

Oxy- and aminoselenation of alkenes utilizing an isolable selenenyl iodide

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Experimental section

General

All synthetic experiments were performed under an argon atmosphere. CHCl_3 was purchased from commercial sources, distilled over CaH_2 , and dried over 4\AA MS. MeCN was purchased from commercial sources, distilled over CaH_2 , and dried over 3\AA MS. Other chemicals were purchased from commercial sources and used as received. Silica gel column chromatography was performed using Kanto Chemical silica gel N60. Preparative thin layer chromatography (PTLC) was performed using Merck silica gel 60 PF254. ^1H NMR spectra were recorded on a JEOL JNM-AL400, a JEOL LAMBDA-400, JEOL ECX-400, or a JEOL ECX-500, and the chemical shifts of ^1H are referenced to the residual proton signal of CDCl_3 (δ 7.25). $^{13}\text{C}\{^1\text{H}\}$ NMR spectra were recorded on a JEOL ECX-400 or a JEOL ECX-500, and the chemical shifts are given relative to CDCl_3 (δ 77.0) as internal standards. $^{77}\text{Se}\{^1\text{H}\}$ NMR spectra were recorded on a JEOL ECX-400 or a JEOL ECX-500, and the chemical shifts of ^{77}Se are referenced to Ph_2Se_2 (δ 480) as an external standard. All spectra were assigned with the aid of DEPT, COSY, HMQC, and HMBC NMR experiments. IR spectra were recorded on a JASCO FT/IR-4100. High-resolution FD-TOF mass spectra were measured on a JEOL JMS-T100GCv "AccuTOF GCv". Melting points (m.p.) were measured with a Yanaco MP-S3 (uncorrected).

General procedure for oxyselenation of cyclohexene (**2a**)

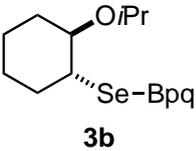
To a solution of BpqSeI (**1a**) (1.0 eq) in CHCl_3 and MeCN (1:1) were added NIS (1.0 eq), cyclohexene (**2a**, 6.0 eq), and ROH (5.0 eq). The resulting mixture was stirred at $25\text{ }^\circ\text{C}$ for 30 min before saturated aq. Na_2SO_3 was added. The two layers were separated, and the aqueous layer was extracted with CHCl_3 . The combined organic layers were dried over MgSO_4 and filtered. The filtrate was concentrated *in vacuo*, and the crude mixture was purified by preparative TLC (hexane/ CHCl_3 = 1:1) to give product **3**.

General procedure for aminoselenation of cyclohexene (**2a**)

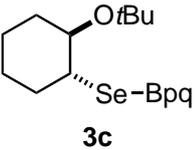
To a solution of BpqSeI (**1a**) (1.0 eq) in CHCl_3 and MeCN (1:1) were added NIS (0.9 eq), cyclohexene (**2a**) (1.0 eq), and amine (1.0 eq). The resulting reaction mixture was stirred at $25\text{ }^\circ\text{C}$ for 10 or 60 min before saturated aq. Na_2SO_3 was added. The two layers were separated, and the aqueous layer was extracted with CHCl_3 . The combined organic layers were dried over MgSO_4 and filtered. The filtrate was concentrated *in vacuo* and the crude mixture was purified by preparative TLC (hexane/ CHCl_3 = 1:1) to give product **4**.

Analytical data of new compounds

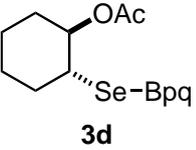
[5',5'''-Bis(2,6-diisopropylphenyl)-2,6,2''',6''''-tetraisopropyl-1,1':3',1'':3'',1''':3''',1''''-quinquephenyl-2''-yl]-*(trans*-2-isopropoxycyclohexyl)selane (**3b**)

**3b** 17.7 mg (16.4 μmol) of **1a** was used, and 15.8 mg of **3b** was obtained (88% yield). **3b**: colorless crystals; m.p. 267-270 °C; ¹H NMR (500 MHz, CDCl₃): δ 7.40 (s, 3H), 7.33 (t, *J* = 7.7 Hz, 4H), 7.29 (s, 4H), 7.20 (d, *J* = 7.7 Hz, 8H), 6.98 (s, 2H), 3.20-3.15 (m, 1H), 3.01 (d, *J* = 3.2 Hz, 1H), 2.89 (s, 8H), 2.82 (d, *J* = 3.2 Hz, 1H), 1.70-1.15 (m, 32H), 1.07 (d, *J* = 6.9 Hz, 24H), 0.76 (d, *J* = 6.0 Hz, 3H), 0.72 (d, *J* = 6.0 Hz, 3H); ¹³C NMR (125 MHz, CDCl₃): δ 149.2 (s), 147.0 (s), 146.9 (s), 142.8 (s), 139.7 (s), 139.3 (s), 129.8 (d), 129.7 (d), 129.5 (d), 129.2 (s), 128.2 (d), 127.9 (d), 122.5 (d), 73.9 (d), 68.4 (d), 47.8 (d), 30.4 (d), 27.4 (t), 27.1 (t), 24.6 (q), 24.5 (q), 24.2 (q), 23.3 (t), 22.3 (q), 21.2 (t); ⁷⁷Se NMR (75 MHz, CDCl₃): δ 282; IR (KBr); 3059, 3033, 2960, 2967, 2867, 1459, 1382, 1362, 803, 763, 753 cm⁻¹; HRMS (FD-TOF) *m/z* 1090.6475 [M]⁺ (calcd for C₇₅H₉₄OSe, 1090.6470).

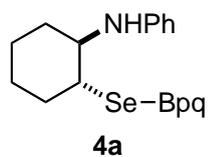
(trans-2-*tert*-Butoxycyclohexyl)[5',5'''-bis(2,6-diisopropylphenyl)-2,6,2''',6''''-tetraisopropyl-1,1':3',1'':3'',1''':3''',1''''-quinquephenyl-2''-yl]selane (**3c**)

**3c** 17.7 mg (16.4 μmol) of **1a** was used, and 9.8 mg of **3c** was obtained (54% yield). **3c**: colorless crystals; m.p. 269-273 °C; ¹H NMR (500 MHz, CDCl₃): δ 7.41 (s, 3H), 7.32 (t, *J* = 7.7 Hz, 8H), 7.21-7.19 (m, 8H), 6.98 (t, *J* = 1.4 Hz, 2H), 3.11 (d, *J* = 2.6 Hz, 1H), 2.90 (s, 8H), 2.72 (s, 1H), 1.90-1.84 (m, 1H), 1.74-1.69 (m, 1H), 1.27-1.02 (m, 54H), 0.67 (s, 9H); ¹³C NMR (125 MHz, CDCl₃): δ 147.1 (s), 146.9 (s), 142.7 (s), 139.6 (s), 139.3 (s), 129.8 (d, two signals were overlapped), 129.3 (d, s two signals were overlapped), 128.4 (d), 127.9 (d), 122.5 (d), 73.1 (s), 67.8 (d), 50.5 (d), 30.4 (d), 27.9 (a), 27.6 (t), 26.7 (t), 24.7 (q), 24.5 (q), 24.2 (q), 24.1 (q), 22.7 (t), 20.7 (t); ⁷⁷Se NMR (75 MHz, CDCl₃): δ 306; IR (KBr); 2959, 2926, 2866, 1458, 1362, 1021, 752 cm⁻¹; HRMS (FD-TOF) *m/z* 1104.6616 [M]⁺ (calcd for C₇₆H₉₆OSe, 1104.6626).

(trans-2-Acetylcyclohexyl)[5',5'''-bis(2,6-diisopropylphenyl)-2,6,2''',6''''-tetraisopropyl-1,1':3',1'':3'',1''':3''',1''''-quinquephenyl-2''-yl]selane (**3d**)

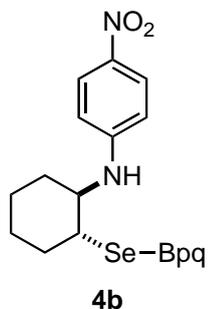
**3d** 17.7 mg (16.4 μmol) of **1a** was used, and 16.5 mg of **3d** was obtained (92% yield). **3d**: colorless crystals; m.p. 285-287 °C; ¹H NMR (500 MHz, CDCl₃): δ 7.42-7.39 (m, 3H), 7.34-7.27 (m, 8H), 7.20-7.18 (m, 8H), 6.98 (t, *J* = 1.4 Hz, 2H), 4.39 (d, *J* = 3.2 Hz, 1H), 2.89 (s, 9H), 1.83-1.77 (m, 1H), 1.73 (s, 3H), 1.66-1.63 (m, 1H), 1.44-1.41 (m, 1H), 1.29-1.21 (m, 5H), 1.17-1.14 (m, 24H), 1.08-1.06 (m, 24H); ¹³C NMR (125 MHz, CDCl₃): δ 169.7 (s), 148.9 (s), 146.8 (s), 142.8 (s), 139.9 (s), 139.7 (s), 139.2 (s), 139.1 (s), 129.9 (d), 129.8 (d), 129.7 (d), 128.4 (d), 127.9 (d), 127.3 (s), 122.6 (d), 122.5 (d), 30.5 (d), 27.5 (t), 26.8 (t), 24.6 (q), 24.5 (q), 24.14 (q), 24.08 (t), 22.9 (t), 21.5 (t), 21.1 (q); ⁷⁷Se NMR (75 MHz, CDCl₃): δ 317; IR (KBr); 3058, 3033, 2961, 2927, 2867, 1741, 1459, 1362, 1233, 1032, 884, 804, 753 cm⁻¹; HRMS (FD-TOF) *m/z* 1090.6091 [M]⁺ (calcd for C₇₄H₉₀O₂Se, 1090.6106).

***N*-(*trans*-2-{{5',5'''-Bis(2,6-diisopropylphenyl)-2,6,2''',6''''-tetraisopropyl-1,1':3',1'':3'',1''':3''',1''''-quinquephenyl-2''-yl}selanyl}cyclohexyl)aniline (**4a**)**



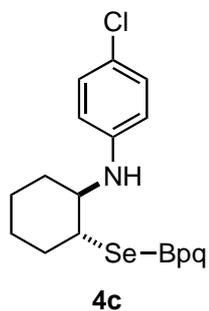
8.8 mg (8.2 μmol) of **1a** was used, and 8.5 mg of **4a** was obtained (92% yield). **4a**: colorless crystals; m.p. >300 $^{\circ}\text{C}$; $^1\text{H NMR}$ (500 MHz, CDCl_3): δ 7.52-7.44 (m, 3H), 7.29 (t, $J = 7.7$ Hz, 4H), 7.22 (s, 4H), 7.16 (d, $J = 7.7$ Hz, 8H), 6.96 (s, 2H), 6.83 (t, $J = 7.9$ Hz, 2H), 6.46 (t, $J = 7.3$ Hz, 1H), 5.89 (d, $J = 7.7$ Hz, 2H), 3.46 (s, 1H), 3.12 (s, 1H), 2.88-2.84 (m, 9H), 2.01-1.95 (m, 1H), 1.56 (t, $J = 4.6$ Hz, 1H), 1.42-1.35 (m, 2H), 1.27-0.98 (m, 52H); $^{13}\text{C NMR}$ (125 MHz, CDCl_3): δ 149.5, 146.8, 146.7, 146.4, 142.8, 139.6, 139.1, 129.6, 129.5, 129.0, 128.7, 128.0, 127.8, 122.4, 117.1, 112.6, 60.4, 46.7, 30.3, 27.5, 26.2, 24.5, 24.4, 24.0, 23.8, 22.4, 15.4; $^{77}\text{Se NMR}$ (75 MHz, CDCl_3): δ 280; **IR** (KBr): 3400, 3057, 2962, 2927, 2867, 1601, 1503, 1460, 1362, 885, 803, 753 cm^{-1} ; **HRMS** (FD-TOF) m/z 1123.6504 $[\text{M}]^+$ (calcd for $\text{C}_{77}\text{H}_{93}\text{NSe}$, 1123.6473).

***N*-(*trans*-2-{{5',5'''-Bis(2,6-diisopropylphenyl)-2,6,2''',6''''-tetraisopropyl-1,1':3',1'':3'',1''':3''',1''''-quinquephenyl-2''-yl}selanyl}cyclohexyl)-4-nitroaniline (**4b**)**



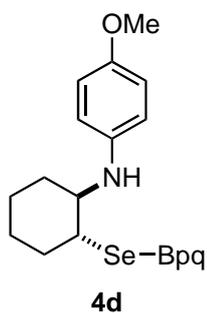
50.0 mg (46.5 μmol) of **1a** was used, and 38.4 mg of **4b** was obtained (71% yield). **4b**: yellow crystals; m.p. >300 $^{\circ}\text{C}$; $^1\text{H NMR}$ (500 MHz, CDCl_3): δ 7.73 (d, $J = 8.9$ Hz, 2H), 7.64 (t, $J = 7.6$ Hz, 1H), 7.55 (d, $J = 7.4$ Hz, 2H), 7.32 (t, $J = 7.7$ Hz, 4H), 7.24 (s, 4H), 7.18-7.16 (m, 8H), 7.03-7.00 (m, 2H), 5.70 (d, $J = 8.0$ Hz, 2H), 4.43 (d, $J = 4.9$ Hz, 1H), 3.23 (s, 1H), 2.86 (s, 9H), 2.06-2.01 (m, 1H), 1.68-1.27 (m, 7H), 1.20-0.88 (m, 48H); $^{13}\text{C NMR}$ (125 MHz, CDCl_3): δ 151.6 (s), 149.4 (s), 146.6 (s), 146.5 (s), 142.3 (s), 139.8 (s), 138.8 (s), 137.8 (s), 129.9 (d, two signals were overlapped), 129.8 (d), 128.9 (d), 128.6 (s), 127.9 (d), 126.3 (d), 122.5 (d), 122.2 (d), 110.4 (d), 53.0 (d), 46.5 (d), 30.4 (d), 27.8 (t), 27.1 (t), 24.5 (q), 24.3 (q), 24.0 (q), 23.2 (t), 21.5 (t); $^{77}\text{Se NMR}$ (75 MHz, 1,1,2,2-tetrachloroethane- d_2 , 120 $^{\circ}\text{C}$): δ 322; **IR** (KBr): 3410, 3060, 2960, 2926, 2866, 1600, 1324, 1112, 803, 752 cm^{-1} ; **HRMS** (FD-TOF) m/z 1168.6320 $[\text{M}]^+$ (calcd for $\text{C}_{78}\text{H}_{92}\text{N}_2\text{O}_2\text{Se}$, 1168.6324).

4-Chloro-*N*-(*trans*-2-{{5',5'''-bis(2,6-diisopropylphenyl)-2,6,2''',6''''-tetraisopropyl-1,1':3',1'':3'',1''':3''',1''''-quinquephenyl-2''-yl}selanyl}cyclohexyl)aniline (4c**)**



50.0 mg (46.5 μmol) of **1a** was used, and 49.9 mg of **4c** was obtained (93% yield). **4c**: white crystals; m.p. >300 $^{\circ}\text{C}$; $^1\text{H NMR}$ (500 MHz, CDCl_3): δ 7.57-7.48 (m, 3H), 7.32 (t, $J = 7.7$ Hz, 4H), 7.25 (s, 4H), 7.18 (d, $J = 8.0$ Hz, 8H), 6.99 (t, $J = 1.4$ Hz, 2H), 6.78 (d, $J = 8.6$ Hz, 2H), 5.77 (d, $J = 8.6$ Hz, 2H), 3.56 (s, 1H), 3.08 (d, $J = 4.0$ Hz, 1H), 2.88-2.82 (m, 9H), 1.21-1.94 (m, 1H), 1.63-1.58 (m, 1H), 1.39-1.06 (m, 54H); $^{13}\text{C NMR}$ (125 MHz, CDCl_3): δ 149.4 (s), 146.71 (s), 146.66 (s), 145.1 (s), 142.6 (s), 139.6 (s), 139.0 (s), 129.8 (d), 129.6 (d), 128.9 (d), 128.8 (s), 128.4 (d), 127.8 (d), 122.47 (d), 122.46 (d), 121.4 (s), 113.2 (d), 53.6 (d), 46.9 (d), 30.4 (d), 28.3 (t), 28.0 (t), 24.5 (q), 24.4 (q), 24.0 (q), 23.6 (t), 21.8 (t); $^{77}\text{Se NMR}$ (75 MHz, 1,1,2,2-tetrachloroethane- d_2 , 120 $^{\circ}\text{C}$): δ 322; **IR** (KBr): 3402, 3059, 2960, 2867, 1597, 1496, 1362, 1055, 885, 813, 752 cm^{-1} ; **HRMS** (FD-TOF) m/z 1157.6065 $[\text{M}]^+$ (calcd for $\text{C}_{78}\text{H}_{92}\text{ClNSe}$, 1157.6084).

***N*-(*trans*-2-{{[5',5'''-Bis(2,6-diisopropylphenyl)-2,6,2''''',6'''''-tetrakisopropyl-1,1':3',1'':3'',1''':3''',1'''''-quinquephenyl-2''-yl]selanyl}cyclohexyl)-4-methoxyaniline (4d)**

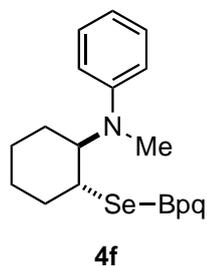


50.0 mg (46.5 μmol) of **1a** was used, and 33.4 mg of **4d** was obtained (62% yield). **4d**: pale yellow crystals; m.p. >300 $^{\circ}\text{C}$; $^1\text{H NMR}$ (500 MHz, CDCl_3): δ 7.48-7.41 (m, 3H), 7.31-7.28 (m, 4H), 7.20-7.15 (m, 12H), 6.96 (s, 2H), 6.44 (d, $J = 8.9$ Hz, 2H), 5.86 (d, $J = 8.3$ Hz, 2H), 3.53 (s, 3H), 3.02 (d, $J = 4.9$ Hz, 1H), 2.93-2.78 (m, 9H), 1.33-1.03 (m, 56H); $^{13}\text{C NMR}$ (125 MHz, CDCl_3): δ 151.9 (s), 149.5 (s), 146.9 (s), 146.8 (s), 142.9 (s), 140.9 (s), 139.7 (s), 139.2 (s), 129.8 (d, two signals were overlapped), 129.6 (d), 129.0 (s), 128.3 (d), 127.9 (d), 122.5 (d), 114.9 (d), 114.2 (d), 55.9 (d), 46.9 (d), 30.5 (d), 29.8 (t), 28.5 (t), 24.6 (q), 24.1 (q), 23.9 (t), 22.1 (t); $^{77}\text{Se NMR}$ (75 MHz, 1,1,2,2-tetrachloroethane- d_2 , 120 $^{\circ}\text{C}$): δ 323; **IR** (KBr): 3056, 2959, 2927, 2866, 1509, 1459, 1241, 885, 805, 754 cm^{-1} ; **HRMS** (FD-TOF) m/z 1153.6585 $[\text{M}]^+$ (calcd for $\text{C}_{79}\text{H}_{95}\text{NOSe}$, 1153.6579).

***N*-(*trans*-2-{{[5',5'''-Bis(2,6-diisopropylphenyl)-2,6,2''''',6'''''-tetrakisopropyl-1,1':3',1'':3'',1''':3''',1'''''-quinquephenyl-2''-yl]selanyl}cyclohexyl)naphthalen-1-amine (4e)**

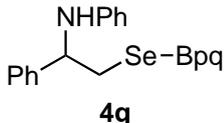
50.0 mg (46.5 μmol) of **1a** was used, and 27.8 mg of **4e** was obtained (51% yield). **4e**: pale yellow crystals; m.p. 175-180 $^{\circ}\text{C}$; $^1\text{H NMR}$ (500 MHz, CDCl_3): δ 7.60-7.57 (m, 2H), 7.53-7.49 (m, 3H), 7.33-7.25 (m, 11H), 7.19-7.10 (m, 8H), 6.97-6.94 (m, 3H), 6.81-6.78 (m, 1H), 5.26 (d, $J = 7.4$ Hz, 1H), 3.37 (s, 1H), 3.08 (s, 1H), 2.89 (s, 8H), 2.11-2.05 (m, 1H), 1.78-1.71 (m, 1H), 1.53-1.27 (m, 6H), 1.17-1.01 (m, 48H); $^{13}\text{C NMR}$ (125 MHz, CDCl_3): δ 149.7 (s), 146.9 (s), 146.8 (s), 142.7 (s), 141.4 (s), 139.7 (s), 139.2 (s), 134.4 (s), 130.1 (d, two signals were overlapped), 129.8 (d), 129.7 (d), 129.0 (s), 128.7 (d), 127.9 (d), 126.5 (d), 125.3 (d), 124.3 (d), 123.4 (s), 122.5 (d), 119.4 (d), 117.1 (d), 103.6 (d), 52.2 (d), 46.7 (d), 30.5 (d), 30.4 (d), 27.8 (t), 27.3 (t), 24.6 (q), 24.4 (q), 24.1 (q), 23.9 (q), 23.4 (t), 21.7 (t); $^{77}\text{Se NMR}$ (75 MHz, 1,1,2,2-tetrachloroethane- d_2 , 120 $^{\circ}\text{C}$): δ 324; **IR** (KBr): 3565, 3060, 2960, 2866, 1459, 1362, 884, 805, 753 cm^{-1} ; **HRMS** (FD-TOF) m/z 1173.6606 $[\text{M}]^+$ (calcd for $\text{C}_{82}\text{H}_{95}\text{NSe}$, 1173.6630).

***N*-(*trans*-2-{{[5',5'''-Bis(2,6-diisopropylphenyl)-2,6,2''''',6'''''-tetrakisopropyl-1,1':3',1'':3'',1''':3''',1'''''-quinquephenyl-2''-yl]selanyl}cyclohexyl)-*N*-methylaniline (4f)**



50.0 mg (46.5 μmol) of **1a** was used, and 51.4 mg of **4f** was obtained (97% yield). **4f**: pale yellow crystals; m.p. 290-295 $^{\circ}\text{C}$; $^1\text{H NMR}$ (500 MHz, CDCl_3): δ 7.32-7.29 (m, 7H), 7.21-7.15 (m, 14H), 6.99 (t, $J = 1.4$ Hz, 2H), 6.71 (t, $J = 7.3$ Hz, 1H), 6.67 (d, $J = 8.3$ Hz, 2H), 3.37-3.25 (m, 1H), 3.03-2.98 (m, 1H), 2.88-2.83 (m, 8H), 2.46 (s, 3H), 1.57-1.53 (m, 4H), 1.41 (d, $J = 11.7$ Hz, 1H), 1.17-1.01 (m, 51H); $^{13}\text{C NMR}$ (125 MHz, CDCl_3): δ 150.6 (s), 150.3 (s), 147.0 (s), 146.9 (s), 143.9 (s), 139.9 (s), 139.3 (s), 137.8 (s), 129.3 (d), 129.1 (d), 128.9 (d), 127.9 (d), 127.7 (d), 127.5 (s), 122.5 (d), 117.7 (d), 114.7 (d), 64.7 (d), 45.4 (d), 33.2 (t), 30.5 (d), 30.2 (q), 27.5 (t), 27.0 (t), 25.2 (t), 24.5 (q), 24.4 (q), 24.2 (q); $^{77}\text{Se NMR}$ (75 MHz, 1,1,2,2-tetrachloroethane- d_2 , 120 $^{\circ}\text{C}$): δ 308; **IR** (KBr): 3058, 2959, 2925, 2866, 1597, 1459, 1362, 882, 753 cm^{-1} ; **HRMS** (FD-TOF) m/z 1137.6656 $[\text{M}]^+$ (calcd for $\text{C}_{79}\text{H}_{95}\text{NSe}$, 1137.6630).

***N*-(2-([5',5'''-Bis(2,6-diisopropylphenyl)-2,6,2''',6''''-tetraisopropyl-1,1':3',1'':3'',1''':3''',1''''-quinquephenyl-2''-yl]selanyl)-1-phenylethyl)aniline (**4g**)**

**4g**

8.9 mg (8.2 μmol) of **1a** was used, and 8.5 mg of **4g** was obtained (90% yield). **4g**: white crystals; **¹H NMR** (500 MHz, CDCl₃): δ 7.35-7.41 (m, 11H), 7.24 (d, *J* = 8.0 Hz, 8H), 7.16-7.20 (m, 3H), 7.08-7.10 (m, 4H), 6.96 (t, *J* = 7.0 Hz, 2H), 6.58 (t, *J* = 7.0 Hz, 1H), 6.22 (d, *J* = 7.5 Hz, 2H), 4.42-4.39 (m, 1H), 4.09 (d, *J* = 3.0 Hz, 1H), 2.84-2.75 (m, 8H), 2.83 (d, *J* = 5.0 Hz, 2H), 1.12-1.16 (m, 48H); **¹³C NMR** (125 MHz, CDCl₃): δ 147.2 (s), 146.9 (d), 146.4 (s), 142.5 (s), 141.8 (s), 140.3 (s), 139.0 (s), 129.9 (s), 129.8 (s), 129.5 (s), 129.1 (d), 128.5 (s), 128.0 (s), 127.8 (s), 127.3 (s), 126.2 (s), 122.6 (d), 117.6 (s), 113.5 (s), 58.0 (s), 37.5 (s), 30.5 (s), 24.5 (d), 24.1 (d); **⁷⁷Se NMR** (75 MHz, CDCl₃): δ 211; **IR** (KBr); 3418, 3060, 2960, 2867, 1600, 1504, 885, 805, 753 cm⁻¹; **HRMS** (FD-TOF) *m/z* 1145.6603 [M]⁺ (calcd for C₈₀H₉₁NSe, 1145.6331).

NMR spectra

Figure S1. ^1H NMR (500 MHz, CDCl_3) spectrum of **3b**.

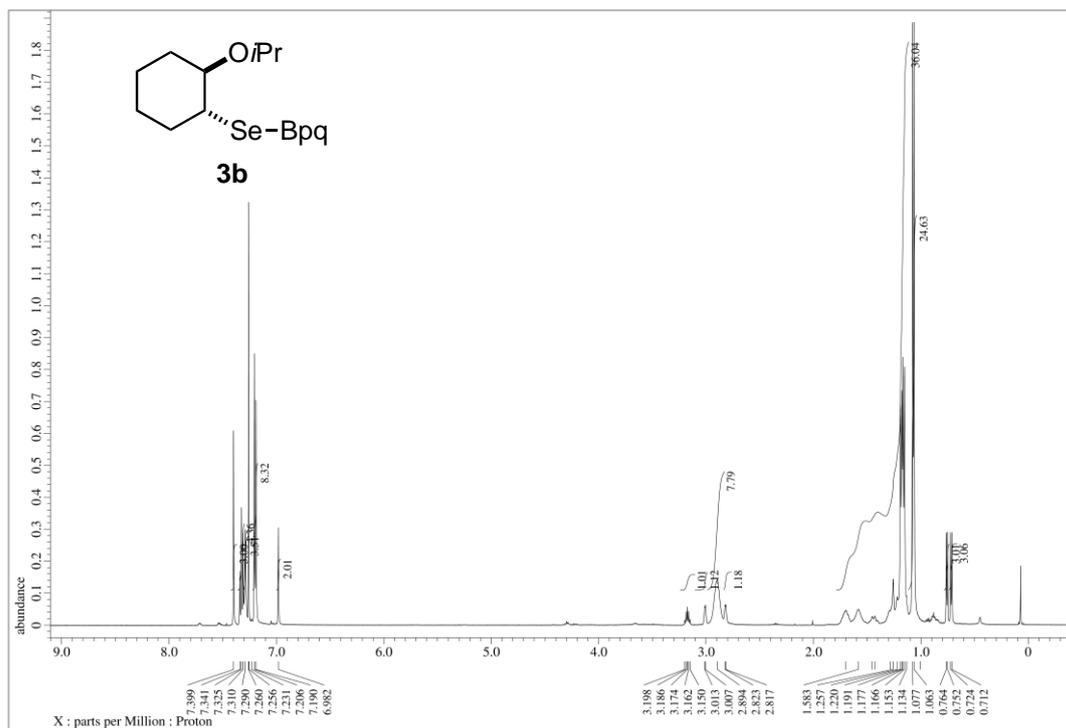


Figure S3. ^1H NMR (500 MHz, CDCl_3) spectrum of **3c**.

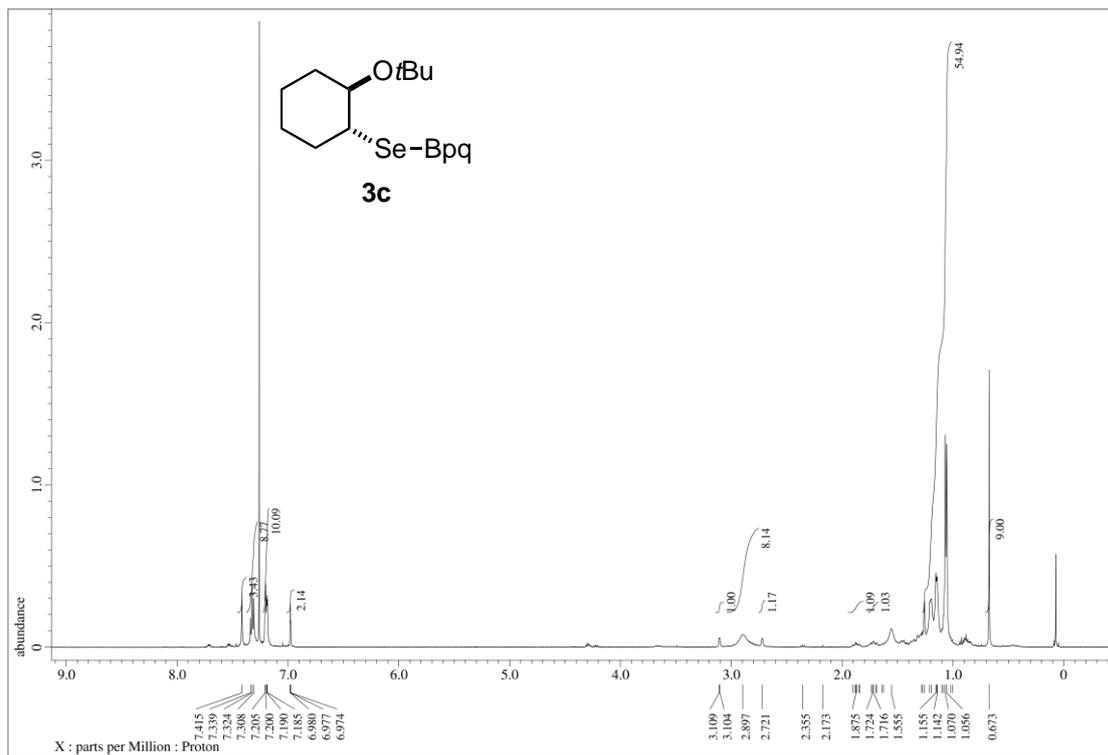


Figure S4. ^{13}C NMR (125 MHz, CDCl_3) spectrum of **3c**.

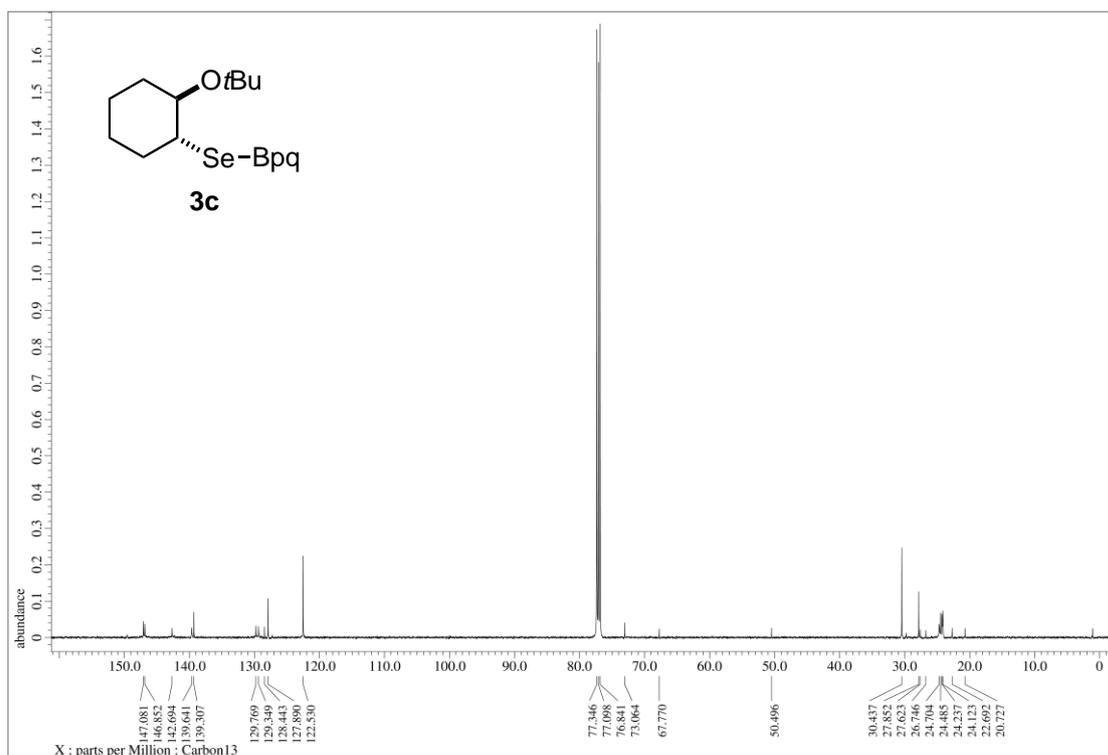


Figure S5. ^1H NMR (500 MHz, CDCl_3) spectrum of **3d**.

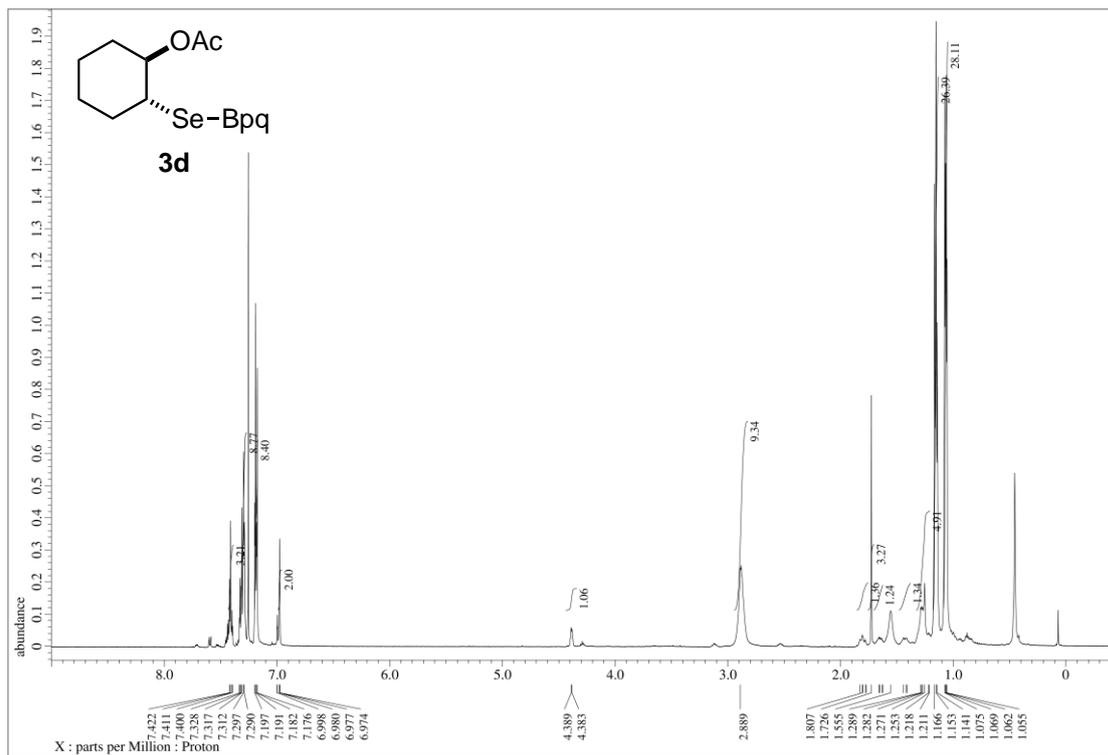


Figure S6. ^{13}C NMR (125 MHz, CDCl_3) spectrum of **3d**.

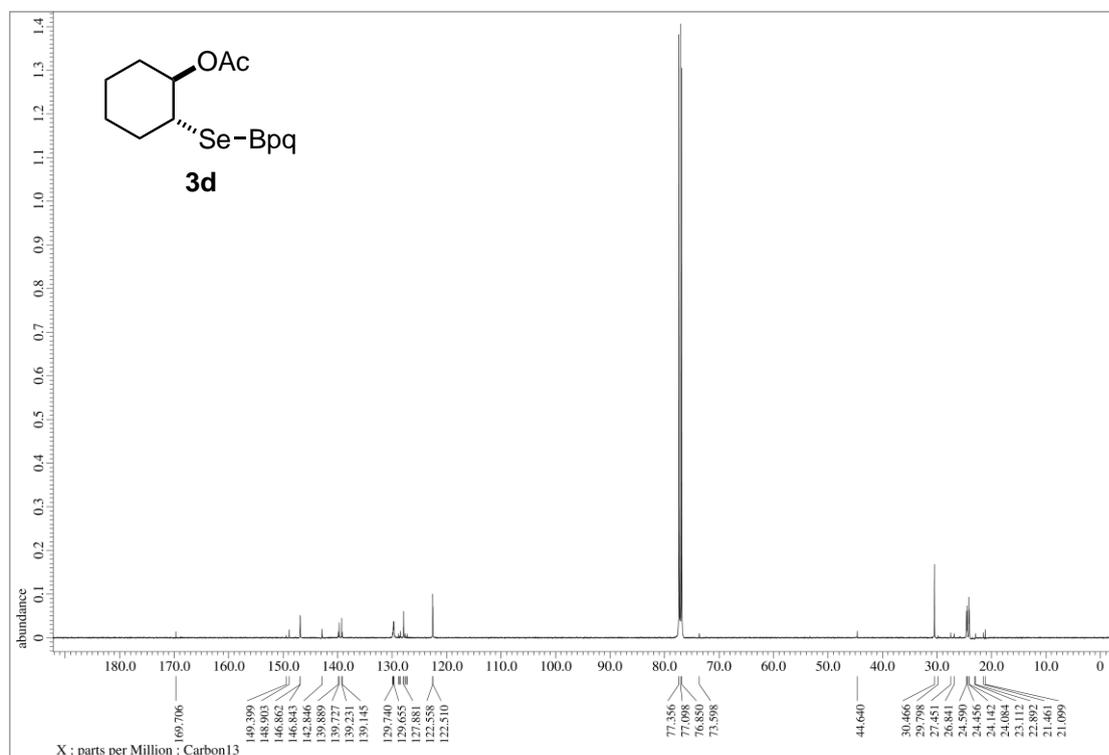


Figure S7. ^1H NMR (500 MHz, CDCl_3) spectrum of **4a**.

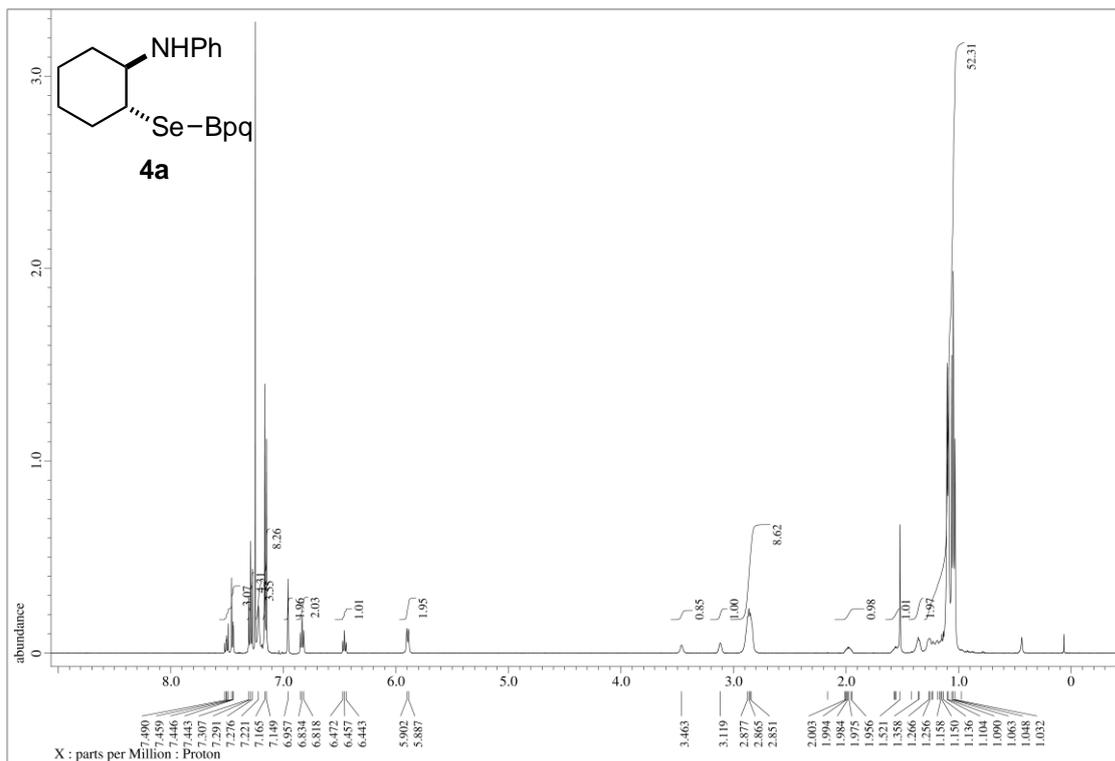


Figure S8. ^{13}C NMR (125 MHz, CDCl_3) spectrum of **4a**.

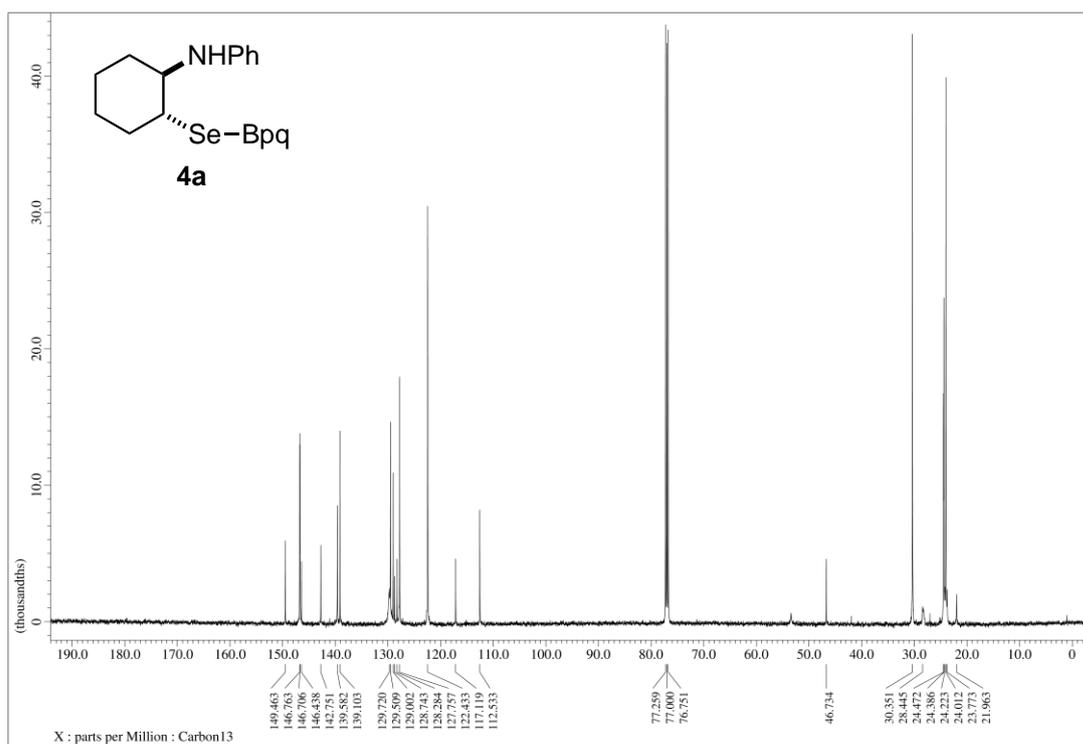


Figure S9. ^1H NMR (500 MHz, CDCl_3) spectrum of **4b**.

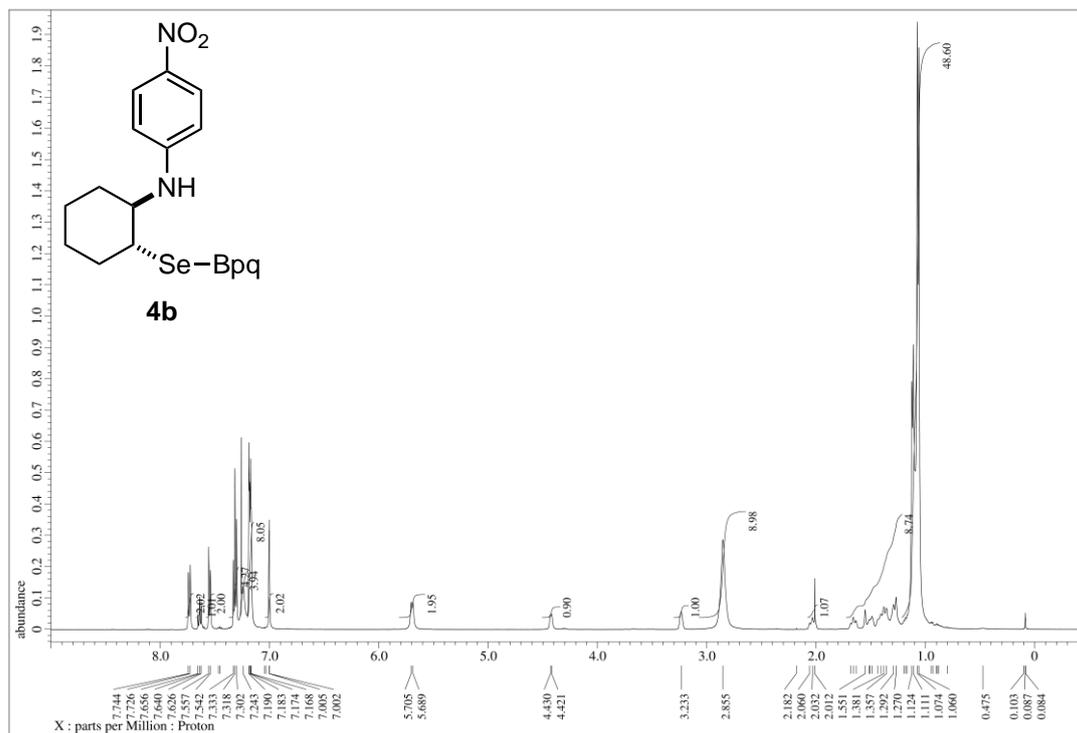


Figure S10. ^{13}C NMR (125 MHz, CDCl_3) spectrum of **4b**.

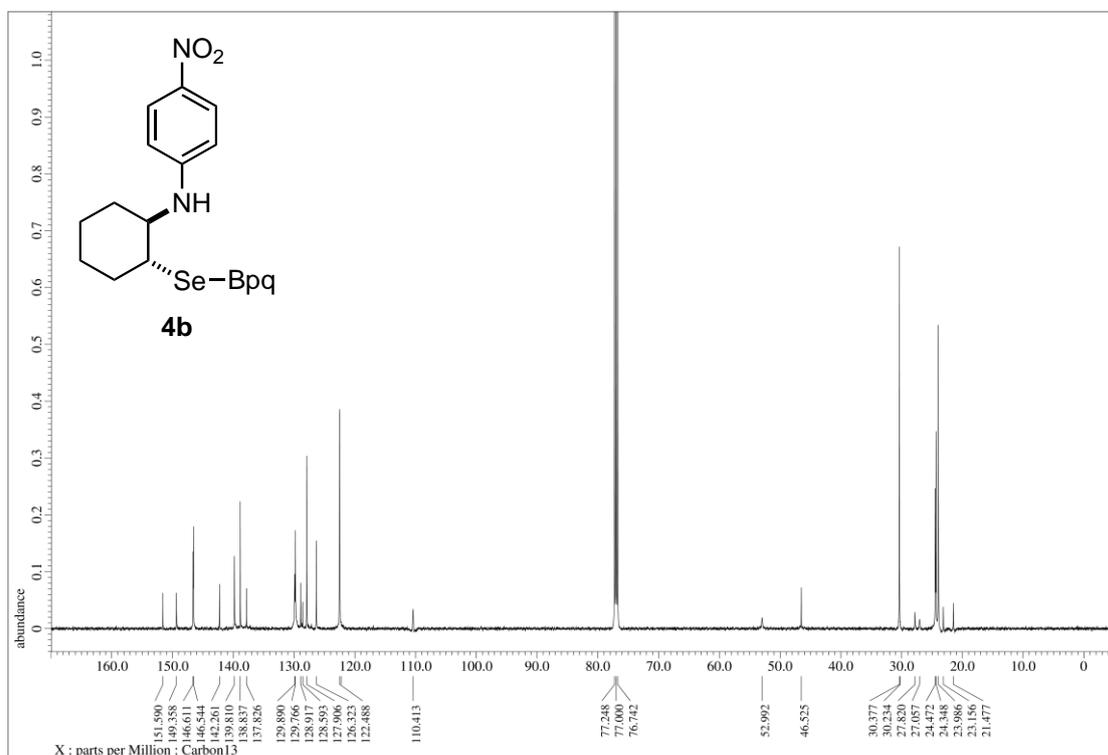


Figure S11. ^1H NMR (500 MHz, CDCl_3) spectrum of **4c**.

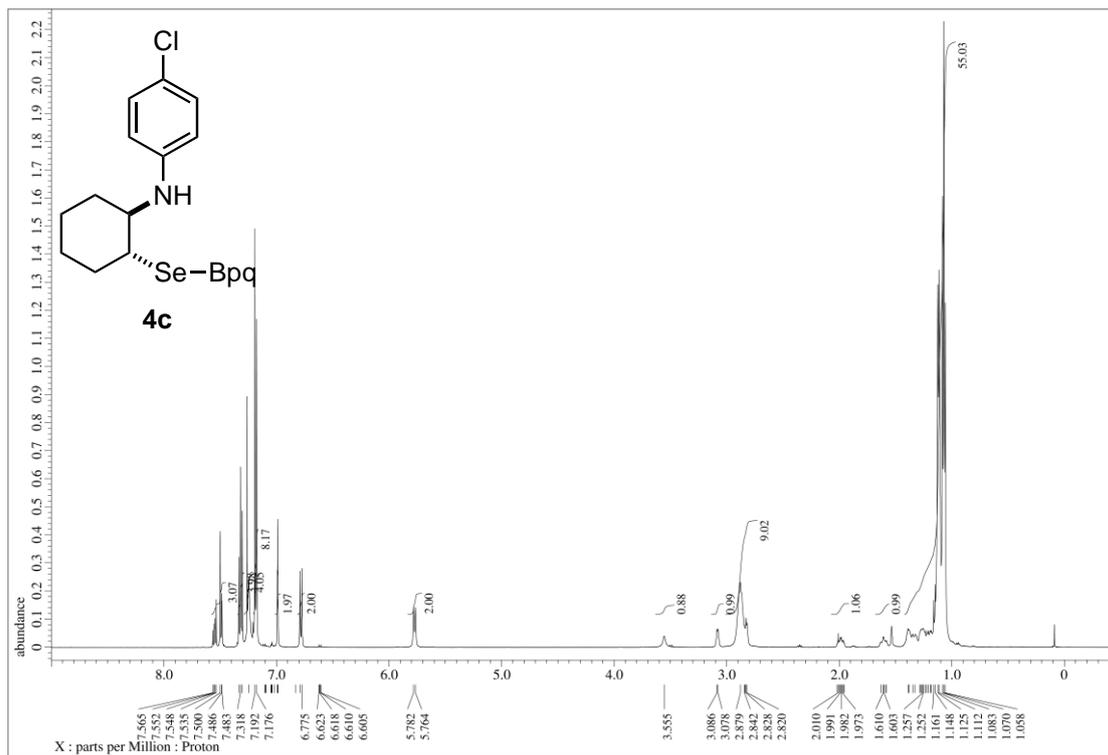


Figure S12. ^{13}C NMR (125 MHz, CDCl_3) spectrum of **4c**.

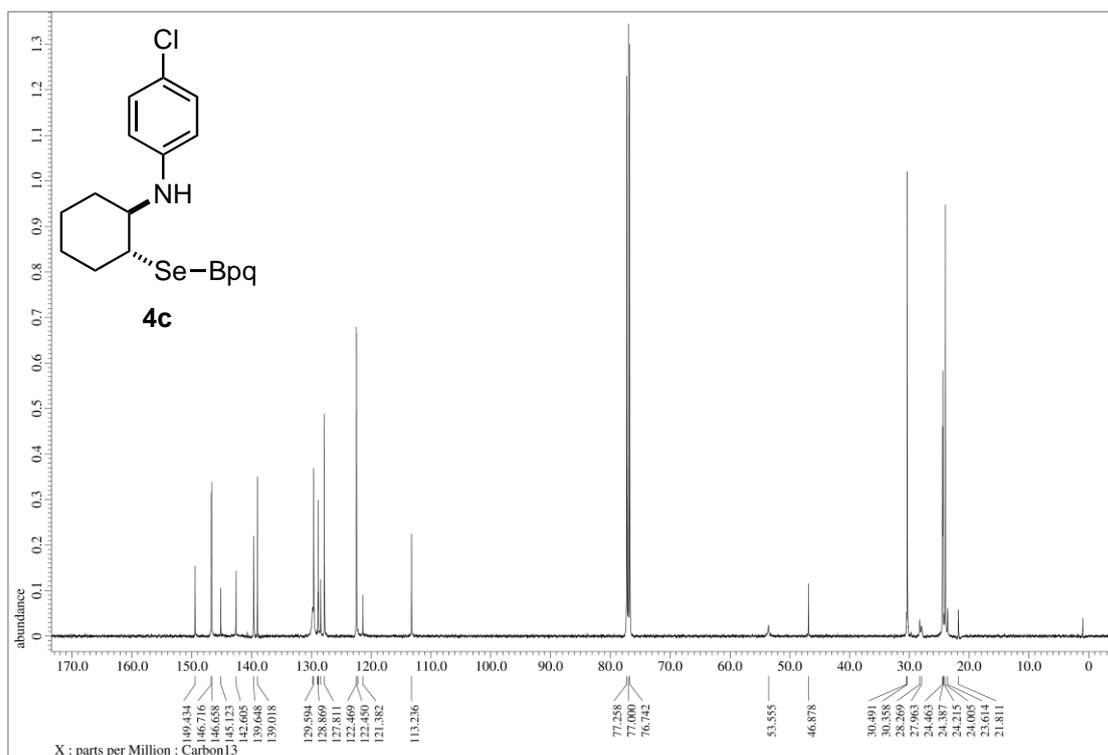


Figure S13. ^1H NMR (500 MHz, CDCl_3) spectrum of **4d**.

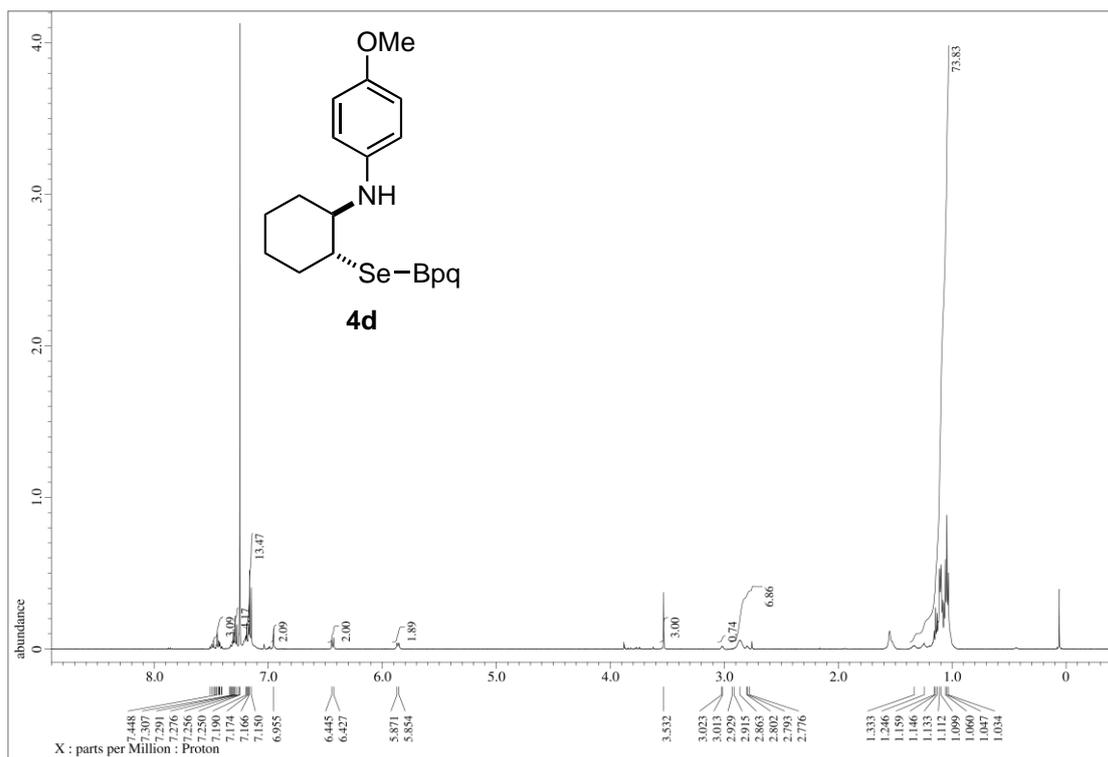


Figure S14. ^{13}C NMR (125 MHz, CDCl_3) spectrum of **4d**.

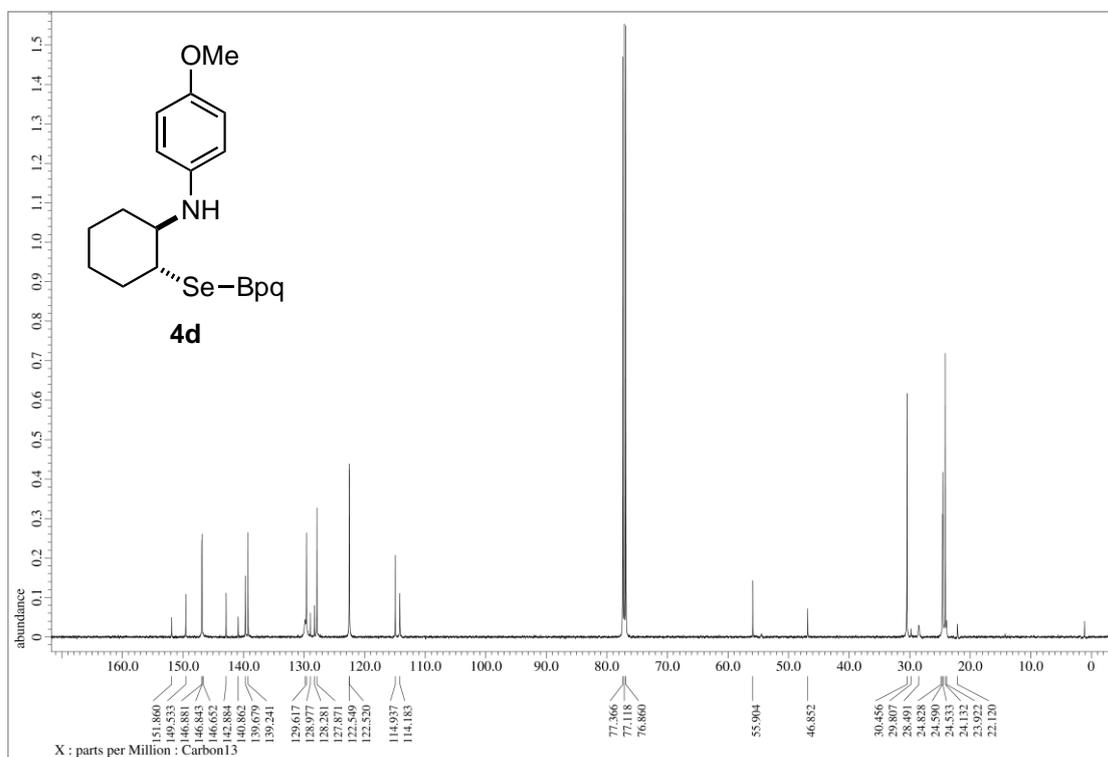


Figure S15. ¹H NMR (500 MHz, CDCl₃) spectrum of 4e.

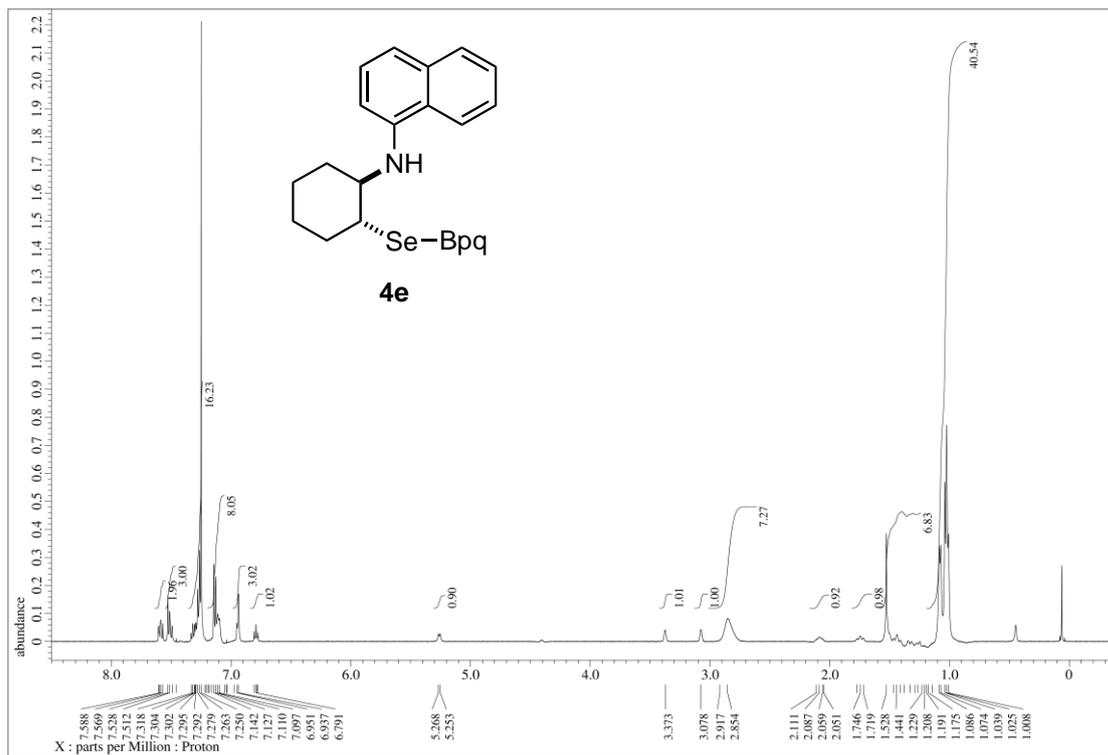


Figure S16. ¹³C NMR (125 MHz, CDCl₃) spectrum of 4e.

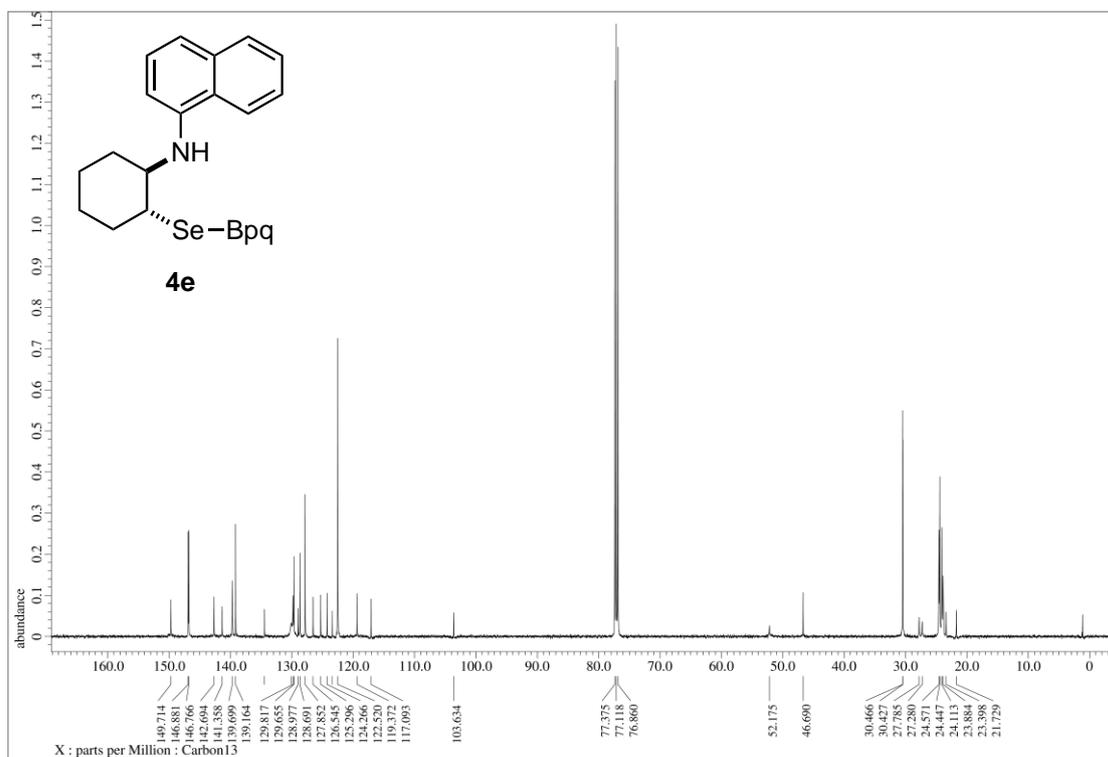


Figure S17. ¹H NMR (500 MHz, CDCl₃) spectrum of **4f**.

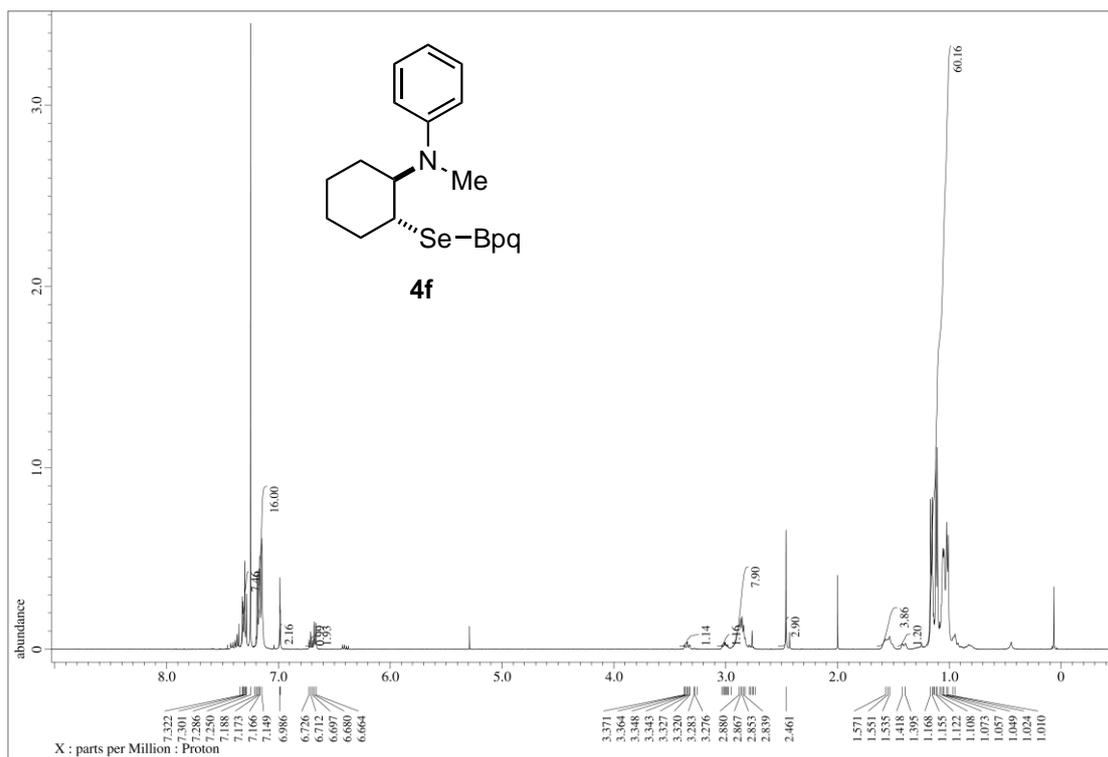


Figure S18. ¹³C NMR (125 MHz, CDCl₃) spectrum of **4f**.

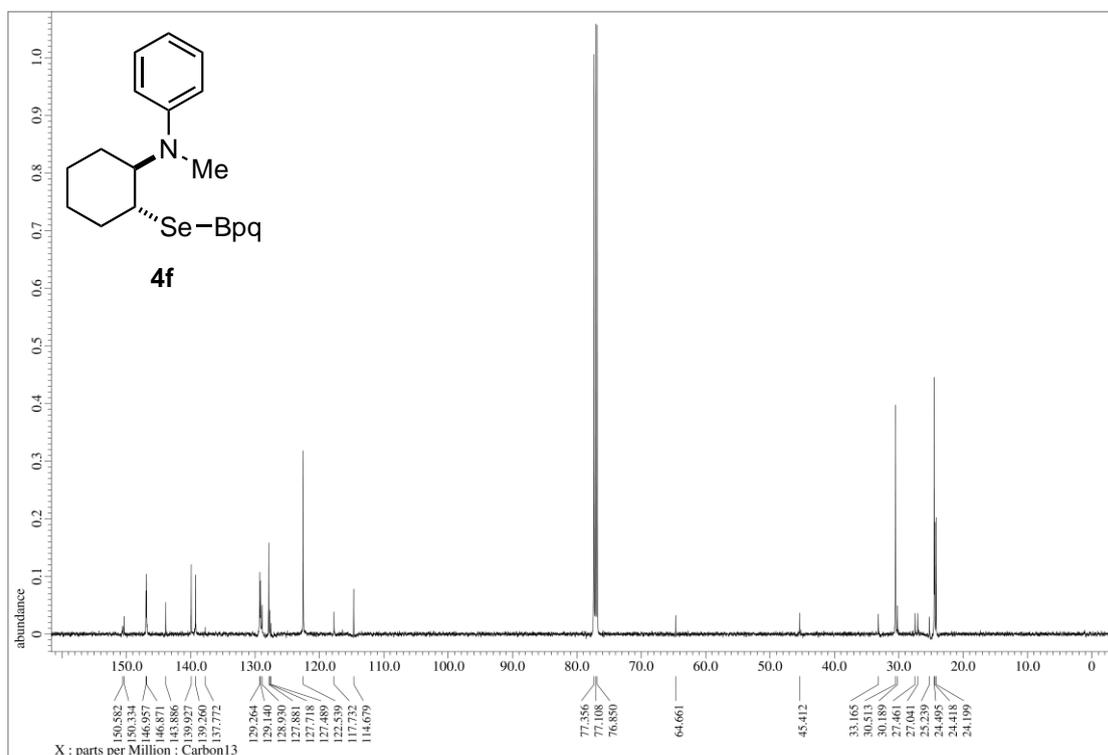


Figure S19. ^1H NMR (500 MHz, CDCl_3) spectrum of **4g**.

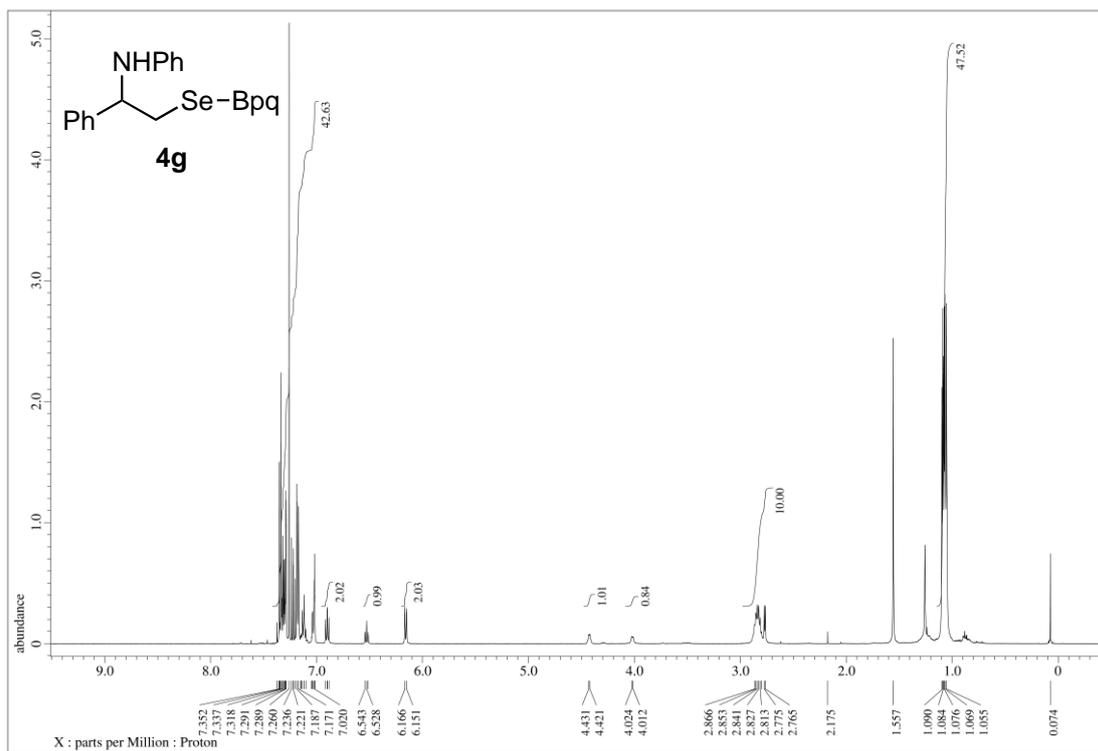


Figure S20. ^{13}C NMR (125 MHz, CDCl_3) spectrum of **4g**.

