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Synthesis of Selenoketone–Platinum Complex

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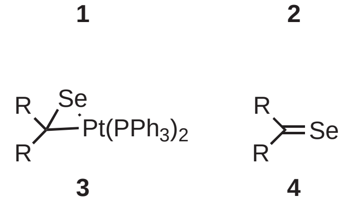
The synthesis of selenoketone–platinum complexes **3a**–**3c** was achieved by reacting selenoketones **4** with (η^2-ethylene)bis(triphenylphosphine)platinum(0) (**1**). 1,1,3,3-Tetramethylindan-2-selone–platinum complex **3b** was determined by X-ray crystallographic analysis to be an η^2-selenoketone–platinum complex. Interestingly, only one isomer of selenofenchone–platinum complex **3c** was formed by this reaction.

Recently, transition-metal complexes containing sulfur and selenium have been extensively studied.[1] Several sulfur–platinum complexes synthesized from (η^2-ethylene)bis(triphenylphosphine)platinum(0) (**1**)[2] are well known, including a thioketone–platinum complex **2**,[2e] a dithiolato–platinum complex,[2e] and a thiolato sulfinato–platinum complex.[2f] Fischer and Zeuner reported the synthesis of selenobenzophenone–chromium and –tungsten complexes in which the lone pair of selenium coordinated to chromium and tungsten, respectively.[3] They also reported the isolation of an η^2-selenoaldehyde–tungsten complex, in which the π-bond of C=Se coordinated to tungsten at −78 °C,[4] but it is unstable at room temperature. Takeda et al. reported that the reaction of an isolable selenoaldehyde with [W(CO)$_5$(thf)] gave an selenoaldehyde–tungsten complex.[5] However, there are no reports on the synthesis of selenocarbonyl–platinum complexes. These results prompted us to look into the possibility of obtaining selenoketone–platinum complex **3** by reacting selenoketone **4**[6,7] with **1**. In this paper, we report the first isolation and characterization of **3** (Scheme 1).

Results and Discussion

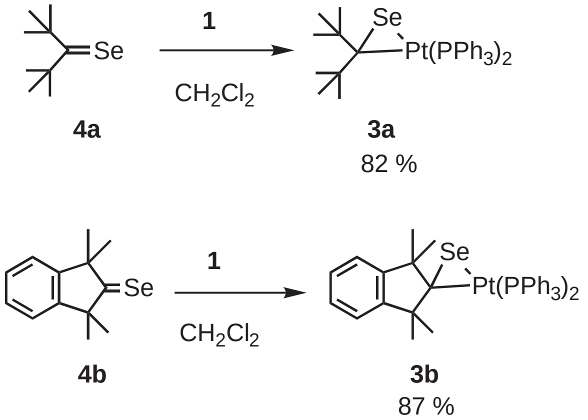
Synthesis of Selenoketone–Platinum Complexes 3a and 3b. Di-*tert*-butyl selenoketone (**4a**),[6c,8] 1,1,3,3-tetramethylindan-2-selone (**4b**),[6c] and selenofenchone (**4c**)[6c,6d] were synthesized by reacting hydrazones with Se$_2$Br$_2$ according to a previously reported method.[6c] Treatment of di-*tert*-butyl selenoketone (**4a**) with (η^2-ethylene)bis(triphenylphosphine)platinum(0) (**1**) (1 equiv) at room temperature for 10 min resulted in the formation of selenoketone–platinum complex **3a** in 82% yield. In the ^{1}H NMR spectrum, signals of methyl and aromatic protons appeared at δ 1.12 (18H), 7.05–7.23 (24H), and 7.56–7.60 (6H). The ratio of methyl to aromatic protons was 18:30. Complex **3b** was also synthesized in a similar manner (Scheme 2).



Scheme 1.

X-ray Crystallographic Analysis of 3b. Recrystallization of **3b** from hexane–dichloromethane (3:1) gave single crystals that were suitable X-ray crystallographic analysis. Figure 1 shows an ORTEP drawing of **3b**. Comparison with the X-ray crystallographic data of thioketone–platinum complex **2a** (bond lengths: C–S 1.781, C–Pt 2.141, Pt–S 2.300, and Pt–P 2.315 and 2.257 Å; bond angles: C–Pt–S 47.1°, S–C–Pt 71.2°, and C–S–Pt 61.7°)[2e] showed that the C–Pt and Pt–P bond lengths of **3b** are similar to those of **2a**. The bond angles of the three-membered ring of **3b** are also similar to those of **2a**. In **3b**, the sum of bond angles of C2–Pt1–Se1, C2–Pt1–P2, P2–Pt1–P1, and P1–Pt1–Se1 of **3b** is 359.9°, and the sum of interior angles of the quadrangle P2–P1–Se1–C2 is 360.1°, suggesting that **3b** is planar. Tokitoh and co-workers reported the synthesis of diselenium–platinum complex **5a** (Scheme 3),[1f] of which the Pt–Se bond lengths (2.4491 and 2.4658 Å) are similar to those of **3b**.

Interestingly, the carbon–selenium bond length of **3b** (C–Se 1.917 Å) is longer than those of normal selenoketones such as 1,5-dimethyl-3,7-dithiabicyclo[3,3,1]nonaneselone (1.774 Å);[9]



Scheme 2.

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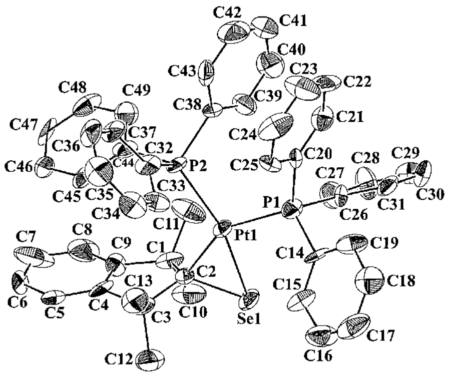
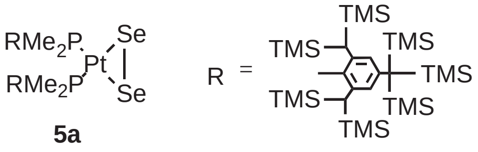
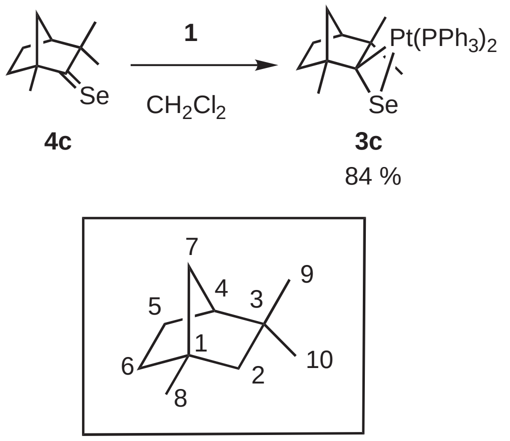


Fig. 1. ORTEP drawing of complex **3b**. Selected bond lengths (Å): Se1–C2 1.917(16); Pt1–Se1 2.414(12); Pt1–C2 2.166(17); Pt1–P1 2.320(9); Pt1–P2 2.273(12) Å. Selected bond angles (°): C2–Pt1–Se1 49.1(4); C2–Se1–Pt1 58.7(5); Se1–C2–Pt1 72.2(6); C2–Pt1–P2 111.0(5); P2–Pt1–P1 99.6(2); P1–Pt1–Se1 100.2(2).



Scheme 3.



Scheme 4.

4,4′-dimethoxyselenobenzophenone (C=Se, 1.790 Å[6f]), and a selenoaldehyde–tungsten complex (C=Se, 1.783 Å).[5a] The C–Se bond length (1.864 Å) of the η^2-selenoaldehyde–tungsten complex reported by Fischer and Zeuner[4] is shorter than that of **3b**. Generally, C–Se single bond lengths are in the range of 1.920–2.000 Å.[7c,10] These results indicate that the carbon–selenium bond of **3b** has single-bond character. Actually, in ^{13}C and ^{77}Se NMR spectra of **3b**, peaks were observed in the single bond region (see later part).

Synthesis of Selenoketone–Platinum Complex 3c. It should be possible to obtain endo and exo isomers of **3c**, when selenofenchone (**4c**) was used as a reactant. However, only one isomer of **3c** was obtained (Scheme 4). One interesting feature of its ^1H NMR spectrum is the appearance of two doublet signals (δ 0.21 and 0.41) for the C7 methylene protons at a much higher field than the signals of **4c** (δ 1.55 and 1.84). Similarly, a signal representative of C9-methyl protons of **3c** resonated at a higher field (δ 0.87) than that of **4c** (δ 1.47), whereas C8- and C10-methyl proton signals of **3c** appeared at δ 1.06 and 1.08, similar to those of **4c** (δ 1.17 and 1.24). These results can be explained by the anisotropy effect of the phenyl groups in **3c**, suggesting that **3c** is the exo isomer.

Table 1. ^{13}C NMR Data of Se–C–Pt in Complexes **3a**–**3c**

	^{13}C NMR data (δ)	
3a	121.63	($J_{Pt\text{–}C} = 510.0$ Hz, $J_{P\text{–}C} = 67.8$, 3.6 Hz)
3b	121.27	($J_{Pt\text{–}C} = 505.1$ Hz, $J_{P\text{–}C} = 67.2$, 3.7 Hz)
3c	124.61	($J_{Pt\text{–}C} = 509.7$ Hz, $J_{P\text{–}C} = 67.8$, 3.0 Hz)

Table 2. ^{31}P NMR Data of Complexes **3a**–**3c**

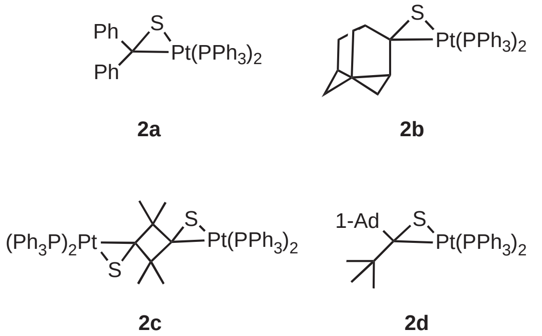
	^{31}P NMR data (δ)	
3a	17.9	($J_{Pt\text{–}P} = 4595$ Hz)
	20.7	($J_{Pt\text{–}P} = 2563$ Hz)
3b	18.6	($J_{Pt\text{–}P} = 4585$ Hz)
	20.5	($J_{Pt\text{–}P} = 2637$ Hz)
3c	19.4	($J_{Pt\text{–}P} = 4647$ Hz)
	20.9	($J_{Pt\text{–}P} = 2523$ Hz)

^{13}C NMR Spectra of 3a–3c. The carbon atom of three-membered cycle Se–C–Pt in **3b** resonated at δ 121.27 in the ^{13}C NMR spectrum (Table 1), and the chemical shifts of the C=Se bond were higher than those of selenoketones **4** (**4a**: δ 291.4,[6d] **4b**: δ 294.0,[6d] **4c**: δ 292.5[6d]). The chemical shifts of the selenium–carbon bonds in selenoaldehyde[5] and selenoaldehyde–tungsten complexes[5] were observed in the range of δ 224.0–240.0. The chemical shifts of the above tungsten complexes are similar to those of normal selenoketones. The result indicates that the carbon–selenium bonds of **3a**–**3c** have single-bond character. No satellite peaks arising from ^{77}Se–^{13}C couplings of **3a**–**3c** were observed.

^{31}P NMR Spectra of 3a–3c. Compound **3b** has two peaks that resonated at δ 18.6 and 20.5 in the ^{31}P NMR spectrum (Table 2). As shown in the ORTEP drawing of **3b**, this complex has a square-planar structure; thus, two peaks for **3b** should appear: one for the carbon-side P atom and the other one for the selenium-side P atom. The assignment of the P atoms of **3a**–**3c** was determined as follows. The reported values of the chemical shifts and the $J_{Pt\text{–}P}$ values of thioketone–platinum complexes **2a**–**2c**[2e] and **2d**[2f] are shown in Table 3. Interestingly, the chemical shifts (δ 17.9–19.4) of the high-field signals of **3a**–**3c** are similar to those (δ 21.4–24.6) of low-field signals of **2a**–**2d**. In contrast, the $J_{Pt\text{–}P}$ values of the low-field signals of **3a**–**3c** are similar to those of the high-field signals of **2a**–**2d**, suggesting that the low-field signals of **3a**–**3c** can be assigned to carbon-side P atoms, and the high-field signals of **3a**–**3c** can be assigned to selenium-side P atoms. The bond length between Se1 and P1 atoms of **3b** (3.632 Å) is similar to that between S1 and P3 atoms of **2a** (3.621 Å) (Scheme 5). The slight difference in chemical shift between the selenium-side P atom of **3** (δ 17.9–19.4) and the sulfur-side P atom of **2** (δ 21.4–24.6) can be attributed to the difference in anisotropy between Pt–Se and Pt–S bonds.

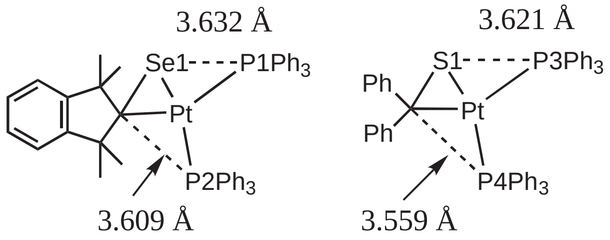
^{77}Se NMR Spectra of 3a–3c. Examination of the ^{77}Se NMR spectra of the three complexes revealed that **3a** showed resonance at a lower field (δ 254.5) than **3b** and **3c**

Table 3. ^{31}P NMR Data of Complexes **2a**–**2d**



2a **2b** **2c** **2d**

	^{31}P NMR data (δ)	
2a	20.7	($J_{\text{Pt–P}} = 3079$ Hz)
	21.4	($J_{\text{Pt–P}} = 4533$ Hz)
2b	20.6	($J_{\text{Pt–P}} = 2691$ Hz)
	23.0	($J_{\text{Pt–P}} = 4423$ Hz)
2c	20.1	($J_{\text{Pt–P}} = 2662$ Hz)
	24.6	($J_{\text{Pt–P}} = 4650$ Hz)
2d	20.2	($J_{\text{Pt–P}} = 2781$ Hz)
	23.5	($J_{\text{Pt–P}} = 4663$ Hz)



3b **2a**

Scheme 5.

Table 4. ^{77}Se NMR Data of Complexes **3a**–**3c**

	^{77}Se NMR data (δ)	
3a	254.5	($J_{\text{Pt–Se}} = 172$ Hz, $J_{\text{P–Se}} = 27$ Hz)
3b	61.0	($J_{\text{Pt–Se}} = 262$ Hz, $J_{\text{P–Se}} = 23$ Hz)
3c	91.3	($J_{\text{Pt–Se}} = 273$ Hz)

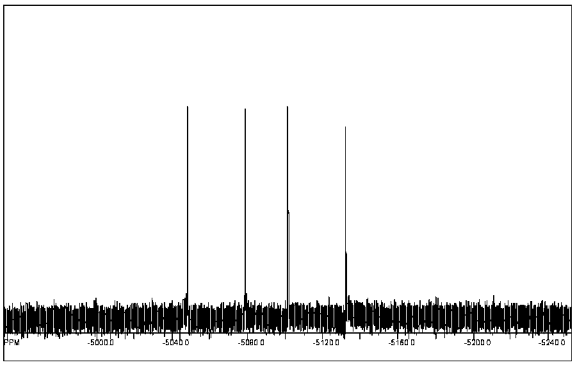
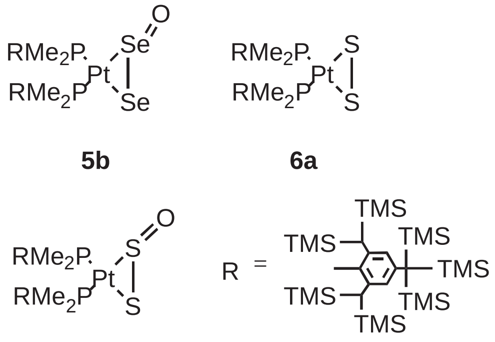


Chart 1. ^{195}Pt NMR of **3b**.

Table 5. ^{195}Pt NMR Data of Complexes **3a**–**3c**

	^{195}Pt NMR data (δ)	
3a	−5074	(dd, $J_{\text{Pt–P}} = 2563$, 4594 Hz)
3b	−5090	(dd, $J_{\text{Pt–P}} = 2637$, 4586 Hz)
3c	−5060	(dd, $J_{\text{Pt–P}} = 2522$, 4645 Hz)



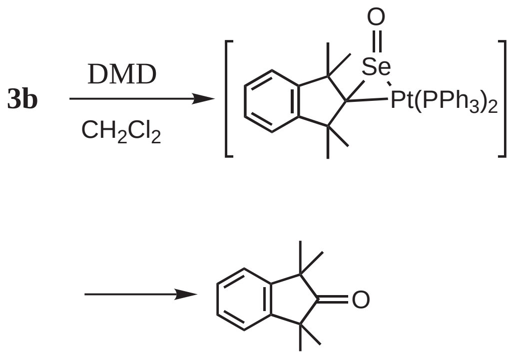
5b **6a** **6b**

Scheme 6.

(δ 61.0 and 91.3, respectively). The $J_{\text{Pt–Se}}$ value of **3a** is 172 Hz, whereas those of **3b** and **3c** are 262 and 273 Hz, respectively, suggesting that the position of the platinum atom in **3b** and **3c** might be different from that of **3a** because of the steric effect of the *tert*-butyl group in **3a** (Table 4). Tokitoh and co-workers reported a broad signal at δ 582 in the ^{77}Se NMR spectrum of diselenium–platinum complex **5a**. No satellite peaks arising from ^{195}Pt–^{77}Se couplings were observed in the ^{77}Se NMR spectrum, whereas a $J_{\text{Pt–Se}}$ value of 262 Hz for the signal of **5a** was determined from the ^{195}Pt NMR spectrum.[1f] The $J_{\text{Pt–Se}}$ value of **5a** is similar to those of **3b** and **3c**. We have previously reported that signals representative of the C–Se single bonds of 1,2,4-triselenolane and 1,3-diselenetane appeared at δ 691, 729, and 780 in the ^{77}Se NMR spectrum, respectively,[11] and the signal of the C=Se double bond of 4,4′-dimethoxyselenobenzophenone resonated at δ 1927.[6f] The chemical shifts of **3a**–**3c** were much higher than those of the above compounds, suggesting that the carbon–selenium bonds of **3a**–**3c** have single-bond character.

^{195}Pt NMR Spectra of 3a–3c. We successfully measured the ^{195}Pt NMR spectra of **3a**–**3c**. Chart 1 shows the ^{195}Pt NMR spectrum of **3b**. Here, the signal representative of **3b** was observed at δ −5090. The $J_{\text{Pt–P}}$ values of **3b** are 2637 and 4586 Hz, which are the same as the data obtained by ^{31}P NMR measurement (Table 5). No satellite peaks arising from the ^{195}Pt–^{77}Se couplings of **3a**–**3c** were observed. The values of platinum signals of **3a**–**3c** are similar to those of Pt$^{\text{II}}$ complexes (**5a**, δ −5030;[1f] Se$_2$O Pt complex **5b**, δ −4768;[1g] disulfur Pt complex **6a**, δ −4983;[1f] and S$_2$O Pt complex **6b**, δ −4708[1g]) (Schemes 3 and 6), whereas the platinum signals of [Pt(PMe$_2$Ph)$_4$] and [Pt{P(OMe)$_3$}$_4$] (Pt^0 complexes) resonated at δ −195 and −1297,[12] respectively, suggesting that **3a**–**3c** are Pt$^{\text{II}}$ complexes.

Thermolysis and Oxidation of 3b. Since **3a**–**3c** were the first selenoketone–platinum complexes to be isolated, the thermolysis and oxidation of **3b** were also studied. When **3b** in toluene-d_8 was refluxed for 1 day, **3b** was recovered unchanged. Although the synthesis of thiobenzophenone *S*-oxide (sulfine)–platinum complex has been reported by Weigand et al.[2b] and Gosselink et al.,[13] to the best of our knowledge, there is no report on the formation of the selenine–platinum complex.



Scheme 7.

Thus, we attempted to synthesize selenine–platinum complex from **3b**. Oxidation of **3b** with dimethyl dioxirane (DMD) gave 1,1,3,3-tetramethylindan-2-one almost quantitatively. Presumably, the initially formed selenine–platinum complex was further transformed to give 1,1,3,3-tetramethylindan-2-one (Scheme 7).

In summary, we have succeeded in synthesizing selenoketone–platinum complexes **3a**–**3c** by the reacting **4a**–**4c** with **1** at room temperature. This is the first example of isolable selenoketone–platinum complexes **3**. The structure of **3b** was determined by X-ray crystallographic analysis. The ^{195}Pt NMR spectra of **3a**–**3c** suggested that **3a**–**3c** are Pt^{II} complexes.

Experimental

General. All chemicals were obtained from commercial suppliers and were used without further purification. Analytical TLC was carried out on precoated plates (Merck silica gel 60, F254), and flash column chromatography was performed with silica (Merck, 70–230 mesh). NMR spectra (^{1}H at 400 MHz; ^{13}C at 100 MHz; ^{31}P at 162 MHz; ^{77}Se at 76 MHz; and ^{195}Pt at 86 MHz) were recorded in $CDCl_3$, and chemical shifts are expressed as δ relative to internal TMS for ^{1}H, internal PhSeSePh (480 ppm) for ^{77}Se NMR, and external Na_2PtCl_6 (D_2O) for ^{195}Pt NMR. Melting points were uncorrected.

Synthesis of Platinum Complex 3a. To a solution of di-*tert*-butyl selenoketone (**4a**) (0.010 g, 0.05 mmol) in dichloromethane (2 mL) was added **1** (0.037 g, 0.05 mmol). After stirring for 10 min, the solvent was evaporated to give a black-yellow solid. The residue was recrystallized from hexane–dichloromethane (3:1) to give yellow crystals of **3a** (0.038 g, 0.041 mmol). **3a**: yellow crystals; mp 202.2–222.3 °C (dec.); ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.12 (s, 18H), 7.05–7.23 (m, 24H), 7.56–7.60 (m, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 37.46 (CH_3, $J_{\text{Pt–C}} = 24.9$ Hz, $J_{\text{P–C}} = 4.3$ Hz), 44.54 (q-C, $J_{\text{P–C}} = 1.9$ Hz), 44.57 (q-C, $J_{\text{P–C}} = 1.2$ Hz), 121.63 (Se–C–Pt, $J_{\text{Pt–C}} = 510$ Hz, $J_{\text{P–C}} = 67.8$ and 3.6 Hz), 127.58 (*meta*-Ph, $J_{\text{P–C}} = 9.8$ Hz), 129.28 (*para*-Ph, $J_{\text{P–C}} = 1.8$ Hz), 129.76 (*para*-Ph, $J_{\text{P–C}} = 2.4$ Hz), 134.39–135.34 (br, *ortho*-Ph), 136.12 (*ipso*-Ph, $J_{\text{Pt–C}} = 40.7$ Hz, $J_{\text{P–C}} = 3.6$ Hz), 136.58 (*ipso*-Ph, $J_{\text{Pt–C}} = 40.0$ Hz, $J_{\text{P–C}} = 4.3$ Hz). ^{31}P NMR ($CDCl_3$, 162 MHz) δ 17.9 ($J_{\text{Pt–P}} = 4595$ Hz), 20.7 ($J_{\text{Pt–P}} = 2563$ Hz). ^{77}Se NMR ($CDCl_3$, 76 MHz) δ 254.5 ($J_{\text{Pt–Se}} = 172$ Hz, $J_{\text{P–Se}} = 27$ Hz). ^{195}Pt NMR ($CDCl_3$, 86 MHz, Na_2PtCl_6) δ −5074 (dd, $J_{\text{Pt–P}} = 4594$, 2563 Hz). Anal. Calcd for $C_{45}H_{48}P_2PtSe{\cdot}H_2O$: C, 57.32; H, 5.35%. Found: C, 57.36, H, 5.23%.

Synthesis of Platinum Complex 3b. To a solution of **4b** (0.013 g, 0.05 mmol) in dichloromethane (2 mL) was added **1** (0.037 g, 0.05 mmol). After stirring for 10 min, the solvent was evaporated to give a black-yellow solid. The residue was recrystallized from hexane–dichloromethane (3:1) to give yellow crystals **3b** (0.042 g, 0.043 mmol). **3b**: yellow crystals; mp 239.1–247.3 °C (dec.); ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.29 (s, 6H), 1.47 (s, 6H), 6.70–7.33 (m, 34H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 30.25 (CH_3, $J_{\text{Pt–C}} = 51.4$ Hz, $J_{\text{P–C}} = 4.9$ Hz), 30.29 (CH_3, $J_{\text{Pt–C}} = 51.4$ Hz, $J_{\text{P–C}} = 4.2$ Hz), 41.59 (CH_3, $J_{\text{Pt–C}} = 37.2$ Hz), 41.67 (CH_3, $J_{\text{Pt–C}} = 37.2$ Hz), 51.4 (q-C), 51.43 (q-C), 121.27 (Se–C–Pt, $J_{\text{Pt–C}} = 505.1$ Hz, $J_{\text{P–C}} = 67.2$ and 3.7 Hz), 122.58 (Ar), 126.31 (Ar), 127.43 (*meta*-Ph, $J_{\text{P–C}} = 9.8$ Hz), 127.70 (*meta*-Ph, $J_{\text{P–C}} = 9.8$ Hz), 129.45 (*para*-Ph), 134.57–135.39 (*ipso*- and *ortho*-Ph), 150.74 (Ar). ^{31}P NMR ($CDCl_3$, 162 MHz) δ 18.6 ($J_{\text{Pt–P}} = 4585$ Hz), 20.5 ($J_{\text{Pt–P}} = 2637$ Hz). ^{77}Se NMR ($CDCl_3$, 76 MHz) δ 61.0 ($J_{\text{Pt–Se}} = 262$ Hz, $J_{\text{P–Se}} = 23$ Hz). ^{195}Pt NMR ($CDCl_3$, 86 MHz, Na_2PtCl_6) δ −5090 (dd, $J_{\text{Pt–P}} = 4586$, 2637 Hz). Anal. Calcd for $C_{49}H_{46}P_2PtSe{\cdot}H_2O$: C, 59.51; H, 4.89%. Found: C, 59.32, H, 4.90%.

X-ray Crystallographic Analysis of Complex 3b. Single crystals of **3b** were obtained by recrystallization from hexane–dichloromethane (3:1) solution. The diffraction data were collected with a DIP Image plate diffractometer with Mo Kα radiation ($\lambda = 0.70930$) to a maximum 2θ value of 51.84° at 298 K. The structure was solved by SIR92[14] and refined SHELXL-97.[15] Complex **3b**; Formula $C_{49}H_{46}P_2PtSe$, FW 969.83, Monoclinic, space group $P2_1/n$, $a = 9.89(5)$ Å, $b = 14.99(5)$ Å, $c = 27.45(5)$ Å, $\beta = 94.3(2)°$, $V = 4058(30) \times 10^1$ Å^3, $Z = 4$, $D_{\text{calcd}} = 1.587$ Mg m^{-3}, μ (Mo Kα) = 4.425 mm^{-1}, the final R and wR were 0.0763 and 0.2237, respectively, using 7953 reflections. Crystallographic data have been deposited with Cambridge Crystallographic Data Centre: Deposition number CCDC-620890 for Compound **3b**. Copies of the 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 336033; e-mail: deposit@ccdc.cam.ac.uk).

Synthesis of Platinum Complex 3c. To a solution of **4c** (0.011 g, 0.05 mmol) in dichloromethane (2 mL) was added **1** (0.037 g, 0.05 mmol). After stirring for 10 min, the solvent was evaporated to give a black-yellow solid. The residue was recrystallized from hexane–dichloromethane (3:1) to give yellow crystals **3c** (0.039 g, 0.042 mmol). **3c**: yellow crystals; mp 222.2–237.6 °C (dec.); ^{1}H NMR ($CDCl_3$, 400 MHz) δ 0.21 (d, $J = 9.2$ Hz, 1H), 0.41 (d, $J = 9.2$ Hz, 1H), 0.87 (s, 3H), 1.06–1.18 (m, 7H), 1.52–1.70 (m, 4H), 7.08–7.60 (m, 30H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 24.43 (CH_3, $J_{\text{Pt–C}} = 31.1$ Hz), 25.81 (CH_2), 32.79 (CH_3, $J_{\text{Pt–C}} = 41.5$ Hz, $J_{\text{P–C}} = 11.1$ and 6.0 Hz), 33.21 (q-C, $J_{\text{P–C}} = 3.0$ Hz), 39.76 (CH_2), 47.19 (CH_3, $J_{\text{Pt–C}} = 47.0$ Hz, $J_{\text{P–C}} = 9.2$ Hz), 48.18 (CH_2, $J_{\text{P–C}} = 3.6$ Hz), 49.76 (CH), 55.80 (q-C), 124.61 (Se–C–Pt, $J_{\text{Pt–C}} = 509.7$ Hz, $J_{\text{P–C}} = 67.8$ and 3.0 Hz), 127.32 (*meta*-Ph, $J_{\text{P–C}} = 3.6$ Hz), 127.42 (*meta*-Ph, $J_{\text{P–C}} = 4.2$ Hz), 129.07 (*para*-Ph), 129.57 (*para*-Ph), 134.34–135.30 (*ipso*- and *ortho*-Ph). ^{31}P NMR ($CDCl_3$, 162 MHz) δ 19.4 ($J_{\text{Pt–P}} = 4647$ Hz), 20.9 ($J_{\text{Pt–P}} = 2523$ Hz). ^{77}Se NMR ($CDCl_3$, 76 MHz) δ 91.3 ($J_{\text{Pt–Se}} = 273$ Hz). ^{195}Pt NMR ($CDCl_3$, 86 MHz, Na_2PtCl_6) δ −5060 (dd, $J_{\text{Pt–P}} = 4645$, 2522 Hz). Anal. Calcd for $C_{46}H_{46}P_2PtSe$: C, 59.10; H, 4.96%. Found: C, 58.83, H, 4.95%.

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