Synthesis, characterization and antimicrobial activities of [Fe(II), Co(II), Ni(II),Cu(II) and Zn(II)] mixed ligand complexes schiff base derived from amoxicillin drug and 4-(dimethylamino)benzaldehyde with nicotinamide

*Taghreed H. Al-Noor, Manhel Reemon Aziz and Ahmed T. AL- Jeboori

Department of Chemistry, Ibn -Al-Haithem College of Education for Pure Science, Baghdad University-Iraq
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ABSTRACT

New Schiff base ligand (E)-6-(2-(4-(dimethylamino)benzylideneamino)-2-(4-hydroxyphenyl)acetamido)-3,3-dimethyl-7-oxo-4-thia-1- azabicyclo[3.2.0]heptane-2-carboxylic acid = (HL) was synthesized via condensation of Amoxicillin and 4(dimethylamino)benzaldehyde in methanol. Figure -1 Polydentate mixed ligand complexes were obtained from 1:1:2 molar ratio reactions with metal ions and HL, 2NA on reaction with $MCl_2 .nH_2O$ salt yields complexes corresponding to the formulas $[M(L)(NA)_2Cl]$,where M=Fe(II),Co(II),Ni(II),Cu(II),and Zn(II), A=nicotinamide .
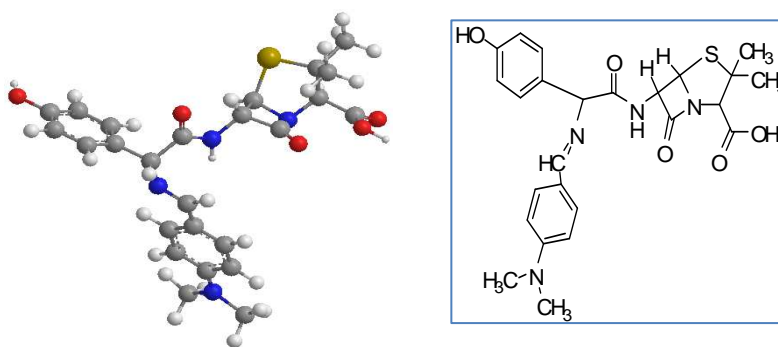
Figure (1): The proposed molecular structure and 3D of (HL)

The ^1H-NMR, FT-IR, UV-Vis and elemental analysis were used for the characterization of the ligand. The complexes were structurally studied through AAS, FT-IR, UV-Vis, chloride contents, conductance, and magnetic susceptibility measurements. All complexes are non-electrolytes in DMSO solution. Octahedral geometries have been suggested for each of the complexes. the Schiff base ligands function as tridentate and the deprotonated enolic form is preferred for coordination. In order to evaluate the effect of the bactericidal activity, these synthesized complexes, in comparison to the un complexed Schiff base has been screened against six bacterial species, Staphylococcus aureus, Escherichia coli. Klebsiella pneumonia, Acinetobacter baumannii, Salmonella and Acinetobacter baumanni and the results are reported.

Key words: Amoxicillin drug, Nicotinamide, mixed ligand) Complexes, Antibacterial activities, and spectral studies.
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INTRODUCTION

Amoxicillin, an acid stable, semi-synthetic drug belongs to a class of antibiotics called the Penicillin (β-lactam antibiotics). It is shown to be effective against a wide range of infections caused by wide range of Gram -positive and Gram- negative bacteria in both human and animals[1-4]. It is a congener of ampicillin (a semi-synthetic amino penicillin) differing from the parent drug only by hydroxylation of the phenyl side chain. It has found a niche in the treatment of ampicillin-responsive infections after oral administration. Chemically amoxicillin is (2S, 5R, 6R) 6-[[(2R)-2-Amino-2, 3, 3-dimethyl-7-oxo- 4-thia-1-azabicyclo[3.2.0]heptanes-2-carboxylic acid [1].

Compounds containing an azomethine group (imine) are a class of important compounds in medicinal and pharmaceutical field. The biological applications of these compounds have attracted remarkable attention. Some Schiff-bases were exhibits antibiotic, antiviral and antitumor agents because of their specific structure. The wide use of antibiotics resulted in the serious medical problem of drugs resistance and public health concern. The synthesis of new derivatives of antibiotics has become an important task to cope with drug resistance problems. [1].

Due to the activities associated with amoxicillin and imines, an attempt was made to generate new derivatives containing imine and amoxicillin in the same molecules. All the synthesized compounds were further characterized

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and evaluated for antibacterial activities. There are many interesting studies on the Schiff bases compounds and their complexes derived from antibiotics [2]. Naz and Iqbal [3] found that the Schiff base complexes derived from amoxicillin having good antibacterial activity in good range when comparison to control (Amoxicillin).

In 2009 El-Said and co-workers [4], Synthesized Mixed ligand complexes of Zn(II) and Cd(II) containing ceftriaxone (Naceftria) or cephradine (Hcefphr) antibiotics and other ligands have been prepared and characterized by elemental analysis, spectral, biological and thermal studies. The complexes have the general formulas $[Cd_2(cephr)(diamine)Cl_3(H_2O)].xH_2O$ $[Cd_3(cephr)(\mu HL)Cl_5(H_2O)]._2H_2O$ where diamine=2,2'-bipyridyl or o-phenanthroline; M= Cd(II) or Zn(II), L=glycine, proline or methionine and x=0-6.

In 2011Sunil, and co- workers [5], synthesis and characterized some new Schiff bases derived from Amoxicillin trihydrate with Cinnamaldehyde and p-Chlorobenzaldehyde and their complexes with bivalent transition metal ions viz. Co(II), Zn(II), Ni(II), and Mn(II), have been synthesized. The ligand and their metal complexes were characterized on the basis of elemental analysis and micro analytical datas. Shift in the characteristic spectral frequency of the metal complexes, confirms the coordination through metal ion with azomethine group. They were screened for antibacterial activity against several bacterial strains namely *E. coli*(-), *S. aureus*(+) *M. luteus*(+) and *B. lichenformis*(+) (ATCC), the metal complexes showed enhanced antibacterial activity compared to uncomplexed ligand.

In 2013 Tghreed and co-workers [6], Synthesis a New Schiff base ligand (Z)-7-(2-(4-(dimethylamino) benzylideneamino)-2-phenylacetamido)-3-methyl-8-oxo-5-thia-1-azabicyclo[4.2.0]oct-2-ene-2-carboxylic acid = (HL)was prepared via condensation of Cephalexin and 4(dimethylamino)benzaldehyde in methanol. Polydentate mixed ligand complexes were obtained from 1:1:2 molar ratio reactions with metal ions and HL, 2NA on reaction with MCl2 .nH2O salt yields complexes corresponding to the formulas $[M(L)(NA)_2Cl]$, where M = Fe(II),Co(II),Ni(II),Cu(II),and Zn(II) and NA= nicotinamide.

The work presented in this paper concerns the Preparation , Characterization and Antimicrobial activities of Fe(II),Co(II),Ni(II),Cu(II), and Zn(II)}Mixed Ligand Complexes Schiff base derived from Amoxicillin drug and 4dimethylamino benzaldehyde with Nicotinamide in 1:1:2(M:L:2NA) ratio.

EXPERIMENTAL SECTION

1-Chemicals
All chemicals used were of reagent grade (supplied by either Merck or Fluka, and used as received, ethanol methanol and dimethylforamaide, and KBr, from (B.D.H). amoxicillin tri hydrate powder) and 4-(dimethylamino) benzaldehyde from Riedial-Dehaen DSM (Spain).

2-Instrumentation
UV-Vis spectra were recorded on a (Shimadzu UV- 160A) Ultra Violet-Visible Spectrophotometer. IR- spectra were taken on a (Shimadzu, FTI R- 8400S) Fourier Transform Infrared Spectrophotometer (4000- 400) cm^{-1} with samples prepared as KBr discs. Elemental micro analysis for the ligand was performed on a (C.H.N.S.O) Perkin Elemar 2400. While metal contents of the complexes were determined by atomic absorption(A.A) technique using a Shimadzu AA 620G atomic absorption spectrophotometer. The Chloride contents of complexes were determined by potentiometric titration method using (686-Titro processor-665. Dosimat Swiss) Molecular weight determined by Rast Camphor method, confirming the monomeric nature of the compounds. Conductivities were measured for 10^{-3}M of complexes in DMSO at 25oC using (conductivity meter, Jewnwary, model 4070). Magnetic measurements were recorded on a Bruker BM6 instrument at 298°K following the Farady's method .Nuclear magnetic resonance spectrum ^{1}H NMR for ligand was recorded in DMSO-d$_6$ using a Bruker 300 MHz instrument with a tetra methyl silane (TMS) as an internal standard. The samples were recorded at Queen Mary, university of Al-Albeit, Jordon, Amman. In addition melting points were obtained using (Stuart Melting Point Apparatus).The proposed molecular structure of the complexes was drawing by using chem.office prog, 3DX (2006).

2.3- preparation of ligand (HL): [7]
A solution of (Amoxi) (0.419 gm, mmole) in methanol (5 ml) was added to a solution of (4DMAB) (0.149 gm, m mole) in methanol (10 ml). The mixture was refluxed for (5 hours) with stirring. The resulting was an orange solution allowed to cool and dried at room temperature, then re-crystallization to the precipitate with ethanol, orange solid was obtained by evaporation of ethanol during (24 hours) Scheme (1), m. p (146-152° C). Anal. Calcd for ligand (HL), C = 60.47%, H = 5.68%, N = 11.28 %. = Found: C = 59.30%, H = 6.37%, N = 10.40%.

2.4- Synthesis of [Cu(L)(NA)₂Cl] complex:[7]
A solution of (HL) (0.496gm, 1 mmole) in methanol (10 ml) and a solution of (NA) (0.244 gm, 2mmole) in methanol (10ml), were added to a stirred solution of Cu (II) chloride dihydrate (0.17 gm, 1mmole) in methanol (5 ml).The resulting mixture was heated under reflux for (5 hours). Then the mixture was filtered and the precipitation was washed with an excess of ethanol and dried at room temperature during (24 hours). A green solid was obtained, m.p (260-266° C).

### 2.5-Synthesis of[Fe(L)(NA)₂Cl], [Co(L)(NA)₂Cl], [Ni(L)(NA)₂Cl, and [Zn(L)(NA)₂Cl] complexes
The method used to prepare these complexes was similar method to that mentioned in preparation of **[Cu(L)(NA)₂Cl]** complex in paragraph above.

2.6-Preparation of Microorganism suspension
A) The micro- organism suspension was prepared by taking 2–4 colonies from all the studied microorganism. Then it was inserted in the physiological solution in 0.85% concentration and was compared with Macferr land tube number 0.5 which is equal to 1.5×108 cell/mm. It is used for Petri dish preparation for the examination of biological activity against the under studied chemical compound.

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B) Inhibition Activity Selection for the complexes in studied Microorganism The agar well diffusion method was used to see the effect of under studied chemical complexes on the microorganism growth. This is done by using 20–25 ml from Nutrient agar medium for each Petri dish. The dish was incubated in incubator for 24 hours at (37°C) to make sure that no contamination would occur in the dish .Bore was made on the cultured medium surface by using cork borer. The chemical complexes were made as 100 m ml per bore and left the central bore containing only DMF. The biological activity for the complexes was defined by measuring the diameter of the inhibition area surrounding each bore in millimeters. [8]
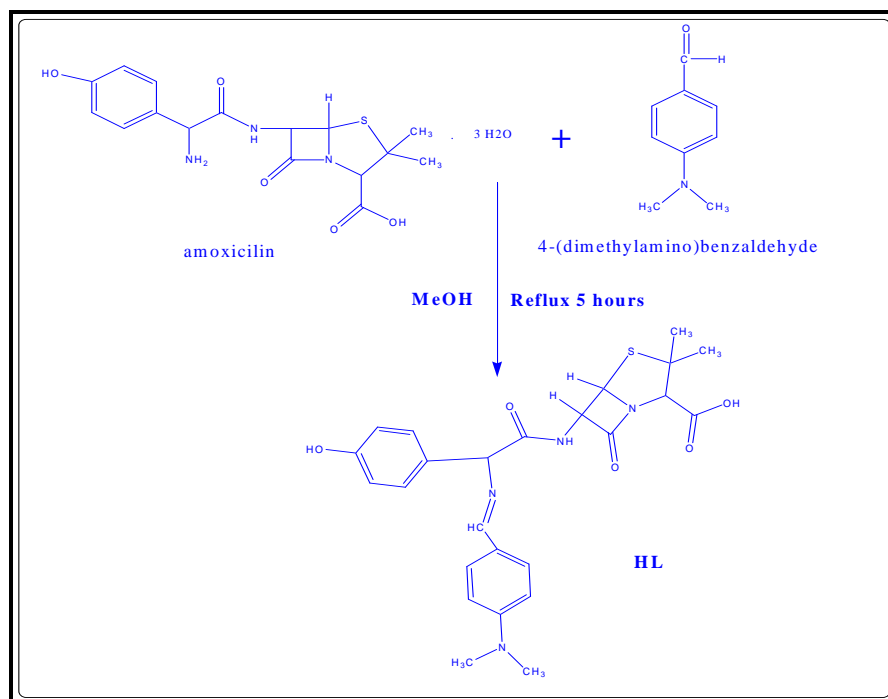
Scheme (1): Schematic representation of synthesis of the ligand (HL)

RESULTS AND DISCUSSION

3. 1-Physical Properties
Ligand (HL) is soluble in(N,N-dimetylformamide (DMF), dimetylsulphoxide (DMSO), methanol (Me OH), ethanol (EtOH), acetone (C_3H_6O), 2-propanol (C_3H_8O) and completely insoluble in water (H_2O),carbon tetra chloride (CCl_4), benzene(C_6H_6), Petroleum ether and chloroform ($CHCl_3$).

3. 2- Characterization of Metal Complexes:
Generally, the complexes were prepared by reacting the respective metal salts with the ligands using 1:1:2 mole ratio, i.e. one mole of metal salt : one mole of HL and two moles of nicotinamide. The formula weights and melting points are given in(Table 1 based on the physicochemical characteristics, it was found that all the complexes were non-hygroscopic, stable at room temperature and appears as powders with high melting points. The solubility of the complexes of ligands was studied in various solvents. They are not soluble in water .All complexes are soluble in (DMF) and (DMSO) solvents. The complexes were analyzed for their metal by atomic absorption measurements and chloride contents were determined by standard methods. (Table-1) for all complexes gave approximated values for theoretical values. Molar conductance values of the soluble complexes in DMSO show values
 (9.4-12.3 Ω^{-1} cm^2 mol^{-1}) indicating that they are all non-electrolytic in nature [9].

FT-IR spectrum of the ligand (HL):
The (FT-IR) spectrum for the starting material amoxicillin , the band at (3456) cm^{-1} due to υ (N–H) primary amine stretching vibration, and (3525) cm^{-1}for (-OH), and amoxicillin major peak absolved at (3176) cm^{-1} (amide N–H and phenol OH stretch). The band at (3039) cm^{-1} benzene ring υ (C–H) stretching vibration. The band at (1774) cm^{-1} is due to υ (C=O) β-Lactam group, (1452) cm^{-1} υ (N–H) bend (CN) stretch combination and (NH$_3^+$) symmetric deformation. The bands at (1585), and (1396) cm^{-1} were assigned to stretching vibration υ (COO$^-$) asymmetric and symmetric stretching vibration, respectively.,υ (COO$^-$)$_{asym}$- υ (COO$^-$)$_{sym}$ =189 cm^{-1}. The bands at (1519) cm^{-1}, (3039) cm^{-1}, (1178) cm^{-1}, and (2970) cm^{-1} were assigned to υ(C=C) aromatic, υ(C–H) aromatic, υ(C–C) aliphatic, and υ(C–C) stretching vibration respectively. The band at (1282) cm^{-1} is due to υ(C–N) cm^{-1} stretching vibration. The band at (1249) cm^{-1} was assigned to υ(C–O) stretching vibration. The band at (557) cm^{-1} was assigned to υ(C–S) stretching vibration.

The spectrum for the starting material 4(dimethylamino)benzaldehyde (DMBA) which exhibits a band due to υ (C–N) were observed in the (1371) cm^{-1}.The bands at (1165) cm^{-1} and (2796) cm^{-1} were assigned to the υ(C–C) and υ(C–H) aliphatic stretching vibration. The very strong bands due to carbonyl group υ(C=O) stretching of (DMBA) were observed in the (1662 -1600) cm^{-1} regions, while the bands at (1548) cm^{-1} and (2819) cm^{-1} were assigned to the υ(C=C) aromatic and υ(C–H) aromatic stretching vibration respectively.

The (FT-IR) spectrum for the ligand (HL),Figure (1),the band at (3298) cm^{-1} due to υ (N–H) secondary amine stretching vibration and disappeared the band for the υ(N–H) primary amine stretching vibration. The spectrum displays a new band at (1658) cm^{-1} is due to azomethine group υ(-HC=N-) stretching vibrations of the ligand. The band at (1735) cm^{-1} is due to υ(C=O) cm^{-1} stretching vibration for (COOH).The band at (1658) cm^{-1} stretching vibration is due to υ (C=O) for β-Lactam group overlapping with υ (-HC=N-) stretching vibrations. The bands at

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(1597) cm^{-1}, and (1377) cm^{-1} were assigned to stretching vibration (COOH) asymmetric and symmetric stretching vibration, respectively. The bands at (1546) cm^{-1},(2962) cm^{-1}, (1168) cm^{-1}, and (2823) cm^{-1} were assigned to υ(C=C) aromatic, υ(C–H) aromatic, υ(C–C) aliphatic and υ(C–C) stretching vibration respectively. The band at (1315) cm^{-1} is due to υ(C–N) cm^{-1} stretching vibration. The band at (1230) cm^{-1} was assigned to υ(C–O) stretching vibration. The band at (555) cm^{-1} was assigned to υ(C–S) stretching vibration. The band at (3298) cm^{-1} stretching vibration is due to υ (–OH) hydroxyl group overlapping with υ (N–H) secondary amine stretching vibration [9-14]. The assignment of the characteristic bands for the starting materials, intermediate compounds and the ligand are summarized in Table (2).

^{1}H NMR spectrum for the ligand (HL):
In 1H NMR spectrum of the ligand (HL) in DMSO-d6 Figure (2), single peaks attributed to methyl groups appeared at (δ 3.031) ppm ($_{2CH3}$) and (2CH$_3$) (δ 1.56) ppm. The signal obtained in range (δ 6.71-7.70) ppm was assigned for doublet due one proton of aromatic ring of phenyl. The signal obtained at (δ 8.20) ppm was assigned for singlet due one proton of -CH=N linkage in the ligand. This confirms the formations of imine ligand. This observation was also supported by the FTIR data of the ligand discussed earlier. One group of four resonance signals attributed to (S–CH) on the dihydrothiazine ring was observed in the (δ 3.421 - 3.660) ppm, Three groups of double peaks given by (CO–CH) and (N–CH) on the β-lactam ring and (NH sec.) amide appeared at (δ 4.8), (δ 4.9) and (δ 8.2) ppm, respectively. single peak attributed to hydroxyl group appeared at (δ 9.67) ppm (17).
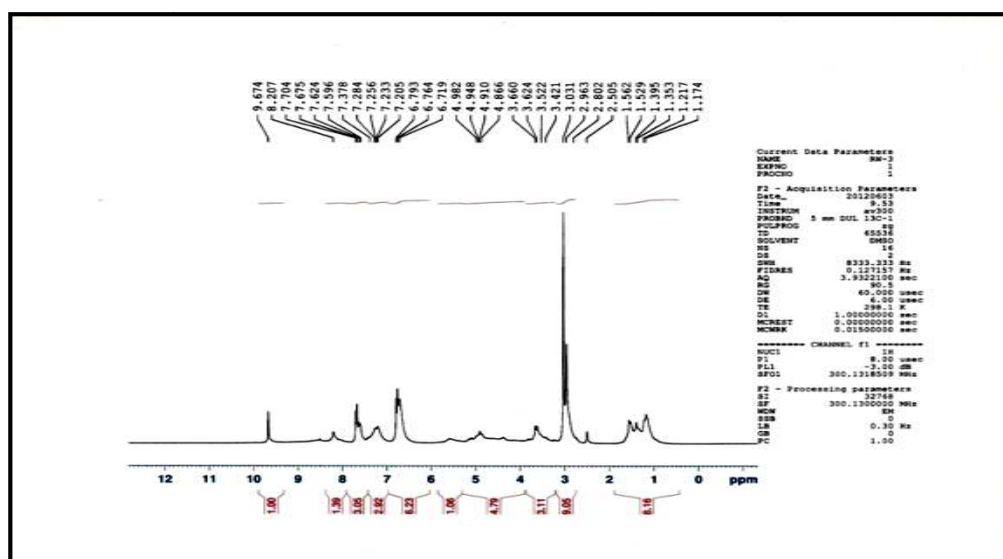

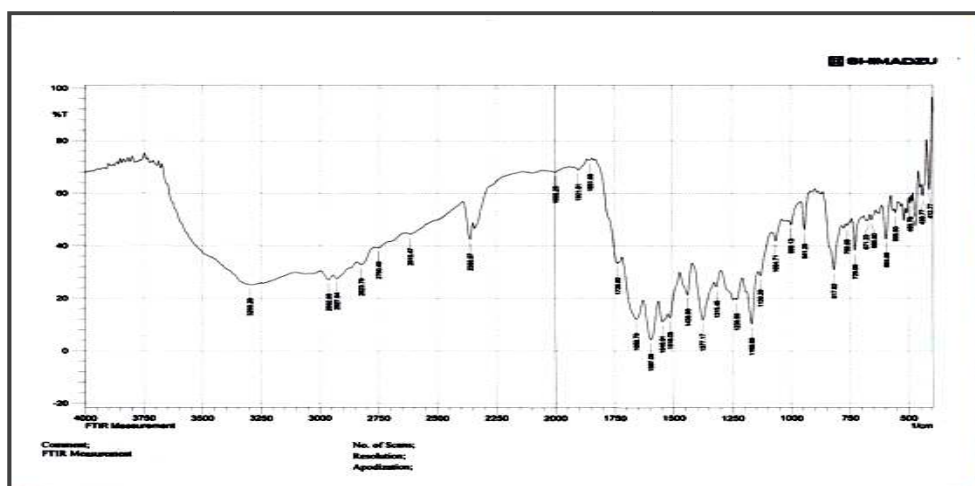
Figure (2): 1H NMR spectrum of the ligand (HL) in DMSO-d6

Figure (3): FT-IR spectrum of (HL)

FT-IR of spectral data for the Schiff base mixed ligands complexes
[Fe(L)(NA)$_2$Cl](1),[Co(L)(NA)$_2$Cl](2),[Ni(L)(NA)$_2$Cl](3),[Cu(L)(NA)$_2$Cl](4), [Zn(L)(NA)$_2$Cl](5):
The spectrum of the (HL) displays a new band at (1658) cm^{-1} is due to υ (HC=N-) group of the azomethine stretching vibrations of the ligand [5,6],on complexation these band has been shifted to higher frequencies (1624), (1624), (1624), (1630), and (1630) cm^{-1} for complexes (1), (2), (3), (4),(5).Infra red spectra for the prepared compounds revealed the presence of wide strong bands between (3541-3317) cm^{-1} due to the stretching vibration υ (O-H) and υ (N-H) in accord with the results in found it difficult to get reasonable resolution between bands due to OH and NH, hence abroad band between (3500 - 2500) cm^{-1} is definitely due to OH and NH stretching. The bands at (1597),and (1377) cm^{-1} were assigned to stretching vibration (COOH) asymmetric and symmetric stretching vibration, respectively. on complexation these bands have been shifted to higher frequencies [(1599), (1600), (1604), (1604), and (1620) cm^{-1} for υ(-COO)asy], and lower frequencies [(1363), (1366), (1366), (1367), and (1363) cm^{-1}, for υ(-COO)$_{sy}$] for the compounds (1) , (2) , (3) ,(4) , and (5), that the coordination with metal was occurred through the oxygen atom of carboxylate ion. The overlap band at (1658) cm^{-1} stretching vibration is due to υ (C=O) for β-Lactam group, these band has been shifted to higher frequency at (1670-1689) cm^{-1} for complexes showing that the coordination is through the Oxygen atom of β-Lactam group. [6] .The bands at (497),

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(486),(470),(489), and (474) cm^{-1} were assigned to υ(M–O) for compounds (1), (2), (3), (4),and (5), indicating that to the carbocylic oxygen, and oxygen of β-Lactam group of the ligand are involved in coordination with metal ions. The bands at (540), (520),(578), (547) and (505) cm^{-1} were assigned to υ(M–N)for compounds (1), (2), (3), (4), and (5), respectively , indicating that the nitrogen of (NA) is involved in coordination with metal ions. [13-15]

(U.V-Vis) Spectrum for the Schiff base ligand:
Magnetic susceptibility was determined at room temperature using solid sample by Gouy method. Diamagnetic correction of metal- ligand system was calculated using the Pascal's constant. .The magnetic moments of the complexes shown in (Table-3)were calculated from the measured magnetic susceptibilities after employing diamagnetic corrections **.**

The electronic spectrum of the ligand has been measured in DMSO solution between 200- 1100 nm at room temperature .In the spectrum of the Schiff base ligand (HL),the absorption band observed at 232 nm (43103 cm^{-1}),and 336 nm(29761cm^{-1}) which are assigned to benzene (π-π*), and (n-π*) transition, respectively. [10-11,17].

The UV-Visible Spectroscopy and Magnetic measurements:
The absorption data for complexes are given in Table (3).
[Fe(L)(NA)$_2$Cl]: The (U.V- Vis) spectrum, exhibits three peaks, the first middle peak at (286 nm)(34965 cm^{-1})(ε_{max} =431 molar^{-1}.cm^{-1}) is due to the ligand field and, the second high peak at (345 nm)(28985 cm^{-1})(ε_{max} =1110 molar^{-1}.cm^{-1}) is due to the (C.T), the third weak peak at (815 nm)(12269 cm^{-1})(ε_{max} =9 molar^{-1}.cm^{-1}), which assigned to (^{5}T2g→^{5}Eg), transition , in an octahedral geometry. in an octahedral geometry.Also, the values of the magnetic moments 3.77 B.M. may be taken as additional evidence for a high spin octahedral Iron(II) geometry.[17]

[Co(L)(NA)$_2$Cl]: The (U.V- Vis) spectrum, exhibits four peaks , the first high intense peak at (267 nm)(37453 cm^{-1})(ε_{max} =1321 molar^{-1}.cm^{-1}), is due to the ligand field and (L.F), while the second third and fourth weak peaks at(830 nm)((υ3=12048 cm^{-1})(ε_{max} =5 molar^{-1}.cm^{-1}), ((υ2=976 nm)(10245 cm^{-1})(ε_{max} =6 molar^{-1}.cm^{-1}), and (υ1= 992 nm)(10080 cm^{-1})(ε_{max} =9 molar^{-1}.cm^{-1}), which assigned to (^{5}Eg → ^{5}T$_2$g) (3A$_2$g → 4T$_1$g(P), (^{4}T$_1$g(F) →^{4}T$_1$g), and ($_4$T$_1$g(F) →4T2g(F) transition respectively ,[17]

υ2/ υ1 =1.019, , υ_1/ υ_2 =0. 98, , from Tanabe-Sugano diagram for d^7 octahedral field the value of 10Dq equal to 10. 080 cm^{-1} , The room temperature magnetic moment (μ_{eff} = 4.52 B.M) corresponded to a high spin octahedral symmetry.[17-18,4]

[Ni(L)(NA)$_2$Cl]: The (U.V- Vis) spectrum, exhibits five peaks , the first high intense peak at (269 nm)(37174 cm^{-1})(ε_{max} =1643 molar^{-1}.cm^{-1}), is due to the ligand field the second small peak at (345 nm)(28985 cm^{-1})(ε_{max} =153 molar^{-1}.cm^{-1}) is due to the (C.T), while the third fourth and fifth weak peaks at(412 nm)(24271 cm^{-1})(ε_{max} =20 molar^{-1}.cm^{-1}), (770 nm)(12987 cm^{-1})(ε_{max} =10 molar^{-1}.cm^{-1}), and (956 nm)(10460 cm^{-1})(ε_{max} =8 molar^{-1}.cm^{-1}), which assigned to ^{3}A$_2$g → ^{3}T$_2$g(υ_1)

(d–d), ^{3}A$_2$g → ^{3}T$_1$g(F)(υ_2) (d–d), and ^{3}A$_2$g→^{3}T$_1$g(P)(υ_3) transition respectively in an octahedral geometry. Also, the values of the magnetic moments 3.11 B.M, may be taken as additional evidence for octahedral nickel (II) geometry . [17-18]

[Cu(L)(NA)$_2$Cl]: The (U.V- Vis) spectrum exhibits two peaks , the first high broad peak at (275 nm)(36363 cm^{-1})(ε_{max} =2100 molar^{-1}.cm^{-1}) is due to the (C.T) , while the second weak broad peak at (974 nm)(10266 cm^{-1})(ε_{max} =42 molar^{-1}.cm^{-1}), which assigned to (^{2}E$_g$→^{2}T$_{2g}$), transition in a high spin octahedral geometry. The complex show a magnetic moment in 2.04 B.M .corresponding to one unpaired electron . [6,17-18]
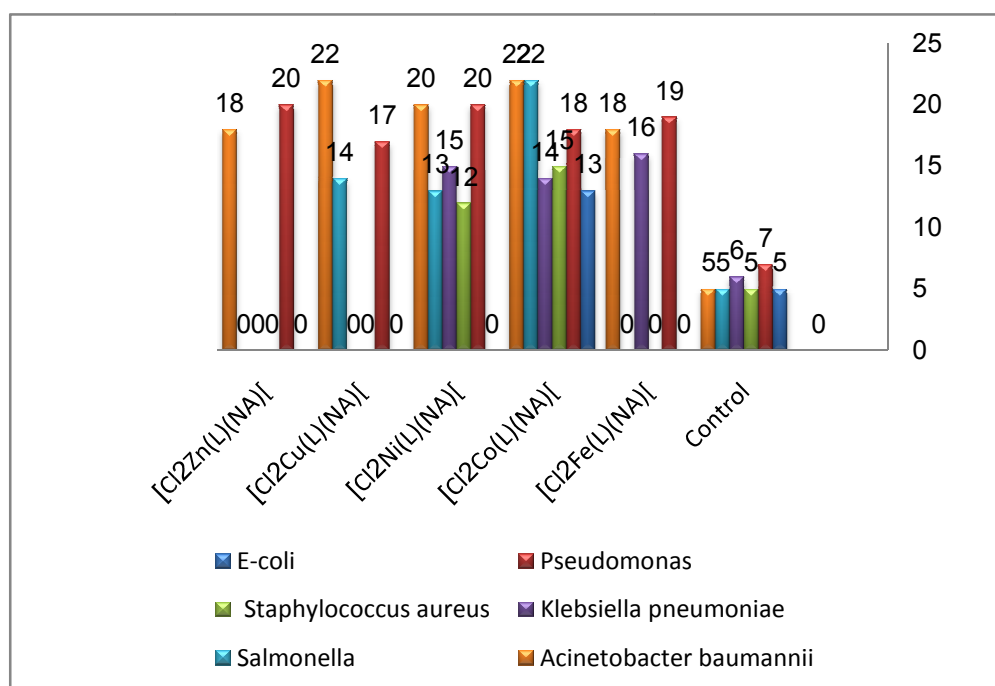

Chart (1) Chart of biological effects of some of the studied complexes

[Zn(L)(NA)$_2$Cl]: The (U.V- Vis) spectrum, two high peaks, the first high peak at (279 nm)(35842 cm^{-1})(ε_{max} =998 molar^{-1}.cm^{-1}) is due to the ligand field and, the second high peak at (342 nm)(29239 cm^{-1})(ε_{max} =1700 molar^{-1}.cm^{-1}

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[1]) is due to the (C.T) in an octahedral geometry. this diamagnetic complex show no appreciable absorptions in the region below 26000 cm^{-1} in DMSO solutions. In accordance with the d10 electronic configuration of Zn(II) . [6,18,20]

Also, the values of the magnetic moment Table (3).may be taken as additional evidence3'32 for their octahedral structure. Molecular weight determined by Rast Camphor method and were found in accordance with calculated value the range of metal complexes (852-858) [6].

Antimicrobial activity:
The in vitro antimicrobial screening results are given in Table 4,Chart (1).On the basis of observed zones of inhibition, all the metal-mixed ligand complexes are active against all six tested organisms which in fact is in agreement with the literature [18-23]. The antibacterial results evidently show that the activity of the Schiff base became more upon coordination to the metal atoms.

Table (1): The physical properties of the compounds

Compounds	M. wt Calc.	M. wt Rast method.	Colour	Yield %	M .p°c (de) °c	Λ_m Ω^{-1} cm^2 mol^{-1}	Metal% theory (exp)	Cl%
[Fe(L)(NA)$_2$Cl] C$_{37}$H$_{39}$ClFeN$_8$O$_7$S	831.11	852.81	Grey Green	77	172 Dec.	9.4	6.72 7.10	4.27 (4.32)
[Co(L)(NA)$_2$Cl] C$_{37}$H$_{39}$ClCoN$_8$O$_7$S	834.20	817.7	Brown	72	300 Dec.	10.2	7.06 7.96	4.25 (4.22)
[Ni(L)(NA)$_2$Cl] C$_{37}$H$_{39}$ClN$_8$NiO$_7$S	833.96	830.6	Yellow	80	300 Dec.	13.1	7.04 6.06	4.25 (4.19)
[Cu(L)(NA)$_2$Cl] C$_{37}$H$_{39}$ClCuN$_8$O$_7$S	838.81	858.0	Green	81	260-266	10.1	7.58 7.06	4.23 (4.26)
[Zn(L)(NA)$_2$Cl] C$_{37}$H$_{39}$ClN$_8$O$_7$SZn	840.68	853. 8	Brown	74	234-140	12.3	7.78 8.06	4.22 (4.29)

M. wt = Molecular Weight, Λm = Molar Conductivity, dec. = decomposition Calc.= calculation

Table (2) FTIR spectral data of the Ligands and there complexes

Compound	Υ (O-H)	Υ (N-H) primary amine	Υ (N-H) Secondary amide	Υ (C=O) β-lactam	υ (HC=N-)	υ$_{as}$ (COO)	υ$_s$ (COO)	Υ (C=C arom.)	Υ (C-C aliph.)	Υ (C-N)	Υ (C-O)	Υ (C-S)	Υ (C-H) arom.	Υ (C-H) aliph.	Υ (M-N)	Υ (M-O)
HL	3298*	-------	3298*	1658*	1658	1597	1377	1546	1168	1315	1230	555	2962	2823	-----	-----
Nicotine amide	------	3367 3259	--------	-------	------	-----	------	1593	1124	1201	-----	------	3061	2787	-----	-----
[Fe(L)(NA)$_2$Cl]	3464	3410	3232	1684*	1624*	1599	1363	1543	1166	1246	1230	553	3060	2970	540	497
[Co(L)(NA)$_2$Cl]	3402	3317	3261, 3197	1684*	1624	1600	1366	1577	1199	1292	1230	552	3078	2754	520	486
[Ni(L)(NA)$_2$Cl]	3406	3321	3267, 3213	1684*	1624	1604	1366	1581	1149	1246	1199	553	3078	2754	578	470
[Cu(L)(NA)$_2$Cl]	3475	3402	3305, 3159	1670	1630	1604	1367	1550	1184	1300	1203	553	3062	2769	547	489
[Zn(L)(NA)$_2$Cl]	3541	3471	3259	1689	1630	1620*	1363	1512	1130	1230	1180	552	2978	2885	505	474

*overlap

Table 3- Electronic Spectral data, magnetic moment, of the studied compounds

Compound	λ nm	ABS	ύ cm^{-1}	ε$_{max}$ (molar^{-1}.cm^{-1})	Assignments	μ$_{eff}$ (BM)
Amox.	277	0.732	36101	732	π→ π*	-
	330	0.057	30303	57	n→ π*	
NA	220	1.548	45454	1548	π→ π*	-
	261	1.104	38314	1104	π→ π*	
4DMAB	208	0.338	48007	338	π→ π*	-
	342	0.493	29239	493	n→ π*	
	336	1.961	29761	1961	n→ π*	
H L	232	1.035	43103	1035	π→ π*	-
	336	1.952	29761	1952	n→ π*	
[Fe(L)(NA)$_2$Cl]	286	0.431	34965	431	L-F	3.77
	345	1.110	28985	1110	C-T	
	815	0.009	12269	9	^{5}T$_{2g}$→^{5}E$_g$	
[Co(L)(NA)$_2$Cl]	267	1.321	37453	1321	L.f	4.52
	830	0.005	12048	5	^{3}A$_{2g}$ → ^{4}T$_1$g(P)	
	976	0.006	10245	6	^{3}A$_{2g}$ → ^{4}T$_1$g(F)	
	992	0.009	10080	9	^{3}A$_{2g}$ (F) →^{3}T$_1$g(F)	
[Ni(L)(NA)$_2$Cl]	269	1.643	37174	1643	L-F	3.11
	345	0.153	28985	153	C-T	
	412	0.020	24271	20	^{3}A2g (F) → ^{3}T1g (P) (v3)	
	770	0.010	12987	10	^{3}A2g(F) → ^{3}T1g(F) (v2)	
	956	0.008	10460	8	^{3}A2g(F) → ^{3}T2g(F) (v1)	
[Cu(L)(NA)$_2$Cl]	275	2.100	36363	2100	L.F	2.04
	974	0.042	10266	42	^{2}E$_g$→^{2}T$_{2g}$	
[Zn(L)(NA)$_2$Cl]	279	1.288	35842	1288	C-T	0.0
	342	1.700	29239	1700	C-T	

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Table(4):Biological activity of the Schiff bases mixed ligands complexes Zone of inhibition (mm)

Compound	E coli	P aeruginosa	Staphylococcus aureus	Klebsiella pneumoniae	Salmonella Typhi	Acinetobacter baumannii
Control	5	7	5	6	5	5
[Fe(L)(NA)$_2$Cl]	0	19	0	16	0	18
[Co(L)(NA)$_2$Cl]	13	18	15	14	22	22
[Ni(L)(NA)$_2$Cl]	0	20	12	15	13	20
[Cu(L)(NA)$_2$Cl]	0	17	0	0	14	22
[Zn(L)(NA)$_2$Cl]	0	20	0	0	0	18

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