Supporting information

PyfSeTs as a Novel and Photosensitive Reagent for the Green Light-Induced Arene C-H Selenenylation: A Verstile Strategy for the Synthesis of Aryl Selenides

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General Information

General information of experiments: Commercial reagents and solvents were used as received and without further purification, unless otherwise stated. Organic solution was concentrated under reduced pressure on a Büchi rotary evaporator using an isopropyl alcohol-dry ice bath. Analytical thin layer chromatography (TLC) was performed on 0.25 mm silica gel plates (Qingdao Haiyang Chemical China), and the compounds were visualized with a UV lamp at 254 nm. Flash chromatography was performed on silica gel 200 - 300 mesh (purchased from Qingdao Haiyang Chemical China) with commercial solvents (purchased from Adamas-beta®). The ^{1}H, ^{13}C, ^{19}F and ^{77}Se NMR spectra were recorded on a Bruker AM 400 or 600 Spectrometer (400 and 150 MHz for ^{1}H, ^{13}C, 564 MHz for ^{19}F and 114 MHz for ^{77}Se NMR, respectively) and are internally referenced to residual solvent signals (note: $CDCl_3$ referenced at 7.26 and 77.16 ppm in ^{1}H and ^{13}C NMR, respectively). Data from the ^{1}H NMR spectroscopy are reported as chemical shift (δ ppm) with the corresponding integration values. Multiplicities were given as s (singlet), d (doublet), t (triplet), dd (double of doublet), and m (multiplets). Coupling constants were reported in Hertz (Hz). Data for ^{13}C, ^{19}F and ^{77}Se NMR are reported in terms of chemical shift. High-resolution mass spectrometry (HRMS) was recorded on Waters LCT Premier XE spectrometer.

General information of photochemistry: The Green LED strip (2 meters, 24 W, Emission at 500 nm - 570 nm) was purchased from Epilight (China). LED strip wrapped on the inside of a 250 mL round bottom flask. A layer of aluminium foil was placed around the outside of the round bottom flask. 30V/5A DC Power Supply (MCH-K305D, MCH Instruments Co., Ltd) was used as power transformer. Tape the connector wires as well as the foil with duct tape to secure both in place. Schleck tube, which is made of pure borosilicate glass, was placed on top of the stirring place (the distance between the tube and the light source was about 5 cm). Position a fan about 20 cm above the reactor for cooling. Temperature should be monitored in real time using a temperature probe to determine the ambient temperature. No filter was used during the reaction in this research.

Mechanism Study

UV-Vis absorption study of 1c

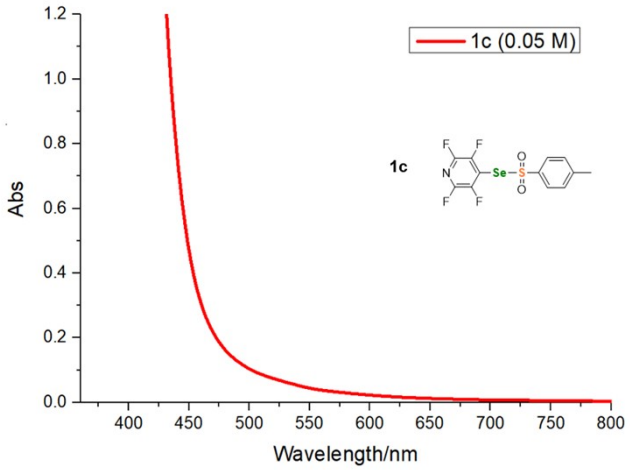
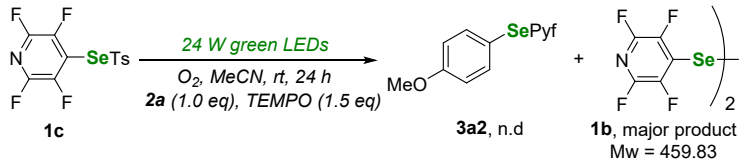


Figure S1. UV-Vis absorption spectra **1c**

Notes: UV-Vis absorption spectra of **1c** in MeCN (3 mL) was recorded in 1 cm path quartz cuvettes using a Shimadzu UV-1800 UV/Vis spectromete.

Radical quenching experiment



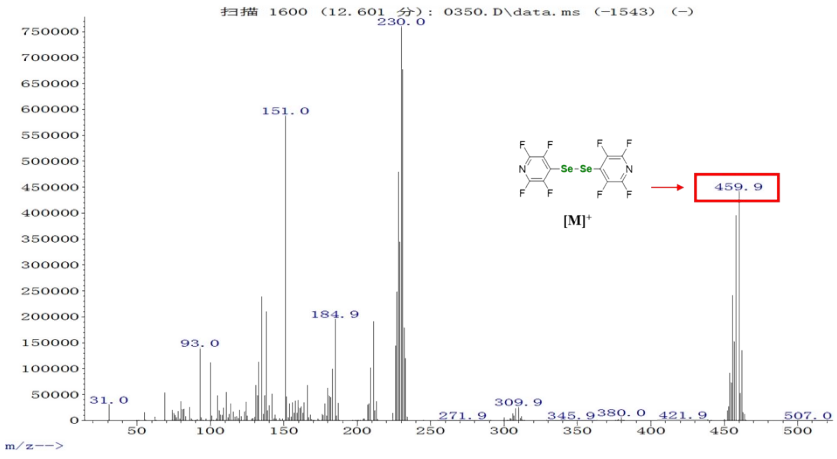
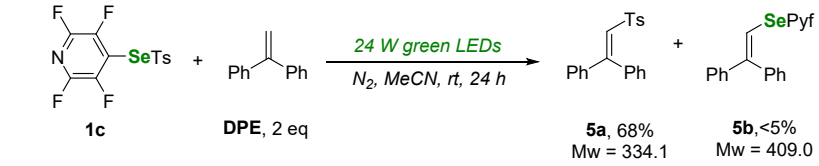


Figure S2. GCMS analysis of the crude product

Notes: The crude product was subjected to GCMS analysis. As expected, the formation of **3a2** was inhibited and **1b** was detected as a major product and confirmed by MS.

Radical trapping experiment



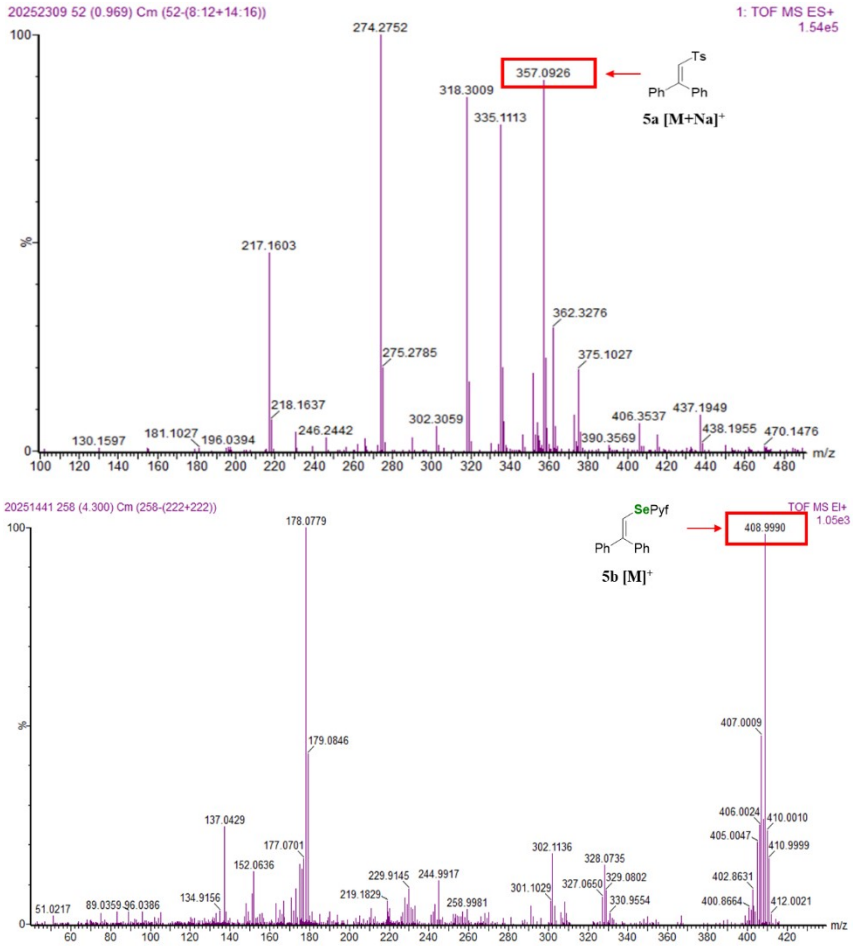
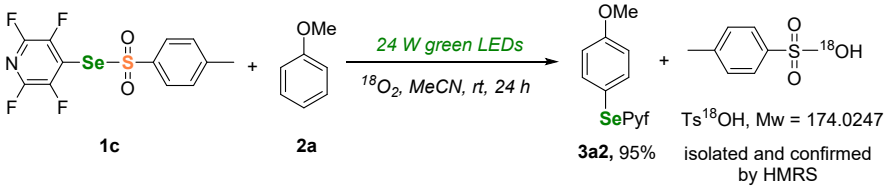


Figure S3. HRMS analysis of the products of radical trapping experiments

Notes: The crude product was subjected to flash column chromatography on silica gel. As demonstrated, **5a** was isolated in 68% yield and only trace **5b** was detected. The structures were determined by HRMS and ^{1}H NMR.

$^{18}O_2$ isotopic labeling experiment



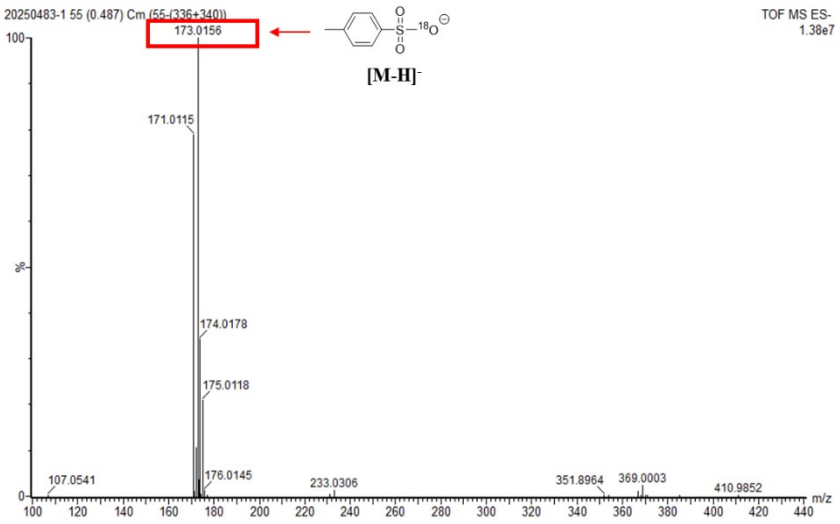
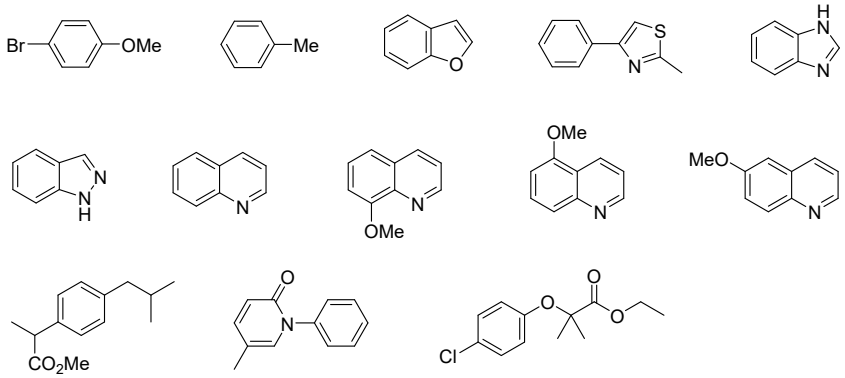


Figure S4. HRMS analysis of Ts^{18}OH

Notes: $^{18}O_2$ was employed as alternative oxidant and stoichiometric amount of Ts^{18}OH was isolated by recrystallization and confirmed by HRMS.

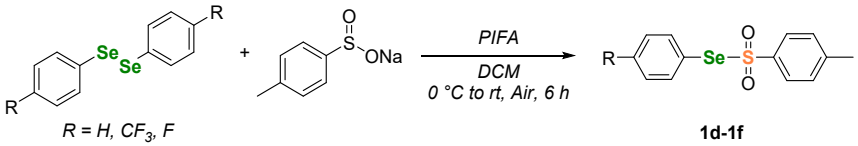
Summary of Unsuccessful Examples



Scheme S1. Unsuccessful examples

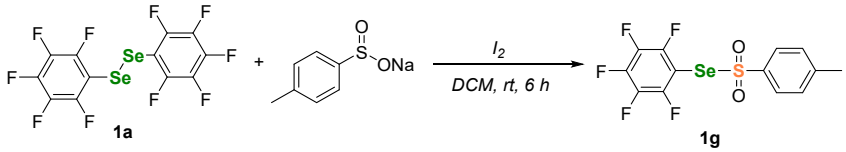
Experiment Procedures and Product Characterization

Synthesis of 1d-1f



To an oven-dried 50 mL Teflon-screw capped Schlenk tube equipped with a magnetic stir bar were added sodium 4-methylbenzenesulfinate (4.0 mmol, 4.0 equiv.), diselenide (1.0 mmol, 1.0 equiv.), and DCM (15 mL) at 0 °C. Then the solution of PIFA (1.1 mmol, 1.1 equiv.) in DCM (5 mL) was added dropwise. The mixture was allowed to warm to room temperature and stirred for 4 h. After that, diluted with H_2O and the organic phase was separated and dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) affording **1d** as a yellow solid (180 mg, 58% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.52 – 7.50 (m, 2H), 7.47 (t, *J* = 7.5 Hz, 1H), 7.40 (d, *J* = 8.4 Hz, 2H), 7.34 (t, *J* = 7.6 Hz, 2H), 7.18 (d, *J* = 8.1 Hz, 2H), 2.41 (s, 3H). HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{10}F_8N_2Se_2$ 311.9723; Found 311.9717. The data of **1d** is consistent with the reported data [1]. **1e-1f** were also synthesized by following this procedure and the spectral data is consistent with the reported data [2].

Synthesis of 1g



I_2 (520 mg, 2.0 mmol, 2.0 equiv.) was added to the mixture of sodium p-tolylsulfinate (572 mg, 3.2 mmol, 3.2 equiv.) and **1a** (494 mg, 1.0 mmol, 1.0 equiv.) in DCM (20 mL, 0.05 M). The mixture was stirred at room temperature for 6 h and filtered through diatomaceous earth and activated carbon. The filtrate was concentrated under vacuum. The residue was purified by flash column chromatography on silica gel (PE – PE/EA = 20:1) to give **1g** as a yellow solid (368 mg, 46% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.59 (d, *J* = 8.2 Hz, 2H), 7.32 (d, *J* = 8.1 Hz, 2H), 2.47 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 148.3-148.2 (m), 146.7-146.6 (m), 146.2, 145.1-144.9 (m), 143.4-143.2 (m), 143.3, 138.7-138.4 (m), 137.0-136.7 (m), 130.1, 127.1, 102.3 (t, *J* = 25.1 Hz), 21.9. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -123.1 – -123.2 (m, 2F), -145.5 – -145.6 (m, 1F), -158.6 – -158.7 (m, 2F). HRMS (EI-TOF) m/z: $[M- C_6F_5Se]^+$ Calcd for $C_7H_7O_2S$ 155.0167; Found 155.0162, $[M-C_7H_7O_2S]^+$ Calcd for C_6F_5Se 246.9085; Found 246.9084.

Cell Viability Assay

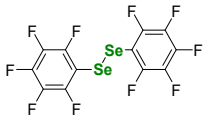
H1299, K562, HepG2 and SY5Y cells were obtained from ATCC. The cells were maintained in DMEM supple-mented with 10% FBS, 100 U/mL penicillin, and 100 mg/mL streptomycin in a

humidified incubator with 5% CO_2 at 37 °C.

Cells were seeded into 96-well plates at a concentration of 1 × 106 cells per well at a volume of 100 μL and cultured overnight. The cells were then treated with various concentrations of compounds to test their cell viability. Following treatment for 72 h, the supernatant was removed and a 10% CCK-8 solution (Targetmol, C0005, Boston) in the medium was added to each well and incubated for 1h in the dark at 37 °C. Next, the absorbance at 450 nm and 620 nm was measured using a microplate reader (Biotek, Vermont).

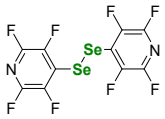
Characterization of Products

1,2-bis(perfluorophenyl)diselane (1a)



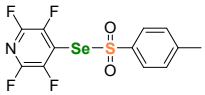
Synthetized by following the typical procedure in the manuscript [3]. **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 148.2-148.0 (m), 146.6-146.4 (m), 143.9-143.7 (m), 142.2-142.0 (m), 138.3-138.0 (m), 136.6-136.3 (m), 103.1 (t, *J* = 25.5 Hz). **^{19}F NMR** (564 MHz, $CDCl_3$) δ -125.0 – -125.1 (m, 2F), -148.5 – -148.6 (m, 1F), -159.2 – -159.3 (m, 2F). HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{12}F_{10}Se_2$ 493.8171; Found 493.8170.

1,2-bis(perfluoropyridin-4-yl)diselane (1b)



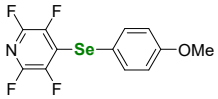
Synthetized by following the typical procedure in the manuscript. **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 144.2-144.0 (m), 143.3-143.1 (m), 142.5-142.3 (m), 141.6-141.3 (m), 122.8 (t, *J* = 22.4 Hz). **^{19}F NMR** (564 MHz, $CDCl_3$) δ -88.4 – -88.5 (m, 2F), -128.5 – -128.6 (m, 2F). HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{10}F_8N_2Se_2$ 459.8264; Found 459.8267.

Se-(perfluoropyridin-4-yl) 4-methylbenzenesulfonoselenoate (1c)



Synthetized by following the typical procedure in the manuscript [4]. **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.64 (d, *J* = 8.4 Hz, 2H), 7.35 (d, *J* = 8.1 Hz, 2H), 2.48 (s, 3H).**^{13}C NMR** (150 MHz, $CDCl_3$) δ: 146.8, 144.5-144.3 (m), 143.4, 143.3-143.0 (m), 142.9-142.6 (m), 141.5-141.3 (m), 130.2, 127.1, 120.9 (t, *J* = 22.9 Hz), 21.9. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -87.7 – -87.8 (m, 2F), -126.4 – -126.5 (m, 2F). HRMS (EI-TOF) m/z: $[M- C_5F_4NSe]^+$ Calcd for $C_7H_7O_2S$ 155.0167; Found 155.0168, $[M-C_7H_7O_2S]^+$ Calcd for C_5F_4NSe 229.9132; Found 229.9134.

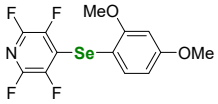
2,3,5,6-tetrafluoro-4-((4-methoxyphenyl)selanyl)pyridine (3a2)



According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (31 mg, 91% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.63 (d, *J* = 8.7 Hz, 2H), 6.86 (d, *J* = 8.8 Hz, 2H), 3.82 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 161.2, 144.3-144.1 (m), 142.6-142.4 (m), 142.4-142.2 (m),140.7-140.5 (m),

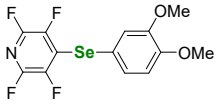
137.9, 127.1 (t, J = 21.4 Hz), 115.5, 115.0, 55.5. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.2 – -91.3 (m, 2F), -132.6 – -132.7 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 331.5. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{12}H_7F_4NOSe$ 336.9629; Found 336.9634.

4-((2,4-dimethoxyphenyl)selanyl)-2,3,5,6-tetrafluoropyridine (3b)



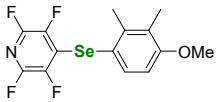
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (26 mg, 70% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.52 (d, J = 9.1 Hz, 1H), 6.48 (s, 1H), 6.46 (d, J = 2.5 Hz, 1H), 3.83 (s, 3H), 3.80 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 163.2, 160.7, 144.1-143.9 (m), 142.5-142.3 (m), 142.3-142.2 (m),140.7-140.5 (m), 137.5, 127.1 (t, J = 20.9 Hz), 105.8, 104.4, 99.3, 56.1, 55.7. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -92.1 – -92.2 (m, 2F), -134.3 – -134.4 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 272.1. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{13}H_9F_4NO_2Se$ 366.9735; Found 366.9740.

4-((3,4-dimethoxyphenyl)selanyl)-2,3,5,6-tetrafluoropyridine (3c)



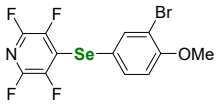
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (27 mg, 75% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.29 (d, J = 8.3 Hz, 1H), 7.18 (s, 1H), 6.82 (d, J = 8.4 Hz, 1H), 3.89 (s, 3H), 3.88 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 150.9, 149.5, 144.3-144.1 (m), 142.6-142.4 (m), 142.4-142.2 (m),140.7-140.5 (m), 129.7, 126.9 (t, J = 21.5 Hz), 119.0, 114.9, 112.0, 56.3, 56.1. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.1 – -91.2 (m, 2F), -132.4 – -132.6 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 343.3. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{13}H_9F_4NO_2Se$ 366.9735; Found 366.9743.

2,3,5,6-tetrafluoro-4-((4-methoxy-2,3-dimethylphenyl)selanyl)pyridine (3d)



According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (26 mg, 72% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.60 (d, J = 8.6 Hz, 1H), 6.68 (d, J = 8.6 Hz, 1H), 3.83 (s, 3H), 2.47 (s, 3H), 2.19 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 159.4, 144.3-144.1 (m), 142.6-142.4 (m), 142.4-142.2 (m), 142.2, 140.7-140.5 (m), 136.0, 127.6 (t, J = 20.9 Hz), 126.9, 117.1, 108.8, 55.7, 20.7, 12.9. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.6 – -91.7 (m, 2F), -133.9 – -134.0 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 310.4. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{14}H_{11}F_4NOSe$ 364.9942; Found 364.9959.

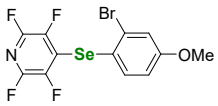
4-((3-bromo-4-methoxyphenyl)selanyl)-2,3,5,6-tetrafluoropyridine (3e)



According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (27 mg, 65% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.88 (s, 1H), 7.63 (7.64 (d, J = 8.6 Hz, 1H)), 6.86 (d, J = 8.5 Hz, 1H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 157.6, 144.3-144.1 (m), 142.7-142.5 (m), 142.4-142.1 (m), 140.6-

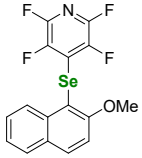
140.4 (m), 140.6, 136.8, 126.3 (t, *J* = 21.4 Hz), 115.8, 112.8, 112.7, 56.5. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -90.7 – -90.8 (m, 2F), -132.1 – -132.3 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 336.2. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{12}H_6BrF_4NOSe$ 414.8734; Found 414.8734.

4-((2-bromo-4-methoxyphenyl)selanyl)-2,3,5,6-tetrafluoropyridine (3f)



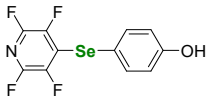
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (25 mg, 60% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.63 (d, *J* = 8.7 Hz, 1H), 7.21 (s, 1H), 6.82 (6.83 (d, *J* = 8.7 Hz, 1H)), 3.82 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 161.7, 144.3-144.1 (m), 142.7-142.3 (m), 142.3-142.1 (m), 140.6-140.4 (m), 138.0, 130.5, 126.3 (t, *J* = 21.4 Hz), 119.2, 118.0, 114.8, 55.9. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -90.9 – -91.0 (m, 2F), -132.8 – -132.9 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 357.8. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{12}H_6BrF_4NOSe$ 414.8734; Found 414.8748.

2,3,5,6-tetrafluoro-4-((2-methoxynaphthalen-1-yl)selanyl)pyridine (3g)



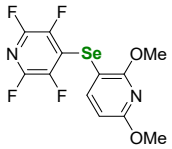
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (17 mg, 45% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 8.36 (d, *J* = 8.6 Hz, 1H), 7.97 (d, *J* = 9.0 Hz, 1H), 7.82 (d, *J* = 8.1 Hz, 1H), 7.57 (t, *J* = 7.7 Hz, 1H), 7.41 (t, *J* = 7.5 Hz, 1H), 7.31 (d, *J* = 9.0 Hz, 1H), 3.96 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 158.6, 144.1-143.9 (m), 142.5-142.4 (m), 142.4-142.3 (m), 140.8-140.6 (m), 135.9, 133.1, 129.7, 128.7, 128.2, 127.3 (t, *J* = 21.0 Hz), 126.6, 124.4, 112.9, 108.8, 57.0. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -92.1 – -92.2 (m, 2F), -134.3 – -134.4 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 192.2. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{16}H_9F_4NOSe$ 386.9785; Found 386.9789.

4-((perfluoropyridin-4-yl)selanyl)phenol (3h)



According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 5 : 1) to give the product as colorless oil (13 mg-17 mg, 41%-80% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.59 (d, *J* = 8.4 Hz, 2H), 6.81 (d, *J* = 8.4 Hz, 2H), 5.17 (s, 1H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 157.4, 144.3-144.1 (m), 142.7-142.4 (m), 142.4-142.2 (m), 140.7-140.5 (m), 127.1 (t, *J* = 20.9 Hz), 117.0, 115.3. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.2 – -91.3 (m, 2F), -132.5 – -132.6 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 331.9. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{11}H_5F_4NOSe$ 322.9472; Found 322.9476.

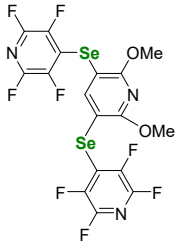
4-((2,6-dimethoxypyridin-3-yl)selanyl)-2,3,5,6-tetrafluoropyridine (3i1)



According to the general procedure A, crude product was purified by flash column chromatography

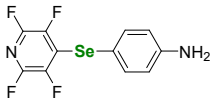
on silica gel (PE/EA = 5 : 1) to give the product as colorless oil (11 mg, 30% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.79 (d, *J* = 8.1 Hz, 1H), 6.31 (d, *J* = 8.2 Hz, 1H), 3.94 (s, 6H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 165.0, 162.6, 148.3, 144.2-144.0 (m), 142.5-142.3 (m), 142.3-142.1 (m), 140.7-140.4 (m), 126.5 (t, *J* = 20.8 Hz), 103.0, 96.5, 54.5, 54.0. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.7 – -91.8 (m, 2F), -134.3 – -134.4 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 269.2. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{12}H_8F_4N_2O_2Se$ 367.9687; Found 367.9689.

4,4'-((2,6-dimethoxypyridine-3,5-diyl)bis(selanediyl))bis(2,3,5,6-tetrafluoropyridine) (3i2)



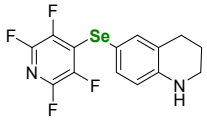
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 5 : 1) to give the product as colorless oil (19 mg, 32% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 8.18 (s, 1H), 3.97 (s, 6H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 164.1, 154.8, 144.2-144.0 (m), 142.6-142.3 (m), 142.3-142.0 (m), 140.6-140.4 (m), 125.7 (t, *J* = 21.0 Hz), 98.1, 55.1. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.1 – -91.2 (m, 2F), -134.1 – -134.2 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 274.9. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{17}H_7F_8N_3O_2Se_2$ 596.8741; Found 596.8742.

4-((perfluoropyridin-4-yl)selanyl)aniline (3j)



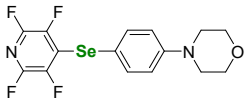
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 10 : 1) to give the product as colorless oil (12 mg, 38% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.49 (d, *J* = 8.5 Hz, 2H), 6.61 (d, *J* = 8.5 Hz, 2H), 3.88 (s, 2H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 148.4, 144.2-144.0 (m), 142.6-142.4 (m), 142.4-142.2 (m), 140.7-140.5 (m), 138.1, 127.7 (t, *J* = 21.0 Hz), 115.9, 111.5. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.6 – -91.7 (m, 2F), -133.0 – -133.1 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 333.7. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{11}H_6F_4N_2Se$ 321.9632; Found 321.9636.

6-((perfluoropyridin-4-yl)selanyl)-1,2,3,4-tetrahydroquinoline (3k)



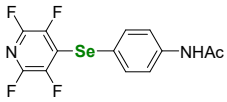
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (14 mg, 40% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.30 – 7.28 (m, 2H), 6.37 (d, *J* = 8.9 Hz, 1H), 3.37 – 3.28 (m, 2H), 2.73 (t, *J* = 6.4 Hz, 2H), 2.00 – 1.87 (m, 2H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 146.5, 144.2-144.0 (m), 142.5-142.3 (m), 142.5-142.2 (m), 140.7-140.5 (m), 137.9, 135.6, 128.1 (t, *J* = 21.5 Hz), 122.3, 114.5, 108.9, 41.7, 26.9, 21.4. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.8 – -91.9 (m, 2F), -133.0 – -133.1 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 334.6. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{14}H_{10}F_4N_2Se$ 361.9945; Found 361.9948.

4-(4-((perfluoropyridin-4-yl)selanyl)phenyl)morpholine (3l)



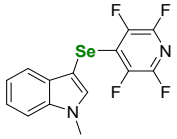
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 10 : 1) to give the product as colorless oil (14 mg, 35% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.59 (d, *J* = 8.8 Hz, 2H), 6.82 (d, *J* = 8.9 Hz, 2H), 3.88 – 3.81 (m, 4H), 3.23 – 3.19 (m, 4H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 152.3, 144.2-144.0 (m), 142.6-142.2 (m), 140.7-140.5 (m), 137.6, 129.4, 127.3 (t, *J* = 21.3 Hz), 115.9, 113.0, 66.8, 48.2. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.4 – -91.5 (m, 2F), -132.7 – -132.8 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 330.2. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{15}H_{12}F_4N_2OSe$ 392.0051; Found 392.0050.

N-(4-((perfluoropyridin-4-yl)selanyl)phenyl)acetamide (3m)



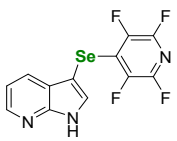
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 5 : 1) to give the product as white solid (35 mg, 95% yield). **^{1}H NMR** (400 MHz, DMSO-d6) δ: 10.10 (s, 1H), 7.55 (s, 4H), 2.01 (s, 3H). **^{13}C NMR** (150 MHz, DMSO-d6) δ: 168.7, 143.5-143.3 (m), 142.3-142.1 (m), 141.9-141.7 (m), 140.6-140.4 (m), 140.4, 135.1, 128.6, 126.3 (t, *J* = 22.1 Hz), 119.9, 119.0, 118.6, 24.1. **^{19}F NMR** (564 MHz, DMSO-d6) δ -92.7 – -92.8 (m, 2F), -132.3 – -132.4 (m, 2F). **^{77}Se NMR** (114 MHz, DMSO-d6) δ: 329.4. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{13}H_8F_4N_2OSe$ 363.9738; Found 363.9739.

1-methyl-3-((perfluoropyridin-4-yl)selanyl)-1H-indole (3n)



According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as white solid (33 mg, 92% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.67 (d, *J* = 7.9 Hz, 1H), 7.41 (s, 1H), 7.35 (d, *J* = 8.1 Hz, 1H), 7.30 (t, *J* = 7.5 Hz, 1H), 7.23 (t, *J* = 7.4 Hz, 1H), 3.83 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 144.1-143.9 (m), 142.8-142.6 (m), 142.5-142.3 (m), 141.1-140.9 (m), 137.2, 136.8, 130.7, 127.2 (t, *J* = 21.6 Hz), 123.0, 121.2, 120.0, 109.9, 92.0, 33.4. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.5 – -91.6 (m, 2F), -133.4 – -133.5 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 149.7. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{14}H_8F_4N_2Se$ 359.9789; Found 359.9783.

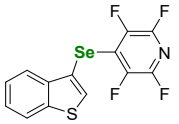
3-((perfluoropyridin-4-yl)selanyl)-1H-pyrrolo[2,3-b]pyridine (3o)



According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 2 : 1) to give the product as white solid (22 mg, 65% yield). **^{1}H NMR** (400 MHz, DMSO-d6) δ: 8.31 (d, *J* = 4.7 Hz, 1H), 7.97 (s, 1H), 7.92 (d, *J* = 7.9 Hz, 1H), 7.21 – 7.18 (m, 1H). **^{13}C NMR** (150 MHz, DMSO-d6) δ: 148.4, 143.8, 143.3-143.1 (m), 142.1-141.9 (m), 141.7-141.5 (m), 140.5-140.2 (m), 134.6, 127.4, 127.0 (t, *J* = 21.8 Hz), 122.1, 116.9, 90.6. **^{19}F NMR** (564

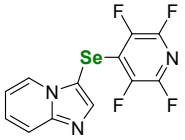
MHz, DMSO-d6) δ -92.9 – -93.0 (m, 2F), -134.3 – -134.4 (m, 2F). **^{77}Se NMR** (114 MHz, DMSO-d6) δ: 167.4. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{12}H_5F_4N_3Se$ 346.9585; Found 346.9588.

4-(benzo[b]thiophen-3-ylselanyl)-2,3,5,6-tetrafluoropyridine (3p)



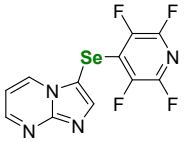
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as white solid (15 mg, 41% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.98 (s, 1H), 7.94 – 7.85 (m, 2H), 7.52 – 7.35 (m, 2H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 144.3-144.1 (m), 142.6-142.5 (m), 142.5-142.4 (m), 140.9-140.7 (m), 139.9, 139.5, 136.1, 125.5, 125.4, 125.3-125.1 (m), 123.5, 123.1, 113.9. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -90.5 – -90.6 (m, 2F), -132.6 – -132.7 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 206.1. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{13}H_5F_4NSSe$ 362.9244; Found 362.9247.

3-((perfluoropyridin-4-yl)selanyl)imidazo[1,2-a]pyridine (3q)



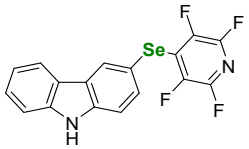
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (DCM/MeOH = 50 : 1) to give the product as colorless oil (20 mg, 57% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 8.44 (d, J = 6.9 Hz, 1H), 7.98 (s, 1H), 7.70 (d, J = 9.1 Hz, 1H), 7.36 (t, J = 7.7 Hz, 1H), 7.03 (t, J = 6.8 Hz, 1H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 144.8, 144.3-144.1 (m), 142.6-142.4 (m), 142.4-142.2 (m), 140.7-140.5 (m), 126.8, 125.4, 124.7 (t, J = 22.0 Hz), 118.4, 114.0. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -89.7 – -89.8 (m, 2F), -134.1 – -134.2 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 137.1. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{12}H_5F_4N_3Se$ 346.9585; Found 346.9586.

3-((perfluoropyridin-4-yl)selanyl)imidazo[1,2-a]pyrimidine (3r)



According to the general procedure A, crude product was purified by flash column chromatography on silica gel (DCM/MeOH = 20 : 1) to give the product as colorless oil (15 mg, 42% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 8.77 (d, J = 6.8 Hz, 1H), 8.70 (d, J = 4.2 Hz, 1H), 8.15 (s, 1H), 7.13 (dd, J = 6.8, 4.1 Hz, 1H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 151.9, 146.4, 144.3-144.1 (m), 142.7-142.4 (m), 142.4-142.2 (m), 140.7-140.5 (m), 133.3, 124.0 (t, J = 22.2 Hz), 110.2, 100.6. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -89.1 – -89.2 (m, 2F), -133.5 – -133.6 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 132.4. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{11}H_4F_4N_4Se$ 347.9537; Found 347.9540.

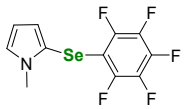
3-((perfluoropyridin-4-yl)selanyl)-9H-carbazole (3s)



According to the general procedure A, crude product was purified by flash column chromatography

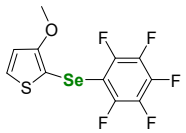
on silica gel (PE/EA = 10 : 1) to give the product as white solid (10 mg, 25% yield). **^{1}H NMR** (400 MHz, DMSO-d6) δ: 11.54 (s, 1H), 8.52 (s, 1H), 8.16 (d, *J* = 7.8 Hz, 1H), 7.69 (d, *J* = 8.5 Hz, 1H), 7.52 (d, *J* = 5.7 Hz, 1H), 7.50 (d, *J* = 6.1 Hz, 1H), 7.42 (t, *J* = 7.6 Hz, 1H), 7.18 (t, *J* = 7.4 Hz, 1H). **^{13}C NMR** (150 MHz, DMSO-d6) δ: 143.9-143.7 (m), 142.6-142.4 (m), 142.4-142.1 (m), 140.9-140.7 (m), 140.5, 132.8, 130.1, 128.3, 127.9 (t, *J* = 21.9 Hz), 126.8, 124.1, 121.1, 119.7, 113.6, 112.7, 111.7. **^{19}F NMR** (564 MHz, DMSO-d6) δ -93.0 – -93.1 (m, 2F), -133.0 – -133.1 (m, 2F). **^{77}Se NMR** (114 MHz, DMSO-d6) δ: 342.0. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{17}H_8F_4N_2Se$ 395.9789; Found 395.9797.

1-methyl-2-((perfluorophenyl)selanyl)-1H-pyrrole (3t')



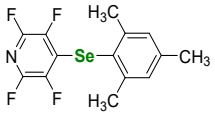
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (31 mg, 87% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 6.80 (d, *J* = 4.4 Hz, 1H), 6.61 (d, *J* = 2.1 Hz, 1H), 6.14 (t, *J* = 3.3 Hz, 1H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 147.7-147.6 (m), 146.1-146.0 (m), 142.8-142.5 (m), 141.0-140.8 (m), 138.5-138.2 (m), 136.8-136.6 (m), 126.5, 121.6, 111.8, 109.3, 104.5 (t, *J* = 26.2 Hz), 35.8. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -128.4 – -128.5 (m, 2F), -152.5 – -152.6 (m, 1F), -160.2 – -160.3 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 119.2. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{11}H_6F_5NSe$ 362.9586; Found 362.9589.

3-methoxy-2-((perfluorophenyl)selanyl)thiophene (3u')



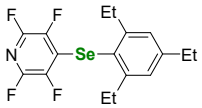
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (26 mg, 71% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.38 (d, *J* = 5.7 Hz, 1H), 6.80 (d, *J* = 5.7 Hz, 1H), 3.91 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 161.7, 147.9-147.7 (m), 146.2-146.0 (m), 142.8-142.6 (m), 141.1-141.0 (m), 138.4-138.2 (m), 136.8-136.5 (m), 130.8, 115.7, 104.5 (t, *J* = 25.2 Hz), 97.4, 59.2. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -127.3 – -127.4 (m, 2F), -152.4 – -152.5 (m, 1F), -160.4 – -160.5 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 115.0. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{11}H_5F_5OSSe$ 359.9146; Found 359.9155.

2,3,5,6-tetrafluoro-4-(mesitylselanyl)pyridine (3v)



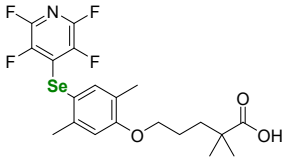
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (22 mg, 62% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 6.98 (s, 2H), 2.47 (s, 6H), 2.30 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 144.3-144.1 (m), 143.4, 142.7-142.4 (m), 142.4-142.2 (m), 140.7-140.5 (m), 140.6, 129.3, 127.3 (t, *J* = 21.1 Hz), 123.5, 24.4, 21.2. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.7 – -91.8 (m, 2F), -134.8 – -134.9 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 245.5. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{14}H_{11}F_4NSe$ 348.9993; Found 348.9996.

2,3,5,6-tetrafluoro-4-((2,4,6-triethylphenyl)selanyl)pyridine (3w)



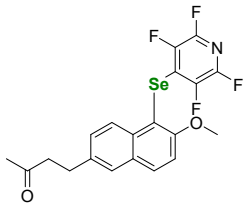
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (28 mg, 71% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.03 (s, 2H), 2.89 (q, *J* = 7.5 Hz, 4H), 2.65 (q, *J* = 7.6 Hz, 2H), 1.26 (t, *J* = 7.6 Hz, 3H), 1.21 (t, *J* = 7.5 Hz, 6H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 149.4, 147.3, 144.3-144.1 (m), 142.7-142.5 (m), 142.2-141.9 (m), 145.4-140.2 (m), 128.4 (t, *J* = 20.3 Hz), 126.7, 122.4, 30.8, 28.8, 15.9, 15.4. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.9 – -92.0 (m, 2F), -135.4 – -135.5 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 237.3. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{17}H_{17}F_4NSe$ 391.0462; Found 391.0461.

5-(2,5-dimethyl-4-((perfluoropyridin-4-yl)selanyl)phenoxy)-2,2-dimethylpentanoic acid (4a)



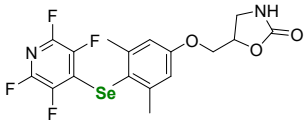
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 10 : 1) to give the product as white solid (30 mg, 62% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.45 (s, 1H), 6.70 (s, 1H), 3.95 (t, *J* = 5.9 Hz, 2H), 2.45 (s, 3H), 2.15 (s, 3H), 1.86 – 1.76 (m, 2H), 1.78 – 1.70 (m, 2H), 1.25 (s, 6H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 184.4, 159.0, 144.3-144.0 (m), 142.6-142.4 (m), 142.4-142.2 (m), 141.7, 140.7-140.5 (m), 139.4, 127.5 (t, *J* = 21.0 Hz), 126.0, 115.2, 112.9, 68.2, 42.1, 36.9, 29.8, 25.1, 23.4, 15.6. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.6 – -91.7 (m, 2F), -133.9 – -134.0 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 294.2. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{20}H_{21}F_4NO_3Se$ 479.0623; Found 479.0624.

4-(6-methoxy-5-((perfluoropyridin-4-yl)selanyl)naphthalen-2-yl)butan-2-one (4b)



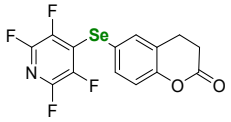
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as white solid (18 mg, 40% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 8.27 (d, *J* = 8.7 Hz, 1H), 7.89 (d, *J* = 9.0 Hz, 1H), 7.60 (s, 1H), 7.40 (d, *J* = 8.7 Hz, 1H), 7.28 (d, *J* = 9.2 Hz, 1H), 3.94 (s, 3H), 3.04 (t, *J* = 7.5 Hz, 2H), 2.85 (t, *J* = 7.5 Hz, 2H), 2.16 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 207.9, 158.3, 144.1-143.9 (m), 142.5-142.4 (m), 142.3-142.2 (m), 140.8-140.6 (m), 137.1, 134.5, 132.6, 129.8, 129.5, 127.4-127.1 (m), 127.3, 126.9, 113.1, 108.7, 57.0, 45.0, 30.2, 29.4. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -92.1 – -92.2 (m, 2F), -134.3 – -134.4 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 192.5. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{20}H_{15}F_4NO_2Se$ 457.0204; Found 457.0205.

5-((3,5-dimethyl-4-((perfluoropyridin-4-yl)selanyl)phenoxy)methyl)oxazolidin-2-one (4c)



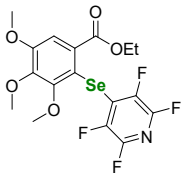
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 5 : 1) to give the product as white solid (29 mg, 64% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 6.72 (s, 2H), 5.80 (s, 1H), 5.00 – 4.94 (m, 1H), 4.15 (d, *J* = 4.8 Hz, 2H), 3.81 – 3.76 (m, 1H), 3.63 – 3.59 (m, 1H), 2.49 (s, 6H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 159.5, 145.6, 144.3-144.1 (m), 142.6-142.4 (m), 142.63-142.1 (m), 140.6-140.4 (m), 127.3 (t, *J* = 20.9 Hz), 118.6, 114.5, 74.1, 67.9, 42.7, 24.8. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.6 – -91.7 (m, 2F), -135.3 – -135.4 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 244.3. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{17}H_{14}F_4N_2O_3Se$ 450.0106; Found 450.0110.

6-((perfluoropyridin-4-yl)selanyl)chroman-2-one (4d)



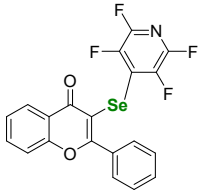
According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (20 mg, 52% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.58 (d, *J* = 8.4 Hz, 1H), 7.54 (s, 1H), 7.02 (d, *J* = 8.4 Hz, 1H), 3.06 – 2.93 (m, 2H), 2.92 – 2.67 (m, 2H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 167.5, 153.4, 144.3-144.1 (m), 142.7-142.5 (m), 142.4-142.3 (m), 140.8-140.6 (m), 136.0, 135.5, 125.9 (t, *J* = 21.5 Hz), 124.5, 120.0, 118.6, 28.8, 23.7. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -90.4 – -90.6 (m, 2F), -131.7 – -131.8 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 332.9. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{17}H_7F_4NO_2Se$ 376.9578; Found 376.9582.

ethyl 3,4,5-trimethoxy-2-((perfluoropyridin-4-yl)selanyl)benzoate (4e)



According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 10 : 1) to give the product as white solid (33 mg, 72% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.30 (s, 1H), 4.41 (q, *J* = 7.1 Hz, 2H), 3.93 (s, 3H), 3.85 (s, 3H), 3.68 (s, 3H), 1.41 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 166.6, 153.8, 153.7, 145.9, 144.0-143.8 (m), 142.3-142.2 (m), 142.2-142.1 (m), 140.6-140.4 (m), 129.0, 128.1 (t, *J* = 21.7 Hz), 115.3, 110.1, 62.2, 61.2, 60.6, 56.4, 14.4. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -92.4 – -92.5 (m, 2F), -133.6 – -133.7 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 278.9. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{17}H_{15}F_4NO_5Se$ 469.0052; Found 469.0052.

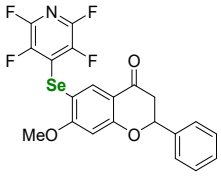
3-((perfluoropyridin-4-yl)selanyl)-2-phenyl-4H-chromen-4-one (4f)



According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 5 : 1) to give the product as colorless oil (13 mg, 28% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 8.19 (d, *J* = 8.1 Hz, 1H), 7.75 (d, *J* = 8.3 Hz, 1H), 7.723 – 7.69 (m, 2H), 7.56 – 7.51 (m, 4H), 7.47 (t, *J* = 7.6 Hz, 1H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 175.0, 166.1, 156.0, 144.0-

143.7 (m), 142.3-142.1 (m), 142.1-141.9 (m), 140.4-140.2 (m), 134.7, 133.3, 131.5, 129.1, 128.6, 126.5, 126.2, 125.2 (t, *J* = 20.9 Hz), 121.6, 118.2, 111.3. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.5 – -91.6 (m, 2F), -133.8 – -133.9 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 248.7. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{20}H_9F_4NO_2Se$ 450.9735; Found 450.9738.

7-methoxy-6-((perfluoropyridin-4-yl)selanyl)-2-phenylchroman-4-one (4g)

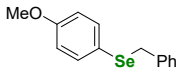


According to the general procedure A, crude product was purified by flash column chromatography on silica gel (PE/EA = 2 : 1) to give the product as white solid (28 mg, 58% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 8.19 (s, 1H), 7.49 – 7.41 (m, 5H), 6.56 (s, 1H), 5.54 – 5.50 (m, 1H), 3.86 (s, 3H), 3.07 (dd, *J* = 16.9, 13.3 Hz, 1H), 2.86 (dd, *J* = 17.0, 3.0 Hz, 1H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 189.7, 165.1, 165.0, 144.2-144.0 (m), 142.6-142.4 (m), 142.3-142.1 (m), 140.6-140.4 (m), 138.3, 135.4, 129.2, 129.1, 126.3, 126.1 (t, *J* = 20.8 Hz), 115.5, 108.0, 100.3, 80.6, 56.8, 44.1. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.3 – -91.4 (m, 2F), -133.7 – -133.8 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 279.6. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{21}H_{13}F_4NO_3Se$ 482.9997; Found 482.9998.

(2-tosylethene-1,1-diyl)dibenzene (5a)

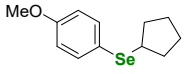
Crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product **5a** as colorless oil (22 mg, 68% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.48 (d, J = 8.3 Hz, 2H), 7.37 – 7.28 (m, 6H), 7.21 (d, *J* = 8.1 Hz, 2H), 7.16 – 7.09 (m, 4H), 7.00 (s, 1H), 2.38 (s, 3H). HRMS (ESI-TOF) m/z: $[M+Na]^+$ Calcd for $C_{21}H_{18}NaO_2S^+$, 357.0920; Found 357.0926. The ^{1}H NMR spectrum data of **5a** is consistent with the literature [5].

benzyl(4-methoxyphenyl)selane (7a)



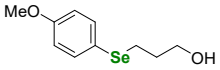
According to the general procedure B, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (21 mg, 77% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.36 (d, *J* = 8.7 Hz, 2H), 7.25 – 7.18 (m, 3H), 7.12 (d, *J* = 6.7 Hz, 2H), 6.77 (d, *J* = 8.7 Hz, 2H), 4.00 (s, 2H), 3.79 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 159.7, 139.3, 136.7, 129.0, 128.5, 126.8, 120.2, 114.7, 55.4, 33.3. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 371.9. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{14}H_{14}OSe$ 278.0210; Found 278.0207.

cyclopentyl(4-methoxyphenyl)selane (7b)



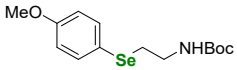
According to the general procedure B, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (20 mg, 78% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.50 (d, *J* = 8.7 Hz, 2H), 6.81 (d, *J* = 8.7 Hz, 2H), 3.80 (s, 3H), 3.53 – 3.46 (m, 1H), 2.02 – 1.95 (m, 2H), 1.76 – 1.57 (m, 6H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 159.5, 139.3, 136.7, 129.0, 120.7, 114.7, 55.4, 42.8, 34.0, 24.9. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 363.5. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{12}H_{16}OSe$ 256.0369; Found 256.0366.

3-((4-methoxyphenyl)selanyl)propan-1-ol (7c)



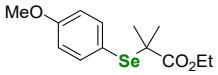
According to the general procedure B, crude product was purified by flash column chromatography on silica gel (PE/EA = 2 : 1) to give the product as colorless oil (18 mg, 75% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.47 (d, *J* = 8.8 Hz, 2H), 6.82 (d, *J* = 8.7 Hz, 2H), 3.79 (s, 3H), 3.73 (t, *J* = 6.1 Hz, 2H), 2.90 (t, J = 7.2 Hz, 2H), 1.93 – 1.87 (m, 2H), 1.54 (s, 1H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 159.5, 135.8, 119.8, 114.9, 62.6, 55.4, 32.8, 25.4. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 277.1. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{10}H_{14}O_2Se$ 246.0159; Found 246.0161.

tert-butyl (2-((4-methoxyphenyl)selanyl)ethyl)carbamate (7d)



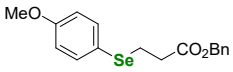
According to the general procedure B, crude product was purified by flash column chromatography on silica gel (PE/EA = 5 : 1) to give the product as colorless oil (20 mg, 62% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.48 (d, *J* = 8.9 Hz, 2H), 6.81 (d, *J* = 8.8 Hz, 2H), 4.88 (s, 1H), 3.79 (s, 3H), 3.35 – 3.31 (m, 2H), 2.89 (t, *J* = 6.6 Hz, 2H), 1.42 (s, 9H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 159.7, 155.8, 136.1, 118.8, 115.1, 62.6, 79.5, 55.4, 40.3, 29.3, 28.5. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 255.4. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{14}H_{21}NO_3Se$ 331.0687; Found 331.0689.

ethyl 2-((4-methoxyphenyl)selanyl)-2-methylpropanoate (7e)



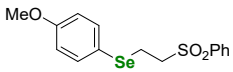
According to the general procedure B, crude product was purified by flash column chromatography on silica gel (PE/EA = 10 : 1) to give the product as colorless oil (18 mg, 60% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.49 (d, *J* = 8.7 Hz, 2H), 6.83 (d, *J* = 8.7 Hz, 2H), 4.09 (q, *J* = 7.1 Hz, 2H), 3.81 (s, 3H), 1.54 (s, 6H), 1.20 (t, *J* = 7.1 Hz, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 174.9, 160.8, 139.6, 118.7, 114.5, 61.1, 55.4, 45.3, 26.2, 14.2. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 546.0. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{13}H_{18}O_3Se$ 302.0421; Found 302.0422.

benzyl 3-((4-methoxyphenyl)selanyl)propanoate (9a)



According to the general procedure C, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (21 mg, 60% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.48 (d, *J* = 8.7 Hz, 2H), 7.39 – 7.32 (m, 5H), 6.81 (d, *J* = 8.7 Hz, 2H), 5.11 (s, 2H), 3.79 (s, 3H), 3.01 (t, *J* = 7.4 Hz, 2H), 2.72 (t, *J* = 7.4 Hz, 2H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 172.2, 159.8, 136.5, 135.9, 128.7, 128.4, 119.0, 115.0, 66.6, 55.4, 35.5, 22.8. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 302.0. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{17}H_{18}O_3Se$ 350.0421; Found 350.0442.

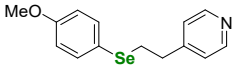
(4-methoxyphenyl)(2-(phenylsulfonyl)ethyl)selane (9b)



According to the general procedure C, crude product was purified by flash column chromatography on silica gel (PE/EA = 10 : 1) to give the product as colorless oil (23 mg, 66% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.85 – 7.83 (m, 2H), 7.70 – 7.62 (m, 1H), 7.68 – 7.64 (m, 2H), 7.37 (d, *J* = 8.8 Hz, 2H), 6.79 (d, *J* = 8.8 Hz, 2H), 3.80 (s, 3H), 3.33 – 3.29 (m, 2H), 2.95 – 2.91 (m, 2H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 160.1, 138.7, 136.4, 134.0, 129.5, 128.2, 117.4, 115.3, 57.1, 55.4, 18.7.

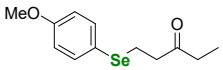
^{77}Se NMR (114 MHz, $CDCl_3$) δ: 310.6. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{15}H_{16}O_3SSe$ 355.9985; Found 355.9986.

4-**(2-((4-methoxyphenyl)selanyl)ethyl)pyridine (9c)**



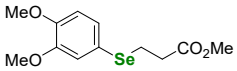
According to the general procedure C, crude product was purified by flash column chromatography on silica gel (PE/EA = 2 : 1) to give the product as colorless oil (15 mg, 51% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 8.52 (s, 2H), 7.47 (d, *J* = 8.6 Hz, 2H), 7.09 (s, 2H), 6.83 (d, *J* = 8.7 Hz, 2H), 3.81 (s, 3H), 3.03 (t, *J* = 8.0 Hz, 2H), 2.93 (t, *J* = 7.7 Hz, 2H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 159.7, 150.4, 149.5, 136.2, 124.1, 119.3, 115.0, 55.4, 36.0, 28.2. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 295.7. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{14}H_{15}NOSe$ 293.0319; Found 293.0321.

1-**((4-methoxyphenyl)selanyl)pentan-3-one (9d)**



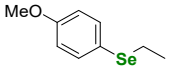
According to the general procedure C, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (11 mg, 40% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.46 (d, *J* = 8.8 Hz, 2H), 6.81 (d, *J* = 8.8 Hz, 2H), 3.79 (s, 3H), 2.97 (t, *J* = 7.2 Hz, 2H), 2.76 (t, *J* = 7.3 Hz, 2H), 2.38 (q, *J* = 7.3 Hz, 2H), 1.03 (t, *J* = 7.3 Hz, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 210.1, 159.6, 136.0, 119.5, 114.9, 55.4, 42.9, 36.2, 21.8, 7.8. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 298.4. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{12}H_{16}O_2Se$ 272.0316; Found 272.0318.

methyl 3-((3,4-dimethoxyphenyl)selanyl)propanoate (9e)



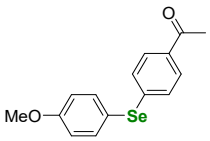
According to the general procedure C, crude product was purified by flash column chromatography on silica gel (PE/EA = 10 : 1) to give the product as colorless oil (16 mg, 52% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.13 (d, *J* = 8.2 Hz, 1H) 7.08 (s, 1H), 6.78 (d, *J* = 8.2 Hz, 1H), 3.88 (s, 3H), 3.87 (s, 3H), 3.67 (s, 3H), 3.02 (t, *J* = 7.4 Hz, 2H), 2.69 (t, *J* = 7.4 Hz, 2H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 172.8, 149.3, 149.2, 127.7, 119.1, 118.1, 111.9, 56.1, 56.0, 51.9, 35.3, 22.9. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 315.5. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{12}H_{16}O_4Se$ 304.0214; Found 304.0216.

ethyl(4-methoxyphenyl)selane (7f)



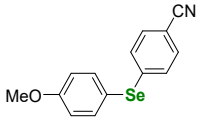
According to the general procedure C, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (15 mg, 70% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.47 (d, *J* = 8.7 Hz, 2H), 6.82 (d, *J* = 8.7 Hz, 2H), 3.80 (s, 3H), 2.82 (q, *J* = 7.4 Hz, 2H), 1.38 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 159.4, 135.8, 120.0, 114.8, 55.4, 22.6, 15.7. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 315.4. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_9H_{12}OSe$ 216.0053; Found 216.0055.

1-**(4-((4-methoxyphenyl)selanyl)phenyl)ethan-1-one (11a)**



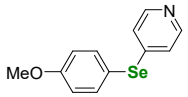
According to the general procedure D, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (14 mg, 45% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.75 (d, *J* = 8.5 Hz, 2H), 7.56 (d, *J* = 8.8 Hz, 2H), 7.27 (d, *J* = 8.6 Hz, 2H), 6.91 (d, *J* = 8.8 Hz, 2H), 3.84 (s, 3H), 2.53 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 197.5, 160.6, 142.2, 138.0, 134.8, 129.0, 128.9, 117.9, 115.6, 55.5, 26.6. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 413.4. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{15}H_{14}O_2Se$ 306.0159; Found 306.0164.

4-((4-methoxyphenyl)selanyl)benzonitrile (11b)



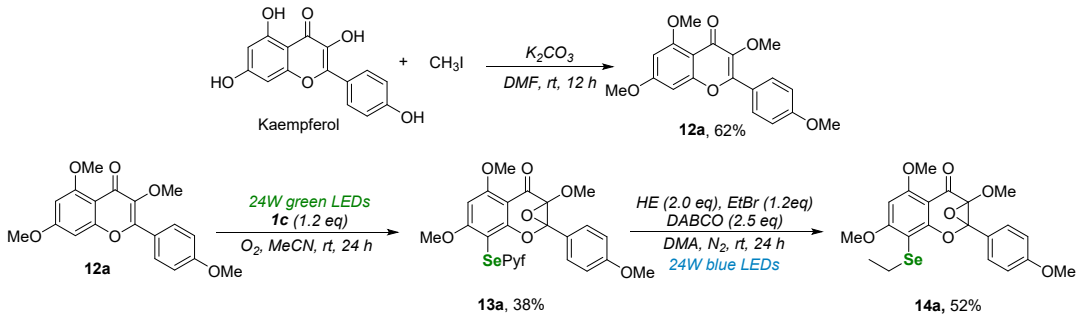
According to the general procedure D, crude product was purified by flash column chromatography on silica gel (PE/EA = 20 : 1) to give the product as colorless oil (13 mg, 47% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.55 (d, *J* = 8.8 Hz, 2H), 7.41 (d, *J* = 8.5 Hz, 2H), 7.24 (d, *J* = 8.4 Hz, 2H), 6.93 (d, *J* = 8.8 Hz, 2H), 3.85 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 160.9, 142.6, 138.0, 134.2, 132.4, 129.2, 119.0, 117.1, 115.8, 109.1, 55.5. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 422.4. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{14}H_{11}NOSe$ 289.0006; Found 289.0004.

4-((4-methoxyphenyl)selanyl)pyridine (11c)



According to the general procedure D, crude product was purified by flash column chromatography on silica gel (PE/EA = 3 : 1) to give the product as colorless oil (15 mg, 56% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 8.29 (d, *J* = 5.3 Hz, 2H), 7.57 (d, *J* = 8.7 Hz, 2H), 7.04 (d, *J* = 6.2 Hz, 2H), 6.94 (d, *J* = 8.7 Hz, 2H), 3.85 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 161.0, 149.4, 147.4, 138.6, 123.4, 116.1, 115.8, 55.5. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 409.5. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{12}H_{11}NOSe$ 265.0006; Found 265.0009.

Synthesis of 14a

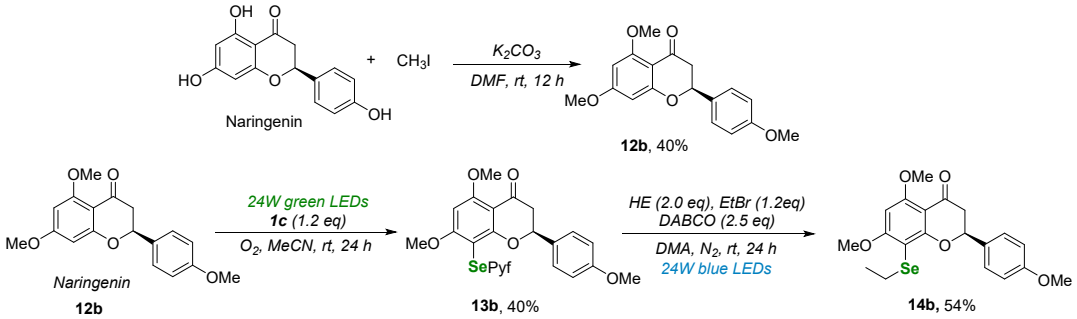


CH_3I (350 μL, 5.0 mmol, 10.0 equiv.) was added to the mixture of Kaempferol (143 mg, 0.5 mmol, 1.0 equiv.) and K_2CO_3 (0.75 g, 5.0 mmol, 10.0 equiv.) in DMF (5 mL, 0.1 M). The mixture was stirred at room temperature for 12 h. After the reaction, the solution was extracted with EtOAc and H_2O. The combined organic layers were washed with brine and dried with Na_2SO_4, filtrated and concentrated under vacuum. The residue was then purified by flash columnchromatography (PE/EA = 2 : 1) to give **12a** as white solid (106 mg, 62%). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 8.07 (d, *J* = 8.7 Hz, 2H), 7.01 (d, *J* = 8.7 Hz, 2H), 6.50 (s, 1H), 6.35 (s, 1H), 3.96 (s, 3H), 3.90 (s, 3H), 3.89 (s, 3H), 3.87 (s, 3H).

A 4 mL vial equipped with a magnetic stirring bar was dried in oven. After cooling the vial to room temperature, PyfSeTs **1c** (46 mg, 0.12 mmol, 1.2 eq), **12a** (34 mg, 0.1 mmol, 1.0 eq) and MeCN (1 mL, 0.1 M) were added to the vial and bubbled with oxygen for 15 minutes. Add a fan to maintain the temperature at 25-30 °C. Photoirradiation was carried out with stirring for 24 hours. After the reaction, the solution was extracted with DCM and H_2O. The combined organic layers were washed with brine and dried with Na_2SO_4, filtrated and concentrated under vacuum. The residue was then purified by flash columnchromatography (PE/EA = 2 : 1) to give desired product **13a** as white solid (22 mg, 38% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.57 (d, *J* = 8.9 Hz, 2H), 6.86 (d, *J* = 8.9 Hz, 2H), 6.13 (s, 1H), 4.00 (s, 3H), 3.98 (s, 3H), 3.78 (s, 3H), 3.69 (s, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 189.1 173.6, 169.1, 165.8, 162.2, 160.3, 144.1-143.9 (m), 142.6-142.4 (m), 142.4-142.3 (m), 140.9-140.7 (m), 127.3, 125.7 (t, *J* = 20.9 Hz), 125.1, 113.9, 103.4, 91.1, 89.6, 88.2, 57.3, 56.6, 55.4, 53.7. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -91.7 – -91.8 (m, 2F), -133.8 – -134.0 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 169.0. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{24}H_{17}F_4NO_7Se$ 587.0106; Found 587.0095.

A 4 mL vial equipped with a magnetic stirring bar was dried in oven. After cooling the vial to room temperature, **13a** (59 mg, 0.1 mmol, 1.0 eq), bromoethane (15 μL, 0.2 mmol, 2.0 eq), HE (50 mg, 0.2 mmol, 2.0 eq), DABCO (28 mg, 0.25 mmol, 2.5 eq) and DMA (1 mL, 0.1 M) were added to the vial, and bubbled with nitrogen for 15 minutes. Add a fan to maintain the temperature at 25-30 °C. Photoirradiation was carried out with stirring for 24 hours. After the reaction, the solution was extracted with EtOAc and H_2O. The combined organic layers were washed with brine and dried with Na_2SO_4, filtrated and concentrated under vacuum. The residue was then purified by flash columnchromatography (PE/EA = 2 : 1) to give desired product **14a** as yellow solid (24 mg, 52% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.74 (d, *J* = 9.0 Hz, 2H), 6.89 (d, *J* = 8.9 Hz, 2H), 6.10 (s, 1H), 3.99 (s, 3H), 3.95 (s, 3H), 3.79 (s, 3H), 3.75 (s, 3H), 3.02 – 2.88 (m, 2H), 1.38 (t, *J* = 7.5 Hz, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 190.0, 174.2, 169.7, 166.5, 160.7, 160.2, 127.5, 125.6, 113.8, 102.9, 92.0, 90.7, 89.3, 57.0, 56.3, 55.4, 53.6, 21.1, 15.8. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 152.0. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{21}H_{22}O_7Se$ 466.0531; Found 466.0544.

Synthesis of 14b



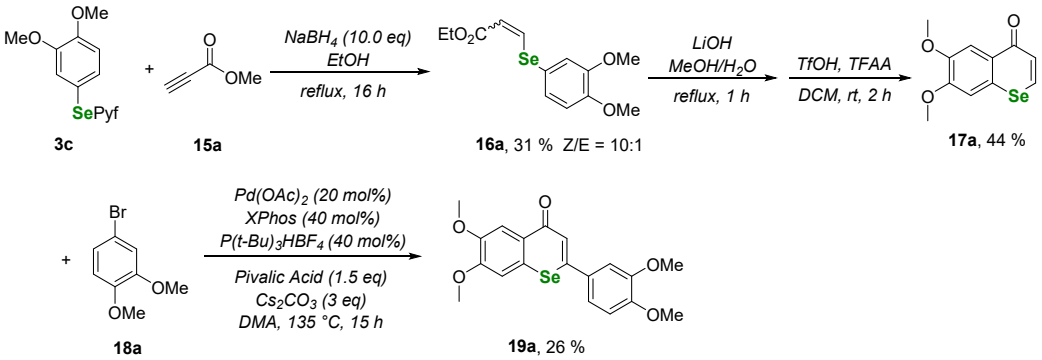
CH_3I (350 μL, 5.0 mmol, 10.0 equiv.) was added to the mixture of Naringenin (136 mg, 0.5 mmol, 1.0 equiv.) and K_2CO_3 (0.75 g, 5.0 mmol, 10.0 equiv.) in DMF (5 mL, 0.1 M). The mixture was stirred at room temperature for 12 h. After the reaction, the solution was extracted with EtOAc and H_2O. The combined organic layers were washed with brine and dried with Na_2SO_4, filtrated and concentrated under vacuum. The residue was then purified by flash columnchromatography (PE/EA = 2 : 1) to give **12b** as white solid (63 mg, 40%). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.36 (d, *J* = 8.7 Hz, 2H), 6.92 (d, *J* = 8.7 Hz, 2H), 6.11 (d, *J* = 2.3 Hz, 1H), 6.06 (d, *J* = 2.3 Hz, 1H), 5.33 (dd, *J* = 13.2,

2.9 Hz, 1H), 3.87 (s, 3H), 3.80 (s, 3H), 3.79 (s, 3H), 3.01 (dd, *J* = 16.5, 13.1 Hz, 1H), 2.74 (dd, *J* = 16.5, 2.9 Hz, 1H).

A 4 mL vial equipped with a magnetic stirring bar was dried in oven. After cooling the vial to room temperature, PyfSeTs **1c** (46 mg, 0.12 mmol, 1.2 eq), **12b** (31 mg, 0.1 mmol, 1.0 eq) and MeCN (1 mL, 0.1 M) were added to the vial and bubbled with oxygen for 15 minutes. Add a fan to maintain the temperature at 25-30 °C. Photoirradiation was carried out with stirring for 24 hours. After the reaction, the solution was extracted with DCM and H_2O. The combined organic layers were washed with brine and dried with Na_2SO_4, filtrated and concentrated under vacuum. The residue was then purified by flash columnchromatography (PE/EA = 2 : 1) to give desired product **13b** as yellow solid (21 mg, 40% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.16 (d, *J* = 8.7 Hz, 2H), 6.87 (d, *J* = 8.8 Hz, 2H), 6.19 (s, 1H), 5.47 – 5.01 (m, 1H), 3.98 (s, 3H), 3.94 (s, 3H), 3.82 (s, 3H), 2.97 (dd, *J* = 16.6, 12.8 Hz, 1H), 2.79 (dd, *J* = 16.6, 3.1 Hz, 1H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 189.2 165.0, 164.3, 163.5, 160.1, 143.8-143.6 (m), 142.2-142.1 (m), 142.0-141.9 (m), 140.5-140.3 (m), 129.8, 127.3, 126.9 (t, *J* = 21.0 Hz), 114.2, 106.6, 93.5, 89.2, 79.5, 56.6, 56.5, 55.5, 45.0. **^{19}F NMR** (564 MHz, $CDCl_3$) δ -92.3 – -92.4 (m, 2F), -134.6 – -134.7 (m, 2F). **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 202.0. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{23}H_{17}F_4NO_5Se$ 543.0208; Found 543.0209.

A 4 mL vial equipped with a magnetic stirring bar was dried in oven. After cooling the vial to room temperature, **13b** (54 mg, 0.1 mmol, 1.0 eq), bromoethane (15 μL, 0.2 mmol, 2.0 eq), HE (50 mg, 0.2 mmol, 2.0 eq), DABCO (28 mg, 0.25 mmol, 2.5 eq) and DMA (1 mL, 0.1 M) were added to the vial, and bubbled with nitrogen for 15 minutes. Add a fan to maintain the temperature at 25-30 °C. Photoirradiation was carried out with stirring for 24 hours. After the reaction, the solution was extracted with EtOAc and H_2O. The combined organic layers were washed with brine and dried with Na_2SO_4, filtrated and concentrated under vacuum. The residue was then purified by flash columnchromatography (PE/EA = 2 : 1) to give desired product **14b** as yellow solid (23 mg, 54% yield). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 7.42 (d, *J* = 8.7 Hz, 2H), 6.93 (d, *J* = 8.8 Hz, 2H), 6.15 (s, 1H), 5.44 – 5.40 (m, 1H), 3.96 (s, 3H), 3.95 (s, 3H), 3.82 (s, 3H), 3.01 (dd, *J* = 16.6, 12.2 Hz, 1H), 2.88 (dd, *J* = 16.5, 3.4 Hz, 1H), 2.80 (q, *J* = 7.5 Hz, 2H), 1.27 (t, *J* = 7.4 Hz, 3H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ: 190.0, 165.9, 164.2, 162.9, 159.8, 131.0, 127.5, 114.2, 106.7, 97.3, 89.0, 78.7, 56.3, 55.4, 45.3, 20.9, 15.6. **^{77}Se NMR** (114 MHz, $CDCl_3$) δ: 170.1. HRMS (EI-TOF) m/z: $[M]^+$ Calcd for $C_{20}H_{22}O_5Se$ 422.0632; Found 422.0637.

Synthesis of 19a



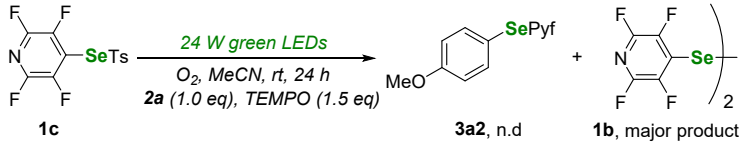
4-((3,4-dimethoxyphenyl)selanyl)-2,3,5,6-tetrafluoropyridine **3c** (74 mg, 0.2 mmol, 1.0 eq), $NaBH_4$ (80mg, 2.0 mmol, 10.0 eq), methyl propiolate **15a** (50 μL, 0.5 mmol, 2.5 eq) and EtOH (2 mL, 0.1 M) were added to the threaded sealing tube, stiring at reflux temperature for 16 hours. After the

reaction, the solution was extracted with DCM and H_2O. The combined organic layers were washed with brine and dried with Na_2SO_4, filtrated and concentrated under vacuum. The residue was then purified by flash columnchromatography (PE/EA = 5 : 1) to give **16a** (20 mg, 31%). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 8.13 (d, *J* = 15.4 Hz, 0.1H), 7.70 (d, *J* = 9.5 Hz, 1H), 7.18 (dd, *J* = 8.2, 2.0 Hz, 1H), 7.17 – 7.15 (m, 0.1H), 7.11 (d, *J* = 1.9 Hz, 1H), 7.06 (d, J = 2.0 Hz, 0.1H), 6.87 (d, *J* = 8.3 Hz, 0.1H), 6.84 (d, *J* = 8.2 Hz, 1H), 6.32 (d, *J* = 9.5 Hz, 1H), 5.77 (d, *J* = 15.4 Hz, 0.1H), 4.26 (q, *J* = 7.2 Hz, 2H), 4.15 (q, *J* = 7.1 Hz, 0.2H), 3.91 (s, 0.6H), 3.89 (s, 6H), 1.33 (t, *J* = 7.1 Hz, 3H), 1.25 (t, *J* = 7.1 Hz, 0.3H).

16a (64 mg, 0.2 mmol, 1.0 eq) in a mixed solution of methanol and water (2 mL, MeOH/H_2O=10/1) were added to the threaded sealing tube, LiOH (42 mg, 1.0 mmol, 5.0 eq) was added to the tube, stiring at reflux temperature for 1 hour. After the reaction, 0.1 M HCl was added for acidification (pH=2-3). The solution was extracted with DCM and H_2O. The combined organic layers were washed with brine and dried with Na_2SO_4, filtrated and concentrated under vacuum to give carboxylic acid product. Then, dissolving carboxylic acid in anhydrous DCM (2 mL, 0.1M), TFAA (168 μL, 1.2 mmol, 6.0 eq) was added and stirred at room temperature for 15 minutes, TfOH (16 μL, 0.16 mmol, 0.8 eq) was added, followed by stirring at room temperature for 2 hours. After the reaction, saturated $NaHCO_3$ solution was added to quench the reaction. The solution was extracted with DCM and H_2O. The combined organic layers were washed with brine and dried with Na_2SO_4, filtrated and concentrated under vacuum. The residue was then purified by flash columnchromatography (PE/EA = 5:1) to give **17a** (24 mg, 44%). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 8.18 (d, *J* = 10.6 Hz, 1H), 8.07 (s, 1H), 7.19 (d, *J* = 10.5 Hz, 1H), 7.02 (s, 1H), 3.99 (s, 3H), 3.97 (s, 3H).

Then, according to the literature procedure [6]: To a dried reaction vessel were added $Pd(OAc)_2$ (5 mg, 20 mol%), XPhos (17 mg, 40 mol%), tri-tert-butylphosphonium hydrogen tetrafluoroborate (12 mg, 40 mol%), pivalic acid (17 μL, 0.15 mmol, 1.5 eq), Cs_2CO_3 (98 mg, 0.3 mmol, 3.0 eq), **17a** (27mg, 0.1 mmol, 1.0 eq), 4-bromo-1,2-dimethoxybenzene **18a** (29 mg, 0.2 mmol, 2.0 eq), and DMA (1mL, 0.1 M). The flask wasplaced in a heating block and heated to 135 °C with constant stirring over 15 h. After completion of the reaction, the resulting mixture was cooled to room temperature, diluted with EtOAc, washed with saturated brine and H_2O, dried over $NaSO_4$, and concentrated. The residue obtained was purified by flash column chromatography (PE/EA = 1 : 1) over silica gel to give the final product **19a** (10 mg, 26%). **^{1}H NMR** (400 MHz, $CDCl_3$) δ: 8.07 (s, 1H), 7.34 (s, 1H), 7.25 – 7.23 (m, 1H), 7.15 (d, *J* = 2.2 Hz, 1H), 7.07 (s, 1H), 6.96 (d, *J* = 8.4 Hz, 1H), 4.02 (s, 3H), 4.00 (s, 3H), 3.96 (s, 3H), 3.95 (s, 3H). HRMS (ESI-TOF) m/z: $[M+H]^+$ Calcd for $C_{19}H_{19}O_5Se^+$ 407.0393; Found 407.0403. The ^{1}H NMR spectrum data of **19a** is consistent with the literature [6].

Radical quenching experiment

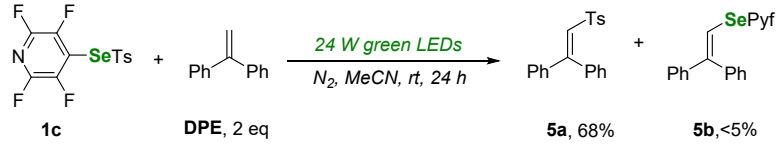


1c **3a2**, n.d **1b**, major product

A 4 mL vial equipped with a magnetic stirring bar was dried in oven. After cooling the vial to room temperature, **1c** (46 mg, 0.12 mmol, 1.2 eq), **2a** (11 μL, 0.1 mmol, 1.0 eq), TEMPO (24 mg, 0.15 mmol, 1.5 eq) and MeCN (1 mL, 0.1 M) were added to the vial and bubbled with oxygen for 15

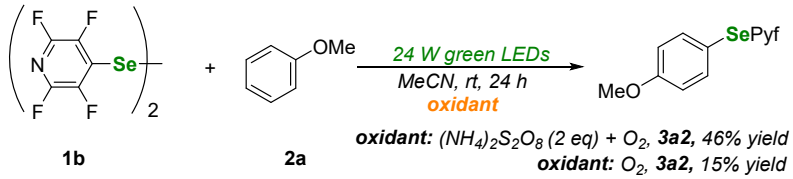
minutes. Add a fan to maintain the temperature at 25-30 °C. Photoirradiation was carried out with stirring for 24 hours. After that, the solution was diluted H_2O and extracted with DCM. The combined organic phase was washed with brine and dried with Na_2SO_4, filtrated and concentrated under vacuum. The residue was subjected to GCMS analysis and it was demonstrated that mainly **1b** was detected and the formation of **3a2** was completely inhibited.

Radical trapping experiment



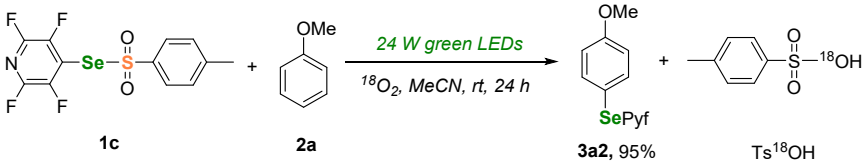
A 4 mL vial equipped with a magnetic stirring bar was dried in oven. After cooling the vial to room temperature, **1c** (46 mg, 0.12 mmol, 1.2 eq), 1,1-diphenylethylene (35 μL, 0.2 mmol, 2.0 eq), MeCN (1 mL, 0.1 M) were added to the vial and bubbled with nitrogen for 15 minutes. Add a fan to maintain the temperature at 25-30 °C. Photoirradiation was carried out with stirring for 24 hours. After that, the solution was diluted with H_2O and extracted with DCM. The combined organic phase was washed with brine and dried with Na_2SO_4, filtrated and concentrated under vacuum. The residue was then purified by flash columnchromatography (PE/EA = 20 : 1) to give **5a** (22 mg, 68%) and **5b** (about 2mg, <5%**)**. The structures were confirmed by HRMS.

Control reactions using 1b as alternative seleno donor



A 4 mL vial equipped with a magnetic stirring bar was dried in oven. After cooling the vial to room temperature, **1b** (28 mg, 0.06 mmol, 0.6 eq), **2a** (11 μL, 0.1 mmol, 1.0 eq) and MeCN (1 mL, 0.1 M) were added to the vial and bubbled with oxygen for 15 minutes or treated with $(NH_4)_2S_2O_8$ (46 mg, 0.2 mmol, 2.0 eq) and oxygen. Add a fan to maintain the temperature at 25-30 °C. Photoirradiation was carried out with stirring for 24 hours. After that, the solvent was removed under vacuum and the crude product was subjected to ^{1}H NMR analysis using mesitylene as the internal standard to calculate the yields of **3a2**.

^{18}O2 isotopic labeling experiment

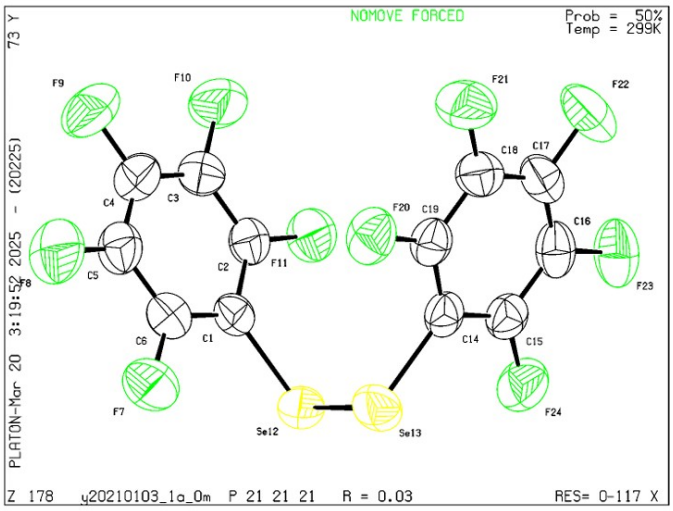


A 4 mL vial equipped with a magnetic stirring bar was dried in oven. After cooling the vial to room temperature, **1c** (46 mg, 0.12 mmol, 1.2 eq), **2a** (11 μL, 0.1 mmol, 1.0 eq) and MeCN (1 mL, 0.1 M)

were added to the vial and bubbled with $^{18}O_2$ for 15 minutes. Add a fan to maintain the temperature at 25-30 °C. Photoirradiation was carried out with stirring for 24 hours. After that, PE (2 mL) was added and the resulting white solid (Ts^{18}OH) was isolated by filtration and subjected to HRMS analysis (see Figure S4 for details). The filtrate was concentrated under vacuum and the residue was subjected to ^{1}H NMR analysis using mesitylene as the internal standard to calculate the yield of **3a2**.

Single-Crystal X-ray Diffraction Data for 1a

Preparation of the single crystals of **1a**: 100 mg of pure **1a** was dissolved in the combined solvents of ethyl ether (0.5 mL) at room temperature. The bottle was sealed by a piece of plastic film with several tiny holes, thus allowing the slow solvent evaporation at 0 °C. After about three days, several small crystals were observed at the bottom of the bottle. The crystals were collected and subjected to the single crystal X-ray diffraction analysis for the determination of the structure of **1a**. The data set was collected by a Bruker proton III ((Bruker, Germany) 298.0 K equipped with Cu radiation source (Kα = 1.54178 Å). Applied with multi-scanabsorption correction, the structure solution was solved and refinement was processed by diamondprogram package.



Bond precision: C-C = 0.0073 A Wavelength=1.54178

Correction method= # Reported T Limits: Tmin= 0.276 Tmax =0.753 AbsCorr = MULTI-SCAN Data completeness= 1.68/1.00

Cell:	a=5.7599(3)	b=9.4957(5)	c=25.7505(13)
	alpha=90	beta=90	gamma=90
Temperature:	299 K		

	Calculated	Reported
Volume	1408.41(13)	1408.41(13)
Space group	P 21 21 21	P 21 21 21
Hall group	P 2ac 2ab	P 2ac 2ab
Moiety formula	C12 F10 Se2	C12 F10 Se2
Sum formula	C12 F10 Se2	C12 F10 Se2
Mr	492.04	492.04
Dx,g cm-3	2.320	2.321
Z	4	4
Mu (mm-1)	7.685	7.685
F000	920.0	920.0
F000’	917.34	
h,k,lmax	6,11,31	6,11,30
Nref	2565[1523]	2553
Tmin,Tmax	0.238,0.541	0.276,0.753
Tmin’	0.148	

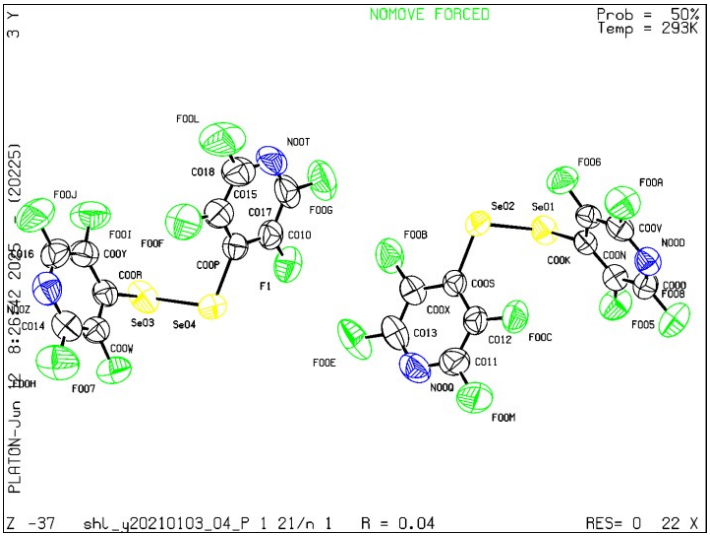
Theta(max)= 68.204

R(reflections)= 0.0288(2514) wR2(reflections)=0.0695(2553)

S = 1.116 Npar= 218

Single-Crystal X-ray Diffraction Data for 1b

Preparation of the single crystals of **1b**: 100 mg of pure **1b** was dissolved in the combined solvents of ethyl ether (0.5 mL) at room temperature. The bottle was sealed by a piece of plastic film with several tiny holes, thus allowing the slow solvent evaporation at 0 °C. After about one day, several small crystals were observed at the bottom of the bottle. The crystals were collected and subjected to the single crystal X-ray diffraction analysis for the determination of the structure of **1b**. The data set was collected by a Bruker proton III ((Bruker, Germany) 298.0 K equipped with Cu radiation source (Kα = 1.54178 Å). Applied with multi-scanabsorption correction, the structure solution was solved and refinement was processed by diamondprogram package.



Bond precision: C-C = 0.0069 A Wavelength=1.54178

Cell:	a=9.8337(4)	b=11.1932(5)	c=24.2439(12)
	alpha=90	beta=96.043(3)	gamma=90
Temperature:	293 K		

	Calculated	Reported
Volume	2653.7(2)	1408.41(13)
Space group	P 21/n	P 21/n
Hall group	-P 2yn	-P 2yn
Moiety formula	C10 F8 N2 Se2	C10 F8 N2 Se2
Sum formula	C10 F8 N2 Se2	C10 F8 N2 Se2
Mr	458.04	458.04
Dx,g cm-3	2.293	2.293
Z	8	8
Mu (mm-1)	7.907	7.907
F000	1712.0	1712.0
F000’	1705.66	

	h,k,lmax	11,13,29	11,13,28
Correc	Nref	4883	4768
tion	Tmin,Tmax	0.177,0.176	0.348,0.753
metho	Tmin'	0.079	

d= # Reported T Limits: Tmin=0.348 Tmax=0.753
AbsCorr = MULTI-SCAN

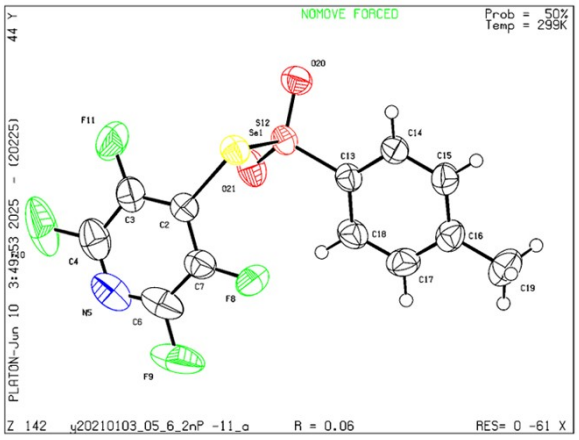
Data completeness= 0.976 Theta(max)= 68.512

R(reflections)= 0.0445(4224) wR2(reflections)=0.1107(4768)

S = 1.036 Npar= 398

Single-Crystal X-ray Diffraction Data for 1c

Preparation of the single crystals of **1c**: 60 mg of pure **1c** was dissolved in the combined solvents of MTBE (0.5 mL) at room temperature. The bottle was sealed by a piece of plastic film with several tiny holes, thus allowing the slow solvent evaporation at room temperature. After about one hour, several small crystals were observed at the bottom of the bottle. The crystals were collected and subjected to the single crystal X-ray diffraction analysis for the determination of the structure of **1c**. The data set was collected by a Bruker proton III ((Bruker, Germany) 298.0 K equipped with Cu radiation source (Kα = 1.54178 Å). Applied with multi-scanabsorption correction, the structure solution was solved and refinement was processed by diamondprogram package.



Bond precision: C-C = 0.0073 A Wavelength=1.54178

Cell:	a=6.5644(13)	b=8.2458(16)	c=13.659(3)
	alpha=102.402(5)	beta=98.371(6)	gamma=103.685(5)
Temperature:	299 K		

Calculated	Reported

	Volume	686.4(2)	1408.41(13)
Correction	Space group	P -1	P 21/n
	Hall group	-P 1	-P 2yn
method= #	Moiety formula	C12 H7 F4 N O2 S Se	C12 H7 F4 N O2 S Se
	Sum formula	C12 H7 F4 N O2 S Se	C12 H7 F4 N O2 S Se
Reported T	Mr	384.21	384.21
	Dx,g cm-3	1.859	1.859
Limits:	Z	2	2
	Mu (mm-1)	5.631	5.631
Tmin= 0.273	F000	376.0	376.0
	F000’	376.31	
Tmax =0.753	h,k,lmax	7,9,16	7,9,16
	Nref	2506	2444
	Tmin,Tmax	0.264,0.363	0.273,0.753
AbsCorr =	Tmin’	0.084	

MULTI-SCAN

Data completeness= 0.975 Theta(max)= 68.238

R(reflections)= 0.0607(2416) wR2(reflections)=0.1558(2444)

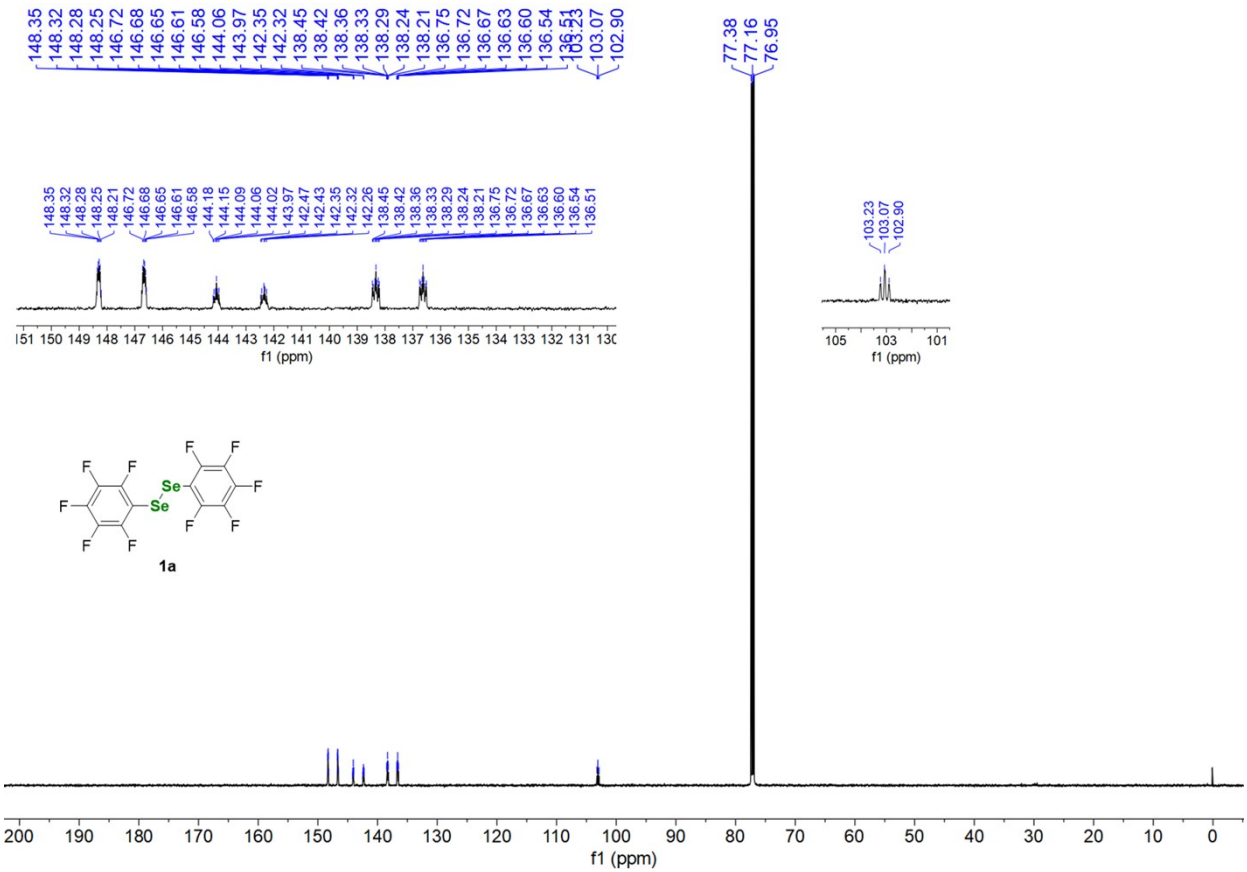
S = 1.073 Npar= 191

References

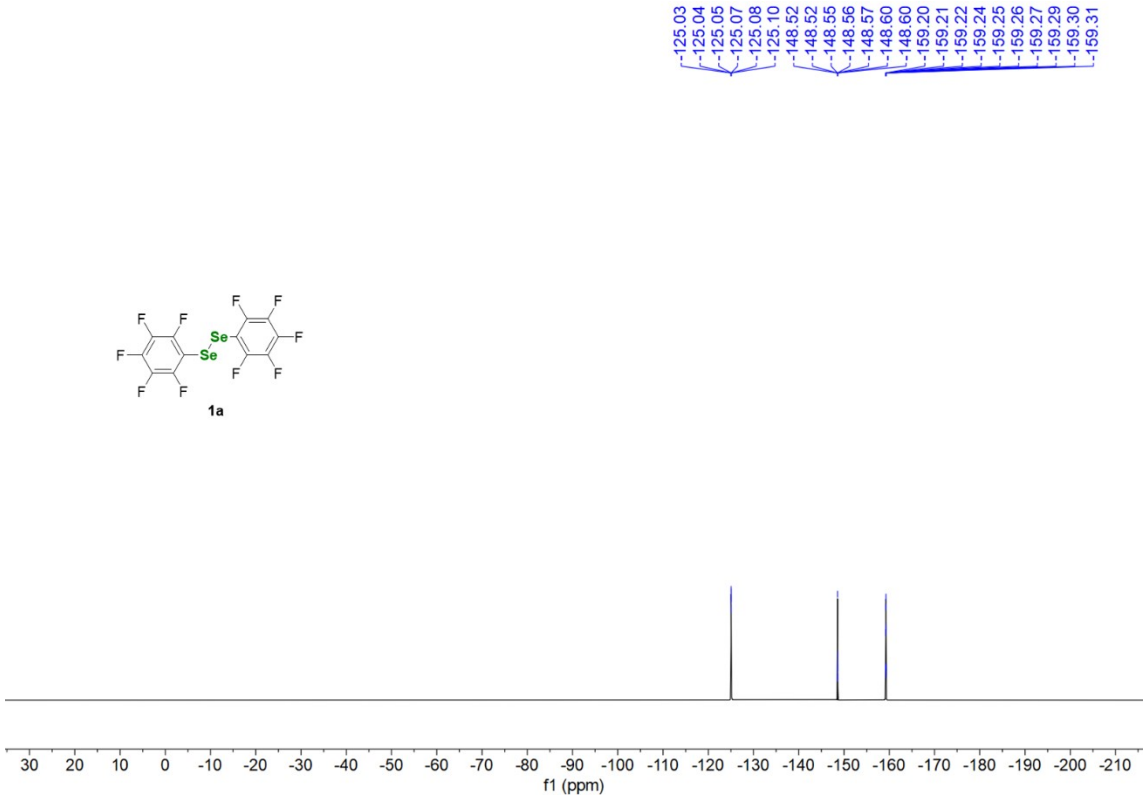
1. S. Lü, Z. Wang, X. Gao, K. Chen, S. Zhu, *Angew. Chem. Int. Ed.* **2023**, *62*, e202300268.
2. X. Gong, S. Sun, M. Ren, Q. Wu, Y. Chen, Y. Xu, *J. Org. Chem*. **2024**, *89*, 4176–4184.
3. T. M. Klapötke, B. Krumm, P. Mayer, K. Polborn, O. P. Ruscitti, *Phosphorus. Sulfur.* **2001**, *172*, 119–128.
4. S.-L. Xie, J.-Z. Yan, M.-J. Xie, X. Li, F. Zhou, M.-Q. Zheng, X.-L. Wang, J. Feng, Y. Zhang, Y.-N. Duan, Y.-D. Niu, D. Li, H.-D. Xia, *Green. Chem.* **2024**, *26*, 323–329.
5. B. Saxena, R. I. Patel, S. Sharma, A. Sharma, *Green. Chem.* **2024**, *26*, 2721–2729.
6. W.-R. Yang, Y.-S. Choi, J.-H. Jeong, *Org. Biomol. Chem*. **2017**, *15*, 3074–3083.

Spectral Data for Products

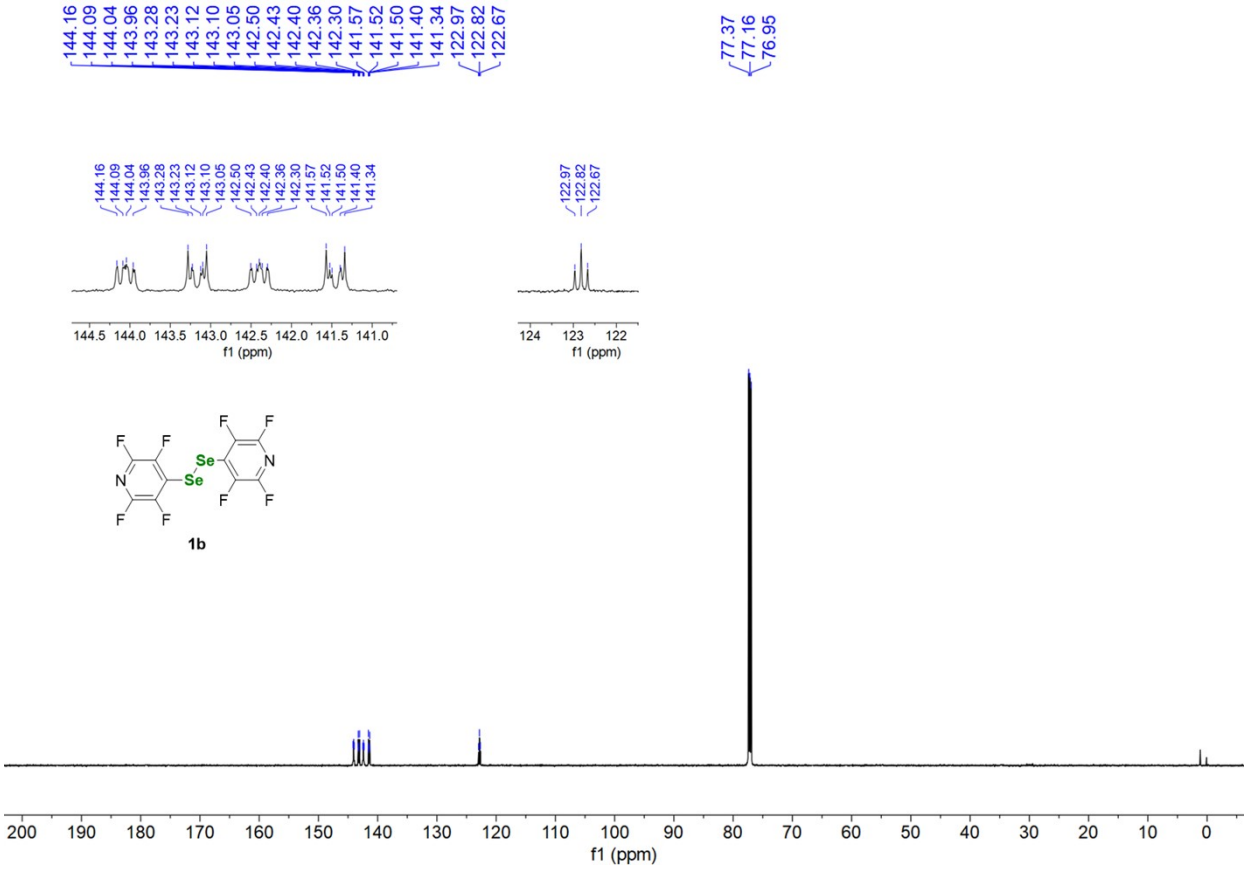
^{13}C NMR spectra of 1a (150 MHz, $CDCl_3$)



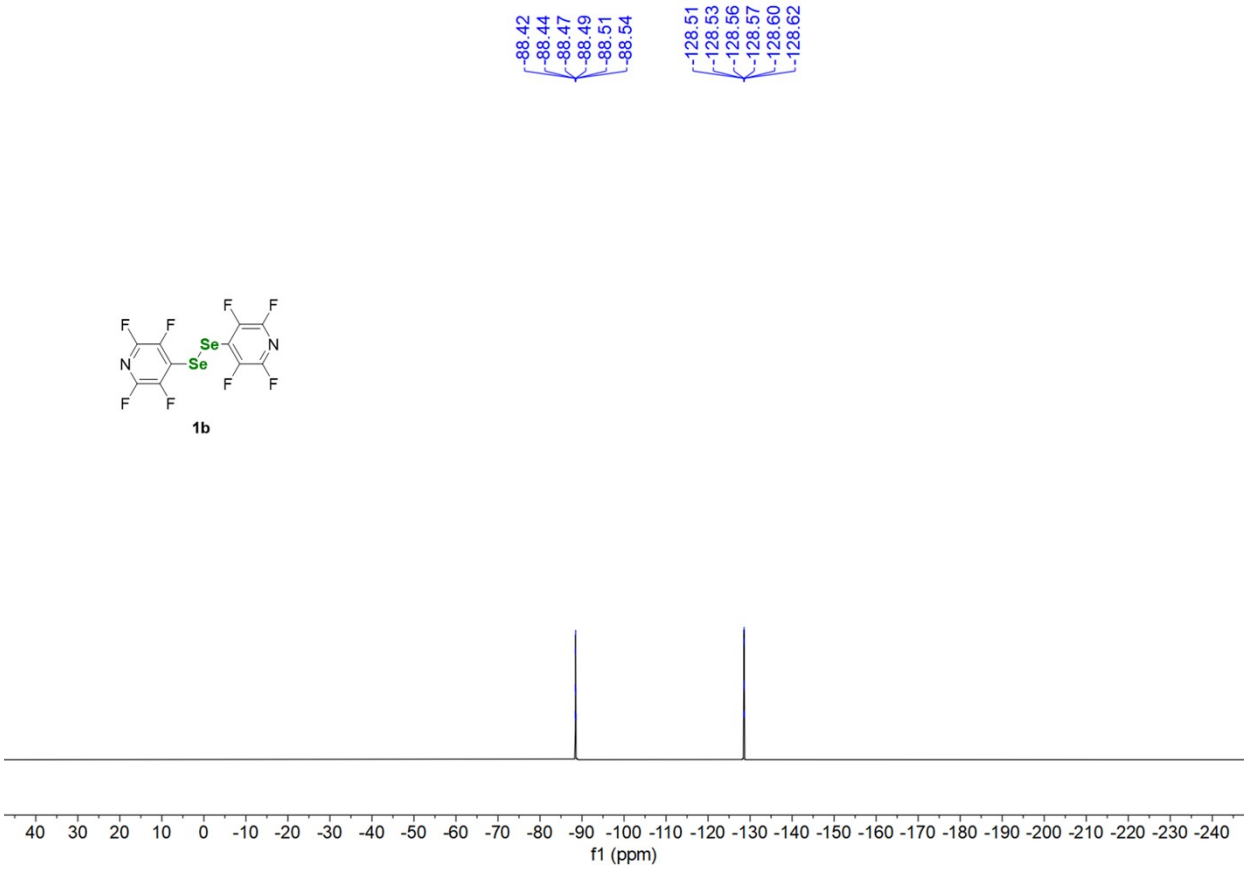
^{19}F NMR spectra of 1a (564 MHz, $CDCl_3$)



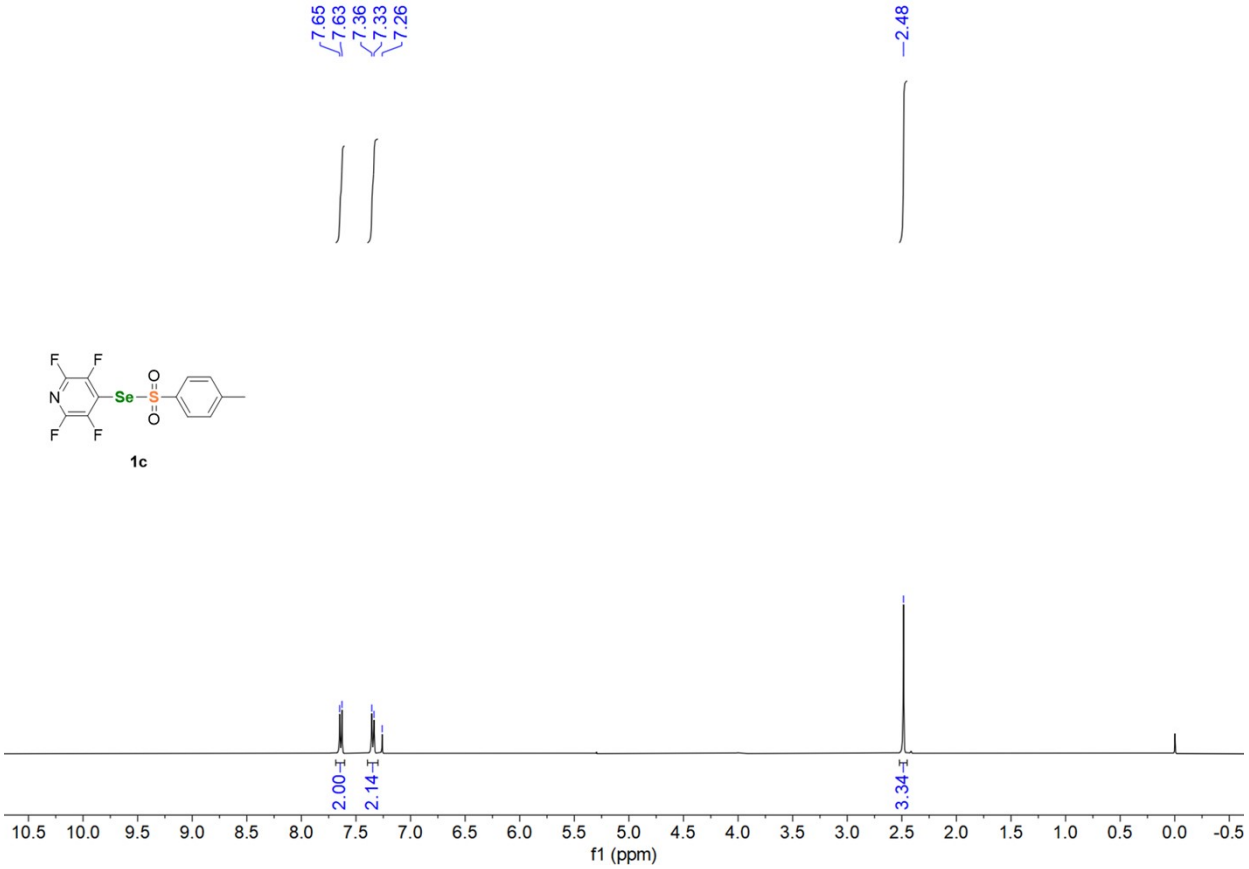
^{13}C NMR spectra of 1b (150 MHz, $CDCl_3$)



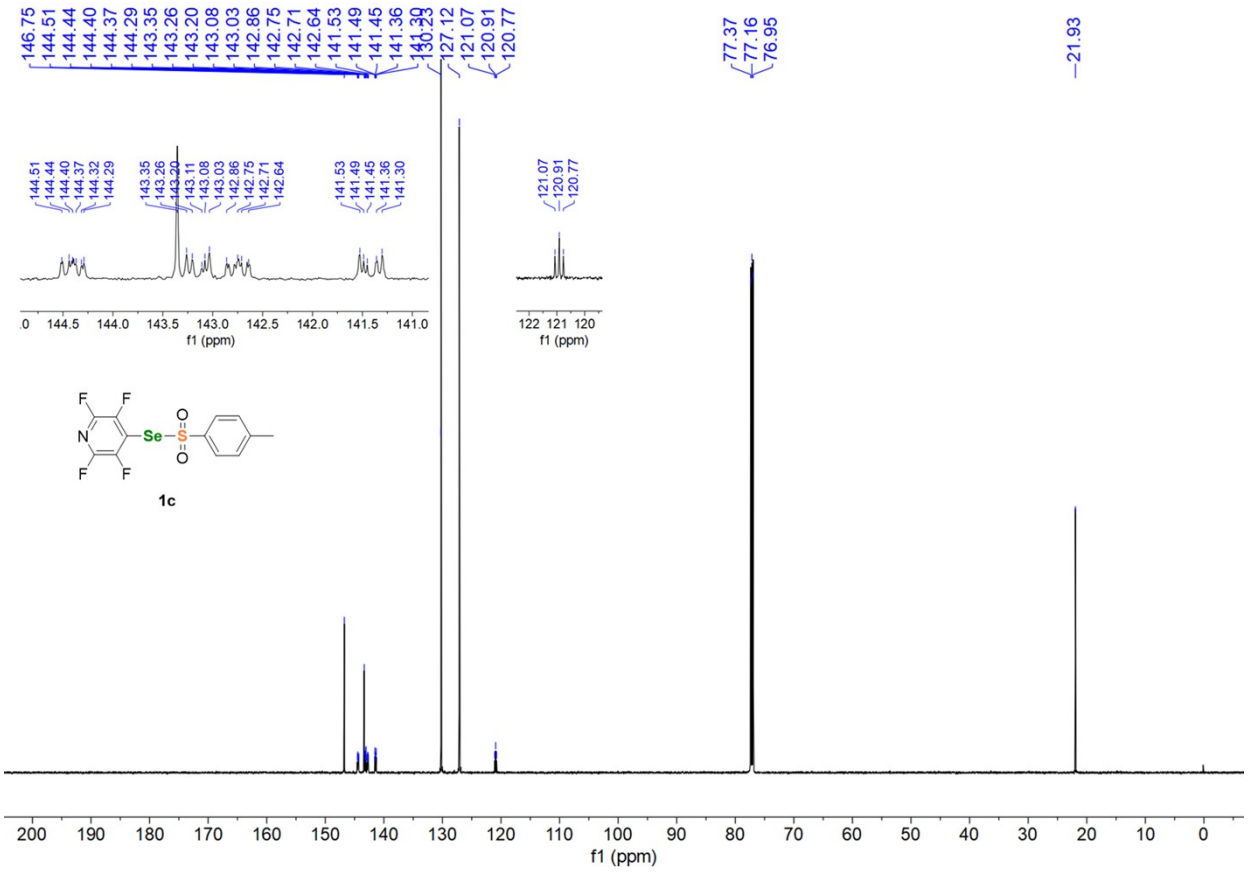
^{19}F NMR spectra of 1b (564 MHz, $CDCl_3$)



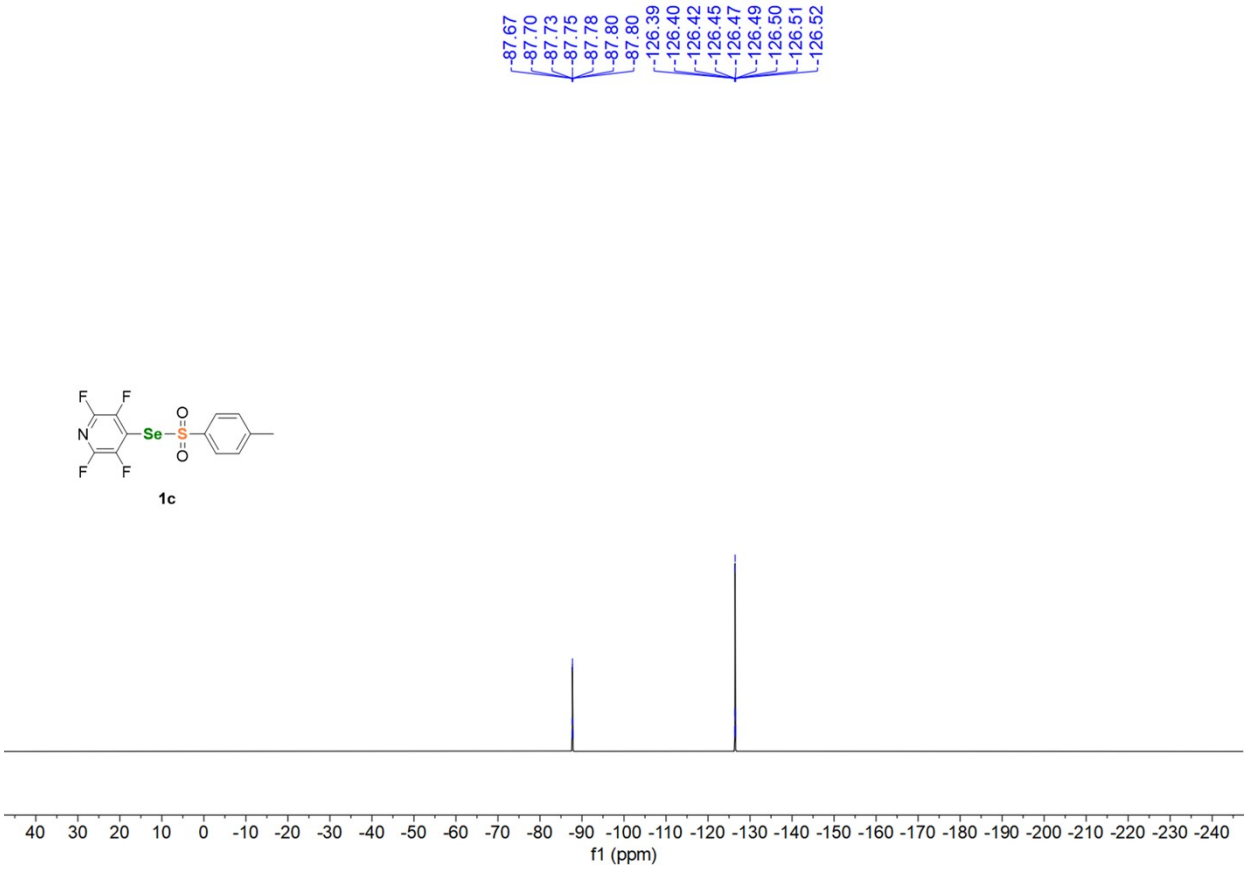
^{1}H NMR spectra of 1c (400 MHz, $CDCl_3$)



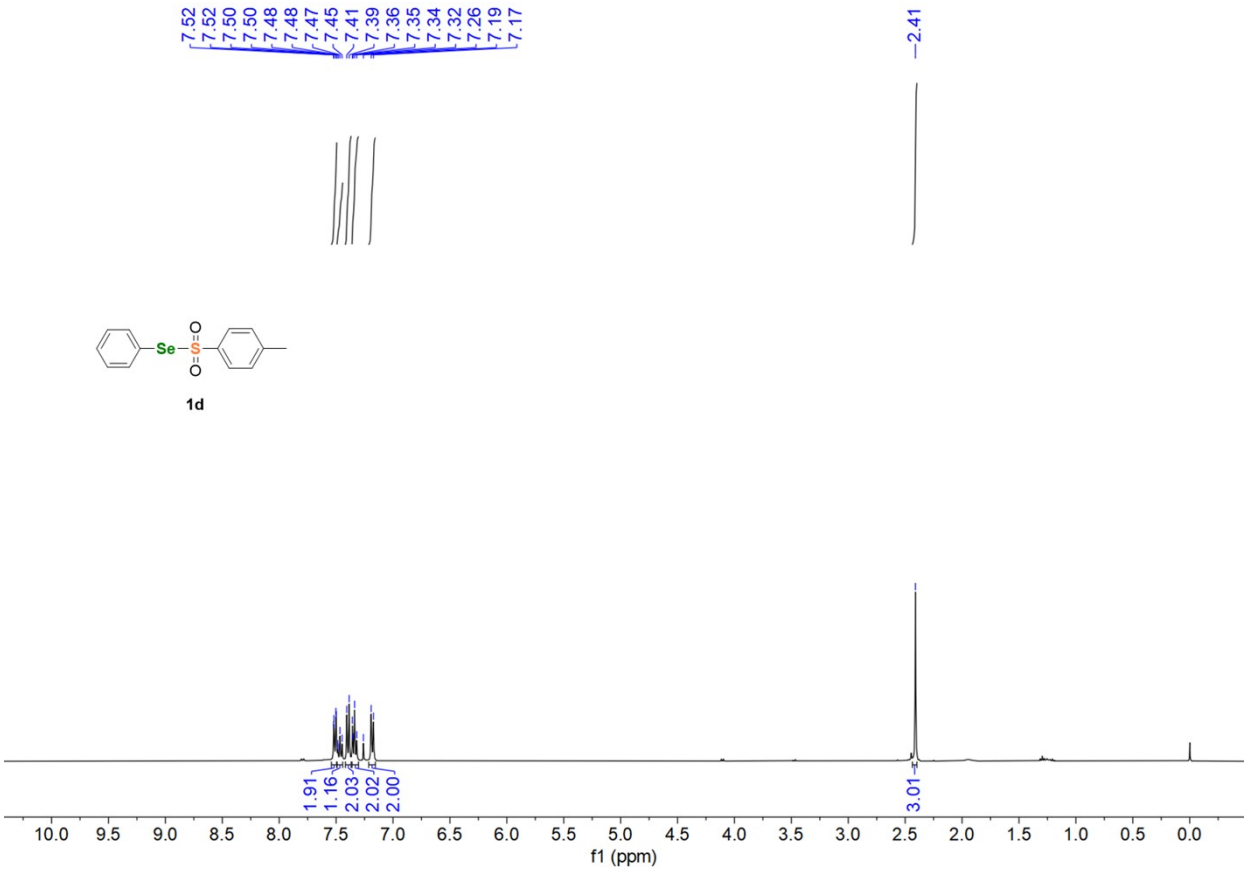
^{13}C NMR spectra of 1c (150 MHz, $CDCl_3$)



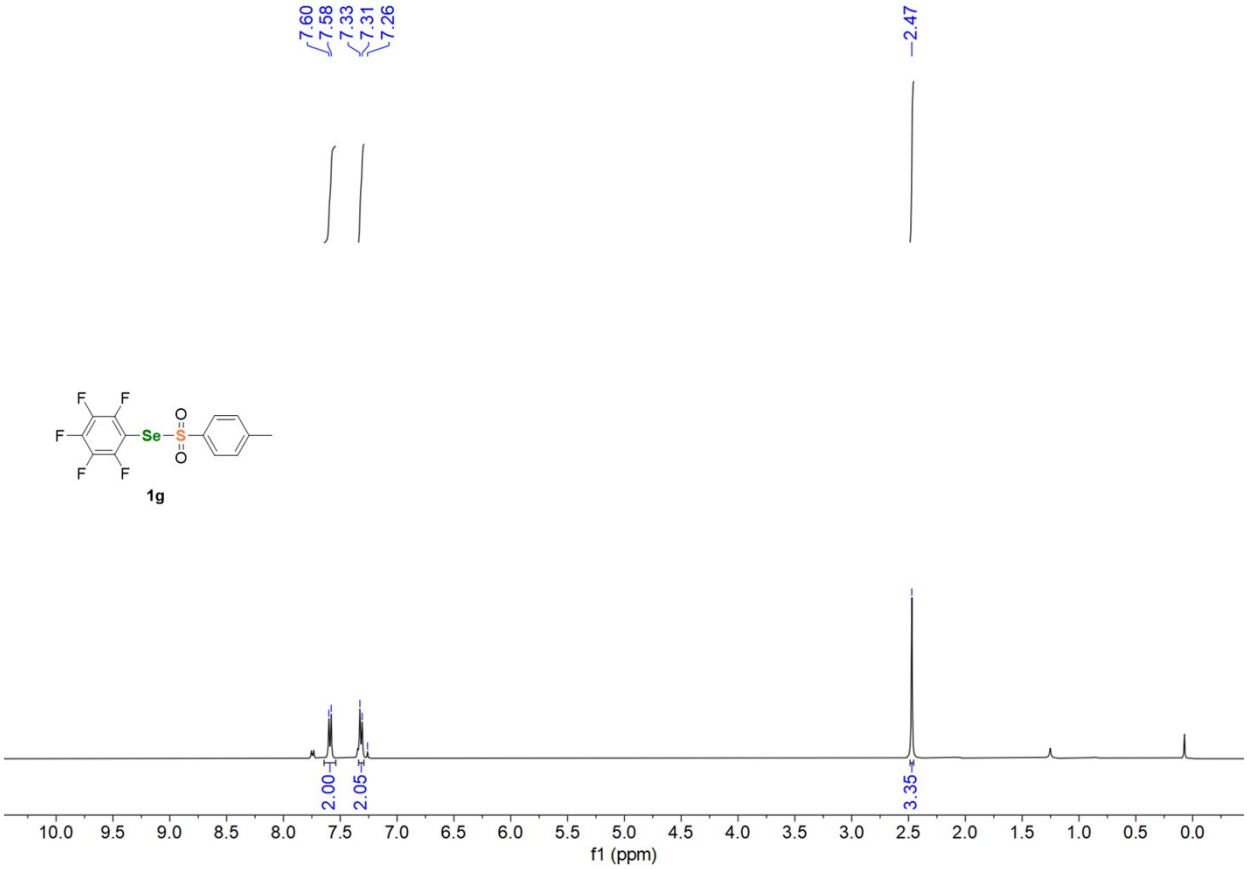
^{19}F NMR spectra of 1c (564 MHz, $CDCl_3$)



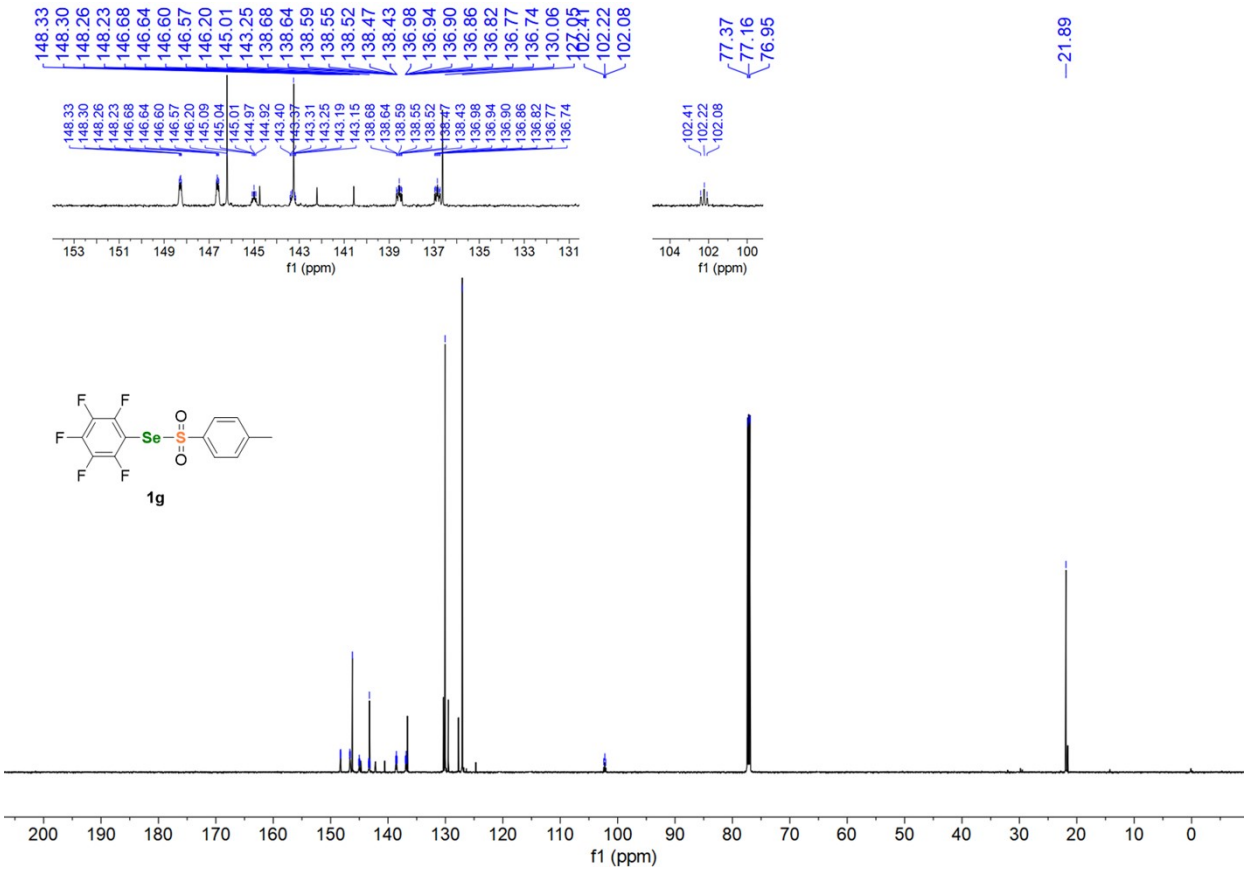
^{1}H NMR spectra of 1d (400 MHz, $CDCl_3$)



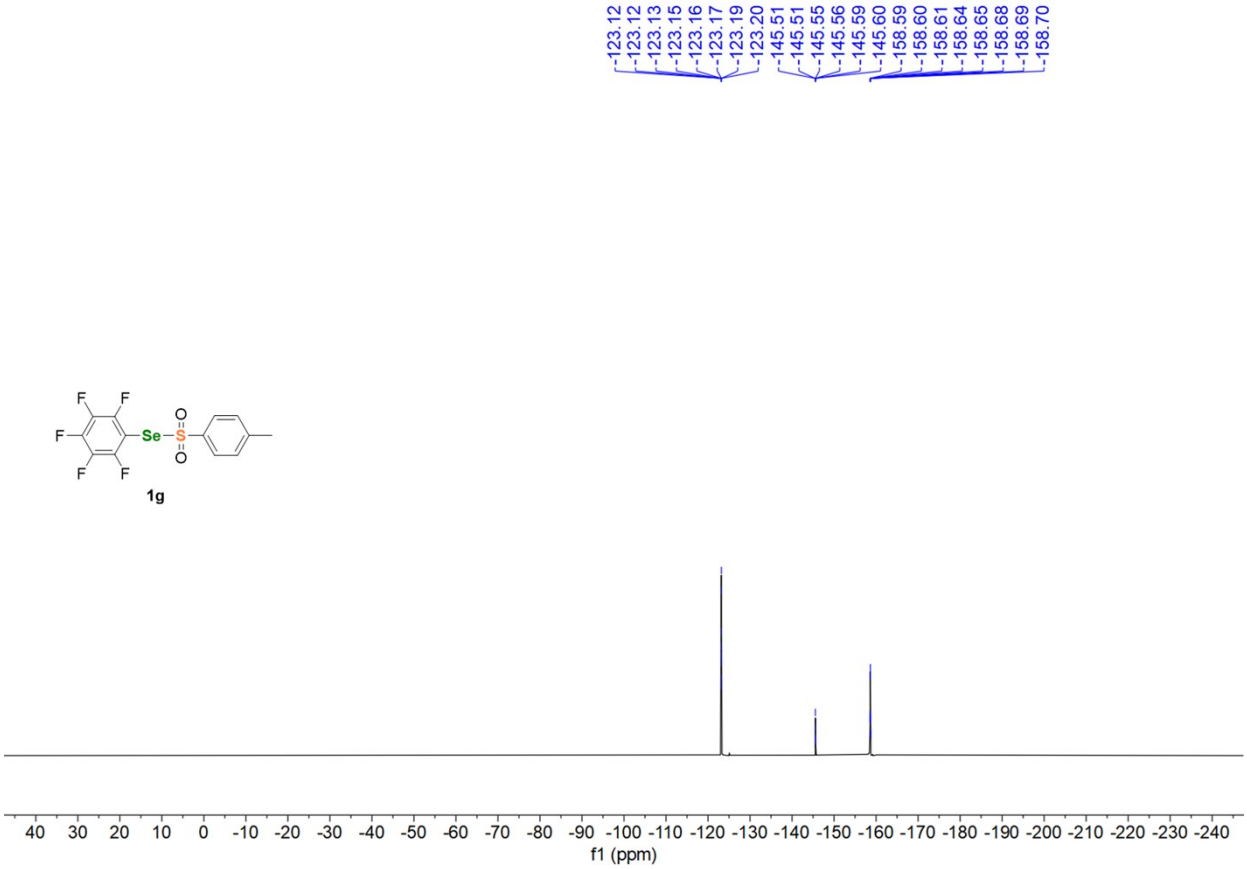
^{1}H NMR spectra of 1g (400 MHz, $CDCl_3$)



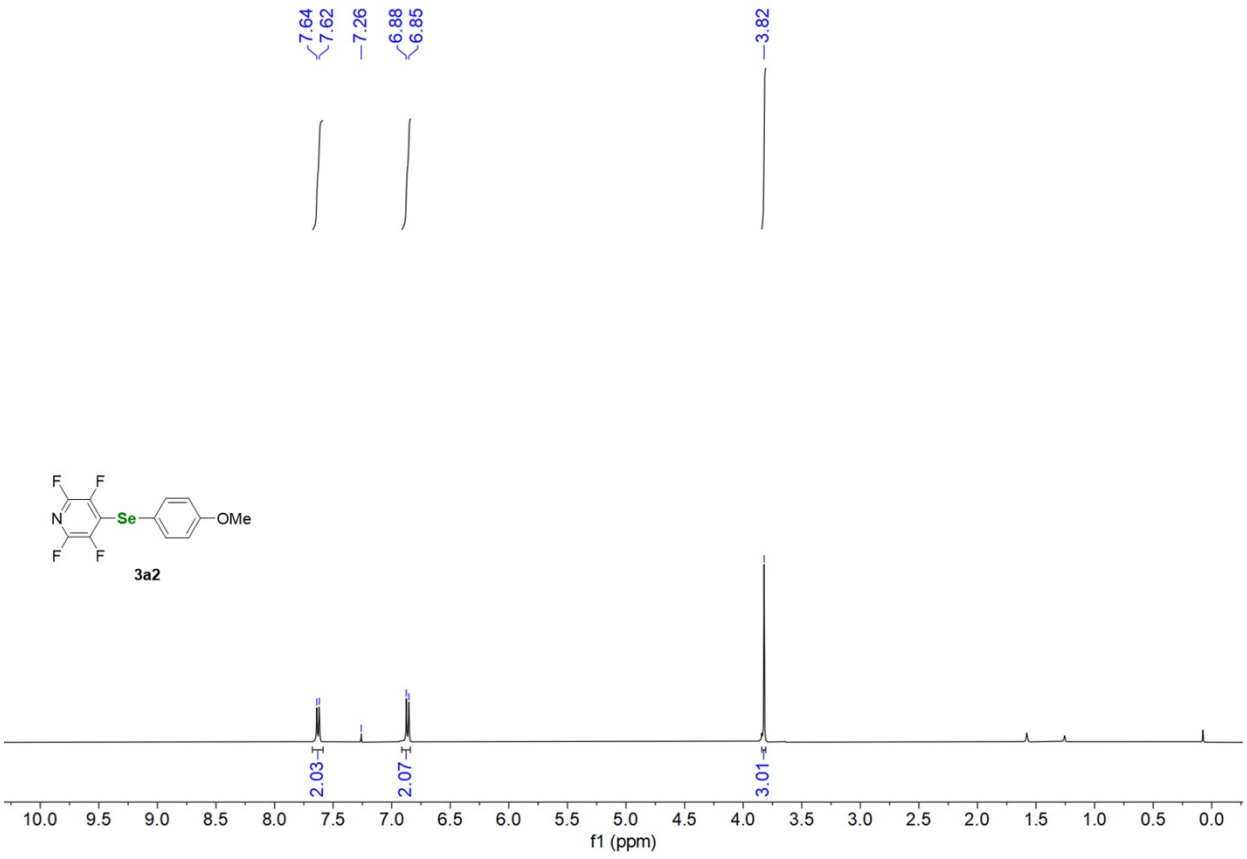
^{13}C NMR spectra of 1g (150 MHz, $CDCl_3$)



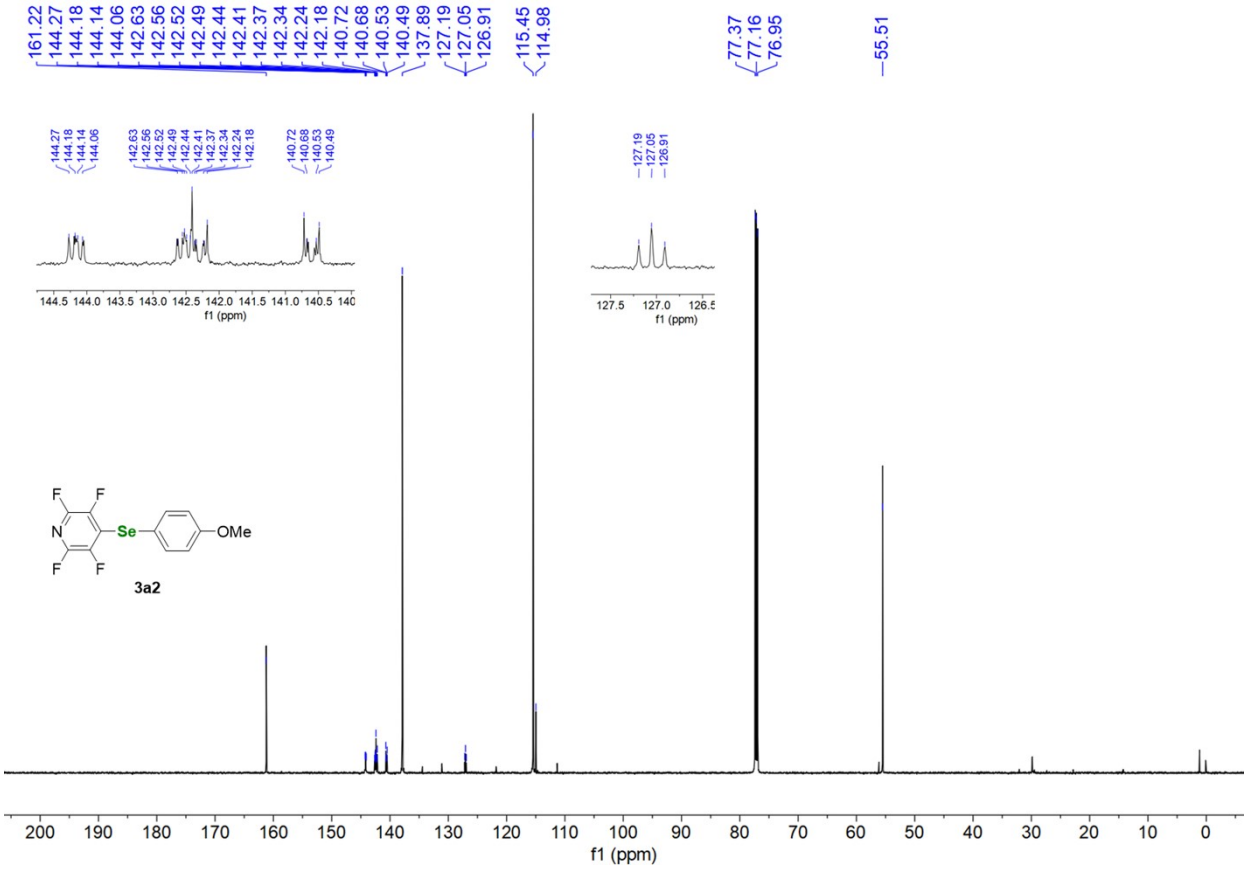
^{19}F NMR spectra of 1g (564 MHz, $CDCl_3$)



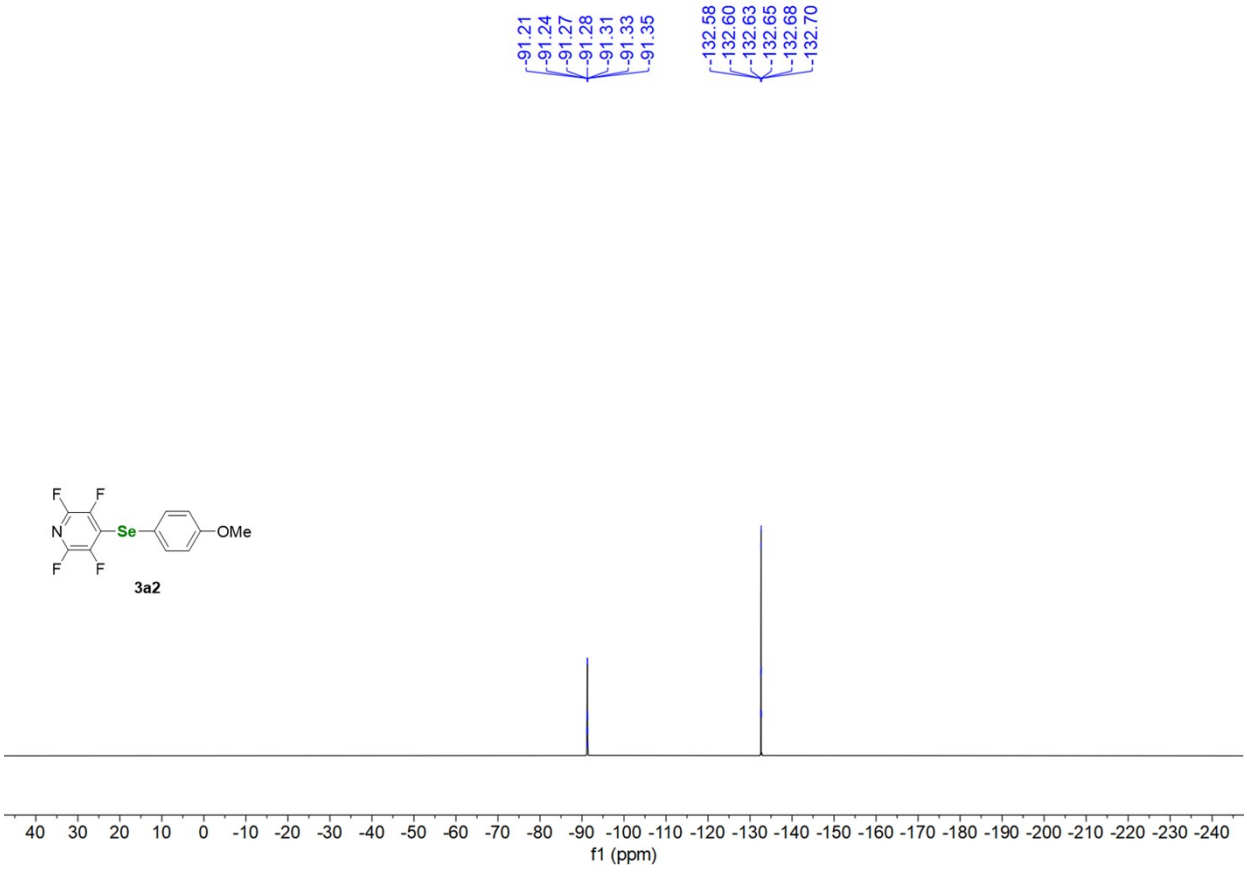
^{1}H NMR spectra of 3a2 (400 MHz, $CDCl_3$)



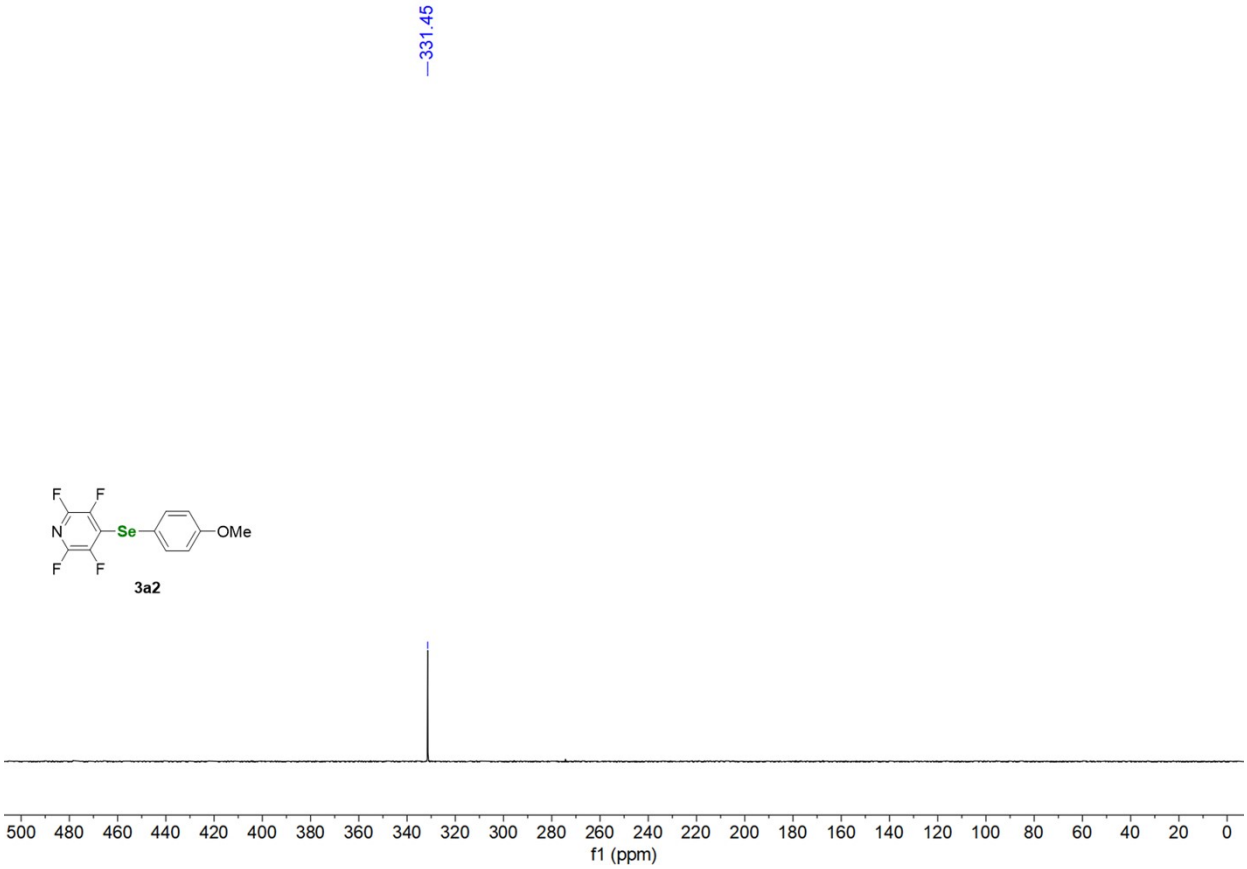
^{13}C NMR spectra of 3a2 (150 MHz, $CDCl_3$)



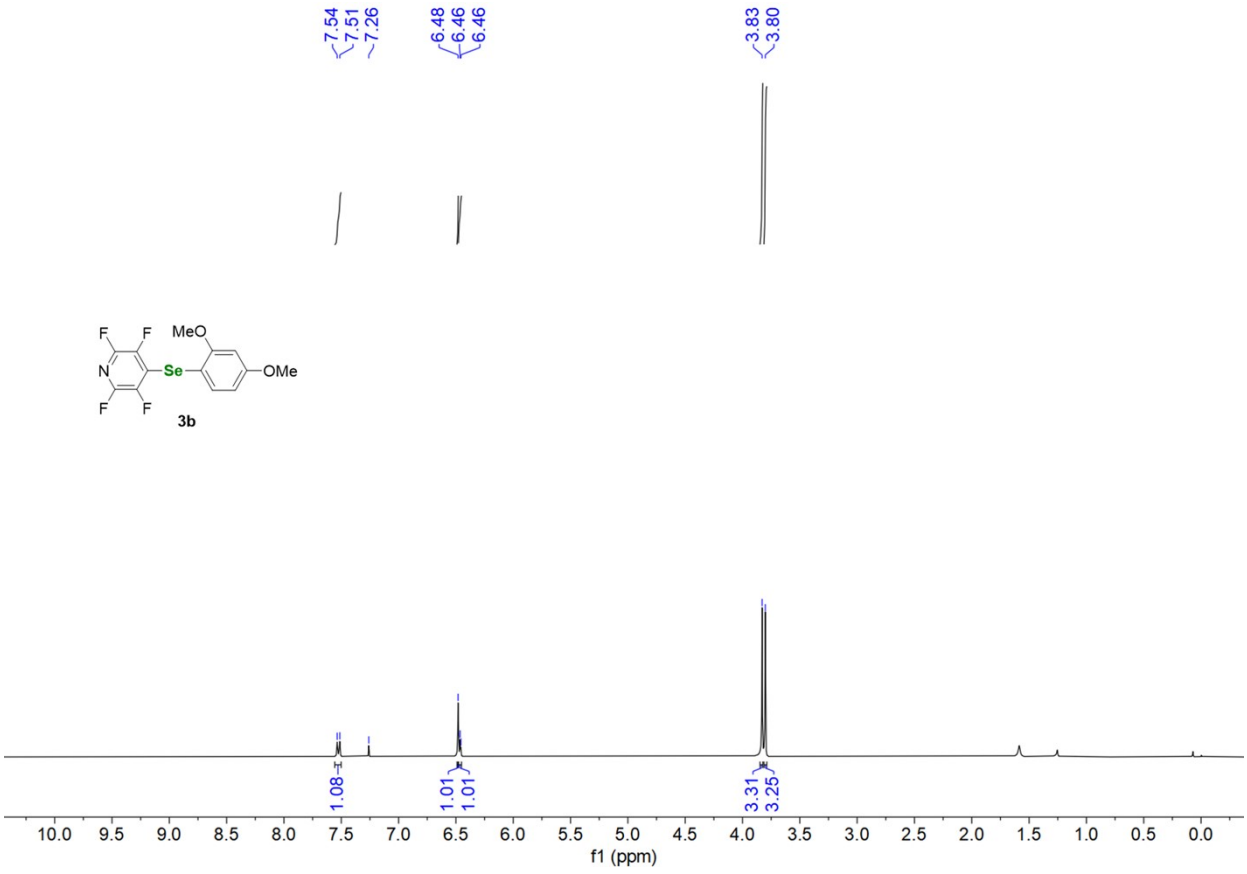
^{19}F NMR spectra of 3a2 (564 MHz, $CDCl_3$)



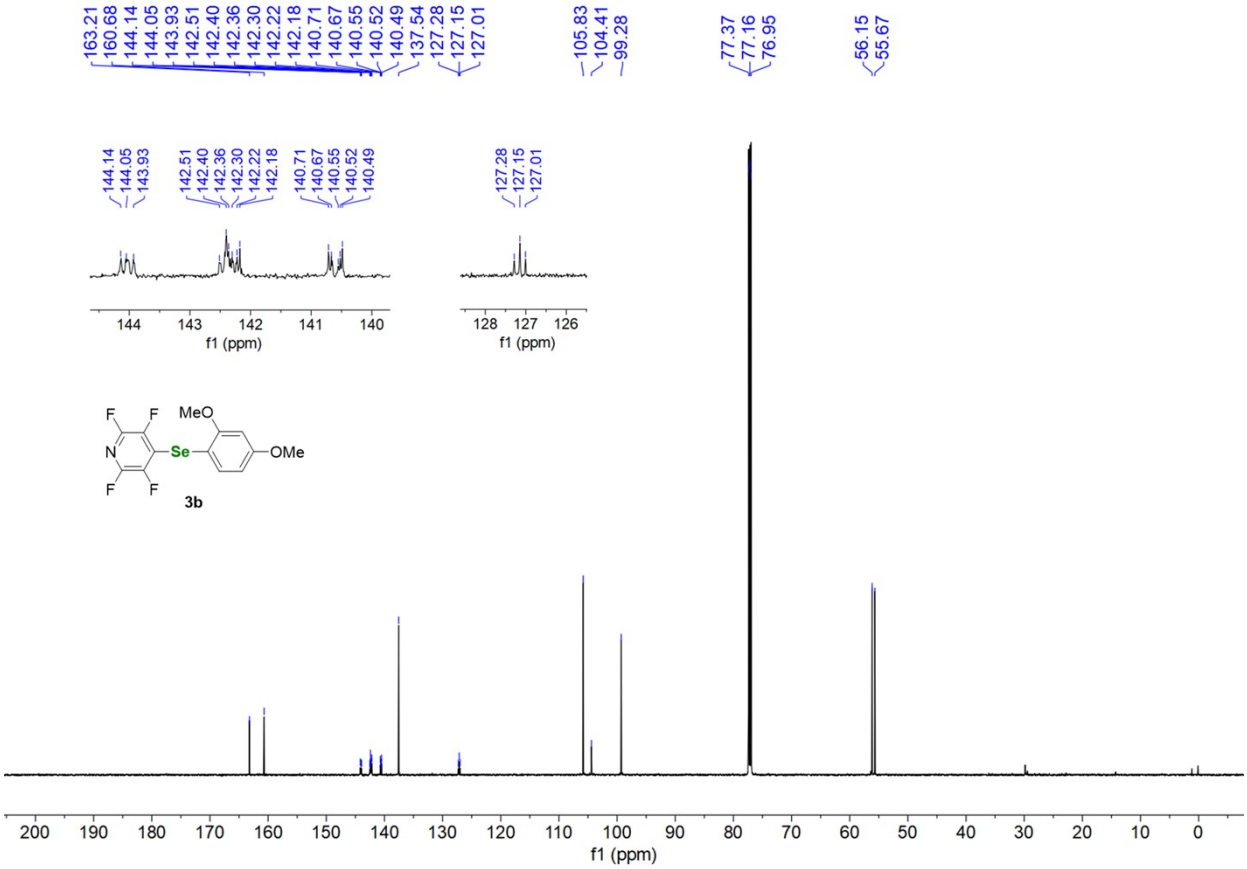
^{77}Se NMR spectra of 3a2 (114 MHz, $CDCl_3$)



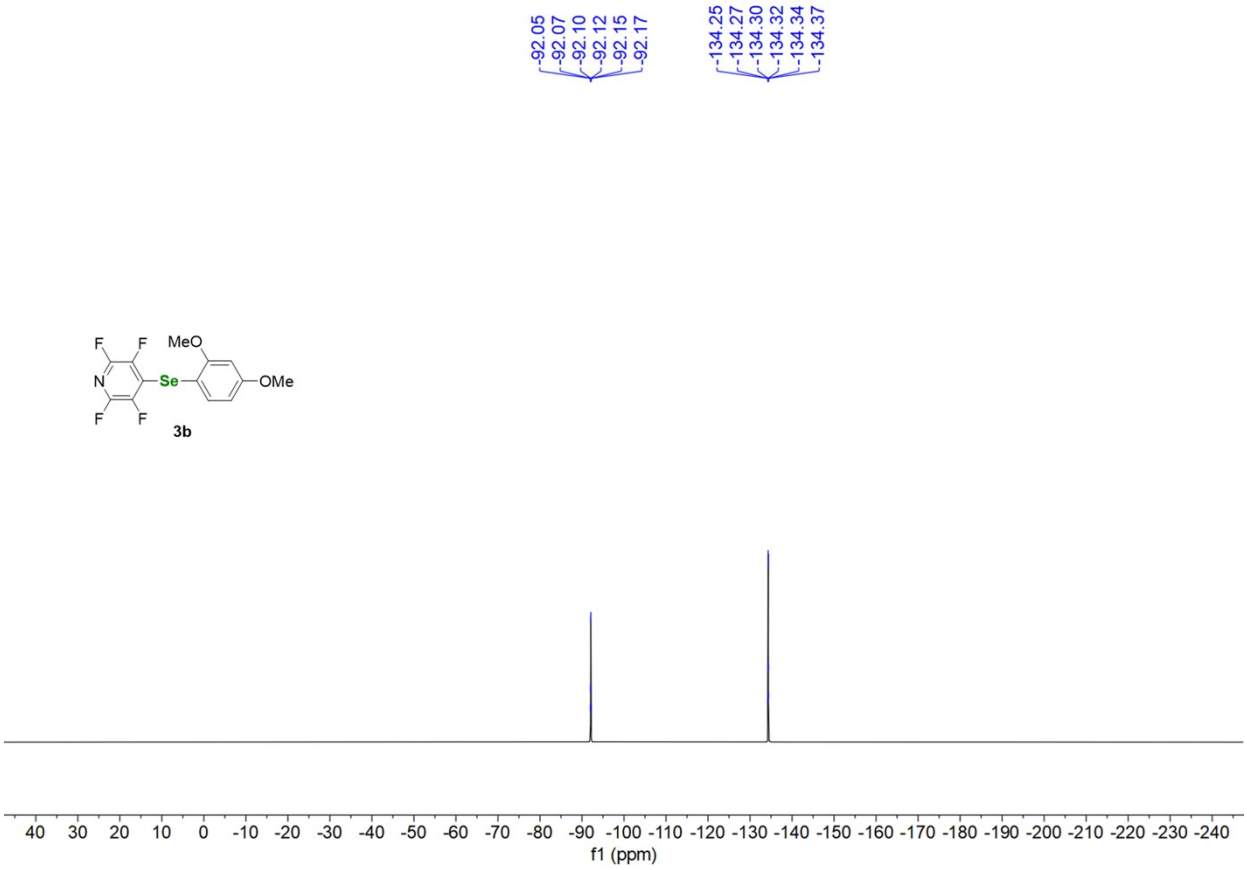
^{1}H NMR spectra of 3b (400 MHz, $CDCl_3$)



^{13}C NMR spectra of 3b (150 MHz, $CDCl_3$)

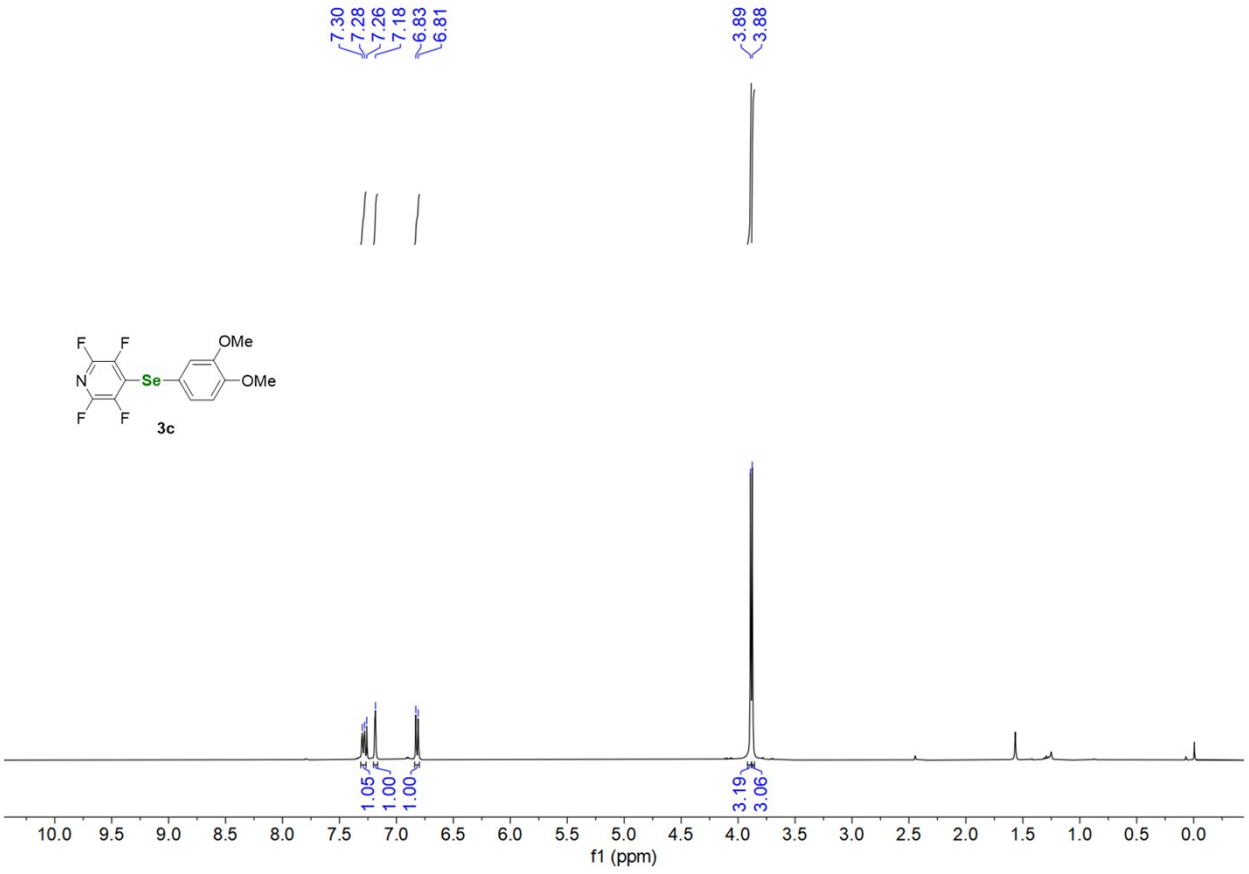


^{19}F NMR spectra of 3b (564 MHz, $CDCl_3$)

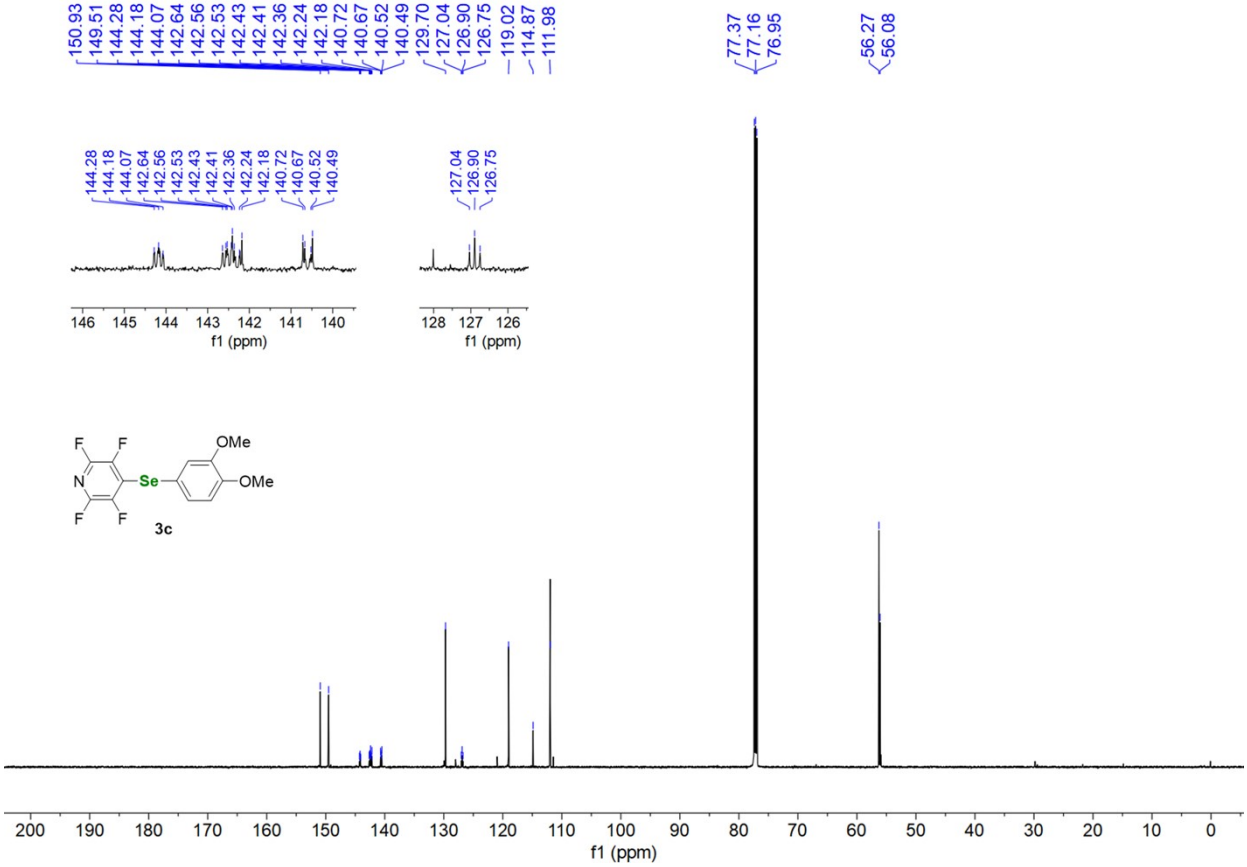


^{77}Se NMR spectra of 3b (114 MHz, $CDCl_3$)

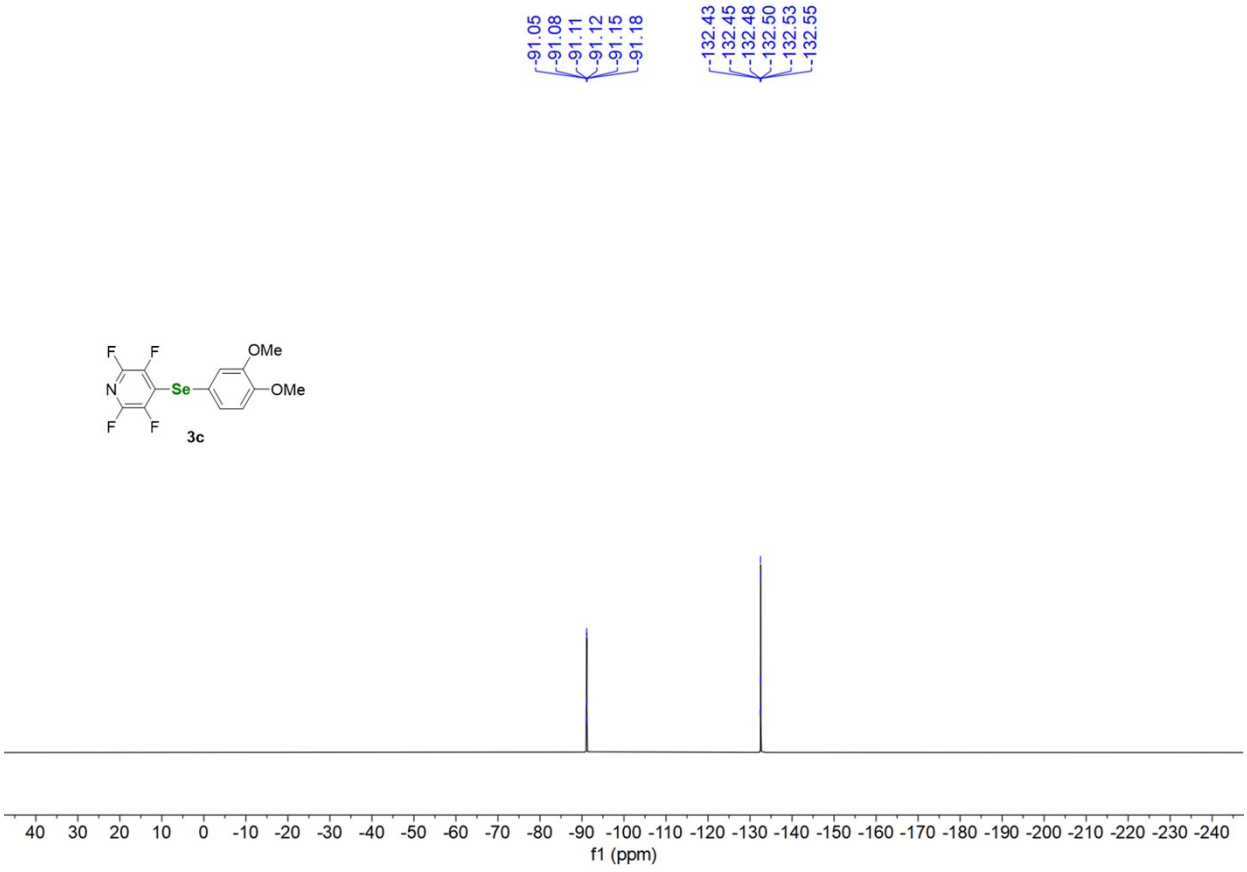
^{1}H NMR spectra of 3c (400 MHz, $CDCl_3$)



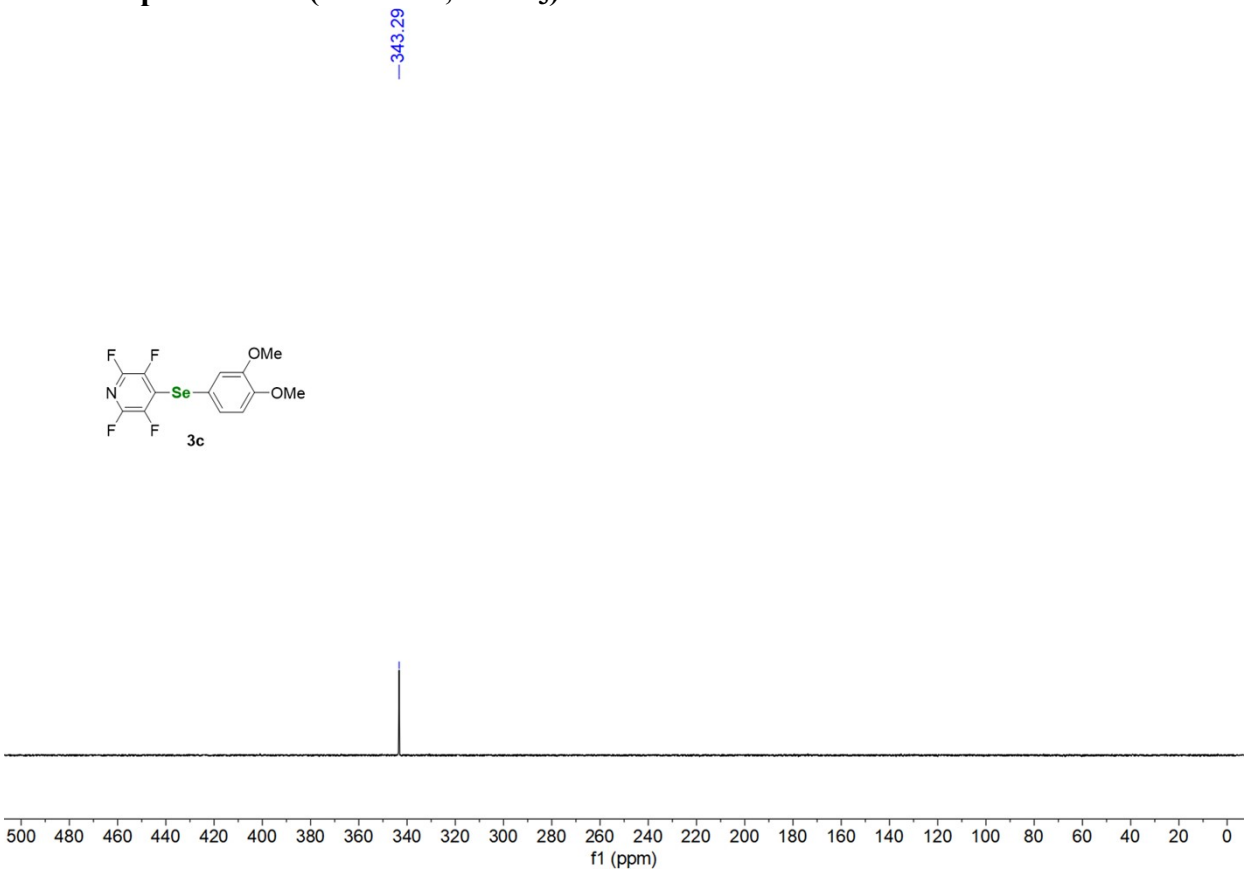
^{13}C NMR spectra of 3c (150 MHz, $CDCl_3$)



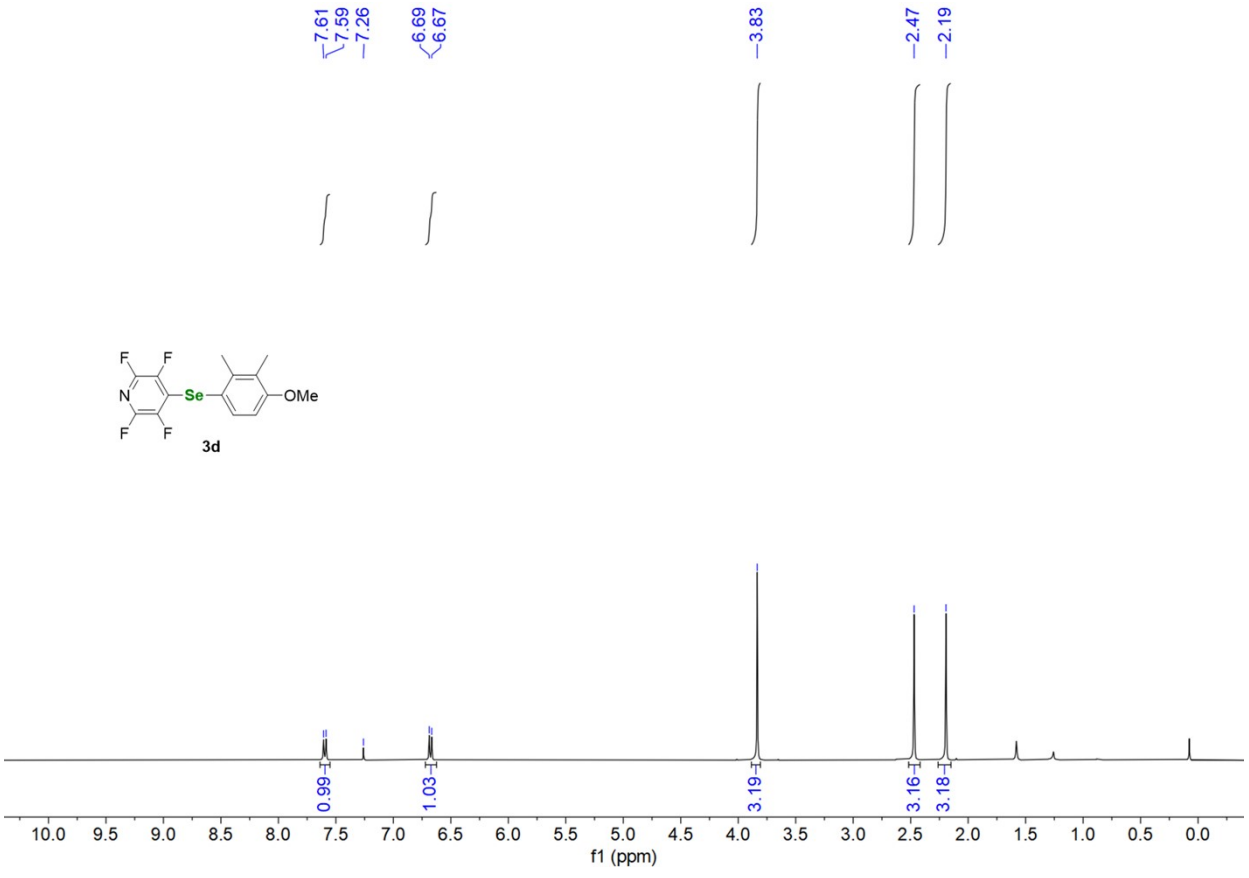
^{19}F NMR spectra of 3c (564 MHz, $CDCl_3$)



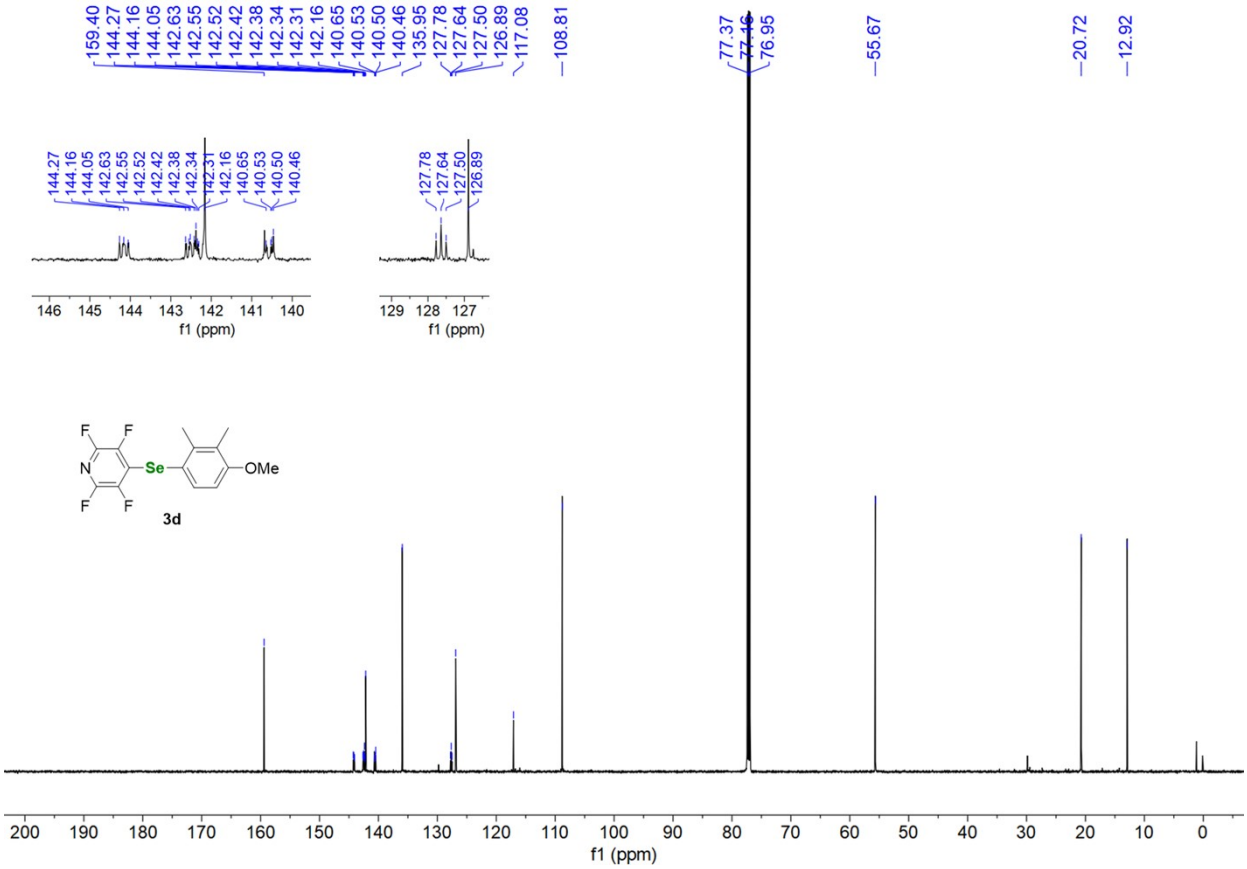
^{77}Se NMR spectra of 3c (114 MHz, $CDCl_3$)



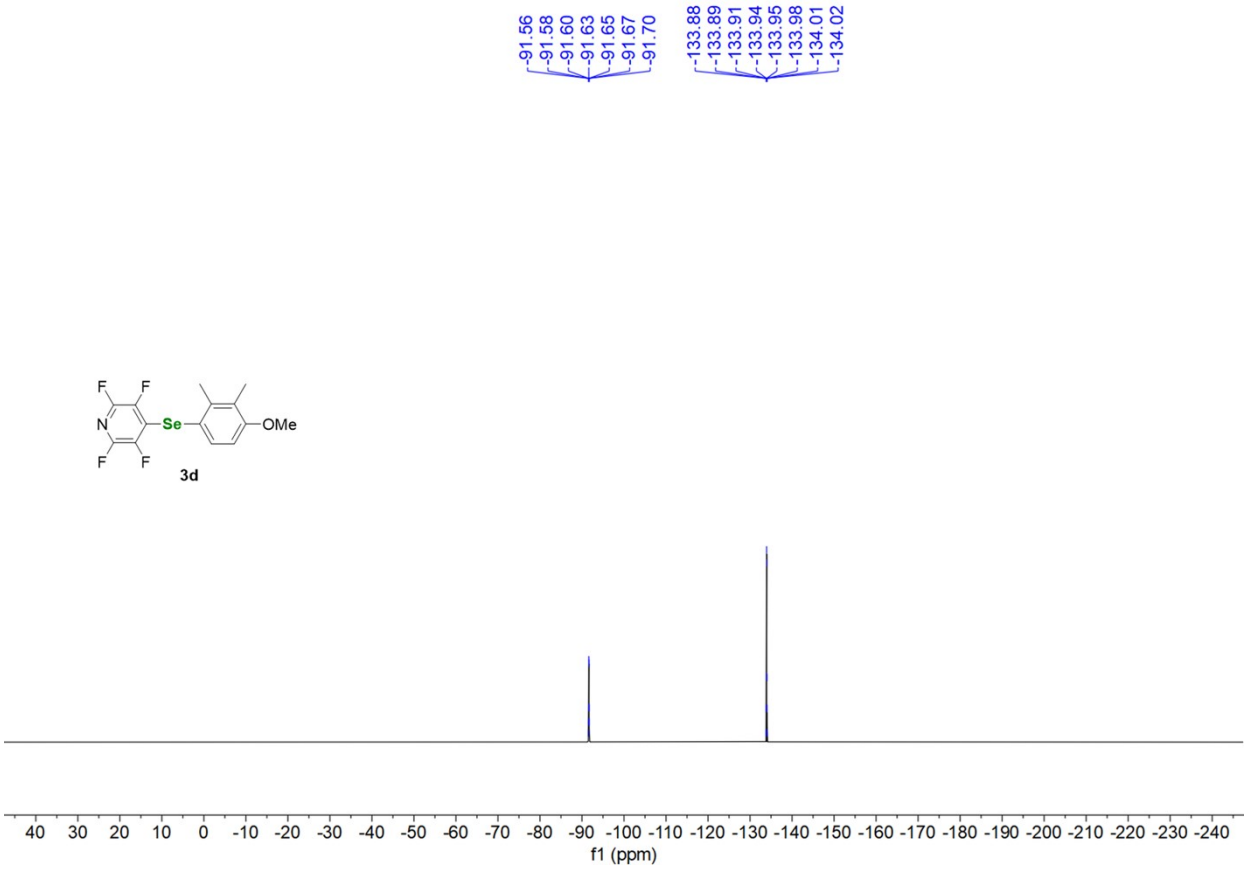
^{1}H NMR spectra of 3d (400 MHz, $CDCl_3$)



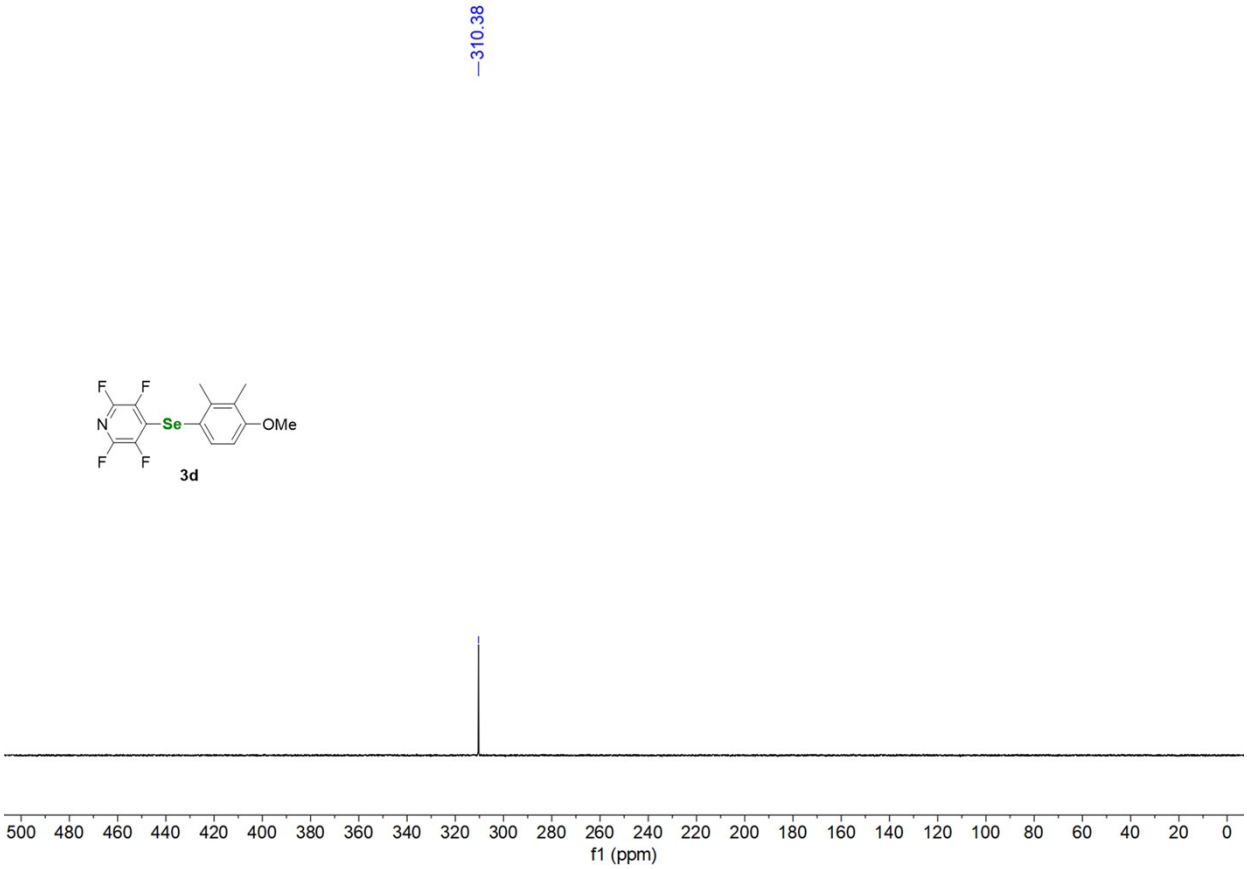
^{13}C NMR spectra of 3d (150 MHz, $CDCl_3$)



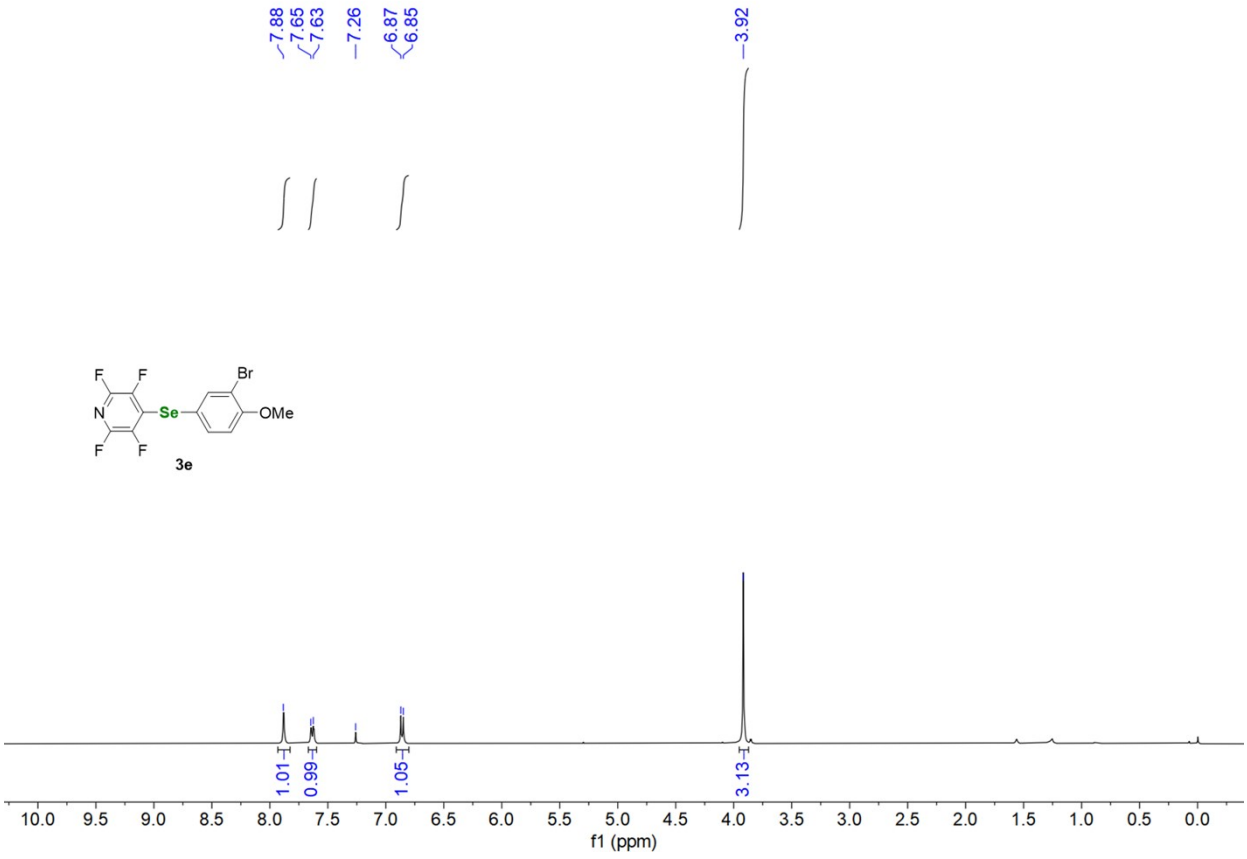
^{19}F NMR spectra of 3d (564 MHz, $CDCl_3$)



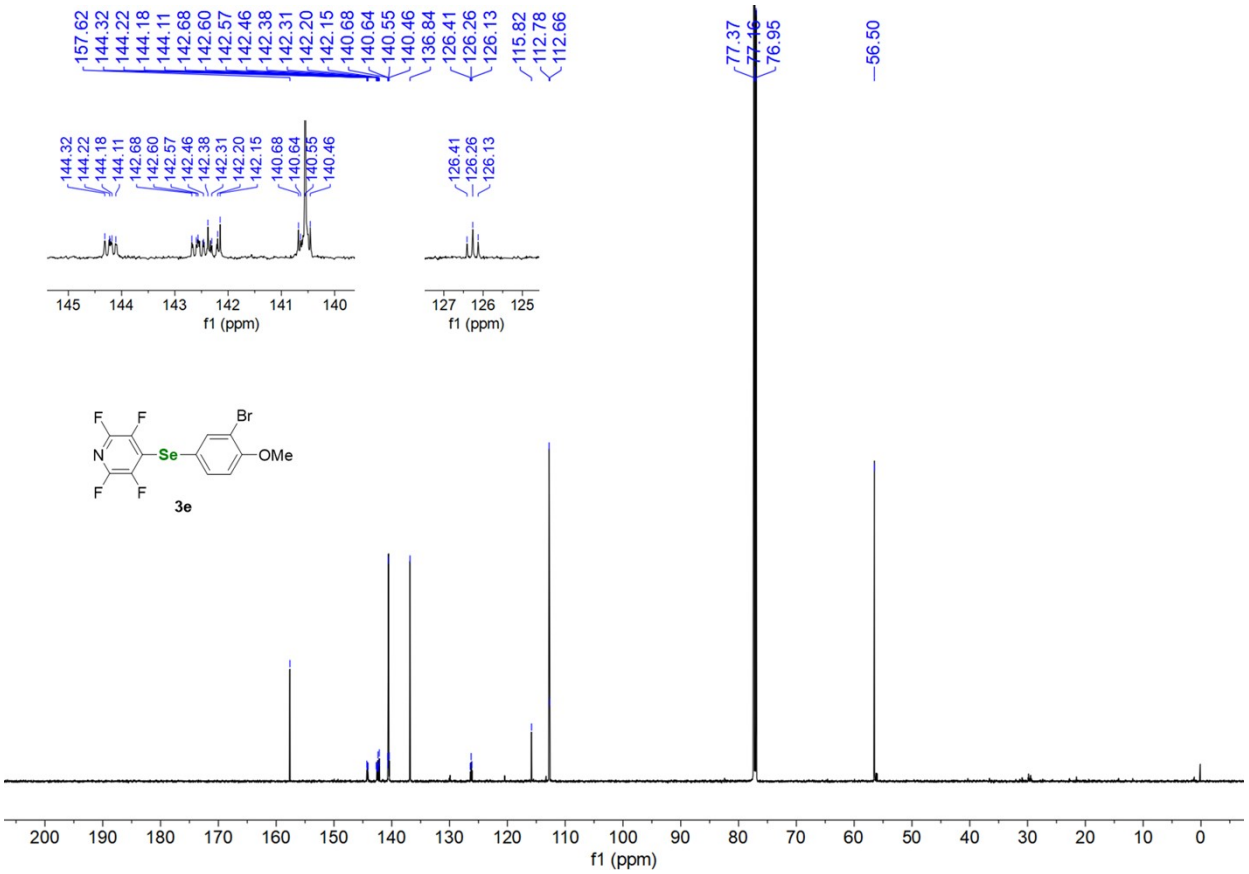
^{77}Se NMR spectra of 3d (114 MHz, $CDCl_3$)



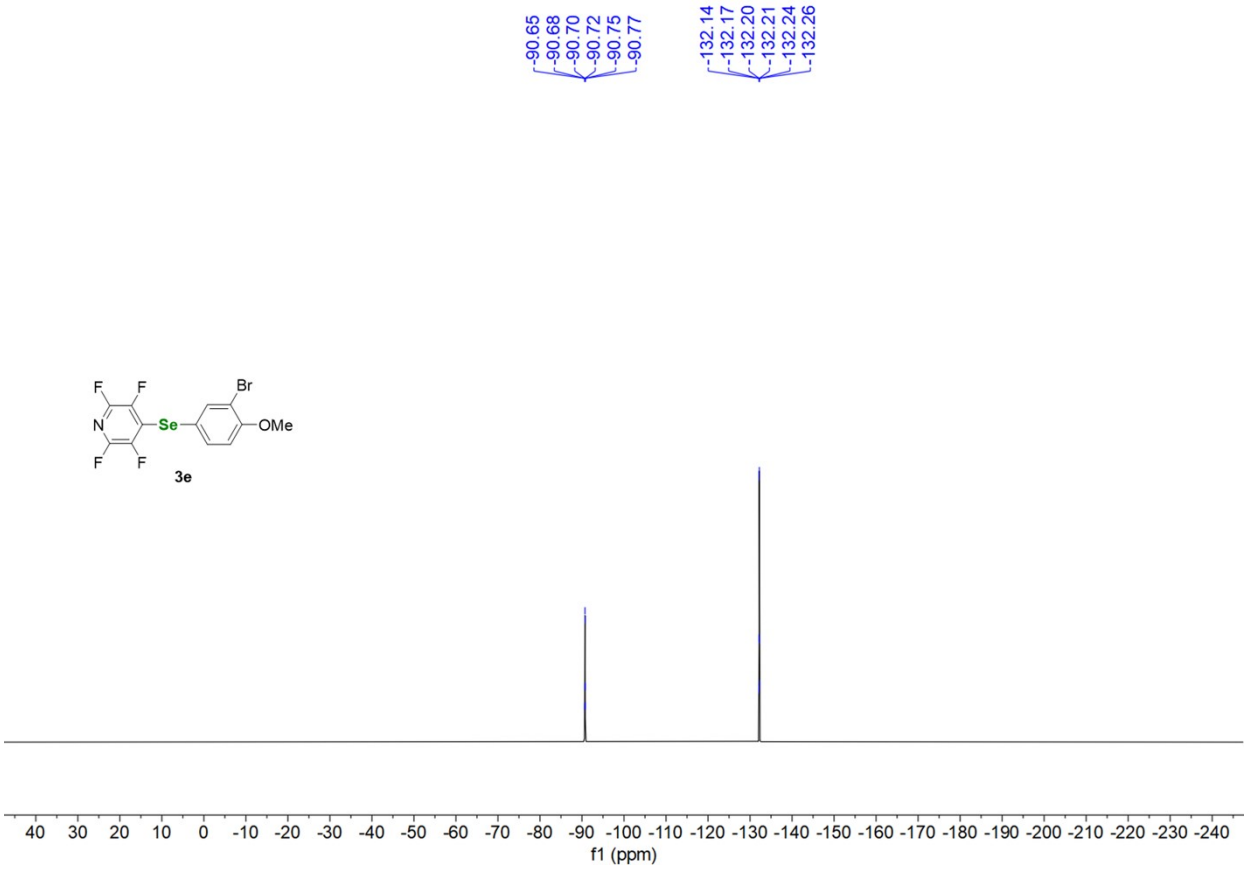
^{1}H NMR spectra of 3e (400 MHz, $CDCl_3$)



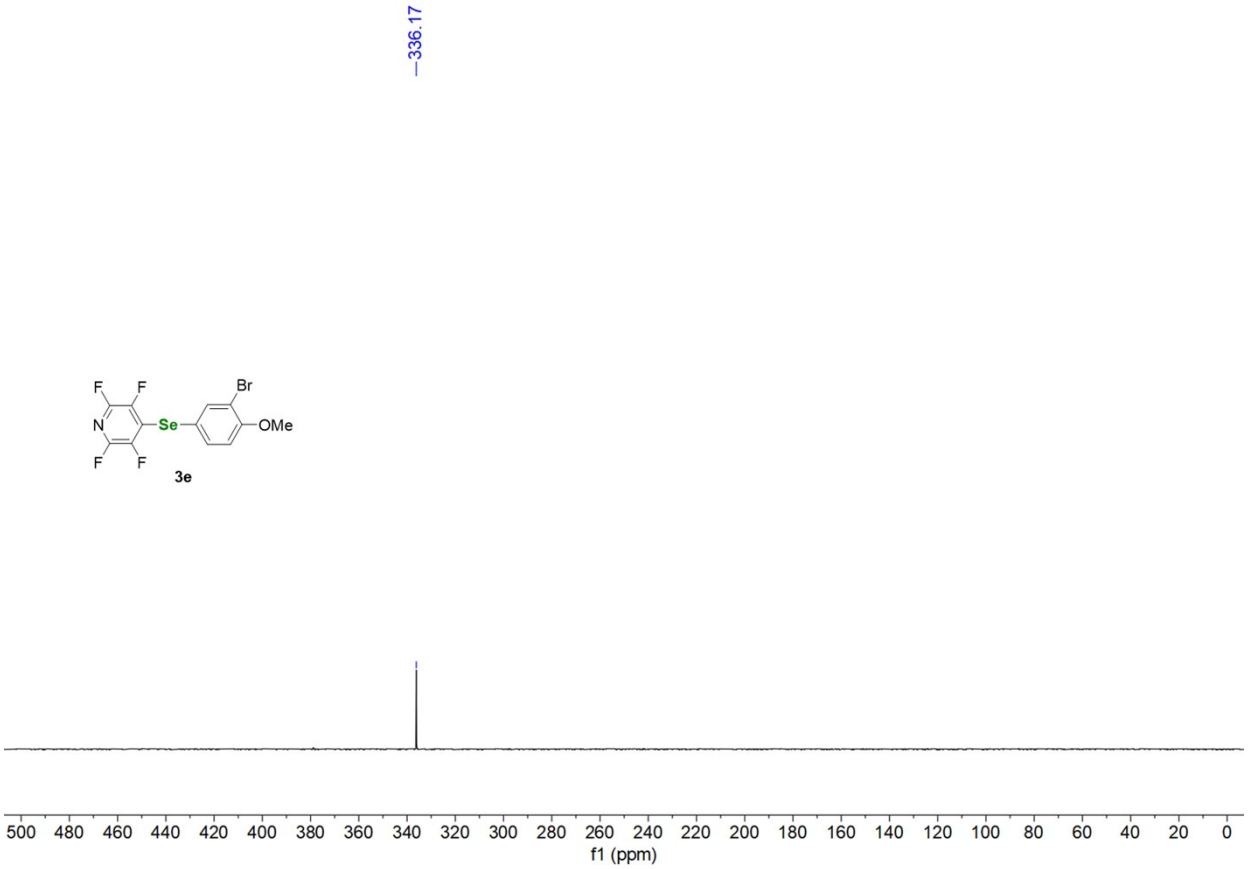
^{13}C NMR spectra of 3e (150 MHz, $CDCl_3$)



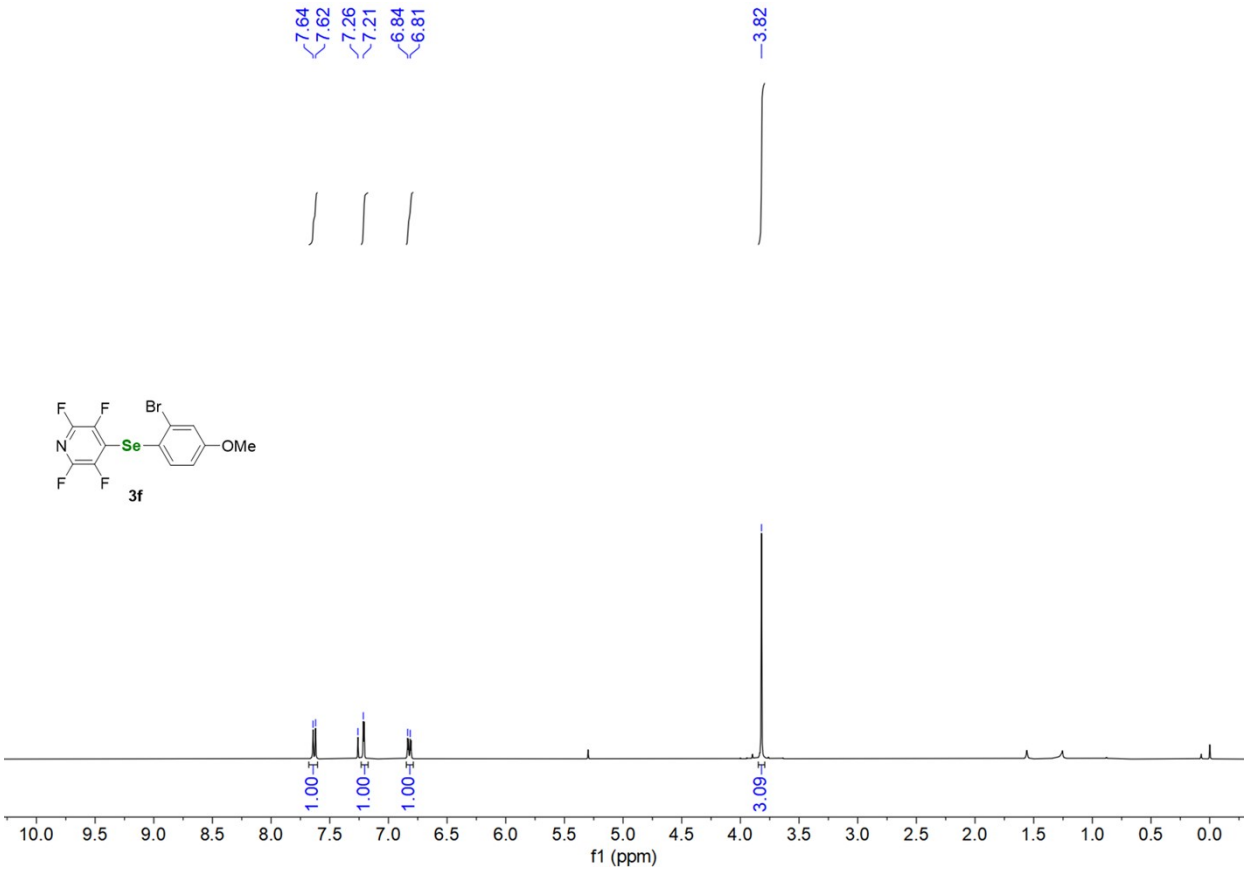
^{19}F NMR spectra of 3e (564 MHz, $CDCl_3$)



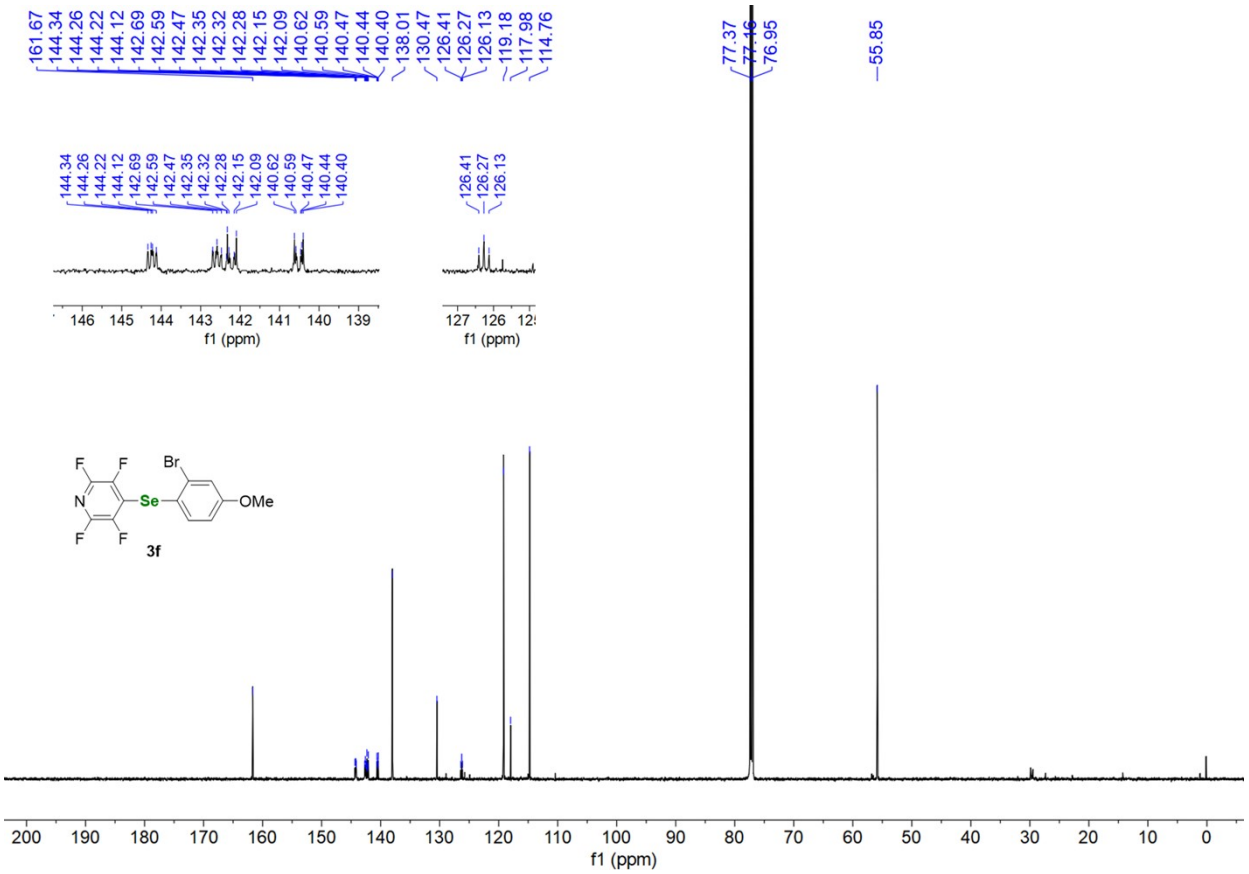
^{77}Se NMR spectra of 3e (114 MHz, $CDCl_3$)



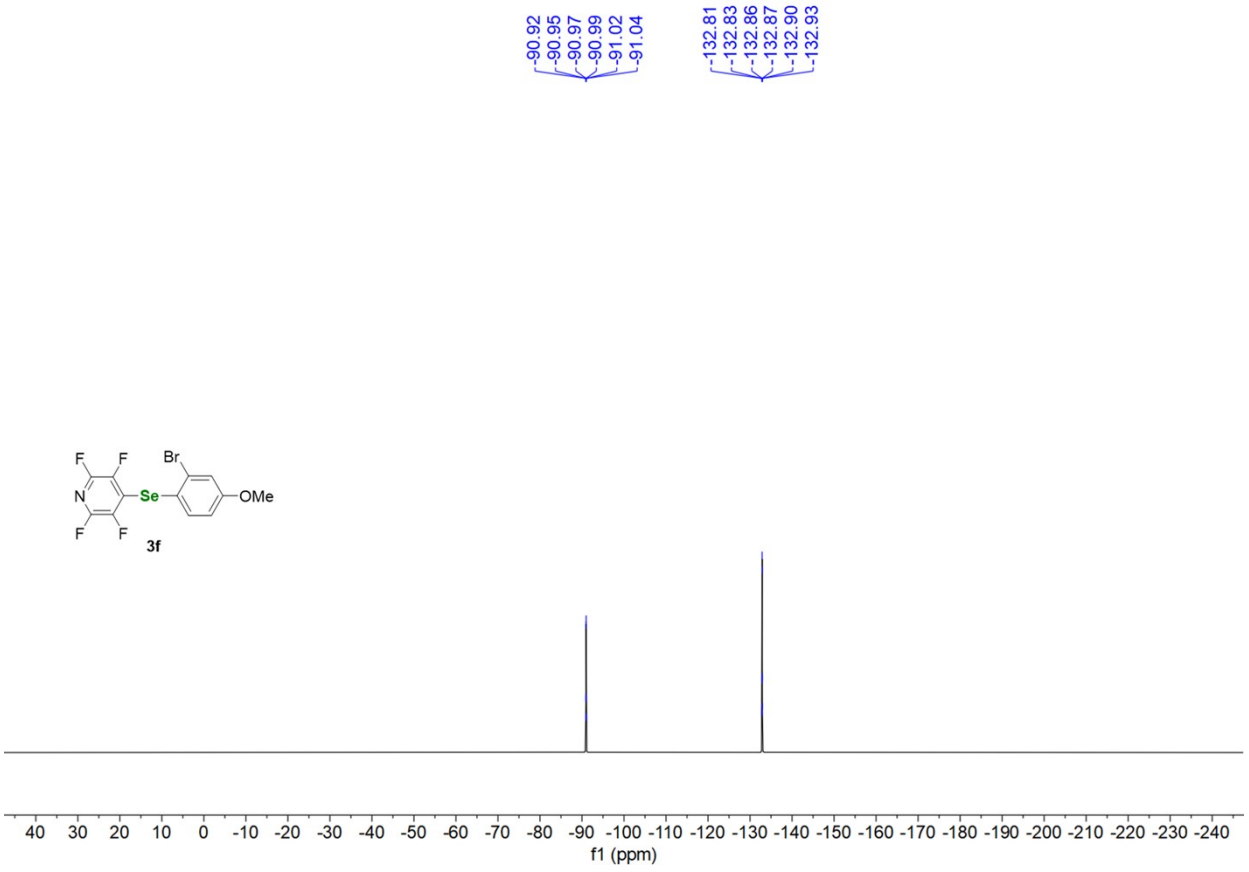
^{1}H NMR spectra of 3f (400 MHz, $CDCl_3$)



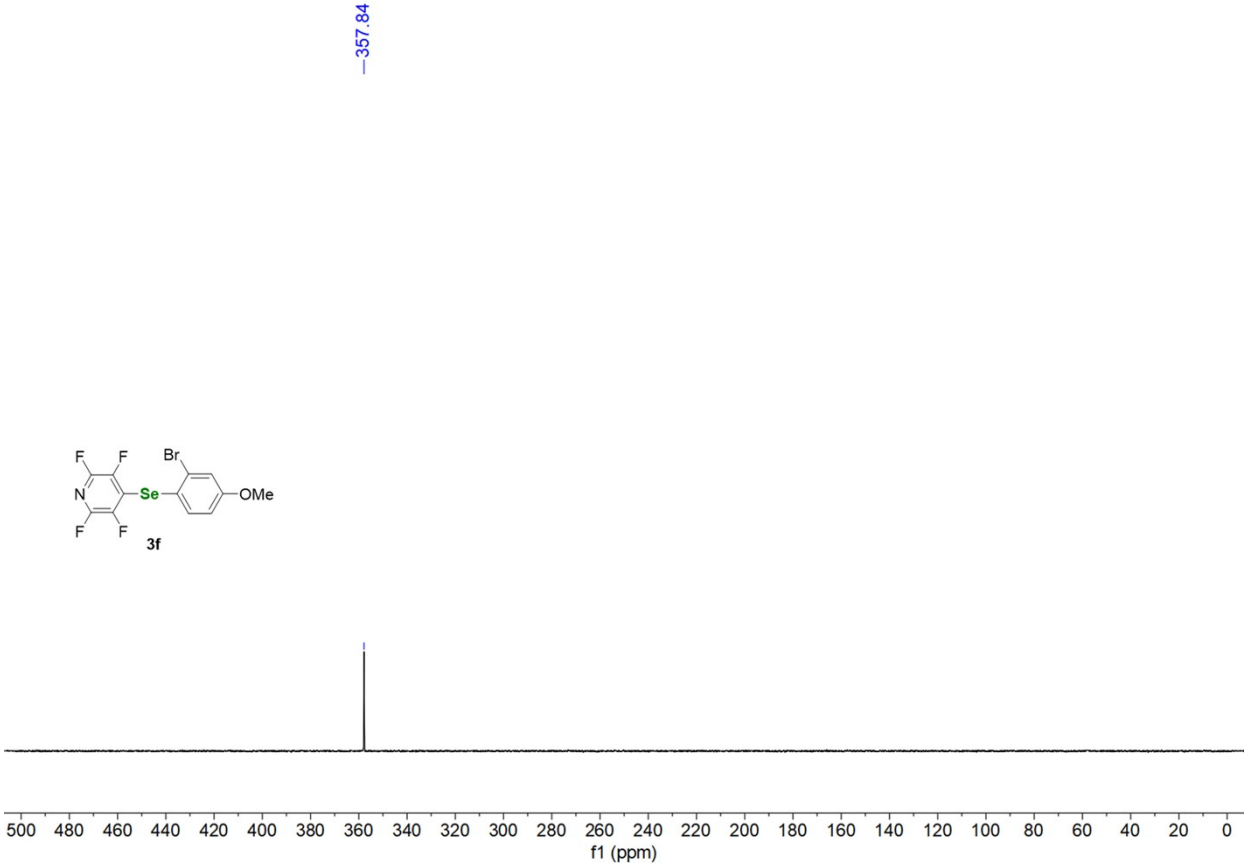
^{13}C NMR spectra of 3f (150 MHz, $CDCl_3$)



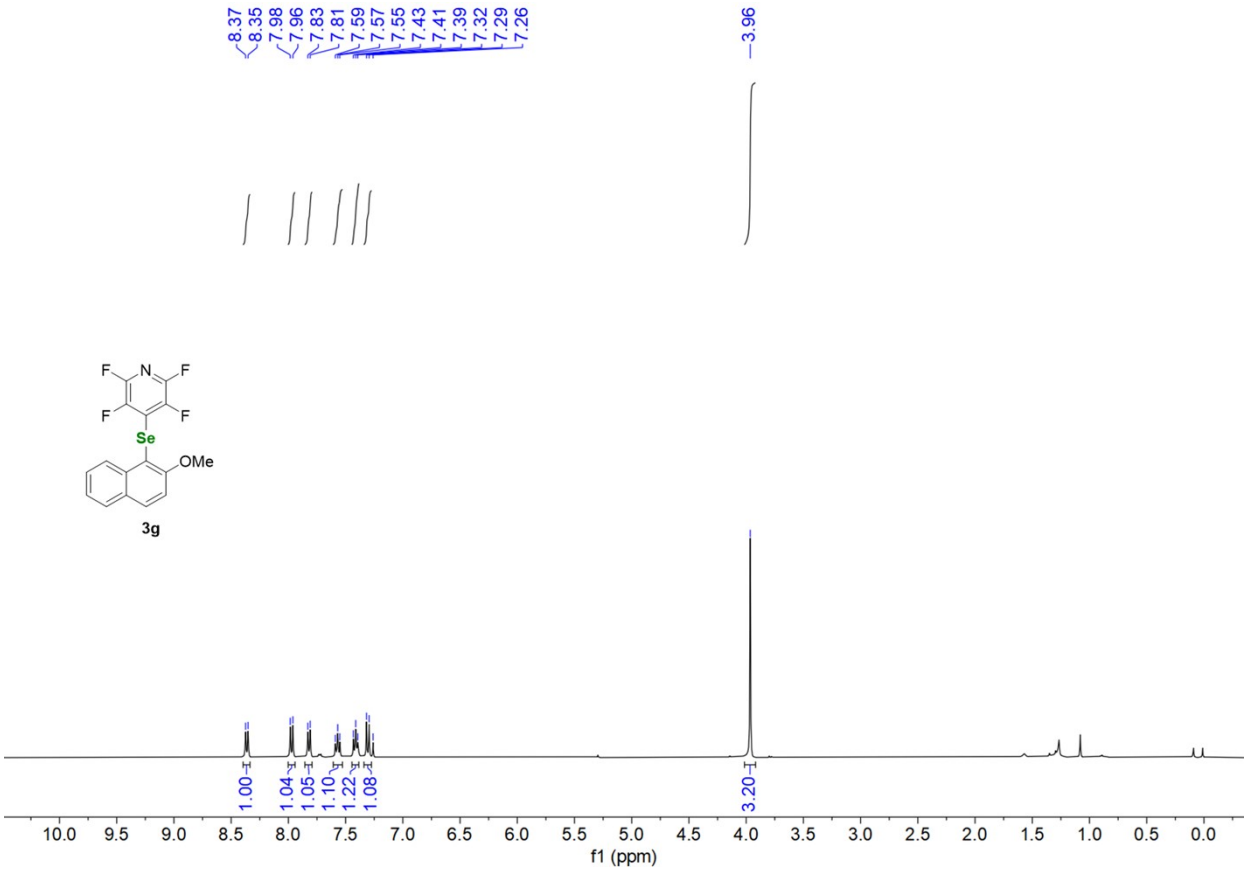
^{19}F NMR spectra of 3f (564 MHz, $CDCl_3$)



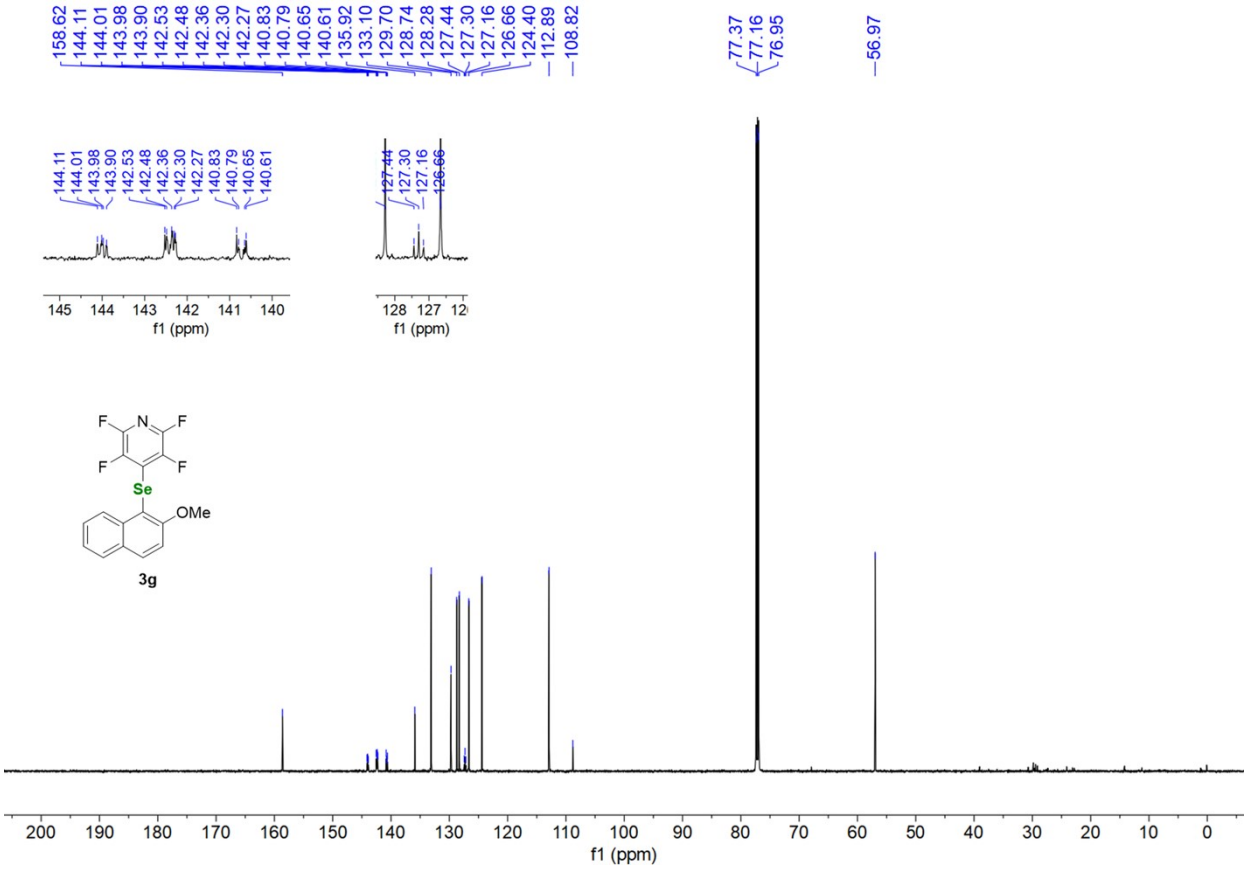
^{77}Se NMR spectra of 3f (114 MHz, $CDCl_3$)



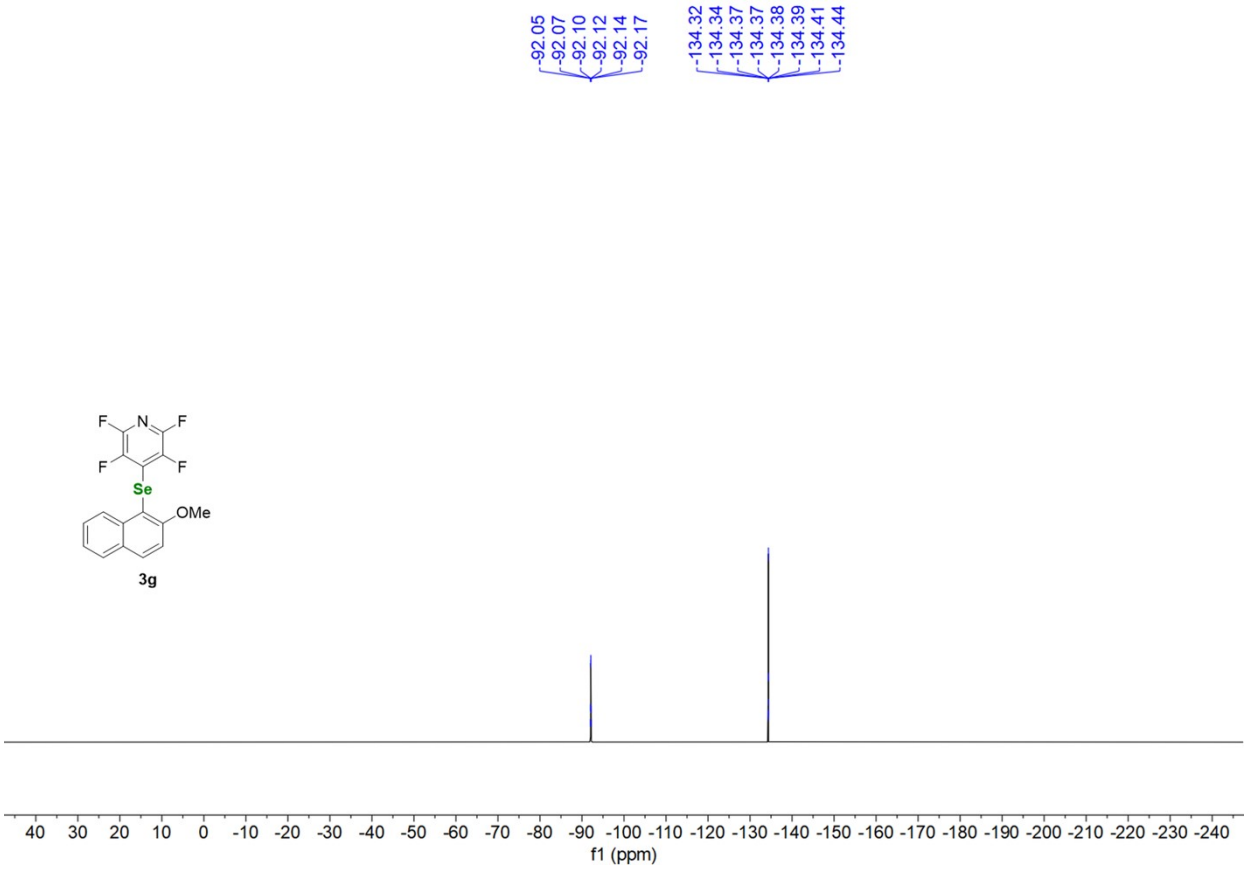
^{1}H NMR spectra of 3g (400 MHz, $CDCl_3$)



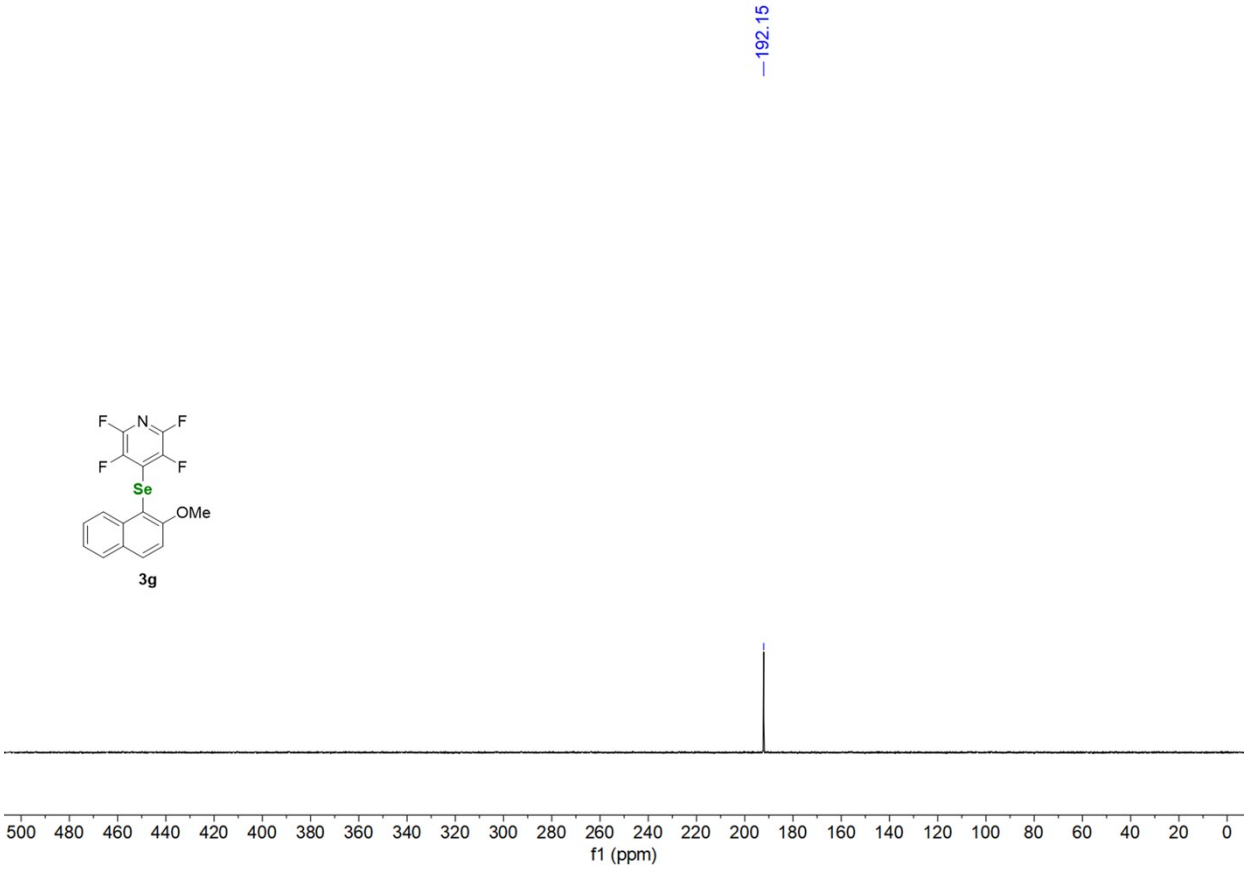
^{13}C NMR spectra of 3g (150 MHz, $CDCl_3$)



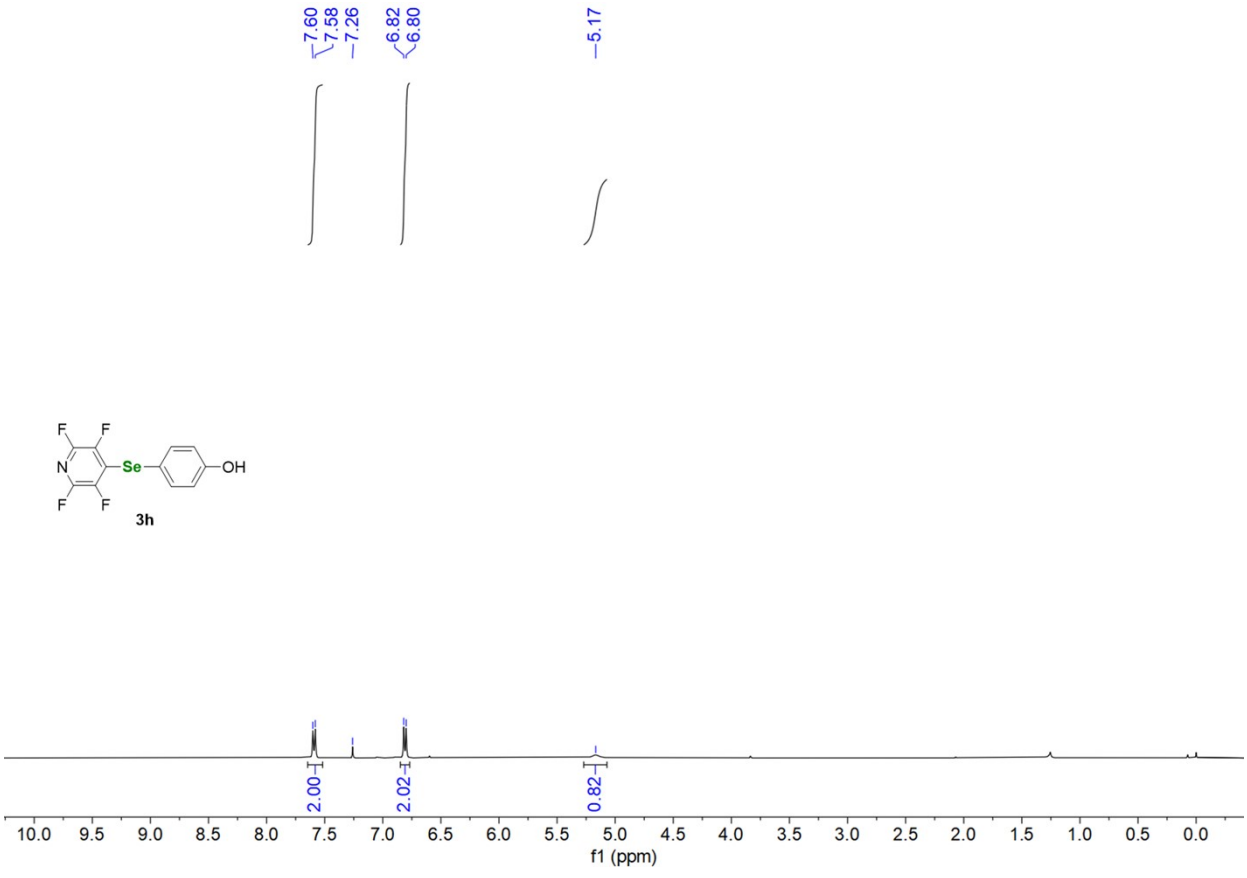
^{19}F NMR spectra of 3g (564 MHz, $CDCl_3$)



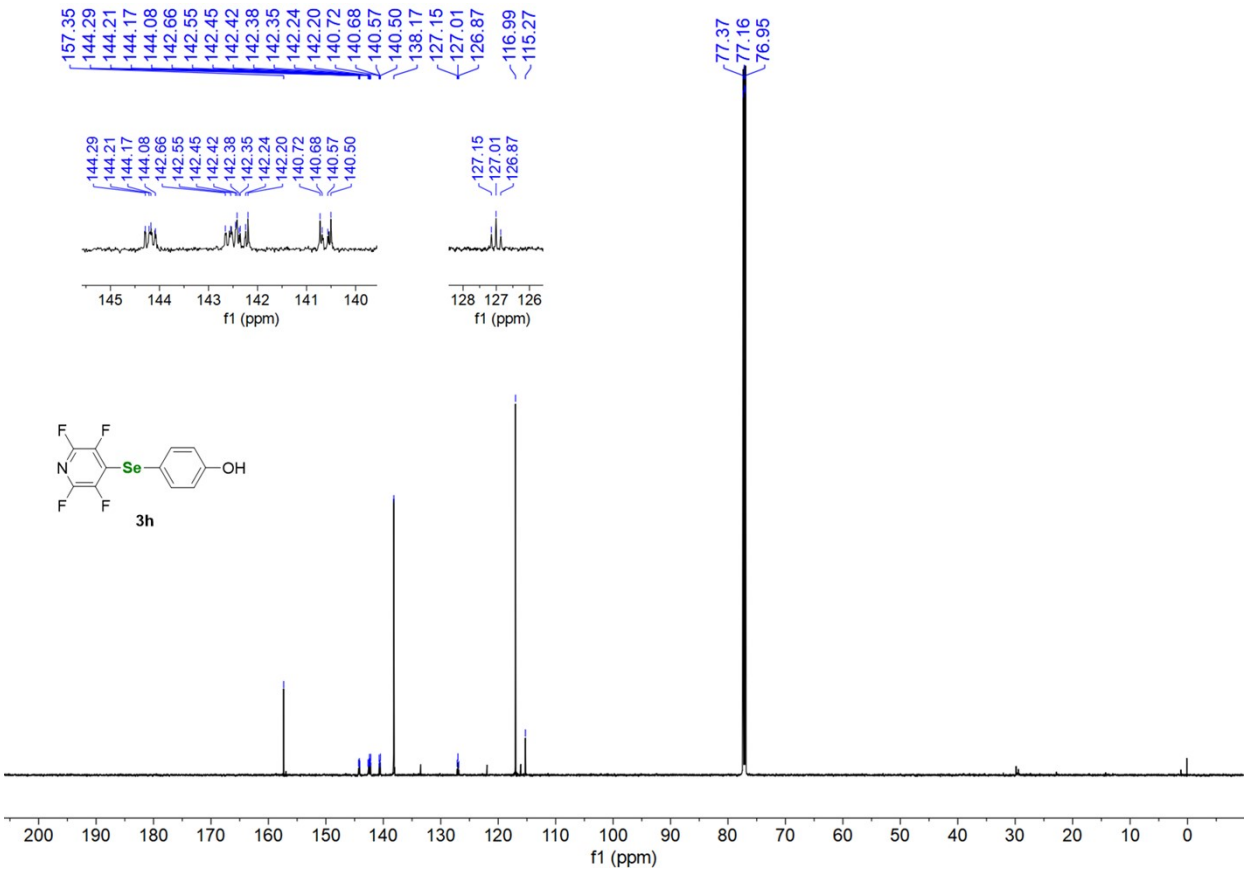
^{77}Se NMR spectra of 3g (114 MHz, $CDCl_3$)



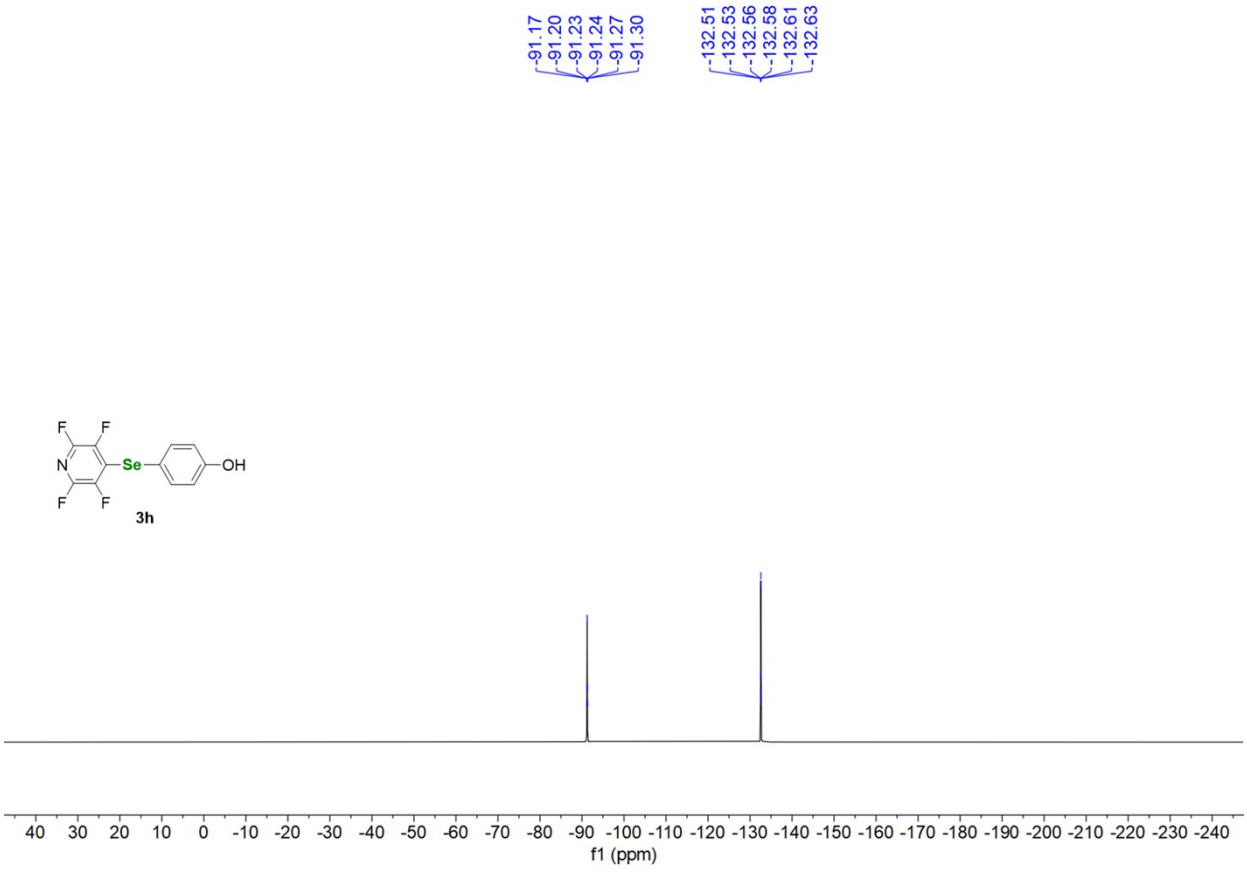
^{1}H NMR spectra of 3h (400 MHz, $CDCl_3$)



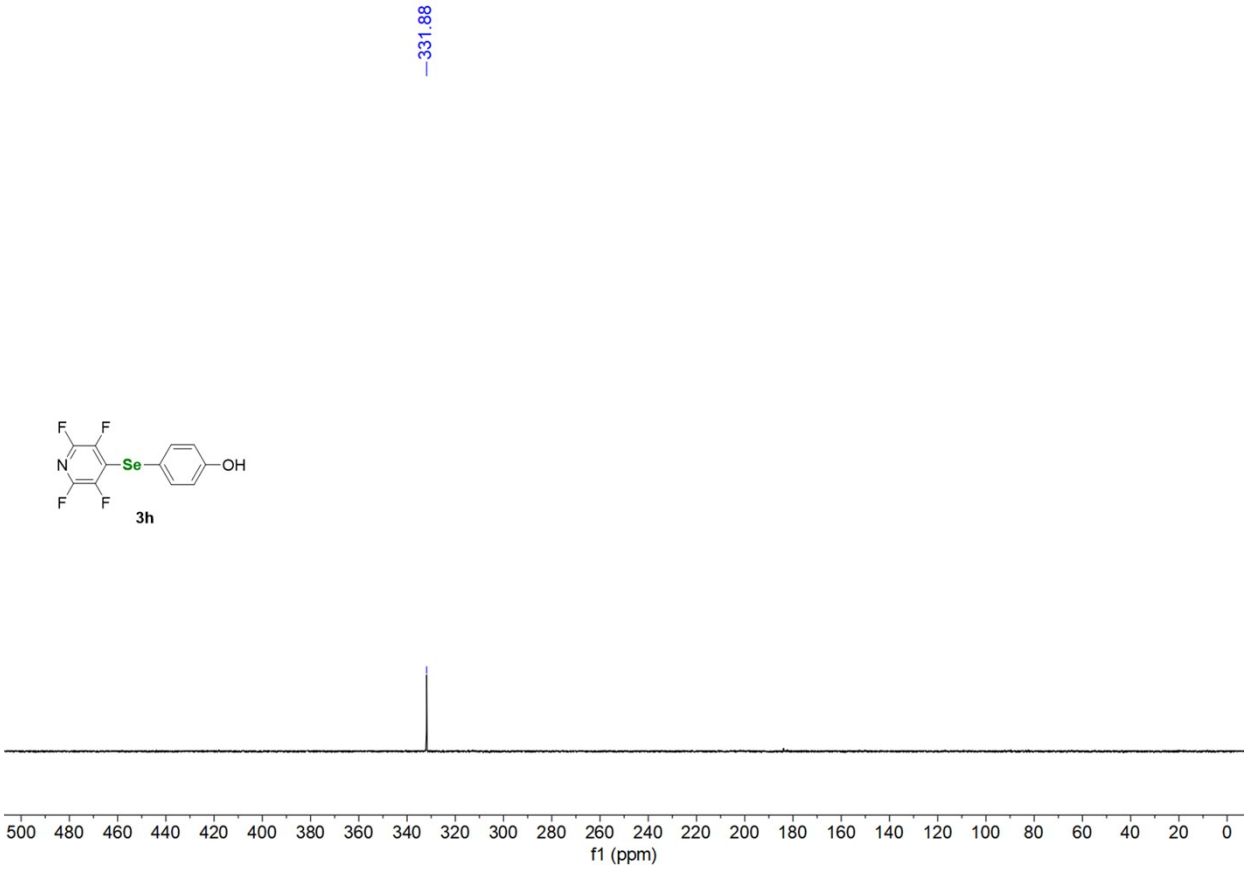
^{13}C NMR spectra of 3h (150 MHz, $CDCl_3$)



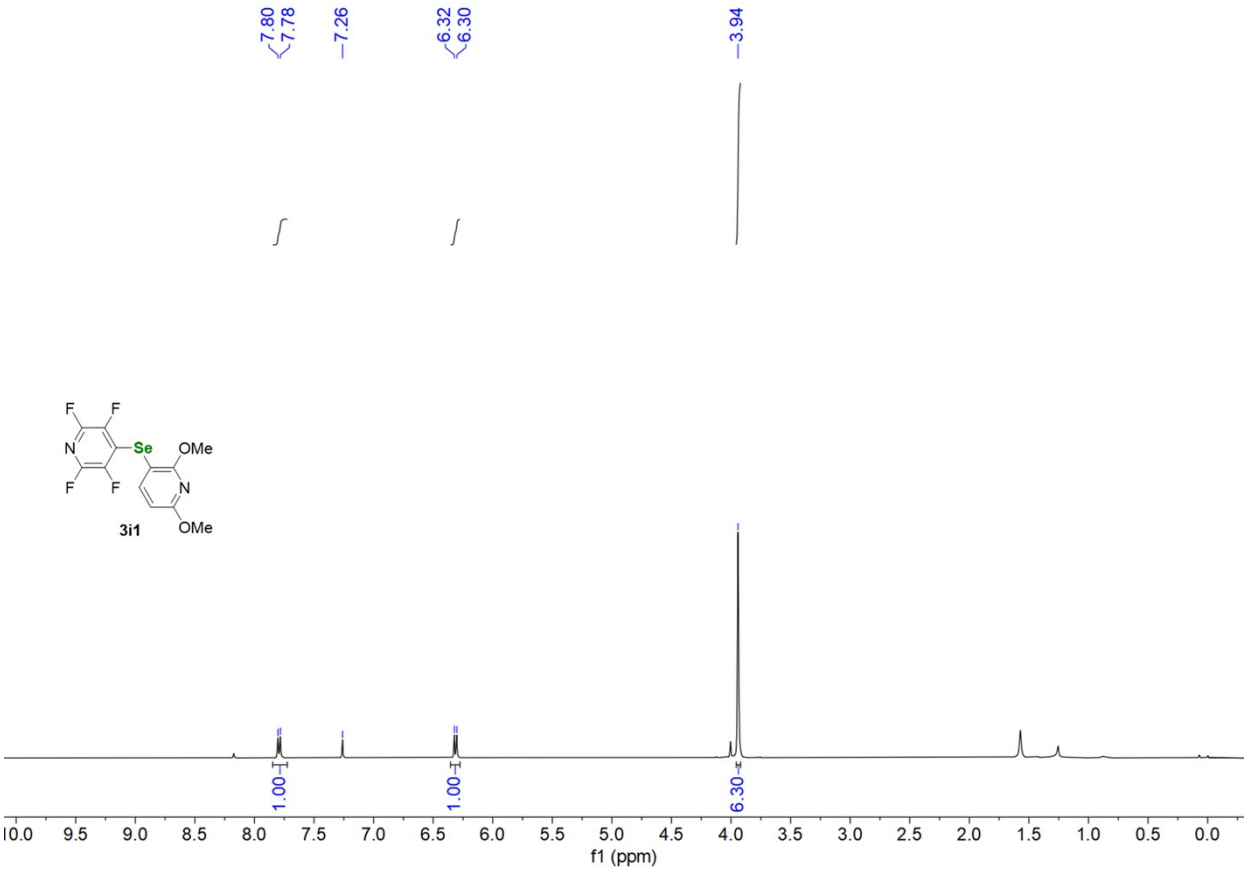
^{19}F NMR spectra of 3h (564 MHz, $CDCl_3$)



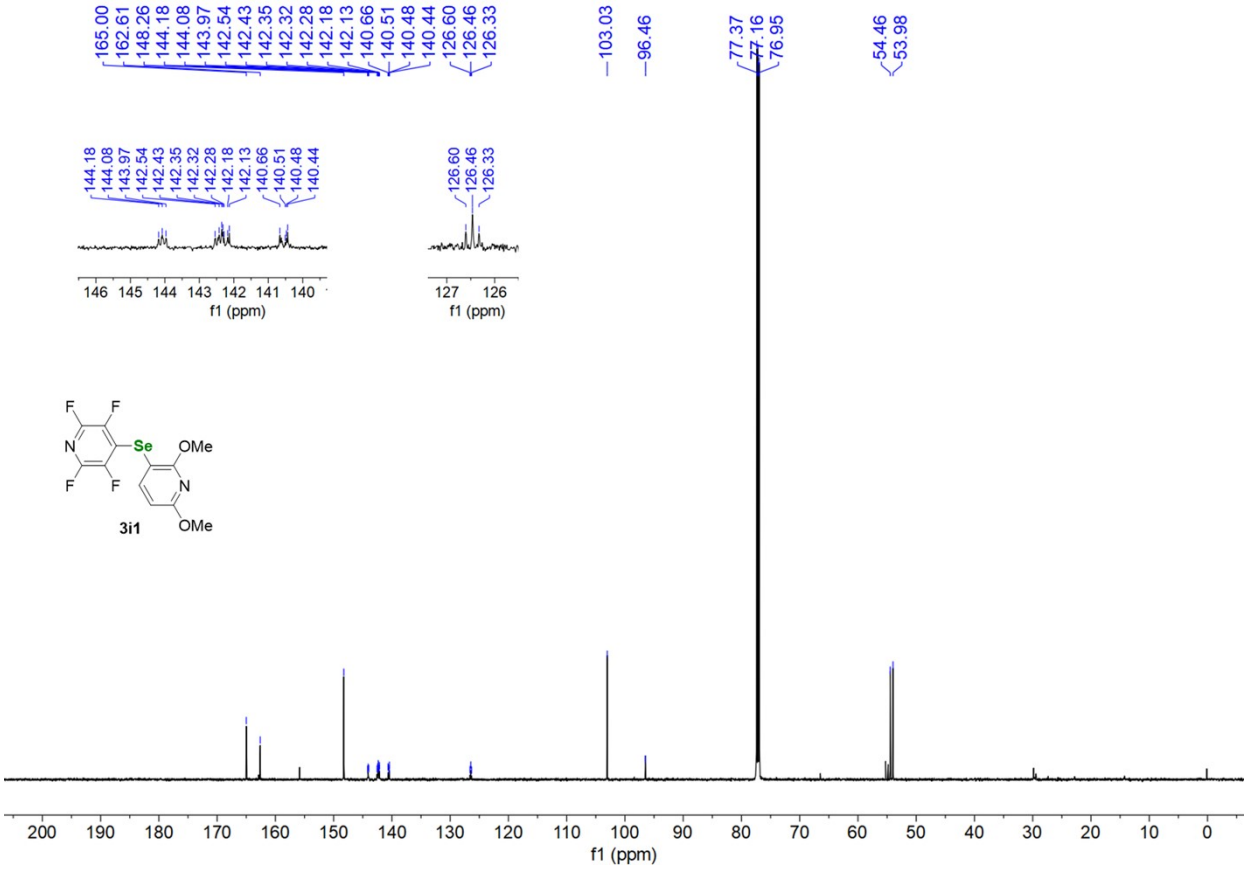
^{77}Se NMR spectra of 3h (114 MHz, $CDCl_3$)



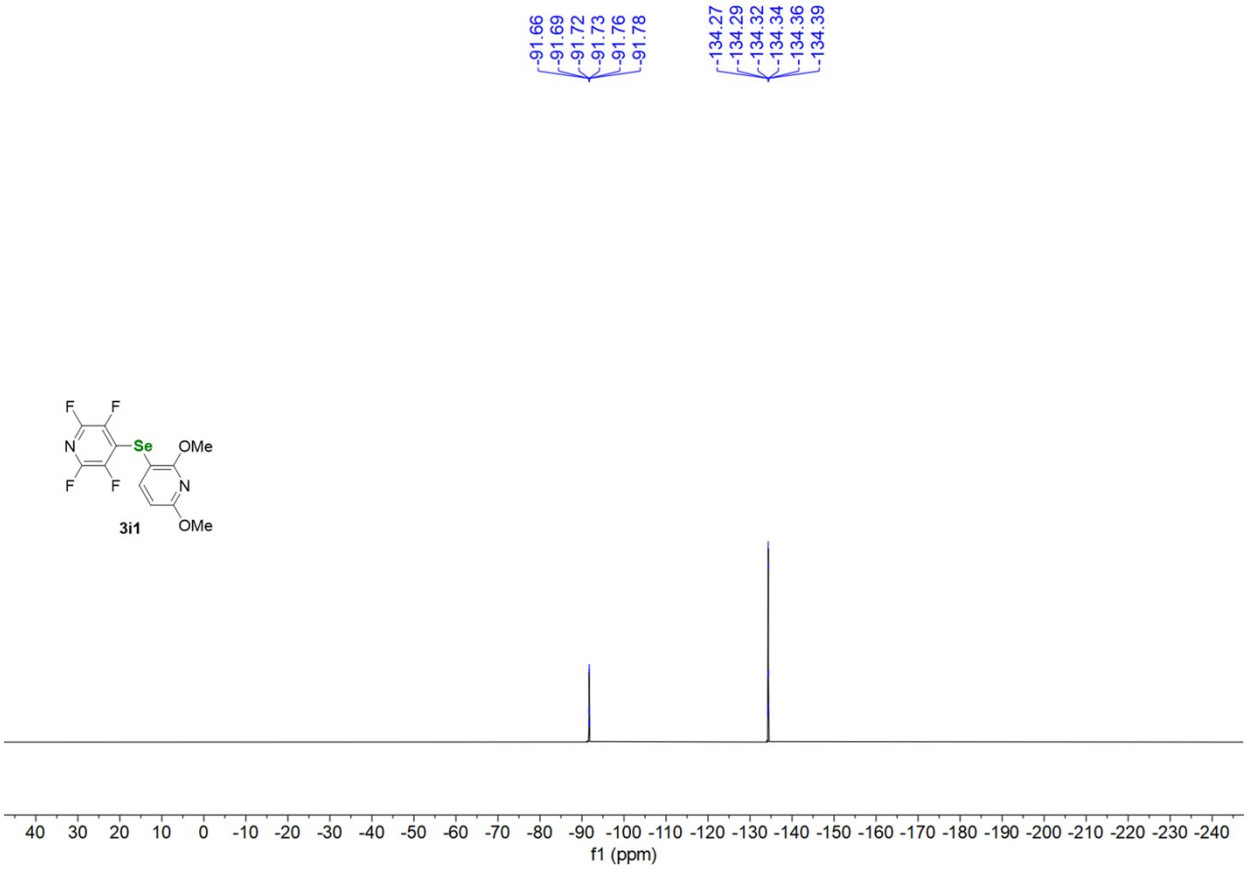
^{1}H NMR spectra of 3i1 (400 MHz, $CDCl_3$)



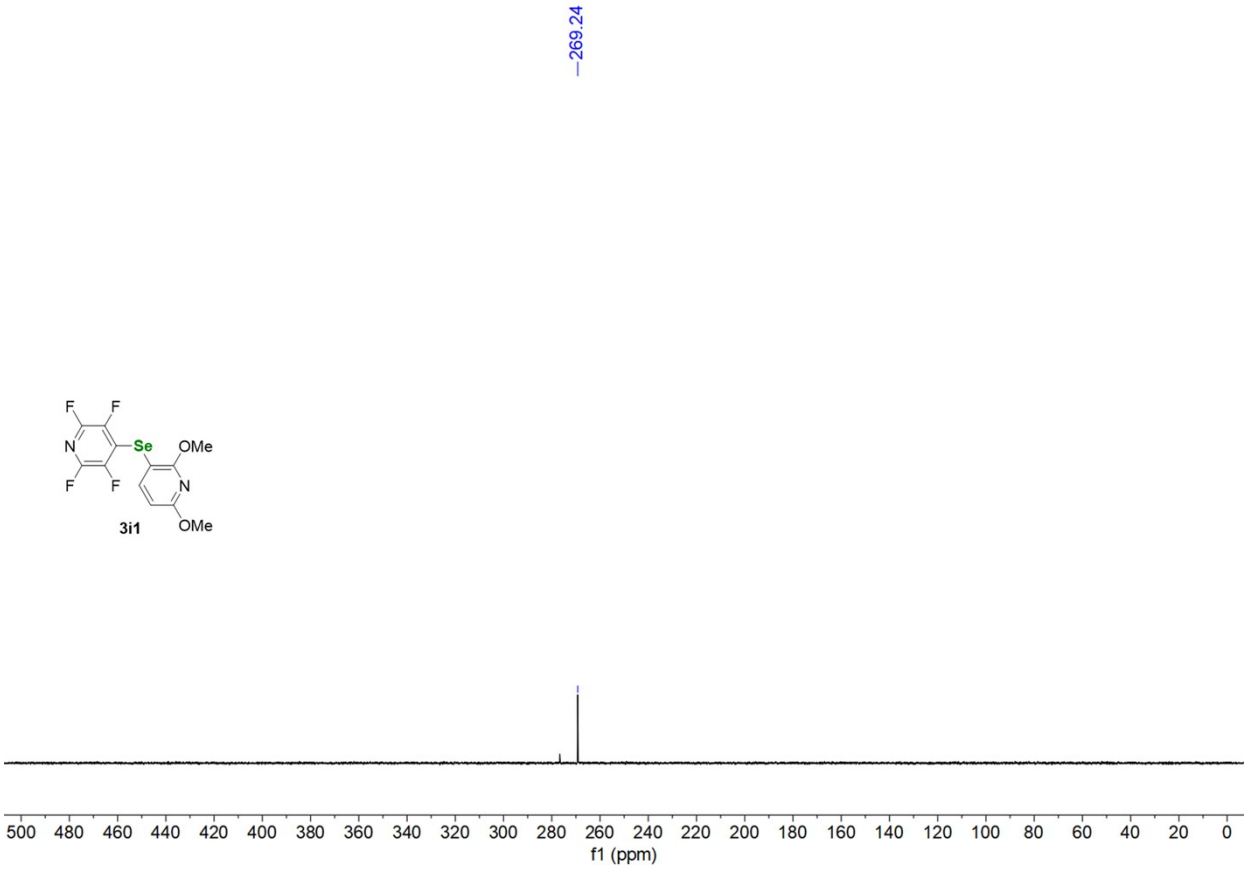
^{13}C NMR spectra of 3i1 (150 MHz, $CDCl_3$)



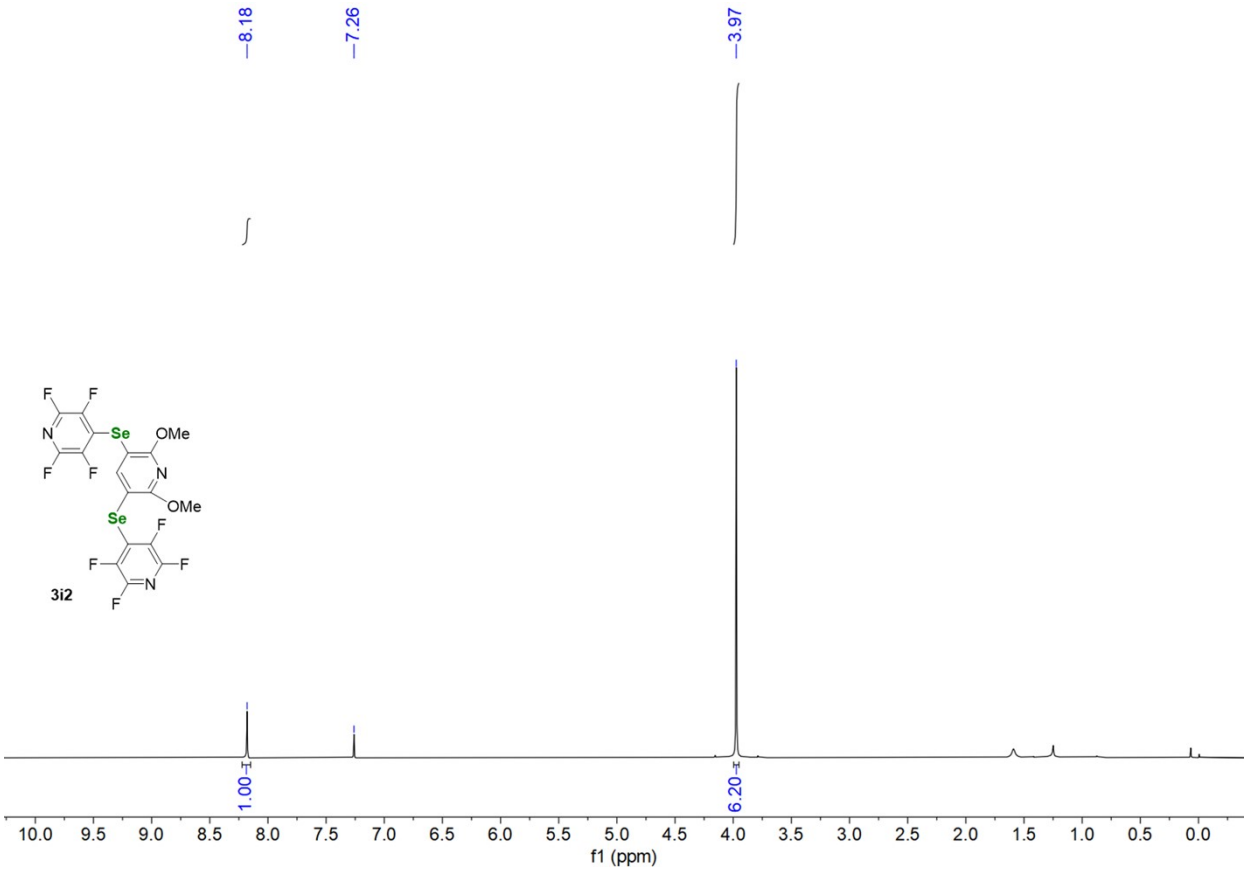
^{19}F NMR spectra of 3i1 (564 MHz, $CDCl_3$)



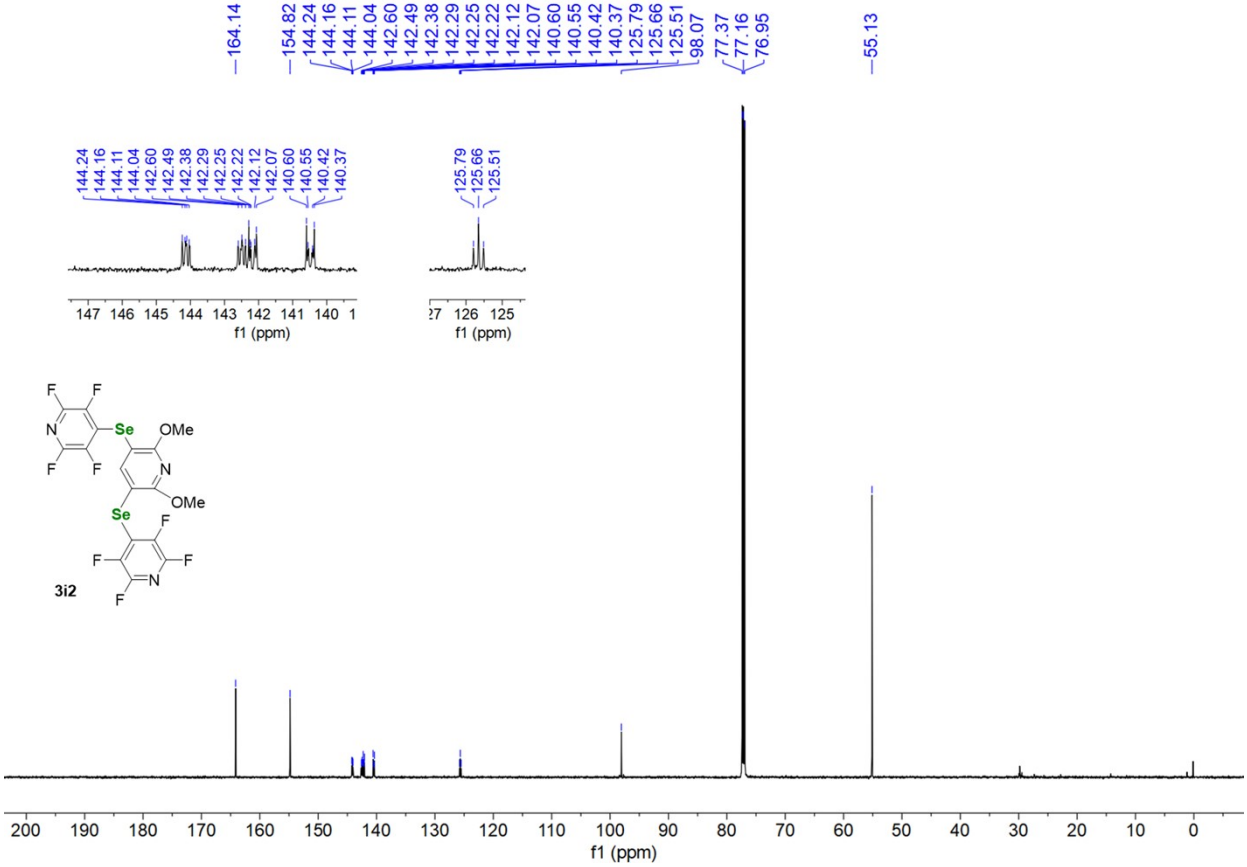
^{77}Se NMR spectra of 3i1 (114 MHz, $CDCl_3$)



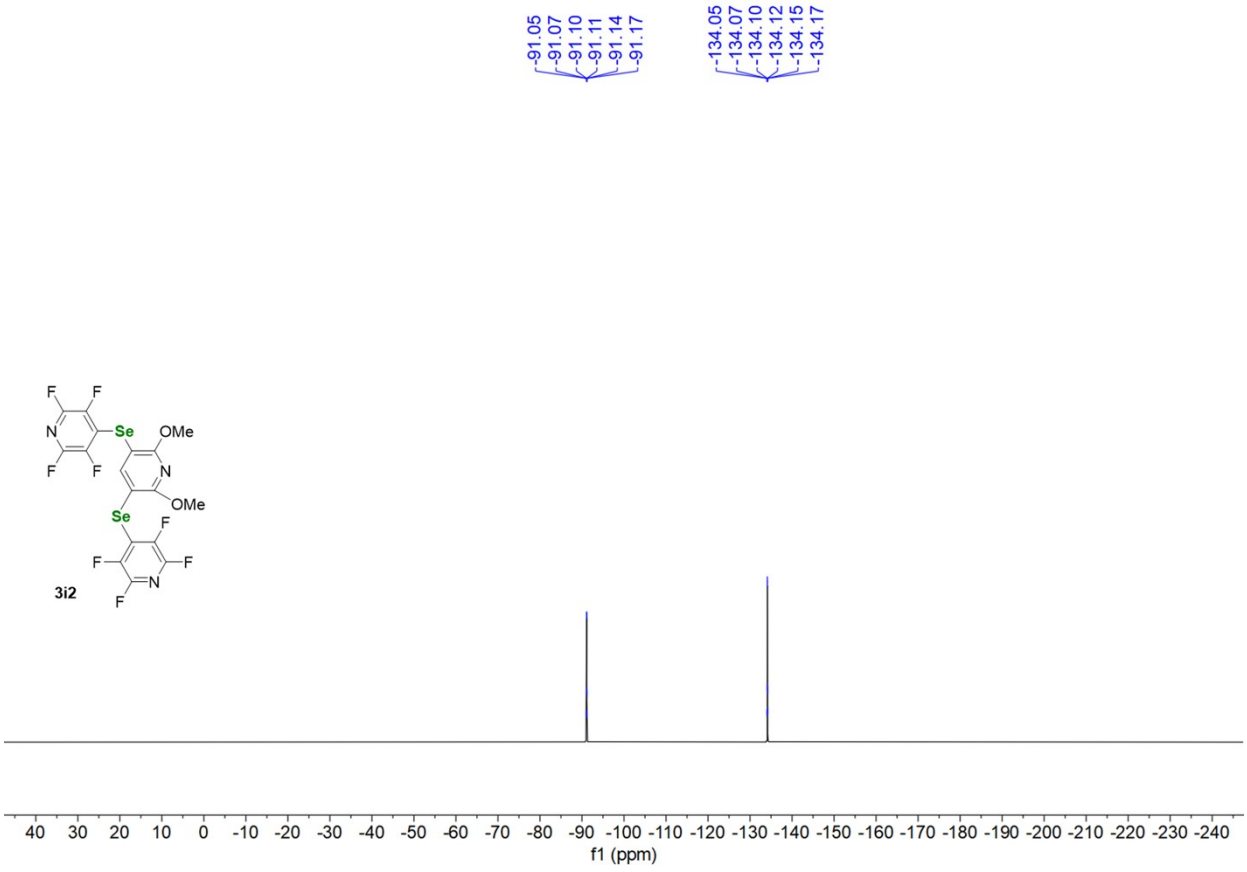
^{1}H NMR spectra of 3i2 (400 MHz, $CDCl_3$)



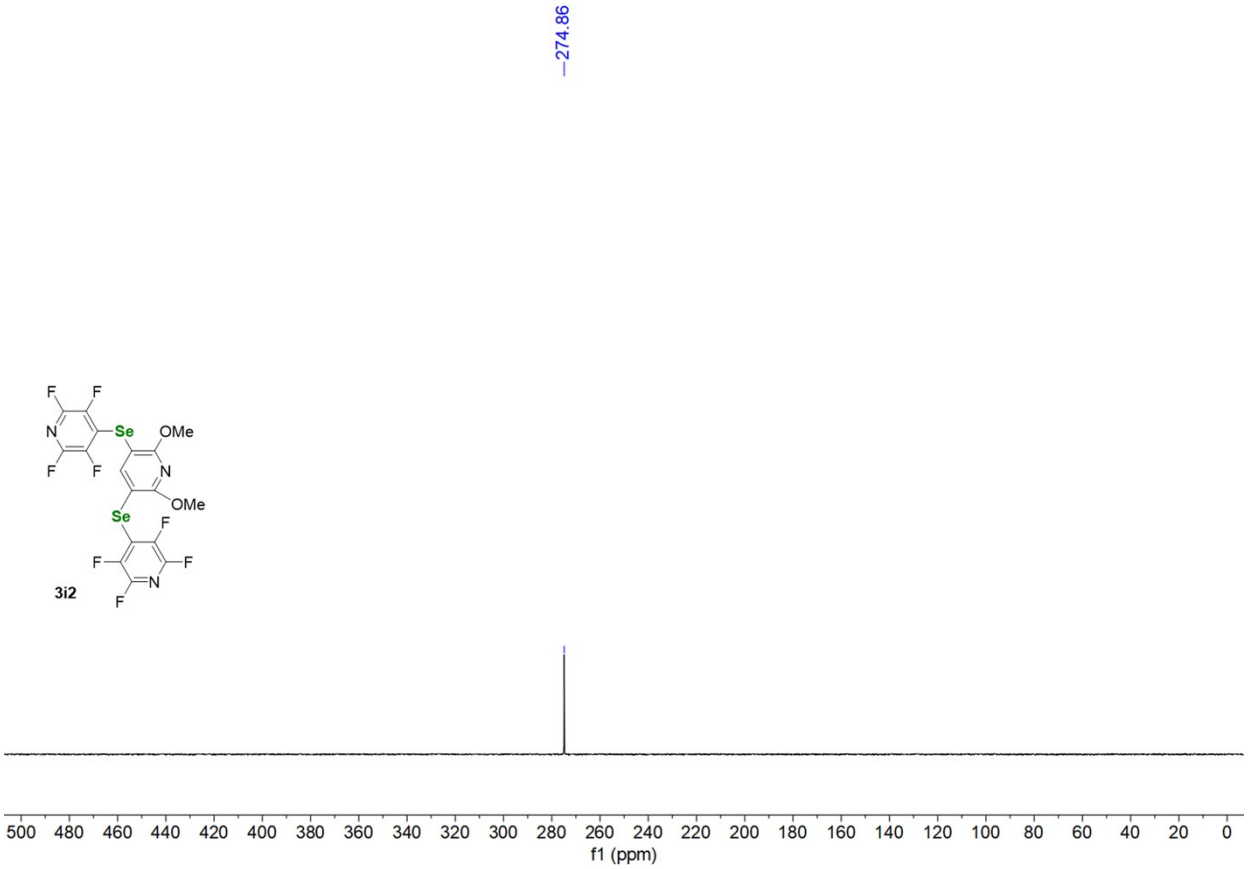
^{13}C NMR spectra of 3i2 (150 MHz, $CDCl_3$)



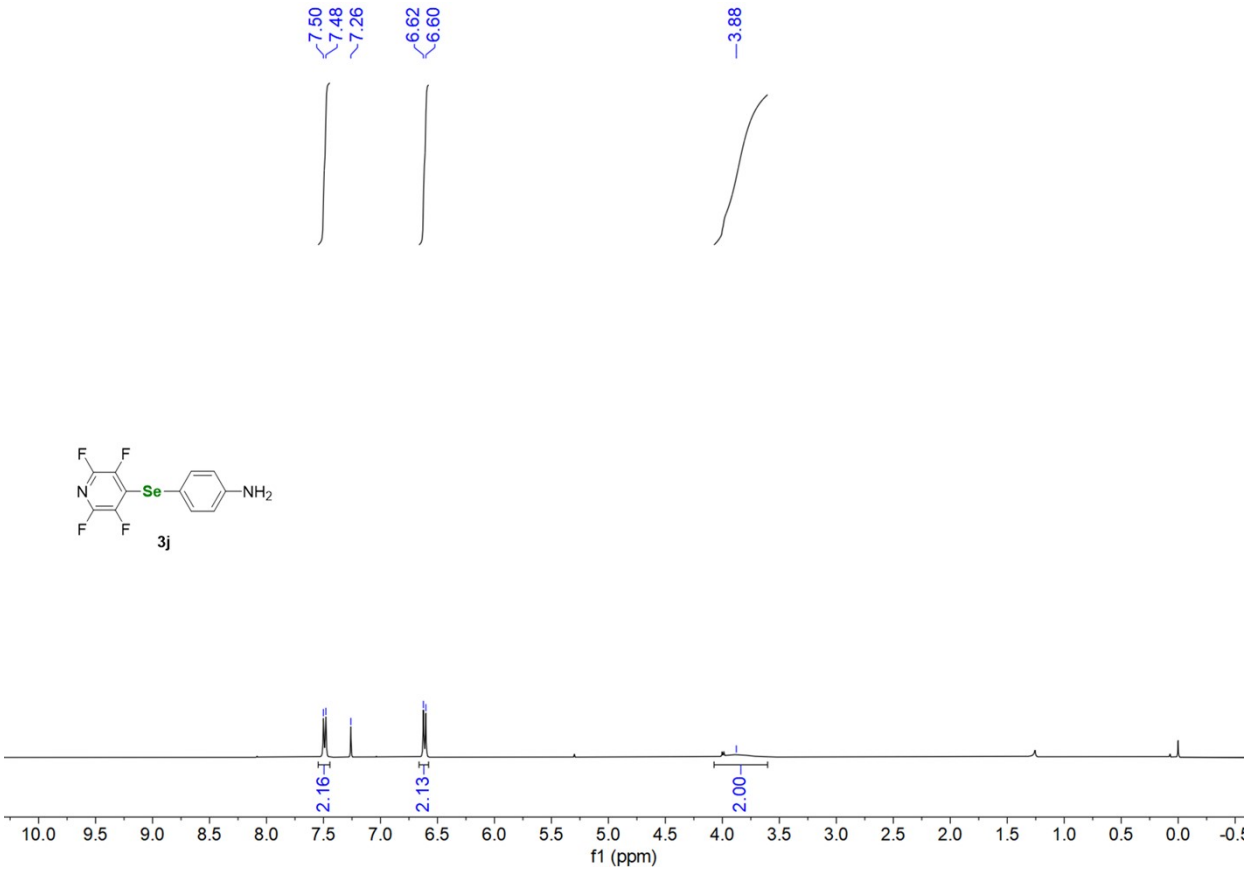
^{19}F NMR spectra of 3i2 (564 MHz, $CDCl_3$)



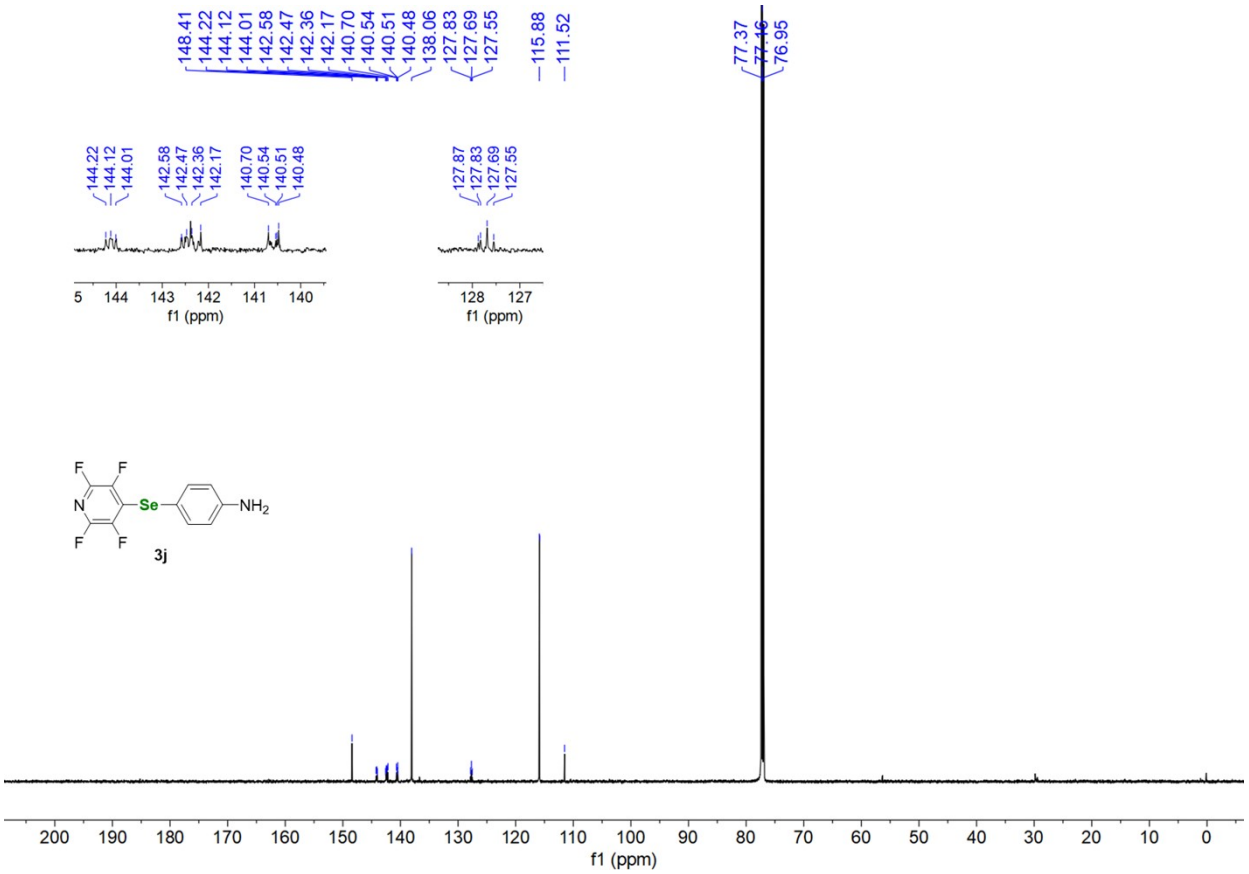
^{77}Se NMR spectra of 3i2 (114 MHz, $CDCl_3$)



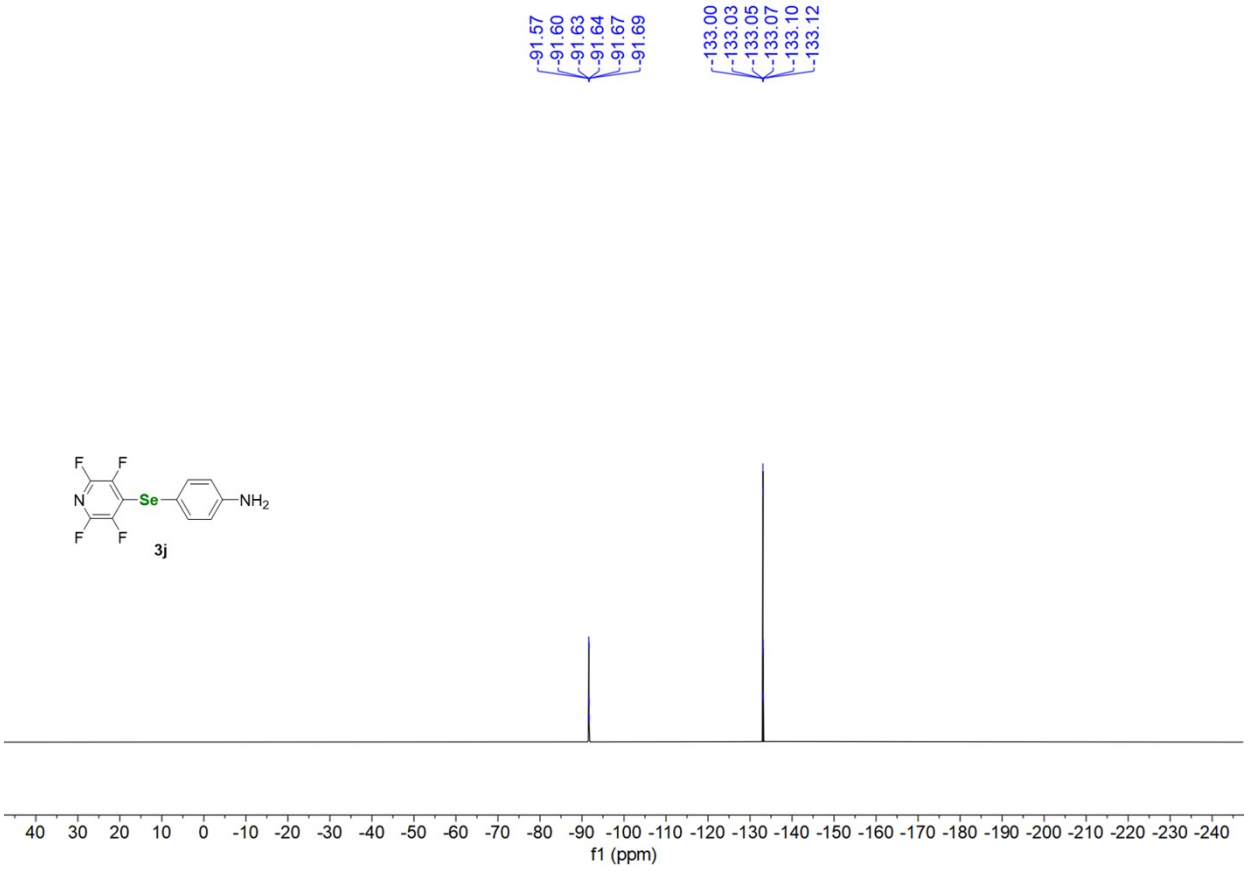
^{1}H NMR spectra of 3j (400 MHz, $CDCl_3$)



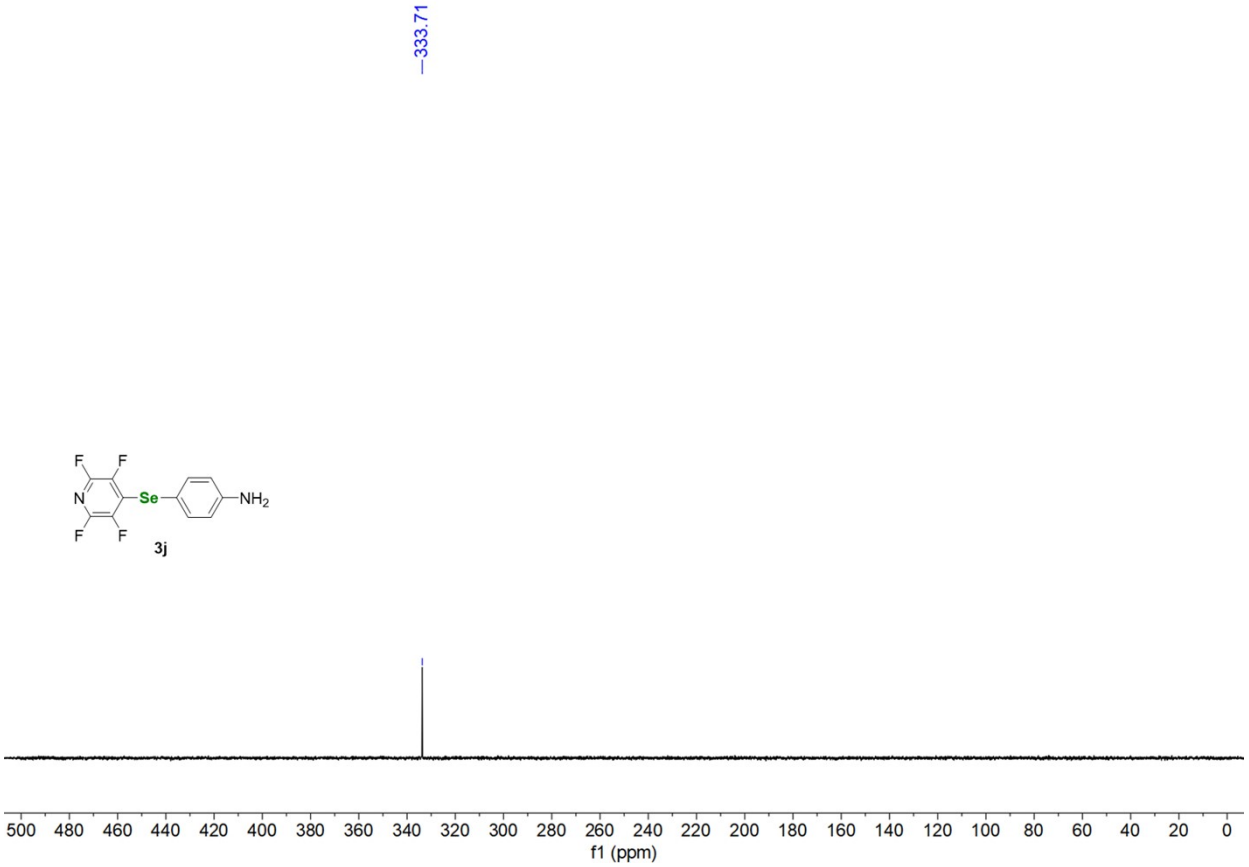
^{13}C NMR spectra of 3j (150 MHz, $CDCl_3$)



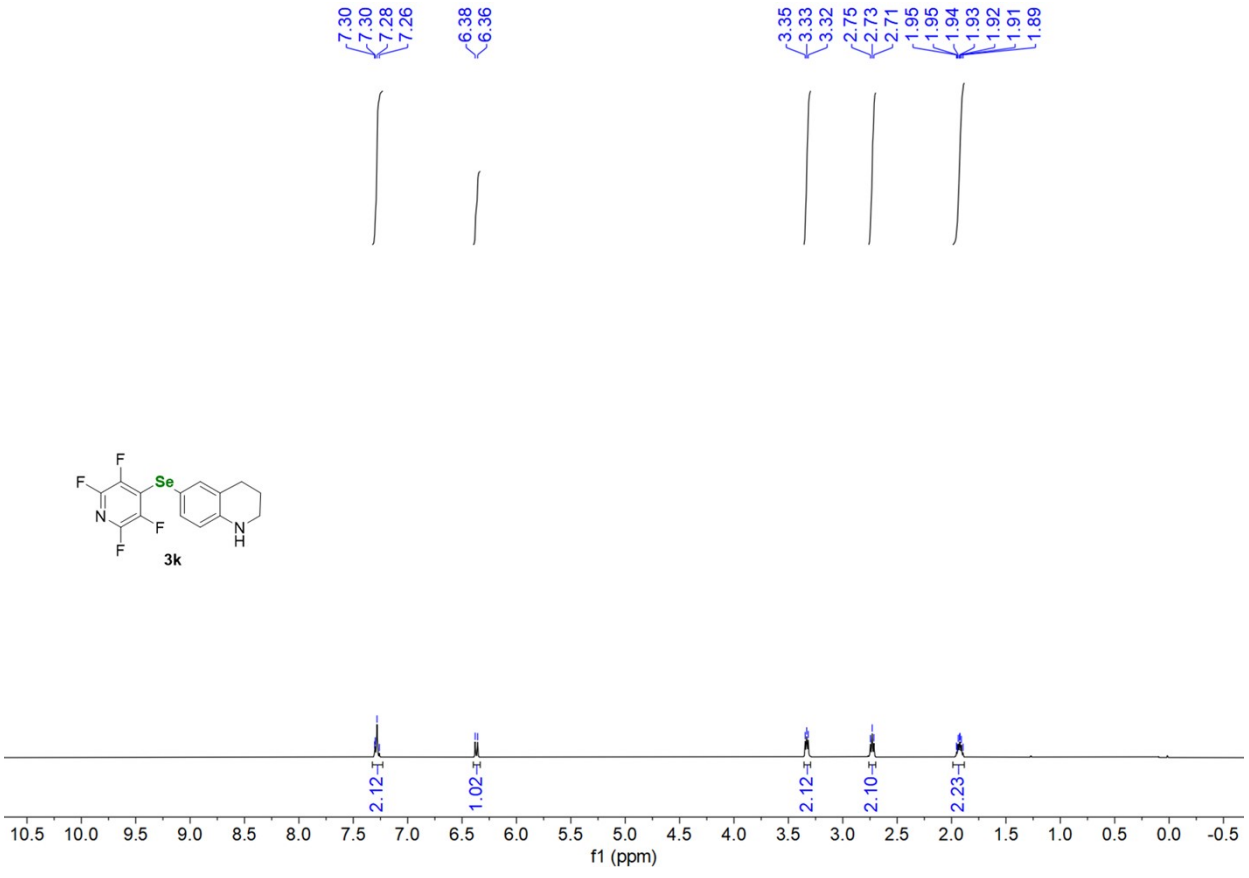
^{19}F NMR spectra of 3j (564 MHz, $CDCl_3$)



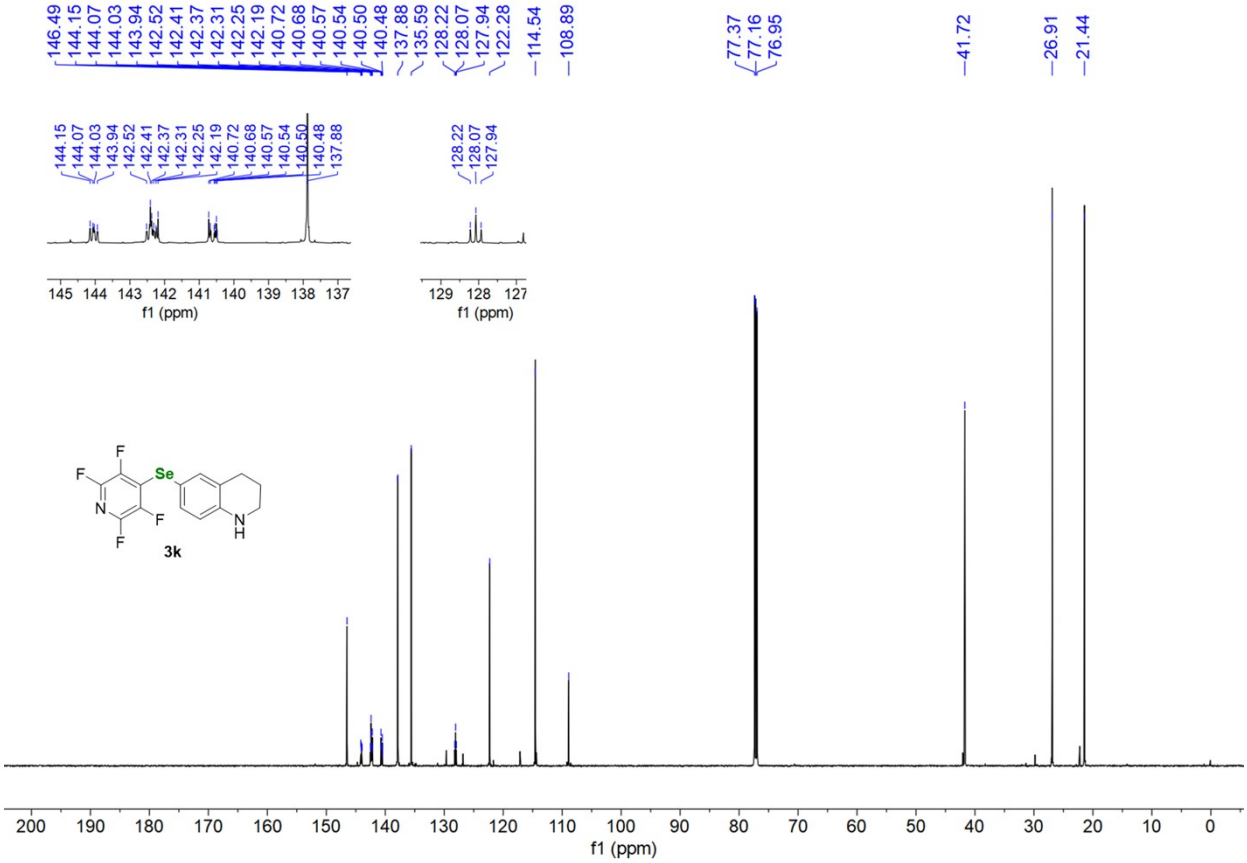
^{77}Se NMR spectra of 3j (114 MHz, $CDCl_3$)



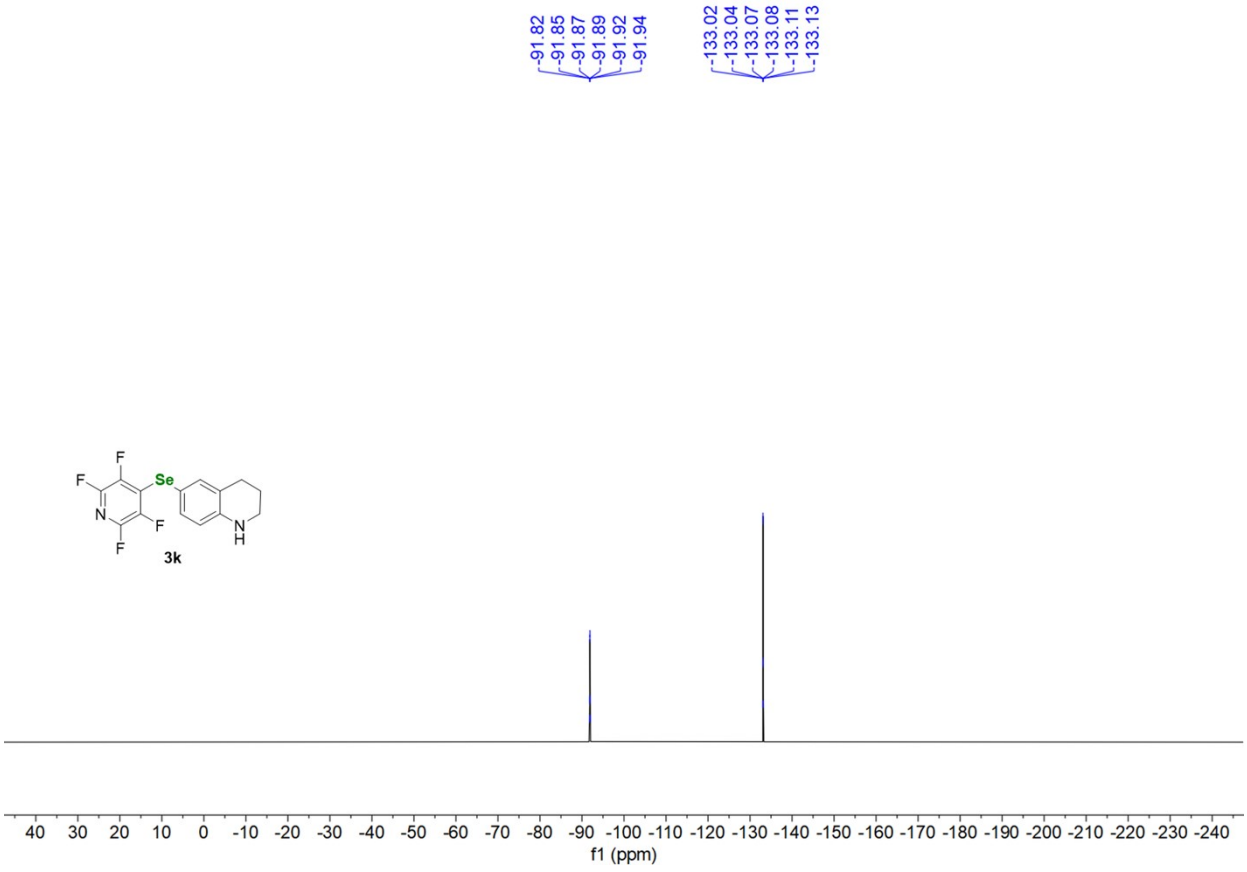
^{1}H NMR spectra of 3k (400 MHz, $CDCl_3$)



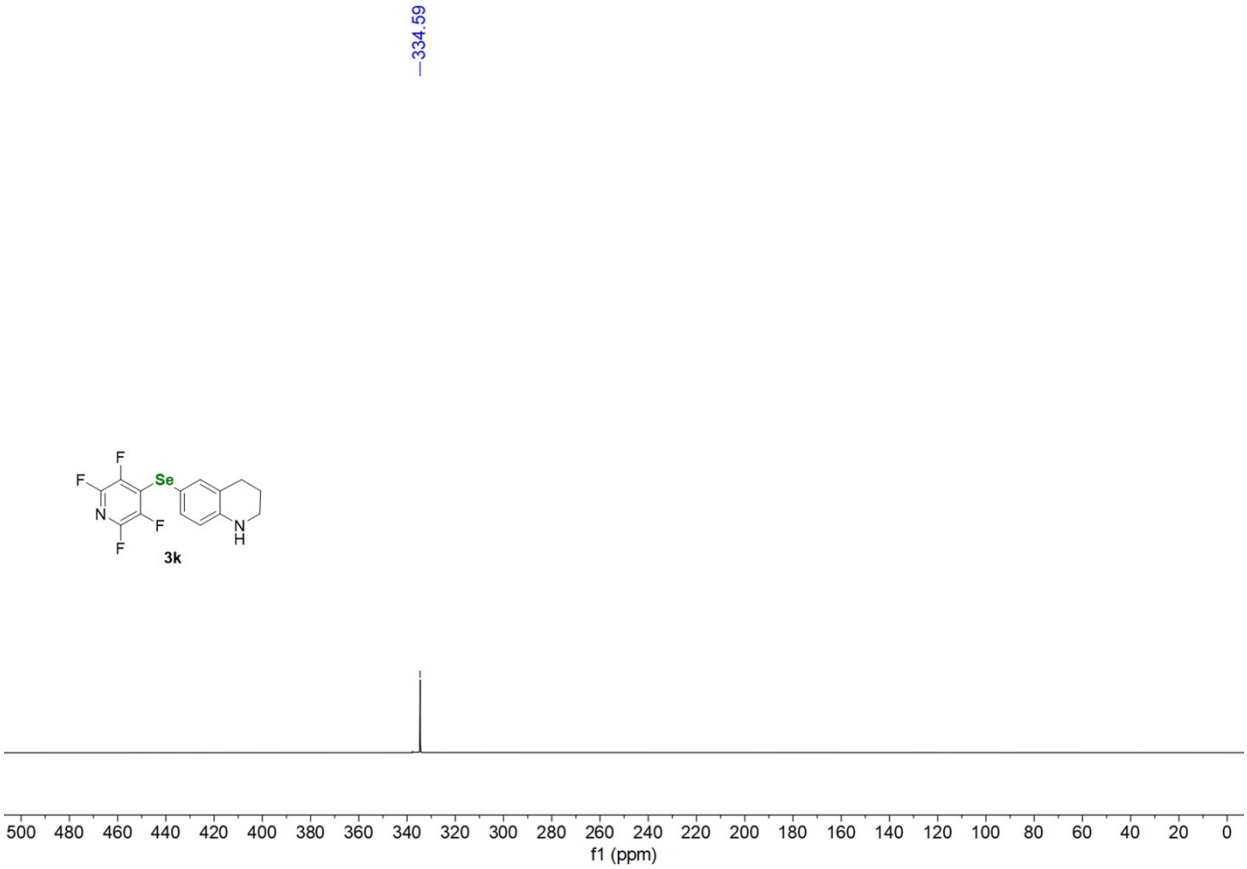
^{13}C NMR spectra of 3k (150 MHz, $CDCl_3$)



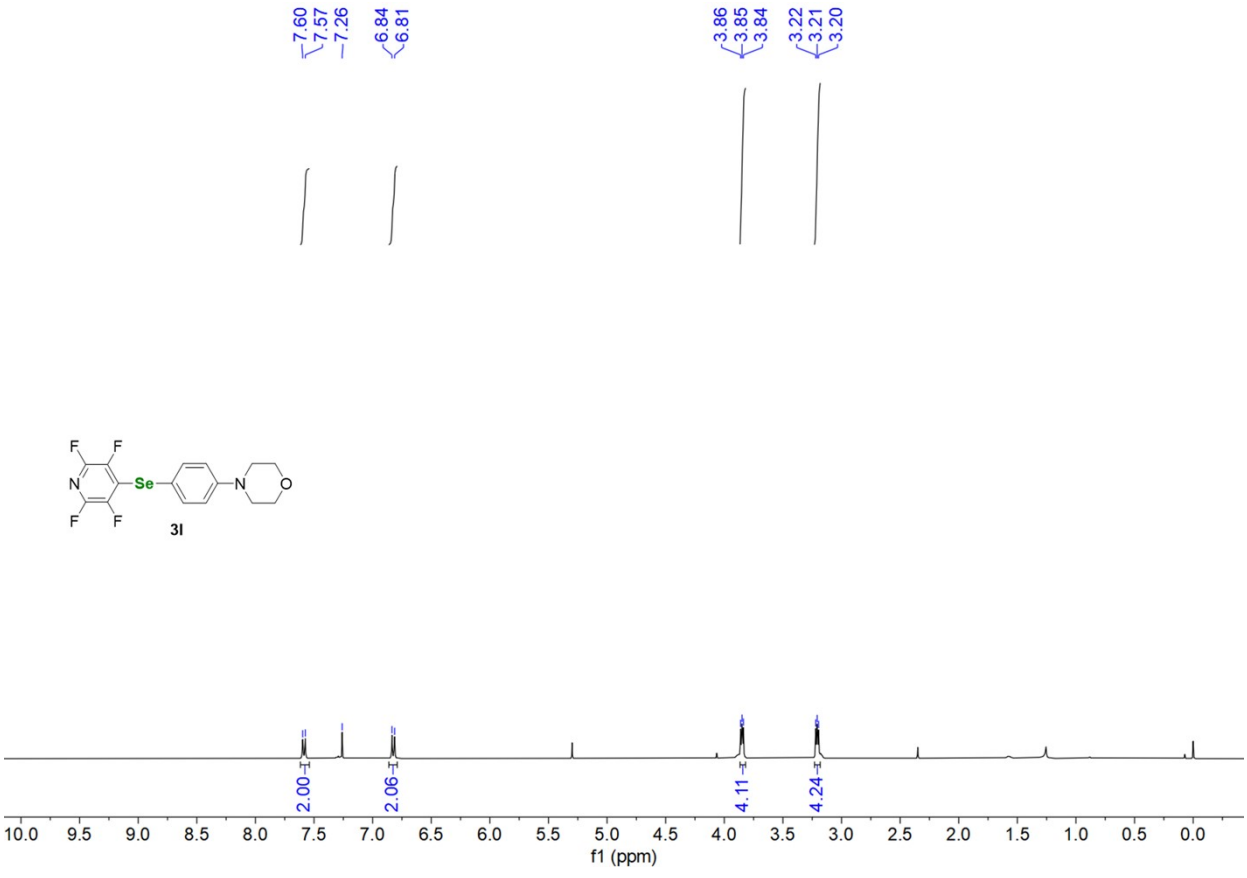
^{19}F NMR spectra of 3k (564 MHz, $CDCl_3$)



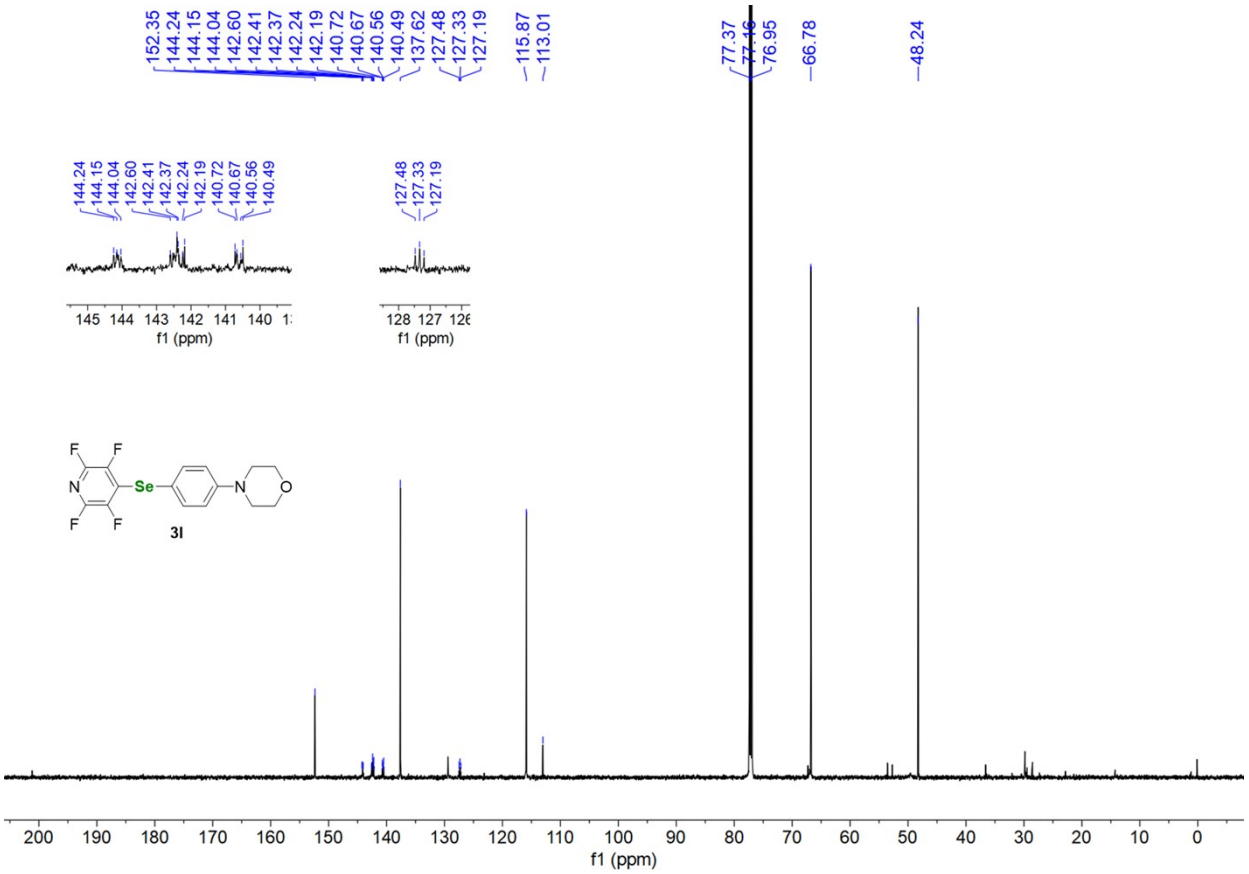
^{77}Se NMR spectra of 3k (114 MHz, $CDCl_3$)



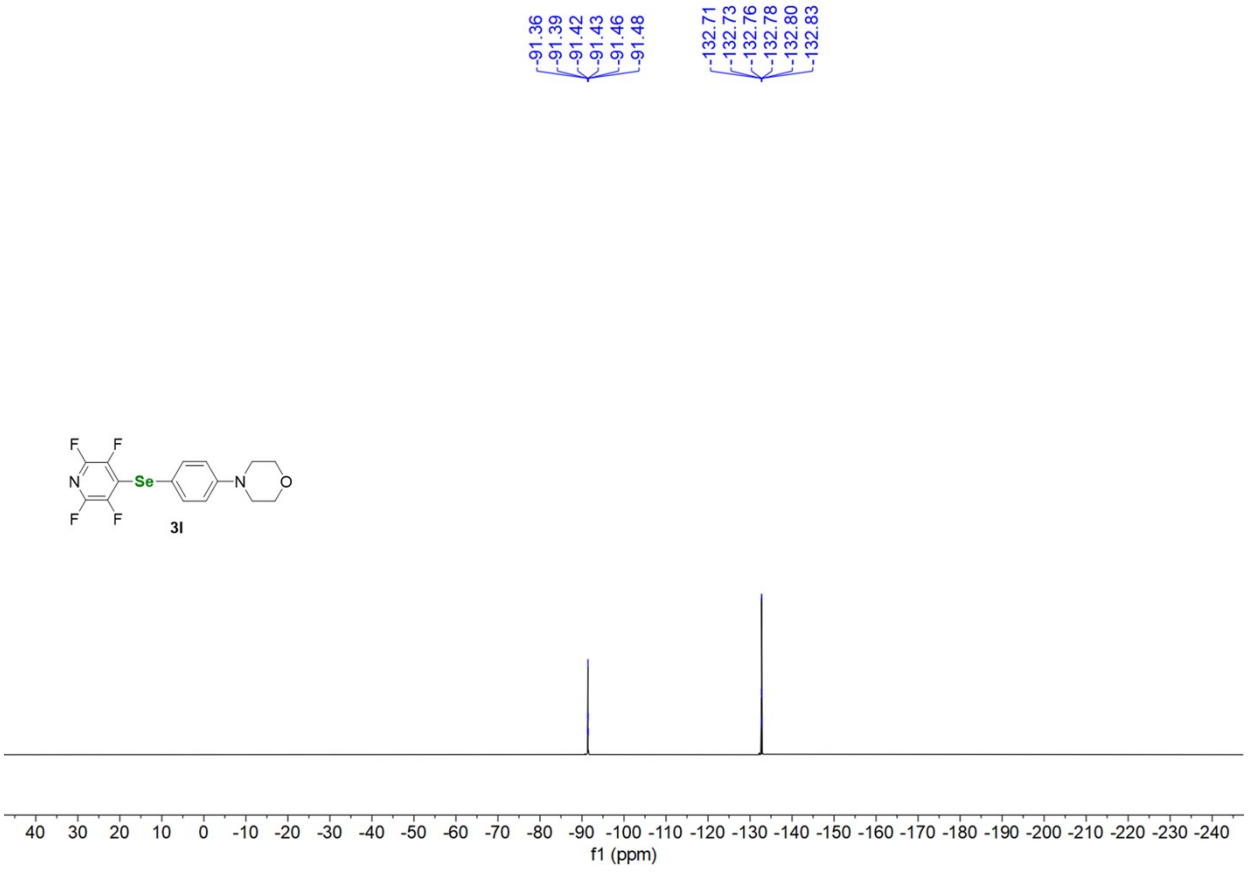
^{1}H NMR spectra of 3l (400 MHz, $CDCl_3$)



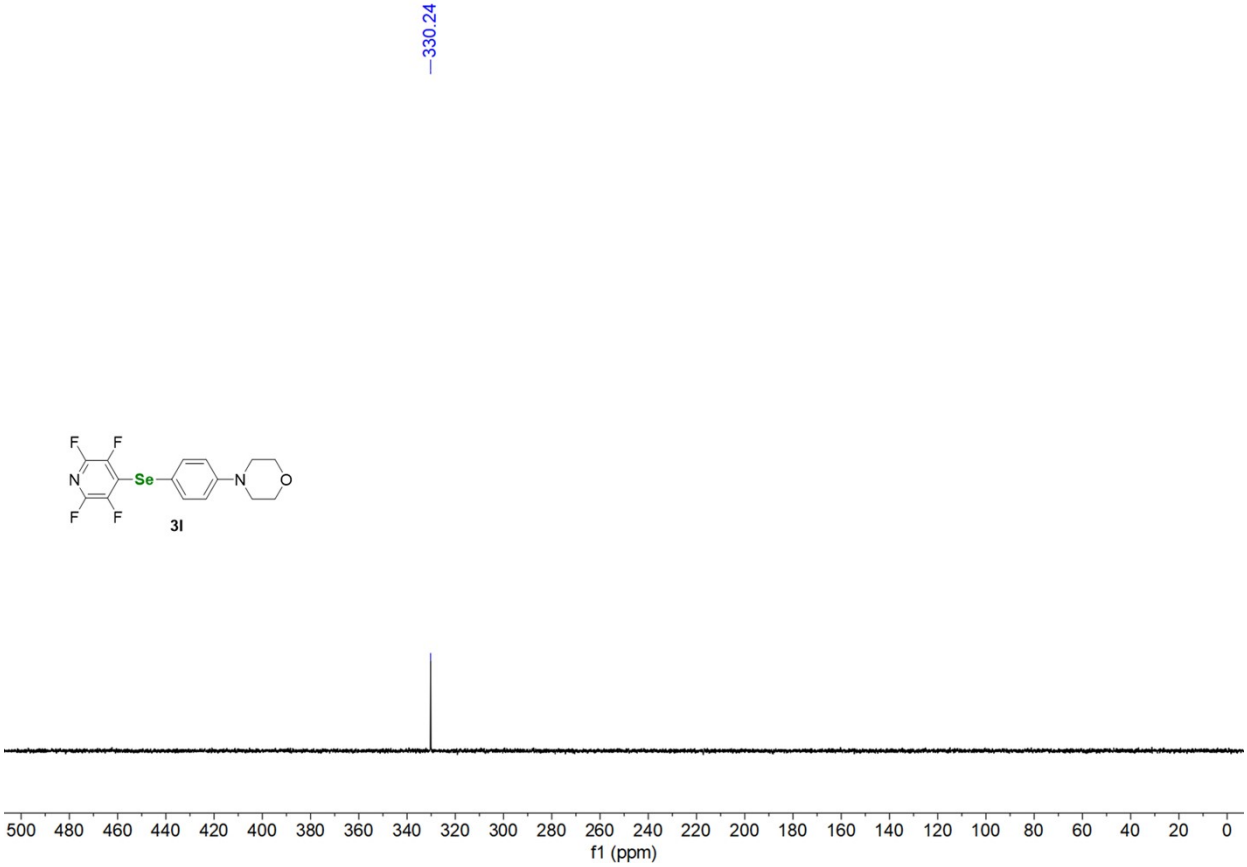
^{13}C NMR spectra of 3l (150 MHz, $CDCl_3$)



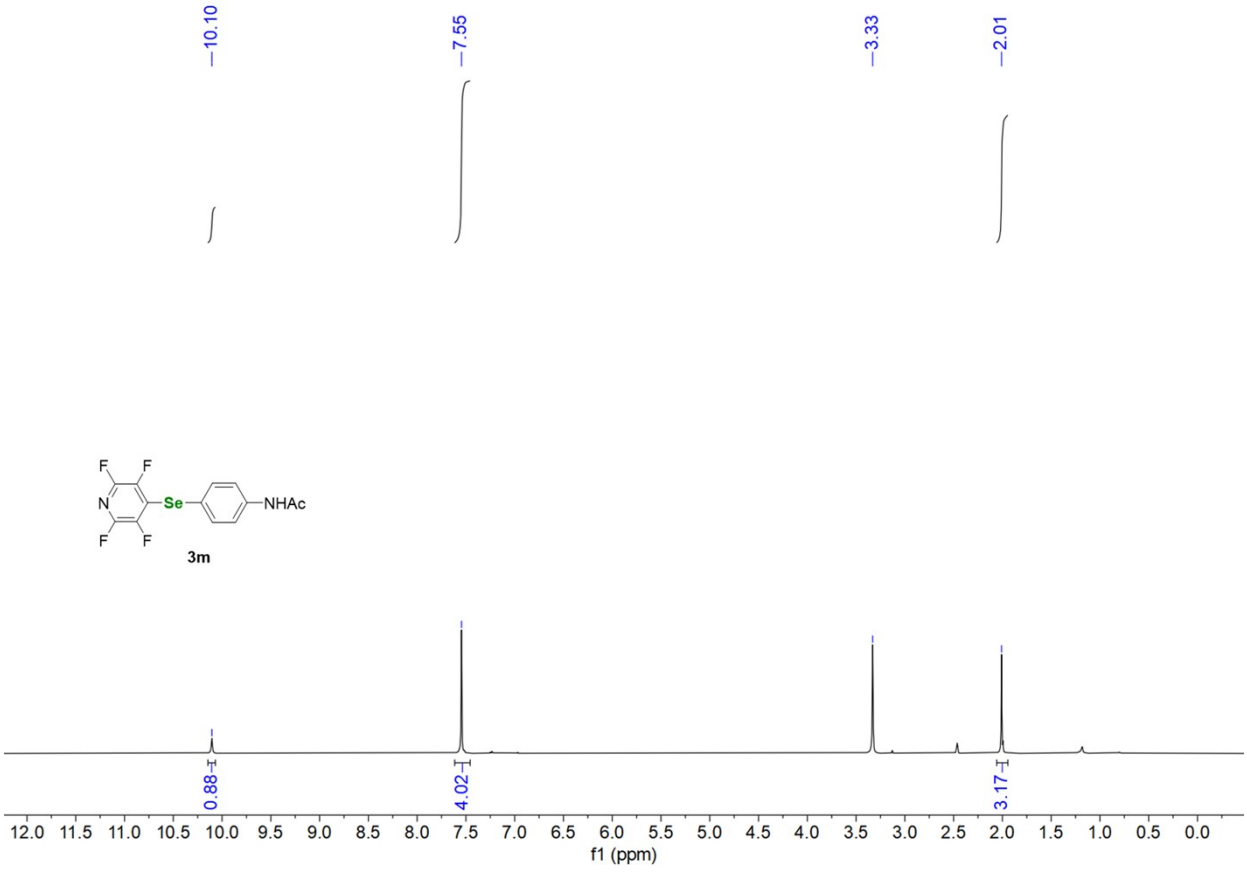
^{19}F NMR spectra of 3l (564 MHz, $CDCl_3$)



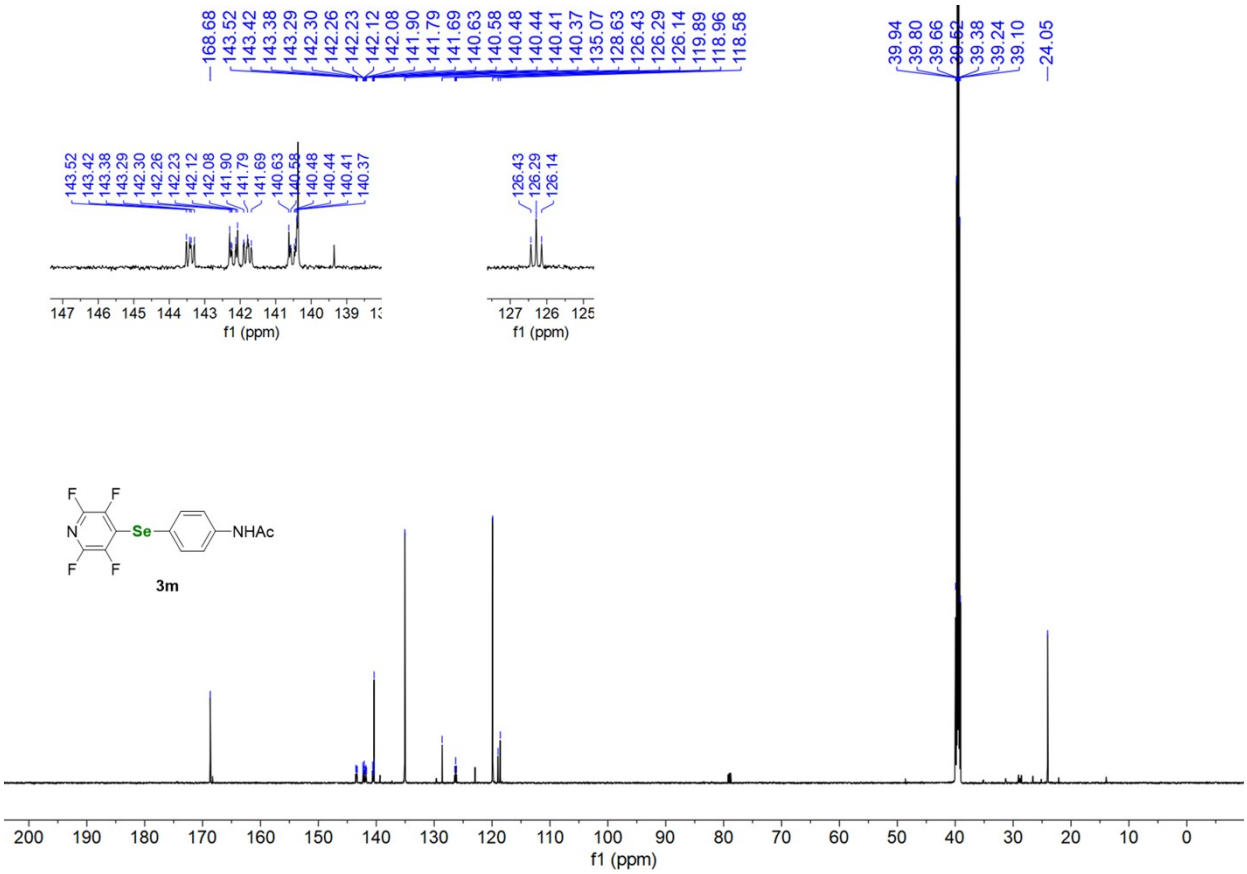
^{77}Se NMR spectra of 3l (114 MHz, $CDCl_3$)



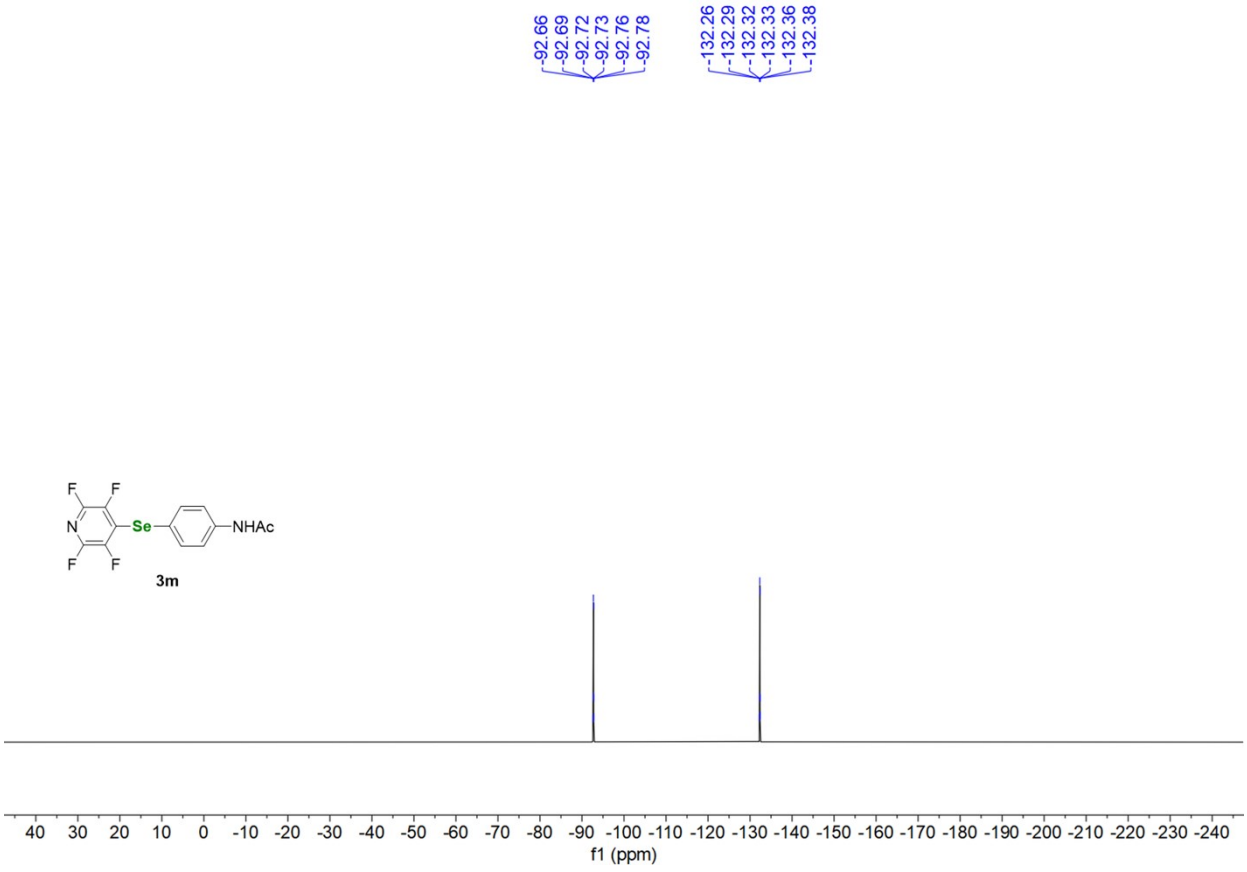
^{1}H NMR spectra of 3m (400 MHz, DMSO-d6)



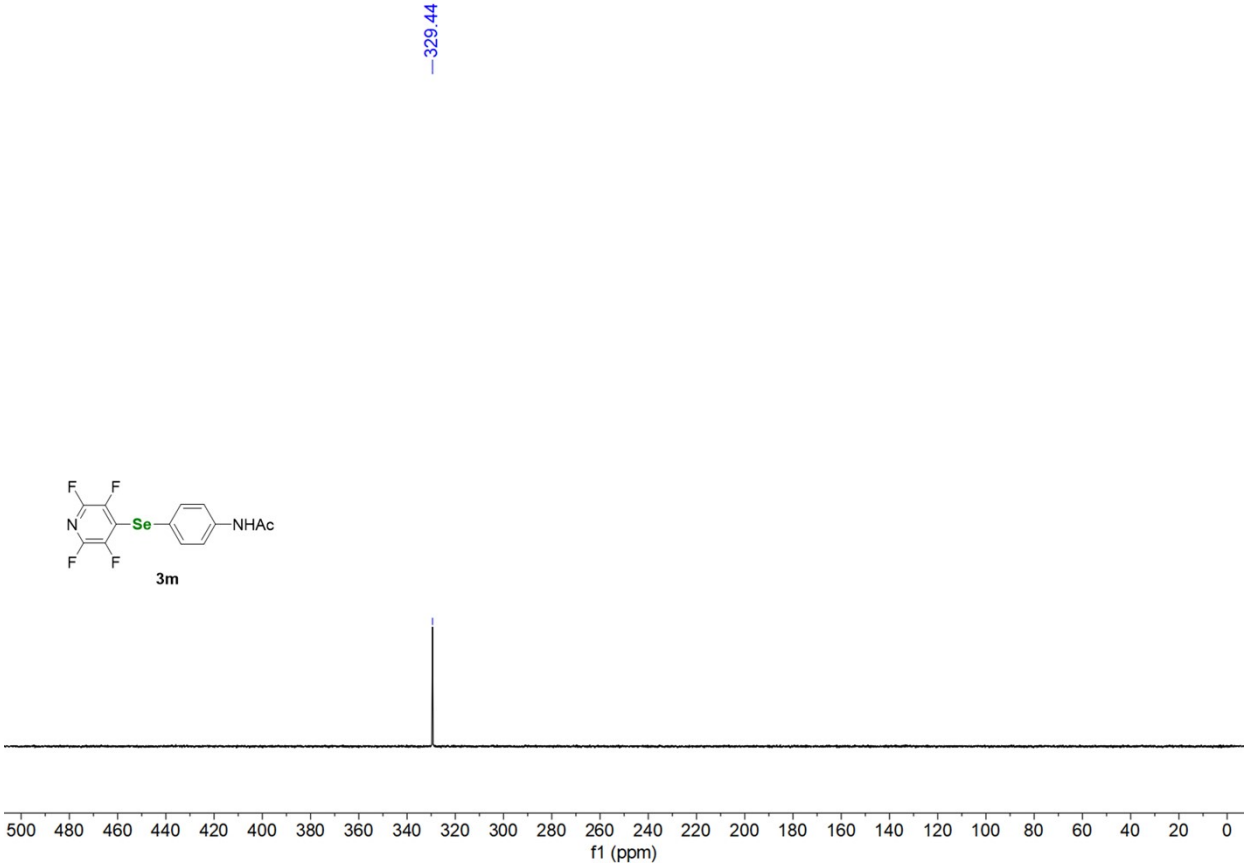
^{13}C NMR spectra of 3m (150 MHz, DMSO-d6)



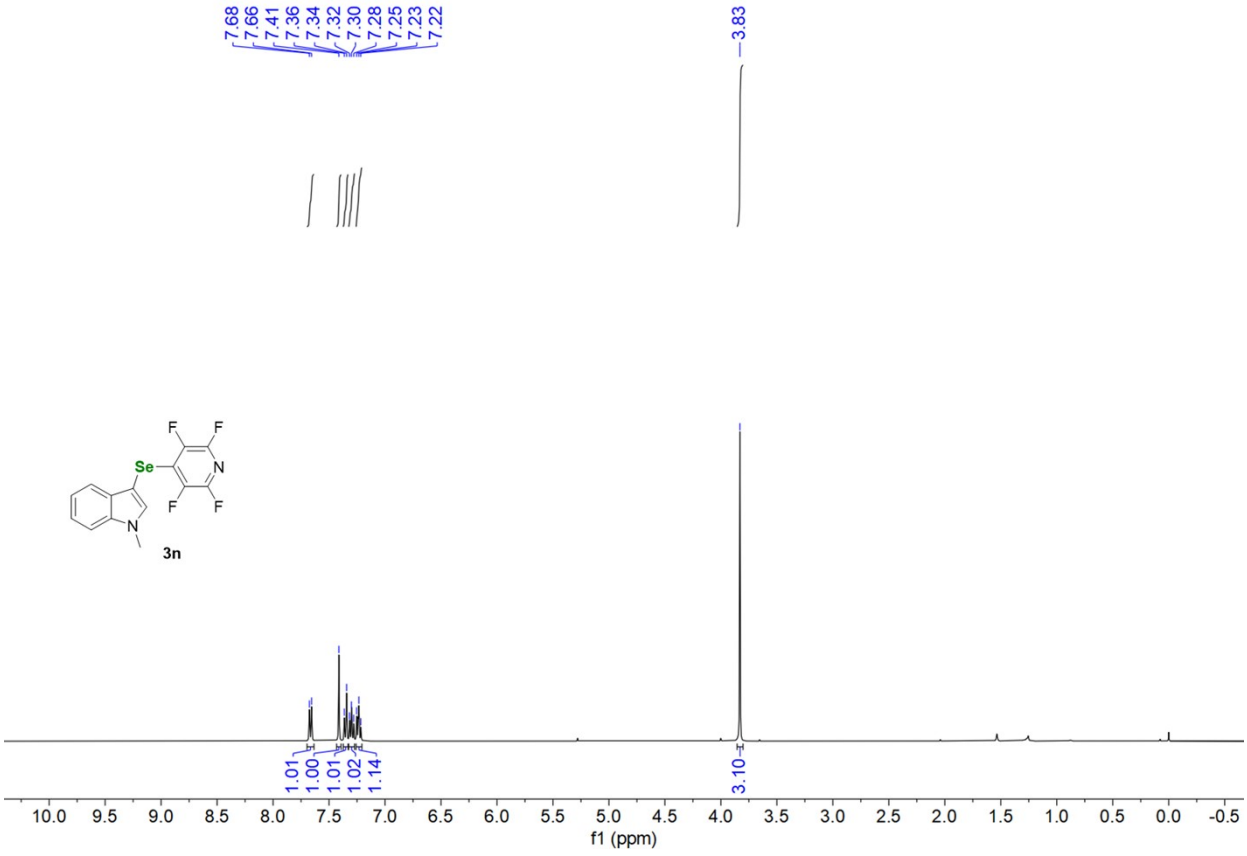
^{19}F NMR spectra of 3m (564 MHz, DMSO-d6)



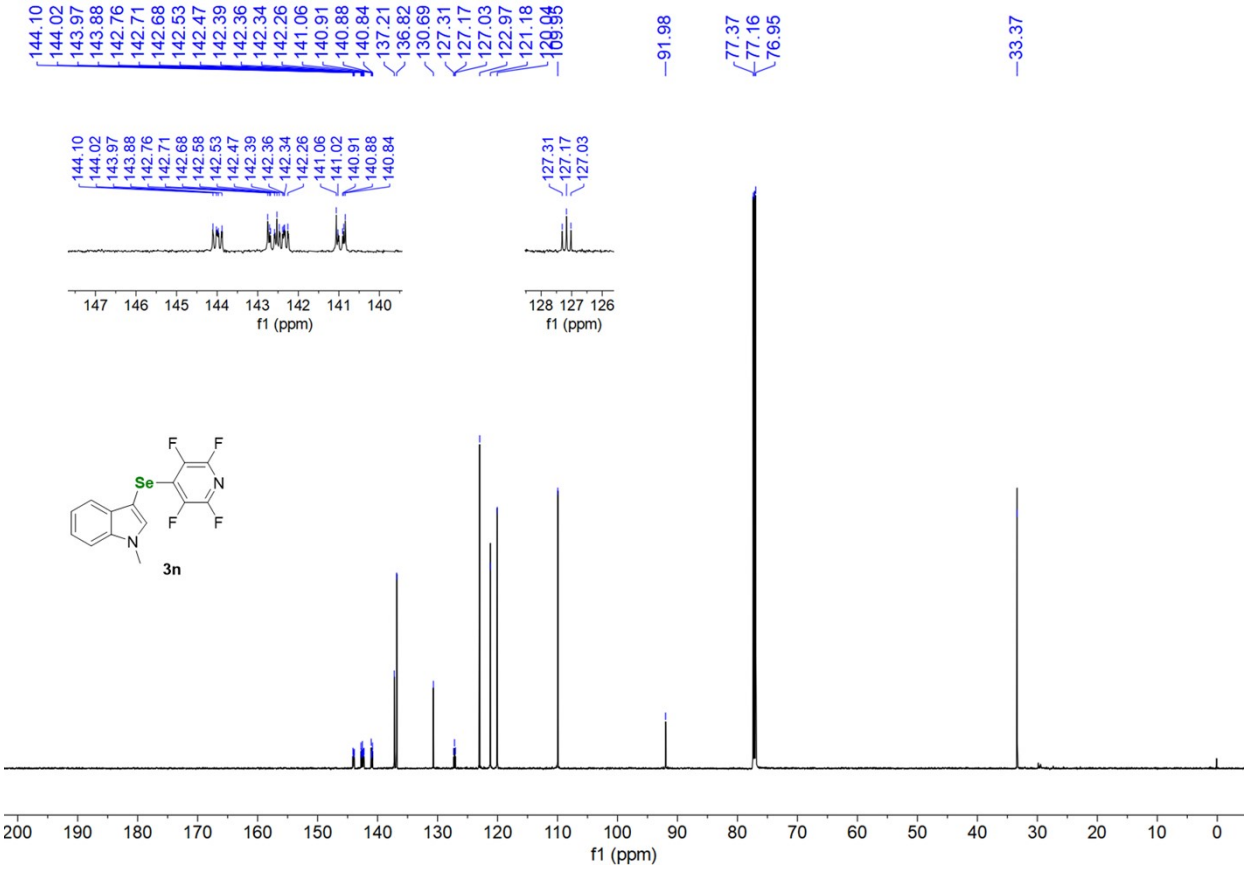
^{77}Se NMR spectra of 3m (114 MHz, DMSO-d6)



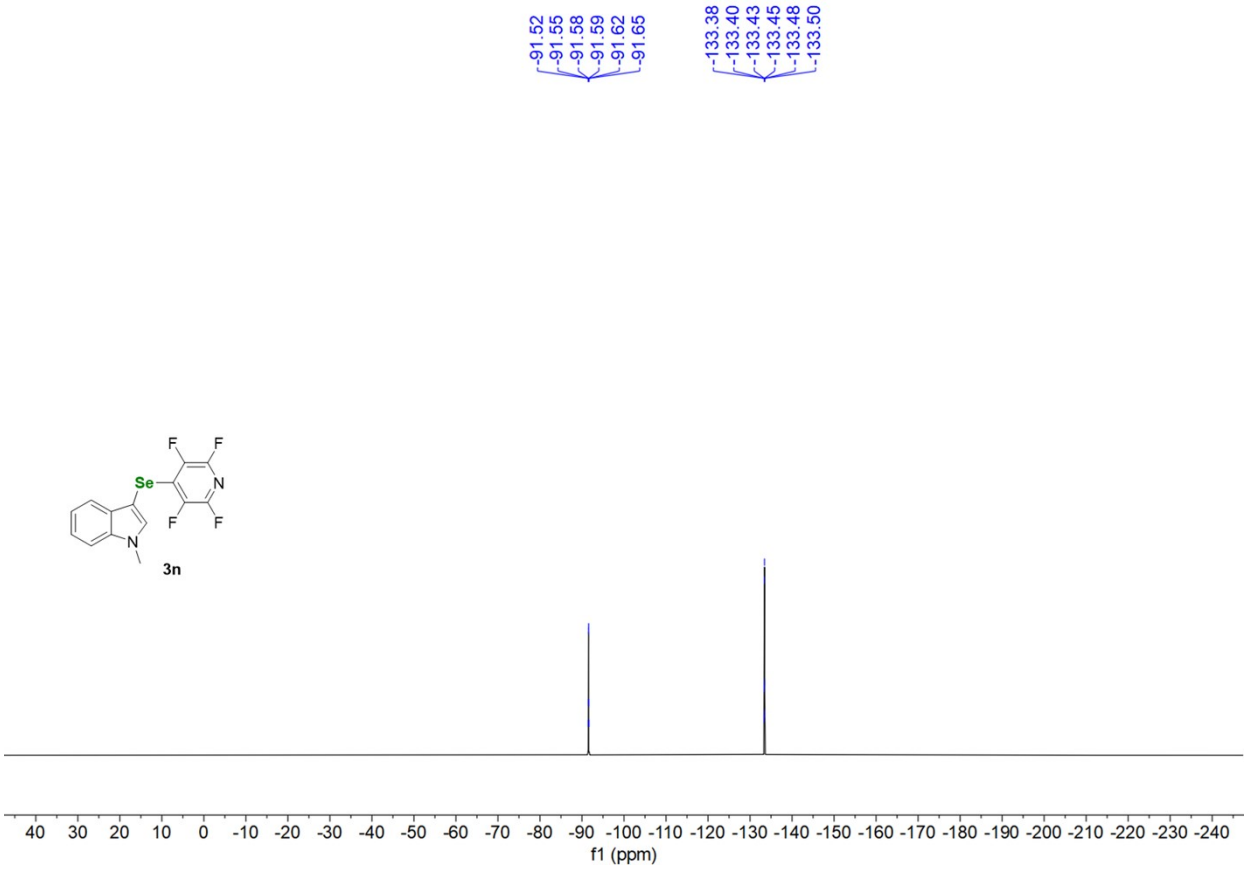
^{1}H NMR spectra of 3n (400 MHz, $CDCl_3$)



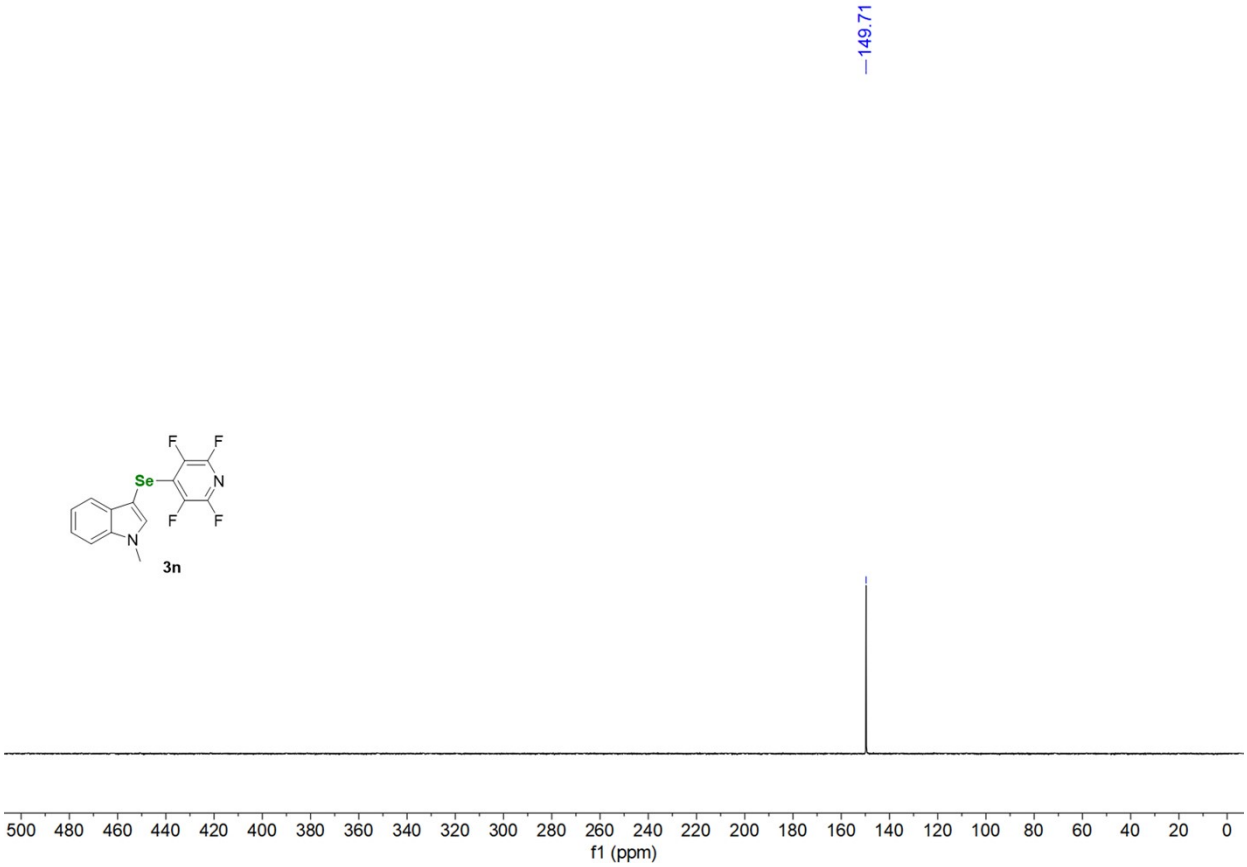
^{13}C NMR spectra of 3n (150 MHz, $CDCl_3$)



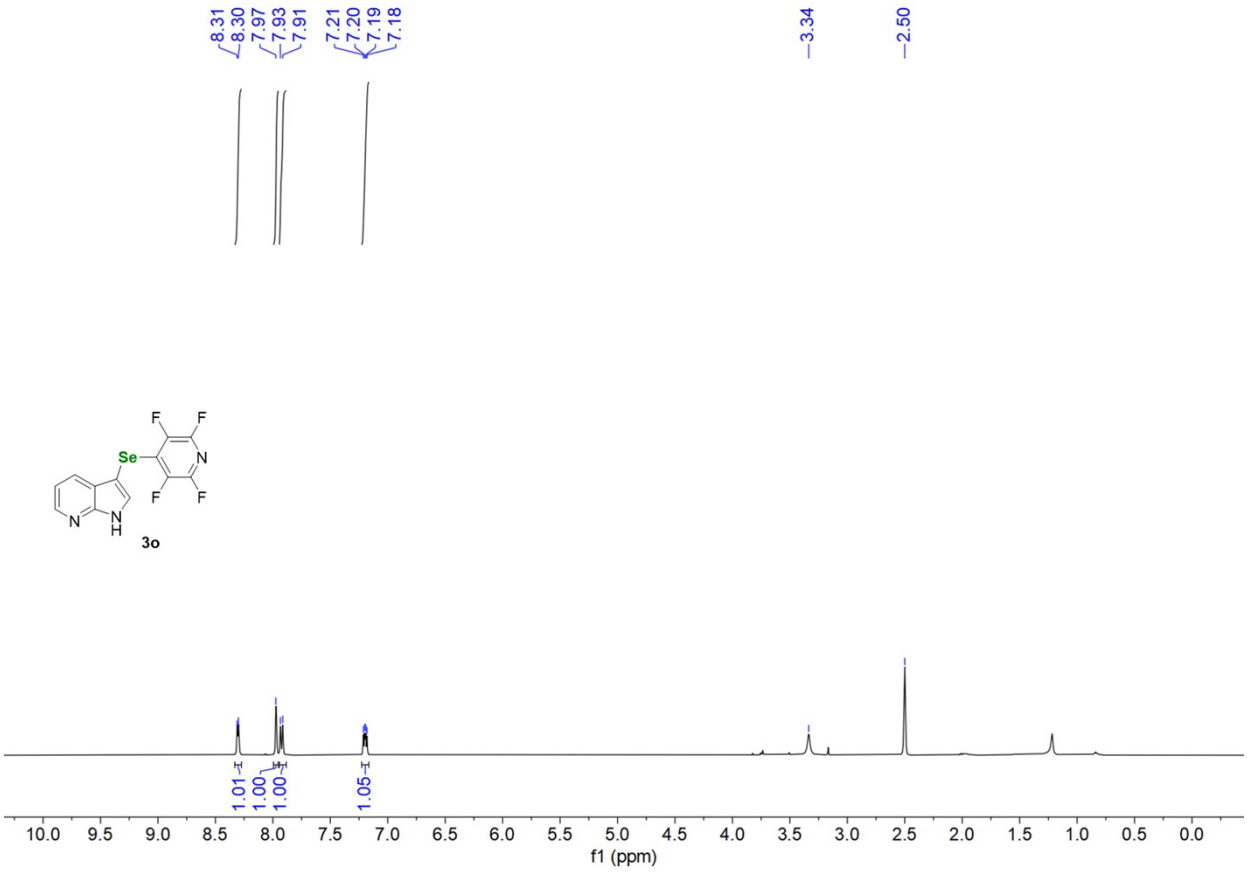
^{19}F NMR spectra of 3n (564 MHz, $CDCl_3$)



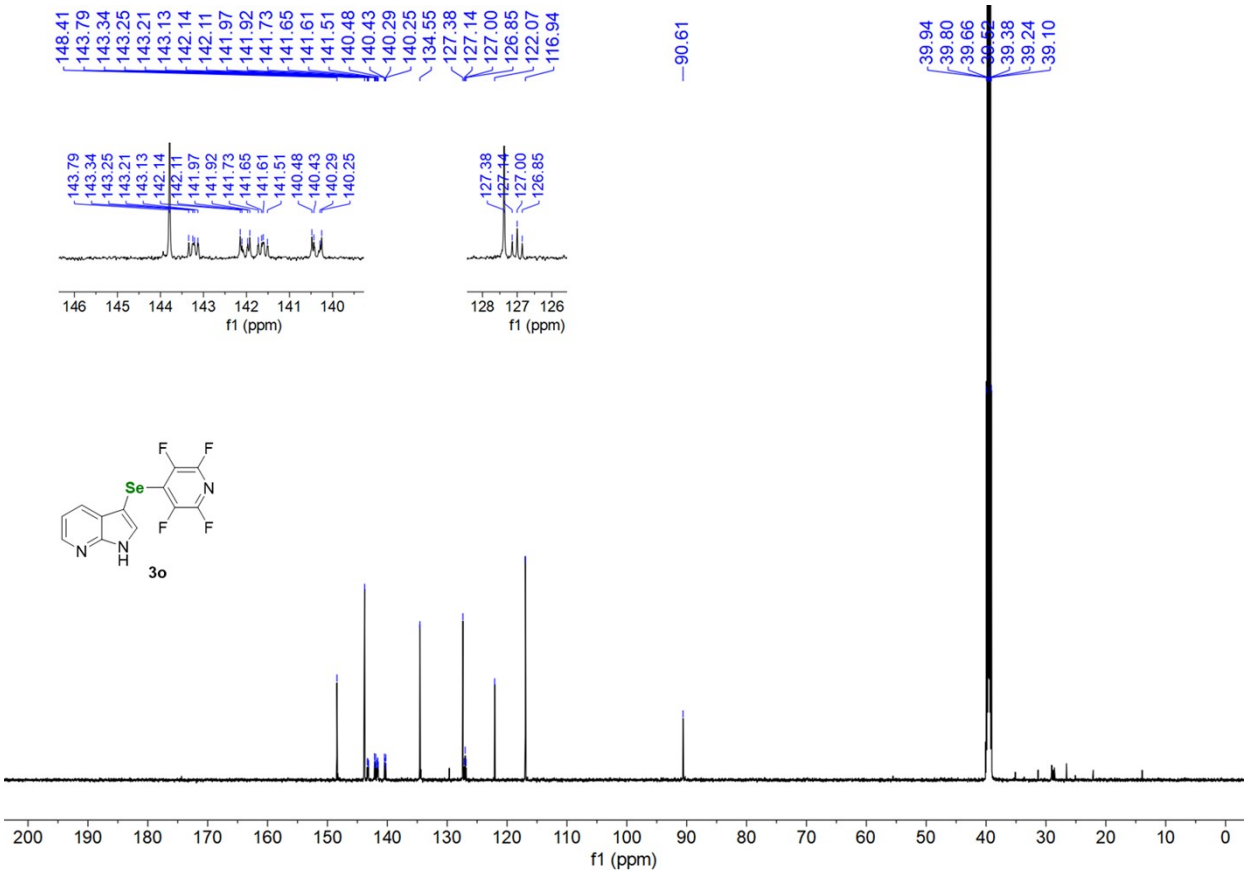
^{77}Se NMR spectra of 3n (114 MHz, $CDCl_3$)



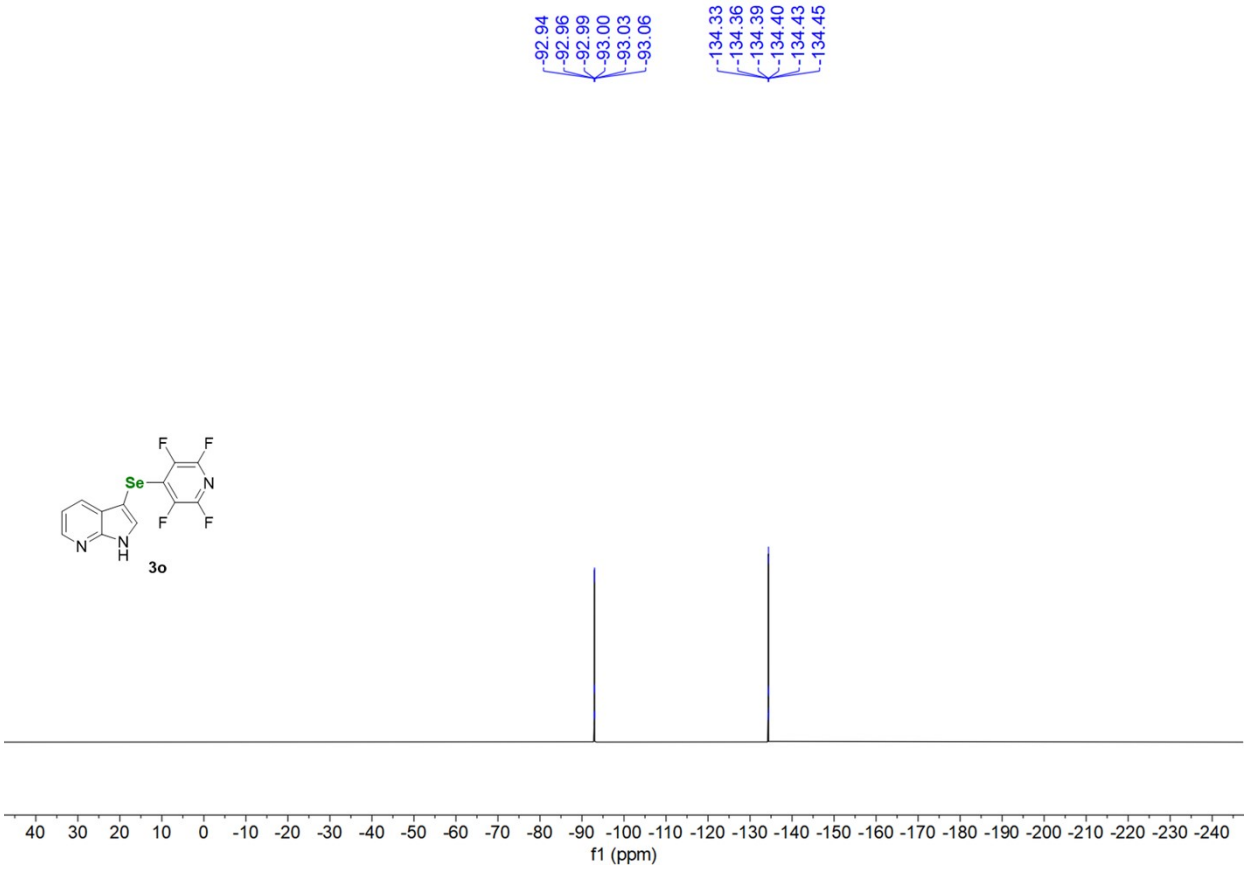
^{1}H NMR spectra of 3o (400 MHz, DMSO-d6)



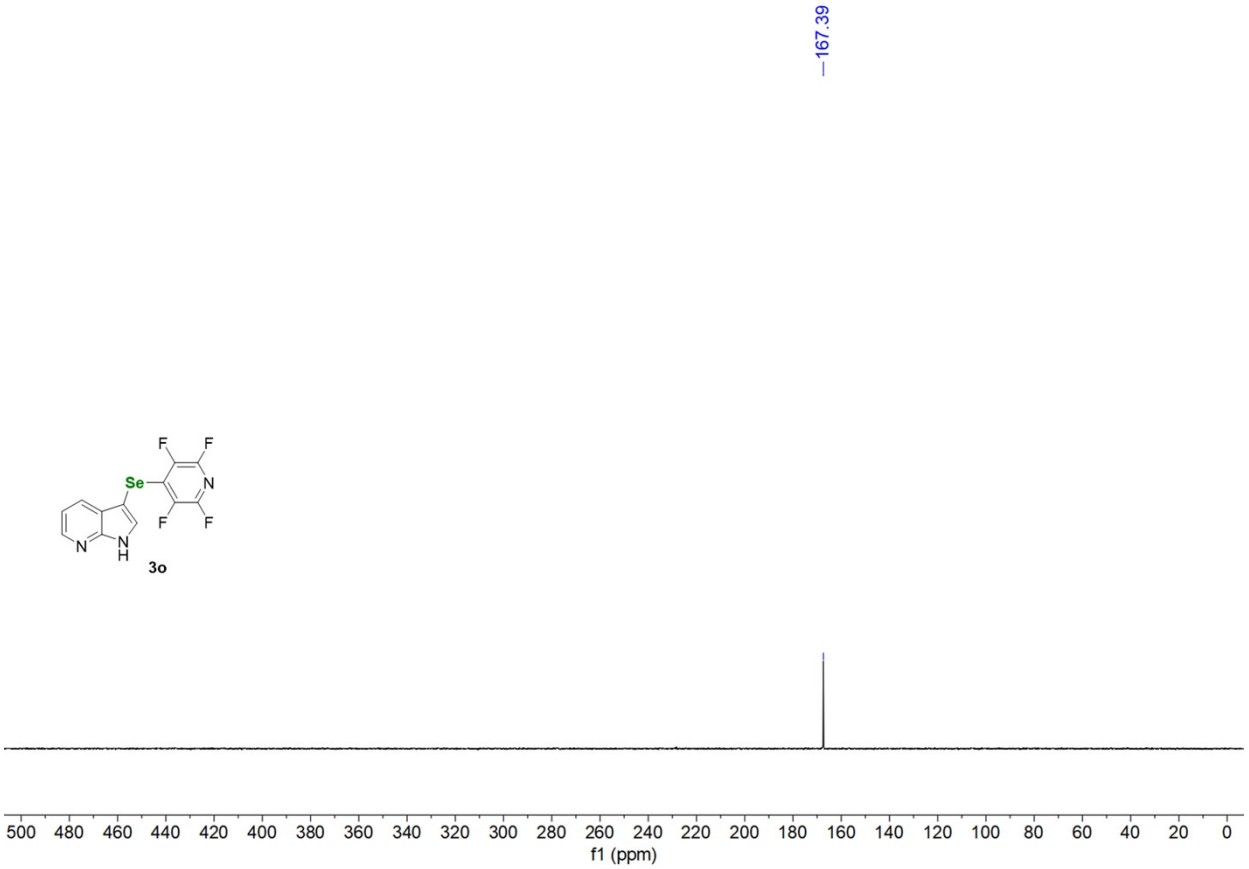
^{13}C NMR spectra of 3o (150 MHz, DMSO-d6)



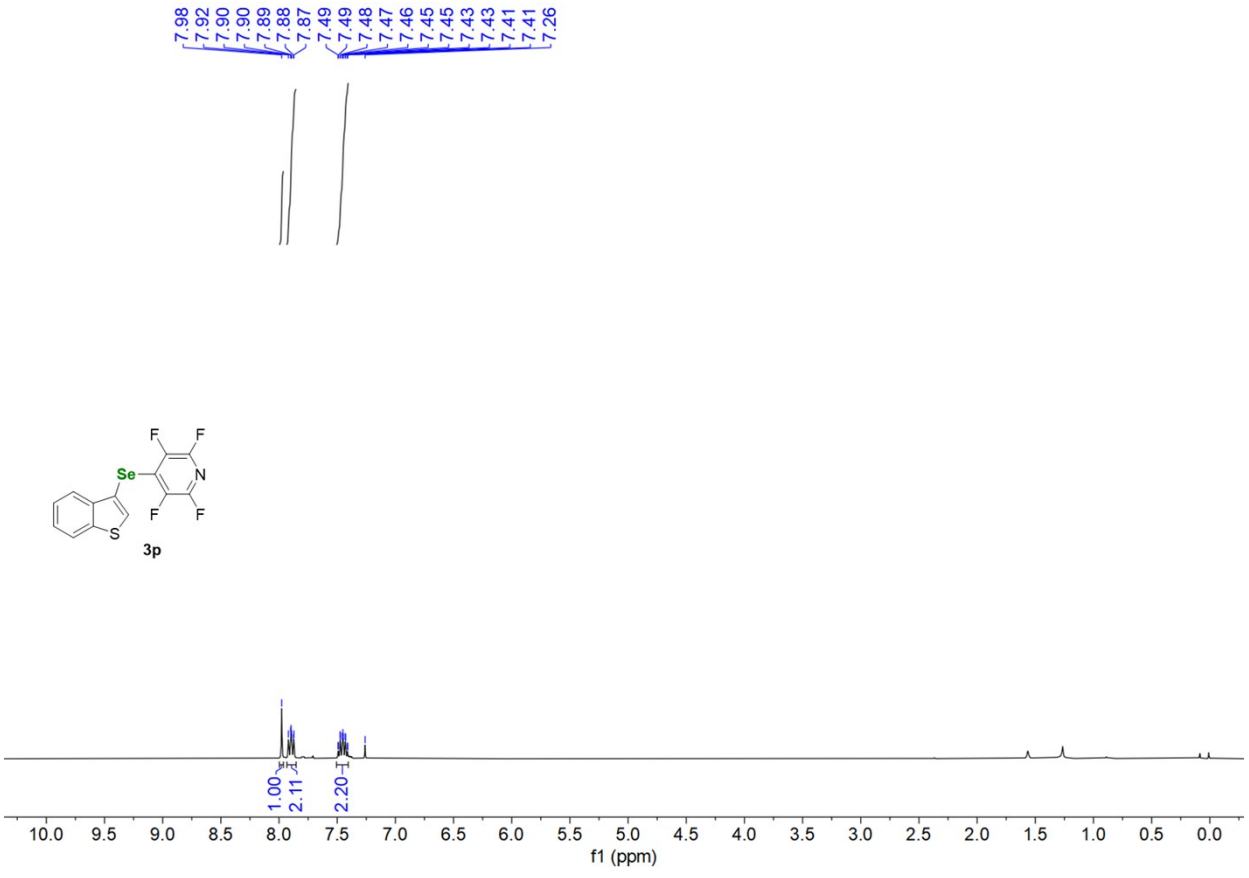
^{19}F NMR spectra of 3o (564 MHz, DMSO-d6)



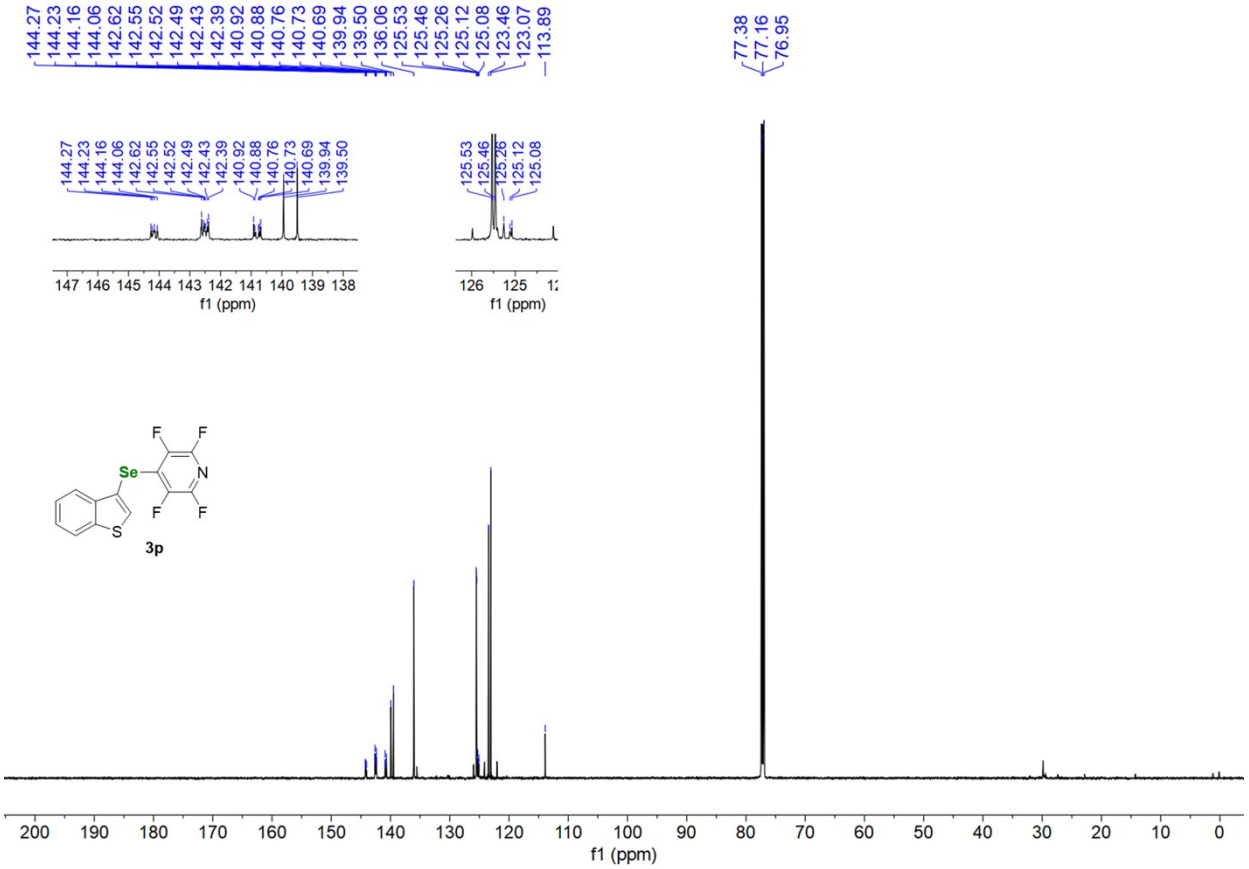
^{77}Se NMR spectra of 3o (114 MHz, DMSO-d6)



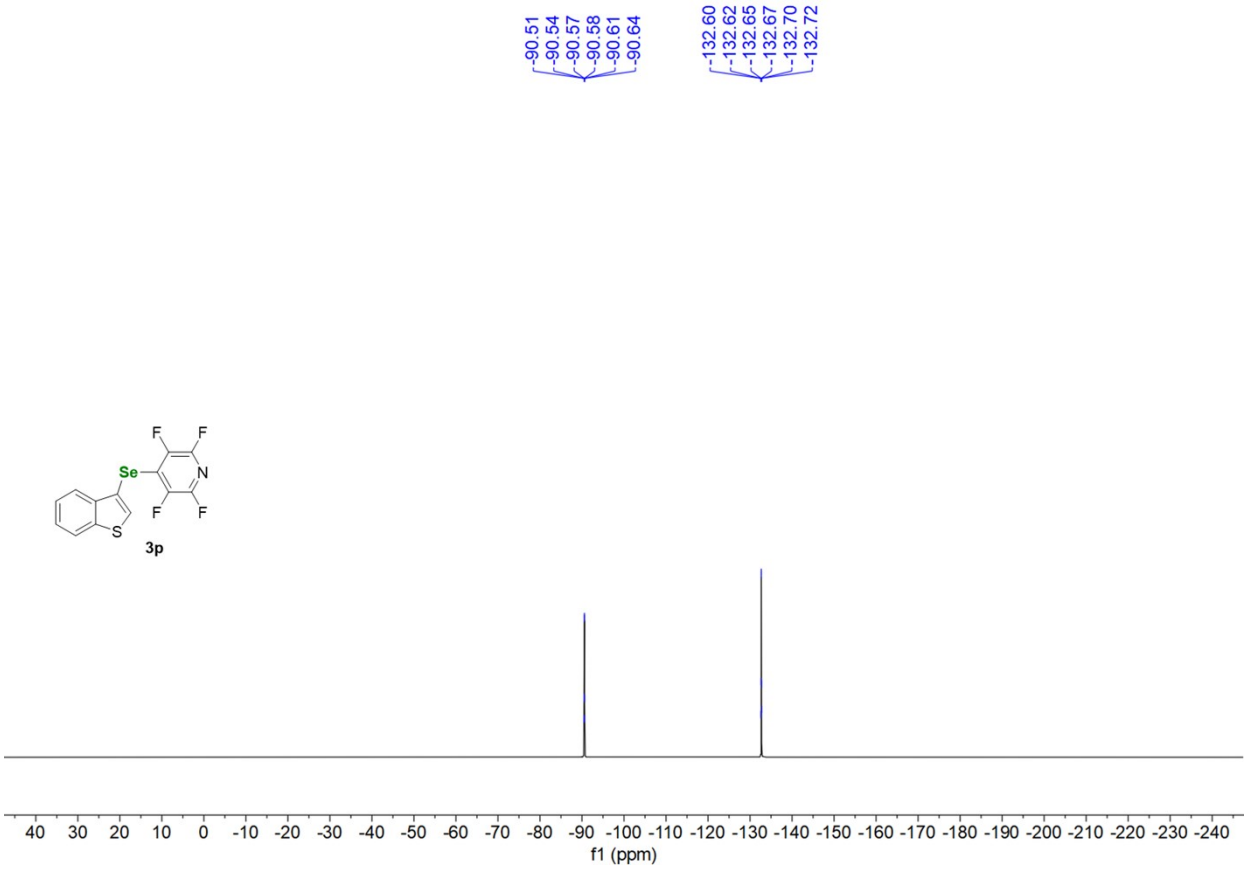
^{1}H NMR spectra of 3p (400 MHz, $CDCl_3$)



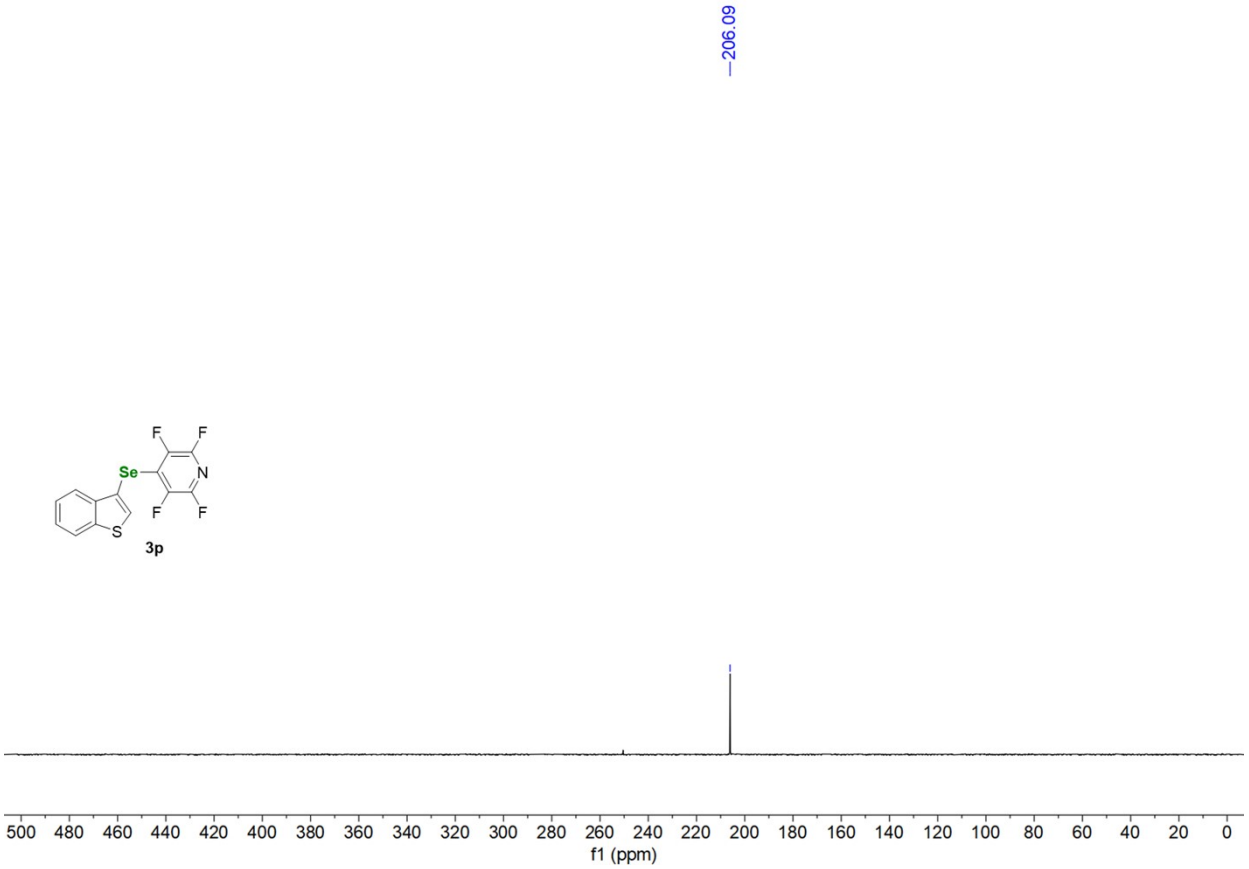
^{13}C NMR spectra of 3p (150 MHz, $CDCl_3$)



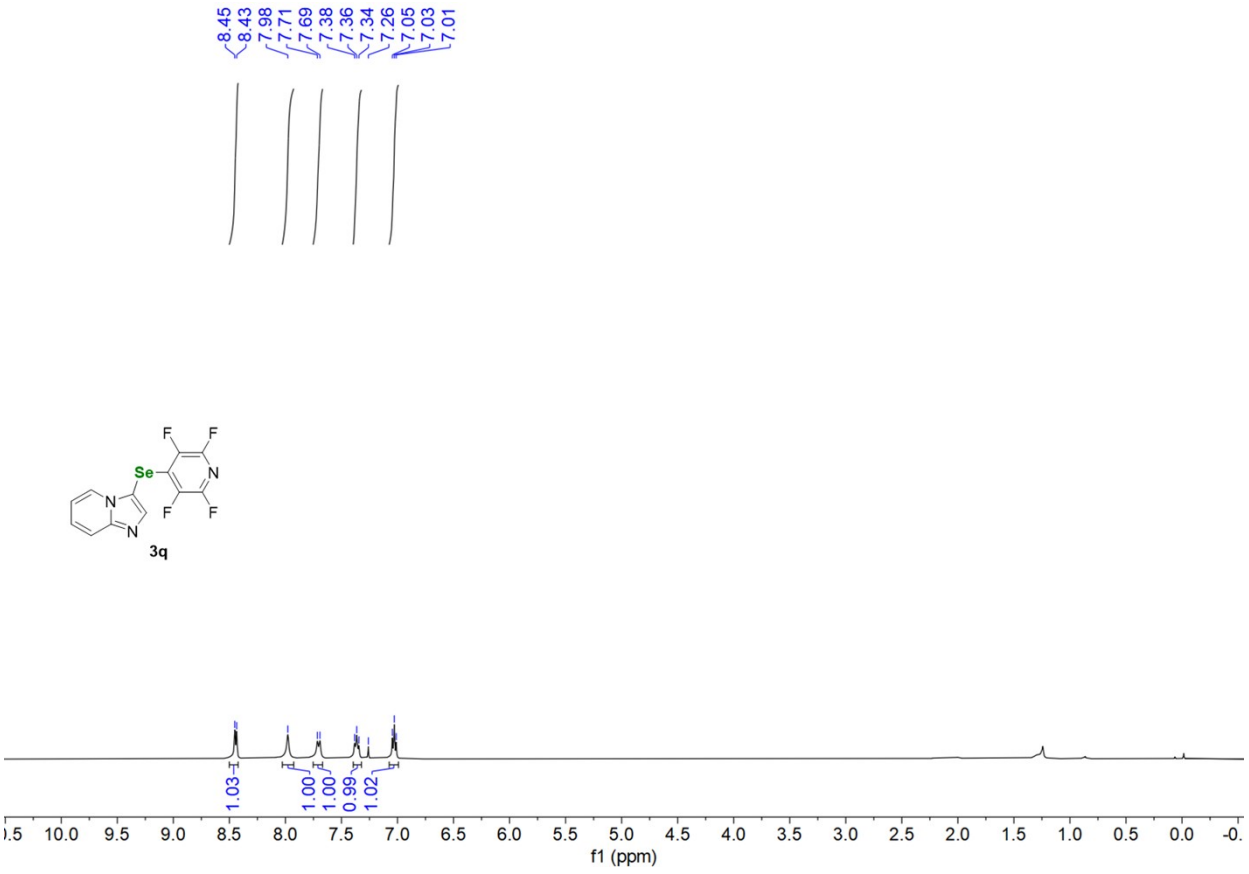
^{19}F NMR spectra of 3p (564 MHz, $CDCl_3$)



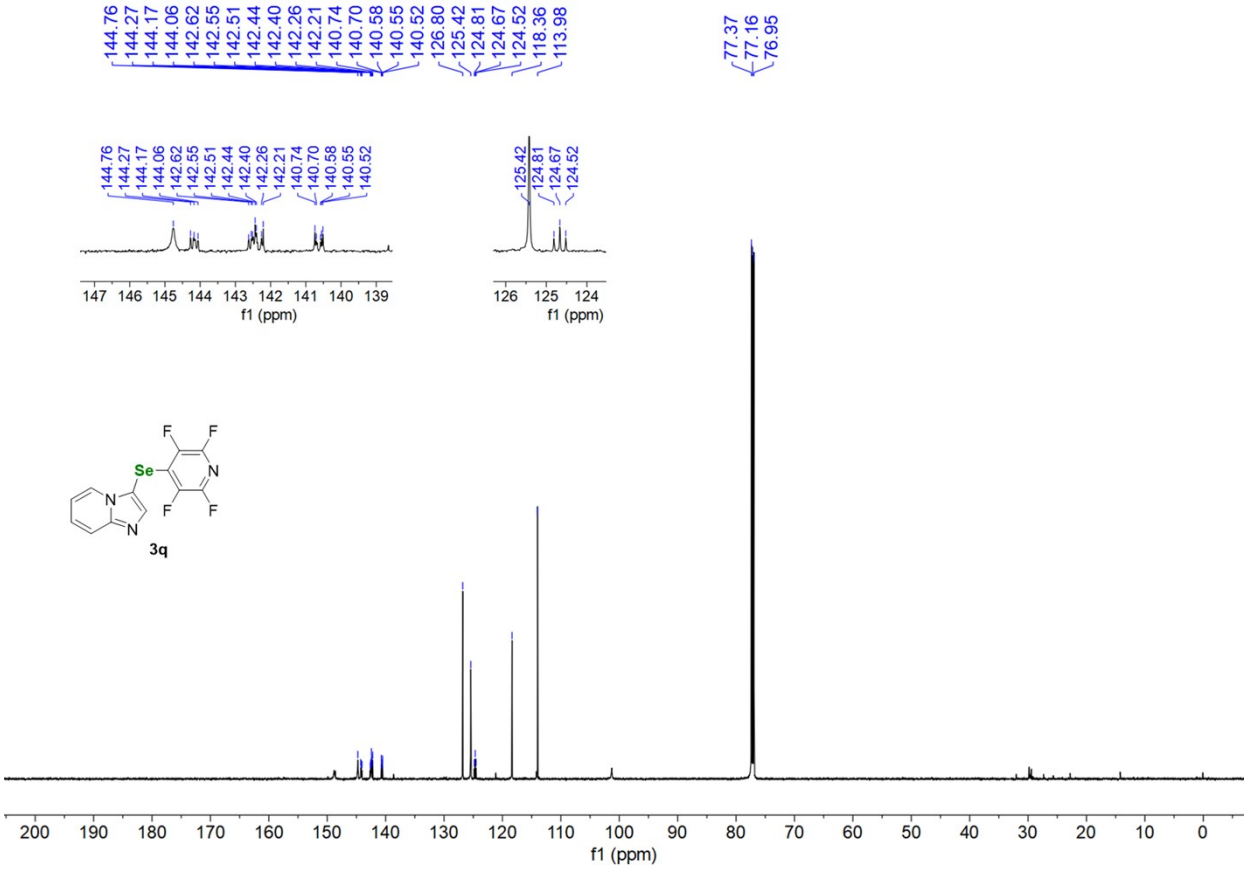
^{77}Se NMR spectra of 3p (114 MHz, $CDCl_3$)



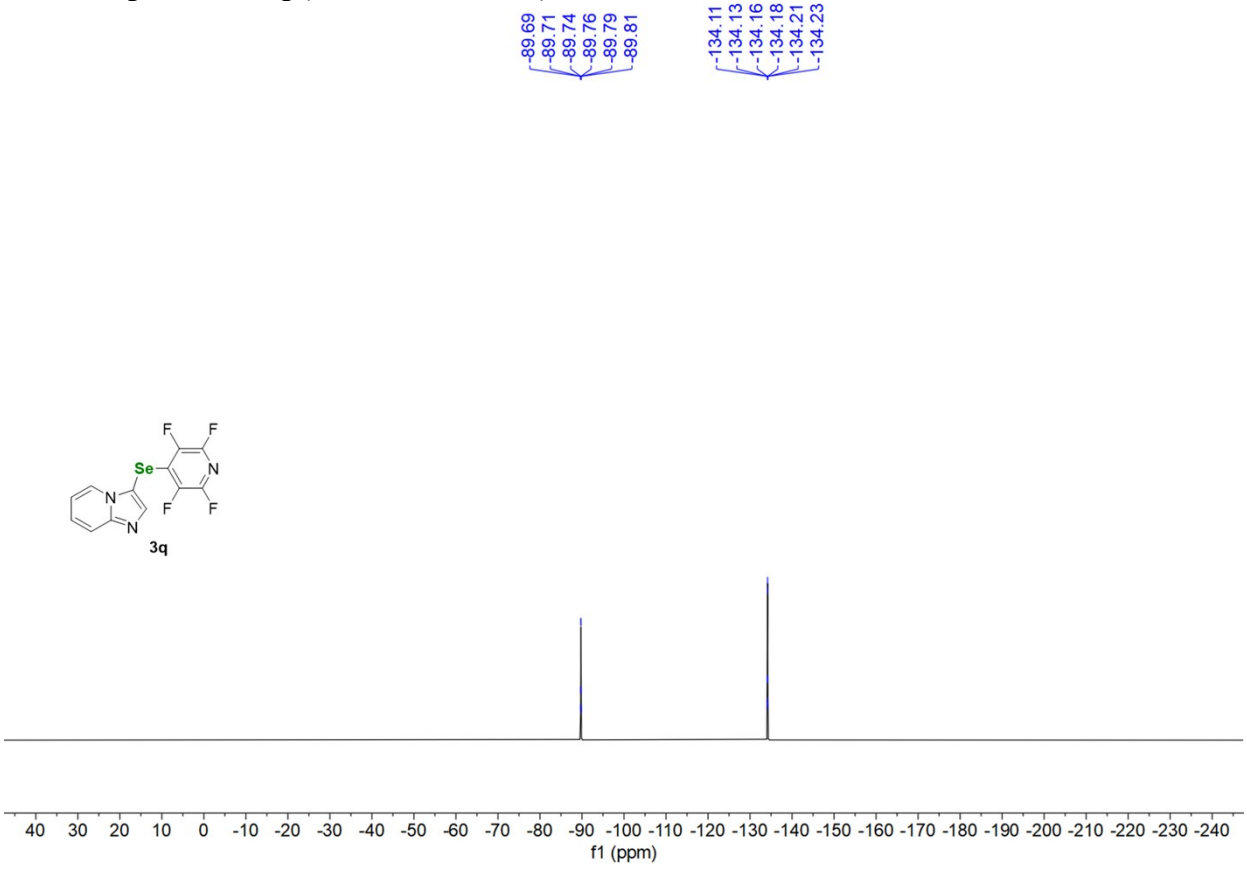
^{1}H NMR spectra of 3q (400 MHz, $CDCl_3$)



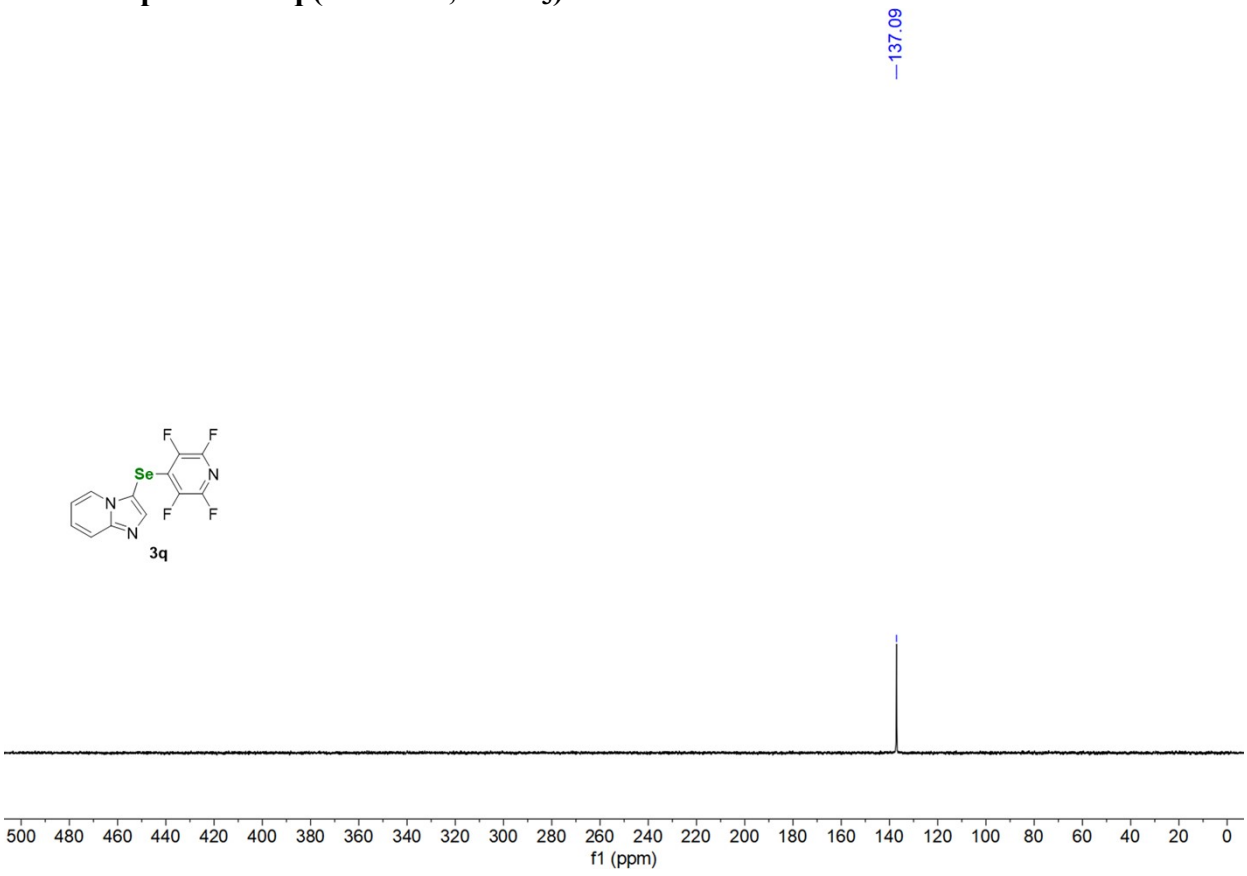
^{13}C NMR spectra of 3q (150 MHz, $CDCl_3$)



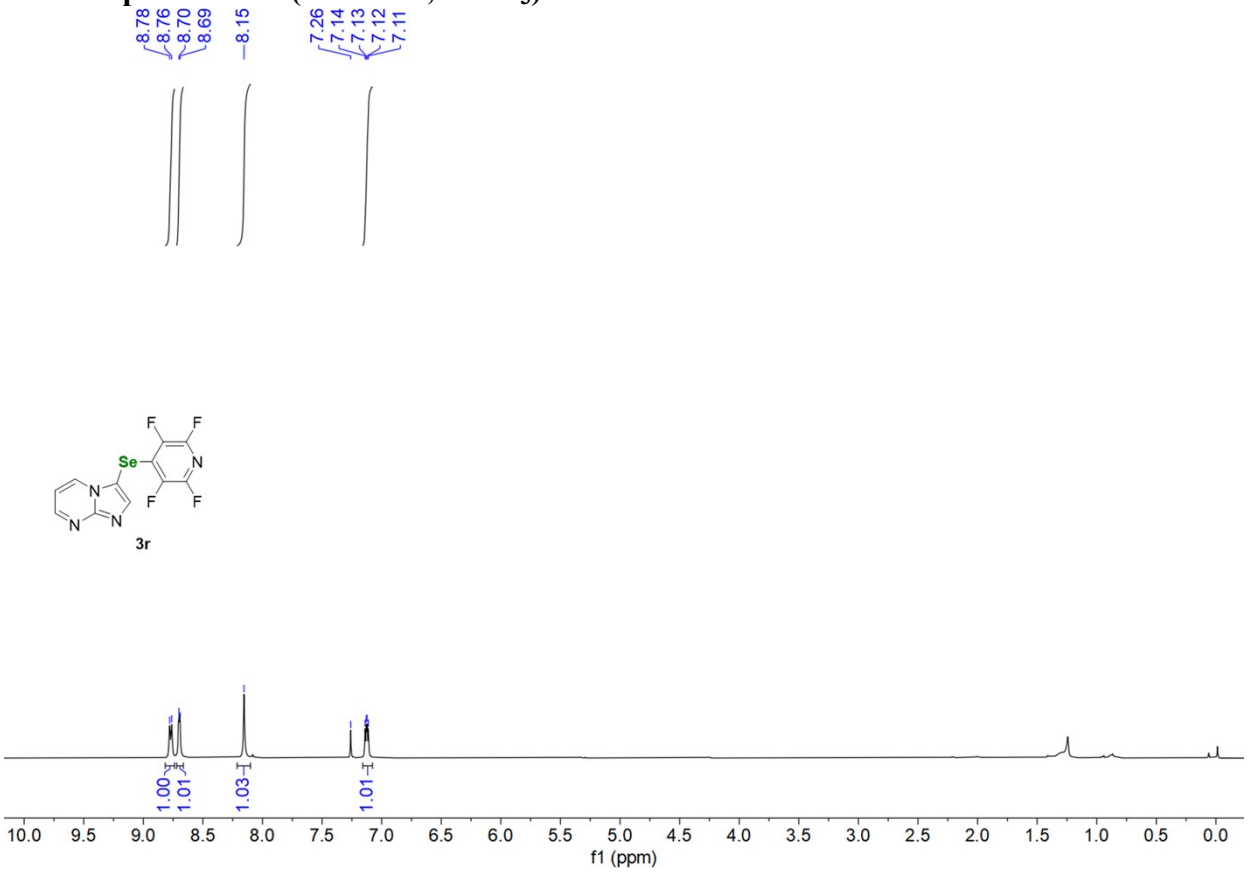
^{19}F NMR spectra of 3q (564 MHz, $CDCl_3$)



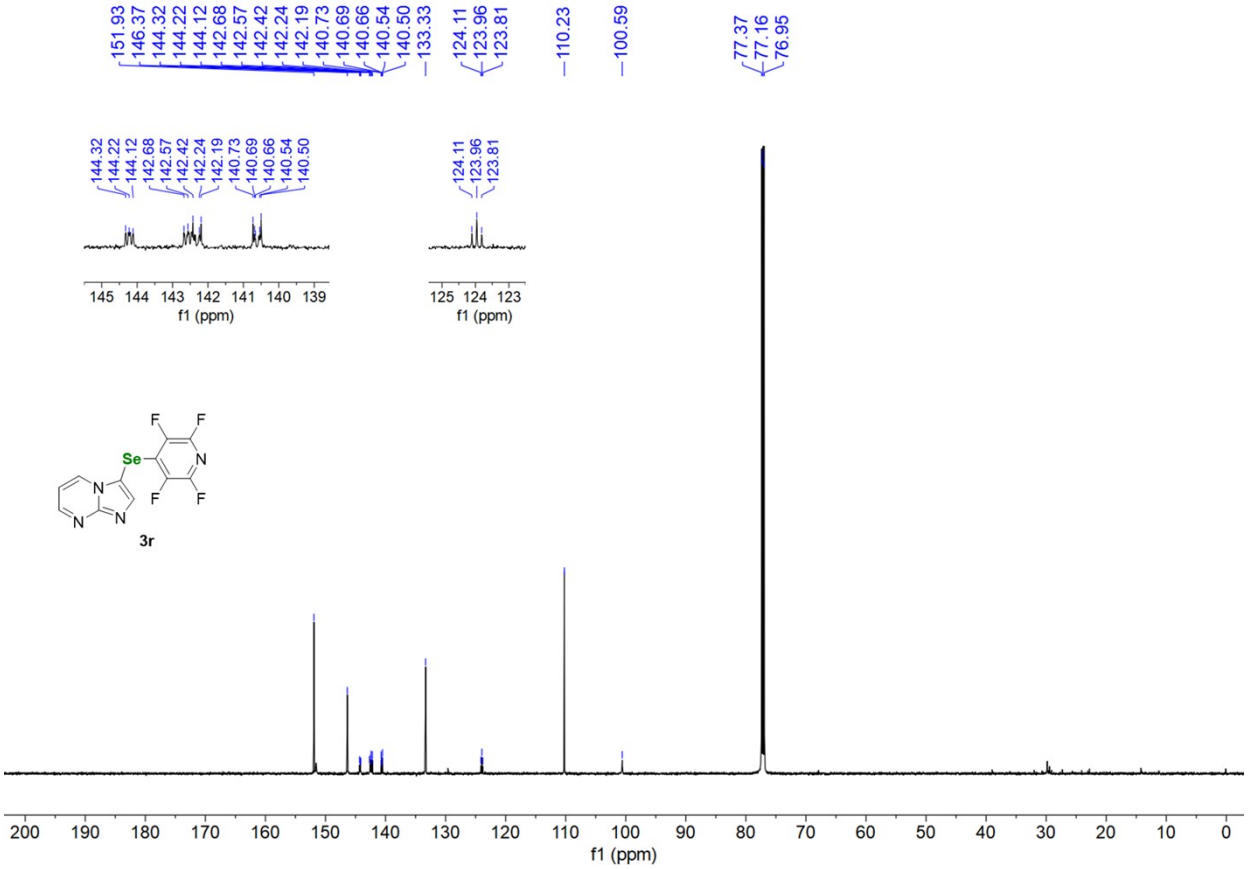
^{77}Se NMR spectra of 3q (114 MHz, $CDCl_3$)



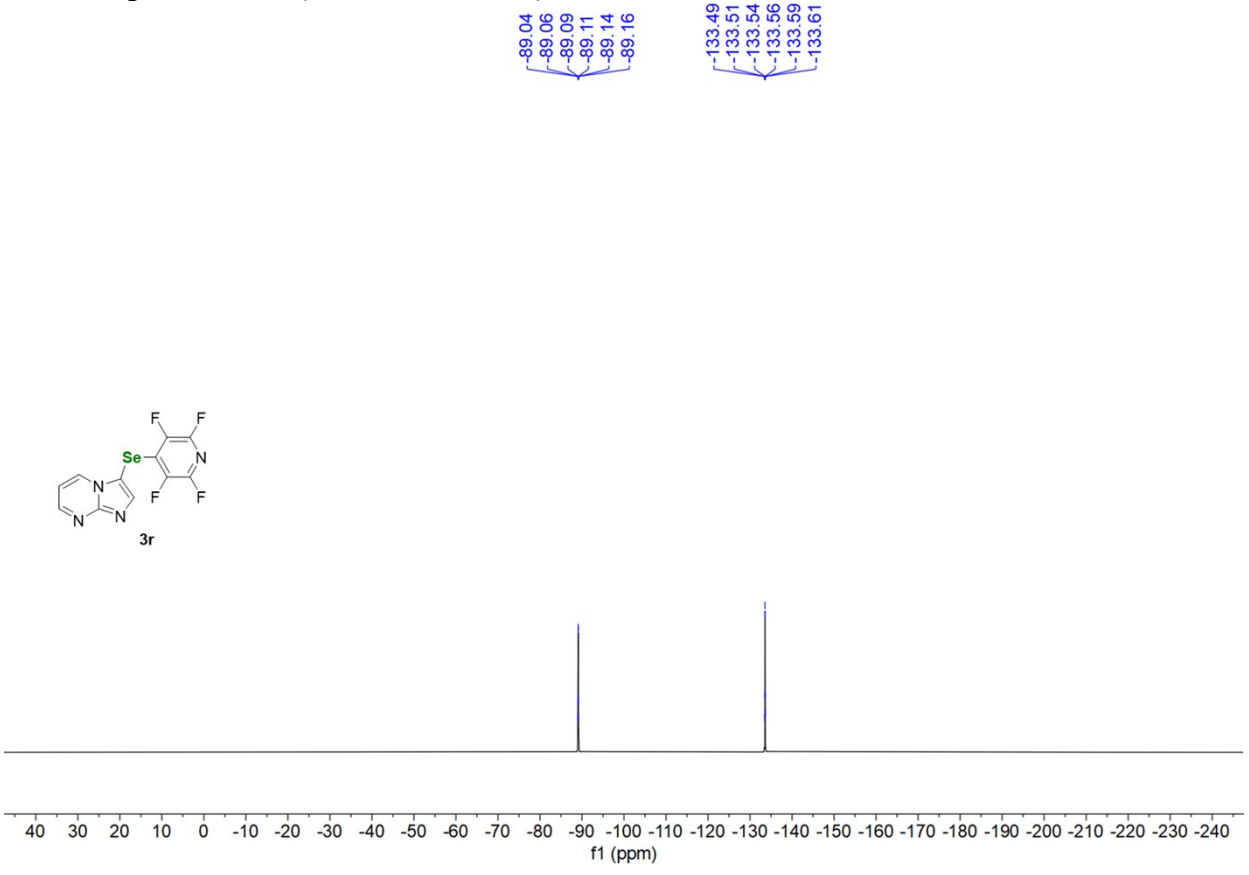
^{1}H NMR spectra of 3r (400 MHz, $CDCl_3$)



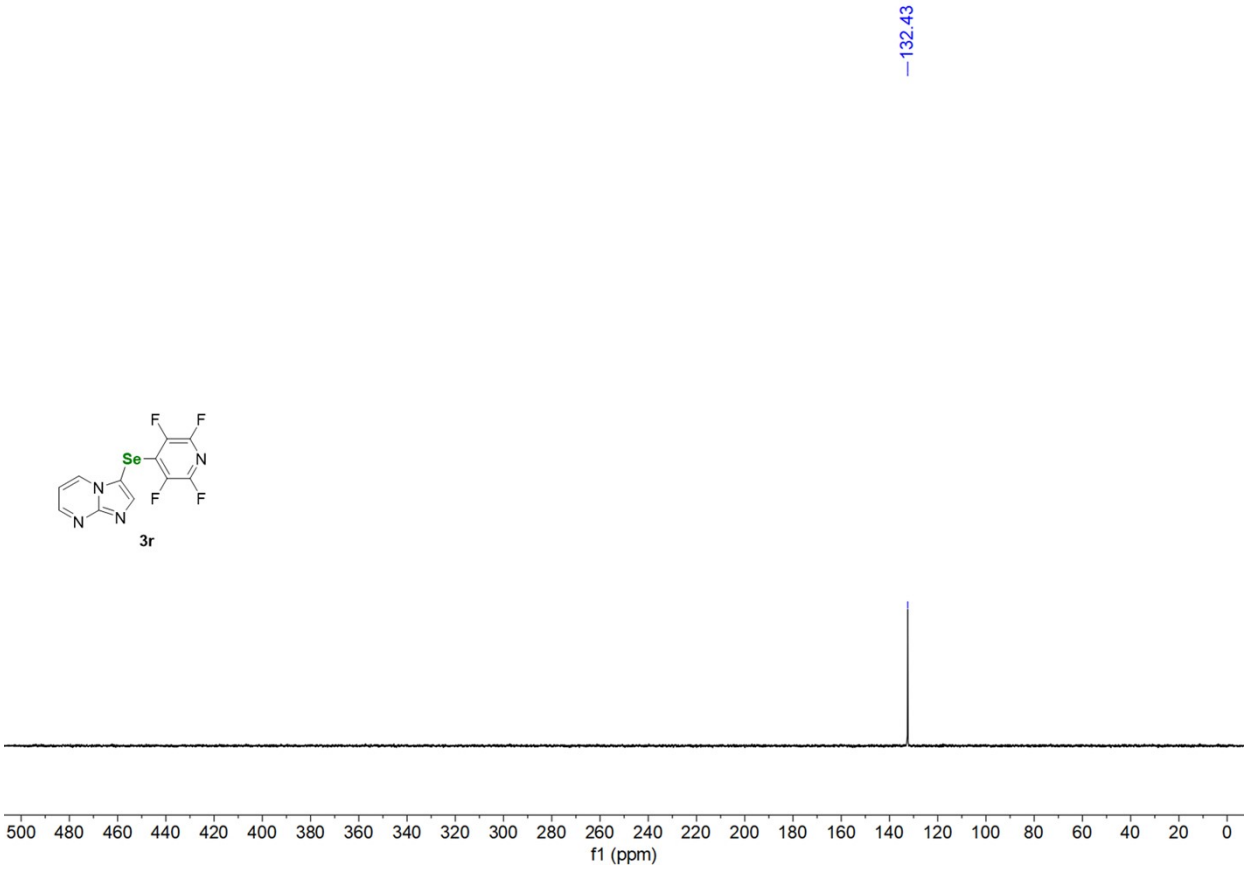
^{13}C NMR spectra of 3r (150 MHz, $CDCl_3$)



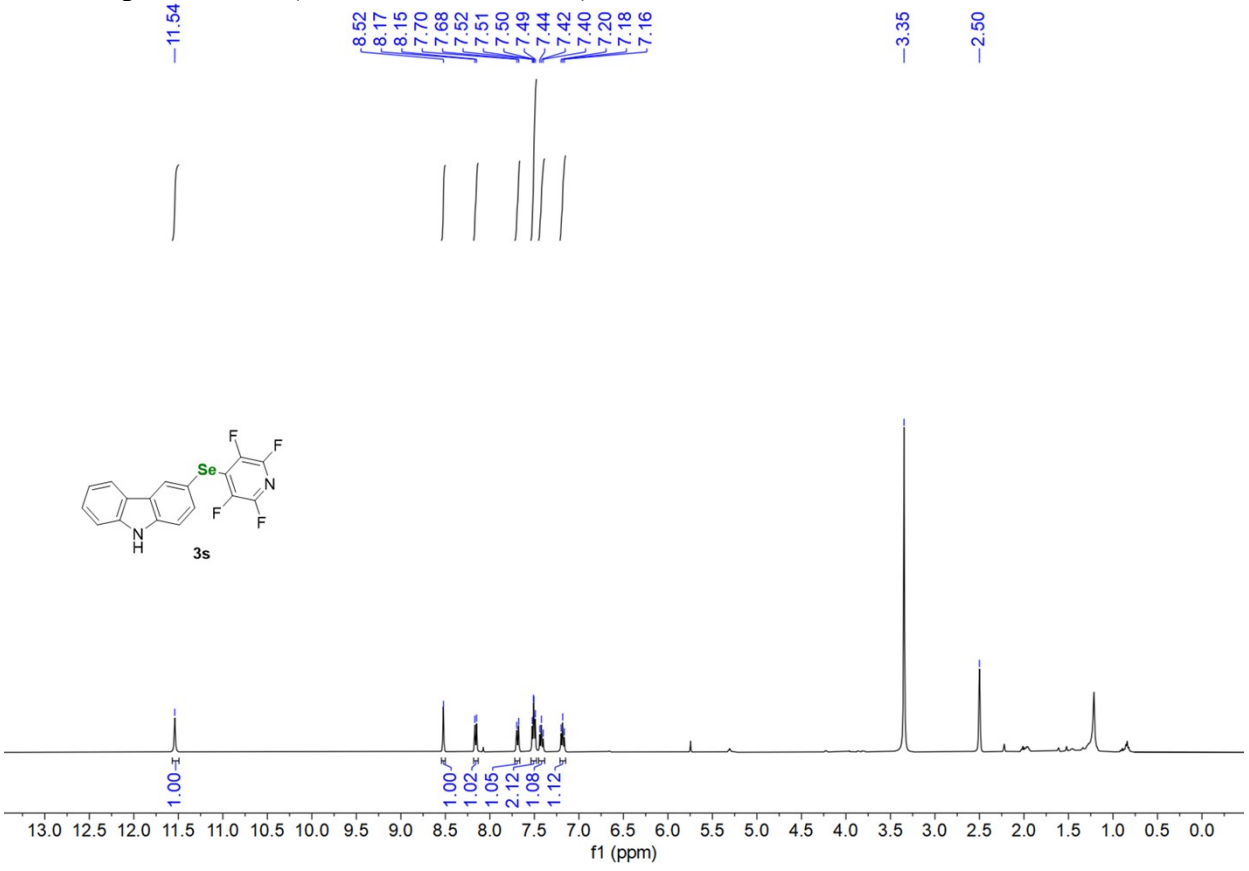
^{19}F NMR spectra of 3r (564 MHz, $CDCl_3$)



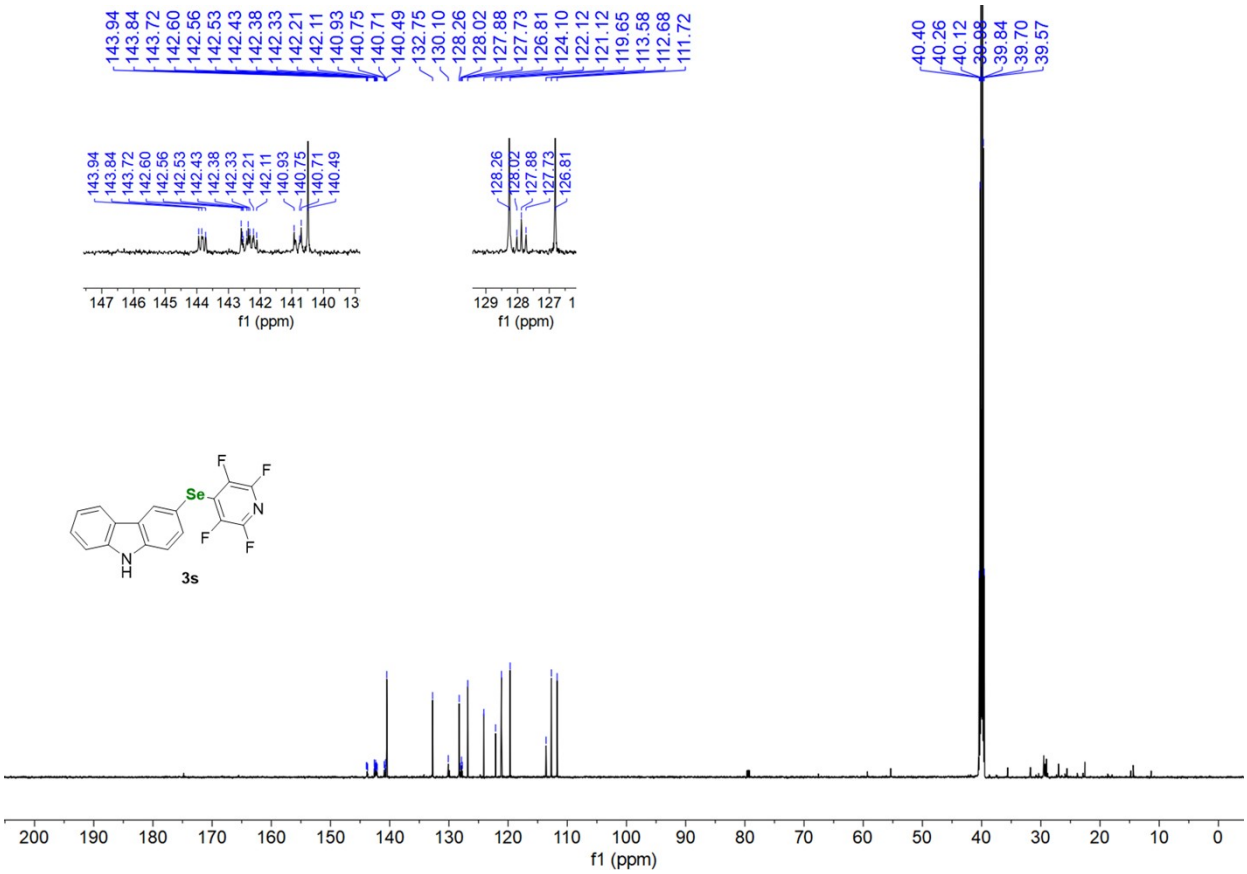
^{77}Se NMR spectra of 3r (114 MHz, $CDCl_3$)



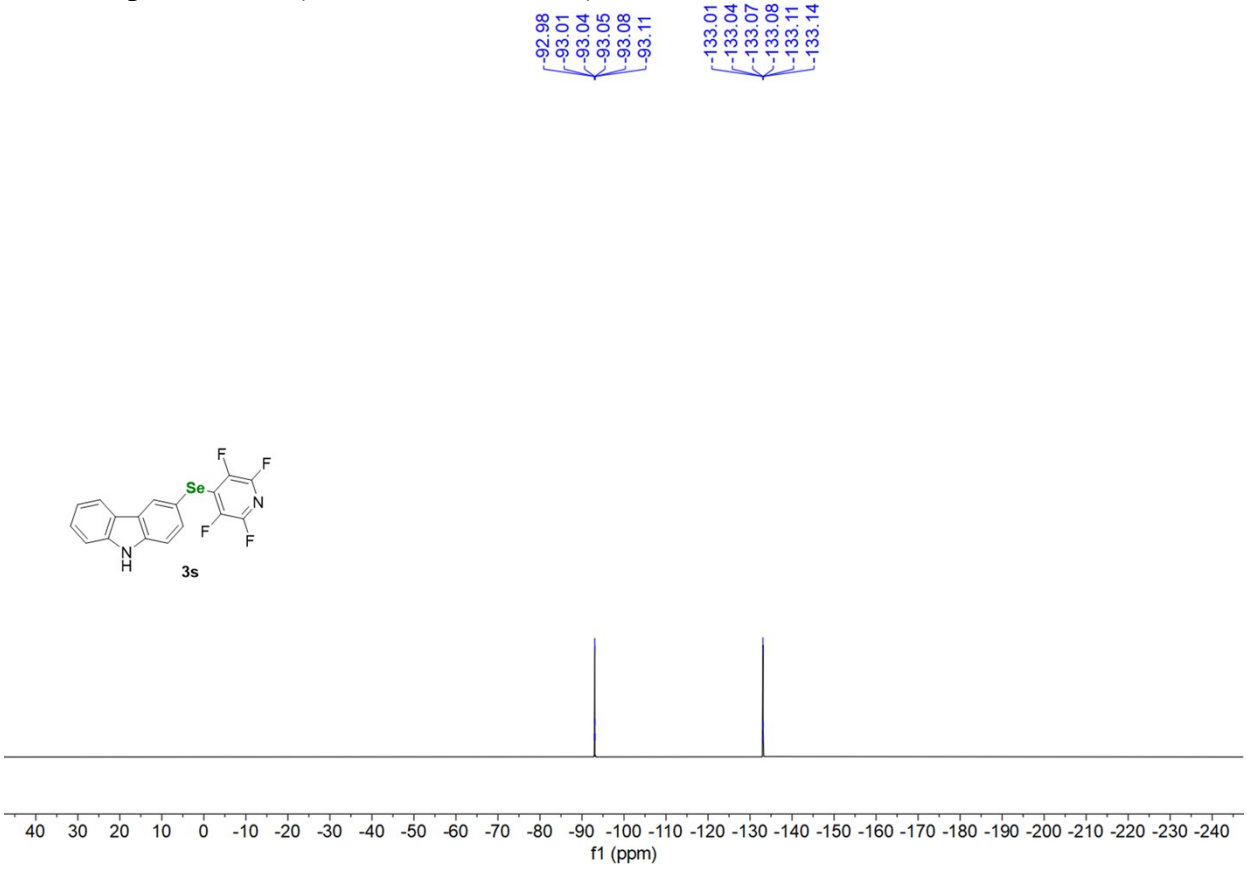
^{1}H NMR spectra of 3s (400 MHz, DMSO-d6)



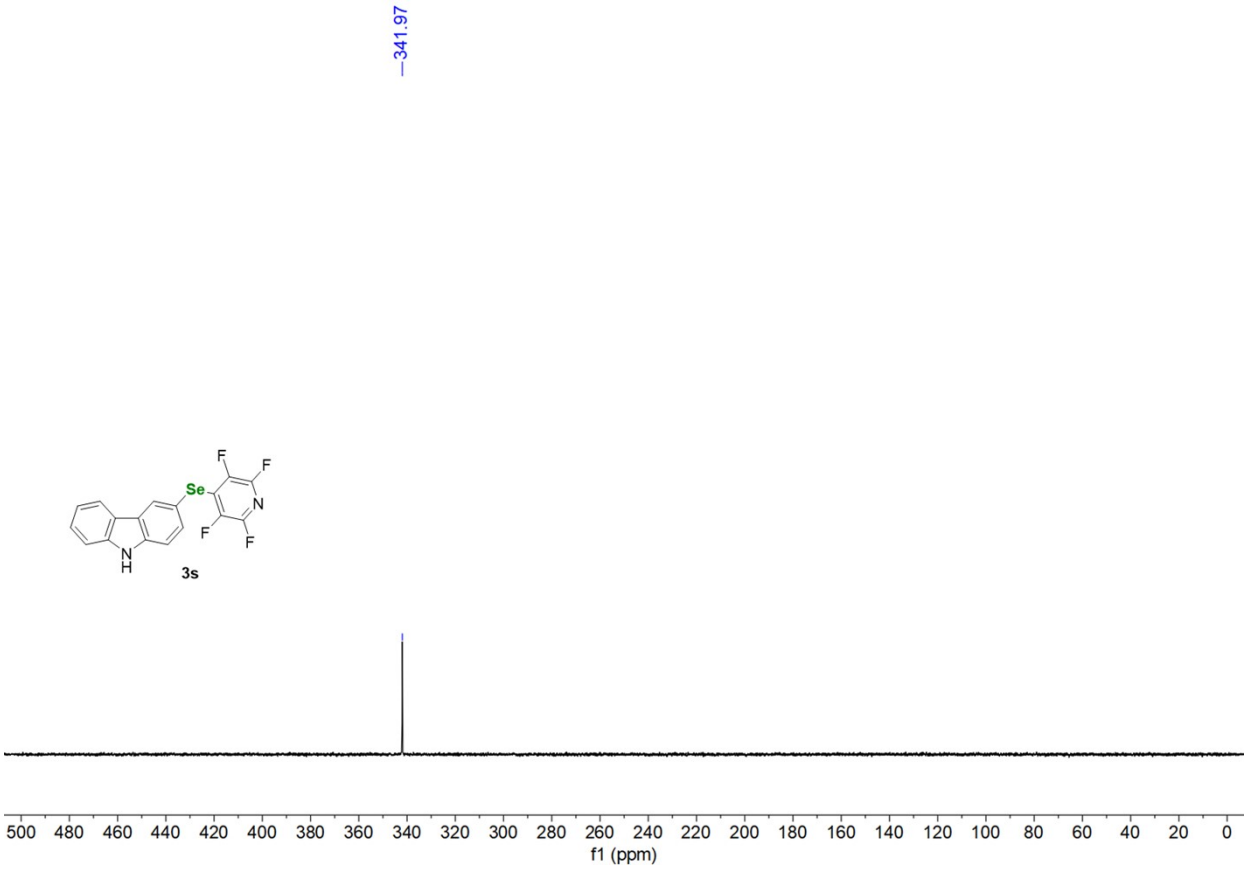
^{13}C NMR spectra of 3s (150 MHz, DMSO-d6)



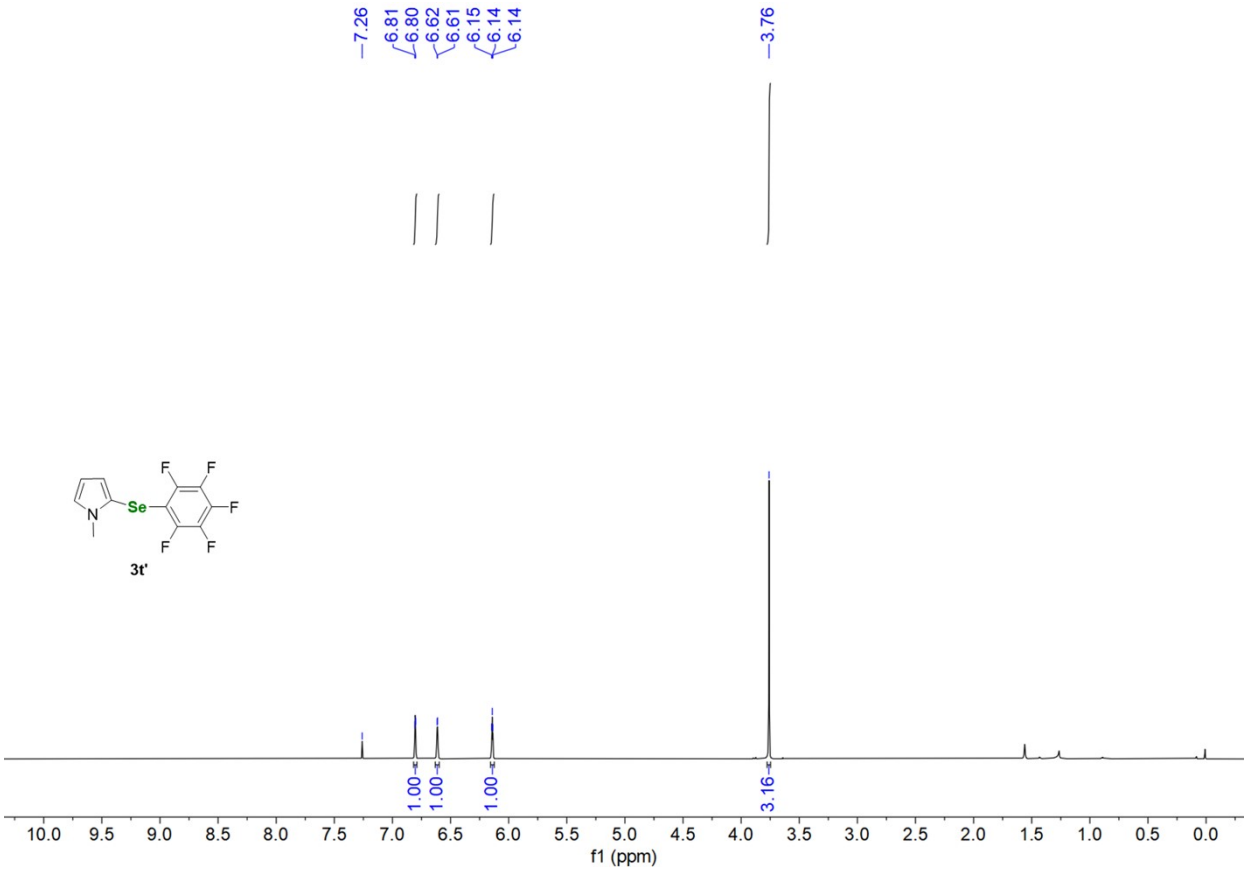
^{19}F NMR spectra of 3s (564 MHz, DMSO-d6)



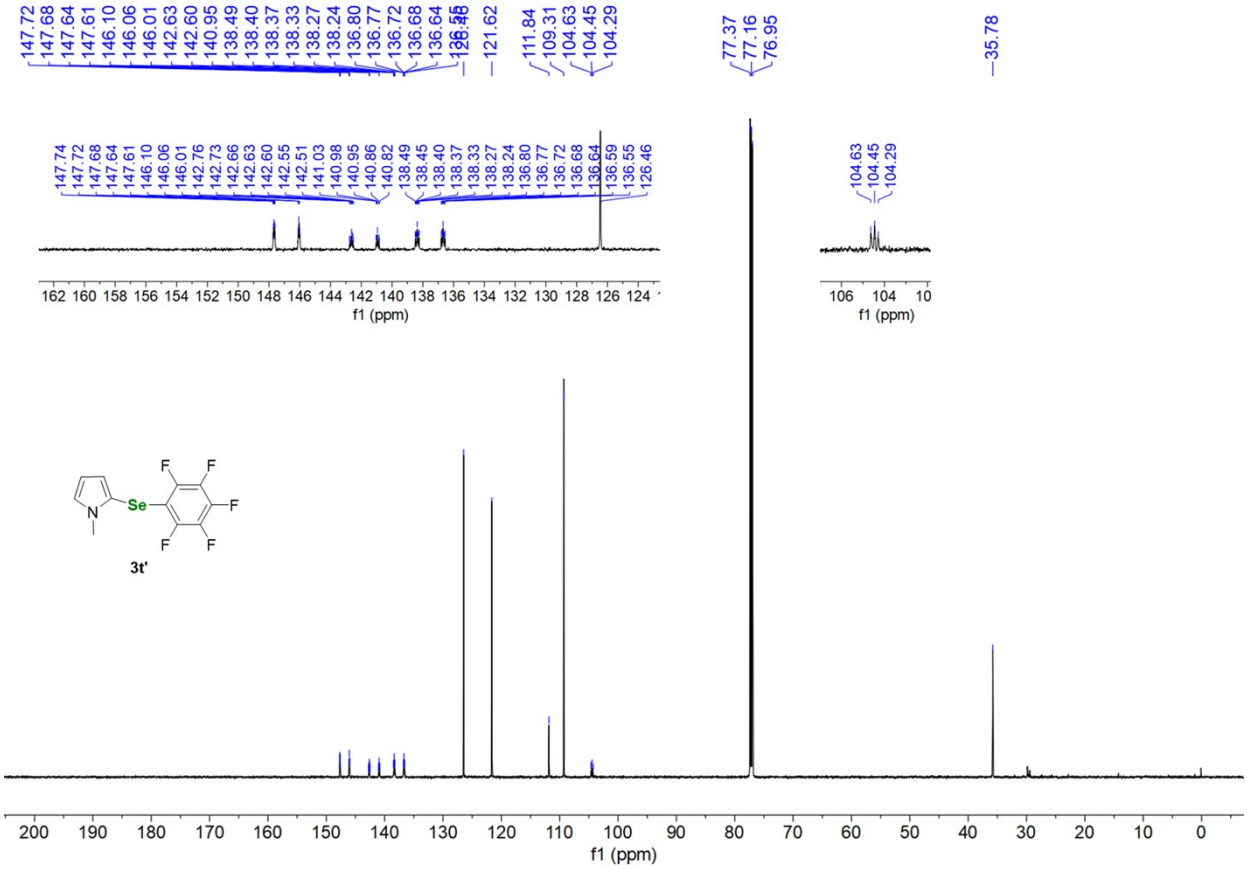
^{77}Se NMR spectra of 3s (114 MHz, DMSO-d6)



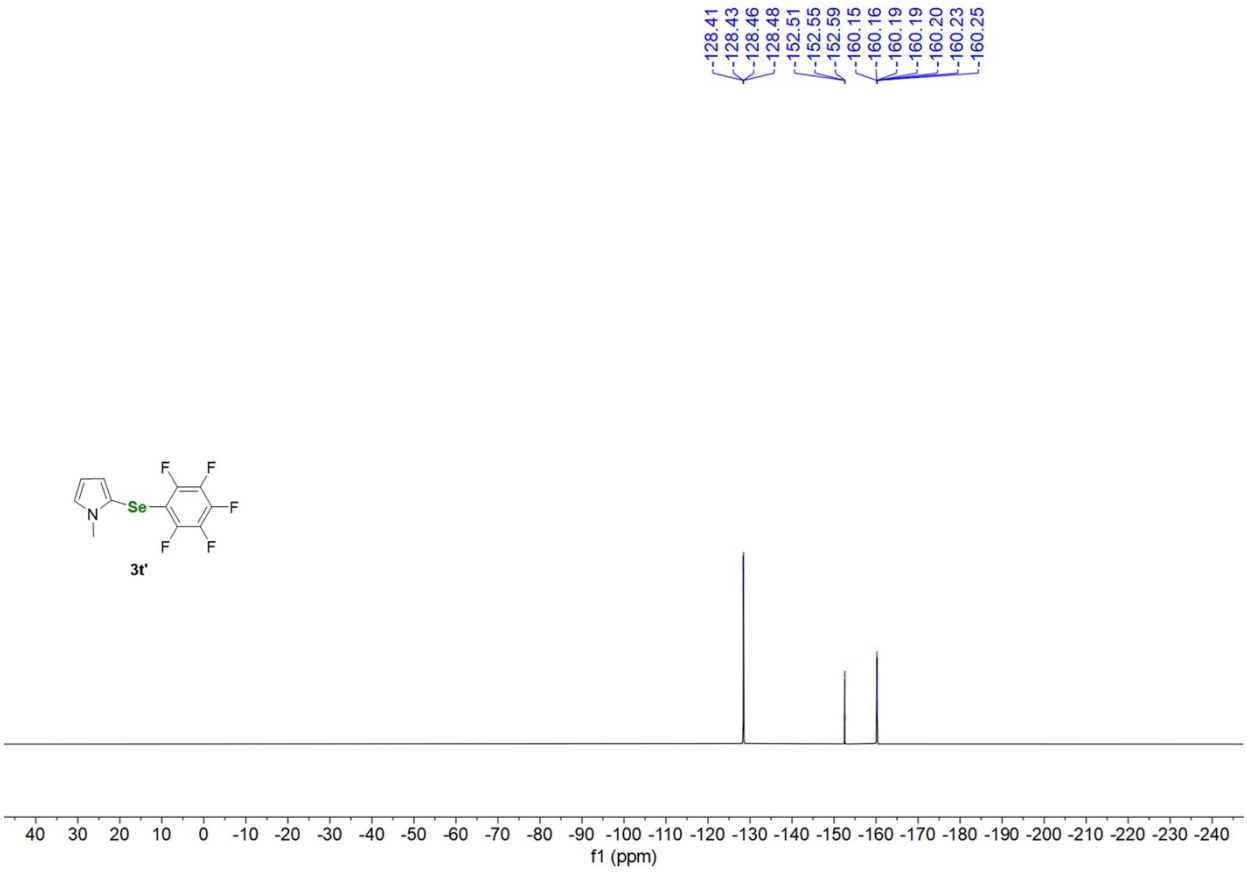
^{1}H NMR spectra of 3t' (400 MHz, $CDCl_3$)



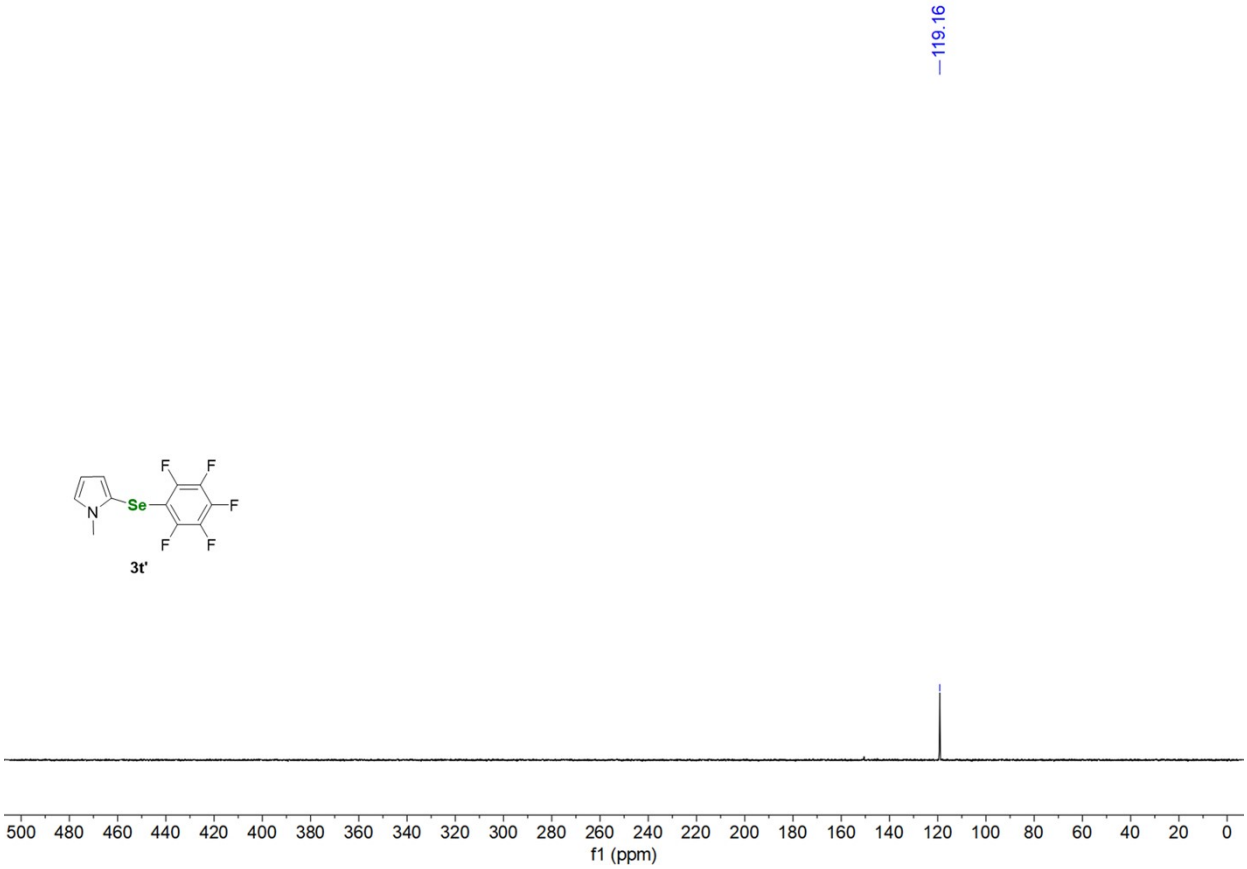
^{13}C NMR spectra of 3t' (150 MHz, $CDCl_3$)



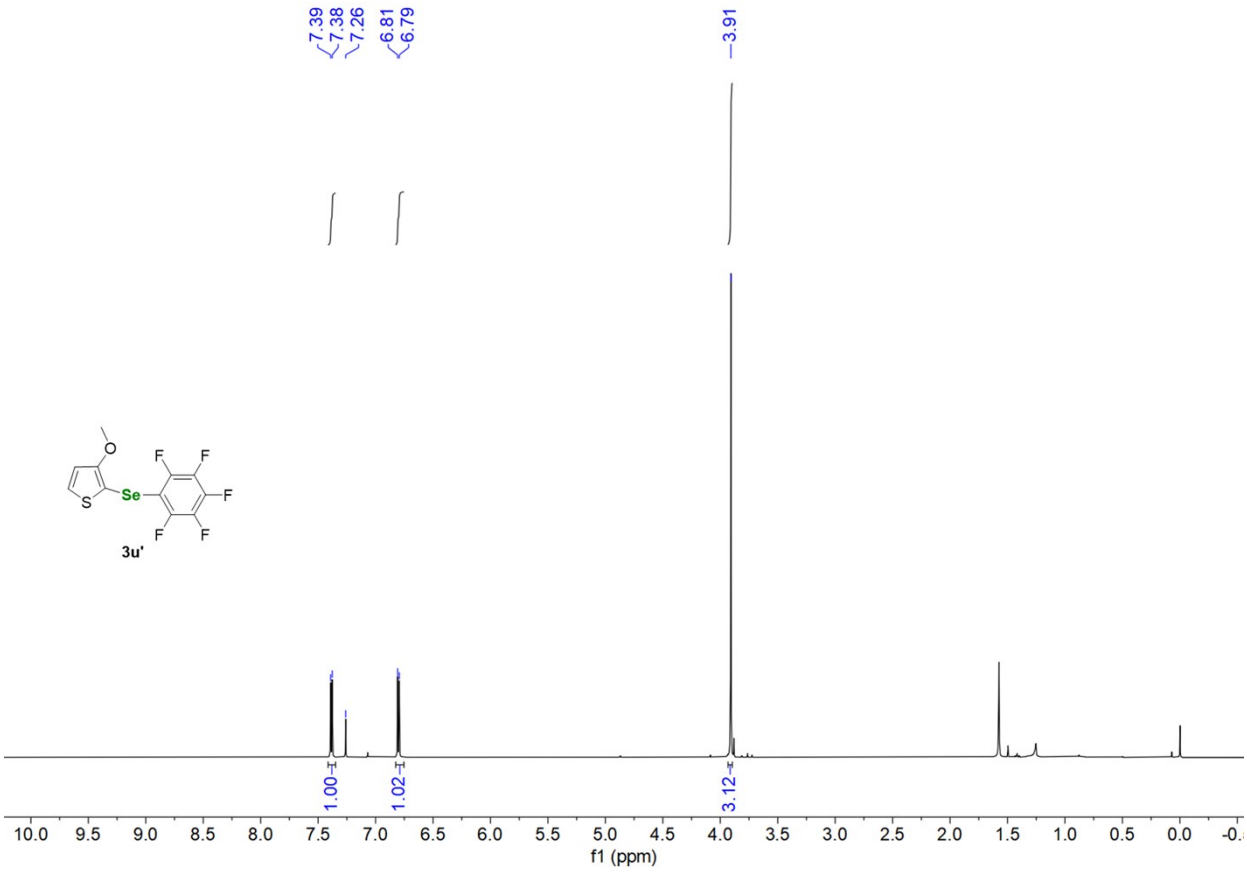
^{19}F NMR spectra of 3t' (564 MHz, $CDCl_3$)



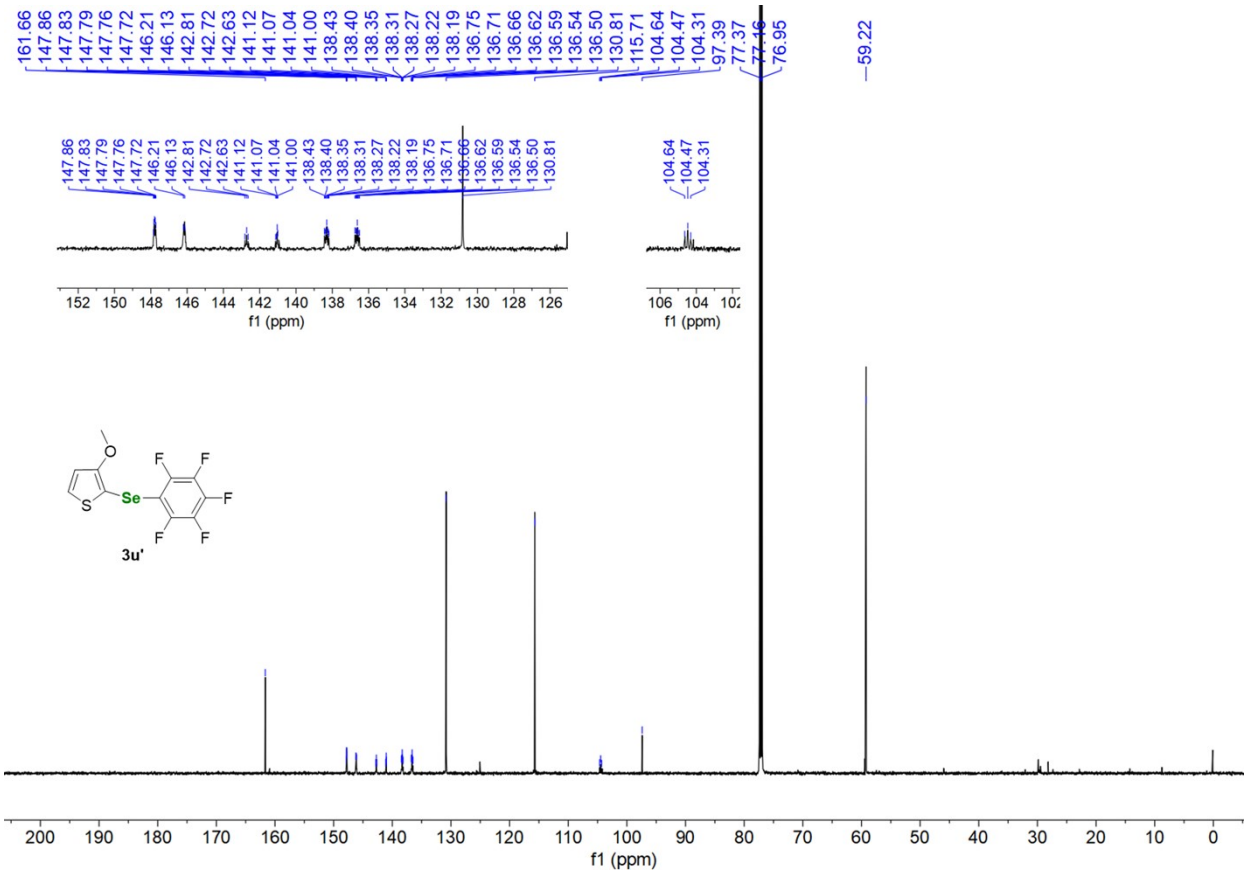
^{77}Se NMR spectra of 3t' (114 MHz, $CDCl_3$)



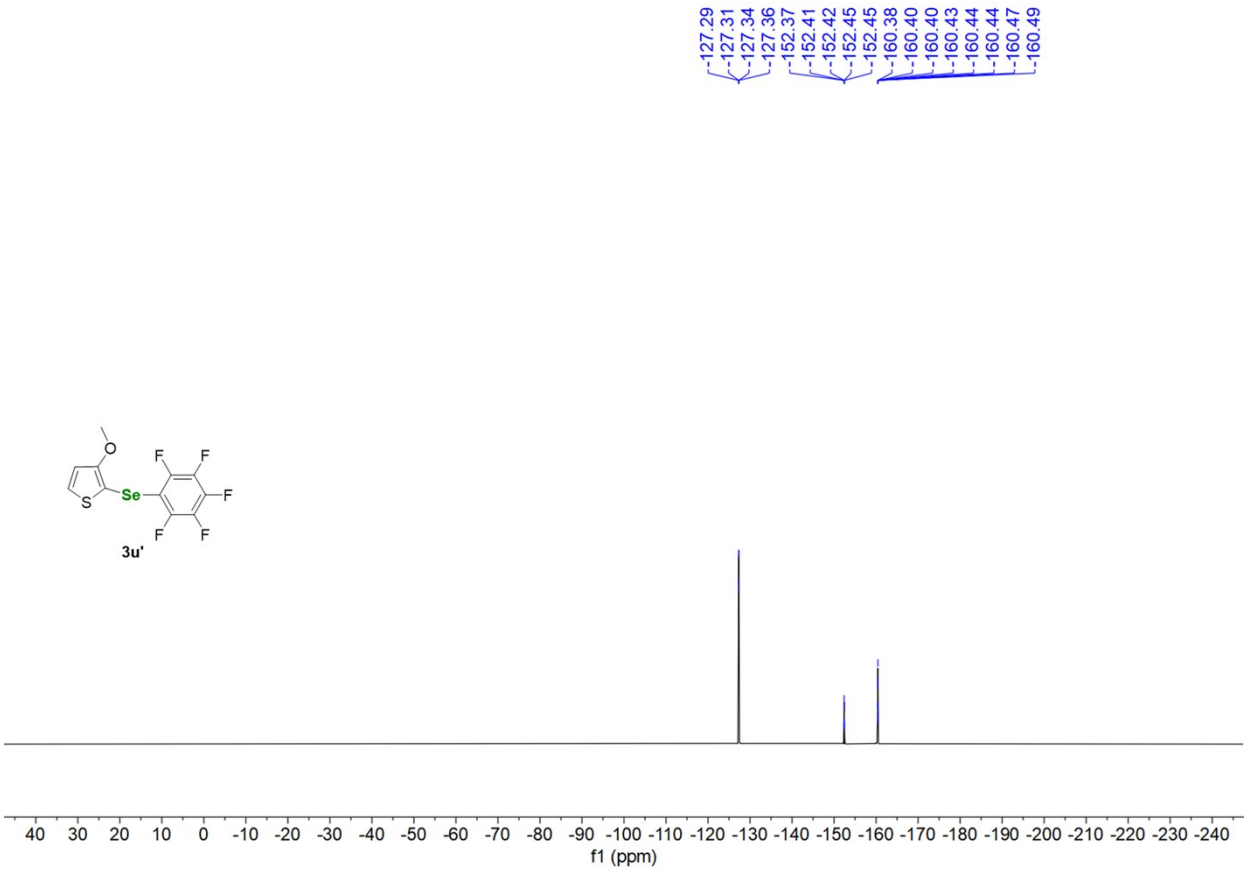
^{1}H NMR spectra of 3u' (400 MHz, $CDCl_3$)



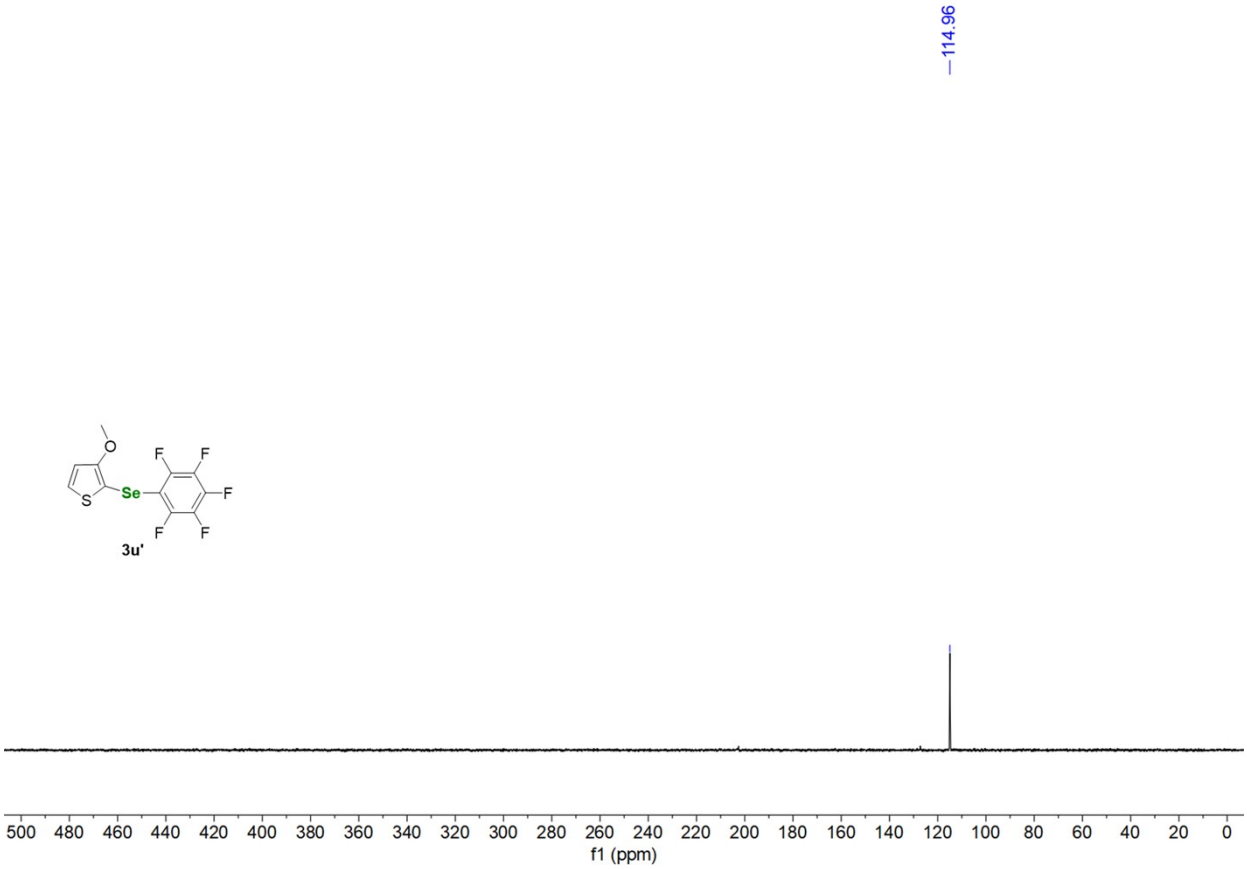
^{13}C NMR spectra of 3u' (150 MHz, $CDCl_3$)



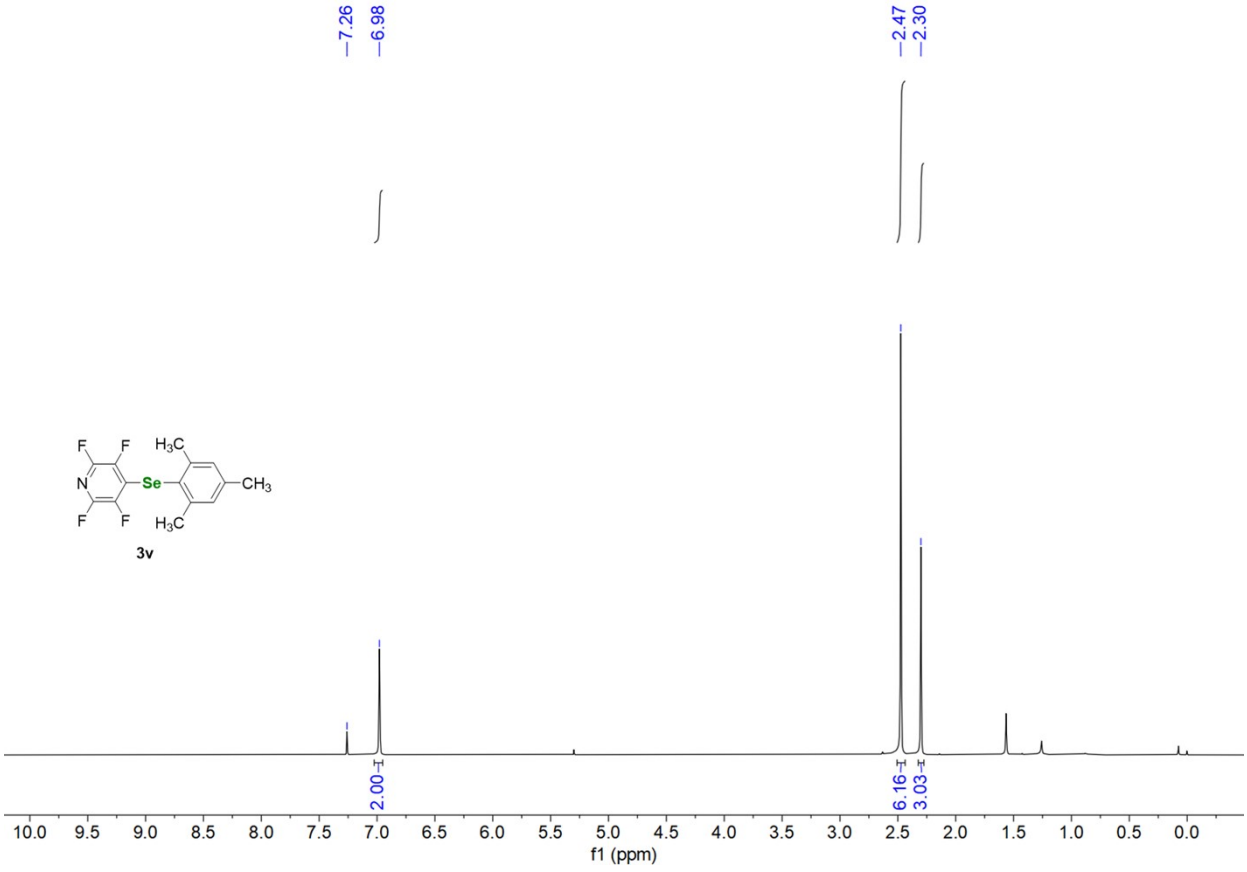
^{19}F NMR spectra of 3u' (564 MHz, $CDCl_3$)



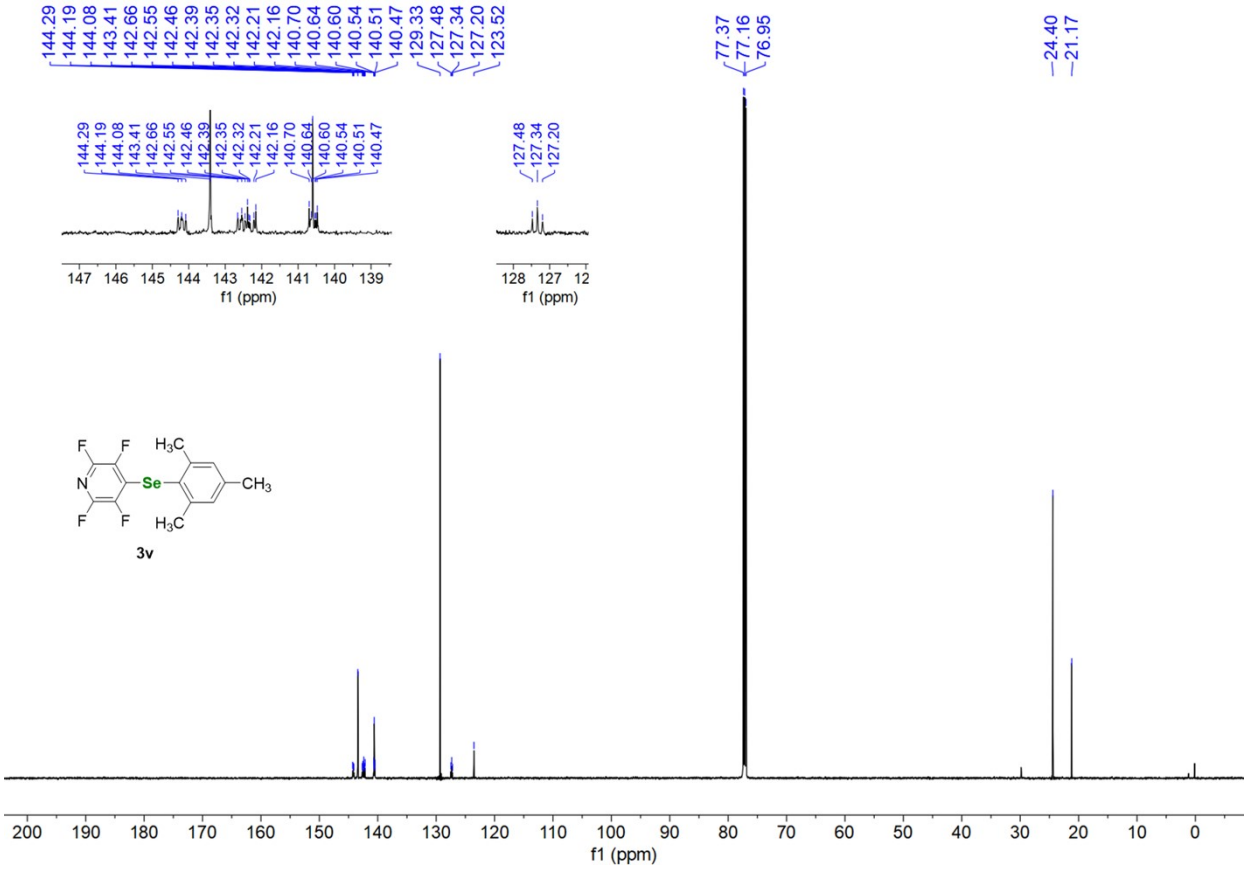
^{77}Se NMR spectra of 3u' (114 MHz, $CDCl_3$)



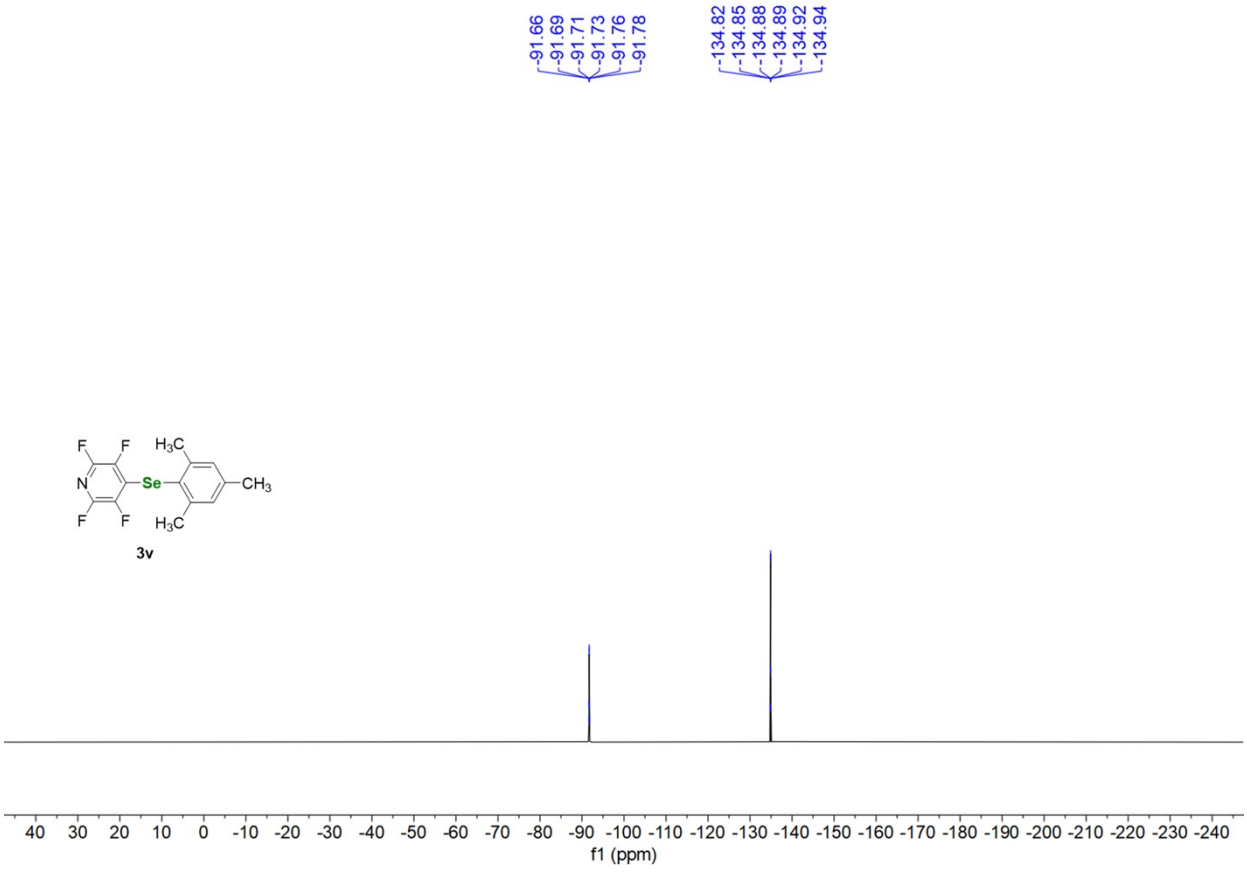
^{1}H NMR spectra of 3v (400 MHz, $CDCl_3$)



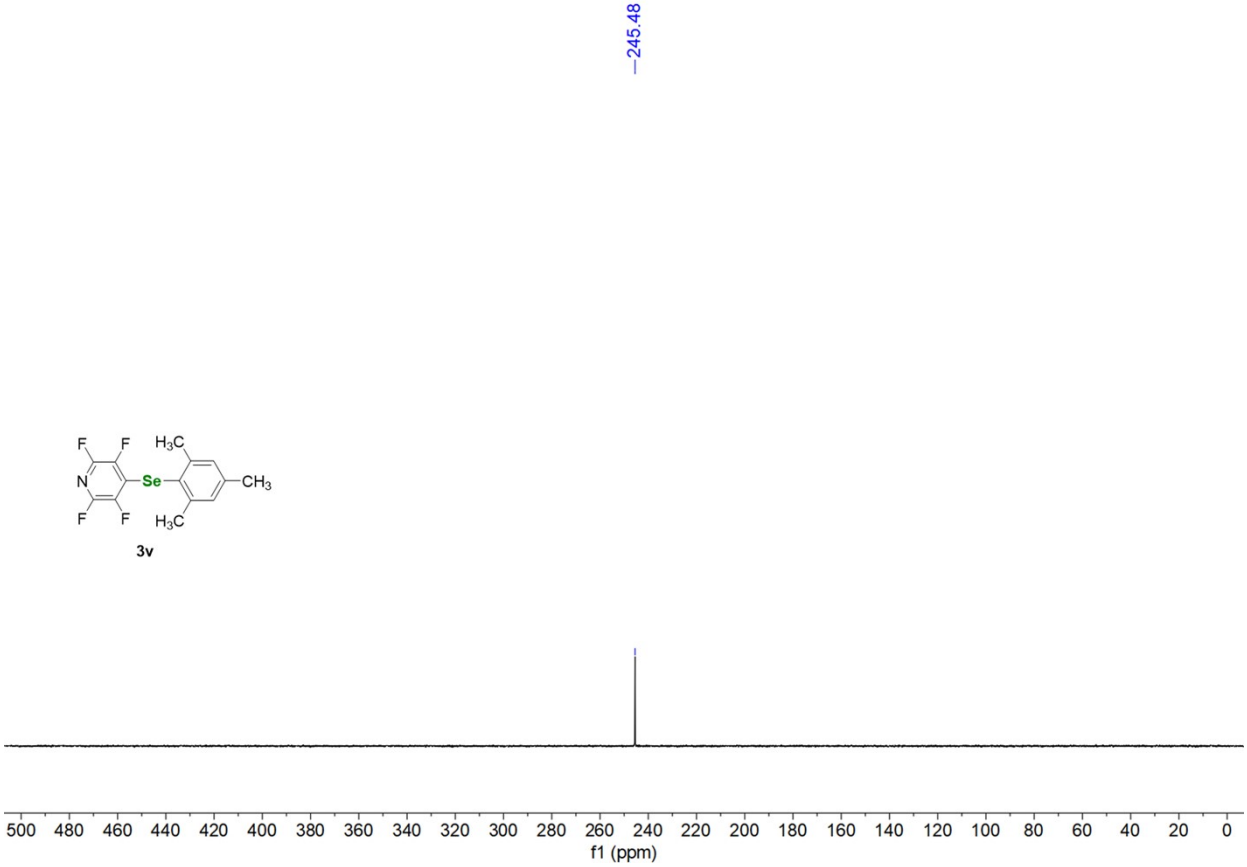
^{13}C NMR spectra of 3v (150 MHz, $CDCl_3$)



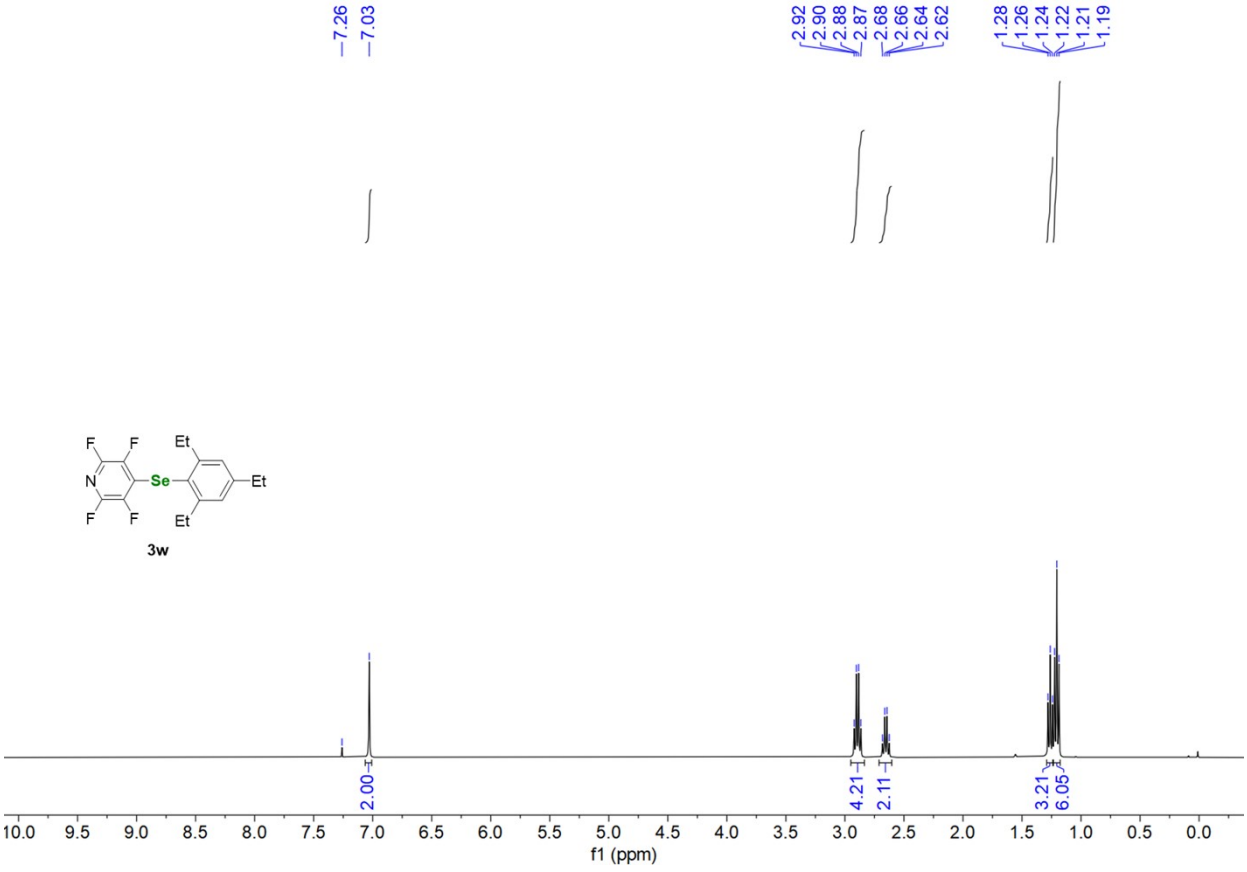
^{19}F NMR spectra of 3v (564 MHz, $CDCl_3$)



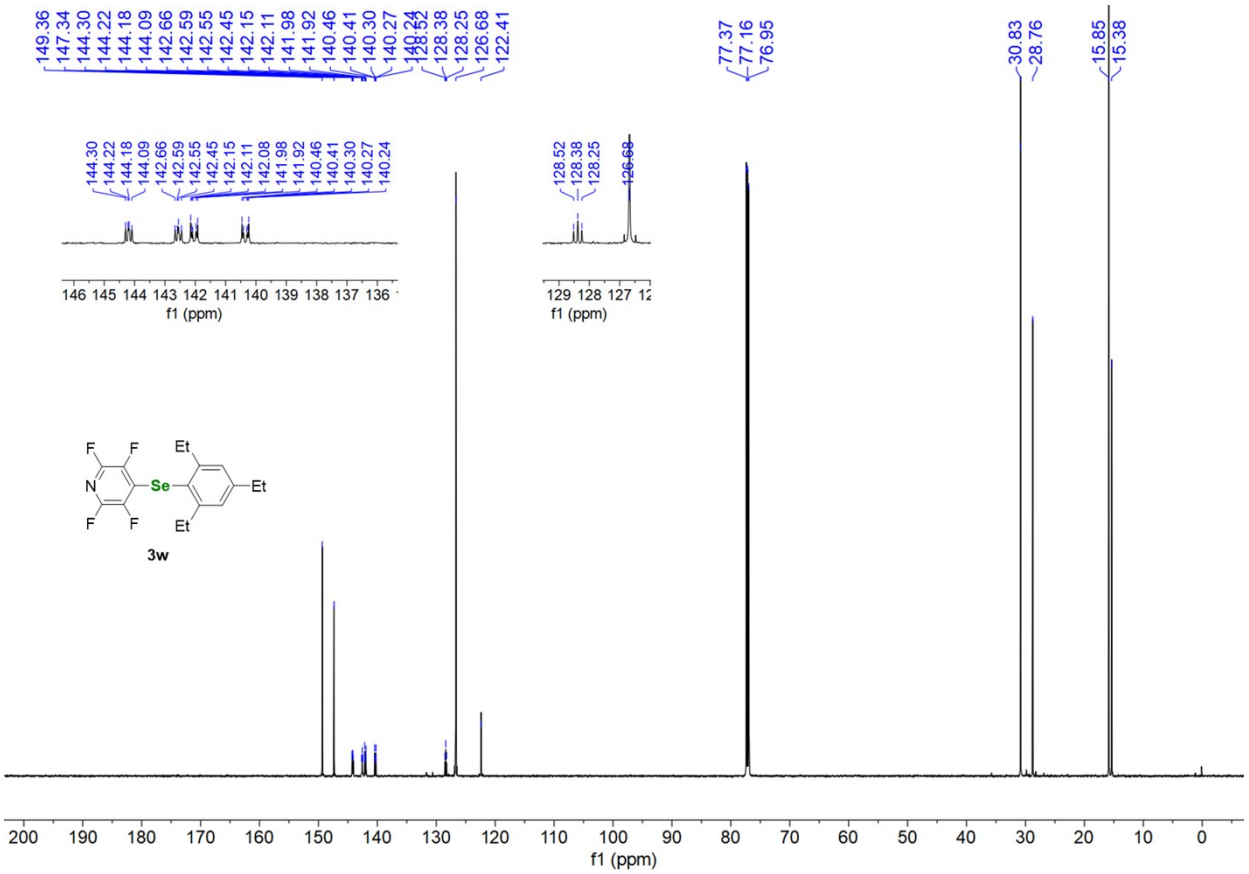
^{77}Se NMR spectra of 3v (114 MHz, $CDCl_3$)



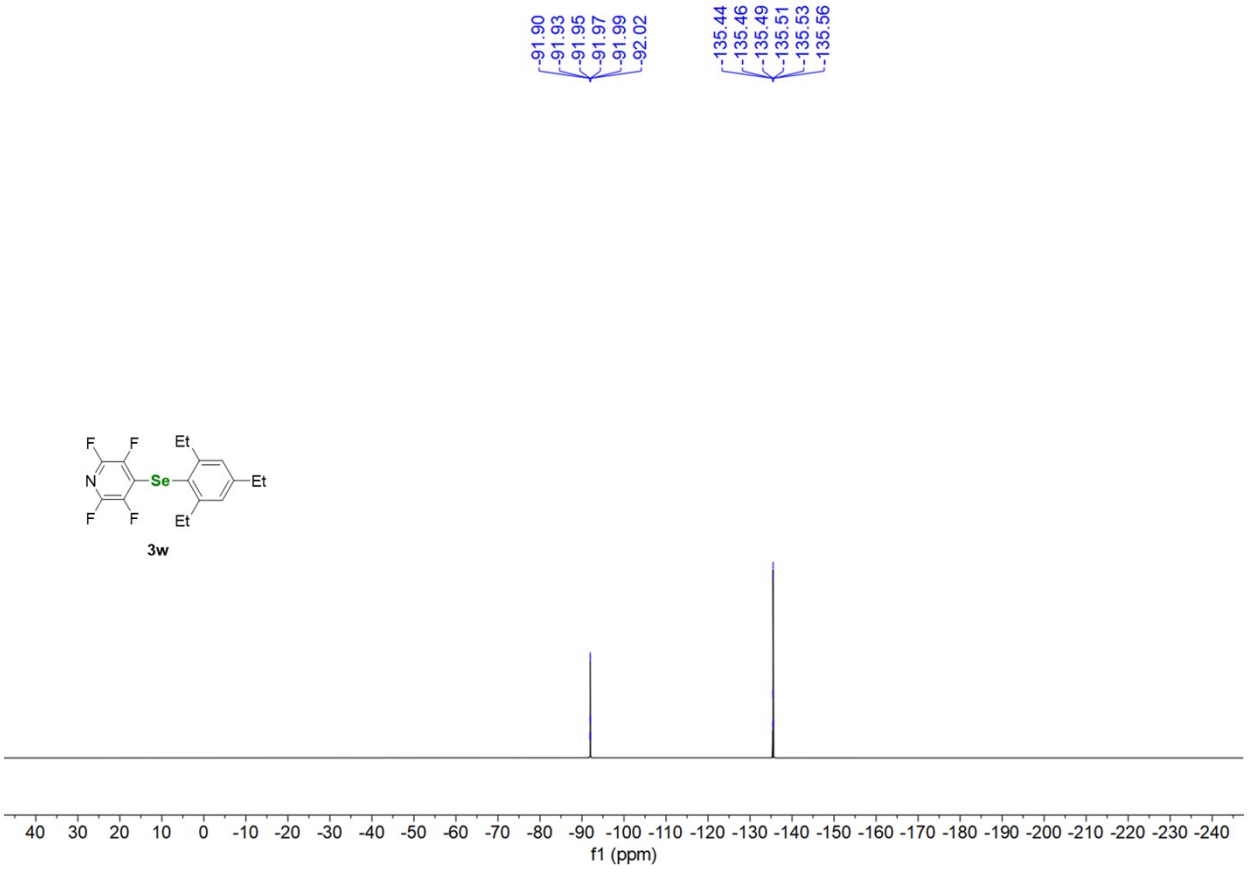
^{1}H NMR spectra of 3w (400 MHz, $CDCl_3$)



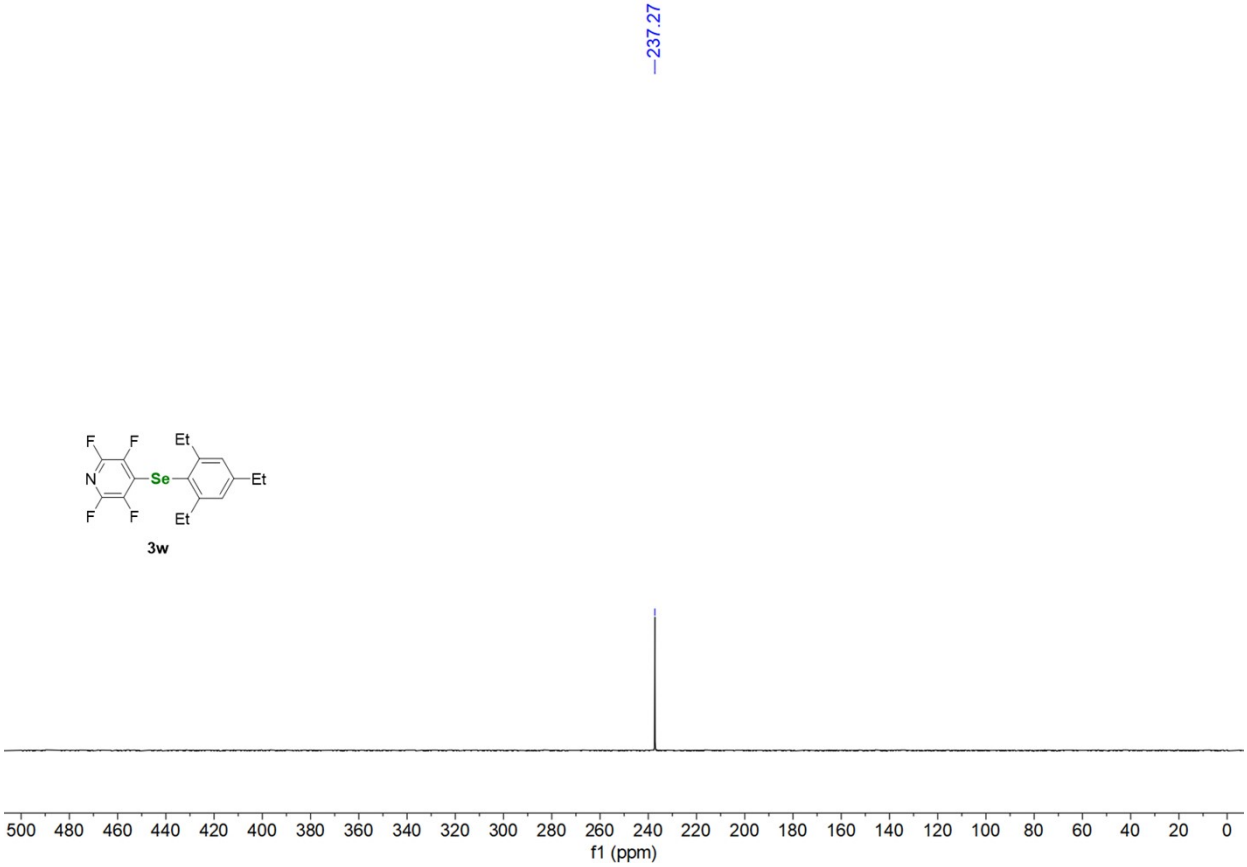
^{13}C NMR spectra of 3w (150 MHz, $CDCl_3$)



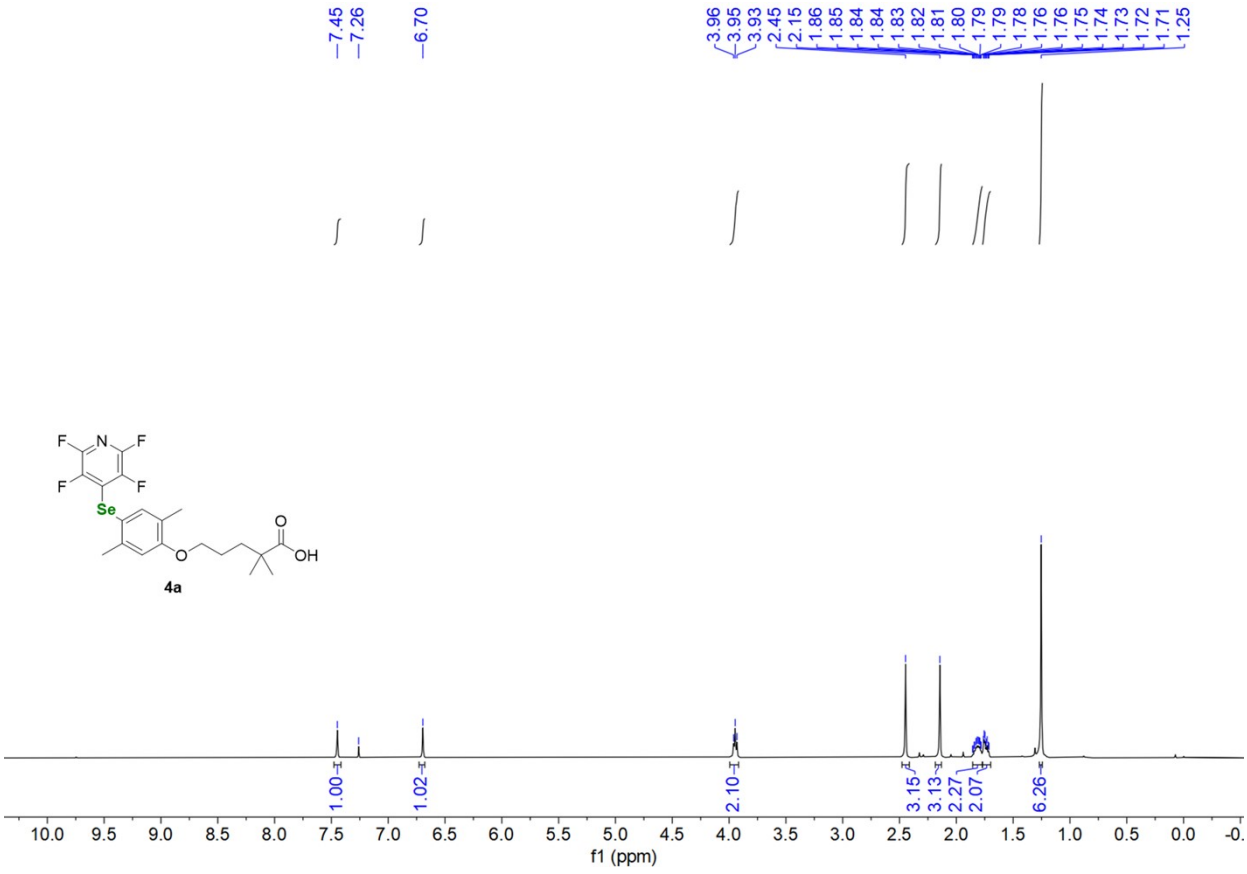
^{19}F NMR spectra of 3w (564 MHz, $CDCl_3$)



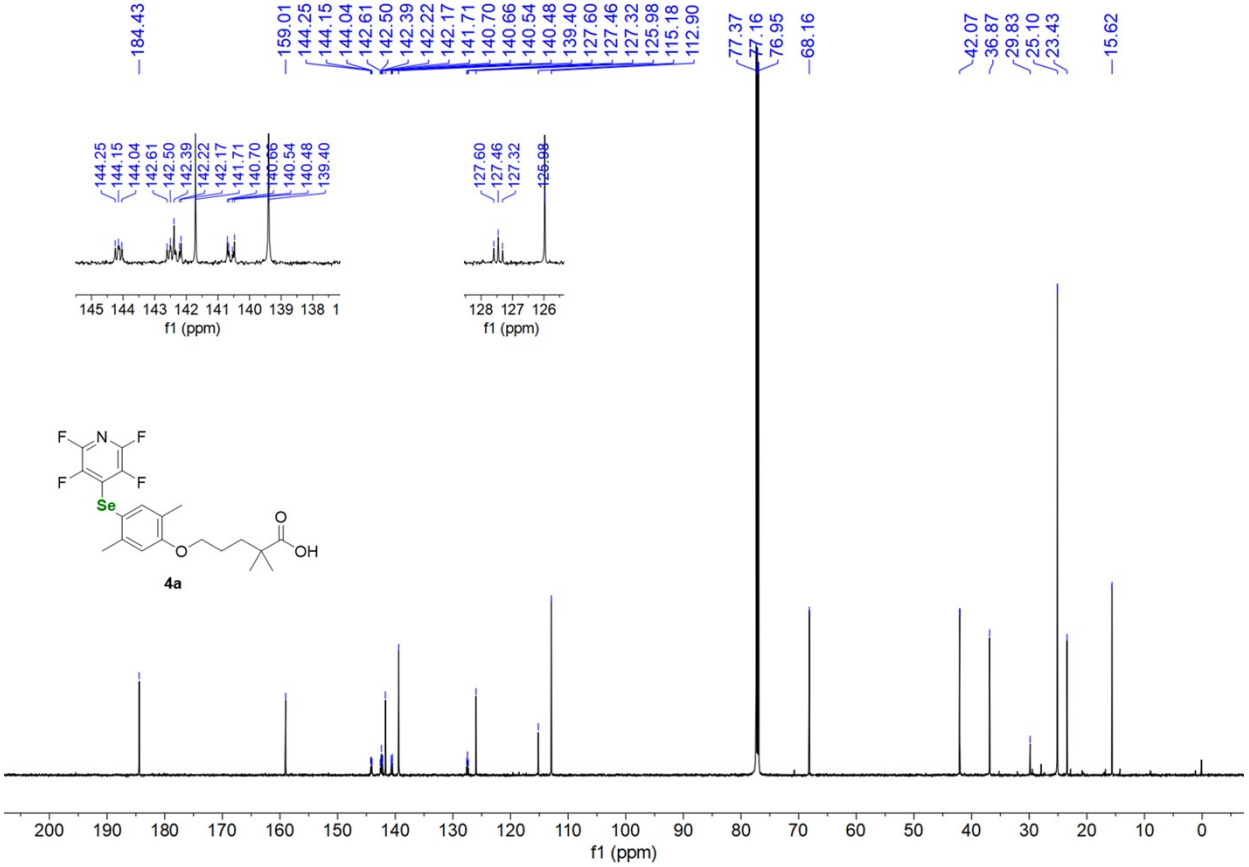
^{77}Se NMR spectra of 3w (114 MHz, $CDCl_3$)



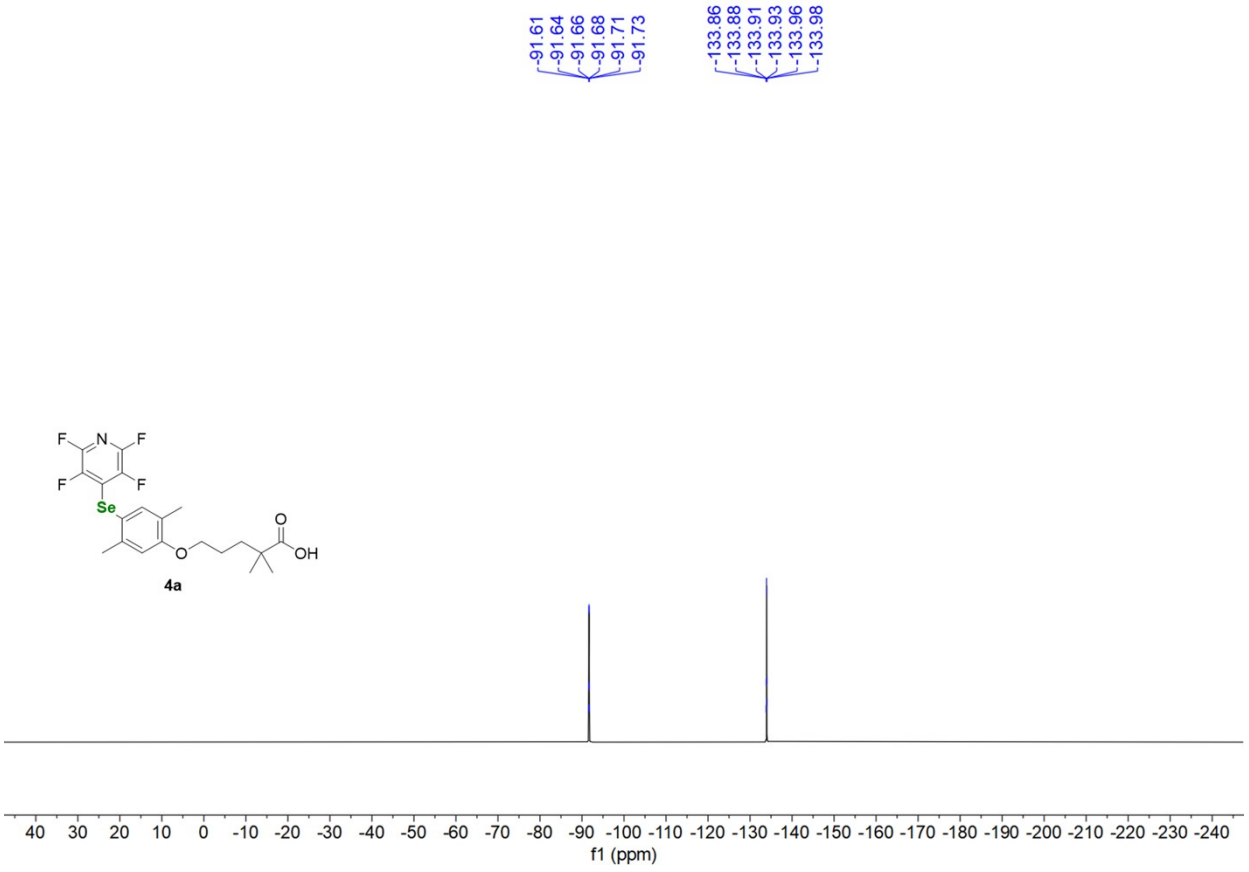
^{1}H NMR spectra of 4a (400 MHz, $CDCl_3$)



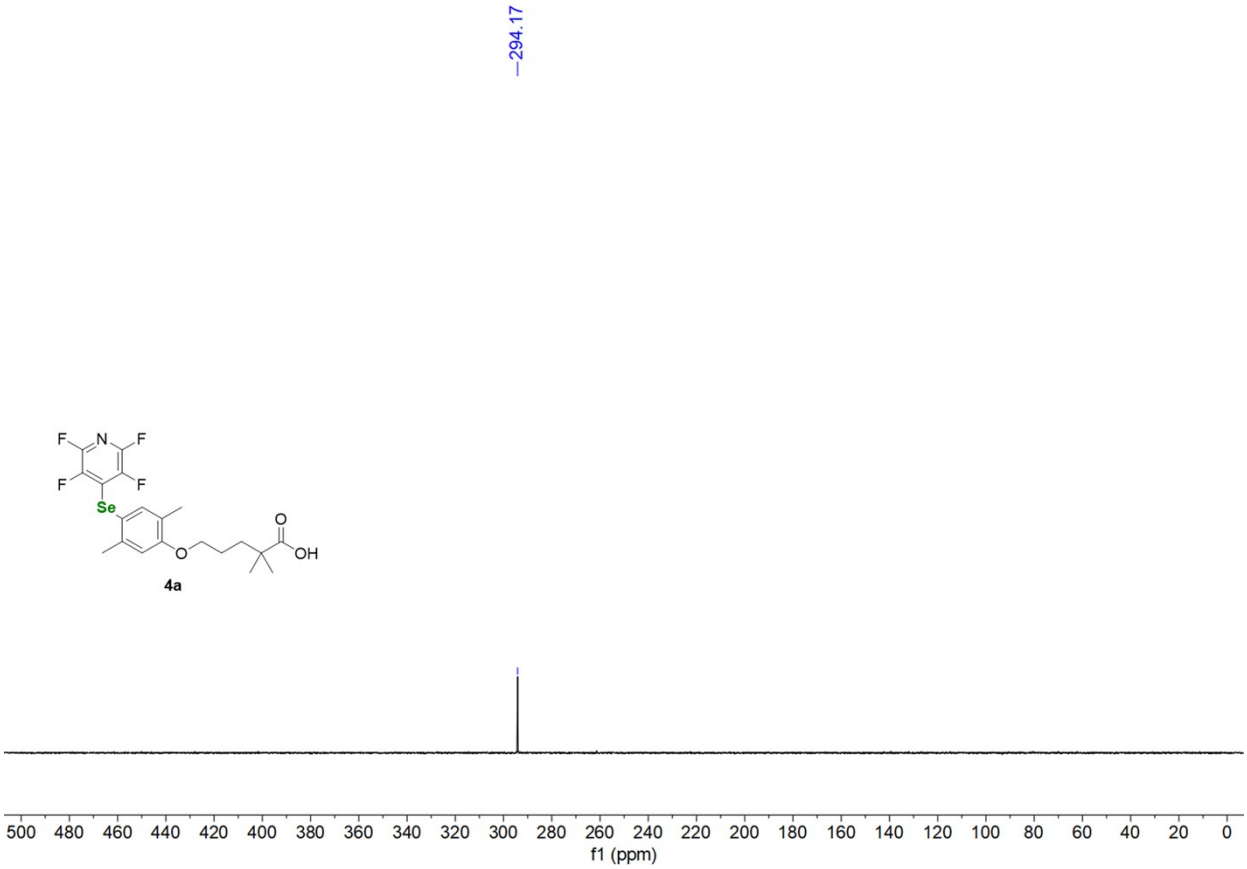
^{13}C NMR spectra of 4a (150 MHz, $CDCl_3$)



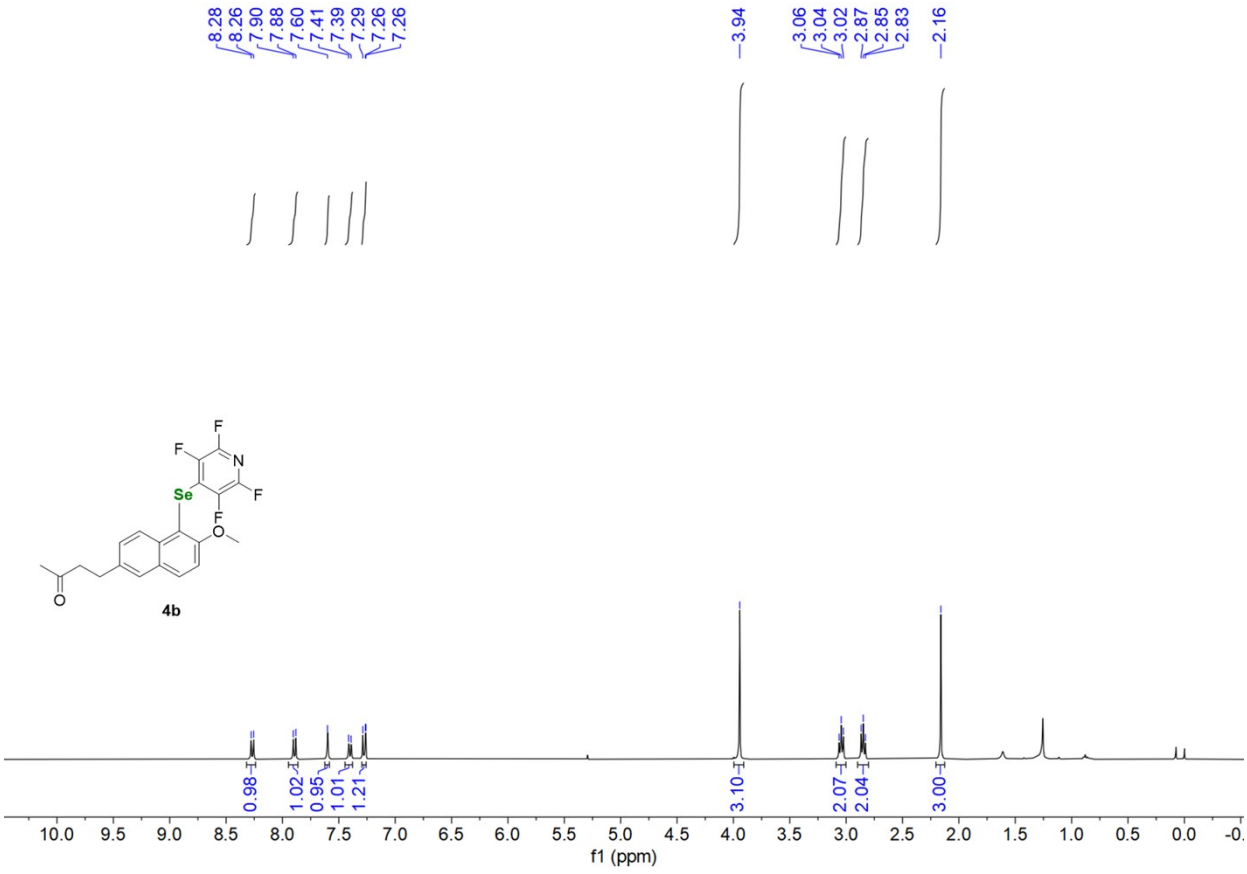
^{19}F NMR spectra of 4a (564 MHz, $CDCl_3$)



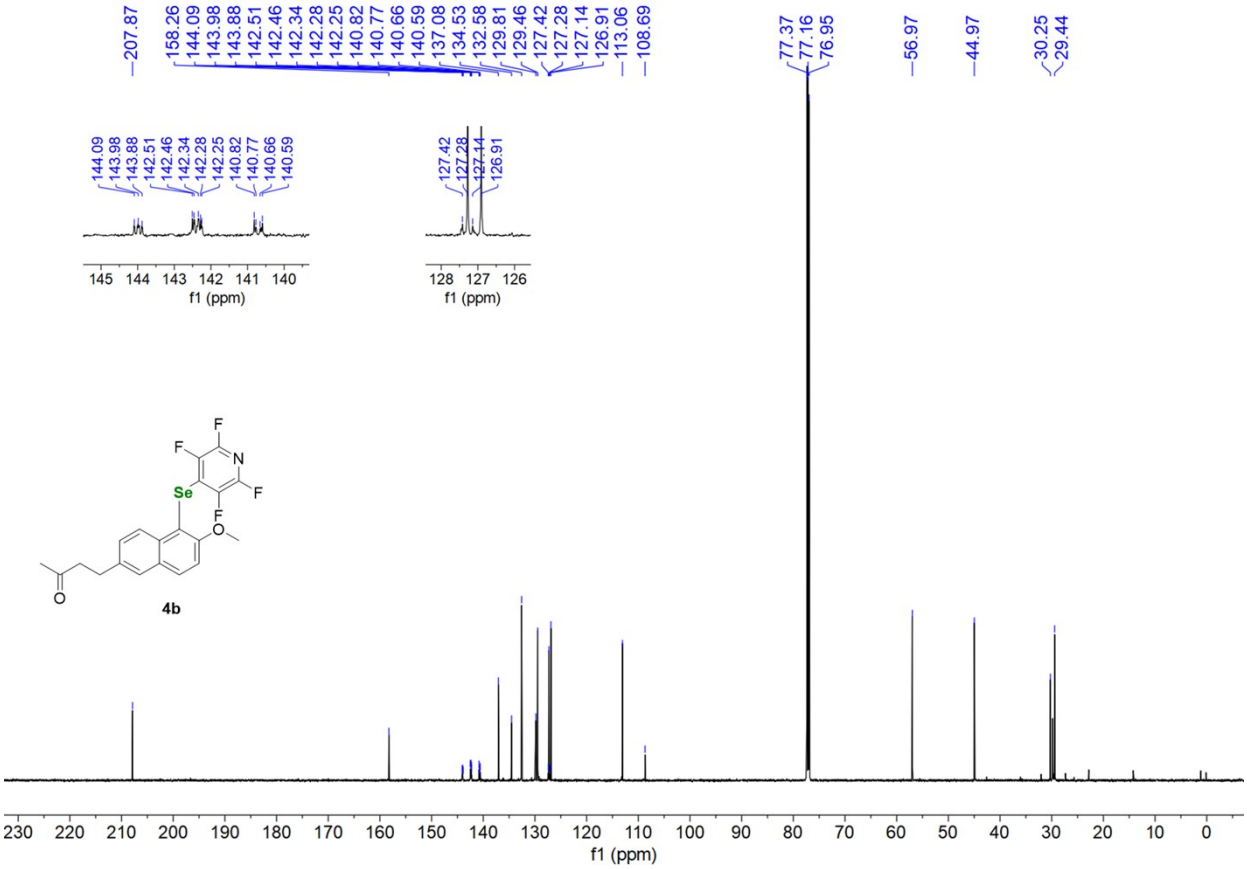
^{77}Se NMR spectra of 4a (114 MHz, $CDCl_3$)



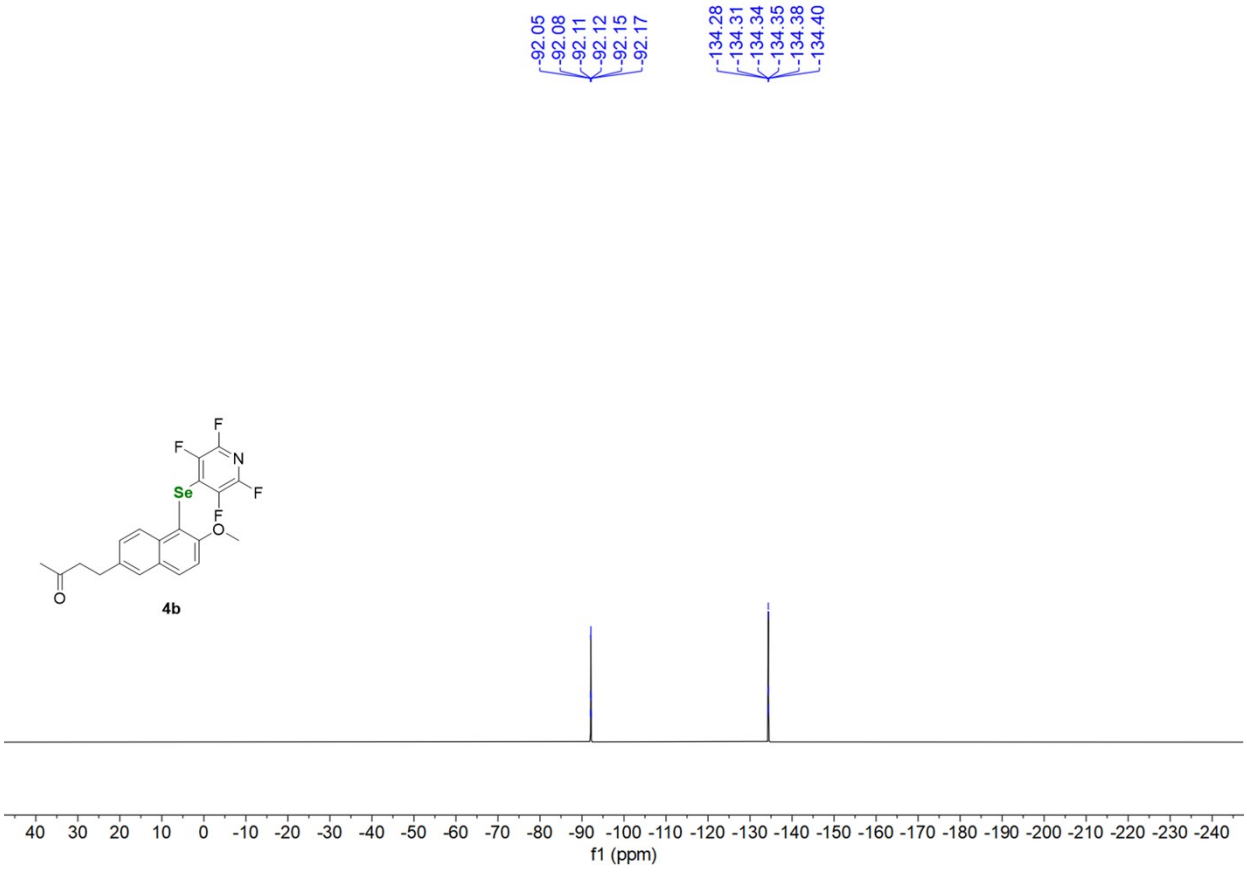
^{1}H NMR spectra of 4b (400 MHz, $CDCl_3$)



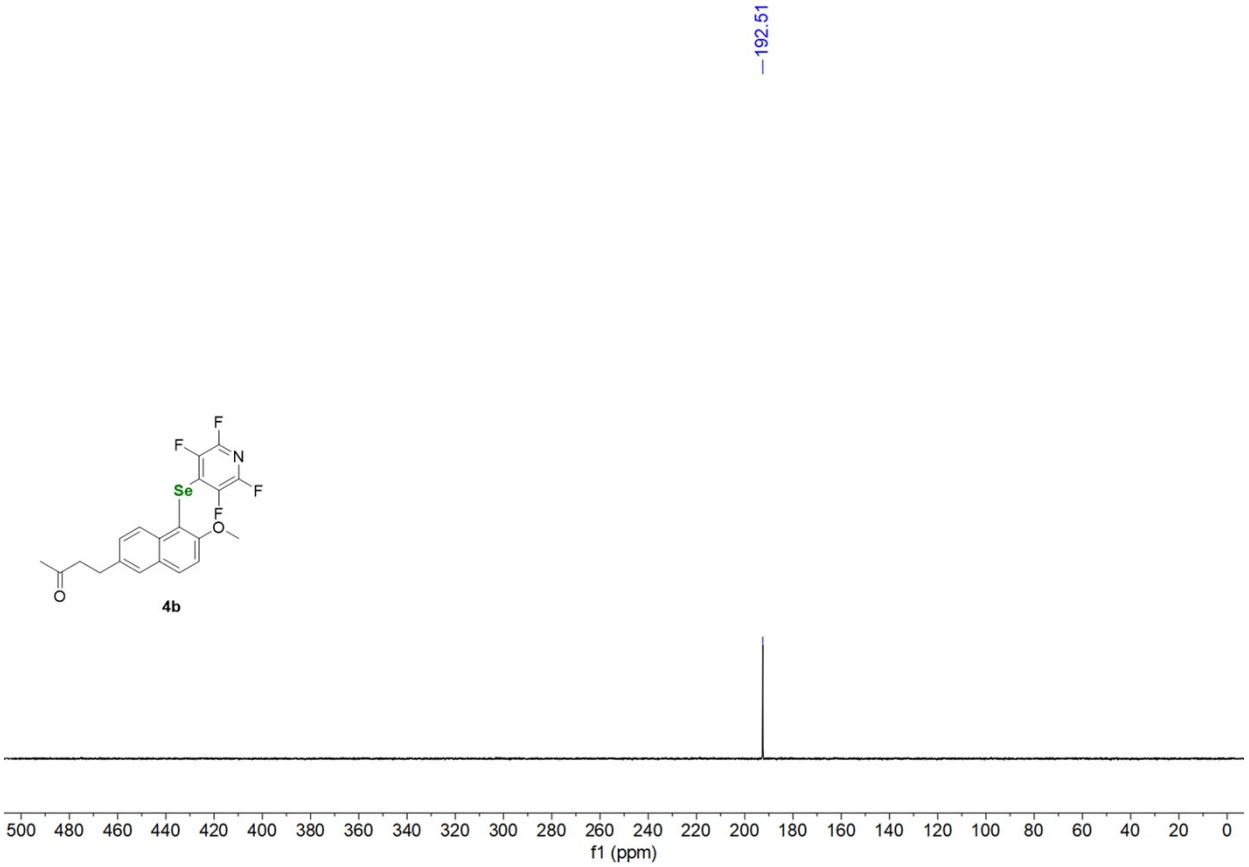
^{13}C NMR spectra of 4b (150 MHz, $CDCl_3$)



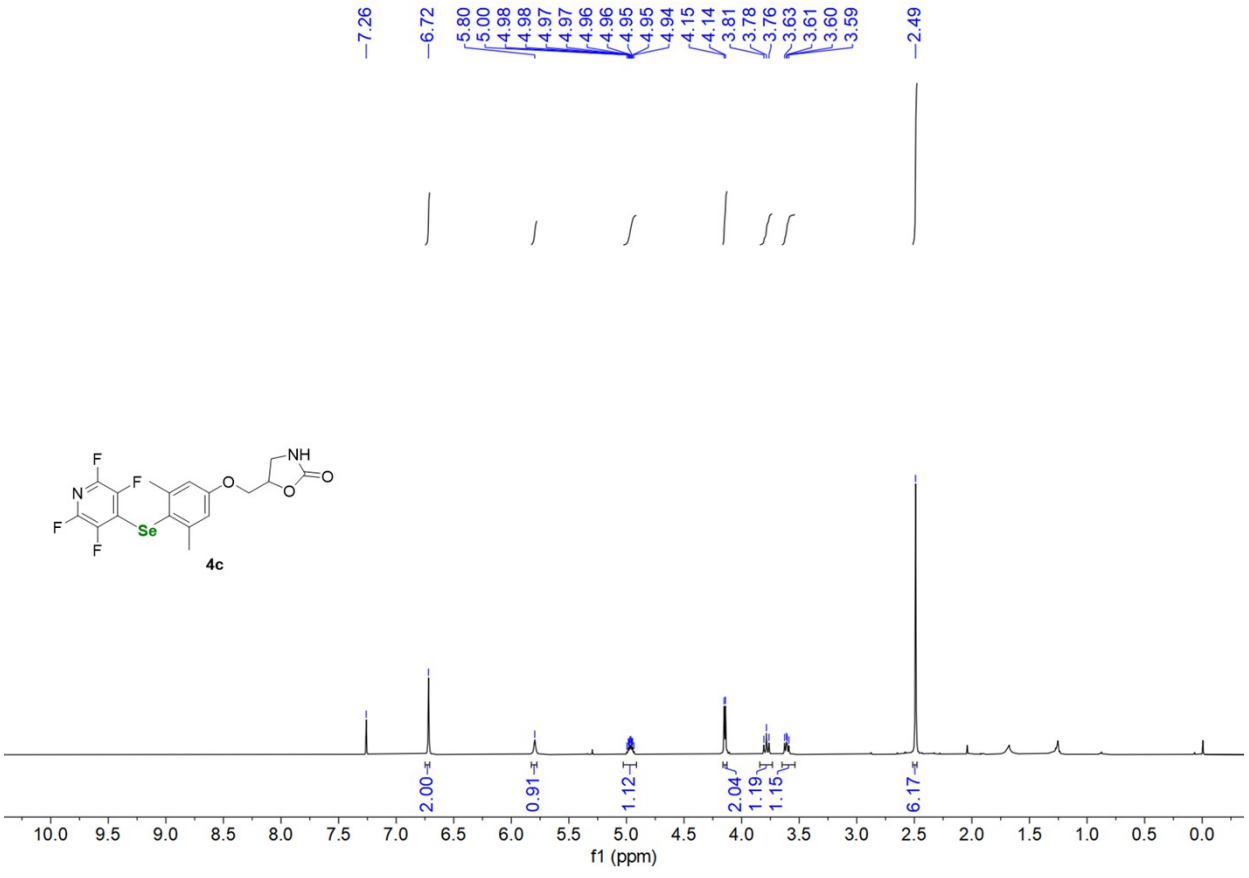
^{19}F NMR spectra of 4b (564 MHz, $CDCl_3$)



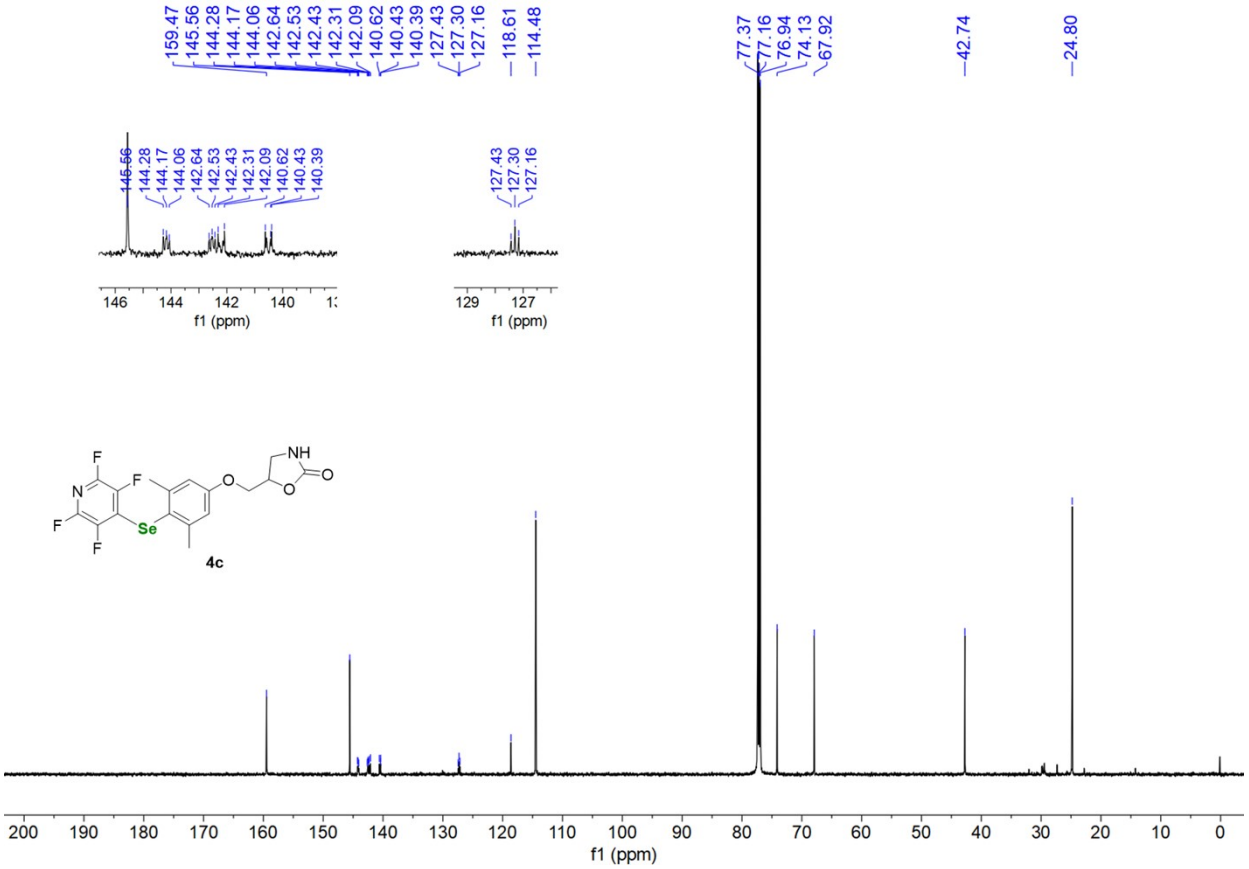
^{77}Se NMR spectra of 4b (114 MHz, $CDCl_3$)



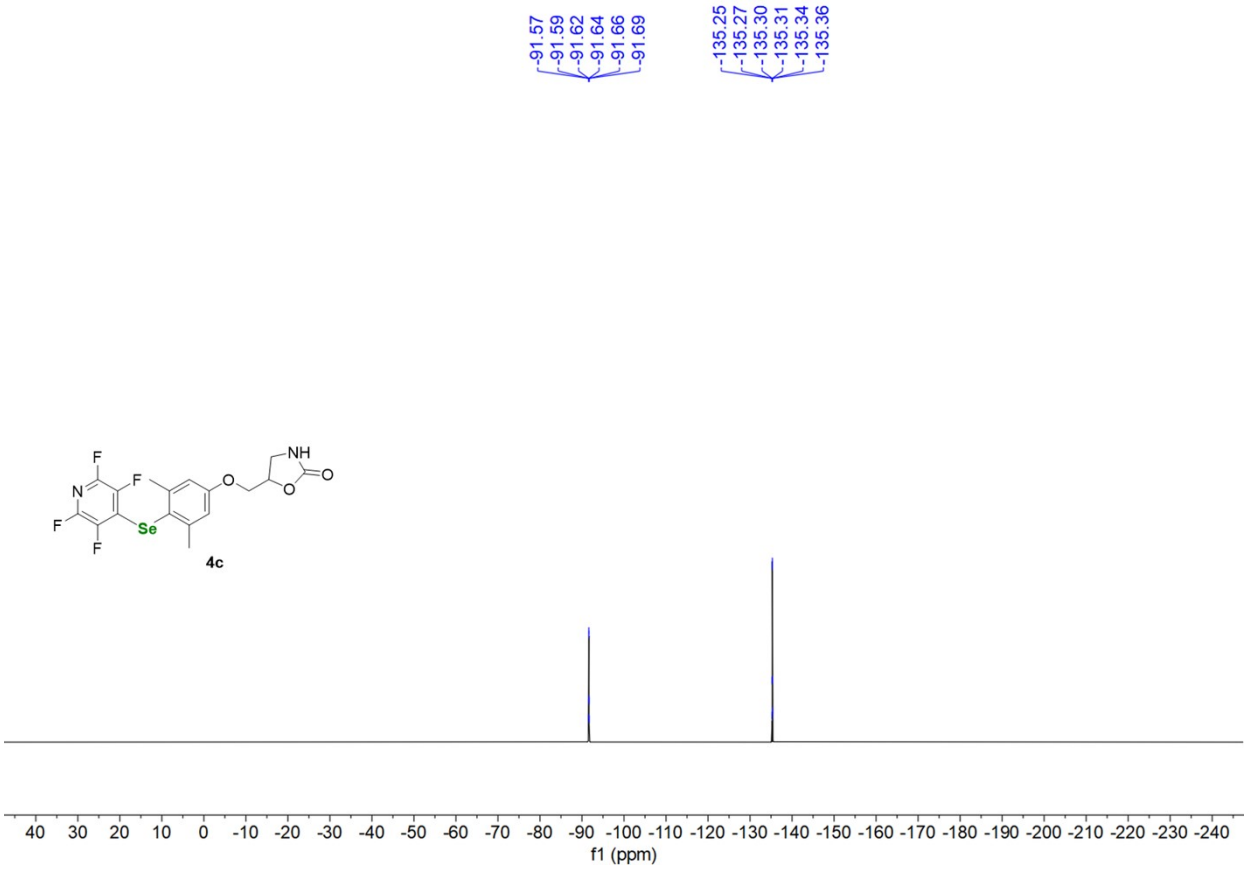
^{1}H NMR spectra of 4c (400 MHz, $CDCl_3$)



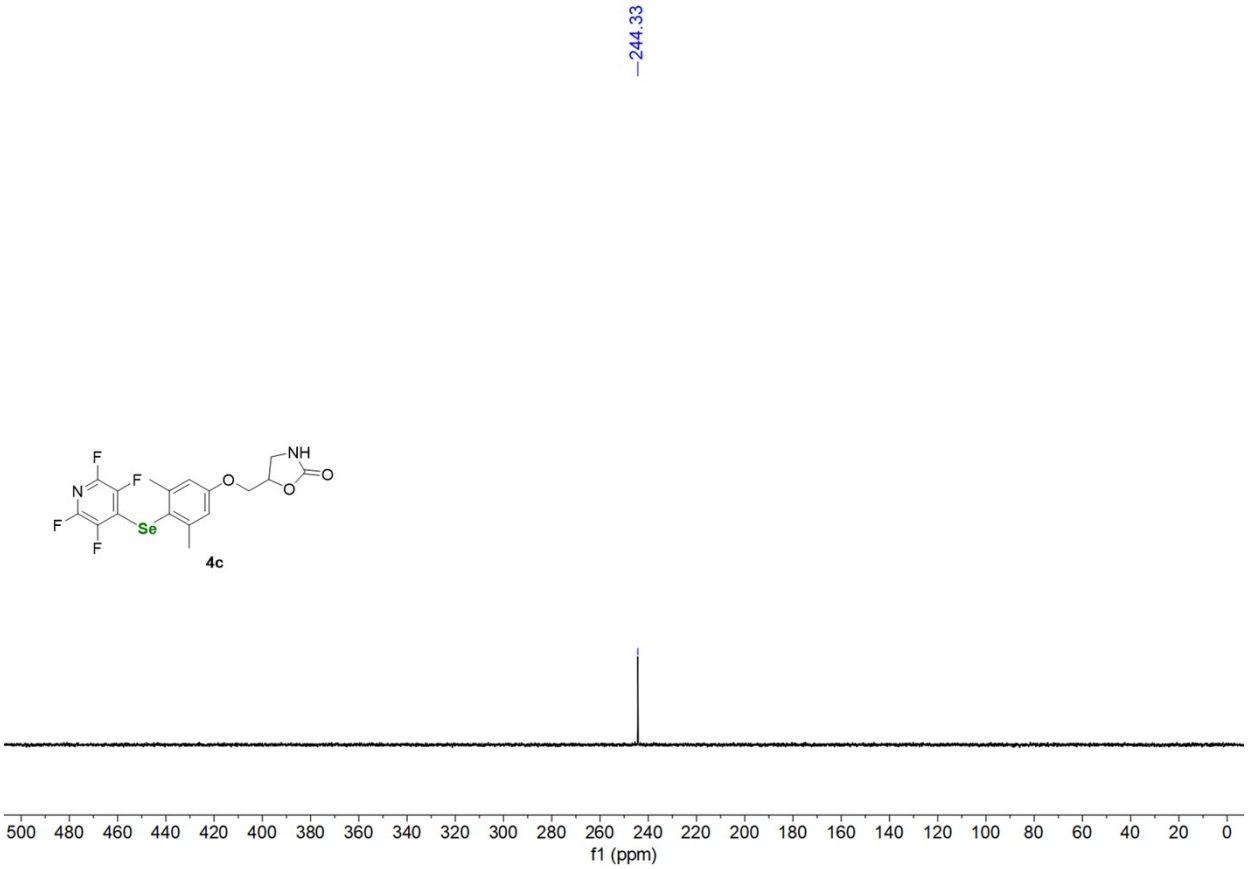
^{13}C NMR spectra of 4c (150 MHz, $CDCl_3$)



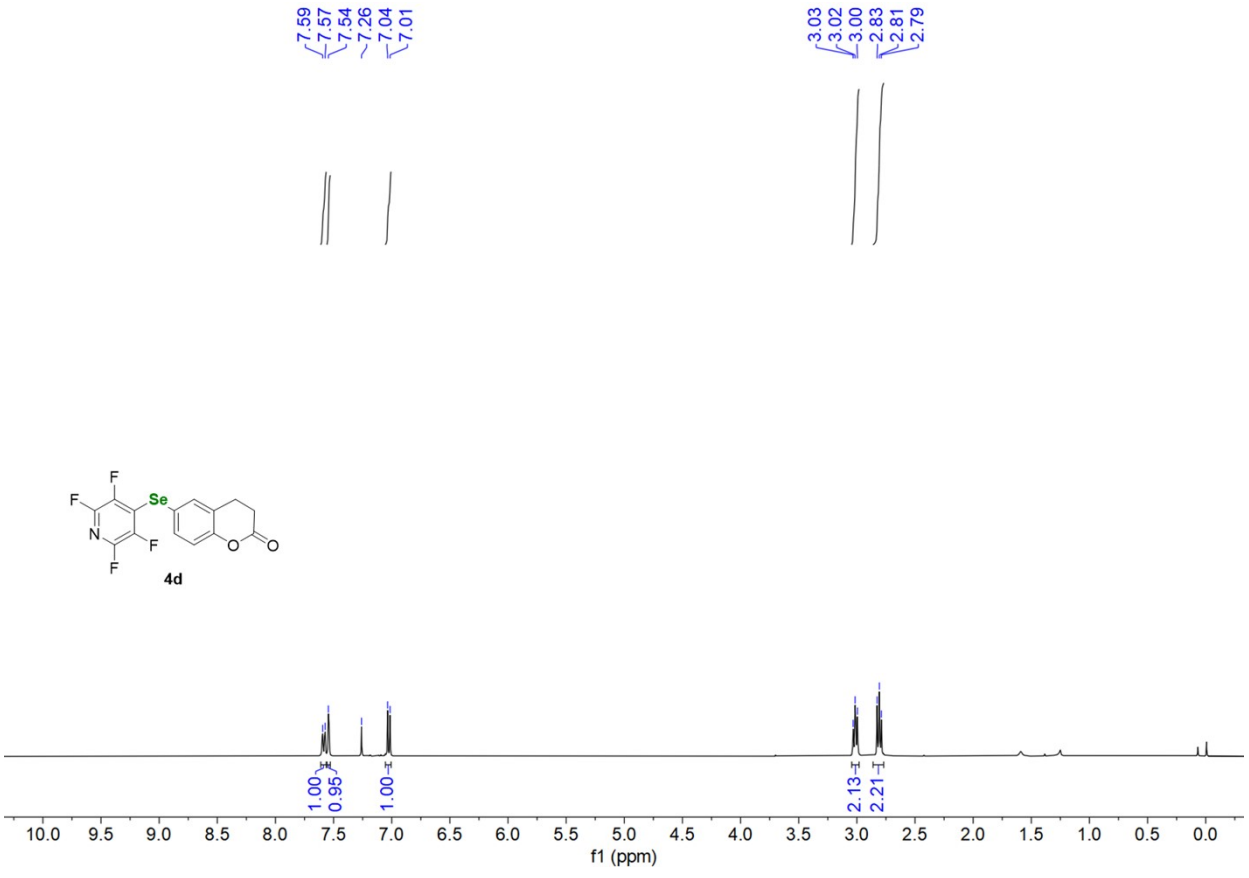
^{19}F NMR spectra of 4c (564 MHz, $CDCl_3$)



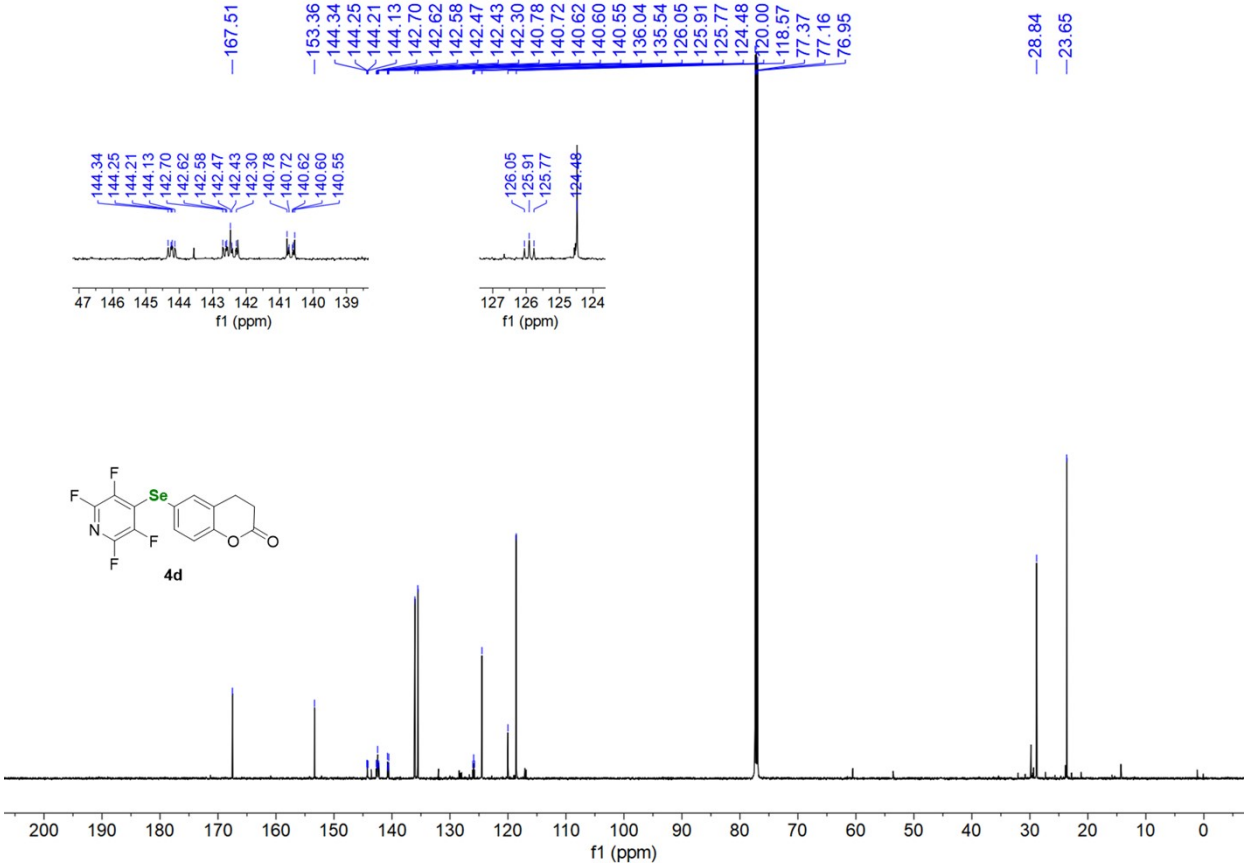
^{77}Se NMR spectra of 4c (114 MHz, $CDCl_3$)



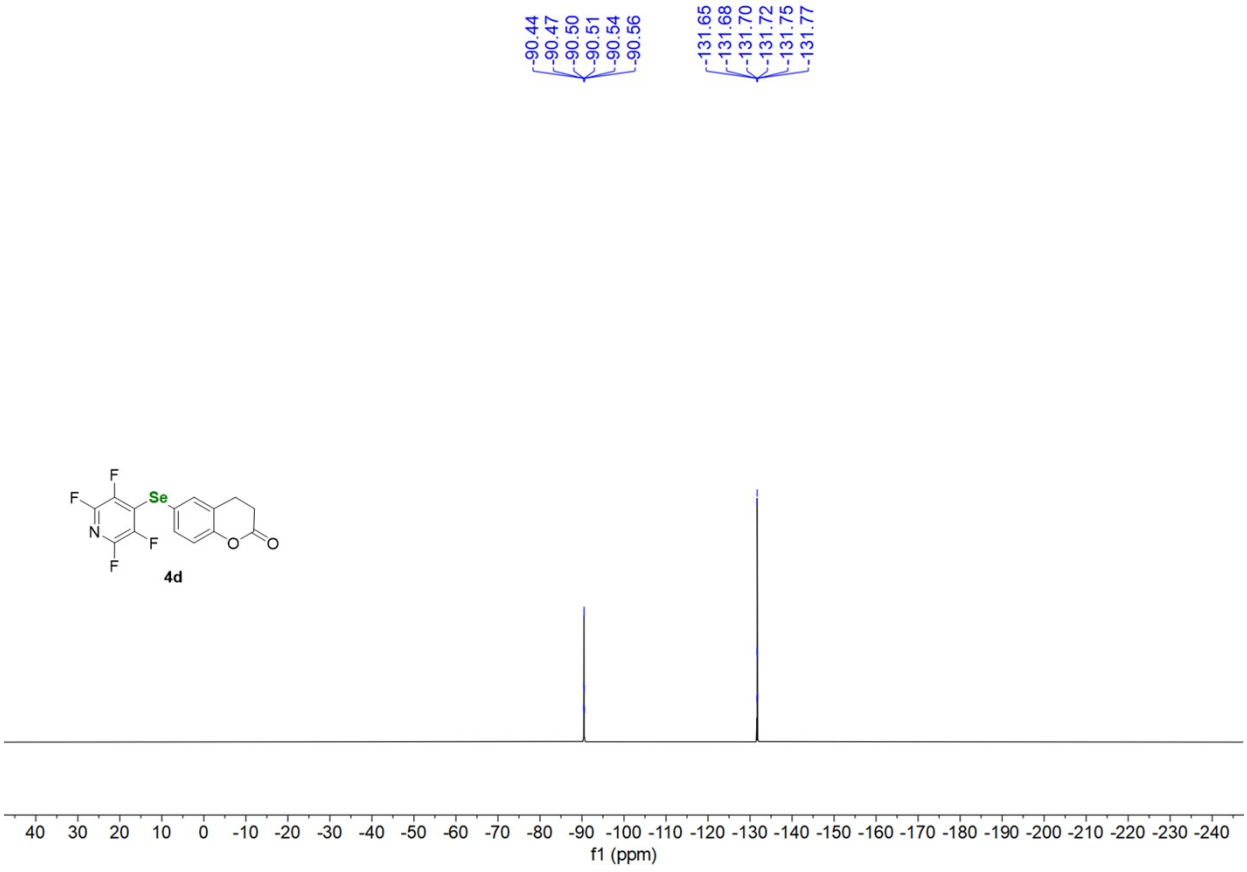
^{1}H NMR spectra of 4d (400 MHz, $CDCl_3$)



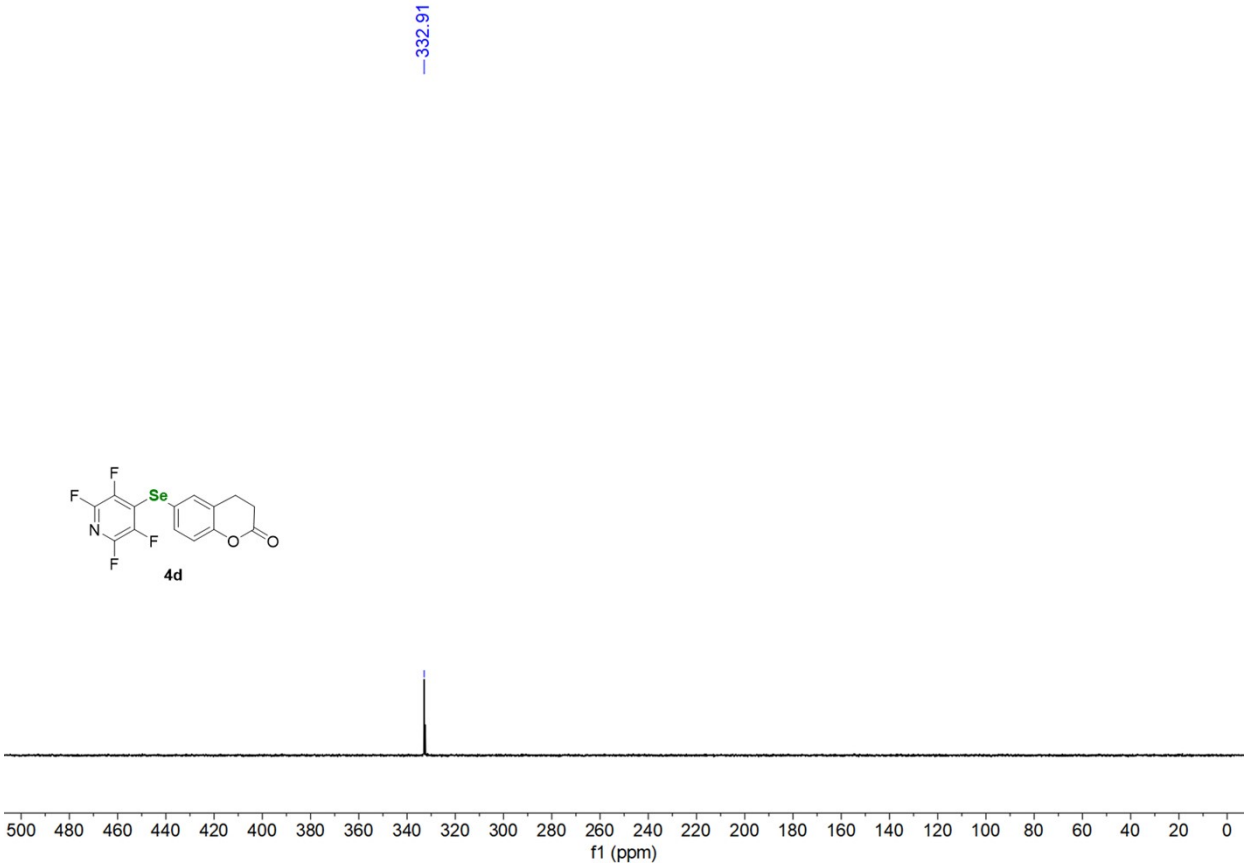
^{13}C NMR spectra of 4d (150 MHz, $CDCl_3$)



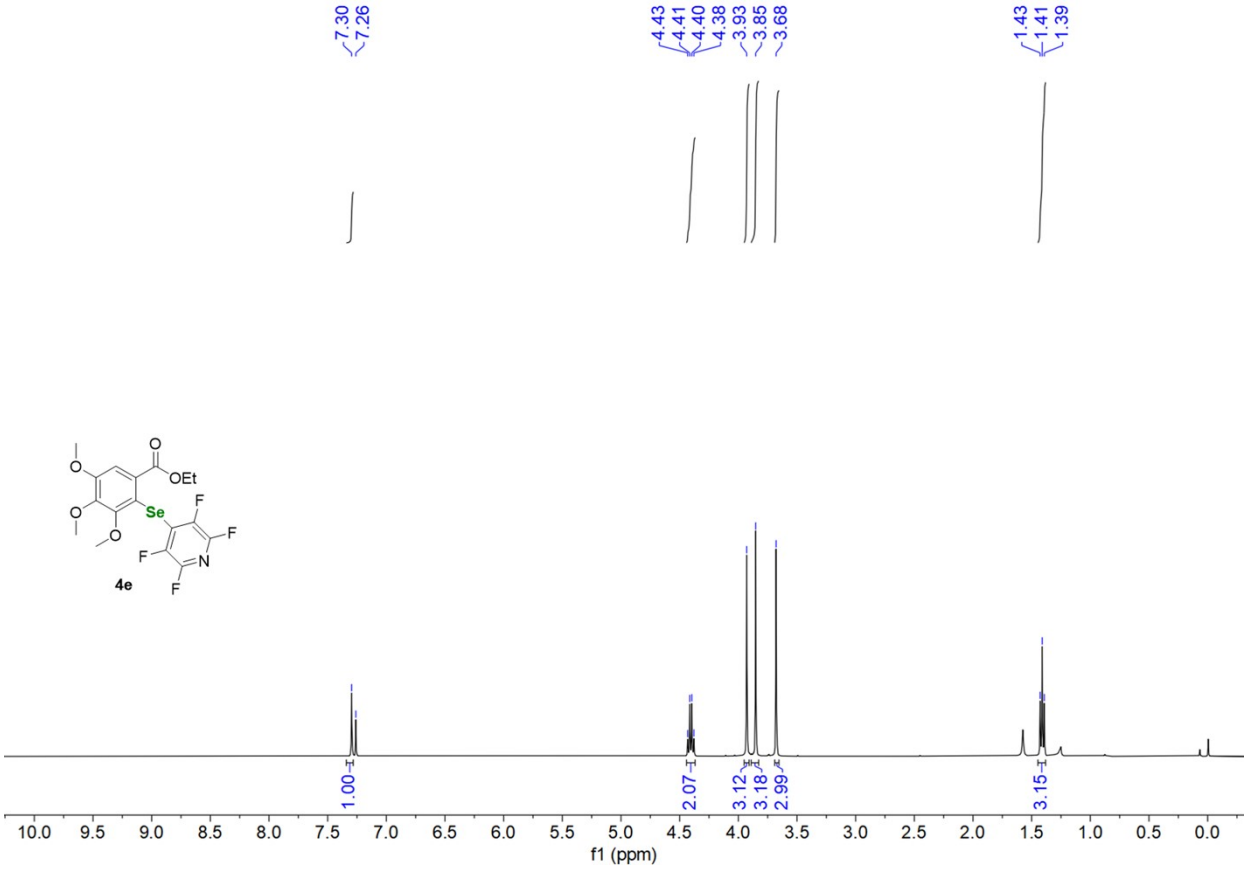
^{19}F NMR spectra of 4d (564 MHz, $CDCl_3$)



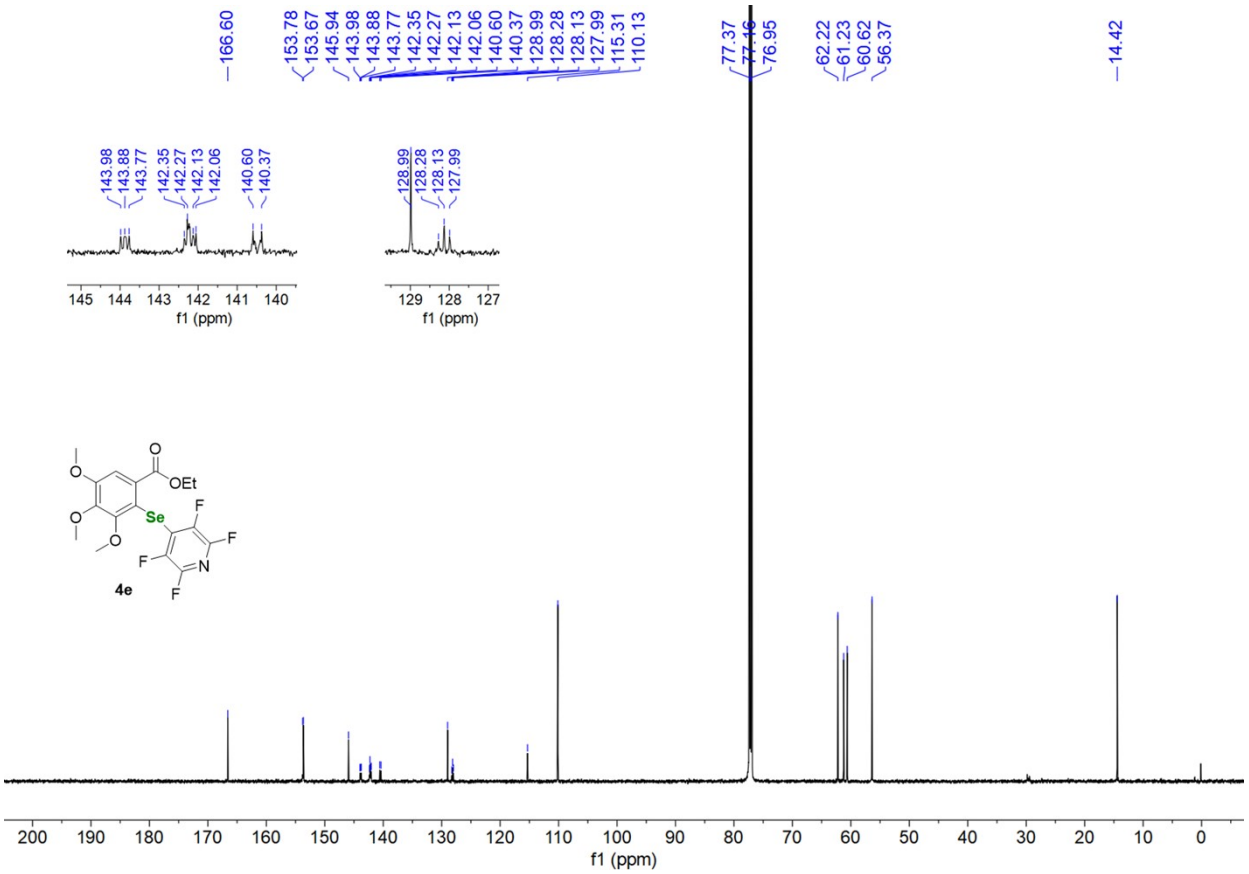
^{77}Se NMR spectra of 4d (114 MHz, $CDCl_3$)



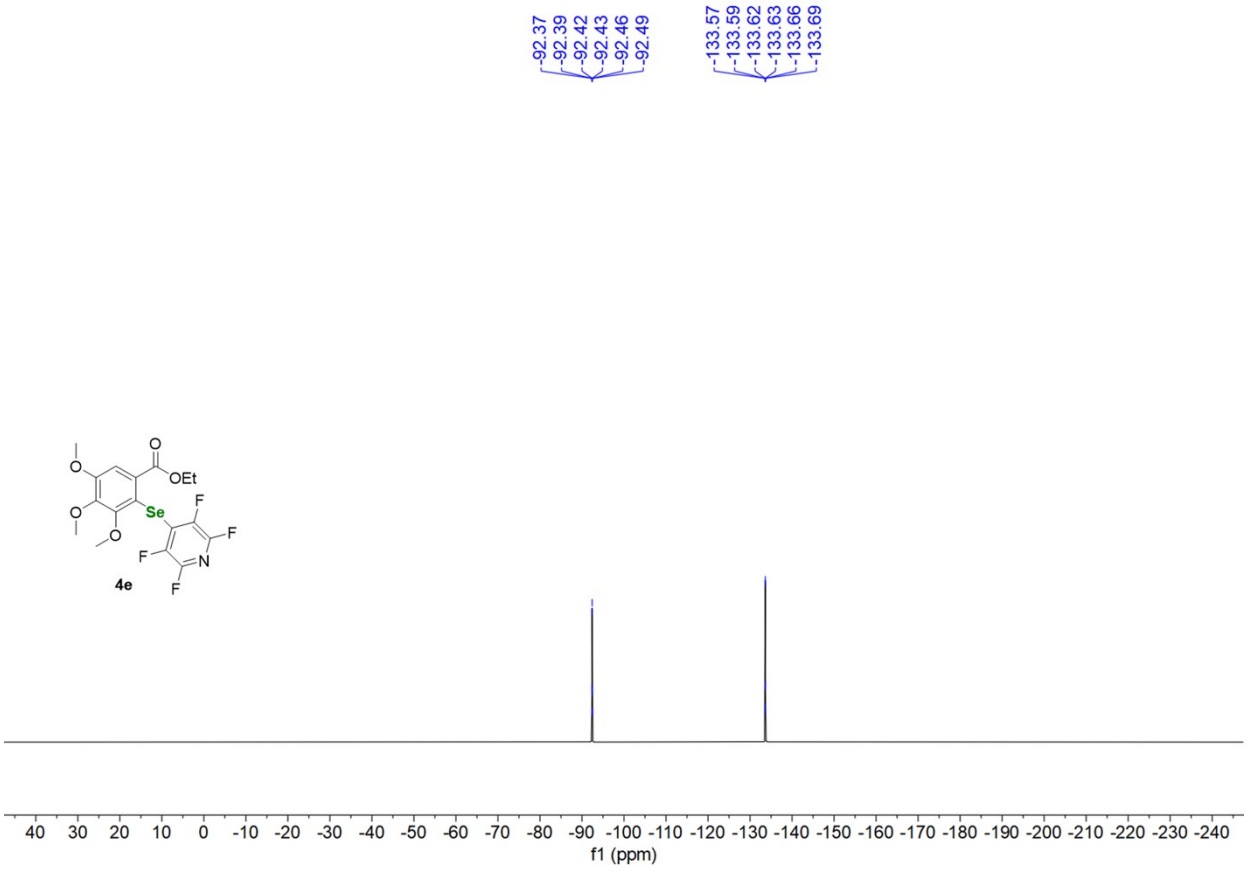
^{1}H NMR spectra of 4e (400 MHz, $CDCl_3$)



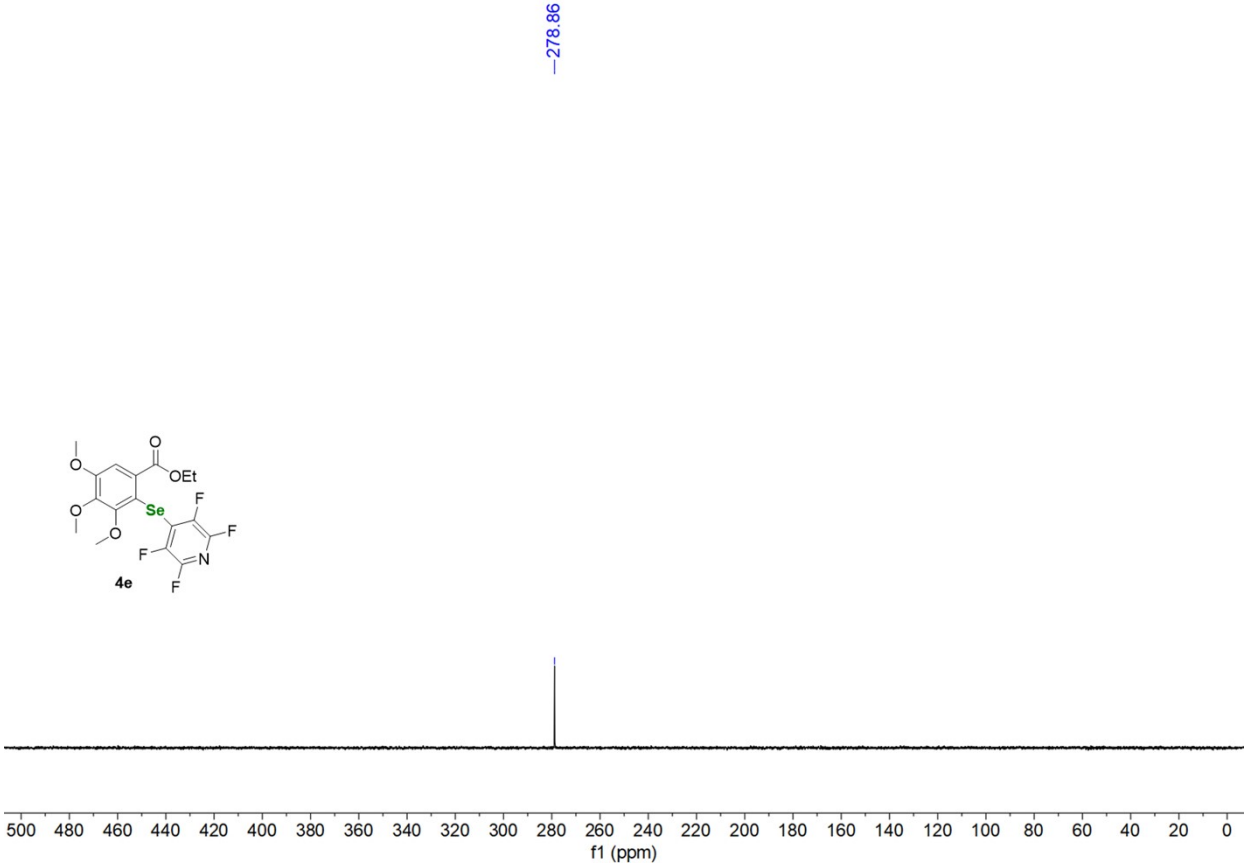
^{13}C NMR spectra of 4e (150 MHz, $CDCl_3$)



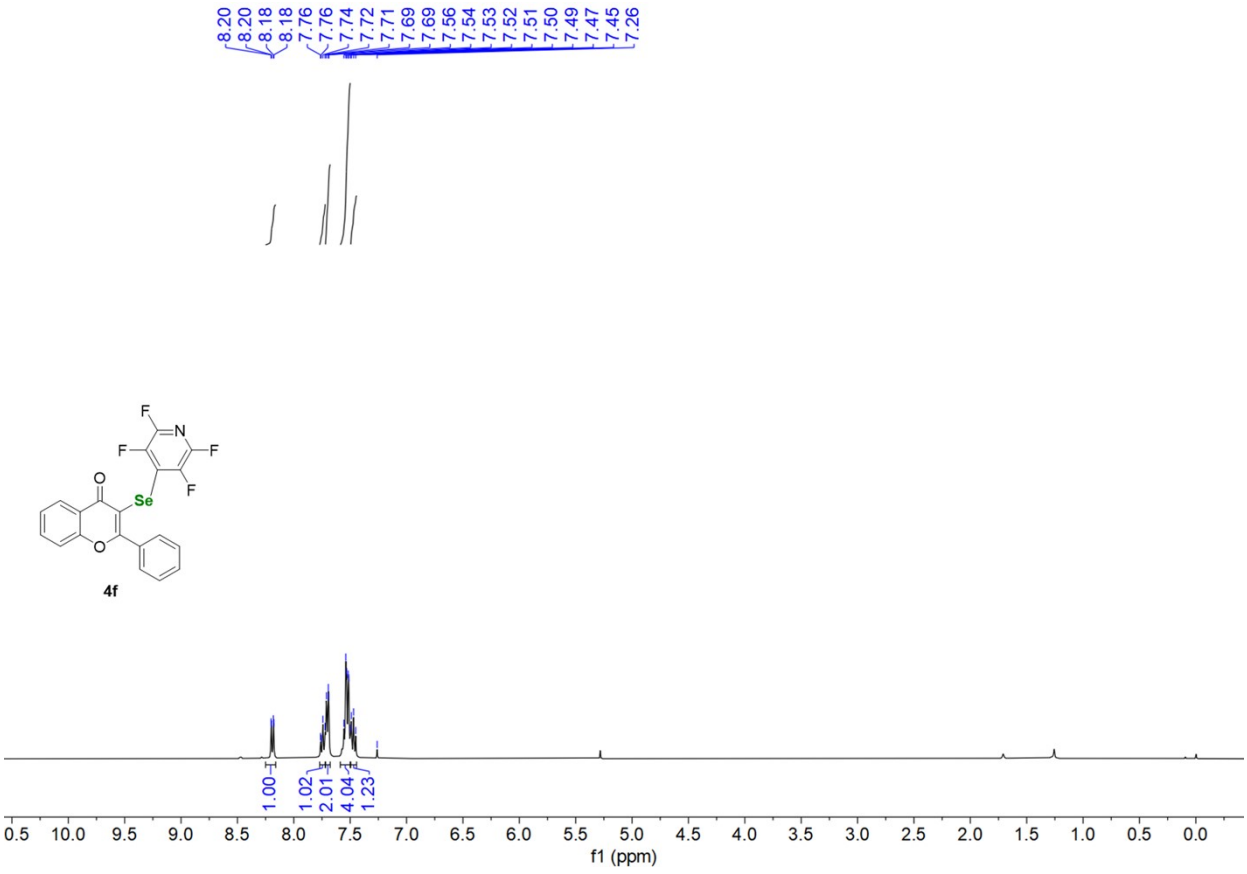
^{19}F NMR spectra of 4e (564 MHz, $CDCl_3$)



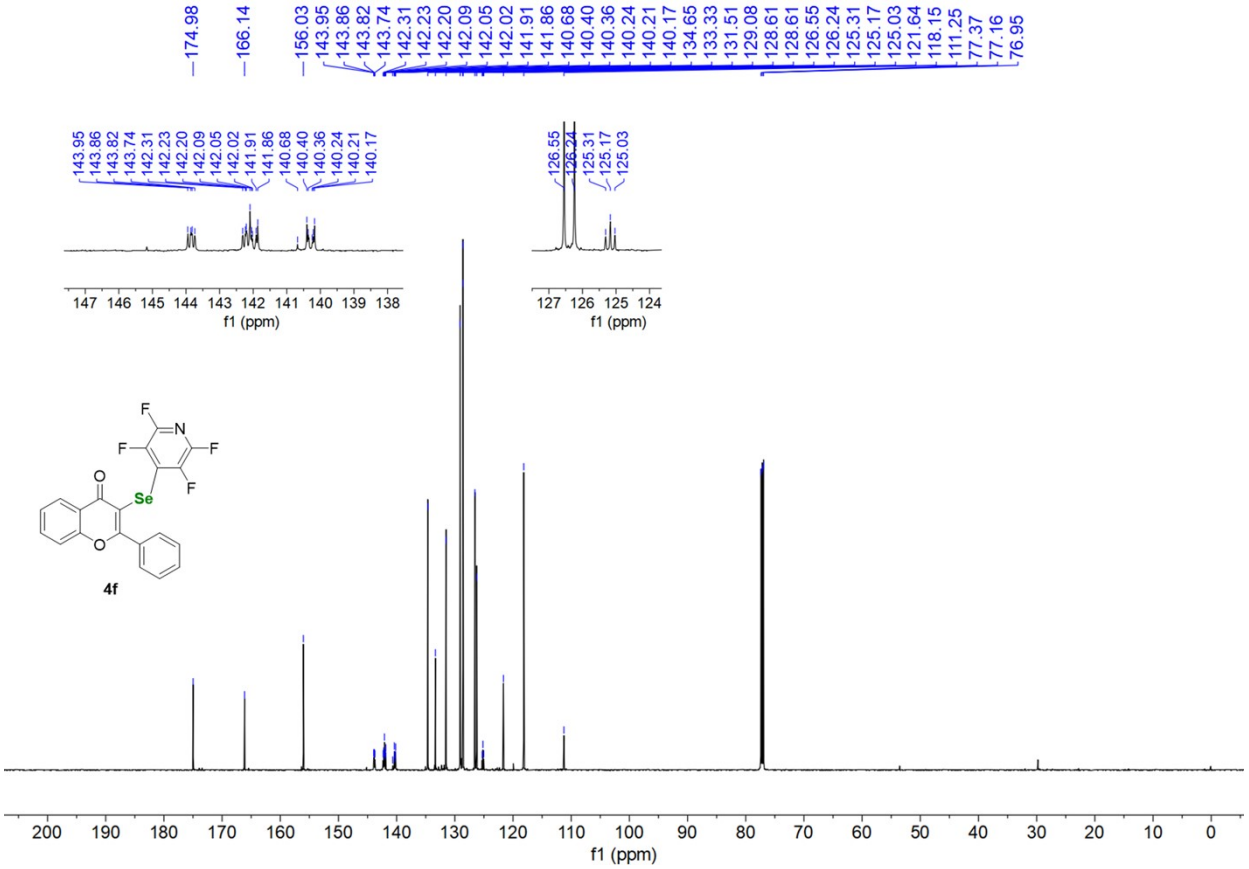
^{77}Se NMR spectra of 4e (114 MHz, $CDCl_3$)



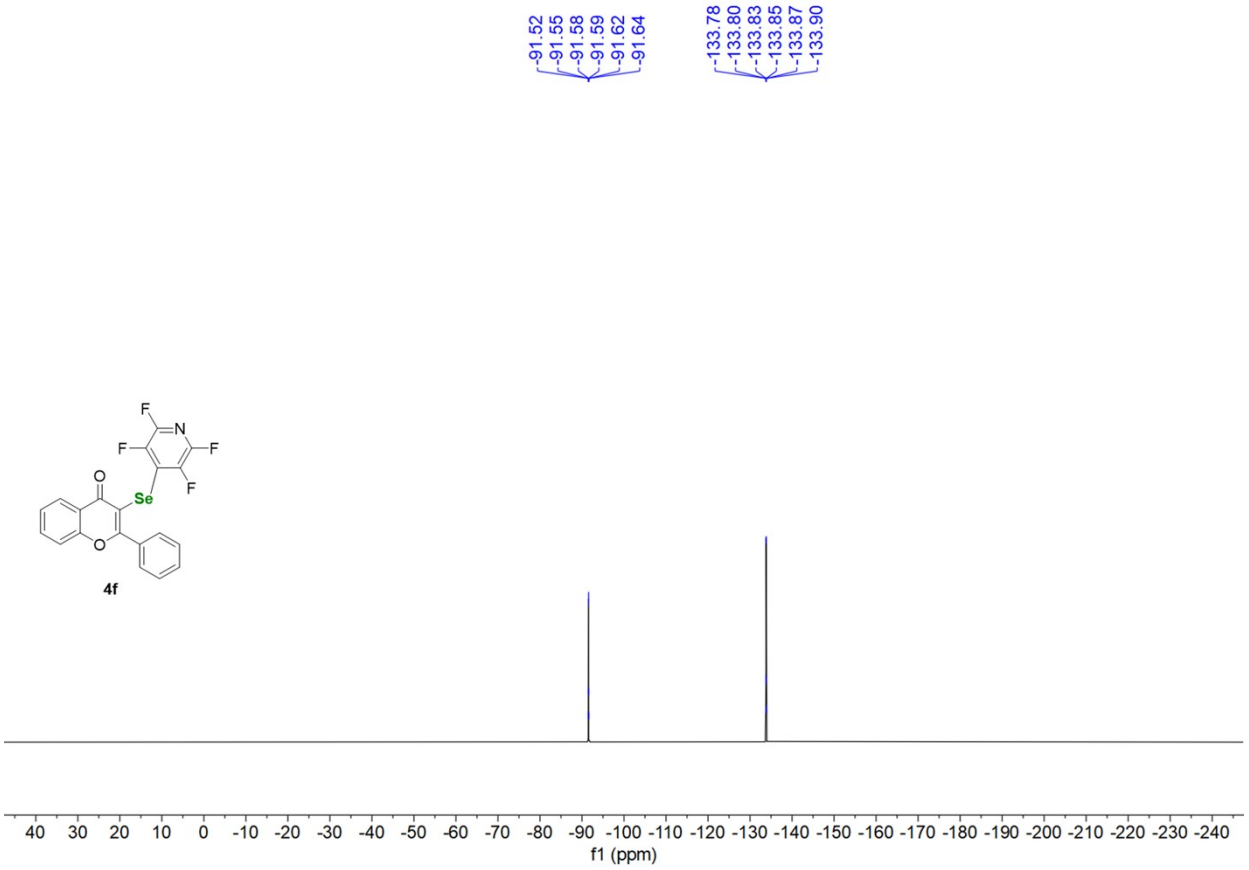
^{1}H NMR spectra of 4f (400 MHz, $CDCl_3$)



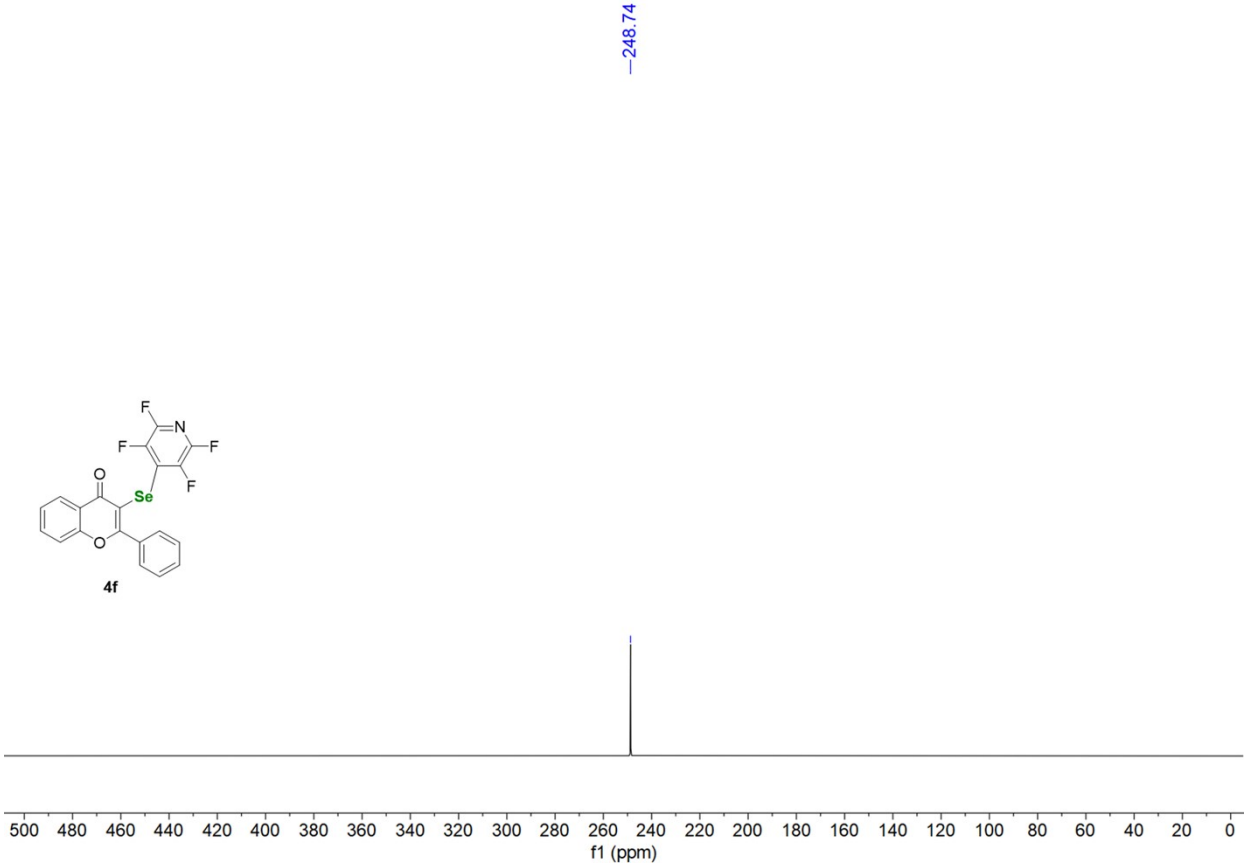
^{13}C NMR spectra of 4f (150 MHz, $CDCl_3$)



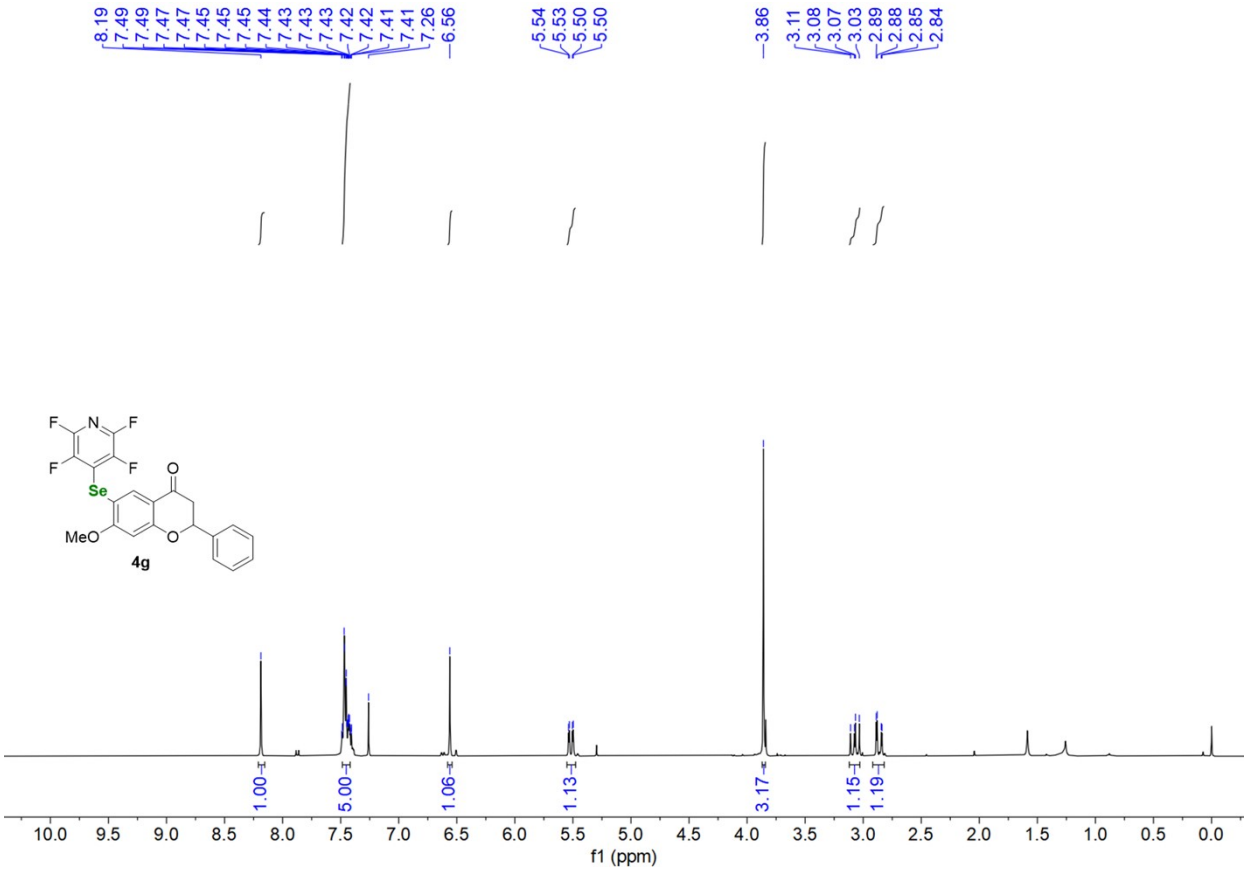
^{19}F NMR spectra of 4f (564 MHz, $CDCl_3$)



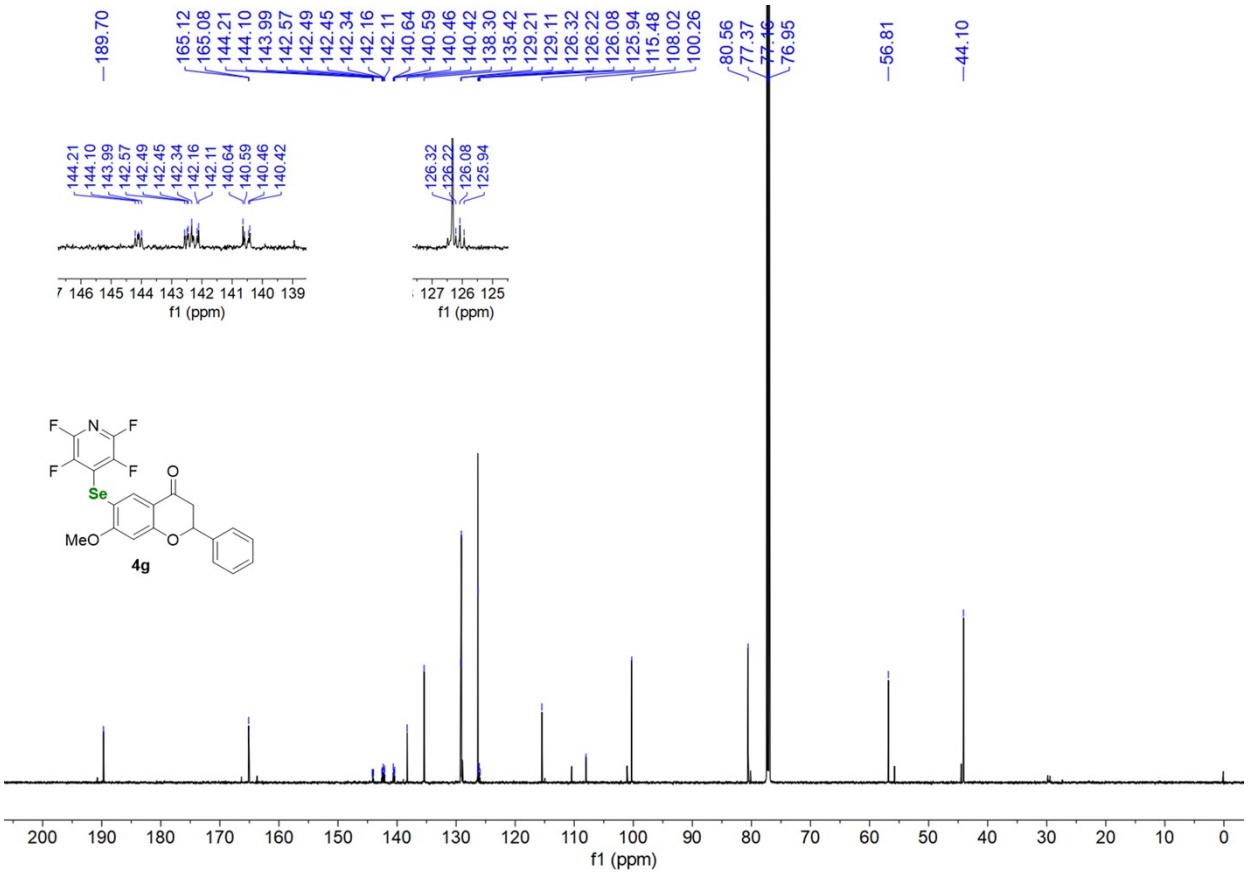
^{77}Se NMR spectra of 4f (114 MHz, $CDCl_3$)



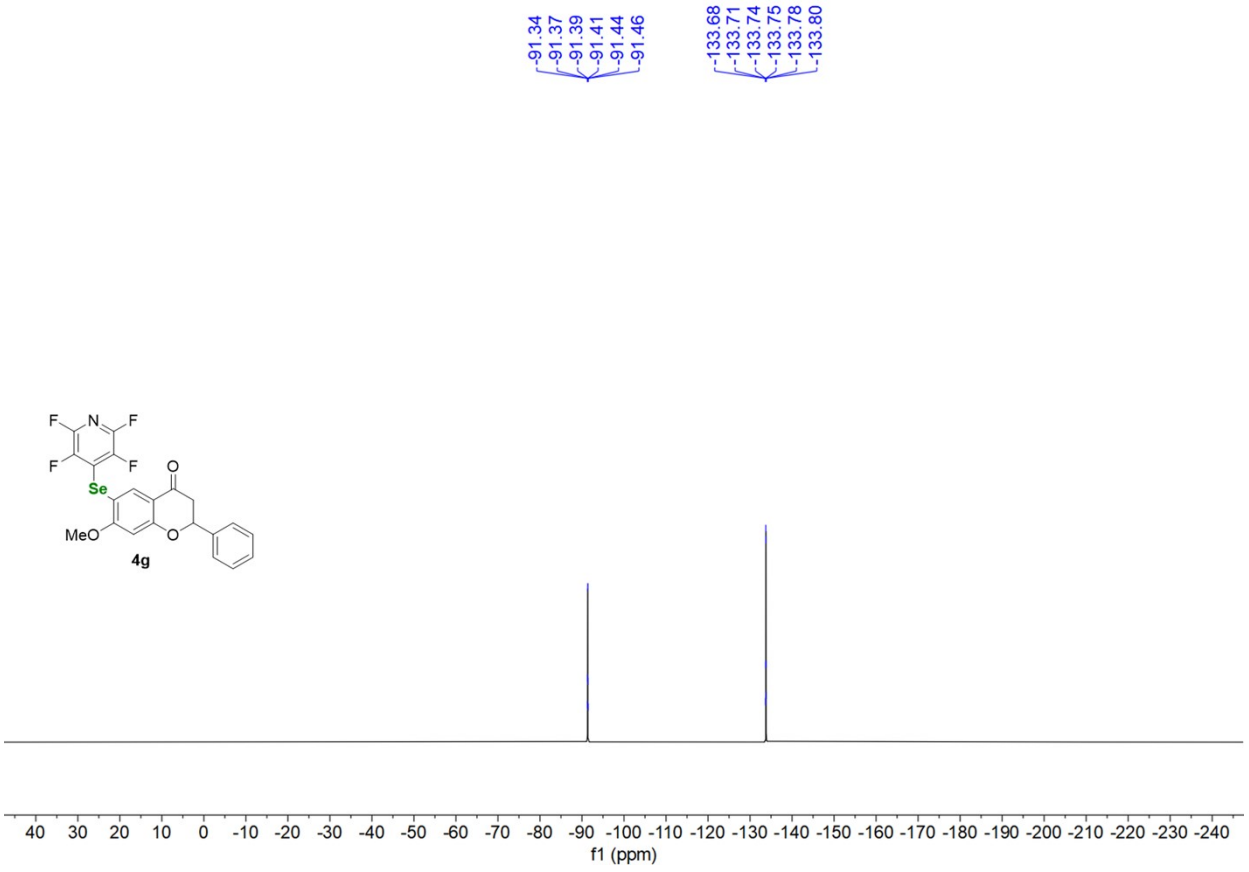
^{1}H NMR spectra of 4g (400 MHz, $CDCl_3$)



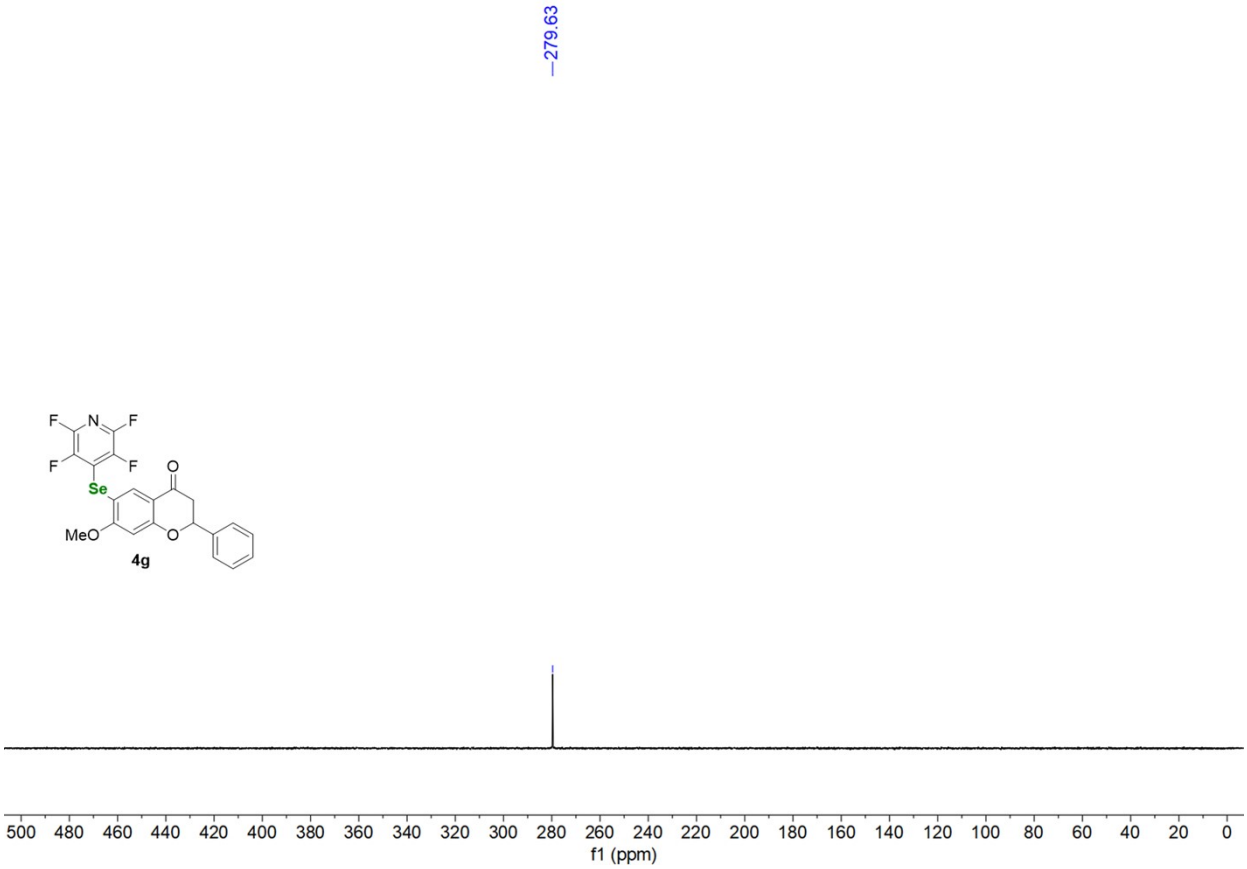
^{13}C NMR spectra of 4g (150 MHz, $CDCl_3$)



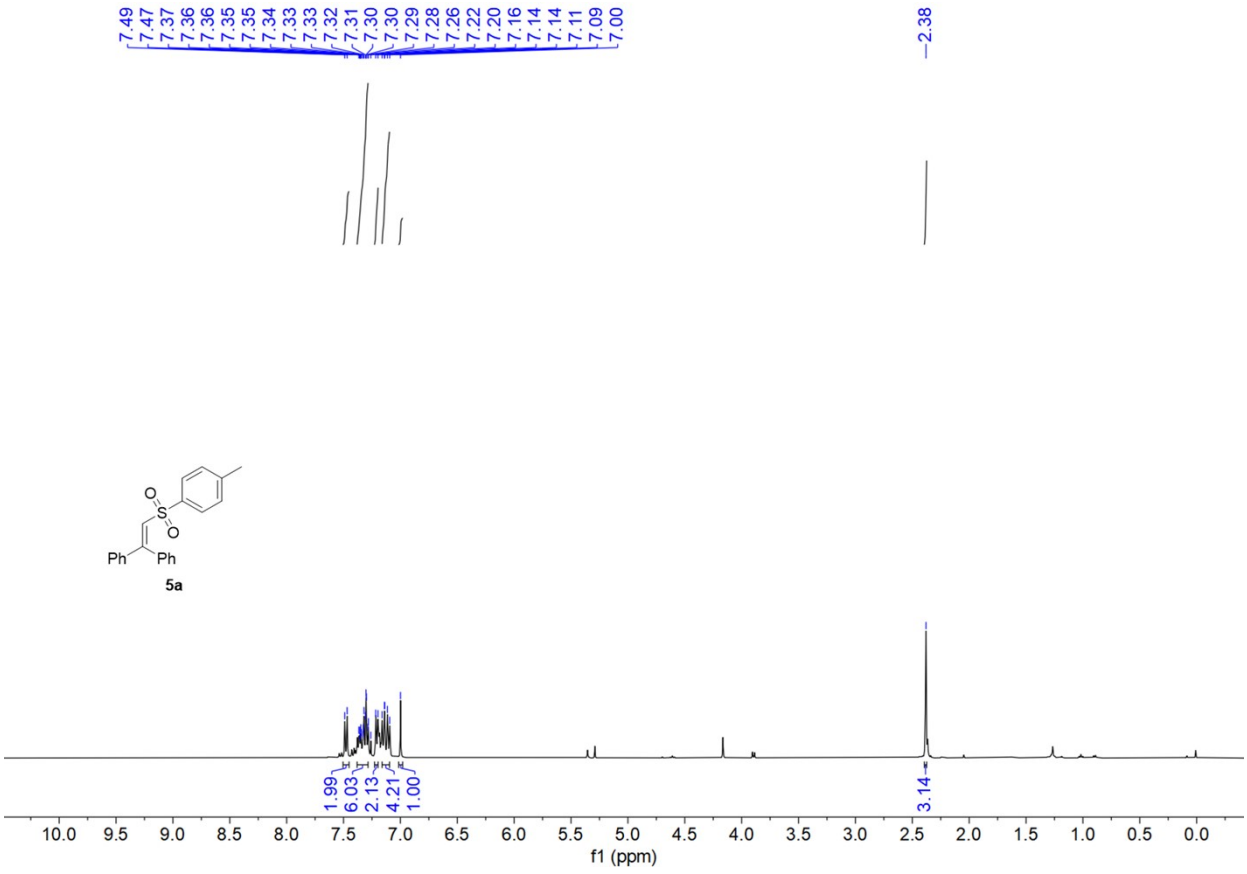
^{19}F NMR spectra of 4g (564 MHz, $CDCl_3$)



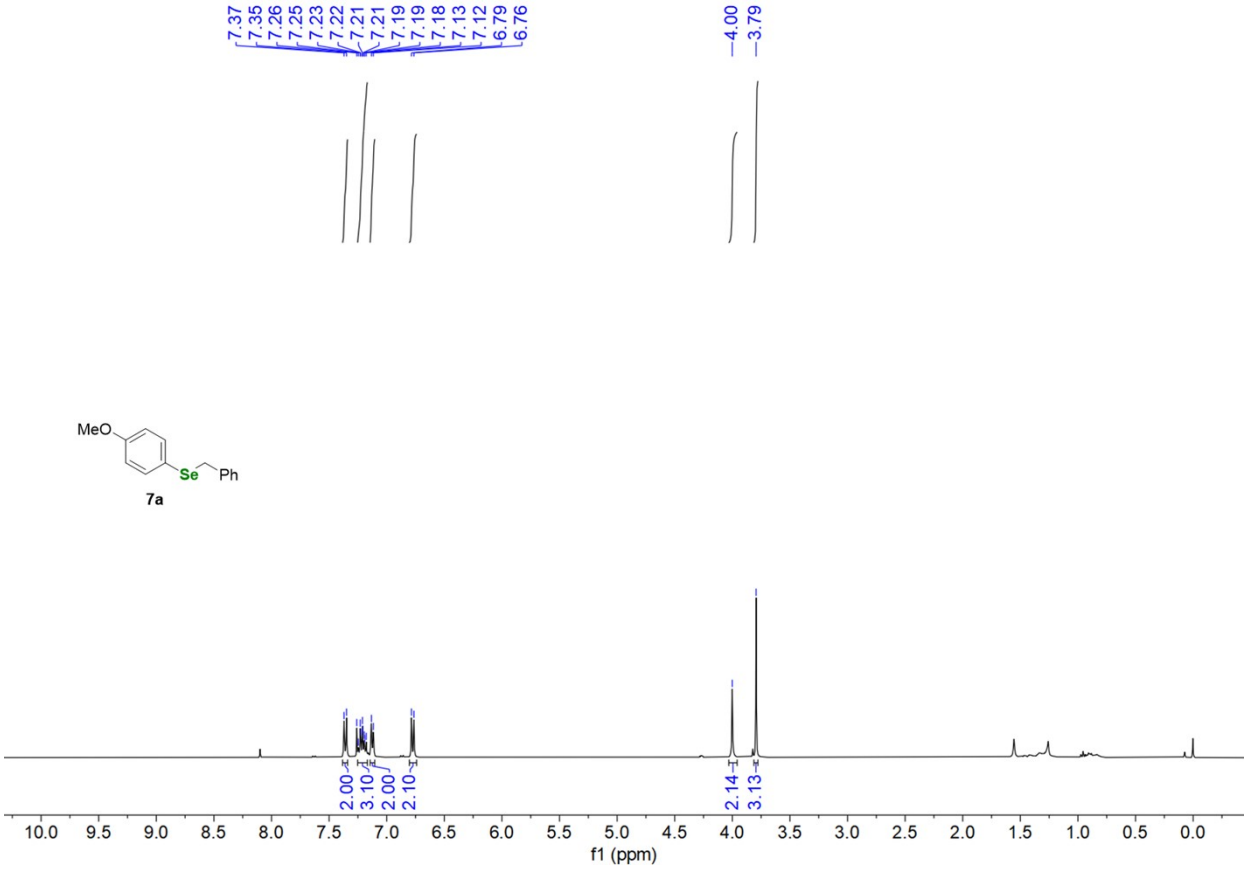
^{77}Se NMR spectra of 4g (114 MHz, $CDCl_3$)



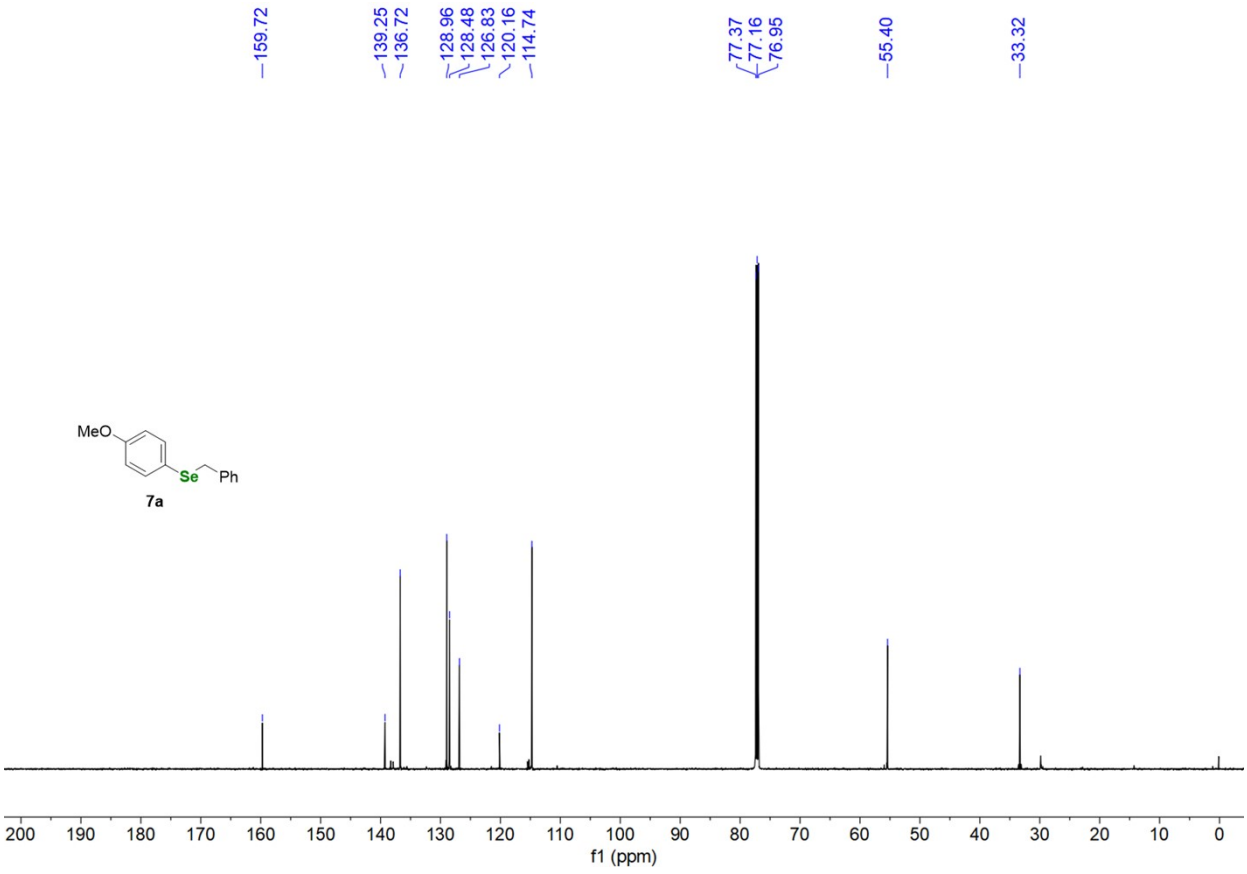
^{1}H NMR spectra of 5a (400 MHz, $CDCl_3$)



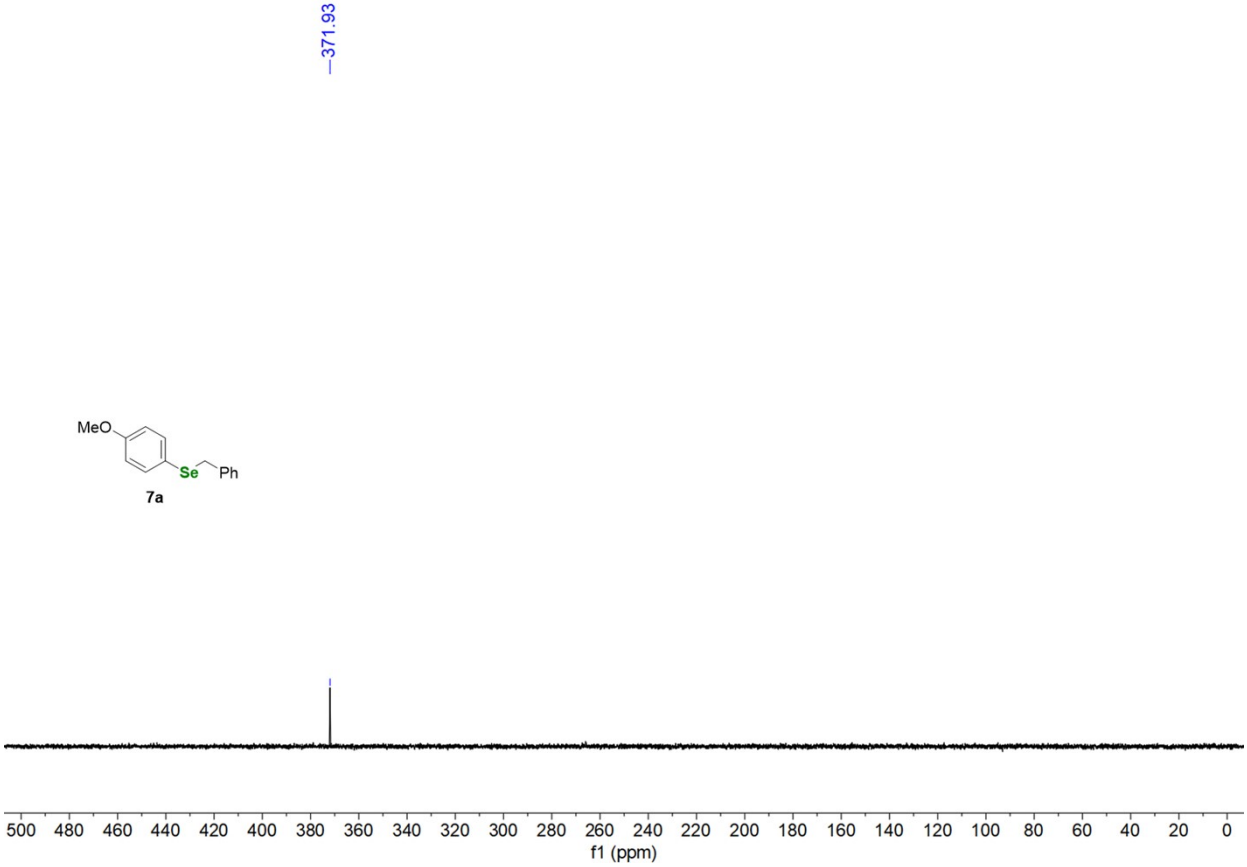
^{1}H NMR spectra of 7a (400 MHz, $CDCl_3$)



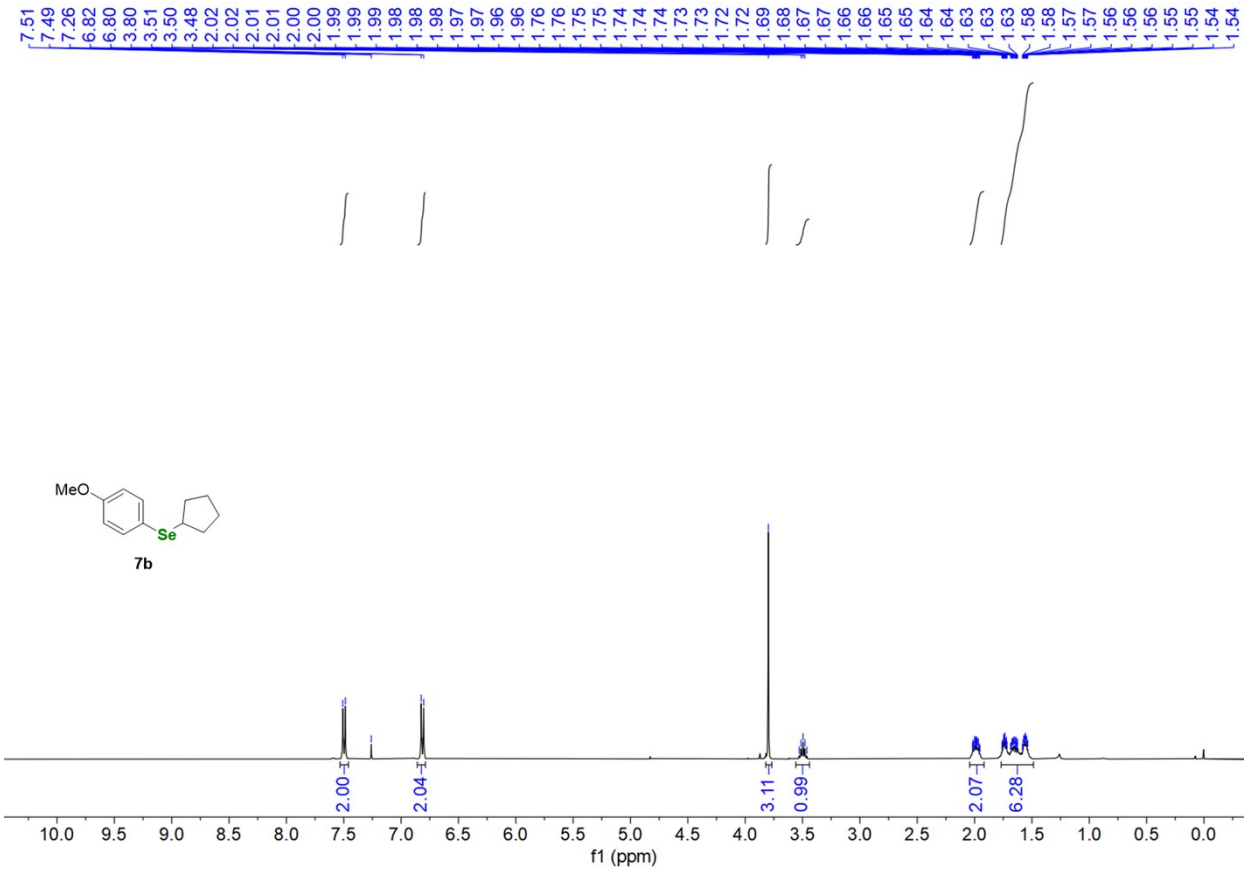
^{13}C NMR spectra of 7a (150 MHz, $CDCl_3$)



^{77}Se NMR spectra of 7a (114 MHz, $CDCl_3$)



^{1}H NMR spectra of 7b (400 MHz, $CDCl_3$)



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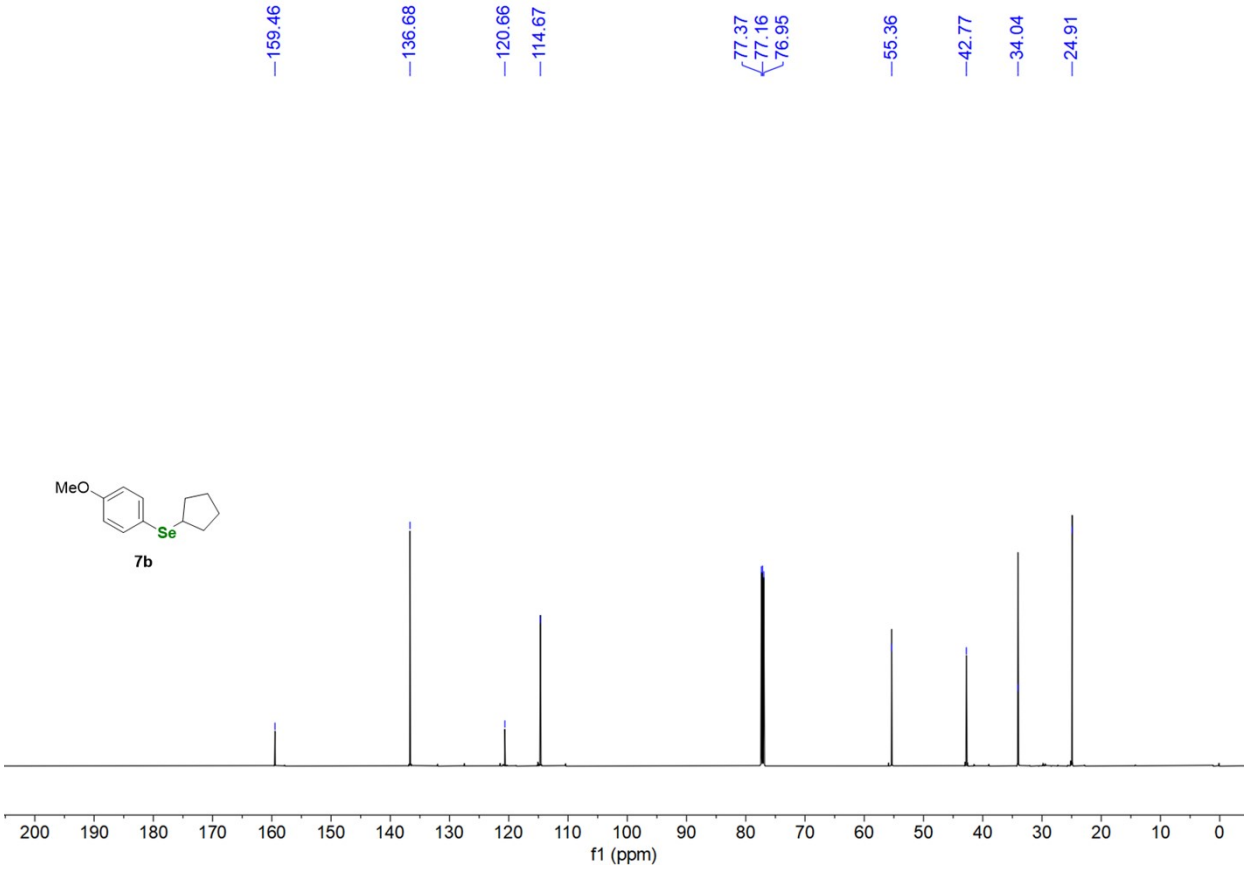
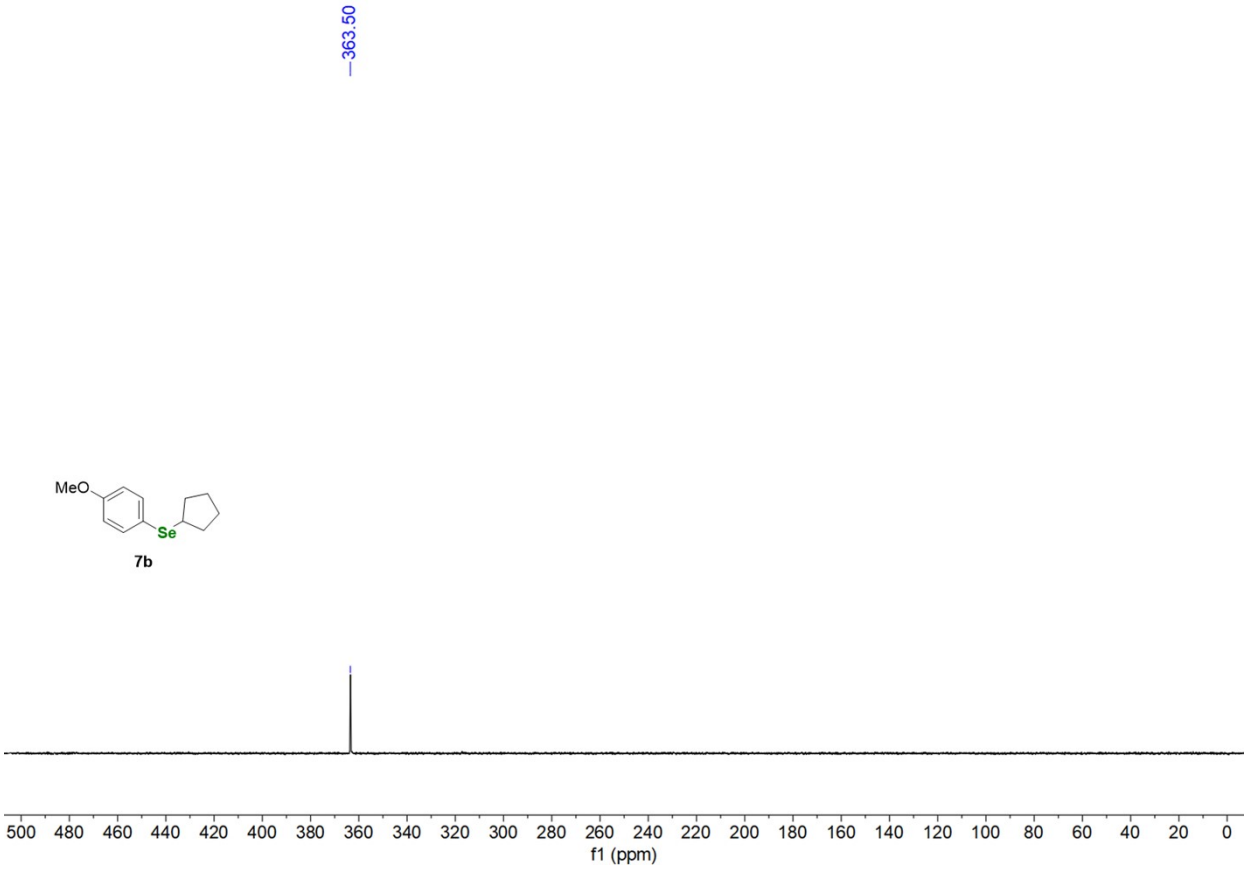
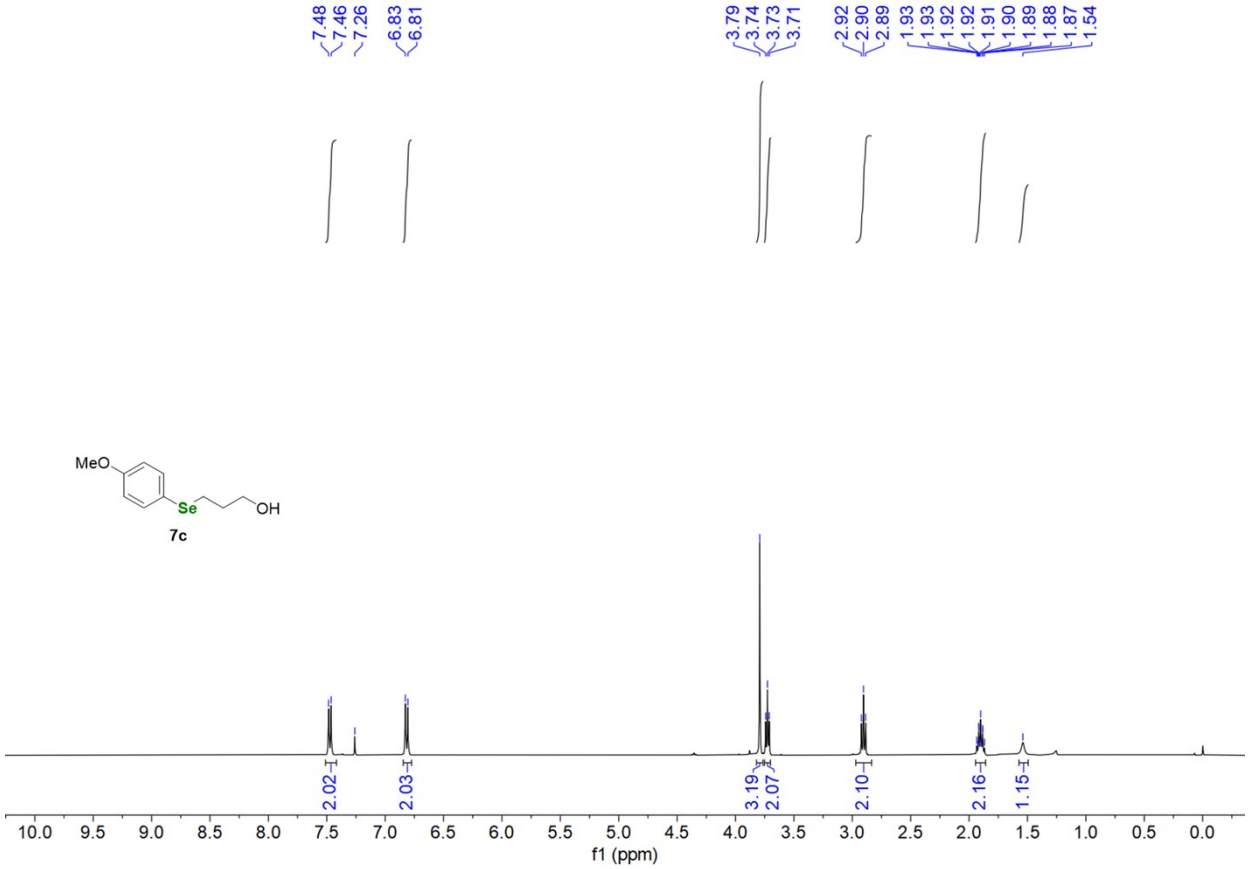


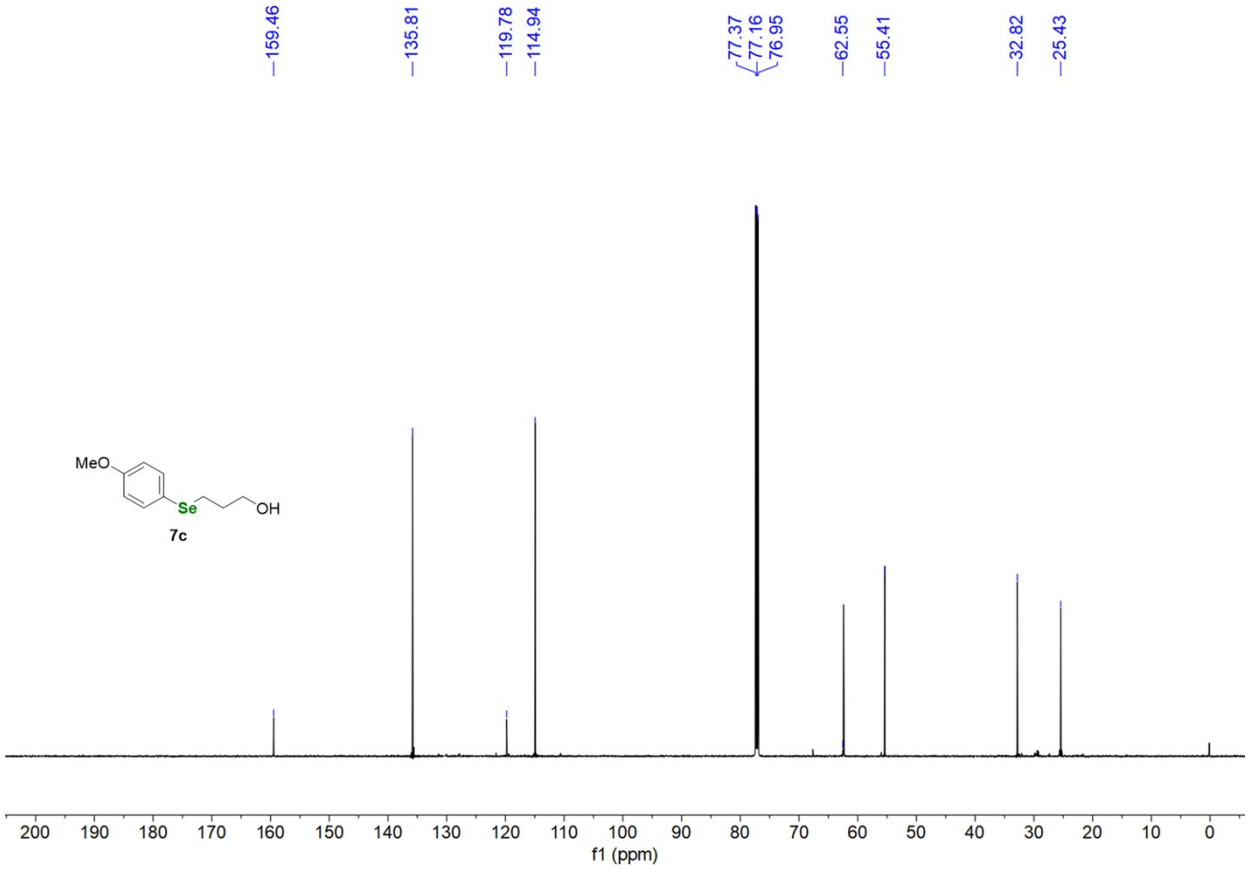
^{77}Se NMR spectra of 7b (114 MHz, $CDCl_3$)



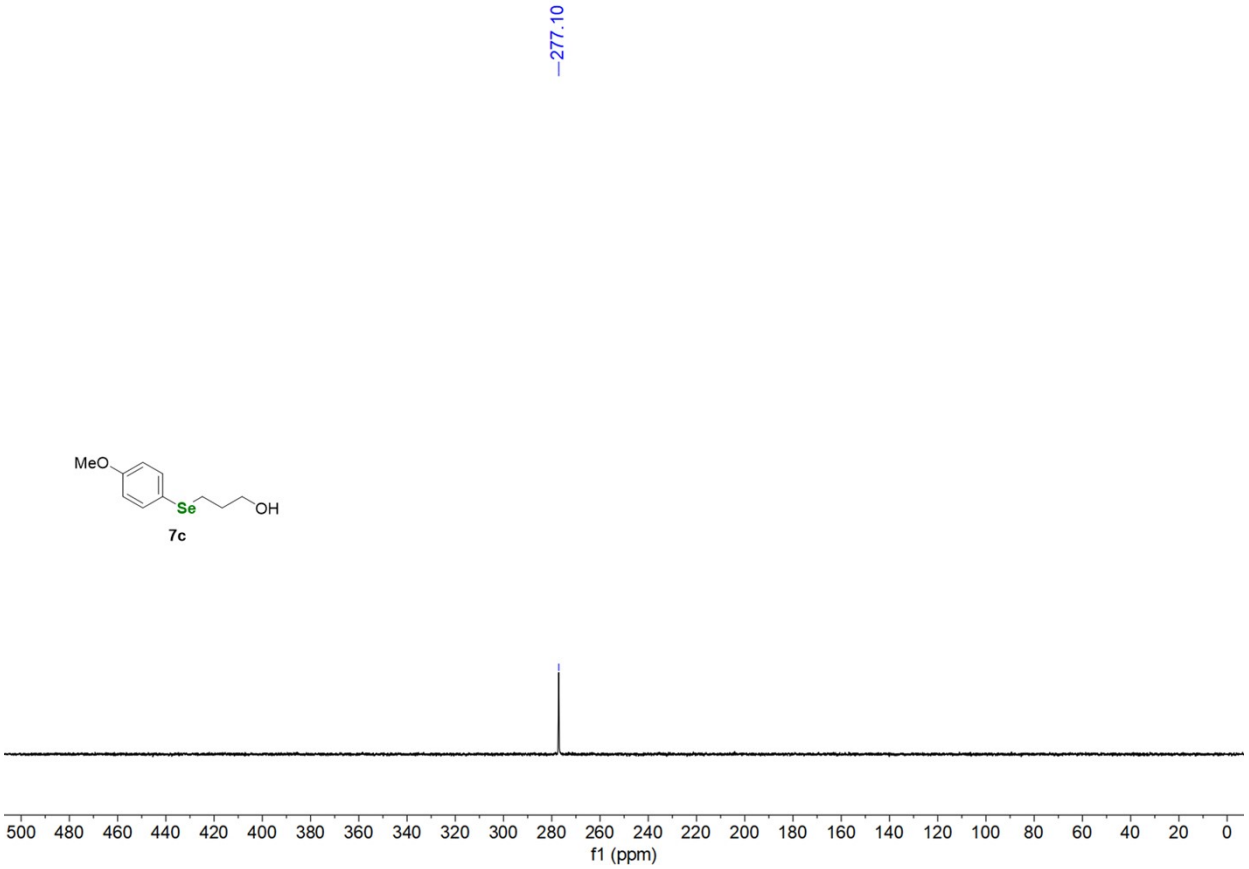
^{1}H NMR spectra of 7c (400 MHz, $CDCl_3$)



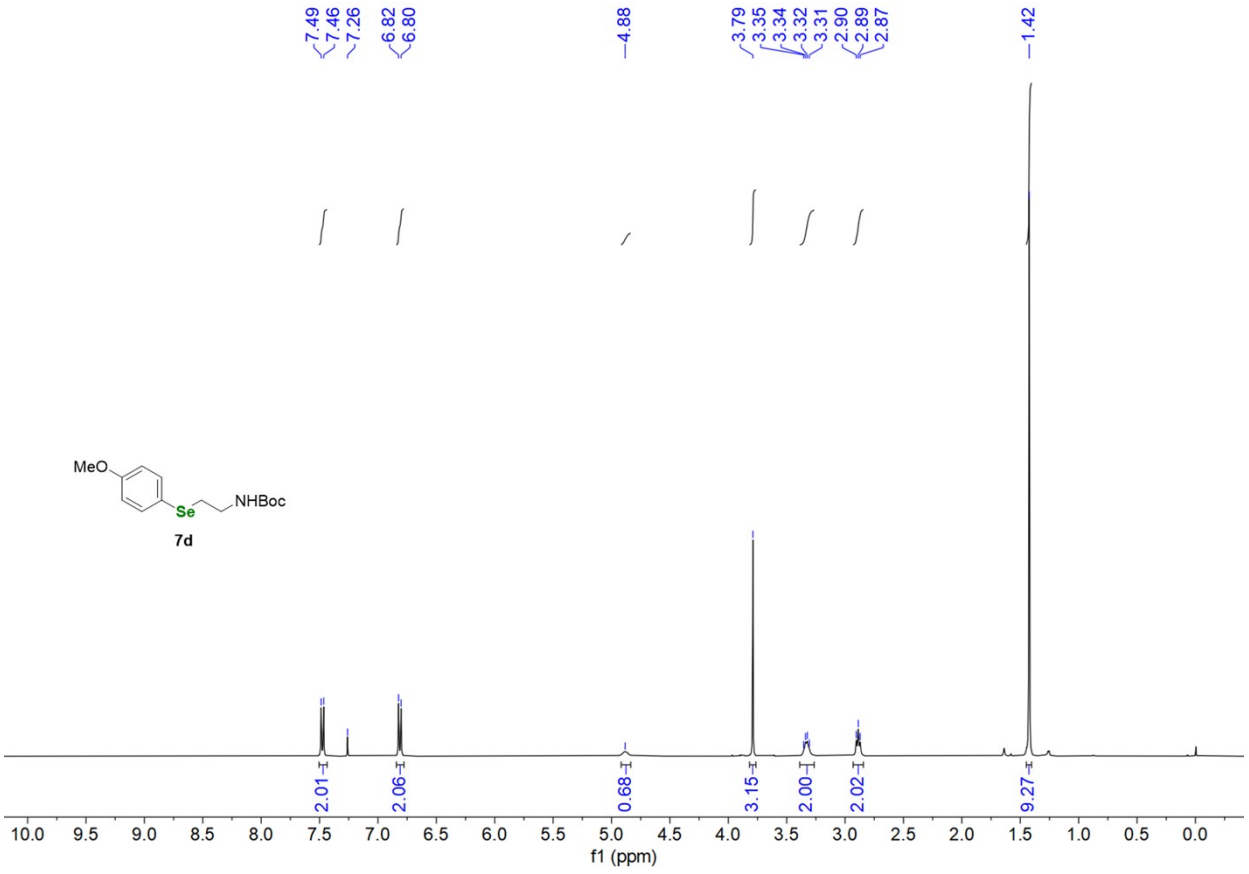
^{13}C NMR spectra of 7c (150 MHz, $CDCl_3$)



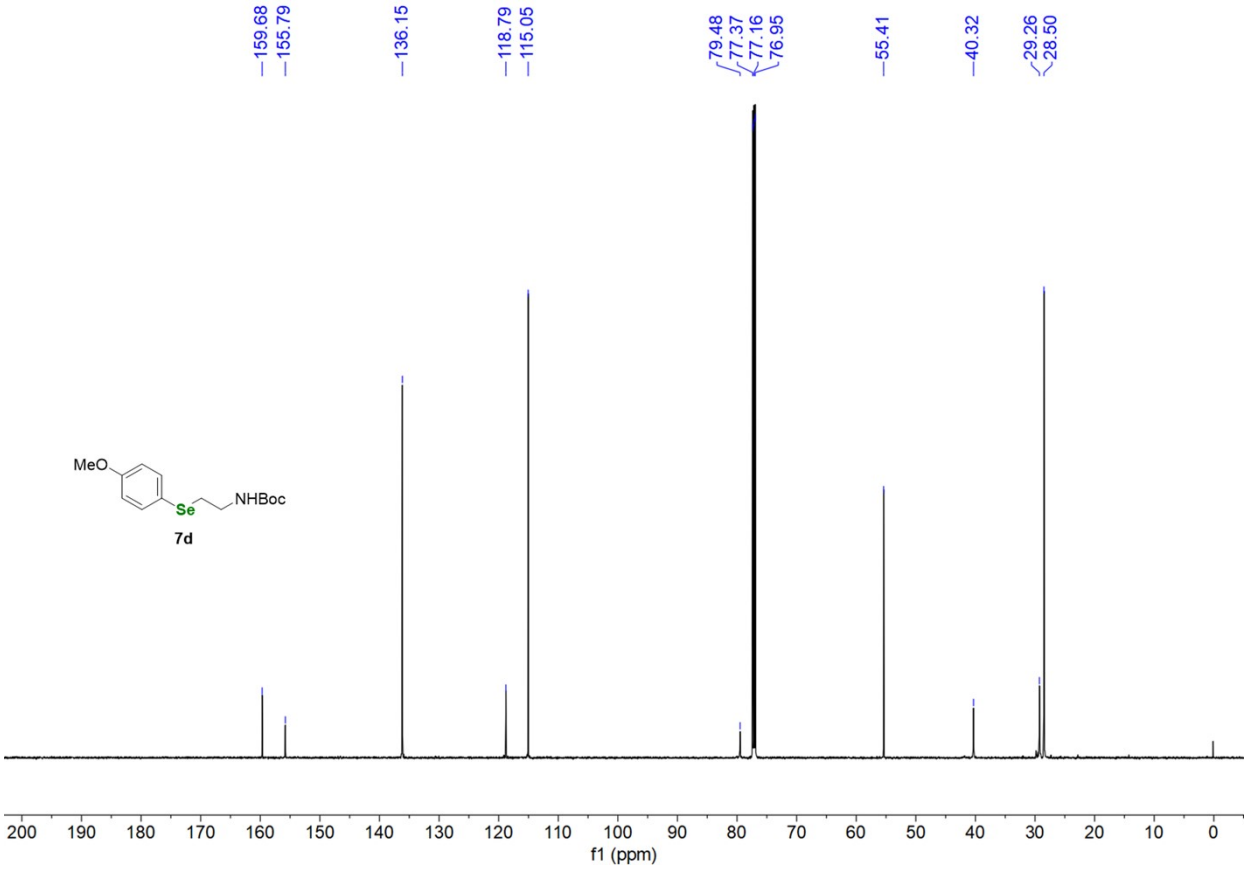
^{77}Se NMR spectra of 7c (114 MHz, $CDCl_3$)



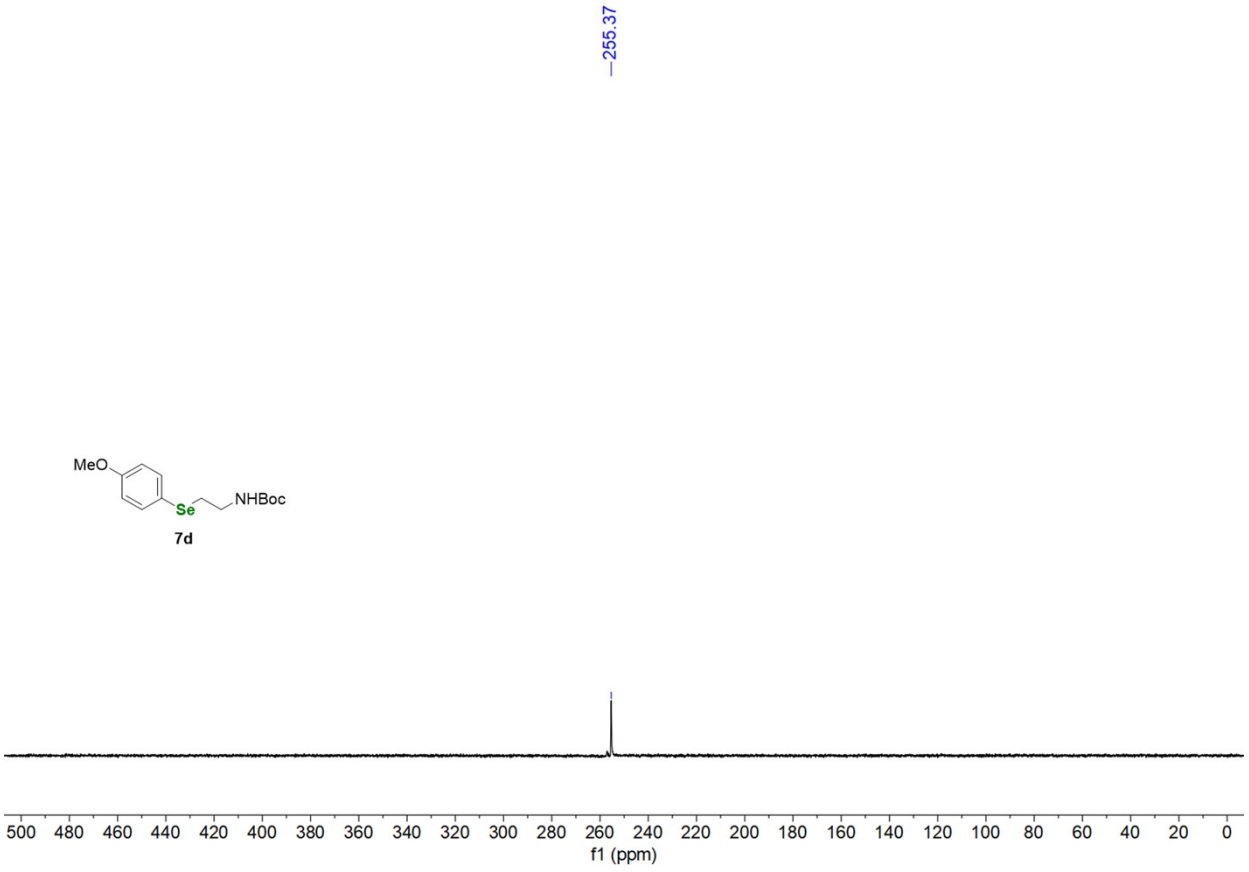
^{1}H NMR spectra of 7d (400 MHz, $CDCl_3$)



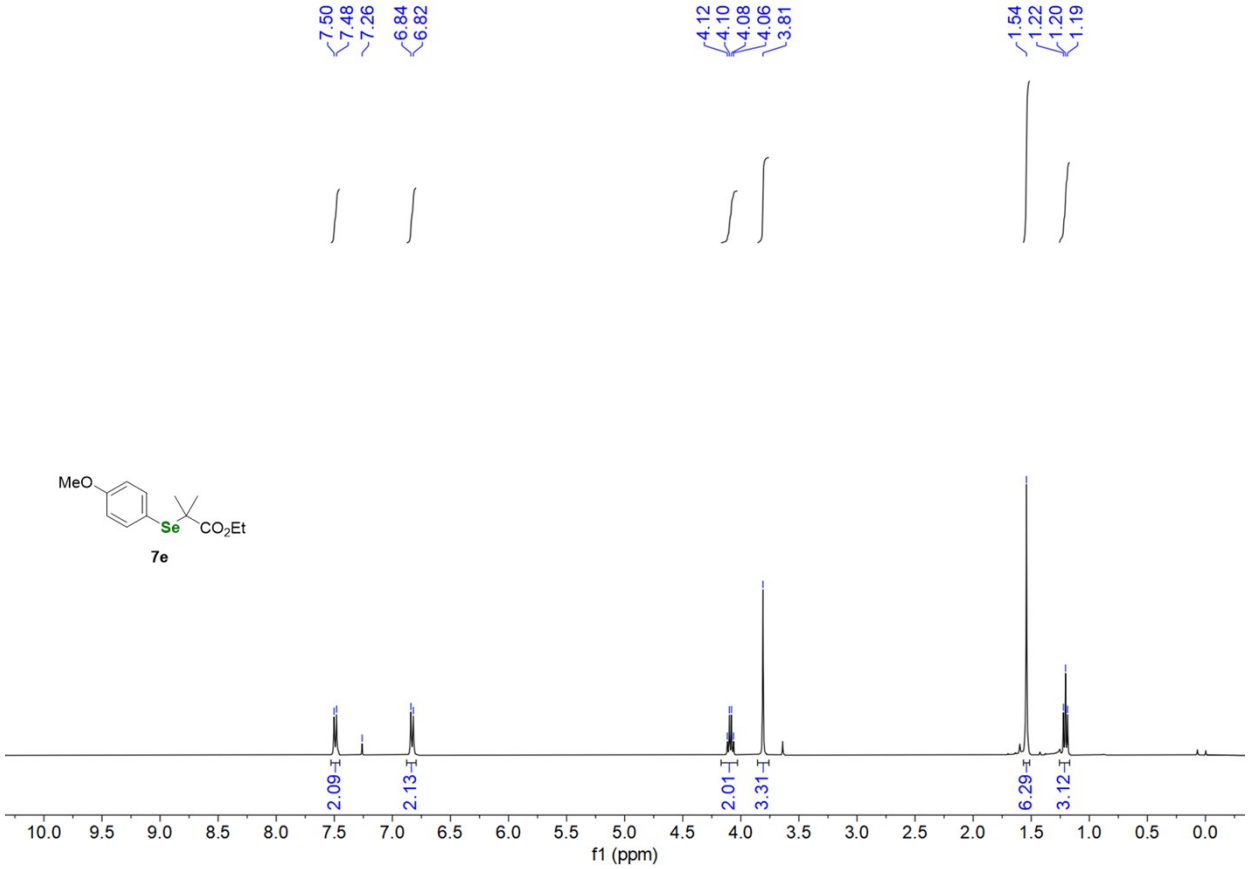
^{13}C NMR spectra of 7d (150 MHz, $CDCl_3$)



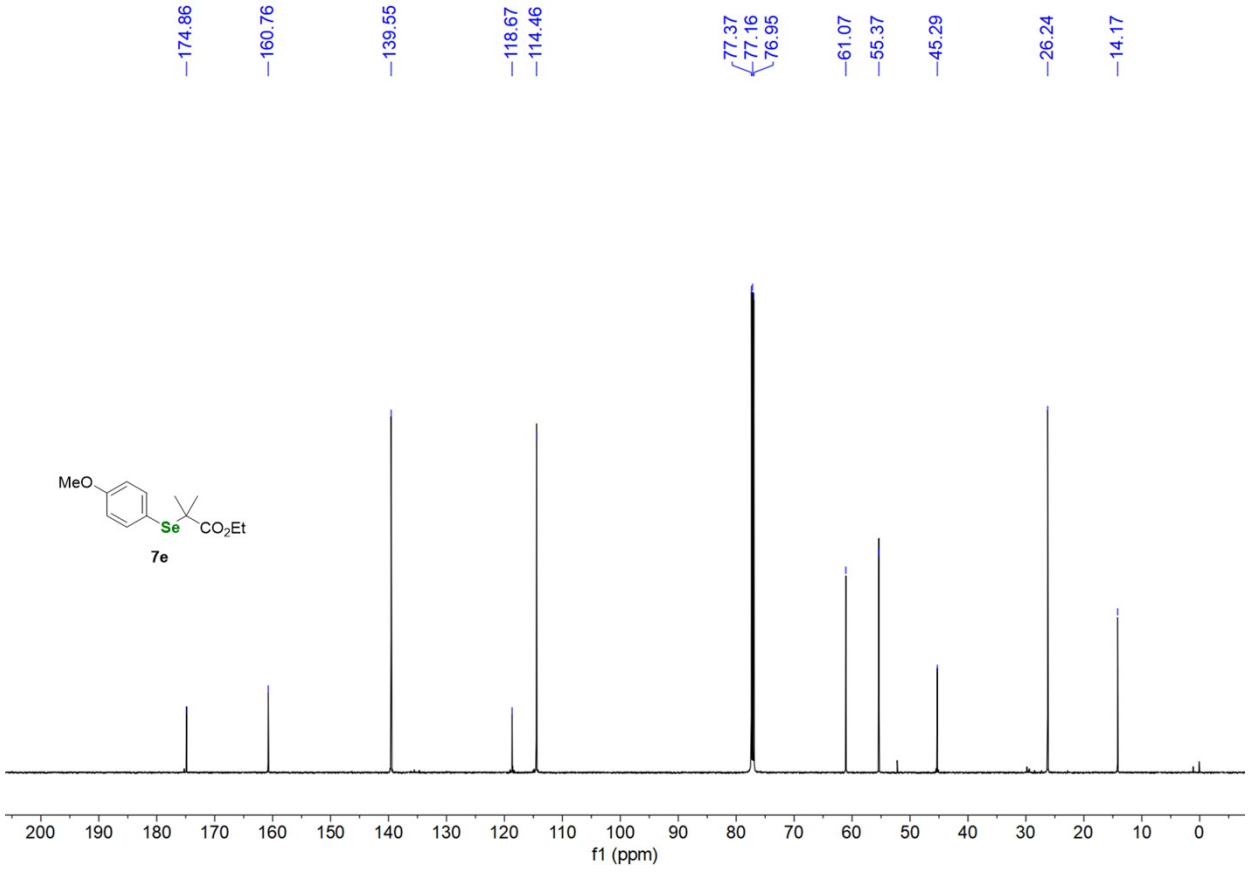
^{77}Se NMR spectra of 7d (114 MHz, $CDCl_3$)



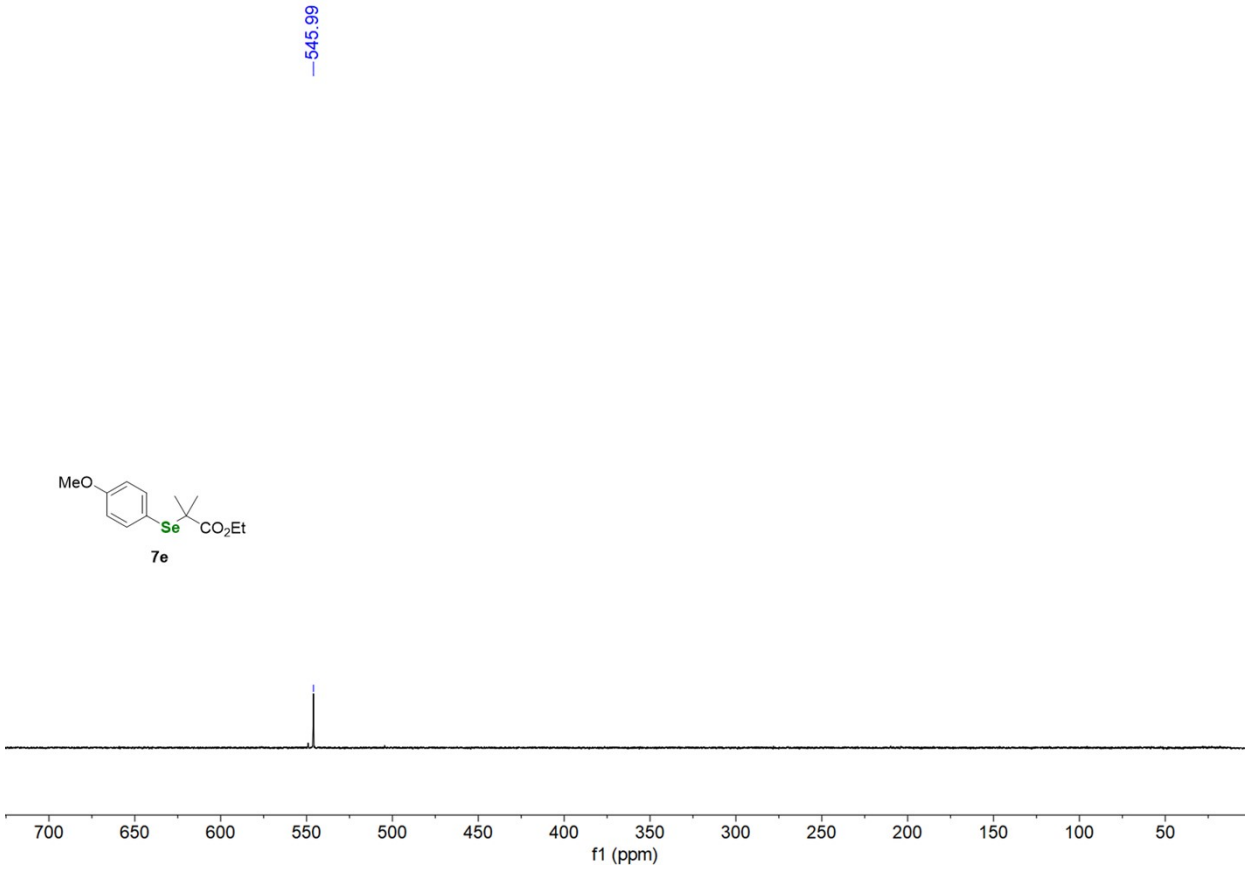
^{1}H NMR spectra of 7e (400 MHz, $CDCl_3$)



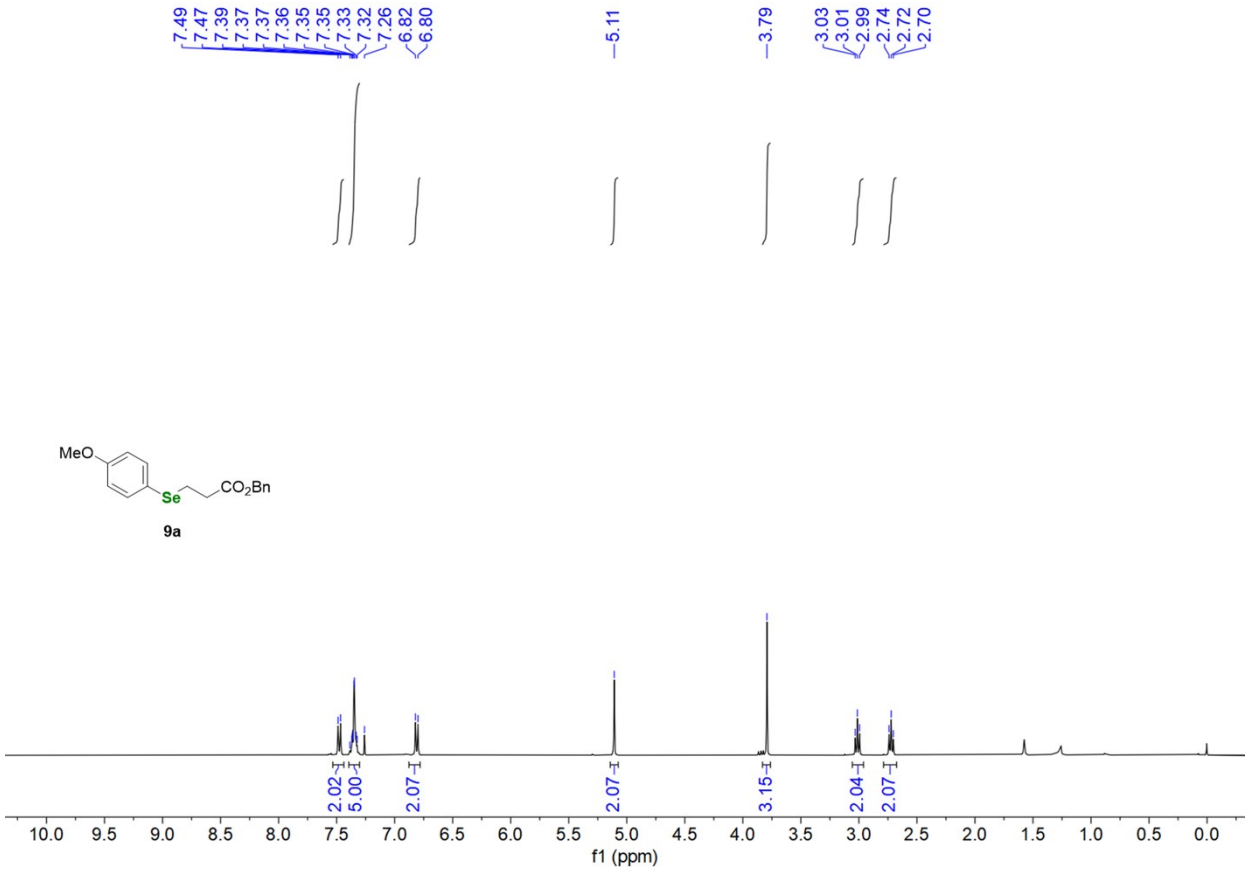
^{13}C NMR spectra of 7e (150 MHz, $CDCl_3$)



^{77}Se NMR spectra of 7e (114 MHz, $CDCl_3$)



^{1}H NMR spectra of 9a (400 MHz, $CDCl_3$)



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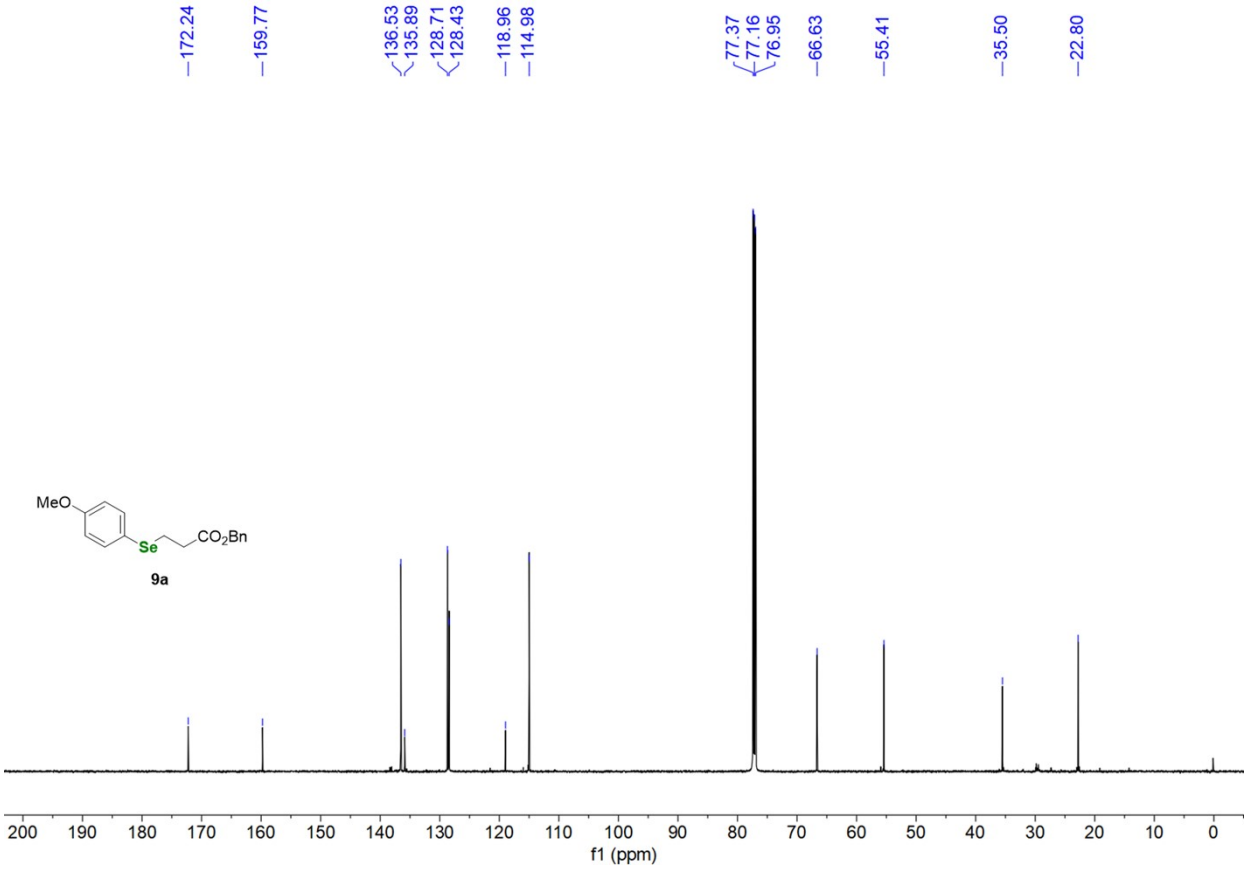
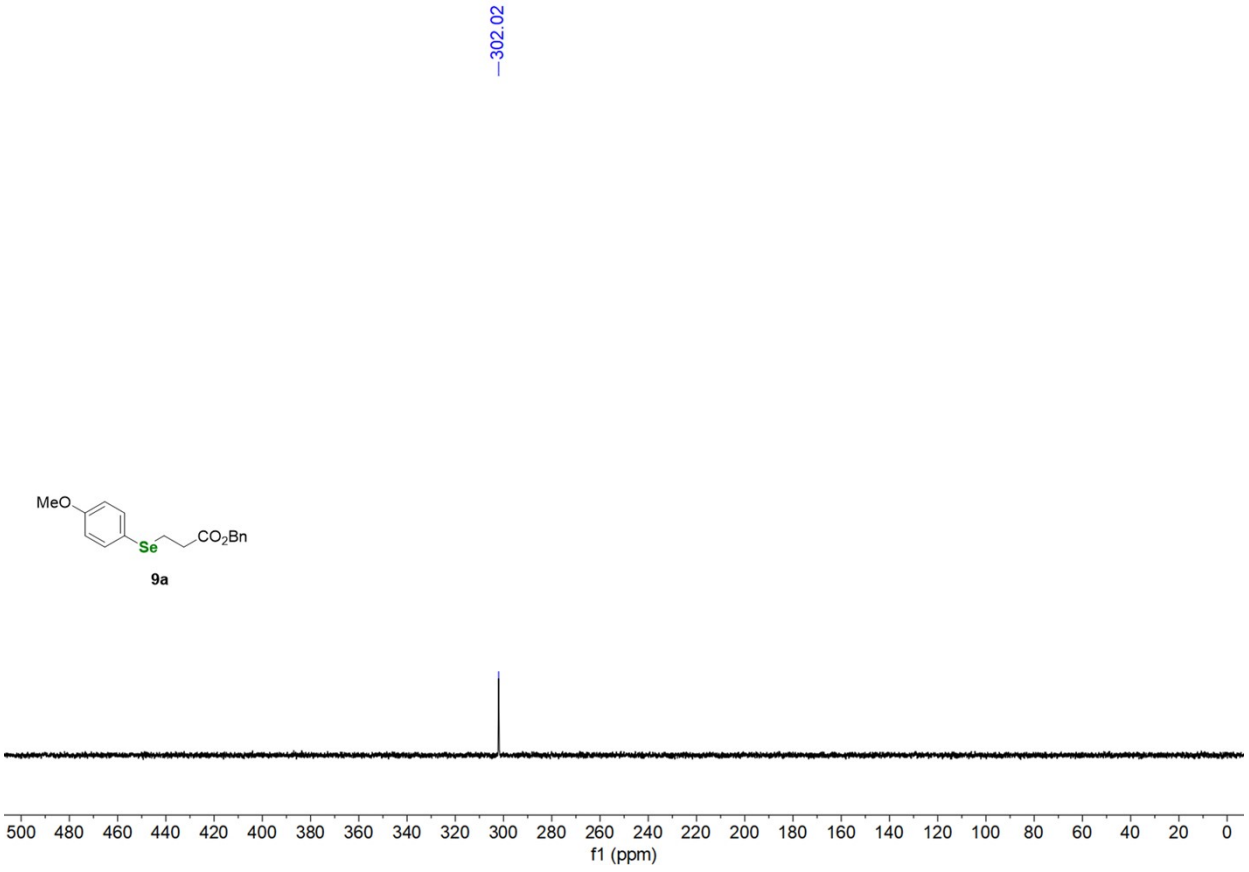


^{77}Se NMR spectra of 9a (114 MHz, $CDCl_3$)



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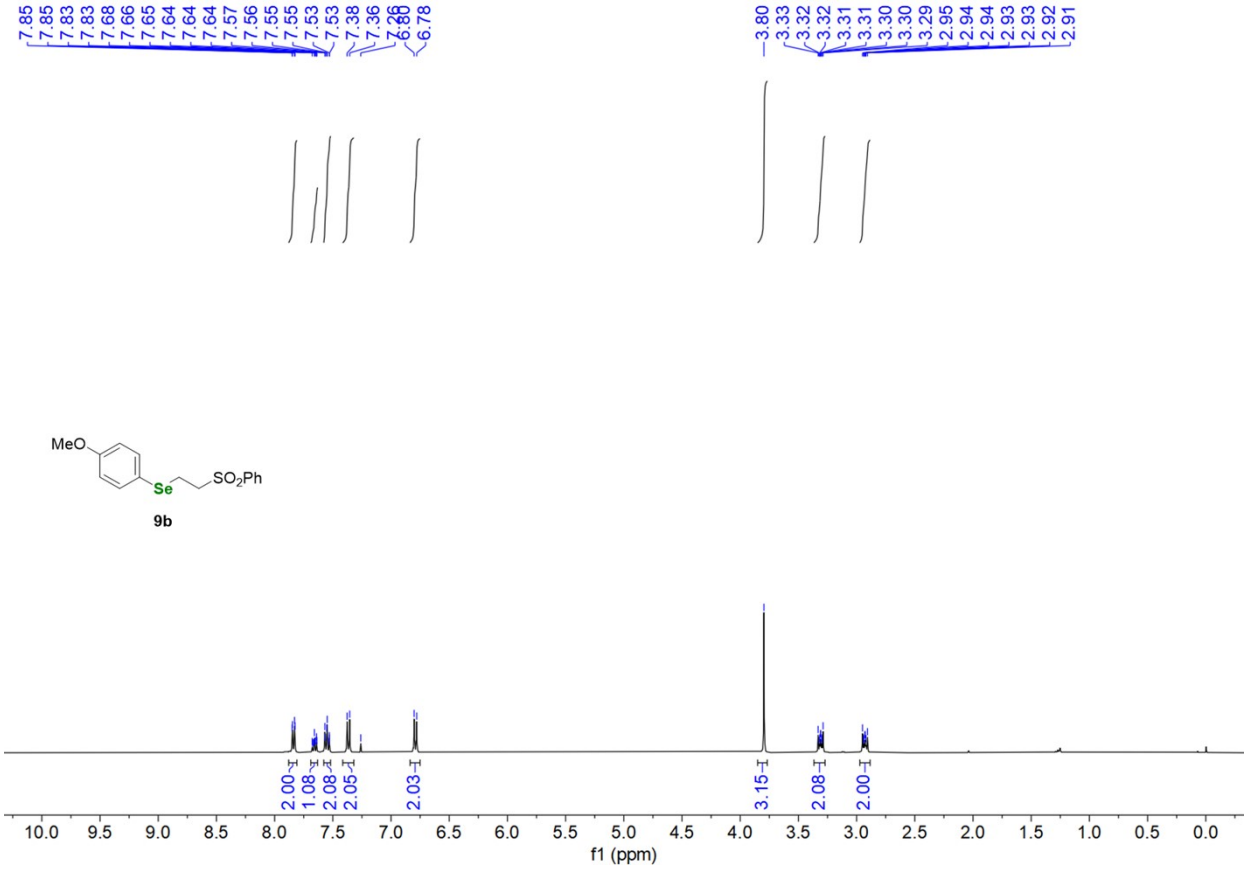

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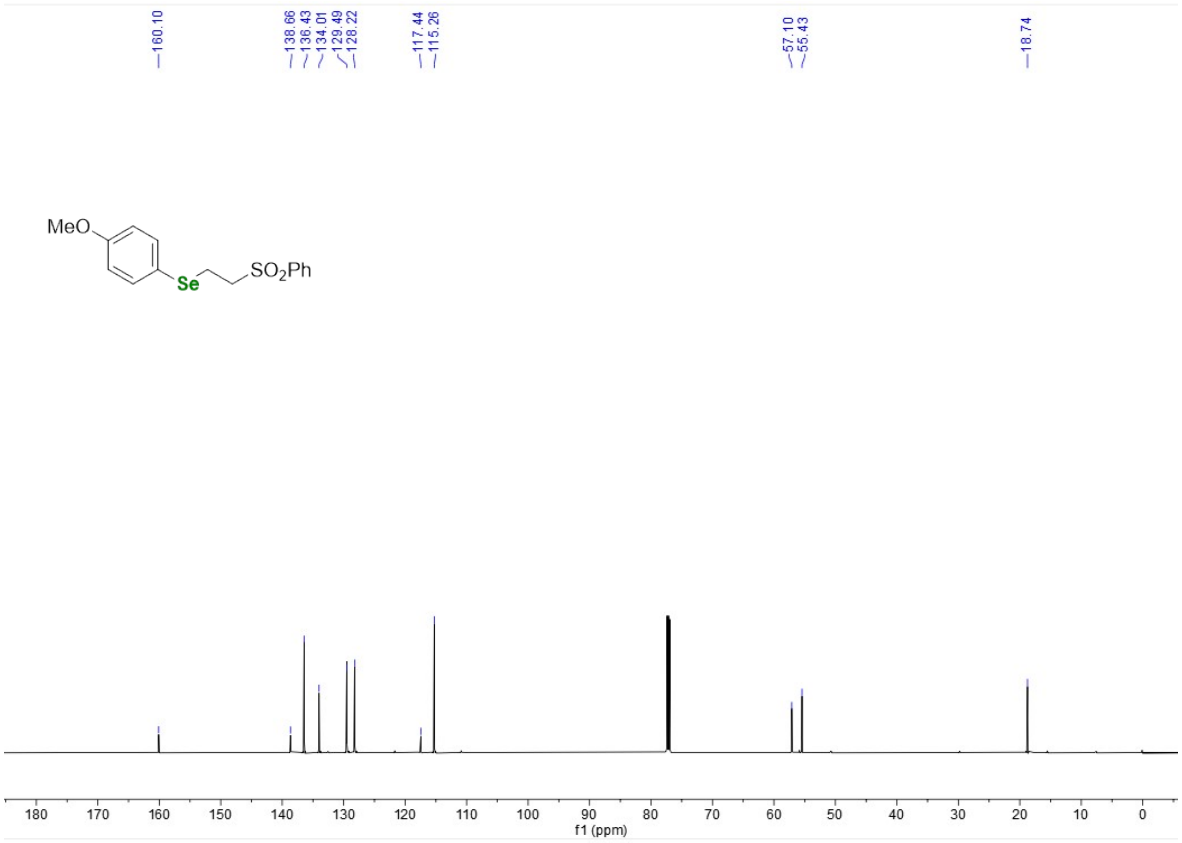
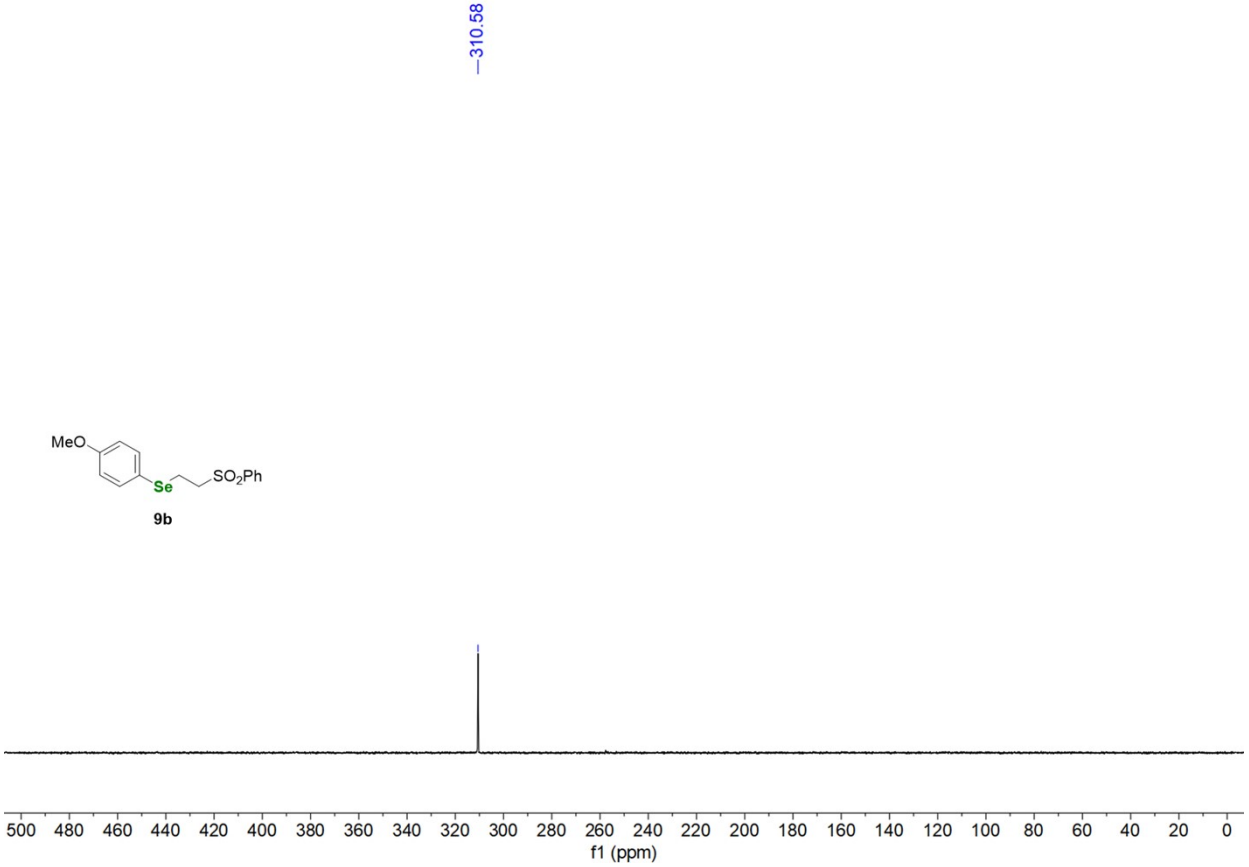


^{77}Se NMR spectra of 9b (114 MHz, $CDCl_3$)



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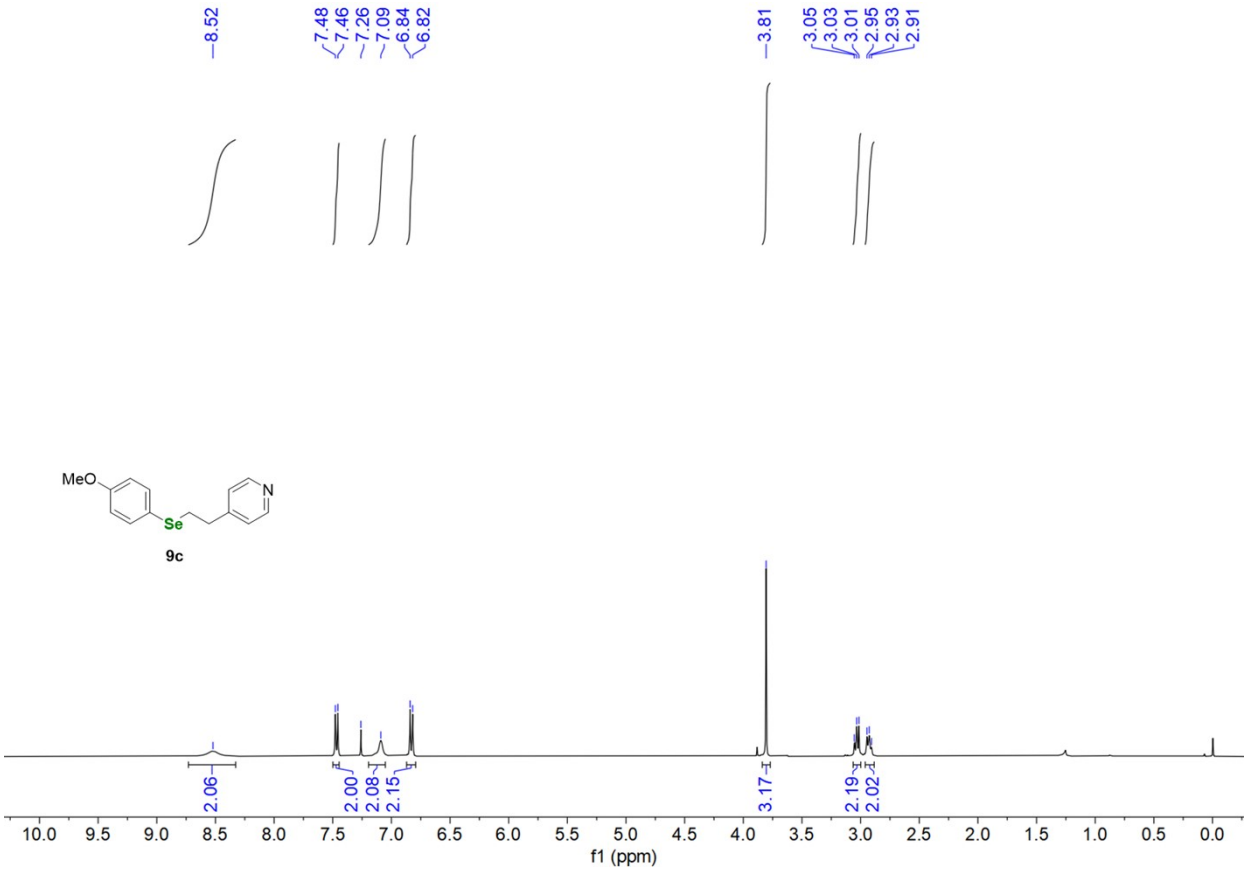
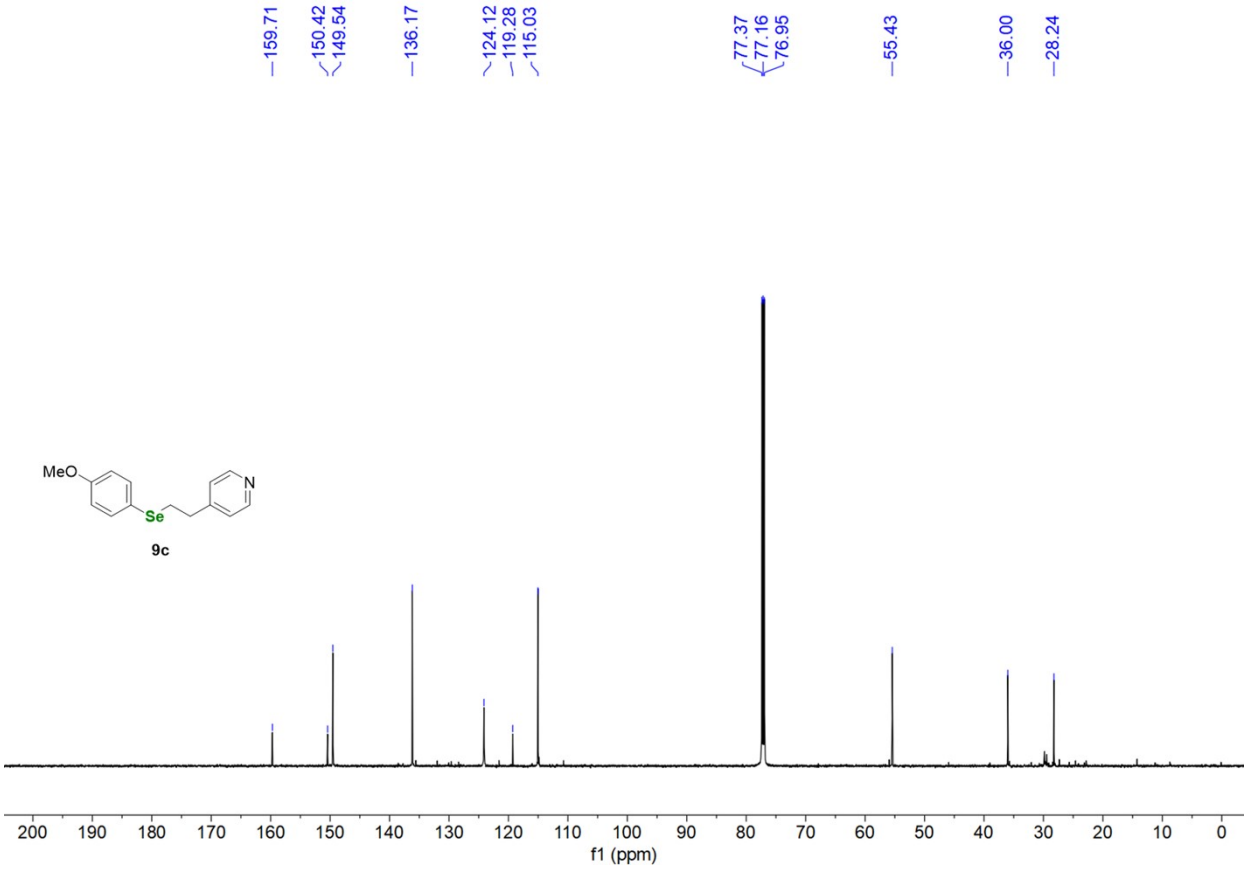
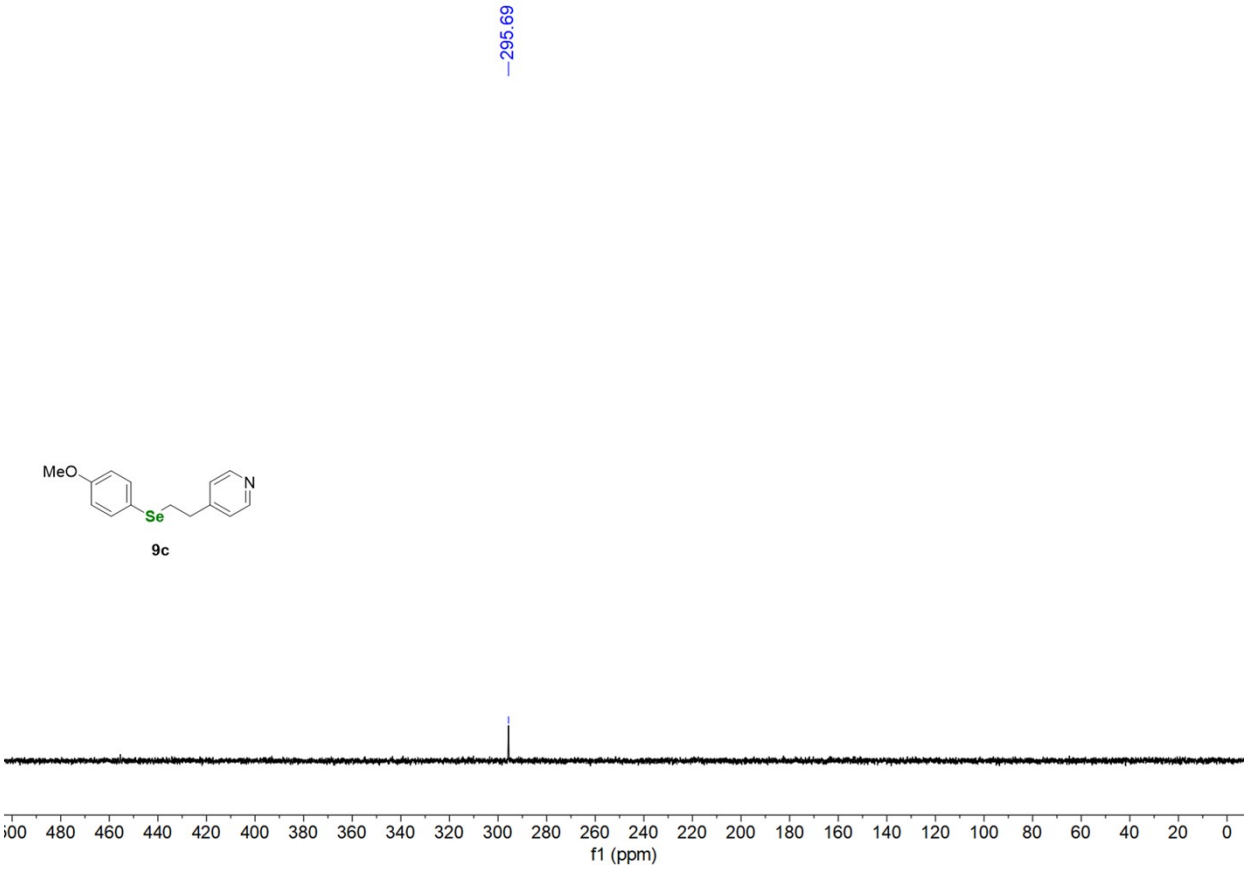


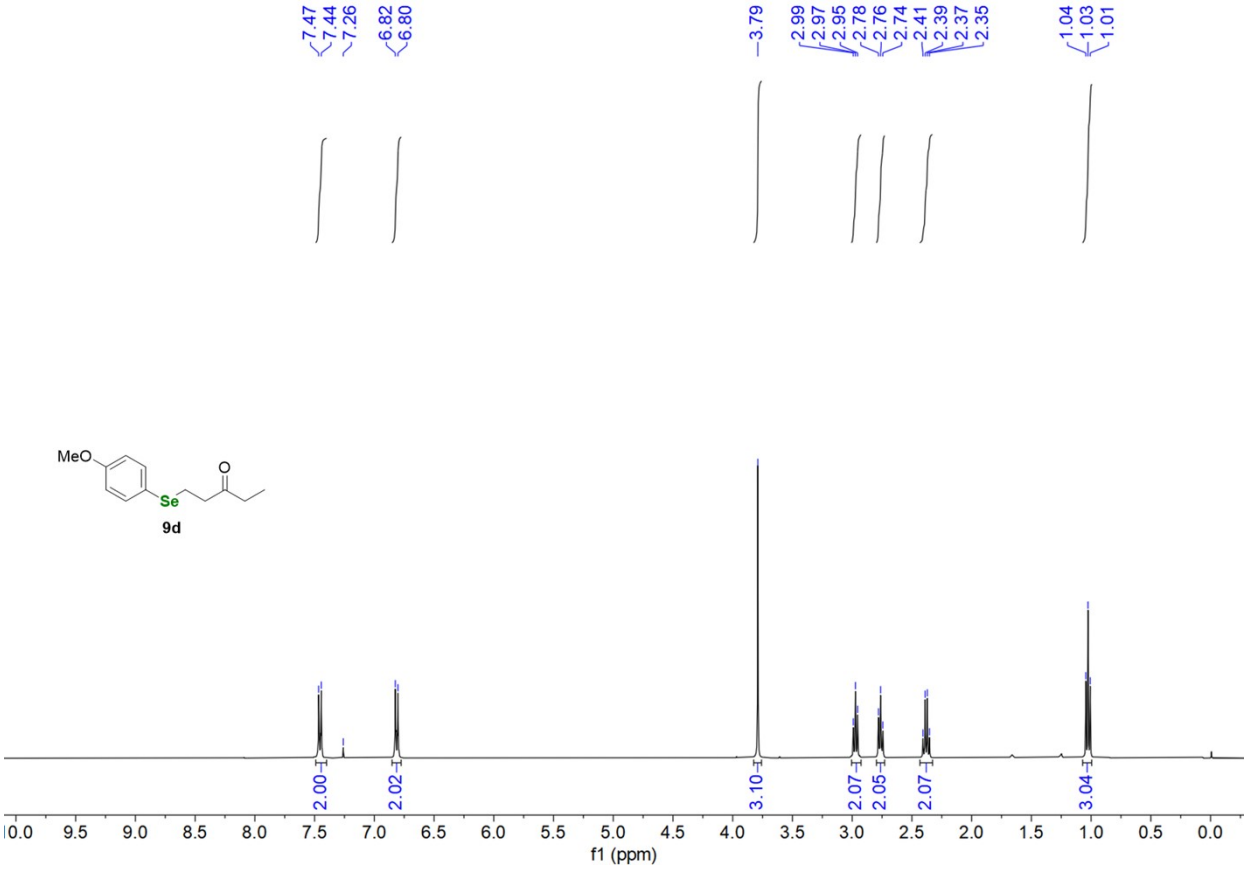
^{13}C NMR spectra of 9c (150 MHz, $CDCl_3$)



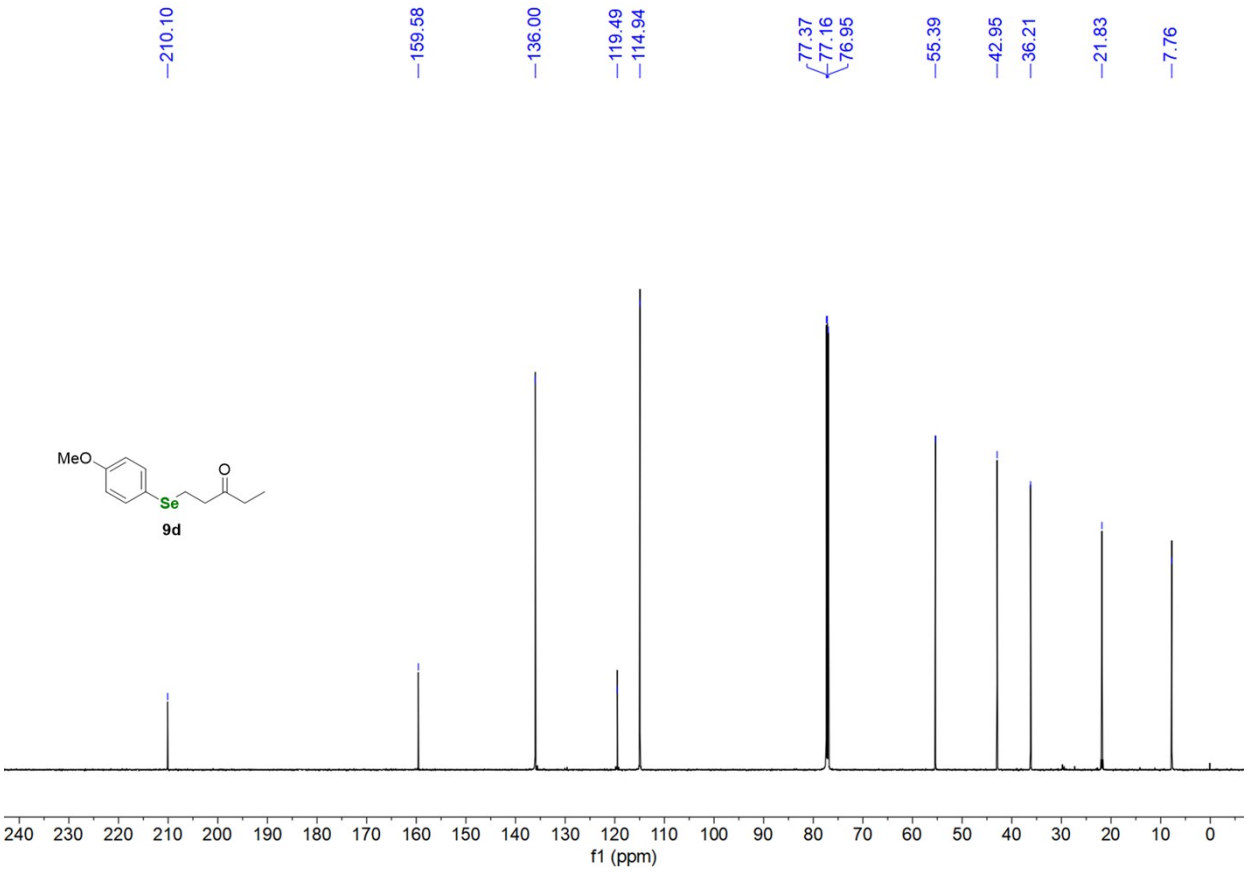
^{77}Se NMR spectra of 9c (114 MHz, $CDCl_3$)



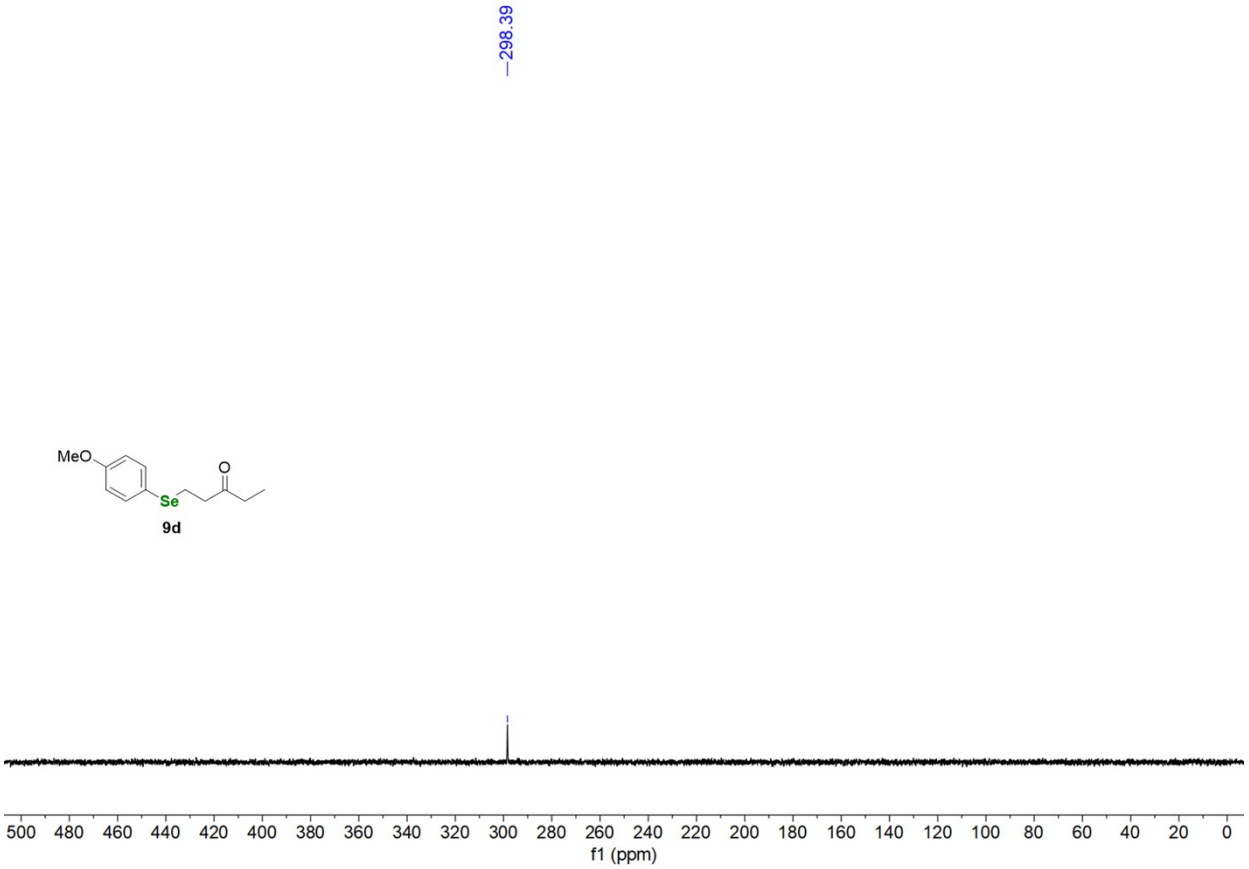
^{1}H NMR spectra of 9d (400 MHz, $CDCl_3$)



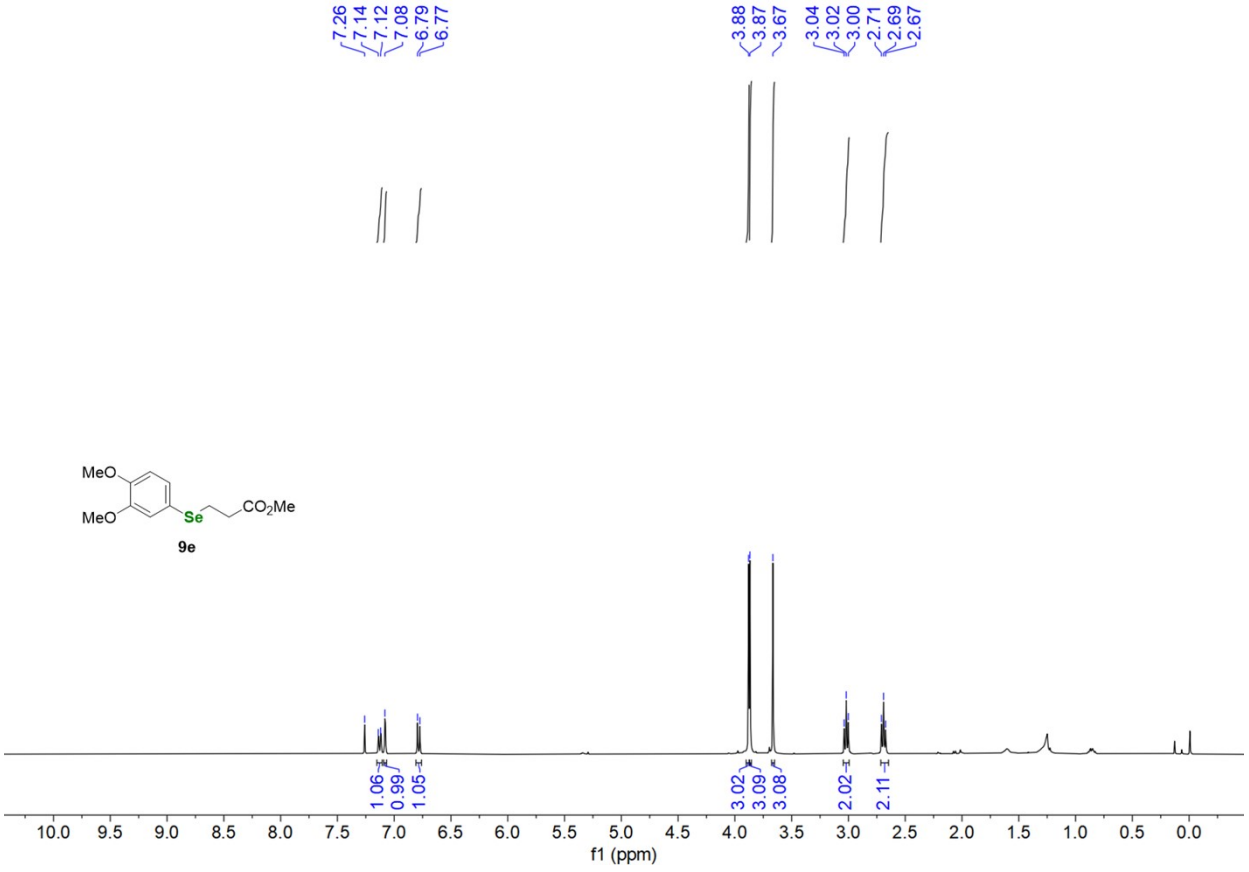
^{13}C NMR spectra of 9d (150 MHz, $CDCl_3$)



^{77}Se NMR spectra of 9d (114 MHz, $CDCl_3$)



^{1}H NMR spectra of 9e (400 MHz, $CDCl_3$)



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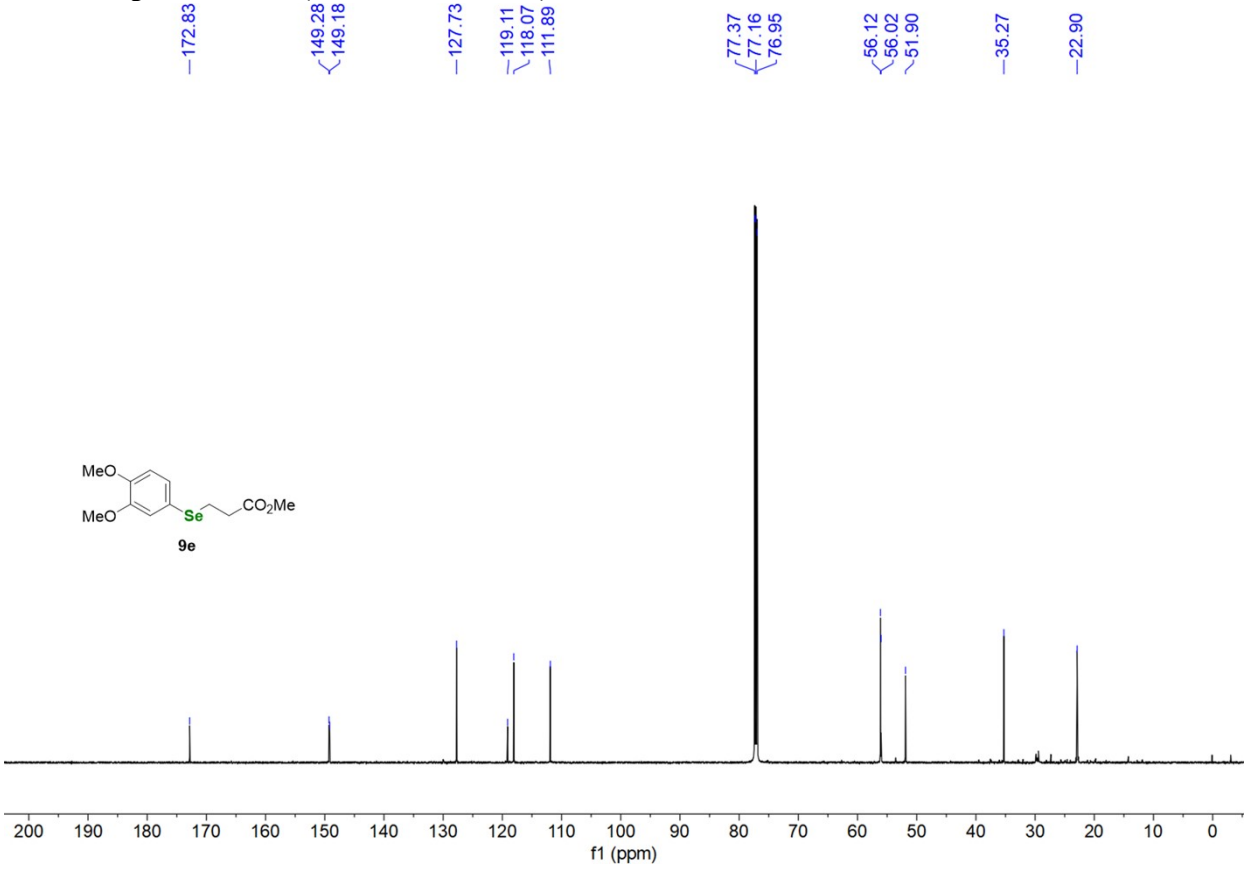
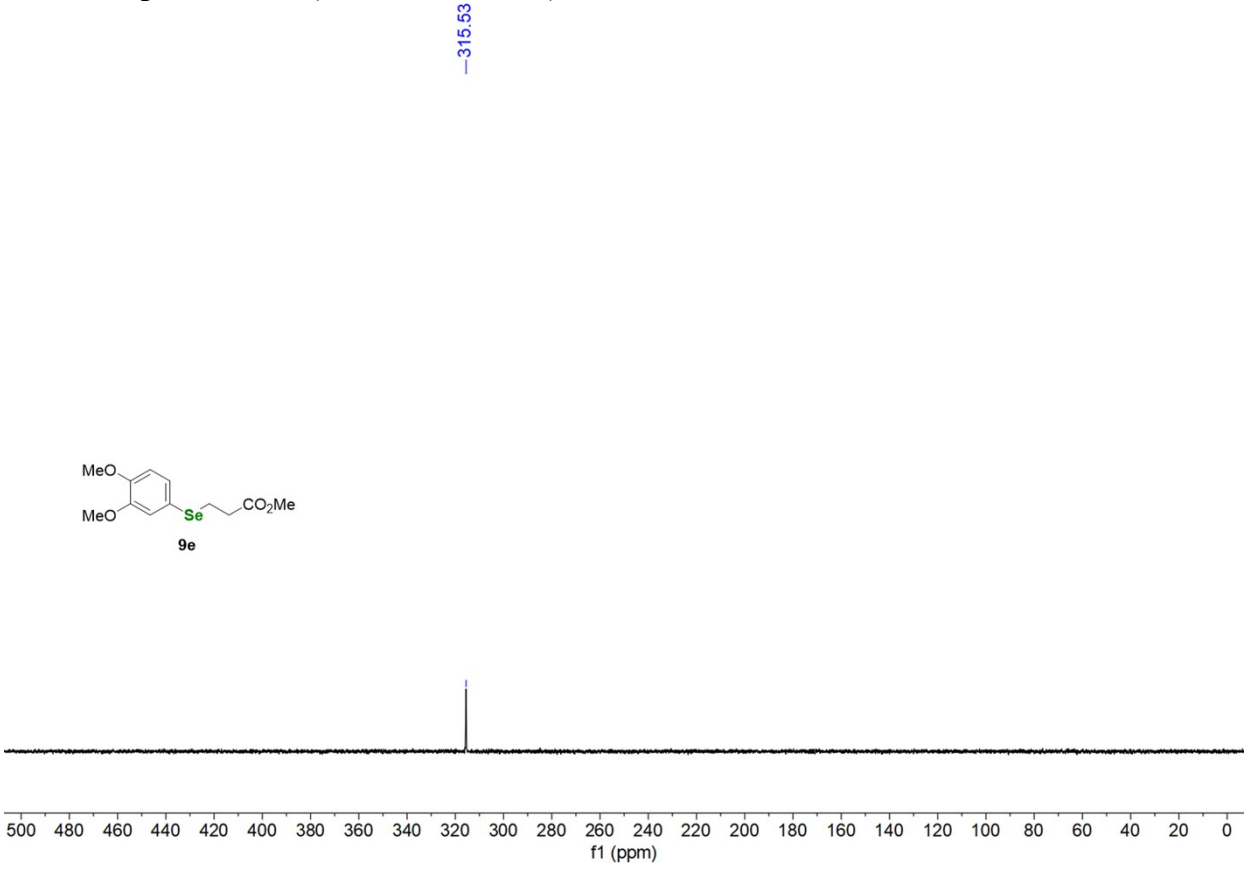
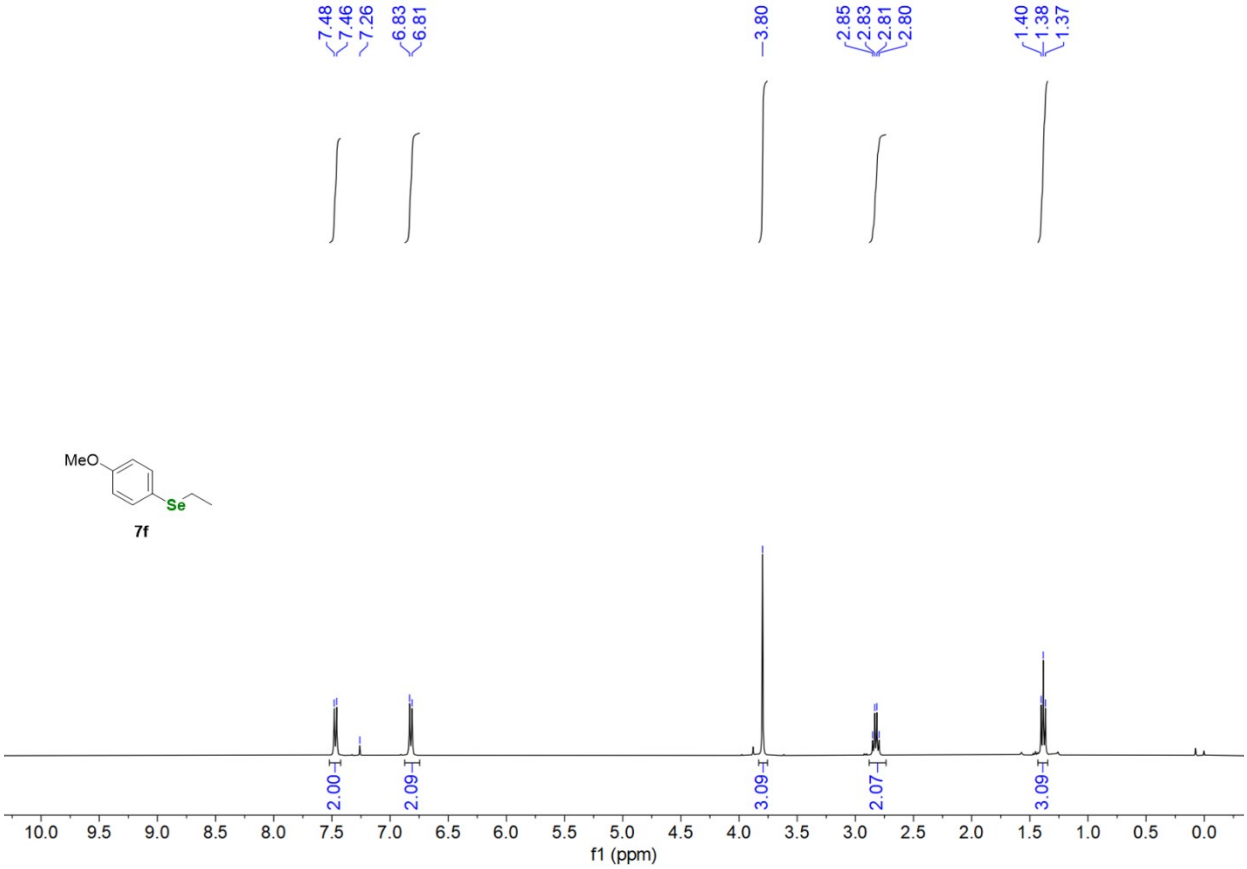


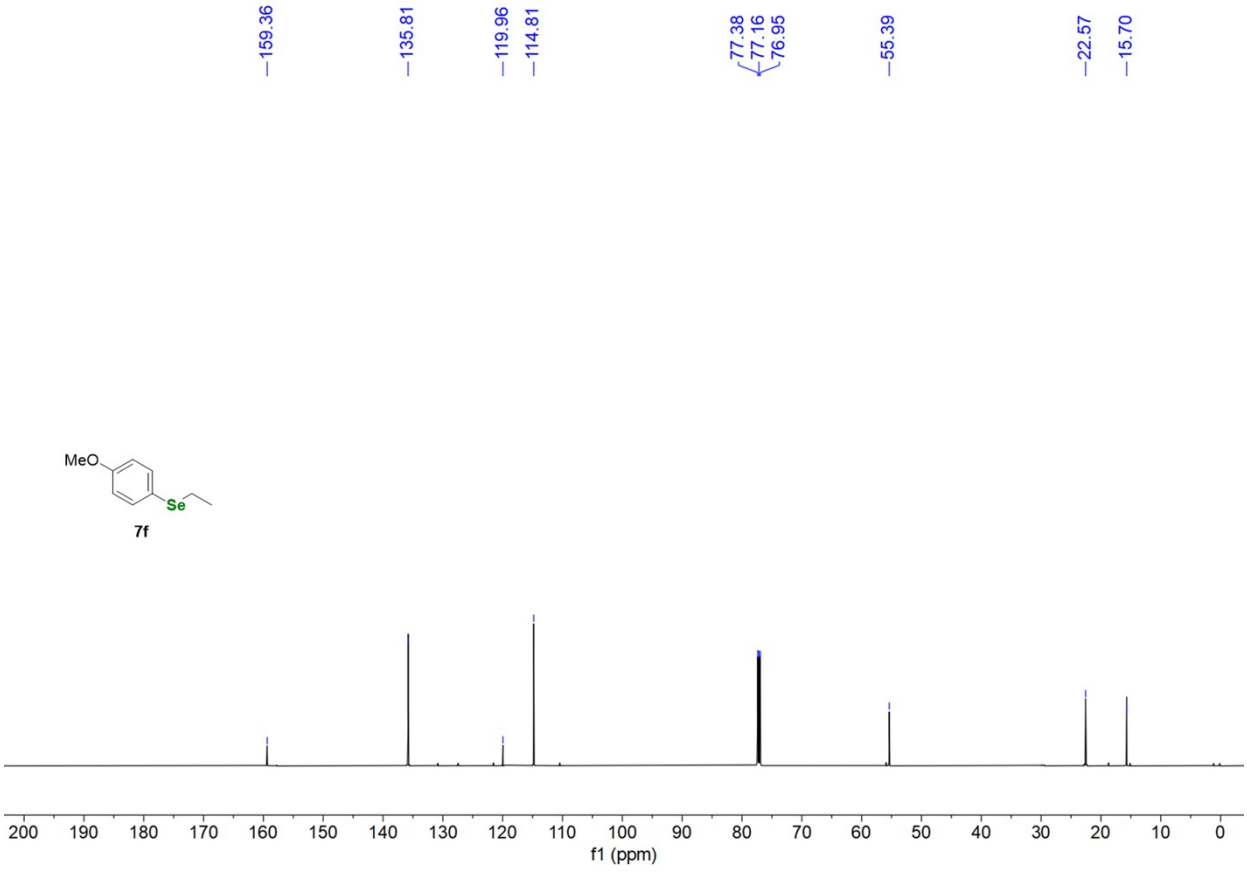
^{77}Se NMR spectra of 9e (114 MHz, $CDCl_3$)



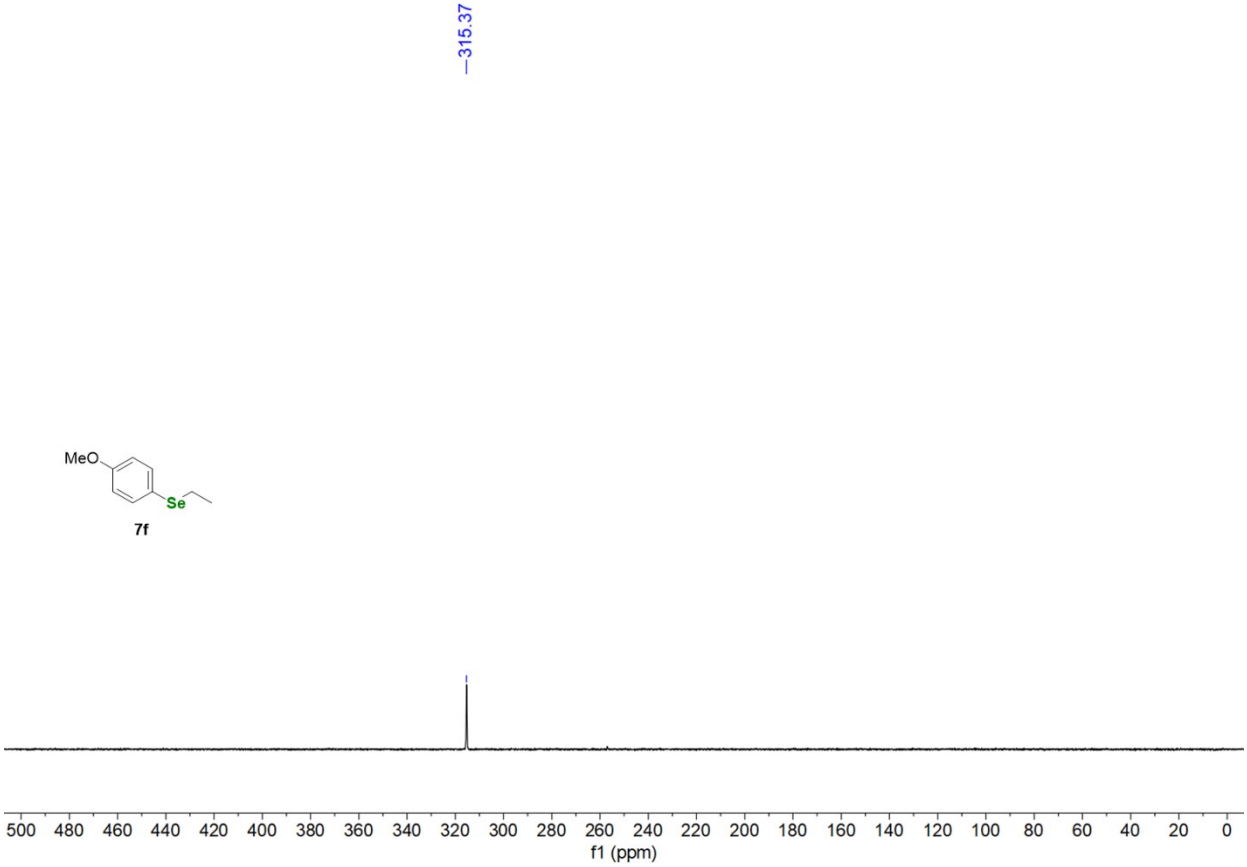
^{1}H NMR spectra of 7f (400 MHz, $CDCl_3$)



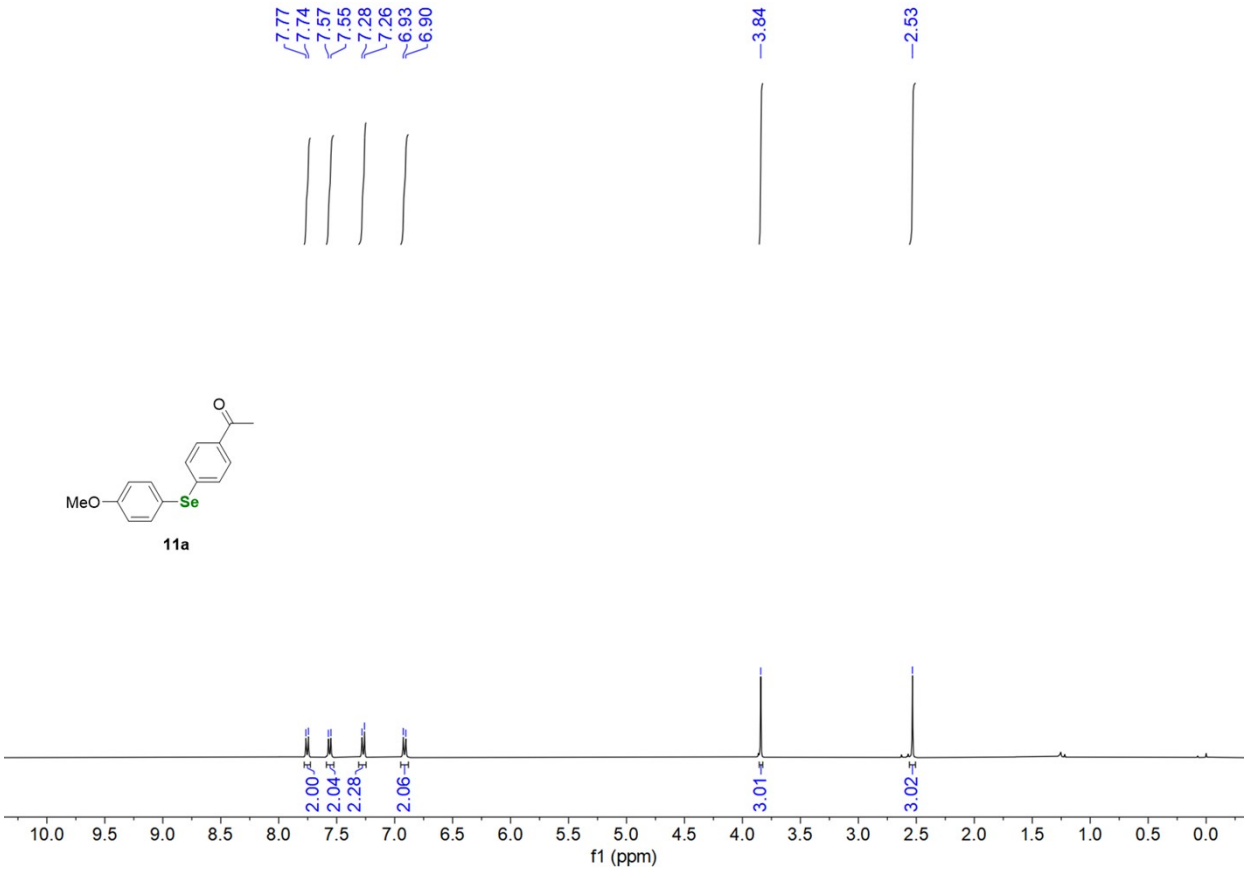
^{13}C NMR spectra of 7f (150 MHz, $CDCl_3$)



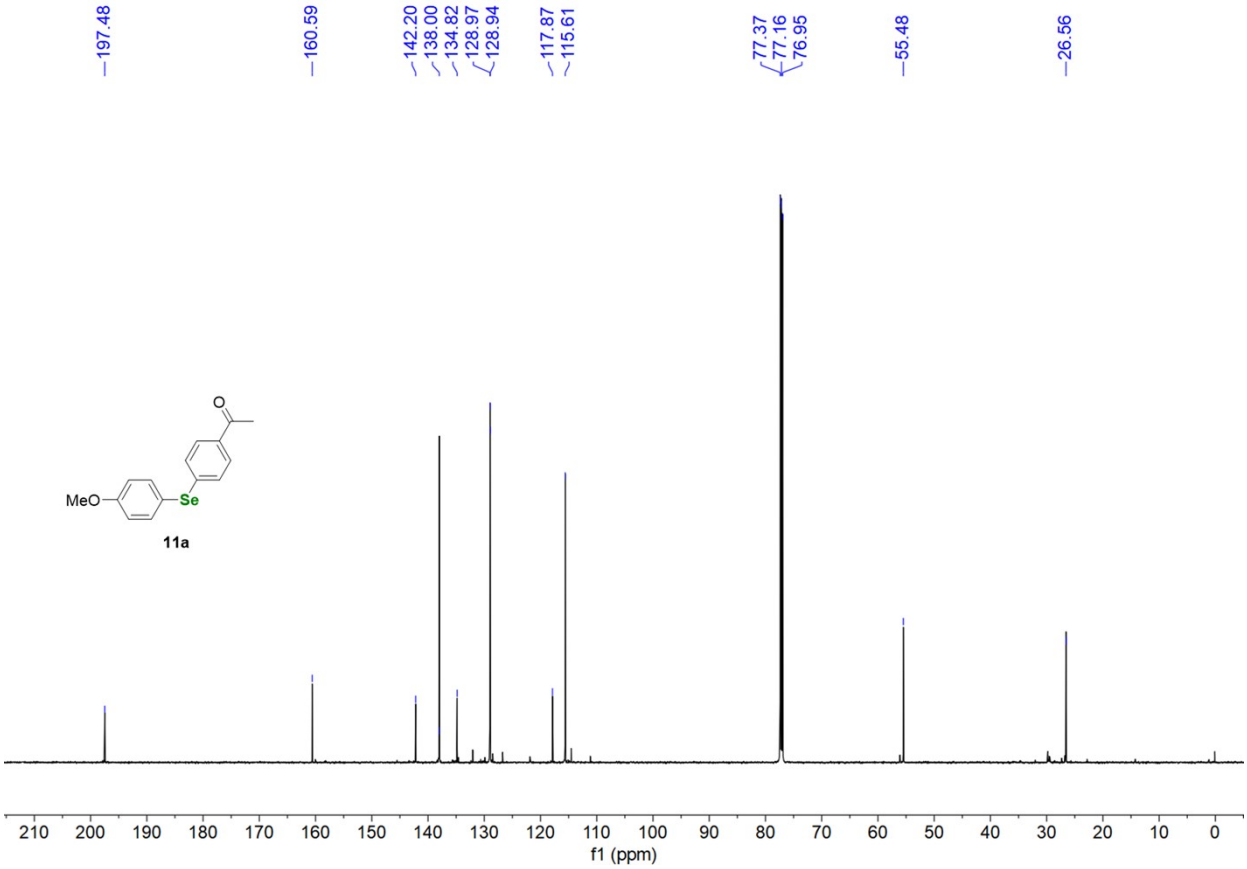
^{77}Se NMR spectra of 7f (114 MHz, $CDCl_3$)



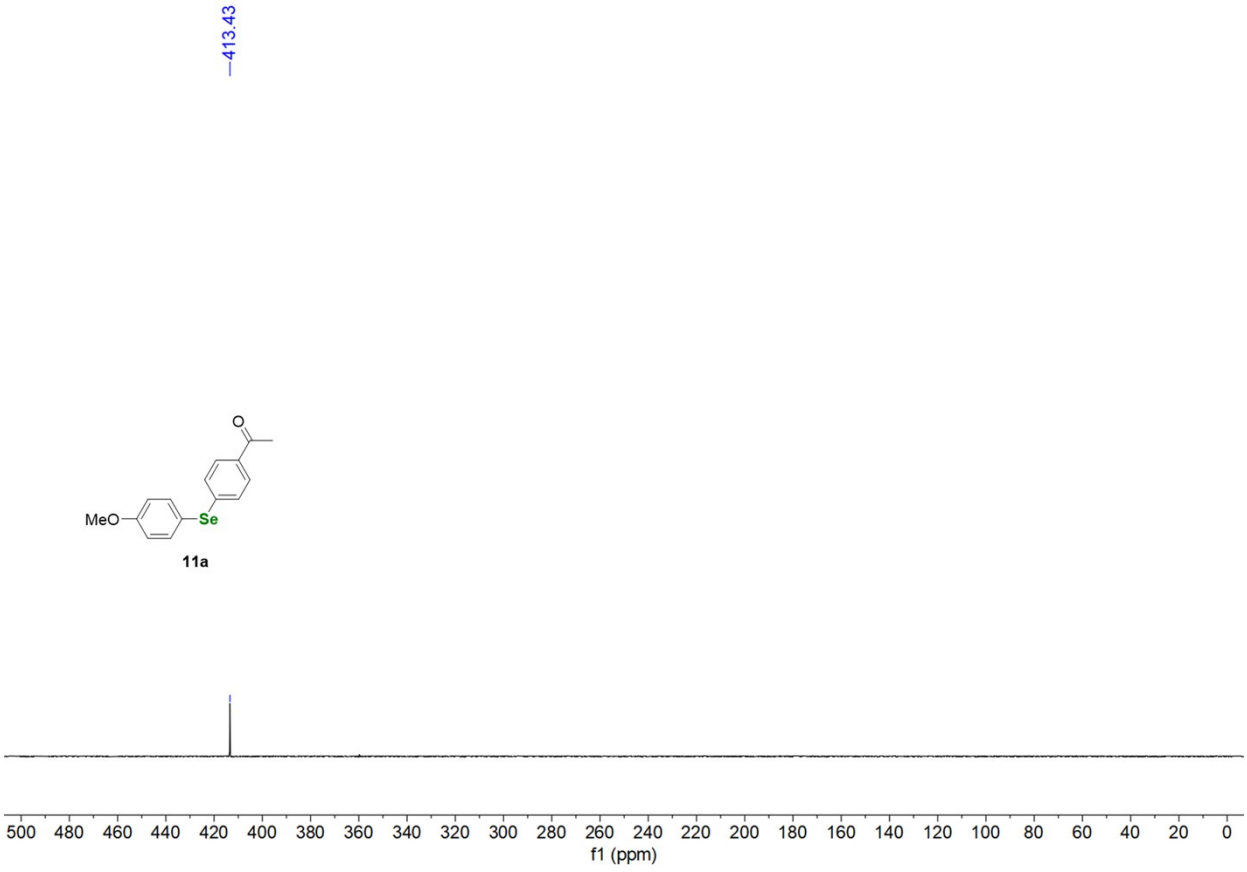
^{1}H NMR spectra of 11a (400 MHz, $CDCl_3$)



^{13}C NMR spectra of 11a (150 MHz, $CDCl_3$)



^{77}Se NMR spectra of 11a (114 MHz, $CDCl_3$)



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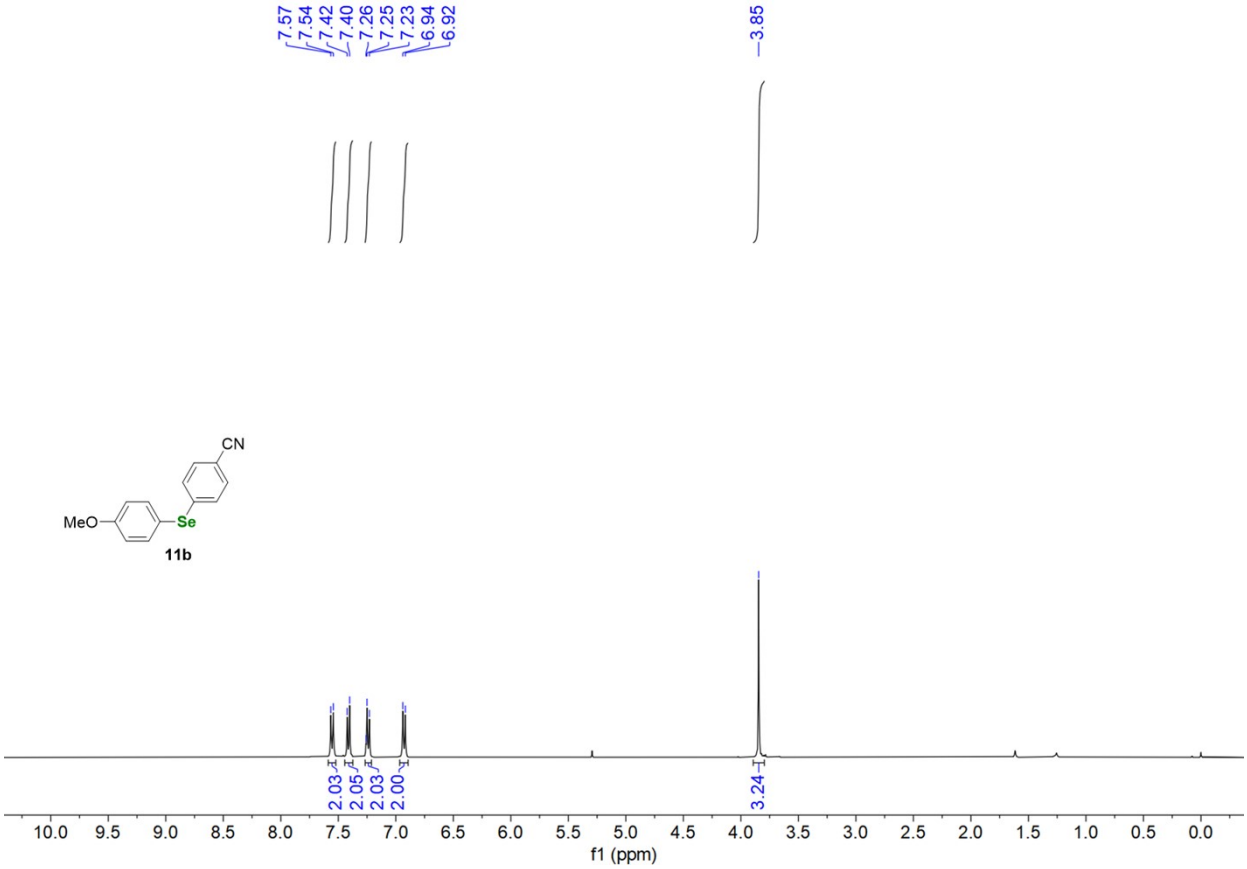
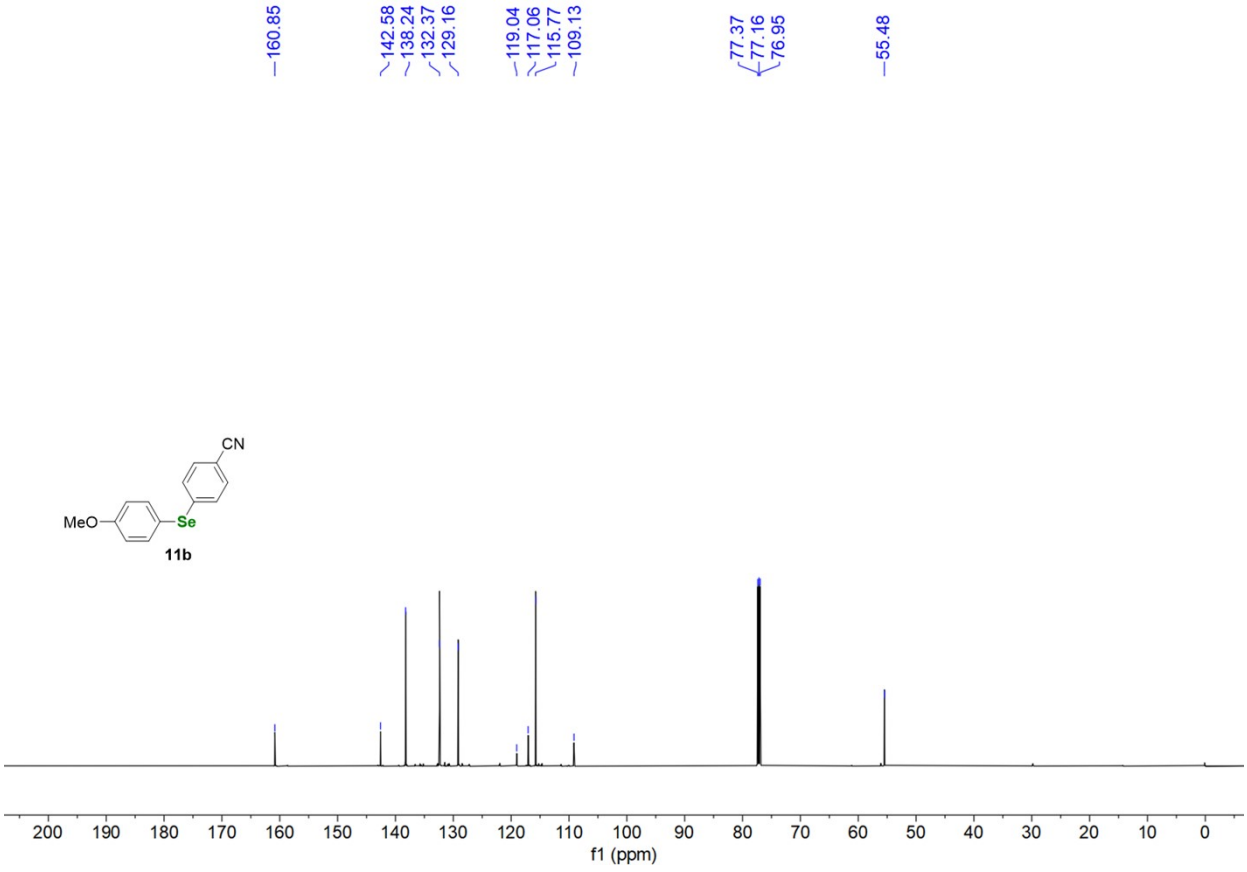
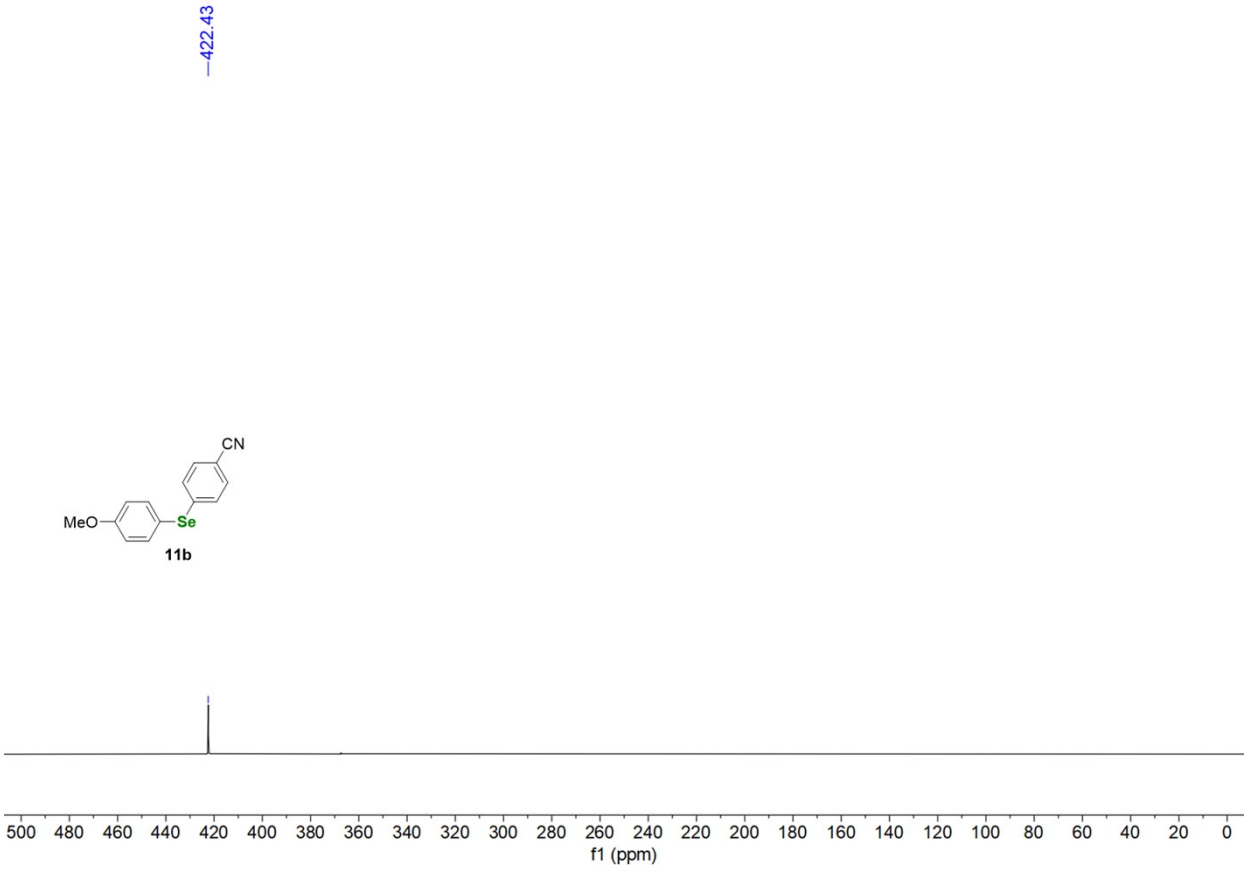


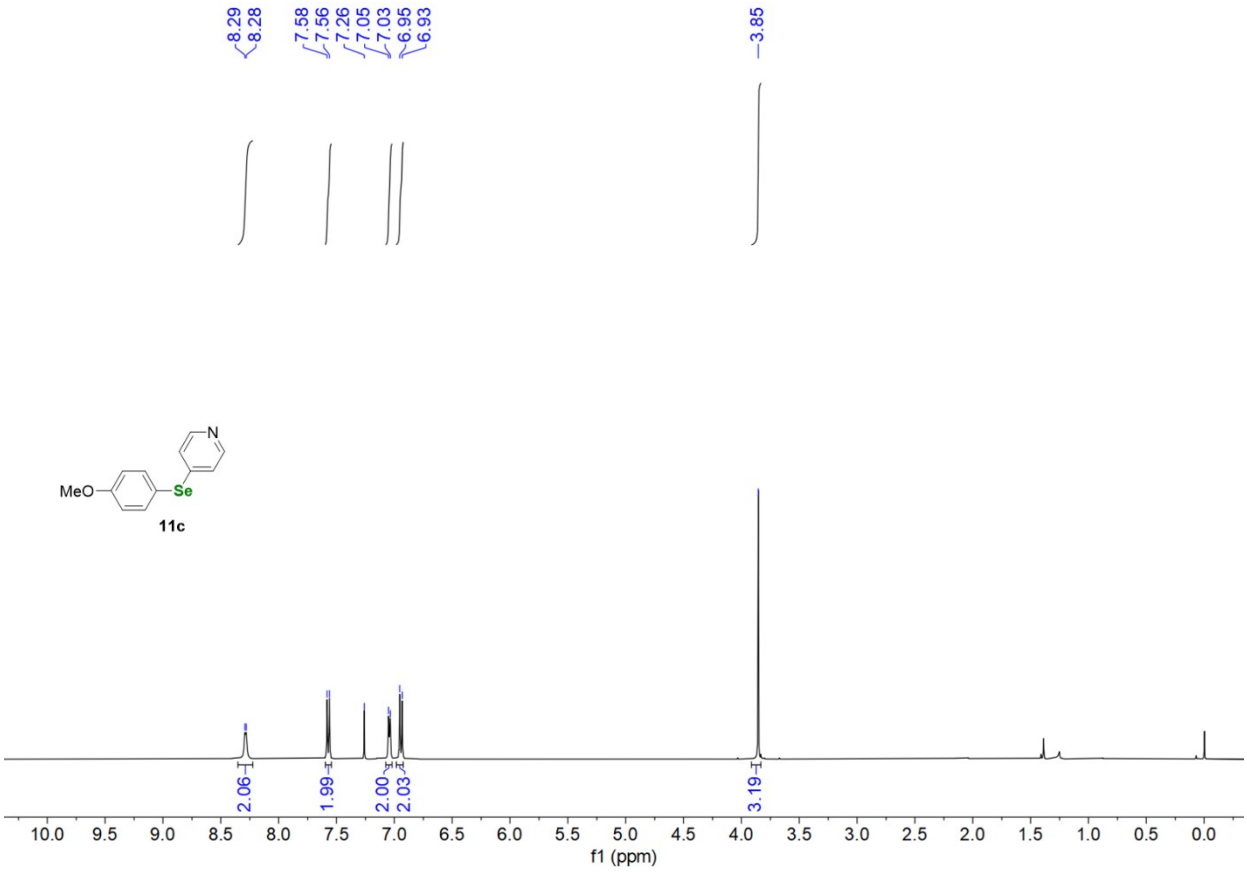
^{13}C NMR spectra of 11b (150 MHz, $CDCl_3$)



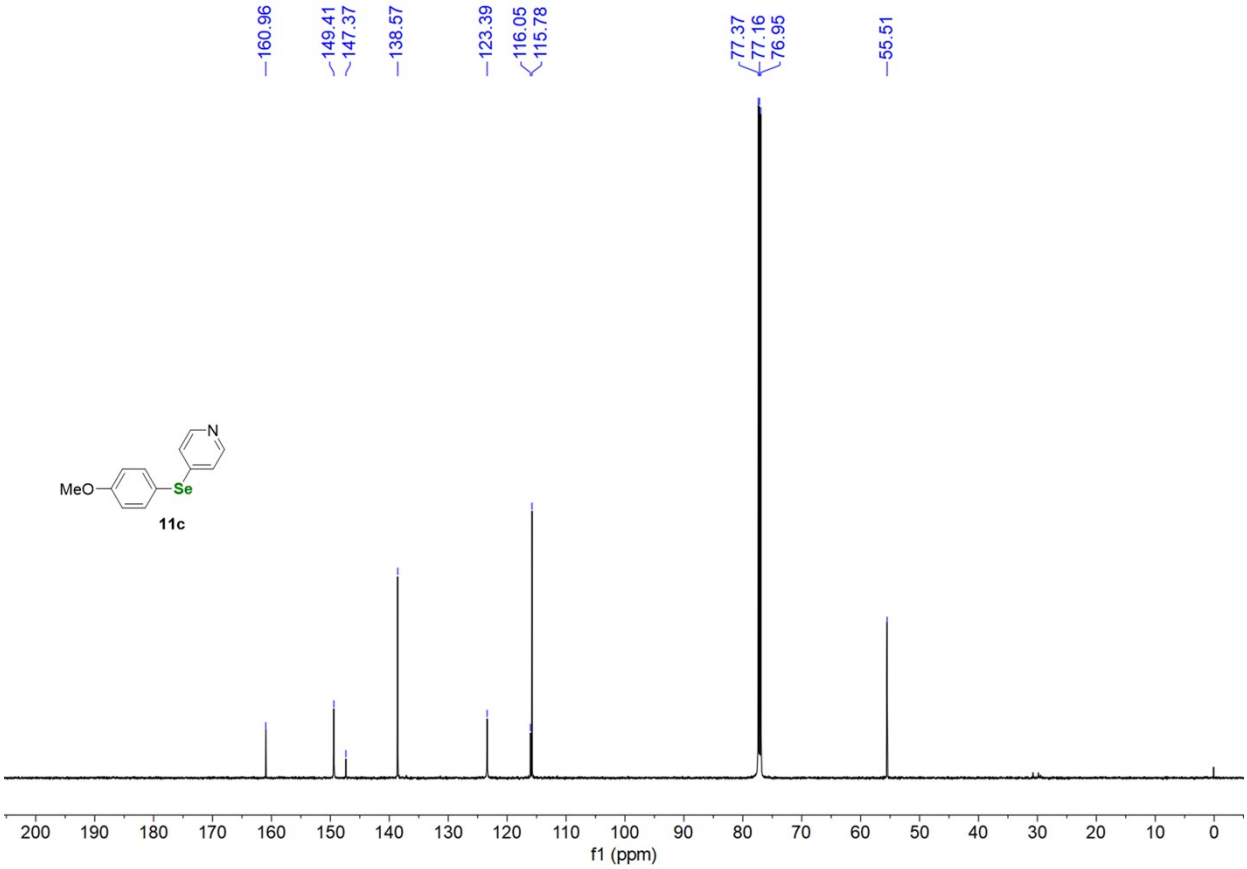
^{77}Se NMR spectra of 11b (114 MHz, $CDCl_3$)



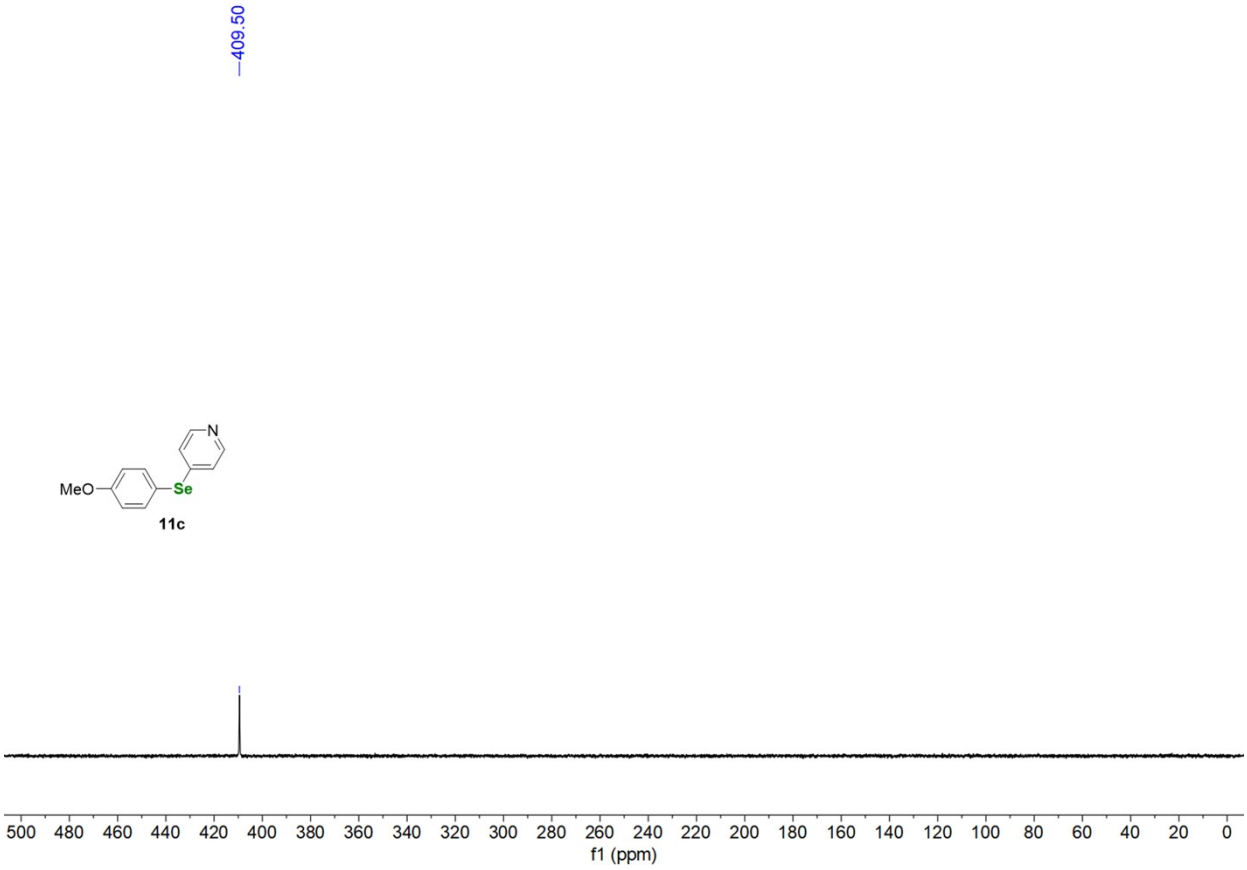
^{1}H NMR spectra of 11c (400 MHz, $CDCl_3$)



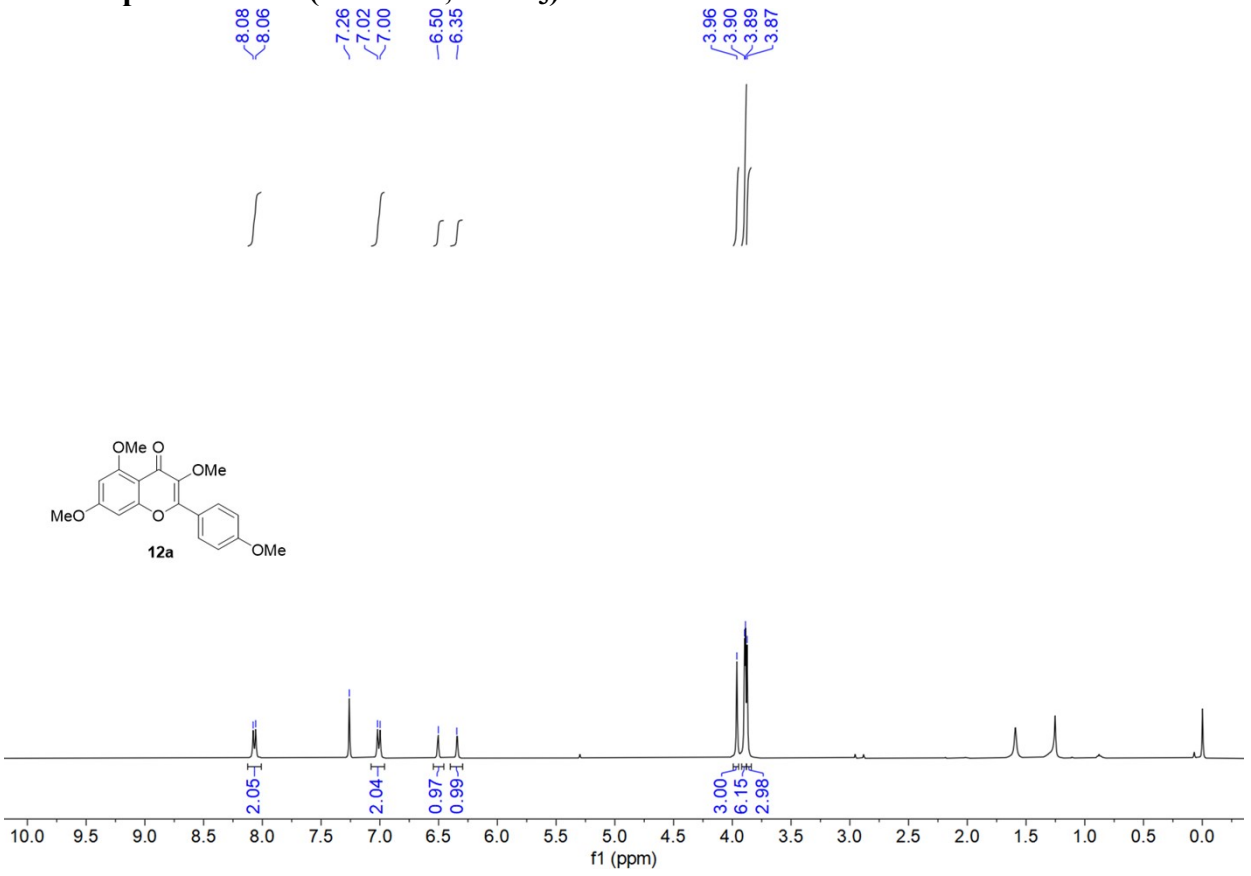
^{13}C NMR spectra of 11c (150 MHz, $CDCl_3$)



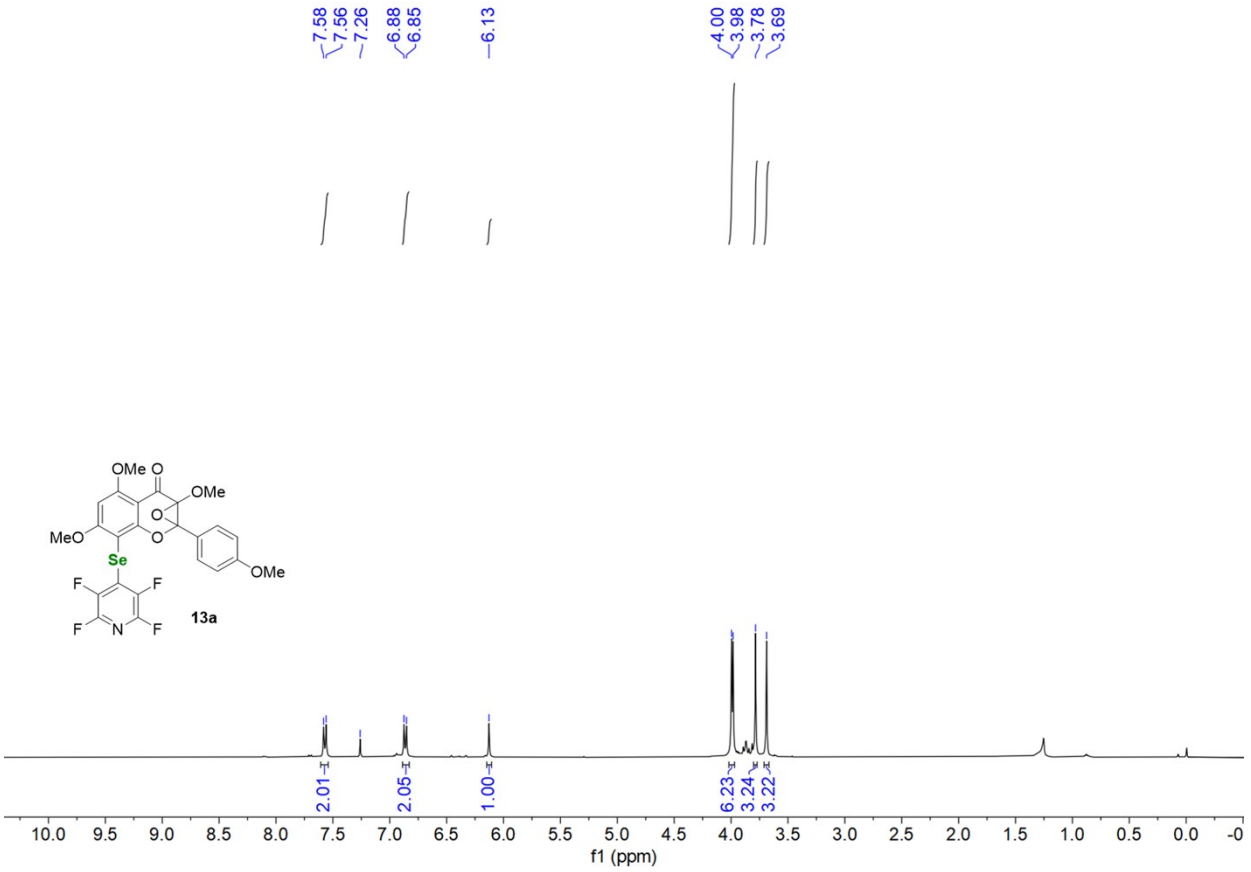
^{77}Se NMR spectra of 11c (114 MHz, $CDCl_3$)



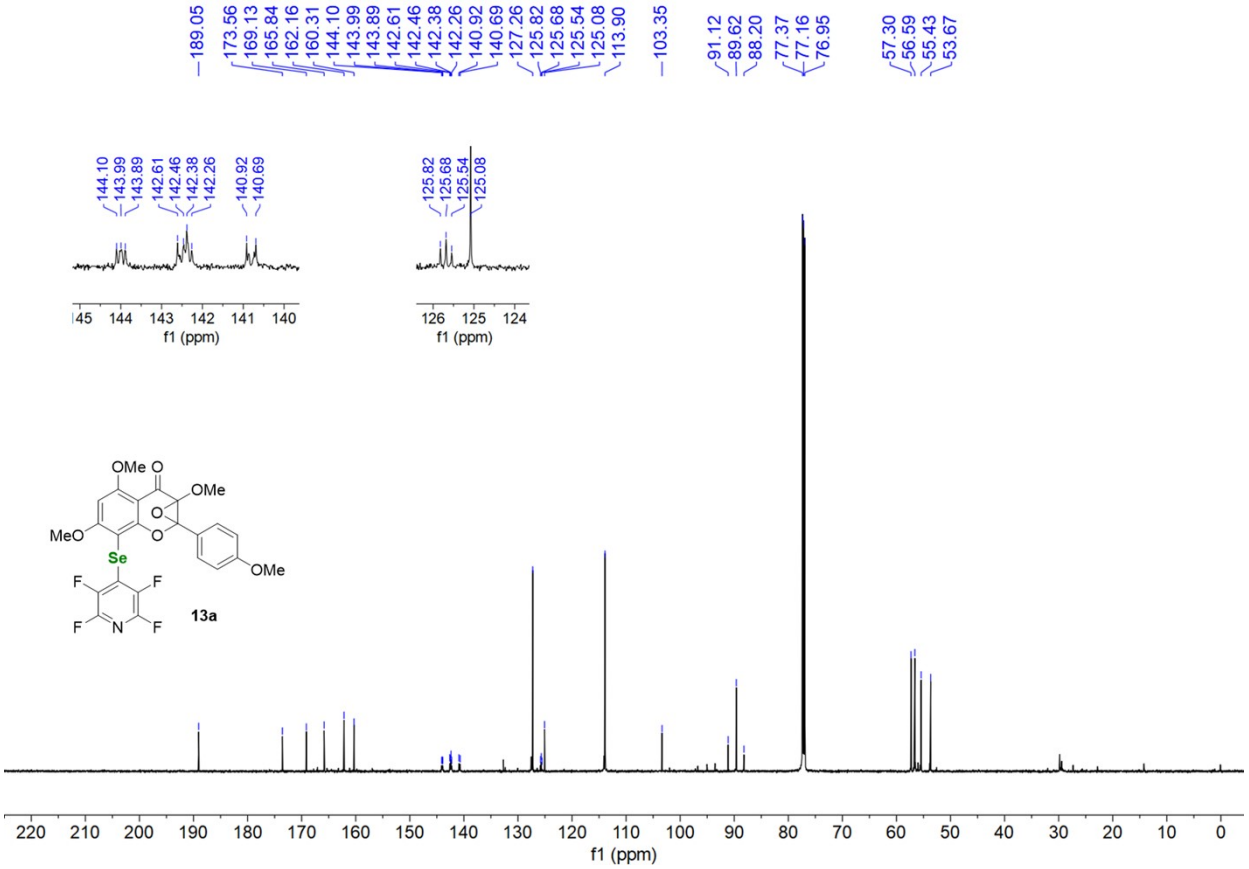
^{1}H NMR spectra of 12a (400 MHz, $CDCl_3$)



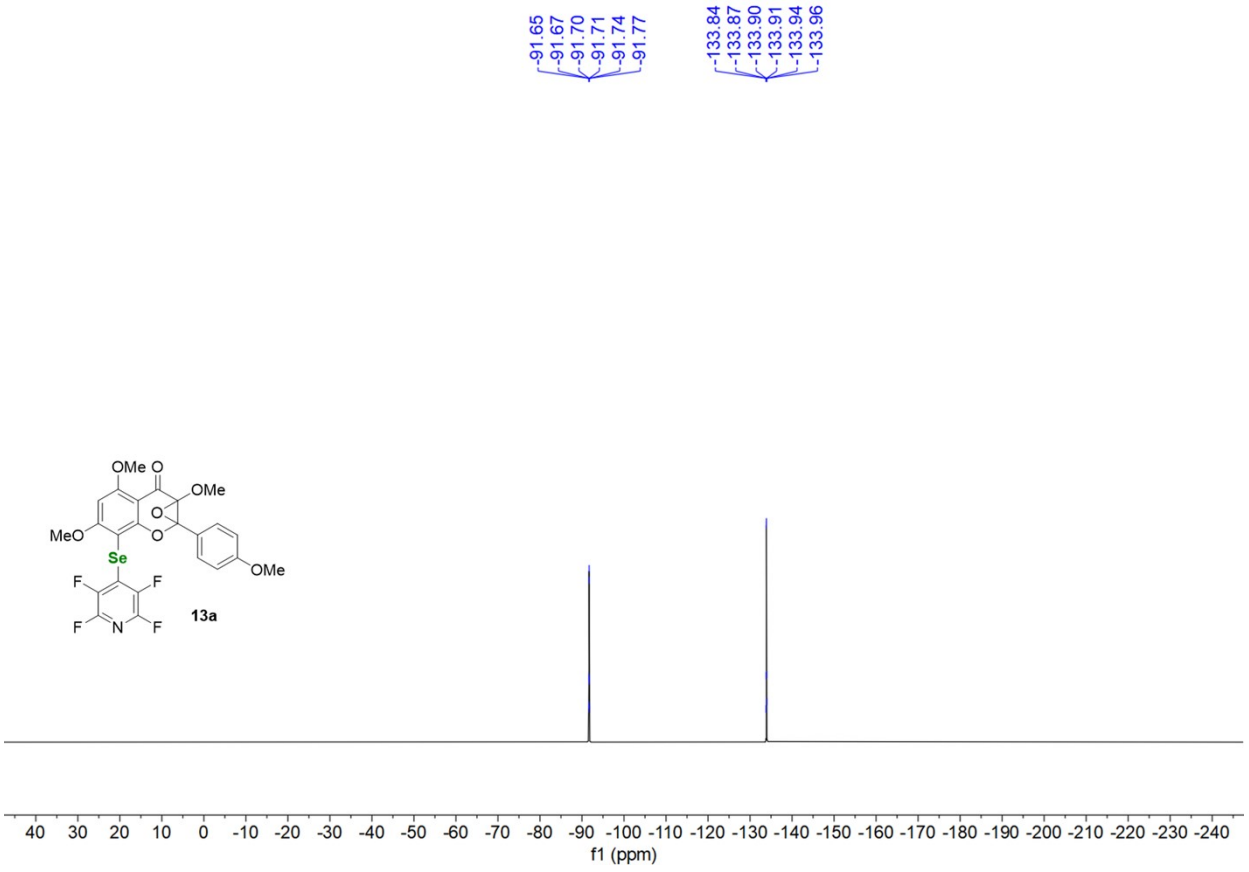
^{1}H NMR spectra of 13a (400 MHz, $CDCl_3$)



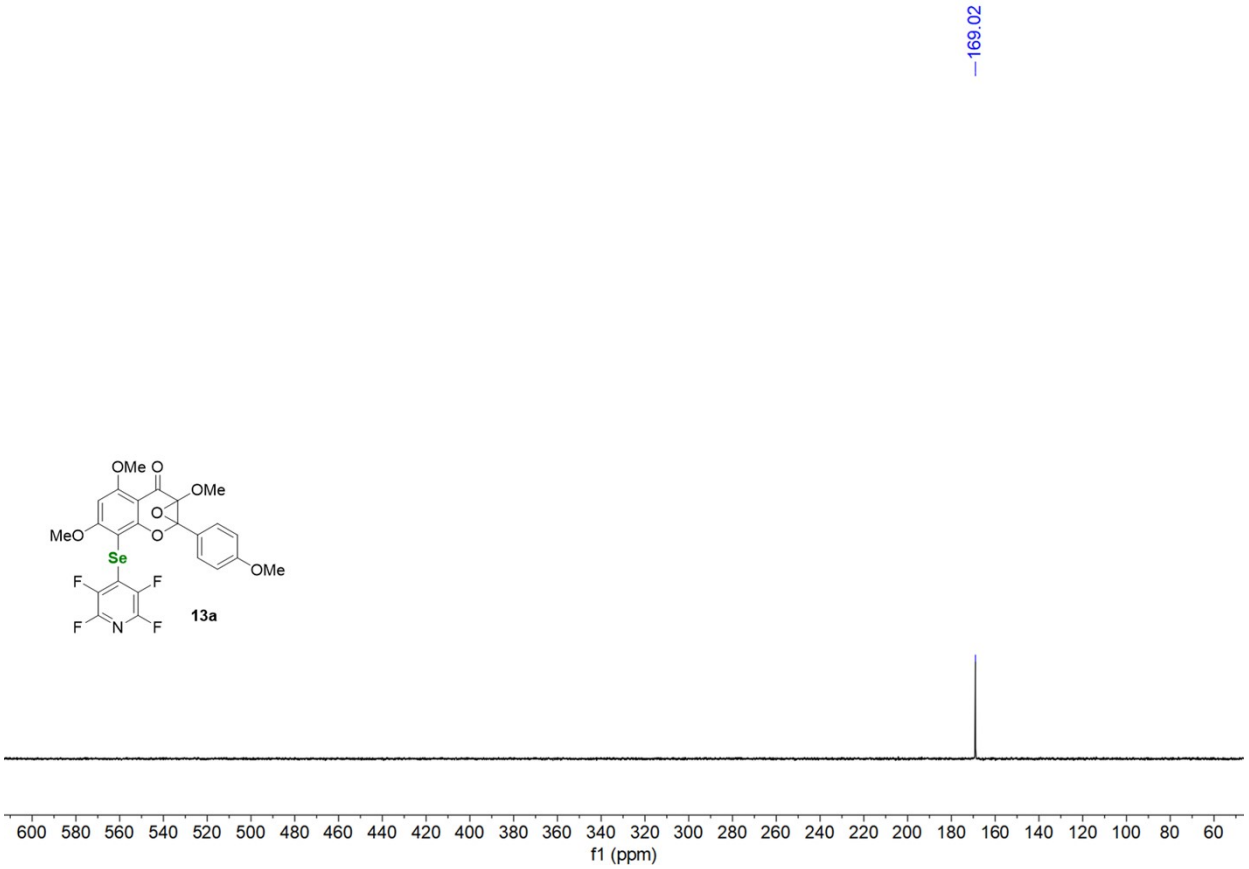
^{13}C NMR spectra of 13a (150 MHz, $CDCl_3$)



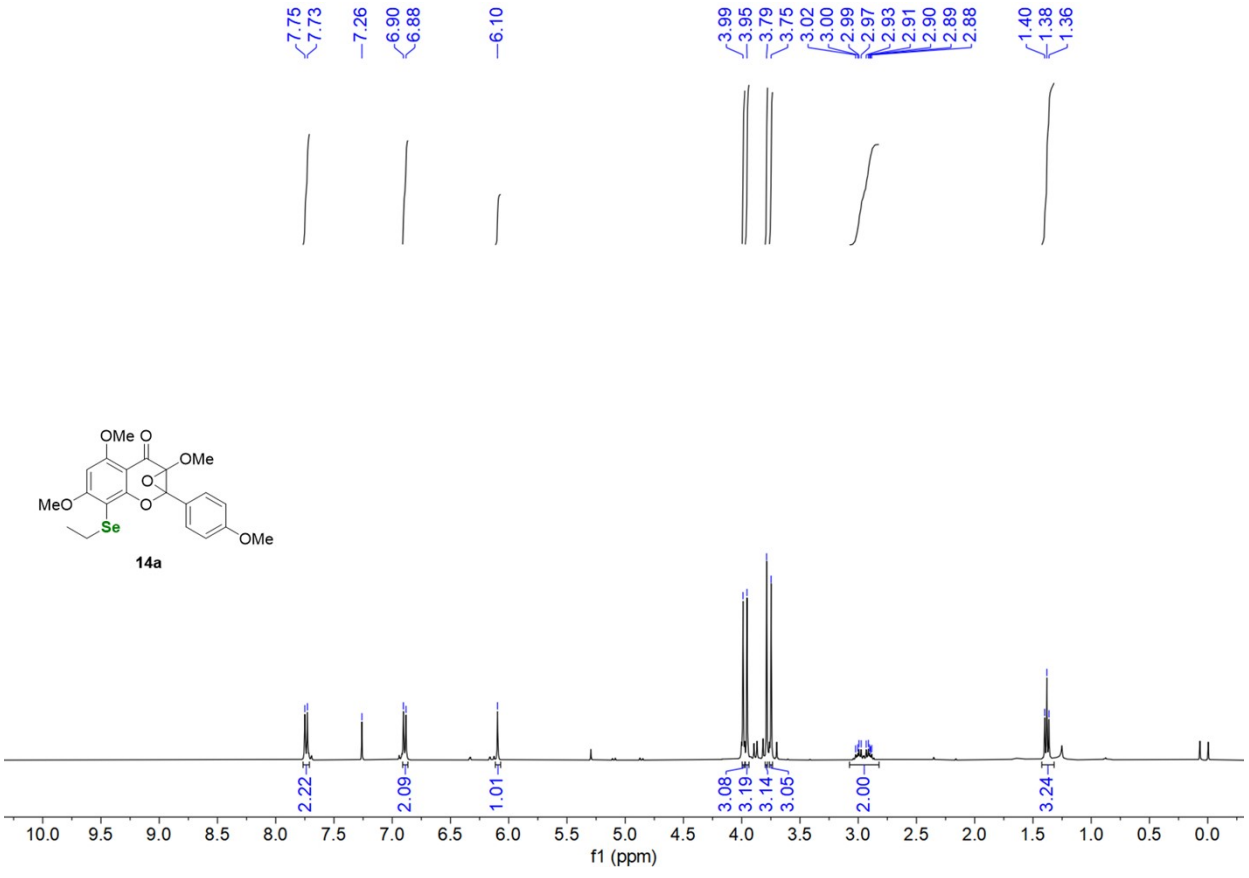
^{19}F NMR spectra of 13a (564 MHz, $CDCl_3$)



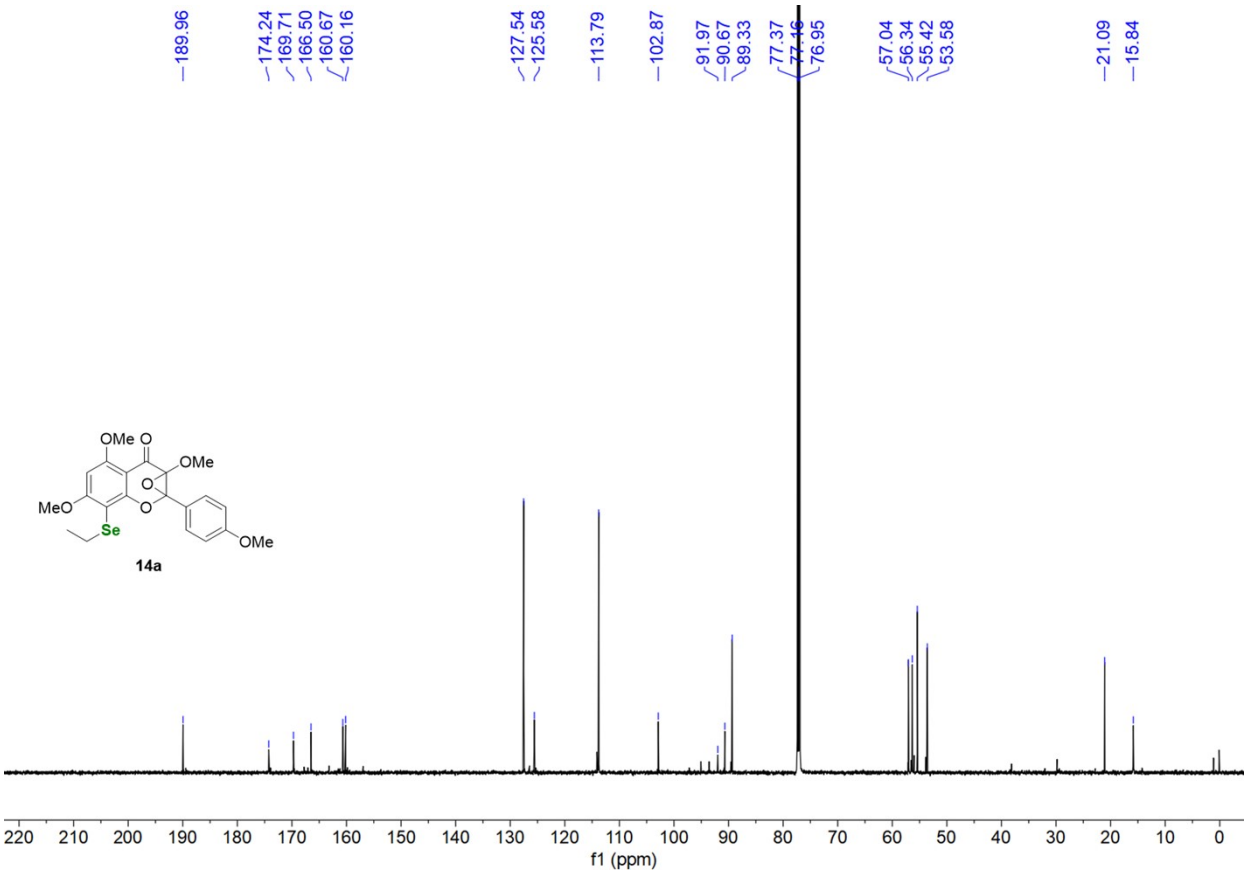
^{77}Se NMR spectra of 13a (114 MHz, $CDCl_3$)



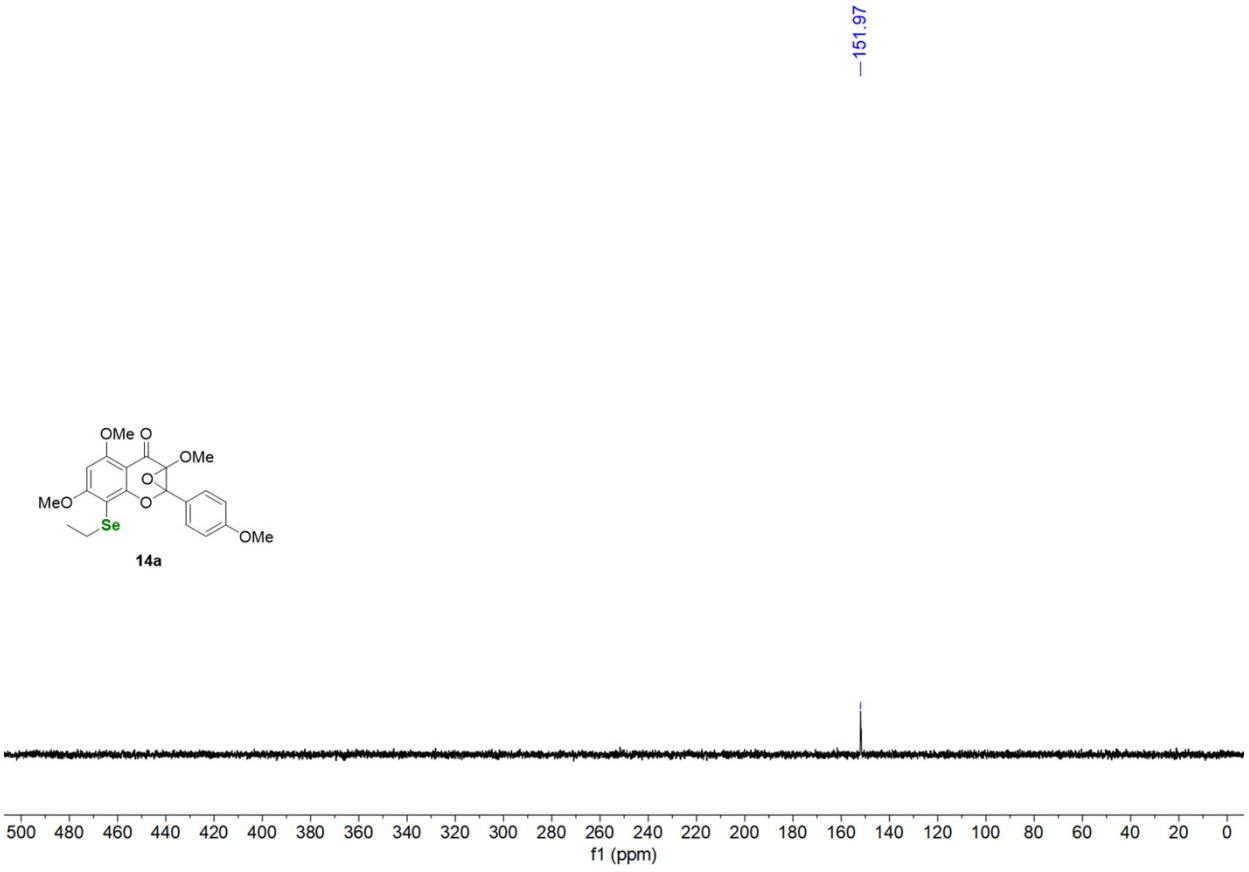
^{1}H NMR spectra of 14a (400 MHz, $CDCl_3$)



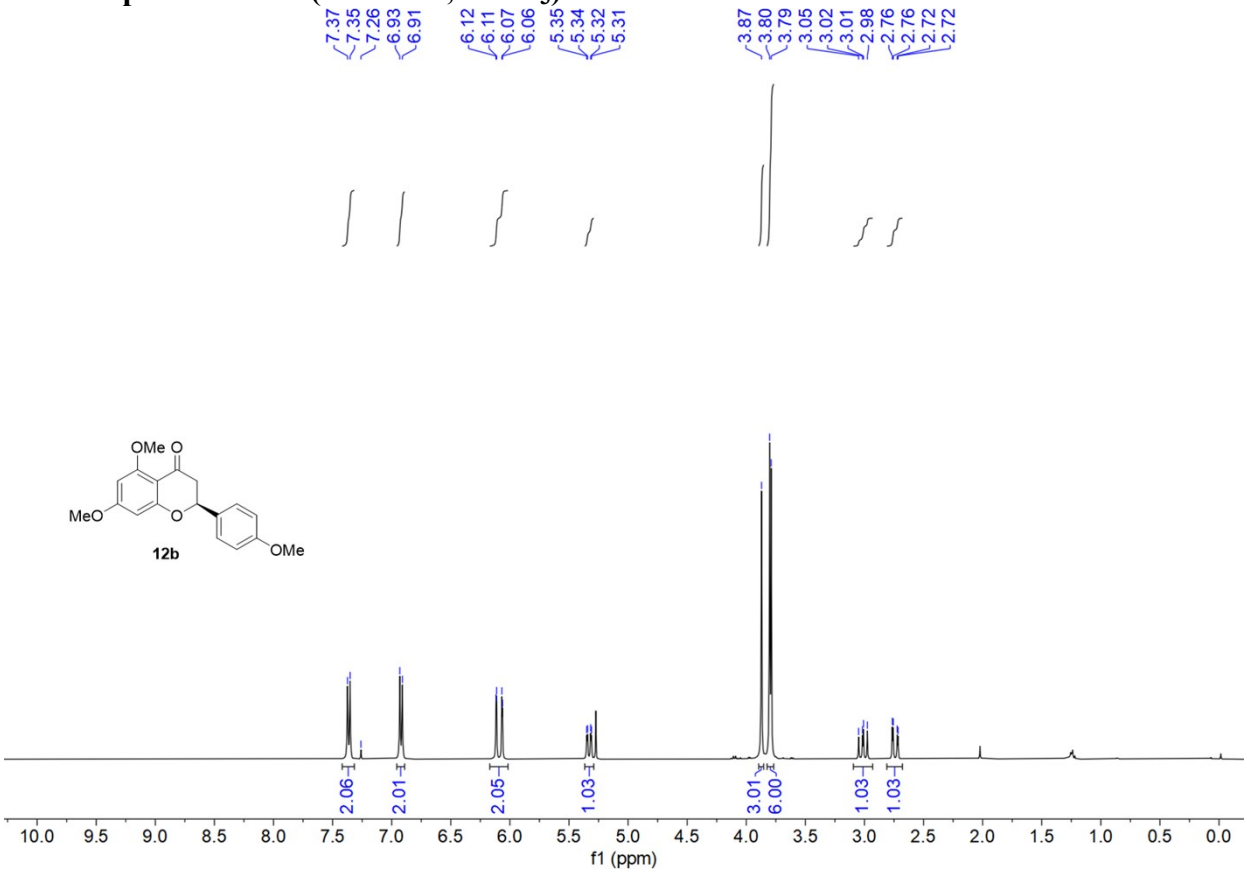
^{13}C NMR spectra of 14a (150 MHz, $CDCl_3$)



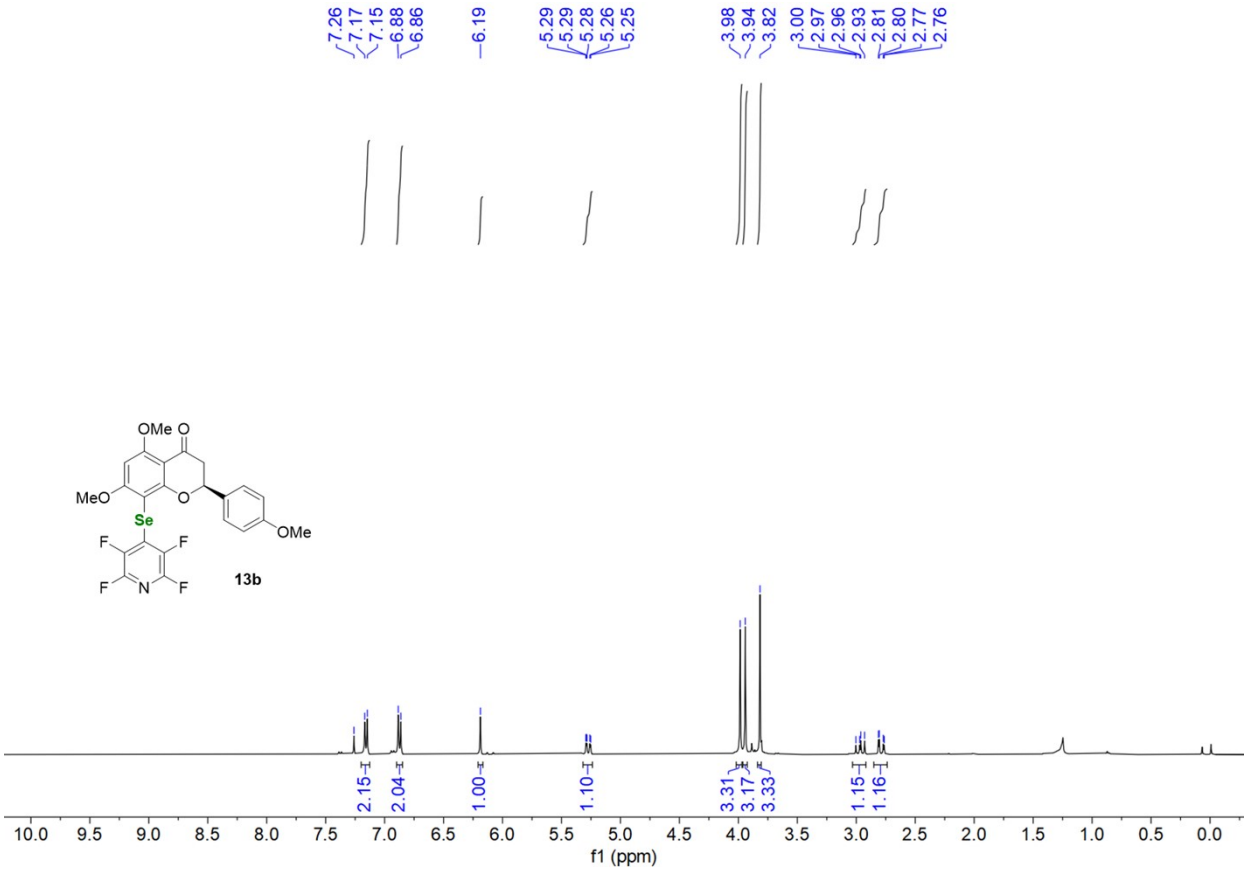
^{77}Se NMR spectra of 14a (114 MHz, $CDCl_3$)



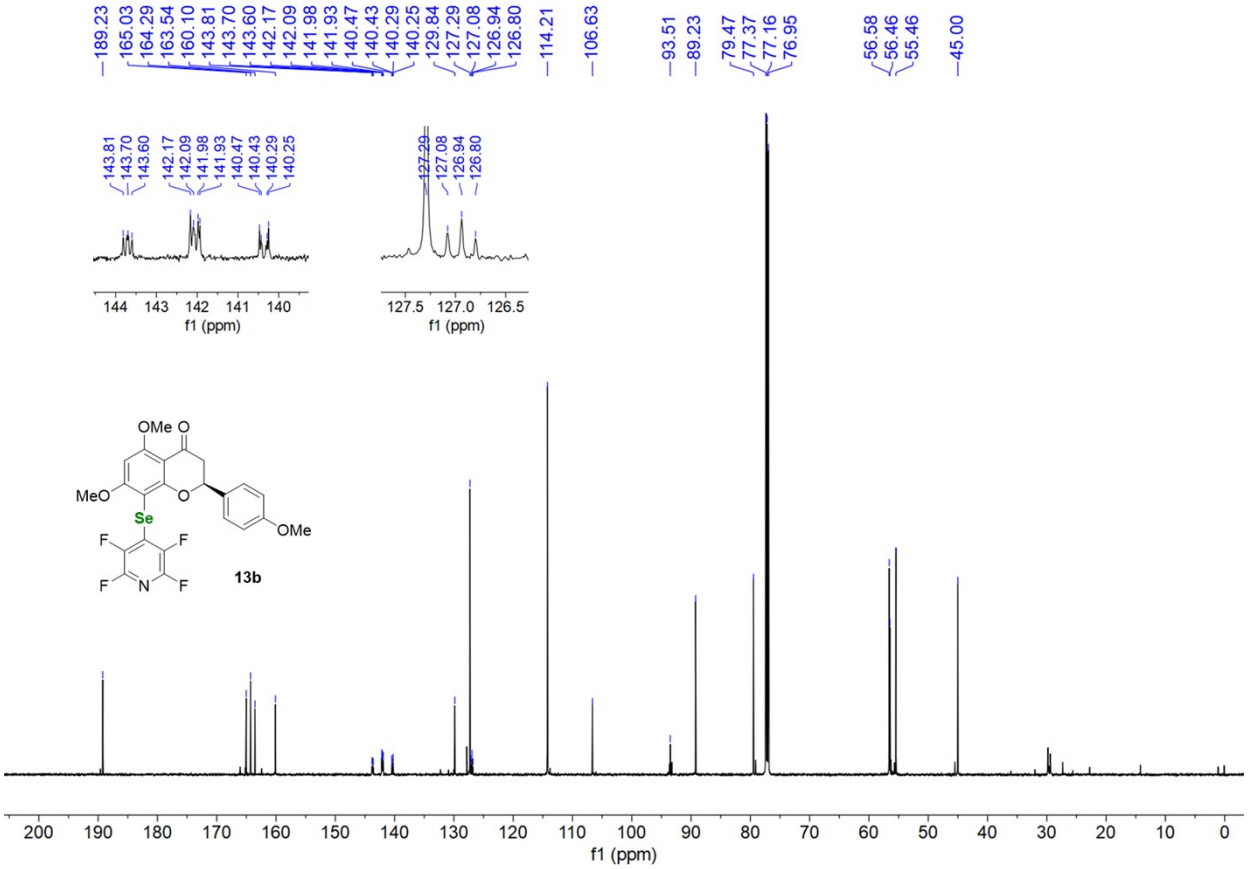
^{1}H NMR spectra of 12b (400 MHz, $CDCl_3$)



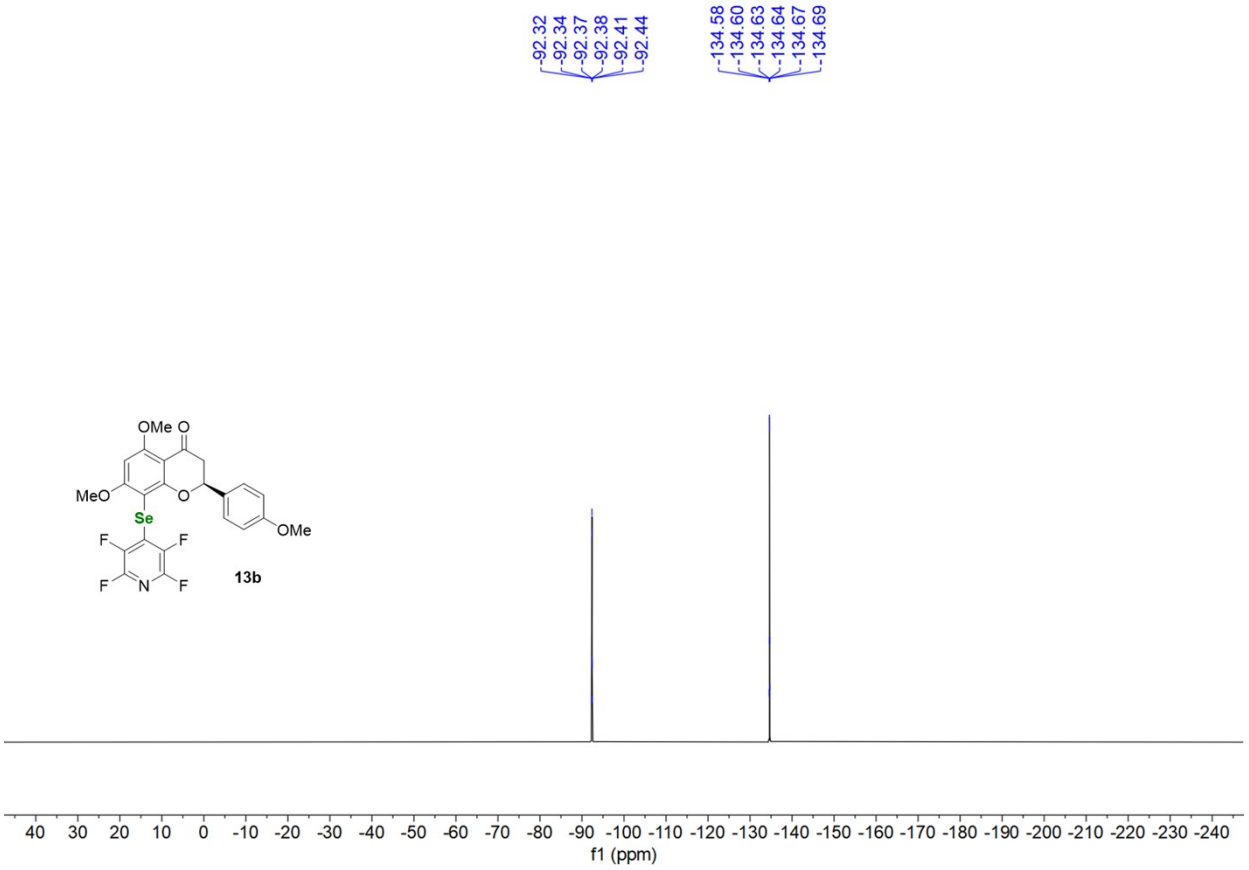
^{1}H NMR spectra of 13b (400 MHz, $CDCl_3$)



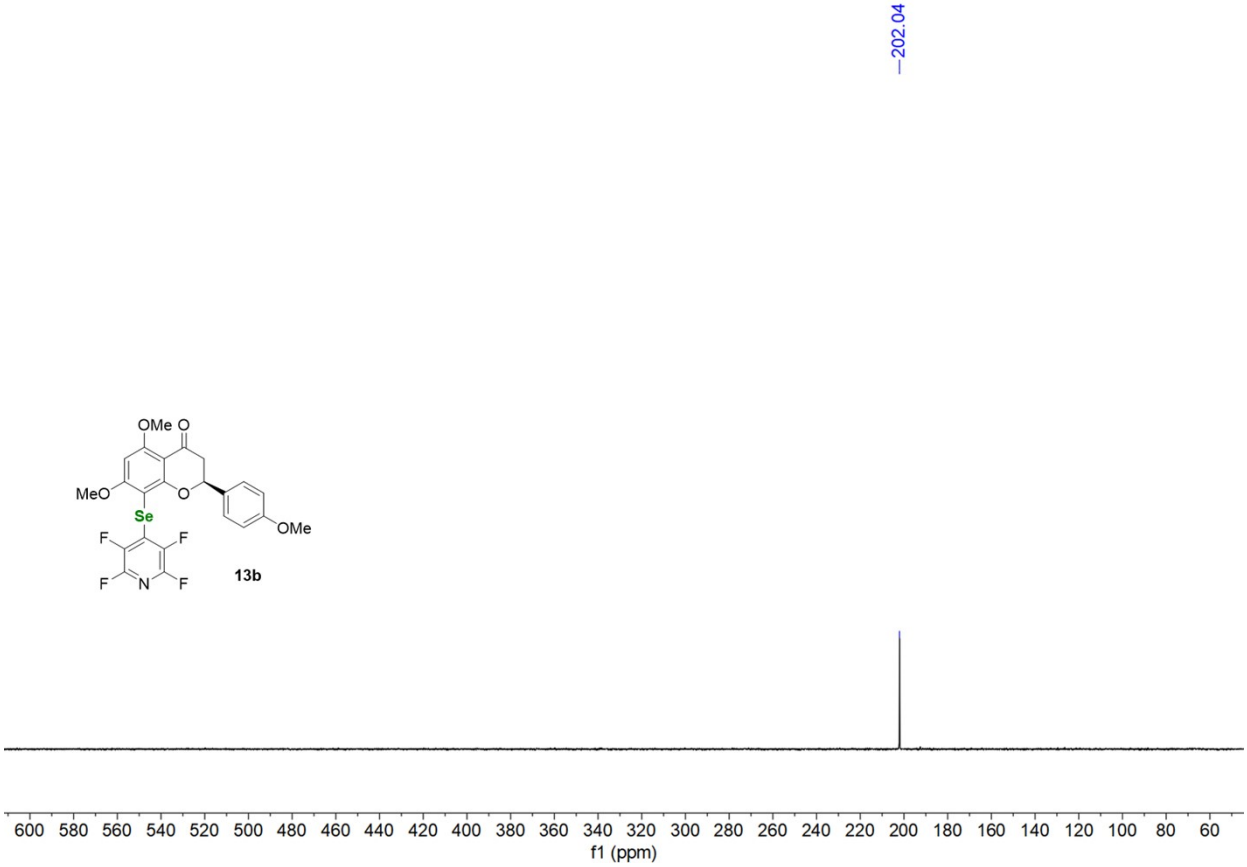
^{13}C NMR spectra of 13b (150 MHz, $CDCl_3$)



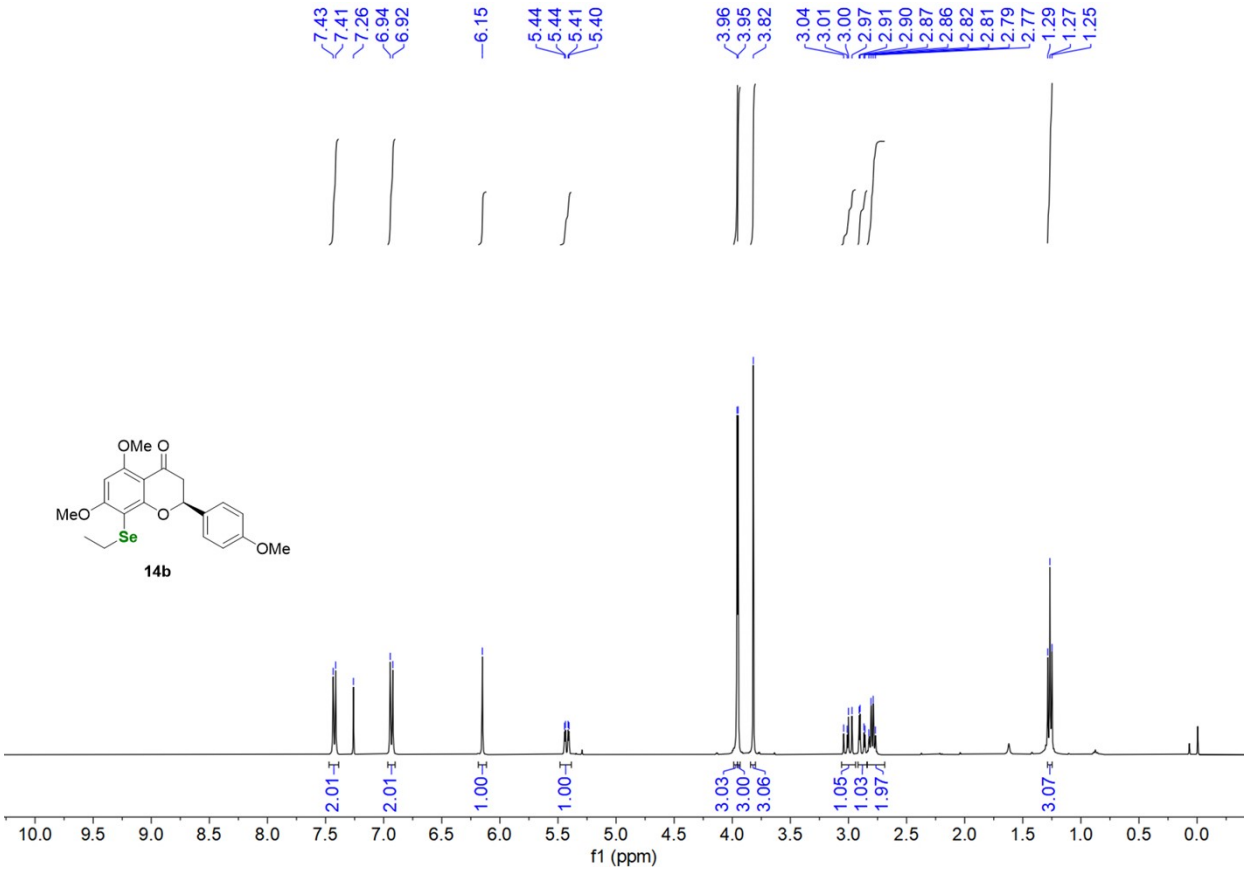
^{19}F NMR spectra of 13b (564 MHz, $CDCl_3$)



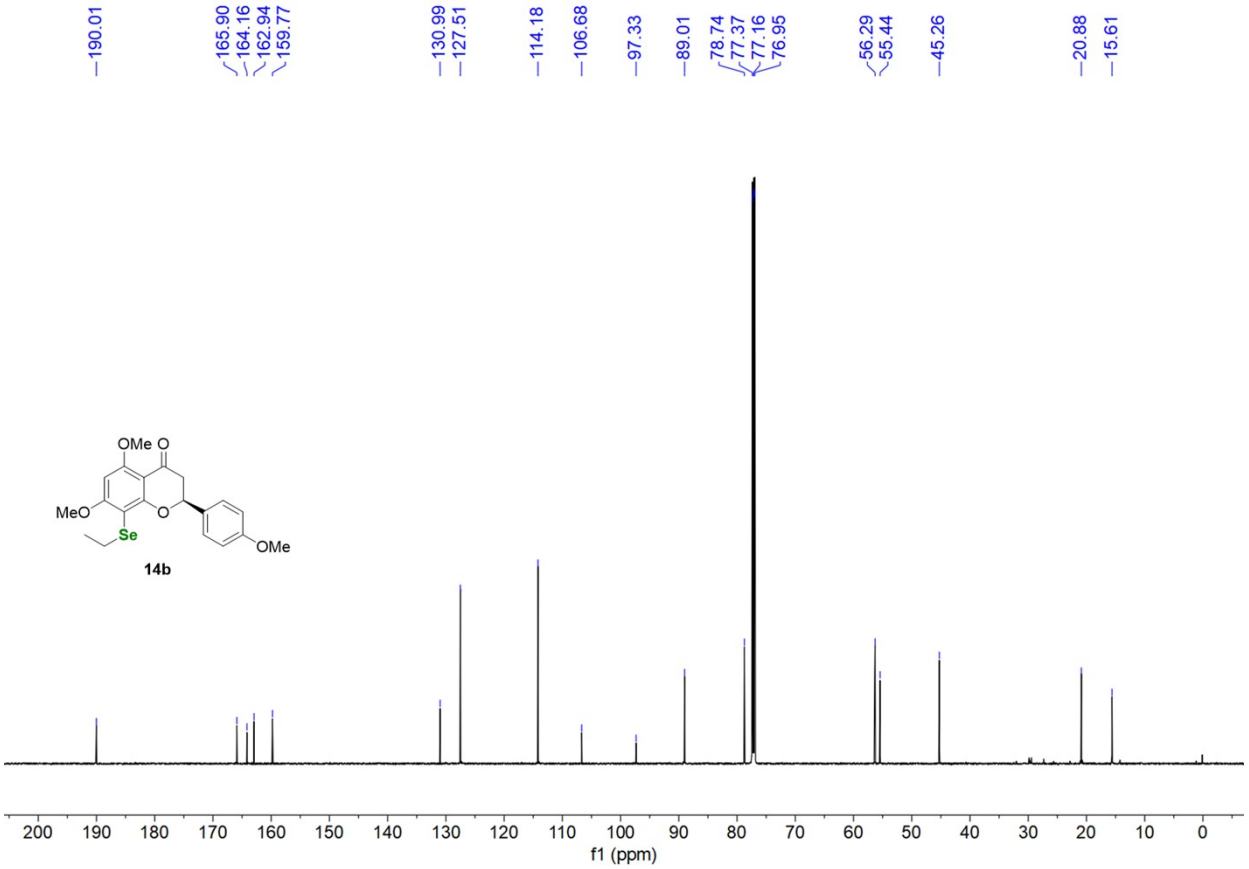
^{77}Se NMR spectra of 13b (114 MHz, $CDCl_3$)



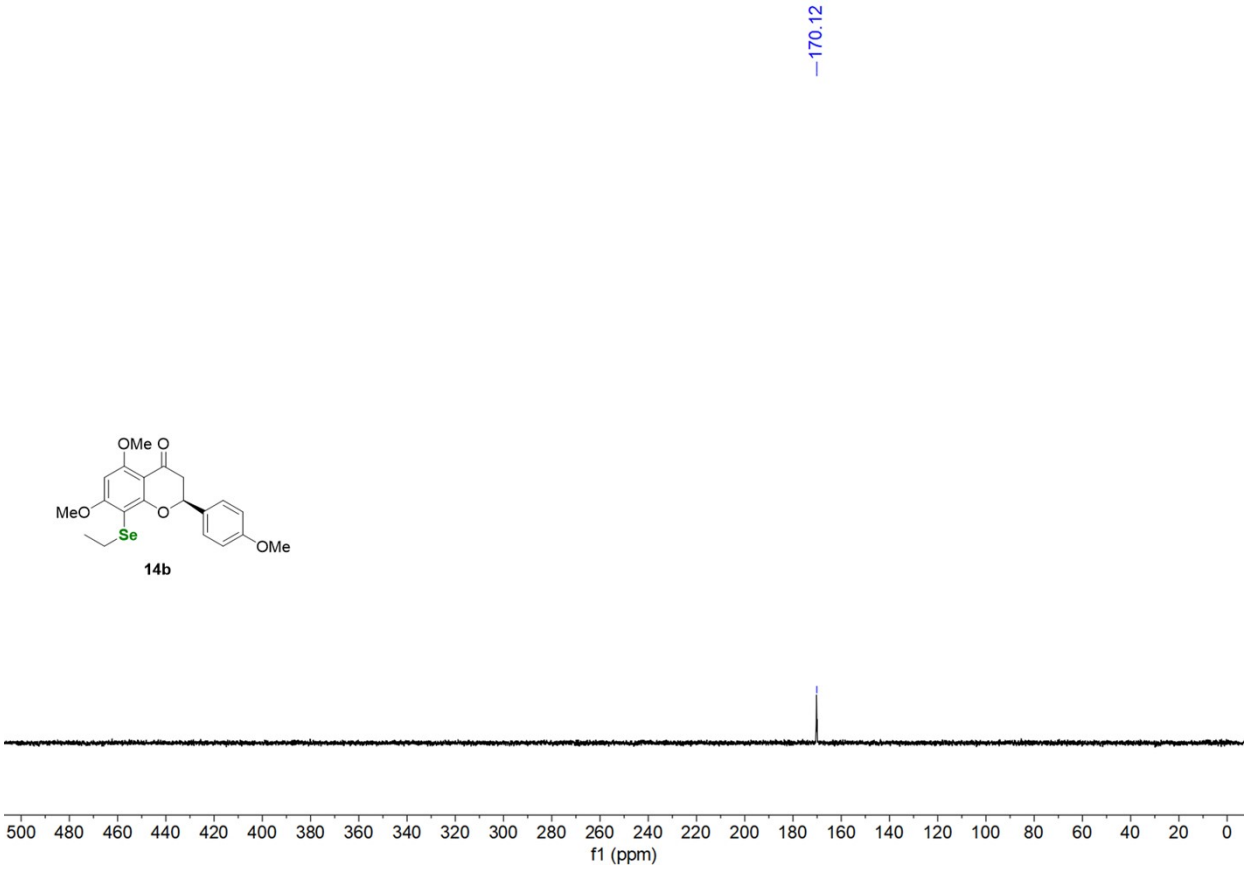
^{1}H NMR spectra of 14b (400 MHz, $CDCl_3$)



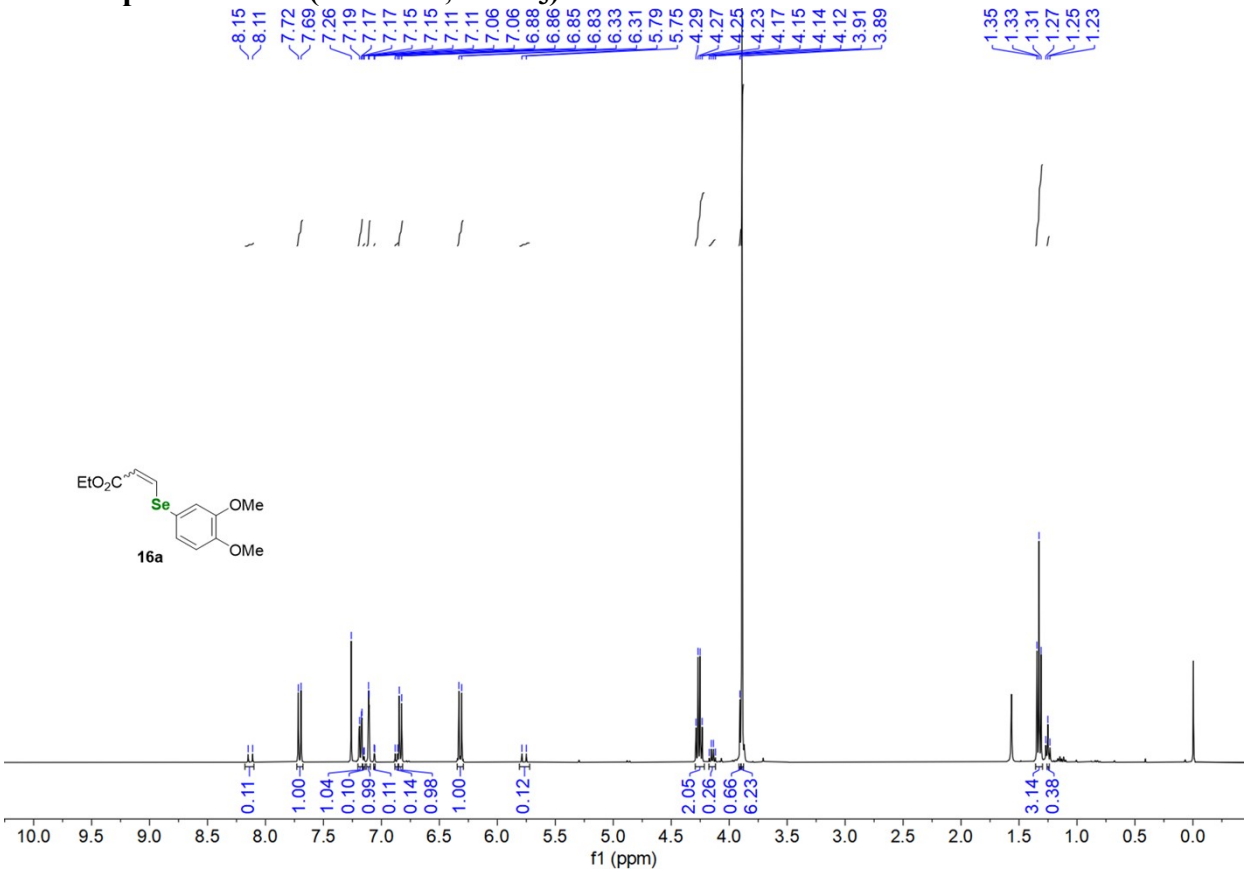
^{13}C NMR spectra of 14b (150 MHz, $CDCl_3$)



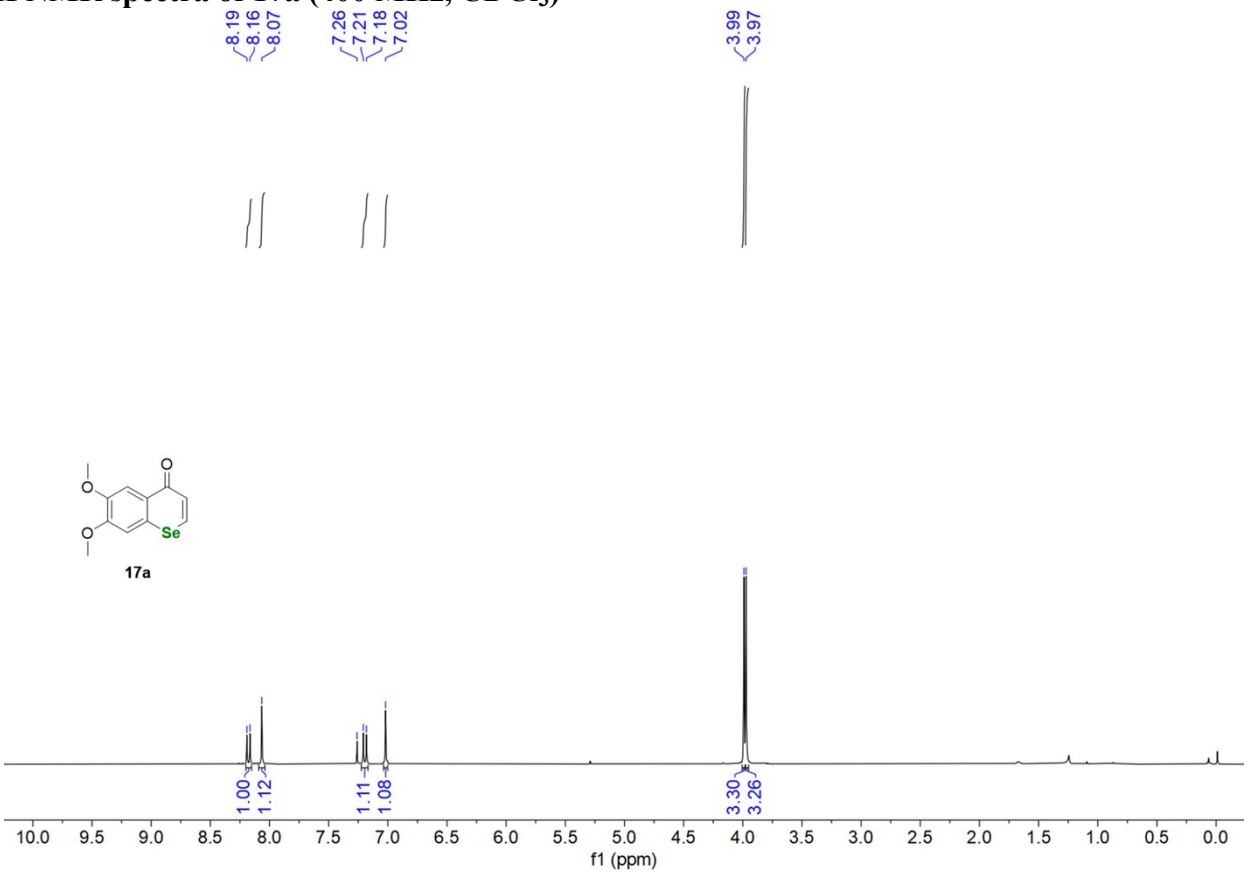
^{77}Se NMR spectra of 14b (114 MHz, $CDCl_3$)



^{1}H NMR spectra of 16a (400 MHz, $CDCl_3$)



^{1}H NMR spectra of 17a (400 MHz, $CDCl_3$)



^{1}H NMR spectra of 19a (400 MHz, $CDCl_3$)