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Preparation, Spectroscopic Study, and Bacterial Activity of Some Metal (II) Complexes with (3-(4-benzoylphenyl) imino) Indolin-2-one Ligand.

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Abstract

The research involves the preparation of a new bidentate Schiff base, 3-(4-benzoyl phenyl imino) indolin-2-one, through the condensation reaction of isatin with 4-amino benzophenone in the presence of glacial acetic acid as a co-agent. The donor atoms (O, N) in the ligand impart a bidentate property, and the complexes were prepared by reacting the ligand (BI=C21H14N2O2) with various chlorides of transition metals, Co^{2+}, Ni^{2+}, Cu^{2+}, and Cd^{2+}, in molar ratios of (1:1) and (2:1) metal:ligand to form complexes with general formulas $[M(BI)_2Cl_2]$ and $[M(BI)Cl_2]$. The ligand and the prepared complexes were characterized by several methods, including physical (melting point and electrical conductivity) and spectral measurements, such as Fourier-transform infrared (FT-IR) spectra, proton nuclear magnetic resonance (^{1}H NMR) spectra, and ultraviolet-visible (UV-Vis) spectra. Magnetic moment measurements and detailed elemental analysis (C, H, N) were performed, along with determining the metal content through atomic absorption technique. All these measurements indicated that the formula $[M(BI)_2Cl_2]$ produced octahedral complexes, while the complexes with the formula $[M(BI)Cl_2]$ exhibited tetrahedral shapes. The biological activity of the ligand and all prepared complexes was evaluated by studying the inhibitory effect on the growth of two different types of Gram-positive and Gram-negative bacteria using the disc diffusion method.

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تحضير ودراسة طيفية وفعالية بكتيرية لمعقدات بعض الفلزات ثنائية التكافؤ مع الليكاند (٣- (٤- بنزويل فنيل) ايمينو) اندولين-٢- ون

زينة أسامة جاسم
جامعة الموصل / كلية التربية للبنات / قسم الكيمياء

الخلاصة

يتضمن البحث تحضير قاعدة شيف جديدة ثنائية السن (٣ - (٤-بنزويل فنيل ايمينو)اندولين-٢-ون من خلال التفاعل التكثيفي للايساتين مع ٤- امينو بنزوفينون بوجود حامض الخليك الثلجي كعامل مساعد، وقد اعطت الذرات المانحة (O,N) في الليكاند خاصية ثنائي السن حيث تم تحضير المعقدات من خلال تفاعل الليكاند ($BI=C_{21}H_{14}N_2O_2$) المحضر مع كلوريدات مختلفة لبعض العناصر الانتقالية Co^{+2},Ni^{+2},Cu^{+2},Cd^{+2} بنسب مولية (1:1) و(2:1) فلز :ليكاند لتكوين معقدات ذوات الصيغ العامة$[M(BI)Cl_2]$,$[M(BI)_2Cl_2]$ وتم تشخيص الليكاند والمعقدات المحضرة بعدة طرق منها فيزيائية (درجة الانصهار والتوصيلية الكهربائية) والقياسات الطيفية و منها اطياف الاشعة تحت الحمراء FT-IR وطيف الرنين النووي المغناطيسي ^1HNMR وطيف الاشعة فوق البنفسجية المرئية UV-Vis . كما أجريت قياسات العزوم المغناطيسية وتحليل الدقيق للعناصر (C.H.N) وتعيين المحتوى الفلزي من خلال تقنية الامتصاص الذري وبينت جميع هذه القياسات ان الصيغة $[M(BI)_2Cl_2]$ أعطت معقدات ثمانية السطوح بينما أظهرت المعقدات ذات الصيغة $[M(BI)Cl_2]$ اشكال رباعية السطوح .كما تم قياس الفعالية البايولوجية لليكاند وجميع المعقدات المحضرة من خلال دراسة التأثير التثبيطي لنمو نوعين مختلفين من البكتريا الموجبة والسالبة لصبغة كرام بطريقة الانتشار بالاقراص.

الكلمات المفتاحية: قاعدة شيف; ٤- أمينو بنزوفينون; معقدات الإيساتين; النشاط البيولوجي; هيئات ثمانية ورباعية السطوح.

Introduction

Schiff base ligands are consider a key point in the development of inorganic chemistry, bioinorganic chemistry, and optical materials (Focsa et al., 2023, 71; Jabeen et al., 2022, 663). These compounds have a significant role in the development of coordination chemistry (Surendar et al., 2023, 107; Alorini et al., 2022, 15) .

Recently, the isatin and its derivatives have played a key role in biomedical applications. Many reports show that Schiff bases ligands derived from isatin and its derivatives have shown wide area in an important biological activity such as antimicrobial, antibacterial, antimalarial, anti-inflammatory, antiviral, enzyme inhibitors, anticonvulsant, herbicidal, anticancer, and other biological activities (El-Serwy et al., 2020, 113; Aziz et al., 2020, 15; Bulatov et al., 2018, 103; Ezekwem et al., 2018, 7).

Isatin possess an indole ring structure, which has an influencing role in heterocyclic ring systems, common to many pharmaceuticals and heterocyclic natural products of biological interest. These materials have also been used in the preparation of metal complexes (Aziz et al., 2020, 15; Bulatov et al., 2018, 103; Ezekwem et al., 2018, 7; Devi et al., 2018, 121; Bekircan et al., 2008, 26).

Schrauzer and Windgassen show that metals complexes might observe conducting properties in 1967 (Schiffnya, 2012,18). In 2011 (Schiffnya, 2012,18), valli and Vinnarasi synthesized a series of complexes of Mn (II), Co (II), Ni (II), Cu (II), Zn (II), and Cd (II). The authors characterize the complexes in the light of spectral studies like IR, UV, and ^{1}H-NMR. Moreover, they showed the antibacterial activity of the complexes. In modern studies (DOĞAN et al., 2019, 67), Isatin-Schiff base complexes (Ni, Co, and Cu) have been synthesized by Dong, etc. they have employed the complexes in photocatalytic applications in order to reduce carbon dioxide (CO_2).

The current paper aims to synthesis and characterize new transitions metals complexes of Schiff base derived from isatin and 4-amino benzophenone. The complexes have been synthesized using various metal ions (Co^{+2}, Ni^{+2}, Cu^{+2}, and Cd^{+2}) with isatin and 4-amino benzophenone.

Materials and Methods

All compounds have been used as supplied by Fluka or Aldrech Companies. Melting points have been carried out using the Stuart SMP30 melting point apparatus. Conductivity measurements of all complexes are record on a 10^{-3}M solution in DMF using Lovibond Con200.The magnetic susceptibility measurements have been carried out by Sherwood Scientific, Cambridge, UK. Infrared spectra of the ligand and all complexes were recorded on a Shimadzu FT−IR using KBr pellets at 400–4000 cm^{-1}. The electronic spectra have been made by a T80 UV/VIS Spectrometer, The elements contents have determined a spectrophotometric method by using atomic absorption spectroscopy type Shimadzu Atomic Absorption Spectrometer. All of the above measurements were conducted at the College of Education for Pure Sciences, University of Tikrit. The ^{1}HNMR of ligand (BI) and complex (7) have been recorded at room temperature with the Bruker DRX system at 400 MHz using TMS as an internal standard in DMSO-d6 at the College of Science, University of Basra. An accurate analysis of the C.H.N elements has been carried out for all the prepared compounds using the American-made Eager300Summarize device.

The antibacterial activity against two types of bacteria have been provided by the department of biology at the College of Science at the University of Mosul.

Synthesis of Ligand

(1mmol ,0.147g) of isatin is dissolved in 20 ml of ethanol at room temperature. After a few minutes of stirring at hot water bath, (1 mmol,0.197g) of 4-aminobenzone has been added gradually drop by drop to the ethanolic solution in the presence of three drops of glacial acetic acid, The reaction mixture was boiled under reflux for (7-8) h and has been colle in ice bath , the product has been filtered, washed with ethanol and dried (Saeed et al., 2024, 103; Abed Janabi et al., 2022, 193; Sujeshwari et al., 2020, 11; Waddai et al., 2018, 34; Hadi, 2013, 27).The chemical reaction equation for the synthesis is given in Figure1.

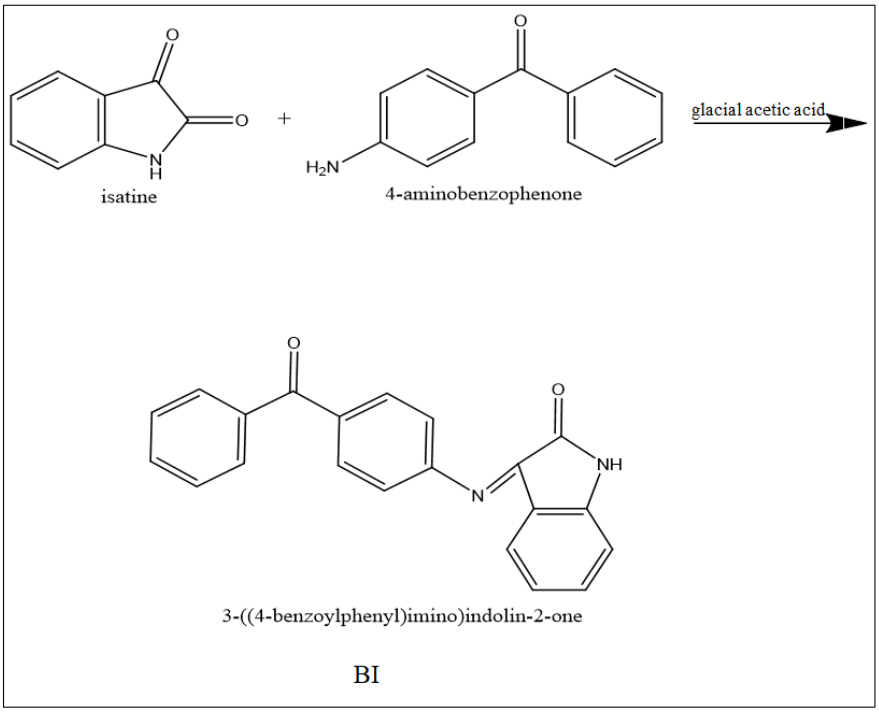


Figure1:Synthesis of ligand BI

Synthesis of Complexes

Add 1 mmol of the metal salts [$CoCl_2.6H_2O$ (0.237g), $NiCl_2.6H_2O$ (0.237g), $CuCl_2.2H_2O$ (0.134g), and $CdCl_2$ (0.138g)] dissolved in the smallest possible amount of ethanol to (0.326 g/1 mmol) and (0.625 g/2 mmol) of the prepared ligand dissolved in ethanol to prepare the complexes at a molar ratio of 1:1 and 1:2.

Then, the mixture is heated under continuous stirring for 3 hours at room temperature, colored precipitates will be obtained. Later, they are filtered off, washed with ethanol, and dried (Waddai et al., 2018, 34; Hadi, 2013, 27).

Results and Discussion:

The prepared complexes were colorful and stable at room temperature. The complexes have been soluble in DMSO and DMF and insoluble in water, methanol and ethanol. Melting points and elemental analysis confirm the compound's expected molecular composition. It is demonstrated through molar conductivity measurements of the prepared complexes, with a concentration of 10^{-3}M and the use of dimethyl formamide (DMF) solvent when the solution is in thermal equilibrium at a temperature of (25°C), that the complexes are consistent with the proposed synthetic formulas and that the complexes fall within the neutral, non-electrolytic (Chandra et al., 2008, 16) . The results are shown in Table1

Table 1: Evaluation of the physical properties and particular analysis of the elements and percentages of the prepared ligands and complexes

Code	Compound	M.wt	Yield %	m.p (C°)	Colour	C%	H%	N%	M%	Λin (DMF) $cm^2.ohm^{-1}.mol^{-1}$
BI	$C_{21}H_{14}N_2O_2$	326.36	80	164	Dark orange	3.68)3.21(	0.31 (0.26)	4.29 4.17	----	----
1	$[Co(BI)_2CI_2]$	782.65	75	108-110	Brown	1.54)1.26(	0.13 (0.34)	1.79 (1.34)	7.53 (8.02)	11
2	$]Co(BI)CI_2[$	456.29	82	316-318	Dark brown	2.63)2.45(	0.22 (0.37)	3.07 (2.85)	12.93 (11.87)	21
3	$]Ni(BI)_2CI_2[$	782.41	85	336*	Reddish orange	1.54 (1.47)	0.13 (0.29)	1.79 (1.46)	7.50 (6.26)	16
4	$]Ni(BI)\ CI_2[$	456.05	80	350*	Pale Orange	2.63 (2.21)	0.22 (0.45)	3.07 (2.66)	12.87 (13.56)	32
5	$]Cu(BI)_2CI_2[$	786.72	78	186-188	Light orange	1.53 (1.82)	0.13 (0.27)	1.78 (1.52)	8.08 (7.67)	29
6	$]Cu(BI)CI_2[$	460.81	70	257-260	Olive	2.61 (2.82)	0.22 (0.37)	3.04 (2.87)	13.79 (14.05)	23
7	$[Cd(BI)_2Cl_2]$	835.95	76	275*	Dark brown	1.44 (1.23)	0.12 (0.97)	1.68 (1.83)	13.45 (14.46)	4
8	$]Cd(BI)CI_2[$	509.59	82	298*	Brown	2.36 (2.21)	0.18 (1.05)	2.75 (2.53)	24.39 (23.45)	23

*Decomp.Temp

Infrared Spectra (I.R)

The IR spectra of the ligand and their transition metal complexes have been measured in the range (400-4000) cm^{-1}. The most important IR data from the spectra of those compounds is tabulated in Table 2. The IR study of the

complexes has been compared with that of the free ligand prepared in order to determine the coordination sites in the complexes .

In the IR data of the ligand, the absorptions in the 1618, 1681, 1730, and 3191 cm^{-1} regions have been attributed to the azomethine group ν(C=N), ν(C=O) amide, ν(C=O) amine, and νNH amide vibrations (El-Serwy et al., 2020, 113; Schiffnya, 2012,18; Valli et al., 2011, 273; Singh et al., 2012, 19), respectively.

In the IR data of all transition metal complexes, ν(C=N) is shifted to lower frequencies at (1600-1606) cm^{-1}, suggesting coordination through the nitrogen. The shifting to lower frequencies of ν(C=O) amide(1652-1658)cm^{-1} in all the complexes suggests bonding through oxygen of the carbonyl amide group (HN-C=O) (Sujeshwari et al., 2020, 11; Waddai et al., 2018, 34; Singh et al., 2012, 19; Alkam et al., 2021, 12).

The groups ν(C=O) amine and ν(NH) amide in the IR spectra of complexes appear at the same position in the ligand, indicating the uncoordination oxygen of the carbonyl and the nitrogen amide in the complex formation (Schiffnya, 2012,18; Waddai et al., 2018, 34; Singh et al., 2012, 19; Alkam et al., 2021, 12; Palaniammal et al., 2022, 67).

The presence of new vibrations is observed ν(M-O) and ν(M-N) in the complexes (520-599) and (416-478) cm^{-1}, respectively, which clearly indicates that the oxygen of amide and nitrogen of azomethane with metals are in coordination (Singh et al., 2012, 19; Abdulghani and Ahmed, 2011, 100). These bands are not observed in the IR spectra of free ligand.

Table 2: Stretching vibrations of active groups of prepared ligands and complexes

NO.	ν(C=N)	ν(C=O) amide	ν(C=O) amine	ν(N-H)	ν(C-H) aromate	ν(M-N)	ν(M-O)
L_1	1618	1681	1730	3191	3031	-------	----------
1	1606	1658	1730	3193	2975	478	550
2	1600	1652	1733	3191	2815	476	599
3	1604	1658	1728	3195	2867 2972	420	555
4	1602	1656	1731	3190	3029	451	567
5	1604	1656	1732	3192	2993	416	520
6	1604	1652	1731	3189	2817 2920 2966	476	561
7	1602	1654	1728	3188	3056	445	535
8	1602	1656	1731	3190	3029	451	520

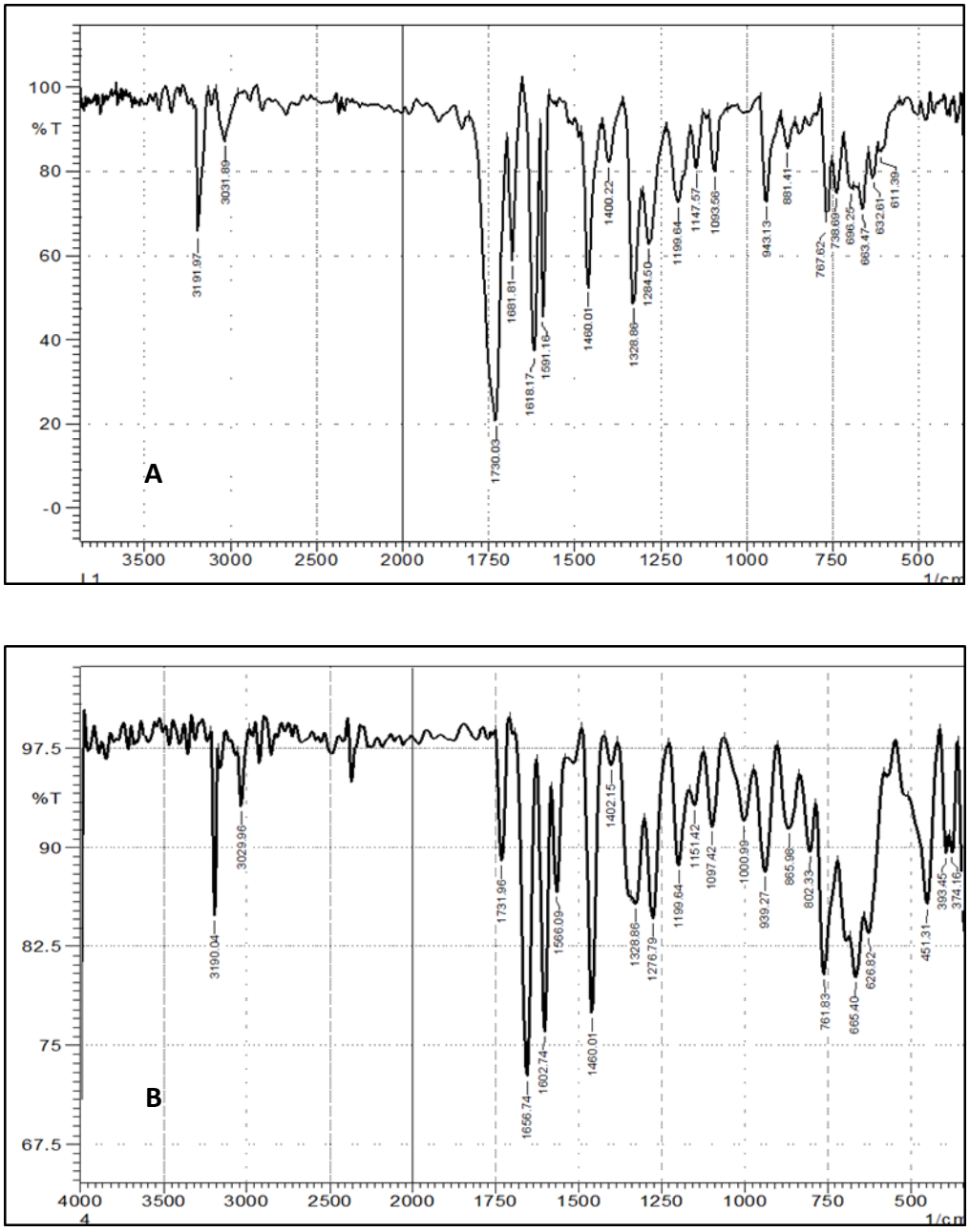


Figure 2: The FT-IR spectra of (A) ligand and (B) complexes (7) [Cd $(BI)_2Cl_2$]

Electronic spectra

The electronic spectra of the prepared ligand and complexes are measured using the solvent dimethyl formamide at a concentration of 10^{-3}M at a temperature of 25 °C, showing the appearance of two absorption bands of the ligand n→π* at

33222 cm^{-1} and π→π* at 35842 cm^{-1} (Saeed and Jasim, 2024, 103; Jasim, 2011, 70; Rasheed, 2013, 1), as shown in Table 2.

The cobalt, nickel, and copper complexes 1, 3, and 5, respectively, have showed values of magnetic moments μeff of 4.6, 2.95 and 2.3, B.M. Complexes 1 and 3 have showed three absorbance bands, which are attributed to the d-d transition, while the copper complex 5 absorption band is in the range of 14750 cm^{-1}. In addition to the appearance of charge transfer bands in the three complexes, the values of the magnetic moments and electronic transitions indicate that all complexes have an octahedral geometry around the metal ions(Jasim, 2011, 70; Rasheed, 2013, 1; AL-Mukhtar and Th.aghwan, 2013, 59) , as shown in Table 3.

While the complexes 2, 4, and 6 of Co^{+2}, Ni^{+2}, and Cu^{+2} give values for the magnetic moments μeff of 4.2, 3.2, and 2.6, respectively, these complexes have showed a different absorption band, which is due to the d-d transitions additional charge transfer transitions (Saeed and Jasim, 2014, 103; Jasim, 2011, 70; Tawfik and Altayy, 2023, 708; AL-Mukhtar and Th.aghwan, 2013, 59), as shown in Table 3. These values suggest tetrahedral geometry for these complexes.

Cd (II) complexes 7 and 8 do not give any absorption bands belonging to the d-d electronic transitions (Saeed and Jasim, 2014, 103; Singh et al., 2012, 19; Tawfik and Altayy, 2023, 708), while giving one absorption band attributed to the charge transfer 30959 and 30497 cm^{-1}, respectively.

Complexes 7 and 8 showed diamagnetic properties because the cadmium element possessed a d^{10} shell in its electronic configuration, which was filled with electrons, which cause the absence of magnetic properties (Saeed and Jasim, 2014, 103; Singh et al., 2012, 19; Tawfik and Altayy, 2023, 708) .

Table 3: Values of magnetic moments and electronic transitions for complexes and prepared ligands

Comp. No	μeff (B.M.)	Bands (cm-1)	Transition	Geometric Shape
(BI)	-------	35842 33222	(π→π*) (n→ π*)	-------
1	4.6	13793 17182 25706 30909	$^4T_1g(F)\rightarrow{}^4T_2g(F)$ (υ_1) $^4T_1g(F)\rightarrow{}^4A_2g(F)$ (υ_2) $^4T_1g(F)\rightarrow{}^4T_1g(p)$ (υ_3) C.T	Octahedral
2	4.2	17185 31884 33112	$^4A_2(F)\rightarrow{}^4T_1(P)(\upsilon_3)$ C.T	Tetrahedral
3	2.95	11587 17482	$^3A_2g(F)\rightarrow{}^3T_2g(F)$ (υ_1) $^3A_2g(F)\rightarrow{}^3T_1g(F)$ (υ_2)	Octahedral

		26525 **33333**	**$^3A_2g(F)\rightarrow{}^3T_1g(p)(\upsilon_3)$** **C.T**	
4	**3.2**	**17361** **29069**	**$^3T_1(F)\rightarrow{}^3T_1(P)(\upsilon_3)$** **C.T**	**Tetrahedral**
5	**2.3**	**14705** **30769**	**$^2Eg\rightarrow{}^2T_2g$** **C.T**	**Octahedral**
6	**2.6**	**16853** **26059**	**$^2T_2(D)\rightarrow{}^2E(D)$** **C.T**	**Tetrahedral**
7	**Dia**	**28985** **31055**	**C.T**	**Octahedral**
8	**Dia**	**29069** **30959**	**C.T**	**Tetrahedral**

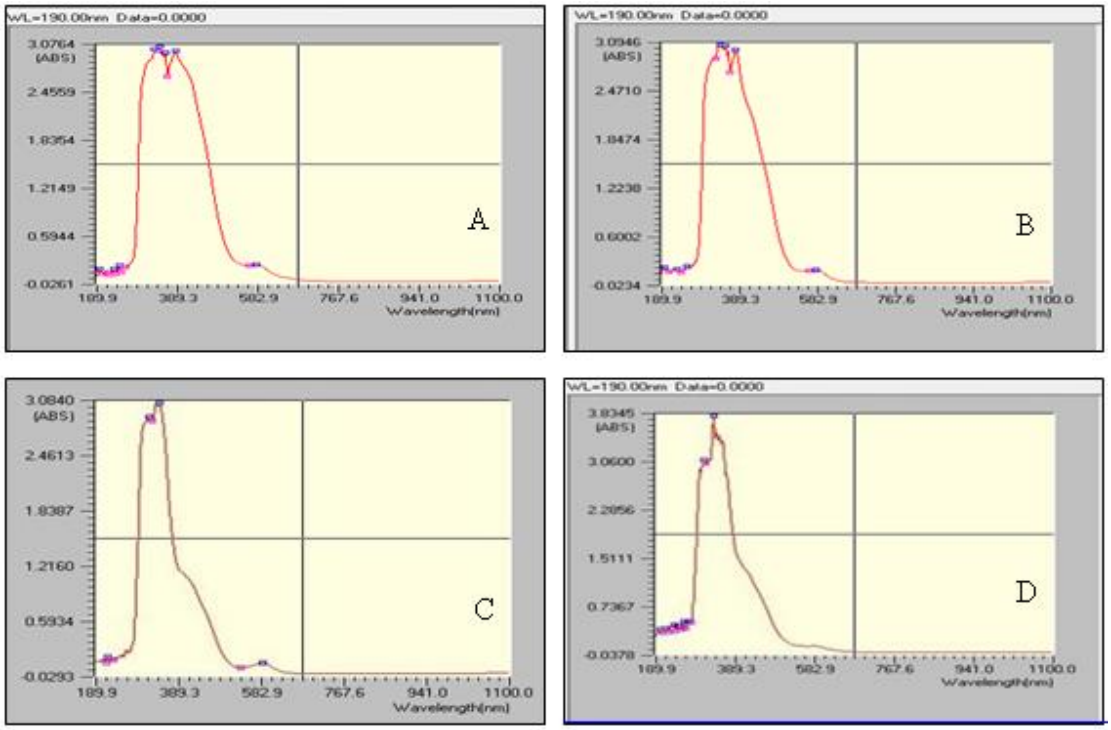


Figure 3: Electronic spectra of complexes (A) $[Co(BI)_2Cl_2]$, (B) $[Ni(BI)Cl_2]$, (C) $[Cu(BI)Cl_2]$, and (D) $[Cd(BI)_2Cl_2]$.

^{1}H NMR spectra

The ^{1}HNMR spectra of the ligand (BI) and complex (7) reveal different signals at chemical shift (δH6.2–7.70 and δH6.45-7.9) ppm correspondingly to the phenyl group protons (El-Serwy et al., 2020, 113; Singh et al., 2012, 19) . One signal has been observed for both the complex and the ligand, showing that the complex's proton is at a chemical shift of δH 11.07 and δH 11.06 ppm, respectively(El-Serwy et al., 2020, 113; Schiffnya, 2012,18) , for the amide group. This indicates that it is not coordinated with the central metal ion. The signals are shown in Figure 5 for the ligand and complex $[Cd(BI)_2Cl_2]$.

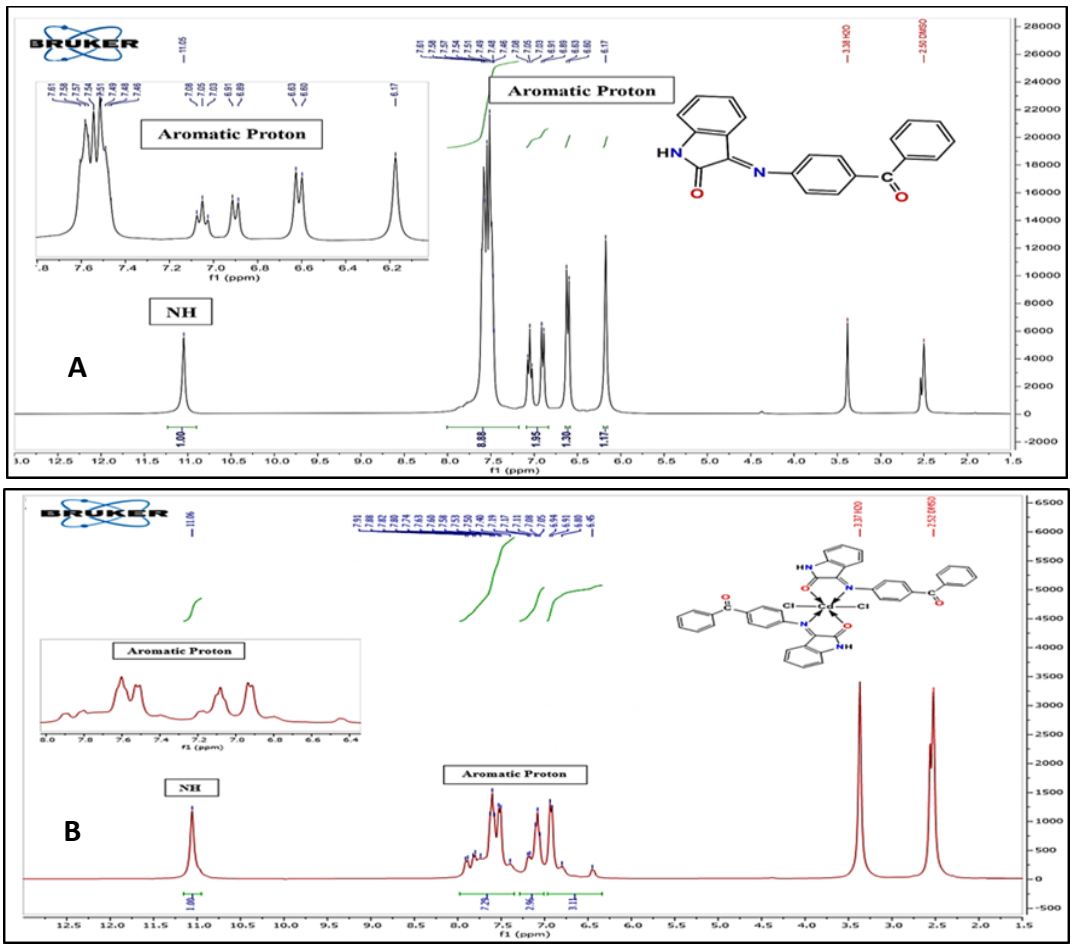


Figure 4:^{1}H-NMR spectra of (A) ligand (BI) and (B) complex[Cd $(BI)_2Cl_2$]

Biological activity

The biological activity of the prepared compound has been studied against two types of bacteria. The first type is a gram-negative bacteria (*Klebsillapneuomniae*), while the second type is a gram-positive bacteria (*Pseudomonas savastanoi)*.

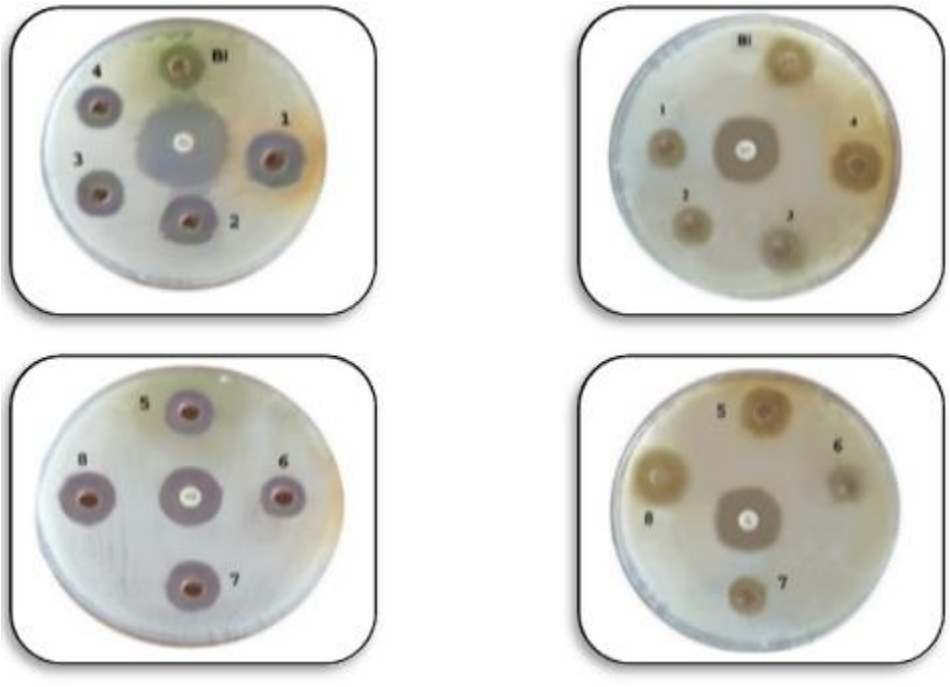
The study depends on making holes in the culture medium inside the dish, then scanning for bacteria and spreading them on the surface of the dish, and then leaving the dishes at 37 ˚C for 20 minutes to complete the impregnation process.

To measure the sensitivity of the studied compounds, following the preparation of a complicated solution at a concentration of 10 µg/ml and their dissolution in DMSO, 100 microliters have been inserted into the holes in the culture medium. In addition, the dishes were wrapped in a specialized incubator at 37 °C for 24 hours. The diameter of the dishes has been taped and measured with a ruler, to show how sensitive the chemicals under measurement are to the antibiotic ciprodar.

All compounds give an inhibitory effect on the types of bacteria used, but to a lesser extent than the control, as the complex $[Cd(C_{21}H_{14}N_2O_2)Cl_2]$ give the highest inhibition value compared to other complexes against *Pseudomonas savastanoi* bacteria (Singh et al., 2012, 19). While the $[Co(C_{21}H_{14}N_2O_2)\ Cl_2]$ complex have provided the maximum inhibition value related to other complexes against *Klebsiella pneumonia* (Ezekwem et al., 2018, 7; Devi et al., 2018, 121 Sujeshwari et al., 2020, 11; Ali et al., 2023, 39), the data on biological activity for the prepared compound are listed in Table 4.

Table 4: The diameters (or areas) of inhibition of the prepared ligands and complexes in millimeters for all compound solutions 10 µg/1 ml

Prepared Ligands and Complexes	***Klebsiella pneumoniae***	***Pseudomonas savastanoi***
Control	**34**	**22**
BI	**12**	**16**
$][Co(BI)_2Cl_2$	**22**	**13**
$] [Co(BI)Cl_2$	**21**	**14**
$] [Ni(BI)_2Cl_2$	**19**	**13**
$]Ni(BI)\ Cl_2[$	**17**	**18**
$]Cu(BI)_2Cl_2[$	**16**	**18**
$]Cu(BI)Cl_2[$	**15**	**12**
$] [Cd(BI)_2Cl_2$	**19**	**13**
$] [Cd(BI)Cl_2$	**19**	**20**



Pseudomonas savastanoi *Klebsiella pneumoniae*

Figure 5: The inhibitory effect of all the prepared compounds on the growth of two types of bacteria.

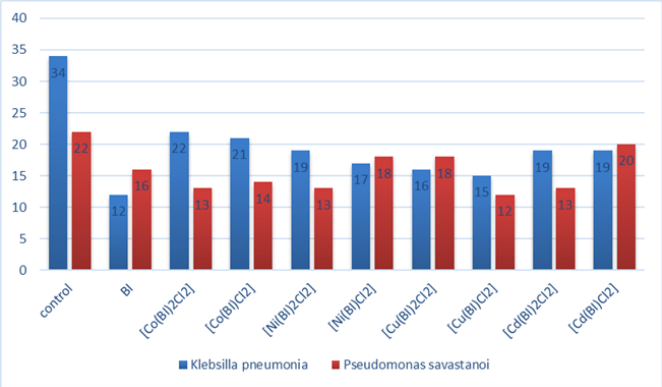


Figure 6: The biological activity of the prepared compounds against *Pseudomonas savastanoi* and *Klebsiella pneumonia*

Conclusions

Through physical and spectroscopic measurements and the measurements of magnetic moments, it is found that some of the complexes have an octahedral structure, and the other part has a tetrahedral structure. The measurements have shown that the ligand behaves like bidentate. This confirms the coordination of the ligand through the imine and carbonyl groups. Molar conductivity measurements also indicate the binding of chloride ions to the central atom, as all conductivity results have showed that all complexes are non-conductive, as shown in the figure7.

The results of the study of the biological activity of the ligand and the prepared complexes against two types of bacteria, gram-negative and gram-positive complexes 8 and 1 show the highest inhibitory activity against Pseudomonas klebsiella pneumonia species, respectively, but to a lesser extent than the control Ciprodar drug.

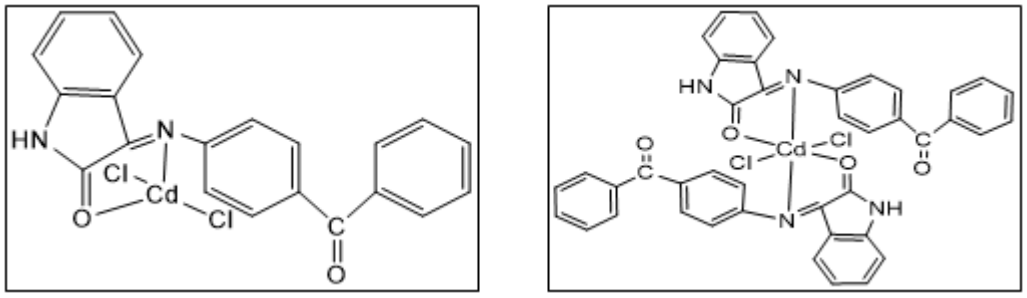


Figure7: Proposed geometric shapes of complexes $[Cd(BI)Cl_2]$ and $[Cd(BI)_2Cl_2]$

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Conflict of Interest

There are no Conflict of Interest. I wanted to make sure that all figures and tables are my own personal property I obtained through practical applications of the outcomes obtained from work

References

1. Focsa M, Apotrosoaei AT, Iacob IM, Vasincu M, Dragan A, Sava M, Binsan AR, Petrovici CD, Profire L. New metal complexes with aril-acetic structure: Preparation, characterization, and in vitro anti-inflammatory effects,. Farmacia, 2023; 71, 3.
2. Jabeen M. A comprehensive review on analytical applications of hydrazone derivatives. Journal of the Turkish Chemical Society Section A: Chemistry. 2022 Aug 8;9(3):663-98.
3. Surendar P, Pooventhiran T, Rajam S, Rao DJ, Manigandan N, Irfan A, Thomas R. Organic quasi-liquid Schiff bases from biomolecules: Synthesis, structure and quantum mechanical studies. Biointerface Res. Appl. Chem. 2023;13:107.
4. Alorini TA, Al-Hakimi AN, Saeed SE, Alhamzi EH, Albadri AE. Synthesis, characterization, and anticancer activity of some metal complexes with a new Schiff base ligand. Arabian Journal of Chemistry. 2022 Feb 1;15(2):103559.
5. El-Serwy WS, Mohamed NA, El-Serwy WS, Kassem EM, Al Shimaa GS. Synthesis, antioxidant, anticoagulant, and fibrinolytic activities of new isatin derivative. Egyptian Pharmaceutical Journal. 2020 Apr 1;19(2):113-23.
6. Aziz T, Ullah A, Ullah R, Haq F, Iqbal M, Khan FU, Kiran M. Synthesis of isatin and its derivatives and their applications in biological system. Biomedical Journal of Scientific & Technical Research.2020;30(4):236,1521.
7. Bulatov E, Sayarova R, Mingaleeva R, Miftakhova R, Gomzikova M, Ignatyev Y, Petukhov A, Davidovich P, Rizvanov A, Barlev NA. Isatin-Schiff base-copper (II) complex induces cell death in p53-positive tumors. Cell Death Discovery. 2018; Nov 13;4(1):103.
8. Ezekwem JE, Visagaperumal D, Chandy V. Synthesis,Characterization and Anti-Bacterial Activity of Isatin Schiff Base derivatives, Asian journal of Chemistry and Pharmaceutical Sciences, 2018; Vol3(1),p7-12.

9. Devi JA, Batra N, Yadav J. Antimicrobioal Activity of Transition Metal Complexes Derived from Schiff Bases of Isatin and Aminophenols, Journal of Chemical and Pharmaceutical Research, 2018; 10(5), p121-125.
10. Bekircan O, Bektas H. Synthesis of Schiff and Mannich bases of isatin derivatives with 4-amino-4, 5-dihydro-1H-1, 2, 4-triazole-5-ones. Molecules. 2008 Sep 10;13(9):21,26-35.
11. Schiffnya LB. Synthesis, characterization and conductivity studies of schiff base ligand derived from isatin and o-phenylenediamine with its cobalt (II) metal complex and lithium-schiff base compound. Malaysian Journal of Analytical Sciences. 2012;16(3):3,18-24.
12. Valli G, Vinnarasi J. Synthesis,Characterization and bio-activity of Metal complexes of isatin derivative, International Journal of Pure&Applied Chemistry, 2011;Vol6.No.3pp.273-278.
13. DOĞAN İS, BÖLEK GG, KAHVECİ B. Synthesis of Some New Isatin Derivatives and Identification of Their Structures. Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi. 2019 Jan 3;23:67-70.
14. Saeed FT, Jasim ZU. Synthesis and Characterization of New Mn (II), Co (II), Ni (II), Cu (II), Zn (II) And Cd (II) Complexes with [(z)-3 ((6-Aminopyridine-2-yl) imino) indolin-2-one] ligand. Kimya Problemleri. 2024;22(1):103-140.
15. Abed Janabi ZM, Jaber Alsalami HS, Al-Khafaji ZS, Hussien SA. Increasing of the corrosion resistance by preparing the trivalent nickel complex. Egyptian Journal of Chemistry. 2022 Jun 1;65(6):193-8.
16. Sujeshwari T, Akila E, Maheswaran P. Effective Biopotencial properties of novel Schiff base metal (II) complexes derived from (1-Methyl-4-nitro-benzene (2-imino-1, 2-dihydro-indol-3-ylidene)-(4-nitro-phenyl)-amine). Eur. J. Mol. Clin. Med.. 2020;7:19,11-24.
17. Waddai FY, Kareem EK, Hussain SA. Synthesis, Spectral Characterization and Antimicrobial Activity of Some Transition Metal Complexes with New Schiff Base Ligand (BDABI). Oriental Journal of Chemistry. 2018 Jan 1;34(1).
18. Hadi MA. Coordination Behavior of N/O donor ligand with some transition metals. Acta Chimica Pharmaceutica Indica. 2013;3(2):127-34.
19. Chandra S, Raizada S, Tyagi M, Sharma PK. Spectroscopic and biological approach of Ni (II) and Cu (II) complexes of 2-pyridinecarboxaldehyde thiosemicarbazone. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy. 2008 Mar 1;69(3):8,16-21.
20. Singh VP, Singh S, Singh DP. Synthesis, characterization and biocidal activity of some transition metal (II) complexes with isatin salicylaldehyde

acyldihydrazones. Journal of enzyme inhibition and medicinal chemistry. 2012 Jun 1;27(3):3,19-29.
21. Alkam HH, Atiyah EM, Majeed NM, Alwan WM. Cupper (ii) and mercury (ii) complexes with schiff base ligands from benzidine with isatin and benzoine: synthesis, spectral characterization, thermal studies and biological activities. Systematic Reviews in Pharmacy. 2021 Jan 1;12(1).
22. Palaniammal A, Vedanayaki S. Synthesis, spectral characterization, biological activity of macrocyclic ligands and metal complexes derived from 3, 4-diaminobenzophenone and diketones. Rasayan J. Chem. 2022 Apr 1;15(2):7,67-72.
23. Abdulghani AJ, Ahmed ZZ. Synthesis,Structure and Characteration of New Metal Complexes of Schiff bases Derived from Isatin N-Benzylisatin and 4-Aminoantipprine, Pakistan Journal of Chemistry, 2011;100-113.
24. Jasim ZU. "Synthesis and Characterization of New Mn (II), Co (II), Ni (II) and Cu (II) Complexes with [αmethyl-N-(3-methylidene indol)-2-amino anthraquinone] Ligand. College of Basic Education Researches Journal. 2011;10(4):5,70-80.
25. Rasheed EM. Synthesis and Characteration of Mn(II),Co(II),Ni(II),Cu(II) and Cd(II) Complexes with new Tridentate (ONO Donor) Schiff Base Ligand,DIYALA JOURNAL FOR PURE SCIENCES, 2013;Vol:9 No:1.
26. Tawfik TE, Altayy MA. New Metal (II) Complexes of 2-Hydroxy-N-(2-Hydroxynaph Thalene-1-yl) Methylene Benzohydrazide: Synthesis and Spectroscopic Studies. College Of Basic Education Research Journal. 2023 Mar 1;19(1):708-40.
27. AL-Mukhtar SE, Th.aghwan M. Synthesis and Characteration of 3-Methoxyprppyldithiocarbamate Complexes with Iron(II),Cobalt(II) ,Nickel(II),Copper(II) and Zinc(II) and Their Adducts with Nitrogen base Ligands, Raf.J.Sci., 2013;Vol.24.No.4 pp.50-59
28. Ali AM, Mohammed HA, Jasim ZU, Abed RR. Characterization and antibacterial evaluation of new complexes of nicotinamide semicarbazon manganese (II), zinc (II), silver (I) synthesizes. Research Journal of Pharmacy and Technology. 2023;16(2):5,39-44.