Preparation , Characterization and Antimicrobial activities of {Fe(II),Co(II),Ni(II),Cu(II),and Zn(II)}Mixed Ligand Complexes Schiff base derived from Cephalexin drug and 4(dimethylamino)benzaldehyde with Nicotinamide

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Abstract

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 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) and NA=nicotinamide .

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 tridentates and the deprotonated enolic form is
preferred for coordination. In order to evaluate the effect ofthe bactericidal activity, these synthesized complexes, in comparison to the uncomplexed Schiff base has been screened against bacterial species., Staphylococcus aureus,Escherichia coil and the results are reported.
Key words:(Cephalexin drug, Nicotinamide ,mixed ligand) Complexes, Antibacterial activities, and spectral studies

1-Introduction

Transition metal complexes containing heterocyclic compounds have been of considerable interest in terms of structural chemistry, catalysis and biological functions. The field has undergone spectacular growth due to the synthesis of multidentate ligands from heterocyclic compounds and the complexes of such ligands form with metal ions [1]. There are a number of multidentate ligands that play important roles in coordination chemistry and catalyst designing. A large number of multidentate ligands have been synthesized and investigated for their metal binding character. Several such ligands possessing C=N (azomethine) group are known as Schiff bases [2].The IR and ¹HNMR spectra of the complexes suggest that cephalexin behaves as a monoanionic tridentate ligand. In vitro antibacterial activities of cephalexin and the complexes were tested .Icbudak and co-workers [3], are reported the mixed-ligand p-hydroxybenzoate complexes of Ni(II),Cu(II) and Zn(II)with nicotinamide and N, N diethylnicotinamide were synthesized and characterized by elemental analysis, magnetic susceptibility measurements and mass spectrometry. When a metal ion combines with a ligand (Drug), the resulting substance is said to be a complex.If the ligand (Drug) which combine with the metal forms one or more rings with the metal, the resulting structure is said to be a metal chelate and the process is known as chelation[4].Beta lactam antibiotics form a bulky family of zwitterionic drugs that are potent inhibitors of bacterial wall biosynthesis,which account for approximately 60% of commercial antibiotics formulations. [5].Cephalexin (structure given in Scheme (1) is one of the most used first generation cephalosporin based antibiotics to treat infections due to its broad antibacterial activity. Its crystalline structure was published by Kennedy et al. [6].In 2006 Jian-ning and co-workers [7],synthesized 4-(Benzeneazo)salicylaldehyde which was synthesized with aniline, sodium nitrite and salicylaldehyde. Two tetradentate ligands, N,N-bis[4-(benzeneazo) salicylaldehyde]-o-phenylenediamine (H_2L) and N,N-bis[4-(benzeneazo) salicylaldehyde]ethylenediamine (H_2L) were formed by the 2:1 molar condensation of 4-(benzeneazo) salicylaldehyde with o-phenylenediamine or ethylenediamine. Their Cu(II), Ni(II), Zn(II),Co(II), Mn(II) and Cd(II) complexes were synthesized and characterized by elemental analysis, molar conductivity measurements, and infrared and electronic spectral data.In 2007 Dursun and co-worker [8],Synthesized Nicotinamide-acetylsalicylato complexes of Co(II), Ni(II), Cu(II), and Zn(II) were

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synthesised and their structural properties were investigated by employing elemental analysis, magnetic susceptibilitiy, solid state UV-vis, direct injection probe mass, FTIR and thermoanalytic TG-DTG methods. It was found that ratio of metal:ligand:ligand is 1:2:2 and the decomposition of each complex starts with dehydration and follows by decomposition of the nicotinamide and acetylsalicylato, respectively.In 2009 El-Said and co-workers [9], 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 2010 Suresh and co-worker [10], synthesized A novel .aminoantipyrene) and vanillin and forms stable complexes with transition metal ions such as Cr (III), Mn (II), Co (II), Ni (II), Cu (II), Zn (II) and Cd (II). Their structures were investigated by elemental analysis, infrared spectroscopy, electronic spectroscopy, NMR spectroscopy; thermo gravimetric analysis and electron spin resonance spectroscopy. On the basis of the studies the coordination sites were proven to be through oxygen of the ring C = O and Nitrogen of the azomethine (-CH = N-)group. The microbiological studies revealed the anti bacterial nature of the complexes. In (2011)   Sunil Joshi, and co-workers [11], synthesized the present study, Schiff bases have been synthesized by the condensation of cephalexin with p-chlorobenzldehyde and cinnamaldehyde respectively in methanol. Further metal salts of Mn (II), Co (II), Ni (II) and Zn (II) have synthesized their metal complexes.

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 Cephalexin drug and 4(dimethylamino)benzaldehyde with Nicotinamide in 1:1:2(M:L:2NA) ratio.

2. Experimental
2.1- Chemical

 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). Cephalexin mono hydrate powder) and 4(dimethylamino)benzaldehyde from Riedial-Dehaen DSM (Spain).


 2.2- 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 Metrohn 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 25°C 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 1H NMR for ligand was recorded in DMSO-d6 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 were drawing by using chem. office prog, 3DX (2006).

 2.3- preparation of ligand (HL): [11]

A solution of (Ceph) (0.365 gm, mmole) in methanol (20 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 (76-80º). yield 78% . Anal. Calcd for ligand(HL) C = 62.74%, H = 5.48%, N = 11.71 %. = Found:
C = 61.71%, H = 6.11%, N = 11.90%.
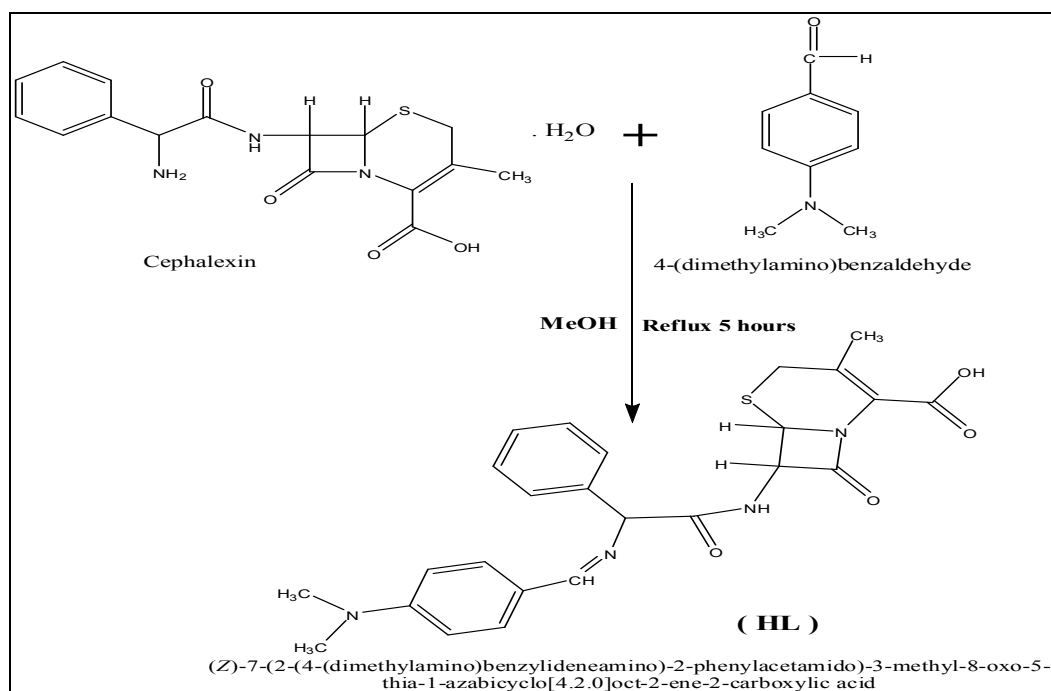
Scheme (1) : Schematic representation of synthesis of the ligand(HL)

2.4 -Synthesis of [Cu(L)(NA)₂Cl] complex : [11]

A solution of (HL) (0.478 gm, mmole) in methanol (10 ml) and a solution of (NA) (0.244 gm, m mole) in methanol (10ml), were added to a stirred solution of Cu (II) chloride dihydrate (0.09 gm, m mole) 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 (272-276) º 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 micro-organism. 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 1.5×10^8 cell/mm. It is used for Petri dish preparation for the examination of biological activity against the under studied chemical compound.

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. [12]

3. Results and Discussion

Physical Properties

Ligand (L) is soluble in(N,N-dimetylformamide (DMF), dimetylsulphoxide (DMSO), methanol (MeOH), ethanol (EtOH), acetone (C₃H₆O), 2-propanol (C₃H₈O) and completely insoluble in water (H₂O), carbon tetra chloride (CCl₄), benzene(C₆H₆), Petroleum ether and chloroform (CHCl₃).

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 I 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) solvent. 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 (5.3-5.8 Ω^{-1} cm^2 mol^{-1}) indicating that they are all non-electrolytic in nature . [13]

FT-IR spectrum of the ligand (L):

The (FT-IR) spectrum for the starting material cephalexin exhibits band at (3275) cm^{-1} due to υ(N–H) primary amine stretching vibration[14].The bands at (3219, 3049) cm^{-1} are due to the υ(N–H) secondary amine stretching vibration .The carboxylic acid group of cephalexin free ligand shows strong absorptions at 1759 cm^{-1}) for υ (C=O) and 3406 cm^{-1} for υ (O- H) stretchings and 1595, 1398 cm-1) due to the $_{asym.}$, sym. stretchings of (COO) group respectively [6]. Where $\Delta \upsilon =[\upsilon_{asym}$ (COO) , υ sym (COO)] is 197 cm^{-1} .These values are quite agreeable with the values reported earlier [14]. The band at (1689) cm^{-1} stretching vibration is due to υ (C=O) for β-Lactum group [14].The carbonyl stretching frequencies for amide, acid and β-lactum groups in cephalexin free ligand have been assigned at 1595 cm-I [109], 1759 cm-1 and 1760 cm-1 [5], respectively .The bands at (1595),and (1398) cm^{-1} were assigned to stretching vibration υ (COO$^-$) asymmetric and symmetric stretching vibration, respectively, $\Delta \upsilon$ (COO$^-$)$_{asym}$- υ (COO$^-$)$_{sym}$ =197 [14].. The bands at (1577), (3010), (1163), and (2388) were assigned to υ(C=C) aromatic, υ(C–H) aromatic, υ(C–C) aliphatic, and υ(C–C) aliphatic stretching vibration respectively. The band at (1280) cm^{-1} is due to υ(C–N) stretching vibration. The band at (1247) cm^{-1} was assigned to υ(C–O) stretching vibration. The band at (580) cm^{-1} was assigned to υ(C–S) ring stretching vibration. [14 - 15].the spectrum for the starting material 4(dimethylamino)benzaldehyde (DMBA) 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[16-17].The very strong bands due to carbonyl group υ(C=O) stretchings of (DMBA) were observed in the (1662 -1600) cm^{-1} regions [15], 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 [18]. The (FT-IR) spectrum for the ligand (L), the band at (3228) 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 (1678) cm^{-1} is due υ (HC=N-) group of the azomethine stretching vibrations of the ligand[15] .The band at (1678) cm^{-1} is due to υ(C=O) cm^{-1} stretching vibration for (COOH) overlapping with azomethine group υ(-HC=N-) .The band at (1678) cm^{-1} stretching vibration is due to υ (C=O) for β-Lactum group overlapping with υ(-HC=N-) and υ(C=O) stretching vibrations. The bands at (1597) and (1373) cm^{-1} were assigned to stretching vibration (COOH) asymmetric and symmetric stretching vibration, respectively. The bands at (1531), (3062), (1168)and (2924) 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 [14-16].The band at (584) cm^{-1} was assigned to υ(C–S) stretching vibration [13 -15-19-].The assignment of the characteristic bands for the starting materials, intermediate compounds and the ligand are summarized in Table (2).

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 characteristic bands in Schiff base are used to determine the binding modes found in the system are υ (HC=N-) group of the azomethine, υ (N-H), υ (M-O), υ (M-N).The assignments of the characteristic bands are summarized in Table (2).on complexation these band has been shifted to lower frequencies (1597), (1624), (1624), (1660), and (1593) cm^{-1}for complexes (1), (2), (3), (4), and (5), (6) This band gets shifted to lower frequency in the complexes, indicating the coordination through azomethine nitrogen to metal atom. [14-15],. The bands at (1597), and (1373) cm^{-1} were assigned to stretching vibration (COOH) asymmetric and symmetric stretching vibration, respectively. on complexation these bands have been shifted to lower and higher frequencies [(1681), (1600), (1624), (1678), and (1539) cm^{-1} for υ(-COO)asy], and [(1377), (1396), (1396), (1375), and (1377) 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.

and the band at (1678w) cm^{-1} stretching vibration is due to υ (C=O) for β-Lactum group, but these band has been shifted to higher frequency at 1681 for complex showing that the coordination is through the Oxygen atom of β-Lactum group. The bands at (439), (482), (459) , (478), and (489) 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-Lactum group of the ligand are involved in coordination with metal ions.

The bands at (540), (582), (528), (505) and (551) cm^{-1} were assigned to υ(M–N) for compounds (1), (2), (3), (4), and (5), respectively , indicating that the amine nitrogen is involved in coordination with metal ions.

(U.V-Vis) Spectrum for the Schiff base ligand:

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(L)) , the absorption band observed at 212 nm (47169 cm^{-1}), 242 nm(41322 cm^{-1}) (267 nm) (59880 cm^{-1}) which   are assigned to benzene (π-π*) transition, and the band at (336 nm) (29761cm^{-1}) is assigned due to(n-π*) transition associated with the azomethine chromosphere (-C=N) [14-15,20].

(U.V-Vis) Spectral data for the Shiff base mixed ligands complexes:

The absorption data for complexes are given in Table (3).

[Fe(L)(NA)$_2$Cl]: The (U.V- Vis) spectrum, exhibits four peaks, the first middle peak at 269 nm (37174 cm^{-1}), is due to the ligand field, while the second high peak at342 nm (29239 cm^{-1}) (is due to the (C.T), the third and fourth weak peaks at 803 nm (12453 cm^{-1}), and 977 nm (10235 cm^{-1}), which assigned to ($^5E \rightarrow {}^5T_2$) (d–d), and ($^5E \rightarrow {}^5T_2$) (d–d) transition respectively in an octahedral geometry.

[Co(L)(NA)$_2$Cl]: The (U.V- Vis) spectrum, exhibits three peaks ,the first high peak shoulder with at 269 nm (37174 cm^{-1}) is due to the ligand field and (C.T), while the second and third weak peaks at (897 nm)(11148 cm^{-1}), and (992 nm)(10080 cm^{-1}) which assigned to ($^5E \rightarrow {}^5T_2$) (d–d), and ($^5E \rightarrow {}^5T_2$) (d–d) transition respectively in an octahedral geometry.

[Ni(L)(NA)$_2$Cl]: The (U.V- Vis) spectrum, exhibits two peaks, the first high intense peak at (268 nm)(37313 cm^{-1}) is due to the ligand field and (C.T) , while the second weak peaks at (992 nm)(10080 cm^{-1}), which assigned to ($^5E \rightarrow {}^5T_2$) (d–d), transition in an octahedral geometry .

[Cu(L)(NA)$_2$Cl]: The (U.V- Vis) spectrum, exhibits two peaks , the first high broad peak at (272 nm)(36764 cm^{-1} is due to the ligand field and (C.T) , while the second weak broad peak at (924 nm)(10822 cm^{-1}), which assigned to ($^5E \rightarrow {}^5T_2$) (d–d), transition in an octahedral geometry.

[Zn(L)(NA)$_2$Cl]: The (U.V- Vis) spectrum, exhibits two high peaks, the first middle peak at 271 nm (36900 cm^{-1}) is due to the ligand field and, the second high peak at (339 nm)(29498 cm^{-1}) is due to the (C.T) in an octahedral geometry.

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 (1060-1092), [11].

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 [24]. The antibacterial results evidently show that the activity of the Schiff base became more upon coordination to the metal atoms.

Chart (1) Chart of biological effects of some of the studied complexes
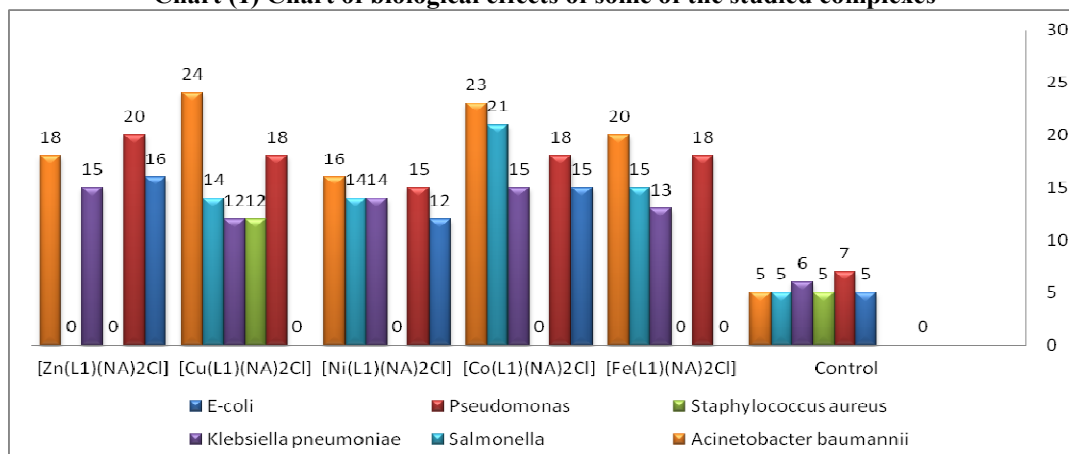
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Table(1): The physical properties of the compounds

Compounds	M. wt Calc.	M. wt Rats method.	Color	Yield %	M .p° c (de) °c	Λ_m s.cm^2.mol^{-1}	Metal% theory (exp)	Cl%
L C$_{25}$H$_{26}$N$_4$O$_4$S	478.17	498.17	orange	78	76-80	-	-	-
[Fe(L)(NA)$_2$ Cl] C$_{37}$H$_{37}$ClFeN$_8$O$_6$S	813.10	823.0	Grey green	87	172 Dec.	5.3	6.87	4.36 (4.50)
[Co(L) (NA)$_2$Cl] C$_{37}$H3$_7$Cl Co N$_8$O$_6$S	815.16	843.5	Violet	77	280 Dec.	5.3	7.22	4.34 (4.50)
[Ni(L)(NA)$_2$Cl] C$_{37}$H$_{37}$Cl Ni N$_8$O$_6$S	815.95	833.10	Yellow	82	280 Dec.	5.8	7.19	4.34 (4.50)
[Cu(L)(NA)$_2$ Cl] C$_{37}$H$_{37}$Cl Cu N$_8$O$_6$S	820.80	829.50	Green	84	272-276	5.4	7.74	4.32 (4.33)
[Zn(L)(NA)$_2$Cl] C$_{37}$H$_{37}$Cl Zn N$_8$O$_6$S	822.67	843.80	Brown	87	102-116	8.6	7.95	4.31 (4.50)

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

Table(2):Data from the Infrared Spectra for the Free Lingands and there Metal Complexes (cm^{-1}).

Compound	(N-H) primary amine	υ(N-H) Secondary amide	υ(C=O) for COOH	υ(C=O) β-lactam	υ(C=O) amide	υ(C=N)	υ$_{as}$ COO	υ$_s$ COO	υ(C=N)	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)
L	-------	3228 overlap	1678 overlap	1678 overlap	1678 overlap	------	1597	1373	1531	1168	1315	1230	594	3062	2924	-----	-----	
Nicotine amide	3367, 3159	--------	--------	-------	1679vs	------	-----	------	1593	1124	1201	-----	------	3061	2787	------	-----	
[Fe(L)(NA)$_2$Cl]	3441	3441 overlap	1681 overlap	1681 overlap	-------	1597	1597 overlap	1377	1539	1168	1288	1248	597	3070	2970	540	439	
Co(L)(NA)$_2$ Cl]	3402	3306 , 3267	1666 overlap	1666 overlap	------	1624	1600	1396	1581	1199	1296	1238		3078	2940	582	482	
Ni(L)(NA)$_2$ Cl]	3406	3321 , 3267	1666 overlap	1666 overlap	------	1624	1624 overlap	1396	1581	1195	1292	1234		3078	2950	528	459	
Cu(L)(NA)$_2$ Cl]	3406	3236	1678 overlap	1678 overlap	------	1660 overlap	1678 overlap	1435	1531	1134	1284	1249		2966	2924	505	478	
Zn(L)(NA)$_2$ Cl]	3410	3363 , 3232	1678 overlap	1678 overlap	-----	1593	1593 overlap	1377	1535	1166	1288	1230		3066	2850	551	489	

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

Compound	λ nm	ABS	$\acute{v}$ cm^{-1}	ε_{max} molar^{-1}.cm^{-1}	Assignments	μ_{eff} (BM)
Ceph	279	0.770	35842	770	$\pi \rightarrow \pi^*$	-
NA	220	1.548	45454	1548	$\pi \rightarrow \pi^*$	-
	261	1.104	38314	1104	$\pi \rightarrow \pi^*$	
4DMAB	208	0.338	48007	338	$\pi \rightarrow \pi^*$	-
	342	0.493	29239	493	$n \rightarrow \pi^*$	
	336	1.961	29761	1961	$n \rightarrow \pi^*$	
L	212	0.953	47169	953	$\pi \rightarrow \pi^*$	-
	242	0.629	41322	629	$\pi \rightarrow \pi^*$	
	267	0.507	59880	507	$\pi \rightarrow \pi^*$	
	336	1.482	29761	1482	$n \rightarrow \pi^*$	
[Fe(L)(NA)$_2$Cl]	269	0.878	71743	878	L-F	4.66
	342	1.556	29239	1556	C-T	
	803	0.012	12453	12	$^5T_{2g} \rightarrow {}^5E_g$	
	977	0.010	10235	10	$^5T_{2g} \rightarrow {}^5E_g$	
[Co(L)(NA)$_2$Cl]	269	1.580	37174	1580	L-F	4.83
	897	0.007	11148	7	C-T	
	992	0.012	10080	12	$^4T_{1g} \rightarrow {}^4A_{2g}$	
[Ni(L)(NA)$_2$Cl]	268	1.562	37313	1562	C-T	2.91
	992	0.011	10080	11	$^3A_{2g} \rightarrow {}^3T_{1g}$	
[Cu(L)(NA)$_2$Cl]	272	1.957	36764	1957	C-T	2.11
	924	0.037	10822	37	$^2E_g \rightarrow {}^2T_{2g}$	
[Zn(L)(NA)$_2$Cl]	271	0.998	36900	998	C-T	Diamag
	339	1.608	29498	1608	C-T	

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

Compound	E-coli	Pseudomonas	Staphylococcus aureus	Klebsiella pneumoniae	Salmonella Typhi	Acinetobacter baumannii
Control	5	7	5	6	5	5
[Fe(L)(NA)$_2$Cl]	0	18	0	13	15	20
[Co(L)(NA)$_2$Cl]	15	18	0	15	21	23
[Ni(L)(NA)$_2$Cl]	12	15	0	14	14	16
[Cu(L)(NA)$_2$Cl]	0	18	12	12	14	24
[Zn(L)(NA)$_2$Cl]	16	20	0	15	0	18

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