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Synthesis, Characterization and Biological Evaluation of the Cr(III), Mn(II), Fe(II), Fe(III), Co(II)Ion Complexes with Mixed Ligands (Quinolone Antibiotics and α-Aminonitrile Derivatives)

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Abstract:

Quinolones L1 (ciprofloxacin) are commonly used antibiotics with high oral absorption and bioavailability. Quinolones bind metal particles, forming bidentate structures, due to the concoction abilities observed on their basis (a carboxylic corrosive ability at the 3-position and, in many cases, a necessary piperazinyl ring (or another N-heterocycle) at the 7-position and a carbonyl oxygen atom at the 4-position). BidentateiligandsL2=2-phenyl-2-(P-methoxyanilinee) acetonitrile was produced by reacting Primary Amin with benzaldehyde in the presence of potassium cyanide and acidic medium. The metal edifices were portrayed by the miniaturized scale component examination (C.H.N), chloride contente, ^{1}H-NMR , ^{13}C-NMR, FT-IR and UV-Vis spectra, molar conductivity and in addition attractive vulnerability estimation. The coordination science and holding practices of the metal particles and ligands has been contem plated by spectra of the building on UV-vis and IR districts. As per the got information the possible coordination geometries of these buildings were proposed as octahedral. A weak electrolyte was discovered in multiple structures. They proposed a formula, based on the related:, to assemble the appropriate metal particle constructions. By constructing a reaction mixture of [Cr(III) Mn (II), Fe (II), Fe(III) and Co(II)] parts separately, in pure ethanol with mixing, the equations [ML1L2Cl (H2O)] were produced. The ligands' (L1 and L2) metal particle edifices accomplished this. [ML1L2Cl (H2O)] and Two-H2O M:{iMn2+,Fe2+,Co2+,} are located. Cl.xH2O., where M: {Cr3+, Fe3+} and x:{2or3}.

Keywords: acetonitrile, 2-phenyl-2-(P-methoxy aniline), quinolones (ciprofloxacin), transition metal-ions.

Introduction

Quinolone derivatives are widely used in the areas of nutrition, medicine, and "impetus, color, components, refineries, and gadgets."As such, the quinolone compounds center and its progeny have been a sought-after objective for the synthesized natural scientist. Quinolones can form metal structures because of their ability to attach to metal ions [1]. In their metal structures, the quinolone sn can act as a bidentate, an unidentate, or a crossing over ligand. The bidentate structure of quinolones is often formed by the combination of one oxygen atom from the depleted carboxylic ring with the ring of the carbonyl oxygen molecule. The nebulous term "quinolone anti-infection agents" describes a family of synthetic anti-infection agents that have bactericidal as its primary ingredient. The arrangement was first used in an intervention in 1960 [2]. Nalidixic acid's therapeutic application had limitations due to its narrow range of motion. A few changes were introduced to the premises core with a view of expanding the antibacterial range and enhancing the pharmacokinetic characteristics, two of which were deemed real: the presentation of a piperazine moiety or another N-heterocyclic in position 7, and the presence of a fluoride particle in positionh6[3]. The new 4-quinolonesh, fluoroquinolones, were discovered around 1980. [4].

Preparation of the Ligand

The ligand (L2) was set up by taking after a formerly reported aside from changing of essential aromatic amine (P-methoxy aniline). Potassium cyanide (0.13g, 0.002moll) was dissolved in (4mL) of distilled water and cooled below 5°C. To this solution, benzaldehyde (0.212g, 0.002molb) in (25mL of 95% ethanol) was added. The mixture was mixed keeping up temperature belowi5°C. glacial acidic acid (0.12g, 0.002mol) was included with constant mixing with keeping the temperature below 5°C, this was trailed by the expansion of P-methoxy aniline (0.476g, 0.002mole) in (10mL of 95% ethanol) and (5mL) of glacial acidic acid (cooled at 5°C) with constant blending in all around ventilated hood. The temperature was kept up at (15°C). By stirring the mixture about 2 hrs and was kept at room temperature for one day. The obtained precipitate (long Purple needles), was washed with dilute HCl (0.2imole) to remove any excess of potassium cyanide. The compound was recrystallized with 95%eethanol. The percentage yield of this procedure was (70.9%). The synthesis of the ligand was shown in reaction below:
Benzaldehyde P-methoxyaniline2-phenyl-2-(P-methoxy aniline) acetonitrile(L2)

Preparation of complexes(C_1-C_5)

Preparation of (C_1) complex: a solution of (0.385gb, 1mmoln) of ciprofloxacin ligand (L1) in (10mL) of Absolut ethanol and (0.258gm, 1mmoll) of 2-phenyl-2-(P-methoxy aniline) acetonitrile ligand in (10mL) of absolute ethanol was added drop wise to an answer of 1.0mmolnof metal chloride(0.197g, 0.266g, 0.198g, 0.270g and 0.238g)for ($CrC_{13}.6H_2O$, $MnC_{12}4H_2O$, $FeCl_2.4H_2O$, $FeCl_{3}.6H_2O$ and $CoCl_2.6H_2O$) separately, dissolved in (20mL) of total ethanol and refluxed with mixing under anhydrous surroundings utilizing Na2SO4(anhydrous) for 24 hr.[7]. The acquired buildings were gathered after vanishing and the compounds were left in the desiccator to be dried under P_2O_5.

Result and Discussion

Creating α-amino nitrile molecules is important since they can be used to synthesize other substances [8]. Several methods were employed to identify the configurations of produced α-amino nitriles, such as C.H.N. (Table 1), FT-IR (Table 2), ^{1}H-NMR and ^{13}C-NMR spectra (Table 3), and UV-visible (Table 4) techniques.

FTIR spectra of ciprofloxacin and α-amino nitrile ligands

The FT-IR spectral data of ciprofloxacin(L_1) and α-amino nitrile ligand (L_2) were shown in Table (2). L1ligand was showed the band at (1706icm-1) which was assigned to the υ(C=O) stretching vibration of the carboxylic group (L1) and the most importin stretching modes exhibited by (L2) which was represented by α-amino and nitrile groups. The bands assigned to stretching vibration of aromatic and aliphatic(C-H) of L1 and L_2 ligands appeared at (3000-3170) cm-1 and (2850-3000) cm-1rrespectively [9]. The band related to υ(C≡N) stretching vibration of the free ligand appeared at (2176cm-1) [10]. The band correlated to υ(N-H) stretching vibrations looked at (3348 cm-1) [11]. The band related to υ (N-H) bending vibration appeared at (1621) cm-1[12-14]

FT-IR spectra of the complexes (C_1-C_5)

The FT-IR spectral data of the complexes were shown in Table (2) and the spectrum of (C_8) was shown in Figure (1). The spectra of all the complexes exhibited characteristic bands of either coordinated water appeared at (3445-3506) cm-1aassigned to υ(OH) of the complexes (C_1-C_5) or cross section water showed up at (748-792) cm-1assigneddto ρw (H_2O) in all complexes [15-17]. New groups were presented up in the area (414-493) cm-1and (501-585) cm-1were assigned to υ(M-O) and υ(M-N), respectively [18]. The band which appeared at 3348 cm^{-1} was assigned the υ(N-H) extending vibration to the (N-H) group of (L2) was shifted in the spectra of the complexes (C_1-C_5) to (3357, 3358, 3361,3356 and 3363) cm^{-1} respectively. This gave a sign that the ligand was collected with the metal ion through the nitrogen atom of α-amino group [19]. The band which appeared data (2176icm^{-1}) was allocated to the extending vibration of υ(C≡N) group of (L_2) which was moved in the spectra of complexes (C1-iC4and C6i-C10) to lower frequencies (2163, 2166, 2170, 2163, 2162, 2163, 2165, 2160 and 2166) cm-1rrespectively which alludes to the linkage of (C≡N) group from nitrogen atom. The range of complex (C_5) demonstrated an expanded move in υ(C≡N) extending vibration towards higher frequency as an effect of coordination with metal ion through the solitary combine electrons of nitrogen atom [20]. The declines of υ(C≡N) extending vibration of metal-ion complexes (C_1-C_4) were ascribed to metal dπ to ligand pπ∗back-holding. Yet, the expansion of υ(C≡N) extending vibration of complex (C_5) recognized to presence of π accepter ligands into complex (C_5) should decrease the back bonding of electrons from the metal into the nitrile ligand. The band at 1631 cm-1which was consigned to the δ(N-H) bending vibration of(N-H) group of (L_2) was shifted in the spectra of metal-ion complexes (C_1-C_5) to (1631, 1629,1616, 1628 and 1629) cm-1rrespectivelyi, this provide more submission that the ligand was coordinated with metal-ions through the nitrogen atom of α-amino group and thus supports the complexes formation [21]. The band at 1706 cm-1 corresponds to the υ(C=O) vibration of stretching of the carboxylic group of (L1). The ionic carboxyl group exhibits two bands of absorption in the range of (1600-1510) cm-1 and (1400-1257) cm-1, which may be assigned to υ(C-O-C) asymmetrical and symmetric, which have been eliminated in the spectra of vibration stretching separately [22]. The absorption band at (1485-1494) cm-1 correlates to the stretching vibrations of the (C-C) and (C-N) bonding in the quinolone ring (L1). The coordination of two oxygen atoms in a quinolone molecule (one from pyridine and the other from the carboxylic group) [22].

^{1}H-NMRzand ^{13}C-NMRaspectra of the ligands and complexes

^{1}H-NMR

The two ligands (L_1 and L_2) were studied using ^{1}H-NMR and spectroscopy, as well as two complexes (C_2, C_5) containing DMSO (d6), as indicated in Table (3) and Figure 2. The 1H-NMR spectrum of the ligand (L1) showed five peaks. The first peak at δ(1.42) ppm was ascribed to the (-CH2-), the second peak at δ(2.22) ppm was assigned to the (=NH) proton, and the third peak at δ(3.46) ppm was accepted to be the (-CH2-N=).[21].]. The forward peak showed up at δ(7.45-7.55) ppm was ascribed to the fragrant protons and the last one showed up at δ(8.92) ppm assigned to the (-COOH) [22]. The ^{1}H-NMR spectra of the ligand (L_2) demonstrated five peaks; The first peak at δ(2.51)ppm was associated to the (-O-CH3)protons, the second peak at δ(2.77)ppm was identified as the dissolvable peak of (DMSO), the third peak at δ(3.62)ppm was compared with the (-NH) proton, and the fourth peak at δ(5.35)ppm was attributed to the (-CH-C≡N). The residual complex's 1H-NMR spectra (C_2, C_5) was identical to that of the ligands; the only variation was that the usual value of (N-H) of the ligand had been shifted by (0.52, 0.36, and 0.36) ppm in those substances, suggesting a structure of organization.

^{13}C-NMR

Spectra The two ligands ($L_1$and L_2) were described by ^{13}C-NMR spectroscopic techniques, in addition to tow compounds (C_2, C_5) utilizing DMSO(d6) as appeared in Table (3) and Figure (3). The ^{13}C-NMR range of (L_1) demonstrated seven peaks; the principal peak showed up at δ(7.7) ppm which was related to the (-CH2-CH2-). The second peak showed up at δ(35.8) ppm was compared to the (= CH-N=) carbon, the third peak showed up at δ(45.8)ppm was allocated to the (-CH2-NH-) carbon, the forward peak showed up at δ(51.3) ppm was assigned to the (-CH2-N=) carbon, the fifth peak showed up at δ(166.2) ppm which was appointed to the (-COOH) carbon, the 6th peak showed up at δ(176.4) ppm was assigned out to the (-C=O) carbon, and the last peak showed up at δ (102-115) ppm was allotted to the sweet-smelling carbon molecules [21]. The ^{13}C-NMR spectra of the ligand (L2) revealed three character tops: the first at δ(38.04) ppm contrasted to the dissolved peak of (DMSO), the second at δ(52.20) ppm connected to the (-CH-C≡N) carbon, and the last at δ(115.37) ppm was attributed to the (-CH-C≡N) carbon particles [22]. The complexes (C_2, C_5) had identical ^{13}C-NMR spectra to the ligands. However, the (L2) ligand's (-CHz-C≡N) carbon was displaced by (0.83, 8.41) ppm in these complicated systems, respectively.

The standard of (-CH-C≡N) carbon was moved in these compound by (1.99, 1.75) ppm and the standard of (-COOH) of (L1) was moved in these complex by (1.99, 1.75) and the standard of (-C=O) of a similar ligand was moved in these complexes by (3.00, 0.74)respectively, this gave a sign for buildings arrangement[23].

Electronic spectra(UV-Vis.)

The electrical absorbance statistics of the ligands (L_1 and L_2) and the metal ion complexes were obtained in ethanol at room temperature and are shown in Table (5), with examples of their spectra depicted in Figures 4–6. The spectra of the two ligands revealed high intensity bands in the range (48543 and 41666) cm-1, which were assigned to $\pi \rightarrow \pi*$ of conjugated system [24]. Low intensity bands appeared in the near UV-visible region (31645 and 34364) cm-1, indicating the $n \rightarrow \pi*$ transition. The concentration and positions of these bands were influenced by the structure of the molecules and the solvent used [25]. The electrical spectrum of the compounds showed new bands, including their intensities and placements. bands are mostly dependent on the ligand field effects, stereochemistry of complexes and electron shape of the metal ions [26].

Thermal analysis of complexes

Warm decay of the complexes (C_1-$C_3$and C_5) takes after TG strategies, warming extent (30-450) °C and warming rate (10 °C/min). The warm decay information for all complexes have three stages where given in Table (5) and their thermographs of Fe(II) complex (C_3) was appeared in Figure (7). The accompanying results were acquired:1. The principal organize which occurred at temperature scope of (50-150)°C. incorporate leaving the lattice water atoms and counter chloride particles [27,28].2. The accompanying stage incorporate leaving the organized water particles and take off the chloride particles at temperatures relying upon security energies came about because of coordination of ligands [29,30].3. The last phase of warm decay of complexes gave metal oxides as last live contingent upon the sort of metal particle and on (M-L) proclivity [31,32]

In vetro Antibacterial Activity

The antibacterial exercises of all compounds were divided against test microbes in particular; Staphylococcuaurouss, Bacillussubtilish(Gram+7), Escherichiacand Pseudomonasyaeruginp(Gram-). Agar , (well-dispersion strategy) used to decide the movement [33]. Borer of 0.6 mm distance across was utilized, the convergence of all compounds was (10^{-3}M) utilizing (DMSO) as a dissolvable and was utilized as a control Gram negative while ciprofloxacin was utilized as a control Gram positive. The dissolvable (DMSO) demonstrated no action againstcthehtried microscopic organisms, while some of arranged compounds indicated great results [34]. Tablei(6) demonstrates the hindrance zones of the dissolvable and the arranged buildings.The hindrance zones Were measured in (mm) and contrasted with the restraint zone of expansive range anti-infection. All edifices demonstrated no movement against the gram negative bacterium (Escherichia coli), which can bring about ailment, for instance, enter toxigenic strains deliver a poison in the gut, coming about regularly in looseness of the bowels [35]. The complexes ($C_2$and C_4) demonstrated most elevated movement against Pseudomonas and Staphylococcus aureus. This bacterium is known for its ability to withstand the majority of anti-infection treatments and for being the underlying cause of several medical conditions and contaminations [36]. Several factors were examined for controlling the biological activities of metal frameworks [37]. Organic activity is influenced by the type of ligand, metal, complex charge, motion arrangement, metal particle design, and metal complex shape [38].

The nomenclature of suggested structures of the complexes

The hypothesized structures of the produced compounds were confirmed by their elemental analysis (C.H.N.), thermal analysis, infrared, 1H-NMRn and 13C-NMRc spectra, UV-Vis spectroscopy, and molar conductance values. According to the observations collected, the structures of the metal ion complexes are suggested as shown in Figures (8, 9, and 10) below:

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Table [1]: Elemental micro analysis and some physical properties of the ligands (L1 and L2) and their prepared complexes

COMP.	FORMULA M.W.T	YIELD %	COLOR	M.P (°C)	C % CAL (FOUND)	H % CAL (FOUN)	CAL (FOUN)	M % CAL (FOUND)	CHLORINE %
L_1	$C_{17}H_{21}FClN_3O_4$ (385.8)	-----	Light White	255-257	52.87 (52.20)	5.44 (5.13)	10.88 (10.07)	------	9.18 (8.65)
L_2	$C_{15}H_{14}N_2O$ (238)	77.6	Leaden	79-83	75.63 (74.88)	5.88 (5.27)	11.76 (11.08)	------	------
C_1	$Cr[L_1L_2Cl(H_2O)]Cl.3H_2O$ (764.7)	86.2	Green	317 Dec.	50.21 (49.48)	4.05 (3.66)	9.15 (7.98)	6.66 (5.19)	9.27 (7.87)
C_2	$[MnL_1L_2Cl\ (H_2O)]\ 2H_2O$ (749.2)	71.7	Pall Yellow	350-352	51.25 (49.76)	3.87 (4.03)	9.34 (7.90)	7.32 (6.10)	9.46 (7.90)
C_3	$[FeL_1L_2Cl(H_2O)]\ 2H_2O$ (714.6)	65.8	Yellow	319 Dec.	53.73 (50.76)	4.05 (3.37)	9.56 (8.84)	7.62 (6.78)	4.84 (3.09)
C_4	$[FeL_1L_2Cl(H_2O)]Cl.2H_2O$ (750.1)	75.2	Yellow	329-332	51.19 (48.75)	3.86 (3.59)	9.33 (7.43)	7.43 (6.1)	9.45 (8.11)

Dec.=Decomposition

Table (2): Characteristic infrared absorption bands of ligands (L_1 and L_2) andtheir metal ions com plexus

Comp.	υ(N−H) cm-1	υ(C≡N) cm-1	υ(C=O) cm-1	δ N−H cm-1	υ(C-O-C) (asy)cm^{-1}	υ(C-O-C) (sy)cm^{-1}	υ(M-O) cm-1	υ(M-N) cm-1
L_1	3378 w.sh	------	1707 v.sh	1625 s.sh	------	------	------	------
L_2	3348 w.sh	2176 s.sh	------	1621	------	------	------	------
C_1	3357 m.sh	2164 s.sh	------	1631 m.sh	1520 w.sh	1300 s.sh	585 w	418 w
C_2	3358 w.sh	2167 m.sh	------	1629 s.sh	1557 m.sh	1300 s.sh	501 w	441 w
C_3	3361 m.br	2170 m.sh	------	1616 w.br	1514 w.sh	1292 s.sh	555 w	443 w
C_4	3356 m.br	2163 m.sh	------	1628 v.sh	1504 m.sh	1247 m.sh	547 w	483 w
C_5	3363 m.br	2204 w.br	------	1629 v.sh	1571 s.sh	1305 m.sh	572 w	420 w

where: s=strong, m= medium, w=weak, v=very, br=broad, sh=sharp

Table (3): ^{1}H-NMR and ^{13}C-NMR of the ligands (L1 and L2) and some of their metal ion complexes

Comp.	Formula	Groups	Chemical Shifts δ(ppm)	Groups	Chemical Shifts δ(ppm)
L_1	$C_{17}H_{21}FClN_3O_4$	(-CH₂-) (=NH) (-CH₂-N=) (Ar-H) (-COOH)	1.42 2.22 3.46 7.45-7.55 8.92	(-CH₂- CH₂-) (-C-H-N=) (- CH₂-NH-) (- CH₂-N=) (- COOH) (-C=O)	7.7 35.8 45.8 51.3 166.2 176.4
L_2	$C_{15}H_{14}N_2O$	(-O-CH₃)	2.51 3.62 5.35	(- CH - ≡N) (-CH-C≡ N)	52.20 115.37
C_2	$[MnL_1L_2Cl(H_2O)]Cl.2H_2O$	(-NH) (=CH-C≡N) (Ar-H)	3.98 5.59 7.62-7.93	(- CH-C ≡N) (-CH-C ≡N) (- COOH)	60.01 120.06 167.46
C_5	$[CoL_1L_2Cl(H_2O)]\ 2H_2O$	(-NH) (=CH-C≡N) (Ar-H) (=NH) (=CH- ≡N) (Ar-H)	3.55 5.87 6.90 3.91 5.80 6.81-7.92	(- CH-C ≡N) (-CH-C ≡N) (- COOH)	57.95 118.91 168.19

Table (4): Electronic spectra, parameter, molar conductance, magnetic susceptibility and suggested stereo chemical of the ligands and their metal ion complexes

Comp.	Wavelength h	Wave no. cm-1	Assignment	Molar Cond. -1 Ω cm2 mol-1	B. M	B- cm-1	β	Dq/B⁻	15B⁻ cm-1	Geometry Suggested
L1	(λ) nm 316 280	31645 48543	$n\rightarrow\pi^*$ $\pi\rightarrow\pi^*$	-------	----	----	----	----	----	---------
L2	291 240	34364 41666	$n\rightarrow\pi^*$ $\pi\rightarrow\pi^*$	------	------	----	----	----	----	---------
C1	---- 600 448	16111* 16666 22321	$^4A2g\rightarrow{}^4T2g$ $^4A2g\rightarrow{}^4T1g(F)$ $^4A2g\rightarrow{}^4T1g(P)$	50.9	3.91	771	0.840	1.25	11566	Octahedral
C2	506	19762	$^6A1g\rightarrow{}^4T1g$	22.3	1.41	----	----	----	----	Octahedral
C3	503	19880	$^5T2g\rightarrow{}^5Eg$	18	2.34	----	----	----	----	Octahedral
C4	758 645	13192 15503	$^6A1g\rightarrow{}^6T1g(G)$ $^6A1g\rightarrow{}^4A1g+{}^4Eg$	29.1	5.72	----	----	----	----	Octahedral
C5	659 ---- 490	15174 15501* 20408	$^4T1g(F)\rightarrow{}^4T2g(F)$ $^4T1g(F)\rightarrow{}^4A2g$ $^4T1g(F)\rightarrow{}^4T1g(P)$	23.3	4.68	641	0.660	1.24	9613	Octahedral

* calculated value

Table (5): Thermal decomposition data for some metal ion complexes

Comp.	Molecular formula	step	Temp. rang of the Decomposition C°	Suggested Formula of resultant compound	Mass loss% Cal.	found
C_1	$[CrL_1L_2Cl(H_2O)]Cl.3H_2O$	1 2 3	80-170 170-210 210-375	$Cr[L_1L_2(H_2O)(Cl)]Cl$ $Cr[L_1L_2]$ Cr_2O_3	7.04 11.6 76.8	5.86 10.4 74.5
C_2	$[MnL_1L_2Cl(H_2O)]Cl.2H_2O$	1 2 3	94-152 152-233 233-397	$Mn[L_1L_2(H_2O)(Cl)]C$ $lMn[L_1L_2]$ MnO	4.58 11.3 74.9	4.04 10.2 73.5
C_3	$[FeL_1L_2Cl(H_2O)]$ $2H_2O$	1 2 3	50-105 105-175 175-380	$[FeL_1L_2Cl(H_2O)]$ $[FeL_1L_2]$ FeO	4.92 7.3 76.7	3.78 6.14 73.7
C_5	$[CoL_1L_2Cl(H_2O)]$ $2H_2O$	1 2 3	60 -140 140 -195 195 -360	$Co[L_1L_2(H_2O)(Cl)]$ $[CoL_1L_2]$ CoO	4.9 7.27 80.1	3.89 6.24 76.8

Table (6): Inhibition zonesbmeasuredhin (mm) of DMSO, ciprofloxacin and metal ion Complexes

Compound	Inhibition zone (mm) *Escherichia coli*	Inhibition zone (mm)*Pseudom*	Inhibition zone (mm)*Staphyl*	Inhibition zone (mm) *Streptococci*
DMSO	----	----	----	----
L_1(ciprofloxacin)	18.50	23.70	18.15	12.23
C1	12.00	35.00	7.00	14.00
C2	8.00	44.00	21.00	18.80
C3	11.00	25.10	6.00	13.00
C4	21.00	40.70	21.00	15.00
C5	22.00	29.40	22.50	18.00

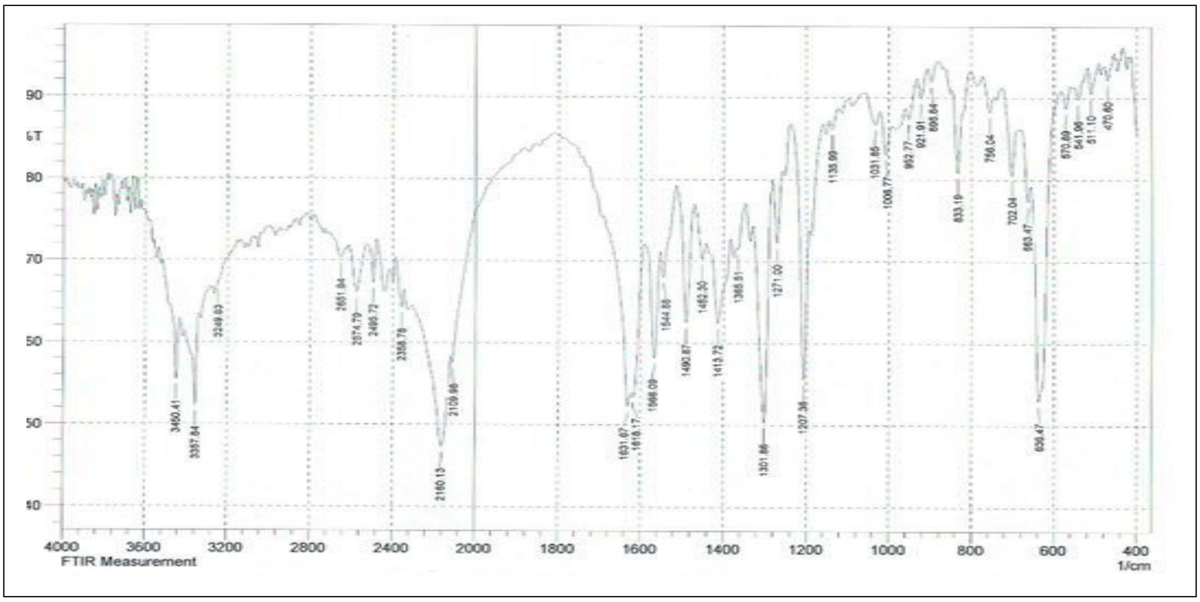


Figure (1)FT-IR spectrum C_3

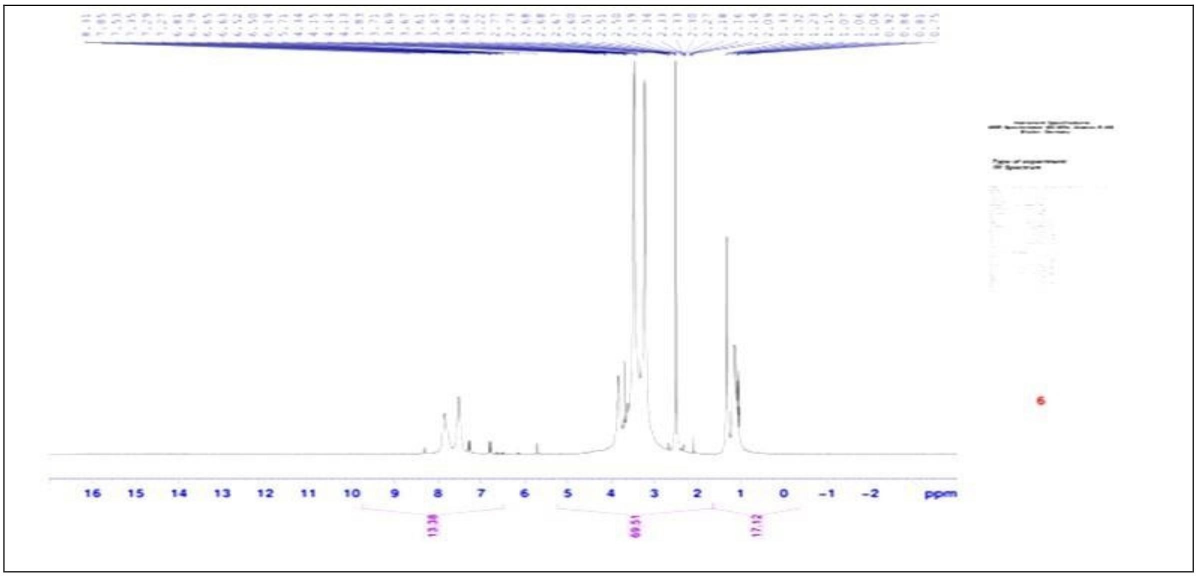


Figure (2) H^1-NMR spectrum C4

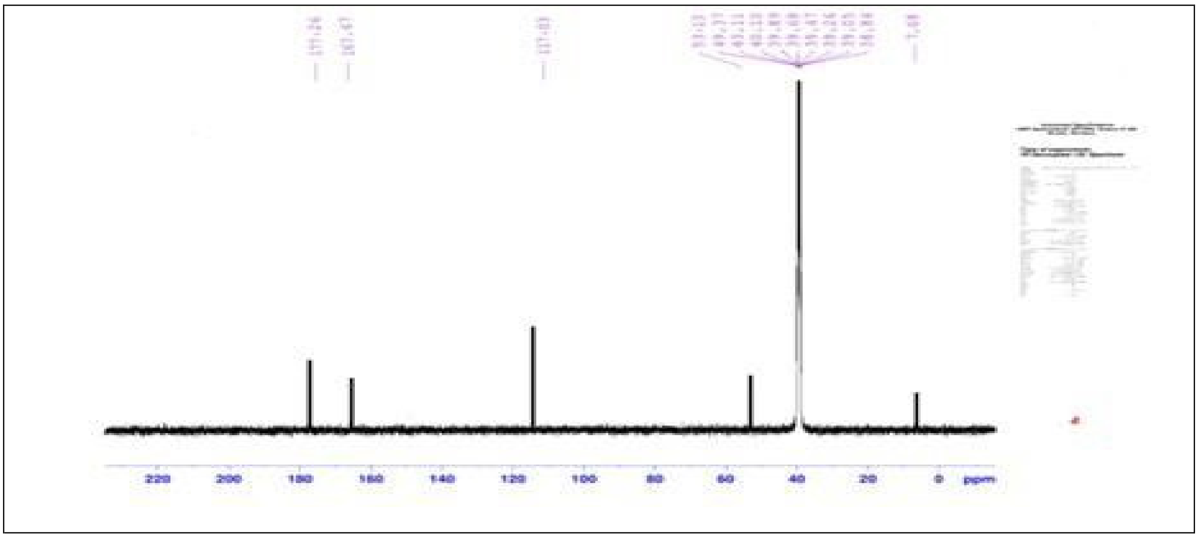


Figure (3) C^{13} NMR – spectrum of C_5

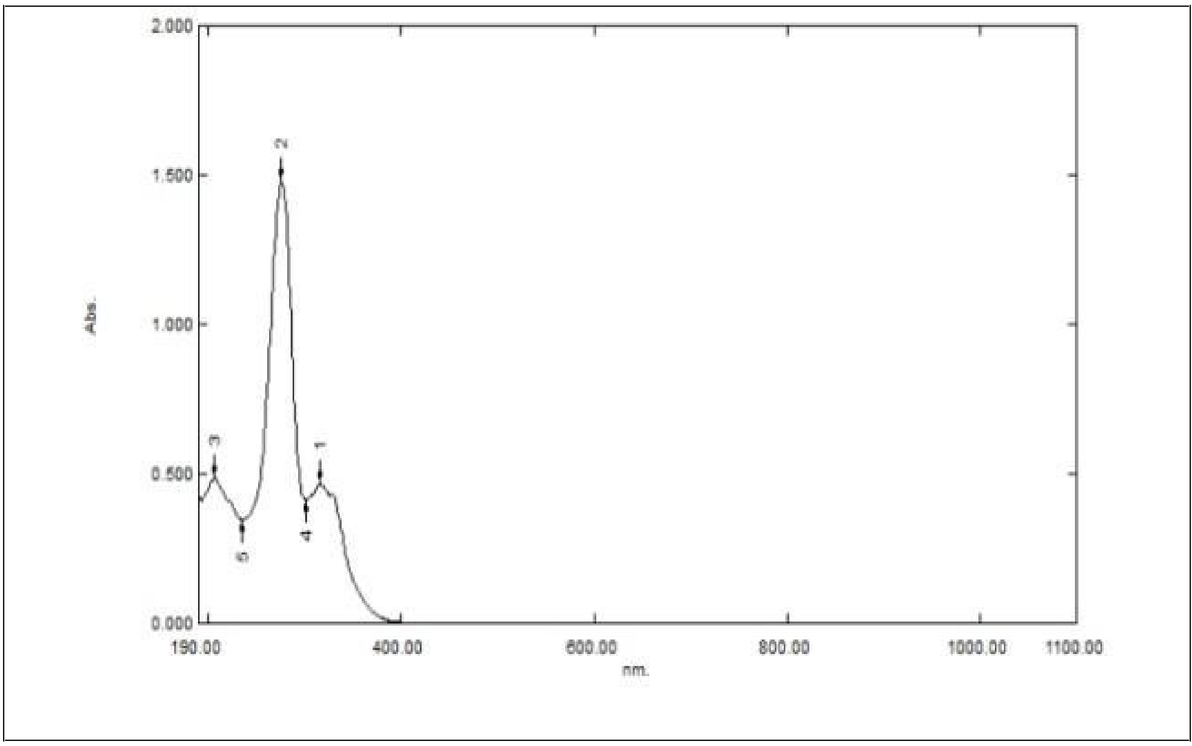


Figure (4) UV. Visible spectrum of L_1

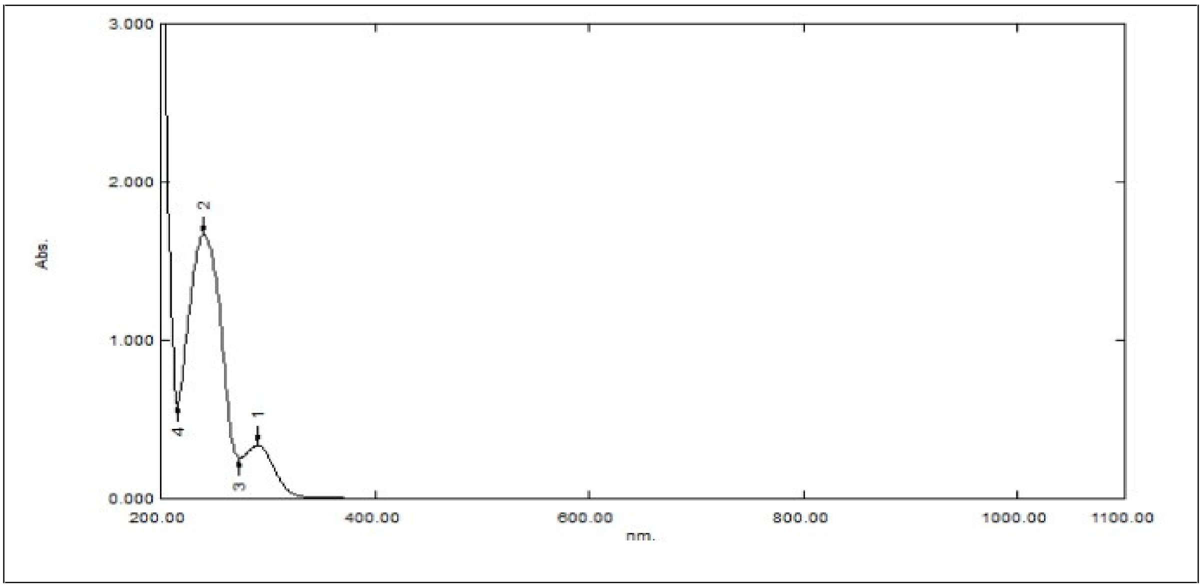


Figure (5) UV. Visible spectrum of L_2

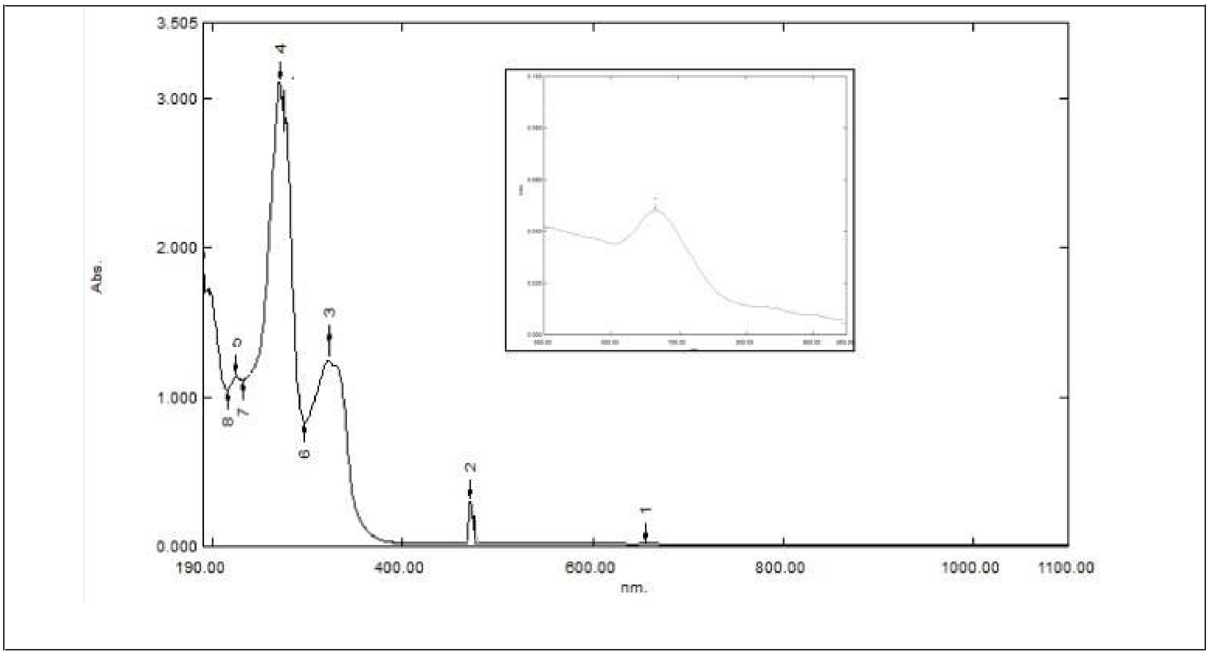


Figure (6) UV. Visible spectrum of C_1

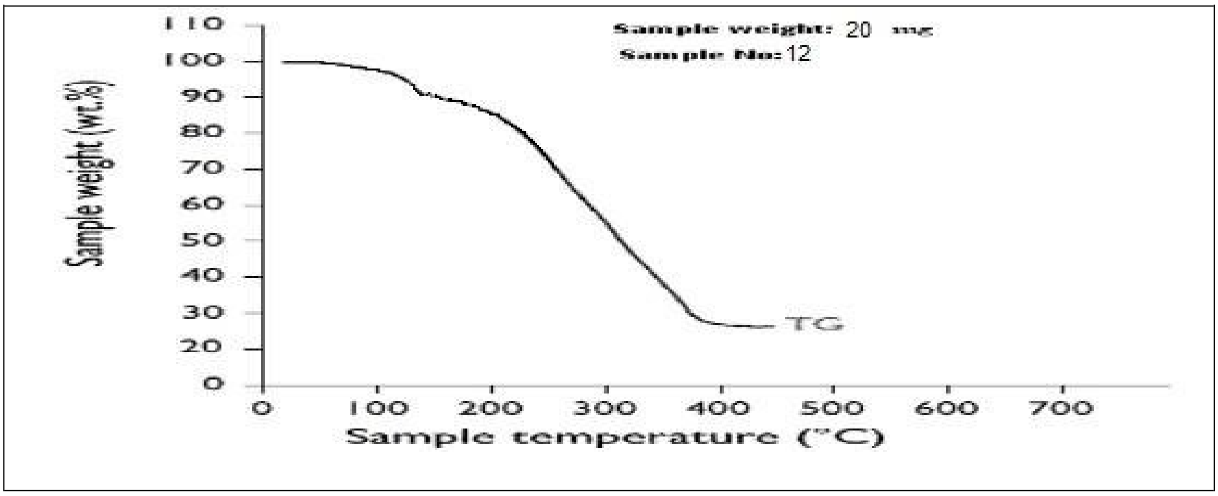
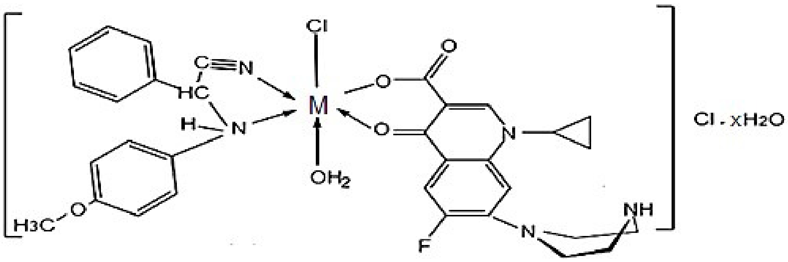


Figure (7) Thermograph of C_4



Where: M {Cr^{3+} or Fe^{3+}} and x {2 or 3}

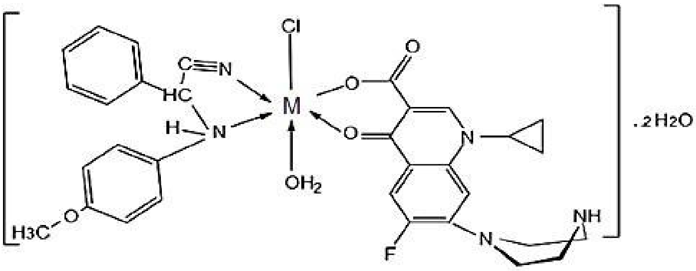
$[CrL_1L_2Cl\ (H_2O)]\ Cl.3H_2O$

[chloro mono aqua ciprofloxacin {2-phenyl -2- (*P*- methoxy anilino) acetonitrile} chrome (III)] chloride (3) hydrate

$[FeL_1L_2Cl\ (H_2O)]\ Cl.\ 2H_2O$

[chloro mono aqua ciprofloxacin {2-phenyl-2-(*P*- methoxyanilino) acetonitrile} iron(III)] chloride dihydrate

Figure (8): Suggested the structures of C_1 and C_4 complexes



$ML_1L_2Cl(H_2O)].2H_2O$

Where: M {Mn^{2+}, Fe^{2+} and Co^{2+}} [chloro mono aqua ciprofloxacin {2phenyl-2-(*P* -methoxyaniline) acetonitrile} metal(II)] dehydrate Figure (9): Suggested structure of C_2, C_3 and C_5 complexes