Acta Crystallographica Section E
Structure Reports Online
ISSN 1600-5368

cis-Dichlorobis(diethyl 2-pyridylmethylphosphonate-κN)platinum(II) hemihydrate, *cis*-$[PtCl_2(2\text{-pmpe})_2]\cdot 0.5H_2O$

Lilianna Chęcińska,[a]* Magdalena Małecka,[a] Justyn Ochocki[b] and Katarzyna Aranowska[b]

[a]Department of Crystallography and Crystal Chemistry, University of Łódź, Pomorska 149/153, 90-236 Łódź, Poland, and [b]Department of Bioinorganic Chemistry, Medical University of Łódź, Muszyńskiego 1, 90-151 Łódź, Poland

Correspondence e-mail: lilach@uni.lodz.pl

Key indicators

Single-crystal X-ray study
T = 293 K
Mean σ(C–C) = 0.012 Å
Disorder in main residue
R factor = 0.036
wR factor = 0.089
Data-to-parameter ratio = 14.7

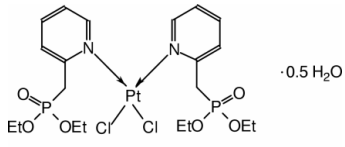
For details of how these key indicators were automatically derived from the article, see http://journals.iucr.org/e.

Received 29 April 2003
Accepted 7 May 2003
Online 16 May 2003

In the title complex, $[PtCl_2(C_{10}H_{16}NO_3P)_2]\cdot 0.5H_2O$, two diethyl 2-pyridylmethylphosphonate (pmpe) ligands are coordinated to the Pt atom *via* their pyridyl N atoms. Two *cis*-chloro ligands complete the distorted square-planar Pt coordination environment. The two pmpe ligands exhibit significantly different conformations. Some atoms in ethoxy groups are positionally disordered. In the crystal structure, a water molecule is found with half-occupancy. Apart from typical hydrogen-bond O(water)—H···O interactions, weak C—H···O and C—H···Cl contacts are also observed.

Comment

The platinum(II) coordination compound *cis*-$[PtCl_2(NH_3)_2]$, *cis*-[diamminedichloroplatinum(II)], clinically known as 'cisplatin', is one of the most important anticancer drugs, successfully used in the treatment of several types of tumours, *e.g.* testicular, ovarian and bladder carcinomas. Nevertheless, severe side effects of cisplatin, such as vomiting, ear damage and kidney toxicity, have been reported. Therefore, intensive investigations in the group of platinum(II)–amine complexes with potential lower toxicity and similar or improved activity have been performed (Lippert, 1999). In recent years, a novel antitumour complex, *cis*-amminedichloro(2-methylpyridine)-platinum(II) (AMD-473), has been selected for clinical trials (Holford *et al.*, 1998). A new class of platinum(II) coordination compounds containing phosphonic acid ligands has been also investigated and showed promising cytostatic activity against osteosarcoma (Klenner *et al.*, 1993; Bloemink *et al.*, 1994).



(I)

Our preliminary studies have shown that platinum(II) complexes with diethyl 2-, 3-, or 4-pyridylmethylphosphonate (pmpe) ligands of the general formula *cis*-$[PtCl_2(pmpe)_2]$ were able to evoke *in vitro* histamine release from murine mast cells (Brzezińska-Błaszczyk *et al.*, 1996) and exhibited *in vivo* cytostatic activity against the mouse Sa 180 sarcoma solid tumour (Ochocki *et al.*, 1995). In this paper, we describe the crystal and molecular structure of the complex, *cis*-$[PtCl_2(2\text{-pmpe})_2]\cdot 0.5H_2O$, (I).

The platinum(II) centre in (I) is coordinated by two N atoms of diethyl 2-pyridylmethylphosphonate ligands. Two *cis* chloro ions complete the square-planar coordination environment of the metal. The geometry at the Pt centre is essen-

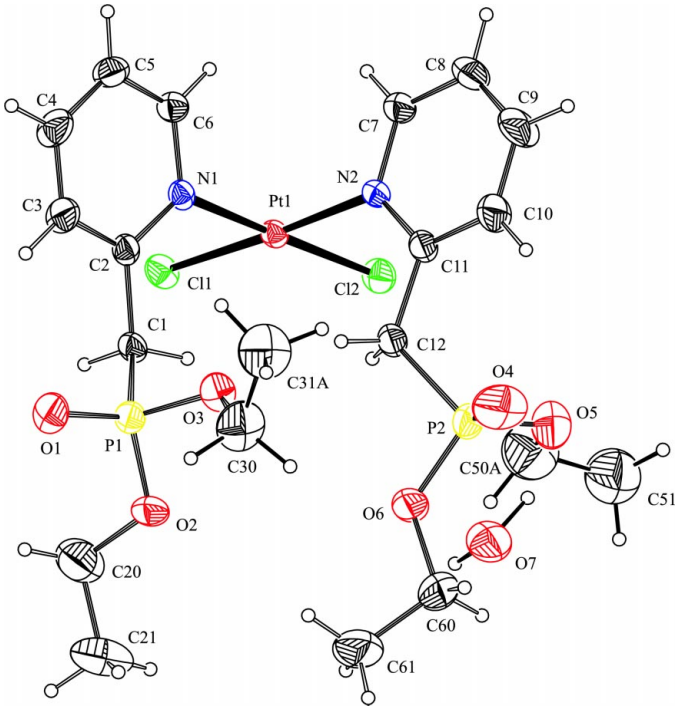


Figure 1
The structure of the title compound, with the atom-numbering scheme. The minor disorder components (atoms C31*B* and C50*B*) have been omitted for clarity. Displacement ellipsoids are drawn at the 20% probability level and H atoms are shown as small spheres of arbitrary radii.

tially planar. The maximum deviation from the mean plane defined by atoms Pt1, Cl1, Cl2, N1 and N2 is 0.111 (5) Å for atom N2. The Pt1—N1/N2 and Pt1—Cl1/Cl2 bond lengths are equal within 3σ (Table 1). The observed metal–ligand distances, Pt1—N and Pt1—Cl, are shorter than the literature values (Orpen *et al.*, 1989) of 2.05 (5) and 2.32 (4) Å, respectively.

The two diethyl 2-pyridylmethylphosphonate ligands are not identical, but have significantly different conformations. Firstly, the mean planes of the two pyridyl rings, N1—C6 and N2—C11, have different orientations with respect to the Pt1 coordination plane. The respective dihedral angles are 70.5 (2) and 85.9 (2)°. The dihedral angle between the the two pyridyl planes is 79.6 (2)°. Secondly, some differences are observed with regard to the rotation of the phosphonate groups about the C1—C2 and C11—C12 bonds, as shown by the torsion angles (see Table 1).

Atoms P1 and P2 adopt distorted tetrahedral configurations. However, the angular parameters, presented in Table 1, indicate that the tetrahedral environment around P2 is more deformed. The differences in the deformations of the PO_3C tetrahedra can be explained by the steric effects of disordered atoms within ethoxy groups. The spatial requirements are different for the disordered terminal methyl group (C31) than for the disordered CH_2 fragment (C50) (see *Experimental*). The latter one is closer to the P atom so its influence on the geometry around P2 is substantial.

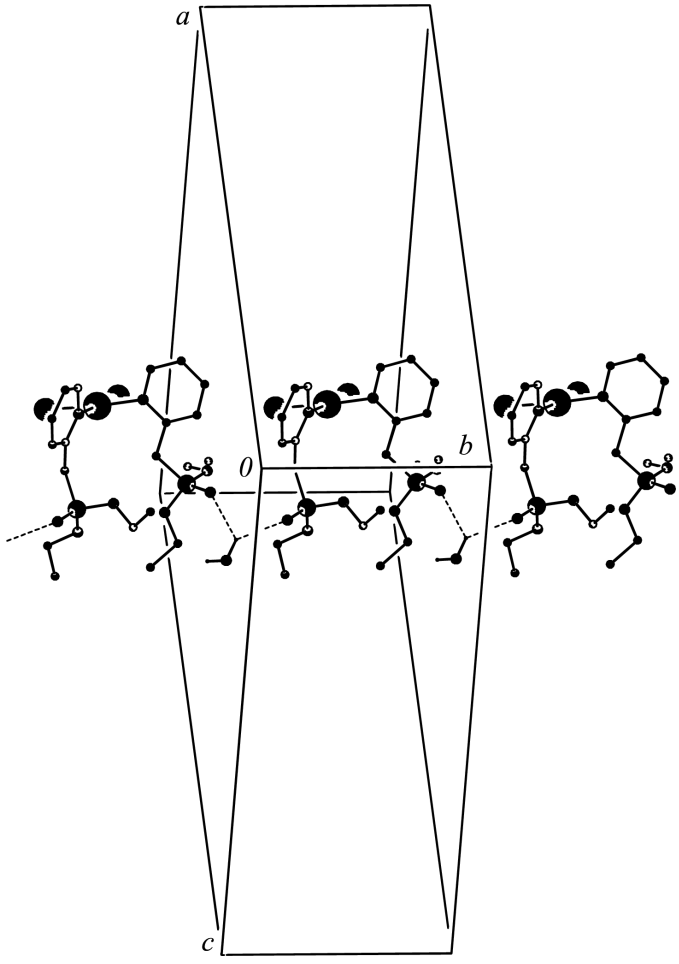


Figure 2
Part of the crystal structure of the title complex, showing the formation of a chain along [010]. H atoms bonded to C atoms have been omitted.

It is worth noting that one half water molecule was found in the asymmetric unit of (I). Atom H72 of the solvent water molecule forms a bifurcated hydrogen bond with non-ester atoms O4 and O1 of the phosphonate groups. As shown in Fig. 2, the molecules of the complex and water are linked into a [010] chain through the hydrogen bond O(water)—H···O.

Additionally, the crystal packing of (I) is stabilized by a number of C—H···O and C—H···Cl interactions. The geometries of these contacts are presented in Table 2.

In conclusion, a search of the November 2002 release of the Cambridge Structural Database (Allen, 2002) suggests that the present structure is a novel type of platinum complex with diethyl pyridylmethylphosphonate ligands.

Experimental

The title complex was prepared by adding two molecular equivalents of diethyl 2-pyridylmethylphosphonate to K_2PtCl_4 in a water/ethanol solution. The reaction mixture was stirred at 303 K for 2 h and partly evaporated. The resulting solution was cooled and transparent yellow crystals suitable for X-ray studies formed after a few days (Ochocki, 1997).

Crystal data

$[PtCl_2(C_{10}H_{16}NO_3P)_2]\cdot 0.5H_2O$	D_x = 1.744 Mg m^{-3}
M_r = 733.40	Mo $K\alpha$ radiation
Monoclinic, $C2/c$	Cell parameters from 7015 reflections
a = 25.6017 (13) Å	θ = 1.6–22.2°
b = 9.5475 (4) Å	μ = 5.37 mm^{-1}
c = 23.6965 (16) Å	T = 293 (2) K
β = 105.343 (5)°	Plate, yellow
V = 5585.7 (5) Å^3	0.5 × 0.3 × 0.1 mm
Z = 8	

Data collection

Kuma KM4CCD diffractometer	3852 reflections with $I > 2\sigma(I)$
ω scans	R_{int} = 0.099
Absorption correction: numerical (*X-RED*; Stoe & Cie, 1999)	θ_{max} = 25.0°
T_{min} = 0.063, T_{max} = 0.505	$h = -30 \rightarrow 30$
29455 measured reflections	$k = -11 \rightarrow 11$
4909 independent reflections	$l = -23 \rightarrow 28$

Refinement

Refinement on F^2	H atoms treated by a mixture of independent and constrained refinement
$R[F^2 > 2\sigma(F^2)]$ = 0.036	$w = 1/[\sigma^2(F_o^2) + (0.0429P)^2]$ where $P = (F_o^2 + 2F_c^2)/3$
$wR(F^2)$ = 0.089	$(\Delta/\sigma)_{max}$ = 0.001
S = 1.02	$\Delta\rho_{max}$ = 1.33 e Å^{-3}
4909 reflections	$\Delta\rho_{min}$ = −1.54 e Å^{-3}
333 parameters	

Table 1
Selected geometric parameters (Å, °).

Pt1—N1	2.035 (5)	P1—O3	1.560 (5)
Pt1—N2	2.038 (5)	P1—O2	1.562 (5)
Pt1—Cl1	2.2851 (15)	C11—C12	1.506 (9)
Pt1—Cl2	2.2896 (16)	C12—P2	1.776 (7)
C2—C1	1.506 (8)	P2—O4	1.455 (7)
C1—P1	1.786 (6)	P2—O5	1.509 (8)
P1—O1	1.447 (5)	P2—O6	1.554 (5)
N1—Pt1—N2	92.65 (18)	O1—P1—C1	116.2 (3)
N1—Pt1—Cl1	88.38 (13)	O3—P1—C1	102.1 (3)
N2—Pt1—Cl1	176.34 (14)	O2—P1—C1	104.1 (3)
N1—Pt1—Cl2	179.22 (14)	O4—P2—O5	104.0 (5)
N2—Pt1—Cl2	87.18 (14)	O4—P2—O6	115.1 (4)
Cl1—Pt1—Cl2	91.74 (6)	O5—P2—O6	111.6 (4)
O1—P1—O3	115.7 (3)	O4—P2—C12	114.8 (4)
O1—P1—O2	114.0 (3)	O5—P2—C12	112.5 (4)
O3—P1—O2	103.1 (3)	O6—P2—C12	99.3 (3)
N1—C2—C1—P1	134.7 (5)	N2—C11—C12—P2	160.1 (5)
C3—C2—C1—P1	−46.5 (8)	C10—C11—C12—P2	−21.0 (10)

Table 2
Hydrogen-bonding geometry (Å, °).

D—H···A	D—H	H···A	D···A	D—H···A
O7—H72···O1^{i}	0.97 (19)	2.28 (19)	3.016 (15)	132 (14)
O7—H72···O4	0.97 (19)	2.31 (17)	3.002 (18)	128 (12)
C3—H3···O1	0.93	2.54	3.211 (10)	129
C4—H4···O1^{ii}	0.93	2.39	3.289 (10)	164
C7—H7···Cl1^{iii}	0.93	2.69	3.571 (7)	159
C10—H10···O4	0.93	2.54	3.239 (12)	132
C12—H12*B*···O3	0.97	2.36	3.296 (9)	162
C20—H20*B*···O7^{iv}	0.97	2.56	3.529 (18)	178
C60—H60*A*···O7	0.97	2.55	3.474 (17)	160

Symmetry codes: (i) $x, 1+y, z$; (ii) $-x, -y, -z$; (iii) $\frac{1}{2}-x, \frac{1}{2}-y, -z$; (iv) $x, y-1, z$.

The largest peak of residual electron density was 2.03 Å from atom H50*D* and the deepest hole was 0.98 Å from atom Pt1. During the refinement of (I) the four ethoxy groups revealed very large atomic displacement parameters. Finally, only two atoms, methyl C31 and methylene C50, appeared to be disordered. The final site-occupation factors refined to 0.55 (5):0.44 (5) for C31*A*/C31*B* and 0.68 (5):0.32 (5) for C50*A*/C50*B*. Similarity restraints were used in the refinement of the atomic displacement parameters of those disordered atoms. Moreover, bond-length restraints were applied to all C—C bonds involving the disordered atoms, and additionally to the C20—C21 and C60—C61 bonds. Satisfactory refinement results were obtained when one half-occupancy O atom of water of crystallization was included in the asymmetric unit. This yields four water molecules per unit cell. The water H atoms were found in difference maps and refined with geometric restraints [O—H = 0.97 (3) Å and H···H = 1.53 (3) Å] and with U_{iso}(H) = 1.5U_{eq}(O). All other atoms were placed in geometrically idealized positions (C—H = 0.93–0.98 Å) and constrained to ride on their parent atoms, with U_{iso}(H) = 1.2U_{eq}(C) [or 1.5U_{eq} for methyl C atom]. Reflections with $2\theta > 50°$ were omitted because of their poor reliability.

Data collection: *CrysAlisCCD* [UNIL IC & Oxford Diffraction (Poland), 20010; cell refinement: *CrysAlisCCD*; data reduction: *CrysAlisRED* [UNIL IC & Oxford Diffraction (Poland), 2001]; program(s) used to solve structure: *SHELXS*97 (Sheldrick, 1997); program(s) used to refine structure: *SHELXL*97 (Sheldrick, 1997); molecular graphics: *PLATON* (Spek, 1998); software used to prepare material for publication: *PARST*97 (Nardelli, 1996).

The authors thank Dr Andrzej Fruziński for skillful experimental assistance.

References

Allen, F. H. (2002). *Acta Cryst.* B**58**, 380–388.

Bloemink, M. J., Dorenbos, J. P., Heetebrij, R. J., Keppler, B. K., Reedijk, J. & Zahn, H. (1994). *Inorg. Chem.* **33**, 1127–1132.

Brzezińska-Błaszczyk, E., Mińcikiewicz, M. & Ochocki, J. (1996). *Eur. J. Pharmacol.* **298**, 155–158.

Holford, J., Raynaud, F., Murrer, B. A., Grimaldi, K., Hartley, J. A., Abrams, M. & Kelland, L. R. (1998). *Anti-Cancer Drug Des.* **13**, 1–18.

Klenner, T., Valenzuela-Paz, P., Amelung, F., Münch, H., Zahn, H., Keppler, B. K. & Blum, H. (1993). *Metal Complexes in Cancer Chemotherapy*, edited by B. K. Keppler, pp. 85–127. Weinheim: VCH.

UNIL IC & Oxford Diffraction (Poland) (2001). *CrysAlisCCD* (Version 1.169) and *CrysAlisRED* (Version 1.169). UNIL IC & Oxford Diffraction (Poland) GmbH, Rogowska 127 A, 54-440 Wrocław, Poland.

Lippert, B. (1999). Editor. *Cisplatin: Chemistry and Biochemistry of a Leading Anticancer Drug*, pp. 1–563. Zurich: Verlag Helv. Chim. Acta; and Weinheim: Wiley-VCH.

Nardelli, M. (1996). *J. Appl. Cryst.* **29**, 296–300.

Ochocki, J. (1997). Polish Patent No. 171 757.

Ochocki, J., Graczyk, J. & Reedijk, J. (1995). *J. Inorg. Biochem.* **59**, 240.

Orpen, A. G., Brammer, L., Allen, F. H., Kennard, O., Watson, D. G. & Taylor, R. (1989). *J. Chem. Soc. Dalton Trans.* pp. S1–84.

Sheldrick, G. M. (1997). *SHELXS*97 and *SHELXL*97. University of Göttingen, Germany.

Spek, A. L. (1998). *PLATON*. University of Utrecht, The Netherlands.

Stoe & Cie (1999). *X-RED*. Version 1.18. Stoe & Cie, Darmstadt, Germany.