C. Separate studies were carried out with the solution alone of DMSO and the showed no activity against any bacterial strains (41). The results of these studies revealed that metals complexes showed an effective in the inhibition of *Acinetobacter baumannii*, Table (4). The ligand and (Co^{+2}, Ni^{+2}, Cu^{+2},Zn^{+2}) complexes were showed an inhibition in some strains in each of *Staphylococcus*, *E. coli*, and *Salmonella typhi*, as shown in Table (5, 6, and 7) . Biological activity of the previous compounds in inhibition of bacterial growth could be attributed to one of the following mechanisms, the first mechanism is by the inhibition of the bacterial cell wall synthesis by bounding to the precursor of the cell wall (42), second mechanism revealed that some antibodies have similar stereo structure to substrate (D-alanyl D-alanine). So it will act competitive inhibitions for the enzymes (transpeptidase and /or carboxpeptidase) which are the main enzymes catalyzed the end step in the biosynthesis of peptidoglycans of the bacterial cell wall (43). Other mechanisms could contributed to the results found in the study which include the inhibition of biosynthesis of bacterial proteins by linking to the ribosoms by doing so, the ribosomes will not be in contact with tRNA, so the bacteria will not survive (44). An other mechanisms were postulated that some antibodies inhibit the denovo synthesis of bacterial DNA by splitting DNA in DNA-enzyme complexes by inhibition DNA ligase (45).

Table 4 : Biological activity of *Acinetobacter baumannii* bacteria of the ligand $[H_2L]$ and its complexes

Compound	Bacteria (zone of inhibition (diameter mm))									
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
H_2L	14	11	Nil	14	16	14	15	12	13	16
[Co(L)](1)	15	10	Nil	15	14	15	12	Nil	16	15
[Ni(L)](2)	14	10	12	14	13	16	13	12	15	15
[Cu(L)](3)	14	10	11	12	13	12	13	13	12	13
[Zn(L)](4)	11	11	Nil	14	13	14	14	12	15	16

A= *Acinetobacter baumannii* bacteria

Table 5 : Biological activity of *Staphylococcus aureus* bacteria of the ligand $[H_2L]$ and its complexes

Compound	Bacteria (zone of inhibition (diameter mm))									
	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}
H_2L	Nil	Nil	16	Nil	Nil	Nil	Nil	Nil	Nil	Nil
[Co(L)](1)	Nil	Nil	16	Nil	Nil	Nil	Nil	Nil	Nil	Nil
[Ni(L)](2)	Nil	Nil	16	Nil	Nil	Nil	Nil	Nil	Nil	Nil
[Cu(L)](3)	9	8	17	9	10	9	8	9	8	11
[Zn(L)](4)	Nil	Nil	18	12	Nil	Nil	12	Nil	Nil	Nil

S= *Staphylococcus aureus* bacteria

Table 6 : Biological activity of *E. coli* bacteria of the ligand $[H_2L]$ and its complexes

Compound	Bacteria (zone of inhibition (diameter mm))									
	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}
H_2L	Nil	Nil	Nil	12	12	10	Nil	11	Nil	10
[Co(L)](1)	9	Nil	Nil	10	7	10	Nil	Nil	Nil	10
[Ni(L)](2)	10	Nil	Nil	11	8	12	Nil	10	Nil	8
[Cu(L)](3)	Nil	Nil	Nil	12	8	12	Nil	10	Nil	10
[Zn(L)](4)	Nil	Nil	Nil	8	8	8	Nil	10	Nil	Nil

E= *E. coli* bacteria

Table 7 : Biological activity of *Salmonella typhi* of the ligand $[H_2L]$ and its complexes

Compound	Bacteria (zone of inhibition (diameter mm))									
	Sal_1	Sal_2	Sal_3	Sal_4	Sal_5	Sal_6	Sal_7	Sal_8	Sal_9	Sal_{10}
H_2L	Nil	11	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
[Co(L)](1)	10	12	9	Nil	Nil	Nil	Nil	Nil	Nil	12
[Ni(L)](2)	Nil	Nil	10	Nil	Nil	Nil	Nil	Nil	Nil	Nil
[Cu(L)](3)	Nil	Nil	Nil	Nil	Nil	Nil	12	9	Nil	Nil
[Zn(L)](4)	10	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Sal= *Salmonella typhi* bacteria

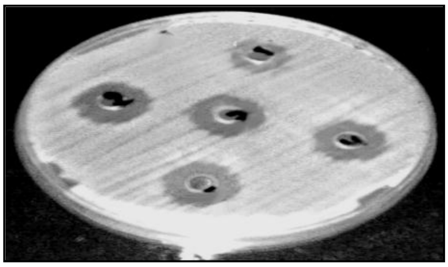


Figure 10: Inhibition zones for *Acinetobacter baumannii* utilizing agar diffusion technique

Figure 11: Inhibition zones for *Staphylococcus aureus* utilizing agar diffusion technique

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