Research Article

Chemical Review and Letters
journal homepage: www.chemrevlett.com
ISSN (online): 2645-4947 (print) 2676-7279

Synthesis, structure, and properties of platinum(II) complexes with monoethanolamine

Asmat Nizami Azizova[1,*], Kh.I. Hasanov[1,2], N.M. Quliyeva[2], G.A. Mansurova[3], M.Yu. Yusifova[1], Sh.H. Qasımov[1]

[1]*Azerbaijan Medical University, Research Center, Baku, Azerbaijan.*
[2]*Western Caspian University, Baku, Azerbaijan.*
[3]*AMU, Department of Pharmaceutical Toxicology and Chemistry, Baku, Azerbaijan.*

ARTICLE INFO

Article history:
Received 26 September 2025
Received in revised form 25 December 2025
Accepted26 December 2025

Keywords:
Platinum(II)
Monoethanolamine
Cis-, trans-structures
Hydrogen bonding
Coordination
Ligand
Denticity
X-ray diffraction analysis

ABSTRACT

New complex compounds of platinum (II) with the biologically active ligand monoethanolamine (HL), featuring *cis-, trans-* $[Pt(H_2L)_2Cl_2]$, $[Pt(H_2L)_2Br_2]$ structures, as well as tetramine $[Pt(H_2L)_4]Cl_2$ types, were synthesized under various conditions. Studies indicate that in all the synthesized complexes, monoethanolamine is coordinated monodentately to the nitrogen atom of the amino group, and deprotonation of the hydroxyl group of the ligand does not occur. It was determined that the composition and structure of the obtained complexes are strongly influenced by the nature of the initial platinum salts and the synthesis conditions. For instance, when *cis*-$[Pt(NH_3Cl)_2]$ is used as the initial platinum (II) salt, its interaction with monoethanolamine under specific conditions results in the formation of a *cis*-complex with the composition $[Pt(H_2L)_2Cl_2]$. In an alkaline medium, the reaction of $PtCl_2$ with monoethanolamine in a 1:10 ratio produces tetramine-type complexes $[Pt(H_2L)_4]Cl_2$. The structure of the resulting *trans*-complex $[Pt(H_2L)_2Cl_2]$ was confirmed through X-ray diffraction analysis. Biological testing revealed that complexes I-IV exhibit varying levels of antitumor activity.

1. Introduction

Tumor therapy continues to be a critical global concern. Platinum-based drugs demonstrate a wide range of antitumor activity. Researchers are particularly focused on biologically active ligands containing S-, O-, P-, and N-donor atoms within their functional groups [1-3].

This interest arises from the capacity of organic bioligands to form chelate complexes. Coordination compounds can also be synthesized by directing ligands to specific coordination sites, achieving varying levels of stability in the coordination center. Additionally, these synthetic processes are considered models for the interactions between complexing agents and proteins in living systems [4]. The process of complexation results in a synergistic effect between the bioactive organic ligand and the complexing agent. The presence of a bioligand in the coordination sphere reduces overall toxicity while enhancing the biological activity of platinum complexes. Furthermore, the metal center can be masked, which slows down the deactivation of the complex or prevents its recognition by specific proteins [5].

Coordination compounds of transition metals with organic molecules form the foundation of living organisms and are widely utilized in medicine, making their biological significance increasingly evident with each passing day [6].

One of the significant biogenic amines found in complex lipids is colamine, also known as β-monoethanolamine, with the chemical formula $H_2NCH_2CH_2OH$ (H_2L). Numerous organic derivatives of monoethanolamine are utilized in medicine as pharmaceutical agents [7]. Among these derivatives, diethanolamine ($HN(CH_2CH_2OH)_2$) and triethanolamine ($N(CH_2CH_2OH)_3$), which is a polydentate ligand, exhibit chelating properties and are employed to remove excess heavy metals from the body [8]. Certain lead compounds with specific MEA derivatives possess protective properties that shield the body from penetrating radiation [9].

* Corresponding author E-mail: azizova.asmat@gmail.com
https://doi.org/10.22034/crl.2025.549425.1700

It is intriguing to examine the influence of various factors on the complexing ability of monoethanolamine. with platinum(II). Firstly, there is evidence in the literature that complexes of some metals containing amino alcohols exhibit moderate antitumor activity. Secondly, monoethanolamine and platinum can form complexes similar to *cis*-dichlorodiammine platinum, which exhibit antitumor activity. Given these factors, it is advisable to study the complexing ability of MEA with platinum(II), determine the coordination capacity of the ligand, establish the maximum number of ligands coordinated around the central atom, and the biological activity of the synthesized complexes.

2. Materials and Methods

The monoethanolamine ligand, $H_2NCH_2CH_2OH$, was obtained from "FERAX" and used without any further purification. IR spectra of the complexes and the ligand were recorded using Thermo Scientific Nicolet iS10 and Bruker IFS-113V spectrometers in vaseline or fluorinated oil suspensions, as well as in KBr pellets, within the frequency ranges of 200–400 cm^{-1} and 400–4000 cm^{-1}. X-ray photoelectron spectra (XPS) were acquired using a Varian VIEE-15 spectrometer with a magnesium anode under vacuum conditions. Elemental analysis of non-metals was conducted on a CHNS-O EMA 502 analyzer. The platinum content was determined through X-ray fluorescence using an EDX-7000P spectrophotometer (SHIMADZU). The thermal behavior of the complexes was analyzed using an STA 449 F3 Jupiter NETZSCH thermogravimetric analyzer at a heating rate of 10°C/min in air, up to a temperature of 1000°C. X-ray diffraction analysis was carried out on a Bruker X8 APEX automatic four-circle diffractometer, equipped with a two-coordinate SSD detector, at 273(2) K using molybdenum radiation and a graphite monochromator, following standard procedures. The electrical conductivity of the complex was measured using a KEL-1M2 conductometer in water-alcohol solutions at 25°C.

Synthesis of the complex *cis*-$[Pt(H_2NCH_2CH_2OH)_2Cl_2]$-$[Pt(H_2L)_2Cl_2]$ (I). A suspension is prepared using 0.67 g (2.2436 mmol) of *cis*-$[Pt(NH_3Cl)_2]$ in a mixture of 10 ml of water and 10 ml of ethanol. To this suspension, 0.55 g (8.9746 mmol) of monoethanolamine is added with stirring. While stirring, 2-3 mL of concentrated hydrochloric acid is added to the reaction mixture. The mixture is then heated in a tightly sealed flask in a water bath at 40°C for four hours. After heating, the reaction solution is evaporated under vacuum at the same temperature until the volume reduces to 8 ml. The resulting solution is cooled to 6°C. After 24 hours, a loose, bright yellow crystalline precipitate forms from the solution. This precipitate is filtered and washed with cold ethanol and ether. The substance is then dried first in air and subsequently in an oven at 70°C until a constant weight is achieved. Yield: 0.55 g (63%).

Synthesis of the complex *trans* – $[Pt(H_2NCH_2CH_2OH)_2Cl_2]$ - $[Pt(H_2L)_2Cl_2]$ (II). The complex $K_2[PtCl_4]$, weighing 0.53 g (1.2816 mmol), is transferred to a tightly sealed flask containing 20 mL of ethanol, which was pre-added. The flask's contents are continuously stirred using a magnetic stirrer at a temperature of 45-50 °C. After 5 days, the $K_2[PtCl_4]$ dissolves in the ethanol solution. The solution is then filtered, and monoethanolamine, weighing 0.34 g (5.6377 mmol), is added with a 10% excess. The reaction mixture is subsequently evaporated using a rotary evaporator at the same temperature until its volume reduces to 7 mL. Upon cooling, a light yellow precipitate forms, which is filtered, washed with cold ethanol and ether, and then dried. The drying process is first conducted under vacuum and then in a drying oven at 60 °C until a constant weight is achieved. The final yield is 0.35 g (71%).

Synthesis of the complex *trans* – $[Pt(H_2NCH_2CH_2OH)_2Br_2]$ - $[Pt(H_2L)_2Br_2]$ (III). $K_2[PtBr_4]\cdot H_2O$, weighing 0.84 g (1.3274 mmol), is dissolved in a mixture of 10 mL of water and 5 mL of ethanol, then filtered. To the filtered solution of $K_2[PtBr_4]$, 0.40 g (5.8390 mmol) of monoethanolamine (a 10% excess), dissolved in 5 mL of ethanol, is added with stirring. The mixture is stirred continuously for 16 hours in a tightly sealed flask at 50 °C. The reaction mixture is then transferred to a porcelain dish and evaporated on a water bath at 60 °C until the volume is reduced to 5 mL. Upon cooling the solution in an ice bath, a finely crystalline lilac-colored precipitate forms. The precipitate is filtered, washed with cold ethanol and ether, and dried in an oven at 80 °C until a constant weight is achieved. Yield: 0.53 g (83%).

Synthesis of the complex – $[Pt(H_2NCH_2CH_2OH)_4]Cl_2$ - $[Pt(H_2L)_4]Cl_2$ (IV). $PtCl_2$, weighing 0.37 g (1.3910 mmol), is transferred to a tightly sealed flask, and 10 mL of 25% aqueous ammonia solution is added. The mixture is stirred for 36 hours at 40°C. Subsequently, 0.85 g (13.9491 mmol) of monoethanolamine is added to the resulting heterogeneous solution, and the reaction continues at the same temperature. It is worth noting that the molar ratio of reactants is 1:10 (M:L = 1:10) and the pH is maintained at 10. After 1.5 hours, the solution becomes homogeneous, and the reaction mixture turns a greenish-yellow color. The resulting solution is filtered and evaporated using a rotary evaporator until a syrupy residue remains.

To this residue, 50 ml of petroleum ether (fraction boiling at 35-50°C) is added, and the mixture is shaken for 15 minutes. A loose yellow precipitate with a greenish tint forms. This precipitate is filtered, washed thoroughly with petroleum ether, and dried under vacuum over P_2O_5 until it reaches a constant weight. Yield: 0.48 g (66.8%).

3. Results and Discussion

The growing interest in platinum diamines, known for their high biological activity, has motivated us to undertake a thorough investigation of the structure of platinum(II) complexes with monoethanolamine. In contrast to complexes of other metals, monoethanolamine-containing platinum complexes can be synthesized with the specific structures necessary for creating biologically active compounds. The results of the elemental analysis for the synthesized complexes I–IV are summarized in Table 1.

To confirm the purity and identity of the obtained *cis*-$[Pt(H_2L)_2Cl_2]$ and *trans*-$[Pt(H_2L)_2Cl_2]$ complexes, X-ray diffraction patterns were analyzed. The diffraction patterns of the ligand differ significantly from those of the synthesized complexes, validating their identity and purity (Figure 1).

The long-wavelength IR spectrum of the complex displays intense absorption bands at 325 and 346 cm^{-1}, which are attributed to the stretching vibrations of the V_{Pt-Cl} bond, thereby confirming the *cis*- structure of these compounds [10].

Table 1. Results of elemental analysis of complexes I - IV.

Complexes	Pt		Cl/Br		N		C		H	
	Fou.	Calc.	Fou.	Calc.	Fou.	Calc.	Fou..	Calc.	Fou.	Calc.
cis-$[Pt(H_2L)_2Cl_2]$	50.44	50.26	7.59	7.20	18.55	18.29	12.67	12.36	3.82	3.60
trans-$[Pt(H_2L)_2Cl_2]$	50.59	50.26	7.40	7.20	18.63	18.29	12.74	12.36	3.93	3.60
trans-$[Pt(H_2L)_2Br_2]$	40.20	40.88	6.11	5.86	33.82	33.53	10.32	10.06	2.66	2.93
$[Pt(H_2L)_4]\ Cl_2$	38.02	38.24	11.33	10.97	13.62	13.91	18.50	18.83	5.19	5.48

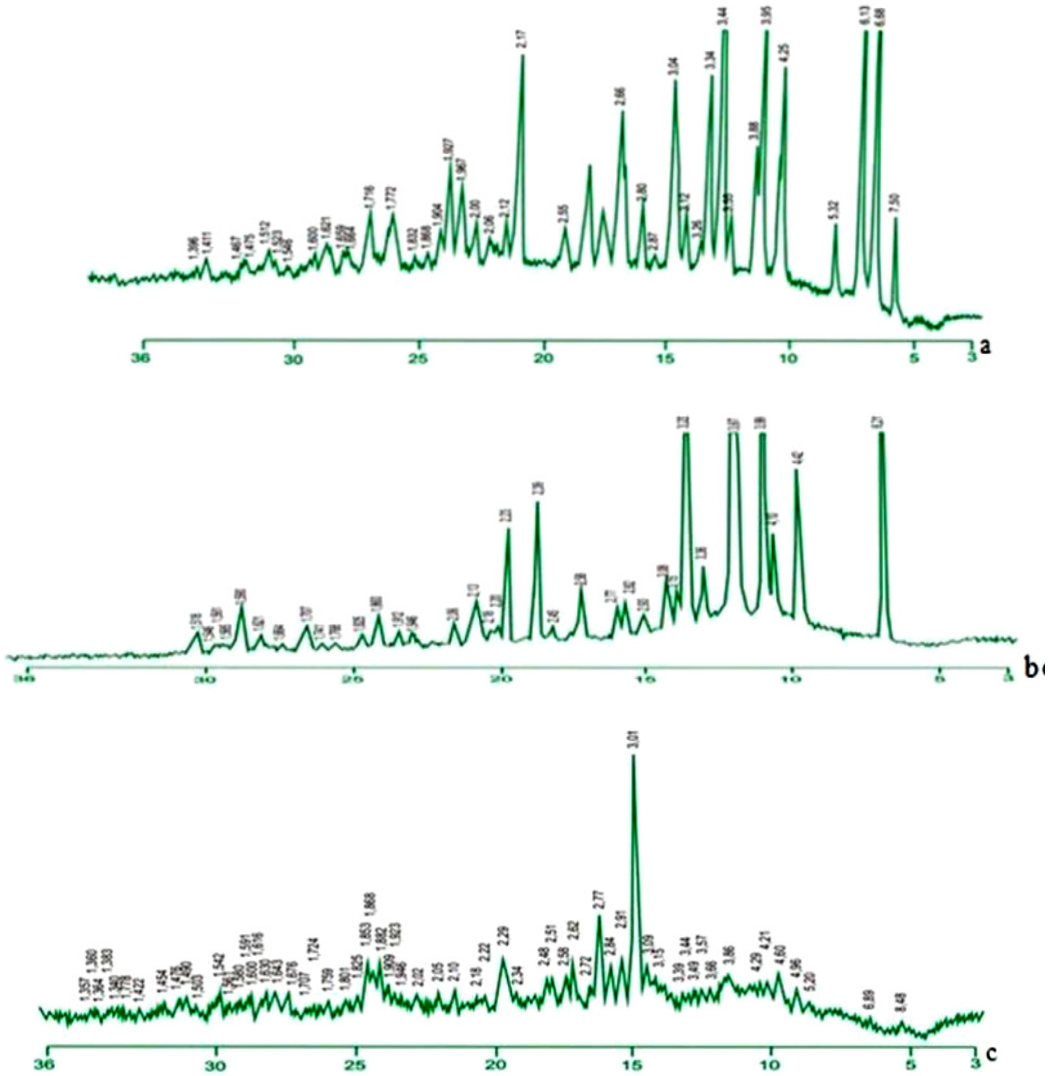

Fig. 1. X-ray diffraction patterns of ligand-L(a) and complexes of *cis*-$[Pt(H_2L)_2Cl_2]$ and *trans*-$[Pt(H_2L)_2Cl_2]$

The monodentate coordination of monoethanolamine via the nitrogen atom in the *cis*-complex $[Pt(H_2L)_2Cl_2]$ is confirmed by the characteristic absorption bands of the coordinated amino group at 3230 and 3212 cm^{-1}, δ_{N-H} at 1580 cm^{-1}, as well as the stretching vibrations of the ν_{Pt-N} bond at 442 and 465 cm^{-1} [10]. The weak IR absorption band observed at 3595 cm^{-1} has been attributed to the free hydroxyl group of the ligand [10,11].

The IR spectroscopic data obtained on the structure of the *cis*-$[Pt(H_2L)_2Cl_2]$ complex are further supported by results from X-ray photoelectron spectroscopy. The experimental value that characterizes the unique distribution of valence electrons around a specific atom in the molecule is determined by the difference between the corresponding energy levels of the free ligand and its complex. For instance, in the X-ray photoelectron spectrum of free monoethanolamine, the nitrogen atom exhibits a binding energy (E_{N1S}) of 398.4 eV. In the *cis*-$[Pt(H_2L)_2Cl_2]$ complex, this binding energy increases to 400.4 eV. This increase in electron density around the nitrogen atom indicates that the ligand is coordinated through the nitrogen atom. The E_{O1S} binding energy remains unchanged between the free ligand and its coordinated form via the nitrogen atom. These findings from X-ray photoelectron spectroscopy align well with previously published data [12].

By varying synthesis conditions and the type of initial platinum(II) salts, *trans*-coordinated chloride and bromide complexes of monoethanolamine were successfully synthesized. An analysis of the structures of the trans-$[Pt(H_2L)_2Cl_2]$ and $[Pt(H_2L)_2Br_2]$ complexes using IR spectroscopy in the region of ν_{Pt-hal} (hal = Cl, Br) stretching vibrations revealed that these complexes adopt a trans-configuration. This conclusion is supported by an absorption band observed at 347 cm^{-1}, corresponding to the stretching vibrations of the ν_{Pt-Cl} bond (Fig. 1 Supp.), and another at 196 cm^{-1}, attributed to the stretching vibrations of the ν_{Pt-Br} bond. Additionally, absorption bands observed at 470 and 473 cm^{-1} are assigned to the stretching vibrations of the ν_{Pt-N} bond in the chloride and bromide complexes, respectively. In contrast, in the IR spectrum of the *cis*-$[Pt(H_2L)_2Cl_2]$ complex, absorption bands at 382 and 425 cm^{-1} are attributed to the ν_{Pt-N} stretching bond (Figure 1).

In both *trans*-and *cis*-complexes, monoethanolamine coordinates through its nitrogen atom, while its hydroxyl group does not participate in coordination. The characteristic absorption band for the coordinated amino group is confirmed by stretching and deformation vibrations: ν_{NH2} = 3237 cm^{-1} and δ_{N-H} at 1584 cm^{-1}. In the bromide analog, the N-H bond stretching vibration occurs at 3224 cm^{-1}, and its deformation vibration (δ_{N-H}) is observed at 1608 cm^{-1} (Fig . 2 Supp.).These results are consistent with previously reported references [10].

The square-planar structure of the coordination polyhedron in the $[Pt(H_2L)_4]Cl_2$ complex is further confirmed by the presence of a single IR absorption band, with a maximum corresponding to the ν_{Pd-N} valence bonds at 548 cm^{-1}. This band is absent in the spectrum of the original ligand. Such a feature is characteristic of square-planar palladium(II) complexes of the tetraamine type, as illustrated in (Fig . 3 Supp.).

According to the selection rules of D_{4h} symmetry, one strong absorption band should be observed in the IR spectrum of the tetraamine-type complex. The IR spectrum of the $[Pt(H_2L)_4]Cl_2$ complex also shows bands corresponding to the stretching vibration δ_{NH2} at 3207 cm^{-1} and the deformation vibration δ_{N-H} at 1434 cm^{-1}. These observations indicate the monodentate coordination of the ligand to the nitrogen atom of the amino group, while the hydroxyl group of the ligand does not participate in the coordination. Refer to (Fig. 4 Supp.) for further details.

In the X-ray photoelectron spectra of the *trans*-complexes $[Pt(H_2L)_2Cl_2]$ and $[Pt(H_2L)_2Br_2]$, the binding energy values for E_{N1S} are 0.6 eV and 0.8 eV higher, respectively, compared to that of the free ligand. This further confirms the monodentate coordination of monoethanolamine at the nitrogen atom. In the *trans*-configuration, the coordinated chlorine and bromine atoms exhibit bond energies of $E_{Cl2}P_{3/2}$ = 198.9 eV and E_{Br3d} = 69.6 eV, respectively [12].

Single crystals of the *trans*-$[Pt(H_2L)_2Cl_2]$ complex were grown and analyzed using X-ray structural analysis. The results obtained were consistent with those from IR spectroscopy and X-ray photoelectron spectroscopy studies.

The crystals of the *trans*-complex $[Pt(H_2L)_2Cl_2]$ are monoclinic at 20°C, with the following parameters: a = 7.613(2) Å, b = 12.481(3) Å, c = 11.940(2) Å, β = 105.85(2)°, Z = 4, and space group $P_{21/c}$. The structure was determined using the heavy atom method and refined through the least-squares method under the isotropic approximation. During refinement, an absorption correction was applied using the DIFABS method [11], with μ (MoKα) = 60.4 cm^{-1}. All hydrogen atoms were identified in the difference synthesis; however, in subsequent calculations, the geometrically calculated coordinates for the hydrogen atoms were used, except for those bonded to nitrogen and oxygen atoms. The final refinement, performed using the full-matrix anisotropic approximation with fixed positional and isotropic temperature parameters, achieved an R-value of 0.0265 for 1484 reflections with $F^2 > 6\sigma(F^2)$.

The structure of the *trans*-complex $[Pt(H_2L)_2Cl_2]$ is depicted in Figure 2, and selected bond lengths and bond angles are listed in Table 2. The complex exhibits a *trans*-configuration, where the platinum atom is coordinated by two chloride ions and two monoethanolamine ligands. Both monoethanolamine ligands are coordinated monodentately through their nitrogen atoms. The hydroxyl groups of the monoethanolamines do not

participate in coordination with the central platinum atom. The platinum atom exhibits a square-planar coordination with a slight tetrahedral distortion. The Pt-N^1 and Pt-N^2 bond lengths are 2.05(2) Å and 2.07(1) Å, respectively, falling within the typical range (2.02-2.10 Å) for platinum complexes with amine ligands [13]. The Pt-Cl^1 and Pt-Cl^2 bond lengths are 2.304(3) Å and 2.290(2) Å, respectively, which are consistent with the usual values for platinum complexes with chloride ligands in the trans configuration, where the amines are positioned. However, the Pt-Cl^2 bond length is primarily influenced by the involvement of the chlorine atom (Cl1) in an intramolecular hydrogen bond with $O^2H…Cl^1$.

In an alkaline medium, when $PtCl_2$ interacts with monoethanolamine, tetramine-type complexes $[Pt(H_2L)_4]Cl_2$ can only be synthesized in a 1:10 ratio. In the tetramine complex $[Pt(H_2L)_4]Cl_2$, a uniform redistribution of electron density between the central platinum atom and the nitrogen atoms of the coordinated ligands occurs, indicating equivalent bonds between platinum and nitrogen. This equivalence is evidenced by a single strong IR absorption band at 505 cm^{-1}, suggesting that the square-planar coordination polyhedron of platinum remains undistorted and possesses D_2h symmetry [13]. IR absorption bands observed at 3200 cm^{-1} and 1616 cm^{-1} are attributed to the coordinated amino group of the ligand and its deformation vibrations, respectively.

The single narrow line at 400.6 eV in the X-ray photoelectron spectrum of the complex further confirms the equivalence of all nitrogen atoms. Due to the presence of hydrogen bonding in the $[Pt(H_2L)_4]Cl_2$ complex, it was not possible to isolate a specific absorption band for the hydroxyl group of the ligand. More distinct absorption bands in the 2200–3300 cm^{-1} region are attributed to hydrogen bonding. Elemental analysis of the $[Pt(H_2L)_4]Cl_2$ complex aligns well with the proposed formula.

Thermal decomposition studies reveal that all complex compounds are thermally stable up to 200 °C. Thermal analysis curves for the *cis*-complex with monoethanolamine (Figure 3) in the temperature range of 200–360 °C show mass loss accompanied by exothermic effects, with a total enthalpy of 1463 J/g and peaks at 278 °C, 291 °C, and 326 °C, along with a minor endothermic effect peaking at 228 °C [14]. The process occurs in three stages: a significant mass loss (~27%) in the first stage corresponds to the elimination of monoethanolamine and decomposition of the complex. Above 500 °C, a slight decrease in mass loss is attributed to the decomposition of platinum oxide. The final product of thermolysis is metallic platinum; the residual mass at temperatures above 800 °C, 50.84%, matches the theoretically calculated platinum content in the sample based on the *cis*-complex, which is 50.26%.

The molar electrical conductivity (μ) of solutions of complexes I–IV at a concentration of 1×10^{-3} mol/dm^3 was measured. Complex IV exhibited a molar conductivity of 216.4 Ohm^{-1} cm^2 mol^{-1}, indicating its nature as a triionic electrolyte. For comparison, $BaCl_2$, a known triionic electrolyte, showed a molar conductivity of 223.1 Ohm^{-1} cm^2 mol^{-1}. In contrast, complexes I–III displayed molar conductivities of 33.6, 41.3, and 19.7 Ohm^{-1} cm^2 mol^{-1}, respectively, confirming their non-electrolyte characteristics (see Table 3).

Table 2. Principal bond lengths and bond angles of the trans complex $[Pt(H_2L)_2Cl_2]$

Connection	***d*, Å**	**Corner *ω*, degree**	***ω***
Pt-Cl^1	2,304(3)	N^2PtN^1	177,4(6)
Pt-Cl^2	2,290(2)	Cl^1PtN^1	85,4(8)
Pt-N^1	2,05(2)	Cl^1PtN^2	89,7(4)
Pt-N^2	2,07(1)	N^2PtCl^2	91,2(5)
		N^1PtCl^2	93,3(3)

Table 3. Some physical and biological characteristics of the complexes.

Complexes	**Solubility g/10 ml,H_2O**	**Decom temp. (melting)**	**Elec. cond. $Ohm^{-1}cm^{-1}$ mol^{-1}**	**Yield %**	**Action on lateral root %**
cis-$[Pt(H_2L)_2Cl_2]$	0.91	194	33.6	63	86
trans-$[Pt(H_2L)_2Cl_2]$	0.96	196	41.3	71	79
trans-$[Pt(H_2L)_2Br_2]$	0.92	201	19.7	83	62
$[Pt(H_2L)_4]$ Cl_2	0.97	198	216.4	67	83

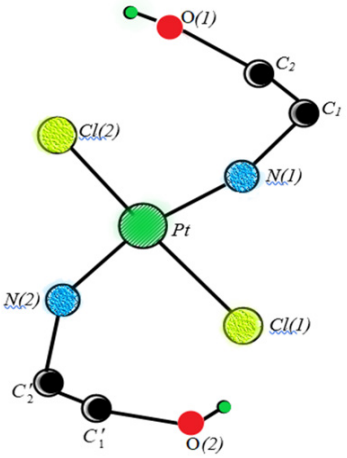

Fig. 2. Molecular structure of the *trans*-complex $[Pt(H_2L)_2Cl_2]$

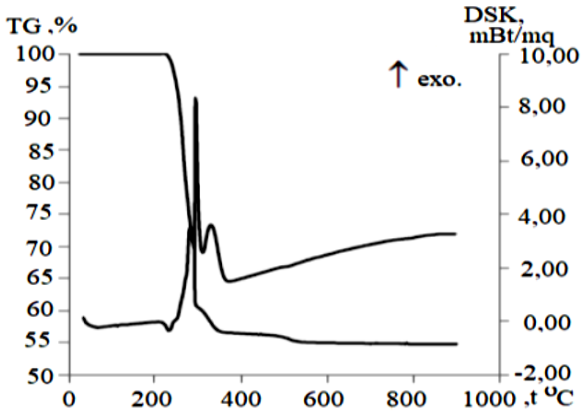

Fig. 3. Results of simultaneous thermal analysis of the Pt(II) *cis*-complex with monoethanolamine.

The references [15,16] indicate that platinum compounds with antitumor activity selectively inhibit mitosis in plant roots, particularly in corn. One of the most potent antitumor drugs, *cis*-dichlorodiammine platinum, serves as an example of a highly effective antimitotic compound, which, at a concentration of 0.001 mg/ml, inhibits cell division in corn roots by 98% within three days.

For the *cis*-$[Pt(NH_3)_2Cl_2]$ complex, the toxicity (LD_{50}) is 13-14 mg/kg, while the therapeutic dose is 7 mg/kg. In comparison, for the *cis*-$[Pt(H_2L)_2Cl_2]$, *trans*-$[Pt(H_2L)_2Cl_2]$, and *trans*-$[Pt(H_2L)_2Br_2]$ structures, as well as the tetramine $[Pt(H_2L)_4]Cl_2$ type, the toxicity levels are 102.146 mg/kg and 173.121 mg/kg, respectively. The study demonstrates that the synthesized complexes I-IV are less toxic than *cis*-dichlorodiammine platinum.

Corn roots were treated with aqueous solutions of complexes I-IV at a concentration of 0.001 mg/ml. After 72 hours, the length of the section where lateral roots had formed was measured, and the change in this length was taken as the average growth. The percentage of lateral root inhibition caused by platinum(II) complexes I-IV is presented in Table 3. The effects of platinum compounds with monoethanolamine (I-IV) on microorganisms and corn roots make them suitable as test subjects for the preliminary selection of compounds with potential for further testing. Screening of all tested platinum(II) complexes with monoethanolamine demonstrated their potential use as antitumor agents. The cytotoxic activity was found to be strongly influenced by the structure of the complexes [17-19].

An analysis of the structure of the synthesized platinum(II) complexes with monoethanolamine, conducted using various physical methods, revealed that the ligand coordinates monodentately to the nitrogen atom of the amino group in both *cis*- and *trans*-configurations. The hydroxyl group of the ligand does not participate in coordination in any of the synthesized complexes. It was also determined that the composition and structure of the resulting complexes are uniquely dependent on the nature of the initial platinum salts and the synthesis conditions. Biological testing of all synthesized complexes revealed that complexes I-IV exhibit varying levels of antitumor activity

4. Conclusion

Optimal conditions for synthesizing monoethanolamine-containing platinum(II) complexes have been identified. These conditions encompass the reactant ratios, temperature, solvent type, and, in certain cases, pH values for the synthesized compounds *cis*-$[Pt(H_2L)_2Cl_2]$, *trans*-$[Pt(H_2L)_2Cl_2]$, $[Pt(H_2L)_2Br_2]$, and the tetraamine $[Pt(H_2L)_4]Cl_2$.

The single crystals of the *trans*-$[Pt(H_2L)_2Cl_2]$ complex were analyzed using X-ray diffraction, with results aligning well with data from IR and X-ray photoelectron spectroscopy. The variation in Pt-Cl bond lengths arises from the involvement of one chlorine atom in an intramolecular OH…Cl hydrogen bond, whose geometric parameters indicate a relatively strong hydrogen bond. The tetraamine complex $[Pt(H_2L)_4]Cl_2$ was synthesized in an alkaline medium (pH = 10) by reacting $PtCl_2$ with monoethanolamine in a 1:10 ratio, followed by precipitation with petroleum ether. A single, narrow peak at 400.6 eV in the X-ray photoelectron spectrum of the complex confirms the equivalence of all nitrogen atoms. Notably, the hydroxyl group of the ligand in all synthesized complexes does not engage in coordination.

Screening of the tested platinum(II) complexes with monoethanolamine revealed their potential as antitumor agents, demonstrating that cytotoxic activity is strongly influenced by the structural characteristics of the complexes. Optimal conditions for synthesizing

monoethanolamine-containing platinum(II) complexes have been identified. These conditions encompass the reactant ratios, temperature, solvent type, and, in certain cases, pH values for the synthesized compounds *cis*-$[Pt(H_2L)_2Cl_2]$, *trans*-$[Pt(H_2L)_2Cl_2]$, $[Pt(H_2L)_2Br_2]$, and the tetraamine $[Pt(H_2L)_4]Cl_2$.

The single crystals of the *trans*-$[Pt(H_2L)_2Cl_2]$ complex were analyzed using X-ray diffraction, with results aligning well with data from IR and X-ray photoelectron spectroscopy. The variation in Pt-Cl bond lengths arises from the involvement of one chlorine atom in an intramolecular OH…Cl hydrogen bond, whose geometric parameters indicate a relatively strong hydrogen bond. The tetraamine complex $[Pt(H_2L)_4]Cl_2$ was synthesized in an alkaline medium (pH = 10) by reacting $PtCl_2$ with monoethanolamine in a 1:10 ratio, followed by precipitation with petroleum ether. A single, narrow peak at 400.6 eV in the X-ray photoelectron spectrum of the complex confirms the equivalence of all nitrogen atoms. Notably, the hydroxyl group of the ligand in all synthesized complexes does not engage in coordination.

Screening of the tested platinum(II) complexes with monoethanolamine revealed their potential as antitumor agents, demonstrating that cytotoxic activity is strongly influenced by the structural characteristics of the complexes

Supplementary files

Supplementary file 1.

References

[1] Barbosa HFG, Attjioui M, Ferreira APG, Moerschbacher BM, Cavalheiro ÉTG. New series of metal complexes by amphiphilic biopolymeric Schiff bases from modified chitosans: Preparation, characterization and effect of molecular weight on its biological applications. Int. J. Biol. Macromol. 2020;145:417-428. doi:10.1016/j.ijbiomac.2019.12.153

[2] Lunagariya MV, Thakor KP, Waghela BN, Pathak C, Patel MN. Design, synthesis, pharmacological evaluation and DNA interaction studies of binuclear Pt(II) complexes with pyrazolo[1,5-a]pyrimidine scaffold. Appl. Organomet. Chem. 2018;32(4):e4222. doi:10.1002/aoc.4222

[3] Bakr EA, Al-Hefnawy GB, Awad MK, Abd-Elatty HH, Youssef MS. New Ni(II), Pd(II) and Pt(II) complexes coordinated to azo pyrazolone ligand with a potent anti-tumor activity: Synthesis, characterization, DFT and DNA cleavage studies. Appl. Organomet. Chem. 2018;32(2):e4104. doi:10.1002/aoc.4104

[4] Hasanov KhI, Azizova AN, Qulieva NM, Adjalova GI, Yusifova MYu, Qasumov ShG. Membrane-protective properties of palladium (II) complexes containing antioxidant fragment as potential radioprotective agents. Chem. Probl. 2025;23(2):214-220. doi:10.32737/2221-8688-2025-2-214-220

[5] Riccardi C, Capasso D, Coppola A, Platella C, Montesarchio D, Di Gaetano S, et al. Synthesis, antiproliferative activity, and DNA binding studies of nucleoamino acid-containing Pt(II) complexes. Pharmaceuticals. 2020;13(10):284. doi:10.3390/ph13100284

[6] Deo RK, Kumar C. Synthesis and spectral characterization of binuclear compounds of Cu(II) and Ni(II) Schiff base. J. Chem. Lett. 2023;4(2):81-85.

[7] Tyukavkina NA, Baukov YuI. Bioorg. Chem. Moscow: Meditsina; 1985.

[8] Hasanov KhI, Mirzai DjI. Cationic-anionic complexes of palladium(II) and platinum(II) with di- and triethanolamines. Chem. Chem. Technol. 2000;43(4):108-111.

[9] Cain MM, Dubois SM. Mise en evidence d'une forme protonee du chlorire de Pb (II) ethanolamine. C. R. Acad. Sci. Paris. 1975;280(1):9-12.

[10] Nakamoto K. IR and Raman spectra of inorganic and coordination compounds. Mir; 1991.

[11] Ajalova GI, Hasanov KhI, Azizova AN, Gasımov ShH, Badalova KK. Synthesis and structure of platinum (II) complexes with decomposition product of dithiodiethylamine β – mercaptoethylamine. Chem. Probl. 2023;21(1):21-28. doi:10.32737/2221-8688-2023-1-21-28

[12] Nefedrov VI. X-ray Electron Spectroscopy of Chemical Compounds. Moscow: Chemistry; 1984.

[13] Azizova AN, Tagiev DB, Qasumov ShH, Hasanov KhI. Six-nuclear complexes platinum(II) and palladium(II) with mercamine and β-mercaptoethanol. J. Gen. Chem. 2018;88(3):478-481. doi:10.1134/S1070363218030179

[14] (a) Yablokov VA, Smeltsova IL, Faerman VI. Thermal stability of amino acids. J. Gen. Chem. 2013;83(3):423-427. (b) Askari E, Alborzi A. Ammonium Iron(III) Sulfate as an Eco-friendly Catalyst for the Synthesis of Spirooxindole Dihydroquinazolinone Derivatives. J. Chem. Tech. 2025;1(2):85-89. (c) Alkherraz A, Elsherif KM, Al-Arbash AM, Abajja SM, Shawish HM. Conductometric Investigation of Schiff Bases and Ni(II) Ions: Stability and Thermodynamics in Nonaqueous Solutions. J. Chem. Lett. 2025;6(3):157-165. (d) Adelabu AM, Abdulsalam S, Hamza SA, Imam M, Abubakar S. Synthesis, characterization and antimicrobial activity of a schiff base derived from 2-aminobenzothiazole with o-vanillin and its copper(II) complex. Med. Med. Chem. 2025;2(3):141-145. (e) Sakhare DT. Synthesis of Schiff Bases Ligand And Biological Activities of Their Transition Metal Complexes. J. Chem. Tech. 2025;1(4):189-195.

[15] (a) Akbarov AB. Synthesis and study of the relationship between chemical and biological properties of coordination compounds of some 3d-ions with bioligands. Coord. Chem. 1989;15(1):3-25; Akbarov AB, Kharitonov YY, Islamov MN. Bioenergetic aspects of the peculiarities of the composition-structure-specific activity relationship of biocomplexes. J. Inorg. Chem. 1993;38(2):312-326. (b) Adam AM, Abdurrahman AM, Nasir MH, Sani UM. Preparation and some physicochemical studies of nickel(II) complex with schiff base derived from acetylacetone and 2–aminopyridine. Chem. Res. Technol. 2024;1(3):150-153. (c) Joshi DKT, Pandya NR. Recent advances in microwave assisted synthesis of biological active 2-aminothiazole-schiff bases and their metal chelates. Med. Med. Chem. 2025;2(3):123-128.

[16] (a) Gozelle M, et al. Studies on the synthesis, characterization, cytotoxic activities and plasmid DNA binding of platinum(II) complexes having 2-substituted benzimidazole ligands. Polyhedron. 2019;161:298-308. (b) Adam AB, Abubakar MY, Abubakar D. Green Organic Synthesis in Drug Development: Advances in Enzyme- and Microorganism-Mediated Processes. Med. Med. Chem. 2024;1(3):115-128. (c) Ishaya EV, Modu BK, Yakubu J, Mohammed B. One Synthesis, characterization, and antimicrobial properties of chromium (III) and iron (III) complexes with schiff base ligands. J. Chem. Tech. 2025;1(4):160-166. (d) Dashtpeyma F, Montazerozohori M, Nasr-Esfahani M. Synthesis, characterization, thermal investigation, and antimicrobial activity of some new bis-imine cadmium (II) complexes. J. Chem. Lett. 2025;6(3):142-156.

[17] Riccardi C, et al. Synthesis, DNA binding studies, and antiproliferative activity of novel Pt(II)-complexes with an L-alanyl-based ligand. J. Inorg. Biochem. 2020;203:110868. doi:10.1016/j.jinorgbio.2019.110868

[18] Zamay TN, et al. Reducing the toxicity of cisplatin by conjugating it with arabinogalactan. Biol. Membr. 2020;37(1):69-75. doi:10.31857/S0233475520010090