Article

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A bio scientific study of the new gold complex as an anti-breast cancer agent, as well as its preparation , Molar Conductivity and Spectral identification of some other metal complexes

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Abstract

Synthesis of Heterocyclic Organic Ligand involved the preparation of non-homogeneous ring ligand derived from ortho-aminobenzylamine. This was achieved by the azo compound prepared in the first step. The second step included the reaction of the azo compound with 4-(benzyloxy)benzaldehyde .ligand was characterized using various spectroscopic and diagnostic techniques, including mass spectrometry, proton nuclear magnetic resonance, Fourier-transform infrared spectroscopy , and ultraviolet-visible spectroscopy . In addition, precise analysis of C, H, N elements and melting point measurements were conducted. the molar ratio (1:2) (M:L) was found for the ligand (BPDIM) to prepare metal complexes for cobalt, and copper (divalent) while maintaining a molar ratio of (1:1) for gold complexes (trivalent). While supporting the values of accurate analysis of elements (C.H.N) and the results of flame atomic absorption spectroscopy, the proposed molecular formulas for all studied complexes were investigated. In addition, infrared spectroscopy, Electronic spectra of metal complexes, molar conductance.The new complexes showed variations in conductance depending on the metal ion and oxidation state. This study aimed to conduct an in vitro cytotoxicity comparative study of BPDIM and its Au(III) complex on human breast cancer cells (MCF-7) and other normal cells. The Au(III) complex was found to be highly selective in targeting cancer cells without affecting normal healthy cells, compared to the ligand. Thus, this complex can be considered as a new drug for treating breast cancer cells (MCF-7), and an attempt in the future to study its effect on other types of cancer.

Keywords: Gold complex, Breast cancer, Heterocyclic Organic Ligand

Introduction

Coordinate chemistry was and still is a specialty that arouses fascination, attention, and passion among chemists and researchers, as it has demonstrated success for drug therapy in the field of treating some severe diseases and introducing many improvements in a variety of medications[1]. The Swiss chemist Alfred Werner (1866–1919) developed the first theory of coordination compounds, as coordination compounds are one of the most important and challenging fields in modern inorganic .chemistry [2]. Coordination compounds have common uses in metallurgy, industrial catalysts, and analytical reagents [3]. Schiff base ligands and their metal complexes are fundamental components in coordination chemistry, with widespread applications in various fields, including chemistry, biology, and material science[4][5]. These compounds are notable for their versatile coordination chemistry and diverse structural and functional properties.

Azo-Schiff base compounds have received increasing attention because they are a new class of chemical compounds due to their electronic properties because they contain two active groups within their chemical structures (the bridge azo (N=N) and azomethine (C=N)) and selectivity and sensitivity towards metal ions. Azo ligands. Some coordination complexes have also been used as anti-cancer drugs, such as platinum [6] and gold[7]. Azo compounds - Schiff bases are important in pharmaceutical fields, and this importance may be due to the azomethine bond responsible for biological activity[8]. Heterocyclic compounds are characterized by containing two or more different types of atoms within their cyclic structure, and the highest percentage of carbon atoms in these cyclic compounds is often followed by atoms such as oxygen, nitrogen, or sulfur[9]. These compounds have received wide attention from researchers, and studies and research have continued on methods of preparing them[10]. These compounds are important in many fields of application, as they are found in most sugars and their derivatives[11]. Heterocyclic compounds are characterized by containing two or more different types of atoms within their cyclic structure, and the highest percentage of carbon atoms in these cyclic compounds is often followed by atoms such as oxygen, nitrogen, or sulfur[12]. These compounds have received wide attention from researchers, and studies and research have continued on methods of preparing them[13]. Schiff bases are generally known as imines or azomethines and act as ligands in various metal complexes[14]. They are formed as condensation products from primary amines and aldehydes or ketones. an inclusive and systematic study was carried out for preparing a series of complexes derived from Schiff bases of salicylaldehyde and its substituents [15]. Later on, several binuclear and multinuclear Schiff base-transition metal complexes were synthesized having broad areas of application (e.g., material science, catalysis, magneto chemistry, bioinorganic chemistry, bioinorganic modeling studies, multi electron redox chemistry, and super conductivity [16].

Several ligands and their complexes have gained a large space in the medical field due to their biological importance as anti-cancer[17], anti-fungal, and inhibitor of the Corona virus

(COVID-19) [18]. For example, in a recent study conducted to prepare[19]. A number of complexes of metal ions with ligands (E)-4-((4, 5-diphenyl-1H-imidazole-2-yl) diazenyl)-N, N-diethylaniline (DPIED), which has proven its biological activity against types of drug-resistant bacteria.

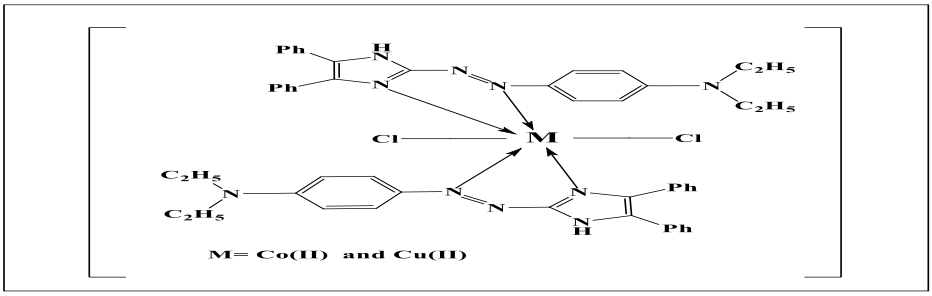

Figure 1: Antibacterial azoimidazole complexes

Materials and Methods

All chemicals were obtained from Merck, BDH and Sigma - Aldrich and used without further purification. Melting point were determined using model 9300 of ligand and its complexes. 1HNMR spectra were recorded as solution in DMSO d6 as solvent using (varian 500MHZ Spectrophotometer) and Mass Spectra were recorded on Shimadzu Agilent Technologies 5975C. The UV-Visible spectra were recorded on Shimadzu spectrophotometer double band model 1700. Magnetic susceptibility measurements were carried out on a balance magnetic MSB-MKI using faraday method. The diamagnetic corrections were made by Pascal's constants. IR spectra were recorded on Shimadzu FTIR 8400 spectrometer using KBr pellet in the wavelength range 4000-400 cm-1. C.H.N Elemental analyses were performed by means of EURO 2012EA 300 C.H.N Elemental analysis. and for toxicological Studies : Autoclave Arnold Sons, USA. Biohazard safety cabinet class II BGenex, USA. Cell culture incubator, Memmert, Germany. Centrifuge Hermle, Germany. Cooling centrifuge,Beckman Model J2-21, USA. Deep freezer (-800C) Marubeni, Japan. Distillatory Ogawa seiki, Japan.

Drying and sterilizing oven, Hermle, Germany. ELISA reader, Organon Teknika, Beelchum. IncubatorMemmert, Germany. Inverted microscope, Leica, Germany. Microtiter plate, multiwall plate and 96 wells Lab-TeK and Nunc, USA. Millipore filter 0.22 µm, Sartorius, Germany. pH-meter, LKB, Sweden. Sterile 25, 75 cm2 tissue culture flasks, Nunc, Denmark. Vacuum pump, Leitz, Germany. Water bath, Memmert, Germany.

Synthesis of the Ligand (BPDIM)

The first step involved the preparation of the azo dye. To achieve this, 0.01 mol (1.222g) of ortho-aminobenzylamine was dissolved in 30ml of distilled water while maintaining a low reaction temperature between 0-5℃. Subsequently, 5ml of concentrated HCl acid was added to the solution with continuous stirring. Additionally, 0.01 mol (0.700g) of $NaNO_2$ was dissolved in 5ml of distilled water with the solution cooled below freezing. The second cooled solution was

then added to the aromatic amine solution with stirring, and the mixture was left for 30 minutes to complete the azoization process.

Following this, a dropwise addition of the diazonium salt solution was carried out with continuous stirring to the formed azo compound solution. The azo compound solution was prepared from 0.01 mol (2.202g) of 5,4-diphenyl-1H-imidazole and 20ml of 40% sodium carbonate solution (Na_2CO_3) in addition to 50ml of absolute ethanol, all at 0℃. The stirring was continued until reaching a pH of approximately 7, monitored using litmus paper. The resulting solution was left to settle for two hours to complete the deposition process. The formed azo was then filtered, washed with distilled water several times, dried, and recrystallized using hot absolute ethanol.

The second step involved the preparation of the azo ligand - the new Schiff base (BPDIM). In this step, 0.0035 mol (0.742g) of benzaldehyde 4-(benzyloxy) was dissolved in 10ml of absolute ethanol, and the mixture was stirred for 2 minutes. Next, 2-3 drops of glacial acetic acid were added, and the solution was left at laboratory temperature for 5 minutes. Following this, prepared solution was added, consisting of 0.0035 mol (1.22g) of azo dye dissolved in 20ml of absolute ethanol.

The solution was then refluxed for 8 hours at a temperature of 78℃, resulting in the formation of the new Schiff base azo ligand (BPDIM). The progress of the reaction was monitored using Thin Layer Chromatography (TLC) with a solvent system of 0.5ml methanol:4.5ml benzene. The product was then cooled, dried, collected, and recrystallized using hot absolute ethanol. The physical properties of the ligand were recorded in Table (2-4), and the preparation steps of the azo ligand - the new Schiff base (BPDIM).

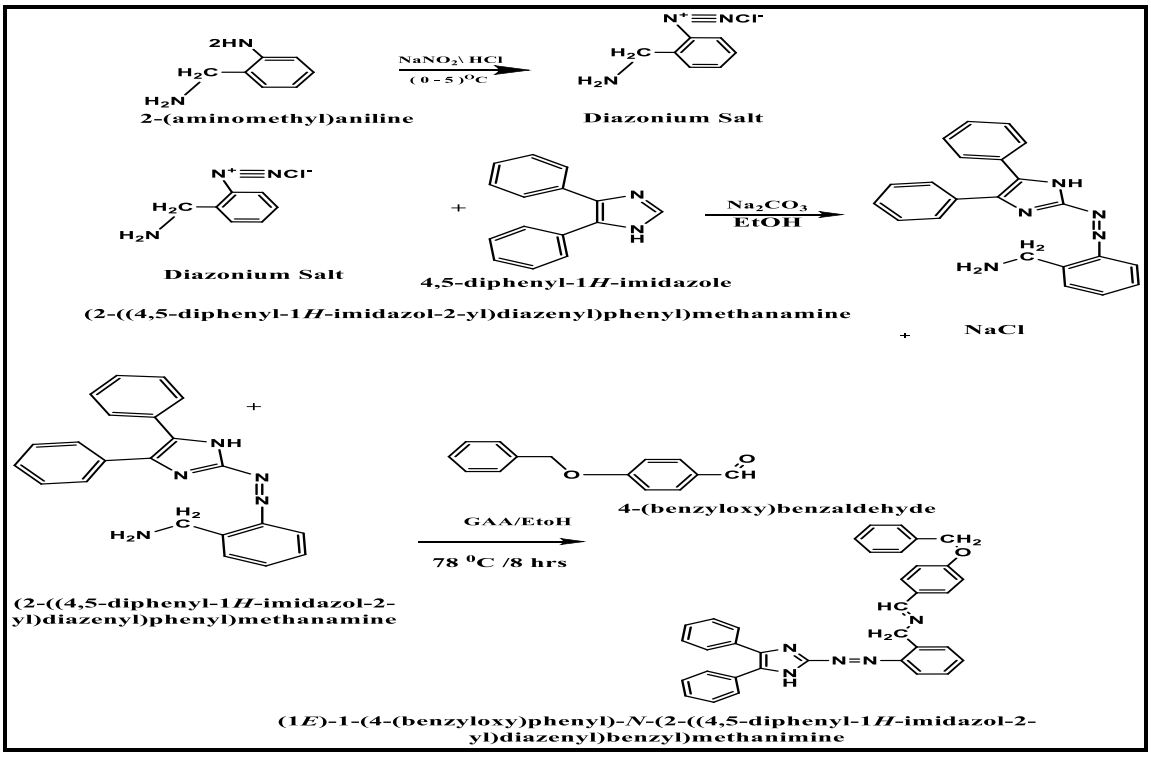

Figure 2: Synthesis steps of the azo ligand - new Schiff base

Synthesis of metal complexes

The metal complexes for the new ligand were prepared with cobalt (II), copper (II), and gold (III) ions, as follows (0.0411g, 0.025g and 1560g) respectively in 10ml absolute ethanol solution with 10ml absolute ethanol solution of (The ligand solution was prepared by dissolving 0.167g (0.0003mol) of the ligand in 10mL of absolute ethanol with a molar ratio of 1:2 (ligand: metal) for cobalt and, cupper complexes, while gold complex molar ration 1:1 ligand: metal. The resulting mixture was refluxed for 1h.The products of complexes were isolated after reduced of volume by evaporation .They were filtered off and dried under vacuum The physical properties of the complexes under study are listed in Table 1.Figure 2 illustrates the steps of preparing the metal complexes with the ligand (BPDIM).

Table 1: The physical properties and retardation factor (Rf) values using the (benzene: methanol) (4.5: 0.5) solvent system for the ligand (BPDIM) (L) and its metal complexes

Cheimiecal formula	M .wt	m. p. ^{O}C	Color	Yeiled%	RF
L: $C_{36}H_{29}N_5O$	547.6	118-120	Yellow	88%	0.87
$[Co(L)_2]Cl_2$	1225.16	140-142	Broon	92%	0.68
$[Cu(L)_2]Cl_2$	1229.77	104-106	Dark Brown	89%	0.76
[Au LCl] Cl_2	850.98	150-152	Brown Dark	80%	0.87

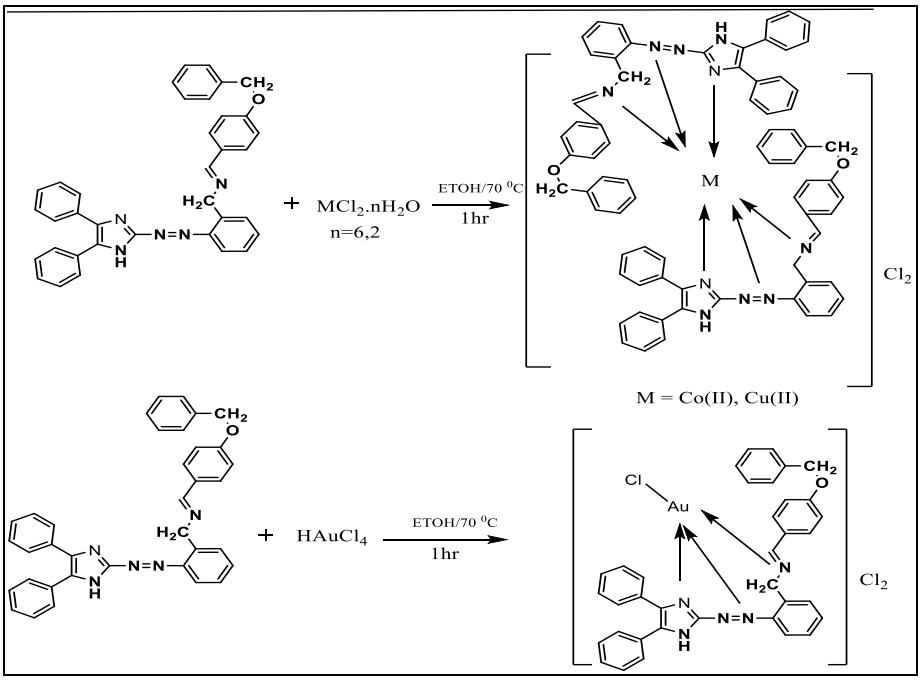

Figure 3: . illustrates the steps for preparing the metal complexes with the ligand (BPDIM)

Cell Cytotoxicity (In Vitro Cytotoxicity) and Viability Assays:

1.cell line

The cell line of human breast cancer cells (MCF-7), which was obtained from (Pastor Institute - Iran), was used in this study, and cancer cells were sustained and developed and tests were performed on them at the University of Tehran.

2. Development of breast cancer cell line (MCF 7-cells)

The method of (Freshney) was followed to grow the cells of the breast cancer cell line (MCF-7) as follows. The cells of the cancer cell line (MCF-7) were thawed using a water bath at a temperature of (37°C), Then the cells of the cancer cell line (MCF-7) were transferred to a container. A culture of animal cells with a diameter of (25 cm^2) contains the culture medium (RBMI-1640) and (10%) cow calf blood serum. Then, it was incubated in an incubator with a percentage of carbon dioxide (5%) at a temperature of (37°C) for 24 hours, and after 24 hours of incubation, and when it was confirmed that there was growth in the cell culture and that it was free of contamination, the cells were examined using an inverted microscope. microscope to ensure its viability, free from contamination, and its growth to the required number (approximately 500-800) thousand Cell/ml. The cells were transferred to the growth cabin and the used culture medium was disposed of by washing the cells with Physiological Slain Solution (PBS), and then a sufficient amount of trypsin was added to the cells and incubated for (30-60 sec) at a temperature of (37 °C) and it was monitored until it transformed from a mono-cell layer to a single cell, then the enzyme was stopped by adding a new growth medium containing bovine calf serum. Then the cells were collected in centrifuge tubes and placed in a centrifuge at 2000

min /r for 10 min at room temperature, to precipitate the cells and get rid of the trypsin and the used culture medium. The filtrate was disposed of, and the cells were suspended in a fresh culture medium containing 10% bovine calf serum. The number of cells was examined by taking a certain volume of the cell suspension, adding to it the same volume of Trepan Blue dye to determine the number of cells and their vitality using Hem cytometer slide and according to the equation (30):

$C = N \times 10^4 \times F$ /ml

Whereas: -

C = the number of cells in one ml of solution **N = the number of cells in the slide**

F = dilution factor **10^4 = slice dimensions**

The viability of the cells in the sample was calculated using a Hemacytometer chip.

Live cell viability ratio = (number of living cells/ number of dead cells)X100 %.

The cell suspension was distributed into new containers and then incubated in a 5% CO2 incubator at (37°C) for 24 hours.

3.MTT staining test for breast cancer cell viability (MCF-7)

In this test, the cytotoxic effect of ligand and Gold on breast cancer cells (MCF-7) were determined for the purpose of demonstrating their efficacy It can be used as a cancer drug.

The cancer line cells were prepared by following the above steps(31), then the cell suspension was placed in a plate with flat-bottom holes and incubated in (5%) CO_2 incubator at (37°C) for 24 hr, then (200 µl) was added. From the cell suspension in each hole, followed by the addition of the prepared concentrations of complex and its ligand at (6.25, 12.5, 25, 50, 100 µg/ml) concentration to the holes. , and by (3)holes for each concentration. The plate was incubated for 24 hours at a temperature of (37°C), Then 10ml of MTT solution was added to each hole at a concentration of 0.5 mg/ml. The plate was incubated for an additional 4hr at (37°C) then (100 µl) of solute solution was added Dimethyl sulfoxide to each hole to dissolve the Formazan Crystals. The absorbance of the sample was read at a wavelength of 570 nm using an ELASIS device.

Antioxidant Activity by DPPH radical scavenging

The measurement of the antioxidant activity was performed by the DPPH radical scavenging method. The free radical scavenging activity of the prepared compounds for ligand DEDIP with complexes (Au(III), Cu(II), Co(II)) was evaluated using DPPH (2,2-diphenyl-1-picrylhydrazyl) assay(140).

For the assay, a solution of 0.3 mM DPPH was prepared in ethanol. Then, 1 mL of this solution was added to 2 mL of the compound solution in ethanol, resulting in a final volume of 3 mL. Different concentrations of the prepared complexes ranging between (50, 100, 150, 200) µg/mL were used, which were prepared by dilution. The mixture was vigorously shaken and left in the

dark at room temperature for half an hour. The absorbance was measured at nm517 using a spectrophotometer.

The standard compound, ascorbic acid, was used for comparison. The percentage of inhibition (%I) or the radical scavenging effect was calculated using the following equation:

$$\%I = 100 * (AC - AS) / AC$$

Where:

AC: Absorbance of the control (DPPH) solution without the test compound

AS: Absorbance of the sample (DPPH) solution with the test compound

Results and discussion

Several azo-Schiff base compounds include two active groups: the bridging azo (N = N) and azomethine (C = N-) groups[20][21]. The presence of these groups in the composition of these compounds has endowed them with distinctive properties and vibrant colors. As a result, they have become the focus of interest for many researchers. In light of this importance, our attention was directed towards the preparation and characterization of four new ligand for azo-Schiff base. This ligand was involved Complexation reaction with ions of cobalt (II), copper (II), and gold (III) [22]. The purity of the organic compound and its metal complexes was ensured using thin-layer chromatography (TLC) before conducting any of the diagnostic analyses employed in the study[23]. Molar conductivity measurements were adopted as a standard indicating whether the prepared complexes possess ionic properties, complemented by magnetic sensitivity measurements to confirm the number of unpaired electrons and match the resulting values with those found in the literature. Infrared spectroscopy was employed to monitor changes in the positions and intensities of effective groupings in ligands' spectra, compared with those of complexes, determining the new bands resulting from coordination. All of this will provide us with an insight into the vacant structure of the new metal complexes[24]. The study also includes in vitro biological assays and the evaluation of the cytotoxicity effects of gold complex to assess their cellular toxicity on breast cancer cells (MCF-7) and normal cells[25].

1. Mass Spectra

Mass spectrometry is one of the essential and crucial diagnostic tools through which the molecular weight and molecular formula of new compounds can be proven[26]. The mass spectrum of the new organic ligand was measured using mass spectrometry. This spectrum showed the presence of molecular ion (M/Z+) for the organic ligand at (547), with percentages of (5%)[27].

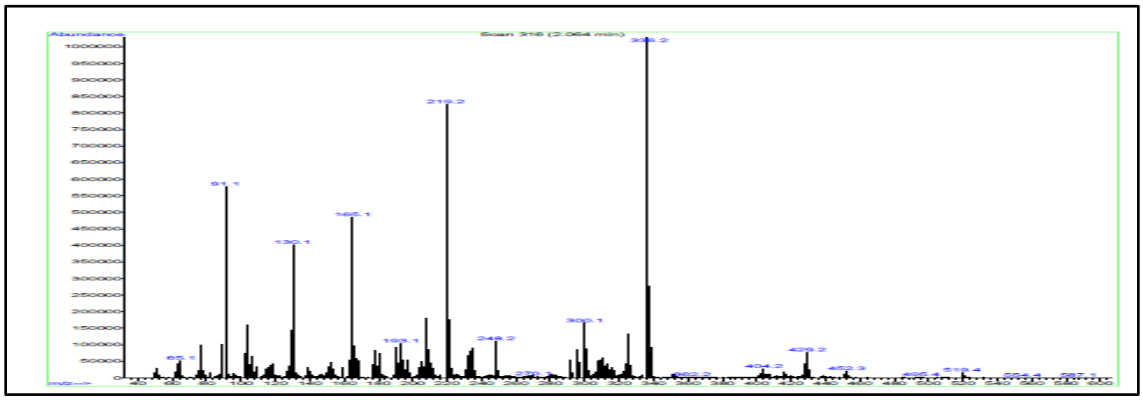

Figure 4: represents the mass spectrum of the ligand

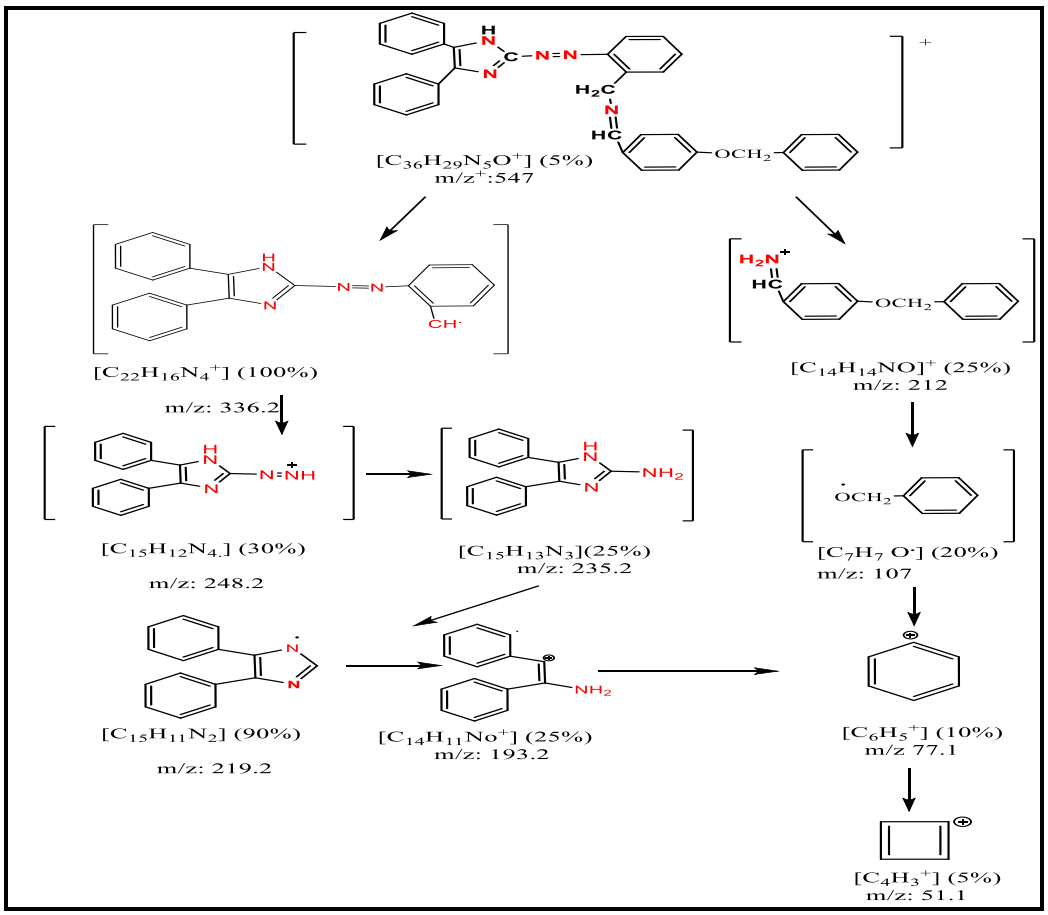

Figure 5: Fragmentation pathways of the ligand

2. ^{1}HNMR spectrum

Magnetic Resonance Imaging (MRI) technology is one of the most important spectroscopic methods for diagnosing compounds, especially organic ones. Through it, the validity of the chemical composition of prepared compounds is confirmed. Some researchers and

experts in this field have indicated that nuclear magnetic resonance spectroscopy alone is sufficient as a diagnostic tool for organic compounds [28].

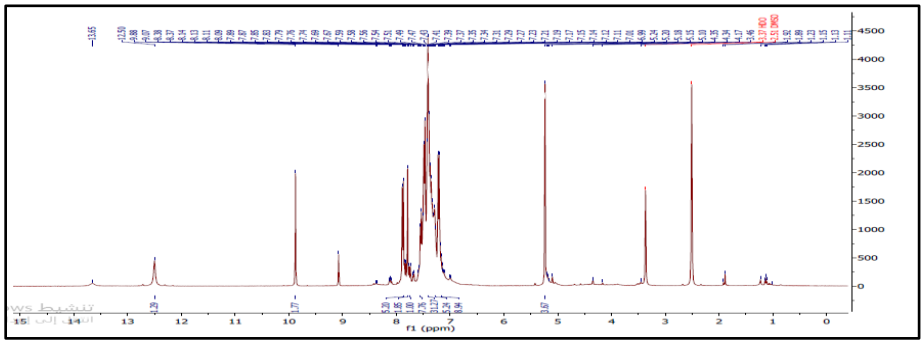

Figure 6: H1 NMR spectrum of the ligand

3. Infrared Spectra

The ligand exhibited distinctive bundles for the effective groups in the ligand spectrum, including a strong stretching bundle at the frequency (11598 cm-1), attributed to the vibration of the azo ν(C=N) bond in the imidazole molecule. Additionally, a weak stretching bundle at the frequency (1452 cm-1) was attributed to the vibration of the azo ν(N=N) bridge group. A medium stretching bundle at the frequency (1687 cm-1) was associated with the vibration of the azo ν(C=N) bond in the azomethine group.

Compound	NH imadazole	υ(C=N) imadazole	υ(C=N) schiff	υ(N=N) azo	υ(M-N)			(M-O)
L: $C_{36}H_{29}N_5O$	3421	1598	1687	1452	-----	-----		
$[Co(L)_2]Cl_2$	3427	1593	1681	1442	569	514	453	00
$[Cu(L)_2]Cl_2$	3433	1595	1685	1448	576	563	511	00
[Au LCl] Cl_2	3425	1595	1674	1446	547	511	445	

Table 2: Frequencies values of infrared spectra and their metal complexes in units (cm-1) for the new ligand (L)

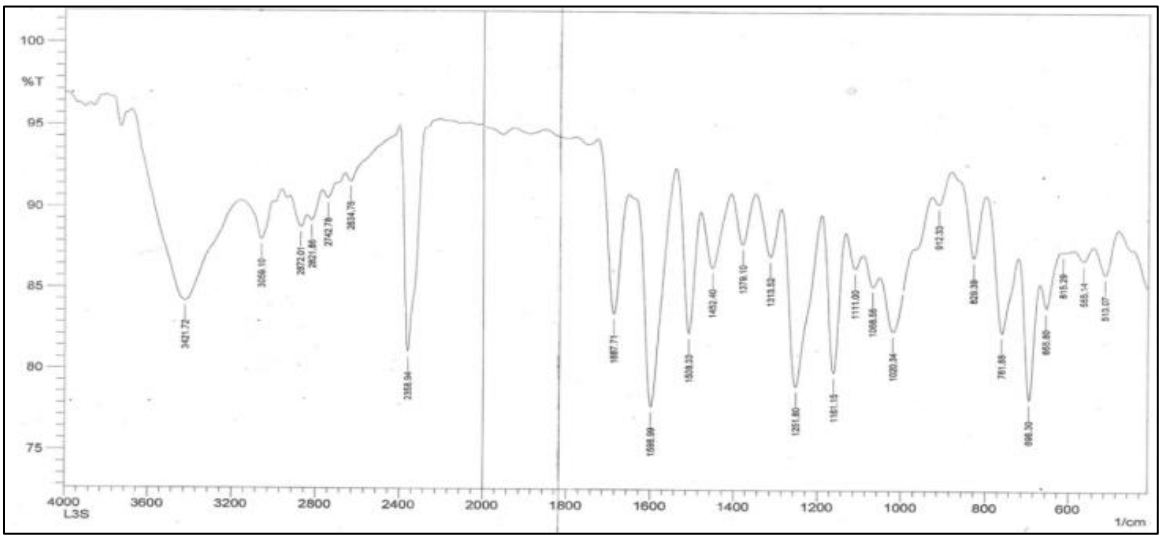

Figure 7: Infrared spectrum for the ligand

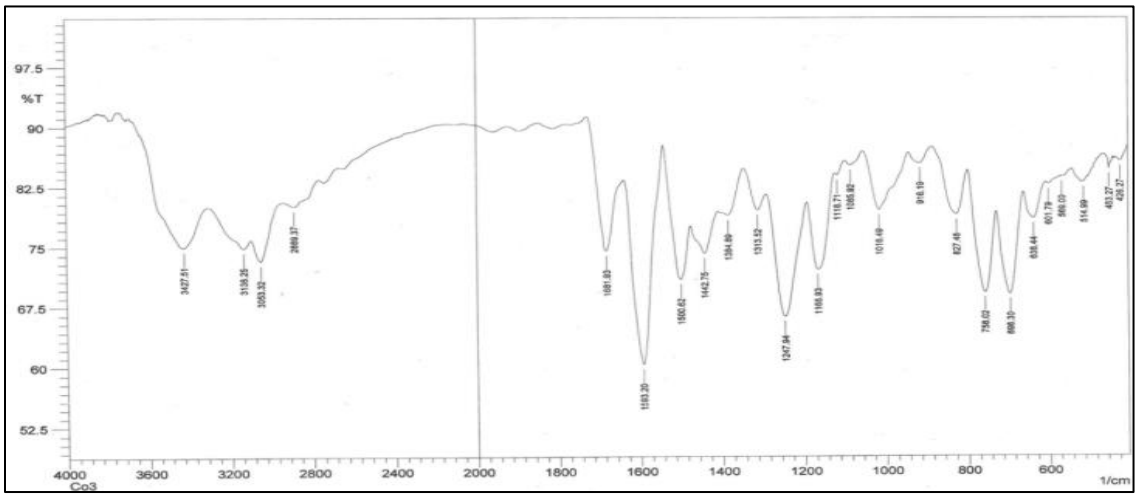

Figure 8: Infrared spectrum for Complex [CoLCl H2O]Cl

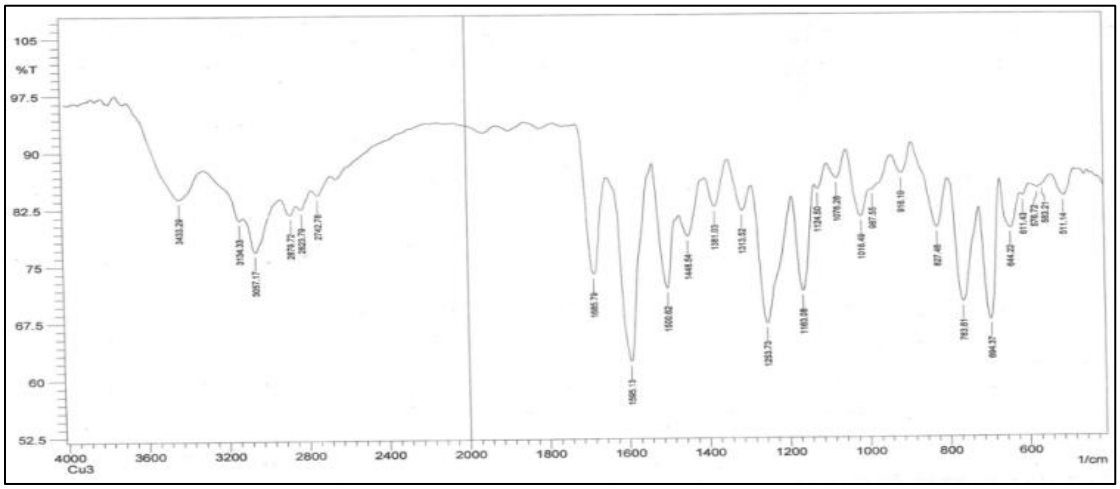

Figure 9: Infrared spectrum for Complex [CuLCl H2O]Cl

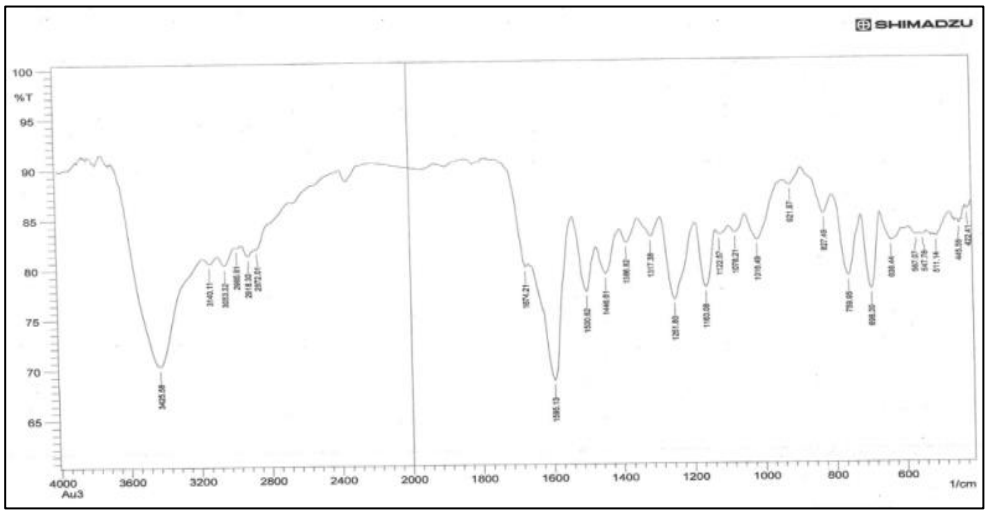

Figure 10: Infrared spectrum for Complex [Au L Cl] Cl2

4. Elemental Micro Analysis

The technique of (C.H.N) for calculating the percentage ratios of carbon, hydrogen, and nitrogen in ligands and their metal complexes derived from them is one of the simple and useful analytical methods for diagnosing chemical compounds. The metallic element ratios in their complexes were calculated using the flame atomic absorption technique[29]. The results of these analyses were included in tables that demonstrate a significant convergence between the practically obtained values and those theoretically calculated. This supports the accuracy of the added ratios of (metal: ligand) on one hand and the proposed formulas for solid metal complexes on the other hand:

Table 3: Results of the precise analysis of elements and the metal ratio in the complex of the ligand (L) and its metal complexes

Formula	M.Wt	Found) Calc. %(			
		C%	H%	N%	M%
(L)= $C_{36}H_{29}N_5O$	547.66	78.95 (79.04)	5.34 (5.51)	12.79 (12.95)	-----
$[Co(L)_2]Cl_2$	1225.16	70.59 (70.66	4.77 (4.90)	11.43 (11.66)	4.81 (4.93)
$[Cu(L)_2]Cl_2$	1229.77	70.32 (70.41	4.75 (4.78)	11.39 (11.41)	5.17 (5.36)
$[AuLCl]Cl_2$.	850.98	50.81 (50.9)	3.44 (3.58)	8.23 (8.30)	23.15 -------

5. Molar conductivity measurements

The molar conductivity of a compound can be measured to determine its ionic formula at a concentration of (1×10^{-3} M). The molar conductivity technique is characterized by general

qualities, including its simplicity in terms of operation and result processing[30]. This technique not only aids researchers in approaching the most accurate suggestion for the geometrical shape of metal complexes but also stands out among other techniques[31]. For metal complexes derived from ligand, the conductivity ranged between (11.13-75) $S.cm^2. mol^{-1}$, and a convergence in values was observed when comparing these results with literature values that indicate the ionic nature of all complexes except those of arsenic and cadmium(M).

Table 4: Molar conductivities and magnetic sensitivities for the new ligand complexes (L)

Compounds	μ_{eff} (B.M)	Conductivity $S.mol^{-1}. Cm^2$	Hybridization	M:L	Detection of $AgNO_3$
$[Co(L)_2]Cl_2$	4.12	72.91	Sp^3d^2	1:2	+
$[Cu(L]Cl_2$	1.73	77.45	Sp^3d^2	1:2	+
$[Au(LCl)]Cl_2$	Dia	71.43	Dsp^2	1:1	+

6. Magnetic Measurements:

It is one of the important diagnostic tools that researchers in the field of inorganic chemistry can refer to for proposing the geometrical shapes of transition metal complexes[32]. Its results are significant in the field of metal complexes. The results of these measurements are utilized to determine the oxidation state of the metal ion and also to identify the number of unpaired electrons in the outermost shell of the metal ion. The electronic effects resulting from these measurements clarify the paramagnetic state of the carefully studied complex, indicating whether it has a high or low spin [33].

7. Electronic Spectra

The UV-Visible spectrum of the new ligand in dimethyl sulfoxide (DMSO) solvent was examined. The absorption spectrum revealed the first peak at (283 nm, 34013.60 cm-1), attributed to($\pi \rightarrow \pi^*$) electron transition due to the presence of double bonds in aromatic rings. The second peak appeared at (415 nm, 23310.02 cm-1), assigned to the ($n \rightarrow \pi^*$) electron transition (161), resulting from the ligand possessing double bonds with non-bonding electron pairs.

The spectrum of the cobalt (II) complex in solution showed an absorption peak at (505 nm, 22471.91 cm-1), and the second peak at (688 nm, 34013.60 cm-1) was attributed to the charge transfer (ML.CT). This observation aligns with literature findings on the appearance of these bands in octahedral cobalt (II) complex spectra. the copper (II) complex spectrum showed an absorption peak at (505 nm, 21691.97 cm-1), also related to charge transfer (ML.CT), consistent with literature on hexacoordinate nickel (II) and copper (II) complexes. The trinuclear gold (III)

complex spectrum showed absorption bands at (489 nm, 35335.68 cm-1), confirming the electronic transition 1A1g→1B1g and indicating a square planar structure with dsp^2 hybridization.

Table 5: Electronic spectra in (nm) and wave numbers in reciprocal centimeters (cm^{-1})

Compounds	λmax (nm)	ύ (cm^{-1})	Transitions	Geometry	Hybridization
(L)= $C_{31}H_{28}N_6O$	283 415	35335.68 24096.38	π →π* n →π*	----------	----------
$[Co(L)_2]Cl_2$	505	19801.98	ML CT $^4T1g \rightarrow {}^4T_1g(p)$	Octahedrl	Sp^3d^2
$[Cu(L)_2]Cl_2$	505	19801.98	ML CT $^2Eg \rightarrow {}^2T_2g$	Octahedral	Sp^3d^2
$[Au(L)_2Cl]Cl_2$	489	20449.89	ML CT $^1A_1g \rightarrow {}^1B_1g$	Square planer	dsp^2

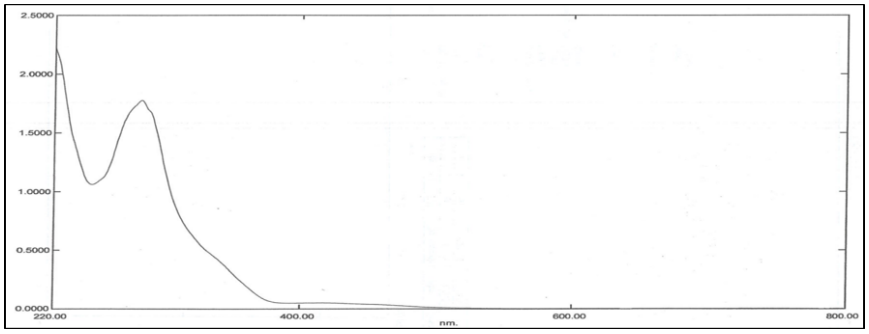

Figure 11: Ultraviolet-Visible spectrum of the ligand

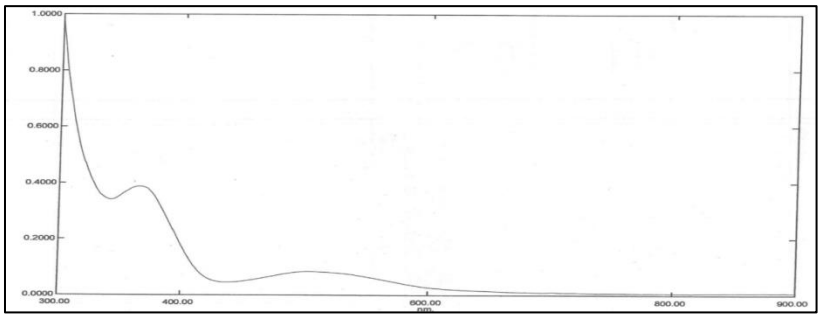

Figure 12: Ultraviolet-Visible spectrum of Complex [Co (L)2] Cl2

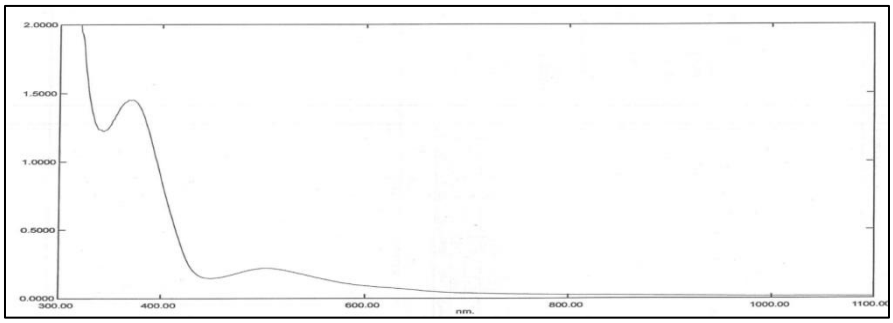

Figure 13: Ultraviolet-Visible spectrum of Complex [Cu (L)2] Cl2

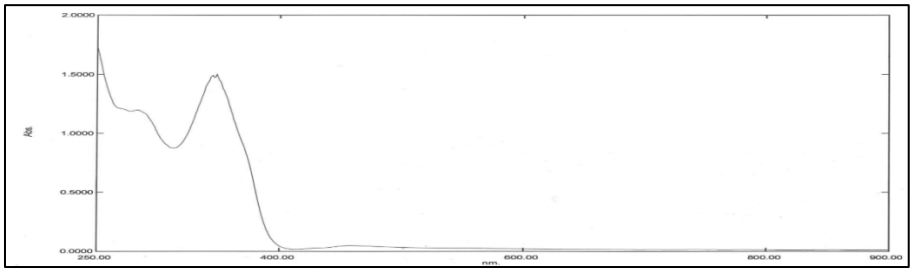

Figure 14: Ultraviolet-Visible spectrum of Complex [Au L Cl]Cl28. The proposed structure of chelate complexes

The geometric shapes of metal complexes in their solid form vary according to several factors, including differences in available coordination sites that participate in ligand composition, the nature of the metal ion incorporated into the complex, and the nature of substituent groups on the ligand rings in terms of type and position[34]. Various geometric shapes have been proposed, including square planar, tetrahedral, square-based pyramid, triangular-based pyramid, octahedral, and other geometric forms. The use of X-ray spectroscopy technology remains fundamental in confirming the geometric shape adopted by the complex.

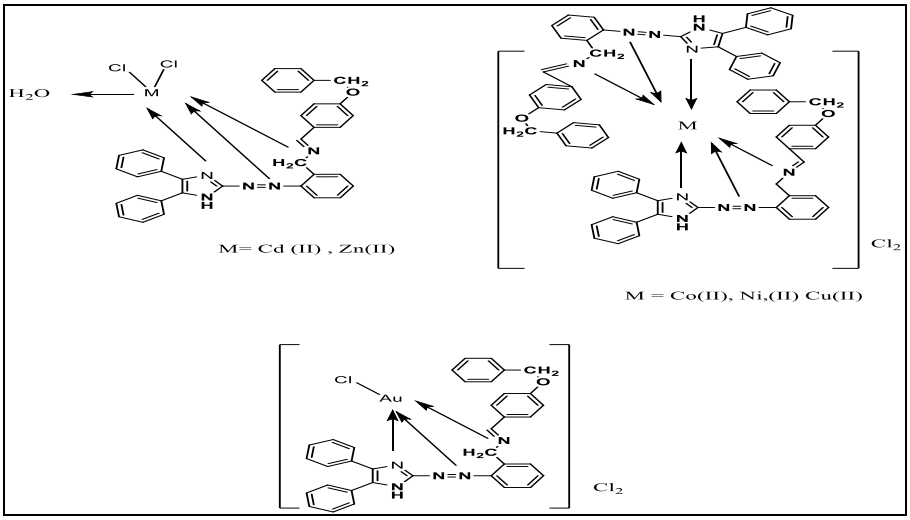

Figure 15: Stereo form of ligand complexes

Effect of Metal complex on growth of breast cancer cell (MCF-7) and Healthy cells (MCF-10A)

Our study included biological and toxicity tests of the gold complexes $[AuLCl]Cl_2$,. The practical part involved studying these complexes on live cells, specifically breast cancer cells and normal cells for comparison. The gold(III) complex prepared in this study showed high selectivity in killing cancer cells. The complex [AuL1Cl] Cl_2 (36.28 µg/mL) required to kill half of the cancer cells, as indicated by the half-maximal inhibitory concentration (IC50), was very safe with non-cancerous cells, needing 308.35 mL/µg of this compound. The complex. The ligand gold(III) complex $[Au(LCl)]Cl_2$ needed 55.40 mL/µg to kill cancer cells and 74.51 mL/µg with normal cells[35]. Consequently, the prepared gold(III) complexes are considered a new and selectively effective treatment for breast cancer[36].

Effect of Complex [AuLCl]Cl2 on the growth of breast cancer cell lines (MCF-7) and Healthy cells (MCF-10A)

The impact of the complex $[Au(LCl)]Cl_2$ on the growth of breast cancer cell line (MCF-7) and on normal cells (MCF-10A) was studied[37]. The results showed a lower cell viability percentage (higher inhibition rate) of 71.28% at a concentration of 100 µg/mL for breast cancer cells (MCF-7), while the normal cells (MCF-10A) exhibited a lower cell viability percentage (higher inhibition rate) of 54.53% at the same concentration. It was found that increasing the compound concentration decreased cell viability, indicating an increased inhibition rate for both cancerous and normal cell lines[38]. Additionally, the results revealed that the half-inhibitory concentration (IC50) of the $[Au(LCl)]Cl_2$ complex for breast cancer cells (MCF-7) was 55.40 µg/mL[39]. This concentration was significantly lower compared to the IC50 for normal cells (MCF-10A), which was 74.51 µg/mL. These findings suggest that the complex could be used as a treatment for breast cancer (MCF-7), as depicted in Figure.

Table 6: illustrates the effect of the [Au(LCl)]Cl2 complex on breast cancer cell line (MCF-7) and compares it with the normal cell line (MCF-10A) at the same concentrations using the MTT assay for 24 hours at a temperature of 37°C.

Con. (µg.mL^{-1})	Mean Percentage (%) for each cell line			
	Cancerous line cells of (MCF-7)		Normal line cells of (MCF-10A)	
	Cell Viability	Cell Inhibition	Cell Viability	Cell Inhibition
6.25	88.74	11.26	86.66	13.34
12.5	81.61	18.39	73.15	26.85
25	74.69	25.31	66.11	33.89
50	58.47	41.53	56.54	43.46
100	28.72	71.28	45.47	54.53
		IC50=55.40		IC50=74.51

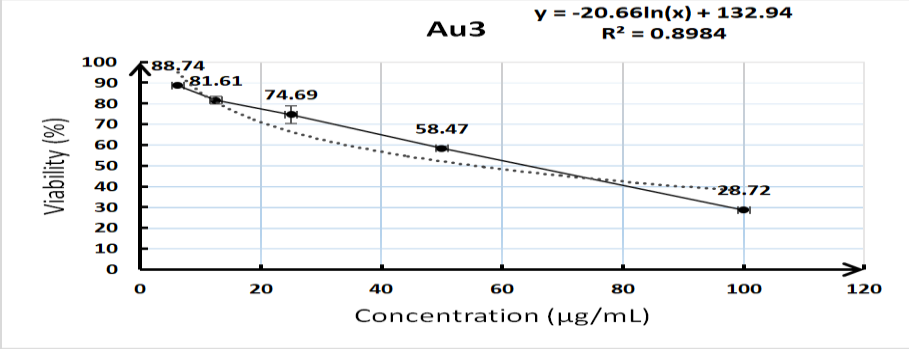

Figure 16: Percentage of Viability in Breast Cancer Cell Line (MCF-7) versus the Concentration of the Complex [Au(LCl)] Cl2

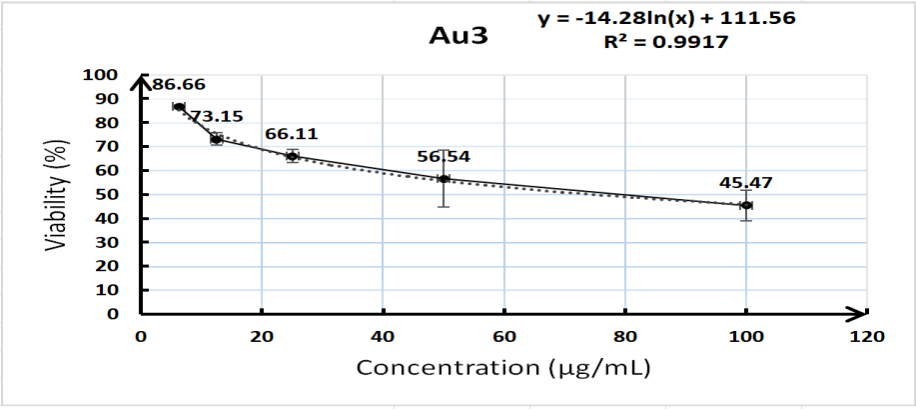

Figure 17: Percentage of Viability in normal breast (MCF-A10) versus the Concentration of the Complex [Au(LCl)] Cl2

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