

Electronic Supplementary Information

for

Regulable selective synthesis of benzofurans and coumarins from aryl propargyl ethers via electrochemical tandem cyclization reaction

Zhaoyue Feng, Xueyi Guan, Haiyang Ma, Yingsibing Fan, Ping Liu* and Peipei Sun*

School of Chemistry and Materials Science, Jiangsu Provincial Key Laboratory of Material Cycle

Processes and Pollution Control, Jiangsu Collaborative Innovation Center of Biomedical

Functional Materials, Nanjing Normal University, Nanjing 210023, China.

pingliu@njnu.edu.cn; sunpeipei@njnu.edu.cn

Contents

1. General information	S
2	
2. Experimental procedures	S2-S5
3. Mechanistic studies	S5-S11
4. Experimental data for the products 3 , 4 , 5 and 6	S11-S34
5. ¹ H and ¹³ C NMR spectra of the products	S35-S96

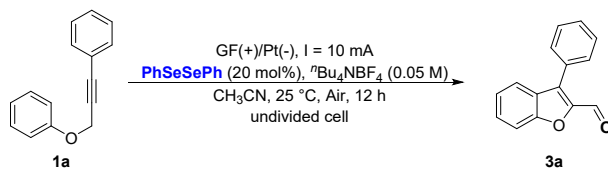
1 General information

All reagents were obtained from commercial suppliers and used without further purification. Platinum plate electrode (10 mm × 10 mm × 0.1 mm), purity above 99.99%, Beijing Jingke Keyi scientific instrument Co., Ltd., China; Graphite felt electrode (10 mm × 40 mm × 2 mm), purity 93-99.9%, Inner Mongolia Wanxing carbon Co., Ltd., China. Reactions were monitored by thin layer chromatography. Column chromatography was performed using silica gel (300–400 mesh). The NMR spectra were recorded on a Bruker Avance 400 spectrometer at 400 MHz (¹H) and 100 MHz (¹³C) in CDCl₃ using tetramethylsilane as the internal standard. The following abbreviations were used to explain the multiplicities: s = singlet, brs = broad singlet, d = doublet, t = triplet, dd = doublet of doublet, dt = doublet of triplet, td = triplet of doublet, q = quartet, m = multiplet. High-resolution mass spectra were obtained with an AB Triple 5600 mass spectrometer by ESI on a TOF mass analyzer. Melting points are uncorrected.

2 Experimental procedures

2.1 General procedure for the electrochemical reaction

2.1.1 General procedure for the synthesis of benzofuran derivatives (taking **3a** as an example)



An oven-dried undivided three-necked flask (25 mL) was charged with 1,2-diphenyldiselenane (**2a**, 31.2 mg, 0.1 mmol), ^tBu₄NBF₄ (164.6 mg, 0.5 mmol). Then CH₃CN (10 mL) and (3-phenoxyprop-1-yn-1-yl)benzene (**1a**, 104.0 mg, 94.5 μL, 0.5 mmol) were added. The flask was equipped with graphite felt electrode (10 mm × 30 mm) as the anode and platinum plate electrode (10 mm × 10 mm) as the cathode (Fig. S1). The reaction mixture was stirred and electrolyzed at a constant current (10 mA) at 25 °C for 12 h. After the reaction was completed, the resulting solution was diluted with EtOAc (10 mL). The organic layer was washed with water (10 mL). The aqueous phase was re-extracted with EtOAc (10 mL × 2). The combined organic layers were dried over Na₂SO₄ and concentrated in vacuum. Subsequently, the crude residue was purified by silica gel chromatography using petroleum ether/ethyl acetate (50:1, v/v) as eluent to afford the desired product **3a** 97.7 mg (yield 88%).

Similar result (86% yield) was obtained when Pt electrode provided by another company (10 mm × 10 mm × 0.2 mm, purity above 99.95%, Shanghai Chuxi Industrial Co., Ltd., China) was used.

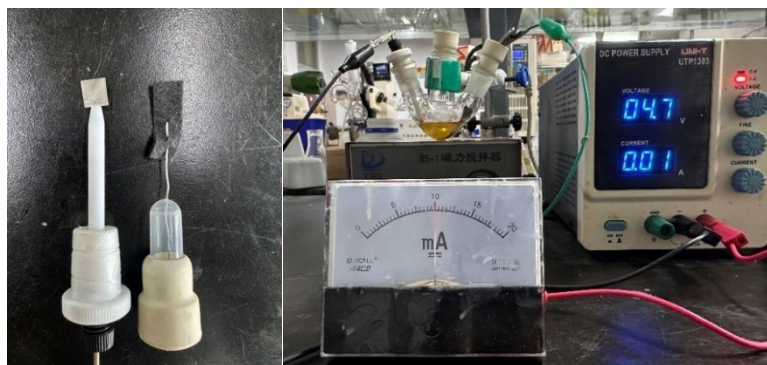
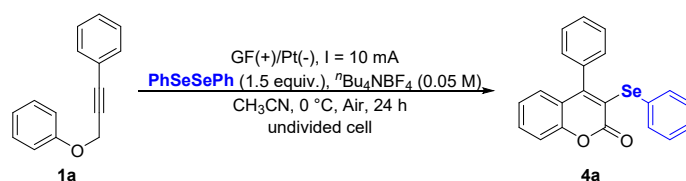


Figure S1 Electrodes and reaction setup for the synthesis of product **3**.

2.1.2 General procedure for the synthesis of coumarin derivatives (taking **4a** as an example)



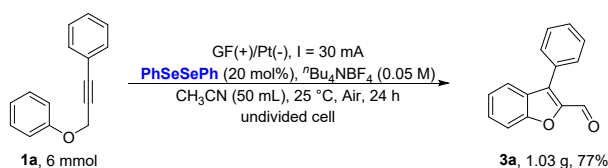
An oven-dried undivided three-necked flask (25 mL) was charged with 1,2-diphenyldiselenane (**2a**, 234.1 mg, 0.75 mmol), $n\text{Bu}_4\text{NBF}_4$ (164.6 mg, 0.5 mmol). Then CH_3CN (10 mL) and (3-phenoxyprop-1-yn-1-yl)benzene (**1a**, 104.0 mg, 94.5 μL , 0.5 mmol) were added. The flask was equipped with graphite felt electrode (10 mm × 30 mm) as the anode and platinum plate electrode (10 mm × 10 mm) as the cathode (Fig. S2). The reaction mixture was stirred and electrolyzed at a constant current (10 mA) at 0 °C for 24 h. After being warmed to room temperature, the resulting solution was diluted with EtOAc (10 mL). The organic layer was washed with water (10 mL). The aqueous phase was re-extracted with EtOAc (10 mL × 2). The combined organic layers were dried over Na_2SO_4 and concentrated in vacuum. Subsequently, the crude residue was purified by silica gel chromatography using petroleum ether/ethyl acetate (20:1, v/v) as eluent to afford the desired product **4a** 143.6 mg (yield 76%).



Figure S2 Reaction setup for the synthesis of product 4.

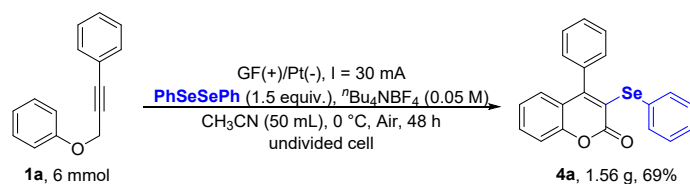
2.2 General procedure for the gram-scale experiment

2.2.1 Gram-scale synthesis of 3a



In an undivided three-necked flask (100 mL), 1,2-diphenyldisilane (**2a**, 374.6 mg, 1.2 mmol), $n\text{Bu}_4\text{NBF}_4$ (823.2 mg, 2.5 mmol), CH_3CN (50 mL) and (3-phenoxyprop-1-yn-1-yl)benzene (**1a**, 1.25 g, 1.13 mL, 6 mmol) were continuously added. The flask was equipped with a graphite felt electrode as the anode and a platinum plate electrode (15 mm × 15 mm) as the cathode. The reaction mixture was stirred and electrolyzed at a constant current (30 mA) under air at 25 °C for 24 h. After the reaction was completed, the resulting solution was diluted with EtOAc (50 mL). The organic layer was washed with water (50 mL). The aqueous phase was re-extracted with EtOAc (50 mL × 2). The combined organic layers were dried over Na_2SO_4 and concentrated in vacuum. Subsequently, the crude residue was purified by silica gel chromatography using petroleum ether/ethyl acetate (50:1, v/v) as eluent to afford the desired product **3a** 1.03 g (yield 77%).

2.2.2 Gram-scale synthesis of 4a

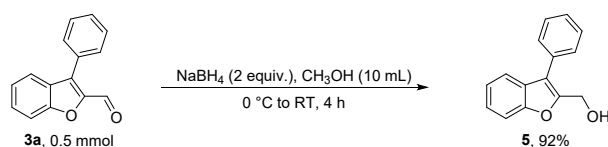


In an undivided three-necked flask (100 mL), 1,2-diphenyldisilane (**2a**, 2.81 g, 9 mmol), $n\text{Bu}_4\text{NBF}_4$ (823.2 mg, 2.5 mmol), CH_3CN (50 mL) and (3-phenoxyprop-1-yn-1-yl)benzene (**1a**, 1.25 g, 1.13 mL, 6 mmol) were continuously added. The flask was equipped with a graphite felt

electrode as the anode and a platinum plate electrode (15 mm × 15 mm) as the cathode. The reaction mixture was stirred and electrolyzed at a constant current (30 mA) under air at 0 °C for 48 h. After the reaction was completed, the resulting solution was diluted with EtOAc (50 mL). The organic layer was washed with water (50 mL). The aqueous phase was re-extracted with EtOAc (50 mL × 2). The combined organic layers were dried over Na₂SO₄ and concentrated in vacuum. Subsequently, the crude residue was purified by silica gel chromatography using petroleum ether/ethyl acetate (20:1, v/v) as eluent to afford the desired product **4a** 1.56 g (yield 69%).

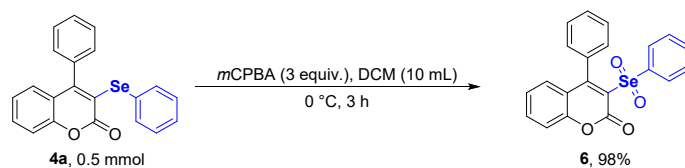
2.3 Procedures for the further transformation of products

2.3.1 The transformation of **3a** to **5**



In a Schlenk flask (25 mL), **3a** (0.5 mmol, 111.0 mg), NaBH₄ (1.0 mmol, 37.8 mg) and CH₃OH (10 mL) were added slowly at 0 °C. After stirring for 4 h at room temperature, the mixture was quenched with saturated aqueous solution of NH₄Cl, and extracted with ethyl acetate, and the combined organic phases were dried over anhydrous Na₂SO₄, filtered, concentrated in *vacuo*. Subsequently, the crude residue was purified by silica gel chromatography using petroleum ether/ethyl acetate (4:1, v/v) as eluent to afford the desired product **5** 103.1 mg (yield 92%).

2.3.1 The transformation of **4a** to **6**

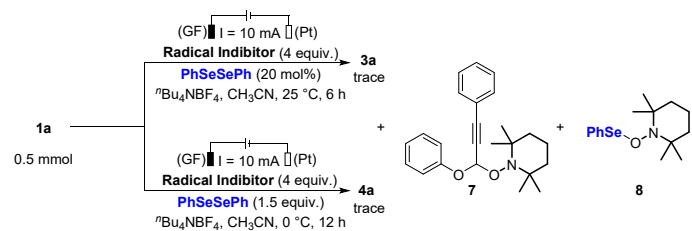


In a Schlenk flask (25 mL), **4a** (0.5 mmol, 189.0 mg), *m*CPBA (1.5 mmol, 258.9 mg) and DCM (10 mL) were added in sequence. After stirring for 3 h at 0 °C, the mixture was quenched with water, and extracted with ethyl acetate, and the combined organic phases were dried over anhydrous Na₂SO₄, filtered, concentrated in *vacuo*. Subsequently, the crude residue was purified by silica gel chromatography using petroleum ether/ethyl acetate (1:1, v/v) as eluent to afford the desired product **6** 200.9 mg (yield 98%).

3. Mechanistic studies

3.1 Control experiments

3.1.1 Radical inhibition reaction



7, HRMS (ESI-TOF) m/z $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{24}\text{H}_{30}\text{NO}_2^+$, 364.2272; found 364.2267.

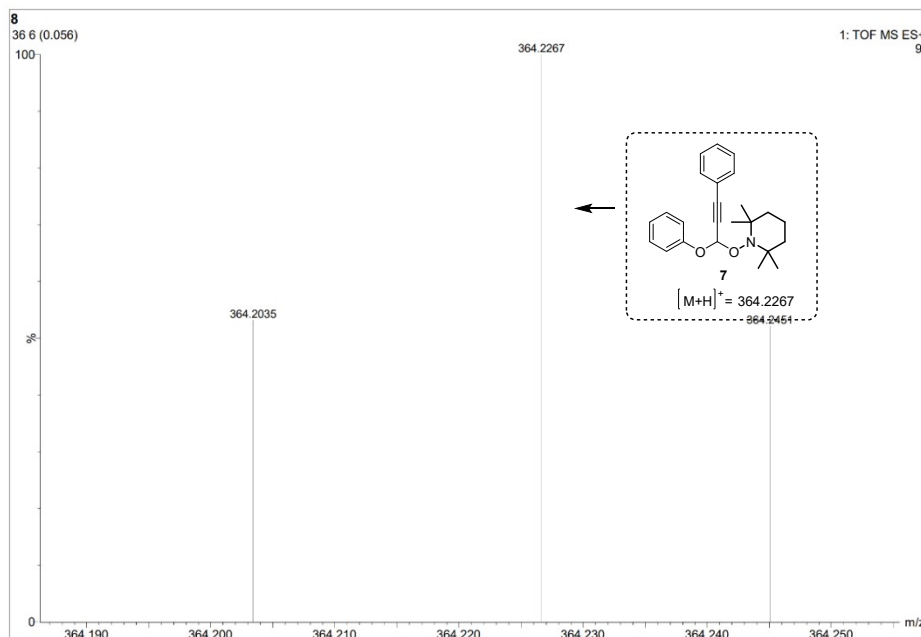


Figure S3 HRMS analysis of the radical-trapping product **7**.

8, HRMS (ESI-TOF) m/z $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{15}\text{H}_{24}\text{NOSe}^+$, 314.1018; found 314.1019.

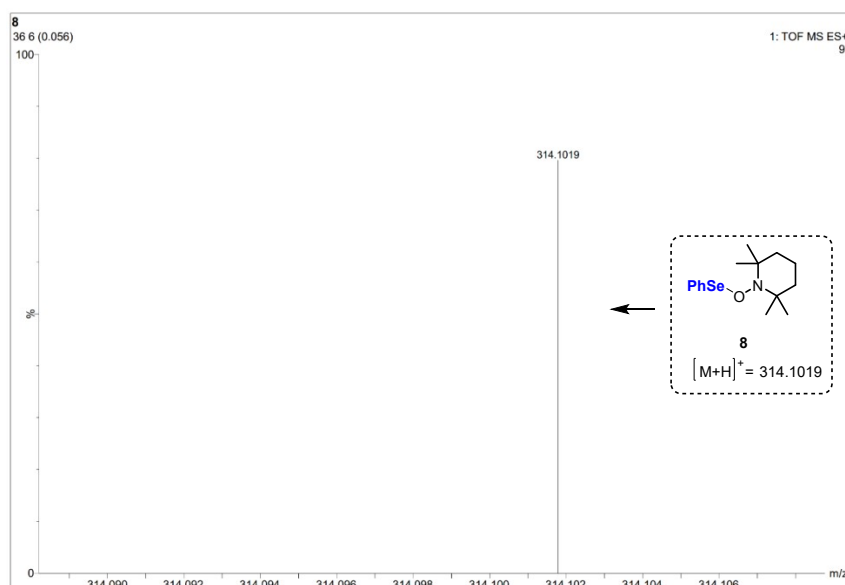
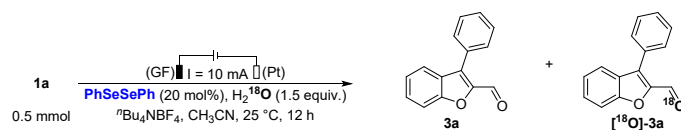


Figure S4 HRMS analysis of the radical-trapping product **8**.

3.1.2 ¹⁸O-Labeling experiment



In an undivided three-necked flask (25 mL), 1,2-diphenyldiselenane (**2a**, 31.2 mg, 0.1 mmol), ${}^t\text{Bu}_4\text{NBF}_4$ (164.6 mg, 0.5 mmol), CH_3CN (10 mL), H_2^{18}O (30.0 mg, 27.2 μL , 1.5 mmol) and (3-phenoxyprop-1-yn-1-yl)benzene (**1a**, 104.0 mg, 94.5 μL , 0.5 mmol) were continuously added. The flask was equipped with a graphite felt electrode (10 mm \times 30 mm) as the anode and a platinum plate electrode (10 mm \times 10 mm) as the cathode. The reaction mixture was stirred and electrolyzed at a constant current (10 mA) under air at 25 °C for 12 h. The ¹⁸O-labeled product was determined by HRMS (Fig. S5).

[¹⁸O]-3a, HRMS (ESI-TOF) m/z $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{15}\text{H}_{11}\text{O}^{18}\text{O}^+$, 225.0796; found 225.0799.

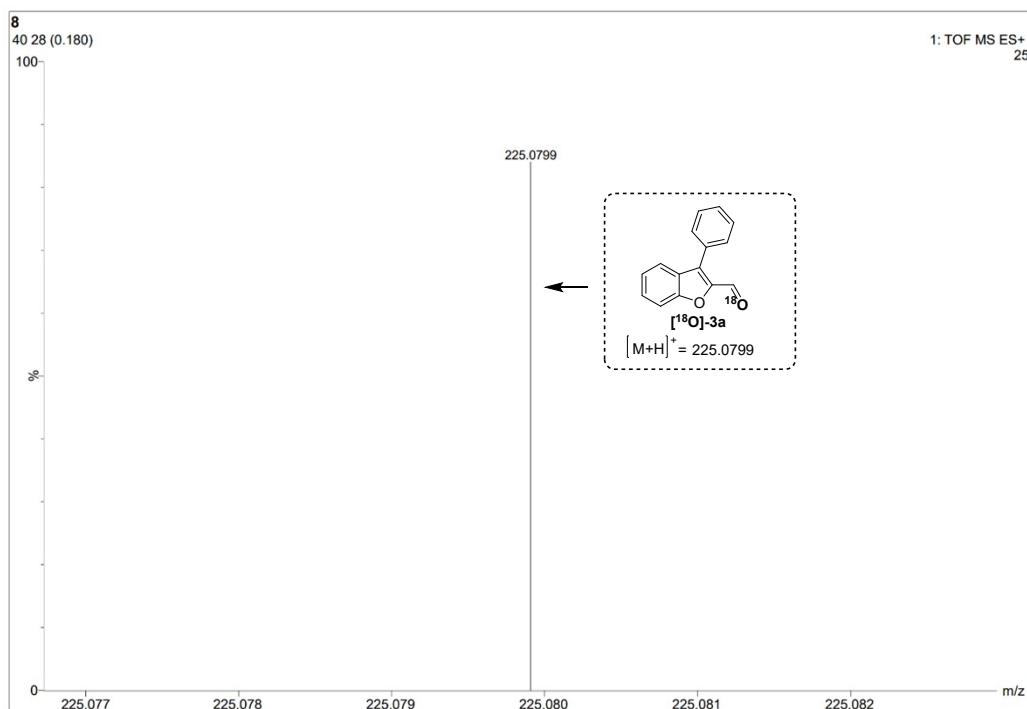
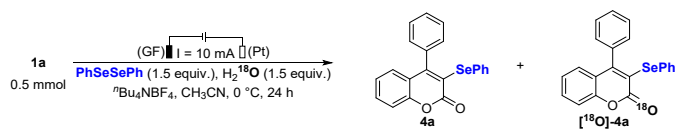


Figure S5 HRMS analysis of the ¹⁸O-labeled product **[¹⁸O]-3a**.



In an undivided three-necked flask (25 mL), 1,2-diphenyldiselenane (**2a**, 234.1 mg, 0.75 mmol), $n\text{Bu}_4\text{NBF}_4$ (164.6 mg, 0.5 mmol), CH_3CN (10 mL), H_2^{18}O (30.0 mg, 27.2 μL , 1.5 mmol) and (3-phenoxyprop-1-yn-1-yl)benzene (**1a**, 104.0 mg, 94.5 μL , 0.5 mmol) were continuously added. The flask was equipped with a graphite felt electrode (10 mm \times 30 mm) as the anode and a platinum plate electrode (10 mm \times 10 mm) as the cathode. The reaction mixture was stirred and electrolyzed at a constant current (10 mA) under air at 0 $^\circ\text{C}$ for 24 h. The ^{18}O -labeled product was determined by HRMS (Fig. S6).

$[^{18}\text{O}]\text{-4a}$, HRMS (ESI-TOF) m/z $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{21}\text{H}_{15}\text{O}^{18}\text{OSe}^+$, 381.0275; found 381.0269.

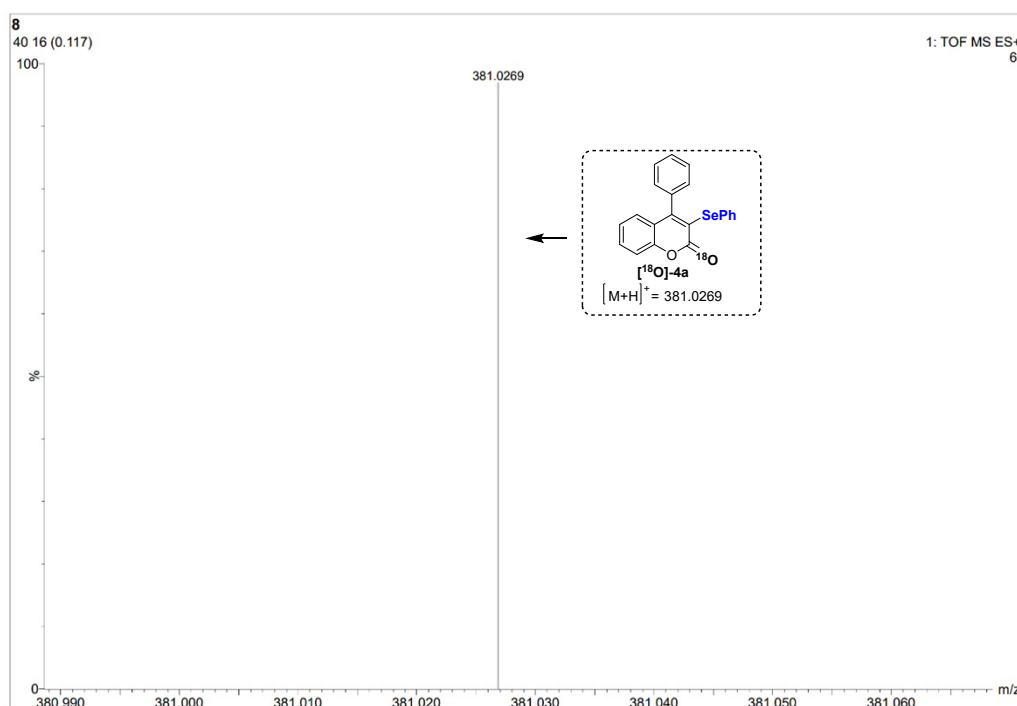
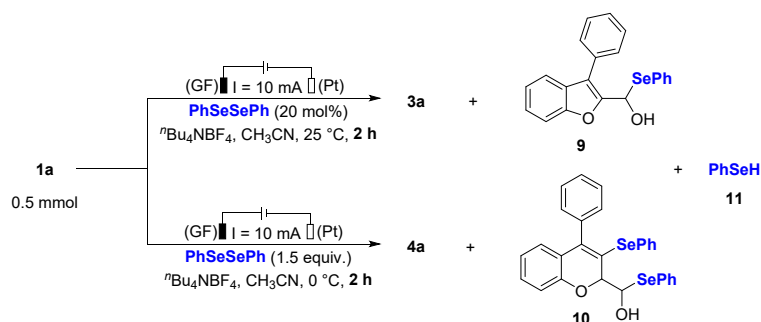


Figure S6 HRMS analysis of the ^{18}O -labeled product $[^{18}\text{O}]\text{-4a}$.

3.1.3 Detection of the possible intermediates



In an undivided three-necked flask (25 mL), 1,2-diphenyldiselenane (**2a**, 31.2 mg, 0.1 mmol or

234.1 mg, 0.75 mmol), $n\text{Bu}_4\text{NBF}_4$ (164.6 mg, 0.5 mmol), CH_3CN (10 mL) and (3-phenoxyprop-1-yn-1-yl)benzene (**1a**, 104.0 mg, 94.5 μL , 0.5 mmol) were continuously added. The flask was equipped with a graphite felt electrode (10 mm \times 30 mm) as the anode and a platinum plate electrode (10 mm \times 10 mm) as the cathode. The reaction mixture was stirred and electrolyzed at a constant current (10 mA) under air at 25 $^\circ\text{C}$ or at 0 $^\circ\text{C}$ for 2 h. The reaction mixture was analyzed by HRMS (Fig. S7-S9)

9, HRMS (ESI-TOF) m/z $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{21}\text{H}_{17}\text{O}_2\text{Se}^+$, 381.0389; found 381.0385.

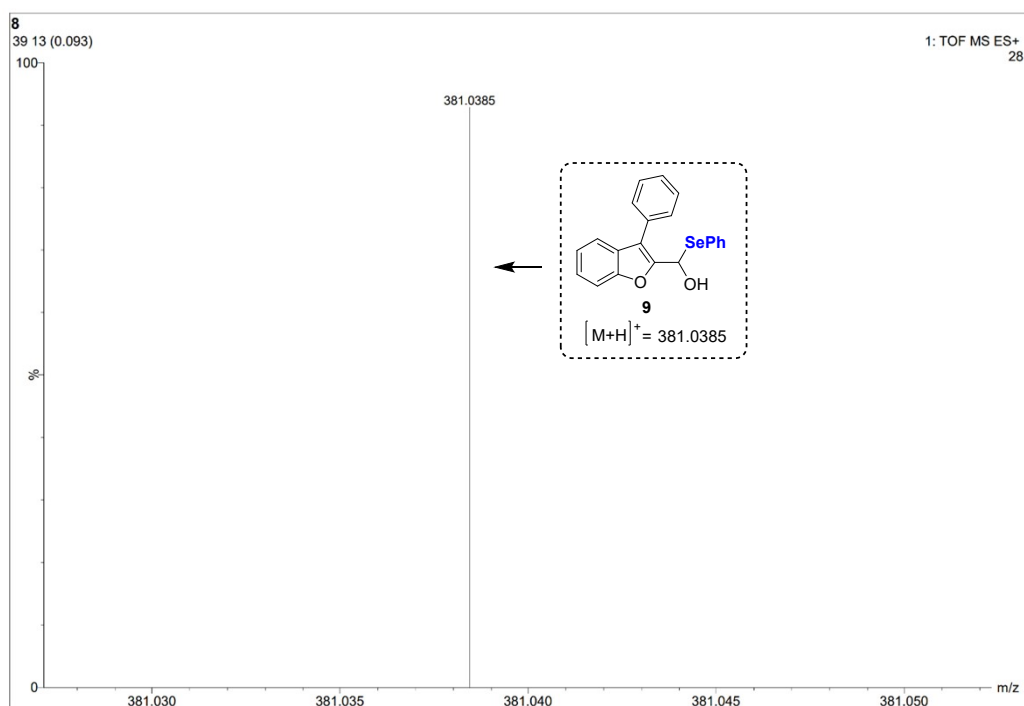


Figure S7 HRMS analysis of the possible intermediate **9**.

10, HRMS (ESI-TOF) m/z $[\text{M}+\text{H}]^+$ calcd for $\text{C}_{28}\text{H}_{23}\text{O}_2\text{Se}_2^+$, 551.0023; found 551.0020.

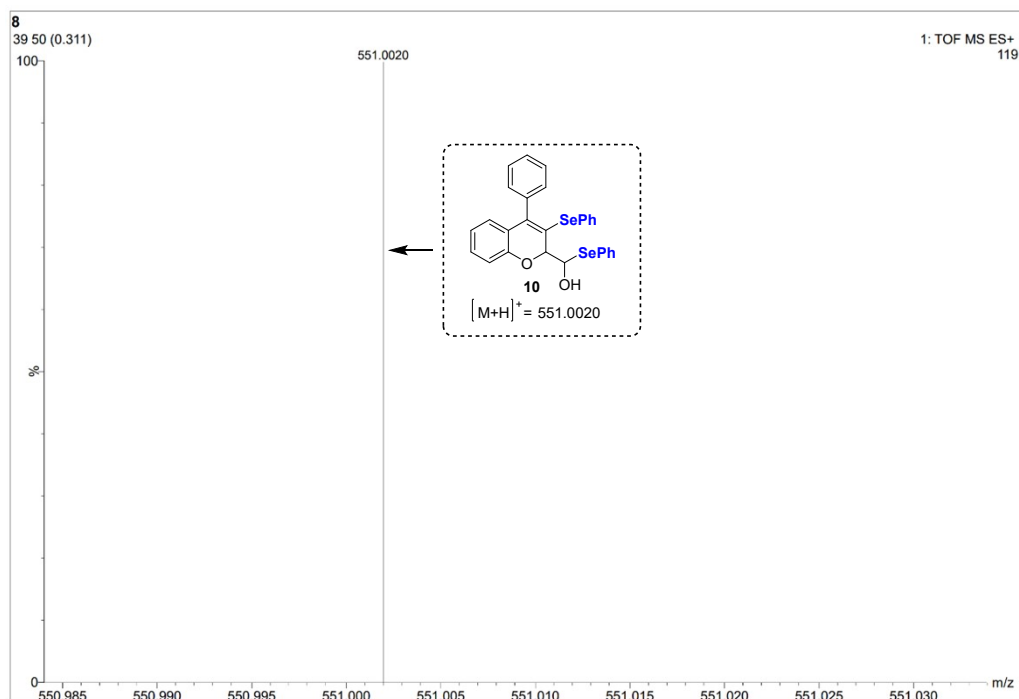


Figure S8 HRMS analysis of the possible intermediate **10**.

11, HRMS (ESI-TOF) m/z $[M+H]^+$ calcd for $C_6H_7Se^+$, 158.9708; found 158.9707.

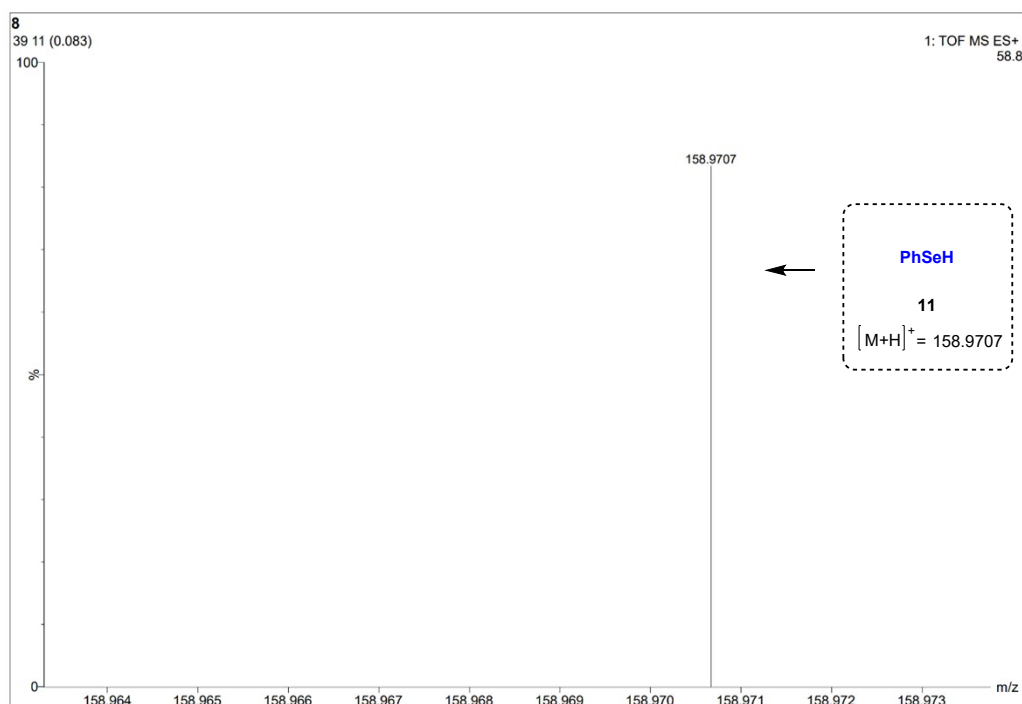


Figure S9 HRMS analysis of the possible intermediate **11**.

3.2 Cyclic voltammetry analysis

Cyclic voltammetry was performed in a three electrodes cell in a three-necked flask at room temperature. The working electrode was a 3 mm diameter glassy carbon disc electrode, and the

counter electrode was a Pt wire. The reference was silver/silver chloride electrode (Ag/AgCl) submerged in saturated aqueous KCl solution. As shown in the Figure S10, **1a** gave an oxidation peak at 1.35 V vs. Ag/AgCl in the range of 0–2.0 V, and **2a** gave an oxidation peak at 1.40 V vs. Ag/AgCl in the range of 0–2.0 V (Fig. S10).

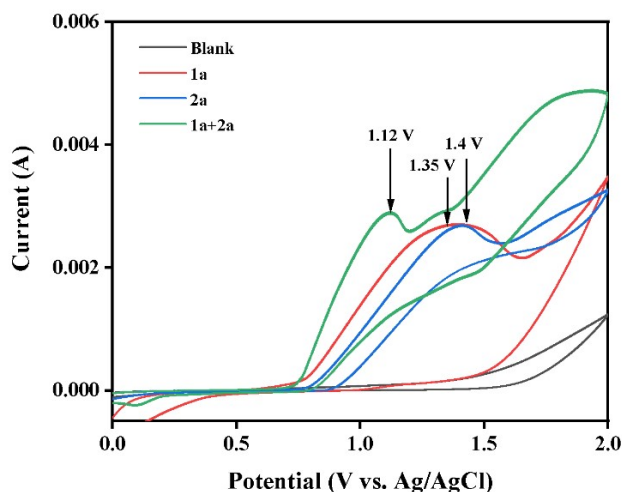
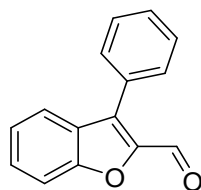
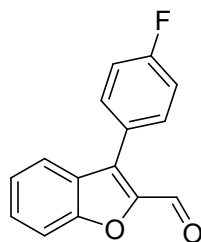


Figure S10 CV scans (scan rate 100 mV s⁻¹) of substrates: Blank (*n*Bu₄NBF₄, 0.02 M in 10 mL CH₃CN, black curve); (3-phenoxyprop-1-yn-1-yl)benzene (**1a**, 0.05 M in CH₃CN, red curve); diphenyl diselenide (**2a**, 0.05 M in CH₃CN, blue curve); **1a** and **2a** (0.05 M in CH₃CN, green curve).

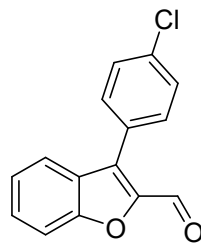
4 Experimental data for the products 3, 4, 5 and 6



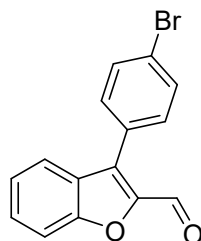
3-Phenylbenzofuran-2-carbaldehyde (3a).¹ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (97.7 mg, 88%), mp 62–64 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.83 (s, 1H), 7.73 (d, *J* = 8.0 Hz, 1H), 7.60 (d, *J* = 8.0 Hz, 3H), 7.52 (t, *J* = 7.7 Hz, 4H), 7.33 (t, *J* = 7.5 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 179.8, 155.4, 147.6, 134.2, 130.0, 129.7, 129.4, 129.20, 129.16, 127.0, 124.3, 122.7, 112.8.



3-(4-Fluorophenyl)benzofuran-2-carbaldehyde (3b). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (99.6 mg, 83%), mp 147–149 °C. ^1H NMR (400 MHz, CDCl_3) δ (ppm) 9.88 (s, 1H), 7.76 (dt, $J = 8.0, 1.0$ Hz, 1H), 7.69–7.58 (m, 4H), 7.43–7.39 (m, 1H), 7.32–7.28 (m, 2H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 179.7, 163.5 (d, $J = 250.2$ Hz), 155.4, 147.6, 133.0, 131.8 (d, $J = 8.4$ Hz), 129.9, 127.0, 125.2 (d, $J = 3.4$ Hz), 124.4, 122.4, 116.4 (d, $J = 21.9$ Hz), 112.9. HRMS (ESI) m/z : $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{15}\text{H}_{10}\text{FO}_2^+$ 241.0660; Found 241.0663.

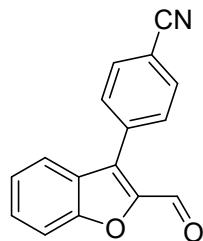


3-(4-Chlorophenyl)benzofuran-2-carbaldehyde (3c). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (107.6 mg, 84%), mp 163–165 °C. ^1H NMR (400 MHz, CDCl_3) δ (ppm) 9.89 (s, 1H), 7.76 (dt, $J = 8.0, 1.0$ Hz, 1H), 7.69 (d, $J = 8.4$ Hz, 1H), 7.63–7.57 (m, 5H), 7.44–7.40 (m, 1H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 179.6, 155.5, 147.6, 135.8, 132.8, 131.2, 129.9, 129.5, 127.7, 126.9, 124.5, 122.4, 113.0. HRMS (ESI) m/z : $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{15}\text{H}_{10}\text{ClO}_2^+$ 257.0364; Found 257.0363.

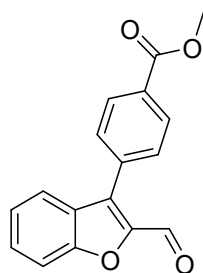


3-(4-Bromophenyl)benzofuran-2-carbaldehyde (3d). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (129.0 mg, 86%), mp 163–165 °C. ^1H NMR (400 MHz, CDCl_3) δ (ppm) 9.89 (s, 1H), 7.76–7.72 (m, 3H), 7.68 (d, $J = 8.4$ Hz, 1H), 7.63–7.59 (m, 1H), 7.56–7.52 (m, 2H), 7.43–7.39 (m, 1H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 179.6, 155.5, 147.6, 132.7, 132.5, 131.4, 129.9, 128.2, 126.8, 124.5,

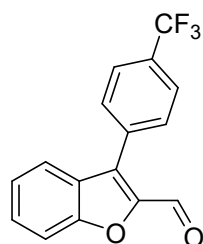
123.95, 122.4, 113.0. HRMS (ESI) m/z : $[M + H]^+$ Calcd for $C_{15}H_{10}BrO_2^+$ 300.9859; Found 300.9861.



4-(2-Formylbenzofuran-3-yl)benzonitrile (3e). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (10:1, v/v). Yellow solid (107.5 mg, 87%), mp 176–178 °C. 1H NMR (400 MHz, $CDCl_3$) δ (ppm) 9.92 (s, 1H), 7.90 (d, $J = 8.2$ Hz, 2H), 7.80 (d, $J = 8.3$ Hz, 2H), 7.74 (d, $J = 8.0$ Hz, 1H), 7.71 (d, $J = 8.4$ Hz, 1H), 7.66–7.62 (m, 1H), 7.44 (t, $J = 7.5$ Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) 179.5, 155.4, 147.7, 134.1, 132.9, 131.1, 130.6, 130.1, 126.5, 124.9, 122.1, 118.3, 113.2, 113.1. HRMS (ESI) m/z : $[M + H]^+$ Calcd for $C_{16}H_{10}NO_2^+$ 248.0707; Found 248.0705.

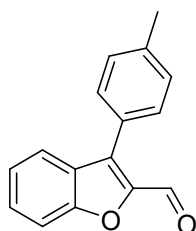


Methyl 4-(2-formylbenzofuran-3-yl)benzoate (3f). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (10:1, v/v). Yellow solid (119.1 mg, 85%), mp 120–122 °C. 1H NMR (400 MHz, $CDCl_3$) δ (ppm) 9.88 (s, 1H), 8.25–8.22 (m, 2H), 7.76–7.71 (m, 3H), 7.66 (d, $J = 8.4$ Hz, 1H), 7.61–7.57 (m, 1H), 7.42–7.38 (m, 1H), 3.99 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) 179.6, 166.4, 155.4, 147.7, 133.8, 132.7, 130.9, 130.3, 130.0, 129.9, 126.7, 124.6, 122.4, 113.0, 52.5. HRMS (ESI) m/z : $[M + H]^+$ Calcd for $C_{17}H_{13}O_4^+$ 281.0809; Found 281.0807.

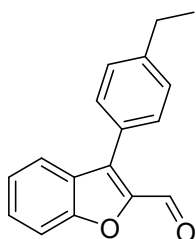


3-(4-(Trifluoromethyl)phenyl)benzofuran-2-carbaldehyde (3g). The product was purified by

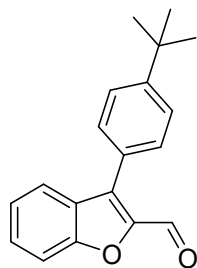
silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (118.9 mg, 82%), mp 103–105 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.91 (s, 1H), 7.87 (d, *J* = 8.2 Hz, 2H), 7.81–7.75 (m, 3H), 7.70 (dt, *J* = 8.4, 1.0 Hz, 1H), 7.65–7.61 (m, 1H), 7.45–7.41 (m, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 179.5, 155.4, 147.8, 133.0, 132.1, 131.4 (q, *J* = 32.9 Hz), 130.4, 130.0, 126.8, 126.2 (q, *J* = 3.8 Hz), 124.7, 123.9 (q, *J* = 272.5 Hz), 122.3, 113.0. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₁₆H₁₀F₃O₂⁺ 291.0628; Found 291.0626.



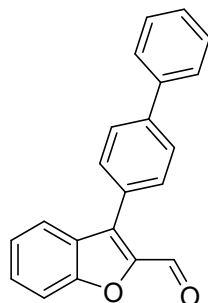
3-(*P*-Tolyl)benzofuran-2-carbaldehyde (3h). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (100.4 mg, 85%), mp 94–96 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.88 (s, 1H), 7.79 (d, *J* = 8.0 Hz, 1H), 7.65 (d, *J* = 8.4 Hz, 1H), 7.58 (d, *J* = 7.4 Hz, 1H), 7.54 (d, *J* = 7.8 Hz, 2H), 7.39 (d, *J* = 7.7 Hz, 3H), 2.48 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 180.0, 155.5, 147.6, 139.7, 134.6, 130.0, 129.9, 129.7, 127.1, 126.2, 124.2, 122.8, 112.8, 21.4. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₁₆H₁₃O₂⁺ 237.0911; Found 237.0918.



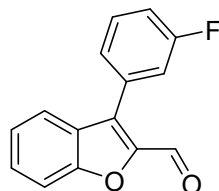
3-(4-Ethylphenyl)benzofuran-2-carbaldehyde (3i). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (101.3 mg, 81%), mp 87–89 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.89 (s, 1H), 7.80 (dd, *J* = 8.1, 1.2 Hz, 1H), 7.66 (d, *J* = 8.4 Hz, 1H), 7.58 (dd, *J* = 7.5, 5.2 Hz, 3H), 7.47–7.34 (m, 3H), 2.79 (q, *J* = 7.6 Hz, 2H), 1.34 (t, *J* = 7.6 Hz, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 180.0, 155.5, 147.6, 145.9, 134.6, 130.0, 129.7, 128.8, 127.1, 126.5, 124.2, 122.8, 112.8, 28.8, 15.5. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₁₇H₁₅O₂⁺ 251.1067; Found 251.1069.



3-(4-(*Tert*-Butyl)phenyl)benzofuran-2-carbaldehyde (3j). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (111.3 mg, 80%), mp 103–105 °C. ^1H NMR (400 MHz, CDCl_3) δ (ppm) 9.90 (s, 1H), 7.81 (d, $J = 7.9$ Hz, 1H), 7.67–7.56 (m, 6H), 7.37 (t, $J = 7.5$ Hz, 1H), 1.42 (s, 9H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 180.0, 155.5, 152.8, 147.6, 134.5, 129.8, 129.7, 127.1, 126.3, 126.2, 124.2, 122.9, 112.8, 34.9, 31.3. HRMS (ESI) m/z : $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{19}\text{H}_{19}\text{O}_2^+$ 279.1380; Found 279.1388.

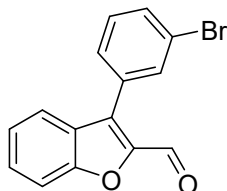


3-([1,1'-Biphenyl]-4-yl)benzofuran-2-carbaldehyde (3k). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (30:1, v/v). Yellow solid (125.2 mg, 84%), mp 176–178 °C. ^1H NMR (400 MHz, CDCl_3) δ (ppm) 9.97 (s, 1H), 7.87–7.82 (m, 3H), 7.76–7.69 (m, 5H), 7.64–7.60 (m, 1H), 7.53 (t, $J = 7.6$ Hz, 2H), 7.47–7.40 (m, 2H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 179.9, 155.5, 147.7, 142.4, 140.1, 133.9, 130.5, 129.8, 129.0, 128.1, 128.0, 127.9, 127.2, 127.1, 124.4, 122.7, 112.9. HRMS (ESI) m/z : $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{21}\text{H}_{15}\text{O}_2^+$ 299.1067; Found 299.1076.

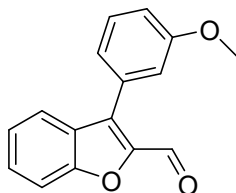


3-(3-Fluorophenyl)benzofuran-2-carbaldehyde (3l). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (79.2 mg, 66%), mp 80–82 °C. ^1H NMR (400 MHz, CDCl_3) δ (ppm) 9.92 (s, 1H), 7.78 (d, $J = 8.0$ Hz, 1H),

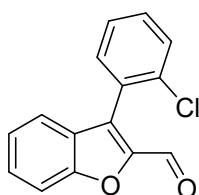
7.68 (d, $J = 8.4$ Hz, 1H), 7.63–7.55 (m, 2H), 7.45–7.36 (m, 3H), 7.29–7.24 (m, 1H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 179.6, 163.0 (d, $J = 248.1$ Hz), 155.4, 147.7, 132.6, 131.3 (d, $J = 8.3$ Hz), 130.9 (d, $J = 8.5$ Hz), 129.9, 126.8, 125.9 (d, $J = 3.1$ Hz), 124.5, 122.4, 116.9 (d, $J = 22.4$ Hz), 116.5 (d, $J = 21.1$ Hz), 113.0. HRMS (ESI) m/z : $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{15}\text{H}_{10}\text{FO}_2^+$ 241.0660; Found 241.0666.



3-(3-Bromophenyl)benzofuran-2-carbaldehyde (3m). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (97.5 mg, 65%), mp 136–138 °C. ^1H NMR (400 MHz, CDCl_3) δ (ppm) 9.89 (s, 1H), 7.80 (t, $J = 1.8$ Hz, 1H), 7.76 (d, $J = 8.0$ Hz, 1H), 7.70–7.66 (m, 2H), 7.62–7.57 (m, 2H), 7.47 (t, $J = 7.8$ Hz, 1H), 7.43–7.39 (m, 1H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 179.5, 155.4, 147.7, 132.7, 132.5, 132.3, 131.3, 130.7, 130.0, 128.7, 126.7, 124.6, 123.3, 122.4, 113.0. HRMS (ESI) m/z : $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{15}\text{H}_{10}\text{BrO}_2^+$ 300.9859; Found 300.9867.

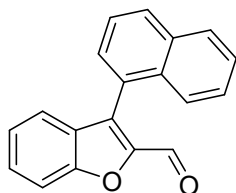


3-(3-Methoxyphenyl)benzofuran-2-carbaldehyde (3n). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (73.1 mg, 58%), mp 89–91 °C. ^1H NMR (400 MHz, CDCl_3) δ (ppm) 9.92 (s, 1H), 7.81 (d, $J = 8.0$ Hz, 1H), 7.67 (d, $J = 8.4$ Hz, 1H), 7.59 (t, $J = 7.7$ Hz, 1H), 7.50 (t, $J = 7.9$ Hz, 1H), 7.39 (t, $J = 7.5$ Hz, 1H), 7.23 (d, $J = 7.6$ Hz, 1H), 7.18 (s, 1H), 7.10 (dd, $J = 8.4, 2.6$ Hz, 1H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 179.9, 160.1, 155.4, 147.7, 134.3, 130.4, 130.3, 129.8, 127.0, 124.3, 122.8, 122.5, 115.6, 114.9, 112.9, 55.5. HRMS (ESI) m/z : $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{16}\text{H}_{13}\text{O}_3^+$ 253.0860; Found 253.0864.

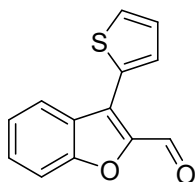


3-(2-Chlorophenyl)benzofuran-2-carbaldehyde (3o). The product was purified by silica gel

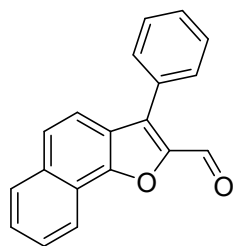
column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (79.4 mg, 62%), mp 89–91 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.76 (s, 1H), 7.69–7.67 (m, 1H), 7.65–7.62 (m, 1H), 7.58 (td, *J* = 7.2, 1.4 Hz, 2H), 7.52–7.45 (m, 3H), 7.39–7.35 (m, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 179.6, 155.3, 148.0, 134.0, 132.5, 130.9, 130.8, 130.5, 129.6, 128.3, 127.3, 127.1, 124.2, 123.1, 112.9. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₁₅H₁₀ClO₂⁺ 257.0364; Found 257.0372.



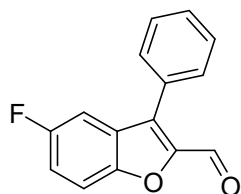
3-(Naphthalen-1-yl)benzofuran-2-carbaldehyde (3p). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (114.3 mg, 84%), mp 142–144 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.71 (s, 1H), 8.07–8.05 (m, 1H), 8.01 (d, *J* = 8.3 Hz, 1H), 7.79 (d, *J* = 8.4 Hz, 1H), 7.74 (d, *J* = 8.4 Hz, 1H), 7.64–7.57 (m, 4H), 7.49–7.43 (m, 2H), 7.32–7.28 (m, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 179.7, 155.3, 148.8, 133.8, 133.2, 132.1, 130.1, 129.8, 129.4, 128.7, 128.3, 127.0, 126.7, 126.4, 125.6, 125.4, 124.3, 123.3, 112.9. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₁₉H₁₃O₂⁺ 273.0911; Found 273.0911.



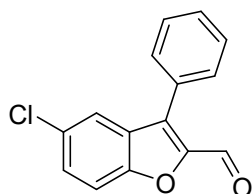
3-(Thiophen-2-yl)benzofuran-2-carbaldehyde (3q). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (30:1, v/v). Yellow solid (78.7 mg, 69%), mp 98–100 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 10.12 (s, 1H), 7.99 (d, *J* = 8.0 Hz, 1H), 7.66 (d, *J* = 8.4 Hz, 1H), 7.63–7.58 (m, 2H), 7.55 (dd, *J* = 3.6, 1.2 Hz, 1H), 7.43 (t, *J* = 7.5 Hz, 1H), 7.29 (dd, *J* = 4.8, 3.2 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 179.6, 155.5, 147.6, 129.9, 129.8, 129.6, 128.6, 128.3, 126.9, 126.6, 124.5, 123.0, 112.9. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₁₃H₉O₂S⁺ 229.0318; Found 229.0315.



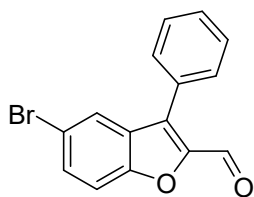
3-Phenyl-naphtho[1,2-*b*]furan-2-carbaldehyde (3r). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (111.6 mg, 82%), mp 134–136 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.89 (s, 1H), 8.52 (dd, *J* = 7.6, 2.0 Hz, 1H), 7.95 (dd, *J* = 7.4, 1.9 Hz, 1H), 7.73–7.56 (m, 9H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 179.0, 152.6, 147.6, 135.4, 134.1, 130.1, 129.4, 129.4, 129.2, 128.5, 127.8, 127.2, 125.4, 122.8, 121.5, 121.3, 118.9. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₁₉H₁₃O₂⁺ 273.0911; Found 273.0903.



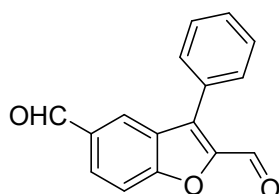
5-Fluoro-3-phenylbenzofuran-2-carbaldehyde (3s). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (88.8 mg, 74%), mp 110–112 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.87 (s, 1H), 7.62–7.55 (m, 6H), 7.40 (dd, *J* = 8.1, 2.7 Hz, 1H), 7.29 (td, *J* = 8.9, 2.7 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 179.8, 159.8 (d, *J* = 242.1 Hz), 151.6, 148.9, 134.0 (d, *J* = 4.7 Hz), 129.8, 129.7, 129.3, 128.7, 127.8 (d, *J* = 10.3 Hz), 118.1 (d, *J* = 26.9 Hz), 113.9 (d, *J* = 9.4 Hz), 107.7 (d, *J* = 25.1 Hz). HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₁₅H₁₀FO₂⁺ 241.0660; Found 241.0657.



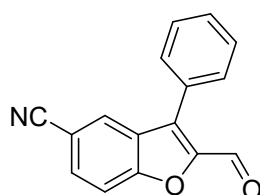
5-Chloro-3-phenylbenzofuran-2-carbaldehyde (3t).² The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (103.7 mg, 81%), mp 142–144 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.88 (s, 1H), 7.74 (d, *J* = 2.1 Hz, 1H), 7.63–7.56 (m, 6H), 7.52 (dd, *J* = 8.9, 2.1 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 179.7, 153.7, 148.5, 133.3, 130.1, 130.0, 129.9, 129.7, 129.4, 128.5, 128.4, 122.1, 114.0.



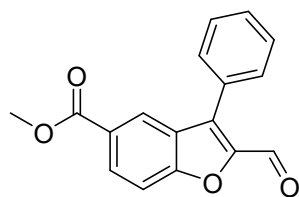
5-Bromo-3-phenylbenzofuran-2-carbaldehyde (3u).² The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (117.0 mg, 78%), mp 143–145 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.87 (s, 1H), 7.88 (d, *J* = 2.0 Hz, 1H), 7.65–7.56 (m, 6H), 7.52 (d, *J* = 8.8 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 179.7, 154.0, 148.3, 133.1, 132.6, 129.9, 129.7, 129.4, 128.9, 128.5, 125.2, 117.5, 114.4.



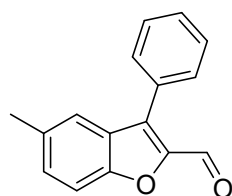
3-Phenylbenzofuran-2,5-dicarbaldehyde (3v). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (5:1, v/v). Yellow solid (91.3 mg, 73%), mp 186–188 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 10.12 (s, 1H), 9.95 (s, 1H), 8.36 (d, *J* = 1.6 Hz, 1H), 8.15 (dd, *J* = 8.7, 1.7 Hz, 1H), 7.81 (d, *J* = 8.6 Hz, 1H), 7.70–7.62 (m, 5H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 190.9, 179.6, 158.4, 148.8, 134.2, 133.4, 130.3, 129.98, 129.95, 129.5, 128.3, 127.8, 126.3, 113.8. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₁₆H₁₁O₂⁺ 251.0703; Found 251.0702.



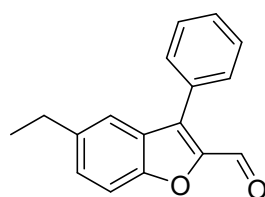
2-Formyl-3-phenylbenzofuran-5-carbonitrile (3w). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (10:1, v/v). Yellow solid (105.0 mg, 85%), mp 200–202 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.96 (s, 1H), 8.17 (d, *J* = 1.4 Hz, 1H), 7.85 (dd, *J* = 8.7, 1.6 Hz, 1H), 7.78 (dd, *J* = 8.7, 0.7 Hz, 1H), 7.65–7.62 (m, 5H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 179.5, 156.7, 148.8, 133.1, 132.4, 130.2, 129.9, 129.6, 128.2, 127.9, 127.8, 118.4, 114.3, 108.6. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₁₆H₁₀NO₂⁺ 248.0707; Found 248.0704.



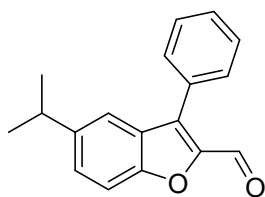
Methyl 2-formyl-3-phenylbenzofuran-5-carboxylate (3x). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (10:1, v/v). Yellow solid (116.3 mg, 83%), mp 156–158 °C. ^1H NMR (400 MHz, CDCl_3) δ (ppm) 9.92 (s, 1H), 8.52 (d, $J = 1.8$ Hz, 1H), 8.28 (dd, $J = 8.8, 1.8$ Hz, 1H), 7.71–7.59 (m, 6H), 3.97 (s, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 179.7, 166.4, 157.7, 148.6, 134.3, 130.9, 130.0, 129.8, 129.4, 128.5, 127.2, 126.8, 125.4, 112.8, 52.4. HRMS (ESI) m/z : $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{17}\text{H}_{13}\text{O}_4^+$ 281.0809; Found 281.0812.



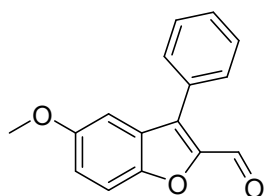
5-Methyl-3-phenylbenzofuran-2-carbaldehyde (3y).² The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (88.6 mg, 75%), mp 109–111 °C. ^1H NMR (400 MHz, CDCl_3) δ (ppm) 9.87 (s, 1H), 7.66–7.63 (m, 2H), 7.62–7.54 (m, 5H), 7.40 (dd, $J = 8.8, 1.7$ Hz, 1H), 2.49 (s, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 179.8, 154.0, 147.9, 134.2, 134.1, 131.4, 130.0, 129.41, 129.35, 129.2, 127.1, 122.0, 112.4, 21.4.



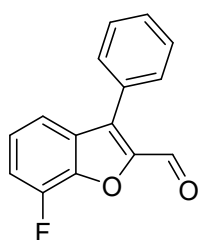
5-Ethyl-3-phenylbenzofuran-2-carbaldehyde (3z). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (88.8 mg, 71%), mp 100–102 °C. ^1H NMR (400 MHz, CDCl_3) δ (ppm) 9.87 (s, 1H), 7.67–7.65 (m, 2H), 7.62–7.56 (m, 5H), 7.44 (dd, $J = 8.8, 1.6$ Hz, 1H), 2.78 (q, $J = 7.6$ Hz, 2H), 1.30 (t, $J = 7.6$ Hz, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 179.8, 154.2, 147.9, 140.6, 134.3, 130.4, 130.0, 129.5, 129.4, 129.2, 127.1, 120.8, 112.5, 28.9, 16.1. HRMS (ESI) m/z : $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{17}\text{H}_{15}\text{O}_2^+$ 251.1067; Found 251.1065.



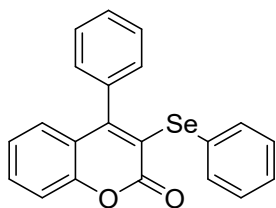
5-Isopropyl-3-phenylbenzofuran-2-carbaldehyde (3aa). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow oil (104.4 mg, 79%). ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.86 (s, 1H), 7.67–7.65 (m, 2H), 7.62–7.55 (m, 5H), 7.48 (dd, *J* = 8.7, 1.8 Hz, 1H), 3.09–3.02 (m, 1H), 1.31 (d, *J* = 7.0 Hz, 6H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 179.8, 154.2, 148.0, 145.3, 134.4, 130.0, 129.5, 129.4, 129.2, 129.1, 127.0, 119.3, 112.6, 34.2, 24.4. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₁₈H₁₇O₂⁺ 265.1224; Found 265.1226.



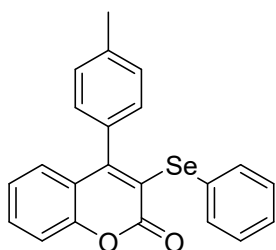
5-Methoxy-3-phenylbenzofuran-2-carbaldehyde (3ab). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow solid (85.7 mg, 68%), mp 162–164 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.83 (s, 1H), 7.65–7.54 (m, 6H), 7.20 (dd, *J* = 9.1, 2.6 Hz, 1H), 7.12 (d, *J* = 2.6 Hz, 1H), 3.85 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 179.7, 157.0, 150.6, 148.4, 134.3, 129.9, 129.4, 129.3, 127.5, 120.1, 114.7, 113.6, 103.0, 56.0. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₁₆H₁₃O₃⁺ 253.0860; Found 253.0861.



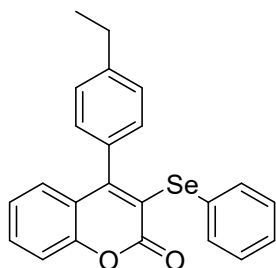
7-Fluoro-3-phenylbenzofuran-2-carbaldehyde (3ac). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (50:1, v/v). Yellow oil (92.4 mg, 77%). ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.92 (s, 1H), 7.66–7.64 (m, 2H), 7.62–7.55 (m, 4H), 7.31 (dd, *J* = 8.4, 3.5 Hz, 2H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 179.6, 148.5 (d, *J* = 253.5 Hz), 148.2, 142.9 (d, *J* = 11.9 Hz), 133.9 (d, *J* = 2.5 Hz), 130.6 (d, *J* = 2.8 Hz), 130.0, 129.7, 129.3, 128.7, 124.9 (d, *J* = 5.5 Hz), 118.3 (d, *J* = 4.4 Hz), 115.4 (d, *J* = 15.8 Hz). HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₁₅H₁₀FO₂⁺ 241.0660; Found 241.0665.



4-Phenyl-3-(phenylselanyl)-2H-chromen-2-one (4a).³ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (143.6 mg, 76%), mp 153–155 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.57–7.52 (m, 1H), 7.48 (dd, J = 5.0, 1.9 Hz, 3H), 7.40 (dd, J = 8.3, 1.2 Hz, 1H), 7.36–7.30 (m, 2H), 7.22–7.15 (m, 6H), 7.09 (dd, J = 8.0, 1.6 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.6, 159.1, 153.5, 136.2, 132.8, 132.1, 130.3, 129.1, 128.9, 128.5, 128.3, 127.8, 127.5, 124.3, 120.8, 120.5, 116.8.

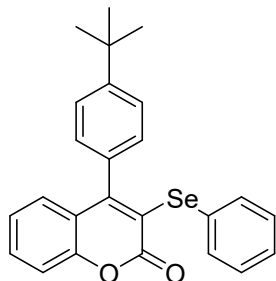


3-(Phenylselanyl)-4-(p-tolyl)-2H-chromen-2-one (4b).³ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (143.1 mg, 73%), mp 117–119 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.56–7.52 (m, 1H), 7.40–7.34 (m, 3H), 7.29 (d, J = 7.9 Hz, 2H), 7.22–7.14 (m, 5H), 7.11 (d, J = 7.9 Hz, 2H), 2.47 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.6, 159.3, 153.5, 138.9, 133.3, 132.7, 132.0, 130.4, 129.2, 129.0, 128.2, 128.1, 127.4, 124.3, 120.60, 120.58, 116.8, 21.5.

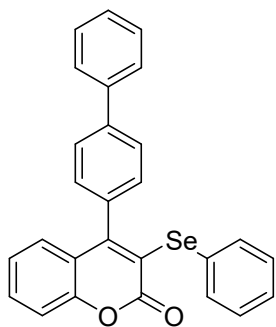


4-(4-Ethylphenyl)-3-(phenylselanyl)-2H-chromen-2-one (4c). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (150.2 mg, 74%), mp 110–112 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.56–7.52 (m, 1H), 7.42–7.38 (m, 1H), 7.34 (dt, J = 6.5, 1.7 Hz, 2H), 7.30 (d, J = 8.0 Hz, 2H), 7.21–7.11 (m, 7H),

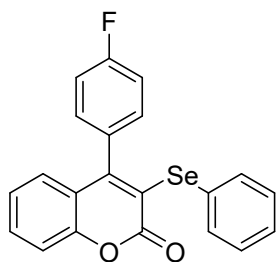
2.76 (q, $J = 7.6$ Hz, 2H), 1.34 (t, $J = 7.6$ Hz, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 159.6, 159.2, 153.5, 145.1, 133.5, 132.7, 131.9, 130.4, 129.0, 128.3, 128.1, 127.9, 127.4, 124.2, 120.7, 120.6, 116.8, 28.8, 15.4. HRMS (ESI) m/z : $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{23}\text{H}_{19}\text{O}_2\text{Se}^+$ 407.0545; Found 407.0550.



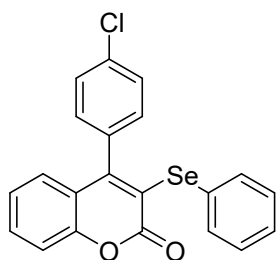
4-(4-(*Tert*-Butyl)phenyl)-3-(phenylselanyl)-2*H*-chromen-2-one (4d).⁴ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (154.1 mg, 71%), mp 156–158 °C. ^1H NMR (400 MHz, CDCl_3) δ (ppm) 7.56–7.51 (m, 1H), 7.45 (d, $J = 8.4$ Hz, 2H), 7.40 (d, $J = 8.9$ Hz, 1H), 7.31–7.28 (m, 2H), 7.21–7.10 (m, 7H), 1.41 (s, 9H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 159.7, 158.9, 153.4, 151.9, 133.1, 132.8, 131.9, 130.5, 129.0, 128.1, 128.0, 127.3, 125.3, 124.2, 120.9, 120.7, 116.8, 34.8, 31.4.



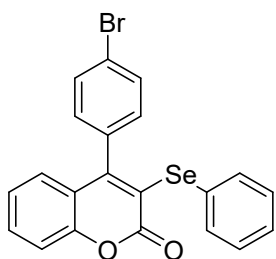
4-([1,1'-biphenyl]-4-yl)-3-(phenylselanyl)-2*H*-chromen-2-one (4e).⁴ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (172.5 mg, 76%), mp 131–133 °C. ^1H NMR (400 MHz, CDCl_3) δ (ppm) 7.70–7.65 (m, 4H), 7.58–7.51 (m, 3H), 7.46–7.42 (m, 2H), 7.35–7.33 (m, 2H), 7.27–7.24 (m, 2H), 7.22–7.13 (m, 5H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 159.7, 158.4, 153.4, 141.6, 140.3, 134.9, 133.1, 132.0, 130.3, 129.1, 129.0, 128.9, 127.84, 127.83, 127.5, 127.2, 127.1, 124.4, 121.1, 120.5, 116.9.



4-(4-Fluorophenyl)-3-(phenylselanyl)-2H-chromen-2-one (4f).³ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (128.7 mg, 65%), mp 139–141 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.58–7.53 (m, 1H), 7.40 (d, J = 8.3 Hz, 1H), 7.32–7.30 (m, 2H), 7.24–7.11 (m, 8H), 7.06 (dd, J = 8.1, 1.6 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 162.8 (d, J = 249.2 Hz), 159.6, 157.7, 153.4, 133.0, 132.1, 132.0 (d, J = 3.6 Hz), 130.3 (d, J = 8.3 Hz), 130.2, 129.1, 127.60, 127.58, 124.4, 121.5, 120.5, 116.9, 115.7 (d, J = 21.8 Hz).

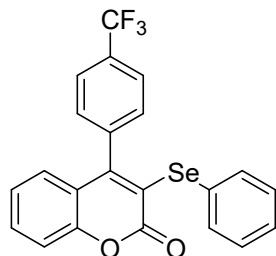


4-(4-Chlorophenyl)-3-(phenylselanyl)-2H-chromen-2-one (4g).³ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (138.0 mg, 67%), mp 128–130 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.58–7.53 (m, 1H), 7.41 (d, J = 8.1 Hz, 3H), 7.32–7.28 (m, 2H), 7.25–7.15 (m, 4H), 7.10 (d, J = 8.0 Hz, 2H), 7.06–7.03 (m, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.5, 157.4, 153.4, 135.0, 134.4, 133.1, 132.2, 130.0, 129.8, 129.1, 128.8, 127.7, 127.5, 124.4, 121.5, 120.3, 117.0.

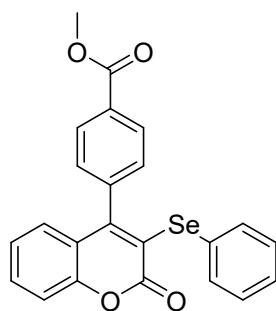


4-(4-Bromophenyl)-3-(phenylselanyl)-2H-chromen-2-one (4h).⁴ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (157.3 mg, 69%), mp 105–107 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.57–7.53 (m, 3H),

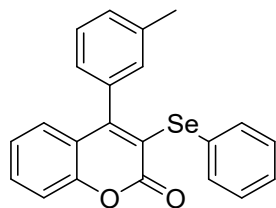
7.31–7.29 (m, 1H), 7.33–7.28 (m, 2H), 7.25–7.15 (m, 4H), 7.06–7.03 (m, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 159.5, 157.3, 153.4, 134.8, 133.1, 132.2, 131.8, 130.0, 129.1, 127.7, 127.5, 124.5, 123.2, 121.4, 120.2, 117.0.



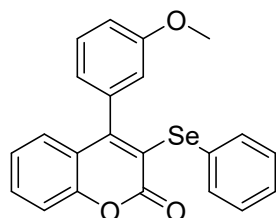
3-(Phenylselanyl)-4-(4-(trifluoromethyl)phenyl)-2H-chromen-2-one (4i).⁴ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow oil (122.7 mg, 55%). ^1H NMR (400 MHz, CDCl_3) δ (ppm) 7.67 (d, $J = 7.9$ Hz, 2H), 7.59–7.55 (m, 1H), 7.43 (d, $J = 8.3$ Hz, 1H), 7.28–7.12 (m, 8H), 6.96 (dd, $J = 8.1, 1.5$ Hz, 1H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 159.5, 156.6, 153.4, 139.4, 133.4, 132.3, 130.8 (q, $J = 32.7$ Hz), 129.8, 129.2, 128.8, 127.8, 127.1, 125.5 (q, $J = 3.7$ Hz), 124.5, 123.8 (q, $J = 272.5$ Hz), 121.8, 120.1, 117.0.



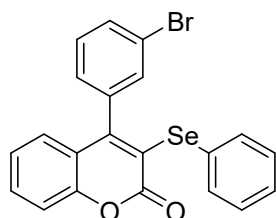
Methyl 4-(2-oxo-3-(phenylselanyl)-2H-chromen-4-yl)benzoate (4j). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (10:1, v/v). Yellow oil (109.0 mg, 50%). ^1H NMR (400 MHz, CDCl_3) δ (ppm) 8.13–8.10 (m, 2H), 7.58–7.54 (m, 1H), 7.41 (dd, $J = 8.3, 1.2$ Hz, 1H), 7.32–7.30 (m, 2H), 7.27–7.25 (m, 2H), 7.22–7.13 (m, 4H), 6.98 (dd, $J = 8.0, 1.6$ Hz, 1H), 4.00 (s, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ (ppm) 166.5, 159.5, 157.8, 153.4, 140.5, 133.1, 132.3, 130.5, 130.0, 129.8, 129.2, 128.5, 127.7, 127.4, 124.5, 121.1, 120.1, 117.0, 52.5. HRMS (ESI) m/z : $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{23}\text{H}_{17}\text{O}_4\text{Se}^+$ 437.0287; Found 437.0293.



3-(Phenylselanyl)-4-(*m*-tolyl)-2*H*-chromen-2-one (4k).⁴ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (141.1 mg, 72%), mp 109–111 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.56–7.52 (m, 1H), 7.41–7.33 (m, 4H), 7.28 (d, J = 6.0 Hz, 1H), 7.22–7.16 (m, 4H), 7.10 (dd, J = 8.0, 1.7 Hz, 1H), 7.02 (d, J = 7.5 Hz, 1H), 6.94 (s, 1H), 2.39 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.7, 159.2, 153.4, 138.2, 136.1, 132.9, 132.0, 130.4, 129.6, 129.0, 128.8, 128.5, 128.0, 127.4, 125.3, 124.3, 120.64, 120.58, 116.8, 21.6.

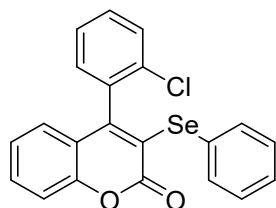


4-(3-Methoxyphenyl)-3-(phenylselanyl)-2*H*-chromen-2-one (4l).⁴ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow oil (153.0 mg, 75%). ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.56–7.52 (m, 1H), 7.42–7.35 (m, 4H), 7.22–7.16 (m, 4H), 7.12 (dd, J = 8.1, 1.8 Hz, 1H), 7.01 (dd, J = 8.4, 2.6 Hz, 1H), 6.80 (d, J = 7.6 Hz, 1H), 6.69–6.68 (m, 1H), 3.80 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.6, 159.5, 158.7, 153.5, 137.4, 132.9, 132.0, 130.3, 129.8, 129.0, 127.9, 127.4, 124.3, 120.6, 120.5, 120.4, 116.8, 114.5, 113.7, 55.3.

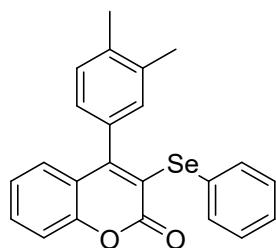


4-(3-Bromophenyl)-3-(phenylselanyl)-2*H*-chromen-2-one (4m).⁴ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (139.1 mg, 61%), mp 103–105 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.59–7.53 (m, 2H), 7.40 (d, J = 8.4 Hz, 1H), 7.34–7.31 (m, 3H), 7.24–7.12 (m, 6H), 7.03 (dd, J = 8.1, 1.5 Hz, 1H). ¹³C

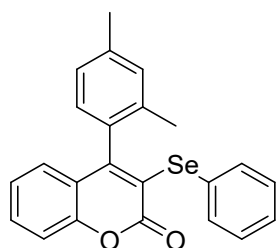
NMR (100 MHz, CDCl₃) δ (ppm) 159.6, 156.7, 153.3, 137.8, 133.4, 132.2, 131.9, 131.2, 130.2, 129.8, 129.2, 127.9, 127.4, 127.0, 124.5, 122.6, 121.7, 120.2, 116.9.



4-(2-Chlorophenyl)-3-(phenylselanyl)-2H-chromen-2-one (4n).⁴ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow oil (136.0 mg, 77%). ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.57–7.50 (m, 2H), 7.47–7.38 (m, 5H), 7.24–7.16 (m, 5H), 6.93 (dd, J = 8.0, 1.5 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.3, 156.2, 153.4, 135.1, 133.3, 132.4, 132.1, 130.5, 130.0, 129.9, 129.3, 129.1, 127.7, 127.2, 127.1, 124.5, 121.8, 119.7, 116.9.

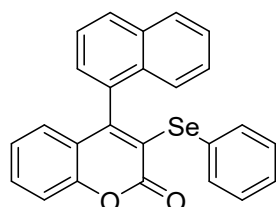


4-(3,4-Dimethylphenyl)-3-(phenylselanyl)-2H-chromen-2-one (4o). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow oil (107.6 mg, 53%). ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.55–7.51 (m, 1H), 7.39 (d, J = 8.8 Hz, 1H), 7.36–7.34 (m, 2H), 7.24 (d, J = 7.8 Hz, 1H), 7.21–7.14 (m, 5H), 6.97 (dd, J = 7.6, 1.9 Hz, 1H), 6.91 (s, 1H), 2.36 (s, 3H), 2.29 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.6, 159.2, 153.4, 137.5, 136.8, 133.7, 132.8, 131.9, 130.4, 129.7, 129.4, 128.9, 128.1, 127.3, 125.7, 124.2, 120.7, 120.5, 116.8, 19.9, 19.8. HRMS (ESI) m/z : [M + H]⁺ Calcd for C₂₃H₁₉O₂Se⁺ 407.0545; Found 407.0550.

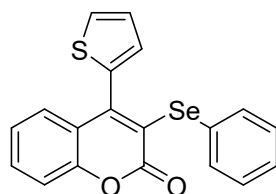


4-(2,4-Dimethylphenyl)-3-(phenylselanyl)-2H-chromen-2-one (4p). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow oil

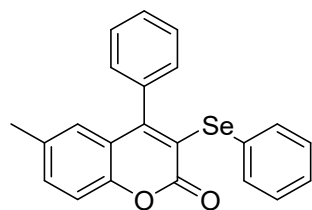
(99.5 mg, 49%). ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.55–7.51 (m, 1H), 7.41–7.38 (m, 3H), 7.23–7.09 (m, 6H), 6.96–6.92 (m, 2H), 2.43 (s, 3H), 2.02 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.4, 159.2, 153.4, 138.9, 134.7, 133.1, 133.0, 132.0, 131.1, 129.7, 129.0, 128.0, 127.5, 126.8, 124.4, 120.9, 120.3, 116.8, 21.4, 19.6. HRMS (ESI) m/z: [M + H]⁺ Calcd for C₂₃H₁₉O₂Se⁺ 407.0545; Found 407.0549.



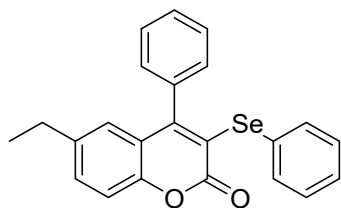
4-(Naphthalen-1-yl)-3-(phenylselanyl)-2H-chromen-2-one (4q).⁴ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (158.4 mg, 74%), mp 127–129 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.99 (d, *J* = 8.3 Hz, 1H), 7.95 (d, *J* = 8.2 Hz, 1H), 7.60–7.50 (m, 3H), 7.46–7.38 (m, 3H), 7.32 (dd, *J* = 7.1, 1.2 Hz, 1H), 7.27 (dd, *J* = 8.3, 1.6 Hz, 2H), 7.15–7.02 (m, 4H), 6.82 (dd, *J* = 8.0, 1.5 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.4, 157.5, 153.3, 133.8, 133.5, 133.4, 132.0, 130.4, 129.4, 129.2, 128.8, 128.6, 127.9, 127.6, 126.9, 126.5, 126.3, 125.3, 125.1, 124.4, 122.4, 120.8, 116.8.



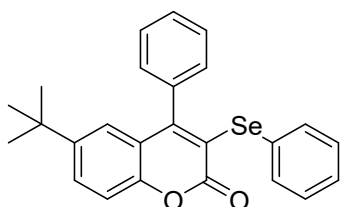
3-(Phenylselanyl)-4-(thiophen-2-yl)-2H-chromen-2-one (4r).³ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (113.3 mg, 59%), mp 132–134 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.57–7.53 (m, 2H), 7.44 (dd, *J* = 7.7, 1.9 Hz, 2H), 7.40–7.34 (m, 2H), 7.24–7.19 (m, 4H), 7.17–7.15 (m, 1H), 7.02 (dd, *J* = 3.6, 1.2 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 153.1, 135.7, 133.1, 132.1, 130.0, 129.3, 129.1, 127.72, 127.65, 127.6, 127.3, 124.4, 123.8, 120.8, 116.8.



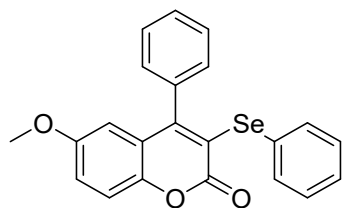
6-Methyl-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one (4s).³ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (147.0 mg, 75%), mp 119–121 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.49–7.47 (m, 3H), 7.37–7.31 (m, 4H), 7.21–7.15 (m, 5H), 6.84 (s, 1H), 2.29 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.8, 159.1, 151.7, 136.4, 134.0, 133.1, 132.7, 130.5, 129.0, 128.8, 128.5, 128.2, 127.6, 127.4, 120.6, 120.2, 116.6, 20.9.



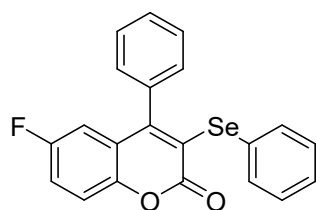
6-Ethyl-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one (4t).³ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (144.1 mg, 71%), mp 126–128 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.48 (dd, *J* = 5.0, 1.9 Hz, 3H), 7.39 (dd, *J* = 8.5, 2.1 Hz, 1H), 7.35–7.32 (m, 3H), 7.21–7.14 (m, 5H), 6.86 (d, *J* = 2.0 Hz, 1H), 2.57 (q, *J* = 7.6 Hz, 2H), 1.15 (t, *J* = 7.6 Hz, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.8, 159.2, 151.8, 140.5, 136.4, 132.7, 131.9, 130.5, 129.0, 128.8, 128.5, 128.3, 127.3, 126.6, 120.6, 120.2, 116.7, 28.3, 15.7.



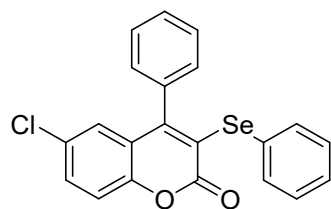
6-(tert-Butyl)-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one (4u).³ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (145.4 mg, 67%), mp 128–130 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.60 (dd, *J* = 8.7, 2.4 Hz, 1H), 7.49–7.48 (m, 3H), 7.36–7.32 (m, 3H), 7.22–7.16 (m, 5H), 7.05 (d, *J* = 2.3 Hz, 1H), 1.21 (s, 9H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.9, 159.6, 151.6, 147.3, 136.3, 132.6, 130.6, 129.7, 129.0, 128.9, 128.4, 128.3, 127.3, 124.2, 120.3, 119.8, 116.4, 34.6, 31.2.



6-Methoxy-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one (4v).⁴ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (132.6 mg, 65%), mp 124–126 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.47 (dd, J = 5.0, 1.7 Hz, 3H), 7.35–7.32 (m, 3H), 7.21–7.15 (m, 5H), 7.12 (dd, J = 9.0, 3.0 Hz, 1H), 6.51 (d, J = 2.9 Hz, 1H), 3.67 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.7, 158.6, 155.9, 148.0, 136.2, 132.9, 130.4, 129.0, 128.9, 128.5, 128.2, 127.4, 121.3, 121.0, 119.1, 117.7, 110.8, 55.7.

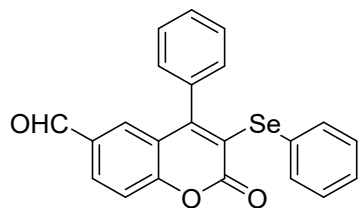


6-Fluoro-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one (4w).³ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow oil (138.6 mg, 70%). ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.49–7.47 (m, 3H), 7.38–7.33 (m, 3H), 7.27–7.15 (m, 6H), 6.75 (dd, J = 9.0, 3.0 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.2, 158.6 (d, J = 243.9 Hz), 157.5 (d, J = 2.9 Hz), 149.5 (d, J = 2.0 Hz), 135.7, 133.2, 129.9, 129.2, 129.1, 128.8, 128.2, 127.7, 122.5, 121.4 (d, J = 8.5 Hz), 119.3 (d, J = 24.7 Hz), 118.3 (d, J = 8.4 Hz), 113.2 (d, J = 25.3 Hz).

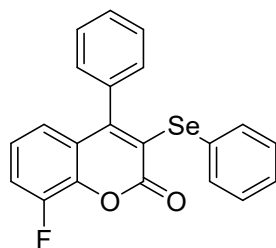


6-Chloro-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one (4x).³ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow oil (150.4 mg, 73%). ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.50–7.47 (m, 4H), 7.35–7.33 (m, 3H), 7.23–7.16 (m, 5H), 7.03 (d, J = 2.5 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 158.9, 157.2, 151.8, 135.5, 133.3, 131.8, 129.8, 129.7, 129.2, 129.1, 128.8, 128.2, 127.7, 127.0, 122.6, 121.6,

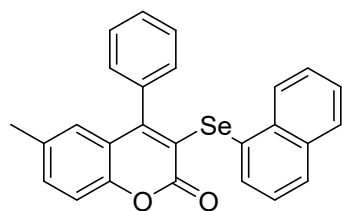
118.2.



2-Oxo-4-phenyl-3-(phenylselanyl)-2H-chromene-6-carbaldehyde (4y). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (5:1, v/v). Yellow solid (129.9 mg, 64%), mp 132–134 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 9.88 (s, 1H), 8.07 (dd, *J* = 8.5, 1.9 Hz, 1H), 7.59 (d, *J* = 1.9 Hz, 1H), 7.54–7.50 (m, 4H), 7.37–7.35 (m, 2H), 7.24–7.17 (m, 5H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 190.1, 158.5, 157.6, 157.0, 135.4, 133.4, 132.6, 131.8, 130.6, 129.6, 129.4, 129.2, 128.9, 128.2, 127.8, 122.6, 120.9, 118.0. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₂₂H₁₅O₃Se⁺ 407.0181; Found 407.0186.

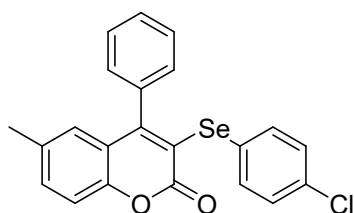


8-Fluoro-4-phenyl-3-(phenylselanyl)-2H-chromen-2-one (4z). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (134.6 mg, 68%), mp 103–105 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.49–7.46 (m, 3H), 7.36–7.29 (m, 3H), 7.23–7.15 (m, 5H), 7.09 (td, *J* = 8.2, 4.7 Hz, 1H), 6.85 (d, *J* = 8.2 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 158.2, 158.1 (d, *J* = 2.5 Hz), 149.5 (d, *J* = 252.2 Hz), 141.8 (d, *J* = 11.8 Hz), 136.0, 133.2, 129.9, 129.11, 129.09, 128.6, 128.2, 127.7, 123.8 (d, *J* = 6.9 Hz), 123.0 (d, *J* = 3.8 Hz), 122.4, 122.2, 118.1 (d, *J* = 17.2 Hz). HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₂₁H₁₄FO₂Se⁺ 397.0138; Found 397.0141.

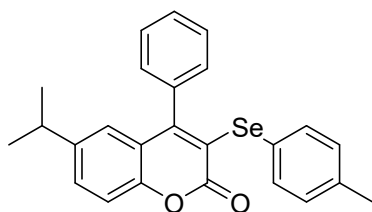


6-Methyl-3-(naphthalen-1-ylselanyl)-4-phenyl-2H-chromen-2-one (4aa). The product was

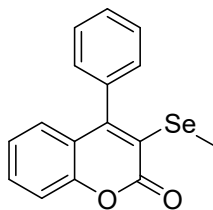
purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (152.5 mg, 69%), mp 129–131 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 8.06–8.03 (m, 1H), 7.78–7.75 (m, 1H), 7.72 (d, *J* = 8.1 Hz, 1H), 7.53 (dd, *J* = 7.2, 1.2 Hz, 1H), 7.45–7.42 (m, 2H), 7.32–7.28 (m, 5H), 7.23–7.19 (m, 1H), 7.04–7.02 (m, 2H), 6.76 (s, 1H), 2.24 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.9, 158.1, 151.4, 135.6, 134.0, 133.9, 133.8, 133.3, 132.8, 129.2, 128.8, 128.6, 128.4, 128.3, 128.1, 127.6, 127.2, 126.5, 126.1, 125.7, 120.9, 120.3, 116.5, 20.9. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₂₆H₁₉O₂Se⁺ 443.0545; Found 443.0544.



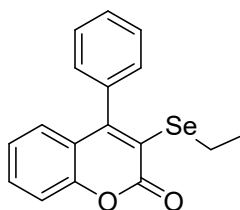
3-((4-Chlorophenyl)selenanyl)-6-methyl-4-phenyl-2H-chromen-2-one (4ab). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow oil (155.5 mg, 73%). ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.50 (dd, *J* = 5.0, 1.9 Hz, 3H), 7.36 (dd, *J* = 8.5, 2.1 Hz, 1H), 7.30 (d, *J* = 8.4 Hz, 1H), 7.27–7.25 (m, 2H), 7.19–7.17 (m, 2H), 7.15–7.12 (m, 2H), 6.83 (s, 1H), 2.29 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.7, 159.1, 151.7, 136.2, 134.3, 134.1, 133.7, 133.3, 129.2, 129.0, 128.6, 128.4, 128.2, 127.6, 120.4, 120.1, 116.6, 20.9. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₂₂H₁₆ClO₂Se⁺ 426.9999; Found 426.9994.



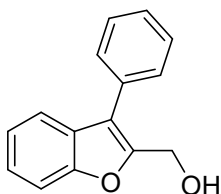
6-Isopropyl-4-phenyl-3-(*p*-tolylselenanyl)-2H-chromen-2-one (4ac). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow solid (160.6 mg, 74%), mp 135–137 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.51–7.49 (m, 3H), 7.42 (dd, *J* = 8.6, 2.2 Hz, 1H), 7.33 (d, *J* = 8.5 Hz, 1H), 7.26–7.20 (m, 4H), 6.98 (d, *J* = 7.9 Hz, 2H), 6.87 (d, *J* = 2.1 Hz, 1H), 2.87–2.80 (m, 1H), 2.30 (s, 3H), 1.16 (d, *J* = 6.9 Hz, 6H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.8, 158.9, 151.8, 145.0, 137.4, 136.4, 133.1, 130.2, 129.8, 128.8, 128.4, 128.3, 126.6, 125.3, 120.8, 120.2, 116.7, 33.6, 24.0, 21.2. HRMS (ESI) *m/z*: [M + H]⁺ Calcd for C₂₅H₂₃O₂Se⁺ 435.0858; Found 435.0855.



3-(Methylselanyl)-4-phenyl-2H-chromen-2-one (4ad).⁵ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow oil (131.1 mg, 83%). ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.58–7.53 (m, 3H), 7.51–7.49 (m, 1H), 7.39 (dd, J = 8.3, 1.1 Hz, 1H), 7.29 (dd, J = 7.3, 1.9 Hz, 2H), 7.18–7.14 (m, 1H), 7.06 (dd, J = 8.0, 1.6 Hz, 1H), 2.27 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.4, 156.0, 153.0, 136.4, 131.3, 129.1, 128.7, 128.3, 127.3, 124.2, 120.5, 120.2, 116.7, 8.4.

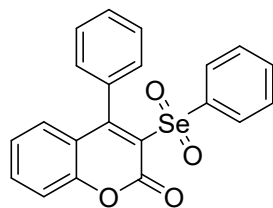


3-(Ethylselanyl)-4-phenyl-2H-chromen-2-one (4ae).⁵ The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (20:1, v/v). Yellow oil (94.1 mg, 57%). ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.57–7.49 (m, 4H), 7.40 (dd, J = 8.2, 1.2 Hz, 1H), 7.29–7.24 (m, 2H), 7.16 (t, J = 7.6 Hz, 1H), 7.05 (dd, J = 8.0, 1.6 Hz, 1H), 2.99 (q, J = 7.5 Hz, 2H), 1.30 (t, J = 7.5 Hz, 3H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 159.6, 157.1, 153.1, 136.6, 131.3, 129.0, 128.7, 128.4, 127.4, 124.2, 120.6, 119.3, 116.7, 21.5, 15.7.



(3-Phenylbenzofuran-2-yl)methanol (5). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (4:1, v/v). Yellow solid (103.1 mg, 92%), mp 90–92 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.71 (d, J = 7.4 Hz, 1H), 7.62–7.60 (m, 2H), 7.54 (t, J = 8.4 Hz, 3H), 7.47–7.43 (m, 1H), 7.41–7.37 (m, 1H), 7.32 (t, J = 7.6 Hz, 1H), 4.85 (s, 2H), 2.73 (brs, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 154.5, 151.8, 131.8, 129.2, 129.0, 128.1, 127.7, 125.0, 123.1, 120.5, 119.8, 111.5, 56.3. HRMS (ESI) m/z : [M + H]⁺ Calcd for C₁₅H₁₃O₂⁺

225.0911; Found 225.0920.

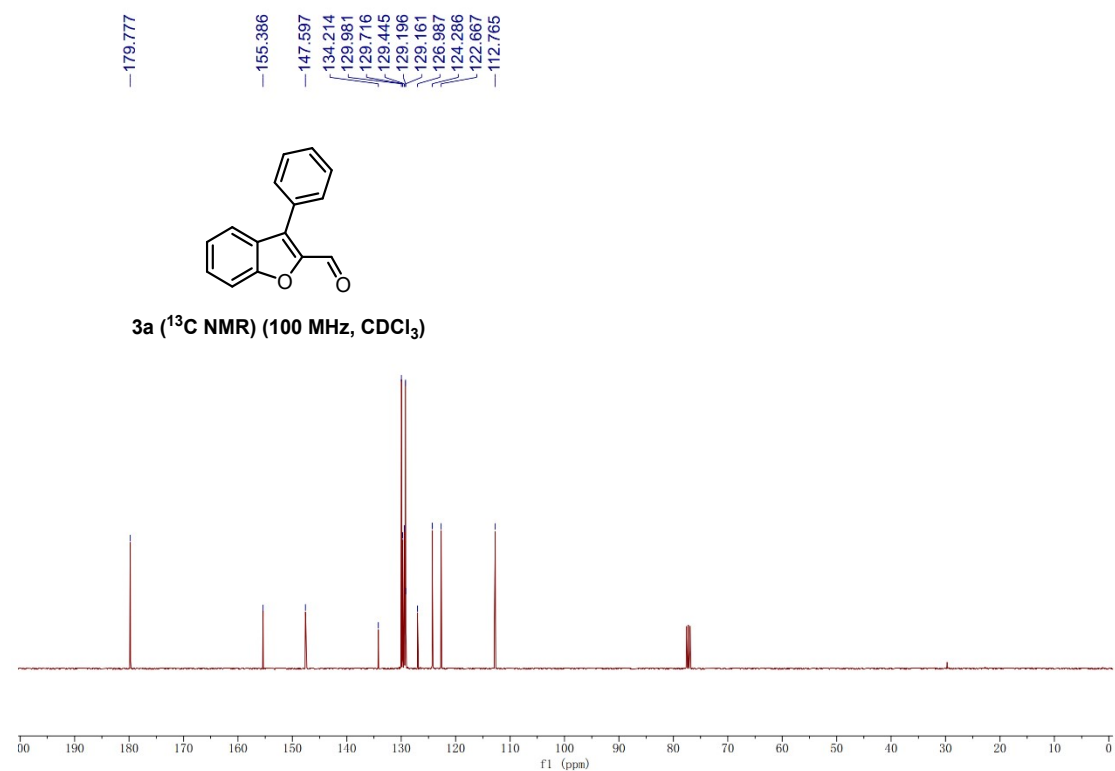
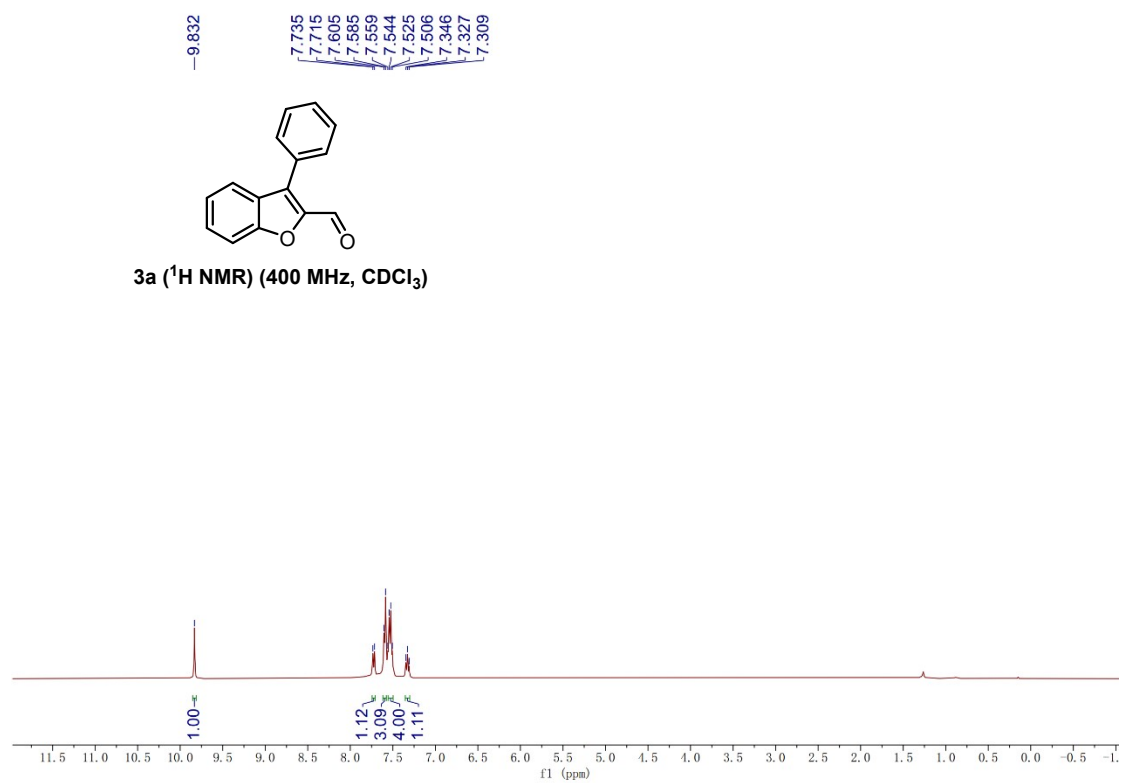


4-Phenyl-3-(phenylselenonyl)-2H-chromen-2-one (6). The product was purified by silica gel column chromatography with petroleum ether/ethyl acetate (1:1, v/v). Yellow solid (200.9 mg, 98%), mp 135–137 °C. ¹H NMR (400 MHz, CDCl₃) δ (ppm) 7.71 (dd, J = 6.7, 3.0 Hz, 2H), 7.62–7.55 (m, 3H), 7.51–7.40 (m, 5H), 7.33 (d, J = 8.3 Hz, 1H), 7.21–7.17 (m, 2H), 7.09 (dd, J = 8.1, 1.6 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ (ppm) 160.1, 157.0, 153.9, 140.1, 133.9, 131.1, 131.0, 130.1, 129.3, 129.0, 128.8, 128.6, 128.4, 126.6, 124.8, 120.1, 117.1. HRMS (ESI) m/z : [M + H]⁺ Calcd for C₂₁H₁₅O₄Se⁺ 411.0131; Found 441.0135.

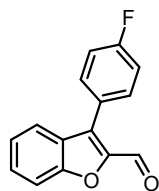
References

- (1) J.-D. Fang, X.-B. Yan, W.-J. Lin, Y.-C. Zhao and X.-Y. Liu, *Org. Lett.*, 2019, **21**, 7635–7638.
- (2) H. Peng, N. Akhmedov, Y. Liang, N. Jiao and X. Shi, *J. Am. Chem. Soc.*, 2015, **137**, 8912–8915.
- (3) J.-D. Fang, X.-B. Yan, L. Zhou, Y.-Z. Wang and X.-Y. Liu, *Adv. Synth. Catal.*, 2019, **361**, 1985–1990.
- (4) J. Fang, X. Yan, L. Zhou, Y. Wang and X. Liu, *Adv. Synth. Catal.*, 2019, **361**, 1985–1990.
- (5) J. Hua, Z. Fang, J. Xu, M. Bian, C. Liu, W. He, N. Zhu, Z. Yang and K. Guo, *Green Chem.*, 2019, **21**, 4706–4711.

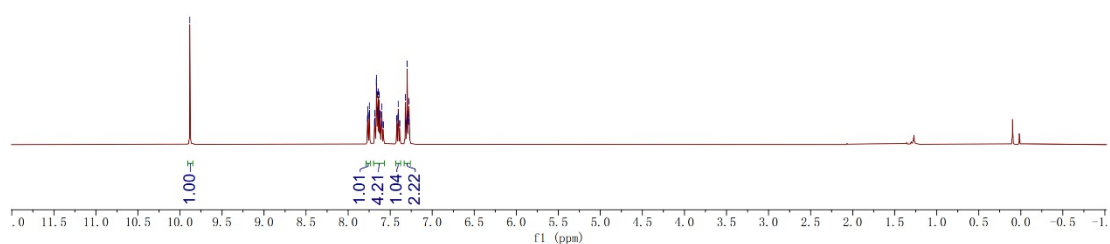
5 ^1H and ^{13}C NMR spectra of the products 3, 4, 5 and 6



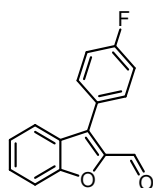
9.882
7.770
7.767
7.765
7.750
7.747
7.745
7.686
7.683
7.681
7.665
7.662
7.660
7.653
7.649
7.644
7.636
7.631
7.623
7.619
7.605
7.602
7.598
7.584
7.580
7.425
7.422
7.407
7.405
7.402
7.387
7.385
7.318
7.313
7.305
7.302
7.297
7.292
7.284
7.281
7.275



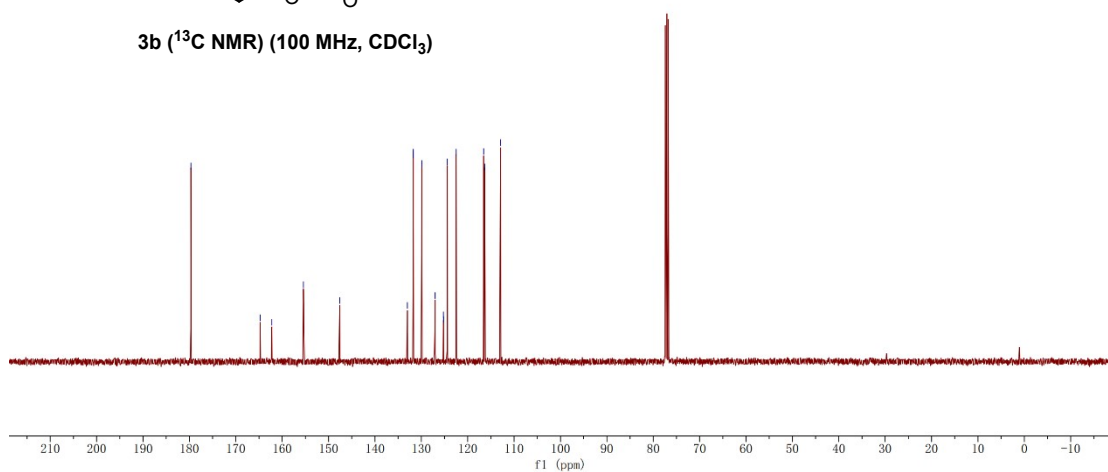
3b (¹H NMR) (400 MHz, CDCl₃)

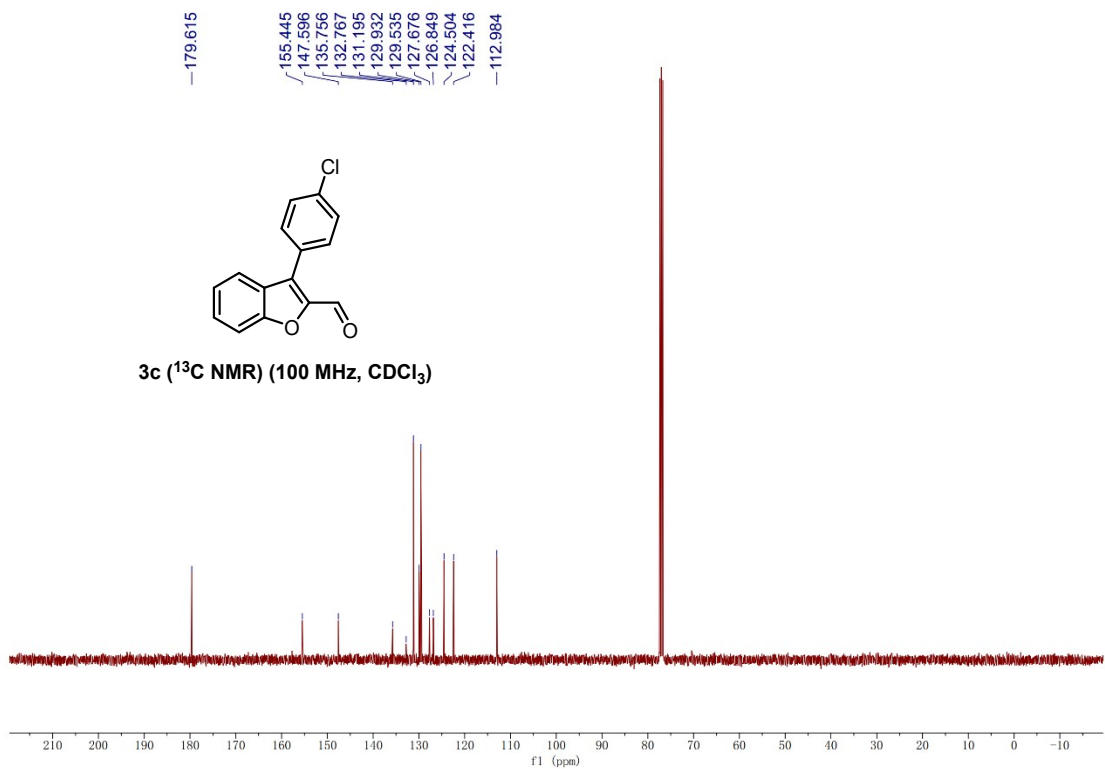
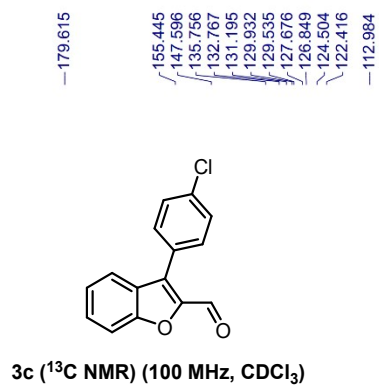
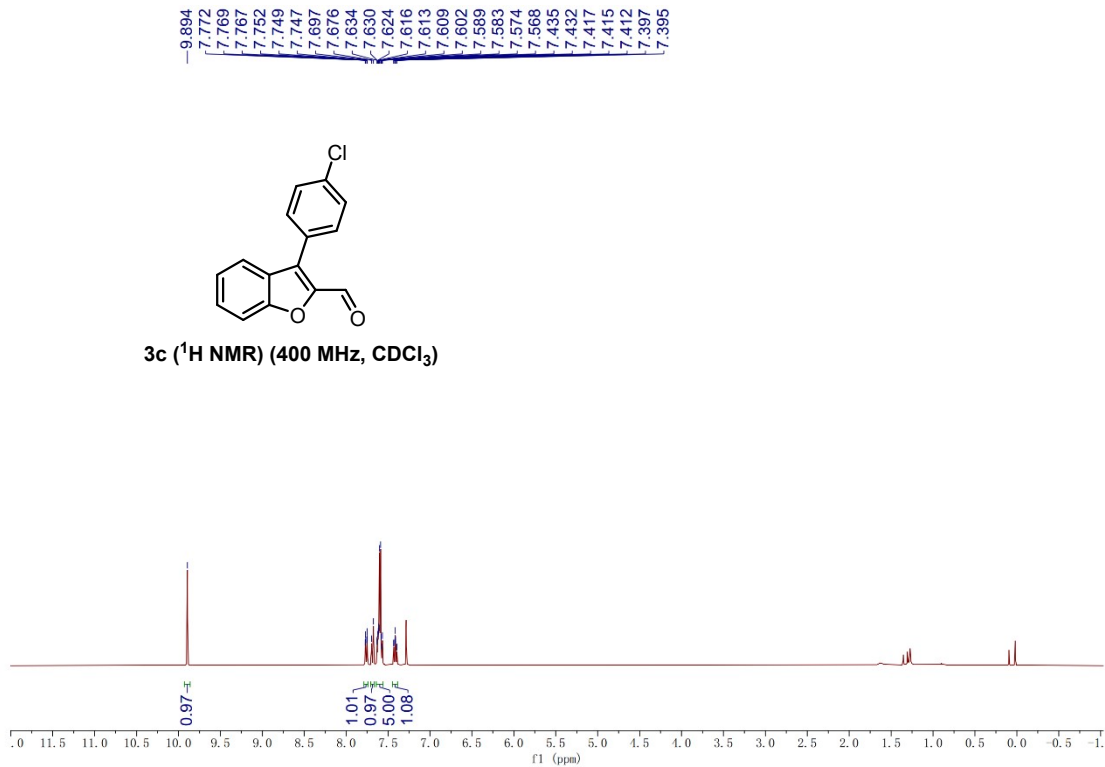
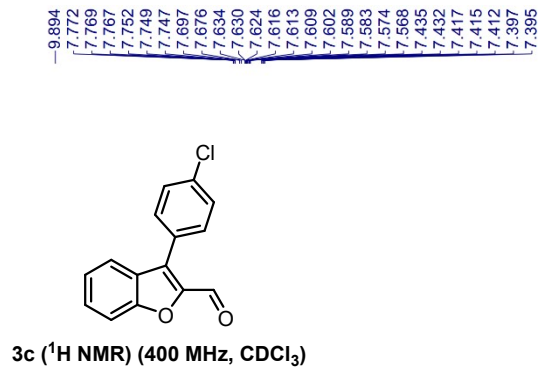


179.664
164.706
162.220
155.423
147.600
133.014
131.806
131.723
129.874
127.010
125.252
125.218
124.426
122.466
116.550
116.332
112.937

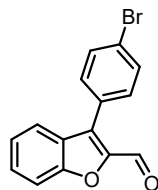


3b (¹³C NMR) (100 MHz, CDCl₃)

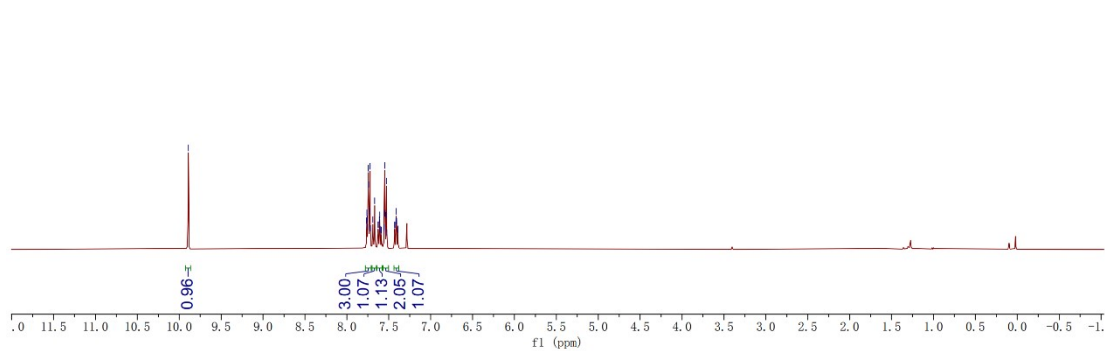




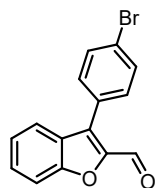
9.891
7.763
7.761
7.758
7.751
7.745
7.740
7.729
7.724
7.718
7.690
7.689
7.628
7.625
7.610
7.607
7.603
7.589
7.586
7.555
7.549
7.544
7.533
7.528
7.522
7.430
7.427
7.412
7.410
7.407
7.392
7.390



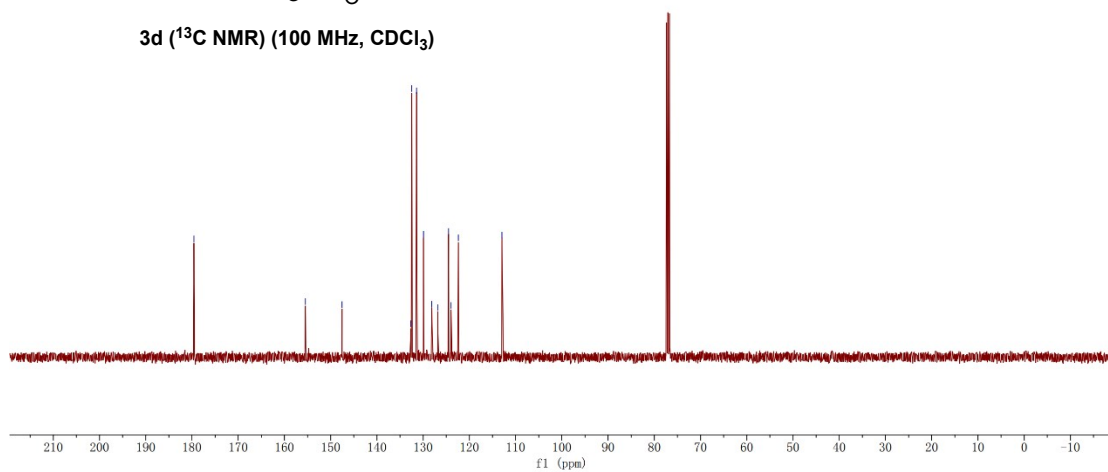
3d (^1H NMR) (400 MHz, CDCl_3)



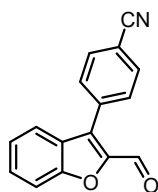
179.576
155.449
147.548
132.703
132.474
131.438
129.916
128.157
126.786
124.505
123.946
122.392
112.968



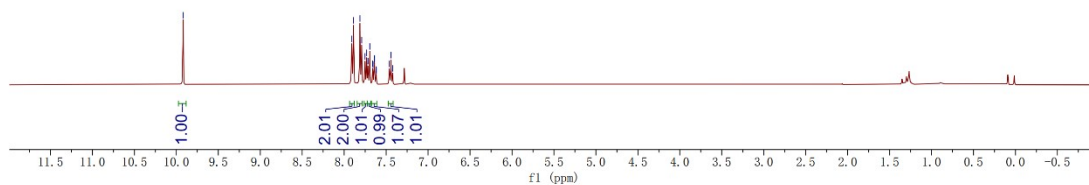
3d (^{13}C NMR) (100 MHz, CDCl_3)



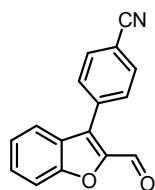
9.919
7.908
7.888
7.812
7.791
7.752
7.732
7.716
7.695
7.659
7.656
7.641
7.638
7.620
7.617
7.461
7.442
7.423



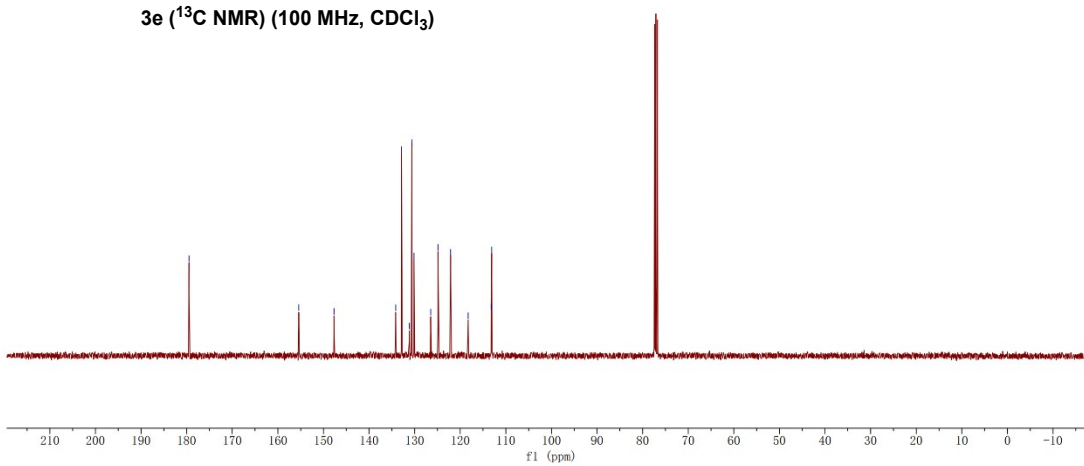
3e (¹H NMR) (400 MHz, CDCl₃)

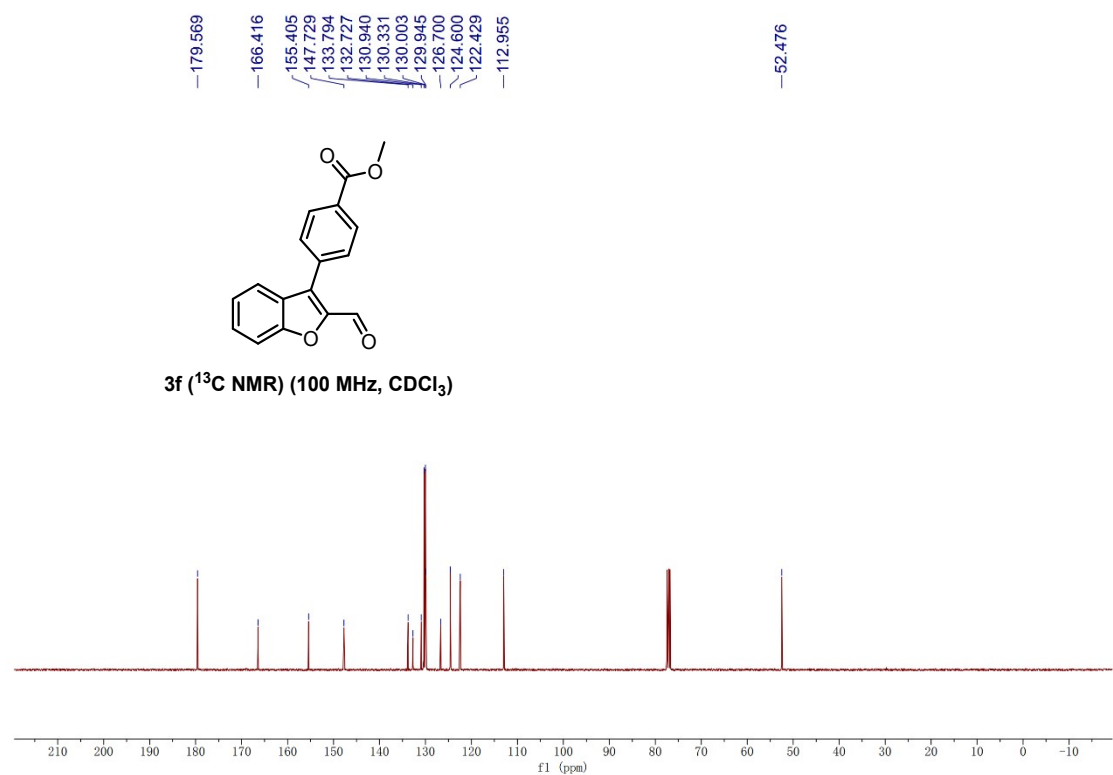
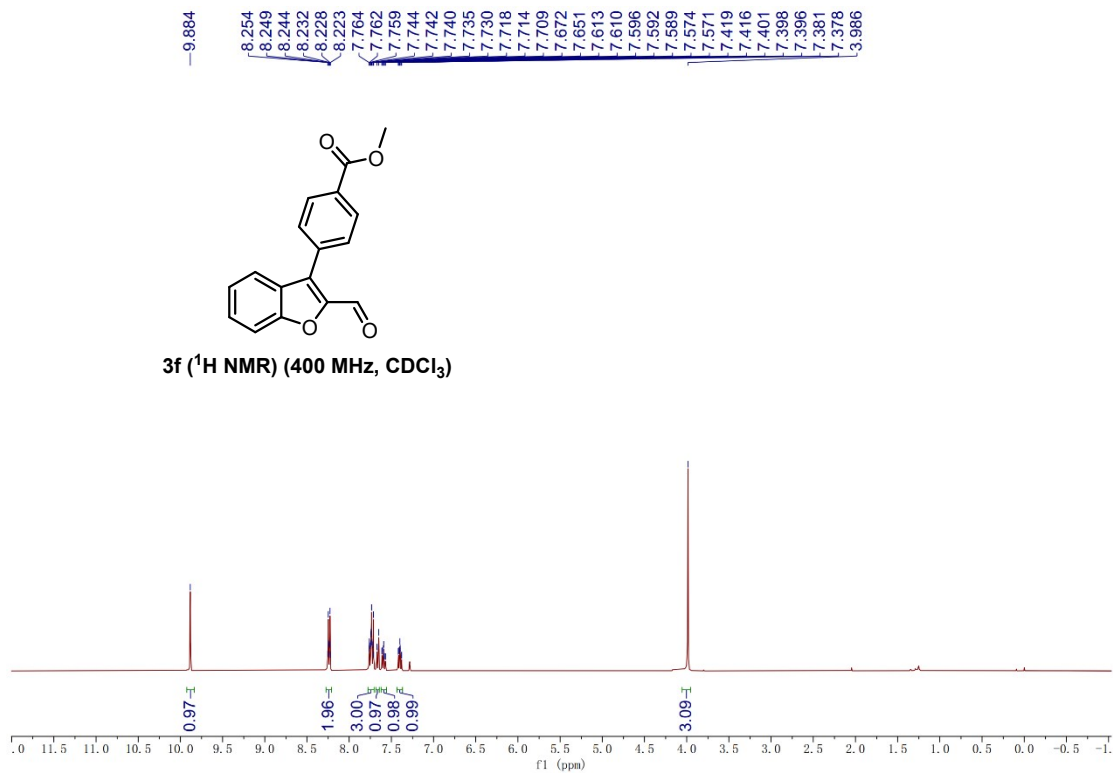
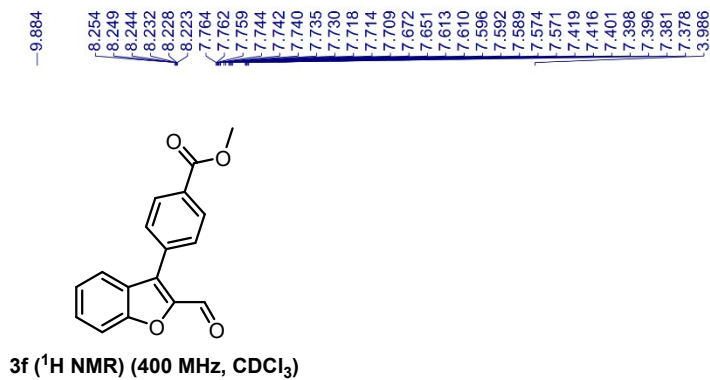


179.474
155.422
147.686
134.139
132.877
131.127
130.641
130.131
126.469
124.869
122.129
118.260
113.210
113.109

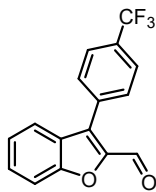


3e (¹³C NMR) (100 MHz, CDCl₃)

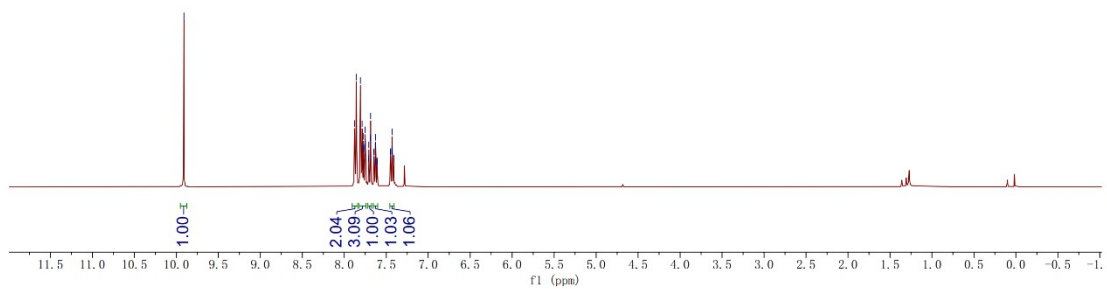




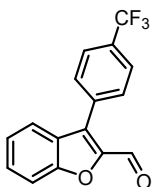
9.911
7.877
7.856
7.808
7.788
7.772
7.770
7.767
7.753
7.750
7.747
7.710
7.708
7.705
7.689
7.687
7.684
7.647
7.644
7.630
7.626
7.623
7.608
7.605
7.450
7.447
7.432
7.430
7.427
7.412
7.410



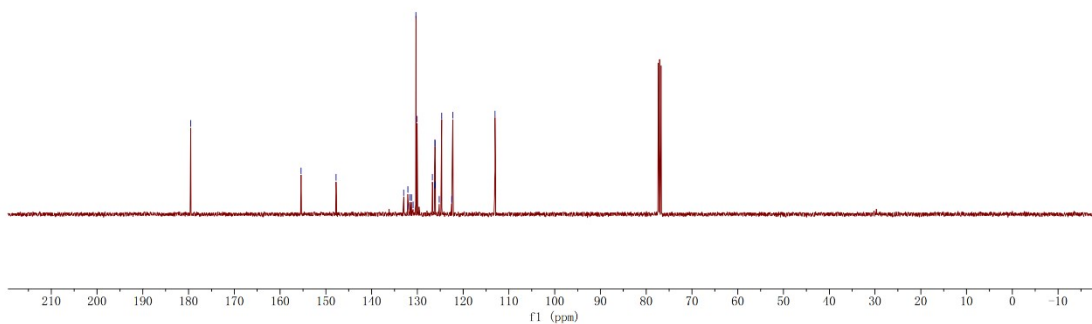
3g (¹H NMR) (400 MHz, CDCl₃)

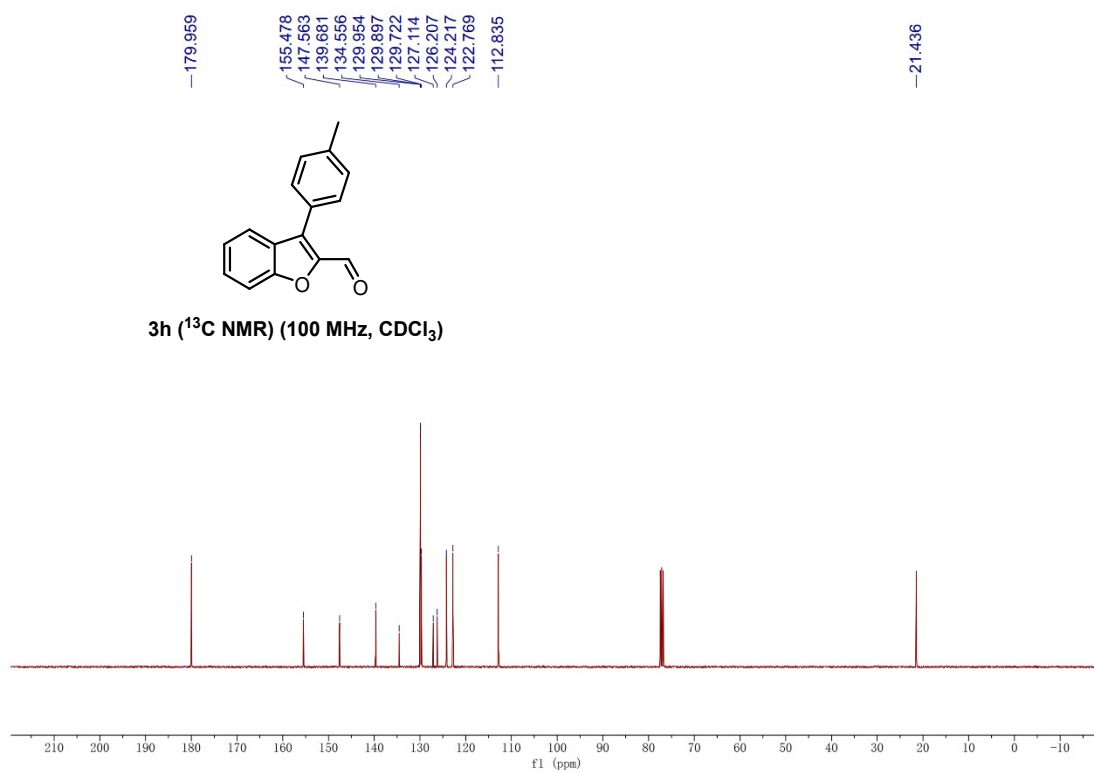
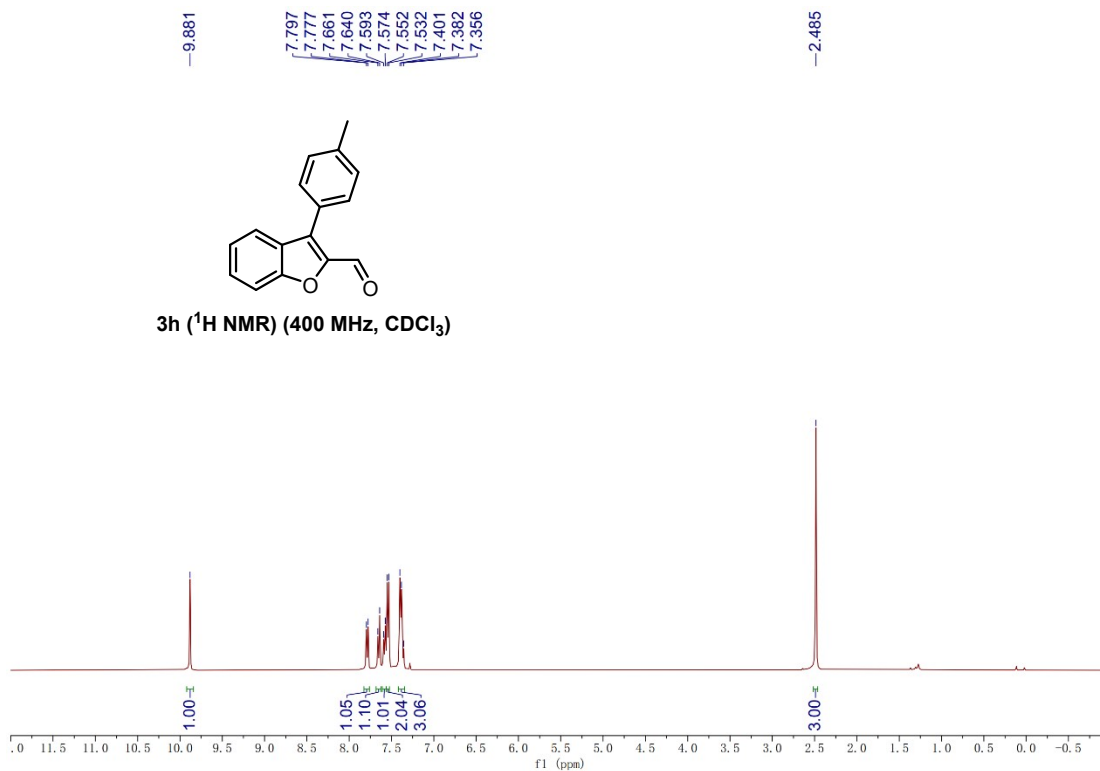


179.521
155.421
143.792
132.072
131.930
131.600
131.273
130.946
130.349
130.024
126.736
126.211
126.173
126.136
126.098
125.219
124.690
122.511
122.288
113.024



3g (¹³C NMR) (100 MHz, CDCl₃)

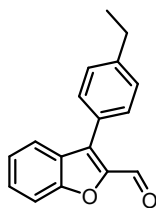




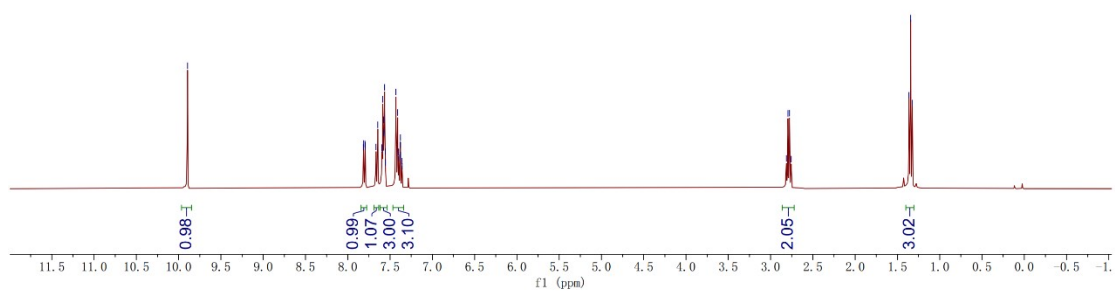
9.895
7.816
7.813
7.796
7.792
7.667
7.646
7.597
7.594
7.585
7.579
7.576
7.565
7.558
7.555
7.431
7.411
7.398
7.395
7.380
7.378
7.375
7.360
7.357

2.814
2.795
2.776
2.757

1.364
1.345
1.326



3i (¹H NMR) (400 MHz, CDCl₃)

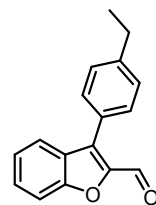


179.987

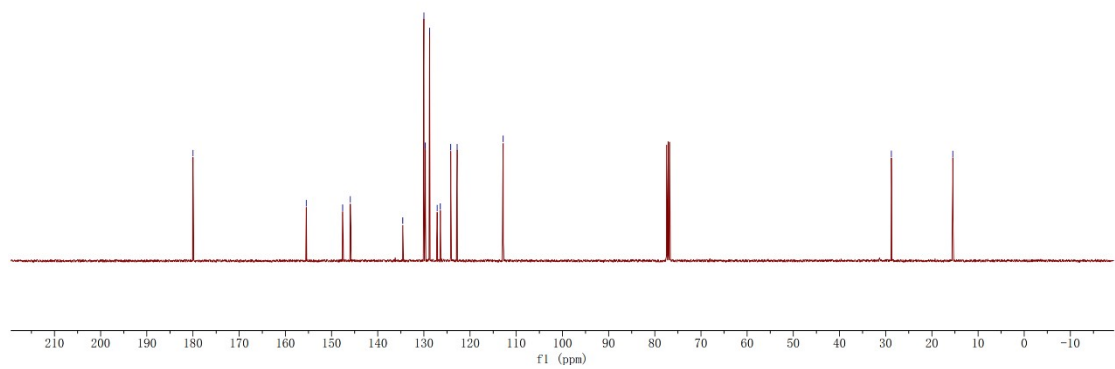
155.490
147.589
145.918
134.568
129.995
129.707
128.773
127.133
126.453
124.200
122.811
112.835

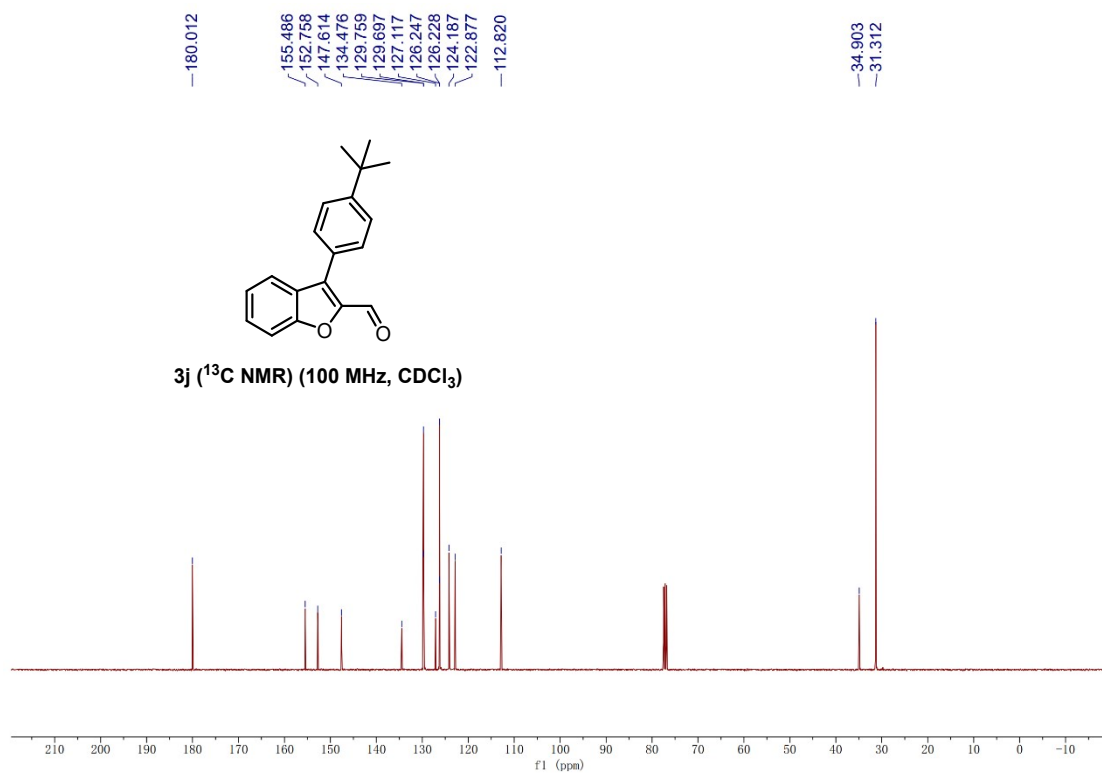
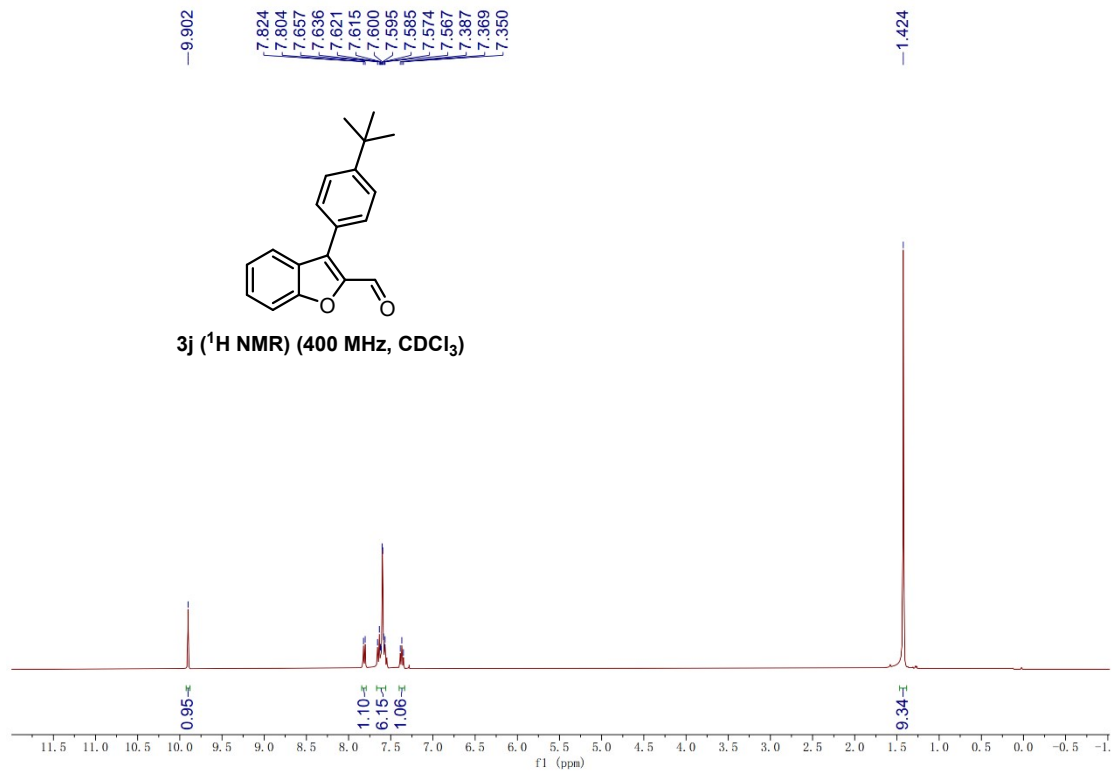
28.768

15.482

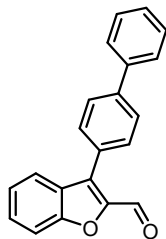


3i (¹³C NMR) (100 MHz, CDCl₃)

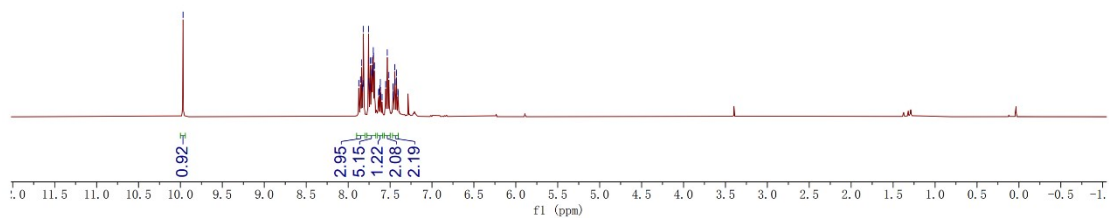




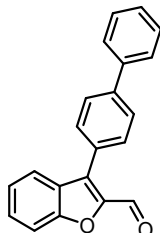
9.969
7.872
7.852
7.837
7.832
7.821
7.816
7.757
7.752
7.741
7.736
7.722
7.718
7.708
7.705
7.700
7.698
7.687
7.636
7.633
7.619
7.615
7.612
7.594
7.552
7.533
7.514
7.467
7.463
7.460
7.444
7.441
7.426
7.423
7.406
7.403



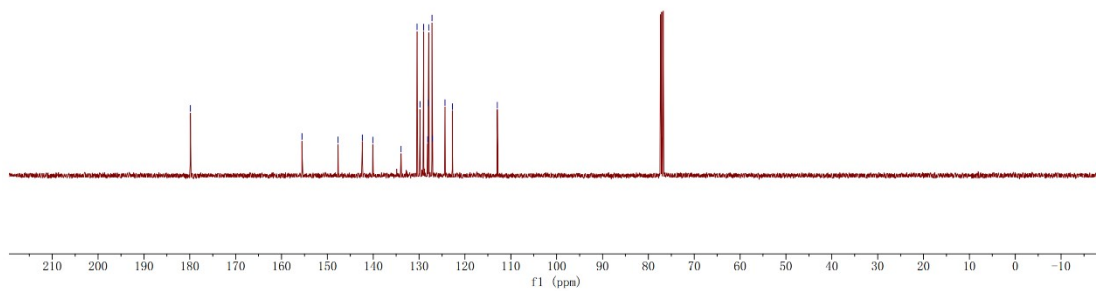
3k (¹H NMR) (400 MHz, CDCl₃)



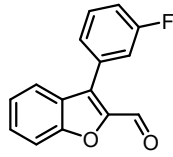
179.878
155.540
147.709
142.387
140.079
133.941
130.451
129.805
129.042
128.120
127.979
127.899
127.188
127.082
124.952
122.743
112.926



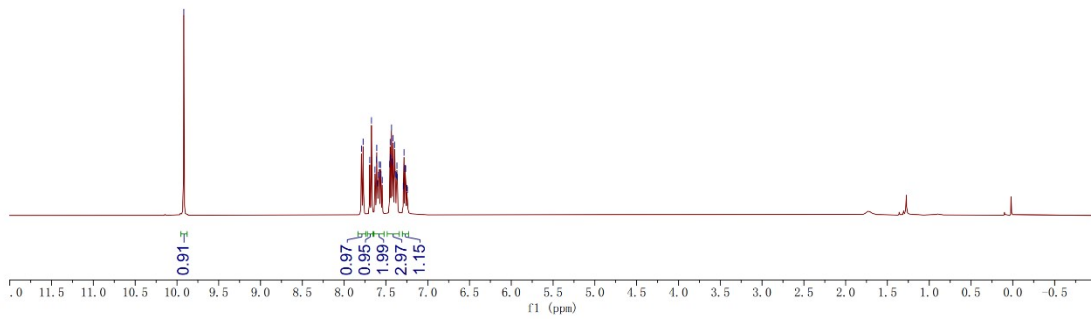
3k (¹³C NMR) (100 MHz, CDCl₃)



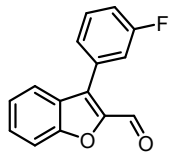
9.917
7.792
7.772
7.693
7.672
7.630
7.613
7.609
7.599
7.588
7.579
7.565
7.559
7.545
7.454
7.450
7.447
7.432
7.428
7.415
7.397
7.387
7.374
7.368
7.363
7.292
7.284
7.271
7.264
7.249
7.243



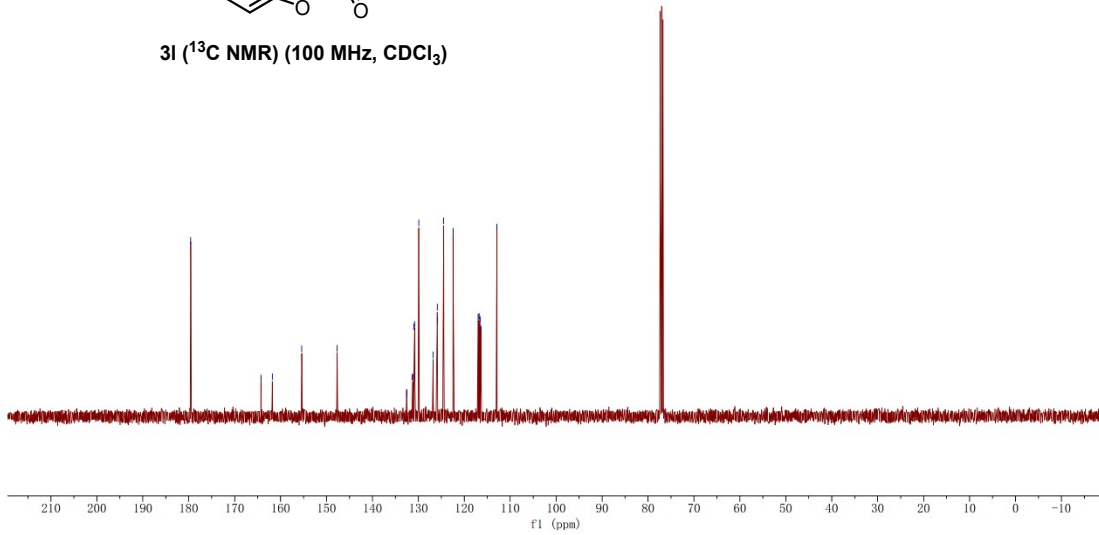
3I (¹H NMR) (400 MHz, CDCl₃)



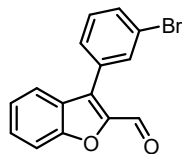
179.573
164.244
161.778
155.413
147.702
132.549
131.328
131.246
130.930
130.845
129.900
126.790
125.875
125.844
124.526
122.426
117.006
116.783
116.575
116.365
112.948



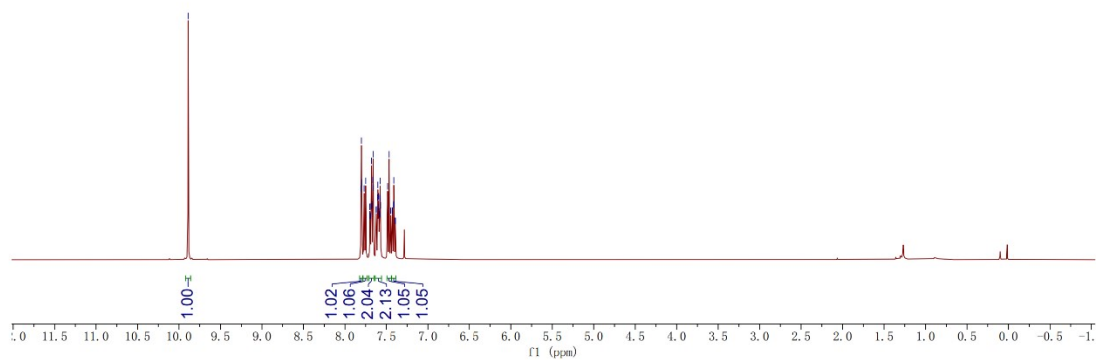
3I (¹³C NMR) (100 MHz, CDCl₃)



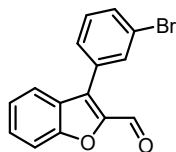
9.890
7.806
7.802
7.797
7.769
7.749
7.701
7.698
7.693
7.685
7.681
7.673
7.663
7.661
7.659
7.624
7.621
7.607
7.603
7.597
7.594
7.590
7.586
7.582
7.578
7.575
7.571
7.485
7.466
7.446
7.431
7.428
7.413
7.411
7.408
7.393
7.390



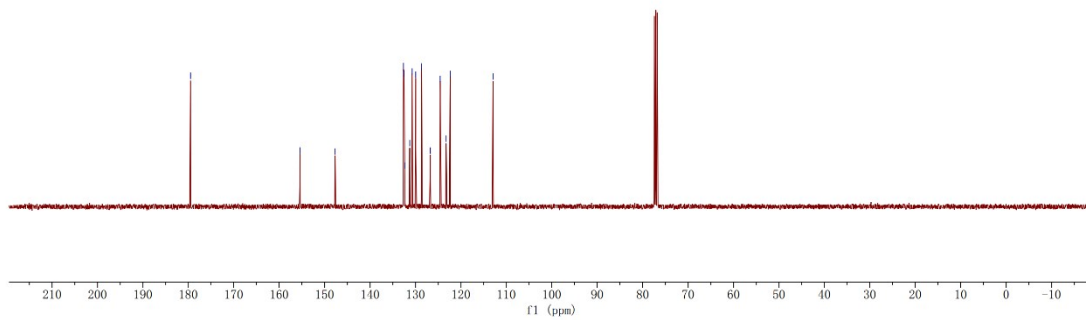
3m (^1H NMR) (400 MHz, CDCl_3)

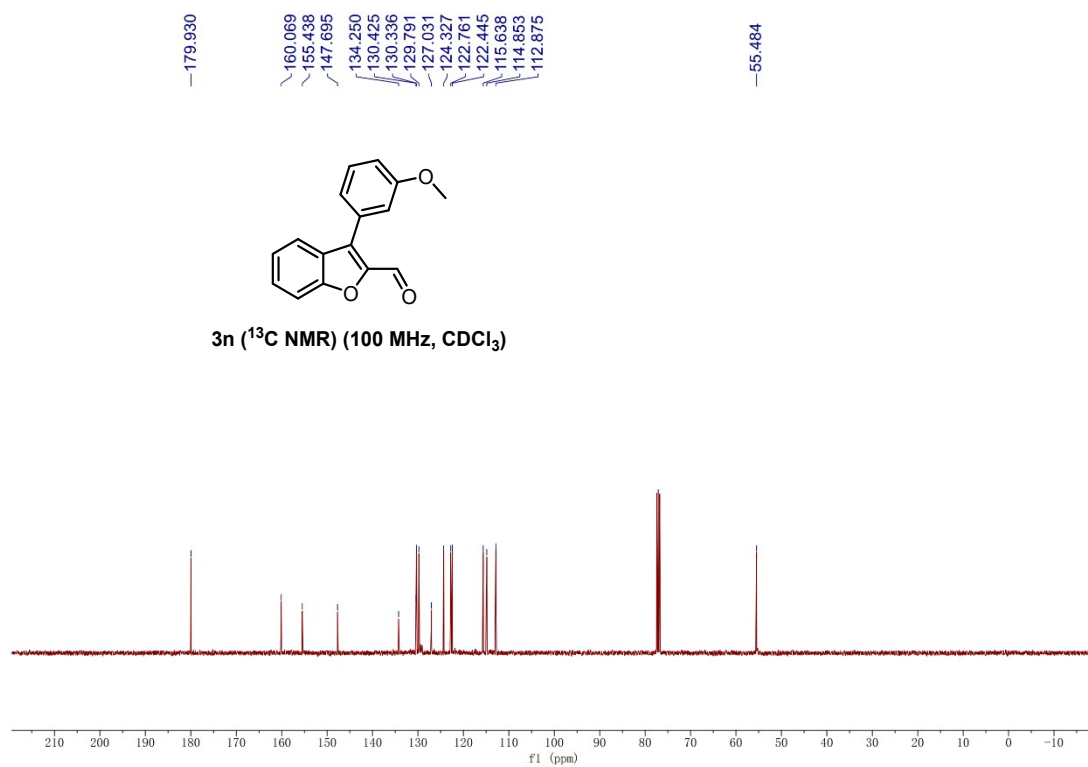
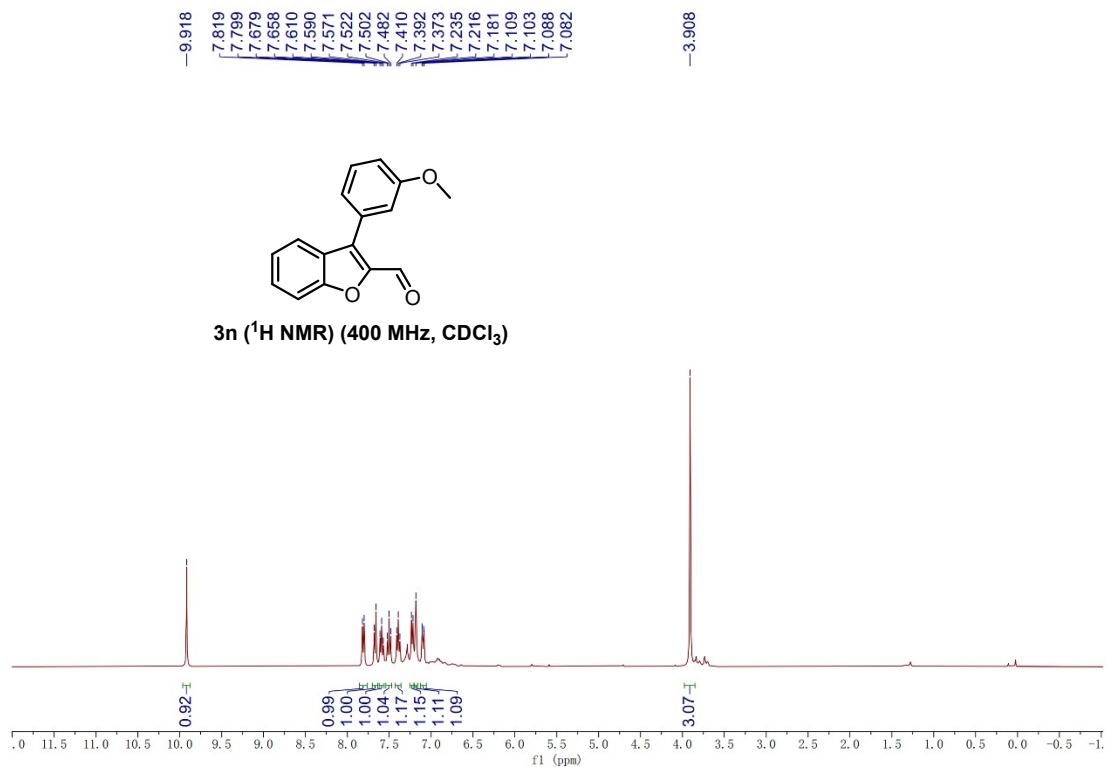


179.522
155.372
147.697
132.649
132.493
132.313
131.264
130.720
129.962
128.657
128.732
124.575
123.247
122.386
112.960

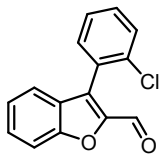


3m (^{13}C NMR) (100 MHz, CDCl_3)

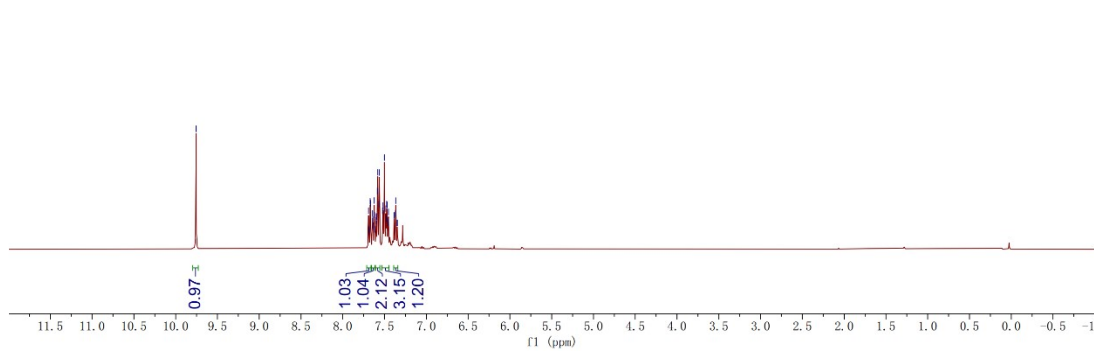




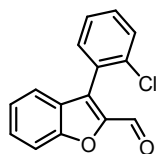
9.756
7.692
7.687
7.672
7.669
7.645
7.641
7.638
7.624
7.620
7.617
7.603
7.600
7.586
7.582
7.567
7.563
7.523
7.518
7.502
7.485
7.479
7.475
7.471
7.460
7.453
7.387
7.384
7.369
7.366
7.349
7.346



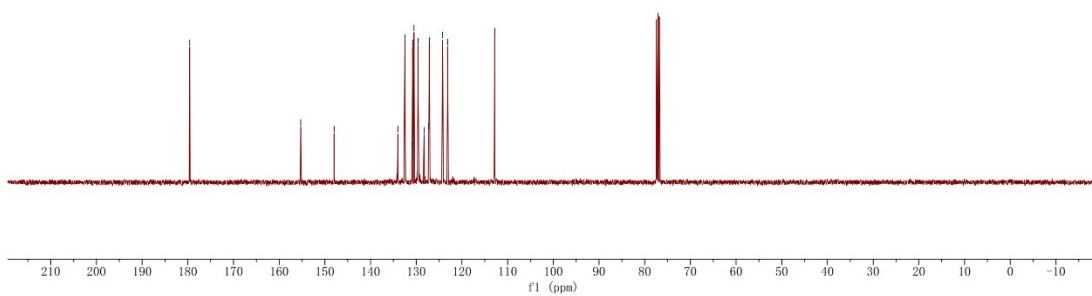
3o (^1H NMR) (400 MHz, CDCl_3)



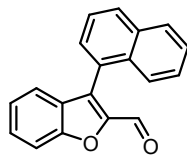
179.591
155.293
147.964
134.010
132.497
130.926
130.780
130.494
129.618
128.286
127.268
127.128
124.242
123.104
112.845



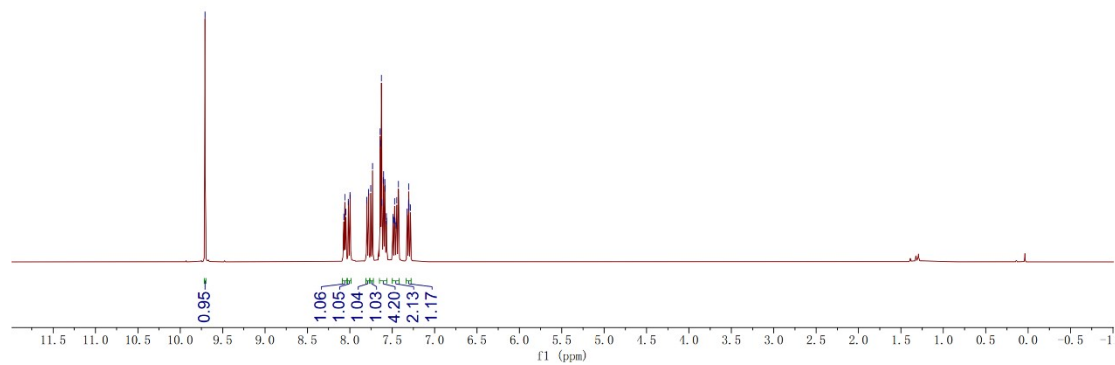
3o (^{13}C NMR) (100 MHz, CDCl_3)



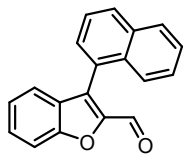
9.707
8.071
8.059
8.047
8.018
7.997
7.800
7.779
7.753
7.732
7.641
7.638
7.628
7.620
7.606
7.602
7.587
7.584
7.569
7.566
7.493
7.490
7.476
7.472
7.468
7.455
7.446
7.426
7.324
7.307
7.304
7.302
7.284



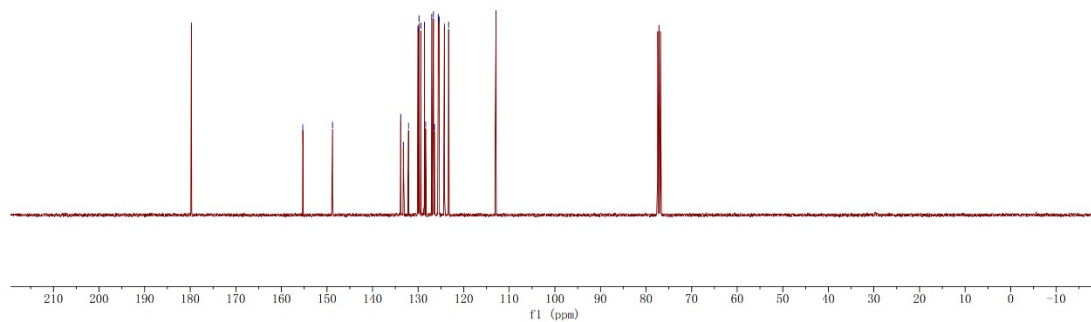
3p (^1H NMR) (400 MHz, CDCl_3)



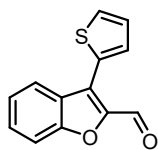
179.738
155.315
148.796
138.816
133.240
132.131
130.056
129.809
129.393
128.651
128.336
127.017
126.648
126.415
125.580
125.386
124.262
123.311
112.940



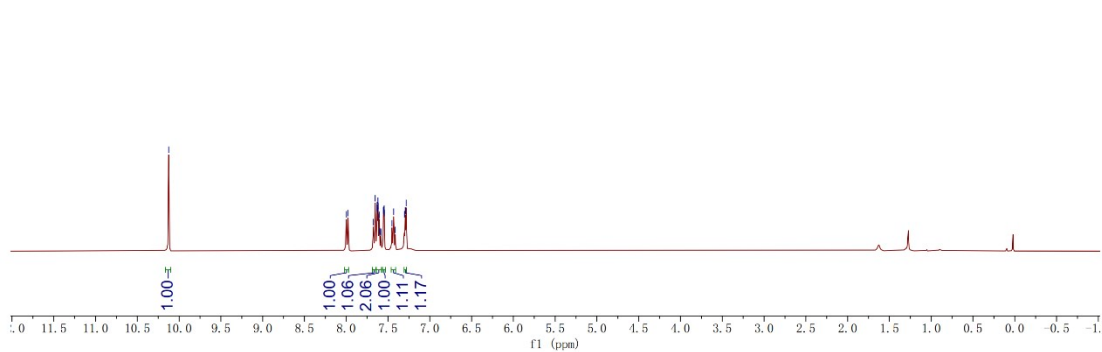
3p (^{13}C NMR) (100 MHz, CDCl_3)



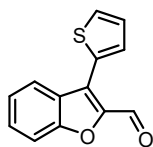
10.125
 7.998
 7.978
 7.674
 7.653
 7.633
 7.630
 7.625
 7.621
 7.617
 7.608
 7.605
 7.601
 7.587
 7.584
 7.566
 7.555
 7.547
 7.544
 7.452
 7.432
 7.415
 7.304
 7.294
 7.291
 7.284



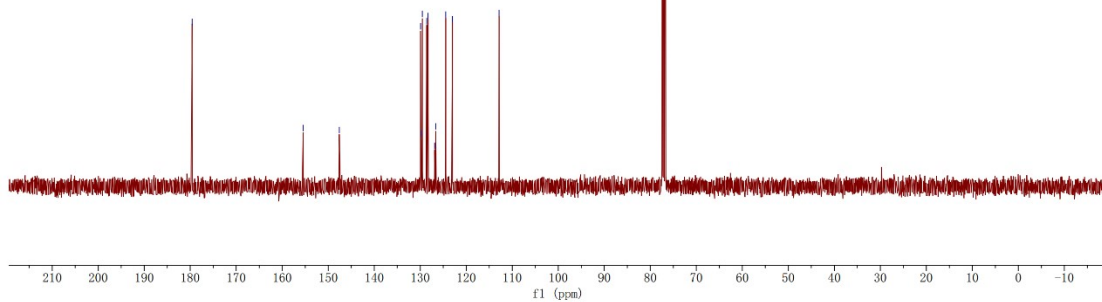
3q (¹H NMR) (400 MHz, CDCl₃)



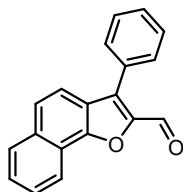
179.572
 155.454
 147.582
 129.921
 129.837
 129.556
 128.605
 128.329
 126.861
 126.608
 124.475
 123.017
 112.878



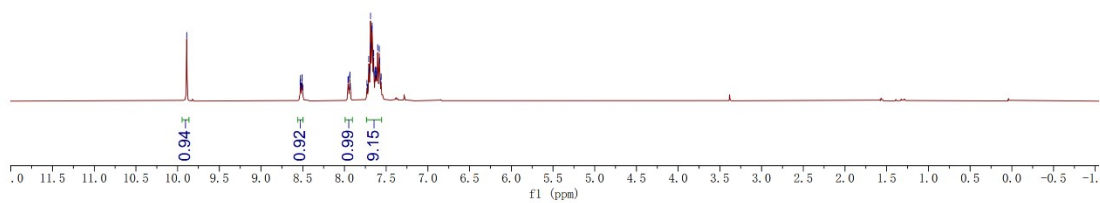
3q (¹³C NMR) (100 MHz, CDCl₃)



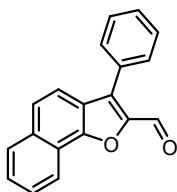
9.891
 8.531
 8.526
 8.520
 8.512
 8.507
 8.501
 7.988
 7.953
 7.939
 7.934
 7.929
 7.731
 7.724
 7.709
 7.702
 7.687
 7.682
 7.672
 7.667
 7.655
 7.650
 7.646
 7.635
 7.631
 7.624
 7.618
 7.613
 7.602
 7.583
 7.577
 7.570
 7.561



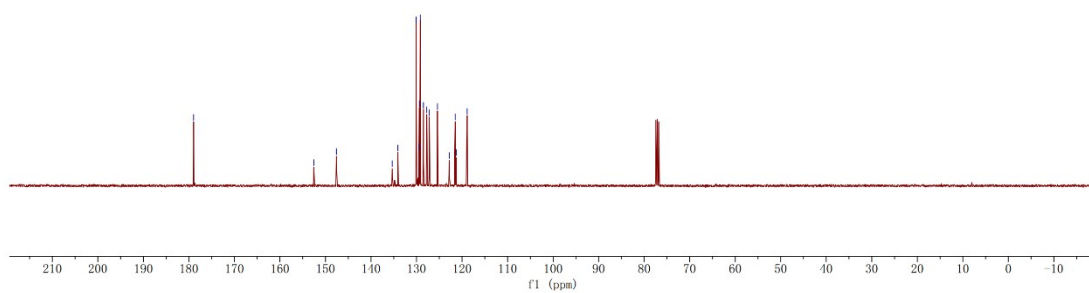
3r (¹H NMR) (400 MHz, CDCl₃)



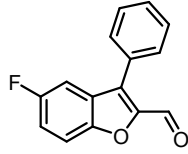
178.981
 152.545
 147.609
 135.354
 134.073
 130.083
 129.441
 129.382
 129.178
 128.486
 127.760
 127.190
 125.391
 122.778
 121.523
 121.300
 118.890



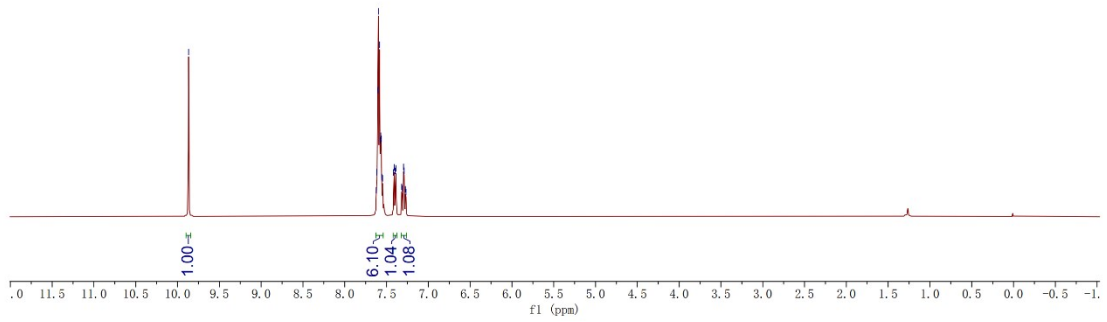
3r (¹³C NMR) (100 MHz, CDCl₃)



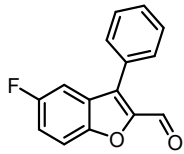
9.867
7.623
7.616
7.606
7.598
7.584
7.575
7.569
7.563
7.556
7.547
7.415
7.409
7.395
7.389
7.319
7.312
7.297
7.290
7.274
7.267



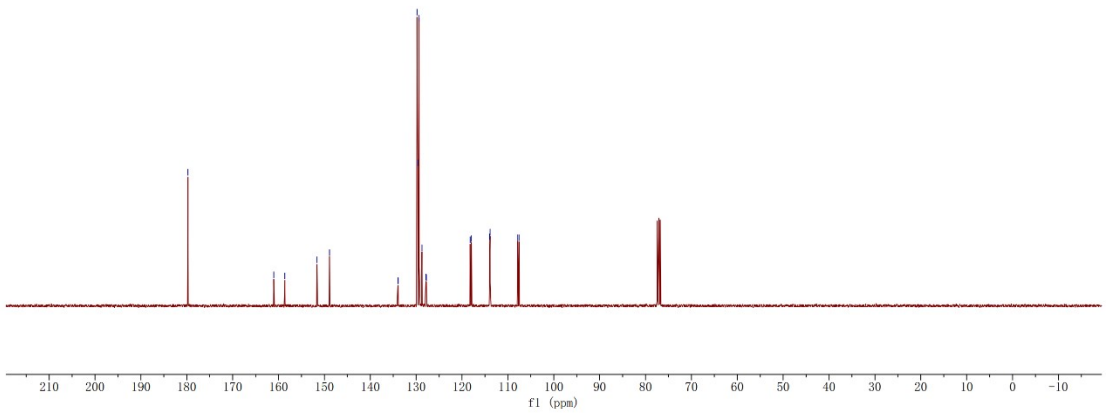
3s (¹H NMR) (400 MHz, CDCl₃)



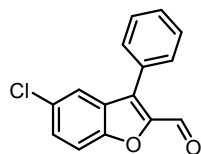
179.755
161.028
158.622
151.621
148.882
133.979
133.932
129.805
129.653
129.338
128.724
127.885
127.783
118.218
117.951
113.978
113.885
107.834
107.584



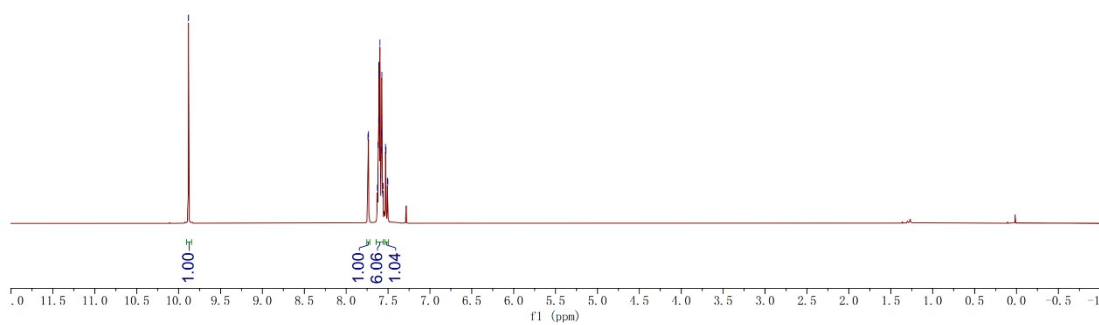
3s (¹³C NMR) (100 MHz, CDCl₃)



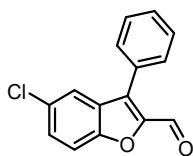
9.881
7.739
7.734
7.626
7.620
7.617
7.614
7.610
7.606
7.596
7.589
7.582
7.577
7.573
7.562
7.559
7.530
7.525
7.508
7.503



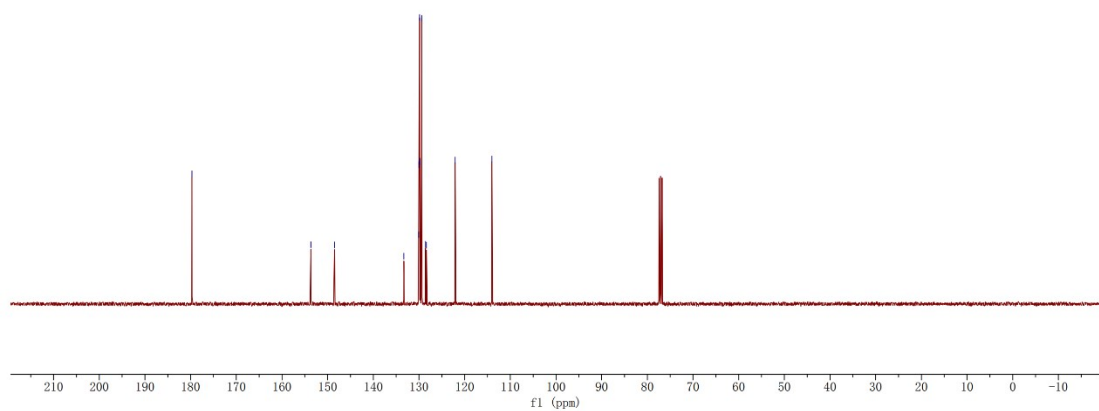
3t (¹H NMR) (400 MHz, CDCl₃)



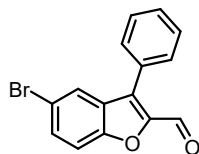
179.711
153.688
148.486
133.323
130.089
130.018
129.879
129.728
129.368
128.545
128.354
122.069
114.019



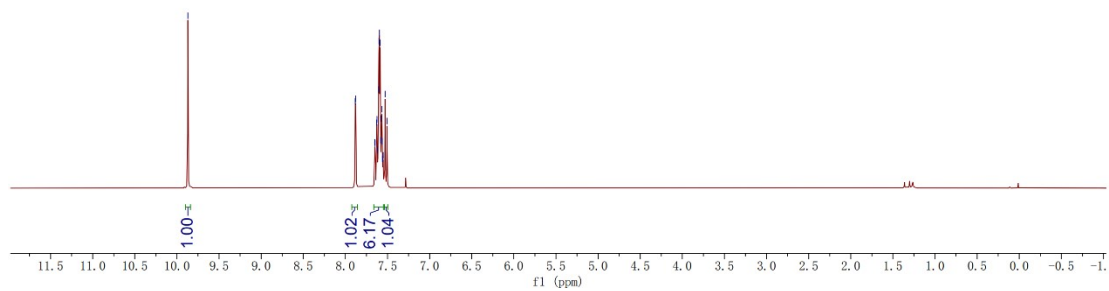
3t (¹³C NMR) (100 MHz, CDCl₃)



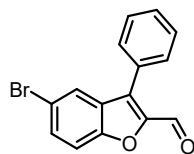
9.870
7.883
7.878
7.651
7.646
7.629
7.624
7.616
7.607
7.601
7.596
7.588
7.580
7.574
7.568
7.563
7.559
7.555
7.551
7.528
7.506



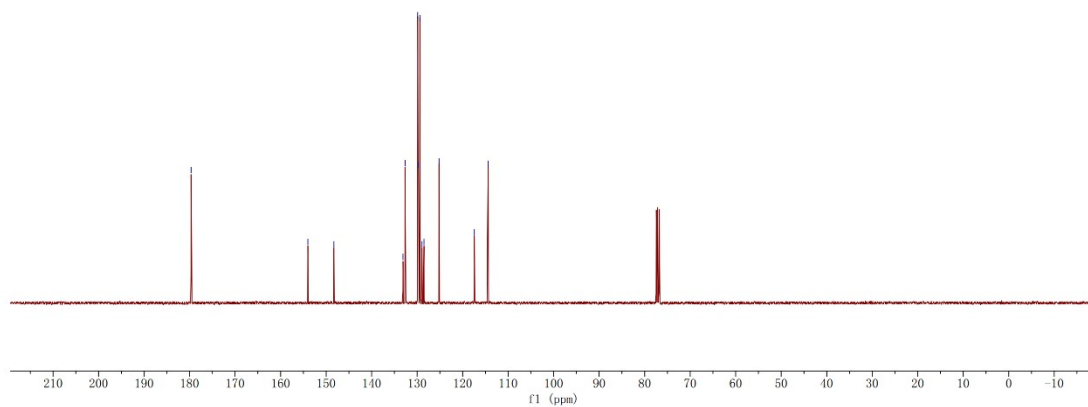
3u (¹H NMR) (400 MHz, CDCl₃)



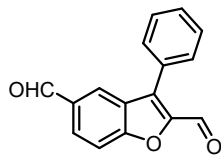
179.668
154.027
148.279
133.121
132.631
129.893
129.739
129.378
128.935
128.505
125.178
117.450
114.409



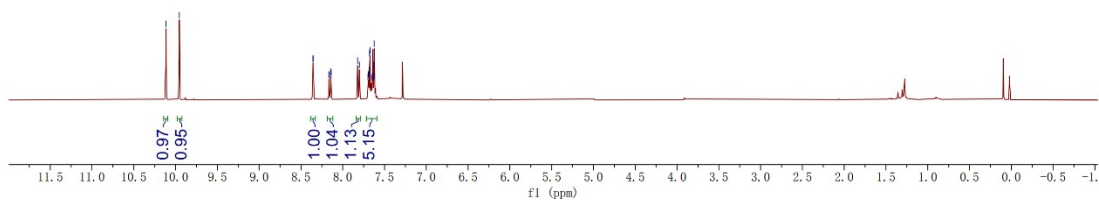
3u (¹³C NMR) (100 MHz, CDCl₃)



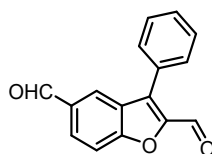
10.116
9.955
8.357
8.353
8.164
8.160
8.143
8.139
7.822
7.800
7.699
7.694
7.683
7.679
7.675
7.656
7.644
7.641
7.637
7.629
7.624
7.618



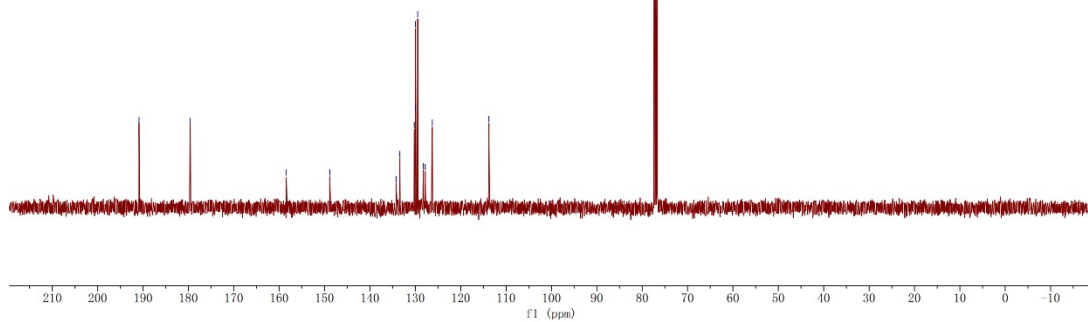
3v (¹H NMR) (400 MHz, CDCl₃)



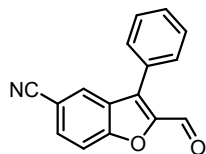
190.874
179.601
158.409
148.825
134.211
133.389
130.246
129.980
129.954
128.266
127.815
126.266
113.784



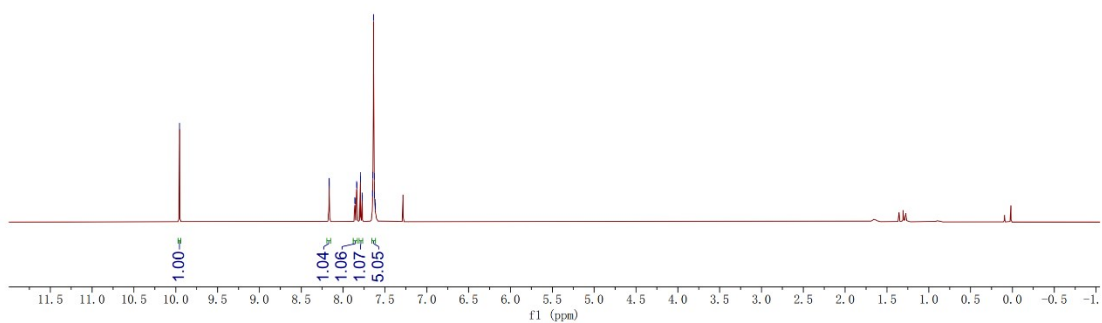
3v (¹³C NMR) (100 MHz, CDCl₃)



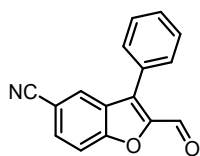
9.956
8.170
8.166
8.164
7.861
7.857
7.839
7.835
7.795
7.793
7.774
7.772
7.649
7.644
7.636
7.629
7.623
7.619
7.615



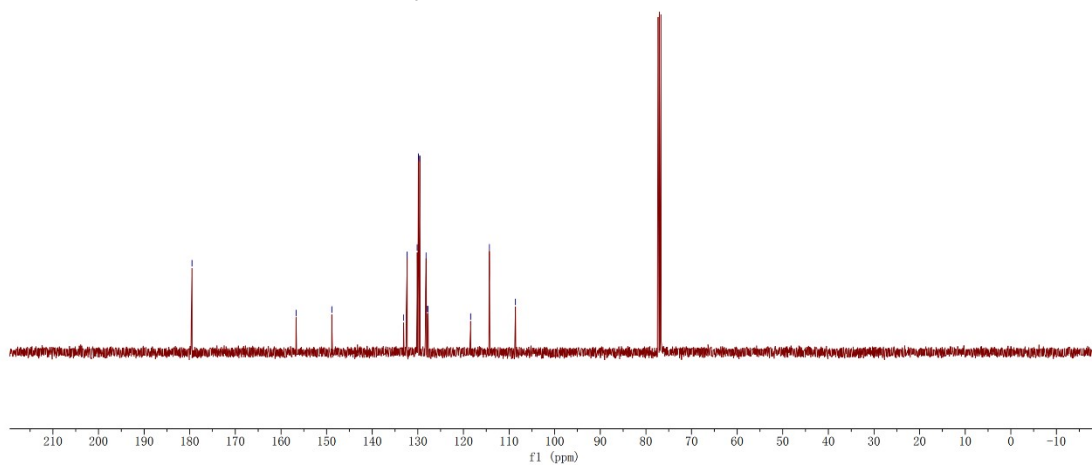
3w (^1H NMR) (400 MHz, CDCl_3)



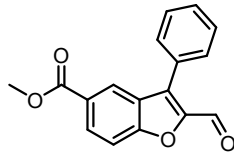
179.514
156.661
148.836
133.079
132.358
130.163
129.854
129.584
128.202
127.877
127.786
118.415
114.297
108.613



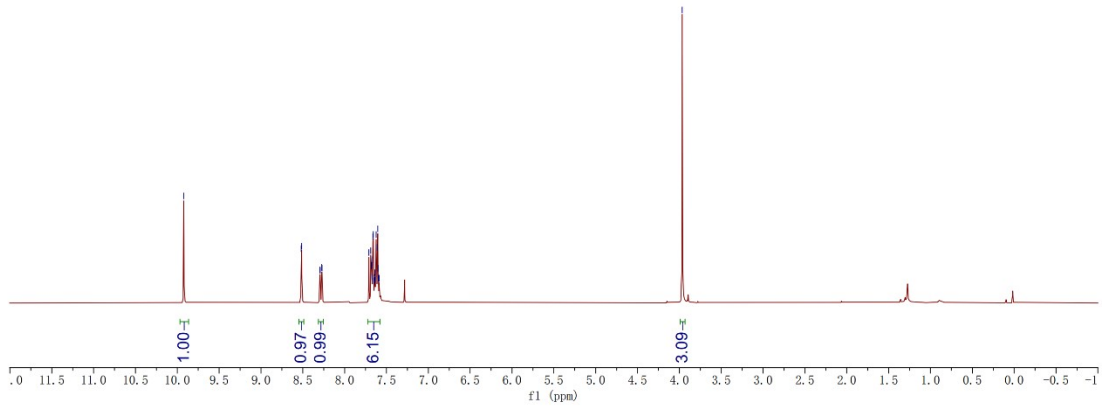
3w (^{13}C NMR) (100 MHz, CDCl_3)



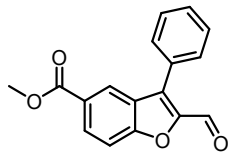
-9.923
 8.519
 8.515
 8.297
 8.292
 8.275
 8.270
 7.710
 7.688
 7.683
 7.677
 7.673
 7.667
 7.663
 7.658
 7.653
 7.645
 7.639
 7.634
 7.624
 7.609
 7.605
 7.599
 7.597
 7.589
 7.587
 3.966



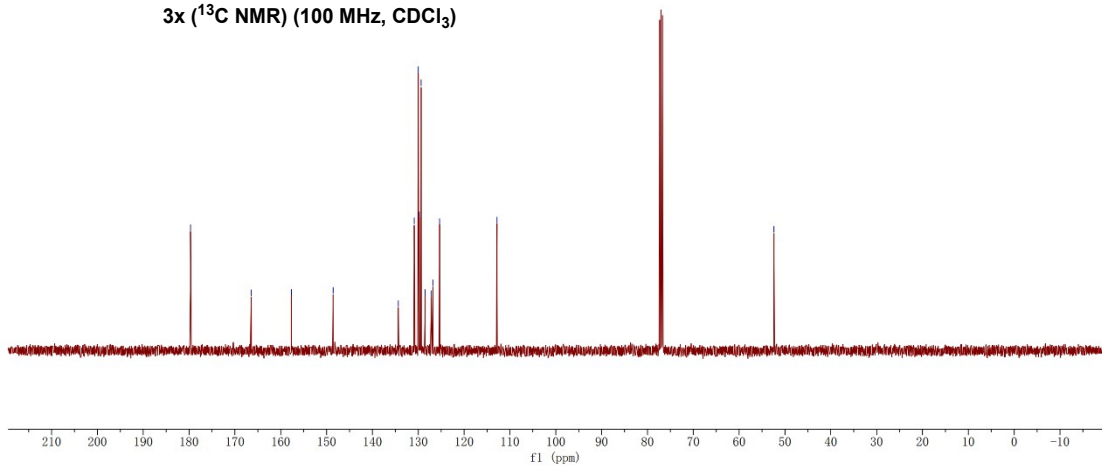
3x (¹H NMR) (400 MHz, CDCl₃)



-179.674
 -166.440
 -157.685
 -148.577
 -134.338
 -130.877
 -130.010
 -129.794
 -129.388
 -128.490
 -127.204
 -126.799
 -125.360
 -112.826
 -52.400

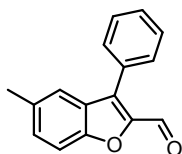


3x (¹³C NMR) (100 MHz, CDCl₃)

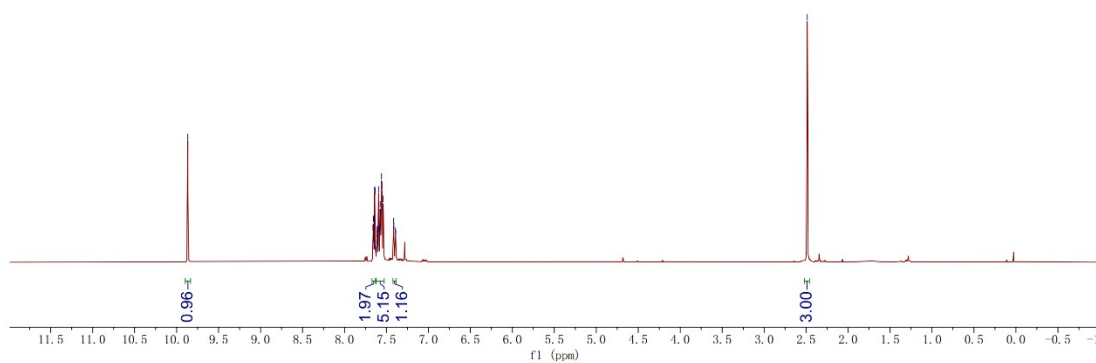


9.868
7.661
7.656
7.651
7.645
7.641
7.637
7.631
7.622
7.616
7.610
7.606
7.595
7.589
7.579
7.575
7.569
7.560
7.553
7.539
7.416
7.411
7.393
7.389

2.485

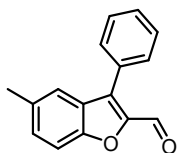


3y (¹H NMR) (400 MHz, CDCl₃)

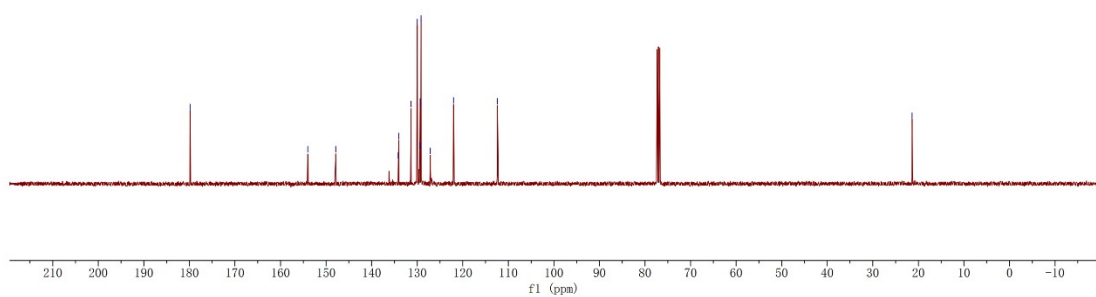


179.841
154.024
147.873
134.166
134.053
131.380
130.004
129.412
129.349
129.161
127.145
122.018
112.382

21.387



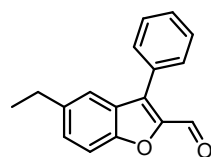
3y (¹³C NMR) (100 MHz, CDCl₃)



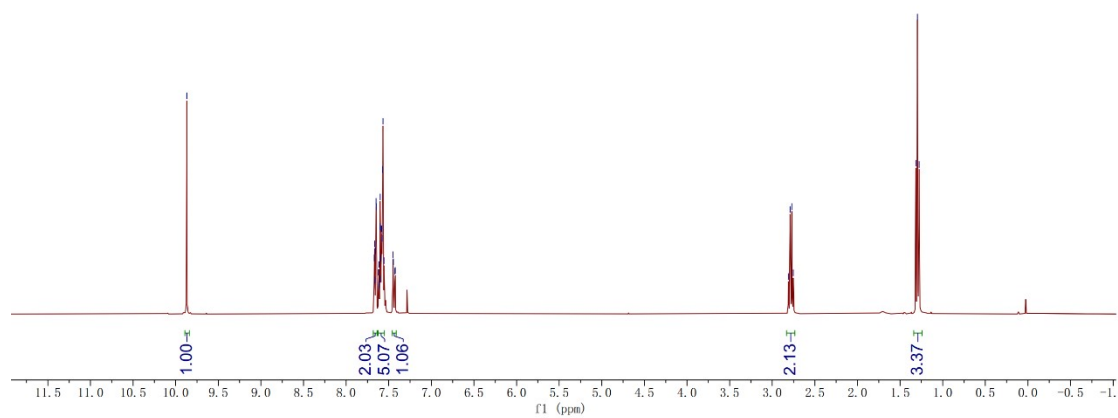
9.869
7.670
7.665
7.660
7.654
7.649
7.646
7.621
7.616
7.611
7.605
7.602
7.599
7.595
7.588
7.581
7.577
7.573
7.567
7.556
7.450
7.446
7.428
7.424

2.810
2.791
2.772
2.753

1.315
1.296
1.277

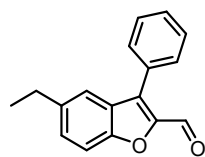


3z ($^1\text{H NMR}$) (400 MHz, CDCl_3)

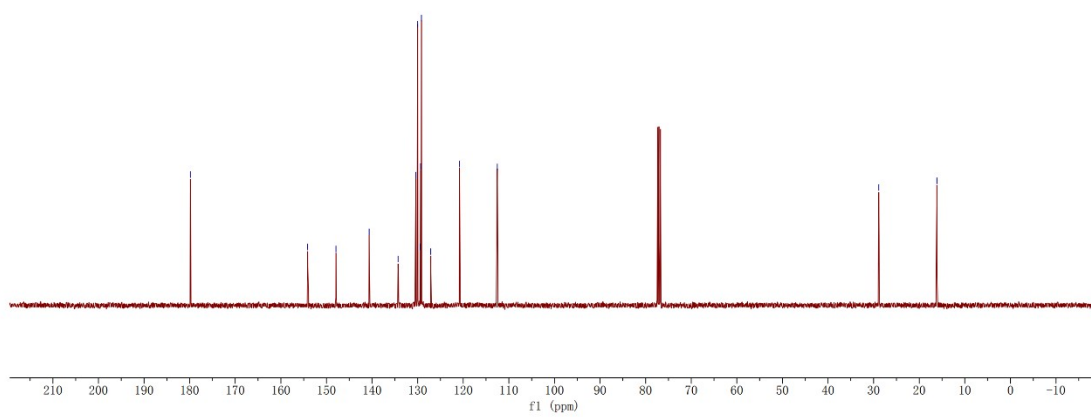


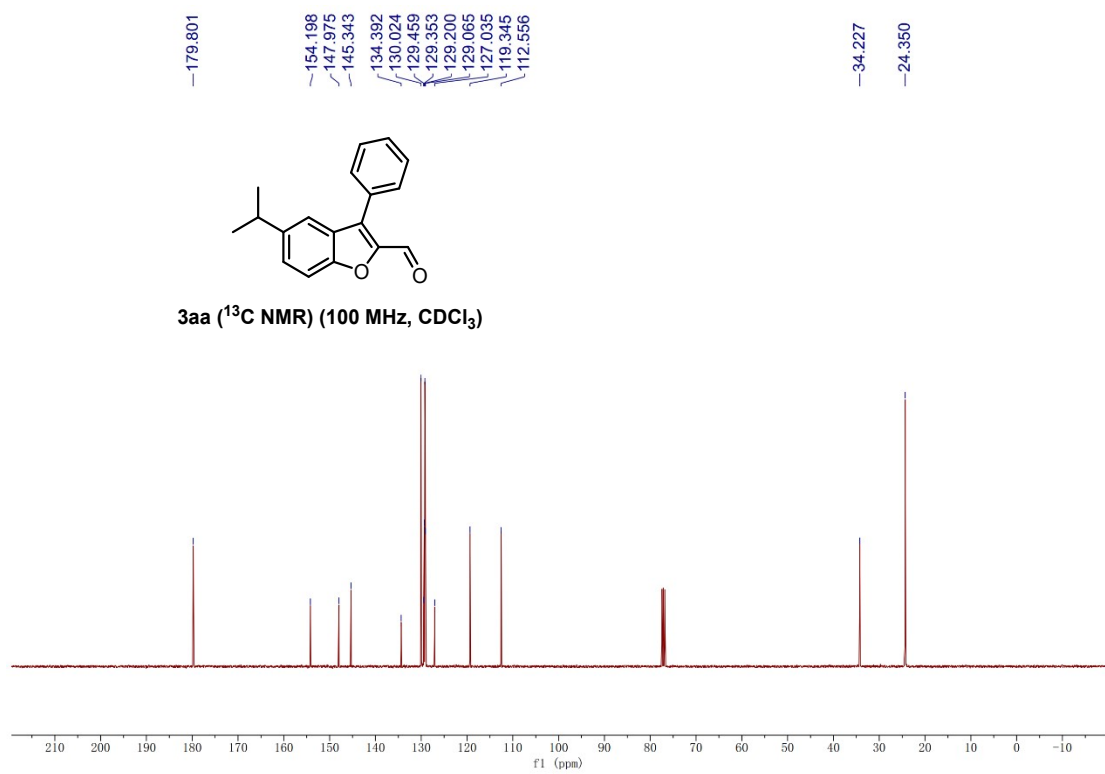
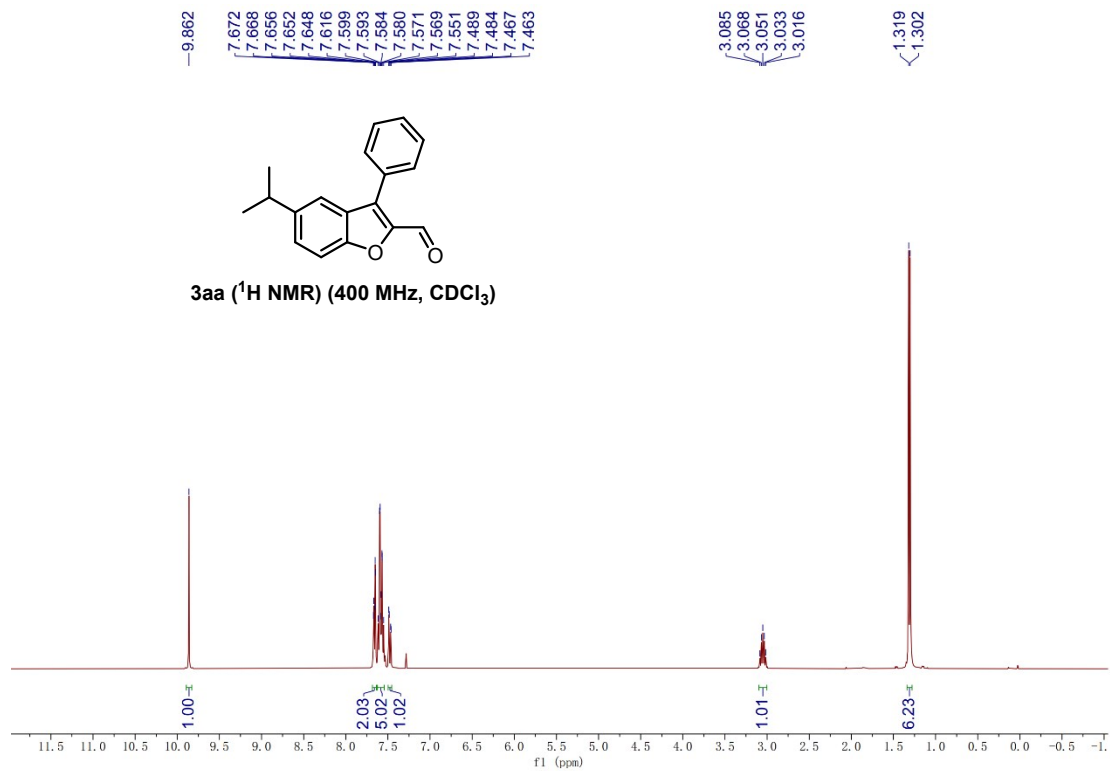
179.835
154.159
147.925
140.634
134.293
130.415
130.016
129.445
129.346
129.175
127.136
120.815
112.528

28.881
16.129

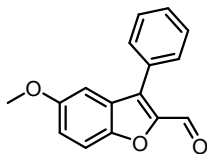


3z ($^{13}\text{C NMR}$) (100 MHz, CDCl_3)

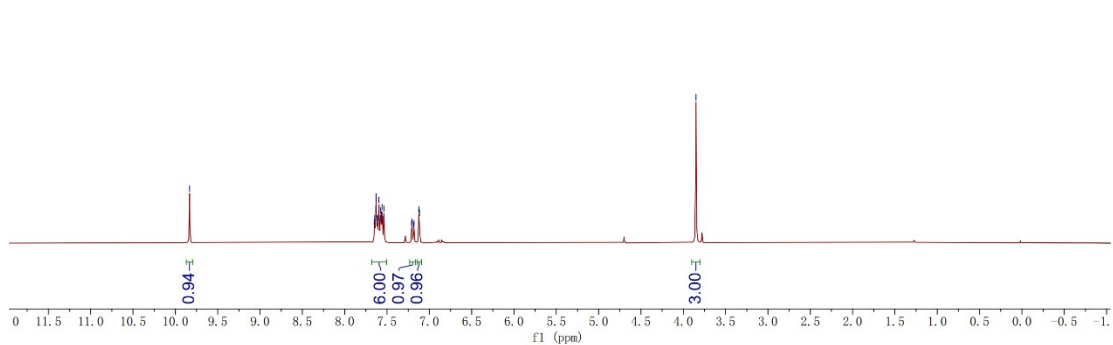




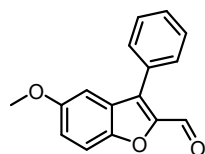
-9.833
 7.650
 7.645
 7.633
 7.630
 7.626
 7.615
 7.612
 7.595
 7.576
 7.569
 7.558
 7.552
 7.536
 7.210
 7.203
 7.187
 7.181
 7.123
 7.117
 -3.850



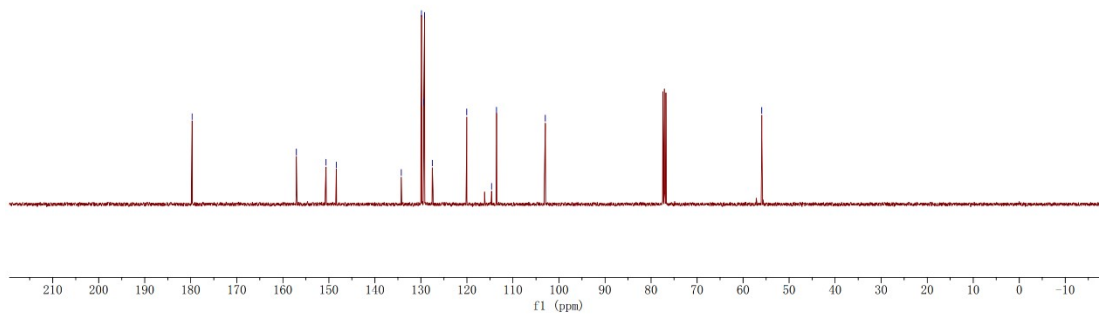
3ab (¹H NMR) (400 MHz, CDCl₃)



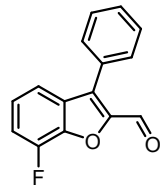
-179.737
 157.036
 150.624
 148.400
 134.249
 129.885
 129.371
 129.247
 127.505
 120.046
 114.654
 113.583
 102.977
 -55.947



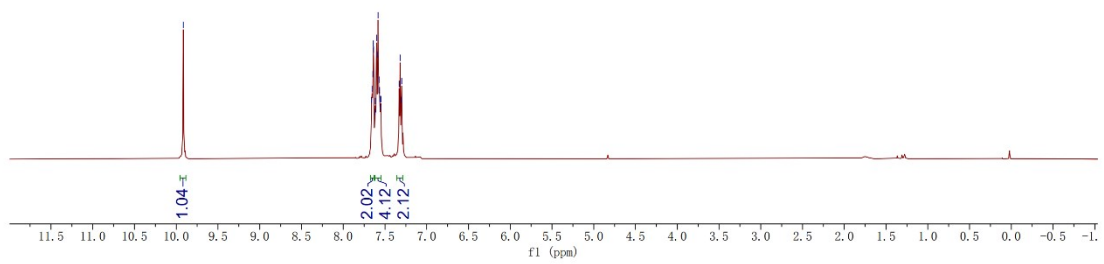
3ab (¹³C NMR) (100 MHz, CDCl₃)



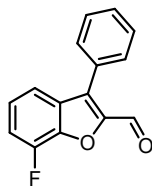
9.915
7.661
7.655
7.645
7.641
7.637
7.621
7.615
7.600
7.587
7.571
7.566
7.559
7.554
7.548
7.330
7.318
7.306
7.300



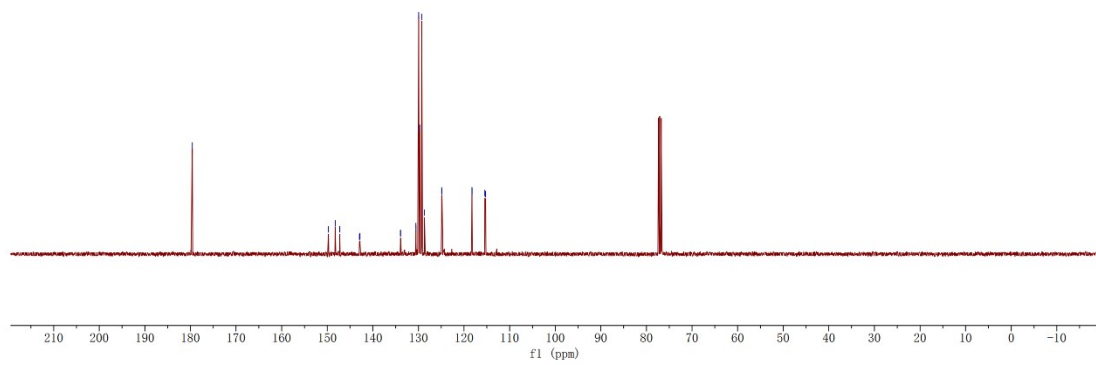
3ac (¹H NMR) (400 MHz, CDCl₃)



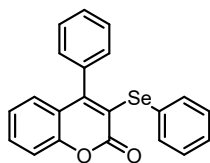
179.593
149.755
148.226
147.235
142.946
142.827
133.932
133.907
130.567
130.540
129.956
129.722
129.279
128.665
124.880
124.625
118.273
118.229
115.438
115.281



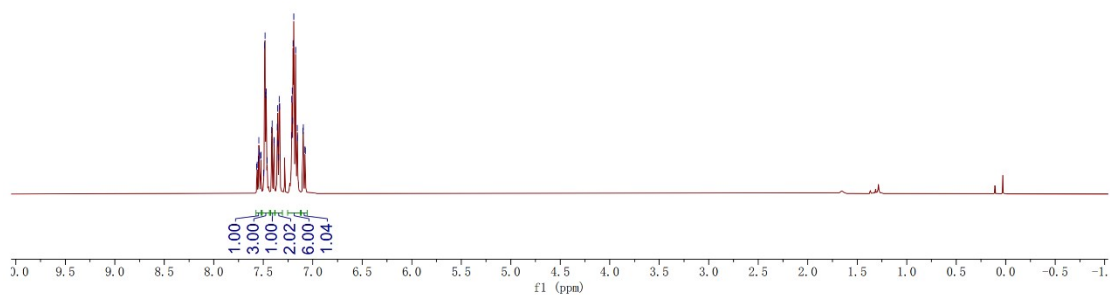
3ac (¹³C NMR) (100 MHz, CDCl₃)



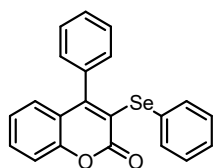
7.566
7.562
7.549
7.545
7.541
7.528
7.524
7.497
7.487
7.482
7.474
7.470
7.461
7.415
7.412
7.394
7.391
7.359
7.355
7.351
7.344
7.339
7.334
7.216
7.213
7.208
7.203
7.199
7.192
7.173
7.157
7.154
7.099
7.095
7.079
7.075



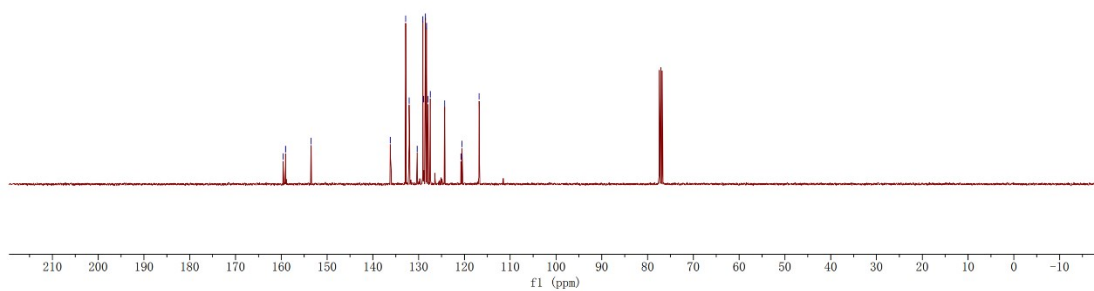
4a (^1H NMR) (400 MHz, CDCl_3)



159.580
159.066
153.492
136.222
132.839
132.065
130.332
129.081
128.915
128.536
128.268
127.968
127.450
124.317
120.745
120.516
116.816

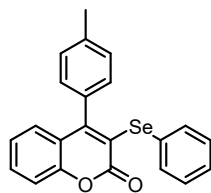


4a (^{13}C NMR) (100 MHz, CDCl_3)

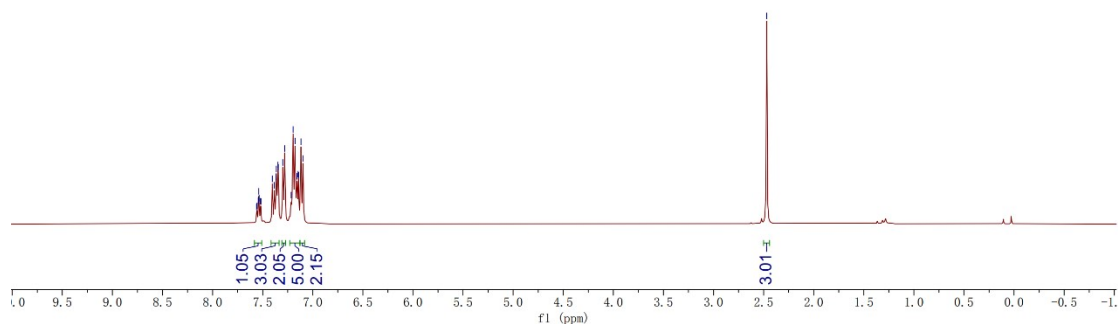


7.561
7.556
7.544
7.539
7.535
7.523
7.518
7.404
7.384
7.367
7.363
7.348
7.343
7.299
7.279
7.216
7.197
7.177
7.156
7.146
7.141
7.117
7.098

-2.469

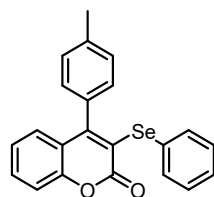


4b (¹H NMR) (400 MHz, CDCl₃)

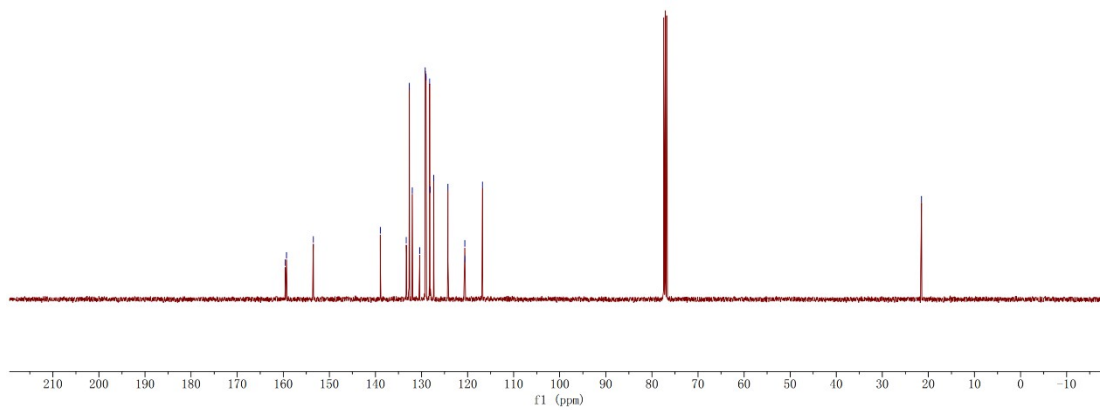


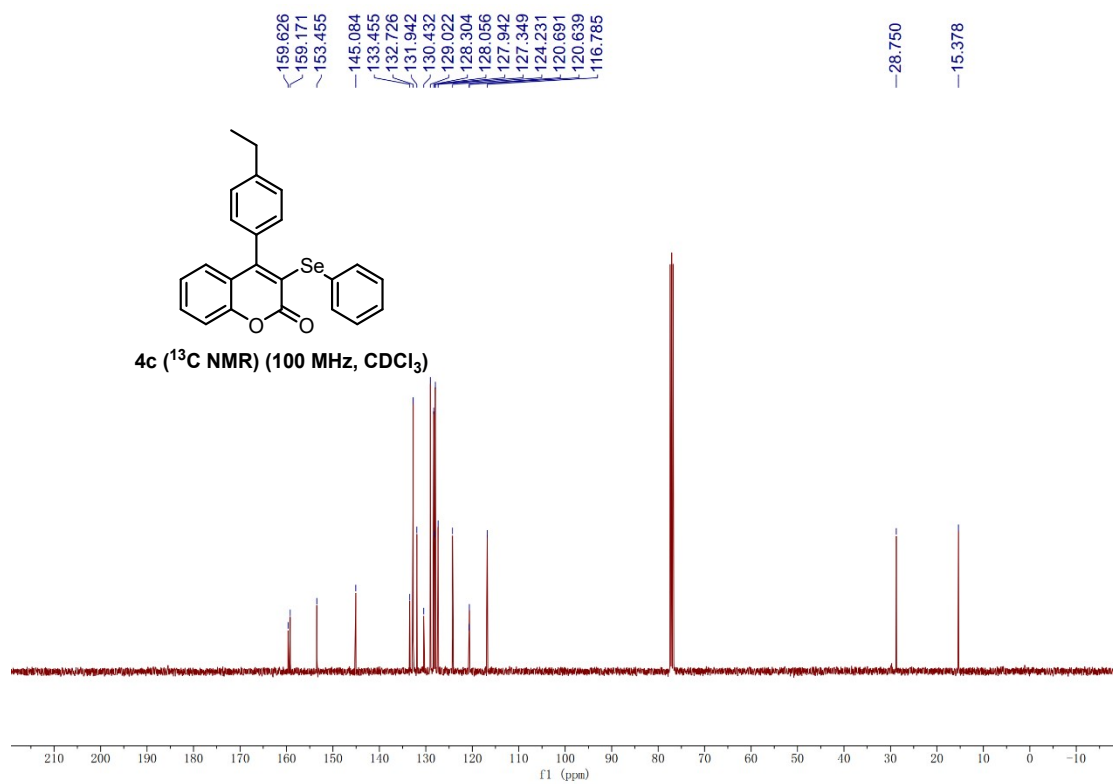
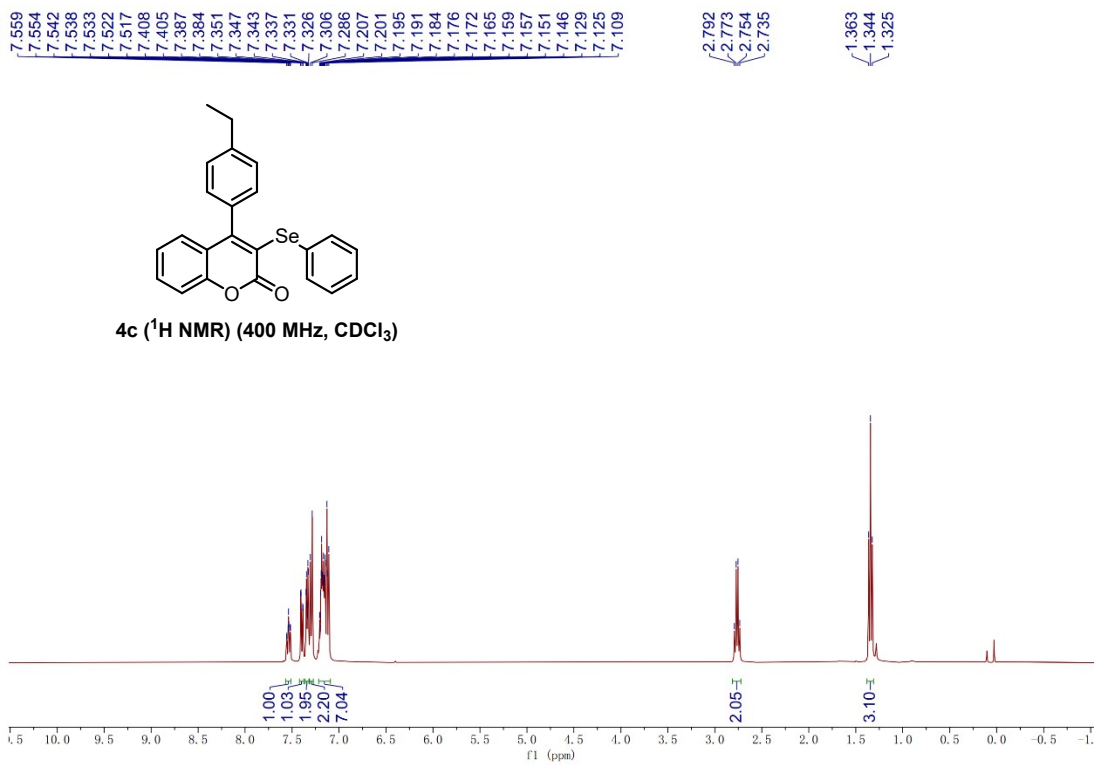
159.568
159.300
153.470
138.942
133.321
132.667
131.994
130.415
129.199
129.027
128.234
128.080
127.377
124.254
120.603
120.575
116.797

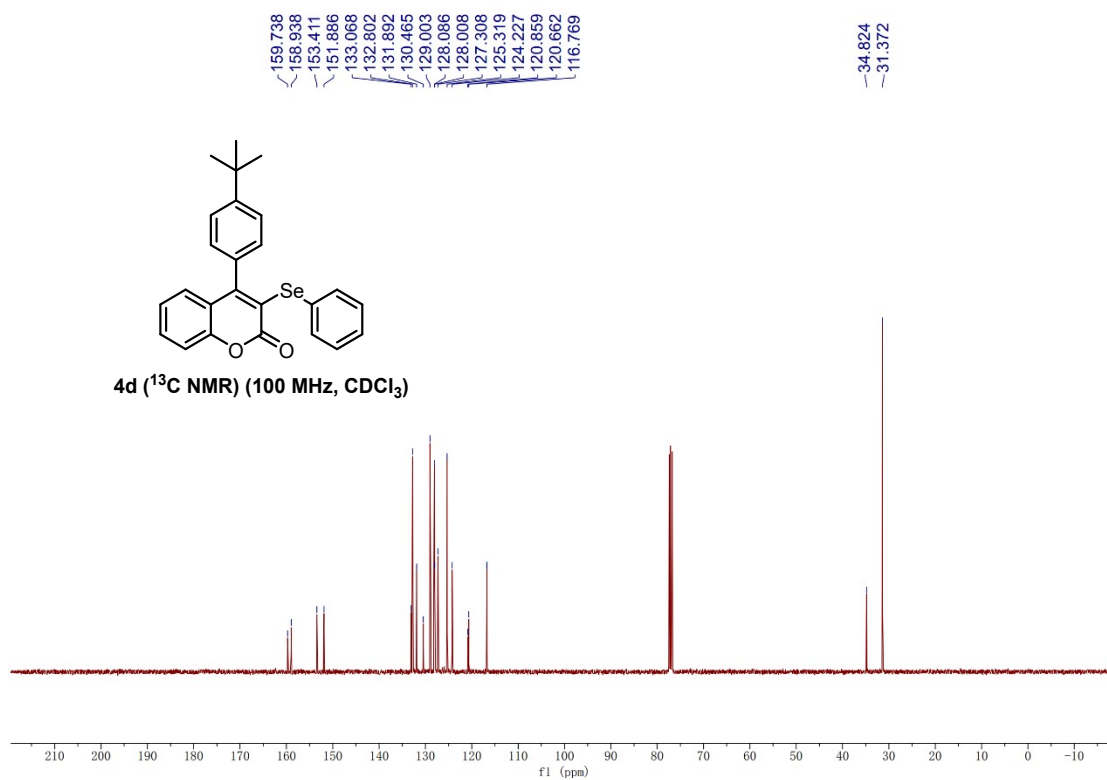
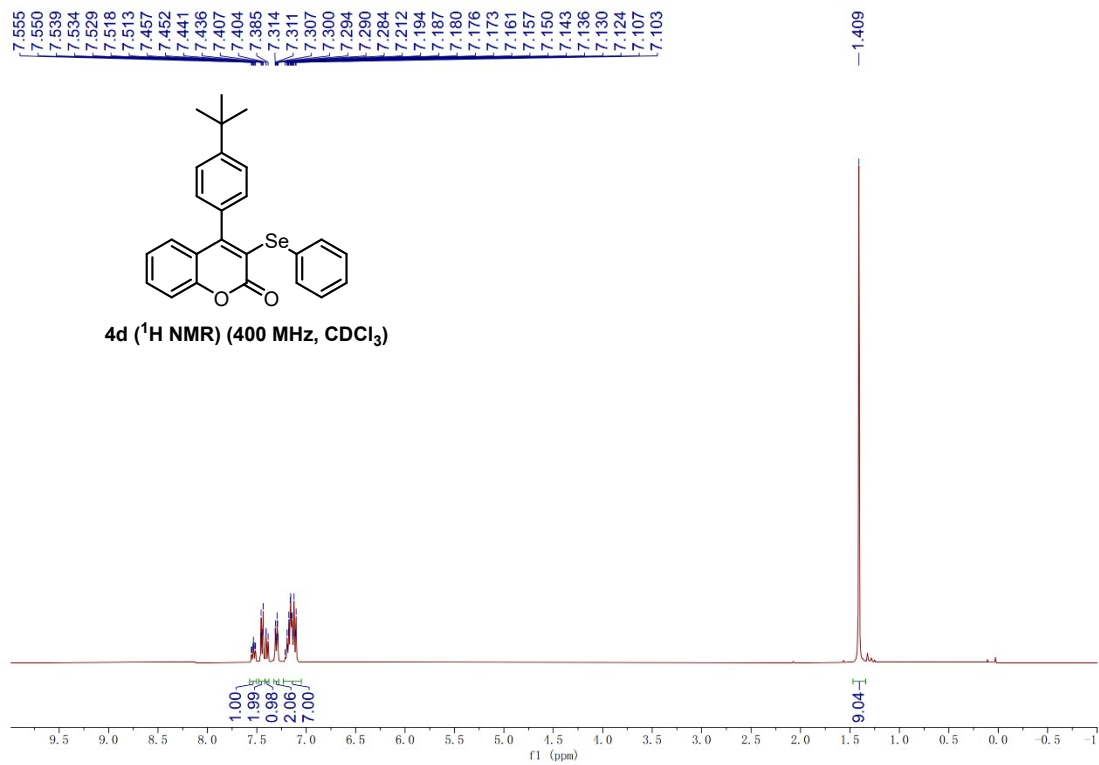
-21.506



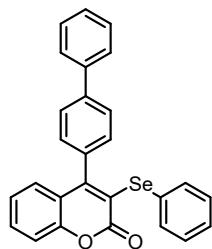
4b (¹³C NMR) (100 MHz, CDCl₃)



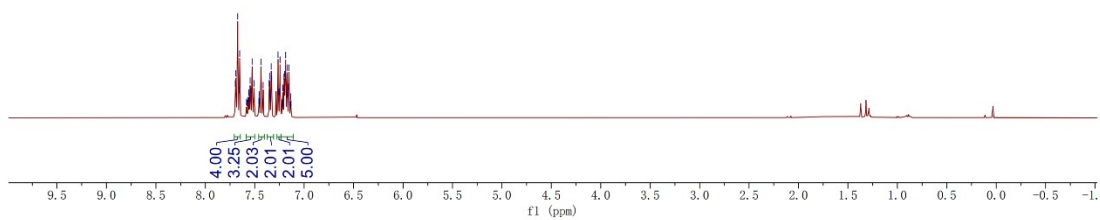




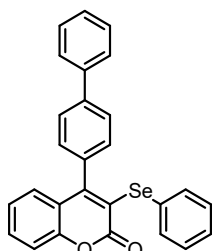
7.696
7.692
7.673
7.657
7.652
7.583
7.576
7.568
7.555
7.546
7.540
7.527
7.507
7.459
7.455
7.452
7.436
7.415
7.353
7.350
7.347
7.339
7.333
7.329
7.265
7.260
7.249
7.244
7.224
7.218
7.212
7.204
7.200
7.193
7.187
7.173
7.169
7.159
7.154
7.141
7.137
7.133



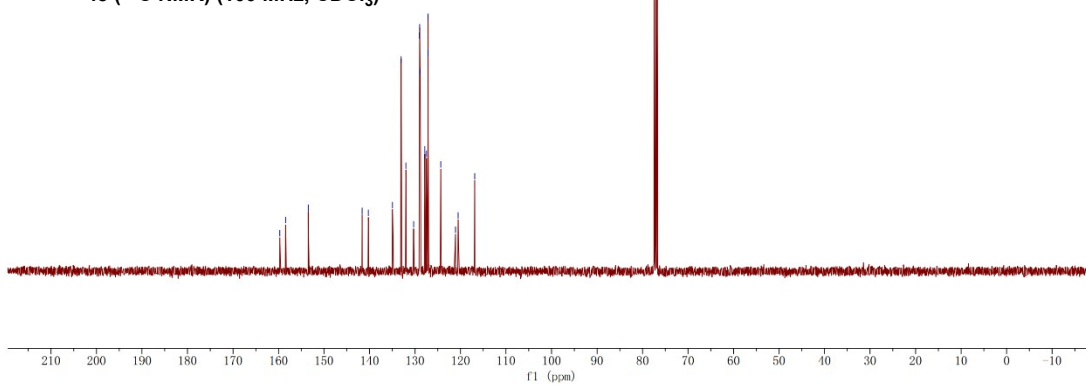
4e ($^1\text{H NMR}$) (400 MHz, CDCl_3)



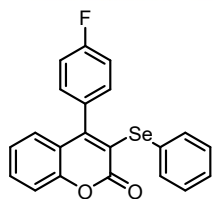
159.703
158.431
153.444
141.622
140.275
134.935
133.053
132.026
130.295
129.047
128.886
128.857
127.844
127.827
127.461
127.162
127.117
124.351
121.102
120.533
116.878



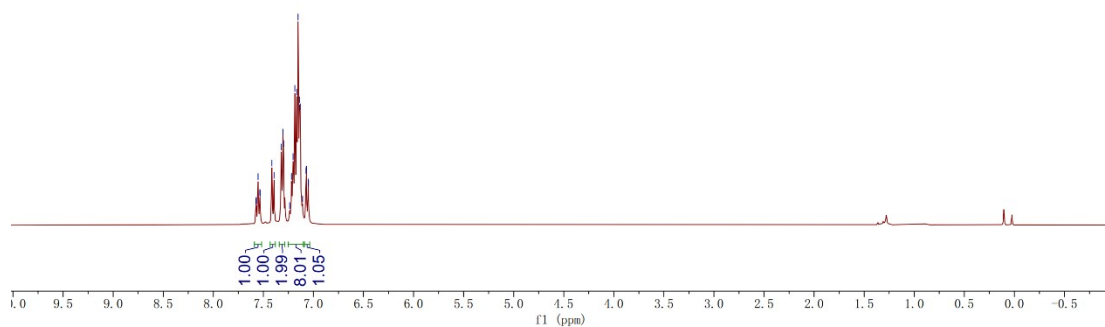
4e ($^{13}\text{C NMR}$) (100 MHz, CDCl_3)



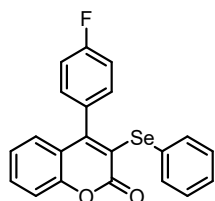
7.575
7.571
7.553
7.536
7.532
7.416
7.394
7.321
7.304
7.299
7.237
7.219
7.204
7.186
7.168
7.153
7.140
7.131
7.109
7.074
7.070
7.054
7.050



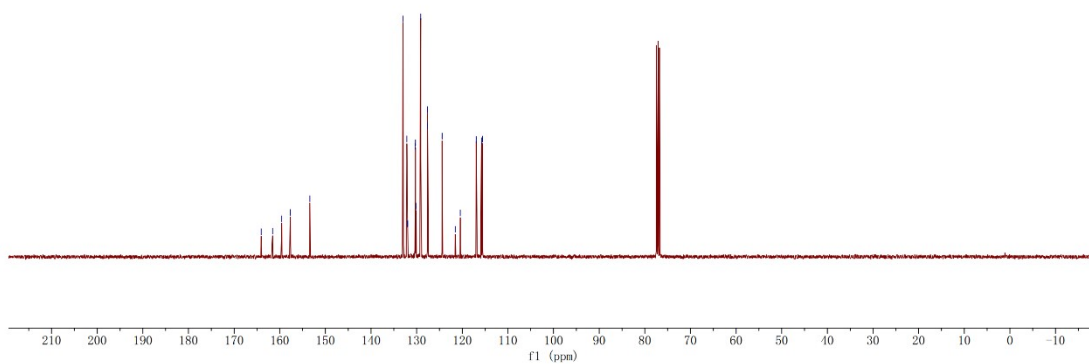
4f (¹H NMR) (400 MHz, CDCl₃)



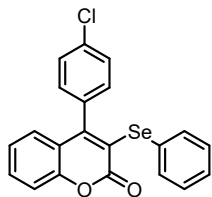
164.052
161.575
159.573
157.719
153.393
132.977
132.153
132.000
131.964
130.347
130.265
130.155
129.117
127.595
127.580
124.410
121.523
120.446
116.924
115.811
115.595



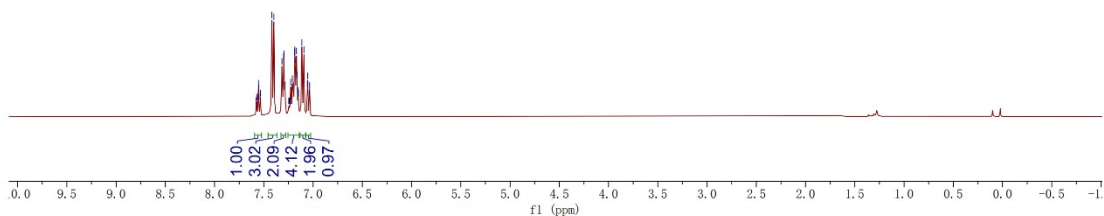
4f (¹³C NMR) (100 MHz, CDCl₃)



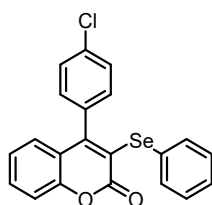
7.577
7.573
7.555
7.551
7.538
7.534
7.418
7.397
7.316
7.299
7.295
7.284
7.247
7.243
7.236
7.227
7.210
7.201
7.188
7.185
7.181
7.169
7.163
7.152
7.149
7.114
7.094
7.058
7.055
7.039
7.034



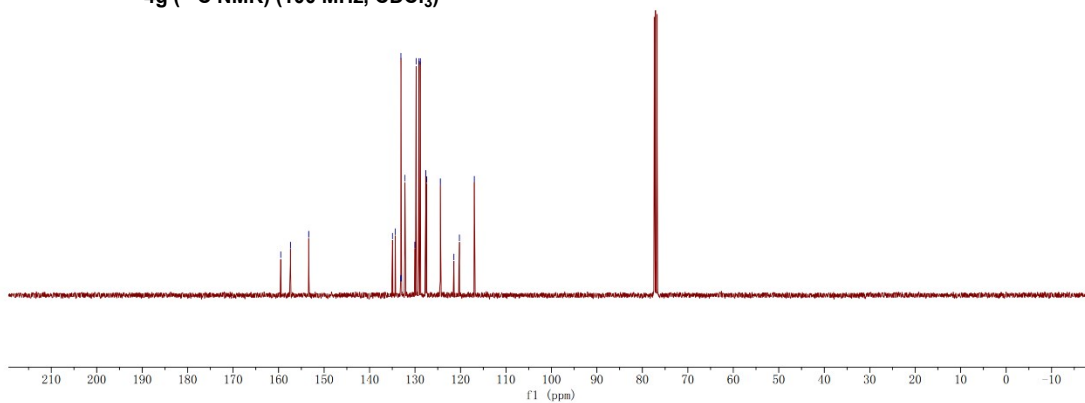
4g (¹H NMR) (400 MHz, CDCl₃)



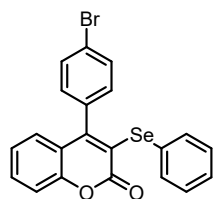
159.529
157.381
153.385
134.370
134.366
133.167
133.109
133.050
132.186
130.038
129.754
128.827
127.649
127.461
124.437
121.465
120.246
116.955



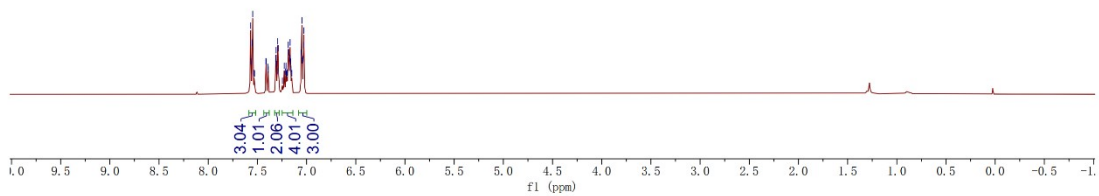
4g (¹³C NMR) (100 MHz, CDCl₃)



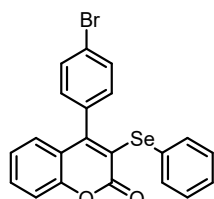
7.569
7.564
7.553
7.549
7.534
7.530
7.414
7.411
7.393
7.390
7.314
7.310
7.306
7.299
7.294
7.289
7.246
7.228
7.213
7.210
7.206
7.201
7.198
7.187
7.181
7.173
7.168
7.162
7.159
7.151
7.055
7.049
7.044
7.035
7.032
7.028



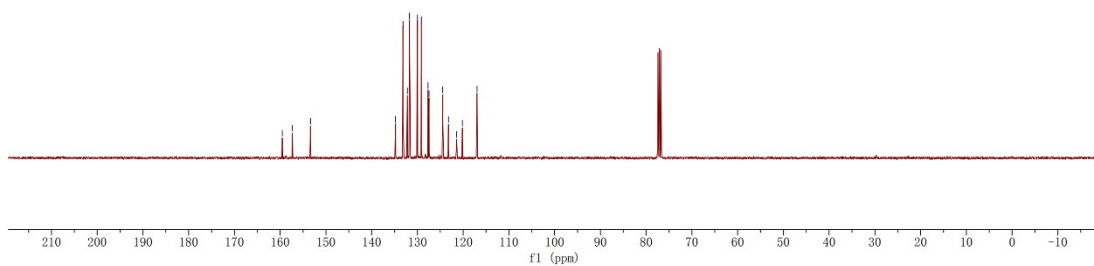
4h (¹H NMR) (400 MHz, CDCl₃)



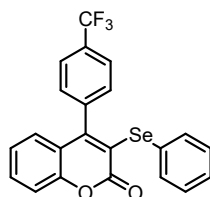
159.536
157.338
153.370
134.822
133.142
132.208
131.763
129.999
129.141
127.664
127.448
124.461
123.196
121.407
120.166
116.958



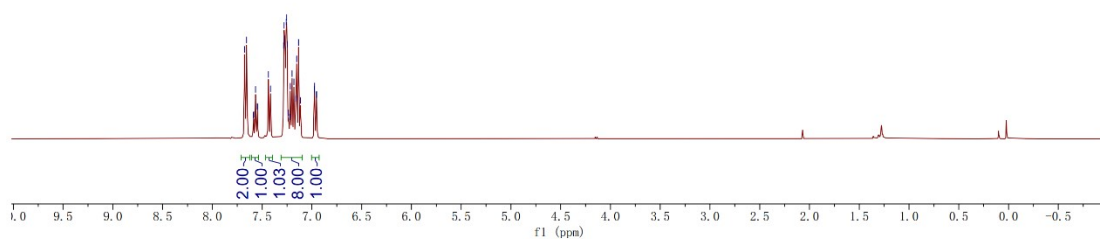
4h (¹³C NMR) (100 MHz, CDCl₃)



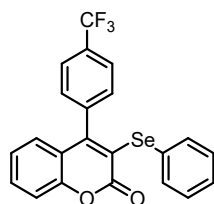
7.676
7.656
7.588
7.585
7.567
7.549
7.545
7.437
7.417
7.284
7.279
7.270
7.259
7.253
7.249
7.235
7.223
7.216
7.199
7.181
7.162
7.153
7.134
7.116
6.972
6.956
6.952



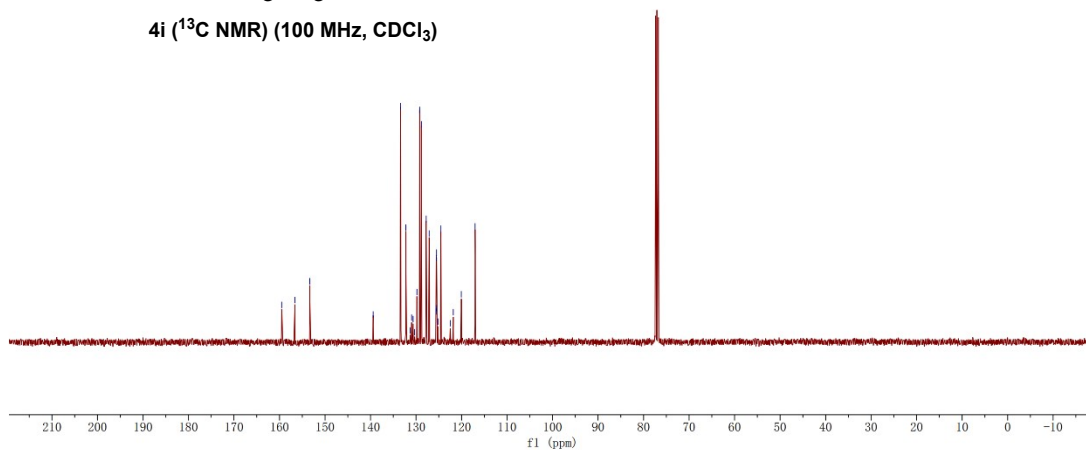
4i (¹H NMR) (400 MHz, CDCl₃)



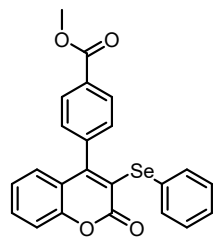
159.517
156.827
153.350
139.415
133.374
132.253
131.292
130.968
130.644
130.320
129.797
129.183
128.827
127.755
127.121
125.574
125.537
125.500
125.463
125.196
124.523
122.488
121.824
120.064
117.032



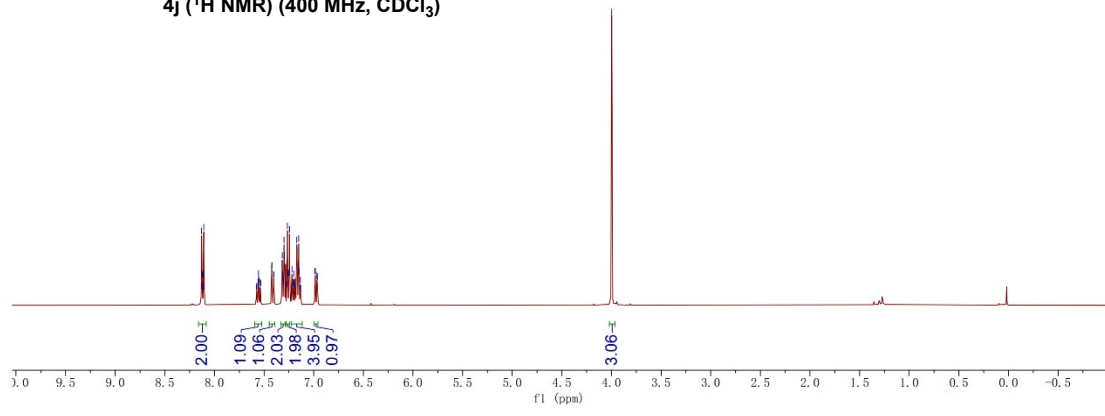
4i (¹³C NMR) (100 MHz, CDCl₃)



8.134
8.129
8.124
8.113
8.108
8.104
7.578
7.574
7.560
7.556
7.553
7.539
7.535
7.424
7.421
7.403
7.400
7.316
7.319
7.313
7.305
7.299
7.295
7.270
7.266
7.261
7.249
7.245
7.220
7.205
7.202
7.198
7.188
7.185
7.171
7.167
7.156
7.152
7.147
7.135
7.131
6.988
6.984
6.968
6.964
3.997

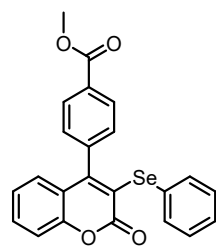


4j (¹H NMR) (400 MHz, CDCl₃)

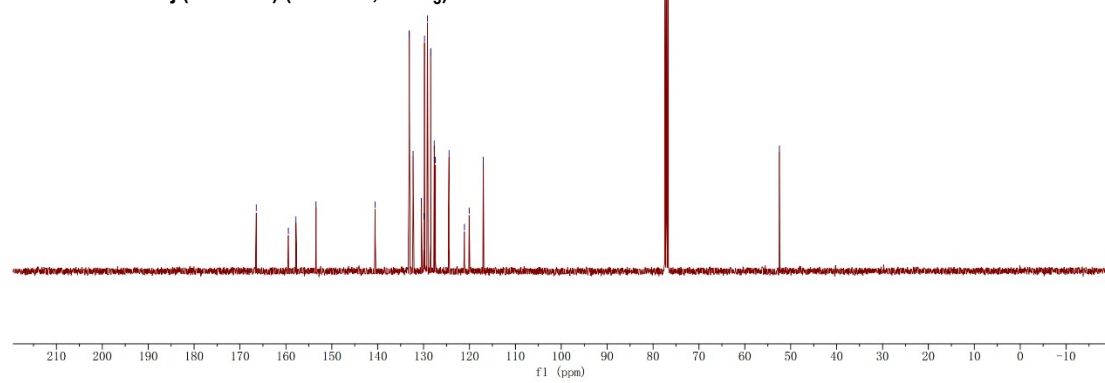


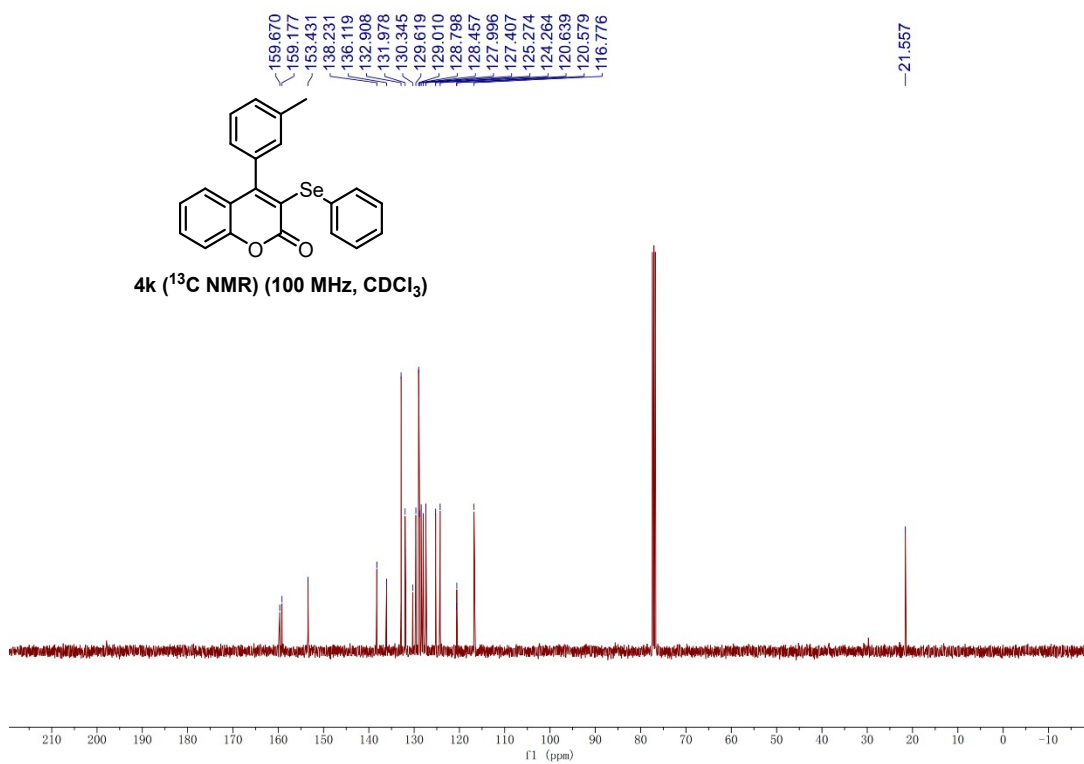
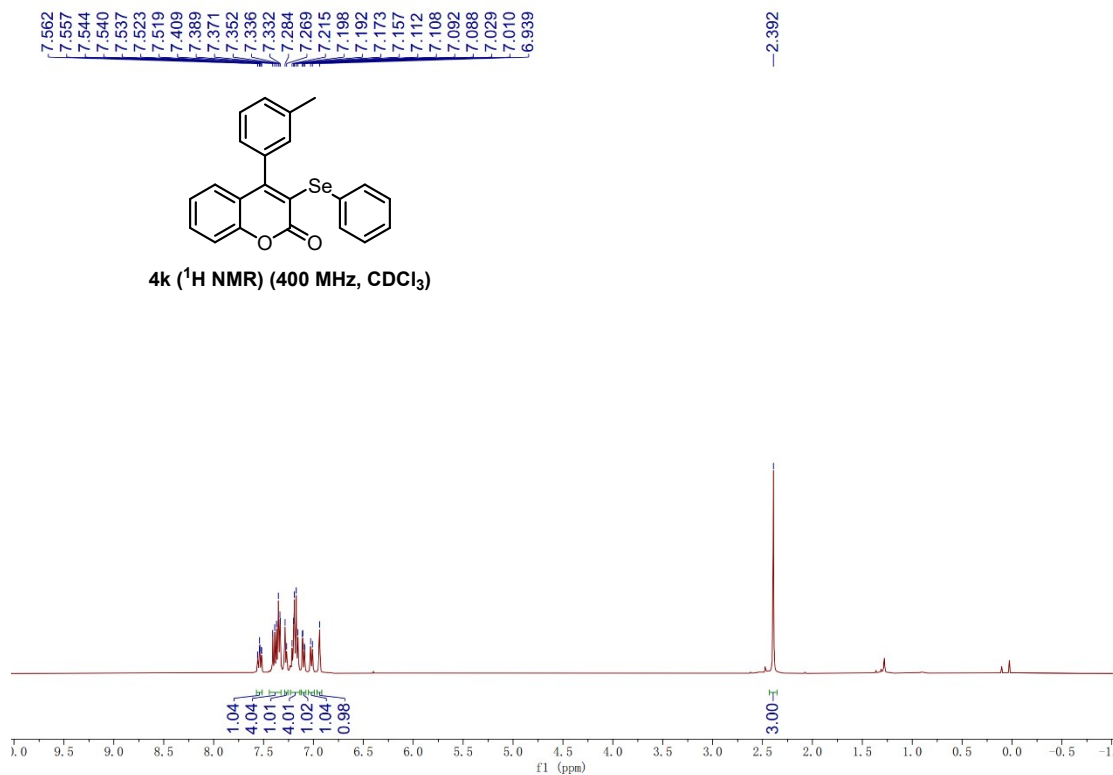
166.485
159.461
157.799
153.442
140.541
133.128
132.279
130.463
129.949
129.794
129.164
128.454
127.706
127.439
124.468
121.081
120.057
116.980

—52.454

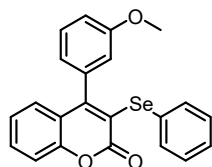


4j (¹³C NMR) (100 MHz, CDCl₃)

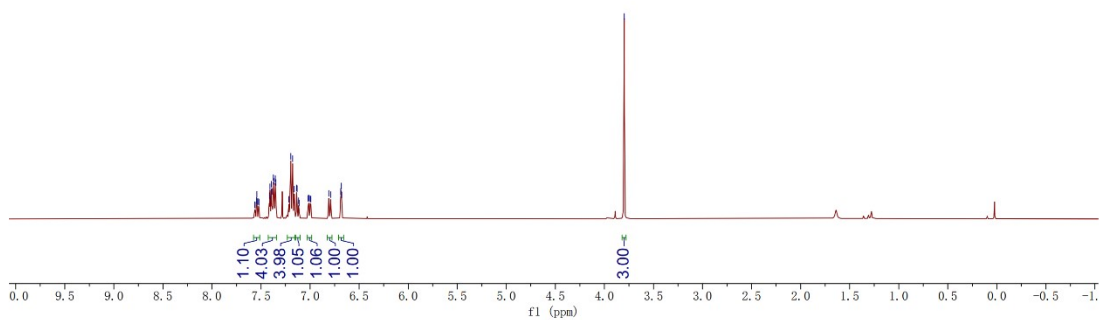




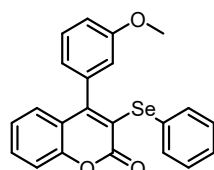
7.564
7.560
7.546
7.543
7.539
7.526
7.521
7.415
7.409
7.396
7.388
7.374
7.369
7.354
7.349
7.217
7.196
7.178
7.162
7.137
7.133
7.117
7.112
7.020
7.014
6.999
6.993
6.809
6.790
6.688
6.682
6.677
-3.799



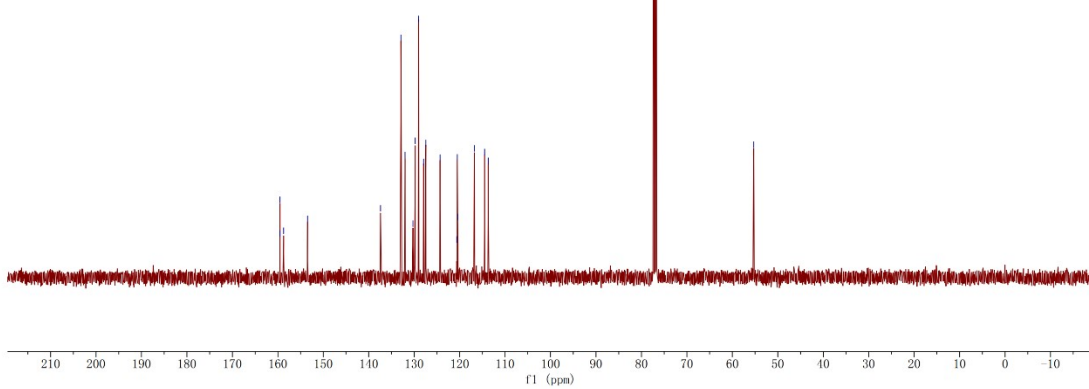
4I ($^1\text{H NMR}$) (400 MHz, CDCl_3)



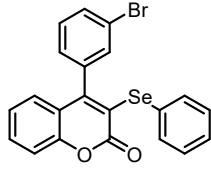
159.563
159.539
158.736
153.449
137.402
132.918
132.022
130.279
129.773
129.040
127.918
127.443
124.300
120.640
120.505
120.426
116.787
114.505
113.701
-55.298



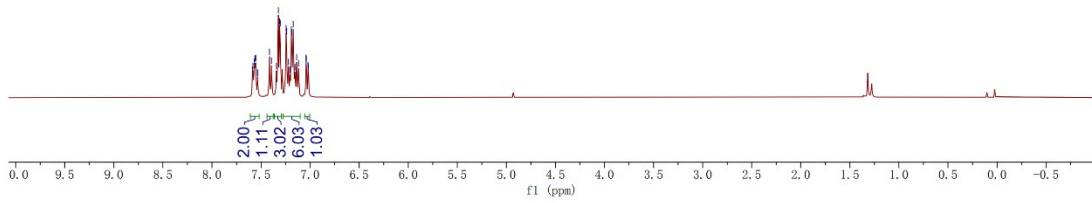
4I ($^{13}\text{C NMR}$) (100 MHz, CDCl_3)



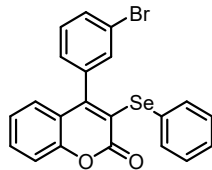
7.587
7.583
7.568
7.563
7.553
7.536
7.414
7.394
7.343
7.324
7.309
7.244
7.239
7.221
7.205
7.192
7.187
7.172
7.155
7.137
7.118
7.042
7.038
7.022
7.018



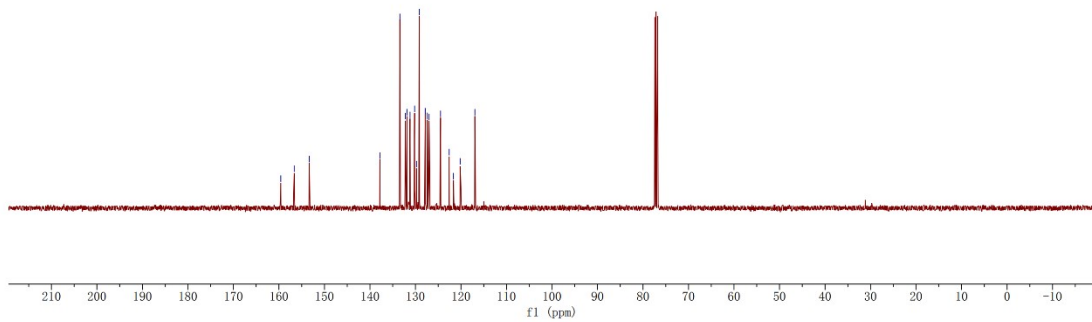
4m (¹H NMR) (400 MHz, CDCl₃)



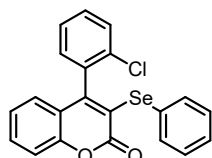
159.591
156.663
153.328
137.808
133.415
132.204
131.900
131.183
130.181
129.765
129.160
127.868
127.370
126.987
124.498
122.572
121.673
120.163
116.936



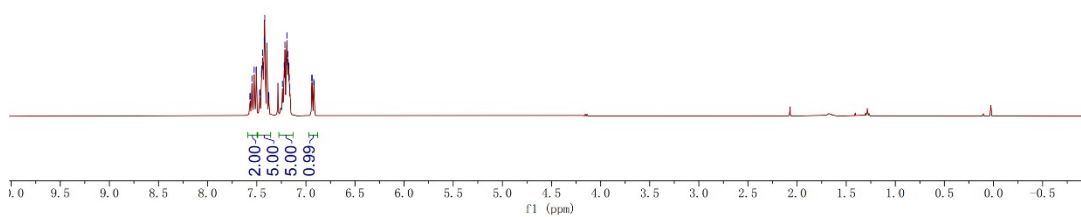
4m (¹³C NMR) (100 MHz, CDCl₃)



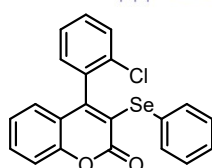
7.570
7.566
7.549
7.527
7.507
7.504
7.472
7.468
7.453
7.449
7.441
7.430
7.425
7.419
7.398
7.379
7.376
7.239
7.222
7.214
7.194
7.187
7.180
7.173
7.169
7.162
6.940
6.920
6.916



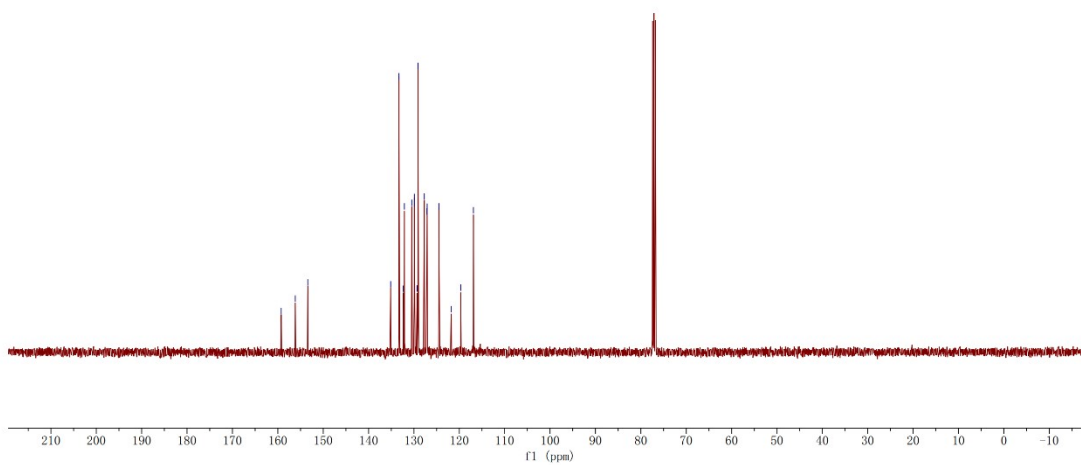
4n (¹H NMR) (400 MHz, CDCl₃)

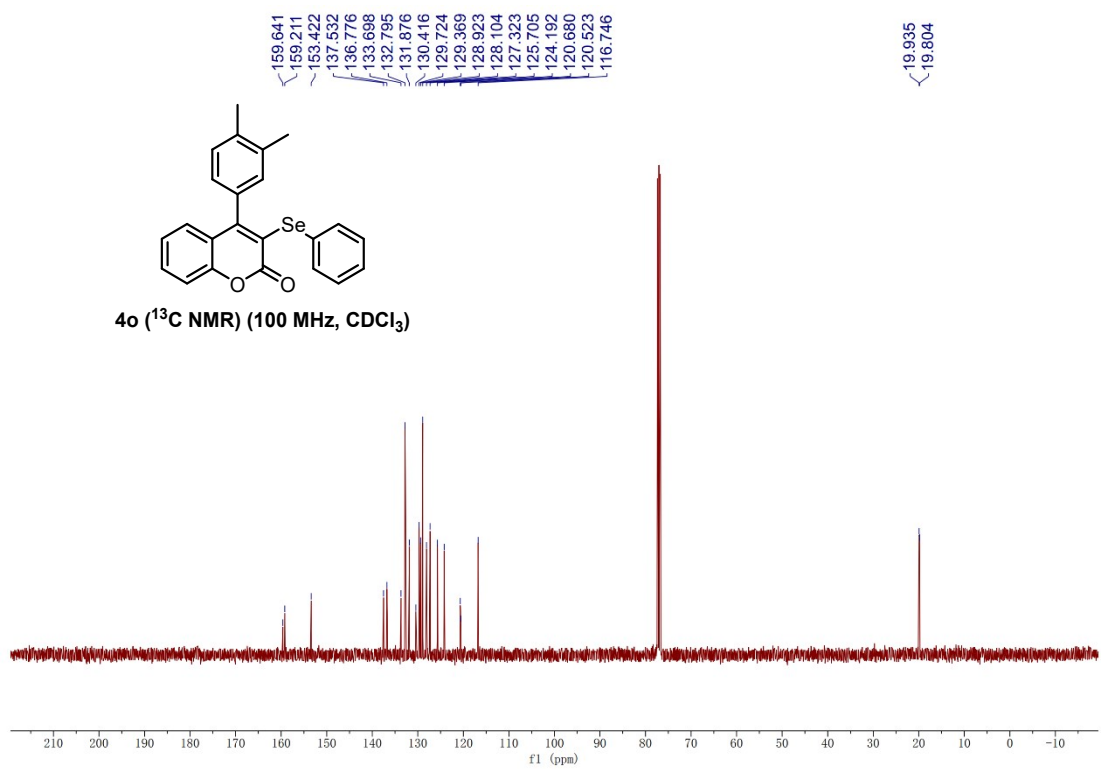
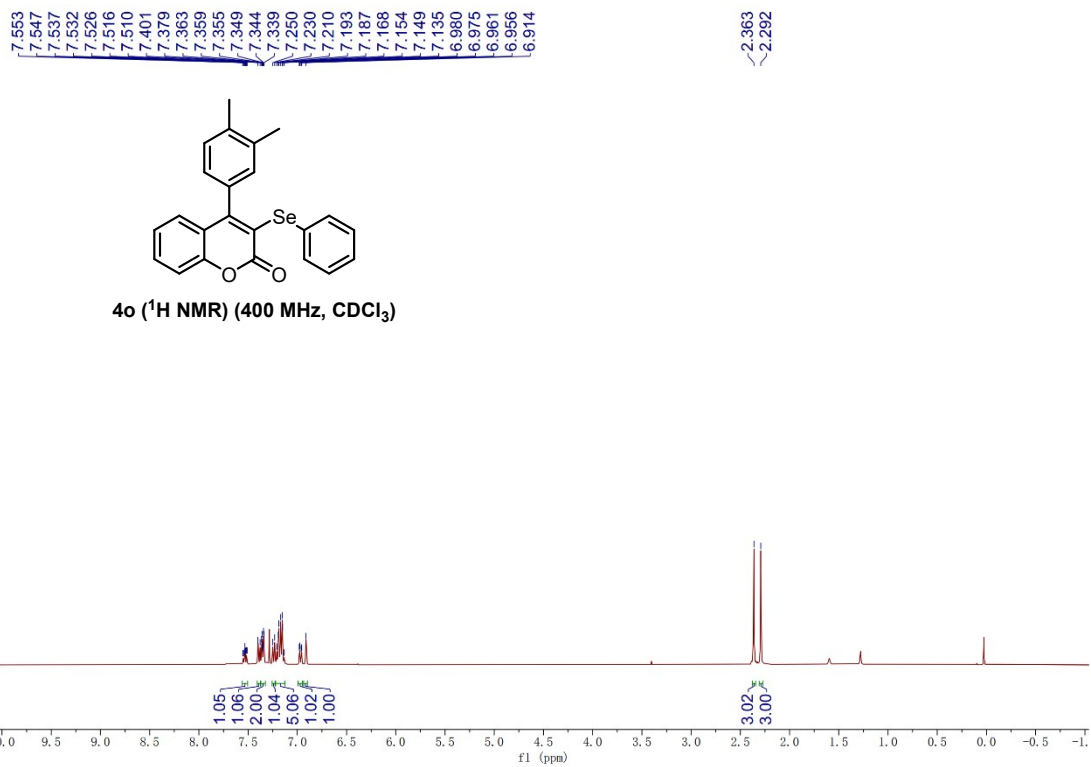


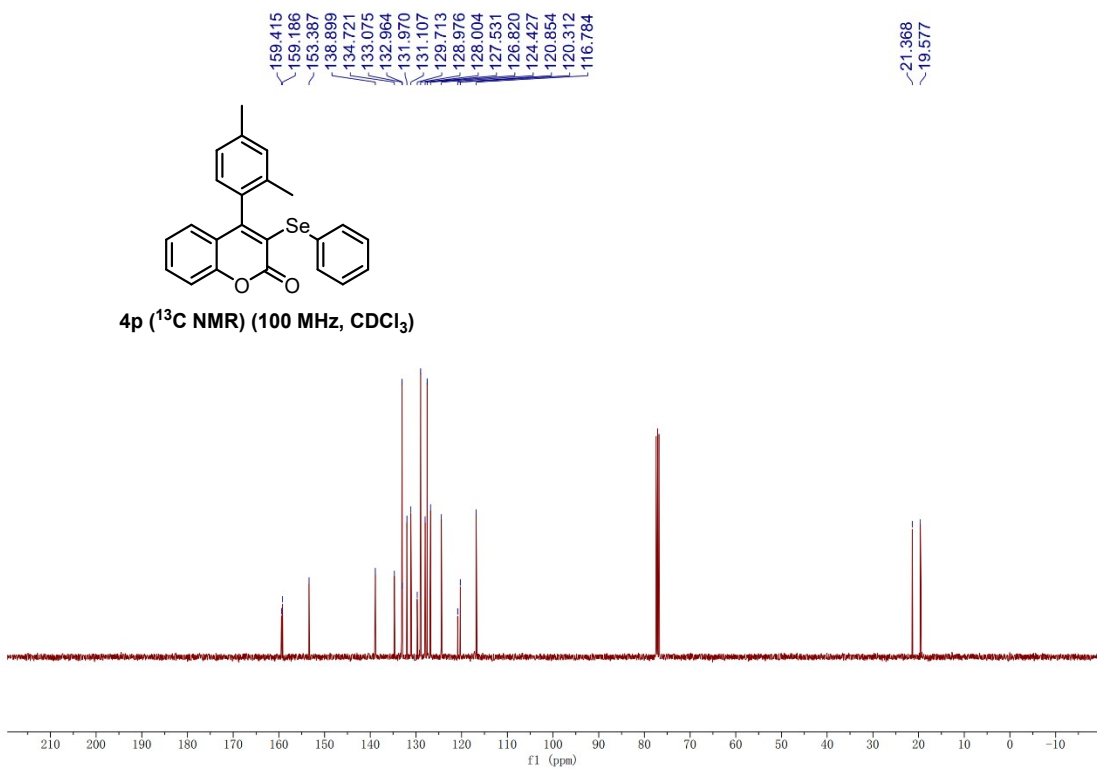
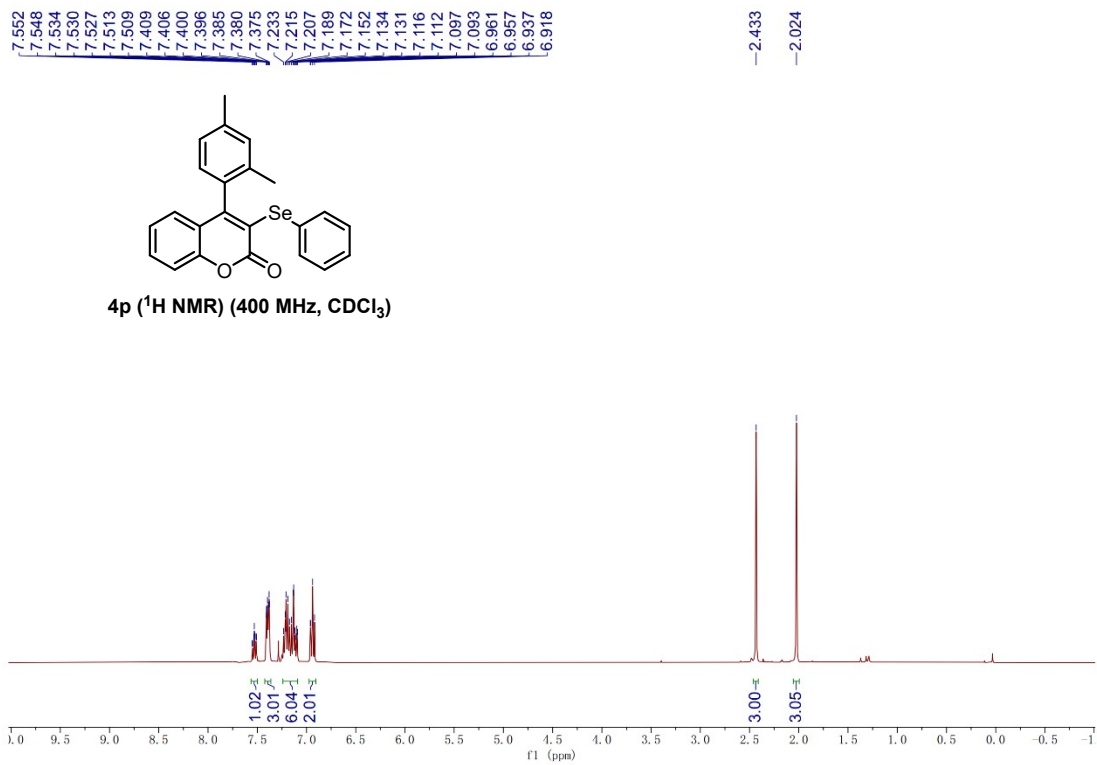
159.261
156.145
153.419
135.135
133.303
132.369
132.106
130.462
129.947
129.909
129.335
129.093
127.735
127.162
127.085
124.504
121.785
119.655
116.902



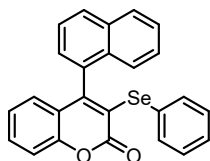
4n (¹³C NMR) (100 MHz, CDCl₃)



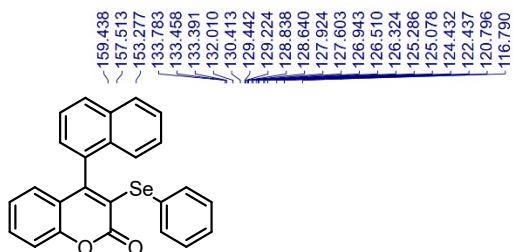
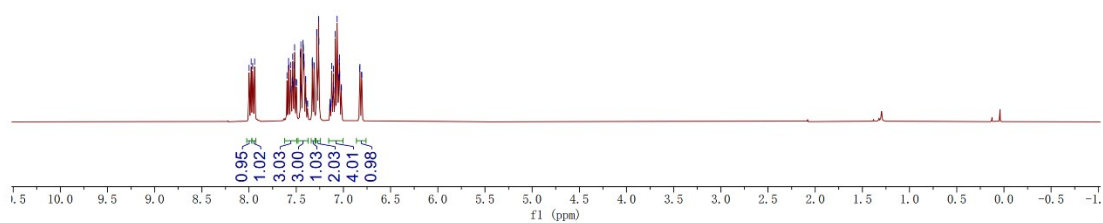




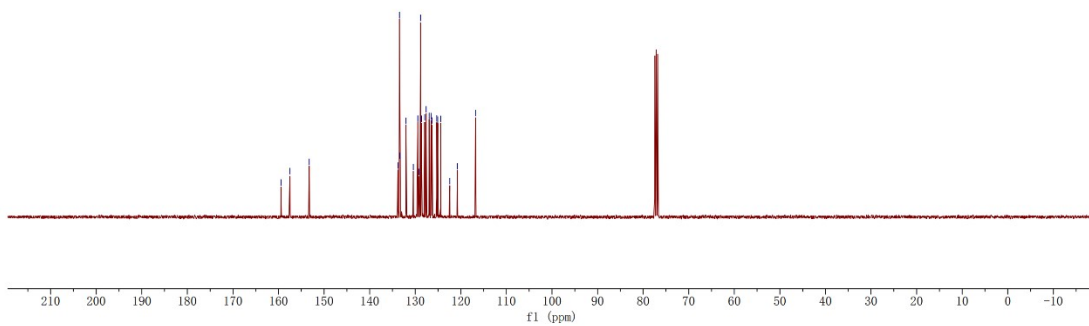
7.999
7.978
7.962
7.941
7.586
7.581
7.578
7.560
7.554
7.542
7.537
7.533
7.522
7.518
7.501
7.497
7.455
7.452
7.445
7.430
7.424
7.419
7.416
7.403
7.400
7.394
7.382
7.379
7.331
7.328
7.314
7.311
7.284
7.280
7.263
7.259
7.146
7.142
7.138
7.131
7.124
7.118
7.110
7.106
7.102
7.085
7.066
7.049
7.044
7.042
7.039
7.024
7.021
6.829
6.809
6.805



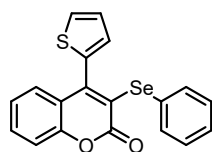
4q (¹H NMR) (400 MHz, CDCl₃)



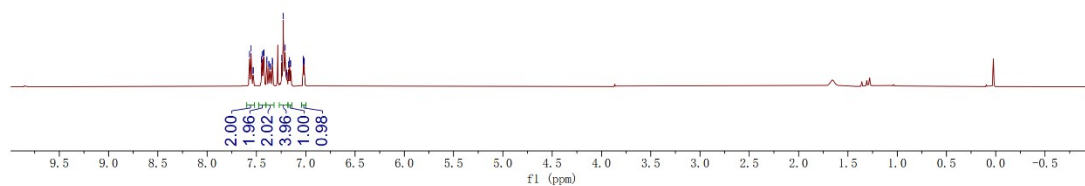
4q (¹³C NMR) (100 MHz, CDCl₃)



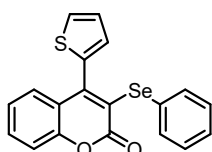
7.570
7.555
7.535
7.531
7.448
7.444
7.429
7.424
7.386
7.383
7.375
7.372
7.359
7.355
7.339
7.335
7.243
7.228
7.209
7.195
7.188
7.174
7.165
7.161
7.153
7.025
7.022
7.016
7.013



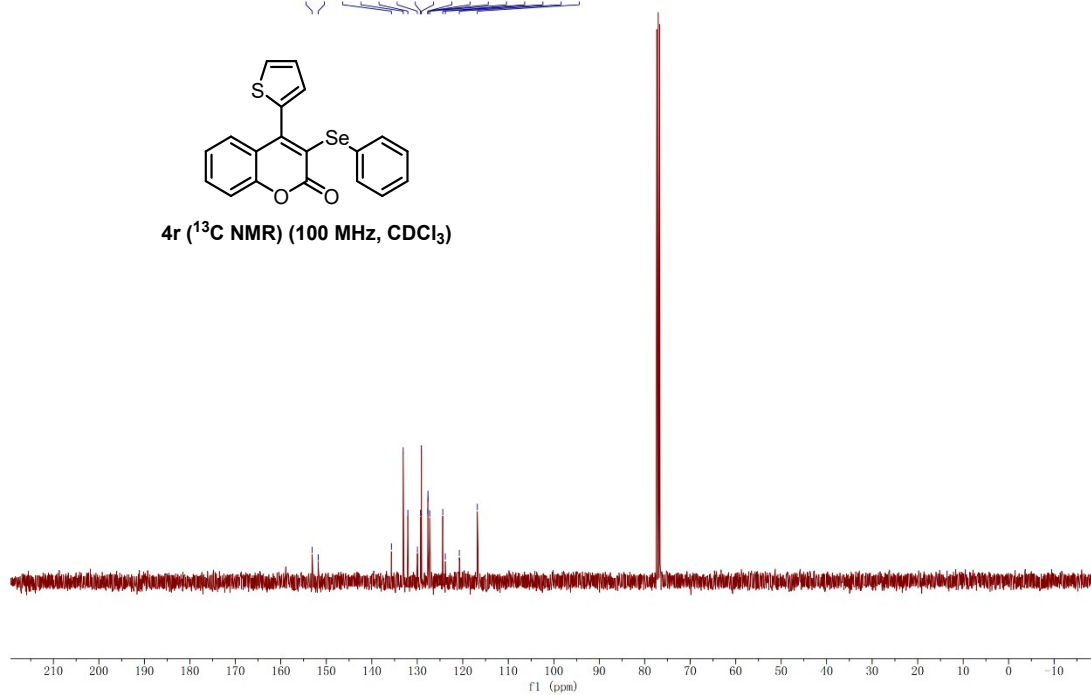
4r (¹H NMR) (400 MHz, CDCl₃)



153.102
151.777
135.679
133.079
132.070
129.985
129.257
129.095
127.720
127.655
127.639
127.279
124.598
123.831
120.761
116.772

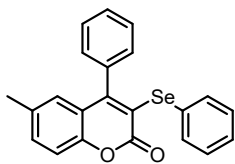


4r (¹³C NMR) (100 MHz, CDCl₃)

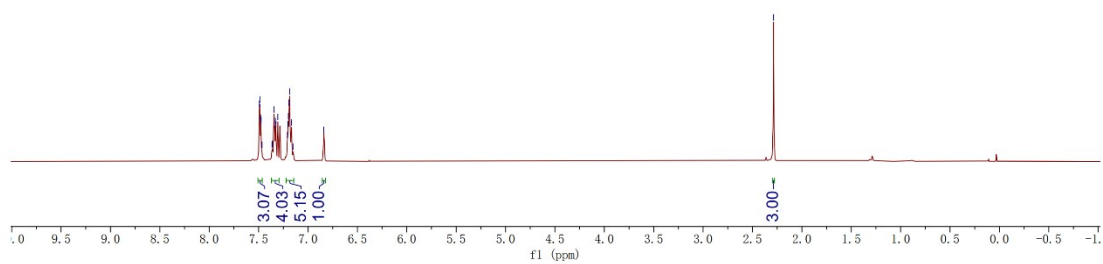


7.493
7.487
7.480
7.475
7.466
7.365
7.360
7.345
7.330
7.325
7.306
7.209
7.204
7.199
7.192
7.187
7.188
7.152
6.842

-2.287

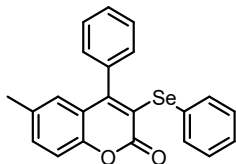


4s (¹H NMR) (400 MHz, CDCl₃)

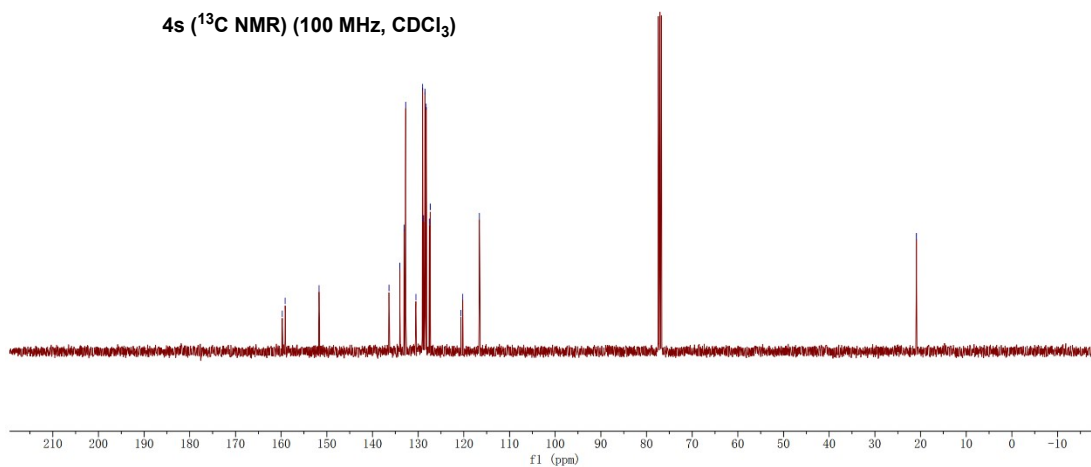


159.751
159.139
151.696
136.382
134.018
133.088
132.725
130.487
129.036
128.824
128.495
128.244
127.596
127.352
120.614
120.208
116.568

-20.909



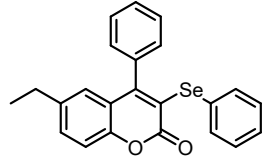
4s (¹³C NMR) (100 MHz, CDCl₃)



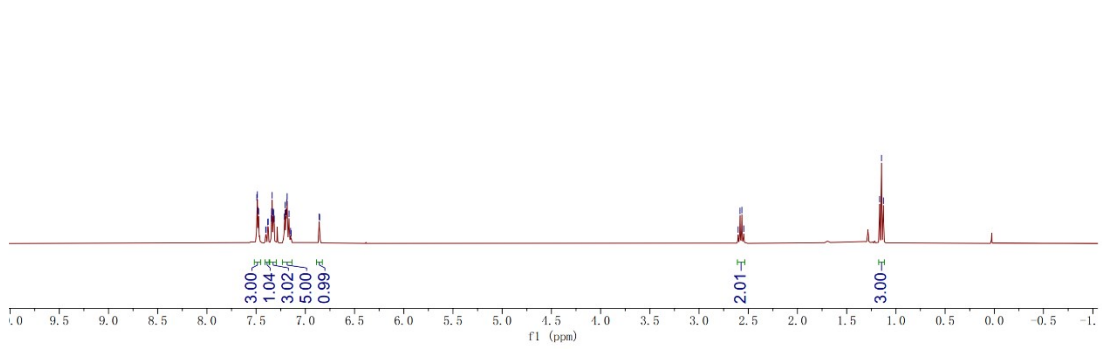
7.493
7.487
7.480
7.475
7.403
7.398
7.382
7.377
7.346
7.342
7.338
7.326
7.322
7.316
7.211
7.206
7.194
7.198
7.190
7.185
7.166
7.150
7.144
6.860
6.855

2.603
2.584
2.565
2.546

1.166
1.147
1.128



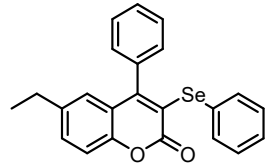
4t (¹H NMR) (400 MHz, CDCl₃)



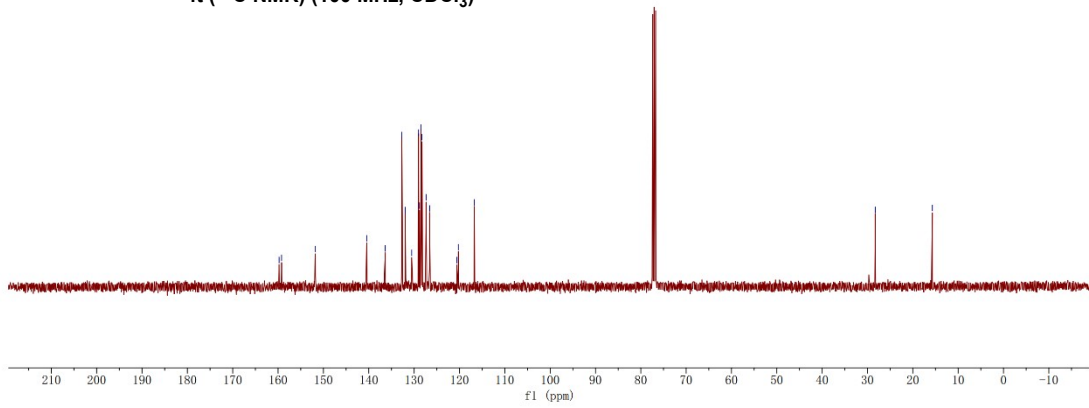
159.769
159.236
151.840
140.447
136.381
132.690
131.928
130.516
129.030
128.825
128.472
128.262
127.330
126.560
120.552
120.242
116.692

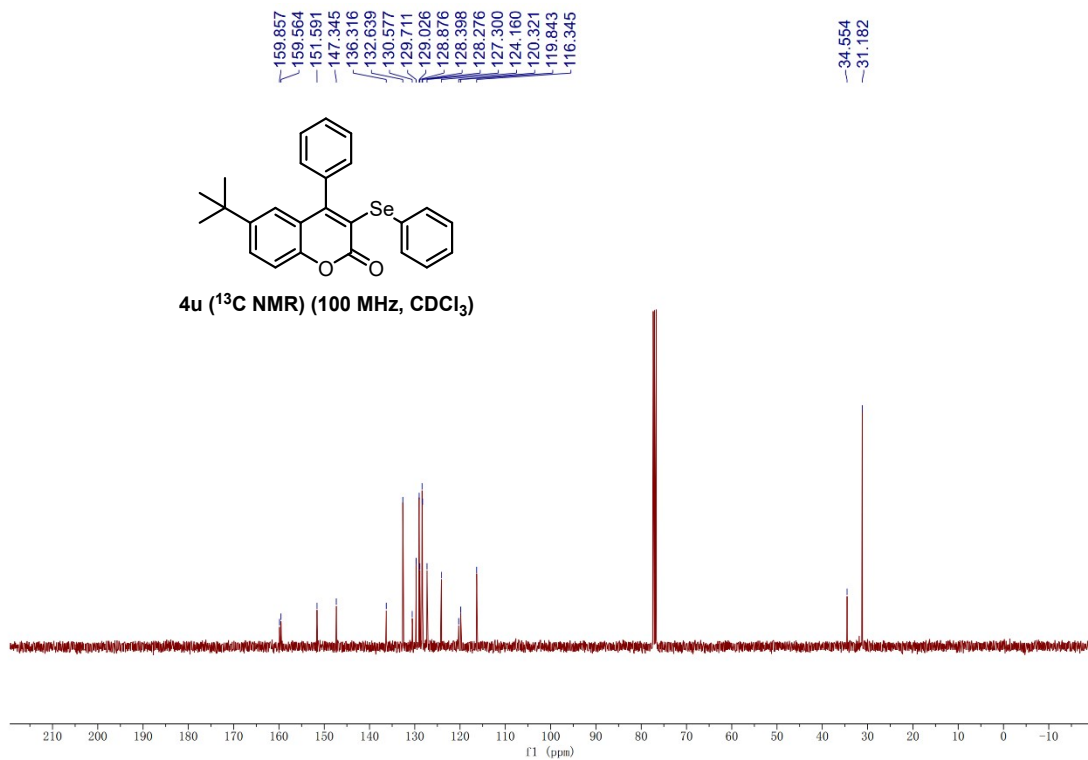
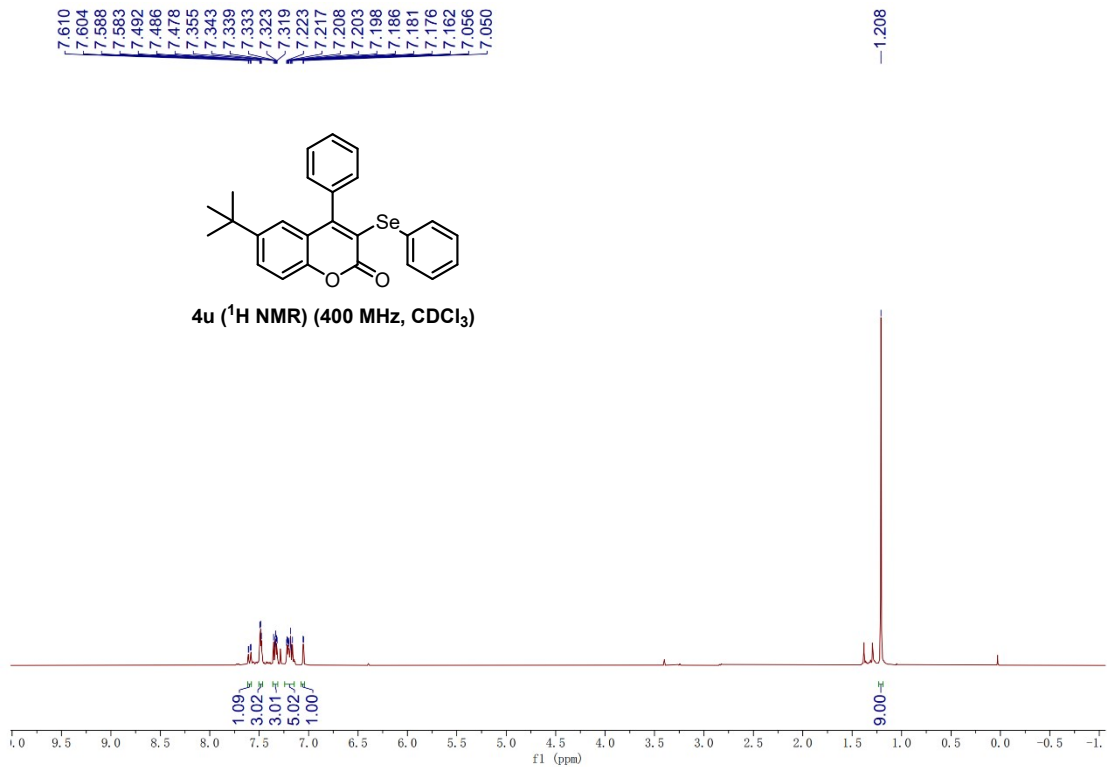
28.277

15.710



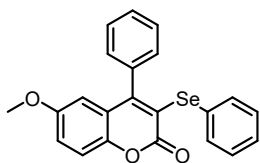
4t (¹³C NMR) (100 MHz, CDCl₃)



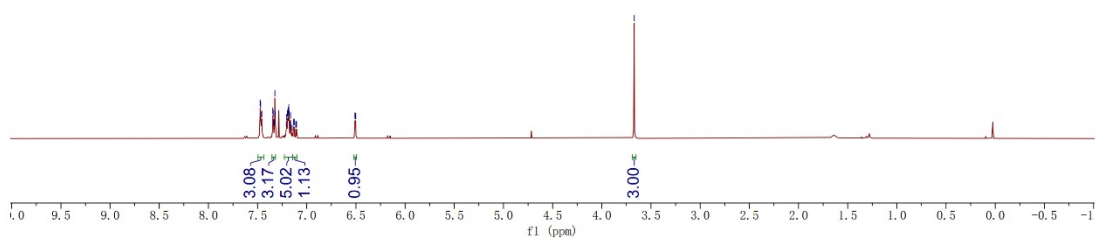


7.475
7.469
7.461
7.458
7.347
7.341
7.324
7.320
7.203
7.198
7.192
7.189
7.183
7.179
7.165
7.135
6.476
6.503

-3.672

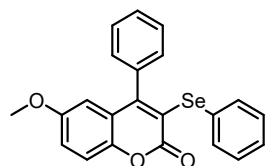


4v (¹H NMR) (400 MHz, CDCl₃)

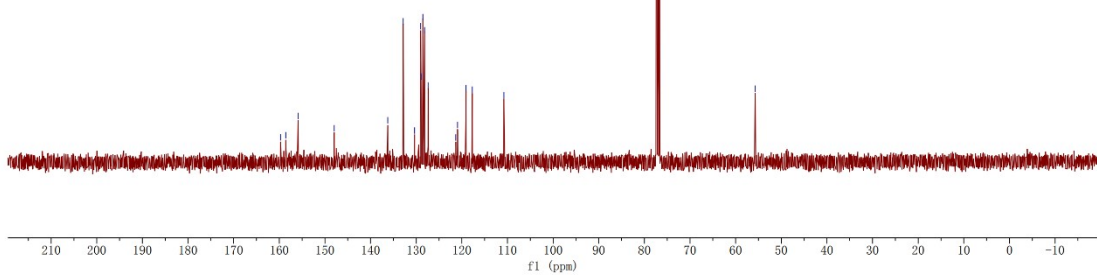


159.711
158.587
155.857
147.972
136.244
132.860
130.352
129.034
128.901
128.539
128.175
127.405
121.343
120.953
119.090
117.721
110.776

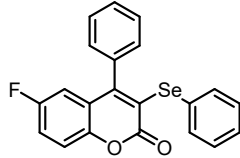
-55.714



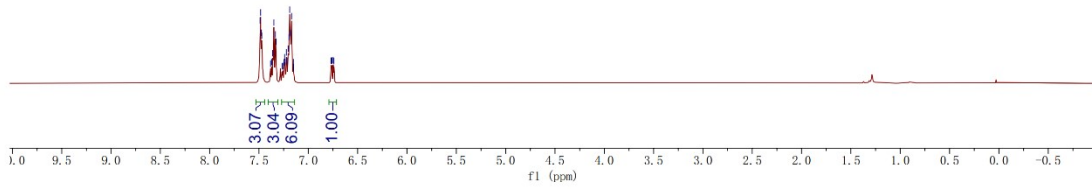
4v (¹³C NMR) (100 MHz, CDCl₃)



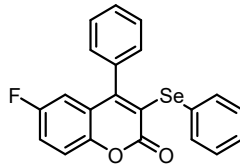
7.489
7.484
7.476
7.472
7.361
7.349
7.333
7.328
7.240
7.222
7.216
7.204
7.196
7.189
7.182
6.770
6.762
6.747
6.740



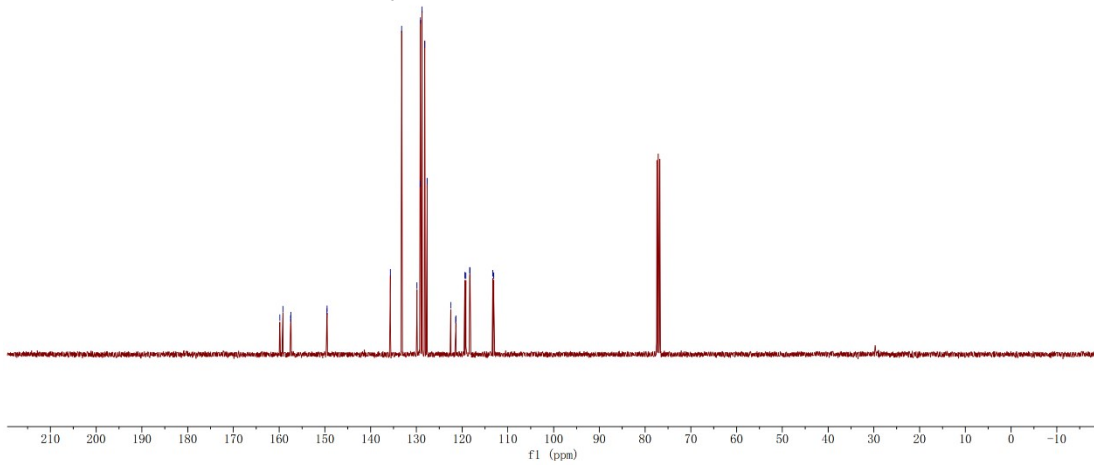
4w (¹H NMR) (400 MHz, CDCl₃)



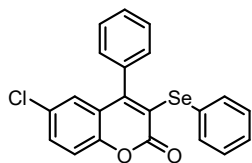
159.845
159.206
157.484
157.455
157.421
149.546
149.525
135.675
133.222
129.878
129.170
129.112
128.748
128.152
127.673
122.492
121.433
121.348
119.433
119.188
118.351
118.267
113.345
113.094



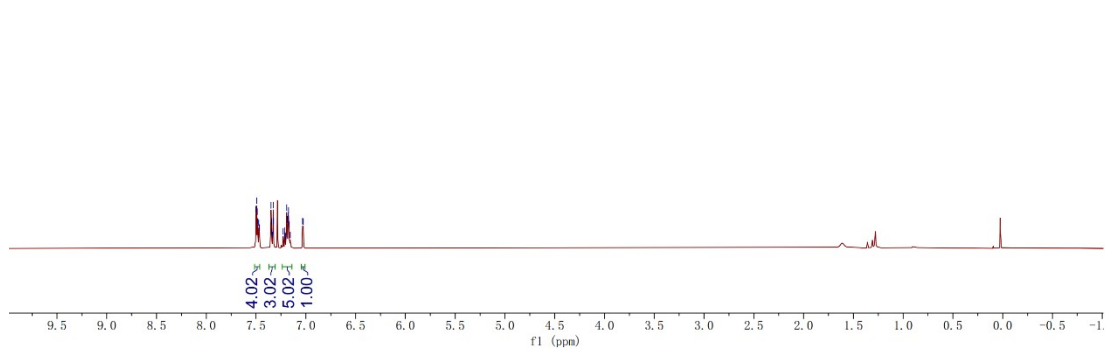
4w (¹³C NMR) (100 MHz, CDCl₃)



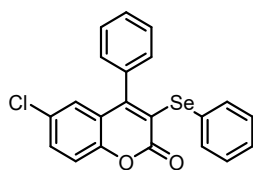
7.501
7.496
7.488
7.483
7.473
7.467
7.350
7.346
7.342
7.335
7.329
7.325
7.228
7.214
7.210
7.206
7.192
7.187
7.178
7.174
7.168
7.157
7.033
7.027



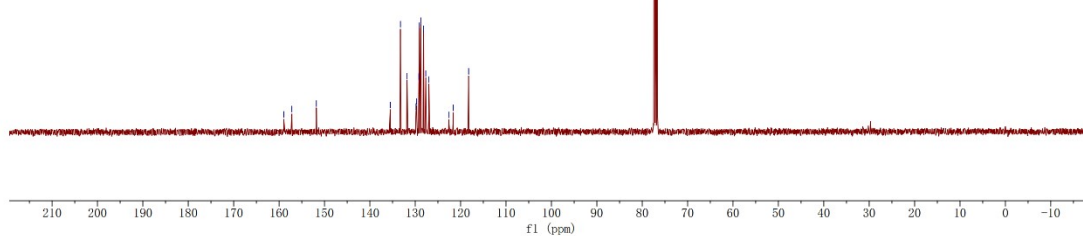
4x (¹H NMR) (400 MHz, CDCl₃)



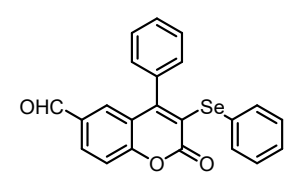
158.925
157.201
151.796
135.524
133.247
131.793
129.820
129.701
129.195
129.098
128.767
128.172
127.692
126.982
122.556
121.612
118.238



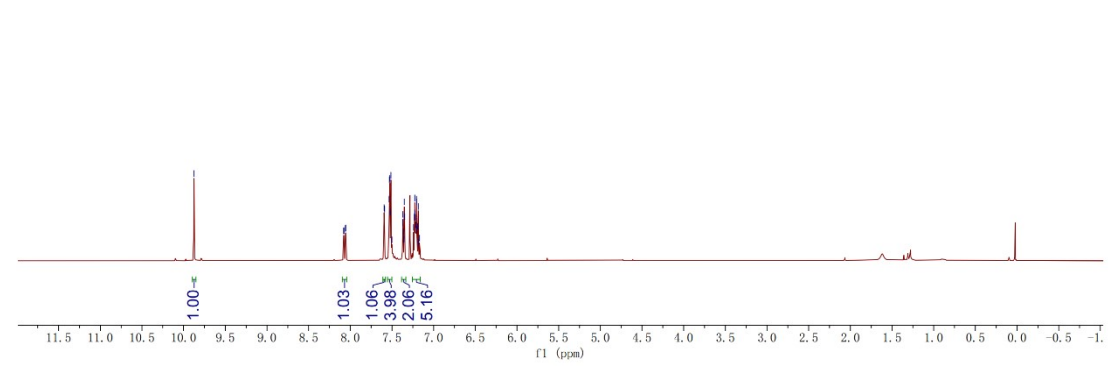
4x (¹³C NMR) (100 MHz, CDCl₃)



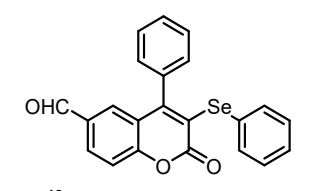
9.876
8.081
8.076
8.060
8.055
7.594
7.589
7.535
7.530
7.525
7.518
7.513
7.501
7.372
7.369
7.366
7.358
7.352
7.348
7.241
7.231
7.226
7.223
7.219
7.214
7.206
7.204
7.200
7.190
7.185
7.180
7.168



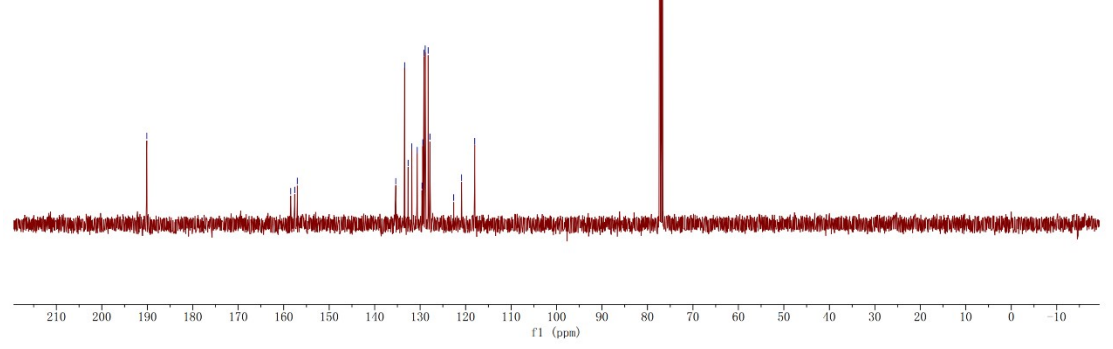
4y (¹H NMR) (400 MHz, CDCl₃)



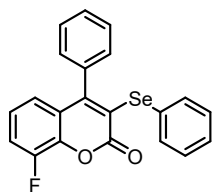
190.094
158.470
157.568
157.039
135.373
133.406
132.634
131.808
130.616
129.590
129.411
129.145
128.894
128.223
127.840
122.634
120.888
117.978



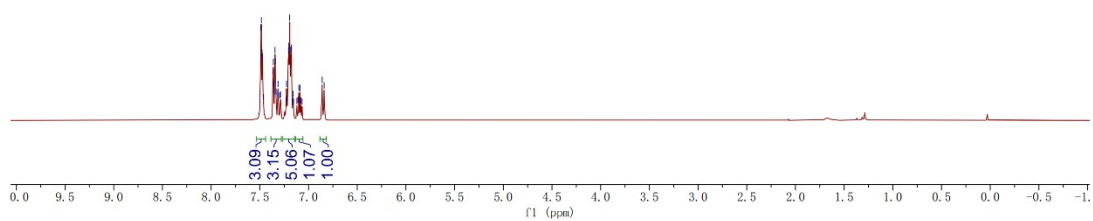
4y (¹³C NMR) (100 MHz, CDCl₃)



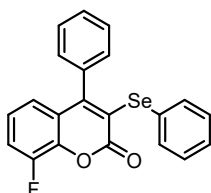
7.489
7.484
7.477
7.472
7.462
7.364
7.360
7.356
7.350
7.344
7.339
7.333
7.316
7.312
7.308
7.292
7.288
7.225
7.219
7.206
7.200
7.193
7.181
7.175
7.163
7.158
7.153
7.119
7.107
7.098
7.087
7.078
7.066
6.859
6.839



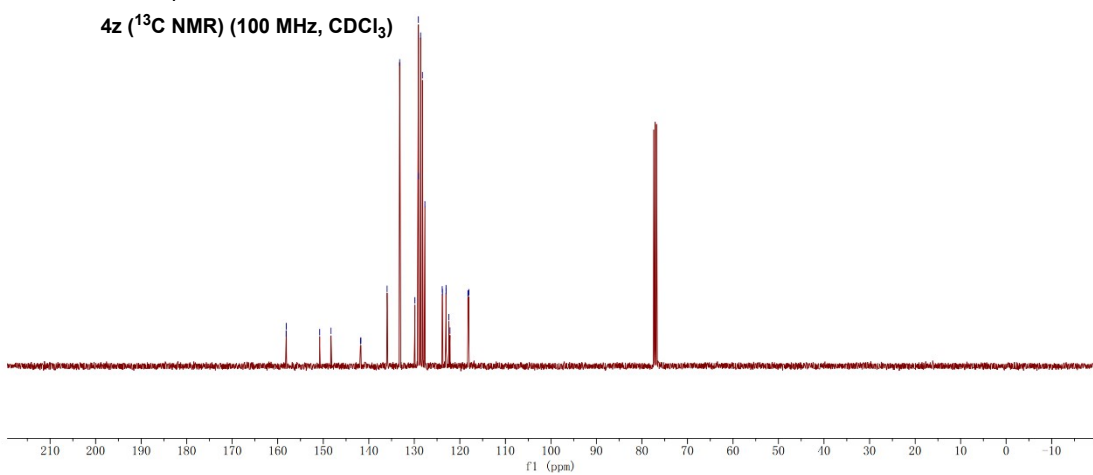
4z (¹H NMR) (400 MHz, CDCl₃)



158.161
158.132
158.108
150.787
148.281
141.837
141.720
135.981
133.221
129.878
129.113
129.092
128.617
128.214
127.688
123.877
123.809
123.028
122.991
122.384
122.149
118.225
118.054

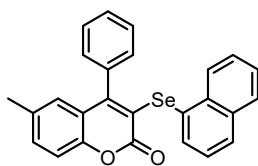


4z (¹³C NMR) (100 MHz, CDCl₃)

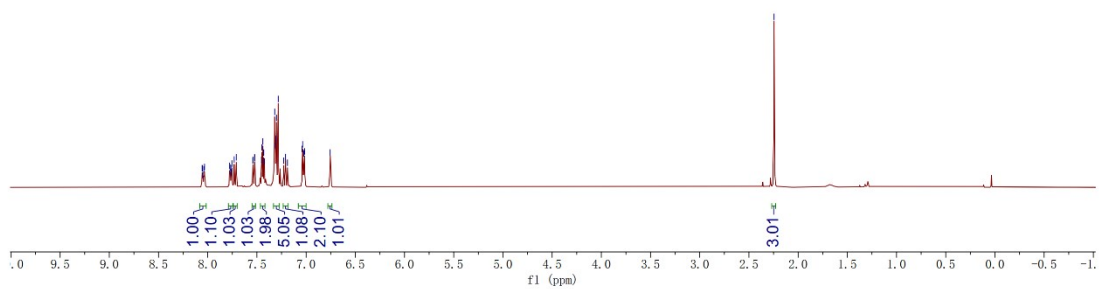


8.057
8.054
8.048
8.039
8.032
7.778
7.772
7.764
7.758
7.754
7.731
7.711
7.541
7.538
7.523
7.520
7.454
7.448
7.439
7.430
7.424
7.319
7.313
7.306
7.301
7.284
7.228
7.210
7.189
7.040
7.036
7.021
7.016
6.757

-2.244

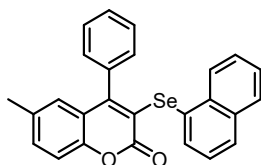


4aa (¹H NMR) (400 MHz, CDCl₃)

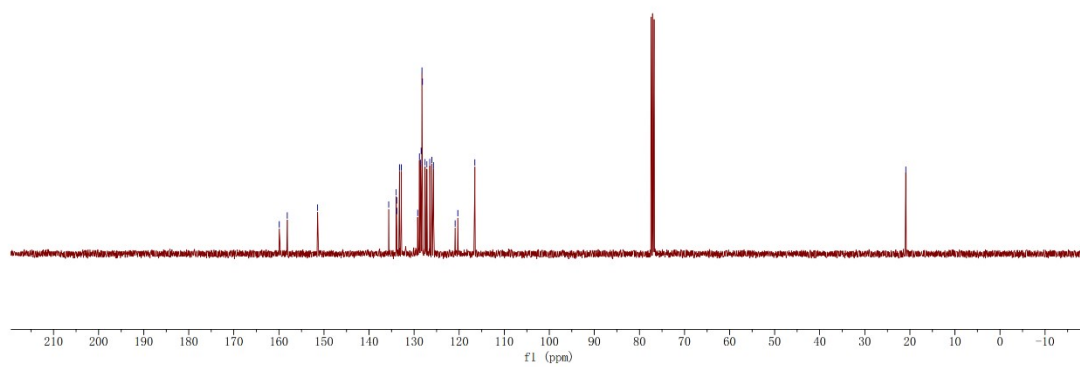


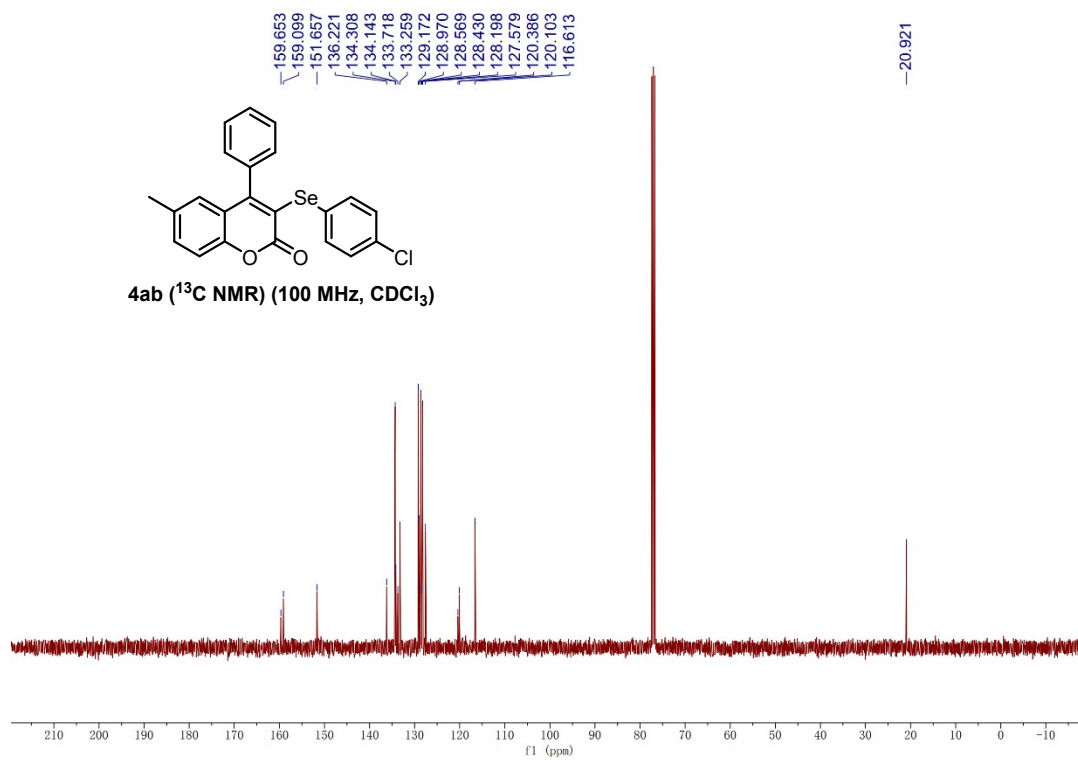
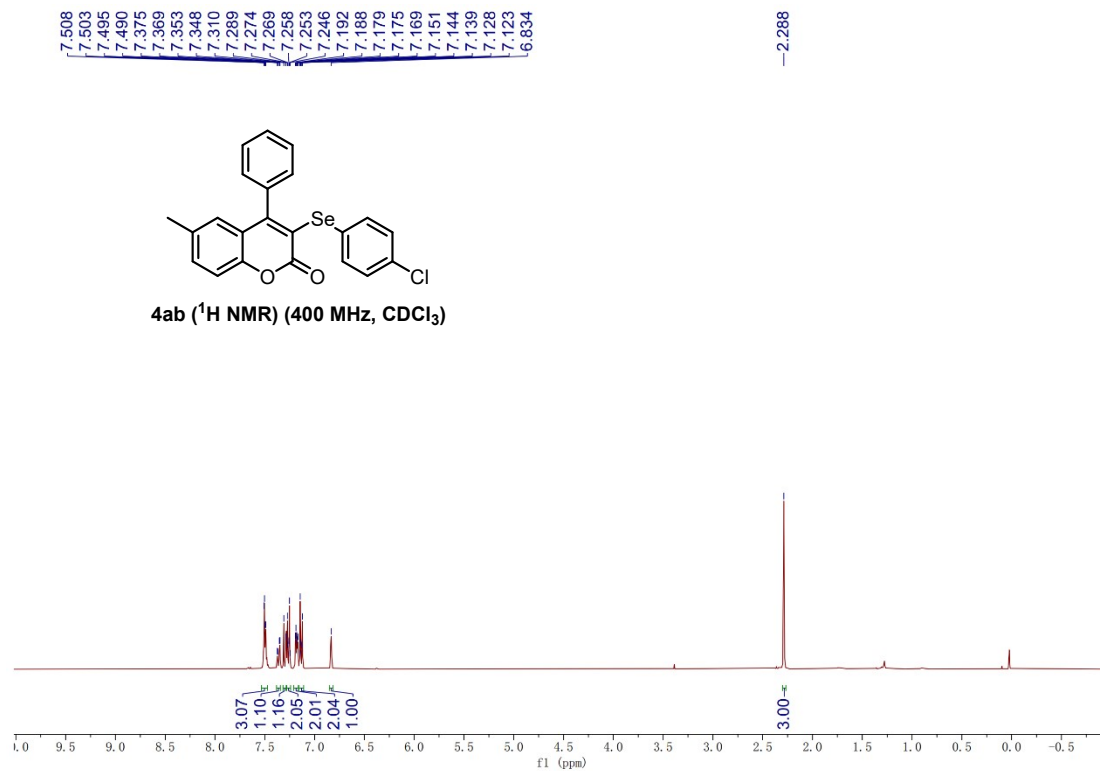
159.901
158.144
151.428
135.645
133.954
133.877
133.844
133.275
132.836
129.208
128.814
128.567
128.442
128.266
128.141
127.560
127.158
126.540
126.045
125.725
120.906
120.311
116.524

-20.898



4aa (¹³C NMR) (100 MHz, CDCl₃)

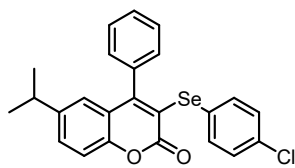




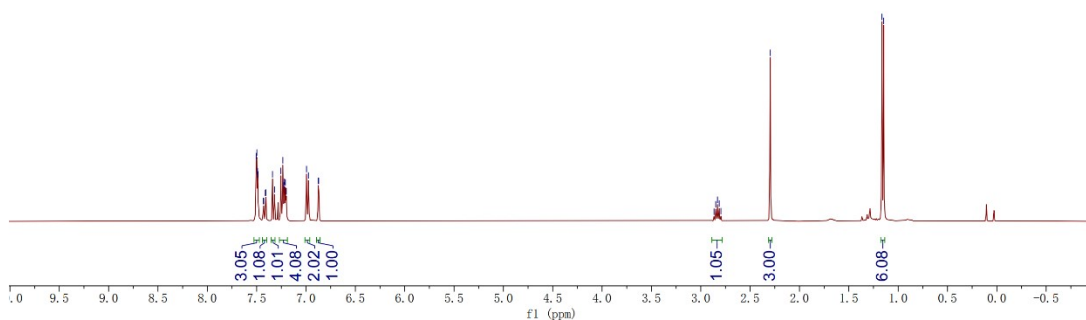
7.505
7.499
7.491
7.488
7.484
7.428
7.412
7.407
7.340
7.319
7.285
7.235
7.224
7.218
7.210
7.200
6.995
6.975
6.877
6.872

2.865
2.848
2.830
2.813
2.796
2.296

1.164
1.147

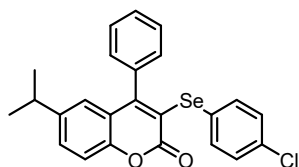


4ac (¹H NMR) (400 MHz, CDCl₃)

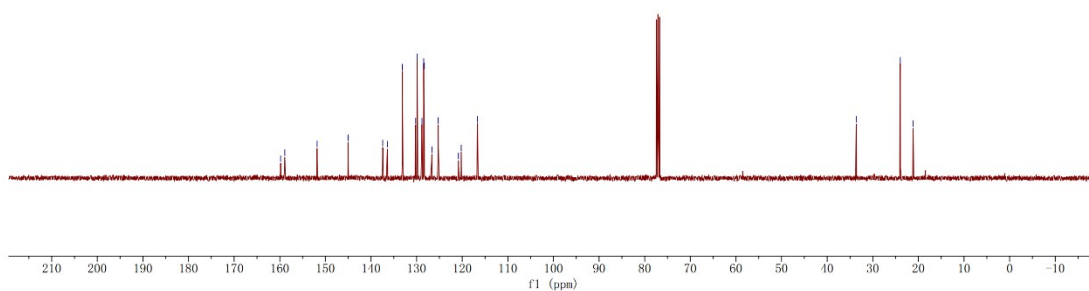


159.823
158.888
151.804
145.019
137.442
136.426
133.120
130.207
129.842
128.822
128.440
128.331
126.630
125.293
120.844
120.215
116.691

33.634
23.970
21.155

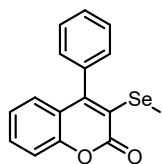


4ac (¹³C NMR) (100 MHz, CDCl₃)

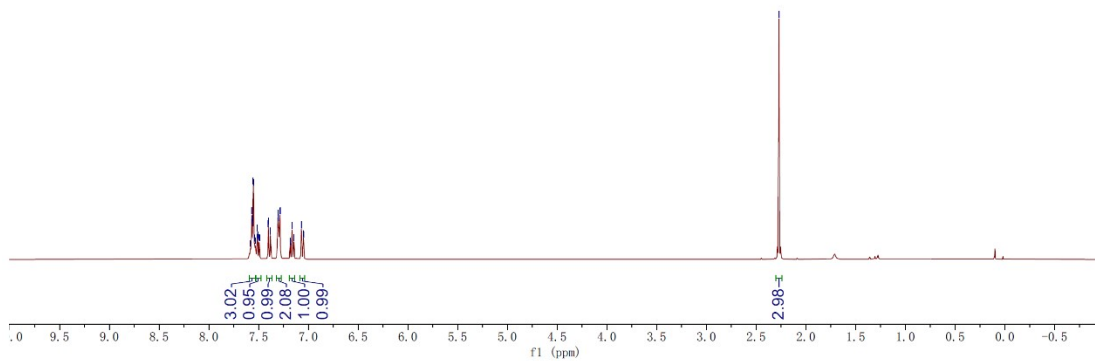


7.582
7.568
7.565
7.558
7.553
7.550
7.540
7.532
7.514
7.510
7.507
7.493
7.489
7.402
7.399
7.381
7.378
7.306
7.300
7.287
7.283
7.184
7.181
7.164
7.146
7.143
7.070
7.066
7.051
7.047

-2.269

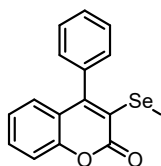


4ad (¹H NMR) (400 MHz, CDCl₃)

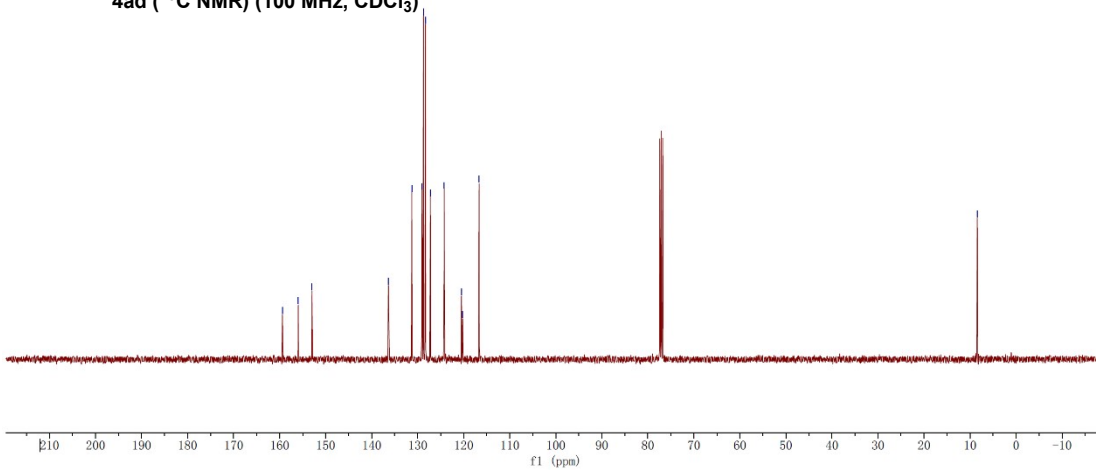


159.397
155.956
152.978
136.364
131.289
129.095
128.738
128.318
127.257
124.239
120.499
120.224
116.652

-8.433



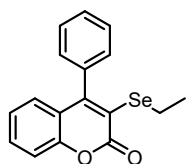
4ad (¹³C NMR) (100 MHz, CDCl₃)



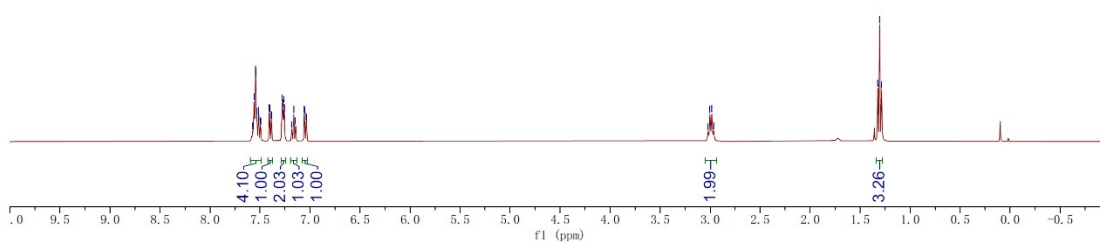
7.573
7.569
7.560
7.545
7.541
7.533
7.515
7.512
7.498
7.494
7.408
7.405
7.387
7.385
7.279
7.273
7.267
7.264
7.259
7.255
7.184
7.163
7.146
7.059
7.055
7.039
7.035

3.020
3.001
2.982
2.964

1.323
1.305
1.286

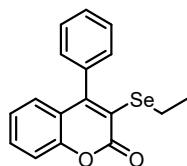


4ae (^1H NMR) (400 MHz, CDCl_3)

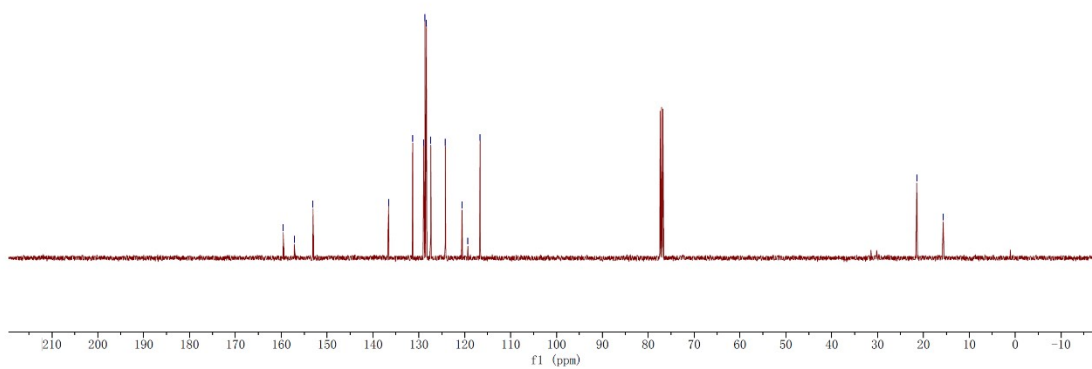


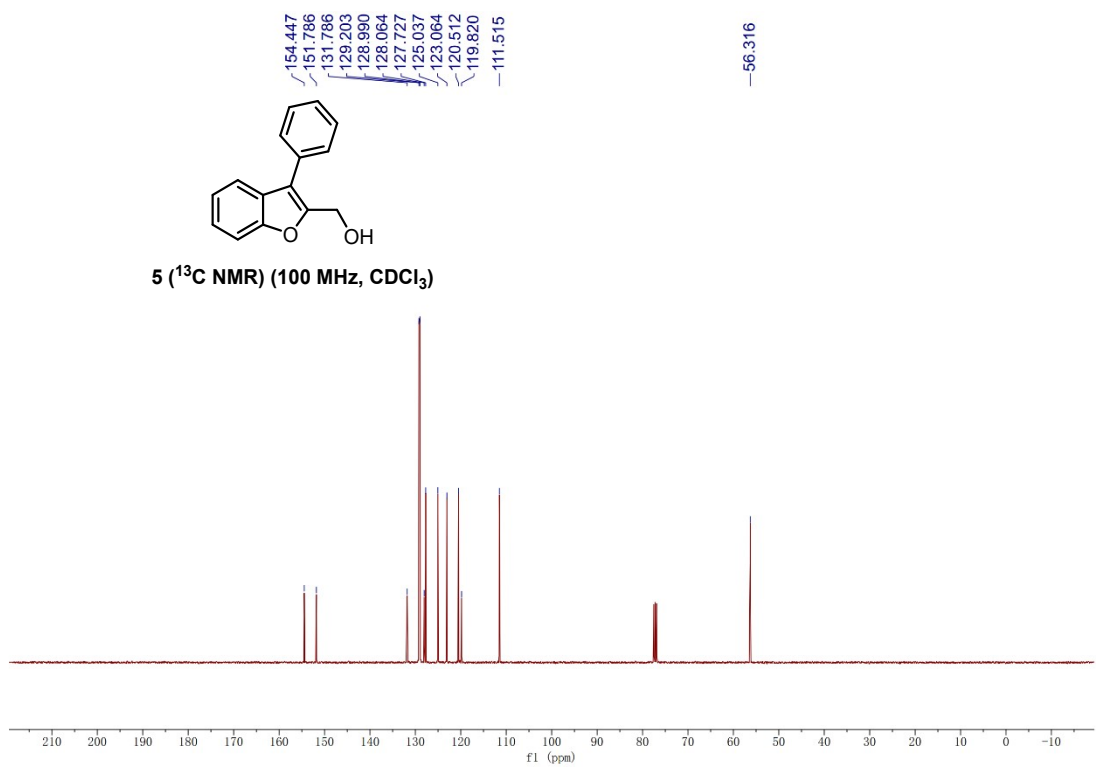
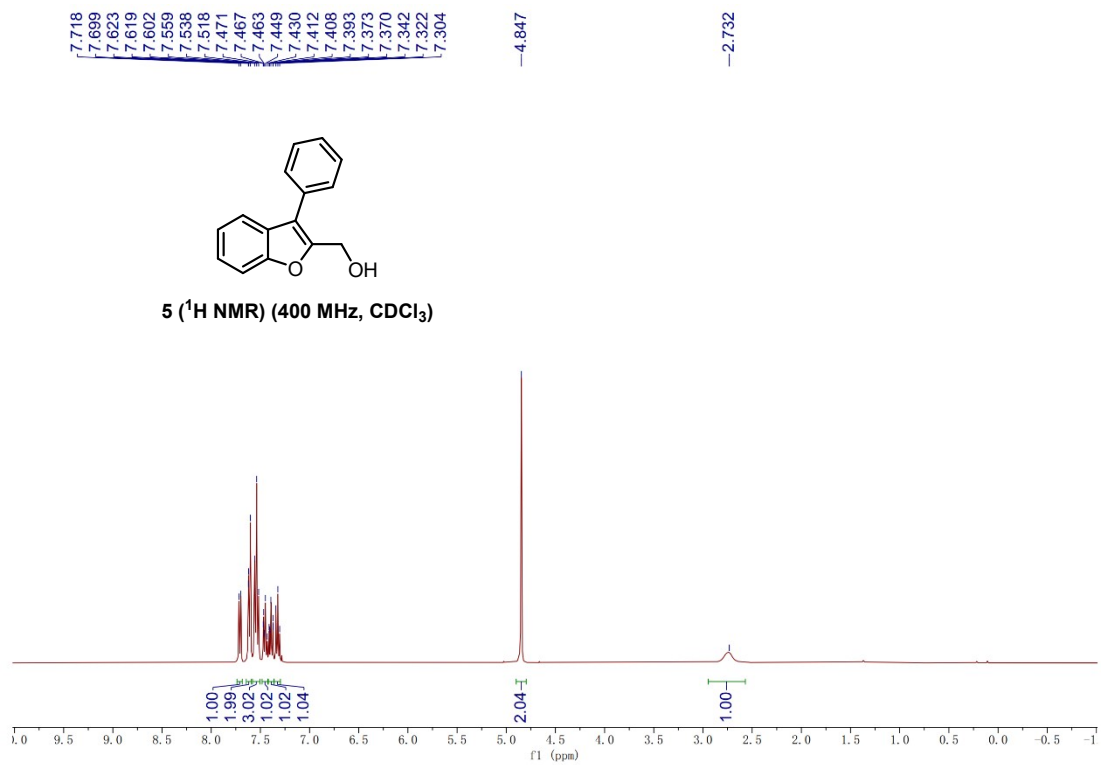
159.561
157.137
153.072
136.598
131.344
128.969
128.675
128.351
127.407
124.225
120.582
119.313
116.651

21.481
15.705

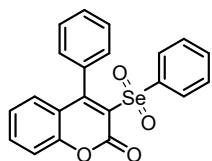


4ae (^{13}C NMR) (100 MHz, CDCl_3)

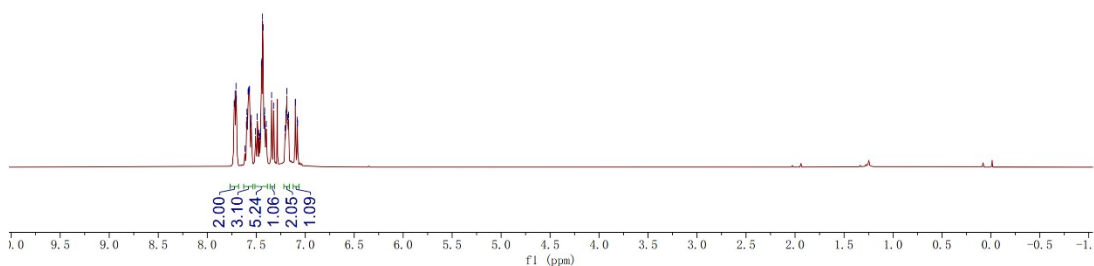




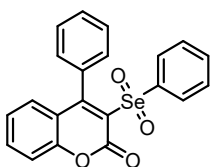
7.726
7.717
7.707
7.702
7.615
7.600
7.595
7.588
7.583
7.577
7.571
7.568
7.554
7.550
7.506
7.488
7.470
7.466
7.456
7.447
7.443
7.435
7.429
7.420
7.415
7.410
7.397
7.343
7.322
7.207
7.197
7.177
7.169
7.102
7.098
7.082
7.078



6 (¹H NMR) (400 MHz, CDCl₃)



160.124
156.974
153.944
140.108
133.877
131.132
130.998
130.057
129.339
129.006
128.774
128.559
128.399
126.586
124.822
120.084
117.100



6 (¹³C NMR) (100 MHz, CDCl₃)

