



Preparation, Synthesis New Azo Ligand (E)-1-(3-((E)-(4,5-diphenyl-1H-imidazol-2-yl)diazenyl)phenyl)ethanone Oxime and Some of its Metal Complexes

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Abstract

The research included the preparation of the New Azo Oxime Ligand derived from 4,5-diphenyl imidazole. The ligand was prepared from the amine reactor with the coupling component in order to prepare the azo salicialdehyde. After this the last compound and hydroxylamine hydrochloride which obtained the ligand mentioned some metallic complexes were prepared for the ions of each element Co(II), Ni(II), Cu(II), Zn(II), Cd(II), Hg(II). The person of ligand and its metal complexes after sedimentation and purification by using the available spectral and analytical methods such as Mass spectrum of ultraviolet- visible and IR spectroscopy.

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Key Words: Ligand Azo - Oxime New, Metal Complexes.

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Introduction

The compounds of oxime are characterized by their active Oxime group. The amphoteric trait of this group is due to the basic nitrogen atom ⁽¹⁾. The hydroxyl group is moderately acidic. The oximino group determines the nature of the reactions of oximes and their properties as well as their effect on the determination of the spatial formulation of these compounds. Many researchers have been interested in this class of compounds where some were used as reagents in analytical chemistry ⁽²⁾ because of their ability to form complex compounds and some used oxidizing agents in polymerization reactions ⁽³⁾ It has also been shown to have a special synthetic effect on lactam formation by means of a pacman rearrange reaction ⁽⁴⁾. The twentieth century antioxidants appeared to be an effective biological agent used as pharmaceuticals ⁽⁵⁾, such as

pharmaceutical antibiotics, hypotensive, Anli Arrhythmia and Antiviral ⁽⁶⁾. The organic Phosphate Oxime were used in conjunction with Intoxication to reduce toxins formed in the body ⁽⁷⁾. It has been used as bactericides and Fungicides ⁽⁸⁾.

Experimental

In this paper, the analytical and spectral measurements of the prepared ligand and the derived complexes of some selected metallic elements were used in this research. The ultraviolet spectra of ligand and its chelating complexes were recorded using a device (Shimadzu 1700) within range (200-800 nm) dissolve in ethanol using quartz cell.

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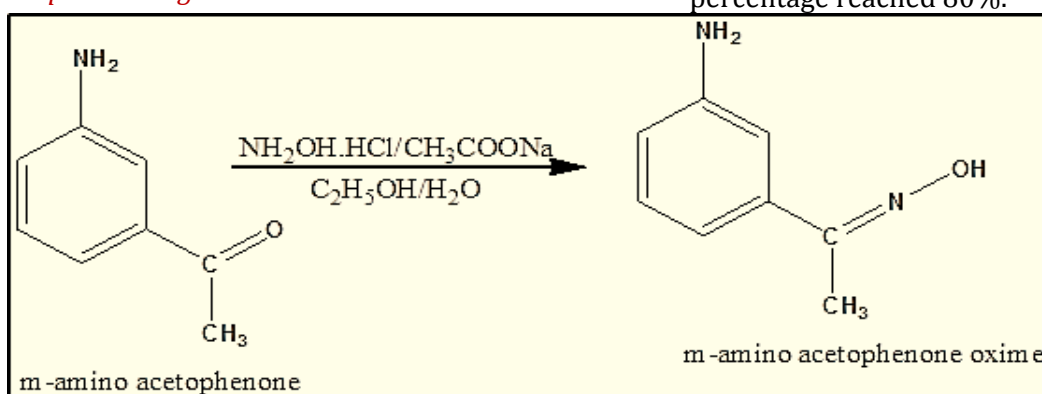
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The melting points of ligand and its solid canine complexes were measured using the device (Stuart melting points SMP 10). The molecular conductivity measurements were recorded for the complexes at $25 \pm 2 \text{ }^\circ\text{C}$ for solution (1×10^{-3}) of the sample in ethanol using a device (Digital conductivity meter Alpha -800). The infrared spectra of the azo compound and its metallic complexes are recorded in their solid state within the rang ($400\text{-}4000\text{cm}^{-1}$) in the solid potassium bromide with the apparatus completion (Shimadzu FTIR 8400 spectrophotometer). The mass spectrometer was also recorded by advice (MSD Direct Probe). Measurements of magnetic sensitivity of solid complexes and at laboratory temperature were performed using a device (Balance Magnetic Susceptibility Model-M.S.B Auto).

Prepare the Ligand



Scheme 1. Synthesis of Schiff base

2)- Prepare the Ligand

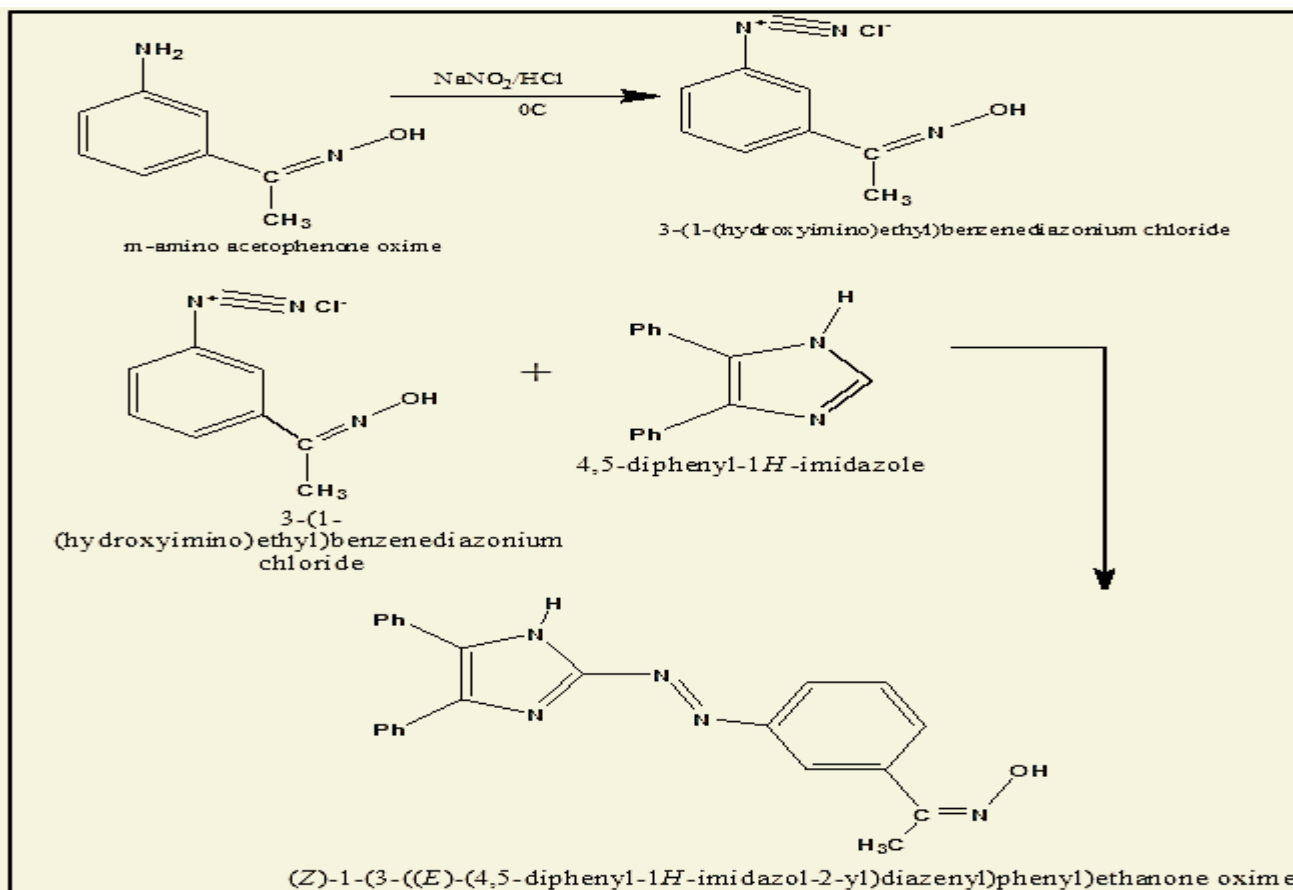
The azo attended Oxime from the diazinium salt pairs of Oxime amine with imidazole in an alcoholic medium dissolve (0.01mole,1.50g) of metal amino acetophenone oxime in a solution resulting from mixing (3ml) of hydrochloric acid with (50ml) distilled water cool the mixture with ice to (0°C), The add a (0.01mol) solution (0.7g) of sodium nitrite dissolved in to drops of distilled water as a drop taking in to account stirring and maintaining the temperature below(5°C).the solution is left to settle for 93o minutes) to complete the process of nitrogen and obtain a solution of diazinium chloride for oxime amine. The said salt solution was

The ligand attends in two stages.

1)- Preparation of Oxime

This compound was prepared form reactor 3-amino acetophenone with hydroxyl amine hydrochloride and in equal proportions by mixing solution in a circular beaker capacity (250ml) (0.001 mol), (1.253g) of actofenone derivative and dissolved in (25ml) ethanol were dissolved with aqueous solution of each mixture (0.05ml, 1.042g) hydroxylamine hydrochloride and (0.015mol,2.04g) sodium acetate in 100ml ethanol. The solution went up for an hour and was set aside to cool the Yellowish white crystals were filtered and washed with cold distilled water and then with ethanol and left aside to dry. It was re-crystallized from hot ethanol and its melting point was recorded at ($129\text{-}131^\circ\text{C}$) while the product percentage reached 80%.

added gradually with continuous stirring to a solution (0.01 mol, 2.2g) from the base of the pairs 4,5-diphenylimidazole dissolved in mixture consisting of (15ml) of ethyl alcohol and (15ml) of sodium hydroxide solution (1mol). The coloration of the solution was observed in an orange color leave the solution for the next day. The acid function was modified to (PH=7) to obtain a reddish orange precipitate. The precipitate was filtered and washed with distilled water to get rid of sodium chloride resulting from the pairs and neutralization process. Dry and recrystallize from ethanol to get the ligand in pure form. The equation below explains how to obtain. The aforementioned ligand.



Scheme 2. Synthesis of Ligand

Prepare the Metal Complexes of the Ligand

the metallic presenters were prepared for Cobalt, Nickel, Copper, Zinc, Cadmium and Mercury ions divulgence the derived from ligand and azo - Oxime (DIDPEO) from the reaction of a solution of (0.762g) of ligand dissolved (50ml) of ethanol with an aqueous solution of the mentioned ions salts. The whites are suitable for the required molar proportion of (metal: ligand) after dissolving them separately in (5ml) of distilled water and after

Table 1. Shows the physical properties of the prepared ligand (DIDPEO) and its complexes

Compounds	Color	m.p $^{\circ}\text{C}$	Yield %
L ($\text{C}_{23}\text{H}_{19}\text{N}_5\text{O}$)	Orange	125-127 $^{\circ}\text{C}$	85%
$[\text{Co}(\text{C}_{23}\text{H}_{19}\text{N}_5\text{O})_2\text{Cl}_2]$	Dark blue	194-196 $^{\circ}\text{C}$	90%
$[\text{Ni}(\text{C}_{23}\text{H}_{19}\text{N}_5\text{O})_2\text{Cl}_2]$	purple	143-145 $^{\circ}\text{C}$	84%
$[\text{Cu}(\text{C}_{23}\text{H}_{19}\text{N}_5\text{O})_2\text{Cl}_2]$	Dark red	190-193 $^{\circ}\text{C}$	92%
$[\text{Zn}(\text{C}_{23}\text{H}_{19}\text{N}_5\text{O})_2\text{Cl}_2]$	Dark red	136-138 $^{\circ}\text{C}$	94%
$[\text{Cd}(\text{C}_{23}\text{H}_{19}\text{N}_5\text{O})_2\text{Cl}_2]$	Dark blue	142-145 $^{\circ}\text{C}$	80%
$[\text{Hg}(\text{C}_{23}\text{H}_{19}\text{N}_5\text{O})_2\text{Cl}_2]$	red	184-186 $^{\circ}\text{C}$	79%

mixing the alcoholic solution of ligand with the aqueous solution of the ions salts under study. These solutions were left to cool and it was noted that sediments of different colors were observed according to the different metal ions complexes to be prepared. The sediments were filtered and dried and each was washed with minimal mixture (alcohol: water) (1:1) and then dried. Melting points were recorded and measurement results were listed in table (1).

Results and Discussion

Mass Spectrum

Mass Spectrum gave good results about fragments of prepared compound by giving most of parts from

it at (381g/mol) which competed with stock compound that act fragment in figurer (1).

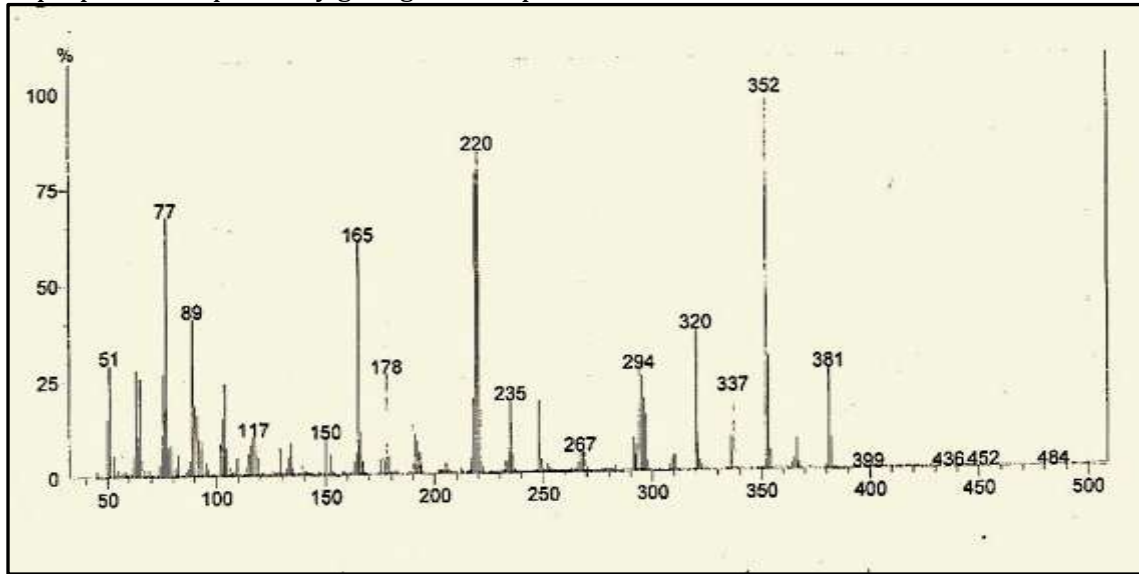
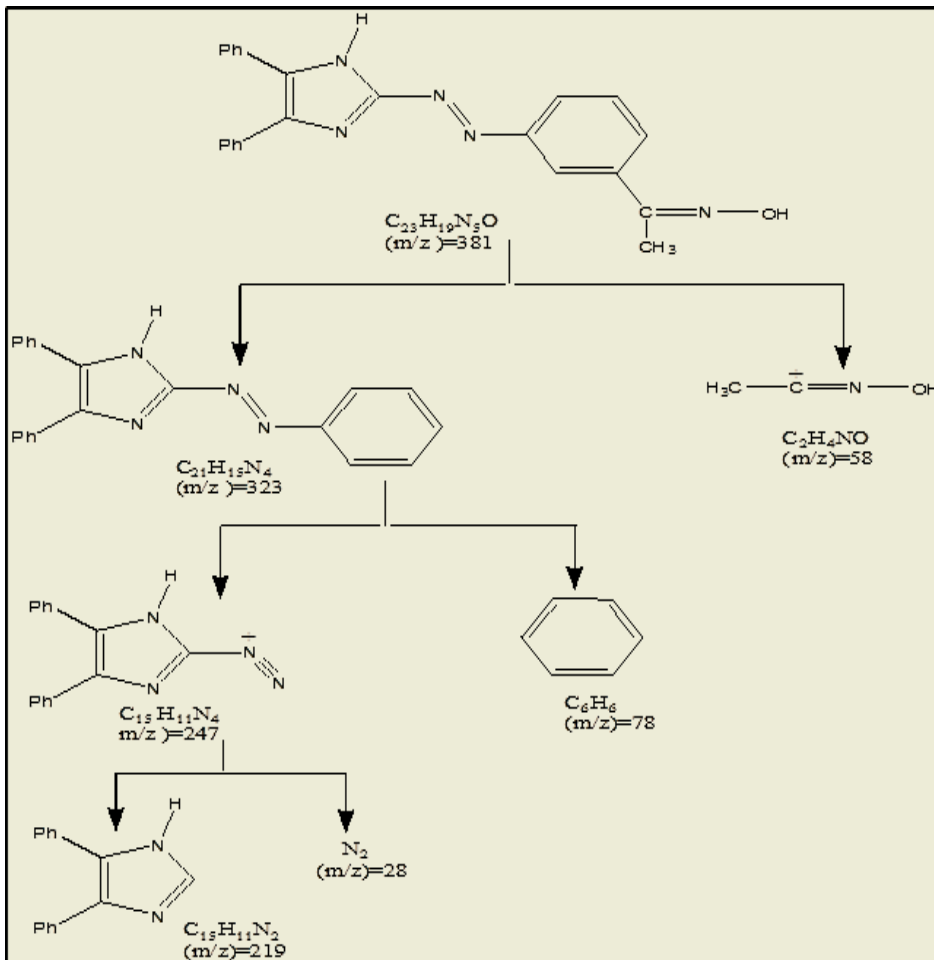


Fig. 1. Mass spectrum of Ligand



Scheme 3. Segment fractionation of the Ligand



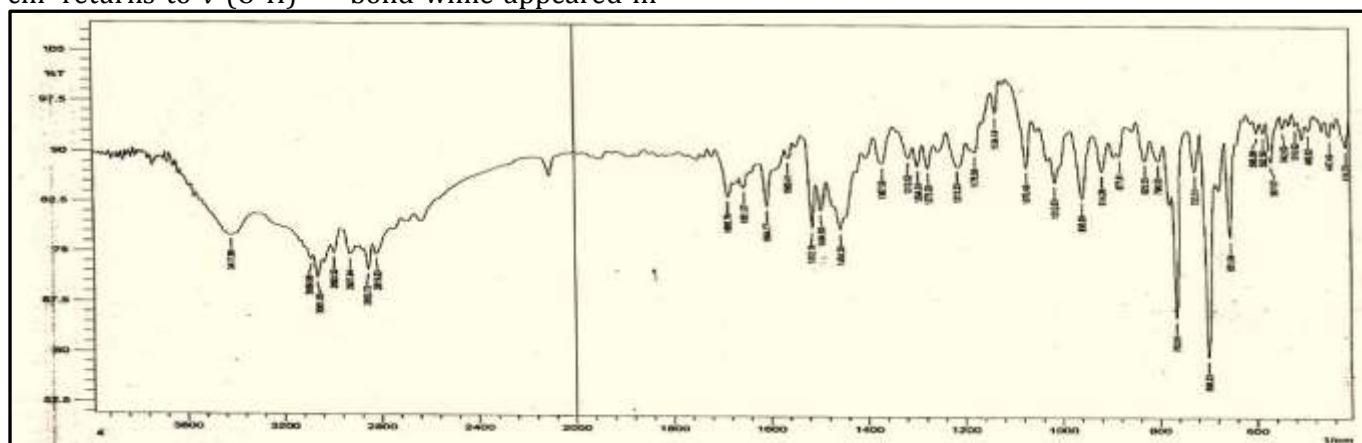
FTIR Spectroscopy

Table 2. IR spectra frequencies for the ligand (DIDPEO) and its metal complexes in cm^{-1}

Compound	ν (C=N) imidazo	ν (N=N) AZO	ν (C=N) Schiff	ν (N-H) imid	ν (O-H)	ν (C-H) aliph	ν (C-H) aroma	ν (M-N)
L= $\text{C}_{23}\text{H}_{19}\text{N}_5\text{O}$	1512	1438	1604	3232	3381	2090	3061
[Co($\text{C}_{23}\text{H}_{19}\text{N}_5\text{O}$) $_2\text{Cl}_2$]	1512	1452	1602	3221	3388	2916	3062	466
[Ni($\text{C}_{23}\text{H}_{19}\text{N}_5\text{O}$) $_2\text{Cl}_2$]	1506	1444	1602	3300	3377	2104	3061	449
[Cu($\text{C}_{23}\text{H}_{19}\text{N}_5\text{O}$) $_2\text{Cl}_2$]	1558	1442	1602	3140	3390	2916	3059	453
[Zn($\text{C}_{23}\text{H}_{19}\text{N}_5\text{O}$) $_2\text{Cl}_2$]	1558	1442	1604	3147	3217	2926	3062	447
[Cd($\text{C}_{23}\text{H}_{19}\text{N}_5\text{O}$) $_2\text{Cl}_2$]	1556	1411	1639	3176	3284	2852	3061	474
[Hg($\text{C}_{23}\text{H}_{19}\text{N}_5\text{O}$) $_2\text{Cl}_2$]	1502	1440	1602	3203	3375	2916	3061	462

The absorption beams of the prepared kids and complexes were followed, as the ligand spectrum showed an absorption beam at the frequency (1512) cm^{-1} that is due to $\nu(\text{C}=\text{N})$ cm^{-1} bond of the imidazole ring⁽⁹⁾, while this package showed a clear difference in the frequency locations in addition to the difference in the intensity and shape of the beams in the spectra Complexes where they appeared at frequencies between (1502-1558) cm^{-1} , which means that the consistency process occurred through the imidazole nitrogen atom with the metal ion, and the ligand spectrum showed a sharp absorption beam at the frequency (1438) cm^{-1} belonging to the azo group $\nu(\text{N}=\text{N})$ ⁽¹⁰⁾ While the spectra of complexes showed a clear shift towards lower frequencies, they varied between (1411-1452) cm^{-1} , indicating The symmetry of the nitrogen atom also the ligand spectrum showed an absorption beam at the frequency (3232) cm^{-1} belonging to the sphincter $\nu(\text{N-H})$ ⁽¹¹⁾, whereas in the complexes this bundle appeared at frequencies between (3140-3300) cm^{-1} . The frequency (3381) cm^{-1} returns to $\nu(\text{O-H})$ ⁽¹²⁾ bond while appeared in

the spectra of complexes at frequencies between (3217-3388) cm^{-1} . The ligand spectrum showed a beam at the (1604) cm^{-1} frequency that returns to $\nu(\text{C}=\text{N})$ ⁽¹³⁾ for the azomethine group. Absorption beams appeared in the spectra of complexes at frequencies between (447-466) due to the association of $\nu(\text{N-M})$ ⁽¹⁴⁾ Harmonicity while the ligand spectrum was devoid of these packages, which indicates that the coordination process between ligand and metal ions occurred through¹⁰⁰ the atom nitrogen atom of the azo group and the nitrogen of the imidazole ring. The ligand spectrum is a beam at the (2900) cm^{-1} frequency that returns to the $\nu(\text{C-H})$ aliphatic. In the spectra of complexes, this beam appeared at frequencies between (2852-2961) cm^{-1} . Also, a beam appeared at the (3061) cm^{-1} frequency that goes back to (C-H)⁽¹⁵⁾ Aromatics and in the spectra of complexes appeared at the frequencies (3059-3062) cm^{-1} .

**Fig. 2.** IR-spectra of the Ligand

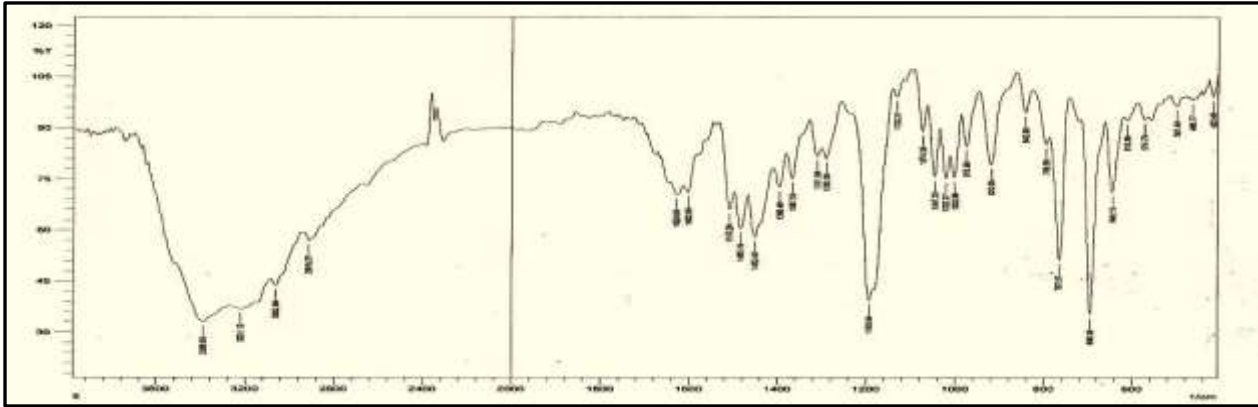


Fig. 3. IR-spectra of Co (II) complex

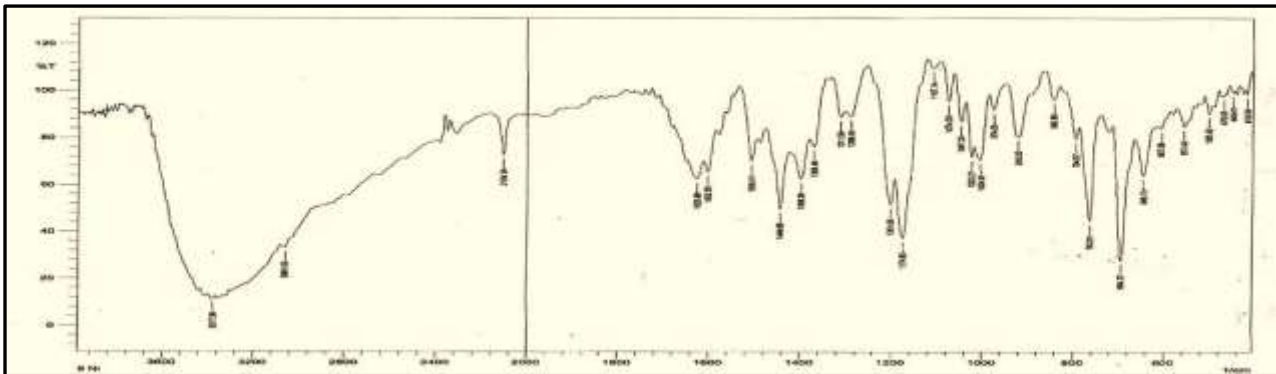


Fig. 4. IR-spectra of Ni (II) complex

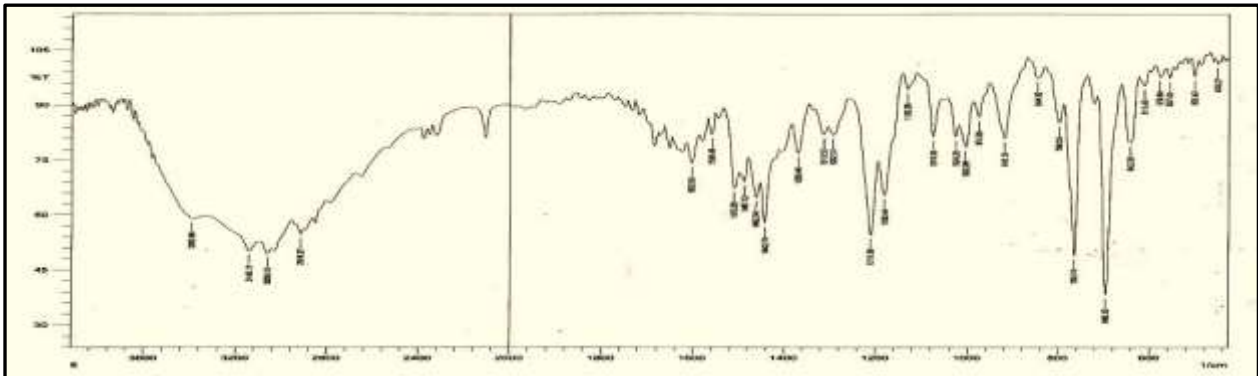


Fig. 5. IR-spectra of Cu (II) complex

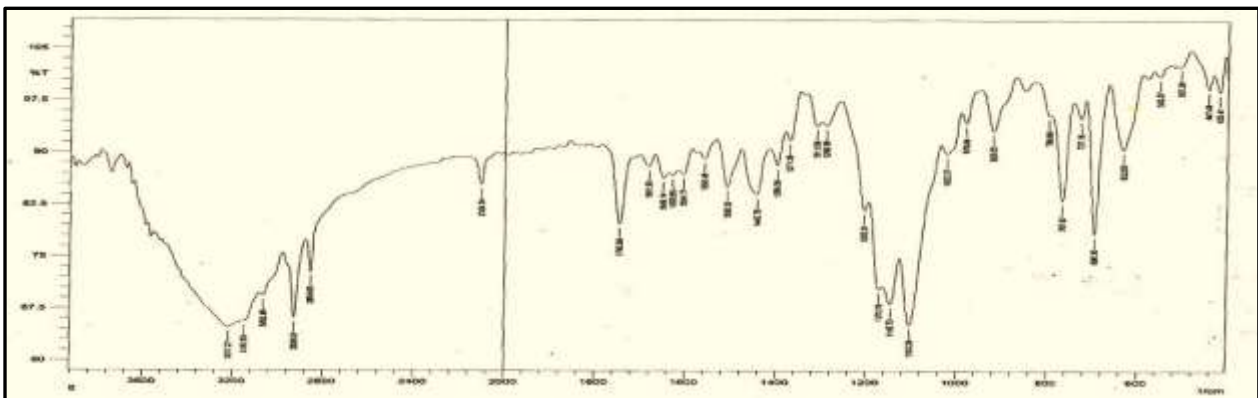


Fig. 6. IR-spectra of Zn (II) complex



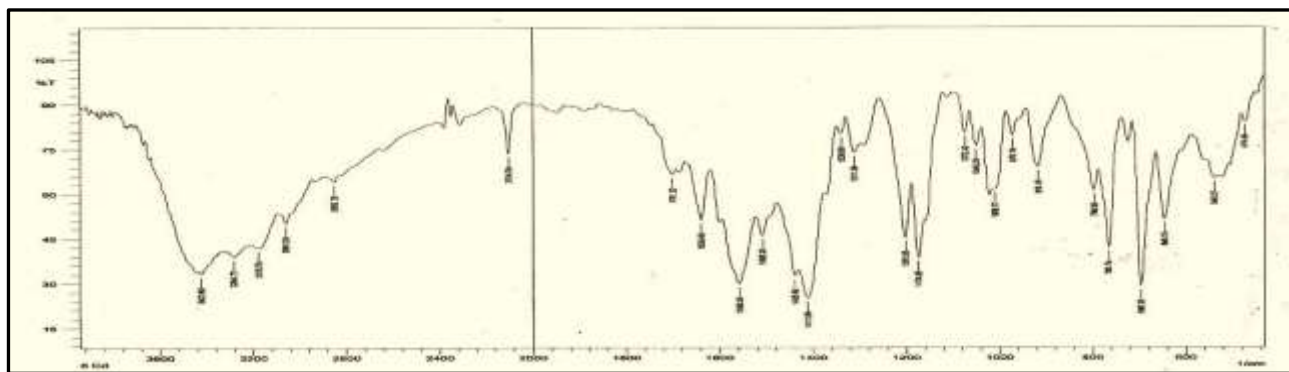


Fig. 7. IR-spectra of Cd (II) complex

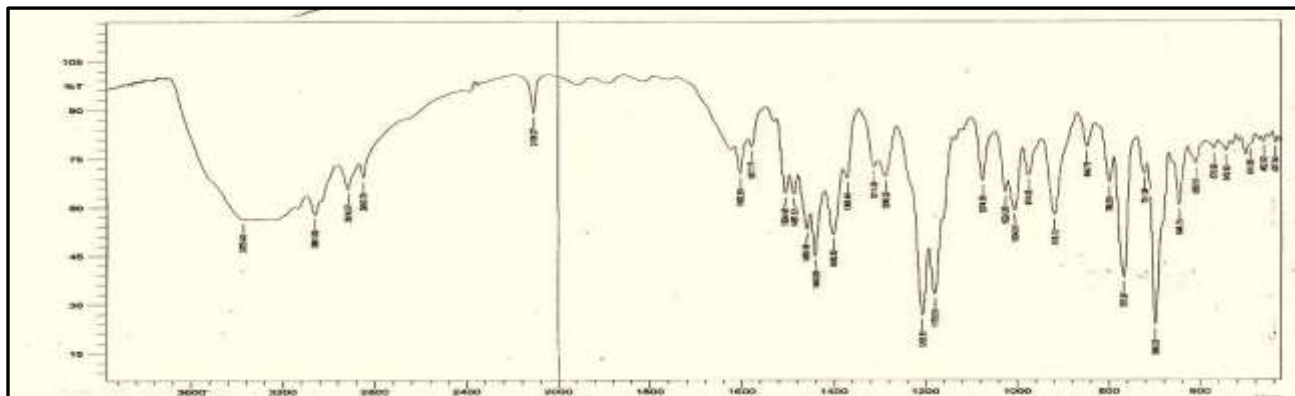


Fig. 8. IR-spectra of Hg (II) complex

Magnetic Susceptibility

The results of the magnetic sensitivity measurements are listed in the table (3) where the magnetic moment value of the Co(II) Complex is (4.35 B.M). This is consistent with the result of octahedral cobalt complex high twisting (t_{2g}, e_g)⁽¹⁶⁾. As for the Ni(II) Complex its magnetic moment value reached (3.24 B.M). This corresponds to the magnetic moment values of the octahedral Nickel complex and indicates the presence of the para magnetic characteristic ⁽¹⁷⁾. The value of the magnetic moment of the Cu(II) Complex reach (1.78B.M), which indicates the presence of the paramagnetic characteristic resulting from the presence of a single electron for the Cu(II) ion in its complexes⁽¹⁸⁾. As for the complexes of both Zn(II),Cd(II) and Hg(II) they have shown Di magnetic properties due to the fullness of the plane (nd) in the electrons⁽¹⁹⁾.

Measurement of Molar Conductivity

From the results obtained, it is clear that the molar electrical conductivity measurements for solutions of canine complexes of ions under study with the ligand and with concentration of (1×10^{-3}) molar per

complex at the laboratory temperature and using ¹⁰² ethanol, which ranged from (8.64-13.38S. $cm^2 \cdot mol^{-1}$) and listed in table (3), We find the lack of ionic properties of all these complexes. These results are identical to what was stated in the literature for metallic complexes devoid of ionic properties ⁽²⁰⁾.

Table 3. Molar conductivity and Magnetic susceptibility values for ligand (DIDPEO) complexes in ethanol

compounds	μ_{eff} (B.M)	Λ_M (S. $cm^2 \cdot mol^{-1}$)
[Co(C ₂₃ H ₁₉ N ₅ O) ₂ Cl ₂]	3.56	12.31
[Ni(C ₂₃ H ₁₉ N ₅ O) ₂ Cl ₂]	2.73	10.57
[Cu(C ₂₃ H ₁₉ N ₅ O) ₂ Cl ₂]	1.78	8.64
[Zn(C ₂₃ H ₁₉ N ₅ O) ₂ Cl ₂]	Dia	12.27
[Cd(C ₂₃ H ₁₉ N ₅ O) ₂ Cl ₂]	Dia	11.42
[Hg(C ₂₃ H ₁₉ N ₅ O) ₂ Cl ₂]	Dia	13.38

Electronic Spectra

The electronic spectra of ligand and its solid metal complexes recorded (d-d) type electronic transitions and charge transfer peak, and the ndlga spectrum showed two absorption peaks at the frequency (302nm)(33112 cm^{-1}) and (454nm) (22026 cm^{-1})⁽²¹⁾. The cobalt (II) complex also showed three permissible transmission beams in Ramahith, that the spectrum did not show the first



beam clearly, while the second package appeared at the (732nm)(13661cm⁻¹) and third at the (468nm)(21367cm⁻¹) frequency did this gives this octahedral shape of the cobalt complex⁽²²⁾. The nickel (II) complex spectrum also showed three primary absorption at frequency (977nm) (10235cm⁻¹) and second at frequency (855nm) (11694cm⁻¹), while the third at frequency (483nm)(20703cm⁻¹) these beams are within the ranges indicated in the literature⁽²³⁾. The confirms that the nickel complex takes the octahedral shape. As for the octahedral copper complex spectrum, it showed three absorption beams, the first at frequency (976nm)(10245cm⁻¹)⁽²⁴⁾, the second at

frequency (884nm) (11312cm⁻¹)and the third at frequency(518nm)(19305cm⁻¹) and this indicates that the copper complex took the octahedral shape deformed. As for electronic spectrum of the complex zinc, cadmium and binary mercury with ligand, it does not possess type (d-d) electronic transmissions because of the fullness of the five (d) orbitals. As new bundles appeared in the metal ion complexes that were not visible in the ligand spectrum, this indicates the consistency of the metal ion with ligand due to the charge transfer (C.T)⁽²⁵⁾.

Table 4. Shows the electronic spectra of ligand and its metal complexes in ethanol solvent

Compound	Assignment	Absorption band(cm ⁻¹)	Proposed Structure
L=(C₂₃H₁₉N₅O)	n→π* charge transfer	33112 22026
[Co(C₂₃H₁₉N₅O)₂Cl₂]	⁴ T _{1g} → ⁴ T _{2g} ⁴ T _{1g} → ⁴ A _{2g} ⁴ T _{1g} → ⁴ T _{1g} 13661 21367	oh
[Ni(C₂₃H₁₉N₅O)₂Cl₂]	³ A _{2g} → ³ T _{2g} ³ A _{2g} → ³ T _{1g} ³ A _{2g} → ³ T _{1g}	10235 11694 20703	oh
[Cu(C₂₃H₁₉N₅O)₂Cl₂]	² B _{1g} → ² A _{1g} ² B _{1g} → ² B _{2g} ² B _{1g} → ² E _g	10245 11312 19305	oh
[Zn(C₂₃H₁₉N₅O)₂Cl₂]	C.T		oh
[Cd(C₂₃H₁₉N₅O)₂Cl₂]	C.T		oh
[Hg(C₂₃H₁₉N₅O)₂Cl₂]	C.T		oh

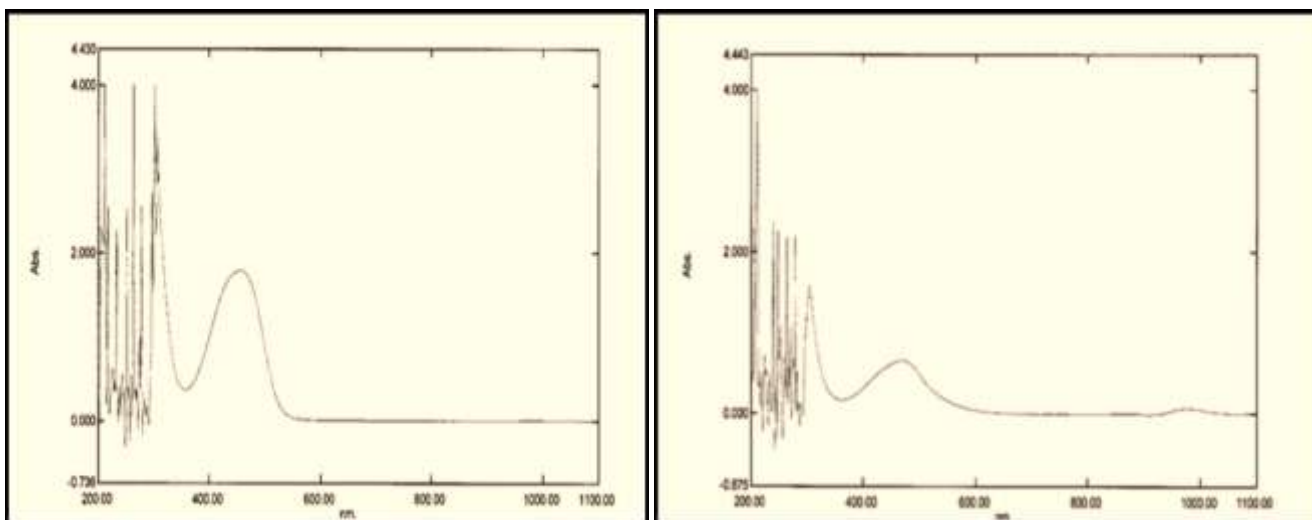


Fig. 9. UV-Vis spectra of Ligand Fig (10): UV-Vis spectra of Co (II)



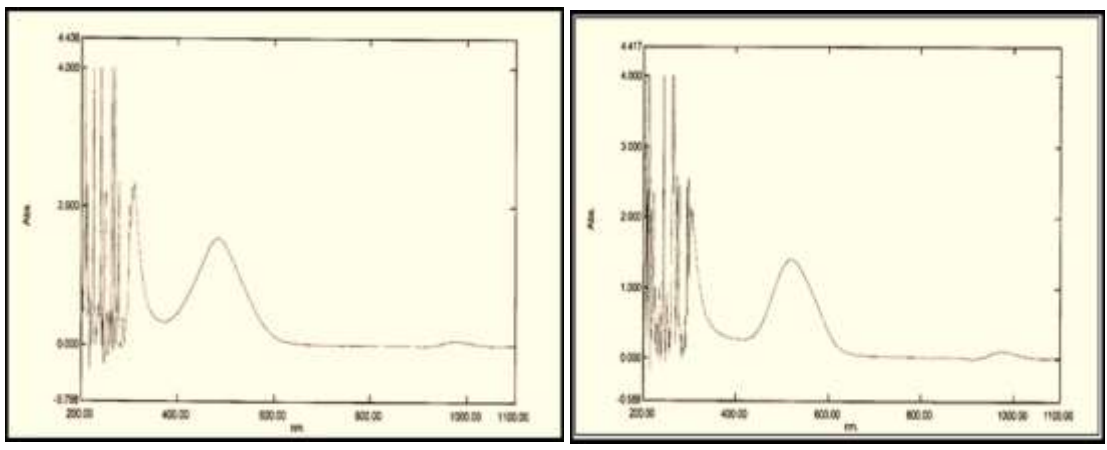


Fig. 11. UV-Vis spectra of Ni (II) Fig (12): UV-Vis spectra of Cu (II)

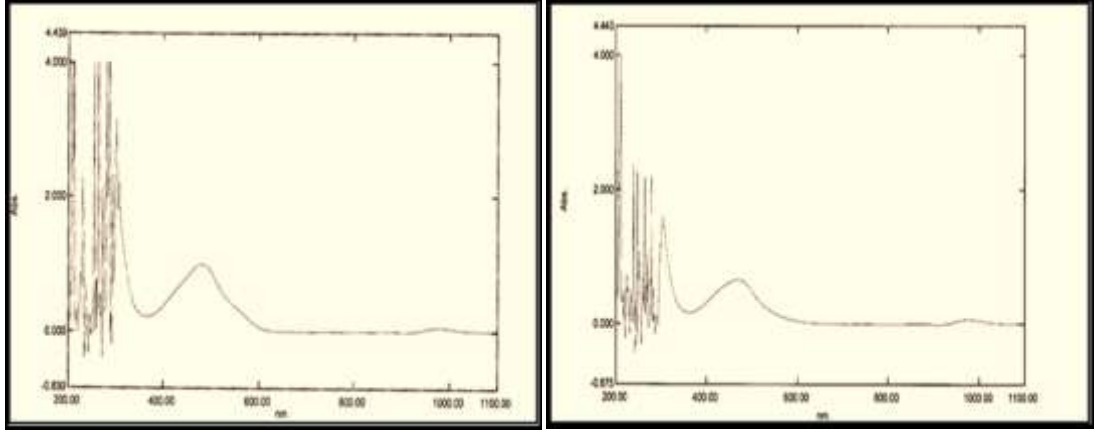


Fig. 13. UV-Vis spectra of Zn (II) Fig (14): UV-Vis spectra of Cd (II)

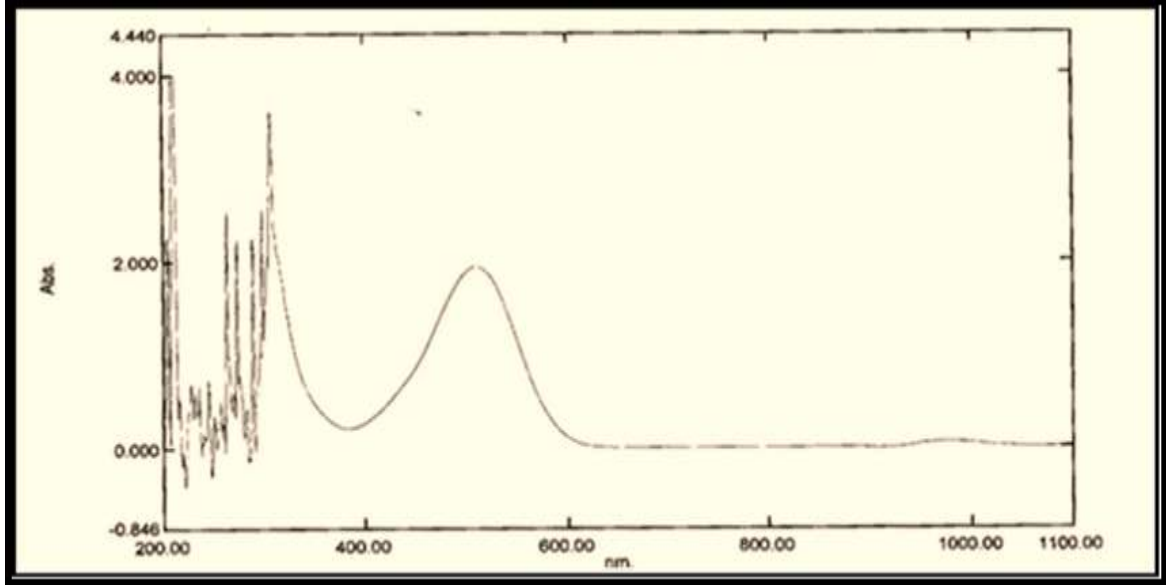


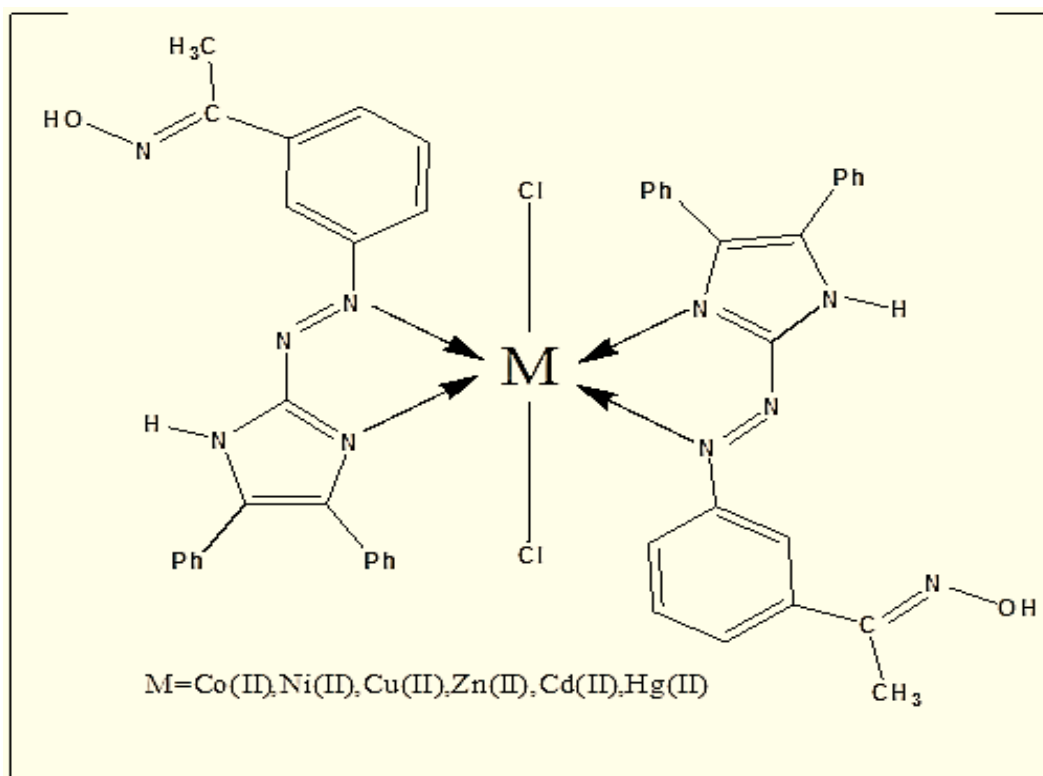
Fig. 15. UV-Vis spectra of Hg (II)

Space Shape

From the results reached it is possible to propose the octahedral form of all metal complexes with

ligand (DIDPEO). The spatial shape of metallic complexes can be illustrated in the following manner.





References

- Hdzbecher Z, Divis L, Kral M, Sucha L, Vlácil F. *Hand Book of Organic Reagent in Inorganic Analysis*. Ellis Horwood Ltd., Chichester 1976: 691.
- Varaprasad DVPR, Mahadevan V. Use of cyclohexanone oxime as an oxidant in redox polymerization: Kinetics of oxidation and polymerization. *Journal of Polymer Science Part A: Polymer Chemistry* 1986; 24(12): 3279-3290.
- D. Bravo-Díaz, C. *Diazo hydroxides, Diazoethers and Related Species*. In Rappoport, Zvi (ed.), *PATAI's Chemistry of Functional Groups*, John Wiley & Sons, Ltd, 2010. <http://doi.org/10.1002/9780470682531.pat0511>.
- Carey FA. *Advanced organic chemistry*. Sundberg, Richard J. (5th ed.). New York: Springer 2007.
- Streitwieser Jr A, Schaeffer WD. Stereochemistry of the Primary Carbon. VI. The Reaction of Optically Active 1-Aminobutane-1-d with Nitrous Acid. Mechanism of the Amine-Nitrous Acid Reaction. *Journal of the American Chemical Society* 1957; 79(11): 2888-2893.
- Friedman L, Jurewicz AT, Bayless JH. Influence of solvent on diazoalkane-alkyldiazonium ion equilibria in amine deaminations. *Journal of the American Chemical Society* 1969; 91(7): 1795-1799. <http://doi.org/10.1021/ja01035a032>.
- Norman ROC. (Richard Oswald Chandler) (2017). *Principles of Organic Synthesis (3rd ed.)*. CRC Press.
- Al-Soud YA, Al-Dwari MN, Al-Masoudi NA. Synthesis, antitumor and antiviral properties of some 1, 2, 4-triazole derivatives. *Il Farmaco* 2004; 59(10): 775-783. <http://doi.org/10.1016/j.farmac.2004.05.006>.
- Filimonov VD, Trusova M, Postnikov P, Krasnokutskaya EA, Lee YM, Hwang HY, Chi KW. Unusually stable, versatile, and pure arenediazonium tosylates: their preparation, structures, and synthetic applicability. *Organic letters* 2008; 10(18): 3961-3964.
- UK CRHF Incident Report – Supersaturated Diazonium salt causes Fatality. UK Chemical Reaction Hazards Forum 2010.
- Kadhium AJ, Hussein AAA, Mahmood DN. Invention of Imidazole & Thiazole-Sulfazane Ligands (Synthesis, Spectral Investigation, Microbial. *International Journal of Pharmaceutical Research* 2020; 12(2): 989-998.
- Peter WA. *Julio de Paula: Physikalische Chemie, Auflage*. Wiley-VCH, Weinheim 2006: 106-108.
- Bailey EM, Krakovsky DJ, Rybak MJ. The triazole antifungal agents: a review of itraconazole and fluconazole. *Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy* 1990; 10(2): 146-153.
- Bourgeois I, Pestel-Caron M, Lemeland JF, Pons JL, Caron F. Tolerance to the glycopeptides vancomycin and teicoplanin in coagulase-negative staphylococci. *Antimicrobial agents and chemotherapy* 2007; 51(2): 740-743.
- Lozynskiy A, Zsidko V, Atamanyuk D, Kaminsky D, Derkach H, Karpenko O, Lesyk R. Synthesis, antioxidant and antimicrobial activities of novel thiopyrano [2, 3-d] thiazoles based on aroylacrylic acids. *Molecular Diversity* 2017; 21(2): 427-436.
- Lozynskiy A, Zimenkovsky B, Nektogayev I, Lesyk R. Arylidene pyruvic acids motif in the synthesis of new thiopyrano [2, 3-d] thiazoles as potential biologically active compounds. *Heterocyclic Communications* 2015; 21(1): 55-59.



- Zelisko N, Karpenko O, Muzychenko V, Gzella A, Grellier P, Lesyk R. Trans-Aconitic acid-based hetero-Diels-Alder reaction in the synthesis of thiopyrano [2, 3-d][1, 3] thiazole derivatives. *Tetrahedron Letters* 2017; 58(18): 1751-1754. <http://doi.org/10.1016/j.tetlet.2017.03.062>.
- Zelisko NI, Finiuk NS, Shvets VM, Medvid YO, Stoika RS, Lesyk RB. Screening of spiro-substituted thiopyrano [2, 3-d] thiazoles for their cytotoxic action on tumor cells. *Biopolymers and Cell* 2017; 33(4): 282-290. <http://doi.org/10.7124/bc.00095A>.
- Kadhim AJ, Mohammed JH, Aljamali NM. Thiazole Amide Derivatives (Synthesis, Spectral Investigation, Chemical Properties, Antifungal Assay). *NeuroQuantology* 2020; 18(1): 16-25. <http://doi.org/10.14704/nq.2020.18.1.NQ20102>.
- Yang XM, Philipp S, Downey JM, Cohen MV. Atrial natriuretic peptide administered just prior to reperfusion limits infarction in rabbit hearts. *Basic research in cardiology* 2006; 101(4): 311-318.
- Yi M, Schultz DE, Lemon SM. Functional significance of the interaction of hepatitis A virus RNA with glyceraldehyde 3-phosphate dehydrogenase (GAPDH): opposing effects of GAPDH and polypyrimidine tract binding protein on internal ribosome entry site function. *Journal of Virology* 2000; 74(14): 6459-6468.
- Yost C, Torres M, Miller JR, Huang E, Kimelman D, Moon RT. The axis-inducing activity, stability, and subcellular distribution of beta-catenin is regulated in *Xenopus* embryos by glycogen synthase kinase 3. *Genes & development* 1996; 10(12): 1443-1454.
- Jury EC, Kabouridis PS, Abba A, Mageed RA, Isenberg DA. Increased ubiquitination and reduced expression of LCK in T lymphocytes from patients with systemic lupus erythematosus. *Arthritis & Rheumatism* 2003; 48(5): 1343-1354.
- Anand-Srivastava MB. Atrial natriuretic factor receptors and signal transduction mechanisms. *Pharmacological Reviews* 1993; 45: 455-497.
- Benford HL, McGowan NWA, Helfrich MH, Nuttall ME, Rogers MJ. Visualization of bisphosphonate-induced caspase-3 activity in apoptotic osteoclasts in vitro. *Bone* 2001; 28(5): 465-473.
- Berry MD. Glyceraldehyde-3-phosphate dehydrogenase as a target for small-molecule disease-modifying therapies in human neurodegenerative disorders. *Journal of Psychiatry and Neuroscience* 2004; 29(5): 337-345.
- Bhattacharya SK, Chakrabarti A, Sandler M, Glover V. Effects of some anxiogenic agents on rat brain monoamine oxidase (MAO) A and B inhibitory (tribulin) activity. *Indian journal of experimental biology* 1996; 34(12): 1190-1193.
- Namiot V, Shchurova L. On quantum-mechanical measurements and processes of development of intelligence. *NeuroQuantology* 2019; 17(9): 1-8. <http://doi.org/10.14704/nq.2019.17.9.NQ19101>
- Obies OJ, Mutar MA, Kadhim RG. Synthesis and characterizations of polyaniline/nylon(6) composites, electrical properties and thermal stability. *NeuroQuantology* 2019; 17(11): 26-33. <http://doi.org/10.14704/nq.2019.17.11.NQ19113>

