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Theoretical Study of the Anticancer Properties of Iproplatin Drug and Comparison with *Cis*-Diamine-dichloro Platinum (II) (CDDP)

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ABSTRACT

Numerous transnational experimenters have strived to understand the medium of action or ameliorate the efficacy of inorganic collaboration composites that have been linked to parade anticancer exertion. The essential challenges of chemotherapy demand that new strategies be developed utilizing different mechanisms of action to intrude the cellular ministry of cancer cells.* In Australia, we have served from the exploration of associates who have told ultramodern platinum chemistry by contributing to our understanding of platinum oxidation and reduction, the medium of action of cisplatin, and unique design strategies for new platinum complexes. The purpose of this review is to give some backgrounds on the history and development of platinum (II) and platinum (IV) complexes. AS an anticancer drug, Iproplatin has a similar function as cis-diamine-dichloro platinum (II) (Cisplatin), but its toxicity varies and is usually lower. In this research, a comparison of anticancer drugs was performed based on cisplatin and its use in the design of newer drugs to determine the comparative index for measuring the drug potency of this category of compounds. In addition, using theoretical calculations, the process of combining iproplatin with the bases of adenine, thymine, cytosine, and guanine forming DNA and comparing it with cisplatin was investigated from the veiwpoint of thermodynamics and activation energy. The results showed that the complex between iproplatin and the organic bases of cytosine and thymine is the most stable state. This complex can be a suitable candidate for anticancer drugs based on the results obtained for each quantum chemical parameter from DFT computational studies. Substitution of either the coordinated chloride or aqua moeities was delved under mock first-order conditions as a function of attention and temperature. Experimental data were corroborated with DFT calculations. The kinetic and mechanistic study of the ligand negotiation responses of a series of transplatinum(II) complexes was performed.

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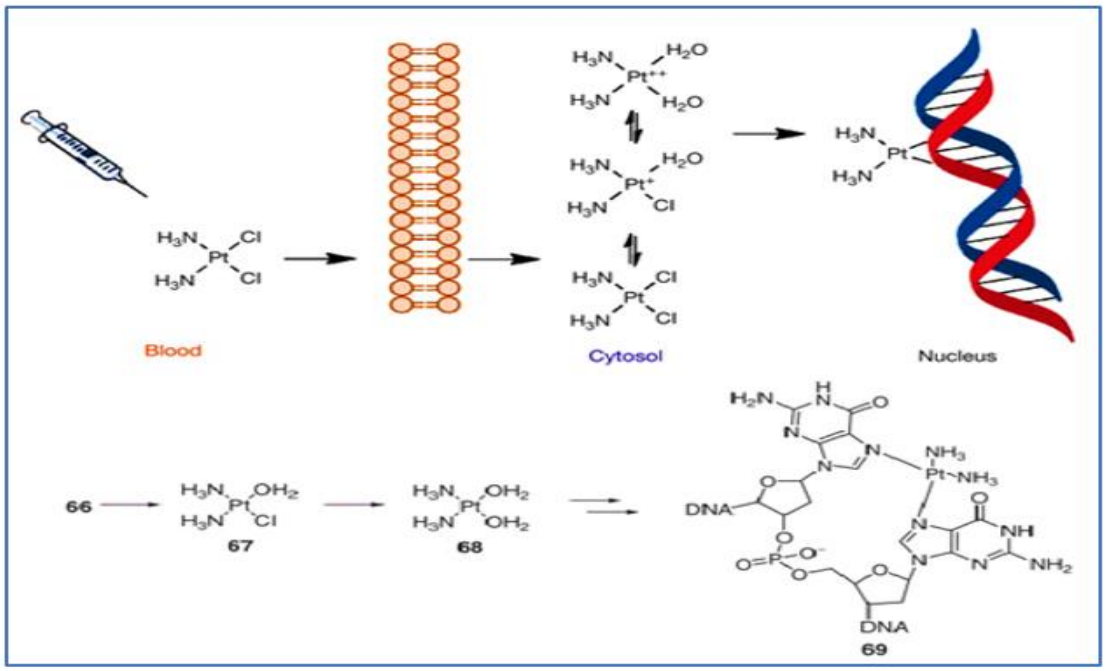
GRAPHICAL ABSTRACT



Introduction

Cancer is a disease in which the body's cells are destroyed during a regulated process, and new cells replace them. Sometimes, the natural process is out of regulation, and the worn-out cells do not disappear, forming a mass that can become a malignant tumor or cancer. Despite many advances in disease control and treatment, significant breakthroughs in the understanding, prevention, and treatment of cancer, cancer is still a global health challenge, so it has been the most common cause of death in industrialized countries in the last half-century [1-3]. Although extensive research in the world does detect the causes of cancer and evaluate its various treatments, and although some progress has been made, the etiological and pathogenic aspects of this disease are still unknown. Etiology and pathogenic models are closely related to the processes that start (etiology) and (pathogenic) maintain a specific disorder or disease [4]. There are currently several treatments for cancer patients that depend on the type of cancer, the patient's age, general health, and how the patient responds to the type of treatment. These treatments include surgery, radiation therapy, gene therapy, and chemotherapy [5,6]. Chemotherapy is one of the most common methods of treating cancer or temporarily alleviating it with certain medications. In general, many chemotherapy drugs, used to treat cancer, often cause alterations in cancer cell division, proliferation, and differentiation. This is done in kinases and various ways, including apoptosis induction, modification of DNA structure, tyrosine, and kinases, and inhibition of mitotic division transcription and replication. A protein kinase is a kinase that selectively modifies other proteins by covalently adding phosphates (phosphorylation) instead of kinases that modify lipids, carbohydrates, or other molecules. Most anticancer drugs used in chemotherapy cannot selectively kill cancer cells and damage healthy

surrounding tissues. In addition, the side effects of these drugs may cause tumor recurrence or drug resistance. Cis-diamino dichloro platinum (cisplatin), an antitumor drug that affects the macromolecular strands of DNA of cancer chromosomes and slows their division, is the most effective compound currently used to treat various cancers. Cisplatin is a mineral complex that damages DNA. Cisplatin dissolves in water, is released into a soluble form in the body, and is considered as an alkylating agent. It is a chemically flat square that is hydrolyzed to an active form suitable for binding to DNA. The binding of cisplatin to genomic DNA in the cell nucleus is the main event responsible for cisplatin's anticancer properties. Cisplatin binds an alkylated group to a DNA molecule by alkylating DNA and inhibiting DNA transcription and replication mechanisms [7,8]. These alterations are DNA processes that trigger cytotoxicity, which leads cancer cells to cell death (**Fig 1**). Cisplatin undergoes biotransformation to cysteinyl glycine conjugates and other higher thiols that is believed to cause toxicity. It is also believed that the mechanism of cisplatin-induced nephrotoxicity is the same as that of tumor cytotoxicity [9]. Besides cisplatin, other drugs with similar structures, such as carboplatin, oxaliplatin, and iproplatin, have similar properties in treating or controlling cancer. Among the clinically tested platinum complexes, iproplatin is structurally unique because it is a quadrivalent complex. Unlike divalent platinum anticancer agents that are square planar complexes, iproplatin has an octahedral configuration, with two hydroxy ligands projecting at 90· above and below the square plane. Iproplatin binds to DNA by forming cross-links and generating platinum- DNA adducts. This results in DNA replication failure and tumor cell death. Because these drugs are more unsuitable for substitution reactions, they impose fewer reactions to kill cancer cells. As a result, drug side effects and loss will be less than platinum complexes due to inactivation.Finally, these complexes can have a higher therapeutic index with less toxicity and activity. One of the main problems of complexes is their stability. This stability is closely related to all heating, oxidation, hydrolysis, or hooding factors. Complexes Paltin (II) is acceptable and stable against these factors. Therefore, the basis of methyl complexes Paltin (II) is not hydrolyzed with dilute acids and oxidized by air moisture. Today, the only metal-containing drugs that target DNA and have clinical applications are platinum-based drugs, which interact mainly with nucleic acid through a covalent bond [10,11].

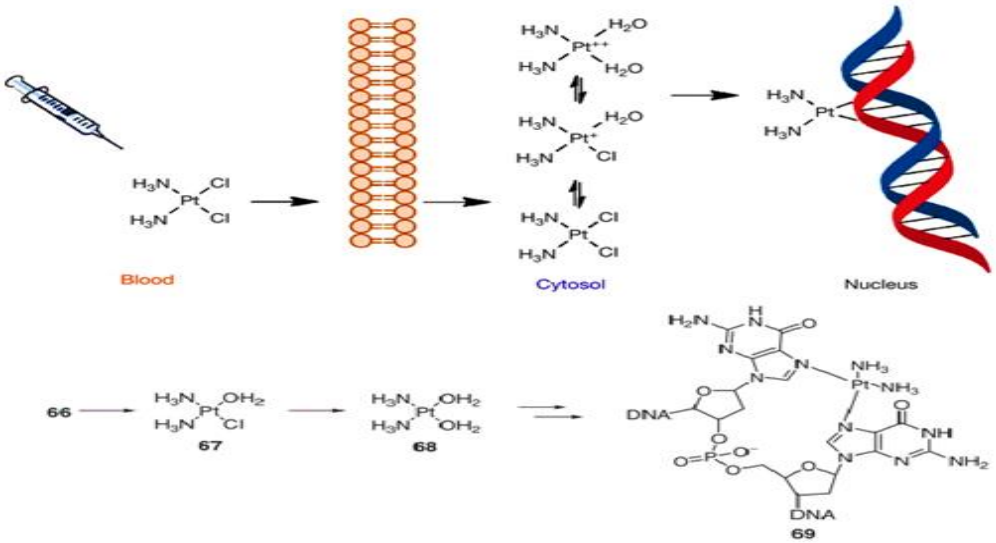


Fig 1.A schematic view of the interaction of iproplatin with nucleic acid

Organic bases are present in the DNA strand with four thymine, cytosine, guanine, thymine, and adenine forms [12]. DNA alkylation involves the addition of alkyl groups to these organic bases. Bases, methyl, or ethyl groups bind to reactive sites on skeletal bases and phosphates in alkylation. One of the most vulnerable sites to alkylation is O_6- guanine. Other alkylation products include O_2- alkyl thymine, O4-alky thymine, O_6- methyl guanine, and O_6- ethyl guanine. Cisplatin has a similar function to alkylating agents and interferes with DNA function by binding between the strands of DNA. When cisplatin enters the cell, its chloride group is released, and then Pt metal with two amines not removed from the cell binds to DNA nucleic acid and forms Pt- DNA cross-links, which are initially only a covalent bond. The most favorable position on the DNA base for the reaction with cisplatin is N_7- deoxyguanosine [13-15]. In recent decades, theoretical advances have been made in the internal reactions of metal-nucleic acid using the computational method based on the technique of quantum chemistry. In this research, metal–polynucleotide interactions are studied related to the above domains [16]. In reactions of flat compounds, platinum (II) (some of the Ligands cause trans-ligands to be easily replaced by other ligands. It is mentioned that these ligands are effective in changing their trans- ligands. There are more trans-synthesis effects; these types of ligands, such as SnCI 3-Zigma Transplant-H are strong, and those such as C_2H_4 and thiourea form strong leg grafts, they also form L-M transplants. The effect of trans substituents in the structures of the pharmaceutical complex is for more stability in space and also causes the bonds of our pharmaceutical complex to experience para or anti placement. Weakens the trans relative to itself and lifts the length of the L-M bond through crystallography By X-ray or from a sight spectrum such as L, M coupling constant in NMR spectrum or frequency. The tensile of L-M in the IR spectrum is confirmed by such a change in the thermodynamic properties of the base state. The base state occurs in a way called trans penetration so that the same effect is presented on the properties of the state [17]. The transition is observed in the succession reaction, and the word trans effect is completely trans in the true sense. Clean trans development refers to differences in succession speeds. So the result of the change in the difference in energy between the base state and the reaction transition state is the critical application of the trans-synthesis effect [18]. A special isomer of coordination compounds is observed in the following equation. With more trans effect than ammonia, cis isomers can be selectively selected, and trans Cl2 2)3 NH(Pt) in each case in the first stage of this succession is the only isomer. It is formed in the following equation in the second stage of cis isomer because the transformer Cl is compared to Cl. It is more variable than cl trans than ammonia because ligand ammonia with trans effect Less, and on the other hand, in the first succession with claire ligand, ammonia trans compared to itself. It is modifiable and is the final product of transdichloride.

Computational Method

The primary purpose of the present study is to measure and evaluate the effects of electron instability, spatial repulsions, and bipolar-bipolar interactions on the structural, electronic, and reactivity properties of the anticancer drug iproplatin and compare it with cis-diamino dichloro-platinum (II). The methods used are tools for determining structural properties in the gas and solvent phases [19]. Quantum mechanical computations of electron density functional theory (DFT) and molecular orbital computations at LANL2DZ theoretical levels were performed to minimize the energy of iproplatin and cis-diamino dichloro platinum (II) structures alone and in the presence of each other using the GAUSSIAN 09 software [20-23]. GAUSSIAN software used DFT computations to fully optimize all structures

reported in this research. The most critical applications of chemical products in coordination compounds are the determination of molecular structure,energy of orbitals, and determining the mechanism of reactions, kinetic study of reactions, vibrational frequencies, ViS-ESR, NMR, UV, and X-ray spectroscopy, the effects of solvents, and also the method used in this study is BLYP3 method. The most critical applications of computational chemicals in this project are optimal structure determination compounds, intermediates, transition states, and frequency calculations [24]. The effective potentials of the nuclei were selected with the base series to calculate Pt and Cl. The base series was used for other atoms. Polarized functions were added for Cl and Pt atoms as follows. Frequency computations were performed at the same level of theory to identify all fixed points on the potential energy level, such as the minimums (without negative frequencies) or transition states (with a negative frequency). Free energy computations were performed in the gas phase at 298. 15·K and pressure of 1 atm. Chemically significant values were used in this discussion. The values were reported in [25]. H-NMR data includes chemical displacements and spin-spin coupling constants for identifying organopaltin complexes has been used. Many structural problems (in the form of Space complex and central atom oxidation state (and the study of species concentration changes over time using this data have been solved. In this study, NMR parameters such as chemical shift tensor isotropy (σ_{iso}), chemical shift tensor anisotropy (σ_{aniso}), and atomic charges in the gas phase were calculated using the GIAO method to obtain structural information, dynamic behavior, and intermolecular interactions of each of these compounds [26]. Theoretical computation performed NBO analysis performed NBO analysis at B3LYP/6-31G for the noted compounds using NBO 5.G software. It should be noted that calculations related to thermodynamic functions and vibrational frequencies were performed in the gas and solvent phases for the mentioned structures, and the effects of solvation with polar, semi-polar, and nonpolar solvents and the role of solvent in the reactivity of these compounds were investigated [27]. The importance of the solvent is evident because, despite the polar compounds, a pure solvent with greater polarity, such as water, provides a reactivity preference close to the solution phase. Frequency computations for iproplatin molecules and cis-diamino dichloro-platinum (II) molecules in the gas phase by the B3LYP method and 31G-6 base series. In this study, the manner of binding iproplatin (cis-dichloro- trans – bis (isopropyl amine) platinum) was investigated while examining the formation process between the drug and DNA- forming the basis of the drug.The iproplatin molecule was initially studied as a drug in the research and the cytosine, guanine, thymine and adenine bases were optimized by GAUSSIAN 09 software, and then the structure of all the complexes generated during the process was optimized, and the results were reported [24-28]. The DFT method is that the ground state properties of a quantum mechanical many-body system are uniquely and completely determined by its one-particle density n(r) alone which is quite remarkable and by no means, self-evident, especially against the background of "conventional" representations of the quantum, Density functional theory (DFT) calculations showed that an increase in chainlength by a methylene unit has no direct electronic significance on the metal center. Increase in chain length, however, posed significant steric hindrance on the substitution sites due to the flexibility of alkyl chains and thus governed the overall reaction pattern. DFT is nowadays widely used for drug designing because of its role in studying properties of drugs and also their interaction with their receptors. Drugs are designed on the basis of their receptors, which bind only specific type of drugs.

Results

Optimization of the components of the mechanisms

We initially optimized the interested drug in this study and its complexes. **Fig 2** demonstrates the IPRO related to the complex in which two Cl atoms are attached to Pt, and the IPRO- 2 OH form is associated with the complex in which Cl atom and two OH groups are attached to Pt.

It should be noted that computations related to thermodynamic functions and vibrational frequencies were performed in the gas and solvent phases for the mentioned structures, and the effects of solvation with polar solvents and the role of solvent in the reactivity of these compounds were investigated. The importance of the solvent is clear because, despite the polar compounds, a pure solvent with a greater polarity, like water, provides a reactivity preference close to the solution phase [29]. In Equation (1), we calculate the adsorption energy between iproplatin and cisplatin as follows:

$$\Delta E_{adsorption} = E_{(iproplatin)} + E_{cl} - E_{(IPRO-2OH)} \quad (1)$$

In this section, the Cl-anion is optimized, and its data are reported in the following.

Optimization of organic bases of cytosine, guanine, thymine, and adenine

According to the previous research, it has been determined where the coordination site of each of the organic bases is. Adenine and guanine are coordinated through N_3 with iproplatin (**Fig 3**) [30].

Optimizing the drug with an organic base

Fig 4 (IA) is related to a complex in which one of the chlorine atoms is replaced by an organic base of adenine, and (IC) is associated with a complex in which one of the chlorine atoms is replaced by an organic base of cytosine.

In addition, in **Fig 4** (IT) is related to a complex in which one of the chlorine atoms is replaced by an organic base of thymine, and (IG) is related to a complex in which one of the chlorine atoms is replaced by an organic base of guanine [31,32]. According to the energies obtained in **Tables 4-6**, we select all structures to generate the next stage complexes in which another organic base molecule replaces the remaining chlorine atom in the previous stage complex, and then we optimize these structures [33].

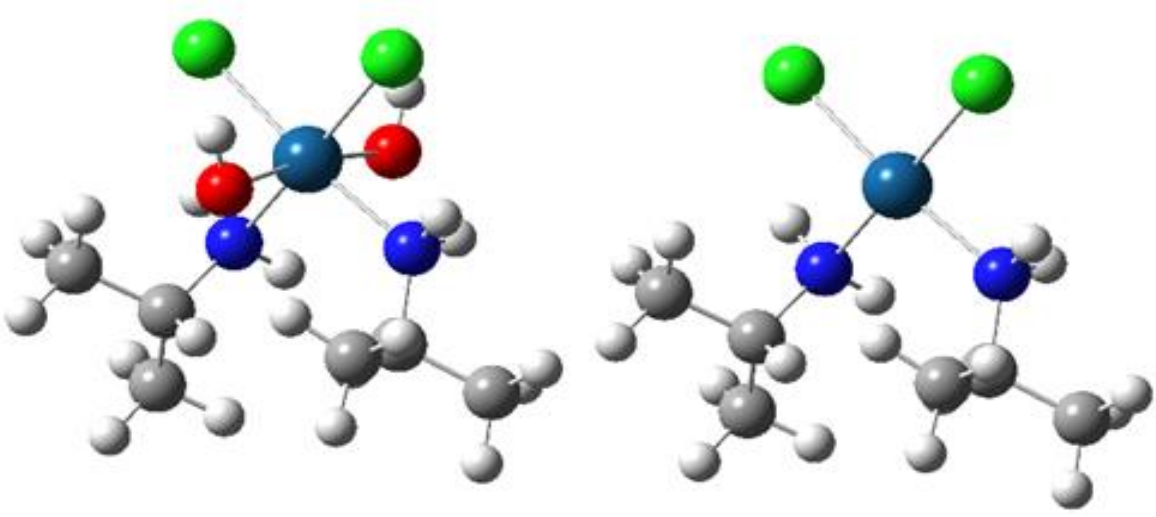


Fig 2. The studied platinum complexes (right: IPRO- 2OH, left: IPRO)

Optimizing the drug with the same organic base

Fig4 displays the complex structure, the difference in **Fig 3**, that there are two organic bases replaced by two chlorine atoms. The purpose of the explanation is that, after moving two chlorine atoms in the basic structures shown in Fig 4, we have formed new structures that have medicinal complexes with different properties.. The importance of the medicinal property of this complex is due to the presence of a chlorine atom in the link of this structure. This way, instead of the first chlorine atom, the organic base of adenine and instead of the second chlorine atom is replaced in cytosine. The same for the other mentioned pairs of organic bases (adenine and guanine) are substituted for two chlorine atoms and also (adenine and thymine), (cytosine and guanine), (cytosine and thymine), and (guanine and thymine), respectively. **Fig 5** represents the complex structure of organic bases (I2A-I2G) related to a complex in one of the chlorine atoms that is replaced by the organic base of the adenine, cytosine, thymine, and guanine, respectively.

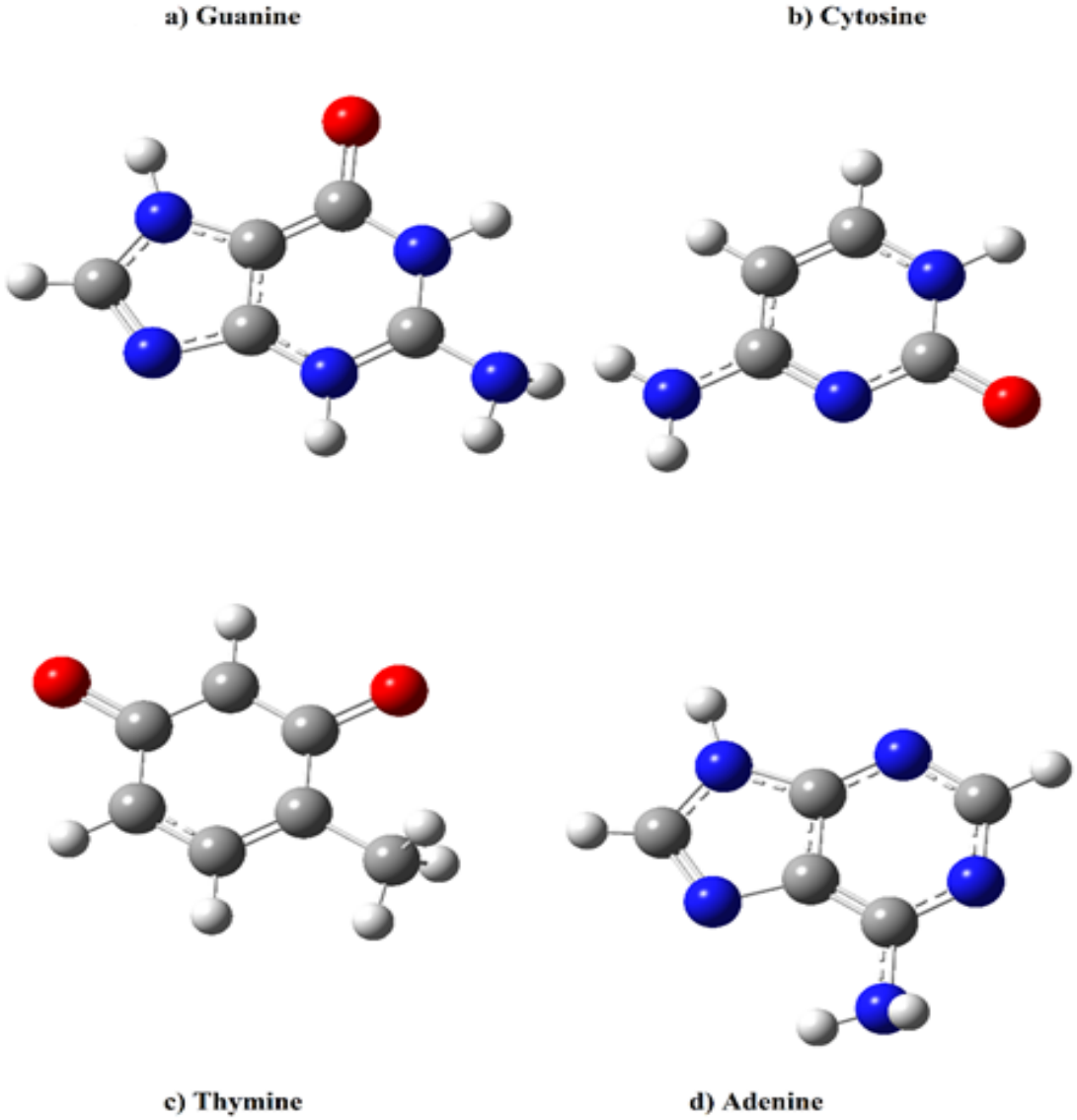


Fig 3. Organic bases of cytosine, guanine, thymine and adenine

The IAG in **Fig 6** is related to a complex in which one of the chlorine atoms is replaced by the organic base of adenine, and the other is replaced by guanine. Also, in **Fig 6**, IAT is related to a complex in which one of the chlorine atoms is replaced by the organic base of adenine, and the other is replaced by thymine. In addition, ICG is related to a complex in which one of the chlorine atoms is replaced by the organic base of cytosine and the other is replaced by guanine [34].

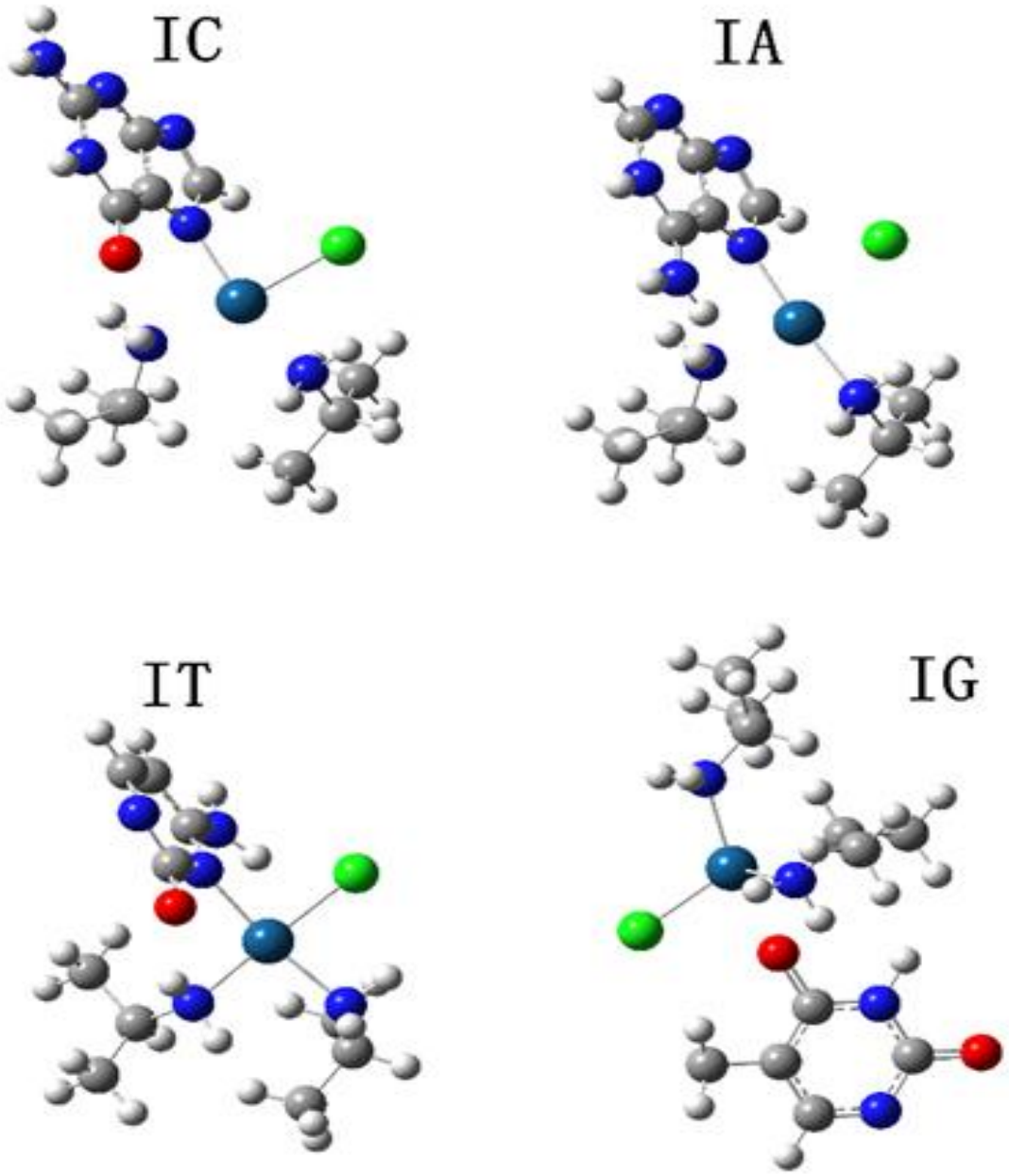


Fig 4. The binding of drug complexes to organic bases (Figure IA is related to a complex in which one of the chlorine atoms is replaced by an organic adenine base, Figure IC is related to a complex in which one of the chlorine atoms is replaced by an organic cytosine base, Figure IT is related to a complex in which one of the chlorine atoms is replaced by an organic base of thymine, and Figure IG is related to a complex in which one of the chlorine atoms is replaced by an organic base of guanine)

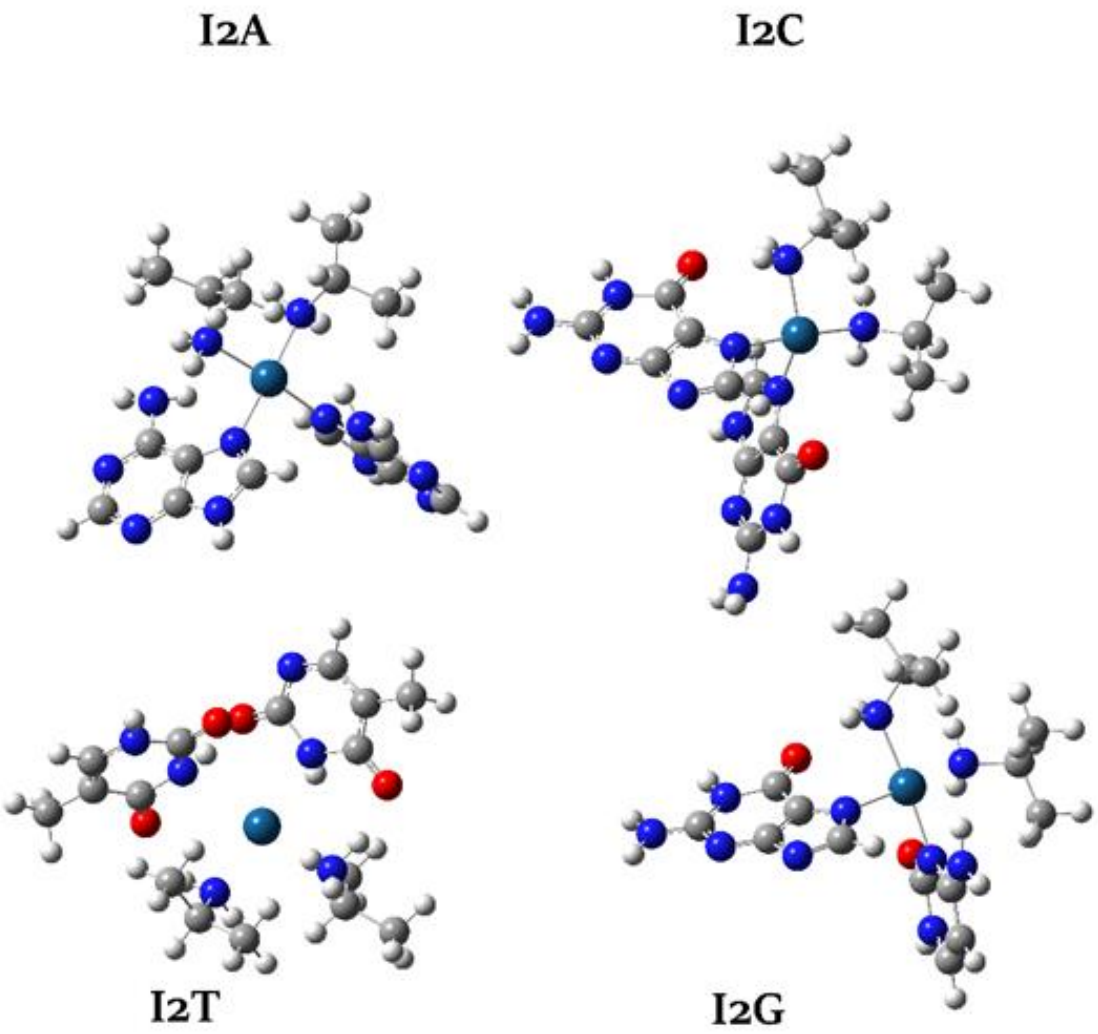


Fig 5. The binding of complexes to organic bases (Figure I2A) is related to a complex in which two chlorine atoms are replaced by two organic adenine bases. Figure I2C is related to a complex in which two of the chlorine atoms are replaced by two organic cytosine bases. Figure I2T is related to a complex in two of the chlorine atoms are replaced by two organic bases of thymine, and Figure I2G is related to a complex in two of the chlorine atoms are replaced by two organic bases of guanine

Optimizing the drug with two different organic bases

In the results of NBO analysis by performing the computations at the theoretical level of B3LYP/6-31G, Mulliken atomic charge distribution on the drug and polymer atoms was computed separately and in the presence of each other using DFT theoretical computations. The results show that the charge density changes in the atoms participating in the electron reaction [35-38]. According to Pauling's theory, electronegativity (χ) is expressed as the ability of an atom in a molecule to absorb electrons, and electrophilicity is expressed as a measure of the electrophilic strength of a molecule. The chemical potential (μ) of a molecule is calculated by Koopmans's theory (Equation (2)). Equations (6)-(8) are obtained from Equations (2)-(4), respectively [39-41]:

$$\mu = \frac{(E_{HOMO}+E_{LUMO})}{2} = -\chi \qquad (2)$$

$$\eta = \frac{(E_{LUMO} - E_{HOMO})}{2} \quad (3)$$

$$S = \frac{1}{2\eta} \quad (4)$$

$$w = \left(\frac{\mu^2}{2\eta}\right) \quad (5)$$

$$\Delta N_{max} = \frac{-\mu}{\eta} \text{ in reaction: } \Delta N_{max} = \frac{-(\mu A - \mu B)}{2(\eta A + \eta B)} \quad (6)$$

$$EI = -E_{HOMO} \quad (7)$$

$$EA = -E_{LUMO} \quad (8)$$

Electron chemical potential (μ, chemical hardness (η), and electrophilicity (w) (Equation (5)), chemical softness (S) and electron charge transfer rate (ΔN_{max}) (Equation (6)), energy gap of molecular orbitals (ELUMO- EHOMO) and electron affinity (EA) (Equations (7) and (8)) and energy of ionization (eV) are calculated by DFT/B3LYP method at B3LYP/6-31g* level.

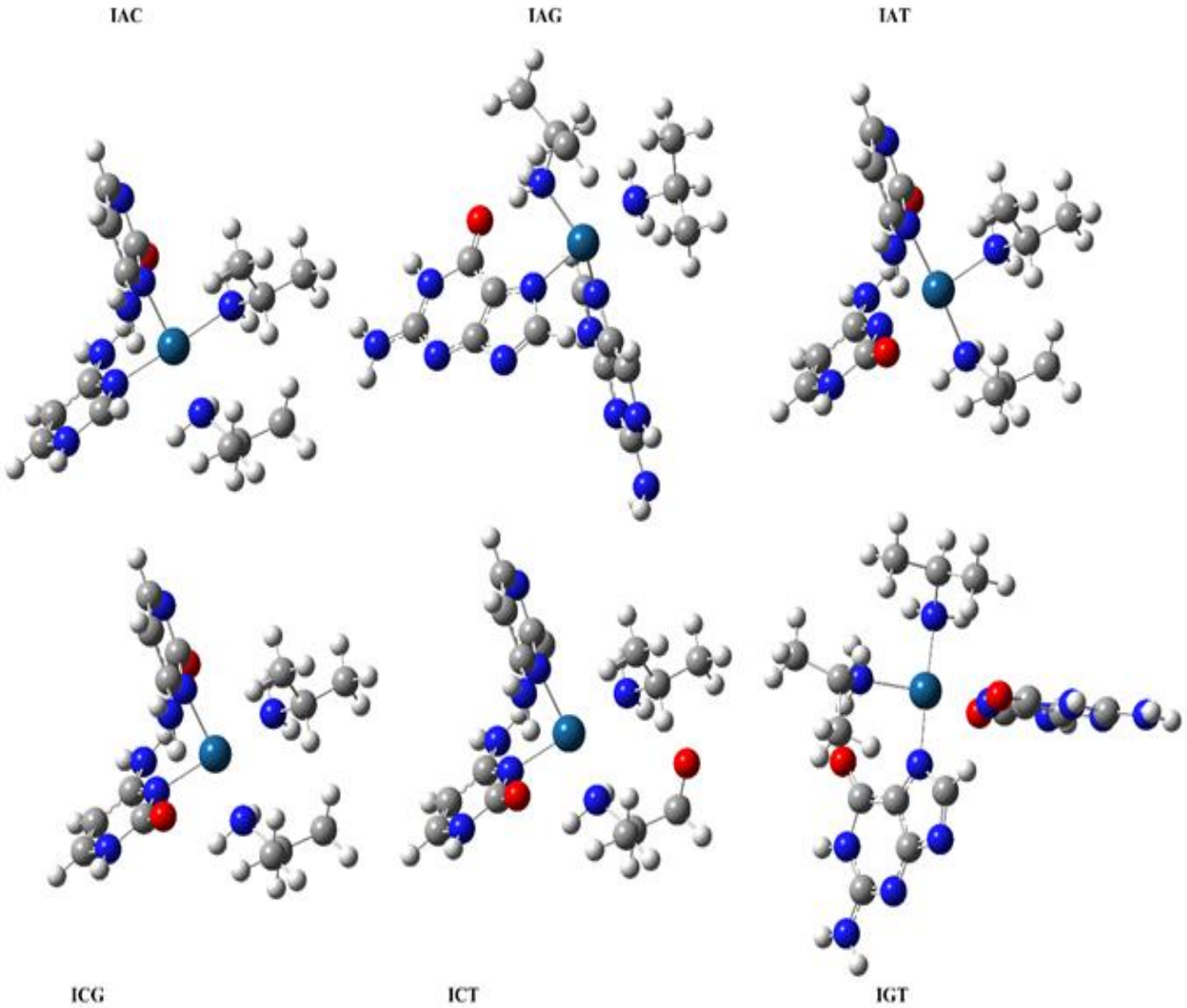


Fig 6. Binding of drug complexes to organic bases (Figure IAC is related to a complex in which one of the chlorine atoms is replaced by the organic base of adenine, and the other one is replaced by cytosine

Discussion

The results of *B3LYP / 6-31G calculations show that when the iproplatin molecule is in the presence of the amino acid, the amount of energy gap in the drug-amino acid complex decreases relative to the energy gap in the iproplatin drug molecule alone. On the other hand, the reactivity of a molecule is related to its energy gap [42]. The effect of stabilizing interactions is increased by decreasing the electron acceptor's energy level and increasing the electron donor's energy level. In addition, the electron configuration is verified by changing the population of the donor and acceptor electrons. In addition, electron instability is confirmed by changing the population of electron donor and acceptor orbitals. The results of quantum mechanical computations at the theoretical level of *B3LYP/6-31G and NBO analysis indicate the structural, energy, bonding, and electron interaction properties and the reactivity of the iproplatin drug and the selected amino acids. The geometrical structure of the organic base with IPROPLATINE by Gauss View and the basic set of 6-31 G * was optimized in terms of energy. The primary purpose of this study is the theoretical evaluation of the response rate of this complex. The highly stable electron structure obtained from the reaction of these compounds is determined by scanning dihedral, bonding angles, and bridging the binding distance between the complex structures using theoretical computation (**Table 1**).

Next, the amount of energy was obtained by the DFT method for Cl anion. The stable electron structure (**Table 2**) (with minimal energy) obtained from the reaction was optimized using the electron density function (DFT) at the theoretical level of B3LYP / 6-31 G.

Hereafter, the stable electron structure (with minimum energy) for organic bases was optimized using the electron density function (DFT) at the theoretical level of B3LYP / 6-31 G (**Table 3**).

These compounds' highly stable electronic structure is determined by scanning the bidirectional and bonding angles and the bonding distance between iproplatin and amino acids using the computations at the theoretical level of B3LYP/6-31G*. The best structure was obtained with the least energy among all the directions studied for the interaction between the drug and the complex.

Table 1. The values obtained from the DFT method for the constructed complexes

Sample	Complex	$E_{(HF)}$ (a.u.)
IPRO	$[((CH_3)_2CHNH2)_2PtCl_2]$	498.2032185-
IPRO-2OH	$[((CH_3)_2CHNH_2)_2PtCl_2\ (OH)_2]$	649.8068008-

Table 2. The amount of energy obtained by the DFT method for Cl anion

$E_{(HF)}(a.u.)$
$CL^- - 14.9986334$

Table 3. The amount of energy obtained by the DFT method for the above-mentioned bases

No.	Complex	E (HF) (a.u.)
1	Adenine	HF=-467.3398575
2	Cytosine	HF=-394.9496995
3	Guanine	HF=-542.5774461
4	Thymeine	HF=-454.1581072

The gas phase with adsorption energy of 0.1241 Kcal/mol and the solvent phase with adsorption energy of 0.564 Kcal/mol show that the adsorption reaction is exothermic and can be performed in both phases in terms of energy (**Tables 4-6**). In this study, the electron transport properties and bond energy properties of the DNA chain have received extensive attention. Charge transport in the DNA chain has been studied by photochemical, biochemical, electrochemical, and direct electrical measurements. Experiments by Barton *et al.* have shown that electron transfer in DNA can span distances of several nanometers. In the calculation, the hydrogen bonds between bases in a base-pair as well as the stacking interaction between the base-pairs in adjacent turns of the double helix are both considered. In addition, we also evaluated the effect of the biochemical environment such as sodium counter-ions and water molecules on the stabilization of DNA segment under irradiation conditions. DFT calculations were performed with the B3LYP hybrid density functional in conjunction with the 6-31G (d) basis set using the GAUSSIAN 09 suite of programs. The B3LYP functional is a combination of Becke's three-parameter hybrid exchange functional and the Lee–Yang–Parr correlation functional. The non-local correlation term is involved in B3LYP functional to overcome the inaccuracy of binding energy caused by local density approximation.

Table 4. The amounts of energy obtained by the DFT method for 12A- 12C- 12T- 12G complexes

No.	Complex	E (HF) (a.u.)	Δ E (kcal/mol)
1	IPROPLATINE + thymine	936.720181-	0.7433933
2	IPROPLATINE + guanine	1024.951283-	0.9316295
3	IPROPLATINE − cytosine	877.3100128-	0.9451386
4	IPROPLATINE − adenine	950.521565	0.1237596

Table 5. The amount of energy obtained by the DFT method for the complexes of figures iproplatin-amino acid

No.	Complex	E (HF) (a.u.)	E (kcal/mol)Δ
1	IPRO − 2Cytosine	1256.9873299-	0.3746531
2	IPRO − 2Adenine	1402.3989432-	0.5647287
3	IPRO − 2guanine	1552.2863634-	0.3626142
4	IPRO − 2thymine	1375.8688127	0.1117262

Table 6. The amount of energy obtained by the DFT method for the complexes of figures iproplatin-amino acid

No.	Complex	E (HF) (a.u.)	E (kcal/mol)Δ
1	IPRO − Cytosine − adenine	1329.3446194-	1.2288936
2	IPRO + guanine + adenine	1477.000501-	1.2007586
3	IPRO + guanine + cytosine	1405.1139376-	0.1105066
4	IPRO + guanine + thymine	1463.7703523	0.4412864
5	IPRO + Thymine + adenine	1389.065513	0.096736
6	IPRO + thymine + cytosine	1317.306189	0.534052

Also, the effects of cis-trans on complexes in HNMR spectators are noticeable. It's going to be. Ligands are widely compared to them by trans-groups and are indifferent to Cis groups affected. That's why the metal-ligand coupling constants depend on the nature of the group or atom is trans to a ligand. As a result, the space structure of complexes can be given by obtaining constant amounts of copalge for these complexes. The trans effect refers to the difference in succession speeds and, therefore, the result of changes in energy between the base state and the reaction transition state is an essential application of the trans-synthesis effect. A particular isomer of coordination compounds is observed in the following equation how. With more trans effects than ammonia, cis isomers can be selectively selected and trans-2Cl 2 (3Pt) (NH) in each case in the first stage of this succession only isomer. It is formed in the following equation in the second stage of isomer cis because the transformer Cl is compared to Cl. It is more variable than cl trans than ammonia because of ligand ammonia with trans effect less. On the other hand, in the first succession with claire ligand, ammonia trans compared to itself. It is modifiable and is the final product of transdichloride. In the past, it was thought that there was no π-reverted interaction from paltin to the group. Alkyl does not exist because they thought that py orbitals and carbon pz were completely linked. Other atoms are involved. However, today, NMR spectroscopy provides information that even in methyl complexes, the π-recursion bond from Platinium (II) moves toward the existing methyl group. As shown in **Fig 7**, molecules with small energy gaps are known as soft, and those with significant energy gaps are called Hard. The hardness parameter changes with the polarization degree in the form of photographs. Hard molecules require higher energy than soft compounds for molecular stimulation.

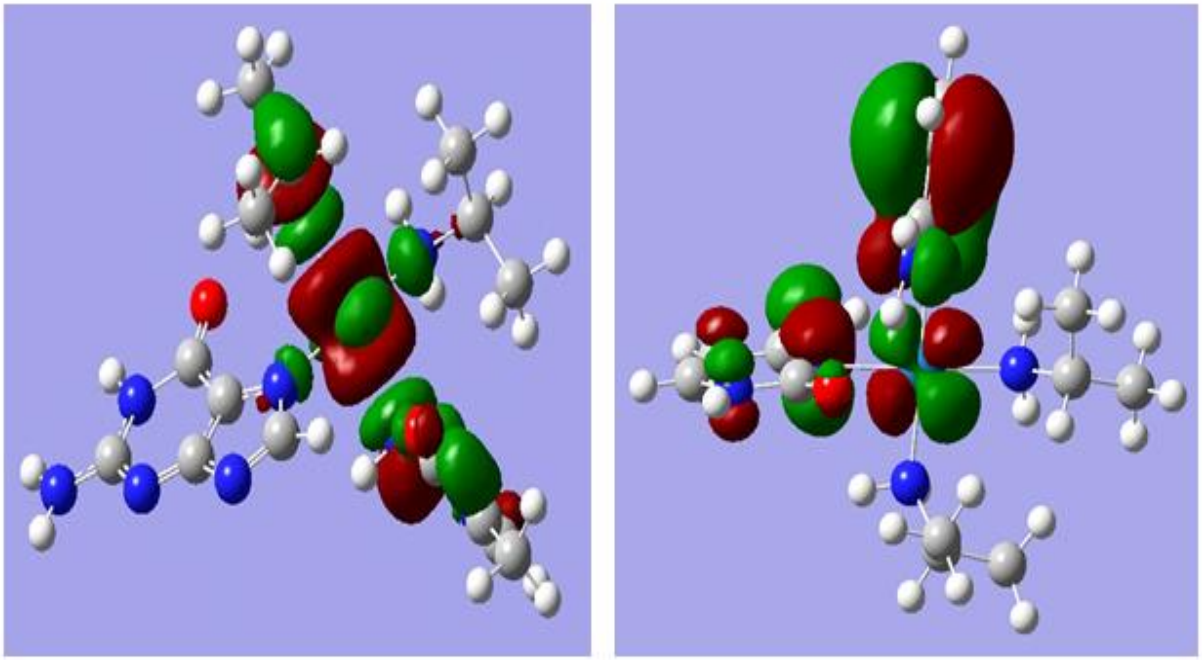


Fig 7. Schematic view of the NBO molecular orbital, as well as the HOMO and LUMO orbitals at the theoretical level of B3LYP/6-31G to study the optimized structure and electronic properties of the molecule

The energy loss between the atom and the ion resulting from separating an electron from it in the gaseous state represents energy. The ionized energy of our structure is lower than other compounds because HOMO orbital energy is higher than other compounds.

Conclusion

In the results of NBO analysis, by performing calculations at the theoretical level of B3LYP/6-31G*, the amount of molycon atomic charge distribution on iproplatin-amino acid atoms is calculated alone and in the presence of each other using DFT theoretical calculations. The results show that the load density changes on the atoms participating in the electronic reaction [43].The results of B3LYP/6-31G* calculations show that when the iproplatin molecule is exposed to the aminoacid, the amount of energy gap in the iproplatin complex with adenine (Eg=-6.286054 eV) is reduced compared to the energy gap in the iproplatin molecule alone (Eg=-6.421104 eV). On the other hand, the reactivity of a molecule is related to its energy gap. Stabilizer orbital interactions increase by decreasing the level of electron acceptor orbital energy and increasing the level of electron orbital energy. In addition, electron incision is confirmed by changing the population of the donor orbitals and the electron acceptor.

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Declarations

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