American Journal of Interdisciplinary Research and Development
ISSN Online: 2771-8948
Website: www.ajird.journalspark.org
Volume 06, July, 2022

INVESTIGATION OF SOME NON-STEROIDAL COMPLEXES

Amira J. Al_Shaheen
Chemistry Department, Education College, Mosul Uni. Mosul
E-mail: amiraalshheen@uomosul edu.org

Miaad A. Al Mula
Chemistry Department, Education College, Mosul Uni. Mosul
E-mail: miaadadil@gmail.com

Abstract

In this study we describe the synthesis and characterization of four and six coordinated compounds of Co(II), Ni(II), Cu(II), Zn(II) and Cd(II) with diclofenacyl hydrazide and vanillin or acetophenone ligands (L_1andL_2).These complexes were characterized by many physicochemical methods such as elemental analysis (CHN),magnetic susceptibility, molar conductance as well as spectral studies such as IR and UV-Visible , and X-ray powder diffraction measurementsT. The ligands have been investigated by NMR spectra,. Furthermore, the complexes have been found to have the formulaes : $[M(L)_2Cl_2]$ where, M= Co(II) , Ni(II) , Cu(II) and Zn(II), whereas, the formula $[M(L)_2(H_2O)_2]X_2$, M= Co(II) , Ni(II) , Cu(II) and Zn(II), X= NO_3^- , Cl^- . $[M(L)_2]X_2$, where, M= Ni(II) , Cu(II) and Cd(II), X= NO_3^- , Cl^- . L = L_1 or L_2 . Infrared spectral data suggest that the two ligands behave as a bidentate ligand with O,N, donor atoms towards the metal ions. On the basis of the above physicochemical measurements, the complexes have an octahedral and tetrahedral or square planar geometries.

Keywords: X-ray powder diffraction, Metal complexes, diclofenacyl Complexes.

1. Introduction

The first time in 1979, Alfred and Rudolf had prepared diclofenac which is a member of non –steroidal anti-inflammatory drug (NSAIDs) known to relief a widely used non steroidal anti-inflammatory drug in treating pain and inflammatory drug [1,2]. Diclofenac is 2-(2,6-dichloranilino) phenyl acetic acid, In recent years it has become evident that dicloinhibicyclooxygenase 1 and 2 which are the enzyme responsible forproducing prostaglandins contribute to inflammation from a varity of causes[3] .This led to the introduction of new compounds with an improved profile our aim to develop new safer drugs and improving the pharmacokinetic and pharmacotoxicological profile through complexation [4]. It has been reported that complexes of metallic salts are more potent and less toxic in many cases as compared to the parent drugs. known to relief symptoms of arthritis, primary dysmenorrhea, fever and also possess mild antiplatelet effect[5] is useful in sepsis-induced acute pneumonia, Hydrazones, a member of the Schiff base family with triatomic >C=N-N< Linkage takes the fore front position in the development of coordination chemistry. Reports on the synthesis, characterization and structural studies on hydrazone ligands derived from (vanillin, acetophenone) show the importance of hydrazone complexes in various fields including analytical and biological field [6].Hydrazone derivatives possessing anti-inflammatory, analgesic, antipyretic and antibacterial activities are also reported in the literature[7]. These complexes which plays an important role in reducing the toxicity of the parent drug and acts as apro-drug [8&9].

2-Experimental

1. Materials and Measurements

All chemicals and solvent used for the syntheses were of analytical grade, the metal salts were commercially available pure samples and all chemicals used throughout this investigation from Merch ,B.D.H., Aldrich or Fluka and used without further purification.

2. Analytical and physical measurements

Melting point and decomposition temperature were determined using STUART-SMPIO melting point apparatus . .IR spectra measurements were recorded using FTIR-Tensor 27-Burker Co.Germany 2003, as kBr pellets in the range in the range (400-4000 cm^{-1}). UV-Visible spectral measurements were recorded using Shimaduz 160 spectrophotomer for 10^{-3} M complexes in DMF solvent at room temp.using 1cm quarts cell in range (200-900)nm . Elemental analysis were carried out on a CHN analyzer type Vector, model EA 3000 single V.3.0 single Euro . The NMR was recorded on Agilant Varian (USA), 500 MHz using deutrated DMSO-d^6 as a solvent. Molar conductance of complexes were measured at room temp for 10^{-3} M in DMF using (BC 3020 professional Bench top conductivity)

Magnetic susceptibility of the complexes was carried out by (Magnetic Susceptibility Balance of Johnson Mattey catalytic system division , (England) .Via Faradys method at room temperature. Metal contents were estimated spectrophotometrically using atomic absorption spectrometer NOVAA 350 Scientific Equipments. X-ray powder diffraction data for compounds were measured by using x-rd xpert PA analytical Phillips Holland and the crystal data for compounds were analyzed by using match program version 1.6 C.

Preparation of the Ligands and the Complexes

1.Synthesis of 2-[(2,6-dichloro-anilino)phenyl acetic acid

This carboxylic acid was prepared by dissolving (15.9 g,0.05 mole) of sodium diclofenac in 45ml of absolute ethanol and then to that drops of conc. hydrochloric acid was added until white precipitated was formed, filtered and washed with cold distilled water and cold absolute ethanol and dried in vacuum many hrs. as in Scheme 1. The yield (85%), b.p 153-155 ^{o}c , empirical formula $C_{14}H_{11}NO_2Cl_2$, White ppt.

	%C	%H	%N
Calc.	56.75	3.71	4.72
Found	57.00	3.62	4.81

2. Synthesis of 2-[(2,6-dichloro-anilino) phenyl acetic acid ethyl ester

The carboxylic acid which was prepared in previous step was esterified by dissolving(11.84 g, 0.04 mole) of it in 35ml of absol.ethanol in presence of 2.0ml of sulfuric acid. The mixture was refluxed for 8hrs . After completion of reaction solvent was removed by add 100m of cold water , followed by extracted with sodium bicarbonate and separated in the organic layer , (Scheme 1). The yield (72%) , b.p 75-77 °c ,empirical formula $C_{16}H_{15}NO_2Cl_2$,orange ppt.

	%C	%H	%N
Calc.	59.52	4.62	4.32
Found	59.49	4.70	-4.52

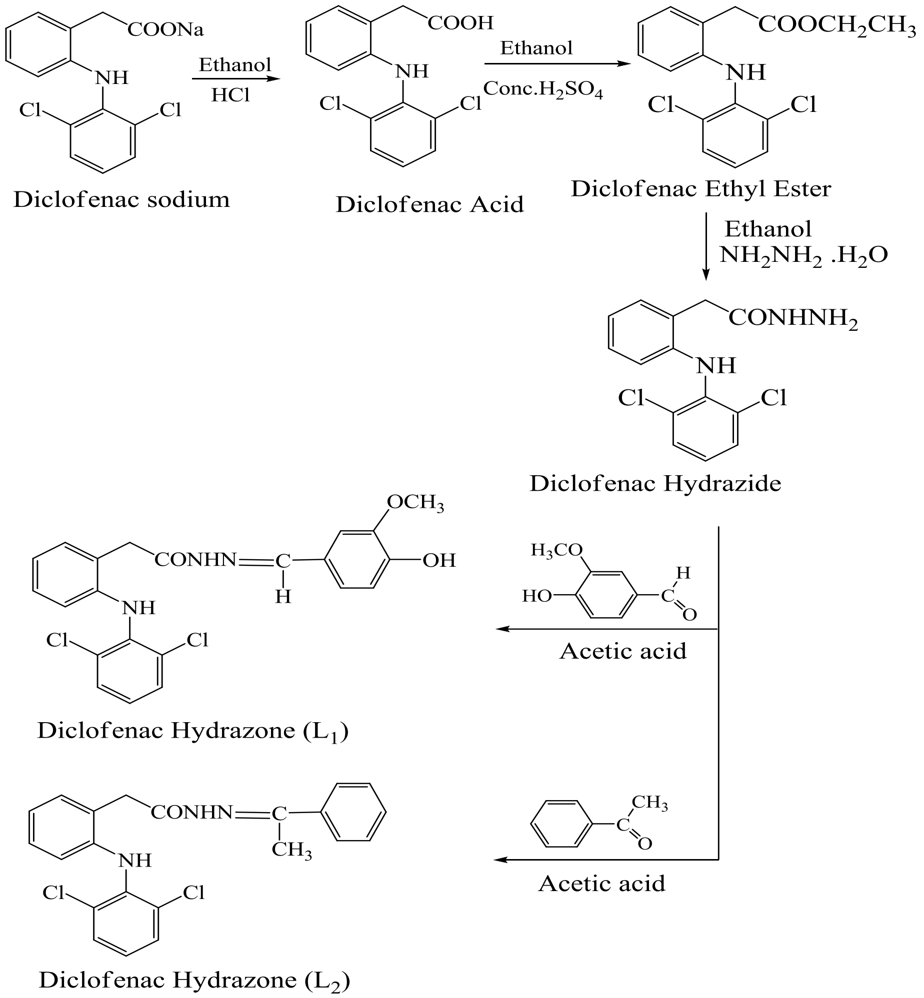
3. Synthesis of 2-[(2,6-dichloro-anilino)phenyl acetic acid hydrazide

The hydrazide was prepared [4] by refluxing (9.72g , 0.03mol) of 2-[(2,6-dichloro-anilino)phenyl acetic acid ethyl ester in 30ml absol.ethanol with an excess of hydrazine hydrate NH_2. $NH_2.H_2O$(85%) for 24h , the reaction mixture was then left to stand overnight .The compound precipitated on standing over night, filtered and washed with cold distilled water . The pure solid white hydrazide was obtained by recrystallization from ethanol and dried in an oven at (70-80) C , (Scheme 1). The yield (80%), mp 136-134C, empirical formula $C_{14}H_{13}N_3OCl_2$., white ppt.

	%C	%H	%N
Calc.	54.19	4.19	13.54
Found	54.23	4.30	13.55

4.Synthesis of hydrazone ligands (L_1 & L_2)

The ligands synthesized according to the method described in the literature [10] by reacting equimolar amount of diclofenacyl hydrazide and vanillin or acetophenone .A hot ethanolic solution of the ligand made by dissolving (3.1g, 0.01 mole) of diclofenacyl hydazide in 15 ml of ethanol has been slowly mixed with a hot ethanolic solution containing (1.52g , 0.01 mole) of vanillin or acetophenone (1.20g, 0.01 mole). The resulting mixture has been refluxed for about 6 hrs. The mixture has been left to stand for nearly two hours. The precipitated compound was filtered ,recrystallized from ethanol, washed with ether and dried under vacuum. The structures of the ligands are shown in Scheme 1.



Scheme **1:** The structures of the ligands

Table 1 : physical properties and analytical data of the ligands

ligands	Empirical formula = M.wt	Colour	m.p (C)	Yield	Elemental analysis calcu. (found)		
					% C	% H	% N
L_1	$C_{22}H_{19}N_3O_3Cl_2$ 444	white	103-104	%71	59.45 (59.73)	4.27 (4.40)	9.45 (9.55)
L_2	$C_{22}H_{19}N_3OCl_2$ 412	white	108-110	%79	64.07 (64.24)	4.61 (4.73)	10.19 (10.03)

4.Synthesis of the complexes

The complexes were obtained by adding an ethanolic solution of metal(II) chloride or nitrate (0.005mol) with the ligand L_1(4.44 gm , 0.01mol) or L_2 (4.12gm , 0.01mol) in the mole ratio 2:1 (L:M) after Mixing, an ethanolic solution has been refluxed for 5hrs

. The volume of the solution was reduced to its half and the precipitated complexes washed with ethanol , followed by diethyl ether and dried in an oven at (70-80)C° [11].

Table 2 : Weight of metal salts used to prepare complexes .

Metal salt	Wt(g) metal salt	metal salt	Wt(g) metal salt
$CoCl_2.6H_2O$	1.19	$CuCl_2.2H_2O$	0.85
$Co(NO_3)_2$. $6H_2O$	1.45	$ZnCl_2$	0.68
$NiCl_2$. $6H_2O$	1.18	$CdCl_2$	0.91
$Ni(NO_3)_2.6H_2O$	1.45		

Table 3 : Characterization , analytical , molar conductance and magnetic susceptibility data of the complexes .

NO.	Formula	Molecular Weight	Colour	Yield	m.p (C)°	Meff B.M	Λ_M DMF Cm^2.Ohm$^-$ ^{1}.mol$^-$	Calculate(Found)%			
								%C	%H	%N	%M
1	$[Co(L_1)_2Cl_2]$	1018	Brown	69	>300	4.76	15	51.86 (52.03)	3.73 (3.60)	8.25 (8.48)	5.79 (6.01)
2	$[Co(L_1)_2(H_2O)_2](NO_3)_2$	1109	Brown	69	>300	4.67	107	47.61 (47.92)	3.78 (4.00)	10.09 (10.13)	5.32 (6.01)
3	$[Ni(L_1)_2]Cl_2$	1017.7	Orange	76	297	Dia	129	51.88 (52.00)	3.73 (3.92)	825 (817)	5.76 (5.87)
4	$[Ni(L_1)_2 (](NO_3)_2$	1070.7	Orange	74	>300	Dia	111	4931 (49.50)	3.54 (3.62)	7.84 (7.96)	5.48 (5.52)
5	$[Cu(L_1)_2]$ Cl_2	1022	Green	64	>300	1.82	119	51.66 (51.88)	3.71 (3.96)	8. 21 (8.03)	6.16 (6.00)
6	$[Zn(L_1)_2Cl_2]$	1024	Yellow	78	>300	Dia	22	51.56 (51.93	3.71 (3.99)	8.20 (8.02)	6.34 (6.55)
7	$[Cd(L_1)\ ]Cl_2$	1071	Yellow	72	>300	Dia	126	49.29 (49.18)	3.54 (3.61)	7.84 (7.96)	10.45 (10.66)
8	$[Co(L_2)_2Cl_2]$	954	Brown	68	>300	4.79	18	55.344 (55.00)	3.98 (4.03)	8.80 (9.19)	6.18 (6.27)
9	$[Co(L_2)_2\ (NO_3)_2\ ]$	1007	Brown	67	>300	4.75	27	52.43 (52.61)	3.77 (4.03)	11.12 (119)9	5.85 (6.00)
10	$[Ni(L_2)_2Cl_2]$	953.7	Green	71	>300	3.31	14	55.36 (55.49.	3.98 (4..01)	8.80 (9.02)	6.15 (6.00)
11	$[Ni(L_2)_2(H_2O)_2](NO_3)_2$	989.7	Green	64	>300	2.92	137	50.63 (50.51)	4.02 (4.15)	8.05 (8.12)	6.58 (7.00)
12	$[Cu(L_2)\ _{2(}H2O)_{2\,]}]\ Cl_2$	994	Green	79	>300	2.01	129	53.11 (53.00)	4.20 (4.41)	8.45 (8.57.)	6..33 6..50)
13	$[Zn(L_2)_2\ (H_2O)\ 2]Cl_2$	996	Yellow	74	>300	Dia	14	53.01 (53.09)	4..21 (4.32)	8.43 (8.56)	6.52 (6.69)
14	$[Cd(L_2)_2]$ Cl_2	1043	Yellow	74	>300	Dia	125	51.06 (49.89)	3.64 (3.70)	8.05 (7..88)	10.73 (10.98)

5.Results and Discussion

Molar conductance values of complexes(1, 6,8,9,10 and 13) in 10^{-3} M DMF are neutral .while complexes (2,3,4,5,7, 11,12and 14) are 1:2 electrolytic nature for nitrate or chloride complexes. The molar conductance values and the metal contents are in a good agreement with given formulations [12],(Table 3).

1-Electronic Spectra and magnetic moment Measurements:

The ultraviolet spectra of the two ligands L_1 and L_2 and their complexes in DMF solution have been recorded giving ultraviolet spectra, d-d spectra and charge transfer spectra (Table 4), and these ligands exhibited two bands at (31746,33557) cm^{-1}, (25062,29069) cm^{-1} assigned to n $\rightarrow \pi^*$ (C=O) and $\pi \rightarrow \pi^*$ (C=N) transitions respectively. All these transitions were also found in the spectra of the complexes but they were shifited to lower frequencies confirming the coordination of the ligands to the metal ions [13] and these values agree with the magnetic moments obtained for hexacoordinated cobalt(II) complexes 1,2,8, and 9 and this value greater than theoretical value (3.87) B.M. due to orbital [14,15]The electronic spectra of these Co(II) complexes exhibited three bands due to ν_1 at (11261-13480) cm^{-1} , ν_2 at (14749-16482) cm^{-1} and ν_3 at(16177-21929) cm^{-1} which are assigned to following transitions:

${}^4T_1g$ (F) $\longrightarrow$ ${}^4T_2g$ (F) ν_1 7500-11000 cm^{-1}
${}^4T_1g$ (F) $\longrightarrow$ ${}^4A_2g$ (F) ν_2 11000-16000 cm^{-}
${}^4T_1g$ (F) $\longrightarrow$ ${}^4T_1g$ (P) ν_3 18000-26000 cm$_{-}$

and these values agree with high spin octahedral configuration. For the hexacoordinated Ni(II) complexes 10,11 exhibit electronic spectrum bands at (12814 , 13333)cm^{-1} , (16286 , 17815) cm^{-1} and (22367 , 26041) cm^{-1} respectively , and assigned to transitions :

${}^3A_2g$ (F) $\longrightarrow$ ${}^3T_2g$ (F) ν_1
${}^3A_2g$ (F) $\longrightarrow$ ${}^3T_1g$ (F) ν_2
${}^3A_2g$ (F) $\longrightarrow$ ${}^3T_1g$ (P) ν_3

The octahedral geometry of Ni(II) ion in the complex is confirmed by the measured magnetic moment values (2.89 , 3.28)B.M.[15,16]. While tetracoordinated Ni(II) complexes 3&4 exhibited two bands due to two

${}^1A_1g$ $\longrightarrow$ ${}^1A_2g$
${}^1A_1g$ $\longrightarrow$ ${}^1B_2g$

transitions ν_1 at (20533,16694) cm^{-1} , ν_2 at (28818,29239) cm^{-1} and charge transfer at(35715 and 36231 cm^{-1} respectively and is confirmed with the measured diamagnetic moment values and is agree with square planar configuration. While the Cu(II) complex 5 exhibits a broad electronic band due to transition ${}^1A_2g$ (F) $\longrightarrow$ ${}^1A_2g$ (F) at (9000-12000) cm^{-1}and is confirmed with the measured magnetic moment value 1.82 B.M. and is agree with square planar configuration. The octahedral Cu(II) complex 12 showed one band at (18456) cm^{-1} and this band may arise from the ${}^2Eg$ $\longrightarrow$ ${}^2E_{1g}$ transition , the magnetic moment obtained for this complexe is confirmed with the measured magnetic moment values (2.01 B.M) [17] (Table 4). is agree with octahedral geometry.

Table 4 : Electronic spectra data of the complexes

Comp.No.	Electronic transition of d-d cm^{-1}			CT
	v_1	v_2	v_3	
1	11261	16482	21929	38167
2	13480	14749	20618	33898
3	20533	28818	-	35715
4	16694	29239	-	36231
5	14513	-	-	29239
8	13333	16306	20491	38464
9	12738	14970	16177	33222
10	13333	16286	22367	31446
11	12814	17825	26041	37313
12	18456	-	-	36101

CT = Charg transfer band

2-Infrared Spectra

The free ligands L_1 and L_2) showed IR spectra bands at 2950 and 2924cm^{-1}which are characteristic of stretching vibration[18]of the NH and other absorption band appeared at (1639 and 1662)cm^{-1} which have been attributed to frequency of C=O amide group. This band in complexes is shifted to lower frequency indicating coordination of carbonyl oxygen atom to the metal ion [19]. Also showed a strong band in the region (1506 and 1548)cm^{-1} , which is characteristic of the azomethine (stretching vibration of (C=N) group and is shifted to lower frequency indicating coordination of azomethine nitrogen atom to the metal[20]. The spectra of L_1 and L_2 showed , a broad band at (1076 , 1060) cm^{-1} due to N-N group shift towards lower frequency on complexation [21] The aqua complexes contain weak to medium abroad band at (3200 – 3600) cm^{-1} due to stretching vibration OH of water . Molecules are coordinated, confirmed by occurrence of additional strong band at (821 – 877) cm^{-1} due to OH rocking vibration [22,23]. The spectra of the complexes showed bands in the region (536 – 628) cm^{-1} and (403 – 500) cm^{-1} are assigned to M-O and M-N stretching bands of the metal complexes[24]. In addition the coordination of chloride could not be inferred from infrared spectra of the complexes because the band occurred beyond the range of our infrared spectrophotometer, whereas for Cl- ionic has been checked by $AgNO_3$. Chloride complexes showed a band at(545-765)cm^{-1} has been attributed to ionic chloride [21].On the other hand, the spectra of some complexes showed the presence of a band at (1380-1392) cm^{-1} due to ionic nature of nitrato group[19] (Table 5).

Table 5: Selected I.R. bands of the ligands and its complexes (in cm^{-1})

Comp No.	υ (N-H)	υ (O-H)	υ (C=N)	υ (N-N)	υ (C=O)	υ (M-O)	υ (M-N)	Other
L_1	2956	3200-3300	1589	1076	1661	--	--	--
L_2	2956	-	1595	1060	1620	--	--	--
1	2950	3200-3300	1452	1026	1583	507	440	--
2	2952	3200-3600	1452	1026	1577	605	450	ν IonicNO_3 1380, 827 ν-OH_2 3600, 765
3	2956	3200-3600	1452	1029	1583	665	450	υ - ionic Cl^- ,605
4	2956	3200-3600	1450	1022	1585	607	460	ν IonicNO_3 1380, 8251
5	2956	3200-3300	1452	1028	1581	609	465	υ - ionic Cl^- ,550
6	2952	3200 - 3600	1450	1026	1589	610	437	--
7	2950	3200-3600	1450	1031	1591	617	435	υ - ionic Cl 570
8	2954	--	1534	1028	1643	612	428	--
9	2956	--	1539	1007	1643	603	400	ν N-O ,950, ν_{as} No_2-,1295 ν_s-No_2-1400
10	2954	-	1502	1000	1649	628	400	--
11	2954	--	1571	1025	1641	550	418	ν IonicNO_3 1392, 825 ν-OH_2 3200, 760
12	2956	--	1471	1055	1638	553	420	υ - ionic Cl 560 ν-OH_2 3200, 761
13	2954	--	1539	1058	1639	565	424	υ - ionic Cl^- ,509 ,,ν-OH_2 3200, 765
14	2954	--	1539	1055	1639	575	445	υ - ionic Cl^- ,545

3- ^{1}HNMR Spectra

The proton nuclear magnetic resonance spectrum for the L_1 and L_2 was carried out using DMSO-d^6 as solvent and the following peaks were detected [5]as shown in Table(6).

Table (6) : ^{1}H.NMR data of ligands L_1 and L_2 in DMSO-d^6

Effective functional groups	**Chemical shift (ppm)**	
	L_1	**L_2**
N=C-CH_3	---	2.30(s,3H) 2.35(s,3H)
CH_2-CO	3.69(s,2H) 4.13(s,2H)	3.86(s,2H) 4.18(s,2H)
OCH_3	3.80(s,3H) 3.84(s,3H)	---
Ar-H	6.28-7.55 (m,10H)	6.28-7.87 (m,12H)
N=CH	7.77(s,1H) 7.95(s,1H)	---
NH	8.12(s,1H) 8.15(s,1H)	8.17(s,1H)
OH	9.53(s,1H) 9.56(s,1H)	---
NH-CO	11.49(s,1H) 11.65(s,1H)	10.77(s,1H) 10.89(s,1H)

4- X-ray Powder Diffraction Analysis

The diffraction patterns for metal complexes was performed using high Score Plus Software (Match program). , the Miller indices (hkl) along with observed and calculated 2Ø angle , d values, and relative intensities the unit cell indexed data parameters were also calculated and the powder XRD patterns of the compounds are completely different from those of the starting materials, the mean crystallite sizes of the complexes, D ,were determined according Scherrer equation ($D = 0.9\lambda / (\beta \cos \theta)$), where λ X -ray wavelength (1.5406 $A^{-\circ}$) , θ is Bragg diffraction angle, and β is the full width at half maximum of the diffraction peak [26,27] Hong .. etal .,.2014) as shown in Table(7) .

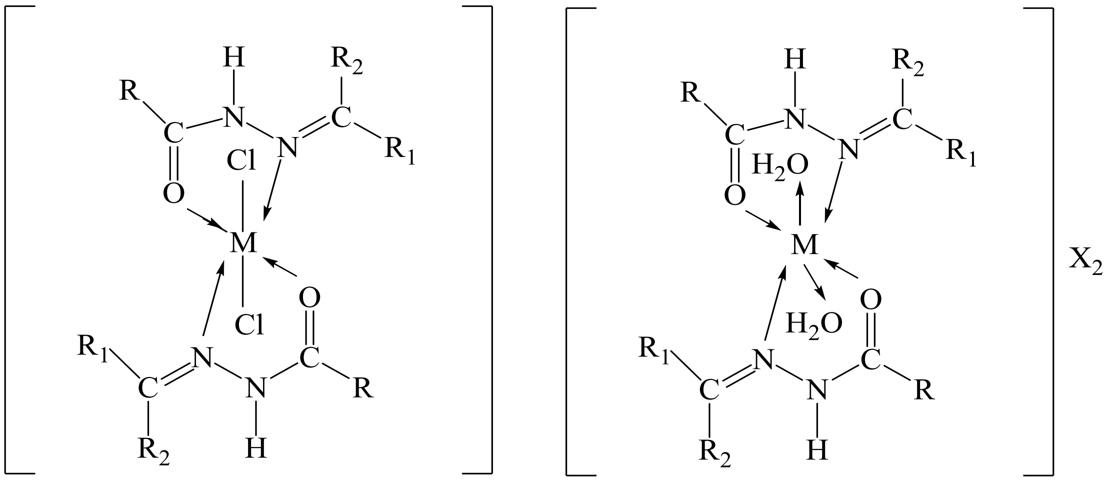
Crystal data and structure refinement for complexes Table 7

No	**Complex**	**1**
1	Molecular Formula	$CoC_{44}H_{38}N_6O_6C6$
2	Molecular weight	1018
3	Crystal system	Monoclinic
4	Space group	P10 (43)
5	Unit cell parameters (A^{o})	a= 6.2319 A^{o} , b= 12.7319 A^{o} , c= 16.1098 A^{o}
6	Cell Volume (A^{o3})	963.33
7	Z	8
8	θ range , deg	2.47 – 29.69
9	Index ranges	2 ≤ h ≤ 6, 0 ≤ k ≤ 12, 2 ≤ L ≤ 2

No	**Complex**	12
1	Molecular Formula	$CuC_{44}H_{42}N_6O_4Cl_6$
2	Molecular weight	994
3	Crystal system	Orthorhobic
4	Space group	P.21(40)
5	Unit cell parameters (A^{o})	a= 12.0197 A^{o} , b=11.9372 A^{o}, c= 6.0482 A^{o}
6	Cell Volume (A^{o3})	1012.3 A^{o}
7	Z	8
8	θ range , deg	20.7 – 28.2
9	Index ranges	≤ h ≤1 0 1 ≤ k ≤ 2 1 ≤ L ≤ 2

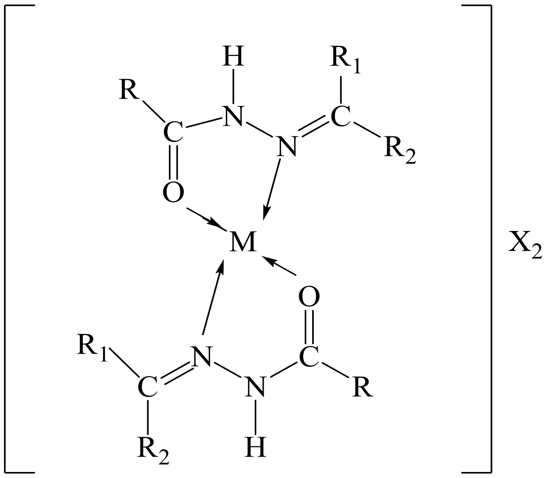
5. Conclusion

The above discussion of various physicochemical, spectral and according to the measurements of XRD analysis, the crystal geometries of some complexes has been established, and we concluded from the ir data the ligands L_1 and L_2 act's as bidentate coordinated to the metal ions through oxygen carbonyl and azomethine nitrogen atoms. Whereas the metal ions are hexacoordinate with most probable octahedral structure or tetracoordinate with square planar or tetrahedral structure have been suggested for most complexes. Fig.(1).



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

X = Cl⁻ , NO3⁻



M= Ni(II) , Cu (II) and Cd(II)

X = Cl⁻ , NO3⁻

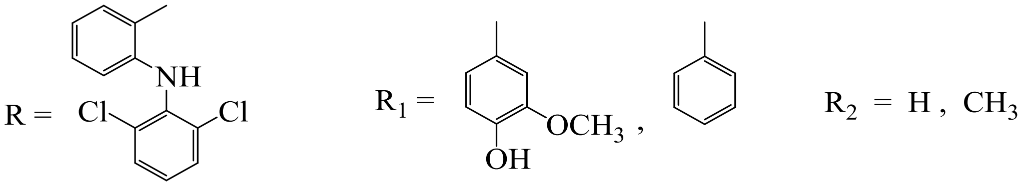


Fig.(1): The structure of the prepared complexes

References

1. Basma G.Eid. and Filippo Caraci(2022),Melittin and Diclofenac Synergistically promote Wound healing in a pathway involving TGF-B1,Pharmacological Research,Vol.175,Jan.,105993. A.H.Abbas ,
2. Elias.A.N.Elias and Fadhil A.A. (2015) , "Synthesis , characterization and biological evaluation of new potentially active hydrazones of naproxen hydrazide.,"Der Phar.chem. , 7(10),93-101
3. Bant C.N. and. Hadjkakou S.K(2016), "Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) in Metal Complexes and Their Effect at the Cellular Level.", Euro. J. Inorg. Chem. , 19,3048-3071.
4. Abbas A.H. , Elias A.N. and Fadhil A.A. (2015) , "Synthesis, characterization and biological evaluation of new potentially active hydrazones of naproxen hydrazide.,"Der Phar.chem. , 7(10),93-101.
5. Al- Shaheen A. J. ,.A.Al-Bayat M.A. and Abid Allah.A.M.,(2018) "Synthesis and Characterization of some Metals(II) complexes with 2-(6- methoxy naphthalene-2-yl) propionic acid(2- hydroxyl benzylidene) hydrazine ligand" . International J. of Enhanced Research in Science ,Technology & Engineering , ISSN :2319-7463 , ISSN: 2319- 7463, Vol7 Issue 4april-, Impact Factor: 4.059.
6. S.Y.Ebrahimipour , I.Sheikhshoaie , A.Crochet ,M.Khaleghi and M.K.Fromm , "A new mixed-ligand copper (II) complex of (E)-N′-(2-hydroxybenzylidene) acetohydrazide: Synthesis, characterization, NLO behavior, DFT calculation and biological activities." , J.Mole.Strct. , 1072 , 267-276 , (2014).
7. A.Kajal , S.Bala , N.Sharma , S.Kamboj and V.Saini , "Therapeutic potential of hydrazones as anti-inflammatory agents." ., Int.J.Med.Chem., 2014 , 1-11 , (2014).
8. K.Kafarska , D.C.Sulikowska and W.M.Wolf , "Novel Co (II) and Cd (II) complexes with non-steroidal anti-inflammatory drugs.", J.Ther.Anal.Calor. , 96(2), 617-621 , (2009).
9. Bhandari S.V, Bothara, K.G., Raut M.K., Patil A.A. Sarkate A.p. and Mokale V.J. (2008) , "Design, synthesis and evaluation of antiinflammatory, analgesic and ulcerogenicity studies of novel S-substituted phenacyl-1, 3, 4-oxadiazole-2-thiol and Schiff bases of diclofenac acid as nonulcerogenic derivatives." , Bio.&Medi.Chem. , 16 (4),1822-1831 ,.
10. Ariana C.F.Santos(2022)."Coordination Compounds of first Raw –Transition Metals,Int.J.Mol.Sci.,23(5),2855.doc..10.3390/ijms 23052855 .
11. Harinath Y., Harikishore D. , Reddy K. , Kumar B. , akshmiK.L and Seshaiah K. , (2011) "Copper (II), nickel (II) complexes of n-heteroaromatic hydrazone: Synthesis, characterization and in vitro antimicrobial evaluation." , J.Chem.pharm.Res. , 3(1),698-706 ,
12. R.S.Baligar and V.K. Revankar, (2006) "Coordination diversity of new mononucleating hydrazone in 3d metal complexes: synthesis, characterization and structural studies." , J.Serb.Chem.Soc. , 71(12) , 1301-1310.

13. W.J.Geary , (1971) "The use of conductivity measurements in organic solvents for the characterisation of coordination compounds." , Coord.chem.Rev. 7(1),81-122 ,.
14. Lever, P.B.A(1968).., "Inorganic electronic spectroscopy " Elsev.pulblish.Co.Ltd. New York.
15. Nicholls D. (1975) , " The Chemistry of iron, cobalt and nickel", Pergamon Press Oxford, pp.1087 .
16. Suttan D. (1998)., " Electronic spectra of transition metal complexes", Mc. Grow-Hill Publishing London, pp. 11-21.
17. Mamata Singh Butcher R.J. and Singh N.K. (2008).," Syntheses and X-ray structural studies of the novel complexes", [Ni(en)2(3-pyt)2] and [Cu(en)2](3-pyt)2 based on 5-(3-pyridyl)-1,3,4- oxadiazole-2-thione, Polyhedron 27, 3151–3159
18. Baran A.U. (2013) ,"Comparative study of microwave-assisted and conventional synthesis of ibuprofen-based acyl hydrazone derivatives." ,Turk.J,Chem. , 37(6),927-935.
19. Mitu, L , Raman N. , Kriza A., Stanica N. and Dianu M,(2009). "Template synthesis, characterization and antimicrobial activity of some new complexes with isonicotinoyl hydrazone ligands.", J.Serb.Chem.Soci.,74(10) ,1075-1084
20. Cotton F.A. and Wilkinson G(1980).., "Advance Inorganic Chemistry" , 4th Ed , John Wiley and Sons , Interscienic , NewYork , P.783 ,
21. Al-Shaheen A.J and Al- BergasA.F, (2020) "Synthesis and Identification of Some Complexes of 4-[N-(2,4-Dihydroxybenzylidene) imino] antipyrinyl with serine (L1) or with theronine (L2) ligands and evaluation of their Bacteria activites", J.of Edu. and Sc. (ISSN 1812-125X), Vol: 29, No: 4, (42-61)
22. Al- Shaheen,A.J.(2017)., "Physicochemical studies and X-ray powder diffraction of new homodinuclear Schiff base complexes", International Journal of Enhanced Research in Science ,Technology & Engineering , ISSN :2319-7463 , ISSN: 2319-7463, Vol. 6 Issue 10, October-2017, Impact Factor: 4.05.
23. Gamo (1960)., "Infrared spectra of water of crystallization in some inorganic chlorides and Sulfate","Bull.Chem.Soc., 34,760,1430
24. Bellamy L.J. (1966)., "The infrared Spectra of complex molecules 3rd ed. Methuen,London.
25. Sallomi I. J. and AI-Shaheen A. 1., (1994), "Complexes of Hydrazide Schiff Bases", Transition, Met-Chern., 19,275.
26. Match!(2003-2007)," Phase Identification from Powder Diffraction, Version 1.6c Licensed to, Ankara University, Department of Geological Engineering site License" (c) Crystal Impact
27. Stout C.H.and Jensen L.H. (1968), "X-ray Structure Determination",
28. Kumar M., S. M.S. H. Roy, Faizi, S. Kumar, M. K. Singh, S. Kishor, Peter S. C., and John R.P. ,(2017,"Synthesis, crystal structure and luminescence properties of acenaphthene benzohydrazide based ligand and its zinc (II) complex.", J. Mole. Stru.1128 , 195-204 .