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Bis(μ-diethyl sulfide-κ^2S:S)bis[(biphenyl-2,2′-diyl)-platinum(II)]

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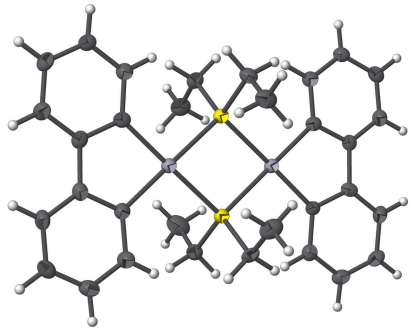
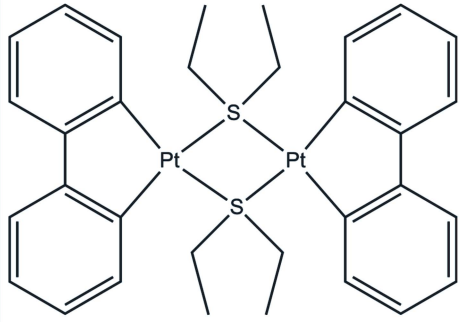
Structural data: full structural data are available from iucrdata.iucr.org

The C_4S_2 donor set in the title compound, $[Pt(C_{12}H_8)\{(C_2H_5)_2S\}]_2$, defines a distorted square-planar geometry about the two Pt^{II} atoms, with very small deviations from planarity. The bidentate nature of the biphenyl dianionic ligand results in C—Pt—C bond angles of 80.9 (2) and 81.2 (2)°; the S—Pt—S bond angles are 78.08 (5) and 78.09 (5)°. The average Pt—C bond length is 2.023 Å [range 2.016 (5)–2.028 (6) Å] and the average of Pt—S bond length is 2.3790 Å [range 2.3742 (14)–2.3837 (14) Å].

3D view



Chemical scheme



Structure description

We are interested in preparing Pt^{II} complexes containing the biphenyl dianion with diimine ligands due to their excited state emission properties (Rillema *et al.*, 2015). $[Pt(C_{12}H_8)\{(C_2H_5)_2S\}]_2$ (Fig. 1) is a synthetic intermediate. The bidentate nature of the 2,2′-biphenyl ligand gave C—Pt—C bite angles of 80.9 (2) and 81.2 (2)°, as expected from previous studies (Rillema *et al.*, 2013), but the S—Pt—S angles of 78.08 (5) and 78.09 (5)° for the square-planar biphenyl–Pt^{II} units bridged by sulfur ligands was ∼2° less than what had been found for a similar diethyl sulfide-bridged platinum(II) complex with four 4-fluorophenyl groups in place of the two bidentate biphenyl ligands (Escola *et al.*, 2014). Substitution of the bridging sulfur ligands with Br gave Br—Pt—Br angles of 83.0 (1)° and Pt—C bond lengths of 2.01 (2) and 2.01 (2) Å for the bis{(μ_2-bromido)[(2,2′-η^2)-4,4′-bis(trifluoromethyl)biphenyl]platinum(II)} anion (Brune *et al.*, 1991).

Synthesis and crystallization

The title compound was synthesized according to previously published procedures (Gilman & Gaj, 1957; Gardner *et al.*, 1973). X-ray quality crystals were obtained by recrystallization from benzene.

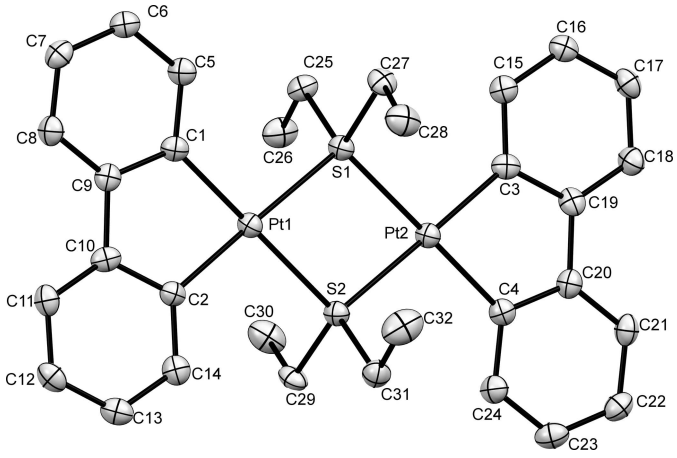


Figure 1
The molecular structure of the title compound with atom labels and 50% probability displacement ellipsoids. H atoms have been omitted for clarity.

Refinement

Crystal data, data collection and structure refinement details are summarized in Table 1.

Table 1
Experimental details.

Crystal data	
Chemical formula	$[Pt_2(C_{12}H_8)_2(C_4H_{10}S)_2]$
M_r	874.91
Crystal system, space group	Monoclinic, $P2_1/n$
Temperature (K)	100
a, b, c (Å)	19.2938 (15), 7.8839 (6), 19.6969 (17)
β (°)	109.639 (5)
V (Å^3)	2821.8 (4)
Z	4
Radiation type	Mo $K\alpha$
μ (mm^{-1})	10.07
Crystal size (mm)	0.05 × 0.02 × 0.01
Data collection	
Diffractometer	Bruker APEXII Ultra
Absorption correction	Multi-scan (*SADABS*; Bruker, 2015)
T_{min}, T_{max}	0.018, 0.048
No. of measured, independent and observed [$I > 2\sigma(I)$] reflections	39433, 6763, 5668
R_{int}	0.052
(sin $\theta/\lambda)_{max}$ (Å^{-1})	0.668
Refinement	
$R[F^2 > 2\sigma(F^2)]$, $wR(F^2)$, S	0.033, 0.066, 1.10
No. of reflections	6763
No. of parameters	329
H-atom treatment	H-atom parameters constrained
$\Delta\rho_{max}$, $\Delta\rho_{min}$ (e Å^{-3})	1.93, −1.80

Computer programs: *APEX2* (Bruker, 2012), *SAINT* (Bruker, 2012), *SHELXT* (Sheldrick, 2015*a*), *SHELXL2015* (Sheldrick, 2015*b*) and *OLEX2* (Dolomanov *et al.*, 2009).

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full crystallographic data

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Bis(*μ*-diethyl sulfide-*κ*^{2}*S*:*S*)bis[(biphenyl-2,2′-diyl)platinum(II)]

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Bis(*μ*-diethyl sulfide-*κ*^{2}*S*:*S*)bis[(biphenyl-2,2′-diyl)platinum(II)]

Crystal data

$[Pt_2(C_{12}H_{10})_2(C_4H_8S)_2]$
M_r = 874.91
Monoclinic, $P2_1/n$
a = 19.2938 (15) Å
b = 7.8839 (6) Å
c = 19.6969 (17) Å
β = 109.639 (5)°
V = 2821.8 (4) Å^3
Z = 4
$F(000)$ = 1664
D_x = 2.059 Mg m^{-3}
Mo $K\alpha$ radiation, λ = 0.71073 Å
Cell parameters from 9904 reflections
θ = 2.2–28.3°
μ = 10.07 mm^{-1}
T = 100 K
Rod, yellow
0.05 × 0.02 × 0.01 mm

Data collection

Bruker APEXII Ultra diffractometer
Radiation source: Micro Focus Rotating Anode, Bruker TXS
Double Bounce Multilayer Mirrors monochromator
Detector resolution: 7.9 pixels mm^{-1}
ω and φ scans
Absorption correction: multi-scan (*SADABS*; Bruker, 2015)
T_{min} = 0.018, T_{max} = 0.048
39433 measured reflections
6763 independent reflections
5668 reflections with $I > 2\sigma(I)$
R_{int} = 0.052
θ_{max} = 28.3°, θ_{min} = 2.8°
h = −23→25
k = −10→10
l = −26→26

Refinement

Refinement on F^2
Least-squares matrix: full
$R[F^2 > 2\sigma(F^2)]$ = 0.033
$wR(F^2)$ = 0.066
S = 1.10
6763 reflections
329 parameters
0 restraints
Primary atom site location: structure-invariant direct methods
Secondary atom site location: difference Fourier map
Hydrogen site location: inferred from neighbouring sites
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.0141P)^2 + 15.5401P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max}$ = 0.001
$\Delta\rho_{max}$ = 1.93 e Å^{-3}
$\Delta\rho_{min}$ = −1.80 e Å^{-3}

Special details

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

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å²)

	x	*y*	*z*	U_{iso}*/U_{eq}
Pt1	1.06321 (2)	0.28426 (3)	0.22858 (2)	0.01920 (6)
Pt2	0.92032 (2)	0.59665 (3)	0.22827 (2)	0.01973 (6)
S1	0.96358 (8)	0.43818 (17)	0.14799 (7)	0.0201 (3)
S2	1.02012 (8)	0.44260 (17)	0.30952 (7)	0.0209 (3)
C1	1.1019 (3)	0.1619 (7)	0.1581 (3)	0.0205 (11)
C2	1.1493 (3)	0.1631 (7)	0.2996 (3)	0.0198 (11)
C3	0.8333 (3)	0.7156 (7)	0.1570 (3)	0.0216 (12)
C4	0.8827 (3)	0.7209 (7)	0.2990 (3)	0.0210 (11)
C5	1.0705 (3)	0.1585 (7)	0.0830 (3)	0.0230 (12)
H5	1.0250	0.2150	0.0607	0.028*
C6	1.1040 (3)	0.0741 (7)	0.0399 (3)	0.0234 (12)
H6	1.0818	0.0746	−0.0110	0.028*
C7	1.1697 (3)	−0.0101 (7)	0.0720 (3)	0.0250 (13)
H7	1.1932	−0.0667	0.0431	0.030*
C8	1.2013 (3)	−0.0117 (7)	0.1466 (3)	0.0248 (12)
H8	1.2462	−0.0708	0.1686	0.030*
C9	1.1680 (3)	0.0720 (7)	0.1893 (3)	0.0204 (11)
C10	1.1955 (3)	0.0738 (7)	0.2690 (3)	0.0207 (12)
C11	1.2586 (3)	−0.0065 (7)	0.3120 (3)	0.0244 (12)
H11	1.2890	−0.0643	0.2903	0.029*
C12	1.2781 (3)	−0.0034 (7)	0.3867 (3)	0.0263 (13)
H12	1.3220	−0.0568	0.4163	0.032*
C13	1.2327 (3)	0.0781 (7)	0.4172 (3)	0.0264 (13)
H13	1.2445	0.0776	0.4681	0.032*
C14	1.1696 (3)	0.1612 (7)	0.3741 (3)	0.0249 (12)
H14	1.1395	0.2182	0.3964	0.030*
C15	0.8112 (3)	0.7139 (7)	0.0820 (3)	0.0227 (12)
H15	0.8405	0.6553	0.0593	0.027*
C16	0.7473 (3)	0.7956 (7)	0.0391 (3)	0.0241 (12)
H16	0.7338	0.7915	−0.0120	0.029*
C17	0.7035 (3)	0.8824 (7)	0.0704 (3)	0.0259 (13)
H17	0.6594	0.9356	0.0412	0.031*
C18	0.7250 (3)	0.8909 (7)	0.1456 (3)	0.0257 (13)
H18	0.6963	0.9538	0.1676	0.031*
C19	0.7881 (3)	0.8078 (7)	0.1883 (3)	0.0221 (12)
C20	0.8163 (3)	0.8089 (7)	0.2682 (3)	0.0231 (12)
C21	0.7823 (3)	0.8892 (7)	0.3106 (3)	0.0259 (13)
H21	0.7366	0.9452	0.2885	0.031*
C22	0.8140 (3)	0.8894 (8)	0.3854 (3)	0.0280 (13)
H22	0.7900	0.9433	0.4146	0.034*
C23	0.8807 (4)	0.8101 (7)	0.4164 (3)	0.0284 (13)
H23	0.9036	0.8122	0.4672	0.034*
C24	0.9149 (3)	0.7269 (7)	0.3742 (3)	0.0257 (13)
H24	0.9610	0.6731	0.3968	0.031*
C25	0.9924 (3)	0.5681 (7)	0.0864 (3)	0.0239 (12)

H25A	1.0208	0.4980	0.0633	0.029*
H25B	0.9485	0.6125	0.0481	0.029*
C26	1.0396 (4)	0.7150 (8)	0.1260 (3)	0.0321 (14)
H26A	1.0111	0.7857	0.1480	0.048*
H26B	1.0548	0.7833	0.0919	0.048*
H26C	1.0832	0.6710	0.1637	0.048*
C27	0.8930 (3)	0.3033 (7)	0.0872 (3)	0.0252 (13)
H27A	0.8484	0.3715	0.0631	0.030*
H27B	0.9111	0.2565	0.0496	0.030*
C28	0.8738 (4)	0.1596 (9)	0.1285 (4)	0.0356 (15)
H28A	0.9175	0.0893	0.1505	0.053*
H28B	0.8348	0.0903	0.0954	0.053*
H28C	0.8567	0.2060	0.1662	0.053*
C29	1.0927 (3)	0.5749 (7)	0.3692 (3)	0.0246 (12)
H29A	1.0747	0.6306	0.4052	0.030*
H29B	1.1356	0.5036	0.3953	0.030*
C30	1.1156 (4)	0.7083 (8)	0.3256 (4)	0.0370 (16)
H30A	1.1325	0.6527	0.2895	0.055*
H30B	1.1555	0.7770	0.3577	0.055*
H30C	1.0734	0.7814	0.3013	0.055*
C31	0.9904 (3)	0.3146 (8)	0.3714 (3)	0.0266 (13)
H31A	1.0338	0.2640	0.4084	0.032*
H31B	0.9642	0.3865	0.3960	0.032*
C32	0.9399 (4)	0.1756 (9)	0.3296 (4)	0.0429 (18)
H32A	0.8964	0.2264	0.2940	0.064*
H32B	0.9247	0.1045	0.3628	0.064*
H32C	0.9660	0.1059	0.3047	0.064*

Atomic displacement parameters (Å²)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
Pt1	0.02093 (11)	0.01524 (10)	0.02032 (11)	0.00053 (8)	0.00548 (8)	0.00055 (8)
Pt2	0.02191 (11)	0.01607 (10)	0.02061 (11)	0.00074 (8)	0.00635 (8)	0.00018 (8)
S1	0.0227 (7)	0.0160 (7)	0.0206 (7)	0.0007 (5)	0.0059 (6)	0.0004 (5)
S2	0.0231 (7)	0.0184 (7)	0.0206 (7)	0.0011 (5)	0.0066 (6)	0.0007 (5)
C1	0.025 (3)	0.016 (3)	0.021 (3)	−0.002 (2)	0.007 (2)	0.002 (2)
C2	0.021 (3)	0.018 (3)	0.020 (3)	−0.003 (2)	0.006 (2)	0.001 (2)
C3	0.026 (3)	0.016 (3)	0.022 (3)	−0.004 (2)	0.007 (2)	−0.001 (2)
C4	0.023 (3)	0.016 (3)	0.024 (3)	−0.001 (2)	0.008 (2)	0.002 (2)
C5	0.028 (3)	0.015 (3)	0.025 (3)	0.002 (2)	0.008 (2)	0.002 (2)
C6	0.030 (3)	0.017 (3)	0.023 (3)	−0.002 (2)	0.009 (2)	0.000 (2)
C7	0.031 (3)	0.019 (3)	0.029 (3)	−0.001 (2)	0.014 (3)	−0.003 (2)
C8	0.026 (3)	0.018 (3)	0.030 (3)	0.004 (2)	0.010 (3)	0.001 (2)
C9	0.023 (3)	0.013 (3)	0.026 (3)	−0.003 (2)	0.009 (2)	−0.001 (2)
C10	0.030 (3)	0.013 (3)	0.021 (3)	−0.005 (2)	0.010 (2)	0.000 (2)
C11	0.023 (3)	0.017 (3)	0.033 (3)	0.002 (2)	0.009 (3)	0.002 (2)
C12	0.027 (3)	0.018 (3)	0.029 (3)	0.003 (2)	0.003 (3)	0.006 (2)
C13	0.033 (3)	0.018 (3)	0.024 (3)	−0.002 (2)	0.005 (3)	0.001 (2)

C14	0.026 (3)	0.018 (3)	0.030 (3)	−0.001 (2)	0.009 (3)	0.000 (2)
C15	0.027 (3)	0.016 (3)	0.026 (3)	0.000 (2)	0.009 (2)	0.001 (2)
C16	0.026 (3)	0.020 (3)	0.024 (3)	−0.003 (2)	0.006 (2)	0.000 (2)
C17	0.023 (3)	0.020 (3)	0.031 (3)	0.003 (2)	0.004 (3)	0.003 (2)
C18	0.027 (3)	0.021 (3)	0.028 (3)	0.005 (2)	0.007 (3)	−0.002 (2)
C19	0.022 (3)	0.015 (3)	0.028 (3)	−0.002 (2)	0.006 (2)	−0.003 (2)
C20	0.024 (3)	0.017 (3)	0.029 (3)	0.000 (2)	0.011 (2)	0.000 (2)
C21	0.024 (3)	0.021 (3)	0.035 (3)	0.003 (2)	0.013 (3)	0.001 (3)
C22	0.034 (3)	0.025 (3)	0.029 (3)	−0.002 (3)	0.016 (3)	−0.004 (3)
C23	0.040 (4)	0.022 (3)	0.024 (3)	−0.001 (3)	0.012 (3)	0.001 (2)
C24	0.030 (3)	0.020 (3)	0.026 (3)	0.005 (2)	0.009 (3)	0.001 (2)
C25	0.033 (3)	0.018 (3)	0.023 (3)	−0.001 (2)	0.012 (3)	0.000 (2)
C26	0.040 (4)	0.027 (3)	0.031 (3)	−0.011 (3)	0.014 (3)	0.000 (3)
C27	0.025 (3)	0.020 (3)	0.027 (3)	−0.005 (2)	0.005 (2)	−0.005 (2)
C28	0.037 (4)	0.033 (4)	0.034 (4)	−0.010 (3)	0.009 (3)	0.000 (3)
C29	0.024 (3)	0.022 (3)	0.021 (3)	−0.001 (2)	−0.001 (2)	−0.005 (2)
C30	0.039 (4)	0.028 (3)	0.037 (4)	−0.006 (3)	0.003 (3)	0.004 (3)
C31	0.028 (3)	0.027 (3)	0.026 (3)	0.002 (2)	0.010 (3)	0.004 (2)
C32	0.060 (5)	0.029 (4)	0.045 (4)	−0.013 (3)	0.026 (4)	−0.006 (3)

Geometric parameters (Å, º)

Pt1—S1	2.3742 (14)	C16—H16	0.9500
Pt1—S2	2.3837 (14)	C16—C17	1.383 (8)
Pt1—C1	2.028 (6)	C17—H17	0.9500
Pt1—C2	2.016 (5)	C17—C18	1.400 (8)
Pt2—S1	2.3759 (14)	C18—H18	0.9500
Pt2—S2	2.3816 (14)	C18—C19	1.390 (8)
Pt2—C3	2.021 (6)	C19—C20	1.482 (8)
Pt2—C4	2.027 (6)	C20—C21	1.378 (8)
S1—C25	1.812 (6)	C21—H21	0.9500
S1—C27	1.823 (6)	C21—C22	1.394 (8)
S2—C29	1.823 (6)	C22—H22	0.9500
S2—C31	1.816 (6)	C22—C23	1.374 (9)
C1—C5	1.396 (8)	C23—H23	0.9500
C1—C9	1.407 (8)	C23—C24	1.387 (8)
C2—C10	1.419 (8)	C24—H24	0.9500
C2—C14	1.386 (8)	C25—H25A	0.9900
C3—C15	1.394 (8)	C25—H25B	0.9900
C3—C19	1.425 (8)	C25—C26	1.517 (8)
C4—C20	1.403 (8)	C26—H26A	0.9800
C4—C24	1.401 (8)	C26—H26B	0.9800
C5—H5	0.9500	C26—H26C	0.9800
C5—C6	1.397 (8)	C27—H27A	0.9900
C6—H6	0.9500	C27—H27B	0.9900
C6—C7	1.381 (8)	C27—C28	1.510 (8)
C7—H7	0.9500	C28—H28A	0.9800
C7—C8	1.390 (8)	C28—H28B	0.9800

C8—H8	0.9500	C28—H28C	0.9800
C8—C9	1.386 (8)	C29—H29A	0.9900
C9—C10	1.478 (7)	C29—H29B	0.9900
C10—C11	1.381 (8)	C29—C30	1.514 (8)
C11—H11	0.9500	C30—H30A	0.9800
C11—C12	1.393 (8)	C30—H30B	0.9800
C12—H12	0.9500	C30—H30C	0.9800
C12—C13	1.376 (8)	C31—H31A	0.9900
C13—H13	0.9500	C31—H31B	0.9900
C13—C14	1.392 (8)	C31—C32	1.512 (9)
C14—H14	0.9500	C32—H32A	0.9800
C15—H15	0.9500	C32—H32B	0.9800
C15—C16	1.396 (8)	C32—H32C	0.9800

S1—Pt1—S2	78.08 (5)	C16—C17—H17	120.4
C1—Pt1—S1	100.76 (16)	C16—C17—C18	119.2 (5)
C1—Pt1—S2	176.78 (16)	C18—C17—H17	120.4
C2—Pt1—S1	177.46 (16)	C17—C18—H18	119.8
C2—Pt1—S2	100.11 (16)	C19—C18—C17	120.4 (5)
C2—Pt1—C1	80.9 (2)	C19—C18—H18	119.8
S1—Pt2—S2	78.09 (5)	C3—C19—C20	113.7 (5)
C3—Pt2—S1	100.21 (16)	C18—C19—C3	121.2 (5)
C3—Pt2—S2	176.99 (16)	C18—C19—C20	125.1 (5)
C3—Pt2—C4	81.2 (2)	C4—C20—C19	114.4 (5)
C4—Pt2—S1	177.17 (16)	C21—C20—C4	121.1 (6)
C4—Pt2—S2	100.35 (16)	C21—C20—C19	124.4 (5)
Pt1—S1—Pt2	102.14 (5)	C20—C21—H21	119.6
C25—S1—Pt1	112.0 (2)	C20—C21—C22	120.8 (6)
C25—S1—Pt2	113.82 (19)	C22—C21—H21	119.6
C25—S1—C27	102.7 (3)	C21—C22—H22	120.6
C27—S1—Pt1	113.5 (2)	C23—C22—C21	118.8 (6)
C27—S1—Pt2	113.1 (2)	C23—C22—H22	120.6
Pt2—S2—Pt1	101.69 (5)	C22—C23—H23	119.6
C29—S2—Pt1	111.5 (2)	C22—C23—C24	120.9 (6)
C29—S2—Pt2	114.43 (19)	C24—C23—H23	119.6
C31—S2—Pt1	114.6 (2)	C4—C24—H24	119.4
C31—S2—Pt2	111.6 (2)	C23—C24—C4	121.1 (6)
C31—S2—C29	103.5 (3)	C23—C24—H24	119.4
C5—C1—Pt1	127.2 (4)	S1—C25—H25A	109.5
C5—C1—C9	117.4 (5)	S1—C25—H25B	109.5
C9—C1—Pt1	115.3 (4)	H25A—C25—H25B	108.1
C10—C2—Pt1	115.4 (4)	C26—C25—S1	110.7 (4)
C14—C2—Pt1	127.8 (4)	C26—C25—H25A	109.5
C14—C2—C10	116.7 (5)	C26—C25—H25B	109.5
C15—C3—Pt2	128.2 (4)	C25—C26—H26A	109.5
C15—C3—C19	116.7 (5)	C25—C26—H26B	109.5
C19—C3—Pt2	115.0 (4)	C25—C26—H26C	109.5
C20—C4—Pt2	115.3 (4)	H26A—C26—H26B	109.5

C24—C4—Pt2	127.5 (4)	H26A—C26—H26C	109.5
C24—C4—C20	117.2 (5)	H26B—C26—H26C	109.5
C1—C5—H5	119.1	S1—C27—H27A	109.6
C1—C5—C6	121.8 (5)	S1—C27—H27B	109.6
C6—C5—H5	119.1	H27A—C27—H27B	108.1
C5—C6—H6	120.2	C28—C27—S1	110.4 (4)
C7—C6—C5	119.5 (5)	C28—C27—H27A	109.6
C7—C6—H6	120.2	C28—C27—H27B	109.6
C6—C7—H7	120.1	C27—C28—H28A	109.5
C6—C7—C8	119.8 (5)	C27—C28—H28B	109.5
C8—C7—H7	120.1	C27—C28—H28C	109.5
C7—C8—H8	119.7	H28A—C28—H28B	109.5
C9—C8—C7	120.7 (5)	H28A—C28—H28C	109.5
C9—C8—H8	119.7	H28B—C28—H28C	109.5
C1—C9—C10	114.2 (5)	S2—C29—H29A	109.7
C8—C9—C1	120.7 (5)	S2—C29—H29B	109.7
C8—C9—C10	125.1 (5)	H29A—C29—H29B	108.2
C2—C10—C9	113.7 (5)	C30—C29—S2	109.8 (4)
C11—C10—C2	121.1 (5)	C30—C29—H29A	109.7
C11—C10—C9	125.1 (5)	C30—C29—H29B	109.7
C10—C11—H11	119.7	C29—C30—H30A	109.5
C10—C11—C12	120.6 (5)	C29—C30—H30B	109.5
C12—C11—H11	119.7	C29—C30—H30C	109.5
C11—C12—H12	120.5	H30A—C30—H30B	109.5
C13—C12—C11	119.0 (5)	H30A—C30—H30C	109.5
C13—C12—H12	120.5	H30B—C30—H30C	109.5
C12—C13—H13	119.7	S2—C31—H31A	109.9
C12—C13—C14	120.5 (6)	S2—C31—H31B	109.9
C14—C13—H13	119.7	H31A—C31—H31B	108.3
C2—C14—C13	121.9 (6)	C32—C31—S2	109.1 (4)
C2—C14—H14	119.0	C32—C31—H31A	109.9
C13—C14—H14	119.0	C32—C31—H31B	109.9
C3—C15—H15	119.0	C31—C32—H32A	109.5
C3—C15—C16	122.1 (5)	C31—C32—H32B	109.5
C16—C15—H15	119.0	C31—C32—H32C	109.5
C15—C16—H16	119.8	H32A—C32—H32B	109.5
C17—C16—C15	120.4 (5)	H32A—C32—H32C	109.5
C17—C16—H16	119.8	H32B—C32—H32C	109.5