Supporting Information

Copper-Catalyzed Diarylation of Se with Aryl Iodides and Heterocycles

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General Information

5-aryl-1,3,4-oxadiazole[1] and 5-aryl-1,3-azole[2] were prepared according to the reported procedures. ^{1}H and ^{13}C spectra of known compounds were in accordance with those described in the literatures. All other reagents were purchased from TCI, Sigma-Aldrich, Alfa Aesar, Acros, and Meryer and used without further purification. Toluene was distilled from Na under nitrogen and stored under nitrogen. ^{1}H NMR (500 MHz), ^{13}C NMR (125 MHz) and ^{19}F NMR (470 MHz) spectra were recorded in $CDCl_3$ or $(CD_3)_2SO$ solutions using a Burker AVANCE 500 spectrometer. High-resolution mass spectra were recorded on an ESI-Q-TOF mass spectrometer. Analysis of crude reaction mixture was done on the Varian 4000 GC/MS and 1200 LC. All reactions were conducted using standard Schlenk techniques. Column chromatography was performed using EM silica gel 60 (300−400 m).

General Experimental Procedures:

General Procedure for C-H arylselenation of 2-Aryl-1,3,4-oxadiazoles: In a 25 mL Schlenk tube equipped with a stir bar were placed 2-aryl-1,3,4-oxadiazoles (0.2 mmol), iodobenzene (0.6 mmol), Se (0.6 mmol), $CuCl_2$ (10 mol %), and Na_2CO_3 (0.8 mmol) in DMF (2 mL). The tube was evacuated and refilled with N_2 three times. The reaction mixture was stirred at 140 ^oC for 24 h. After it was cooled, the reaction mixture was diluted with 10 mL of ethyl ether, and filtered through a pad of silica gel, followed by washing the pad of silica gel with the same solvent (20 mL). The filtrate was washed with water (3×15 mL). The organic phase was dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was then purified by flash chromatography on silica gel to provide the corresponding product.

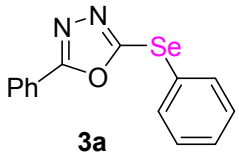
General Procedure for C-H arylselenation of 5-Aryl-1,3-azoles: In a 25 mL Schlenk tube equipped with a stir bar were placed 5-aryl-1,3-azoles (0.2 mmol), iodobenzene (0.6 mmol), Se (0.6 mmol), $CuCl_2$ (10 mol %), and Cs_2CO_3 (1.4 mmol) in DMF (2 mL). The tube was evacuated and refilled with N_2 three times. The reaction mixture was stirred at 140 ^oC for 24 h. After it was cooled, the reaction mixture was diluted with 10 mL of ethyl ether, and filtered through a pad of silica gel, followed by washing the pad of silica gel with the same solvent (20 mL). The filtrate was washed with water (3×15 mL). The organic phase was dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was then purified by flash chromatography on silica gel to provide the corresponding product.

Procedure for C-H arylselenation of quinoline N-Oxide: In a 25 mL Schlenk tube equipped with a stir bar were placed quinoline N-Oxide (0.2 mmol), iodobenzene 2 (0.6 mmol), Se (0.6 mmol), CuI (10 mol %), 1,10-Phen (10 mol%) and Ag_2CO_3 (0.4

mmol) in toluene (2 mL). The tube was evacuated and refilled with O_2 three times. The reaction mixture was stirred at 140 ^oC for 24 h. After it was cooled, the reaction mixture was diluted with 10 mL of ethyl ether, and filtered through a pad of silica gel, followed by washing the pad of silica gel with the same solvent (20 mL). The filtrate was washed with water (3×15 mL). The organic phase was dried over Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was then purified by flash chromatography on silica gel to provide the corresponding product.

Characterization of Products in Details :

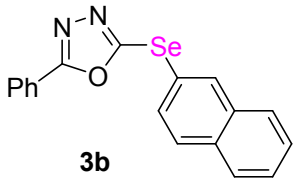
2-Phenyl-5-(phenylselanyl)-1,3,4-oxadiazole[3]



3a

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (85 % yield) , mp 52-53 ℃. The ^{1}H, ^{13}C NMR spectra were in accordance with those described in the literature.

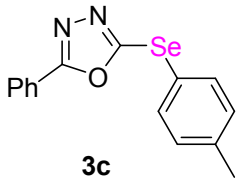
2-(Naphthalen-2-ylselanyl)-5-phenyl-1,3,4-oxadiazole



3b

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a white solid (88 % yield) , mp 106-107 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 8.28 (s, 1H), 7.94-7.92 (m, 2H), 7.85-7.80 (m, 3H), 7.76 (dd, *J* = 8.6, 1.7 Hz, 1H), 7.55-7.51 (m, 2H), 7.49-7.46 (m, 1H), 7.44-7.41 (m, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$): δ 167.3, 156.2, 134.8, 133.9, 133.3, 131.8, 131.3, 129.5, 129.0, 127.9, 127.8, 127.4, 126.9, 126.8, 123.5, 121.4. **HRMS** (ESI): calcd for $C_{18}H_{12}Cl_2OSe$ $[M + H]^+$ 353.0188, found 353.0165.

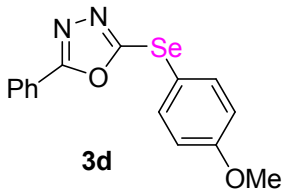
2-Phenyl-5-(p-tolylselanyl)-1,3,4-oxadiazole



3c

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a white solid (93 % yield), mp 83-84 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 7.93 (d, *J* = 7.2 Hz, 2H), 7.64 (d, J = 8.0 Hz, 2H), 7.49-7.42 (m, 3H), 7.18 (d, *J* = 8.0 Hz, 2H), 2.35 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$): δ 167.1, 156.6, 140.1, 135.3, 135.2, 131.8, 130.7, 129.0, 126.8, 123.6, 120.4, 21.3. **HRMS** (ESI): calcd for $C_{15}H_{12}N_2OSe$ $[M + H]^+$ 317.0188, found 317.0188.

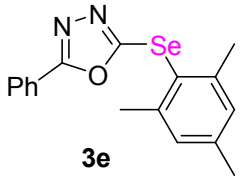
2-(4-Methoxyphenylselanyl)-5-phenyl-1,3,4-oxadiazole



3d

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (83 % yield), mp 94-95 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 7.92 (d, *J* = 7.0 Hz, 2H), 7.69 (d, J = 8.8 Hz, 2H), 7.49-7.42 (m, 3H), 6.90 (d, *J* = 8.8 Hz, 2H), 3.80 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$): δ 167.0, 161.0, 156.9, 137.5, 131.7, 126.7, 123.6, 115.5, 113.9, 55.4. **HRMS** (ESI): calcd for $C_{15}H_{12}N_2O_2Se$ $[M + H]^+$ 333.0137, found 333.0104.

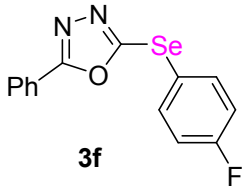
2-(Mesitylselanyl)-5-phenyl-1,3,4-oxadiazole



3e

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a white solid (95 % yield), mp 115-116 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 7.91-7.90 (m, 2H), 7.48-7.42 (m, 3H), 7.01 (s, 2H), 2.56 (s, 6H), 2.30 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$): δ 166.8, 156.6, 143.6, 140.6, 131.6, 129.3, 128.9, 126.7, 123.7, 122.7, 24.4, 21.1. **HRMS** (ESI): calcd for $C_{17}H_{16}N_2OSe$ $[M + H]^+$ 345.0501, found 345.0531.

2-(4-Fluorophenylselanyl)-5-phenyl-1,3,4-oxadiazole

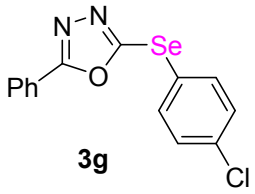


3f

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (76 % yield), mp 73-74 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 7.95-7.93 (m, 2H), 7.79-7.75 (m, 2H), 7.52-7.44 (m, 3H), 7.11-7.08 (m, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$): δ 167.2, 163.7 (d, *J* = 251.0 Hz), 156.2, 137.7 (d, *J* = 8.3 Hz), 131.9, 129.0, 126.8, 123.5, 118.6 (d, *J* = 3.3 Hz), 117.2 (d, *J* = 22.2 Hz); **^{19}F NMR** (470 MHz, $CDCl_3$): δ -110.2 (s, 1F). **HRMS** (ESI): calcd for

$C_{14}H_9FN_2OSe$ $[M + H]^+$ 320.9937, found 320.9943.

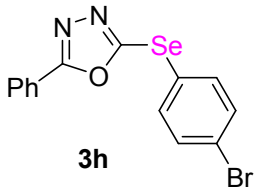
2-(4-Chlorophenylselanyl)-5-phenyl-1,3,4-oxadiazole



3g

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (74 % yield), mp 86-87 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 7.95 (d, *J* = 7.3 Hz, 2H), 7.70 (d, *J* = 8.5 Hz, 2H), 7.52-7.49 (m, 1H), 7.48-7.45 (m, 2H), 7.36 (d, J = 8.4 Hz, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 167.3, 155.8, 136.4, 136.3, 131.9, 130.1, 129.1, 126.8, 123.4, 122.2. **HRMS** (ESI): calcd for $C_{14}H_9ClN_2OSe$ $[M + H]^+$ 336.9642, found 336.9662.

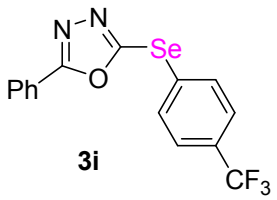
2-(4-Bromophenylselanyl)-5-phenyl-1,3,4-oxadiazole



3h

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (62 % yield), mp 91-92 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 7.96-7.94 (m, 2H), 7.64-7.62 (m, 2H), 7.52-7.45 (m, 5H); **^{13}C NMR** (125 MHz, $CDCl_3$): δ 167.3, 155.6, 136.6, 133.0, 131.9, 129.1, 126.8, 124.5, 123.4, 122.9. **HRMS** (ESI): calcd for $C_{14}H_9BrN_2OSe$ $[M + Na]^+$ 402.8961, found 402.8989.

2-Phenyl-5-(4-(trifluoromethyl)phenylselanyl)-1,3,4-oxadiazole

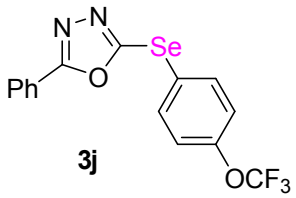


3i

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (39 % yield), mp 82-83 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 7.99-7.98 (m, 2H), 7.88 (d, *J* = 8.0 Hz, 2H), 7.64 (d, *J* = 8.0 Hz, 2H), 7.55-7.47 (m, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$): δ

167.5, 155.0, 134.4, 132.1, 131.7 (d, J = 4.0 Hz), 131.3 (d, J = 32.8 Hz), 129.1, 126.6, 126.0 (q, J = 3.7 Hz), 123.6 (q, J = 272.5 Hz), 123.3; **^{19}F NMR** (470 MHz, $CDCl_3$): δ -62.9 (s, 3F). **HRMS** (ESI): calcd for $C_{15}H_9F_3N_2OSe$ $[M + H]^+$ 370.9905, found 370.9903.

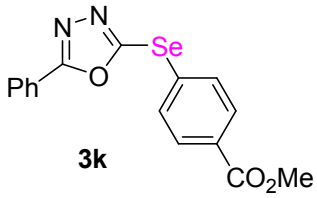
2-Phenyl-5-(4-(trifluoromethoxy)phenylselanyl)-1,3,4-oxadiazole



3j

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (57 % yield), mp 72-73 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 7.96 (d, J = 8.0 Hz, 2H), 7.82 (d, J = 8.5 Hz, 2H), 7.54-7.46 (m, 3H), 7.24 (d, J = 9.0 Hz, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$): δ167.4, 155.6, 150.3, 136.8, 136.7, 131.9, 129.1, 126.8, 122.2, 122.1, 120.3 (q, J = 258.2 Hz); **^{19}F NMR** (470 MHz, $CDCl_3$): δ -57.8 (s, 3F). **HRMS** (ESI): calcd for $C_{15}H_9F_3N_2O_2Se$ $[M + H]^+$ 386.9854, found 386.9847.

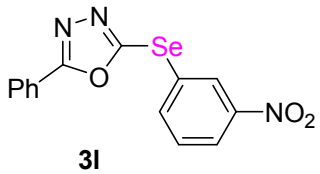
Methyl 4-(5-phenyl-1,3,4-oxadiazol-2-ylselanyl)benzoate



3k

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a white solid (41 % yield), mp 105-106 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 8.03 (d, J = 8.0 Hz, 2H), 7.98 (d, J = 7.0 Hz, 2H), 7.80 (d, J = 8.5 Hz, 2H), 7.55-7.47 (m, 3H), 3.93 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$): δ 167.5, 166.2, 155.1, 133.8, 132.0, 130.9, 130.7, 130.6, 129.1, 126.9, 123.3, 52.4. **HRMS** (ESI): calcd for $C_{16}H_{12}N_2O_3Se$ $[M + Na]^+$ 382.9911, found 382.9921.

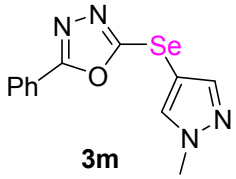
2-(3-nitrophenylselanyl)-5-phenyl-1,3,4-oxadiazole



3l

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (29 % yield), mp 110-111 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 8.66 (s, 1H), 8.29 (dd, *J* = 8.2, 1.3 Hz, 1H), 8.11 (d, *J* = 7.7 Hz, 1H), 7.99 (d, *J* = 7.2 Hz, 2H), 7.61 (t, *J* = 8.0 Hz, 1H), 7.56-7.53 (m, 1H), 7.51-7.48 (m, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$): δ 167.6, 154.8, 148.6, 140.5, 132.2, 130.6, 129.2, 127.1, 126.9, 126.0, 124.5, 123.2. **HRMS** (ESI): calcd for $C_{14}H_9N_3O_3Se$ $[M + H]^+$ 347.9882, found 347.9882.

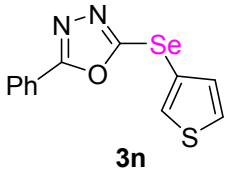
2-(1-Methyl-1H-pyrazol-4-ylselanyl)-5-phenyl-1,3,4-oxadiazole



3m

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a white solid (74 % yield), mp 107-108 ℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.96-7.94 (m, 2H), 7.74 (s, 1H), 7.71 (s, 1H), 7.52-7.45 (m, 3H), 3.97 (s, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 167.0, 156.3, 145.0, 136.1, 131.8, 129.0, 126.8, 123.5, 95.4, 39.4; **HRMS** (ESI): calcd for $C_{12}H_{10}N_4OSe$ $[M + H]^+$ 307.0093, found 307.0098.

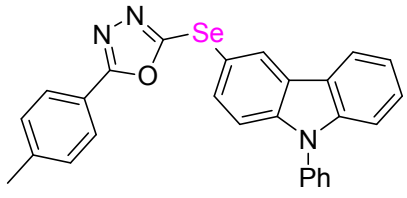
2-Phenyl-5-(thiophen-3-ylselanyl)-1,3,4-oxadiazole



3n

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a white solid (80 % yield), mp 86-87 ℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.96-7.94 (m, 2H), 7.75-7.74 (m, 1H), 7.53-7.45 (m, 3H), 7.43-7.42 (m, 1H), 7.33 (d, *J*=4.9Hz, 1H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 167.1, 155.9, 132.8, 132.1, 131.8, 129.0, 127.4, 126.8, 123.5, 115.7; **HRMS** (ESI): calcd for $C_{12}H_8N_2OSSe$ $[M + H]^+$ 308.9596, found 308.9596.

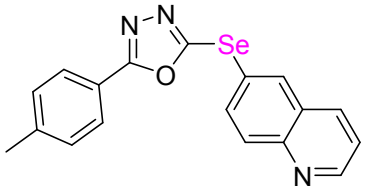
2-(9-phenyl-9H-carbazol-3-ylselanyl)-5-p-tolyl-1,3,4-oxadiazole



3o

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (72 % yield), mp 119-120 ℃. **^{1}H NMR** (500 MHz, CD_3Cl): δ 8.64 (s 1H), 8.20 (d, *J* = 7.8 Hz, 1H), 7.88-7.83 (m, 3H), 7.68-7.64 (m, 2H), 7.59-7.52 (m, 3H), 7.49-7.43 (m, 3H), 7.39-7.36 (m, 1H), 7.27 (d, *J* = 8.0 Hz, 2H), 2.35 (s, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 167.3, 156.9, 142.2, 141.4, 141.3, 137.0, 133.4, 130.0, 129.7, 128.6, 128.0, 127.1, 126.8, 126.7, 124.7, 122.6, 120.9, 120.7, 120.6, 113.3, 111.1, 110.1, 21.6. **HRMS** (ESI): calcd for $C_{27}H_{19}N_3OSe$ $[M + H]^+$ 482.0766, found 482.0792.

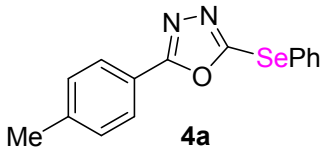
2-(quinolin-6-ylselanyl)-5-p-tolyl-1,3,4-oxadiazole



3p

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a white solid (51 % yield), mp 141-142 ℃. **^{1}H NMR** (500 MHz, CD_3Cl): δ 8.98 (s 1H), 8.28 (s, 1H), 8.16-8.10 (m, 2H), 8.00 (d, *J* = 7.8 Hz, 1H), 7.84 (d, *J* = 7.8 Hz, 2H), 7.47 (q, *J* = 4.1 Hz, 1H), 7.27-7.25 (m, 2H), 2.39 (s, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 167.6, 155.3, 151.7, 148.1, 142.6, 135.9, 134.7, 134.3, 131.1, 129.8, 128.8, 126.8, 122.8, 122.0, 120.6, 21.6. **HRMS** (ESI): calcd for $C_{18}H_{13}N_3OSe$ $[M + H]^+$ 368.0291, found 368.0279.

2-(Phenylselanyl)-5-p-tolyl-1,3,4-oxadiazole

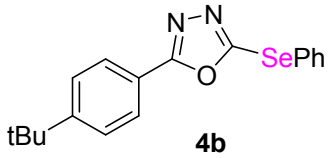


4a

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a white solid (87 % yield), mp 65-66 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 7.83 (d, *J* = 8.2 Hz, 2H), 7.76-7.74 (m, 2H), 7.43-7.36 (m, 3H), 7.25 (d, *J* = 8.2 Hz, 2H), 2.39 (m, 3H). **^{13}C NMR** (125

MHz, $CDCl_3$): δ 167.4, 155.7, 142.4, 134.9, 129.8, 129.7, 129.5, 126.8, 124.4, 120.8, 21.6. **HRMS** (ESI): calcd for $C_{15}H_{12}N_2OSe$ $[M + H]^+$ 317.0188, found 317.0159.

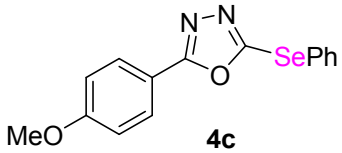
2-(4-Tert-butylphenyl)-5-(phenylselanyl)-1,3,4-oxadiazole[3]



4b

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow liquid (91 % yield). The ^1H, ^{13}C NMR spectra were in accordance with those described in the literature.

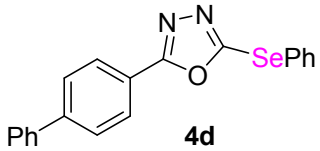
2-(4-Methoxyphenyl)-5-(phenylselanyl)-1,3,4-oxadiazole[3]



4c

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (94 % yield), mp 96-97 ℃. The ^1H, ^{13}C NMR spectra were in accordance with those described in the literature.

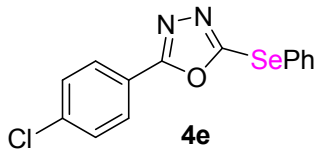
2-(Biphenyl-4-yl)-5-(phenylselanyl)-1,3,4-oxadiazole



4d

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a white solid (81 % yield), mp 104-105 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 8.0 (d, J = 8.0 Hz, 2H), 7.76 (d, J = 7.6 Hz, 2H), 7.66 (d, J = 8.0 Hz, 2H), 87.59 (d, J = 7.6 Hz, 2H), 7.45-7.37 (m, 6H). **^{13}C NMR** (125 MHz, $CDCl_3$)：δ 167.1, 156.2, 144.6, 139.7, 135.1, 129.9, 129.6, 129.0, 128.2, 127.6, 127.3, 127.1, 124.3, 122.3. **HRMS** (ESI): calcd for $C_{20}H_{14}N_2OSe$ $[M + H]^+$ 379.0344, found 379.0343.

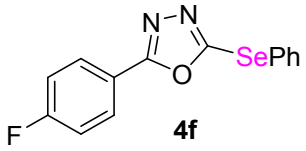
2-(4-Chlorophenyl)-5-(phenylselanyl)-1,3,4-oxadiazole[3]



4e

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (66 % yield), mp 86-87 ℃. The ^{1}H, ^{13}C NMR spectra were in accordance with those described in the literature.

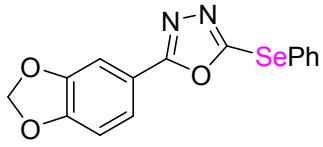
2-(4-Fluorophenyl)-5-(phenylselanyl)-1,3,4-oxadiazole



4f

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (53 % yield), mp 85-86 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 7.97 -7.94 (m, 2H), 7.76 (d, *J* = 7.0 Hz, 2H), 7.45-7.37 (m, 3H), 7.15 (t, *J* = 8.5 Hz, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$)**:** δ 166.4, 165.8, 163.8, 156.3, 135.1, 129.9, 129.7, 129.2, 129.1, 124.2, 119.9, 119.9, 116.5, 116.3. ^{19}F NMR (470 MHz, $CDCl_3$): δ -106.5 (s, 1F). **HRMS** (ESI): calcd for $C_{14}H_9FN_2OSe$ $[M + H]^+$ 320.9937, found 320.9937.

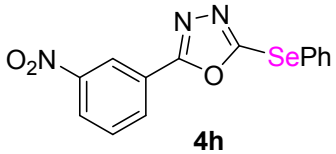
2-(Benzo[d][1,3]dioxol-5-yl)-5-(phenylselanyl)-1,3,4-oxadiazole



4g

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (77 % yield), mp 91-92 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 7.74-7.73 (m, 2H), 7.46 (dd, *J* = 8.1, 1.6 Hz, 1H), 7.42 - 7.35 (m, 4H), 6.84 (d, *J* = 8.1 Hz, 1H), 6.01 (s, 2H). **^{13}C NMR** (125 MHz, $CDCl_3$): δ 166.9, 155.5, 150.7, 148.2, 134.9, 129.8, 129.6, 124.4, 121.9, 117.3, 108.8, 106.8, 101.9. **HRMS** (ESI): calcd for $C_{15}H_{10}N_2O_3Se$ $[M + H]^+$ 346.9930, found 346.9937.

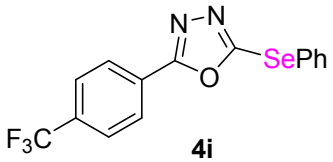
2-(3-Nitrophenyl)-5-(phenylselanyl)-1,3,4-oxadiazole



4h

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (61 % yield), mp 110-111 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 8.78 (s, 1H), 8.39 – 8.31 (m, 2H), 7.80 (d, *J* = 7.5 Hz, 2H), 7.71 (t, *J* = 8.0 Hz,1H), 7.50 - 7.42 (m, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$): δ 165.2, 157.7, 148.6, 135.4, 132.3, 130.4, 130.0, 130.0, 126.2, 125.2, 123.6, 121.7. **HRMS** (ESI): calcd for $C_{14}H_9N_3O_3Se$ $[M + H]^+$ 347.9982, found 347.9982.

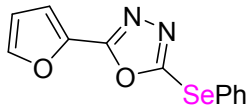
2-(Phenylselanyl)-5-(4-(trifluoromethyl)phenyl)-1,3,4-oxadiazole



4i

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (64 % yield), mp 73-74 ℃. **^{1}H NMR** (500 MHZ, $CDCl_3$): δ 8.08 (d, *J* = 8.0 Hz, 2H), 7.79 (d, *J* = 7.0 Hz, 2H), 7.74 (d, *J* = 8.5 Hz, 2H),7.48 - 7.41 (m, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$): δ 166.0, 157.4, 135.3, 133.5, 129.9, 129.9, 127.1, 126.7, 126.1, 126.1, 126.1, 126.1, 124.6, 123.8, 122.4. ^{19}F NMR (470 MHz, $CDCl_3$): δ -63.14 (s, 3F). **HRMS** (ESI): calcd for $C_{15}H_9F_3N_2OSe$ $[M + H]^+$ 370.9905, found 370.9903.

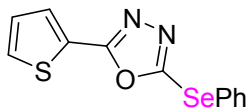
2-(Furan-2-yl)-5-(phenylselanyl)-1,3,4-oxadiazole[3]



4j

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (89 % yield), mp 59-60 ℃. The ^{1}H, ^{13}C NMR spectra were in accordance with those described in the literature.

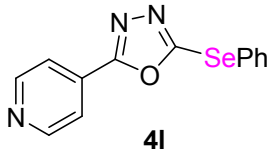
2-(Phenylselanyl)-5-(thiophen-2-yl)-1,3,4-oxadiazole



4k

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (85 % yield), mp 63-64 ℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.74-7.73 (m, 2H), 7.64-7.63 (m, 1H), 7.51-7.50 (m, 1H), 7.42-7.7.35 (m, 3H), 7.11-7.09 (m, 1H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 163.4, 155.5, 135.0, 130.4, 129.9, 129.8, 129.6, 128.2, 124.7, 124.2; **HRMS** (ESI): calcd for $C_{12}H_8N_2OSSe$ $[M + H]^+$ 308.9596, found 308.9598.

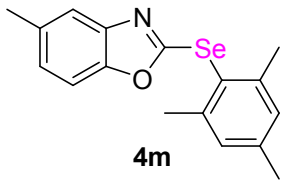
2-(Phenylselanyl)-5-(pyridin-4-yl)-1,3,4-oxadiazole



4l

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (71 % yield), mp 87-88 ℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 8.78 (s 2H), 7.80-7.78 (m, 4H), 7.47-7.41 (m, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 165.3, 158.2, 150.8, 135.4, 135.4, 130.6, 130.0, 129.9, 123.5, 120.1; **HRMS** (ESI): calcd for $C_{13}H_9N_3OSe$ $[M + H]^+$ 303.9984, found 304.0015.

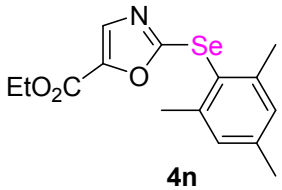
2-(Mesitylselanyl)-5-methylbenzo[d]oxazole



4m

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (44 % yield), mp 119-120 ℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.38 (s 1H), 7.26-7.24 (m, 1H), 7.03 (s, 2H), 7.00 (d, J = 8.3 Hz, 1H), 2.51 (s, 6H), 2.41 (s, 3H), 2.32 (s, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 158.4, 150.9, 143.5, 142.6, 140.2, 133.9, 129.2, 124.8, 123.4, 118.8, 109.3, 24.4, 21.4, 21.1. **HRMS** (ESI): calcd for $C_{17}H_{17}NOSe$ $[M + H]^+$ 332.0548, found 332.0547.

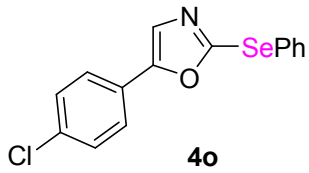
Ethyl 2-(mesitylselanyl)oxazole-5-carboxylate



4n

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (68 % yield), mp 68-69 ℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.62 (s 1H), 7.01 (s, 2H), 4.34 (q, *J* = 7.1 Hz, 2H), 2.48 (s, 6H), 2.30 (s, 3H), 1.35 (t, *J* = 7.1 Hz, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 159.3, 157.4, 145.2, 143.3, 140.6, 135.5, 129.3, 129.0, 123.2, 61.3, 24.3, 21.1, 14.2. **HRMS** (ESI): calcd for $C_{15}H_{17}NO_3Se$ $[M + H]^+$ 340.0447, found 340.0463.

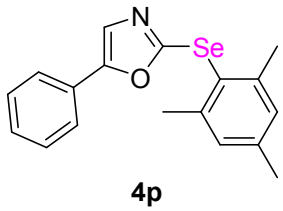
5-(4-Chlorophenyl)-2-(phenylselanyl)oxazole



4o

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (57 % yield), mp 98-99 ℃. **^{1}H NMR** (500 MHz, $(CD_3)_2SO$): δ 7.82 (s 1H), 7.72-7.70 (m, 2H), 7.64 (d, *J* = 8.5 Hz, 2H), 7.51 (d, *J* = 8.5 Hz, 2H), 7.45-7.43 (m, 3H); **^{13}C NMR** (125MHz, $(CD_3)_2SO$): δ 153.0, 151.2, 133.6, 133.1, 129.7, 129.1, 128.8, 126.1, 125.7, 125.4, 125.2. **HRMS** (ESI): calcd for $C_{15}H_{10}ClNOSe$ $[M + H]^+$ 335.9689, found 335.9717.

2-(Mesitylselanyl)-5-phenyloxazole

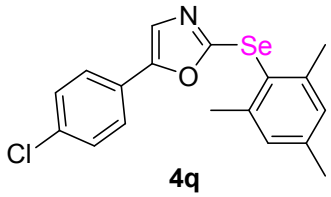


4p

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (51 % yield), mp 65-66 ℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.50-7.50 (m, 1H), 7.48 (s, 1H), 7.37-7.34 (m, 2H), 7.28-7.26 (m, 1H), 7.25-7.24 (m, 1H), 7.00 (s, 2H), 2.54 (s, 6H), 2.30 (s, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ154.1, 152.7, 143.3, 140.0, 129.1, 128.8, 128.2, 127.8, 124.1, 123.8, 123.7, 24.4, 21.1; **HRMS** (ESI): calcd for $C_{18}H_{17}NOSe$ $[M + H]^+$ 344.0548, found

344.0568.

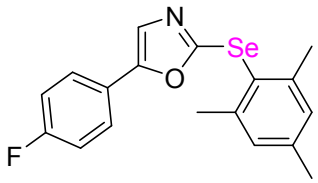
5-(4-Chlorophenyl)-2-(mesitylselanyl)oxazole



4q

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (54 % yield), mp 103-104 ℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.42-7.40 (m, 2H), 7.33-7.31 (m, 2H), 7.24 (s, 1H), 7.00-6.99 (m, 2H), 2.53 (s, 6H), 2.30 (s, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 153.2, 153.1, 143.3, 140.1, 133.9, 129.2, 129.1, 126.3, 125.1, 124.1, 123.9, 24.4, 21.1; **HRMS** (ESI): calcd for $C_{18}H_{16}ClNOSe$ $[M + H]^+$ 378.0159, found 378.0181.

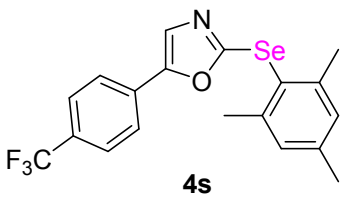
5-(4-Fluorophenyl)-2-(mesitylselanyl)oxazole



4r

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (47 % yield), mp 102-103 ℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.47-7.44 (m, 4H), 7.19 (s, 1H), 7.05 (t, J = 7.6Hz, 2H), 7.00 (s, 2H), 2.54(s, 6H), 2.29 (s, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 162.53 (d, J = 248Hz), 153.3, 152.7, 143.3, 140.1, 129.1, 125.7 (d, J = 8.2Hz), 124.2 (d, J = 3.1Hz), 124.1, 123.3, 116.0 (d, J = 22.3Hz), 24.4, 21.1; **^{19}F NMR** (470 MHz, $CDCl_3$): δ -112.4 (s, 1F); **HRMS** (ESI): calcd for $C_{18}H_{16}FNOSe$ $[M + H]^+$ 362.0454, found 362.0453.

2-(Mesitylselanyl)-5-(4-(trifluoromethyl)phenyl)oxazole

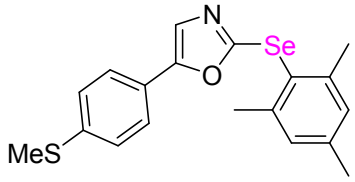


4s

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a

yellow liquid (38 % yield). **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.63-7.58 (m, 4H), 7.36 (s, 1H), 7.02-7.03 (m, 2H), 2.54(s, 6H), 2.31 (s, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 162.53 (d, *J* = 248Hz), 153.3, 152.7, 143.3, 140.1, 129.1, 125.7 (d, *J* = 8.2Hz), 124.2 (d, *J* = 3.1Hz), 124.1, 123.3, 116.0 (d, *J* = 22.3Hz), 24.4, 21.1; **^{19}F NMR** (470 MHz, $CDCl_3$): δ -112.4 (s, 1F); **HRMS** (ESI): calcd for $C_{19}H_{16}F_3NOSe$ $[M + H]^+$ 412.0422, found 412.0442.

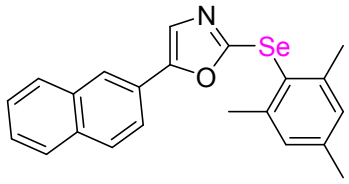
2-(Mesitylselanyl)-5-(4-(methylthio)phenyl)oxazole



4t

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (58 % yield), mp 112-113 ℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.40 (s, 1H), 7.39 (s, 1H), 7.22 (s, 1H), 7.21-7.20 (m, 2H), 7.00 (s, 2H), 2.53(s, 6H), 2.47 (s, 3H), 2.29 (s, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 153.8, 152.4, 143.3, 140.0, 139.0, 129.1, 126.6, 124.6, 124.2, 123.3, 24.4, 21.1, 15.6; **HRMS** (ESI): calcd for $C_{19}H_{19}NOSSe$ $[M + H]^+$ 390.0426, found 390.0439.

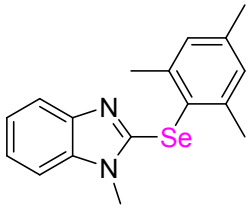
2-(Mesitylselanyl)-5-(naphthalen-2-yl)oxazole



4u

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (60 % yield), mp 103-104 ℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.97 (s, 1H), 7.80-7.77 (m, 3H), 7.57 (dd, *J* = 8.5, 1.6Hz, 1H), 7.47-7.44 (m, 2H), 7.35-7.34 (m, 1H), 2.56 (s, 6H), 2.30 (s, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 154.2, 153.1, 143.4, 140.1, 133.3, 133.0, 129.2, 128.7, 128.2, 127.8, 126.7, 126.4, 125.1, 124.2, 124.1, 122.6, 121.8, 24.5, 21.1; **HRMS** (ESI): calcd for $C_{22}H_{19}NOSe$ $[M + H]^+$ 394.0705, found 394.0729.

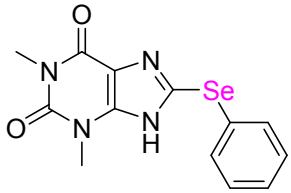
2-(Mesitylselanyl)-1-methyl-1H-benzo[d]imidazole



4v

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow solid (63 % yield), mp 122-123 ℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 7.67-7.65 (m, 1H), 7.22-7.15 (m, 3H), 6.94 (s, 2H), 3.57 (s, 3H), 2.43 (s, 3H), 2.26 (s, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 145.9, 144.1, 142.7, 139.3, 136.7, 129.3, 125.1, 122.2, 121.8, 119.2, 108.7, 31.2, 24.3, 21.0. **HRMS** (ESI): calcd for $C_{17}H_{18}N_2Se$ $[M + H]^+$ 331.0708, found 331.0707.

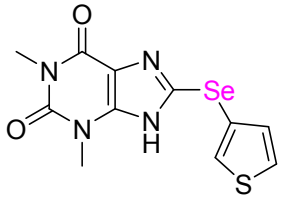
1,3-Dimethyl-8-(phenylselanyl)-1H-purine-2,6(3H,9H)-dione



4w

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a white solid (65 % yield), mp 58-59 ℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 11.05 (s, 1H), 7.66-7.65 (m, 2H), 7.41-7.34 (m, 3H), 3.60 (s, 3H), 3.38 (s, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ154.5, 151.4, 149.7, 143.1, 134.8, 130.1, 129.5, 125.5, 109.1, 30.2, 28.3; **HRMS** (ESI): calcd for $C_{13}H_{12}N_4O_2Se$ $[M + H]^+$ 337.0198, found 337.0238.

1,3-Dimethyl-8-(thiophen-3-ylselanyl)-1H-purine-2,6(3H,9H)-dione

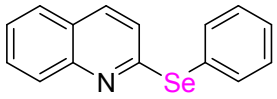


4x

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a white solid (74 % yield), mp 236-237 ℃. **^{1}H NMR** (500 MHz, $CDCl_3$): δ 10.9 (s, 1H), 7.66 (s,

1H), 7.38-7.37 (m, 1H), 7.20-7.19 (m, 1H), 3.52 (s, 3H), 3.34 (s, 3H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 153.5, 150.3, 148.8 142.4, 131.8, 131.6, 127.1, 116.0, 108.0, 29.2, 27.3. **HRMS** (ESI): calcd for $C_{11}H_{10}N_4O_2SSe$ $[M + H]^+$ 342.9763, found 342.9798.

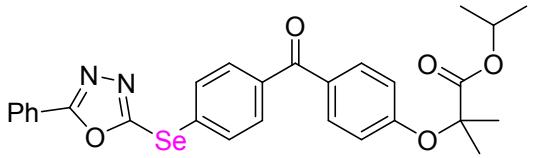
2-(phenylselanyl)quinoline



4y

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a white solid (27 % yield), mp 135-136 ℃. **^{1}H NMR** (400 MHz, $(CD_3)_2SO$): δ 8.47 (d, *J* = 8.6 Hz, 1H), 8.02 (d, *J* = 8.0 Hz, 1H), 7.87-7.78 (m, 4H), 7.71-7.67 (m, 1H), 7.65-7.56 (m, 3H), 6.70 (d, J = 9.1 Hz, 1H); **^{13}C NMR** (125MHz, $(CD_3)_2SO$): δ 147.6, 140.4, 137.5, 131.4, 130.8, 130.6, 129.2, 128.2, 128.1, 126.3, 126.0, 120.4, 118.1. **HRMS** (ESI): calcd for $C_{15}H_{11}NSe$ $[M + H]^+$ 286.0130, found 286.0091.

Isopropyl 2-methyl-2-(4-(4-(5-phenyl-1,3,4-oxadiazol-2-ylselanyl)benzoyl)phenoxy)propanoate



5a

Following the general procedure, using 20 / 1 petroleum ether / EtOAc as the eluant afforded a yellow liquid (27 % yield). **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.00 (d, *J* = 7.2 Hz, 2H), 7.84 (d, *J* = 8.2 Hz, 2H), 7.76-7.73 (m, 4H), 7.56-7.49 (m, 3H), 6.86 (d, *J* = 8.8 Hz, 2H), 5.12-5.04 (qt, J = 12.4, 6.3 Hz, 1H), 1.66 (s, 6H), 1.20 (d, *J* = 6.3 Hz, 6H); **^{13}C NMR** (125MHz, $CDCl_3$): δ 194.4, 173.0, 159.9, 138.9, 133.8, 132.1, 132.0, 130.8, 130.0, 129.2, 129.1, 126.9, 123.4, 117.3, 79.5, 69.3, 25.4, 21.5. **HRMS** (ESI): calcd for $C_{28}H_{26}N_2O_5Se$ $[M + H]^+$ 551.1080, found 551.1106.

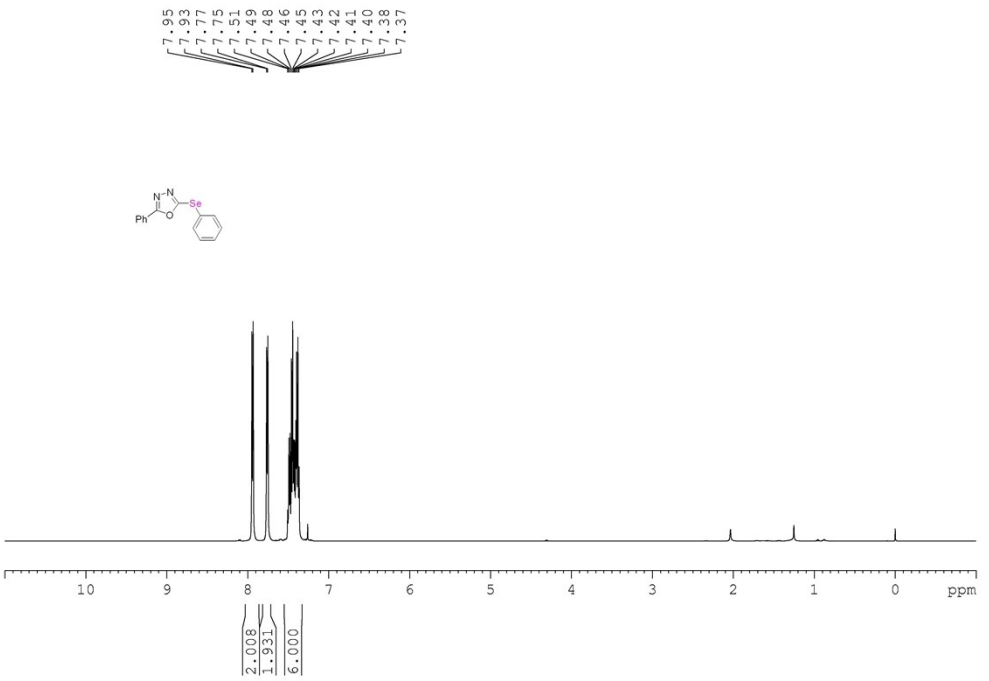
References:

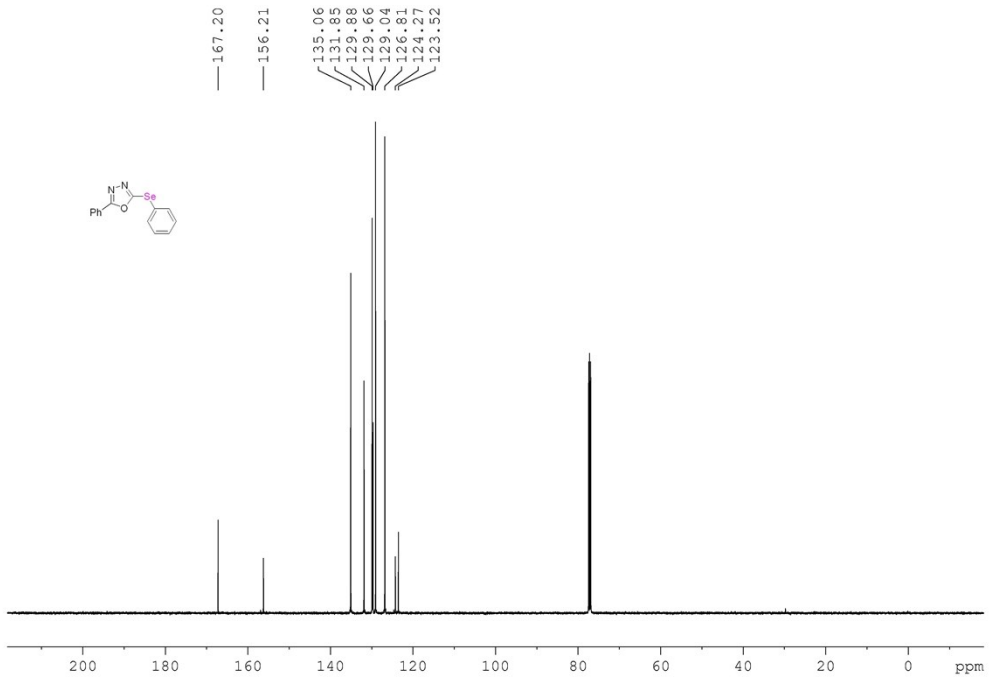
(1) T. Kawano, K. Hirano, T. Satoh, M. Miura, *J. Am. Chem. Soc.* 2010, **132**, 6900.

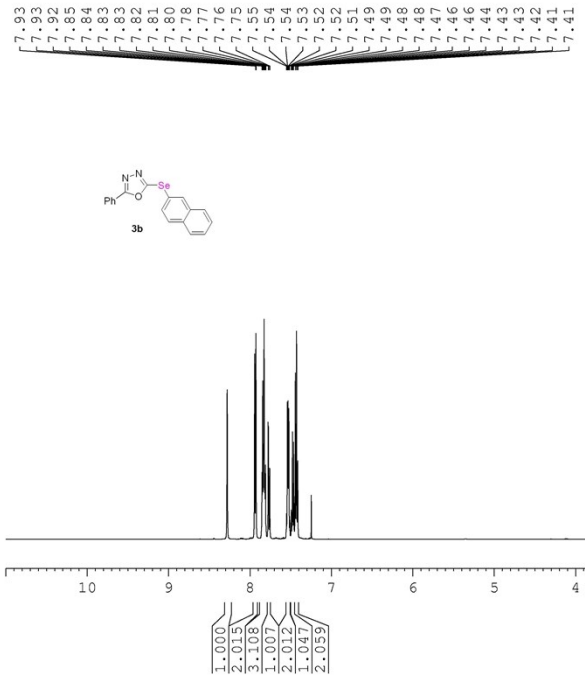
(2) F. Besselièvre, F. Mahuteau-Betzer, D. S. Grierson, S. Piguel, *J. Org. Chem.* 2008, **73**, 3278.

(3) J. Rafique, S. Saba, A. R. Rosário, G. Zeni, A. L. Braga, *RSC Adv.* 2014, **4**, 51648.

^{1}H, ^{13}C and ^{19}F NMR spectra of products



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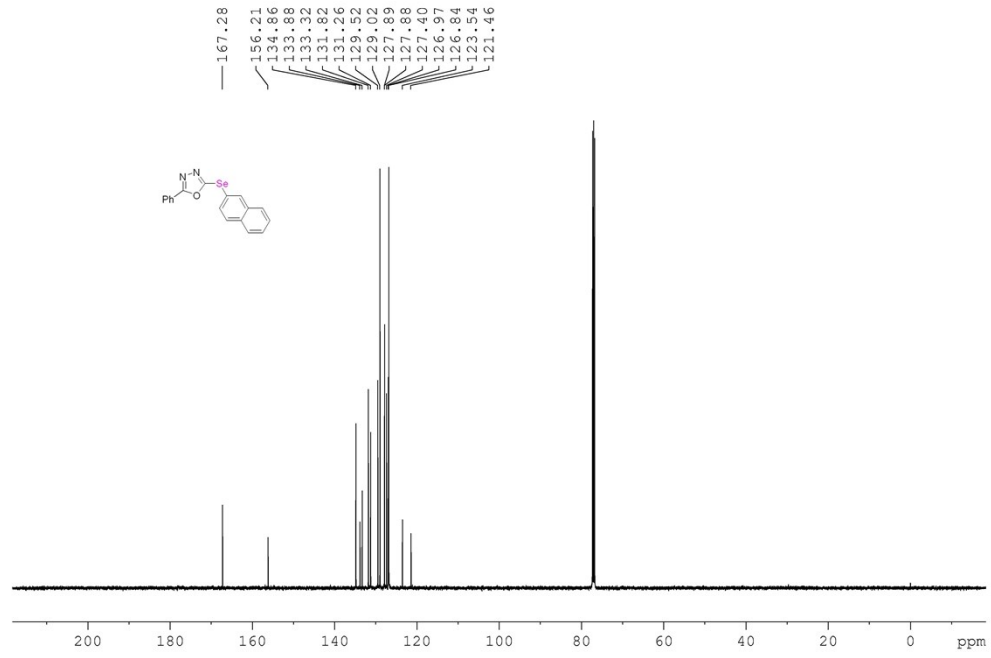
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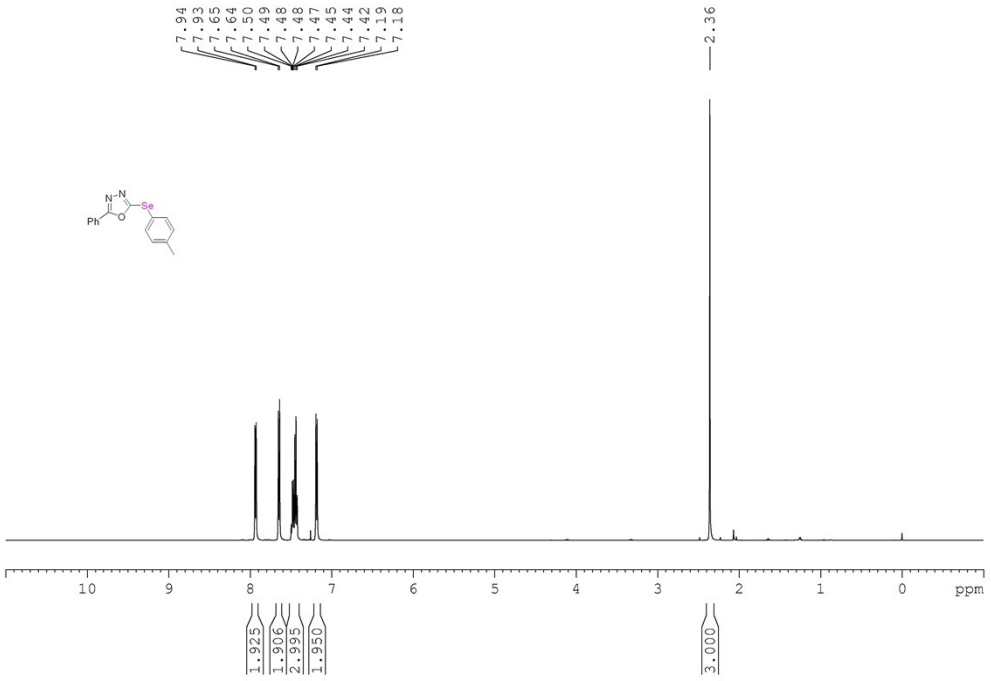
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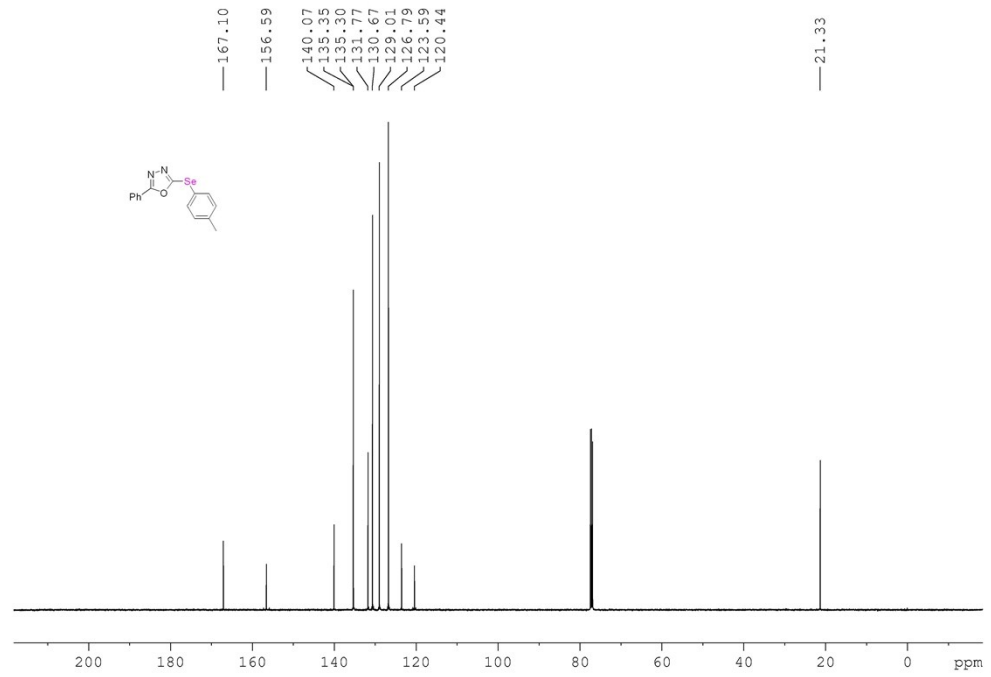
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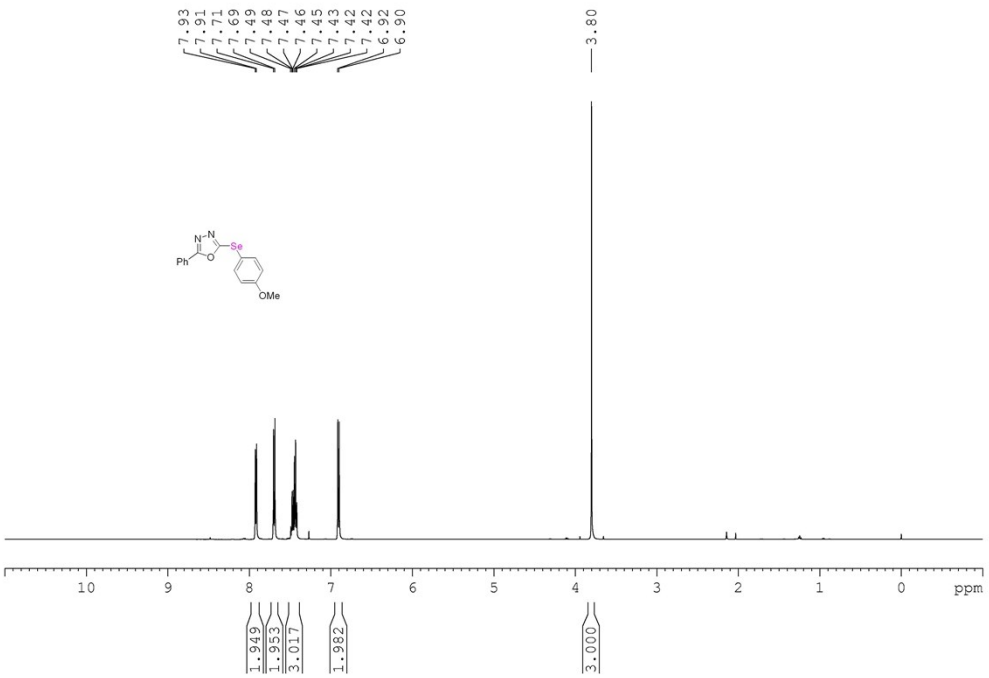
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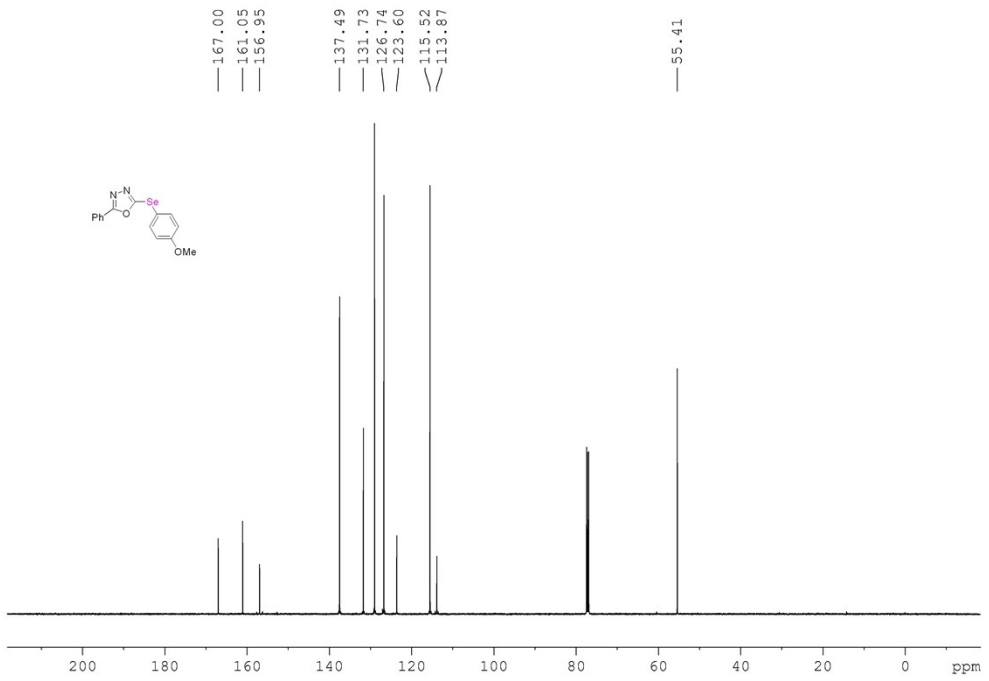
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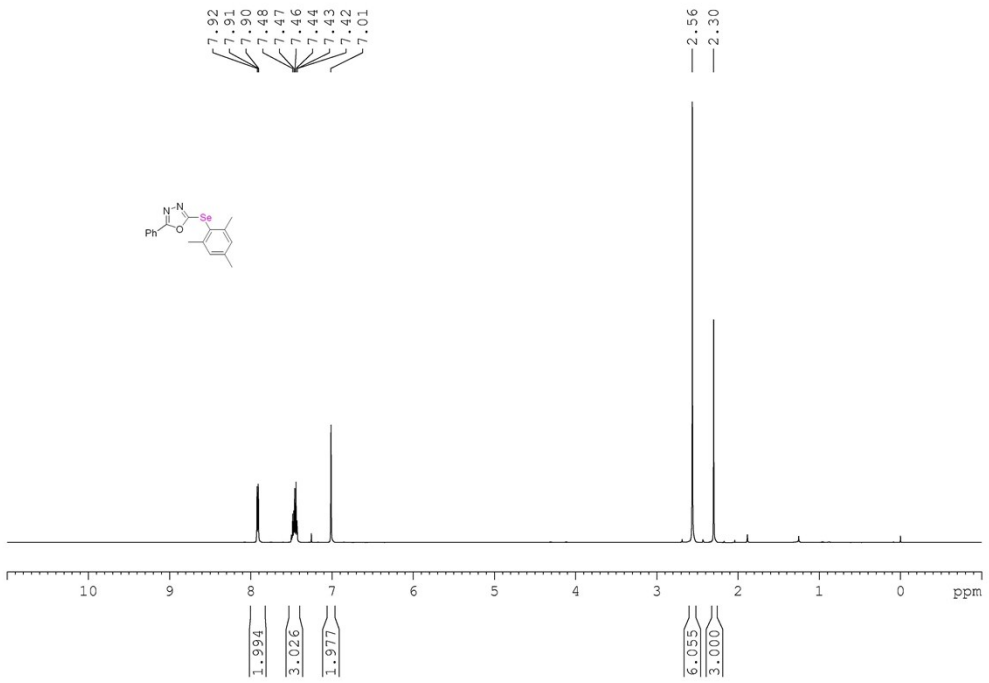
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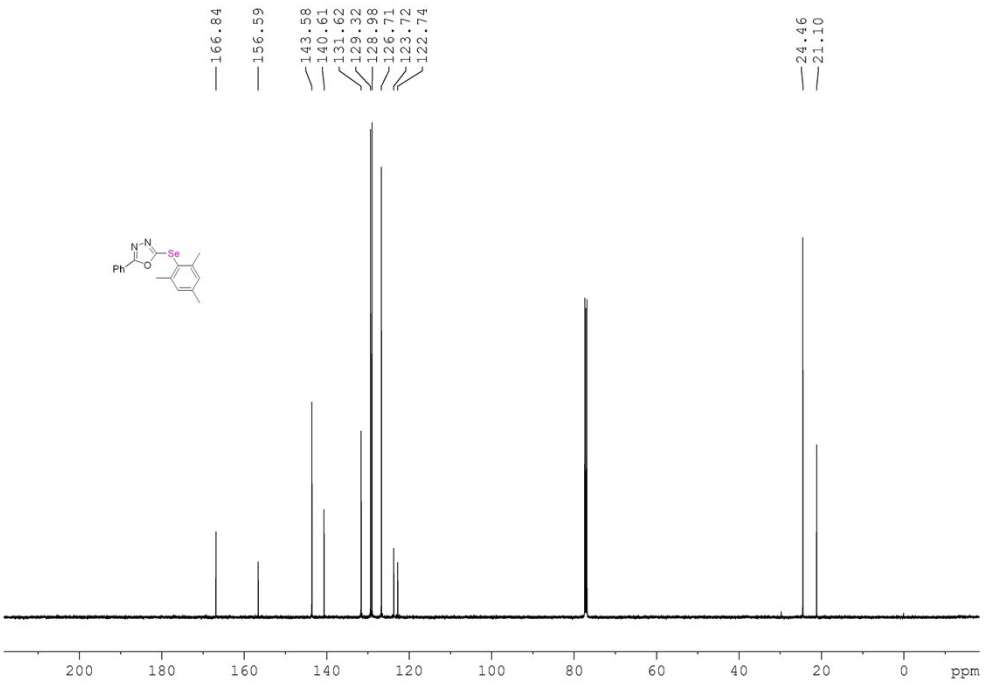
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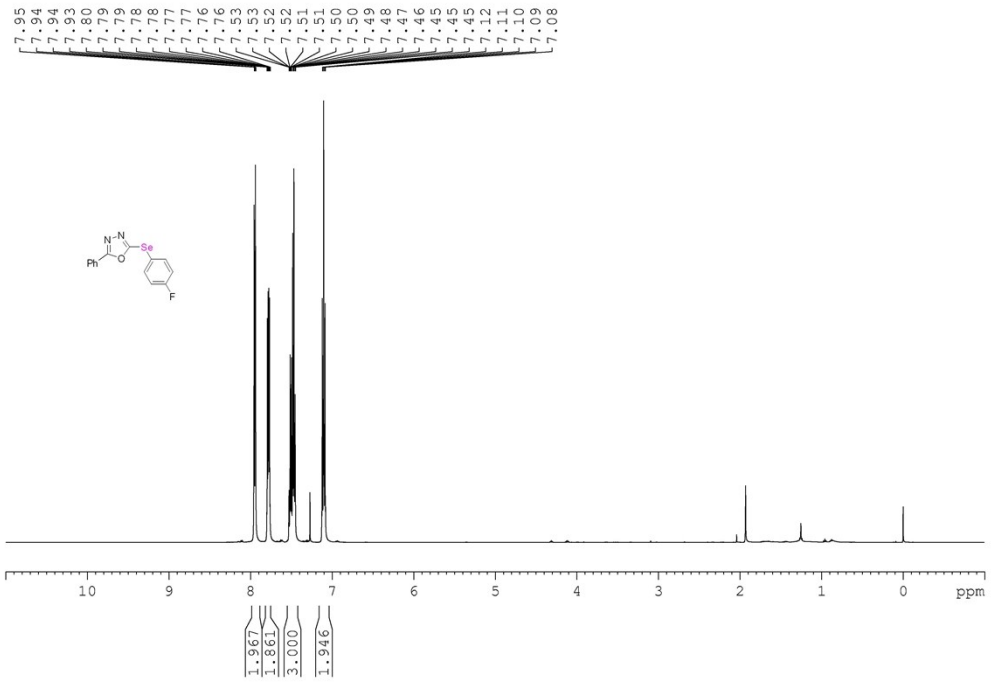
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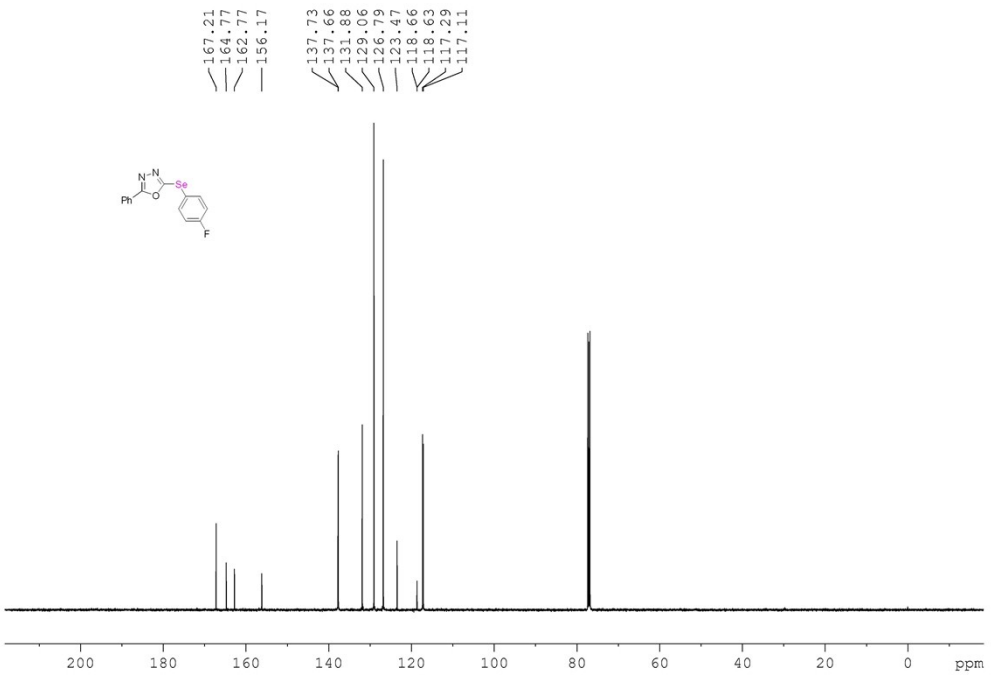
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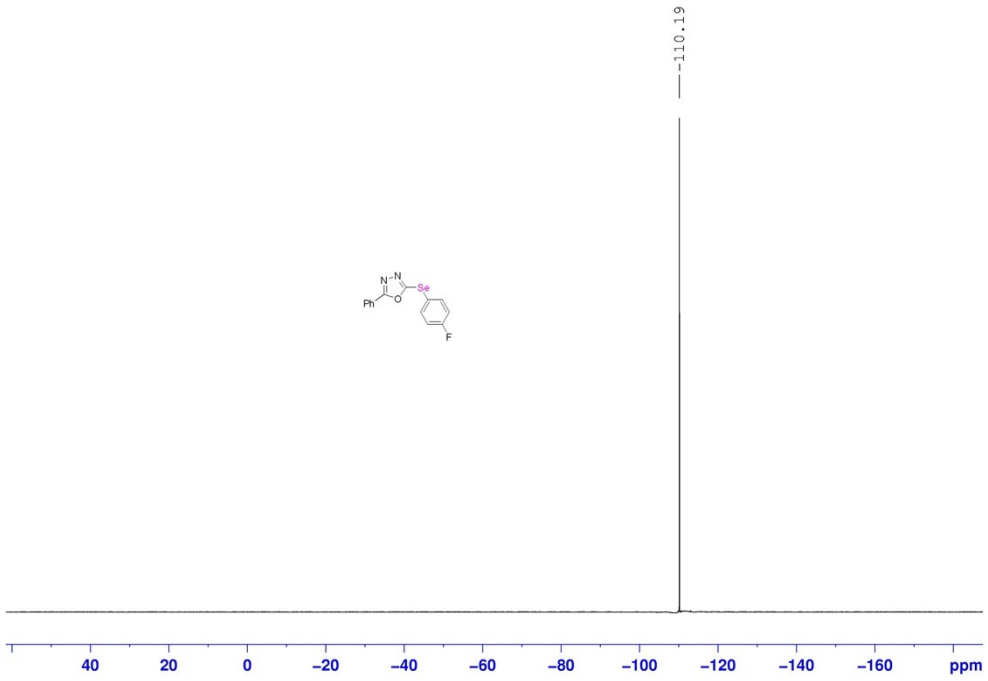
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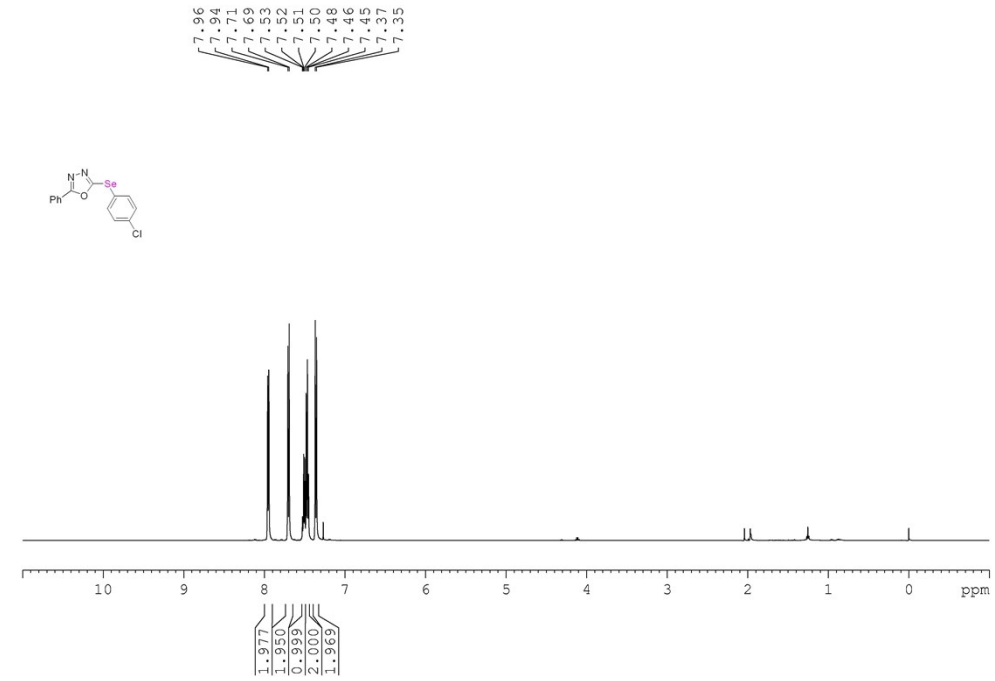
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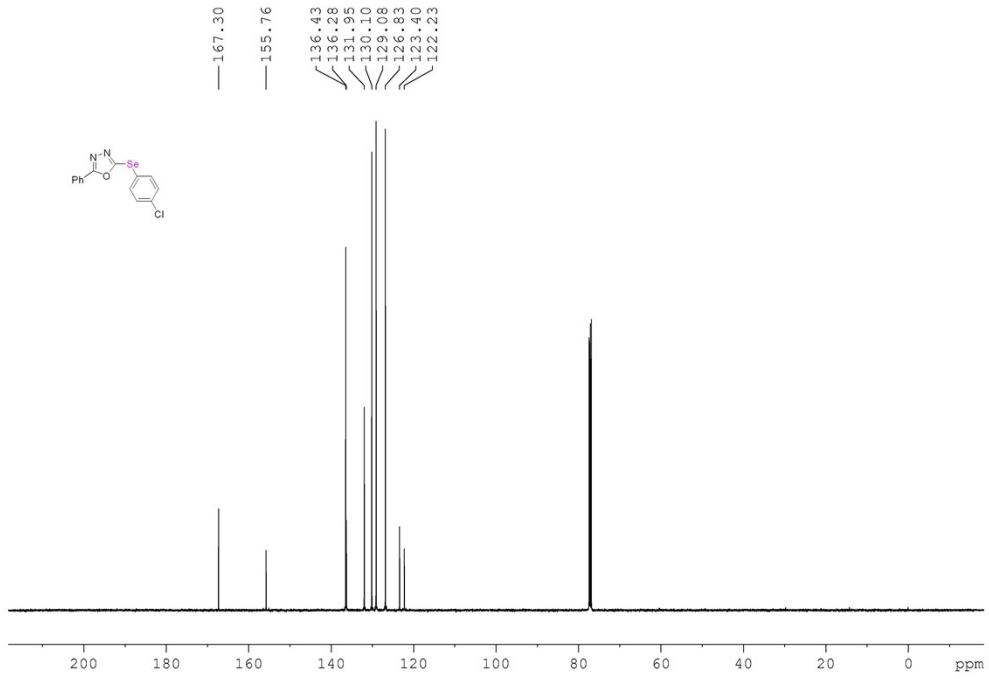
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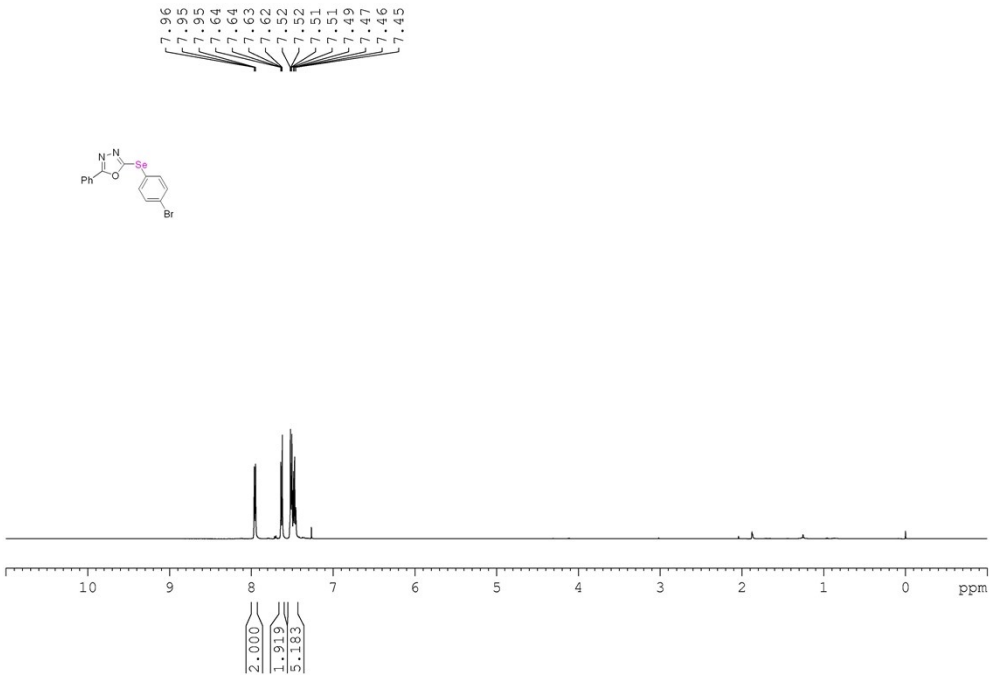
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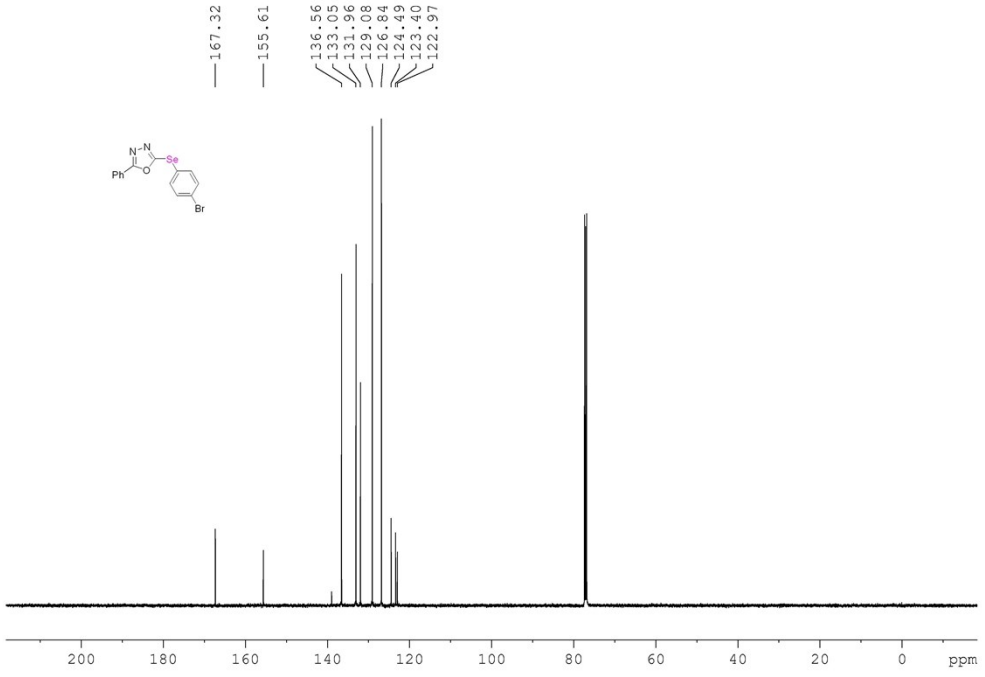
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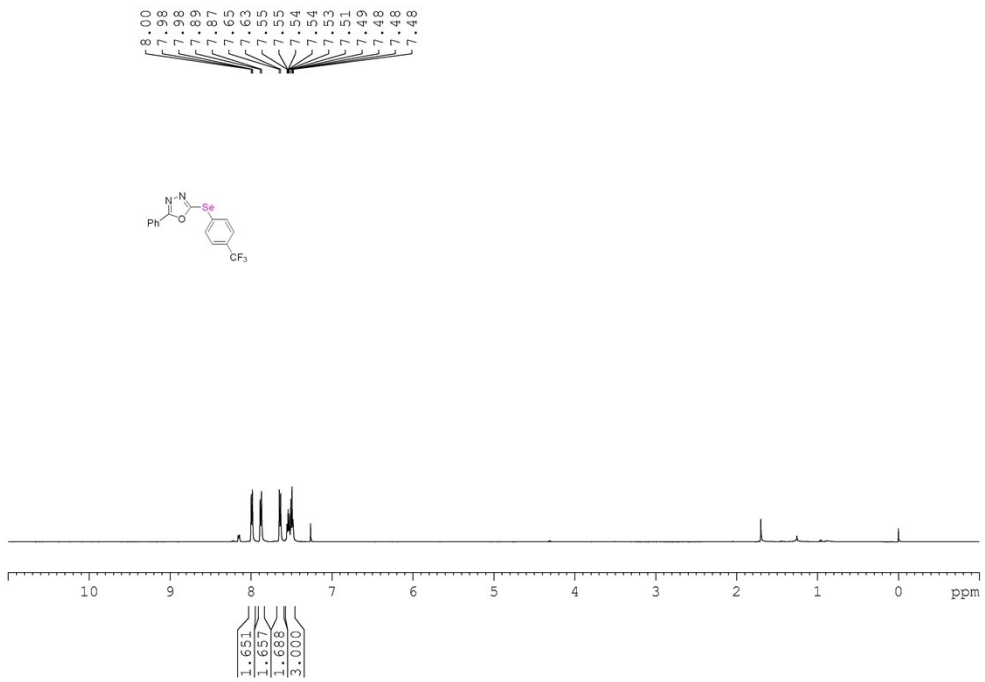
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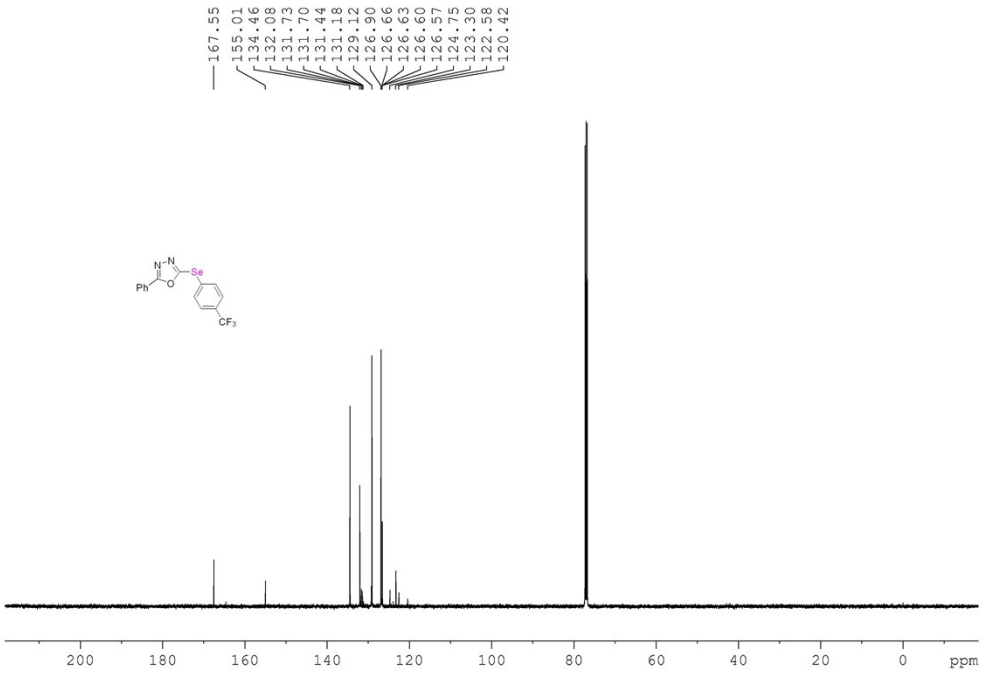
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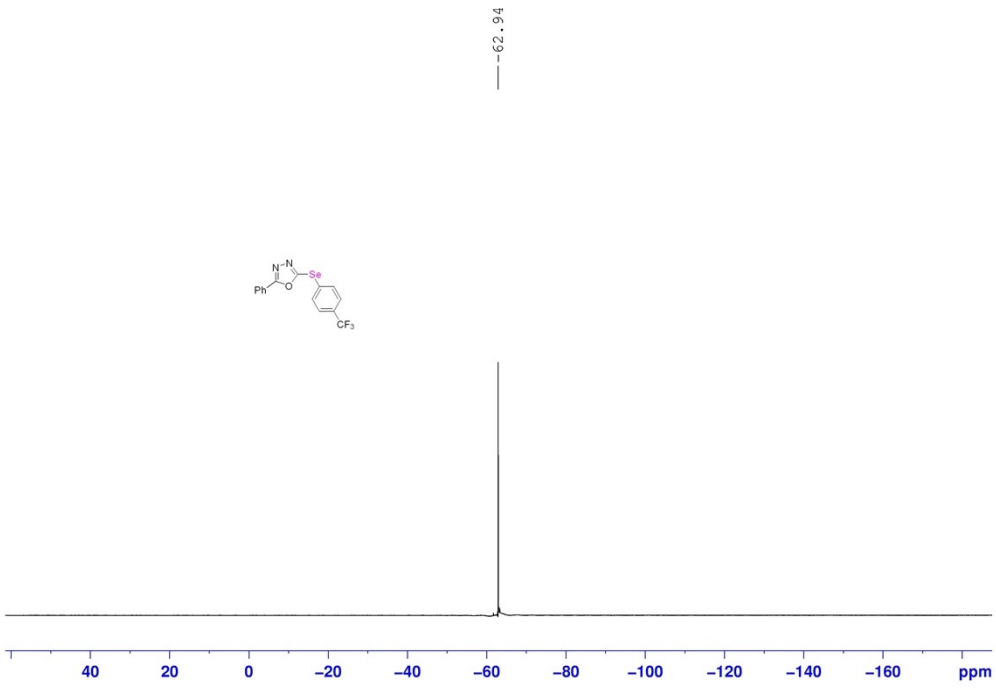
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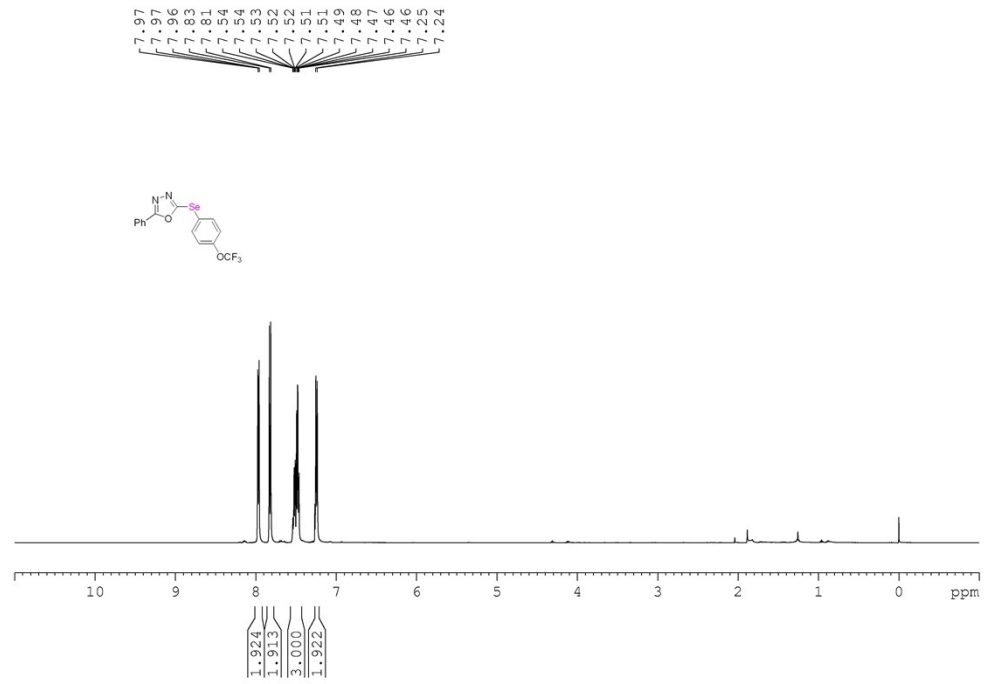
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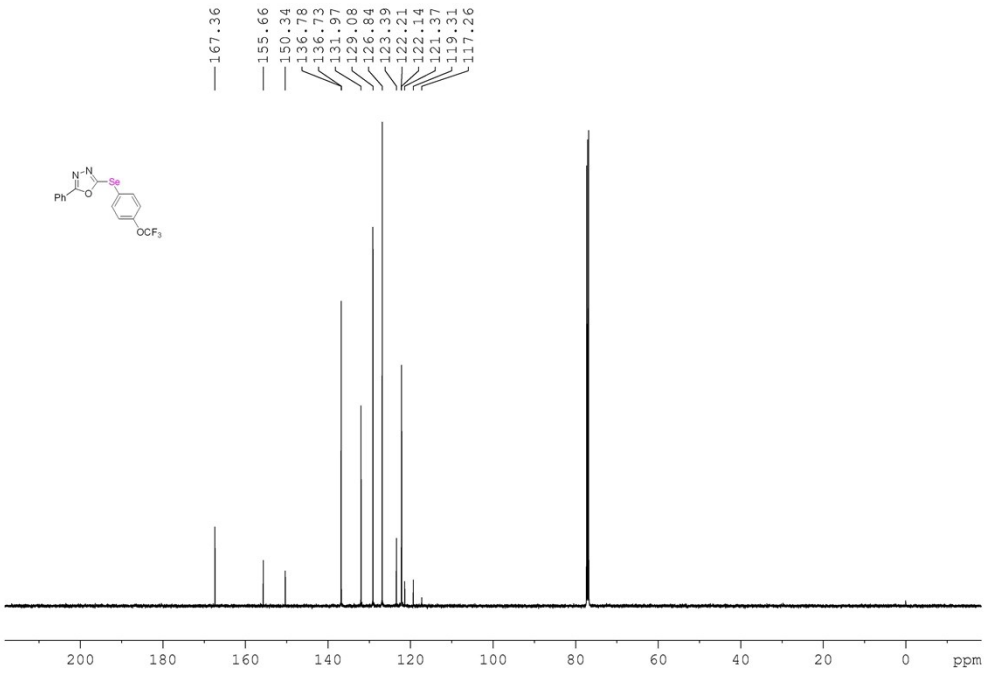
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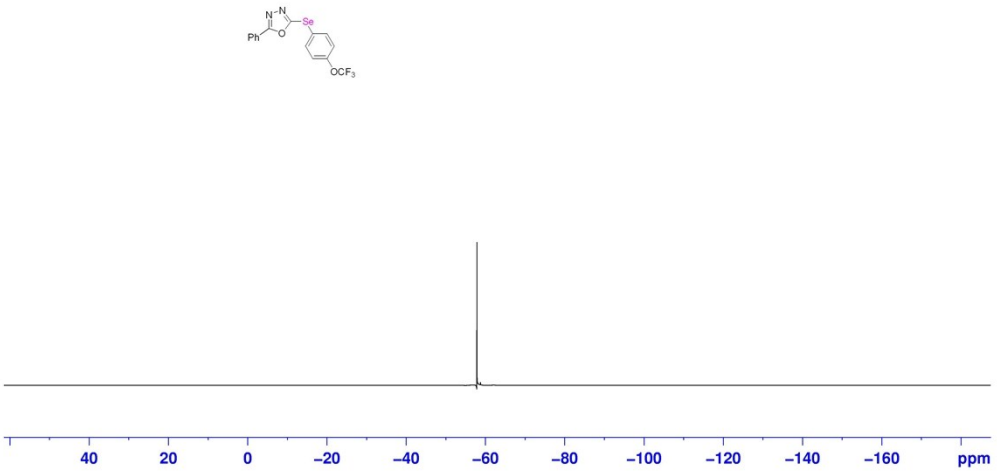
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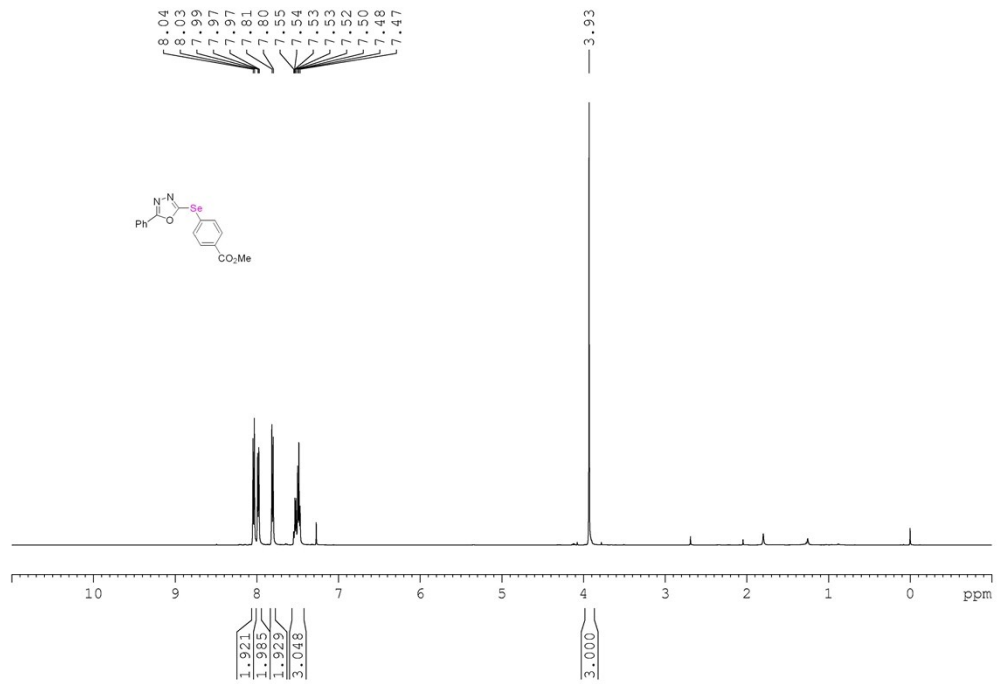
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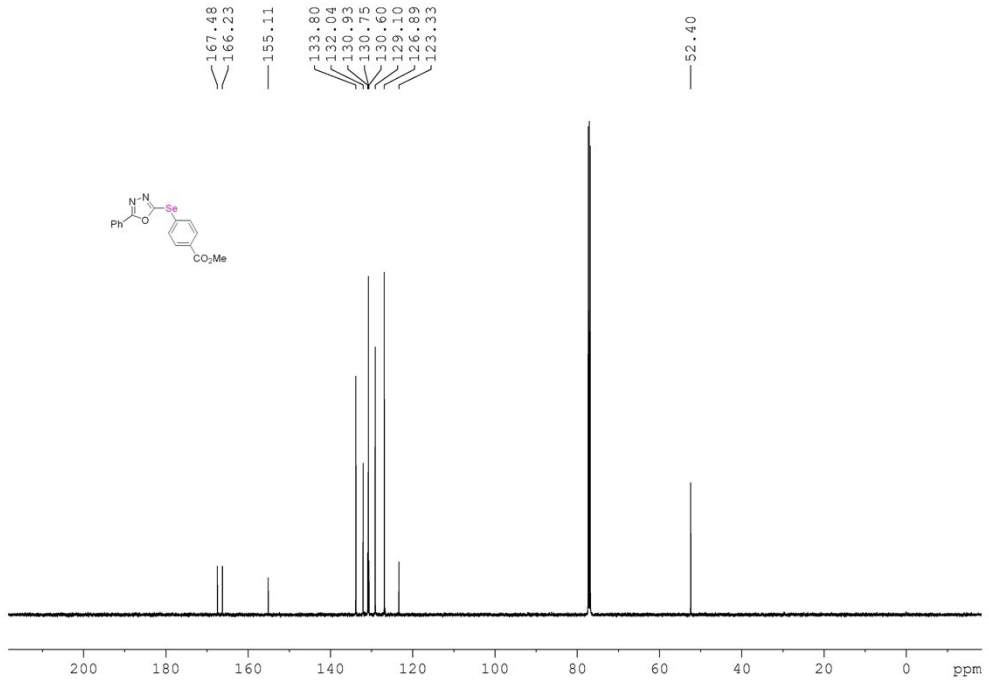
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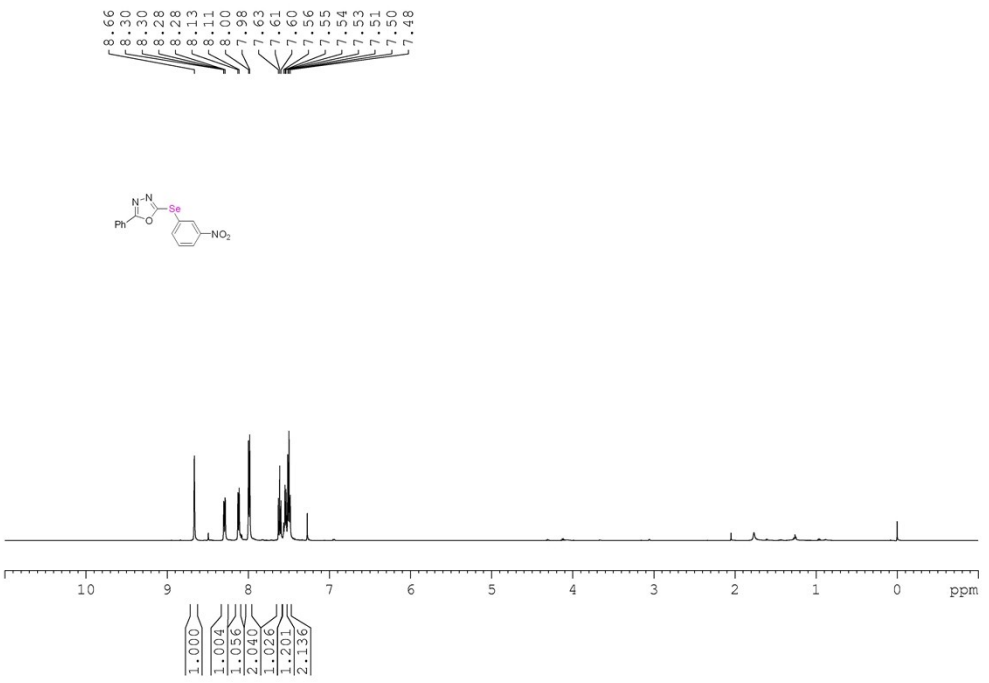
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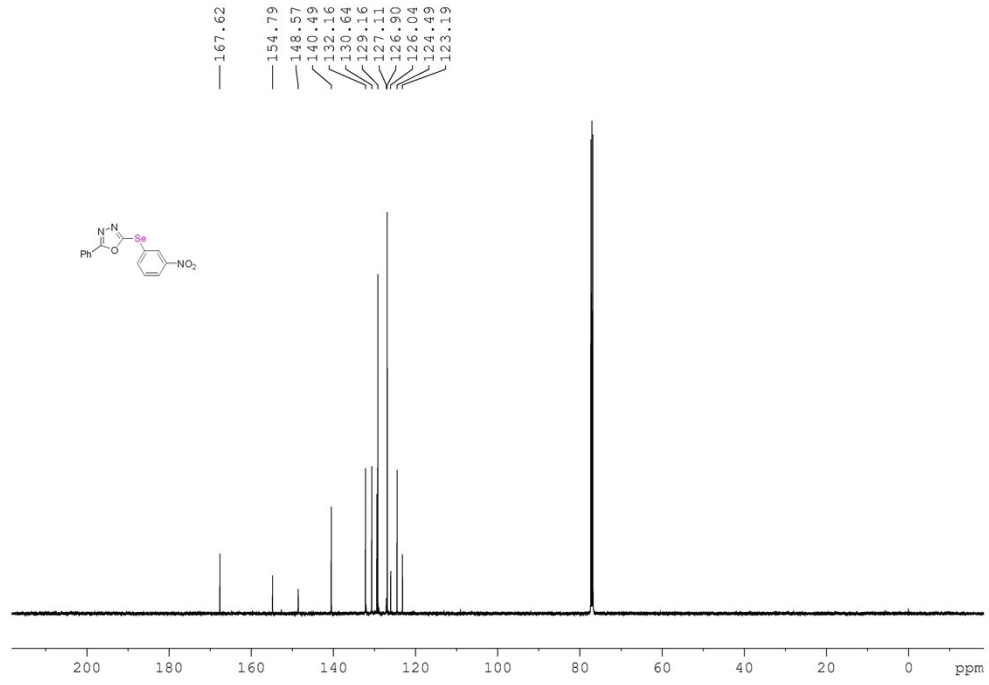
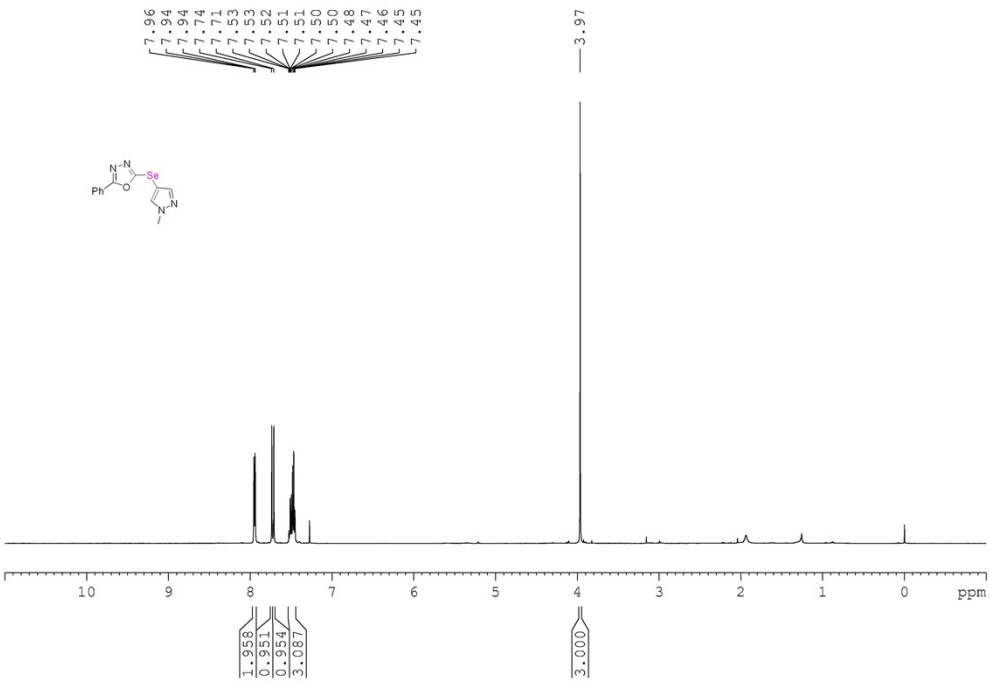
8.30
8.30
8.28
8.28
8.13
8.11
8.00
7.98
7.63
7.61
7.60
7.56
7.55
7.54
7.53
7.51
7.50
7.48
Ph
Se
NO2
10
9
8
7
6
5
4
3
2
1
0
ppm
1.000
1.004
1.056
2.040
1.026
1.201
2.136


167.62
154.79
148.57
140.49
132.16
130.64
129.16
127.11
126.90
126.04
124.49
123.19
Ph
Se
NO2
200
180
160
140
120
100
80
60
40
20
0
ppm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7.94
7.94
7.74
7.71
7.53
7.52
7.51
7.51
7.50
7.50
7.48
7.47
7.46
7.45
7.45
3.97
Ph
Se
N
10
9
8
7
6
5
4
3
2
1
0
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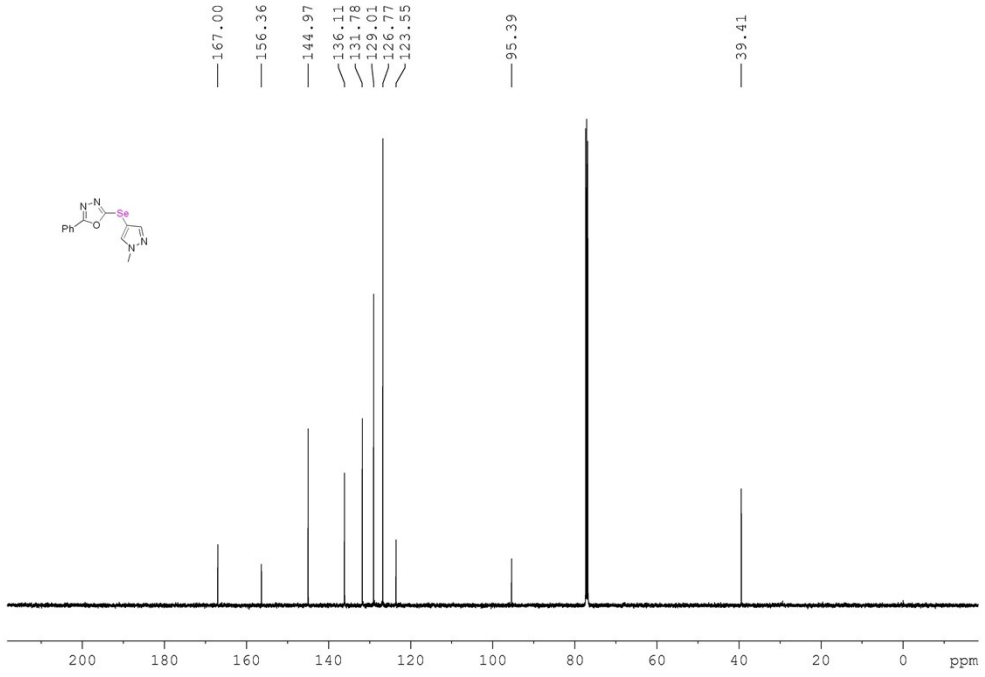
0.954
3.087
3.000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144.97
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129.01
126.77
123.55
95.39
39.41
Ph
Se
N
O
N
N
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160
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120
100
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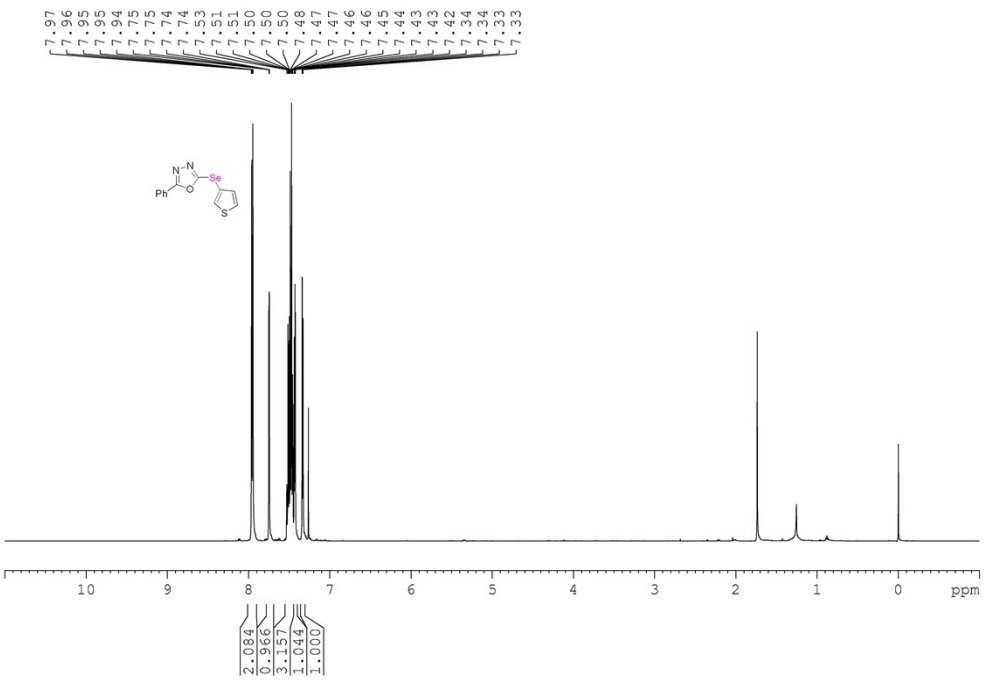
60
40
20
0
ppm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7.96
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7.75
7.75
7.74
7.74
7.53
7.51
7.51
7.50
7.50
7.50
7.48
7.47
7.47
7.46
7.46
7.45
7.44
7.43
7.43
7.42
7.34
7.34
7.33
7.33
Ph
Se
N
O
S
10
9
8
7
6
5
4
3
2
1
0
ppm
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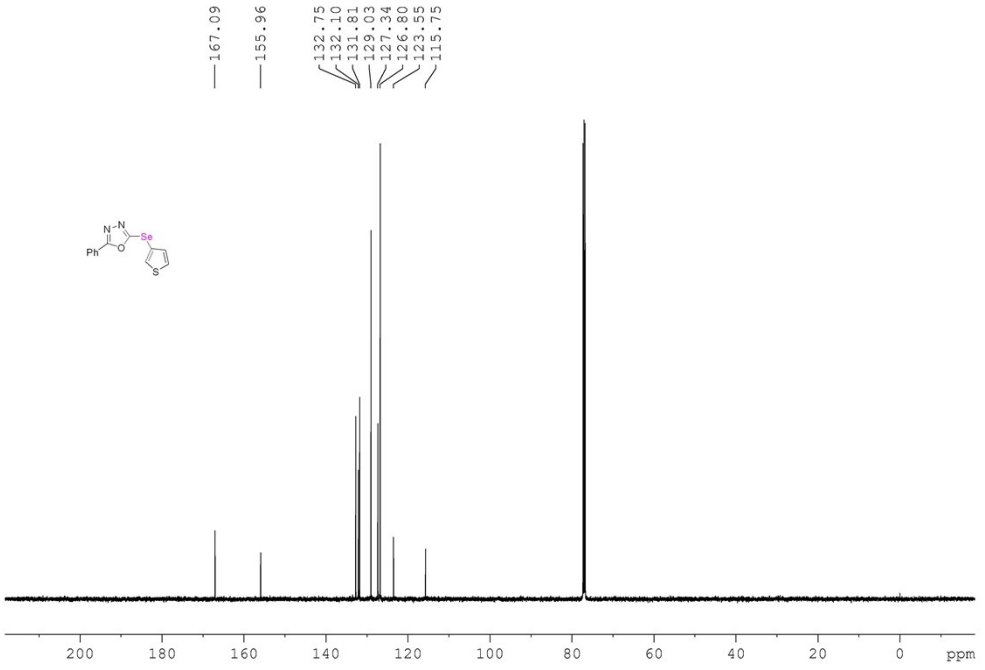
0.966
3.157
1.044
1.000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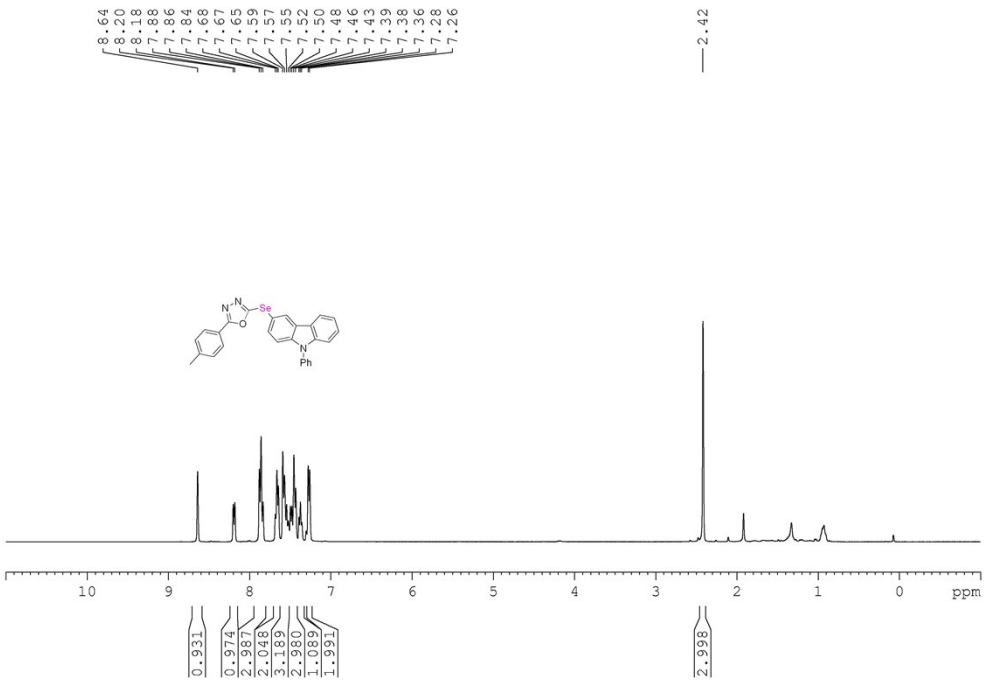
155.96
132.75
132.10
131.81
129.03
127.34
126.80
123.55
115.75
Ph
Se
S
200
180
160
140
120
100
80
60
40
20
0
ppm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8.20
8.18
7.88
7.86
7.84
7.68
7.67
7.65
7.59
7.57
7.55
7.52
7.50
7.48
7.46
7.43
7.39
7.38
7.36
7.28
7.26
2.42
Se
N
Ph
10
9
8
7
6
5
4
3
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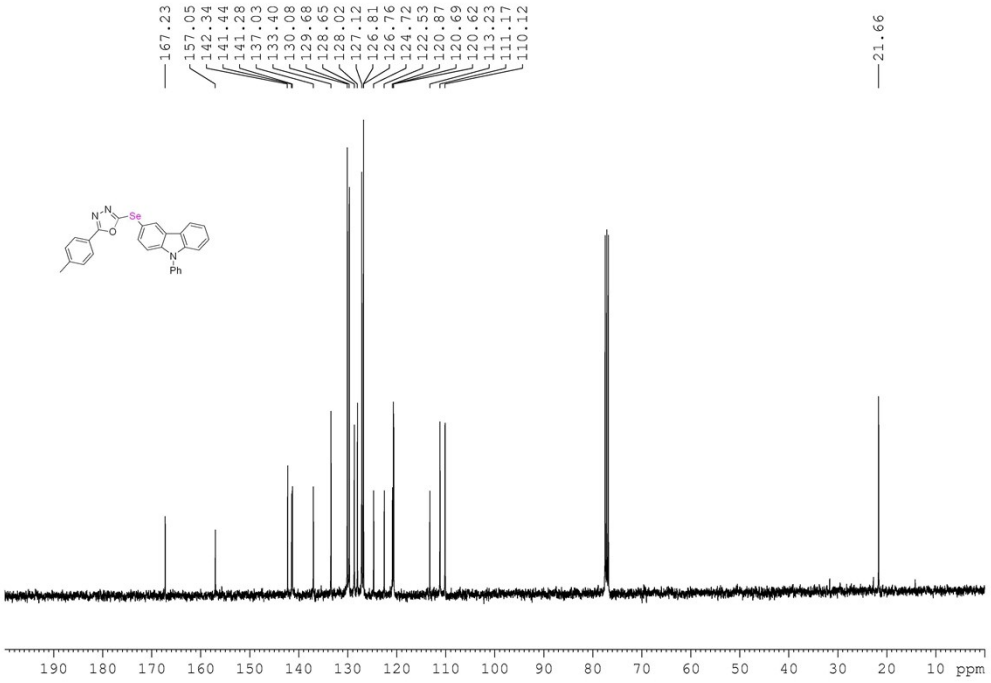
3.189
2.980
1.089
1.991
2.998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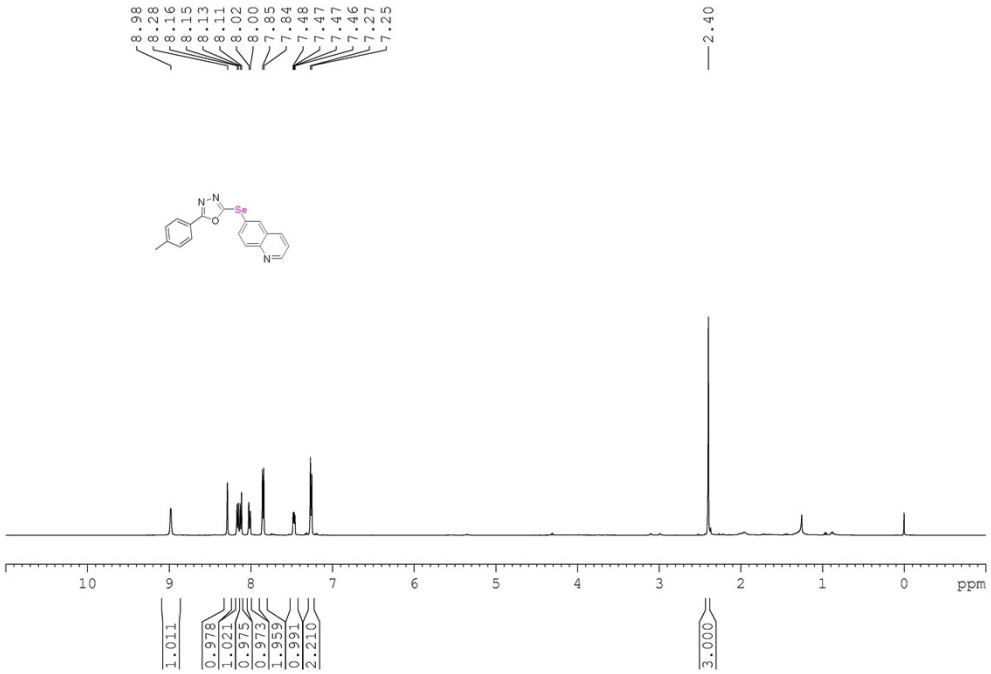
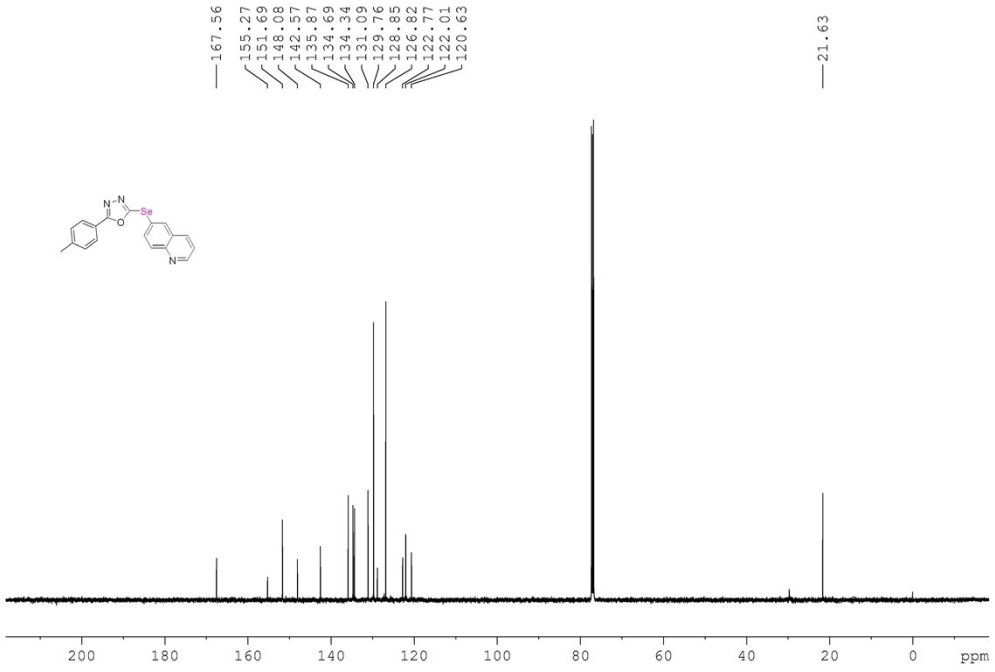
157.05
142.34
141.44
141.28
137.03
133.40
130.08
129.68
128.65
128.02
127.12
126.81
126.76
124.72
122.53
120.87
120.69
120.62
113.23
111.17
110.12
21.66
Se
N
O
Ph
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm


8.98
8.28
8.16
8.15
8.13
8.11
8.02
8.00
7.85
7.84
7.48
7.47
7.47
7.46
7.27
7.25
2.40
Se
N
O
N
10 9 8 7 6 5 4 3 2 1 0 ppm
1.011
0.978
1.021
0.975
0.973
1.959
0.991
2.210
3.000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155.27
151.69
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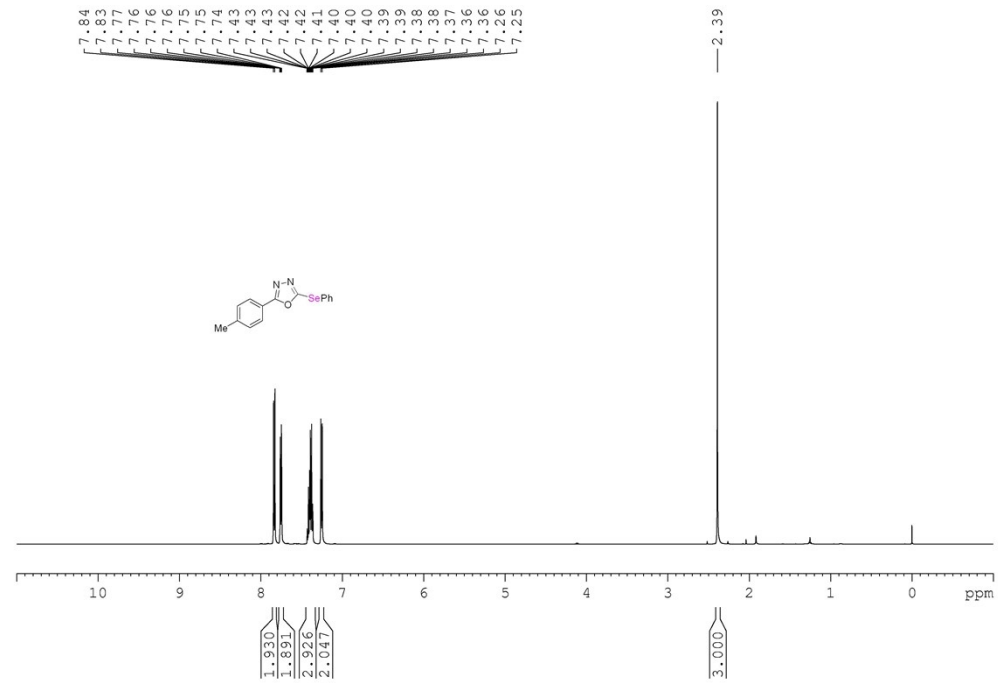
142.57
135.87
134.69
134.34
131.09
129.76
128.85
126.82
122.77
122.01
120.63
21.63
Se
N
N
O
200
180
160
140
120
100
80
60
40
20
0
ppm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7.83
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7.76
7.76
7.76
7.75
7.75
7.74
7.43
7.43
7.42
7.42
7.41
7.40
7.40
7.40
7.39
7.39
7.38
7.38
7.37
7.36
7.36
7.26
7.25
2.39
SePh
Me
N
N
O
10
9
8
7
6
5
4
3
2
1
0
ppm
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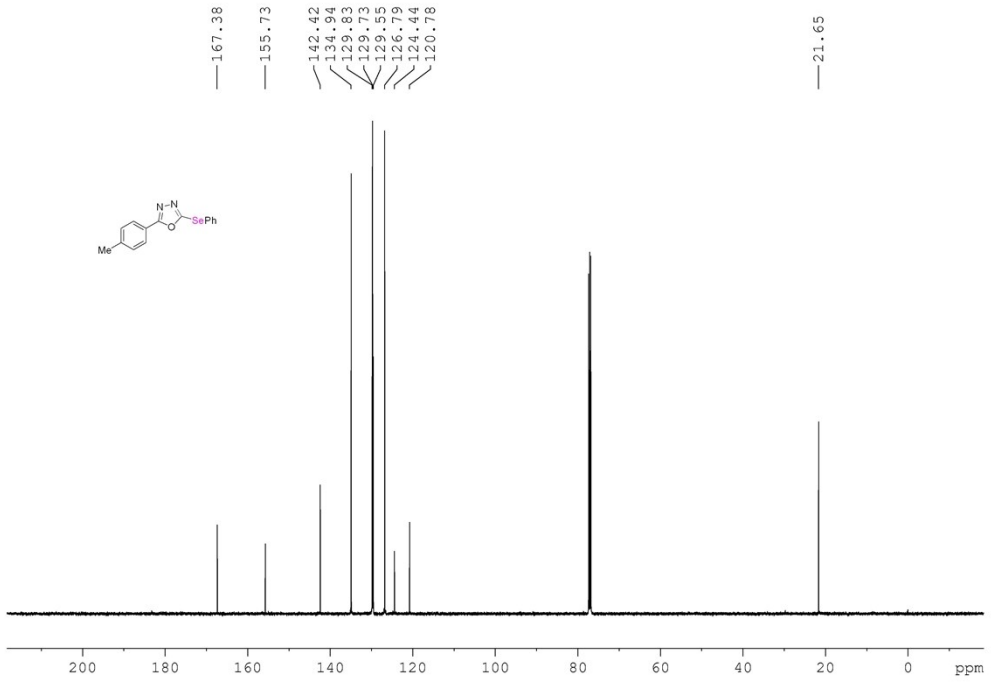
1.891
2.926
2.047
3.000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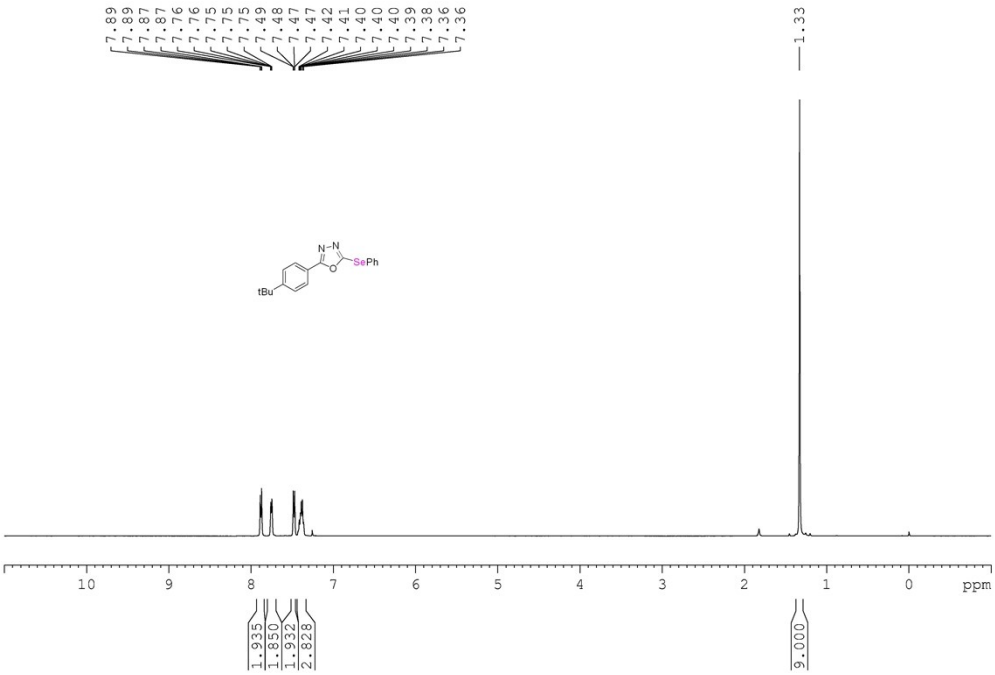
155.73
142.42
134.94
129.83
129.73
129.55
126.79
124.44
120.78
21.65
N
N
O
SePh
Me
200
180
160
140
120
100
80
60
40
20
0
ppm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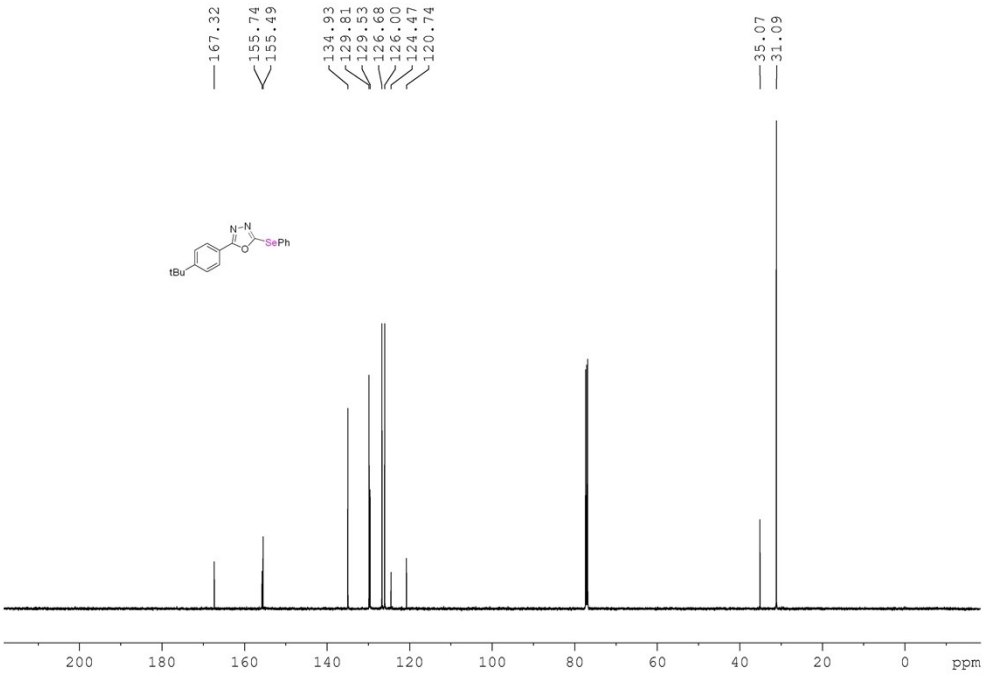
7.89
7.87
7.87
7.76
7.76
7.75
7.75
7.75
7.49
7.48
7.47
7.47
7.42
7.41
7.40
7.40
7.40
7.39
7.38
7.36
7.36
1.33
N
N
O
SePh
tBu
10
9
8
7
6
5
4
3
2
1
0
ppm
1.935
1.850
1.932
2.828
9.000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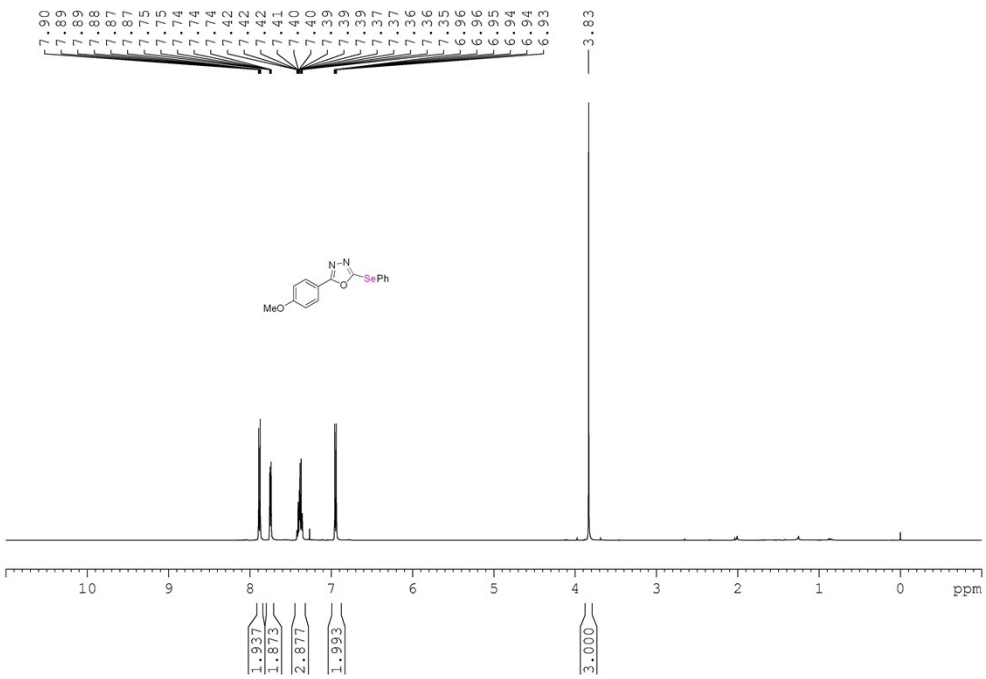
155.74
155.49
134.93
129.81
129.53
126.68
126.00
124.47
120.74
35.07
31.09
N-N
SePh
tBu
200
180
160
140
120
100
80
60
40
20
0
ppm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7.89
7.89
7.88
7.87
7.87
7.75
7.75
7.74
7.74
7.74
7.42
7.42
7.41
7.40
7.40
7.39
7.39
7.39
7.37
7.37
7.36
7.36
7.35
6.96
6.96
6.95
6.94
6.94
6.93
3.83
N-N
SePh
MeO
10
9
8
7
6
5
4
3
2
1
0
ppm
1.937
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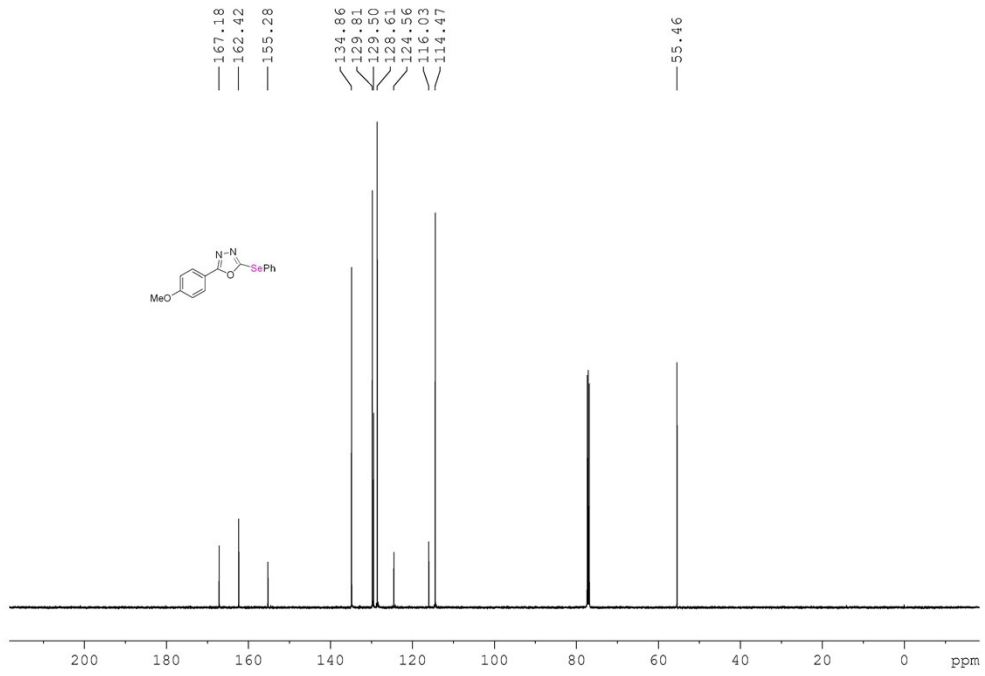
2.877
1.993
3.000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162.42
155.28
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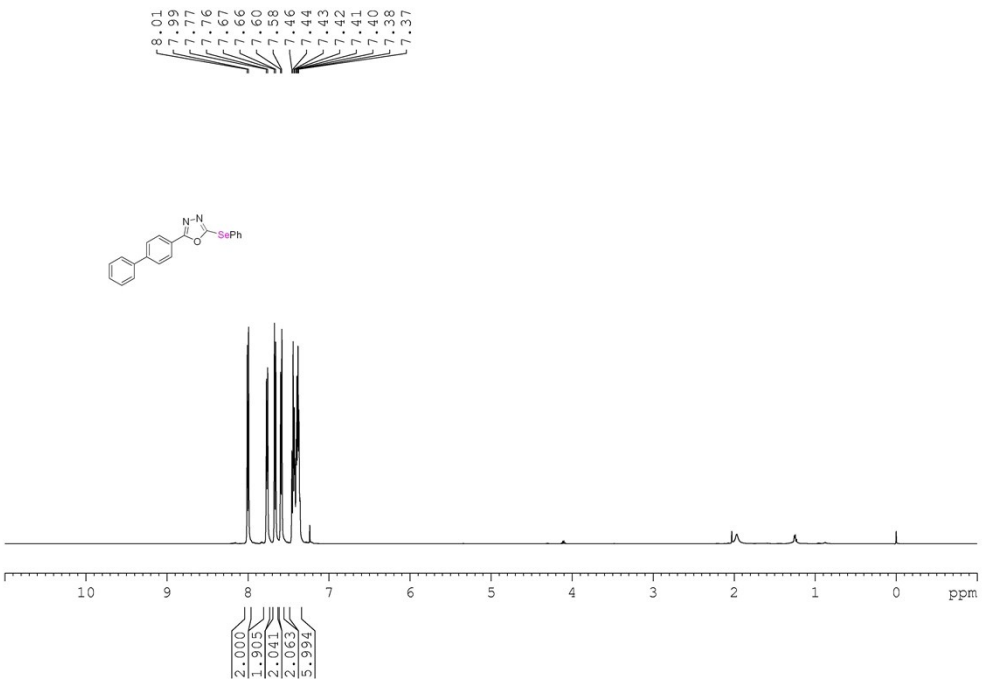
129.81
129.50
128.61
124.56
116.03
114.47
55.46
N
N
O
SePh
MeO
200
180
160
140
120
100
80
60
40
20
0
ppm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7.99
7.77
7.76
7.67
7.66
7.60
7.58
7.46
7.44
7.43
7.42
7.41
7.40
7.38
7.37
N
N
O
SePh
10
9
8
7
6
5
4
3
2
1
0
ppm
2.000
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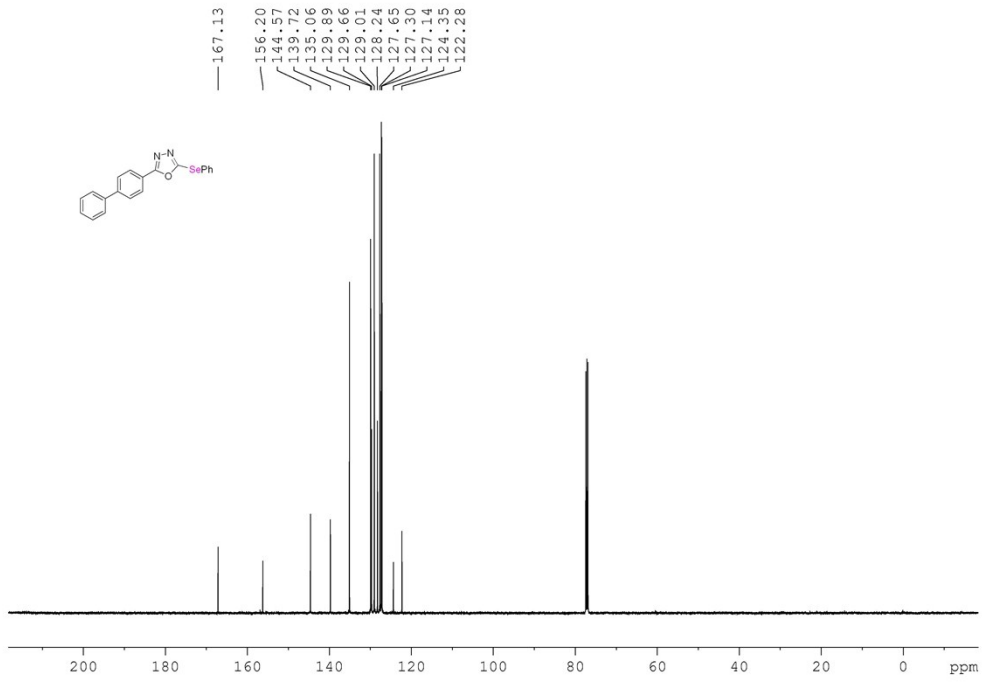
2.041
2.063
5.994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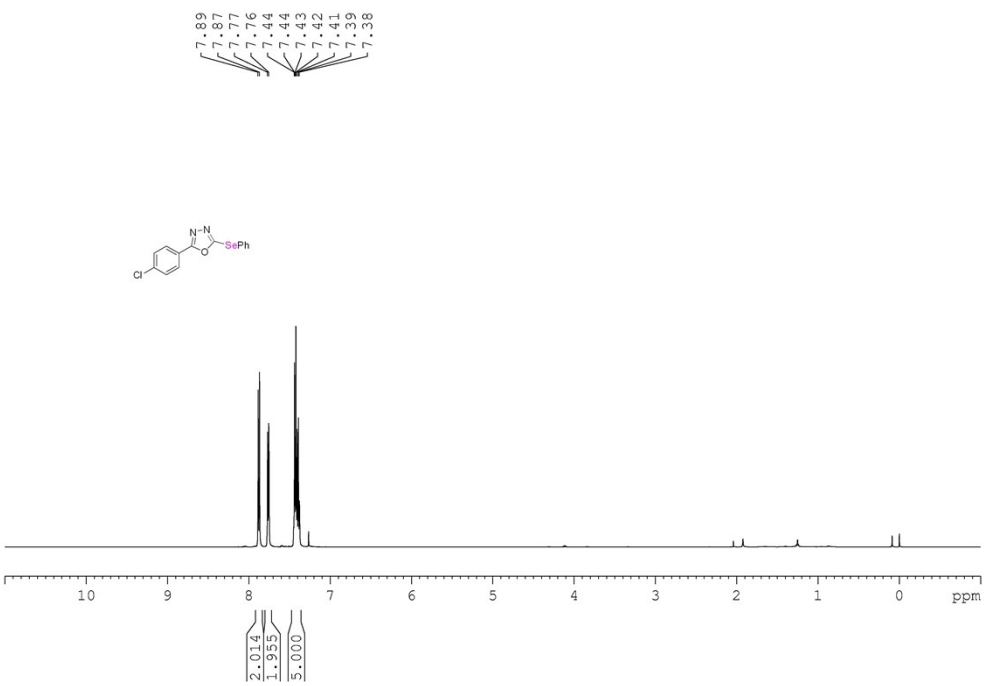
156.20
144.57
139.72
135.06
129.89
129.66
129.01
128.24
127.65
127.30
127.14
124.35
122.28
N
N
O
SePh
200
180
160
140
120
100
80
60
40
20
0
ppm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7.87
7.77
7.76
7.44
7.44
7.43
7.42
7.41
7.39
7.38
N
N
O
SePh
Cl
10
9
8
7
6
5
4
3
2
1
0
ppm
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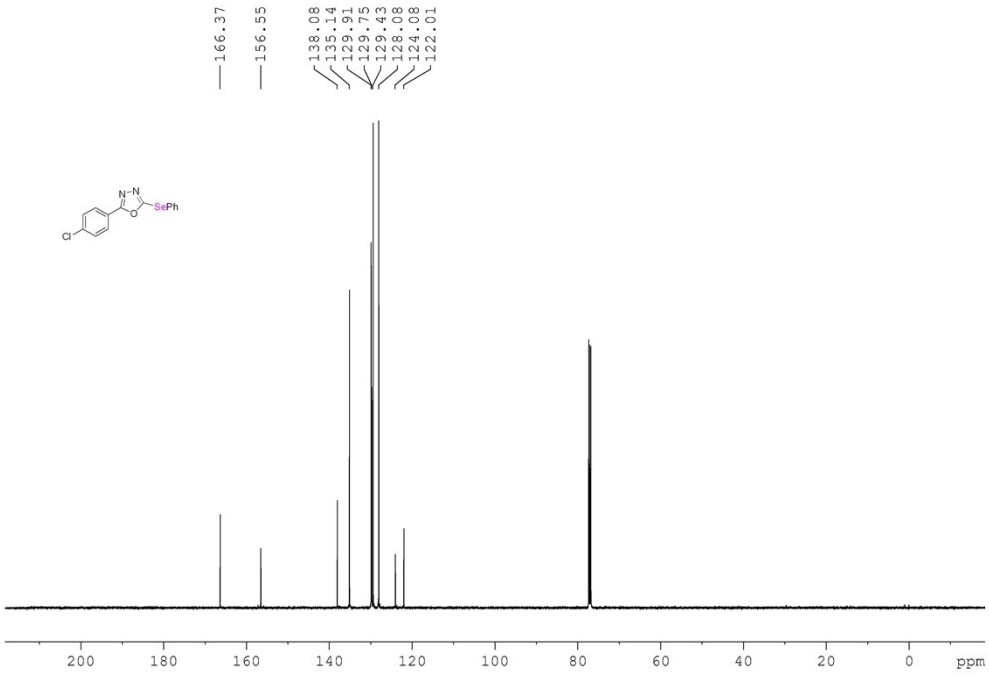
1.955
5.000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156.55
138.08
135.14
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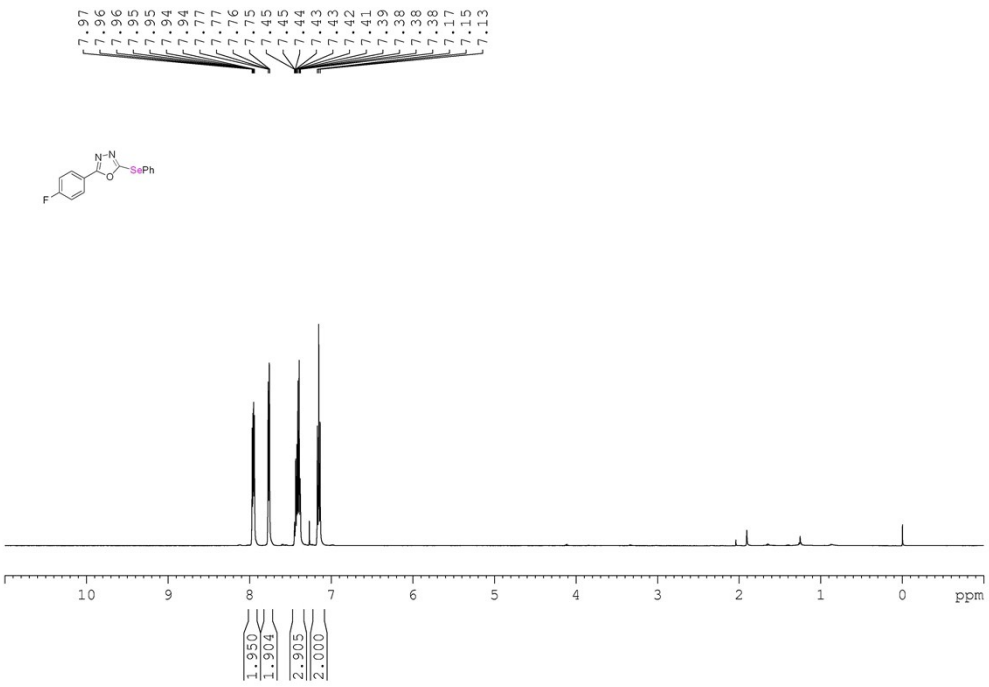
129.43
128.08
124.08
122.01
N
N
O
SePh
Cl
200
180
160
140
120
100
80
60
40
20
0
ppm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7.94
7.94
7.77
7.77
7.76
7.75
7.45
7.45
7.44
7.43
7.43
7.42
7.41
7.39
7.38
7.38
7.38
7.17
7.15
7.13
N
N
O
SePh
F
10
9
8
7
6
5
4
3
2
1
0
ppm
1.950
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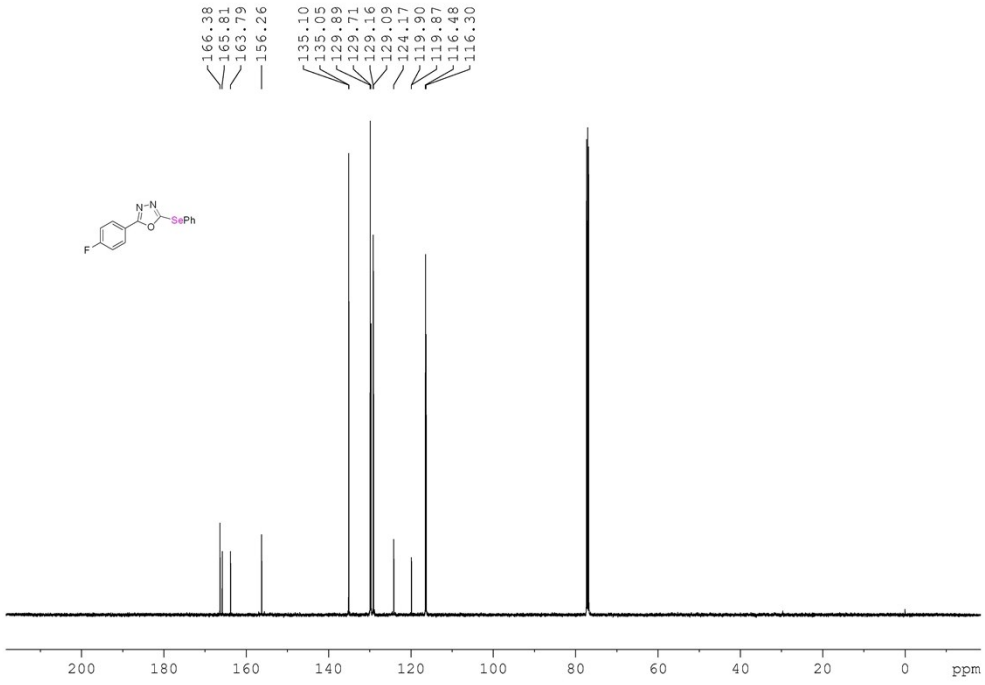
2.905
2.000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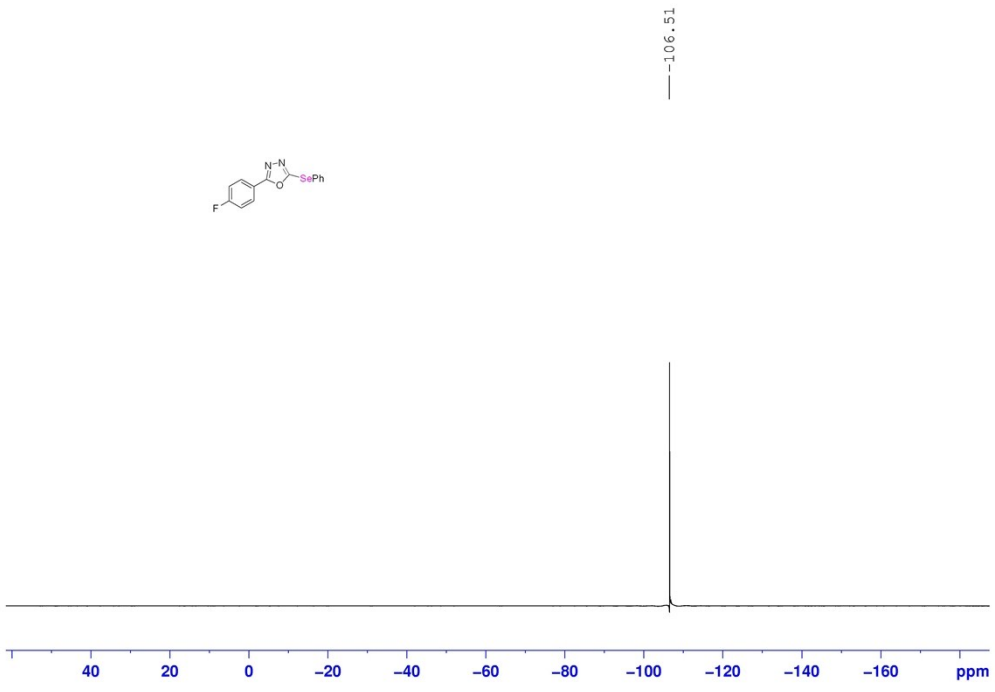
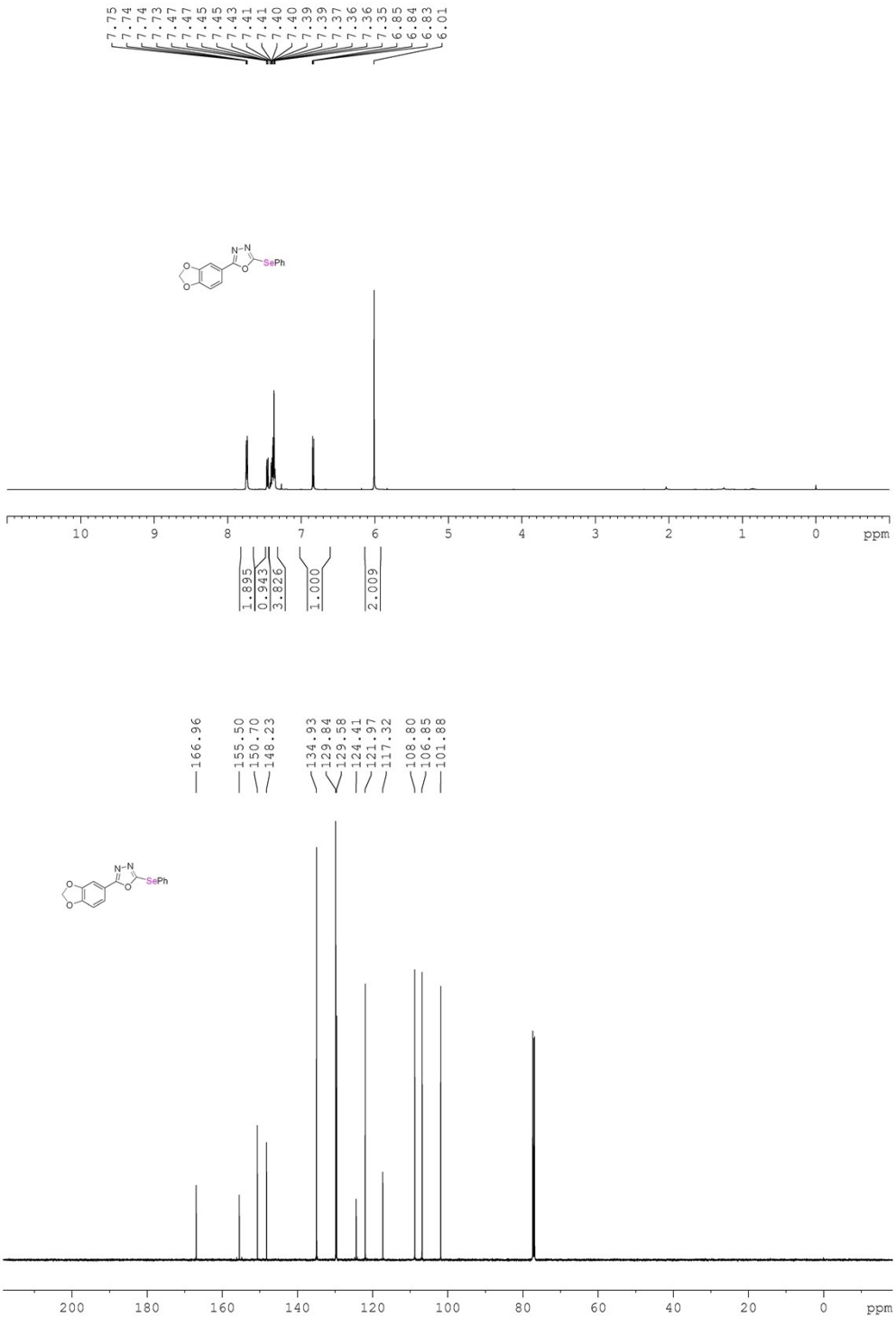
165.81
163.79
156.26
135.10
135.05
129.89
129.71
129.16
129.09
124.17
119.90
119.87
116.48
116.30
N
N
O
SePh
F
200
180
160
140
120
100
80
60
40
20
0
ppm


-106.51
N
N
O
SePh
F
40
20
0
−20
−40
−60
−80
−100
−120
−140
−160
ppm


7.75
7.74
7.74
7.73
7.47
7.47
7.45
7.45
7.43
7.41
7.41
7.40
7.40
7.39
7.39
7.37
7.36
7.36
7.35
6.85
6.84
6.83
6.01
SePh
10
9
8
7
6
5
4
3
2
1
0
ppm
1.895
0.943
3.826
1.000
2.009
166.96
155.50
150.70
148.23
134.93
129.84
129.58
124.41
121.97
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101.88
SePh
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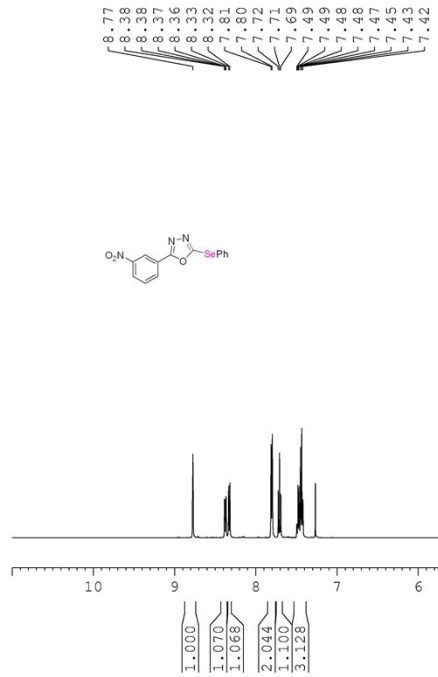
160
140
120
100
80
60
40
20
0
ppm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8.38
8.37
8.36
8.33
8.32
7.81
7.80
7.72
7.71
7.69
7.49
7.49
7.48
7.48
7.47
7.45
7.43
7.42
SePh
10
9
8
7
6
5
4
3
2
1
0
ppm
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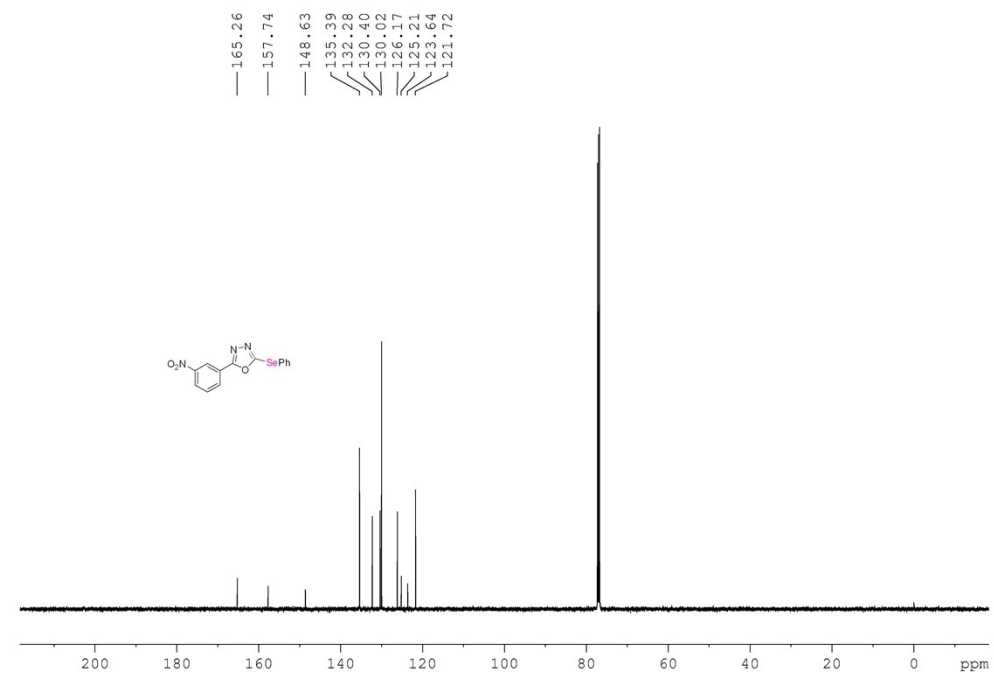
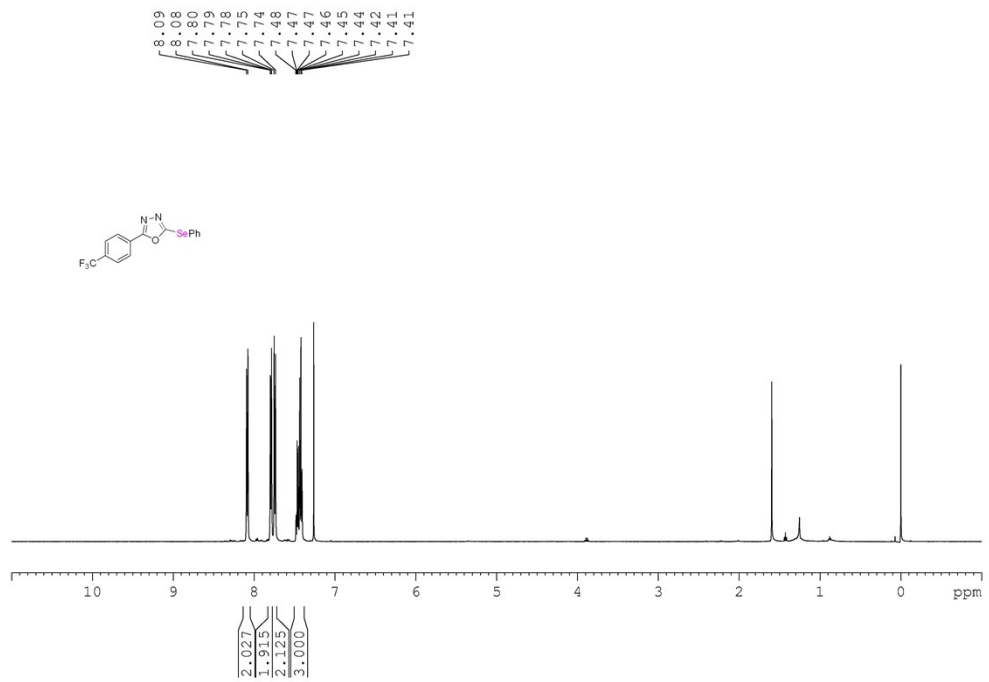
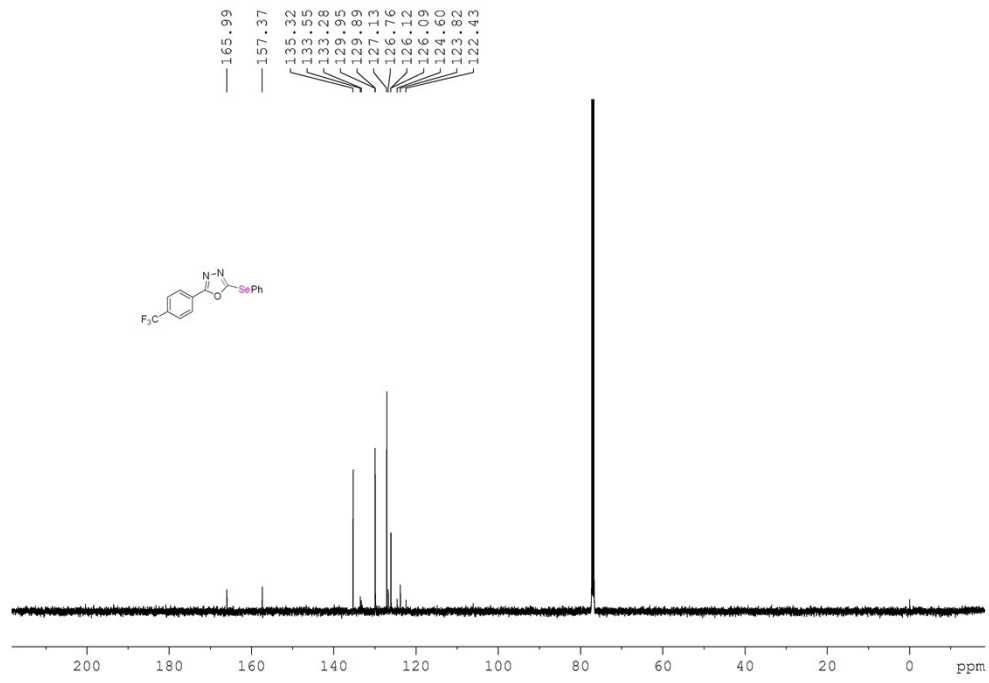
1.070
1.068
2.044
1.100
3.128


165.26
157.74
148.63
135.39
132.28
130.40
130.02
126.17
125.21
123.64
121.72
SePh
200
180
160
140
120
100
80
60
40
20
0
ppm


8.09
8.08
7.80
7.79
7.78
7.75
7.74
7.48
7.47
7.47
7.46
7.45
7.44
7.42
7.41
7.41
SePh
F3C
10
9
8
7
6
5
4
3
2
1
0
ppm
2.027
1.915
2.125
3.000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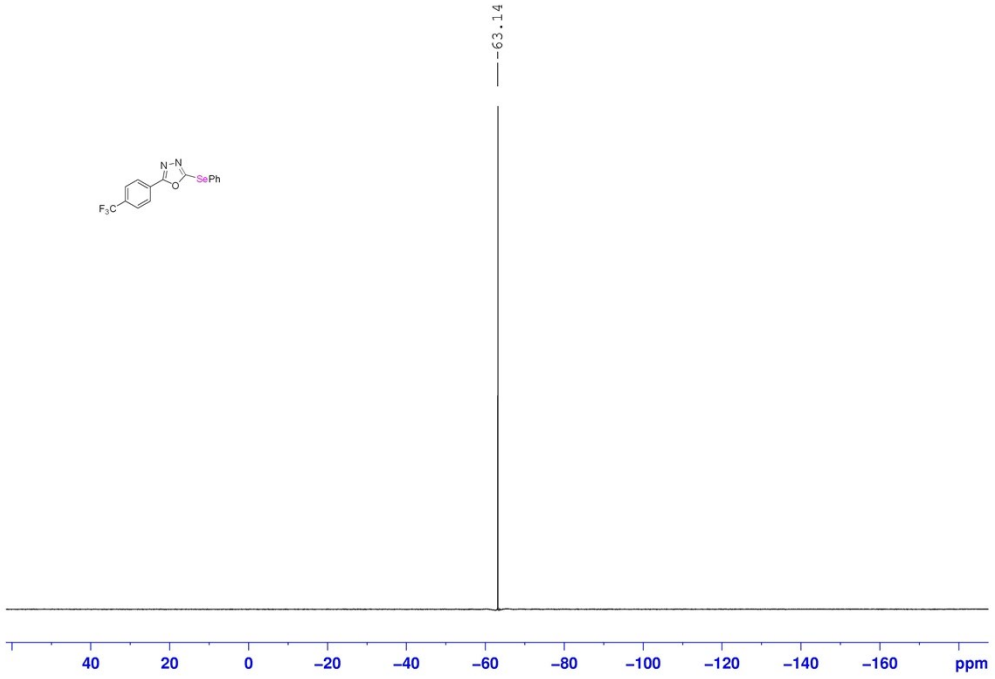
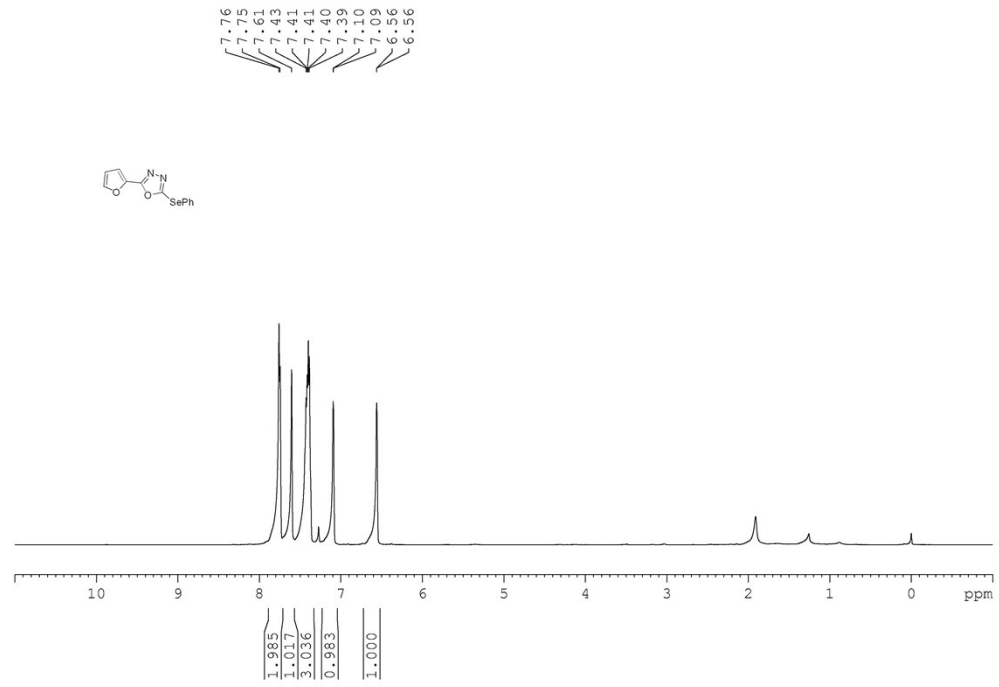
157.37
135.32
133.55
133.28
129.95
129.89
127.13
126.76
126.12
126.09
124.60
123.82
122.43
SePh
F3C
200
180
160
140
120
100
80
60
40
20
0
ppm


-63.14
SePh
F3C
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
ppm


7.76
7.75
7.61
7.43
7.41
7.40
7.39
7.10
7.09
6.56
6.56
SePh
10
9
8
7
6
5
4
3
2
1
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ppm
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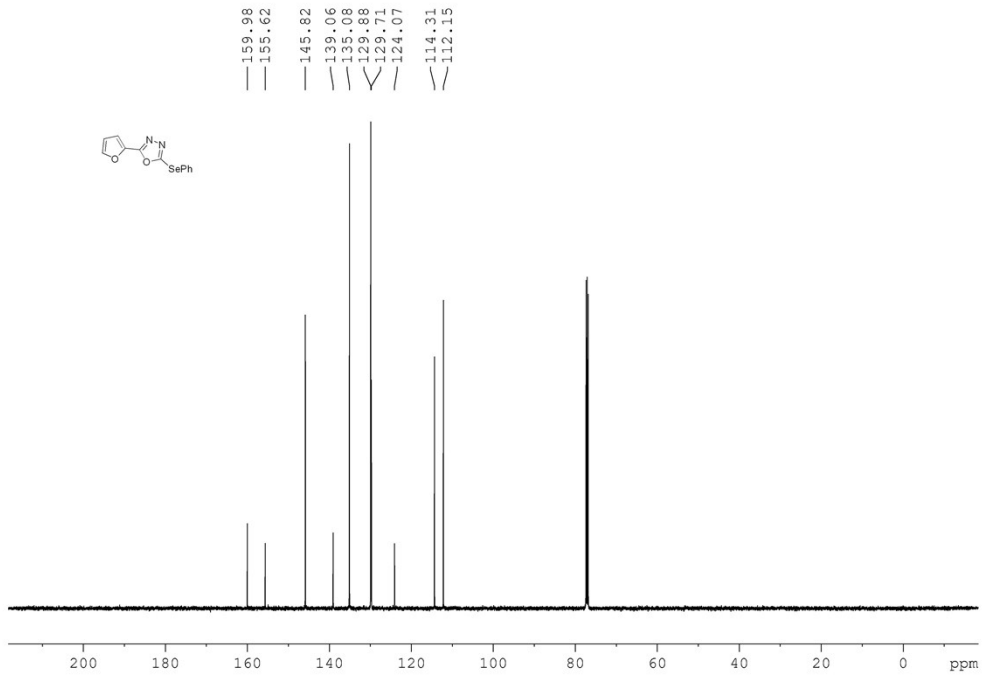
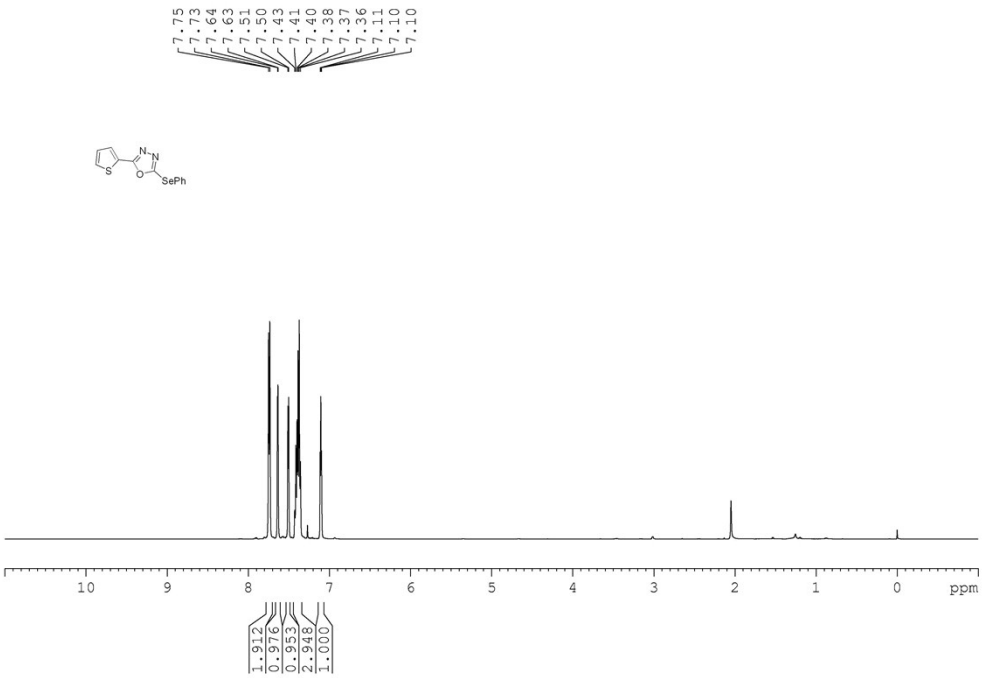
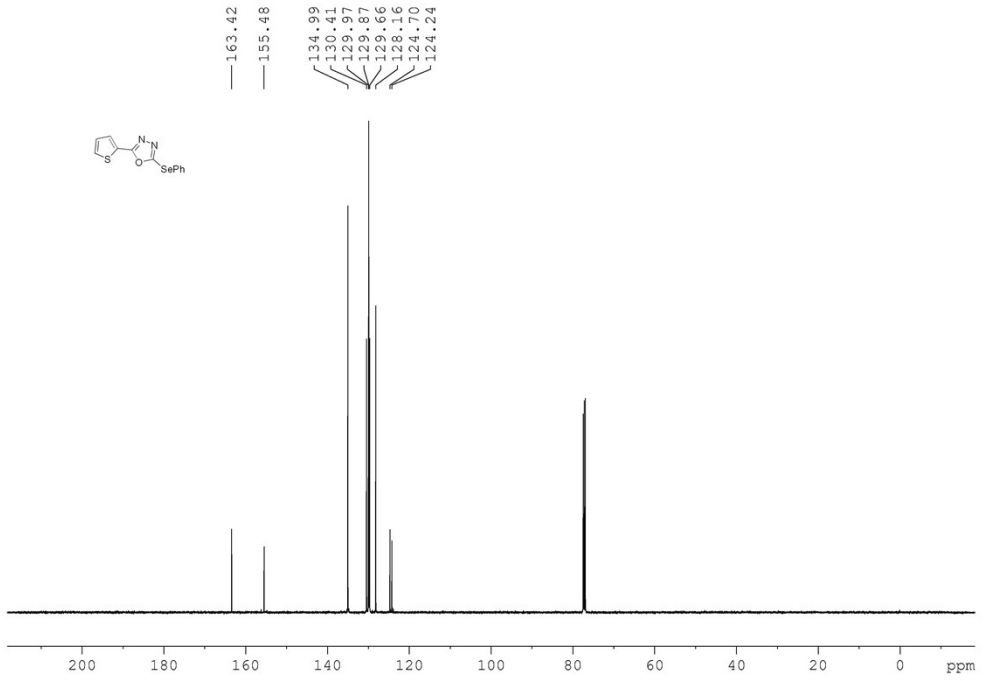
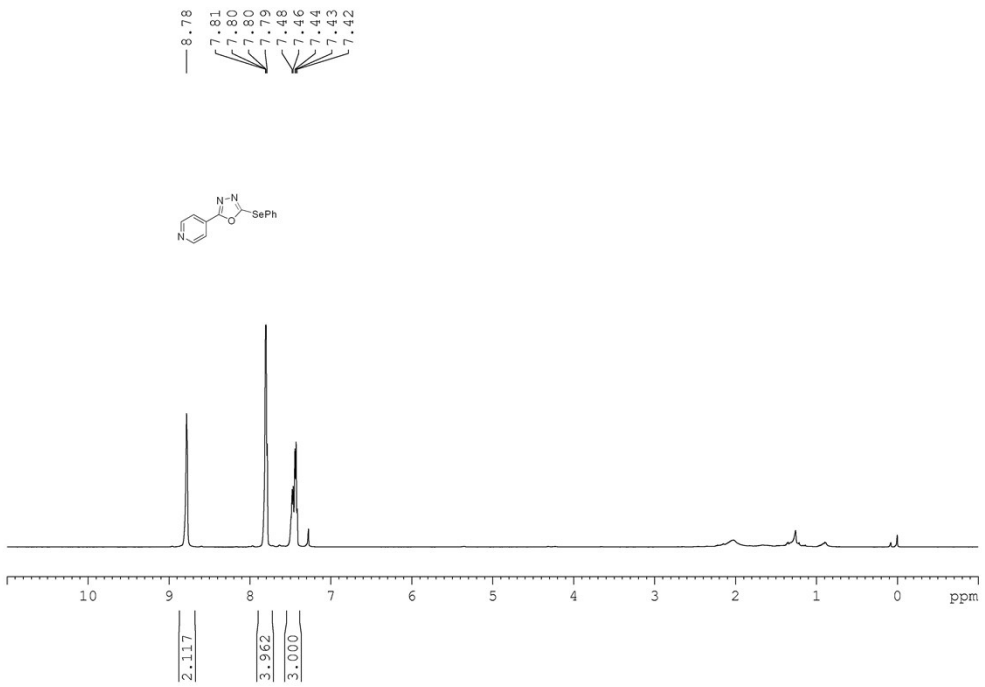
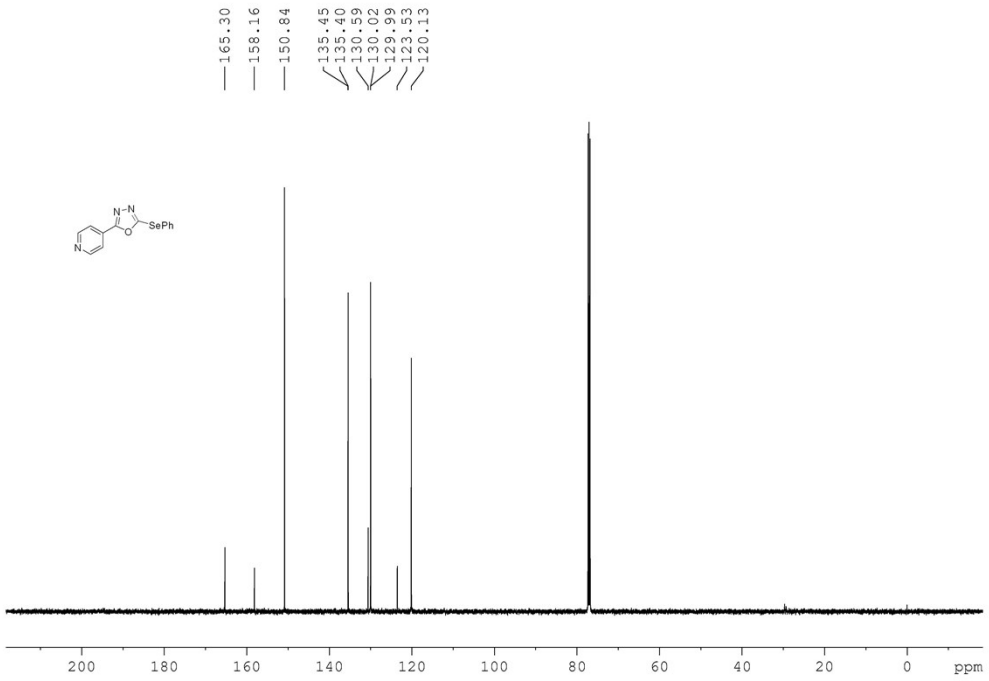
1.017
3.036
0.983
1.000

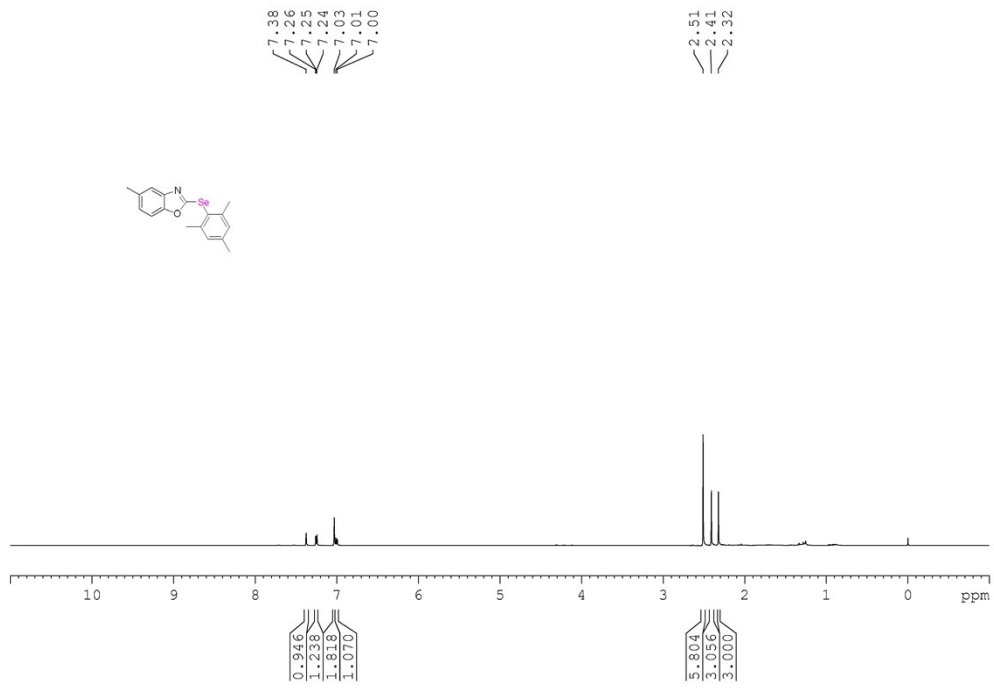

159.98
155.62
145.82
139.06
135.08
129.88
129.71
124.07
114.31
112.15
SePh
200
180
160
140
120
100
80
60
40
20
0
ppm


7.75
7.73
7.64
7.63
7.51
7.50
7.43
7.41
7.40
7.38
7.37
7.36
7.11
7.10
7.10
SePh
10
9
8
7
6
5
4
3
2
1
0
ppm
1.912
0.976
0.953
2.948
1.000


163.42
155.48
134.99
130.41
129.97
129.87
129.66
128.16
124.70
124.24
SePh
200
180
160
140
120
100
80
60
40
20
0
ppm


8.78
7.81
7.80
7.80
7.79
7.48
7.46
7.44
7.43
7.42
SePh
10
9
8
7
6
5
4
3
2
1
0
ppm
2.117
3.962
3.000


165.30
158.16
150.84
135.45
135.40
130.59
130.02
129.99
123.53
120.13
SePh
N
N
O
200
180
160
140
120
100
80
60
40
20
0
ppm


7.38
7.26
7.25
7.24
7.03
7.01
7.00
2.51
2.41
2.32
N
Se
O
10
9
8
7
6
5
4
3
2
1
0
ppm
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1.818
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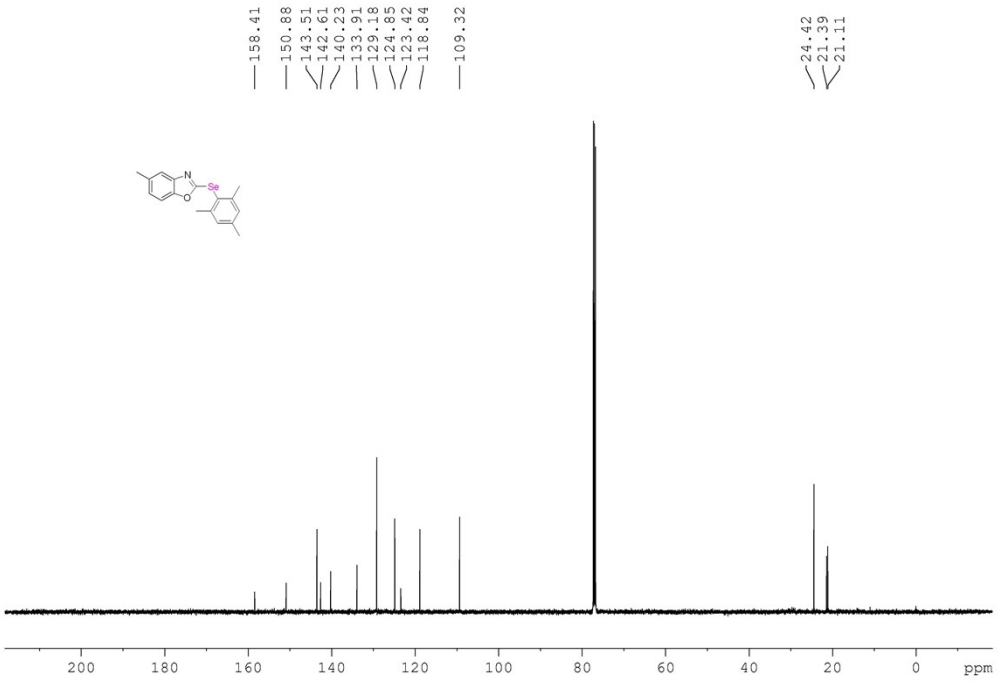
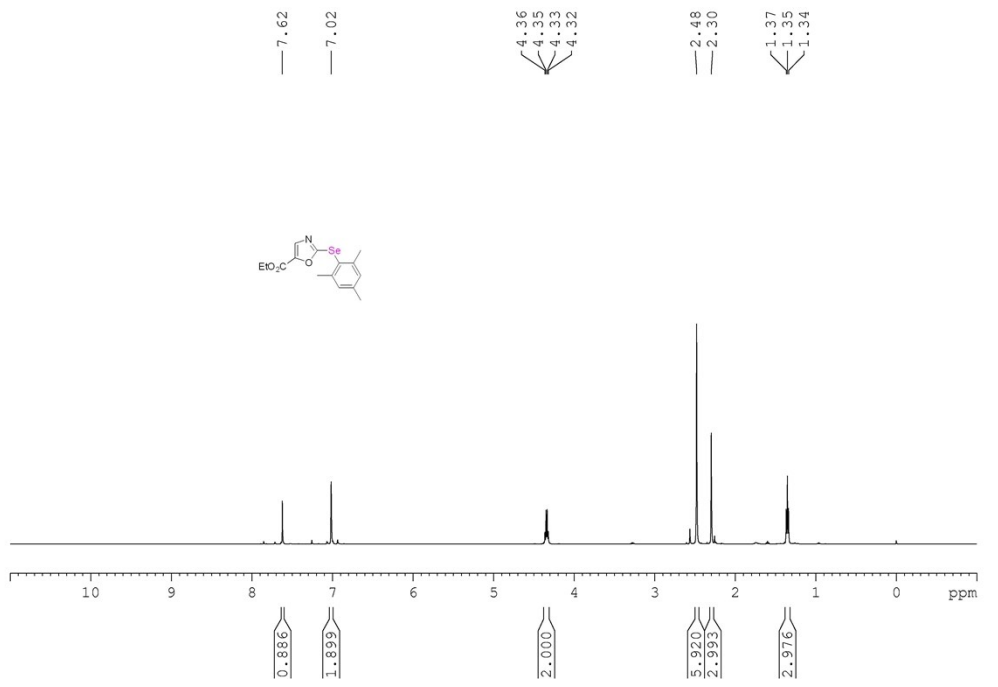
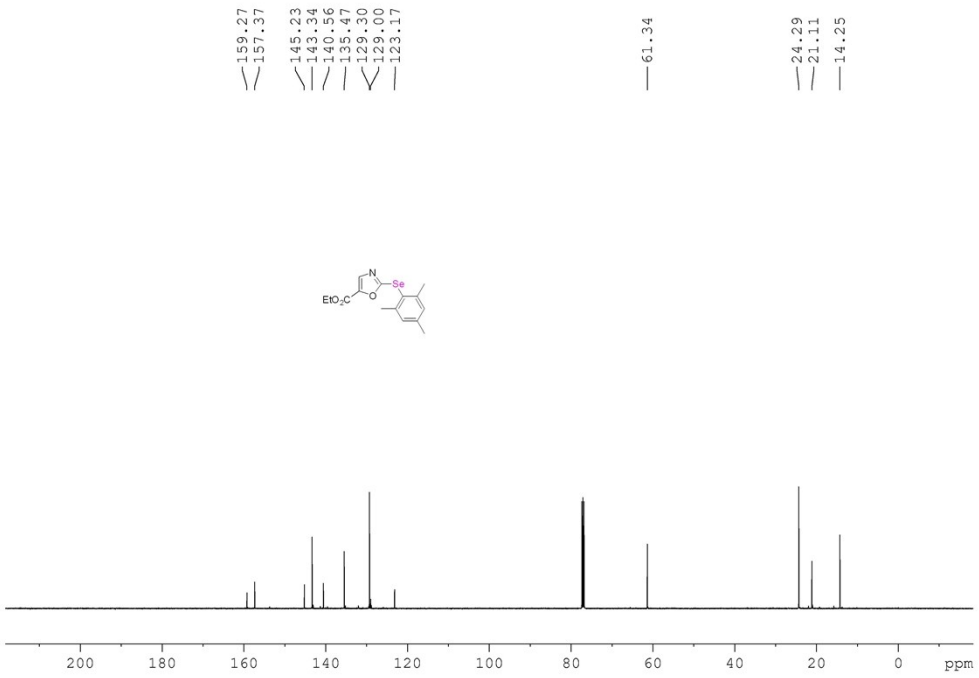
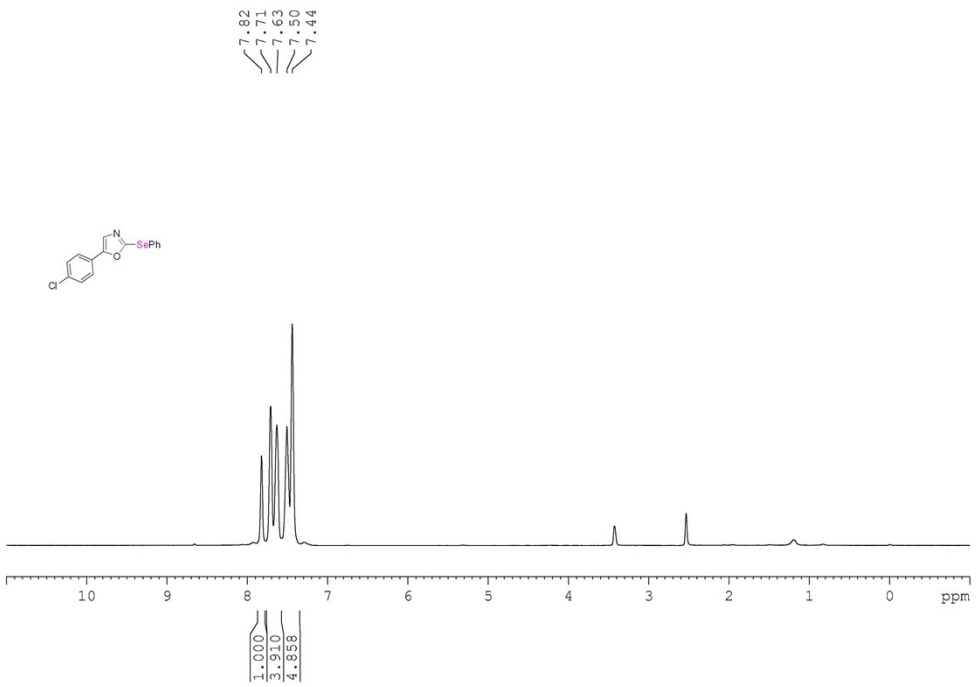
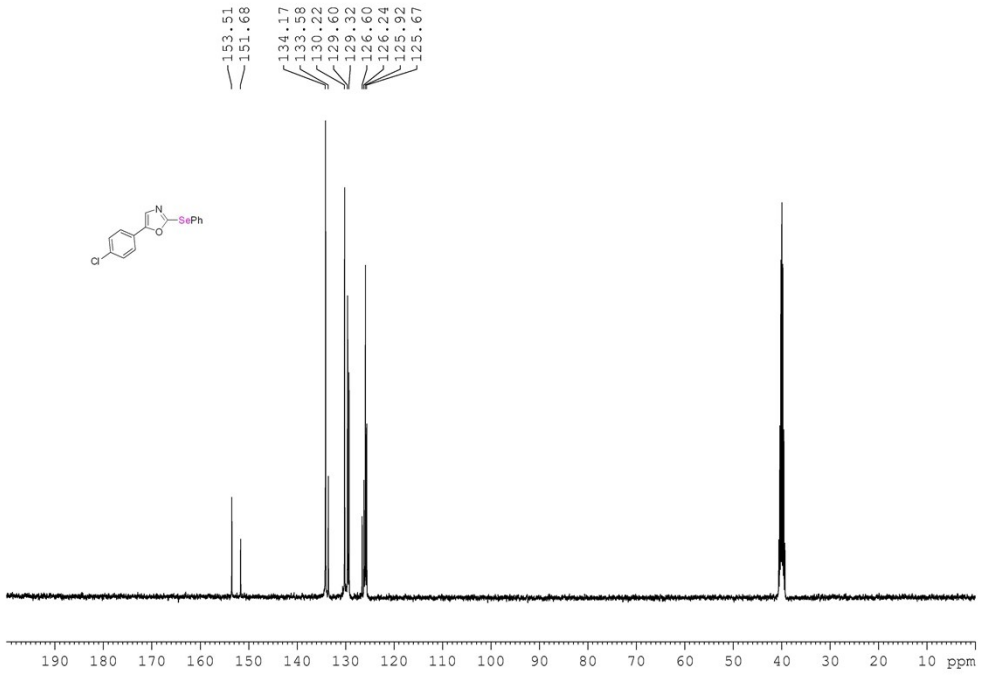
5.804
3.056
3.000

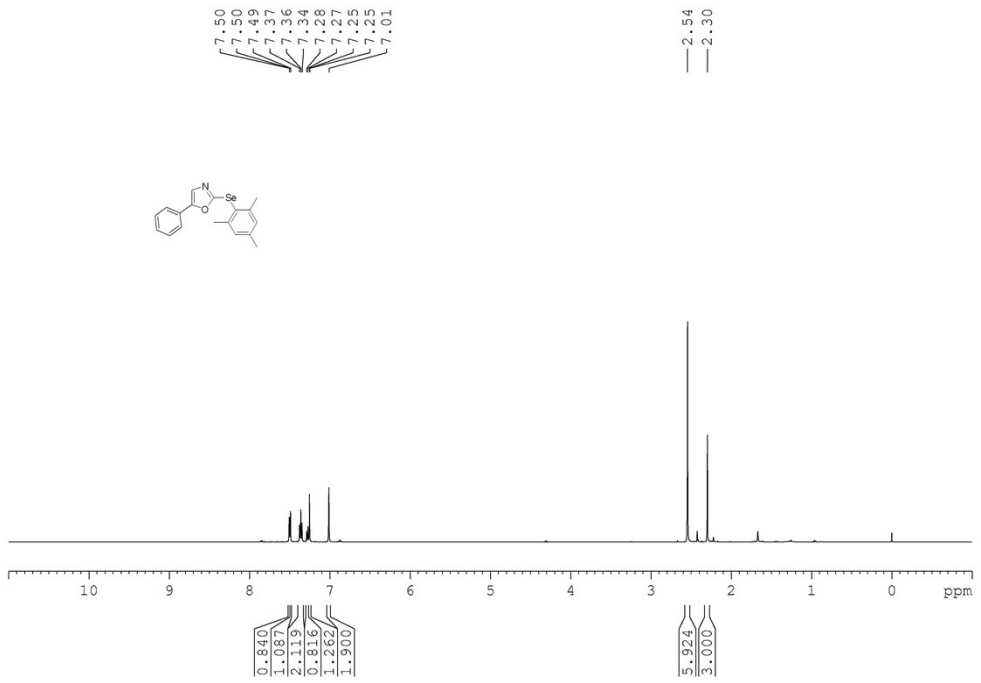

158.41
150.88
143.51
142.61
140.23
133.91
129.18
124.85
123.42
118.84
109.32
24.42
21.39
21.11
200
180
160
140
120
100
80
60
40
20
0
ppm

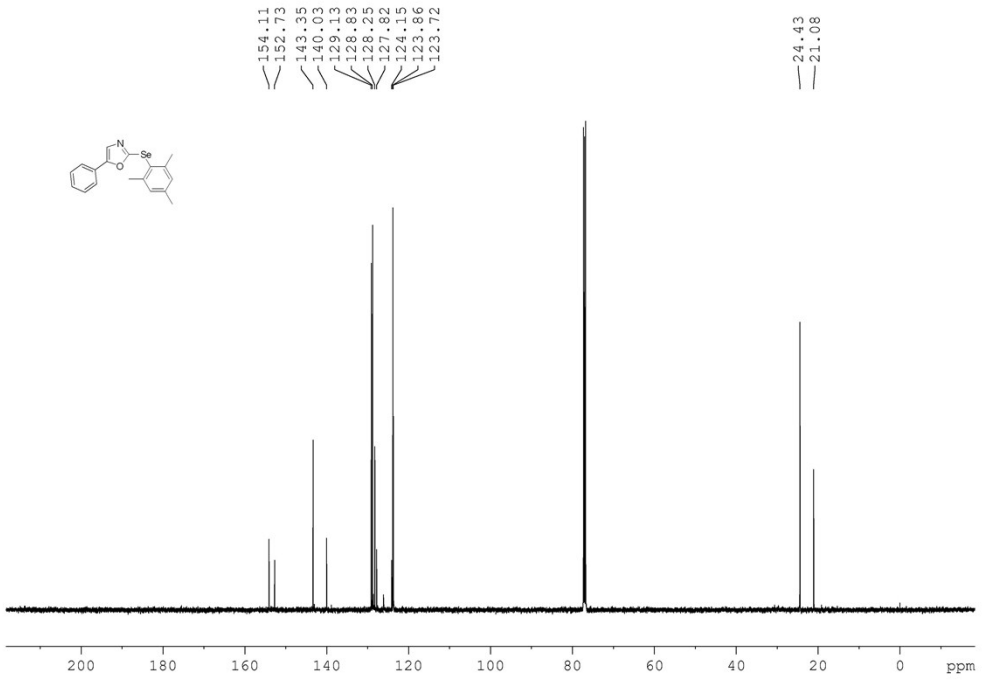

7.62
7.02
4.36
4.35
4.33
4.32
2.48
2.30
1.37
1.35
1.34
10
9
8
7
6
5
4
3
2
1
0
ppm
0.886
1.899
2.000
5.920
2.993
2.976

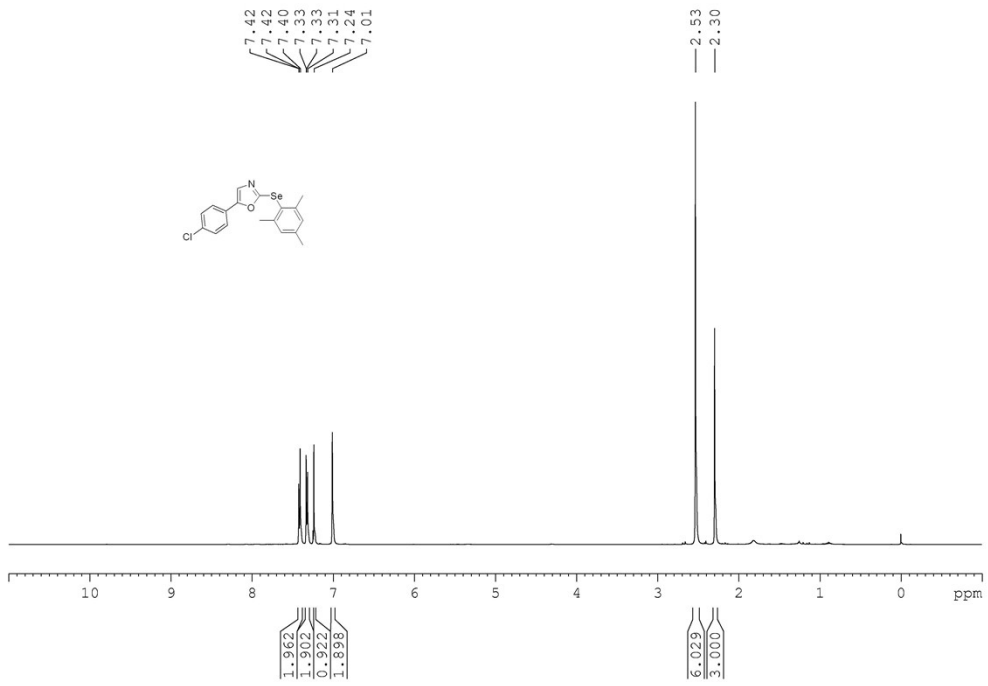

159.27
157.37
145.23
143.34
140.56
135.47
129.30
129.00
123.17
61.34
24.29
21.11
14.25
EtO2C
N
O
Se
200
180
160
140
120
100
80
60
40
20
0
ppm


7.82
7.71
7.63
7.50
7.44
Cl
N
O
SePh
10
9
8
7
6
5
4
3
2
1
0
ppm
1.000
3.910
4.858


153.51
151.68
134.17
133.58
130.22
129.60
129.32
126.60
126.24
125.92
125.67
N
O
SePh
Cl
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm


7.50
7.50
7.49
7.37
7.36
7.34
7.28
7.27
7.25
7.25
7.01
2.54
2.30
N
O
Se
10 9 8 7 6 5 4 3 2 1 0 ppm
0.840
1.087
2.119
0.816
1.262
1.900
5.924
3.000


154.11
152.73
143.35
140.03
129.13
128.83
128.25
127.82
124.15
123.86
123.72
24.43
21.08
N
Se
O
200
180
160
140
120
100
80
60
40
20
0
ppm


7.42
7.42
7.40
7.33
7.33
7.31
7.24
7.01
2.53
2.30
N
Se
O
Cl
10
9
8
7
6
5
4
3
2
1
0
ppm
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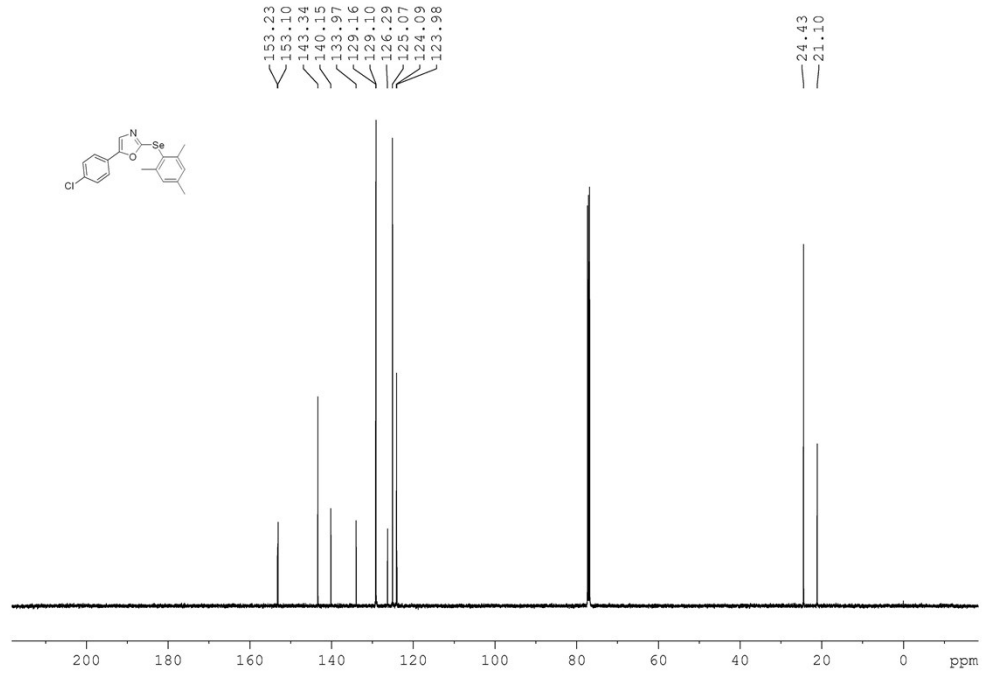
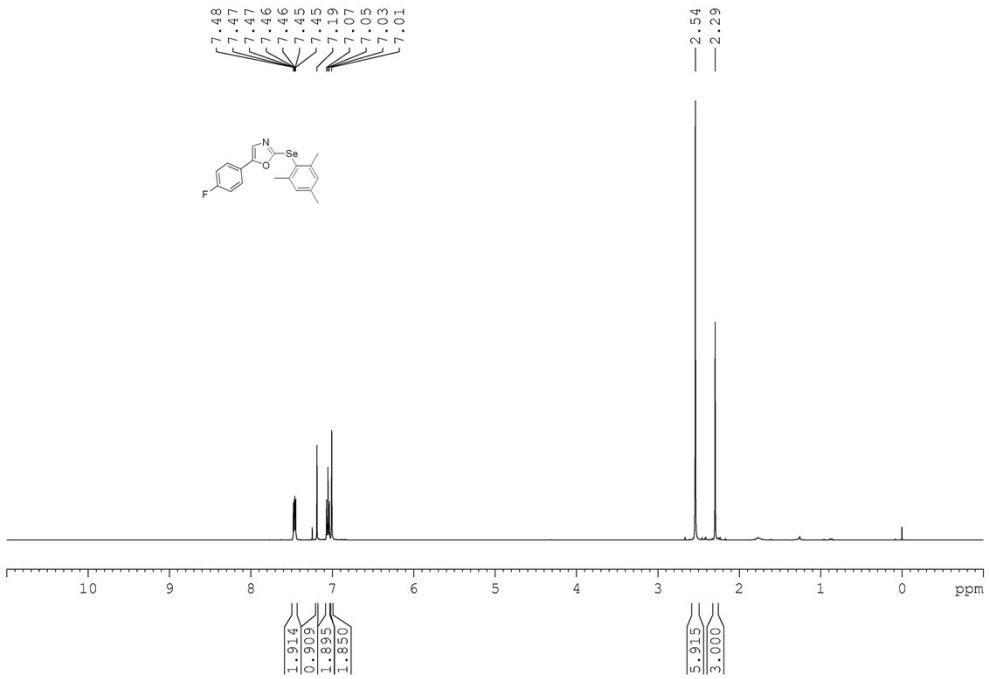
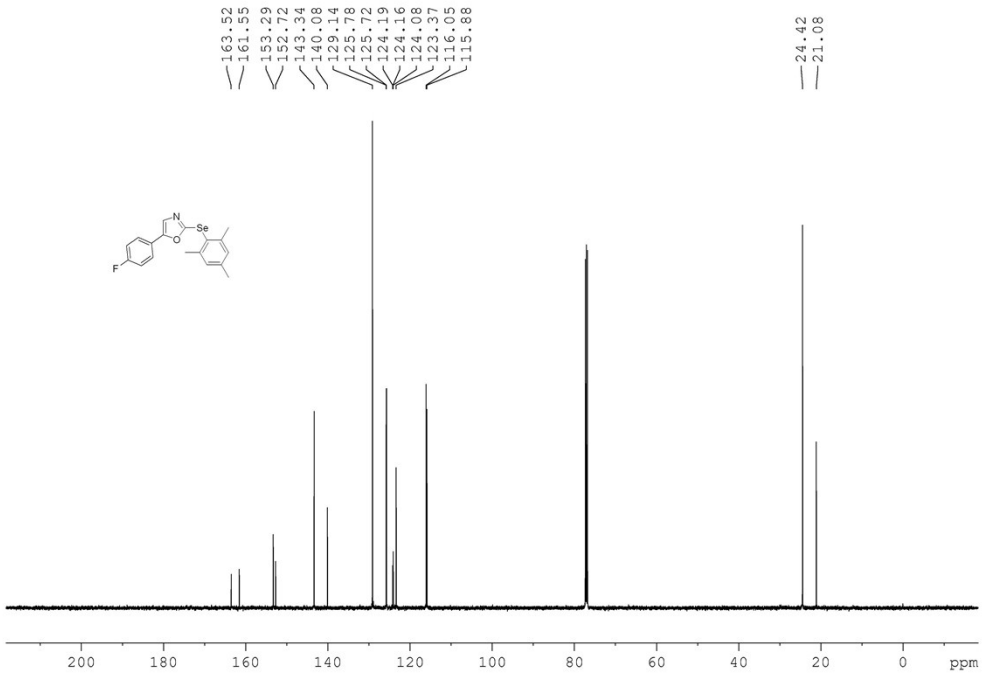
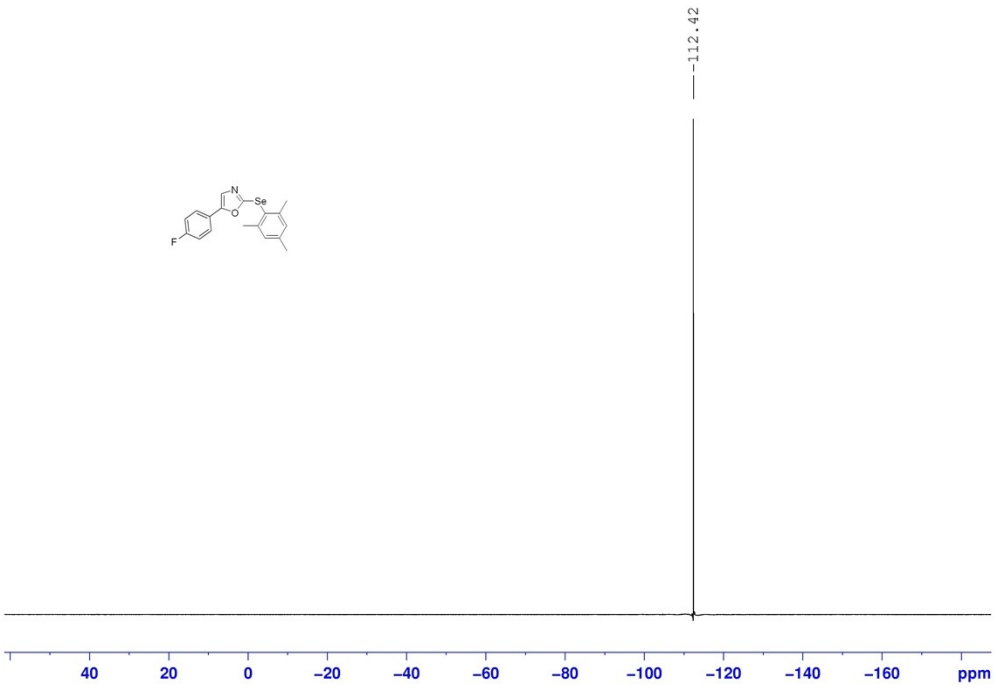
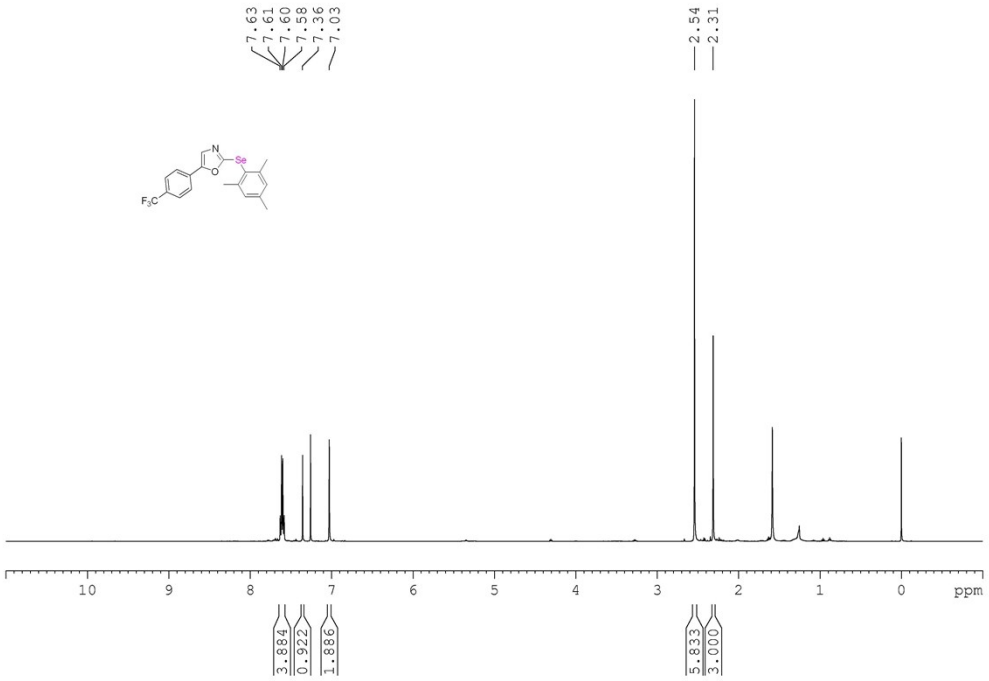
0.922
1.898
6.029
3.000

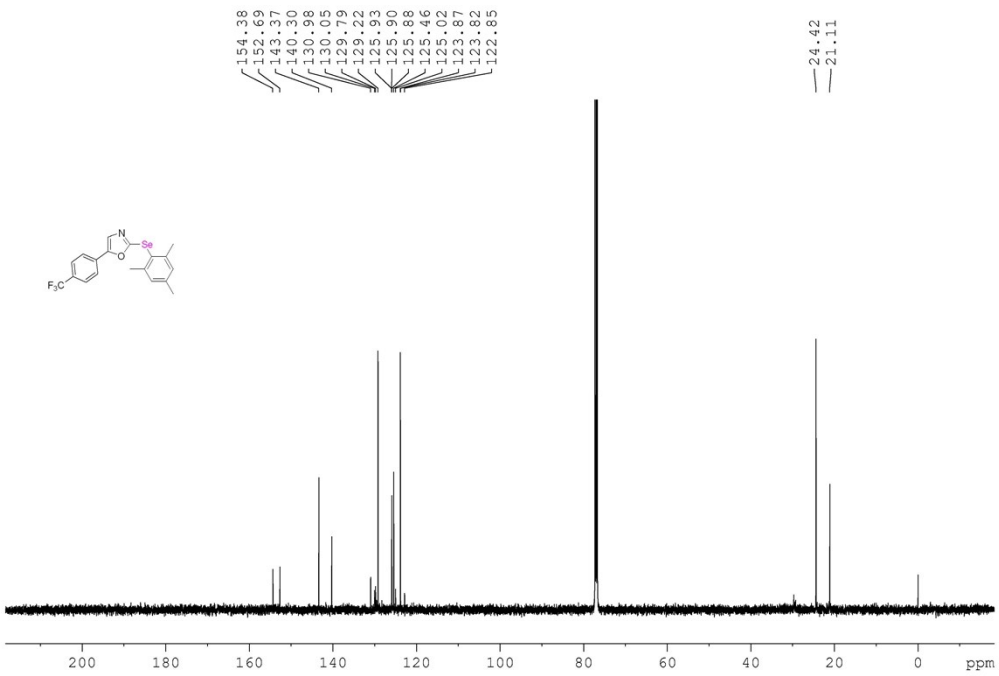

153.23
153.10
143.34
140.15
133.97
129.16
129.10
126.29
125.07
124.09
123.98
24.43
21.10
N
Se
O
Cl
200
180
160
140
120
100
80
60
40
20
0
ppm

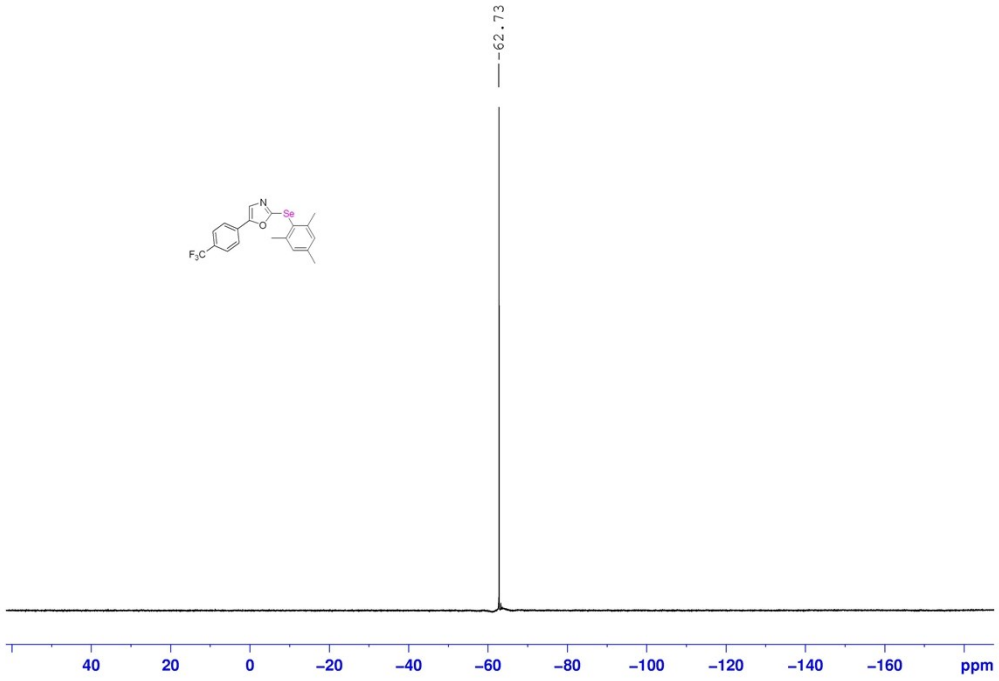

7.48
7.47
7.47
7.46
7.46
7.45
7.45
7.19
7.07
7.05
7.03
7.01
2.54
2.29
N
Se
O
F
10
9
8
7
6
5
4
3
2
1
0
ppm
1.914
0.909
1.895
1.850
5.915
3.000


163.52
161.55
153.29
152.72
143.34
140.08
129.14
125.78
125.72
124.19
124.16
124.08
123.37
116.05
115.88
24.42
21.08
N
Se
O
F
200
180
160
140
120
100
80
60
40
20
0
ppm


-112.42
N
Se
O
F
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
ppm


7.63
7.61
7.60
7.58
7.36
7.03
2.54
2.31
3.884
0.922
1.886
5.833
3.000
10
9
8
7
6
5
4
3
2
1
0
ppm


154.38
152.69
143.37
140.30
130.98
130.05
129.79
129.22
125.93
125.90
125.88
125.46
125.02
123.87
123.82
122.85
24.42
21.11
200
180
160
140
120
100
80
60
40
20
0
ppm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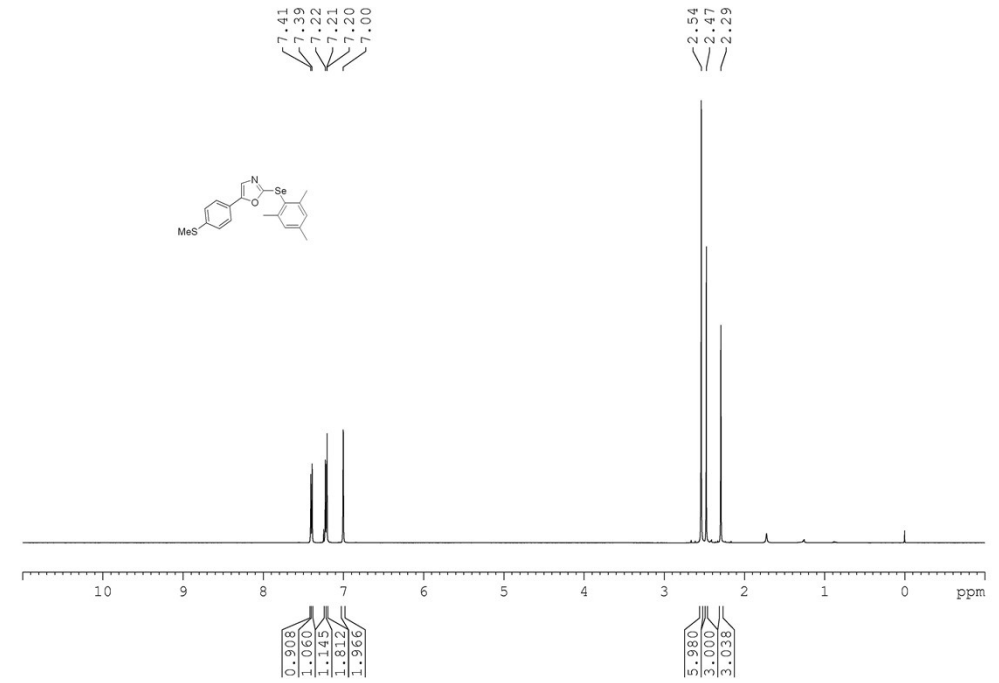
N
O
Se
F3C
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
ppm


7.41
7.39
7.22
7.21
7.20
7.00
2.54
2.47
2.29
N
O
Se
MeS
10
9
8
7
6
5
4
3
2
1
0
ppm
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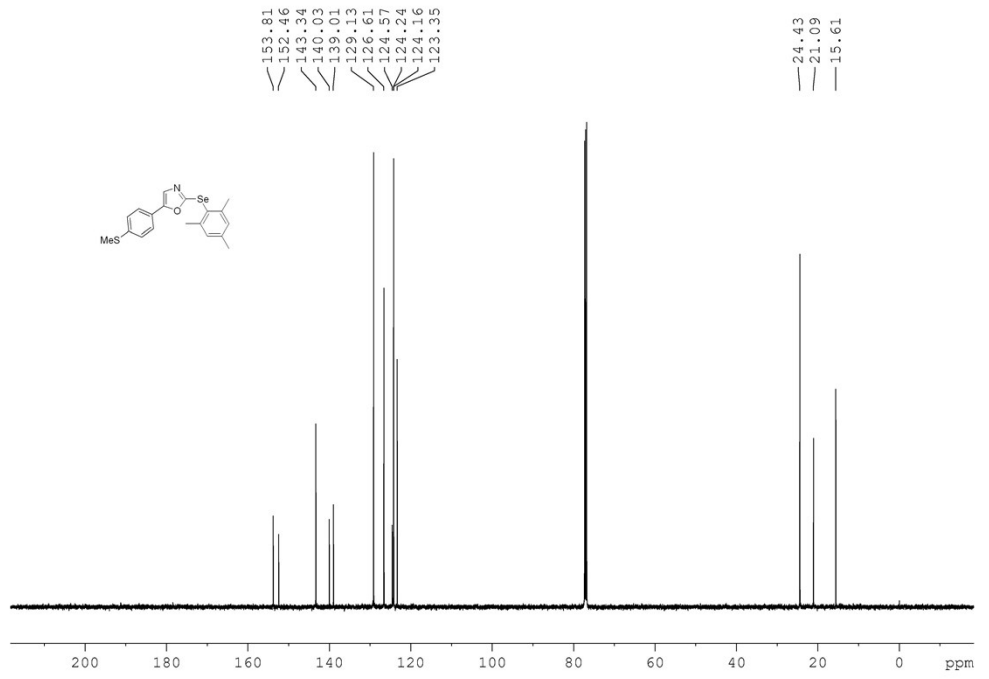
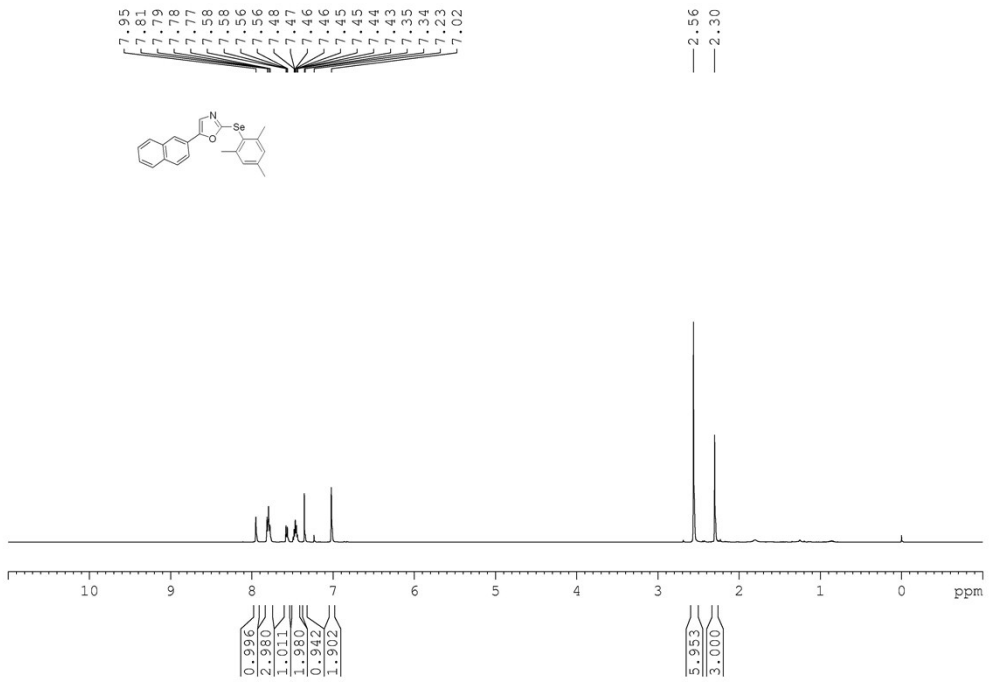
1.060
1.145
1.812
1.966
5.980
3.000
3.038


153.81
152.46
143.34
140.03
139.01
129.13
126.61
124.57
124.24
124.16
123.35
24.43
21.09
15.61
N
Se
MeS
200
180
160
140
120
100
80
60
40
20
0
ppm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7.58
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7.56
7.56
7.48
7.47
7.46
7.46
7.45
7.45
7.44
7.43
7.35
7.34
7.23
7.02
2.56
2.30
N
Se
10
9
8
7
6
5
4
3
2
1
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ppm
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1.011
1.980
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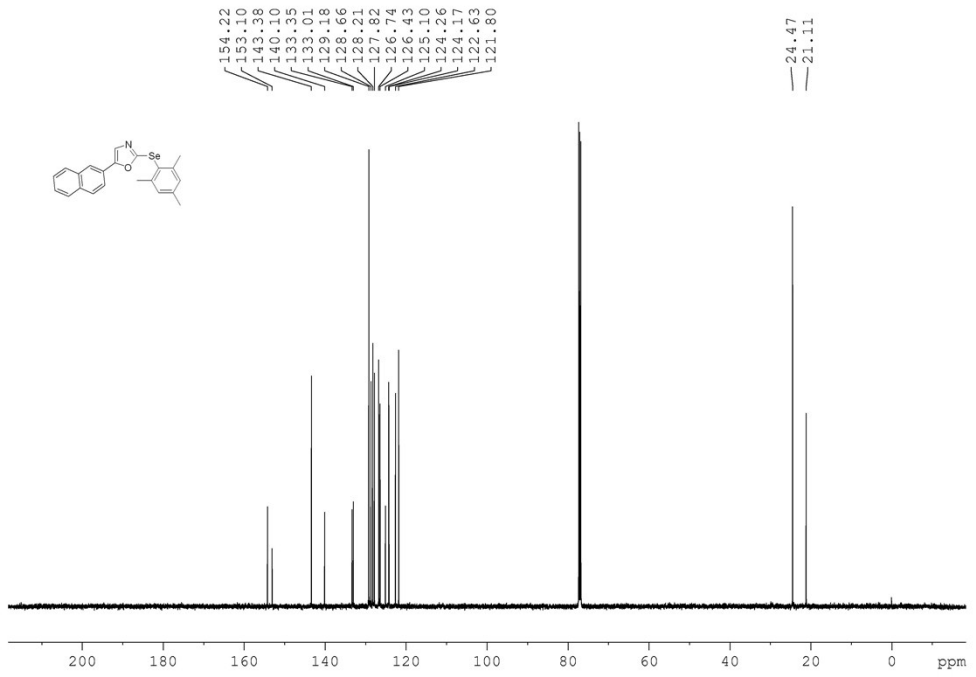
1.902
5.953
3.000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153.10
143.38
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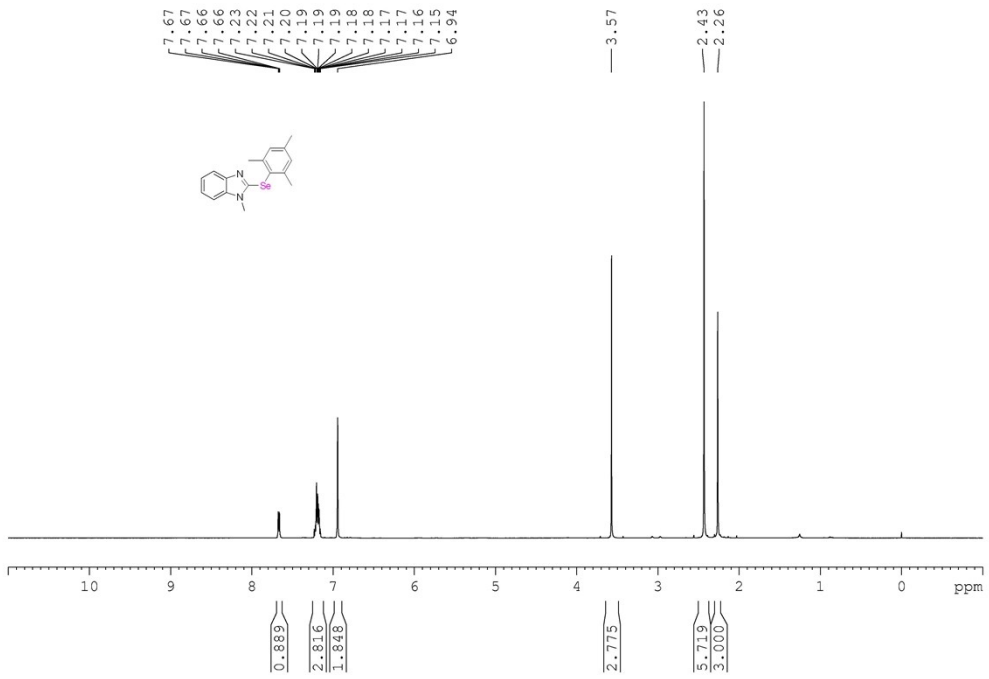
133.01
129.18
128.66
128.21
127.82
126.74
126.43
125.10
124.26
124.17
122.63
121.80
24.47
21.11
N
Se
O
200
180
160
140
120
100
80
60
40
20
0
ppm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7.67
7.66
7.66
7.23
7.22
7.21
7.20
7.19
7.19
7.19
7.18
7.18
7.17
7.17
7.16
7.15
6.94
3.57
2.43
2.26
N
N
Se
10
9
8
7
6
5
4
3
2
1
0
ppm
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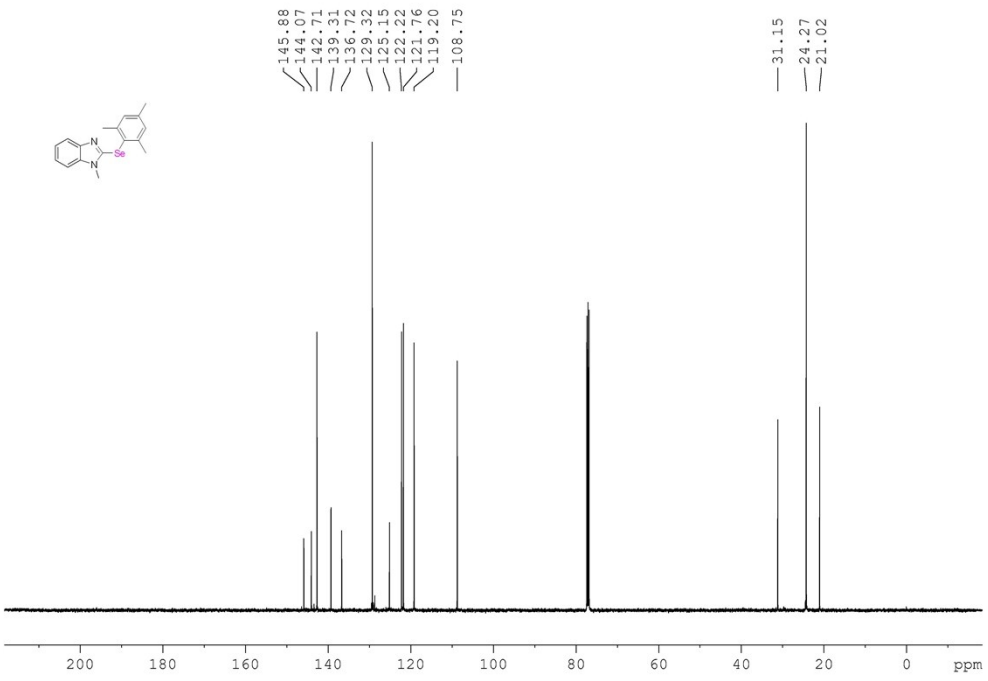
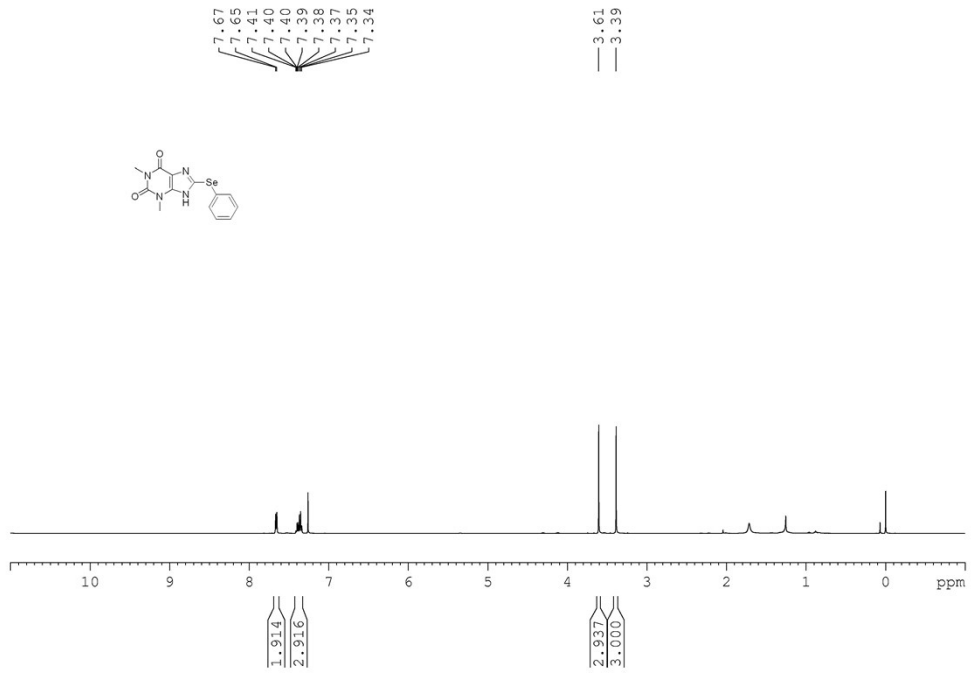
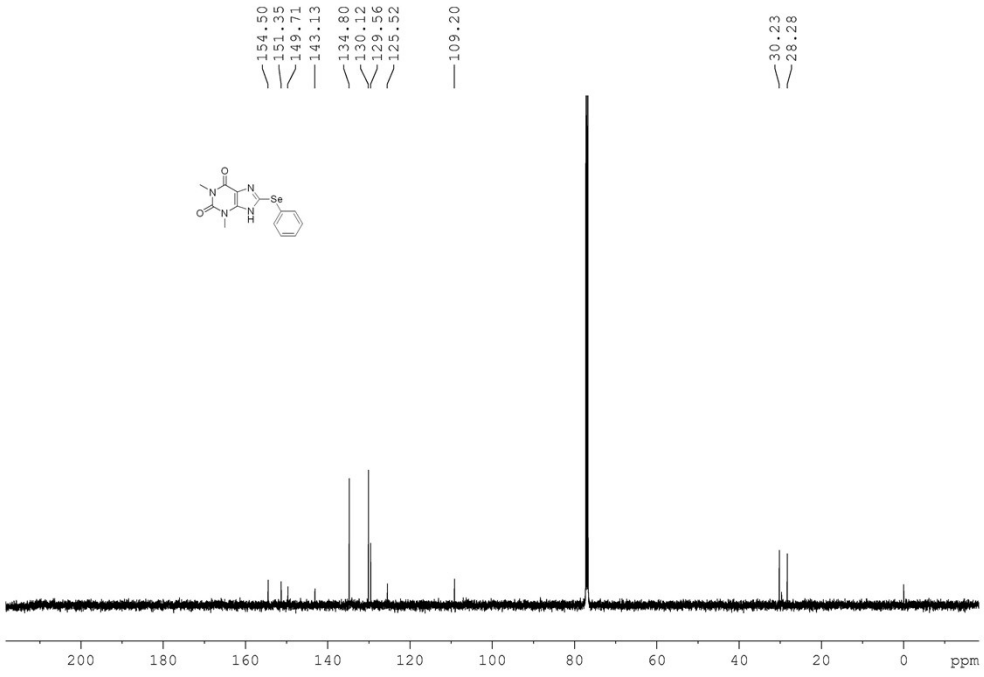
1.848
2.775
5.719
3.000


145.88
144.07
142.71
139.31
136.72
129.32
125.15
122.22
121.76
119.20
108.75
31.15
24.27
21.02
Se
200
180
160
140
120
100
80
60
40
20
0
ppm


7.67
7.65
7.41
7.40
7.40
7.39
7.38
7.37
7.35
7.34
3.61
3.39
Se
10
9
8
7
6
5
4
3
2
1
0
ppm
1.914
2.916
2.937
3.000


154.50
151.35
149.71
143.13
134.80
130.12
129.56
125.52
109.20
30.23
28.28
Se
200
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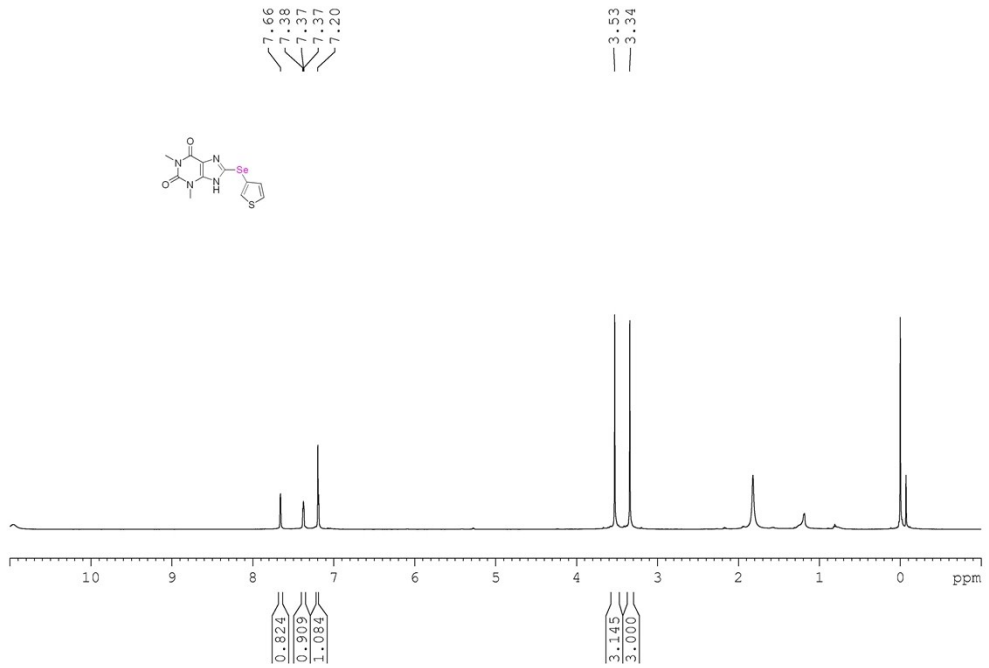
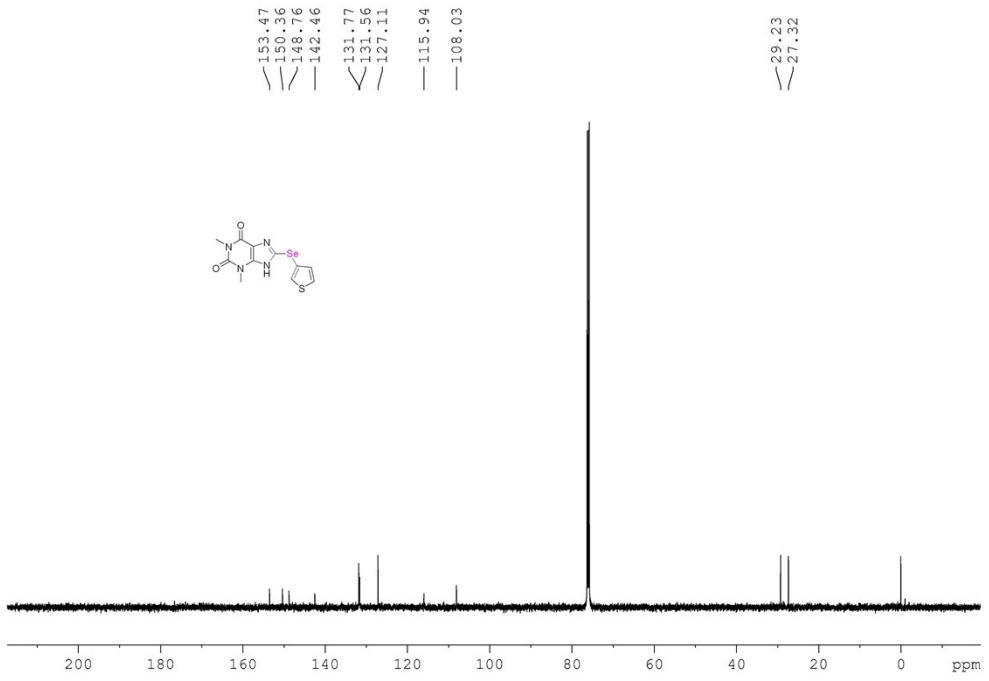
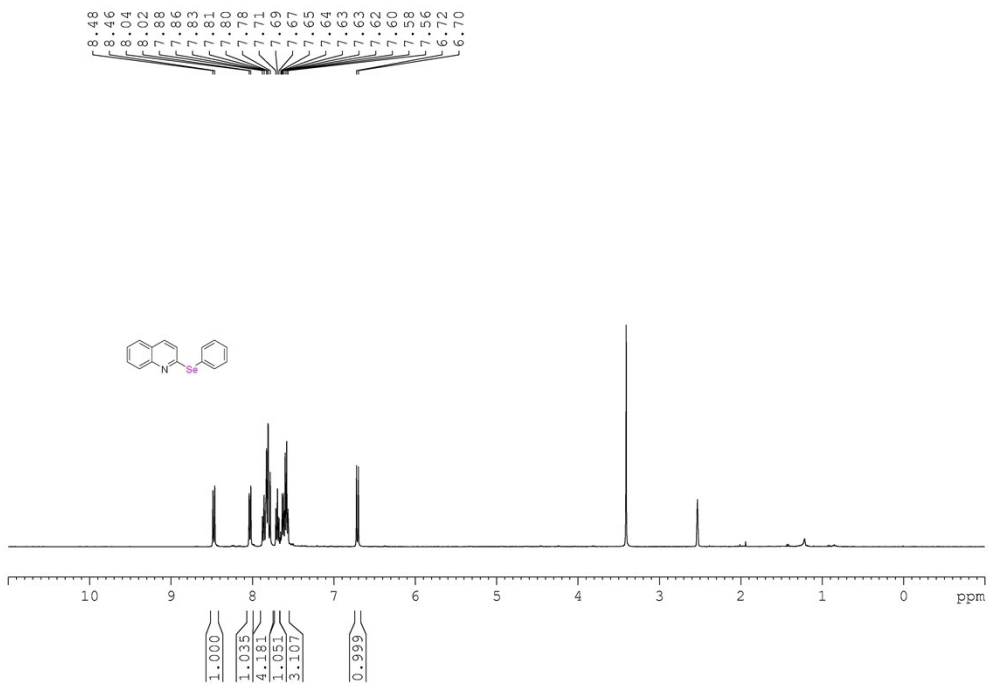
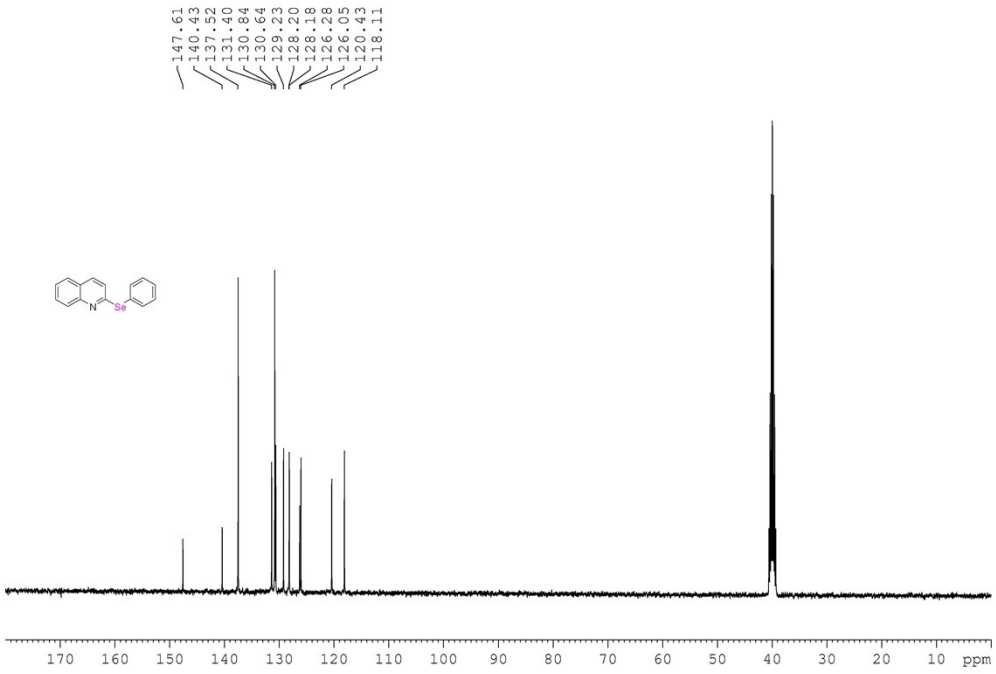
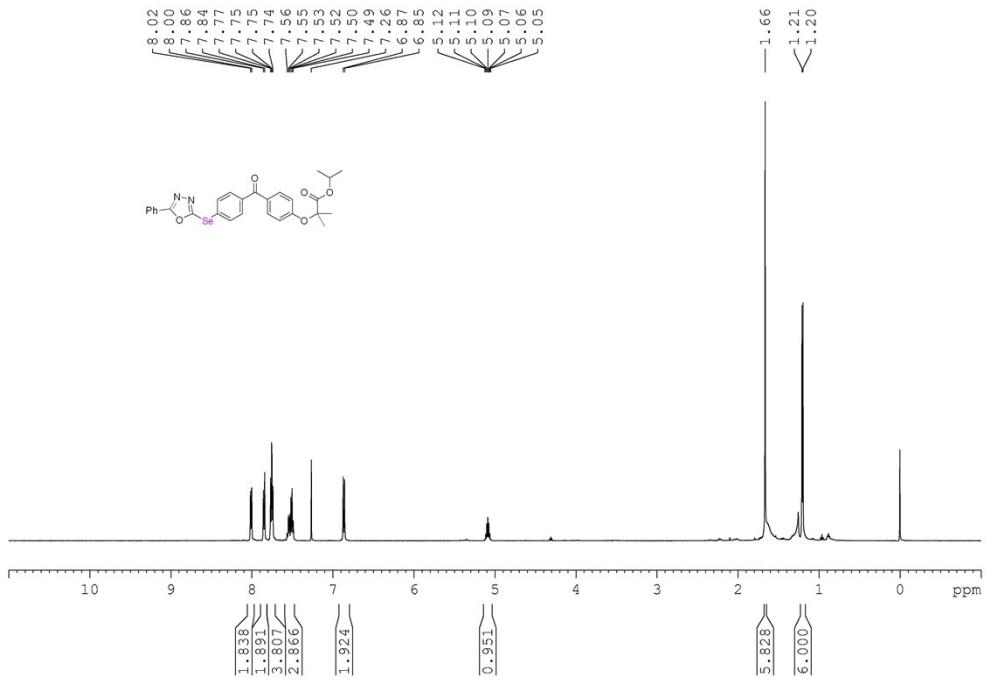
160
140
120
100
80
60
40
20
0
ppm

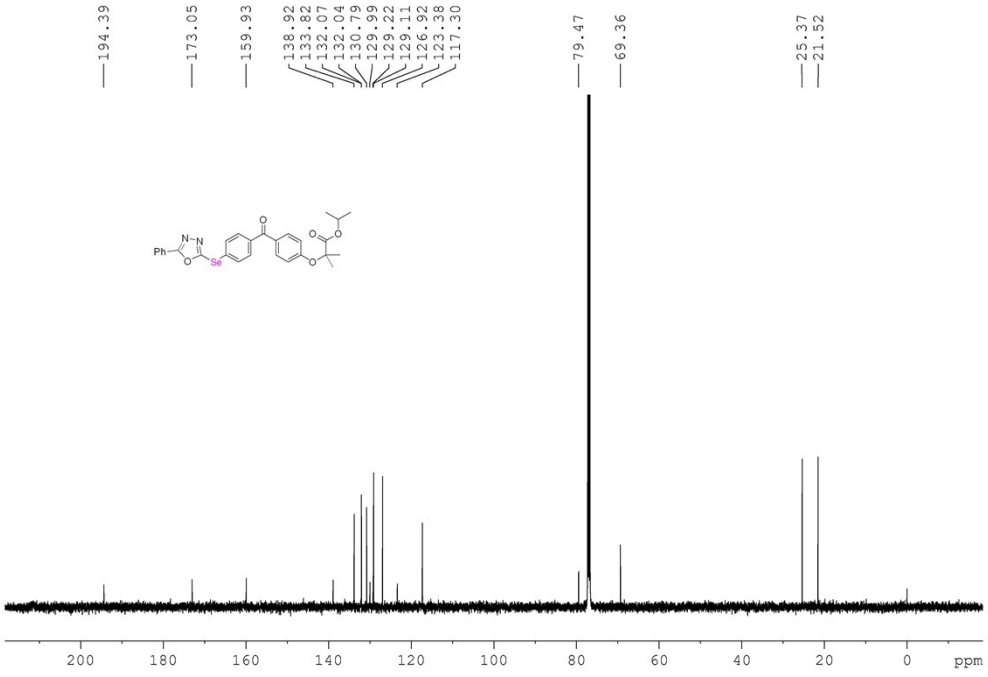

7.66
7.38
7.37
7.37
7.20
3.53
3.34
Se
S
10
9
8
7
6
5
4
3
2
1
0
ppm
0.824
0.909
1.084
3.145
3.000


153.47
150.36
148.76
142.46
131.77
131.56
127.11
115.94
108.03
29.23
27.32
Se
S
200
180
160
140
120
100
80
60
40
20
0
ppm


8.48
8.46
8.04
8.02
7.88
7.86
7.83
7.81
7.80
7.78
7.71
7.69
7.67
7.65
7.64
7.63
7.63
7.62
7.60
7.58
7.56
6.72
6.70
N
Se
10
9
8
7
6
5
4
3
2
1
0
ppm
1.000
1.035
4.161
1.051
3.107
0.999


147.61
140.43
137.52
131.40
130.84
130.64
129.23
128.20
128.18
126.28
126.05
120.43
118.11
N
Se
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm


8.02
8.00
7.86
7.84
7.77
7.75
7.75
7.74
7.56
7.55
7.53
7.52
7.50
7.49
7.26
6.87
6.85
5.12
5.11
5.10
5.09
5.07
5.06
5.05
1.66
1.21
1.20
Ph
N
N
O
Se
O
O
O
10 9 8 7 6 5 4 3 2 1 0 ppm
1.838
1.891
3.807
2.866
1.924
0.951
5.828
6.000


194.39
173.05
159.93
138.92
133.82
132.07
132.04
130.79
129.99
129.22
129.11
126.92
123.38
117.30
79.47
69.36
25.37
21.52
Ph
N
N
O
Se
O
O
O
200
180
160
140
120
100
80
60
40
20
0
ppm