Supporting Information

Assembly of tetracyclic tetrahydrocarbazoles via visible-light promoted cascade process

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1. General information

All the commercial reagents including solvents were used directly without further purification. Compound **1** was synthesized according to our previous work[1]. All the experiments were monitored by thin layer chromatography (TLC) with UV light. The TLC employed 0.25 mm silica gel coated on glass plates. Purification of products was carried out by silica gel 60 F-254 TLC plates of 20 cm × 20 cm and column chromatography with silica gel 60 (300-400 mesh). Melting points were recorded without correction on RY-1G of Tianjin Xintianguang instrument company. NMR spectra were recorded on Bruker 400 MHz and 600 MHz spectrometers. High resolution mass spectra (HRMS) were measured on Agilent 6210 ESI/TOF MS instrument. The X-ray data were collected at 100 K on a Rigaku Oxford Diffraction Supernova Dual Source, Cu at Zero equipped with an AtlasS2 CCD using Cu Kα radiation.

References:

1. Z. Yin, Y. Yu, H. Mei, J. Han, *Green Chem.*, 2021, **23**, 3256-3260.

2. General procedure for the cascade reaction

Into a vail were taken indole derivative **1** (0.1 mmol), bromodifluoroacetate **2** (0.6 mmol), *fac*-[lr(ppy)$_3$] (0.002 mmol), TMEDA (1.2 mmol), DMF (2 mL) and the mixture was stirred at room temperature in the presence of 4.5 W blue LEDs for 3 h. Then, the reaction was diluted with H_2O (25 mL) and the mixture was extracted with EtOAc (20 mL × 3). The combined organic layers were dried with anhydrous Na_2SO_4, filtered and concentrated in vacuum. The product **3** was purified by TLC plate of 20 cm × 20 cm using petroleum ether/ethyl acetate (5:1, v/v) as eluent.

3. Large scale synthesis

Into a flask were taken indole derivative **1a** (3.0 mmol), ethyl bromodifluoroacetate **2a** (18.0 mmol), *fac*-[lr(ppy)$_3$] (0.06 mmol), TMEDA (36.0 mmol), DMF (60 mL) and the mixture was stirred at room temperature in the presence of 4.5 W blue LEDs for 3 h. Then, the reaction was diluted with H_2O (150 mL) and the mixture was extracted with EtOAc (50 mL × 3). The combined organic layers were dried with anhydrous Na_2SO_4, filtered and concentrated in vacuum. The product **3aa** was purified by column chromatography using petroleum ether/ethyl acetate (7:1, v/v) as eluent.

4. Procedure for the reduction reaction of 3aa

Into a vail flushed with N_2 were taken **3aa** (0.1 mmol), $NaBH_4$ (0.5 mmol) and THF (2 mL), followed by the addition of CF_3COOH (0.5 mmol) dropwise. The reaction was heated to reflux for 4 h. After the addition of H_2O (10 mL), the mixture was extracted with $CHCl_3$ (3 × 10 mL). The combined organic layers were dried with anhydrous Na_2SO_4, filtered and concentrated in vacuum. The product **6** was purified by TLC plate of 20 cm × 20 cm using petroleum ether/ethyl acetate (4:1, v/v) as eluent.

5. X-ray crystallography of 3aa

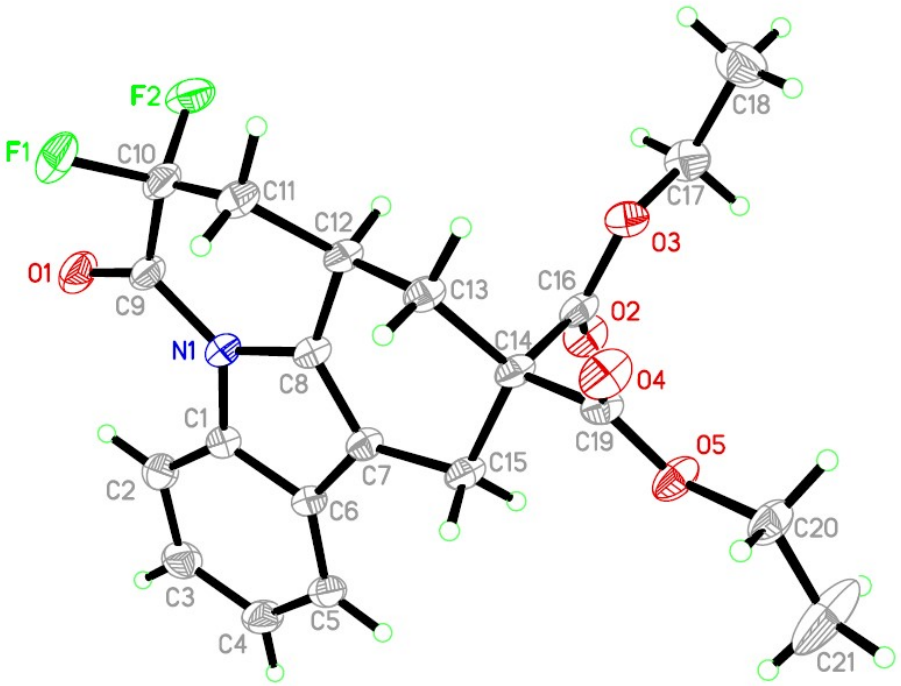
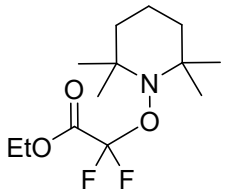


Figure S1. ORTEP diagram showing of **3aa**

(CCDC number is 2129484, the ellipsoids are drawn at a 30% probability level)

6. ESI-MS detection of 4 and 5aa



4

ESI-MS m/z: $[M+Na]^+$ calcd for $C_{13}H_{23}F_2NNaO_3^+$ 302.2, found 302.1.

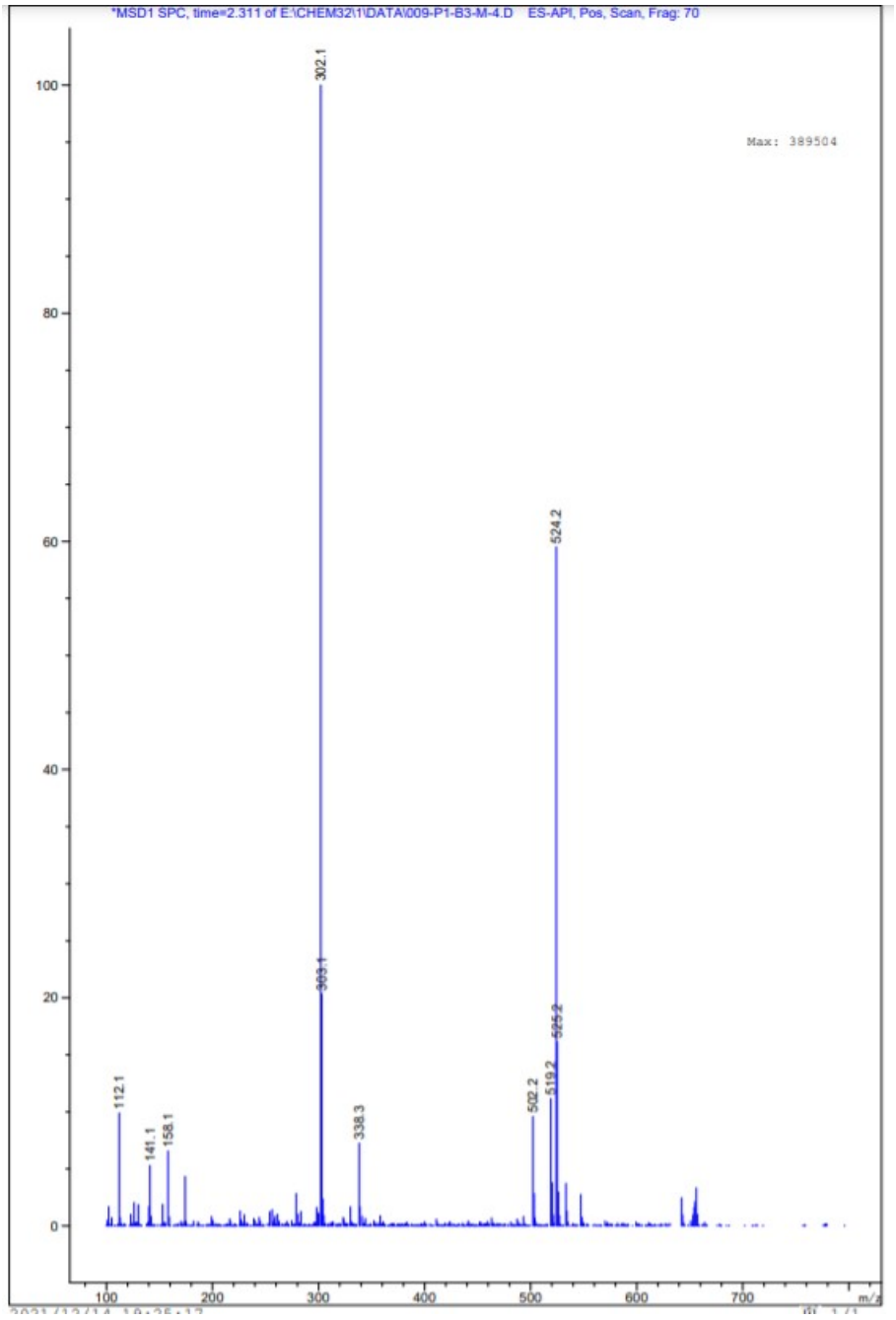
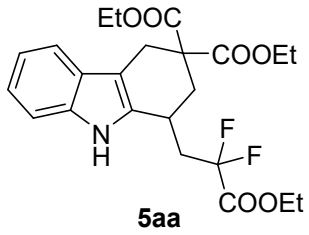


Figure S2. ESI-MS detection of **4.**



5aa

ESI-MS m/z: $[M+H]^+$ calcd for $C_{23}H_{28}F_2NO_6^+$ 452.2, found 452.1.

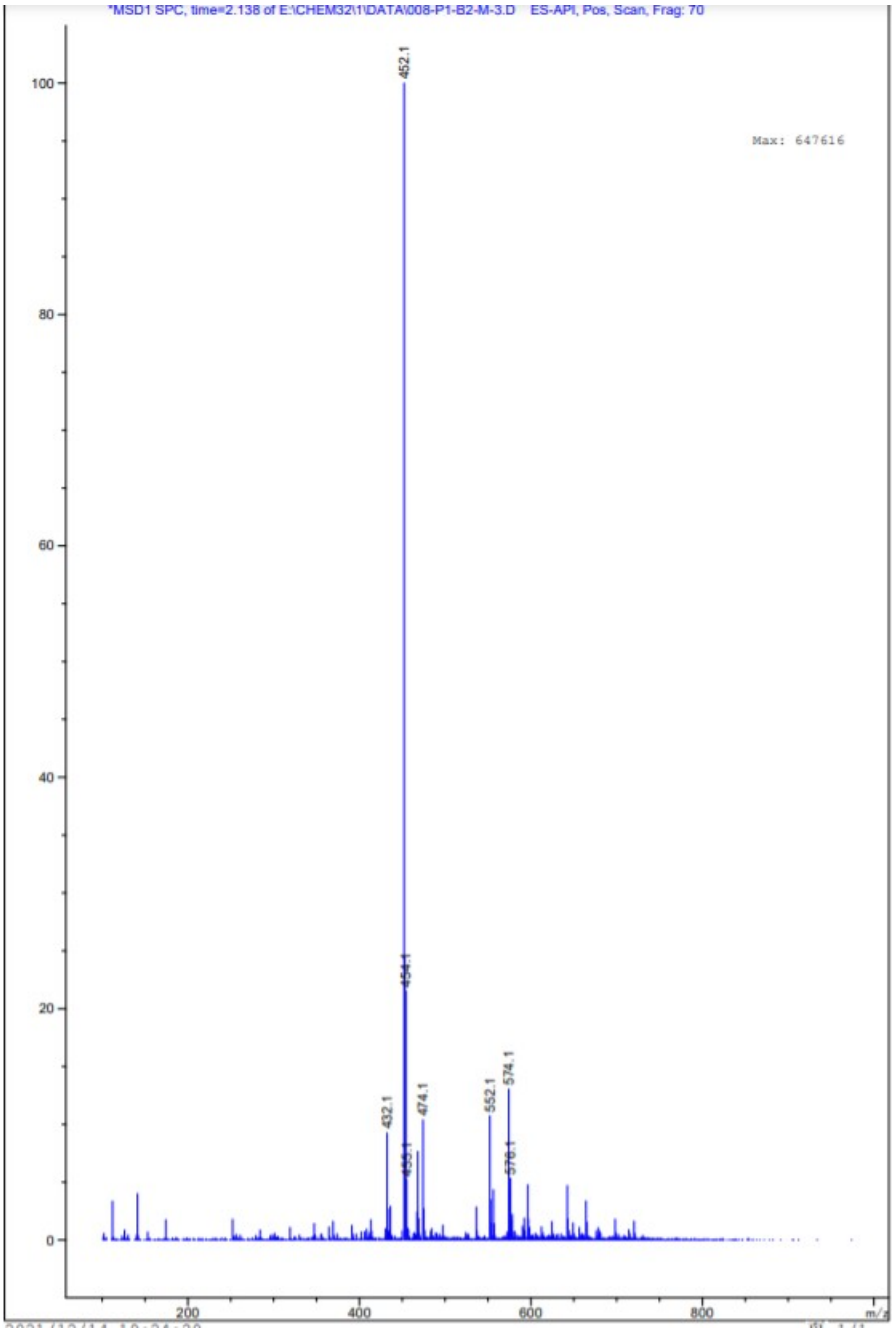
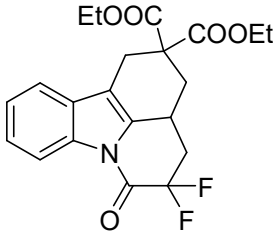
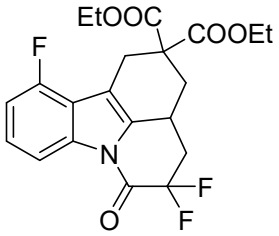


Figure S3. ESI-MS detection of **5aa.**

7. Characterization data of compounds 3 and 6

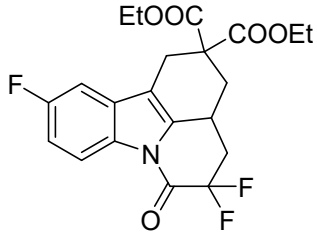


Compound **3aa**: 33.2 mg, 82% yield, white solid, mp 85-86 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.37-8.35 (m, 1H), 7.50-7.48 (m, 1H), 7.42-7.35 (m, 2H), 4.34-4.23 (m, 4H), 3.67 (d, *J* = 16.84 Hz, 1H), 3.30-3.24 (m, 1H), 2.96-2.91 (m, 1H), 2.86-2.76 (m, 2H), 2.23-2.06 (m, 1H), 2.01-1.95 (m, 1H), 1.36 (t, *J* = 7.16 Hz, 3H), 1.30 (t, *J* = 7.12 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 171.0, 169.9, 158.5 (t, *J* = 31.3 Hz), 134.9, 132.3, 129.7, 125.5, 125.3, 118.7, 116.6, 115.7 (dd, *J* = 243.5, 250.2 Hz), 114.6, 62.2, 62.1, 54.0, 38.1 (t, *J* = 22.4 Hz), 33.7, 26.5, 25.0 (d, *J* = 9.2 Hz), 14.1, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -100.7 (d, *J* = 285.3 Hz, 1F), -105.6 (d, *J* = 285.2 Hz, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{21}H_{22}F_2NO_5^+$ 406.1461, found 406.1469.

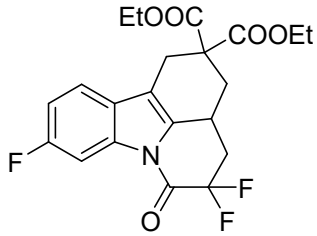


Compound **3ba**: 19.7 mg, 47% yield, white solid, mp 117-118 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.14-8.12 (m, 1H), 7.33-7.27 (m, 1H), 7.05-7.00 (m, 1H), 4.36-4.23 (m, 4H), 3.85 (d, *J* = 17.40 Hz, 1H), 3.26-3.19 (m, 1H), 3.09 (d, *J* = 17.32 Hz, 1H), 2.83-2.75 (m, 2H), 2.23-2.07 (m, 1H), 2.01-1.94 (m, 1H), 1.35-1.27 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.8, 170.0, 158.6 (t, *J* = 31.5 Hz), 157.4 (d, *J* = 246.9 Hz), 136.9 (d, *J* = 9.5 Hz), 132.2, 126.5 (d, *J* = 7.0 Hz), 118.3 (d, *J* = 20.3 Hz), 115.6 (dd, *J* = 243.7, 251.1 Hz), 112.6 (d, *J* = 3.8 Hz), 112.5, 111.4 (d, *J* = 18.4 Hz), 62.2, 62.1, 54.0, 37.9 (t, *J* = 22.1 Hz), 33.4, 27.6, 25.0 (d, *J* = 9.3 Hz), 14.1, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$):

δ = -100.8 (d, *J* = 285.6 Hz, 1F), -105.8 (d, *J* = 285.5 Hz, 1F), -123.2 (s, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{21}H_{21}F_3NO_5^+$ 424.1366, found 424.1377.

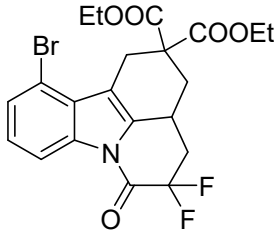


Compound **3ca**: 25.1 mg, 59% yield, white solid, mp 151-152 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.32-8.28 (m, 1H), 7.17-7.07 (m, 2H), 4.36-4.23 (m, 4H), 3.61 (d, *J* = 16.92 Hz, 1H), 3.29-3.23 (m, 1H), 2.93-2.76 (m, 3H), 2.24-2.08 (m, 1H), 2.00-1.94 (m, 1H), 1.36 (t, *J* = 7.24 Hz, 3H), 1.30 (t, *J* = 7.24 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.8, 169.8, 161.9 (d, *J* = 241.8 Hz), 158.3 (t, *J* = 30.8 Hz), 134.1, 131.2, 131.1, 117.6 (d, *J* = 9.1 Hz), 115.6 (dd, *J* = 243.9, 251.1 Hz), 114.3 (d, *J* = 3.6 Hz), 113.0 (d, *J* = 24.7 Hz), 105.2 (d, *J* = 24.5 Hz), 62.3, 62.2, 53.9, 38.1 (t, *J* = 22.2 Hz), 33.6, 26.3, 25.1 (d, *J* = 9.3 Hz), 14.1, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -100.8 (d, *J* = 286.4 Hz, 1F), -105.7 (d, *J* = 285.6 Hz, 1F), -116.2 (s, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{21}H_{21}F_3NO_5^+$ 424.1366, found 424.1374.

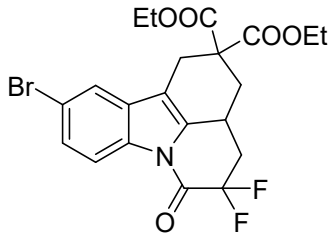


Compound **3da**: 27.6 mg, 65% yield, white solid, mp 138-139 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.12-8.09 (m, 1H), 7.43-7.39 (m, 1H), 7.15-7.09 (m, 1H), 4.34-4.23 (m, 4H), 3.64 (d, *J* = 16.96 Hz, 1H), 3.28-3.22 (m, 1H), 2.95-2.76 (m, 3H), 2.23-2.06 (m, 1H), 2.00-1.93 (m, 1H), 1.35 (t, *J* = 7.08 Hz, 3H), 1.30 (t, *J* = 7.04 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.8, 169.9, 162.5 (d, *J* = 241.7 Hz), 158.5 (t, *J* = 30.8 Hz), 135.2 (d, *J* = 12.3 Hz), 132.6 (d, *J* = 3.9 Hz), 126.0, 119.4 (d, *J*

= 9.5 Hz), 115.6 (dd, *J* = 243.5, 251.0 Hz), 114.2, 113.2 (d, *J* = 23.7 Hz), 104.5 (d, *J* = 28.2 Hz), 62.3, 62.2, 54.0, 38.1 (t, *J* = 22.2 Hz), 33.6, 26.4, 25.1 (d, *J* = 9.2 Hz), 14.1, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -100.7 (d, *J* = 286.5 Hz, 1F), -105.8 (d, *J* = 286.6 Hz, 1F), -115.2 (s, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{21}H_{21}F_3NO_5^+$ 424.1366, found 424.1377.

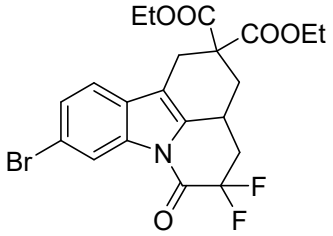


Compound **3ea**: 34.3 mg, 71% yield, white solid, mp 169-170 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.38 (d, *J* = 8.08 Hz, 1H), 7.49 (d, *J* = 7.84 Hz, 1H), 7.24-7.20 (m, 1H), 4.35-4.24 (m, 4H), 4.16 (d, *J* = 17.12 Hz, 1H), 3.24-3.14 (m, 2H), 2.82-2.77 (m, 2H), 2.23-2.07 (m, 1H), 2.01-1.94 (m, 1H), 1.36-1.28 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 171.0, 170.0, 158.4 (t, *J* = 31.2 Hz), 136.0, 133.4, 129.3, 129.0, 126.5, 115.5, 115.4 (dd, *J* = 243.5, 250.7 Hz), 114.9, 114.1, 62.2, 62.1, 53.9, 37.9 (t, *J* = 21.8 Hz), 33.1, 28.4, 25.2 (d, *J* = 9.3 Hz), 14.1, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -101.0 (d, *J* = 286.7 Hz, 1F), -105.7 (d, *J* = 286.3 Hz, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{21}H_{21}BrF_2NO_5^+$ 484.0566, found 484.0576.

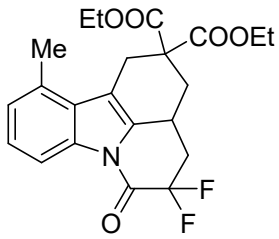


Compound **3fa**: 40.8 mg, 84% yield, white solid, mp 128-129 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.23 (d, *J* = 8.60 Hz, 1H), 7.63 (s, 1H), 7.50 (d, *J* = 8.60 Hz, 1H), 4.32-4.23 (m, 4H), 3.62 (d, *J* = 16.92 Hz, 1H), 3.30-3.23 (m, 1H), 2.93-2.76 (m, 3H), 2.24-2.08 (m, 1H), 2.00-1.94 (m, 1H), 1.35 (t, *J* = 7.00 Hz, 3H), 1.30 (t, *J* = 7.00 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.7, 169.8, 158.4

(t, J = 32.4 Hz), 133.7, 133.6, 131.5, 128.3, 121.8, 118.7, 117.8, 115.6 (dd, J = 243.5, 250.5 Hz), 113.8, 62.3, 62.2, 53.9, 38.0 (t, J = 22.4 Hz), 33.6, 26.3, 25.1 (d, J = 9.1 Hz), 14.1, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -100.8 (d, J = 286.5 Hz, 1F), -105.8 (d, J = 286.5 Hz, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{21}H_{21}BrF_2NO_5^+$ 484.0566, found 484.0579.

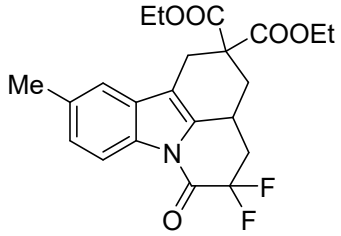


Compound **3ga**: 35.3 mg, 73% yield, white solid, mp 182-183 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.55 (s, 1H), 7.51 (d, J = 8.28 Hz, 1H), 7.36 (d, J = 8.20 Hz, 1H), 4.33-4.23 (m, 4H), 3.64 (d, J = 16.92 Hz, 1H), 3.28-3.21 (m, 1H), 2.95-2.77 (m, 3H), 2.22-2.07 (m, 1H), 2.00-1.94 (m, 1H), 1.35 (t, J = 7.12 Hz, 3H), 1.30 (t, J = 6.96 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.8, 169.8, 158.4 (t, J = 30.7 Hz), 135.5, 132.9, 128.6, 128.5, 119.7, 119.6, 119.0, 115.6 (dd, J = 243.9, 251.2 Hz), 114.3, 62.3, 62.2, 53.9, 38.0 (t, J = 22.2 Hz), 33.6, 26.3, 25.0 (d, J = 9.2 Hz), 14.1, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -100.7 (d, J = 286.6 Hz, 1F), -105.8 (d, J = 286.5 Hz, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{21}H_{21}BrF_2NO_5^+$ 484.0566, found 484.0577.

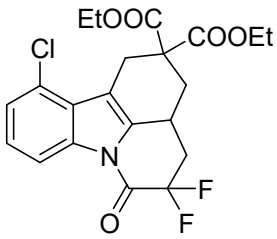


Compound **3ha**: 22.7 mg, 54% yield, white solid, mp 150-151 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.25 (d, J = 8.20 Hz, 1H), 7.28-7.24 (m, 1H), 7.11 (d, J = 7.48 Hz, 1H), 4.33-4.24 (m, 4H), 3.93 (d, J = 16.84 Hz, 1H), 3.27-3.11 (m, 2H), 2.82-2.75 (m, 2H), 2.66 (s, 3H), 2.20-1.93 (m, 2H), 1.36-1.27 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 171.1, 170.0, 158.5 (t, J = 31.1 Hz), 135.1, 131.7,

130.9, 128.5, 126.9, 125.5, 115.6 (dd, J = 243.4, 250.2 Hz), 115.1, 114.3, 62.2, 62.1, 54.3, 38.1 (t, J = 22.1 Hz), 33.3, 29.0, 25.0 (d, J = 9.3 Hz), 19.6, 14.1, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -100.9 (d, J = 285.3 Hz, 1F), -105.5 (d, J = 285.2 Hz, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{22}H_{24}F_2NO_5^+$ 420.1617, found 420.1627.

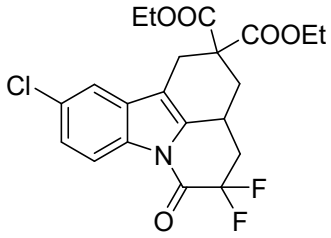


Compound **3ia**: 25.1 mg, 60% yield, white solid, mp 110-111 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.22 (d, J = 8.36 Hz, 1H), 7.28 (s, 1H), 7.21 (d, J = 8.44 Hz, 1H), 4.30-4.22 (m, 4H), 3.64 (d, J = 16.88 Hz, 1H), 3.29-3.20 (m, 1H), 2.93-2.74 (m, 3H), 2.48 (s, 3H), 2.21-2.05 (m, 1H), 1.99-1.93 (m, 1H), 1.35 (t, J = 7.24 Hz, 3H), 1.30 (t, J = 7.16 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 171.0, 169.9, 158.3 (t, J = 33.8 Hz), 135.1, 133.0, 132.4, 130.0, 126.6, 118.9, 116.1, 115.6 (dd, J = 244.1, 250.6 Hz), 114.4, 62.2, 62.1, 54.0, 38.1 (t, J = 22.2 Hz), 33.7, 26.5, 25.0 (d, J = 9.4 Hz), 21.6, 14.1, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -100.7 (d, J = 285.4 Hz, 1F), -105.6 (d, J = 285.3 Hz, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{22}H_{24}F_2NO_5^+$ 420.1617, found 420.1627.

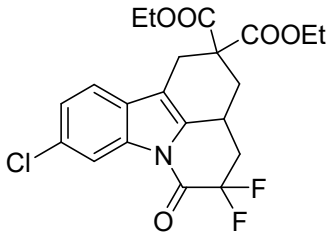


Compound **3ka**: 27.6 mg, 63% yield, white solid, mp 157-158 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.31 (d, J = 6.48 Hz, 1H), 7.32-7.26 (m, 2H), 4.35-4.24 (m, 4H), 4.09 (d, J = 17.32 Hz, 1H), 3.23-3.13 (m, 2H), 2.84-2.76 (m, 2H), 2.23-2.07 (m, 1H), 2.01-1.95 (m, 1H), 1.36-1.27 (m, 6H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.9, 170.0, 158.5 (t, J = 32.8 Hz), 136.0, 133.2, 127.4, 126.5, 126.2,

126.0, 115.5 (dd, J = 243.7, 250.9 Hz), 115.0, 114.4, 62.2, 62.1, 54.0, 37.9 (t, J = 21.9 Hz), 33.2, 28.3, 25.1 (d, J = 9.2 Hz), 14.1, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -100.9 (d, J = 285.7 Hz, 1F), -105.7 (d, J = 285.8 Hz, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{21}H_{21}ClF_2NO_5^+$ 440.1071, found 440.1083.

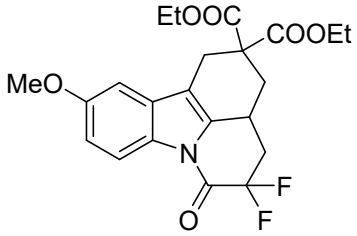


Compound **3la**: 30.9 mg, 70% yield, white solid, mp 117-118 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.29 (d, J = 8.56 Hz, 1H), 7.47 (s, 1H), 7.36 (d, J = 8.68 Hz, 1H), 4.33-4.23 (m, 4H), 3.62 (d, J = 16.92 Hz, 1H), 3.30-3.23 (m, 1H), 2.93-2.77 (m, 3H), 2.24-2.08 (m, 1H), 2.00-1.94 (m, 1H), 1.36 (t, J = 7.00 Hz, 3H), 1.30 (t, J = 7.00 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.8, 169.8, 158.4 (t, J = 31.6 Hz), 133.9, 133.3, 131.1, 131.0, 125.6, 118.8, 117.4, 115.6 (dd, J = 243.6, 250.9 Hz), 114.0, 62.3, 62.2, 53.9, 38.0 (t, J = 22.2 Hz), 33.6, 26.3, 25.1 (d, J = 9.2 Hz), 14.1, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -100.8 (d, J = 286.6 Hz, 1F), -105.8 (d, J = 286.5 Hz, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{21}H_{21}ClF_2NO_5^+$ 440.1071, found 440.1082.

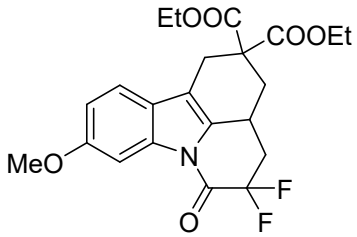


Compound **3ma**: 29.1 mg, 66% yield, white solid, mp 173-174 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.39 (s, 1H), 7.41 (d, J = 8.24 Hz, 1H), 7.36 (d, J = 8.36 Hz, 1H), 4.32-4.23 (m, 4H), 3.64 (d, J = 16.92 Hz, 1H), 3.28-3.22 (m, 1H), 2.95-2.76 (m, 3H), 2.23-2.07 (m, 1H), 2.00-1.94 (m, 1H), 1.35 (t, J = 7.12 Hz, 3H), 1.30 (t, J = 7.04 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 170.8, 169.8, 158.4

(t, J = 31.4 Hz), 135.3, 133.0, 131.4, 128.2, 125.7, 119.4, 116.9, 115.6 (dd, J = 243.7, 251.2 Hz), 114.2, 62.3, 62.2, 54.0, 38.0 (t, J = 22.2 Hz), 33.6, 26.3, 25.1 (d, J = 9.2 Hz), 14.1, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -100.7 (d, J = 286.6 Hz, 1F), -105.8 (d, J = 285.9 Hz, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{21}H_{21}ClF_2NO_5^+$ 440.1071, found 440.1079.

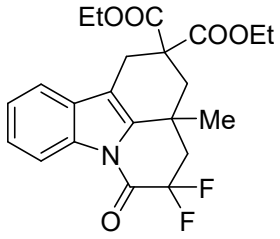


Compound **3na**: 27.5 mg, 63% yield, white solid, mp 120-121 °C. ^{1}H NMR (600 MHz, $CDCl_3$): δ = 8.24 (d, J = 8.58 Hz, 1H), 6.97-6.95 (m, 2H), 4.34-4.24 (m, 4H), 3.89 (s, 3H), 3.62 (d, J = 16.86 Hz, 1H), 3.27-3.23 (m, 1H), 2.93-2.90 (m, 1H), 2.84-2.76 (m, 2H), 2.19-2.09 (m, 1H), 1.99-1.95 (m, 1H), 1.35 (t, J = 7.08 Hz, 3H), 1.30 (t, J = 7.08 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 171.0, 169.9, 158.1 (t, J = 31.6 Hz), 157.8, 133.1, 131.0, 129.3, 117.3, 115.7 (dd, J = 244.0, 250.6 Hz), 114.4, 112.9, 102.5, 62.2, 62.1, 55.7, 54.0, 38.2 (t, J = 22.3 Hz), 33.7, 26.5, 25.1 (d, J = 9.3 Hz), 14.1, 14.0. ^{19}F NMR (565 MHz, $CDCl_3$): δ = -100.9 (d, J = 286.2 Hz, 1F), -105.7 (d, J = 286.3 Hz, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{22}H_{24}F_2NO_6^+$ 436.1566, found 436.1578.

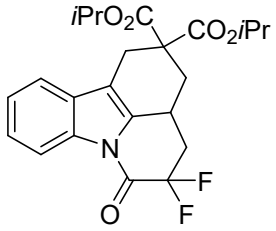


Compound **3oa**: 31.5 mg, 72% yield, white solid, mp 141-142 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.96 (s, 1H), 7.37 (d, J = 8.52 Hz, 1H), 6.99 (d, J = 8.52 Hz, 1H), 4.33-4.23 (m, 4H), 3.90 (s, 3H), 3.63 (d, J = 16.96 Hz, 1H), 3.27-3.20 (m, 1H), 2.94-2.74 (m, 3H), 2.20-2.04 (m, 1H), 1.98-1.92 (m, 1H), 1.35 (t, J = 6.92 Hz, 3H), 1.30 (t, J = 6.88 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 171.0,

169.9, 158.6, 136.0, 130.8, 123.3, 119.1, 114.4, 113.7, 101.2, 62.2, 62.1, 55.9, 54.1, 38.1 (t, J = 22.3 Hz), 33.7, 26.5, 25.0 (d, J = 9.3 Hz), 14.1, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -100.6 (d, J = 285.4 Hz, 1F), -105.6 (d, J = 286.2 Hz, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{22}H_{24}F_2NO_6^+$ 436.1566, found 436.1580.

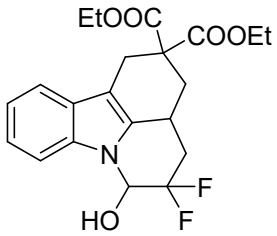


Compound **3qa**: 27.6 mg, 66% yield, white solid, mp 139-140 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.40 (d, J = 7.28 Hz, 1H), 7.52 (d, J = 6.96 Hz, 1H), 7.42-7.36 (m, 2H), 4.34-4.13 (m, 4H), 3.69 (d, J = 16.84 Hz, 1H), 2.96 (d, J = 16.88 Hz, 1H), 2.76-2.61 (m, 2H), 2.53-2.39 (m, 2H), 1.38 (s, 3H), 1.34 (t, J = 7.16 Hz, 3H), 1.25 (t, J = 7.20 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 171.3, 171.1, 158.9 (t, J = 31.1 Hz), 136.8, 135.2, 129.8, 125.6, 125.3, 118.8, 116.6, 115.6 (t, J = 246.3 Hz), 113.8, 62.1, 62.0, 53.4, 45.1 (t, J = 20.8 Hz), 41.8, 29.8 (d, J = 9.1 Hz), 26.5 (d, J = 5.6 Hz), 26.0, 14.0, 13.9. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -91.3 (d, J = 297.8 Hz, 1F), -94.8 (d, J = 297.9 Hz, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{22}H_{24}F_2NO_5^+$ 420.1617, found 420.1629.



Compound **3sa**: 33.7 mg, 78% yield, white solid, mp 113-114 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.37 (d, J = 7.32 Hz, 1H), 7.51 (d, J = 6.32 Hz, 1H), 7.41-7.35 (m, 2H), 5.19-5.04 (m, 2H), 3.63 (d, J = 16.88 Hz, 1H), 3.30-3.24 (m, 1H), 2.93 (d, J = 16.92 Hz, 1H), 2.83-2.76 (m, 2H), 2.23-2.07 (m, 1H), 1.99-1.93 (m, 1H), 1.34-1.28 (m, 9H), 1.25 (d, J = 6.32 Hz, 3H). ^{13}C NMR (100 MHz,

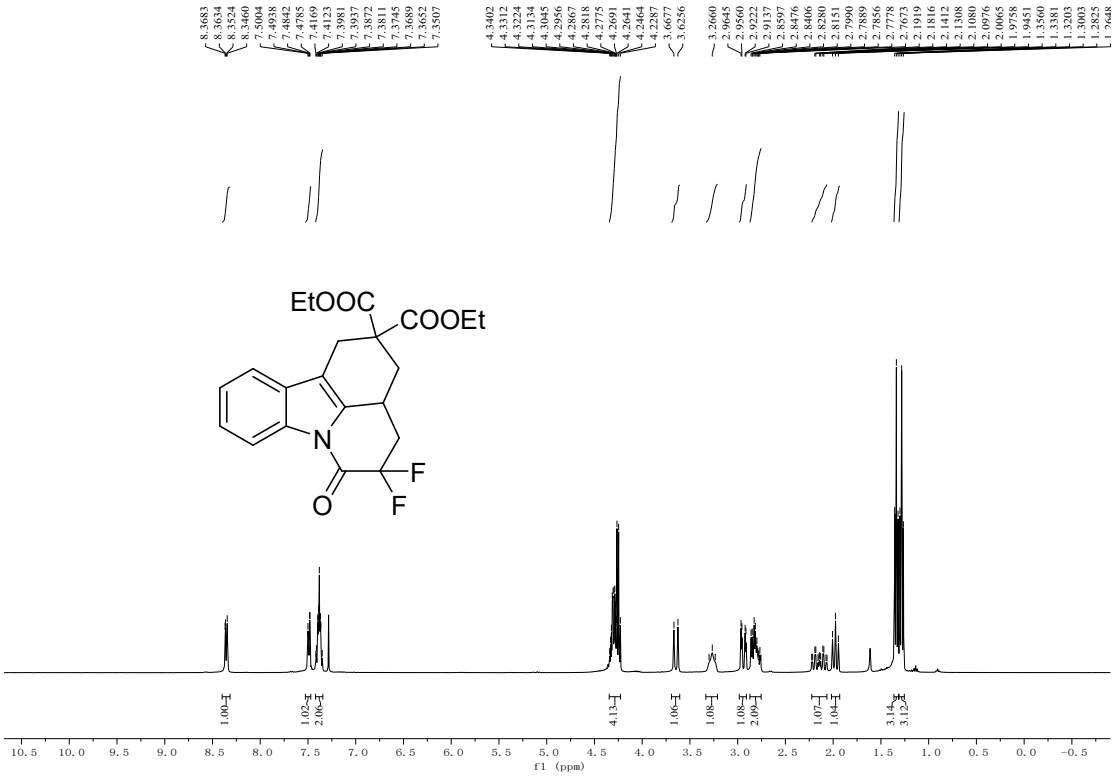
$CDCl_3$): δ = 170.5, 169.4, 158.5 (t, *J* = 30.8 Hz), 135.0, 132.3, 129.8, 125.5, 125.2, 118.7, 116.5, 115.7 (dd, *J* = 243.5, 250.6 Hz), 114.7, 69.8, 69.7, 54.0, 38.2 (t, *J* = 22.2 Hz), 33.7, 26.4, 25.0 (d, *J* = 9.3 Hz), 21.7, 21.6, 21.5, 21.4. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -100.9 (d, *J* = 285.6 Hz, 1F), -105.7 (d, *J* = 285.4 Hz, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{23}H_{26}F_2NO_5^+$ 434.1744, found 434.1785.



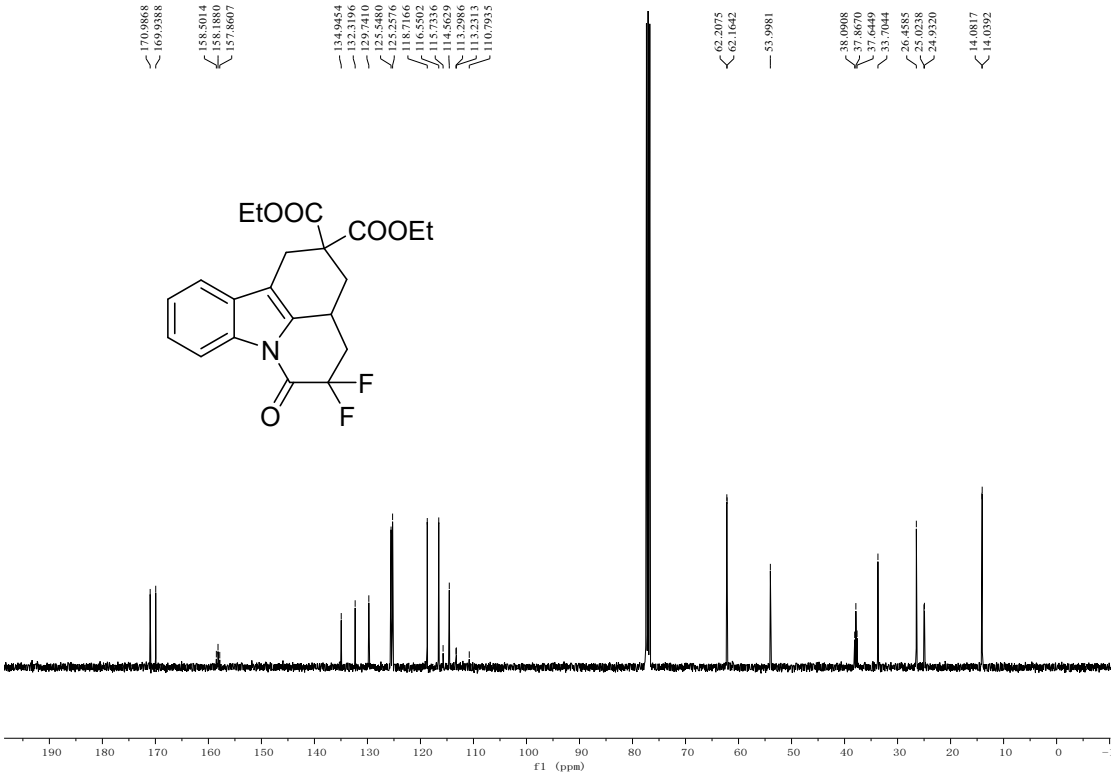
Compound **6**: 28.2 mg, 69% yield, white solid, mp 155-156 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.73-7.71 (m, 1H), 7.52-7.50 (m, 1H), 7.27-7.19 (m, 2H), 5.59-5.51 (m, 1H), 4.34-4.16 (m, 4H), 3.70 (d, *J* = 16.16 Hz, 1H), 3.17-.311 (m, 2H), 2.99-2.94 (m, 1H), 2.77-2.63 (m, 2H), 1.92-1.77 (m, 2H), 1.34 (t, *J* = 7.12 Hz, 3H), 1.28 (t, *J* = 7.08 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 171.6, 170.4, 138.3, 132.5, 128.5, 122.7, 121.8 (dd, *J* = 242.8, 245.6 Hz), 121.2, 118.4, 112.0, 107.7, 80.5 (dd, *J* = 23.9, 37.3 Hz), 61.9, 61.8, 54.4, 36.7 (dd, *J* = 20.9, 23.8 Hz), 34.2, 26.9, 25.3 (d, *J* = 7.2 Hz), 14.1, 14.0. ^{19}F NMR (376 MHz, $CDCl_3$): δ = -103.6 (d, *J* = 251.6 Hz, 1F), -116.5 (d, *J* = 251.8 Hz, 1F). HRMS (ESI) m/z: $[M+H]^+$ calcd for $C_{21}H_{24}F_2NO_5^+$ 408.1617, found 408.1626.

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

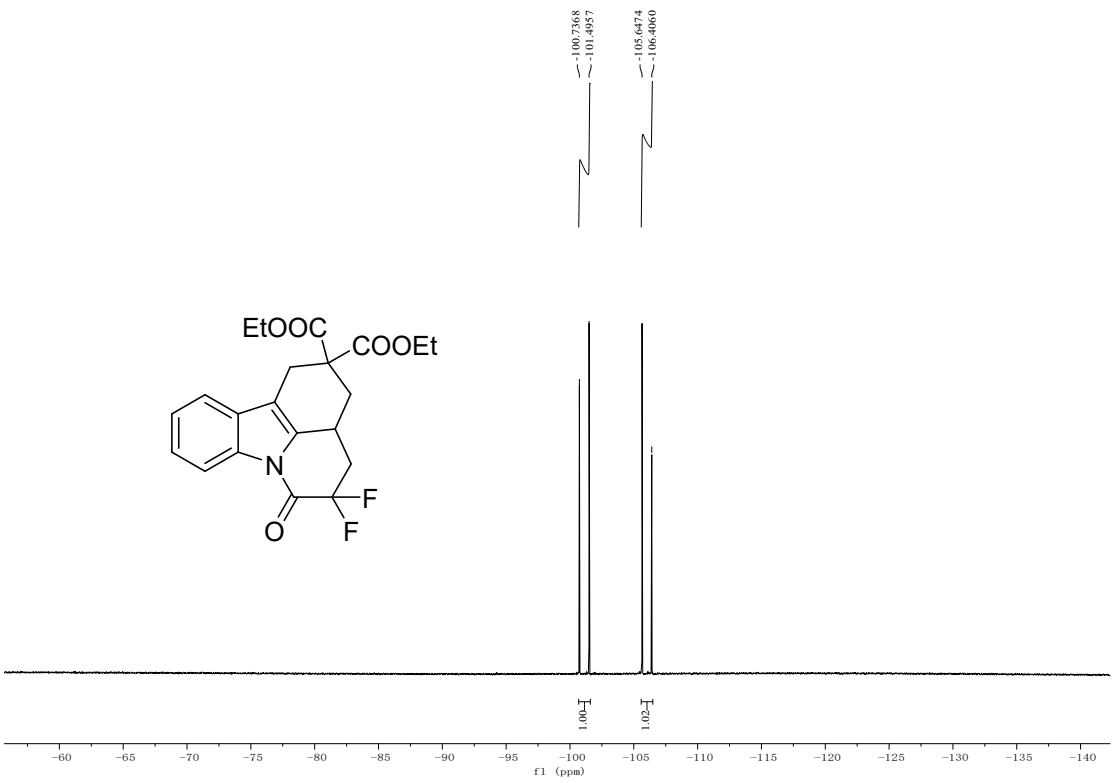
^{1}H NMR (400 MHz, $CDCl_3$) of **3aa**:



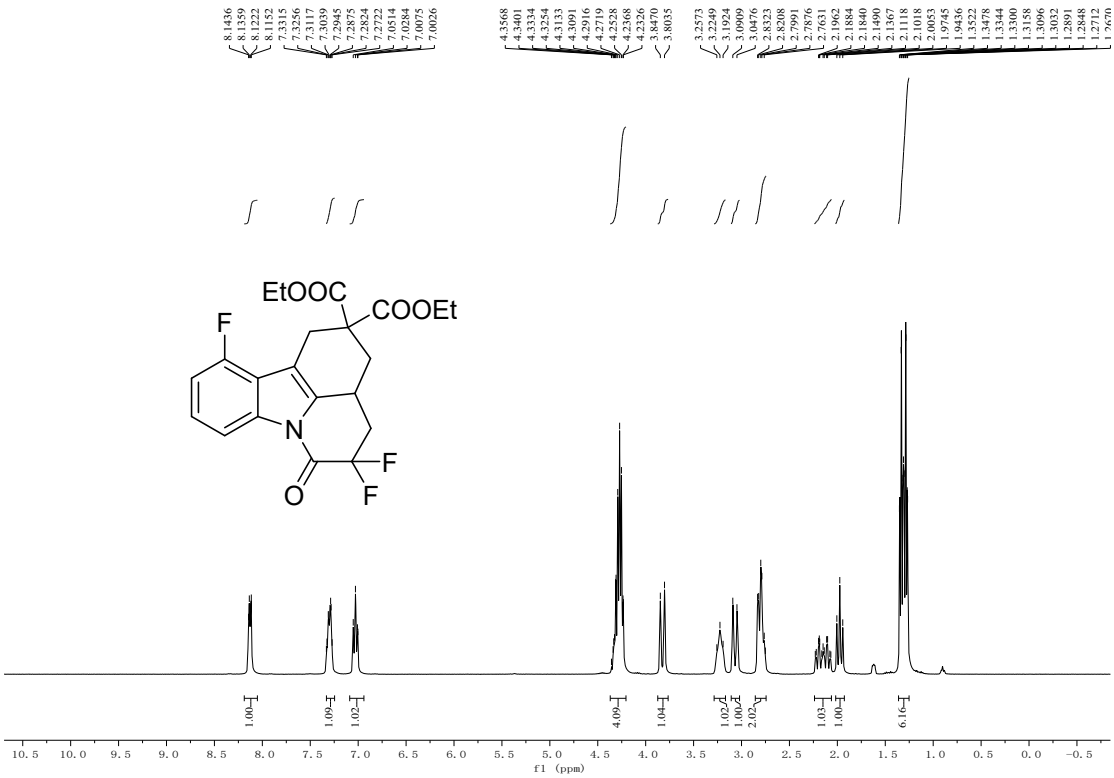
^{13}C NMR (100 MHz, $CDCl_3$) of **3aa**:



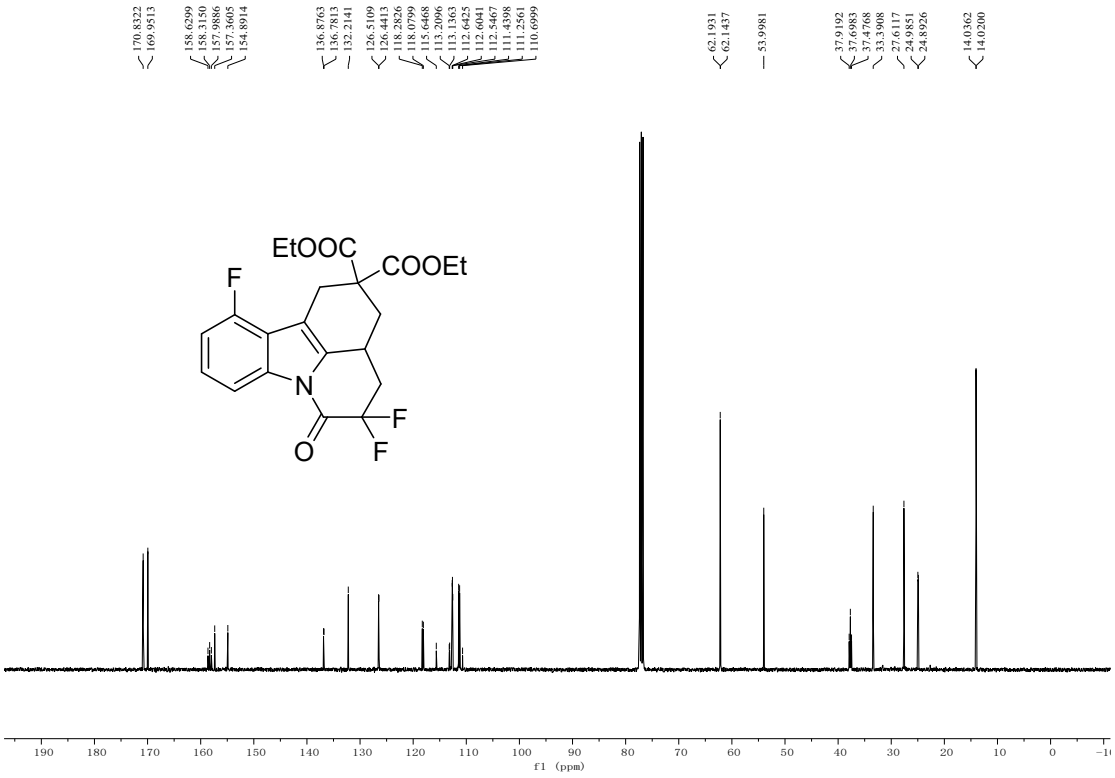
^{19}F NMR (376 MHz, $CDCl_3$) of **3aa**:



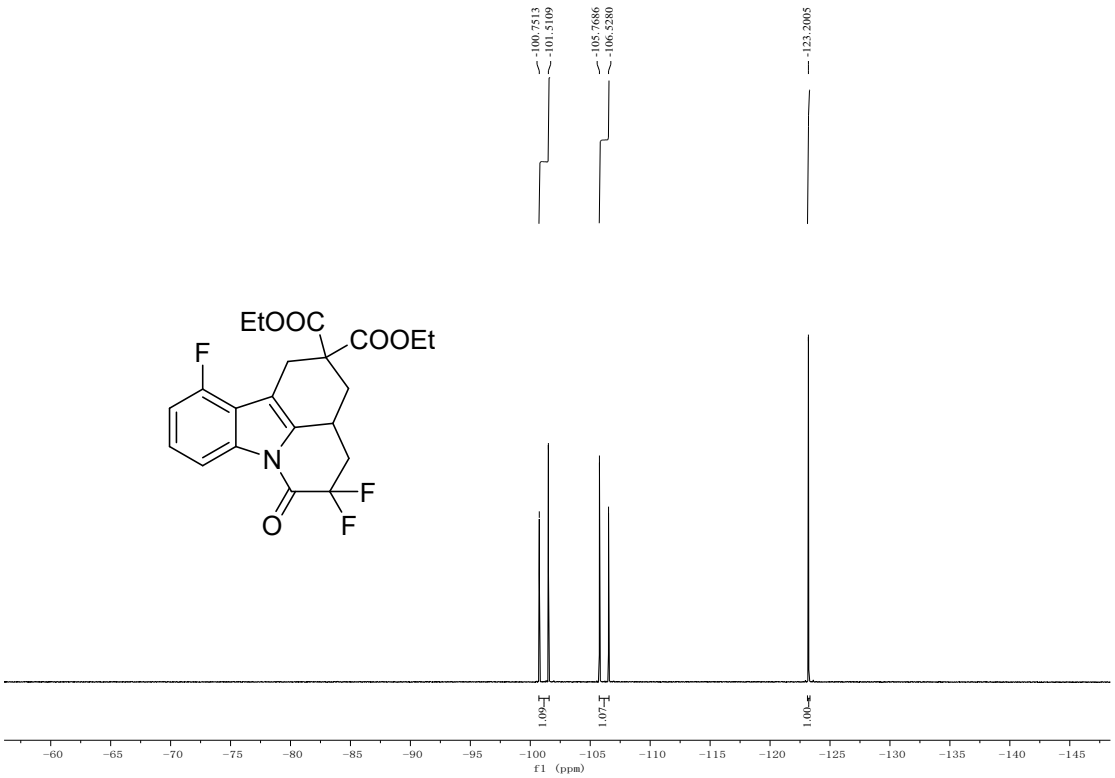
^{1}H NMR (400 MHz, $CDCl_3$) of **3ba**:



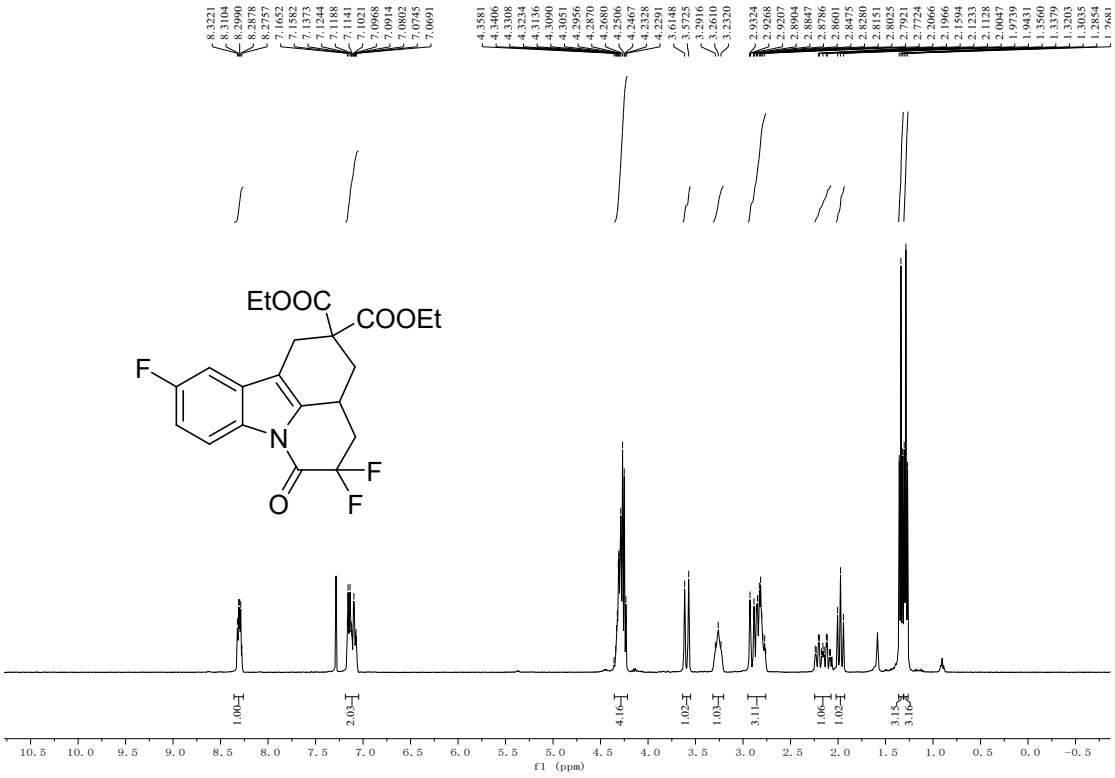
^{13}C NMR (100 MHz, $CDCl_3$) of **3ba**:



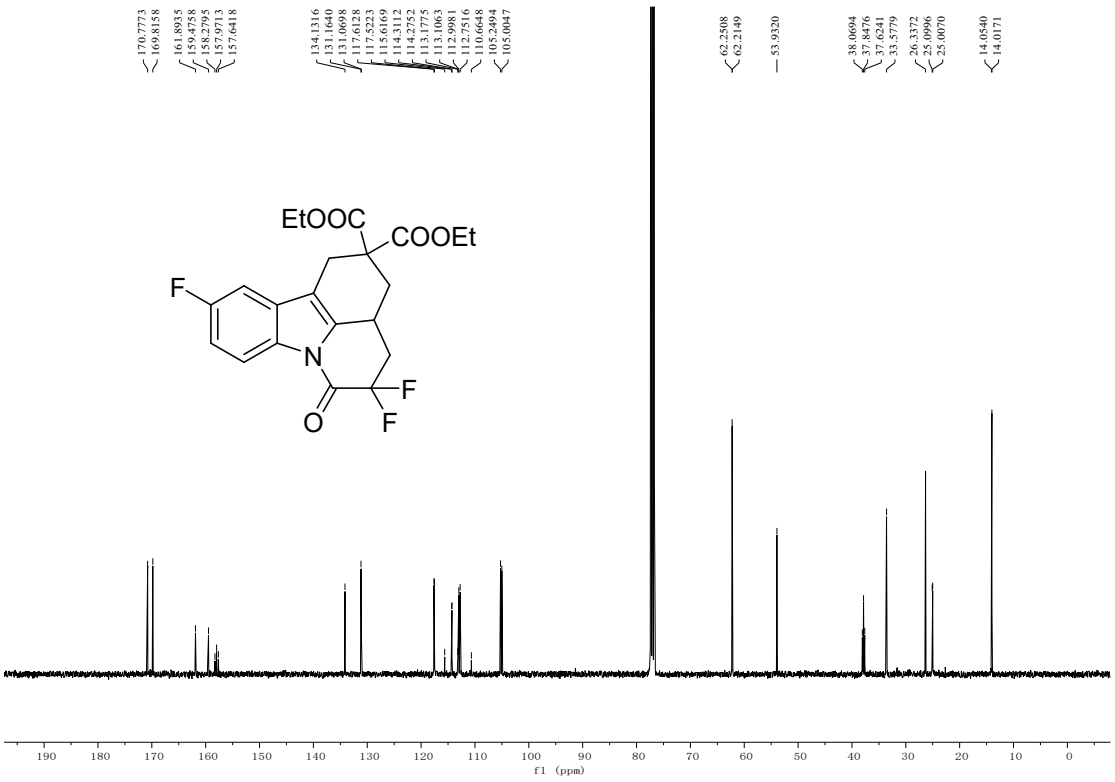
^{19}F NMR (376 MHz, $CDCl_3$) of **3ba**:



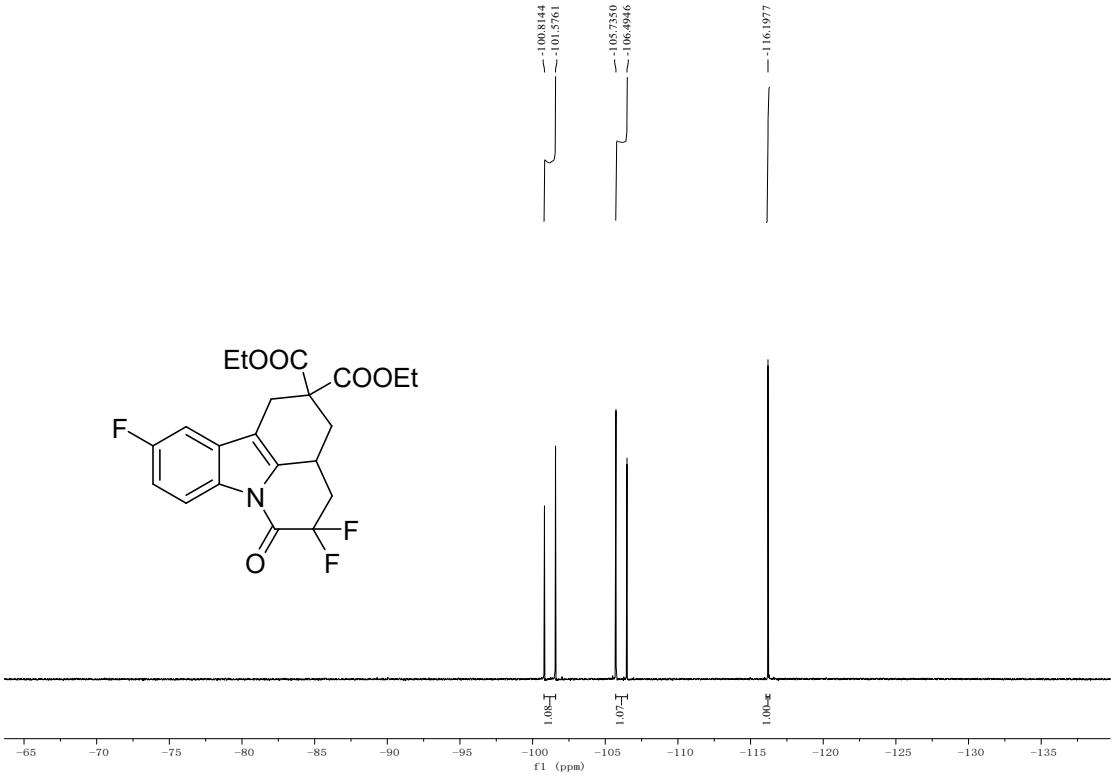
^{1}H NMR (400 MHz, $CDCl_3$) of **3ca**:



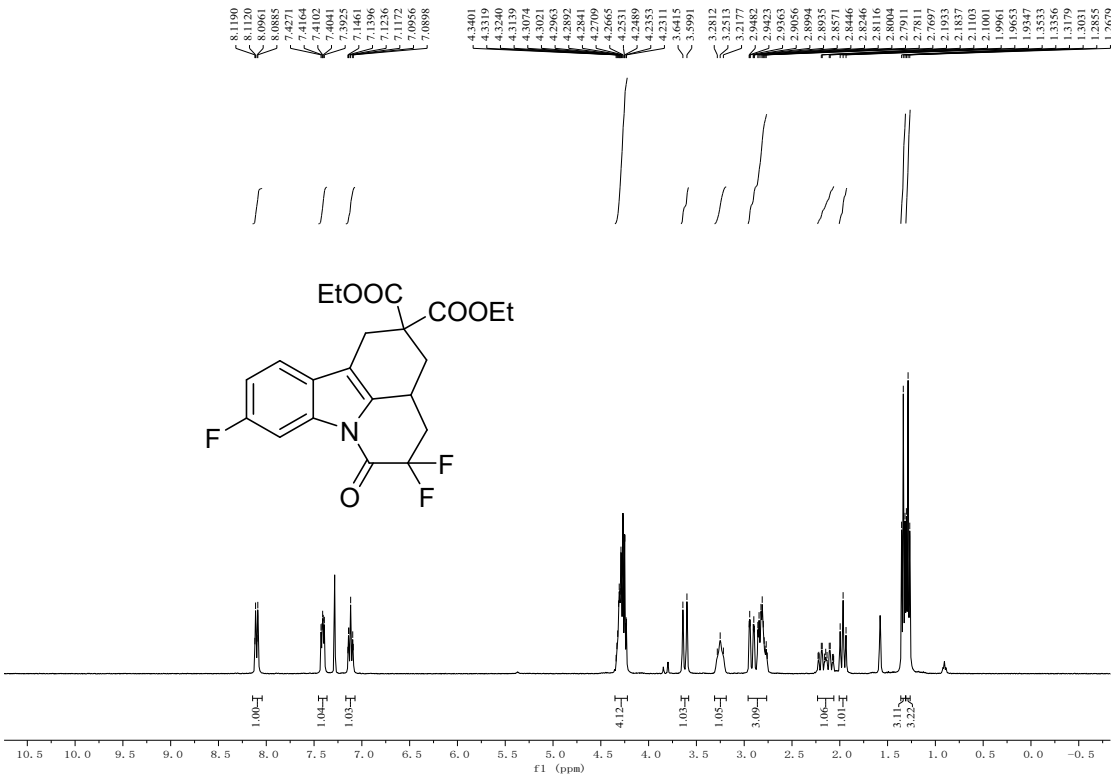
^{13}C NMR (100 MHz, $CDCl_3$) of **3ca**:



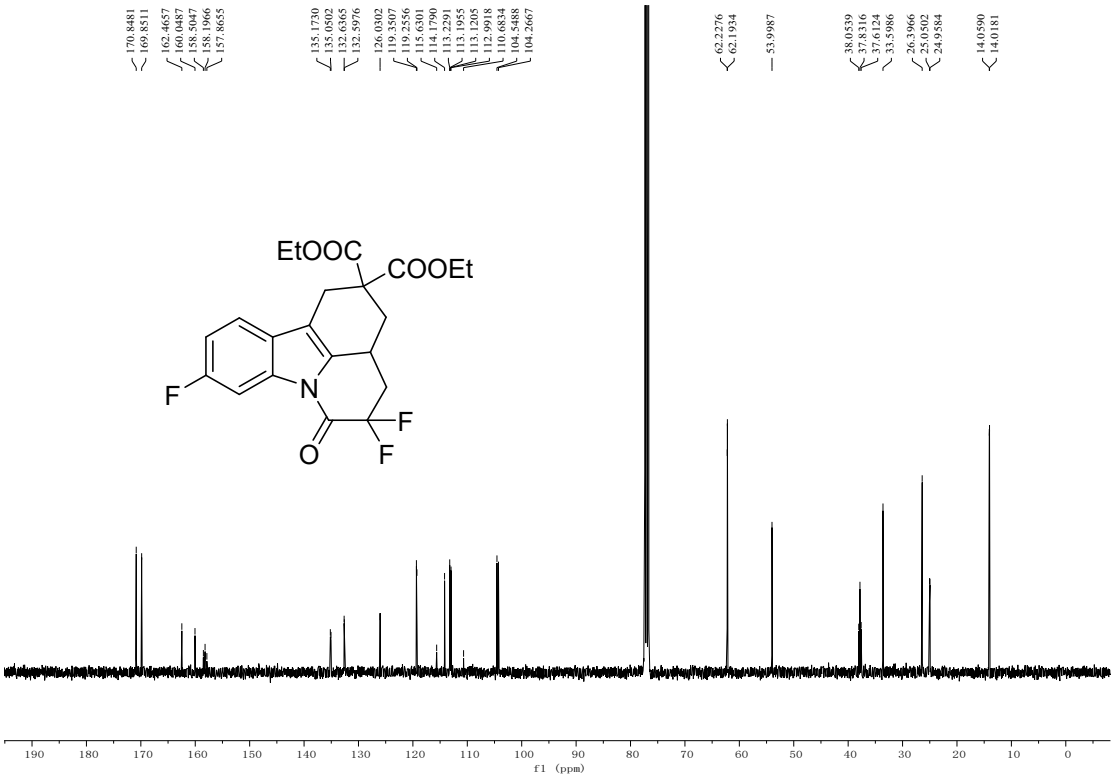
^{19}F NMR (376 MHz, $CDCl_3$) of **3ca**:



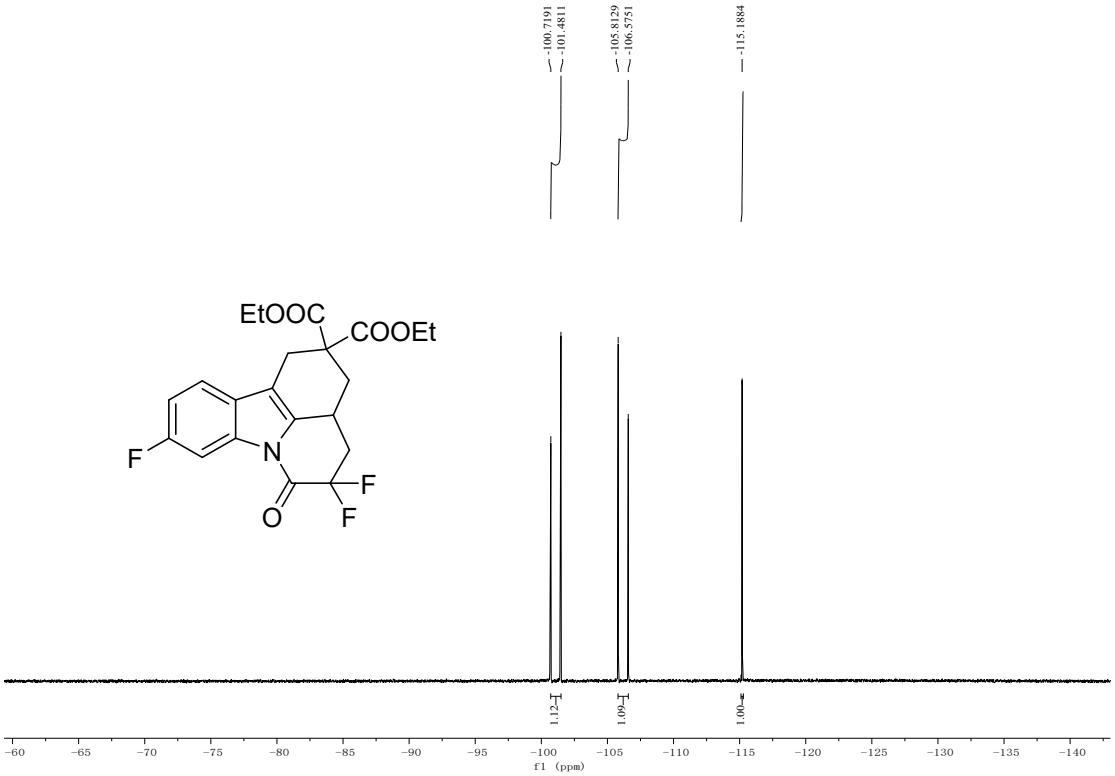
^{1}H NMR (400 MHz, $CDCl_3$) of **3da**:



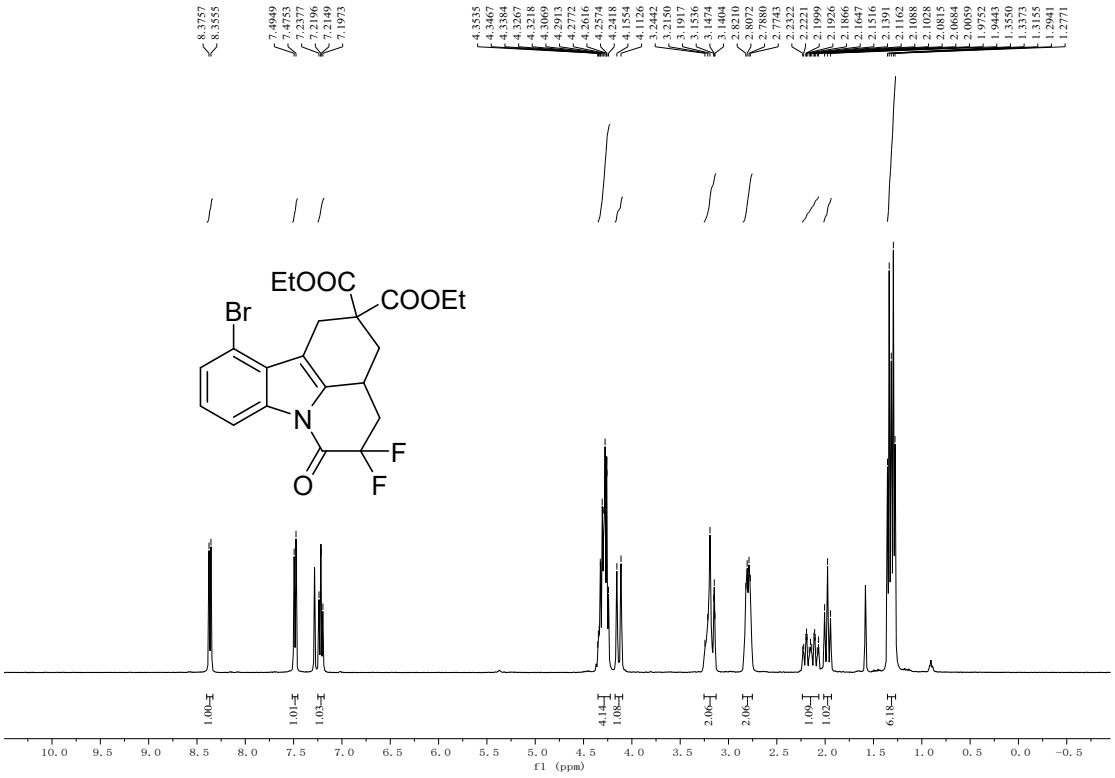
^{13}C NMR (100 MHz, $CDCl_3$) of **3da**:



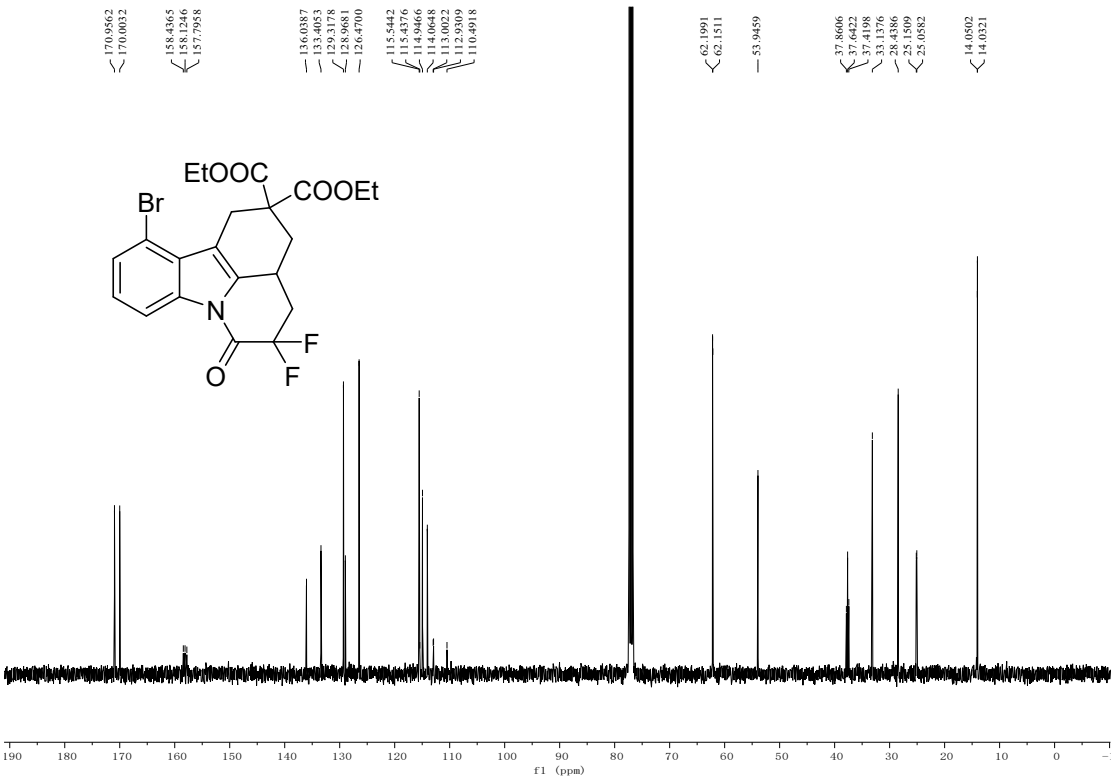
^{19}F NMR (376 MHz, $CDCl_3$) of **3da**:



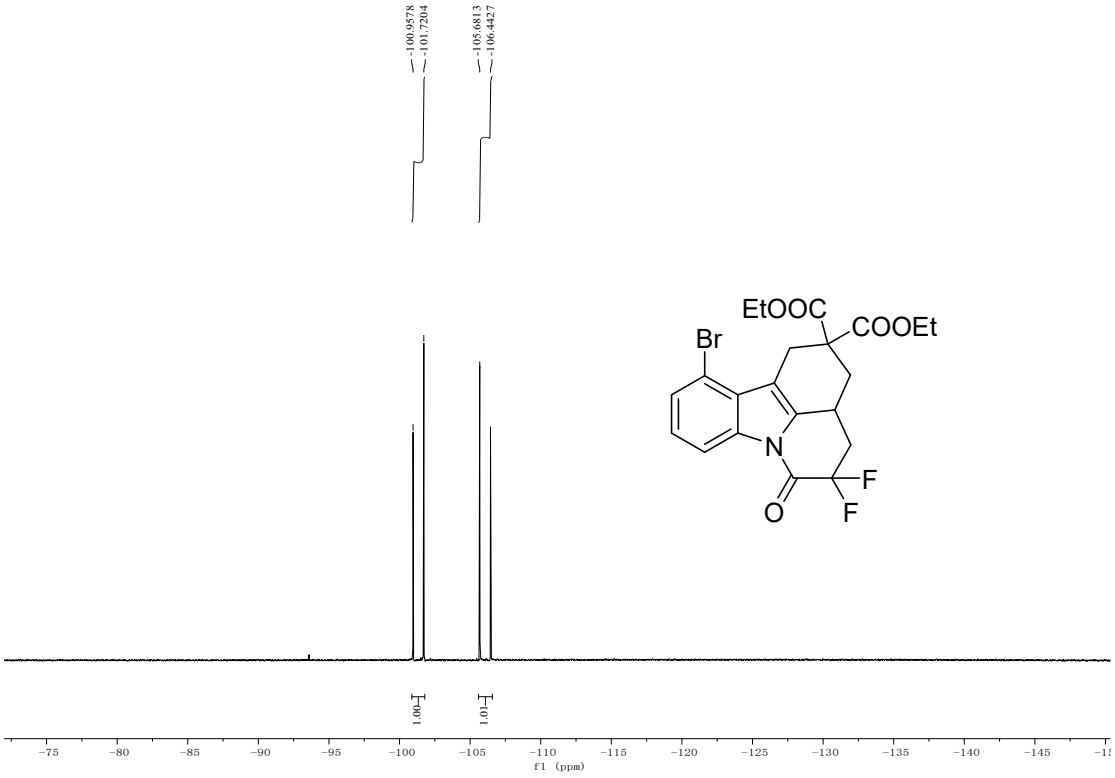
^{1}H NMR (400 MHz, $CDCl_3$) of **3ea**:



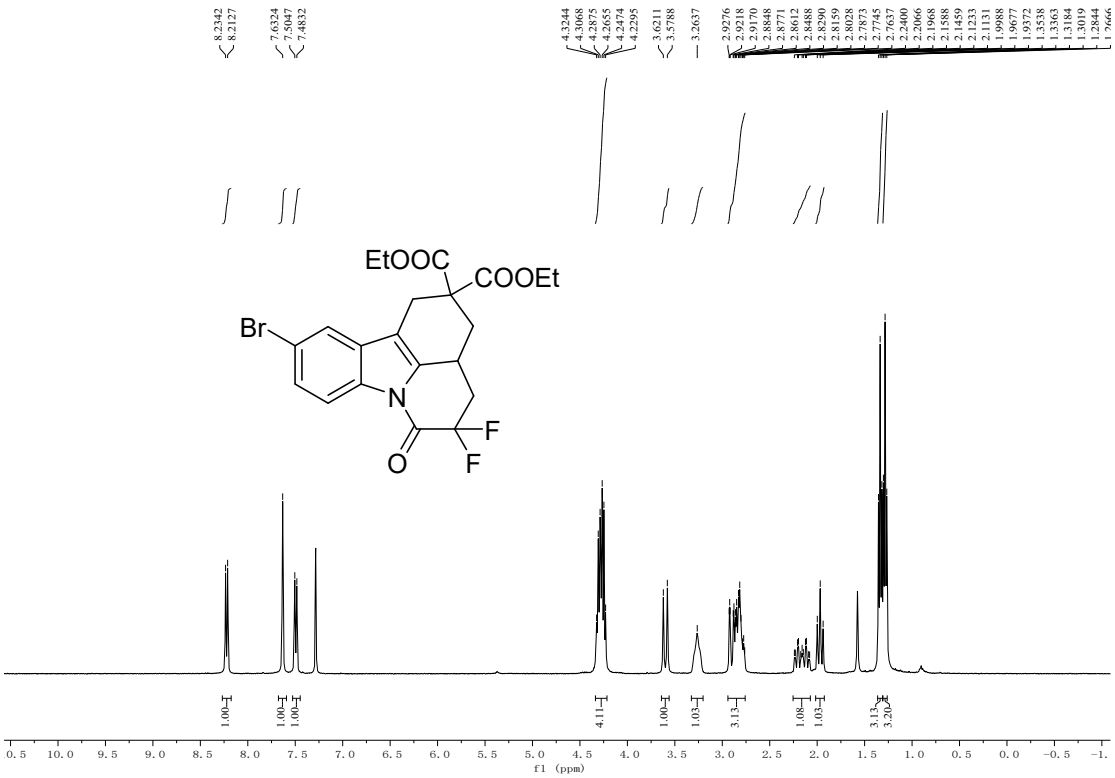
^{13}C NMR (100 MHz, $CDCl_3$) of **3ea**:



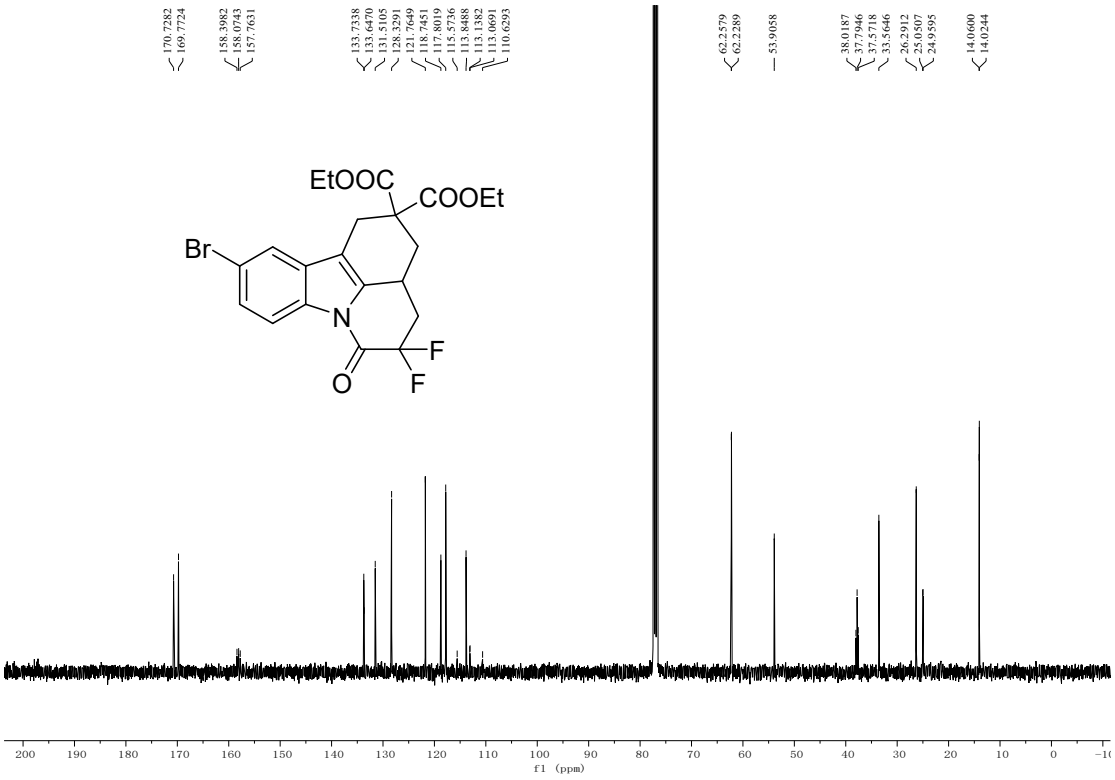
^{19}F NMR (376 MHz, $CDCl_3$) of **3ea**:



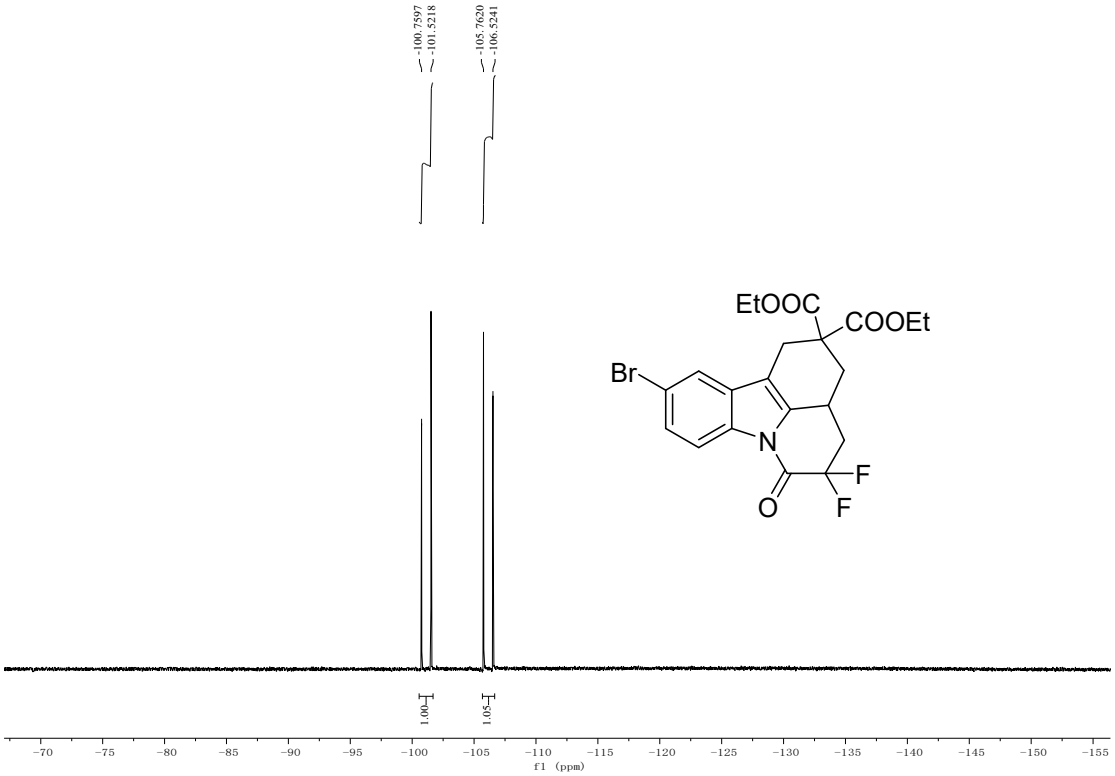
^{1}H NMR (400 MHz, $CDCl_3$) of **3fa**:



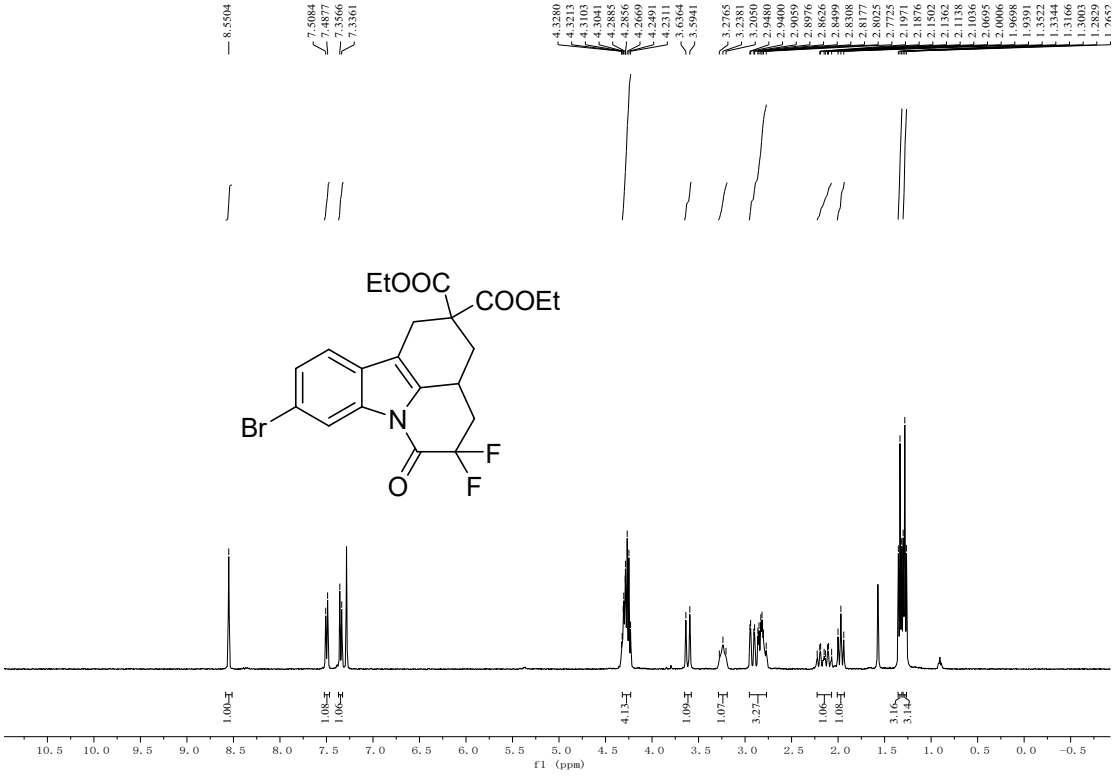
^{13}C NMR (100 MHz, $CDCl_3$) of **3fa**:



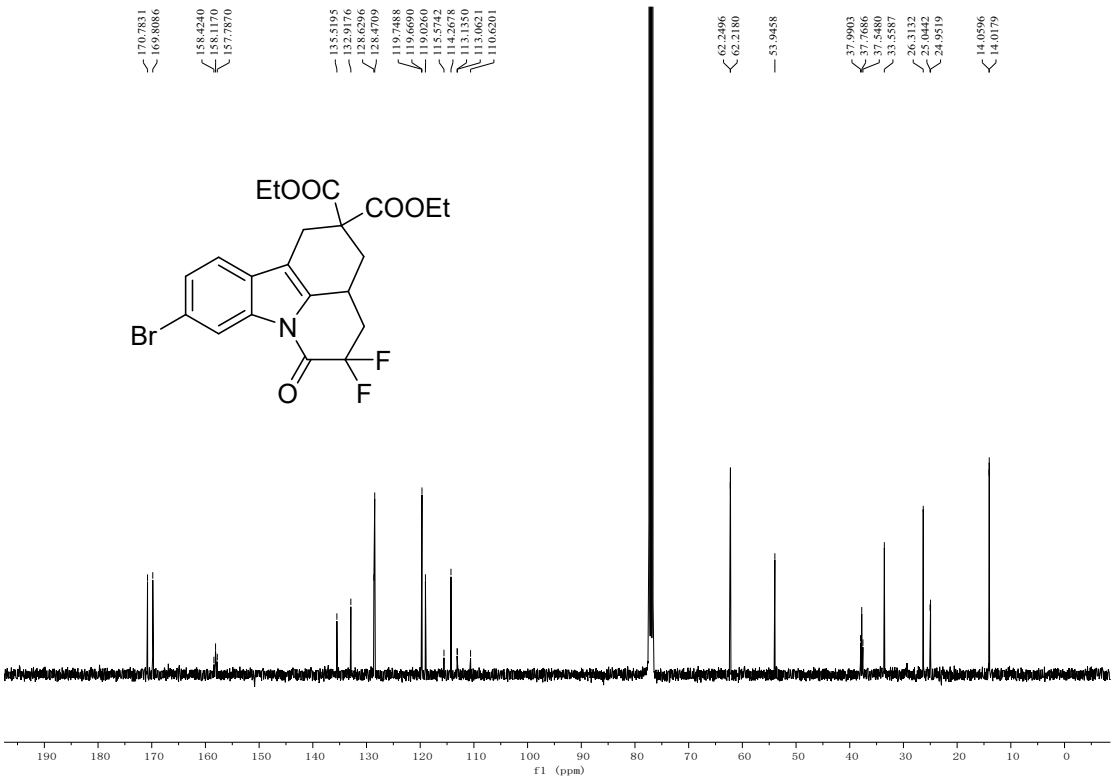
^{19}F NMR (376 MHz, $CDCl_3$) of **3fa**:



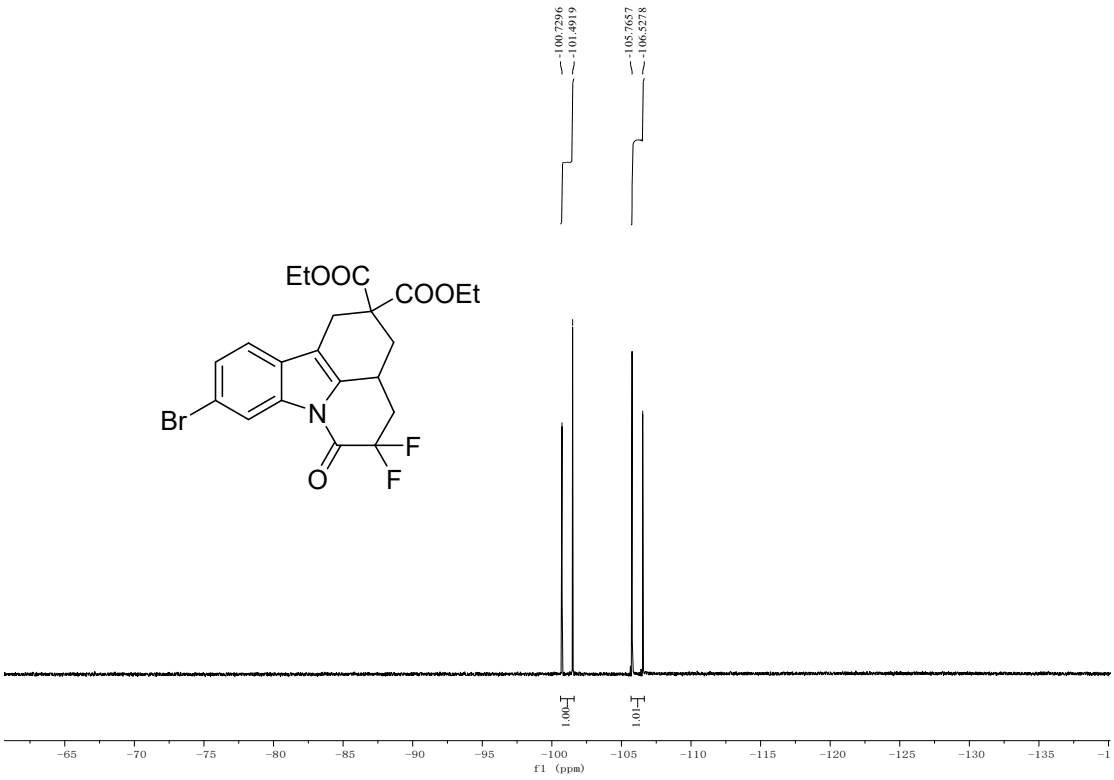
^{1}H NMR (400 MHz, $CDCl_3$) of **3ga**:



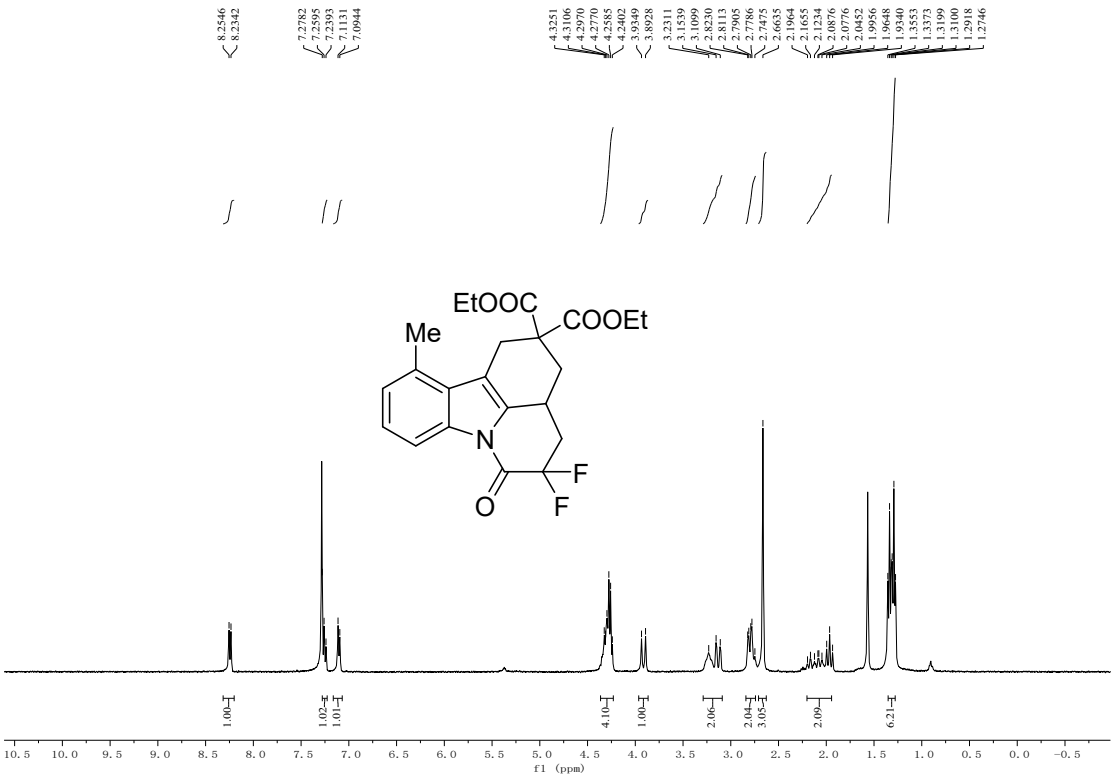
^{13}C NMR (100 MHz, $CDCl_3$) of **3ga**:



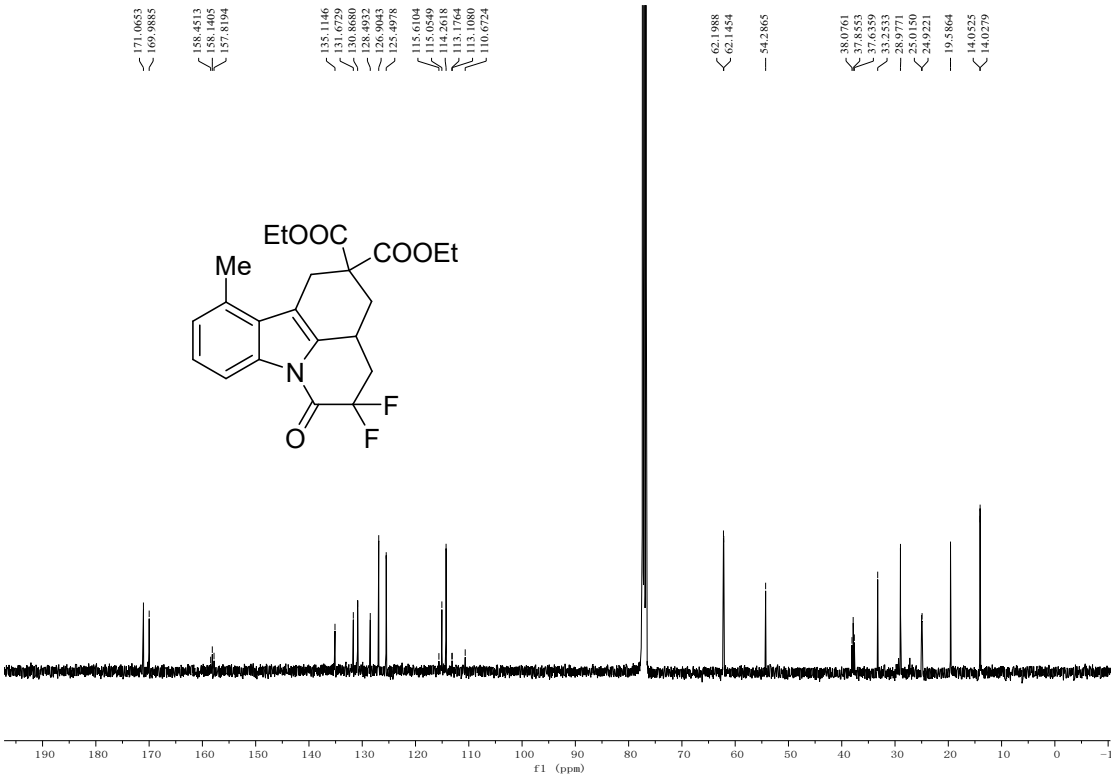
^{19}F NMR (376 MHz, $CDCl_3$) of **3ga**:



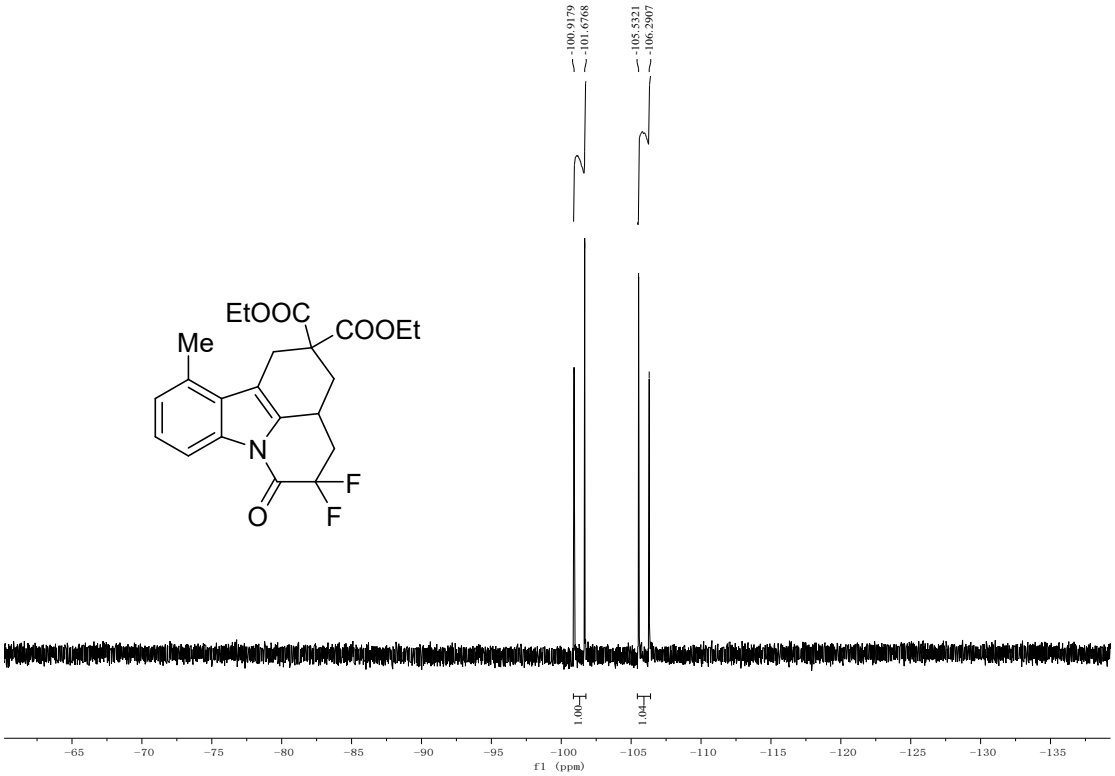
^{1}H NMR (400 MHz, $CDCl_3$) of **3ha**:



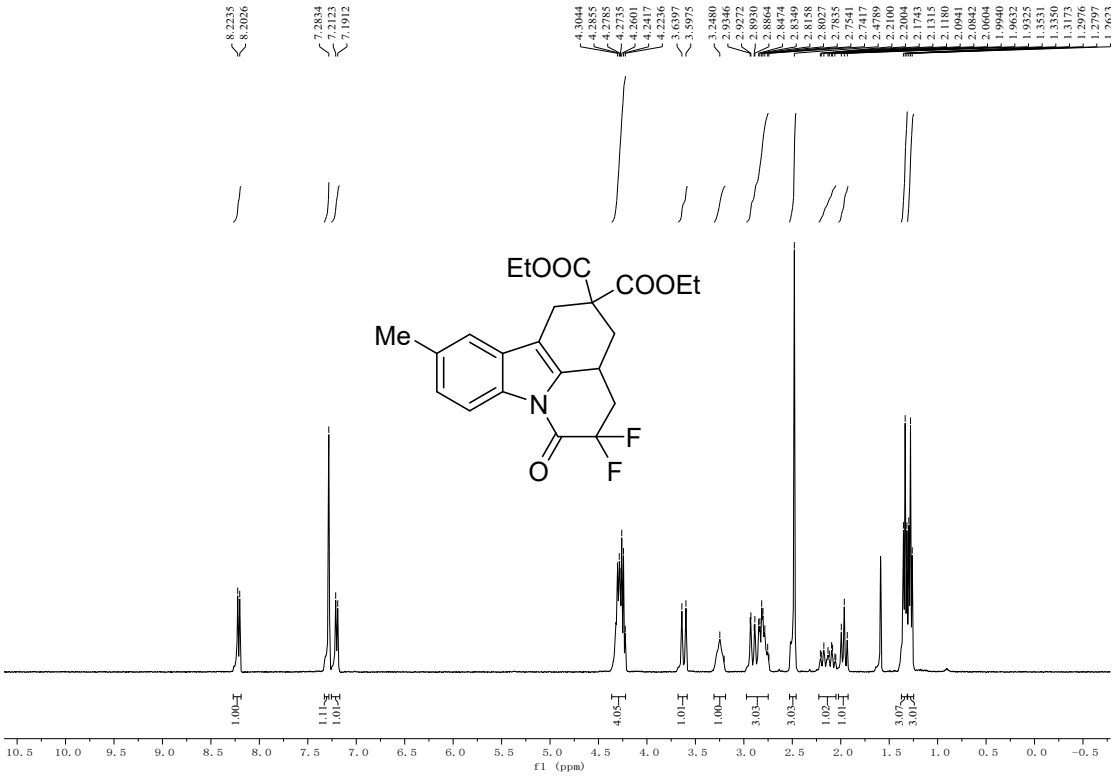
^{13}C NMR (100 MHz, $CDCl_3$) of **3ha**:



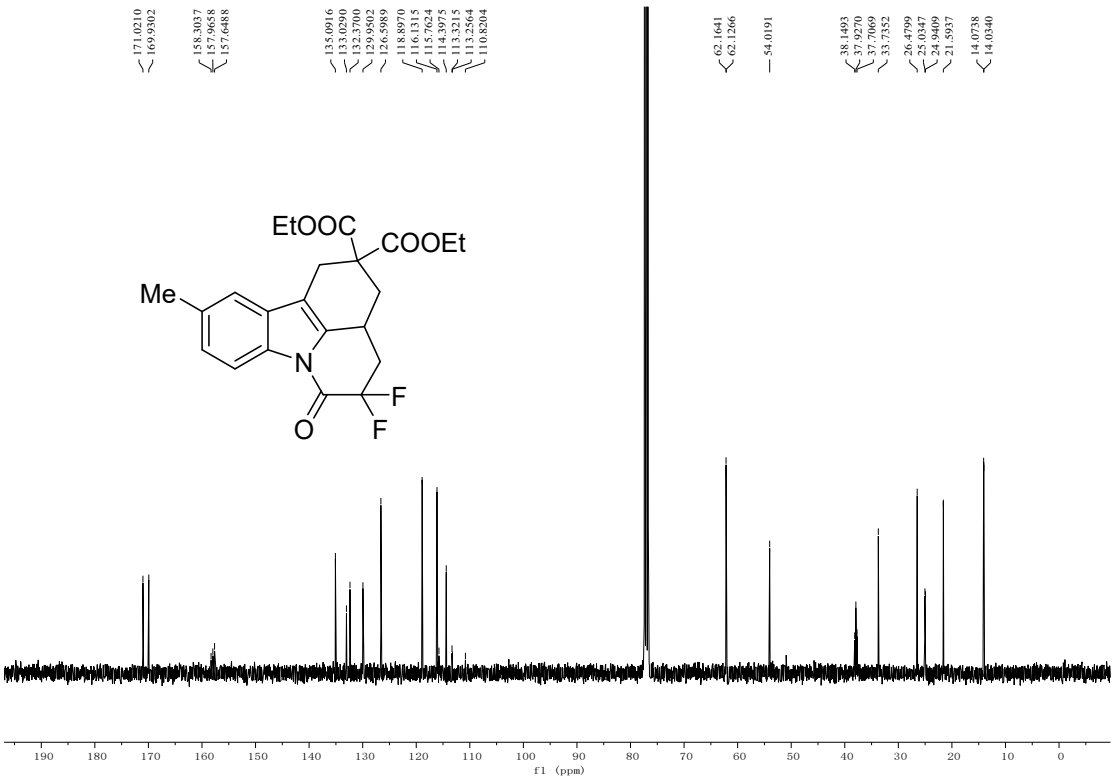
^{19}F NMR (376 MHz, $CDCl_3$) of **3ha**:



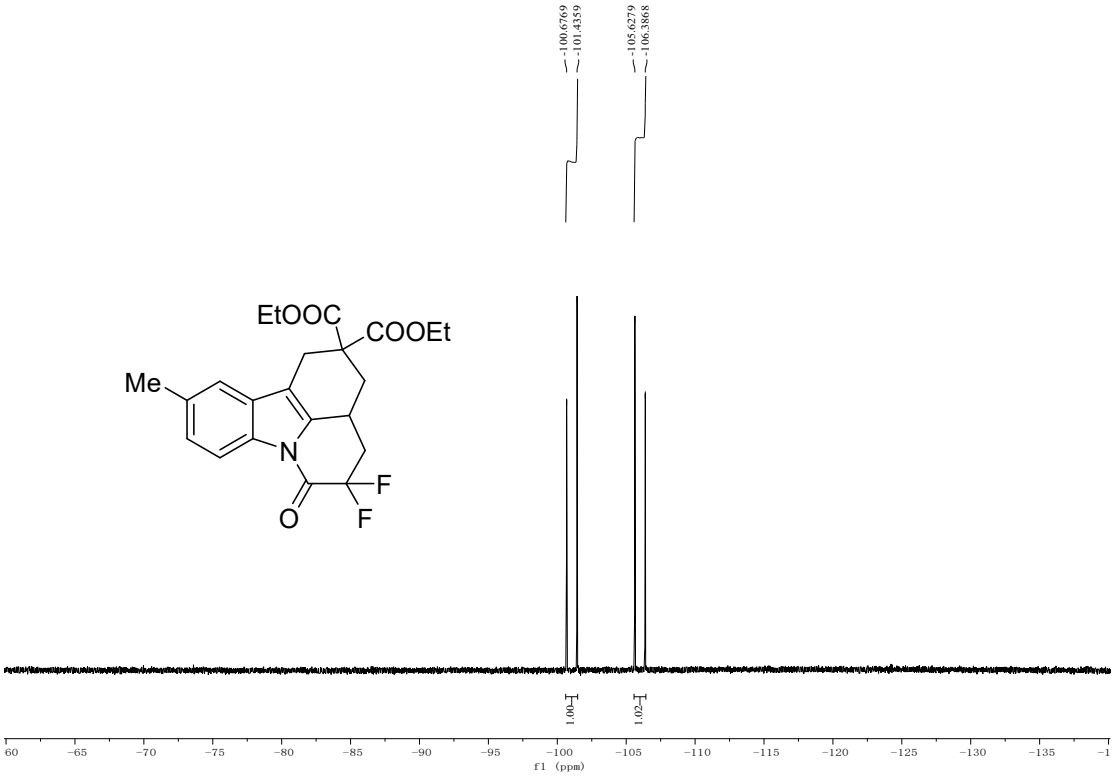
^{1}H NMR (400 MHz, $CDCl_3$) of **3ia**:



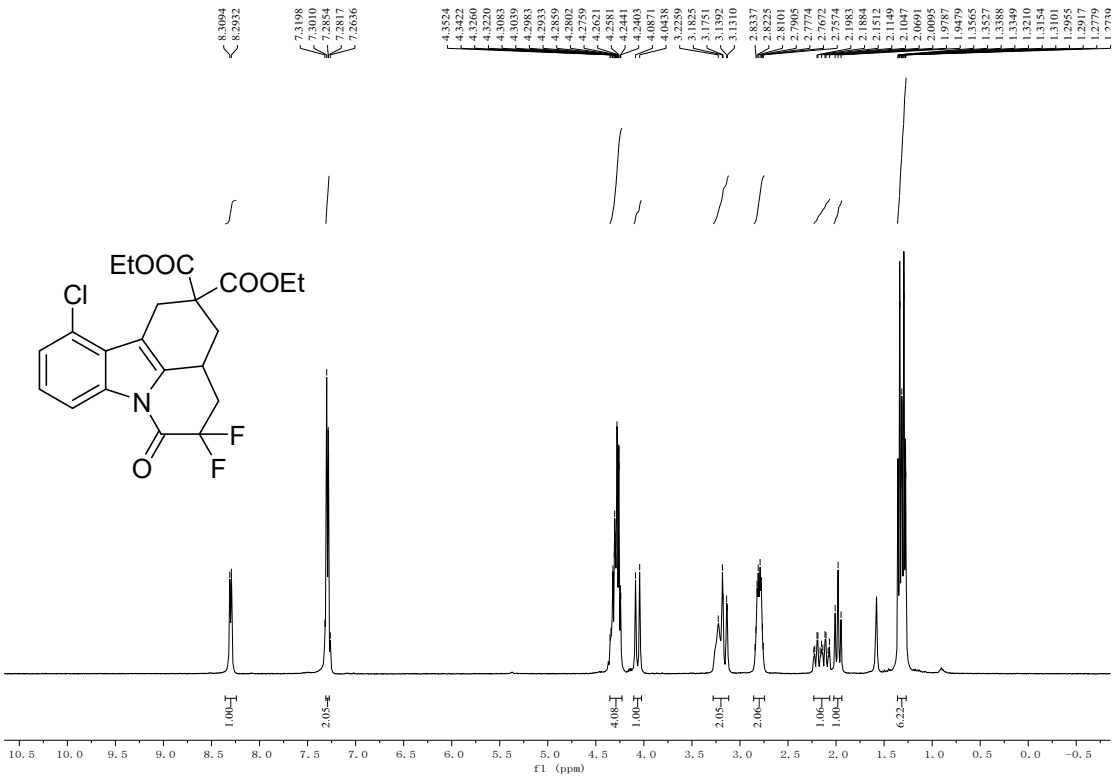
^{13}C NMR (100 MHz, $CDCl_3$) of **3ia**:



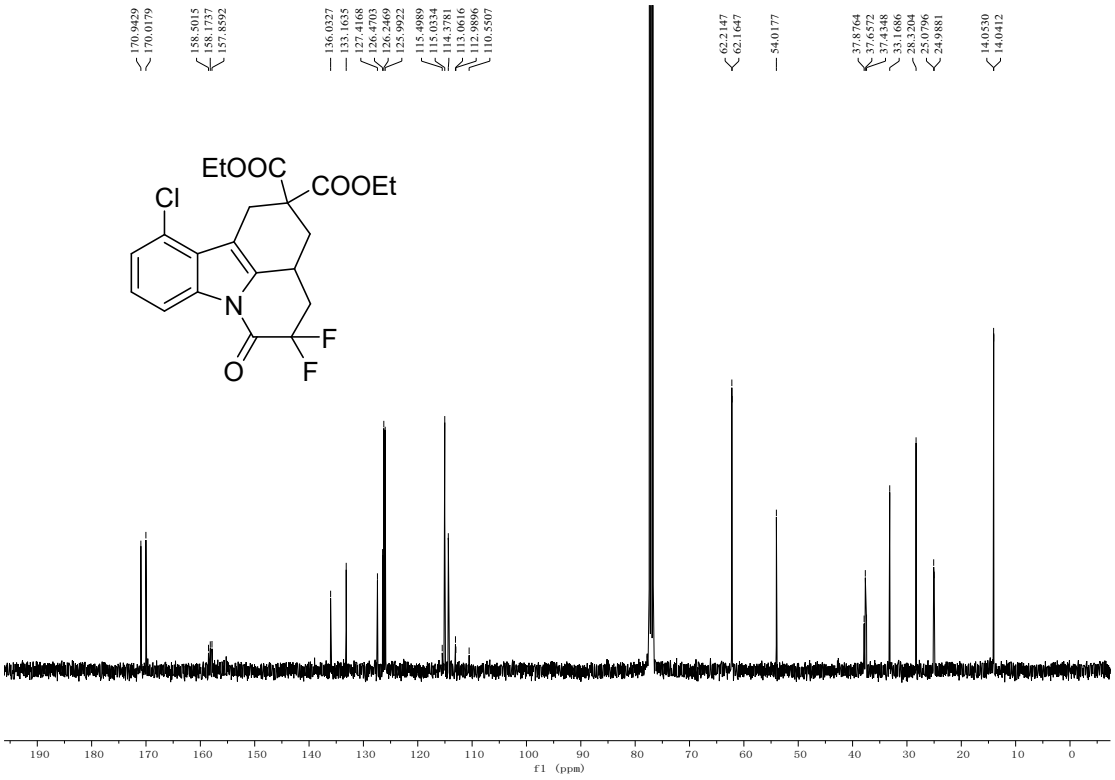
^{19}F NMR (376 MHz, $CDCl_3$) of **3ia**:



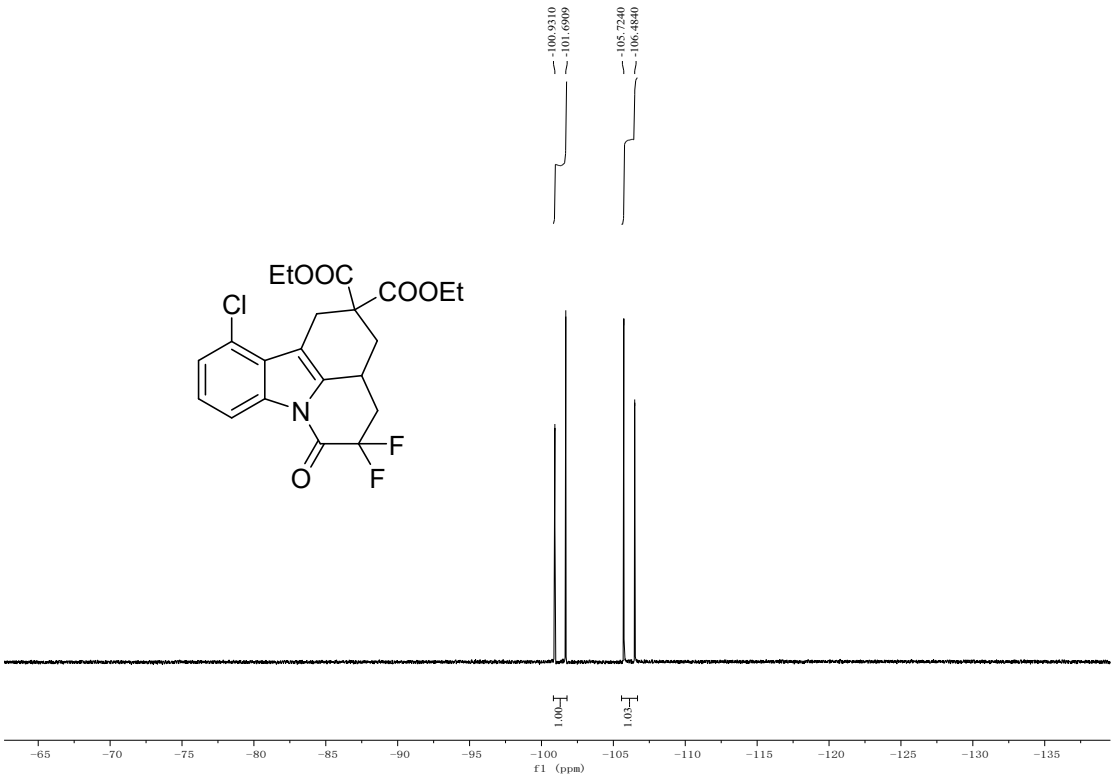
^{1}H NMR (400 MHz, $CDCl_3$) of **3ka**:



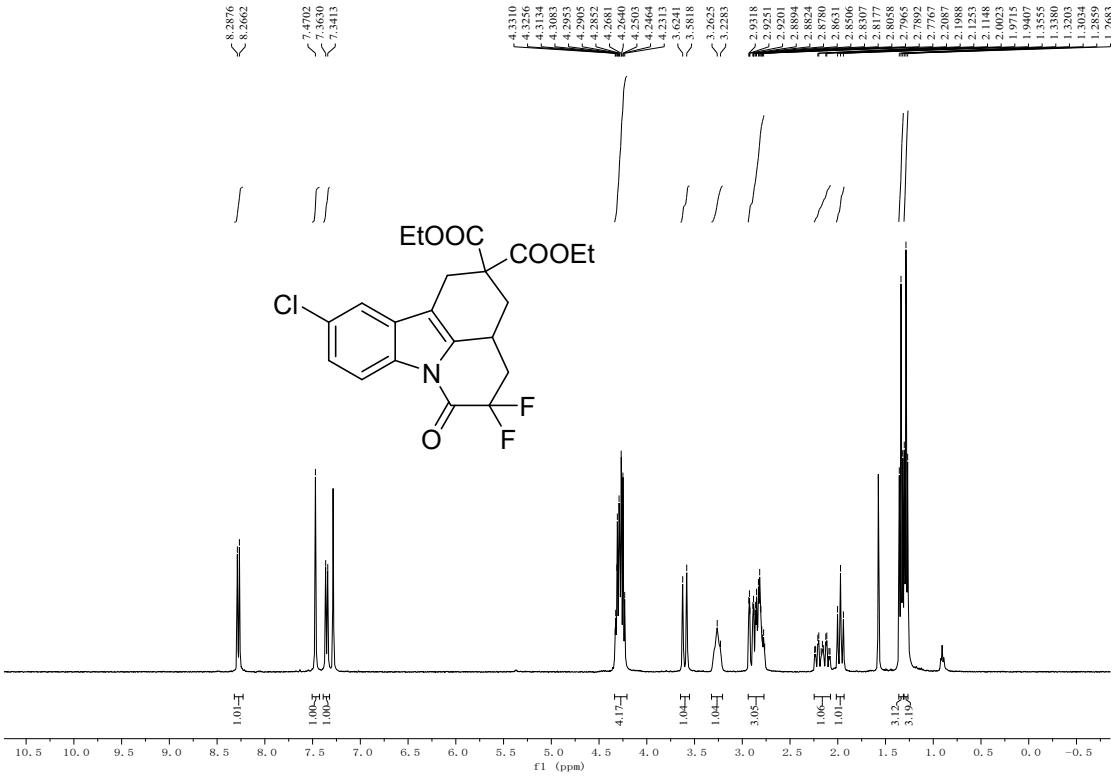
^{13}C NMR (100 MHz, $CDCl_3$) of **3ka**:



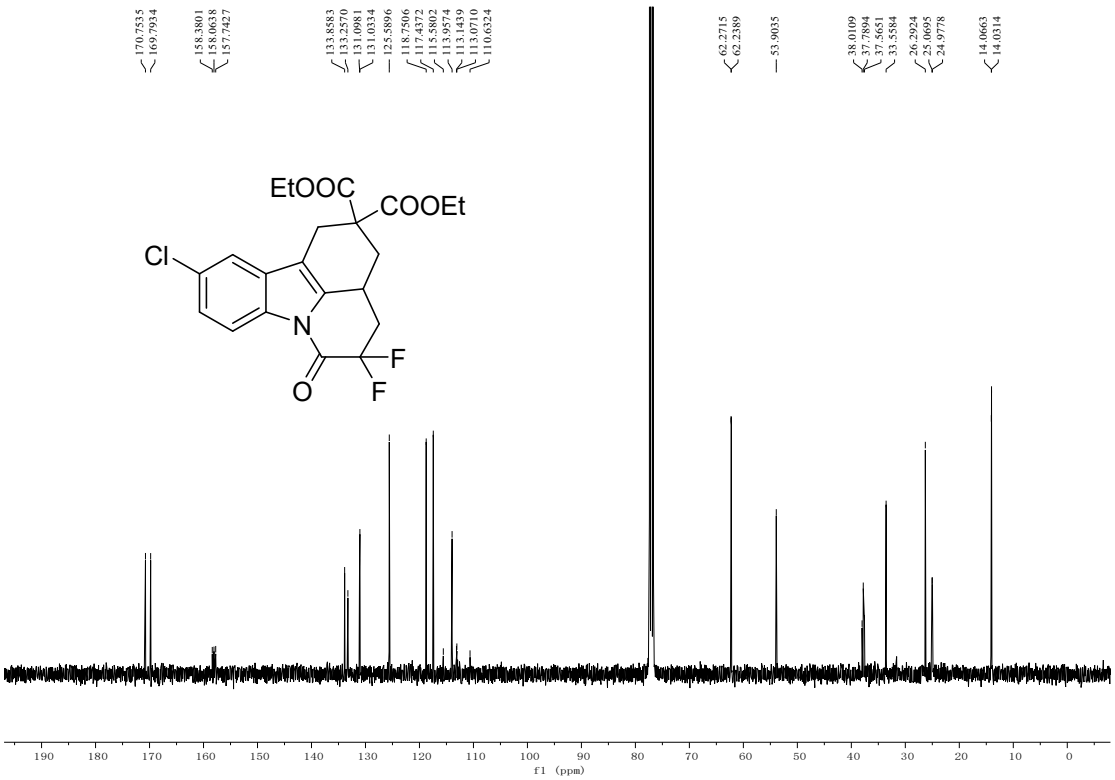
^{19}F NMR (376 MHz, $CDCl_3$) of **3ka**:



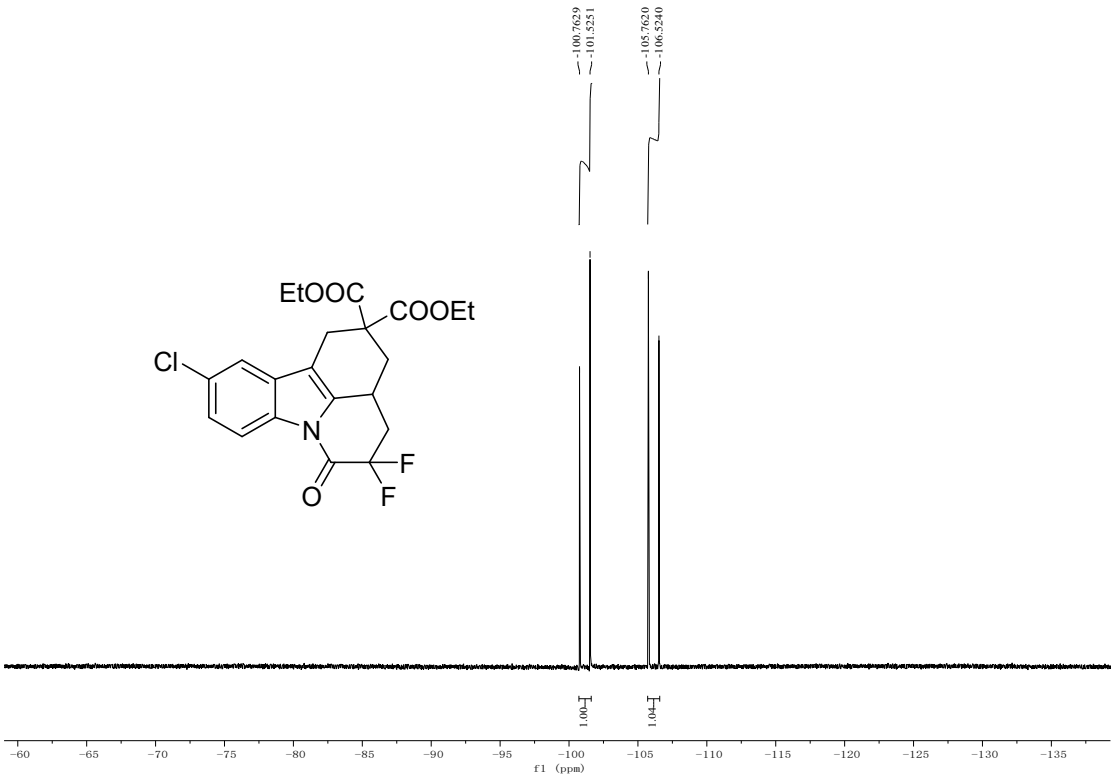
^{1}H NMR (400 MHz, $CDCl_3$) of **3la**:



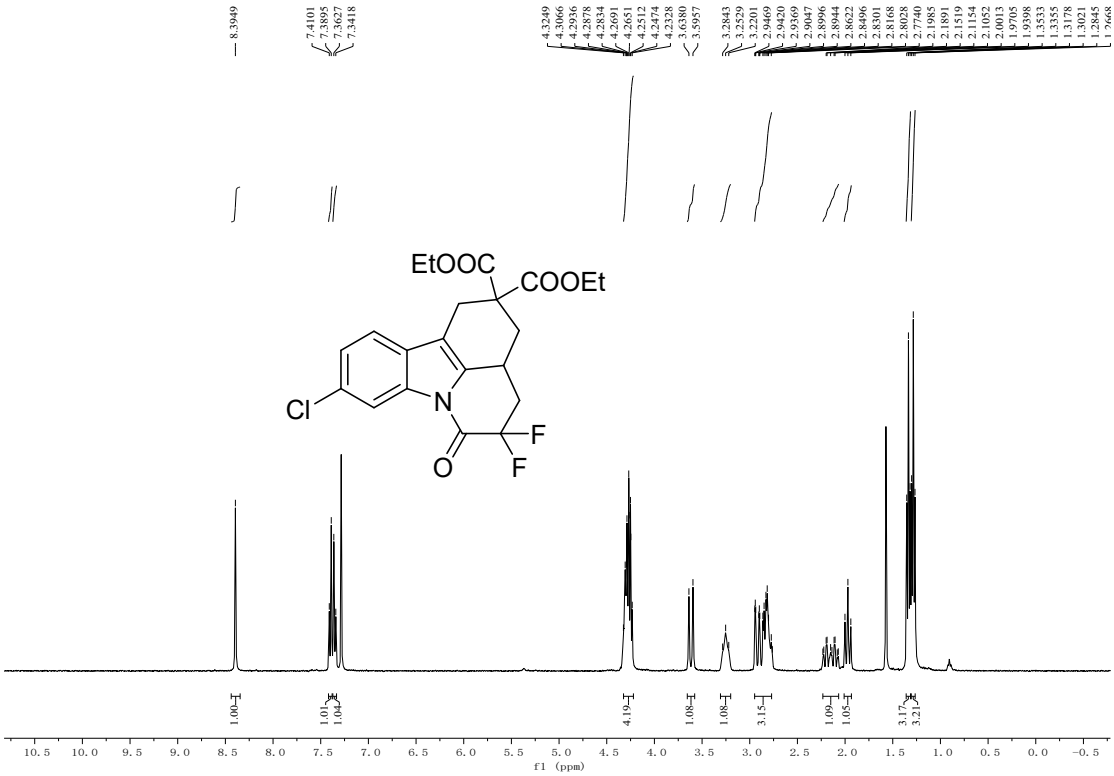
^{13}C NMR (100 MHz, $CDCl_3$) of **3la**:



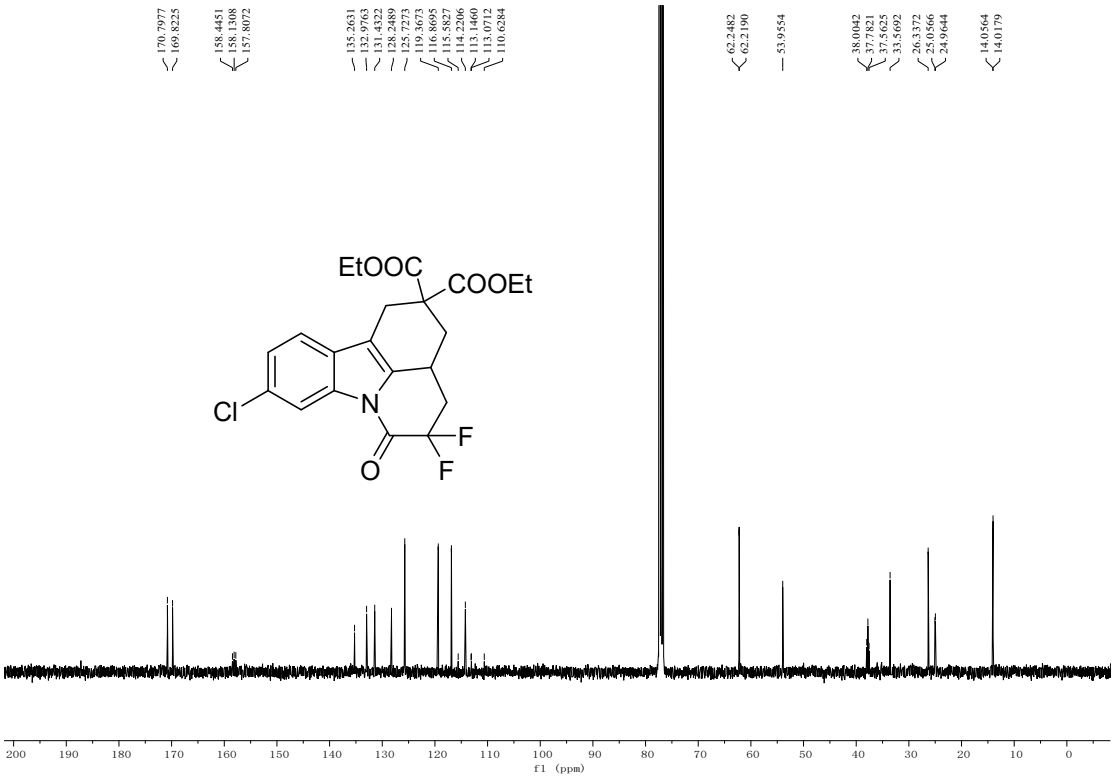
^{19}F NMR (376 MHz, $CDCl_3$) of **3la**:



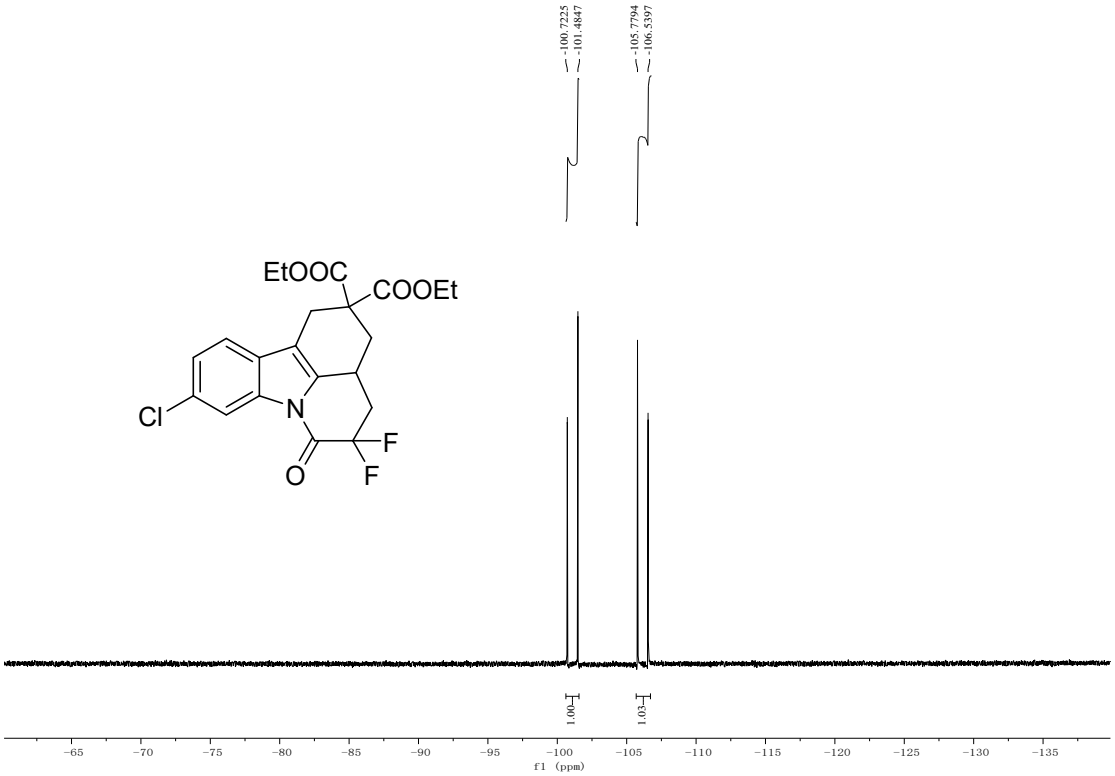
^{1}H NMR (400 MHz, $CDCl_3$) of **3ma**:



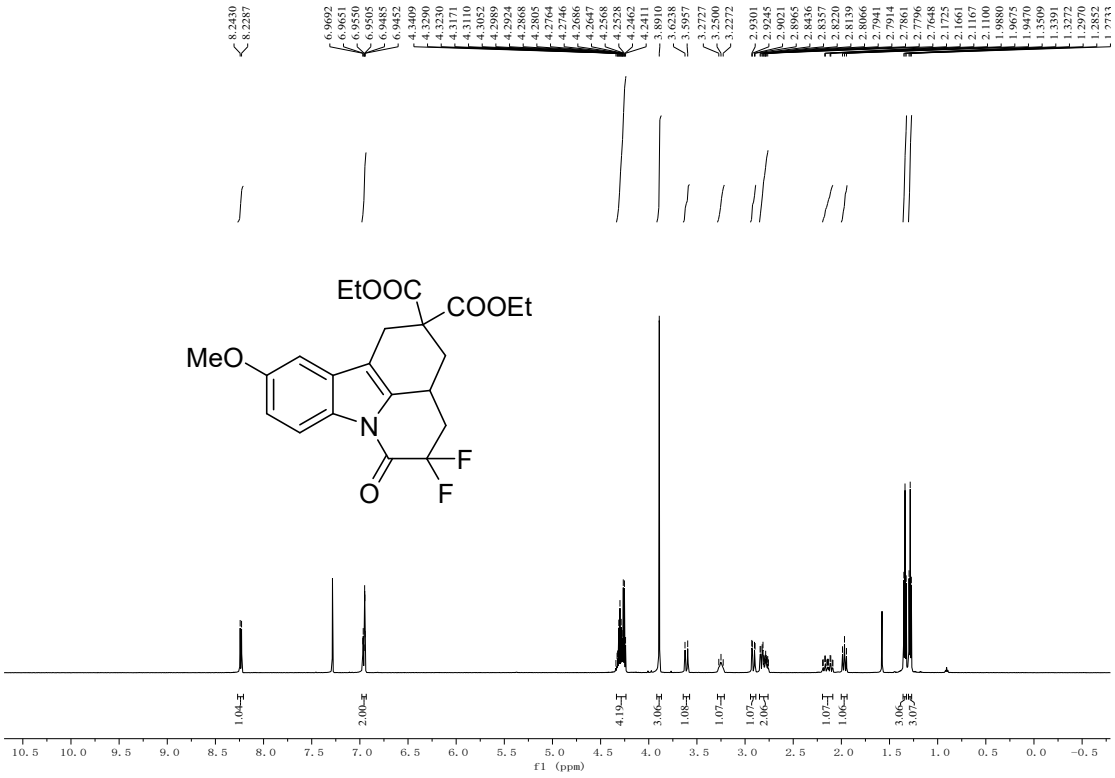
^{13}C NMR (100 MHz, $CDCl_3$) of **3ma**:



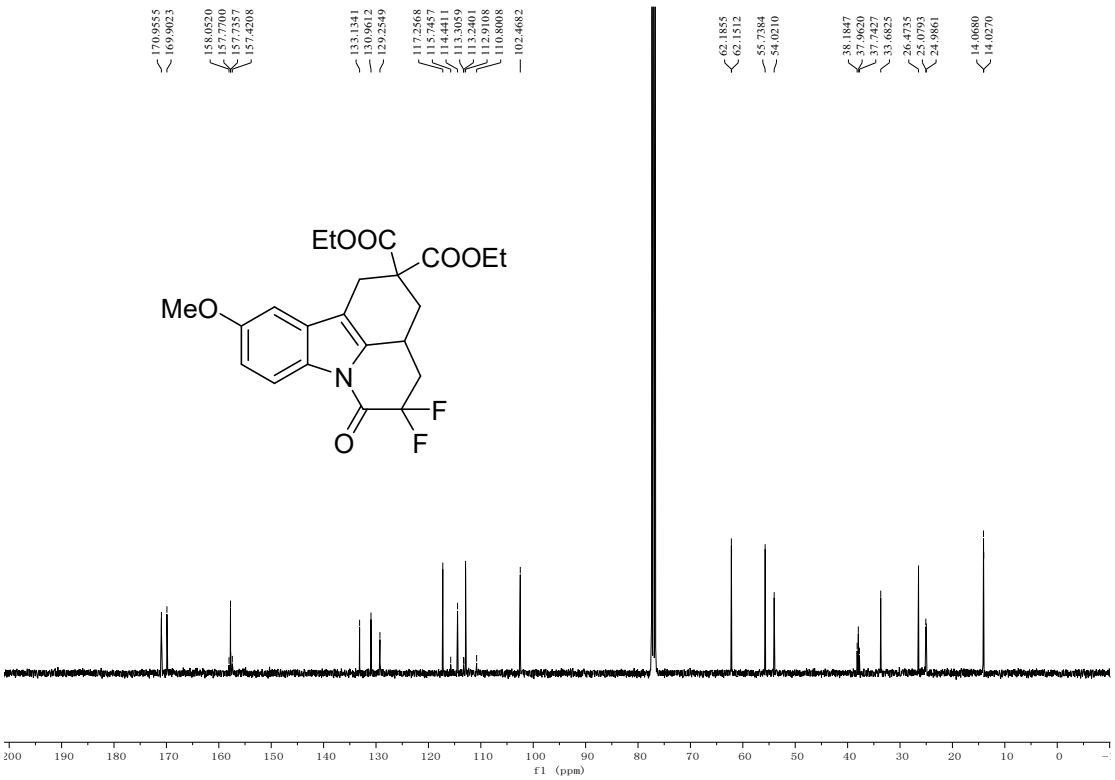
^{19}F NMR (376 MHz, $CDCl_3$) of **3ma**:



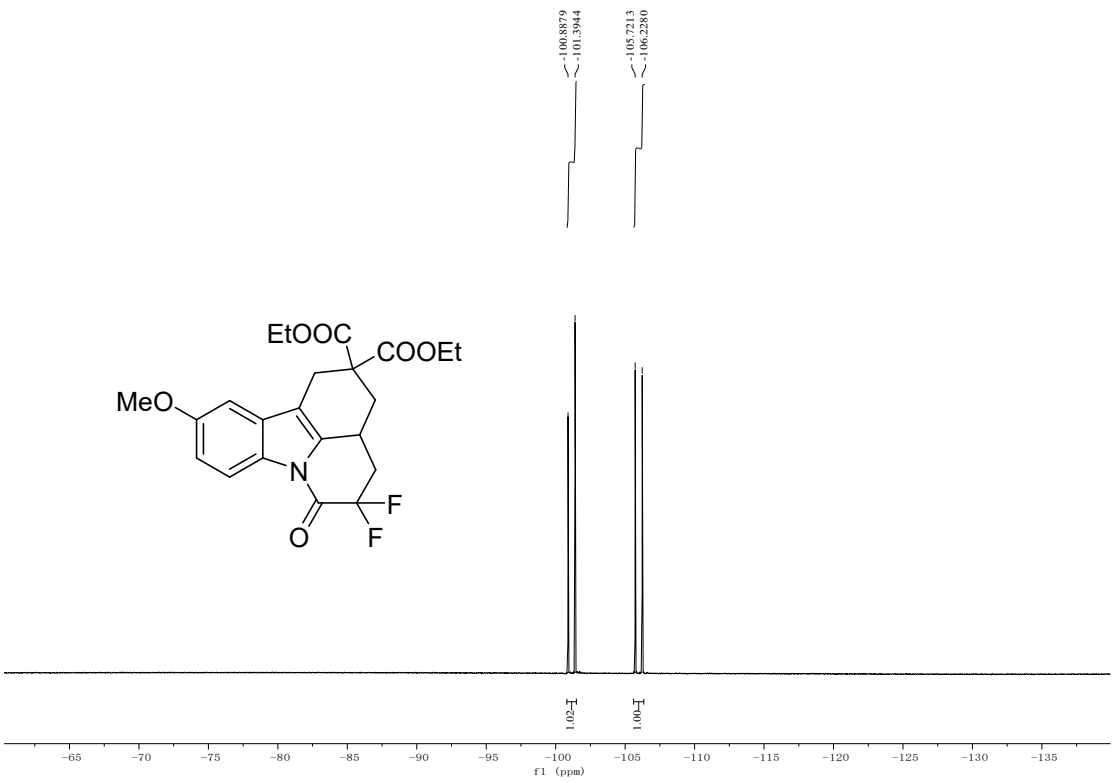
^{1}H NMR (600 MHz, $CDCl_3$) of **3na**:



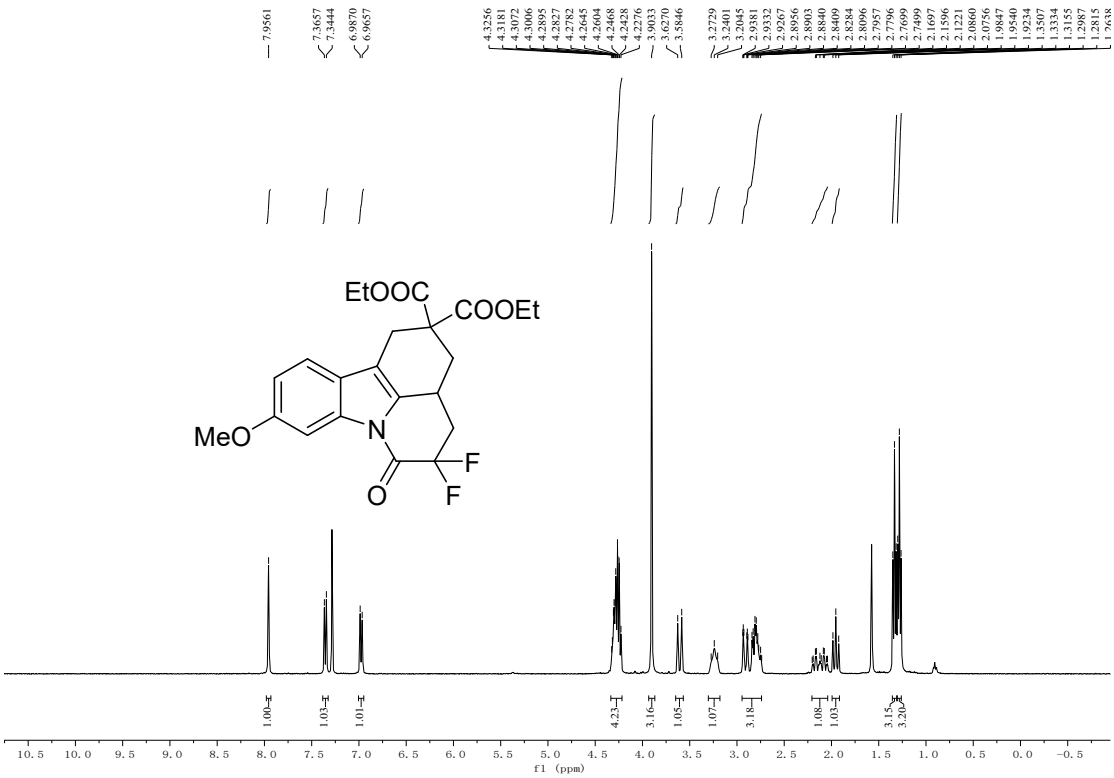
^{13}C NMR (100 MHz, $CDCl_3$) of **3na**:



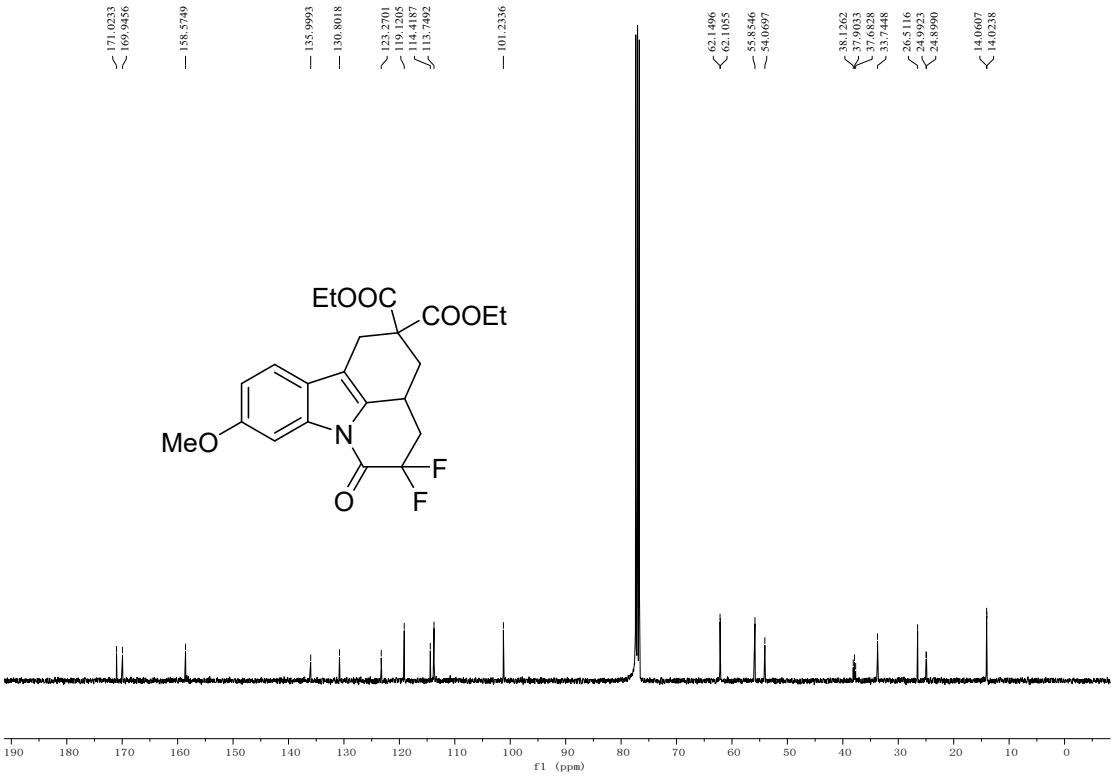
^{19}F NMR (565 MHz, $CDCl_3$) of **3na**:



^{1}H NMR (400 MHz, $CDCl_3$) of **3oa**:

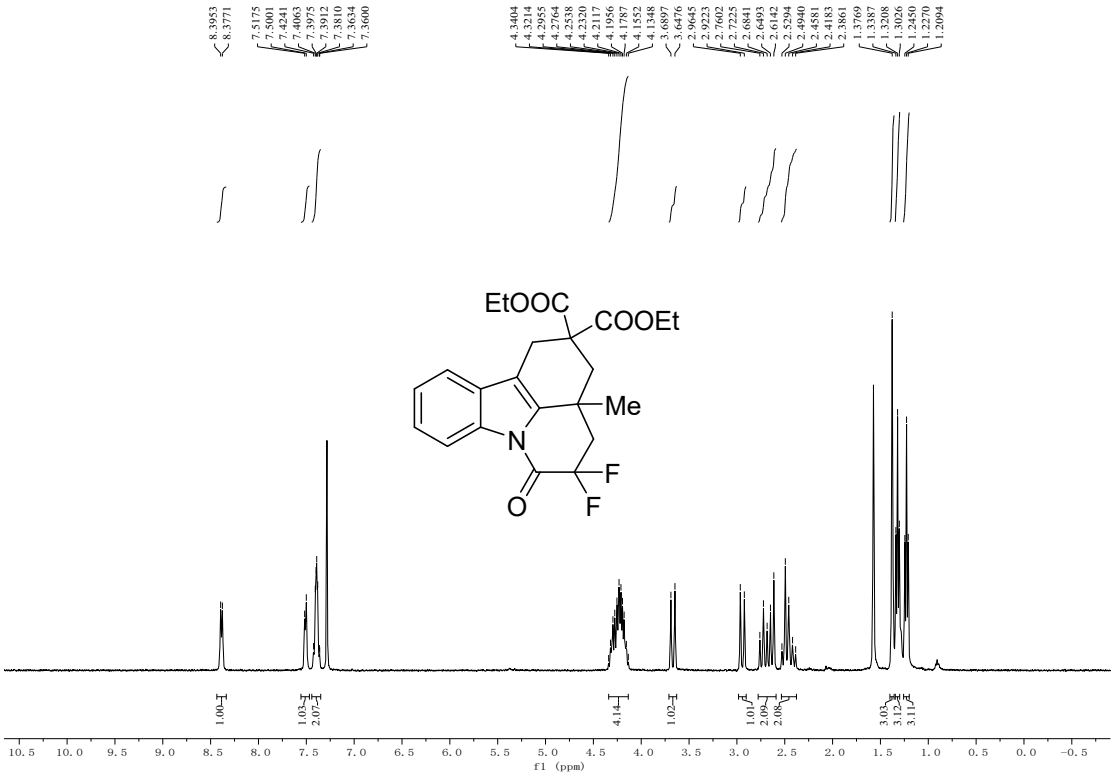


^{13}C NMR (100 MHz, $CDCl_3$) of **3oa**:

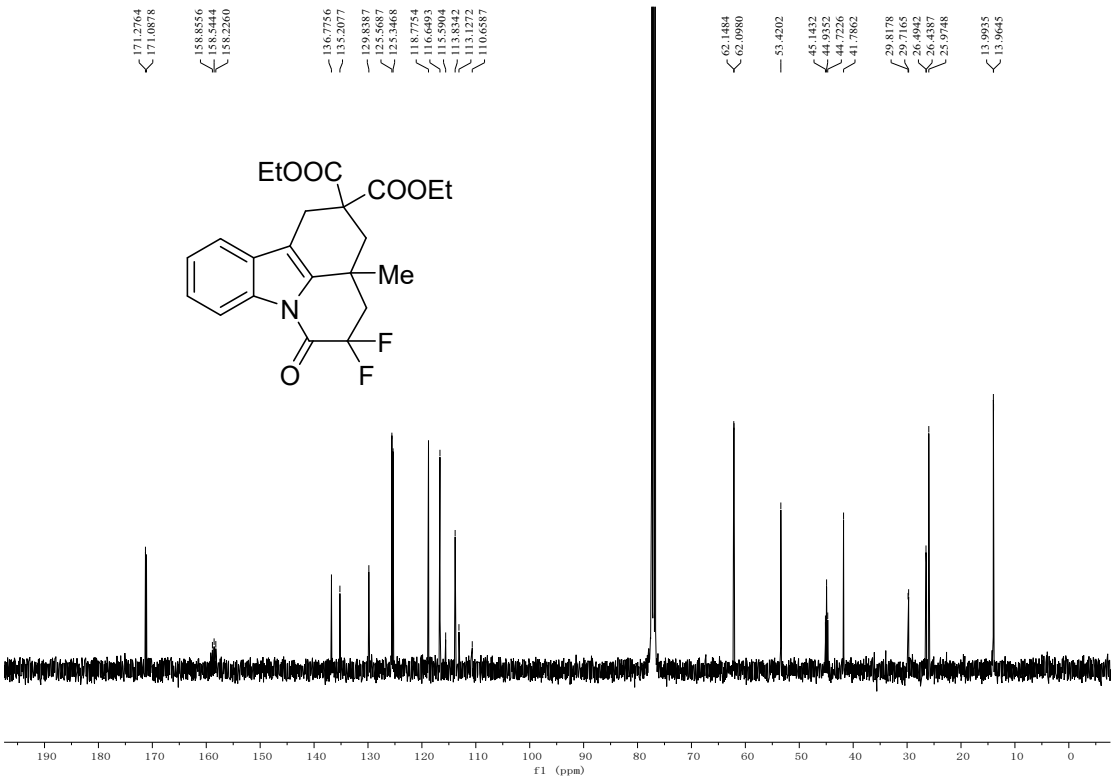


^{19}F NMR (376 MHz, $CDCl_3$) of **3oa**:

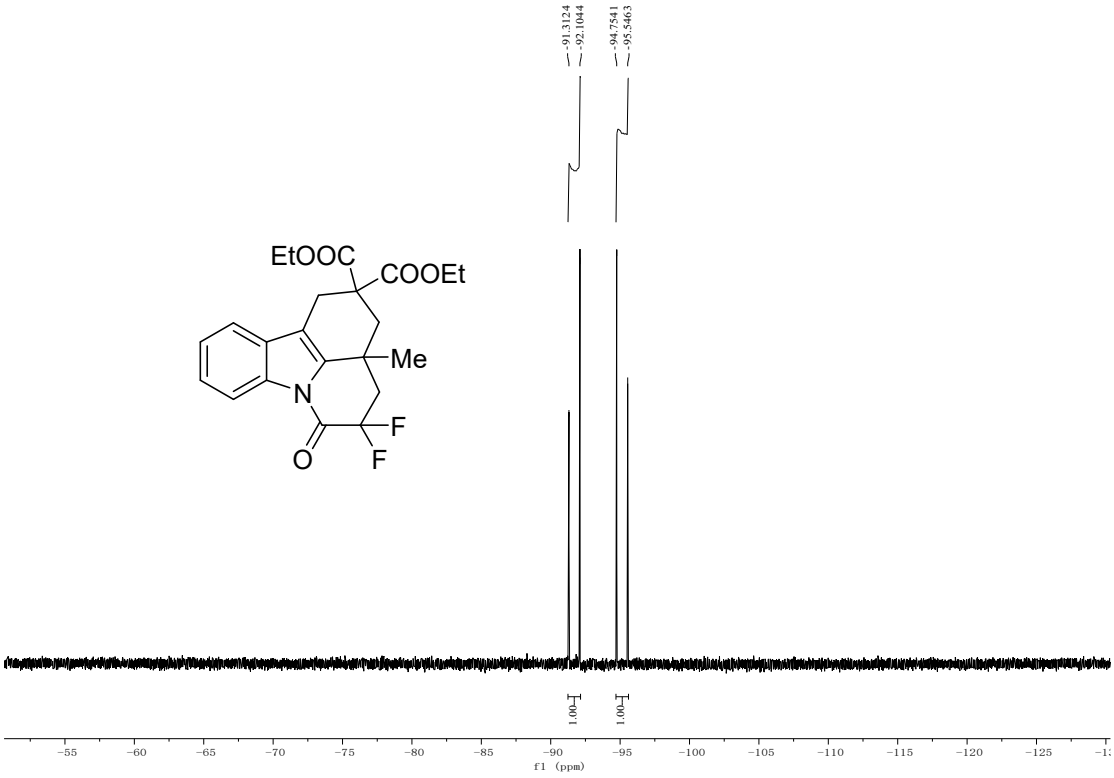
^{1}H NMR (400 MHz, $CDCl_3$) of **3qa**:



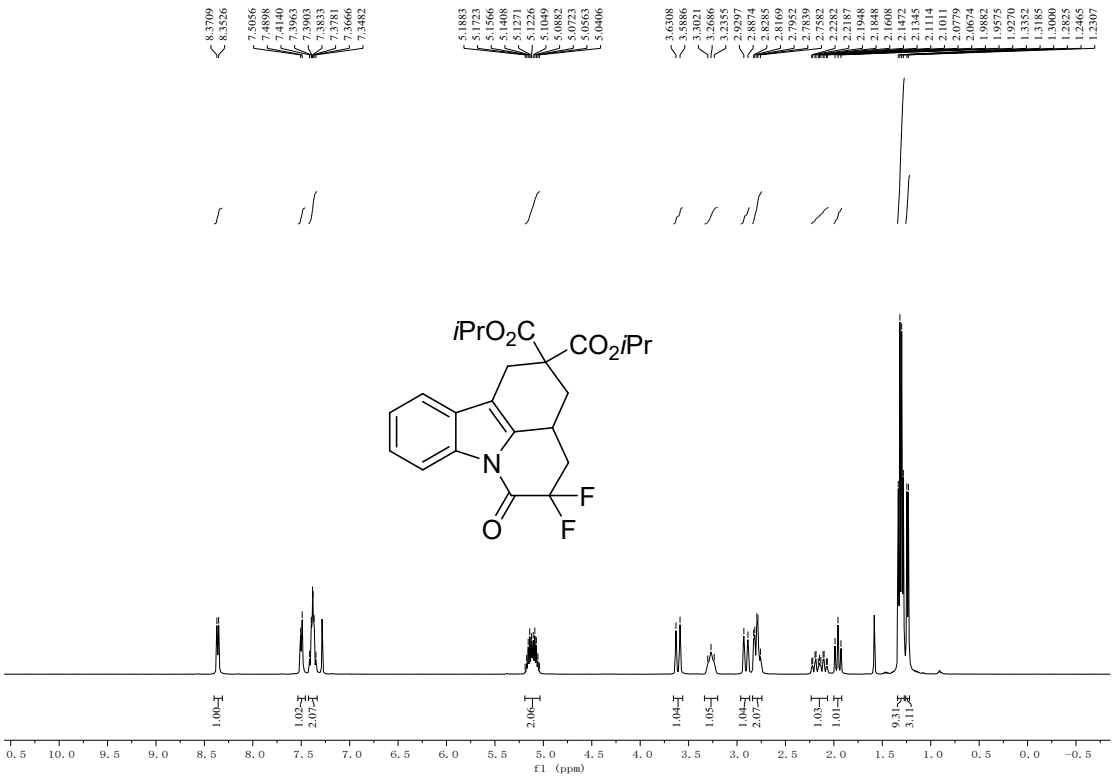
^{13}C NMR (100 MHz, $CDCl_3$) of **3qa**:



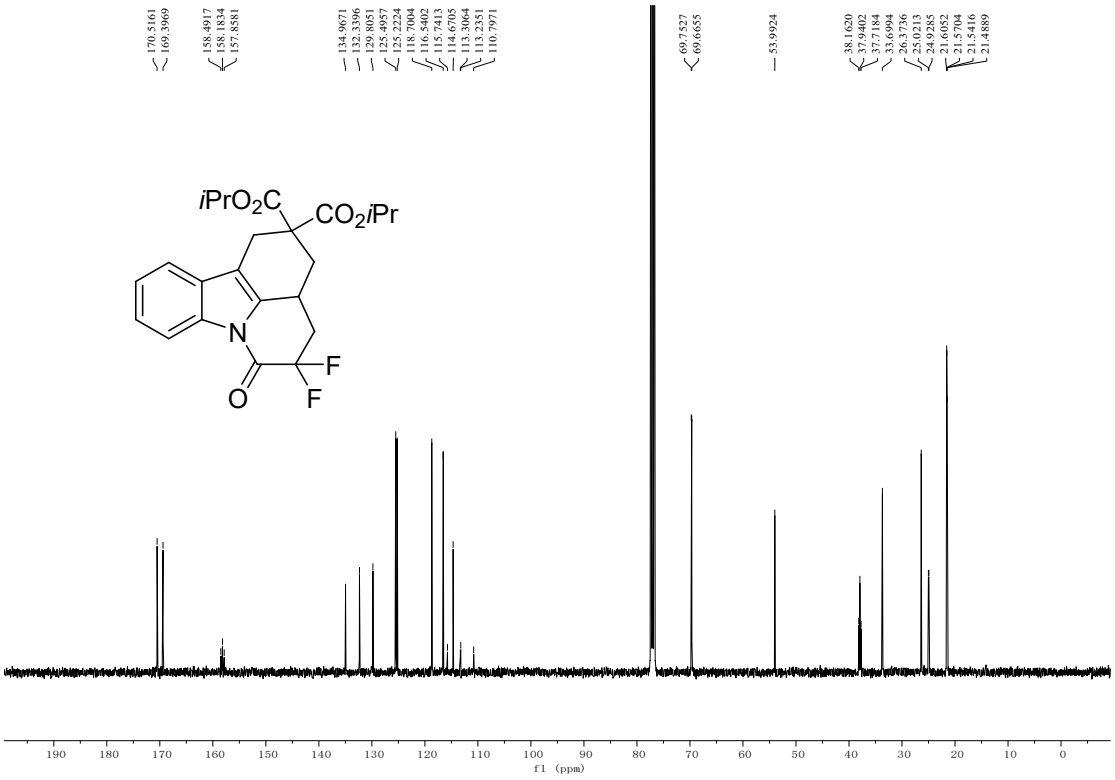
^{19}F NMR (376 MHz, $CDCl_3$) of **3qa**:



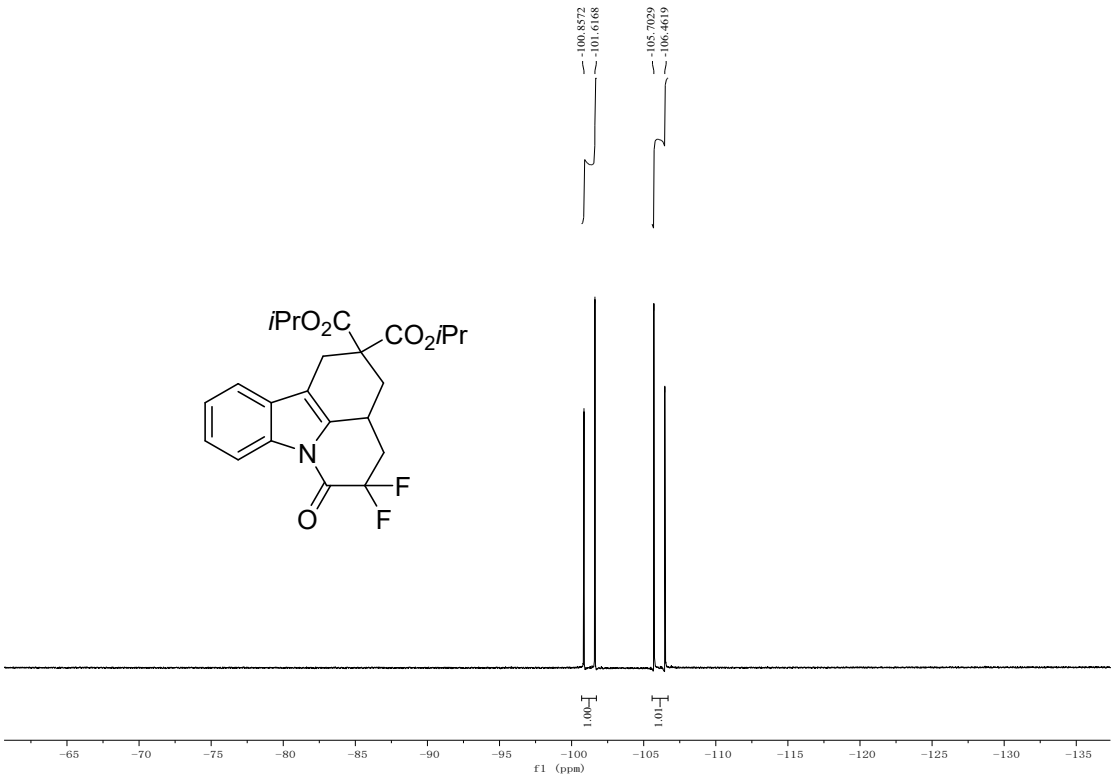
^{1}H NMR (400 MHz, $CDCl_3$) of **3sa**:



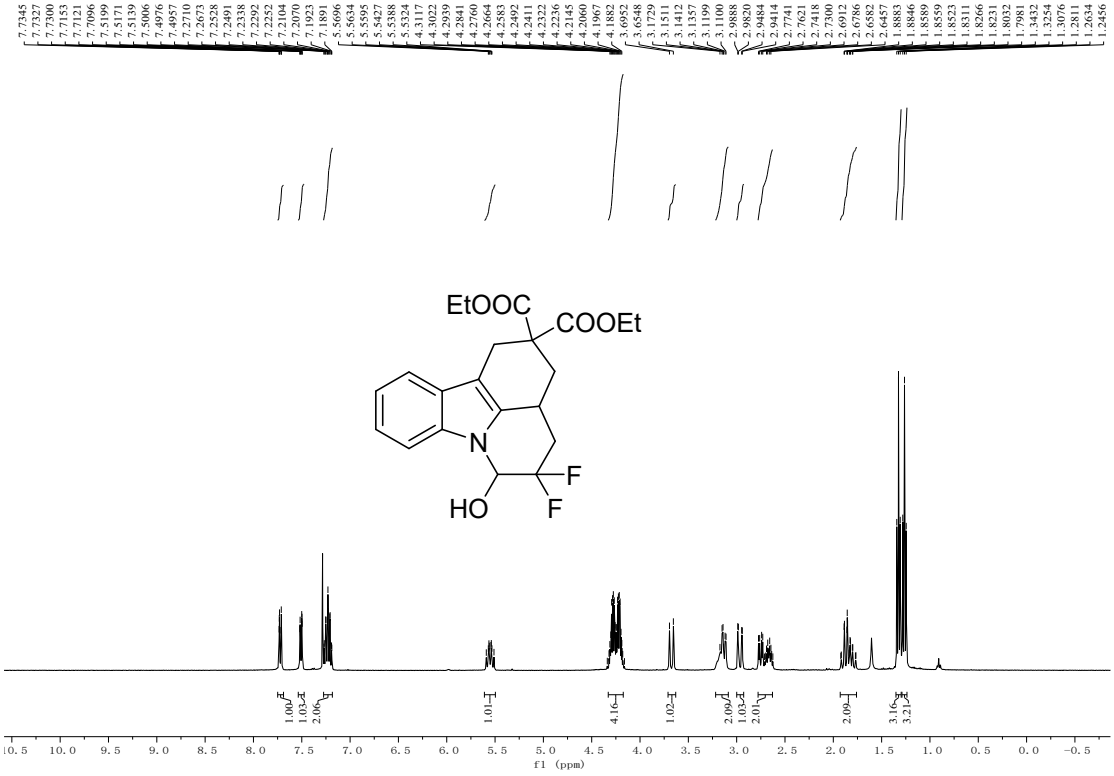
^{13}C NMR (100 MHz, $CDCl_3$) of **3sa**:



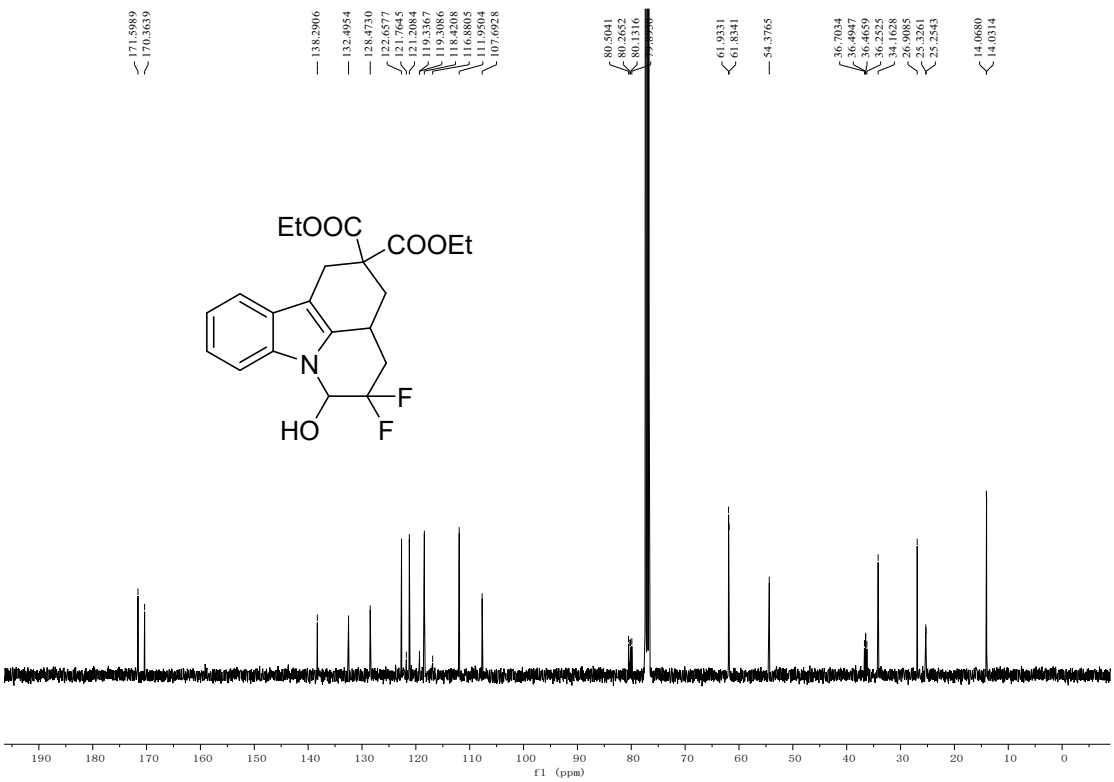
^{19}F NMR (376 MHz, $CDCl_3$) of **3sa**:



^{1}H NMR (400 MHz, $CDCl_3$) of **6**:



^{13}C NMR (100 MHz, $CDCl_3$) of **6**:



^{19}F NMR (376 MHz, $CDCl_3$) of **6**: