metal-organic compounds

Di-*μ*-chlorido-bis[chlorido(*η*²-ethene)-platinum(II)]

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Zeise's dimer, $[Pt_2Cl_4(C_2H_4)_2)]$, consists of two independent dimeric molecules in the unit cell, one of which is crystallographically centrosymmetric. All Pt atoms are essentially square planar with bridging and *trans* terminal chloride groups. The ethene groups are orthogonal to the molecular square plane. In the non-centrosymmetric molecule, the two square planes subtend an angle of 160.10 (13)° at the bridging Cl atoms. The crystal structure exhibits layers of molecules running approximately parallel to the (001) face, with a layer of the centrosymmetric dimer stacked directly between two layers of the non-centrosymmetric molecules [Pt···Pt = 4.053 (1) and 4.090 (1) Å]. Within this stack, the ethene groups of the central molecule are located between two terminal chloride groups of the adjacent molecules. Adjacent three-layer sandwiches are staggered from each other so that stacking occurs for only one square plane, disrupting any further interaction by one Pt atom but allowing a weaker Pt···Pt interaction [4.249 (1) Å]. The non-centrosymmetric molecule layer exhibits a weak hydrogen bond between a terminal chloride and an ethene H atom of an adjacent molecule.

Related literature

Zeise's salt, $K[PtCl_3(\eta^2\text{-}C_2H_4)]\cdot H_2O$, and Zeise's dimer, $Pt_2(\mu\text{-}Cl)_2Cl_2(\eta^2\text{-}C_2H_4)_2$, are pivotal in our understanding of the interaction between organic molecules and transition metals (Zeise, 1831; Anderson, 1934). For historical background, see: Hunt (1984). However, it was not until 1975, after many difficulties, that the crystal structure of Zeise's salt was finally successfully solved (Love *et al.*, 1975). The structure of the historically significant Zeise's dimer has never been determined crystallographically, although analogues have been reported (Dempsey & Baenziger, 1955; Jain & Jain, 2005; Otto *et al.*, 2003). For related literature, see: Aullón & Alvarez (1997); Boag & Ravetz (1995); Zettlitzer *et al.* (1986).
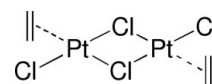
Experimental

Crystal data

$[Pt_2Cl_4(C_2H_4)_2]$	γ = 73.142 (10)°
M_r = 588.06	V = 761.97 (16) Å³
Triclinic, $P\bar{1}$	Z = 3
a = 6.6413 (8) Å	Mo $K\alpha$ radiation
b = 10.1222 (13) Å	μ = 28.49 mm⁻¹
c = 12.2397 (15) Å	T = 293 (2) K
α = 87.230 (10)°	0.20 × 0.10 × 0.10 mm
β = 75.462 (9)°	

Data collection

Nicolet $R3m/V$ diffractometer	3502 independent reflections
Absorption correction: ψ scan	2740 reflections with $I > 2\sigma(I)$
($XPREP$; Siemens, 1995)	R_{int} = 0.039
T_{min} = 0.150, T_{max} = 0.954	3 standard reflections
(expected range = 0.009–0.058)	every 100 reflections
3804 measured reflections	intensity decay: none

Refinement

$R[F^2 > 2\sigma(F^2)]$ = 0.054	137 parameters
$wR(F^2)$ = 0.140	H-atom parameters constrained
S = 1.08	$\Delta\rho_{max}$ = 3.86 e Å⁻³
3502 reflections	$\Delta\rho_{min}$ = −3.24 e Å⁻³

Table 1
Selected geometric parameters (Å, °).

Pt1···Pt2ⁱ	4.0531 (10)	Pt3···Pt3ⁱⁱⁱ	4.2494 (14)
Pt1···Pt3ⁱⁱ	4.0901 (10)		
Pt2ⁱ···Pt1···Pt3ⁱⁱ	173.87 (2)	Pt1ⁱⁱ···Pt3···Pt3ⁱⁱⁱ	159.86 (3)

Symmetry codes: (i) $x, y, z + 1$; (ii) $-x + 1, -y, -z + 1$; (iii) $-x, -y, -z + 1$.

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

D—H···A	D—H	H···A	D···A	D—H···A
C31—H31A···Cl2ⁱᵛ	0.97	2.79	3.71 (2)	159

Symmetry code: (iv) $x, y - 1, z$.

Data collection: *P3 Diffractometer Control Program* (Siemens, 1990); cell refinement: *XSCANS* (Siemens, 1996); data reduction: *XSCANS*; program(s) used to solve structure: *SHELXTL-Plus* (Sheldrick, 1995); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *SHELXTL-Plus*; software used to prepare material for publication: *SHELXL97*.

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: SI2052).

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supplementary materials

Di-*μ*-chlorido-bis[chlorido(*η²*-ethene)platinum(II)]

N. M. Boag and M. S. Ravetz

Comment

Bis(μ_2-chloro)dichlorobis(η^2-ethene)diplatinum(II) (Zeize's dimer) consists of two independent dimeric molecules in the unit cell, one of which is crystallographically centrosymmetric (Fig. 1). All platinum atoms are essentially square planar with bridging and terminal chloride groups. The ethylene groups are *trans* to each other across the dimeric unit in both molecules and are essentially orthogonal to the square plane geometry of their coordinated platinum atom. The non-centrosymmetric molecule exhibits a small hinge angle of 160.10 (13)° at the bridging chlorides. The overall geometry and molecular dimensions are comparable to related palladium and platinum structures, (Jain & Jain, 2005; Otto *et al.*, 2003) including the palladium analogue (Dempsey & Baenziger, 1955). Amongst these, however, only bis(μ_2-chloro)dichlorobis(η^2-1,3-di-*tert*-butyl-2,2-dimethyl-1,3-diaza-2-sila-4- cyclopentene)dipalladium(II) is not rigorously planar (hinge angle = 150.9°) (Zettlitzer *et al.*, 1986).

The title compound exhibits a layered structure running approximately parallel to the (0 0 1) face with a layer of the centrosymmetric dimer directly stacked between two layers of the non-centrosymmetric molecules (Pt(1)···Pt(2) 4.053 (1) Å and Pt(1')···Pt(3) 4.090 (1) Å). Within this stack, the ethylene groups of the central molecule are located between two terminal chloride groups of the adjacent molecules (τ ~90° (Aullón & Alvarez, 1997)). Adjacent three layer sandwiches are staggered from each other so that stacking occurs for only one square plane, disrupting any further interaction by Pt(2), but allowing a weaker Pt(3)···Pt(3) interaction (4.249 (1) Å). The direct Pt···Pt interaction thus extends for only five layers (Fig. 2). The Pt···Pt distances are comparable to those in K_2[PtCl$_4$] in which the electronic effects of any interaction are classified as minimal (Aullón & Alvarez, 1997). By contrast, in the palladium analogue, the molecules stack directly above each other, but with a 90° twist between adjacent Pd$_2$(μ_2-Cl)$_2$ units leading to parallel Pd···Cl···Pd chains (3.76 Å) (Dempsey & Baenziger, 1955).

Within the presented structure, the non-centrosymmetric molecule layer exhibits a weak hydrogen bond between one terminal chloride and an ethylene hydrogen on an adjacent molecule (Fig. 2).

Experimental

The title compound was prepared by literature methods and subsequently isolated from dichloromethane/hexane as as a few small irregular red crystals following crystallization of the residue of its reaction mixture with SbPh$_3$ in refluxing tetrachloroethane (Boag & Ravetz, 1995).

Refinement

The hydrogen atoms were placed in calculated positions and allowed to ride on their respective atoms, with C—H = 0.97 Å and U_{iso}(H) = 1.2 U_{eq}(C).
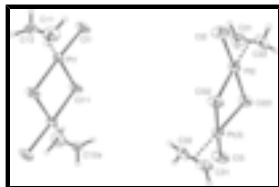
supplementary materials

Figures

Fig. 1. The two independent molecules of the title compound, showing the atom-labelling scheme. Displacement ellipsoids are drawn at the 50% probability level.
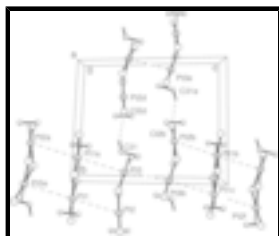

Fig. 2. Packing diagram of the title compound showing stacking between molecules and hydrogen bonding. For the sake of clarity, only the H atoms involved in hydrogen bonding have been included. Atoms marked with an a, b, c, d, e and f are at the symmetry positions $(1 - x, -y, -z)$, $(-x, 1 - y, 1 - z)$, $(1 + x, 1 + y, 1 + z)$, $(x, y - 1, z)$, $(-x, 1 - y, 1 - z)$ and $(x - 1, 1 + y, 1 + z)$ respectively.

Di-µ-chlorido-bid[chlorido(η^2-ethene)platinum(II)]

Crystal data

$[Pt_2Cl_4(C_2H_4)_2]$	$Z = 3$
$M_r = 588.06$	$F_{000} = 768$
Triclinic, $P\bar{1}$	$D_x = 3.845$ Mg m^{-3}
Hall symbol: -P 1	Mo $K\alpha$ radiation $\lambda = 0.71073$ Å
$a = 6.6413$ (8) Å	Cell parameters from 49 reflections
$b = 10.1222$ (13) Å	$\theta = 7.3–15.3°$
$c = 12.2397$ (15) Å	$\mu = 28.49$ mm^{-1}
$\alpha = 87.230$ (10)°	$T = 293$ (2) K
$\beta = 75.462$ (9)°	Irregular block, red
$\gamma = 73.142$ (10)°	$0.20 \times 0.10 \times 0.10$ mm
$V = 761.97$ (16) Å^3	

Data collection

Nicolet R3m/V diffractometer	$R_{int} = 0.039$
Radiation source: fine-focus sealed tube	$\theta_{max} = 27.6°$
Monochromator: graphite	$\theta_{min} = 2.1°$
$T = 293(2)$ K	$h = 0\rightarrow8$
intensity fitting of $\theta/2\theta$ scans	$k = -12\rightarrow13$
Absorption correction: ψ scan (XPREP; Siemens, 1995)	$l = -15\rightarrow15$
$T_{min} = 0.150$, $T_{max} = 0.954$	3 standard reflections
3804 measured reflections	every 100 reflections
3502 independent reflections	intensity decay: none
2740 reflections with $I > 2\sigma(I)$	

Refinement

Refinement on F^2	H-atom parameters constrained
Least-squares matrix: full	$w = 1/[\sigma^2(F_o^2) + (0.0717P)^2 + 15.2811P]$ where $P = (F_o^2 + 2F_c^2)/3$
$R[F^2 > 2\sigma(F^2)] = 0.054$	$(\Delta/\sigma)_{max} < 0.001$
$wR(F^2) = 0.140$	$\Delta\rho_{max} = 3.86$ e Å^{-3}
$S = 1.08$	$\Delta\rho_{min} = -3.24$ e Å^{-3}
3502 reflections	Extinction correction: SHELXL97 (Sheldrick, 1997)
137 parameters	Extinction coefficient: 0.0030 (3)

Special details

Experimental. The few crystals isolated were not particularly well formed and showed evidence of not being single− a few spurious diffactions peaks and peaks showing shoulders. The final structure exhibits multiple unassigned electron density features within 1 Å of both the platinum and chlorine atoms.

10 reflections having 2θ between 12.82 and 32.77 degrees giving 360 ψ scans for parameter estimation

Geometry. All e.s.d.'s (except the e.s.d. in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell e.s.d.'s are taken into account individually in the estimation of e.s.d.'s in distances, angles and torsion angles; correlations between e.s.d.'s in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell e.s.d.'s is used for estimating e.s.d.'s involving l.s. planes.

Least-squares planes (*x*,*y*,*z* in crystal coordinates) and deviations from them (* indicates atom used to define plane)

− 0.2484 (0.0142) *x* − 0.7140 (0.0203) *y* + 11.7169 (0.0078) *z* = 3.3733 (0.0090)

* 0.0000 (0.0000) Pt2 * 0.0000 (0.0000) Cl23 * 0.0000 (0.0000) Cl32

Rms deviation of fitted atoms = 0.0000

0.1666 (0.0141) *x* + 2.7437 (0.0193) *y* + 11.3718 (0.0094) *z* = 3.7927 (0.0059)

Angle to previous plane (with approximate e.s.d.) = 19.90 (0.13)

* 0.0000 (0.0000) Pt3 * 0.0000 (0.0000) Cl23 * 0.0000 (0.0000) Cl32

Rms deviation of fitted atoms = 0.0000

− 0.0376 (0.0125) *x* + 1.0741 (0.0106) *y* + 11.7155 (0.0076) *z* = 3.9458 (0.0050)

Angle to previous plane (with approximate e.s.d.) = 9.70 (0.14)

* 0.0028 (0.0027) Pt2 * −0.0109 (0.0028) Pt3 * 0.3044 (0.0033) Cl2 * 0.3102 (0.0034) Cl3 * −0.3029 (0.0030) Cl23 * −0.3036 (0.0031) Cl32

Rms deviation of fitted atoms = 0.2493

− 0.1017 (0.0209) *x* + 0.7141 (0.0035) *y* + 11.7343 (0.0116) *z* = 11.6834 (0.0220)

Angle to previous plane (with approximate e.s.d.) = 2.05 (0.16)

* 0.0000 (0.0000) Pt1 * 0.0000 (0.0000) Cl11 * 0.0000 (0.0000) Cl11_$1

Rms deviation of fitted atoms = 0.0000

− 0.1017 (0.0209) x + 0.7141 (0.0035) y + 11.7343 (0.0116) z = 11.6834 (0.0220)

Angle to previous plane (with approximate e.s.d.) = 0.00 (0.19)

* 0.0000 (0.0000) Pt1_$1 * 0.0000 (0.0000) Cl11 * 0.0000 (0.0000) Cl11_$1

Rms deviation of fitted atoms = 0.0000

− 0.1032 (0.0192) x + 0.7215 (0.0147) y + 11.7325 (0.0097) z = 11.6810 (0.0192)

Angle to previous plane (with approximate e.s.d.) = 0.05 (0.18)

* 0.0013 (0.0025) Pt1 * −0.0013 (0.0025) Pt1_$1 * −0.0007 (0.0013) Cl1 * 0.0007 (0.0014) Cl11 * 0.0007 (0.0013) Cl1_$1 * −0.0007 (0.0014) Cl11_$1

Rms deviation of fitted atoms = 0.0009

3.2046 (0.0430) x − 7.0595 (0.0521) y + 2.2326 (0.2470) z = 2.6178 (0.2425)

Angle to previous plane (with approximate e.s.d.) = 87.90 (1.21)

* 0.0000 (0.0000) Pt1 * 0.0000 (0.0000) C11 * 0.0000 (0.0000) C12

Rms deviation of fitted atoms = 0.0000

− 0.1015 (0.0212) x + 0.7235 (0.0186) y + 11.7332 (0.0103) z = 11.6828 (0.0211)

Angle to previous plane (with approximate e.s.d.) = 87.90 (1.21)

* 0.0013 (0.0026) Pt1 * −0.0007 (0.0013) Cl1 * 0.0000 (0.0001) Cl11 * −0.0007 (0.0013) Cl11_$1

Rms deviation of fitted atoms = 0.0008

5.4046 (0.0316) x + 8.0081 (0.0511) y + 2.7407 (0.2779) z = 4.2011 (0.0831)

Angle to previous plane (with approximate e.s.d.) = 86.04 (1.36)

* 0.0000 (0.0001) Pt2 * 0.0000 (0.0001) C21 * 0.0000 (0.0000) C22

Rms deviation of fitted atoms = 0.0000

− 0.2622 (0.0125) x − 0.7660 (0.0207) y + 11.7074 (0.0068) z = 3.3593 (0.0073)

Angle to previous plane (with approximate e.s.d.) = 87.96 (1.36)

* −0.0070 (0.0027) Pt2 * 0.0036 (0.0014) Cl2 * 0.0036 (0.0014) Cl23 * −0.0002 (0.0001) Cl32

Rms deviation of fitted atoms = 0.0043

5.3896 (0.0286) x + 7.8027 (0.0677) y + 0.3253 (0.2328) z = 1.0068 (0.0793)

Angle to previous plane (with approximate e.s.d.) = 76.27 (1.17)

* 0.0000 (0.0001) Pt3 * 0.0000 (0.0000) C31 * 0.0000 (0.0000) C32

Rms deviation of fitted atoms = 0.0000

0.2017 (0.0123) x + 2.8713 (0.0199) y + 11.3424 (0.0108) z = 3.8031 (0.0057)

Angle to previous plane (with approximate e.s.d.) = 88.61 (1.10)

* −0.0179 (0.0027) Pt3 * 0.0093 (0.0014) Cl3 * −0.0005 (0.0001) Cl23 * 0.0091 (0.0014) Cl32

Rms deviation of fitted atoms = 0.0111

Refinement. Refinement of F^2 against ALL reflections. The weighted R-factor wR and goodness of fit S are based on F^2, convention-al R-factors R are based on F, with F set to zero for negative F^2. The threshold expression of $F^2 > \sigma(F^2)$ is used only for calculating R-factors(gt) *etc*. and is not relevant to the choice of reflections for refinement. R-factors based on F^2 are statistically about twice as large as those based on F, and R- factors based on ALL data will be even larger.

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters ($Å^2$)

	x	y	z	U_{iso}*/U_{eq}
Pt1	0.50253 (10)	0.17030 (6)	0.98966 (5)	0.03098 (19)
Cl1	0.2485 (8)	0.3697 (5)	0.9750 (5)	0.0527 (12)
Cl11	0.2524 (7)	0.0431 (5)	0.9952 (4)	0.0445 (10)
C11	0.752 (3)	0.263 (2)	0.9248 (19)	0.056 (5)
H11A	0.8938	0.2015	0.8895	0.067*
H11B	0.7140	0.3476	0.8840	0.067*
C12	0.701 (3)	0.2771 (19)	1.0430 (17)	0.046 (5)
H12A	0.6282	0.3695	1.0753	0.056*
H12B	0.8085	0.2229	1.0808	0.056*
Pt2	0.17340 (10)	0.30150 (7)	0.30995 (5)	0.0318 (2)
Pt3	0.22859 (10)	−0.04306 (7)	0.34055 (5)	0.0315 (2)
Cl2	0.3916 (8)	0.4329 (6)	0.3243 (5)	0.0574 (13)
Cl3	−0.0144 (8)	−0.1663 (6)	0.3785 (5)	0.0573 (13)
Cl23	−0.0320 (7)	0.1547 (5)	0.2967 (4)	0.0423 (10)
Cl32	0.4598 (6)	0.0964 (5)	0.3035 (4)	0.0406 (9)
C21	−0.108 (3)	0.471 (2)	0.3702 (18)	0.052 (5)
H21A	−0.2419	0.4481	0.4044	0.062*
H21B	−0.0883	0.5454	0.4093	0.062*
C22	−0.048 (3)	0.470 (2)	0.2542 (17)	0.051 (5)
H22A	0.0087	0.5446	0.2203	0.062*
H22B	−0.1447	0.4473	0.2154	0.062*
C31	0.493 (3)	−0.225 (2)	0.3172 (17)	0.046 (4)
H31A	0.4656	−0.3089	0.2983	0.055*
H31B	0.6333	−0.2160	0.2752	0.055*
C32	0.430 (3)	−0.186 (2)	0.4305 (16)	0.046 (4)
H32A	0.5294	−0.1518	0.4592	0.055*
H32B	0.3615	−0.2448	0.4823	0.055*

Atomic displacement parameters (Å²)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
Pt1	0.0319 (3)	0.0189 (3)	0.0421 (3)	−0.0048 (2)	−0.0128 (2)	0.0047 (2)
Cl1	0.047 (3)	0.026 (2)	0.081 (3)	0.001 (2)	−0.025 (2)	0.013 (2)
Cl11	0.0291 (19)	0.023 (2)	0.082 (3)	−0.0028 (17)	−0.0217 (19)	0.006 (2)
C11	0.038 (10)	0.056 (14)	0.086 (15)	−0.033 (10)	−0.019 (10)	0.020 (11)
C12	0.044 (10)	0.024 (9)	0.076 (13)	0.000 (8)	−0.033 (9)	−0.008 (9)
Pt2	0.0305 (3)	0.0243 (3)	0.0434 (4)	−0.0096 (3)	−0.0127 (2)	0.0061 (2)
Pt3	0.0302 (3)	0.0240 (3)	0.0420 (3)	−0.0095 (3)	−0.0102 (2)	0.0022 (2)
Cl2	0.046 (3)	0.036 (3)	0.096 (4)	−0.018 (2)	−0.020 (3)	−0.003 (3)
Cl3	0.042 (2)	0.037 (3)	0.100 (4)	−0.024 (2)	−0.018 (2)	0.014 (3)
Cl23	0.037 (2)	0.032 (2)	0.067 (3)	−0.0145 (18)	−0.0242 (19)	0.0080 (19)
Cl32	0.0276 (18)	0.028 (2)	0.069 (3)	−0.0107 (17)	−0.0158 (17)	0.0055 (19)
C21	0.038 (9)	0.031 (11)	0.073 (13)	0.014 (8)	−0.016 (9)	−0.011 (9)
C22	0.050 (11)	0.048 (13)	0.059 (11)	−0.015 (10)	−0.022 (9)	0.031 (9)
C31	0.034 (9)	0.025 (10)	0.077 (13)	−0.003 (8)	−0.016 (9)	−0.001 (9)
C32	0.041 (10)	0.037 (11)	0.063 (11)	−0.012 (8)	−0.023 (8)	0.024 (9)

Geometric parameters (Å, °)

Pt1—C11	2.108 (18)	Pt3—Cl3	2.261 (5)
Pt1—C12	2.157 (18)	Pt3—Cl32	2.324 (4)
Pt1—Cl1	2.257 (5)	Pt3—Cl23	2.376 (4)
Pt1—Cl11^i	2.328 (4)	C21—C22	1.38 (3)
Pt1—Cl11	2.366 (5)	C21—H21A	0.9700
Cl11—Pt1^i	2.328 (4)	C21—H21B	0.9700
C11—C12	1.41 (3)	C22—H22A	0.9700
C11—H11A	0.9700	C22—H22B	0.9700
C11—H11B	0.9700	C31—C32	1.39 (3)
C12—H12A	0.9700	C31—H31A	0.9700
C12—H12B	0.9700	C31—H31B	0.9700
Pt2—C22	2.114 (19)	C32—H32A	0.9700
Pt2—C21	2.132 (17)	C32—H32B	0.9700
Pt2—Cl2	2.274 (5)	Pt1—Pt1^i	3.4539 (14)
Pt2—Cl23	2.325 (4)	Pt2—Pt3	3.4117 (10)
Pt2—Cl32	2.363 (4)	Pt1—Pt2^{ii}	4.0531 (10)
Pt3—C31	2.118 (18)	Pt1—Pt3^{iii}	4.0901 (10)
Pt3—C32	2.133 (17)	Pt3—Pt3^{iv}	4.2494 (14)
C11—Pt1—C12	38.5 (8)	C31—Pt3—Cl32	91.9 (6)
C11—Pt1—Cl1	90.9 (7)	C32—Pt3—Cl32	92.4 (6)
C12—Pt1—Cl1	92.3 (5)	Cl3—Pt3—Cl32	176.35 (17)
C11—Pt1—Cl11^i	92.7 (7)	C31—Pt3—Cl23	159.9 (6)
C12—Pt1—Cl11^i	91.3 (5)	C32—Pt3—Cl23	161.6 (6)
Cl1—Pt1—Cl11^i	176.20 (18)	Cl3—Pt3—Cl23	91.83 (18)
C11—Pt1—Cl11	159.9 (7)	Cl32—Pt3—Cl23	84.76 (15)

C12—Pt1—Cl11	161.3 (6)	Pt2—Cl23—Pt3	93.05 (14)
Cl1—Pt1—Cl11	90.94 (17)	Pt3—Cl32—Pt2	93.42 (14)
Cl11[i]—Pt1—Cl11	85.26 (15)	C22—C21—Pt2	70.4 (11)
Pt1[i]—Cl11—Pt1	94.74 (15)	C22—C21—H21A	116.6
C12—C11—Pt1	72.7 (11)	Pt2—C21—H21A	116.6
C12—C11—H11A	116.3	C22—C21—H21B	116.6
Pt1—C11—H11A	116.3	Pt2—C21—H21B	116.6
C12—C11—H11B	116.3	H21A—C21—H21B	113.6
Pt1—C11—H11B	116.3	C21—C22—Pt2	71.8 (10)
H11A—C11—H11B	113.3	C21—C22—H22A	116.4
C11—C12—Pt1	68.9 (10)	Pt2—C22—H22A	116.4
C11—C12—H12A	116.8	C21—C22—H22B	116.4
Pt1—C12—H12A	116.8	Pt2—C22—H22B	116.4
C11—C12—H12B	116.8	H22A—C22—H22B	113.4
Pt1—C12—H12B	116.8	C32—C31—Pt3	71.5 (10)
H12A—C12—H12B	113.8	C32—C31—H31A	116.4
C22—Pt2—C21	37.8 (8)	Pt3—C31—H31A	116.4
C22—Pt2—Cl2	92.1 (6)	C32—C31—H31B	116.4
C21—Pt2—Cl2	90.6 (6)	Pt3—C31—H31B	116.4
C22—Pt2—Cl23	91.5 (6)	H31A—C31—H31B	113.4
C21—Pt2—Cl23	92.7 (6)	C31—C32—Pt3	70.4 (10)
Cl2—Pt2—Cl23	176.34 (18)	C31—C32—H32A	116.6
C22—Pt2—Cl32	159.9 (6)	Pt3—C32—H32A	116.6
C21—Pt2—Cl32	162.0 (6)	C31—C32—H32B	116.6
Cl2—Pt2—Cl32	91.34 (17)	Pt3—C32—H32B	116.6
Cl23—Pt2—Cl32	85.03 (15)	H32A—C32—H32B	113.6
C31—Pt3—C32	38.1 (8)	Pt2[ii]—Pt1—Pt3[iii]	173.87 (2)
C31—Pt3—Cl3	91.8 (6)	Pt1[iii]—Pt3—Pt3[iv]	159.86 (3)
C32—Pt3—Cl3	90.5 (6)		
C11—Pt1—Cl11—Pt1[i]	84.8 (19)	C32—Pt3—Cl32—Pt2	−147.4 (6)
C12—Pt1—Cl11—Pt1[i]	−80.1 (15)	Cl23—Pt3—Cl32—Pt2	14.44 (16)
Cl1—Pt1—Cl11—Pt1[i]	179.90 (19)	C22—Pt2—Cl32—Pt3	−95.5 (18)
Cl11[i]—Pt1—Cl11—Pt1[i]	0.0	C21—Pt2—Cl32—Pt3	69 (2)
Cl1—Pt1—C11—C12	92.6 (11)	Cl2—Pt2—Cl32—Pt3	164.7 (2)
Cl11[i]—Pt1—C11—C12	−88.8 (11)	Cl23—Pt2—Cl32—Pt3	−14.76 (17)
Cl11—Pt1—C11—C12	−172.3 (13)	Cl2—Pt2—C21—C22	92.6 (13)
Cl1—Pt1—C12—C11	−88.5 (12)	Cl23—Pt2—C21—C22	−89.0 (13)
Cl11[i]—Pt1—C12—C11	92.6 (12)	Cl32—Pt2—C21—C22	−171.2 (15)
Cl11—Pt1—C12—C11	171.7 (14)	Cl2—Pt2—C22—C21	−88.3 (13)
C22—Pt2—Cl23—Pt3	174.6 (6)	Cl23—Pt2—C22—C21	92.4 (13)
C21—Pt2—Cl23—Pt3	−147.7 (6)	Cl32—Pt2—C22—C21	172.1 (14)
Cl32—Pt2—Cl23—Pt3	14.42 (16)	Cl3—Pt3—C31—C32	−88.4 (11)
C31—Pt3—Cl23—Pt2	−95.7 (16)	Cl32—Pt3—C31—C32	91.5 (11)
C32—Pt3—Cl23—Pt2	67.0 (18)	Cl23—Pt3—C31—C32	171.3 (13)
Cl3—Pt3—Cl23—Pt2	164.0 (2)	Cl3—Pt3—C32—C31	92.3 (11)
Cl32—Pt3—Cl23—Pt2	−14.67 (17)	Cl32—Pt3—C32—C31	−90.0 (11)
C31—Pt3—Cl32—Pt2	174.5 (6)	Cl23—Pt3—C32—C31	−170.4 (14)

Symmetry codes: (i) −*x*+1, −*y*, −*z*+2; (ii) *x*, *y*, *z*+1; (iii) −*x*+1, −*y*, −*z*+1; (iv) −*x*, −*y*, −*z*+1.

Hydrogen-bond geometry (Å, °)

D—H···A	D—H	H···A	D···A	D—H···A
C31—H31A···Cl2ᵛ	0.97	2.79	3.71 (2)	159

Symmetry codes: (v) *x*, *y*−1, *z*.

Fig. 1

Fig. 2