Supporting Information for:

"Model Study on Trapping of Protein Selenenic Acids by Utilizing a Stable Synthetic Congener"

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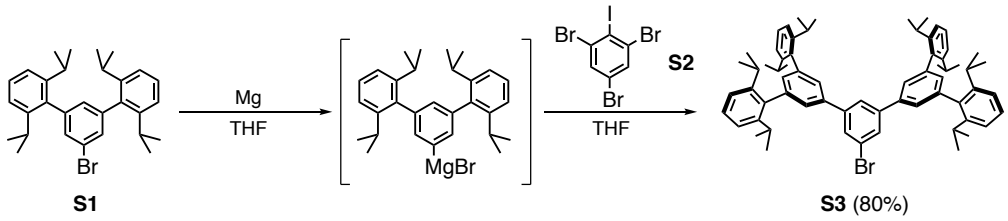
Contents

1. Experimental Section

General experimental methods: Unless otherwise stated, all operations were performed by using high-vacuum and standard Schlenk techniques under an argon atmosphere. THF (anhydrous) was purchased from Kanto Chemical and passed through a Kayama Oxygen solvent purification system prior to use. Other solvents were purchased from commercial sources and used as received. **S1**[1], **S2**,[2] **5**[3], and cyclooctyne (**14**)[4] were prepared according to the literature procedure. Other chemicals were purchased from commercial sources and used as received. Silica gel column chromatography was performed using Kanto silica gel N60 or Merck silica gel 60. Preparative thin layer chromatography (PTLC) was performed using Merck silica gel 60 PF_{254}. ^1H NMR spectra were recorded on a JEOL ECS-400, a JEOL ECX-500, or a JEOL ECZ-500, and the chemical shifts of ^1H are referenced to the residual proton signal of $CDCl_3$ (δ 7.25) or C_6D_6 (δ 7.15). ^{13}C NMR spectra were recorded on JEOL ECS-400, a JEOL ECX-500, or a JEOL ECZ-500, and the chemical shifts of ^{13}C are referenced to the signal of $CDCl_3$ (δ 77.0) or C_6D_6 (δ 128.0). ^{77}Se NMR spectra were recorded on a JEOL ECX-500, and the chemical shifts of ^{77}Se are referenced to the diphenyl diselenide (δ 480) as 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 by utilizing a KBr disk. Mass spectra were measured on a JEOL JMS-T100GCv "AccuTOF GCv" using a field desorption probe. Melting points were measured with a Yanaco MP-S3 and are uncorrected.

Synthesis of quinquephenyl bromide S3.

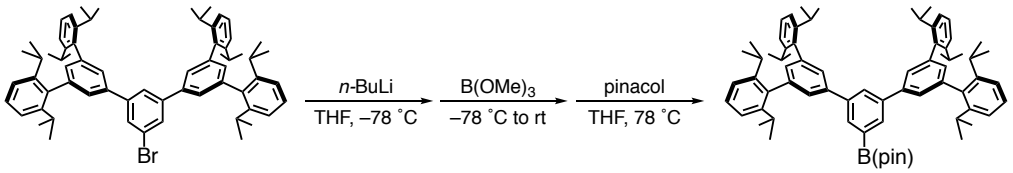


To a Grignard reagent prepared by the reaction of 2-bromo-1,3-diisopropylbenzene (**S1**) (12.97 g, 27.2 mmol) and magnesium turnings (0.9476 g, 39.0 mmol) in THF (50 mL) was added a solution of 1,3,5-tribromo-2-iodobenzene (**S2**) (4.179 g, 9.48 mmol) over 30 min at 75 ˚C. The reaction mixture was stirred at 75 ˚C overnight and then treated with 1 M HCl at 0 ˚C. After extraction with ether, the combined organic layer was dried over $MgSO_4$ and evaporated in vacuo. To the resulting oily mixture was added EtOH to precipitate white solids, which was collected by filtration. It was purified by silica gel column chromatography (hexane:$CHCl_3$ = 7:1) to give quinquephenyl bromide **S3** (6.923 g, 7.29 mmol, 80%) as colorless crystals.

S3: colorless crystals; M.p. >300 ˚C; ^1H NMR (400 MHz, $CDCl_3$) δ 1.04 (d, J = 6.8 Hz, 24H), 1.14 (d, J = 6.8 Hz, 24H), 2.73 (sept, J = 6.8 Hz, 8H), 7.03 (t, J = 1.5 Hz, 2H), 7.19 (d, J = 7.7 Hz, 8H), 7.32 (t, J = 7.7 Hz, 4H), 7.39 (d, J = 1.5 Hz, 4H), 7.69 (d, J = 1.5 Hz, 2H), 7.73 (t, J = 1.5 Hz, 1H); ^{13}C NMR (100 MHz,

$CDCl_3$) δ 24.2 (q), 24.3 (q), 30.4 (d), 122.6 (d), 123.3 (s), 125.2 (d), 126.5 (d), 128.1 (d), 129.5 (d), 130.6 (d), 138.8 (s), 139.5 (s), 141.3 (s), 143.7 (s), 146.7 (s). Anal. Calcd. for $C_{66}H_{77}Br$: C, 83.42; H, 8.17. Found: C, 83.69; H, 8.47.

Synthesis of arylboronic acid pinacol ester 4.

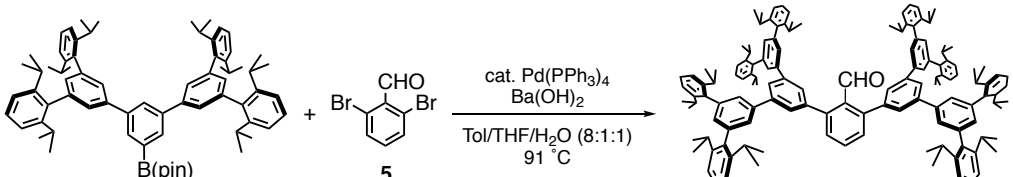


S3 **4** (69%)

To a solution of **S3** (6.923 g, 7.29 mmol) in THF (30 mL) was added *n*-BuLi (1.5 M in hexane, 5.2 mL, 7.8 mmol) at –78 ˚C over 30 min. After the reaction mixture was stirred for 30 min at –78 ˚C, trimethyl borate (0.86 mL, 7.7 mmol) was added at –78 ˚C, and it was allowed to warm to room temperature and stirred overnight. The reaction mixture was treated with 1 M HCl and extracted with Et_2O. The combined organic layer was dried over $MgSO_4$, and the solvent was evaporated in vacuo. To the resulting residue was added THF (15 mL) and pinacol (0.860 g, 7.28 mmol), and it was stirred at 78 ˚C overnight. After evaporation of the solvent, the crude mixture was purified by silica gel column chromatography (hexane:$CHCl_3$ = 7:1) to give **4** (4.072 g, 4.09 mmo, 69%) as colorless crystals.

4: colorless crystals; M.p. >300 ˚C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.06 (d, J = 6.9 Hz, 24H), 1.16 (d, J = 6.9 Hz, 24H), 1.32 (s, 12H), 2.79 (sept, J = 6.9 Hz, 8H), 7.02 (d, J = 1.2 Hz, 2H), 7.22 (d, J = 7.6 Hz, 8H), 7.35 (t, J = 7.6 Hz, 4H), 7.48 (d, J = 1.6 Hz, 4H), 7.94 (d, J = 1.6 Hz, 1H), 8.04 (d, J = 1.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.1 (q), 24.4 (q), 24.9 (q), 30.4 (d), 84.0 (s), 122.5 (d), 126.6 (d), 127.9 (d), 129.2 (d), 129.8 (d), 132.8 (d), 139.1 (s), 140.77 (s), 140.83 (s), 121.1 (s), 146.7 (s). Anal. Calcd. for $C_{56}H_{57}BO_2$: C, 87.03; H, 7.43. Found: C, 87.13; H, 7.72.

Synthesis of BpsCHO 5.



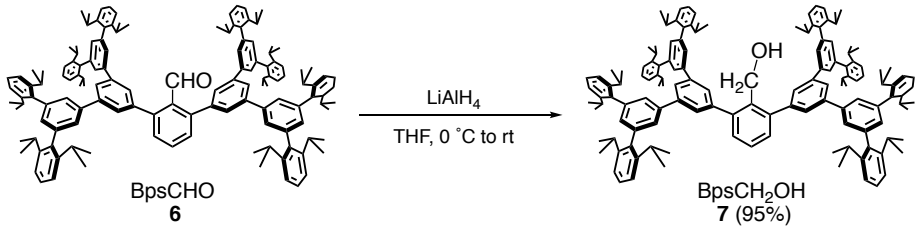
4 **5** BpsCHO
6 (98%)

Toluene and H_2O were degassed through bubbling of argon for 1 h prior to use. A mixture of **4** (1.798 g, 1.804 mmol), **5** (0.267 g, 1.01 mmol), $Pd(PPh_3)_4$ (0.225 g, 0.195 mmol), and $Ba(OH)_2$•$8H_2O$ (2.842 g, 9.01 mmol) in a mixed solvent of THF (36 mL), THF (4.5 mL), and H_2O (4.5 mL) was stirred at 91 ˚C for 21 h. After cooling to room temperature, the reaction mixture was passed through a pad of celite, and the solvent was evaporated in vacuo. The crude mixture was purified by silica gel column chromatography

(hexane:$CHCl_3$ = 4:1) to give BpsCHO **6** (1.633 g, 0886 mmol, 98%) as colorless crystals.

6: colorless crystals; M.p. 275.2-277.5 ˚C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.03 (d, J = 6.8 Hz, 48H), 1.10 (d, J = 6.8 Hz, 48H), 2.74 (sept, J = 6.8 Hz, 16H), 6.99 (t, J = 1.6 Hz, 4H), 7.17 (d, J = 7.8 Hz, 16H), 7.31 (t, J = 7.8 Hz, 8H), 7.44 (d, J = 1.6 Hz, 8H), 7.47 (d, J = 8.4 Hz, 2H), 7.53 (d, J = 1.6 Hz, 4H), 7.59 (t, J =8.4 Hz, 1H), 7.86 (t, J = 1.6 Hz, 2H), 10.13 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 24.1 (q), 24.3 (q), 30.4 (d), 122.5 (d), 125.5 (d), 126.4 (d), 127.5 (d), 127.9 (d), 130.3 (d), 130.8 (d), 131.8 (d), 133.0 (s), 139.0 (s), 140.1 (s), 140.8 (s), 141.1 (s), 141.5 (s), 144.1 (s), 146.7 (s), 193.6 (d); LRMS (FD) m/z 1843 [M^+]. Anal. Calcd for $C_{139}H_{158}O$: C, 90.50; H, 8.63. Found: C, 90.48, H, 8.34.

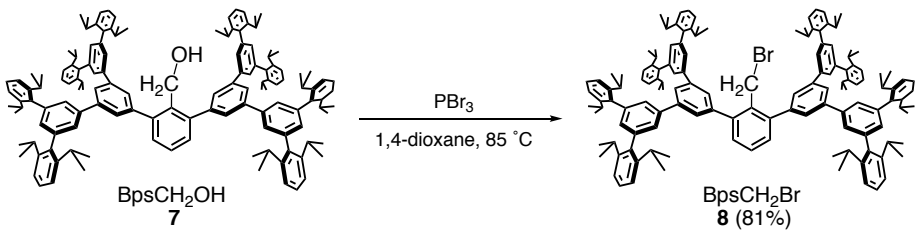
Synthesis of $BpsCH_2OH$ 7.



To a mixture of $LiAlH_4$ (101.2 mg, 2.67 mmol) in THF (12 mL) was added a solution of **6** (0.572 g, 0.310 mmol) in THF (8 mL) at 0 ˚C over 15 min. The reaction mixture was allowed to warm to room temperature and stirred for 3 h, and then 1 M aq. HCl was carefully added at 0 ˚C. After extraction with $CHCl_3$, the combined organic layer was dried over $MgSO_4$, and the solvent was evaporated in vacuo. The crude mixture was recrystallized from hexane/acetonitrile to give **7** (0.544 g, 0.295 mmol, 95%) as colorless crystals.

7: colorless crystals; M.p. >300 ˚C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.03 (d, J = 6.8 Hz, 48H), 1.09 (d, J = 6.8 Hz, 48H), 2.74 (sept, J = 6.8 Hz, 16H), 4.63 (d, J = 6.0 Hz, 2H), 6.99 (t, J = 1.5 Hz, 4H), 7.17 (d, J = 6.8 Hz, 16H), 7.32 (t, J = 6.8 Hz, 8H), 7.45 (d, J = 1.6 Hz, 8H), 7.71 (d, J = 1.6 Hz, 4H), 7.85 (t, J = 1.6 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 24.1 (q), 24.3 (q), 30.4 (d), 122.5 (d), 125.3 (d), 126.4 (d), 127.5 (d), 127.9 (d), 130.0 (d), 130.2 (d), 135.2 (d), 139.0 (s), 140.3 (s), 141.1 (s), 141.6 (s, two singlets are overlapped, judged by HMBC), 142.3(s), 143.2 (s), 146.7 (s); LRMS (FD) m/z 1845 [M^+].

Synthesis of $BpsCH_2Br$ 8.

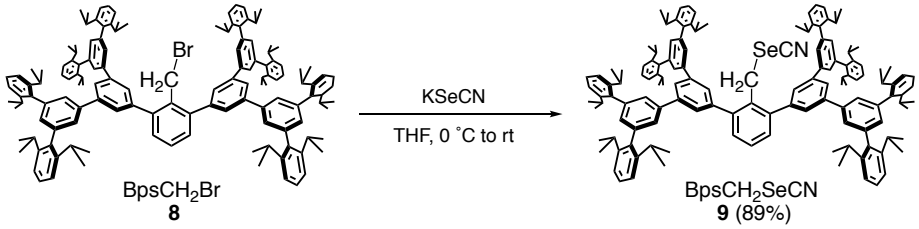


To a solution of **7** (52.3 mg, 28.3 μmol) in 1,4-dioxane (1.5 mL) was added PBr_3 (7.8 μL, 83 μmol), and

the resulting solution was stirred at 85 ˚C for 18 h. After the reaction mixture was cooled to room temperature, ice-cooled water was added, and the resulting pale yellow solution was stirred at room temperature until it became colorless. After extraction with $CHCl_3$, the combined organic layer was dried over $MgSO_4$, and the solvent was evaporated in vacuo. The crude mixture was recrystallized from hexane to give **8** (44.0 mg, 23.1 μmol, 81%) as colorless crystals.

8: colorless crystals; M.p. >300 ˚C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.04 (d, J = 6.8 Hz, 48H), 1.09 (d, J = 6.8 Hz, 48H), 2.75 (sept, J = 6.8 Hz, 16H), 4.38 (s, 2H), 7.00 (t, J = 1.6 Hz, 4H), 7.18 (d, J =8.0 Hz, 16H), 7.32 (t, J = 7.6 Hz, 8H), 7.30-7.45 (m, 11H), 7.36 (t, J = 7.6 Hz, 2H), 7.50 (d, J = 1.6 Hz, 8H), 7.77 (d, J = 1.6 Hz, 4H), 7.89 (t, J = 1.6 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 24.1 (q), 24.3 (q), 30.3 (d), 67.1 (t), 122.5 (d), 125.5 (d), 126.4 (d), 127.3 (d), 127.9 (d), 128.2 (d), 130.03 (d), 130.2 (d), 132.9 (s), 139.0 (s), 140.2 (s), 141.0 (s), 141.3 (s), 141.6 (s), 143.5 (s), 146.7 (s); LRMS (FD) m/z 1907 [M$^+$].

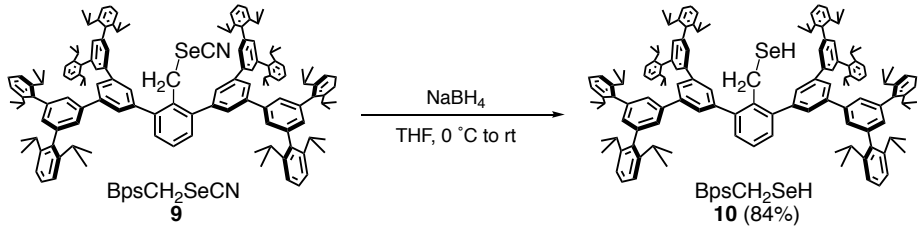
Synthesis of BpsCH$_2$SeCN 9.



To a mixture of potassium selenocyanate (145.8 mg, 1.03 mmol) in THF (4 mL) was added a solution of **8** (574.6 mg, 0.301 mmol) in THF (4 mL) at 0 ˚C over 10 min. The reaction mixture was allowed to warm to room temperature and stirred for 3 h. After addition of water, the mixture was extracted with toluene. The organic layer was washed with brine and dried over $MgSO_4$. After evaporation of solvent in vacuo, the crude mixture was recrystallized from hexane to give **9** (518.7 mg, 0.268 mmol, 89%) as colorless crystals.

9: colorless crystals; M.p. >300 ˚C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.03 (d, J = 6.8 Hz, 48H), 1.09 (d, J = 6.8 Hz, 48H), 2.75 (sept, J = 6.8 Hz, 16H), 4.37 (s, 2H), 7.00 (t, J = 1.6 Hz, 4H), 7.17 (d, J = 7.6 Hz, 16H), 7.32 (t, J = 7.6 Hz, 8H), 7.33 (t, J = 7.2 Hz, 1H), 7.37 (d, J = 7.2 Hz, 2H), 7.45 (d, J =1.6 Hz, 8H), 7.58 (d, J = 1.6 Hz, 4H), 7.89 (t, J = 1.6 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 24.2 (q), 24.3 (q), 30.4 (d), 77.2 (t), 100.8 (s), 122.5 (d), 126.0 (d), 126.4 (d), 127.0 (d), 127.9 (d), 128.3 (d), 130.1 (d), 130.2 (s), 130.3 (d), 138.9 (s), 140.1 (s), 141.1 (s), 141.2 (s), 141.9 (s), 143.5 (s), 146.7 (s); ^{77}Se NMR (95 MHz, $CDCl_3$) δ 244; IR (KBr) 2152 cm^{-1} (ν(CN)); LRMS (FD) m/z 1934 [M$^+$].

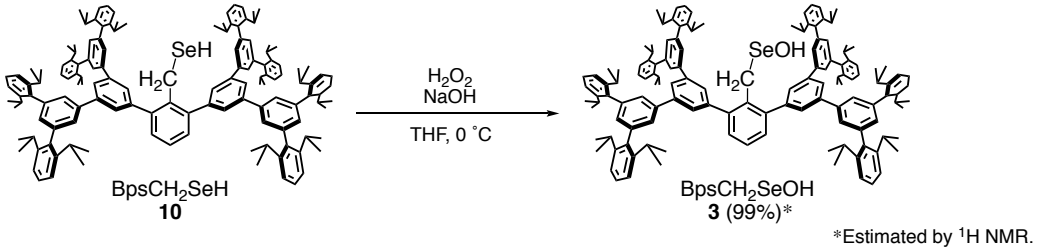
Synthesis of $BpsCH_2SeH$ 10.



The following reaction and workup were performed under argon atmosphere. A solution of **9** (58.7 mg, 30.3 μmol) in THF (2 mL) was degassed through three freeze-pump-thaw cycles, and the flask was flushed with argon. To a solution of $NaBH_4$ (3.3 mg, 87 μmol) in MeOH (2 mL), which was degassed through three freeze-pump-thaw cycles, was added the degassed solution of **9** at –3 ˚C over 5 min. After the reaction mixture was stirred at room temperature for 2 h, degassed water (0.5 mL) was added. Extraction was performed by using $CHCl_3$ that was degassed through bubbling of argon and then pre-cooled at 0 ˚C. The combined organic layer was dried over $MgSO_4$, and the solvent was evaporated in vacuo. The crude mixture was recrystallized from hexane to give **10** (48.7 mg, 25.5 μmol, 84%) as colorless crystals.

10: colorless crystals; M.p. 293.8-296.0 ˚C (dec); ^{1}H NMR (400 MHz, $CDCl_3$) δ –0.13 (t, J = 6.4 Hz, 1H), 1.03 (d, J = 6.8 Hz, 48H), 1.09 (d, J = 6.8 Hz, 48H), 2.76 (sept, J = 6.8 Hz, 16H), 3.74 (d, J = 6.4 Hz, 2H), 7.00 (t, J = 1.4 Hz, 4H), 7.17 (d, J = 7.3 Hz, 16H), 7.29-7.35 (m, 11H), 7.48 (d, J = 1.4 Hz, 8H), 7.69 (d, J = 1.4 Hz, 4H), 7.88 (t, J = 1.4 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 16.9 (t), 24.2 (q), 24.4 (q), 30.5 (d), 122.6 (d), 125.2 (d), 126.6 (d), 126.8 (d), 127.3 (d), 128.0 (d), 130.0 (d), 130.3 (d), 136.5 (s), 139.1 (s), 140.2 (s), 141.1 (s), 141.5 (s), 142.2 (s), 142.5 (s), 146.8 (s); ^{77}Se NMR (95 MHz, $CDCl_3$) δ 95; LRMS (FD) m/z 1909 [M^+].

Synthesis of $BpsCH_2SeOH$ 3.

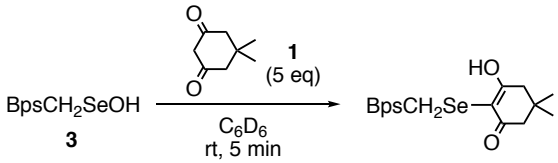


A stock solution of H_2O_2 (30%, 30 μL, 0.26 mmol) in THF (1 mL) and that of NaOH (94.3 mg, 2.36 mmol) in H_2O (8.0 mL) were prepared prior to the reaction. To a solution of **10** (69.0 mg, 36.1 μmol) in THF (2 mL) were added 0.12 mL of the stock solution of NaOH (36 μmol) and 125 μL of that of H_2O_2 (36 μmol) at 0 ˚C, and the reaction mixture was stirred for 2 h at 0 ˚C. Then, the solvent was evaporated in vacuo, and NMR measurement of the crude mixture in C_6D_6 showed that selenenic acid **3** was formed in 99% yield. Selenenic acid **3** can also prepared from oxidation of **10** with $NaBO_3$. To a solution of **10** (16.9 mg, 8.9 μmol) was added an aqueous solution of $NaBO_3$ (0.18 M, 106 μL, 19 μmol) at –2 ˚C. The solution was

stirred at the same temperature at the same temperature for 30 min and then at room temperature for 1 h. After treatment with 3% aq. $NaHSO_3$, the mixture was extracted with $CHCl_3$ under an argon atmosphere. The combined organic layer was dried over $MgSO_4$ and evaporated in vacuo. ^{1}H NMR measurement of the crude mixture in C_6D_6 showed that **3** was formed quantitatively.

3: colorless crystals; M.p. 250.0-251.5 ˚C; ^{1}H NMR (400 MHz, C_6D_6) δ 1.07 (d, J = 6.8 Hz, 48H), 1.14 (d, J = 6.8 Hz, 48H), 2.03 (s, 1H), 2.99 (sept, J = 6.9 Hz, 16H), 4.18 (s, 2H), 6.91-7.02 (A_2B pattern, 3H), 7.10 (t, J = 1.6 Hz, 4H), 7.20 (d, J = 7.6 Hz, 16H), 7.34 (t, J =7.6 Hz, 8H), 7.67 (d, J = 1.6 Hz, 8H), 7.77 (d, J = 1.6 Hz, 4H), 8.06 (d, J = 1.6 Hz, 2H); ^{13}C NMR (125 MHz, C_6D_6) δ 24.4 (q), 24.6 (d), 30.8 (d), 35.5 (t), 122.0 (d), 126.5 (d), 127.2 (d), 128.4 (d), 128.7 (d), 130.1 (d), 130.9 (d), 132.8 (d), 139.4 (s), 141.6 (s), 141.9 (s), 142.1 (s), 142.3 (s), 142.8 (s), 143.1 (s), 146.9 (s); ^{77}Se NMR (95 MHz, C_6D_6) δ 1243; IR ($CHCl_3$) ν 3511 cm^{-1} (OH). Anal. Calcd. for $C_{139}H_{160}OSe$ C, 86.69; H, 8.37. Found: C, 86.43; H, 8.43.

Reaction of 3 with dimedone (1).

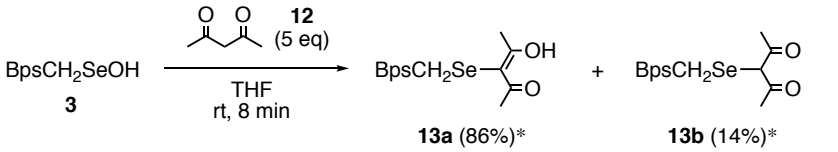


*Estimated by ^{1}H NMR.

To **3** (15.0 mg, 7.8 μmol) in an NMR tube with a J-young valve was added a solution of **1** (5.5 mg, 39 μmol) in C_6D_6 (0.6 mL) at room temperature, and the tube was carefully sealed. In the ^{1}H NMR measurement after 5 min, selenide **11** was formed quantitatively. After extraction with $CHCl_3$, the combined organic layer was dried over $MgSO_4$, and the solvent was evaporated in vacuo. The crude mixture was purified by PTLC (hexane:$CHCl_3$ = 2:1) to afford **11** (8.0 mg, 3.9 μmol, 50%) as colorless crystals

11: colorless crystals; M.p. 225.0-228.0 ˚C; ^{1}H NMR (400 MHz, C_6D_6) δ 0.46 (s, 6H), 1.06 (d, J =6.8 Hz, 48H), 1.14 (d, J = 6.8 Hz, 48), 1.63 (s, 2H), 1.69 (s, 2H), 3.02 (sept, J = 6.8 Hz, 16H), 3.81 (s, 2H), 6.80 (s, 1H), 6.92-6.99 (A_2B pattern, 3H), 7.10 (t, J = 1.4 Hz, 4H), 7.18 (d, J = 7.2 Hz, 16H), 7.32 (t, J = 7.2 Hz, 8H), 7.81 (d, J =1.4 Hz, 8H), 8.01 (d, J = 1.4 Hz, 4H), 8.16 (t, J = 1.4 Hz, 2H); ^{13}C NMR (100 MHz, C_6D_6) δ 24.5 (q), 24.6 (q), 27.8 (q), 29.0 (s), 30.8 (d), 41.2 (t), 50.3 (t), 106.3 (s), 122.9 (d), 126.2 (d), 127.1 (d), 128.5 (d), 128.6 (d), 130.6 (d), 130.9 (d), 132.0 (d), 139.6 (s), 141.8 (s), 142.4 (s), 142.66 (s), 142.74 (s), 143.8 (s), 147.0 (s), 174.6 (s), 190.6 (s); ^{77}Se NMR (95 MHz, C_6D_6) δ 79.

Reaction of 3 with acetylacetone (12).



*Estimated by ^{1}H NMR.

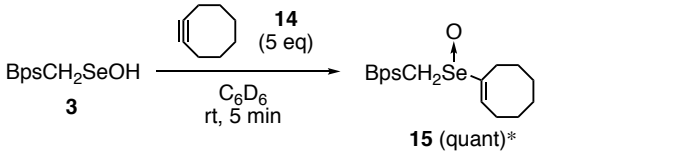
To a solution of **3** (169 mg, 88.0 μmol) in THF (6.6 mL) was added **12** (45 μL, 0.44 μmol) at room temperature. After the reaction mixture was allowed to react for 8 min, the solvent was evacuated in vacuo to afford a mixture of **13a** and **13b** (**13a**:**13b** = 86:14, estimated by ^{1}H NMR). The crude mixture was purified by silica gel column chromatography (hexane:$CHCl_3$ = 3:1), and subsequent reprecipitation from hexane afforded a mixture of **13a** and **13b** (110 mg, 54.7 μmol, 63%; **13a**:**13b** = 93:7, estimated by ^{1}H NMR).

13a : ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.02 (d, *J* = 6.9 Hz, 48H), 1.09 (d, *J* = 6.9 Hz, 48H), 1.66 (s, 6H), 2.73 (sept, *J* = 6.9 Hz, 16H), 3.89 (s, 2H), 3.84 (s, 2H), 6.99 (t, *J* = 1.4 Hz, 3H), 7.17 (d, *J* = 7.8 Hz, 16H), 7.25-7.33 (m, 11H), 7.42 (d, *J* = 1.7 Hz, 8H), 7.62 (d, *J* = 1.7 Hz, 4H), 7.78 (t, *J* = 1.7 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 24.39 (q), 24.54 (q), 25.39 (q), 28.72 (t), 30.64 (d), 99.93 (s), 125.54 (d), 126.94 (d), 127.67 (d), 128.20 (d), 130.36 (d), 130.43 (d), 132.67 (s), 139.18 (s), 140.67 (s), 141.36 (s), 141.83 (s), 142.71 (s), 143.21 (s), 197.16 (s); ^{77}Se NMR (95 MHz, $CDCl_3$) δ 247.

13b : ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.03 (d, *J* = 6.6 Hz, 48H), 1.08 (d, *J* = 6.8 Hz, 48H), 1.62 (s, 6H), 2.73 (sept, *J* = 6.9 Hz, 16H), 3.64 (s, 2H), 3.84 (s, 2H), 6.99 (t, *J* = 1.4 Hz, 3H), 7.17 (d, *J* = 7.8 Hz, 16H), 7.27-7.33 (m, 11H), 7.42 (d, *J* = 1.5 Hz, 8H), 7.59 (d, *J* = 1.5 Hz, 4H), 7.80 (t, *J* = 1.5 Hz, 2H); ^{77}Se NMR (95 MHz, $CDCl_3$) δ 329.

The following data were obtained for a mixture of **13a** and **13b** (**13a**:**13b** = 92:8); M.p. >300 ˚C; LRMS (FD) *m/z* 2007 [M^+]; Anal. Calcd. for $C_{144}H_{166}O_2Se$ C, 86.14; H, 8.33. Found: C, 86.11; H, 8.39.

Reaction of 3 with cyclooctyne (14).



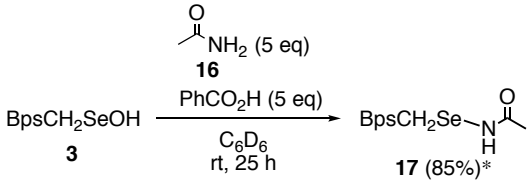
A stock solution of cyclooctyne **(14)** (5.4 μL, 43 μmol) in C_6D_6 (0.40 mL) was prepared. To a solution of **2** (14.0 mg, 7.3 μmol) in C_6D_6 (0.40 mL) was added a part of the stock solution of **14** (0.20 mL, 22 μmol as **14**) at room temperature. In the ^{1}H NMR measurement after 5 min, it was found that **15** was formed quantitatively. The reaction mixture was extracted with $CHCl_3$, and the combined organic layer was dried over $MgSO_4$. After evaporation of the solvent in vacuo, the resulting crude mixture was purified by PTLC (hexane:$CHCl_3$ = 2:1) to afford **15** (9.5 mg, 4.7 μmol, 65%) as colorless solids.

15: colorless solids; M.p. 227.0-229.0 ˚C; ^{1}H NMR (400 MHz, C_6D_6) δ 1.07 (d, *J* = 6.8 Hz, 48H), 1.12 (d, *J* = 6.8 Hz, 48H), 1.10-1.39 (m, 8H), 1.44-1.55 (m, 1H), 1.66-1.91 (m, 3H), 2.99 (sept, *J* = 6.8 Hz, 16H), 3.71 (d, *J* = 12.0 Hz, 1H), 3.83 (d, *J* = 12.0 Hz, 1H), 5.88 (t, *J* = 8.0 Hz, 1H), 6.92-7.04 (A_2B pattern, 3H), 7.10 (brs, 4H), 7.18 (d, *J* = 7.6 Hz, 16H), 7.31 (t, *J* = 7.6 Hz, 8H), 7.65-8.01 (br, 12H), 8.17 (t, *J* = 1.6 Hz, 2H); ^{13}C NMR (125 MHz, C_6D_6) δ 24.1 (q), 24.3 (q), 24.7 (t), 25.3 (t), 25.8 (t), 26.3 (t), 28.1 (t), 29.4 (t), 30.6 (d), 51.6 (t), 122.6 (d), 125.5 (d), 126.9 (d), 127.1 (d), 128.2 (d), 129.2 (d), 130.2 (d), 130.9 (d), 132.5 (d), 139.2

(s), 141.1 (s), 141.6 (s), 142.1 (s), 142.5 (s), 142.9 (s), 143.5 (s), 146.6 (s), 146.7 (s); ^{77}Se NMR (95 MHz, C_6D_6) δ 920; IR (KBr) ν 1055 cm^{-1} (Se=O).

Reactions of 3 with acetamide (16).

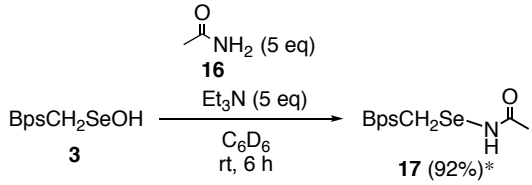
(i) Under acidic conditions



*Estimated by ^{1}H NMR.

The reaction was carried out in an NMR tube with a J-young valve. To a solution of **3** (13.5 mg, 7.0 μmol) in C_6D_6 (0.6 mL) was added acetamide **16** (2.2 mg, 37 μmol), benzoic acid (4.4 mg, 36 μmol), and bis(trimethylsilyl)methane (1 drop, internal standard). The tube was carefully sealed, and the reaction at room temperature was monitored by ^{1}H NMR spectroscopy. After 25 h, *N*-selenoamide **17** was formed in 85% yield, which was confirmed by ^{1}H NMR measurement. The reaction mixture was opened in air and extracted with chloroform. The combined organic layer was dried over $MgSO_4$, and the solvent was evaporated in vacuo. The resulting crude mixture was purified by PTLC (hexane:$CHCl_3$ = 1:1) to give **17** (5.0 mg, 2.5 μmol, 36%).

(ii) Under basic conditions

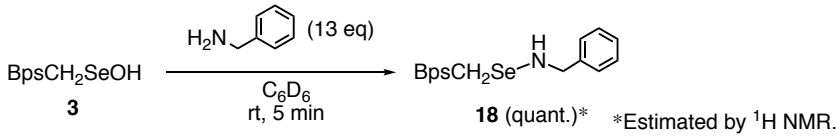


*Estimated by ^{1}H NMR.

The reaction was carried out in an NMR tube with a J-young valve at room temperature. To a solution of **3** (22.8 mg, 11.9 μmol) in C_6D_6 (0.6 mL) was added acetamide **16** (2.7 mg, 46 μmol), triethylamine (4.7 μL, 47 μmol), and bis(trimethylsilyl)methane (1 drop, internal standard). The tube was carefully sealed, and the reaction at room temperature was monitored by ^{1}H NMR spectroscopy. After 6 h, **17** was formed in 92% yield, which was confirmed by ^{1}H NMR measurement. The reaction mixture was opened in air and extracted with chloroform. The combined organic layer was dried over $MgSO_4$, and the solvent was evaporated in vacuo. The crude mixture was purified by PTLC (hexane:$CHCl_3$ = 1:1) to give **17** (12.4 mg, 6.3 μmol, 53%). **17**: colorless solids; Mp 227.0-229.0 ˚C; ^{1}H NMR (500 MHz, $CDCl_3$, 320 K) δ 1.05 (d, *J* = 6.8 Hz, 48H), 1.12 (d, *J* = 6.8 Hz, 48H), 1.48 (s, 3H, C*H*$_3$C(=O)NH), 2.77 (sept, *J* = 6.8 Hz, 16H), 4.26 (brs, 2H, C*H*$_2$Se), 5.27 (s, 1H, N*H*), 7.01(t, *J* =1.2 Hz, 4H), 7.18 (d, *J* = 7.8 Hz, 16H), 7.29-7.37 (m, 10H), 7.47 (d, *J* = 1.2 Hz),

7.62 (br, 4H), 7.88 (br, 2H); ^{13}C NMR (500 MHz, $CDCl_3$, 320 K) δ 21.2 (br, q), 24.2 (q), 24.3 (q), 30.5 (d), 34.8 (br, t), 122.6 (d, one doublet overlapped), 125.4 (br, d), 126.5 (d), 127.4 (d), 128.0 (d), 130.0 (d), 130.5 (d), 139.0 (s, one singlet overlapped), 140.2 (s), 141.3 (s), 141.7 (s), 142.6 (br, s), 146.8 (s), 170.6 (br, s, C=O); ^{77}Se NMR (95 MHz, $CDCl_3$, 320 K) δ 690.

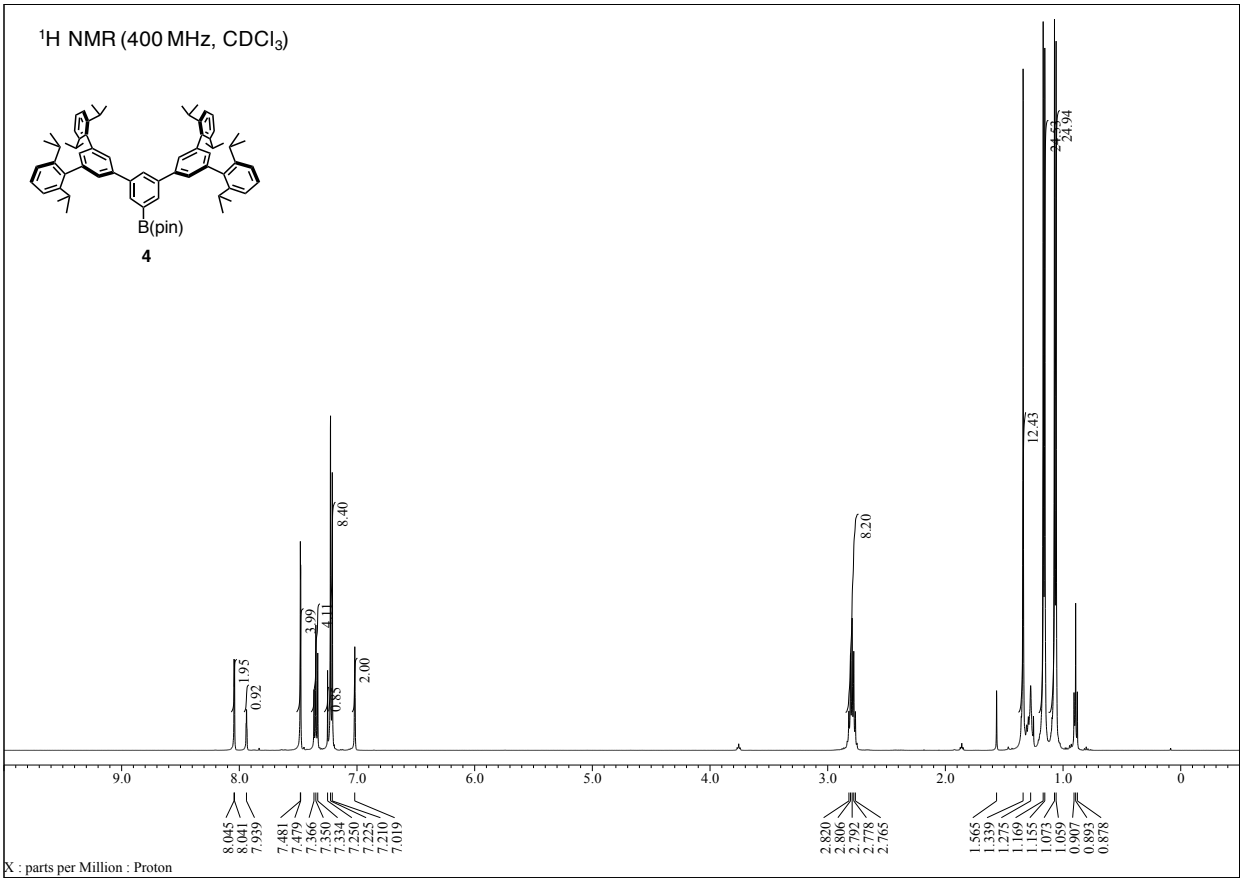
Reaction of 3 with benzylamine.

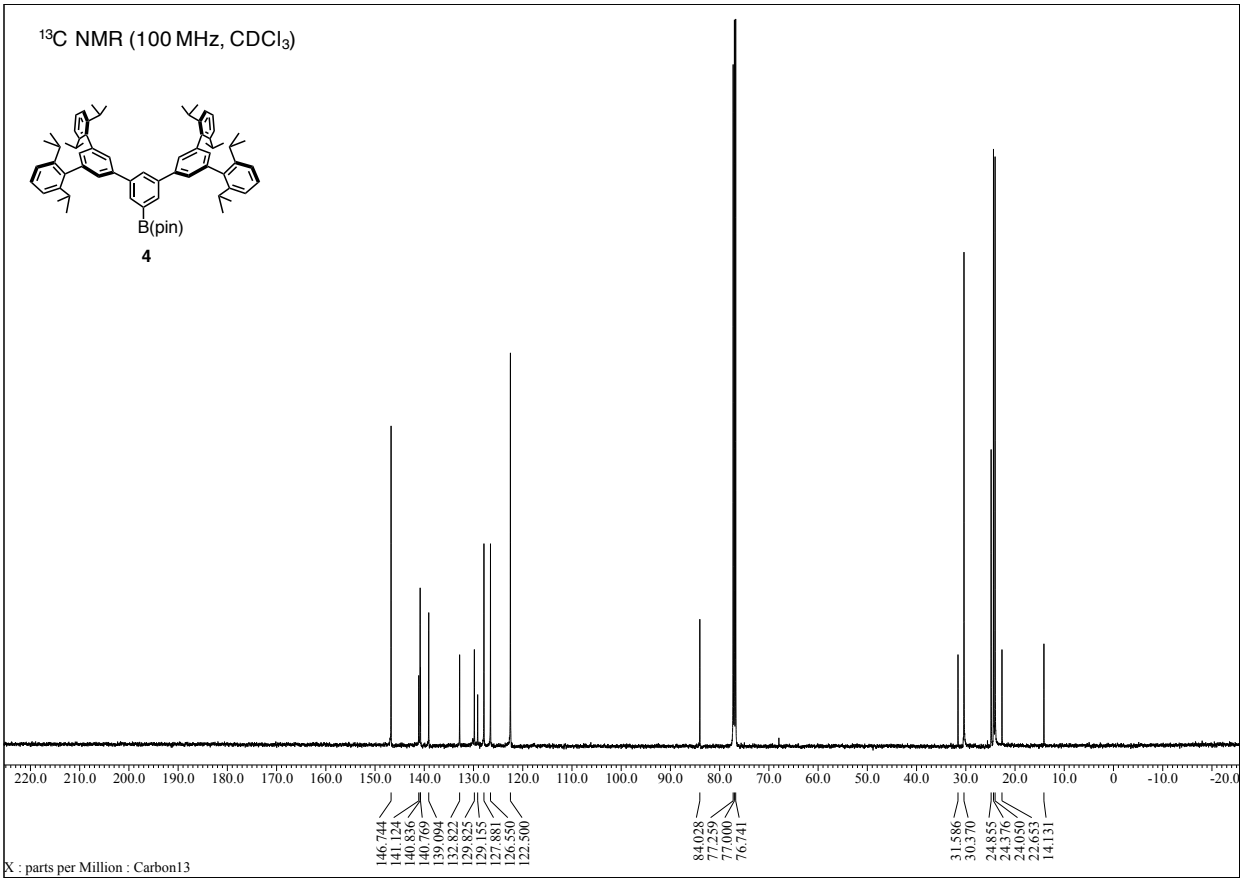


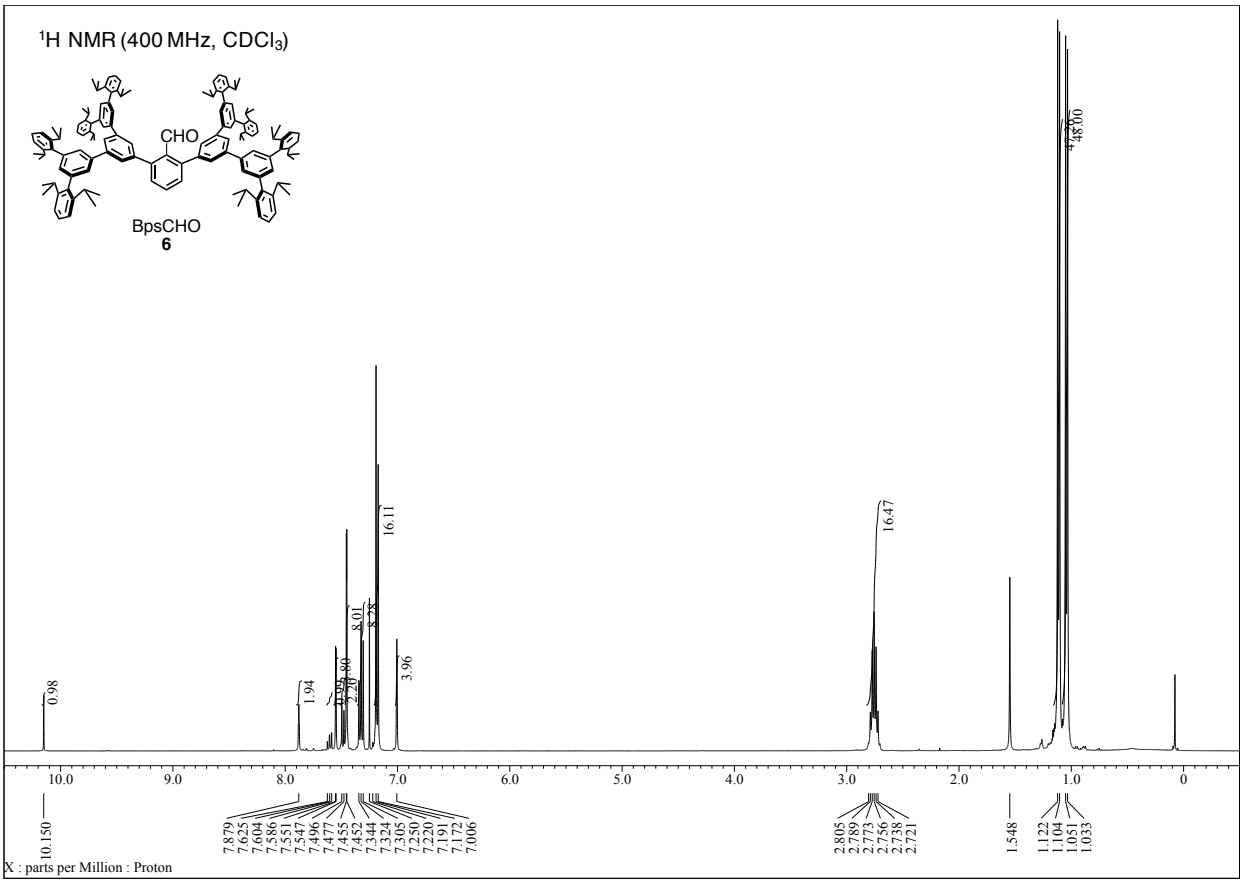
The reaction was carried out in an NMR tube with a J-young valve at room temperature. To a solution of **3** (8.2 mg, 4.3 μmol) in C_6D_6 (0.6 mL) was added benzylamine (6.0 μL, 55 μmol) and bis(trimethylsilyl)methane (1 drop, internal standard). The tube was carefully sealed, and the reaction was monitored by ^{1}H NMR spectroscopy. After 30 min, selenenamide **18** was formed quantitatively, which was confirmed by ^{1}H NMR measurement. Purification by PTLC was unsuccessful due to complete decomposition of **18**. Isolation of **18** was accomplished in another experiment through precipitation from $CHCl_3$/CH_3CN, where **18** (51.5 mg, 25.5 μmol, 68%) was obtained from **3** (72.6 mg, 37.7 μmol) and benzylamine (21 μL, 0.19 mmol).

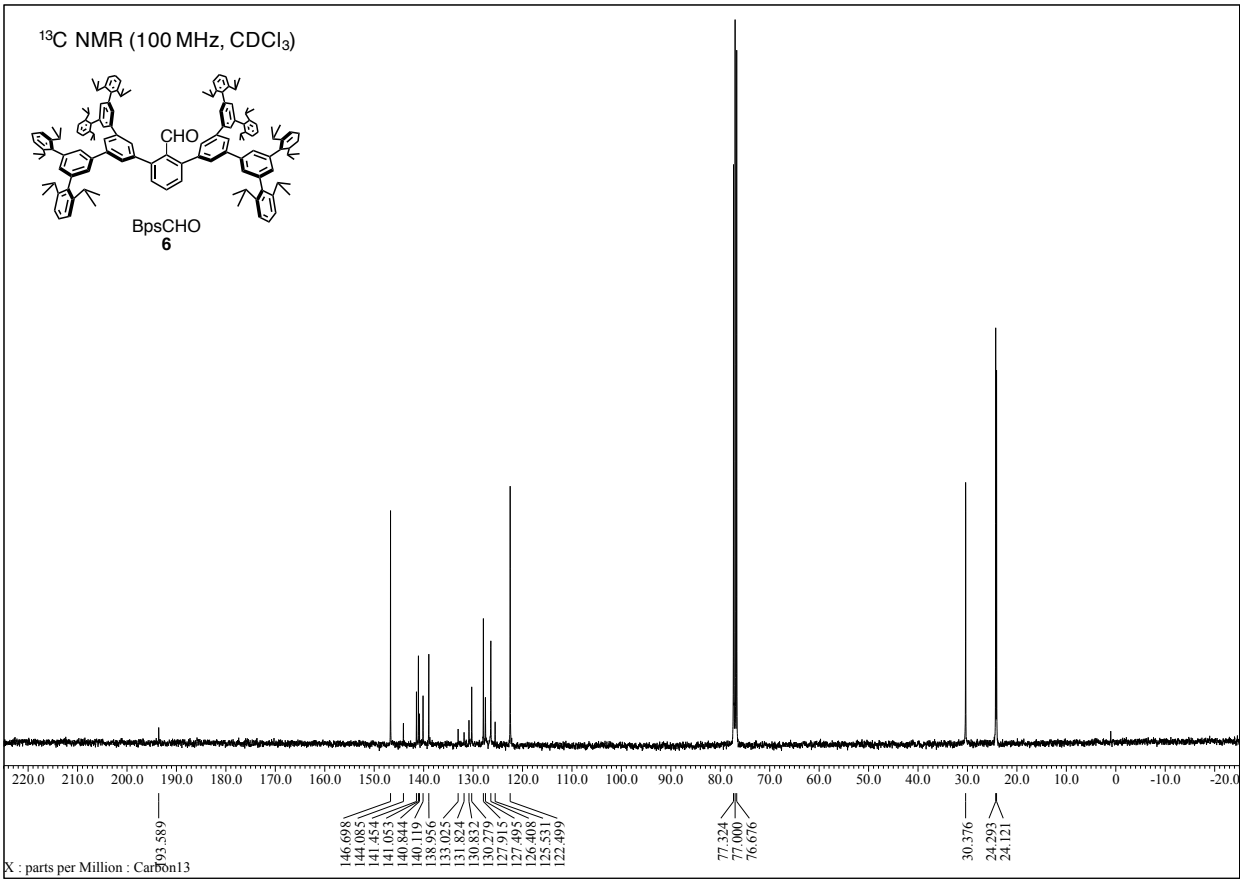
18: white crystals; Mp 226.5-228.0 °C; ^{1}H NMR (400 MHz, C_6D_6) δ 1.02 (d, J = 6.8 Hz, 48H), 1.07 (d, J = 6.8 Hz, 48H), 2.94 (sept, J =6.8 Hz, 16H), 3.50 (s, 2H), 3.66 (s, 2H), 6.73-6.75 (m, 3H), 6.80-6.92 (m, 5H), 7.04 (t, J =1.5 Hz, 4H), 7.13 (d, J = 7.6 Hz, 16H), 7.28 (t, J =7.6 Hz, 8H), 7.63 (d, J = 1.5 Hz, 8H), 7.82 (d, J = 1.6 Hz, 4H), 8.00 (t, J =1.6 Hz); ^{13}C NMR (100 MHz, C_6D_6) δ 24.1 (q), 24.3 (q), 30.6 (d), 58.8 (t), 86.7 (t), 122.7 (d), 125.4 (d), 126.3 (s), 126.9 (d), 127.8 (d), 128.0 (d), 128.2 (d), 128.3 (d), 128.5 (d), 129.8 (d), 130.7 (d), 134.0 (d), 139.2 (s), 140.9 (s), 141.3 (s), 141.7 (s), 141.9 (s), 142.8 (s), 142.9 (s), 146.7 (s); ^{77}Se NMR (95 MHz, C_6D_6) δ 709.

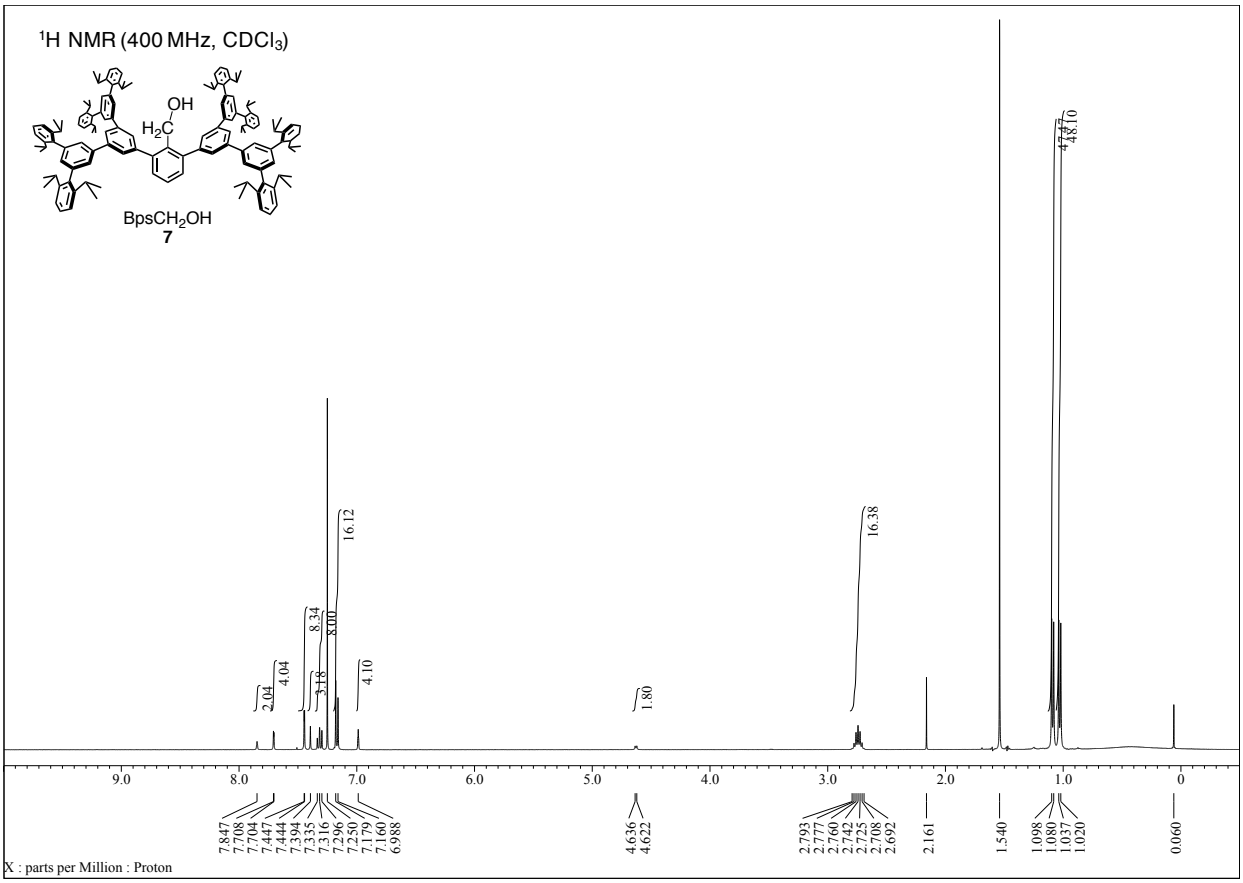
2. NMR data

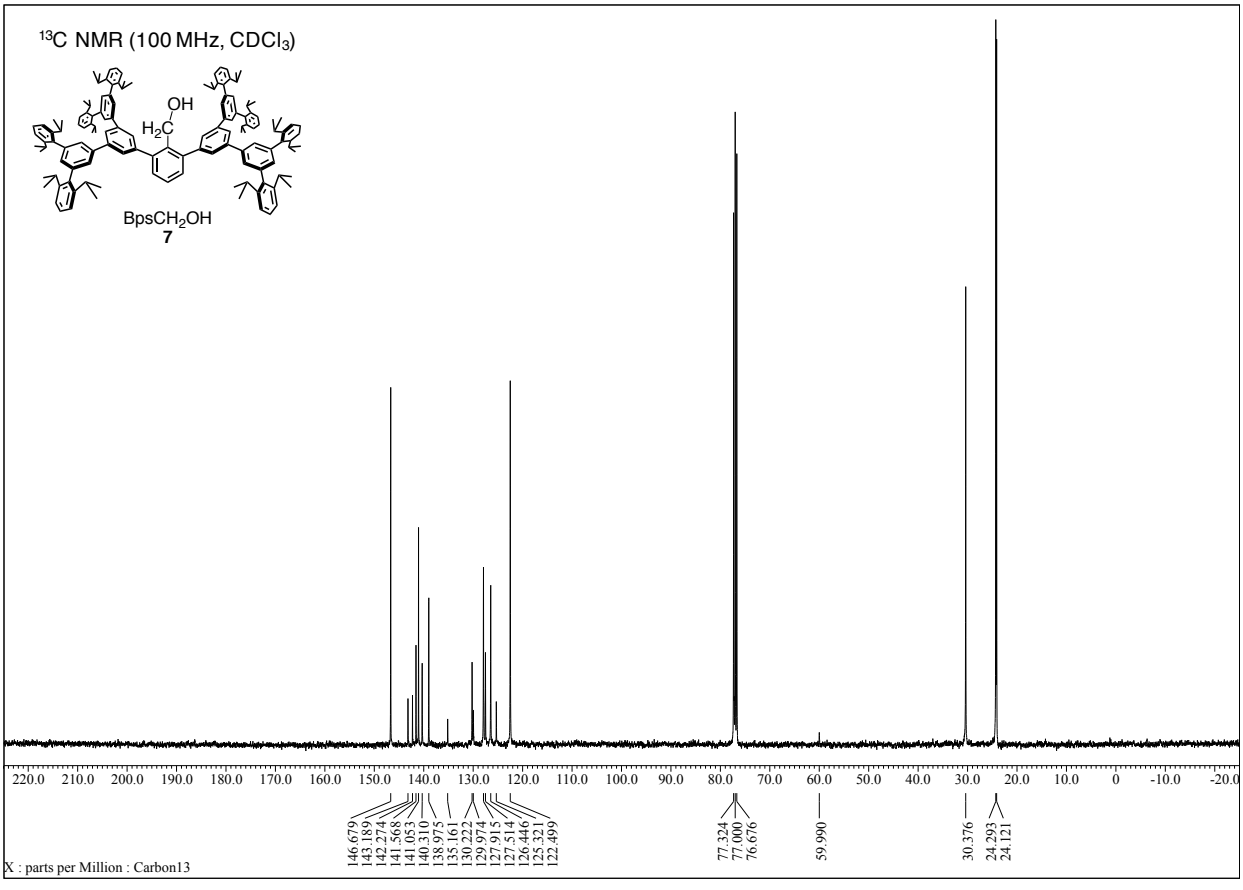

^{1}H NMR (400 MHz, $CDCl_3$)
B(pin)
4
12.43
8.40
8.20
3.99
4.11
1.95
0.92
0.85
2.00
24.94
8.045
8.041
7.939
7.481
7.479
7.366
7.350
7.334
7.250
7.225
7.210
7.019
2.820
2.806
2.792
2.778
2.765
1.565
1.339
1.275
1.169
1.155
1.073
1.059
0.907
0.893
0.878
X : parts per Million : Proton

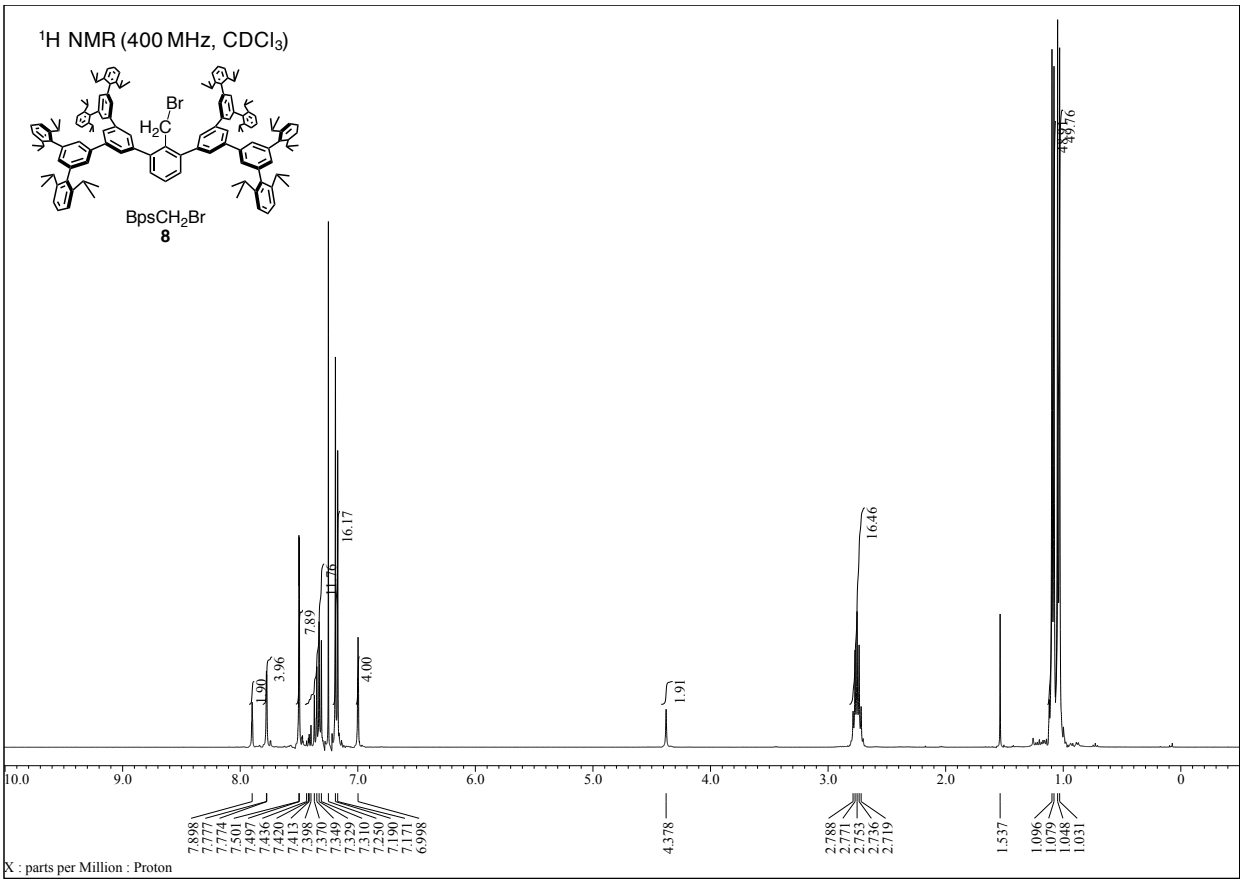

^{13}C NMR (100 MHz, $CDCl_3$)
B(pin)
4
146.744
141.124
140.836
140.769
139.094
132.822
129.825
129.155
127.881
126.550
122.500
84.028
77.259
77.000
76.741
31.586
30.370
24.855
24.376
24.050
22.653
14.131
X : parts per Million : Carbon13

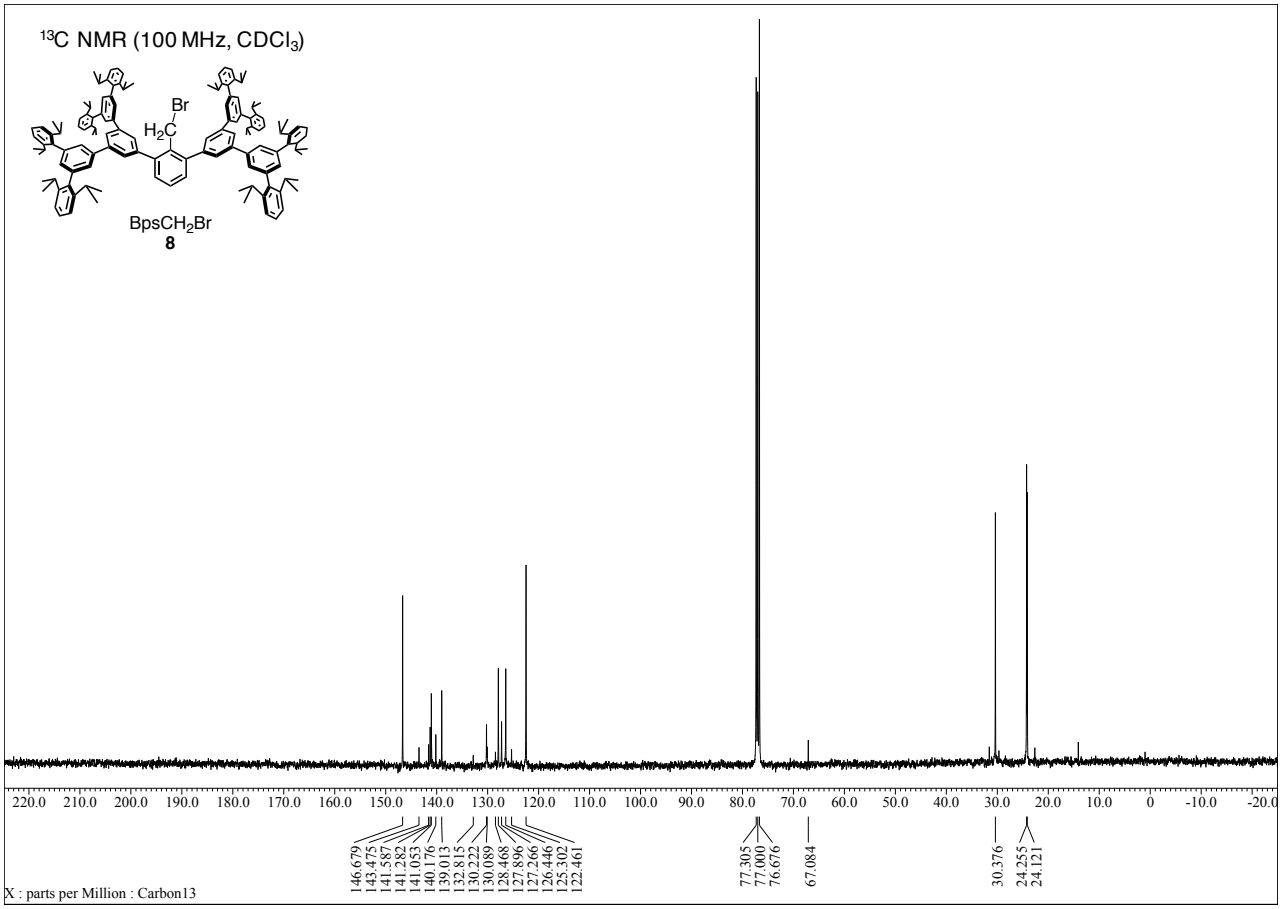

^{1}H NMR (400 MHz, $CDCl_3$)
CHO
BpsCHO
6
0.98
1.94
3.96
8.01
8.28
16.11
16.47
48.00
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
10.150
7.879
7.625
7.604
7.586
7.551
7.547
7.496
7.477
7.455
7.452
7.344
7.324
7.305
7.250
7.220
7.191
7.172
7.006
2.805
2.789
2.773
2.756
2.738
2.721
1.548
1.122
1.104
1.051
1.033
X : parts per Million : Proton

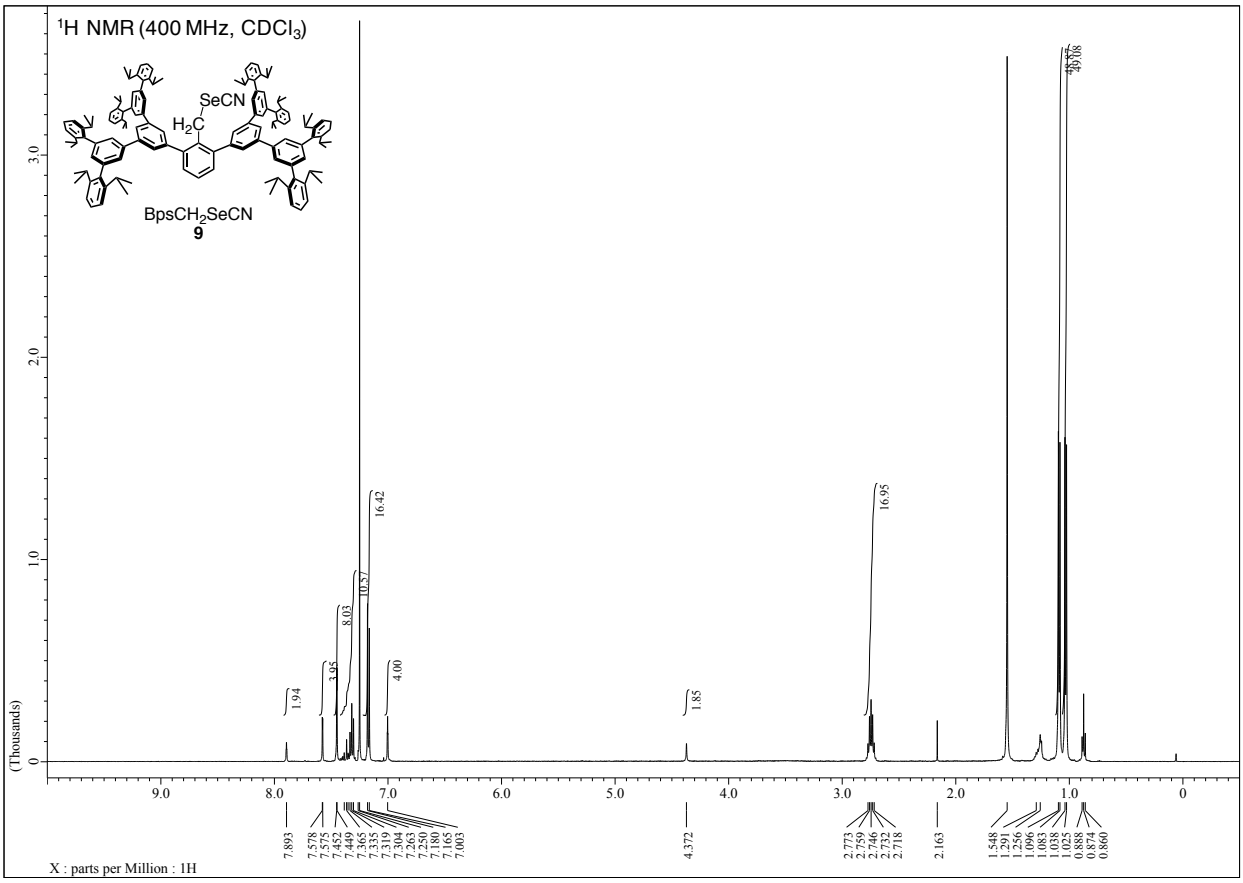

^{13}C NMR (100 MHz, $CDCl_3$)
CHO
BpsCHO
6
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
-10.0
-20.0
193.589
146.698
144.085
141.454
141.053
140.844
140.119
138.956
133.025
131.824
130.832
130.279
127.915
127.495
126.408
125.531
122.499
77.324
77.000
76.676
30.376
24.293
24.121
X : parts per Million : Carbon13

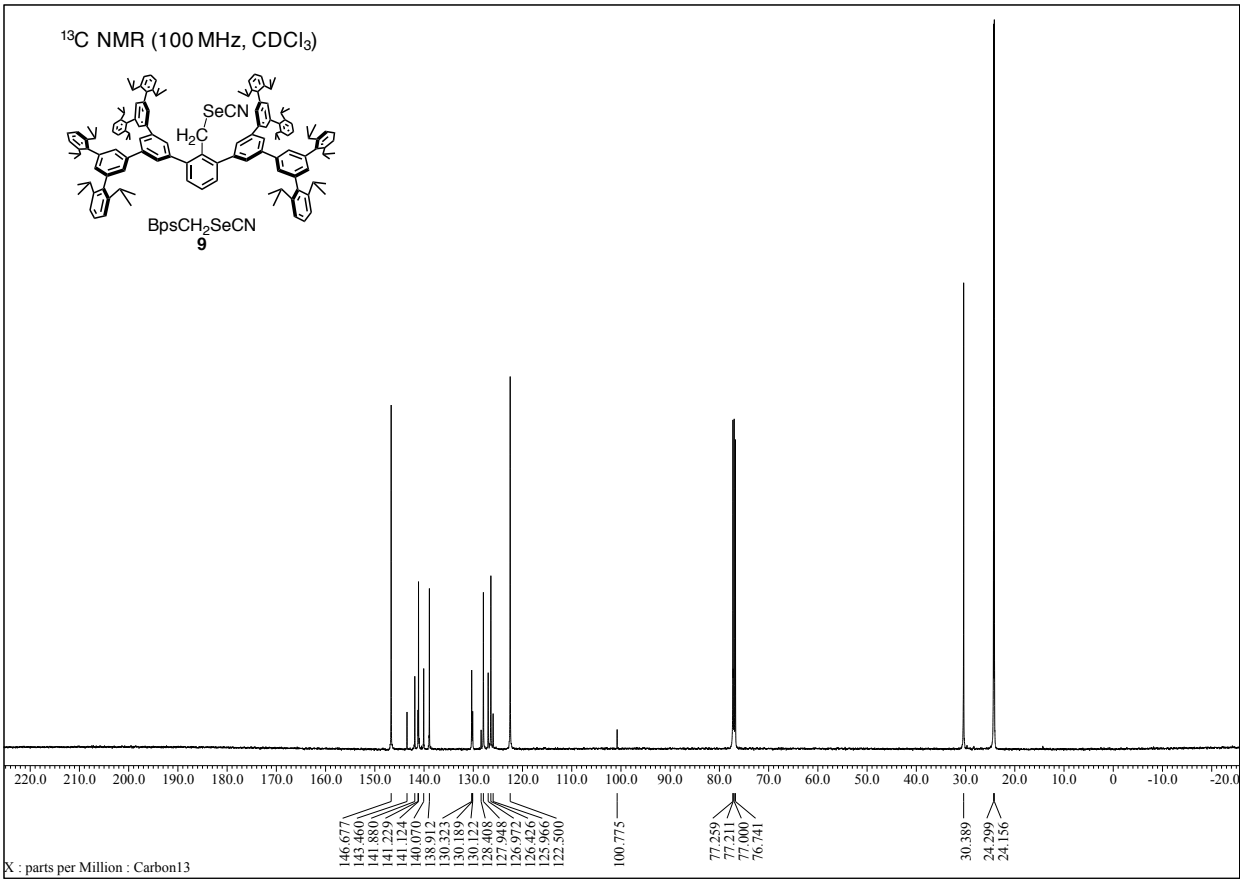

^{1}H NMR (400 MHz, $CDCl_3$)
OH
H_2C
$BpsCH_2OH$
7
2.04
4.04
3.18
8.34
8.00
16.12
4.10
1.80
16.38
47.37
48.10
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.847
7.708
7.704
7.447
7.444
7.344
7.335
7.316
7.296
7.250
7.179
7.160
6.988
4.636
4.622
2.793
2.777
2.760
2.742
2.725
2.708
2.692
2.161
1.540
1.098
1.080
1.057
1.020
0.060
X : parts per Million : Proton

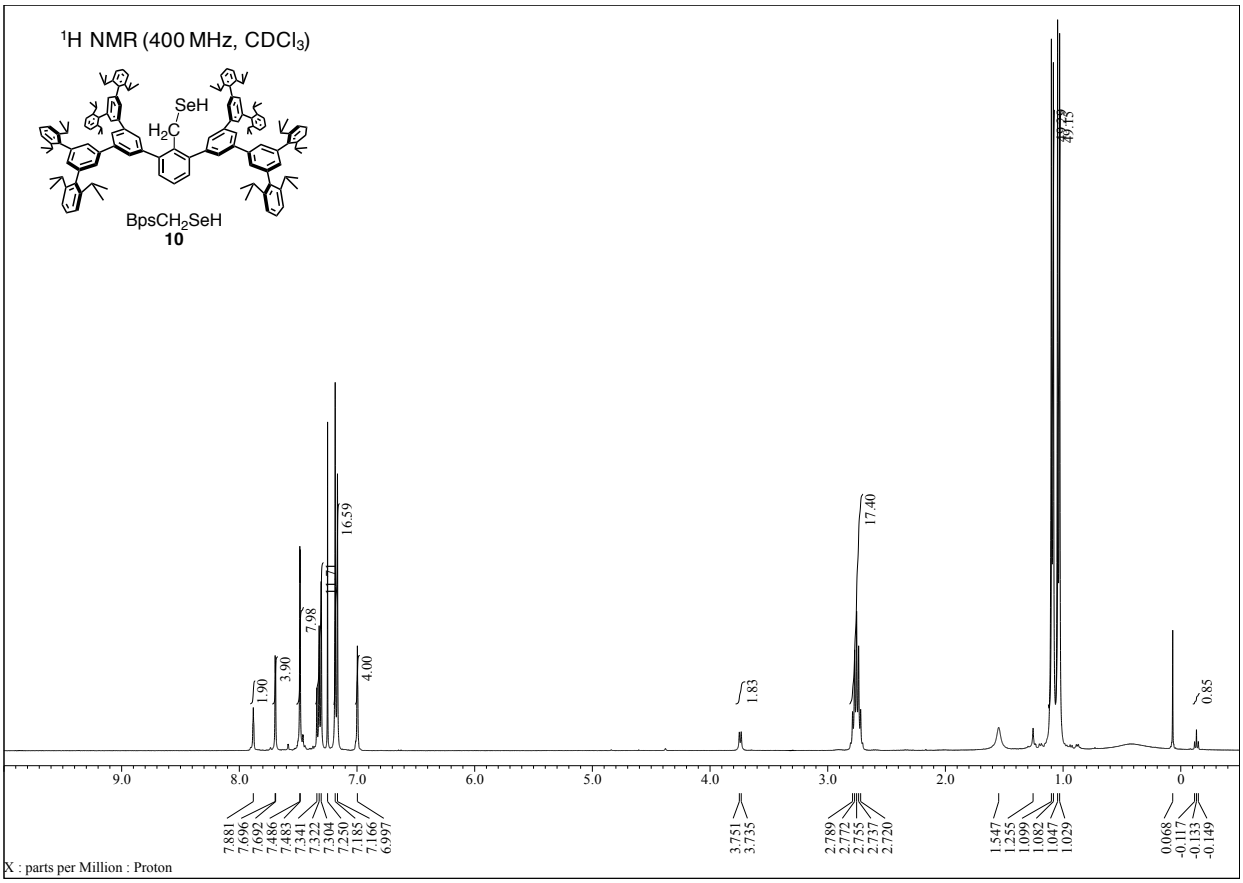

^{13}C NMR (100 MHz, $CDCl_3$)
OH
H_2C
$BpsCH_2OH$
7
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
-10.0
-20.0
146.679
143.189
142.274
141.568
141.053
140.310
138.975
135.161
130.222
129.974
127.915
127.514
126.446
125.321
122.499
77.324
77.000
76.676
59.990
30.376
24.293
24.121
X : parts per Million : Carbon13

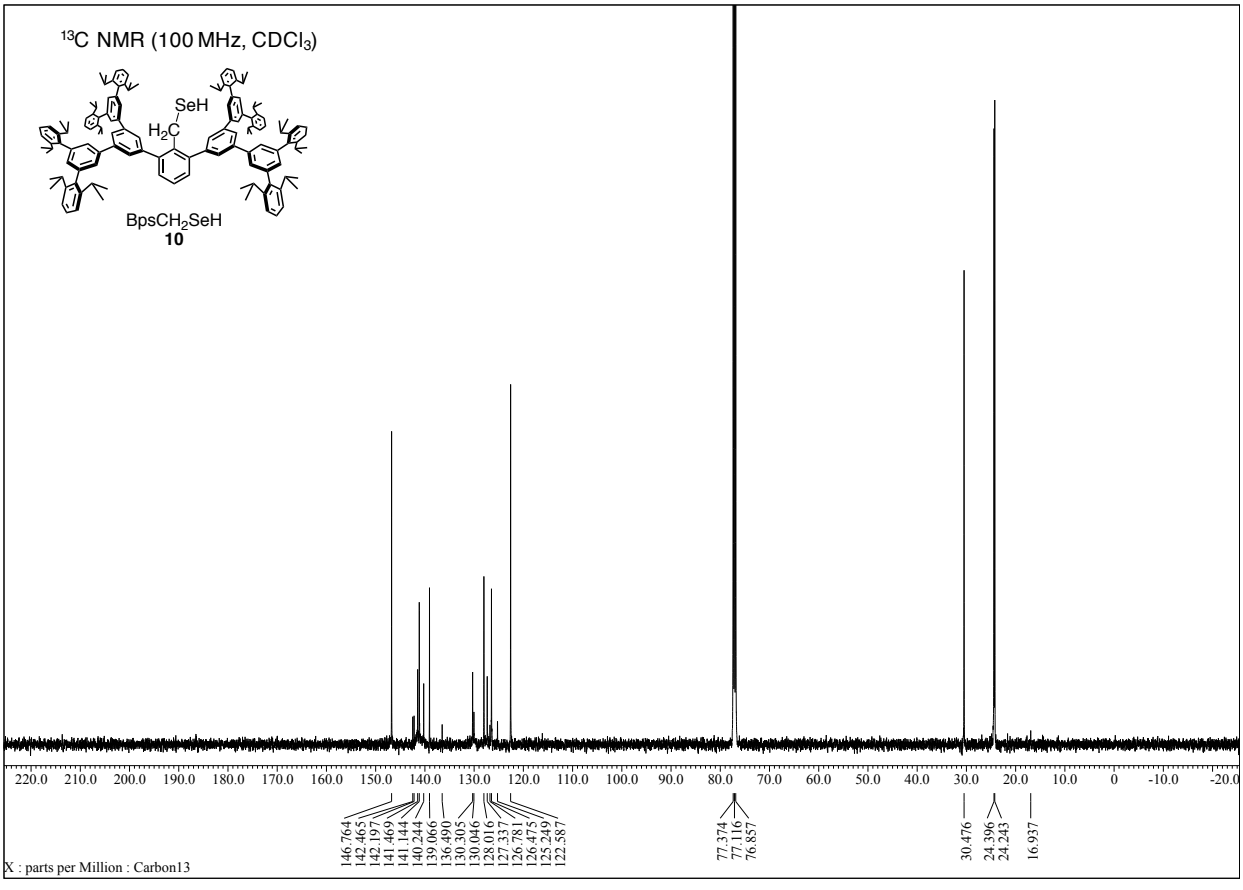

^{1}H NMR (400 MHz, CDCl$_3$)
Br
H$_2$C
BpsCH$_2$Br
8
1.90
3.96
7.89
11.76
16.17
4.00
1.91
16.46
49.76
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.898
7.777
7.774
7.501
7.497
7.436
7.420
7.413
7.398
7.370
7.349
7.329
7.310
7.250
7.190
7.171
6.998
4.378
2.788
2.771
2.753
2.736
2.719
1.537
1.096
1.079
1.048
1.031
X : parts per Million : Proton

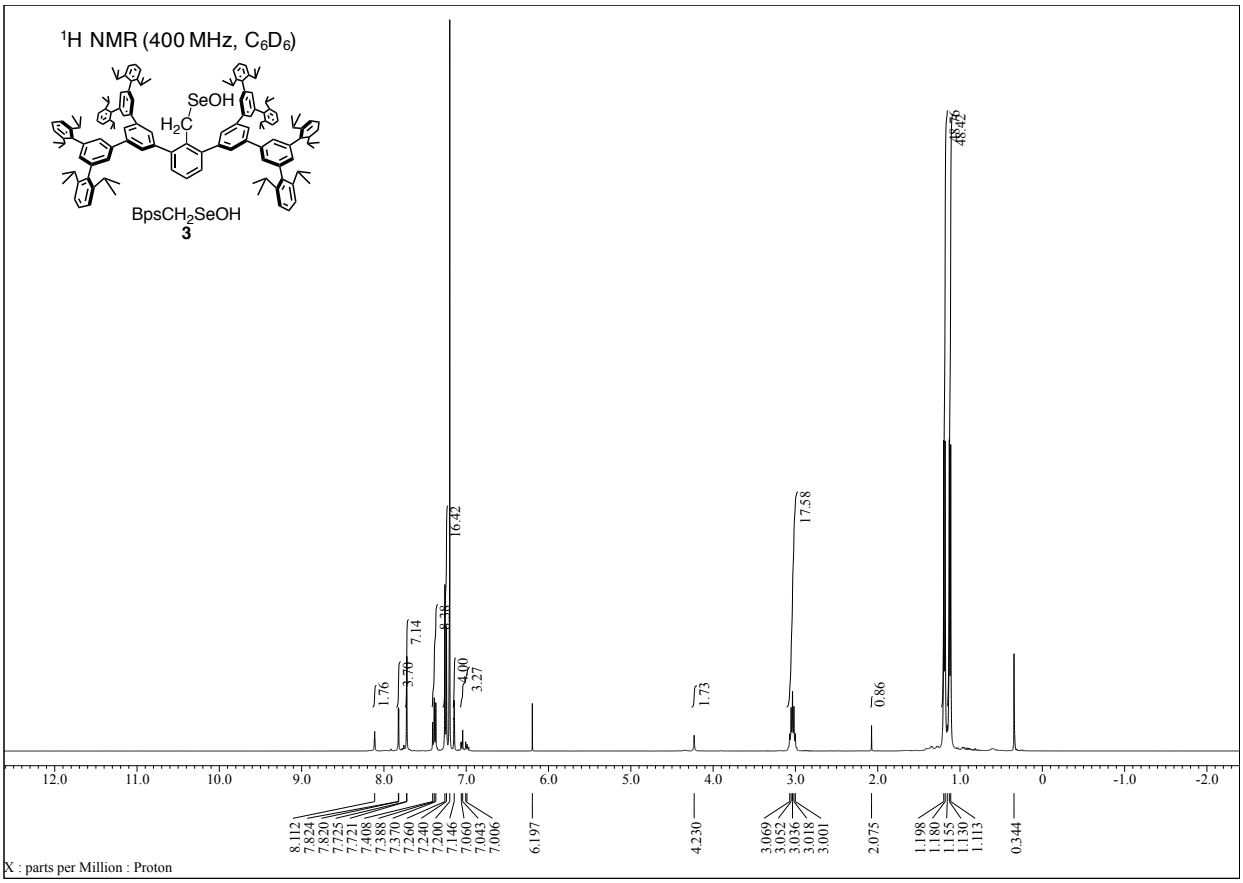

^{13}C NMR (100 MHz, CDCl$_3$)
Br
H$_2$C
BpsCH$_2$Br
8
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
-10.0
-20.0
146.679
143.475
141.587
141.282
141.053
140.176
139.013
132.815
130.222
130.089
128.468
127.896
127.266
126.446
125.302
122.461
77.305
77.000
76.676
67.084
30.376
24.255
24.121
X : parts per Million : Carbon13

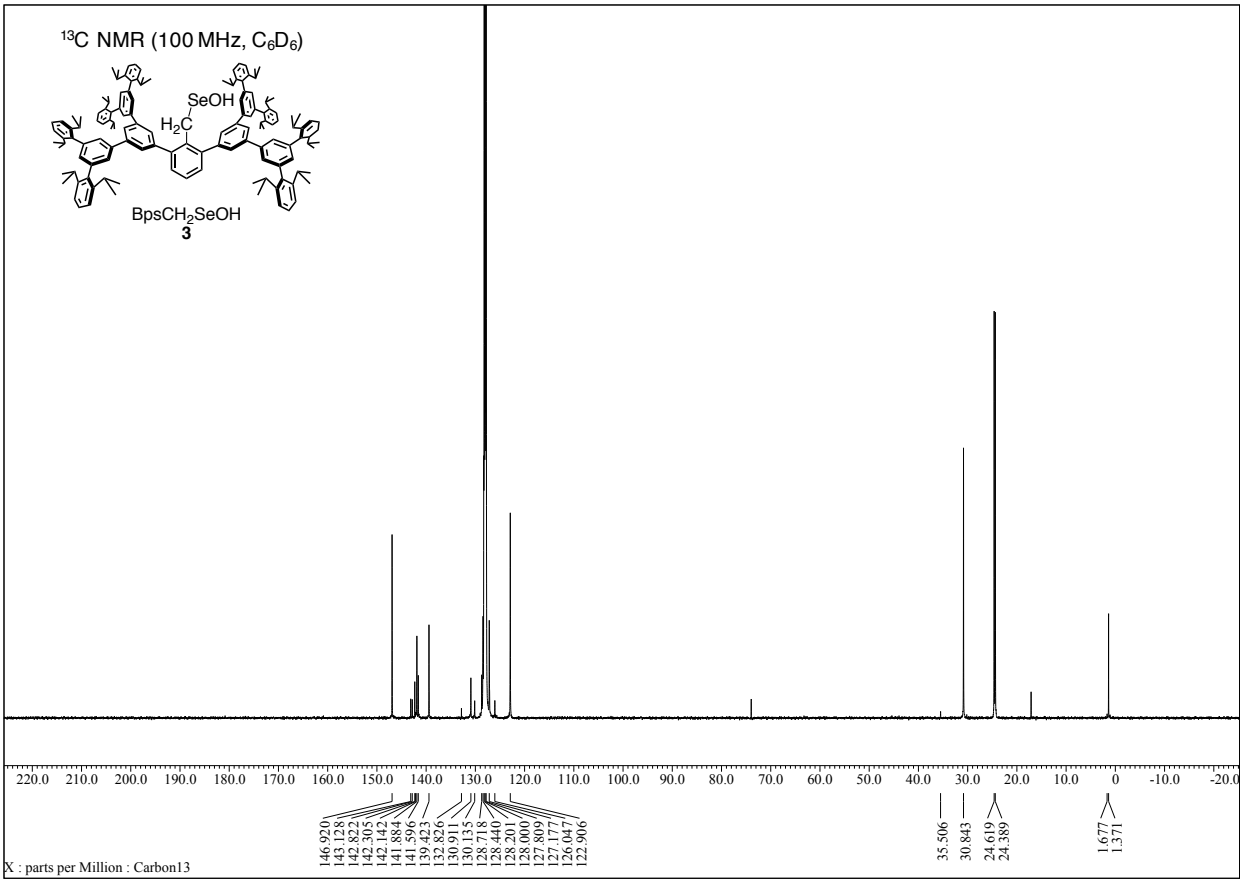

^{1}H NMR (400 MHz, $CDCl_3$)
SeCN
H_2C
$BpsCH_2SeCN$
9
(Thousands)
X : parts per Million : 1H

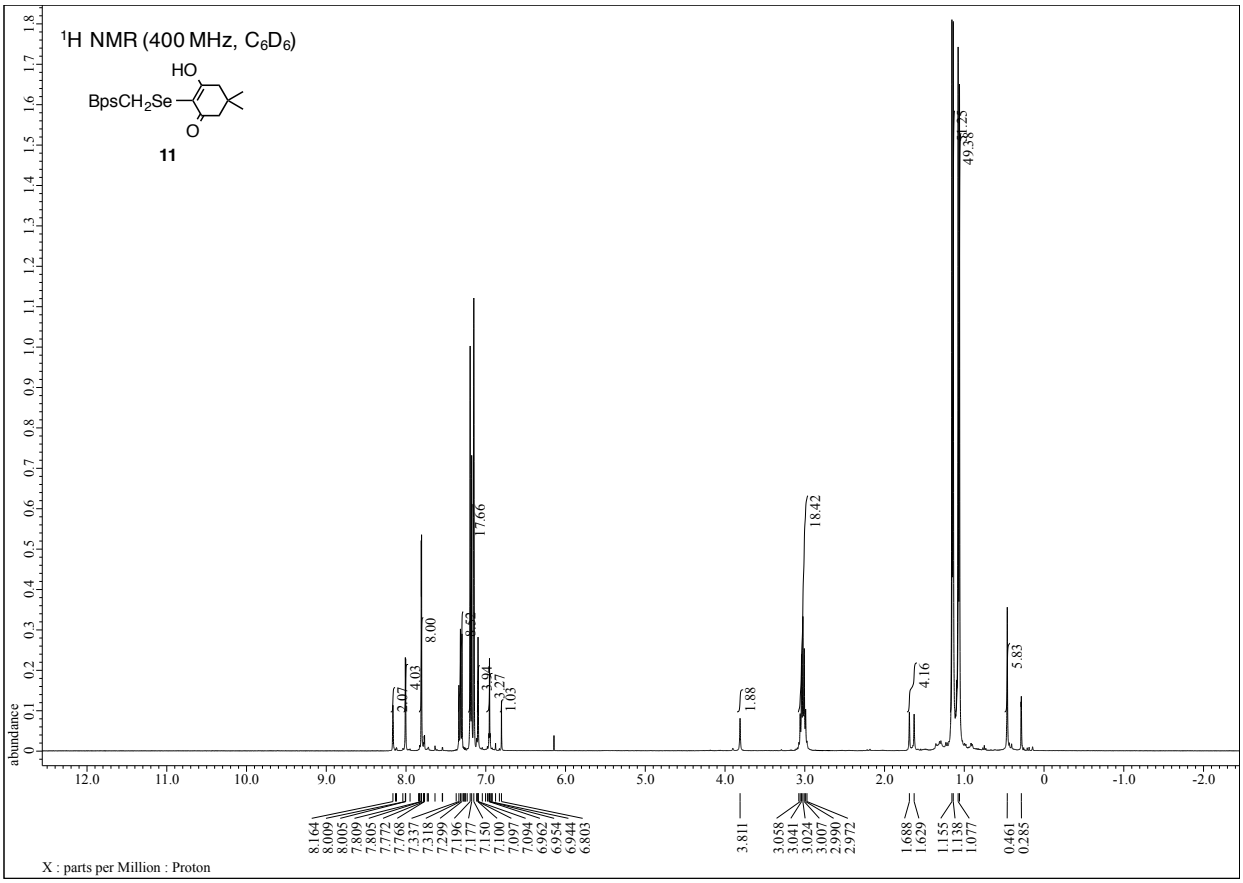

^{13}C NMR (100 MHz, $CDCl_3$)
SeCN
H_2C
$BpsCH_2SeCN$
9
X : parts per Million : Carbon13

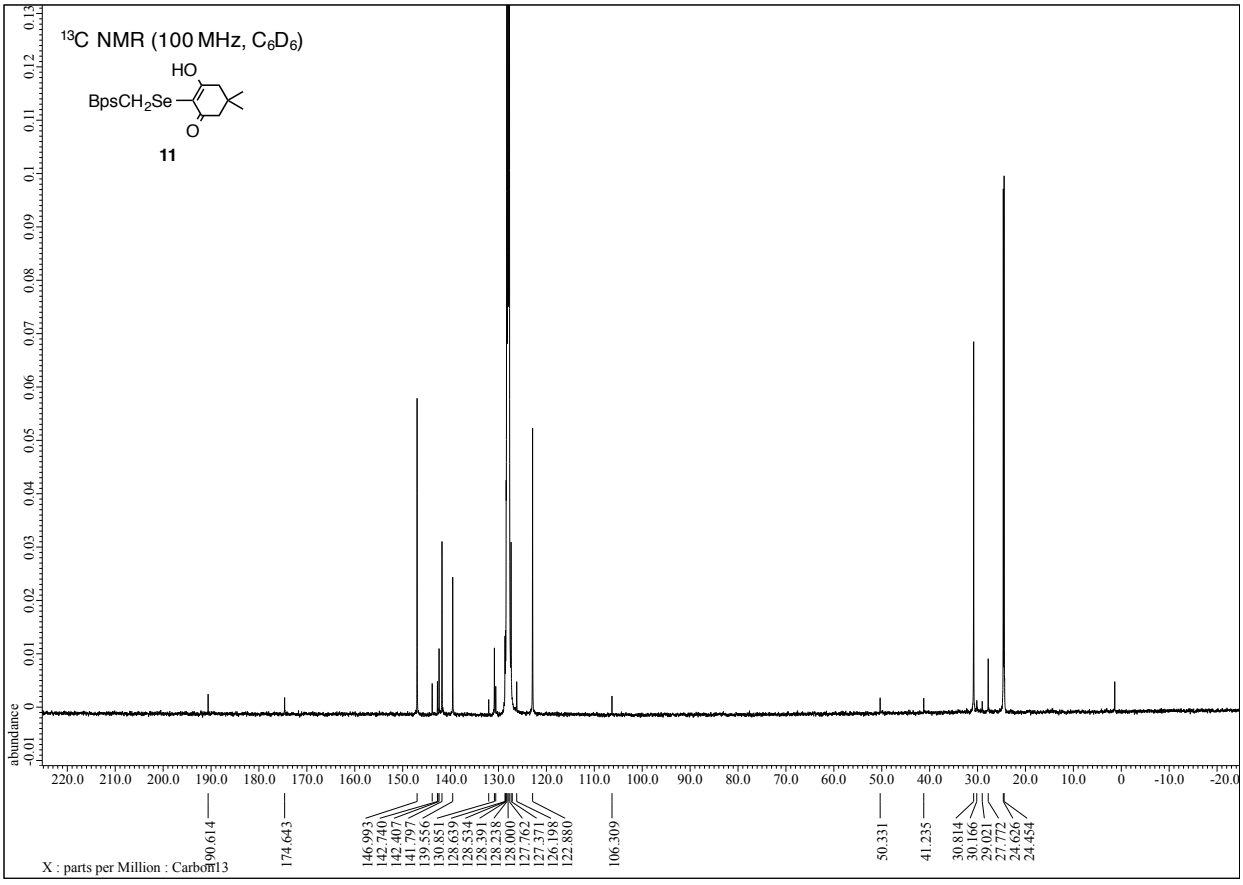

^{1}H NMR (400 MHz, $CDCl_3$)
SeH
H_2C
$BpsCH_2SeH$
10
1.90
3.90
7.98
11.71
16.59
4.00
1.83
17.40
49.73
0.85
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.881
7.696
7.692
7.486
7.483
7.341
7.322
7.304
7.250
7.185
7.166
6.997
3.751
3.735
2.789
2.772
2.755
2.737
2.720
1.547
1.255
1.099
1.082
1.047
1.029
0.068
-0.117
-0.133
-0.149
X : parts per Million : Proton

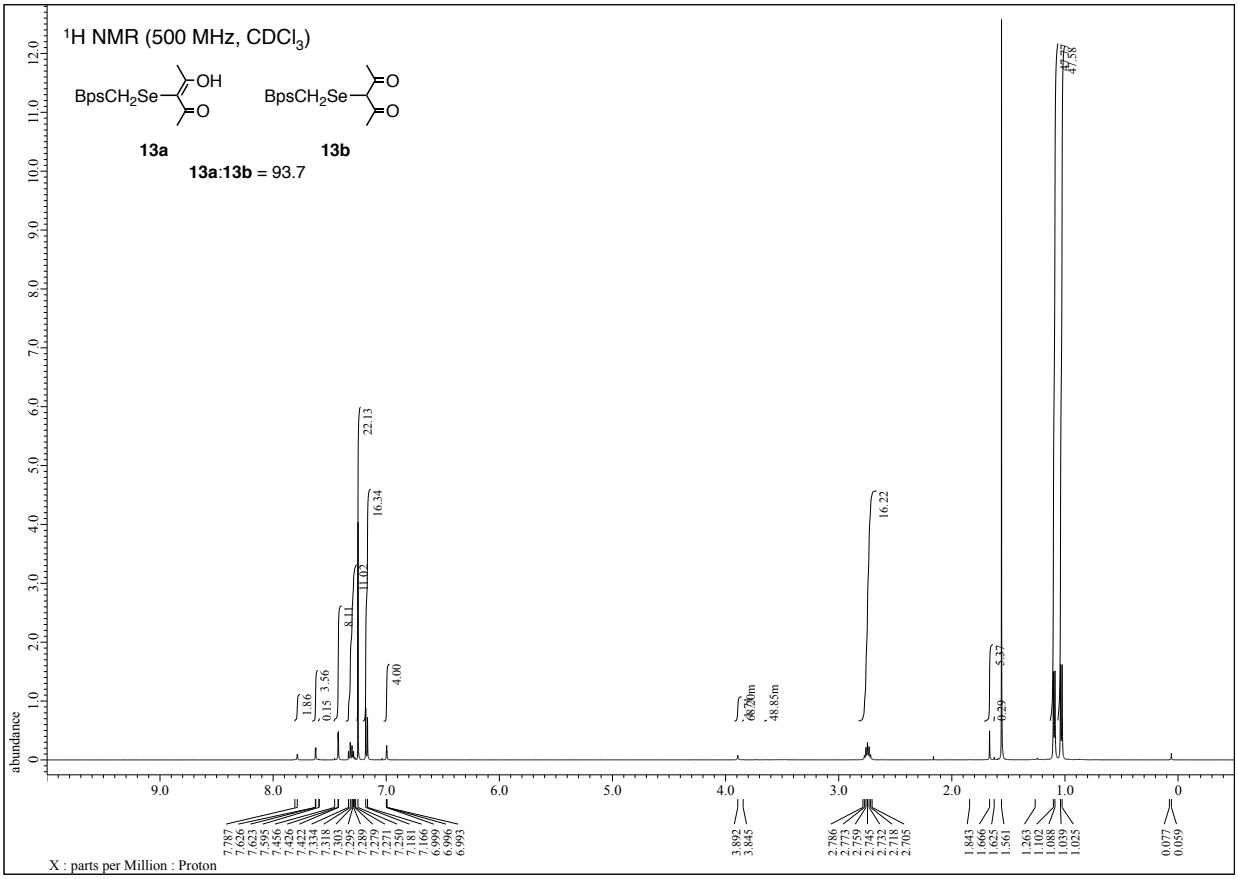

^{13}C NMR (100 MHz, $CDCl_3$)
SeH
H_2C
$BpsCH_2SeH$
10
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
-10.0
-20.0
146.764
142.465
142.197
141.469
141.144
140.244
139.066
136.490
130.305
130.046
128.016
127.337
126.781
126.475
125.249
122.587
77.374
77.116
76.857
30.476
24.396
24.243
16.937
X : parts per Million : Carbon13

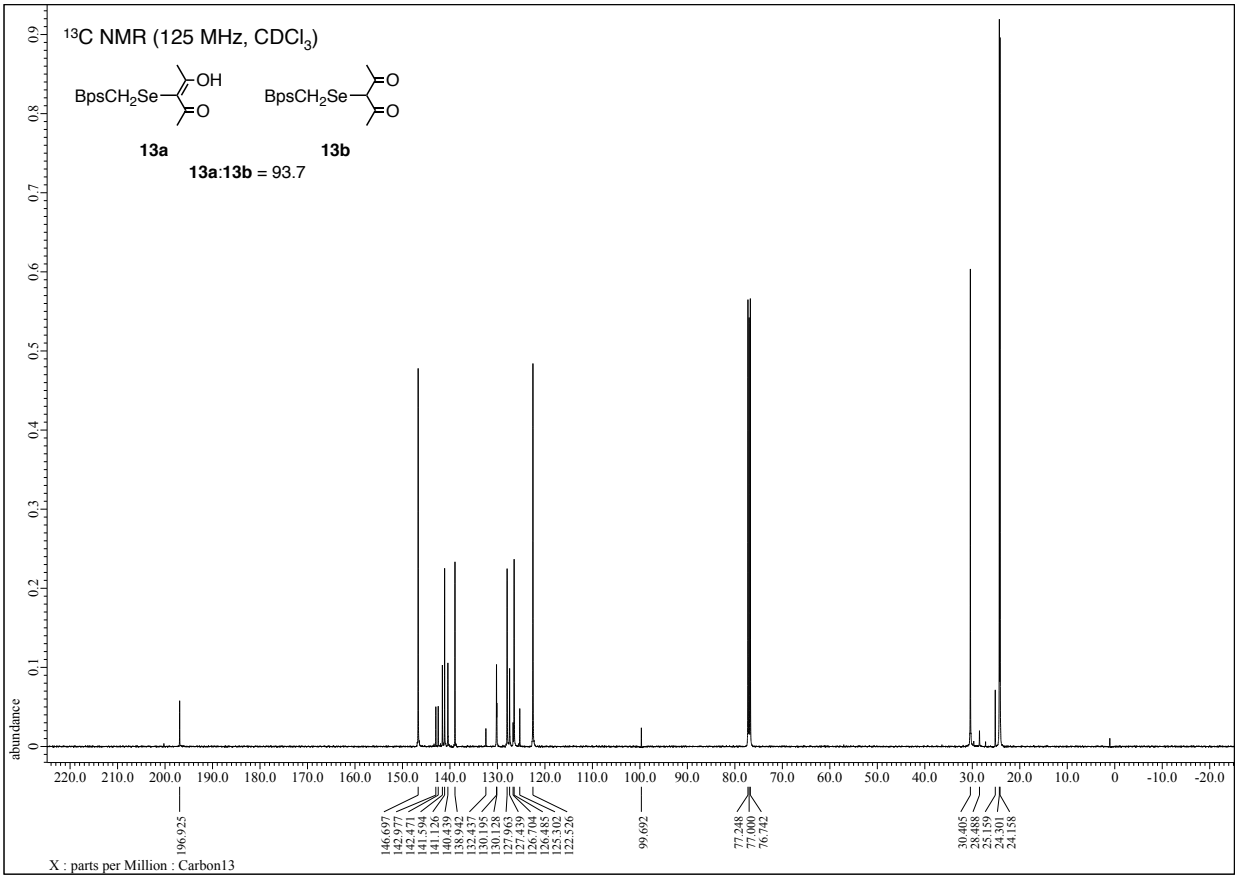

^{1}H NMR (400 MHz, C_6D_6)
SeOH
H_2C
$BpsCH_2SeOH$
3
1.76
3.70
7.14
8.38
16.42
4.00
3.27
1.73
17.58
0.86
48.42
48.76
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
8.112
7.824
7.620
7.525
7.721
7.408
7.388
7.370
7.260
7.240
7.200
7.146
7.060
7.043
7.006
6.197
4.230
3.069
3.052
3.036
3.018
3.001
2.075
1.198
1.180
1.155
1.130
1.113
0.344
X : parts per Million : Proton

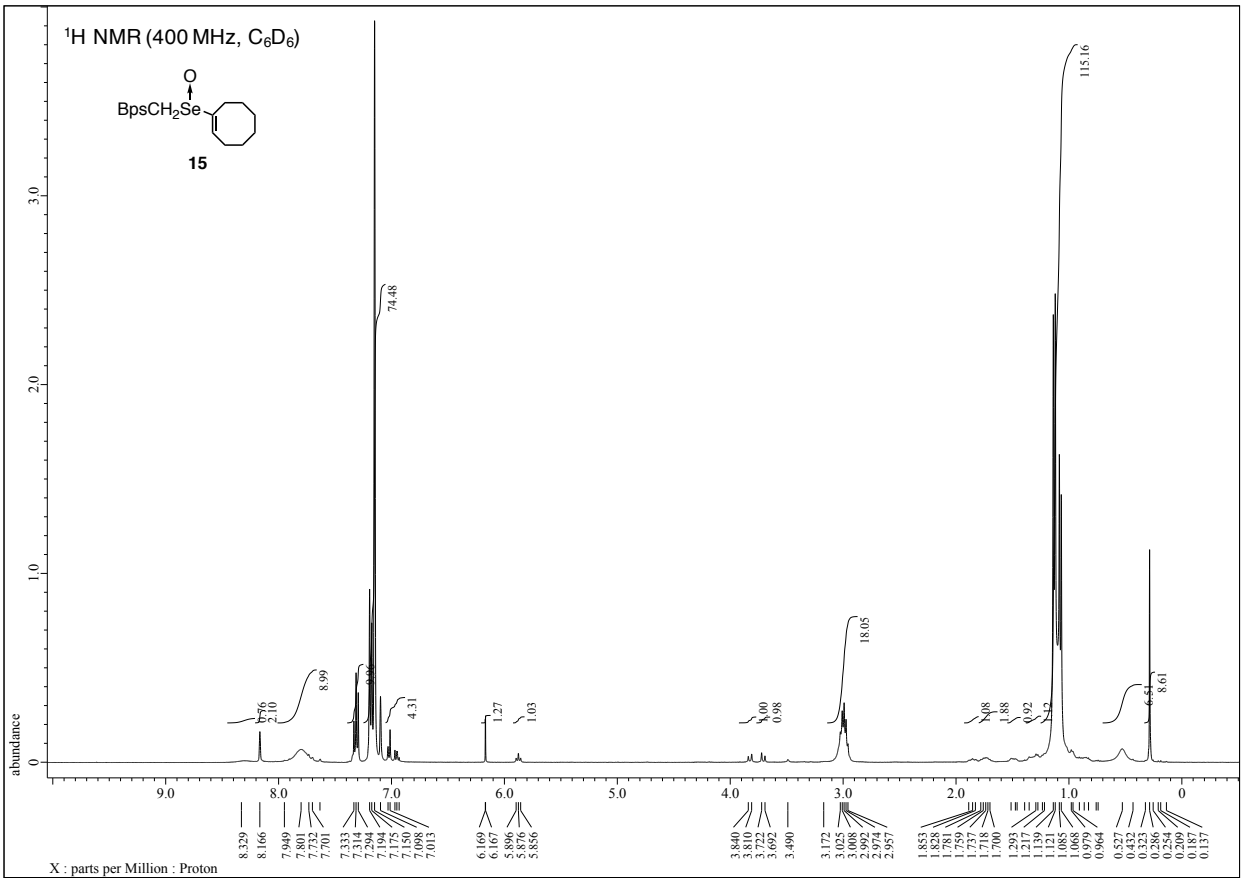

^{13}C NMR (100 MHz, C_6D_6)
SeOH
H_2C
$BpsCH_2SeOH$
3
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
-10.0
-20.0
146.920
143.128
142.822
142.305
142.142
141.884
141.596
139.423
132.826
130.911
130.135
128.718
128.440
128.201
128.000
127.809
127.177
126.047
122.906
35.506
30.843
24.619
24.389
1.677
1.371
X : parts per Million : Carbon13

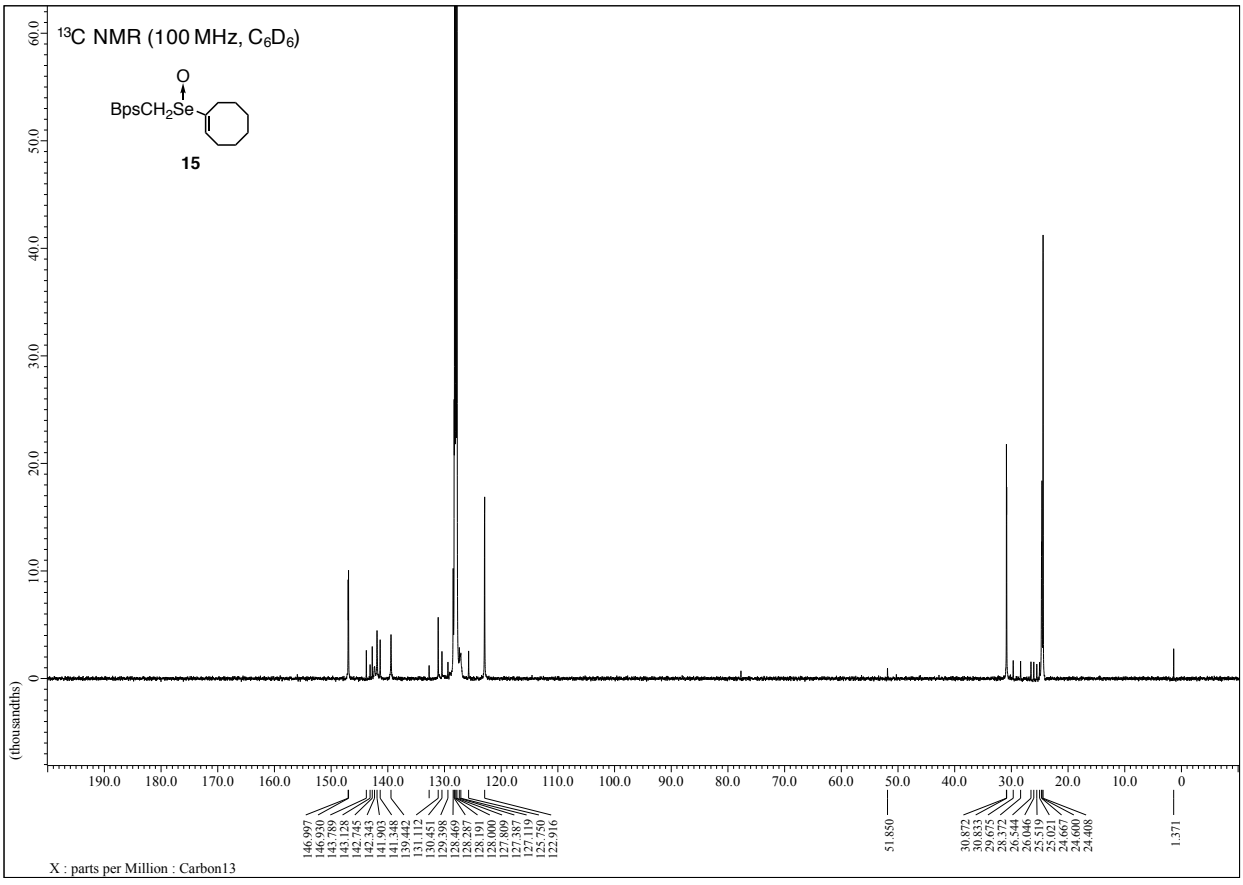

^{1}H NMR (400 MHz, C_6D_6)
HO
BpsCH$_2$Se
O
11
abundance
X : parts per Million : Proton

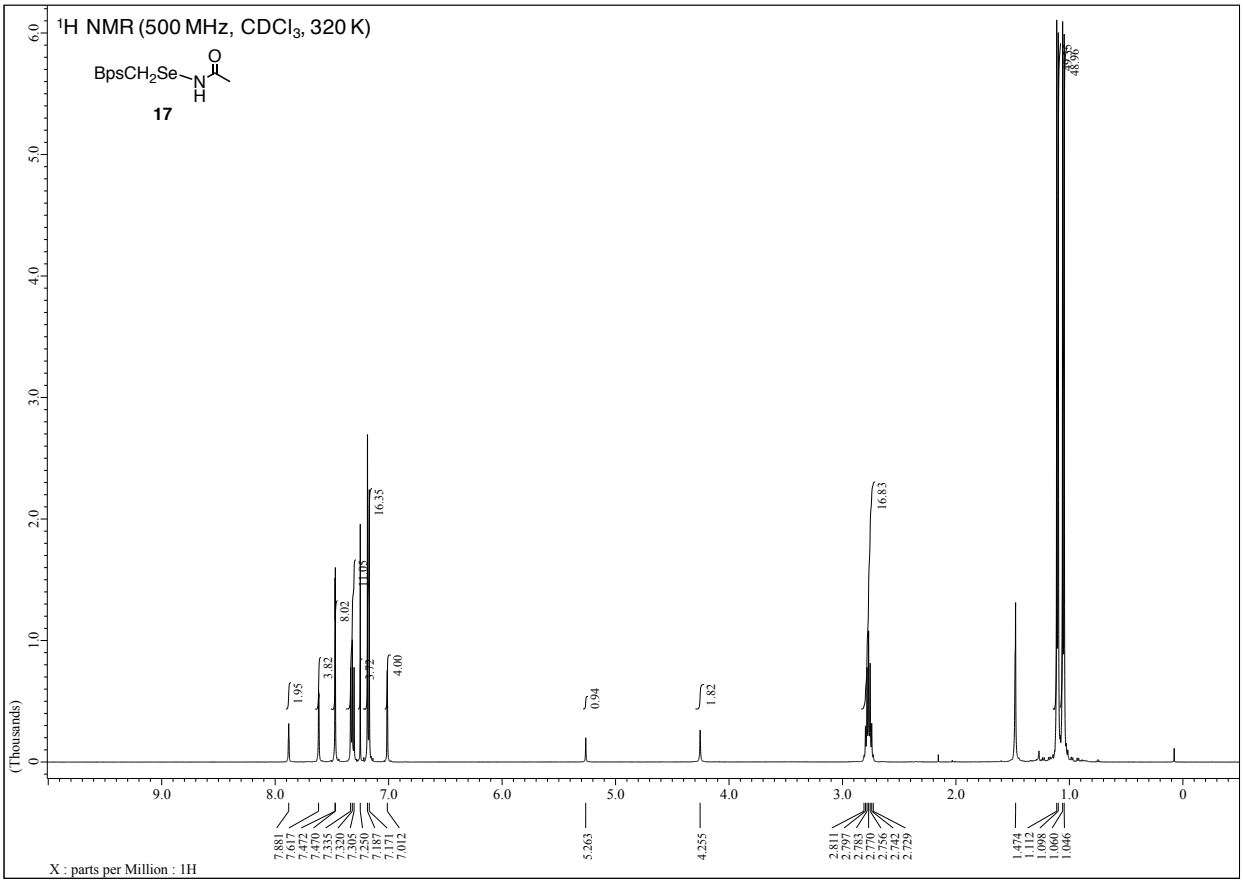

^{13}C NMR (100 MHz, C_6D_6)
HO
BpsCH$_2$Se
O
11
abundance
X : parts per Million : Carbon13

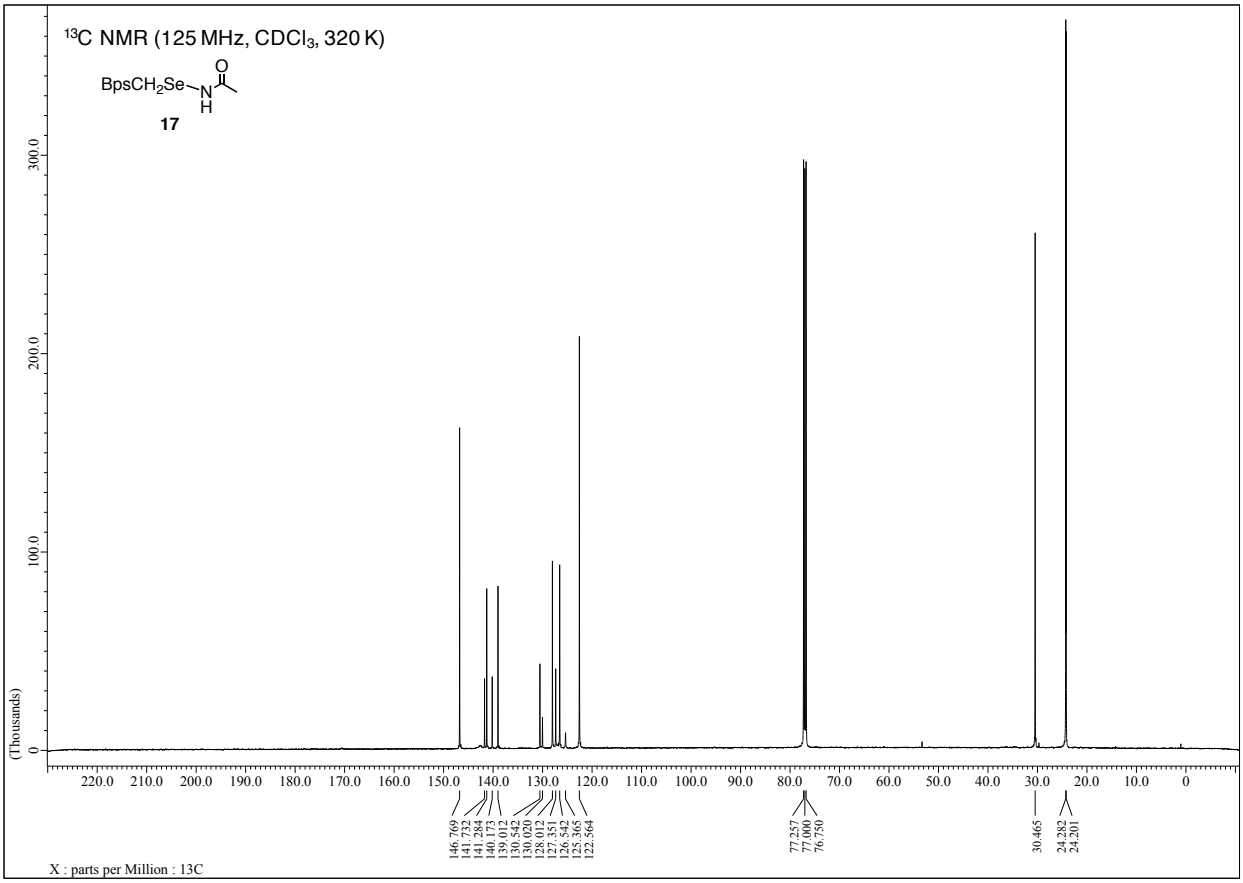

^{1}H NMR (500 MHz, $CDCl_3$)
BpsCH2Se
OH
O
13a
BpsCH2Se
O
O
13b
13a:13b = 93.7
abundance
X : parts per Million : Proton

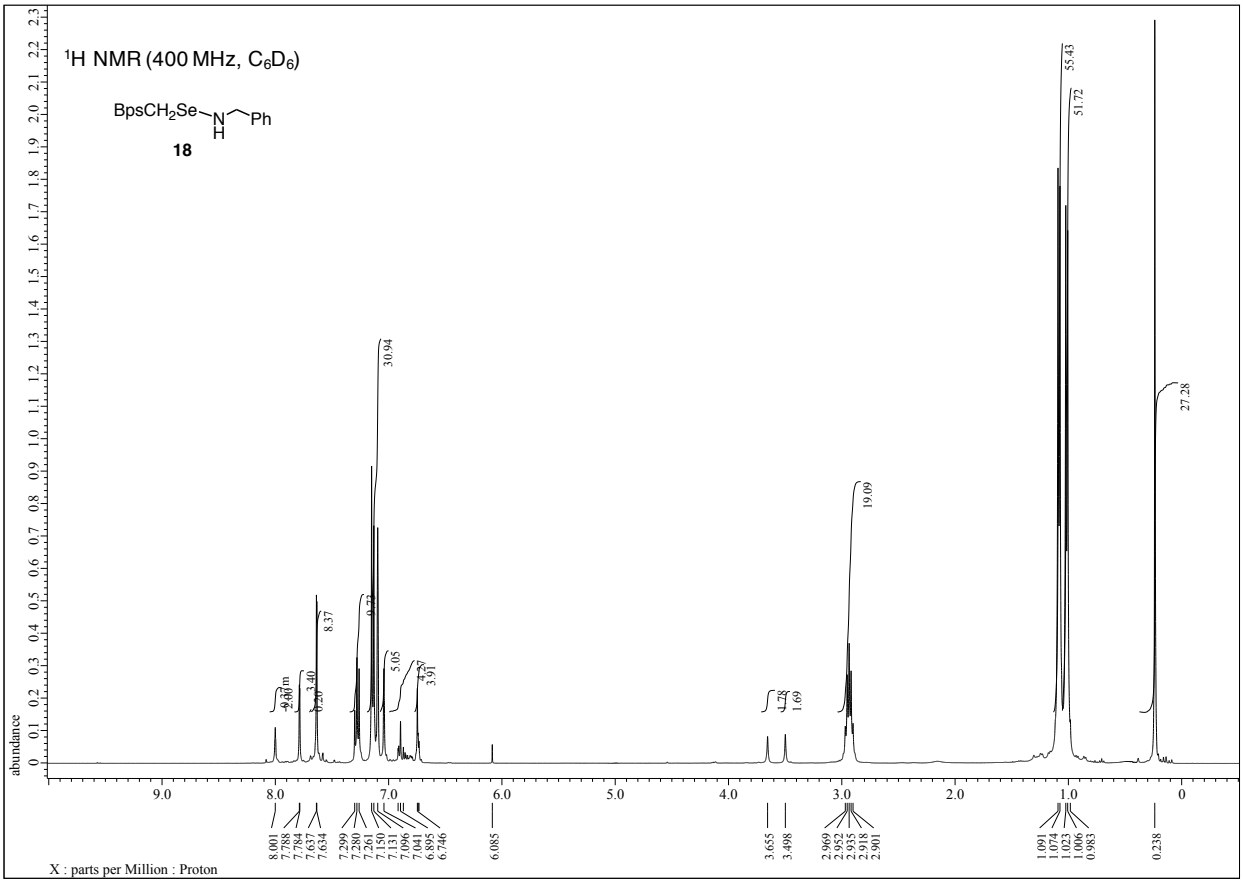

^{13}C NMR (125 MHz, $CDCl_3$)
BpsCH2Se
OH
O
13a
BpsCH2Se
O
O
13b
13a:13b = 93.7
abundance
X : parts per Million : Carbon13

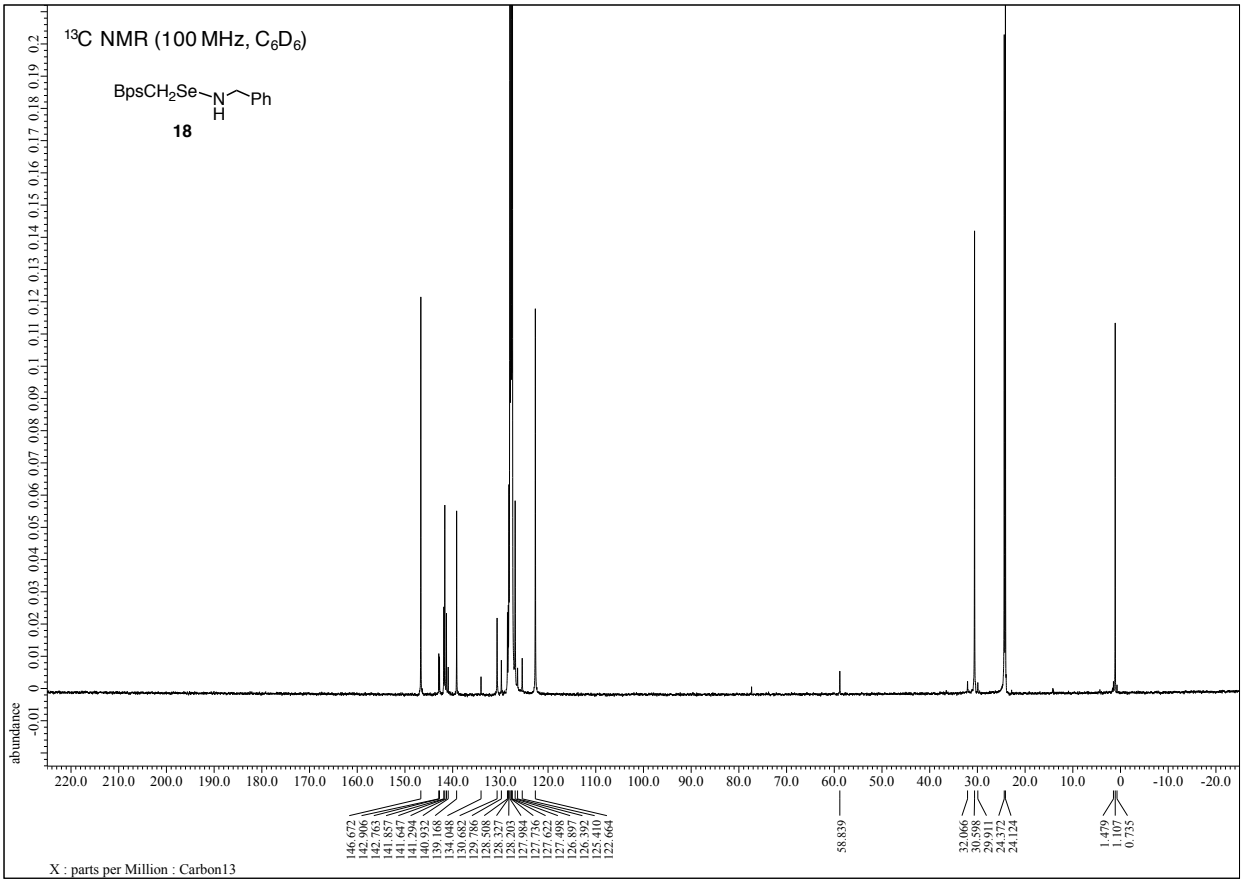

^{1}H NMR (400 MHz, C_6D_6)
O
BpsCH$_2$Se
15
abundance
X : parts per Million : Proton


^{13}C NMR (100 MHz, C_6D_6)
O
BpsCH$_2$Se
15
(thousandths)
X : parts per Million : Carbon13


^{1}H NMR (500 MHz, $CDCl_3$, 320 K)
BpsCH2Se
N
H
O
17
(Thousands)
X : parts per Million : 1H


^{13}C NMR (125 MHz, $CDCl_3$, 320 K)
BpsCH2Se
N
H
O
17
(Thousands)
X : parts per Million : 13C


^{1}H NMR (400 MHz, C_6D_6)
BpsCH$_2$Se–N(H)–Ph
18
abundance
X : parts per Million : Proton


^{13}C NMR (100 MHz, C_6D_6)
BpsCH$_2$Se–N(H)–Ph
18
abundance
X : parts per Million : Carbon13

References

1 Goto, K.; Yamamoto, G.; Tan, B.; Okazaki, R. *Tetrahedron Lett*. **2001**, *42*, 4875-4877.

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3 Lulinski, S.; Serwatowski, J. *J. Org. Chem*. **2003**, *68*, 5384-5387.

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