Electronic Supplementary Material (ESI) for Green Chemistry.

Photoinduced, Additive- and Photosensitizer-free Multi-component Synthesis of Naphthoselenazol-2-amines With Air in Water

Hong-Tao Ji, Ke-Li Wang, Wen-Tao Ouyang, Qing-Xia Luo, Hong-Xia Li, Wei-Min He*

School of Chemistry and Chemical Engineering, University of South China, Hengyang 421001, China

E-mail: weiminhe@usc.edu.cn

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1. General Information

Unless otherwise noted, all reagents and solvents were obtained from commercial suppliers and used without further purification. GC yield was detected by Agilent GC-MS 8890/5977B. Thin layer chromatography (TLC) employed glass 0.25 mm silica gel plates. Flash chromatography columns were packed with 200-300 mesh silica gel. ^{1}H NMR spectra were recorded at 500 MHz and ^{13}C NMR spectra were recorded at 125 MHz by using a Bruker Avance 500 spectrometer. ^{19}F NMR data were collected at 471 MHz with complete proton decoupling. Chemical shifts were calibrated using residual undeuterated solvent as an internal reference (^{1}H NMR: $CDCl_3$ 7.26 ppm, ^{13}C NMR: $CDCl_3$ 77.16 ppm,), the chemical shifts (δ) were expressed in ppm and J values were given in Hz. The following abbreviations were used to describe peak splitting patterns when appropriate: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, dd = doublet of doublets, br = broad. Mass spectra were performed on a spectrometer operating on ESI-TOF. UV/Vis spectra were recorded using a Shimadzu UV-2600 spectrophotometer. The crude products were purified by HPLC (LaboACE LC-5060, Japan Analytical Industry Co., Ltd., Japan) equipped with Jaigel 2.5 HR columns with dichloromethane as the eluent. Cyclic voltammetry was performed on a CHI 660E potentiostat, and the conditions are as follow: a glassy carbon disk working electrode (diameter, 3 mm), Pt disk and Ag/AgCl (0.3 M in MeCN) as counter and reference electrode. The fluorescence emission intensities were recorded on a Hitachi F-7100 fluorescence spectrophotometer.

Photographic depiction of the reaction setup:

Manufacturer：Beijing Rogertech Ltd.

Model：RLR-22CU

Value: 5836.430 μW/cm²/nm

Energy peak wavelength：453 nm

Peak width at half-height：22.1 nm

Material of the irradiation vessel：Schlenk flask

Not use any filters

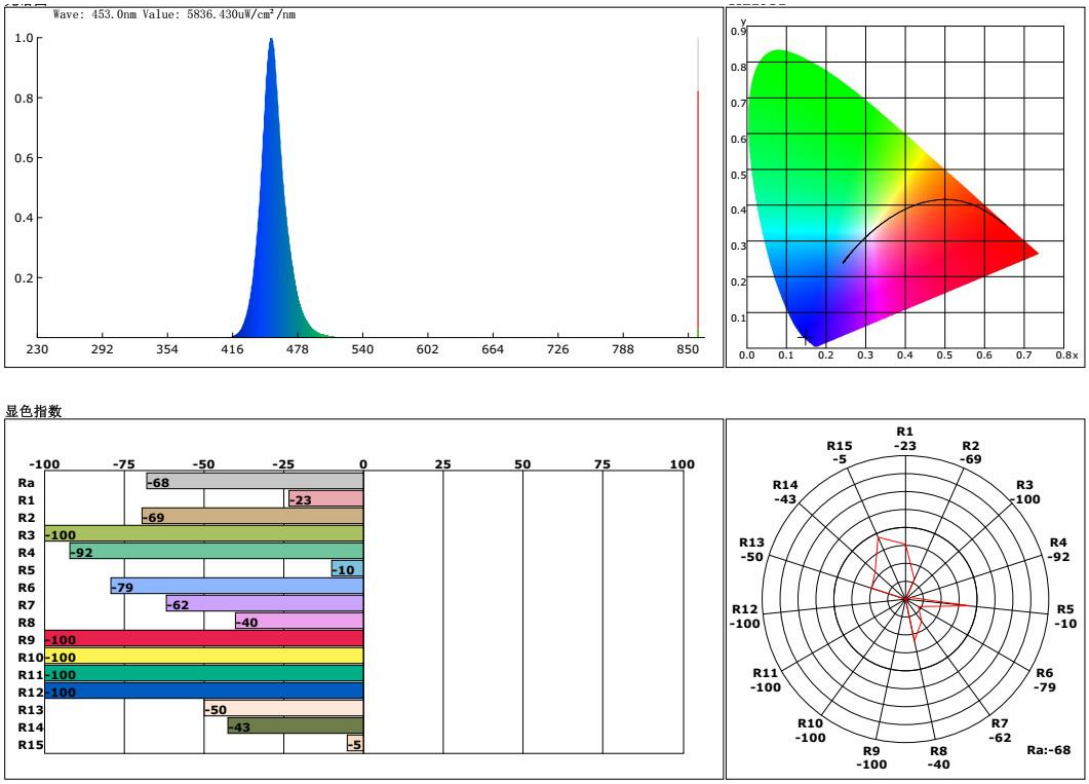
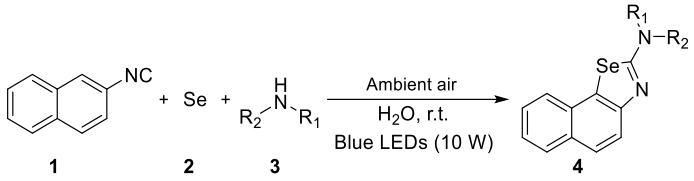


Figure S1 LED spectrum test report

Figure S2 Photographic depiction of the reaction setup

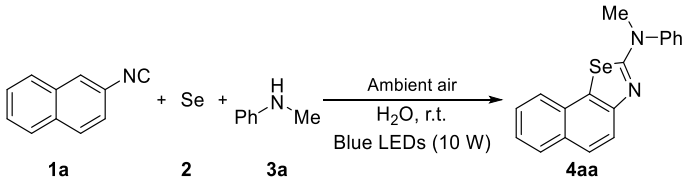
2. Experimental Section

2.1 General Experimental Procedures for Compounds 4



To a 10 mL Schlenk flask equipped with a stirring bar were added 2-isocyanonaphthalene **1** (0.20 mmol), selenium powder **2** (0.24 mmol), amine **3** (0.24 mmol) and H_2O (2.0 mL). The reaction mixture was stirred and irradiatted by 10 W blue LEDs (455 nm) under room temperature for 12 hrs. After completion, the reaction mixture was extracted with 5 mL ethyl acetate, organic phase was dried and concentrated under reduced pressure. The pure products **4** were purified and obtained by flash chromatography on silica gel (elute: petroleum ether/ethyl acetate, 10:1 to 5:1).

2.2 Large Scale Synthesis of 4aa



To an Schlenk flask (50 mL) equipped with a stirring bar were added 2-isocyanonaphthalene **1a** (5.0 mmol), selenium powder **2** (6.0 mmol), *N*-methylaniline **3a** (6.0 mmol), and H_2O (30.0 mL). The reaction mixture was stirred and irradiatted by 10 W blue LEDs (455 nm) under room temperature. After completion, the reaction mixture was extracted with ethyl acetate, organic phase was dried and concentrated under reduced pressure. The pure products **4aa** were purified by HPLC in a yield of 81% (1.37 g).

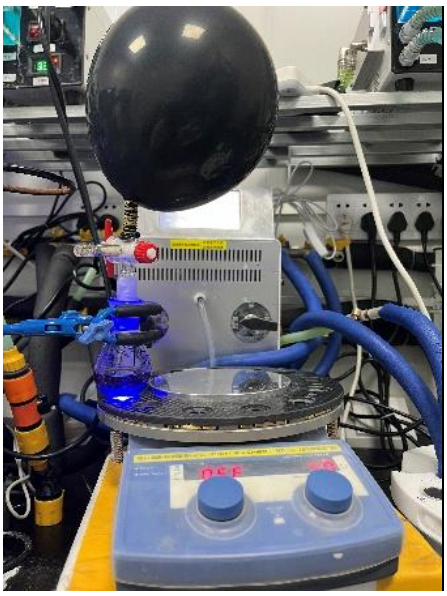
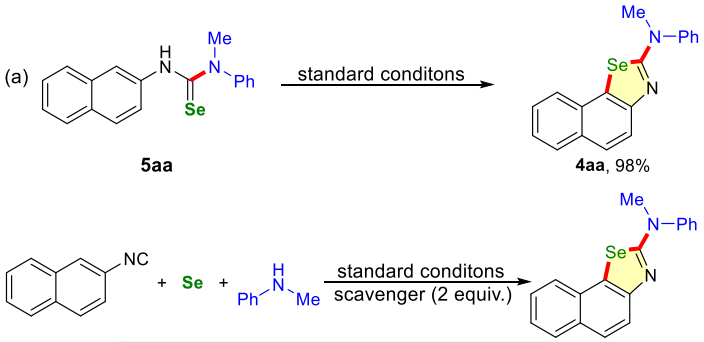


Figure S3 Photographic depiction of Gram-scale synthesis

2.3 Radical Trapped Experiments



	Scavenger	Species Tested	4aa
(b)	TEMPO	radical	72%
(c)	BHT	radical	69%
(d)	DBACO	singlet oxygen ($^1O_2$)	94%
(e)	benzoquinone	superoxide radical ($O_2^{\bullet-}$)	trace
(f)	$K_2S_2O_8$	electron scavenger (e^-)	trace

(a) Under the standard conditions, the intermediate **5aa** was added to 2 mL H_2O, the reaction was monitored by TLC. Upon completion, the reaction mixture was analyzed by GC and a 98% GC yield of **4aa** was detected.

(b) To a 10.0 mL Schlenk flask equipped with a magnetic stirring bar were added 2-isocyanonaphthalene **1a** (0.2 mmol), selenium powder **2** (0.24 mmol), and *N*-methylaniline **3a** (0.24 mmol), radical scavengers (TEMPO, 0.4 mmol) and H_2O (2.0 mL). Then the reaction mixture was stirred and irradiated by 10 W blue LEDs at ambient temperature for 12 hrs. The reaction mixture was analyzed by GC and a 72% GC yield of **4aa** was detected.

(c) To a 10.0 mL Schlenk flask equipped with a magnetic stirring bar were added 2-isocyanonaphthalene **1a** (0.2 mmol), selenium powder **2** (0.24 mmol), and *N*-methylaniline **3a** (0.24 mmol), radical scavengers (BHT, 0.4 mmol) and H_2O (2.0 mL). Then the reaction mixture was stirred and irradiated by 10 W blue LEDs at ambient temperature for 12 hrs. The reaction mixture was analyzed by GC and a 69% GC yield of **4aa** was detected.

(d) To a 10.0 mL Schlenk flask equipped with a magnetic stirring bar were added 2-isocyanonaphthalene **1a** (0.2 mmol), selenium powder **2** (0.24 mmol), and *N*-methylaniline **3a** (0.24 mmol), scavengers (DBACO, 0.4 mmol) and H_2O (2.0 mL). Then the reaction mixture was stirred and irradiated by 10 W blue LEDs at ambient temperature for 12 hrs. The reaction mixture was analyzed by GC and a 94% GC yield of **4aa** was detected.

(e) To a 10.0 mL Schlenk flask equipped with a magnetic stirring bar were added 2-isocyanonaphthalene **1a** (0.2 mmol), selenium powder **2** (0.24 mmol), and *N*-methylaniline **3a** (0.24 mmol), scavengers (benzoquinone, 1 mmol) and H_2O (2.0 mL). Then the reaction mixture was stirred and irradiated by 10 W blue LEDs at ambient temperature for 12 hrs. The reaction mixture was analyzed by GC and a trace amount of **4aa** was detected.

(f) To a 10.0 mL Schlenk flask equipped with a magnetic stirring bar were added 2-isocyanonaphthalene **1a** (0.2 mmol), selenium powder **2** (0.24 mmol), and *N*-methylaniline **3a** (0.24 mmol), scavengers ($K_2S_2O_8$, 0.4 mmol) and H_2O (2.0 mL). Then the reaction mixture was stirred and irradiated by 10 W blue LEDs at ambient temperature for 12 hrs. The reaction mixture was analyzed by GC and a trace amount of **4aa** was detected.

2.4 Effect of Visible Light Irradiation

The reaction between **1a** (0.2 mmol), **2** (0.24 mmol) and **3a** (0.24 mmol) was conducted under the standard conditions on a 0.2 mmol scale. The mixture was subjected to sequential periods of stirring under visible light irradiation (10 W blue LEDs) under an air atmosphere at room temperature with 3 hrs and followed by stirring in the absence of light with 3 hrs. At each time point, one reaction system was suspended and the yield was detected by GC.

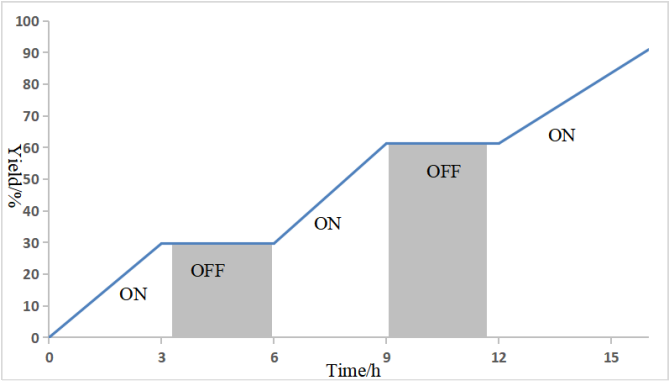


Figure S4 Visible light irradiation on/off experiments

2.5 UV/Vis Absorption Experiment

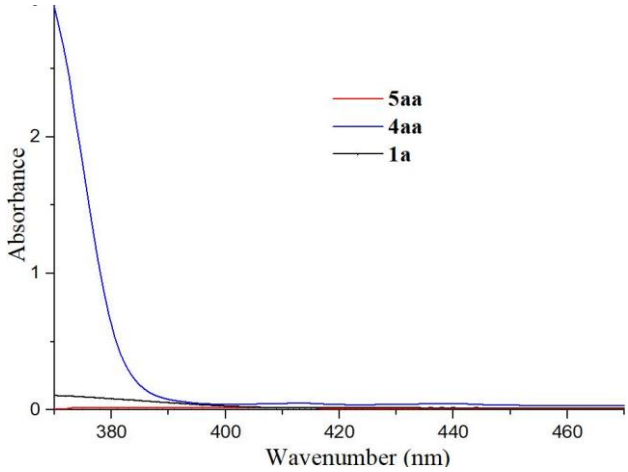


Figure S5 UV/Vis spectroscopic measurements

The UV/Vis absorption spectra of **1a**, **4aa** and selenourea **5aa** were recorded in 1 cm path quartz cuvettes in a concentration of 0.003 M by using a Shimadzu UV-2600 spectrophotometer, respectively.

2.6 Fluorescence Quenching Experiments

The fluorescence emission intensities were measured using a Hitachi F-7100 fluorescence spectrophotometer at an excitation wavelength of 385 nm. The samples consisted of **4aa** (1 mM), the in-situ-formed complex (a mixture of **4aa** and **5aa**) dissolved in THF. The resulting emission intensity data were collected.

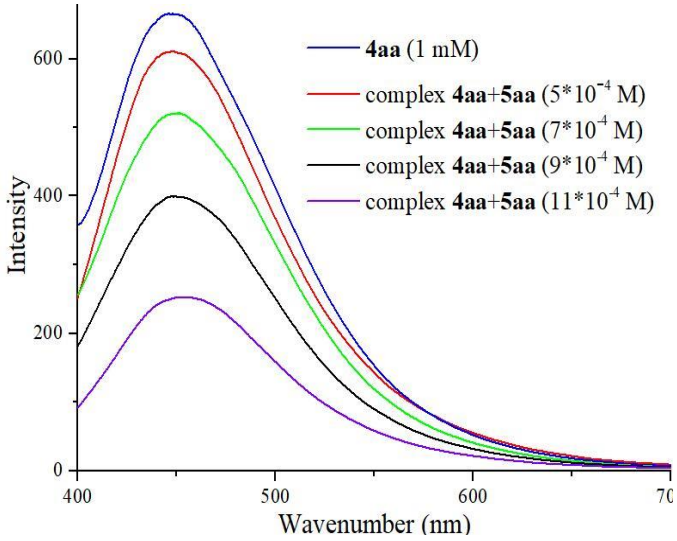


Figure S6 Fluorescence quenching experiments

2.7 Cyclic voltammetry studies

CV measurements were performed on a CHI 660E potentiostat, and the conditions are as follow: a glassy carbon disk working electrode (diameter, 3 mm), Pt disk and Ag/AgCl as counter and reference electrode. Cyclic voltammograms of reactants and their mixtures in 0.3 M tetrabutylammonium bromide glassy carbon disk working electrode (diameter, 3 mm), Pt disk and Ag/AgCl (0.1 M in EtOH) as counter and reference electrode at 100 mV/s scan rate: a) 5 mM of **4aa** in MeCN (10 mL) (black line), (2) 5 mM of **5aa** in MeCN (10 mL) (red line).

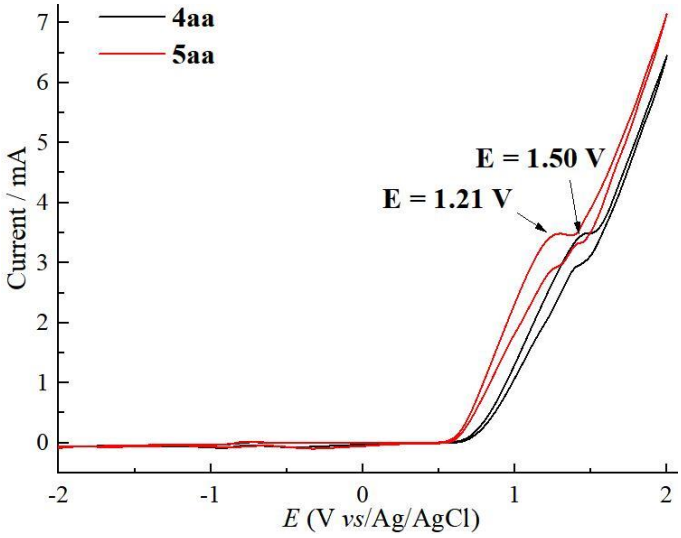


Figure S7 Cyclic voltammogram experiments of **4aa** and **5aa** in an electrolyte of $^{n}Bu_4NBr$ (0.3 M) in MeCN from -2 V to +2 V at room temperature

2.8 Calculation of Apparent Quantum Yield

$$E_{photon} = \frac{hc}{\lambda_{inc}(455\ nm)} = \frac{6.63x10^{-34}\ J.Sx3x\ 10^{8}\ m.s^{-1}}{455x\ 10^{-9}\ m} = 4.37x10^{-19}\ J$$

$$E_{total}=PSt = 17.47x\ 10^{-3}\ W.cm^{-2}x4.78\ cm^{2}\ x12x3600s = 3.6x10^{3}\ J$$

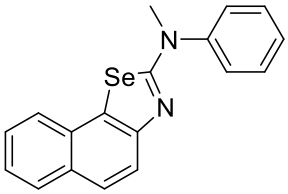
$$\text{Number of incident photons} = \frac{E_{photon}}{E_{tota}} = \frac{3.6x10^{3}\ J}{4.37x10^{-19}\ J} = 8.24x10^{21} = 13.58\ mmol$$

$$A.Q.Y(\%) = \frac{\text{Number of Product}}{\text{Number of incident photons}} = \frac{0.194mmol}{13.58\ mmol} = 1.4\ \% < 1$$

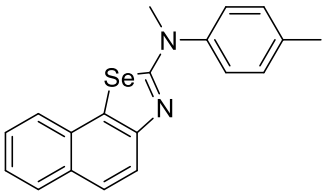
Figure S8 Apparent Quantum Yield

Where h (J·s) is Planck's constant, c ($m \cdot s^{-1}$) is the speed of light and λinc (m) is the wavelength of the incident light. P ($W \cdot cm^{-2}$) is the power density of the incident light, S (cm^2) is the irradiation area and t (s) is the photoreaction time.

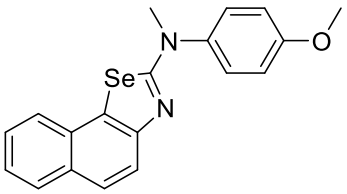
3. Characterization data of products



N-phenyl-N-methylnaphtho[2,1-d][1,3]selenazol-2-amine (4aa): 97%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.85 (d, J = 8.0 Hz, 1H), 7.83-7.75 (m, 2H), 7.50 (d, J = 4.4 Hz, 5H), 7.46-7.33 (m, 3H), 3.69 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.58, 152.23, 147.08, 130.44, 130.12, 129.77, 129.56, 128.68, 127.64, 126.69, 126.51, 125.89, 125.82, 123.89, 120.81, 40.38; HRMS: calcd for $C_{18}H_{15}N_2Se$ $[M+H]^+$ 339.0395, found 339.0393.

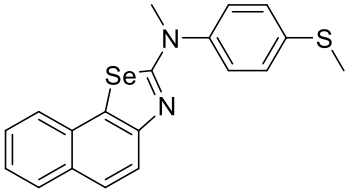


N-methyl-N-(p-tolyl)naphtho[2,1-d][1,3]selenazol-2-amine (4ab): 87%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.85 (d, J = 8.1 Hz, 1H), 7.81 (d, J = 8.7 Hz, 1H), 7.77 (d, J = 8.7 Hz, 1H), 7.48 (d, J = 8.1 Hz, 1H), 7.46-7.39 (m, 1H), 7.38-7.34 (m, 3H), 7.30 (d, J = 8.0 Hz, 2H), 3.66 (s, 3H), 2.43 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.93, 152.32, 144.58, 137.75, 130.71, 130.42, 129.73, 129.45, 128.64, 126.62, 126.46, 125.84, 125.76, 123.78, 120.72, 40.32, 21.12; HRMS: calcd for $C_{19}H_{17}N_2Se$ $[M+H]^+$ 353.0551, found 353.0545.

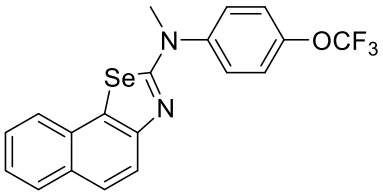


N-(4-methoxyphenyl)-N-methylnaphtho[2,1-d][1,3]selenazol-2-amine (4ac): 86%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.84 (d, J = 8.1 Hz, 1H), 7.82-7.73 (m, 2H), 7.48 (d, J = 8.2 Hz, 1H), 7.41 (t, J = 7.5 Hz, 1H), 7.38-7.3 (m, 3H), 7.02-6.96 (m, 2H), 3.85 (s, 3H), 3.63 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.48, 158.98, 152.57, 140.12, 130.50, 129.98, 129.44, 128.64, 127.79, 126.61, 126.45, 125.78, 123.75,

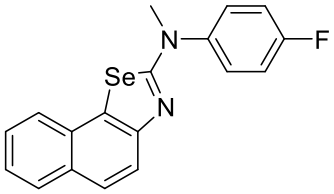
120.78, 115.26, 55.44, 40.41; HRMS: calcd for $C_{19}H_{17}N_2OSe$ $[M+H]^+$ 369.0501, found 369.0501.



N-methyl-N-(4-(methylthio)phenyl)naphtho[2,1-d][1,3]selenazol-2-amine (4ad): 84%, black oil. ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.91 (d, J = 8.0 Hz, 1H), 7.81 (d, J = 8.7 Hz, 1H), 7.71 (d, J = 8.7 Hz, 1H), 7.59 (d, J = 7.8 Hz, 1H), 7.53-7.48 (m, 2H), 7.45 (t, J = 6.9 Hz, 1H), 7.41-7.34 (m, 3H), 3.54 (s, 3H), 2.52 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 169.06, 152.19, 143.41, 137.99, 130.01, 129.21, 129.08, 128.65, 127.20, 127.03, 126.79, 126.49, 125.81, 124.13, 120.66, 40.27, 14.66; HRMS: calcd for $C_{19}H_{17}N_2SSe$ $[M+H]^+$ 385.0272, found 385.0275.

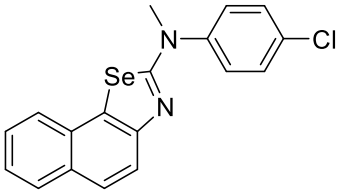


N-methyl-N-(4-(trifluoromethoxy)phenyl)naphtho[2,1-d][1,3]selenazol-2-amine (4ae): 90%, yellow oil. ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.93 (d, J = 8.1 Hz, 1H), 7.84 (d, J = 8.7 Hz, 1H), 7.79-7.74 (d, 2H), 7.72 (d, J = 8.7 Hz, 1H), 7.66 (d, J = 8.2 Hz, 1H), 7.54 (d, J = 8.4 Hz, 2H), 7.51-7.44 (m, 1H), 7.40 (t, J = 7.5 Hz, 1H), 3.59 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 168.58, 151.95, 146.78, 145.35, 129.98, 129.36, 129.19, 128.68, 127.74, 127.12, 126.93, 125.91, 124.33, 122.78, 121.12, 120.75, 119.08 (q, J = 257.04 Hz), 40.60. ^{19}F NMR (471 MHz, DMSO-d_6) δ -56.88; HRMS: calcd for $C_{19}H_{14}F_3N_2OSe$ $[M+H]^+$ 423.0218, found 423.0217.

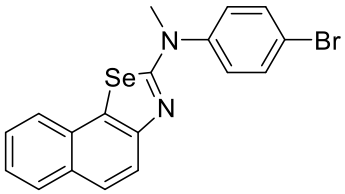


N-(4-fluorophenyl)-N-methylnaphtho[2,1-d][1,3]selenazol-2-amine (4af): 85%, black oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.85 (d, J = 8.1 Hz, 1H), 7.78 (q, J = 8.7 Hz, 2H), 7.49 (d, J = 8.1 Hz, 1H), 7.46-7.41 (m, 3H), 7.38-7.35 (m, 1H), 7.22-7.14 (m, 2H), 3.63 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.68, 162.51, 160.53 (t, J = 10.0

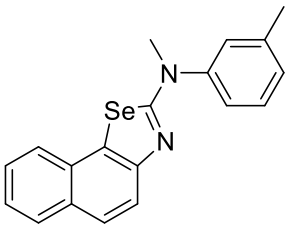
Hz), 152.26, 143.03, 143.00, 136.40, 130.40, 130.02, 129.53, 128.68, 128.22, 128.15 (d, J = 8.82 Hz), 126.77, 126.58 (d, J = 23.94 Hz), 125.79, 123.97, 120.81, 117.12, 116.94 (d, J = 22.68 Hz), 40.54. ^{19}F NMR (471 MHz, $CDCl_3$) δ -112.76; HRMS: calcd for $C_{18}H_{14}FN_2Se$ $[M+H]^+$ 357.0301, found 357.0304.



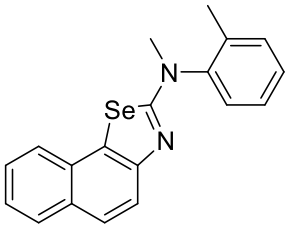
N-(4-chlorophenyl)-N-methylnaphtho[2,1-d][1,3]selenazol-2-amine (4ag): 84%, yellow oil. ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.93 (d, J = 8.1 Hz, 1H), 7.83 (d, J = 8.7 Hz, 1H), 7.72 (d, J = 8.7 Hz, 1H), 7.68-7.62 (m, 3H), 7.60 (d, J = 8.7 Hz, 2H), 7.51-7.44 (m, 1H), 7.42-7.39 (m, 1H), 3.58 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 168.61, 151.98, 145.28, 131.70, 130.15, 129.96, 129.30, 129.16, 128.67, 127.65, 127.10, 126.89, 125.85, 124.28, 120.72, 40.43; HRMS: calcd for $C_{18}H_{14}ClN_2Se$ $[M+H]^+$ 373.0005, found 373.0007.



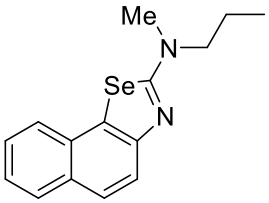
N-(4-bromophenyl)-N-methylnaphtho[2,1-d][1,3]selenazol-2-amine (4ah): 80%, yellow oil. ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.93 (d, J = 8.1 Hz, 1H), 7.83 (d, J = 8.7 Hz, 1H), 7.74-7.71 (m, 3H), 7.63 (d, J = 8.2 Hz, 1H), 7.60-7.52 (m, 2H), 7.51-7.44 (m, 1H), 7.41-7.38 (m, 1H), 3.57 (d, J = 1.1 Hz, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 168.48, 151.95, 145.68, 133.07, 129.96, 129.31, 129.17, 128.68, 127.86, 127.10, 126.89, 125.85, 124.29, 120.72, 120.03, 40.40; HRMS: calcd for $C_{18}H_{14}BrN_2Se$ $[M+H]^+$ 416.9500, found 416.9503.



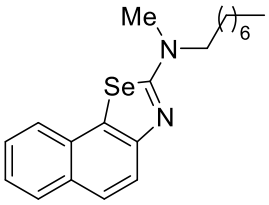
N-methyl-N-(m-tolyl)naphtho[2,1-d][1,3]selenazol-2-amine (4ai): 88%, yellow oil. ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.91 (d, J = 8.1 Hz, 1H), 7.81 (d, J = 8.7 Hz, 1H), 7.71 (d, J = 8.7 Hz, 1H), 7.59 (d, J = 8.2 Hz, 1H), 7.50-7.31 (m, 5H), 7.23 (d, J = 7.5 Hz, 1H), 3.57 (s, 3H), 2.36 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 168.92, 152.11, 146.65, 139.94, 130.04, 130.01, 129.09, 129.02, 128.63, 128.43, 126.97, 126.74, 126.11, 125.82, 124.09, 122.66, 120.65, 40.21, 20.93; HRMS: calcd for $C_{19}H_{17}N_2Se$ $[M+H]^+$ 353.0551, found 353.0549.



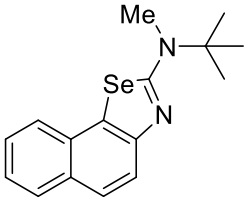
N-methyl-N-(o-tolyl)naphtho[2,1-d][1,3]selenazol-2-amine (4aj): 83%, yellow oil, ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.87-7.74 (m, 3H), 7.46-7.31 (m, 7H), 3.60 (s, 3H), 2.34 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.22, 152.61, 145.30, 136.61, 132.15, 130.53, 130.24, 129.29, 129.14, 128.66, 128.47, 128.08, 126.67, 126.48, 125.74, 123.75, 120.72, 39.26, 17.44; HRMS: calcd for $C_{19}H_{17}N_2Se$ $[M+H]^+$ 353.0551, found 353.0555.



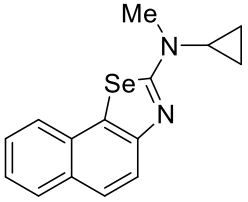
Methyl-N-propylnaphtho[2,1-d][1,3]selenazol-2-amine (4ak): 98%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.75-7.74 (m, 1H), 7.64 (s, 2H), 7.50-7.48 (m, 1H), 7.38-7.35 (m, 1H), 7.27-7.24 (m, 1H), 3.39-3.37 (t, J = 5 Hz, 2H), 3.11 (s, 3H), 1.68-1.64 (m, 2H), 0.91-0.88 (t, J = 7.5 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.47, 152.87, 130.71, 129.37, 129.14, 128.79, 126.76, 126.60, 125.81, 123.63, 120.73, 56.59, 38.84, 20.63, 11.39; HRMS: calcd for $C_{15}H_{17}N_2Se$ $[M+H]^+$ 305.0551, found 305.0553.



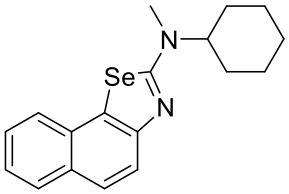
Methyl-N-octylnaphtho[2,1-d][1,3]selenazol-2-amine (4al): 90%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89-7.77 (m, 3H), 7.64-7.62 (m, 1H), 7.51-7.48 (m, 1H), 7.40-7.37 (m, 1H), 3.55-3.52 (t, J = 7.5 Hz, 2H), 3.24 (s, 3H), 1.77-1.72 (m, 2H), 1.39-1.32 (m, 10H), 0.94-0.91 (t, J = 7.5 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.38, 152.85, 130.72, 129.35, 129.14, 128.78, 126.74, 126.58, 125.81, 123.62, 120.73, 55.07, 38.75, 31.85, 29.40, 29.28, 27.29, 26.90, 22.69, 14.16; HRMS: calcd for $C_{20}H_{27}N_2Se$ $[M+H]^+$ 375.1334, found 375.1330.



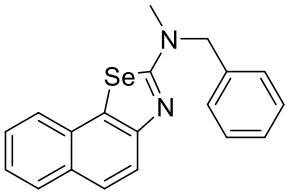
(tert-butyl)-N-methylnaphtho[2,1-d][1,3]selenazol-2-amine (4am): 95%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.90-7.68 (m, 4H), 7.52-7.39 (m, 2H), 3.18 (s, 3H), 1.67 (s, 9H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 168.84, 152.63, 130.60, 129.78, 129.21, 128.75, 126.47, 126.41, 126.32, 123.64, 121.22, 59.37, 39.13, 28.31; HRMS: calcd for $C_{16}H_{19}N_2Se$ $[M+H]^+$ 319.0708, found 319.0713.



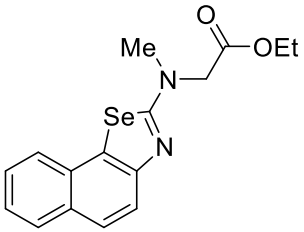
N-cyclopropyl-N-methylnaphtho[2,1-d][1,3]selenazol-2-amine (4an): 92%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7,90-7.37 (m, 6H), 3.39-3.31 (m, 3H), 2.82-2.27 (m, 1H), 0.98-0.91 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 171.52, 152.17, 130.65, 129.91, 129.32, 128.78, 126.61, 126.56, 125.95, 123.86, 121.00, 38.48, 36.18, 8.89; HRMS: calcd for $C_{15}H_{15}N_2Se$ $[M+H]^+$ 303.0395, found 303.0399.



N-cyclohexyl-N-methylnaphtho[2,1-d][1,3]selenazol-2-amine (4ao): 65%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.85 (d, J = 8.1 Hz, 1H), 7.74 (s, 2H), 7.60 (d, J = 8.2 Hz, 1H), 7.50-7.44 (m, 1H), 7.36 (t, J = 7.5 Hz, 1H), 3.85 (s, 1H), 3.11 (s, 3H), 1.97-1.87 (m, 4H), 1.75-1.71 (m, 1H), 1.60-1.41 (m, 4H), 1.21-1.11 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.77, 152.58, 130.57, 129.00, 128.68, 128.59, 126.62, 126.46, 125.66, 123.47, 120.60, 62.23, 33.28, 30.09, 25.75, 25.40; HRMS: calcd for $C_{18}H_{21}N_2Se$ $[M+H]^+$ 345.0864, found 345.0867.

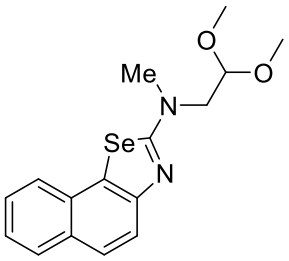


N-benzyl-N-methylnaphtho[2,1-d][1,3]selenazol-2-amine (4ap): 72%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.87 (d, J = 8.1 Hz, 1H), 7.78 (s, 2H), 7.61 (d, J = 8.1 Hz, 1H), 7.48 (t, J = 7.5 Hz, 1H), 7.41-7.28 (m, 6H), 4.81 (s, 2H), 3.18 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.96, 152.60, 136.20, 130.60, 129.71, 129.17, 128.75, 128.72, 127.73, 127.54, 126.80, 126.59, 125.74, 123.72, 120.75, 57.45, 38.90; HRMS: calcd for $C_{19}H_{17}N_2Se$ $[M+H]^+$ 353.0551, found 353.0551.

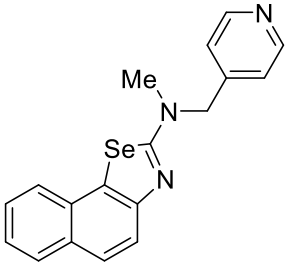


Ethyl N-methyl-N-(naphtho[2,1-d][1,3]selenazol-2-yl)glycinate (4aq): 88%, light yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89-7.35 (m, 6H), 4.44 (s, 2H), 4.28-4.22 (m, 2H), 3.29-3.23 (m, 3H), 1.32-1.27 (m, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.60, 169.12, 152.40, 130.62, 129.31, 128.79, 126.83, 126.68, 125.87, 125.84,

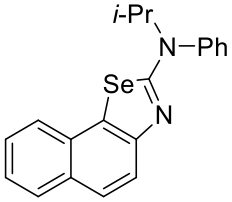
123.96, 121.05, 61.43, 53.74, 41.07, 14.25; HRMS: calcd for $C_{16}H_{17}N_2O_2Se$ $[M+H]^+$ 349.0450, found 349.0447.



N-(2,2-dimethoxyethyl)-N-methylnaphtho[2,1-d][1,3]selenazol-2-amine (4ar): 95%, white oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.76-7.75 (d, J = 5 Hz, 1H), 7.65 (d, J = 5 Hz, 2H), 7.52-7.50 (d, J = 10 Hz, 1H), 7.39-7.36 (t, J = 7.5 Hz, 1H), 7.28-7.25 (t, J = 7.5 Hz, 1H), 4.63-4.60 (t, J = 7.5 Hz, 1H), 3.60-3.59 (d, J = 5 Hz, 2H), 3.36 (s, 6H), 3.16 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.40, 152.74, 130.68, 129.83, 129.19, 128.79, 126.80, 126.66, 125.85, 123.79, 120.89, 102.98, 55.81, 55.04, 41.31; HRMS: calcd for $C_{16}H_{19}N_2O_2Se$ $[M+H]^+$ 351.0606, found 351.0607.

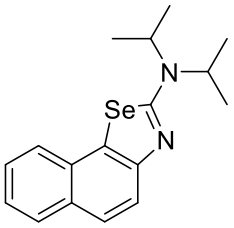


Methyl-N-(pyridin-4-ylmethyl)naphtho[2,1-d][1,3]selenazol-2-amine (4as): 70%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.60-8.54 (m, 2H), 7.89-7.20 (m, 8H), 4.85 (s, 2H), 3.18 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.72, 152.48, 150.20, 145.77, 130.62, 130.23, 129.34, 128.84, 127.03, 126.81, 125.81, 124.05, 122.36, 120.89, 55.70, 39.75; HRMS: calcd for $C_{18}H_{16}N_3Se$ $[M+H]^+$ 354.0504, found 354.0500.

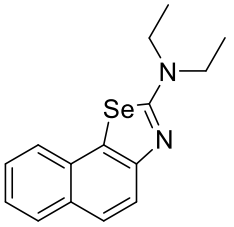


Isopropyl-N-phenylnaphtho[2,1-d][1,3]selenazol-2-amine (4at): 72%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.75-7.65 (m, 3H), 7.48-7.43 (m, 3H), 7.35-7.17 (m, 5H),

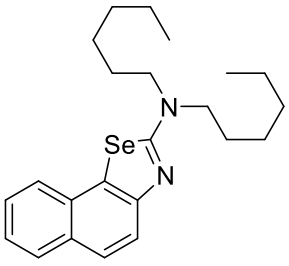
5.20-5.14 (m, 1H), 1.21 (s, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.81, 152.60, 142.20, 130.94, 130.51, 130.16, 129.57, 129.35, 129.16, 128.70, 126.63, 126.45, 125.88, 123.68, 120.85, 51.42, 21.26; HRMS: calcd for $C_{20}H_{19}N_2Se$ $[M+H]^+$ 367.0708, found 367.0710.



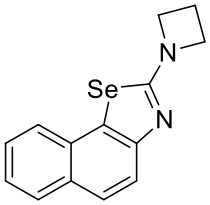
N,N-diisopropylnaphtho[2,1-d][1,3]selenazol-2-amine (4au): 84%, yellow solid. ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.91 (d, J = 8.1 Hz, 1H), 7.77 (d, J = 8.7 Hz, 1H), 7.63-7.61 (m, 2H), 7.51-7.49 (m, 1H), 7.38-7.35 (m, 1H), 3.88-3.80 (m, 2H), 1.42 (d, J = 6.7 Hz, 12H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 165.68, 152.77, 130.05, 128.69, 128.49, 127.34, 126.94, 126.49, 125.75, 123.58, 120.47, 19.97; HRMS: calcd for $C_{17}H_{21}N_2Se$ $[M+H]^+$ 333.0864, found 333.0867.



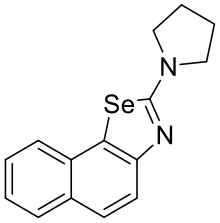
N,N-diethylnaphtho[2,1-d][1,3]selenazol-2-amine (4av): 90%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.88-7.82 (m, 1H), 7.74 (s, 2H), 7.59 (d, J = 8.2 Hz, 1H), 7.50-7.44 (m, 1H), 7.39-7.32 (m, 1H), 3.60 (q, J = 7.2 Hz, 4H), 1.33 (t, J = 7.2 Hz, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 168.21, 152.81, 130.65, 129.03, 128.94, 128.69, 126.58, 126.46, 125.74, 123.46, 120.59, 46.55, 12.86; HRMS: calcd for $C_{15}H_{17}N_2Se$ $[M+H]^+$ 305.0551, found 305.0552.



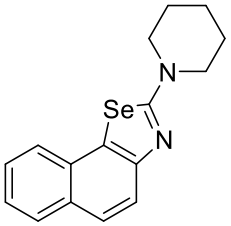
N,N-dihexylnaphtho[2,1-d][1,3]selenazol-2-amine (4aw): 70%, yellow oil. ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.90 (d, J = 8.2 Hz, 1H), 7.77 (d, J = 8.7 Hz, 1H), 7.62 (t, J = 8.3 Hz, 2H), 7.49 (t, J = 7.5 Hz, 1H), 7.36 (t, J = 7.5 Hz, 1H), 3.46 (t, J = 7.5 Hz, 4H), 1.65 (t, J = 7.4 Hz, 4H), 1.28 (q, J = 7.8, 7.0 Hz, 12H), 0.88-0.82 (m, 6H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 168.15, 152.63, 130.19, 128.68, 128.55, 128.31, 126.98, 126.63, 125.59, 123.68, 120.41, 31.03, 27.01, 26.00, 22.11, 13.94; HRMS: calcd for $C_{23}H_{33}N_2Se$ $[M+H]^+$ 417.1803, found 417.1805.



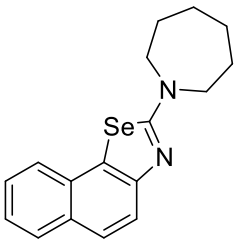
2-(azetidin-1-yl)naphtho[2,1-d][1,3]selenazole (4ax): 98%, white oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.84 (d, J = 8.1 Hz, 1H), 7.75 (s, 2H), 7.58 (d, J = 8.2 Hz, 1H), 7.46 (t, J = 7.5 Hz, 1H), 7.36 (t, J = 7.5 Hz, 1H), 4.20 (t, J = 7.5 Hz, 4H), 2.53-2.47 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.39, 152.54, 130.80, 130.46, 129.27, 128.79, 126.90, 126.70, 125.96, 123.92, 120.76, 53.60, 17.24; HRMS: calcd for $C_{14}H_{13}N_2Se$ $[M+H]^+$ 289.0238, found 289.0236.



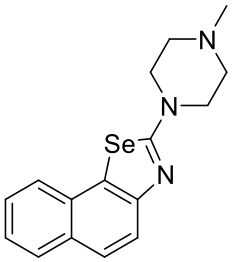
2-(pyrrolidin-1-yl)naphtho[2,1-d][1,3]selenazole (4ay): 75%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.85 (d, J = 8.1 Hz, 1H), 7.81-7.72 (m, 2H), 7.60 (d, J = 8.2 Hz, 1H), 7.47 (t, J = 7.5 Hz, 1H), 7.36 (t, J = 7.5 Hz, 1H), 3.58 (d, J = 6.4 Hz, 4H), 2.11-2.03 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 166.00, 152.76, 130.69, 129.18, 128.94, 128.67, 126.71, 126.48, 125.72, 123.50, 120.62, 50.41, 25.60; HRMS: calcd for $C_{15}H_{15}N_2Se$ $[M+H]^+$ 303.0395, found 303.0394.



2-(piperidin-1-yl)naphtho[2,1-d][1,3]selenazole (4az): 95%, white oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.83 (d, J = 8.1 Hz, 1H), 7.77-7.67 (m, 2H), 7.58 (d, J = 8.2 Hz, 1H), 7.45 (t, J = 7.5 Hz, 1H), 7.34 (t, J = 7.5 Hz, 1H), 3.60 (t, J = 5.2 Hz, 4H), 1.73-1.68 (m, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.16, 152.60, 130.67, 129.34, 129.26, 128.79, 126.77, 126.60, 125.85, 123.74, 120.76, 51.01, 25.46, 24.36; HRMS: calcd for $C_{16}H_{17}N_2Se$ $[M+H]^+$ 317.0551, found 317.0555.

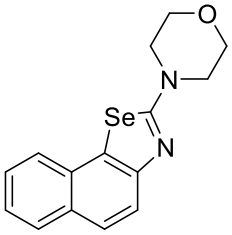


2-(azepan-1-yl)naphtho[2,1-d][1,3]selenazole (4aA): 84%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.85 (d, J = 8.1 Hz, 1H), 7.75 (s, 2H), 7.60 (d, J = 8.1 Hz, 1H), 7.47 (t, J = 7.5 Hz, 1H), 7.36 (t, J = 7.5 Hz, 1H), 3.68 (t, J = 6.1 Hz, 4H), 1.95-1.81 (m, 4H), 1.65-1.61 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.08, 152.81, 130.60, 128.93, 128.78, 128.65, 126.58, 126.43, 125.68, 123.40, 120.56, 51.90, 27.83, 27.52; HRMS: calcd for $C_{17}H_{19}N_2Se$ $[M+H]^+$ 331.0708, found 331.0706.

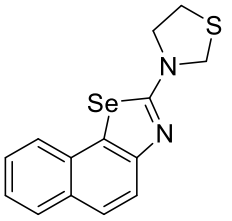


2-(4-methylpiperazin-1-yl)naphtho[2,1-d][1,3]selenazole (4aB): 70%, yellow oil. ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.93 (d, J = 8.1 Hz, 1H), 7.81 (d, J = 8.6 Hz, 1H), 7.65 (t, J = 7.7 Hz, 2H), 7.52 (t, J = 7.5 Hz, 1H), 7.40 (t, J = 7.5 Hz, 1H), 3.57 (t, J = 5.1 Hz, 4H), 2.45 (t, J = 5.1 Hz, 4H), 2.23 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ

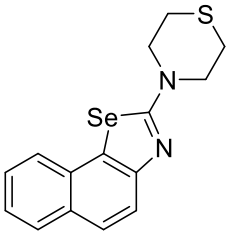
169.59, 152.16, 130.13, 129.08, 128.82, 128.76, 127.14, 126.84, 125.71, 124.11, 120.62, 53.88, 49.19, 45.68; HRMS: calcd for $C_{16}H_{18}N_3Se$ $[M+H]^+$ 332.0660, found 332.0661.



4-(naphtho[2,1-d][1,3]selenazol-2-yl)morpholine (4aC): 85%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.87 (d, J = 8.1 Hz, 1H), 7.75 (q, J = 8.7 Hz, 2H), 7.62 (d, J = 8.2 Hz, 1H), 7.49 (t, J = 7.5 Hz, 1H), 7.39 (t, J = 7.5 Hz, 1H), 3.85 (t, J = 5.0 Hz, 4H), 3.66-3.61 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.37, 151.98, 130.47, 129.66, 129.38, 128.76, 126.94, 126.69, 125.80, 124.07, 120.84, 66.24, 49.63; HRMS: calcd for $C_{15}H_{15}N_2OSe$ $[M+H]^+$ 319.0344, found 319.0347.

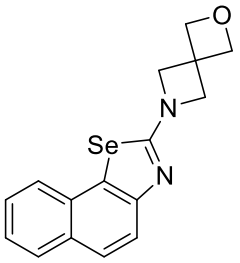


3-(naphtho[2,1-d][1,3]selenazol-2-yl)thiazolidine (4aD): 95%, white oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.87 (d, J = 8.1 Hz, 1H), 7.77 (s, 2H), 7.61 (d, J = 8.1 Hz, 1H), 7.51-7.48 (m, 1H), 7.41-7.38 (m, 1H), 4.73 (s, 2H), 3.92 (t, J = 6.2 Hz, 2H), 3.22 (t, J = 6.2 Hz, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 165.76, 152.16, 130.63, 130.29, 129.43, 128.83, 127.08, 126.79, 125.86, 124.15, 120.96, 53.66, 52.42, 30.69; HRMS: calcd for $C_{14}H_{13}N_2SSe$ $[M+H]^+$ 320.9959, found 320.9955.

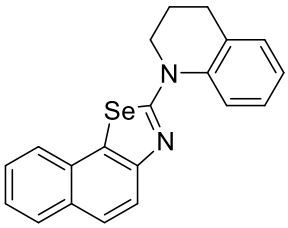


4-(naphtho[2,1-d][1,3]selenazol-2-yl)thiomorpholine (4aE): 95%, white solid. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.84 (d, J = 8.1 Hz, 1H), 7.74 (d, J = 8.7 Hz, 1H), 7.69 (d,

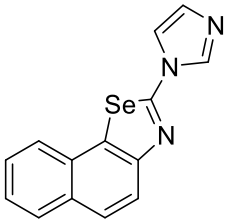
J = 8.7 Hz, 1H), 7.58 (d, *J* = 8.2 Hz, 1H), 7.47 (t, *J* = 7.5 Hz, 1H), 7.37 (t, *J* = 7.5 Hz, 1H), 4.00-3.93 (m, 4H), 2.81-2.74 (m, 4H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.36, 152.24, 130.57, 129.78, 129.42, 128.84, 126.98, 126.76, 125.82, 124.06, 120.86, 52.65, 26.79; HRMS: calcd for $C_{15}H_{15}N_2SSe$ $[M+H]^+$ 335.0116, found 335.0119.



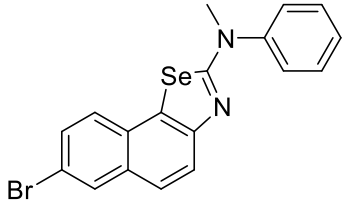
6-(naphtho[2,1-d][1,3]selenazol-2-yl)-2-oxa-6-azaspiro[3.3]heptane (4aF): 96%, white oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.86 (d, *J* = 8.1 Hz, 1H), 7.76 (s, 2H), 7.59 (d, *J* = 8.1 Hz, 1H), 7.48 (t, *J* = 7.5 Hz, 1H), 7.39 (t, *J* = 7.5 Hz, 1H), 4.86 (s, 3H), 4.33 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.04, 152.18, 130.95, 130.71, 129.45, 128.84, 127.09, 126.84, 125.97, 124.24, 120.83, 80.77, 62.86, 39.73; HRMS: calcd for $C_{16}H_{15}N_2OSe$ $[M+H]^+$ 331.0344, found 331.0347.



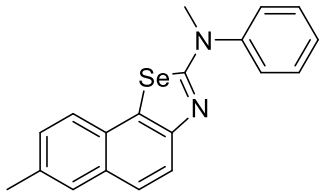
2-(3,4-dihydroquinolin-1(2H)-yl)naphtho[2,1-d][1,3]selenazole (4aG): 97%, yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.87 (d, *J* = 8.1 Hz, 1H), 7.77 (d, *J* = 8.1 Hz, 1H), 7.74-7.65 (m, 2H), 7.49 (d, *J* = 8.2 Hz, 1H), 7.37 (t, *J* = 7.5 Hz, 1H), 7.33-7.26 (m, 1H), 7.20-7.13 (m, 1H), 7.10 (d, *J* = 7.4 Hz, 1H), 7.03 (t, *J* = 7.4 Hz, 1H), 4.05 (t, *J* = 6.2 Hz, 2H), 2.72 (t, *J* = 6.4 Hz, 2H), 2.04-1.95 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 167.88, 151.23, 141.41, 131.00, 130.37, 129.89, 129.11, 128.99, 128.71, 126.81, 126.70, 126.62, 125.96, 124.50, 124.18, 120.96, 120.51, 49.80, 27.35, 23.45; HRMS: calcd for $C_{20}H_{17}N_2Se$ $[M+H]^+$ 365.0551, found 365.0556.



2-(1H-imidazol-1-yl)naphtho[2,1-d][1,3]selenazole (4aH): 60%, yellow oil. ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.62 (s, 1H), 8.10 (d, J = 8.0 Hz, 1H), 8.04 (dd, J = 5.5, 3.0 Hz, 4H), 7.68 (t, J = 7.4 Hz, 1H), 7.62 (t, J = 7.5 Hz, 1H), 7.23 (d, J = 1.4 Hz, 1H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 157.75, 149.25, 136.90, 134.31, 130.96, 130.55, 129.73, 128.96, 127.97, 127.86, 126.59, 126.49, 122.13, 118.96; HRMS: calcd for $C_{14}H_{10}N_3Se$ $[M+H]^+$ 300.0034, found 300.0034.



7-bromo-N-methyl-N-phenylnaphtho[2,1-d][1,3]selenazol-2-amine (4ba): 73%, yellow oil, ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.22 (s, 1H), 7.83 (d, J = 8.7 Hz, 1H), 7.76 (d, J = 8.7 Hz, 1H), 7.65-7.59 (m, 3H), 7.59-7.54 (m, 3H), 7.47-7.42 (m, 1H), 3.60 (s, 3H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 169.39, 152.69, 146.56, 130.49, 130.37, 129.73, 129.07, 128.60, 128.03, 127.95, 126.10, 125.83, 121.72, 116.81, 40.37; HRMS: calcd for $C_{18}H_{14}BrN_2Se$ $[M+H]^+$ 416.9500, found 416.9503.



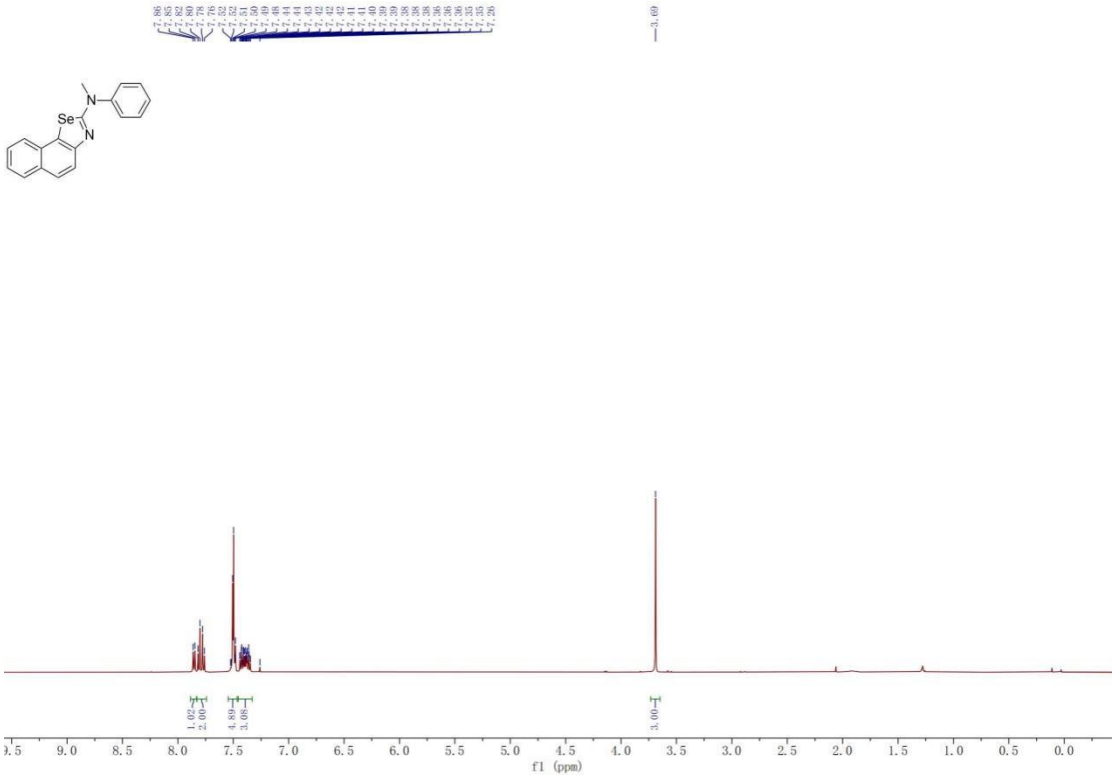
N,7-dimethyl-N-phenylnaphtho[2,1-d][1,3]selenazol-2-amine (4ca): 84%, yellow oil. ^{1}H NMR (500 MHz, DMSO-d_6) δ 7.78-7.64 (m, 3H), 7.62-7.49 (m, 5H), 7.42 (t, J = 7.3 Hz, 1H), 7.31 (d, J = 8.3 Hz, 1H), 3.59 (s, 3H), 2.44 (s, 3H); ^{13}C NMR (125 MHz, DMSO-d_6) δ 168.43, 151.44, 146.66, 133.28, 130.20, 129.29, 129.02, 128.99, 128.14, 127.63, 127.53, 126.11, 125.70, 125.68, 120.60, 40.26, 21.02; HRMS: calcd for $C_{19}H_{17}N_2Se$ $[M+H]^+$ 353.0551, found 353.0549.

4. Reference

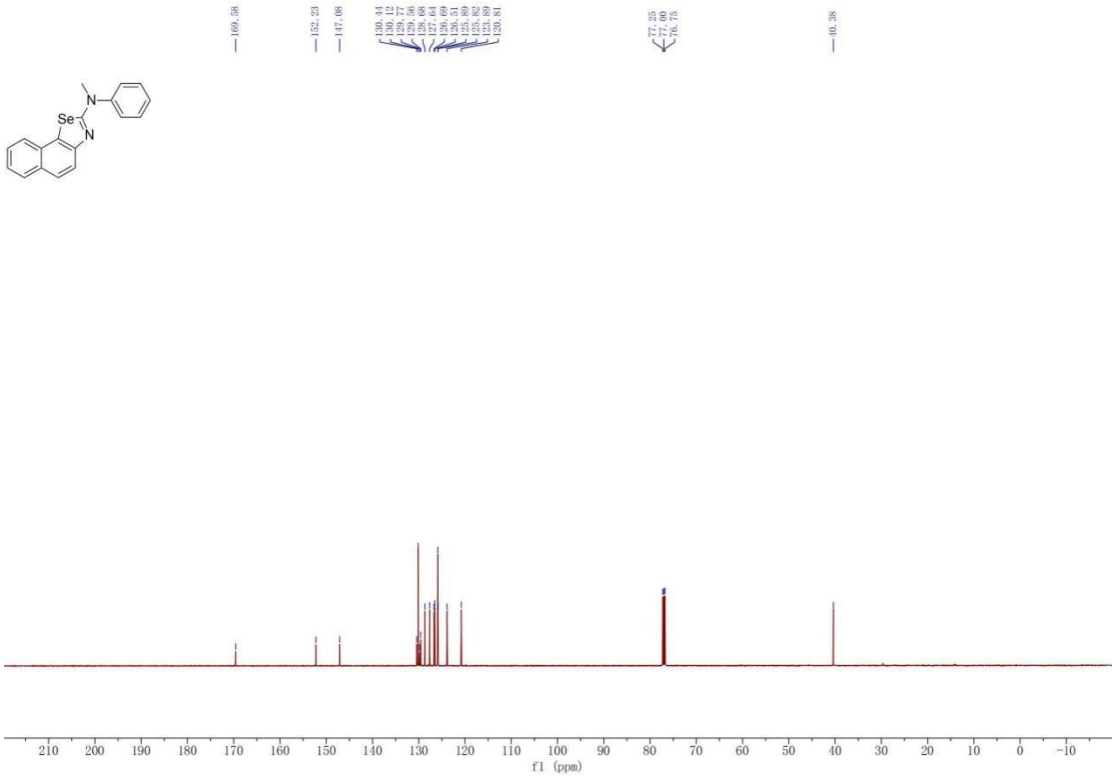
1. H. Liu, Z.-L. Ye, Z.-J. Cai and S.-J. Ji, Green Chem., 2023, **25**, 4239.

2. Y. Fang, Z.-L. Zhu, P. Xu, S.-Y. Wang and S.-J. Ji, Green Chem., 2017, **19**, 1613.

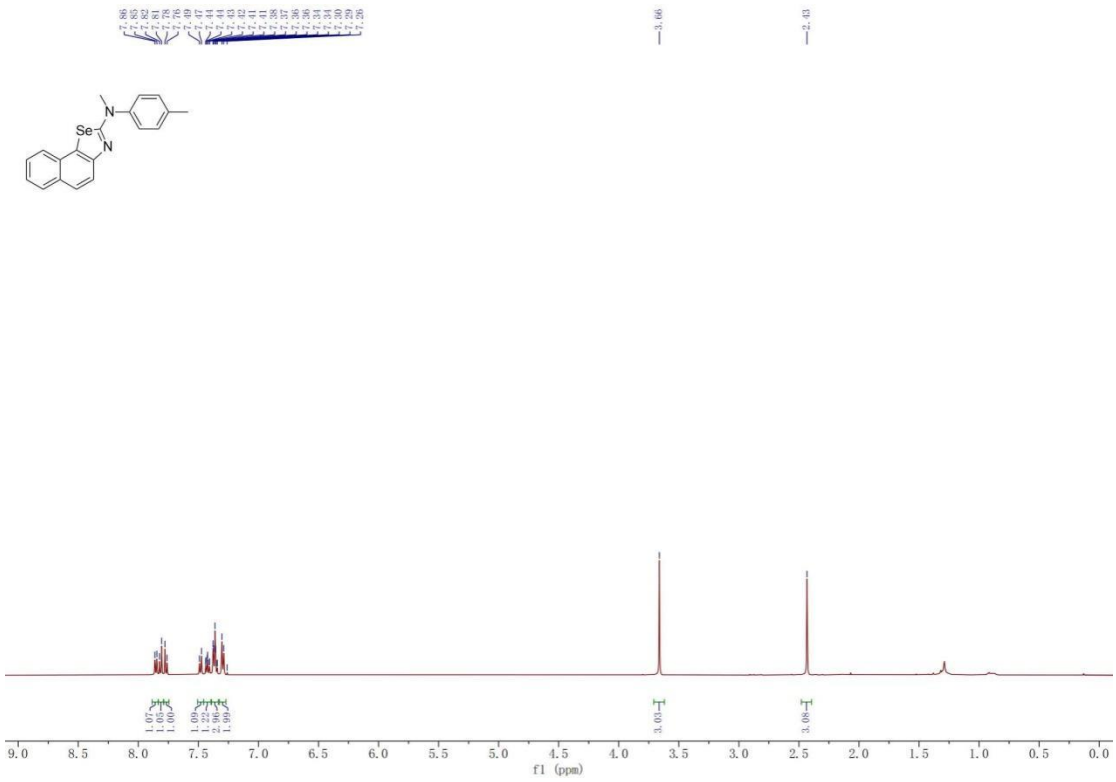
5. ^{1}H, ^{19}F and ^{13}C NMR spectra of products



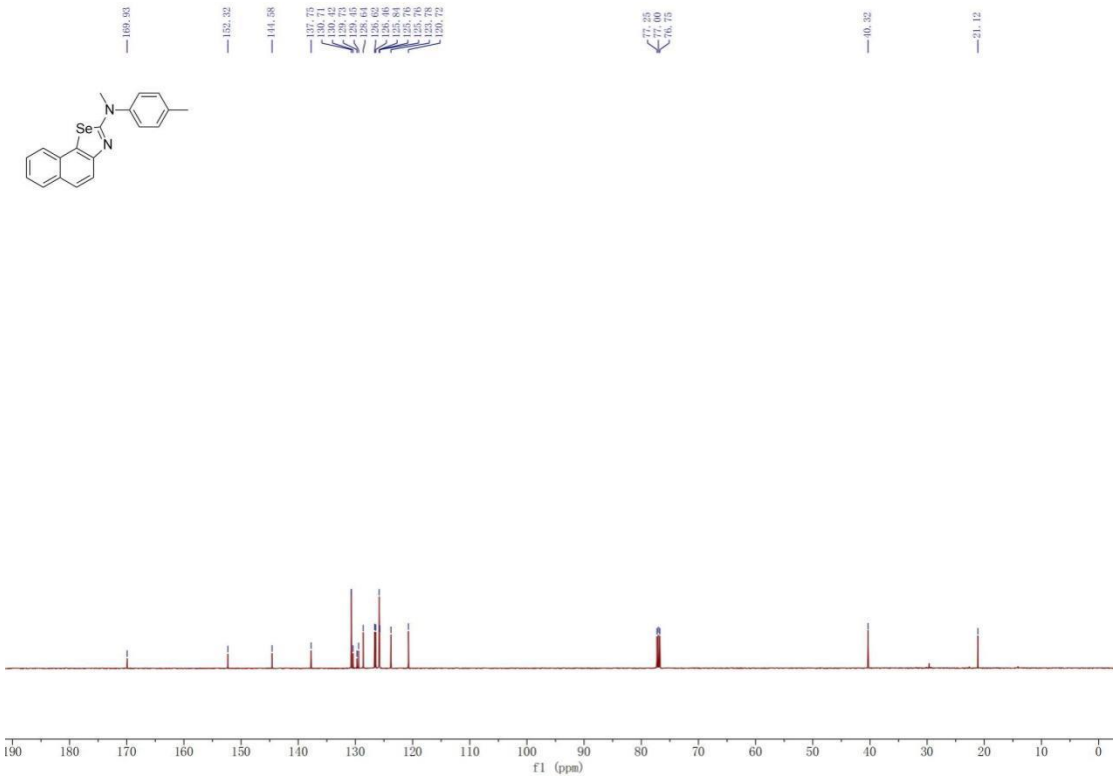
^{1}H NMR of compound **4aa**



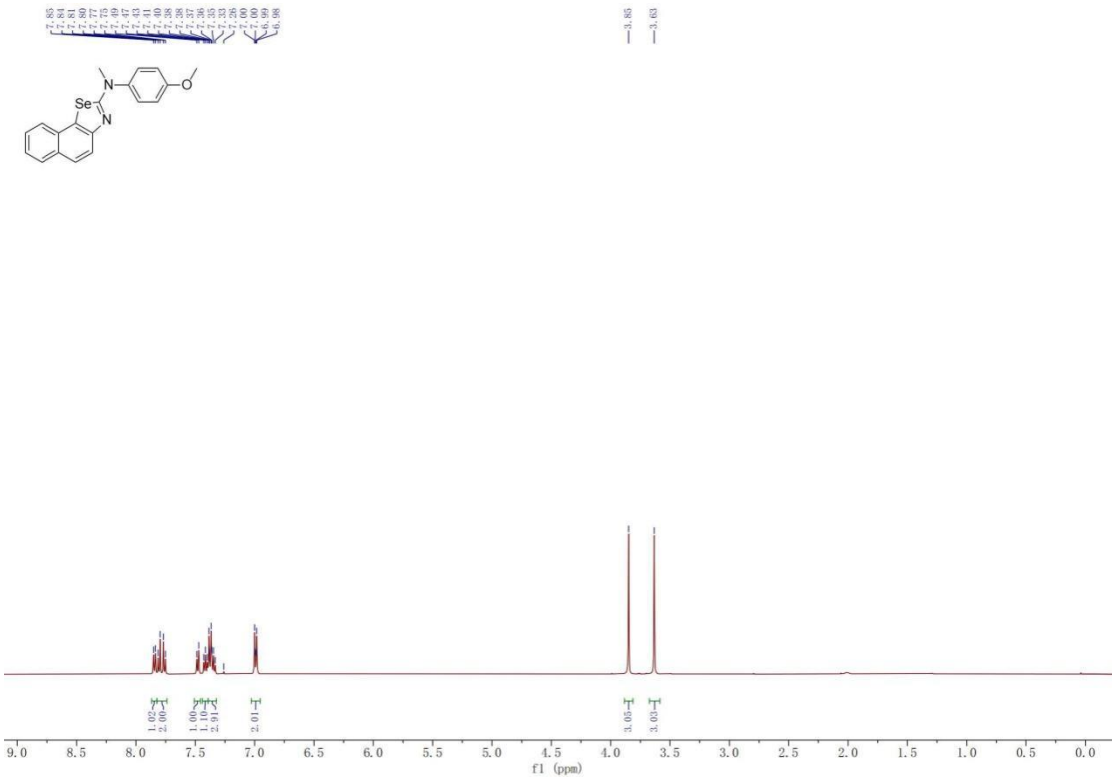
^{13}C NMR of compound **4aa**



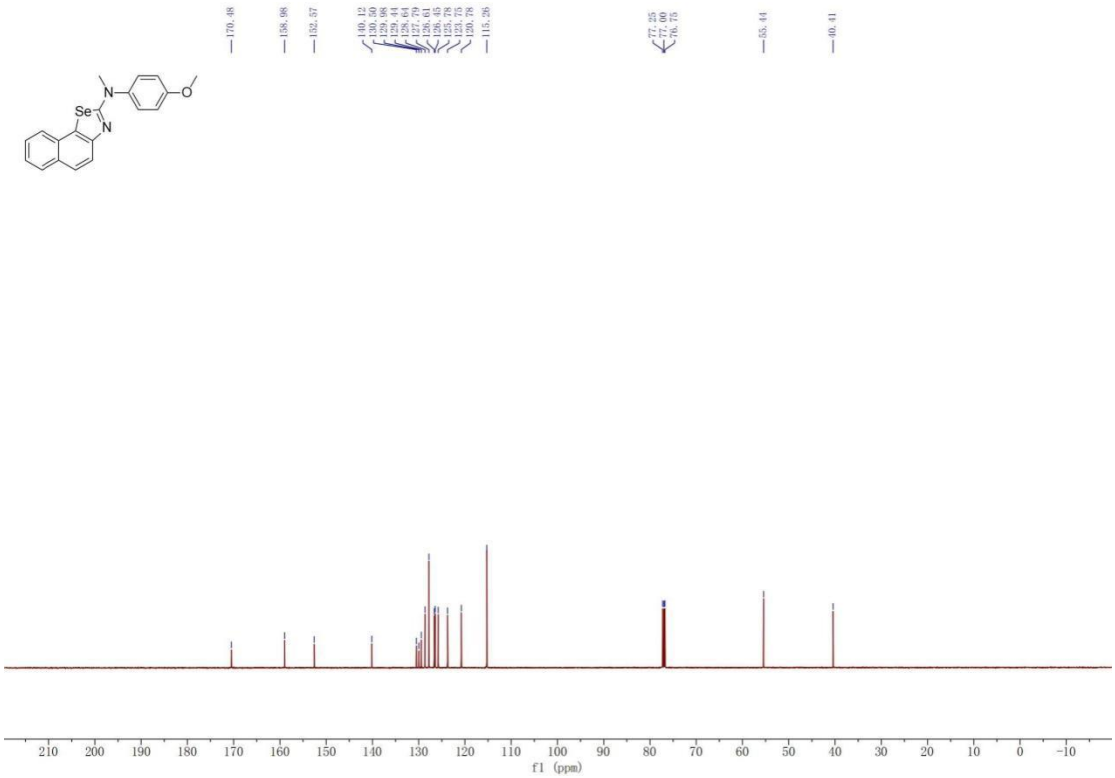
^{1}H NMR of compound **4ab**



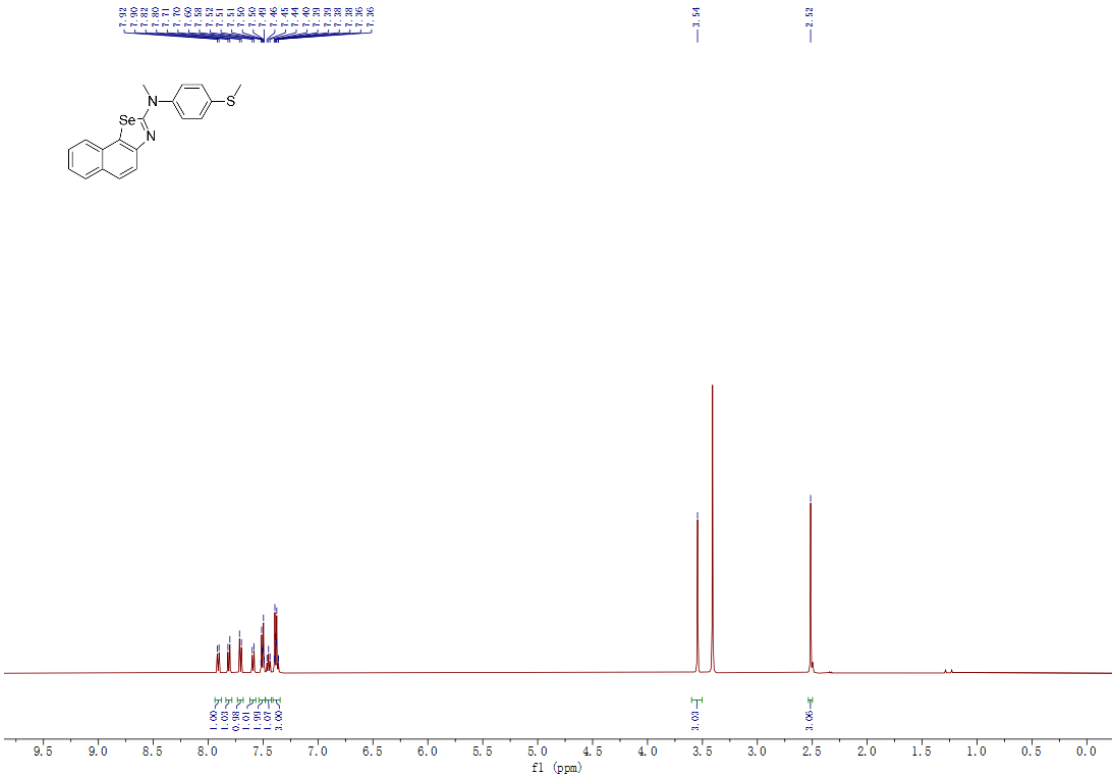
^{13}C NMR of compound **4ab**



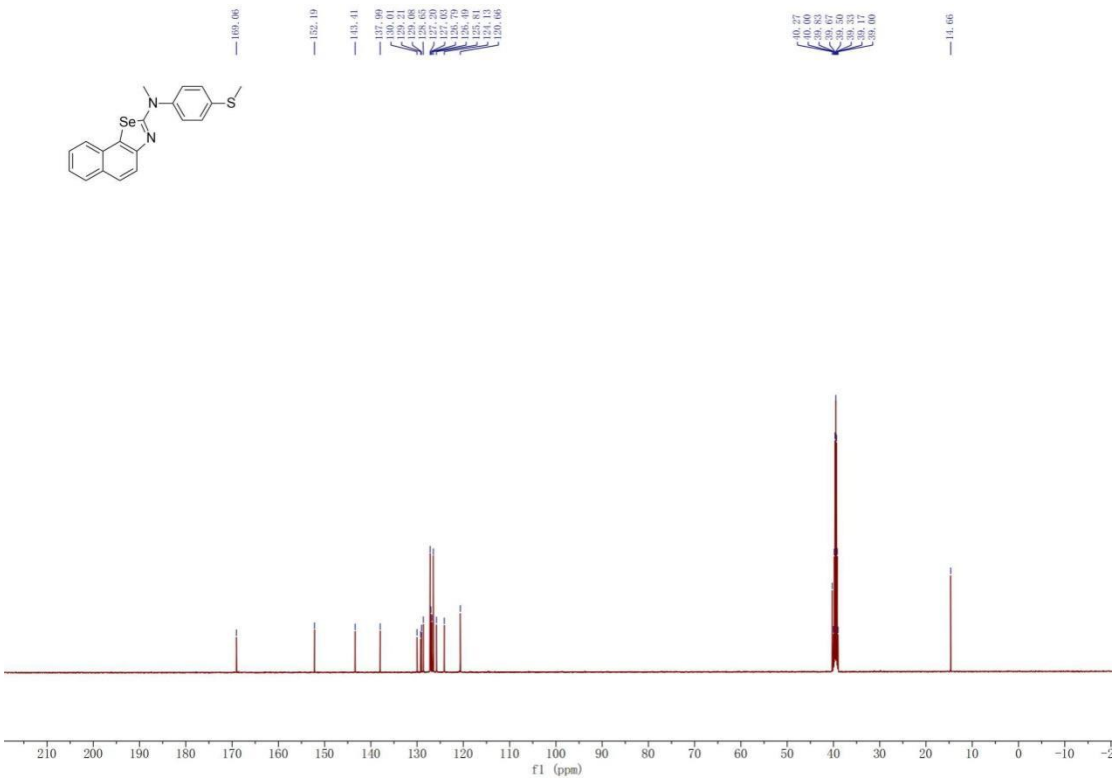
^{1}H NMR of compound **4ac**



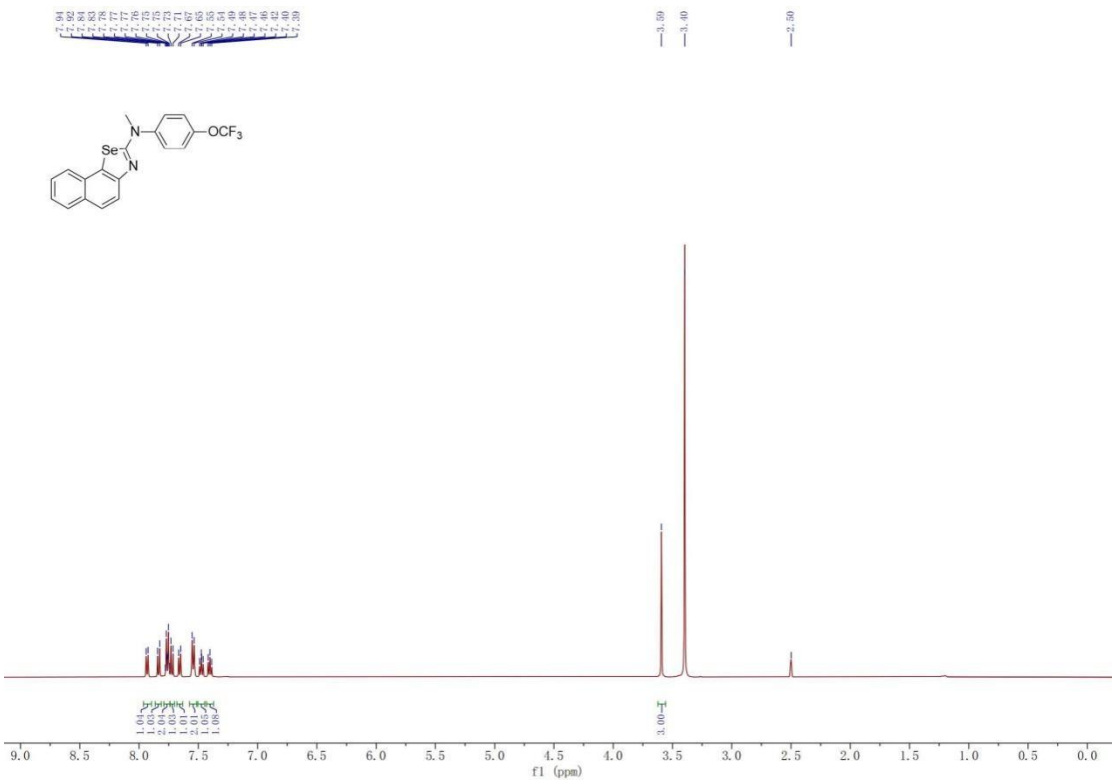
^{13}C NMR of compound **4ac**



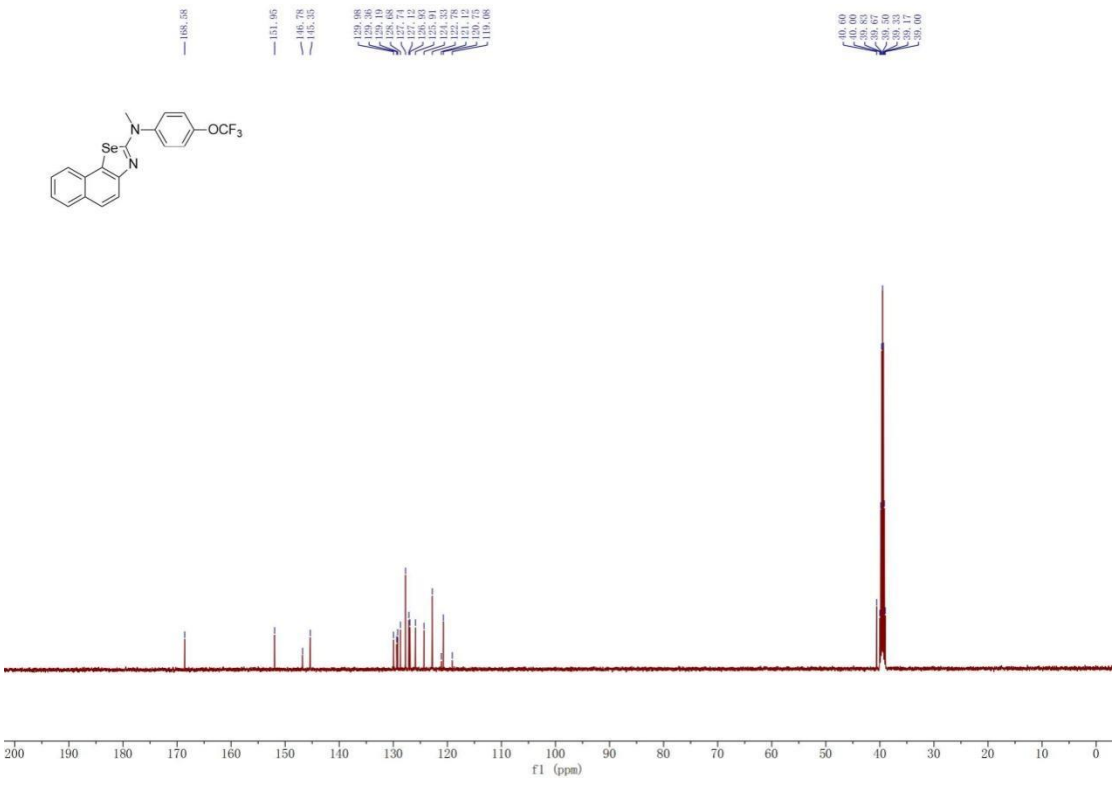
^{1}H NMR of compound **4ad**



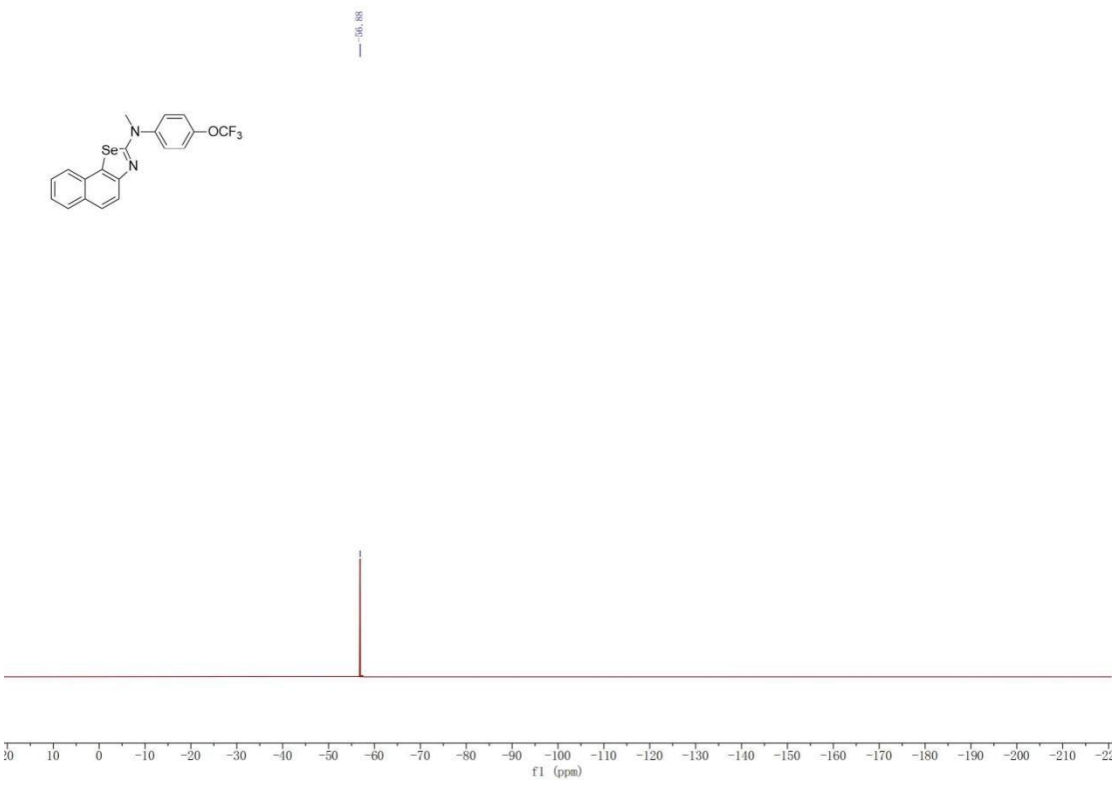
^{13}C NMR of compound **4ad**



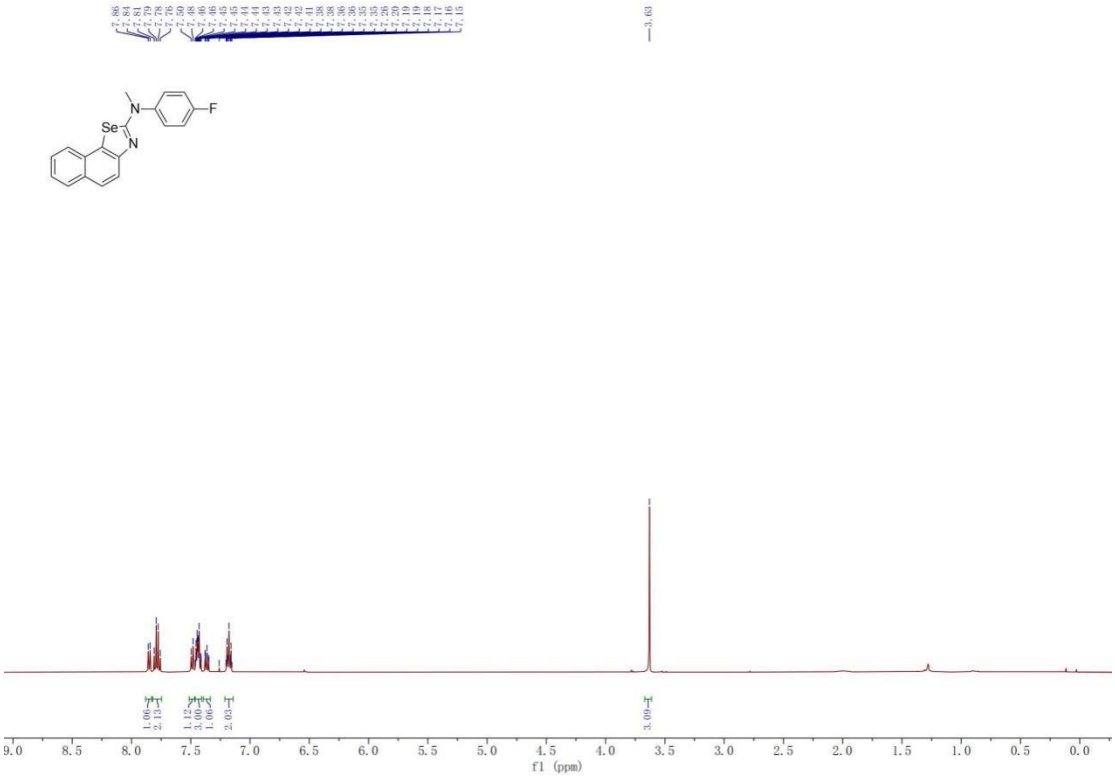
^{1}H NMR of compound **4ae**



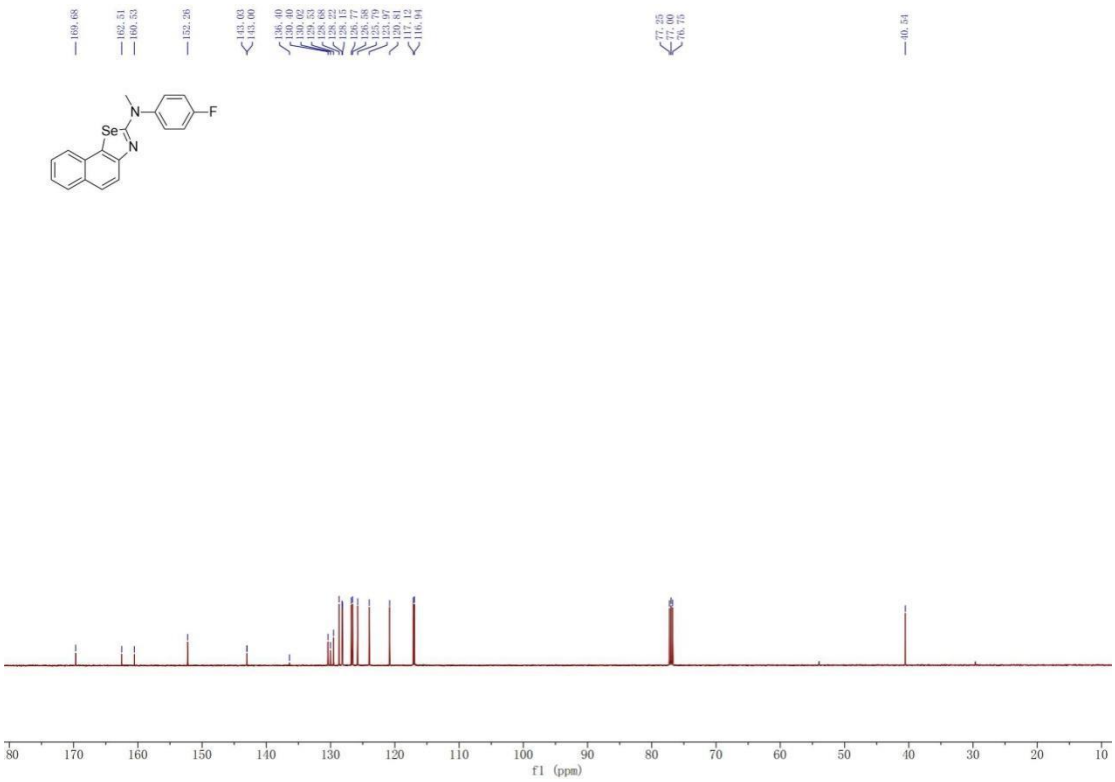
^{13}C NMR of compound **4ae**



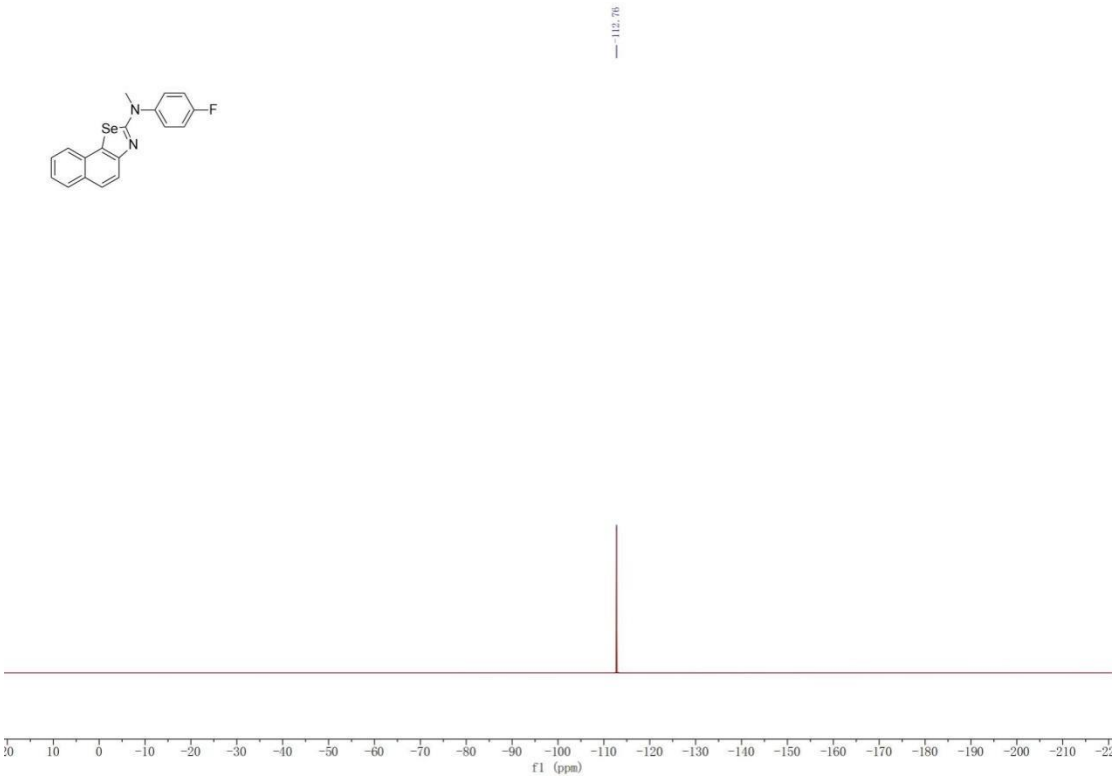
^{19}F NMR of compound **4ae**



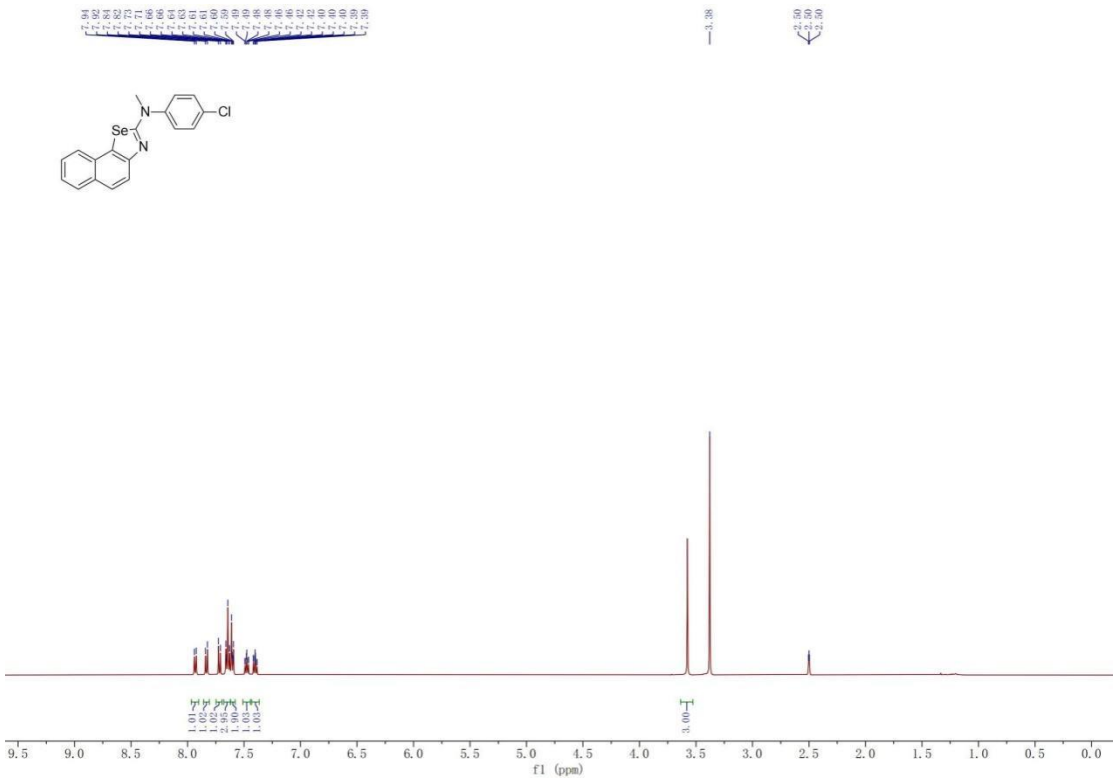
^{1}H NMR of compound **4af**



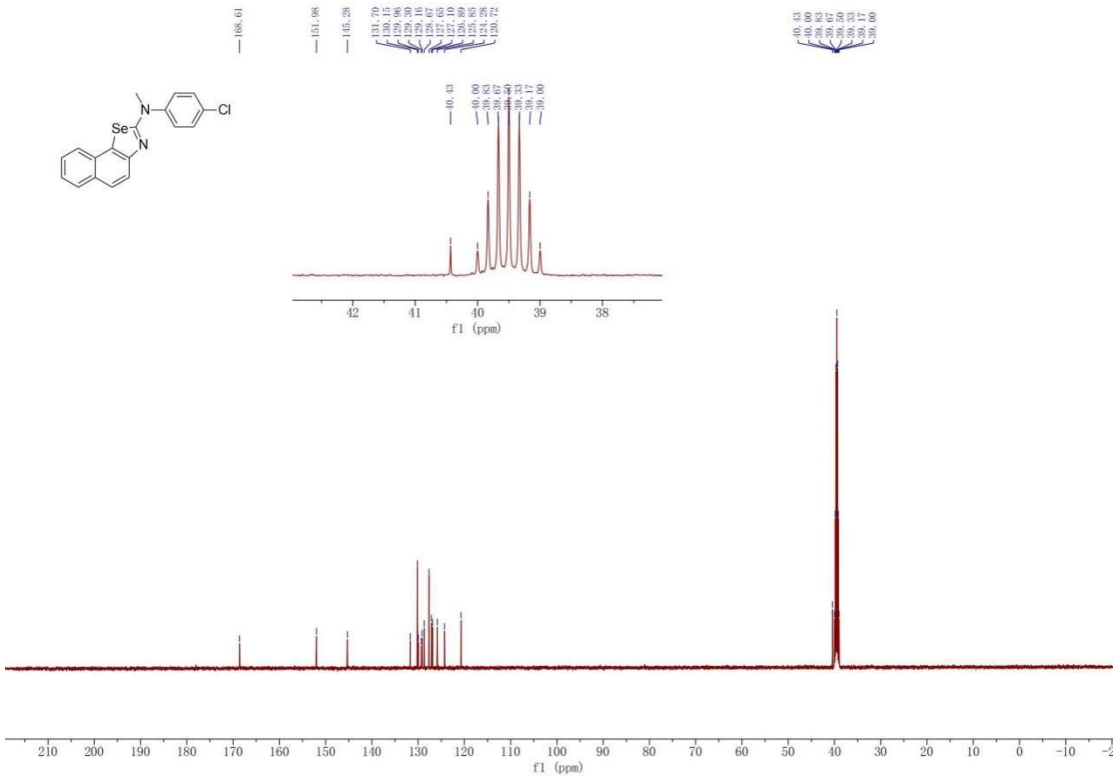
^{13}C NMR of compound **4af**



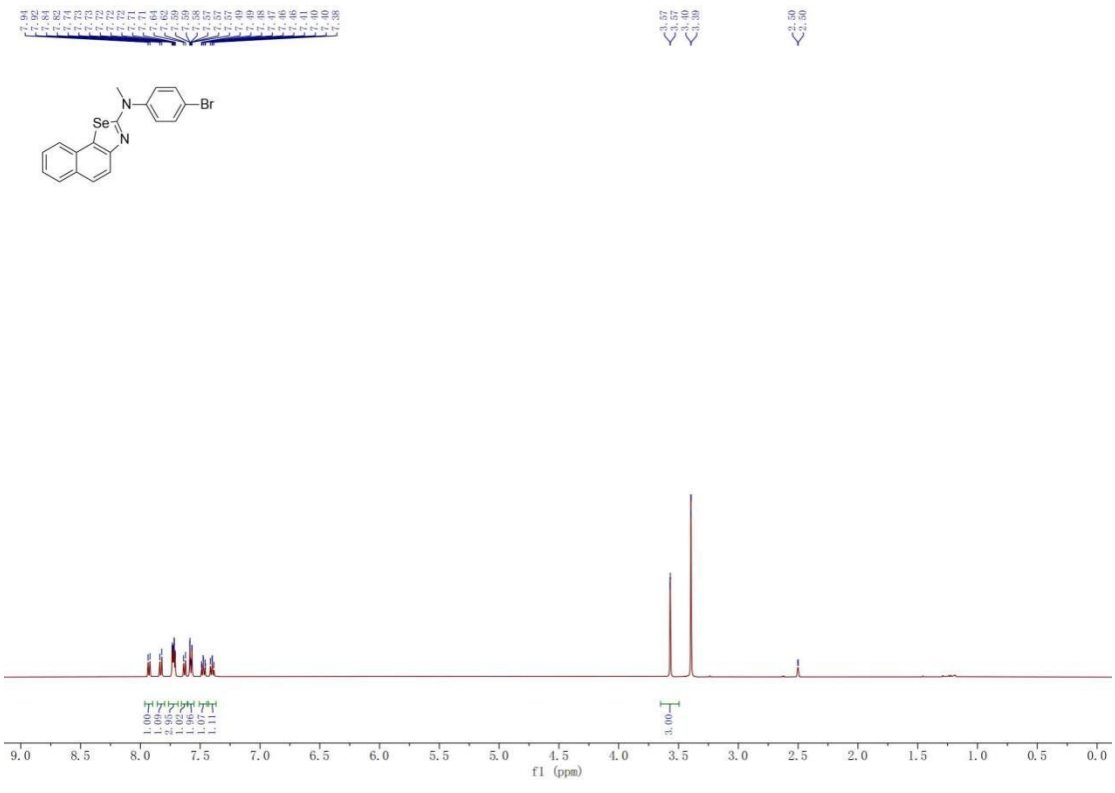
^{19}F NMR of compound **4af**



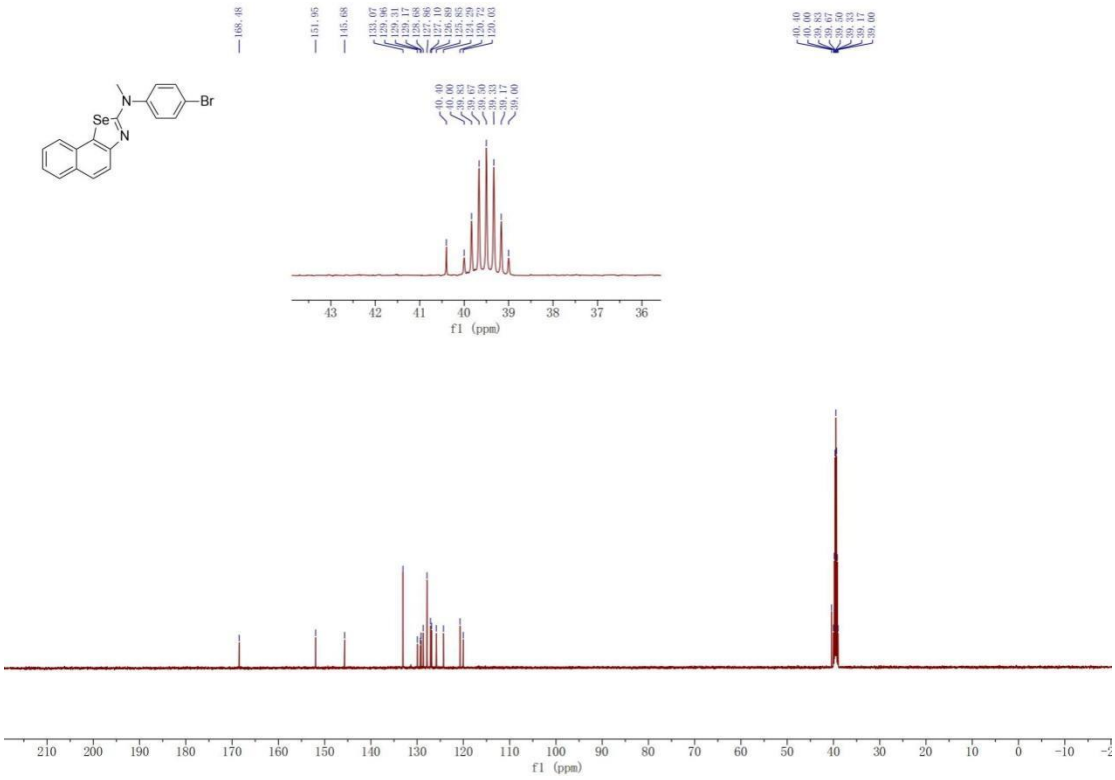
^{1}H NMR of compound **4ag**



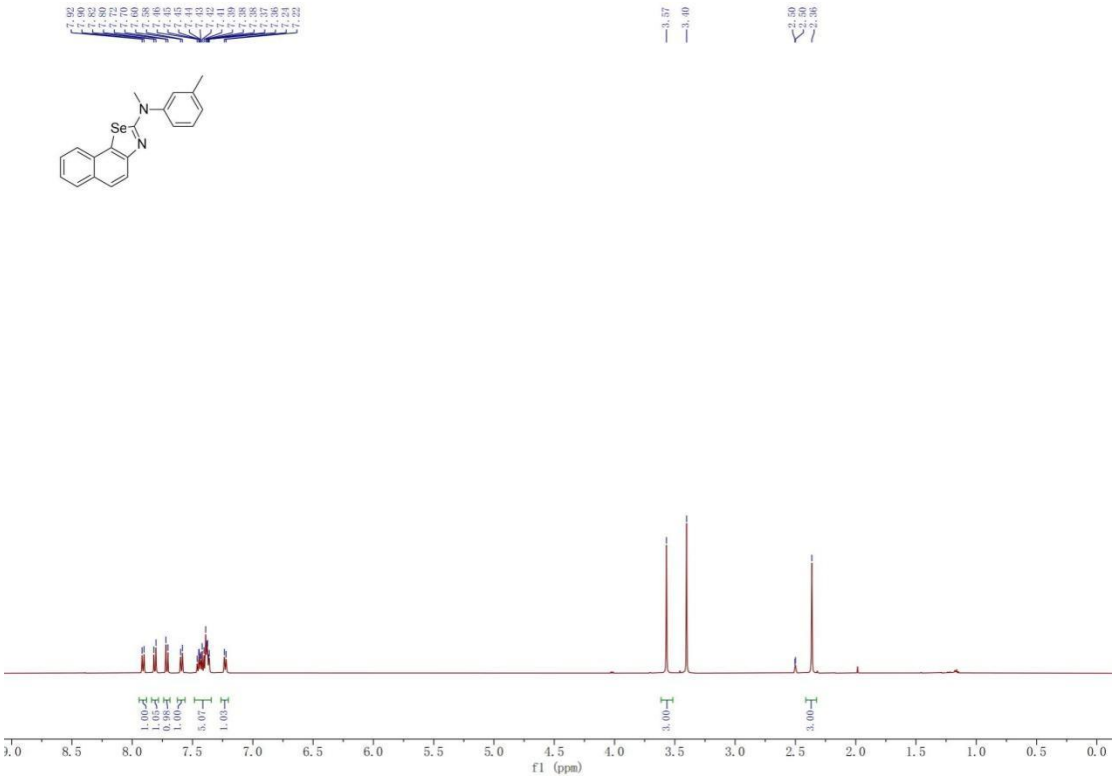
^{13}C NMR of compound **4ag**



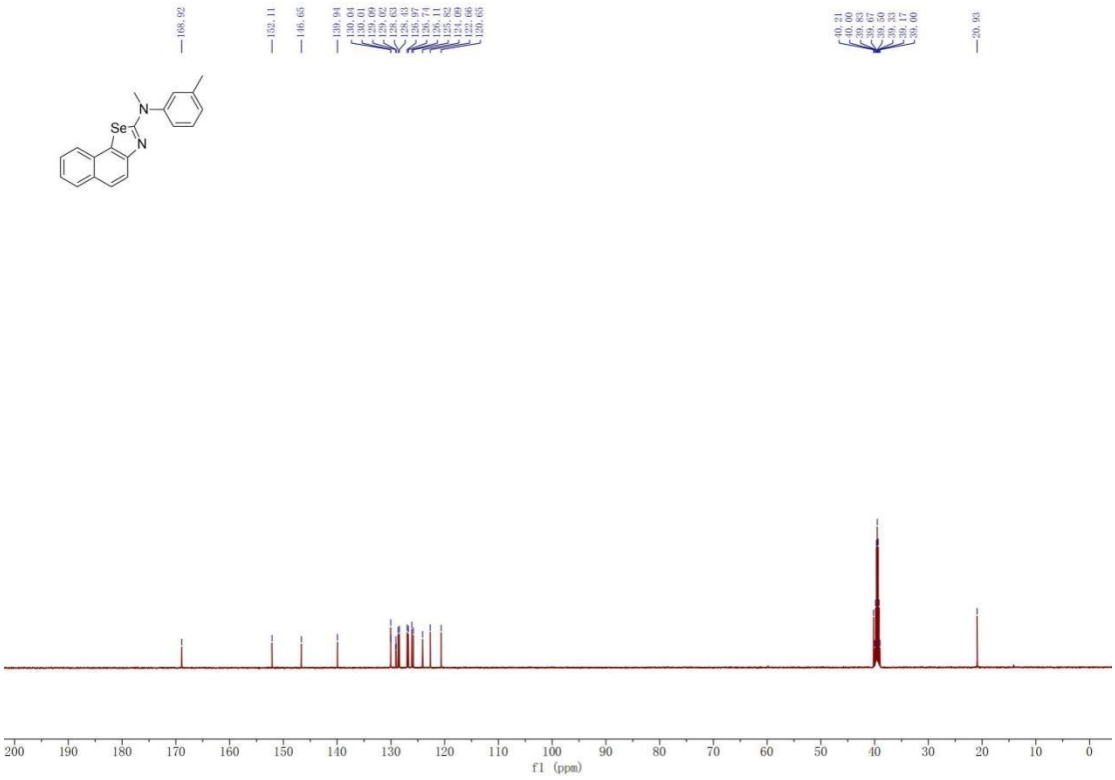
^{1}H NMR of compound **4ah**



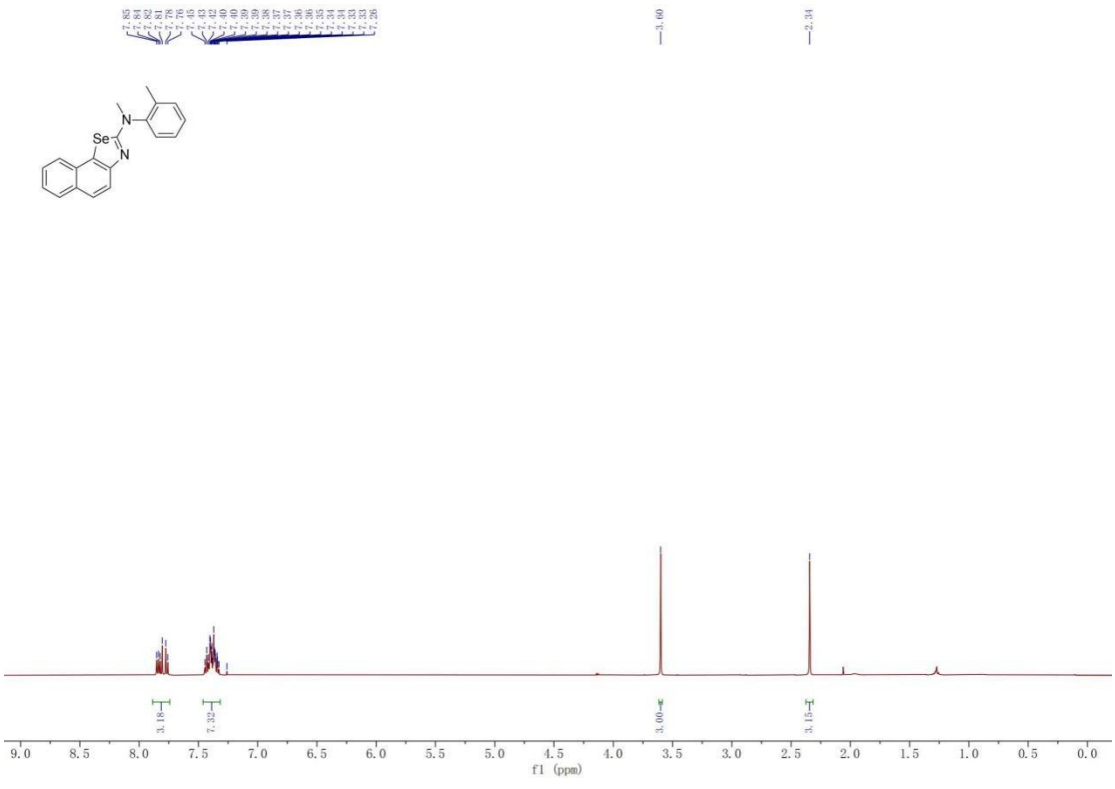
^{13}C NMR of compound **4ah**



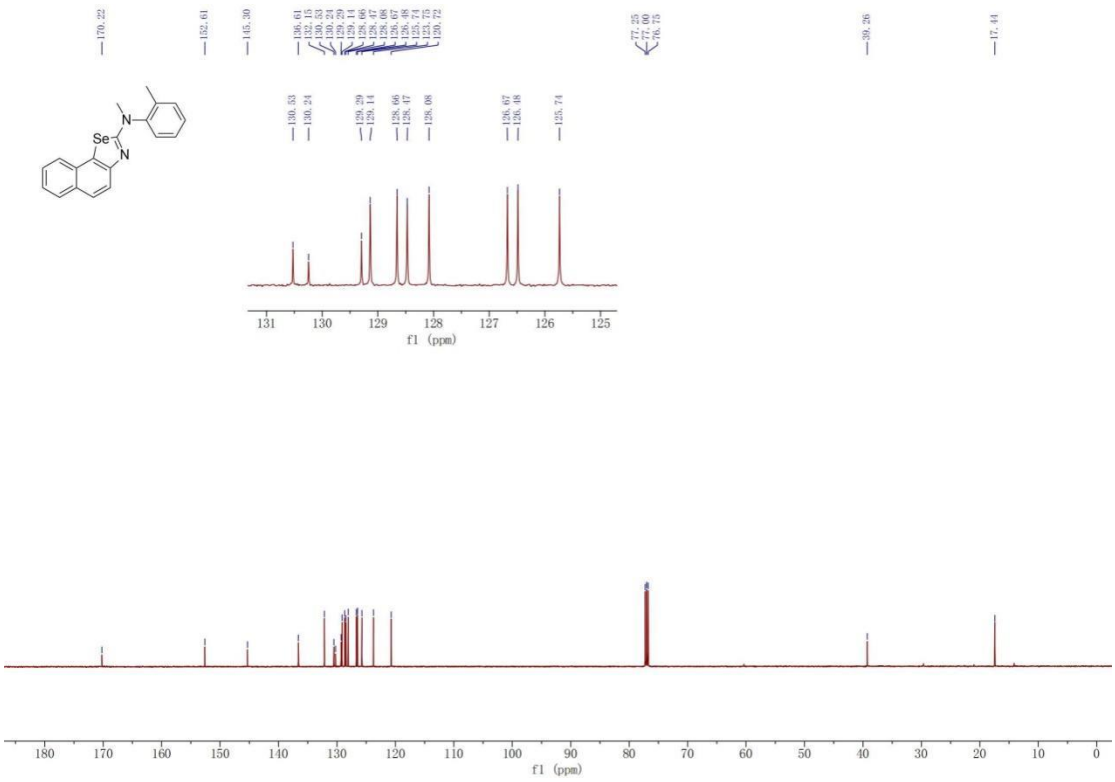
^{1}H NMR of compound **4ai**



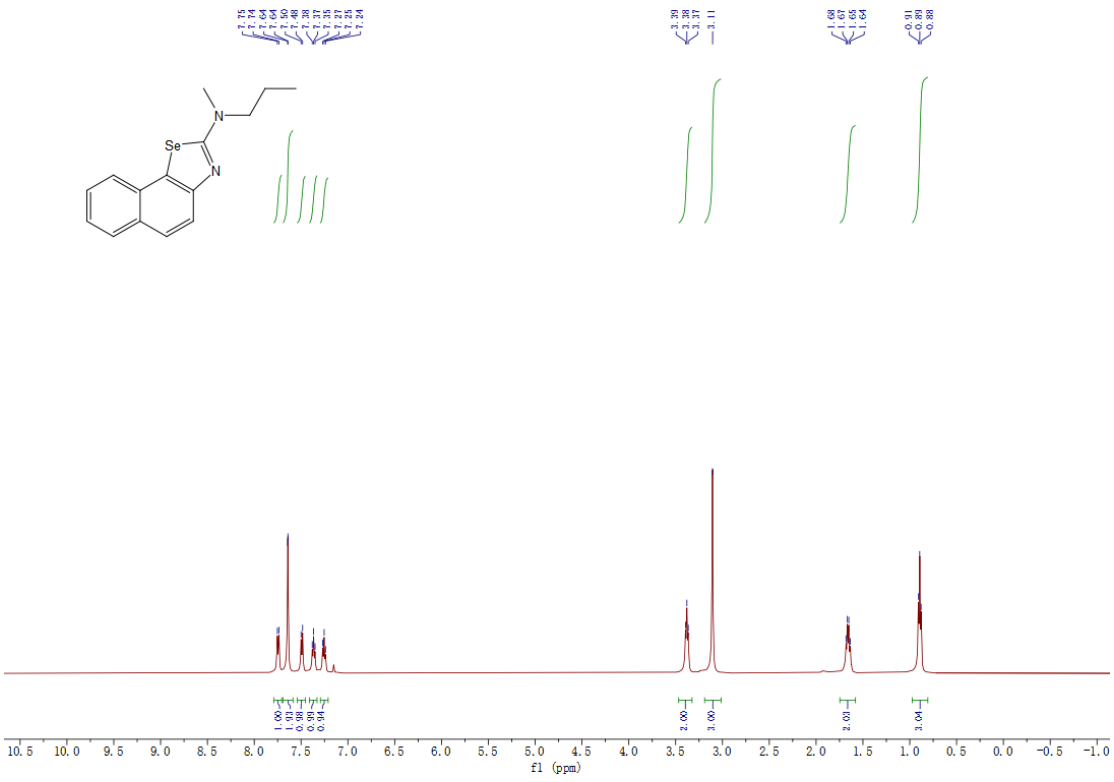
^{13}C NMR of compound **4ai**



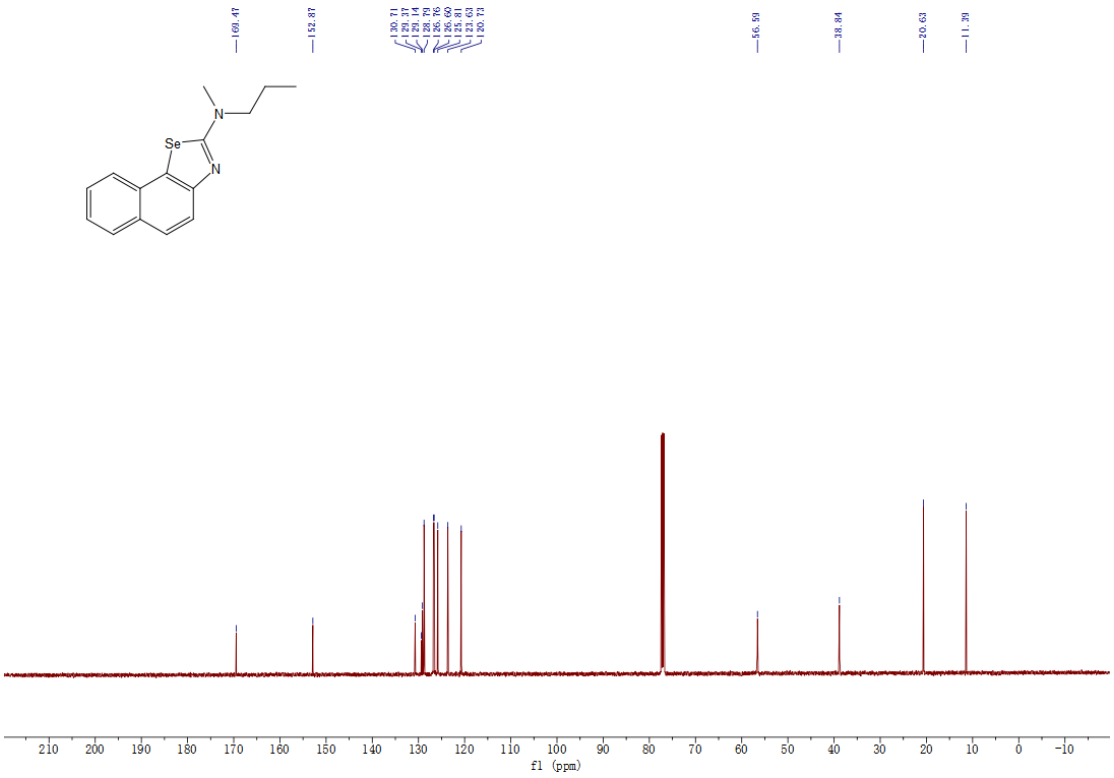
^{1}H NMR of compound **4aj**



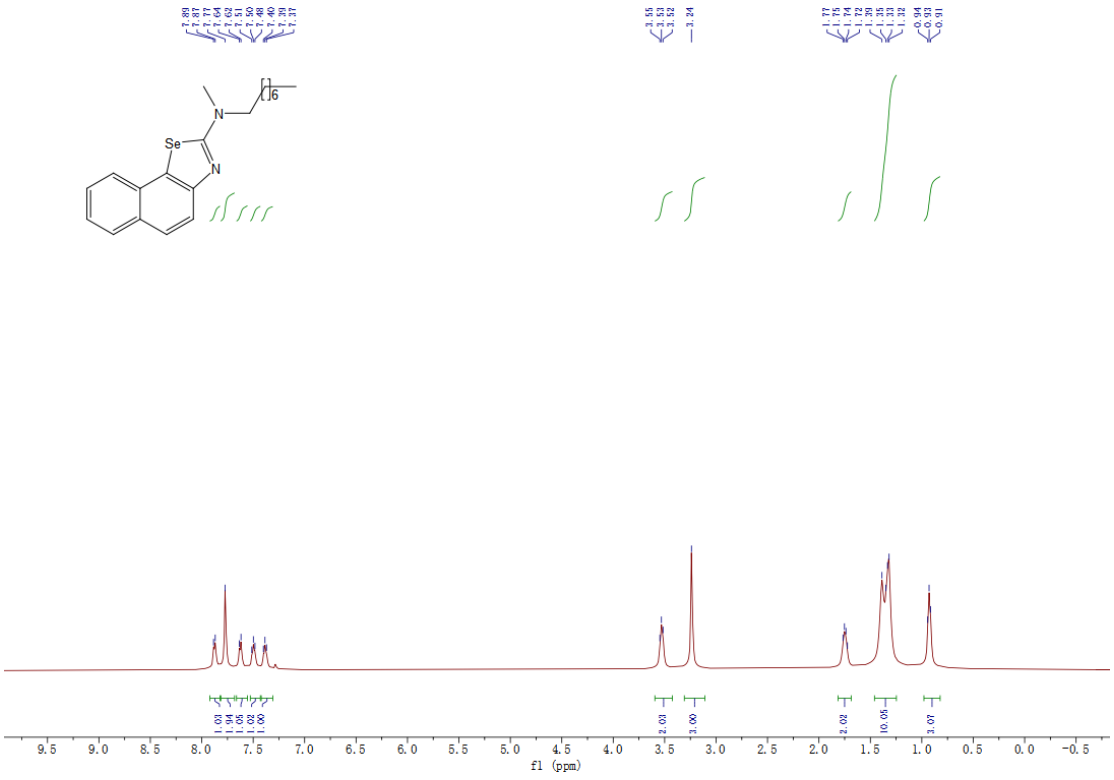
^{13}C NMR of compound **4aj**



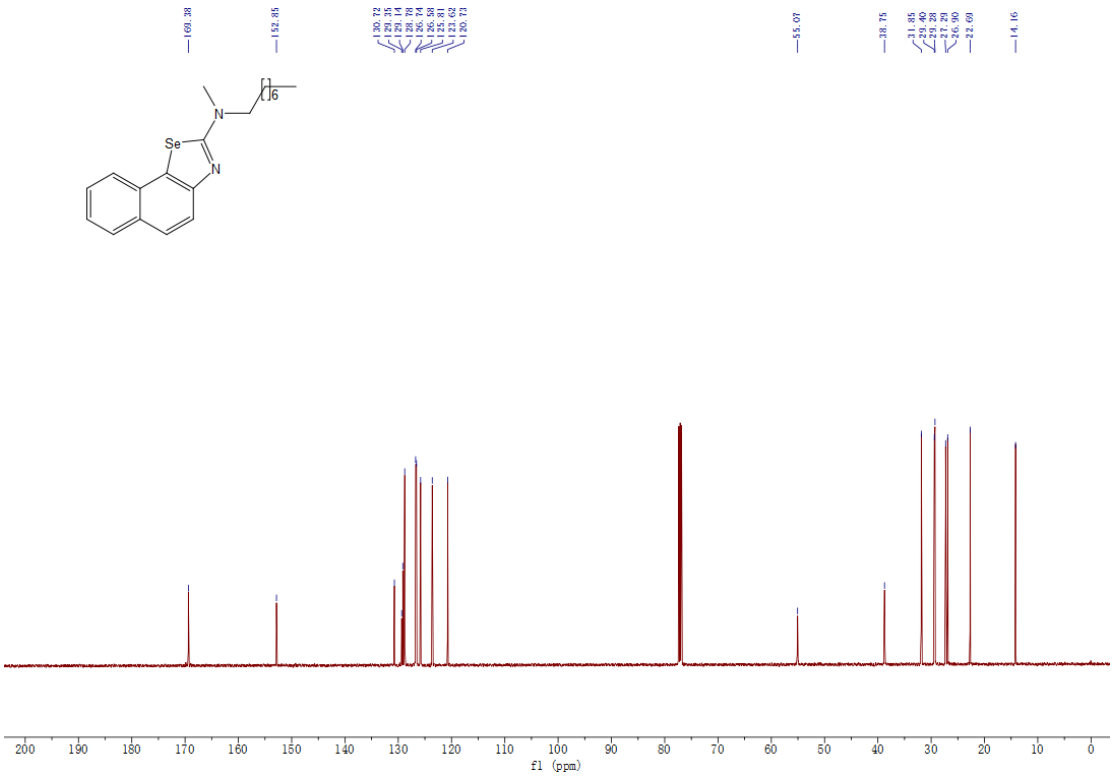
^{1}H NMR of compound **4ak**



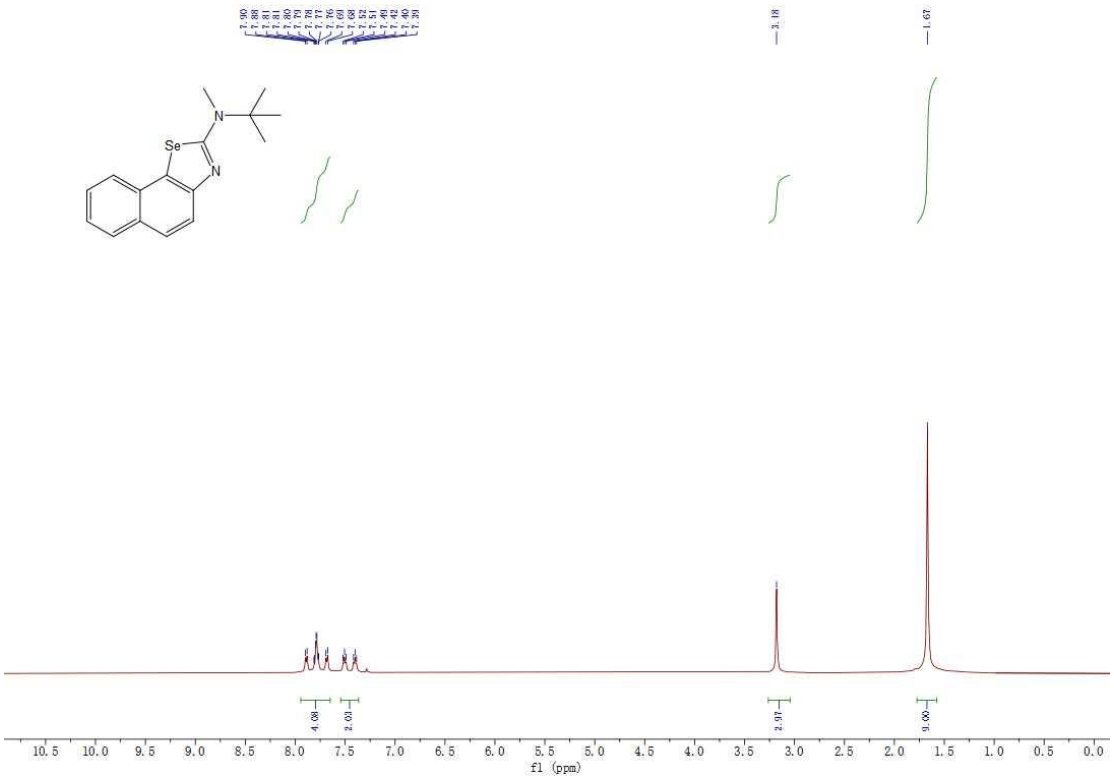
^{13}C NMR of compound **4ak**



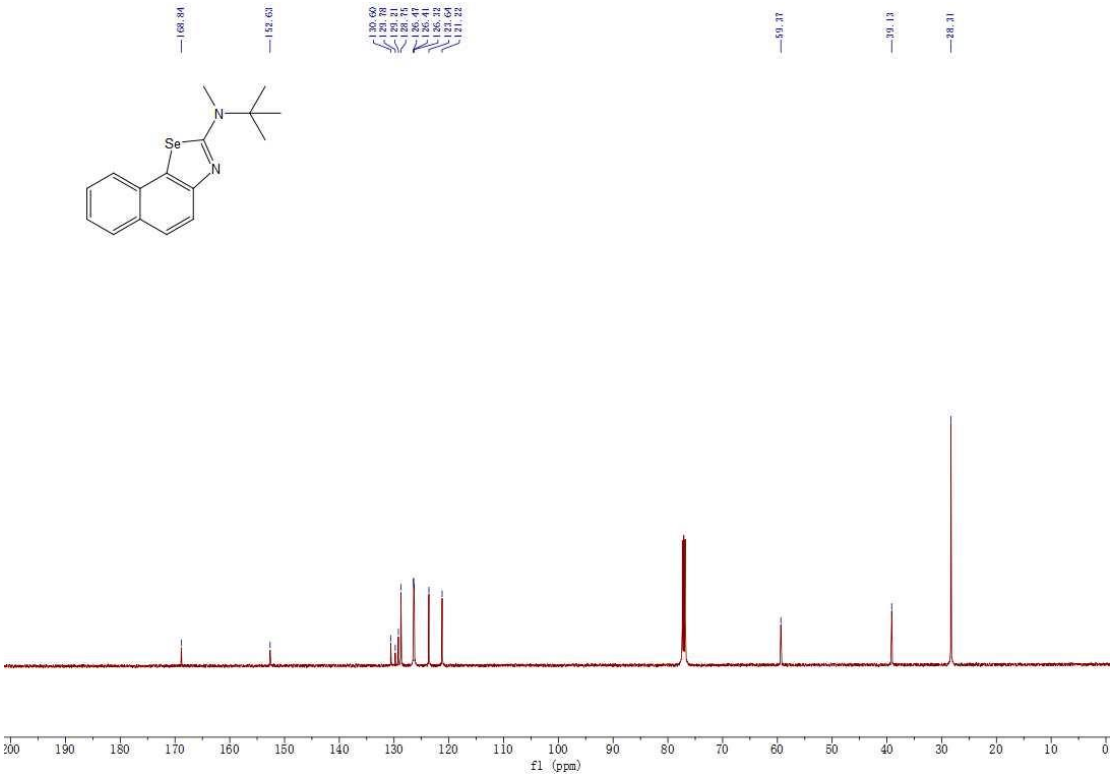
^{1}H NMR of compound **4al**



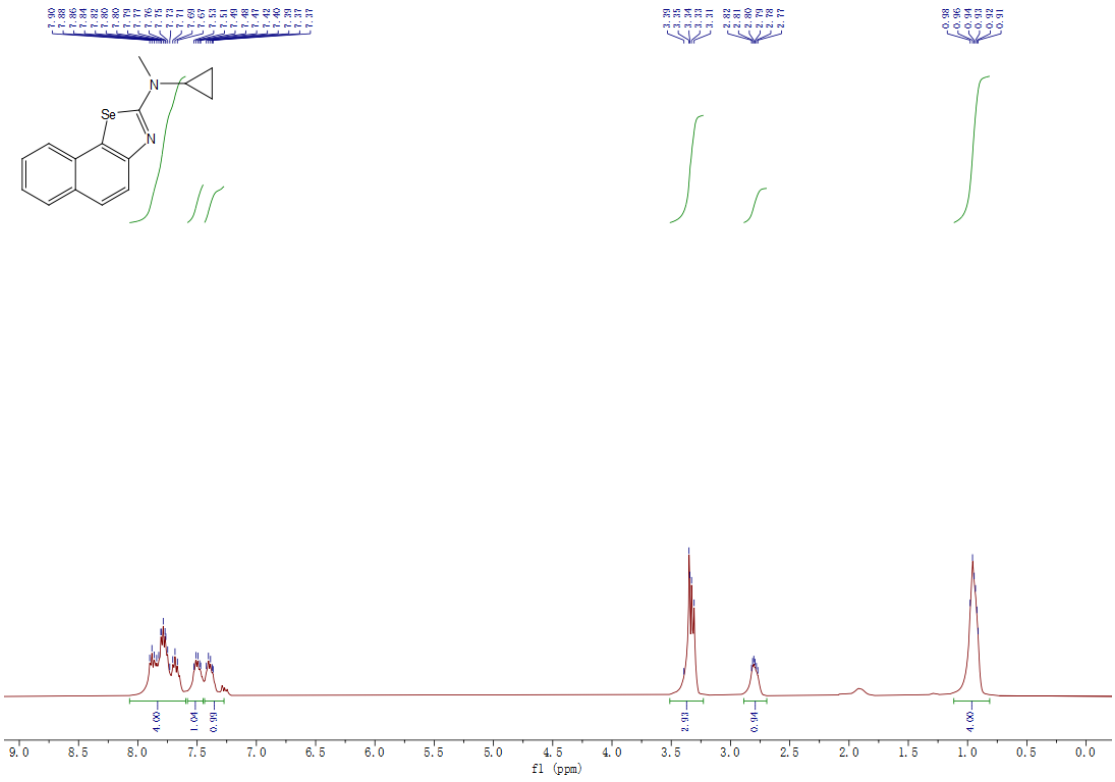
^{13}C NMR of compound **4al**



^{1}H NMR of compound **4am**



^{13}C NMR of compound **4am**



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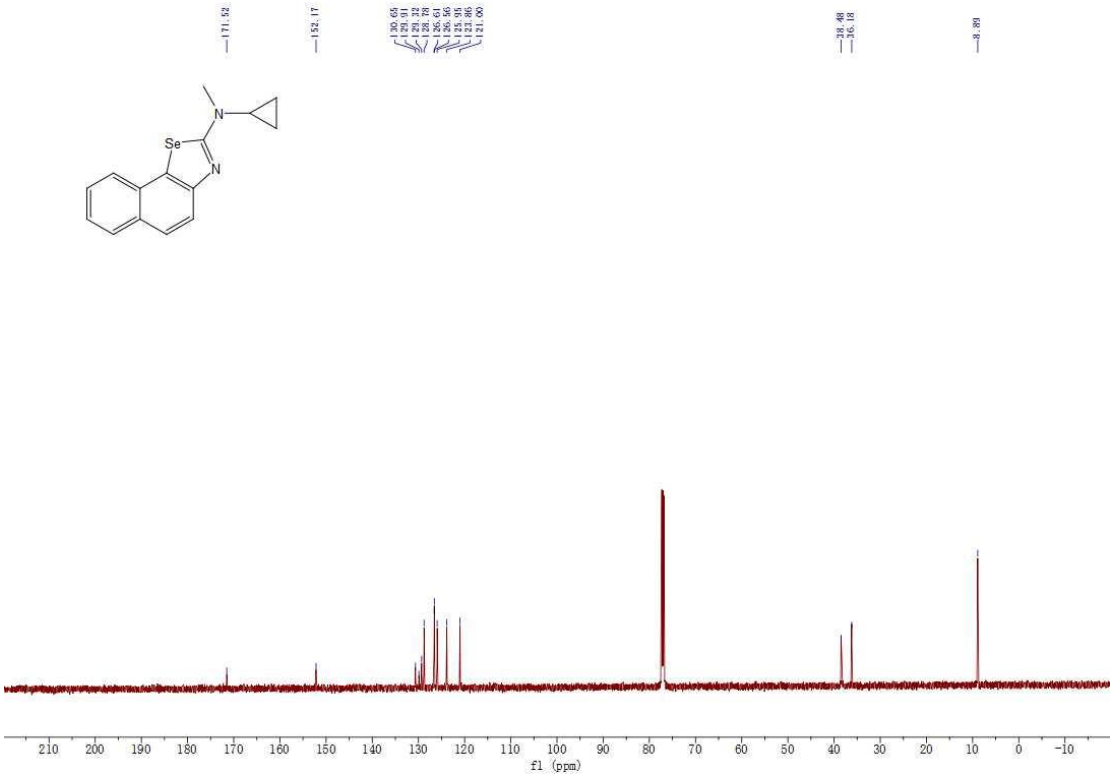
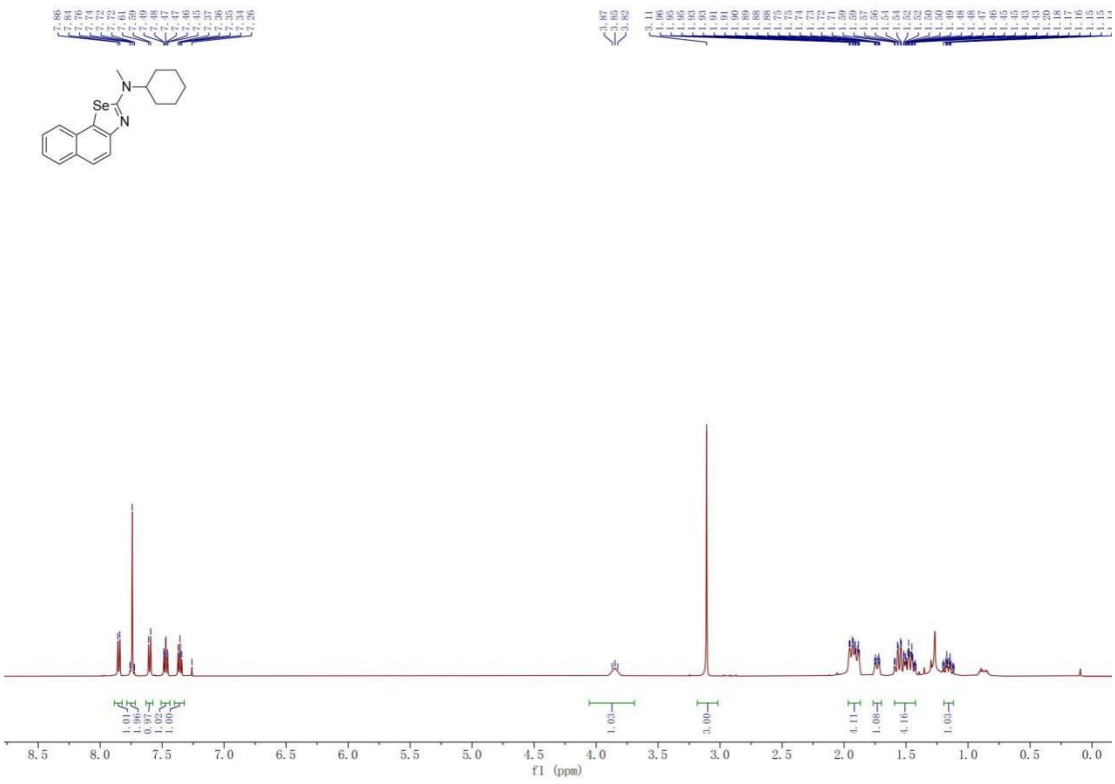
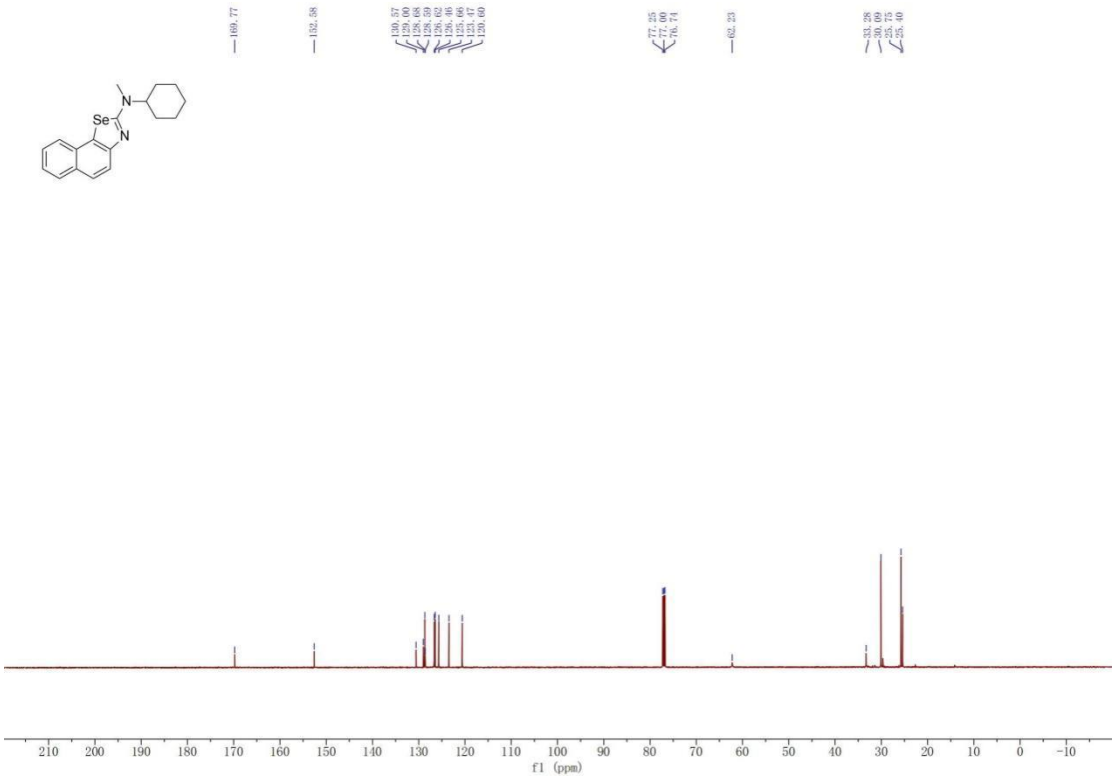


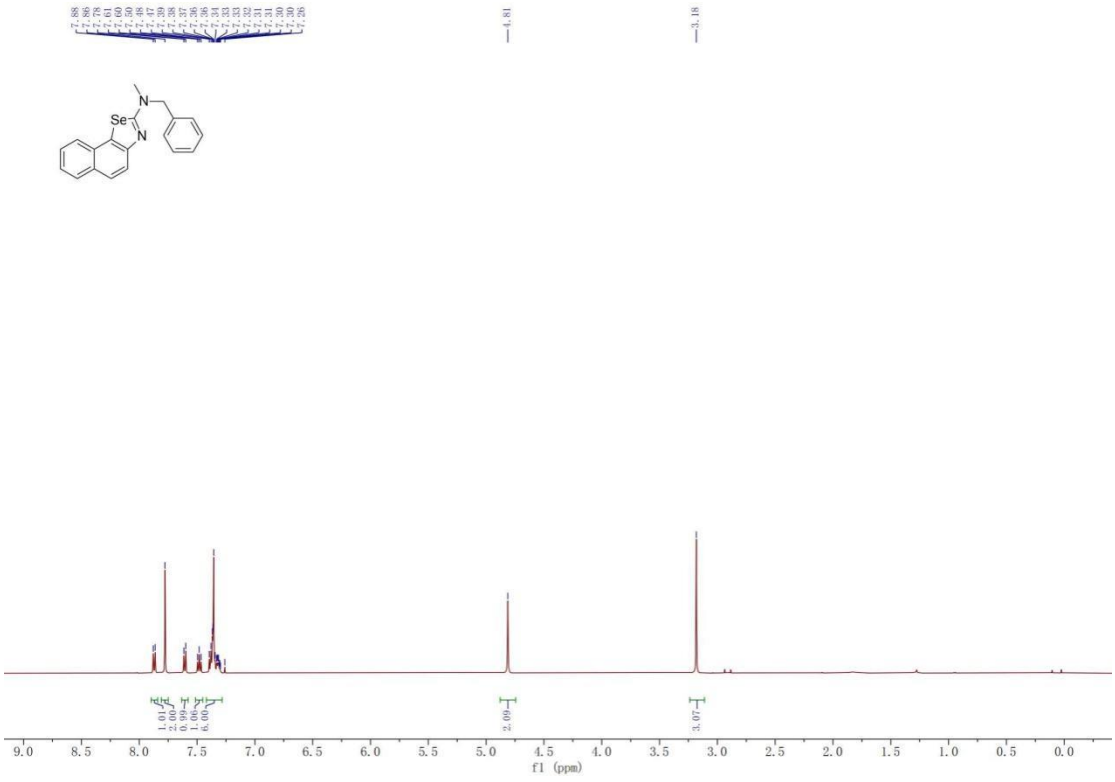
^{13}C NMR of compound **4an**



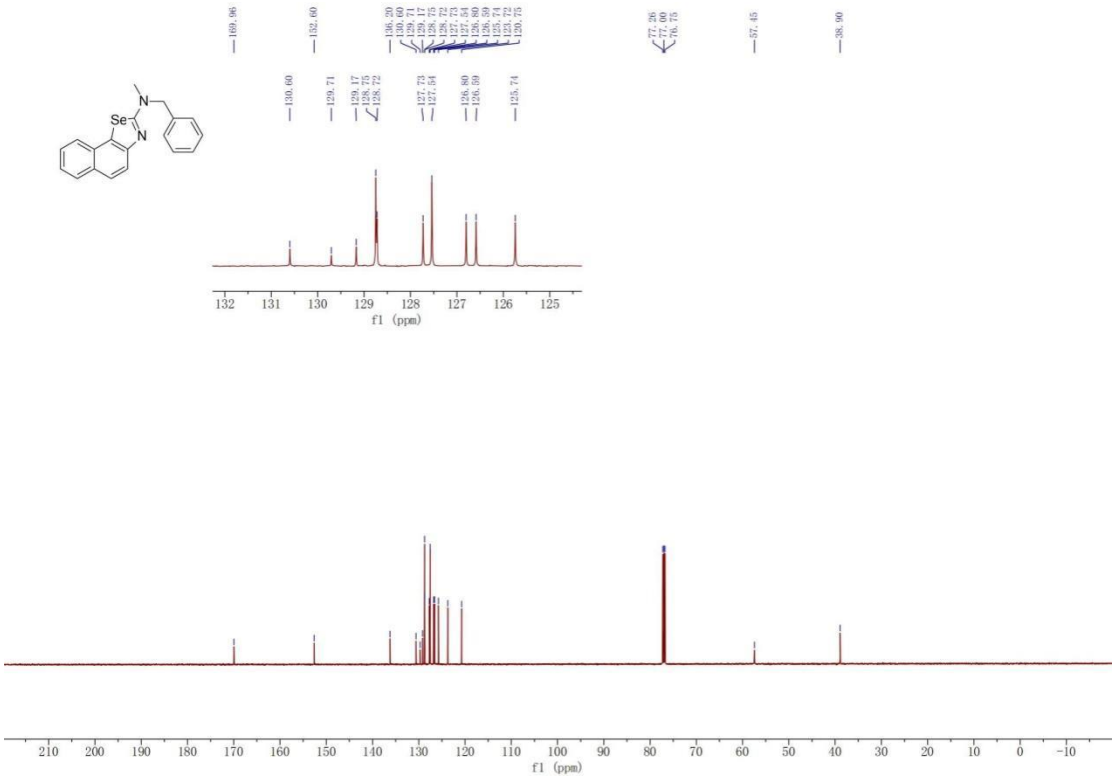
^{1}H NMR of compound **4ao**



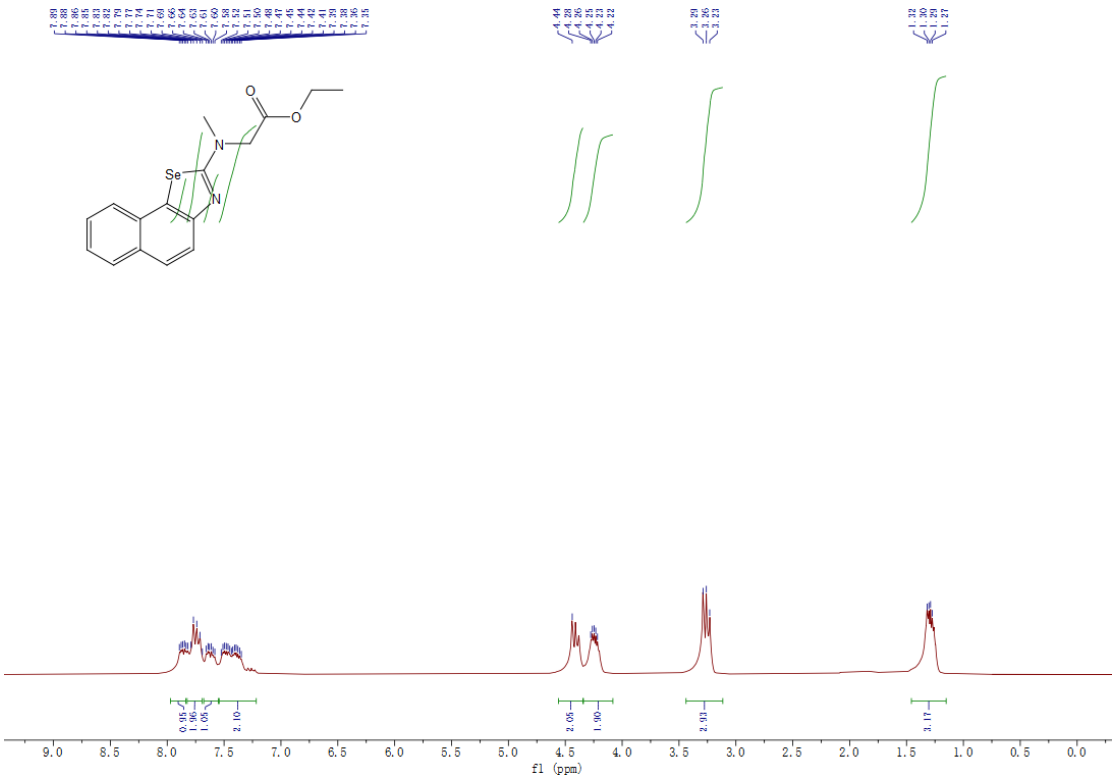
^{13}C NMR of compound **4ao**



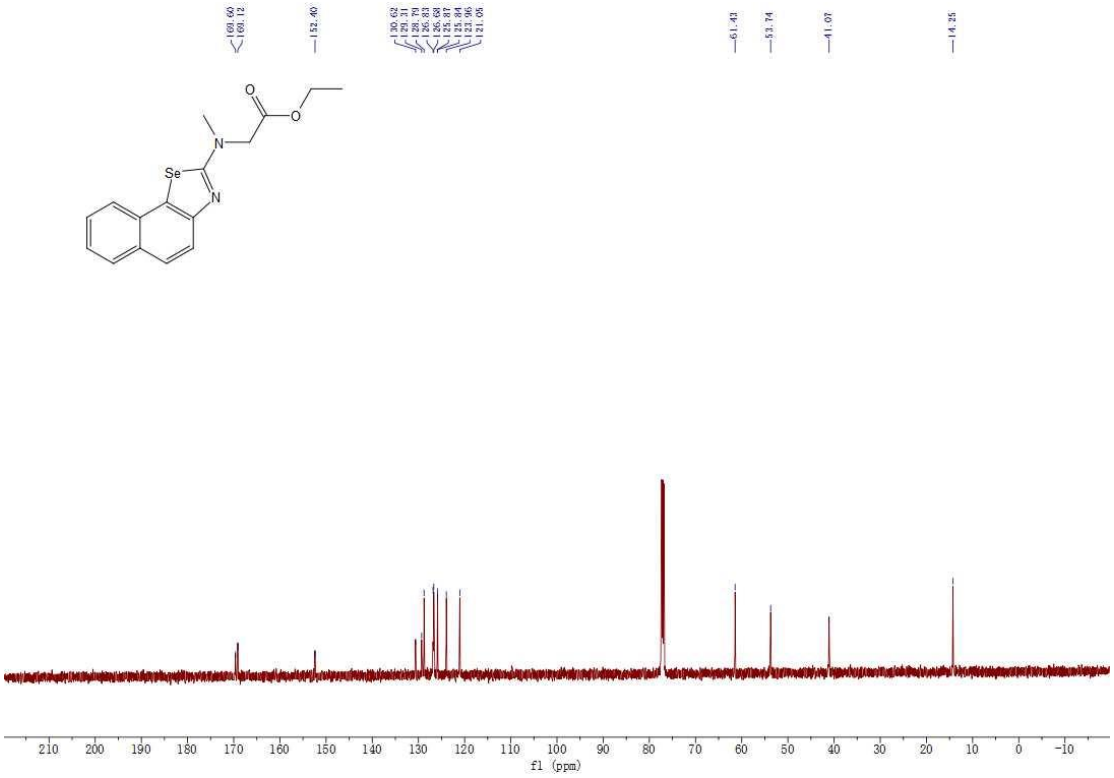
^{1}H NMR of compound **4ap**



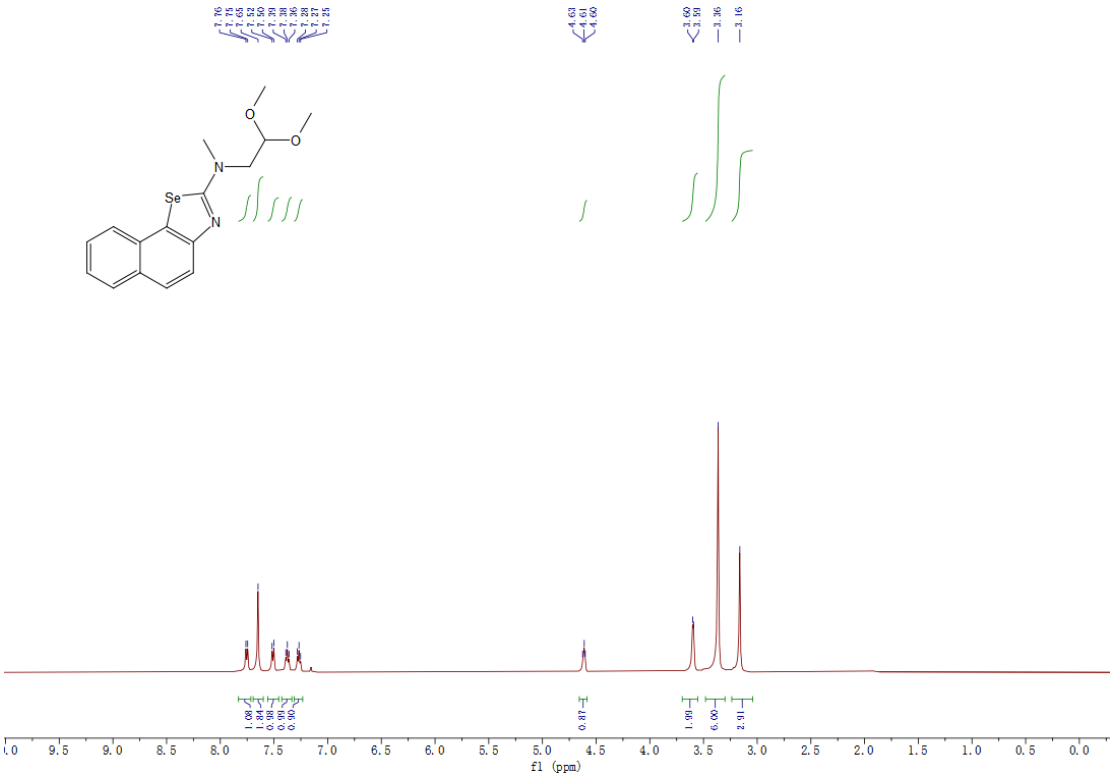
^{13}C NMR of compound **4ap**



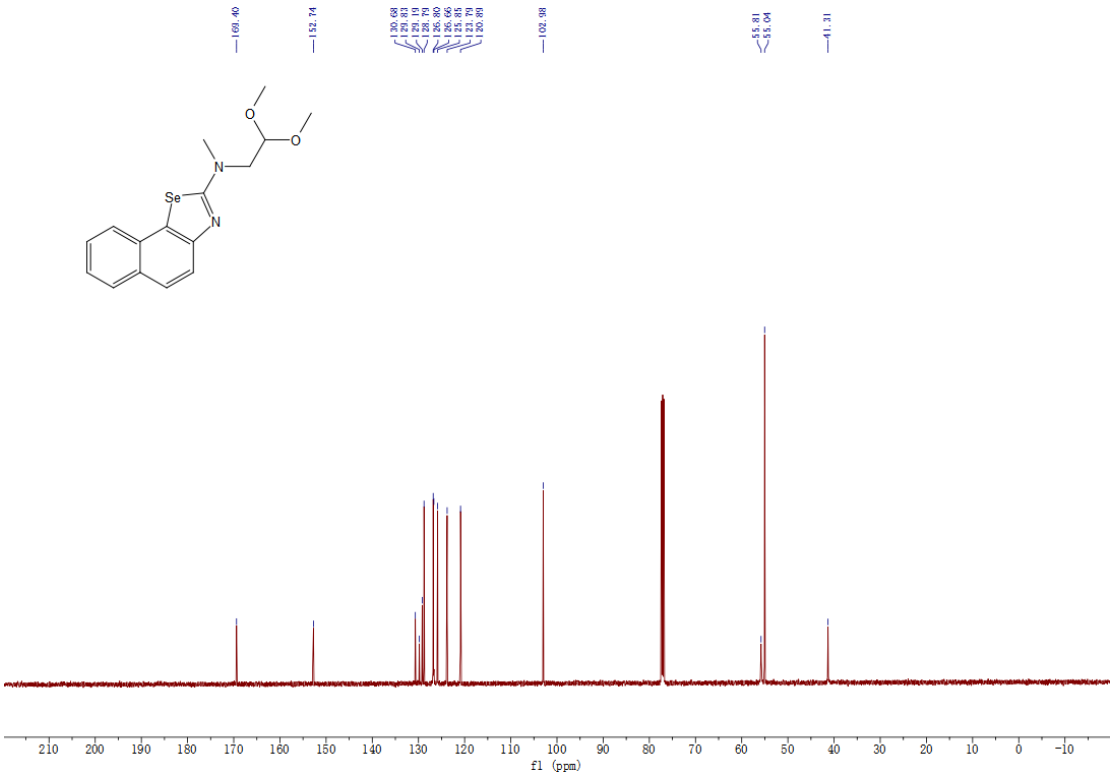
^{1}H NMR of compound **4aq**



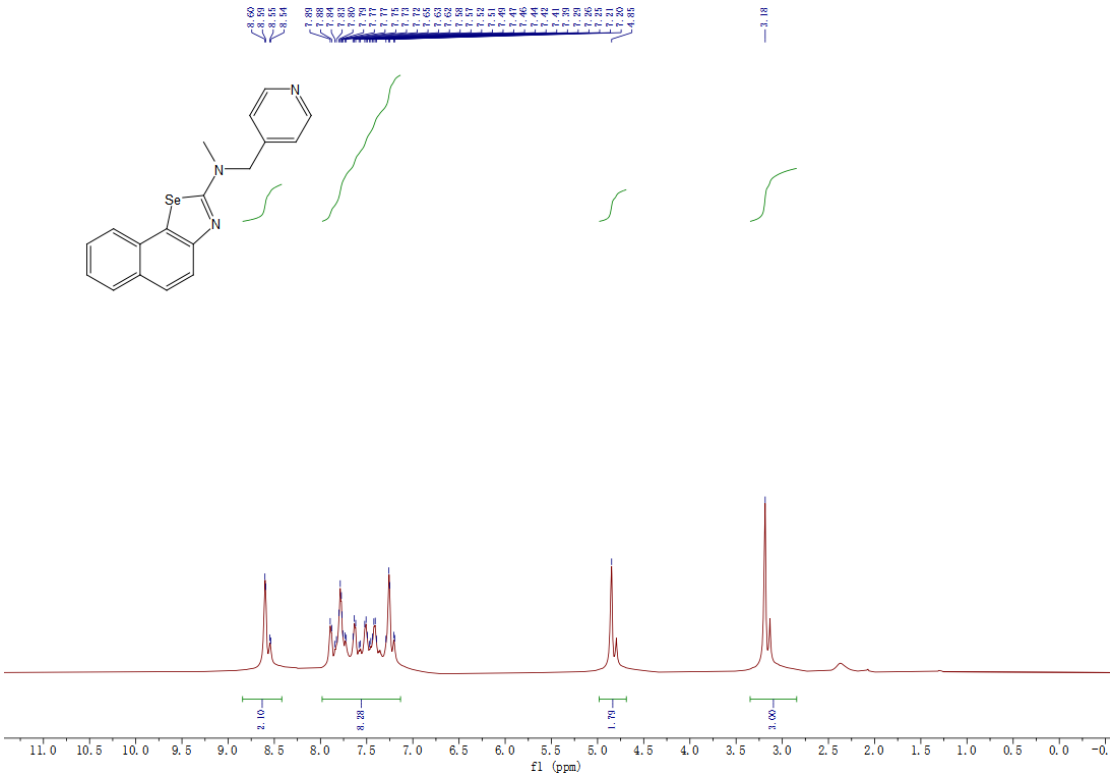
^{13}C NMR of compound **4aq**



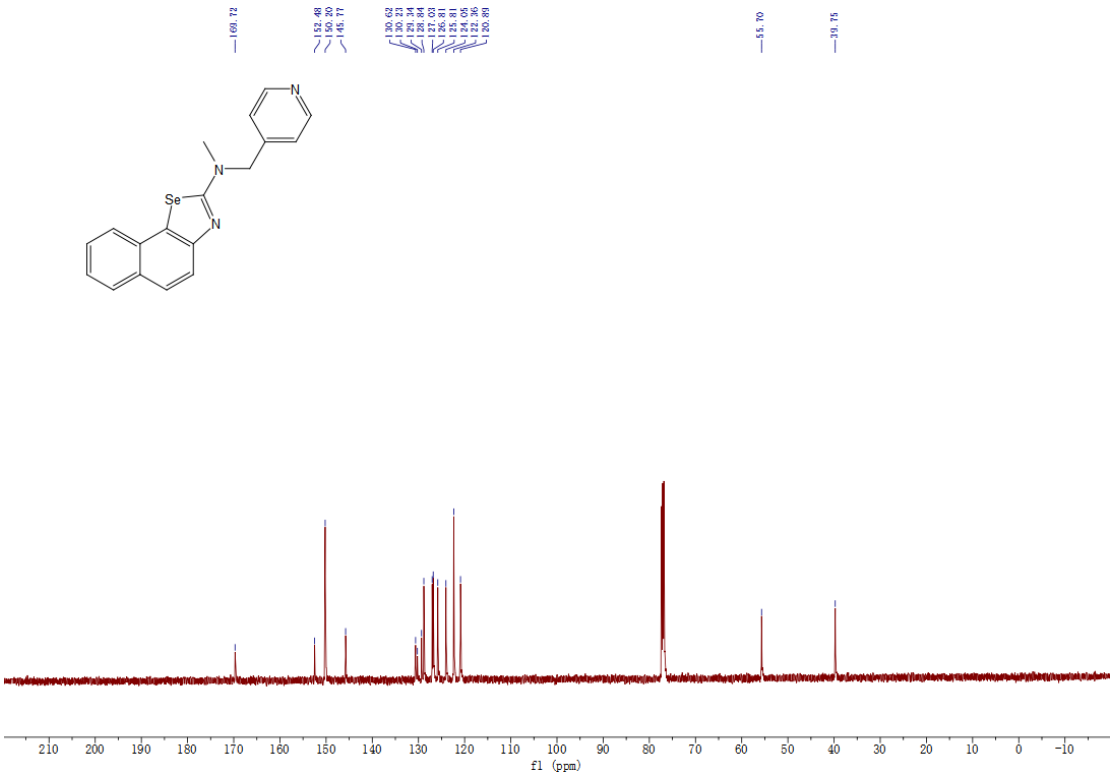
^{1}H NMR of compound **4ar**



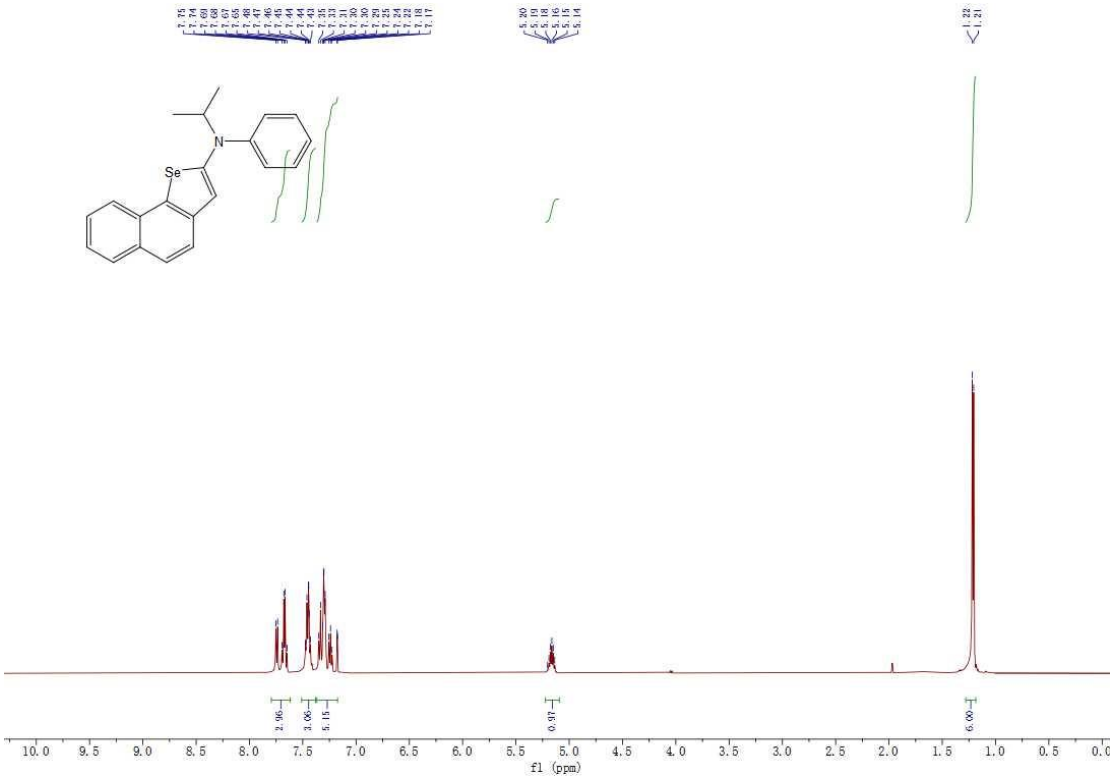
^{13}C NMR of compound **4ar**



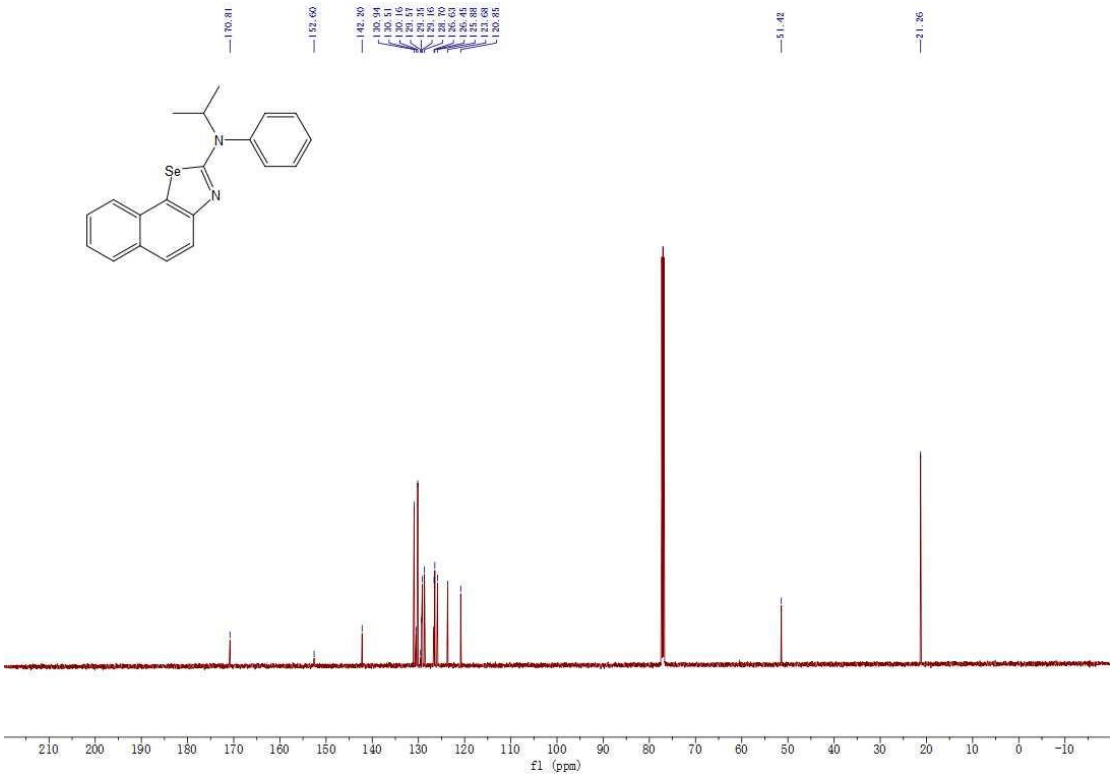
^{1}H NMR of compound **4as**



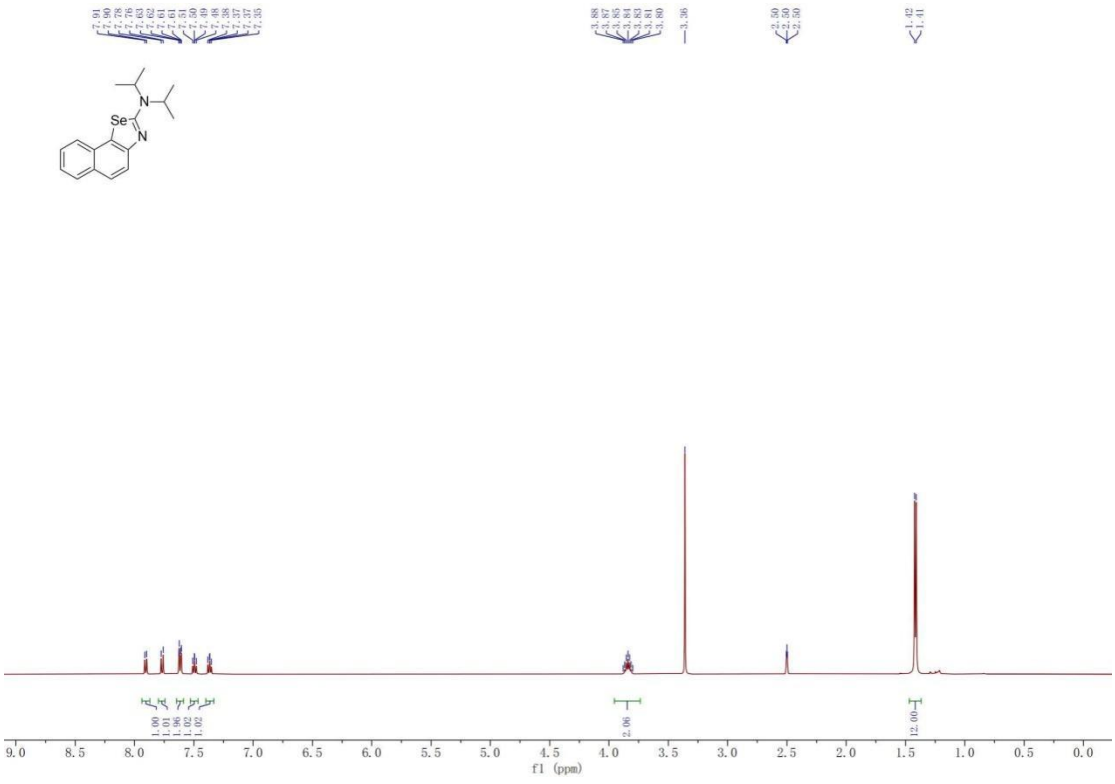
^{13}C NMR of compound **4as**



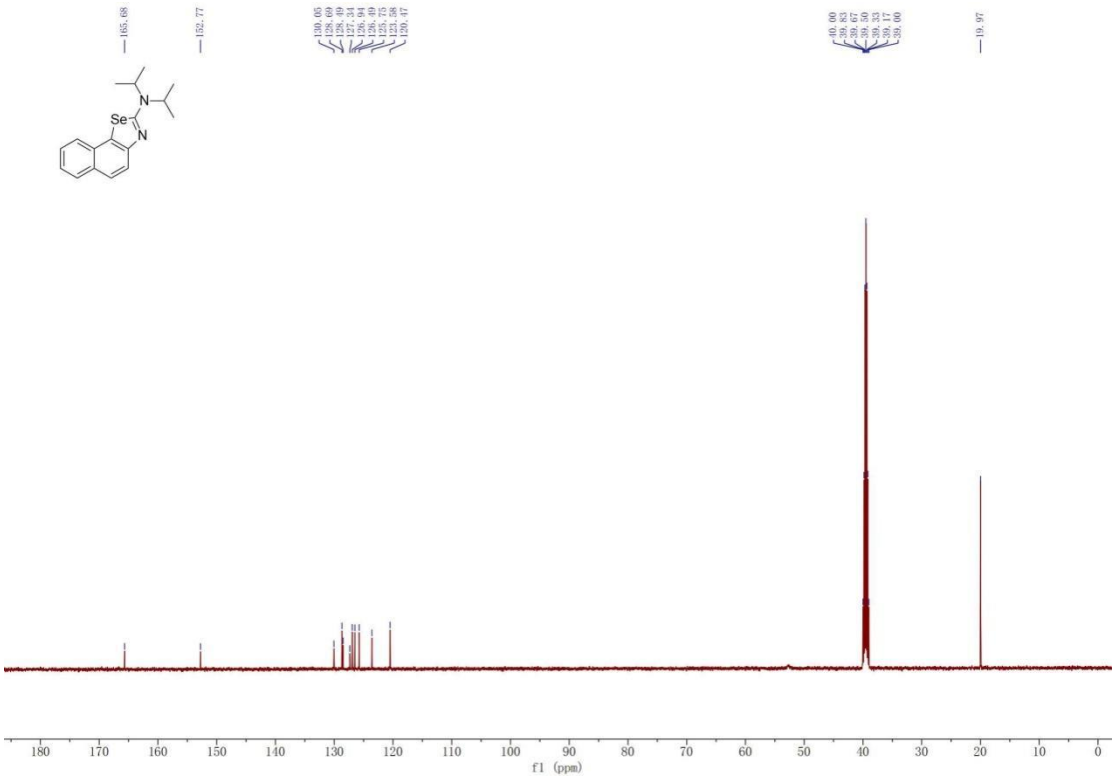
^{1}H NMR of compound **4at**



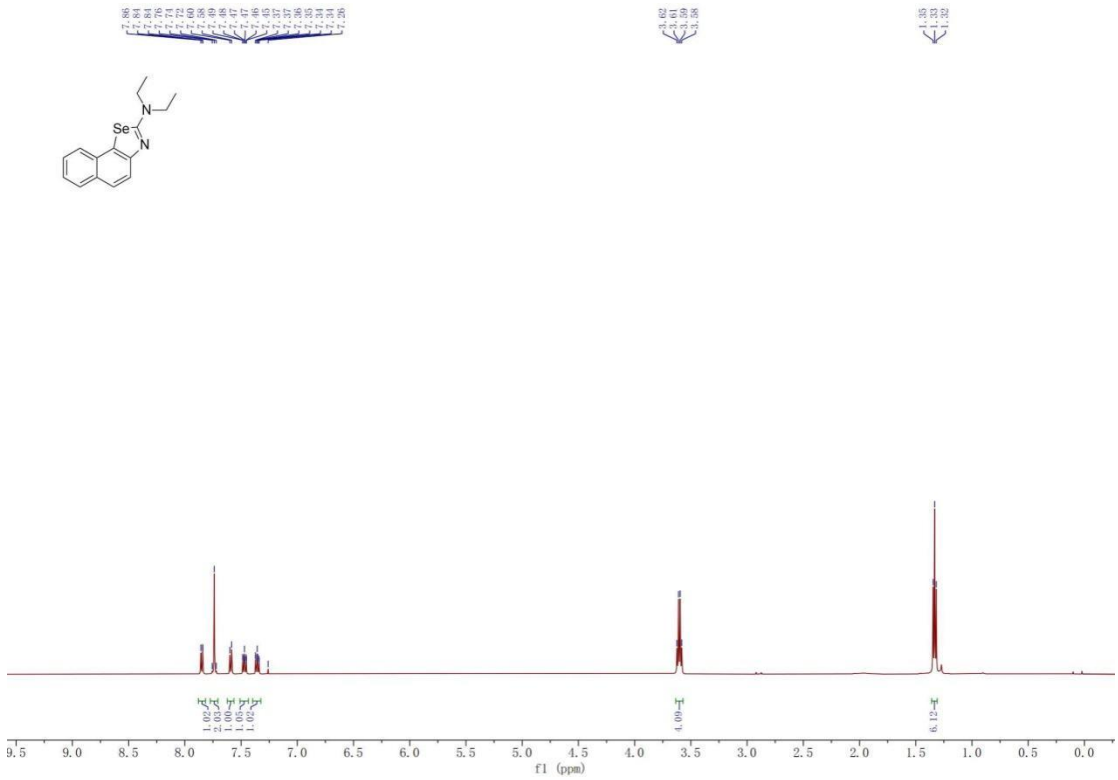
^{13}C NMR of compound **4at**



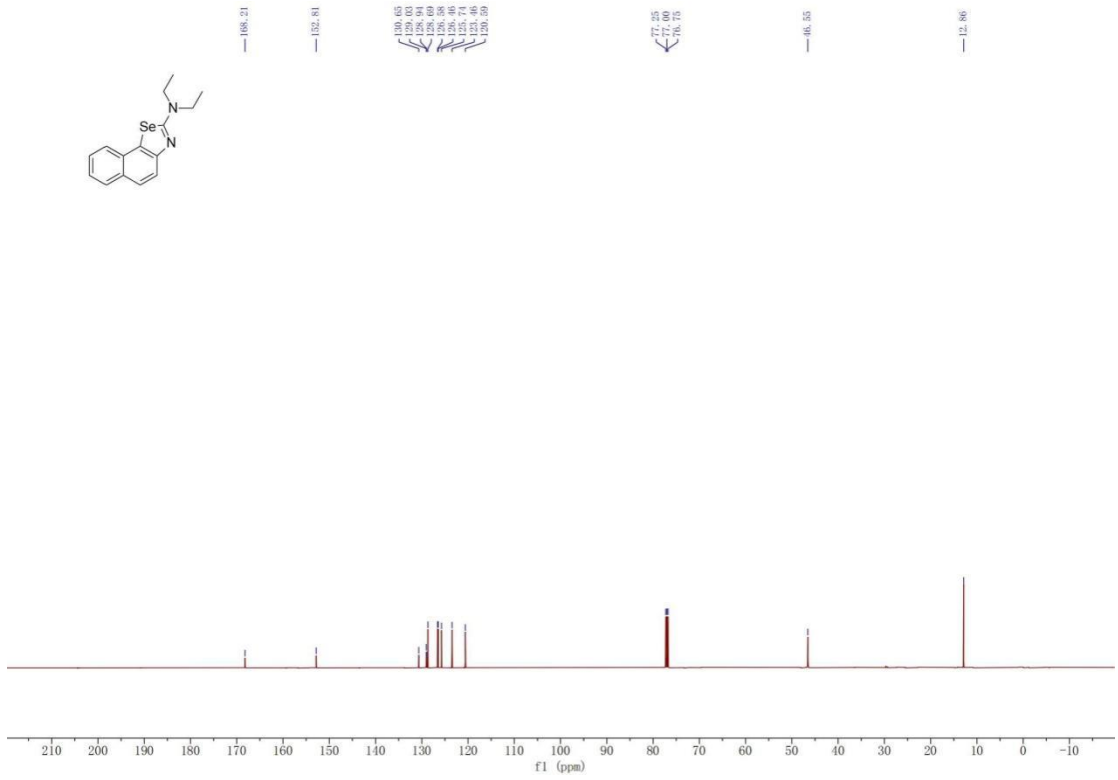
^{1}H NMR of compound **4au**



^{13}C NMR of compound **4au**



^{1}H NMR of compound **4av**



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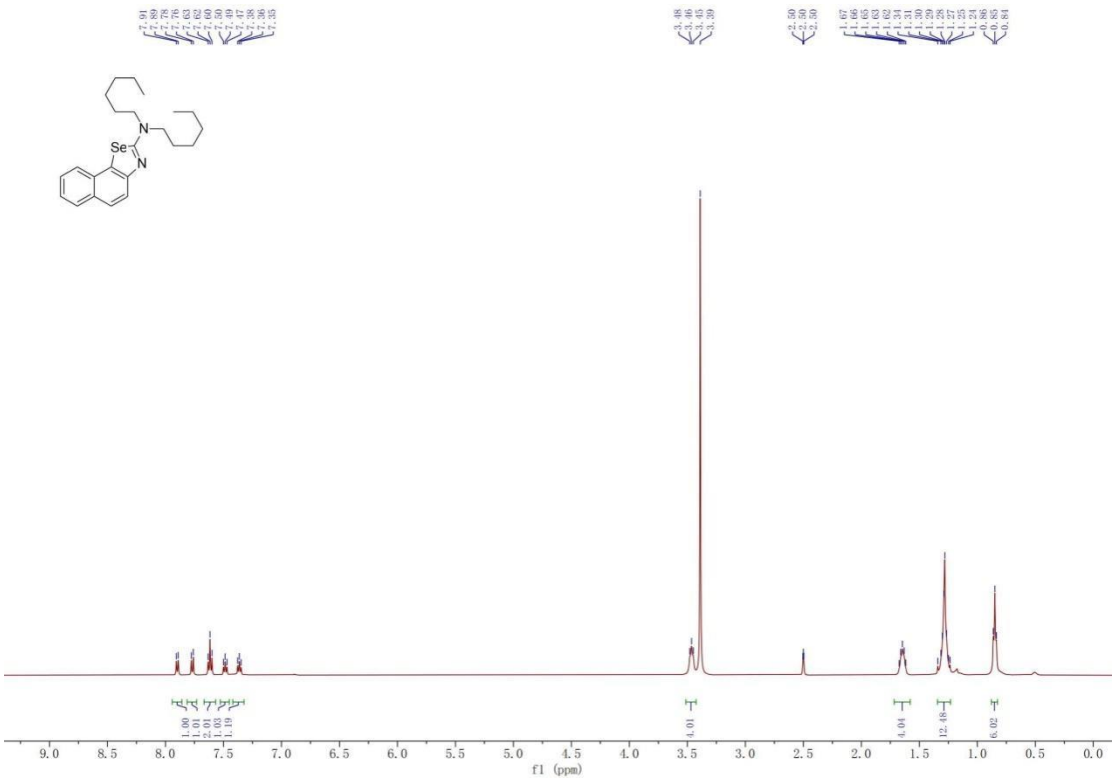
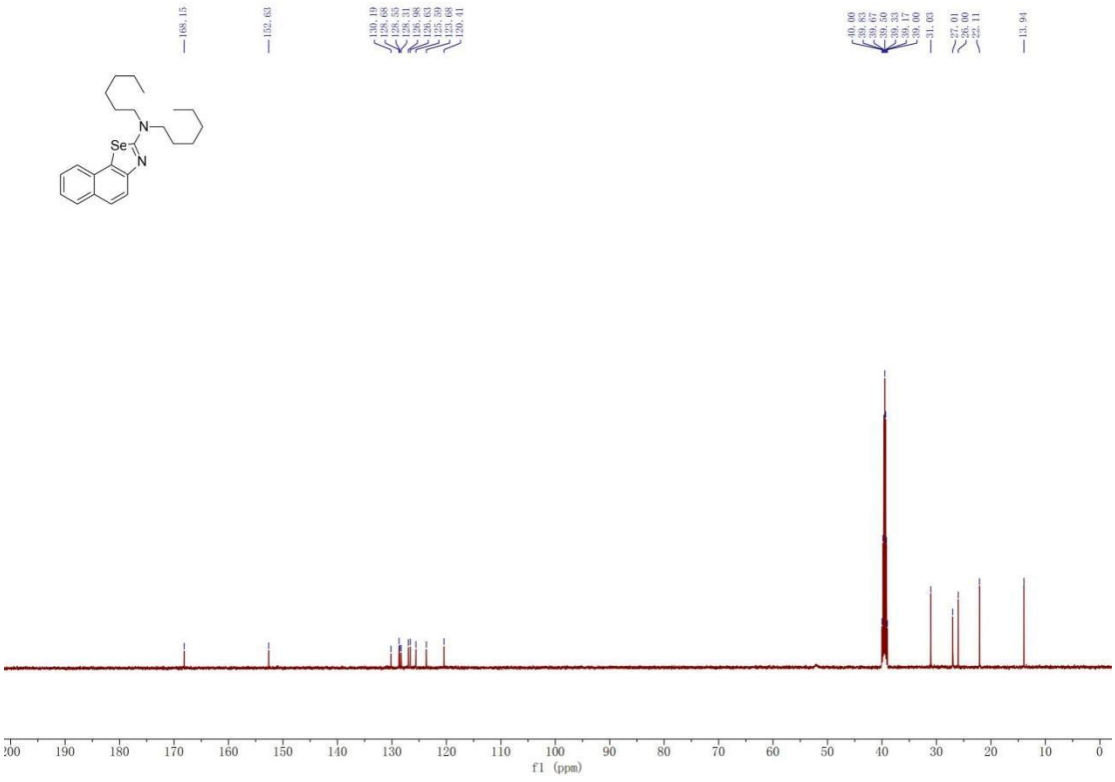
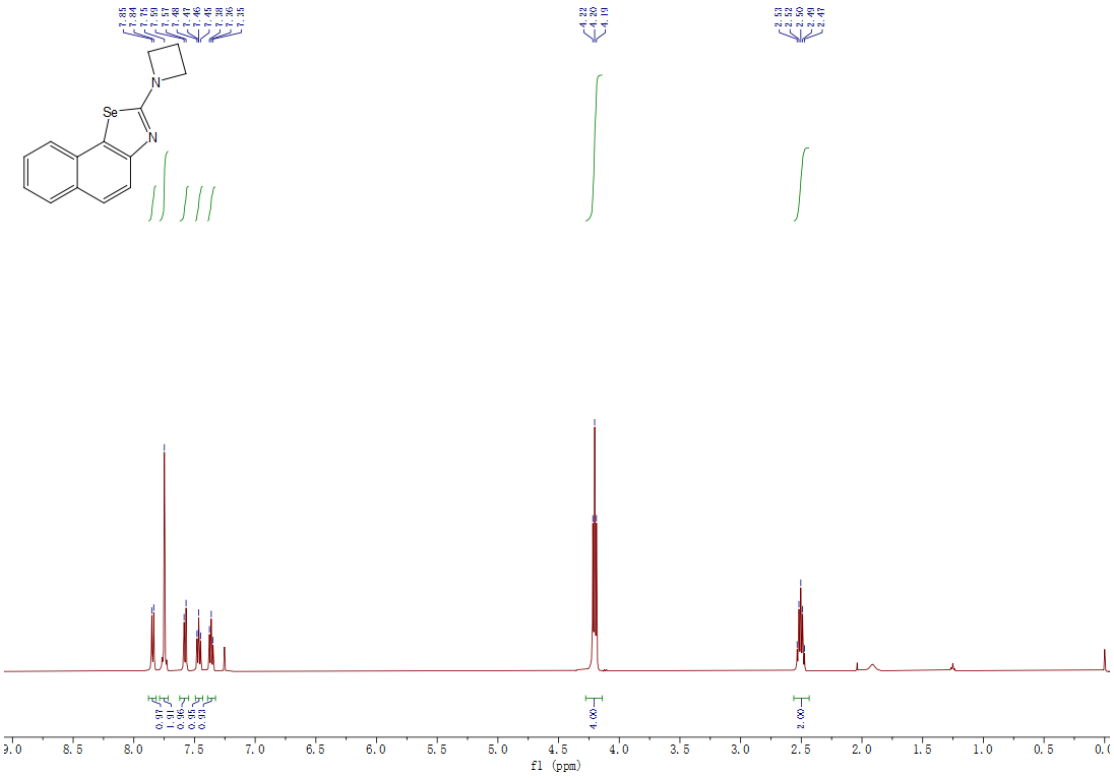


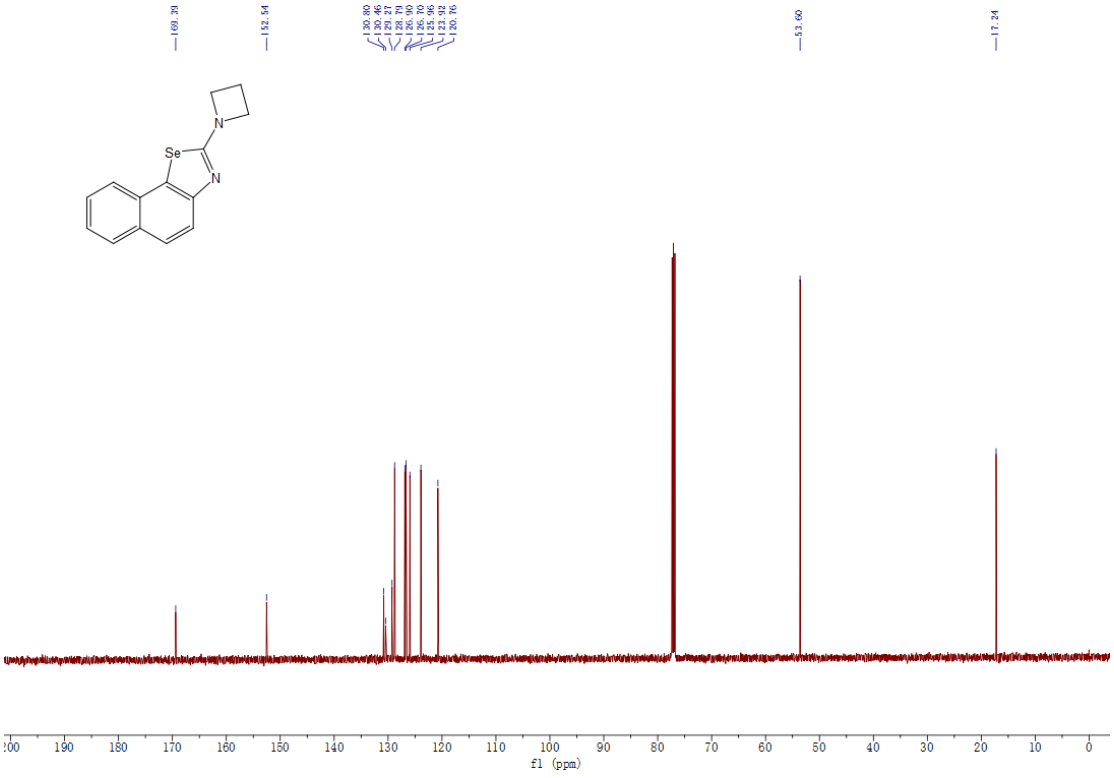
^{1}H NMR of compound **4aw**



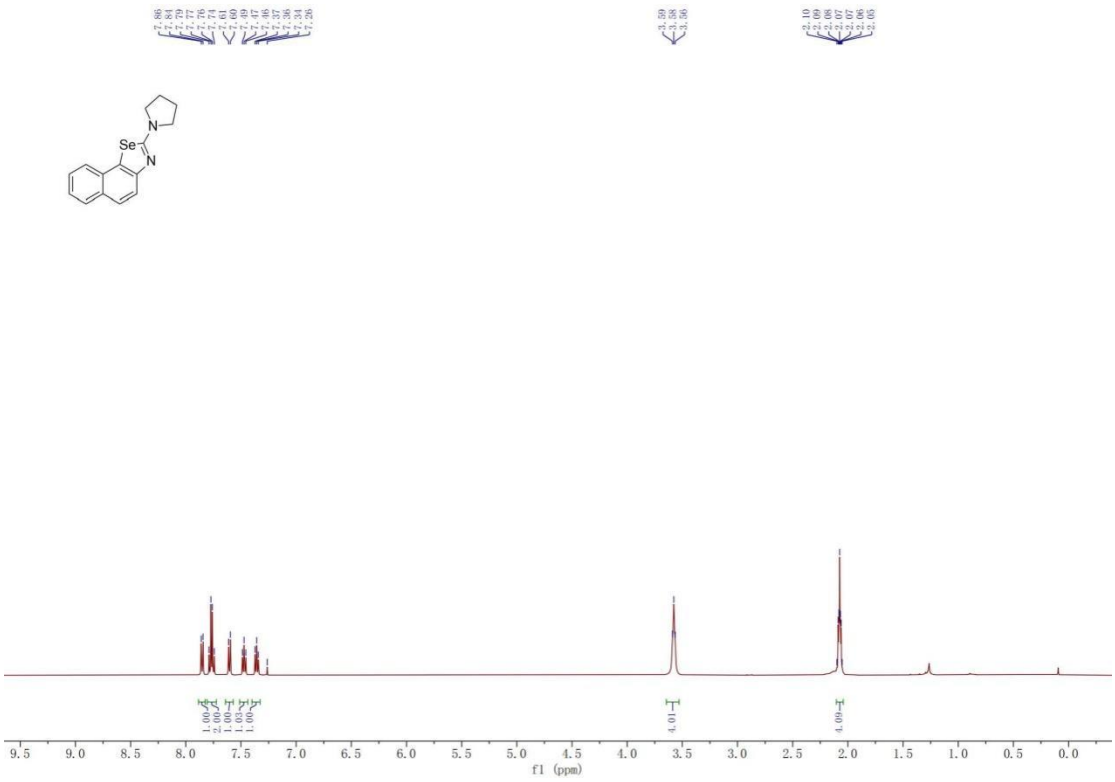
^{13}C NMR of compound **4aw**



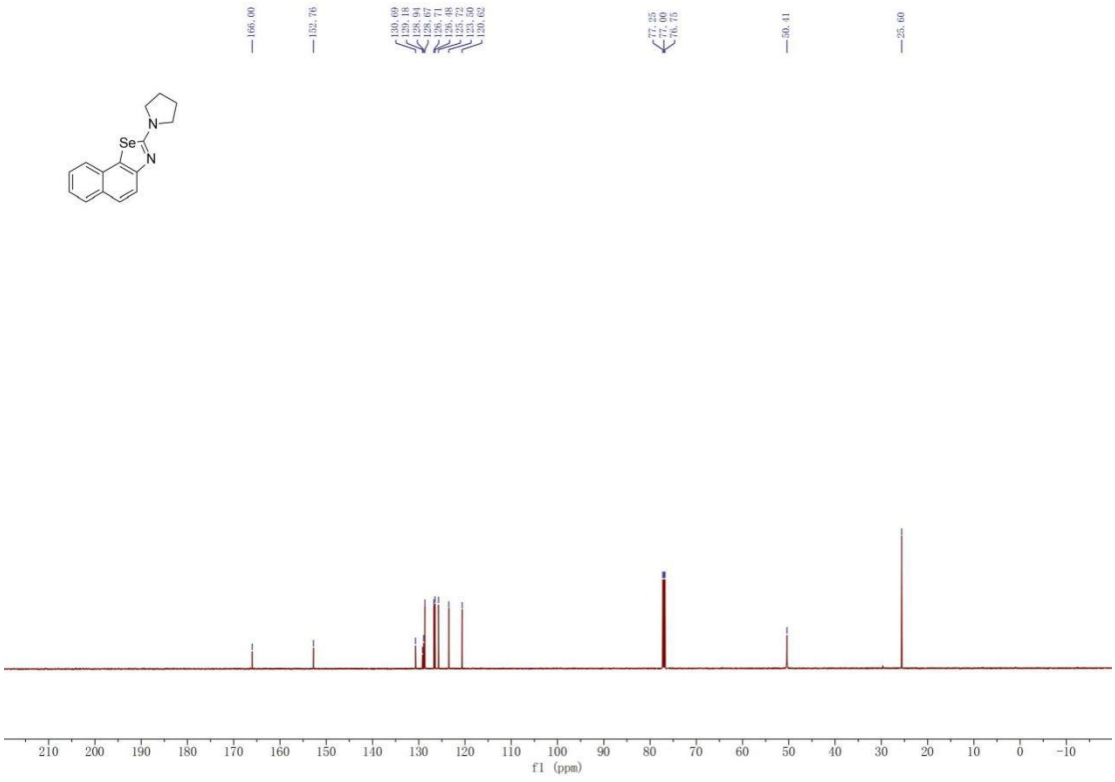
^{1}H NMR of compound **4ax**



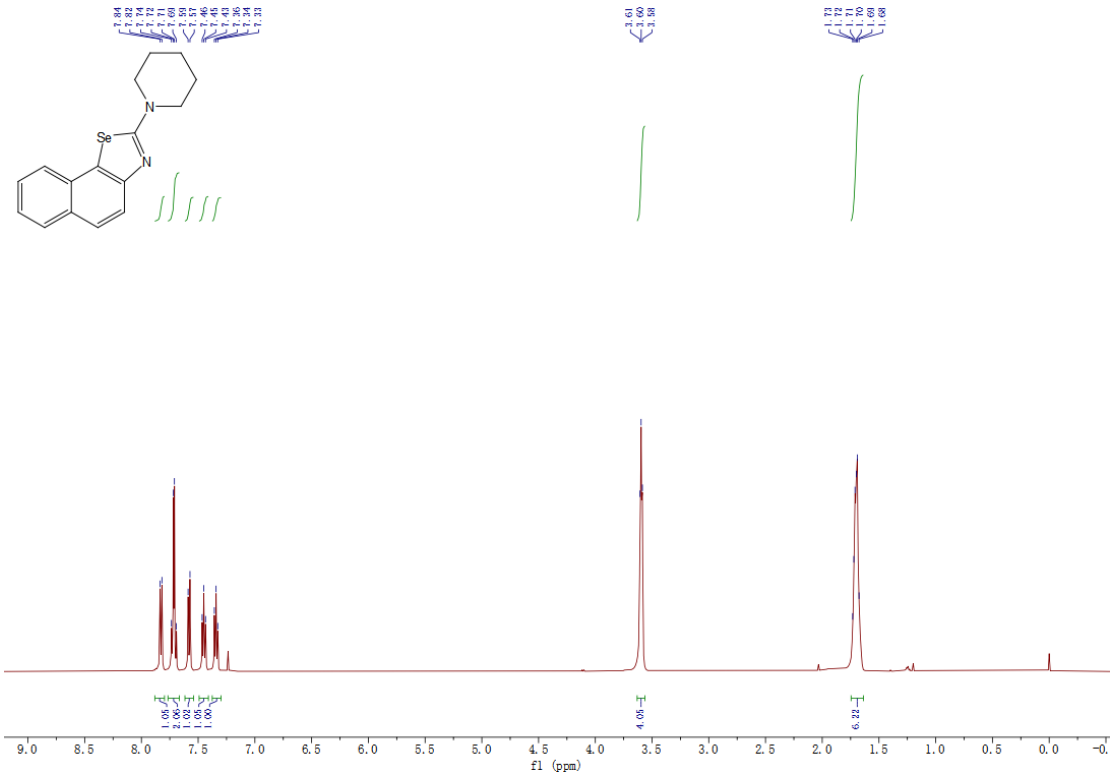
^{13}C NMR of compound **4ax**



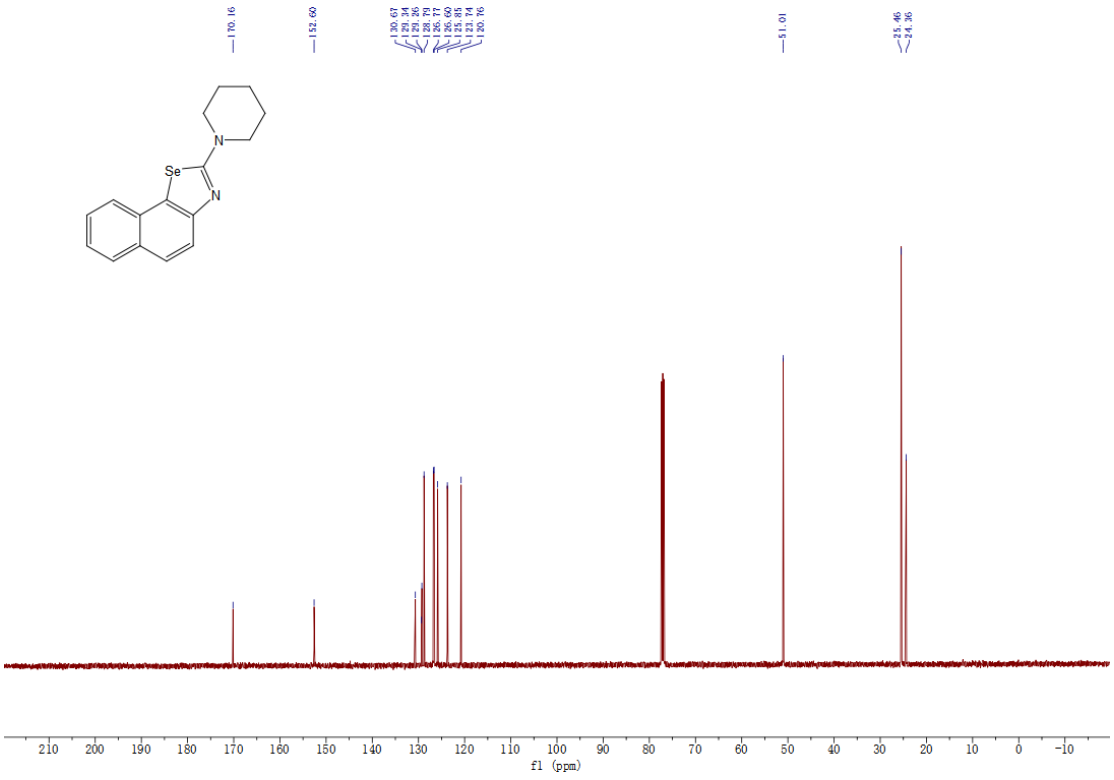
^{1}H NMR of compound **4ay**



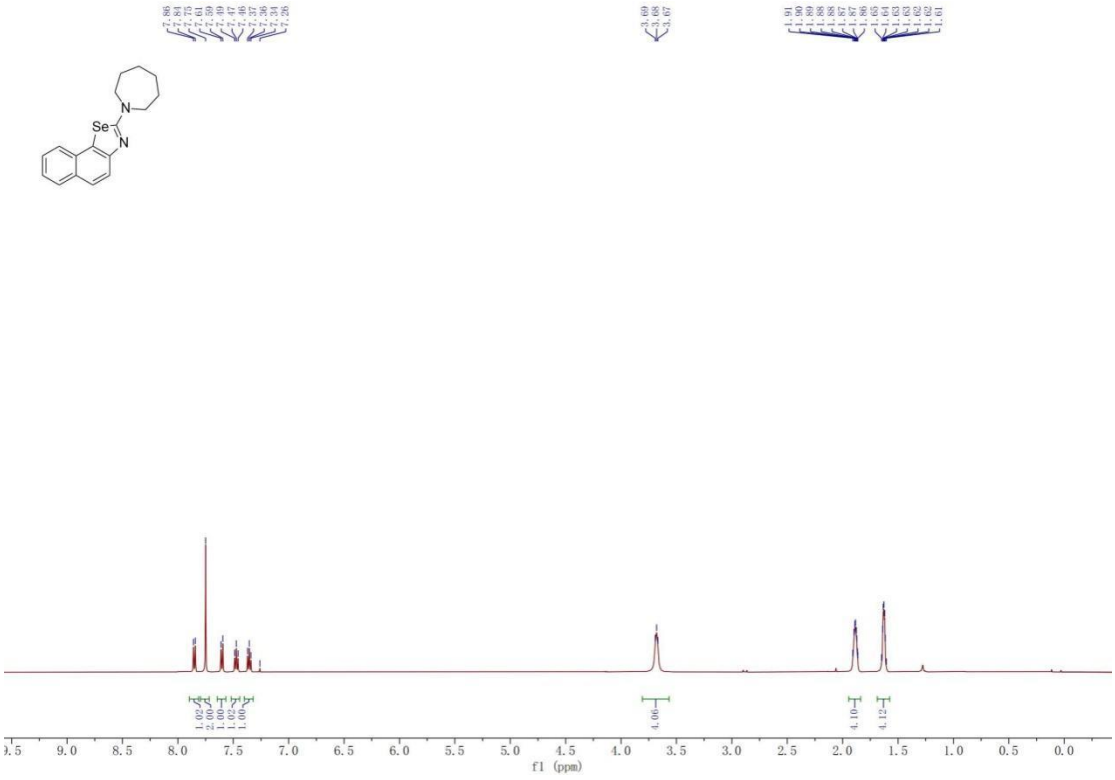
^{13}C NMR of compound **4ay**



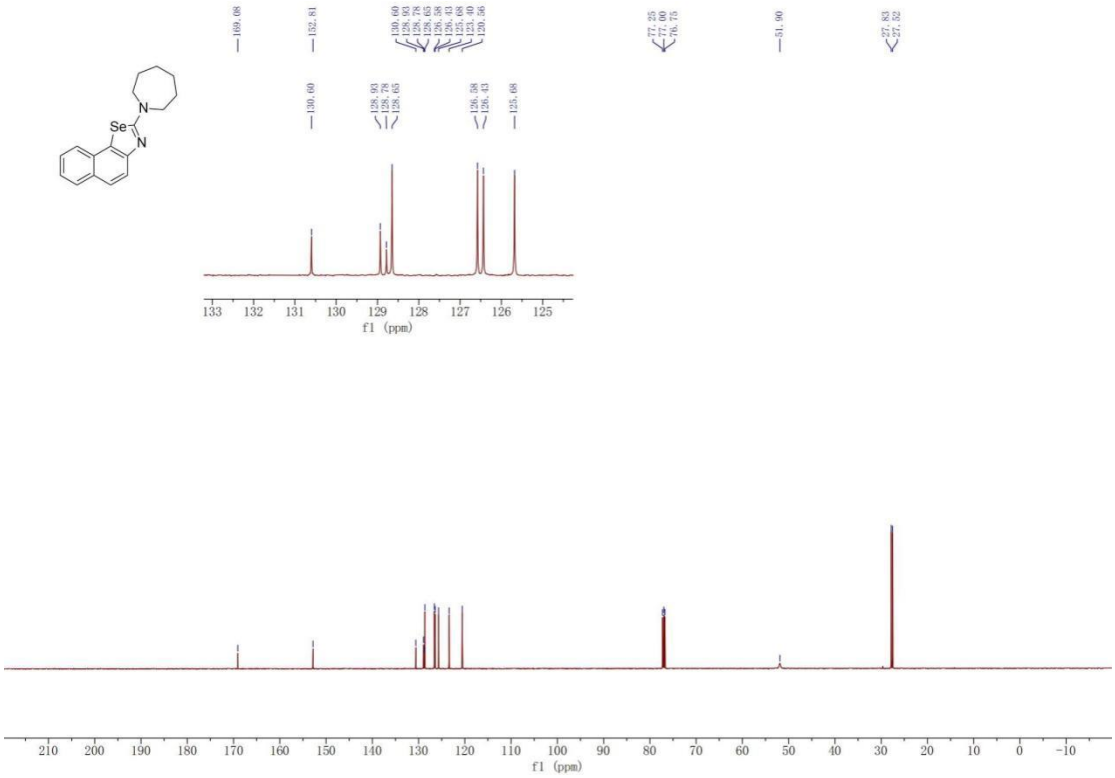
^{1}H NMR of compound **4az**



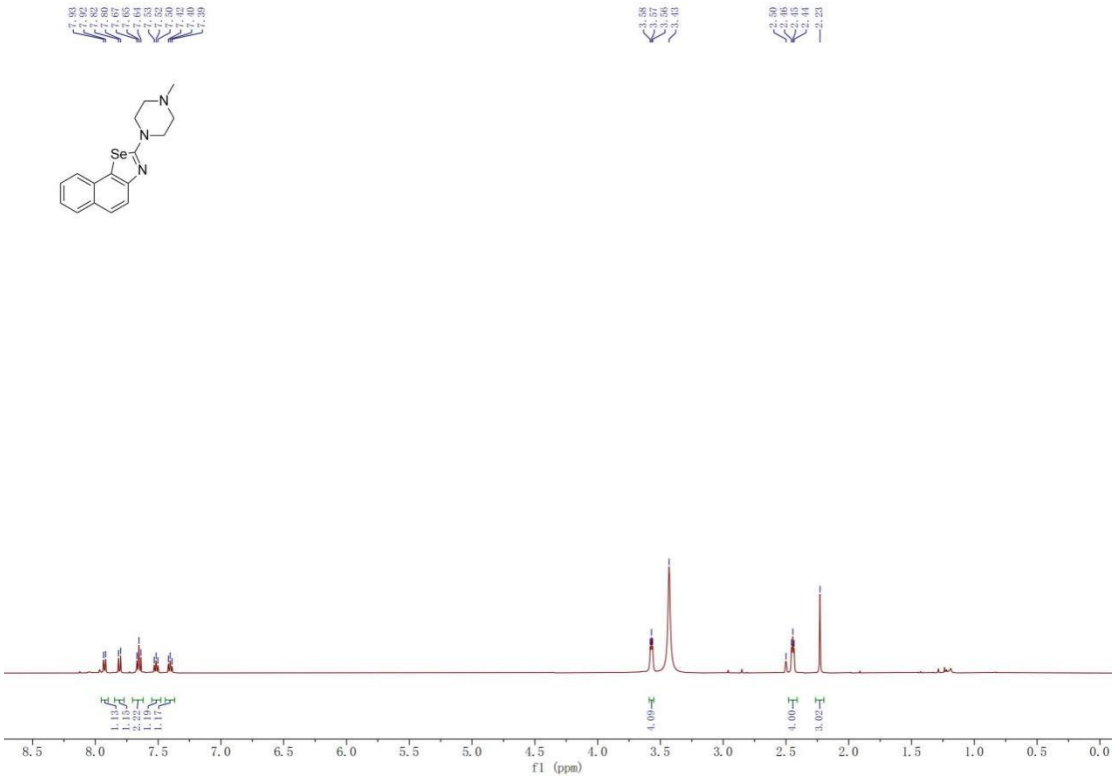
^{13}C NMR of compound **4az**



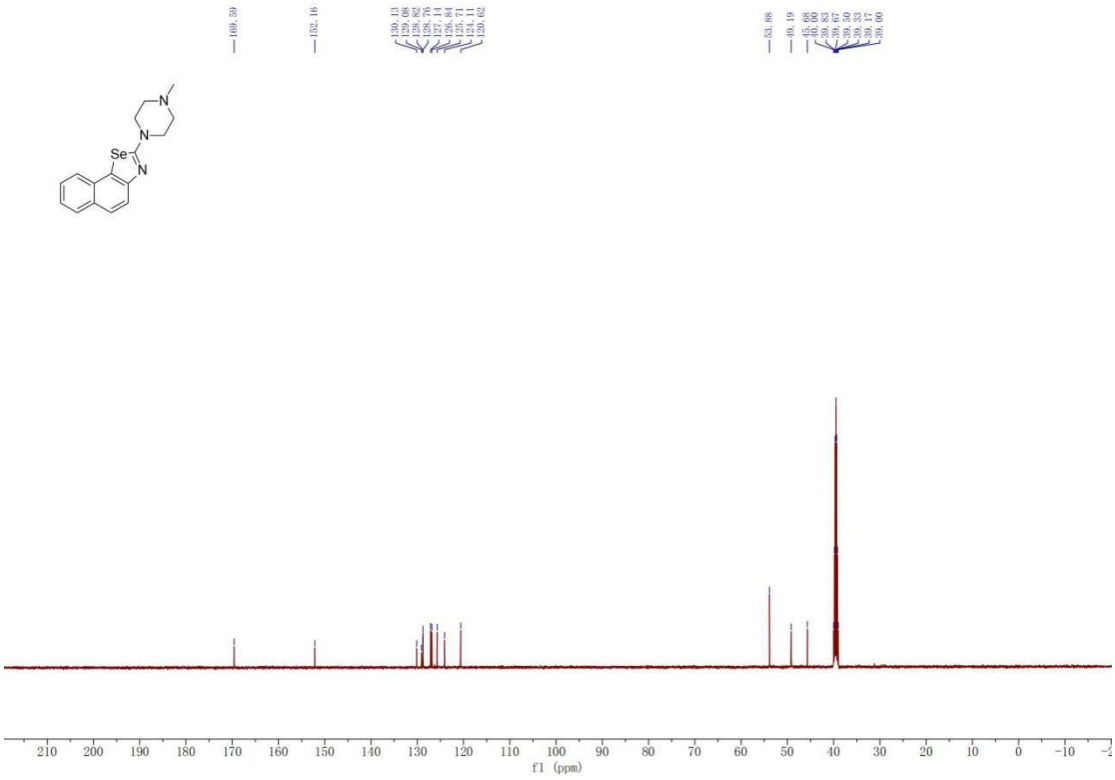
^{1}H NMR of compound **4aA**



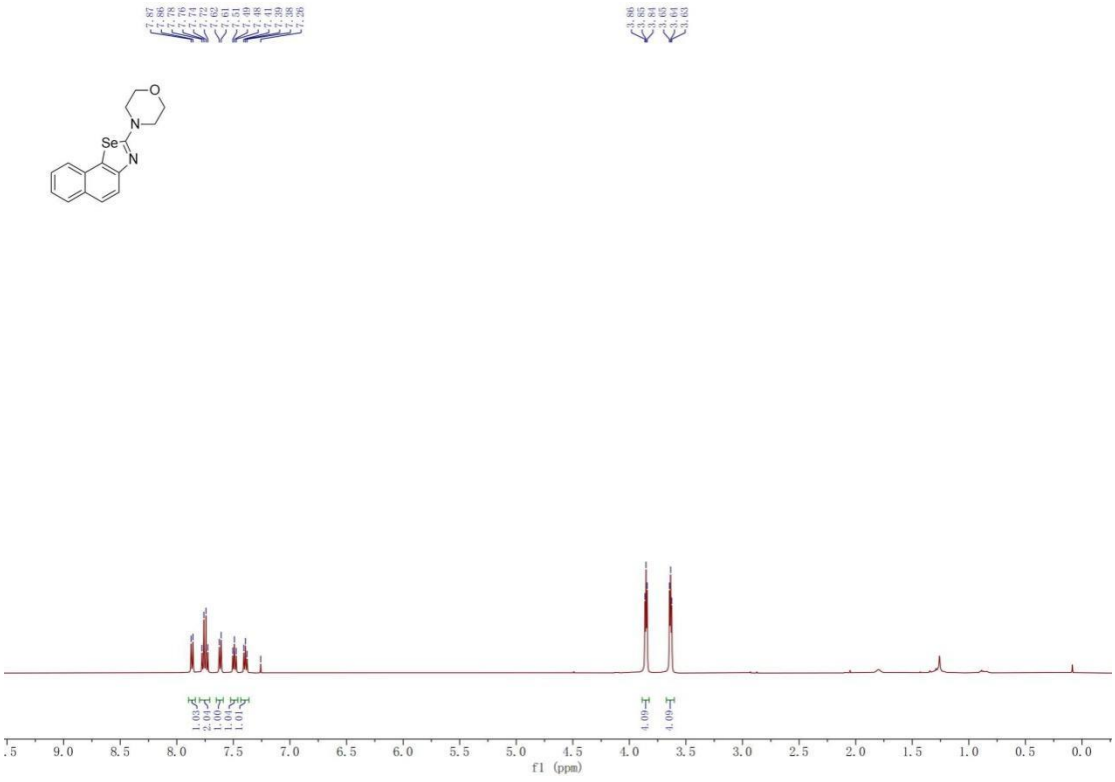
^{13}C NMR of compound **4aA**



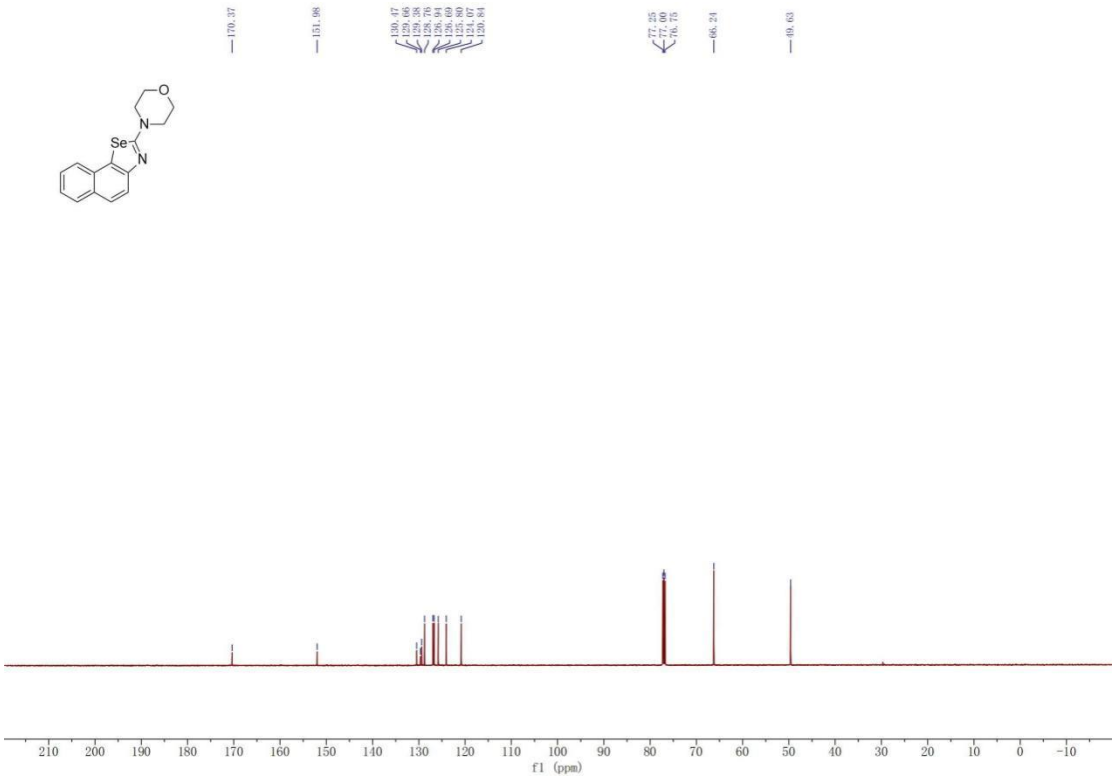
^{1}H NMR of compound **4aB**



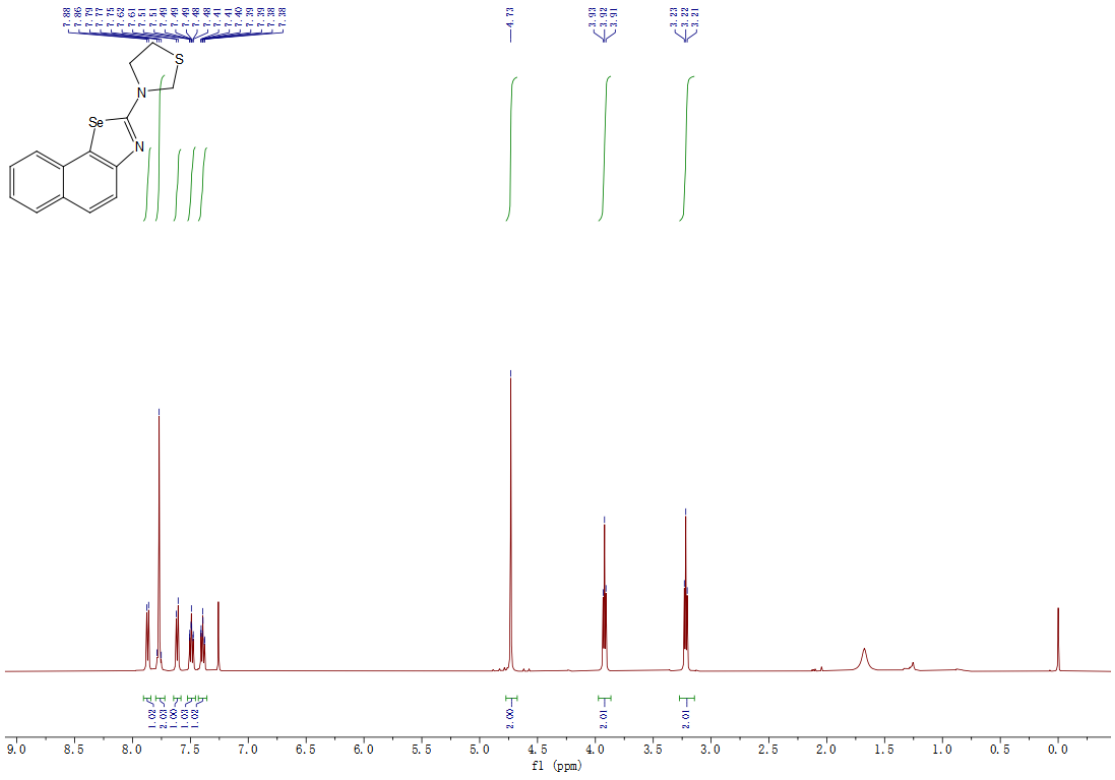
^{13}C NMR of compound **4aB**



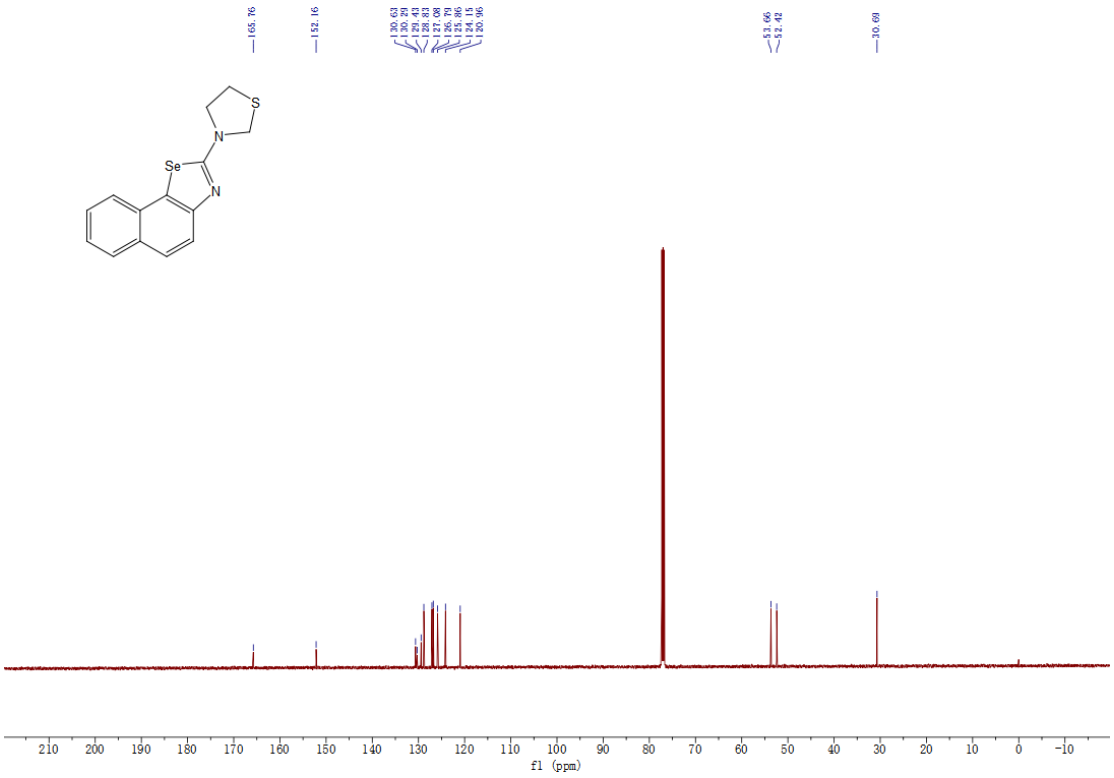
^{1}H NMR of compound **4aC**



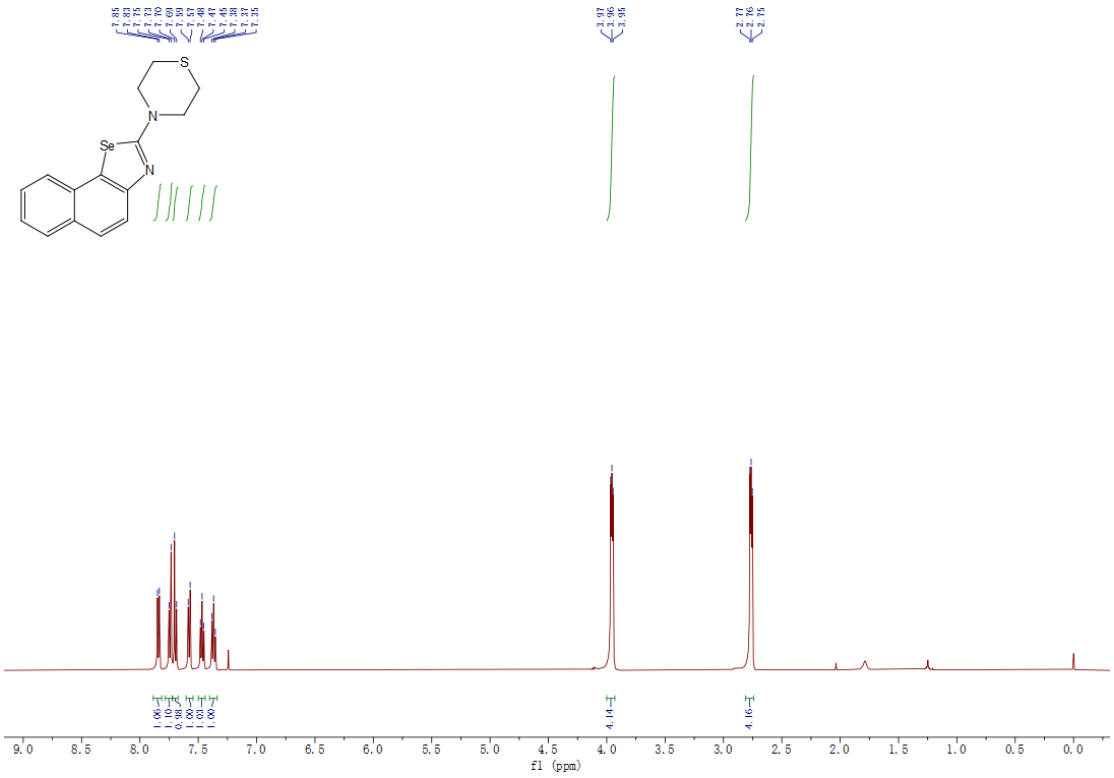
^{13}C NMR of compound **4aC**



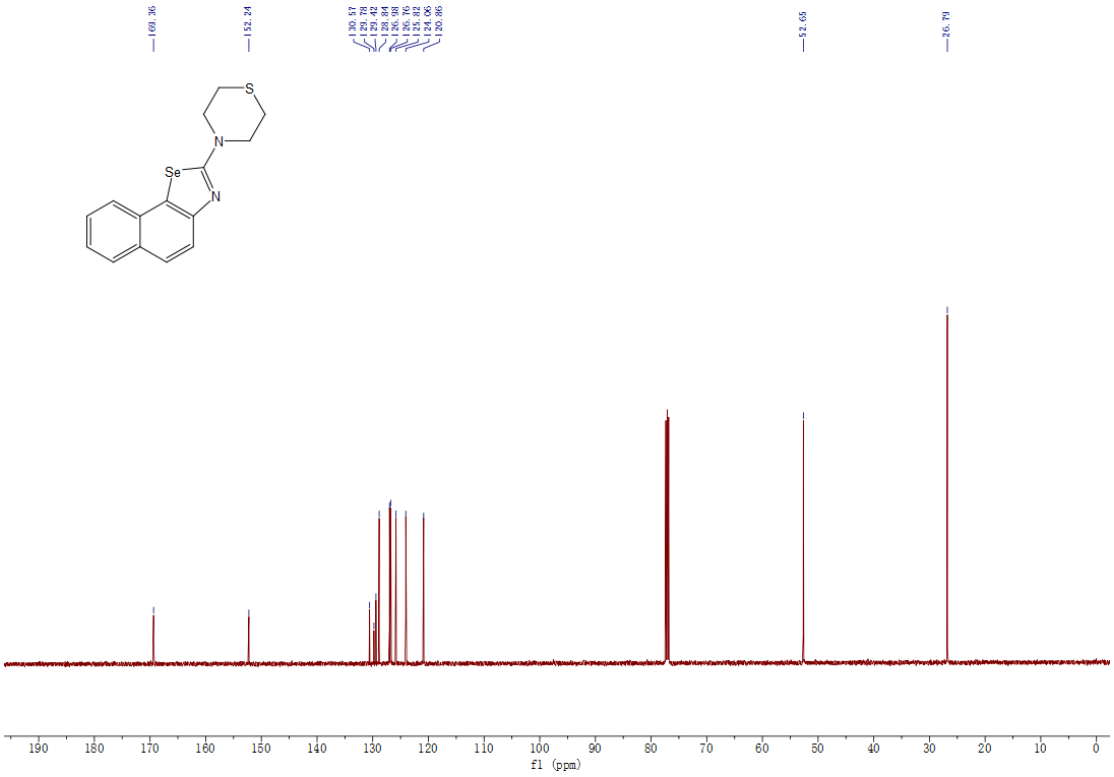
^{1}H NMR of compound **4aD**



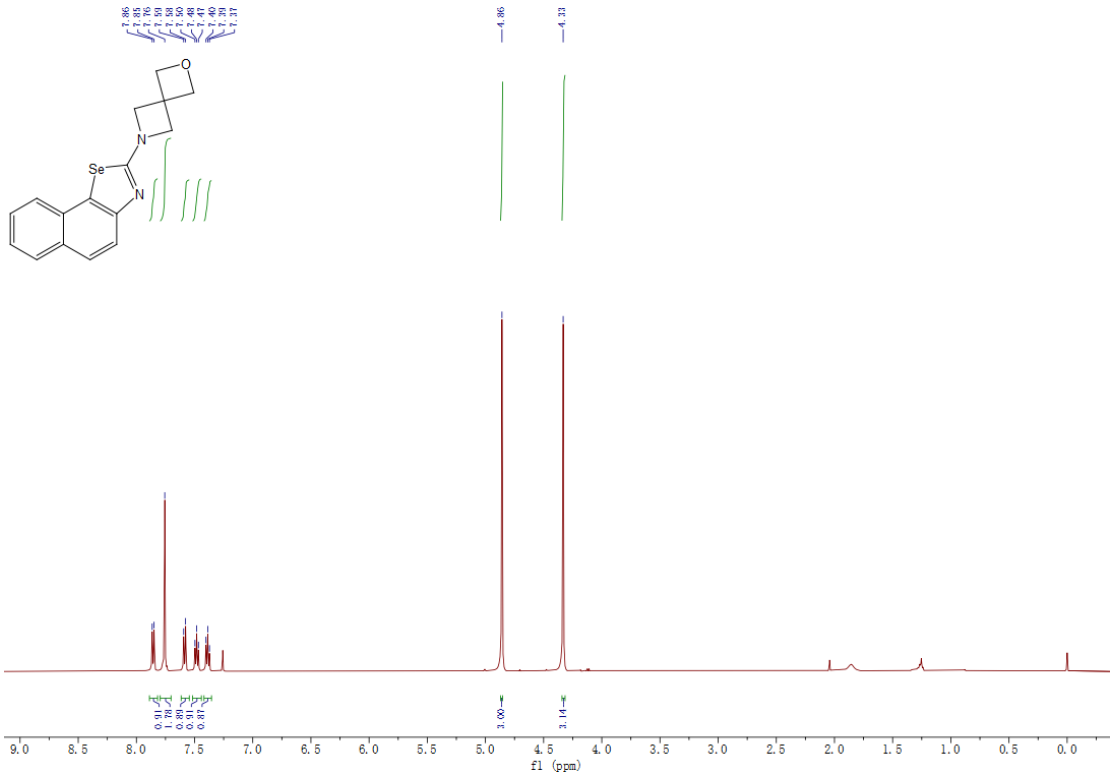
^{13}C NMR of compound **4aD**



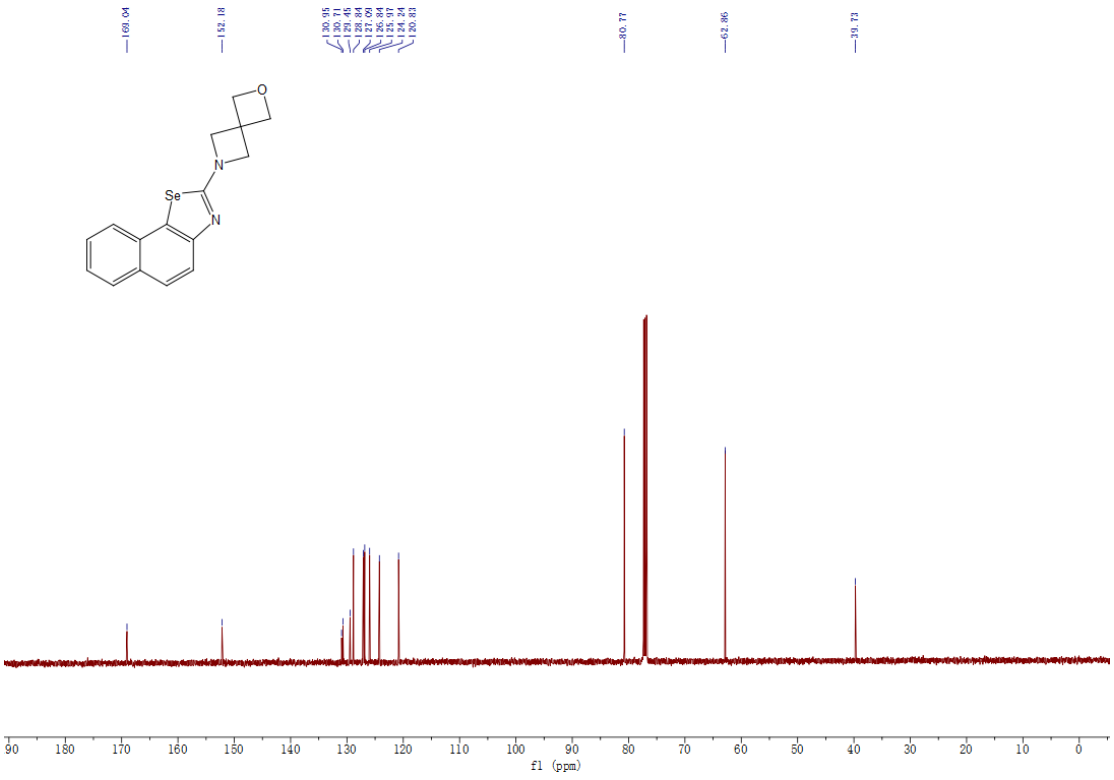
^{1}H NMR of compound **4aE**



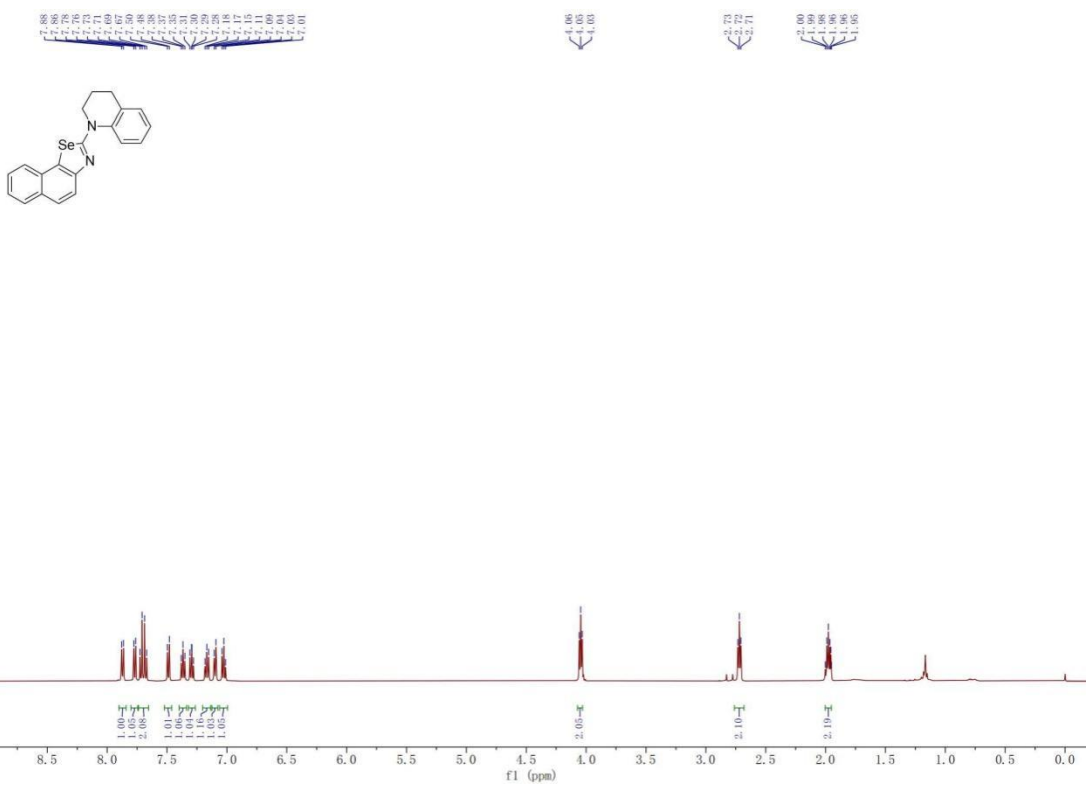
^{13}C NMR of compound **4aE**



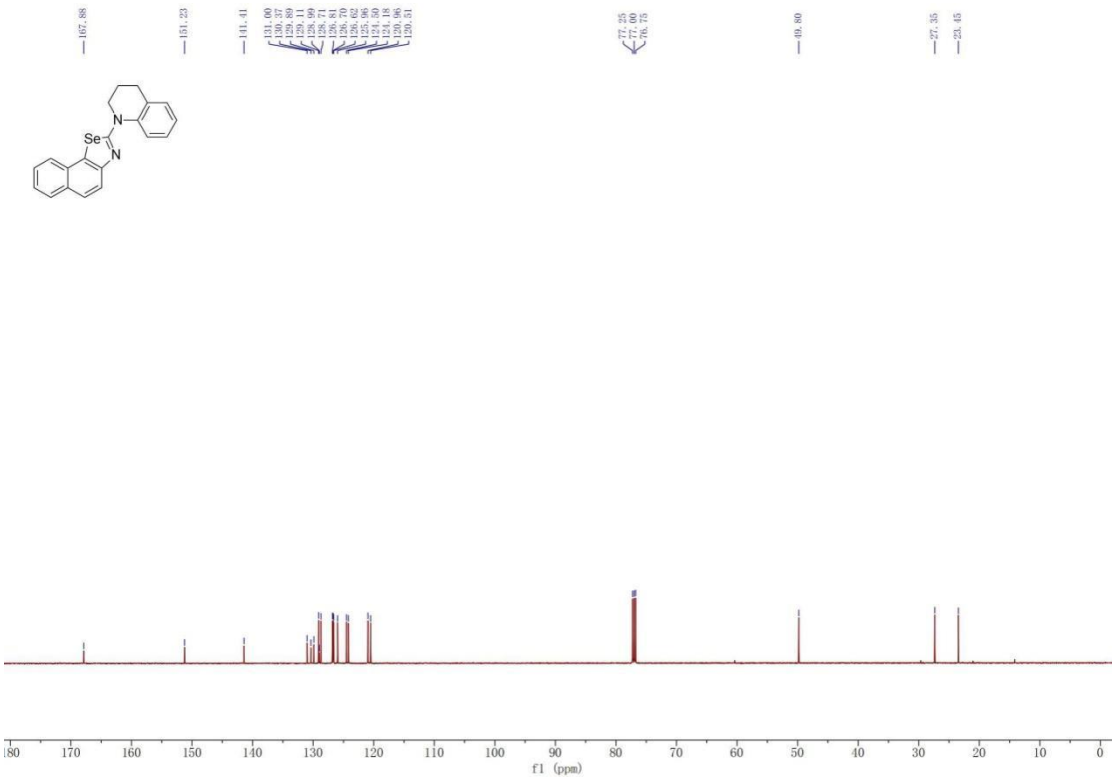
^{1}H NMR of compound **4aF**



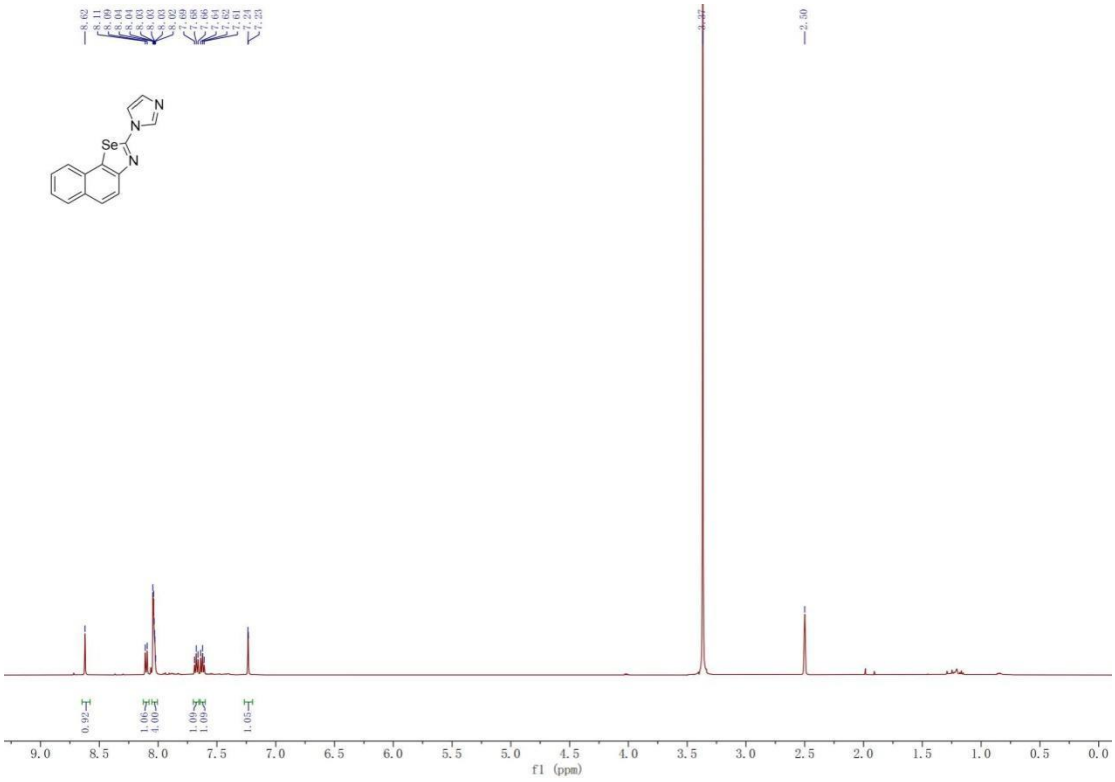
^{13}C NMR of compound **4aF**



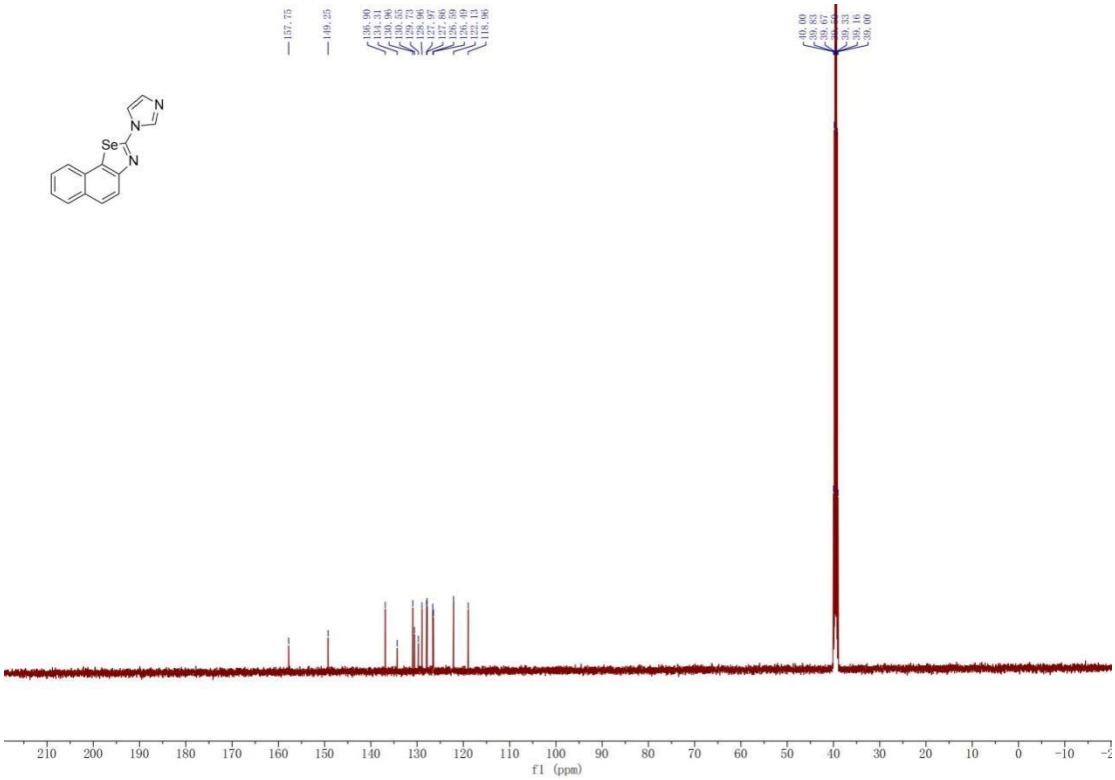
^{1}H NMR of compound **4aG**



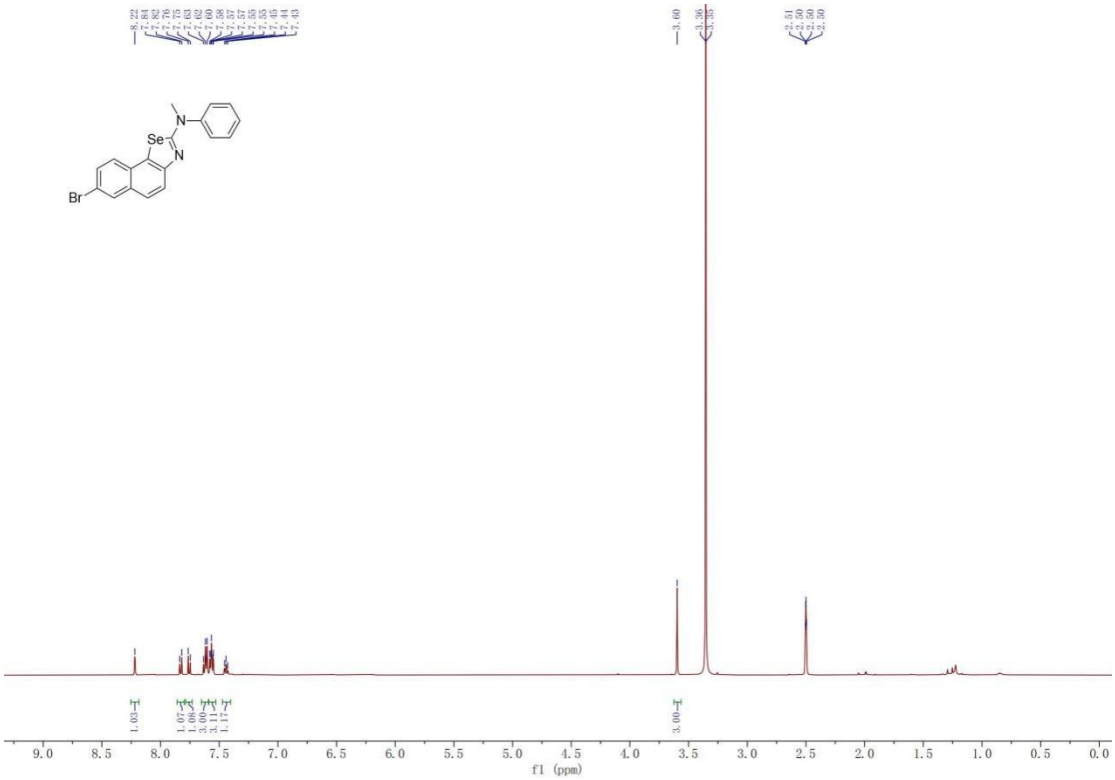
^{13}C NMR of compound **4aG**



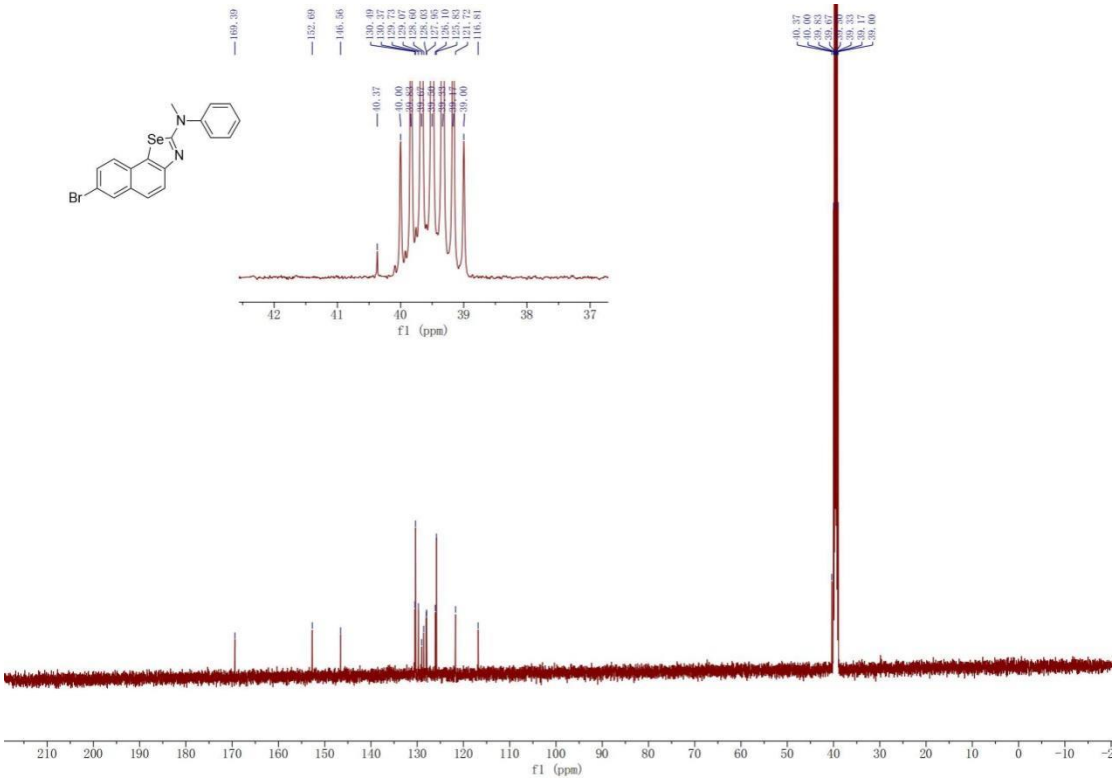
^{1}H NMR of compound **4aH**



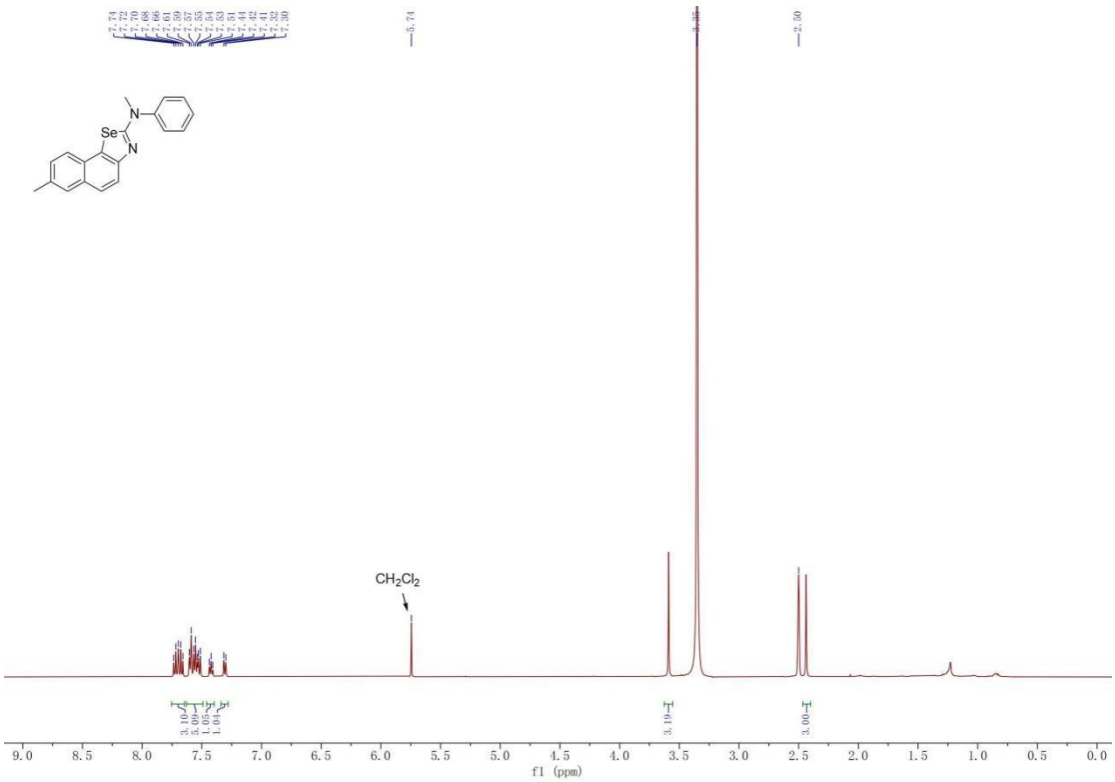
^{13}C NMR of compound **4aH**



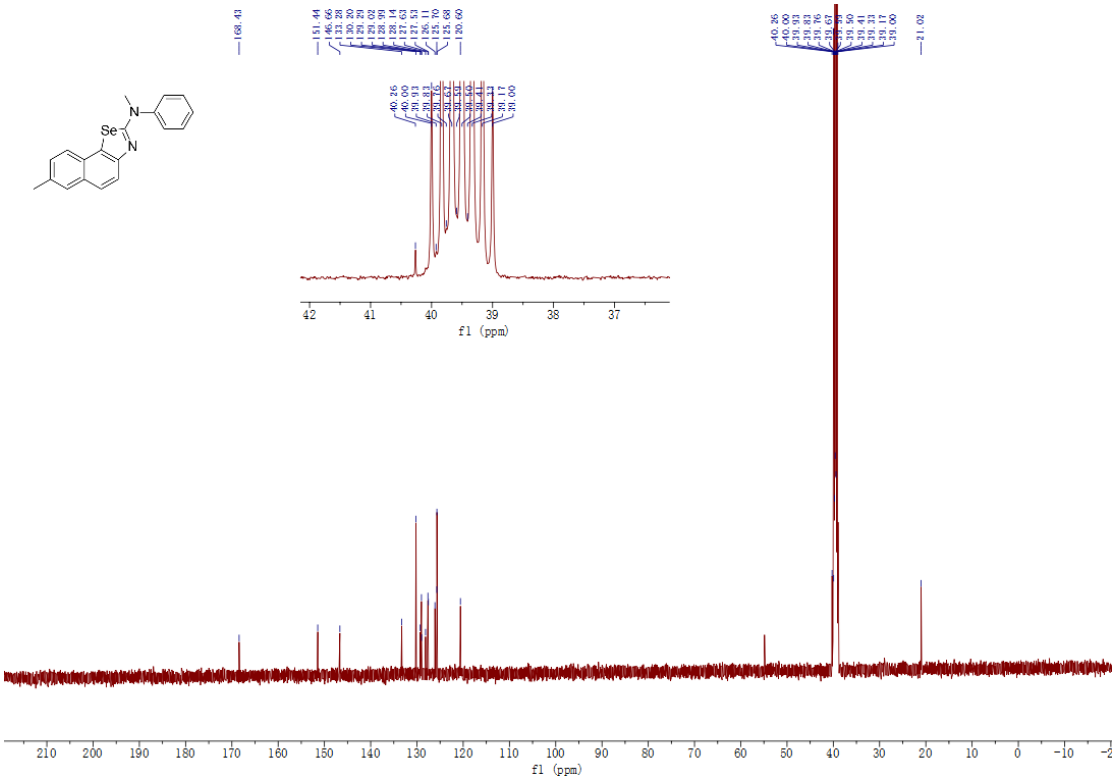
^{1}H NMR of compound **4ba**



^{13}C NMR of compound **4ba**



^{1}H NMR of compound **4ca**



^{13}C NMR of compound **4ca**