PLATINUM(II) AND PALLADIUM(II) THIOLATE COMPLEXES; SYNTHESIS, CHARACTERIZATION, CRYSTAL STRUCTURE, DFT, HIRSHFELD SURFACE ANALYSIS AND ANTICANCER STUDIES

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ABSTRACT. The synthesis and characterization of platinum(II) and palladium(II) mixed ligand complexes, [M(mtzS)₂(dppm)] (M = Pt or Pd), have been described. These complexes were synthesized through a one-pot reaction involving K₂MCl₄, KmtzS (prepared from HmtzS and KOH), and dppm. The prepared complexes 1 and 2 have been characterized by using various analytical techniques including conductivity measurements, IR spectroscopy, UV-Vis spectroscopy, ³¹P and ¹H NMR spectroscopy and by X-ray crystallographic studies. The in vitro anti-cancer activity of complexes 1 and 2 against breast cancer cells (MCF7 cell line), was evaluated using the MTT assay showed a moderate activity with an IC₅₀ value of 27.59 µg/ml for 1 and 28.82 µg/ml for 2. Additionally, the ligands and complexes underwent full geometry optimization using density functional theory (DFT). The calculated geometric and spectral data were found to be in good agreement with the experimental results. Theoretical calculations of molecular orbitals (HOMO-LUMO) and their energies suggested the occurrence of charge transfer within the complexes.

KEY WORDS: Platinum(II), Palladium(II), Thiolate, Diphosphine, X-ray crystallography

INTRODUCTION

The coordination chemistry of heterocyclic compounds become more interesting in the last decade [1-4]. Heterocyclic thiones which are recognized for their important exo-cyclic thione group have formed various metal complexes with different metals through either S or N atoms [5-9]. Thione groups (C=S) are mostly known for their contribution toward metal complexes due to their special pi-character. The pi-bonding in M-S=C contribution is 50-70% [10]. It is well known that thione groups to exhibit rich electron density, therefore it have the potential to form multiple coordination modes (Figure 1) [1, 9, 10]. Moreover, the bioactivity of sulfur-containing compounds especially thiones has interested more researchers [1].

![Figure 1. Some of the coordination modes of thione, and thiolate-metal complexes.](image)

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2-Mercapto-5-methyl-1,3,4-thiadiazole (HmtzS) complexes have attracted several of research
groups [11, 12]. This ligand is ambient, the non-deprotonated form can act as a monodentate
bound to metal through the thione group (Figure 1A) as in [Pd(HmtzS)₂]Cl₂ [12]. Bharati and co-
workers [11] reported the synthesis of several of complexes in which the deprotonated thiol form
adopted three different coordination modes; ionically or covalently bounded through the sulfur
atom (Figure 1B), or through the deprotonating thiadiazole ring nitrogen adjacent to the thiol
sulfur (Figure 1C) and as N,S chelating bidentate bonded through the thiolate sulfur and the
thiadiazole ring nitrogen adjacent to it, forming a four membered chelate ring (Figure 1D).

Mixed ligand mercury(II) complexes of 2-mercapto-5-methyl-1,3,4-thiadiazole (HmtzS) and
phosphines or diamines have been recently reported [8]. The mtzS⁻ ligand coordinated through
the sulfur atom of thiol group. Platinum(II) or palladium(II) thione complexes have shown high
anticancer properties [5, 6]. Literature has extensively reported mixed ligand complexes of
platinum(II) thiols and tertiary phosphine ligands [13-15]. Also synthesis and characterization of
palladium(II) mixed ligand complexes of the types [Pd(mtzS)₂(dppf)], dppf = bis(diphenylphosphino)ferrocene and [Pd(mtzS)₂(P₄H₂)₂] n = 2-4 have been reported [5]
as single linkage sulfur bounded (thiolate) isomers, except for n = 3 dppp for which a mixture of
sulfur- and nitrogen- bounded linkage isomers were obtained. Unfortunately, palladium complex
for n = 1, bis(diphenylphosphino)methane (dppm) did not prepared.

As part of our interests in sulfur containing ligands [5, 7, 16-21], we herein report synthesis of
palladium(II) and palladium(II) thione complexes of 2-mercapto-5-methyl-1,3,4-
thiadiazole (HmtzS) and bis(diphenylphosphino)methane (dppm). The prepared complexes were
characterized by different spectroscopic techniques including x-ray crystallography for
[Pt(mtzS)₂(dppm)] I. Furthermore, the prepared complexes were studied for their anticancer
activities and theoretical investigations.

**EXPERIMENTAL**

**General methods and apparatus**

All reactions were carried out in air using standard bench reagents. K₂PtCl₄, K₂PdCl₄, 2-mercapto-
5-methyl-1,3,4-thiadiazole (HmtzS) and bis(diphenylphosphino)methane (dppm) were
commercial products and used without further purifications. Molar electrical conductivity
measurements were carried out using a Meter CON 700 Bench top conductivity meter. The NMR
spectra were recorded at the University of Basra, College of Education, Iraq, using a Bruker 400
MHz ultra-shield ii DMSO-d₆ solvent. IR spectra were recorded on a Shimadzu CORP-
A221375003225 spectrophotometer using KBr discs in the 400–4000 cm⁻¹ range. The UV–Vis.
spectra of the free ligands and their complexes were obtained in the DMSO solvent with a
concentration of (10⁻³ M) using Shimadzu spectrophotometer (AEUV1609 (UK) CO.) within the
400–4000 cm⁻¹ range. Melting points were measured on Melting Point-MPD-100 Pixel
Technology CO., Limited melting point apparatus and were uncorrected. The cytotoxic effects of
complexes 1 and 2 against human breast cancer cell (MCF7) were studied by MTT assay method.

**Synthesis of [Pt(mtzS)₂(dppm)] (I)**

A solution of 5-methyl-1,3,4-thiadiazole-2-thiol (HmtzS ) (0.0264 g, 0.2 mmol) and KOH (0.0 1
g, 0.2 mmol) in methanol (20 mL) was added to the a solution of K₂PtCl₄ (0.0326 g, 0.1 mmol)
in water (5 mL) in mole ratio (1:2) of (M:L). The reaction mixture was heated under reflux for 2 h,
during which the color of the solution changed to orange. A solution of bis(diphenylphosphino)methane (dppm) (0.0384 g, 0.1 mmol) in CH₂Cl₂ (5 mL) was added. The mixture of was stirred overnight at room temperature, to afford a clear yellow solution. The solution was filtrated off to remove any suspended particles to get good crystals and the filtrate was set aside for slow evaporation of solvent to give after one week yellow-needles crystals.

Synthesis and characterization, platinum(II) and palladium(II) thiolate complexes

Yellow needles, 0.0630 g, 75% yield, IR (KBr): 3049 w, 2929 w, 1435 s, 1105 m, 736 s, 505 m, 328 s, and 278 s cm⁻¹. UV-Visible: (349 nm), (310 nm). Molar conductivity (DMSO, 10⁻³ M): 3.1 (ohm⁻¹cm²mol⁻¹). ³¹P-{¹H-NMR (DMSO-d₆, δ ppm): -48.17 (s, JPt-P 2632 Hz). ¹H-{³¹P}NMR (DMSO-d₆, δ ppm): -52.28. ¹H-{³¹P} NMR (DMSO-d₆, δ ppm): 2.45(s, 6H, CH₃-mtzS), 4.98 (s, 2H, CH₂-dppm), 7.14–8.02 (m, 20H, H-Ph, dppm). m.p. (208-210 °C).

**Synthesis of [Pd(mtzS)₂(dppm)] (2)**

Complex (2) was prepared and isolated using a method similar to that used for (1) an orange powder. Orange color, 0.0432 g, 57% yield. IR (KBr): 3049 w, 2945 w, 1436 s, 1101 m, 731 s, 505 m, 308 s, and 327 cm⁻¹. UV-Visible: (264 nm), (294 nm), (313 nm). Molar conductivity (DMSO, 10⁻³ M): 4.9 (ohm⁻¹cm²mol⁻¹). ³¹P-{¹H-NMR (DMSO-d₆, δ ppm): -52.28. ¹H-{³¹P} NMR (DMSO-d₆, δ ppm): 2.45(s, 6H, CH₃-mtzS), 4.98 (s, 2H, CH₂-dppm), 7.14–8.02 (m, 20H, H-Ph, dppm). m.p. (189-191 °C).

**Single X-ray crystal structure of [Pt(mtzS)₂(dppm)] (1)**

Yellow needle crystals suitable for X-ray crystallographic study were obtained by slow evaporation of CH₂Cl₂ solution. Suitable crystal was mounted on glass fibers and all geometric and intensity data were taken from these samples using a Bruker SMART APEX CCD diffractometer using graphite-monochromatic Mo-K radiation (ν = 0.71073 Å) at 293 ±2 K. Absorption corrections were made using the OLEX2 software package [22]. All structures were solved by direct methods with SHELXTL [23] and refined using full-matrix least-square routines against F² with Diamond. Non-hydrogen atoms were refined with anisotropic displacement parameters. Table 1. shows these data.

<table>
<thead>
<tr>
<th>Crystal data</th>
</tr>
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<tbody>
<tr>
<td>Deposition No.</td>
</tr>
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</tr>
<tr>
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</tr>
<tr>
<td>Formula weight</td>
</tr>
<tr>
<td>Colour</td>
</tr>
<tr>
<td>Size/mm³</td>
</tr>
<tr>
<td>T/K</td>
</tr>
<tr>
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<tr>
<td>F(000)</td>
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<tr>
<td>Wavelength/Å</td>
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<tr>
<td>Radiation type</td>
</tr>
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</table>

RESULTS AND DISCUSSION

Synthesis of \([\text{M(mtzS)}_2\text{dppm}]\) (1) and (2)

We have previously been developed three-steps synthesis of diphosphine-thionate complexes \([\text{ML}_2\text{(diphosphine)}]\) [16, 17, 24-26]. This involves the treatment of thiol LH with palladium(II) or platinum(II) precursors to give complexes of the type \([\text{MCl}_2\text{(LH)}_2]\). These can be converted to \([\text{ML}_2]\) by treatment with base, which in turn is converted to the final product on treatment with diphosphine. This method was only partially successful leading to a mixture of products. Then we used another synthetic route to synthesize the desired products by treatment of \([\text{MCl}_2\text{(diphosphine)}]\) with two equivalents of potassium thiolates which afford clean products [5].

Now we developed a one-pot synthesis of 1 and 2 by treatment of \(\text{K}_2\text{MCl}_4\) (\(\text{M} = \text{Pt or Pd}\)) with two equivalents of \(\text{KmtzS}\) (prepared in situ from \(\text{HmtzS}\) and \(\text{KOH}\)) followed by one equivalent of dppm to afford \([\text{Pt(mtzS)}_2\text{dppm}]\) (1) and \([\text{Pd(mtzS)}_2\text{dppm}]\) (2) in 75 and 57% yield, respectively (Scheme 1).

\[
\text{K}_2\text{MCl}_4 + 2\text{HmtzS} + \text{dppm} \rightarrow 2\text{KOH} \rightarrow 2\text{M} = \text{Pt (1)}
\]

Scheme 1. Synthesis of complexes 1 and 2.

Characterization of \([\text{M(mtzS)}_2\text{dppm}]\) (1) and (2)

The newly prepared complexes 1 and 2 were characterized based on spectroscopic and analytical data. The IR spectra of complexes 1 and 2 showed no \(\nu(\text{SH})\) band which typically appears within the 2600-2500 cm\(^{-1}\) range [5] indicating the deprotonating of the HmtzS ligand. The strong
absorption bands appeared in complexes (1), (2) within 1108-1101 and 736-731 cm⁻¹ ranges, attributed to ν(N-N) and ν(C-S) [5, 27]. Furthermore, the spectra exhibited two distinctive bands of phosphine at 1435 and 505 cm⁻¹ attributed to ν(P-Ph) and ν(P-C), respectively. While the IR spectra are less informative, the NMR spectra are more informative. The 31P-{1H}-NMR spectra of 1 and 2 each showed a single phosphorus resonance at δP = -48.17 and -52.26 ppm, respectively indicating a single isomer formation for each. The negative chemical shifts indicate that dppm behaves as chelate in both complexes [28, 29]. The small phosphorus-platinum coupling constant for [Pt(mtzS)dpmm] (1) of 2632 Hz as compared to [PtCl2(dpmm)] (Jpt-p 3083 Hz) [30] suggests the ligand mtzS bind through the sulfur atom. The 1H-{31P}-NMR spectra were as expected each displaying multiples between δ 7.02-7.99 and 8.02-7.02 ppm assigned to the phenyl protons, a singlet at δ 4.22 and 4.96 ppm assigned to the aromatic and methylene protons of dpmm ligands respectively and a singlet at δ 2.36 and 2.45 ppm assigned to the methyl group of the mtzS ligand. Clearly, 31P, and 1H-NMR spectra indicated that two mtzS and one dpmm ligands are incorporated in each complex. The low molar conductivity 3.1 and 4.1 ohm⁻¹ cm⁻¹ mol⁻¹ (for10⁻² M in DMSO) and negative AgNO₃ test indicate a non-electrolyte behavior of complexes 1 and 2 and suggest that they are neutral.

The electronic spectra of free ligands (HmtzS) and (dpmm) exhibited two bands in the 249-319 nm range attributed to π-π* and n-π* transitions of the aromatic ring [31, 32]. The bands within 349-264 nm range in the spectra of complexes 1 and 2 were assigned to C.T. transitions, respectively. These electronic spectral data, indicated that both complexes 1 and 2 pose square planer geometry [17, 27].

**X-ray crystal structure of [Pt(mtzS)₂(dpmm)] (1)**

In order to ascertain the precise arrangement of ligands around the platinum(II) center and confirm thiodiazole binding mod in this complex, a crystallographic study was carried out on [Pt(mtzS)₂(dpmm)] (1), the results of which are displayed in Figure 2 and Tables 1 and 2. Bond angles, bond lengths and hydrogen bonding for (1) are displayed in Table 2. The Pt(II) is coordinated to two phosphorus atoms of the dpmm ligand and two sulfur atoms of thiodiazole adopting square planar geometry. The Pt-P bond lengths range [2.2571(17) and 2.2751(18) Å] and Pt-S bond lengths range [2.3527(18) and 2.3539(18) Å] are within the expected range found in related complexes [33-35]. The diphosphine bit angle of 74.22(6)° is slightly larger than those found in [Pt(tsac)₂(dpmm)] of 73.82(5)° [36] while the S-Pt-S angle of 80.42(7)° being smaller than that found in [Pt(tsac)₂(dpmm)] of 86.24(4)°. The C(21)-H(21)… S(31), C(12)-H(12)… S(21), C(6)-H(6B)… S(42), and C(6)-H(6C)…N(43) intramolecular hydrogen bonds stabilize the square planer crystal structure of 1 (Table 2).

**DFT studies**

The Gaussian 09 package’s B3LYP correlation function computation method has been used to further understand the electronic structure of the ligands (dpmm), (HmtzS) and complexes 1 and 2. The highest occupied molecular orbital (HOMO) and the lowest unoccupied molecular orbital (LUMO) were calculated for both ligands and complexes. The EHOMO, ELUMO, and ΔE energy gaps of (HmtzS), (dpmm) and complexes 1 and 2 are exhibited in Table 3 and Figure 3. The energy gap ΔE of the free bis(diphenylphosphino)methane (dpmm) and (HmtzS) ligands are 1.0680 and 6.2160 eV respectively, while that of complexes 1 and 2 are 0.6525 and -3.058 eV, respectively. The energy gap that splits the HOMO and LUMO orbitals is associated with the reactivity and stability of compounds. Compounds with a small energy gap (ΔE) are more reactive than ones with a big energy gap (ΔE). In addition, compound with a high-energy gap is more stable than one with a low-energy gap. Calculations illustrated that the ligand dpmm has a lower energy gap (1.0680 eV) than that of (HmtzS) (6.2160 eV), which means that dppm is more reactive than...
HmtzS, towards metal ions [37]. In comparison with dppm and (HmtzS) ligand. The synthesized Pt(II) complex 1 is higher energy gap (0.6525 eV) than Pd(II) complex 2 (-3.058 eV), then complex Pt(II) is more stable that complex Pd(II) [31].

Figure 2. Single-crystal X-ray molecular structure of complex 1. Ellipsoids with a 20% of probability, (H atoms are omitted for clarity).

Table 2. Selected bond lengths (Å), bond angles (°) and hydrogen bonding of the complex.

<table>
<thead>
<tr>
<th>Atoms</th>
<th>Bond length</th>
<th>Atoms</th>
<th>Bond angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt1-P1</td>
<td>2.2751(18)</td>
<td>P1-P1-S2</td>
<td>103.62(6)</td>
</tr>
<tr>
<td>Pt1-P2</td>
<td>2.2571(17)</td>
<td>P1-P1-S3</td>
<td>175.79(6)</td>
</tr>
<tr>
<td>Pt1-S2</td>
<td>2.3539(18)</td>
<td>P2-P1-P1</td>
<td>74.22(6)</td>
</tr>
<tr>
<td>Pt1-S3</td>
<td>2.3527(19)</td>
<td>P2-P1-S2</td>
<td>177.72(7)</td>
</tr>
<tr>
<td>P1-C13</td>
<td>1.819(6)</td>
<td>P2-P1-S3</td>
<td>101.76(6)</td>
</tr>
<tr>
<td>P1-C19</td>
<td>1.863(6)</td>
<td>S3-P1-S2</td>
<td>80.42(7)</td>
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<tr>
<td>P1-C7</td>
<td>1.816(7)</td>
<td>C13-P1-P1</td>
<td>120.1(2)</td>
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<tr>
<td>P2-C26</td>
<td>1.825(7)</td>
<td>C19-P1-P1</td>
<td>94.4(2)</td>
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<td>P2-C19</td>
<td>1.842(7)</td>
<td>C7-P1-Pt1</td>
<td>120.2(2)</td>
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<td>1.804(6)</td>
<td>C13-P1-C19</td>
<td>102.5(3)</td>
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<td>S-C</td>
<td>1.702(7)</td>
<td>C7-P1-C19</td>
<td>102.0(3)</td>
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<tr>
<td>N-C</td>
<td>1.268(9)-1.308(8)</td>
<td>C7-P1-C13</td>
<td>111.6(3)</td>
</tr>
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</table>

Hydrogen-bond geometry (Å, °)

<table>
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<tr>
<th>Hydrogen bonding</th>
<th>d(D-H)/Å</th>
<th>d(H-A)/Å</th>
<th>d(D-A)/Å</th>
<th>D-H-A (°)</th>
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<tbody>
<tr>
<td>C(21)-H(21)…S(31)</td>
<td>0.93</td>
<td>3.00</td>
<td>3.774(9)</td>
<td>141.6</td>
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<tr>
<td>C(12)-H(12)…S(21)</td>
<td>0.93</td>
<td>2.97</td>
<td>3.834(8)</td>
<td>155.1</td>
</tr>
<tr>
<td>C(6)-H(6B)…S(42)</td>
<td>0.96</td>
<td>3.02</td>
<td>3.837(8)</td>
<td>144.3</td>
</tr>
<tr>
<td>C(6)-H(6C)…N(43)</td>
<td>0.96</td>
<td>2.57</td>
<td>3.388(10)</td>
<td>143.5</td>
</tr>
</tbody>
</table>

Symmetry code: 1-1+X,+Y,+Z; 2-1/2+X,3/2-Y,-1/2+Z; 31/2+X,3/2-Y,1/2+Z.
We used the natural bond orbital (NBO) approach to calculate the atomic charge distribution on each complex atom. From the NBO analysis, we can predict electron delocalization, atomic charge distribution, and intra-atomic interaction of atoms within a compound [38]. The calculated natural atomic charges of ligands and complexes 1 and 2 are listed in Figure 4. The natural charge on Pt(II) and Pd(II) ions (+2.0 e) changed lowered on complex formation to (-0.45975 and -0.58567 e) respectively, showing that electron transfer occurred from (3s, 3p) orbitals of S and P atoms to Pt(II) and Pd(II) (5d and 4d) orbitals of central metal atoms. However, the atomic charge on the sulfur atom change from (S7(0.02577e) in the free ligand to a higher positive charge (S7(0.13344),S8(0.18627),S6(0.09777)and S7(0.28897) in complexes 1 and 2 respectively, this is an evidence that the sulfur atom of (HmtzS) ligand is more strongly bounded to Pd(II) and Pt(II) in complexes [5, 39].

Table 3. HOMO-LUMO orbital energies (eV) and NBO charges (e) of dppm, (HmtzS) ligands and complexes 1 and 2.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>dppm</th>
<th>HmtzS</th>
<th>Complex 1</th>
<th>Complex 2</th>
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<tr>
<td>$E_{\text{HOMO}}$</td>
<td>-5.2756</td>
<td>-7.603</td>
<td>-4.8530</td>
<td>-1.4169</td>
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<tr>
<td>$E_{\text{LUMO}}$</td>
<td>-4.2076</td>
<td>-1.387</td>
<td>-4.2005</td>
<td>-4.4757</td>
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<tr>
<td>$\Delta E$</td>
<td>1.0680</td>
<td>6.2160</td>
<td>0.6525</td>
<td>-3.058</td>
</tr>
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</table>

Hirshfeld surfaces analysis (HAS)

The Hirshfeld surface analyses (HSA) and the fingerprints of complex 1 were attained using Crystal Explorer 21.5 program.22. Surfaces that were mapped through $d_{\text{norm}}$, shape index, and curvature are presented in (Figure 5) the shape index and curvedness were mapped across ranges of -1.0000 to 1.0000 and -4.0000 to 0.4000, respectively, while the $d_{\text{norm}}$ surface has been mapped across a range of -0.0490 to 1.3232. As demonstrated in (Figure 5), the 2D fingerprint plots disclose that the chief intermolecular interactions in complex (1) are C...C, H...C/C...H, C...S/S...C, H...H, N/N...H, N...C/C...N, Pt...H/H...Pt, S...N/N...S, and S...H/H...S. The highest contribution to the overall Hirshfeld surface occurs due to H...H close contacts with 44.9%. The percentages of C...C, H...C/C...H, C...S/S...H, H...N/N...H, H...C/C...N, Pt...H/H...Pt, S...N/N...S, and S...H/H...S. interactions are 0.2, 19.9, 1.5, 9.4, 0.5, 1.1, 0.8, and 21.7, % of the complex surface, respectively [40]. The $d_{\text{norm}}$ Hirshfeld surface shows red, blue and white spots, which indicate the presence of N-H...H, H...H, and C-H...H, intermolecular interaction (respectively) in the crystal structure of complex 1. The shape index of Hirshfeld surfaces with blue triangles denoting convex portions of the compound inside the surface and red triangles denoting concave regions above the surface. As a result of the stacking compound's phenyl carbon atoms can be used to investigate $\pi-\pi$ interactions [41]. The existence of interaction in the complex is also shown by green flat areas on the curvedness (HS) [42].
Figure 3. Surface plots of HOMO and LUMO orbitals of dppm, HmtzS ligands and complexes 1 and 2.
Cytotoxicity study of complexes 1 and 2

Using the MTT assay, the cytotoxicity of 1 and 2 was evaluated against the breast cancer (MCF-7 cancer cells) line to determine the \( IC_{50} \) value (\( IC_{50} \) is the concentration that inhibits 50% of the proliferation of MCF-7 cells) [43]. The results were plotted in Table 4. From these data, the following characteristics were noted. The complex with a lower \( IC_{50} \) value is more active compound and has better anticancer activity. Complexes 1 and 2 exposed moderate activity to MCF-7 cell lines with an \( IC_{50} \) value of 27.59 µg/mL 28.82 µg/mL respectively in comparison with the published value of \( IC_{50} \) of the anticancer drug (cisplatin) (\( IC_{50} = 24.67-94.00 \) µg/mL at 6.25, 12.5, 25.50 and 100 µg/mL concentrations incubated for 72 hours on MCF-7 cells) [27, 44].

Table 4. Percentage cell viability, concentration (µg/mL) and \( IC_{50} \) values of complexes 1 and 2 against MCF7 cell line.

<table>
<thead>
<tr>
<th>Complexes</th>
<th>Concentrations (µg/mL)</th>
<th>Relative Cell Viability (%)</th>
<th>Control</th>
<th>( IC_{50} )</th>
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<tr>
<td></td>
<td>500</td>
<td>250</td>
<td>125</td>
<td>62.5</td>
</tr>
<tr>
<td>[Pt(mtzS)₂(dppm)] (1)</td>
<td>14.1569</td>
<td>33.6273</td>
<td>45.7983</td>
<td>47.0423</td>
</tr>
<tr>
<td>[Pd(mtzS)₂(dppm)] (2)</td>
<td>1.7974</td>
<td>28.02275</td>
<td>38.1653</td>
<td>47.53525</td>
</tr>
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</table>
CONCLUSION

In this work, that palladium(II) and platinum(II) complexes, [Pd(mtzS)₂(dppm)] (1) and [Pt(mtzS)₂(dppm)] (2) have been shown, in good yield via a one-pot reaction involving K₂MCl₄, KmtzS, and bis(diphenylphosphino)methane (dppm). Spectroscopic data and the single X-ray crystal of complex 1 showed a square planner arrangement in which dppm ligand bonded in a bidentate chelate fashion, while the two mtz ligands bonded in a monodentate fashion through the sulfur atom. Complexes 1 and 2 showed good cytotoxicity against Breast cancer (MCF-7) cell lines with IC₅₀ Mention at which concentration of the complexes 1 and 2 have showed that value within (27.59-28.82) μg/mL range.

Supplementary data

CCDC (2244269) contain the supplementary crystallographic data for complex 1. These data can be obtained free of charge via http://www.ccdc.cam.ac.uk/conts/retrieving.html, or from the Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK; fax: (+44) 1223-336-033; or e-mail: deposit@ccdc.cam.ac.uk.
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