Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.

Supplementary Information

Atom-economical selenation of electron-rich arenes and phosphonates with molecular oxygen at room temperature

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General Information

All manipulations with air-sensitive reagents were carried out under a dry nitrogen atmosphere. Unless otherwise stated, all commercial reagents were used without additional purification. Solvents were dried using standard methods and distilled before use. TLC was performed on silica gel plates (Merck silica gel 60, f_{254}), and the spots were visualized with UV light (254 and 365 nm) or by charring the plate dipped in $KMnO_4$ or vanillin charring solution. ^1H NMR was recorded at 300 MHz (Bruker-DPX), 400 MHz (JEOL-JNM-ECZ400S/L1) and 600 MHz (Bruker-Avance) frequency and ^{13}C NMR spectra were recorded at 75 MHz (Bruker-DPX) 100 MHz (JEOL-JNM-ECZ400S/L1) and 150 MHz (Bruker-Avance) frequency in $CDCl_3$ solvent using TMS as the internal standard. Chemical shifts were measured in parts per million (ppm) referenced to 0.0 ppm for tetramethylsilane. The following abbreviations were used to explain multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, quin = quintet, sex = sextet, m = multiplet, br. = broad. Coupling constants, *J* were reported in Hertz unit (Hz). HRMS (m/z) were measured using EI and ESI techniques (JEOL-JMS 700 and Q-Tof Micro mass spectrometer respectively).

General Procedure for the C-Se Bond Formation

Method-A :

A mixture of arene (1 equiv) and benzeneselenol (1.2 equiv) with DMF as a solvent was taken in a vessel under air. This reaction mixture was allowed to stir for 15 minutes to 6 h at room temperature in open air. After completion (detected by TLC), the reaction mixture was extracted with ethyl acetate and cold water. The organic layer was dried over anhydrous Na_2SO_4 and the solvent was evaporated under reduced pressure. The crude product was purified by column chromatography using ethyl acetate/hexane (5:95 to 15:85) as eluent to afford the desired product.

Method-B :

A mixture of arene (1 equiv) and diaryldiselenide or diaryldiselenide (0.6 equiv) with DMF as a solvent was taken in a vessel under air. This reaction mixture was allowed to stir for 15 minutes to 6 h at room temperature in open air. After completion (detected by TLC), the reaction mixture was extracted with ethyl acetate and cold water. The organic layer was dried over anhydrous Na_2SO_4 and the solvent was evaporated under reduced pressure. The crude product was purified by column chromatography using ethyl acetate/hexane (5:95 to 15:85) as eluent to afford the desired product.

General Procedure for the Se-P Bond Formation

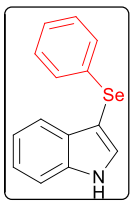
Method-C :

A mixture of dialkyl phosphonate or diaryl phosphonate (1 equiv) and diaryldiselenide or dialkyldiselenide (0.6 equiv) with DMF as a solvent was taken in a vessel under O_2 atmosphere. This reaction mixture was allowed to stir for 36 h at room temperature in presence of O_2 balloon. After completion (detected by TLC), the reaction mixture was extracted with ethyl acetate and cold water. The organic layer was dried over anhydrous Na_2SO_4 and the solvent was evaporated under reduced pressure. The crude product was purified by column chromatography using ethyl acetate/hexane (10:90 to 20:80) as eluent to afford the desired product.

Method-D :

A mixture of benzene selenol (1.0 equiv) and dialkyl phosphonate or diaryl phosphonate (1.2 equiv) with DMF as a solvent was taken in a vessel under O_2 atmosphere. This reaction mixture was allowed to stir for 36 h at room temperature in presence of O_2 balloon. After completion (detected by TLC), the reaction mixture was extracted with ethyl acetate and cold water. The organic layer was dried over anhydrous Na_2SO_4 and the solvent was evaporated under reduced pressure. The crude product was purified by column chromatography using ethyl acetate/hexane (10:90 to 20:80) as eluent to afford the desired product.

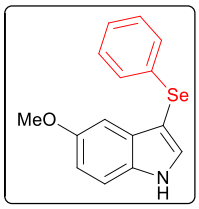
Characterization Data for Seleno-Carbon Product:



3-(Phenylselanyl)-1*H*-indole, 4a[1]:

The reaction is conducted for 15 minutes by using indole (0.2 mmol, 23.4 mg) with benzeneselenol (1.2 equiv, 37.9 mg) or diphenyl diselenide (0.6 equiv, 37.4 mg) and afforded the desired product as a white solid, 54.6 mg (100% by Method-A) and 50.2 mg (92% by Method-B).

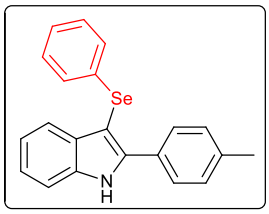
^{1}H NMR (400 MHz, D_6-DMSO): δ 11.68 (s, 1H), 7.73-7.72 (m, 1H), 7.49 (d, *J* = 8.0 Hz, 1H), 7.40 (d, *J* = 8.0 Hz, 1H), 7.18-7.04 (m, 7H); ^{13}C NMR (100 MHz, D_6-DMSO): δ 136.6, 133.7, 132.7, 129.5, 129.0, 128.1, 125.6, 121.98, 120.0, 118.98, 112.1, 95.0.



5-Methoxy-3-(phenylselanyl)-1*H*-indole, 4b[1]:

The reaction is conducted for 30 minutes by using 5-methoxyindole (0.2mmol, 29.2 mg) with benzeneselenol (1.2 equiv, 37.9 mg) or diphenyl diselenide (0.6 equiv, 37.4 mg) and afforded the desired product as a white solid, 60.6 mg (100% by Method-A) and 57.6 mg (95% by Method-B).

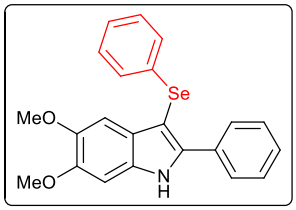
^{1}H NMR (400 MHz, D_6-DMSO): δ 8.35 (br. s, 1H), 7.42 (d, *J* = 2.4 Hz, 1H), 7.31 (d, *J* = 8.8 Hz, 1H), 7.25-7.22 (m, 2H), 7.15-7.07 (m, 4H), 6.92 (dd, *J* = 8.8 Hz, 2.4 Hz, 1H), 3.80 (s, 3H); ^{13}C NMR (100 MHz, D_6-DMSO): δ 156.2, 134.0, 132.0, 131.3, 130.8, 129.1, 128.5, 125.6, 113.6, 112.4, 101.5, 97.6, 55.9.



3-(Phenylselanyl)-2-(p-tolyl)-1*H*-indole, 4c[2]:

The reaction is conducted for 2 hours by using 2-(p-tolyl)-1H-indole (0.2 mmol, 41.2 mg) with benzeneselenol (1.2 equiv, 37.9 mg) or diphenyl diselenide (0.6 equiv, 37.4 mg) and afforded the desired product as a white solid, 72.6 mg (100% by Method-A) and 71.1mg (98% by Method-B).

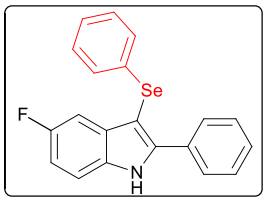
^{1}H NMR (400 MHz, $CDCl_3$): δ 8.52 (br. s, 1H), 7.69-7.65 (m, 1H), 7.62 (d, *J* = 8.0 Hz, 2H), 7.43 (d, *J* = 8.0 Hz, 1H), 7.29-7.17 (m, 6H), 7.16-7.08 (m, 3H), 2.40 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 142.5, 138.8, 136.2, 134.3, 132.2, 129.5, 129.23, 129.17, 128.5, 128.3, 125.5, 123.2, 121.2, 120.9, 111.1, 95.4, 21.5.



5,6-Dimethoxy-2-phenyl-3-(phenylselanyl)-1*H*-indole, 4d:

The reaction is conducted for 2 hours by using 5,6-dimethoxy-2-phenyl-1H-indole (0.2mmol, 50.4 mg) with benzeneselenol (1.2 equiv, 37.9 mg) or diphenyl diselenide (0.6 equiv, 37.4 mg)and afforded the desired product as a white solid, 81.8 mg (100% by Method-A) and 73.6mg (90% by Method-B).

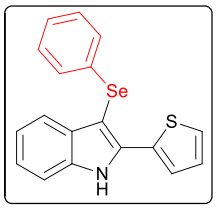
^{1}H NMR (300 MHz, D_6-DMSO): δ 11.80 (br. s, 1H), 7.77 (d, J = 7.8 Hz, 2H), 7.44 (t, J = 7.5 Hz, 2H), 7.34 (t, J = 7.2 Hz, 1H), 7.20-7.08 (m, 5H), 7.01 (s, 1H), 6.89 (s, 1H), 3.83 (s, 3H), 3.69 (s, 3H); ^{13}C NMR (75 MHz, D_6-DMSO): δ 147.6, 145.7, 140.2, 133.9, 132.2, 130.7, 129.3, 128.4, 128.1, 127.8, 127.6, 125.5, 124.5, 101.4, 95.3, 92.8, 55.8; HRMS (ESI, m/z) calcd. for $C_{22}H_{19}NNaO_2Se$ $[M + Na]^+$: 432.0479; found: 432.0485; ^{77}Se NMR (76.3 MHz, $CDCl_3$): 463.9.



5-Fluoro-2-phenyl-3-(phenylselanyl)-1*H*-indole, 4e[5]:

The reaction is conducted for 2 hours by using 5-fluoro-2-phenyl-1H-indole (26.8 mg, 2mmol) with benzeneselenol (1.2 equiv, 37.9 mg) or diphenyl diselenide (0.6 equiv, 37.4 mg) and afforded the desired product as a white solid, 58.0 mg (100% by Method-A) and 49.3 mg (85% by Method-B).

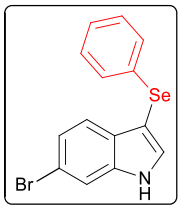
^{1}H NMR (400 MHz, D_6-DMSO): δ 8.58 (br. s, 1H), 7.74-7.71 (m, 2H), 7.47-7.36 (m, 4H), 7.31 (dd, J = 9.2 Hz, 2.4 Hz, 1H), 7.21-7.09 (m, 5H), 7.00 (td, J = 9.2 Hz, 2.4 Hz, 1H); ^{13}C NMR (100 MHz, D_6-DMSO): δ 160.0, 157.7, 143.9, 133.7, 133.2, 133.1, 132.6, 131.8, 129.2, 12.97, 128.8, 128.6, 128.4, 125.7.



3-(Phenylselanyl)-2-(thiophen-2-yl)-1*H*-indole, 4f:

The reaction is conducted for 2 hours by using 2-(thiophen-2-yl)-1H-indole (39.6 mg, 2mmol) with benzeneselenol (1.2 equiv, 37.9 mg) and afforded the desired product as a white solid, 70.8 mg (100% by Method-A).

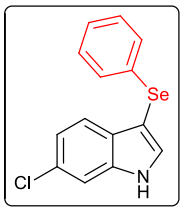
^{1}H NMR (400 MHz, D_6-DMSO): δ 12.13 (br. s, 1H), 7.77 (dd, J = 3.6 Hz, 1.2 Hz, 1H), 7.61 (dd, J = 5.2 Hz, 1.2 Hz, 1H), 7.49 (t, J = 7.6 Hz, 2H), 7.24-7.08 (m, 8H); ^{13}C NMR (100 MHz, D_6-DMSO): δ 136.8, 136.4, 133.2, 133.1, 131.5, 129.2, 127.94, 127.88, 127.1, 126.4, 125.7, 122.9, 120.5, 119.3, 111.5, 93.6; HRMS (ESI, m/z) calcd. for $C_{18}H_{13}NNaSSe$ $[M + Na]^+$: 377.9832; found: 377.9805; ^{77}Se NMR (76.3 MHz, $CDCl_3$): 206.7.



6-Bromo-3-(phenylselanyl)-1*H*-indole, 4g[4]:

The reaction is conducted for 4 hours by using 6-bromoindole (2mmol, 38.6 mg) with benzeneselenol (1.2 equiv, 37.9 mg) or diphenyl diselenide (0.6 equiv, 37.4 mg) and afforded the desired product as a white solid, 63.0 mg (90% by Method-A) 60.9 mg (87% by Method-B).

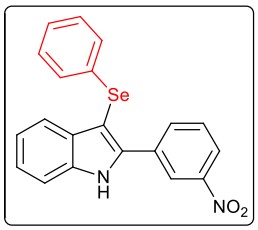
^{1}H NMR (400 MHz, D_6-DMSO): δ 11.78 (br. s, 1H), 7.73 (s, 1H), 7.69 (d, J = 1.6 Hz, 1H), 7.32 (d, J = 8.4 Hz, 1H), 7.17 (dd, J = 8.8 Hz, 1.6 Hz, 1H), 7.14-7.07 (m, 5H); ^{13}C NMR (100 MHz, D_6-DMSO): δ 137.7, 133.9, 133.4, 129.3, 128.8, 128.4, 126.0, 123.2, 121.0, 115.1, 114.9, 95.8.



6-Chloro-3-(phenylselanyl)-1*H*-indole, 4h[4]:

The reaction is conducted by 5 hours using 6-chloroindole(0.2 mmol, 30.0 mg) with benzeneselenol (1.2 equiv, 37.9 mg) and afforded the desired product as a white solid, 56.3 mg (92% by method-A).

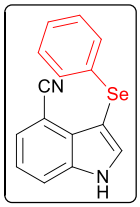
^{1}H NMR (300 MHz, D_6-DMSO): δ 11.82 (br. s, 1H), 7.79 (d, J = 2.1 Hz, 1H), 7.56 (d, J = 2.1 Hz, 1H), 7.39 (d, J = 8.4 Hz, 1H), 7.19-7.06 (m, 6H); ^{13}C NMR (75 MHz, D_6-DMSO): δ 137.0, 133.99, 133.4, 129.2, 128.4, 128.3, 128.2, 126.9, 125.8, 120.5, 111.8, 95.5.



2-(3-Nitrophenyl)-3-(phenylselanyl)-1*H*-indole, 4i:

The reaction is conducted by 4 hours using 2-(3-nitrophenyl)-3-(phenylselanyl)-1H-indole (44.8 mg, 0.2mmol) with diphenyl diselenide (0.6 equiv, 37.4 mg) and afforded the desired product as a white solid, 70.9 mg (90% by method-B).

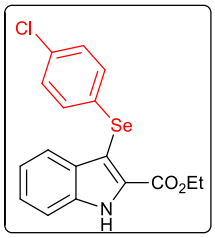
^{1}H NMR (400 MHz, D_6-DMSO): δ 12.33 (s, 1H), 8.67 (s, 1H), 8.24 (dd, *J* = 8.0 Hz, 1.2 Hz, 1H), 8.19 (dt, *J* = 1.2 Hz, 0.8 Hz, 1H), 7.73 (t, *J* = 8.4 Hz, 1H), 7.49 (d, *J* = 8.0 Hz, 1H), 7.45 (d, *J* = 8.0 Hz, 1H), 7.21 (t, *J* = 6.8 Hz, 1H), 7.14-7.04 (m, 6H); ^{13}C NMR (100 MHz, D_6-DMSO): δ 148.3, 139.7, 137.2, 135.2, 133.6, 131.7, 130.6, 129.9, 128.4, 126.4, 123.9, 123.41, 123.38, 121.3, 120.5, 112.7, 95.6; HRMS (ESI, m/z) calcd. for $C_{20}H_{14}N_2NaO_2Se$ [M + Na]$^{+}$: 417.0118; found: 417.0111.



3-(Phenylselanyl)-1*H*-indole-4-carbonitrile, 4j[1]:

The reaction is conducted for 2 hours by using 4-cyanoindole(28.2 mg, 0.2 mmol) with benzeneselenol (1.2 equiv, 37.9 mg) and afforded the desired product as a white solid, 23.8 mg (40% by Method-A).

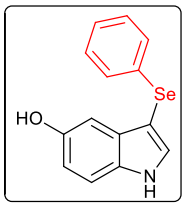
^{1}H NMR (400 MHz, D_6-DMSO): δ 12.27 (br. s, 1H), 7.98 (s, 1H), 7.83 (d, *J* = 8.4 Hz, 1H), 7.55 (d, *J* = 7.6 Hz, 1H), 7.30 (t, *J* = 8.0 Hz, 1H), 7.18-7.10 (m, 5H); ^{13}C NMR (100 MHz, D_6-DMSO): δ 137.0, 136.9, 134.2, 129.1, 128.5, 127.9, 127.5, 125.8, 121.9, 117.7, 117.5, 101.6, 94.4.



Ethyl 3-((4-chlorophenyl)selanyl)-1*H*-indole-2-carboxylate, 4k:

The reaction is conducted for 4 hours by using ethyl 1*H*-indole-2-carboxylate (37.6 mg, 0.2mmol) with bis(4-chlorophenyl) diselenide (45.7 mg, 0.6 equiv.) and afforded the desired product as a white solid, 64.2 mg (85% by Method-B).

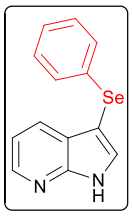
^{1}H NMR (400 MHz, $CDCl_3$): δ 9.35 (br. s, 1H), 7.50 (dd, *J* = 8.0 Hz, 0.8 Hz, 1H), 7.44 (d, *J* = 8.4 Hz, 1H), 7.34 (td, *J* = 7.2 Hz, 1.2 Hz, 1H), 7.26-7.23 (m, 2H), 7.15-7.10 (m, 3H), 4.41 (quin, *J* = 7.2 Hz, 2H), 1.36 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 161.4, 136.2, 132.3, 131.7,130.8, 130.5, 129.2, 128.7, 126.2, 122.6, 121.6, 112.2, 105.7, 61.6, 14.4; HRMS (ESI, m/z) calcd. for $C_{17}H_{14}ClNNaO_2Se$ [M + Na]$^{+}$: 401.9776; found: 401.9776; ^{77}Se NMR (76.3 MHz, $CDCl_3$): 258.0.



3-(Phenylselanyl)-1*H*-indol-5-ol, 4l[1]:

The reaction is conducted for 6 hours by using ethyl 5-hydroxy-indole (26.4 mg, 0.2 mmol) with diphenyl diselenide (0.6 equiv, 37.4 mg)and afforded the desired product as a white solid, 49.1 mg (85% by Method-B).

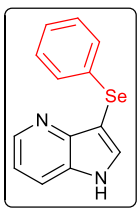
^{1}H NMR (400 MHz, D_6-DMSO): δ 11.40 (s, 1H), 8.83 (s, 1H), 7.62 (d, *J* = 2.4 Hz, 1H), 7.31 (d, *J* = 8.8 Hz, 1H), 7.19-7.08 (m, 5H), 6.77 (d, *J* = 2.4 Hz, 1H), 6.70 (dd, *J* = 8.4 Hz, 2.4 Hz, 1H); ^{13}C NMR (100 MHz, D_6-DMSO): δ 151.6, 133.9, 132.9, 130.9, 130.5, 129.0, 127.8, 125.4, 112.6, 112.4, 102.9, 93.8; HRMS (ESI, m/z) calcd. for $C_{18}H_{13}NNaSSe$ $[M + Na]^+$: 311.9904; found: 311.9886.



3-(Phenylselanyl)-1*H*-pyrrolo[2,3-b]pyridine, 4m[3]:

The reaction is conducted for 2 hours by using 7-azaindole (23.4 mg, 0.2 mmol) with benzeneselenol (1.2 equiv, 37.9 mg) or diphenyl diselenide (0.6 equiv, 37.4 mg)and afforded the desired product as a white solid, 50.9 mg (93% by Method-A) and 47.6mg (87% by Method-B).

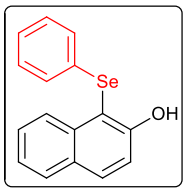
^{1}H NMR (400 MHz, D_6-DMSO): δ 12.25 (s, 1H), 8.28 (d, *J* = 4.4 Hz, 1H), 7.88 (s, 1H), 7.77 (d, *J* = 8.0 Hz, 1H), 7.17-7.10 (m, 6H); ^{13}C NMR (100 MHz, D_6-DMSO): δ 148.9, 143.5, 133.4, 133.1, 129.1, 128.3, 127.3, 125.8, 121.8, 116.5, 94.0.



3-(Phenylselanyl)-1*H*-pyrrolo[3,2-b]pyridine, 4n:

The reaction is conducted for 2 hours by using 4-azaindole(23.4 mg, 0.2 mmol) with benzeneselenol (1.2 equiv, 37.9 mg) or diphenyl diselenide (0.6 equiv, 37.4 mg) and afforded the desired product as a white solid, 49.3 mg (90% by Method-A).

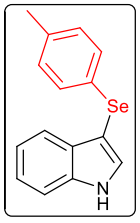
^{1}H NMR (300 MHz, D_6-DMSO): δ 11.88 (br. s, 1H), 8.37 (d, *J* = 4.5 Hz, 1H), 7.99 (d, *J* = 1.8 Hz, 1H), 7.87 (d, *J* = 8.1 Hz, 1H), 7.22-7.07 (m, 6H); ^{13}C NMR (75 MHz, D_6-DMSO): δ 147.5, 144.8, 137.5, 135.4, 130.5, 130.3, 129.7, 126.9, 120.7, 118.6, 97.6.



1-(Phenylselanyl)naphthalen-2-ol, 4o[1]:

The reaction is conducted for 36 hours by using 2-naphthol (28.6mg, 0.2 mmol) with benzeneselenol (1.2 equiv, 37.9 mg) and afforded the desired product as a white solid, 51 mg (85% by Method-A).

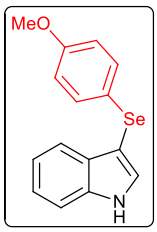
^{1}H NMR (400 MHz, $CDCl_3$): δ 8.29 (d, *J* = 8.8 Hz, 1H), 7.89 (d, *J* = 8.8 Hz, 1H), 7.79 (d, *J* = 8.0 Hz, 1H), 7.52-7.47 (m, 1H), 7.38-7.34 (m, 2H), 7.17-7.12 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 156.3, 135.9, 132.9, 130.6, 129.5, 129.2, 128.6, 128.0, 127.0, 126.7, 123.9, 116.7, 109.1; ^{77}Se NMR (76.3 MHz, $CDCl_3$): 152.2.



3-(*p*-tolylselanyl)-1*H*-indole, 4q[1]:

The reaction is conducted for 2 hours by using ethyl indole (0.2 mmol, 23.4 mg) with bis(4-methylphenyl) diselenide (41.0 mg, 0.6 equiv.) and afforded the desired product as a white solid, 52.8 mg (92% by Method-B).

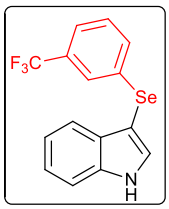
^{1}H NMR (600 MHz, $CDCl_3$): δ 8.46 (br.s, 1H), 7.65 (d, *J* = 9.0 Hz, 1H), 7.49 (d, *J* = 2.4 Hz, 1H), 7.45 (d, *J* = 7.8 Hz, 1H), 7.27 (td, *J* = 7.2 Hz, 1.2 Hz, 2H), 7.19-7.17 (m, 3H), 6.97 (d, *J* = 7.8 Hz, 2H), 2.25 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 136.3, 135.4, 132.3, 130.9, 129.9, 129.7, 128.9, 122.8, 120.7, 120.4, 111.3, 98.6, 20.9.



3-((4-methoxyphenyl)selanyl)-1*H*-indole, 4r[1]:

The reaction is conducted for 2 hours by using ethyl indole (0.2 mmol, 23.4 mg) with bis(4-methoxyphenyl) diselenide (44.9 mg, 0.6 equiv.) and afforded the desired product as a white solid, 54.5 mg (90% by Method-B).

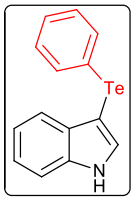
^{1}H NMR (600 MHz, $CDCl_3$): δ 8.39 (br.s, 1H), 7.68 (d, *J* = 7.8 Hz, 1H), 7.46 (d, *J* = 2.4 Hz, 1H), 7.42 (dd, *J* = 8.4 Hz, 1.2 Hz, 1H), 7.29-7.26 (m, 3H), 7.19 (t, *J* = 7.2 Hz, 1H), 6.74 (d, *J* = 8.4 Hz, 2H), 3.74 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 158.3, 136.3, 131.2, 130.6, 129.8, 123.3, 122.8, 120.7, 120.3, 114.7, 111.3, 99.4, 55.2.



3-((3-(trifluoromethyl)phenyl)selanyl)-1*H*-indole, 4s:

The reaction is conducted for 2 hours by using ethyl indole (0.2 mmol, 23.4 mg) with bis(3-trifluoromethylphenyl) diselenide (53.9 mg, 0.6 equiv.) and afforded the desired product as a white solid, 47.7 mg (70% by Method-B).

^{1}H NMR (600 MHz, $CDCl_3$): δ 8.54 (br.s, 1H), 7.61 (d, *J* = 7.8 Hz, 1H), 7.55 (s, 1H), 7.53 (d, *J* = 2.4 Hz, 1H), 7.47 (d, *J* = 8.4 Hz, 1H), 7.35 (d, *J* = 7.8 Hz, 1H), 7.33-7.28 (m, 2H), 7.22-7.19 (m, 2H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 136.4, 135.2, 131.7, 131.5, 131.1 (q, *J* = 32.1 Hz), 129.6, 129.2, 125.0 (q, *J* = 3.9 Hz), 123.8 (d, *J* = 271.0 Hz) 123.2, 122.3 (q, *J* = 3.9 Hz), 121.1, 120.1, 111.5, 97.2; HRMS (ESI, m/z) calcd. for $C_{15}H_{11}F_3NSe$ $[M + H]^+$: 342.0009; found: 342.0006; ^{77}Se NMR (76.3 MHz, $CDCl_3$): 225.0.

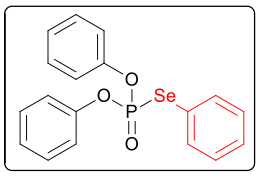


3-(phenyltellanyl)-1H-indole, 4t:

The reaction is conducted for 2 hours by using ethyl indole (0.2 mmol, 23.4 mg) with 1,2-diphenylditellane (49.7 mg, 0.6 equiv.) and afforded the desired product as a white solid, 16.1 mg (25% by Method-B).

^{1}H NMR (600 MHz, $CDCl_3$): δ 8.55 (br.s, 1H), 7.68 (d, *J* = 7.8 Hz, 1H), 7.58 (d, *J* = 1.8 Hz, 1H), 7.46 (d, *J* = 8.4 Hz, 1H), 7.43 (d, *J* = 7.2 Hz, 2H), 7.29 (t, *J* = 7.2 Hz, 1H), 7.22 (t, *J* = 7.2 Hz, 1H), 7.14 (t, *J* = 7.2 Hz, 1H), 7.09 (t, *J* = 7.2 Hz, 2H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 136.3, 135.5, 134.3, 132.3, 129.1, 126.6, 122.9, 122.1, 120.9, 116.4, 111.1, 81.0.

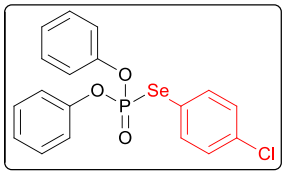
Characterization Data for Selenophosphorous Product:



_O,O_,Se-triphenyl phosphoroselenoate, 6a:

The reaction is conducted by using diphenyl phosphite with benzeneselenl or diphenyl diselenide and afforded the desired product as a gummy liquid, 54.4 mg (70% by Method-C), 46.7 mg (60% by Method-D).

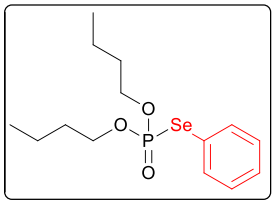
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.6-7.5 (m, 2H), 7.4-7.3 (m, 7H), 7.2-7.1 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 150.3 (d, J_{C-P} = 8.5 Hz), 136.3 (d, J_{C-P} = 4.8 Hz), 129.9 (d, J_{C-P} = 1.3 Hz), 129.7 (d, J_{C-P} = 2.5 Hz), 129.4 (d, J_{C-P} = 2.9 Hz), 125.7 (d, J_{C-P} = 2.1 Hz), 122.7 (d, J_{C-P} = 9.1 Hz), 120.7 (d, J_{C-P} = 5.3 Hz); ^{31}P NMR (160 MHz, $CDCl_3$): δ 10.09; HRMS (EI, m/z) calcd. For $C_{18}H_{15}O_3PSe$ $[M]^+$: 389.9924; found: 389.9926; ^{77}Se NMR (76.3 MHz, $CDCl_3$): 298.4 (d, J_{Se-P} = 544.5 Hz).



Se-(4-chlorophenyl) _O,O_-diphenyl phosphoroselenoate, 6b:

The reaction is conducted by using diphenyl phosphite (46.8 mg, 0.2mmol) with bis(4-chlorophenyl) diselenide(45.7 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 33.8 mg (40% by Method-C).

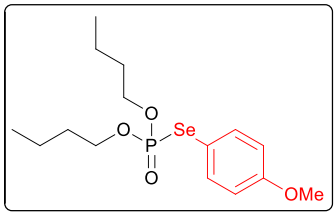
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.45 (dd, J = 8.4 Hz, 1.8 Hz, 2H), 7.37(t, J = 7.8 Hz, 4H), 7.26 (d, J = 9.0 Hz, 3H), 7.24-7.22 (m, 5H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 150.1 (d, J_{C-P} = 8.7 Hz), 137.5 (d, J_{C-P} = 4.6 Hz), 135.9 (d, J_{C-P} = 3.7 Hz), 129.8, 129.7 (d, J_{C-P} = 2.4 Hz), 125.7, 120.6, 120.5; IR (neat): υ_{max} 3069, 2924, 1589, 1483, 1180, 932, 764 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 8.59; HRMS (EI, m/z) calcd. For $C_{18}H_{14}ClO_3PSe$ $[M]^+$: 423.9534; found: 423.9532.



_O,O_-Dibutyl Se-phenyl phosphoroselenoate, 6c[6]:

The reaction is conducted by using dibutyl phosphonate with diphenyl diselenide or benzeneselenol and afforded the desired product as a gummy liquid, 49 mg (74% by Method-C) 52.5mg (75% by Method-D).

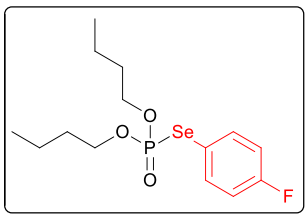
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.62 (d, J = 7.8 Hz, 2H), 7.33 (t, J = 7.2 Hz, 1H), 7.30-7.28 (m, 2H), 4.14-4.03 (m, 4H), 1.61 (quin, J = 7.2 Hz, 4H), 1.33 (sex, J = 7.8 Hz, 4H), 0.88 (t, J = 7.2 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 135.5 (d, J_{C-P} = 4.5 Hz),129.4 (d, J_{C-P} = 1.8 Hz), 128.7 (d, J_{C-P} = 2.5 Hz), 123.8 (d, J_{C-P} = 8.2 Hz), 67.6 (d, J_{C-P} = 0.3 Hz), 32.0 (d, J_{C-P} = 7.2 Hz), 18.7, 13.6; IR (neat): υ_{max} 2960, 1578, 1469, 1256, 1019, 738, 537 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 18.02; HRMS (EI, m/z) calcd. For $C_{14}H_{23}O_3PSe$ $[M]^+$: 350.0550; found: 350.0546.



***O,O*-Dibutyl Se-(4-methoxyphenyl) phosphoroselenoate, 6d**:

The reaction is conducted by using dibutyl phosphonate(38.8 mg, 0.2mmol) with bis(4-methoxyphenyl) diselenide(44.7 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 69.1 mg (91% by Method-C).

^{1}H NMR (600 MHz, $CDCl_3$): δ 7.54 (dd, J = 9.0 Hz, 2.4 Hz, 2H), 6.84 (d, J = 9.0 Hz, 2H), 4.14-4.04 (m, 4H), 4.09-4.04 (m, 2H), 3.80 (s, 3H), 1.63 (quin, J = 7.2 Hz, 4H), 1.35 (sex, J = 7.8 Hz, 4H), 0.90 (t, J = 7.8 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 160.2 (d, J_{C-P} = 2.5 Hz), 137.2 (d, J_{C-P} = 4.2 Hz), 115.1 (d, J_{C-P} = 2.2 Hz), 113.5 (d, J_{C-P} = 8.7 Hz), 67.4 (d, J_{C-P} = 6.4 Hz), 55.3, 32.0 (d, J_{C-P} = 6.3 Hz), 18.7, 13.5; ^{31}P NMR (120 MHz, $CDCl_3$): δ 18.40; HRMS (EI, m/z) calcd. For $C_{15}H_{25}O_4PSe$ $[M]^+$: 380.0656; found: 380.0662; ^{77}Se NMR (76.3 MHz, $CDCl_3$): 251.2 (d, J_{Se-P} = 491.1 Hz).

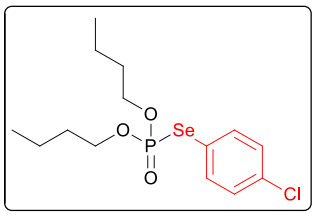


***O,O*-Dibutyl Se-(4-fluorophenyl) phosphoroselenoate, 6e**:

The reaction is conducted by using dibutyl phosphonate(38.8 mg, 0.2mmol) with bis(4-fluorophenyl) diselenide (41.8 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 58.1 mg (79% by Method-C).

^{1}H NMR (600 MHz, $CDCl_3$): δ 7.63-7.60 (m, 2H), 7.01 (t, J = 8.4 Hz, 2H), 4.16-4.12 (m, 2H), 4.11-4.04 (m, 2H), 1.63 (quin, J = 7.2 Hz, 4H), 1.35 (sex, J = 7.8 Hz, 4H), 0.91 (t, J =

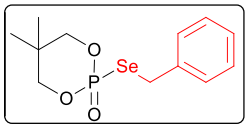
7.8 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 163.2 (dd, *J* = 247.6 Hz, 2.8 Hz), 137.6 (dd, *J* = 8.1 Hz, 4.3 Hz), 118.3 (dd, *J* = 8.5 Hz, 3.4 Hz), 116.7 (dd, *J* = 21.7 Hz, 2.2 Hz), 67.6 (d, *J* = 6.4 Hz), 32.0 (d, *J* = 7.3 Hz), 18.6, 13.5; IR (neat): υ_{max} 2961, 1484, 1232, 1016, 830, 538 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 18.32; HRMS (ESI, m/z) calcd. for $C_{14}H_{22}FNaO_3PSe$ $[M + Na]^+$: 391.0354; found: 391.0359.



_O,O_-Dibutyl Se-(4-chlorophenyl) phosphoroselenoate, 6f[6]:

The reaction is conducted by using dibutyl phosphonate (38.8 mg, 0.2mmol) with bis(4-chlorophenyl) diselenide (45.7 mg, 0.6 equiv) and afforded the desired product as a gummy liquid 58.3 mg (76% by Method-C).

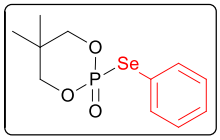
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.57 (d, *J* = 6.6 Hz, 2H), 7.28 (d, *J* = 8.4 Hz, 2H), 4.16-4.11 (m, 2H), 4.1-4.05 (m, 2H), 1.63 (quin, *J* = 6.6 Hz, 4H), 1.35 (sex, *J* = 7.2 Hz, 4H), 0.91 (t, *J* = 7.2 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 136.7 (d, J_{C-P} = 4.8 Hz), 135.2 (d, J_{C-P} = 3.1 Hz), 129.6 (d, J_{C-P} = 2.1 Hz), 121.9 (d, J_{C-P} = 8.5 Hz), 67.7 (d, J_{C-P} = 6.6 Hz), 31.99 (d, J_{C-P} = 7.2 Hz), 18.6, 13.5; IR (neat): υ_{max} 2959, 1470, 1256, 1011, 536 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 17.26; HRMS (EI, m/z) calcd. For $C_{14}H_{22}ClO_3PSe$ $[M]^+$: 384.0160; found: 384.0152.



2-(Benzylselanyl)-5,5-dimethyl-1,3,2-dioxaphosphinane 2-oxide, 6g:

The reaction is conducted by using 5,5-dimethyl-1,3,2-dioxaphosphinane 2-oxide (30.0 mg, 0.2 equiv) with dibenzyl diselenide(40.8 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 41.6 mg (65% by Method-C).

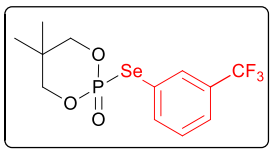
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.37 (d, *J* = 7.2 Hz, 2H), 7.30 (t, *J* = 7.2 Hz, 2H), 7.24 (t, *J* = 7.2 Hz, 1H), 4.2 (d, *J* = 12.0 Hz, 2H), 4.0 (dd, *J* = 10.8 Hz, 4.2 Hz, 2H), 3.84-3.78 (m, 2H), 1.29 (s, 3H), 0.85 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 137.8 (d, J_{C-P} = 5.2 Hz), 128.99, 128.7, 127.5, 77.6 (d, J_{C-P} = 6.9 Hz), 32.4 (d, J_{C-P} = 6.6 Hz), 28.2 (d, J_{C-P} = 4.2 Hz), 22.2, 20.5; IR (neat): υ_{max} 2924, 1458, 1257, 1050, 770, 517 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 13.33; HRMS (ESI, m/z) calcd. for $C_{12}H_{17}NaO_3PSe$ $[M + Na]^+$: 342.9978; found: 342.9972.



5,5-Dimethyl-2-(phenylselanyl)-1,3,2-dioxaphosphinane-2-oxide, 6h:

The reaction is conducted by using 5,5-dimethyl-1,3,2-dioxaphosphinane 2-oxide with diphenyl diselenide or benzeneselenol and afforded the desired product as a gummy liquid 39.6 mg (65% by Method-C), 50.02 mg (82% by Method-D).

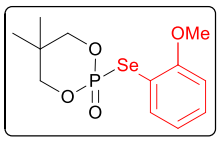
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.72-7.71 (m, 2H), 7.37 (td, J = 7.2 Hz, 1.2 Hz, 1H), 7.34-7.31 (m, 2H), 4.16 (dd, J = 10.8 Hz, 4.2 Hz, 2H), 3.90-3.84 (m, 2H), 1.28 (s, 3H), 0.87 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 135.9 (d, J_{C-P} = 9.3 Hz), 129.6 (d, J_{C-P} = 4.2 Hz), 129.0 (d, J_{C-P} = 5.2 Hz), 121.8 (d, J_{C-P} = 15.9 Hz), 32.5 (d, J_{C-P} = 13.9 Hz), 22.1, 20.4; IR (neat): υ_{max} 2967, 2926, 1472, 1265, 988, 778, 530 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 9.65; HRMS (EI, m/z) calcd. For $C_{11}H_{15}O_3PSe$ $[M]^+$: 305.9924; found: 305.9921; ^{77}Se NMR (76.3 MHz, $CDCl_3$): 248.1 (d, J_{Se-P} = 479.6 Hz).



5,5-Dimethyl-2-((3-(trifluoromethyl)phenyl)selanyl)-1,3,2-dioxaphosphinane 2-oxide, 6i:

The reaction is conducted by using 5,5-dimethyl-1,3,2-dioxaphosphinane 2-oxide (30.0 mg, 0.2 equiv) with bis(3-trifluoromethylphenyl) diselenide(53.9 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 51.4 mg (69% by Method-C).

^{1}H NMR (600 MHz, $CDCl_3$): δ 7.96 (d, J = 7.8 Hz, 1H), 7.93 (s, 1H), 7.63 (d, J = 7.8 Hz, 1H), 7.63 (d, J = 7.8 Hz, 1H), 7.46 (t, J = 7.8 Hz, 1H), 4.18 (dd, J = 10.8 Hz, 4.2 Hz, 2H), 3.95-3.89 (m, 2H), 1.29 (s, 3H), 0.89 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 139.2 (d, J = 4.2 Hz), 132.2-132.1 (m), 131.8 (dd, J = 32.5 Hz, 3.4 Hz), 130.0 (d, J = 2.1 Hz), 126.1-125.8 (m), 123.4 (J = 271.2 Hz), 123.0 (J = 7.8 Hz), 32.5 (d, J = 6.7 Hz), 22.0, 20.3; IR (neat): υ_{max} 2927, 1320, 1055, 773, 519 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 17.66, 17.62; HRMS (ESI, m/z) calcd. for $C_{12}H_{15}F_3O_3PSe$ $[M + H]^+$: 374.9876; found: 374.9857; ^{77}Se NMR (76.3 MHz, $CDCl_3$): 260.6 (d, J_{Se-P} = 477.0 Hz).

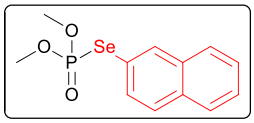


2-((2-Methoxyphenyl)selanyl)-5,5-dimethyl-1,3,2-dioxaphosphinane 2-oxide, 6j:

The reaction is conducted by using 5,5-dimethyl-1,3,2-dioxaphosphinane 2-oxide (30.0 mg, 0.2 equiv) with bis(2-methoxyphenyl) diselenide (44.7 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 52.4 mg (78% by Method-C).

^{1}H NMR (600 MHz, $CDCl_3$): δ 7.83 (d, J = 7.8 Hz, 1H), 7.33 (t, J = 7.8 Hz, 1H), 6.93-6.90 (m, 2H), 4.23 (dd, J = 10.8 Hz, 3.6 Hz, 2H), 3.88 (s, 3H), 3.86-3.80 (m, 2H), 1.29 (s, 3H), 0.87 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 158.6 (d, J_{C-P} = 4.3 Hz), 137.2 (d, J_{C-P} = 3.9

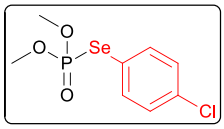
Hz), 130.5 (d, $J_{C\text{-}P}$ = 2.2 Hz), 121.9 (d, $J_{C\text{-}P}$ = 2.2 Hz), 111.2 (d, $J_{C\text{-}P}$ = 2.1 Hz), 78.1 (d, $J_{C\text{-}P}$ = 7.2 Hz), 55.9, 32.5 (d, $J_{C\text{-}P}$ = 6.7 Hz), 22.2, 20.4; ^{31}P NMR (120 MHz, $CDCl_3$): δ 9.57; HRMS (EI, m/z) calcd. For $C_{12}H_{17}O_4PSe$ $[M]^+$: 336.0030; found: 336.0022; ^{77}Se NMR (76.3 MHz, $CDCl_3$): 171.1 (d, $J_{Se\text{-}P}$ = 481.4 Hz).



_O,O_-Dimethyl Se-naphthalen-2-yl phosphoroselenoate, 6k:

The reaction is conducted by using dimethyl phosphonate(22.0 mg, 0.2mmol) with bis(2-naphthyl) diselenide (49.5 mg, 0.6 equiv)and afforded the desired product as a gummy liquid, 49.7 mg (79% by Method-C).

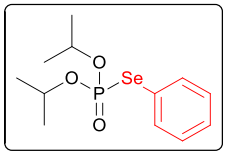
^{1}H NMR (600 MHz, $CDCl_3$): δ 8.47 (d, J = 8.4 Hz, 1H), 7.99 (dd, J = 7.8 Hz, 3.0 Hz, 1H), 7.91 (d, J = 8.4 Hz, 1H), 7.86 (d, J = 7.8 Hz, 1H), 7.62 (t, J = 7.2 Hz, 1H), 7.55 (t, J = 7.2 Hz, 1H), 7.43 (t, J = 7.8 Hz, 1H), 3.75 (s, 3H), 3.73 (s, 3H); ^{13}C NMR (150 MH_Z, $CDCl_3$): δ 136.6 (d, $J_{C\text{-}P}$ = 4.9 Hz), 134.9 (d, $J_{C\text{-}P}$ = 3.3 Hz), 134.2 (d, $J_{C\text{-}P}$ = 2.1 Hz), 130.4 (d, $J_{C\text{-}P}$ = 3.3 Hz), 128.7, 127.9, 127.2, 126.5, 125.9 (d, $J_{C\text{-}P}$ = 3.1 Hz), 122.5 (d, $J_{C\text{-}P}$ = 9.3 Hz), 54.1 (d, $J_{C\text{-}P}$ = 6.0 Hz); IR (neat): υ_{max} 2951, 2850, 1500, 1254, 1019, 768, 525 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 21.06; HRMS (EI, m/z) calcd. For $C_{12}H_{13}O_3PSe$ $[M]^+$: 315.9768; found: 315.9760; ^{77}Se NMR (76.3 MHz, $CDCl_3$): 184.3 (d, $J_{Se\text{-}P}$ = 499.3 Hz).



Se-(4-chlorophenyl) _O,O_-dimethyl phosphoroselenoate, 6l[6]:

The reaction is conducted by using dimethyl phosphonate(22.0 mg, 0.2mmol) with bis(4-chlorophenyl) diselenide (45.7 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 41.8 mg (70% by Method-C).

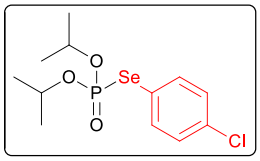
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.57 (dd, J = 9.0 Hz, 1.8 Hz, 2H), 7.30 (d, J = 8.4 Hz, 2H), 3.82 (s, 3H), 3.79 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 136.8 (d, $J_{C\text{-}P}$ = 4.8 Hz), 135.5 (d, $J_{C\text{-}P}$ = 3.1 Hz), 129.8 (d, $J_{C\text{-}P}$ = 2.5 Hz), 121.3 (d, $J_{C\text{-}P}$ = 8.7 Hz), 54.1 (d, $J_{C\text{-}P}$ = 5.8 Hz); IR (neat): υ_{max} 2951, 2851, 1470, 1256, 1017, 822, 526 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 21.17; HRMS (EI, m/z) calcd. For $C_8H_{10}ClO_3PSe$ $[M]^+$: 299.9221; found: 299.9230.



_O,O_-Diisopropyl Se-phenyl phosphoroselenoate, 6m[6]:

The reaction is conducted by using diisopropyl Phosphite with benzeneselenol and afforded the desired product as a gummy liquid, 45.1 mg (70% by Method-D).

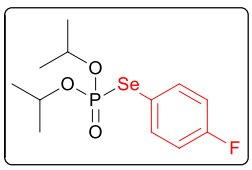
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.65-7.63 (m, 2H), 7.33-7.25 (m, 3H), 4.80-4.72 (m, 2H), 1.31 (d, J = 6.4 Hz, 6H), 1.23 (d, J = 6.0 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 135.2 (d, J_{C-P} = 19.2 Hz), 129.4 (d, J_{C-P} = 8.0 Hz), 128.6 (d, J_{C-P} = 9.6 Hz), 124.6 (d, J_{C-P} = 34.4 Hz), 73.2 (d, J_{C-P} = 26.4 Hz), 23.9 (d, J_{C-P} = 15.2 Hz), 23.6 (d, J_{C-P} = 24.4 Hz); ^{31}P NMR (160 MHz, $CDCl_3$): δ 15.40; HRMS (ESI, m/z) calcd. for $C_{12}H_{20}O_3PSe$ $[M + H]^+$: 323.0315; found: 323.0321.



Se-(4-chlorophenyl) *O,O*-diisopropyl phosphoroselenoate, 6n[6]:

The reaction is conducted by using diisopropyl (33.2 mg, 0.2 mmol) with bis(4-chlorophenyl) diselenide (45.7 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 56.1 mg (79% by using Method-C).

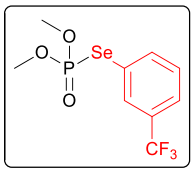
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.60 (dd, J = 8.4 Hz, 1.8 Hz, 2H), 7.28 (d, J = 8.4 Hz, 2H), 4.81-4.75 (m, 2H), 1.34 (d, J = 6.6 Hz, 6H), 1.28 (d, J = 6.6 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 136.4 (d, J_{C-P} = 4.8 Hz), 134.9 (d, J_{C-P} = 2.7 Hz), 129.5 (d, J_{C-P} = 1.9 Hz), 122.7 (d, J_{C-P} = 8.4 Hz), 73.3 (d, J_{C-P} = 6.6 Hz), 23.8 (d, J_{C-P} = 3.7 Hz), 23.5 (d, J_{C-P} = 5.7 Hz); ^{31}P NMR (120 MHz, $CDCl_3$): δ 13.88; HRMS (EI, m/z) calcd. For $C_{12}H_{18}ClO_3PSe$ $[M]^+$: 355.9847; found: 355.9831.



Se-(4-fluorophenyl) *O,O*-diisopropyl phosphoroselenoate, 6o:

The reaction is conducted by using diisopropyl phosphonate (33.2 mg, 0.2 mmol) with bis(4-fluorophenyl) diselenide (41.8 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 47.6 mg (70% by Method-C).

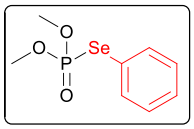
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.66-7.63 (m, 2H), 7.01 (t, J = 9.0 Hz, 2H), 4.80-4.75 (m, 2H), 1.34 (d, J = 6.0 Hz, 6H), 1.27 (d, J = 6.6 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 163.1 (dd, J = 247.5 Hz, 2.7 Hz), 137.3 (dd, J = 8.2 Hz, 4.3 Hz), 119.0 (dd, J = 8.4 Hz, 3.4 Hz), 116.6 (dd, J = 21.6 Hz, 1.8 Hz), 73.2 (d, J = 6.6 Hz), 23.8 (d, J = 3.9 Hz), 23.5 (d, J = 5.5 Hz); IR (neat): υ_{max} 2981, 1486, 1248, 980, 569 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 14.28, 14.25; HRMS (ESI, m/z) calcd. for $C_{12}H_{18}FNaO_3PSe$ $[M + Na]^+$: 363.0041; found: 363.0046.



***O,O*-Dimethyl Se-(3-(trifluoromethyl)phenyl) phosphoroselenoate, 6p**:

The reaction is conducted by using dimethyl phosphonate (22.0 mg, 0.2mmol) with bis(3-trifluoromethylphenyl) diselenide (53.9 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 47.3 mg (71% by Method-C).

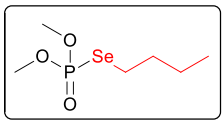
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.9 (s, 1H), 7.86 (d, *J* = 7.8 Hz, 1H), 7.64 (d, *J* = 7.8 Hz, 1H), 7.47 (t, *J* = 7.8 Hz, 1H), 3.83 (s, 3H), 3.81 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 138.8 (d, *J* = 4.2 Hz), 132.2-132.1 (m), 131.8 (dd, *J* = 32.4 Hz, 1.6 Hz), 129.9 (d, *J* = 2.1 Hz), 125.8-125.7 (m), 124.4 (d, *J* = 8.4 Hz), 123.3 (d, *J* = 271.0 Hz) 54.2 (d, *J* = 5.8 Hz); IR (neat): υ_{max} 2955, 1320, 1025, 792, 526 cm^{-1}; ^{31}P NMR (160 MHz, $CDCl_3$): δ 21.25; HRMS (EI, m/z) calcd. For $C_9H_{10}F_3O_3PSe$ $[M]^+$: 333.9485; found: 333.9491.



***O,O*-Dimethyl Se-phenyl phosphoroselenoate, 6q**[7]:

The reaction is conducted by using dimethyl phosphonate with diphenyl diselenide or benzeneselenol and afforded the desired product as a gummy liquid, 45.6 mg (86% by Method-A) 42.9 mg (81% by Method-C), 32.2 mg (75% by Method-D).

^{1}H NMR (600 MHz, $CDCl_3$): δ 7.66-7.64 (m, 2H), 7.38 (td, *J* = 7.2, 1.2 Hz, 1H), 7.35-7.32 (m, 2H), 3.82 (s, 3H), 3.80 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 135.6 (d, $J_{C\text{-}P}$ = 4.5 Hz), 129.6 (d, $J_{C\text{-}P}$ = 2.2 Hz), 128.9 (d, $J_{C\text{-}P}$ = 2.7 Hz), 123.2 (d, $J_{C\text{-}P}$ = 8.7 Hz), 53.9 (d, $J_{C\text{-}P}$ = 5.5 Hz); IR (neat): υ_{max} 2951, 2851, 1577, 1446, 1254, 1020, 524 cm^{-1}; ^{31}P NMR (160 MHz, $CDCl_3$): δ 22.61; HRMS (EI, m/z) calcd. For $C_8H_{11}O_3PSe$ $[M]^+$: 265.9611; found: 265.9618.

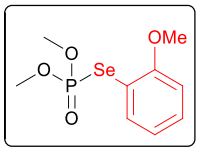


Se-butyl *O,O*-dimethyl phosphoroselenoate, 6r[8]:

The reaction is conducted by using dimethyl phosphonate (22.0 mg, 0.2mmol) with dibutyl diselenide (32.7 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 24.5mg (50% by Method-C).

^{1}H NMR (600 MHz, $CDCl_3$): δ 3.80 (s, 3H), 3.78 (s, 3H), 2.91-2.86 (m, 2H), 1.76 (quin, *J* = 7.2 Hz, 2H), 1.43 (sex, *J* = 7.2 Hz, 2H), 0.94 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 53.5 (d, $J_{C\text{-}P}$ = 5.5 Hz), 33.2 (d, $J_{C\text{-}P}$ = 4.3 Hz), 26.2 (d, $J_{C\text{-}P}$ = 4.5 Hz), 22.7, 13.4;

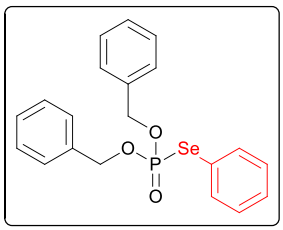
IR (neat): υ_{max} 2927, 2856, 1458, 1255, 1023, 770, 527 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 25.25.



Se-(2-methoxyphenyl) *O,O*-dimethyl phosphoroselenoate, 6s:

The reaction is conducted by using dimethyl phosphonate (22.0 mg, 0.2mmol) with bis(2-methoxyphenyl) diselenide (44.7 mg, 0.6 equiv) and afforded the desired product as a gummy liquid,42.5mg (72% by Method-C).

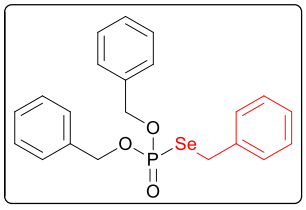
^1H NMR (600 MHz, $CDCl_3$): δ 7.67 (d, J = 7.8 Hz, 1H), 7.34 (t, J = 7.8 Hz, 1H), 6.93-6.91 (m, 2H), 3.89 (s, 3H), 3.82 (s, 3H), 3.80 (s, 3H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 158.7 (d, J_{C-P} = 4.3 Hz), 136.9 (d, J_{C-P} = 3.9 Hz), 130.6 (d, J_{C-P} = 2.4 Hz), 121.7 (d, J_{C-P} = 2.1 Hz), 112.5 (d, J_{C-P} = 8.1 Hz), 111.2 (d, J_{C-P} = 2.2 Hz), 55.9, 53.8 (d, J_{C-P} = 5.2 Hz); IR (neat): υ_{max} 2950, 2846, 1471, 1251, 1019, 526 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 22.44; HRMS (EI, m/z) calcd. For $C_9H_{13}O_4PSe$ $[M]^+$: 295.9717; found: 295.9710; ^{77}Se NMR (76.3 MHz, $CDCl_3$): 160.8 (d, J_{Se-P} = 501.4 Hz).



***O,O*-Dibenzyl Se-phenyl phosphoroselenoate, 6t[7]:**

The reaction is conducted by using diphenyl phosphite with dibenzyl diselenide or benzeneselenol and afforded the desired product as a gummy liquid, 62.7 mg (75% by Method-C), 66.8 mg (80% by Method-D).

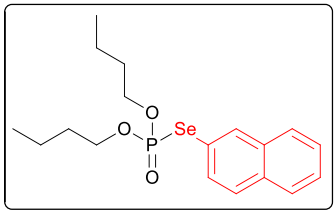
^1H NMR (600 MHz, $CDCl_3$): δ 7.58 (d, J = 7.2 Hz, 2H), 7.37-7.33 (m, 7H), 7.30-7.25 (m, 6H), 5.17-5.10 (m, 4H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 135.8 (d, J_{C-P} = 4.8 Hz), 135.2 (d, J_{C-P} = 7.8 Hz), 129.5 (d, J_{C-P} = 2.1 Hz), 128.9 (d, J_{C-P} = 2.7 Hz), 128.5, 128.5, 128.0, 123.2 (d, J_{C-P} = 8.7 Hz), 69.1 (d, J_{C-P} = 6.0 Hz); IR (neat): υ_{max} 3060, 2945, 1579, 1455, 1253, 991, 738, 529 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 0.54; HRMS (EI, m/z) calcd. For $C_{20}H_{19}O_3PSe$ $[M]^+$: 418.0237; found: 418.0224.



***O,O*,Se-tribenzyl phosphoroselenoate, 6u:**

The reaction is conducted by using dibenzyl phosphonate (52.4 mg, 0.2 mmol) with dibenzyl diselenide (40.8 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 47.5mg (55% by Method-C).

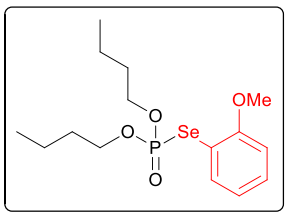
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.40-7.36 (m, 10H), 7.31-7.23 (m, 5H), 5.13-5.10 (m, 2H), 5.04-5.00 (m, 2H), 4.06 (d, J = 12.6 Hz, 2H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 138.0 (d, $J_{C\text{-}P}$ = 5.1 Hz), 135.3 (d, $J_{C\text{-}P}$ = 7.8 Hz), 128.9, 128.7, 128.6, 128.1, 127.4, 126.9, 68.7 (d, $J_{C\text{-}P}$ = 5.4 Hz), 29.7 (d, $J_{C\text{-}P}$ = 4.5 Hz); IR (neat): υ_{max} 3032, 2933, 1495, 1455, 1252, 991, 740, 530 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 21.18; HRMS (EI, m/z) calcd. For $C_{21}H_{21}O_3PSe$ $[M]^+$: 432.0394; found: 432.0387.



***O,O*-Dibutyl Se-naphthalen-2-yl phosphoroselenoate, 6v:**

The reaction is conducted by using dibutyl phosphonate (38.8 mg, 0.2mmol) with bis(2-naphthyl) diselenide (49.5 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 59.2mg (74% by Method-C).

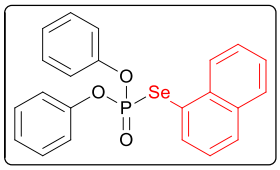
^{1}H NMR (600 MHz, $CDCl_3$): δ 8.18 (s, 1H), 7.85-7.83 (m, 1H), 7.81-7.78 (m, 2H), 7.70 (d, J = 8.4 Hz, 1H), 7.54-7.51 (m, 2H), 4.19-4.10 (m, 4H), 1.64 (quin, J = 6.6 Hz, 4H), 1.34 (sex, J = 7.8 Hz, 4H), 0.88 (t, J = 7.8 Hz, 6H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 135.2 (d, $J_{C\text{-}P}$ = 5.8 Hz), 133.8 (d, $J_{C\text{-}P}$ = 2.2 Hz), 132.9 (d, $J_{C\text{-}P}$ = 1.9 Hz), 131.98 (d, $J_{C\text{-}P}$ = 3.7 Hz), 128.9 (d, $J_{C\text{-}P}$ = 1.2 Hz), 127.7, 127.5, 126.8, 126.6, 121.0 (d, $J_{C\text{-}P}$ = 8.7 Hz), 67.6 (d, $J_{C\text{-}P}$ = 6.3 Hz),32.0 (d, $J_{C\text{-}P}$ = 7.2 Hz), 18.7, 13.5; IR (neat): υ_{max} 2958, 1462, 1253, 1018, 537 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 17.96; HRMS (EI, m/z) calcd. For $C_{18}H_{25}O_3PSe$ $[M]^+$: 400.0707; found: 400.0702; ^{77}Se NMR (76.3 MHz, $CDCl_3$): 266.1 (d, $J_{Se\text{-}P}$ = 484.2 Hz).



***O,O*-Dibutyl Se-(2-methoxyphenyl) phosphoroselenoate, 6w**:

The reaction is conducted by using dibutyl phosphite (49.5 mg, 0.6 equiv) with diphenyl diselenide (44.7 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 57.7 mg (76% by Method-C).

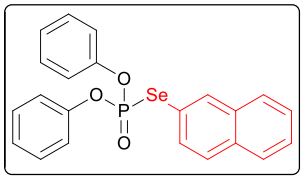
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.69 (dt, *J* = 7.6 Hz, 1.6, 1H), 7.33-7.29 (m, 1H), 6.92-6.88 (m, 2H), 4.17-4.08 (m, 4H), 3.87 (s, 3H), 1.63 (quin, *J* = 6.8 Hz, 4H), 1.39-1.30 (m, 4H), 0.89 (t, *J* = 7.2 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 136.6 (d, *J* = 15.6 Hz), 130.3 (d, *J* = 8.4 Hz), 121.7 (d, *J* = 7.6 Hz), 111.1 (d, *J* = 7.6 Hz), 67.5 (d, *J* = 24.8 Hz), 55.9, 32.1 (d, *J* = 28.8 Hz), 18.8, 13.7; IR (neat): υ_{max} 2960, 1580, 1470, 1251, 1020, 538 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 18.30; HRMS (EI, m/z) calcd. For $C_{15}H_{25}O_4PSe$ $[M]^+$: 380.0656; found: 380.0653.



Se-naphthalen-1-yl *O,O*-diphenyl phosphoroselenoate, 6x:

The reaction is conducted by using diphenyl phosphite (46.8 mg, 0.2mmol) with bis(1-naphthyl) diselenide (49.5 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 37.8 mg (43% by Method-C).

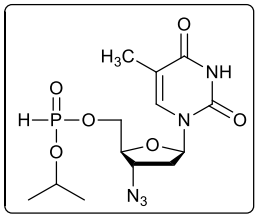
^{1}H NMR (600 MHz, $CDCl_3$): δ 8.19 (d, *J* = 8.4 Hz, 1H), 7.93-7.91 (m, 2H), 7.85 (d, *J* = 8.4 Hz, 1H), 7.51 (t, *J* = 7.8 Hz, 1H), 7.45 (t, *J* = 7.8 Hz, 1H), 7.39 (t, *J* = 7.8 Hz, 1H), 7.31-7.28 (m, 4H), 7.19 (t, *J* = 7.2 Hz, 2H), 7.14-7.13 (m, 4H); ^{13}C NMR (150 MHz, $CDCl_3$): δ150.2 (d, $J_{C\text{-}P}$ = 8.7 Hz), 137.2 (d, $J_{C\text{-}P}$ = 5.4 Hz), 134.9 (d, $J_{C\text{-}P}$ = 3.3 Hz), 134.2 (d, $J_{C\text{-}P}$ = 2.5 Hz), 130.8 (d, $J_{C\text{-}P}$ = 3.6 Hz), 129.7, 128.4, 128.1, 127.2, 126.5, 125.8 (d, $J_{C\text{-}P}$ = 3.7 Hz), 125.4 (d, $J_{C\text{-}P}$ = 0.9 Hz), 122.0 (d, $J_{C\text{-}P}$ = 9.9 Hz), 120.4 (d, $J_{C\text{-}P}$ = 5.1 Hz); IR (neat): υ_{max} 3060, 2925, 1590, 1489, 1187, 932, 511 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 8.60; HRMS (ESI, m/z) calcd. for $C_{22}H_{18}O_3PSe$ $[M + H]^+$: 441.0159; found: 441.0155.



Se-naphthalen-2-yl *O,O*-diphenyl phosphoroselenoate, 6y:

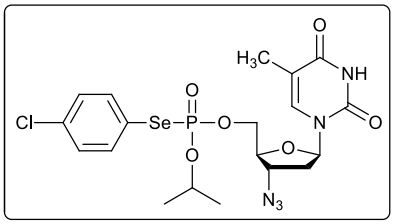
The reaction is conducted by using diphenyl phosphite (46.8 mg, 0.2mmol) with bis(2-naphthyl) diselenide (49.5 mg, 0.6 equiv) and afforded the desired product as a gummy liquid, 71.3 mg (81% by using Method-C).

^{1}H NMR (600 MHz, $CDCl_3$): δ 8.01 (s, 1H), 7.85 (d, *J* = 7.8 Hz, 1H), 7.78 (d, *J* = 8.4 Hz, 1H), 7.74 (d, *J* = 7.2 Hz, 1H), 7.60 (d, *J* = 9.0 Hz, 1H), 7.57-7.52 (m, 2H), 7.87-7.34 (m, 4H), 7.25-7.22 (m, 7H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 150.2 (d, $J_{C\text{-}P}$ = 8.2 Hz), 136.4 (d, $J_{C\text{-}P}$ = 6.0 Hz), 133.7 (d, $J_{C\text{-}P}$ = 2.7 Hz), 133.1 (d, $J_{C\text{-}P}$ = 2.1 Hz), 132.3 (d, $J_{C\text{-}P}$ = 3.6 Hz), 129.8, 129.1 (d, $J_{C\text{-}P}$ = 2.2 Hz), 127.7 (d, $J_{C\text{-}P}$ = 4.3 Hz), 127.2, 126.7, 125.6, 120.6 (d, $J_{C\text{-}P}$ = 5.1 Hz), 119.7 (d, $J_{C\text{-}P}$ = 9.6 Hz); IR (neat): υ_{max} 2924, 1589, 1488, 1185, 932, 521 cm^{-1}; ^{31}P NMR (120 MHz, $CDCl_3$): δ 9.84; HRMS (ESI, m/z) calcd. for $C_{22}H_{17}NaO_3PSe$ $[M + Na]^+$: 462.9978; found: 462.9981.



((2S,3S,5R)-3-azido-5-(5-methyl-2,4-dioxo-3,4-dihydropyrimidin-1(2H)-yl)tetrahydrofuran-2-yl)methyl isopropyl phosphonate (O)[10],[11]:

^{1}H NMR (600 MHz, $CDCl_3$): δ 8.48 (br.s, 1H), 7.42, 7.37*(s, 1H), 6.94, 6.92*(d, *J* = 702.6 Hz, 1H, P-H), 6.22-6.19 (m, 1H), 4.83-4.79 (m, 1H), 4.37-4.26 (m, 2H), 4.06-4.03 (m, 1H), 2.48-2.44 (m, 1H), 2.37-2.33 (m, 1H), 1.95 (s, 3H), 1.40-1.38 (m, 6H); ^{13}C NMR (150 MHz, $CDCl_3$): δ 163.3, 149.9, 135.3, 135.2*, 111.6, 111.5*, 84.9, 82.2, 82.1*, 72.3 (*J* = 5.8 Hz), 63.9*(*J* = 5.4 Hz), 59.98, 59.95*, 37.45, 37.42*, 24.06 (*J* = 3.9 Hz), 23.80, 23.76*, 12.50, 12.47*; ^{31}P NMR (400 MHz, $CDCl_3$): δ 7.55, 6.95*; HRMS (ESI, m/z) calcd. for $C_{13}H_{20}N_5NaO_6P$ $[M + Na]^+$: 396.1049; found: 390.1046.



***O*-(((2S,3S,5R)-3-azido-5-(5-methyl-2,4-dioxo-3,4-dihydropyrimidin-1(2H)-yl)tetrahydrofuran-2-yl)methyl) Se-(4-chlorophenyl) *O*-isopropyl phosphoroselenoate (P):**

The reaction is conducted for 36 hours by using **O** (**Scheme 4**) with bis(4-chlorophenyl) diselenide and afforded the desired product as a gummy liquid.

^{1}H NMR (400 MHz, $CDCl_3$): δ 9.59 (br.s, 1H), 7.56-7.53 (m, 2H), 7.29-7.24 (m, 3H), 6.21 (t, *J* = 6.4 Hz, 1H), 6.16*(t, *J* = 6.4, 1H), 4.89-4.79 (m, 1H), 4.37-4.12 (m, 3H), 3.98-3.96 (m, 1H), 2.41-2.35 (m, 1H), 2.26-2.16 (m, 1H), 1.83, 1.79*(s, 3H), 1.36-1.33 (m, 3H), 1.29-1.27 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 164.1, 150.42, 150.37*, 137.0 (dd, *J* = 7.6 Hz, 4.7 Hz), 136.0-135.9 (m), 135.36, 135.33*, 129.9 (dd, *J* = 4.3 Hz, 1.6 Hz), 121.2 (*J* = 9.2 Hz), 111.6, 84.9, 84.7*, 82.2-82.0 (m), 74.8-74.7 (m), 66.0-65.9 (m), 60.1, 59.9*, 37.6, 24.04, 24.01*, 23.6, 23.5*, 12.6, 12.5*; ^{31}P NMR (400 MHz, $CDCl_3$): δ 17.25, 17.17; HRMS (ESI, m/z) calcd. for $C_{19}H_{24}ClN_5O_6PSe$ $[M + H]^+$: 564.0318; found: 564.0312.

*a pair of disstreoisomers: different chemical shifts assigned to the same centre.

Reference:

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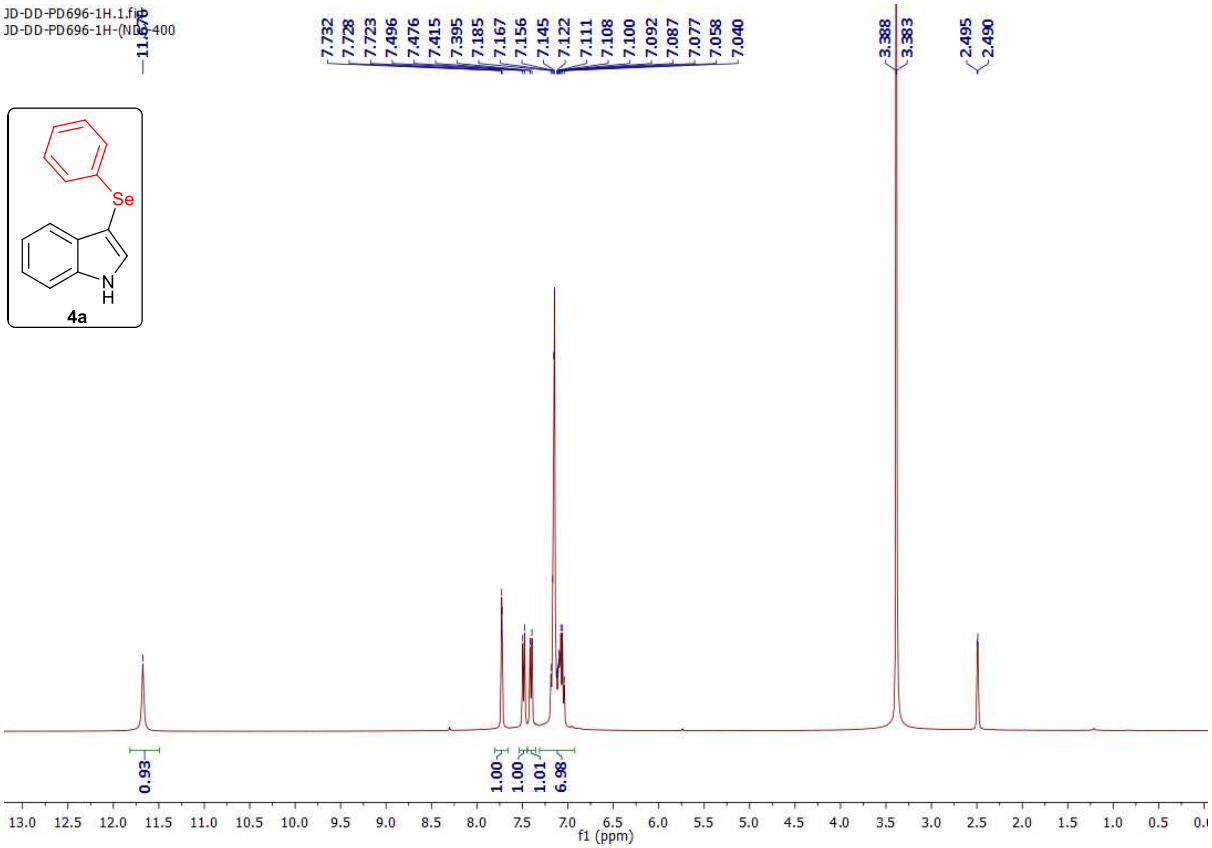
Spectral Data: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JD-DD-PD696-1H-(NDA-400
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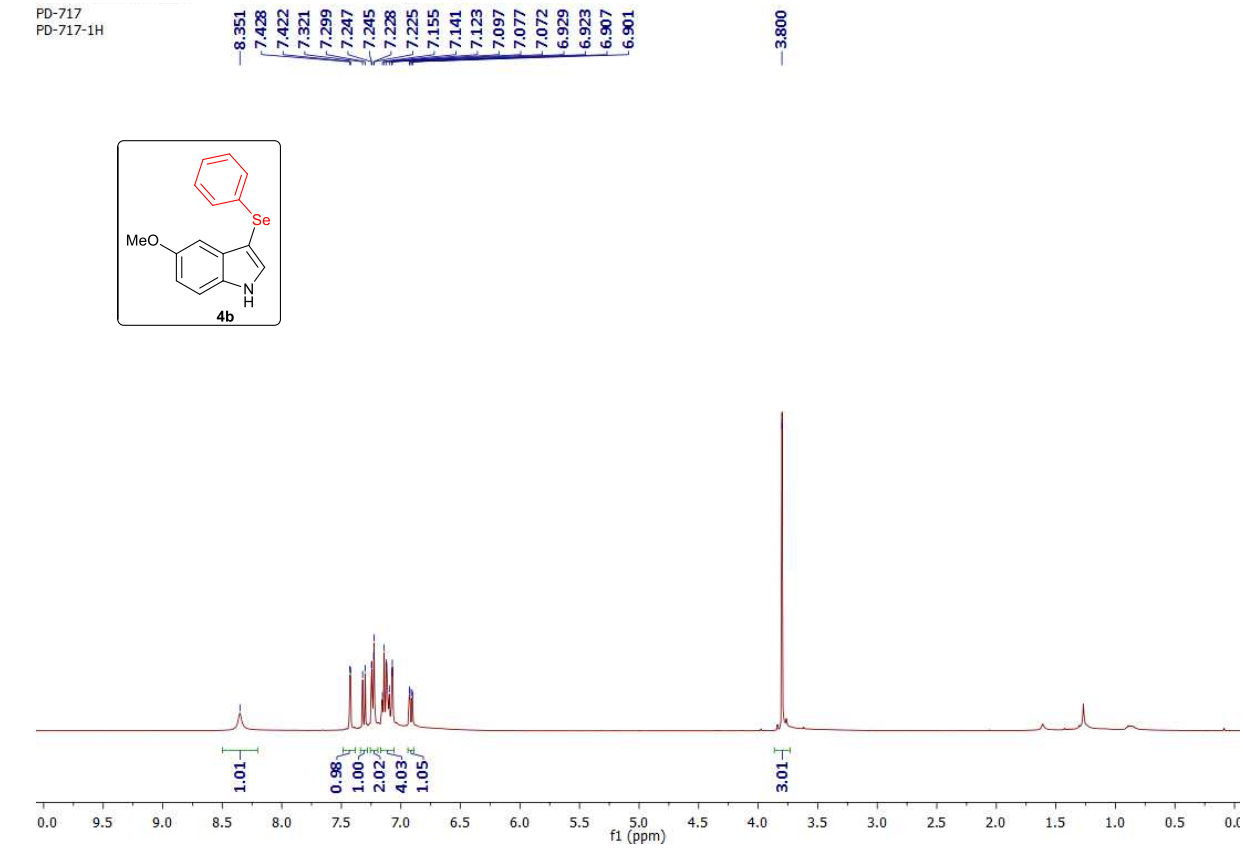
7.732
7.728
7.723
7.496
7.476
7.415
7.395
7.185
7.167
7.156
7.145
7.122
7.111
7.108
7.100
7.092
7.087
7.077
7.058
7.040
3.388
3.383
2.495
2.490
Se
N
H
4a
0.93
1.00
1.00
1.01
6.98
f1 (ppm)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PD-717-1H
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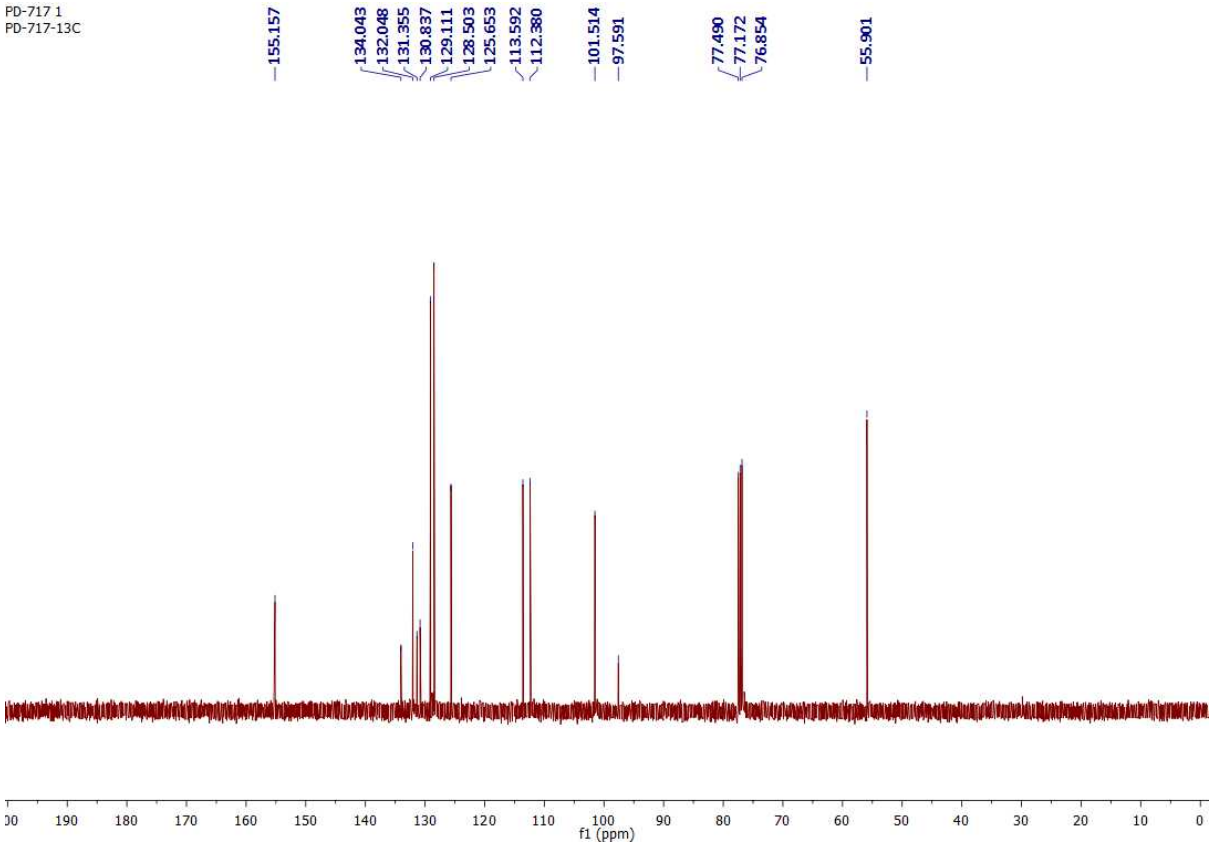
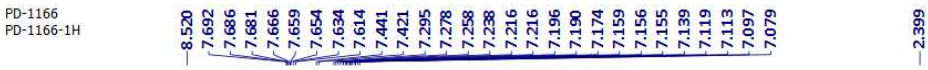
7.428
7.422
7.321
7.299
7.247
7.245
7.228
7.225
7.155
7.141
7.123
7.097
7.077
7.072
6.929
6.923
6.907
6.901
3.800
Se
MeO
N
H
4b
1.01
0.98
1.00
2.02
4.03
1.05
3.01
f1 (ppm)


PD-717 1
PD-717-13C
155.157
134.043
132.048
131.355
130.837
129.111
128.503
125.653
113.592
112.380
101.514
97.591
77.490
77.172
76.854
55.901
f1 (ppm)


PD-1166
PD-1166-1H
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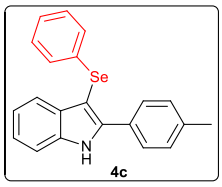
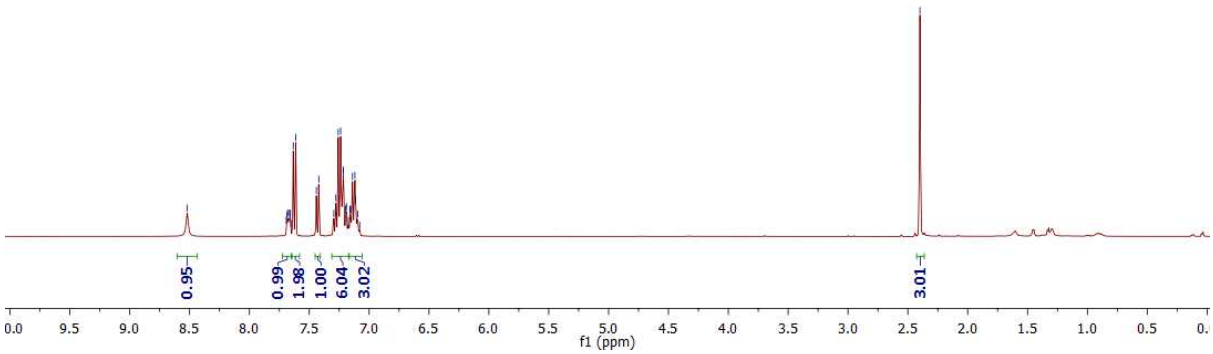
7.686
7.681
7.666
7.659
7.654
7.634
7.614
7.441
7.421
7.295
7.278
7.258
7.238
7.216
7.196
7.190
7.174
7.159
7.156
7.155
7.139
7.119
7.113
7.097
7.079
2.399


Se
N
H
4c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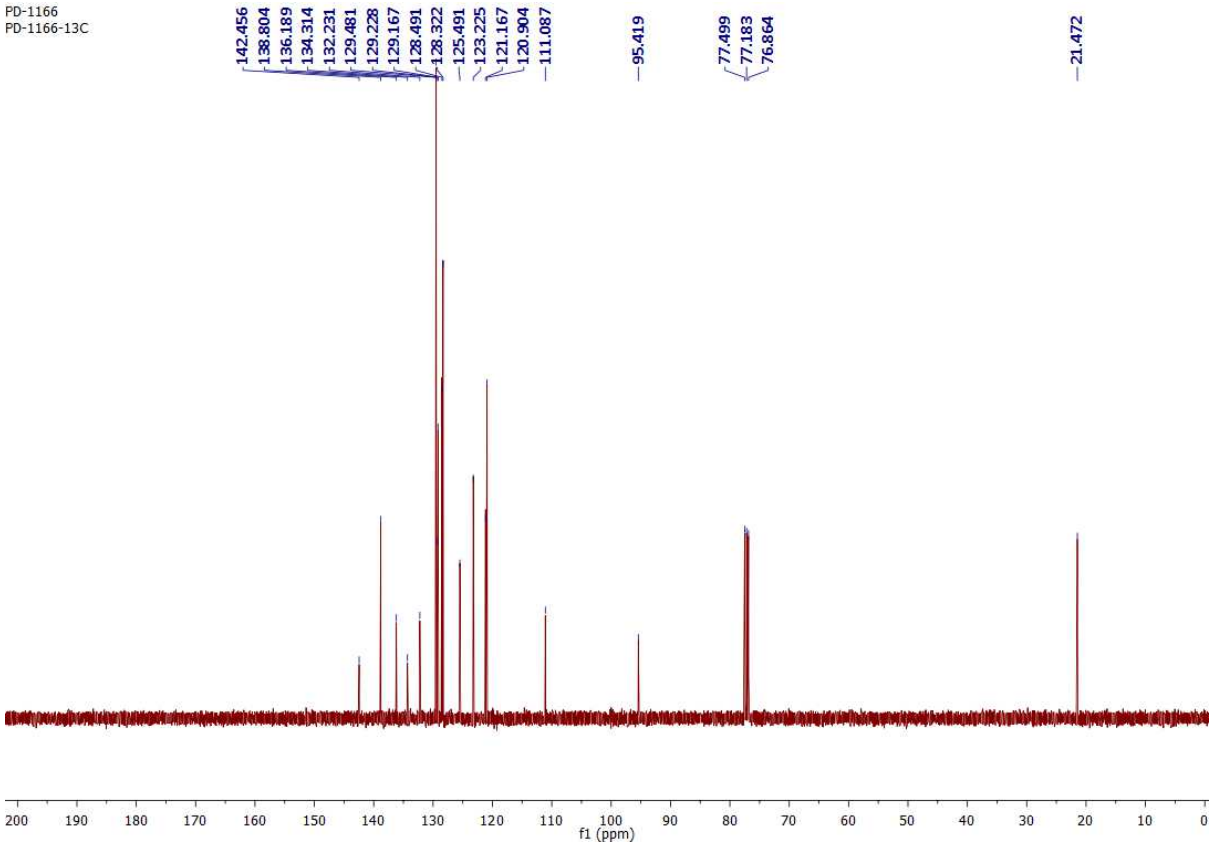
0.99
1.98
1.00
6.04
3.02
3.01
f1 (ppm)


PD-1166
PD-1166-13C
142.456
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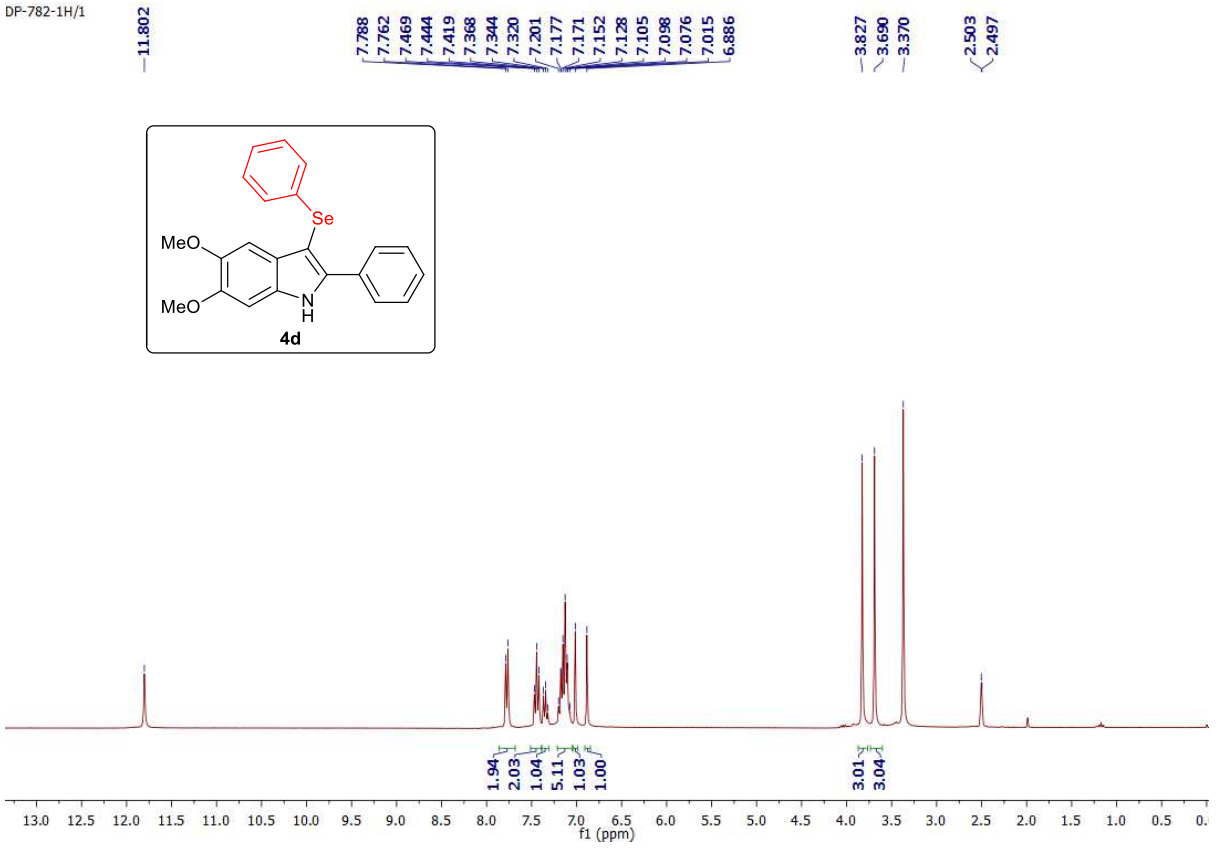
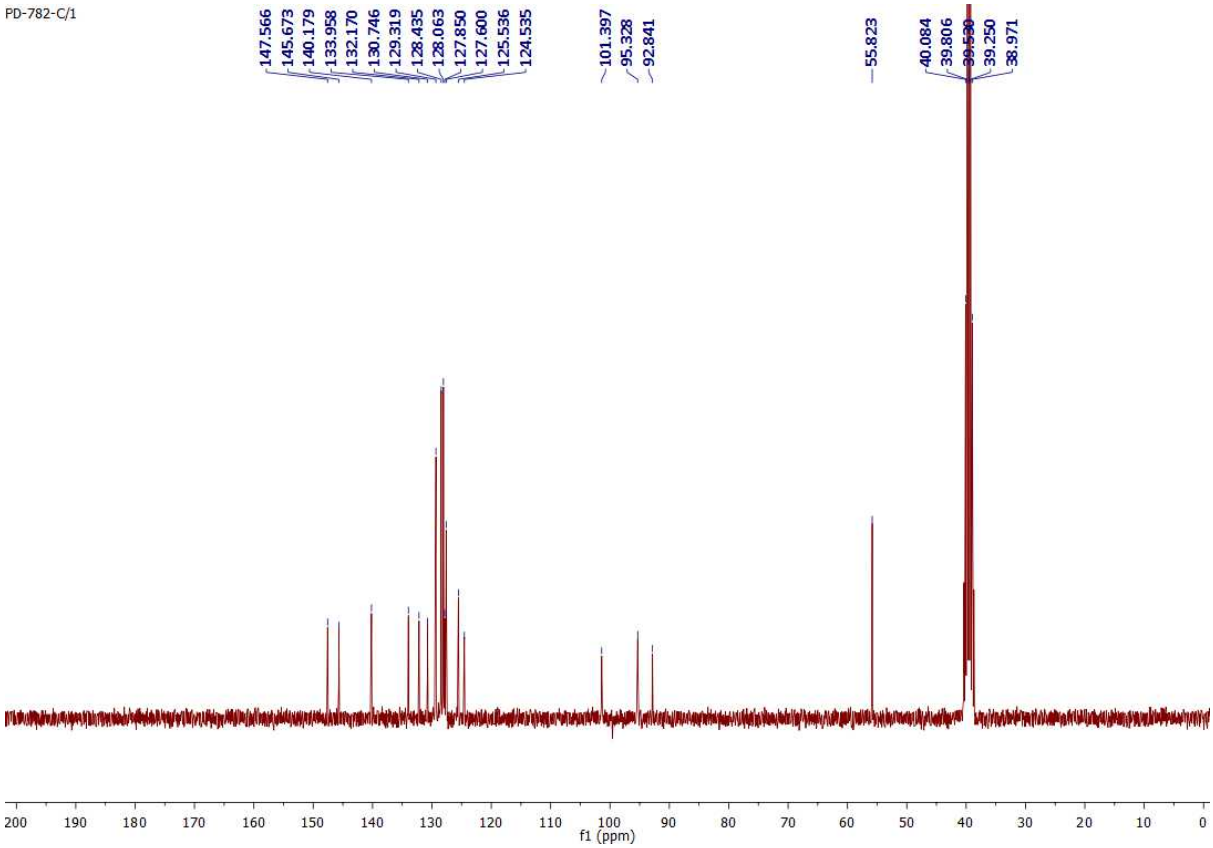
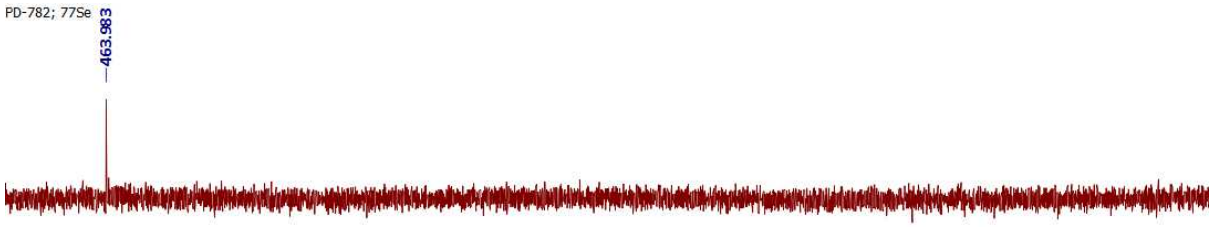
136.189
134.314
132.231
129.481
129.228
129.167
128.491
128.322
125.491
123.225
121.167
120.904
111.087
95.419
77.499
77.183
76.864
21.472
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

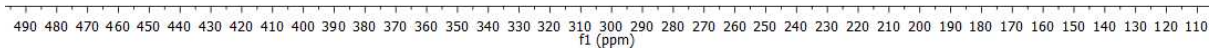
DP-782-1H/1



PD-782-C/1




PD-782; 77Se
463.983


490 480 470 460 450 440 430 420 410 400 390 380 370 360 350 340 330 320 310 300 290 280 270 260 250 240 230 220 210 200 190 180 170 160 150 140 130 120 110
f1 (ppm)


pd-1167fa
single_pulse
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7.737
7.733
7.728
7.720
7.716
7.713
7.470
7.466
7.448
7.433
7.429
7.420
7.416
7.413
7.405
7.399
7.389
7.378
7.367
7.356
7.320
7.314
7.297
7.291
7.260
7.207
7.202
7.186
7.162
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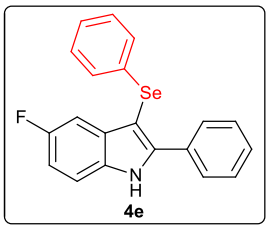
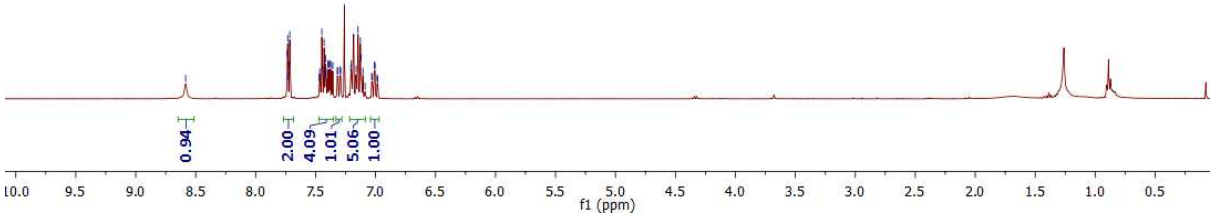
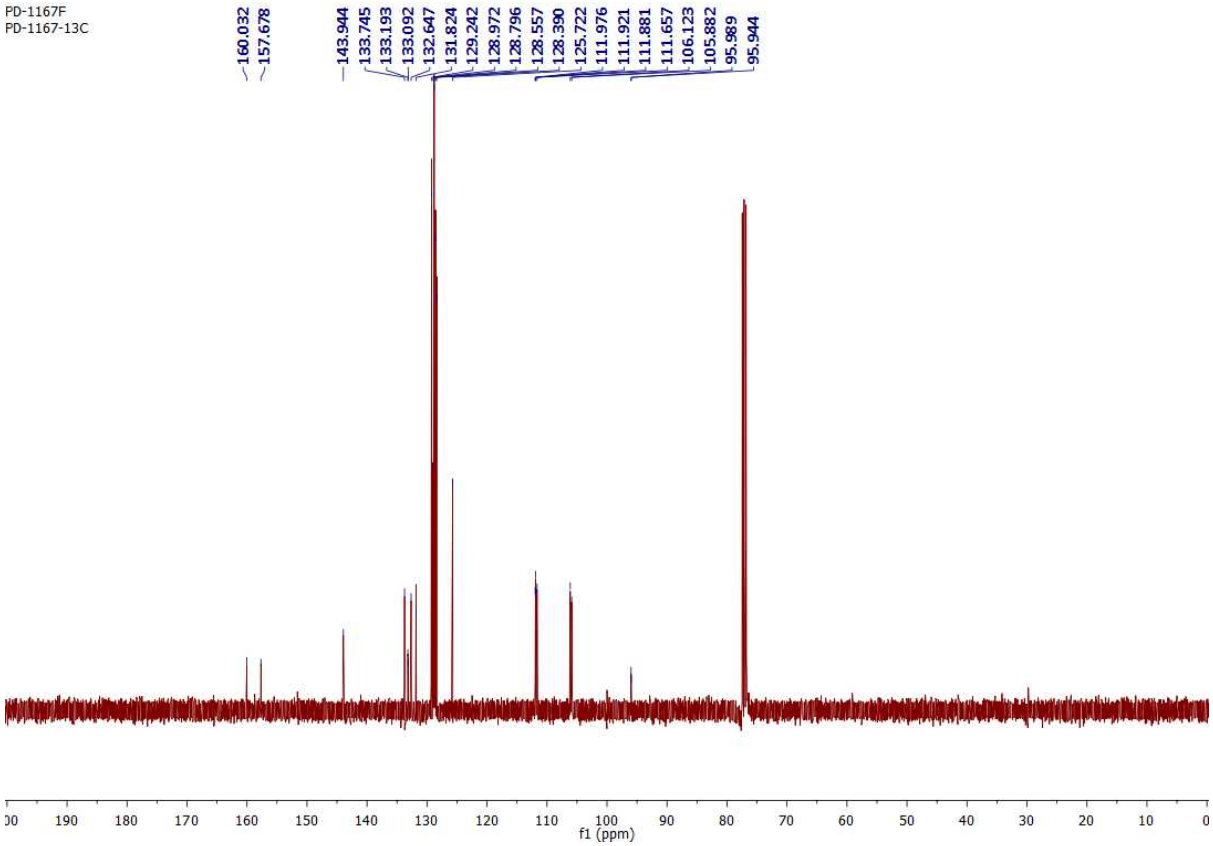
7.026
7.010
7.004
6.988
6.982


Se
F
N
H
4e


0.94
2.00
4.09
1.01
5.06
1.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)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PD-1167-13C
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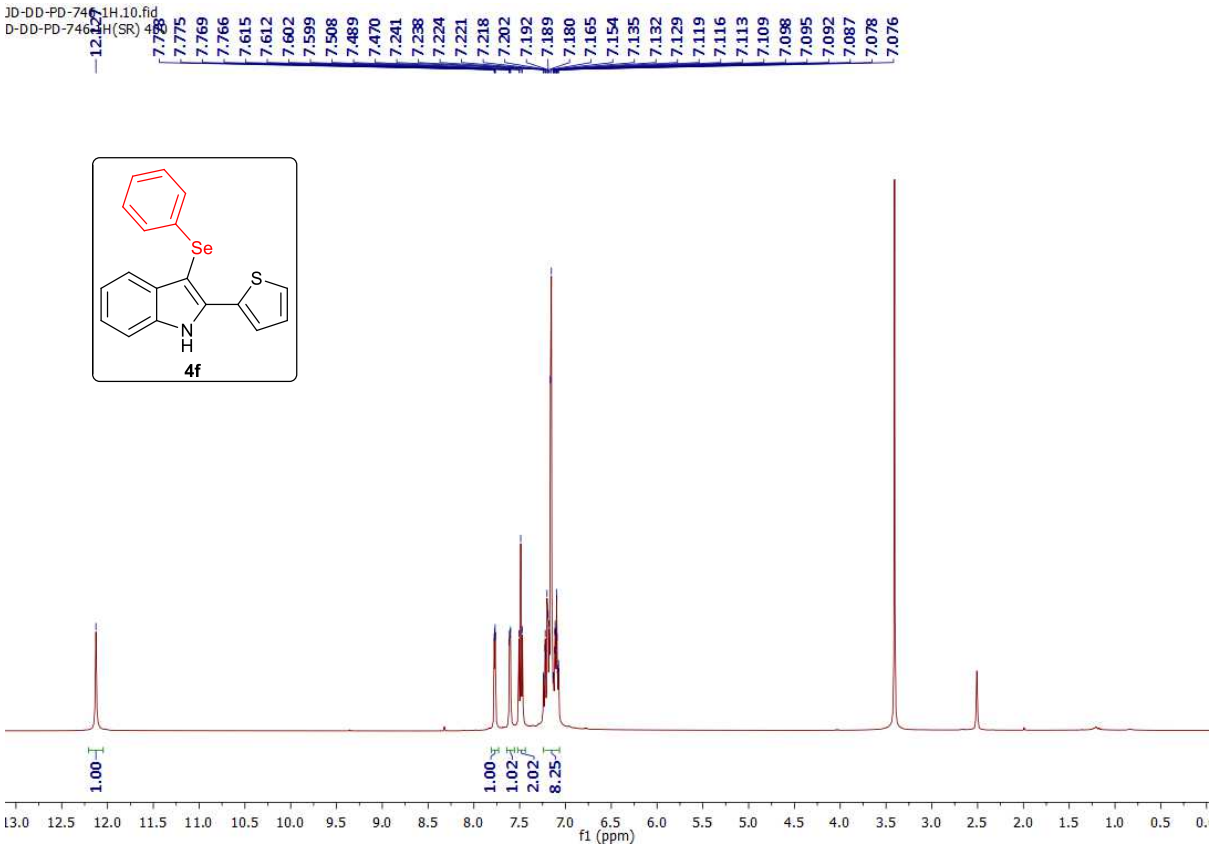
157.678
143.944
133.745
133.193
133.092
132.647
131.824
129.242
128.972
128.796
128.557
128.390
125.722
111.976
111.921
111.881
111.657
106.123
105.882
95.989
95.944
f1 (ppm)


JD-DD-PD-746-1H.10.fid
D-DD-PD-746-1H(SR) 4
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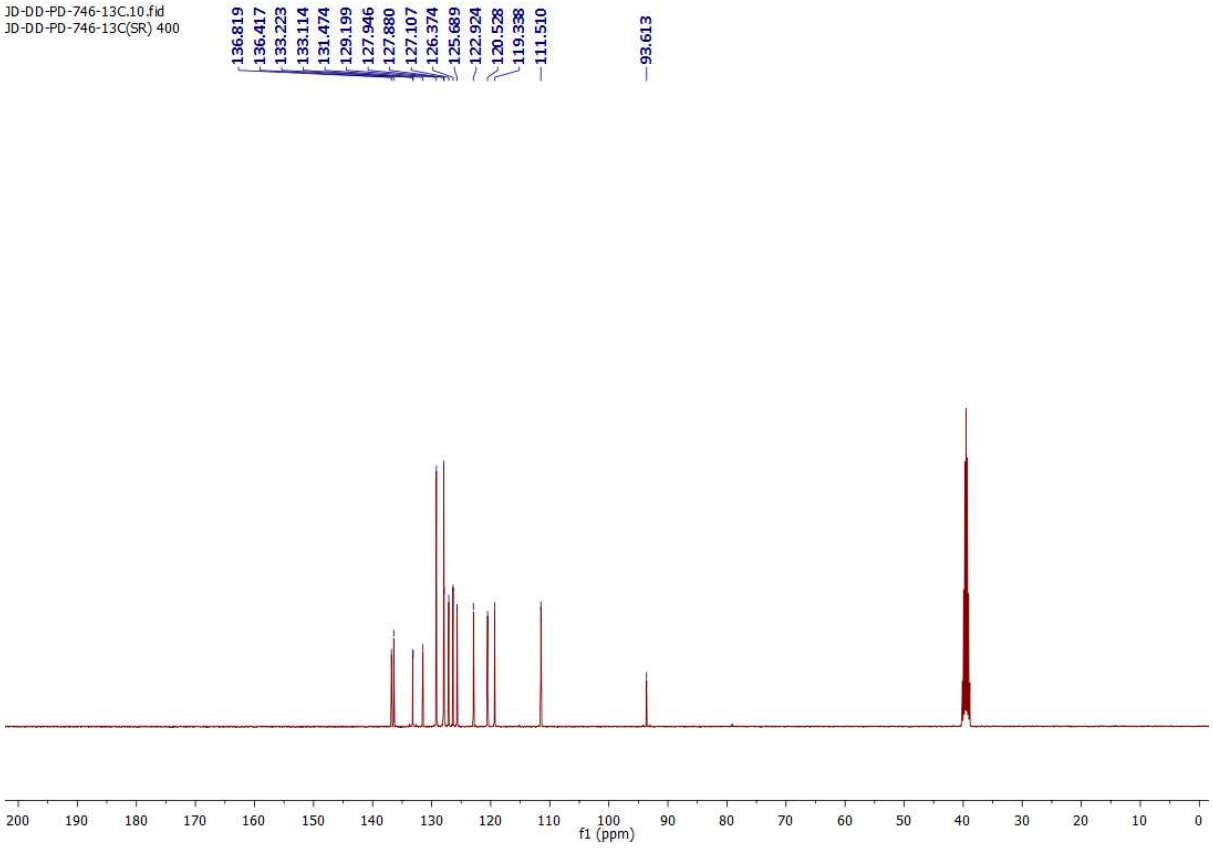
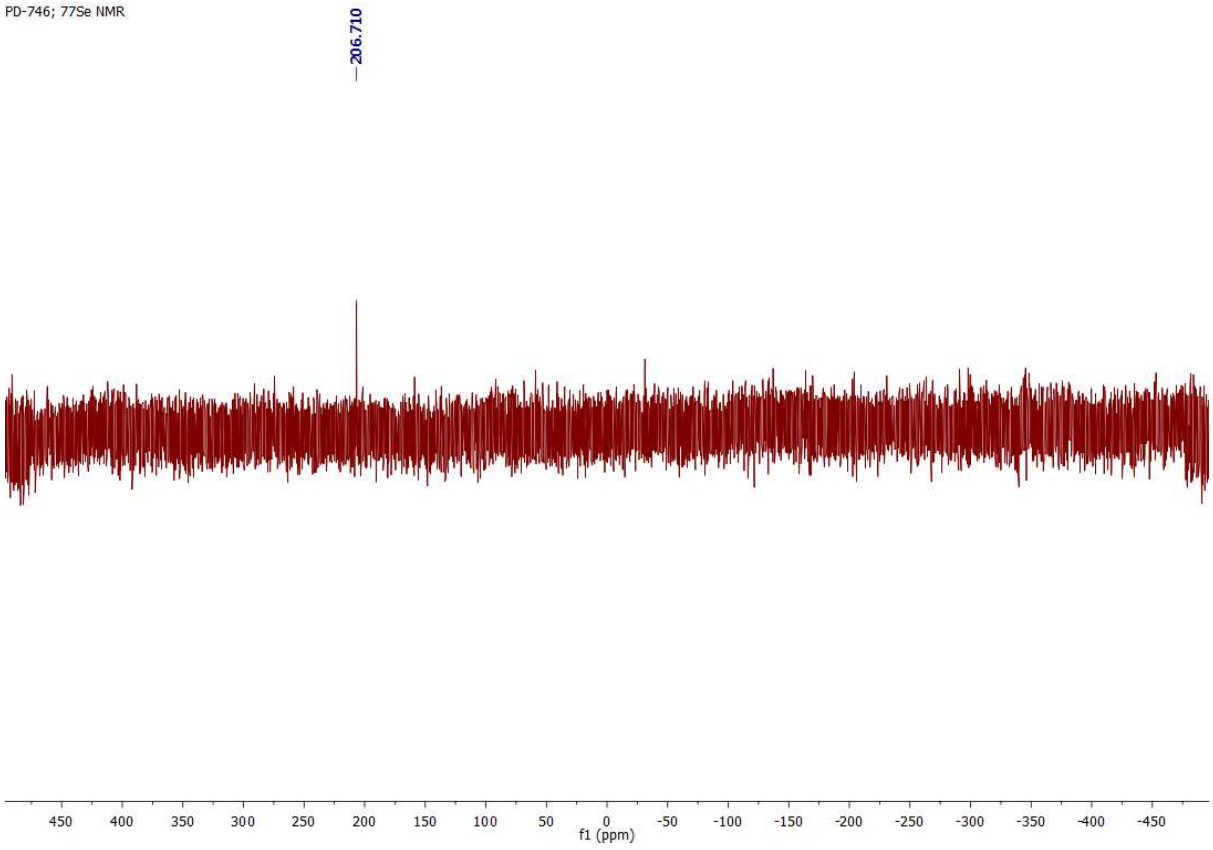
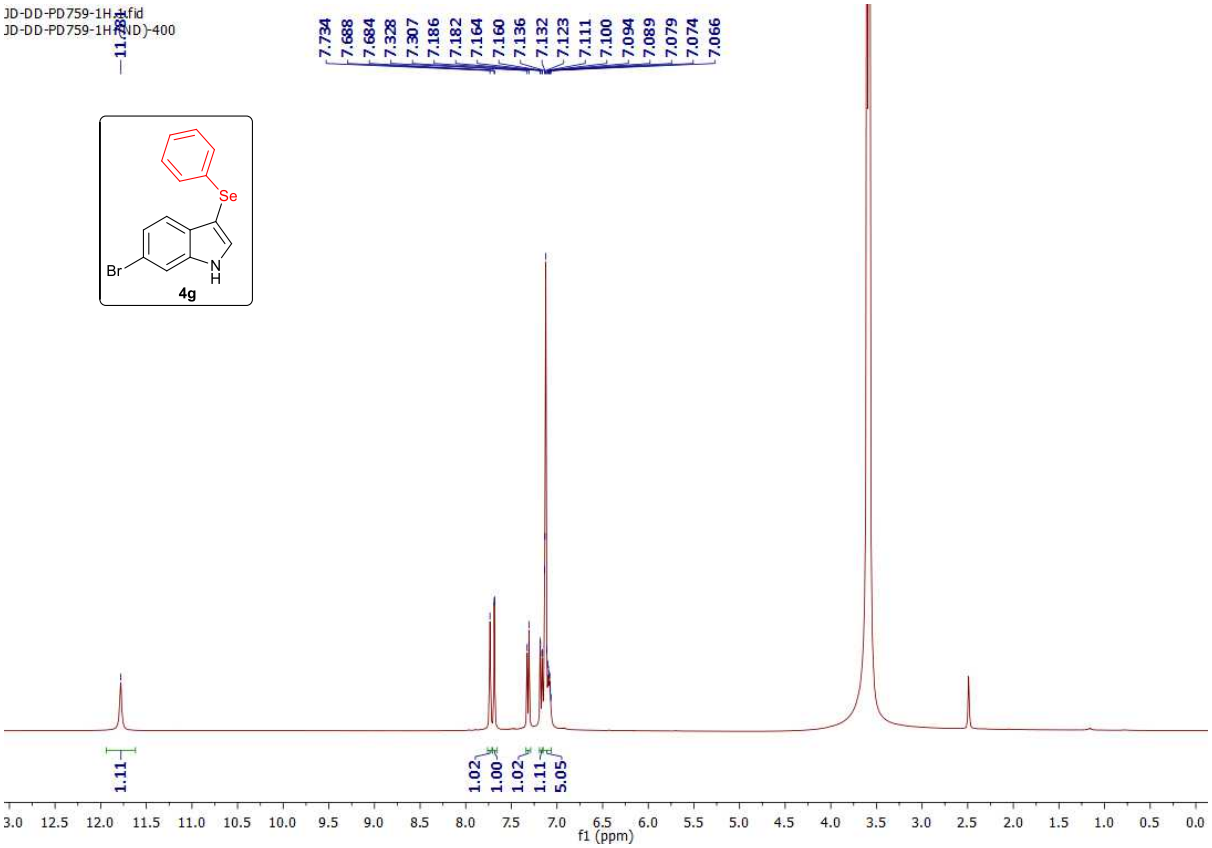
7.788
7.775
7.769
7.766
7.615
7.612
7.602
7.599
7.508
7.489
7.470
7.241
7.238
7.224
7.221
7.218
7.202
7.192
7.189
7.180
7.165
7.154
7.135
7.132
7.129
7.119
7.116
7.113
7.109
7.098
7.095
7.092
7.087
7.078
7.076
Se
S
N
H
4f
1.00
1.00
1.02
2.02
8.25
f1 (ppm)

JD-DD-PD-746-13C.10.fid
JD-DD-PD-746-13C(SR) 400



PD-746; 77Se NMR

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7.688
7.684
7.328
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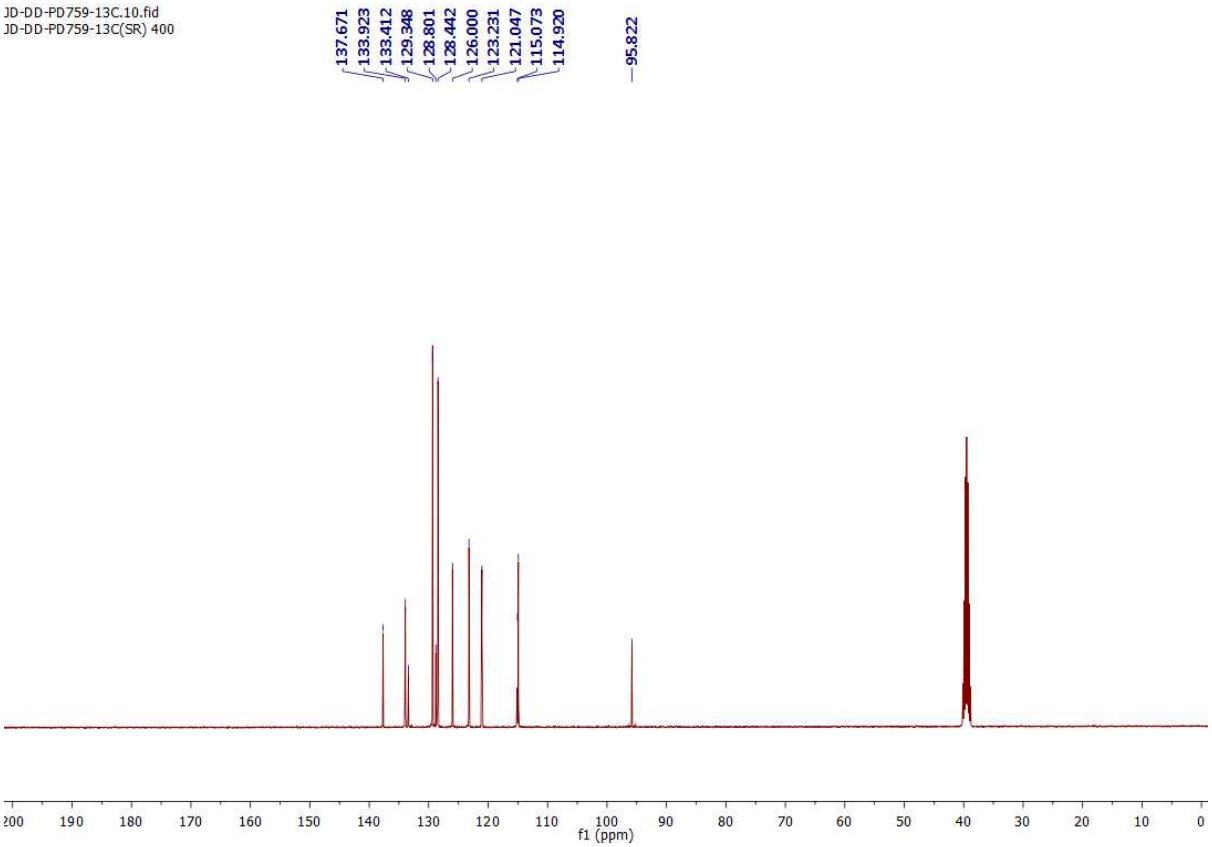
7.186
7.182
7.164
7.160
7.136
7.132
7.123
7.111
7.100
7.094
7.089
7.079
7.074
7.066
Se
Br
N
H
4g
1.11
1.02
1.00
1.02
1.11
5.05
f1 (ppm)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JD-DD-PD759-13C(SR) 400
137.671
133.923
133.412
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123.231
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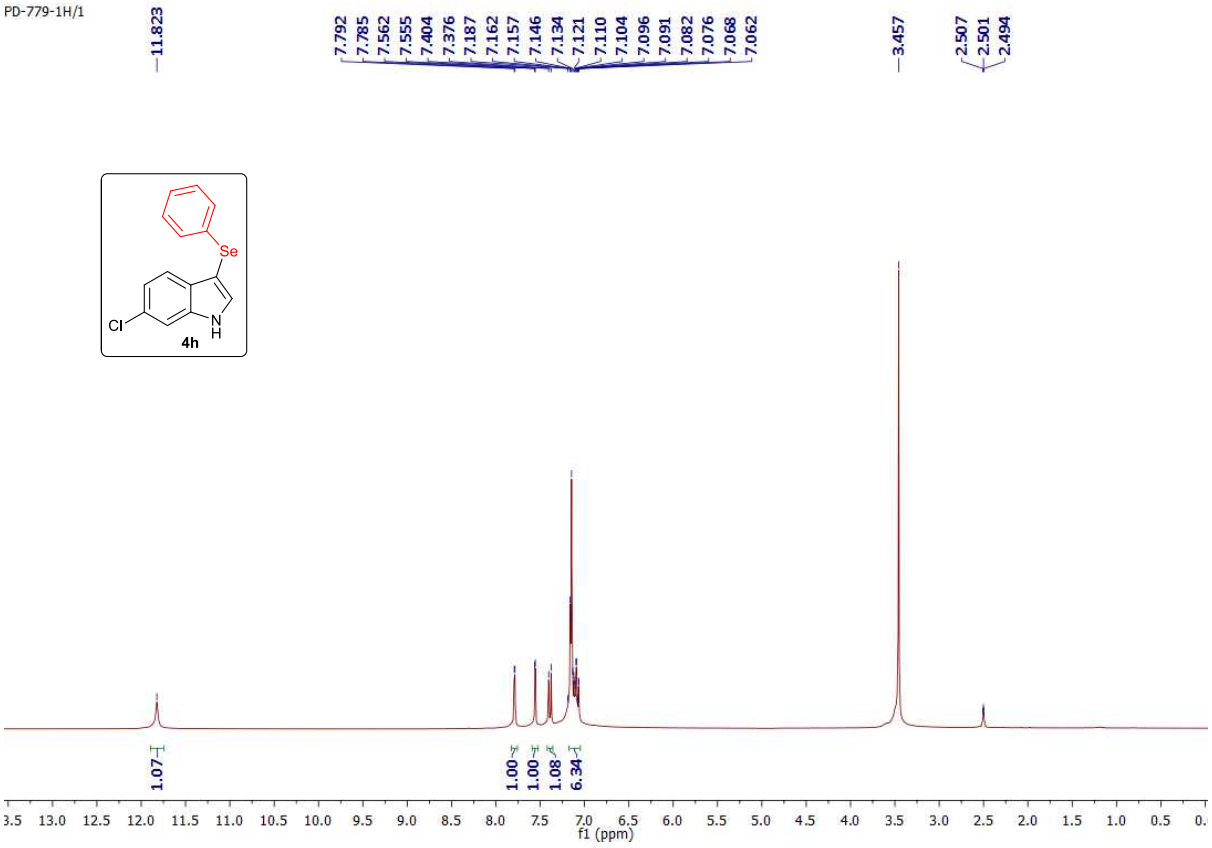
114.920
95.822
f1 (ppm)

PD-779-1H/1



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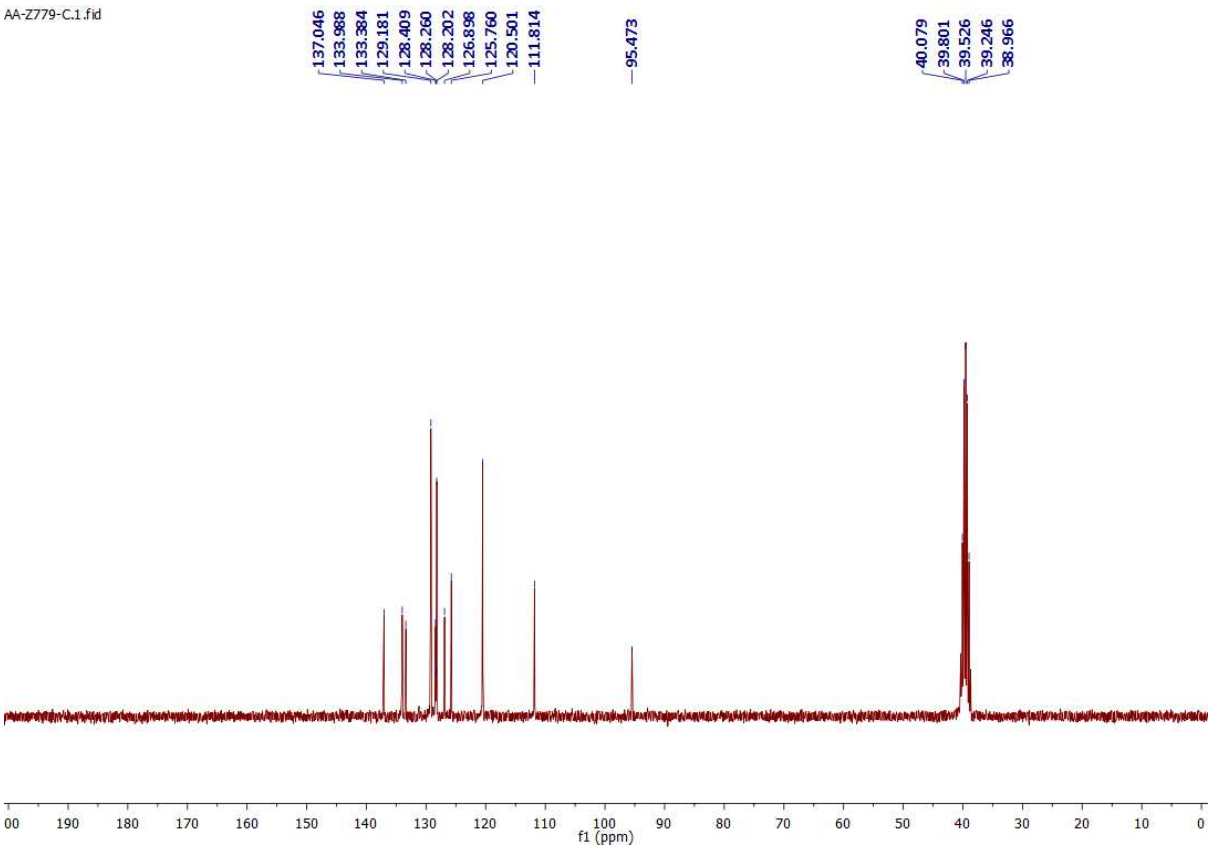

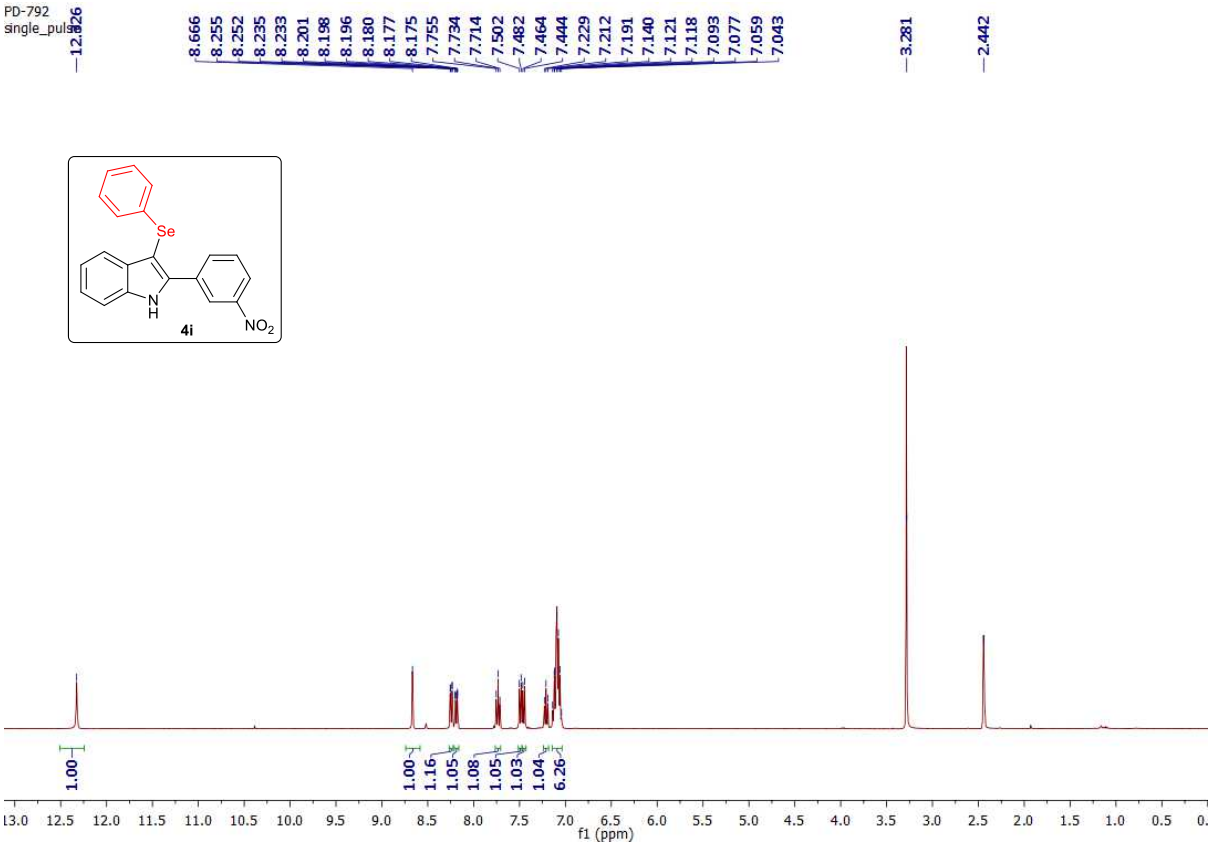
PD-792
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12.626
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8.252
8.235
8.233
8.201
8.198
8.196
8.180
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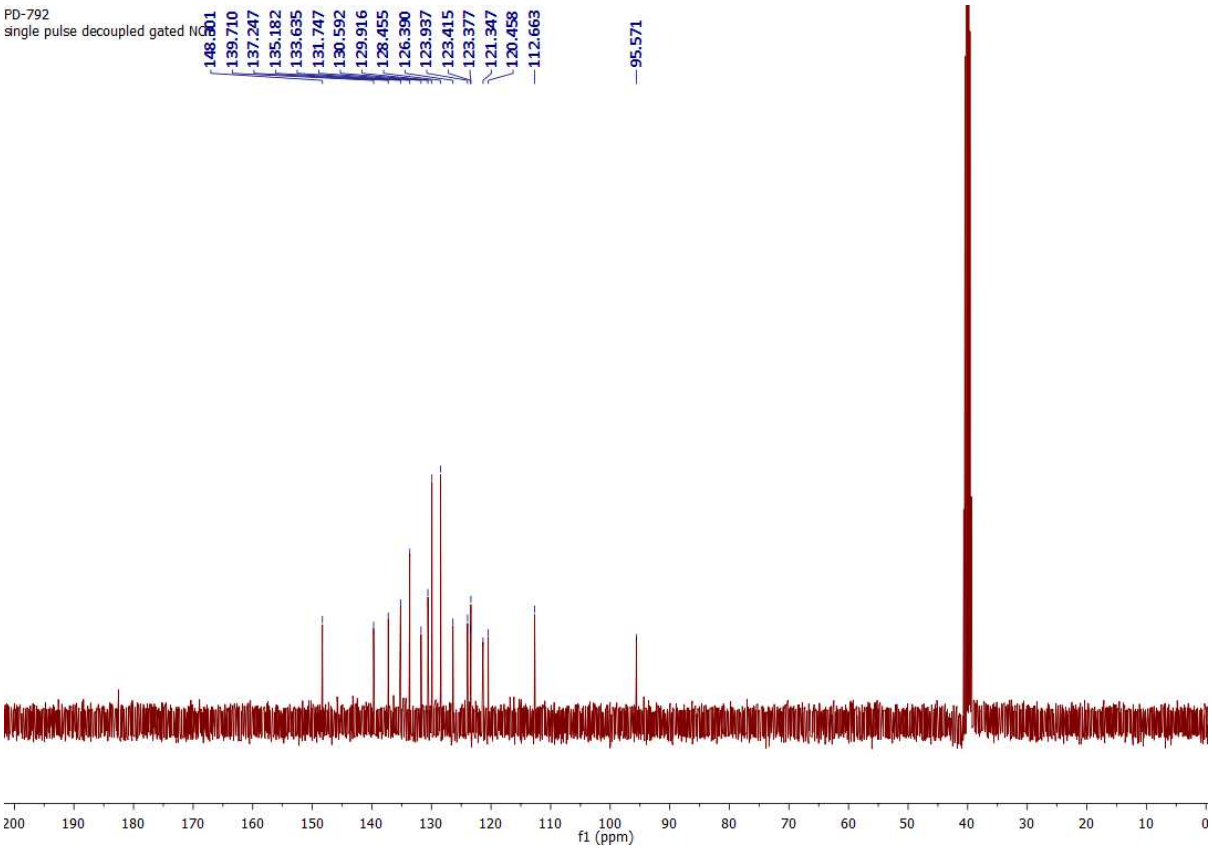
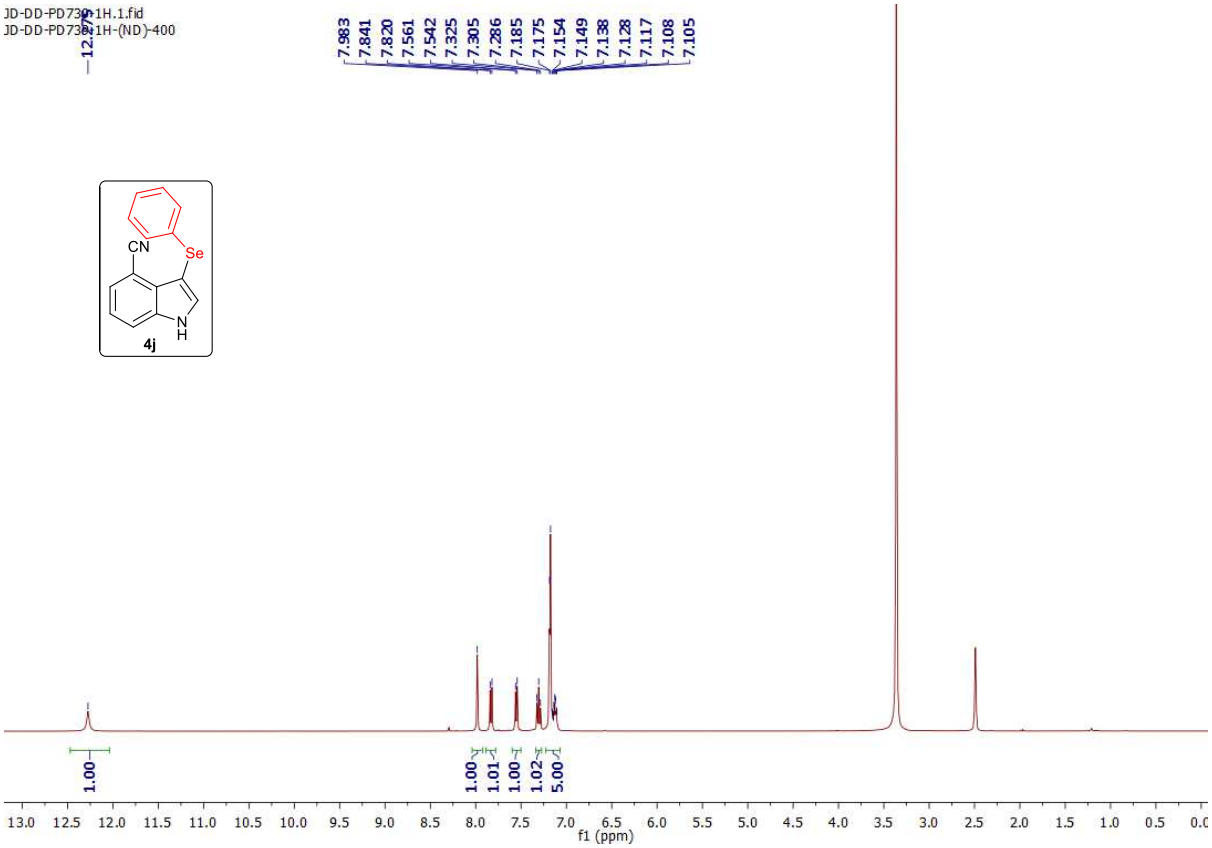
8.175
7.755
7.734
7.714
7.502
7.482
7.464
7.444
7.229
7.212
7.191
7.140
7.121
7.118
7.093
7.077
7.059
7.043
3.281
2.442
Se
N
H
4i
NO2
1.00
1.00
1.16
1.05
1.08
1.05
1.03
1.04
6.26
f1 (ppm)


PD-792
single pulse decoupled gated NOE
148.301
139.710
137.247
135.182
133.635
131.747
130.592
129.916
128.455
126.390
123.937
123.415
123.377
121.347
120.458
112.663
95.571
f1 (ppm)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7.841
7.820
7.561
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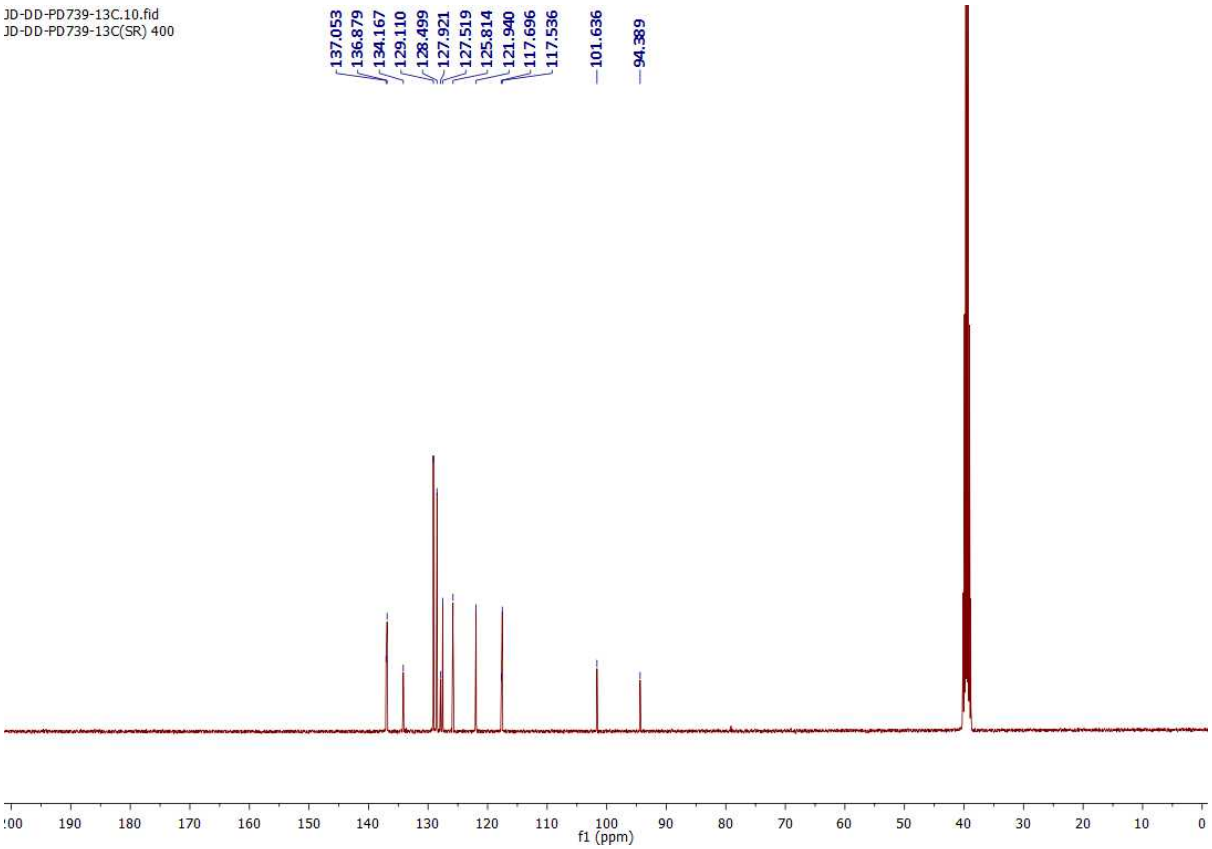
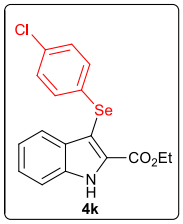
7.325
7.305
7.286
7.185
7.175
7.154
7.149
7.138
7.128
7.117
7.108
7.105
CN
Se
N
H
4j
1.00
1.00
1.01
1.00
1.02
5.00
f1 (ppm)

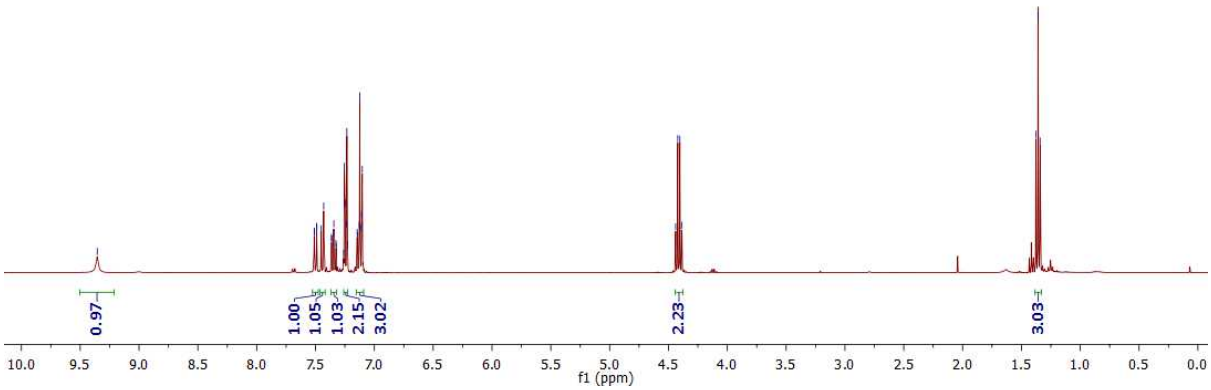

JD-DD-PD739-13C.10.fid
JD-DD-PD739-13C(SR) 400
137.053
136.879
134.167
129.110
128.499
127.921
127.519
125.814
121.940
117.696
117.536
101.636
94.389
f1 (ppm)

PD-1009
PD-1009-1H

9.355
7.511
7.509
7.491
7.489
7.451
7.430
7.365
7.362
7.347
7.344
7.327
7.324
7.261
7.255
7.248
7.238
7.233
7.227
7.146
7.144
7.128
7.124
7.119
7.108
7.103
4.439
4.421
4.403
4.385
1.377
1.359
1.341

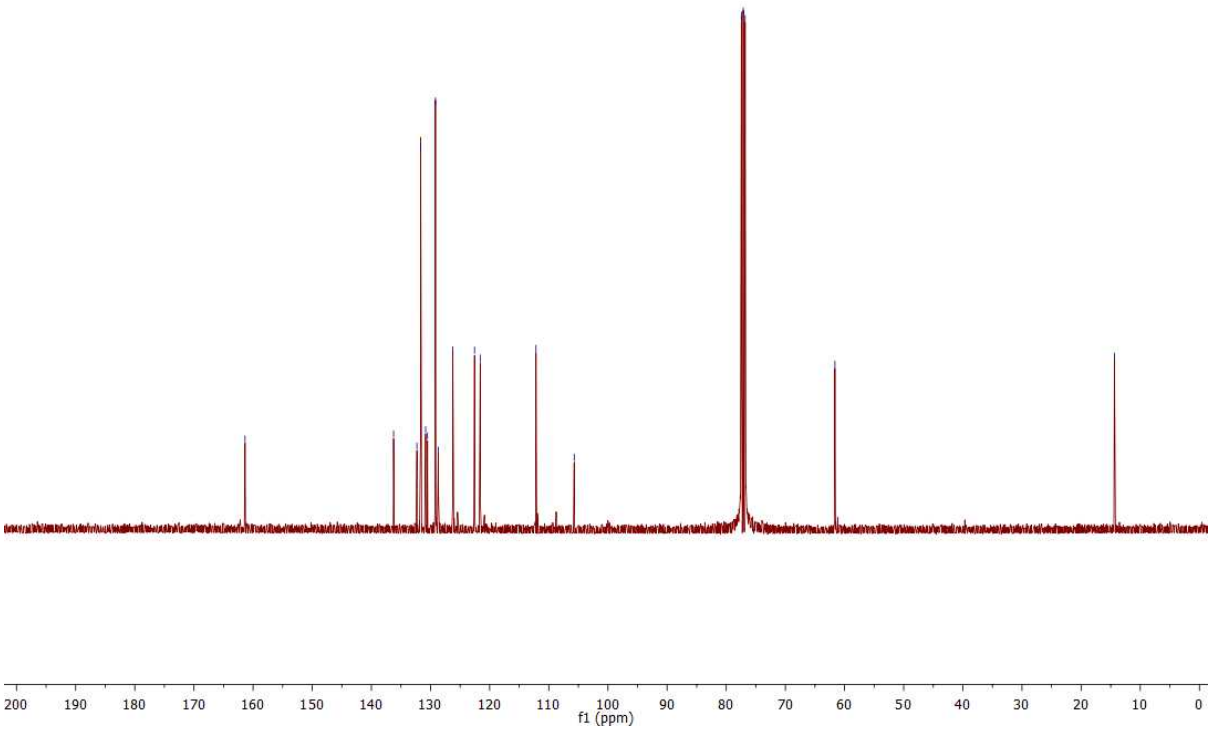


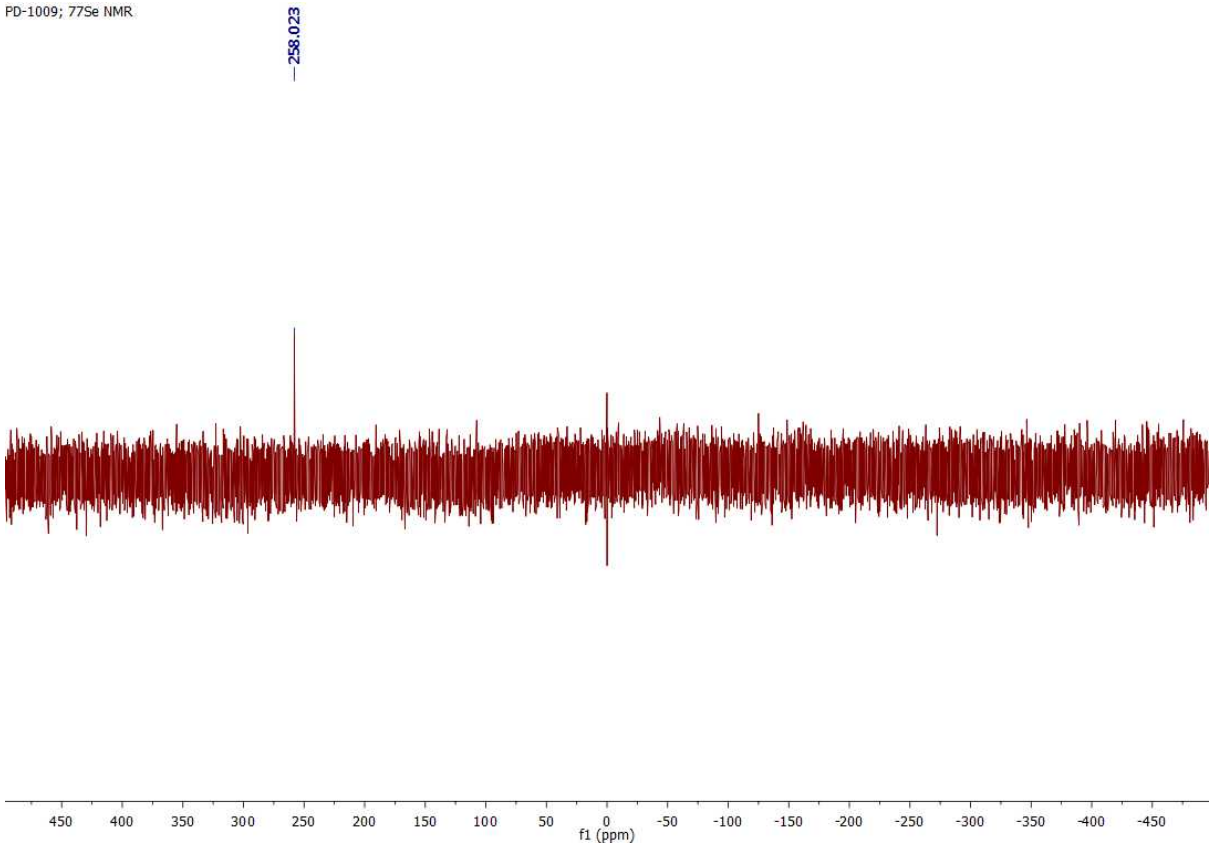
4k

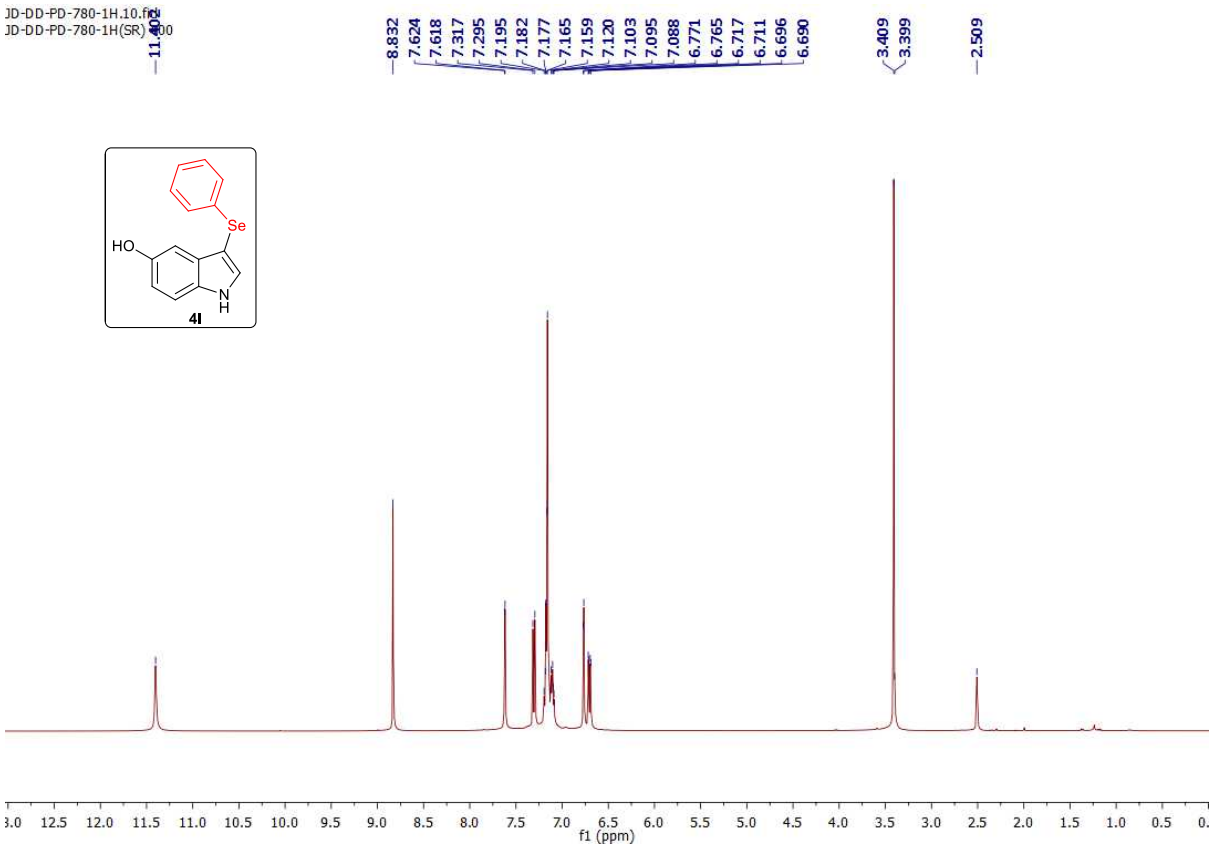


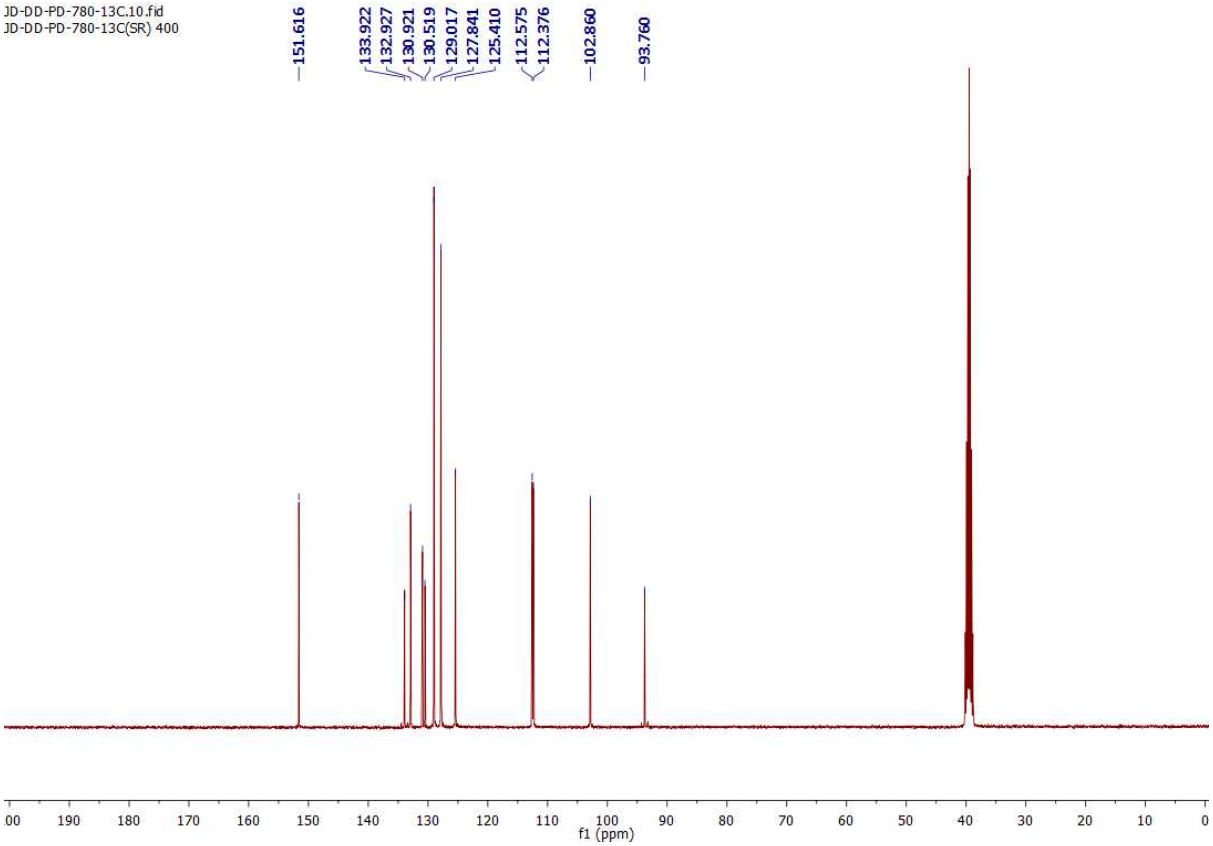
PD-1009
PD-1009-13C

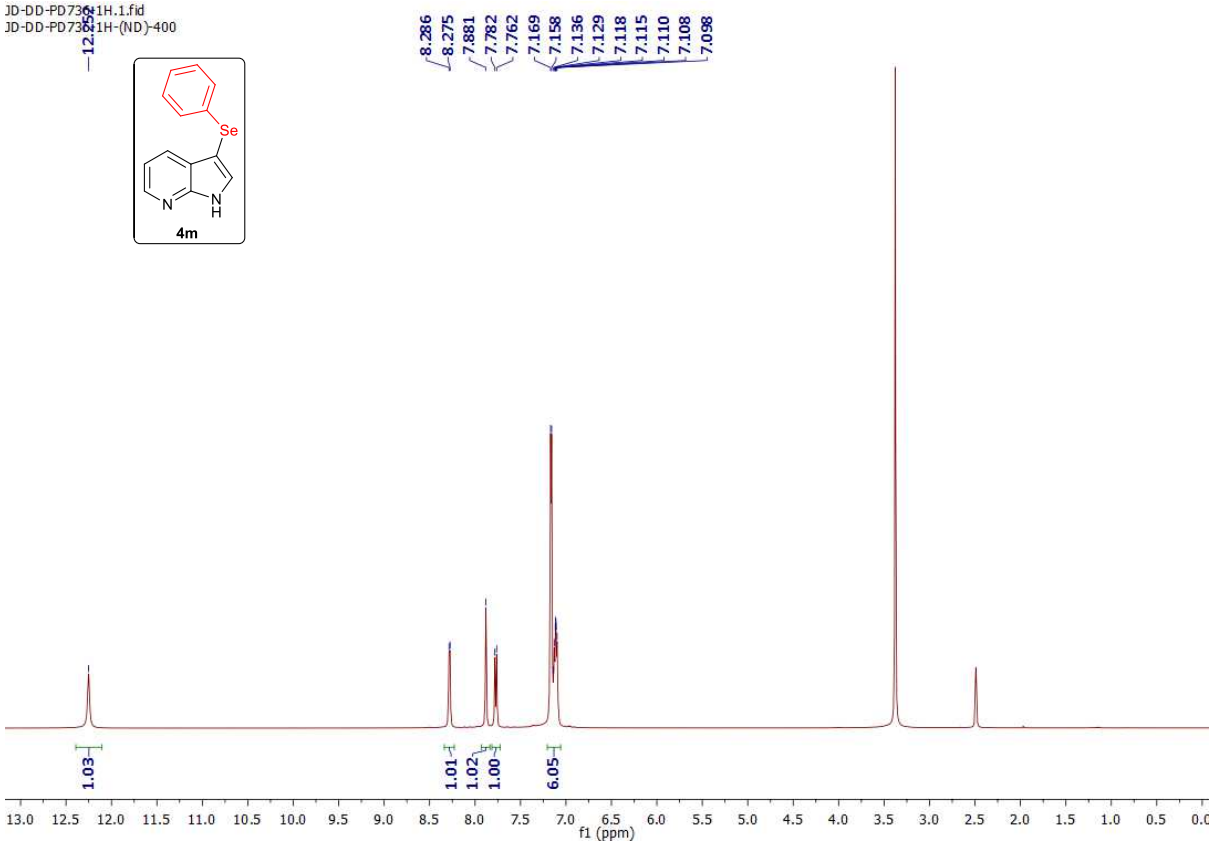
161.357
136.246
132.302
131.672
130.831
130.511
129.165
128.691
126.233
122.557
121.594
112.170
105.706
77.438
77.121
76.801
61.626
14.374

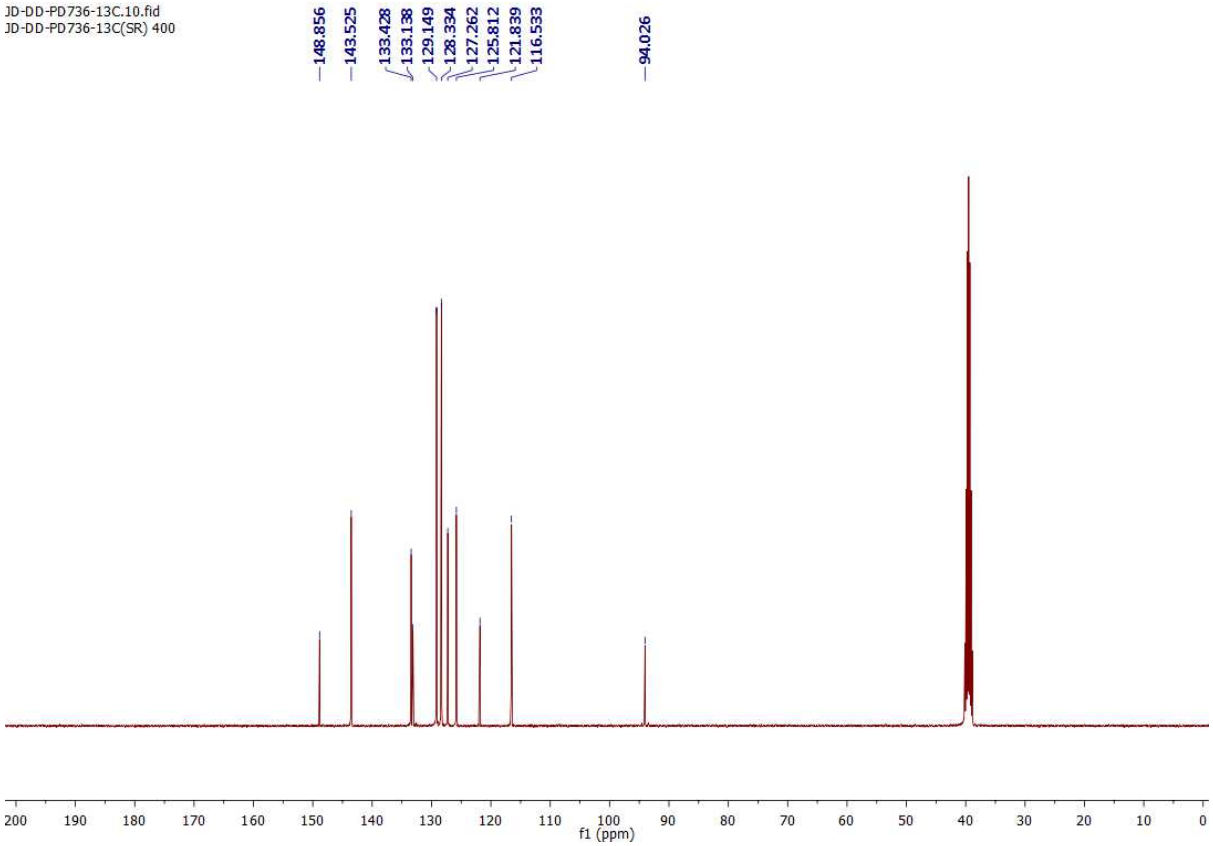


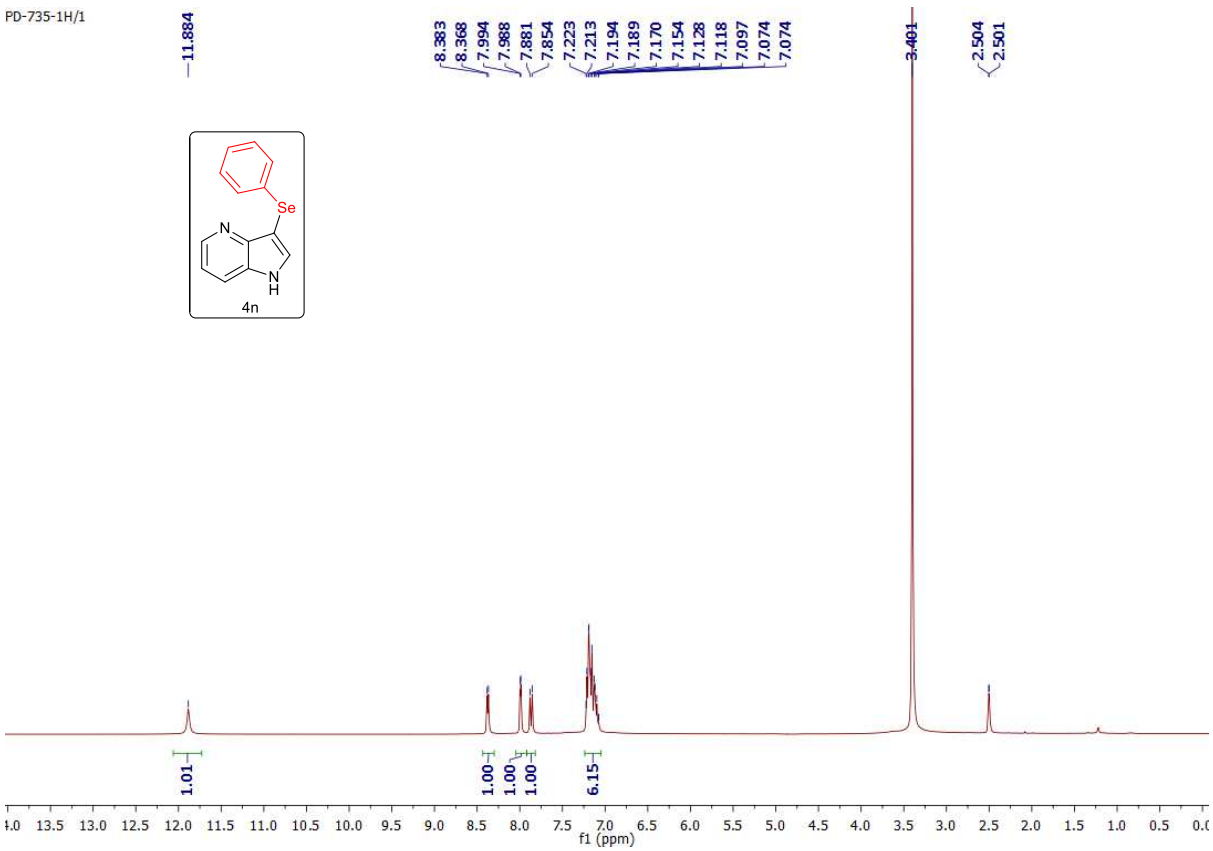

PD-1009; 77Se NMR
258.023
450 400 350 300 250 200 150 100 50 0 -50 -100 -150 -200 -250 -300 -350 -400 -450
f1 (ppm)

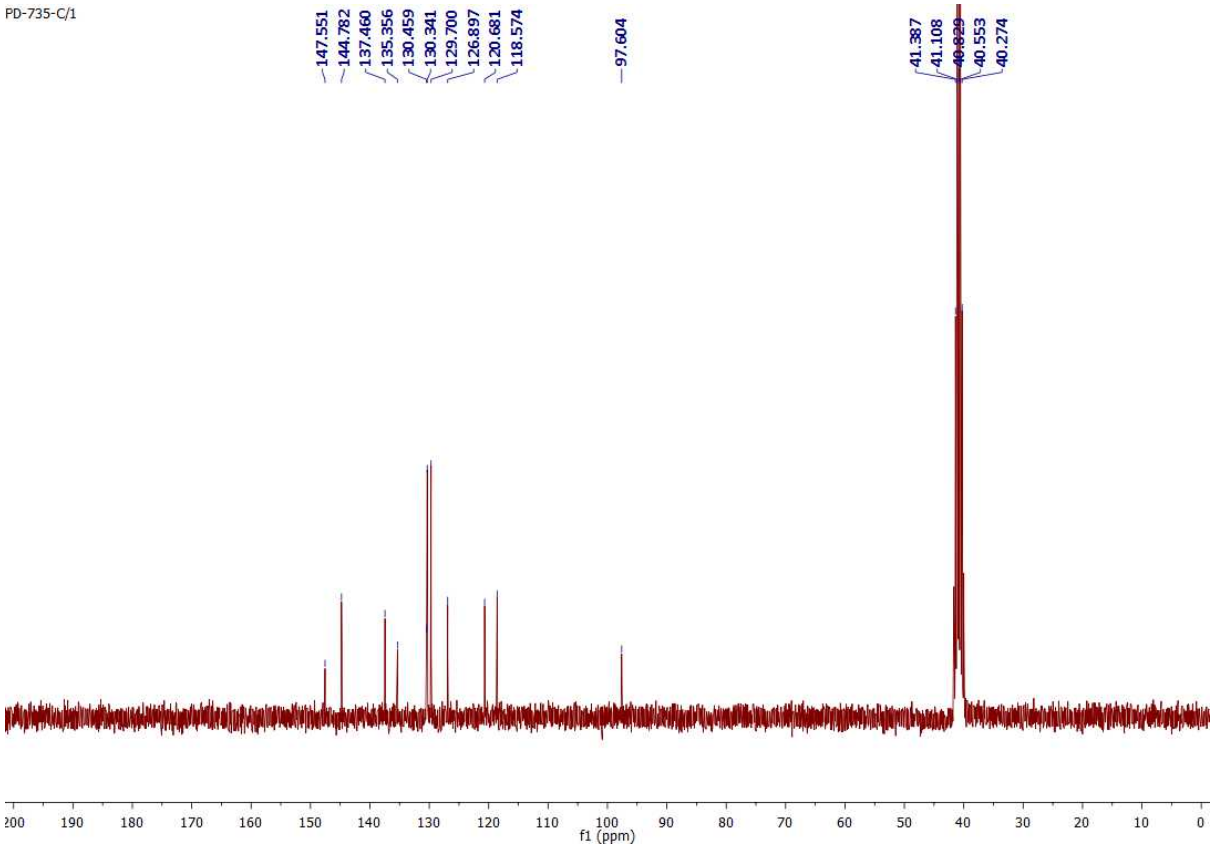

JD-DD-PD-780-1H.10.fid
JD-DD-PD-780-1H(SR) 400
11.402
8.832
7.624
7.618
7.317
7.295
7.195
7.182
7.177
7.165
7.159
7.120
7.103
7.095
7.088
6.771
6.765
6.717
6.711
6.696
6.690
3.409
3.399
2.509
HO
Se
N
H
4l
f1 (ppm)


JD-DD-PD-780-13C.10.fid
JD-DD-PD-780-13C(SR) 400
151.616
133.922
132.927
130.921
130.519
129.017
127.841
125.410
112.575
112.376
102.860
93.760
f1 (ppm)

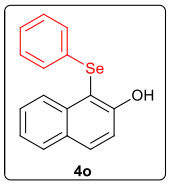

JD-DD-PD736-1H.1.fid
JD-DD-PD736-1H-(ND)-400
12.252
8.286
8.275
7.881
7.782
7.762
7.169
7.158
7.136
7.129
7.118
7.115
7.110
7.108
7.098
Se
N
H
4m
1.03
1.01
1.02
1.00
6.05
f1 (ppm)

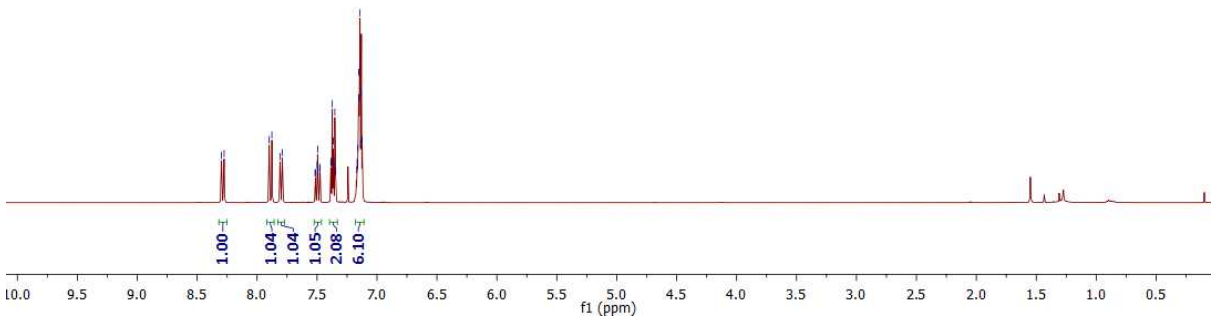

JD-DD-PD736-13C.10.fid
JD-DD-PD736-13C(SR) 400
148.856
143.525
133.428
133.138
129.149
128.334
127.262
125.812
121.839
116.533
94.026
f1 (ppm)

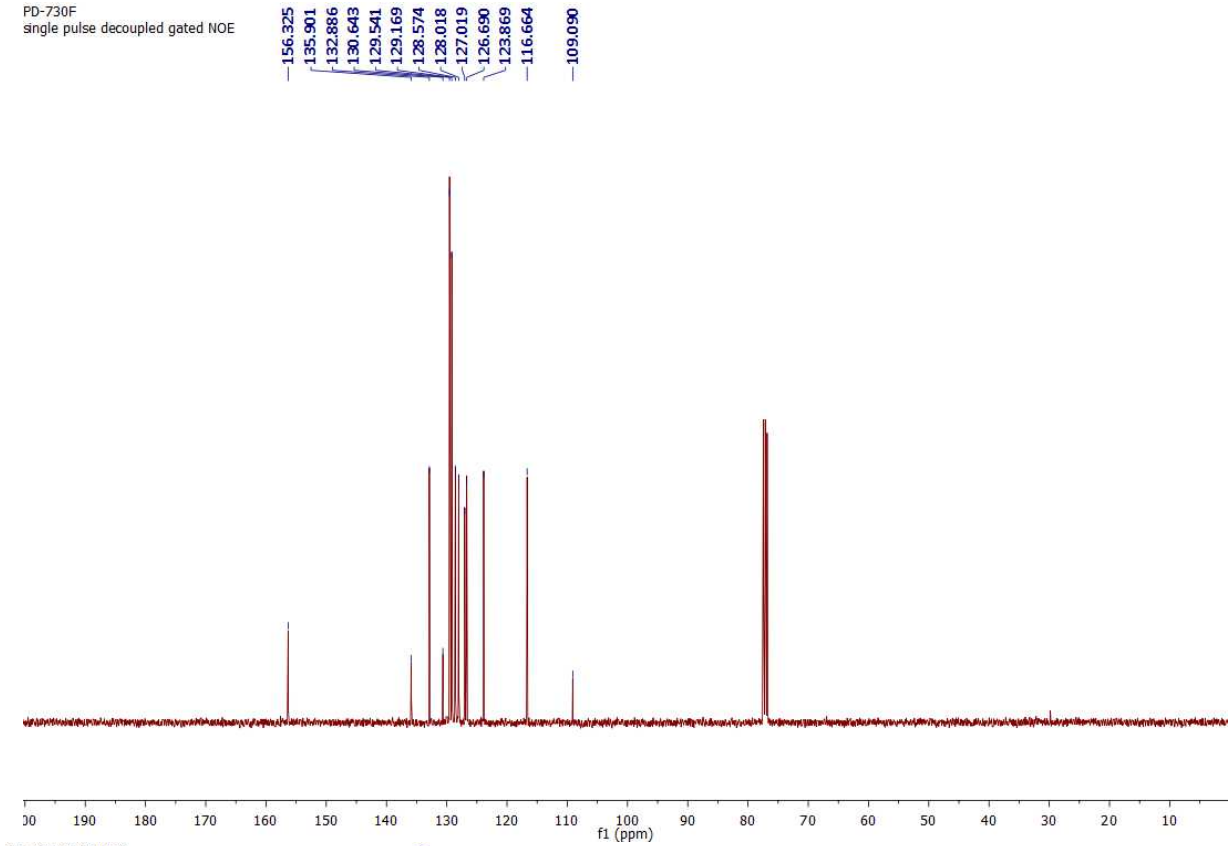

PD-735-1H/1
11.884
8.383
8.368
7.994
7.988
7.881
7.854
7.223
7.213
7.194
7.189
7.170
7.154
7.128
7.118
7.097
7.074
7.074
3.401
2.504
2.501
Se
N
N
H
4n
1.01
1.00
1.00
1.00
6.15
f1 (ppm)

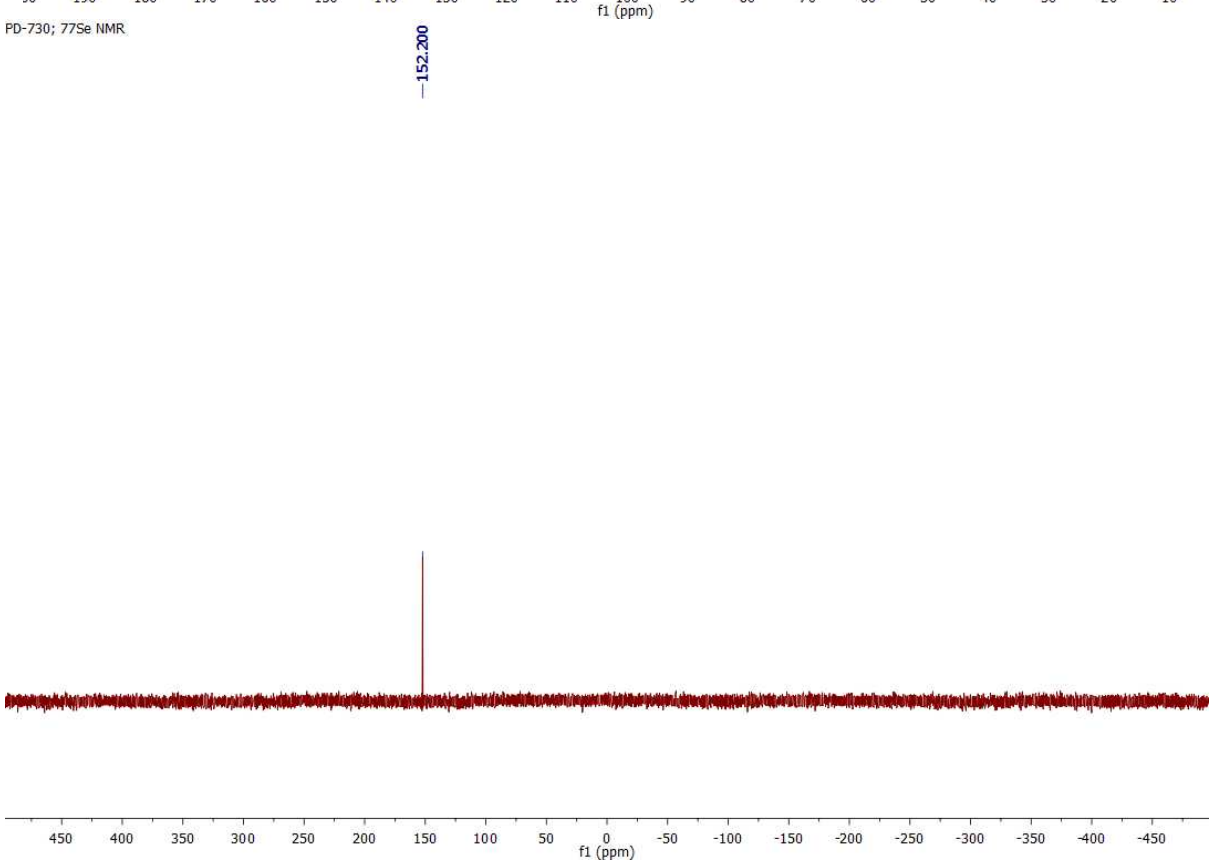

PD-735-C/1
147.551
144.782
137.460
135.356
130.459
130.341
129.700
126.897
120.681
118.574
97.604
41.387
41.108
40.829
40.553
40.274
f1 (ppm)

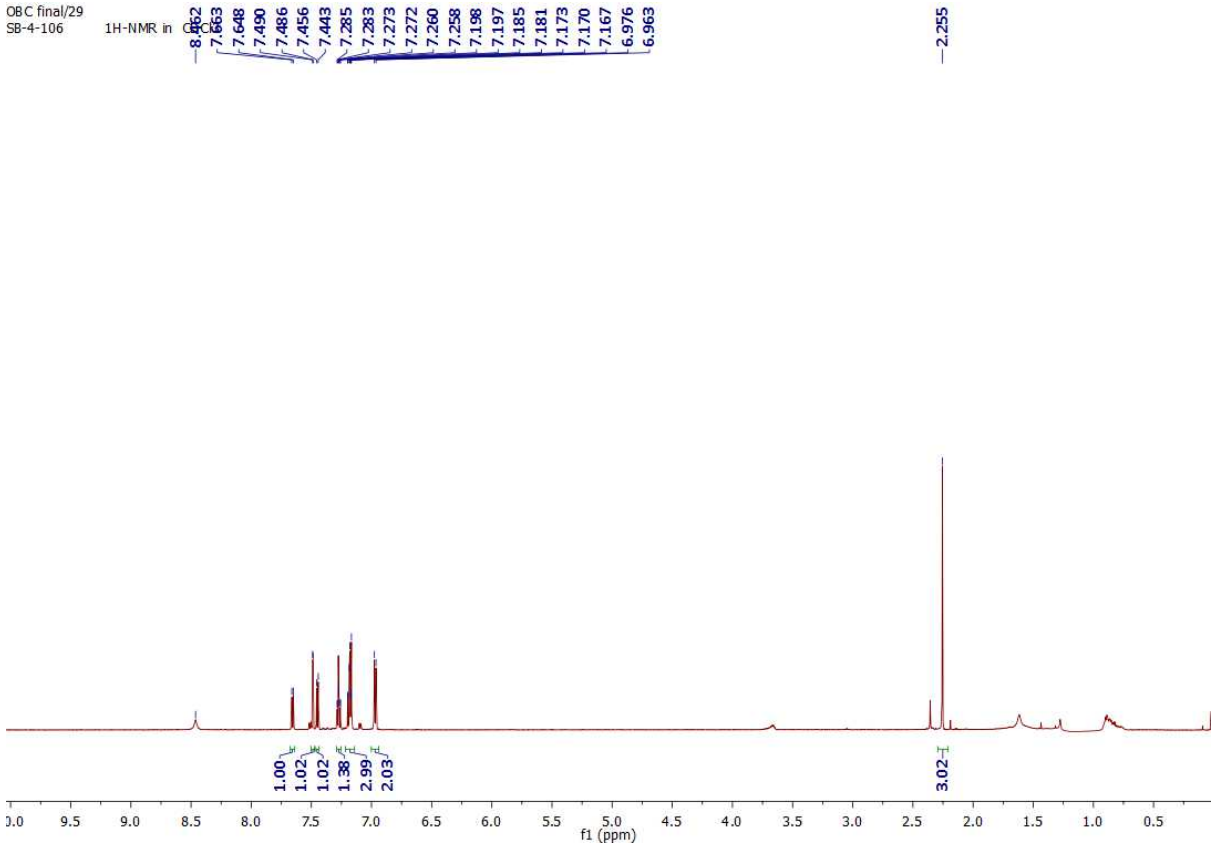

PD-730F
single_pulse
8.297
8.275
7.899
7.877
7.809
7.789
7.516
7.513
7.499
7.495
7.492
7.478
7.474
7.385
7.382
7.374
7.365
7.362
7.352
7.345
7.169
7.165
7.162
7.159
7.151
7.148
7.141
7.136
7.134
7.124

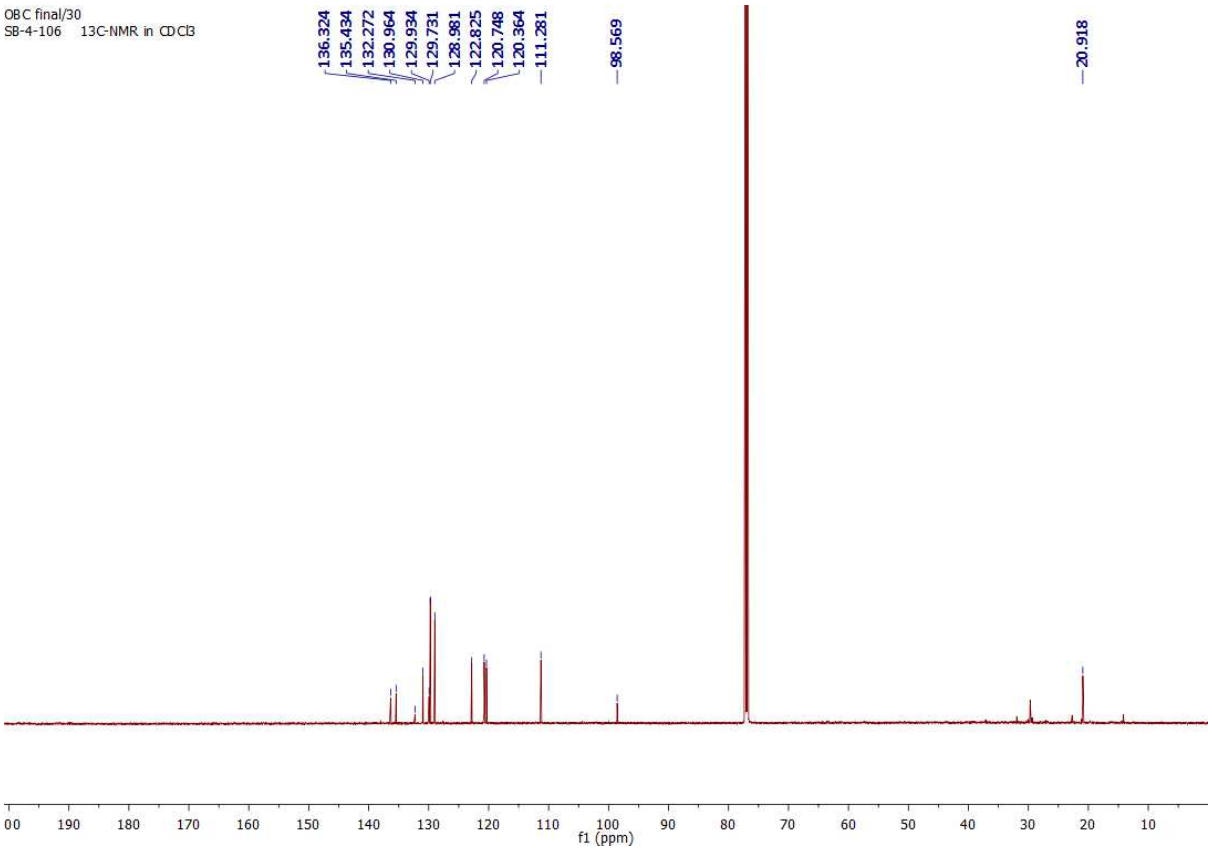

Se
OH
4o


1.00
1.04
1.04
1.05
2.08
6.10
f1 (ppm)

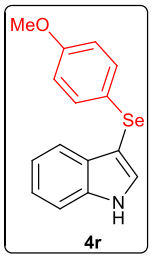

PD-730F
single pulse decoupled gated NOE
156.325
135.901
132.886
130.643
129.541
129.169
128.574
128.018
127.019
126.690
123.869
116.664
109.090
f1 (ppm)


PD-730; 77Se NMR
152.200
f1 (ppm)

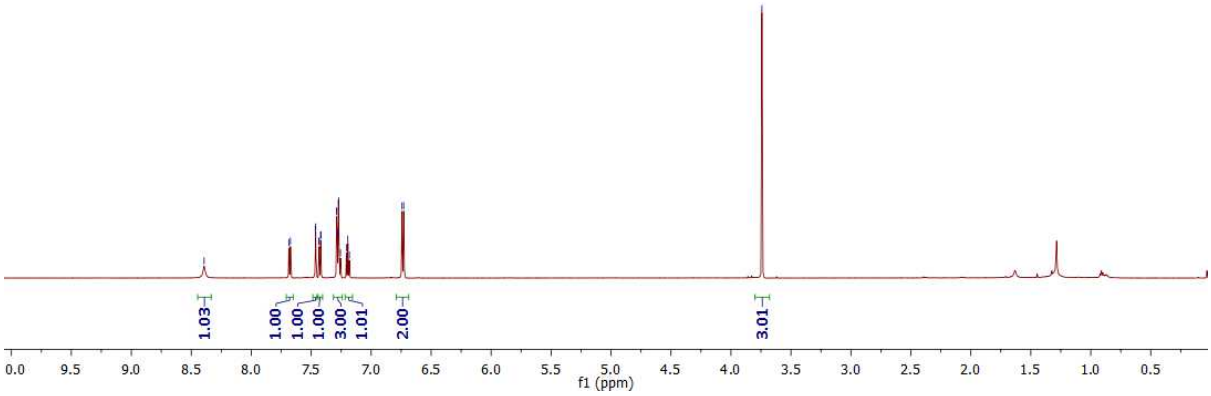

OBC final/29
SB-4-106 1H-NMR in CDCl3
8.662
7.663
7.648
7.490
7.486
7.456
7.443
7.285
7.283
7.273
7.272
7.260
7.258
7.198
7.197
7.185
7.181
7.173
7.170
7.167
6.976
6.963
2.255
1.00
1.02
1.02
1.38
2.99
2.03
3.02
f1 (ppm)


OBC final/30
SB-4-106 13C-NMR in CDCl3
136.324
135.434
132.272
130.964
129.934
129.731
128.981
122.825
120.748
120.364
111.281
98.569
20.918
f1 (ppm)

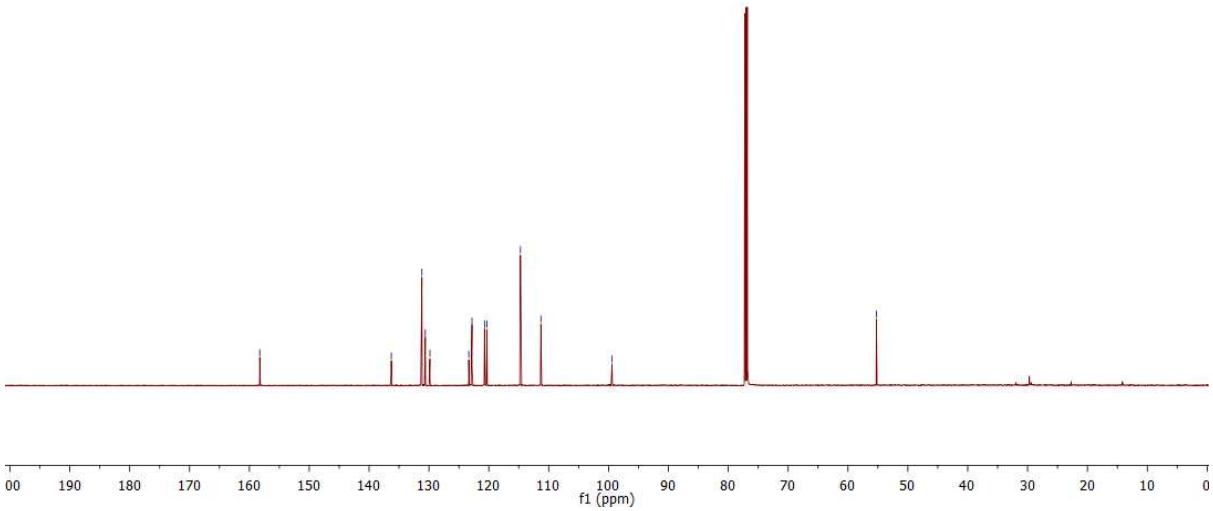

7.466
7.462
7.435
7.433
7.421
7.420
7.288
7.287
7.276
7.272
7.256
7.207
7.195
7.182
6.743
6.729
3.742


MeO
Se
N
H

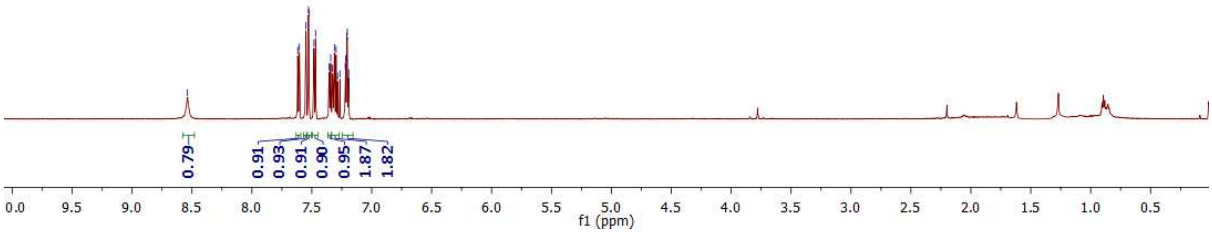
4r

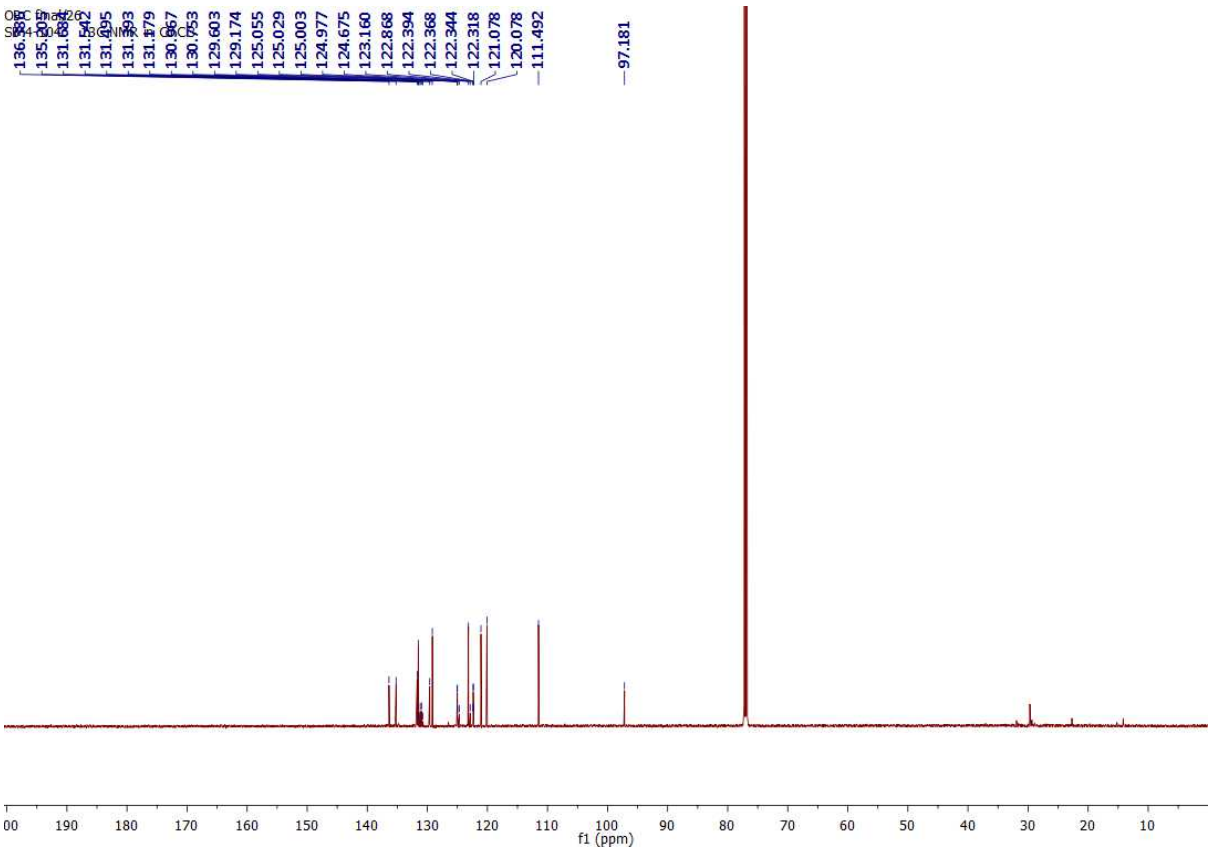

1.03
1.00
1.00
1.00
3.00
1.01
2.00
3.01
f1 (ppm)


OBC final/28
SB-4-105 13C-NMR in CDCl3
158.271
136.297
131.185
130.608
129.840
123.352
122.810
120.718
120.315
114.717
111.299
99.418
55.250

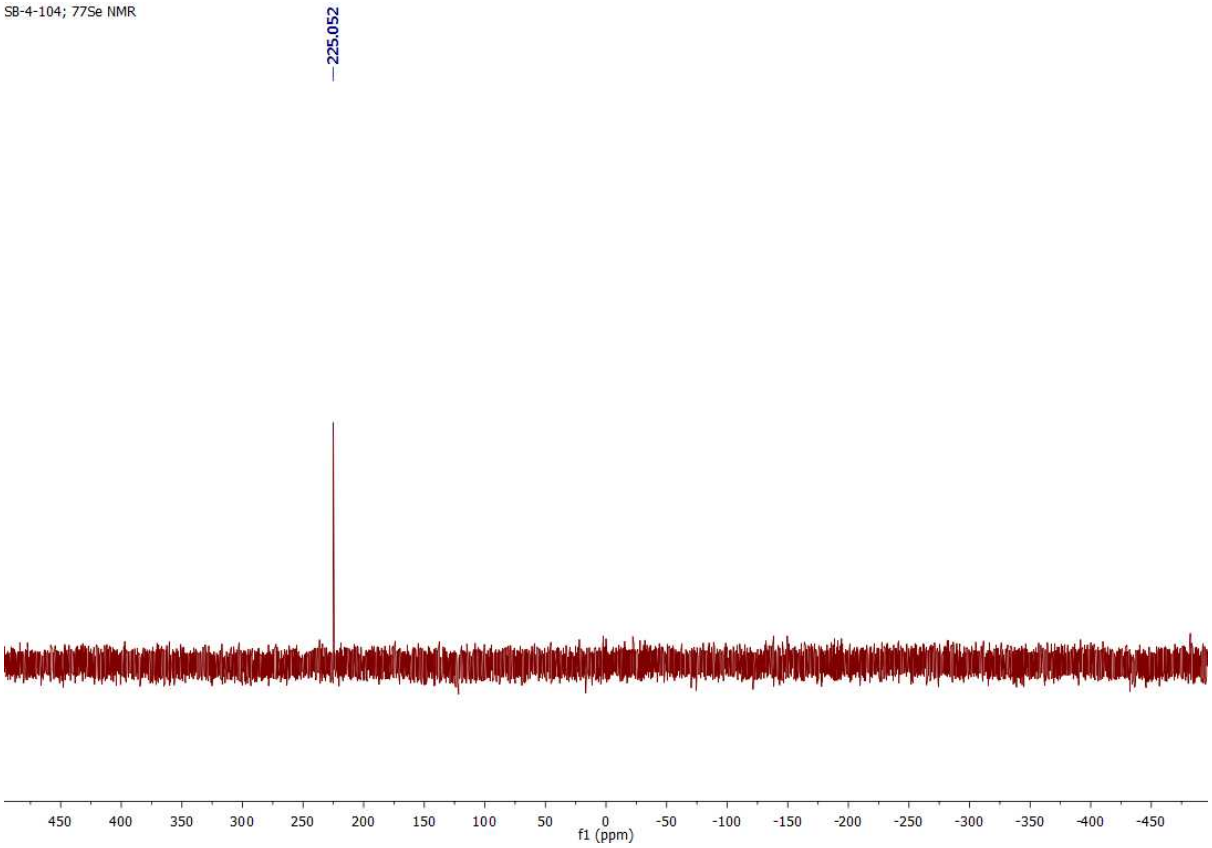

f1 (ppm)


OBC final/25
SB-4-104
1H-NMR in CDCl3
8.500
7.617
7.604
7.549
7.528
7.524
7.482
7.468
7.355
7.342
7.327
7.311
7.297
7.285
7.265
7.221
7.217
7.208
7.204
7.194
7.192

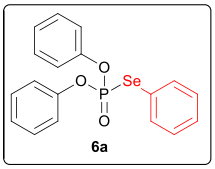

0.79
0.91
0.93
0.91
0.90
0.95
1.87
1.82
f1 (ppm)


97.181
f1 (ppm)

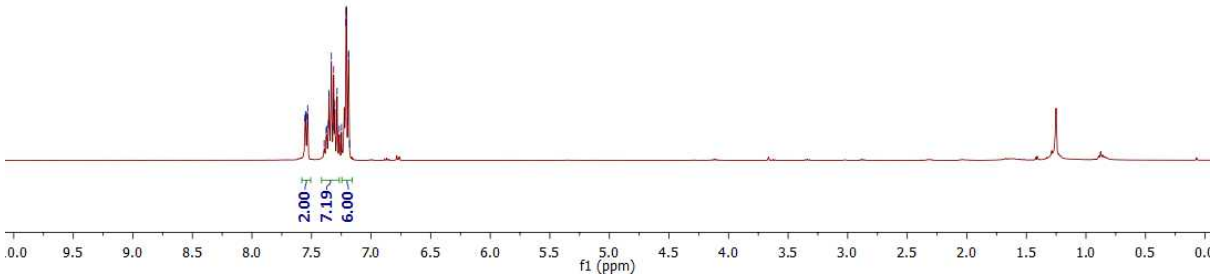
SB-4-104; 77Se NMR



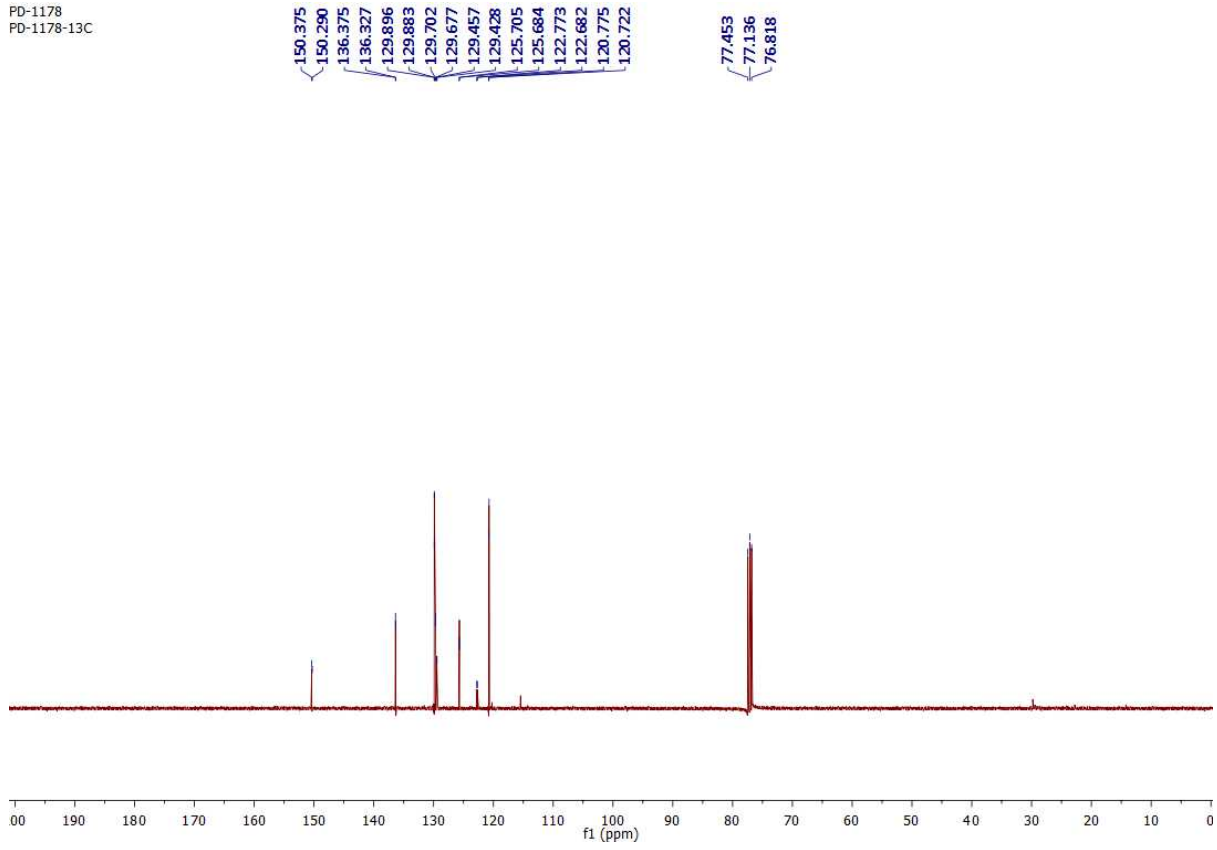
PD-1176
PD-1176-1



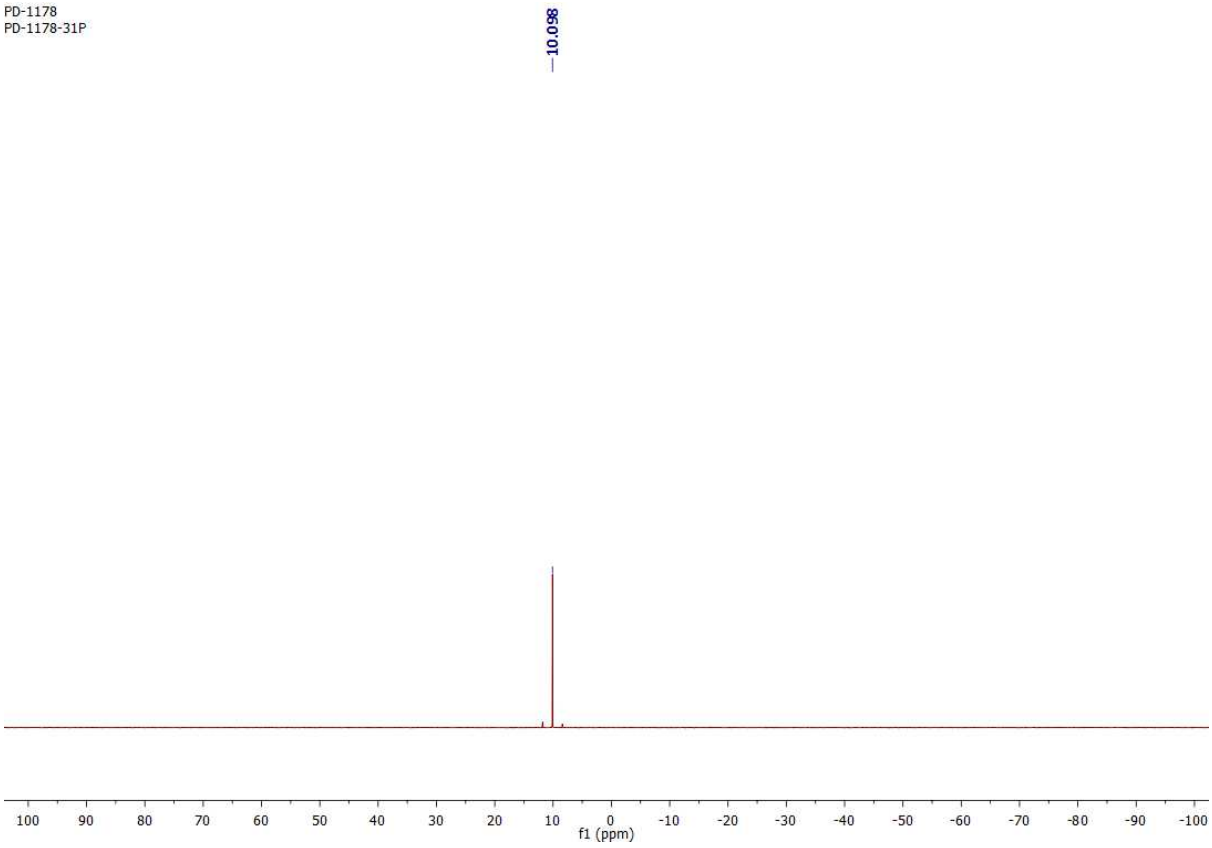
6a



PD-1178
PD-1178-13C

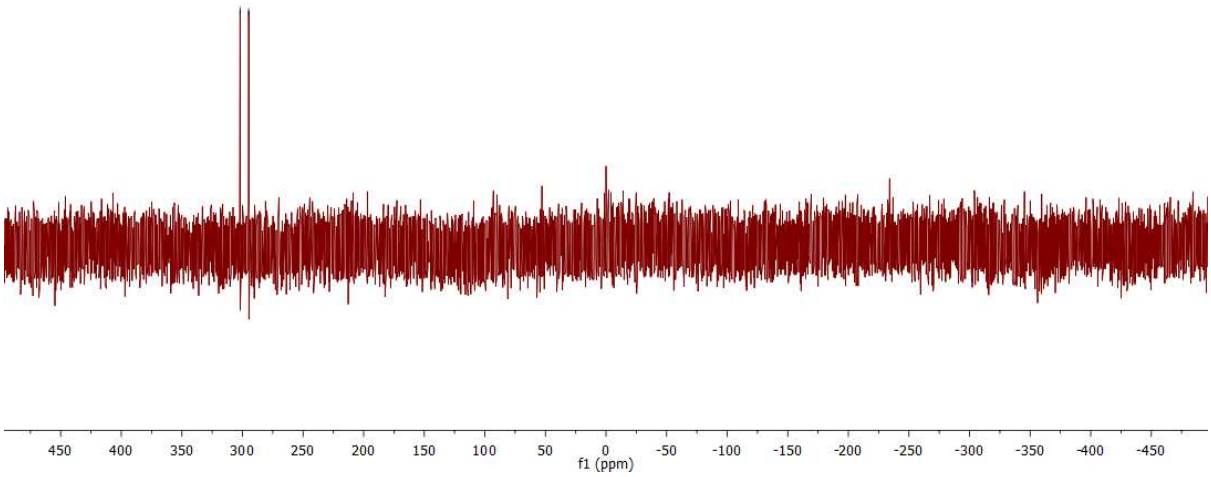


PD-1178
PD-1178-31P



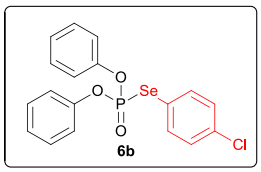
PD-1178; 77Se NMR

302.011
294.874

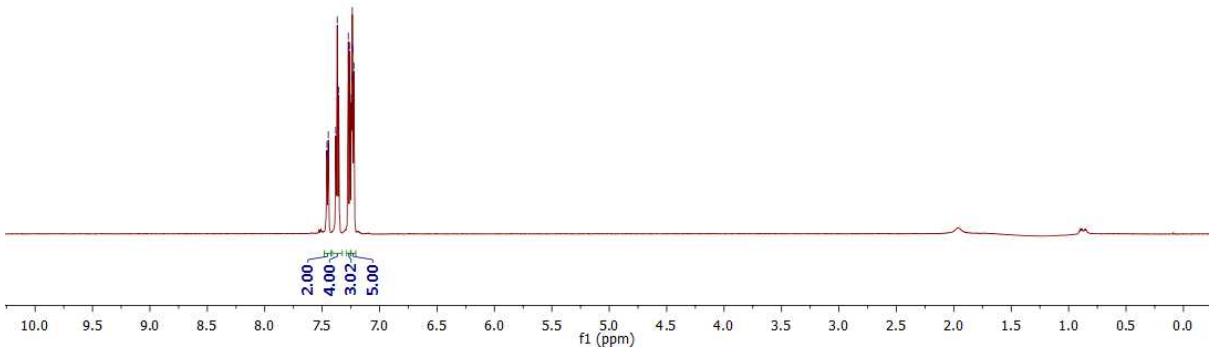


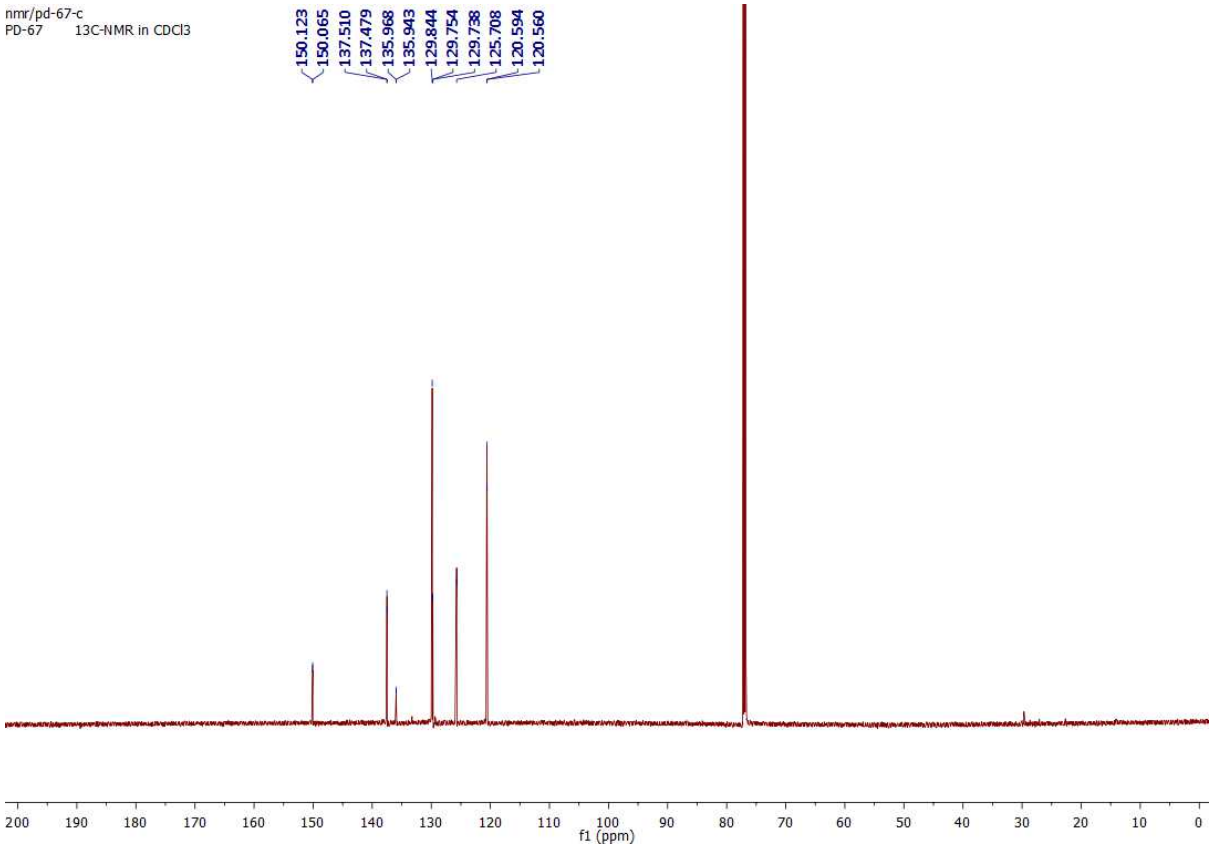
seleno phospho NMR/pd-67-h
PD-67 1H-NMR in CDCl3

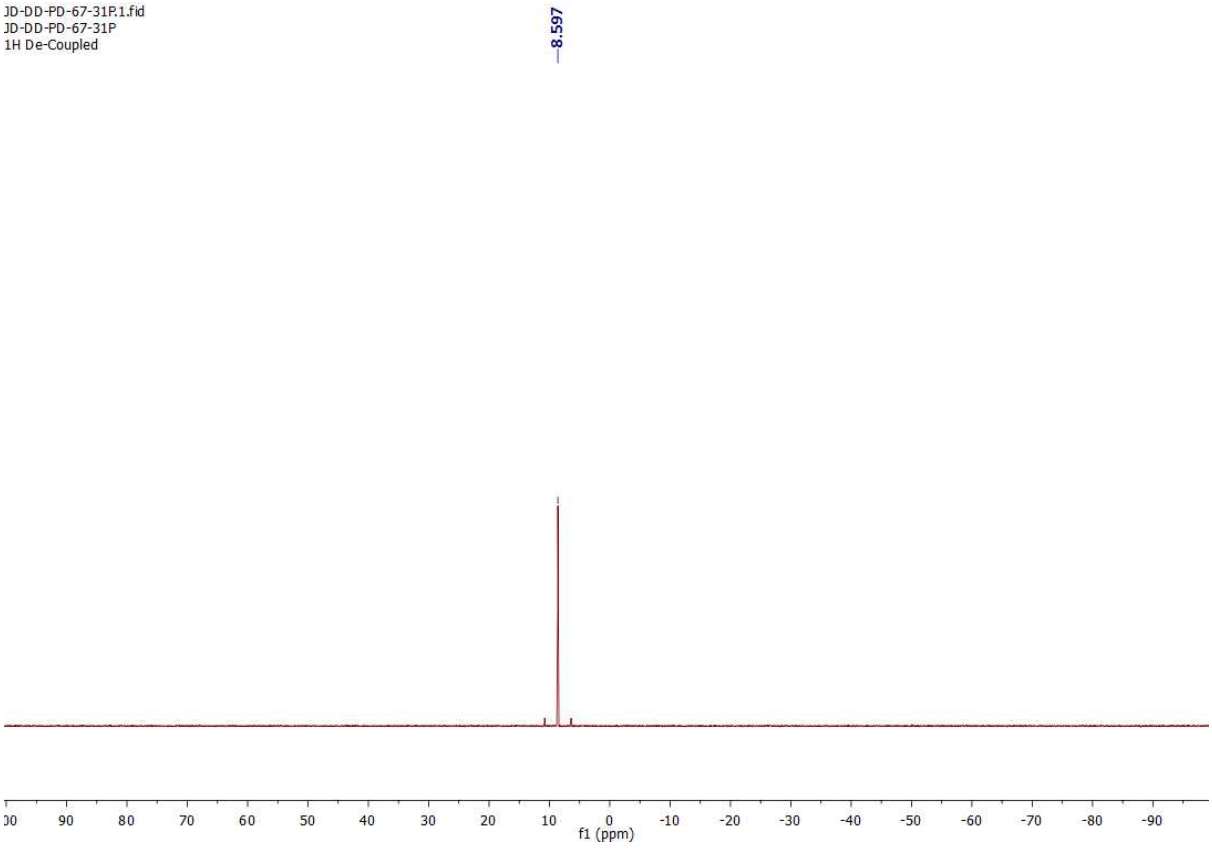
7.461
7.458
7.447
7.444
7.382
7.369
7.356
7.273
7.258
7.246
7.240
7.237
7.235
7.224



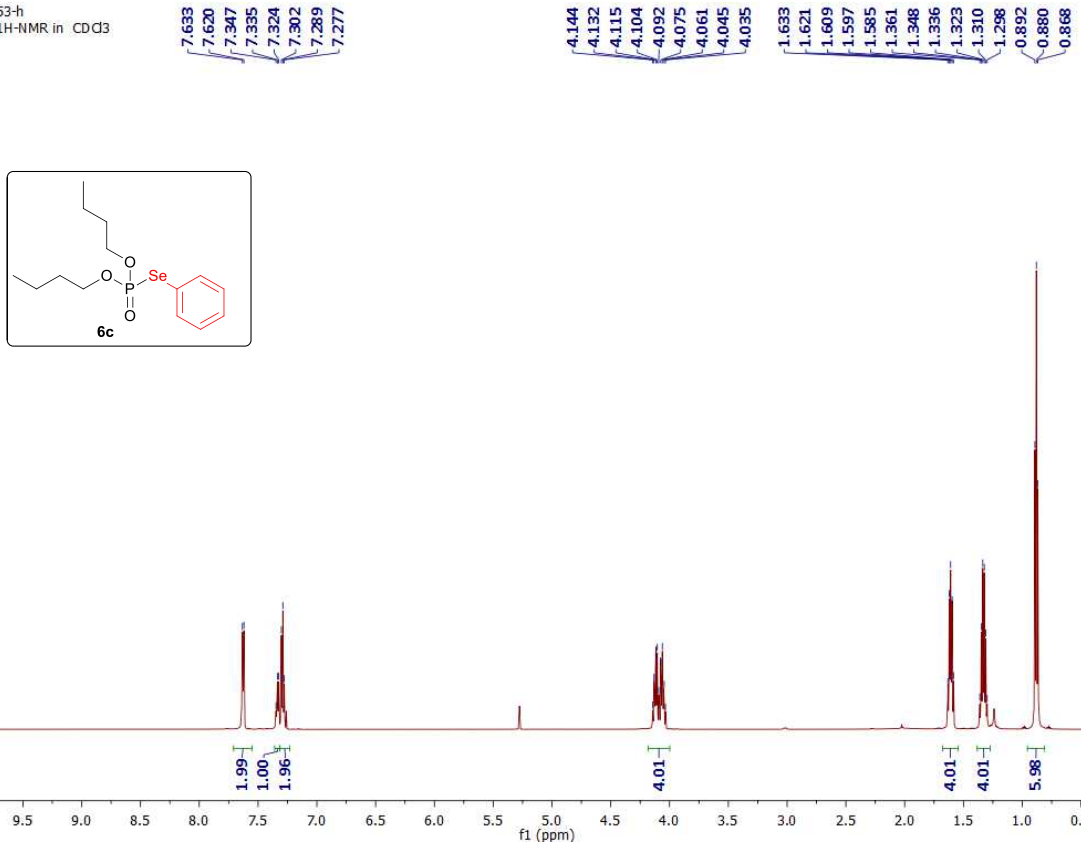
6b



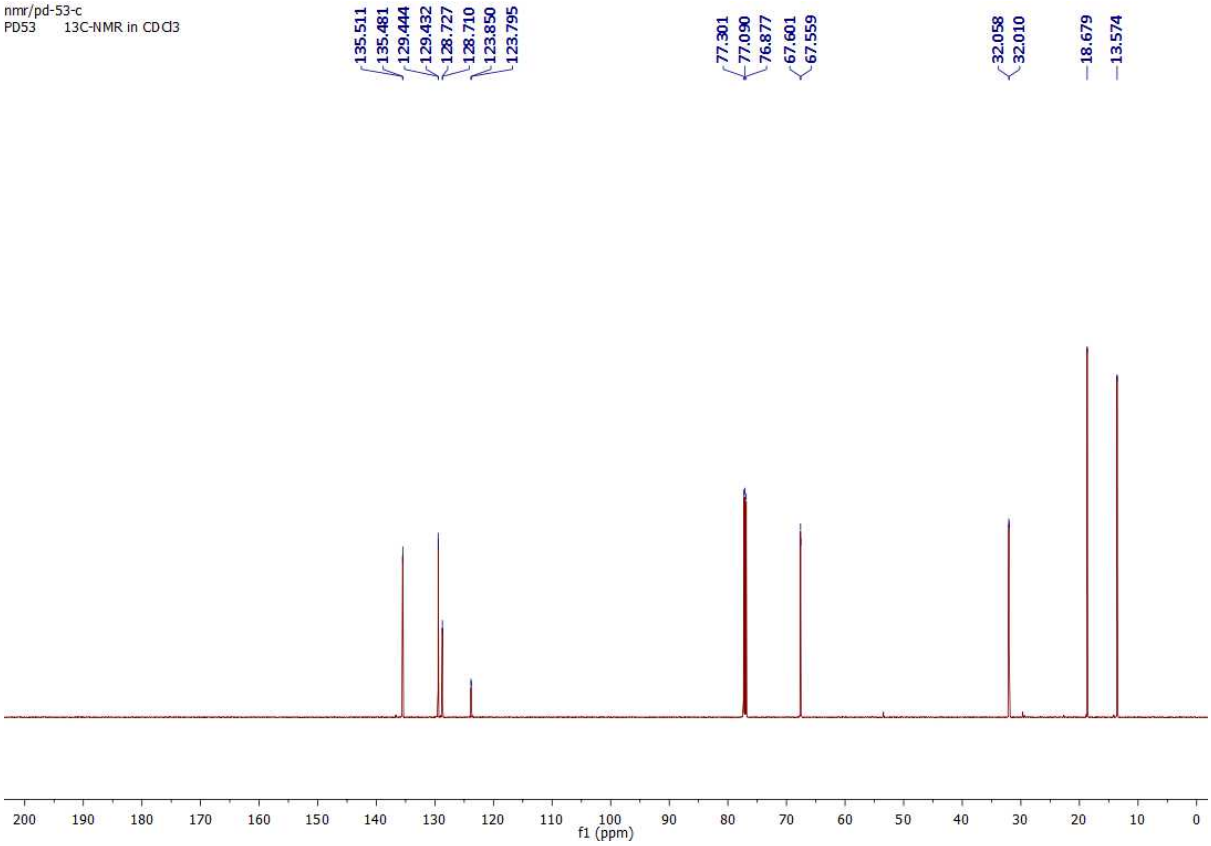

nmr/pd-67-c
PD-67 13C-NMR in CDCl3
150.123
150.065
137.510
137.479
135.968
135.943
129.844
129.754
129.738
125.708
120.594
120.560
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


JD-DD-PD-67-31P.1.fid
JD-DD-PD-67-31P
1H De-Coupled
8.597
90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90
f1 (ppm)

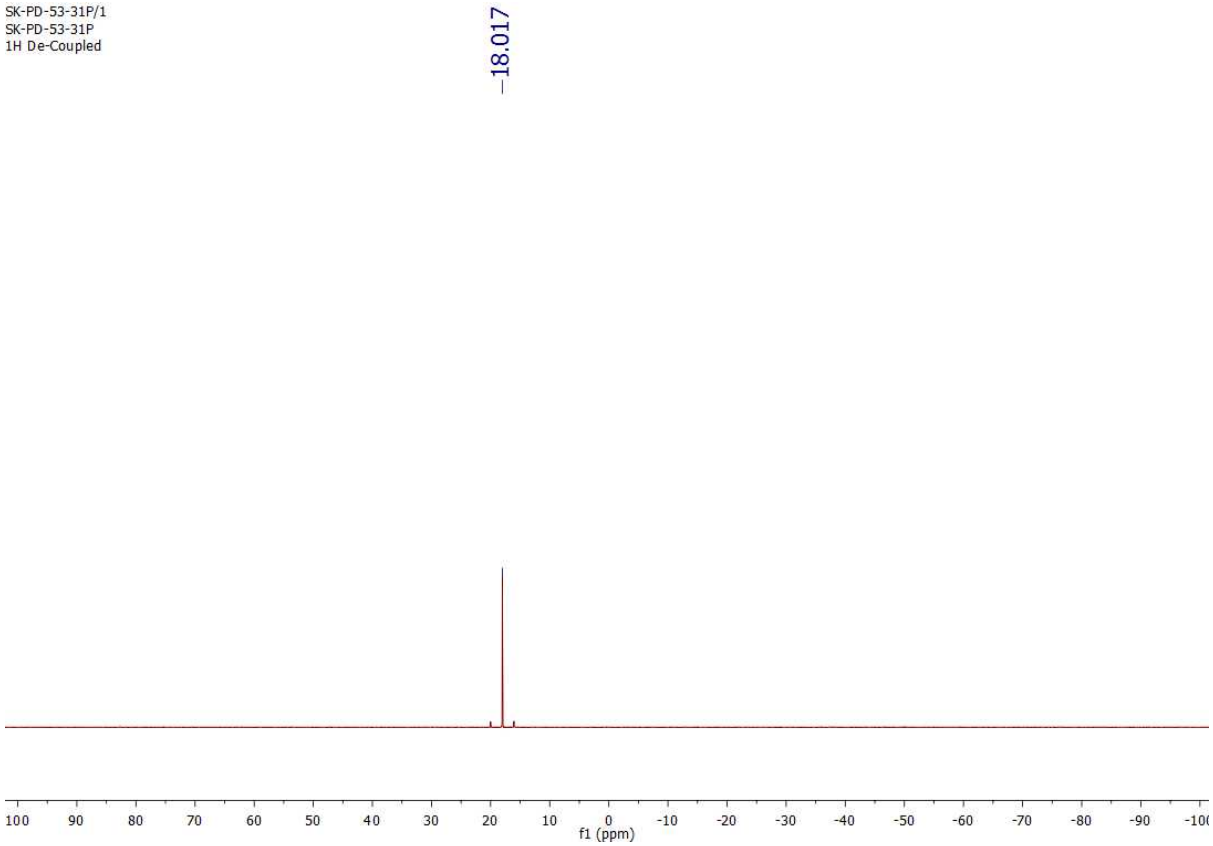
nmr/pd-53-h
PD53 1H-NMR in CDCl3



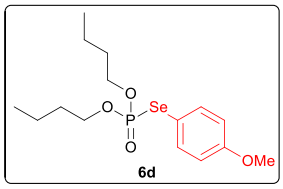
nmr/pd-53-c
PD53 13C-NMR in CDCl3



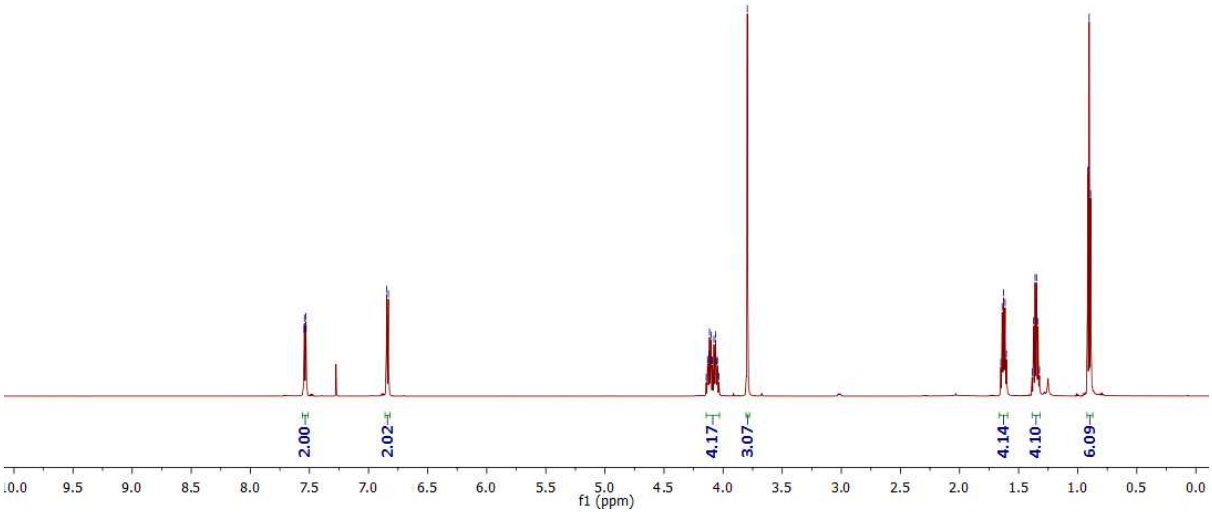
SK-PD-53-31P/1
SK-PD-53-31P
1H De-Coupled



nmr/pd-63-h
PD-63 1H-NMR in CDCl3

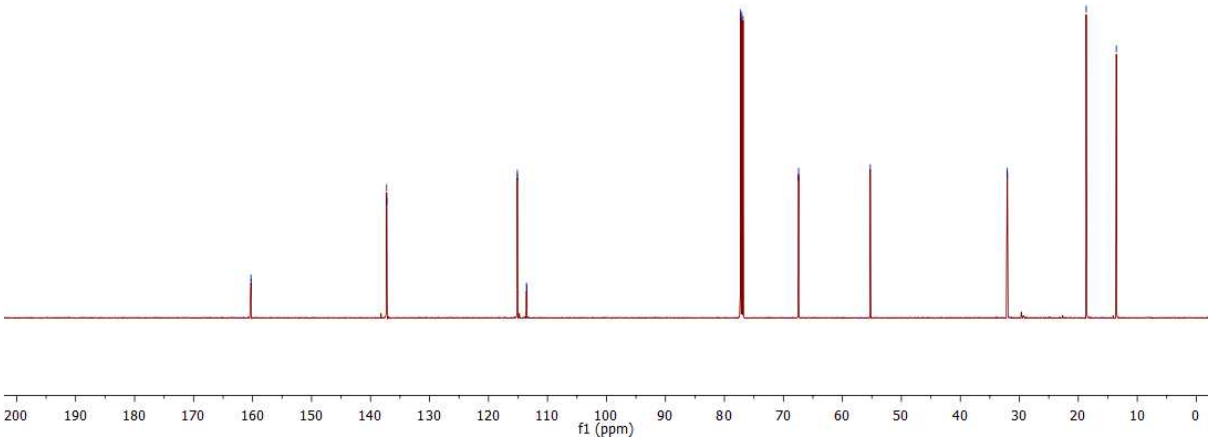


6d



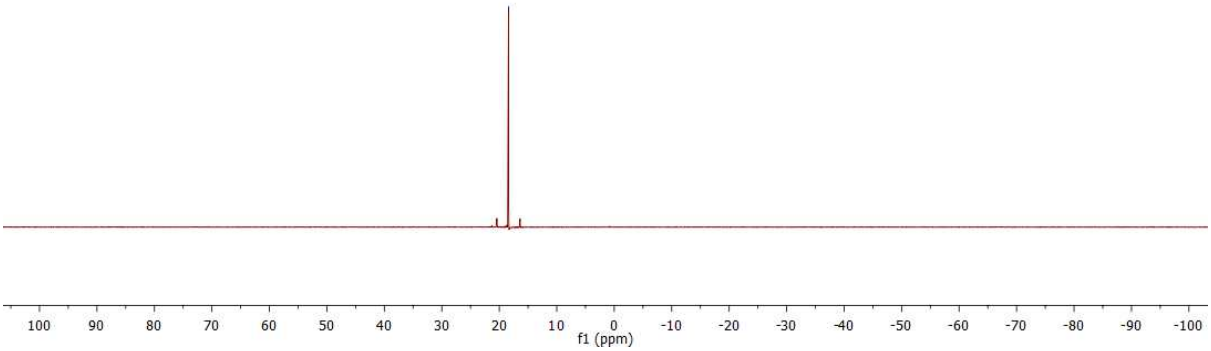
nmr/pd-63-c
PD-63 13C-NMR in CDCl3

160.270
160.253
137.267
137.239
115.107
115.092
113.569
113.511
77.253
77.041
76.829
67.462
67.419
55.272
32.061
32.013
18.659
13.553

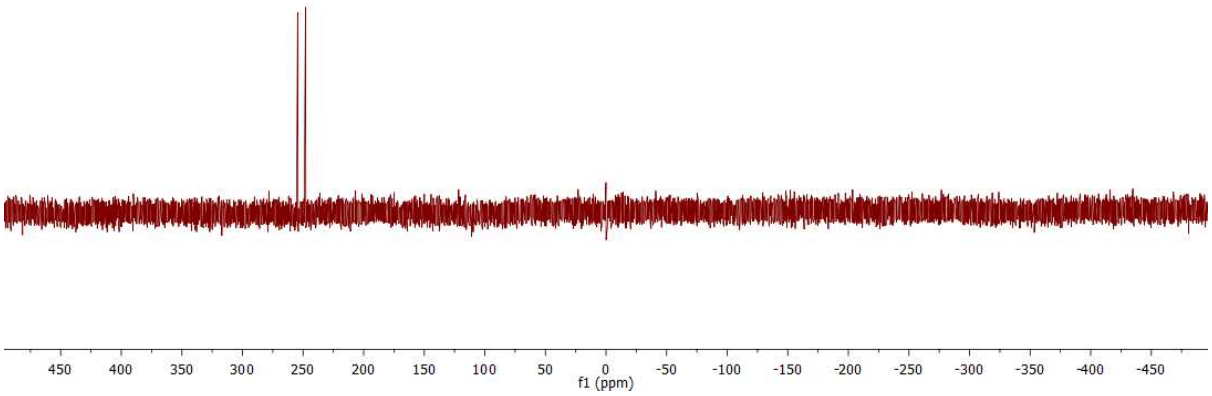


SK-PD-63-31P/1
SK-PD-63-31P
1H De-Coupled

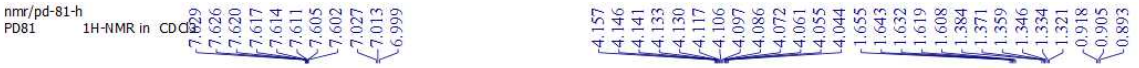
18.40

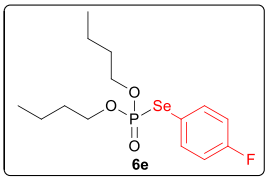


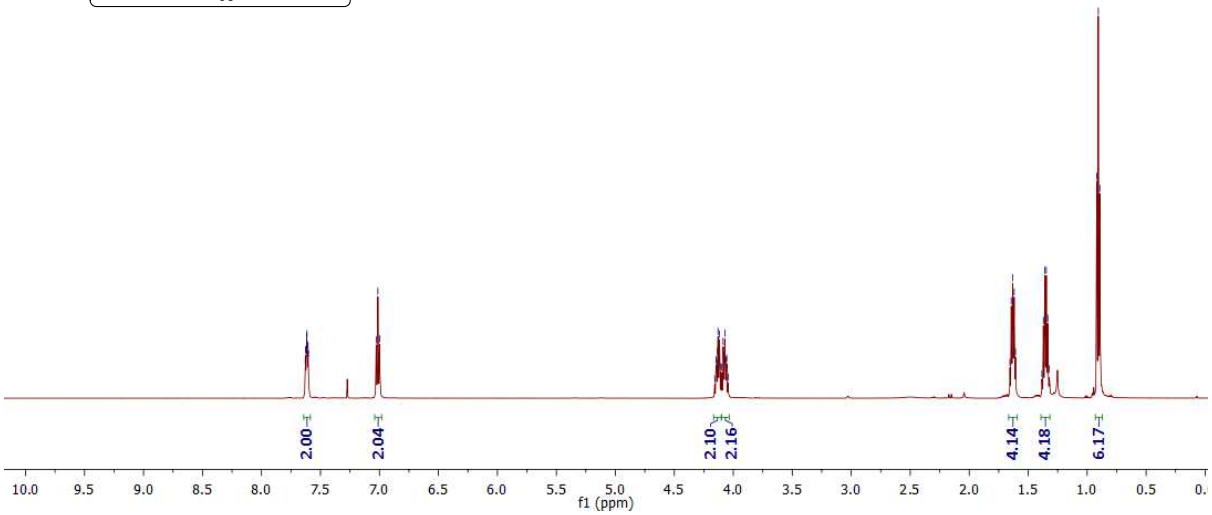
PD-63; 77Se NMR

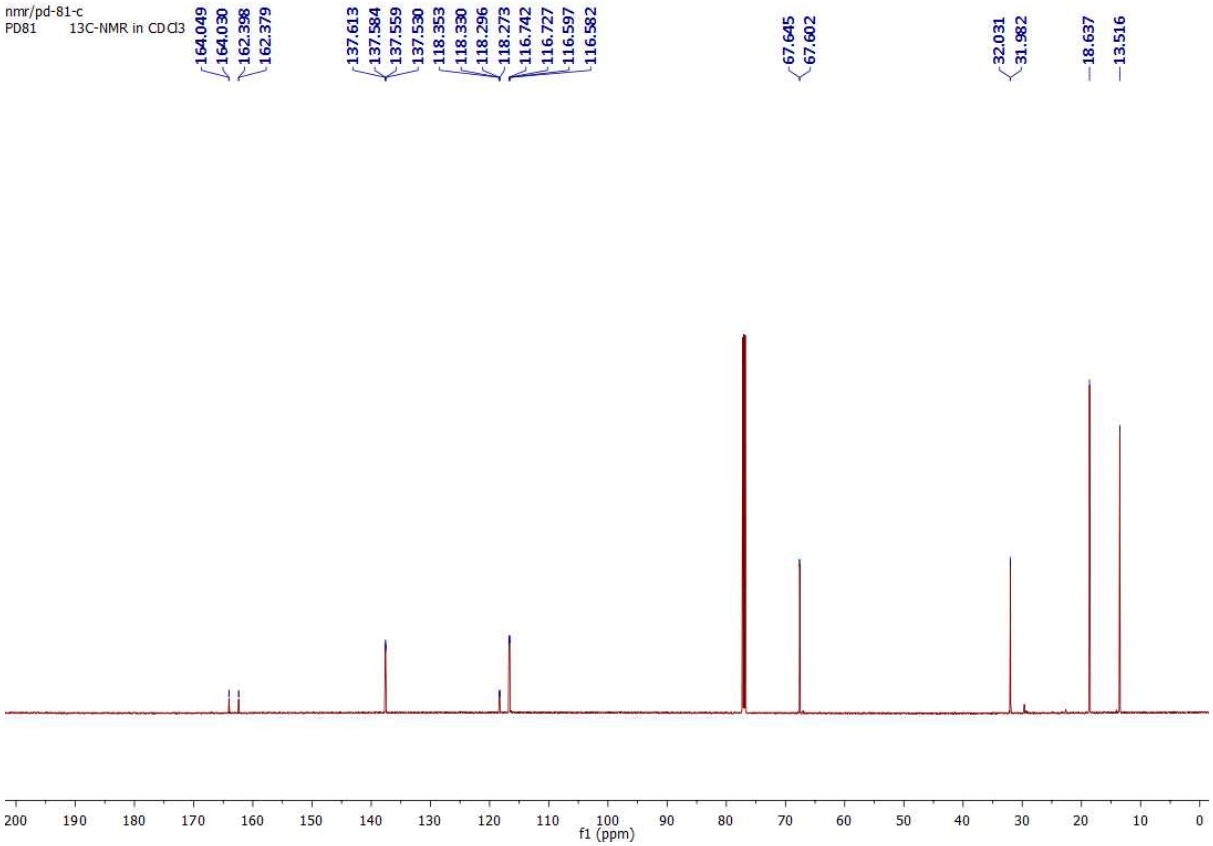


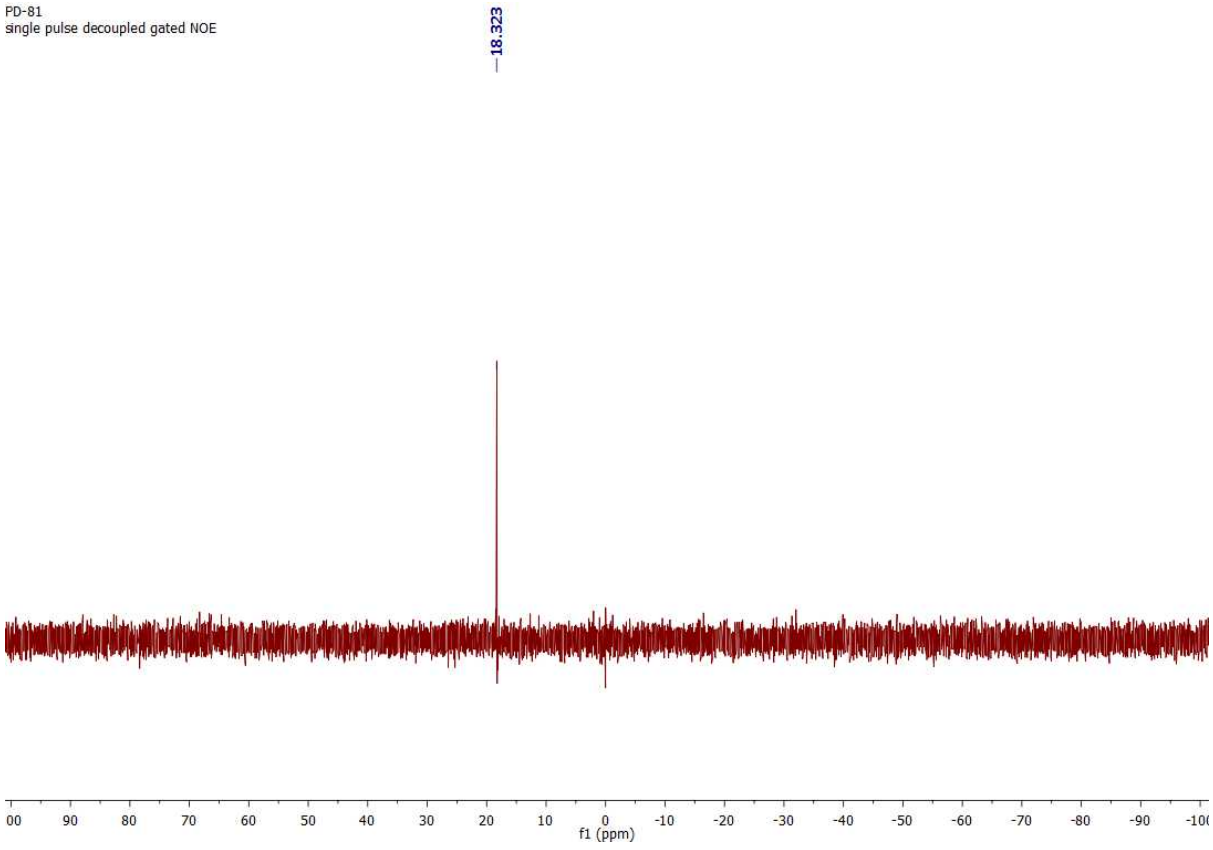
nmr/pd-81-h
PD81 1H-NMR in CDCl3








nmr/pd-81-c
PD81 13C-NMR in CDCl3
164.049
164.030
162.398
162.379
137.613
137.584
137.559
137.530
118.353
118.330
118.296
118.273
116.742
116.727
116.597
116.582
67.645
67.602
32.031
31.982
18.637
13.516
f1 (ppm)


PD-81
single pulse decoupled gated NOE
18.323
f1 (ppm)

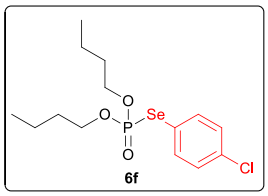
nmr/pd-82-h
PD82 1H-NMR in CDCl3

7.577 7.566 7.289 7.275

4.163 4.151 4.146 4.139 4.134 4.126 4.122 4.111 4.100 4.089 4.085 4.083 4.078 4.075 4.072 4.069 4.063 4.058 4.047

1.657 1.646 1.634 1.621 1.610 1.384 1.372 1.359 1.346 1.334 1.322

0.918 0.906 0.893



6f

nmr/pd-82-c
PD82 13C-NMR in CDCl3

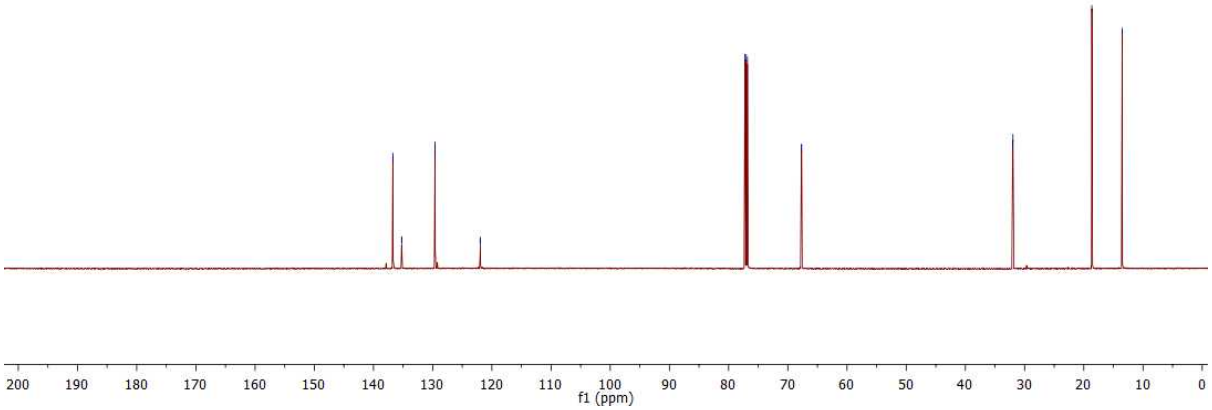
136.728 136.696 135.244 135.223 129.602 129.588 121.976 121.919

77.242 77.030 76.818 67.708 67.664

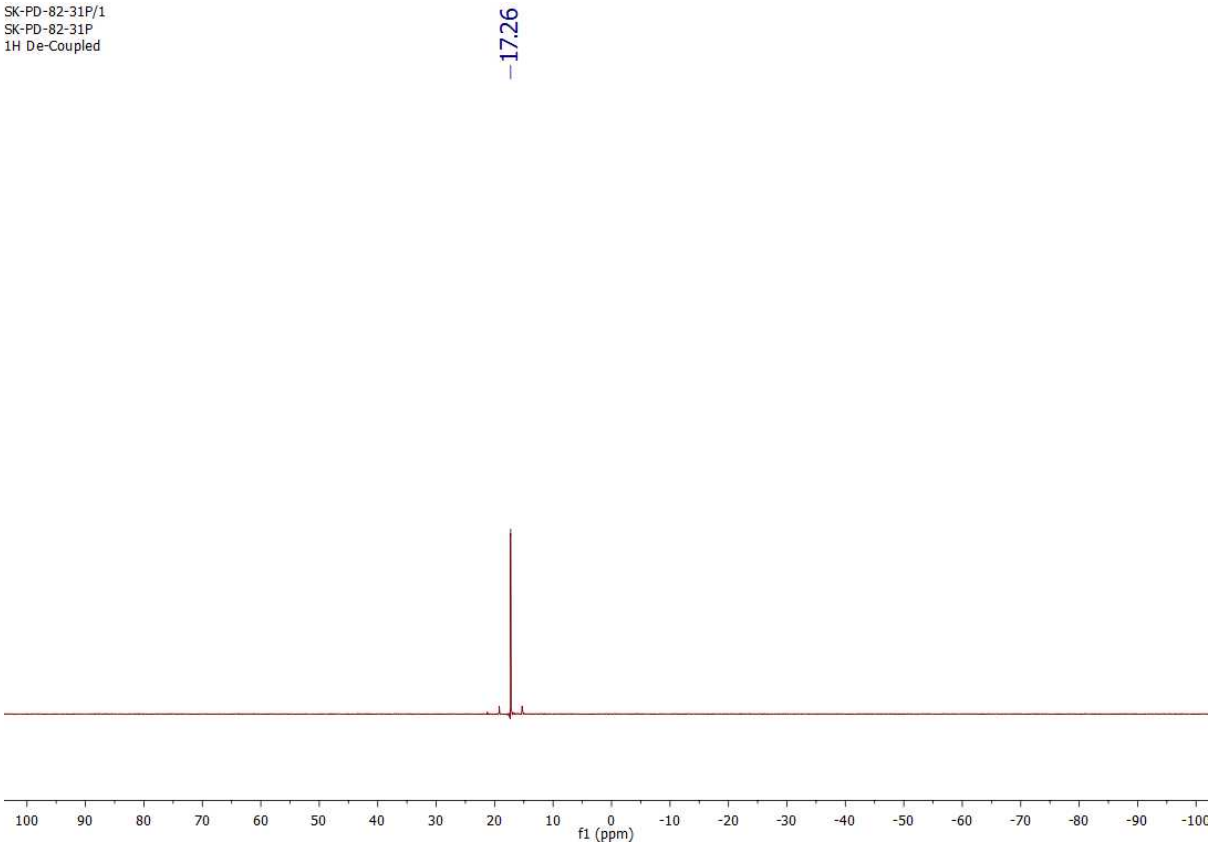
32.019 31.971

18.641

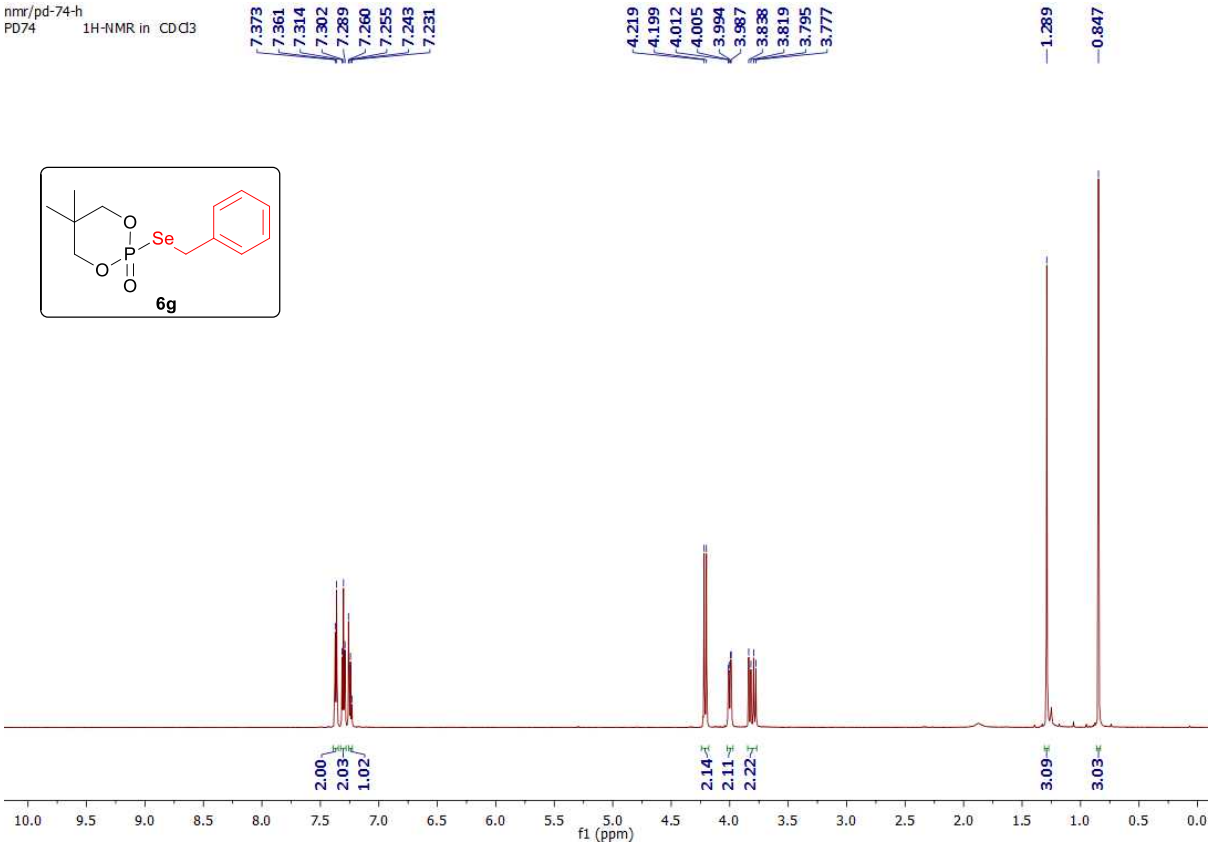
13.519

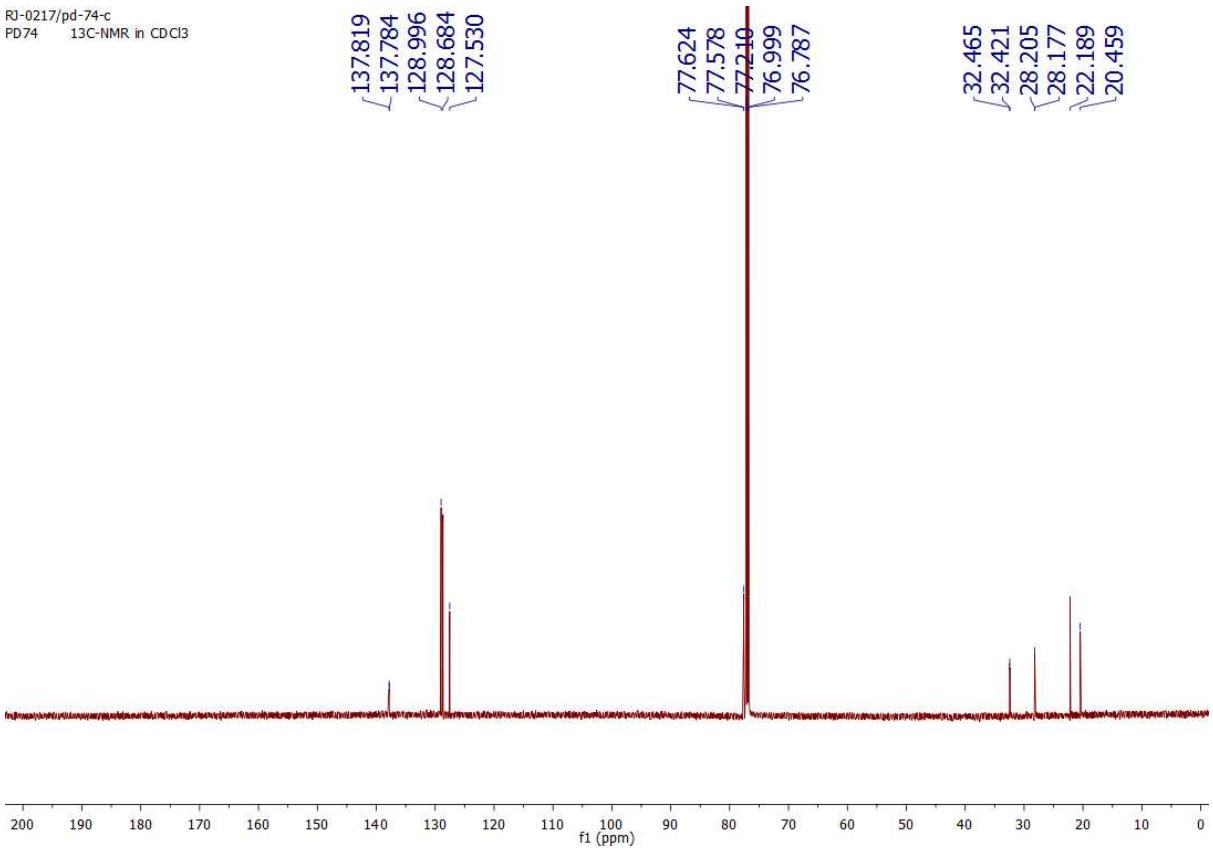


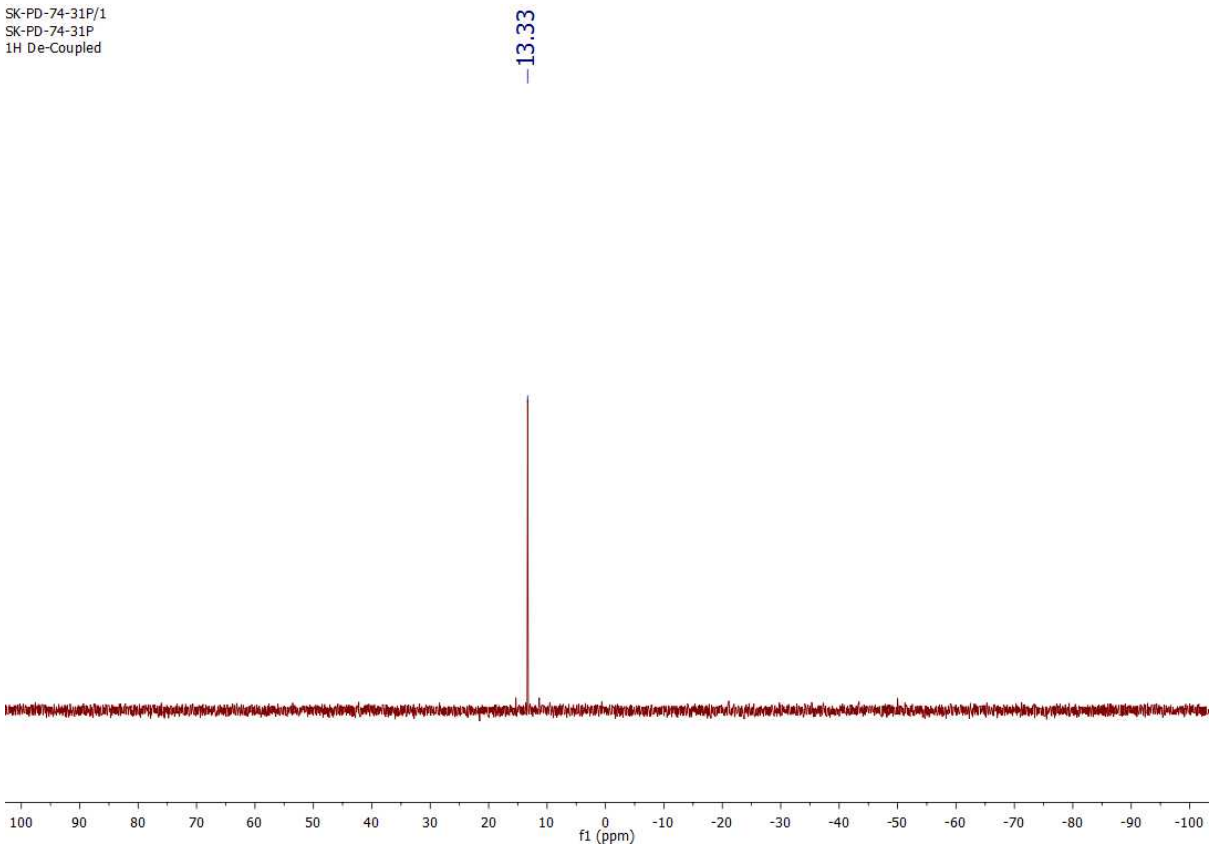
SK-PD-82-31P/1
SK-PD-82-31P
1H De-Coupled

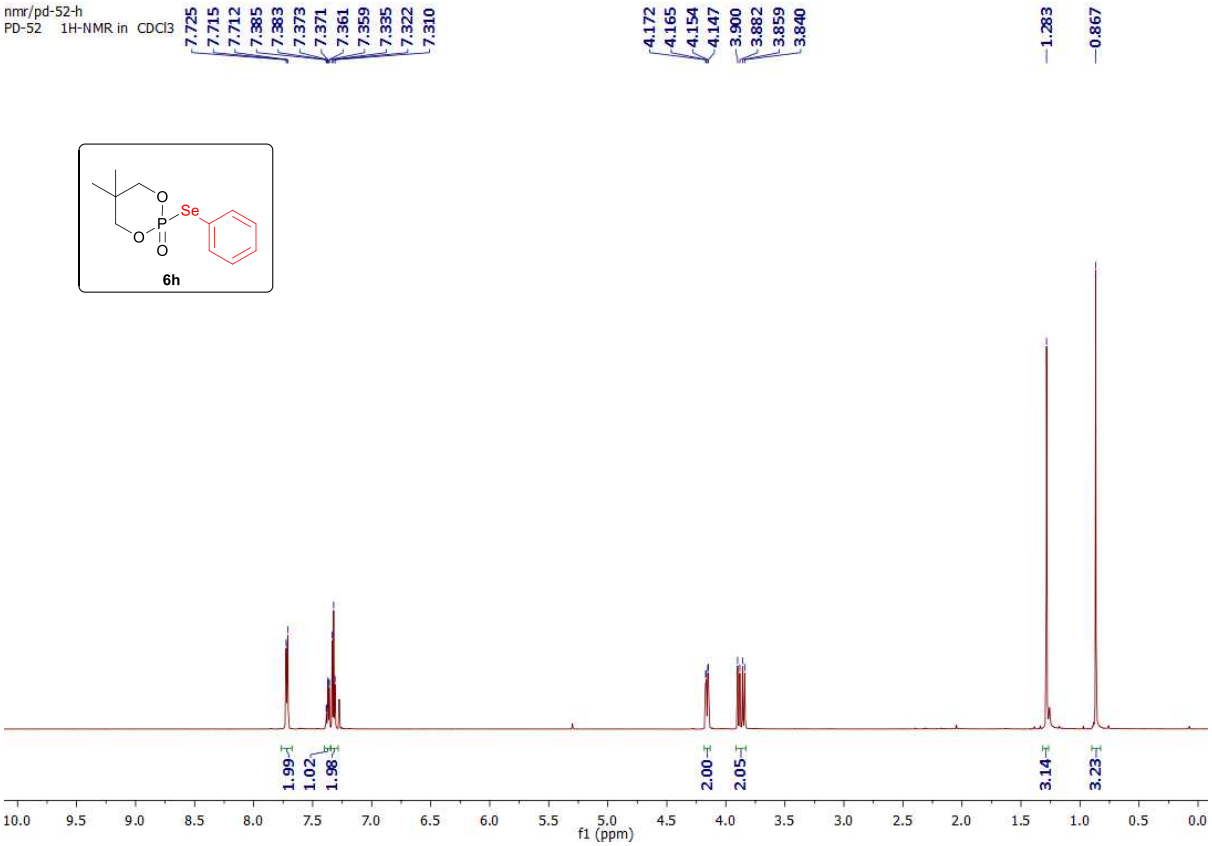


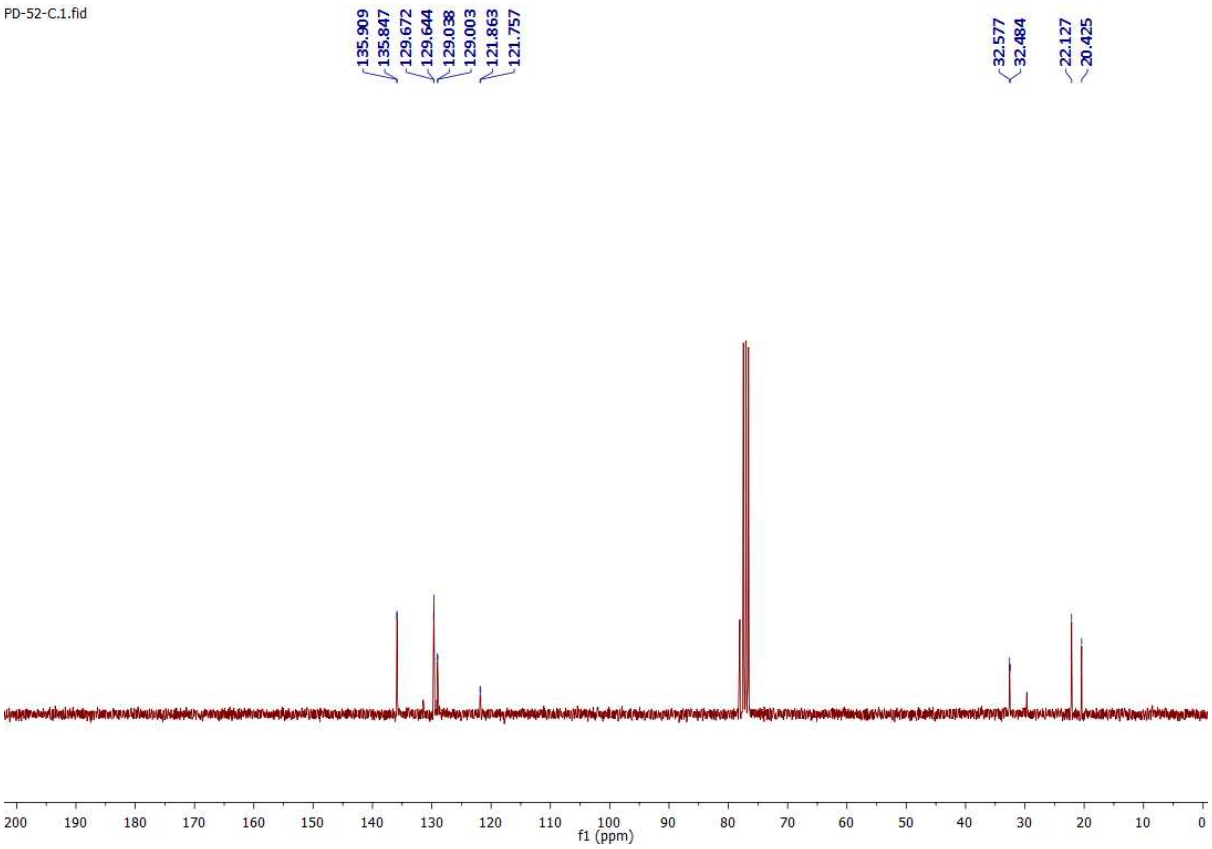
nmr/pd-74-h
PD74 1H-NMR in CDCl3

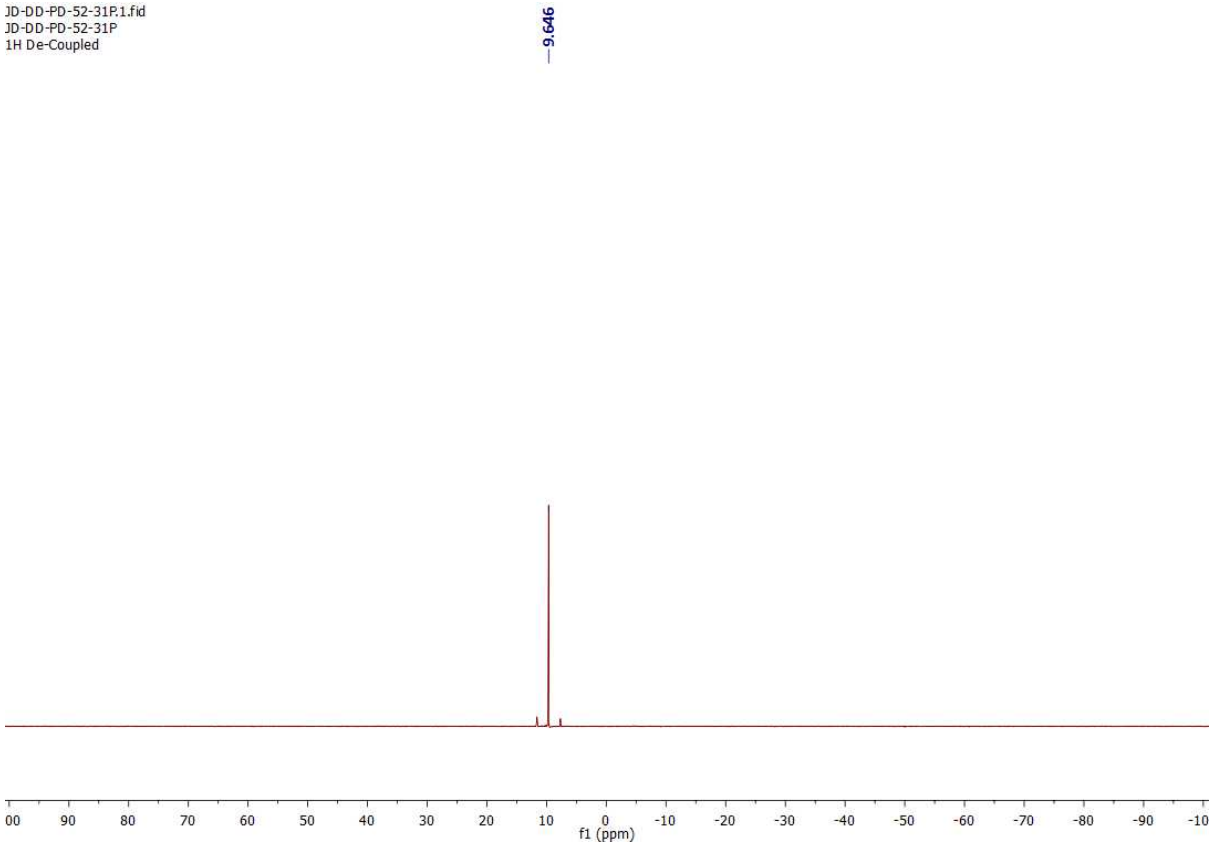


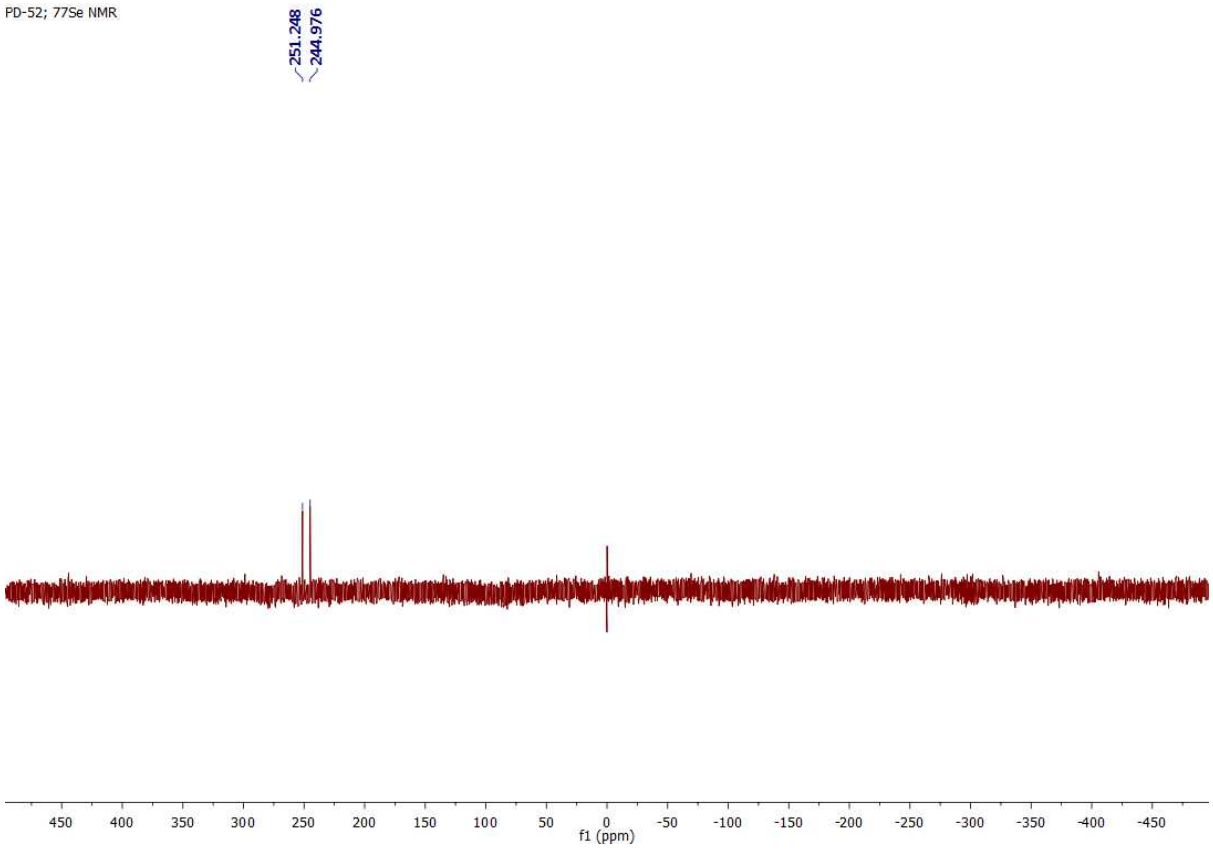

RJ-0217/pd-74-c
PD74 13C-NMR in CDCl3
137.819
137.784
128.996
128.684
127.530
77.624
77.578
77.210
76.999
76.787
32.465
32.421
28.205
28.177
22.189
20.459
f1 (ppm)

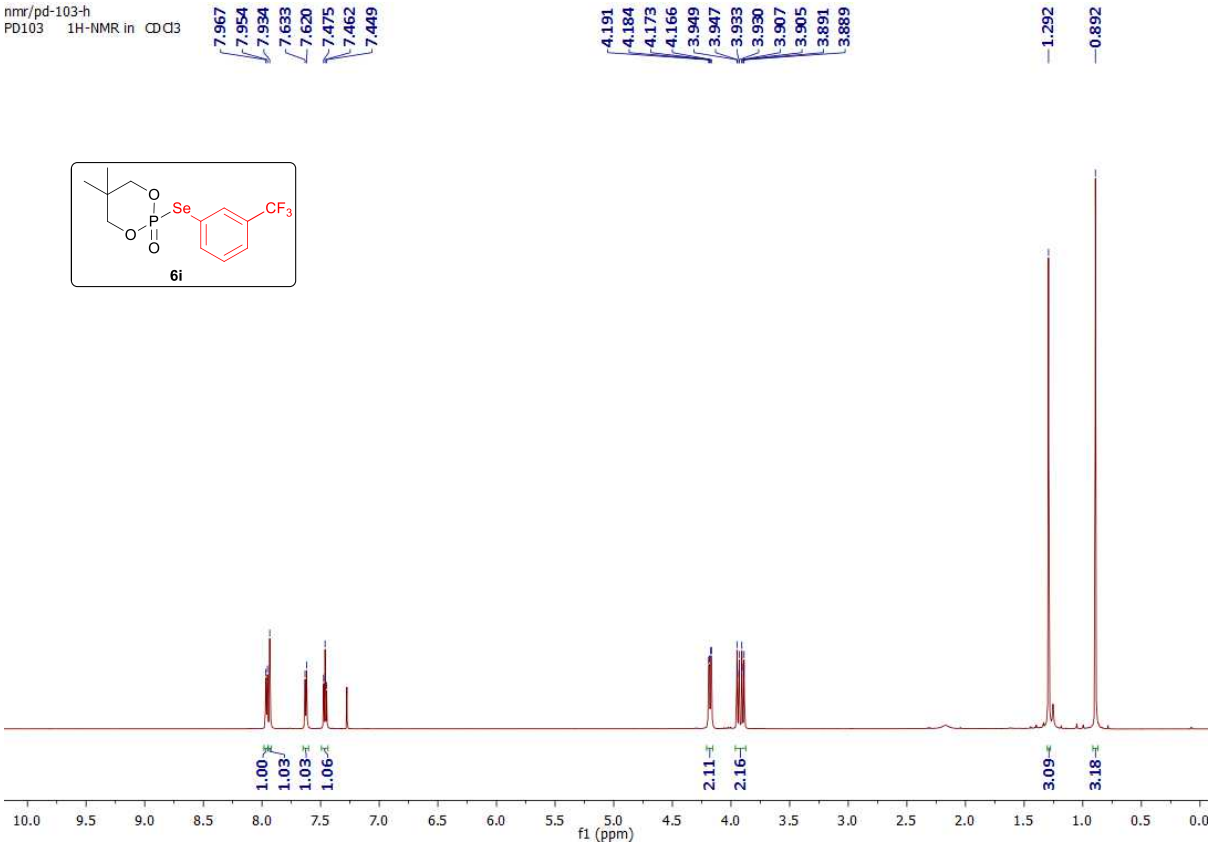

SK-PD-74-31P/1
SK-PD-74-31P
1H De-Coupled
13.33
f1 (ppm)

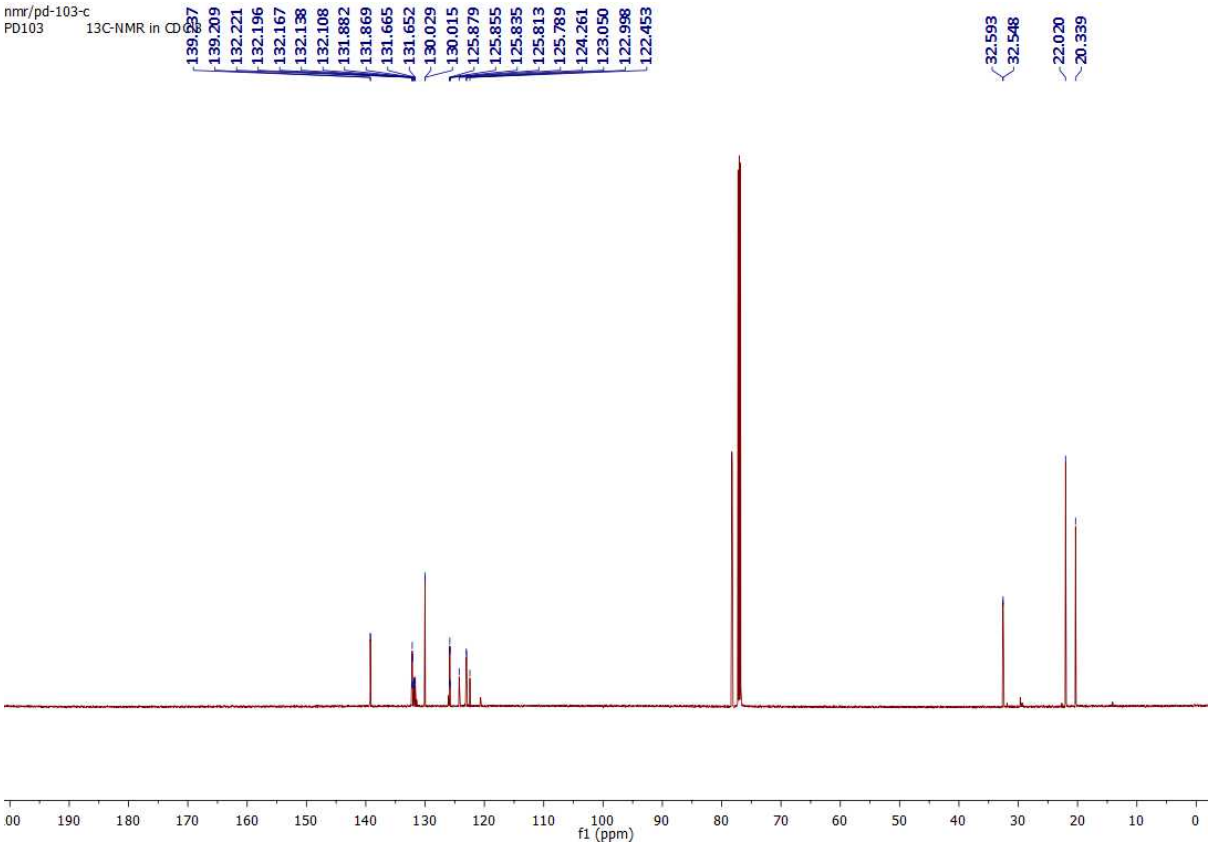

nmr/pd-52-h
PD-52 1H-NMR in CDCl3
7.725
7.715
7.712
7.385
7.383
7.373
7.371
7.361
7.359
7.335
7.322
7.310
4.172
4.165
4.154
4.147
3.900
3.882
3.859
3.840
1.283
0.867
Se
6h
1.99
1.02
1.98
2.00
2.05
3.14
3.23
f1 (ppm)


PD-52-C.1.fid
135.909
135.847
129.672
129.644
129.038
129.003
121.863
121.757
32.577
32.484
22.127
20.425
f1 (ppm)

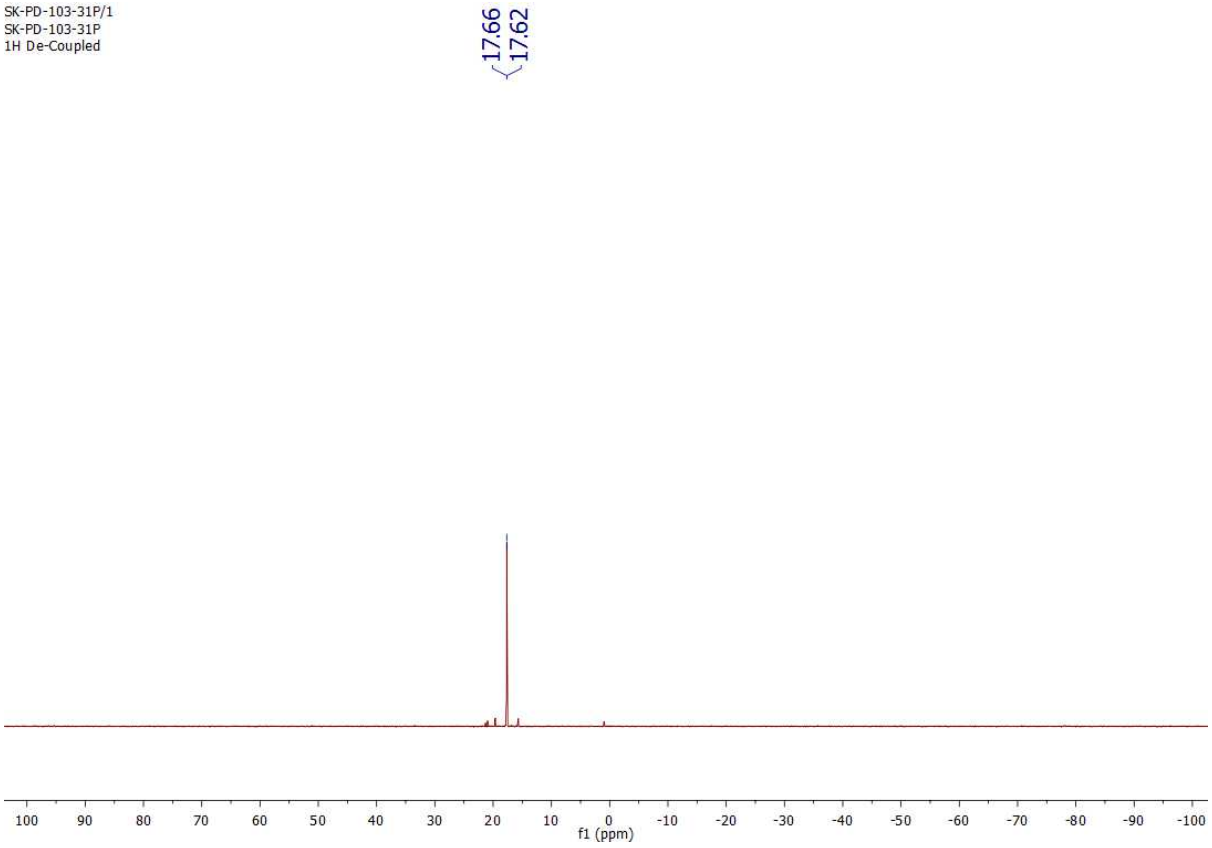

JD-DD-PD-52-31P.1.fid
JD-DD-PD-52-31P
1H De-Coupled
9.646
f1 (ppm)


PD-52; 77Se NMR
251.248
244.976
f1 (ppm)

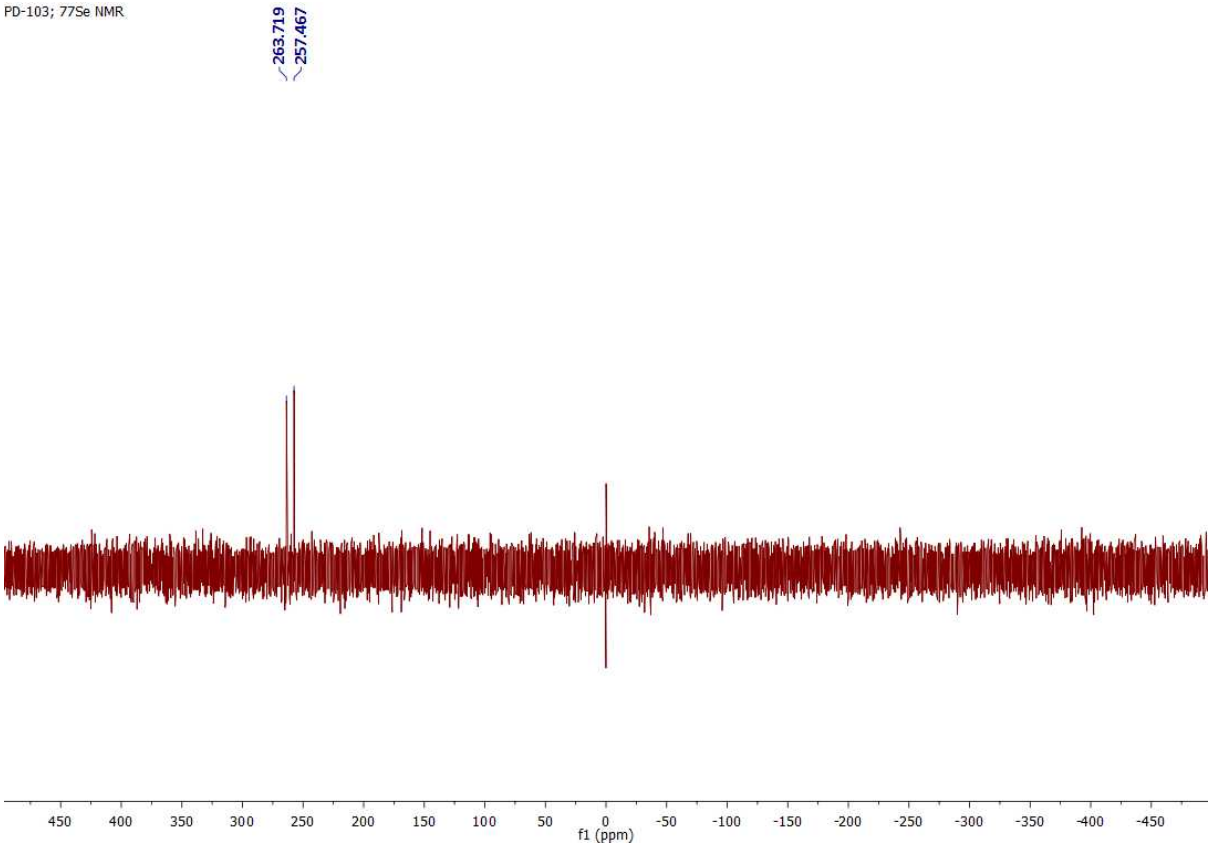

nmr/pd-103-h
PD103 1H-NMR in CDCl3
7.967
7.954
7.934
7.633
7.620
7.475
7.462
7.449
4.191
4.184
4.173
4.166
3.949
3.947
3.933
3.930
3.907
3.905
3.891
3.889
1.292
0.892
Se
CF3
O
P
O
O
6i
1.00
1.03
1.03
1.06
2.11
2.16
3.09
3.18
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

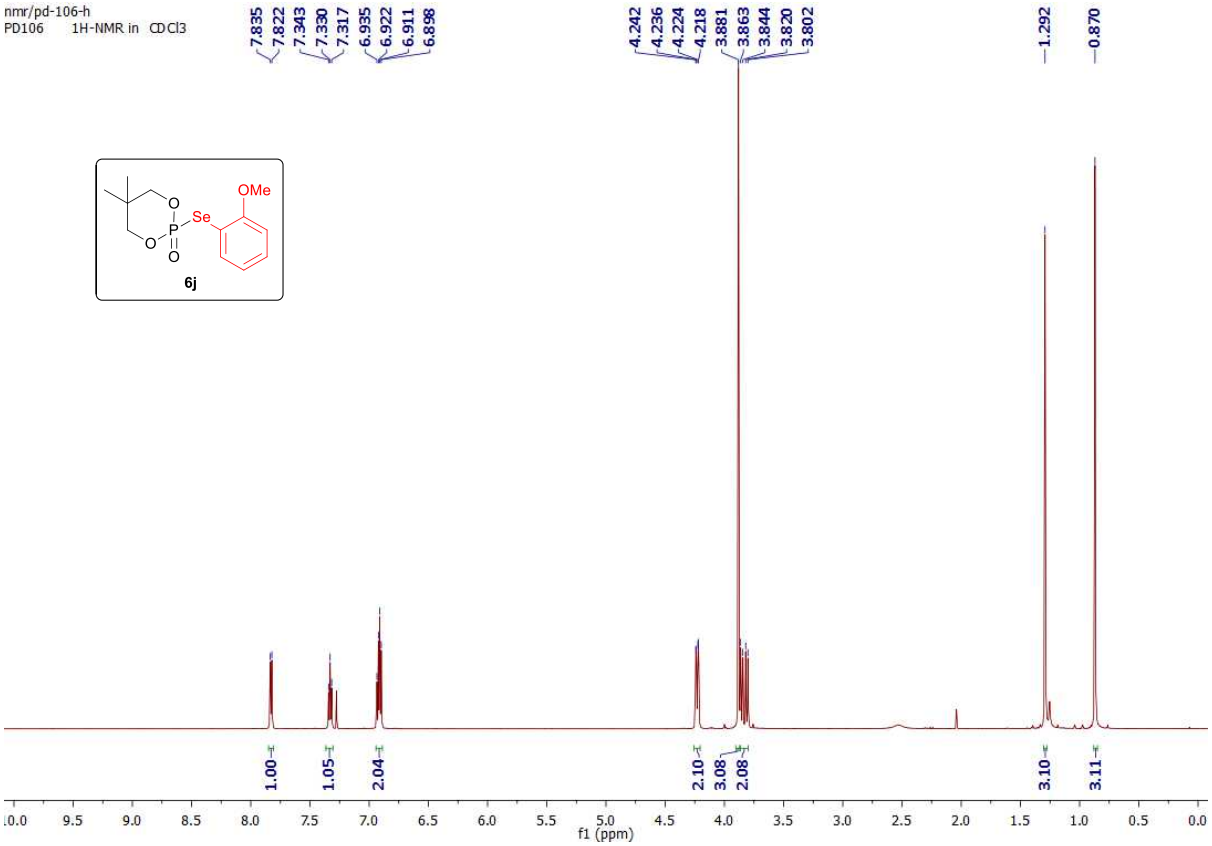

nmr/pd-103-c
PD103 13C-NMR in CDCl3
139.227
139.209
132.221
132.196
132.167
132.138
132.108
131.882
131.869
131.665
131.652
130.029
130.015
125.879
125.855
125.835
125.813
125.789
124.261
123.050
122.998
122.453
32.593
32.548
22.020
20.339
00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

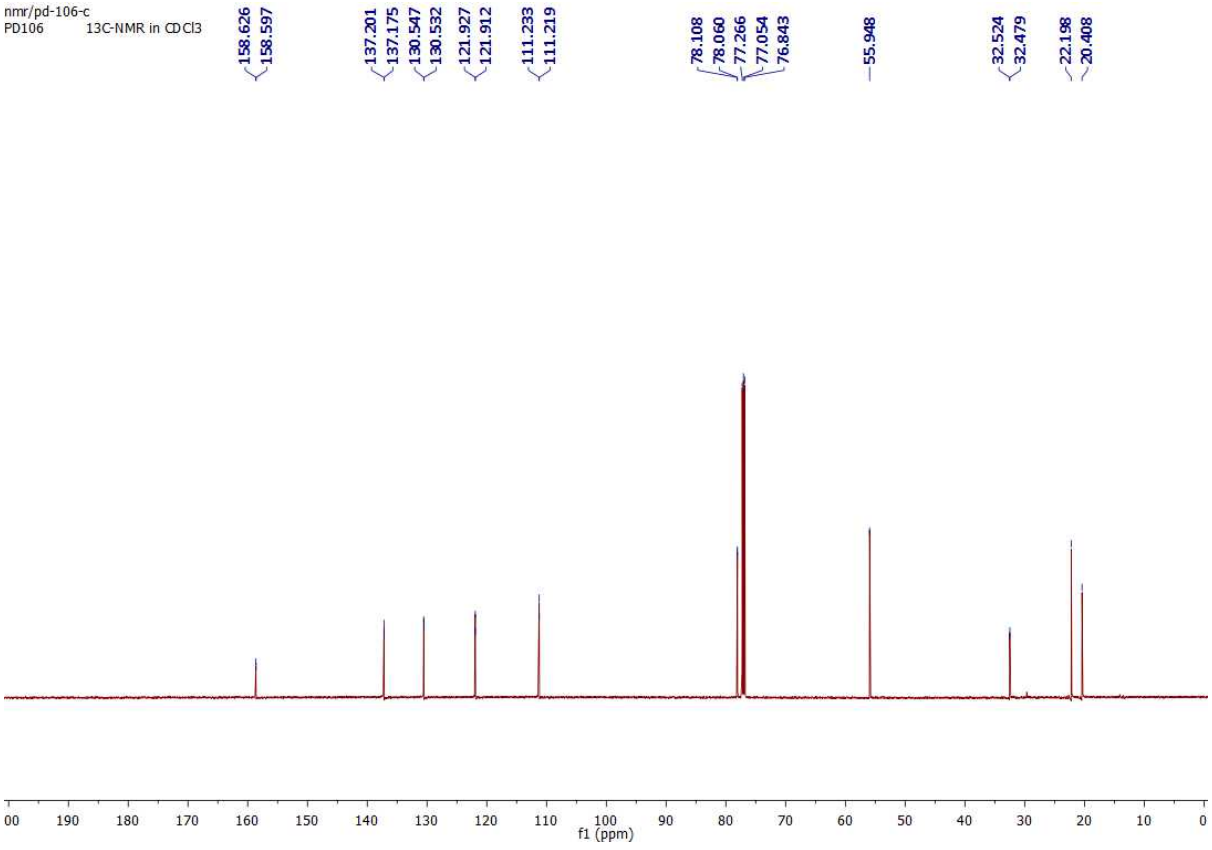
SK-PD-103-31P/1
SK-PD-103-31P
1H De-Coupled



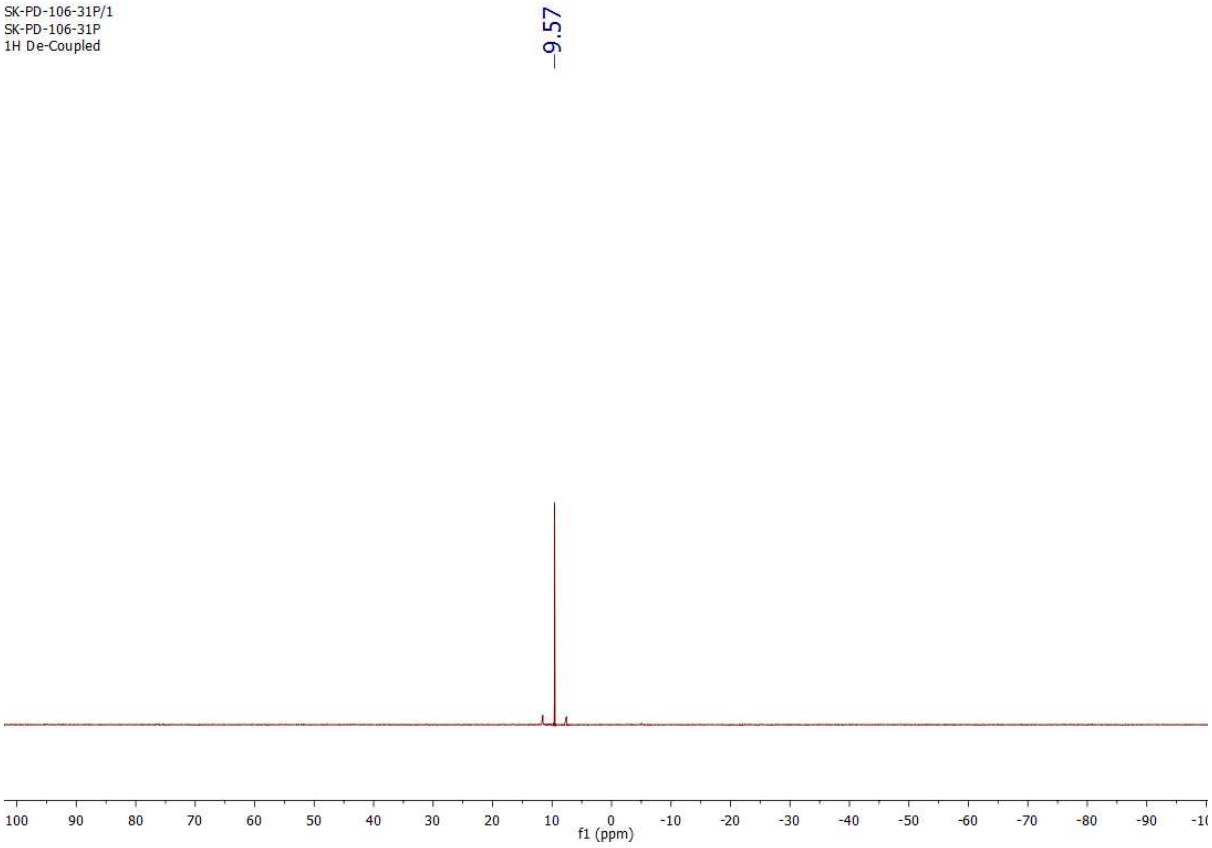
PD-103; 77Se NMR



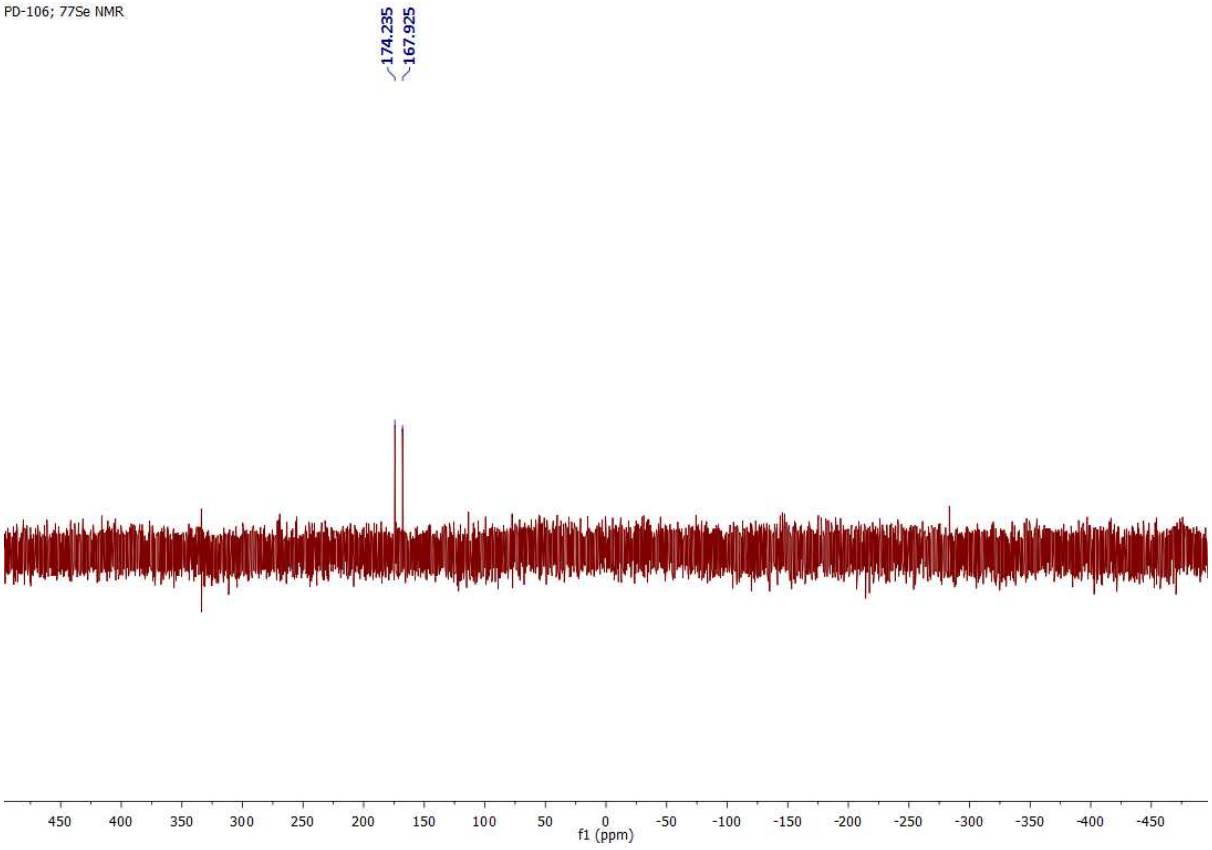

nmr/pd-106-h
PD106 1H-NMR in CDCl3
7.835
7.822
7.343
7.330
7.317
6.935
6.922
6.911
6.898
4.242
4.236
4.224
4.218
3.881
3.863
3.844
3.820
3.802
1.292
0.870
OMe
Se
O
P
O
O
6j
1.00
1.05
2.04
2.10
3.08
2.08
3.10
3.11
f1 (ppm)

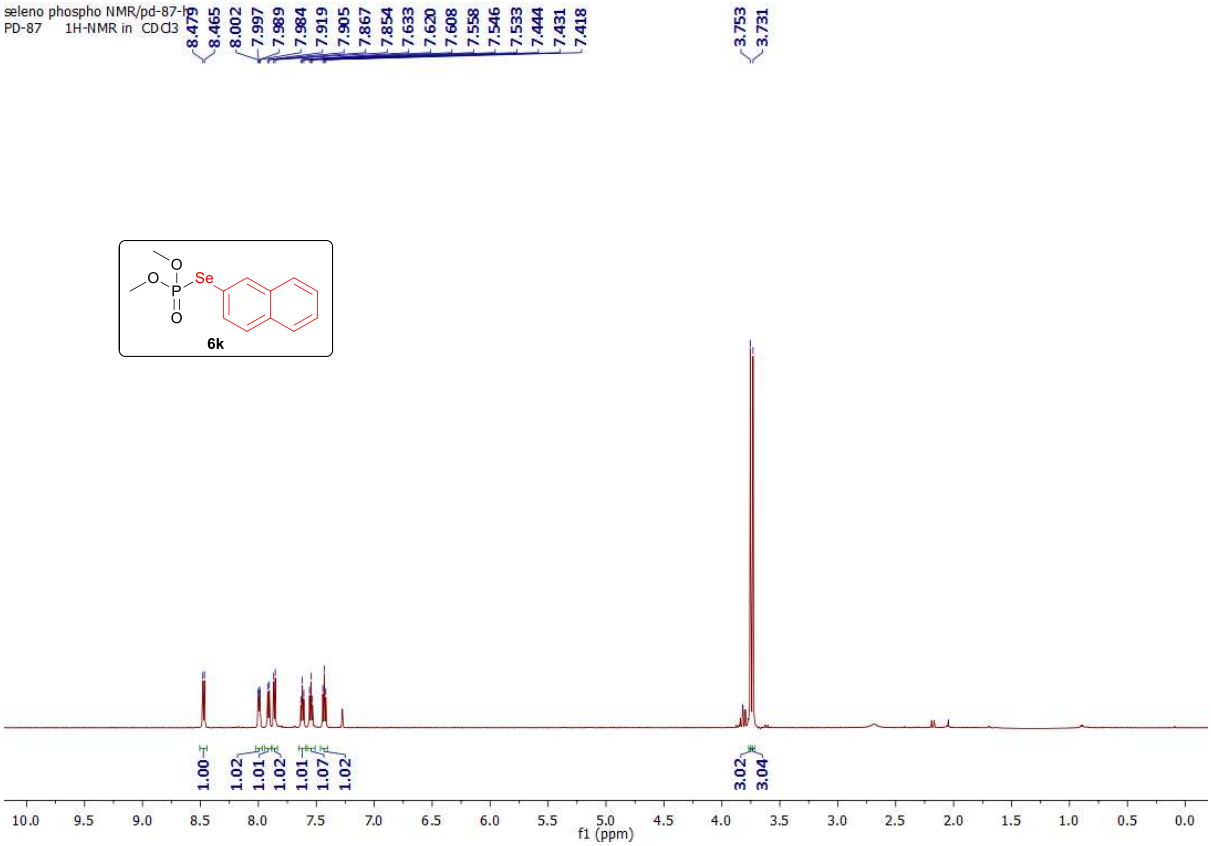

nmr/pd-106-c
PD106 13C-NMR in CDCl3
158.626
158.597
137.201
137.175
130.547
130.532
121.927
121.912
111.233
111.219
78.108
78.060
77.266
77.054
76.843
55.948
32.524
32.479
22.198
20.408
f1 (ppm)

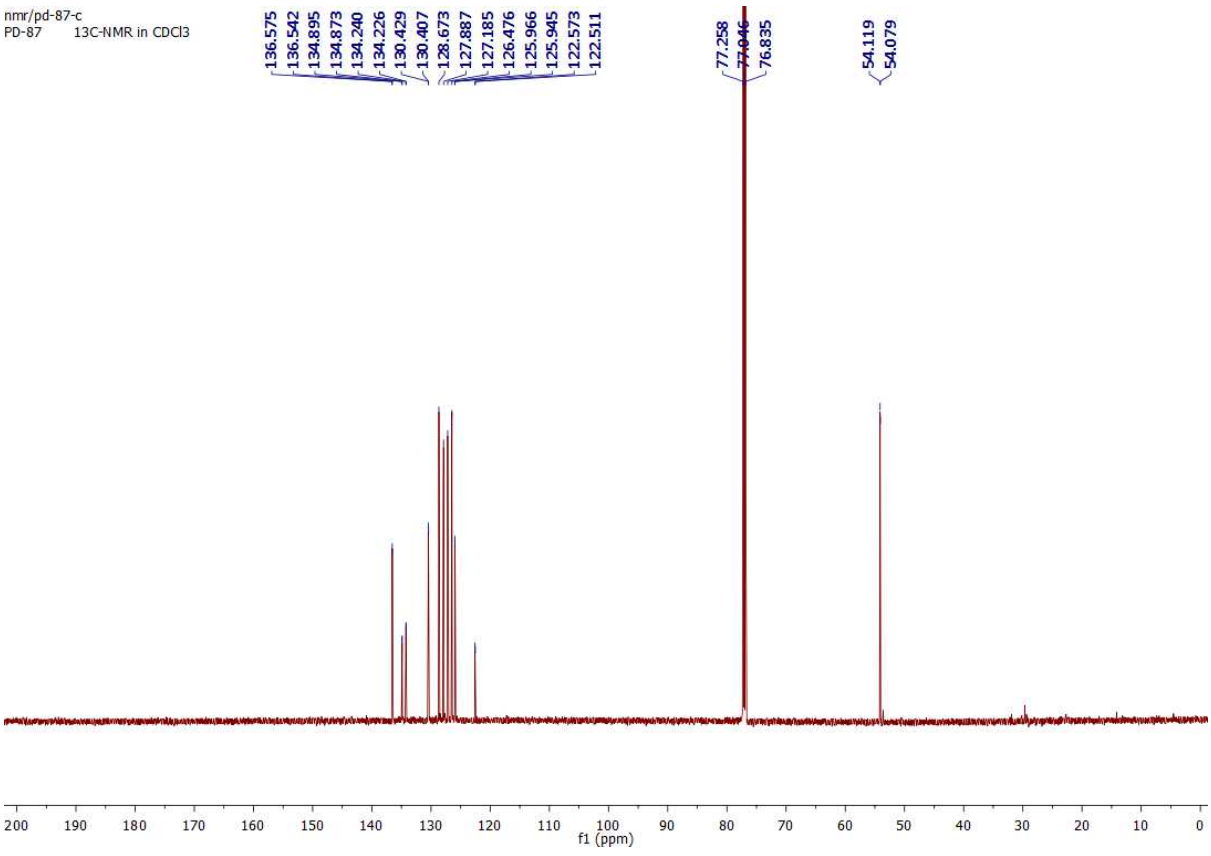
SK-PD-106-31P/1
SK-PD-106-31P
1H De-Coupled



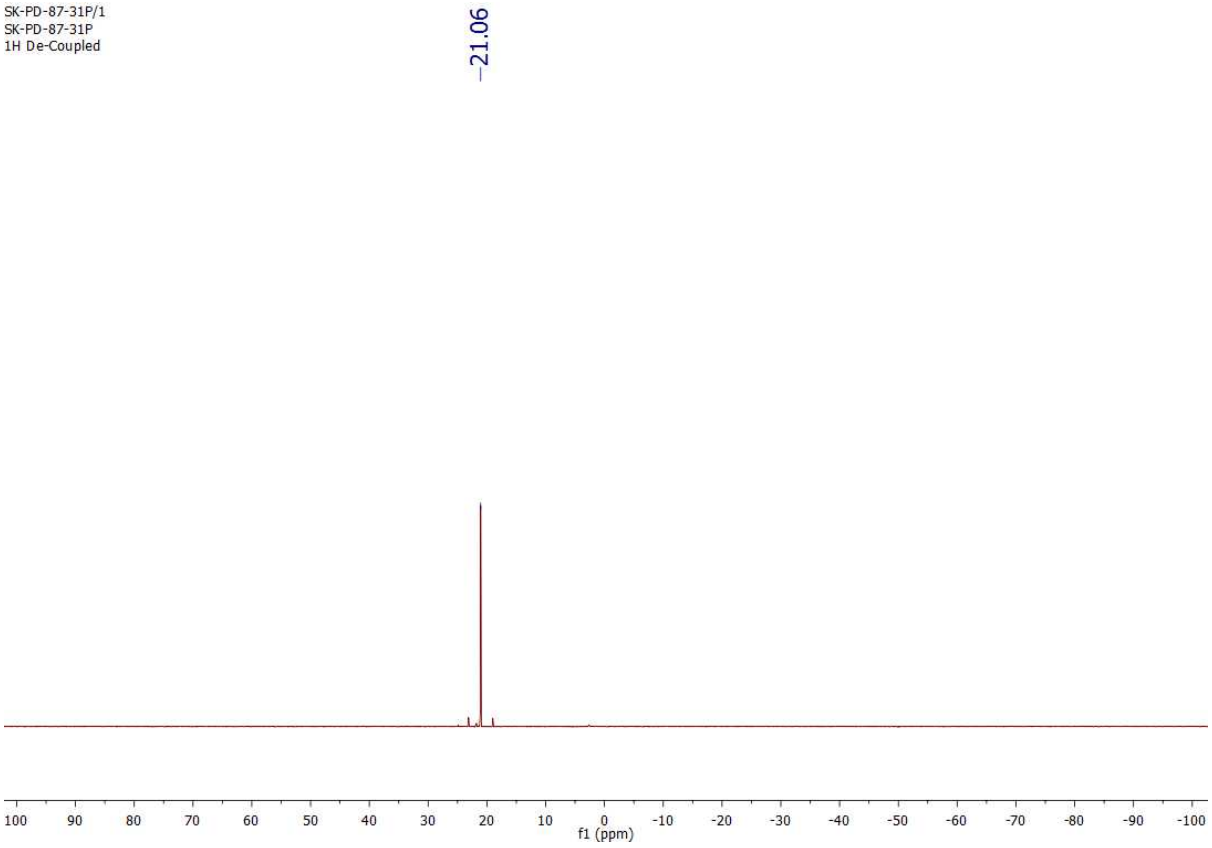
PD-106; 77Se NMR



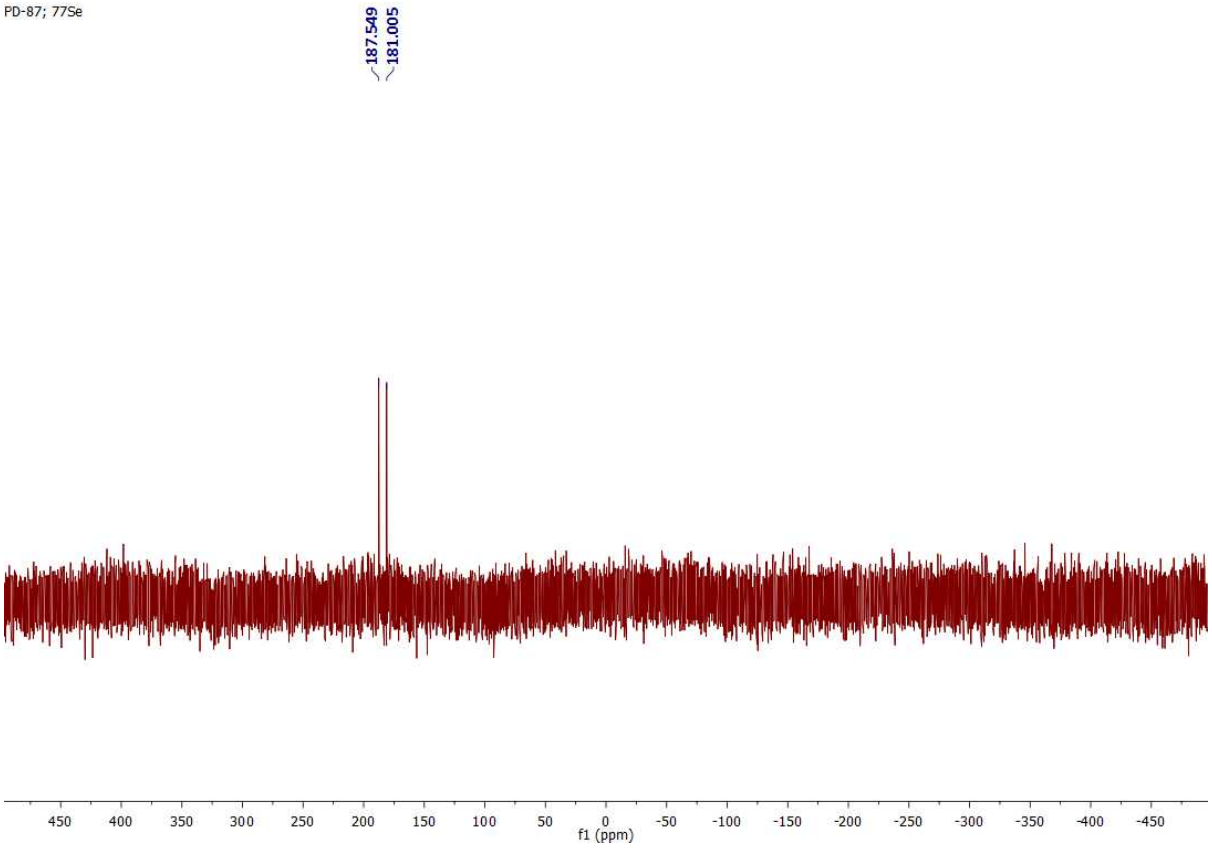

seleno phospho NMR/pd-87-h
PD-87 1H-NMR in CDCl3
8.479
8.465
8.002
7.997
7.989
7.984
7.919
7.905
7.867
7.854
7.633
7.620
7.608
7.558
7.546
7.533
7.444
7.431
7.418
3.753
3.731
Se
O
P
6k
1.00
1.02
1.01
1.02
1.01
1.07
1.02
3.02
3.04
f1 (ppm)


nmr/pd-87-c
PD-87 13C-NMR in CDCl3
136.575
136.542
134.895
134.873
134.240
134.226
130.429
130.407
128.673
127.887
127.185
126.476
125.966
125.945
122.573
122.511
77.258
77.046
76.835
54.119
54.079
f1 (ppm)

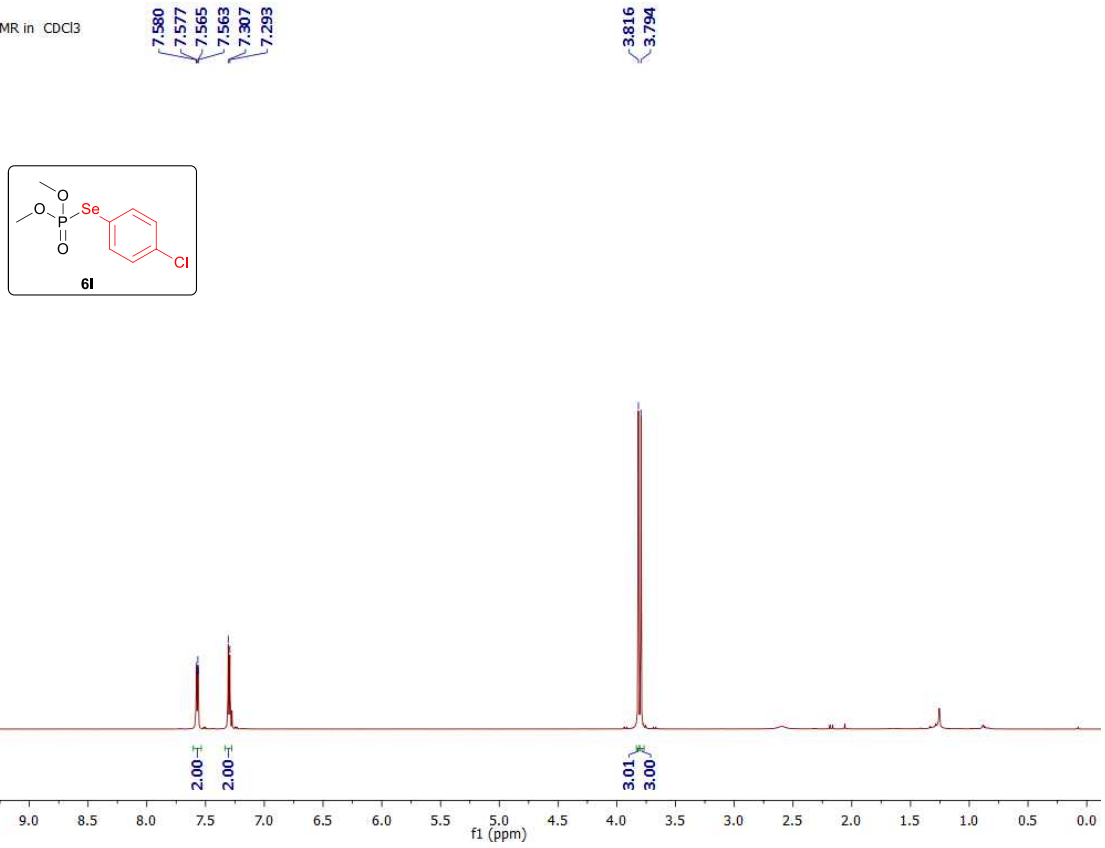
SK-PD-87-31P/1
SK-PD-87-31P
1H De-Coupled



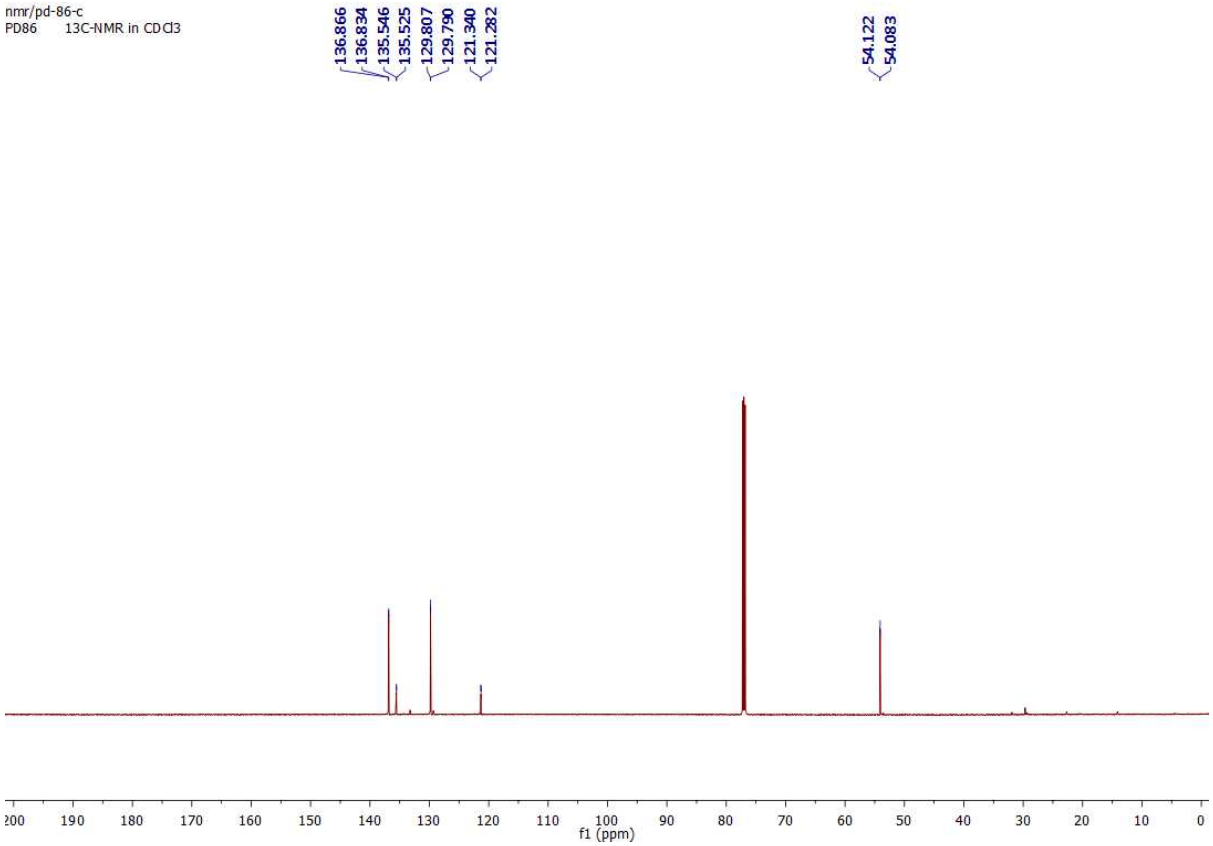
PD-87; 77Se



nmr/pd-86-h
PD86 1H-NMR in CDCl3

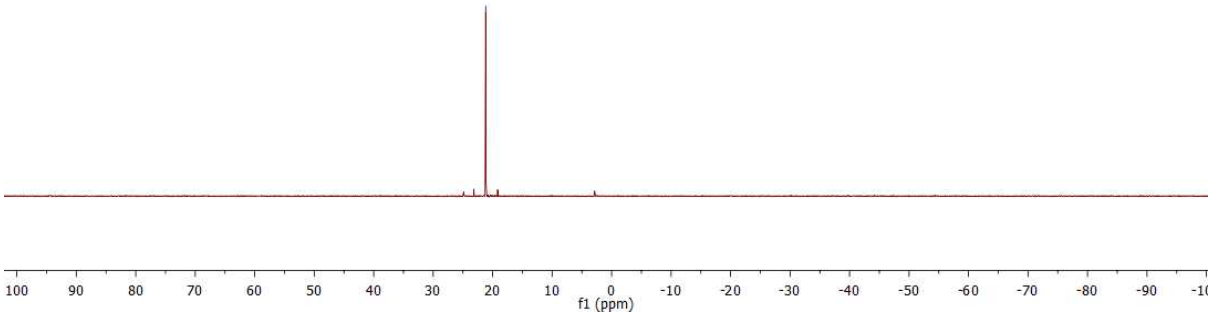


nmr/pd-86-c
PD86 13C-NMR in CDCl3



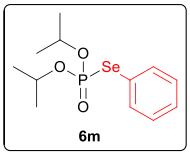
SK-PD-86-31P/1
SK-PD-86-31P
1H De-Coupled

21.17

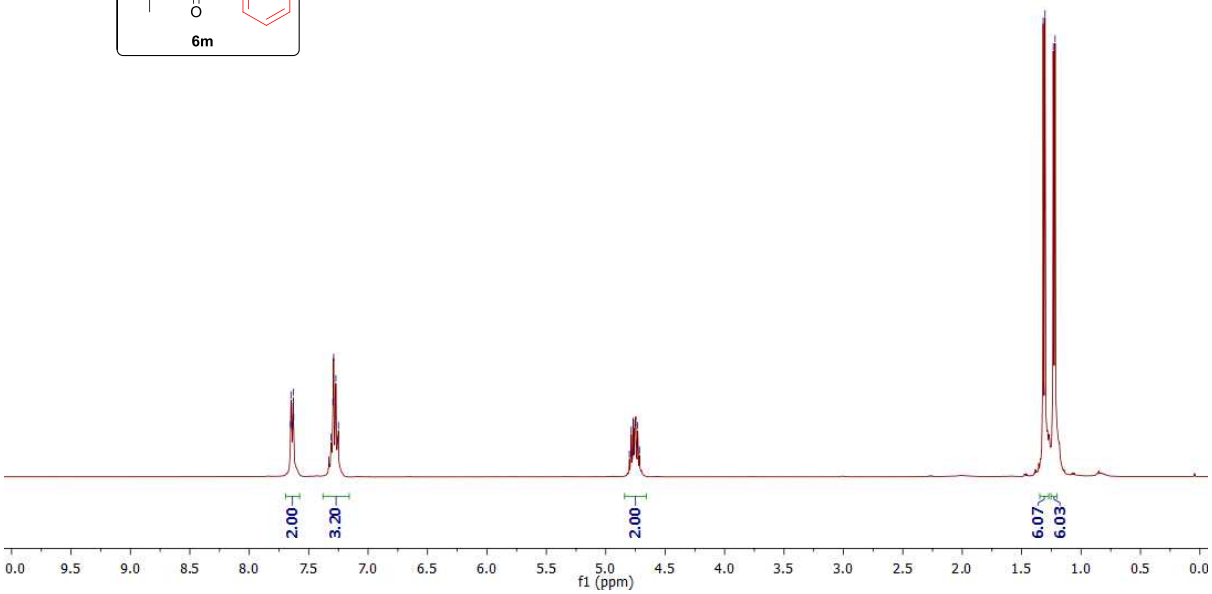


PD-711
PD-711-1H

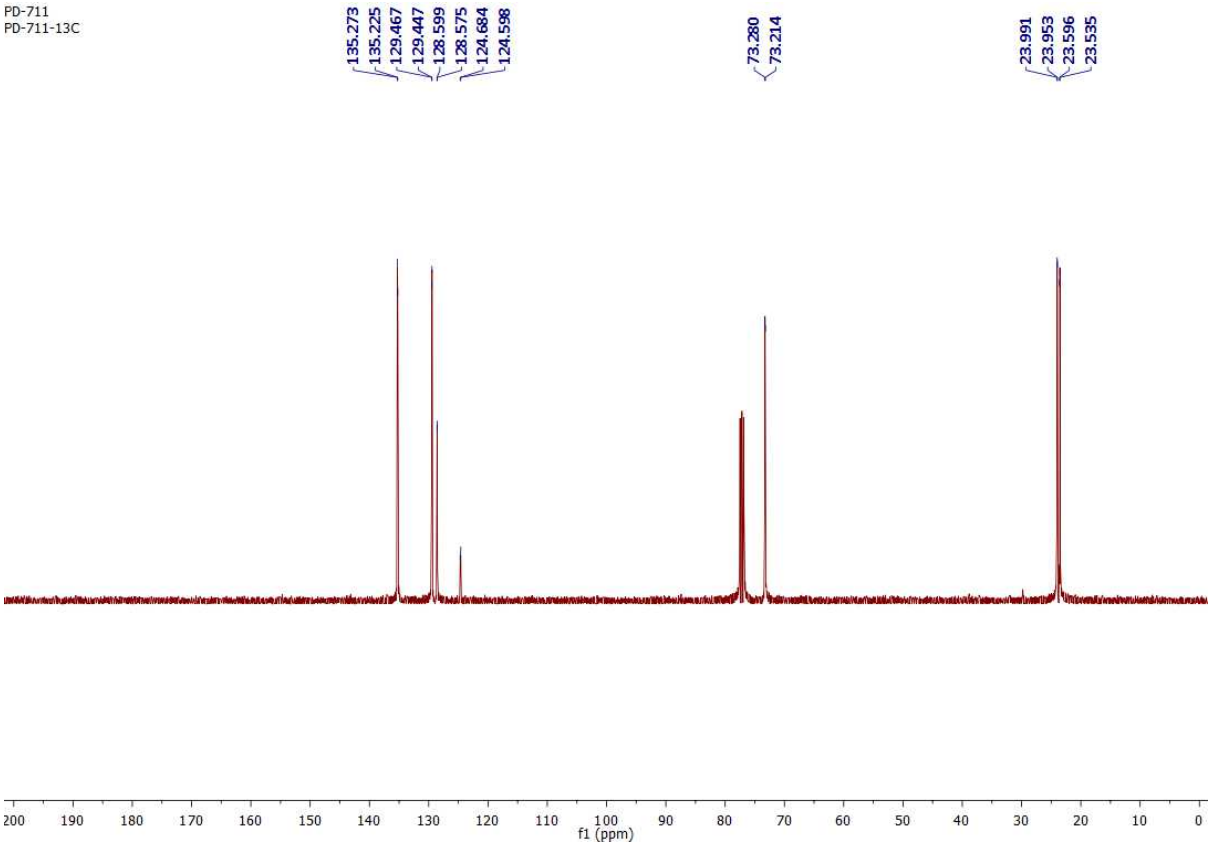
7.653 7.649 7.645 7.636 7.630 7.626 7.331 7.311 7.296 7.290 7.271 7.258 7.249
4.801 4.786 4.774 4.755 4.739 4.731 4.716
1.319 1.303 1.234 1.219



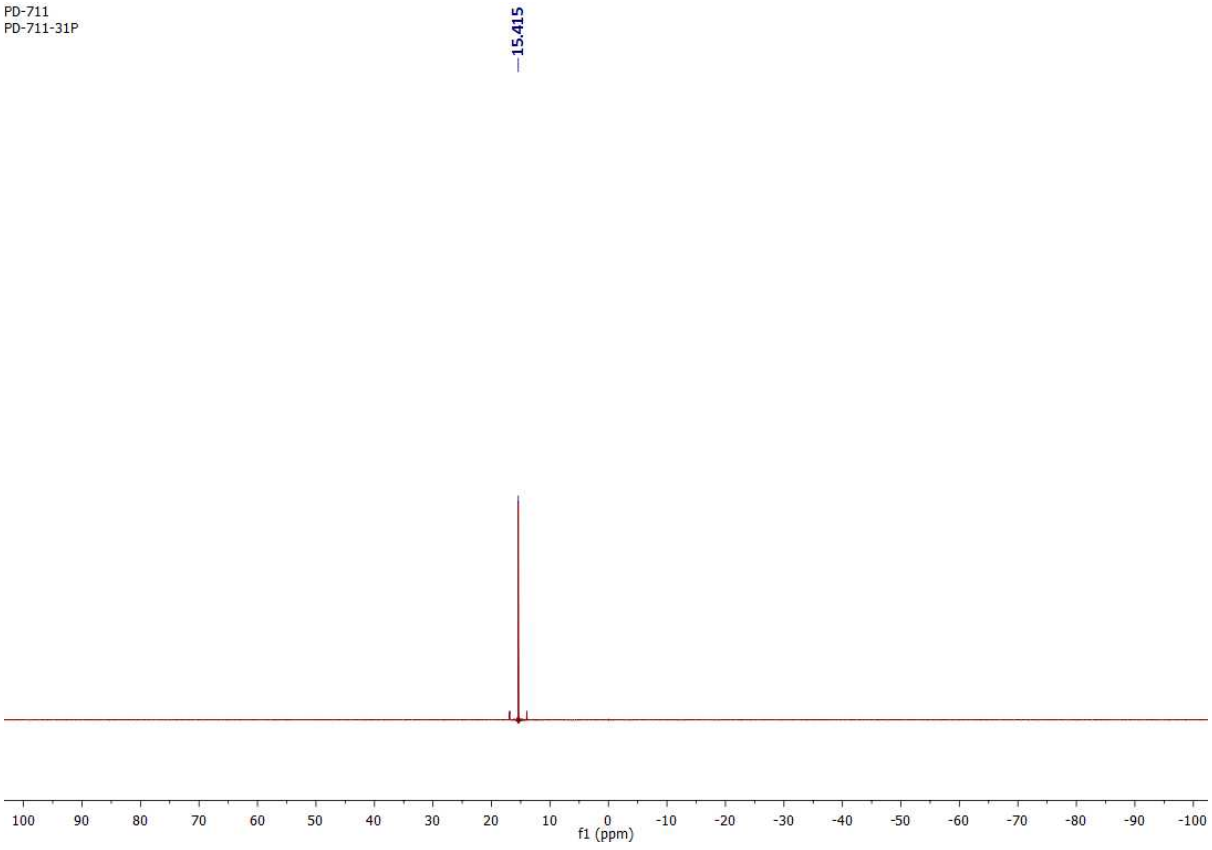
6m



PD-711
PD-711-13C

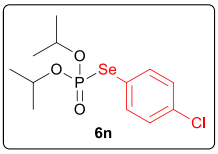


PD-711
PD-711-31P

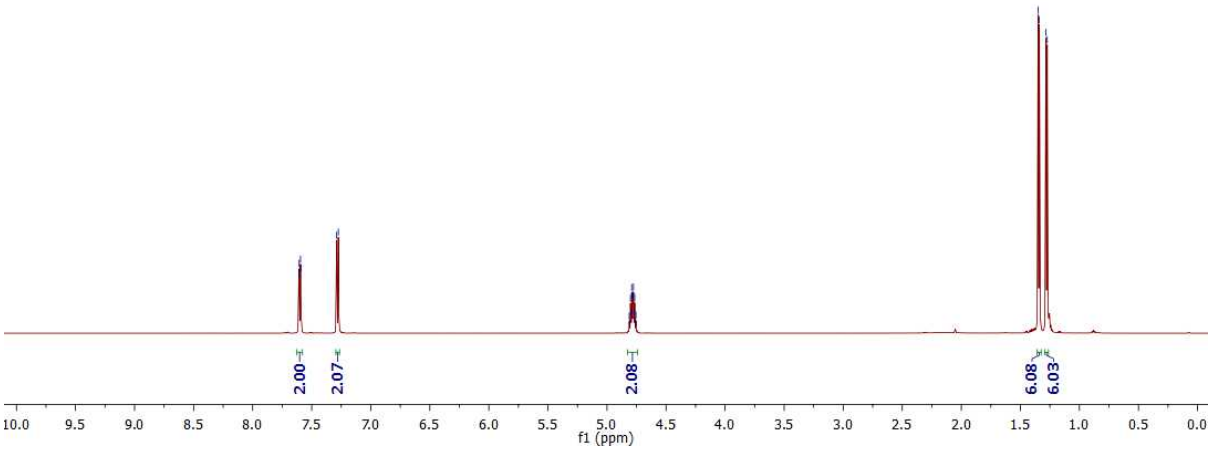


nmr/pd-100-h
PD100 1H-NMR in CDCl3

7.609 7.606 7.595 7.592 7.289 7.275 4.812 4.806 4.801 4.796 4.791 4.786 4.781 4.775 4.770 4.765 4.760 4.755 1.350 1.339 1.283 1.272

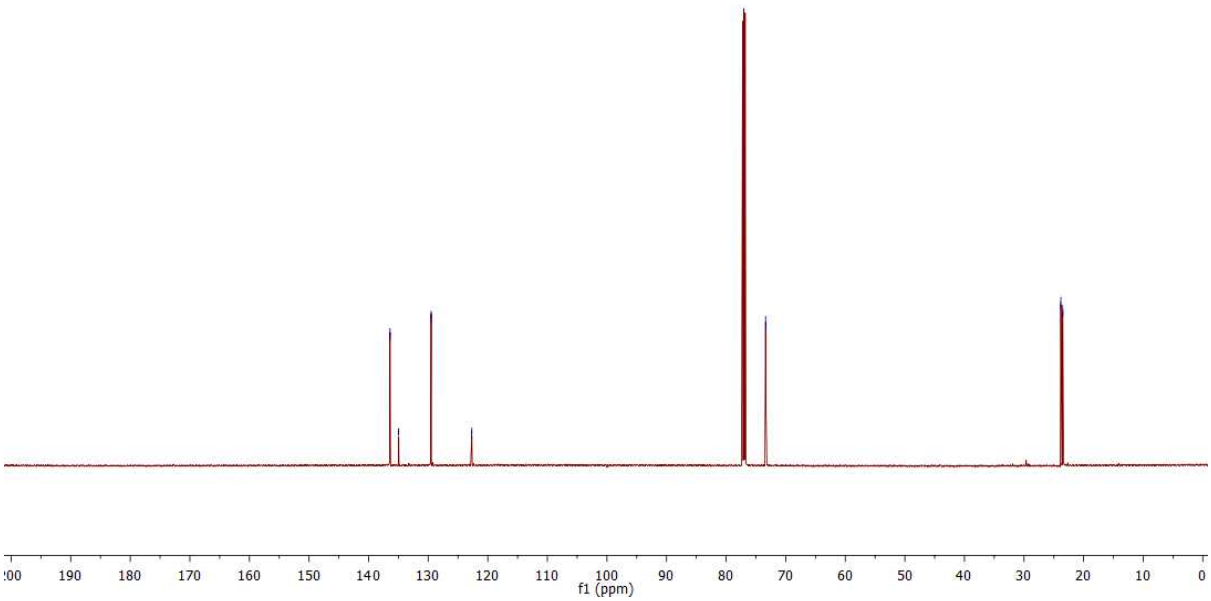


6n

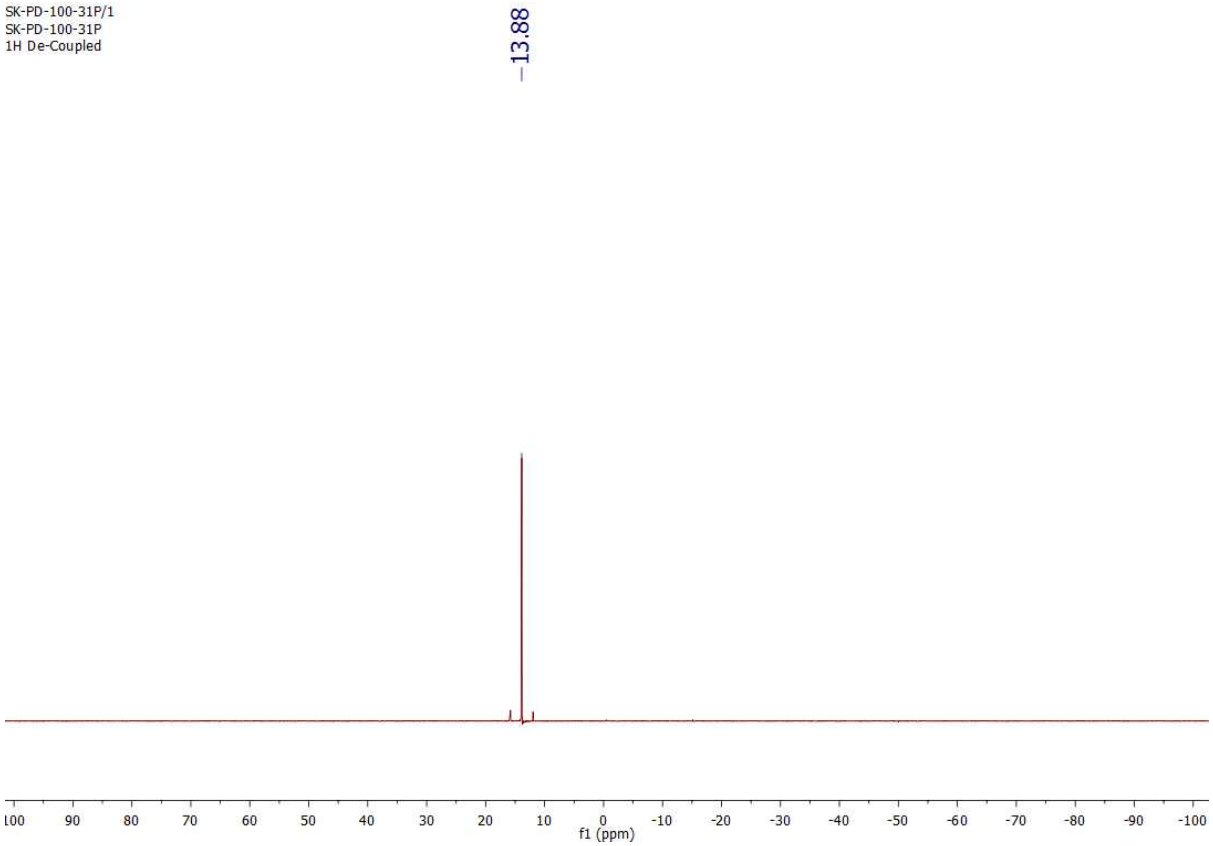


nmr/pd-100-c
PD100 13C-NMR in CDCl3

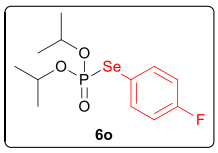
136.416 136.384 134.968 134.950 129.515 129.502 122.727 122.671 73.376 73.332 23.849 23.824 23.511 23.473



SK-PD-100-31P/1
SK-PD-100-31P
1H De-Coupled

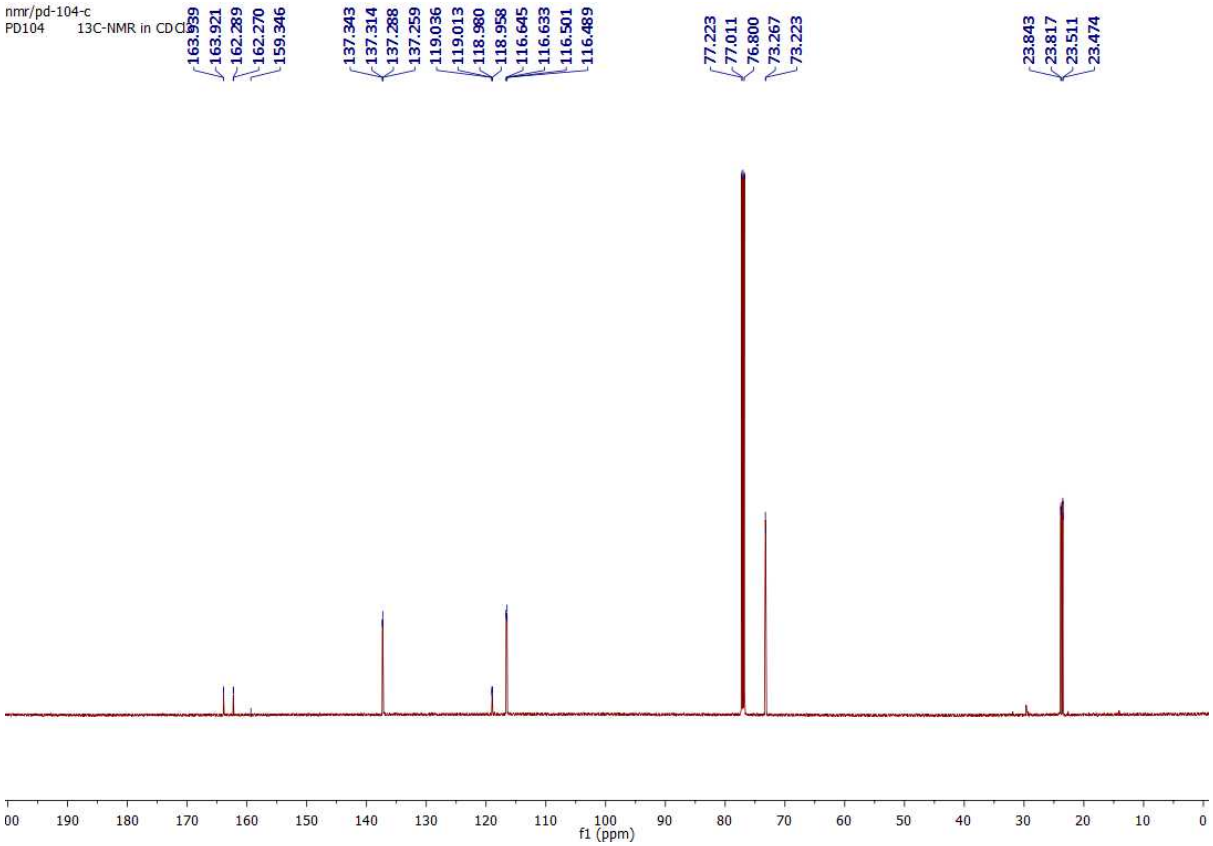


seleno phospho NMR/pd-104
PD-104 1H-NMR in CDCl3

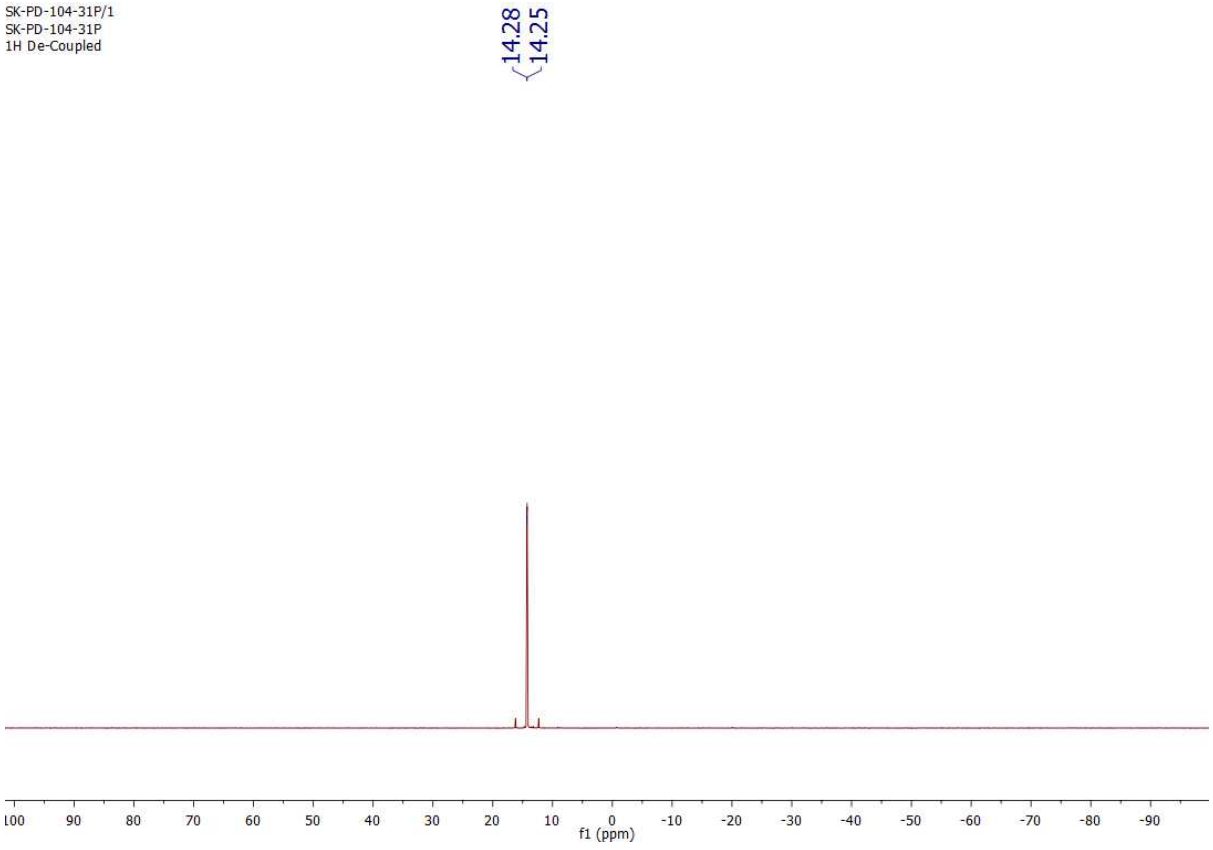


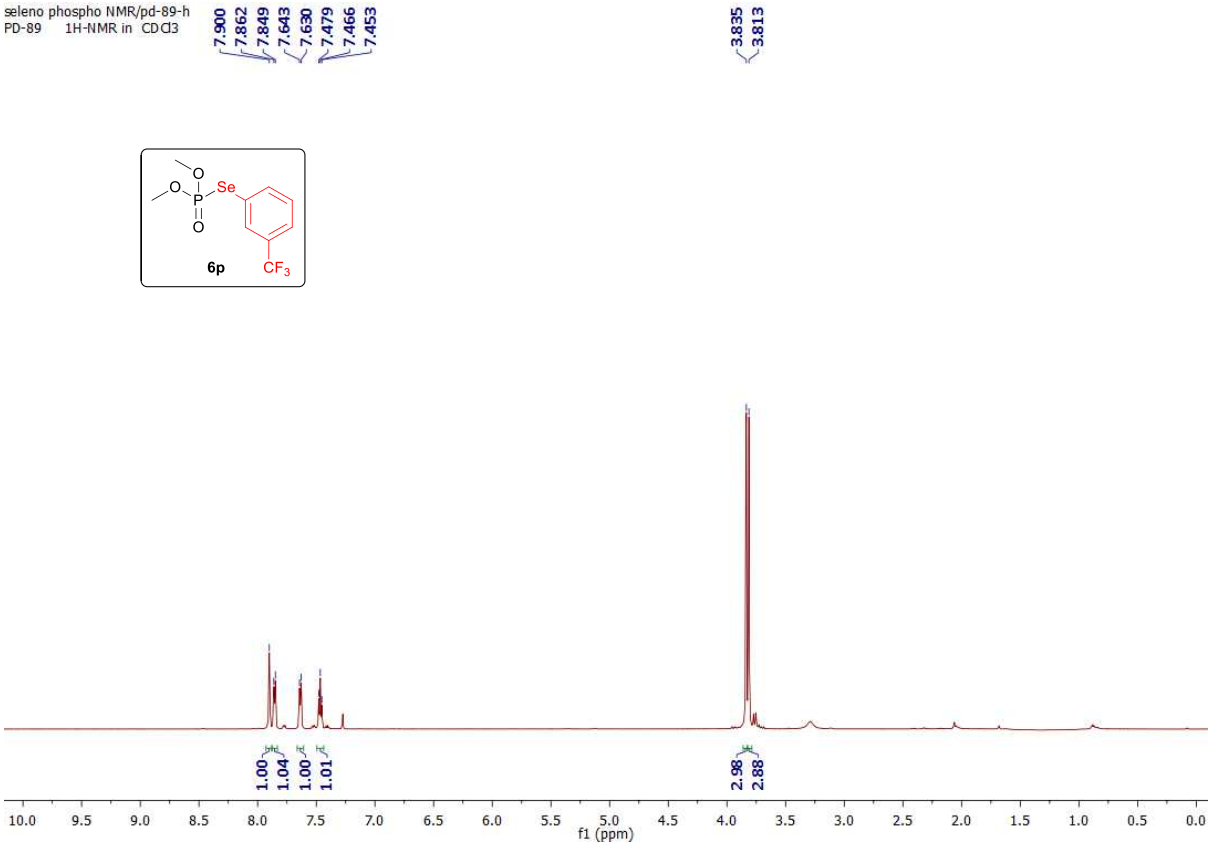
6o

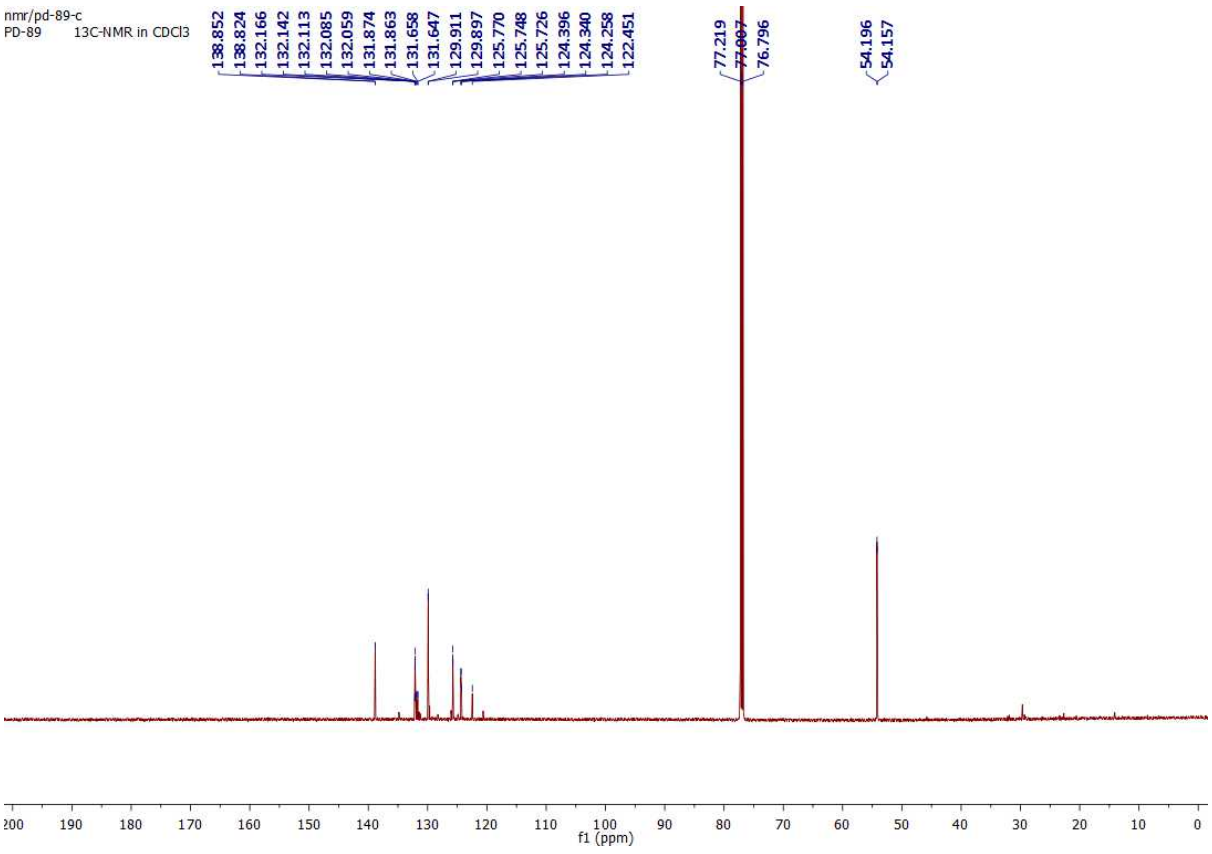
nmr/pd-104-c
PD104 13C-NMR in CDCl3



SK-PD-104-31P/1
SK-PD-104-31P
1H De-Coupled

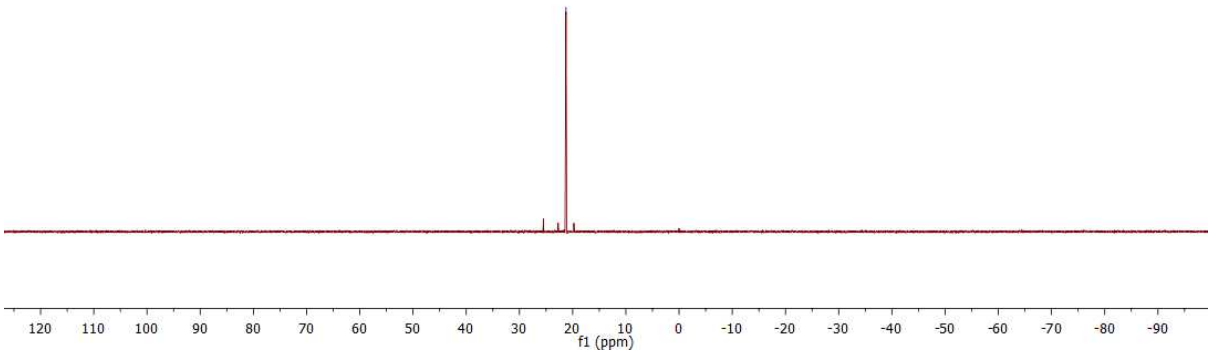



seleno phospho NMR/pd-89-h
PD-89 1H-NMR in CDCl3
7.900
7.862
7.849
7.643
7.630
7.479
7.466
7.453
3.835
3.813
Se
6p
CF3
1.00
1.04
1.00
1.01
2.98
2.88
f1 (ppm)


nmr/pd-89-c
PD-89 13C-NMR in CDCl3
138.852
138.824
132.166
132.142
132.113
132.085
132.059
131.874
131.863
131.658
131.647
129.911
129.897
125.770
125.748
125.726
124.396
124.340
124.258
122.451
77.219
77.007
76.796
54.196
54.157
f1 (ppm)

PD-89F
single pulse decoupled gated NOE

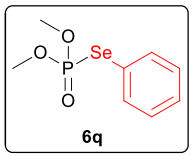
21.254



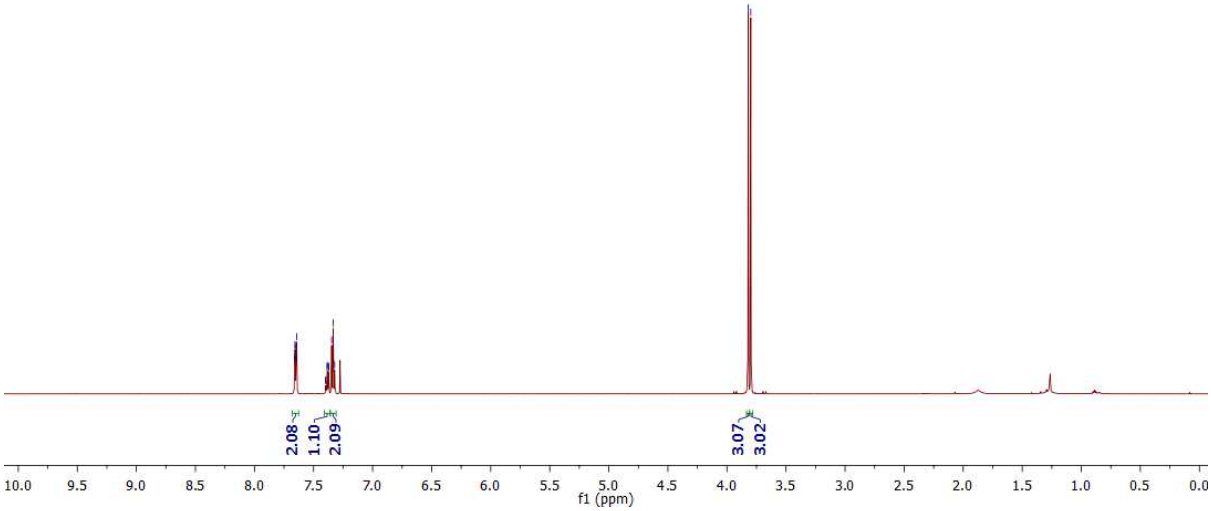
nmr/pd-65-h
PD65 1H-NMR in

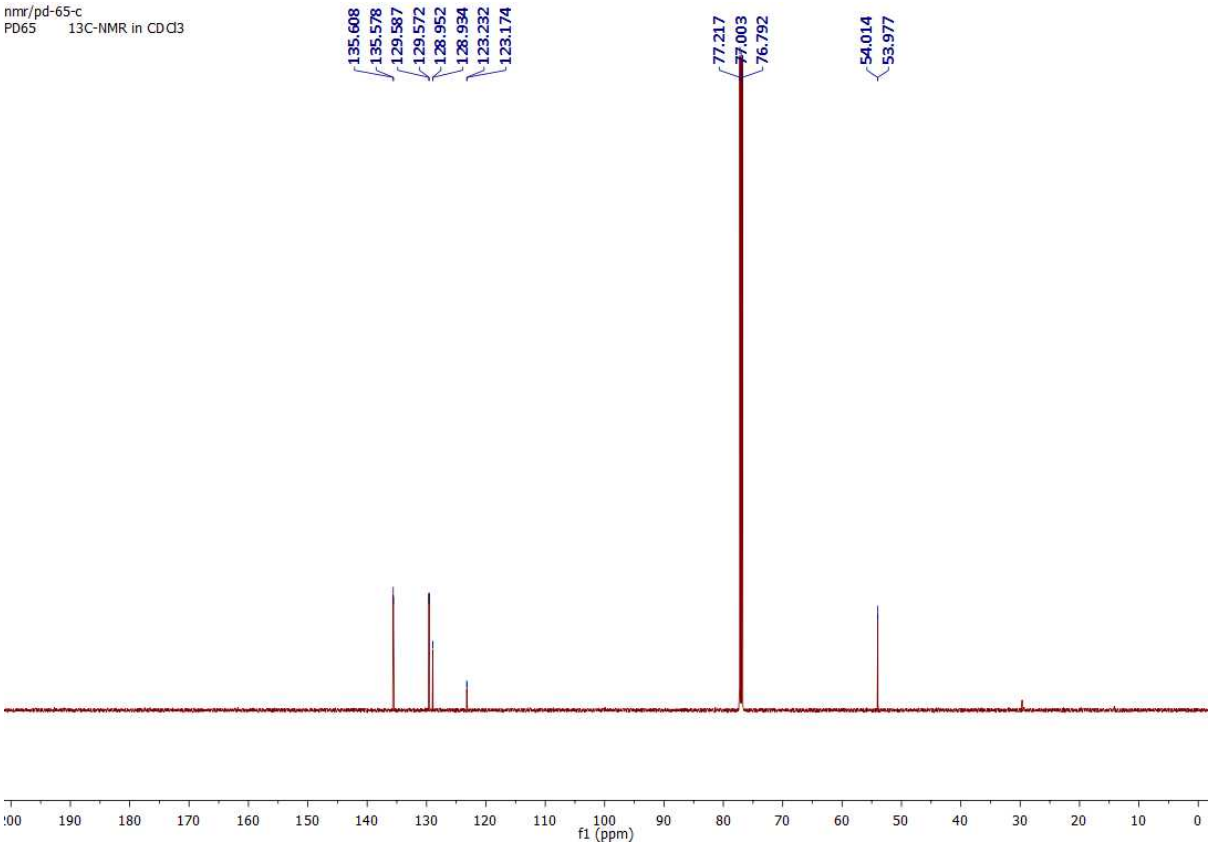
7.660 7.657 7.656 7.647 7.644 7.641 7.398 7.396 7.386 7.383 7.373 7.371 7.347 7.334 7.322

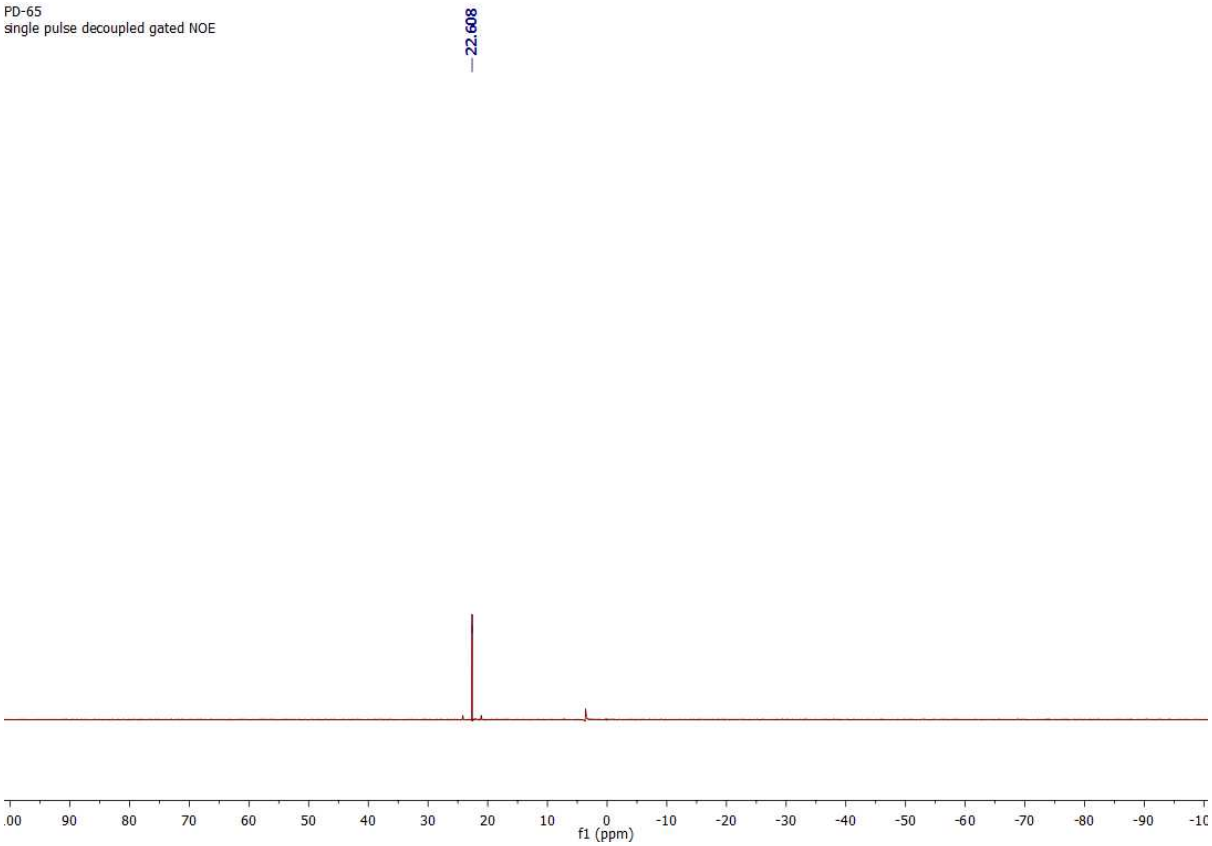
3.820 3.798



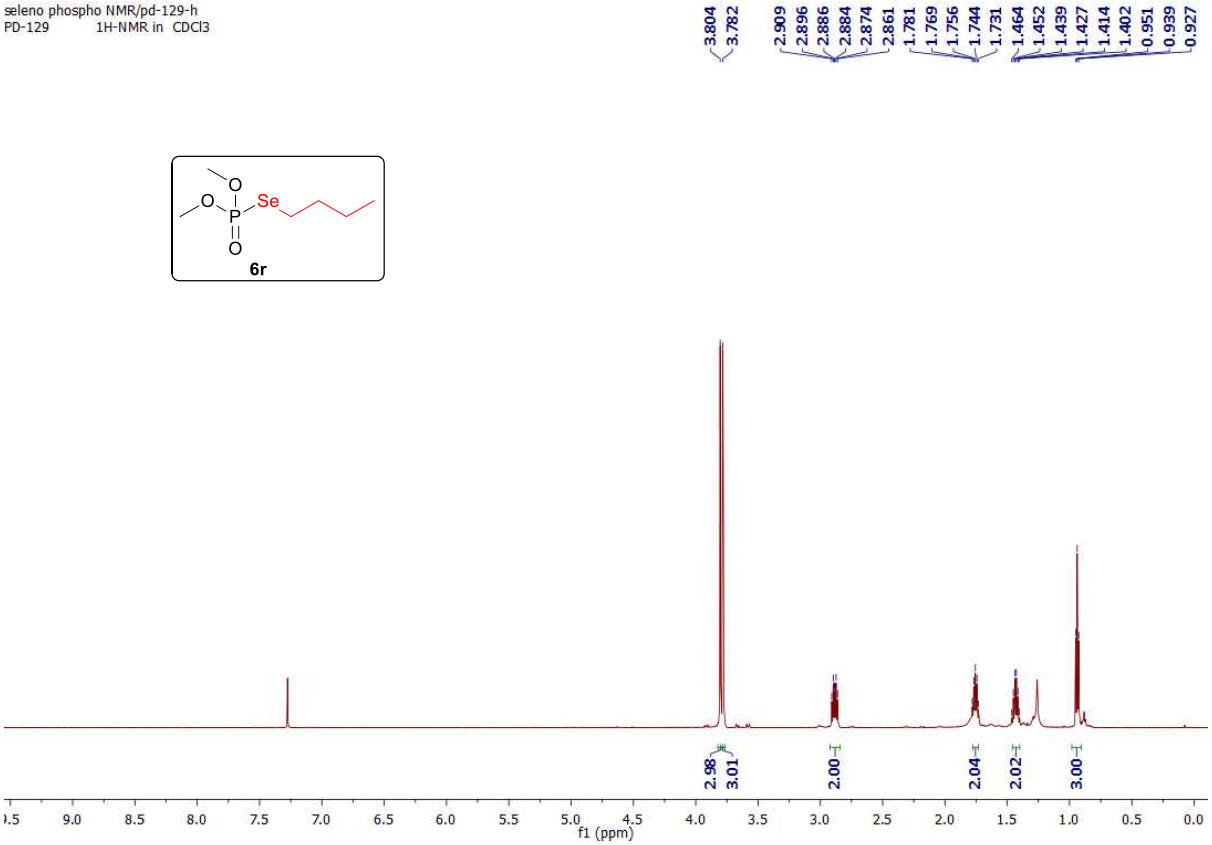
6q



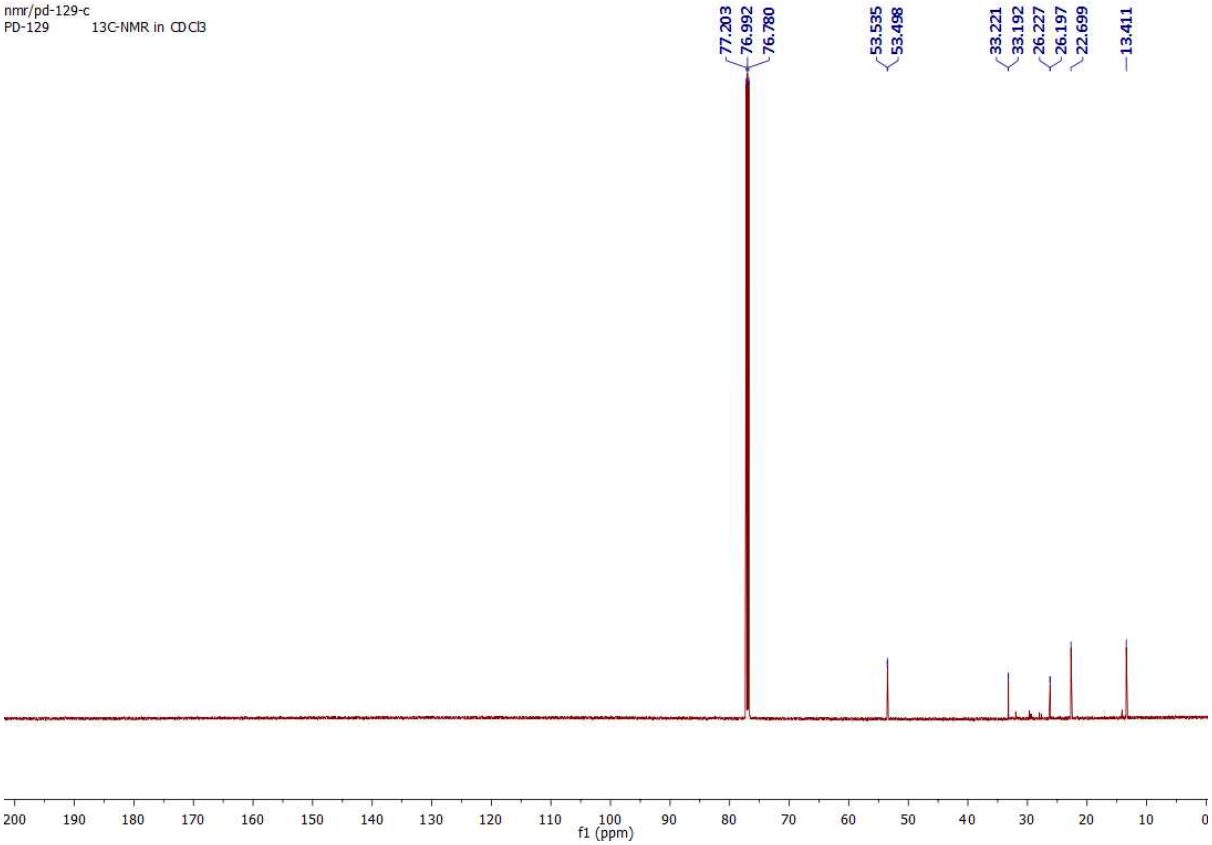

nmr/pd-65-c
PD65 13C-NMR in CDCl3
135.608
135.578
129.587
129.572
128.952
128.934
123.232
123.174
77.217
77.003
76.792
54.014
53.977
f1 (ppm)


PD-65
single pulse decoupled gated NOE
22.608
f1 (ppm)

seleno phospho NMR/pd-129-h
PD-129 1H-NMR in CDCl3

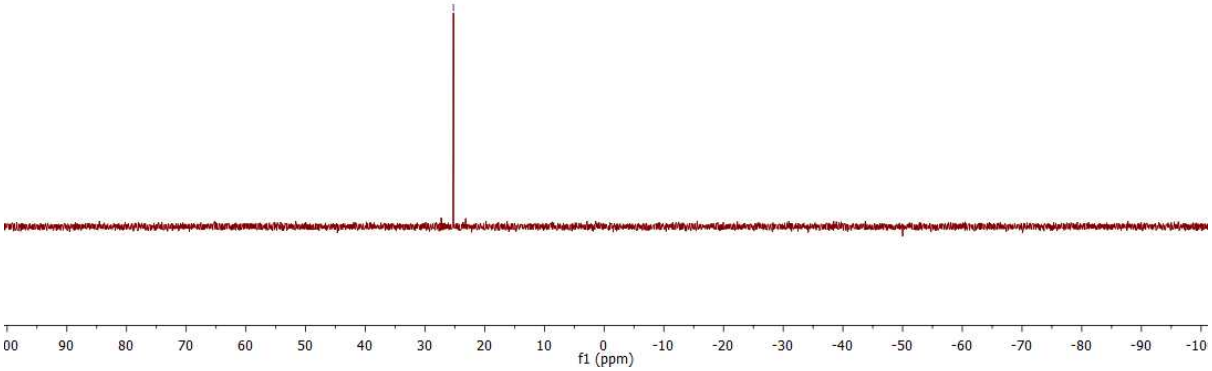


nmr/pd-129-c
PD-129 13C-NMR in CDCl3



SK-PD-129-31P/1
SK-PD-129-31P
1H De-Coupled

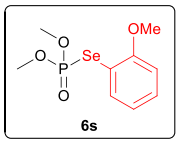
25.25



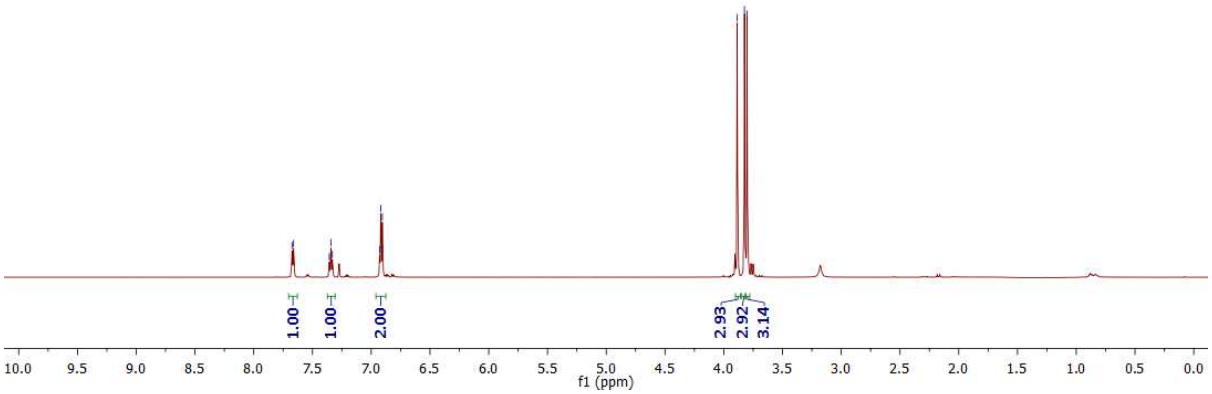
seleno phospho NMR/pd-88-h
PD-88 1H-NMR in CDCl3

7.674 7.661 7.357 7.344 7.331 6.929 6.918 6.906

3.886 3.824 3.802

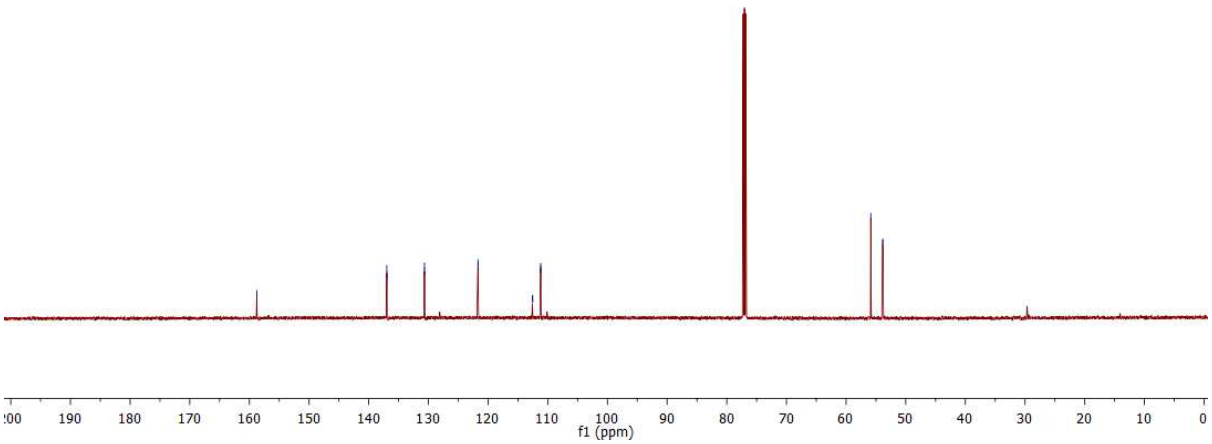


6s



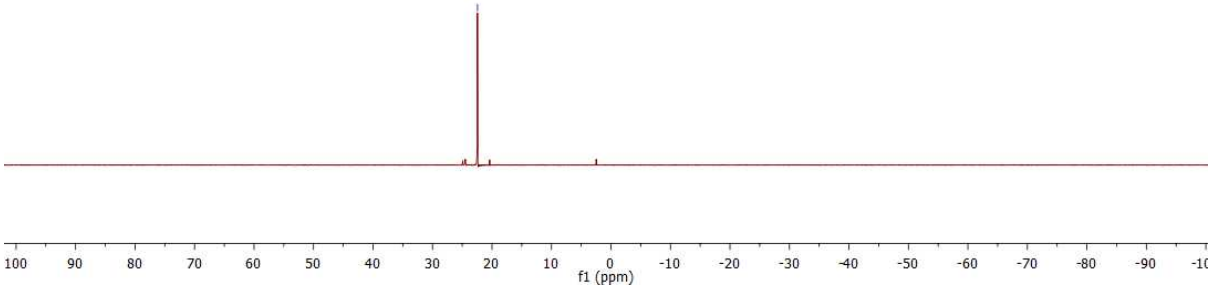
nmr/pd-88-c
PD-88 13C-NMR in CDCl3

158.768
158.739
136.976
136.950
130.664
130.648
121.700
121.686
112.568
112.514
111.188
111.173
55.857
53.875
53.840

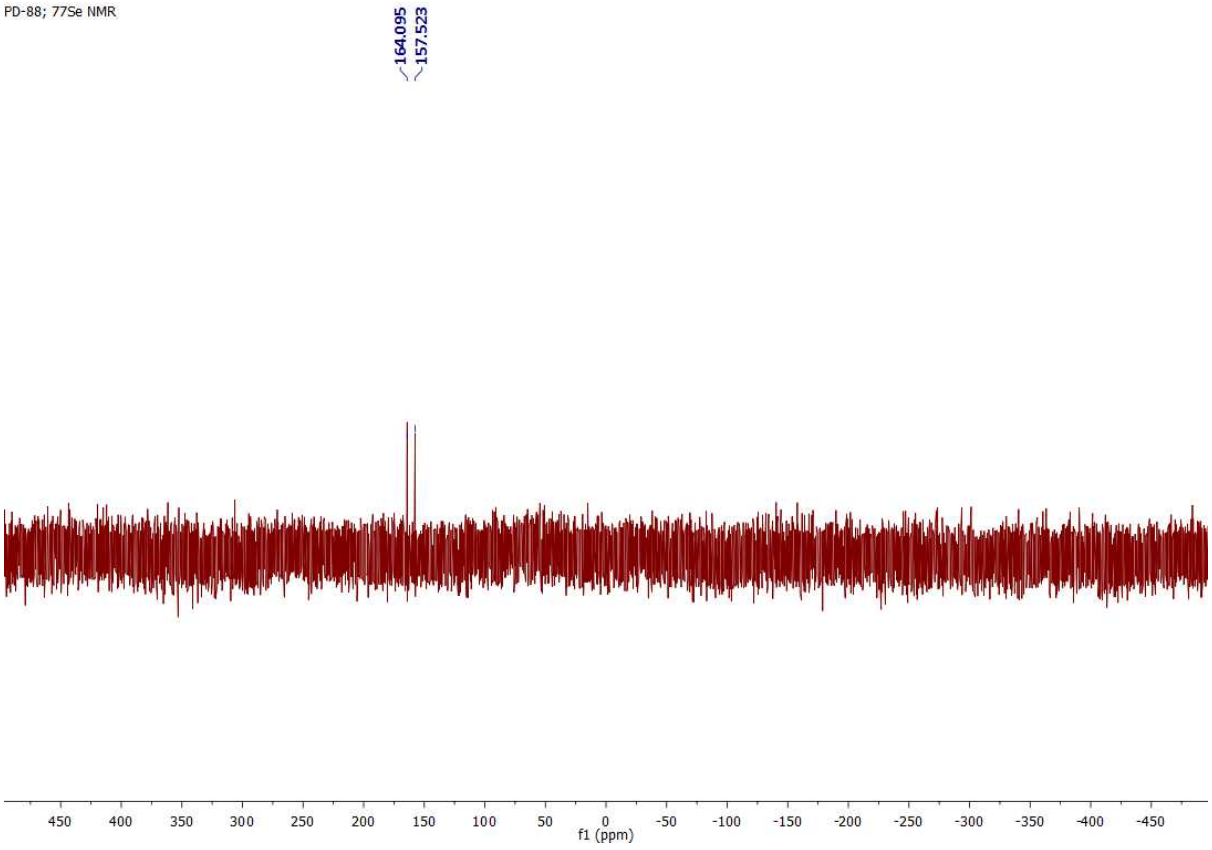


JD-DD-PD-88-31P.1.fid
JD-DD-PD-88-31P
1H De-Coupled

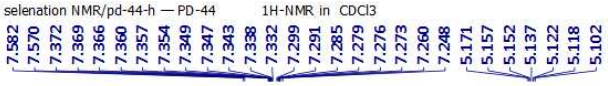
22.438

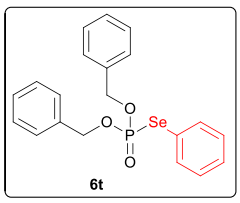


PD-88; 77Se NMR

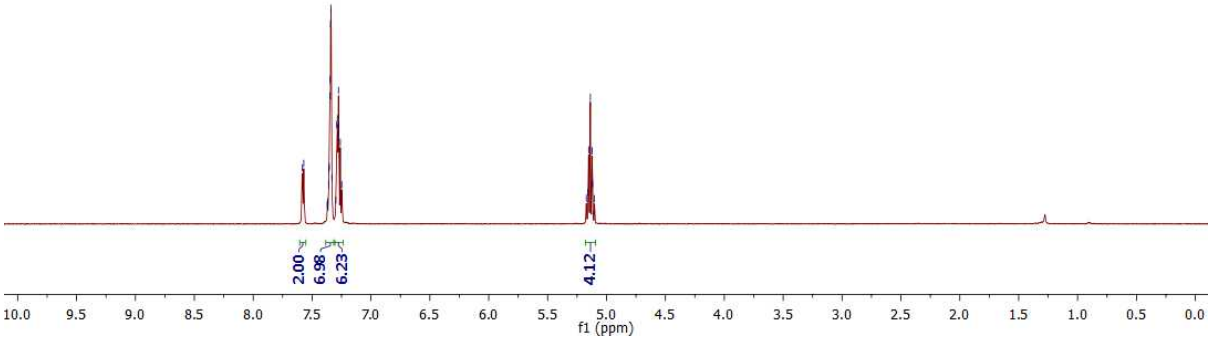


600 MHz selenation NMR/pd-44-h — PD-44 1H-NMR in CDCl3





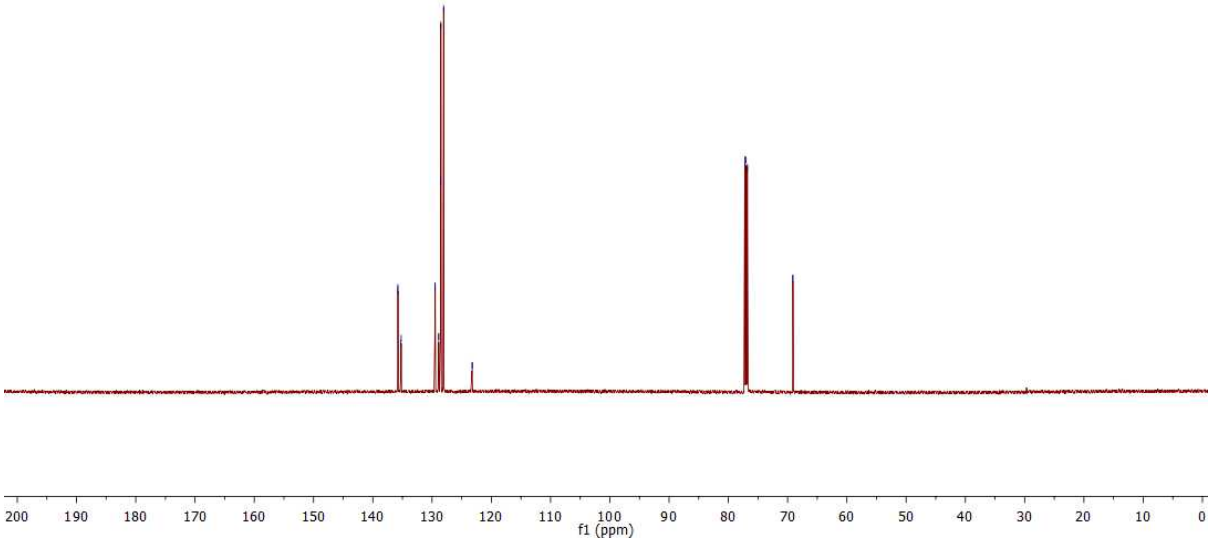
6t



nmr/pd-44-c
PD-44 13C-NMR in CDCl3

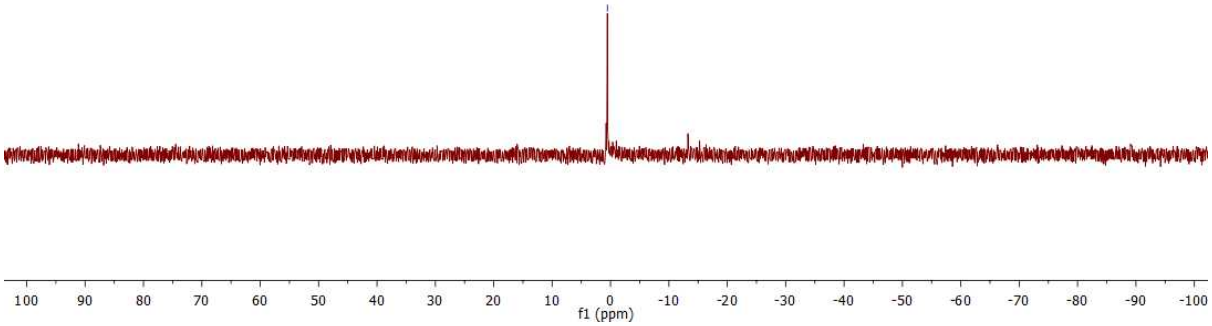
135.789
135.757
135.264
135.212
129.482
129.468
128.887
128.869
128.542
128.517
128.046
123.246
123.188

77.214
77.003
76.789
69.139
69.099



SK-PD-44-31P/1
SK-PD-44-31P
1H De-Coupled

-0.542

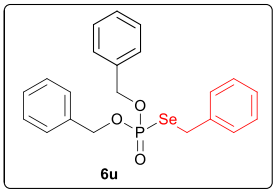


nmr/pd-58-h
PD58 1H-NMR in CDCl3

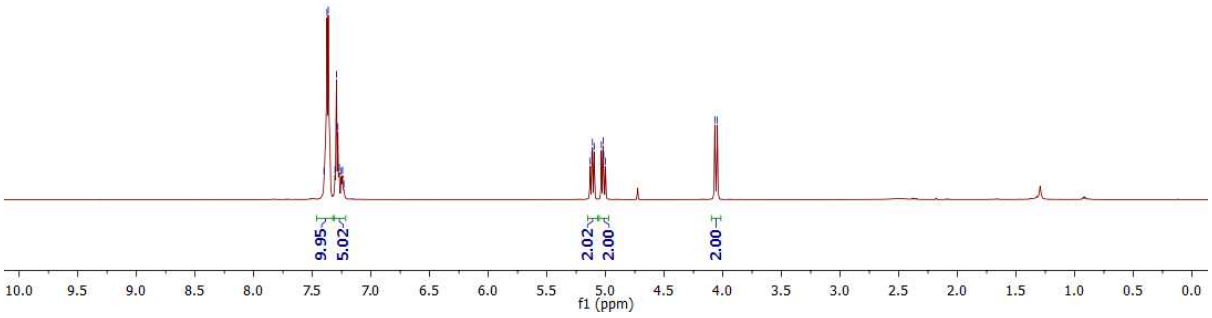
7.401 7.375 7.364 7.307 7.294 7.283 7.270 7.253 7.242 7.231

5.131 5.116 5.111 5.097 5.035 5.020 5.016 5.001

4.068 4.047



6u

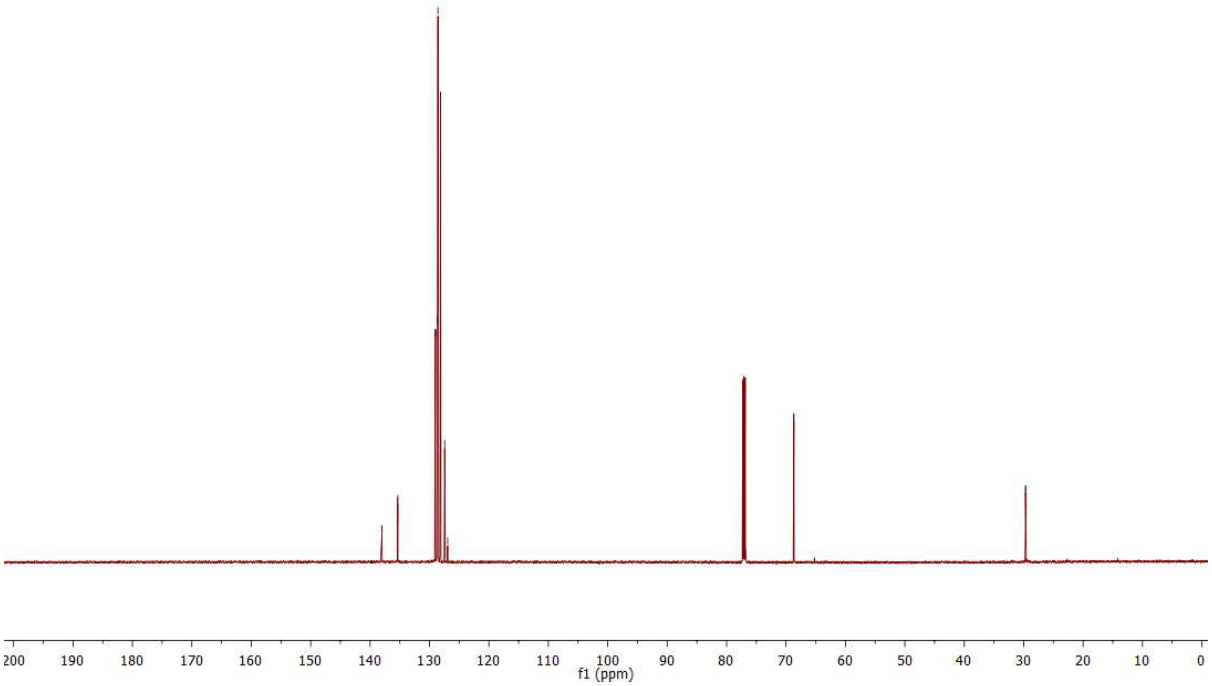


RJ-0217/pd-58-c
PD58 13C-NMR in CDCl3

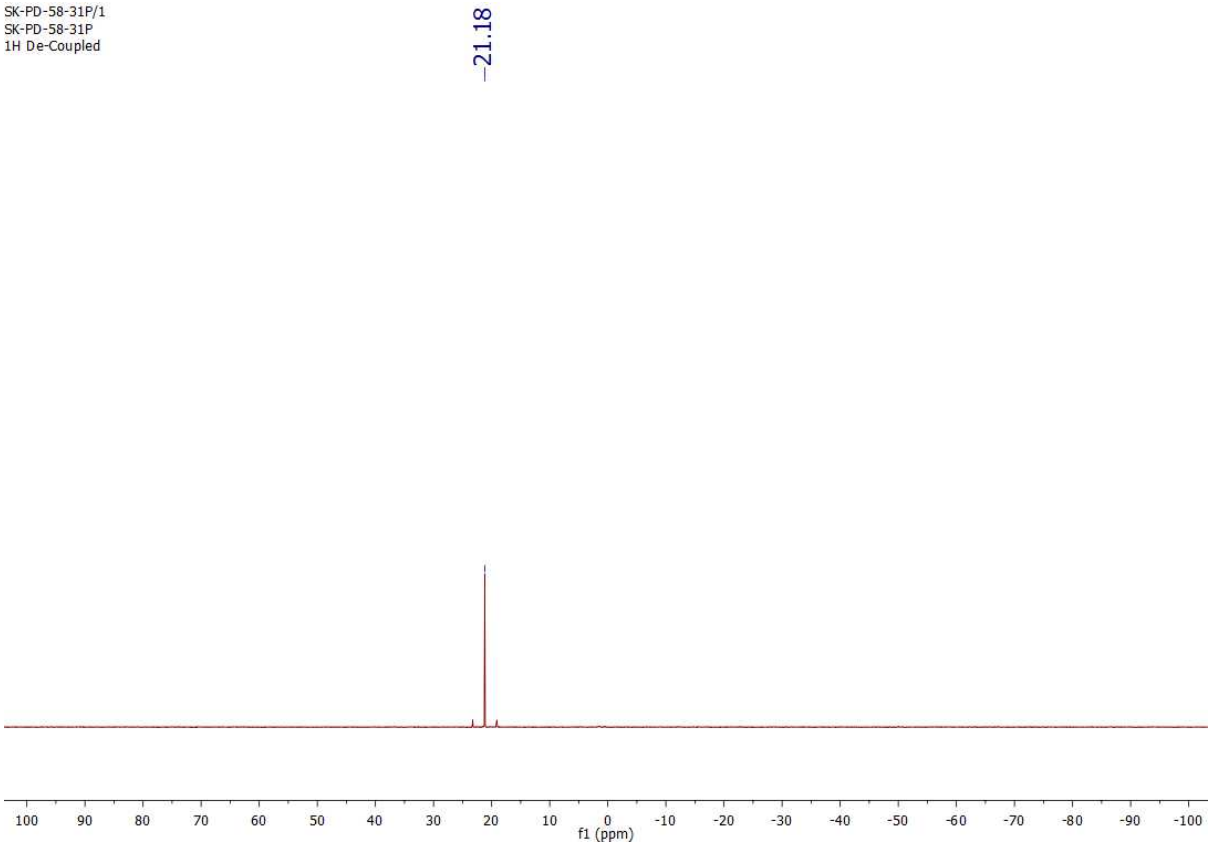
138.039 138.005 135.380 135.328 128.993 128.683 128.585 128.153 127.447 126.942

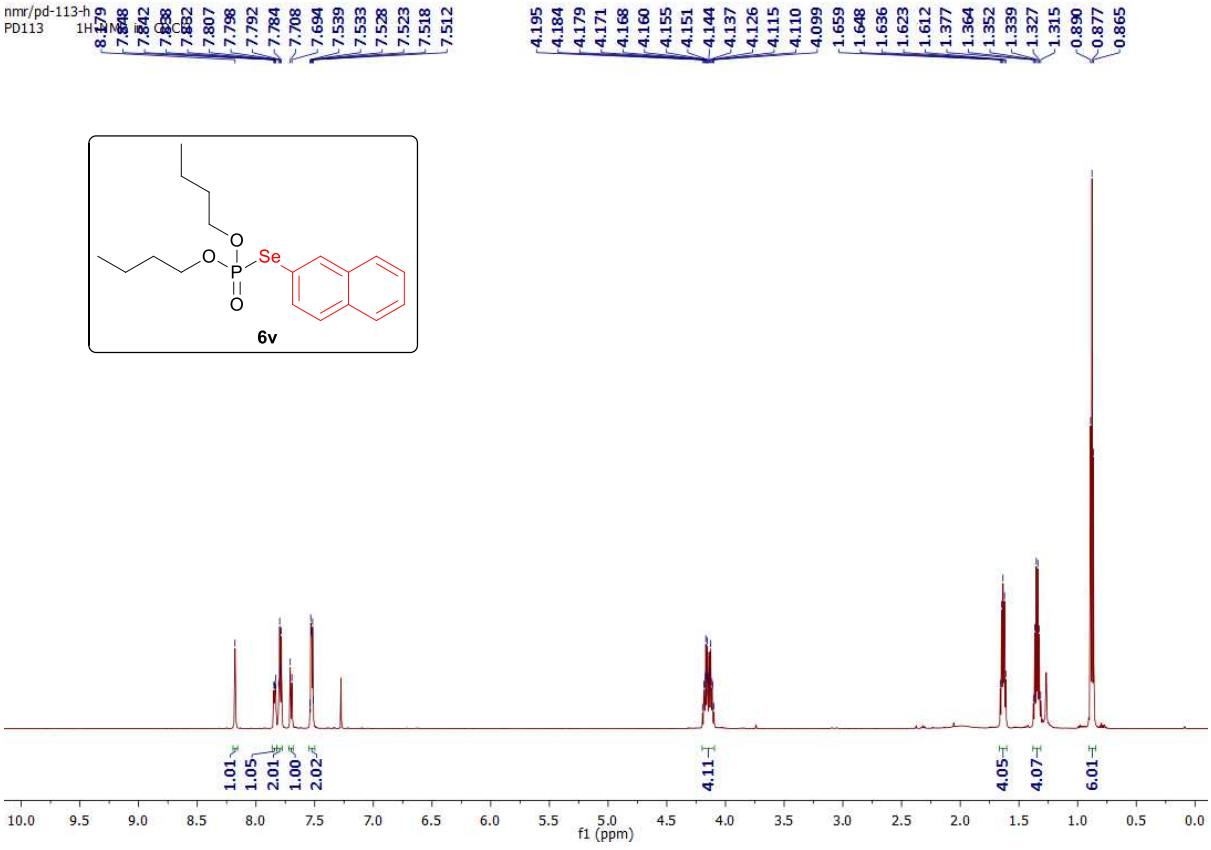
68.703 68.667

29.697 29.667



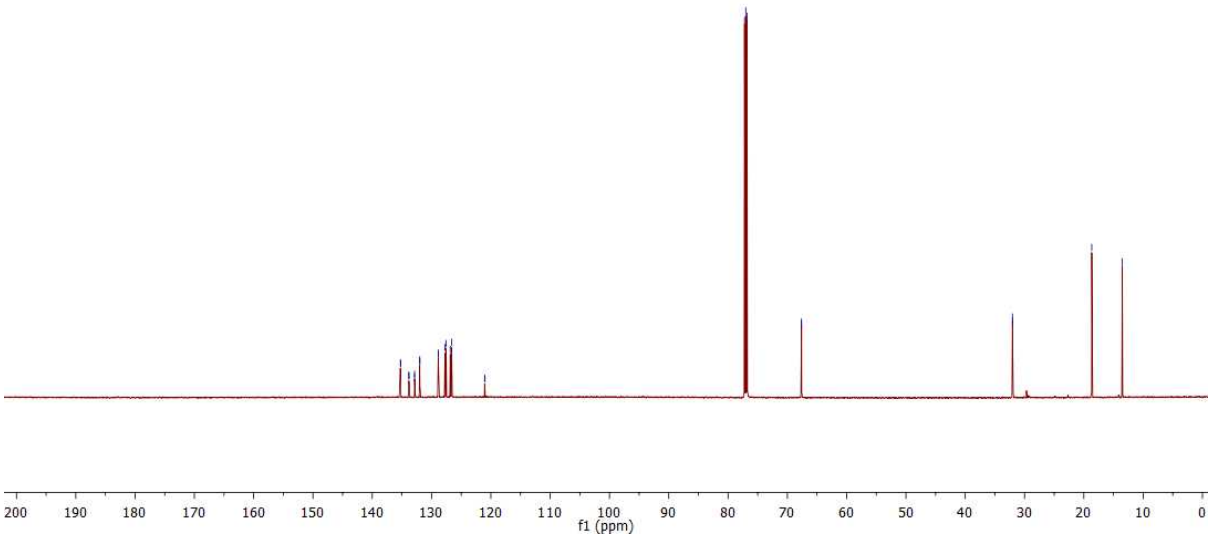
SK-PD-58-31P/1
SK-PD-58-31P
1H De-Coupled





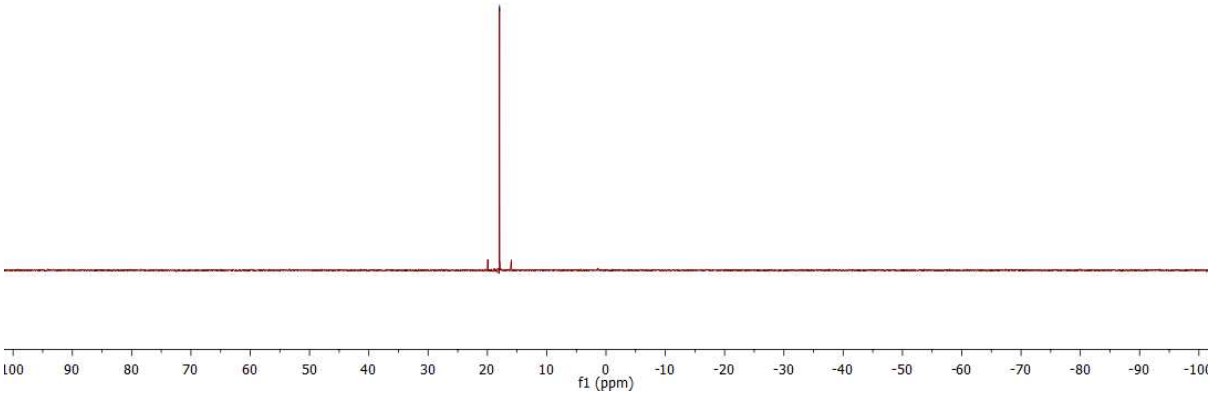
nmr/pd-113-c
PD113 13C-NMR in CDCl3

135.259
135.220
133.830
133.815
132.872
132.859
131.997
131.972
128.884
128.876
127.738
127.545
126.850
126.632
121.049
120.991
77.221
77.010
76.799
67.642
67.600
32.043
31.995
18.664
13.514



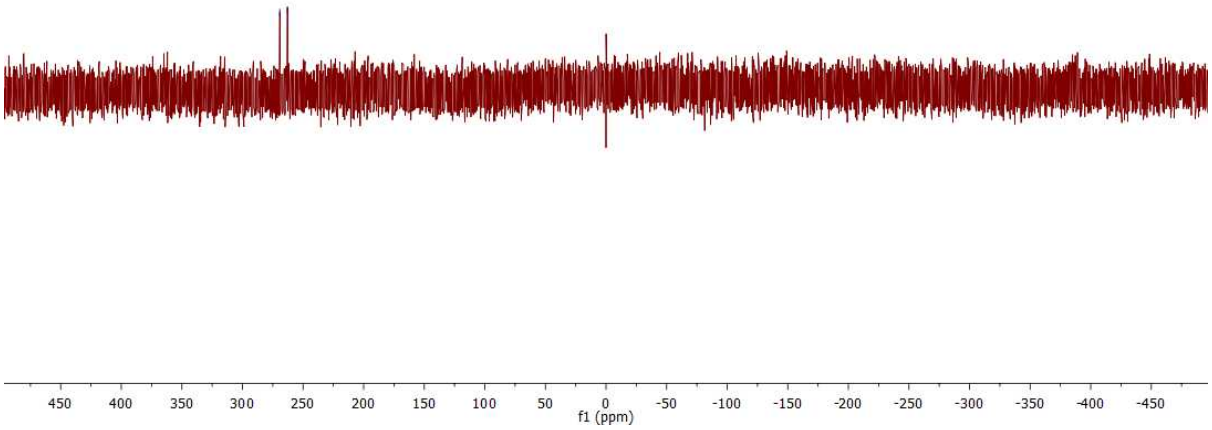
SK-PD-113-31P/1
SK-PD-113-31P
1H De-Coupled

17.96



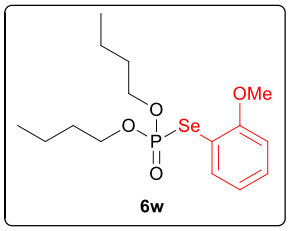
PD-113; 77Se NMR

269.241
262.895

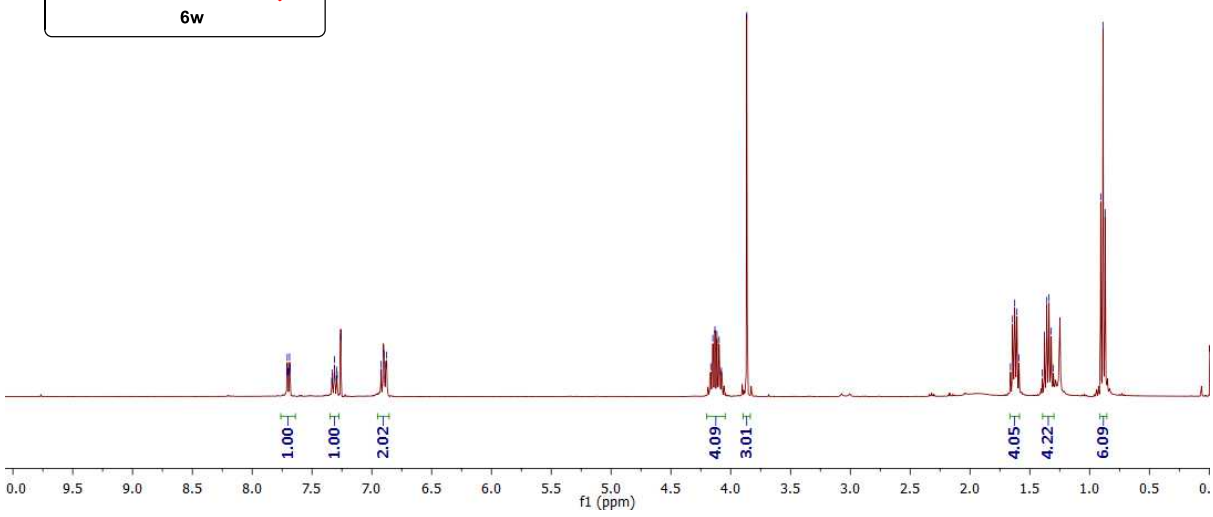


PD-83
single_pulse

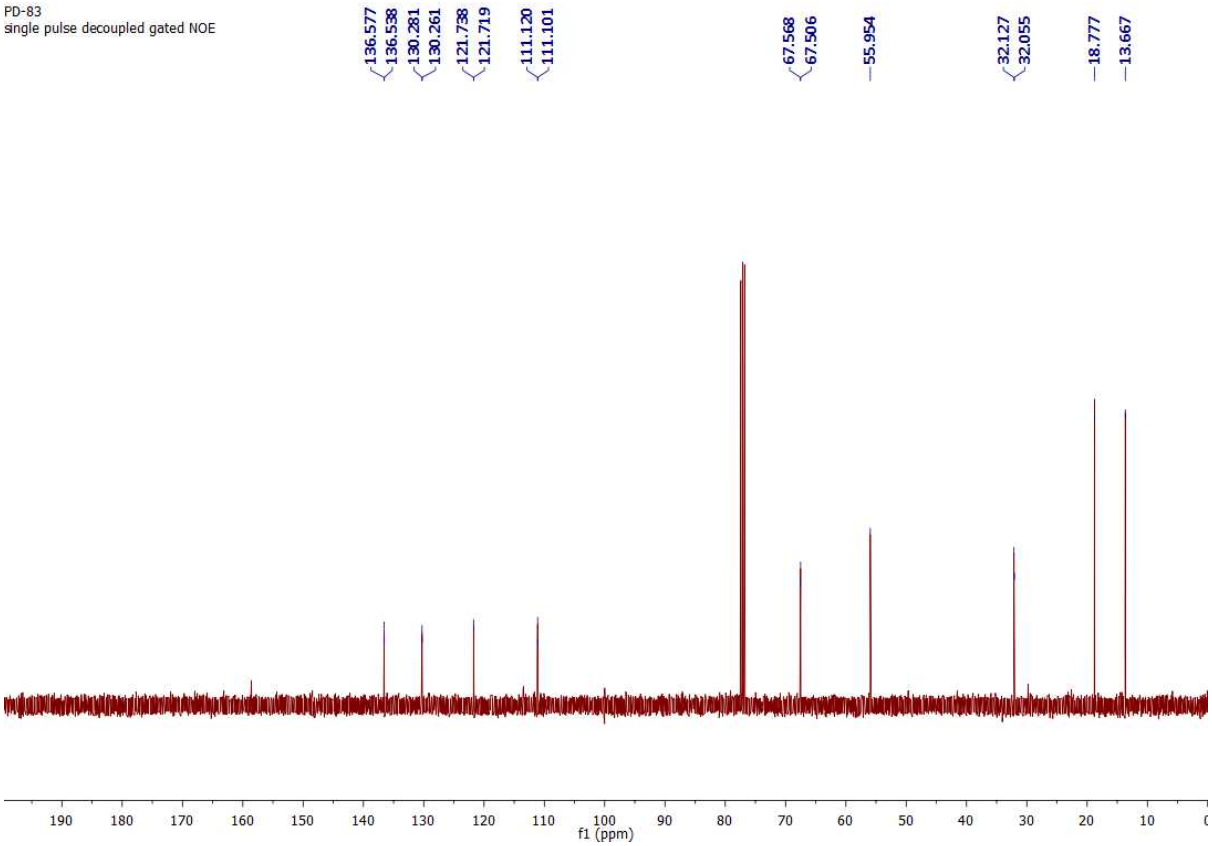
7.710 7.706 7.702 7.691 7.687 7.684 7.335 7.331 7.328 7.312 7.296 7.292 7.289 7.260 6.925 6.922 6.901 6.891 6.884 6.876
4.166 4.149 4.132 4.115 4.097 4.077 3.866
1.661 1.644 1.626 1.607 1.590 1.396 1.377 1.358 1.339 1.321 1.302 0.907 0.889 0.870



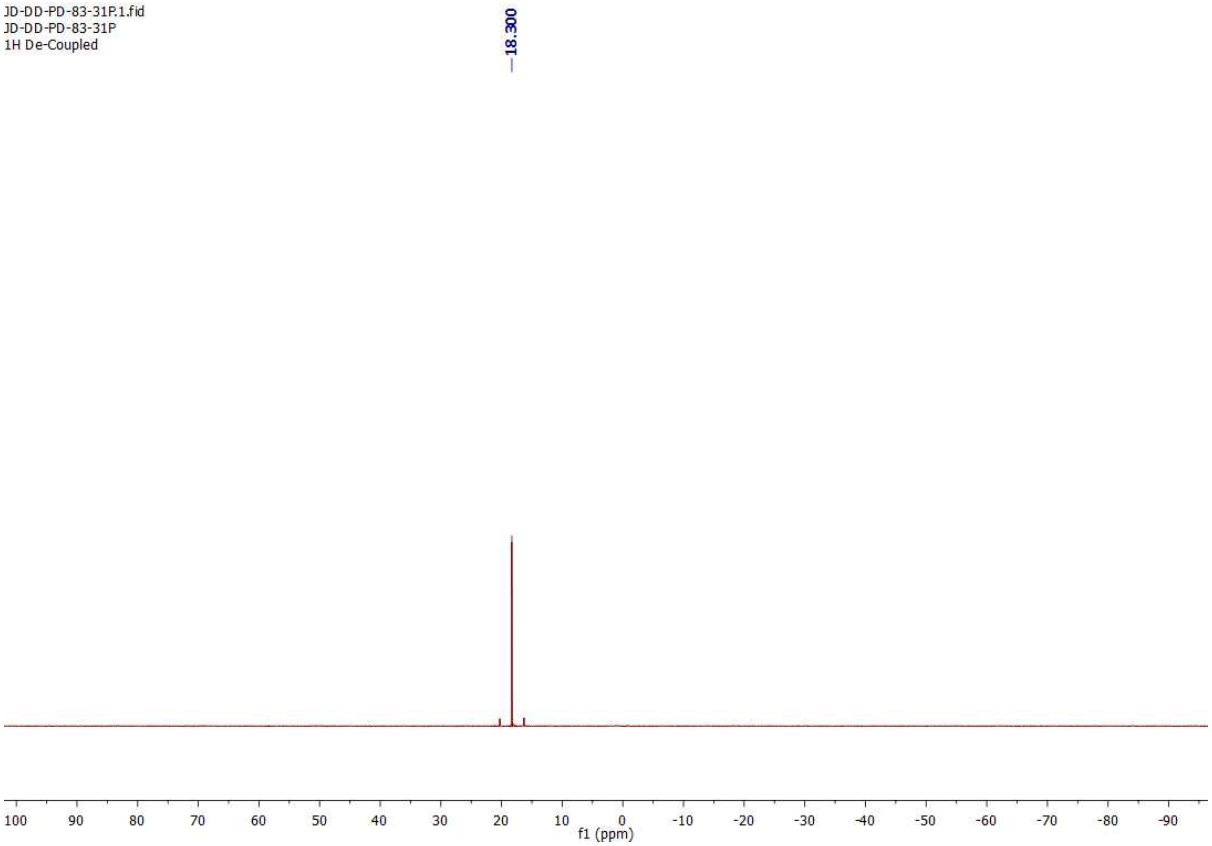
6w



PD-83
single pulse decoupled gated NOE

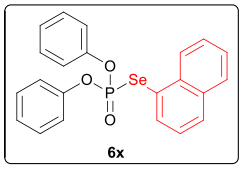


JD-DD-PD-83-31P.1.fid
JD-DD-PD-83-31P
1H De-Coupled

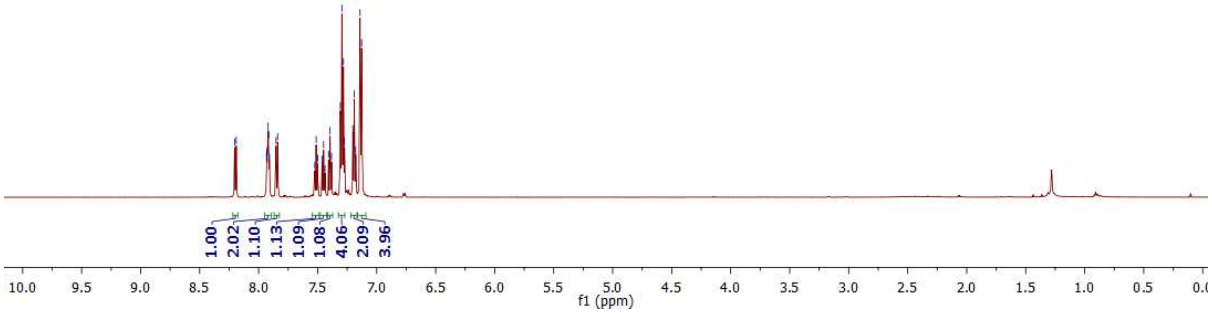


nmr/pd-64-c
PD-64 1H-NMR in CDCl3

8.204 8.188 7.934 7.930 7.926 7.920 7.914 7.908 7.853 7.839 7.525 7.513 7.500 7.463 7.450 7.437 7.408 7.395 7.382 7.308 7.295 7.282 7.273 7.202 7.190 7.178 7.141 7.127

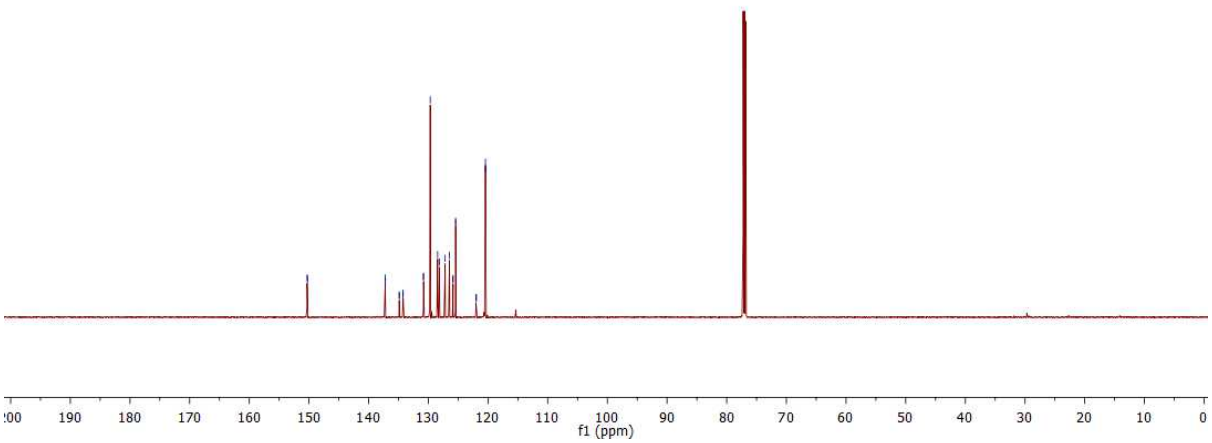


6x

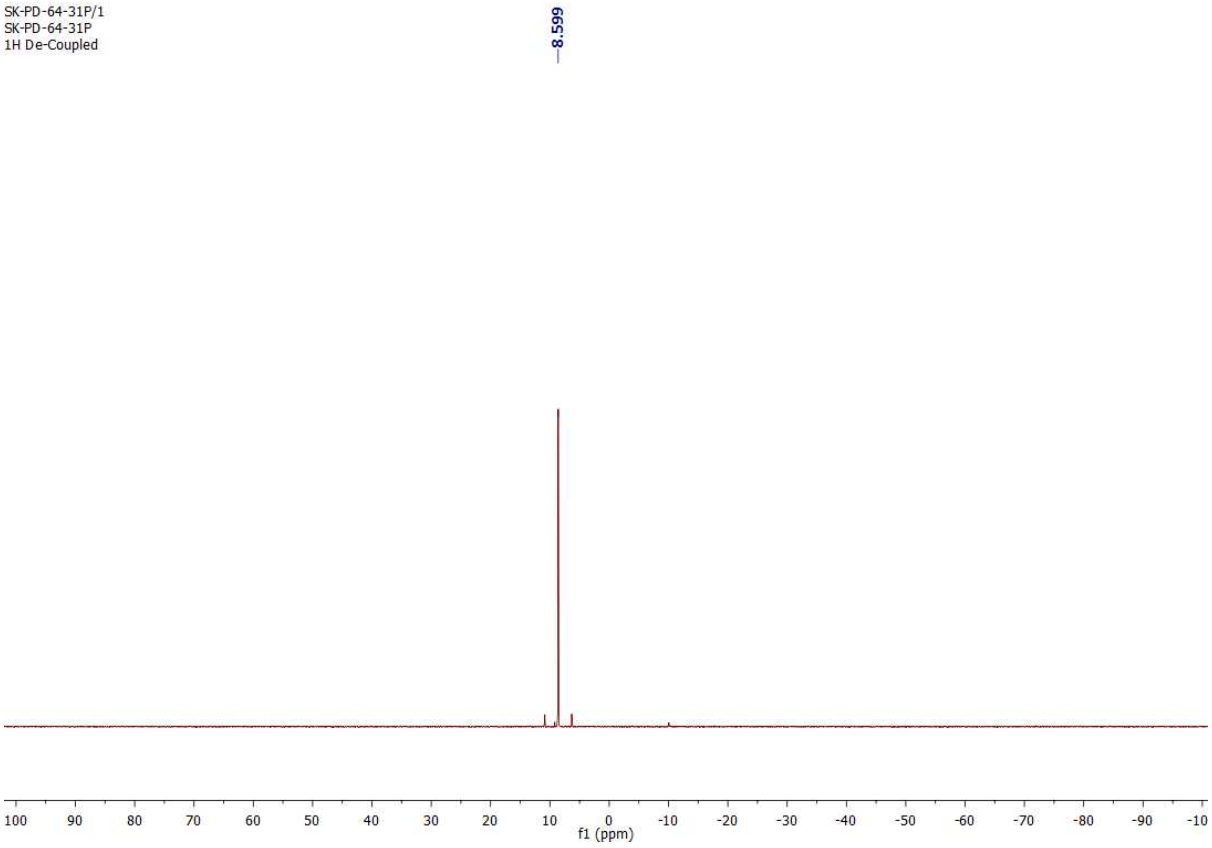


nmr/pd-64-c
PD-64 13C-NMR in CDCl3

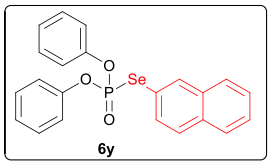
150.312 150.254 137.227 137.191 134.884 134.862 134.236 134.219 130.828 130.804 129.685 128.444 128.153 127.185 126.461 125.875 125.850 125.432 125.426 122.010 121.944 120.458 120.424



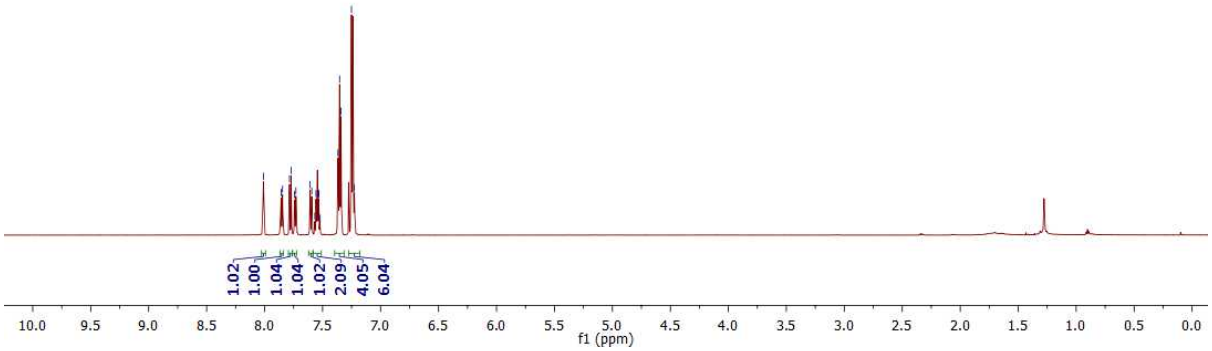
SK-PD-64-31P/1
SK-PD-64-31P
1H De-Coupled

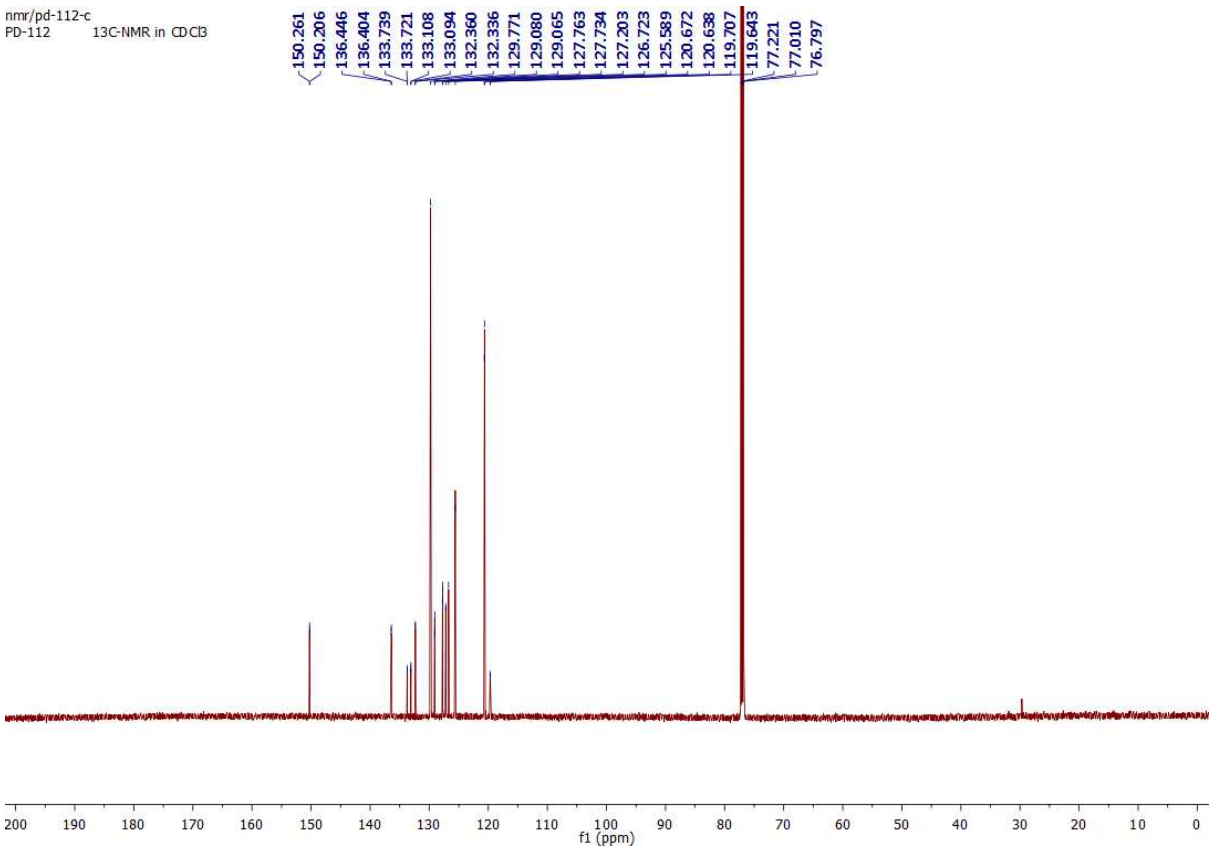


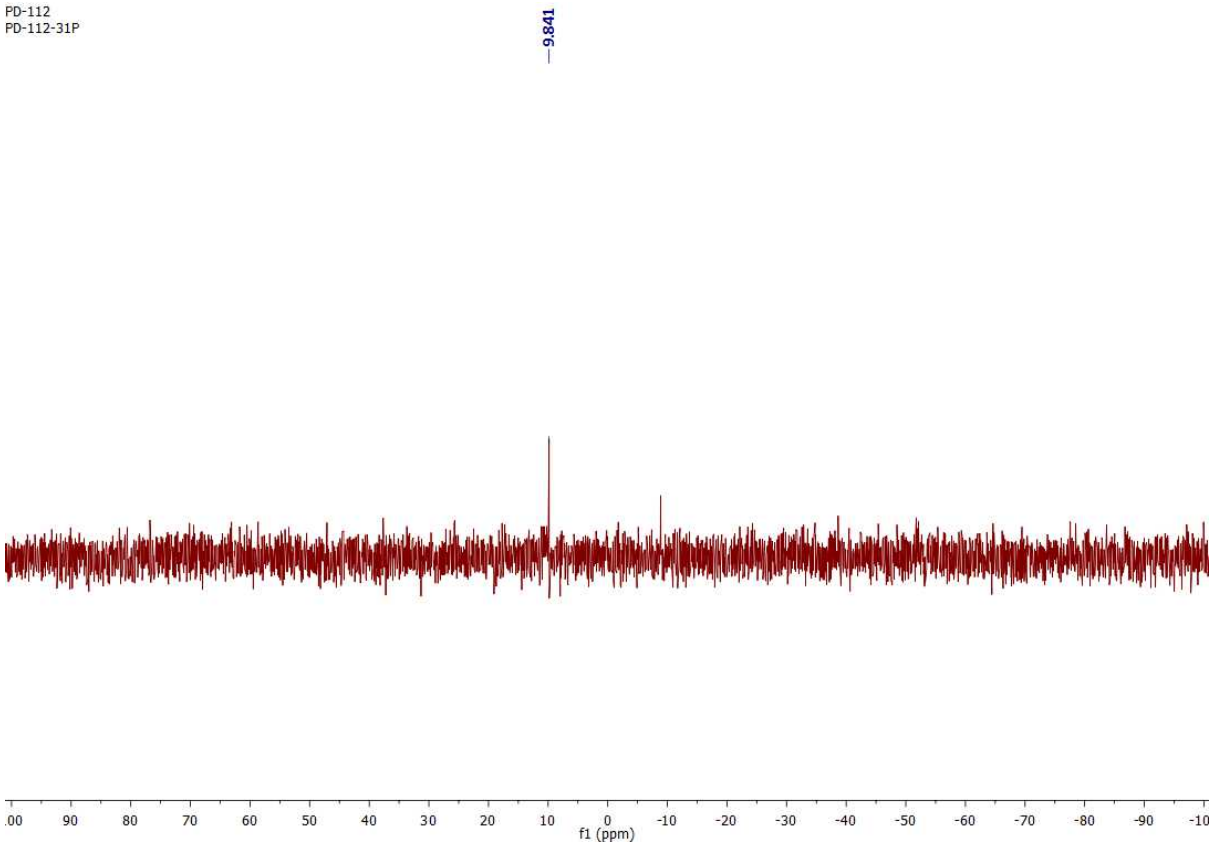
nmr/pd-112-h
PD-112

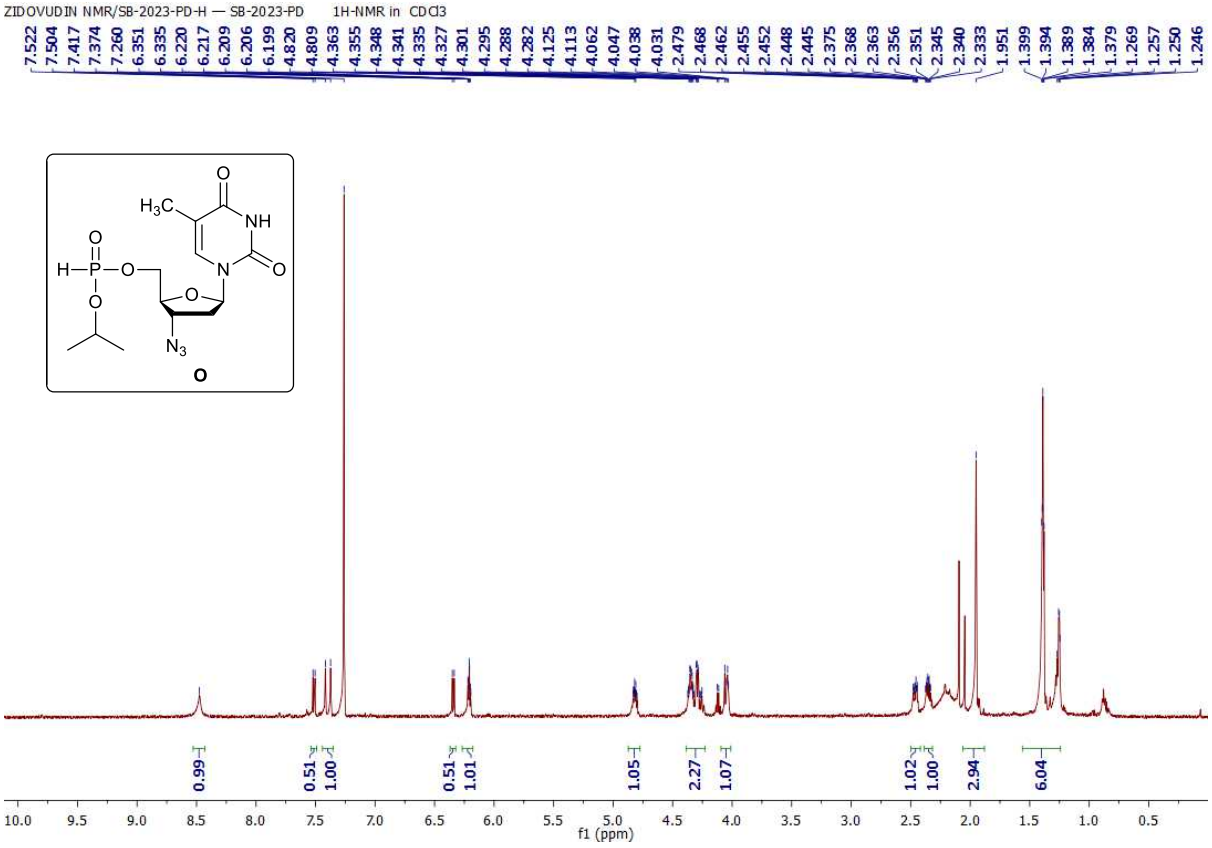


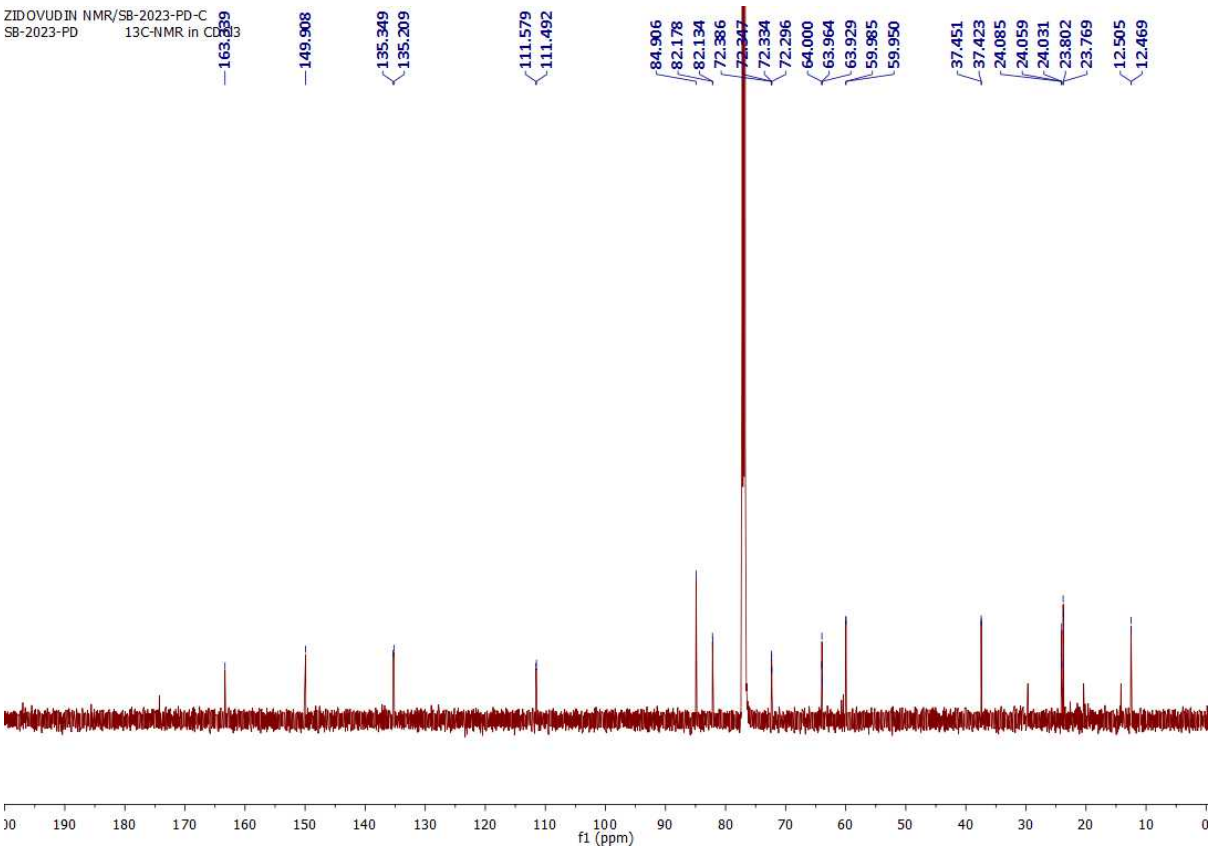
6y



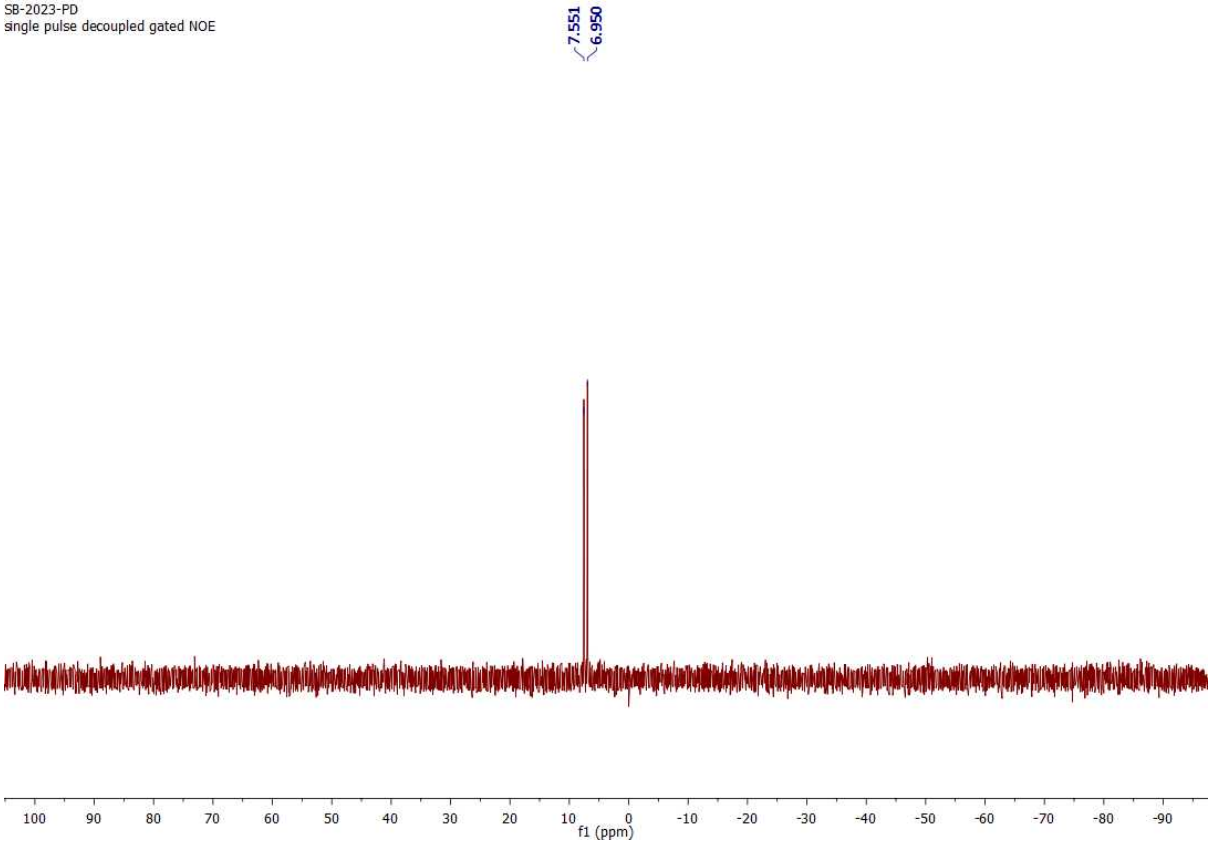

nmr/pd-112-c
PD-112 13C-NMR in CDCl3
150.261
150.206
136.446
136.404
133.739
133.721
133.108
133.094
132.360
132.336
129.771
129.080
129.065
127.763
127.734
127.203
126.723
125.589
120.672
120.638
119.707
119.643
77.221
77.010
76.797
f1 (ppm)

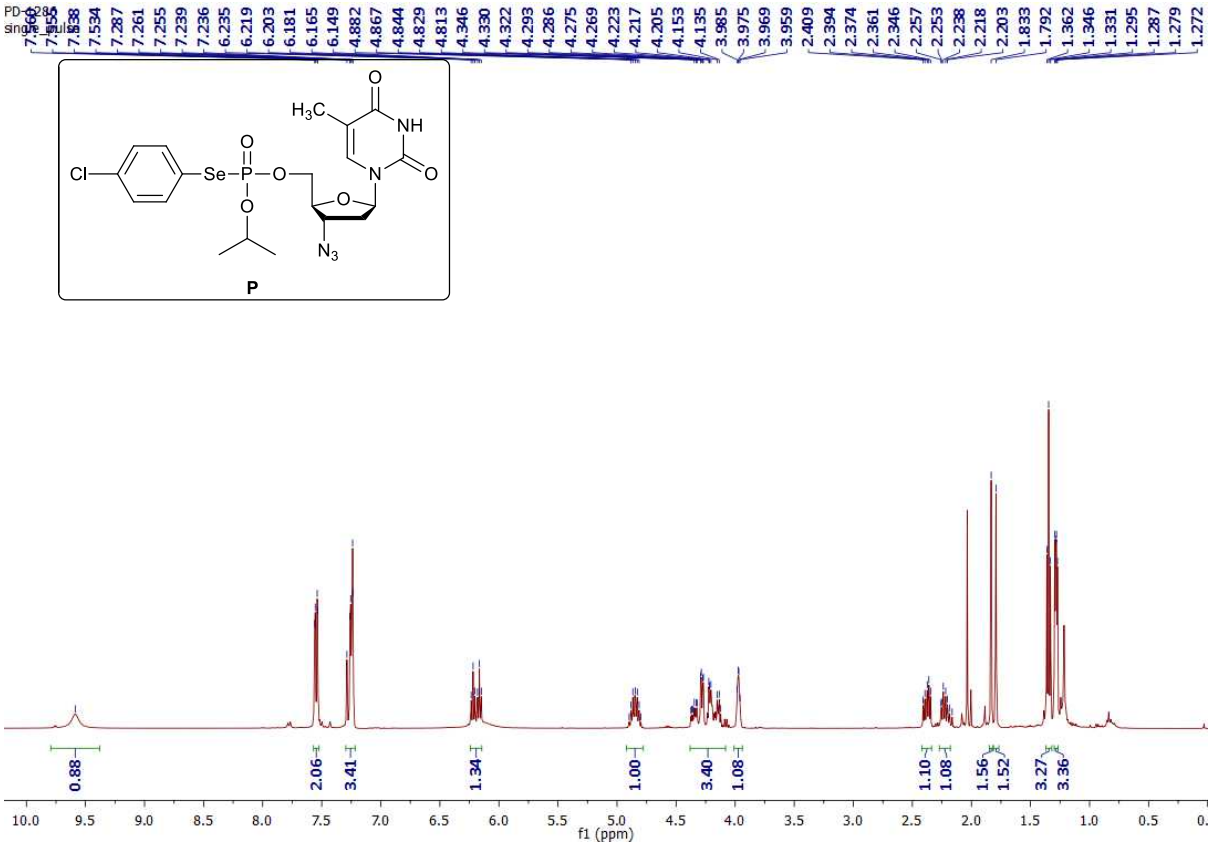

PD-112
PD-112-31P
9.841
f1 (ppm)


ZIDOVUDIN NMR/SB-2023-PD-H — SB-2023-PD 1H-NMR in CDCl3
7.522 7.504 7.417 7.374 7.260 6.351 6.335 6.220 6.217 6.209 6.206 6.199 4.820 4.809 4.363 4.355 4.348 4.341 4.335 4.327 4.301 4.295 4.288 4.282 4.125 4.113 4.062 4.047 4.038 4.031 2.479 2.468 2.462 2.455 2.452 2.448 2.445 2.375 2.368 2.363 2.356 2.351 2.345 2.340 2.333 1.951 1.399 1.394 1.389 1.384 1.379 1.269 1.257 1.250 1.246
O
H3C
NH
H—P—O
O
N
O
O
N3
O
0.99 0.51 1.00 0.51 1.01 1.05 2.27 1.07 1.02 1.00 2.94 6.04
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)


ZIDOVUDIN NMR/SB-2023-PD-C
SB-2023-PD 13C-NMR in CDCl3
163.339
149.908
135.349 135.209
111.579 111.492
84.906 82.178 82.134 72.386 72.347 72.334 72.296 64.000 63.964 63.929 59.985 59.950
37.451 37.423 24.085 24.059 24.031 23.802 23.769 12.505 12.469
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

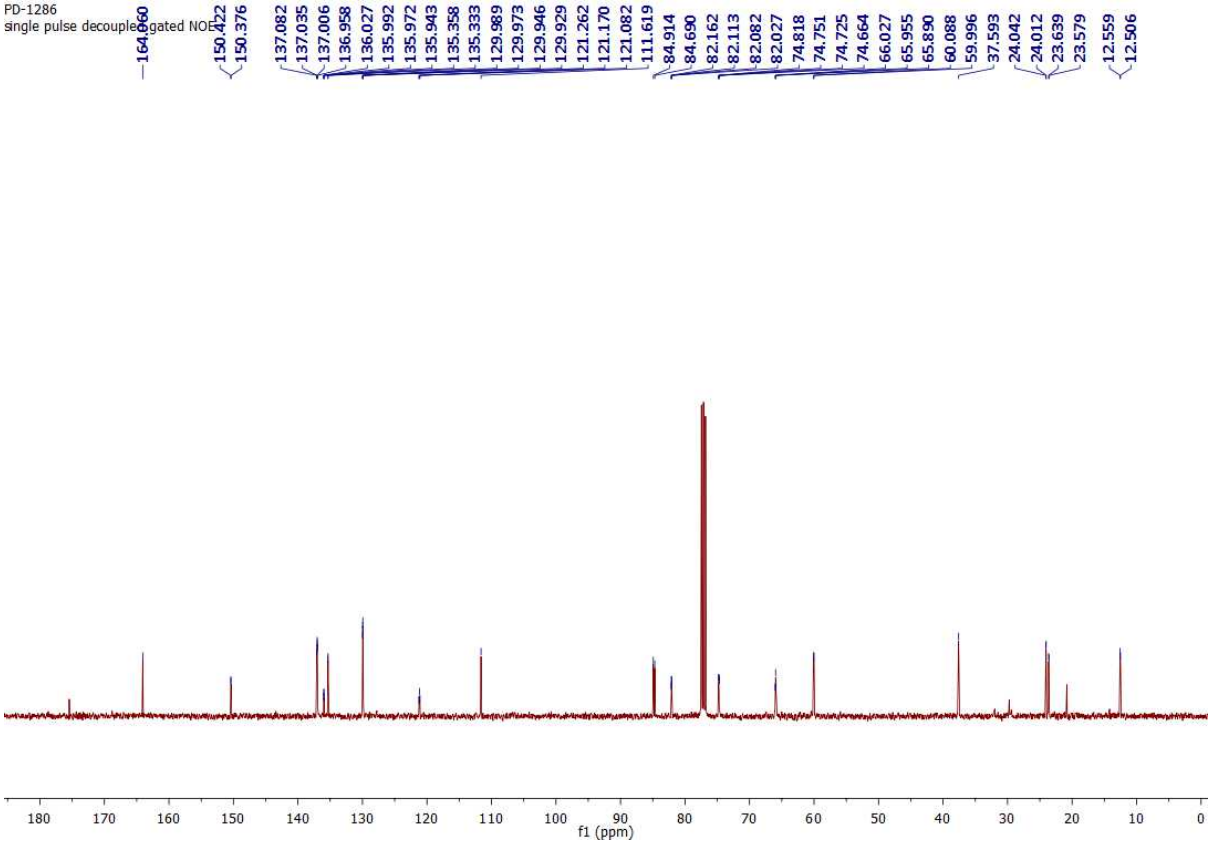
SB-2023-PD
single pulse decoupled gated NOE





P

PD-1286
single pulse decoupled gated NOE



PD-1286
single pulse decoupled gated NOE