Supporting information

Electrochemical oxidative cyclization of activated alkynes with diselenides or disulfides: access to functionalized coumarins or quinolinones

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1. General information

Unless otherwise indicated, all the regents and solvents were purchased from commercial suppliers and used without any further purification. 1H spectra were recorded in $CDCl_3$ on 400MHz NMR spectrometers and resonances (•) are given in parts per million relative to tetramethylsilane. Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q =quartet, p = penta, dd = doublet of doublets, dt = doublet of triplets, ddt = doublet of doublet of triplets, dtd = doublet of triplet of doublets, m = multiplet, br = broad), coupling constant (J) in Hertz (Hz), and integration. ^{13}C NMR were recorded at 100 MHz and chemical data for carbons are reported in parts per million (ppm, δ scale) downfield from tetramethylsilane and are referenced to the carbon resonance of the solvent. Column chromatography was generally performed on Silicycle silica gel (200-300 mesh). Analytical thin-layer chromatography (TLC) was performed on 0.2 mm coated silica gel plates (HSGF 254) and visualized the course of the reactions using a UV light (254 nm or 365 nm). High-resolution mass spectra (HRMS) were obtained on an Agilent mass spectrometer using ESI-TOF (electrosprayionization-time of flight).

2. Experimental section

General procedure for the synthesis of product 4

A 50 mL vial was charged with substrate **1** (0.5 mmol), **2** (0.5 mmol, 1.0equiv.), $^{n}Bu_4NPF_6$ (1.0 mmol, 2equiv.), CH_3CN/HFIP (10 mL, v/v = 4/1) and a magnetic stir bar. The vial was equipped with platinum electrodes (1.5 cm×1.5 cm×0.1 mm) as cathode, graphite rod (Φ 6 mm) as the anode. The whole cell was undivided cell. The reaction mixture was stirred and electrolyzed at a constant current of 15mA at room temperature for 2 hours (2.2 F). After completing reaction, it was monitored with TLC. The solvent was removed with a rotary evaporator. The pure product **4** was obtained by flash chromatography on silica gel using petroleum ether and ethyl acetate as the eluent.

General procedure for the synthesis of product 5

A 50 mL vial was charged with substrate **1** (0.5 mmol), **3** (0.5 mmol, 1.0equiv.), $^{n}Bu_4NPF_6$ (1.0 mmol, 2equiv.), CH_3CN/HFIP (10 mL, v/v = 4/1) and a magnetic stir bar. The vial was equipped with platinum electrodes (1.5 cm×1.5 cm×0.1 mm) as cathode, graphite rod (Φ 6 mm) as the anode and was then flushed with nitrogen. The whole cell was undivided cell. The reaction mixture was stirred and electrolyzed at a constant current of 15mA at room temperature for 2 hours (2.2 F). After completing reaction, it was monitored with TLC. The solvent was removed with a rotary evaporator. The pure product **5** was obtained by flash chromatography on silica gel using petroleum ether and ethyl acetate as the eluent.

General procedure for the synthesis of product 7

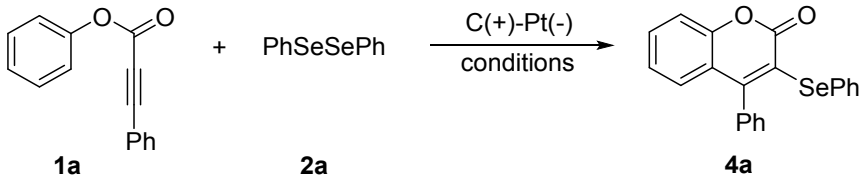
A 50 mL vial was charged with substrate **6** (0.5 mmol), **2** (0.5 mmol, 1.0equiv.), $^{n}Bu_4NPF_6$ (1.0 mmol, 2equiv.), CH_3CN/HFIP (10 mL, v/v = 4/1) and a magnetic stir bar.

The vial was equipped with platinum electrodes (1.5 cm×1.5 cm×0.1 mm) as cathode, graphite rod (Φ 6 mm) as the anode. The whole cell was undivided cell. The reaction mixture was stirred and electrolyzed at a constant current of 15mA at room temperature for 2 hours (2.2 F). After completing reaction, it was monitored with TLC. The solvent was removed with a rotary evaporator. The pure product **7** was obtained by flash chromatography on silica gel using petroleum ether and ethyl acetate as the eluent.

General procedure for the synthesis of product 8

A 50 mL vial was charged with substrate **6** (0.5 mmol), **3** (0.5 mmol, 1.0equiv.), $^{n}Bu_4NPF_6$ (1.0 mmol, 2equiv.), CH_3CN/HFIP (10 mL, v/v = 4/1) and a magnetic stir bar. The vial was equipped with platinum electrodes (1.5 cm×1.5 cm×0.1 mm) as cathode, graphite rod (Φ 6 mm) as the anode and was then flushed with nitrogen. The whole cell was undivided cell. The reaction mixture was stirred and electrolyzed at a constant current of 15mA at room temperature for 2 hours (2.2 F). After completing reaction, it was monitored with TLC. The solvent was removed with a rotary evaporator. The pure product **8** was obtained by flash chromatography on silica gel using petroleum ether and ethyl acetate as the eluent.

3. Screening of mixed solvents[a]

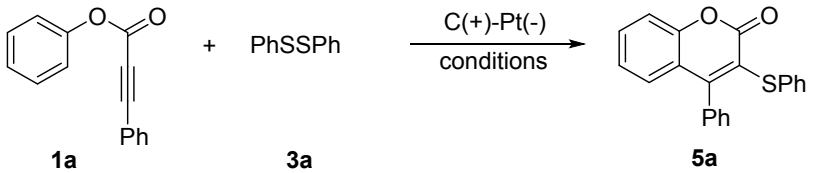


1a **2a** **4a**

Entry	Solvent	Yield[b] (%)
1	CH_3CN/HFIP (v/v = 4/1)	**83**
2	CH_3CN/TFE (v/v = 4/1)	56
3	CH_3CN/H_2O (v/v = 4/1)	0
4	CH_3CN/CH_3OH (v/v = 4/1)	0
5	CH_3CN/DCE (v/v = 4/1)	49
6	CH_3CN/HFIP (v/v = 1/1)	69
7	CH_3CN/HFIP (v/v = 2/1)	73
8	CH_3CN/HFIP (v/v = 3/1)	78
9	CH_3CN/HFIP (v/v = 5/1)	70

[a]Reaction conditions：Pt plate cathode (15 mm × 15 mm × 0.1 mm) cathode, graphite rod anode (Φ 6 mm), constant current = 15 mA, **1a** (0.5 mmol), **2a** (0.5 mmol), $^{n}Bu_4NPF_6$ (1 mmol), mixed solvents (10 mL), room temperature, 2h (2.2 F/mol), undivided cell. [b]Isolated yield.

4. Optimization of reaction conditions of 1a with 3a[a]



1a **3a** **5a**

Entry	Solvent	Electrolyte (equiv.)	I (mA)	Yield[b] (%)
1	CH_3CN	$^nBu_4NPF_6$	15	25
2	HFIP	$^nBu_4NPF_6$	15	33
3	DCE	$^nBu_4NPF_6$	15	15
4	CH_3CN/HFIP	$^nBu_4NPF_6$	15	**53**
5	CH_3CN/TFE	$^nBu_4NPF_6$	15	44
6	CH_3CN/DCE	$^nBu_4NPF_6$	15	37
7	CH_3CN/H_2O	$^nBu_4NPF_6$	15	0
8	CH_3CN/CH_3OH	$^nBu_4NPF_6$	15	0
9	CH_3CN/HFIP	$^nBu_4NBF_4$	15	49
10	CH_3CN/HFIP	$^nBu_4NI$	15	0
11	CH_3CN/HFIP	$^nBu_4NBr$	15	0
12	CH_3CN/HFIP	Et_4NClO_4	15	45
13	CH_3CN/HFIP	$^nBu_4NPF_6$	10	46
14	CH_3CN/HFIP	$^nBu_4NPF_6$	20	50
15	CH_3CN/HFIP	$^nBu_4NPF_6$	15	39[c]
16	CH_3CN/HFIP	$^nBu_4NPF_6$	15	45[d]

[a]Reaction conditions: Pt plate cathode (15 mm × 15 mm × 0.1 mm) cathode, graphite rod anode (Φ 6 mm), **1a** (0.5 mmol), **3a** (0.5 mmol), solvent (10 mL, v/v = 4/1), electrolyte, constant current, room temperature, 2h, N_2, undivided cell. [b]Isolated yield. [c]0.5 equiv. of **3a**. [d]2 equiv. of **3a**.

5. X-ray crystallography structure of compound 4i

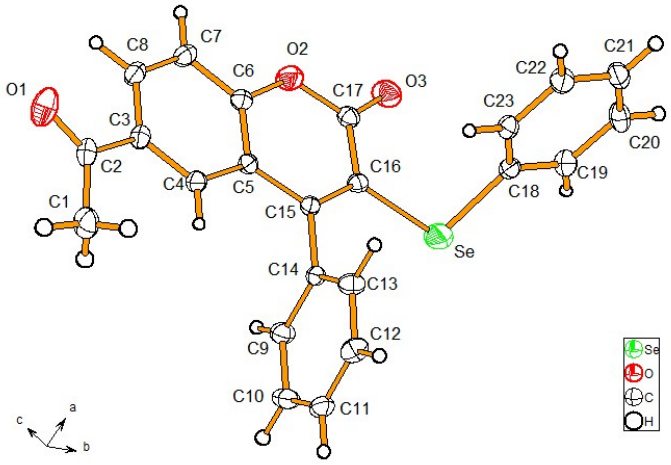
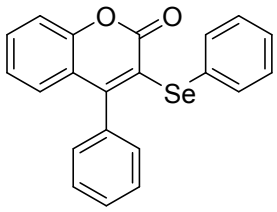


Figure S1. X-ray structure of **4i**

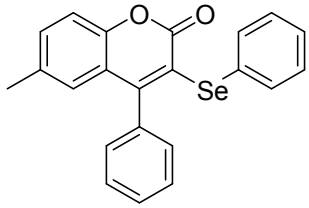
6. Cyclic voltammetry experiment

Cyclic voltammograms of **1a**, **2a** and **3a** were performed in a three-electrode cell connected to a schlenk line under nitrogen at room temperature. The working electrode was a steady glassy carbon disk electrode while the counter electrode was a platinum wire. The reference was an Ag/AgCl electrode submerged in saturated aqueous KCl solution. (1) **1a** (0.5mmol) and a mixed solvent (MeCN/HFIP = 4/1, 10 mL) containing $^{n}Bu_4NPF_6$ (1 mmol) were poured into the electrochemical cell in cyclic voltammetry experiments. The scan rate was 0.10 V/s, ranging from 0 V to 2.5 V. (2) **2a** (0.5mmol) and a mixed solvent (MeCN/HFIP = 4/1, 10 mL) containing $^{n}Bu_4NPF_6$ (1 mmol) were poured into the electrochemical cell in cyclic voltammetry experiments. The scan rate was 0.10 V/s, ranging from 0 V to 2.5 V. (3) **3a** (0.5mmol) and a mixed solvent (MeCN/HFIP = 4/1, 10 mL) containing $^{n}Bu_4NPF_6$ (1 mmol) were poured into the electrochemical cell in cyclic voltammetry experiments. The scan rate was 0.10 V/s, ranging from 0 V to 2.5 V.

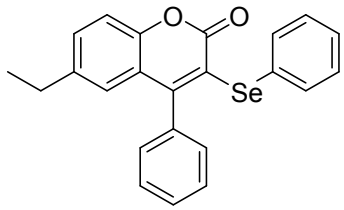
7. Analytical data of products 4, 5 , 7 ,8 , 10a



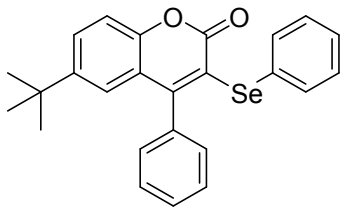
4-phenyl-3-(phenylselanyl)-2H-chromen-2-one **(4a)**. Yellow solid (83%, 0.157g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.44 (ddd, *J* = 8.6, 7.3, 1.6 Hz, 1H), 7.38 (dd, *J* = 5.0, 1.7 Hz, 3H), 7.32 – 7.28 (m, 1H), 7.24 (dt, *J* = 6.6, 1.5 Hz, 2H), 7.14 – 7.03 (m, 6H), 6.98 (dd, *J* = 8.0, 1.5 Hz, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.52 , 157.99 , 152.44 , 135.17 , 131.78 , 130.98 , 129.26 , 128.01 , 127.84 , 127.47 , 127.21 , 126.90 , 126.39 , 123.23 , 119.71 , 119.46 , 115.77 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{21}H_{15}O_2Se$ 379.0232 found 379.0230.



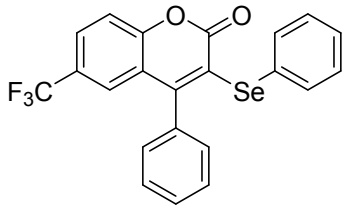
6-methyl-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one **(4b)**. Yellow solid (85%, 0.166g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.36 (dd, *J* = 5.0, 1.7 Hz, 3H), 7.22 (ddd, *J* = 8.1, 3.9, 1.8 Hz, 3H), 7.17 (d, *J* = 8.4 Hz, 1H), 7.10 – 7.01 (m, 5H), 6.74 – 6.70 (m, 1H), 2.16 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.68 , 158.10 , 150.61 , 135.29 , 132.97 , 132.04 , 131.63 , 129.41 , 127.97 , 127.77 , 127.44 , 127.16 , 126.54 , 126.28 , 119.51 , 119.12 , 115.49 , 19.86 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{22}H_{17}O_2Se$ 393.0388 found 393.0385.



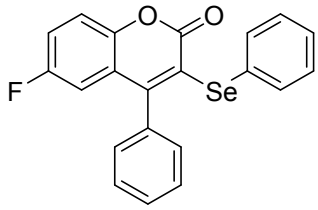
6-ethyl-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one **(4c)**. Yellow solid (82%, 0.166g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.37 (dd, *J* = 5.0, 1.7 Hz, 3H), 7.28 (dd, *J* = 8.5, 2.0 Hz, 1H), 7.25 – 7.20 (m, 3H), 7.12 – 7.03 (m, 5H), 6.75 (d, *J* = 1.8 Hz, 1H), 2.47 (q, *J* = 7.6 Hz, 2H), 1.04 (t, *J* = 7.6 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.71 , 158.18 , 150.80 , 139.40 , 135.33 , 131.66 , 130.88 , 129.48 , 127.98 , 127.78 , 127.43 , 127.22 , 126.28 , 125.51 , 119.51 , 119.20 , 115.64 , 27.23 , 14.66 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{23}H_{19}O_2Se$ 407.0545 found 407.0549.



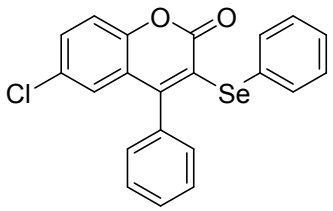
6-(tert-butyl)-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one **(4d)**. Yellow solid (86%, 0.186g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.47 (dd, *J* = 8.7, 2.3 Hz, 1H), 7.37 – 7.32 (m, 3H), 7.23 – 7.18 (m, 3H), 7.11 – 7.00 (m, 5H), 6.94 (d, *J* = 2.3 Hz, 1H), 1.08 (s, 9H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.77 , 158.51 , 150.50 , 146.27 , 135.19 , 131.55 , 129.49 , 128.67 , 127.95 , 127.83 , 127.34 , 127.18 , 126.22 , 123.08 , 119.21 , 118.75 , 115.26 , 33.47 , 30.12 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{25}H_{23}O_2Se$ 435.0858 found 435.0860.



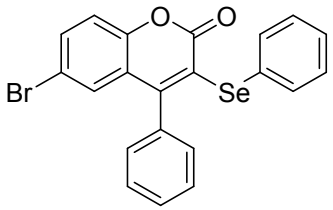
4-phenyl-3-(phenylselanyl)-6-(trifluoromethyl)-2H-chromen-2-one **(4e)**. Yellow solid (81%, 0.180g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.65 (dd, *J* = 8.7, 1.9 Hz, 1H), 7.42 – 7.36 (m, 4H), 7.25 – 7.21 (m, 3H), 7.14 – 7.03 (m, 5H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 157.50 , 156.19 , 154.06 , 134.16 , 132.31 , 128.56 , 128.36 , 128.09 , 127.83 , 127.31 (q, *J* = 4 Hz) , 127.14 , 126.76 , 125.72 (q, *J* = 33 Hz) , 124.03 (q, *J* = 4 Hz) , 123.70 , 121.97 , 119.52 , 116.62 . ^{19}F NMR (376 MHz, Chloroform-*d*) δ -62.05 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{22}H_{14}F_3O_2Se$ 447.0106 found 447.0104.



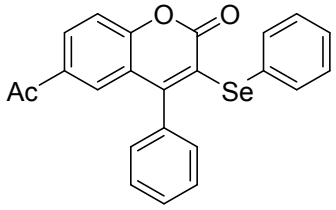
6-fluoro-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one **(4f)**. Yellow solid (79%, 0.156g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.37 (dd, *J* = 5.0, 1.9 Hz, 3H), 7.28 – 7.21 (m, 3H), 7.16 – 7.03 (m, 6H), 6.64 (dd, *J* = 9.0, 2.9 Hz, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.17 , 157.61 (d, *J* = 236 Hz) , 156.39 (d, *J* = 3 Hz), 148.47 (d, *J* = 2 Hz) , 134.62 , 132.17 , 128.81 , 128.11 , 128.05 , 127.68 , 127.09 , 126.61 , 121.43 , 120.34 (d, *J* = 9 Hz), 118.25 (d, *J* = 25 Hz) , 117.25 (d, *J* = 9 Hz) , 112.17 (d, *J* = 25 Hz) . ^{19}F NMR (376 MHz, Chloroform-*d*) δ -116.74 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{21}H_{14}FO_2Se$ 397.0138 found 397.0142.



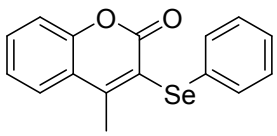
6-chloro-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one **(4g)**. Yellow solid (80%, 0.165g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.38 – 7.32 (m, 4H), 7.23 – 7.18 (m, 3H), 7.12 – 7.02 (m, 5H), 6.91 (d, *J* = 2.4 Hz, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 157.82 , 156.13 , 150.70 , 134.43 , 132.16 , 130.74 , 128.76 , 128.61 , 128.14 , 128.04 , 127.71 , 127.10 , 126.62 , 125.90 , 121.46 , 120.52 , 117.18 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{21}H_{14}ClO_2Se$ 412.9842 found 412.9837.



6-bromo-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one **(4h)**. Yellow solid (84%, 0.192g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.49 (dd, *J* = 8.8, 2.3 Hz, 1H), 7.38 (dd, *J* = 5.0, 1.9 Hz, 3H), 7.25 – 7.20 (m, 2H), 7.16 (d, *J* = 8.8 Hz, 1H), 7.13 – 7.03 (m, 6H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 157.78 , 156.05 , 151.19 , 134.42 , 133.59 , 132.18 , 128.91 , 128.77 , 128.16 , 128.05 , 127.73 , 127.12 , 126.64 , 121.48 , 121.00 , 117.50 , 116.02 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{21}H_{14}BrO_2Se$ 456.9337 found 456.9339.

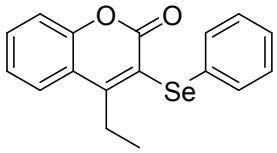


6-acetyl-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one **(4i)**. Yellow solid (80%, 0.192g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 8.00 (dd, *J* = 8.6, 2.1 Hz, 1H), 7.58 (d, *J* = 2.0 Hz, 1H), 7.39 (dd, *J* = 5.0, 1.9 Hz, 3H), 7.32 (d, *J* = 8.6 Hz, 1H), 7.25 – 7.20 (m, 2H), 7.12 – 7.02 (m, 5H), 2.35 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 194.94 , 157.63 , 157.04 , 155.10 , 134.41 , 132.30 , 132.15 , 130.54 , 128.72 , 128.29 , 128.06 , 127.72 , 127.50 , 127.17 , 126.65 , 121.01 , 119.28 , 116.15 , 25.41 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{23}H_{17}O_3Se$ 421.0337 found 421.0341.

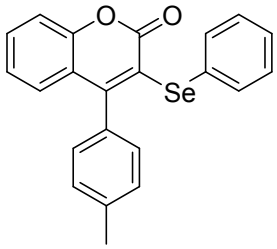


4-methyl-3-(phenylselanyl)-2H-chromen-2-one **(4k)**. Yellow solid (85%, 0.134g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.58 (d, *J* = 8.0 Hz, 1H), 7.47 (t, *J* = 7.8 Hz, 1H), 7.40 – 7.34 (m, 2H), 7.28 – 7.20 (m, 2H), 7.19 – 7.12 (m, 3H), 2.64 (s, 3H). ^{13}C NMR (101

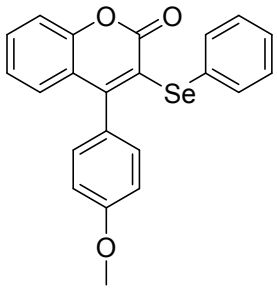
MHz, Chloroform-*d*) δ 158.51 , 155.89 , 151.93 , 131.17 , 130.56 , 129.57 , 128.33 , 126.22 , 124.54 , 123.42 , 119.12 , 118.89 , 115.97 , 19.57 . HRMS (TOF) m/z $[M + H]^+$ Calcd for $C_{16}H_{13}O_2Se$ 317.0075 found 317.0076.



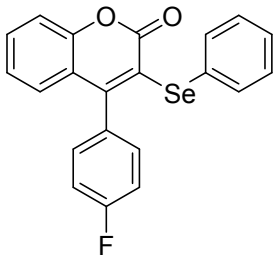
4-ethyl-3-(phenylselanyl)-2H-chromen-2-one **(4l)**. Yellow solid (83%, 0.137g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.63 (dd, *J* = 8.1, 1.4 Hz, 1H), 7.48 (ddd, *J* = 8.5, 7.3, 1.5 Hz, 1H), 7.43 – 7.38 (m, 2H), 7.31 – 7.21 (m, 2H), 7.19 – 7.13 (m, 3H), 3.23 (q, *J* = 7.6 Hz, 2H), 1.18 (t, *J* = 7.6 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 161.56 , 158.44 , 152.65 , 131.14 , 130.58 , 129.53 , 128.28 , 126.24 , 124.47 , 123.43 , 117.90 , 117.67 , 116.32 , 26.17 , 12.92 . HRMS (TOF) m/z $[M + H]^+$ Calcd for $C_{17}H_{15}O_2Se$ 331.0232 found 331.0236.



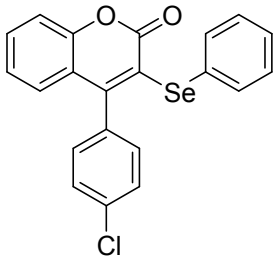
3-(phenylselanyl)-4-(p-tolyl)-2H-chromen-2-one **(4m)**. Yellow solid (80%, 0.157g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.39 (ddd, *J* = 8.6, 6.8, 2.1 Hz, 1H), 7.27 – 7.21 (m, 3H), 7.15 (d, *J* = 7.8 Hz, 2H), 7.08 – 6.95 (m, 7H), 2.33 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.42 , 158.13 , 152.40 , 137.83 , 132.25 , 131.68 , 130.89 , 129.36 , 128.11 , 127.92 , 127.17 , 126.98 , 126.29 , 123.17 , 119.54 , 115.67 , 20.40 . HRMS (TOF) m/z $[M + H]^+$ Calcd for $C_{22}H_{17}O_2Se$ 393.0388 found 393.0384.



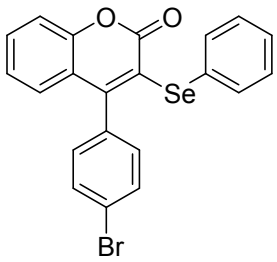
4-(4-methoxyphenyl)-3-(phenylselanyl)-2H-chromen-2-one **(4n)**. Yellow solid (79%, 0.161g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.43 (ddd, *J* = 8.6, 5.6, 3.2 Hz, 1H), 7.30 – 7.22 (m, 3H), 7.12 – 7.01 (m, 7H), 6.91 – 6.86 (m, 2H), 3.80 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.99 , 158.54 , 157.72 , 152.44 , 131.70 , 130.86 , 129.45 , 128.82 , 127.96 , 127.41 , 126.95 , 126.33 , 123.17 , 119.87 , 119.70 , 115.76 , 112.86 , 54.33 . HRMS (TOF) m/z $[M + H]^+$ Calcd for $C_{22}H_{17}O_3Se$ 409.0337 found 409.0339.



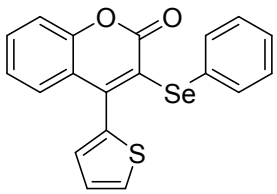
4-(4-fluorophenyl)-3-(phenylselanyl)-2H-chromen-2-one **(4o)**. Yellow solid (80%, 0.158g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.44 (ddd, *J* = 8.6, 7.4, 1.5 Hz, 1H), 7.29 (dd, *J* = 8.3, 0.9 Hz, 1H), 7.23 – 7.18 (m, 2H), 7.13 – 6.99 (m, 8H), 6.95 (dd, *J* = 8.0, 1.5 Hz, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 161.77 (d, *J* = 248 Hz), 158.45 , 156.61 , 152.35 , 131.95 , 131.06 , 130.95 (d, *J* = 3 Hz), 129.30 , 129.22 , 129.11 , 128.04 , 126.52 (d, *J* = 2 Hz), 123.33 , 120.48 , 119.40 , 115.85 , 114.63 (d, *J* = 22 Hz) . ^{19}F NMR (376 MHz, Chloroform-*d*) δ -111.80 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{21}H_{14}FO_2Se$ 397.0138 found 397.0143.



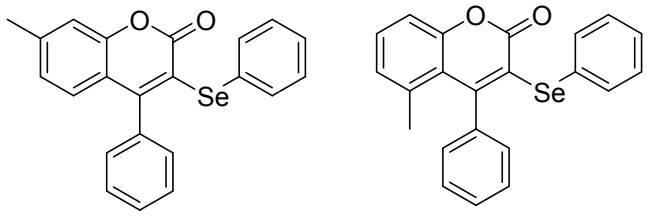
4-(4-chlorophenyl)-3-(phenylselanyl)-2H-chromen-2-one **(4p)**. Yellow solid (82%, 0.169g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.42 (ddd, *J* = 8.6, 7.4, 1.5 Hz, 1H), 7.27 (td, *J* = 6.7, 1.3 Hz, 3H), 7.20 – 7.16 (m, 2H), 7.12 – 6.96 (m, 6H), 6.92 (dd, *J* = 8.0, 1.4 Hz, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.37 , 156.27 , 152.29 , 133.87 , 133.28 , 132.02 , 131.10 , 128.97 , 128.69 , 128.03 , 127.73 , 126.55 , 126.38 , 123.36 , 120.34 , 119.15 , 115.83 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{21}H_{14}ClO_2Se$ 412.9842 found 412.9837.



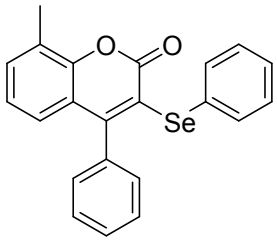
4-(4-bromophenyl)-3-(phenylselanyl)-2H-chromen-2-one **(4q)**. Yellow solid (83%, 0.189g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.44 (td, *J* = 7.8, 7.3, 1.7 Hz, 3H), 7.31 – 7.27 (m, 1H), 7.20 (dd, *J* = 8.1, 1.2 Hz, 2H), 7.15 – 7.03 (m, 4H), 6.93 (d, *J* = 8.4 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.39 , 156.20 , 152.34 , 133.78 , 132.12 , 131.10 , 130.70 , 128.95 , 128.05 , 126.59 , 126.37 , 123.36 , 122.13 , 120.38 , 119.12 , 115.88 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{21}H_{14}BrO_2Se$ 456.9337 found 456.9330.



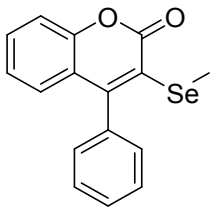
3-(phenylselanyl)-4-(thiophen-2-yl)-2H-chromen-2-one **(4r)**. Yellow solid (50%, 0.096g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.44 (ddd, *J* = 8.8, 6.2, 1.3 Hz, 2H), 7.33 (dd, *J* = 7.6, 1.8 Hz, 2H), 7.29 – 7.22 (m, 2H), 7.14 – 7.07 (m, 4H), 7.05 (dd, *J* = 5.0, 3.6 Hz, 1H), 6.91 (dd, *J* = 3.5, 1.1 Hz, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 157.87 , 152.05 , 150.73 , 134.62 , 132.04 , 131.03 , 128.95 , 128.22 , 128.05 , 126.69 , 126.61 , 126.24 , 123.36 , 122.77 , 119.71 , 115.71 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{19}H_{13}O_2SSe$ 384.9796 found 384.9792.



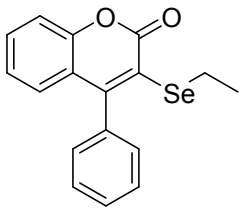
7-methyl-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one **(4s1)**, 5-methyl-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one, **(4s2)**. Yellow solid (85%, 0.166g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.35 (tt, *J* = 5.2, 3.0 Hz, 3H), 7.29 – 7.20 (m, 2H), 7.12 – 7.02 (m, 6H), 6.91 – 6.82 (m, 2H), 2.33 (s, 2H), 1.63 (s, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.79 , 158.48 , 158.40 , 157.70 , 153.43 , 152.55 , 142.49 , 139.42 , 136.88 , 135.33 , 131.51 , 131.33 , 130.43 , 129.75 , 129.53 , 127.99 , 127.97 , 127.75 , 127.70 , 127.60 , 127.38 , 127.17 , 126.77 , 126.67 , 126.28 , 126.22 , 124.44 , 121.11 , 118.00 , 117.53 , 117.09 , 115.85 , 114.55 , 22.26 , 20.64 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{22}H_{17}O_2Se$ 393.0388 found 393.0383.



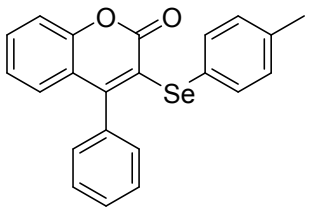
8-methyl-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one **(4t)**. Yellow solid (75%, 0.147g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.35 (dd, *J* = 5.0, 1.8 Hz, 3H), 7.30 – 7.21 (m, 3H), 7.11 – 7.02 (m, 5H), 6.94 (t, *J* = 7.7 Hz, 1H), 6.82 – 6.77 (m, 1H), 2.40 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.56 , 158.40 , 150.81 , 135.56 , 132.30 , 131.78 , 129.41 , 127.97 , 127.72 , 127.38 , 127.21 , 126.32 , 125.19 , 124.71 , 122.69 , 119.29 , 119.24 , 14.56 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{22}H_{17}O_2Se$ 393.0388 found 393.0382.



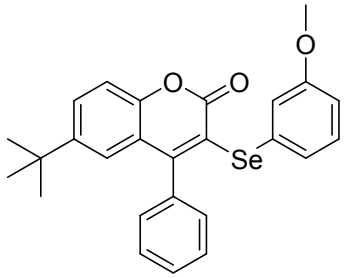
3-(methylselanyl)-4-phenyl-2H-chromen-2-one **(4u)**. Yellow solid (80%, 0.126g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.48 – 7.37 (m, 4H), 7.27 (dd, *J* = 8.3, 1.0 Hz, 1H), 7.20 – 7.16 (m, 2H), 7.05 (td, *J* = 7.7, 7.3, 1.2 Hz, 1H), 6.95 (dd, *J* = 8.0, 1.5 Hz, 1H), 2.15 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.33 , 154.89 , 151.90 , 135.29 , 130.23 , 128.04 , 127.68 , 127.26 , 126.20 , 123.18 , 119.43 , 119.14 , 115.58 , 7.37 . HRMS (TOF) m/z $[M + H]^+$ Calcd for $C_{16}H_{13}O_2Se$ 317.0075 found 317.0078.



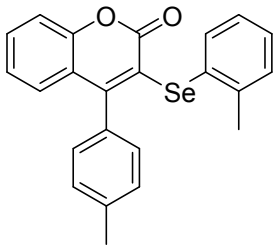
3-(ethylselanyl)-4-phenyl-2H-chromen-2-one **(4v)**. Yellow solid (78%, 0.128g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.50 – 7.39 (m, 4H), 7.30 (dd, *J* = 8.3, 1.0 Hz, 1H), 7.20 – 7.15 (m, 2H), 7.07 (ddd, *J* = 8.3, 7.3, 1.2 Hz, 1H), 6.95 (dd, *J* = 8.0, 1.5 Hz, 1H), 2.90 (q, *J* = 7.5 Hz, 2H), 1.21 (t, *J* = 7.5 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.53 , 156.08 , 152.04 , 135.57 , 130.29 , 127.92 , 127.63 , 127.31 , 126.36 , 123.18 , 119.55 , 118.30 , 115.62 , 20.45 , 14.65 . HRMS (TOF) m/z $[M + H]^+$ Calcd for $C_{17}H_{15}O_2Se$ 331.0232 found 331.0235.



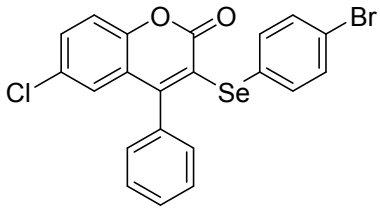
4-phenyl-3-(p-tolylselanyl)-2H-chromen-2-one **(4w)**. Yellow solid (81%, 0.158g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.41 – 7.33 (m, 4H), 7.24 (dd, *J* = 8.3, 1.0 Hz, 1H), 7.15 – 7.12 (m, 2H), 7.09 – 7.05 (m, 2H), 7.02 (td, *J* = 7.7, 7.2, 1.2 Hz, 1H), 6.94 (dd, *J* = 8.0, 1.5 Hz, 1H), 6.86 (d, *J* = 7.9 Hz, 2H), 2.16 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.44 , 157.45 , 152.37 , 136.50 , 132.30 , 130.82 , 128.79 , 127.79 , 127.43 , 127.26 , 126.81 , 125.37 , 123.17 , 120.06 , 119.50 , 115.68 , 20.09 . HRMS (TOF) m/z $[M + H]^+$ Calcd for $C_{22}H_{17}O_2Se$ 393.0388 found 393.0387.



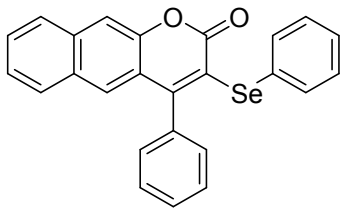
6-(tert-butyl)-3-((3-methoxyphenyl)selanyl)-4-phenyl-2H-chromen-2-one **(4x)**. Yellow solid (80%, 0.185g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.50 (dd, *J* = 8.7, 2.3 Hz, 1H), 7.38 (dd, *J* = 5.0, 1.7 Hz, 3H), 7.25 (d, *J* = 8.7 Hz, 1H), 7.11 (dd, *J* = 6.5, 3.1 Hz, 2H), 6.98 (t, *J* = 8.0 Hz, 1H), 6.95 (d, *J* = 2.3 Hz, 1H), 6.81 (dt, *J* = 7.7, 1.1 Hz, 1H), 6.76 (dd, *J* = 2.4, 1.6 Hz, 1H), 6.64 (ddd, *J* = 8.3, 2.5, 0.8 Hz, 1H), 3.65 (s, 3H), 1.11 (s, 9H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.87 , 158.67 , 158.57 , 150.56 , 146.32 , 135.24 , 130.48 , 128.72 , 128.70 , 127.80 , 127.31 , 127.25 , 123.76 , 123.13 , 119.15 , 118.80 , 116.83 , 115.32 , 112.18 , 54.21 , 33.52 , 30.14 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{26}H_{25}O_3Se$ 465.0963 found 465.0960.



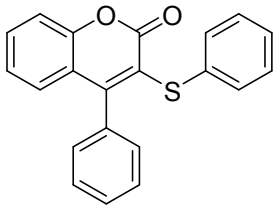
4-(p-tolyl)-3-(o-tolylselanyl)-2H-chromen-2-one **(4y)**. Yellow solid (84%, 0.170g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.42 (ddd, *J* = 8.6, 7.0, 1.8 Hz, 1H), 7.30 – 7.27 (m, 1H), 7.12 (t, *J* = 8.7 Hz, 3H), 7.09 – 6.95 (m, 6H), 6.86 (td, *J* = 7.0, 6.6, 2.4 Hz, 1H), 2.33 (s, 3H), 2.18 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.31 , 157.89 , 152.37 , 138.24 , 137.80 , 132.09 , 131.69 , 130.77 , 130.42 , 128.91 , 128.06 , 126.98 , 126.80 , 126.41 , 125.35 , 123.14 , 119.60 , 119.42 , 115.73 , 21.29 , 20.38 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{23}H_{19}O_2Se$ 407.0545 found 407.0549.



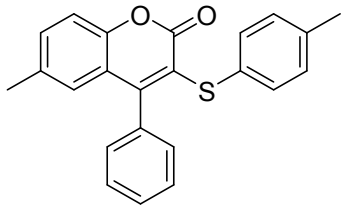
3-((4-bromophenyl)selanyl)-6-chloro-4-phenyl-2H-chromen-2-one **(4z)**. Yellow solid (78%, 0.191g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.43 – 7.37 (m, 4H), 7.24 (d, *J* = 8.8 Hz, 1H), 7.18 (d, *J* = 2.3 Hz, 2H), 7.12 – 7.05 (m, 4H), 6.93 (d, *J* = 2.4 Hz, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 157.75 , 156.17 , 150.72 , 134.32 , 133.99 , 131.13 , 130.94 , 128.78 , 128.32 , 127.81 , 127.42 , 127.09 , 125.94 , 121.21 , 121.16 , 120.46 , 117.25 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{21}H_{13}BrClO_2Se$ 490.8947 found 490.8945.



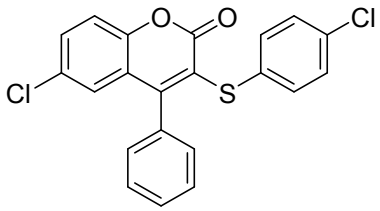
4-phenyl-3-(phenylselanyl)-2H-benzo[g]chromen-2-one **(4za)**. Yellow solid (75%, 0.160g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.92 (d, *J* = 8.9 Hz, 1H), 7.75 (dd, *J* = 8.0, 1.1 Hz, 1H), 7.50 – 7.41 (m, 4H), 7.33 – 7.27 (m, 3H), 7.18 – 7.15 (m, 2H), 7.12 (dd, *J* = 5.1, 1.9 Hz, 3H), 7.02 (ddd, *J* = 8.5, 6.9, 1.5 Hz, 1H), 6.91 (d, *J* = 8.9 Hz, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.04 , 157.91 , 153.28 , 139.58 , 133.41 , 131.41 , 130.45 , 129.71 , 128.53 , 128.19 , 128.04 , 126.89 , 126.36 , 126.13 , 124.55 , 124.32 , 116.26 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{25}H_{17}O_2Se$ 429.0388 found 429.0385.



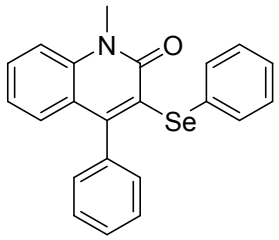
4-phenyl-3-(phenylthio)-2H-chromen-2-one **(5a)**. Yellow solid (53%, 0.088g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.47 (ddd, *J* = 8.7, 7.2, 1.6 Hz, 1H), 7.44 – 7.40 (m, 3H), 7.34 – 7.31 (m, 1H), 7.18 (d, *J* = 1.7 Hz, 3H), 7.14 – 7.09 (m, 5H), 7.03 (dd, *J* = 8.0, 1.5 Hz, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.19 , 157.94 , 152.36 , 133.90 , 133.85 , 131.18 , 128.30 , 128.02 , 127.93 , 127.52 , 127.28 , 127.15 , 125.70 , 123.32 , 120.84 , 119.49 , 115.85 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{21}H_{15}O_2S$ 331.0787 found 331.0789.



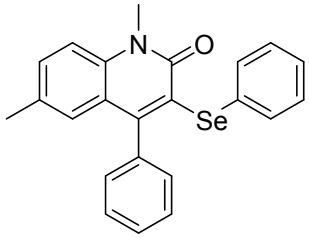
6-methyl-4-phenyl-3-(p-tolylthio)-2H-chromen-2-one **(5b)**. Yellow solid (55%, 0.098g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.45 – 7.40 (m, 3H), 7.25 (dd, *J* = 8.4, 1.7 Hz, 1H), 7.20 – 7.14 (m, 3H), 7.05 – 7.01 (m, 2H), 6.93 (d, *J* = 8.0 Hz, 2H), 6.76 (s, 1H), 2.20 (s, 6H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.39 , 157.42 , 150.47 , 135.77 , 134.09 , 133.00 , 132.07 , 130.26 , 128.78 , 128.68 , 127.88 , 127.47 , 127.33 , 126.70 , 121.22 , 119.22 , 115.56 , 20.03 , 19.88 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{23}H_{19}O_2S$ 359.1100 found 359.1108.



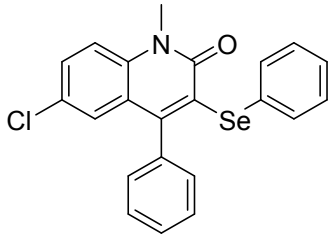
6-chloro-3-((4-chlorophenyl)thio)-4-phenyl-2H-chromen-2-one **(5c)**. Yellow solid (56%, 0.112g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.46 – 7.42 (m, 3H), 7.39 (dd, *J* = 8.8, 2.5 Hz, 1H), 7.24 (d, *J* = 8.8 Hz, 1H), 7.17 – 7.13 (m, 2H), 7.10 – 7.03 (m, 4H), 6.96 (d, *J* = 2.4 Hz, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 157.35 , 156.17 , 150.62 , 133.04 , 132.26 , 131.68 , 131.13 , 130.36 , 128.88 , 128.47 , 128.12 , 127.84 , 127.18 , 126.21 , 122.29 , 120.49 , 117.30 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{21}H_{13}Cl_2O_2S$ 399.0008 found 399.0004.



1-methyl-4-phenyl-3-(phenylselanyl)quinolin-2(1H)-one **(7a)**. Yellow solid (85%, 0.166g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.44 (ddd, *J* = 8.6, 7.1, 1.6 Hz, 1H), 7.31 – 7.26 (m, 4H), 7.19 – 7.14 (m, 2H), 7.07 – 6.95 (m, 7H), 3.71 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.49 , 153.96 , 138.80 , 136.95 , 131.10 , 130.69 , 129.83 , 127.75 , 127.63 , 127.19 , 127.00 , 125.62 , 125.10 , 120.99 , 120.41 , 113.14 , 29.82 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{22}H_{18}NOSe$ 392.0548 found 392.0549.

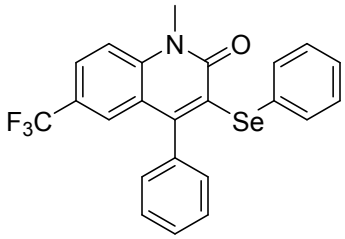


1,6-dimethyl-4-phenyl-3-(phenylselanyl)quinolin-2(1H)-one **(7b)**. Yellow solid (86%, 0.174g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.33 – 7.26 (m, 4H), 7.21 (d, *J* = 8.6 Hz, 1H), 7.19 – 7.16 (m, 2H), 7.06 – 6.97 (m, 5H), 6.83 (s, 1H), 3.71 (s, 3H), 2.17 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.42 , 153.84 , 137.14 , 136.97 , 131.07 , 130.90 , 130.54 , 127.74 , 127.67 , 127.30 , 127.19 , 126.97 , 125.56 , 125.13 , 120.37 , 113.09 , 29.83 , 19.69 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{23}H_{20}NOSe$ 406.0705 found 406.0709.

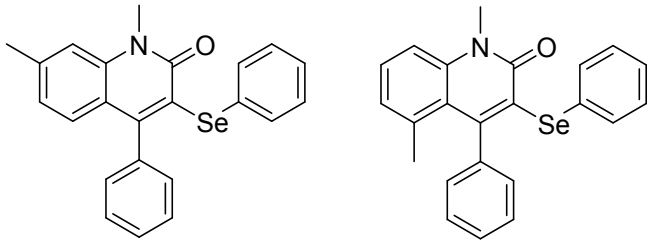


6-chloro-1-methyl-4-phenyl-3-(phenylselanyl)quinolin-2(1H)-one **(7c)**. Yellow solid (81%, 0.172g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.39 (dd, *J* = 9.0, 2.4 Hz, 1H), 7.30 (dd, *J* = 5.0, 1.8 Hz, 3H), 7.24 (d, *J* = 9.0 Hz, 1H), 7.17 (dt, *J* = 6.6, 1.5 Hz, 2H), 7.07 – 6.97 (m, 6H), 3.69 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.17 , 152.27 , 137.26 , 136.18 , 131.57 , 130.20 , 129.61 , 127.80 , 127.59 , 127.45 , 127.33 , 127.10 , 126.58 , 126.49 , 125.89 , 121.53 , 114.61 , 29.98 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for

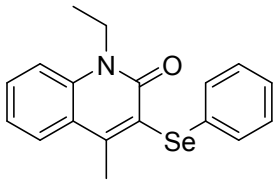
$C_{22}H_{17}ClNOSe$ 426.0158 found 426.0152.



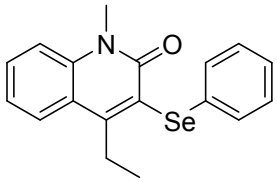
1-methyl-4-phenyl-3-(phenylselanyl)-6-(trifluoromethyl)quinolin-2(1H)-one **(7d)**. Yellow solid (79%, 0.181g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.68 (dd, *J* = 8.9, 1.8 Hz, 1H), 7.41 (d, *J* = 8.9 Hz, 1H), 7.33 (dd, *J* = 5.0, 1.9 Hz, 4H), 7.21 – 7.16 (m, 2H), 7.10 – 6.99 (m, 5H), 3.75 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.44 , 152.85 , 140.67 , 135.89 , 131.71 , 130.02 , 127.86 , 127.61 , 127.54 , 127.47 , 126.03 , 125.92 (q, *J* = 3 Hz), 124.70 (q, *J* = 3 Hz) , 124.13 , 123.22 (q, *J* = 33 Hz), 121.43 , 120.19 , 113.74 , 30.06 . ^{19}F NMR (376 MHz, Chloroform-*d*) δ -61.89 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{23}H_{17}F_3NOSe$ 460.0422 found 460.0428.



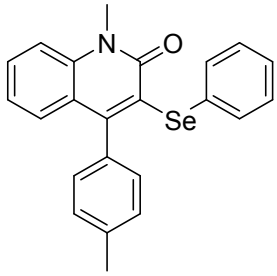
1,7-dimethyl-4-phenyl-3-(phenylselanyl)quinolin-2(1H)-one **(7e1)**, 1,5-dimethyl-4-phenyl-3-(phenylselanyl)quinolin-2(1H)-one **(7e2)**. Yellow solid (82%, 0.166g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.36 – 7.15 (m, 6H), 7.10 – 6.91 (m, 6H), 6.83 (dd, *J* = 18.8, 8.2 Hz, 1H), 3.71 (s, 2H), 3.69 (s, 1H), 2.39 (s, 2H), 1.67 (s, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.72 , 158.78 , 154.31 , 154.23 , 141.37 , 140.72 , 140.13 , 139.02 , 137.28 , 137.18 , 131.52 , 130.99 , 130.91 , 130.38 , 129.34 , 127.76 , 127.73 , 127.64 , 127.61 , 127.13 , 127.00 , 126.95 , 126.59 , 125.96 , 125.50 , 125.45 , 123.54 , 122.35 , 118.68 , 118.33 , 113.36 , 112.16 , 30.77 , 29.79 , 23.61 , 21.08 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{23}H_{20}NOSe$ 406.0705 found 406.0700.



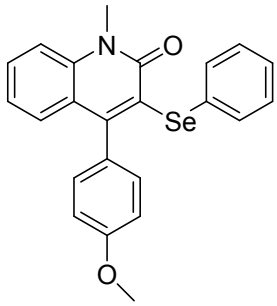
1-ethyl-4-methyl-3-(phenylselanyl)quinolin-2(1H)-one (**7g**). Yellow solid (80%, 0.137g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.77 (dd, *J* = 8.1, 1.4 Hz, 1H), 7.57 (ddd, *J* = 8.6, 7.2, 1.5 Hz, 1H), 7.42 – 7.36 (m, 3H), 7.26 – 7.14 (m, 4H), 4.39 (q, *J* = 7.1 Hz, 2H), 2.70 (s, 3H), 1.35 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 160.04 , 150.96 , 138.47 , 132.14 , 130.95 , 130.89 , 129.14 , 126.50 , 126.42 , 122.00 , 121.38 , 114.31 , 38.54 , 21.06 , 12.77 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{18}H_{18}NOSe$ 344.0548 found 344.0549.



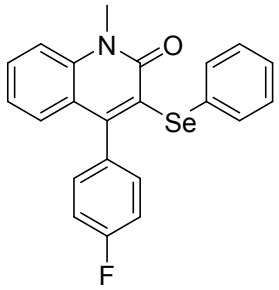
4-ethyl-1-methyl-3-(phenylselanyl)quinolin-2(1H)-one (**7h**). Yellow solid (82%, 0.140g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.76 (dd, *J* = 8.2, 1.2 Hz, 1H), 7.50 (ddd, *J* = 8.5, 7.2, 1.4 Hz, 1H), 7.36 – 7.26 (m, 3H), 7.21 – 7.16 (m, 1H), 7.13 – 7.04 (m, 3H), 3.65 (s, 3H), 3.29 (q, *J* = 7.6 Hz, 2H), 1.15 (t, *J* = 7.6 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.50 , 156.56 , 139.21 , 131.04 , 129.97 , 129.67 , 128.05 , 125.43 , 125.22 , 123.56 , 121.18 , 118.58 , 113.67 , 29.82 , 26.48 , 13.44 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{18}H_{18}NOSe$ 344.0548 found 344.0544.



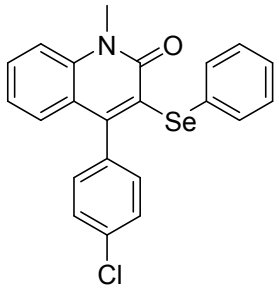
1-methyl-3-(phenylselanyl)-4-(p-tolyl)quinolin-2(1H)-one **(7i)**. Yellow solid (84%, 0.170g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.42 (ddd, *J* = 8.5, 7.2, 1.5 Hz, 1H), 7.27 (d, *J* = 8.3 Hz, 1H), 7.18 (dd, *J* = 7.5, 1.9 Hz, 2H), 7.11 – 7.06 (m, 3H), 7.02 – 6.90 (m, 6H), 3.68 (s, 3H), 2.30 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.49 , 154.13 , 138.79 , 136.79 , 134.07 , 131.05 , 130.77 , 129.76 , 127.88 , 127.75 , 127.67 , 127.57 , 125.56 , 125.06 , 120.95 , 120.57 , 113.10 , 29.78 , 20.35 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{23}H_{20}NOSe$ 406.0705 found 406.0708.



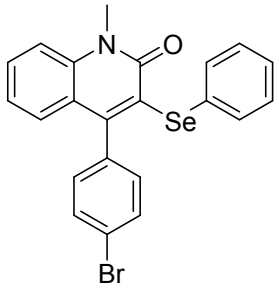
4-(4-methoxyphenyl)-1-methyl-3-(phenylselanyl)quinolin-2(1H)-one **(7j)**. Yellow solid (80%, 0.168g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.45 (ddd, *J* = 8.6, 7.1, 1.5 Hz, 1H), 7.30 (d, *J* = 8.1 Hz, 1H), 7.16 (ddd, *J* = 18.3, 7.7, 1.5 Hz, 3H), 7.04 – 6.94 (m, 6H), 6.83 – 6.79 (m, 2H), 3.76 (s, 3H), 3.71 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.57 , 158.30 , 153.64 , 138.80 , 131.15 , 130.83 , 129.73 , 129.28 , 129.04 , 127.70 , 125.61 , 120.95 , 120.78 , 113.12 , 112.62 , 54.25 , 29.78 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{23}H_{20}NO_2Se$ 422.0654 found 422.0657.



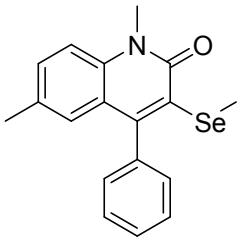
4-(4-fluorophenyl)-1-methyl-3-(phenylselanyl)quinolin-2(1H)-one **(7k)**. Yellow solid (78%, 0.159g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.49 (ddd, *J* = 8.6, 6.6, 2.1 Hz, 1H), 7.34 (d, *J* = 8.5 Hz, 1H), 7.16 (dd, *J* = 8.1, 1.4 Hz, 2H), 7.09 – 6.93 (m, 9H), 3.75 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 161.34 (d, *J* = 246 Hz) , 159.55 , 152.47 , 138.75 , 132.68 (d, *J* = 4 Hz) , 131.48 , 130.50 , 129.86 , 129.58 (d, *J* = 8 Hz) , 127.80 , 127.25 , 126.14 , 125.84 , 121.10 , 120.50 , 114.28 (d, *J* = 22 Hz) , 113.25 , 29.84 . ^{19}F NMR (376 MHz, Chloroform-*d*) δ -113.39 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{22}H_{17}FNOSe$ 410.0454 found 410.0455.



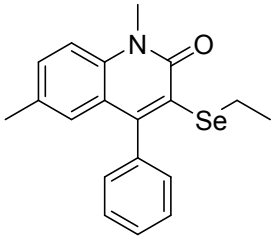
4-(4-chlorophenyl)-1-methyl-3-(phenylselanyl)quinolin-2(1H)-one **(7l)**. Yellow solid (82%, 0.174g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.49 (ddd, *J* = 8.6, 6.0, 2.6 Hz, 1H), 7.34 (d, *J* = 8.5 Hz, 1H), 7.26 – 7.21 (m, 2H), 7.18 – 7.13 (m, 2H), 7.10 – 6.99 (m, 5H), 6.97 – 6.93 (m, 2H), 3.76 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.51 , 152.06 , 138.73 , 135.07 , 133.02 , 131.65 , 130.36 , 129.87 , 129.19 , 127.80 , 127.46 , 127.11 , 126.06 , 125.90 , 121.12 , 120.27 , 113.27 , 29.84 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{22}H_{17}ClNOSe$ 426.0158 found 426.0162.



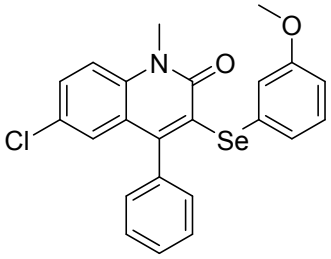
4-(4-bromophenyl)-1-methyl-3-(phenylselanyl)quinolin-2(1H)-one **(7m)**. Yellow solid (83%, 0.195g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.49 (ddd, *J* = 8.6, 6.0, 2.6 Hz, 1H), 7.40 – 7.36 (m, 2H), 7.34 (d, *J* = 8.5 Hz, 1H), 7.17 – 7.13 (m, 2H), 7.10 – 6.99 (m, 5H), 6.91 – 6.86 (m, 2H), 3.75 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.50 , 151.97 , 138.72 , 135.53 , 131.71 , 130.40 , 130.33 , 129.87 , 129.47 , 127.81 , 127.08 , 126.03 , 125.91 , 121.24 , 121.13 , 120.19 , 113.27 , 29.83 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{22}H_{17}BrNOSe$ 469.9653 found 469.9657.



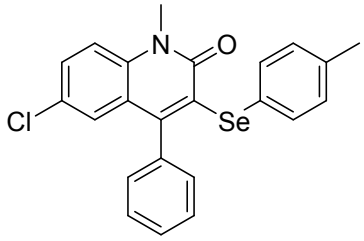
1,6-dimethyl-3-(methylselanyl)-4-phenylquinolin-2(1H)-one **(7n)**. Yellow solid (84%, 0.144g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.45 – 7.38 (m, 3H), 7.25 (dd, *J* = 8.6, 1.6 Hz, 1H), 7.21 – 7.14 (m, 3H), 6.80 (s, 1H), 3.72 (s, 3H), 2.17 (s, 3H), 2.06 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.53 , 150.74 , 137.26 , 136.25 , 130.47 , 130.31 , 127.87 , 127.43 , 127.19 , 126.60 , 124.61 , 120.35 , 112.99 , 29.49 , 19.73 , 7.18 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{18}H_{18}NOSe$ 344.0548 found 344.0545.



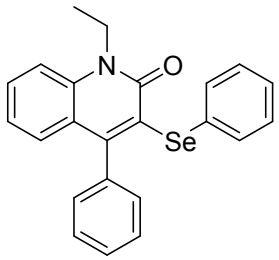
3-(ethylselanyl)-1,6-dimethyl-4-phenylquinolin-2(1H)-one (**7o**). Yellow solid (80%, 0.143g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.43 (dtd, *J* = 6.8, 5.4, 2.1 Hz, 3H), 7.28 (dd, *J* = 8.6, 1.7 Hz, 1H), 7.23 (d, *J* = 8.6 Hz, 1H), 7.16 – 7.13 (m, 2H), 6.81 (s, 1H), 3.75 (s, 3H), 2.84 (q, *J* = 7.5 Hz, 2H), 2.19 (s, 3H), 1.17 (t, *J* = 7.5 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 160.75 , 153.10 , 138.66 , 137.46 , 131.51 , 131.42 , 128.93 , 128.42 , 128.12 , 127.89 , 124.64 , 121.49 , 114.04 , 30.61 , 21.10 , 20.76 , 15.79 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{19}H_{20}NOSe$ 358.0705 found 358.0706.



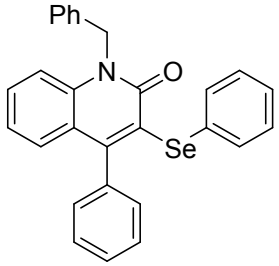
6-chloro-3-((3-methoxyphenyl)selanyl)-1-methyl-4-phenylquinolin-2(1H)-one **(7p)**. Yellow solid (73%, 0.166g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.42 (dd, *J* = 9.0, 2.4 Hz, 1H), 7.32 (dd, *J* = 5.0, 2.0 Hz, 3H), 7.27 (d, *J* = 9.0 Hz, 1H), 7.05 – 7.00 (m, 3H), 6.97 – 6.92 (m, 1H), 6.77 (dt, *J* = 7.7, 1.2 Hz, 1H), 6.69 (dd, *J* = 2.4, 1.6 Hz, 1H), 6.61 (ddd, *J* = 8.3, 2.5, 0.8 Hz, 1H), 3.73 (s, 3H), 3.63 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.40 , 129.66 , 128.53 , 127.64 , 127.41 , 127.29 , 126.52 , 123.80 , 121.58 , 116.81 , 114.60 , 111.74 , 54.13 , 30.00 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{23}H_{19}ClNO_2Se$ 456.0264 found 456.0269.



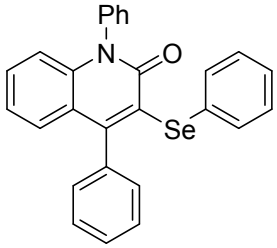
6-chloro-1-methyl-4-phenyl-3-(p-tolylselanyl)quinolin-2(1H)-one **(7q)**. Yellow solid (81%, 0.178g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.40 (dd, *J* = 9.0, 2.4 Hz, 1H), 7.33 (dd, *J* = 5.0, 1.9 Hz, 3H), 7.24 (d, *J* = 9.0 Hz, 1H), 7.10 (d, *J* = 8.1 Hz, 2H), 7.06 – 6.99 (m, 3H), 6.84 (d, *J* = 7.9 Hz, 2H), 3.70 (s, 3H), 2.18 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.23 , 151.89 , 137.21 , 136.29 , 135.94 , 132.00 , 129.49 , 128.65 , 127.67 , 127.43 , 127.31 , 126.56 , 126.48 , 121.62 , 114.55 , 29.98 , 20.10 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{23}H_{19}ClNOSe$ 440.0315 found 440.0316.



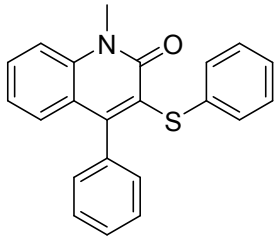
1-ethyl-4-phenyl-3-(phenylselanyl)quinolin-2(1H)-one **(7r)**. Yellow solid (86%, 0.174g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.47 (ddd, *J* = 8.6, 7.1, 1.6 Hz, 1H), 7.37 – 7.29 (m, 4H), 7.19 (dt, *J* = 8.5, 1.8 Hz, 2H), 7.11 – 6.96 (m, 7H), 4.36 (q, *J* = 7.1 Hz, 2H), 1.33 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.93 , 153.74 , 137.85 , 137.08 , 131.21 , 130.71 , 129.73 , 127.92 , 127.74 , 127.69 , 127.23 , 127.01 , 125.63 , 125.40 , 120.76 , 120.44 , 113.00 , 37.67 , 11.65 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{23}H_{20}NOSe$ 406.0705 found 406.0709.



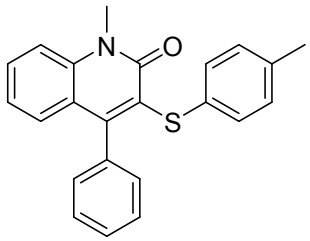
1-benzyl-4-phenyl-3-(phenylselanyl)quinolin-2(1H)-one **(7s)**. Yellow solid (78%, 0.182g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.36 – 7.29 (m, 4H), 7.26 – 7.12 (m, 8H), 7.12 – 7.00 (m, 6H), 6.94 (t, *J* = 7.9 Hz, 1H), 5.54 (s, 2H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.63 , 154.45 , 138.27 , 137.01 , 135.31 , 131.12 , 130.78 , 129.77 , 127.78 , 127.73 , 127.69 , 127.27 , 127.12 , 126.28 , 125.85 , 125.69 , 125.29 , 121.07 , 120.70 , 113.93 , 46.26 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{28}H_{22}NOSe$ 468.0861 found 468.0869.



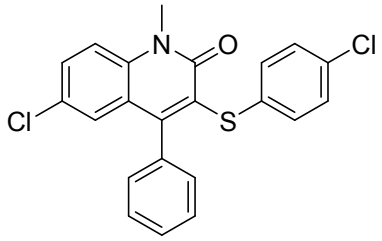
1,4-diphenyl-3-(phenylselanyl)quinolin-2(1H)-one **(7t)**. Yellow solid (76%, 0.172g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.51 (t, *J* = 7.6 Hz, 2H), 7.42 (t, *J* = 7.4 Hz, 1H), 7.37 – 7.32 (m, 3H), 7.26 – 7.22 (m, 4H), 7.17 – 6.94 (m, 8H), 6.62 (d, *J* = 8.4 Hz, 1H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 160.50 , 155.55 , 141.00 , 138.08 , 132.77 , 131.41 , 130.32 , 130.19 , 128.90 , 128.86 , 128.80 , 128.73 , 128.35 , 128.32 , 128.16 , 126.93 , 126.86 , 122.22 , 121.28 , 116.06 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{27}H_{20}NOSe$ 454.0705 found 454.0708.



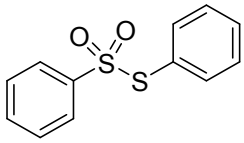
1-methyl-4-phenyl-3-(phenylthio)quinolin-2(1H)-one **(8a)**. Yellow solid (55%, 0.094g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.51 (ddd, *J* = 8.6, 7.1, 1.6 Hz, 1H), 7.40 – 7.34 (m, 4H), 7.16 – 7.11 (m, 3H), 7.10 – 7.01 (m, 6H), 3.73 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.30 , 154.43 , 138.90 , 135.80 , 135.53 , 130.11 , 127.98 , 127.69 , 127.60 , 127.40 , 127.30 , 127.23 , 124.96 , 124.87 , 121.10 , 120.33 , 113.20 , 29.73 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{22}H_{18}NOS$ 344.1104 found 344.1105.



1-methyl-4-phenyl-3-(p-tolylthio)quinolin-2(1H)-one **(8b)**. Yellow solid (57%, 0.102g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.49 (ddd, *J* = 8.6, 7.1, 1.6 Hz, 1H), 7.41 – 7.32 (m, 4H), 7.17 – 7.10 (m, 3H), 7.07 – 6.98 (m, 3H), 6.90 (d, *J* = 8.0 Hz, 2H), 3.72 (s, 3H), 2.18 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 159.29 , 153.86 , 138.81 , 135.90 , 134.85 , 131.74 , 129.94 , 128.51 , 127.90 , 127.68 , 127.29 , 127.18 , 125.50 , 121.05 , 120.37 , 113.16 , 29.69 , 20.02 . HRMS (TOF) m/z [M + H]$^{+}$ Calcd for $C_{23}H_{20}NOS$ 358.1260 found 358.1257.



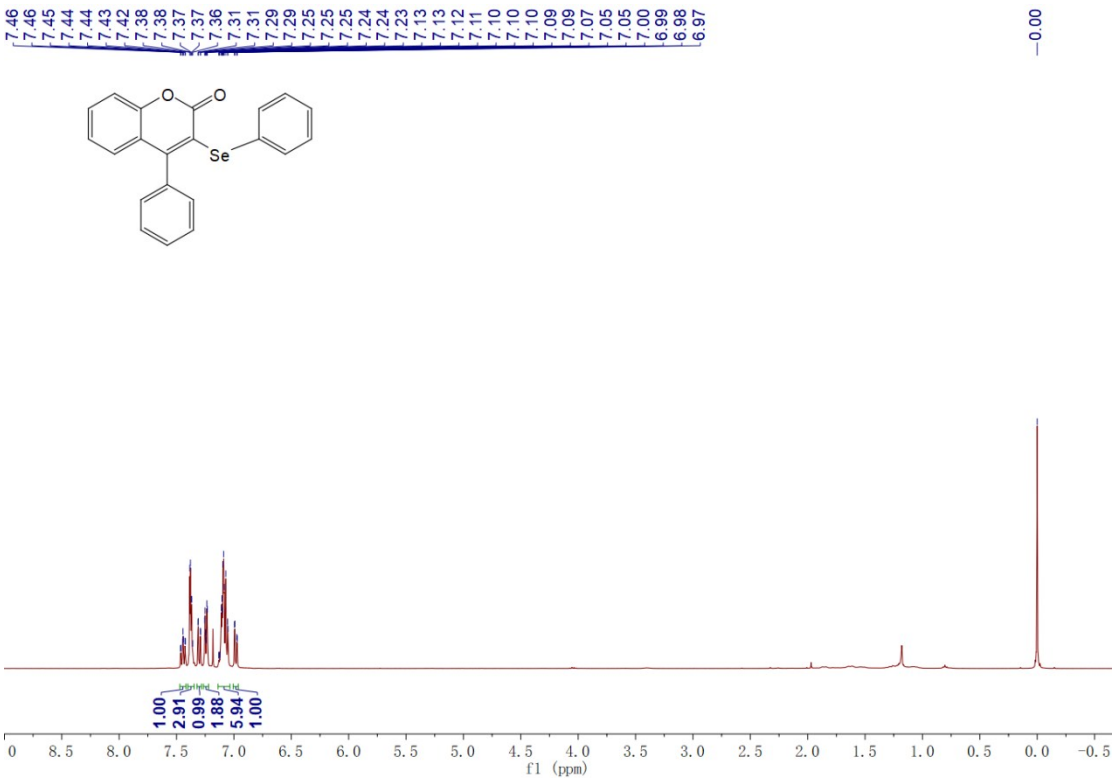
6-chloro-3-((4-chlorophenyl)thio)-1-methyl-4-phenylquinolin-2(1H)-one **(8c)**. Yellow solid (58%, 0.120g). ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.45 (dd, *J* = 9.0, 2.4 Hz, 1H), 7.42 – 7.39 (m, 3H), 7.28 (d, *J* = 9.0 Hz, 1H), 7.13 – 7.09 (m, 2H), 7.07 – 6.99 (m, 5H), 3.70 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 158.78 , 152.92 , 137.35 , 134.96 , 133.47 , 131.25 , 130.14 , 129.30 , 127.89 , 127.71 , 127.63 , 127.51 , 126.90 , 126.53 , 121.35 , 114.72 , 29.91 . HRMS (TOF) m/z $[M + H]^+$ Calcd for $C_{22}H_{16}Cl_2NOS$ 412.0324 found 412.0327.

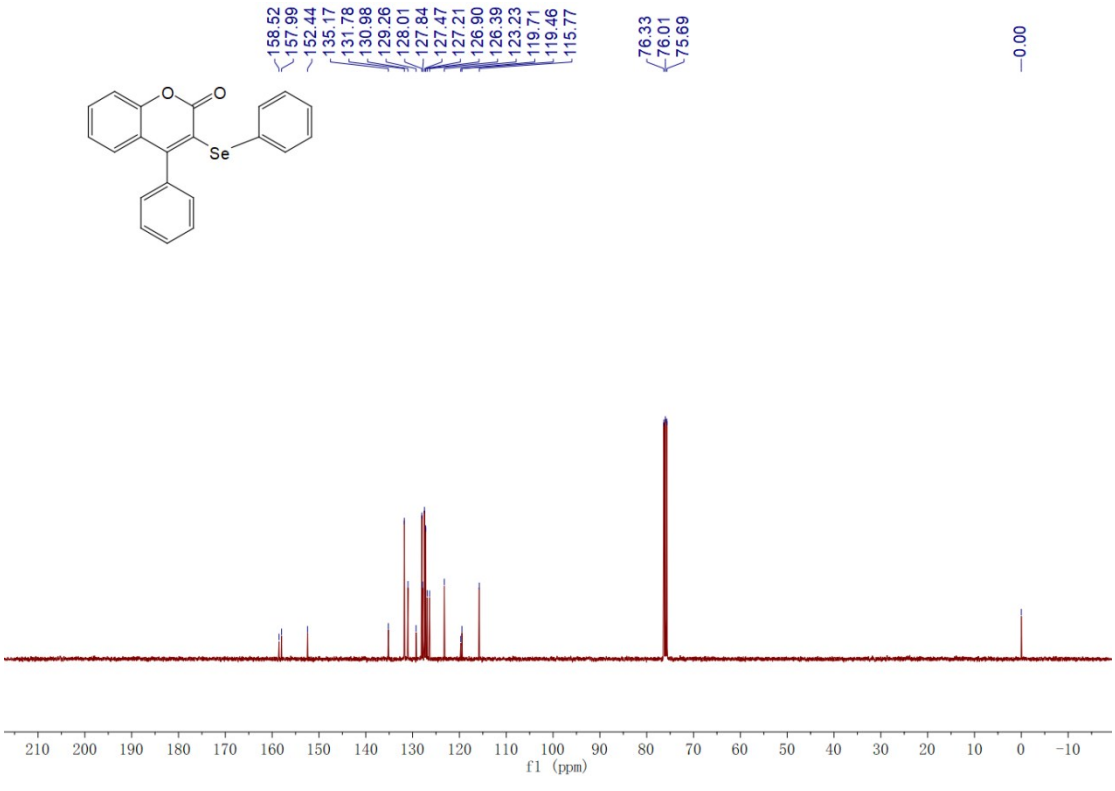


S-phenyl benzenesulfonothioate **(10a)**. Yellow liquid. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.53 – 7.46 (m, 3H), 7.42 – 7.37 (m, 1H), 7.34 (td, *J* = 7.2, 1.9 Hz, 2H), 7.26 (qd, *J* = 6.2, 1.8 Hz, 4H). ^{13}C NMR (101 MHz, Chloroform-*d*) δ 141.88 , 135.56 , 132.63 , 130.41 , 128.42 , 127.78 , 126.78 , 126.52 . HRMS (TOF) m/z $[M + H]^+$ Calcd for $C_{12}H_{11}O_2S_2$ 251.0195 found 251.0199.

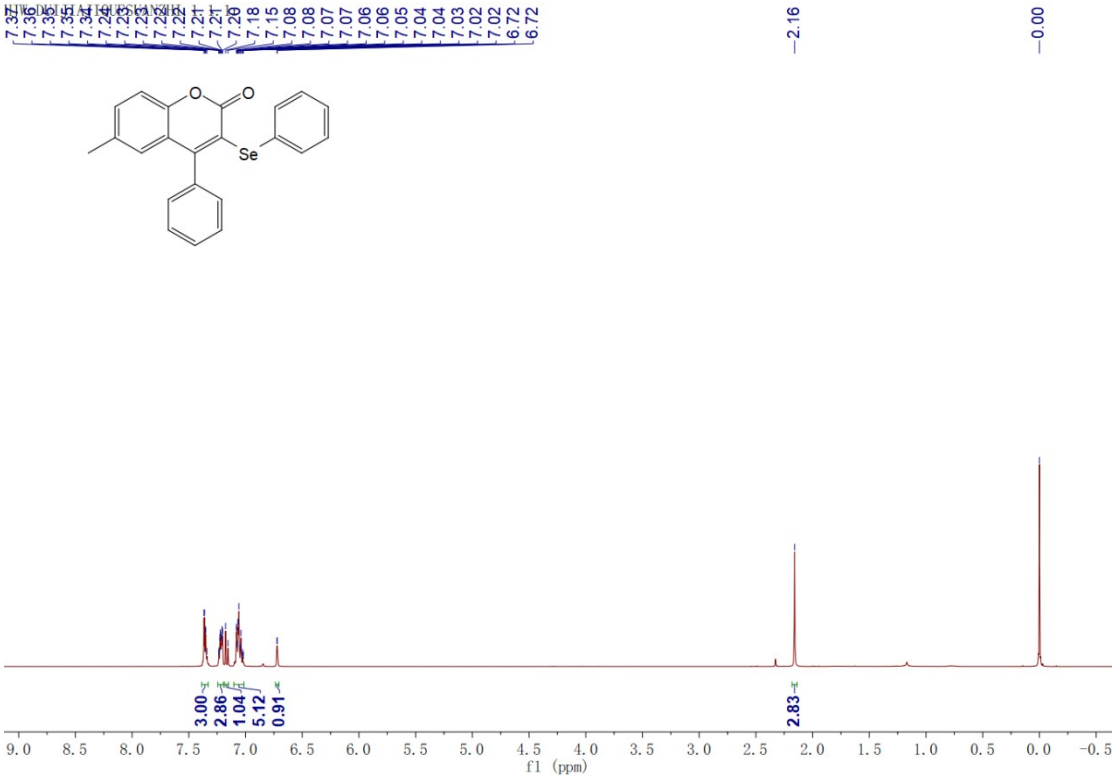
8. ^{1}H NMR, ^{13}C NMR and ^{19}F NMR spectra

Product 4a





Product 4b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7.05
7.04
7.04
7.03
7.02
7.02
6.72
6.72
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O
Se
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1.04
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2.83
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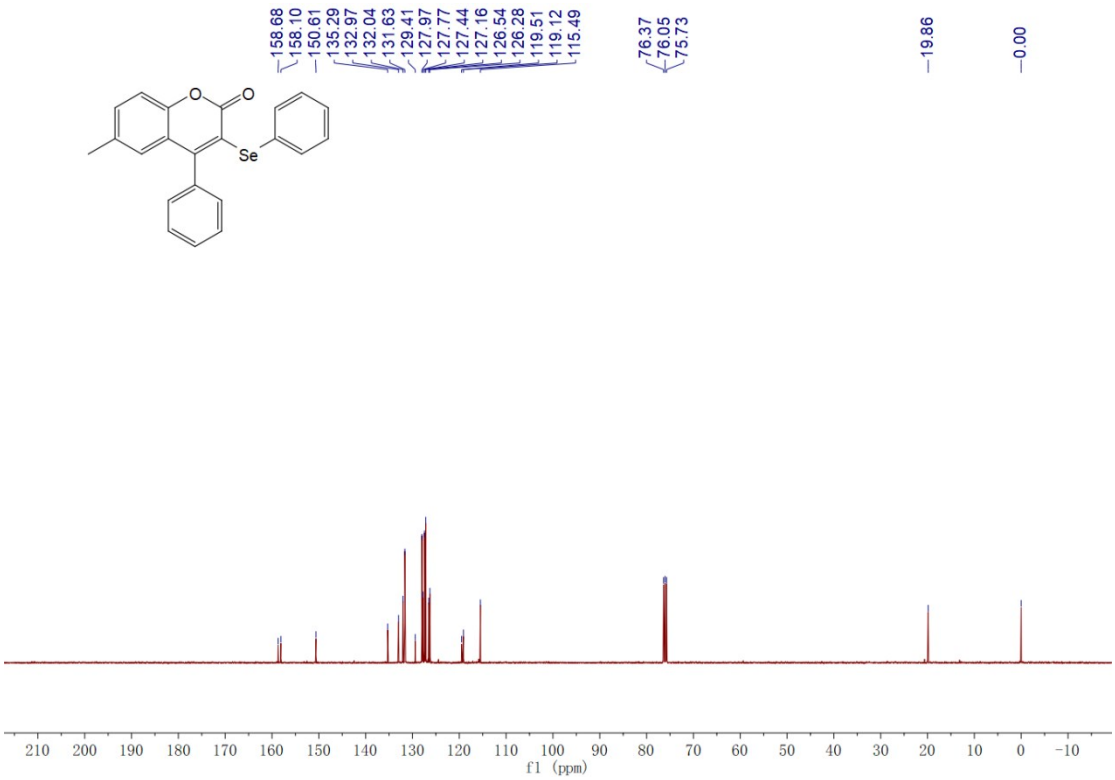
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119.12
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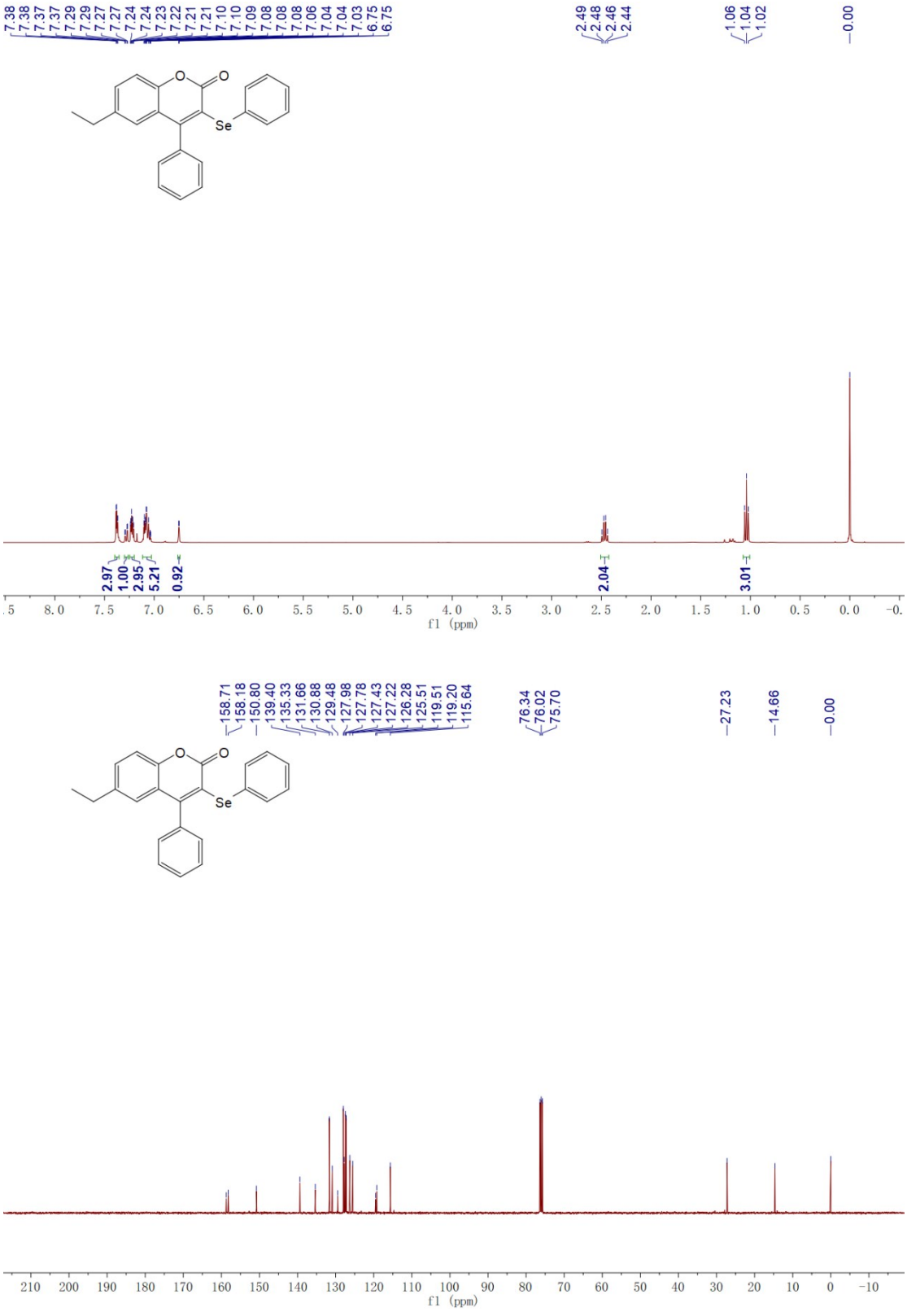
Se
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

Product 4c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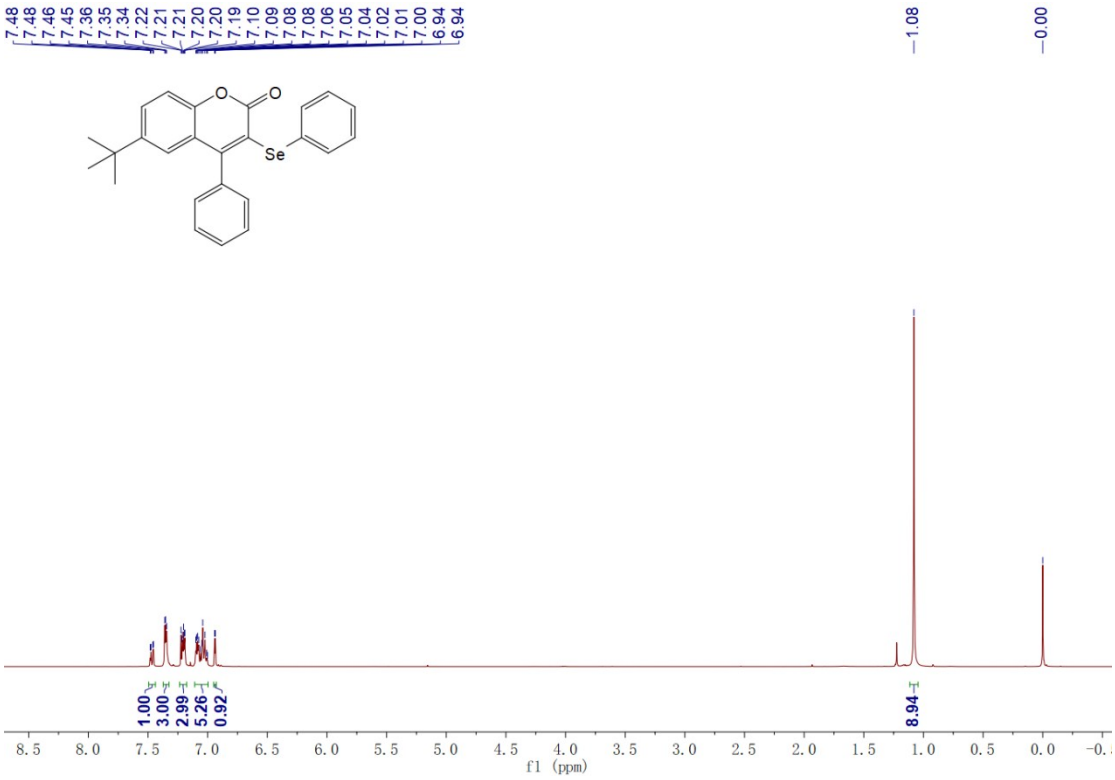
O
Se
f1 (ppm)

Product 4d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7.08
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7.04
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7.01
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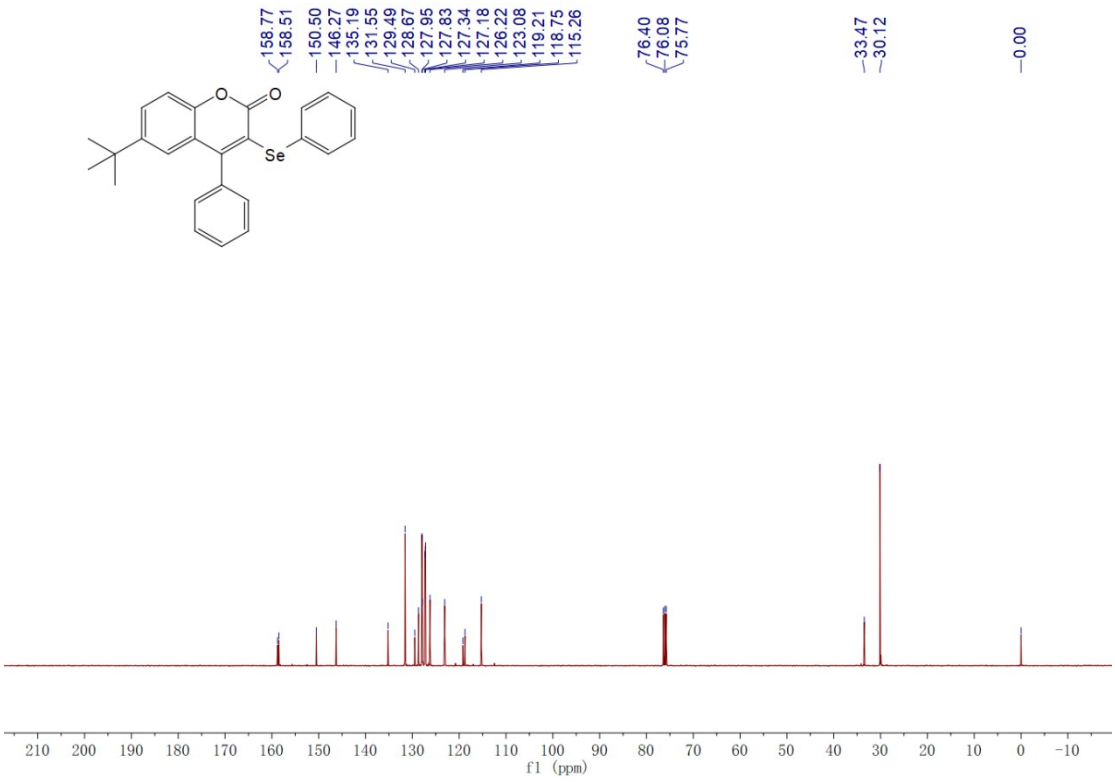
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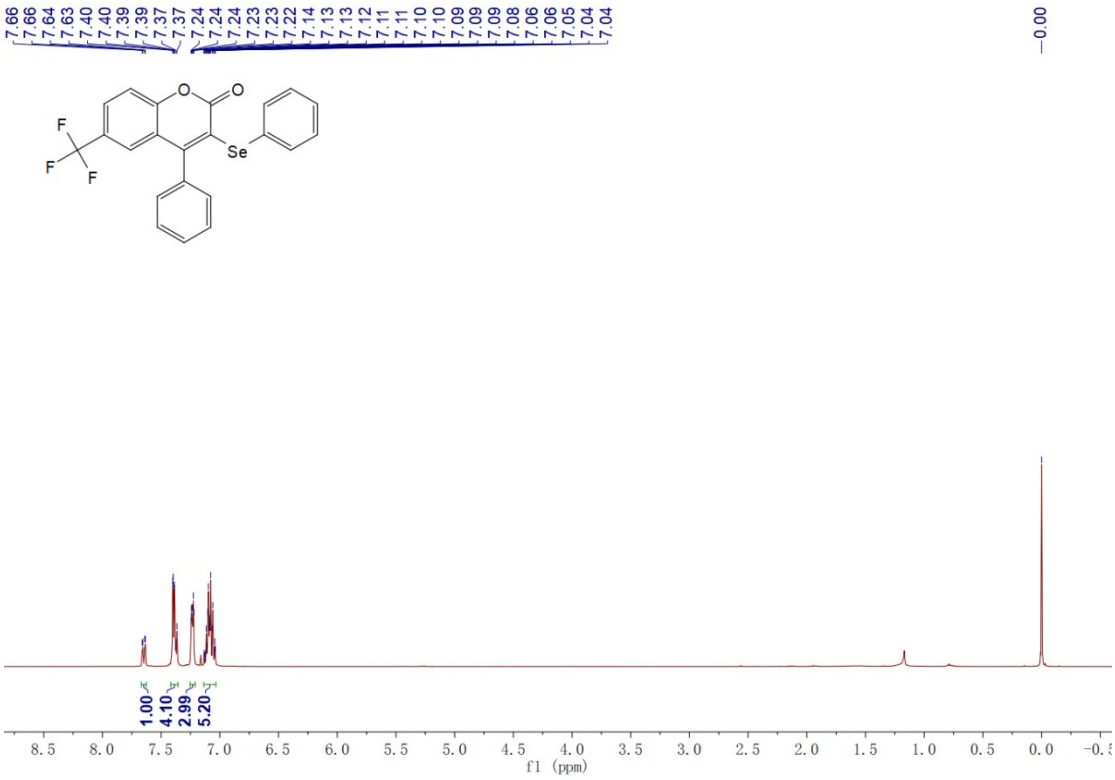
Se
f1 (ppm)

Product 4e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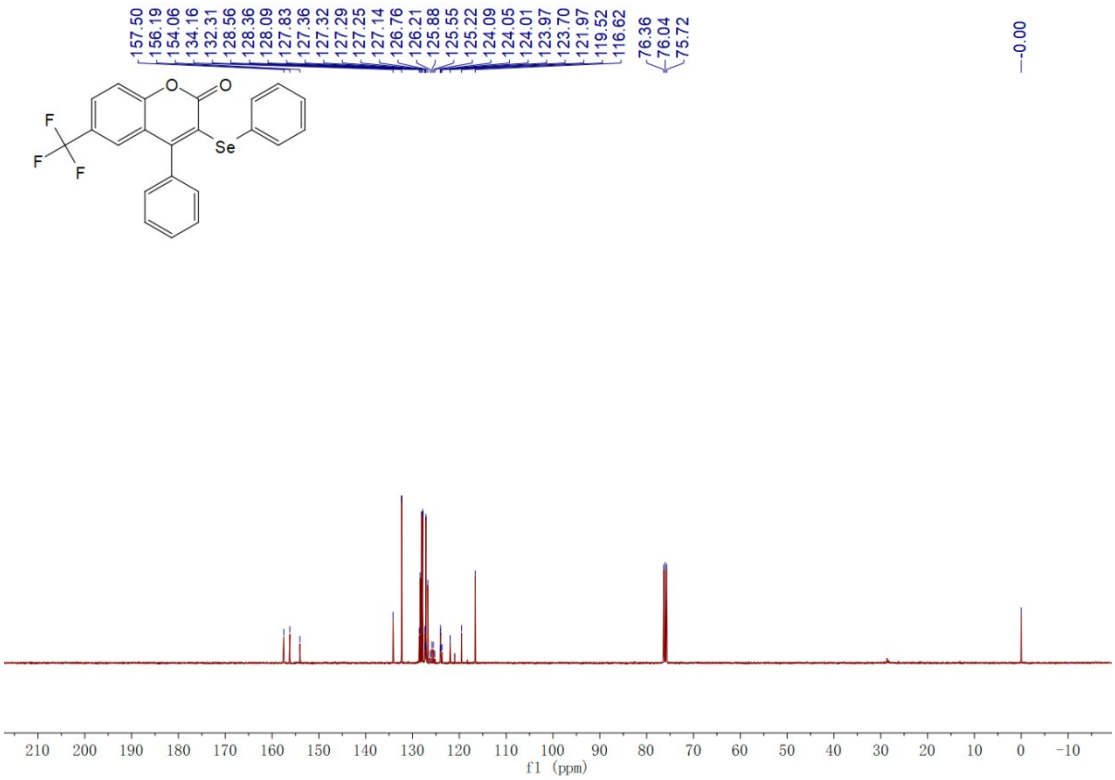
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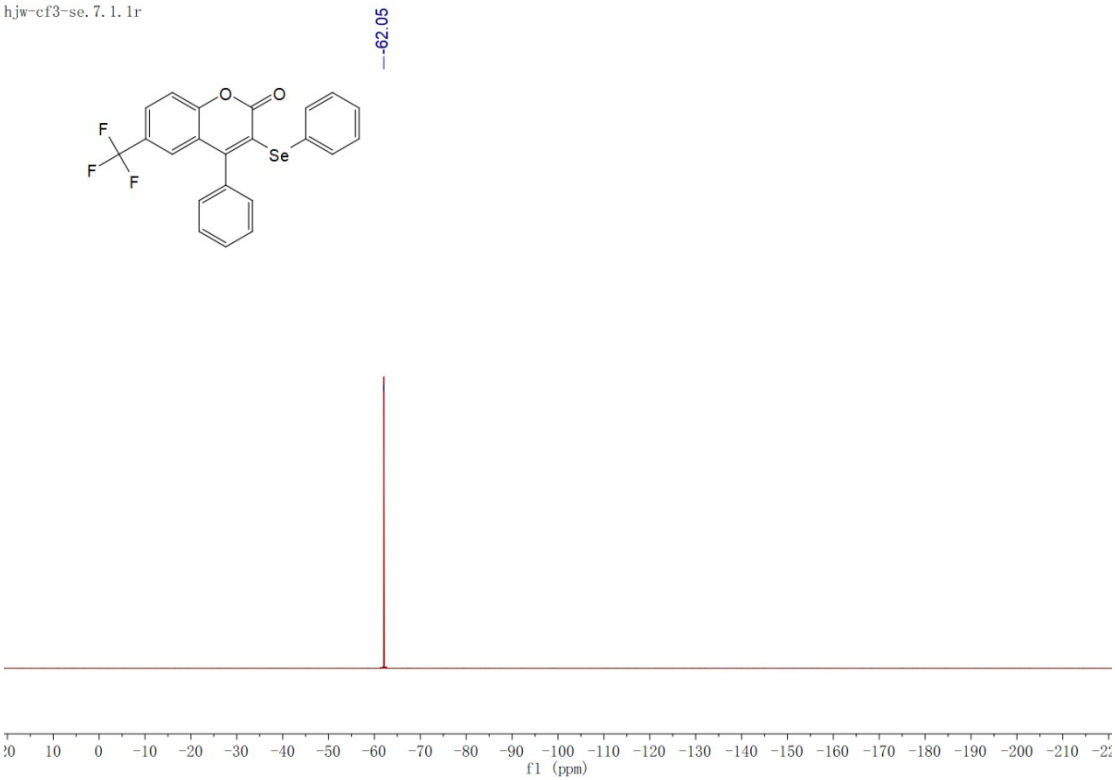
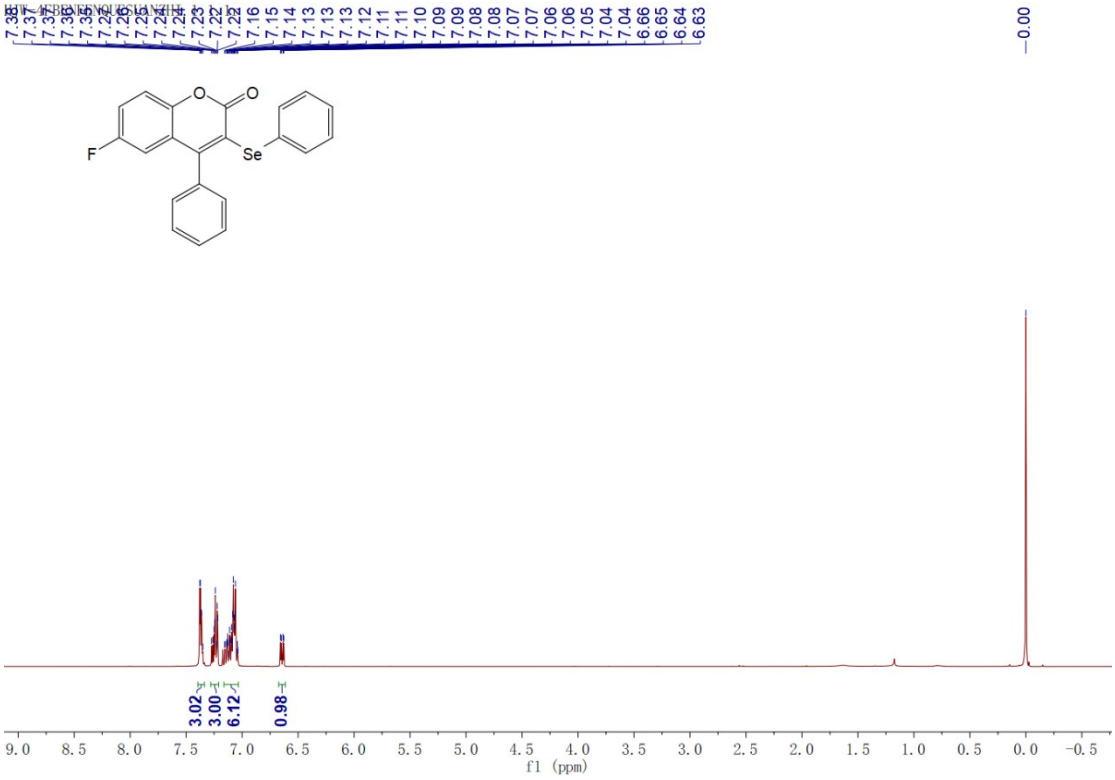
Se
f1 (ppm)

hjw-cf3-se.7.1.1r



Product 4f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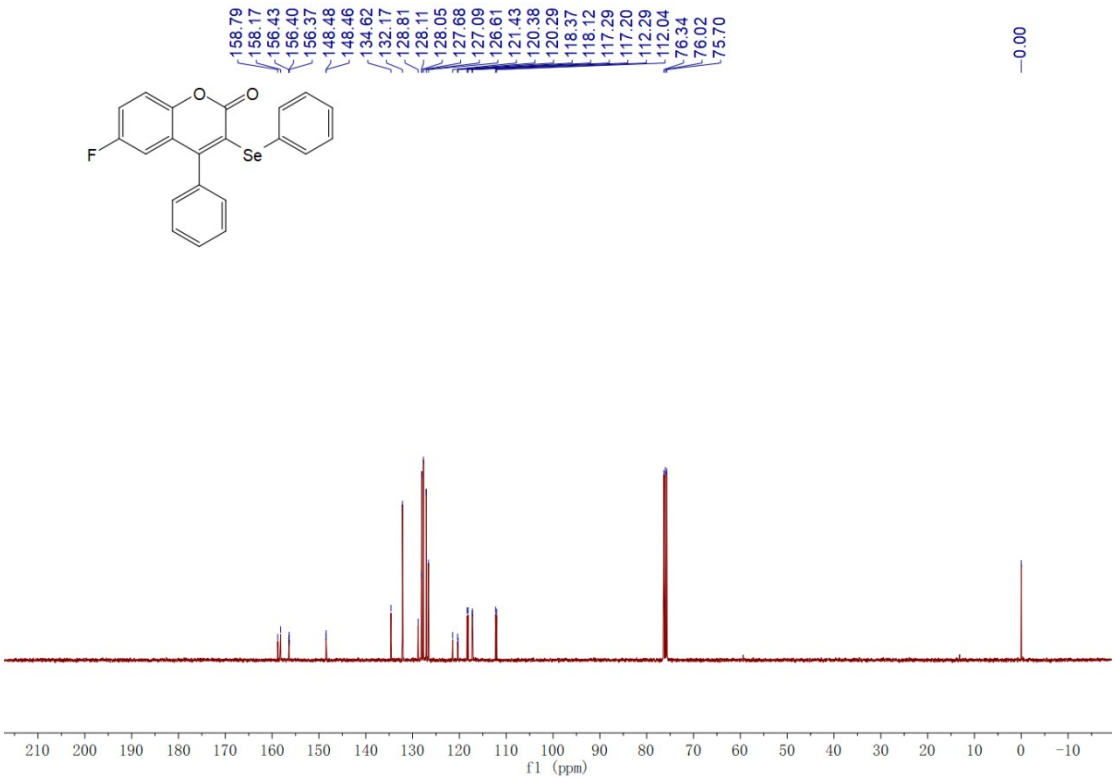
f1 (ppm)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O
F
Se
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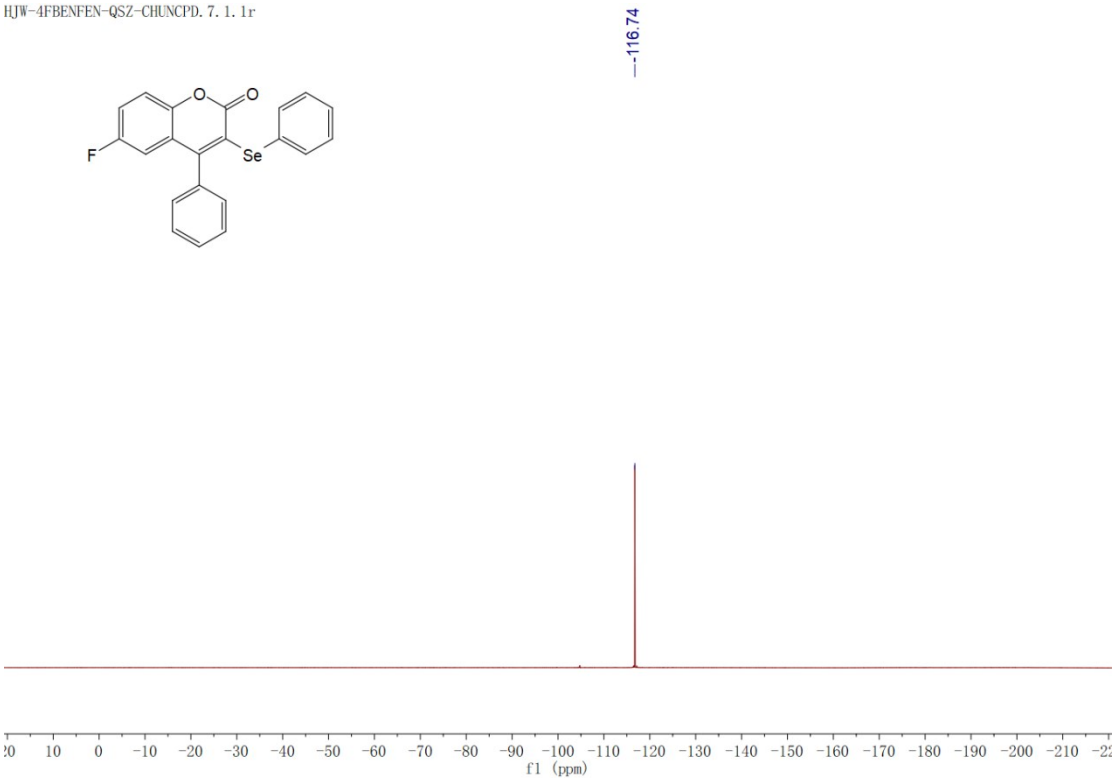
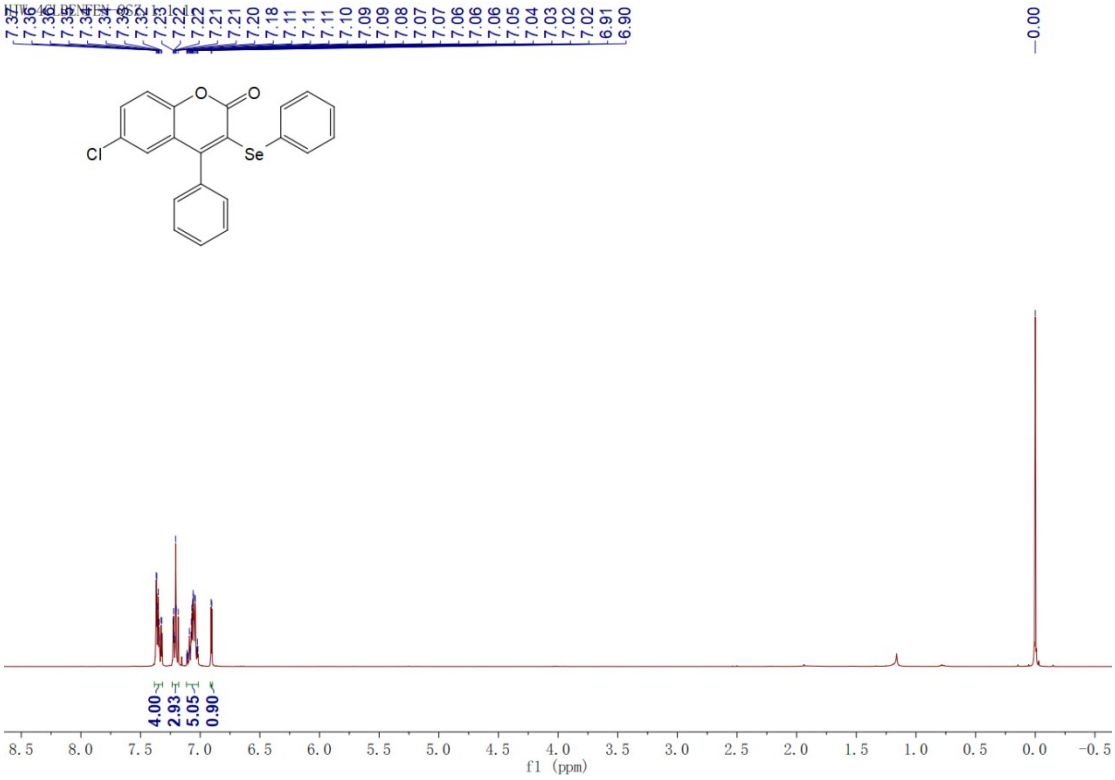
f1 (ppm)

HJW-4FBENFEN-QSZ-CHUNCPD.7.1.1r



Product 4g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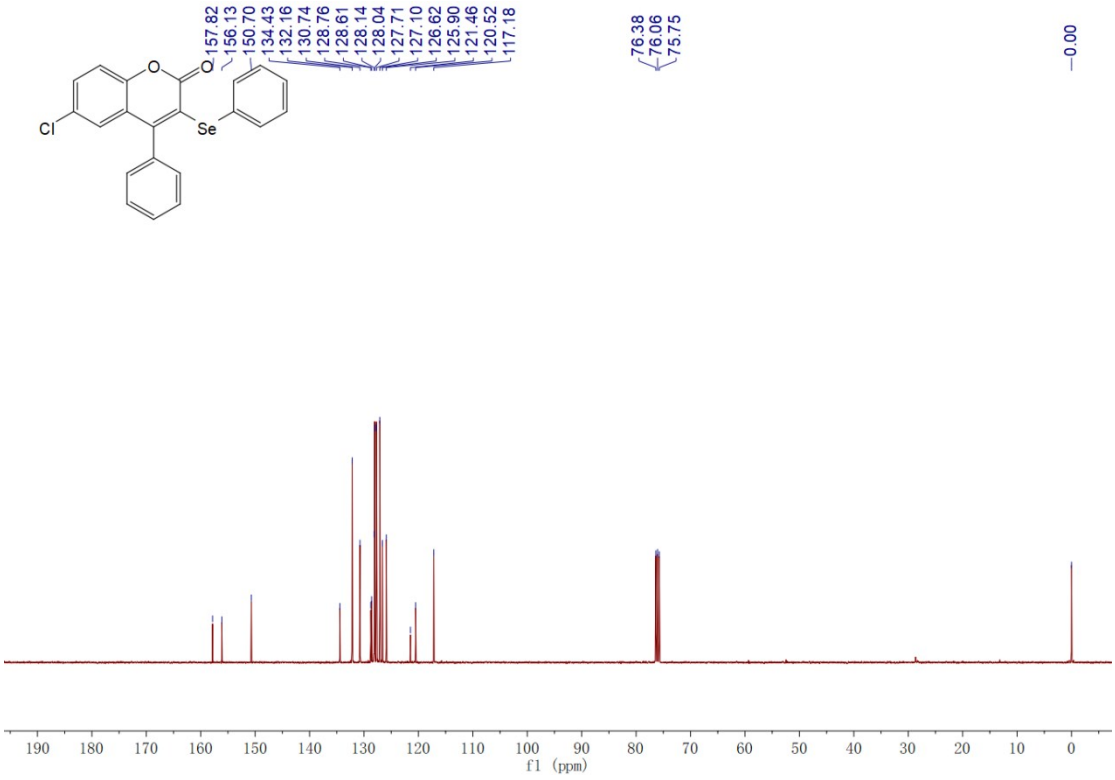
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Se
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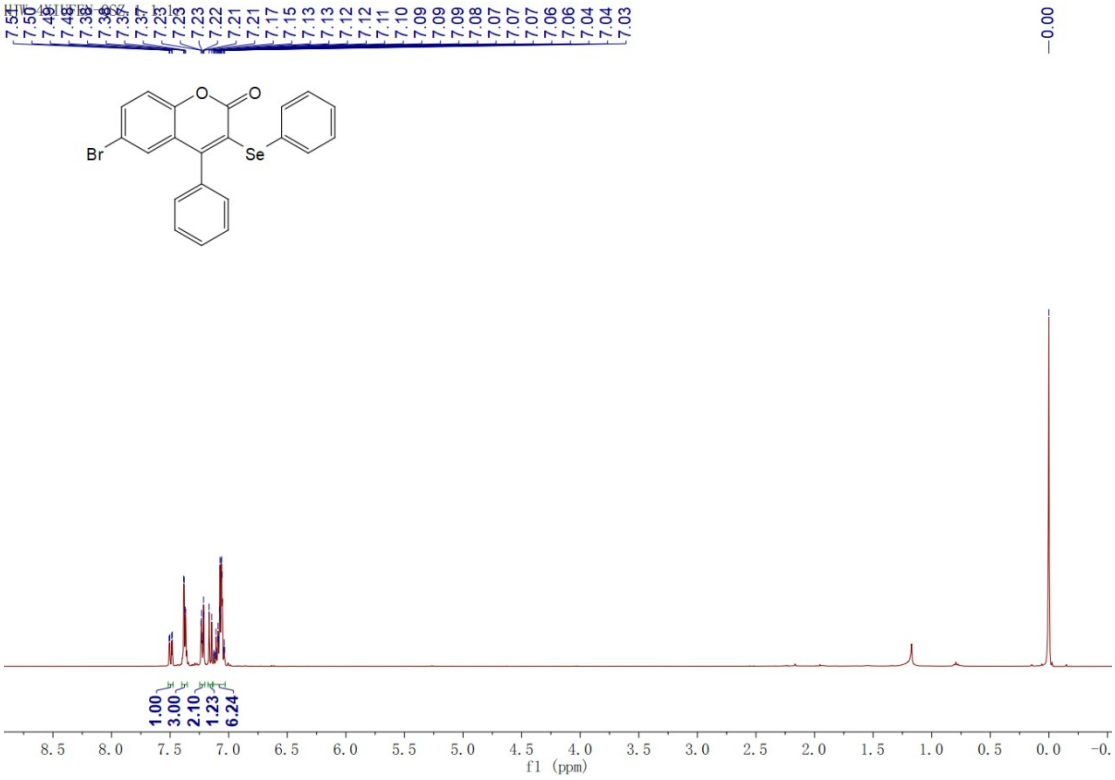
f1 (ppm)

Product 4h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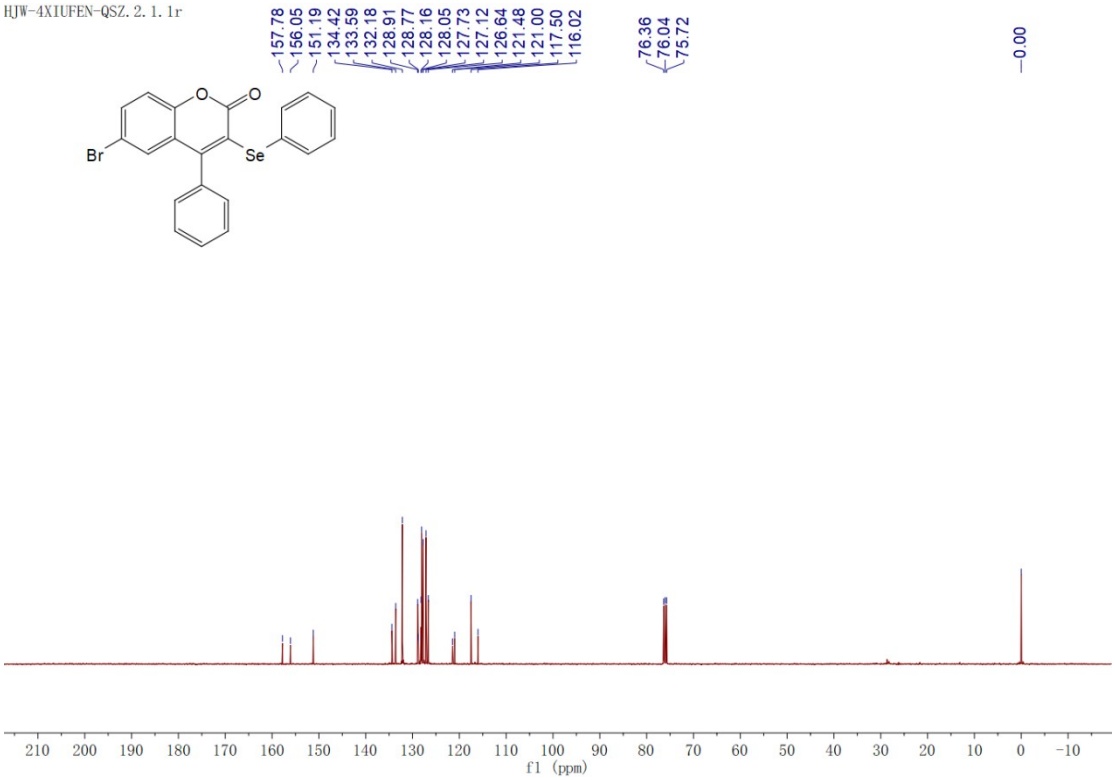
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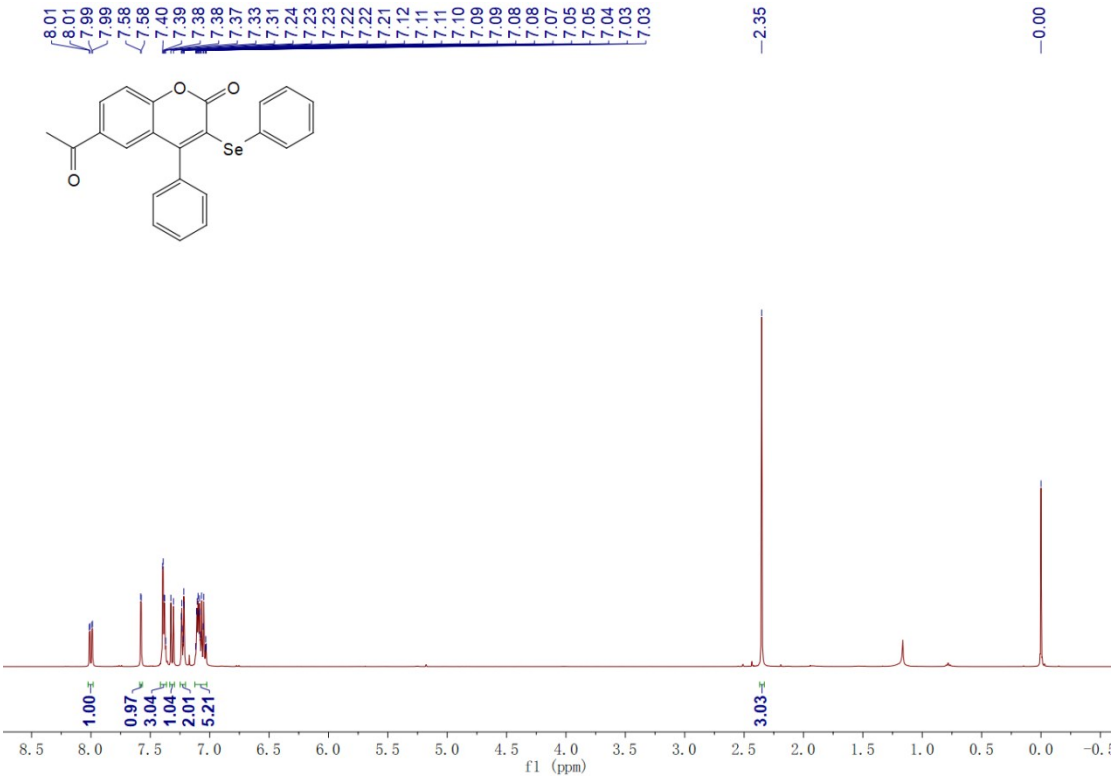
Br
Se
f1 (ppm)

Product 4i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7.03
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2.35
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2.01
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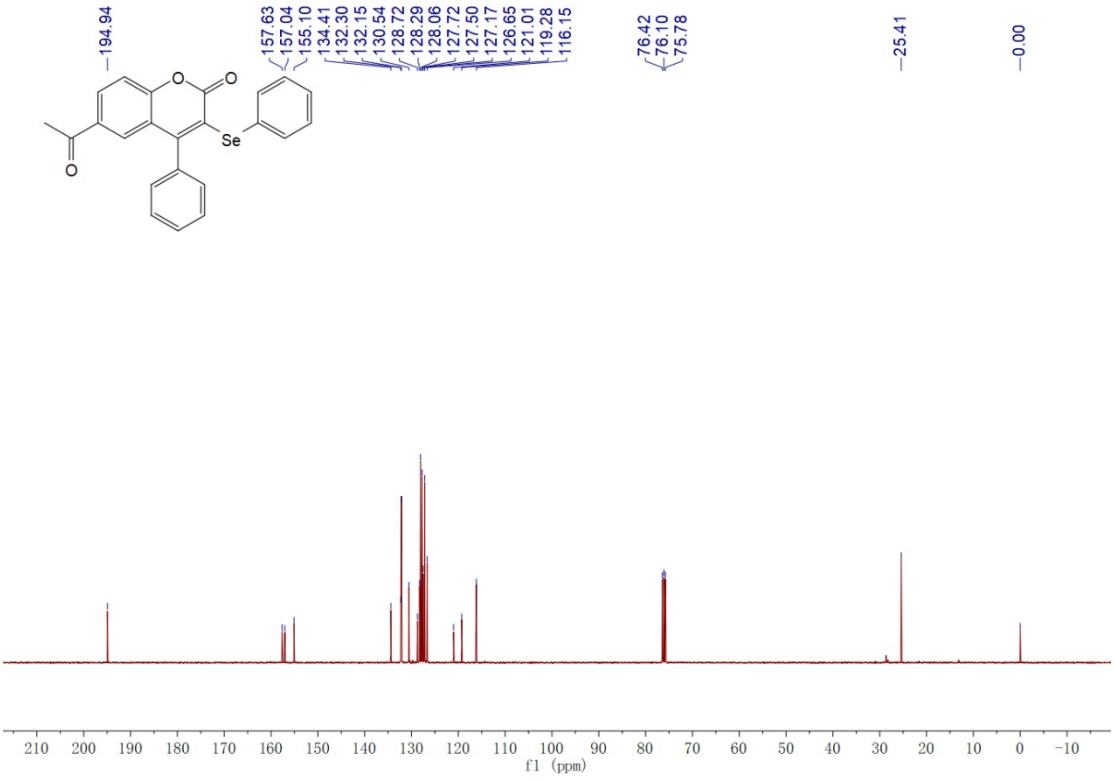
f1 (ppm)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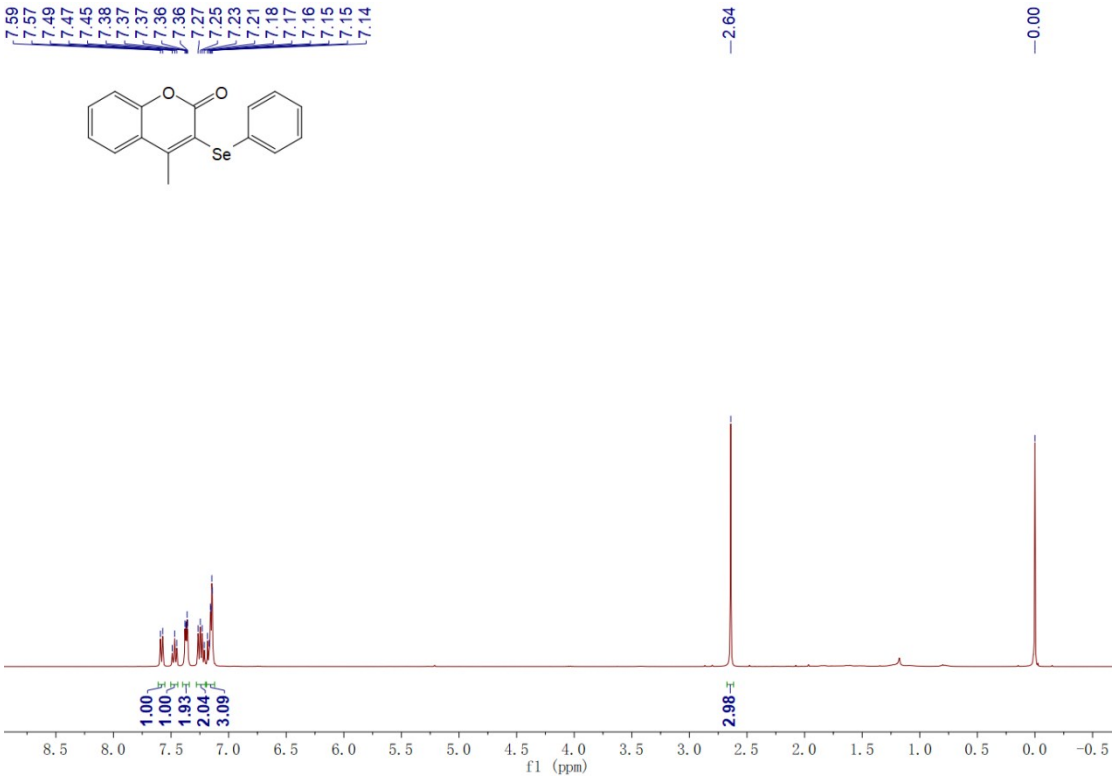
O
O
Se
O
f1 (ppm)

Product 4k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7.15
7.15
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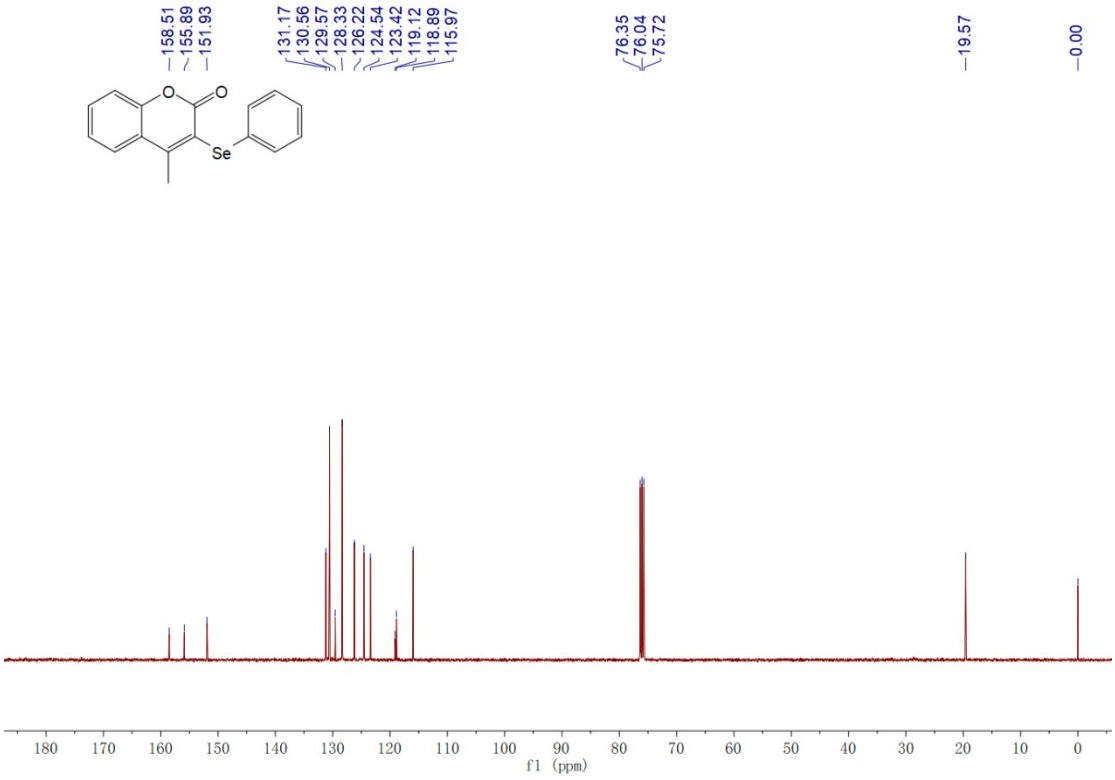
f1 (ppm)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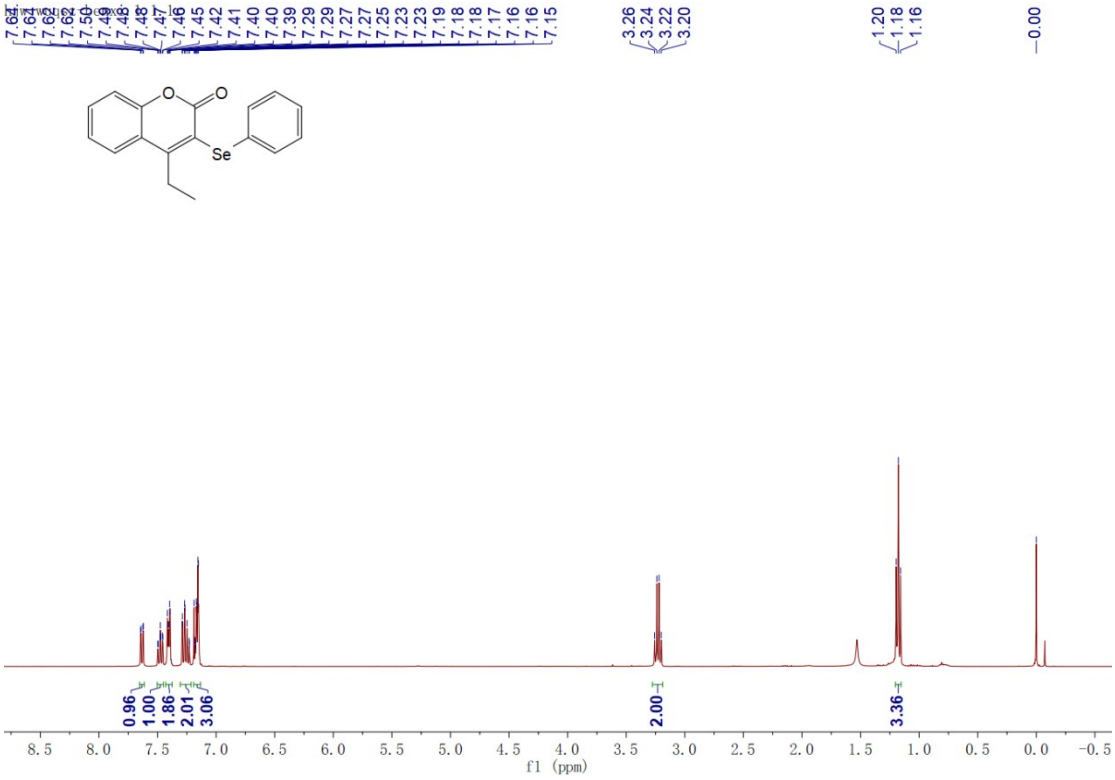
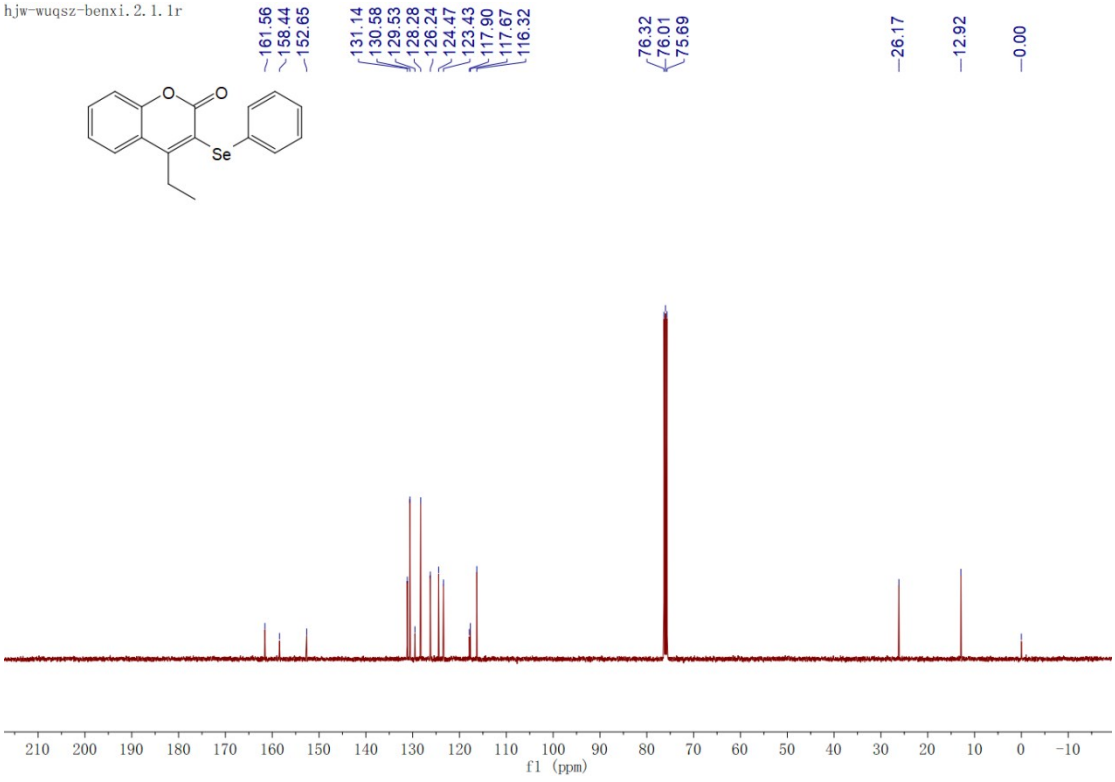
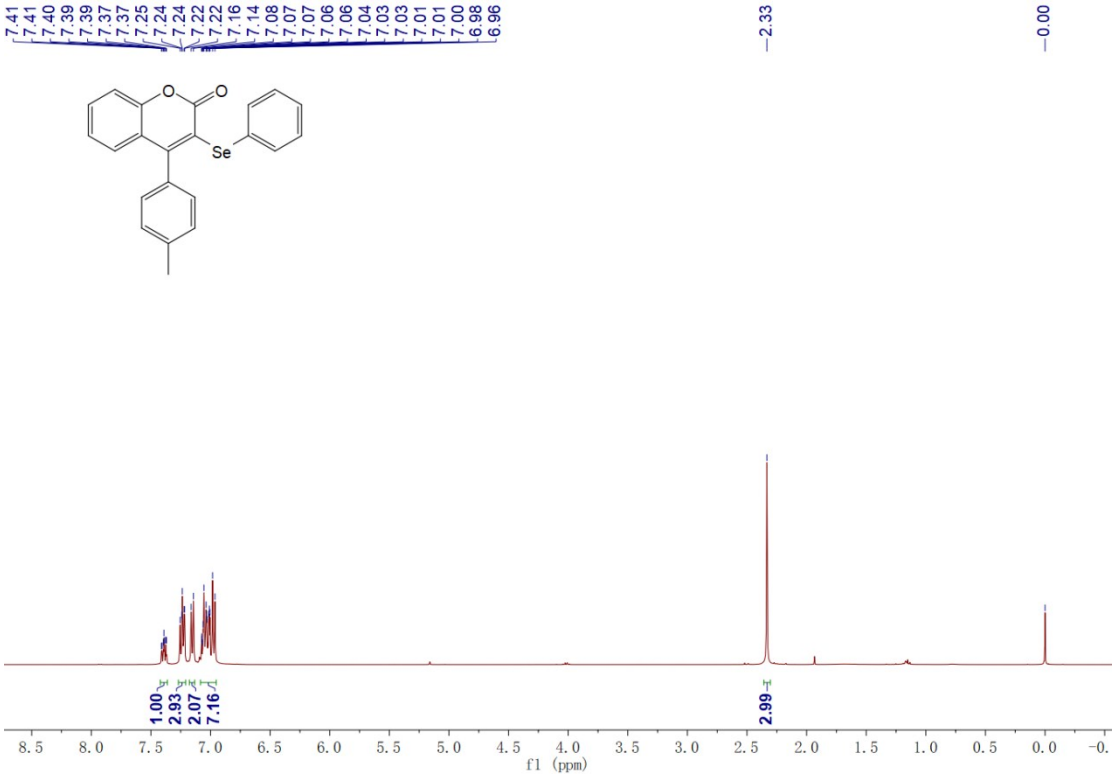
76.04
75.72
19.57
0.00
O
O
Se
f1 (ppm)

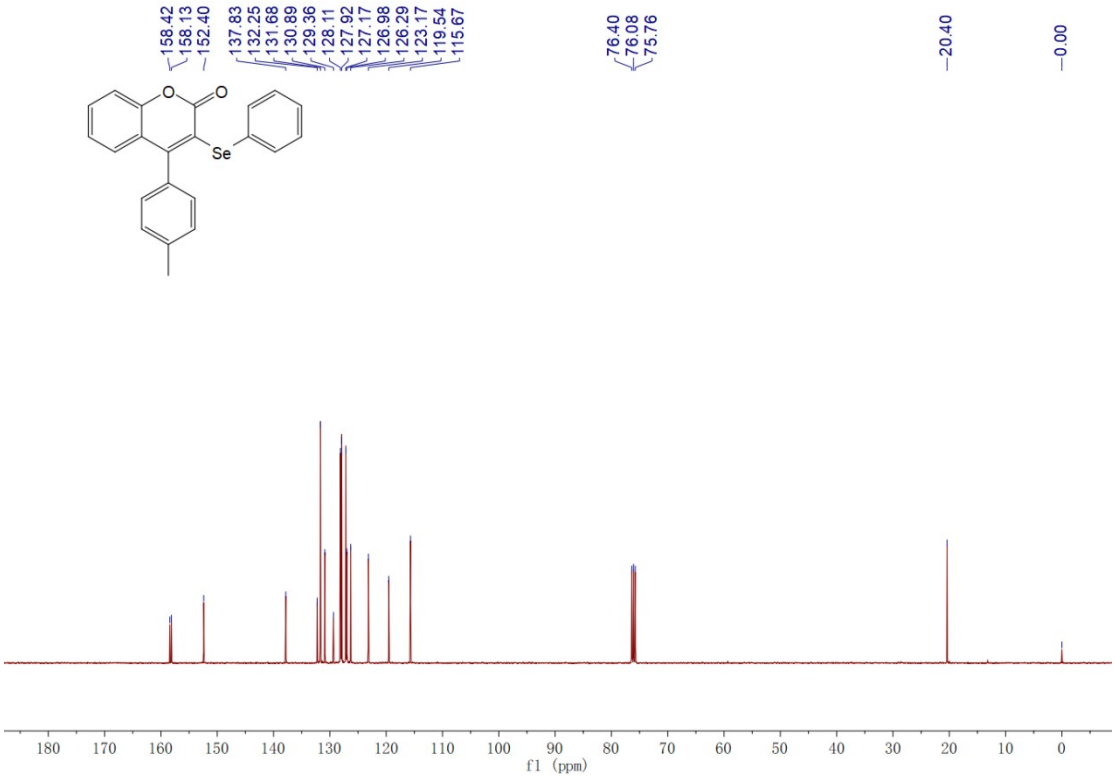
Product 4l


7.64
7.64
7.62
7.62
7.62
7.62
7.50
7.49
7.48
7.48
7.47
7.46
7.45
7.42
7.41
7.40
7.40
7.39
7.29
7.29
7.27
7.27
7.25
7.23
7.23
7.19
7.18
7.18
7.17
7.16
7.16
7.15
3.26
3.24
3.22
3.20
1.20
1.18
1.16
0.00
O
O
Se
0.96
1.00
1.86
2.01
3.06
2.00
3.36
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

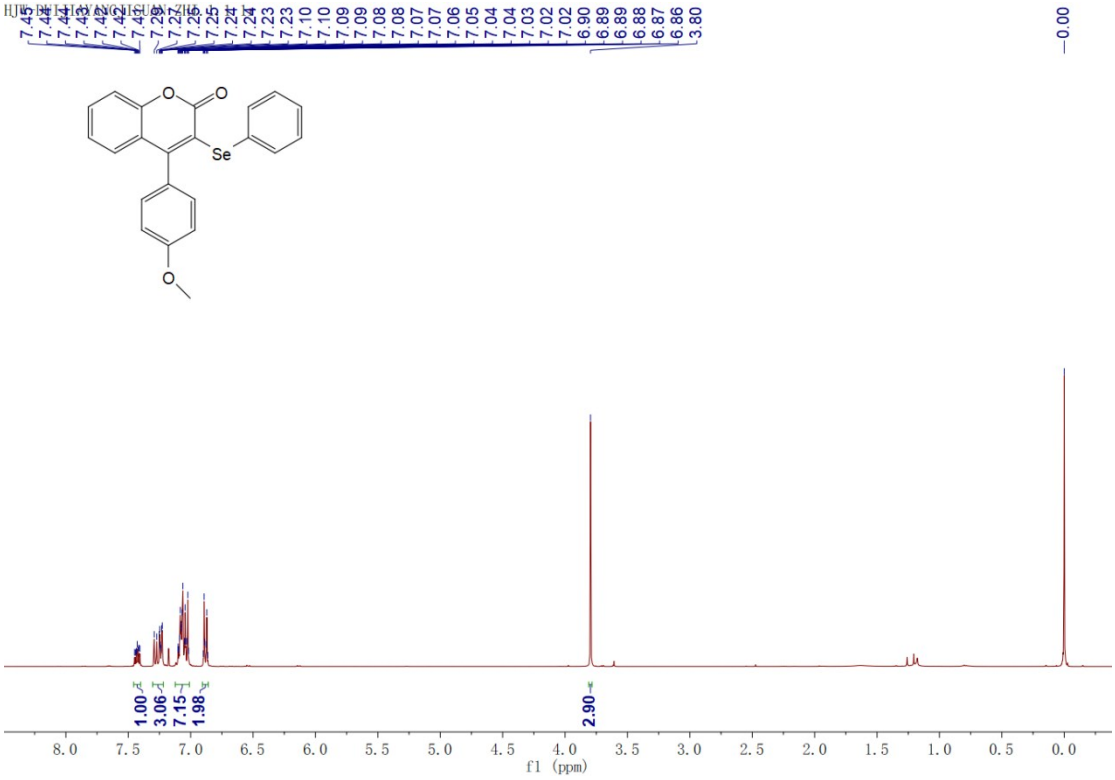

hjw-wuqsz-benxi.2.1.1r
161.56
158.44
152.65
131.14
130.58
129.53
128.28
126.24
124.47
123.43
117.90
117.67
116.32
76.32
76.01
75.69
26.17
12.92
0.00
O
O
Se
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

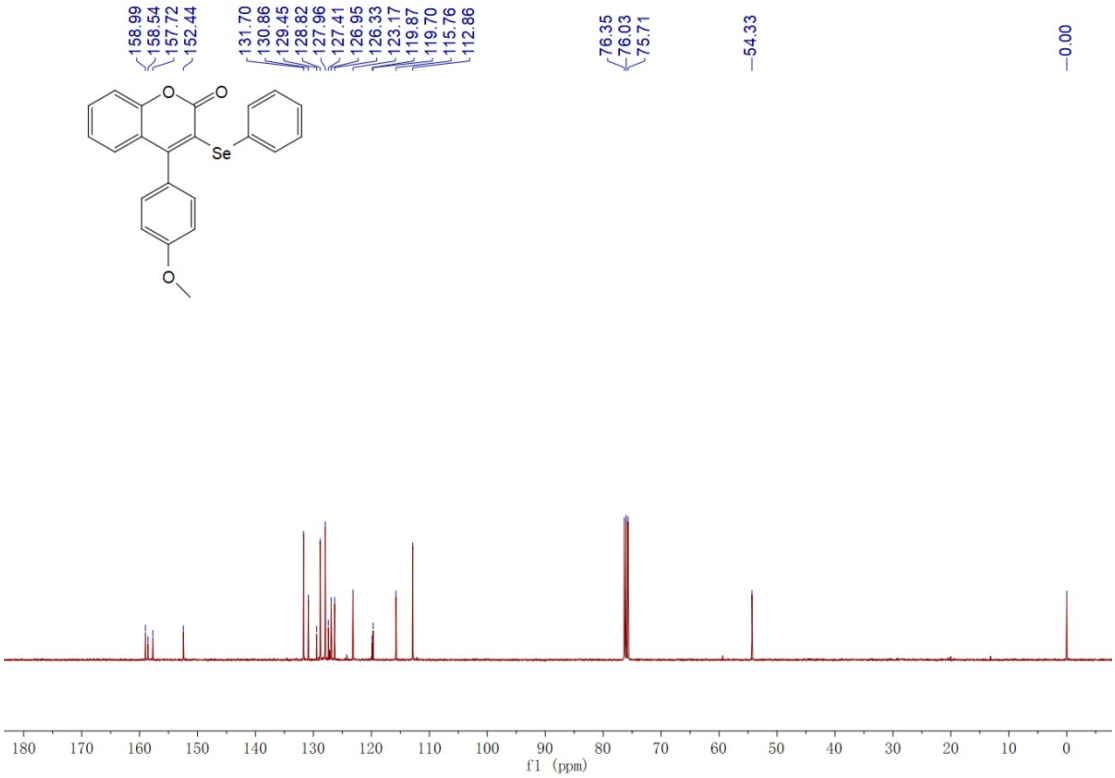
Product 4m


7.41
7.41
7.40
7.39
7.39
7.37
7.37
7.25
7.24
7.24
7.22
7.22
7.16
7.14
7.08
7.07
7.07
7.06
7.06
7.04
7.03
7.03
7.01
7.01
7.00
6.98
6.96
2.33
0.00
O
O
Se
1.00
2.93
2.07
7.16
2.99
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.
f1 (ppm)

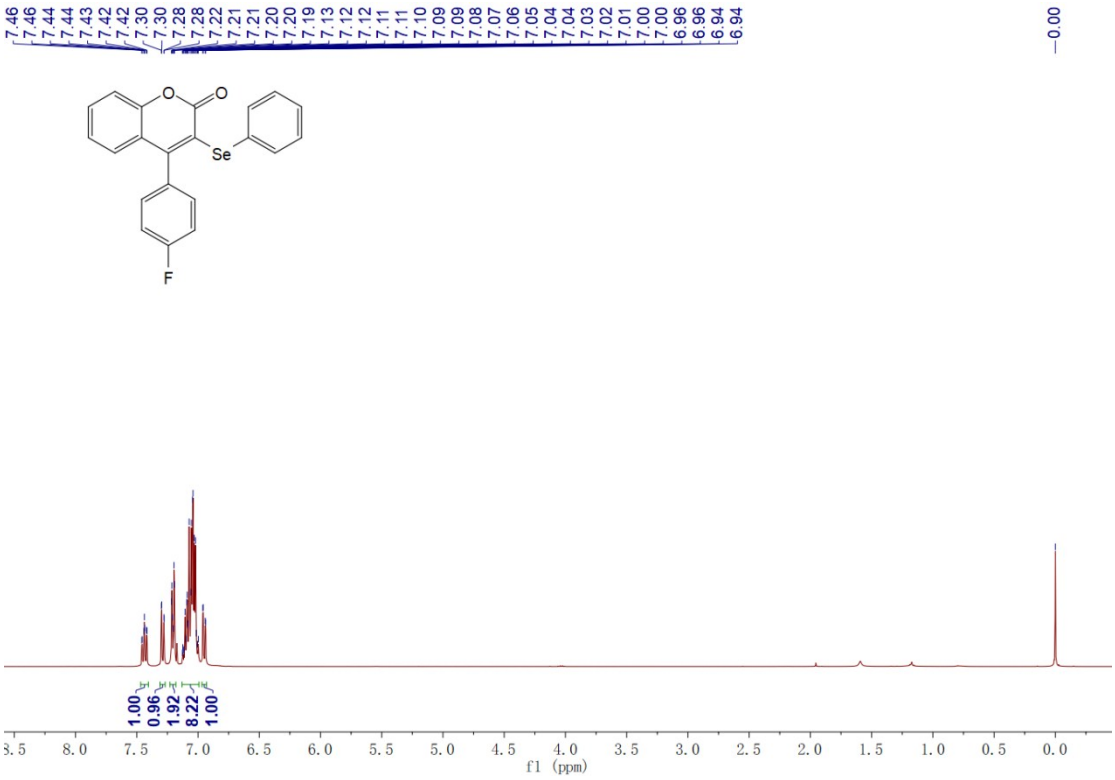

158.42
158.13
152.40
137.83
132.25
131.68
130.89
129.36
128.11
127.92
127.17
126.98
126.29
123.17
119.54
115.67
76.40
76.08
75.76
20.40
0.00
O
O
Se
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

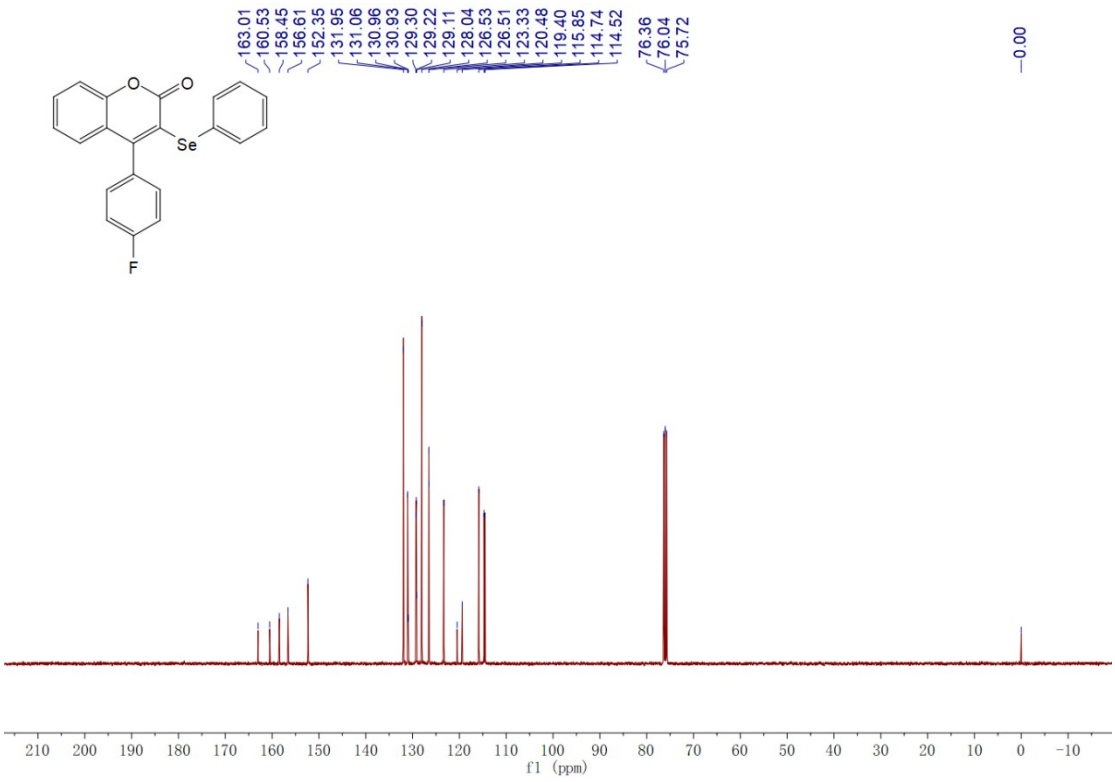
Product 4n


7.45
7.44
7.44
7.43
7.43
7.42
7.42
7.41
7.29
7.25
7.25
7.24
7.24
7.24
7.23
7.23
7.10
7.10
7.09
7.09
7.08
7.08
7.07
7.07
7.06
7.05
7.04
7.04
7.03
7.02
7.02
6.90
6.89
6.89
6.88
6.87
6.86
3.80
0.00
O
O
Se
O
1.00
3.06
7.15
1.98
2.90
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

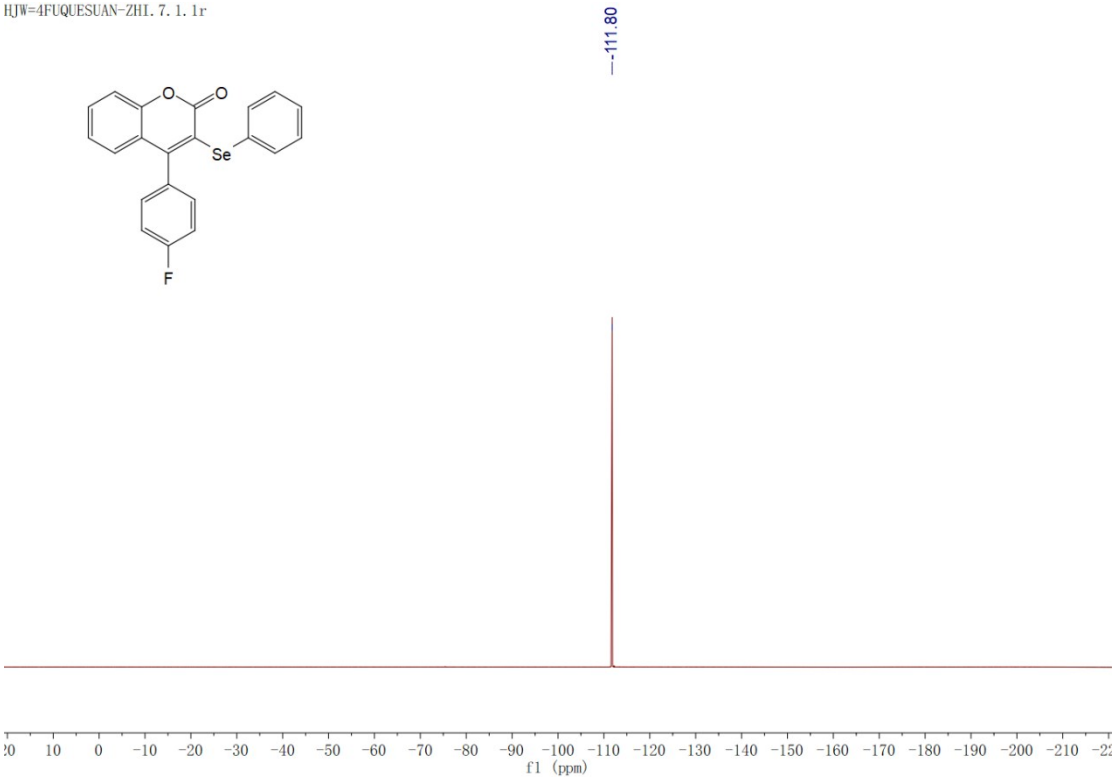

158.99
158.54
157.72
152.44
131.70
130.86
129.45
128.82
127.96
127.41
126.95
126.33
123.17
119.87
119.70
115.76
112.86
76.35
76.03
75.71
54.33
0.00
O
O
Se
O
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Product 4o

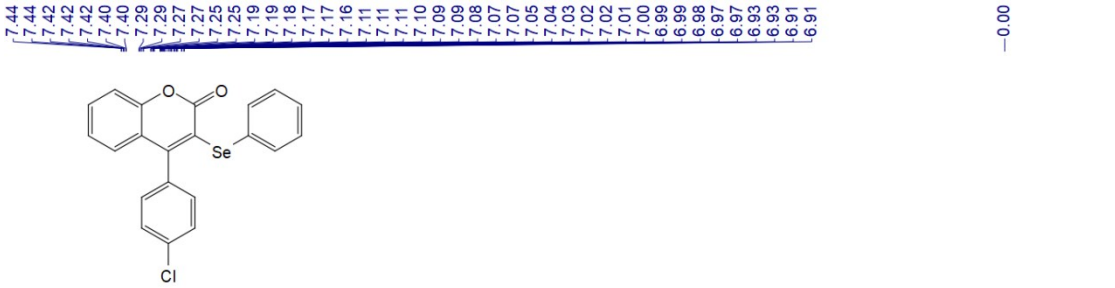

7.46
7.46
7.44
7.44
7.43
7.42
7.42
7.30
7.28
7.28
7.22
7.21
7.21
7.20
7.20
7.19
7.13
7.12
7.12
7.11
7.11
7.10
7.09
7.09
7.08
7.07
7.06
7.05
7.04
7.04
7.03
7.02
7.01
7.00
7.00
6.96
6.96
6.94
6.94
0.00
O
O
Se
F
1.00
0.96
1.92
8.22
1.00
f1 (ppm)

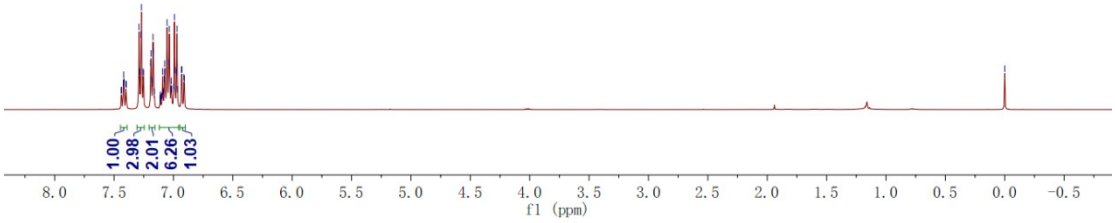

163.01
160.53
158.45
156.61
152.35
131.95
131.06
130.96
130.93
129.30
129.22
129.11
128.04
126.53
126.51
123.33
120.48
119.40
115.85
114.74
114.52
76.36
76.04
75.72
0.00
O
O
Se
F
f1 (ppm)

HJW=4FUQUESUAN-ZHI.7.1.1r

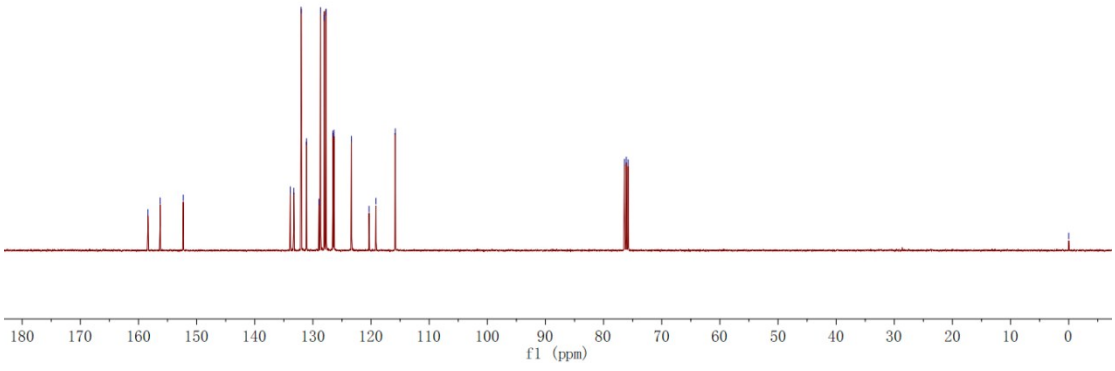


Product 4p

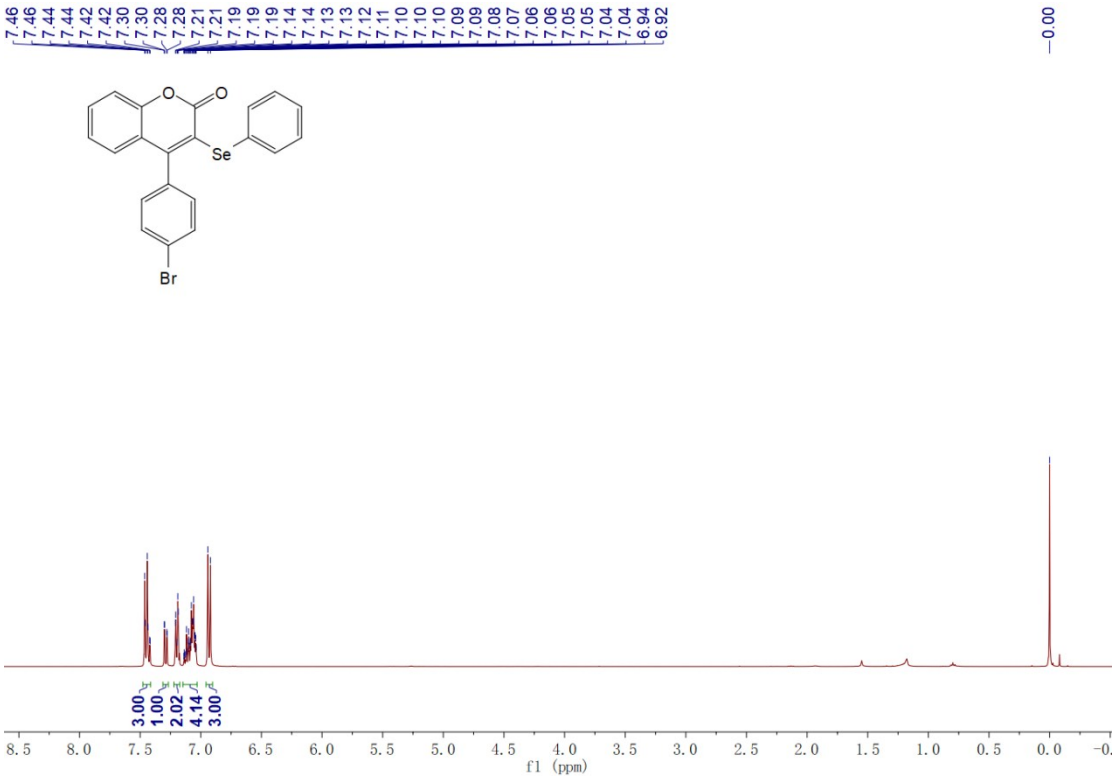

7.44
7.44
7.42
7.42
7.42
7.40
7.40
7.29
7.29
7.27
7.27
7.25
7.25
7.19
7.19
7.18
7.17
7.17
7.16
7.11
7.11
7.11
7.10
7.09
7.09
7.08
7.07
7.07
7.05
7.04
7.03
7.02
7.02
7.01
7.00
6.99
6.99
6.98
6.97
6.97
6.93
6.93
6.91
6.91
0.00
O
O
Se
Cl

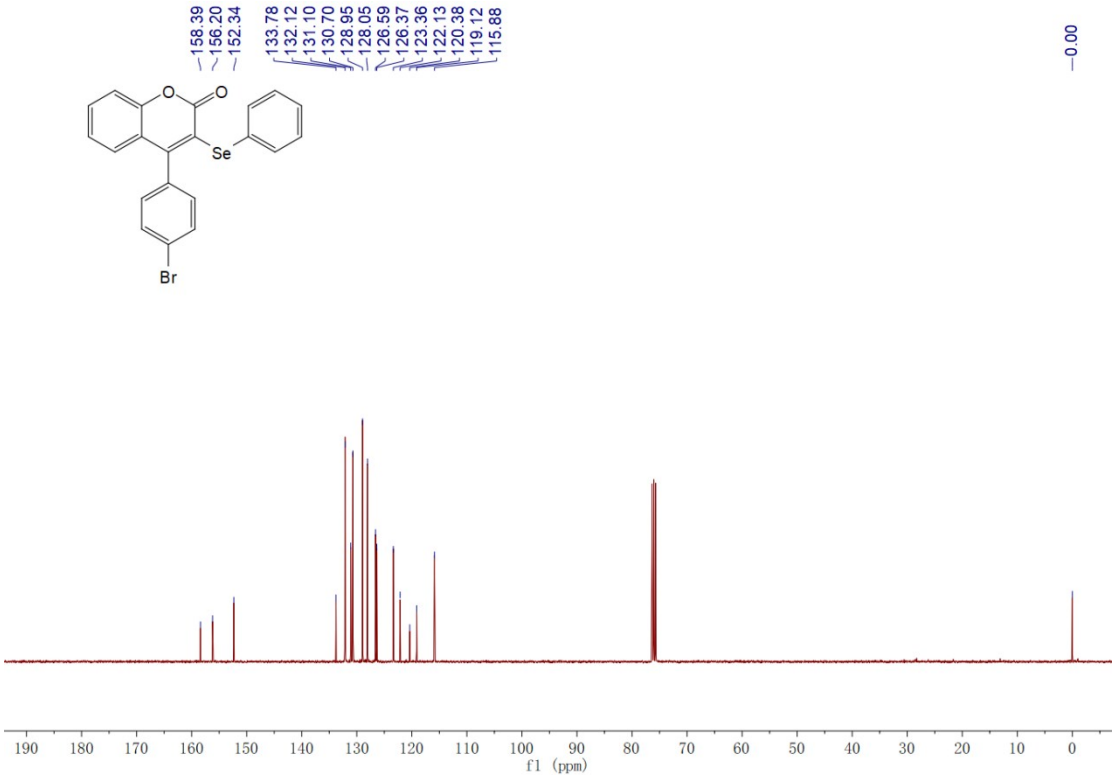

1.00
2.98
2.01
6.26
1.03
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


158.37
156.27
152.29
133.87
133.28
132.02
131.10
128.97
128.69
128.03
127.73
126.55
126.38
123.36
120.34
119.15
115.83
76.40
76.09
75.77
0.00
O
O
Se
Cl

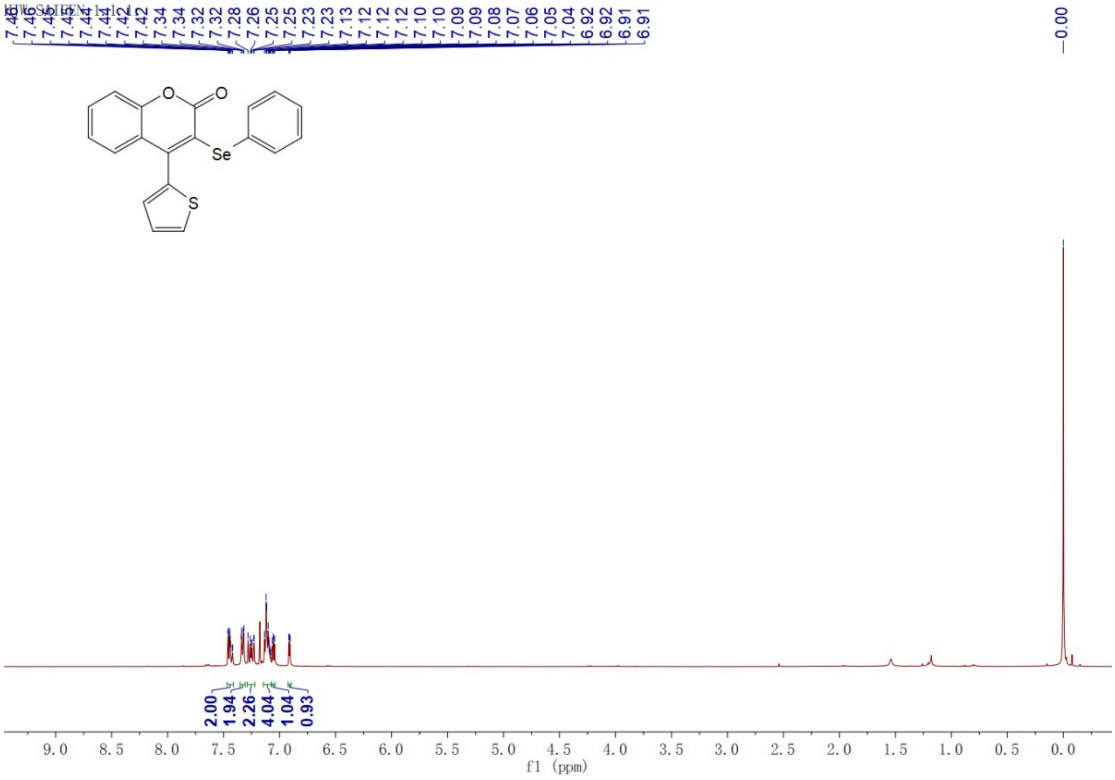

180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

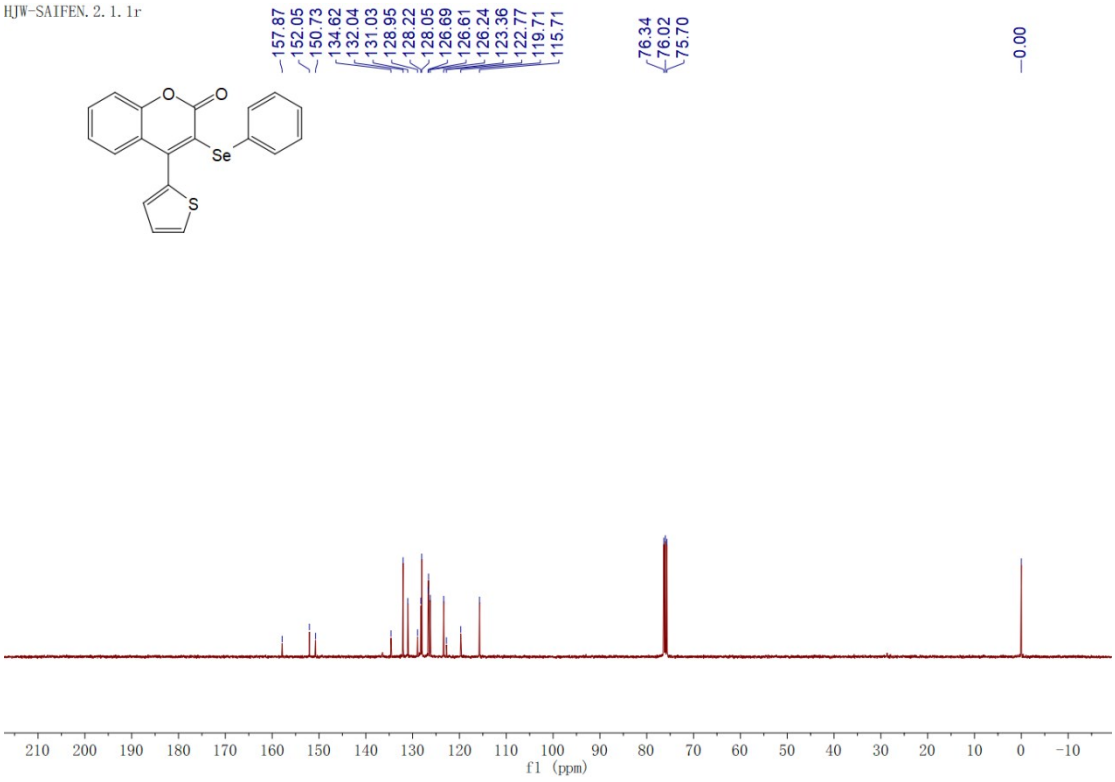
Product 4q


7.46
7.46
7.44
7.44
7.42
7.42
7.30
7.30
7.28
7.28
7.21
7.21
7.19
7.19
7.19
7.14
7.14
7.13
7.13
7.12
7.11
7.10
7.10
7.09
7.09
7.08
7.07
7.06
7.06
7.05
7.05
7.04
7.04
6.94
6.92
0.00
O
O
Se
Br
3.00
1.00
2.02
4.14
3.00
f1 (ppm)

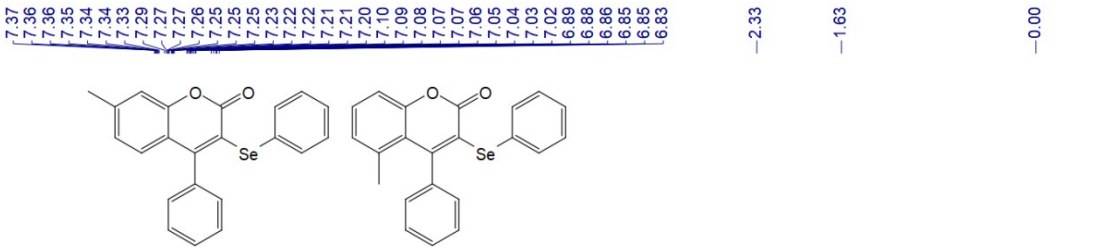

158.39
156.20
152.34
133.78
132.12
131.10
130.70
128.95
128.05
126.59
126.37
123.36
122.13
120.38
119.12
115.88
0.00
O
O
Se
Br
f1 (ppm)

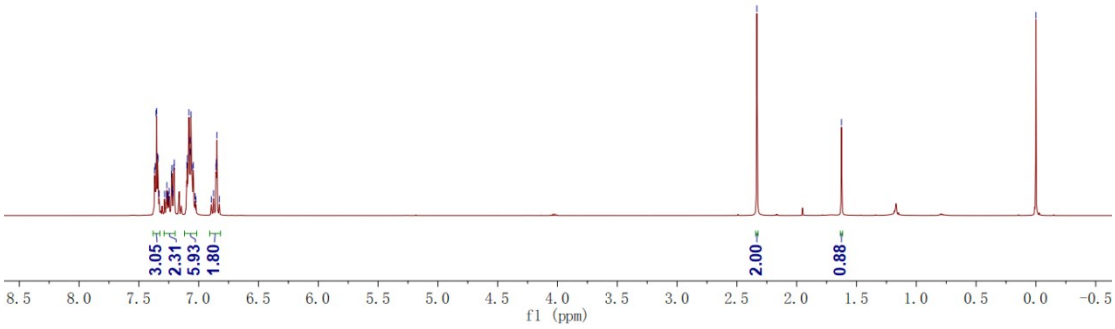
Product 4r

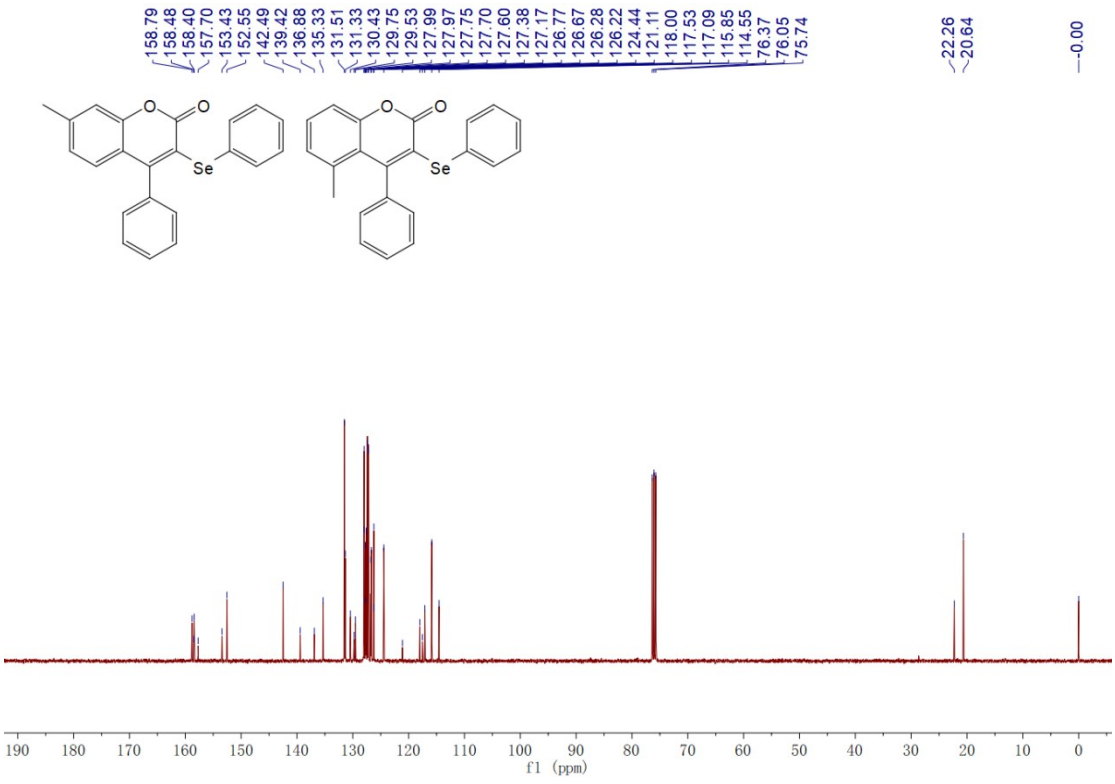

7.46
7.46
7.45
7.45
7.44
7.44
7.42
7.42
7.42
7.34
7.34
7.32
7.28
7.26
7.25
7.25
7.23
7.13
7.12
7.12
7.12
7.10
7.09
7.09
7.08
7.07
7.06
7.05
7.04
6.92
6.92
6.91
6.91
0.00
O
O
Se
S
2.00
1.94
2.26
4.04
1.04
0.93
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


HJW-SAIFEN.2.1.1r
157.87
152.05
150.73
134.62
132.04
131.03
128.95
128.22
128.05
126.69
126.61
126.24
123.36
122.77
119.71
115.71
76.34
76.02
75.70
0.00
O
O
Se
S
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

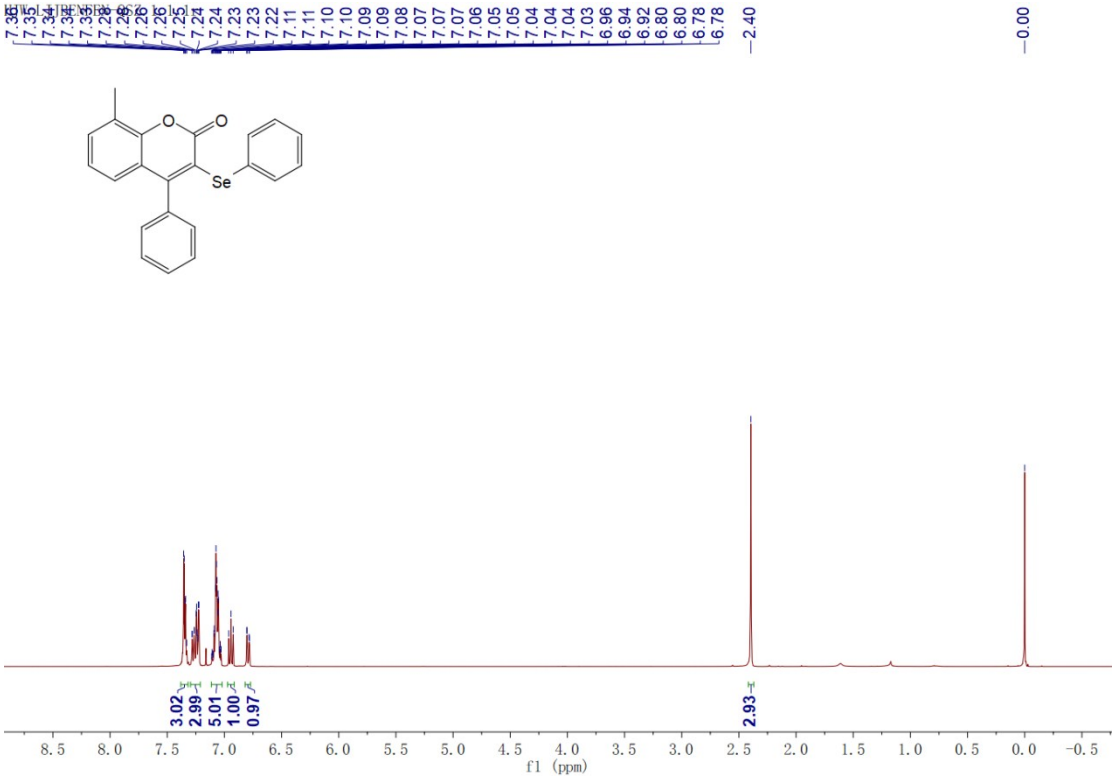
Product 4s

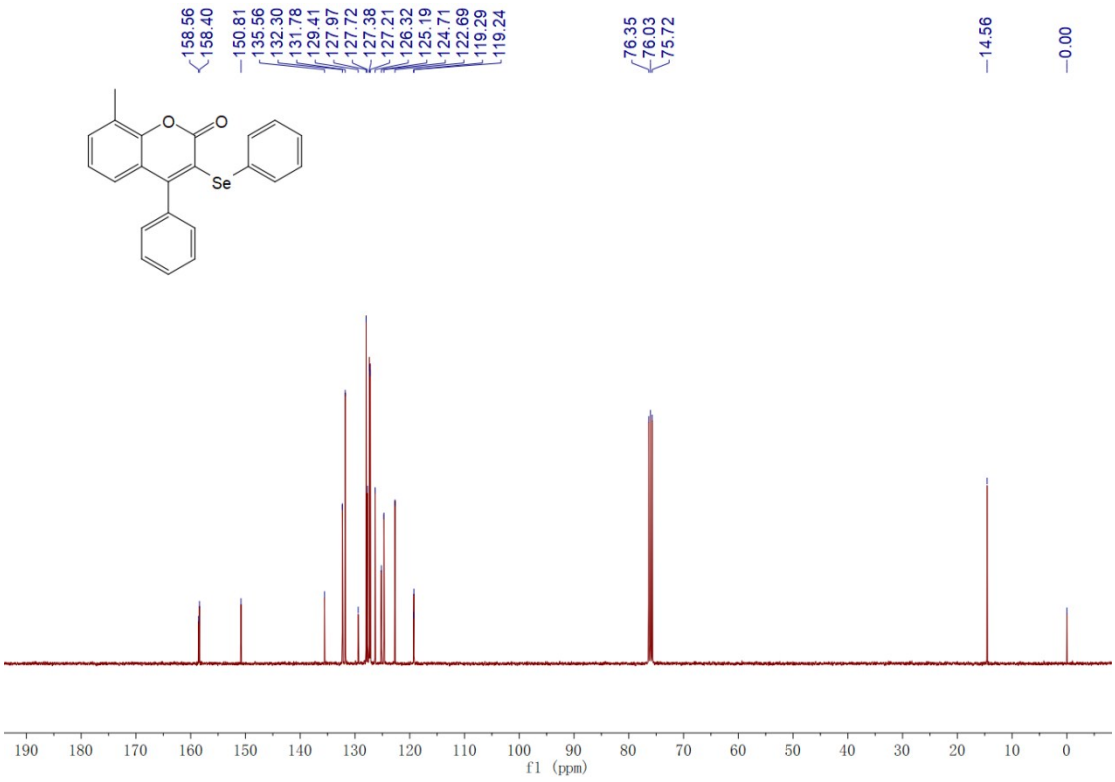

7.37
7.36
7.36
7.35
7.34
7.34
7.33
7.29
7.27
7.27
7.26
7.25
7.25
7.25
7.23
7.22
7.22
7.21
7.21
7.20
7.10
7.09
7.08
7.07
7.07
7.06
7.05
7.04
7.03
7.02
6.89
6.88
6.86
6.85
6.85
6.83
2.33
1.63
0.00
O
O
Se
O
O
Se


3.05
2.31
5.93
1.80
2.00
0.88
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

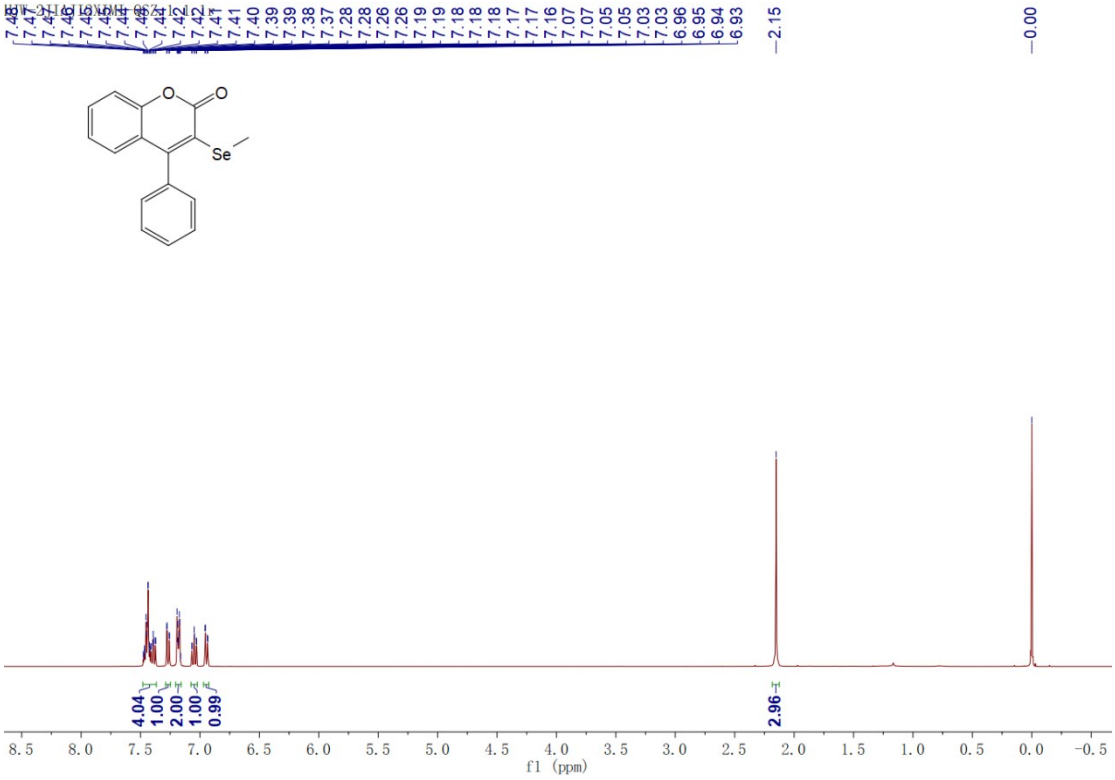

158.79
158.48
158.40
157.70
153.43
152.55
142.49
139.42
136.88
135.33
131.51
131.33
130.43
129.75
129.53
127.99
127.97
127.75
127.70
127.60
127.38
127.17
126.77
126.67
126.28
126.22
124.44
121.11
118.00
117.53
117.09
115.85
114.55
76.37
76.05
75.74
22.26
20.64
0.00
O
O
Se
O
O
Se
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

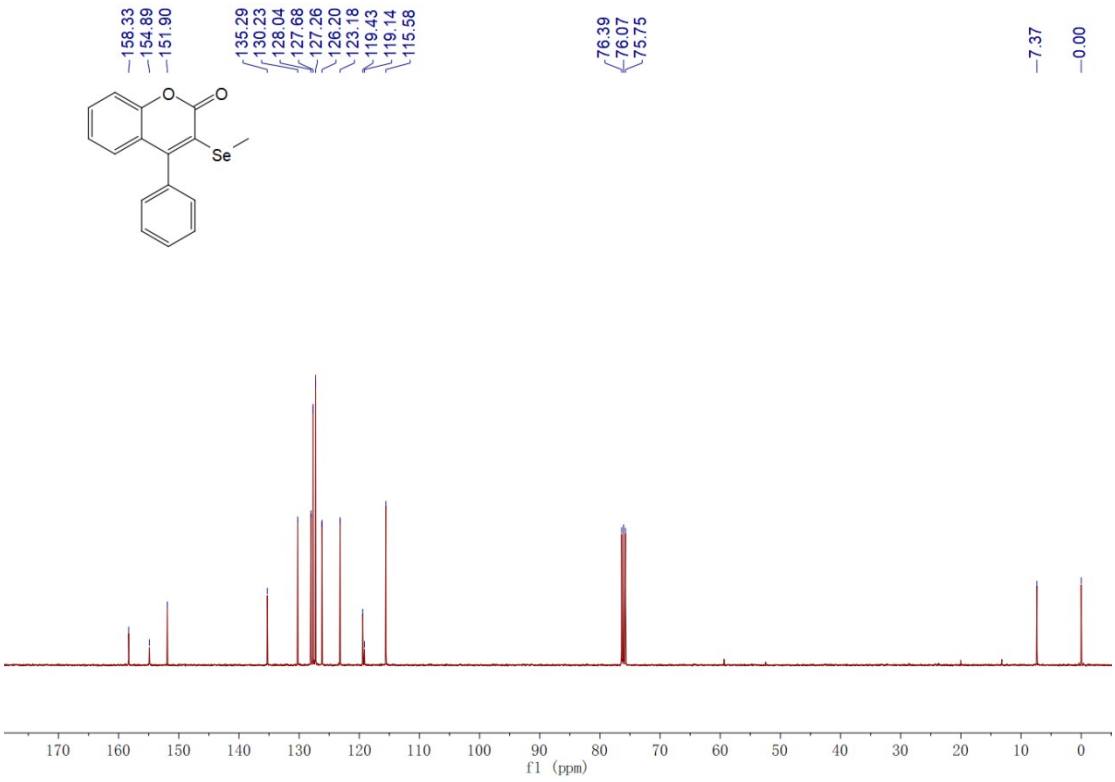
Product 4t


7.36
7.35
7.34
7.34
7.33
7.26
7.26
7.26
7.25
7.24
7.24
7.23
7.23
7.22
7.11
7.11
7.10
7.10
7.09
7.09
7.08
7.07
7.07
7.07
7.06
7.05
7.05
7.04
7.04
7.04
7.03
6.96
6.94
6.92
6.80
6.80
6.78
6.78
2.40
0.00
O
O
Se
3.02
2.99
5.01
1.00
0.97
2.93
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
f1 (ppm)

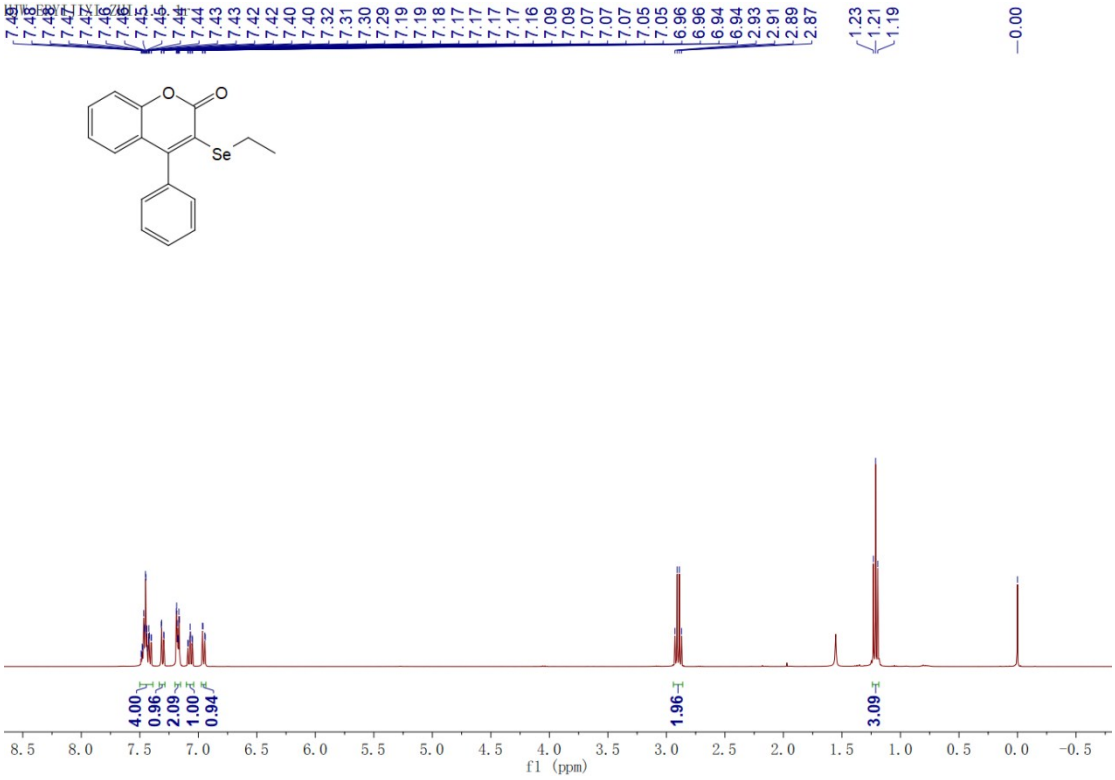

158.56
158.40
150.81
135.56
132.30
131.78
129.41
127.97
127.72
127.38
127.21
126.32
125.19
124.71
122.69
119.29
119.24
76.35
76.03
75.72
14.56
0.00
O
O
Se
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

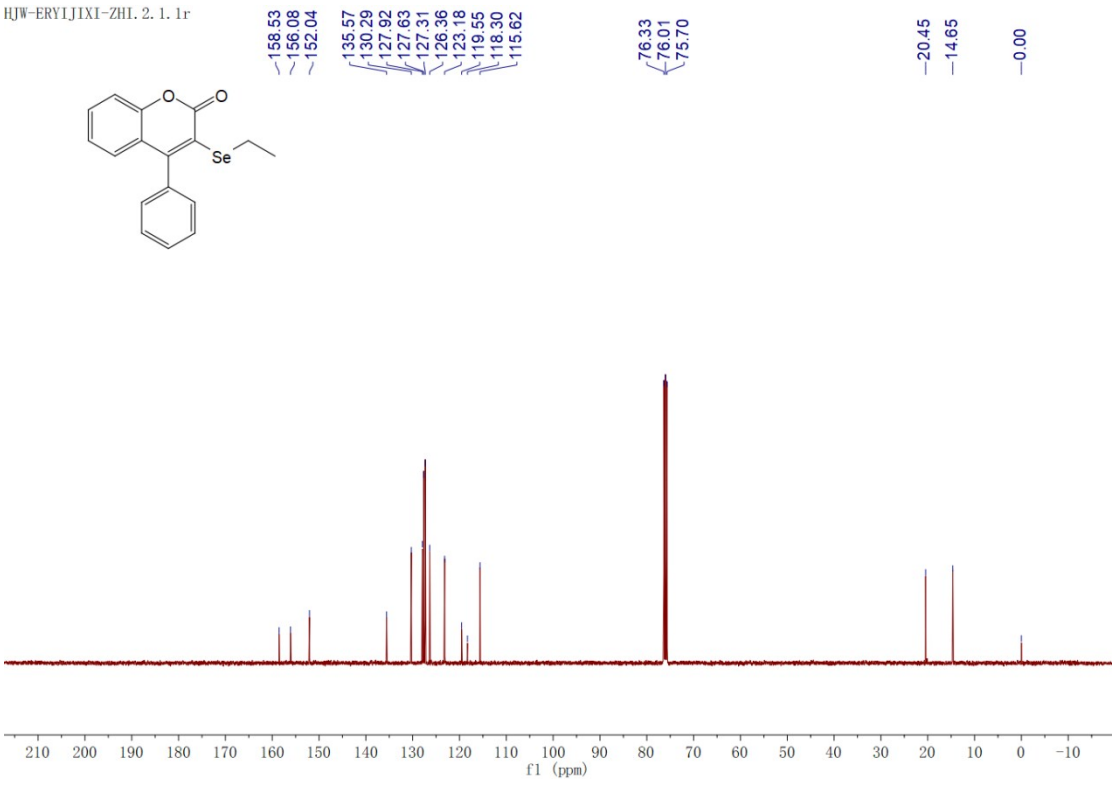
Product 4u


7.48
7.47
7.47
7.46
7.45
7.44
7.44
7.42
7.42
7.41
7.41
7.40
7.39
7.39
7.38
7.37
7.28
7.28
7.26
7.26
7.19
7.19
7.18
7.18
7.17
7.16
7.07
7.07
7.05
7.05
7.03
7.03
6.96
6.95
6.94
6.93
2.15
0.00
O
O
Se
4.04
1.00
2.00
1.00
0.99
2.96
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


158.33
154.89
151.90
135.29
130.23
128.04
127.68
127.26
126.20
123.18
119.43
119.14
115.58
76.39
76.07
75.75
7.37
0.00
O
O
Se
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Product 4v

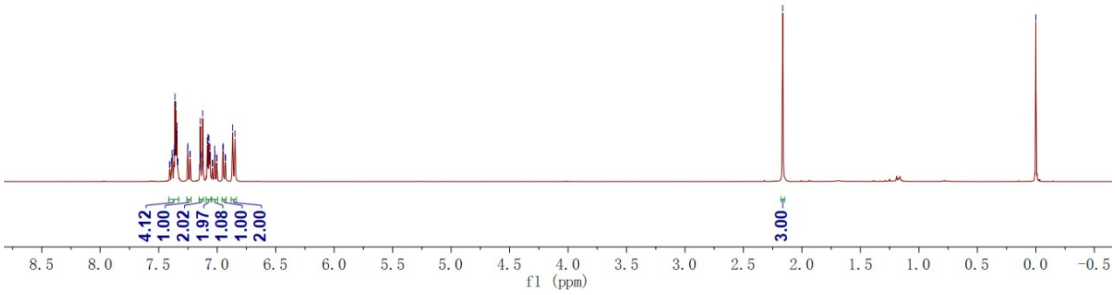

7.49 7.48 7.47 7.46 7.45 7.44 7.43 7.42 7.40 7.32 7.31 7.30 7.29 7.19 7.18 7.17 7.16 7.09 7.07 7.05 6.96 6.94 2.93 2.91 2.89 2.87
1.23 1.21 1.19
0.00
O
O
Se
4.00 0.96 2.09 1.00 0.94
1.96
3.09
f1 (ppm)


HJW-ERYIJIXI-ZHI.2.1.1r
158.53 156.08 152.04 135.57 130.29 127.92 127.63 127.31 126.36 123.18 119.55 118.30 115.62
76.33 76.01 75.70
20.45 14.65
0.00
O
O
Se
f1 (ppm)

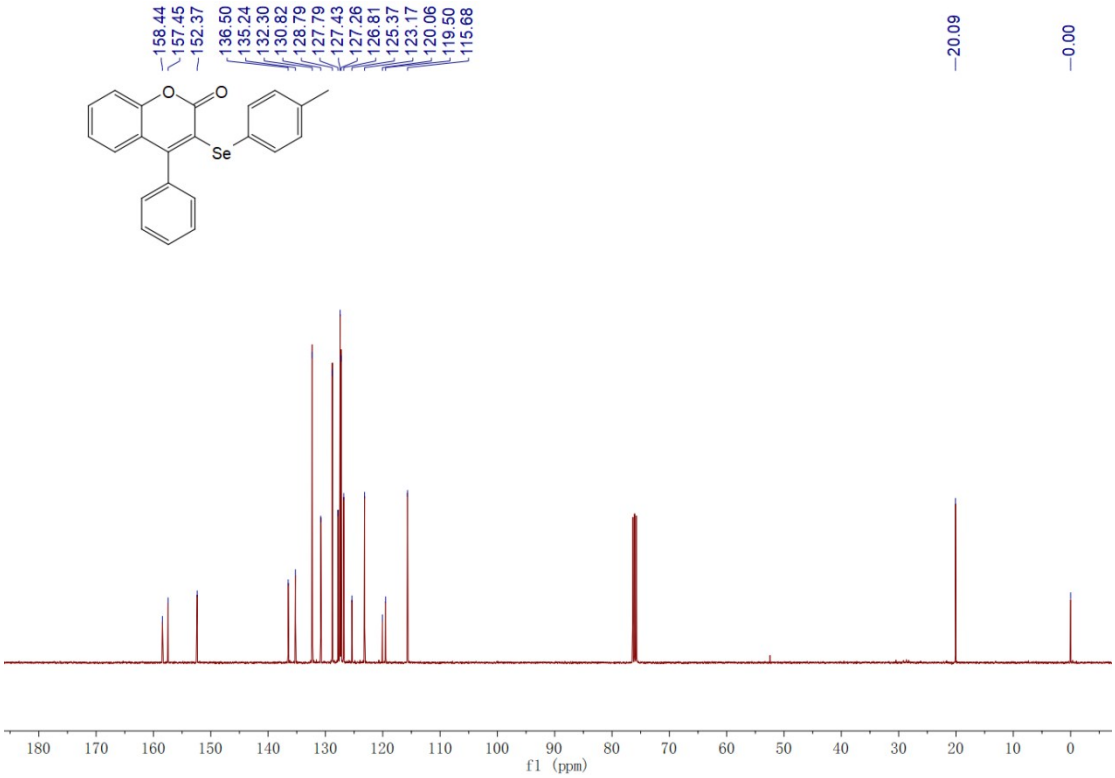
Product 4w


7.48
7.38
7.37
7.36
7.35
7.34
7.25
7.23
7.15
7.14
7.13
7.12
7.08
7.07
7.06
7.04
7.02
7.00
6.95
6.93
6.87
6.85
2.16
0.00

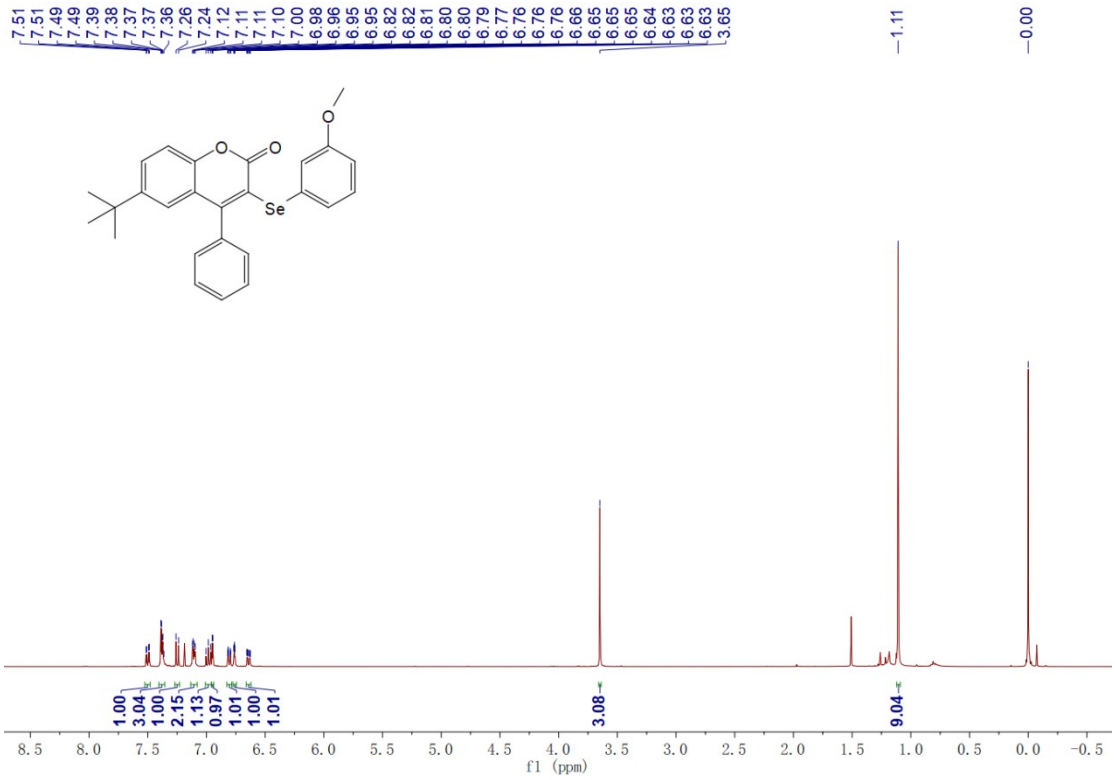
O
O
Se

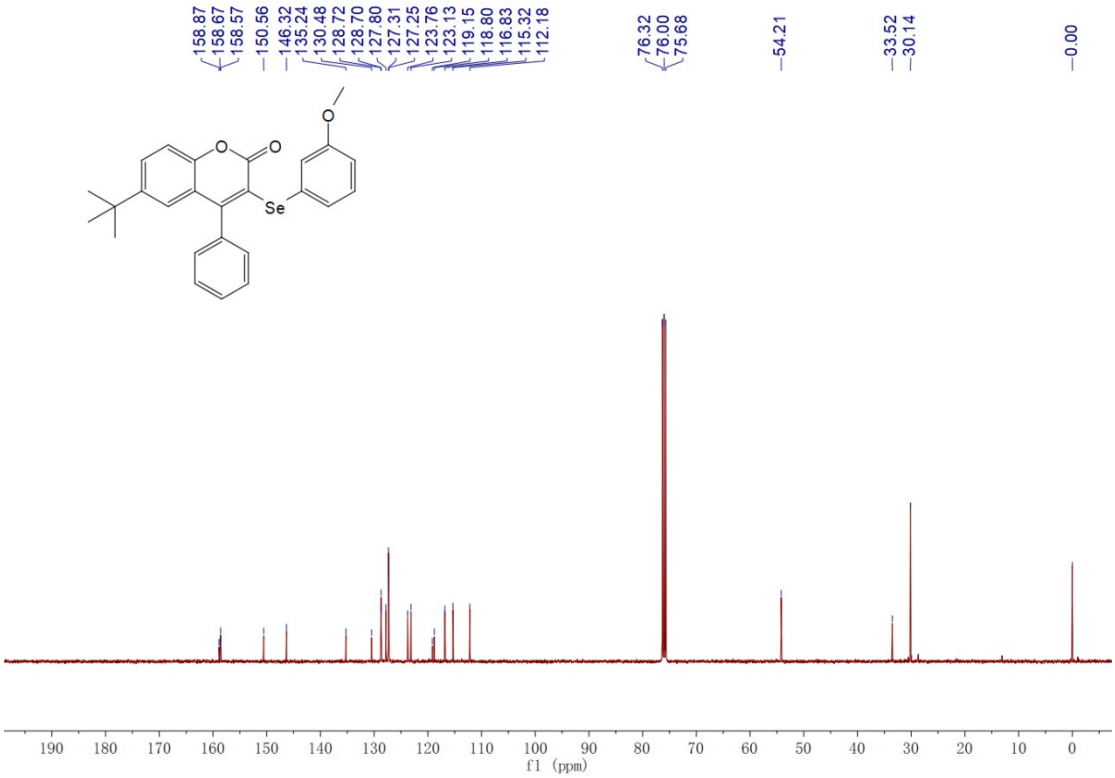

4.12
1.00
2.02
1.97
1.08
1.00
2.00
3.00
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

O
O
Se

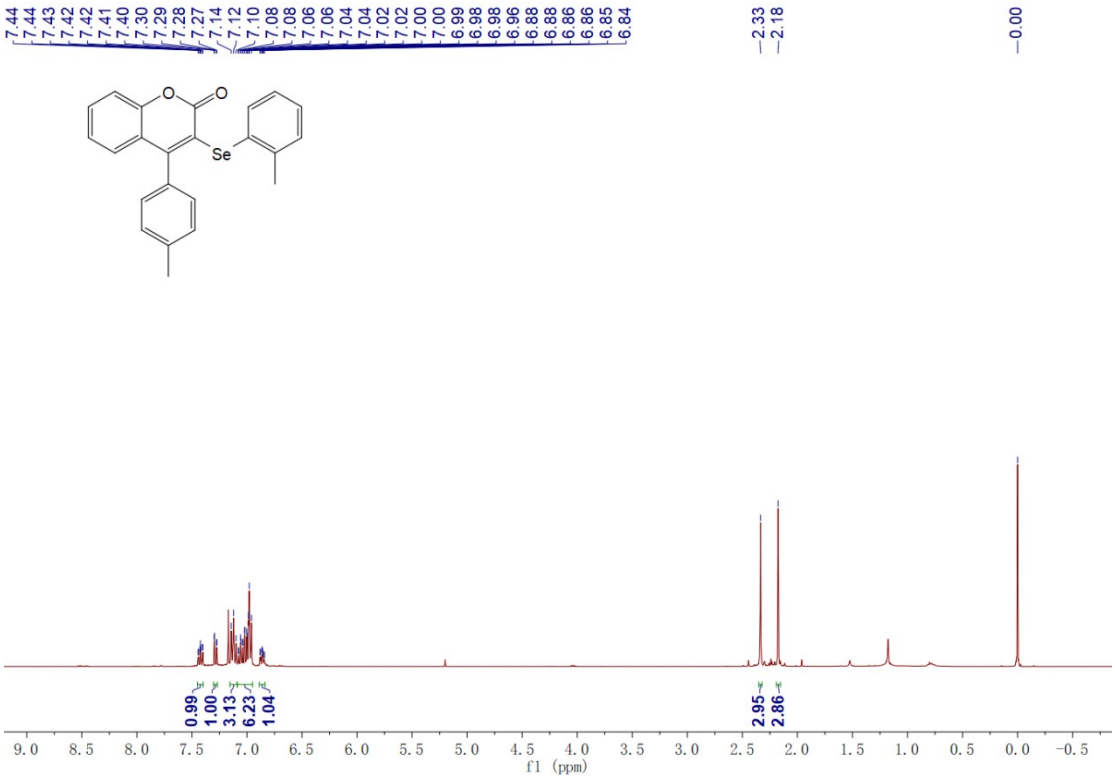

158.44
157.45
152.37
136.50
135.24
132.30
130.82
128.79
127.79
127.43
127.26
126.81
125.37
123.17
120.06
119.50
115.68
20.09
0.00
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

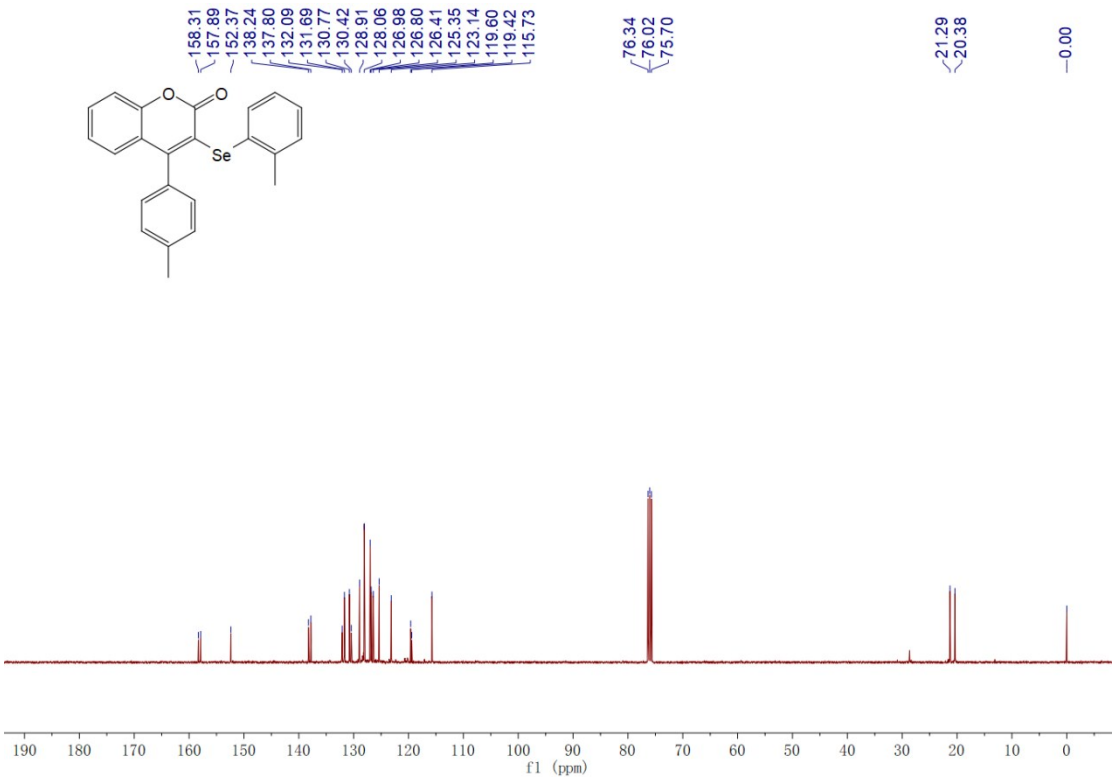
Product 4x


7.51
7.51
7.49
7.49
7.39
7.38
7.37
7.37
7.36
7.26
7.24
7.12
7.11
7.11
7.10
7.00
6.98
6.96
6.95
6.95
6.82
6.82
6.81
6.80
6.80
6.79
6.77
6.76
6.76
6.66
6.65
6.65
6.65
6.64
6.63
6.63
6.63
3.65
1.11
0.00
O
O
O
Se
1.00
3.04
1.00
2.15
1.13
0.97
1.01
1.00
1.01
3.08
9.04
f1 (ppm)

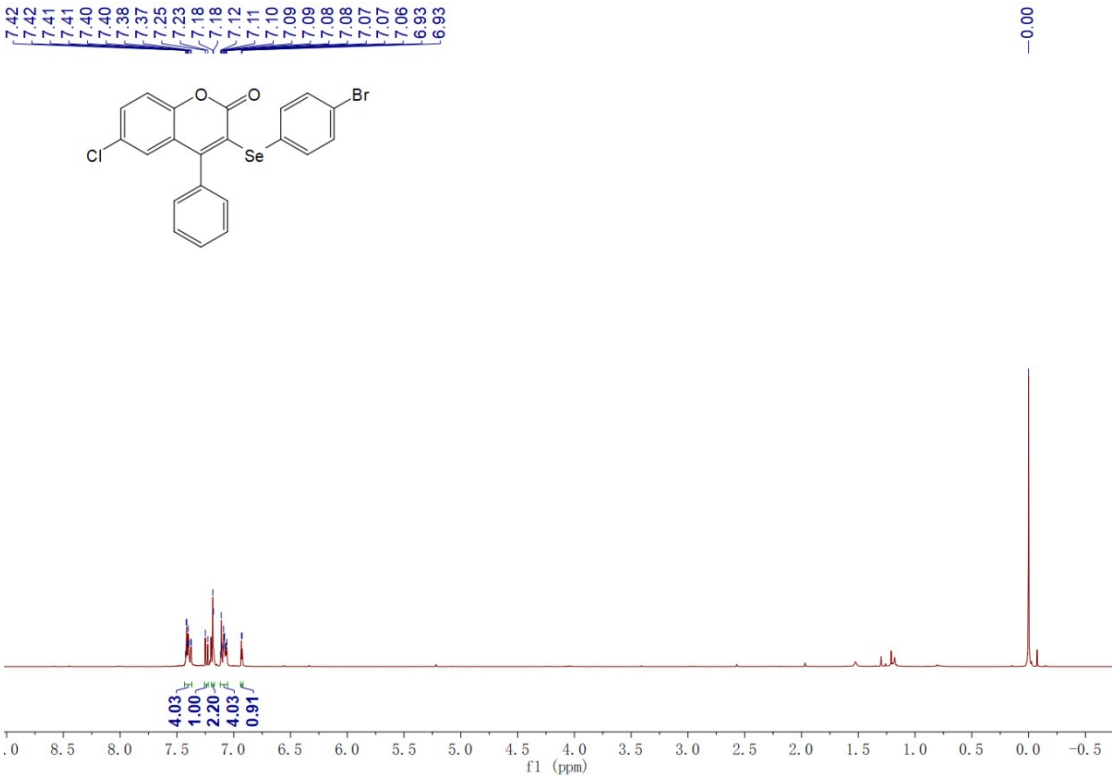

158.87
158.67
158.57
150.56
146.32
135.24
130.48
128.72
128.70
127.80
127.31
127.25
123.76
123.13
119.15
118.80
116.83
115.32
112.18
76.32
76.00
75.68
54.21
33.52
30.14
0.00
O
O
O
Se
f1 (ppm)

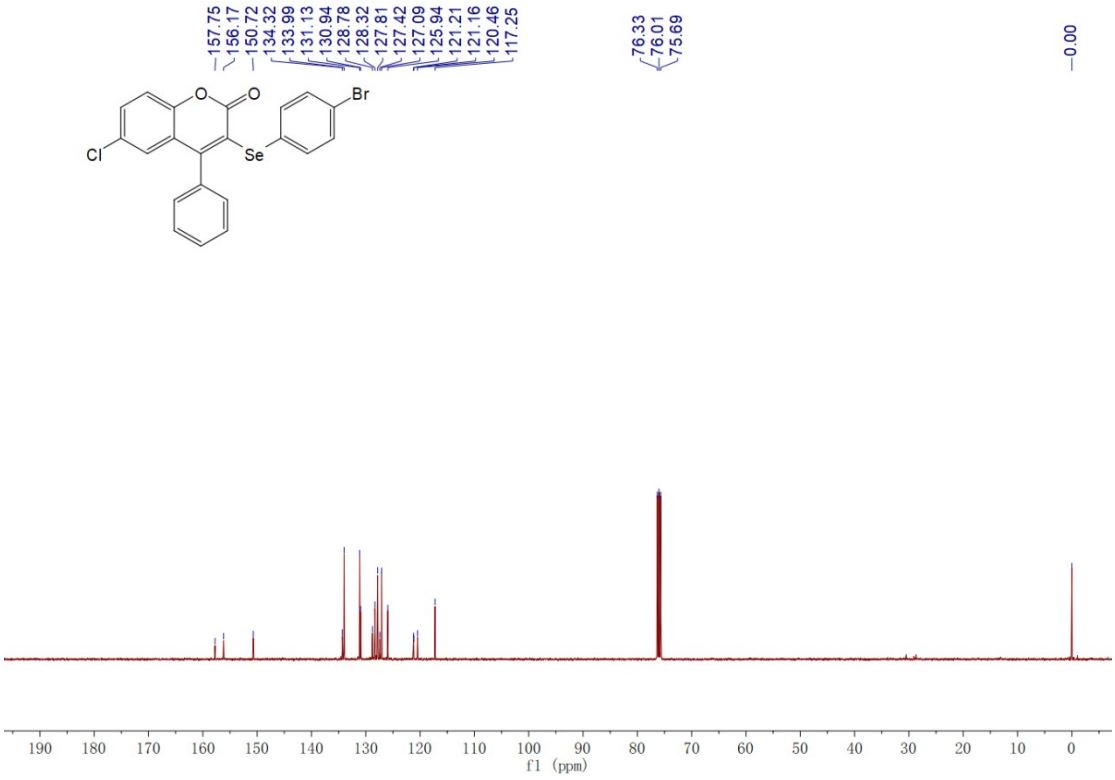
Product 4y


7.44
7.44
7.43
7.42
7.42
7.41
7.40
7.30
7.29
7.28
7.27
7.14
7.12
7.10
7.08
7.08
7.06
7.06
7.04
7.04
7.02
7.02
7.00
7.00
6.99
6.98
6.98
6.96
6.88
6.86
6.86
6.85
6.84
2.33
2.18
0.00
O
O
Se
0.99
1.00
3.13
6.23
1.04
2.95
2.86
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5
f1 (ppm)

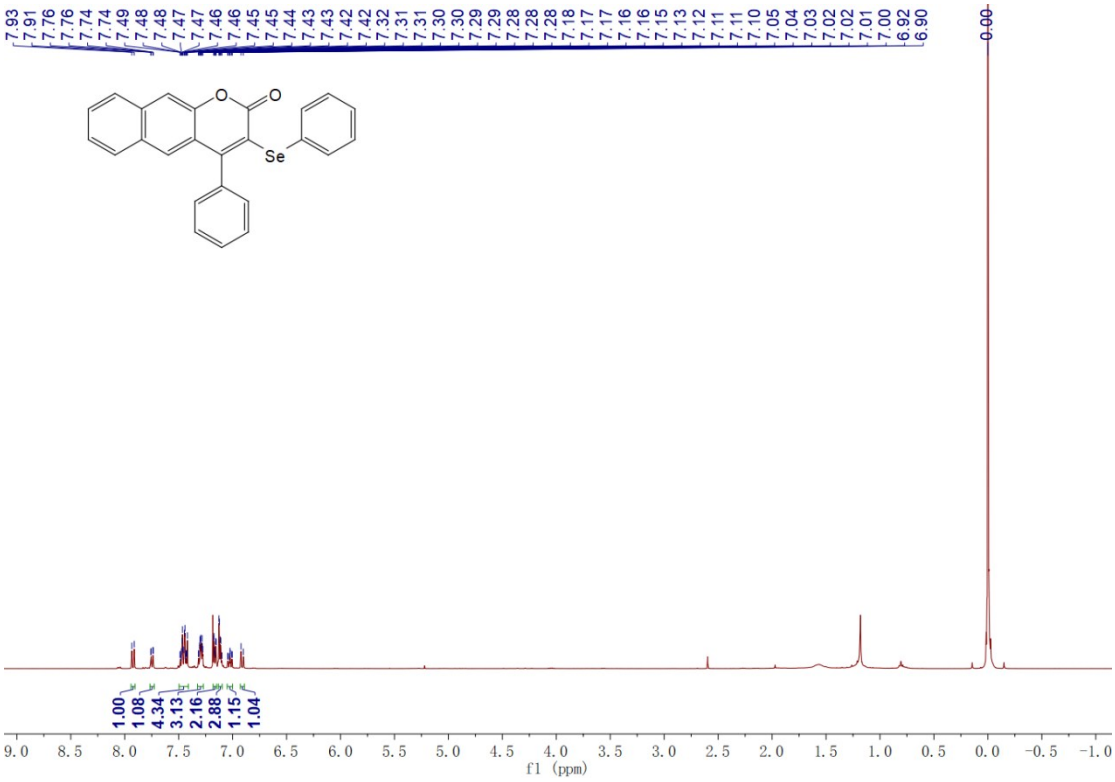

158.31
157.89
152.37
138.24
137.80
132.09
131.69
130.77
130.42
128.91
128.06
126.98
126.80
126.41
125.35
123.14
119.60
119.42
115.73
76.34
76.02
75.70
21.29
20.38
0.00
O
O
Se
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

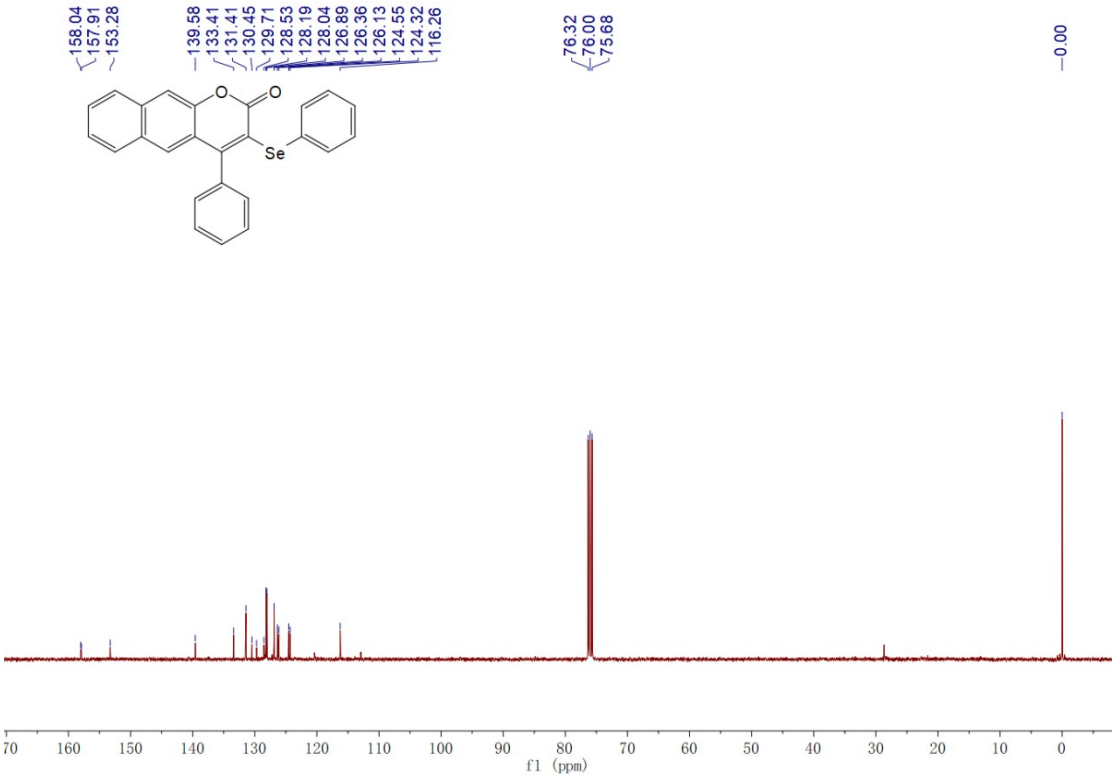
Product 4z


7.42
7.42
7.41
7.41
7.40
7.40
7.38
7.37
7.25
7.23
7.18
7.18
7.12
7.11
7.10
7.09
7.09
7.08
7.08
7.07
7.07
7.06
6.93
6.93
0.00
O
O
Br
Cl
Se
4.03
1.00
2.20
4.03
0.91
f1 (ppm)

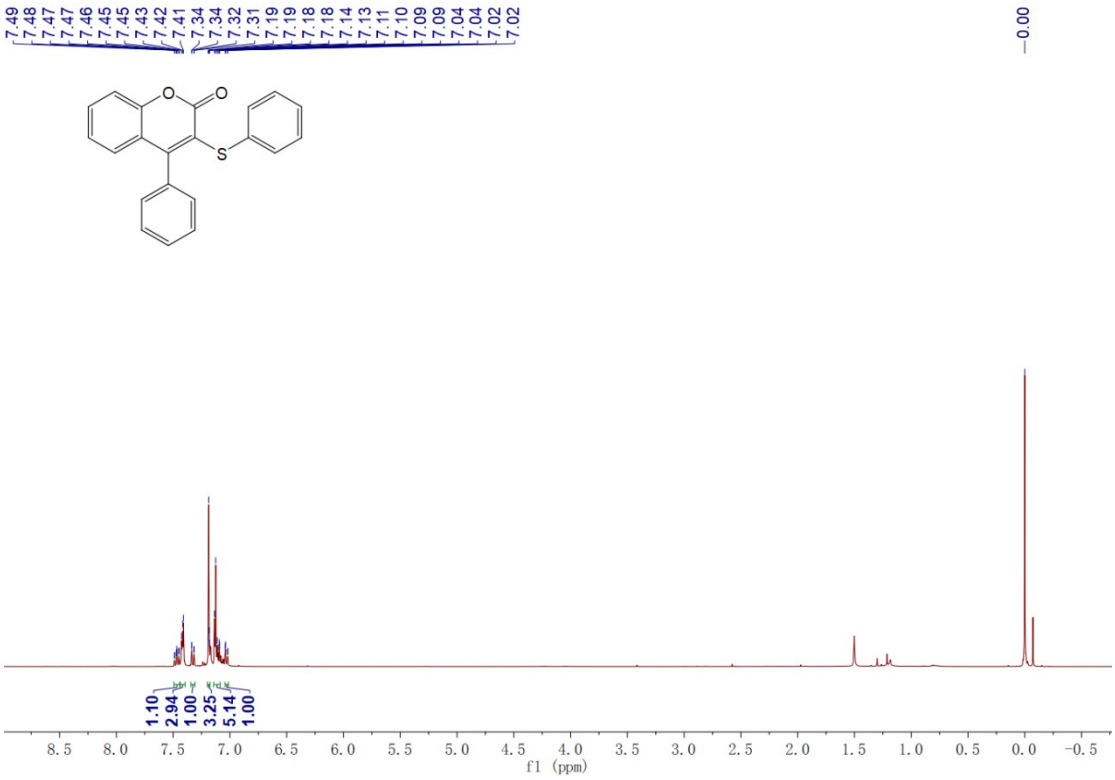

157.75
156.17
150.72
134.32
133.99
131.13
130.94
128.78
128.32
127.81
127.42
127.09
125.94
121.21
121.16
120.46
117.25
76.33
76.01
75.69
0.00
O
O
Br
Cl
Se
f1 (ppm)

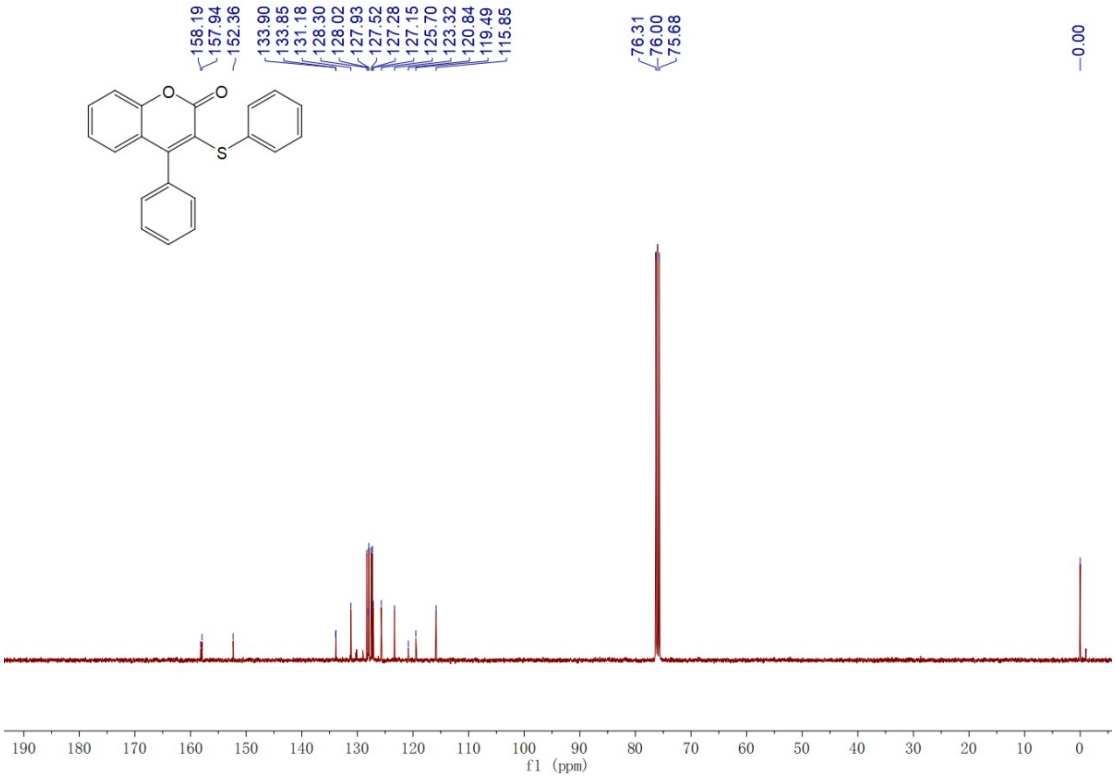
Product 4za


7.93
7.91
7.76
7.76
7.74
7.74
7.49
7.48
7.48
7.47
7.47
7.46
7.46
7.45
7.45
7.44
7.43
7.43
7.42
7.42
7.32
7.31
7.31
7.30
7.30
7.29
7.29
7.28
7.28
7.18
7.17
7.17
7.16
7.16
7.15
7.13
7.12
7.11
7.11
7.10
7.05
7.04
7.03
7.02
7.02
7.01
7.00
6.92
6.90
0.00
O
O
Se
1.00
1.08
4.34
3.13
2.16
2.88
1.15
1.04
f1 (ppm)

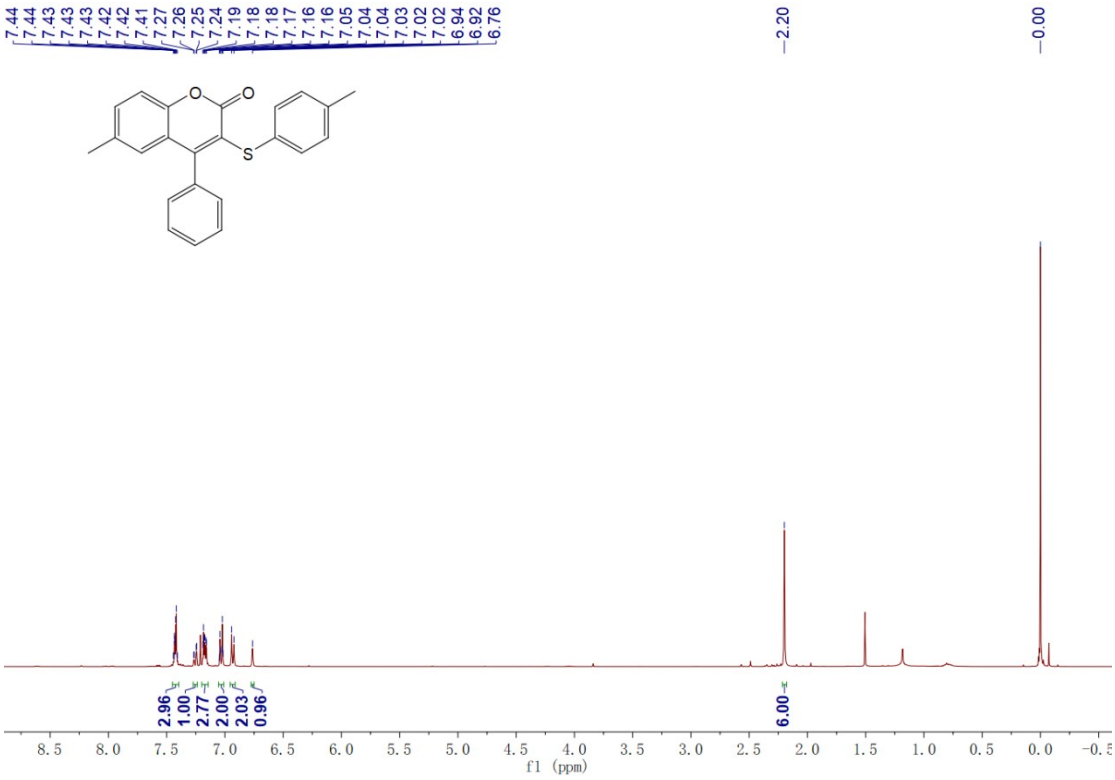

158.04
157.91
153.28
139.58
133.41
131.41
130.45
129.71
128.53
128.19
128.04
126.89
126.36
126.13
124.55
124.32
116.26
76.32
76.00
75.68
0.00
O
O
Se
f1 (ppm)

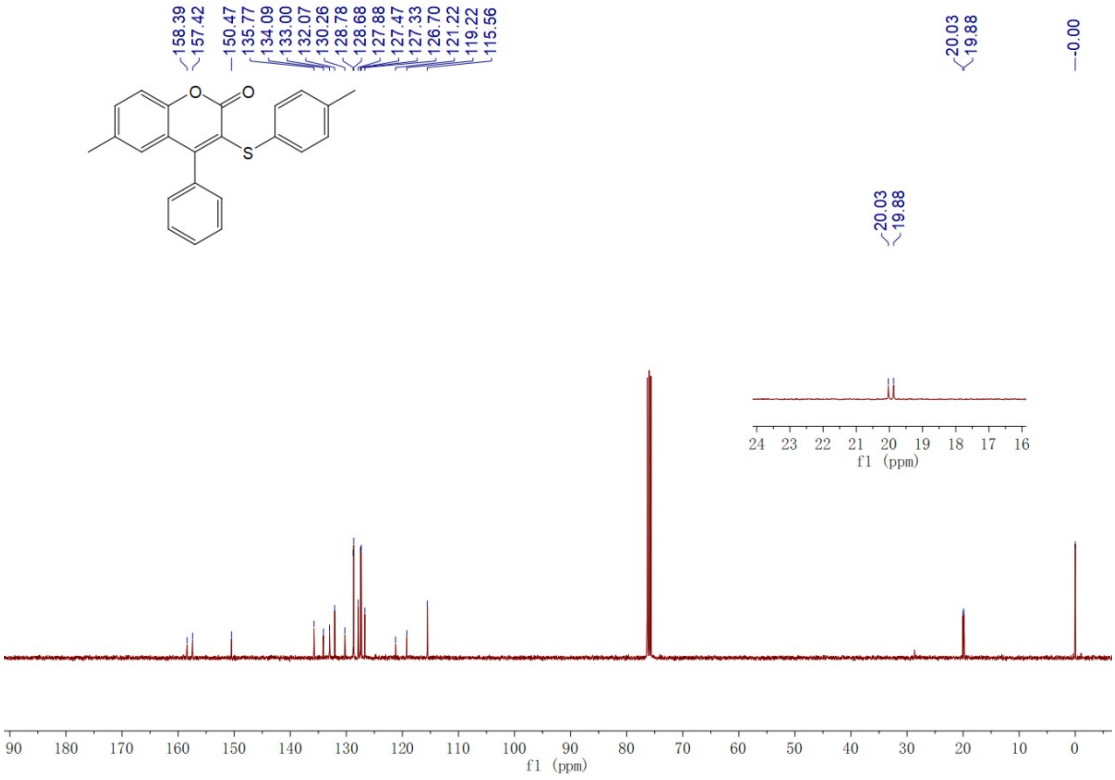
Product 5a


7.49
7.48
7.47
7.47
7.46
7.45
7.45
7.43
7.42
7.41
7.34
7.34
7.32
7.31
7.19
7.19
7.18
7.18
7.14
7.13
7.11
7.10
7.09
7.09
7.04
7.04
7.02
7.02
0.00
O
O
S
1.10
2.94
1.00
3.25
5.14
1.00
f1 (ppm)

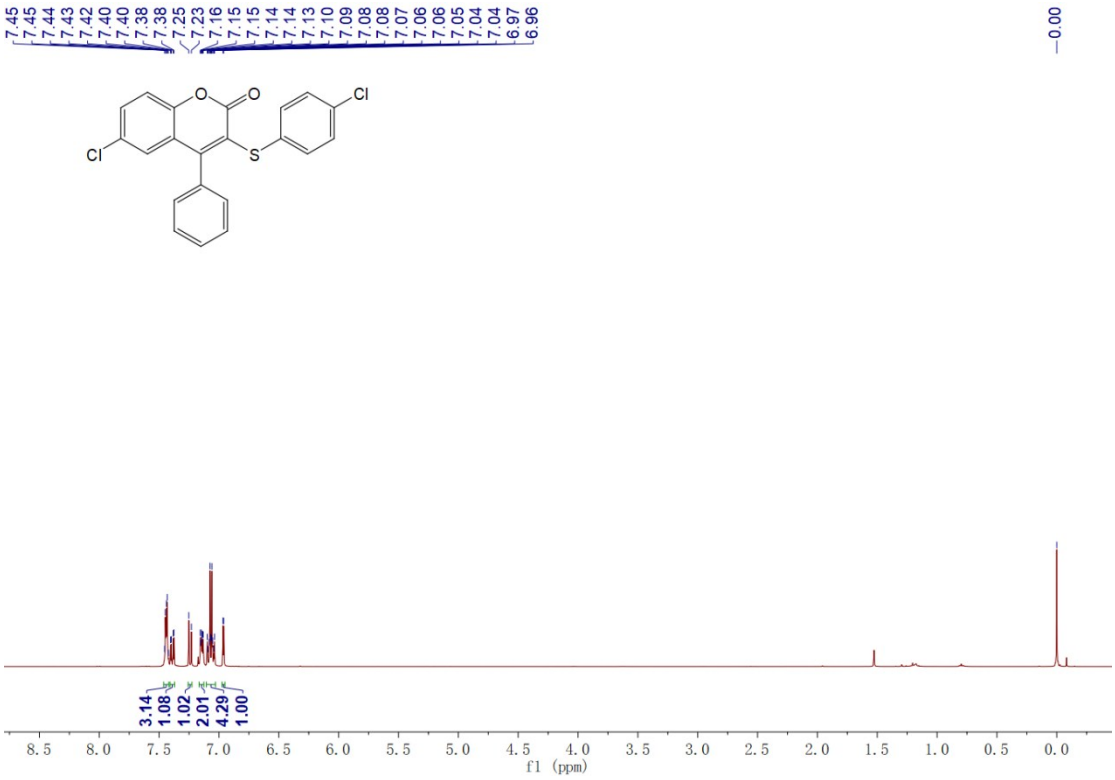

158.19
157.94
152.36
133.90
133.85
131.18
128.30
128.02
127.93
127.52
127.28
127.15
125.70
123.32
120.84
119.49
115.85
76.31
76.00
75.68
0.00
O
O
S
f1 (ppm)

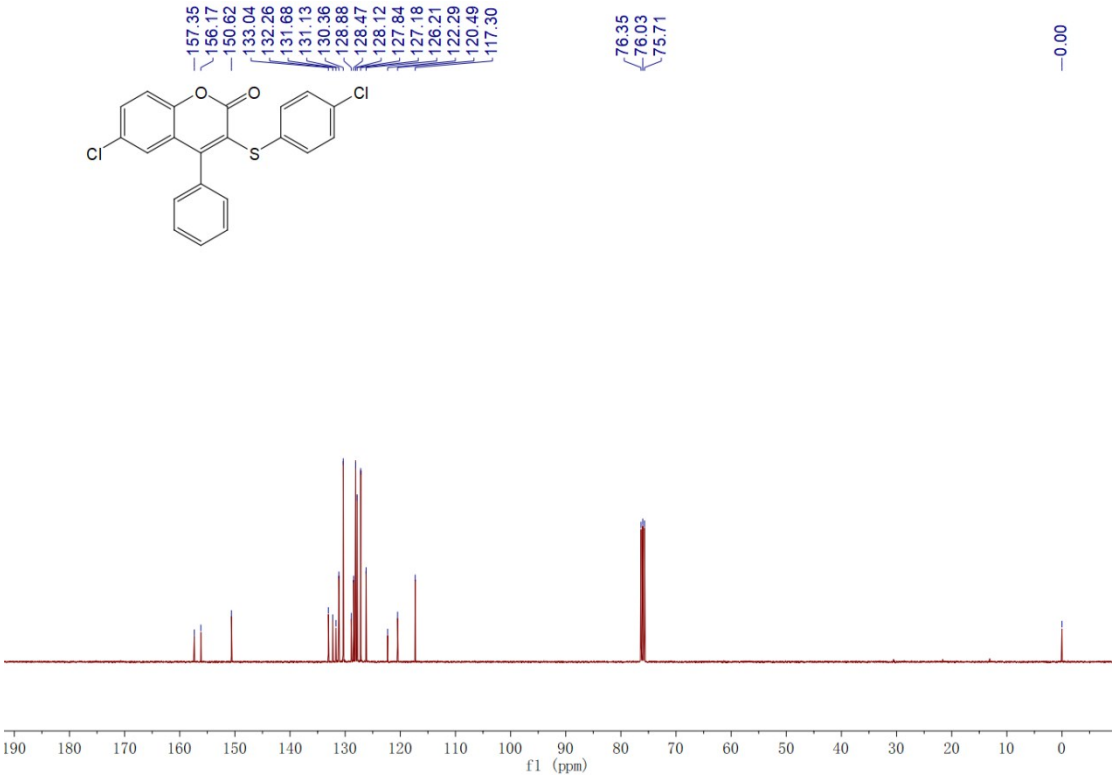
Product 5b


7.44
7.44
7.43
7.43
7.43
7.42
7.42
7.41
7.27
7.26
7.25
7.24
7.19
7.18
7.18
7.17
7.16
7.16
7.05
7.04
7.04
7.03
7.02
7.02
6.94
6.92
6.76
2.20
0.00
O
O
S
2.96
1.00
2.77
2.00
2.03
0.96
6.00
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

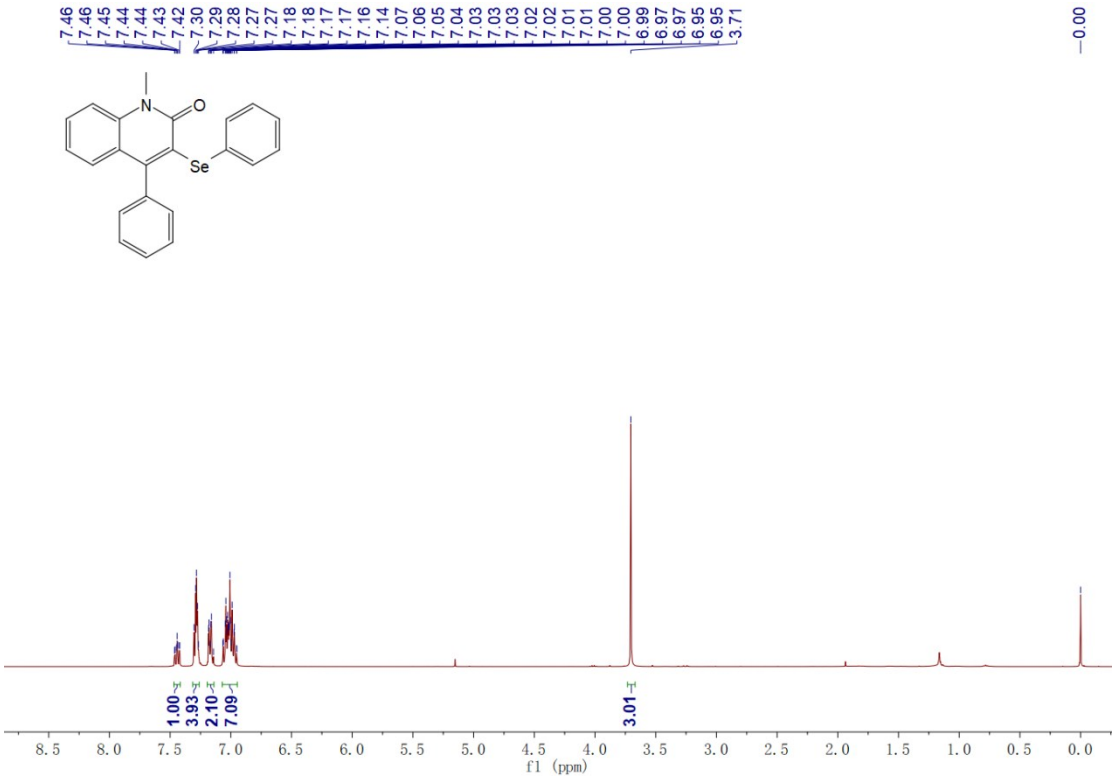

158.39
157.42
150.47
135.77
134.09
133.00
132.07
130.26
128.78
128.68
127.88
127.47
127.33
126.70
121.22
119.22
115.56
20.03
19.88
0.00
O
O
S
20.03
19.88
24 23 22 21 20 19 18 17 16
f1 (ppm)
90 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

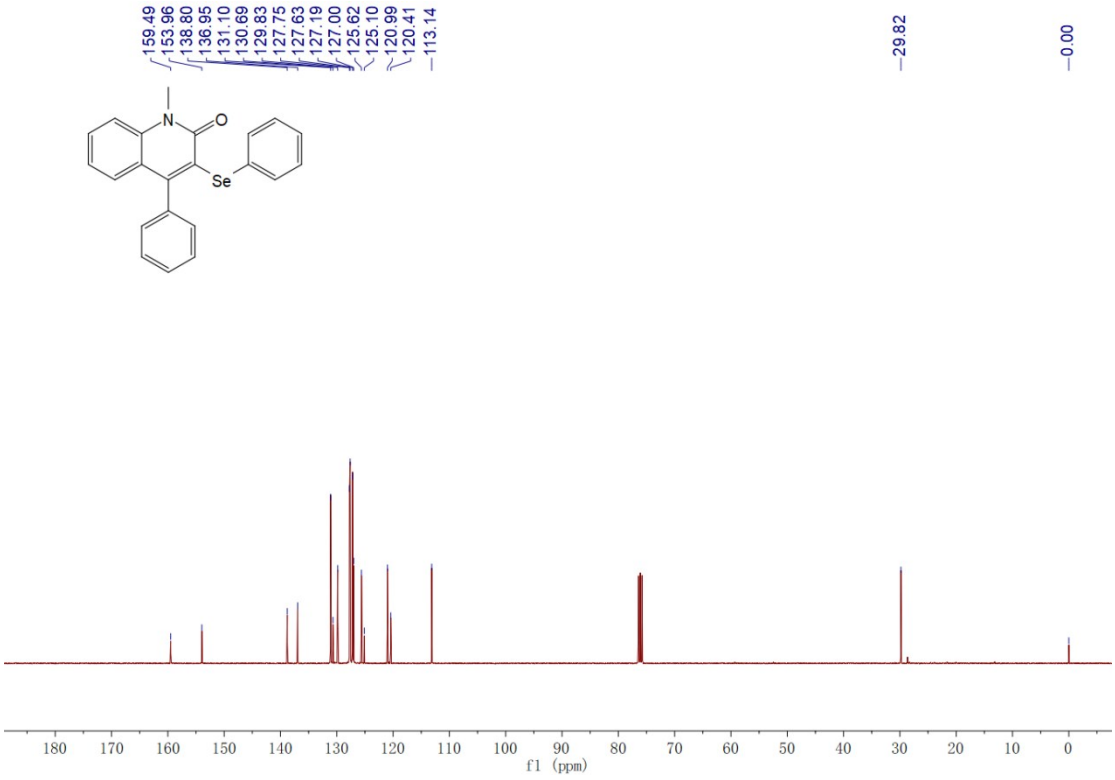
Product 5c


7.45
7.45
7.44
7.43
7.42
7.40
7.40
7.38
7.25
7.23
7.16
7.15
7.15
7.14
7.14
7.13
7.10
7.09
7.08
7.08
7.07
7.06
7.06
7.05
7.04
7.04
6.97
6.96
0.00
O
O
Cl
Cl
S
3.14
1.08
1.02
2.01
4.29
1.00
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

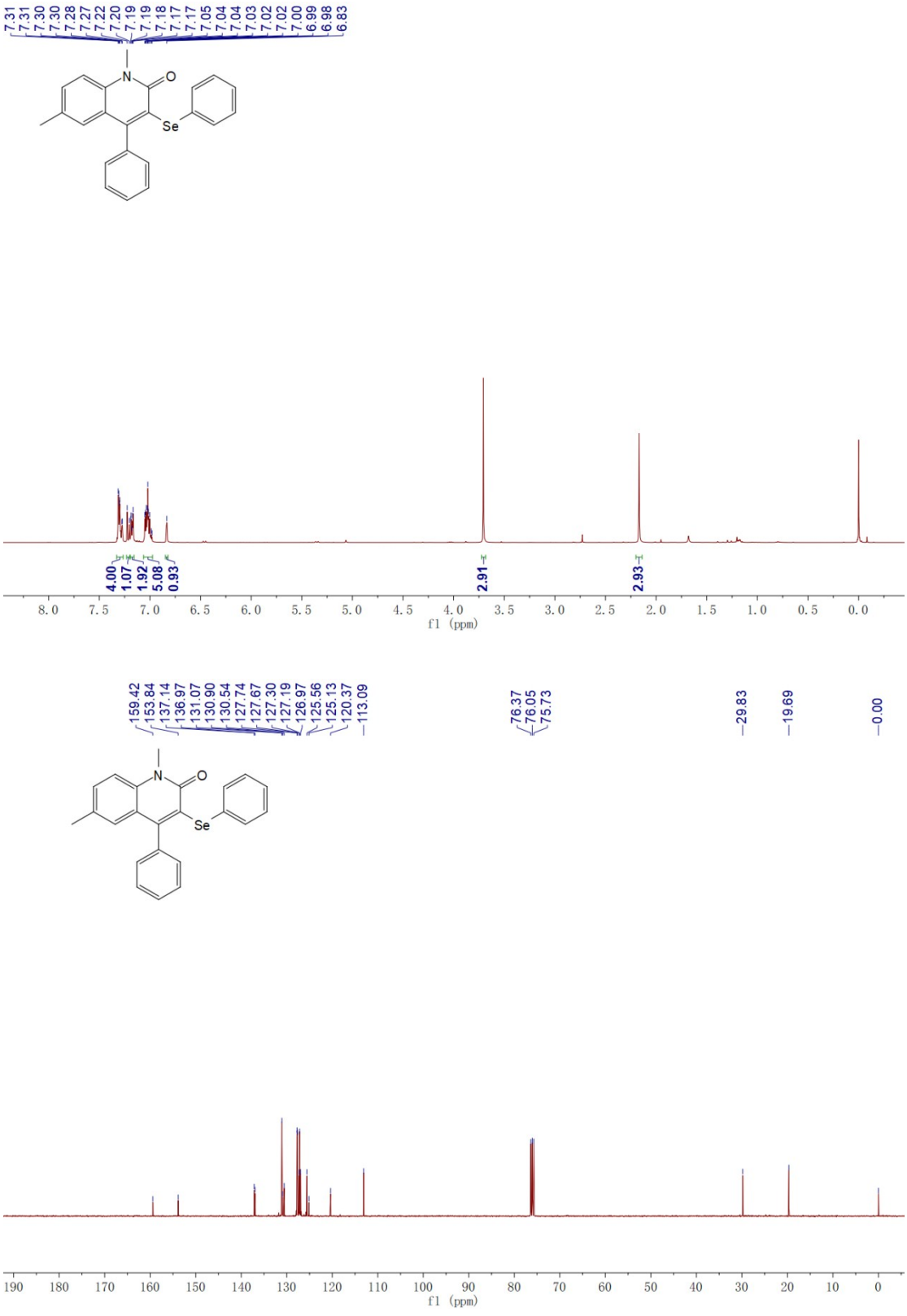

157.35
156.17
150.62
133.04
132.26
131.68
131.13
130.36
128.88
128.47
128.12
127.84
127.18
126.21
122.29
120.49
117.30
76.35
76.03
75.71
0.00
O
O
Cl
Cl
S
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Product 7a

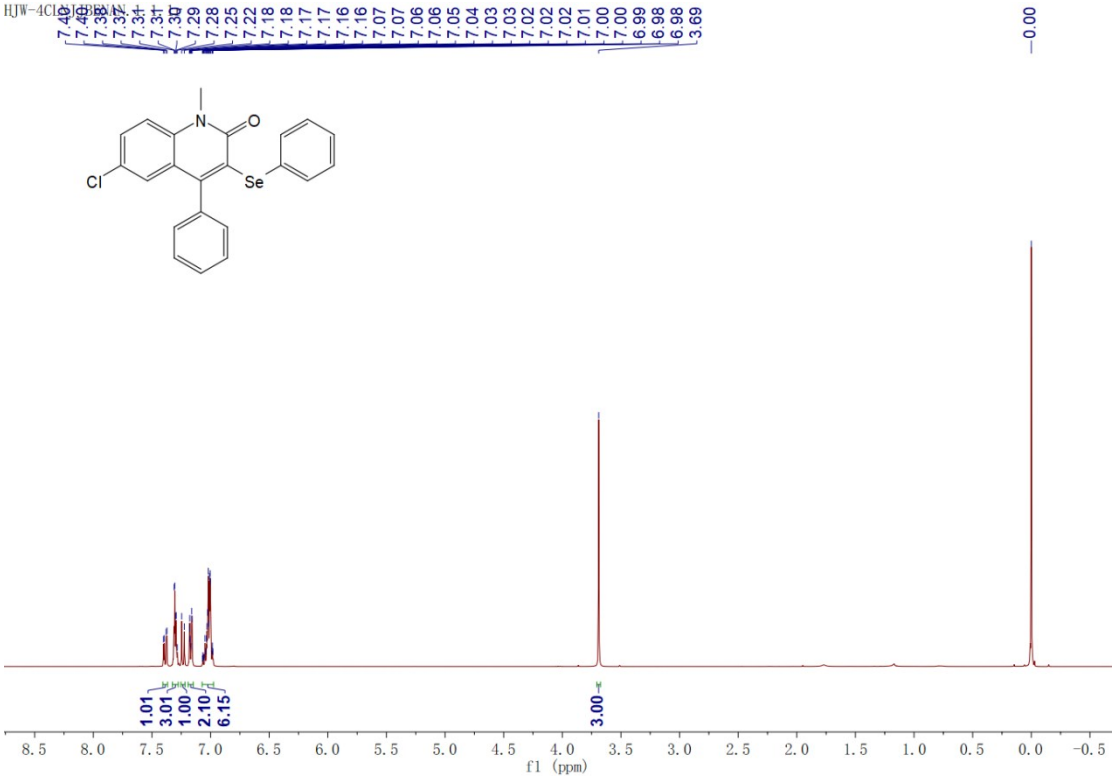

7.46
7.46
7.45
7.44
7.44
7.43
7.42
7.30
7.29
7.28
7.27
7.27
7.18
7.18
7.17
7.17
7.16
7.14
7.07
7.06
7.05
7.04
7.03
7.03
7.03
7.02
7.02
7.01
7.01
7.00
7.00
6.99
6.97
6.97
6.95
6.95
3.71
0.00
N
O
Se
1.00
3.93
2.10
7.09
3.01
f1 (ppm)

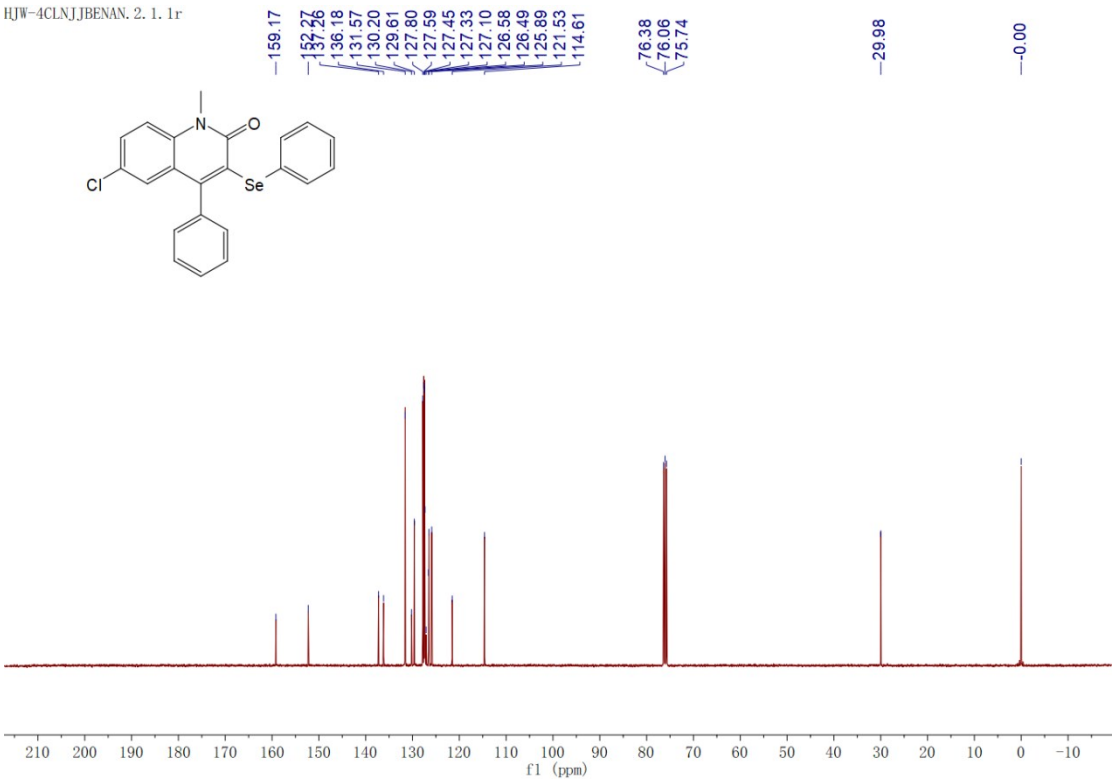

159.49
153.96
138.80
136.95
131.10
130.69
129.83
127.75
127.63
127.19
127.00
125.62
125.10
120.99
120.41
113.14
29.82
0.00
N
O
Se
f1 (ppm)

Product 7b

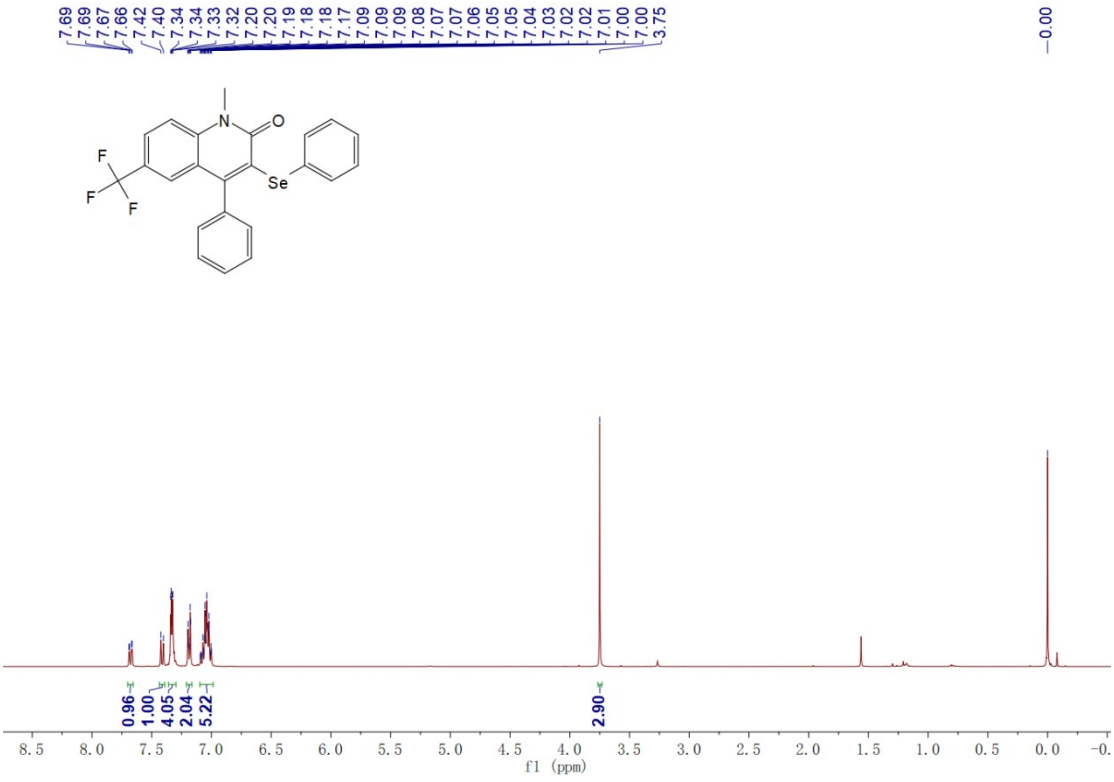

7.31
7.31
7.30
7.30
7.28
7.27
7.22
7.20
7.19
7.19
7.18
7.17
7.17
7.05
7.04
7.04
7.03
7.02
7.02
7.00
6.99
6.98
6.83
N
O
Se
4.00
1.07
1.92
5.08
0.93
2.91
2.93
f1 (ppm)
159.42
153.84
137.14
136.97
131.07
130.90
130.54
127.74
127.67
127.30
127.19
126.97
125.56
125.13
120.37
113.09
76.37
76.05
75.73
29.83
19.69
0.00
f1 (ppm)

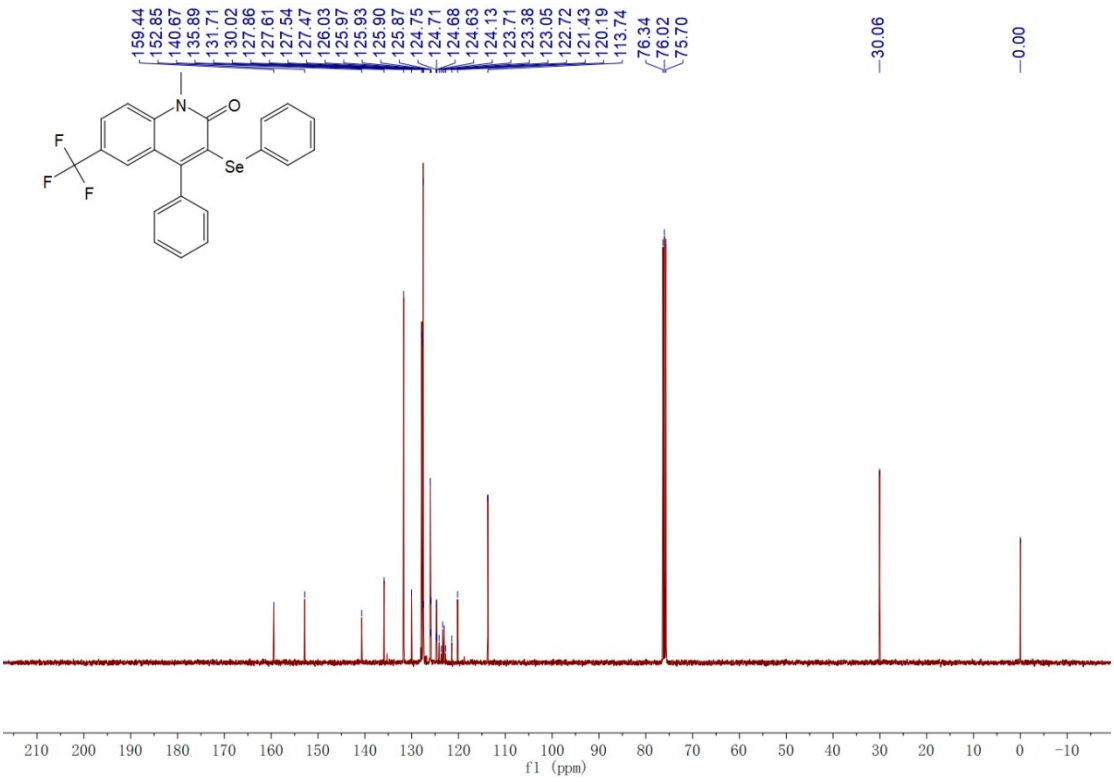
Product 7c


7.40
7.40
7.38
7.37
7.34
7.31
7.30
7.29
7.28
7.25
7.22
7.18
7.18
7.17
7.17
7.16
7.16
7.07
7.07
7.06
7.06
7.05
7.04
7.03
7.03
7.02
7.02
7.02
7.01
7.00
7.00
6.99
6.98
6.98
3.69
0.00
N
O
Cl
Se
1.01
3.01
1.00
2.10
6.15
3.00
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

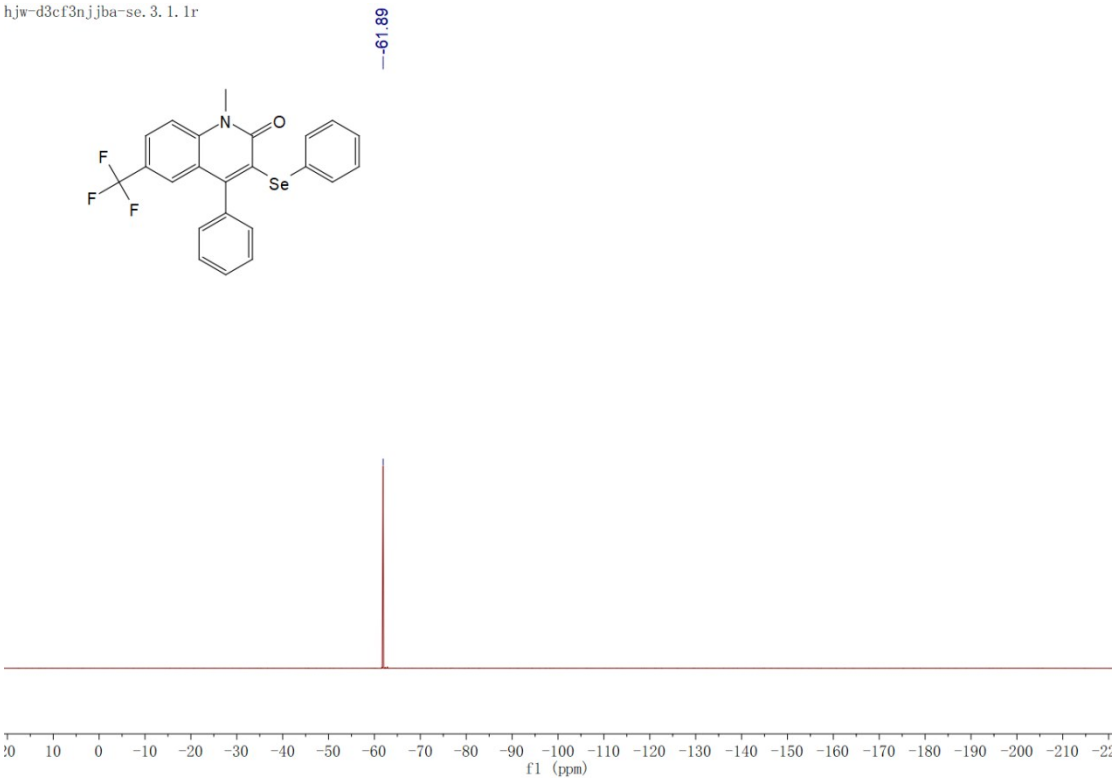

HJW-4CLNJJBENAN.2.1.1r
159.17
152.27
137.26
136.18
131.57
130.20
129.61
127.80
127.59
127.45
127.33
127.10
126.58
126.49
125.89
121.53
114.61
76.38
76.06
75.74
29.98
0.00
N
O
Cl
Se
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Product 7d

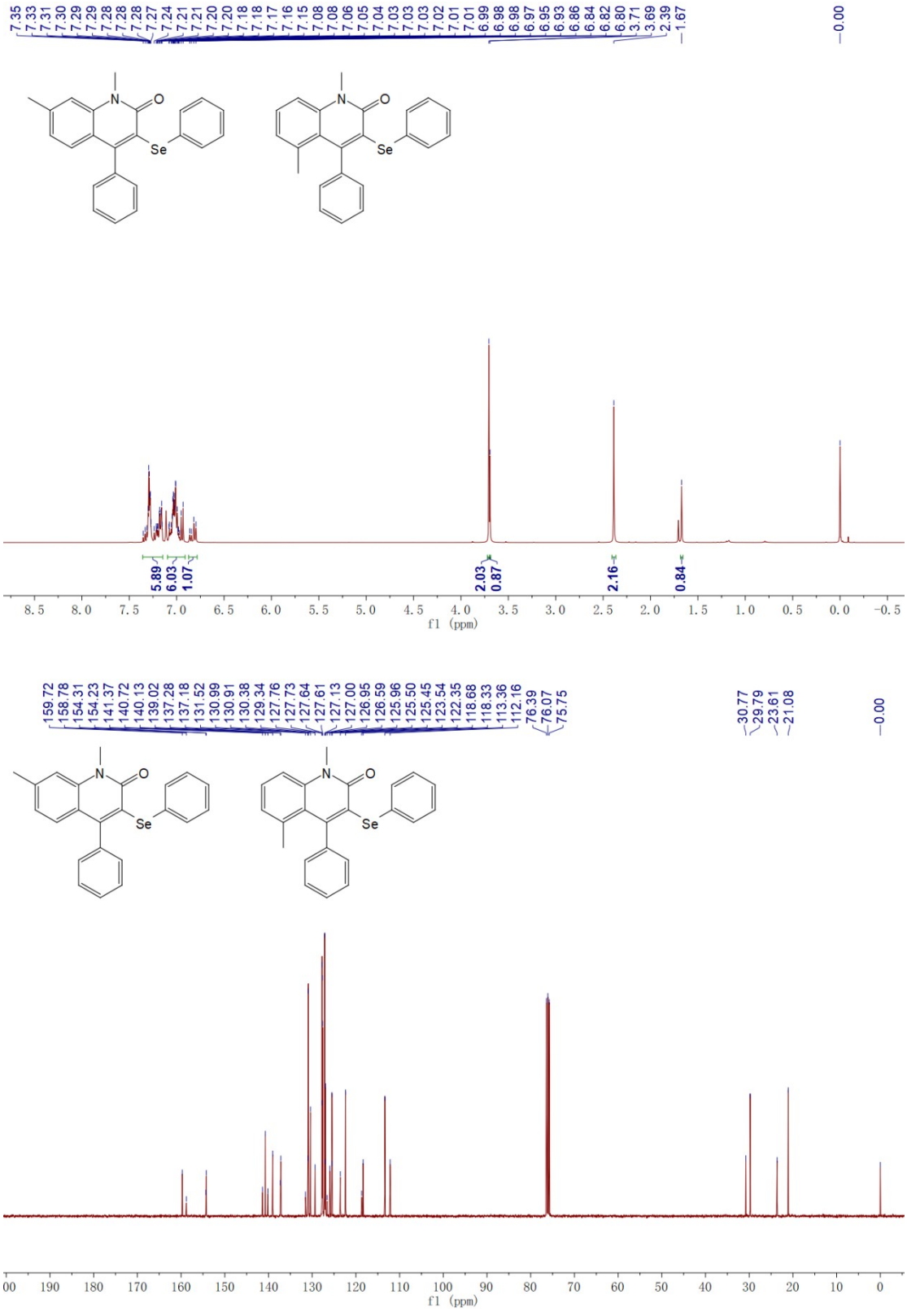

7.69
7.69
7.67
7.66
7.42
7.40
7.34
7.34
7.33
7.32
7.20
7.20
7.19
7.18
7.18
7.17
7.09
7.09
7.09
7.08
7.07
7.07
7.06
7.05
7.05
7.04
7.03
7.02
7.02
7.01
7.00
7.00
7.00
3.75
0.00
N
O
F
F
F
Se
0.96
1.00
4.05
2.04
5.22
2.90
f1 (ppm)


159.44
152.85
140.67
135.89
131.71
130.02
127.86
127.61
127.54
127.47
126.03
125.97
125.93
125.90
125.87
124.75
124.71
124.68
124.63
124.13
123.71
123.38
123.05
122.72
121.43
120.19
113.74
76.34
76.02
75.70
30.06
0.00
N
O
F
F
F
Se
f1 (ppm)

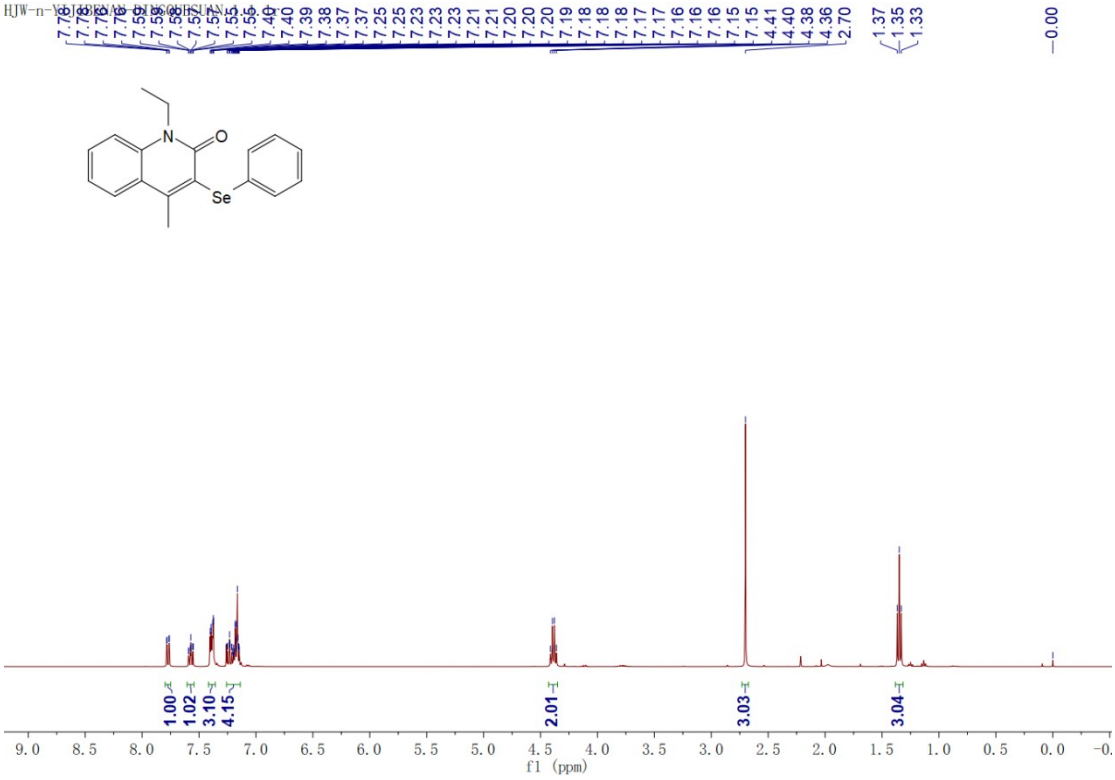
hjw-d3cf3njjba-se.3.1.1r

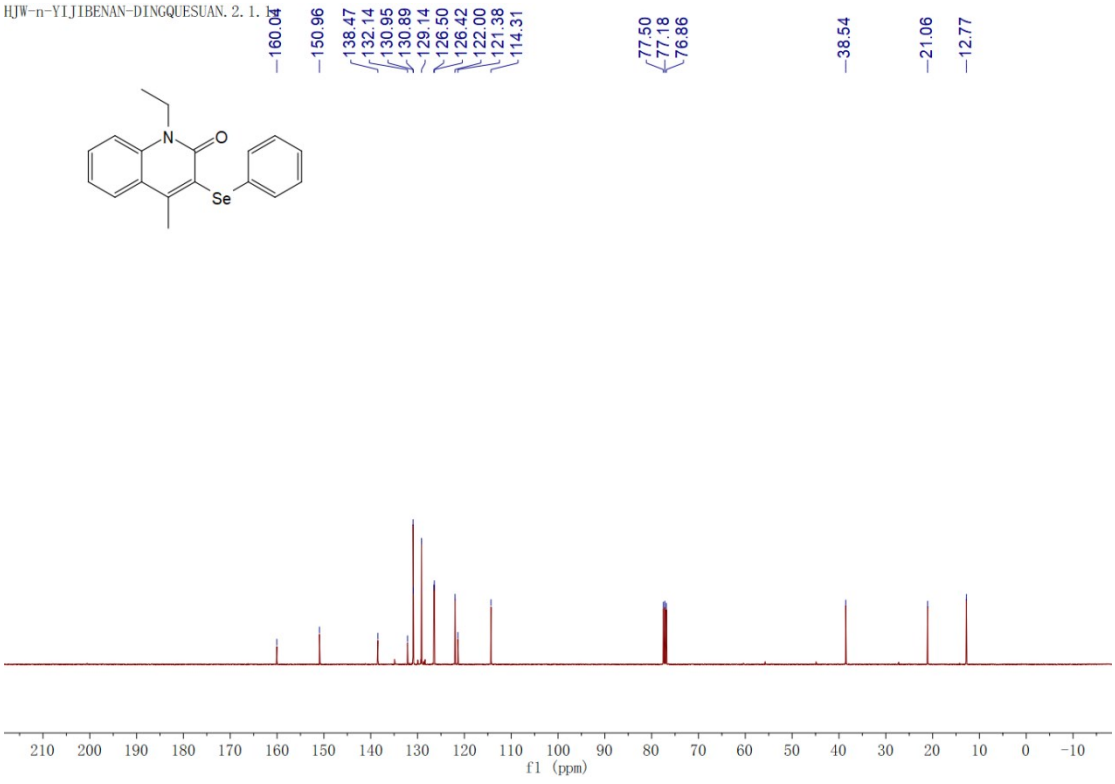


Product 7e

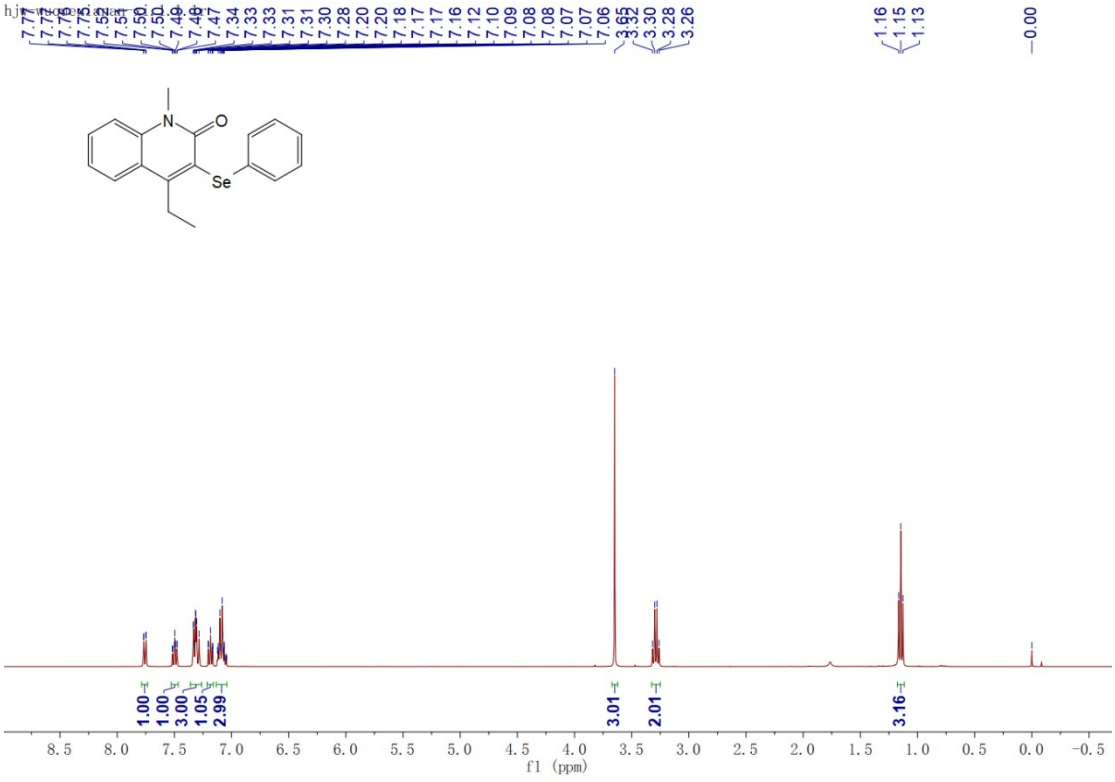

7.35 7.33 7.31 7.30 7.29 7.29 7.28 7.28 7.28 7.27 7.24 7.21 7.21 7.20 7.20 7.18 7.18 7.17 7.16 7.15 7.08 7.08 7.06 7.05 7.04 7.03 7.03 7.03 7.02 7.01 7.01 6.99 6.98 6.98 6.97 6.95 6.93 6.86 6.84 6.82 6.80 3.71 3.69 2.39 1.67
0.00
N
O
Se
5.89
6.03
1.07
2.03
0.87
2.16
0.84
f1 (ppm)
159.72 158.78 154.31 154.23 141.37 140.72 140.13 139.02 137.28 137.18 131.52 130.99 130.91 130.38 129.34 127.76 127.73 127.64 127.61 127.13 127.00 126.95 126.59 125.96 125.50 125.45 123.54 122.35 118.68 118.33 113.36 112.16 76.39 76.07 75.75
30.77 29.79 23.61 21.08
0.00
f1 (ppm)

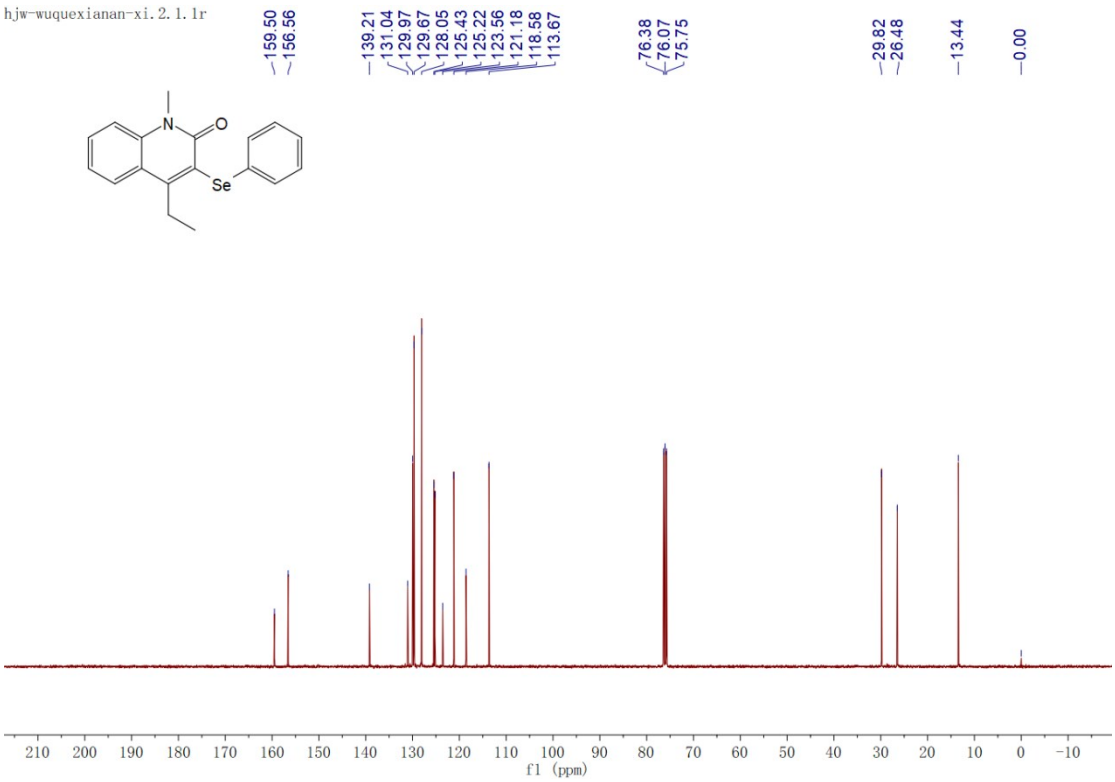
Product 7g


7.78 7.77 7.76 7.59 7.58 7.57 7.55 7.56 7.40 7.39 7.38 7.37 7.37 7.25 7.25 7.23 7.23 7.23 7.21 7.21 7.20 7.20 7.20 7.19 7.18 7.18 7.18 7.17 7.17 7.16 7.16 7.16 7.15 7.15 4.41 4.40 4.38 4.36 2.70 1.37 1.35 1.33 0.00
N
O
Se
1.00 1.02 3.10 4.15 2.01 3.03 3.04
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

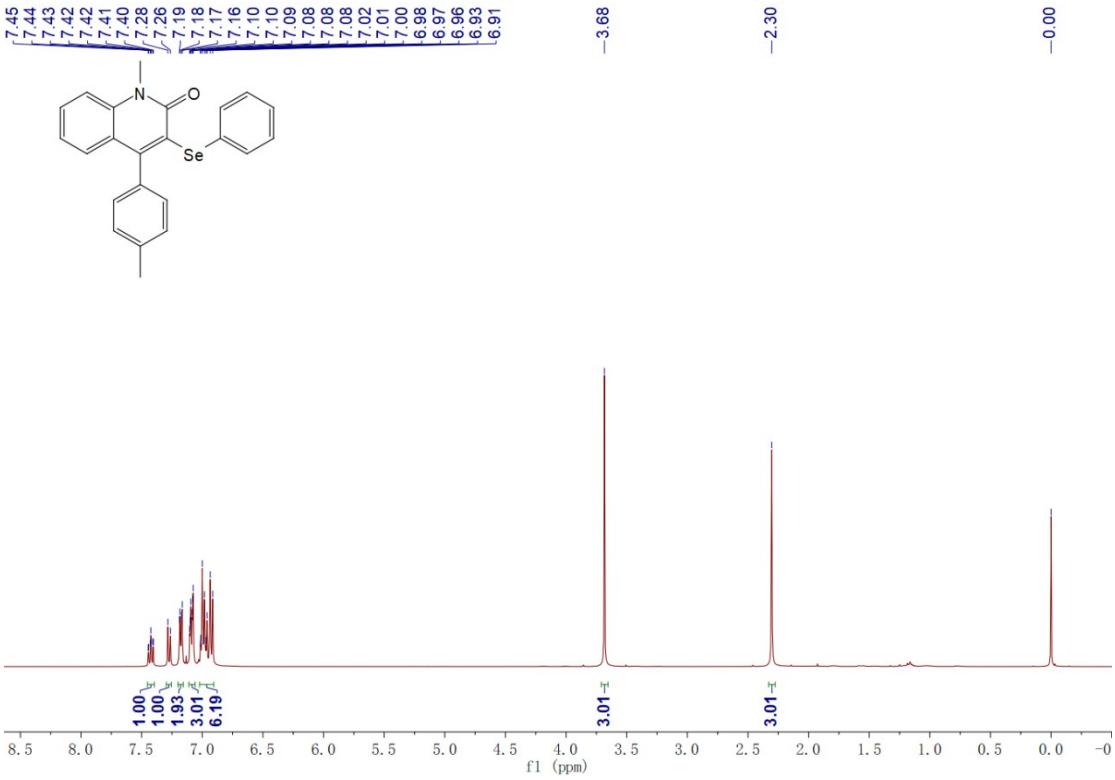

HJW-n-YIJIBENAN-DINGQUESUAN.2.1.1r
160.04 150.96 138.47 132.14 130.95 130.89 129.14 126.50 126.42 122.00 121.38 114.31 77.50 77.18 76.86 38.54 21.06 12.77
N
O
Se
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

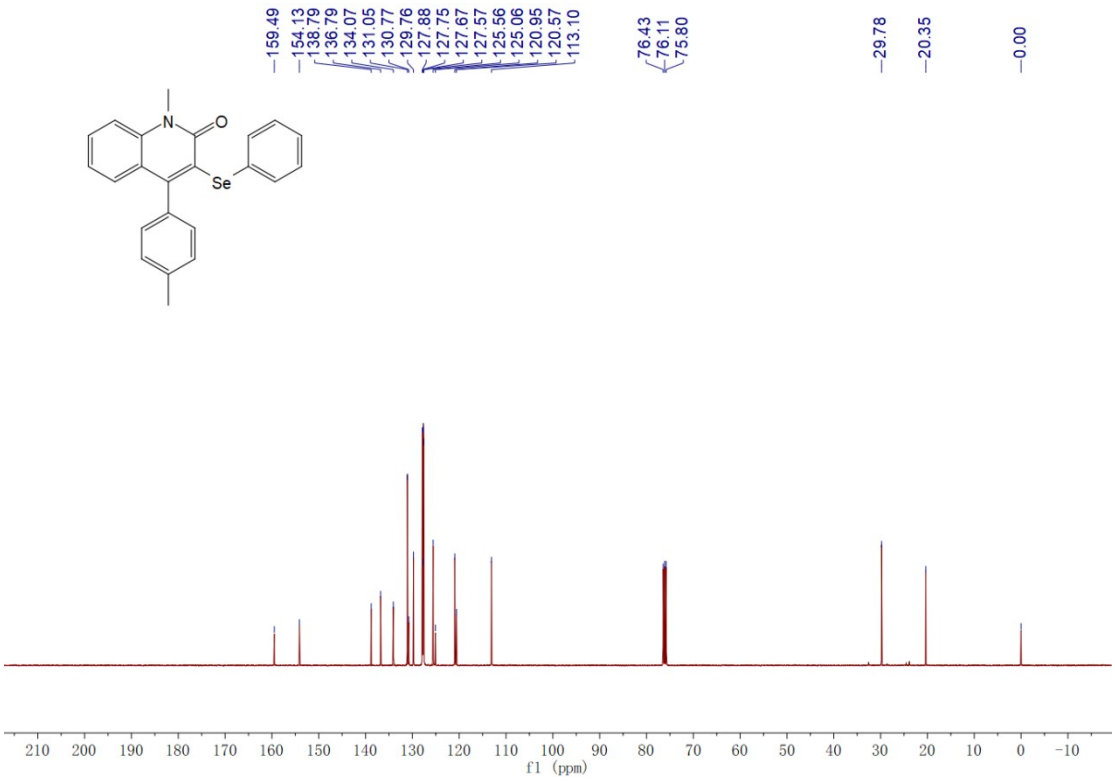
Product 7h


7.77
7.74
7.76
7.75
7.52
7.53
7.50
7.50
7.49
7.48
7.47
7.34
7.33
7.31
7.31
7.30
7.28
7.20
7.20
7.18
7.17
7.17
7.16
7.12
7.10
7.09
7.08
7.08
7.07
7.07
7.06
3.32
3.30
3.28
3.26
1.16
1.15
1.13
0.00
N
O
Se
1.00
1.00
3.00
1.05
2.99
3.01
2.01
3.16
f1 (ppm)

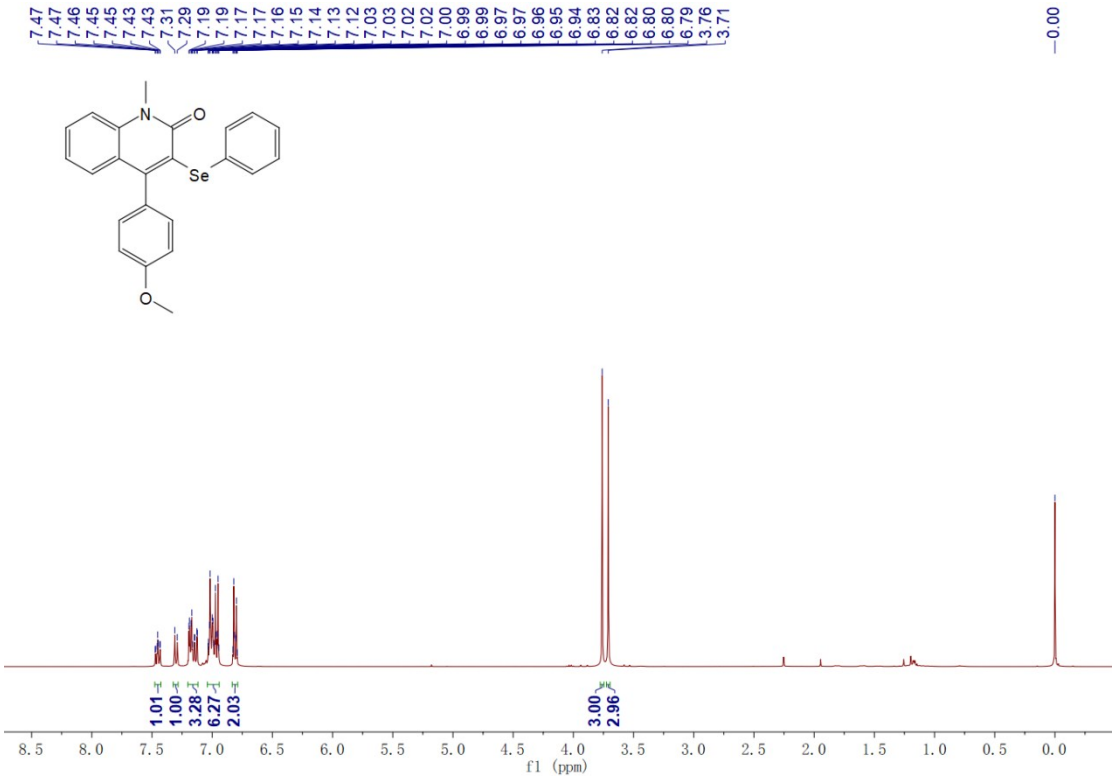

hjw-wuquexianan-xi.2.1.1r
159.50
156.56
139.21
131.04
129.97
129.67
128.05
125.43
125.22
123.56
121.18
118.58
113.67
76.38
76.07
75.75
29.82
26.48
13.44
0.00
N
O
Se
f1 (ppm)

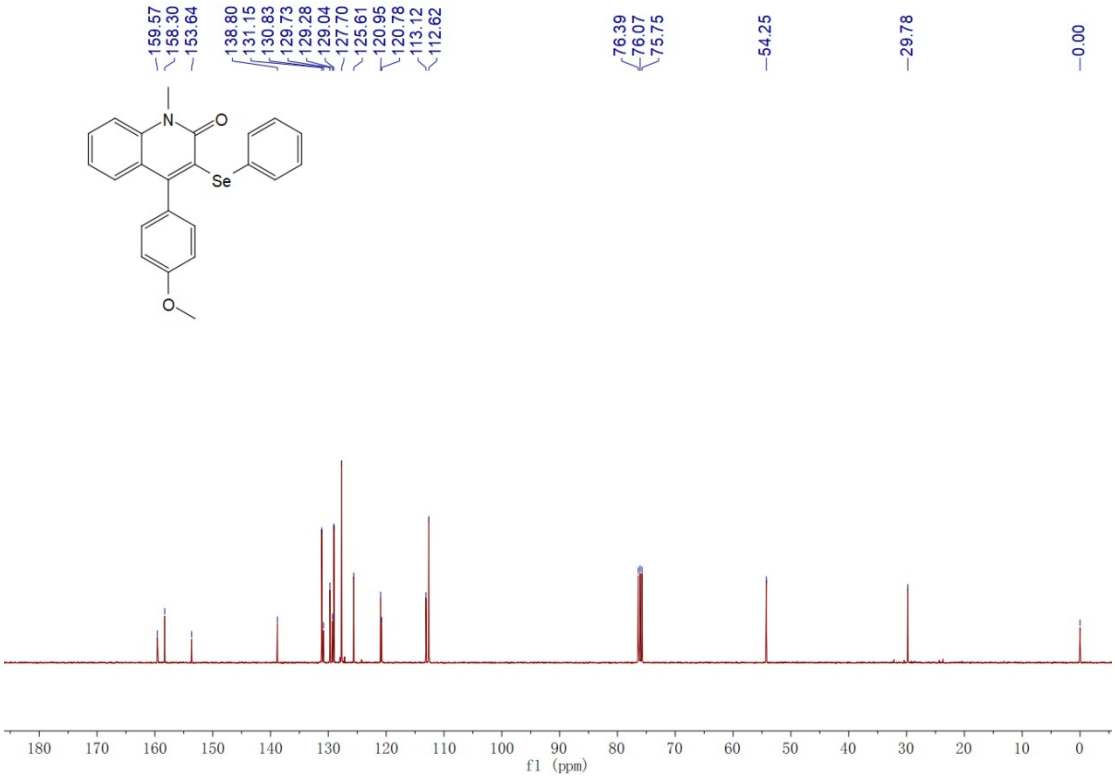
Product 7i


7.45
7.44
7.43
7.42
7.42
7.41
7.40
7.28
7.26
7.19
7.18
7.17
7.16
7.10
7.10
7.09
7.08
7.08
7.02
7.01
7.00
6.98
6.97
6.96
6.93
6.91
3.68
2.30
0.00
N
O
Se
1.00
1.00
1.93
3.01
6.19
3.01
3.01
f1 (ppm)

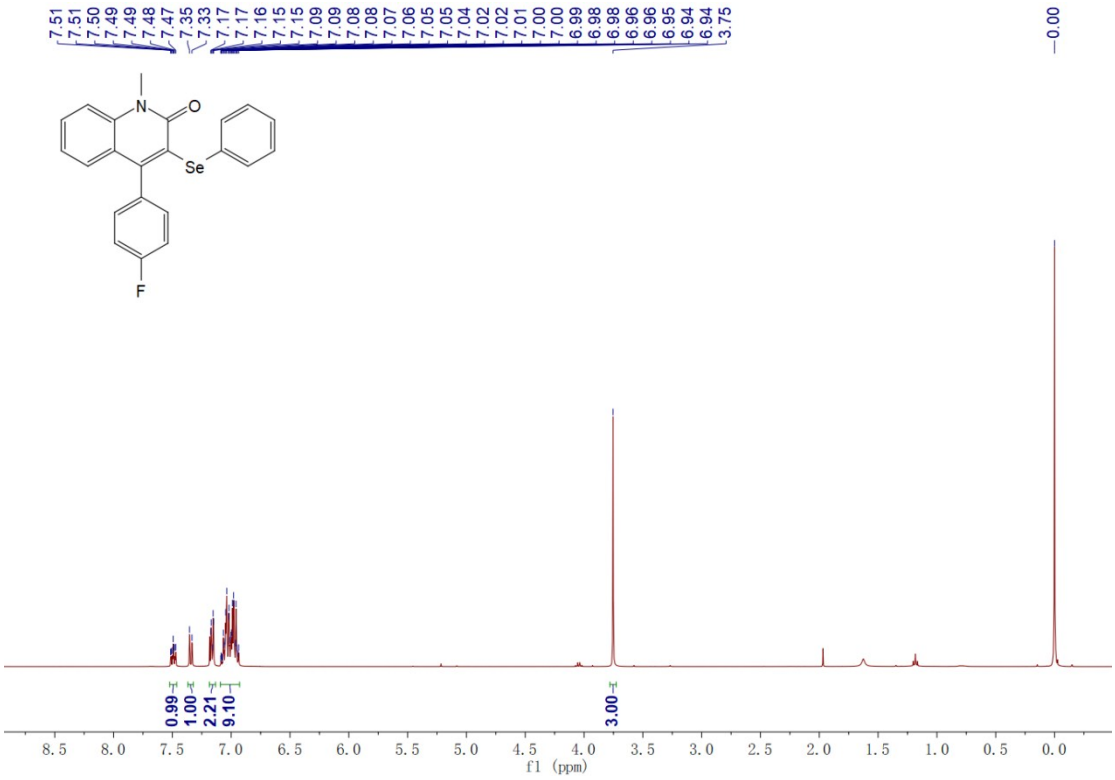

159.49
154.13
138.79
136.79
134.07
131.05
130.77
129.76
127.88
127.75
127.67
127.57
125.56
125.06
120.95
120.57
113.10
76.43
76.11
75.80
29.78
20.35
0.00
N
O
Se
f1 (ppm)

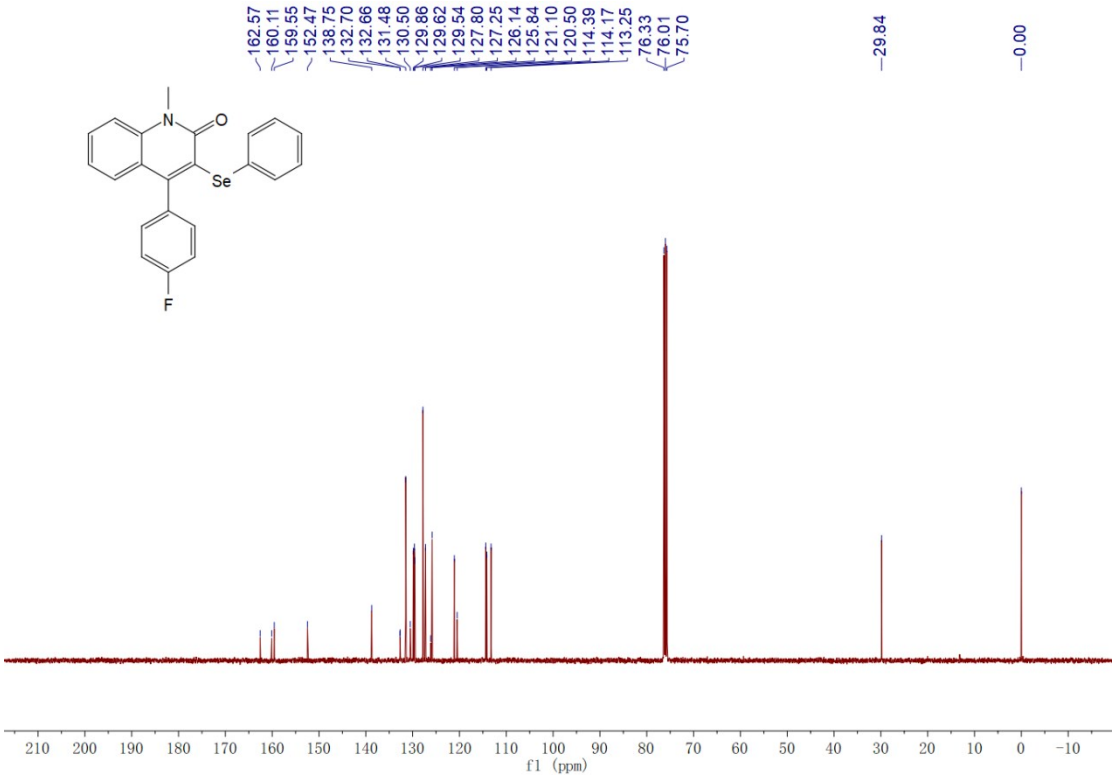
Product 7j


7.47
7.47
7.46
7.45
7.45
7.43
7.43
7.31
7.29
7.19
7.19
7.17
7.17
7.16
7.15
7.14
7.13
7.12
7.03
7.03
7.02
7.02
7.00
6.99
6.99
6.97
6.97
6.96
6.95
6.94
6.83
6.82
6.82
6.80
6.80
6.79
3.76
3.71
0.00
N
O
Se
O
1.01
1.00
3.28
6.27
2.03
3.00
2.96
f1 (ppm)

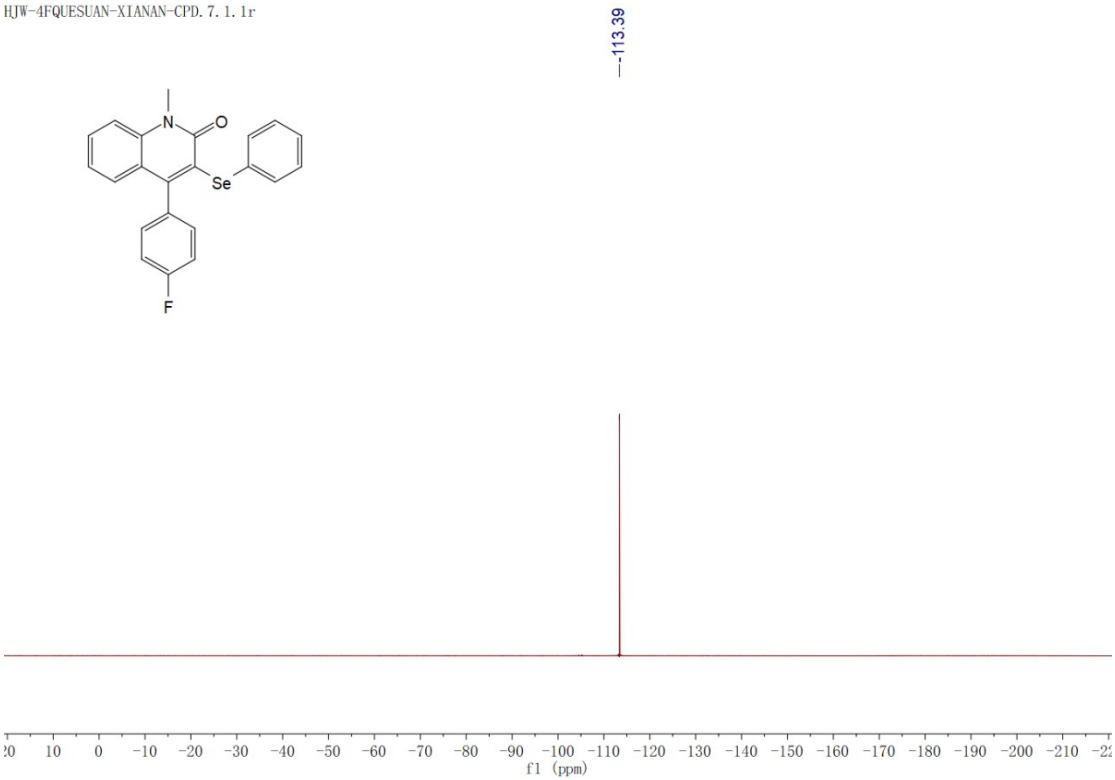

159.57
158.30
153.64
138.80
131.15
130.83
129.73
129.28
129.04
127.70
125.61
120.95
120.78
113.12
112.62
76.39
76.07
75.75
54.25
29.78
0.00
N
O
Se
O
f1 (ppm)

Product 7k

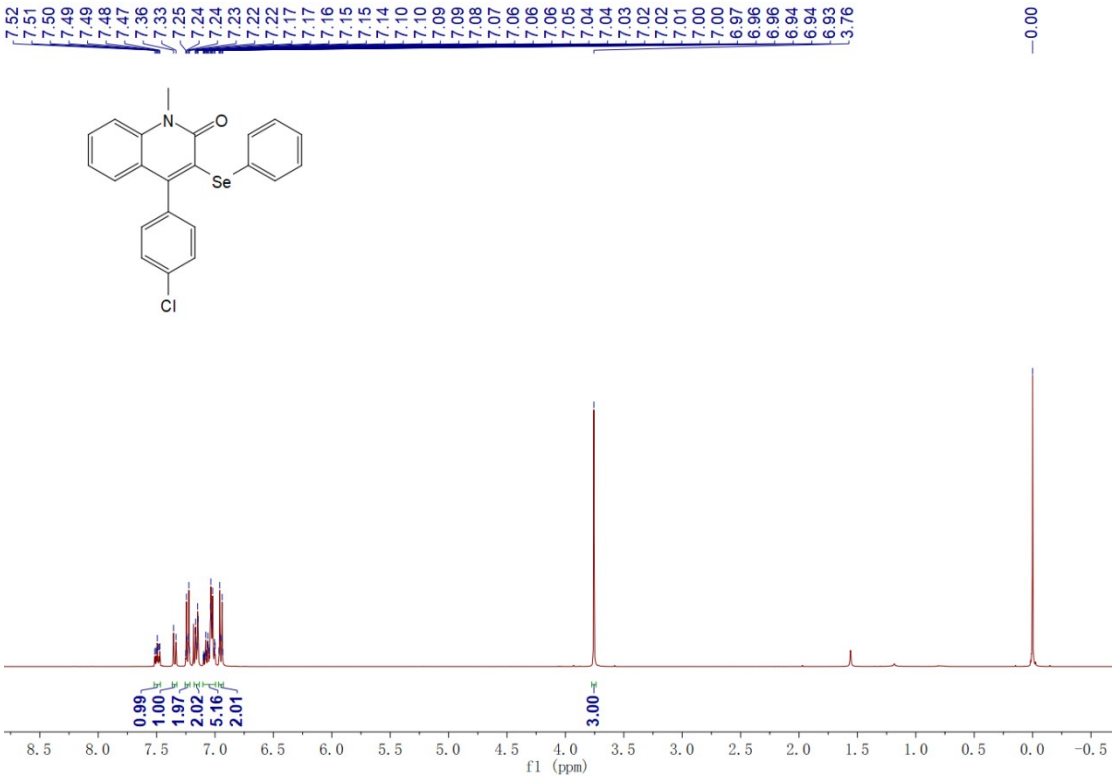

7.51
7.51
7.50
7.49
7.49
7.48
7.47
7.35
7.33
7.17
7.17
7.16
7.15
7.15
7.09
7.09
7.08
7.08
7.07
7.06
7.05
7.05
7.04
7.02
7.02
7.01
7.00
7.00
6.99
6.98
6.98
6.96
6.96
6.95
6.94
6.94
3.75
0.00
N
O
Se
F
0.99
1.00
2.21
9.10
3.00
f1 (ppm)

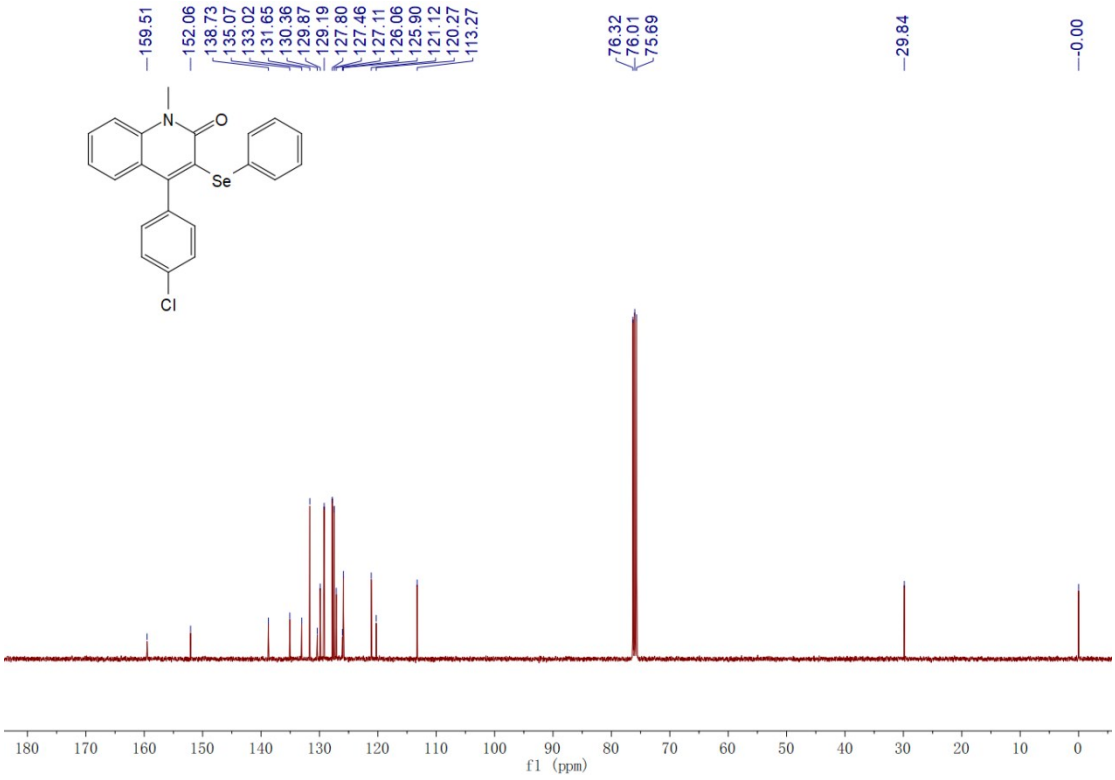

162.57
160.11
159.55
152.47
138.75
132.70
132.66
131.48
130.50
129.86
129.62
129.54
127.80
127.25
126.14
125.84
121.10
120.50
114.39
114.17
113.25
76.33
76.01
75.70
29.84
0.00
N
O
Se
F
f1 (ppm)

HJW-4FQUESUAN-XIANAN-CPD.7.1.1r

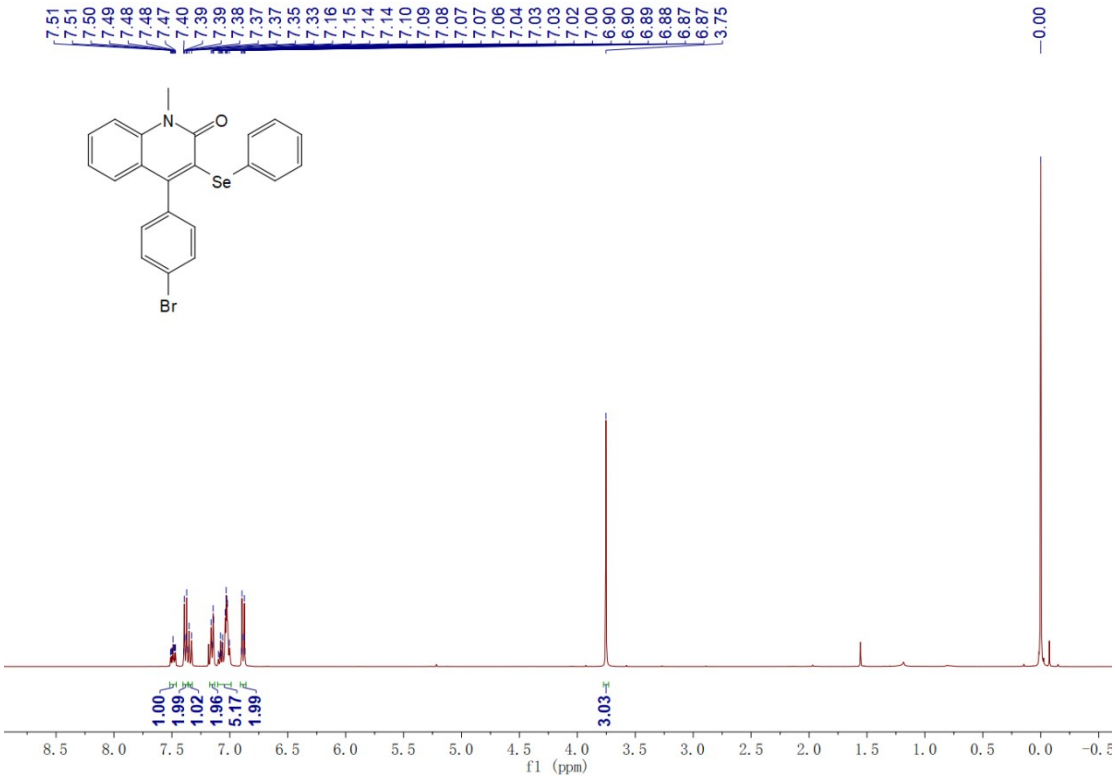


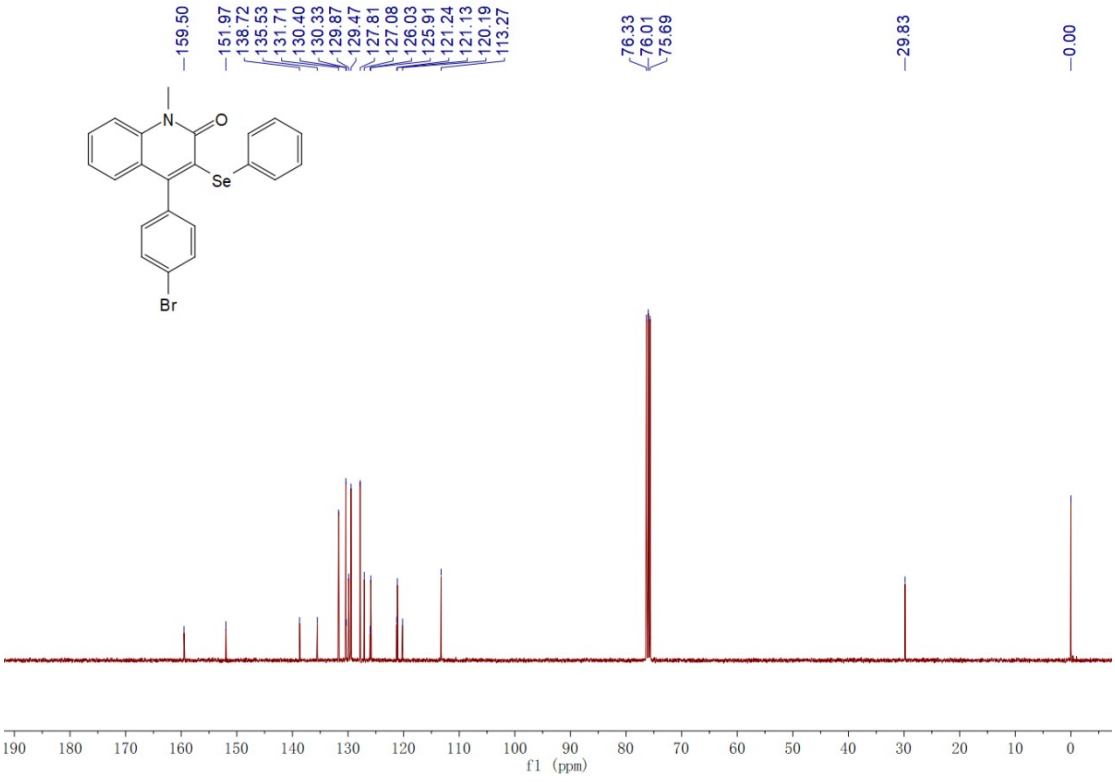
Product 7l


7.52
7.51
7.50
7.49
7.49
7.48
7.47
7.36
7.33
7.25
7.24
7.24
7.23
7.22
7.22
7.17
7.17
7.16
7.15
7.15
7.14
7.10
7.10
7.09
7.09
7.08
7.07
7.06
7.06
7.06
7.05
7.04
7.04
7.03
7.02
7.02
7.01
7.00
7.00
6.97
6.96
6.96
6.94
6.94
6.93
3.76
0.00
N
O
Se
Cl
0.99
1.00
1.97
2.02
5.16
2.01
3.00
f1 (ppm)

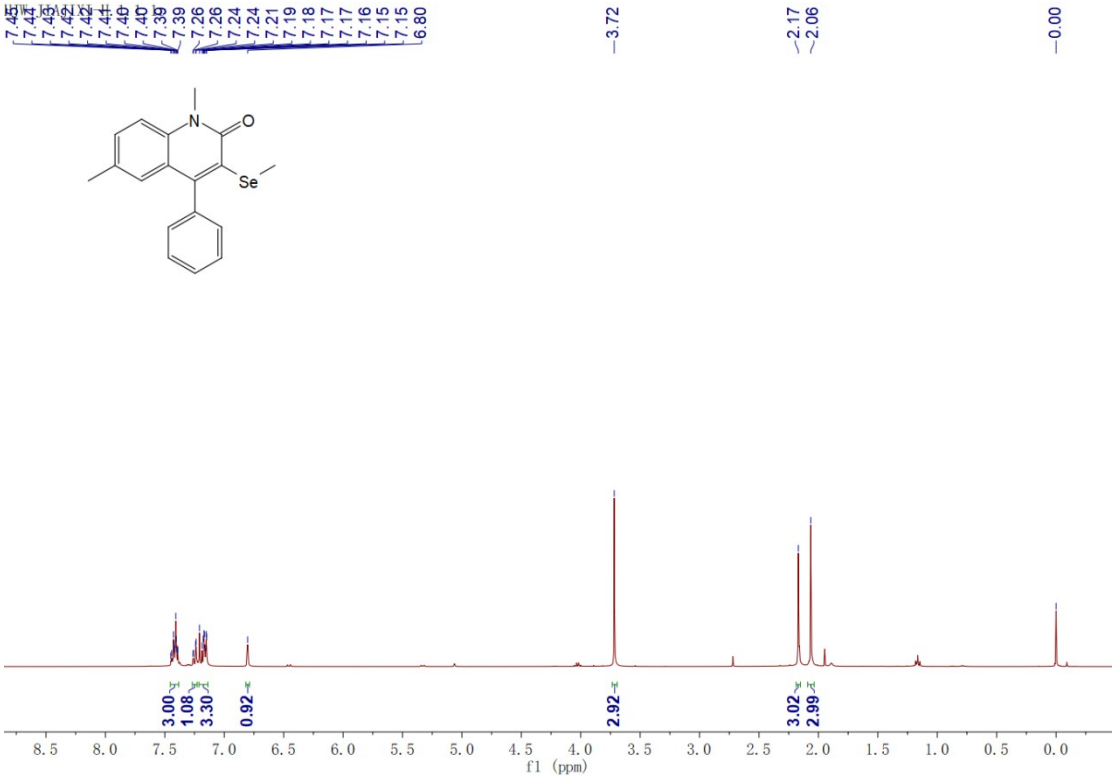

159.51
152.06
138.73
135.07
133.02
131.65
130.36
129.87
129.19
127.80
127.46
127.11
126.06
125.90
121.12
120.27
113.27
76.32
76.01
75.69
29.84
0.00
N
O
Se
Cl
f1 (ppm)

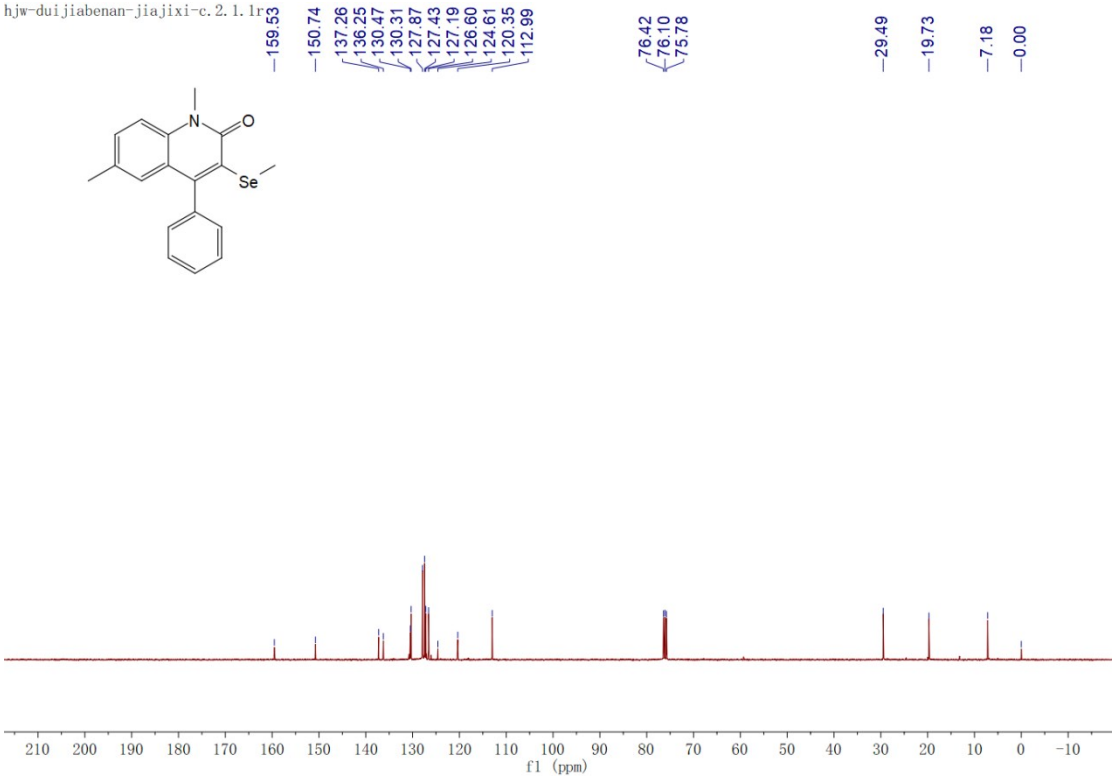
Product 7m


7.51
7.51
7.50
7.49
7.48
7.48
7.47
7.40
7.39
7.39
7.38
7.37
7.37
7.35
7.33
7.16
7.15
7.14
7.14
7.10
7.09
7.08
7.07
7.07
7.06
7.04
7.03
7.02
7.00
6.90
6.90
6.89
6.88
6.87
6.87
3.75
0.00
N
O
Se
Br
1.00
1.99
1.02
1.96
5.17
1.99
3.03
f1 (ppm)

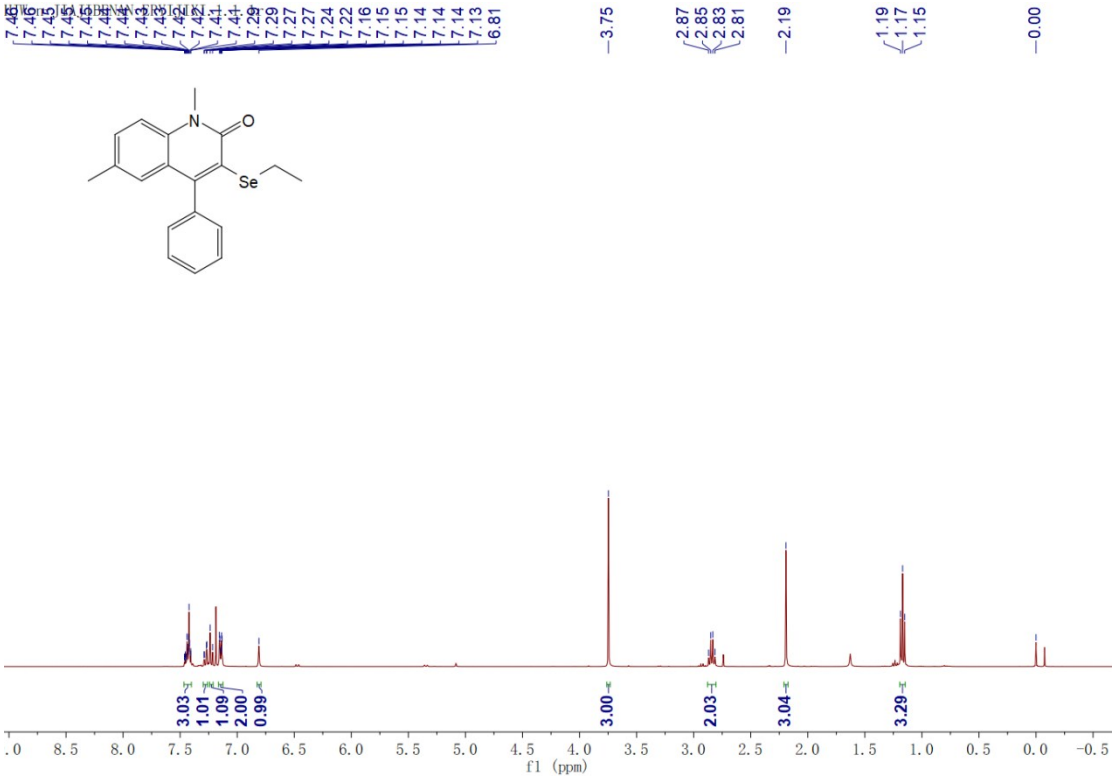

159.50
151.97
138.72
135.53
131.71
130.40
130.33
129.87
129.47
127.81
127.08
126.03
125.91
121.24
121.13
120.19
113.27
76.33
76.01
75.69
29.83
0.00
N
O
Se
Br
f1 (ppm)

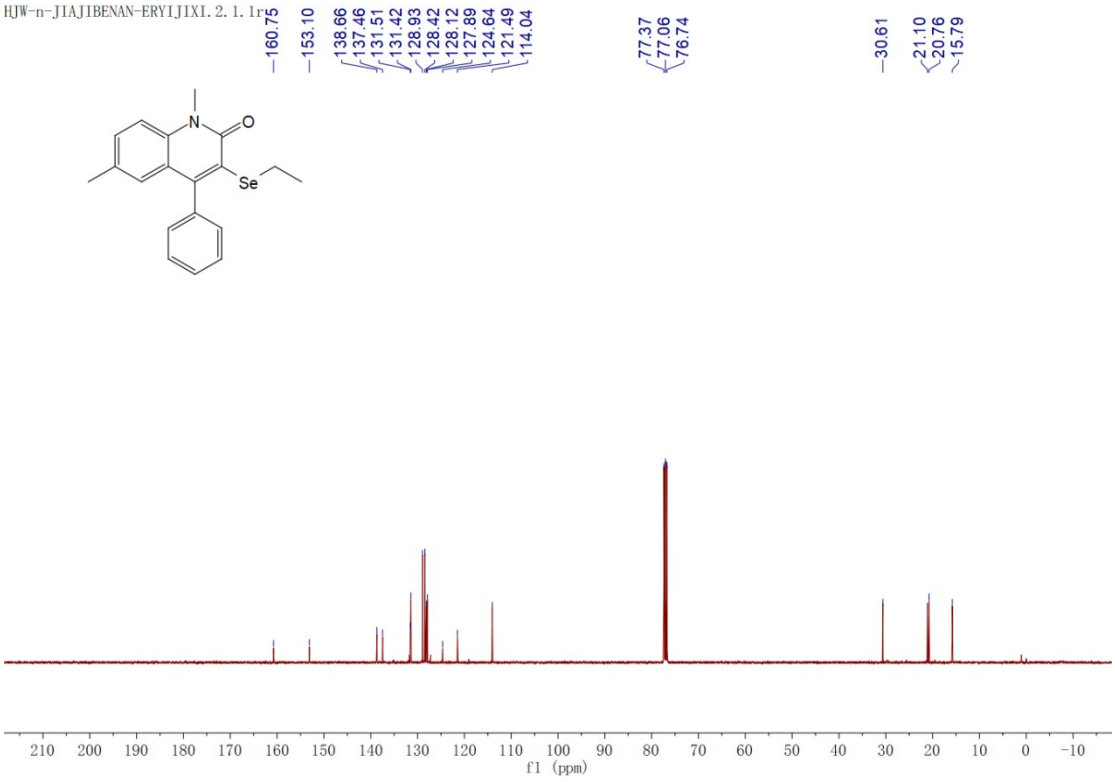
Product 7n


7.45
7.44
7.43
7.42
7.41
7.40
7.39
7.26
7.24
7.21
7.19
7.18
7.17
7.16
7.15
6.80
3.72
2.17
2.06
0.00
N
O
Se
3.00
1.08
3.30
0.92
2.92
3.02
2.99
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

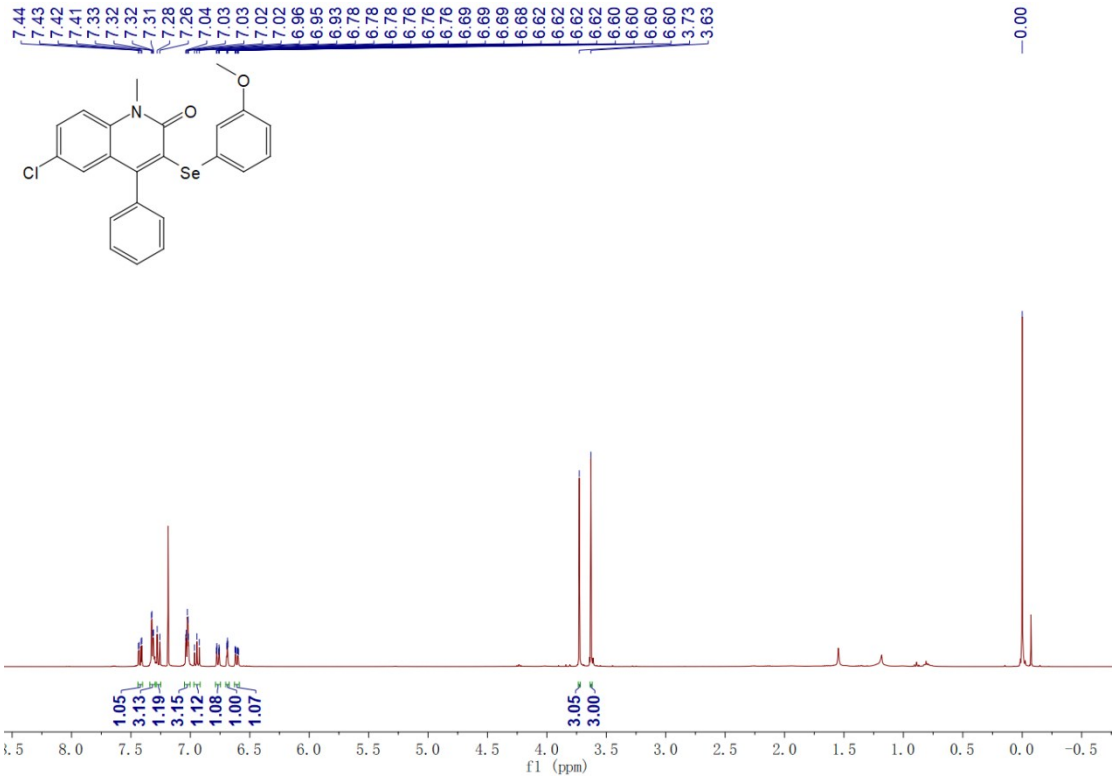

hjw-duijiabenan-jiajixi-c.2.1.1r
159.53
150.74
137.26
136.25
130.47
130.31
127.87
127.43
127.19
126.60
124.61
120.35
112.99
76.42
76.10
75.78
29.49
19.73
7.18
0.00
N
O
Se
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

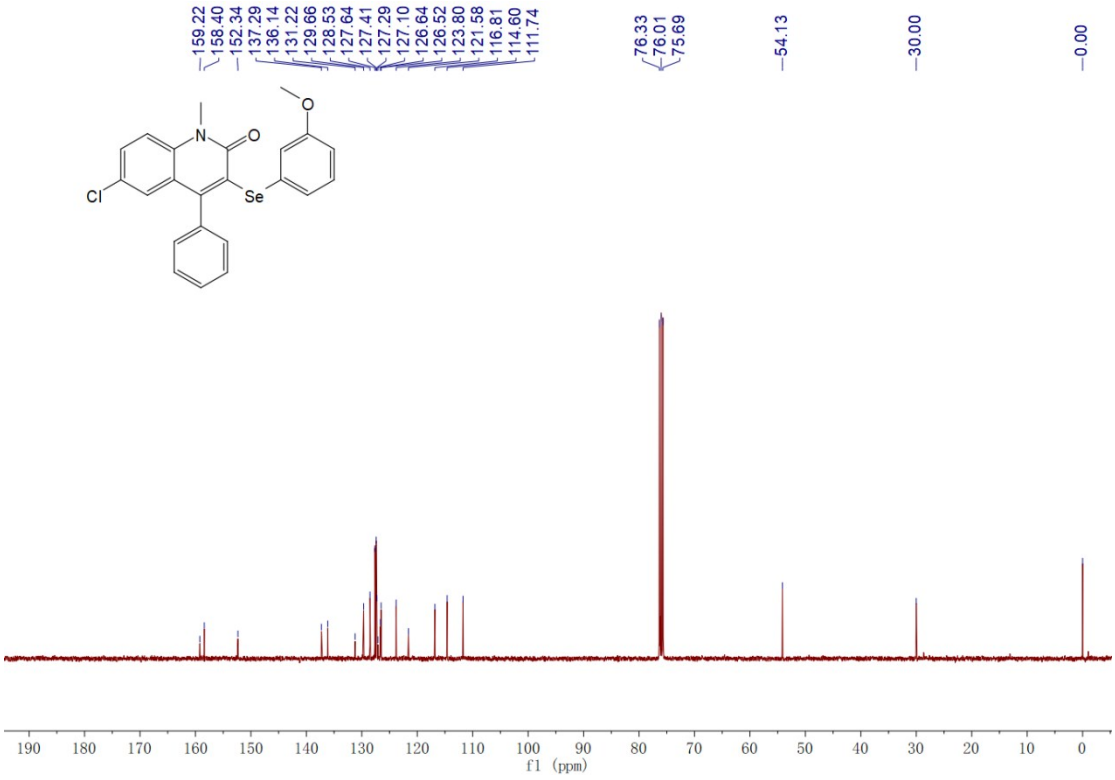
Product 7o


7.46
7.45
7.45
7.45
7.45
7.44
7.44
7.43
7.43
7.42
7.42
7.41
7.41
7.41
7.29
7.29
7.27
7.27
7.24
7.22
7.16
7.15
7.15
7.14
7.14
7.14
7.13
6.81
3.75
2.87
2.85
2.83
2.81
2.19
1.19
1.17
1.15
0.00
N
O
Se
3.03
1.01
1.09
2.00
0.99
3.00
2.03
3.04
3.29
f1 (ppm)

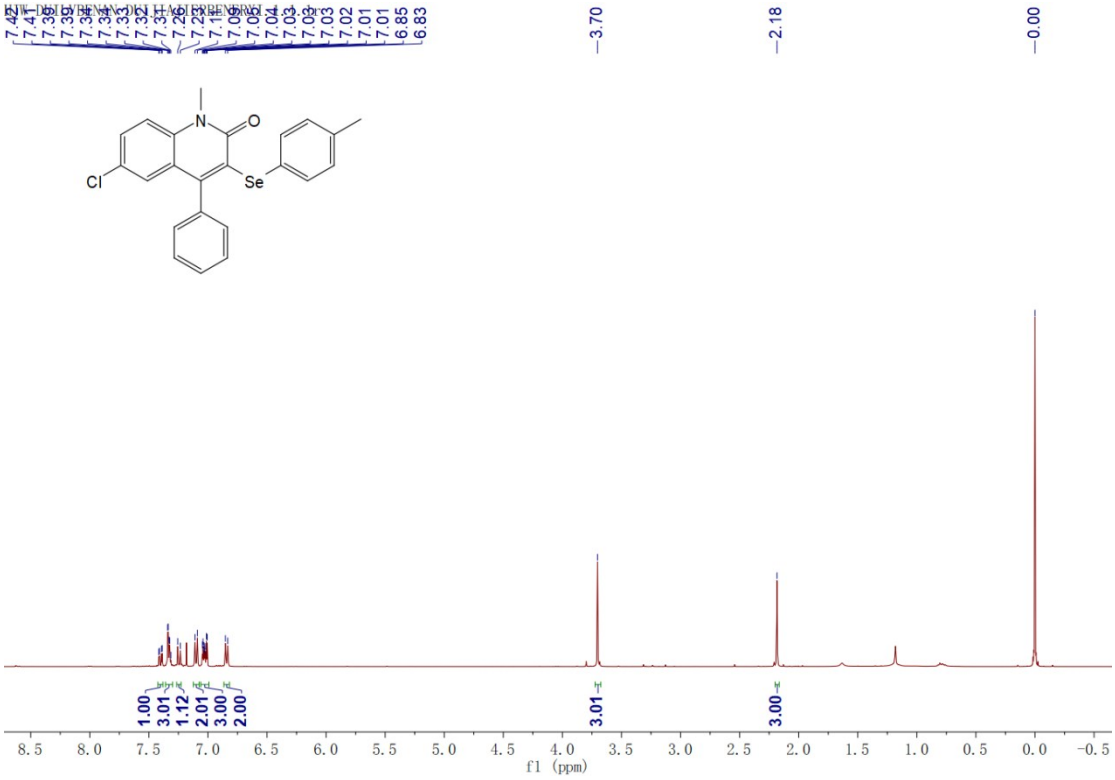

HJW-n-JIAJIBENAN-ERYIJIXI.2.1.1r
160.75
153.10
138.66
137.46
131.51
131.42
128.93
128.42
128.12
127.89
124.64
121.49
114.04
77.37
77.06
76.74
30.61
21.10
20.76
15.79
N
O
Se
f1 (ppm)

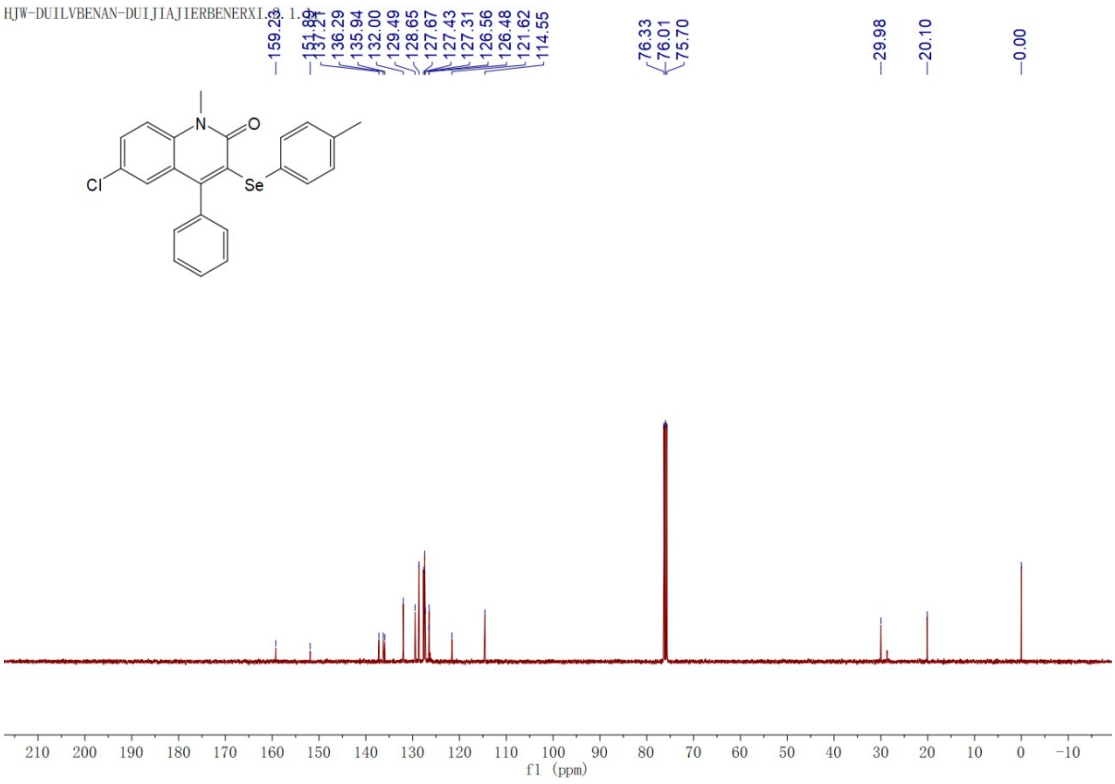
Product 7p


7.44
7.43
7.42
7.41
7.33
7.32
7.32
7.31
7.28
7.26
7.04
7.03
7.03
7.02
7.02
6.96
6.95
6.93
6.78
6.78
6.78
6.76
6.76
6.76
6.69
6.69
6.68
6.62
6.62
6.62
6.60
6.60
6.60
6.60
3.73
3.63
0.00
N
O
O
Cl
Se
1.05
3.13
1.19
3.15
1.12
1.08
1.00
1.07
3.05
3.00
f1 (ppm)

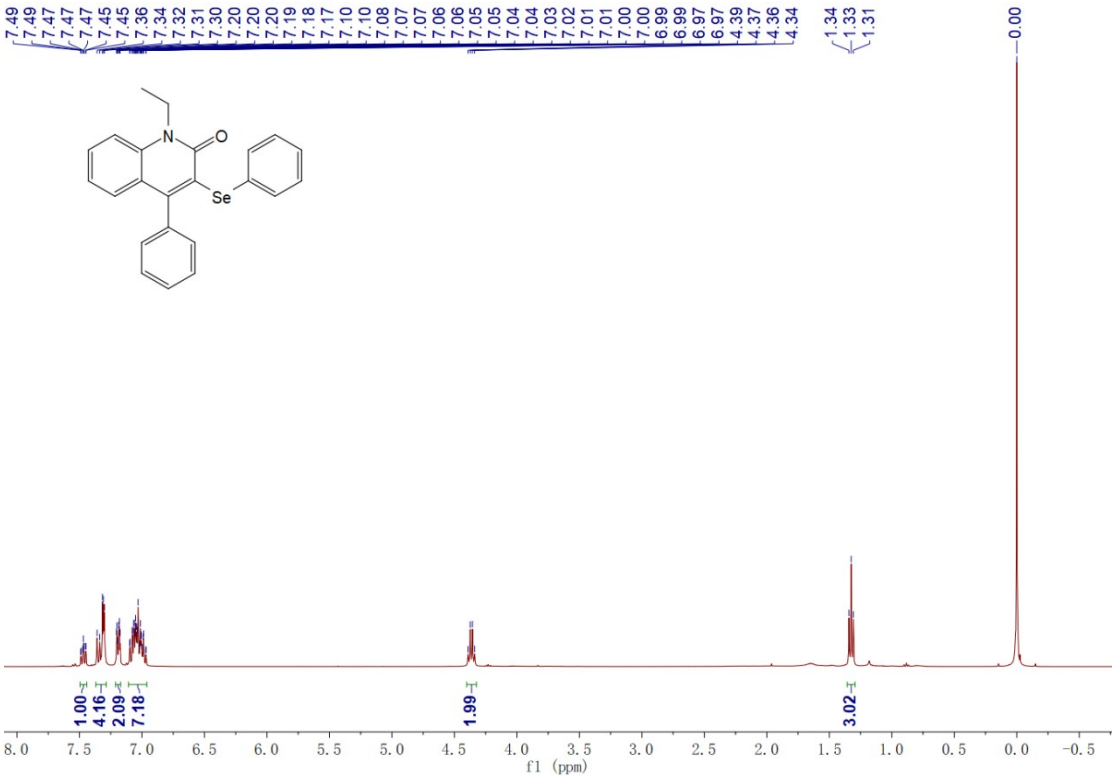

159.22
158.40
152.34
137.29
136.14
131.22
129.66
128.53
127.64
127.41
127.29
127.10
126.64
126.52
123.80
121.58
116.81
114.60
111.74
76.33
76.01
75.69
54.13
30.00
0.00
N
O
O
Cl
Se
f1 (ppm)

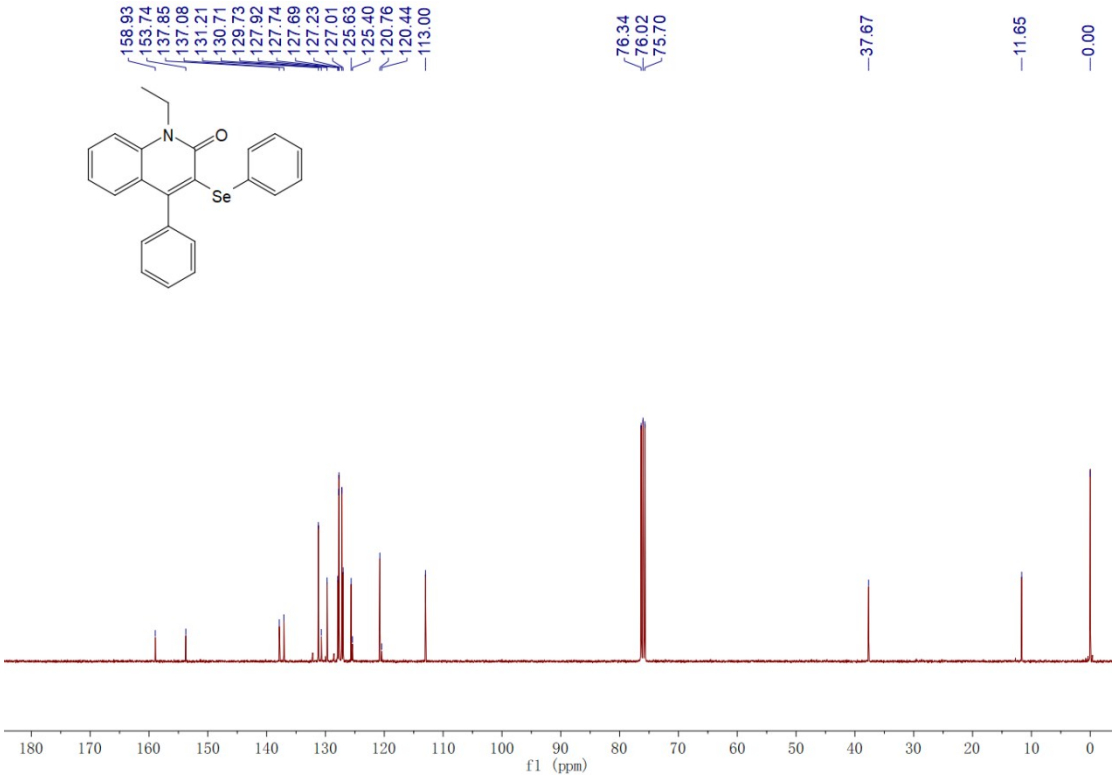
Product 7q


7.42
7.41
7.39
7.39
7.38
7.34
7.33
7.32
7.31
7.26
7.22
7.10
7.09
7.08
7.04
7.03
7.03
7.03
7.02
7.01
7.01
6.85
6.83
3.70
2.18
0.00
N
O
Cl
Se
1.00
3.01
1.12
2.01
3.00
2.00
3.01
3.00
f1 (ppm)

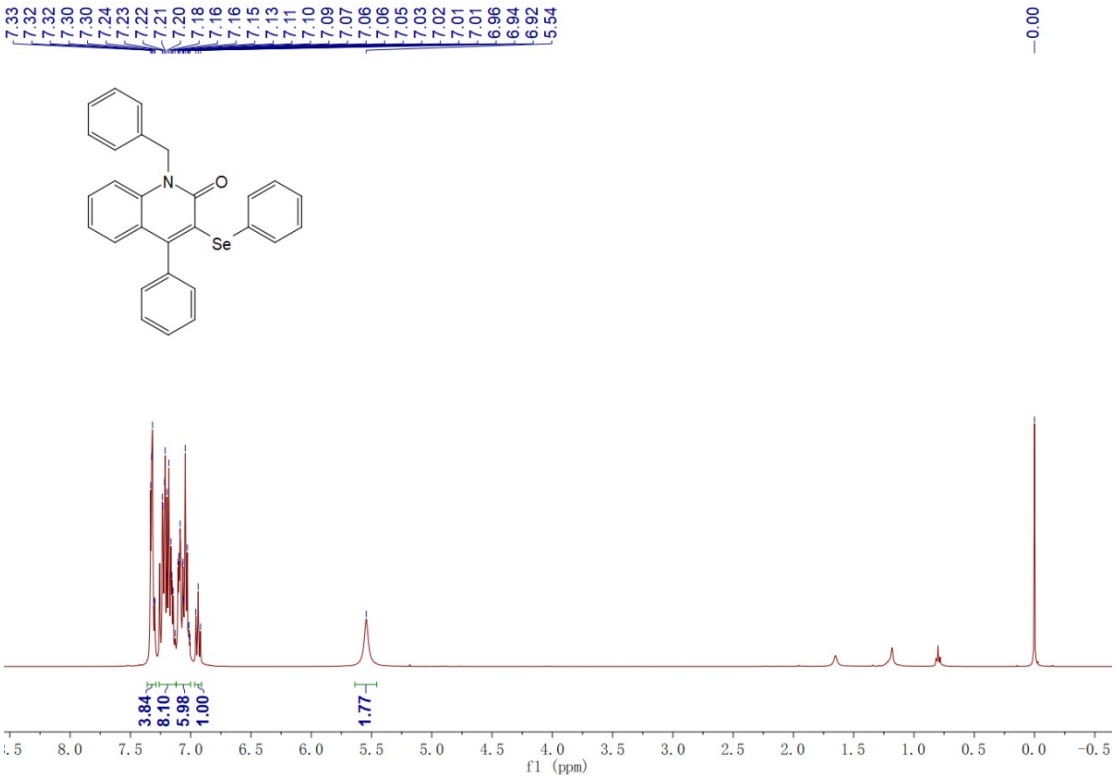

HJW-DUILVBENAN-DUIJIAJIERBENERXI-3.1.1
159.23
151.89
137.27
136.29
135.94
132.00
129.49
128.65
127.67
127.43
127.31
126.56
126.48
121.62
114.55
76.33
76.01
75.70
29.98
20.10
0.00
N
O
Cl
Se
f1 (ppm)

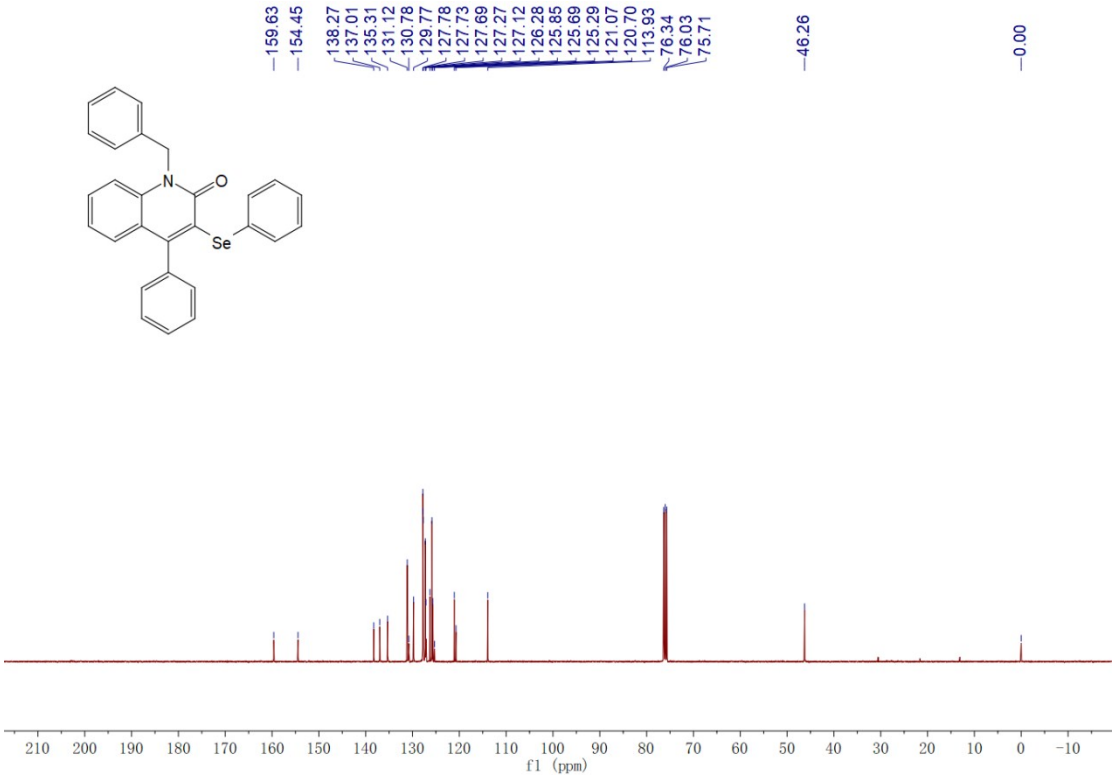
Product 7r


7.49
7.49
7.47
7.47
7.47
7.45
7.45
7.36
7.34
7.32
7.31
7.30
7.20
7.20
7.20
7.19
7.18
7.17
7.10
7.10
7.08
7.07
7.07
7.06
7.06
7.05
7.05
7.04
7.04
7.03
7.02
7.01
7.01
7.00
7.00
6.99
6.99
6.97
6.97
4.39
4.37
4.36
4.34
1.34
1.33
1.31
0.00
N
O
Se
1.00
4.16
2.09
7.18
1.99
3.02
f1 (ppm)

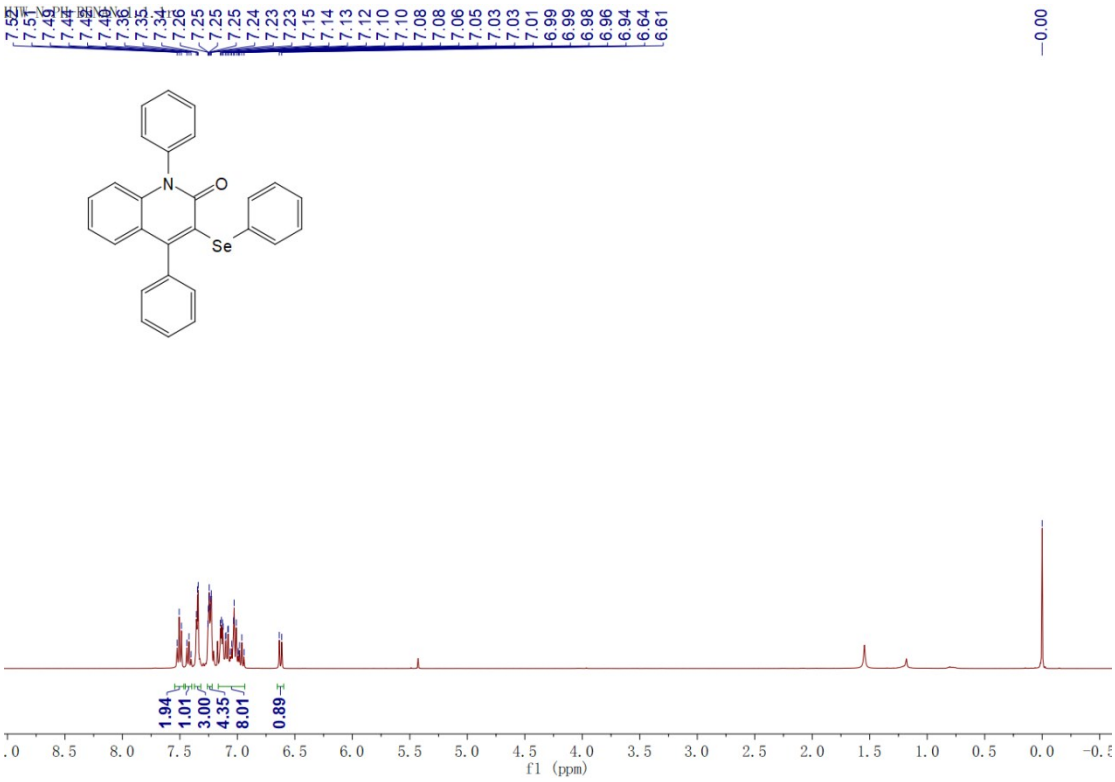

158.93
153.74
137.85
137.08
131.21
130.71
129.73
127.92
127.74
127.69
127.23
127.01
125.63
125.40
120.76
120.44
113.00
76.34
76.02
75.70
37.67
11.65
0.00
N
O
Se
f1 (ppm)

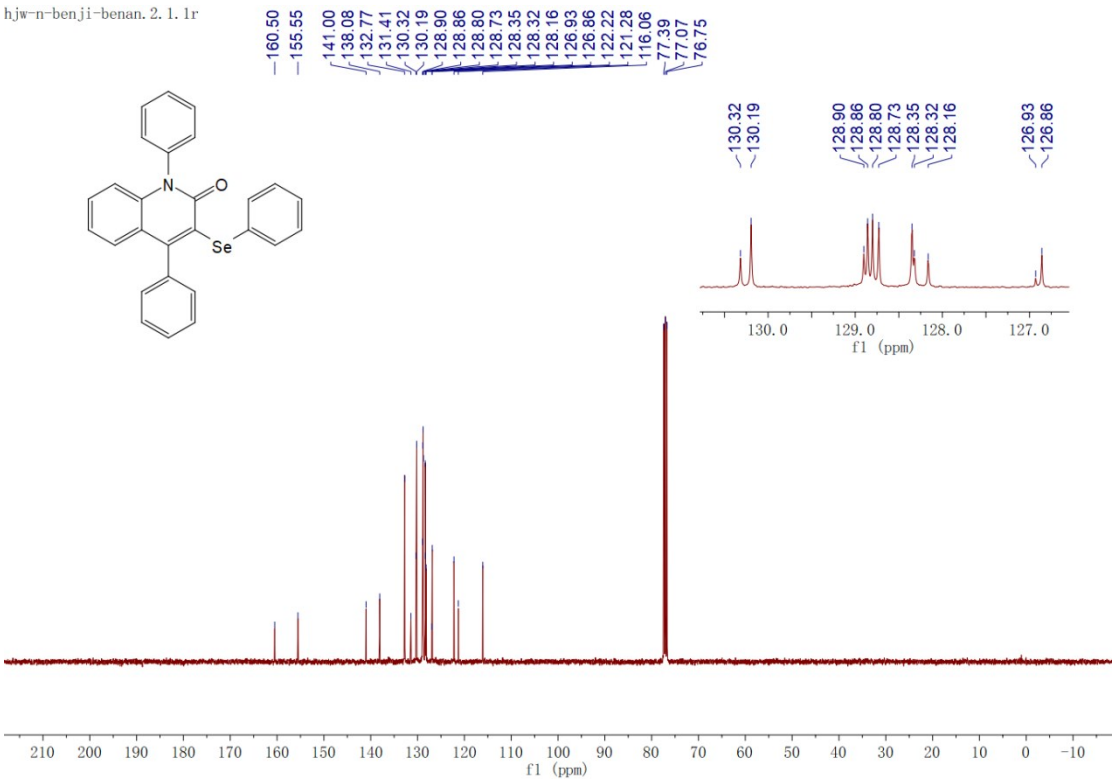
Product 7s


7.33
7.32
7.32
7.30
7.30
7.24
7.23
7.22
7.21
7.20
7.18
7.16
7.16
7.15
7.13
7.11
7.10
7.09
7.07
7.06
7.06
7.05
7.03
7.02
7.01
7.01
6.96
6.94
6.92
5.54
0.00
N
O
Se
3.84
8.10
5.98
1.00
1.77
f1 (ppm)

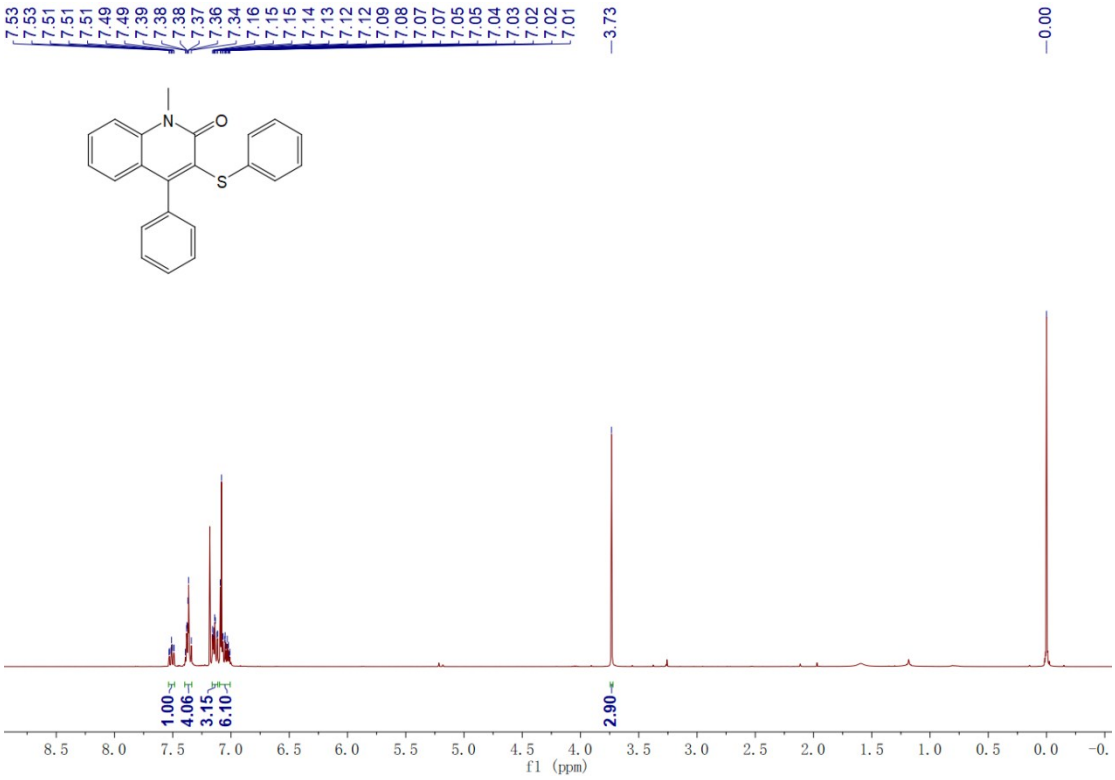

159.63
154.45
138.27
137.01
135.31
131.12
130.78
129.77
127.78
127.73
127.69
127.27
127.12
126.28
125.85
125.69
125.29
121.07
120.70
113.93
76.34
76.03
75.71
46.26
0.00
N
O
Se
f1 (ppm)

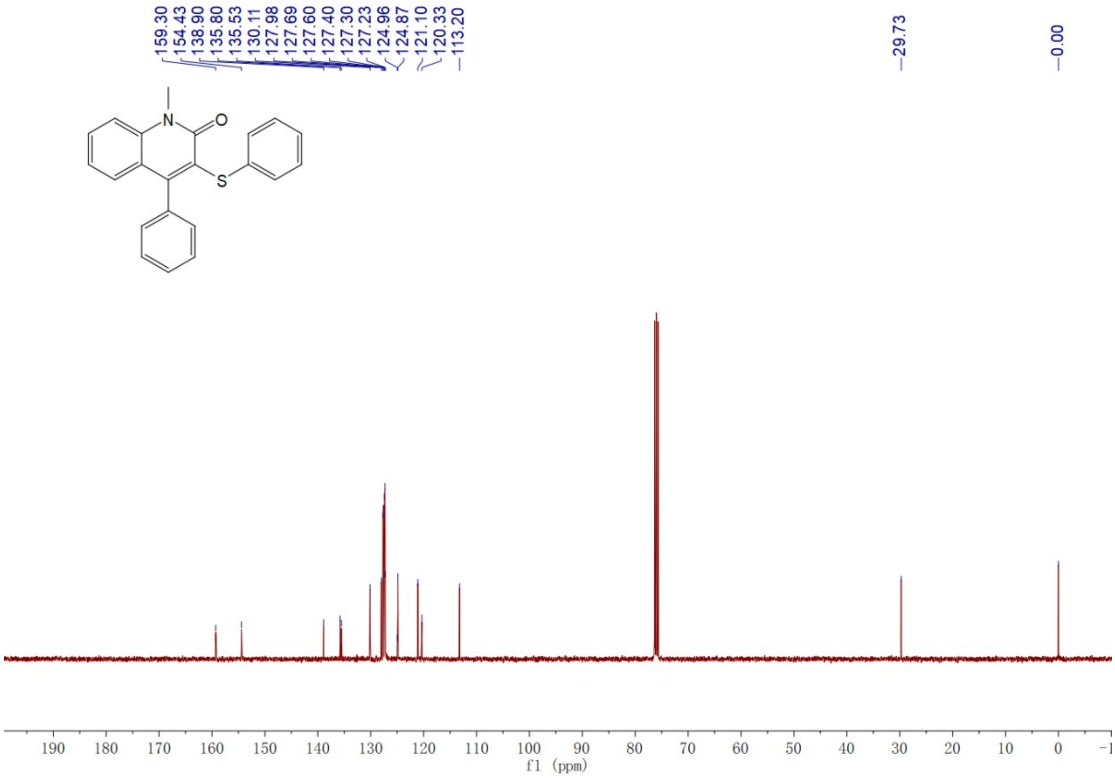
Product 7t


7.52
7.51
7.49
7.44
7.40
7.36
7.35
7.34
7.26
7.25
7.25
7.25
7.24
7.23
7.23
7.15
7.14
7.13
7.12
7.10
7.10
7.08
7.08
7.06
7.05
7.03
7.01
6.99
6.99
6.98
6.96
6.94
6.64
6.61
0.00
O
N
Se
1.94
1.01
3.00
4.35
8.01
0.89
f1 (ppm)

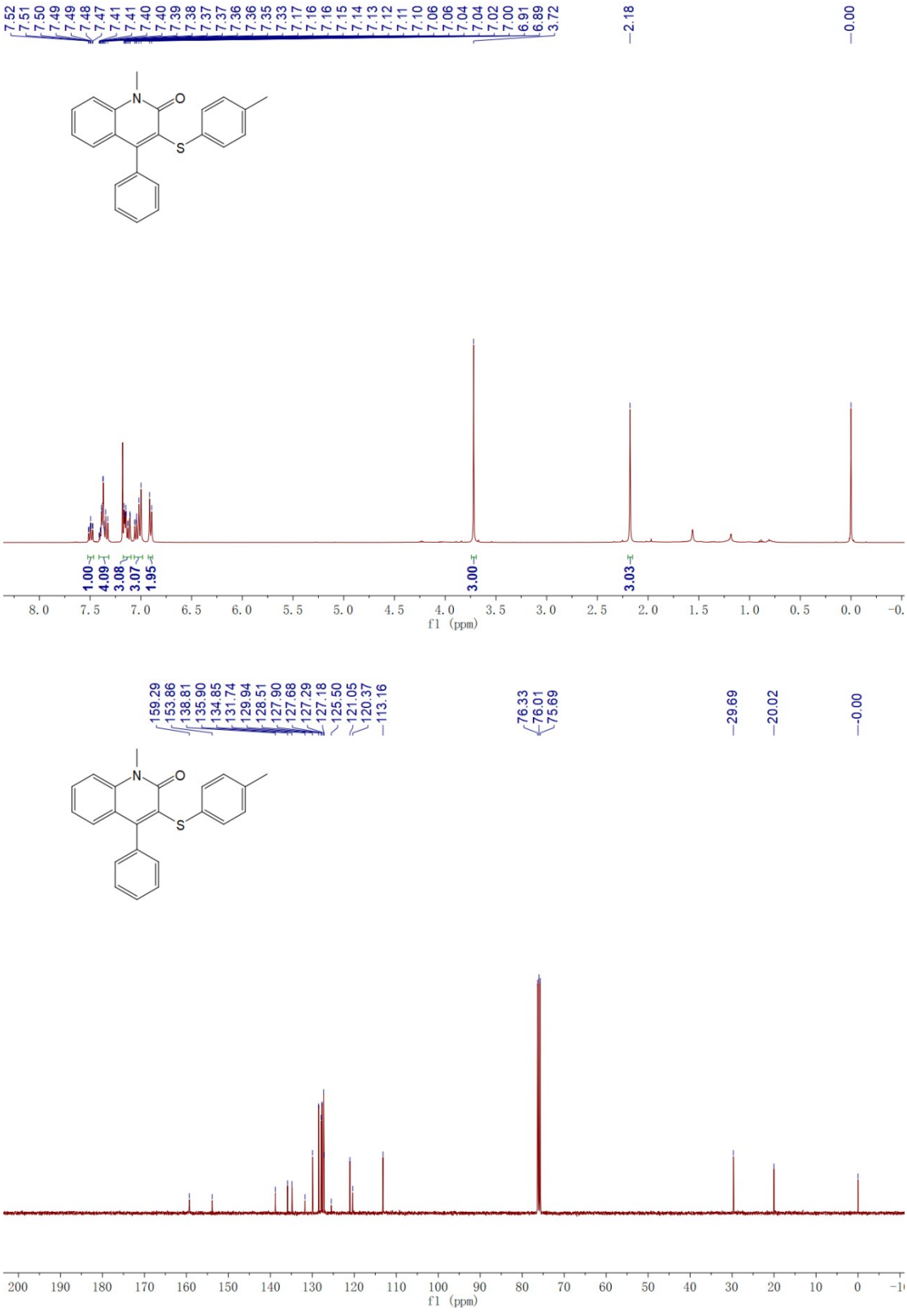

hjw-n-benji-benan.2.1.1r
160.50
155.55
141.00
138.08
132.77
131.41
130.32
130.19
128.90
128.86
128.80
128.73
128.35
128.32
128.16
126.93
126.86
122.22
121.28
116.06
77.39
77.07
76.75
O
N
Se
130.32
130.19
128.90
128.86
128.80
128.73
128.35
128.32
128.16
126.93
126.86
f1 (ppm)
f1 (ppm)

Product 8a

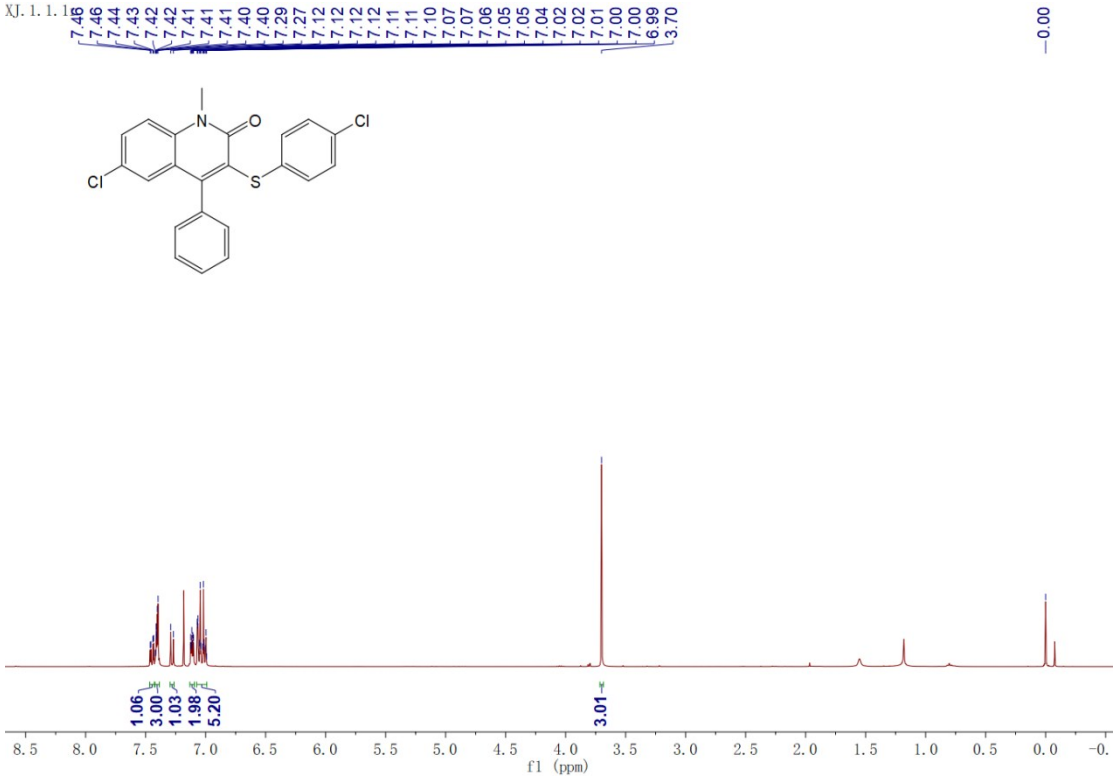

7.53
7.53
7.51
7.51
7.51
7.49
7.49
7.39
7.38
7.38
7.37
7.36
7.34
7.16
7.15
7.15
7.14
7.13
7.12
7.12
7.09
7.08
7.07
7.07
7.05
7.05
7.04
7.03
7.02
7.02
7.01
3.73
0.00
N
O
S
1.00
4.06
3.15
6.10
2.90
f1 (ppm)

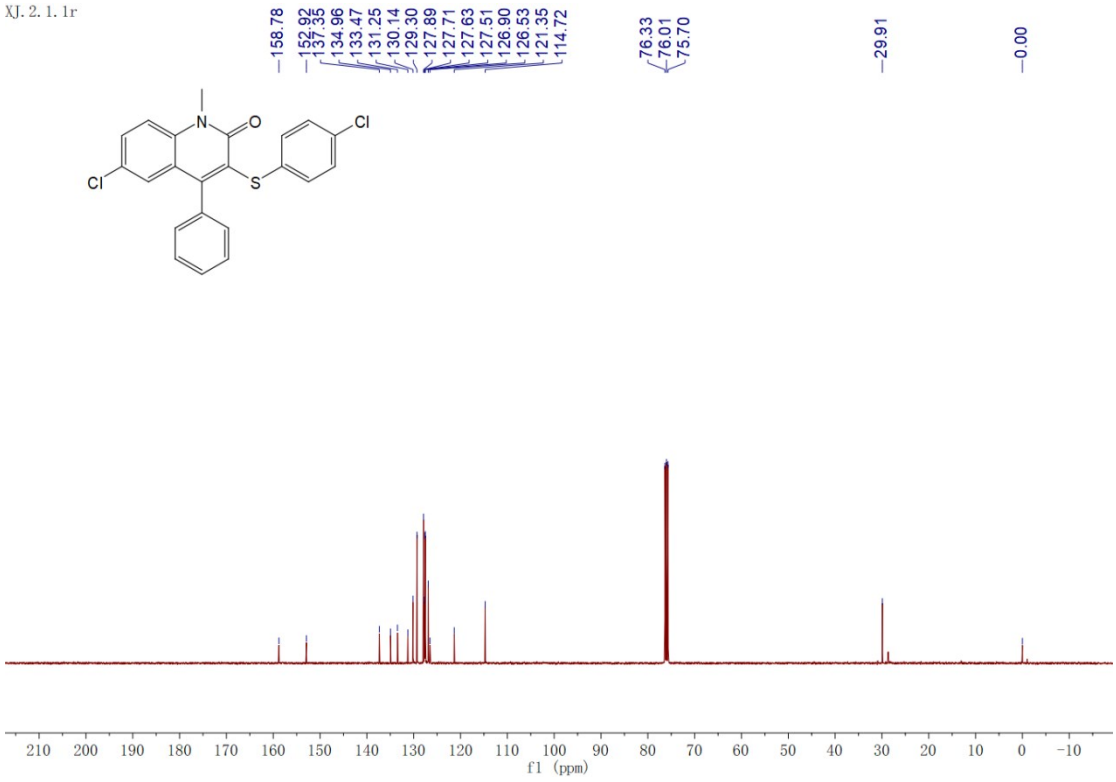

159.30
154.43
138.90
135.80
135.53
130.11
127.98
127.69
127.60
127.40
127.30
127.23
124.96
124.87
121.10
120.33
113.20
29.73
0.00
N
O
S
f1 (ppm)

Product 8b

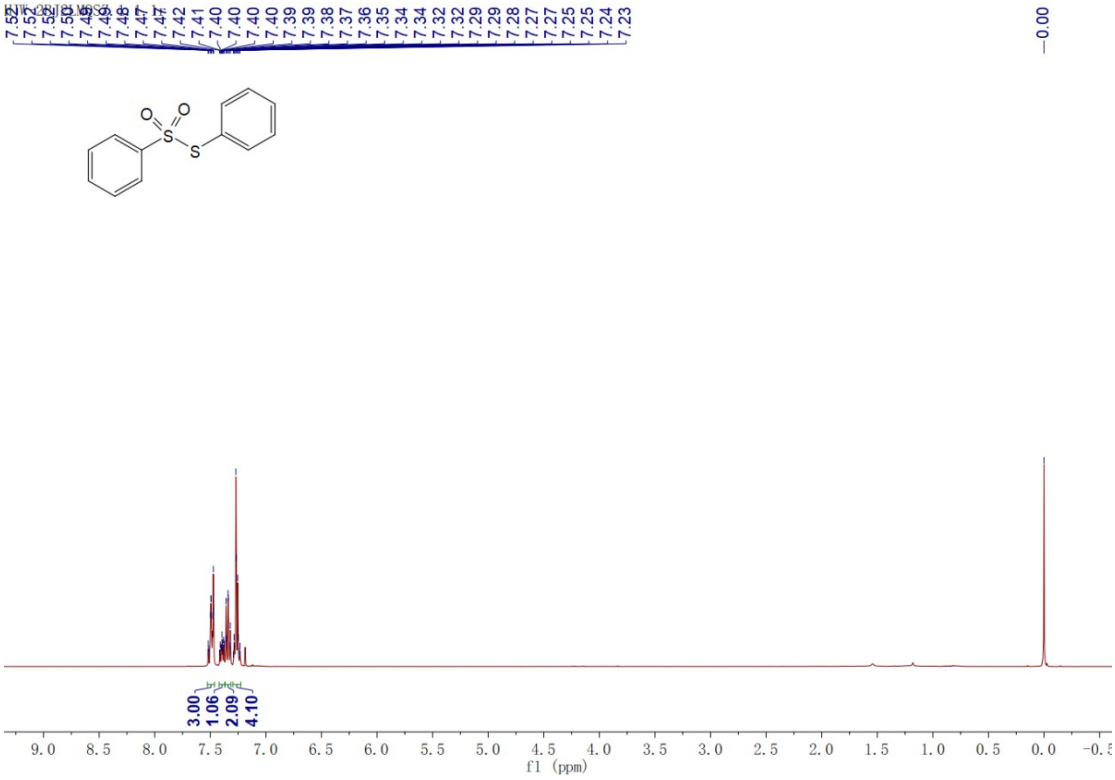

7.52
7.51
7.50
7.49
7.49
7.48
7.47
7.41
7.41
7.40
7.40
7.39
7.38
7.37
7.37
7.36
7.36
7.35
7.33
7.17
7.16
7.16
7.15
7.14
7.13
7.12
7.11
7.10
7.06
7.06
7.04
7.04
7.02
7.00
6.91
6.89
3.72
2.18
0.00
N
O
S
1.00
4.09
3.08
3.07
1.95
3.00
3.03
f1 (ppm)
159.29
153.86
138.81
135.90
134.85
131.74
129.94
128.51
127.90
127.68
127.29
127.18
125.50
121.05
120.37
113.16
76.33
76.01
75.69
29.69
20.02
0.00
f1 (ppm)

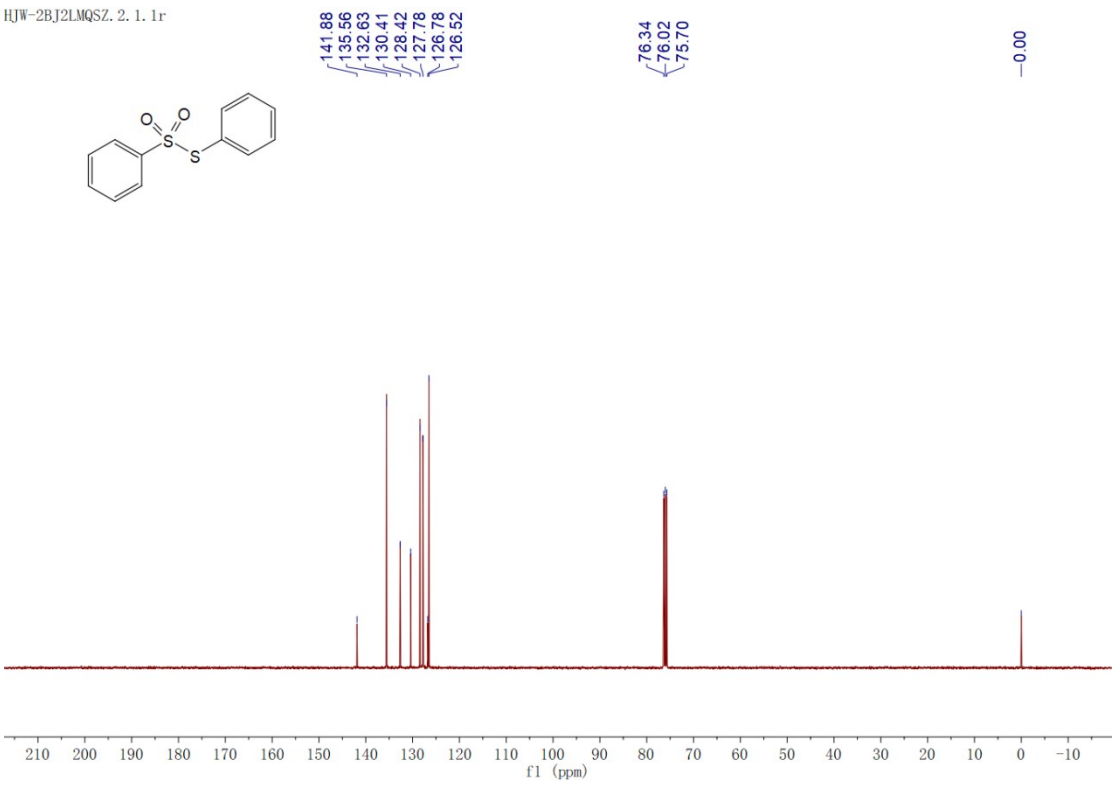
Product 8c


XJ. 1. 1. 1r
7.46
7.46
7.44
7.43
7.42
7.42
7.41
7.41
7.41
7.40
7.40
7.29
7.27
7.12
7.12
7.12
7.11
7.11
7.10
7.07
7.07
7.06
7.05
7.05
7.04
7.02
7.02
7.01
7.00
7.00
6.99
3.70
0.00
N
O
Cl
Cl
S
1.06
3.00
1.03
1.98
5.20
3.01
f1 (ppm)


XJ. 2. 1. 1r
158.78
152.92
137.35
134.96
133.47
131.25
130.14
129.30
127.89
127.71
127.63
127.51
126.90
126.53
121.35
114.72
76.33
76.01
75.70
29.91
0.00
N
O
Cl
Cl
S
f1 (ppm)

Product 10a


7.52
7.51
7.50
7.49
7.48
7.47
7.42
7.41
7.40
7.39
7.38
7.37
7.36
7.35
7.34
7.32
7.29
7.28
7.27
7.25
7.24
7.23
0.00
3.00
1.06
2.09
4.10
f1 (ppm)


HJW-2BJ2LMQSZ.2.1.1r
141.88
135.56
132.63
130.41
128.42
127.78
126.78
126.52
76.34
76.02
75.70
0.00
f1 (ppm)