Supporting Information

Total synthesis of (±)-3-demethoxyerythratidinone via Tf_2O-promoted cascade reaction of enaminone

Mingliang Lou,[a] Xiaolei Liu,[b] Shoule Han,[ac] Songlin Bai,[ad] and Xiangbing Qi[ac*]

[a.] National Institute of Biological Sciences (NIBS), Beijing 102206, China.

[b.] Institute for Smart Materials & Engineering, School of Chemistry and Chemical Engineering, University of Jinan, Jinan 250022, Shandong, China.

[c.] Tsinghua Institute of Multidisciplinary Biomedical Research, Tsinghua University, Beijing 100084, China.

[d.] School of Life Sciences, Tsinghua University, Beijing 100084, China.

*Corresponding author: qixiangbing@nibs.ac.cn.

Contents

1. General Information 3

2. General Procedures for Syntheses of Substrates 4

3. General Procedures for Tf_2O-Promoted Cascade Reaction 6

4. Characterization Data of Substrates 17 and Products 19 7

5. Hydrolysis of the Enol Triflate in Compound 19a 26

6. Total Synthesis of 3-Demethoxyerythratidinone (3) 27

7. Comparative Spectral Data 31

8. References 32

9. X-Ray Crystallography Data of 19p and 19q 33

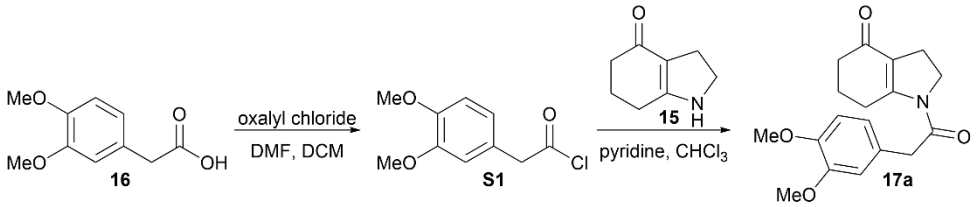
10. Copies of NMR Spectra 37

1. General Information

All reactions were carried out under an argon atmosphere in flame-dried glassware with magnetic stirring unless otherwise indicated. Commercially obtained reagents were used as received. Solvents were dried by passage through an activated alumina column under argon. Liquids and solutions were transferred via syringe. Reactions were monitored by UPLC-MS and thin layer chromatography (TLC). Visualization was accomplished with UV light, iodine, $KMnO_4$ or phosphomolybdic acid. All silica gel column chromatography was performed using silica gel with particle size of 300-400 mesh. ^1H and ^{13}C NMR spectra were recorded on Varian Inova-400 spectrometers. Data for ^1H NMR spectra are reported relative to $CDCl_3$ (7.26 ppm) as an internal standard and are reported as follows: chemical shift (δ), multiplicity (s, singlet; d, doublet; t, triplet; q, quartet; quint, quintet; m, multiplet; br, broad), coupling constant *J* (hertz), and integration. Data for ^{13}C NMR spectra are reported relative to $CDCl_3$ (77.2 ppm) as an internal standard and are reported in terms of chemical shifts (δ). Mass spectral data were obtained on an Agilent 1290 LC-6540 QTOF instrument.

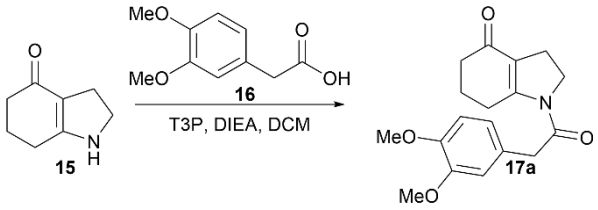
2. General Procedures for Syntheses of Substrates

2.1 General Method A (take **17a** for example):



To a solution of **16** (1.5 mmol, 294 mg, 1.5 equiv.) in 5.0 mL of anhydrous DCM was added anhydrous DMF (0.15 mmol, 11 mg, 0.15 equiv.) at room temperature. The mixture was cooled to 0 °C and oxalyl chloride (1.8 mmol, 228 mg, 1.8 equiv.) was added dropwise. After being stirred at 0 °C for 10 min, the reaction mixture was moved to room temperature and stirred at room temperature for 3 h. The reaction mixture was concentrated under reduced pressure to give crude **S1**, which was dissolved in 1.0 mL of $CHCl_3$ and used directly for next step. To a solution of **15** (1.0 mmol, 137 mg, 1.0 equiv.) in 2.0 mL of $CHCl_3$ was added pyridine (2.0 mmol, 158 mg, 2.0 equiv.) at room temperature. The mixture was cooled to 0 °C and the freshly prepared **S1** was added dropwise. After being stirred at 0 °C for 10 min, the reaction mixture was moved to room temperature and stirred at room temperature for 16 h. The reaction was quenched with a saturated sodium bicarbonate aqueous solution and the mixture was extracted three times with DCM. The combined organic layer was washed with brine, dried over anhydrous sodium sulfate, and concentrated under reduced pressure to give a residue, which was purified via column chromatography (0−2% methanol in dichloromethane) to give **17a** as a white solid (0.80 mmol, 252 mg, 80% yield).

2.2 General Method B (take **17a** for example):

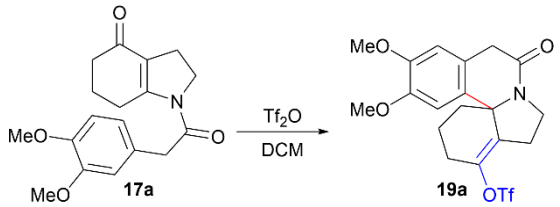


To a solution of **15** (1.0 mmol, 137 mg, 1.0 equiv.) and **16** (1.0 mmol, 196 mg, 1.0 equiv.) in 5.0 mL of DCM was added DIEA (2.0 mmol, 259 mg, 2.0 equiv.) at room temperature. The mixture was cooled to 0 °C, and T3P (2.0 mmol, 1.27 g, 2.0 equiv., 50 wt % in EA) was added dropwise. After being stirred at 0 °C for 10 min, the reaction mixture was moved to room temperature and stirred at room temperature for 16 h. The reaction mixture was diluted with water and extracted three times with DCM. The combined organic layer was washed with brine, dried over anhydrous sodium sulfate, and concentrated under reduced pressure to give a residue, which was purified via

column chromatography (0−2% methanol in dichloromethane) to give **17a** as a white solid (0.85 mmol, 268 mg, 85% yield).

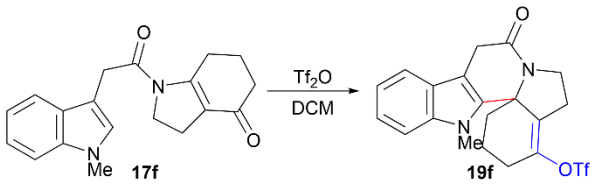
3. General Procedures for Tf_2O-Promoted Cascade Reaction

3.1 General Method C (take **19a** for example):



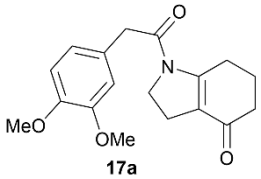
To a solution of **17a** (0.2 mmol, 63 mg, 1.0 equiv.) in 1.0 mL of anhydrous DCM in a sealed tube was added Tf_2O (0.4 mmol, 113 mg, 2.0 equiv.) dropwise at room temperature. After being stirred at room temperature for 30 min, the reaction mixture was moved to 35 °C and stirred at 35 °C for 24 h. After being cooled to room temperature, the reaction was quenched with a saturated sodium bicarbonate aqueous solution and the mixture was extracted three times with DCM. The combined organic layer was washed with brine, dried over anhydrous sodium sulfate, and concentrated under reduced pressure to give a residue, which was purified via column chromatography (0−2% methanol in dichloromethane) to give **19a** as a brown solid (0.15 mmol, 65.3 mg, 73% yield).

3.2 General Method D (take **19f** for example):



To a solution of **17f** (0.2 mmol, 61.6 mg, 1.0 equiv.) in 1.0 mL of anhydrous DCM in a sealed tube was added Tf_2O (0.4 mmol, 113 mg, 2.0 equiv.) dropwise at -78 °C. After being stirred at -78 °C for 1 h, the reaction mixture was moved to -20 °C and stirred at -20 °C for 24 h. The reaction was quenched with a saturated sodium bicarbonate aqueous solution and the mixture was extracted three times with DCM. The combined organic layer was washed with brine, dried over anhydrous sodium sulfate, and concentrated under reduced pressure to give a residue, which was purified via column chromatography (0−2% methanol in dichloromethane) to give **19f** as a brown solid (0.13 mmol, 57.7 mg, 66% yield).

4. Characterization Data of Substrates 17 and Products 19



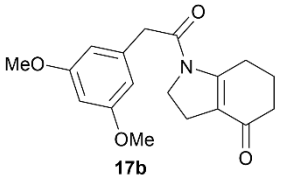
17a

1-(2-(3,4-dimethoxyphenyl)acetyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (**17a**): prepared from 2-(3,4-dimethoxyphenyl)acetic acid and **15** following General Method B, 268 mg, 85% yield, white solid, mp 117–119 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.83 (d, J = 8.0 Hz, 1H), 6.81–6.75 (m, 2H), 3.98 (t, J = 9.0 Hz, 2H), 3.87 (s, 3H), 3.86 (s, 3H), 3.66 (s, 2H), 3.06 (t, J = 5.9 Hz, 2H), 2.75 (t, J = 9.0 Hz, 2H), 2.35 (t, J = 6.5 Hz, 2H), 2.02 (quint, J = 6.3 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.52, 170.49, 161.57, 149.16, 148.29, 125.52, 121.29, 120.27, 112.10, 111.28, 55.87, 48.59, 43.07, 36.54, 26.13, 24.63, 22.67;

HRMS (ESI) calculated for $C_{18}H_{22}NO_4$ $[M+H]^+$ m/z 316.1549, found 316.1550.



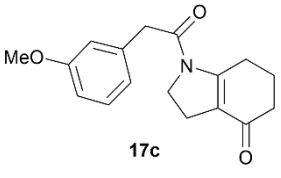
17b

1-(2-(3,5-dimethoxyphenyl)acetyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (**17b**): prepared from 2-(3,5-dimethoxyphenyl)acetic acid and **15** following General Method A, 265 mg, 84% yield, light-yellow solid, mp 126–128 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.42–6.40 (m, 2H), 6.40–6.37 (m, 1H), 3.96 (t, J = 9.3 Hz, 2H), 3.79 (s, 3H), 3.78 (s, 3H), 3.66 (s, 2H), 3.07 (t, J = 7.0 Hz, 2H), 2.74 (t, J = 9.8 Hz, 2H), 2.36 (t, J = 6.6 Hz, 2H), 2.03 (quint, J = 7.5, 7.0 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.39, 169.86, 161.40, 160.89, 135.22, 120.17, 107.05, 98.79, 55.17, 48.48, 43.64, 36.43, 25.97, 24.48, 22.52;

HRMS (ESI) calculated for $C_{18}H_{22}NO_4$ $[M+H]^+$ m/z 316.1549, found 316.1543.



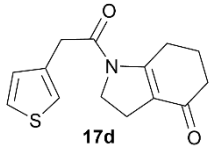
17c

1-(2-(3-methoxyphenyl)acetyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (17c): prepared from 2-(3-methoxyphenyl)acetic acid and **15** following General Method A, 228 mg, 80% yield, light-yellow solid, mp 75–77 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27 (t, J = 7.8 Hz, 1H), 6.84 (d, J = 1.8 Hz, 1H), 6.83–6.79 (m, 2H), 3.97 (t, J = 9.1 Hz, 2H), 3.80 (s, 3H), 3.70 (s, 2H), 3.07 (t, J = 6.1 Hz, 2H), 2.74 (t, J = 9.1 Hz, 2H), 2.36 (t, J = 6.6 Hz, 2H), 2.03 (quint, J = 6.2 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.41, 170.01, 161.40, 159.72, 134.55, 129.66, 121.24, 120.15, 114.77, 112.36, 55.05, 48.46, 43.38, 36.43, 25.97, 24.47, 22.52;

HRMS (ESI) calculated for $C_{17}H_{20}NO_3$ $[M+H]^+$ m/z 286.1443, found 286.1438.



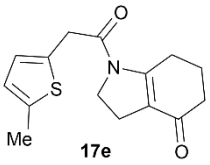
17d

1-(2-(thiophen-3-yl)acetyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (**17d**): prepared from 2-(thiophen-3-yl)acetic acid and **15** following General Method A, 211 mg, 81% yield, light-yellow solid, mp 99–101 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34 (dd, J = 4.9, 3.0 Hz, 1H), 7.14 (d, J = 2.4 Hz, 1H), 7.03 (d, J = 4.9 Hz, 1H), 3.99 (t, J = 9.1 Hz, 2H), 3.75 (s, 2H), 3.07 (t, J = 6.0 Hz, 2H), 2.76 (t, J = 9.0 Hz, 2H), 2.39 (t, J = 6.6 Hz, 2H), 2.04 (quint, J = 6.3 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 195.82, 169.30, 160.94, 132.62, 127.84, 125.51, 122.36, 119.69, 47.99, 37.41, 35.99, 25.53, 24.06, 22.10;

HRMS (ESI) calculated for $C_{14}H_{16}NO_2S$ $[M+H]^+$ m/z 262.0901, found 262.0899.



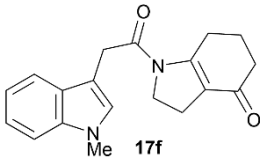
17e

1-(2-(5-methylthiophen-2-yl)acetyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (**17e**): prepared from 2-(5-methylthiophen-2-yl)acetic acid and **15** following General Method A, 195 mg, 71% yield, brown solid, mp 109–111 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.70 (s, 1H), 6.61 (s, 1H), 4.02 (t, J = 9.1 Hz, 2H), 3.83 (s, 2H), 3.07 (s, 2H), 2.77 (t, J = 10.0 Hz, 2H), 2.45 (s, 3H), 2.36 (t, J = 6.6 Hz, 2H), 2.03 (quint, J = 6.3 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.57, 169.30, 161.19, 139.96, 132.01, 126.68, 124.90, 120.50, 48.61, 37.83, 36.59, 26.08, 24.67, 22.67, 15.28;

HRMS (ESI) calculated for $C_{15}H_{18}NO_2S$ $[M+H]^+$ m/z 276.1058, found 276.1057.



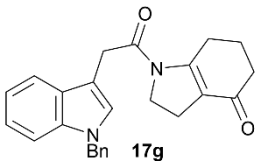
17f

1-(2-(1-methyl-1H-indol-3-yl)acetyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (**17f**): prepared from 2-(1-methyl-1H-indol-3-yl)acetic acid and **15** following General Method A, 216 mg, 70% yield, light-yellow solid, mp 143–145 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, J = 8.6 Hz, 1H), 7.32 (d, J = 8.3 Hz, 1H), 7.25 (t, J = 7.6 Hz, 1H), 7.15 (t, J = 7.4 Hz, 1H), 7.03 (s, 1H), 4.02 (t, J = 9.6 Hz, 2H), 3.83 (s, 2H), 3.77 (s, 3H), 3.07 (t, J = 6.1 Hz, 2H), 2.72 (t, J = 8.6 Hz, 2H), 2.34 (t, J = 6.6 Hz, 2H), 2.01 (quint, J = 7.3, 6.7 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.54, 170.70, 161.91, 136.93, 127.61, 127.54, 122.01, 120.10, 119.41, 118.71, 109.45, 105.84, 48.68, 36.54, 33.80, 32.81, 26.19, 24.65, 22.70;

HRMS (ESI) calculated for $C_{19}H_{20}N_2O_2$ $[M+H]^+$ m/z 309.1603, found 309.1602.



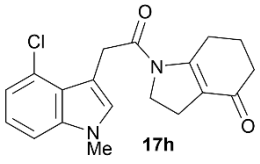
17g

1-(2-(1-benzyl-1H-indol-3-yl)acetyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (**17g**): prepared from 2-(1-benzyl-1H-indol-3-yl)acetic acid and **15** following General Method A, 273 mg, 71% yield, white solid, mp 56–58 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (d, J = 7.8 Hz, 1H), 7.32–7.27 (m, 3H), 7.26–7.25 (m, 1H), 7.21 (t, J = 7.5 Hz, 1H), 7.16 (d, J = 7.0 Hz, 1H), 7.14–7.08 (m, 3H), 5.31 (s, 2H), 4.03 (t, J = 9.1 Hz, 2H), 3.86 (s, 2H), 3.08 (t, J = 6.1 Hz, 2H), 2.72 (t, J = 9.1 Hz, 2H), 2.35 (t, J = 6.6 Hz, 2H), 2.02 (quint, J = 6.4 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.69, 170.64, 161.94, 137.38, 136.65, 128.81, 127.89, 127.73, 127.14, 126.85, 122.28, 120.15, 119.71, 119.00, 110.00, 106.75, 50.04, 48.68, 36.59, 33.95, 26.23, 24.70, 22.72;

HRMS (ESI) calculated for $C_{25}H_{25}N_2O_2$ $[M+H]^+$ m/z 385.1916, found 385.1920.



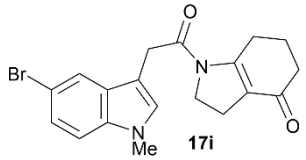
17h

1-(2-(4-chloro-1-methyl-1H-indol-3-yl)acetyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (**17h**): prepared from 2-(4-chloro-1-methyl-1H-indol-3-yl)acetic acid and **15** following General Method A, 270 mg, 79% yield, brown solid, mp 155–157 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (d, J = 8.0 Hz, 1H), 7.11 (t, J = 7.8 Hz, 1H), 7.06 (d, J = 7.5 Hz, 1H), 7.03 (s, 1H), 4.10 (t, J = 9.1 Hz, 4H), 3.76 (s, 3H), 3.12–3.04 (m, 2H), 2.81 (t, J = 9.1 Hz, 2H), 2.37 (t, J = 6.2 Hz, 2H), 2.04 (quint, J = 6.2 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.49, 171.19, 161.75, 138.28, 129.32, 125.69, 124.08, 122.22, 120.08, 119.85, 108.35, 106.43, 48.48, 36.47, 33.94, 32.91, 25.96, 24.56, 22.59;

HRMS (ESI) calculated for $C_{19}H_{20}ClN_2O_2$ $[M+H]^+$ *m*/*z* 343.1213, found 343.1210.



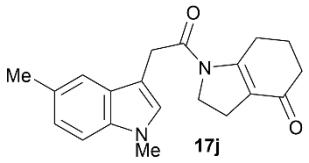
17i

1-(2-(5-bromo-1-methyl-1H-indol-3-yl)acetyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (**17i**): prepared from 2-(5-bromo-1-methyl-1H-indol-3-yl)acetic acid and **15** following General Method A, 283 mg, 73% yield, white solid, mp 159–161 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (s, 1H), 7.32 (d, *J* = 8.6 Hz, 1H), 7.18 (d, *J* = 8.3 Hz, 1H), 7.04 (s, 1H), 4.03 (t, *J* = 9.3 Hz, 2H), 3.78 (s, 2H), 3.76 (s, 3H), 3.08 (t, *J* = 7.3 Hz, 2H), 2.79 (t, *J* = 9.2 Hz, 2H), 2.36 (t, *J* = 7.1 Hz, 2H), 2.03 (quint, *J* = 7.3 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.57, 170.26, 161.64, 135.58, 129.31, 128.99, 124.73, 121.30, 120.19, 112.76, 111.02, 105.67, 48.61, 36.57, 33.29, 32.97, 26.15, 24.68, 22.68;

HRMS (ESI) calculated for $C_{19}H_{20}BrN_2O_2$ $[M+H]^+$ *m*/*z* 387.0708, found 387.0711.



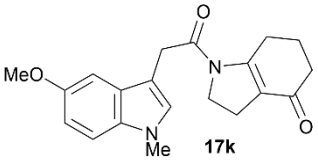
17j

1-(2-(1,5-dimethyl-1H-indol-3-yl)acetyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (**17j**): prepared from 2-(1,5-dimethyl-1H-indol-3-yl)acetic acid and **15** following General Method A, 190 mg, 59% yield, brown solid, mp 136–138 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (s, 1H), 7.21 (d, *J* = 8.8 Hz, 1H), 7.08 (d, *J* = 8.4 Hz, 1H), 6.98 (s, 1H), 4.03 (t, *J* = 9.1 Hz, 2H), 3.81 (s, 2H), 3.75 (s, 3H), 3.09 (t, *J* = 5.7 Hz, 2H), 2.73 (t, *J* = 9.9 Hz, 2H), 2.47 (s, 3H), 2.35 (t, *J* = 6.1 Hz, 2H), 2.01 (quint, *J* = 6.0 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.39, 170.62, 161.72, 135.20, 128.44, 127.59, 127.50, 123.46, 119.86, 118.12, 108.99, 105.04, 48.44, 36.39, 33.61, 32.63, 26.00, 24.46, 22.52, 21.35;

HRMS (ESI) calculated for $C_{20}H_{23}N_2O_2$ $[M+H]^+$ *m*/*z* 323.1759, found 323.1760.



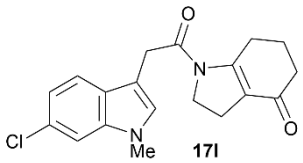
17k

1-(2-(5-methoxy-1-methyl-1H-indol-3-yl)acetyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (**17k**): prepared from 2-(5-methoxy-1-methyl-1H-indol-3-yl)acetic acid and **15** following General Method A, 243 mg, 72% yield, brown solid, mp 124–126 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21 (d, J = 8.9 Hz, 1H), 7.05 (d, J = 1.8 Hz, 1H), 6.98 (s, 1H), 6.91 (dd, J = 8.5, 2.6 Hz, 1H), 4.03 (t, J = 9.1 Hz, 2H), 3.87 (s, 3H), 3.80 (s, 2H), 3.75 (s, 3H), 3.08 (t, J = 6.0 Hz, 2H), 2.73 (t, J = 9.0 Hz, 2H), 2.35 (t, J = 6.6 Hz, 2H), 2.02 (quint, J = 6.4 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.43, 170.55, 161.70, 153.97, 132.22, 128.07, 127.76, 119.95, 112.04, 110.12, 105.11, 100.53, 55.84, 48.49, 36.45, 33.82, 32.84, 26.07, 24.54, 22.57;

HRMS (ESI) calculated for $C_{20}H_{23}N_2O_3$ $[M+H]^+$ m/z 339.1708, found 339.1705.



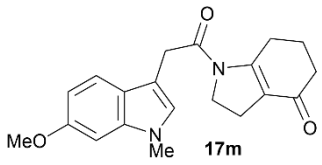
17l

1-(2-(6-chloro-1-methyl-1H-indol-3-yl)acetyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (**17l**): prepared from 2-(6-chloro-1-methyl-1H-indol-3-yl)acetic acid and **15** following General Method A, 263 mg, 77% yield, brown solid, mp 154–156 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (d, J = 8.5 Hz, 1H), 7.31 (d, J = 1.8 Hz, 1H), 7.10 (dd, J = 8.5, 1.8 Hz, 1H), 7.01 (s, 1H), 4.03 (t, J = 9.1 Hz, 2H), 3.80 (s, 2H), 3.74 (s, 3H), 3.07 (t, J = 6.1 Hz, 2H), 2.75 (t, J = 9.1 Hz, 2H), 2.35 (t, J = 6.6 Hz, 2H), 2.02 (quint, J = 6.2 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.57, 170.36, 161.73, 137.34, 128.43, 128.04, 126.21, 120.20, 120.04, 119.80, 109.50, 106.30, 48.64, 36.57, 33.54, 32.88, 26.16, 24.68, 22.69;

HRMS (ESI) calculated for $C_{19}H_{20}ClN_2O_2$ $[M+H]^+$ m/z 343.1213, found 343.1213.



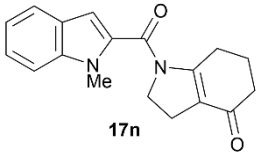
17m

1-(2-(6-methoxy-1-methyl-1H-indol-3-yl)acetyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (**17m**): prepared from 2-(6-methoxy-1-methyl-1H-indol-3-yl)acetic acid and **15** following General Method A, 71 mg, 21% yield, brown solid, mp 206–208 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (d, J = 8.4 Hz, 1H), 6.90 (s, 1H), 6.81 (d, J = 9.9 Hz, 1H), 6.76 (s, 1H), 4.03 (t, J = 9.1 Hz, 2H), 3.88 (s, 3H), 3.80 (s, 2H), 3.72 (s, 3H), 3.07 (t, J = 6.1 Hz, 2H), 2.72 (t, J = 8.9 Hz, 2H), 2.34 (t, J = 6.6 Hz, 2H), 2.02 (quint, J = 6.4 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.51, 170.64, 161.84, 156.56, 137.62, 126.35, 121.86, 119.99, 119.42, 109.31, 105.82, 92.84, 55.65, 48.56, 36.49, 33.87, 32.71, 26.09, 24.56, 22.61;

HRMS (ESI) calculated for $C_{20}H_{23}N_2O_3$ $[M+H]^+$ *m*/*z* 339.1708, found 339.1709.



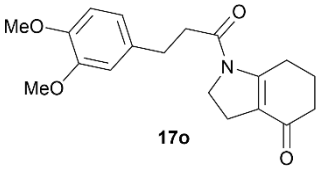
17n

1-(1-methyl-1H-indole-2-carbonyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (**17n**): prepared from 1-methyl-1H-indole-2-carboxylic acid and **15** following General Method A, 206 mg, 70% yield, brown solid, mp 135–137 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (d, *J* = 8.0 Hz, 1H), 7.42–7.33 (m, 2H), 7.18 (dd, *J* = 8.0, 1.9 Hz, 1H), 6.87 (s, 1H), 4.21 (t, *J* = 8.0 Hz, 2H), 3.92 (s, 3H), 2.87–2.68 (m, 4H), 2.43 (t, *J* = 6.5 Hz, 2H), 2.04 (quint, *J* = 6.1 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.40, 162.53, 161.16, 138.69, 131.42, 125.86, 124.75, 122.19, 120.75, 110.13, 106.96, 51.56, 36.86, 31.44, 26.62, 24.80, 23.18;

HRMS (ESI) calculated for $C_{18}H_{19}N_2O_2$ $[M+H]^+$ *m*/*z* 295.1446, found 295.1445.



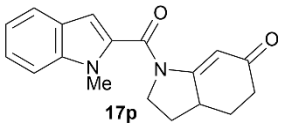
17o

1-(3-(3,4-dimethoxyphenyl)propanoyl)-1,2,3,5,6,7-hexahydro-4H-indol-4-one (**17o**): prepared from 3-(3,4-dimethoxyphenyl)propanoic acid and **15** following General Method A, 250 mg, 76% yield, light-yellow solid, mp 139–141 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.81 (d, *J* = 8.6 Hz, 1H), 6.78–6.73 (m, 2H), 3.94–3.82 (m, 8H), 3.06 (s, 2H), 2.94 (t, *J* = 7.5 Hz, 2H), 2.73 (t, *J* = 9.4 Hz, 2H), 2.66 (t, *J* = 7.5 Hz, 2H), 2.36 (t, *J* = 6.6 Hz, 2H), 2.04 (quint, *J* = 5.8, 5.4 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.30, 171.41, 161.24, 148.71, 147.34, 133.05, 120.00, 119.88, 111.63, 111.13, 55.73, 55.67, 48.24, 38.17, 36.38, 29.80, 26.01, 24.32, 22.53;

HRMS (ESI) calculated for $C_{19}H_{24}NO_4$ $[M+H]^+$ *m*/*z* 330.1705, found 330.1706.



17p

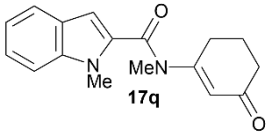
1-(1-methyl-1H-indole-2-carbonyl)-1,2,3,3a,4,5-hexahydro-6H-indol-6-one (**17p**): prepared from 1-methyl-1H-indole-2-carboxylic acid and 1,2,3,3a,4,5-hexahydro-6H-

indol-6-one following General Method B, 182 mg, 62% yield, white solid, mp 216–218 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (d, J = 7.4 Hz, 1H), 7.42–7.32 (m, 2H), 7.16 (dt, J = 7.2, 1.5 Hz, 1H), 6.90 (s, 1H), 6.78 (s, 1H), 4.22 (dd, J = 10.6, 8.3 Hz, 1H), 4.05 (td, J = 11.1, 5.7 Hz, 1H), 3.91 (s, 3H), 3.14–3.01 (m, 1H), 2.56–2.51 (m, 1H), 2.46–2.21 (m, 3H), 1.83 (ddd, J = 26.5, 12.3, 4.6 Hz, 1H), 1.68 (qd, J = 11.9, 8.2 Hz, 1H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 199.85, 163.15, 162.89, 138.61, 131.16, 125.74, 124.80, 122.16, 120.71, 110.11, 109.54, 106.65, 52.94, 41.36, 36.47, 31.48, 29.61, 28.09;

HRMS (ESI) calculated for $C_{18}H_{19}N_2O_2$ $[M+H]^+$ m/z 295.1446, found 295.1442.



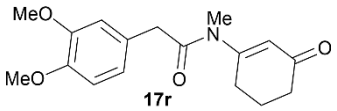
17q

***N*,1-dimethyl-N-(3-oxocyclohex-1-en-1-yl)-1H-indole-2-carboxamide** (**17q**): prepared from 1-methyl-1H-indole-2-carboxylic acid and 3-(methylamino)cyclohex-2-en-1-one following General Method B, 73 mg, 26% yield, gum.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (d, J = 8.4 Hz, 1H), 7.45–7.32 (m, 2H), 7.17 (t, J = 7.7 Hz, 1H), 6.83 (s, 1H), 5.87 (s, 1H), 3.95 (s, 3H), 3.43 (s, 3H), 2.42 (t, J = 6.2 Hz, 2H), 2.37 (t, J = 6.5 Hz, 2H), 1.86 (quint, J = 6.3 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 199.14, 164.50, 164.16, 139.06, 132.09, 125.96, 124.99, 122.37, 120.82, 117.24, 110.17, 107.88, 37.43, 36.85, 31.35, 31.13, 22.65;

HRMS (ESI) calculated for $C_{17}H_{19}N_2O_2$ $[M+H]^+$ m/z 283.1446, found 283.1446.



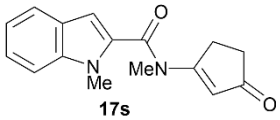
17r

2-(3,4-dimethoxyphenyl)-N-methyl-N-(3-oxocyclohex-1-en-1-yl)acetamide (**17r**): prepared from 2-(3,4-dimethoxyphenyl)acetic acid and 3-(methylamino)cyclohex-2-en-1-one following General Method B, 173 mg, 57% yield, brown solid, mp 77–79 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.81 (d, J = 8.1 Hz, 1H), 6.74 (s, 1H), 6.71 (d, J = 8.1 Hz, 1H), 5.83 (s, 1H), 3.86 (s, 3H), 3.85 (s, 3H), 3.73 (s, 2H), 3.14 (s, 3H), 2.43 (t, J = 6.0 Hz, 2H), 2.37 (t, J = 6.7 Hz, 2H), 1.95 (quint, J = 6.2 Hz, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 199.32, 171.03, 162.99, 149.08, 148.07, 126.62, 122.58, 121.08, 112.02, 111.23, 55.88, 55.86, 41.69, 36.94, 35.09, 28.85, 22.13;

HRMS (ESI) calculated for $C_{17}H_{22}NO_4$ $[M+H]^+$ m/z 304.1549, found 304.1546.



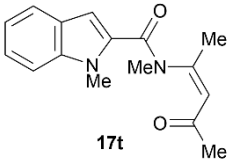
17s

***N*,1-dimethyl-N-(3-oxocyclopent-1-en-1-yl)-1H-indole-2-carboxamide** (**17s**): prepared from 1-methyl-1H-indole-2-carboxylic acid and 3-(methylamino)cyclopent-2-en-1-one following General Method A, 51 mg, 19% yield, brown solid, mp 161–163 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (d, J = 8.0 Hz, 1H), 7.48–7.35 (m, 2H), 7.19 (t, J = 7.1 Hz, 1H), 6.90 (s, 1H), 5.67 (s, 1H), 3.94 (s, 3H), 3.50 (s, 3H), 3.13–2.99 (m, 2H), 2.54–2.38 (m, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 206.17, 174.23, 164.97, 139.33, 130.86, 125.81, 125.38, 122.52, 121.08, 113.42, 110.28, 108.66, 38.99, 34.68, 31.41, 29.88;

HRMS (ESI) calculated for $C_{16}H_{17}N_2O_2$ $[M+H]^+$ *m*/*z* 269.1290, found 269.1282.



17t

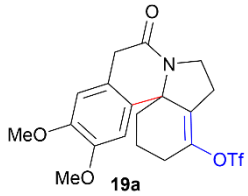
(Z)-N,1-dimethyl-N-(4-oxopent-2-en-2-yl)-1H-indole-2-carboxamide (**17t**): prepared from 1-methyl-1H-indole-2-carboxylic acid and (Z)-4-(methylamino)pent-3-en-2-one following General Method A, 208 mg, 77% yield, gum.

Note: compound **17t** is not stable during purification through silica gel column chromatography and it should be purified as soon as possible to obtain pure materials. It exists as a mixture of rotamers according to ^{1}H and ^{13}C NMR.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66–7.54 (m, 2H), 7.41–7.27 (m, 3.8H), 7.18–7.07 (m, 2H), 6.69 (s, 1H), 6.58 (s, 0.6H), 6.05 (s, 1H), 5.90 (s, 0.6H), 3.94 (s, 3H), 3.91 (s, 2H), 3.39 (s, 3H), 3.21 (s, 2H), 2.25 (s, 3H), 2.16 (s, 3H), 2.13 (s, 2H), 1.96 (s, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 197.53, 195.00, 164.31, 163.79, 156.88, 150.76, 138.66, 138.38, 132.28, 132.07, 126.17, 126.02, 124.42, 123.59, 122.25, 122.04, 121.74, 120.54, 120.10, 119.29, 109.97, 109.95, 106.97, 104.49, 36.70, 34.24, 32.24, 31.36, 31.21, 31.10, 23.26, 21.56;

HRMS (ESI) calculated for $C_{16}H_{19}N_2O_2$ $[M+H]^+$ *m*/*z* 271.1446, found 271.1439.



19a

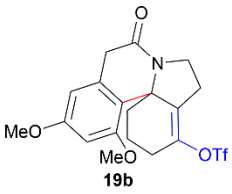
11,12-dimethoxy-8-oxo-2,3,5,6,8,9-hexahydro-1H-indolo[7a,1-a]isoquinolin-4-yl trifluoromethanesulfonate (**19a**): prepared from **17a** following General Method C, the reaction mixture was stirred at room temperature for 0.5 h before being stirred at 35 °C for 24 h, 65 mg, 73% yield, brown solid, mp 69–71 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.73 (s, 2H), 4.22 (t, J = 10.0 Hz, 1H), 3.86 (s, 3H), 3.83 (s, 3H), 3.68 (d, J = 17.8 Hz, 1H), 3.46 (d, J = 17.8 Hz, 1H), 3.21 (td, J = 11.6, 5.8 Hz, 1H), 2.85 (dd, J = 14.1, 5.7 Hz, 1H), 2.68–2.44 (m, 2H), 2.32–2.24 (m, 1H), 2.06–2.04 (m, 1H), 1.98–1.86 (m, 1H), 1.69–1.53 (m, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.15, 148.53, 147.29, 143.12, 133.41, 129.66, 124.39, 118.39 (q, $J_{C\text{-}F}$ = 319.7 Hz), 111.51, 107.48, 66.81, 56.11, 55.92, 44.81, 38.17, 31.94, 26.51, 26.17, 18.06;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.36;

HRMS (ESI) calculated for $C_{19}H_{21}F_3NO_6S$ $[M+H]^+$ m/z 448.1041, found 448.1043.



19b

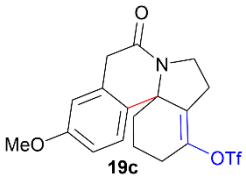
11,13-dimethoxy-8-oxo-2,3,5,6,8,9-hexahydro-1H-indolo[7a,1-a]isoquinolin-4-yl trifluoromethanesulfonate (**19b**): prepared from **17b** following General Method C, the reaction mixture was stirred at room temperature for 0.5 h before being stirred at 35 °C for 24 h, 67 mg, 75% yield, brown solid, mp 149–151 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.35 (s, 2H), 4.07 (dd, J = 11.1, 8.5 Hz, 1H), 3.79 (s, 3H), 3.73 (s, 3H), 3.72 (d, J = 17.8 Hz, 1H), 3.48 (d, J = 17.9 Hz, 1H), 3.09 (td, J = 11.4, 5.8 Hz, 1H), 2.89 (dd, J = 13.5, 5.8 Hz, 1H), 2.64 (ddd, J = 17.7, 7.4, 4.5 Hz, 1H), 2.46–2.37 (m, 1H), 2.35–2.21 (m, 1H), 2.14 (dt, J = 11.8, 3.2 Hz, 1H), 1.96–1.83 (m, 1H), 1.73–1.57 (m, 1H), 1.48 (ddd, J = 14.8, 11.8, 3.3 Hz, 1H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 169.26, 159.86, 157.15, 144.34, 136.32, 133.08, 118.95, 118.33 (q, $J_{C\text{-}F}$ = 320.0 Hz), 104.96, 97.03, 65.19, 55.26, 55.19, 43.84, 39.36, 34.30, 26.88, 26.33, 18.40;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.61;

HRMS (ESI) calculated for $C_{19}H_{21}F_3NO_6S$ $[M+H]^+$ *m/z* 448.1041, found 448.1042.



19c

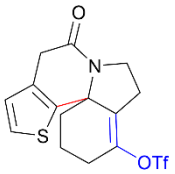
11-methoxy-8-oxo-2,3,5,6,8,9-hexahydro-1H-indolo[7a,1-a]isoquinolin-4-yl trifluoromethanesulfonate (**19c**): prepared from **17c** following General Method C, the reaction mixture was stirred at room temperature for 0.5 h before being stirred at 75 °C for 24 h, 36 mg, 43% yield, light-red gum.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.02 (d, *J* = 8.0 Hz, 1H), 6.80–6.72 (m, 2H), 4.21 (dd, *J* = 11.3, 8.6 Hz, 1H), 3.80 (s, 3H), 3.73 (d, *J* = 17.8 Hz, 1H), 3.51 (d, *J* = 17.8 Hz, 1H), 3.20 (td, *J* = 11.6, 5.8 Hz, 1H), 2.84 (dd, *J* = 14.0, 5.7 Hz, 1H), 2.67–2.56 (m, 1H), 2.56–2.41 (m, 1H), 2.33–2.18 (m, 1H), 2.07–1.99 (m, 1H), 1.95–1.83 (m, 1H), 1.71–1.46 (m, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 169.59, 159.38, 143.40, 134.09, 132.93, 129.59, 124.77, 118.34 (q, $J_{C\text{-}F}$ = 320.0 Hz), 114.22, 111.20, 66.50, 55.31, 44.63, 38.79, 31.96, 26.38, 26.07, 17.94;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.25;

HRMS (ESI) calculated for $C_{18}H_{19}F_3NO_5S$ $[M+H]^+$ *m/z* 418.0936, found 418.0932.



19d

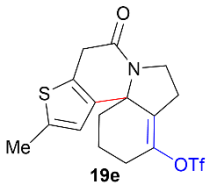
8-oxo-2,3,5,6,8,9-hexahydro-1H-thieno[2',3':3,4]pyrido[2,1-i]indol-4-yl trifluoromethanesulfonate (**19d**): prepared from **17d** following General Method C, the reaction mixture was stirred at room temperature for 0.5 h before being stirred at 40 °C for 24 h, 57 mg, 72% yield, light-yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.17 (d, *J* = 5.0 Hz, 1H), 6.88 (d, *J* = 5.0 Hz, 1H), 4.27 (dd, *J* = 11.4, 8.5 Hz, 1H), 3.62 (d, *J* = 18.4 Hz, 1H), 3.52 (d, *J* = 18.3 Hz, 1H), 3.18 (td, *J* = 11.7, 5.5 Hz, 1H), 2.84 (dd, *J* = 14.1, 5.5 Hz, 1H), 2.73–2.62 (m, 1H), 2.55–2.43 (m, 1H), 2.42–2.28 (m, 1H), 2.08 (dt, *J* = 12.0, 3.2 Hz, 1H), 2.05–1.82 (m, 2H), 1.66 (td, *J* = 12.7, 4.8 Hz, 1H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.28, 143.05, 137.56, 133.97, 133.61, 126.79, 124.41, 118.32 (q, $J_{C\text{-}F}$ = 320.2 Hz), 64.73, 45.09, 34.91, 33.24, 27.01, 25.66, 17.96;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.06;

HRMS (ESI) calculated for $C_{15}H_{15}F_3NO_4S_2$ $[M+H]^+$ *m*/*z* 394.0394, found 394.0395.



19e

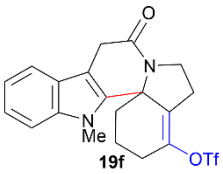
11-methyl-8-oxo-2,3,5,6,8,9-hexahydro-1H-thieno[3',2':3,4]pyrido[2,1-i]indol-4-yl trifluoromethanesulfonate (**19e**): prepared from **17e** following General Method C, the reaction mixture was stirred at room temperature for 0.5 h before being stirred at 50 °C for 24 h, 42 mg, 51% yield, brown solid, mp 116–118 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.37 (s, 1H), 4.25 (dd, *J* = 11.4, 8.4 Hz, 1H), 3.58 (s, 2H), 3.14 (td, *J* = 11.7, 5.5 Hz, 1H), 2.82 (dd, *J* = 14.0, 5.4 Hz, 1H), 2.69–2.56 (m, 1H), 2.55–2.44 (m, 1H), 2.41 (s, 3H), 2.37–2.23 (m, 1H), 2.01–1.89 (m, 2H), 1.79–1.64 (m, 1H), 1.64–1.53 (m, 1H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 169.33, 142.44, 138.85, 138.29, 133.88, 128.97, 122.05, 118.38 (q, $J_{C\text{-}F}$ = 320.1 Hz), 65.12, 44.89, 33.87, 33.65, 27.03, 26.03, 17.99, 15.25;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.24;

HRMS (ESI) calculated for $C_{16}H_{16}F_3NO_4S_2$ $[M+H]^+$ *m*/*z* 408.0551, found 408.0551.



19f

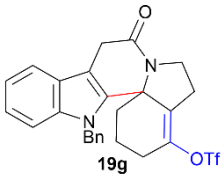
14-methyl-8-oxo-2,3,5,6,9,14-hexahydro-1H,8H-pyrido[3,4-b:2,1-i']diindol-4-yl trifluoromethanesulfonate (**19f**): prepared from **17f** following General Method D, the reaction mixture was stirred at -78 °C for 1 h before being stirred at -20 °C for 24 h, 58 mg, 66% yield, brown solid, mp 68–70 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (d, *J* = 7.9 Hz, 1H), 7.32 (d, *J* = 8.3 Hz, 1H), 7.25 (t, *J* = 7.6 Hz, 1H), 7.15 (t, *J* = 7.4 Hz, 1H), 4.24 (dd, *J* = 11.0, 8.7 Hz, 1H), 3.84 (d, *J* = 18.9 Hz, 1H), 3.79 (s, 3H), 3.61 (d, *J* = 18.9 Hz, 1H), 3.20 (td, *J* = 11.5, 5.5 Hz, 1H), 2.98 (dd, *J* = 13.7, 5.4 Hz, 1H), 2.78–2.55 (m, 2H), 2.48–2.33 (m, 1H), 2.32–2.20 (m, 1H), 2.07–1.96 (m, 1H), 1.79–1.61 (m, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.99, 144.76, 138.07, 136.33, 132.30, 124.88, 122.21, 120.07, 118.30 (q, $J_{C\text{-}F}$ = 319.8 Hz), 117.92, 109.64, 108.35, 64.27, 44.53, 36.15, 31.09, 30.43, 27.35, 27.09, 18.13;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.34;

HRMS (ESI) calculated for $C_{20}H_{20}F_3N_2O_4S$ $[M+H]^+$ *m/z* 441.1096, found 441.1103.



19g

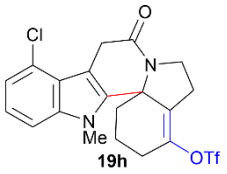
14-benzyl-8-oxo-2,3,5,6,9,14-hexahydro-1H,8H-pyrido[3,4-b:2,1-i']diindol-4-yl trifluoromethanesulfonate (**19g**): prepared from **17g** following General Method D, the reaction mixture was stirred at -78 °C for 1 h before being stirred at room temperature for 24 h, 46 mg, 45% yield, brown gum.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62–7.52 (m, 1H), 7.32–7.08 (m, 6H), 6.70–6.60 (m, 2H), 5.62 (d, *J* = 17.6 Hz, 1H), 5.44 (d, *J* = 17.6 Hz, 1H), 4.14 (dd, *J* = 11.1, 8.4 Hz, 1H), 3.91 (d, *J* = 19.4 Hz, 1H), 3.67 (d, *J* = 18.9 Hz, 1H), 3.10 (td, *J* = 11.5, 5.5 Hz, 1H), 2.67 (dd, *J* = 13.8, 5.4 Hz, 1H), 2.63–2.46 (m, 2H), 2.35–2.23 (m, 1H), 2.03–1.88 (m, 1H), 1.85–1.63 (m, 3H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.94, 144.79, 138.36, 137.33, 136.63, 132.27, 128.52, 127.28, 125.33, 125.30, 122.67, 120.54, 118.17 (q, $J_{C\text{-}F}$ = 319.9 Hz), 118.14, 110.70, 109.74, 64.38, 46.84, 44.40, 36.42, 31.40, 27.21, 18.03;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.51;

HRMS (ESI) calculated for $C_{26}H_{24}F_3N_2O_4S$ $[M+H]^+$ *m/z* 517.1409, found 517.1414.



19h

10-chloro-14-methyl-8-oxo-2,3,5,6,9,14-hexahydro-1H,8H-pyrido[3,4-b:2,1-i']diindol-4-yl trifluoromethanesulfonate (**19h**): prepared from **17h** following General Method D, the reaction mixture was stirred at -78 °C for 1 h before being stirred at 0 °C for 24 h, 48 mg, 51% yield, brown solid, mp 187–189 °C.

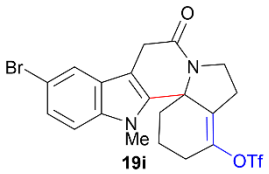
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (d, *J* = 7.9 Hz, 1H), 7.12 (t, *J* = 7.7 Hz, 1H), 7.09 (d, *J* = 7.5 Hz, 1H), 4.49 (d, *J* = 19.4 Hz, 1H), 4.25 (dd, *J* = 11.2, 8.5 Hz, 1H), 3.78 (s, 3H), 3.76 (d, *J* = 18.7 Hz, 1H), 3.21 (td, *J* = 11.5, 5.6 Hz, 1H), 3.00 (dd, *J* = 13.7, 5.5

Hz, 1H), 2.77–2.55 (m, 2H), 2.47–2.34 (m, 1H), 2.33–2.24 (m, 1H), 2.10–1.98 (m, 1H), 1.77–1.55 (m, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.87, 145.01, 139.15, 137.32, 132.27, 125.73, 122.48, 122.40, 120.73, 118.29 (q, J_{C-F} = 319.7 Hz), 108.40, 108.34, 63.85, 44.51, 36.06, 32.25, 30.76, 27.34, 27.08, 18.13;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.31;

HRMS (ESI) calculated for $C_{20}H_{19}ClF_3N_2O_4S$ $[M+H]^+$ *m/z* 475.0706, found 475.0705.



19i

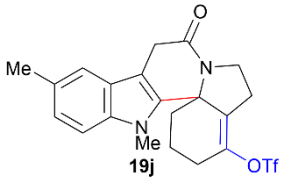
11-bromo-14-methyl-8-oxo-2,3,5,6,9,14-hexahydro-1H,8H-pyrido[3,4-b:2,1-i']diindol-4-yl trifluoromethanesulfonate (**19i**): prepared from **17i** following General Method D, the reaction mixture was stirred at -78 °C for 1 h before being stirred at room temperature for 24 h, 59 mg, 57% yield, brown solid, mp 130–132 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (d, *J* = 1.9 Hz, 1H), 7.31 (dd, *J* = 8.9, 2.1 Hz, 1H), 7.17 (d, *J* = 8.8 Hz, 1H), 4.23 (dd, *J* = 11.2, 8.5 Hz, 1H), 3.76 (s, 3H), 3.76 (d, *J* = 18.9 Hz, 1H), 3.57 (d, *J* = 18.9 Hz, 1H), 3.19 (td, *J* = 11.5, 5.6 Hz, 1H), 2.98 (dd, *J* = 13.8, 5.5 Hz, 1H), 2.77–2.54 (m, 2H), 2.47–2.33 (m, 1H), 2.30–2.22 (m, 1H), 2.10–1.99 (m, 1H), 1.78–1.57 (m, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.51, 144.95, 137.67, 136.82, 132.14, 126.51, 125.05, 120.56, 118.35 (q, J_{C-F} = 319.9 Hz), 113.36, 111.22, 107.98, 64.23, 44.58, 36.21, 31.01, 30.67, 27.41, 27.12, 18.20;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.30;

HRMS (ESI) calculated for $C_{20}H_{19}BrF_3N_2O_4S$ $[M+H]^+$ *m/z* 519.0201, found 519.0201.



19j

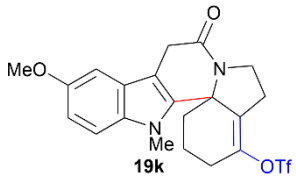
11,14-dimethyl-8-oxo-2,3,5,6,9,14-hexahydro-1H,8H-pyrido[3,4-b:2,1-i']diindol-4-yl trifluoromethanesulfonate (**19j**): prepared from **17j** following General Method D, the reaction mixture was stirred at -78 °C for 1 h before being stirred at 0 °C for 24 h, 46 mg, 51% yield, brown solid, mp 158–160 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28 (s, 1H), 7.20 (d, J = 8.4 Hz, 1H), 7.08 (d, J = 8.4 Hz, 1H), 4.24 (dd, J = 11.2, 8.5 Hz, 1H), 3.80 (d, J = 18.9 Hz, 1H), 3.75 (s, 3H), 3.58 (d, J = 18.9 Hz, 1H), 3.19 (td, J = 11.5, 5.6 Hz, 1H), 2.98 (dd, J = 13.7, 5.4 Hz, 1H), 2.78–2.54 (m, 2H), 2.45 (s, 3H), 2.44–2.33 (m, 1H), 2.25 (dd, J = 8.7, 3.4 Hz, 1H), 2.09–1.95 (m, 1H), 1.77–1.64 (m, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 171.05, 144.70, 136.57, 136.30, 132.34, 129.48, 125.06, 123.82, 118.31 (q, $J_{C\text{-}F}$ = 319.8 Hz), 117.52, 109.34, 107.78, 64.25, 44.53, 36.15, 31.07, 30.44, 27.35, 27.09, 21.30, 18.11;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.34;

HRMS (ESI) calculated for $C_{21}H_{22}F_3N_2O_4S$ $[M+H]^+$ m/z 455.1252, found 455.1258.



19k

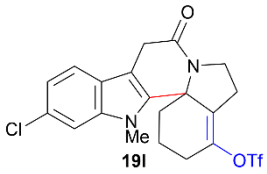
11-methoxy-14-methyl-8-oxo-2,3,5,6,9,14-hexahydro-1H,8H-pyrido[3,4-b:2,1-i']diindol-4-yl trifluoromethanesulfonate (**19k**): prepared from **17k** following General Method D, the reaction mixture was stirred at -78 °C for 1 h before being stirred at 0 °C for 24 h, 39 mg, 41% yield, brown solid, mp 88–90 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (d, J = 8.6 Hz, 1H), 6.94–6.87 (m, 2H), 4.24 (dd, J = 11.2, 8.5 Hz, 1H), 3.85 (s, 3H), 3.78 (d, J = 18.9 Hz, 1H), 3.75 (s, 3H), 3.59 (d, J = 18.8 Hz, 1H), 3.19 (td, J = 11.5, 5.5 Hz, 1H), 2.97 (dd, J = 13.7, 5.5 Hz, 1H), 2.78–2.53 (m, 2H), 2.48–2.33 (m, 1H), 2.33–2.19 (m, 1H), 2.11–1.92 (m, 1H), 1.78–1.61 (m, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 171.00, 154.53, 144.80, 136.86, 133.42, 132.33, 125.19, 118.36 (q, $J_{C\text{-}F}$ = 320.0 Hz), 112.51, 110.55, 107.86, 99.57, 64.34, 55.93, 44.58, 36.16, 31.21, 30.56, 27.39, 27.14, 18.20;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.34;

HRMS (ESI) calculated for $C_{21}H_{22}F_3N_2O_5S$ $[M+H]^+$ m/z 471.1201, found 471.1209.



19l

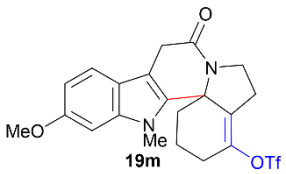
12-chloro-14-methyl-8-oxo-2,3,5,6,9,14-hexahydro-1H,8H-pyrido[3,4-b:2,1-i']diindol-4-yl trifluoromethanesulfonate (**19l**): prepared from **17l** following General Method D, the reaction mixture was stirred at -78 °C for 1 h before being stirred at room temperature for 24 h, 61 mg, 64% yield, brown solid, mp 85–87 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 (d, J = 8.4 Hz, 1H), 7.30 (s, 1H), 7.12 (d, J = 8.4 Hz, 1H), 4.24 (dd, J = 11.2, 8.6 Hz, 1H), 3.79 (d, J = 18.8 Hz, 1H), 3.74 (s, 3H), 3.59 (d, J = 18.9 Hz, 1H), 3.19 (td, J = 11.6, 5.6 Hz, 1H), 2.99 (dd, J = 13.7, 5.4 Hz, 1H), 2.77–2.56 (m, 2H), 2.48–2.34 (m, 1H), 2.30–2.21 (m, 1H), 2.10–1.97 (m, 1H), 1.79–1.64 (m, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.61, 144.85, 138.50, 137.09, 132.16, 128.17, 123.47, 120.77, 118.84, 118.30 (q, $J_{C\text{-}F}$ = 319.8 Hz), 109.77, 108.65, 64.22, 44.55, 36.16, 31.03, 30.58, 27.37, 27.06, 18.16;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.30;

HRMS (ESI) calculated for $C_{20}H_{19}ClF_3N_2O_4S$ $[M+H]^+$ m/z 475.0706, found 475.0707.



19m

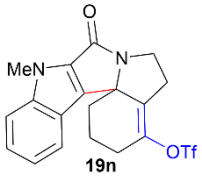
12-methoxy-14-methyl-8-oxo-2,3,5,6,9,14-hexahydro-1H,8H-pyrido[3,4-b:2,1-i']diindol-4-yl trifluoromethanesulfonate (**19m**): prepared from **17m** following General Method D, the reaction mixture was stirred at -78 °C for 1 h before being stirred at -20 °C for 24 h, 43 mg, 46% yield, brown solid, mp 77–79 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (d, J = 8.6 Hz, 1H), 6.82 (dd, J = 8.6, 2.2 Hz, 1H), 6.77 (d, J = 2.1 Hz, 1H), 4.25 (dd, J = 11.2, 8.4 Hz, 1H), 3.87 (s, 3H), 3.78 (d, J = 18.9 Hz, 1H), 3.73 (s, 3H), 3.58 (d, J = 18.9 Hz, 1H), 3.19 (td, J = 11.7, 5.7 Hz, 1H), 2.97 (dd, J = 13.6, 5.6 Hz, 1H), 2.77–2.54 (m, 2H), 2.48–2.34 (m, 1H), 2.31–2.18 (m, 1H), 2.10–1.96 (m, 1H), 1.81–1.62 (m, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 171.00, 156.72, 144.68, 138.99, 135.03, 132.49, 119.43, 118.64, 118.33 (q, $J_{C\text{-}F}$ = 319.8 Hz), 109.84, 108.46, 93.46, 64.32, 55.78, 44.57, 36.27, 31.16, 30.52, 27.39, 27.14, 18.18;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.34;

HRMS (ESI) calculated for $C_{21}H_{22}F_3N_2O_5S$ $[M+H]^+$ m/z 471.1201, found 471.1209.



19n

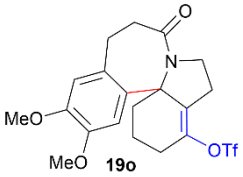
9-methyl-8-oxo-2,3,5,6,8,9-hexahydro-1H-pyrrolo[4,3-b:2,1-i']diindol-4-yl trifluoromethanesulfonate (**19n**): prepared from **17n** following General Method D, the reaction mixture was stirred at -78 °C for 1 h before being stirred at room temperature for 24 h, 71 mg, 83% yield, white solid, mp 143–145 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 (d, J = 8.2 Hz, 1H), 7.42 (d, J = 7.9 Hz, 1H), 7.38 (t, J = 7.2 Hz, 1H), 7.23 (t, J = 6.8 Hz, 1H), 4.16 (dd, J = 11.6, 7.9 Hz, 1H), 3.97 (s, 3H), 3.11 (td, J = 12.2, 4.5 Hz, 1H), 3.01–2.88 (m, 1H), 2.76 (dd, J = 14.2, 4.6 Hz, 1H), 2.73–2.49 (m, 2H), 2.46–2.31 (m, 1H), 2.27–2.16 (m, 1H), 2.07–1.93 (m, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 169.72, 143.65, 142.14, 135.78, 134.29, 131.82, 125.09, 121.19, 121.18, 121.03, 118.42 (q, $J_{C\text{-}F}$ = 320.2 Hz), 111.35, 69.48, 44.97, 33.53, 30.03, 29.76, 26.07, 17.91;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.13;

HRMS (ESI) calculated for $C_{19}H_{18}F_3N_2O_4S$ $[M+H]^+$ m/z 427.0939, found 427.0945.



19o

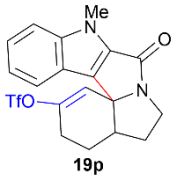
12,13-dimethoxy-3-oxo-2,3,6,8,9,10-hexahydro-1H,5H-benzo[3,4]azepino[2,1-i]indol-7-yl trifluoromethanesulfonate (**19o**): prepared from **17o** following General Method C, the reaction mixture was stirred at room temperature for 0.5 h before being stirred at 55 °C for 24 h, 40 mg, 43% yield, brown solid, mp 147–149 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.77 (s, 1H), 6.64 (s, 1H), 3.97–3.87 (m, 1H), 3.84 (s, 3H), 3.81 (s, 3H), 3.45–3.29 (m, 2H), 3.26–3.09 (m, 2H), 2.88 (dd, J = 14.2, 7.0 Hz, 1H), 2.77 (d, J = 12.0 Hz, 1H), 2.70 (dt, J = 14.7, 4.6 Hz, 1H), 2.52–2.43 (m, 2H), 2.43–2.29 (m, 1H), 1.98–1.88 (m, 1H), 1.82 (t, J = 13.2 Hz, 1H), 1.64–1.50 (m, 1H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 171.65, 148.00, 146.30, 144.09, 134.64, 130.43, 128.13, 118.32 (q, $J_{C\text{-}F}$ = 319.7 Hz), 114.98, 110.13, 66.96, 56.01, 55.86, 46.19, 36.60, 33.51, 28.39, 26.11, 24.51, 18.81;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.47;

HRMS (ESI) calculated for $C_{20}H_{23}F_3NO_6S$ $[M+H]^+$ m/z 462.1198, found 462.1208.



19p

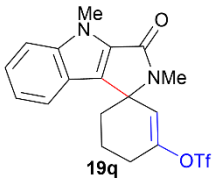
9-methyl-8-oxo-4,4a,5,6,8,9-hexahydro-3H-pyrrolo[4,3-b:2,1-i']diindol-2-yl trifluoromethanesulfonate (**19p**): prepared from **17p** following General Method D, the reaction mixture was stirred at -78 °C for 1 h before being stirred at 35 °C for 24 h, 39 mg, 46% yield, brown solid, mp 146–148 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 (d, J = 8.0 Hz, 1H), 7.42 (d, J = 8.3 Hz, 1H), 7.37 (td, J = 6.8, 1.1 Hz, 1H), 7.21 (td, J = 7.5, 1.2 Hz, 1H), 5.58 (s, 1H), 3.96 (s, 3H), 3.74 (dt, J = 11.4, 8.9 Hz, 1H), 3.44 (ddd, J = 11.7, 8.4, 3.4 Hz, 1H), 2.77–2.64 (m, 1H), 2.58 (dd, J = 18.2, 6.2 Hz, 1H), 2.50–2.39 (m, 1H), 2.39–2.28 (m, 2H), 2.18–2.04 (m, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 166.14, 149.47, 142.66, 133.62, 131.03, 124.65, 121.08, 120.91, 120.16, 119.92, 118.40 (q, $J_{C\text{-}F}$ = 320.2 Hz), 111.12, 68.56, 41.39, 39.24, 30.94, 30.02, 23.00, 21.48;

^{19}F NMR (376 MHz, $CDCl_3$) δ -73.56;

HRMS (ESI) calculated for $C_{19}H_{18}F_3N_2O_4S$ $[M+H]^+$ *m/z* 427.0939, found 427.0946.



19q

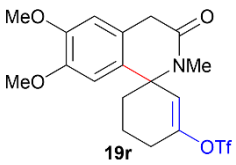
2',4'-dimethyl-3'-oxo-3',4'-dihydro-2'H-spiro[cyclohexane-1,1'-pyrrolo[3,4-b]indol]-2-en-3-yl trifluoromethanesulfonate (**19q**): prepared from **17q** following General Method D, the reaction mixture was stirred at -78 °C for 1 h before being stirred at -20 °C for 24 h, 56 mg, 68% yield, white solid, mp 129–131 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 (d, J = 8.1 Hz, 1H), 7.44 (d, J = 8.4 Hz, 1H), 7.37 (t, J = 7.7 Hz, 1H), 7.22 (t, J = 7.5 Hz, 1H), 5.42 (s, 1H), 4.00 (s, 3H), 3.04 (s, 3H), 2.71–2.61 (m, 2H), 2.49–2.34 (m, 1H), 2.26–2.08 (m, 2H), 1.90–1.81 (m, 1H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 161.85, 152.24, 142.35, 133.50, 130.27, 124.16, 120.85, 120.83, 120.69, 119.95, 118.42 (q, $J_{C\text{-}F}$ = 320.4 Hz), 111.10, 62.47, 31.03, 30.05, 27.13, 25.62, 20.18;

^{19}F NMR (376 MHz, $CDCl_3$) δ -73.64;

HRMS (ESI) calculated for $C_{18}H_{18}F_3N_2O_4S$ $[M+H]^+$ *m/z* 415.0939, found 415.0949.



19r

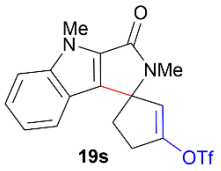
6',7'-dimethoxy-2'-methyl-3'-oxo-3',4'-dihydro-2'H-spiro[cyclohexane-1,1'-isoquinolin]-2-en-3-yl trifluoromethanesulfonate (**19r**): prepared from **17r** following General Method D, the reaction mixture was stirred at -78 °C for 1 h before being stirred at 0 °C for 24 h, 38 mg, 44% yield, brown gum.

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.78 (s, 1H), 6.66 (s, 1H), 5.82 (s, 1H), 3.88 (s, 3H), 3.86 (s, 3H), 3.64 (d, J = 4.2 Hz, 2H), 3.04 (s, 3H), 2.63–2.41 (m, 2H), 1.98–1.71 (m, 4H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 169.62, 151.97, 148.92, 147.36, 128.33, 123.28, 122.24, 118.35 (q, $J_{C\text{-}F}$ = 319.8 Hz), 110.51, 110.09, 64.28, 56.12, 55.99, 36.41, 32.73, 30.18, 27.29, 18.82;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.13;

HRMS (ESI) calculated for $C_{18}H_{21}F_3NO_6S$ $[M+H]^+$ m/z 436.1041, found 436.1043.



19s

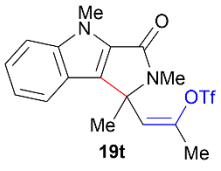
2',4'-dimethyl-3'-oxo-3',4'-dihydro-2'H-spiro[cyclopentane-1,1'-pyrrolo[3,4-b]indol]-2-en-3-yl trifluoromethanesulfonate (**19s**): prepared from **17s** following General Method D, the reaction mixture was stirred at -78 °C for 1 h before being stirred at -20 °C for 48 h, 35 mg, 44% yield, brown solid, mp 127–129 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51 (d, J = 8.0 Hz, 1H), 7.44 (d, J = 8.4 Hz, 1H), 7.37 (t, J = 7.7 Hz, 1H), 7.22 (t, J = 7.5 Hz, 1H), 5.46 (s, 1H), 3.99 (s, 3H), 3.07–3.01 (m, 2H), 3.00 (s, 3H), 2.61 (ddd, J = 14.5, 8.9, 5.7 Hz, 1H), 2.36 (ddd, J = 14.1, 8.6, 5.2 Hz, 1H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 161.74, 152.15, 142.48, 133.40, 130.00, 124.28, 120.86, 120.45, 119.55, 119.28, 118.60 (q, $J_{C\text{-}F}$ = 318.9 Hz), 111.17, 69.53, 31.10, 30.68, 30.20, 24.77;

^{19}F NMR (376 MHz, $CDCl_3$) δ -73.17;

HRMS (ESI) calculated for $C_{17}H_{16}F_3N_2O_4S$ $[M+H]^+$ m/z 401.0783, found 401.0775.



19t

(Z)-1-(1,2,4-trimethyl-3-oxo-1,2,3,4-tetrahydropyrrolo[3,4-b]indol-1-yl)prop-1-en-2-yl trifluoromethanesulfonate (**19t**): prepared from **17t** following General Method D, the reaction mixture was stirred at -78 °C for 1 h before being stirred at 0 °C for 24 h, 57 mg, 71% yield, light-yellow solid, mp 112–114 °C.

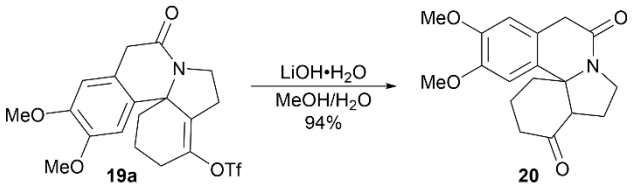
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, J = 8.1 Hz, 1H), 7.43 (d, J = 8.3 Hz, 1H), 7.36 (*t*, J = 7.5 Hz, 1H), 7.21 (t, J = 7.5 Hz, 1H), 5.12 (s, 1H), 3.99 (s, 3H), 3.02 (s, 3H), 2.11 (s, 3H), 1.79 (s, 3H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 161.75, 147.38, 142.38, 133.49, 131.23, 124.12, 120.98, 120.60, 120.33, 119.60, 118.14 (q, $J_{C\text{-}F}$ = 318.0 Hz), 111.02, 60.14, 30.08, 24.90, 24.25, 20.58;

^{19}F NMR (376 MHz, $CDCl_3$) δ -74.14;

HRMS (ESI) calculated for $C_{17}H_{18}F_3N_2O_4S$ $[M+H]^+$ *m*/*z* 403.0939, found 403.0934.

5. Hydrolysis of the Enol Triflate in Compound 19a



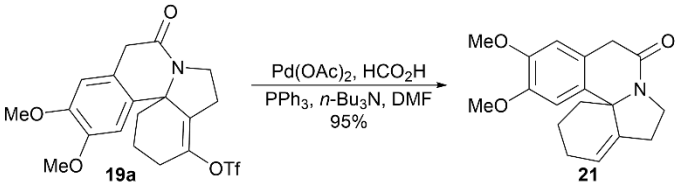
11,12-dimethoxy-2,3,5,6-tetrahydro-1H-indolo[7a,1-a]isoquinoline-4,8(4aH,9H)-dione (**20**): To a solution of **19a** (0.15 mmol, 67 mg, 1.0 equiv.) in 1.8 mL of a mixture of MeOH/H_2O (5:1 v/v) was added LiOH·H_2O (0.75 mmol, 32 mg, 5.0 equiv.) at 0 °C. After being stirred at 0 °C for 10 min, the reaction mixture was moved to room temperature and stirred at room temperature for 2.5 h. The reaction mixture was diluted with water and extracted three times with DCM. The combined organic layer was washed with brine, dried over anhydrous sodium sulfate, and concentrated under reduced pressure to give a residue, which was purified via column chromatography (0−2% methanol in dichloromethane) to give **20** as a white solid (0.14 mmol, 44.4 mg, 94% yield), mp 178–180 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.70 (s, 1H), 6.46 (s, 1H), 3.90–3.85 (m, 1H), 3.87 (s, 3H), 3.81 (s, 3H), 3.71 (d, J = 19.0 Hz, 1H), 3.68–3.59 (m, 1H), 3.49 (d, J = 18.7 Hz, 1H), 3.23–3.11 (m, 1H), 2.65 (td, J = 14.9, 14.1, 6.1 Hz, 1H), 2.53 (d, J = 15.4 Hz, 1H), 2.34 (t, J = 9.3 Hz, 2H), 2.10–1.98 (m, 1H), 1.92 (d, J = 12.3 Hz, 2H), 1.68 (t, J = 15.9 Hz, 1H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 211.09, 167.47, 148.64, 147.47, 131.27, 124.29, 111.00, 108.49, 69.87, 57.86, 56.17, 56.07, 43.64, 37.76, 37.27, 32.39, 26.98, 20.72;

HRMS (ESI) calculated for $C_{18}H_{22}NO_4$ $[M+H]^+$ m/z 316.1549, found 316.1545.

6. Total Synthesis of 3-Demethoxyerythratidinone (3)

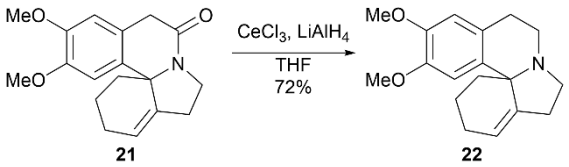


11,12-dimethoxy-2,3,5,6-tetrahydro-1H-indolo[7a,1-a]isoquinolin-8(9H)-one (**21**): A solution of **19a** (0.65 mmol, 289 mg, 1.0 equiv.), HCO_2H (3.23 mmol, 149 mg, 5.0 equiv.), *n*-Bu_3N (2.59 mmol, 480 mg, 4.0 equiv.), PPh_3 (0.13 mmol, 34 mg, 0.2 equiv.), and $Pd(OAc)_2$ (0.07 mmol, 15 mg, 0.1 equiv.) in 3 mL of anhydrous DMF in a sealed tube was bubbled with argon for 15 min. Then the reaction mixture was stirred at 70 °C for 4 h. After being cooled to room temperature, the reaction mixture was diluted with ethyl acetate, and the mixture was sequentially washed with a 1 N hydrochloride acid aqueous solution, a saturated sodium bicarbonate aqueous solution, and brine. The organic phase was dried over anhydrous sodium sulfate, and concentrated under reduced pressure to give a residue, which was purified via column chromatography (0−2% methanol in dichloromethane) to give **21** as a brown solid (0.62 mmol, 184 mg, 95% yield), mp 81–83 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.72 (s, 1H), 6.67 (s, 1H), 5.92 (s, 1H), 4.08 (dd, J = 10.7, 7.9 Hz, 1H), 3.86 (s, 3H), 3.83 (s, 3H), 3.70 (d, J = 17.7 Hz, 1H), 3.43 (d, J = 17.7 Hz, 1H), 3.13 (td, J = 11.2, 5.8 Hz, 1H), 2.37 (dd, J = 12.5, 5.6 Hz, 1H), 2.34–2.18 (m, 3H), 2.05–1.96 (m, 1H), 1.77–1.65 (m, 1H), 1.62–1.37 (m, 2H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.36, 147.83, 146.46, 139.19, 131.32, 124.96, 122.69, 111.06, 108.06, 64.26, 55.86, 55.75, 44.60, 38.09, 32.52, 30.93, 23.21, 17.45;

HRMS (ESI) calculated for $C_{18}H_{22}NO_3$ $[M+H]^+$ m/z 300.1599, found 300.1599.



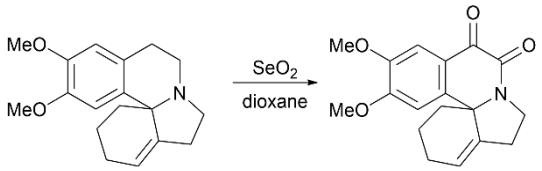
11,12-dimethoxy-2,3,5,6,8,9-hexahydro-1H-indolo[7a,1-a]isoquinoline (**22**): To a solution of **21** (0.5 mmol, 150 mg, 1.0 equiv.) in 2.5 mL of anhydrous THF was added $CeCl_3$ (1.5 mmol, 370 mg, 3.0 equiv.) at room temperature. The reaction mixture was stirred at room temperature for 30 min before being moved to 0 °C. $LiAlH_4$ (1.5 mmol, 57 mg, 3.0 equiv.) was added portionwise to the reaction mixture at 0 °C. After being stirred at 0 °C for 10 min, the reaction mixture was moved to room temperature and stirred at room temperature for 30 h. The reaction was cooled to 0 °C and quenched with a 5% ammonium hydroxide aqueous solution. The mixture was then diluted with

water and extracted several times with ethyl acetate until all target material was extracted into organic phase. The combined organic layer was washed with brine, dried over anhydrous sodium sulfate, and concentrated under reduced pressure to give a residue, which was purified via column chromatography (0−5% methanol in dichloromethane containing 0.1% saturated ammonium hydroxide aqueous solution) to give **22** as a brown oil (0.36 mmol, 103 mg, 72% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.65 (s, 1H), 6.56 (s, 1H), 5.70 (s, 1H), 3.80 (s, 3H), 3.77 (s, 3H), 3.65–3.48 (m, 1H), 3.19 (dd, J = 14.2, 7.6 Hz, 1H), 3.11–2.91 (m, 2H), 2.80–2.56 (m, 2H), 2.55–2.39 (m, 1H), 2.35–2.08 (m, 3H), 2.05–1.85 (m, 1H), 1.85–1.57 (m, 3H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 147.84, 146.45, 139.02, 129.13, 124.48, 121.19, 111.53, 111.39, 62.71, 55.83, 55.65, 45.78, 40.73, 35.06, 27.27, 24.13, 21.59, 17.36;

HRMS (ESI) calculated for $C_{18}H_{24}NO_2$ $[M+H]^+$ m/z 286.1807, found 286.1812.



22 **23**

11,12-dimethoxy-2,3,5,6-tetrahydro-1H-indolo[7a,1-a]isoquinoline-8,9-dione (**23**): A solution of **22** (0.04 mmol, 10 mg, 1.0 equiv.) and SeO_2 (0.21 mmol, 23 mg, 6.0 equiv.) in 1 mL of anhydrous 1,4-dioxane in a sealed tube was stirred at 100 °C under argon for 23 h. After being cooled to room temperature, the reaction mixture was filtered through Celite, and the filtrate was concentrated under reduced pressure to give a residue, which was purified via column chromatography (0−2% methanol in dichloromethane) to give **23** as a brown solid, mp 191–193 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 (s, 1H), 6.70 (s, 1H), 5.99 (s, 1H), 4.25 (dt, J = 11.7, 3.4 Hz, 1H), 3.94 (s, 3H), 3.93 (s,3H), 3.37 (q, J = 9.8 Hz, 1H), 2.62–2.45 (m, 2H), 2.36–2.19 (m, 2H), 2.03–1.89 (m, 1H), 1.82–1.64 (m, 2H), 1.51–1.34 (m, 1H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 180.85, 159.24, 152.61, 148.99, 141.28, 137.87, 124.43, 124.27, 110.35, 107.29, 63.19, 56.29, 56.21, 45.61, 42.25, 32.13, 23.11, 17.26;

HRMS (ESI) calculated for $C_{18}H_{20}NO_4$ $[M+H]^+$ m/z 314.1392, found 314.1398.

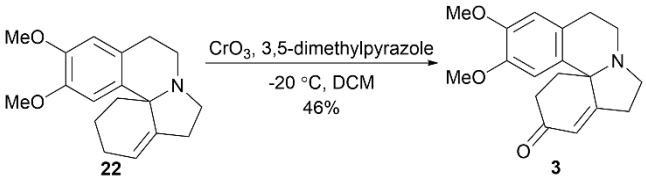
22 **24**

11,12-dimethoxy-5,6-dihydro-1H-indolo[7a,1-a]isoquinoline-3,8,9(2H)-trione (**24**): To a solution of CrO_3 (0.63 mmol, 63 mg, 18.0 equiv.) in 1 mL of anhydrous DCM was added 3,5-dimethylpyrazole (0.63 mmol, 61 mg, 18.0 equiv.) in one portion at -20 °C. The reaction mixture was stirred at -20 °C for 20 min before a solution of **22** (0.04 mmol, 10 mg, 1.0 equiv.) in 0.5 mL of anhydrous DCM was added portionwise. After being stirred at -20 °C for 1 h, the reaction mixture was moved to room temperature and stirred at room temperature for 20 h. The mixture was filtered through Celite and the filtrate was diluted with a saturated sodium bicarbonate aqueous solution and the mixture was extracted three times with DCM. The combined organic phase was washed with brine, dried over anhydrous sodium sulfate, and concentrated under reduced pressure to give a residue, which was purified via column chromatography (0−2% methanol in dichloromethane) to give **24** as a brown solid, mp 238–240 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (s, 1H), 6.58 (s, 1H), 6.32 (s, 1H), 4.45 (dd, J = 10.9, 7.8 Hz, 1H), 3.90 (s, 3H), 3.83 (s, 3H), 3.56 (td, J = 11.4, 6.4 Hz, 1H), 2.91–2.72 (m, 2H), 2.59 (td, J = 12.8, 5.3 Hz, 1H), 2.44 (dd, J = 18.8, 4.9 Hz, 1H), 2.17 (ddd, J = 18.6, 13.4, 5.1 Hz, 1H), 2.05 (dd, J = 12.2, 4.5 Hz, 1H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 196.77, 179.40, 161.89, 158.23, 153.09, 149.56, 136.18, 125.12, 124.43, 111.15, 105.81, 64.23, 56.29, 45.07, 42.94, 33.55, 32.28;

HRMS (ESI) calculated for $C_{18}H_{18}NO_5$ $[M+H]^+$ m/z 328.1185, found 328.1185.



22 3

3-demethoxyerythratidinone (**3**): To a solution of CrO_3 (6.31 mmol, 626 mg, 18.0 equiv.) in 7 mL of anhydrous DCM was added 3,5-dimethylpyrazole (6.31 mmol, 607 mg, 18.0 equiv.) in one portion at -20 °C. The reaction mixture was stirred at -20 °C for 1 h before a solution of **22** (0.35 mmol, 100 mg, 1.0 equiv.) in 3.5 mL of anhydrous DCM was added portionwise. After being stirred at -20 °C for 9 h, the reaction mixture was filtered through Celite. The filtrate was diluted with a saturated sodium bicarbonate aqueous solution and the mixture was extracted three times with DCM. The combined organic phase was washed with brine, dried over anhydrous sodium sulfate, and concentrated under reduced pressure to give a residue, which was purified via column chromatography (0−5% methanol in dichloromethane) to give **3** as a white solid (0.16 mmol, 48 mg, 46% yield), mp 98–100 °C (lit[1] 101–102 °C).

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.64 (s, 1H), 6.55 (s, 1H), 6.10 (s, 1H), 3.85 (s, 3H), 3.74 (s, 3H), 3.48 (ddd, J = 14.5, 11.9, 6.6 Hz, 1H), 3.24 (dd, J = 14.9, 7.0 Hz, 1H),

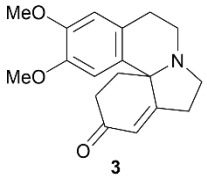
3.12–2.97 (m, 2H), 2.85 (q, *J* = 8.9 Hz, 1H), 2.78–2.65 (m, 1H), 2.63–2.40 (m, 4H), 2.31 (ddd, *J* = 12.4, 5.5, 2.0 Hz, 1H), 2.23–2.12 (m, 1H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 199.65, 169.35, 148.38, 146.87, 125.77, 124.79, 123.68, 112.83, 110.29, 63.55, 56.06, 55.94, 45.79, 40.17, 36.27, 32.92, 28.77, 21.49;

HRMS (ESI) calculated for $C_{18}H_{22}NO_3$ $[M+H]^+$ *m*/*z* 300.1599, found 300.1608.

7. Comparative Spectral Data

Table S1 Comparison of ^{1}H and ^{13}C NMR spectra data of synthetic 3-demethoxyerythratidinone with reported data[2]



3

^{1}H NMR		^{13}C NMR	
Synthesized (400 MHz, $CDCl_3$)	Reported (400 MHz, $CDCl_3$)	Synthesized (100 MHz, $CDCl_3$)	Reported (100 MHz, $CDCl_3$)
6.64 (s, 1H)	6.65 (s, 1H)	199.65	199.53
6.55 (s, 1H)	6.56 (s, 1H)	169.35	169.11
6.10 (s, 1H)	6.10 (t, *J* = 1.9 Hz, 1H)	148.38	148.60
3.85 (s, 3H)	3.85 (s, 3H)	146.87	147.10
3.74 (s, 3H)	3.74 (s, 3H)	125.77	125.86
3.48 (ddd, *J* = 14.5, 11.9, 6.6 Hz, 1H)	3.48 (ddd, *J* = 14.5, 11.7, 6.6 Hz, 1H)	124.79	124.98
3.24 (dd, *J* = 14.9, 7.0 Hz, 1H)	3.23 (ddd, *J* = 14.5, 7.6, 1.3 Hz, 1H)	123.68	123.28
3.12–2.97 (m, 2H)	3.11–3.00 (m, 2H)	112.83	113.07
2.85 (q, *J* = 8.9 Hz, 1H)	2.89–2.68 (m, 2H)	110.29	110.59
2.78–2.65 (m, 1H)		63.55	63.71
2.63–2.40 (m, 4H)	2.62–2.38 (m, 4H)	56.06	56.21
2.31 (ddd, *J* = 12.4, 5.5, 2.0 Hz, 1H)	2.31 (ddd, *J* = 12.5, 5.6, 2.1 Hz, 1H)	55.94	56.05
2.23–2.12 (m, 1H)	2.19 (ddd, *J* = 14.1, 12.4, 5.6 Hz, 1H)	45.79	45.96
		40.17	40.31
		36.27	36.29
		32.92	32.99
		28.77	28.82
		21.49	21.63

8. References

1 Y. Tsuda, Y. Sakai, A. Nakai, M. Kaneko, Y. Ishiguro, K. Isobe, J. Taga and T. Sano, *Chem. Pharm. Bull.*, 1990, **38**, 1462-1472.
2 H. T. Luu, S. Wiesler, G. Frey and J. Streuff, *Org. Lett.*, 2015, **17**, 2478-2481.

9. X-Ray Crystallography Data of 19p and 19q

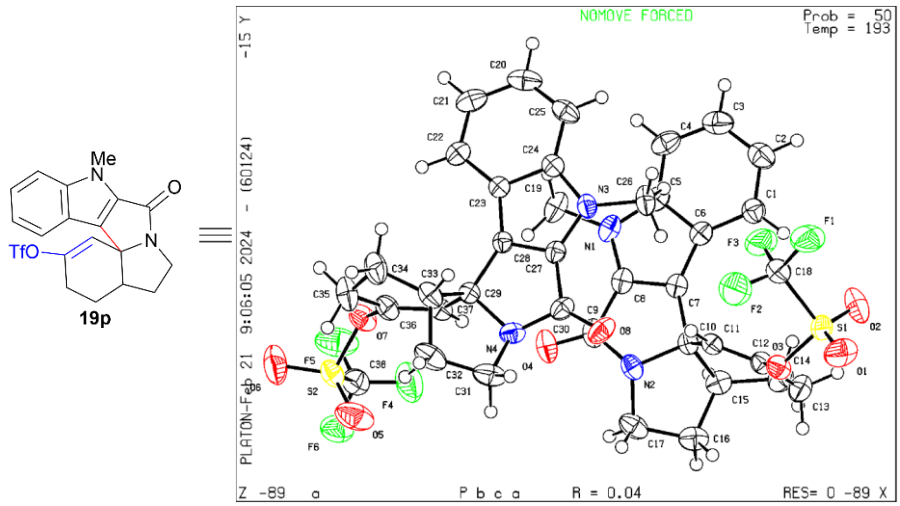


Figure S1 Crystal structure of **19p** (CCDC 2336176). A single crystal of compound **19p** was obtained by slowly volatilizing a solution of **19p** in a mixture of DCM/MeOH at room temperature.

Table S2 Cell parameters of compound **19p**

Bond precision:	C-C = 0.0026 A	Wavelength=1.54178	
Cell:	a=19.2019(4)	b=13.9245(3)	c=28.2926(5)
	alpha=90	beta=90	gamma=90
Temperature: 193 K			
	Calculated	Reported	
Volume	7564.8(3)	7564.8(3)	
Space group	P b c a	P b c a	
Hall group	-P 2ac 2ab	-P 2ac 2ab	
Moiety formula	C19 H17 F3 N2 O4 S	C19 H17 F3 N2 O4 S	
Sum formula	C19 H17 F3 N2 O4 S	C19 H17 F3 N2 O4 S	
Mr	426.41	426.40	
Dx,g cm-3	1.498	1.498	
Z	16	16	
Mu (mm-1)	2.061	2.061	
F000	3520.0	3520.0	
F000'	3538.00		
h,k,lmax	23,16,34	23,16,34	

Nref	6962	6950
Tmin,Tmax	0.781,0.814	0.674,0.753
Tmin'	0.781	
Correction method= # Reported T Limits: Tmin=0.674 Tmax=0.753		
AbsCorr = MULTI-SCAN		
Data completeness= 0.998		Theta(max)= 68.464
R(reflections)= 0.0381(6154)		wR2(reflections)= 0.1046(6950)
S = 1.062		Npar= 525

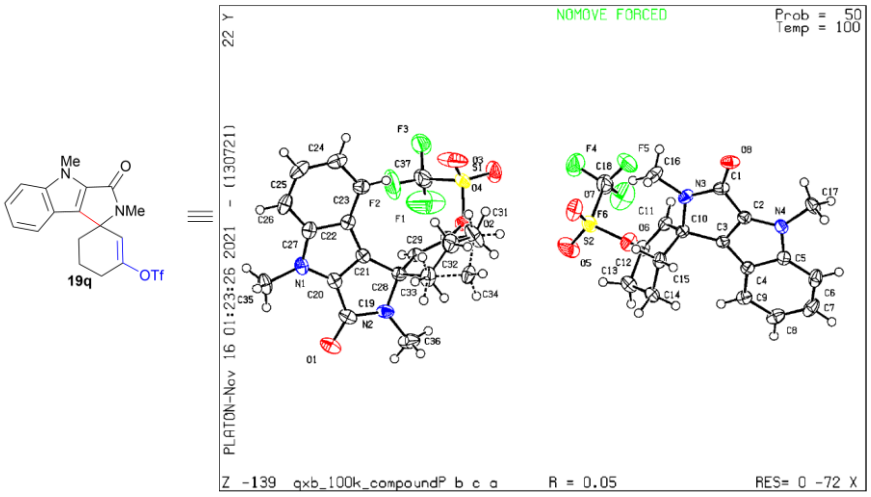


Figure S2 Crystal structure of **19q** (CCDC 2034445). A single crystal of compound **19q** was obtained by slowly volatilizing a solution of **19q** in MeOH at room temperature.

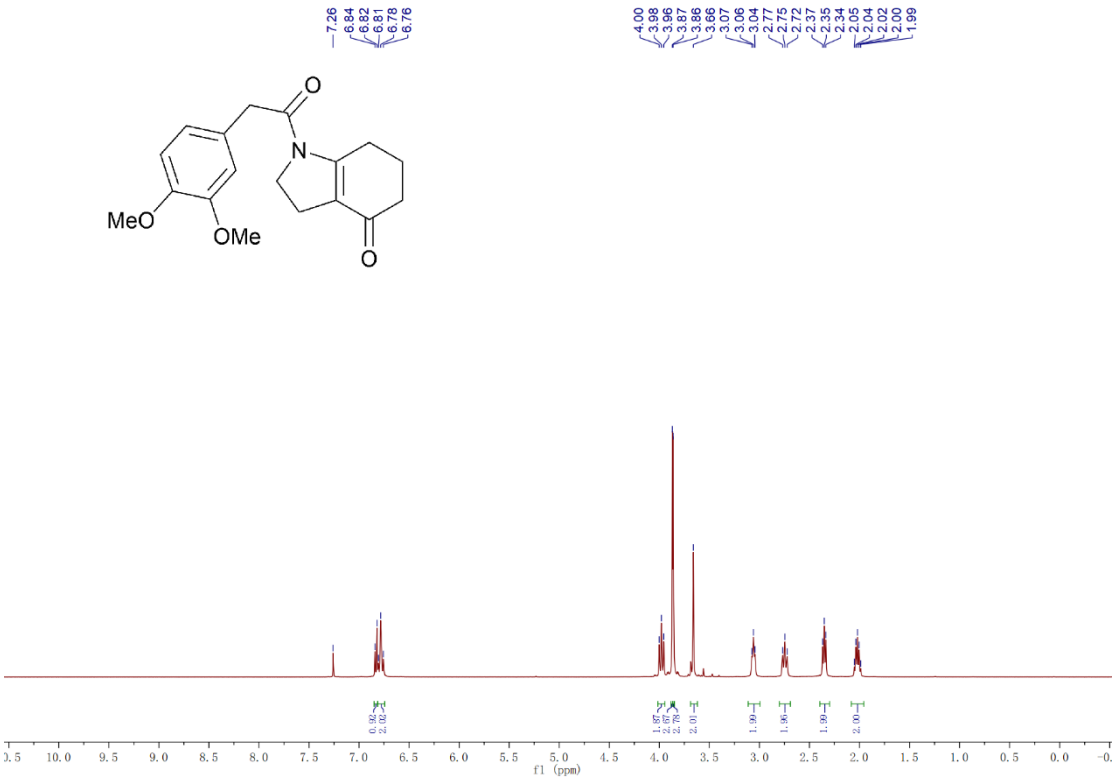
Table S3 Cell parameters of compound **19q**

Bond precision:	C-C = 0.0031 A	Wavelength=1.54184	
Cell:	a=19.4210(1)	b=13.8099(1)	c=27.8614(2)
	alpha=90	beta=90	gamma=90
Temperature: 100 K			
	Calculated	Reported	
Volume	7472.49(9)	7472.48(9)	
Space group	P b c a	P b c a	
Hall group	-P 2ac 2ab	-P 2ac 2ab	
Moiety formula	C18 H17 F3 N2 O4 S	C18 H17 F3 N2 O4 S	
Sum formula	C18 H17 F3 N2 O4 S	C18 H17 F3 N2 O4 S	
Mr	414.40	414.39	
Dx,g cm-3	1.473	1.473	
Z	16	16	
Mu (mm-1)	2.067	2.067	
F000	3424.0	3424.0	
F000'	3441.73		
h,k,lmax	24,17,34	24,17,34	
Nref	7686	7447	
Tmin,Tmax	0.780,0.813	0.605,1.000	

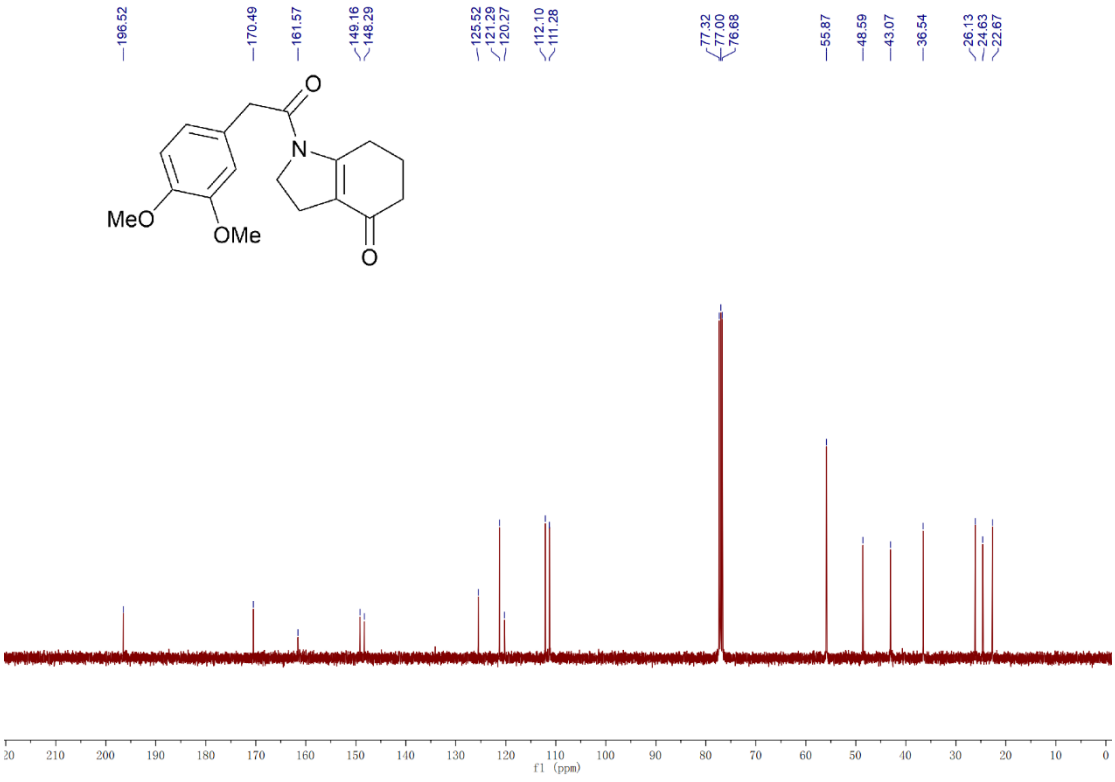
Tmin'	0.780
Correction method= # Reported T Limits: Tmin=0.605 Tmax=1.000	
AbsCorr = MULTI-SCAN	
Data completeness= 0.969	Theta(max)= 74.917
R(reflections)= 0.0518(6840)	wR2(reflections)= 0.1334(7447)
S = 1.063	Npar= 519

10. Copies of NMR Spectra

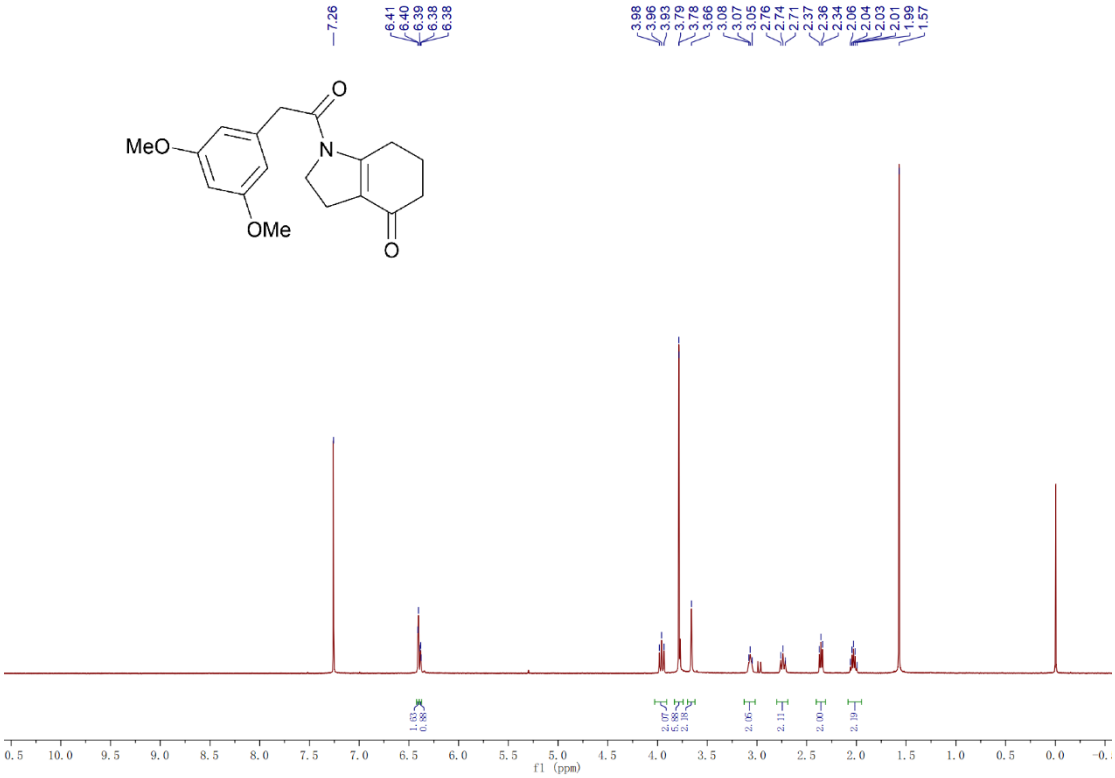
Compound **17a**, ^{1}H NMR, 400 MHz, $CDCl_3$



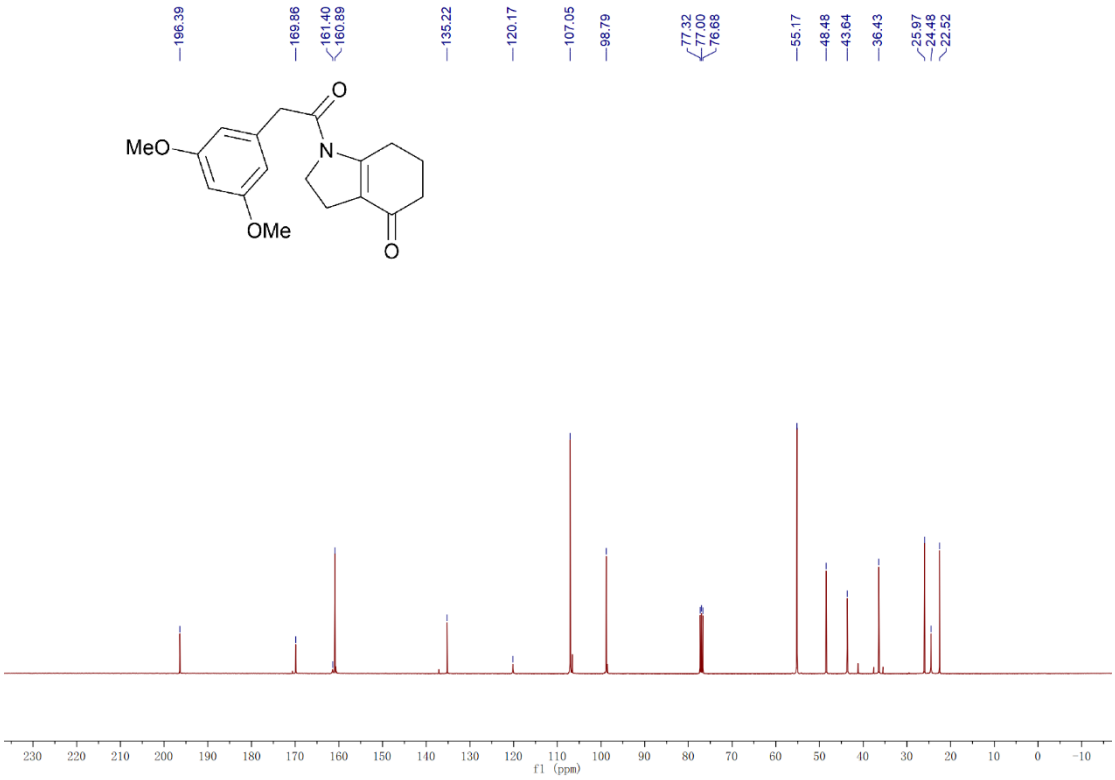
Compound **17a**, ^{13}C NMR, 100 MHz, $CDCl_3$



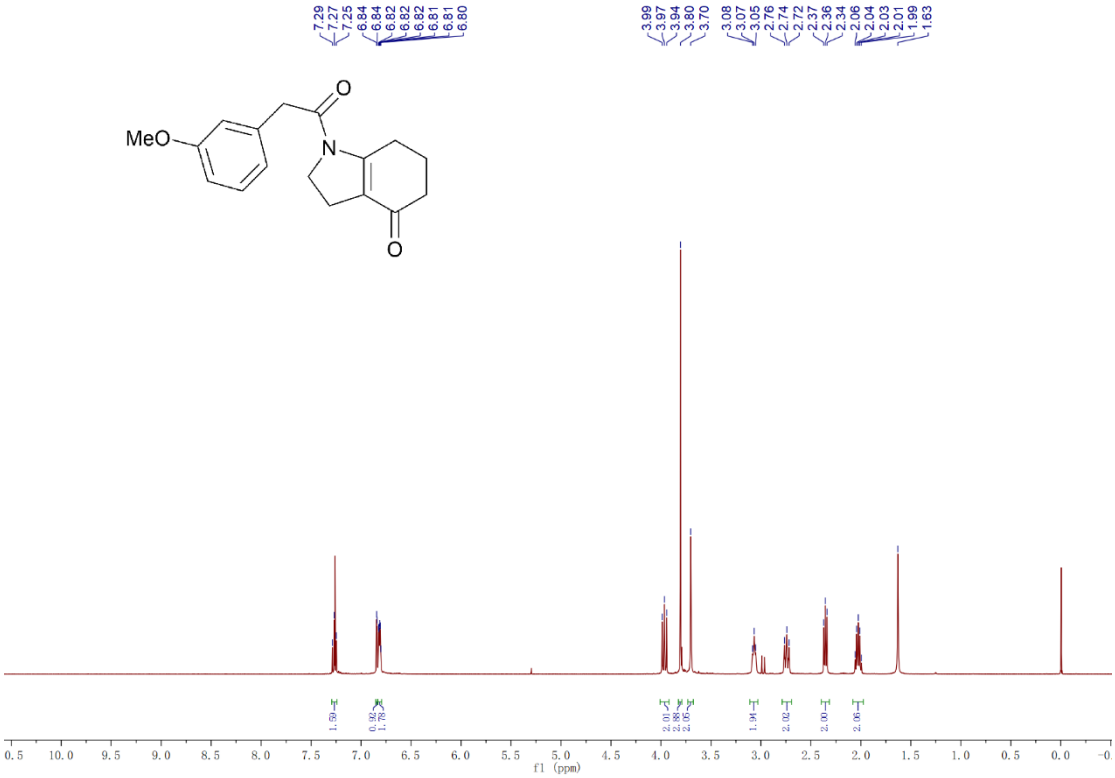
Compound **17b**, ^{1}H NMR, 400 MHz, $CDCl_3$



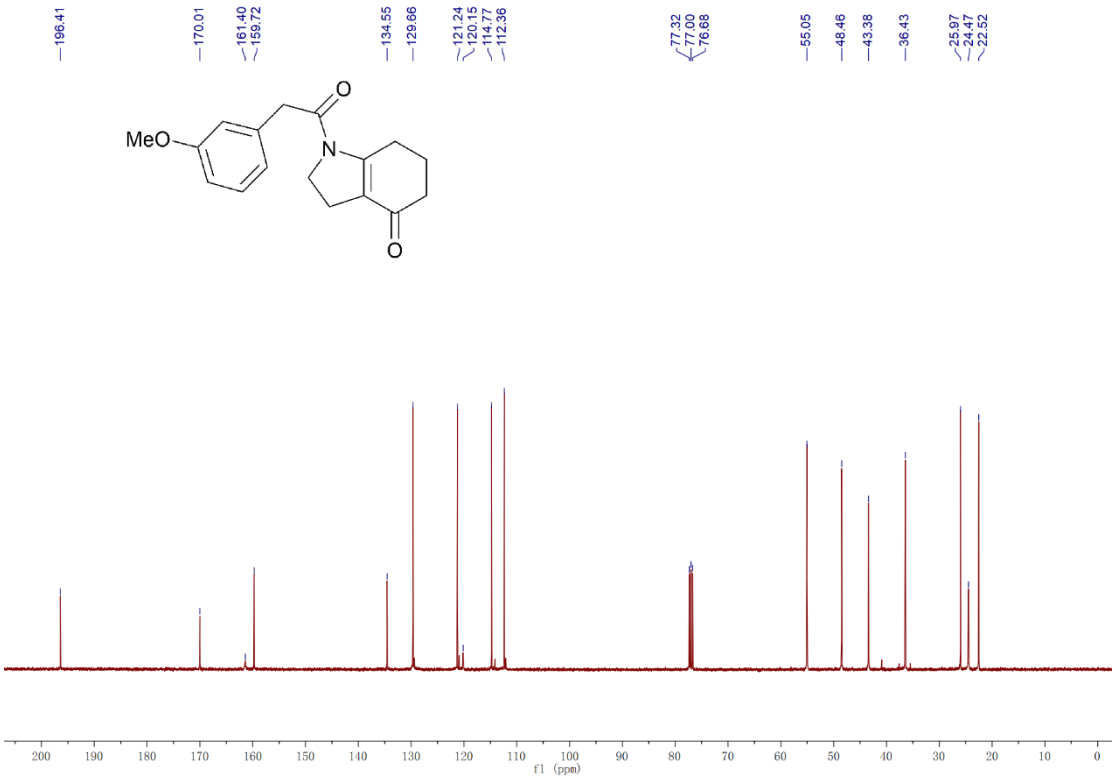
Compound **17b**, ^{13}C NMR, 100 MHz, $CDCl_3$



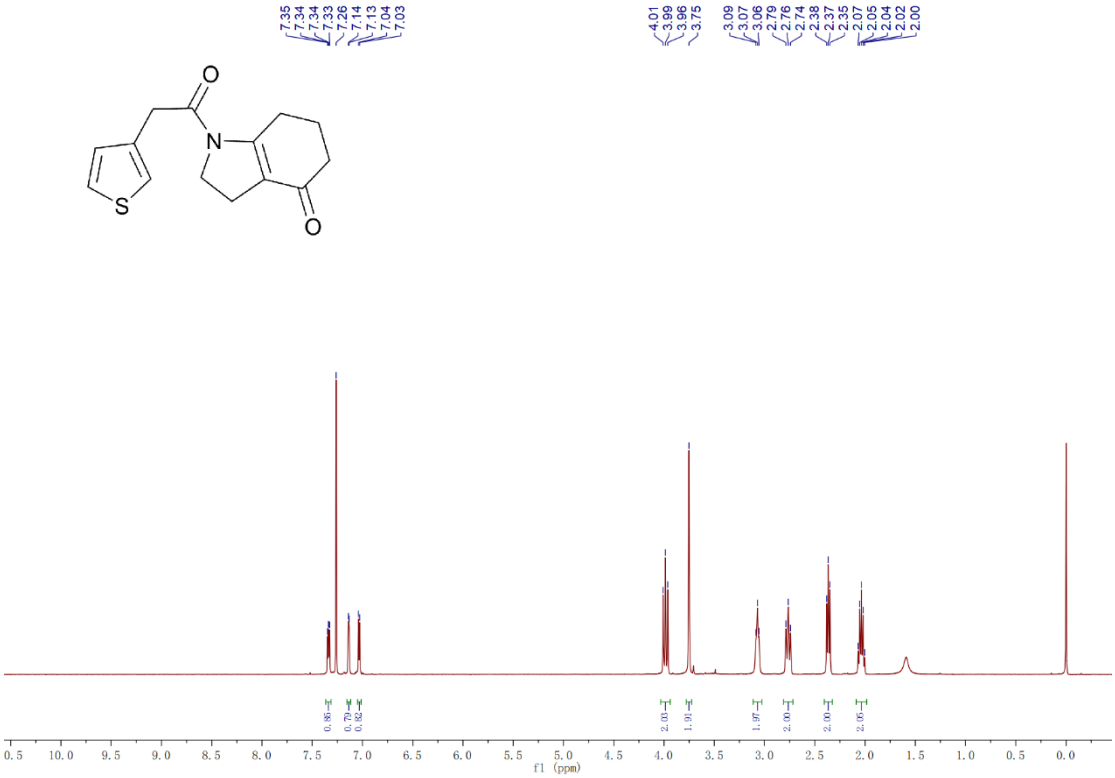
Compound **17c**, ^{1}H NMR, 400 MHz, $CDCl_3$



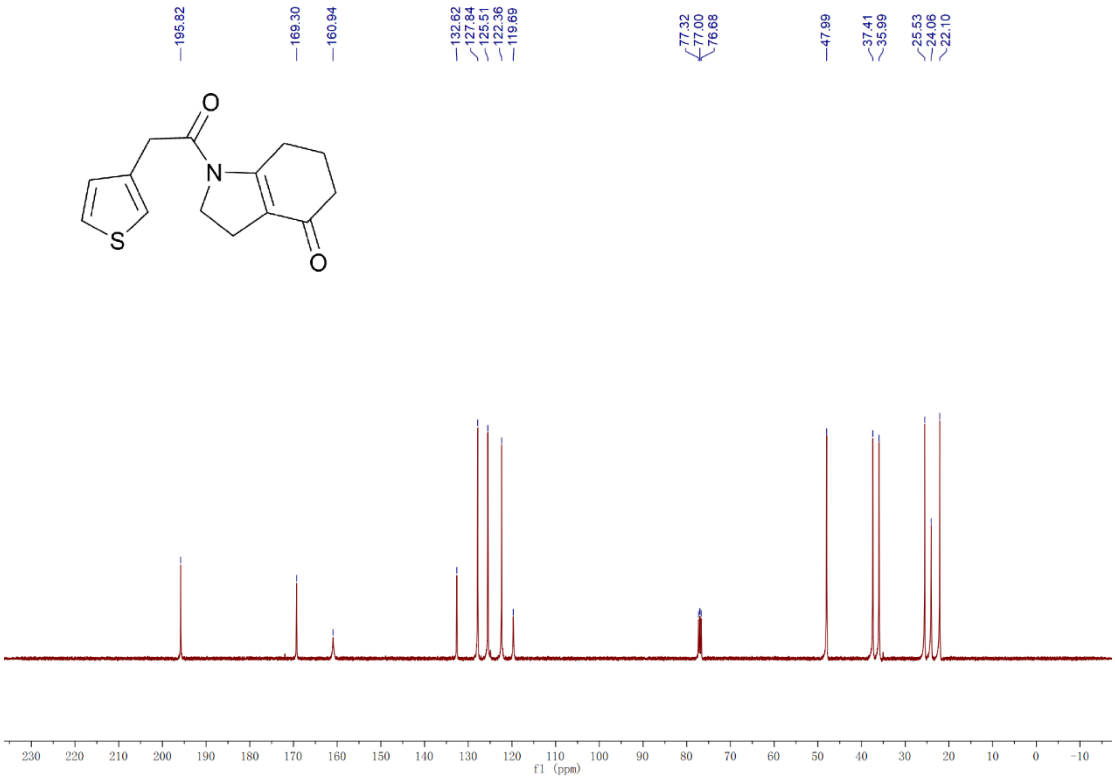
Compound **17c**, ^{13}C NMR, 100 MHz, $CDCl_3$



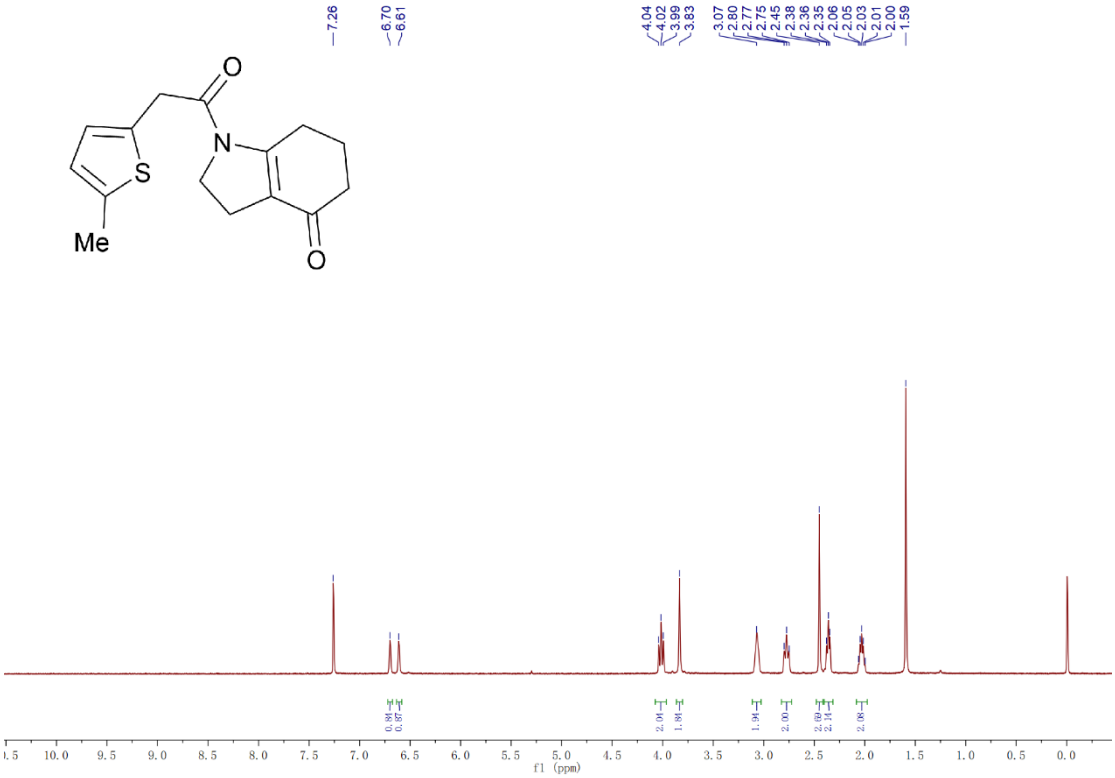
Compound **17d**, ^{1}H NMR, 400 MHz, $CDCl_3$



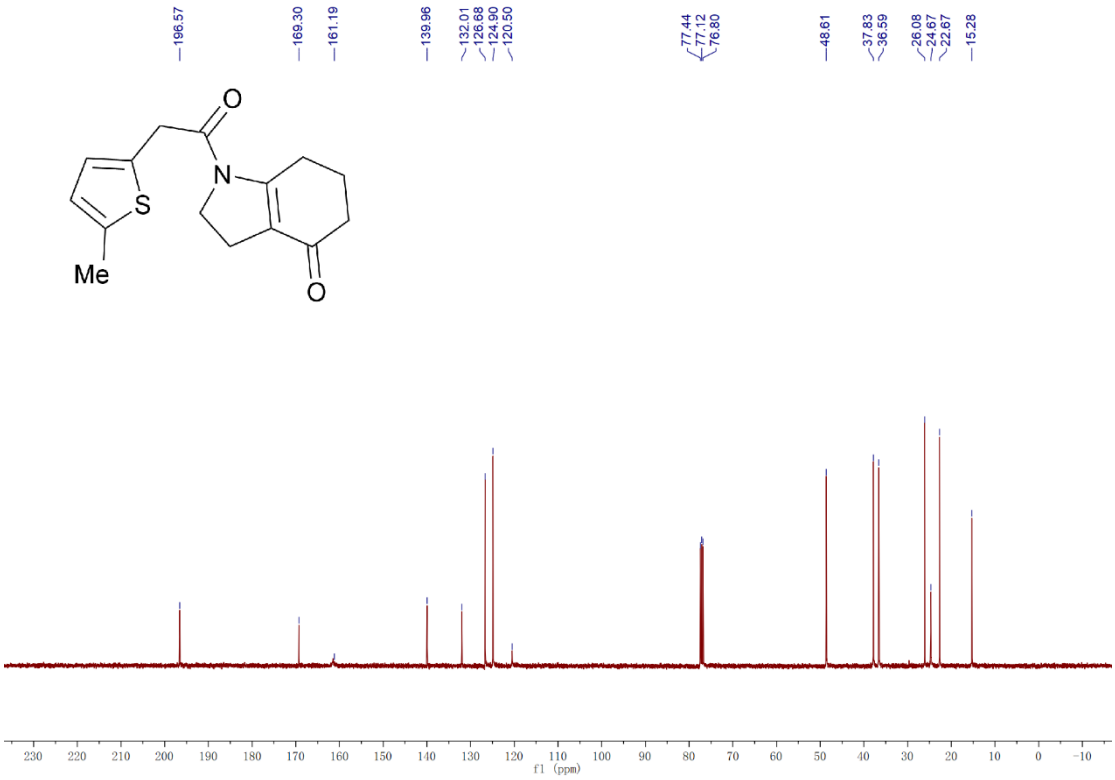
Compound **17d**, ^{13}C NMR, 100 MHz, $CDCl_3$



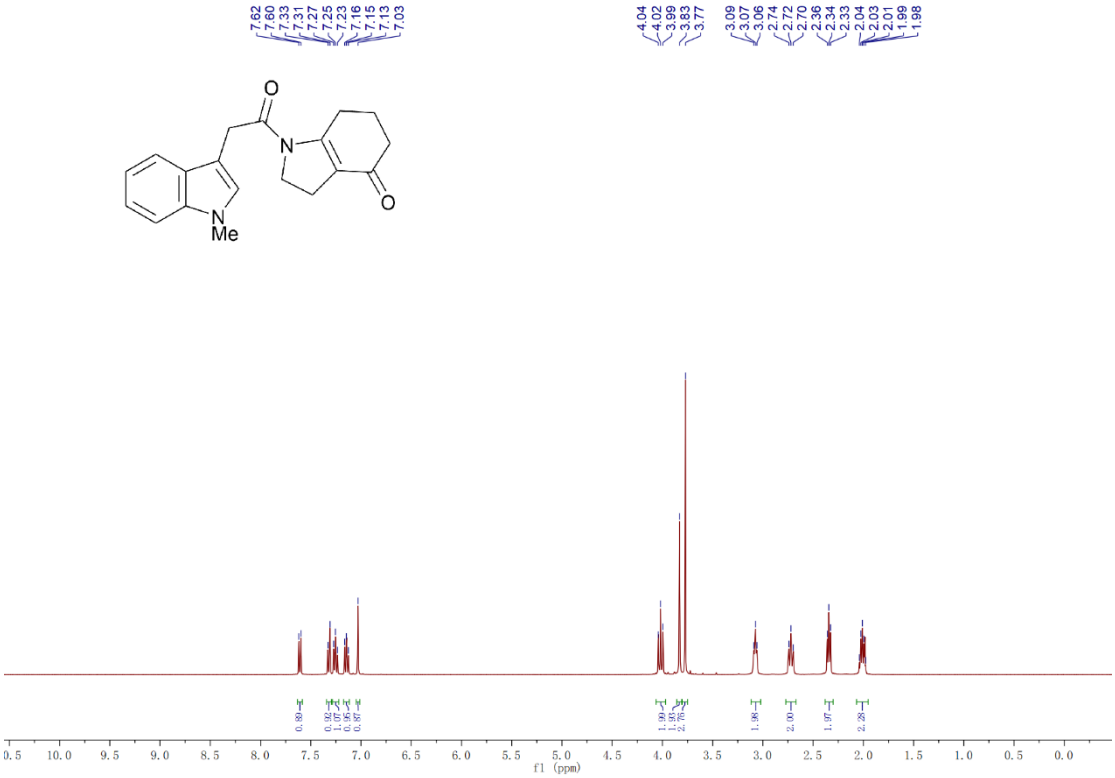
Compound **17e**, ^{1}H NMR, 400 MHz, $CDCl_3$



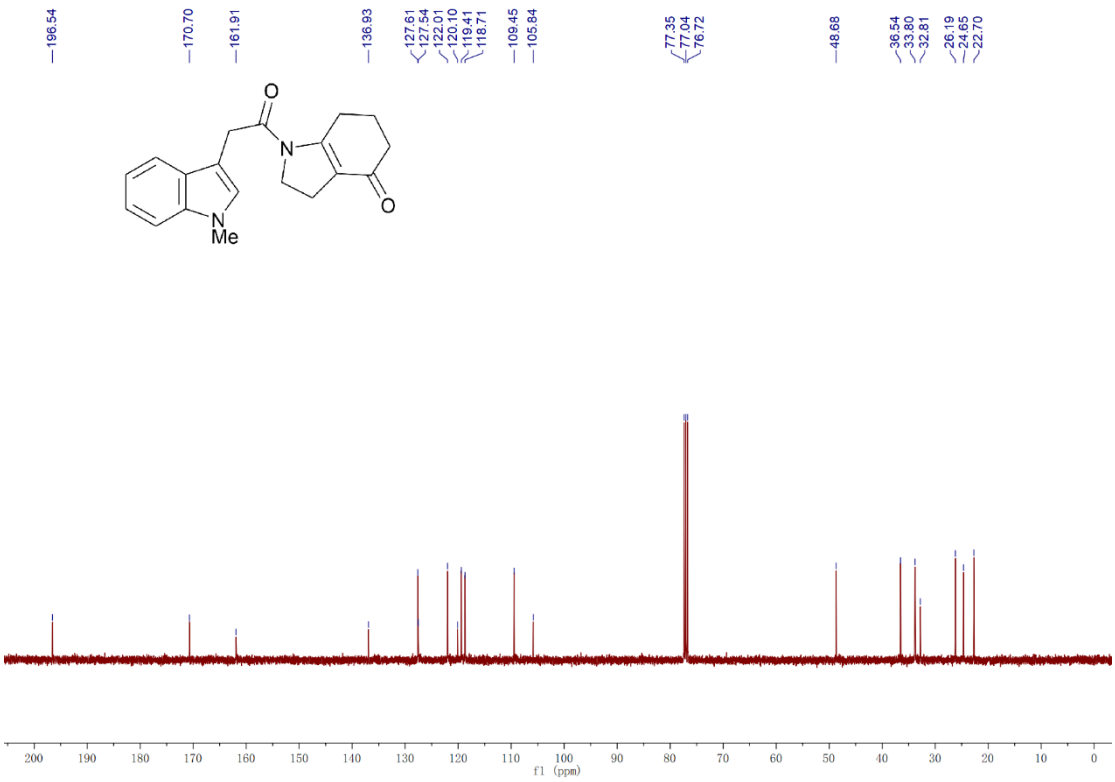
Compound **17e**, ^{13}C NMR, 100 MHz, $CDCl_3$



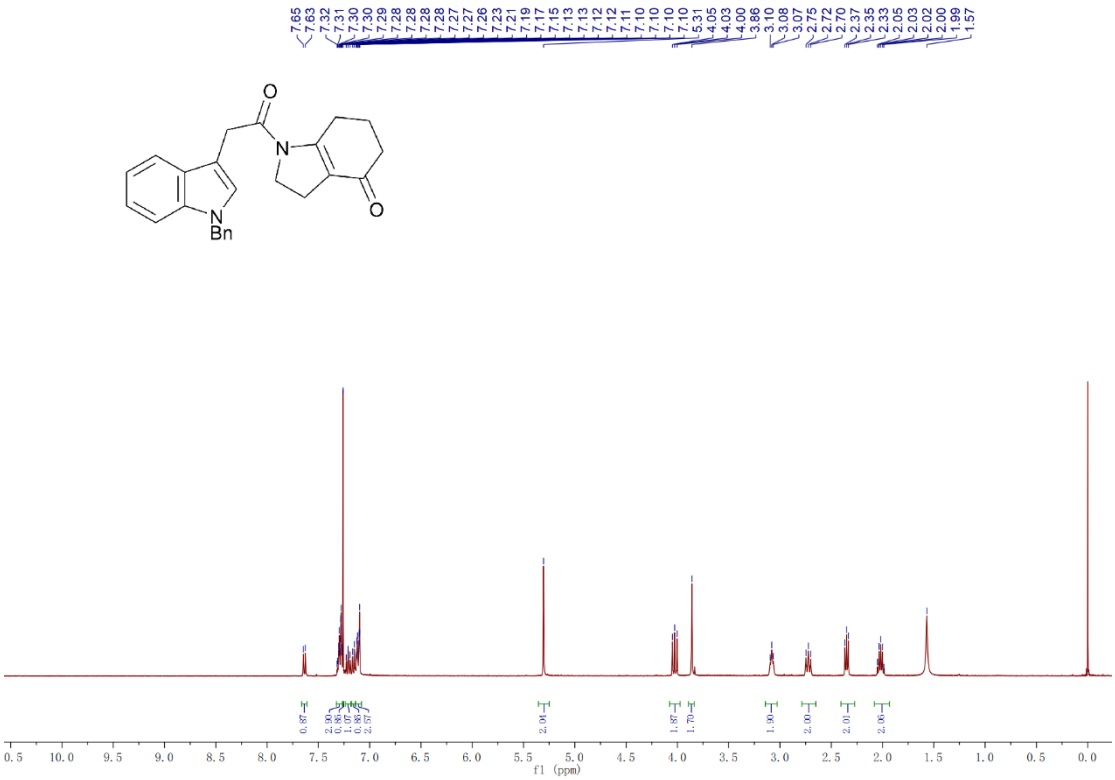
Compound **17f**, ^{1}H NMR, 400 MHz, $CDCl_3$



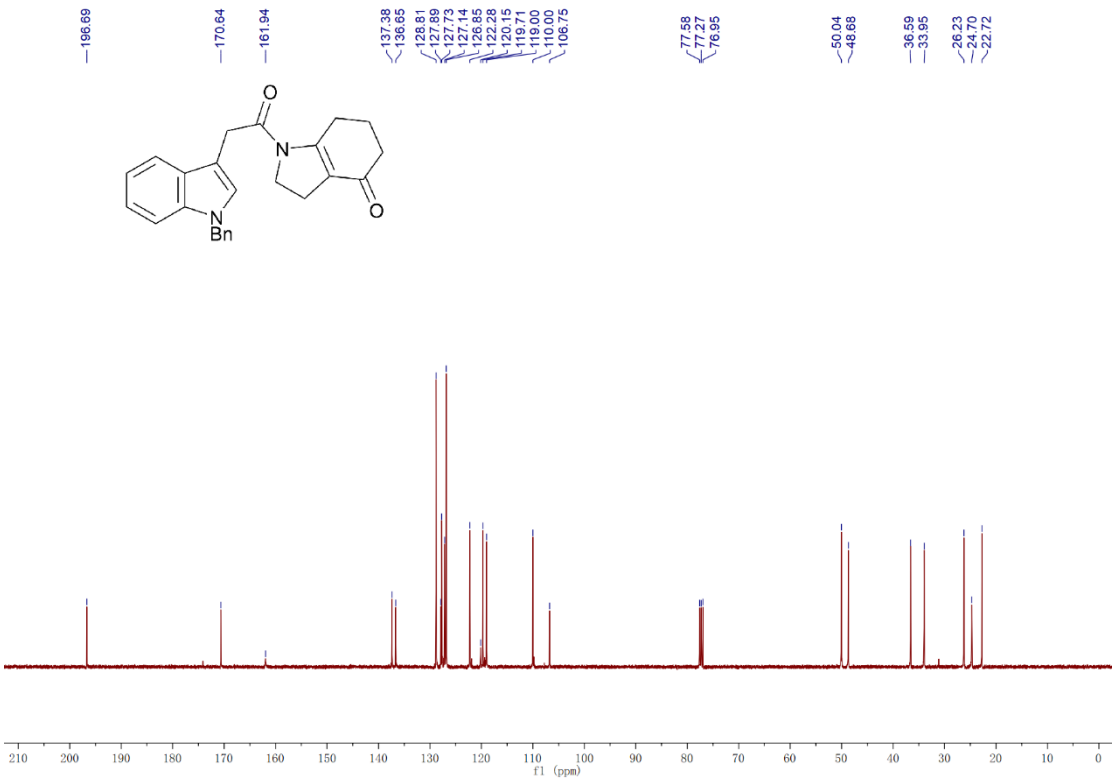
Compound **17f**, ^{13}C NMR, 100 MHz, $CDCl_3$



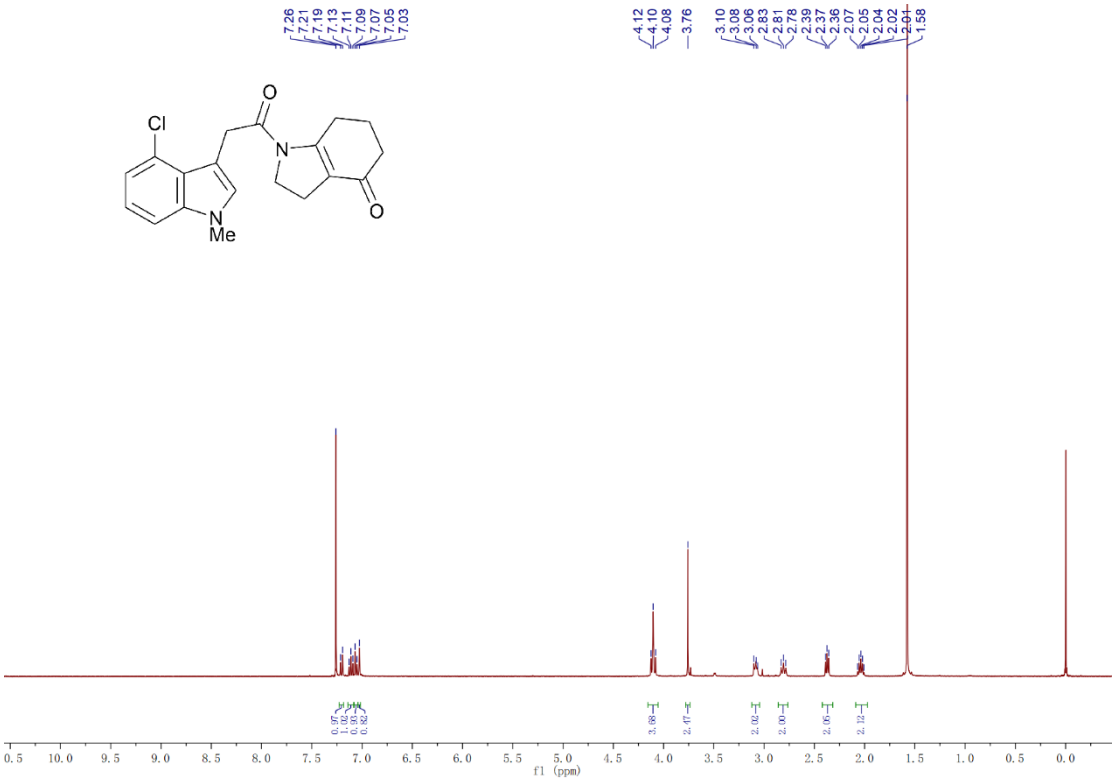
Compound **17g**, ^{1}H NMR, 400 MHz, $CDCl_3$



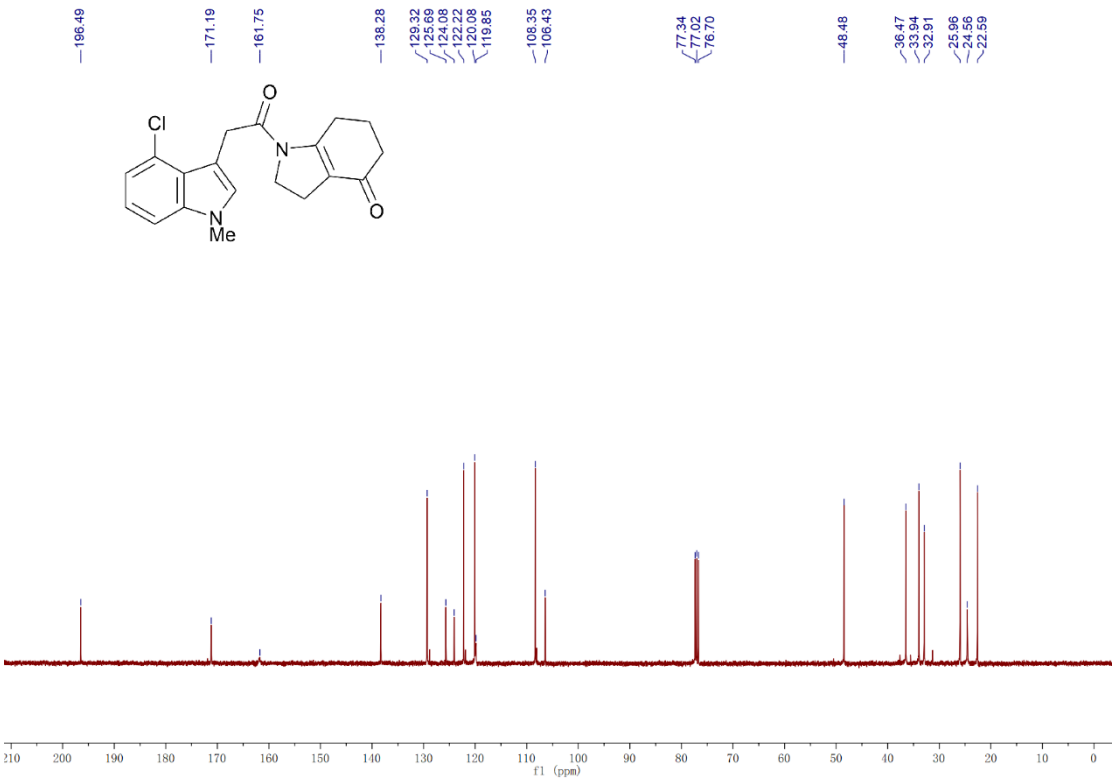
Compound **17g**, ^{13}C NMR, 100 MHz, $CDCl_3$



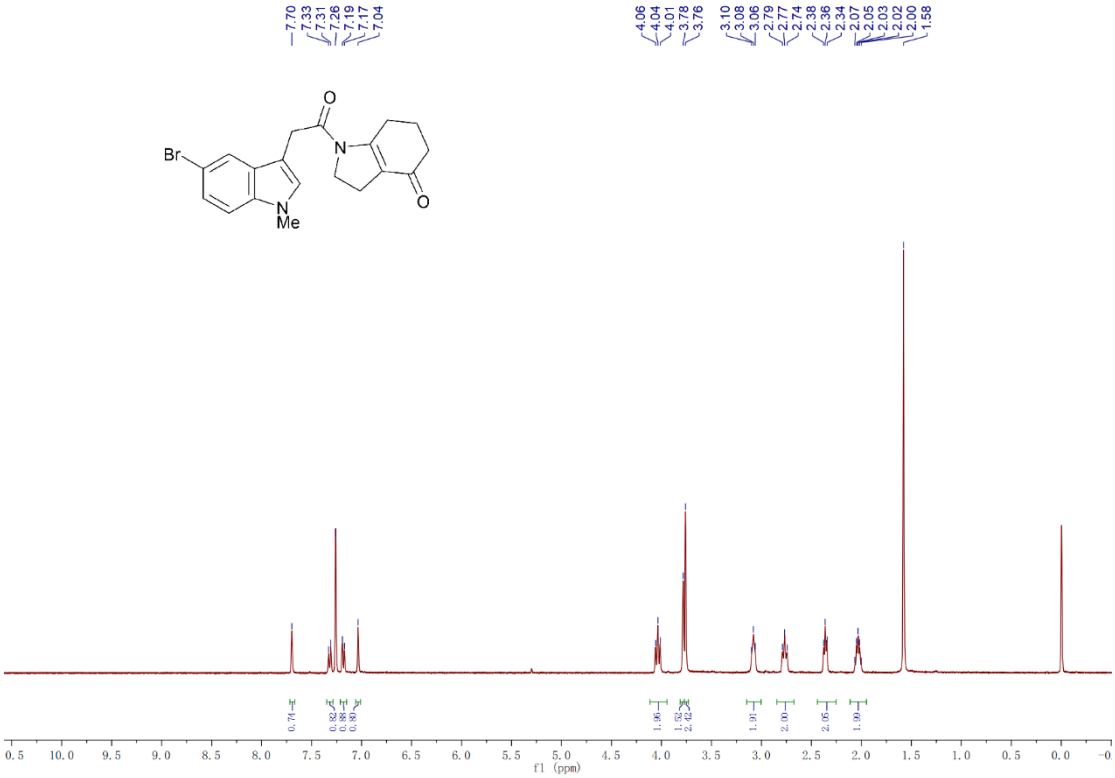
Compound **17h**, ^{1}H NMR, 400 MHz, $CDCl_3$



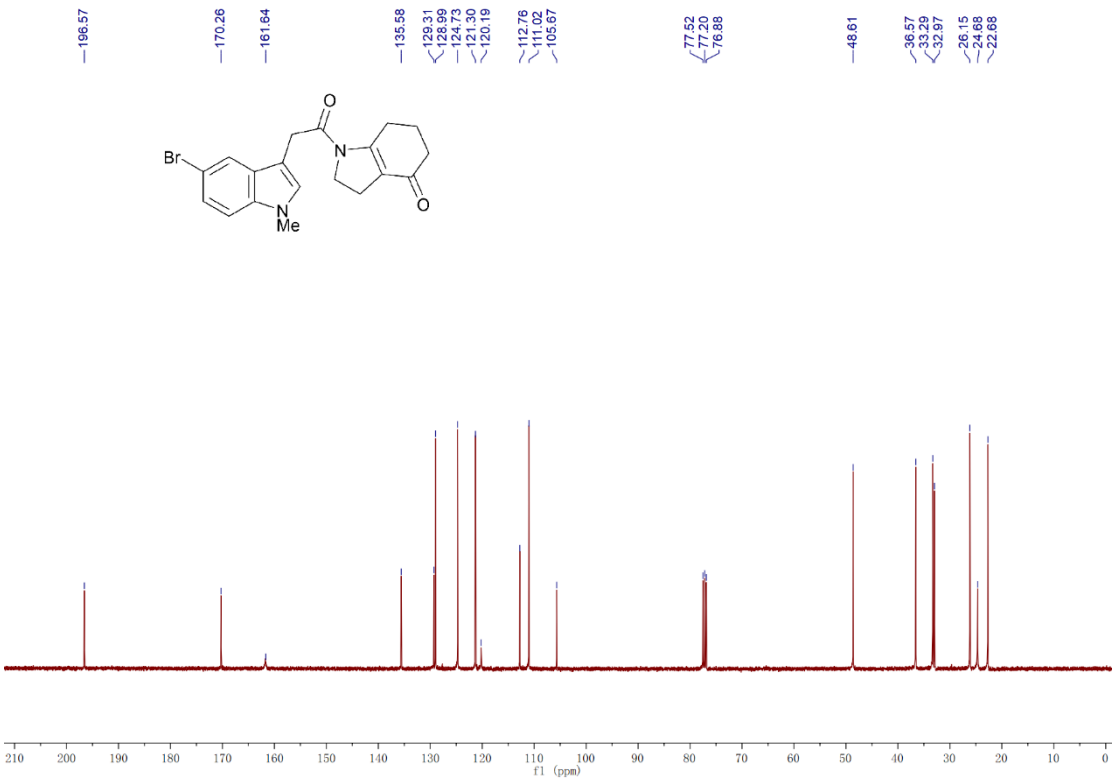
Compound **17h**, ^{13}C NMR, 100 MHz, $CDCl_3$



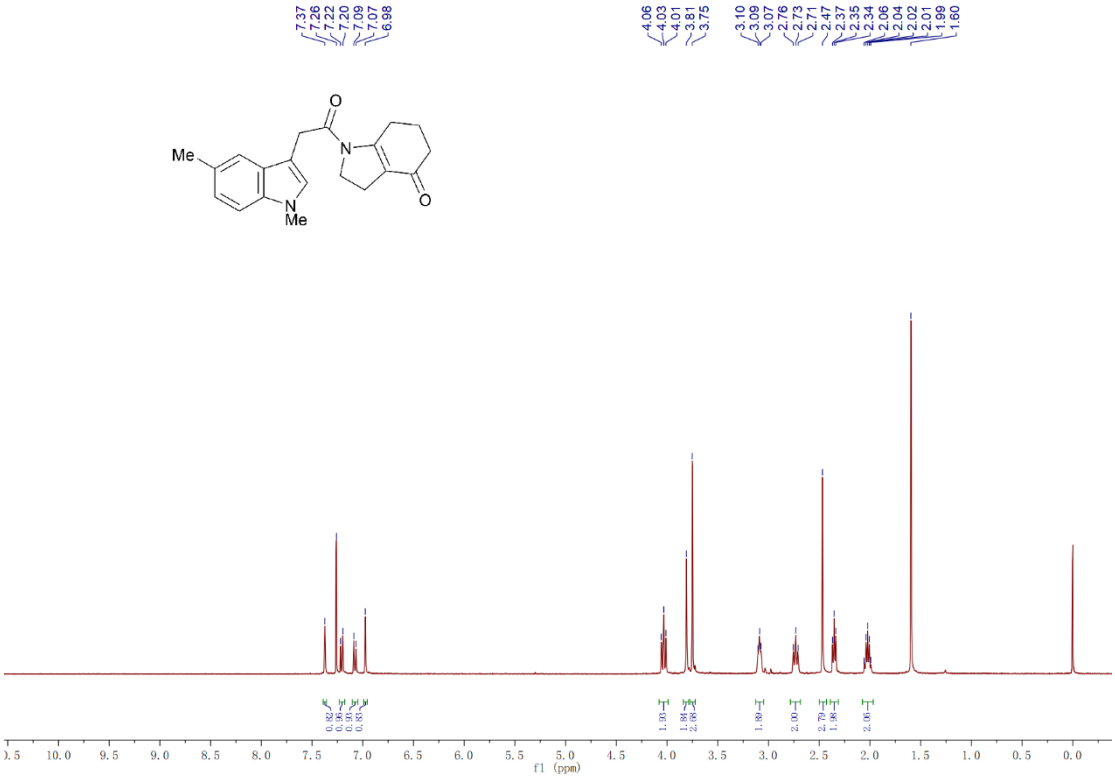
Compound **17i**, ^{1}H NMR, 400 MHz, $CDCl_3$



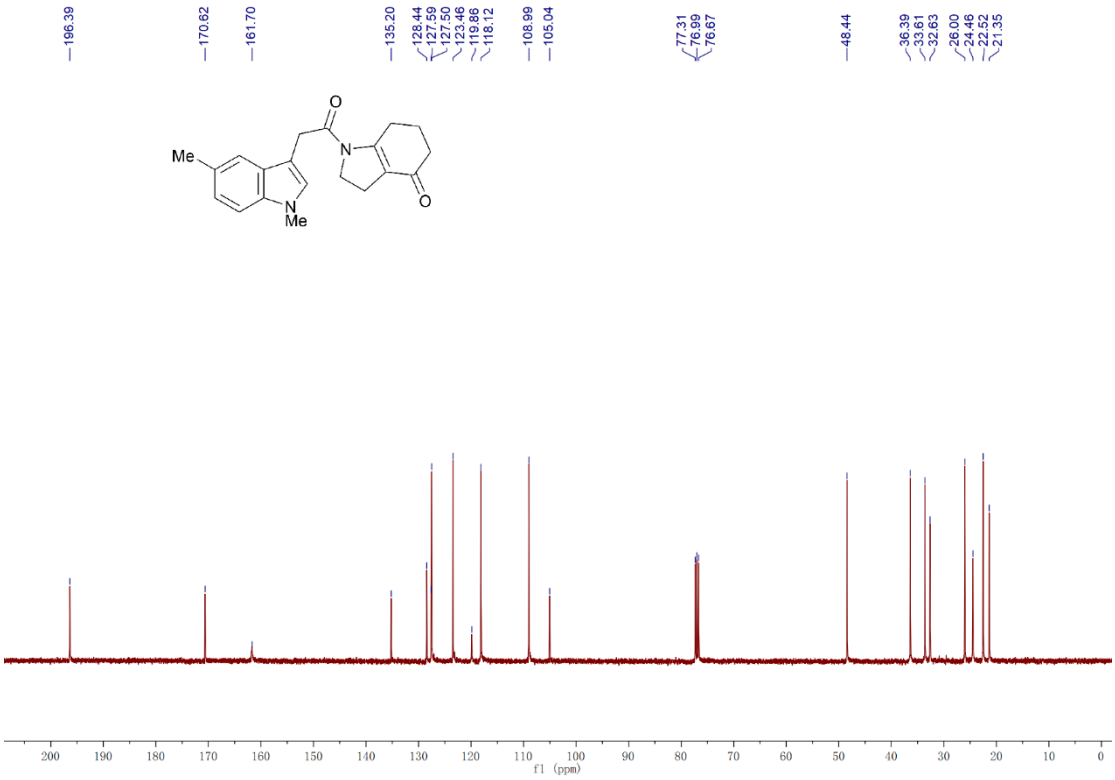
Compound **17i**, ^{13}C NMR, 100 MHz, $CDCl_3$



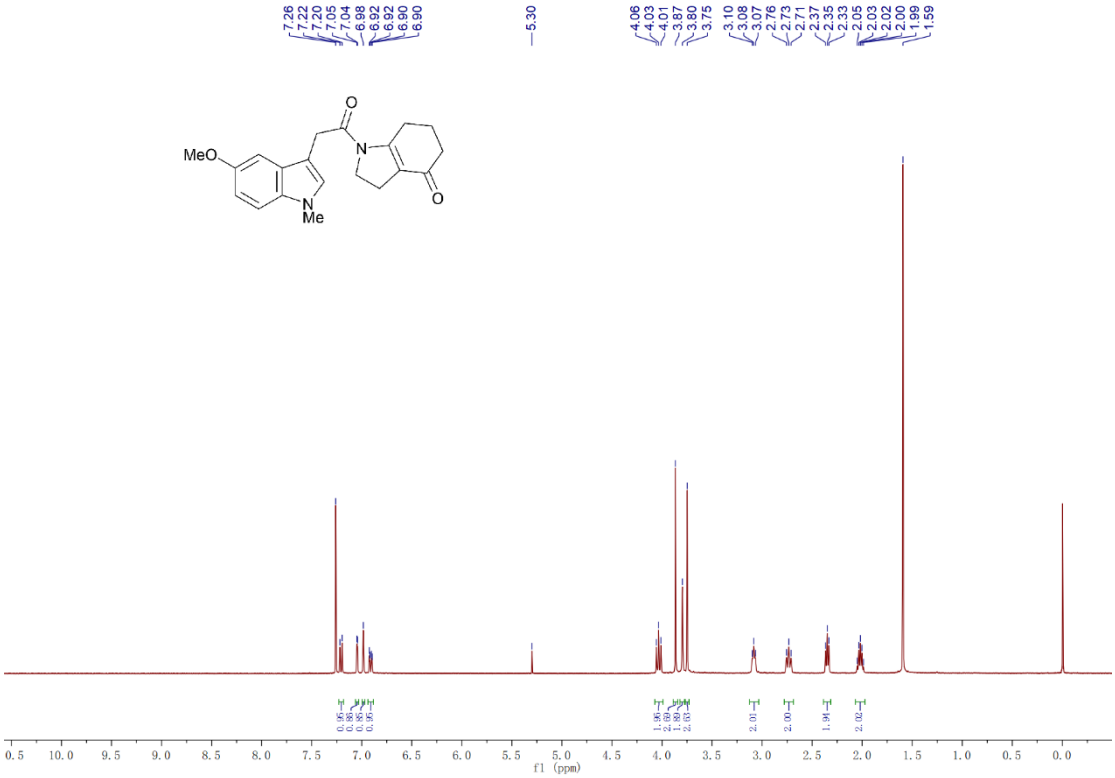
Compound **17j**, ^{1}H NMR, 400 MHz, $CDCl_3$



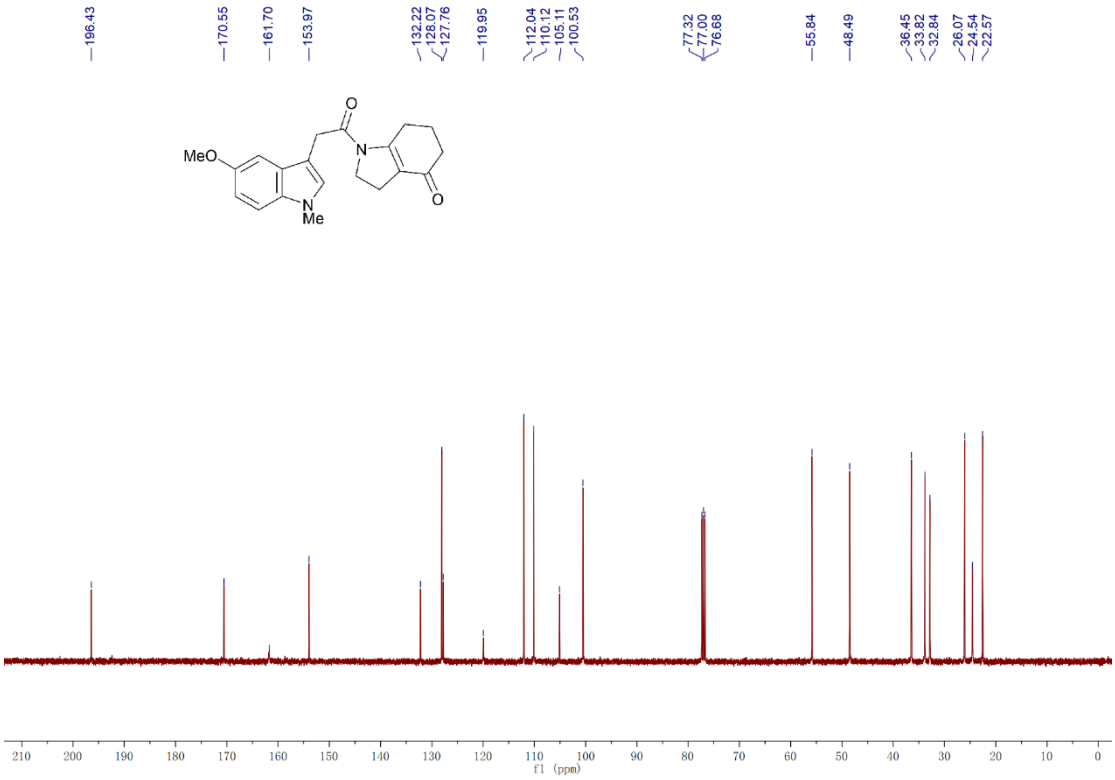
Compound **17j**, ^{13}C NMR, 100 MHz, $CDCl_3$



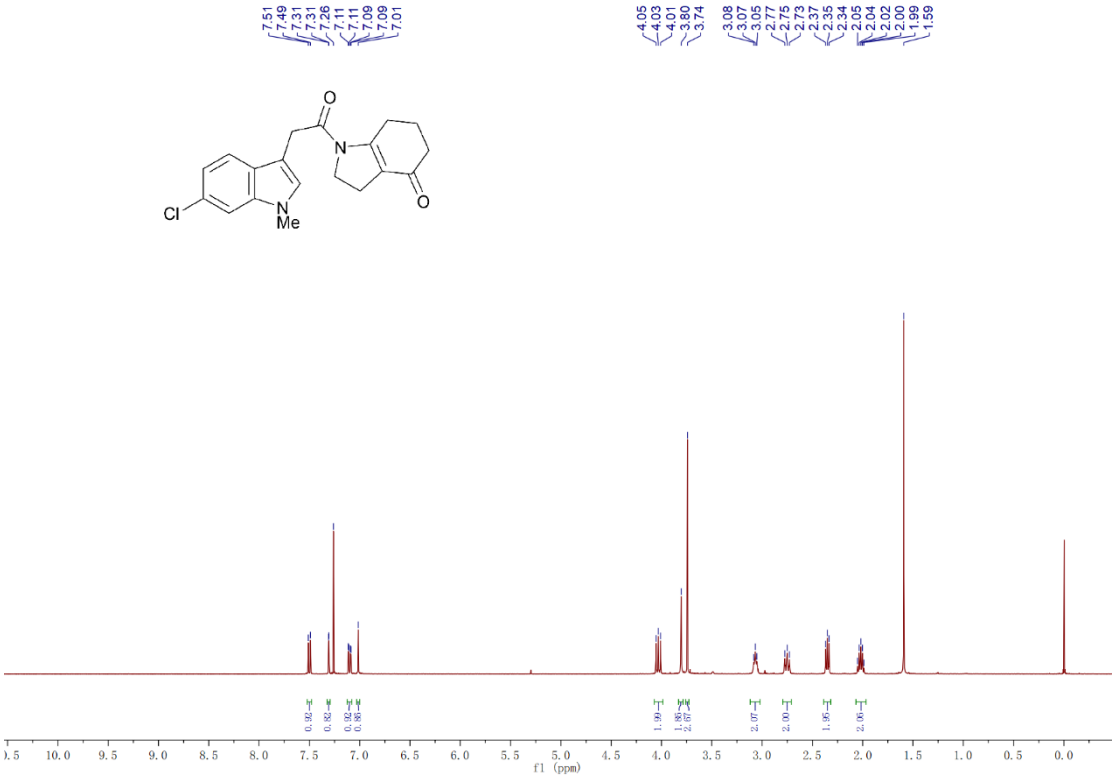
Compound **17k**, ^{1}H NMR, 400 MHz, $CDCl_3$



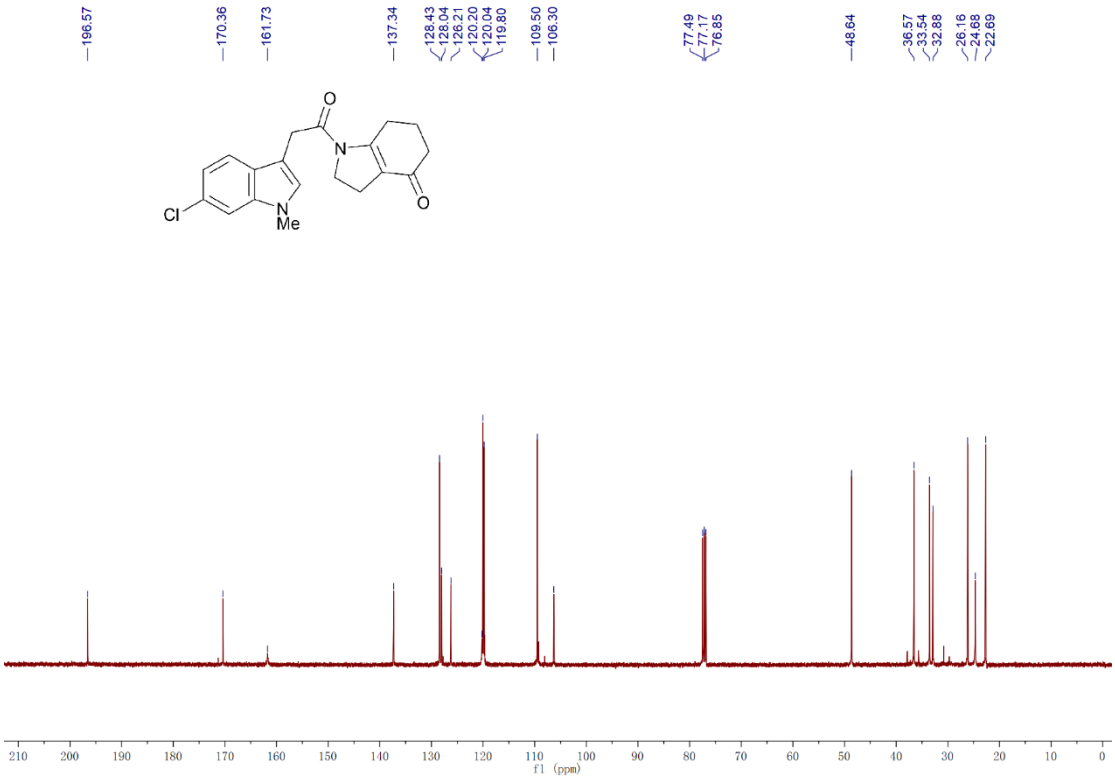
Compound **17k**, ^{13}C NMR, 100 MHz, $CDCl_3$



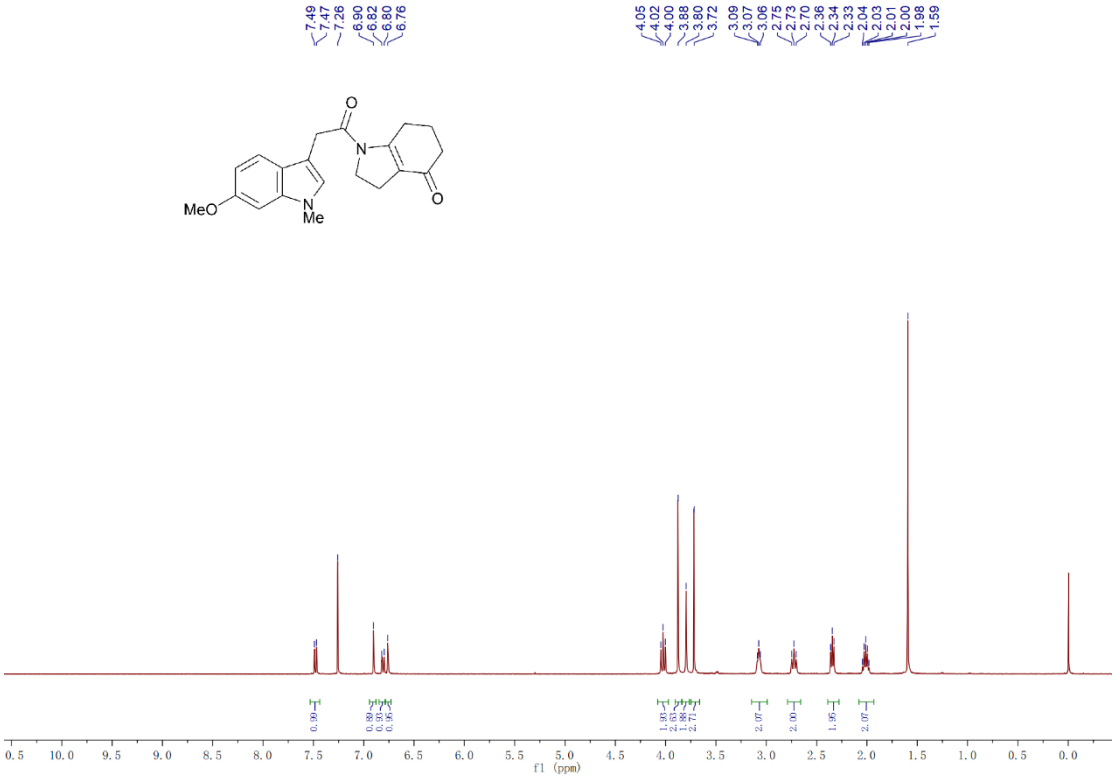
Compound **17l**, ^{1}H NMR, 400 MHz, $CDCl_3$



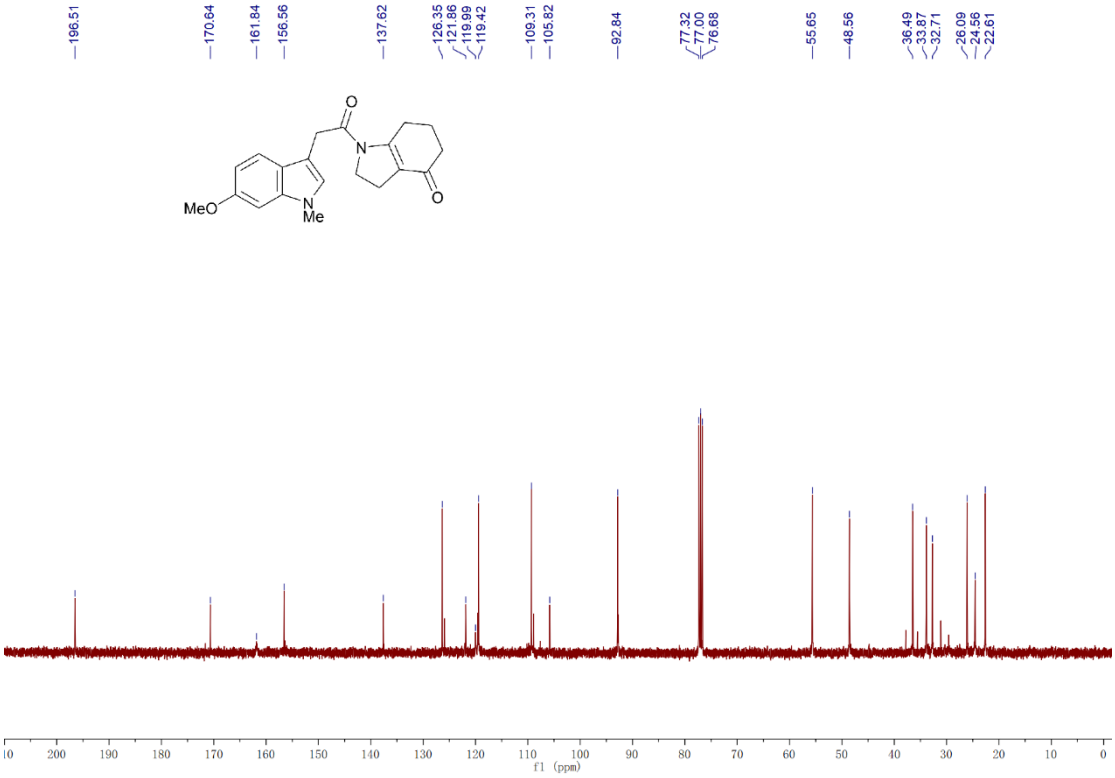
Compound **17l**, ^{13}C NMR, 100 MHz, $CDCl_3$



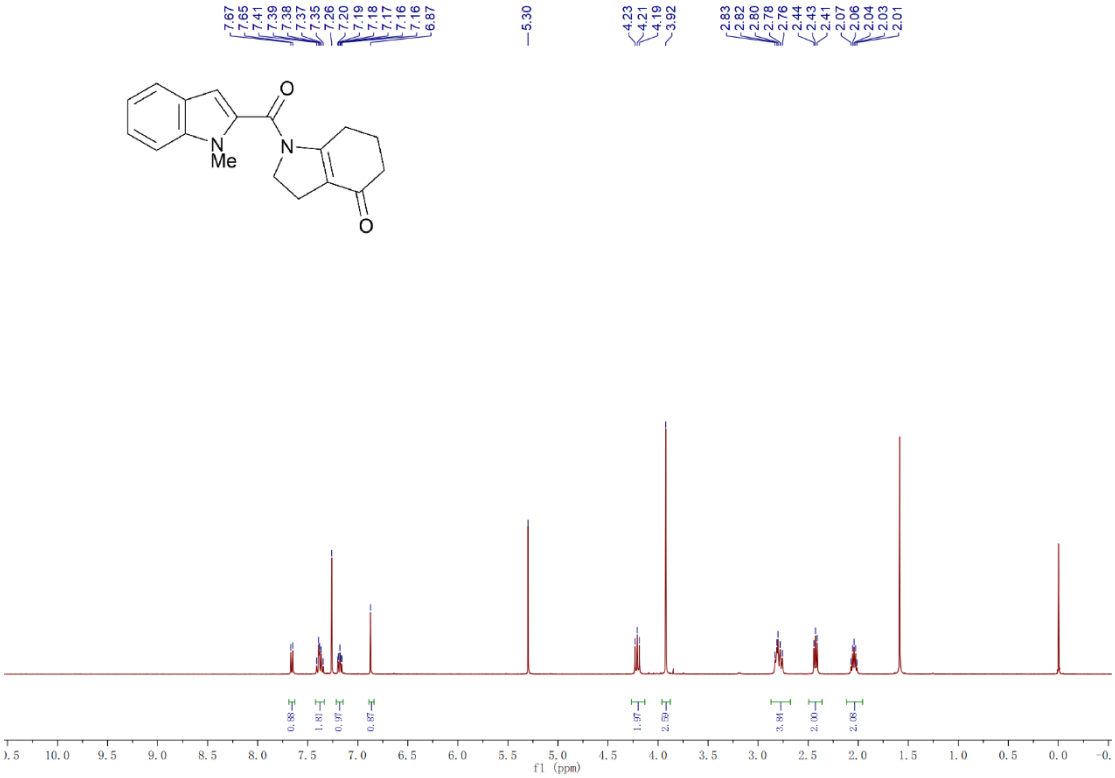
Compound **17m**, ^{1}H NMR, 400 MHz, $CDCl_3$



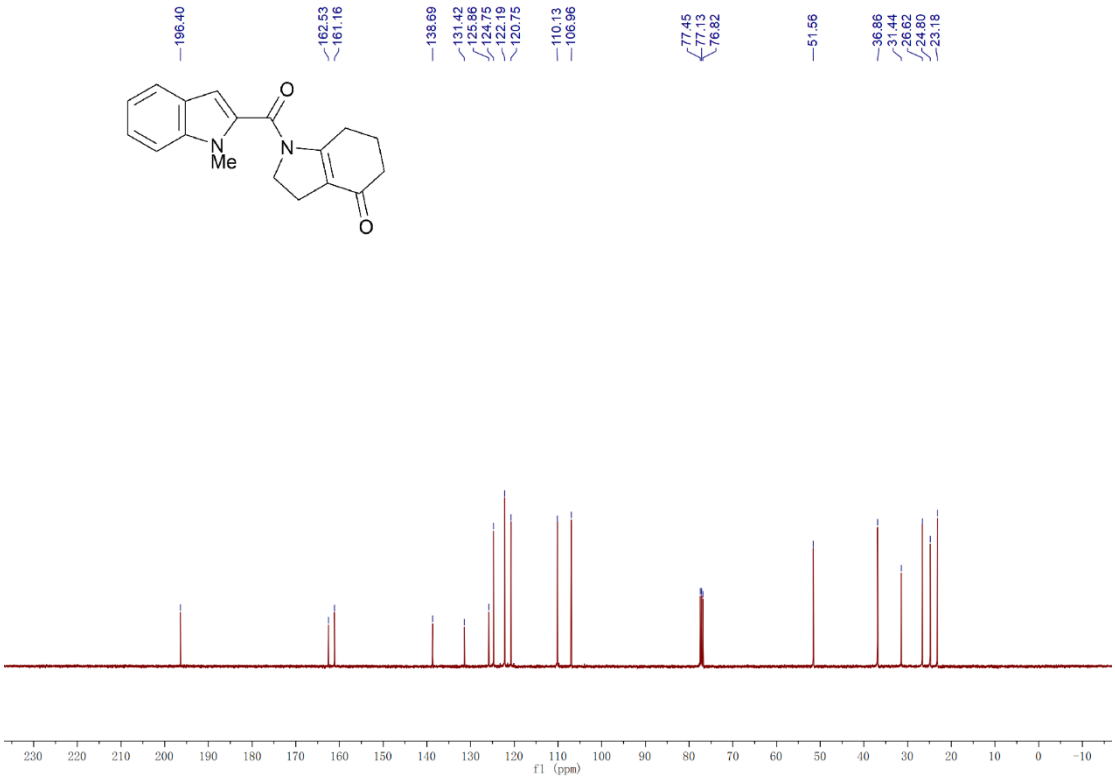
Compound **17m**, ^{13}C NMR, 100 MHz, $CDCl_3$



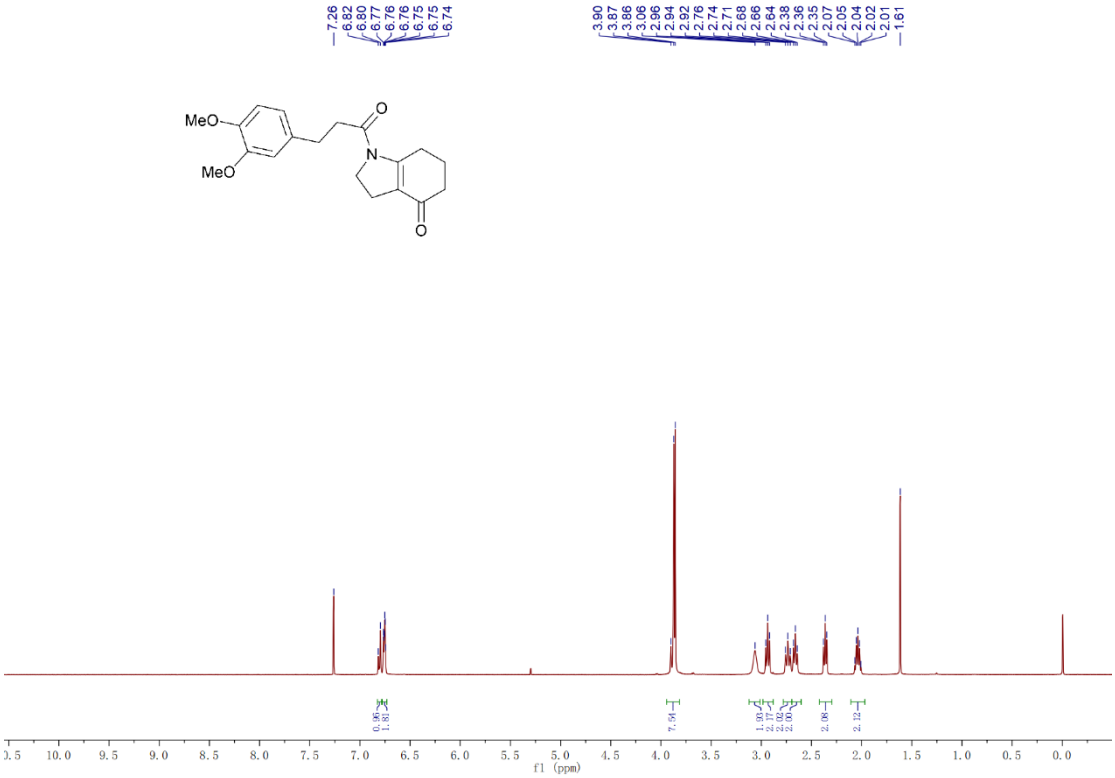
Compound **17n**, ^{1}H NMR, 400 MHz, $CDCl_3$



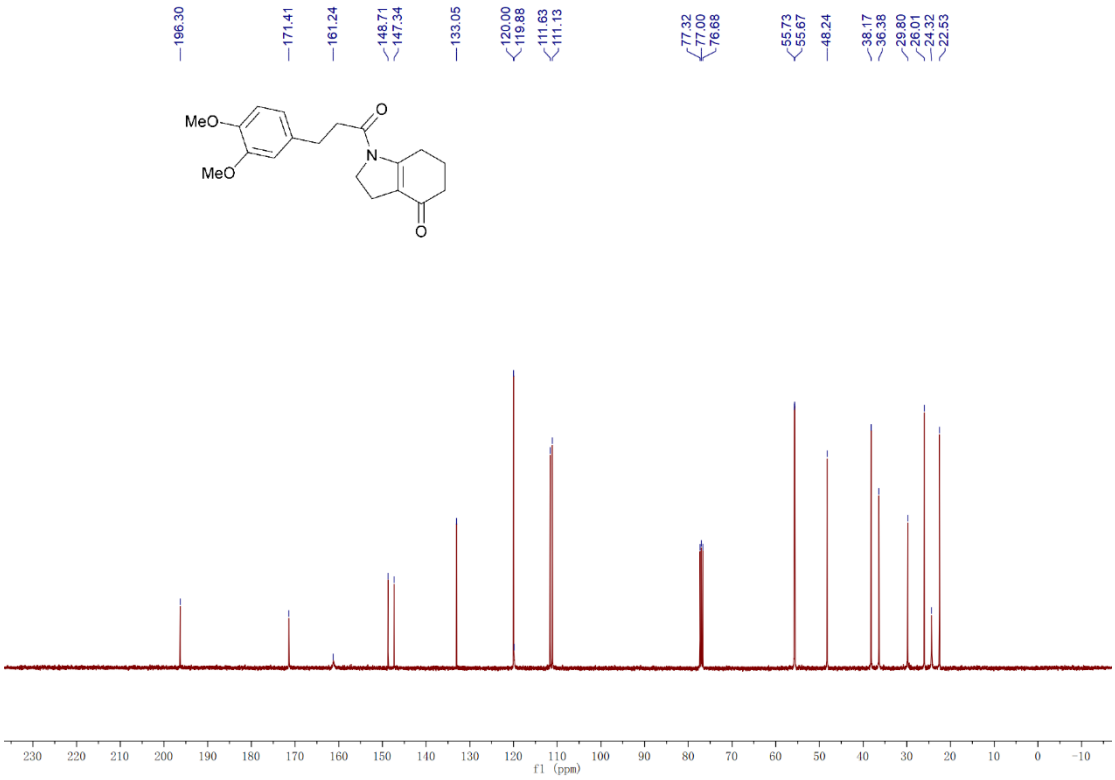
Compound **17n**, ^{13}C NMR, 100 MHz, $CDCl_3$



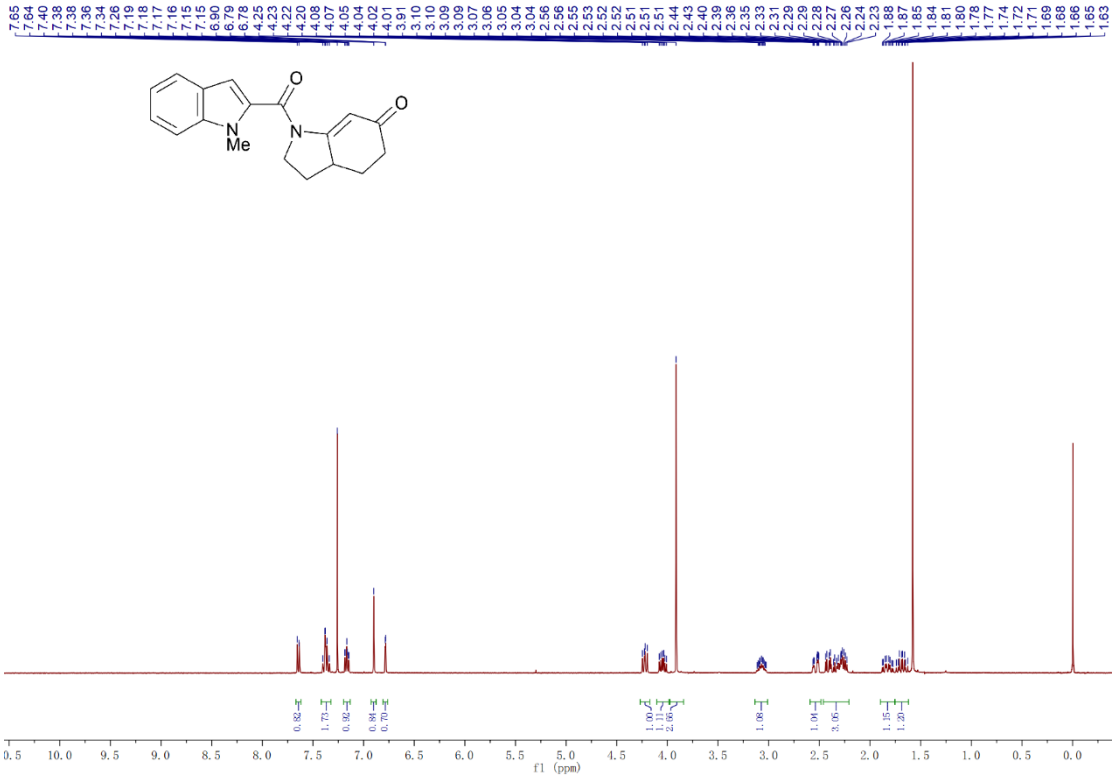
Compound **17o**, ^{1}H NMR, 400 MHz, $CDCl_3$



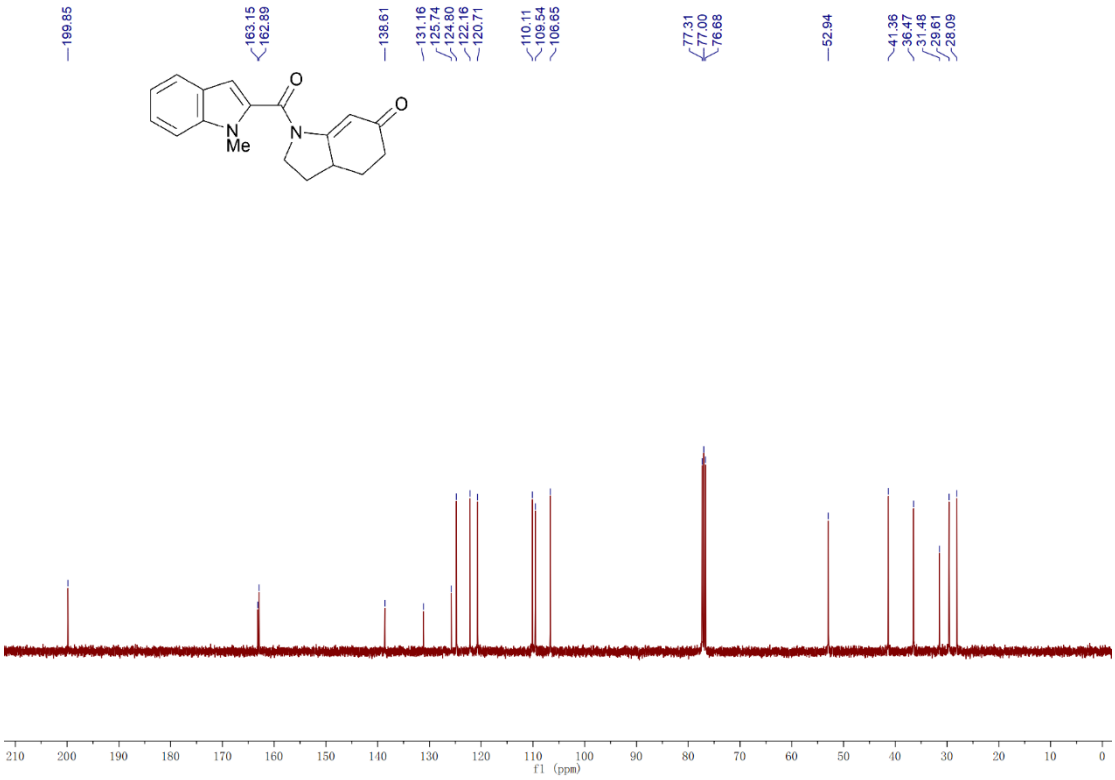
Compound **17o**, ^{13}C NMR, 100 MHz, $CDCl_3$



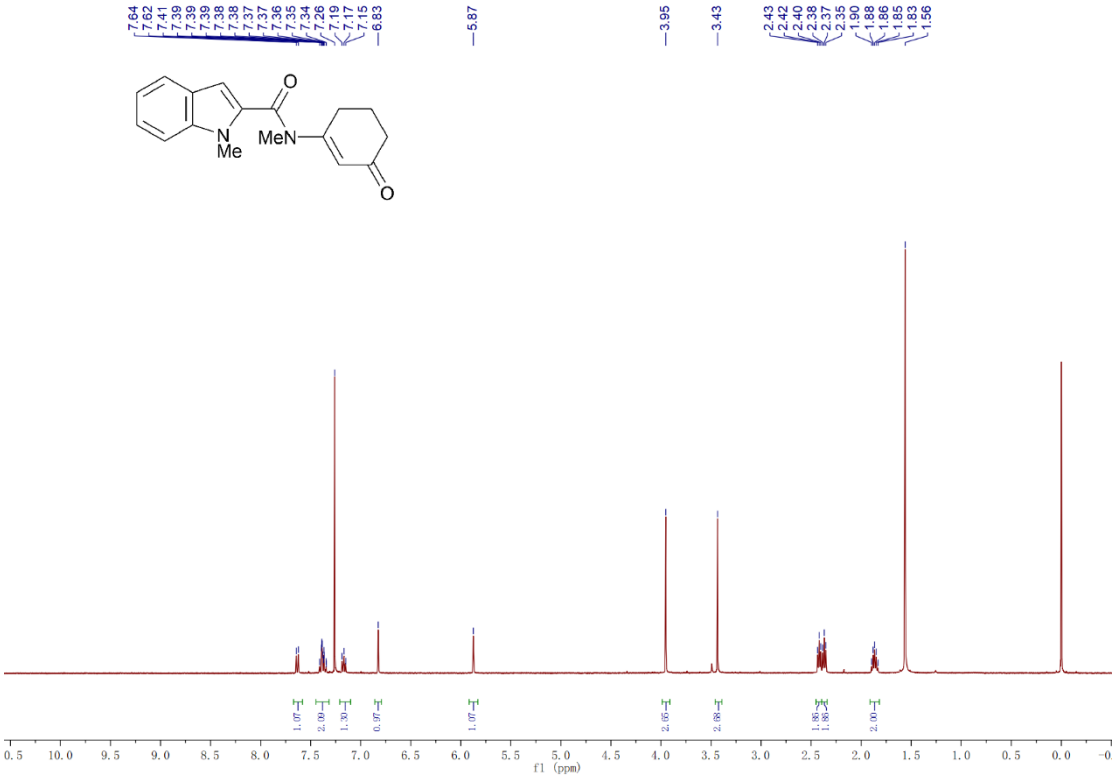
Compound **17p**, ^{1}H NMR, 400 MHz, $CDCl_3$



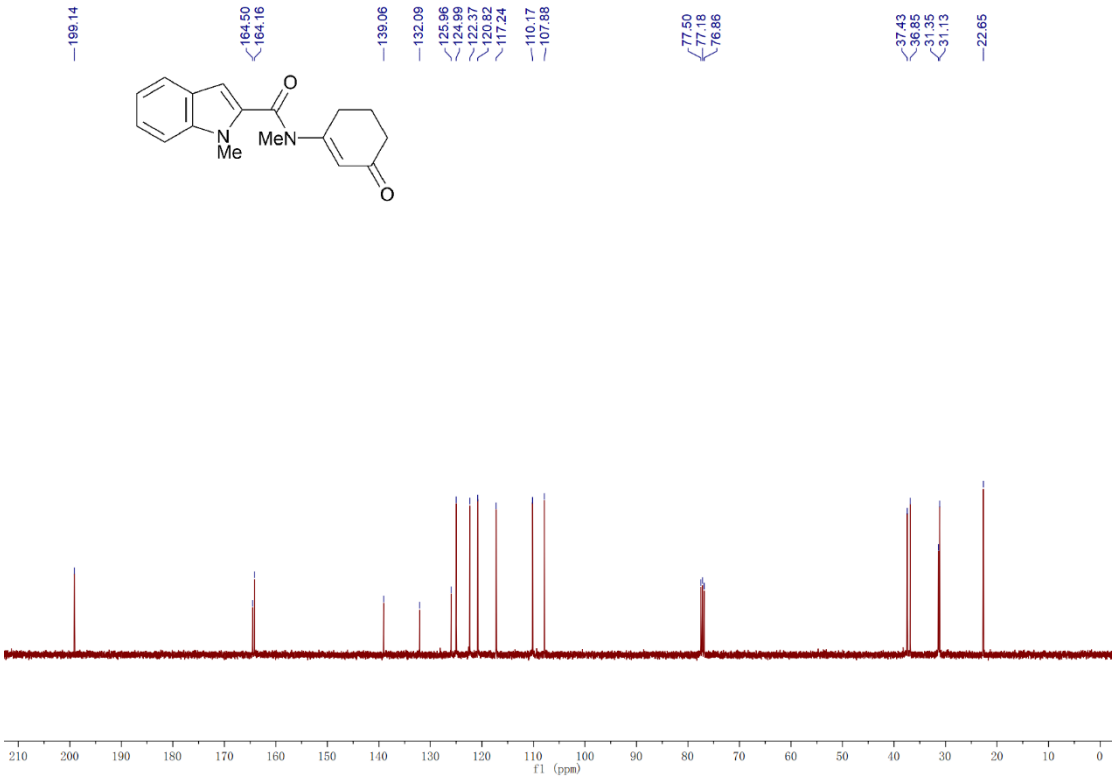
Compound **17p**, ^{13}C NMR, 100 MHz, $CDCl_3$



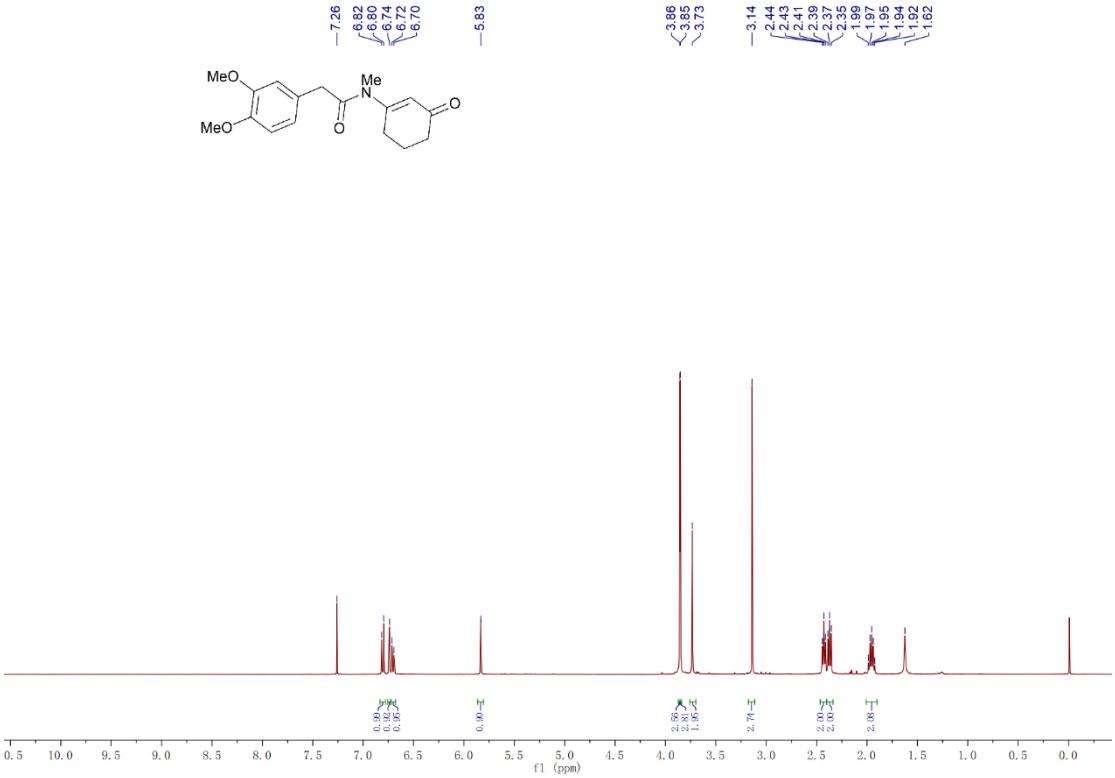
Compound **17q**, ^{1}H NMR, 400 MHz, $CDCl_3$



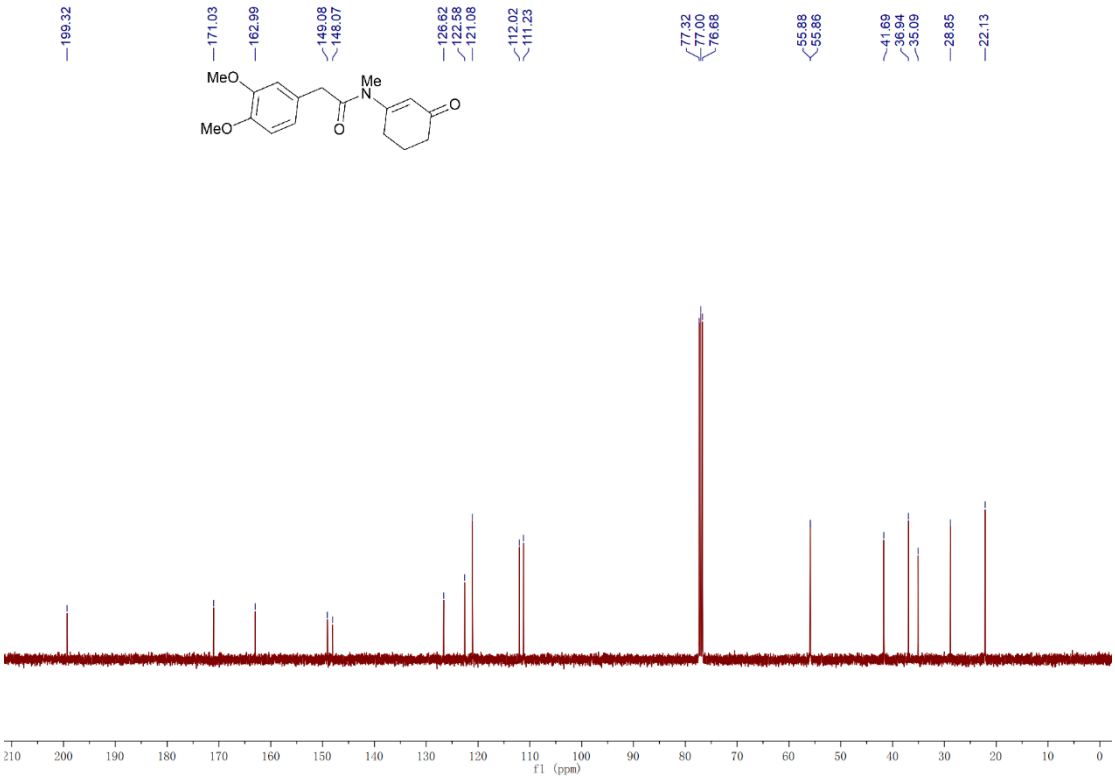
Compound **17q**, ^{13}C NMR, 100 MHz, $CDCl_3$



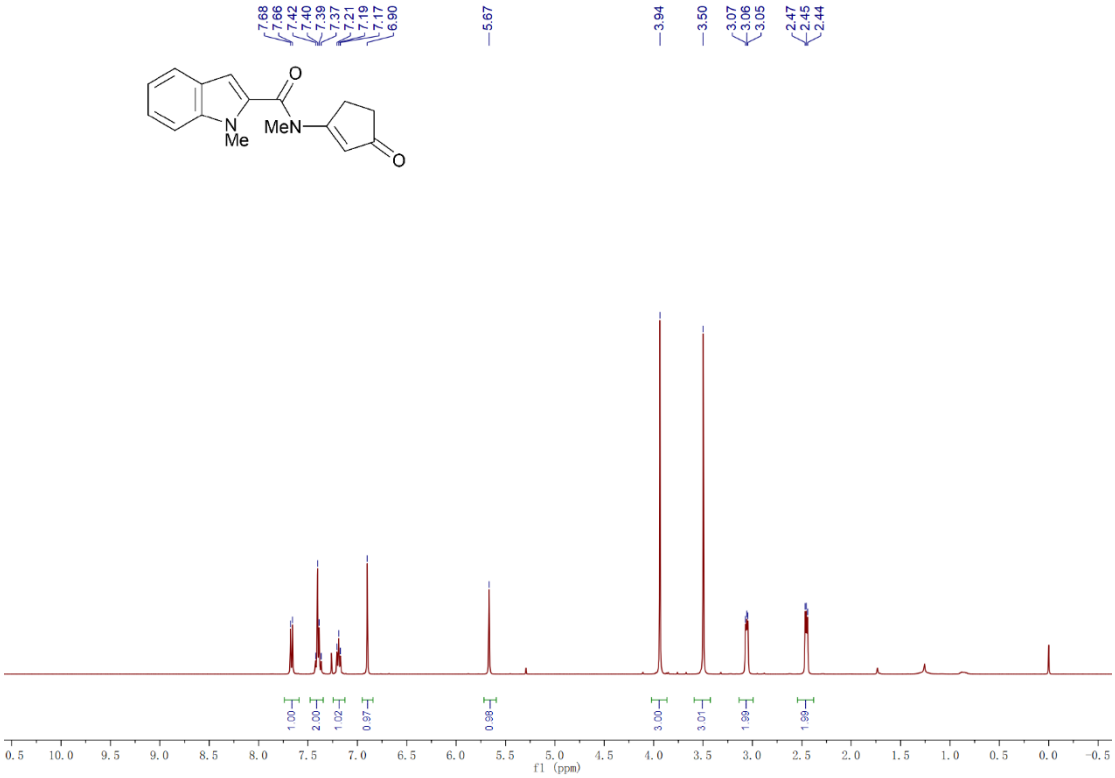
Compound **17r**, ^{1}H NMR, 400 MHz, $CDCl_3$



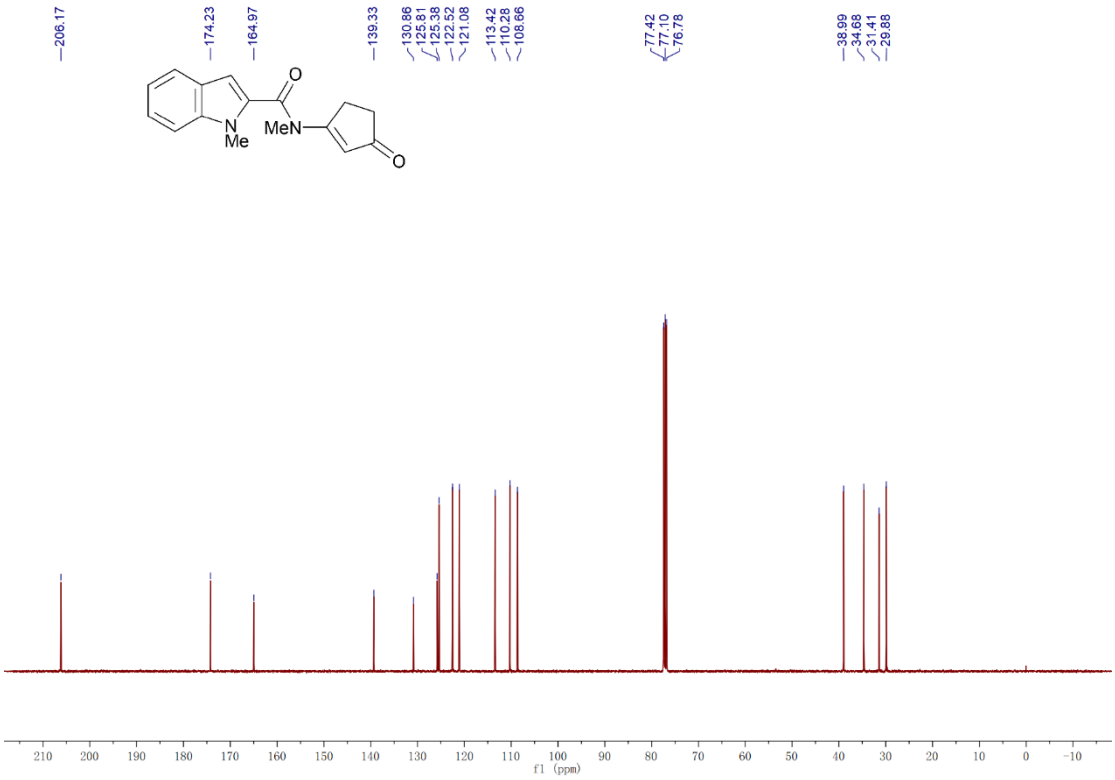
Compound **17r**, ^{13}C NMR, 100 MHz, $CDCl_3$



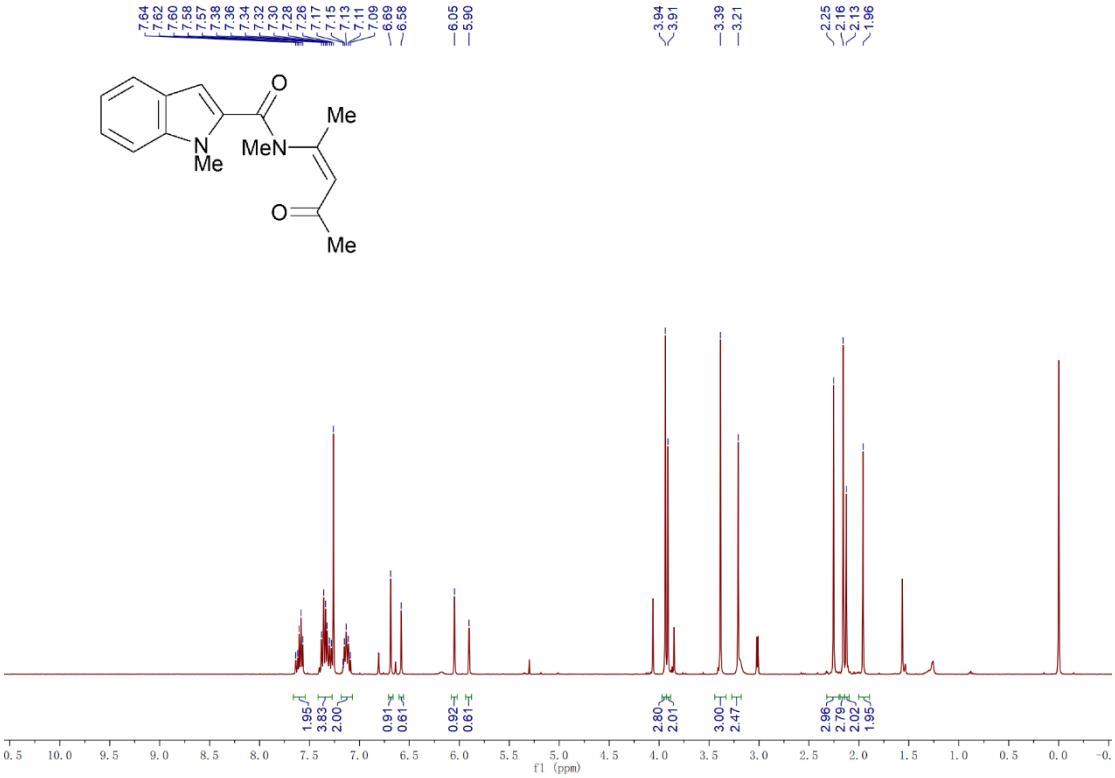
Compound **17s**, ^{1}H NMR, 400 MHz, $CDCl_3$



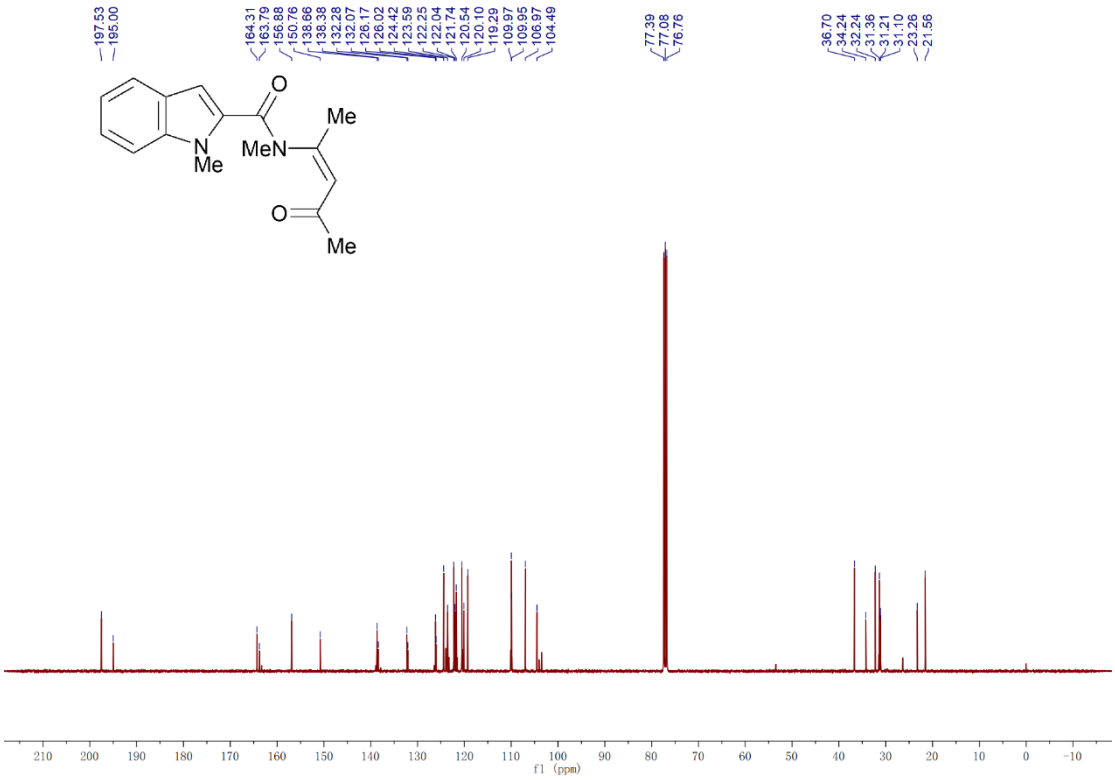
Compound **17s**, ^{13}C NMR, 100 MHz, $CDCl_3$



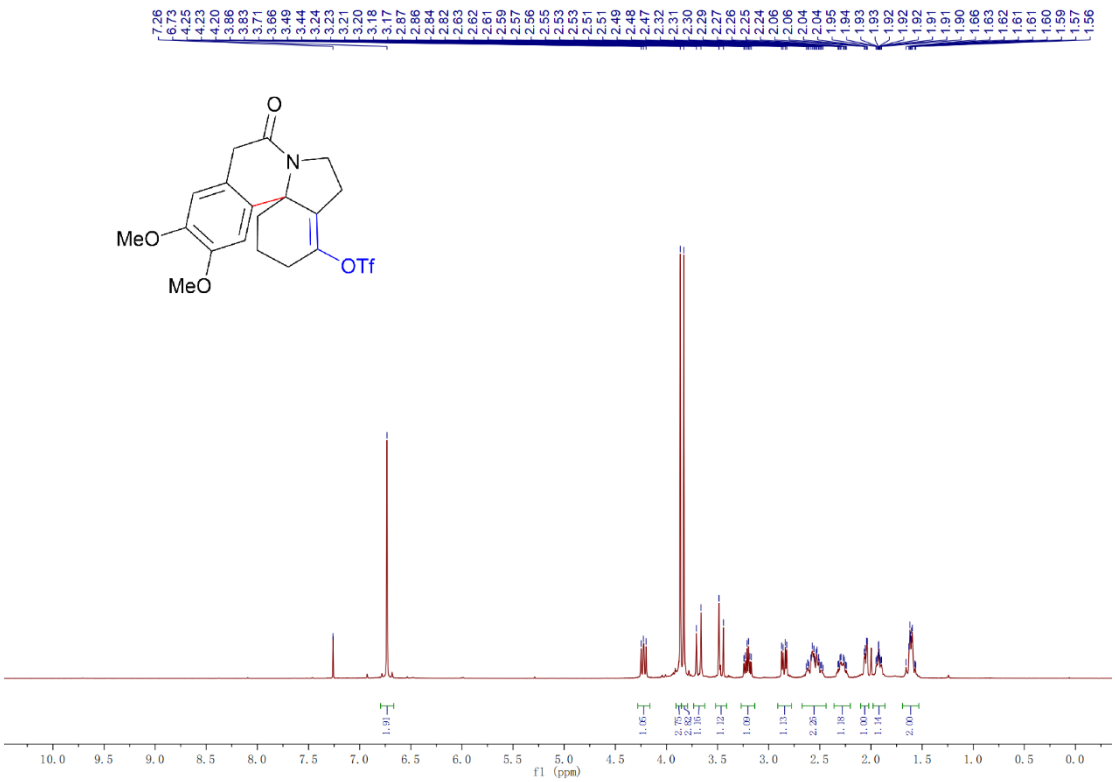
Compound **17t**, ^{1}H NMR, 400 MHz, $CDCl_3$



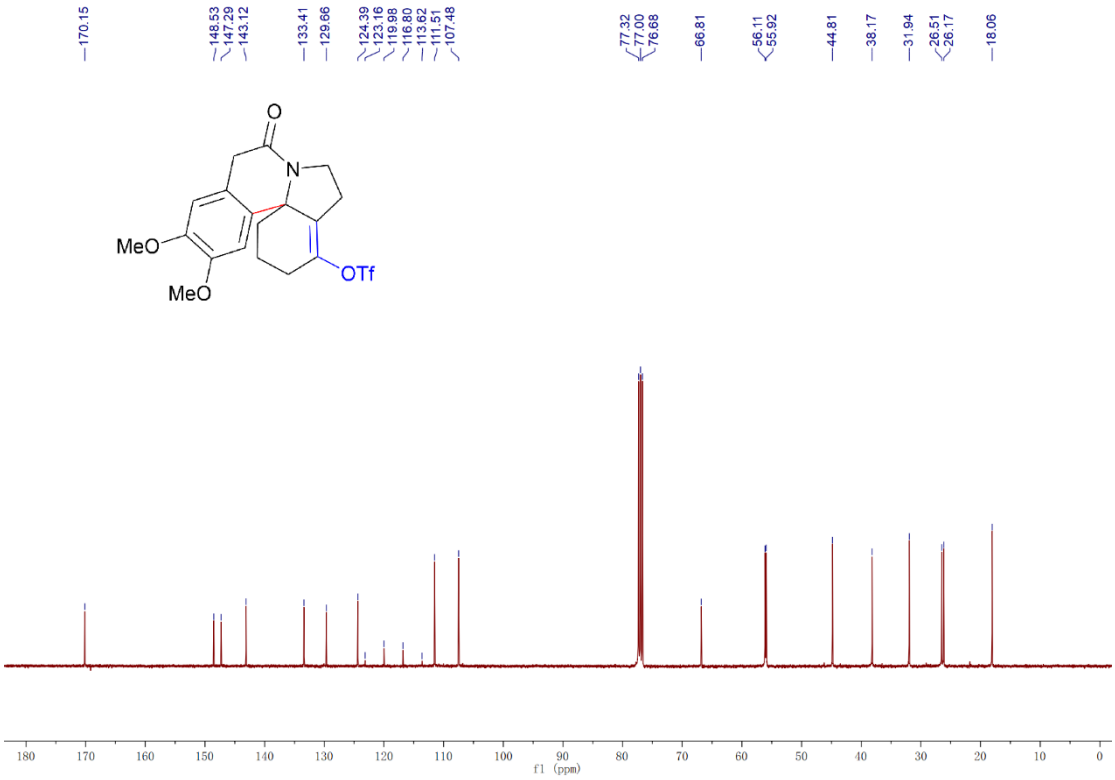
Compound **17t**, ^{13}C NMR, 100 MHz, $CDCl_3$



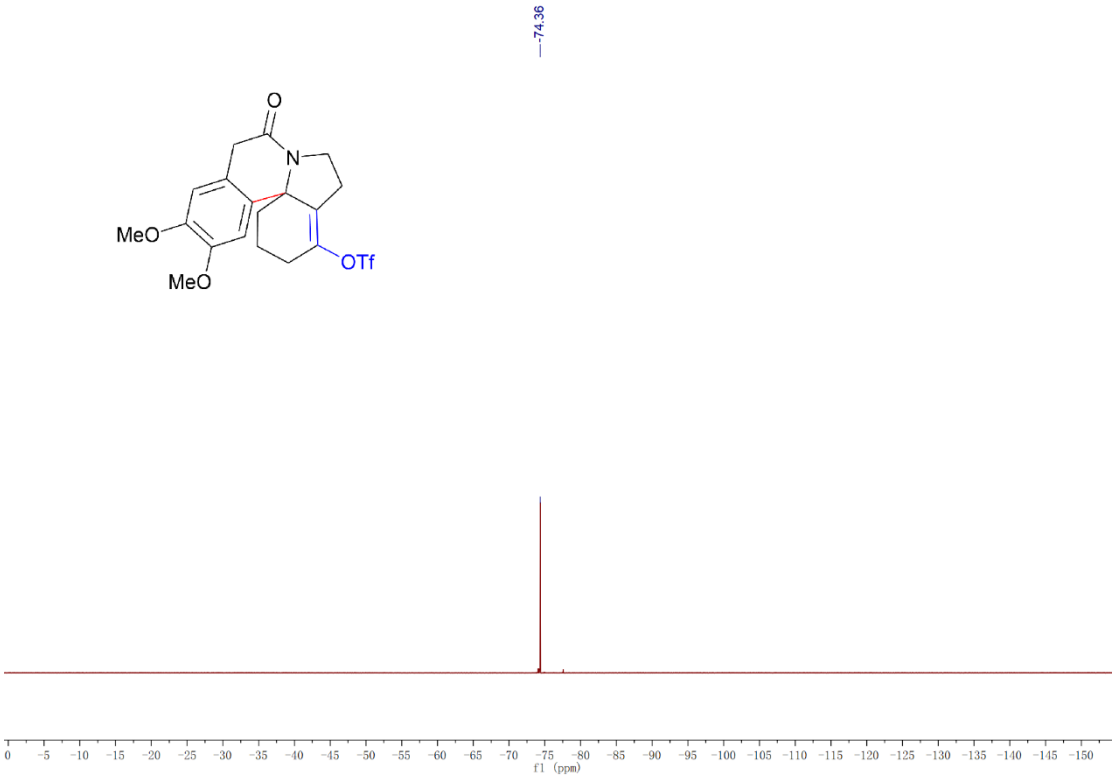
Compound **19a**, ^{1}H NMR, 400 MHz, $CDCl_3$



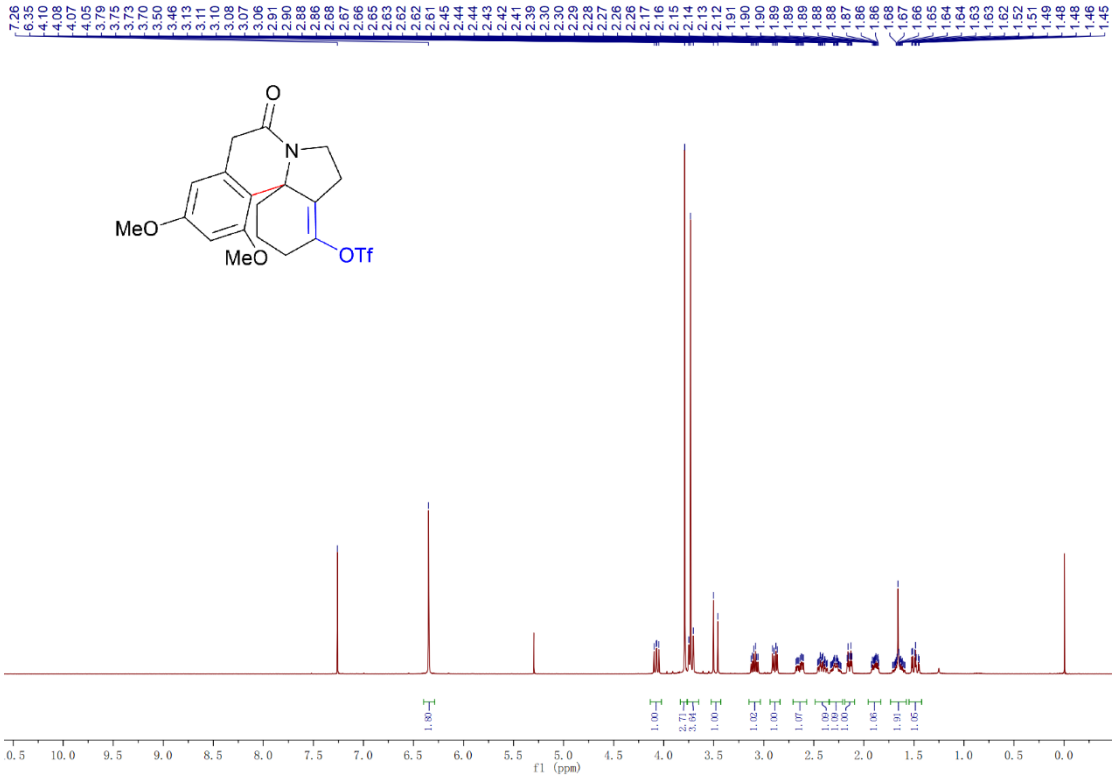
Compound **19a**, ^{13}C NMR, 100 MHz, $CDCl_3$



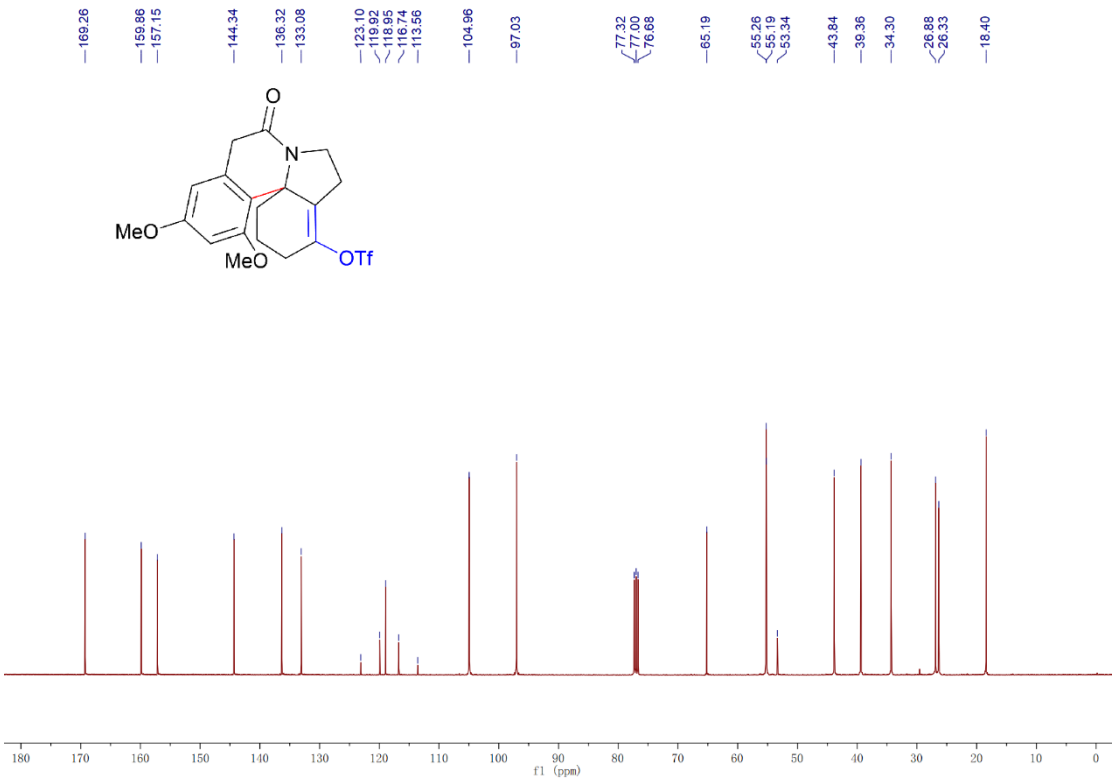
Compound **19a**, ^{19}F NMR, 376 MHz, $CDCl_3$



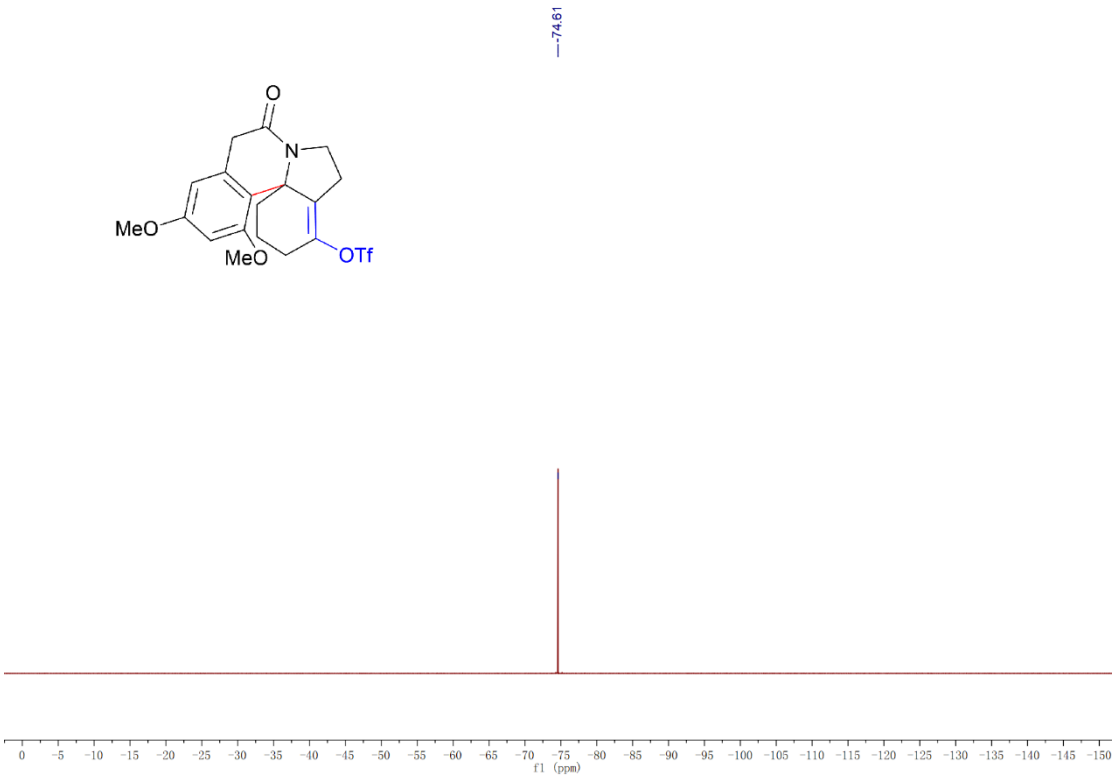
Compound **19b**, ^{1}H NMR, 400 MHz, $CDCl_3$



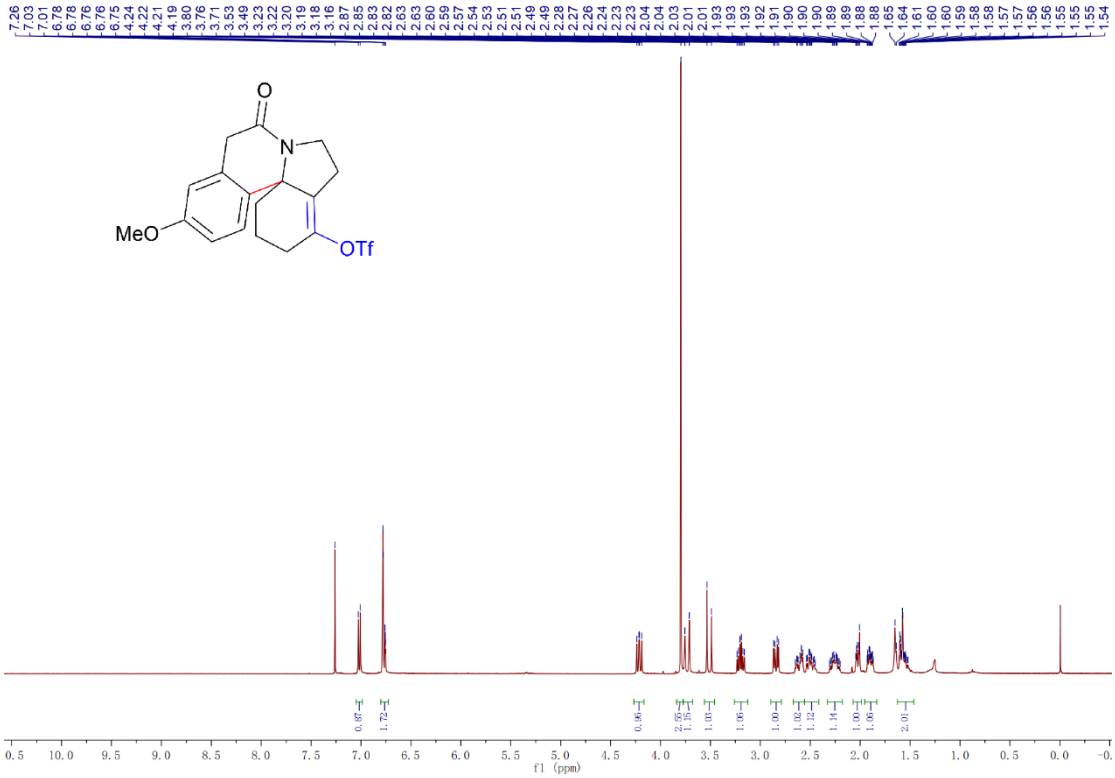
Compound **19b**, ^{13}C NMR, 100 MHz, $CDCl_3$



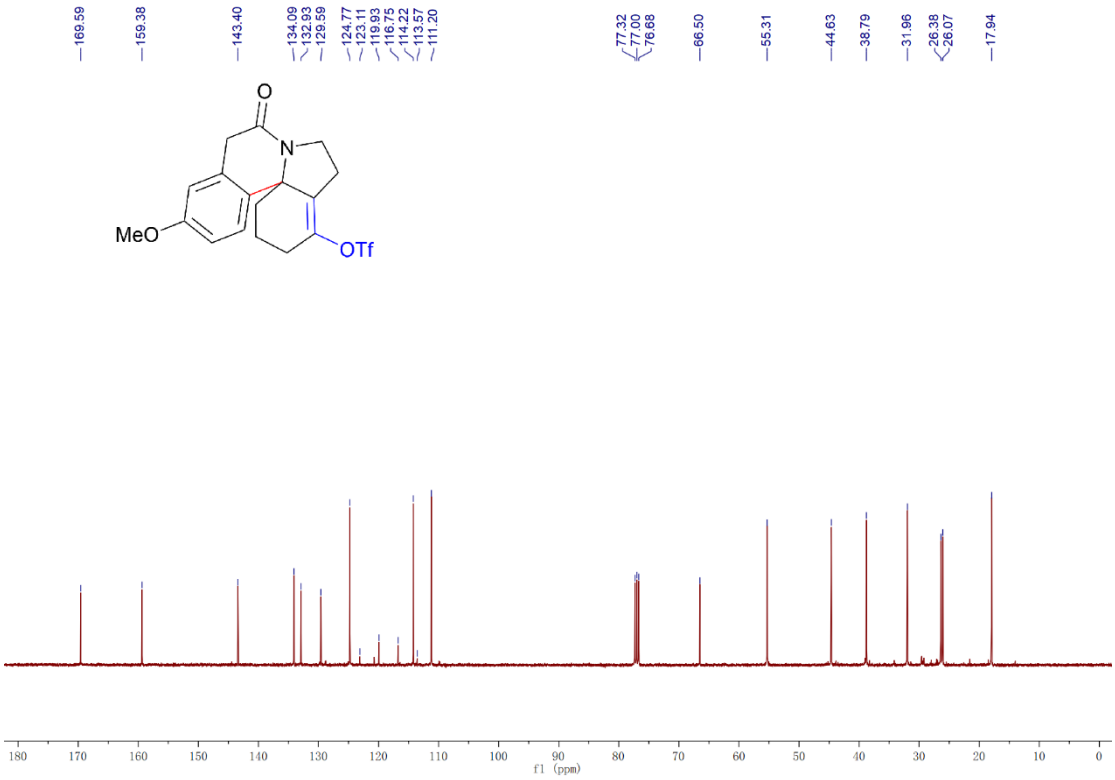
Compound **19b**, ^{19}F NMR, 376 MHz, $CDCl_3$



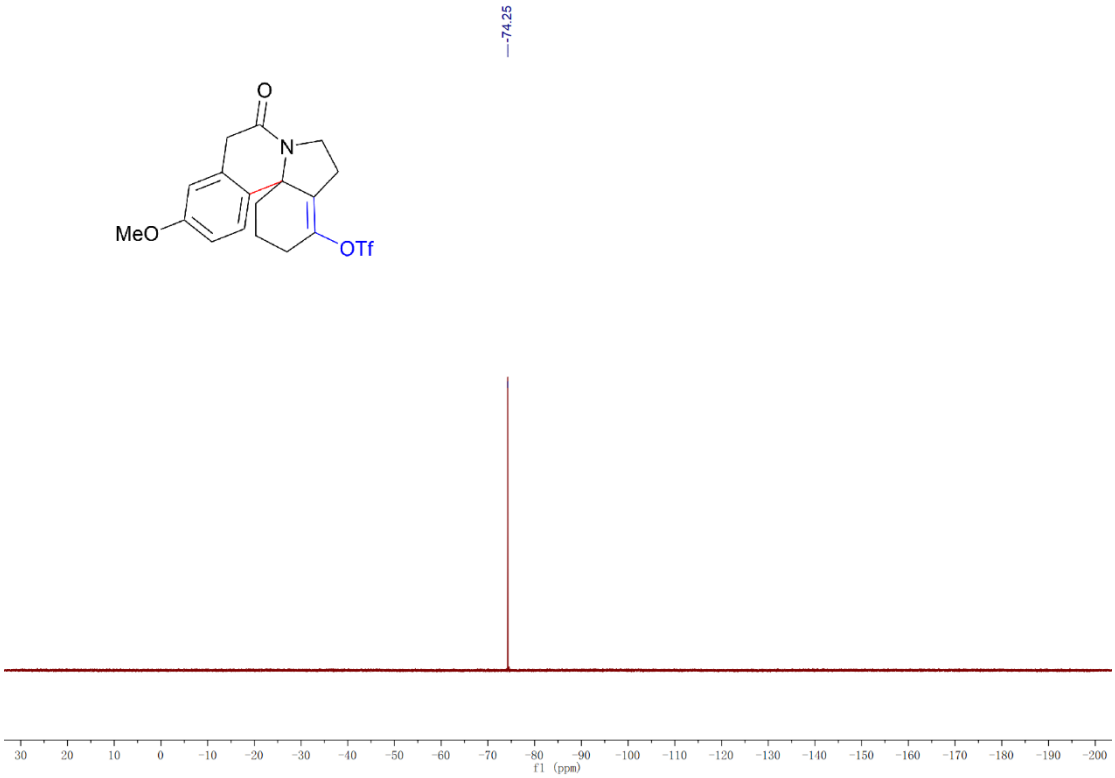
Compound **19c**, ^{1}H NMR, 400 MHz, $CDCl_3$



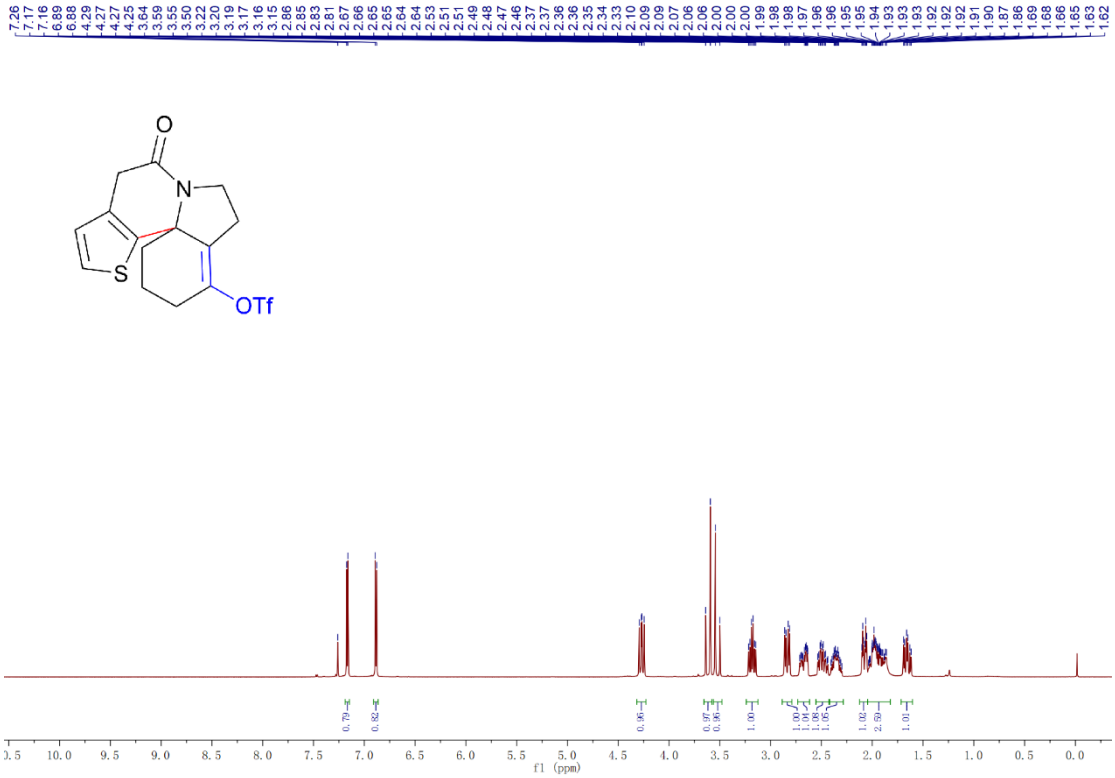
Compound **19c**, ^{13}C NMR, 100 MHz, $CDCl_3$



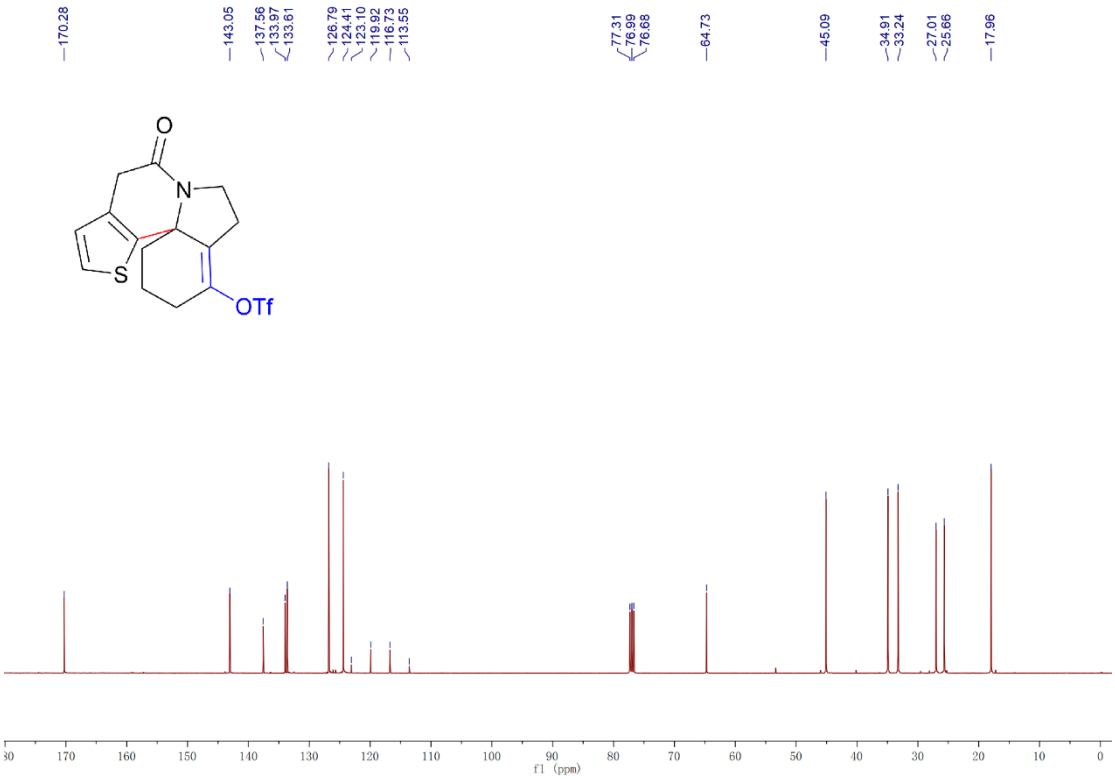
Compound **19c**, ^{19}F NMR, 376 MHz, $CDCl_3$



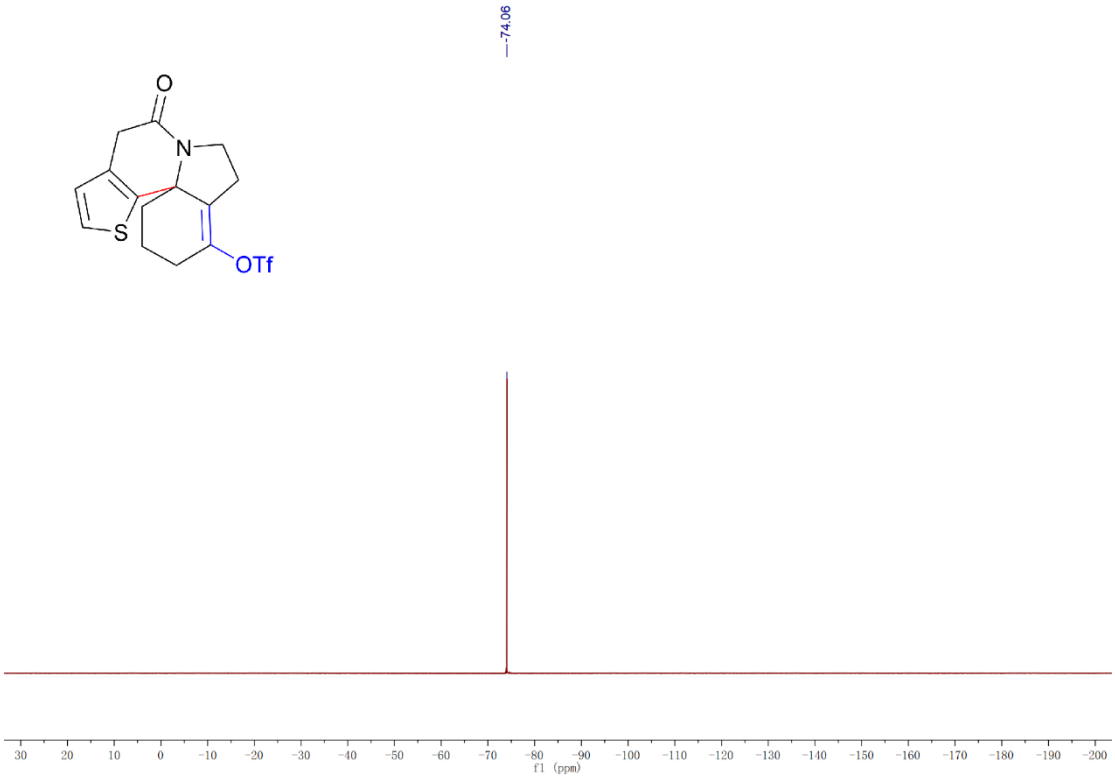
Compound **19d**, ^{1}H NMR, 400 MHz, $CDCl_3$



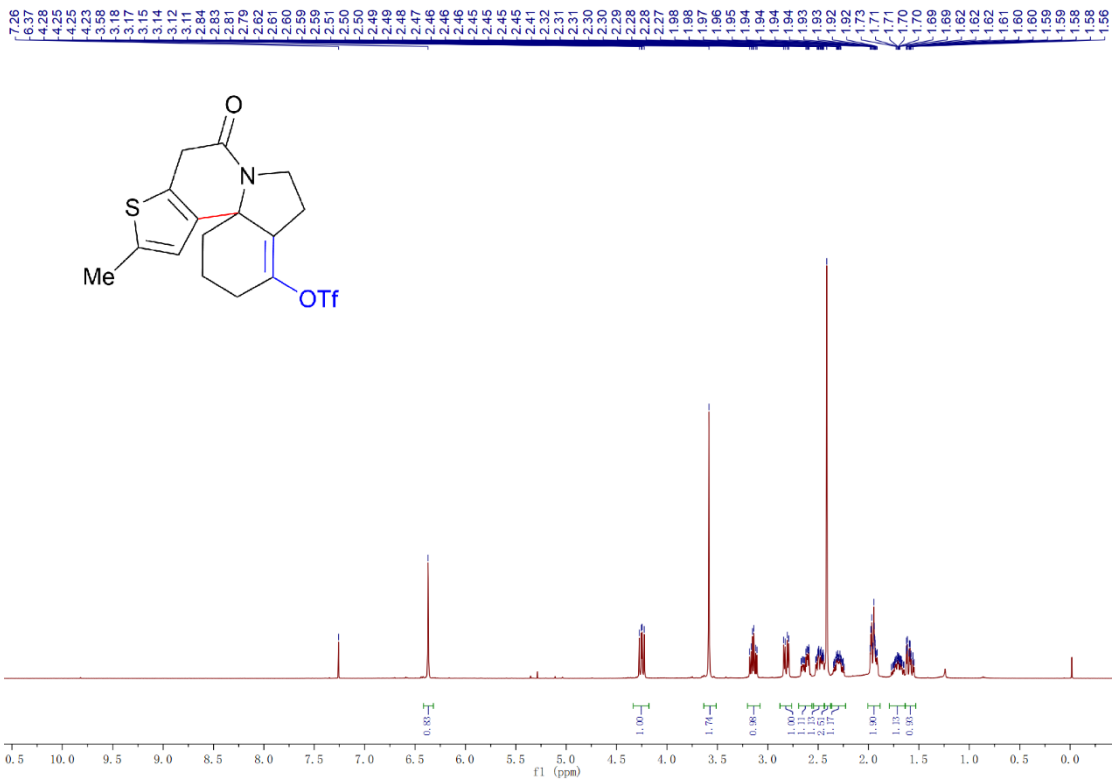
Compound **19d**, ^{13}C NMR, 100 MHz, $CDCl_3$



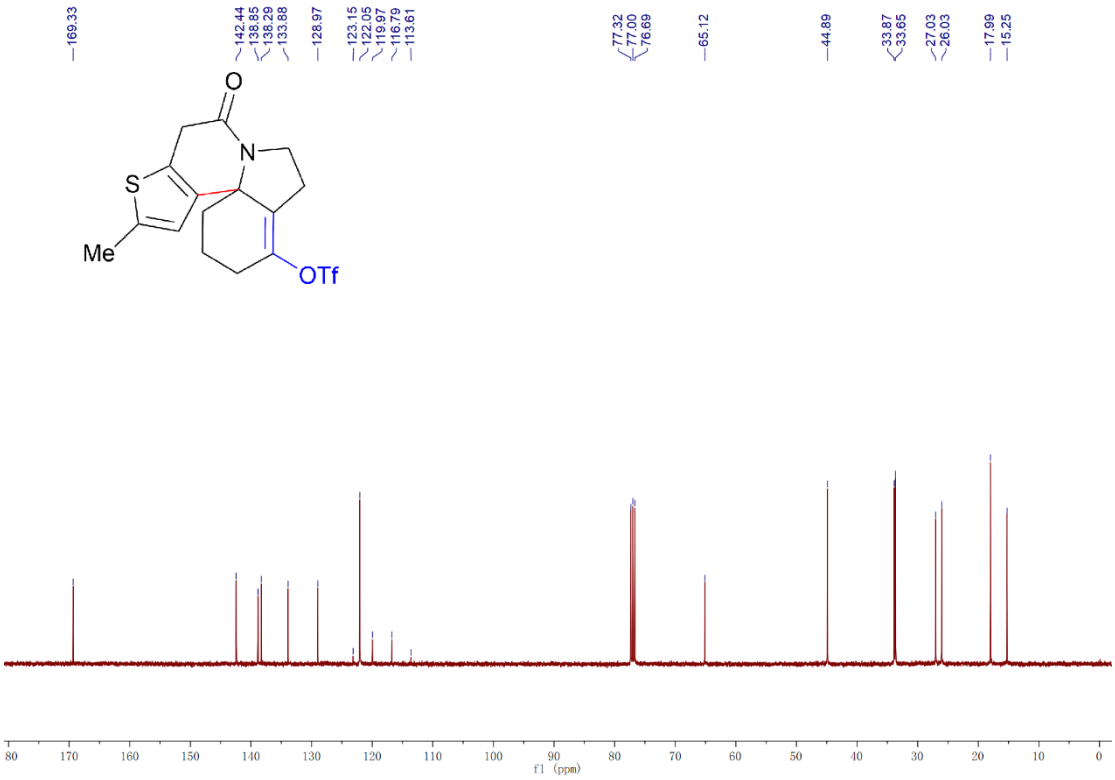
Compound **19d**, ^{19}F NMR, 376 MHz, $CDCl_3$



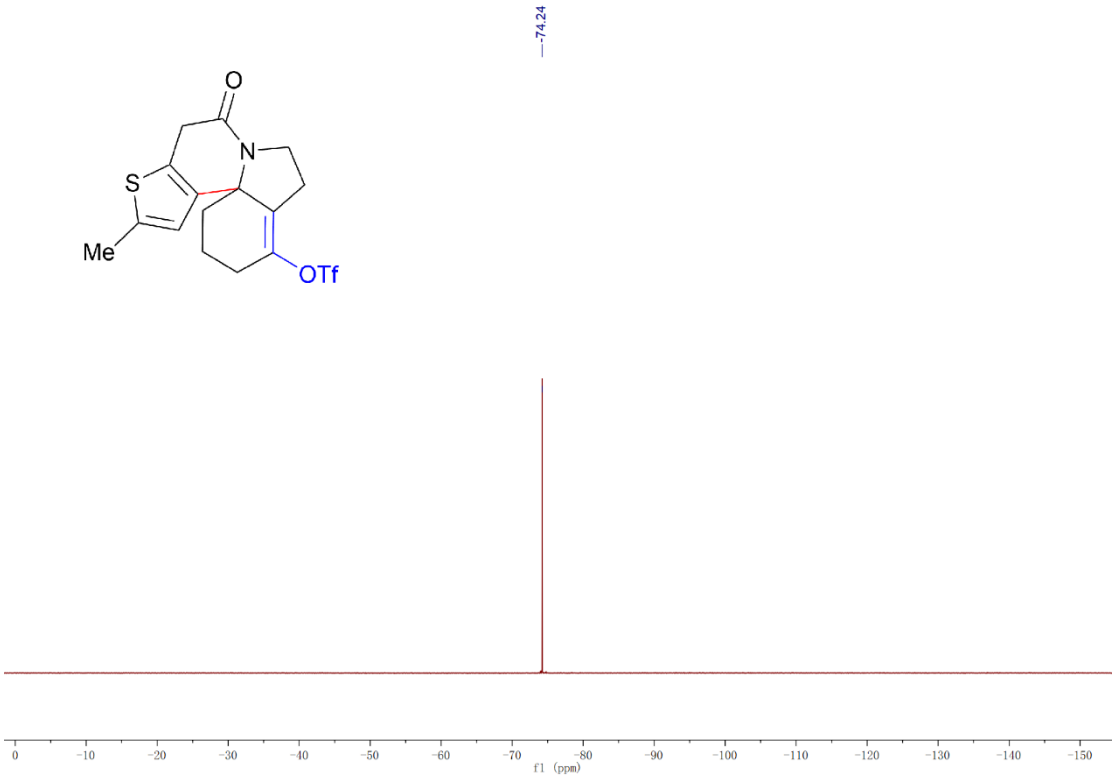
Compound **19e**, ^{1}H NMR, 400 MHz, $CDCl_3$



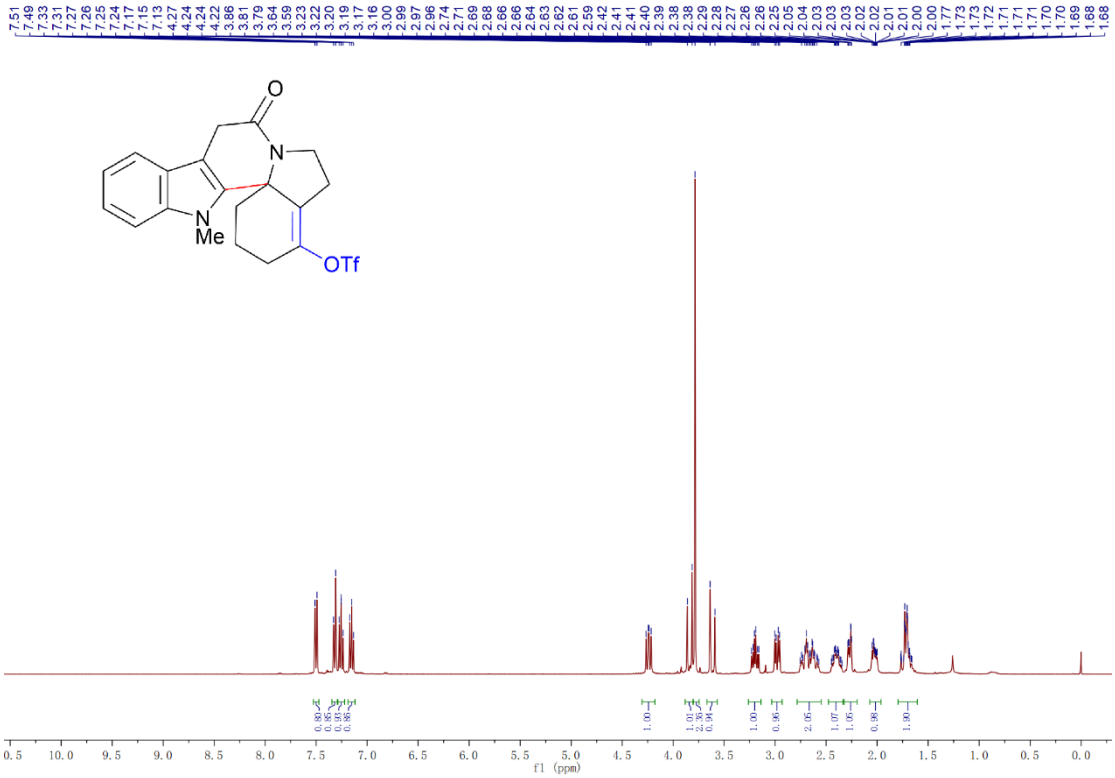
Compound **19e**, ^{13}C NMR, 100 MHz, $CDCl_3$



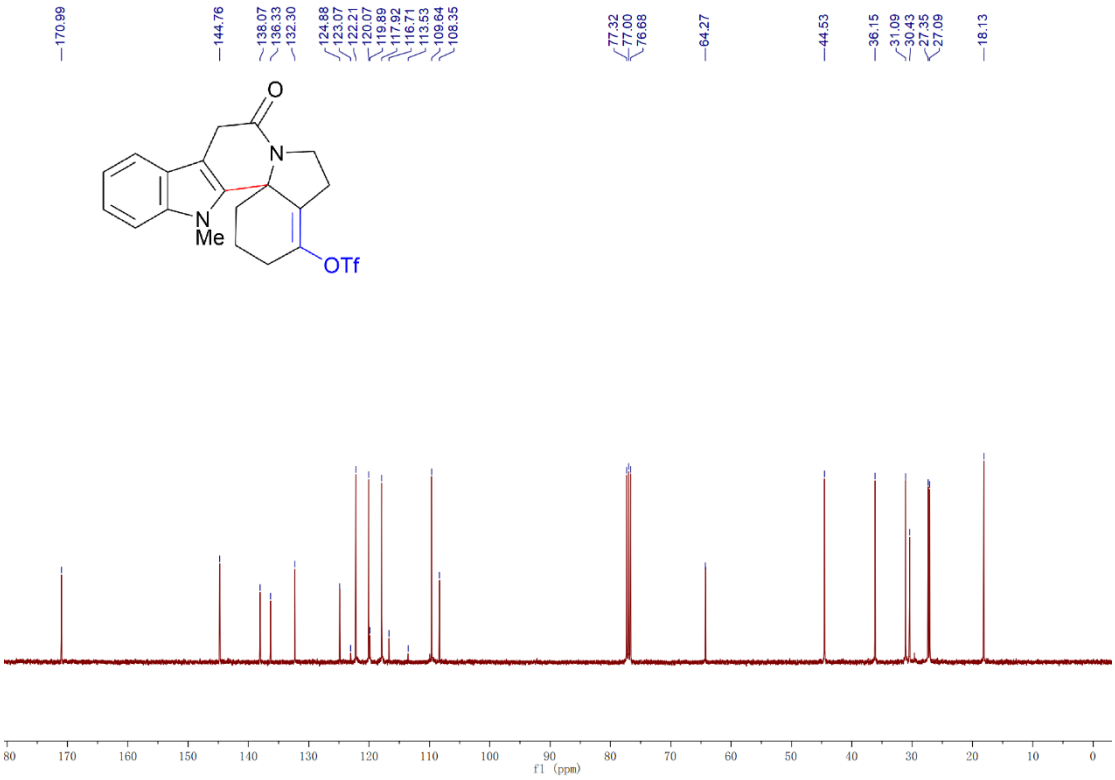
Compound **19e**, ^{19}F NMR, 376 MHz, $CDCl_3$



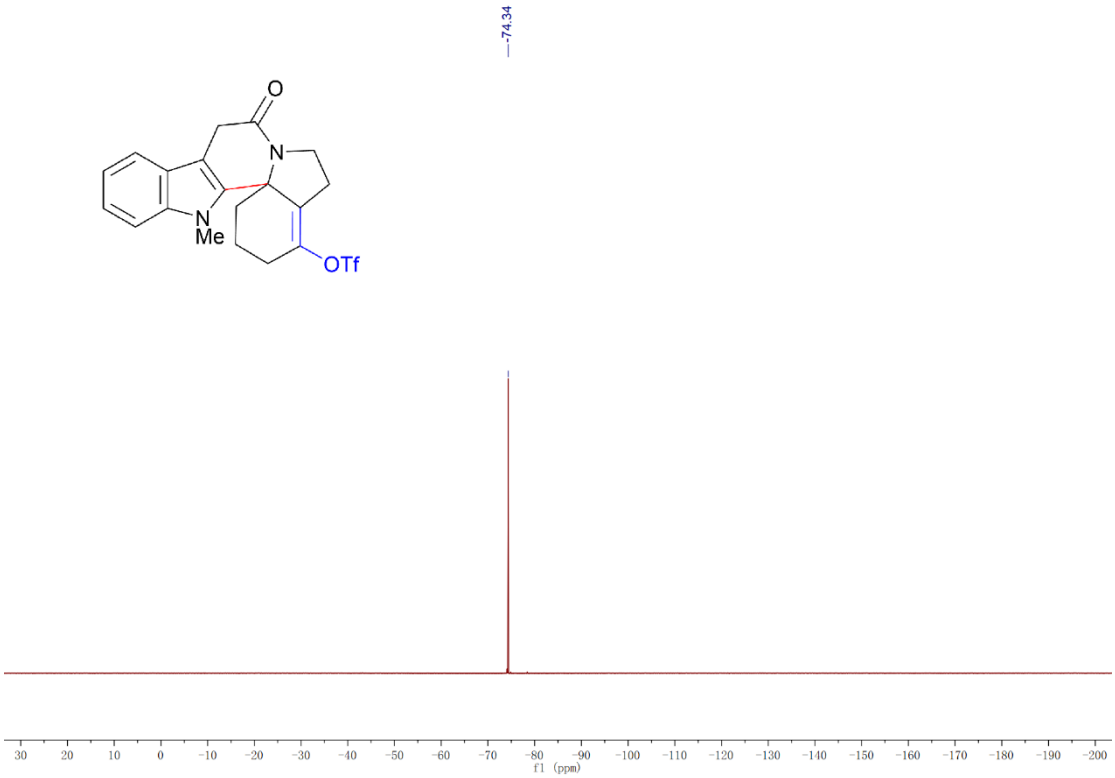
Compound **19f**, ^{1}H NMR, 400 MHz, $CDCl_3$



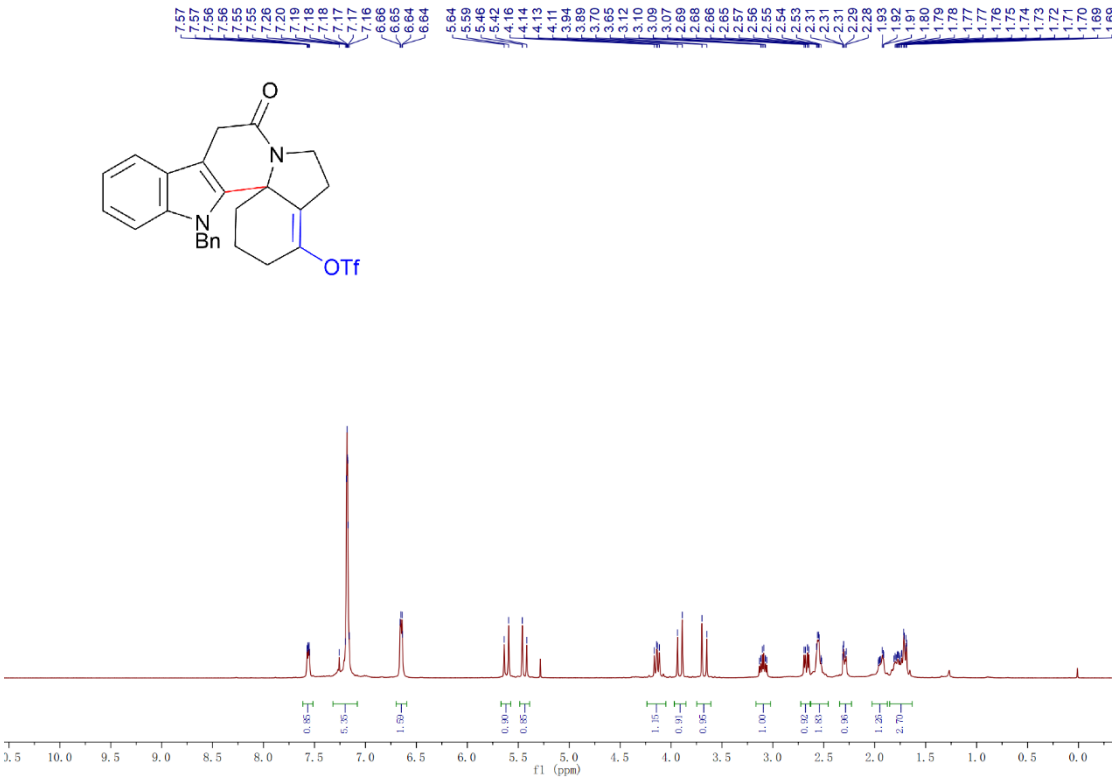
Compound **19f**, ^{13}C NMR, 100 MHz, $CDCl_3$



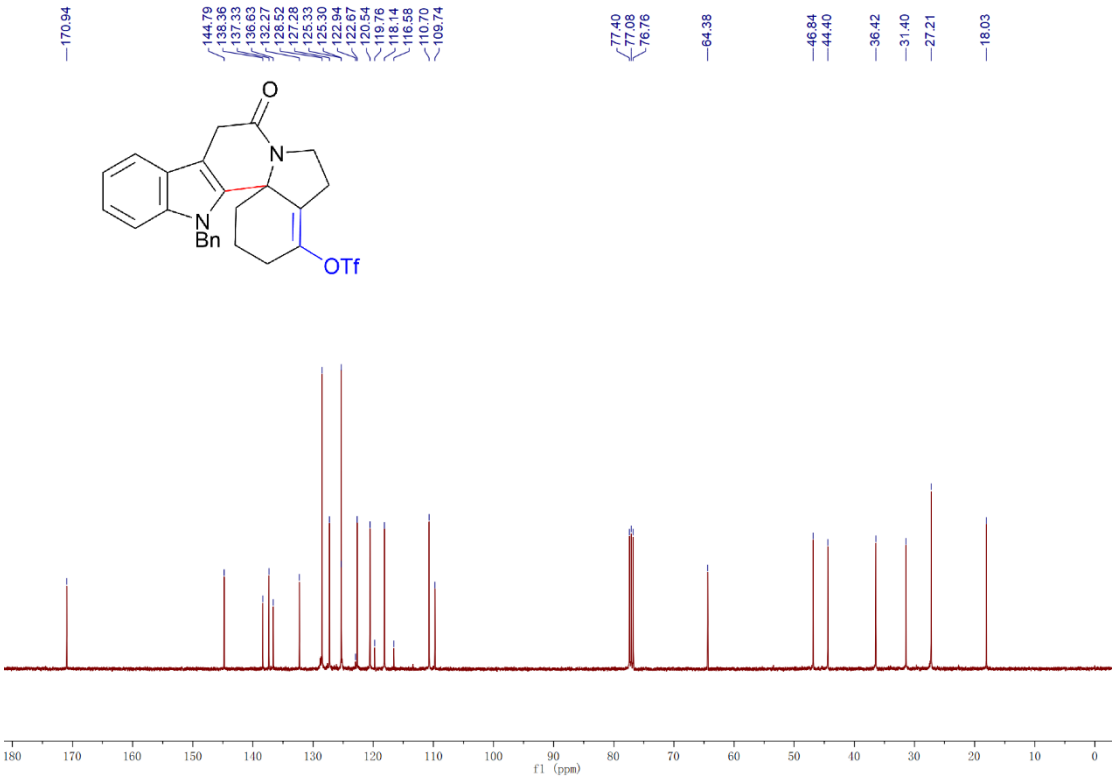
Compound **19f**, ^{19}F NMR, 376 MHz, $CDCl_3$



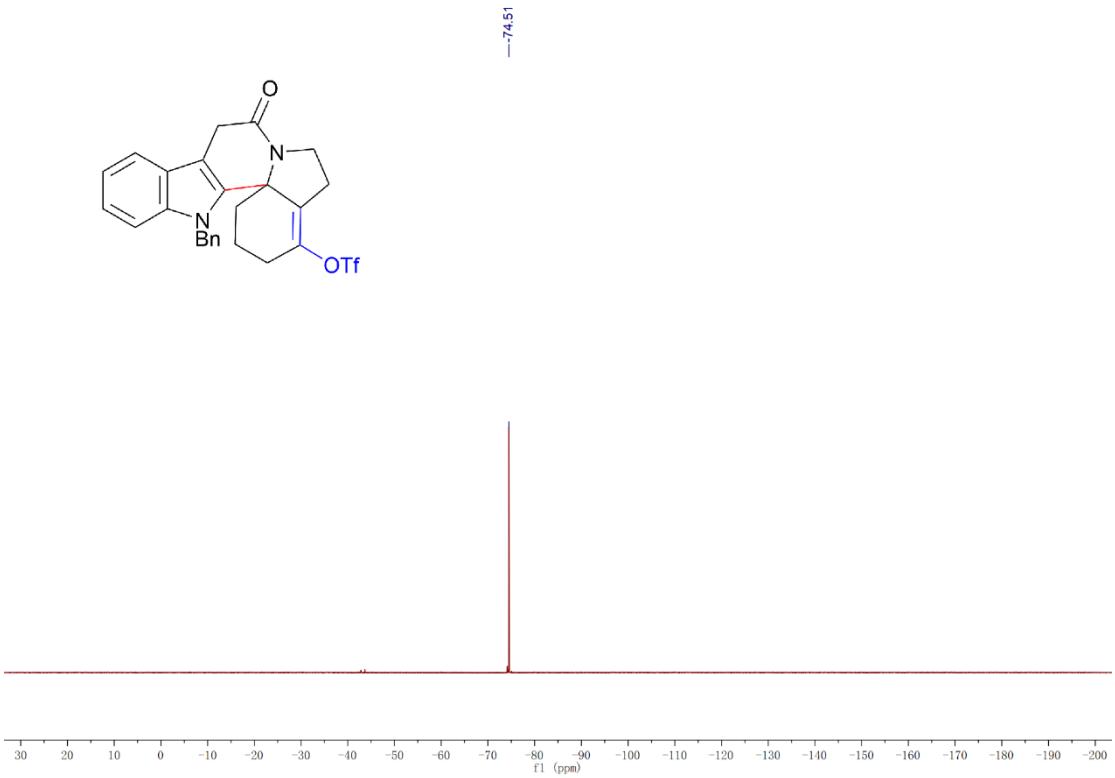
Compound **19g**, ^{1}H NMR, 400 MHz, $CDCl_3$



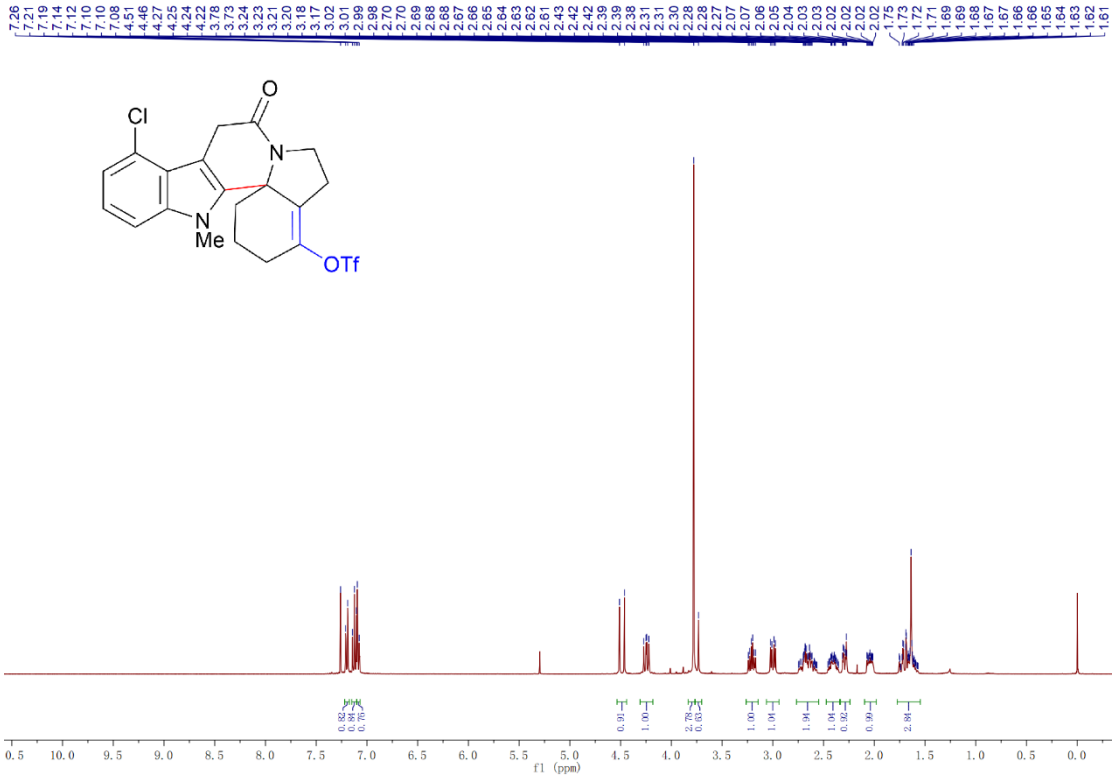
Compound **19g**, ^{13}C NMR, 100 MHz, $CDCl_3$



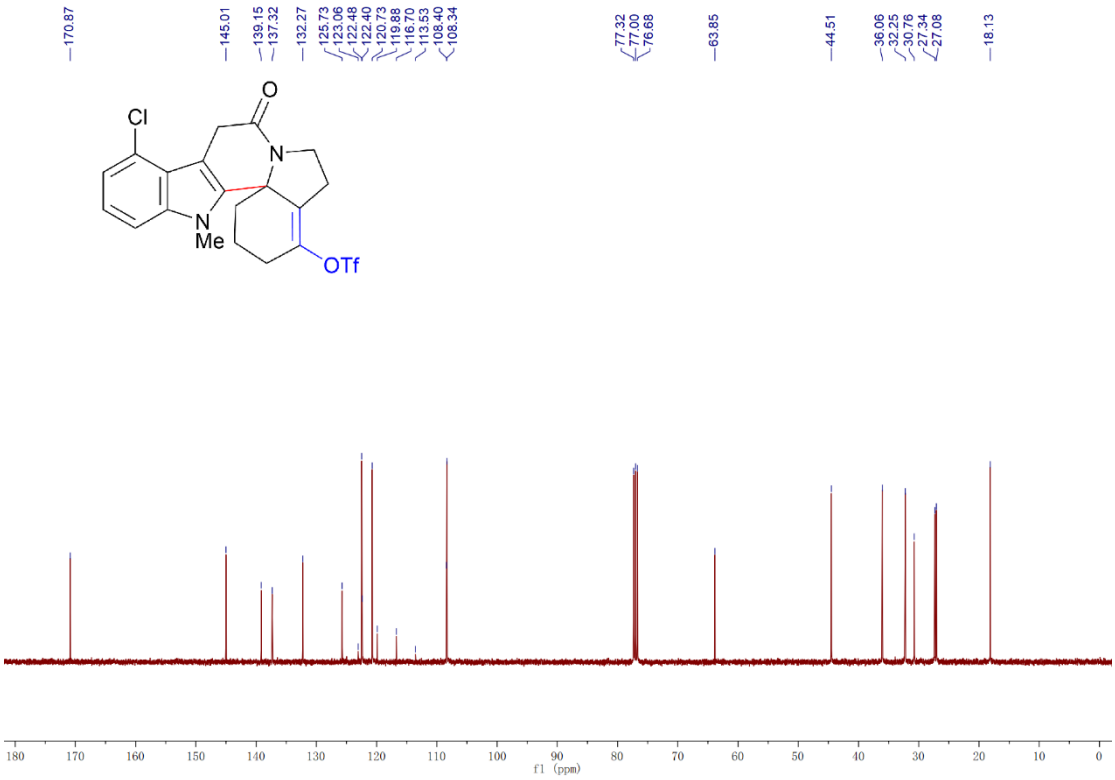
Compound **19g**, ^{19}F NMR, 376 MHz, $CDCl_3$



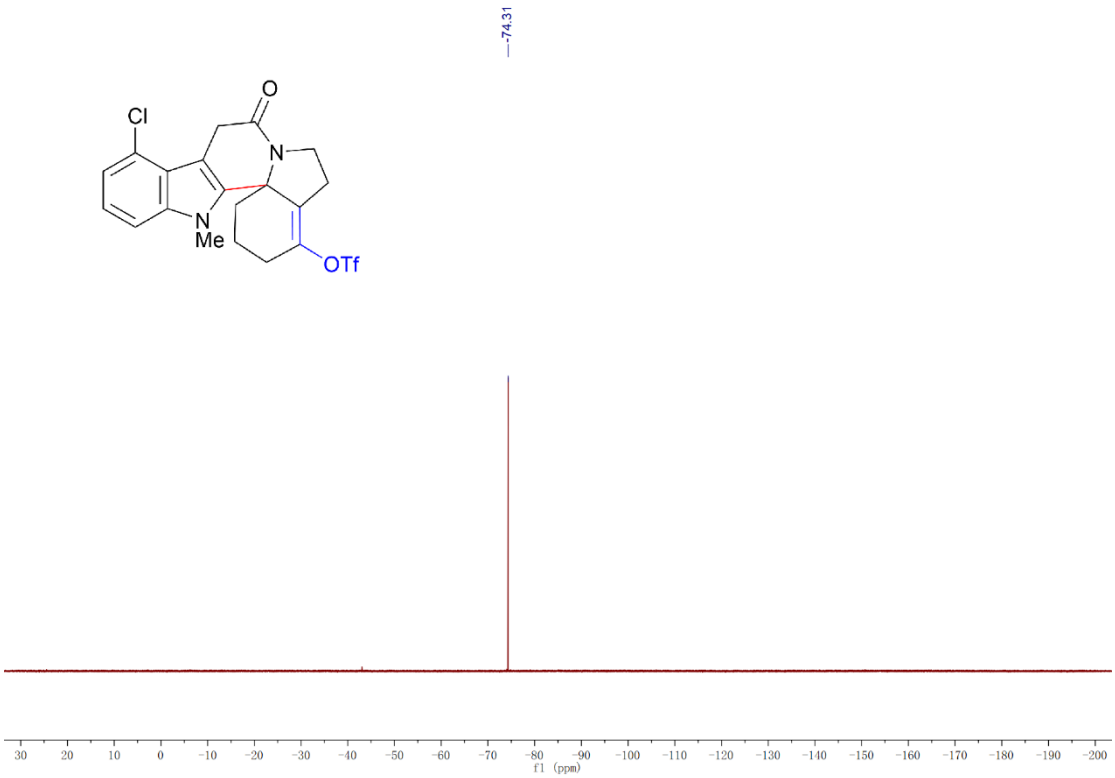
Compound **19h**, ^{1}H NMR, 400 MHz, $CDCl_3$



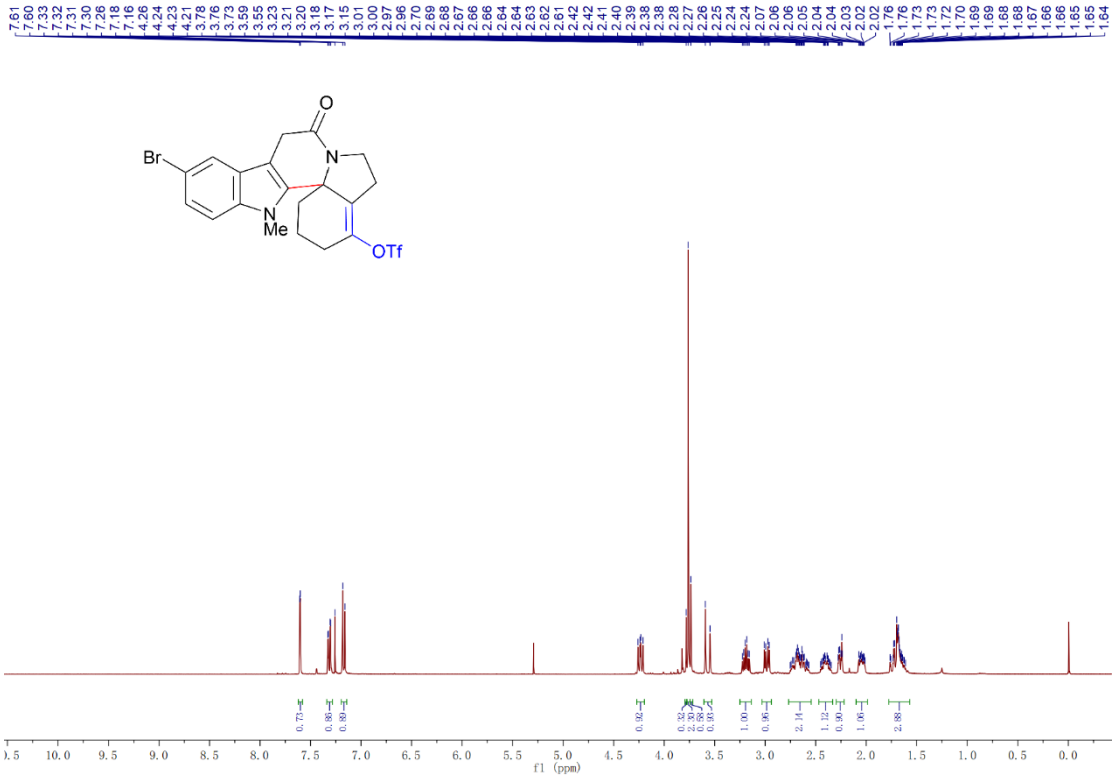
Compound **19h**, ^{13}C NMR, 100 MHz, $CDCl_3$



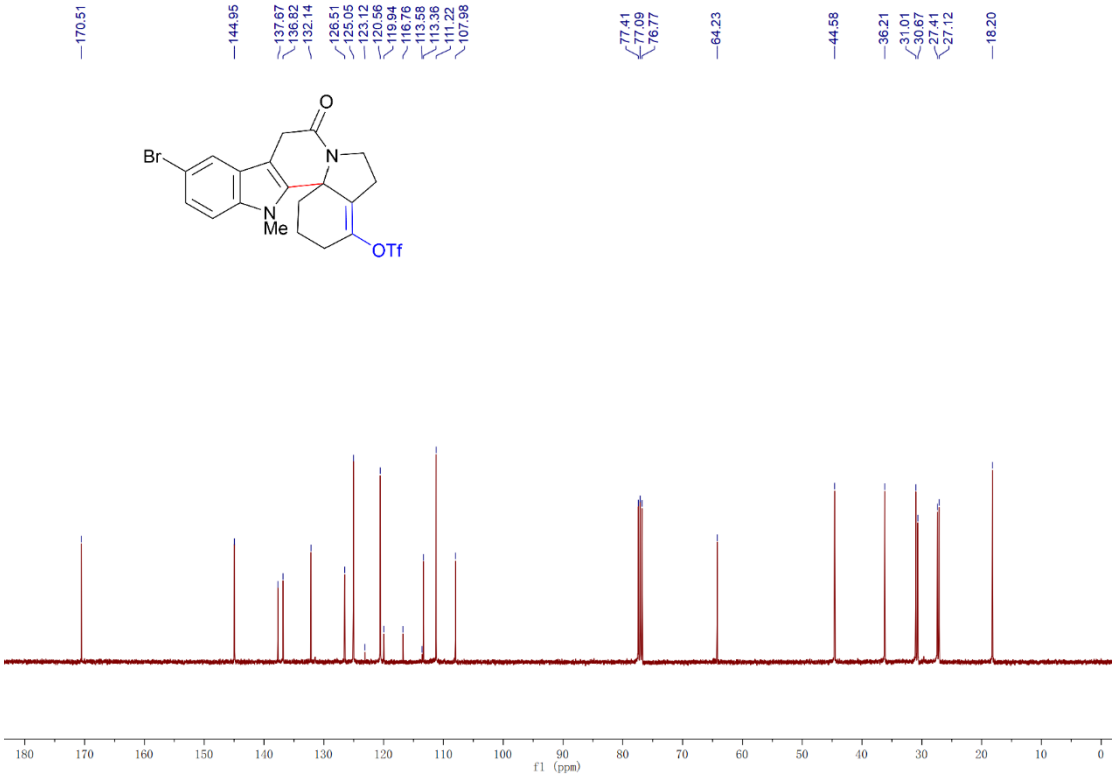
Compound **19h**, ^{19}F NMR, 376 MHz, $CDCl_3$



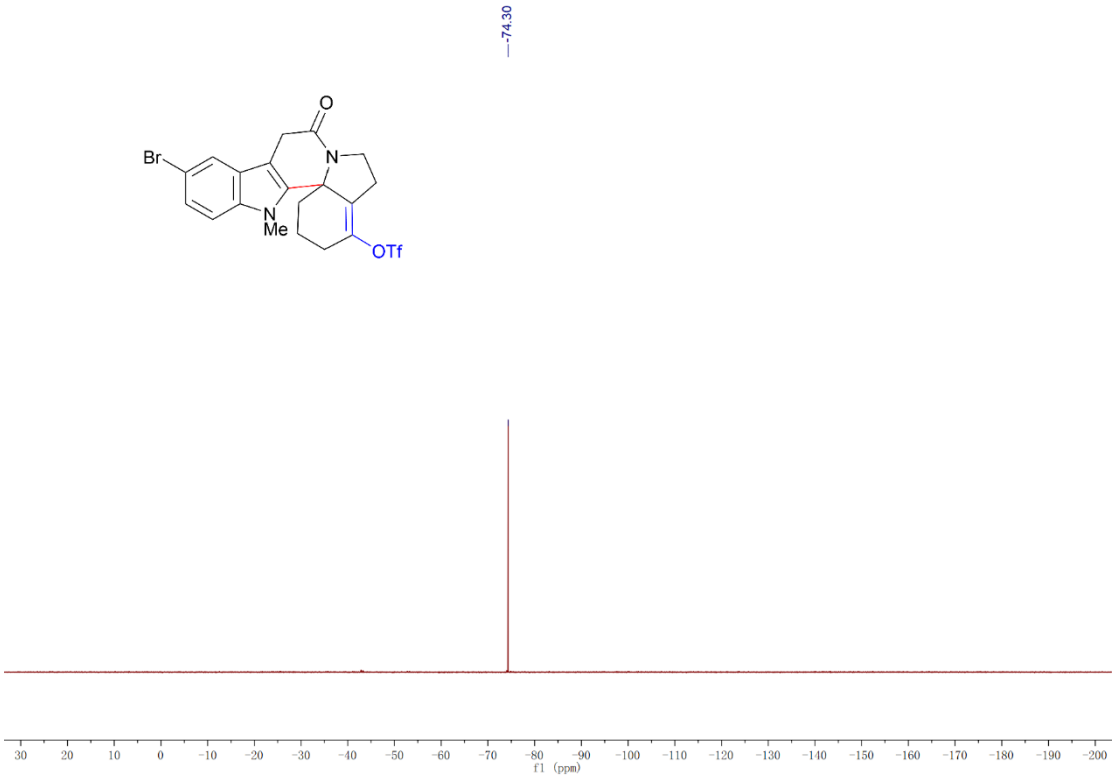
Compound **19i**, ^{1}H NMR, 400 MHz, $CDCl_3$



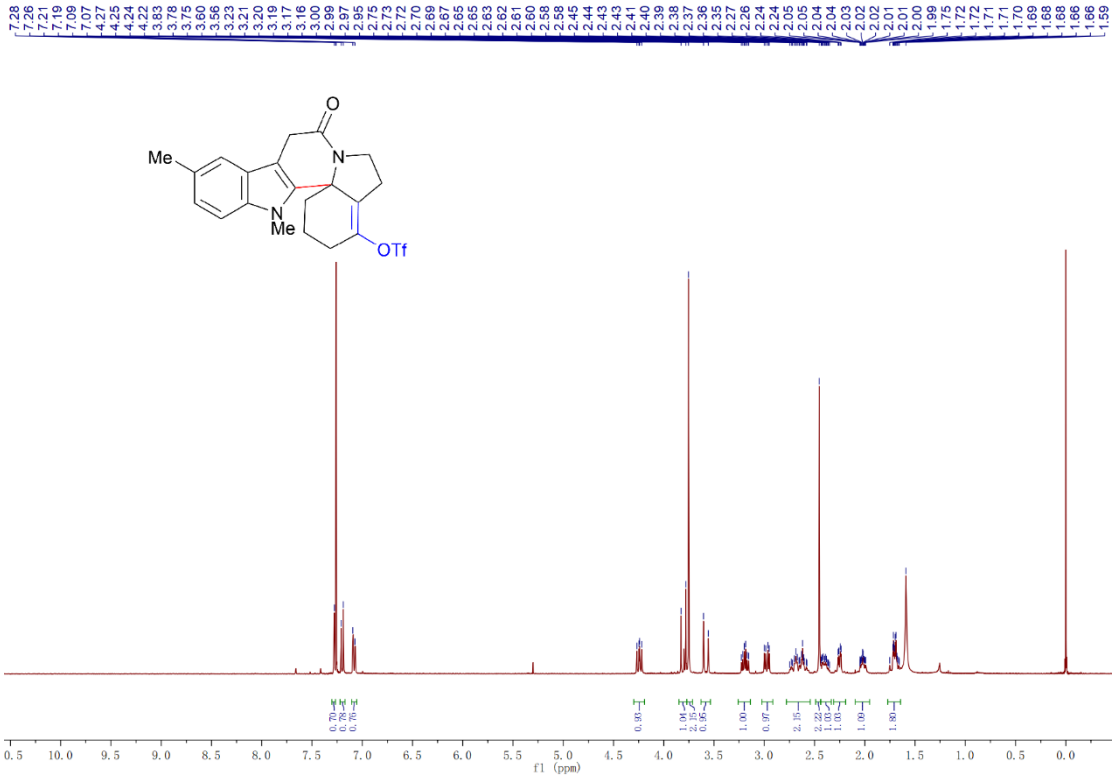
Compound **19i**, ^{13}C NMR, 100 MHz, $CDCl_3$



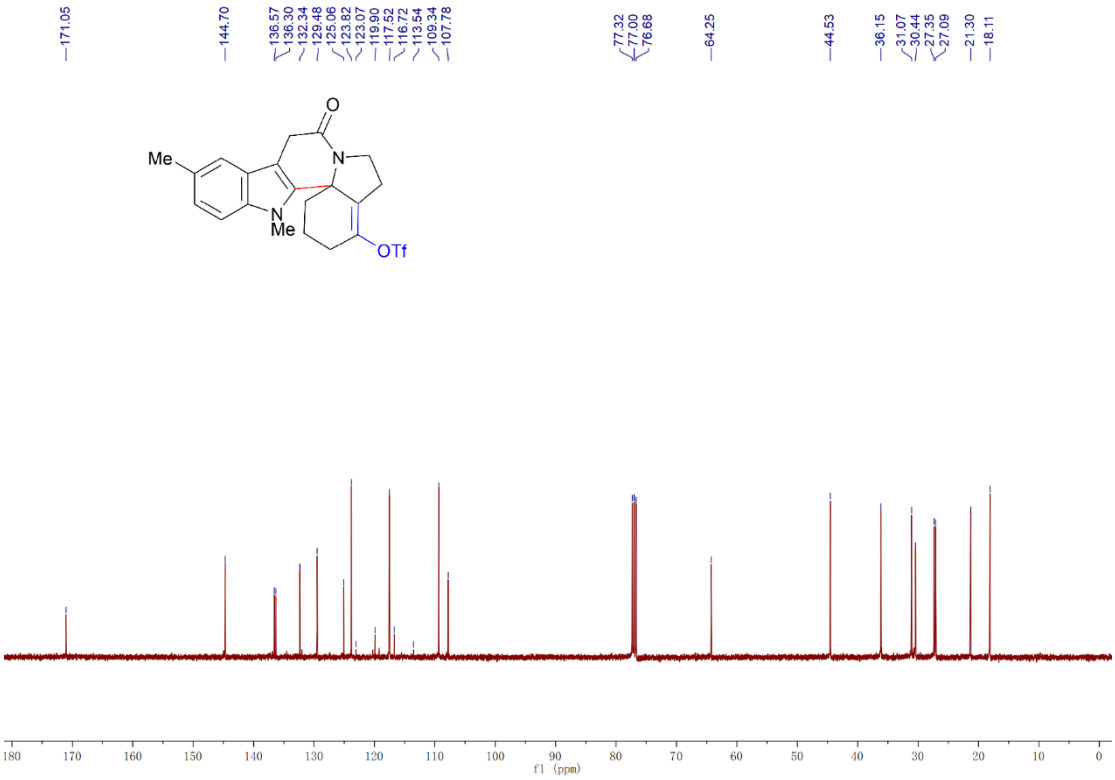
Compound **19i**, ^{19}F NMR, 376 MHz, $CDCl_3$



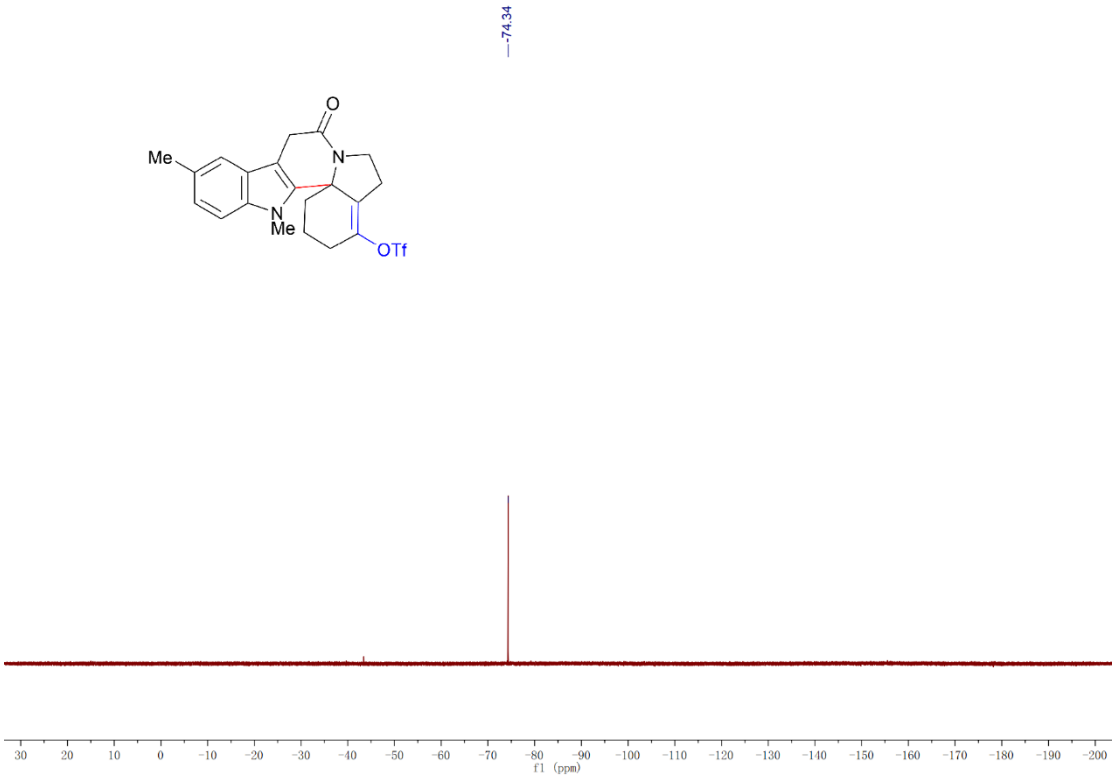
Compound **19j**, ^{1}H NMR, 400 MHz, $CDCl_3$



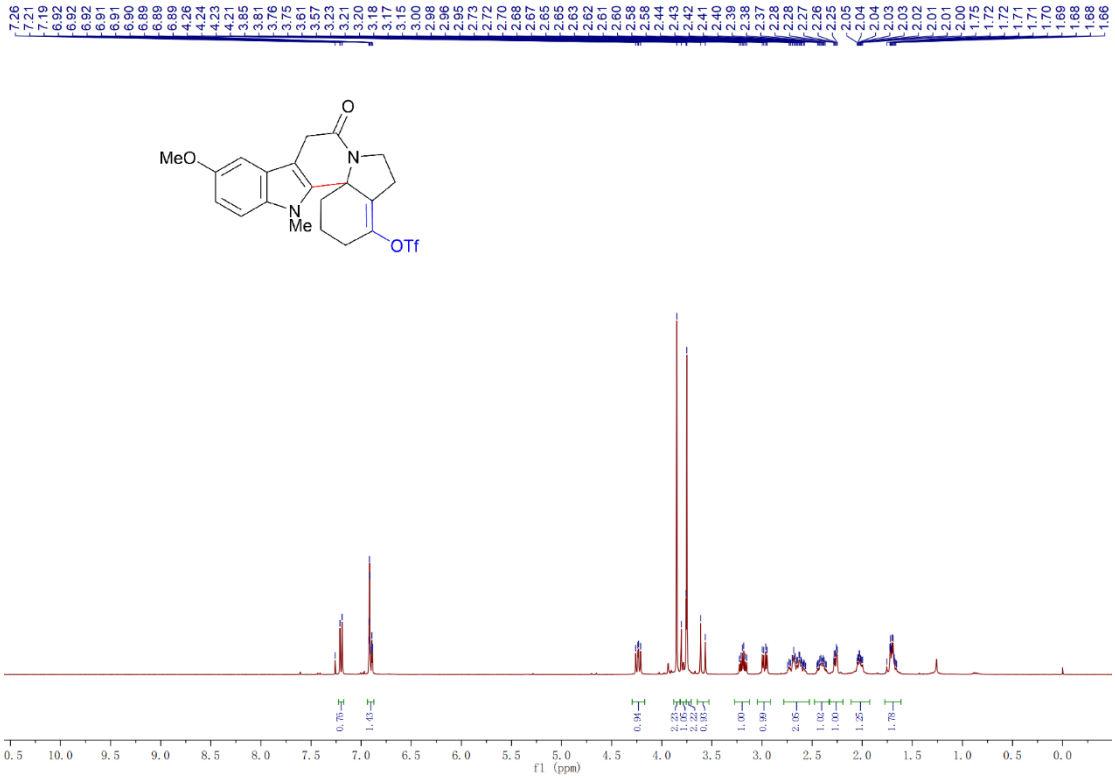
Compound **19j**, ^{13}C NMR, 100 MHz, $CDCl_3$



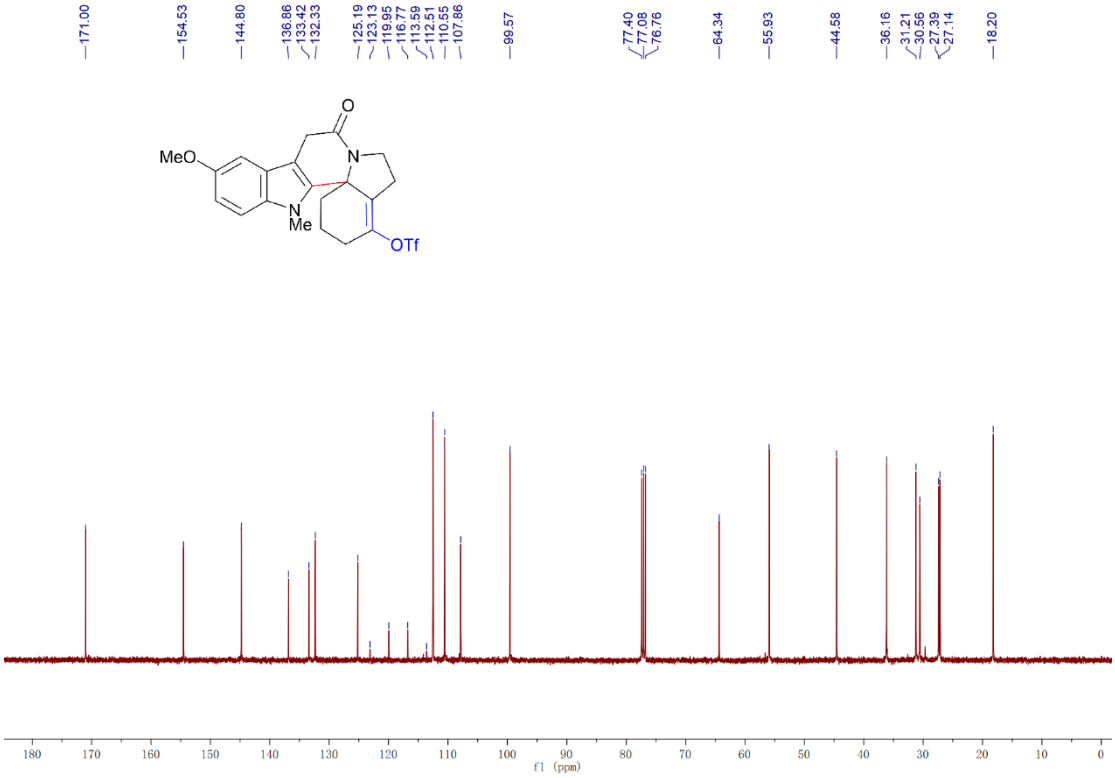
Compound **19j**, ^{19}F NMR, 376 MHz, $CDCl_3$



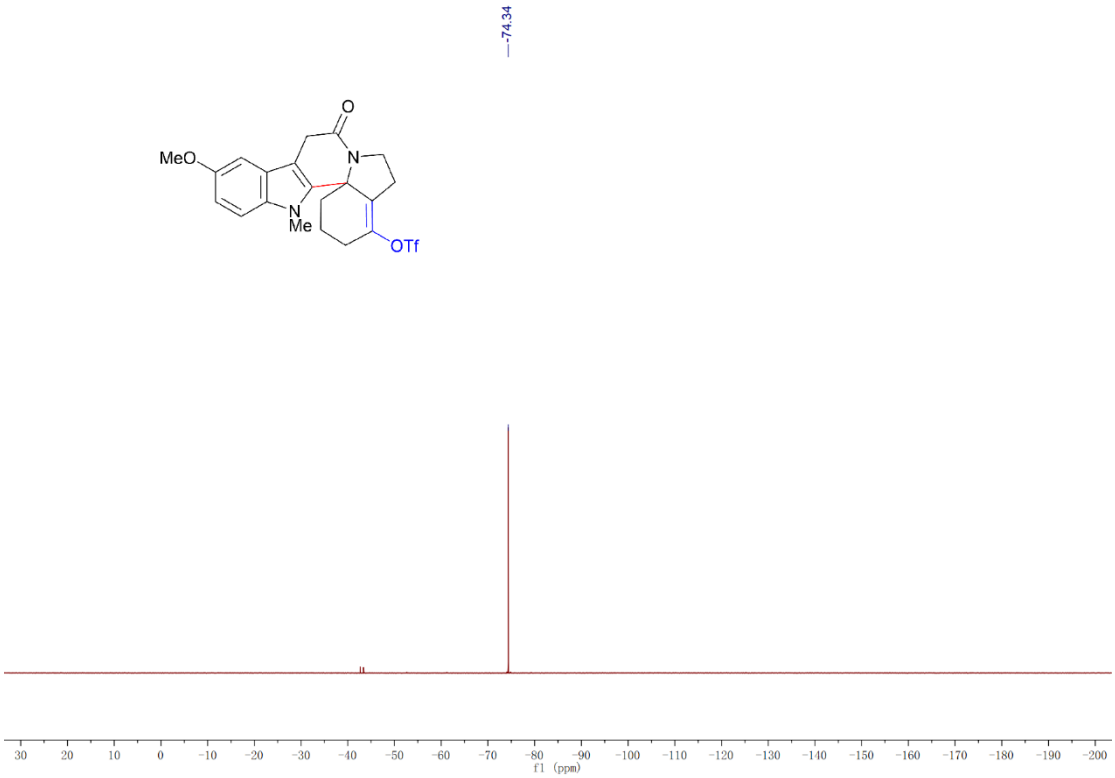
Compound **19k**, ^{1}H NMR, 400 MHz, $CDCl_3$



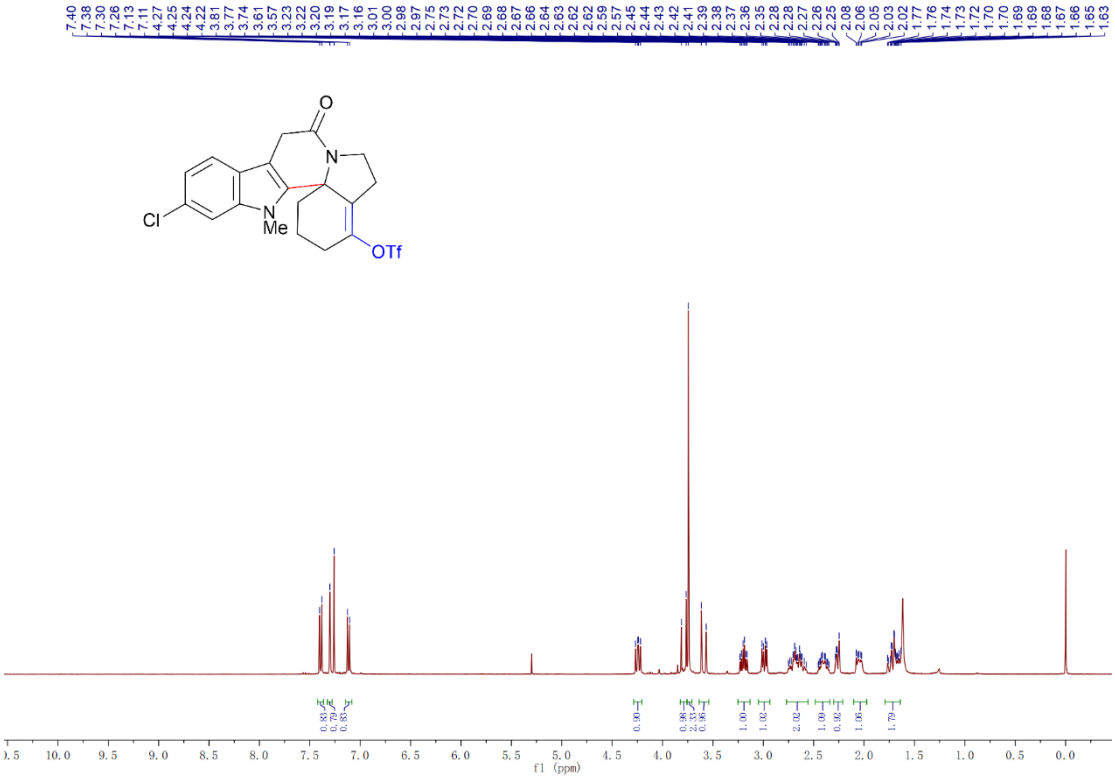
Compound **19k**, ^{13}C NMR, 100 MHz, $CDCl_3$



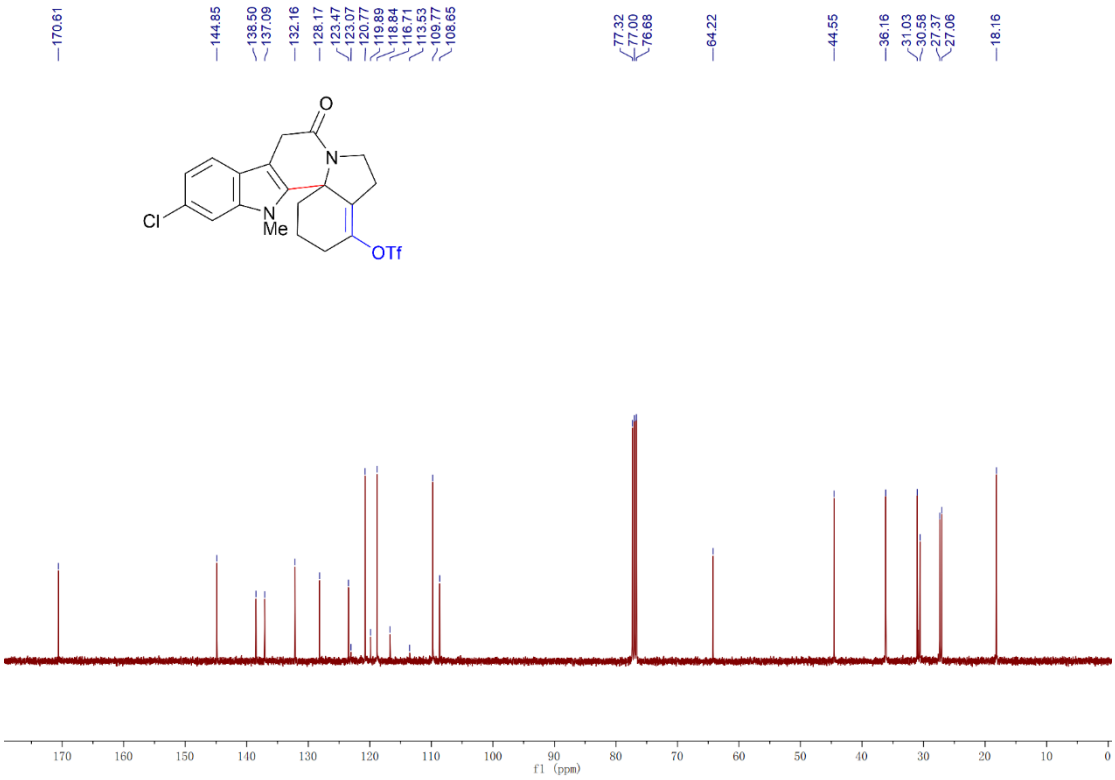
Compound **19k**, ^{19}F NMR, 376 MHz, $CDCl_3$



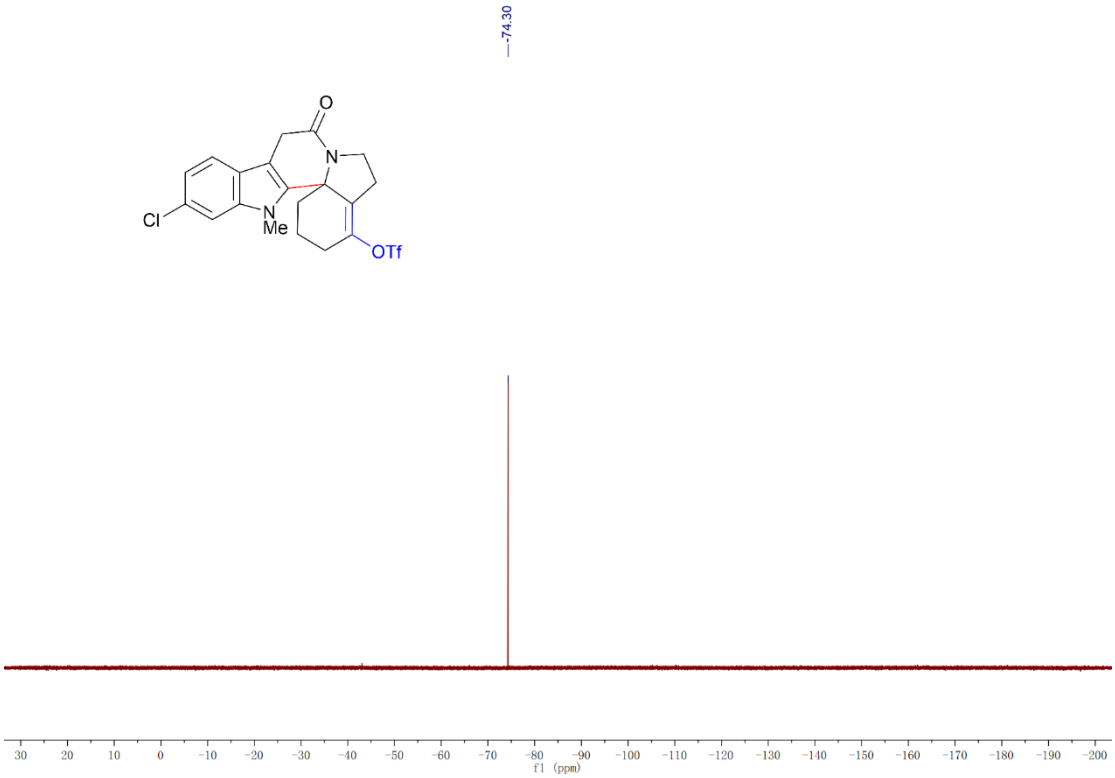
Compound **19l**, ^{1}H NMR, 400 MHz, $CDCl_3$



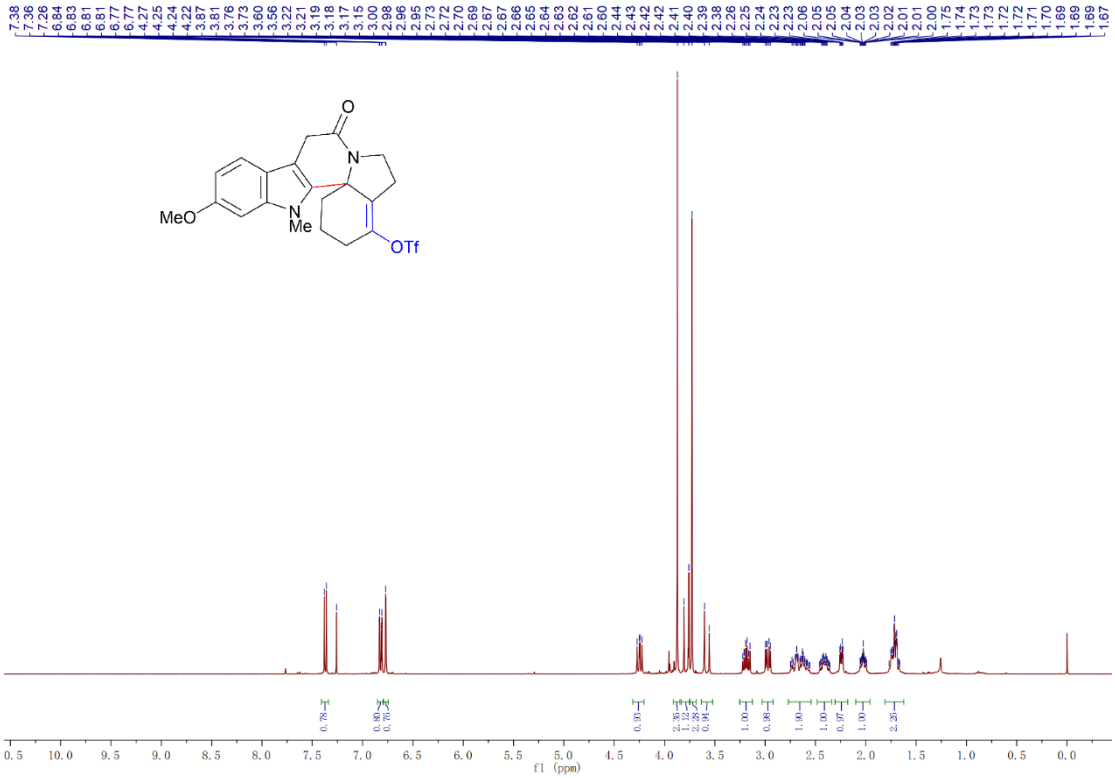
Compound **19l**, ^{13}C NMR, 100 MHz, $CDCl_3$



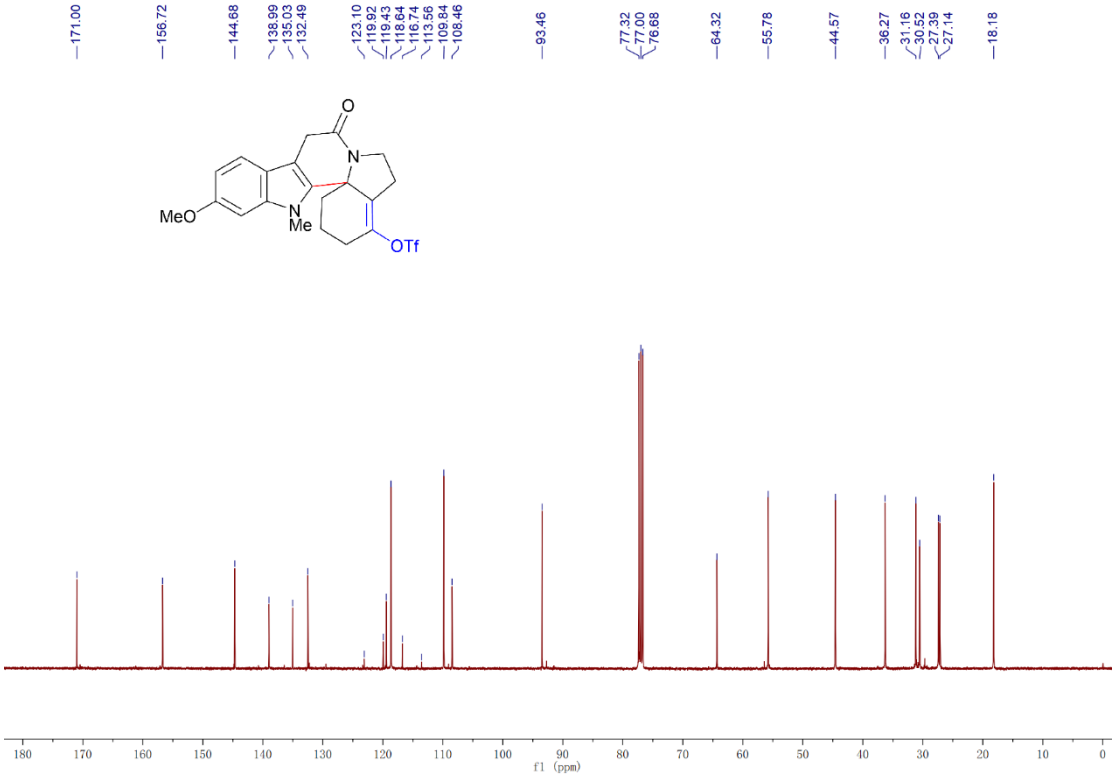
Compound **19l**, ^{19}F NMR, 376 MHz, $CDCl_3$



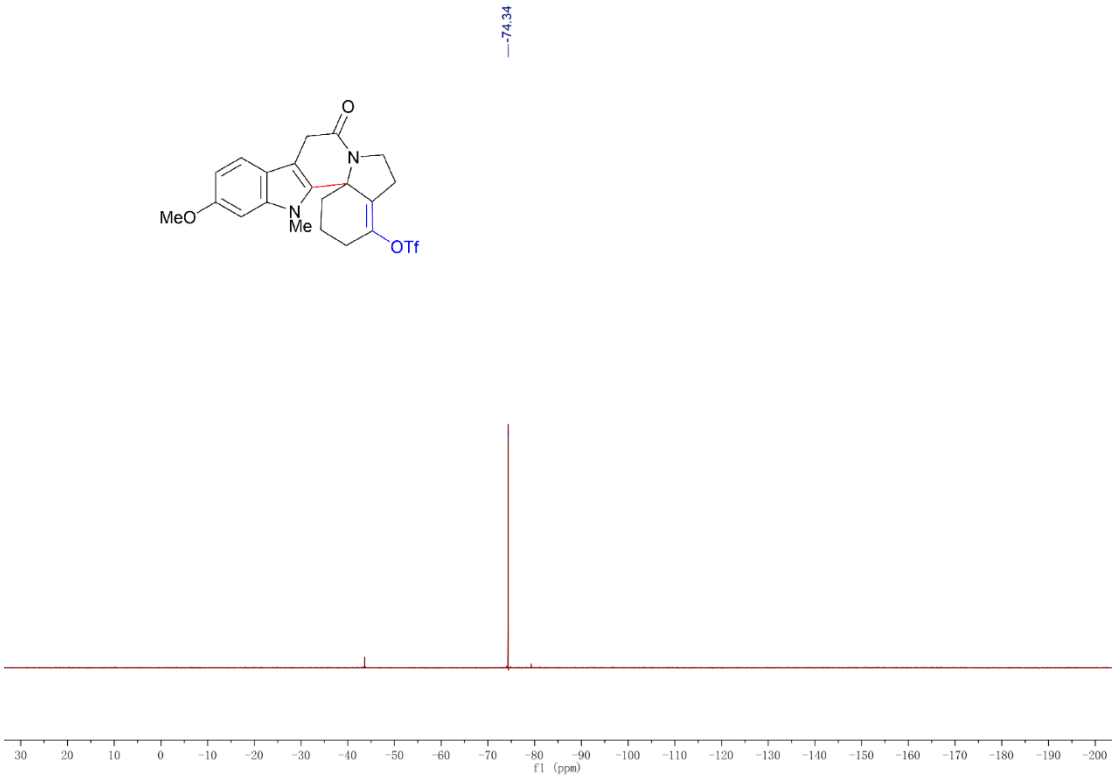
Compound **19m**, ^{1}H NMR, 400 MHz, $CDCl_3$



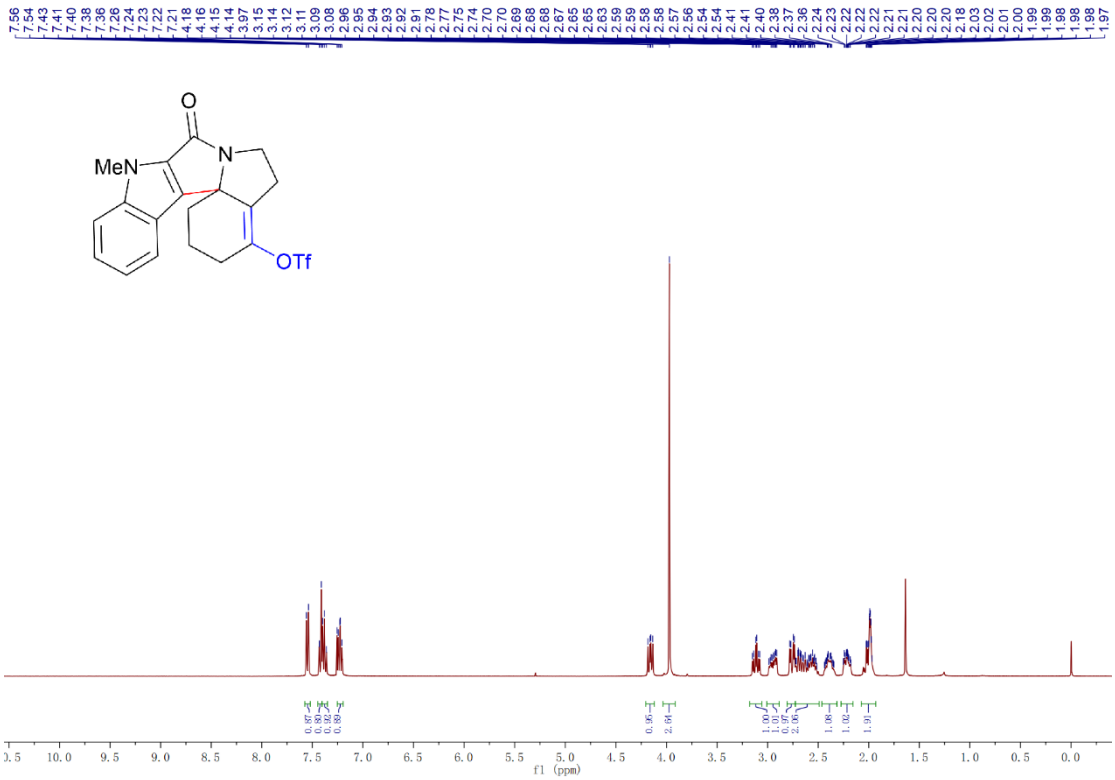
Compound **19m**, ^{13}C NMR, 100 MHz, $CDCl_3$



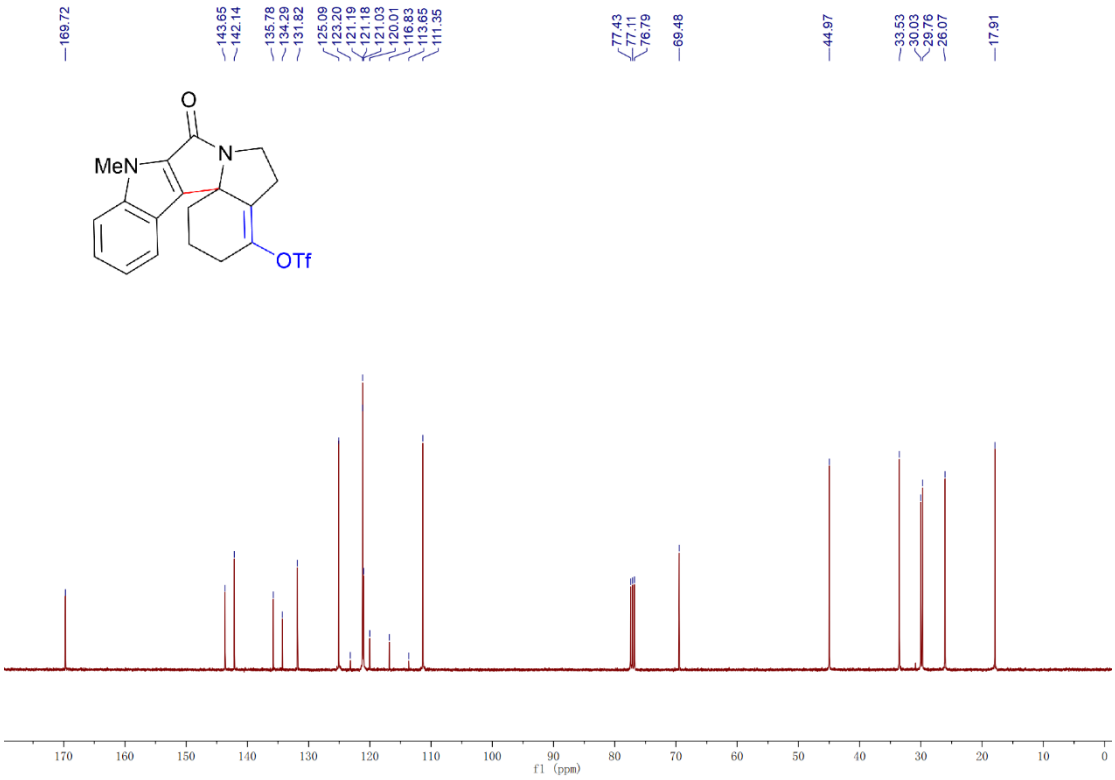
Compound **19m**, ^{19}F NMR, 376 MHz, $CDCl_3$



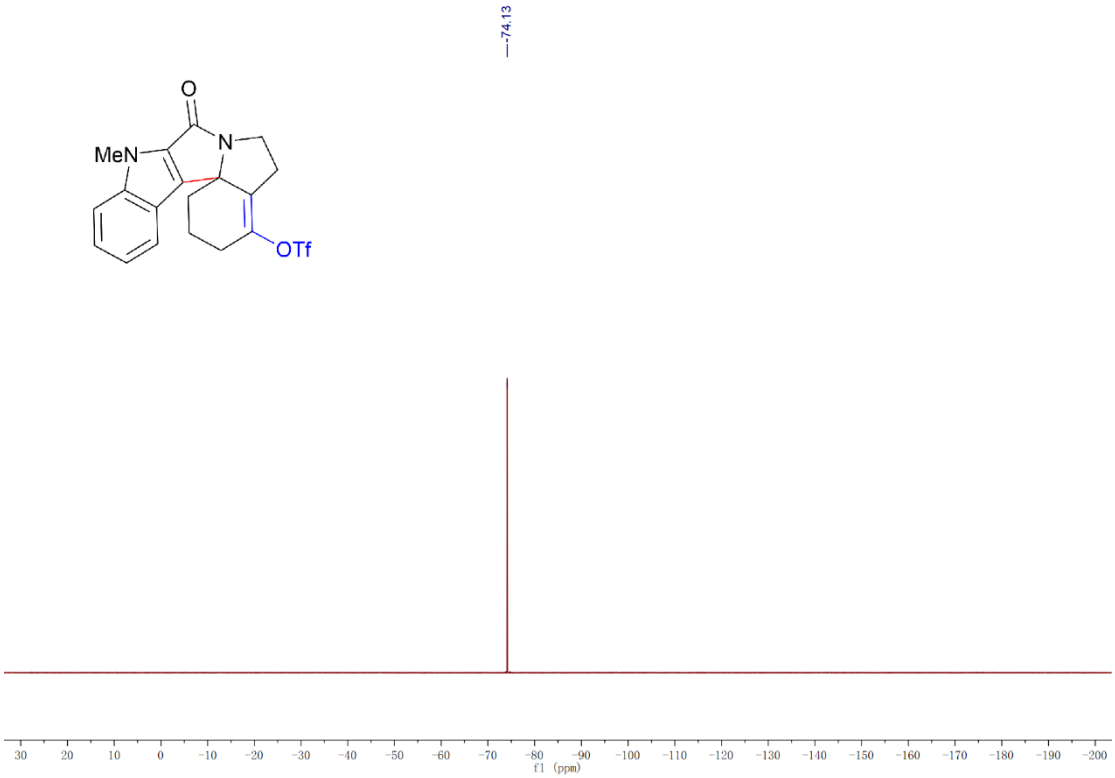
Compound **19n**, ^{1}H NMR, 400 MHz, $CDCl_3$



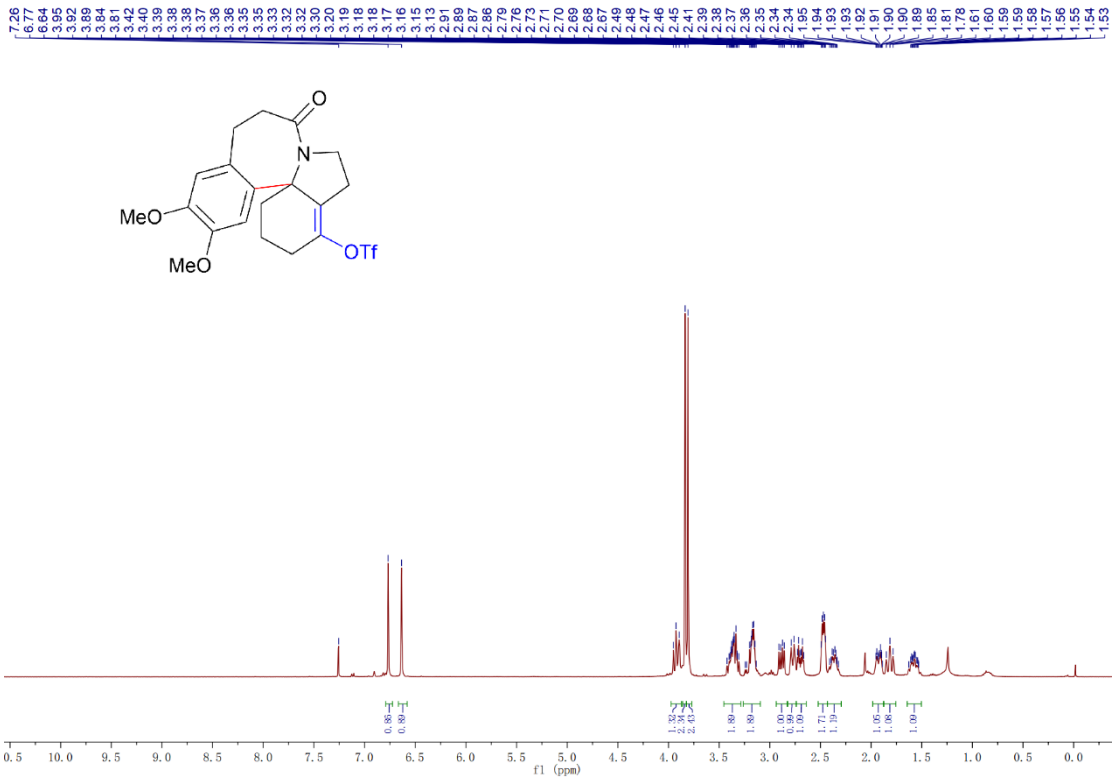
Compound **19n**, ^{13}C NMR, 100 MHz, $CDCl_3$



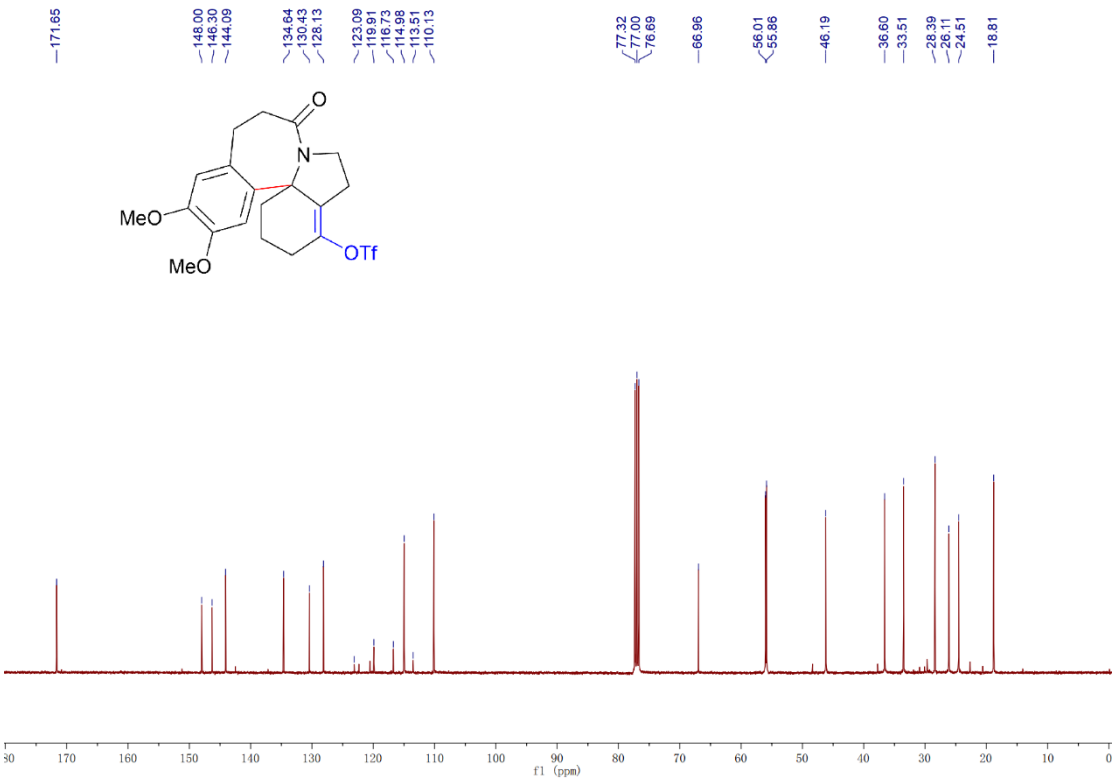
Compound **19n**, ^{19}F NMR, 376 MHz, $CDCl_3$



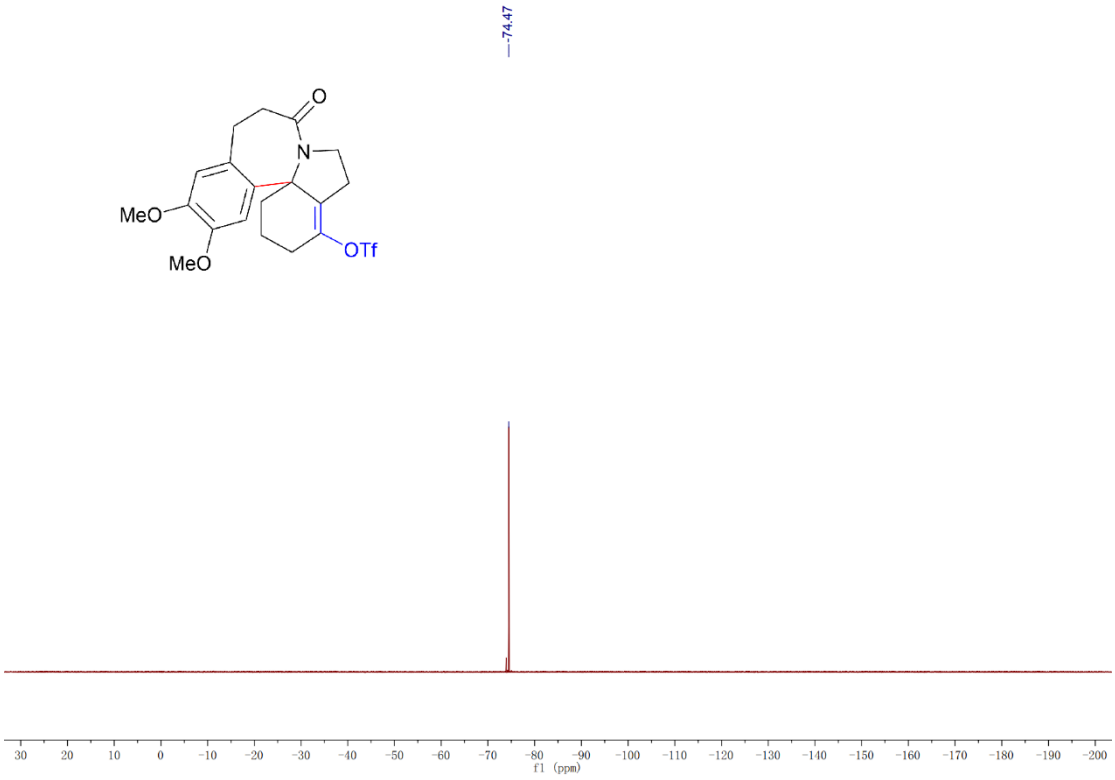
Compound **19o**, ^{1}H NMR, 400 MHz, $CDCl_3$



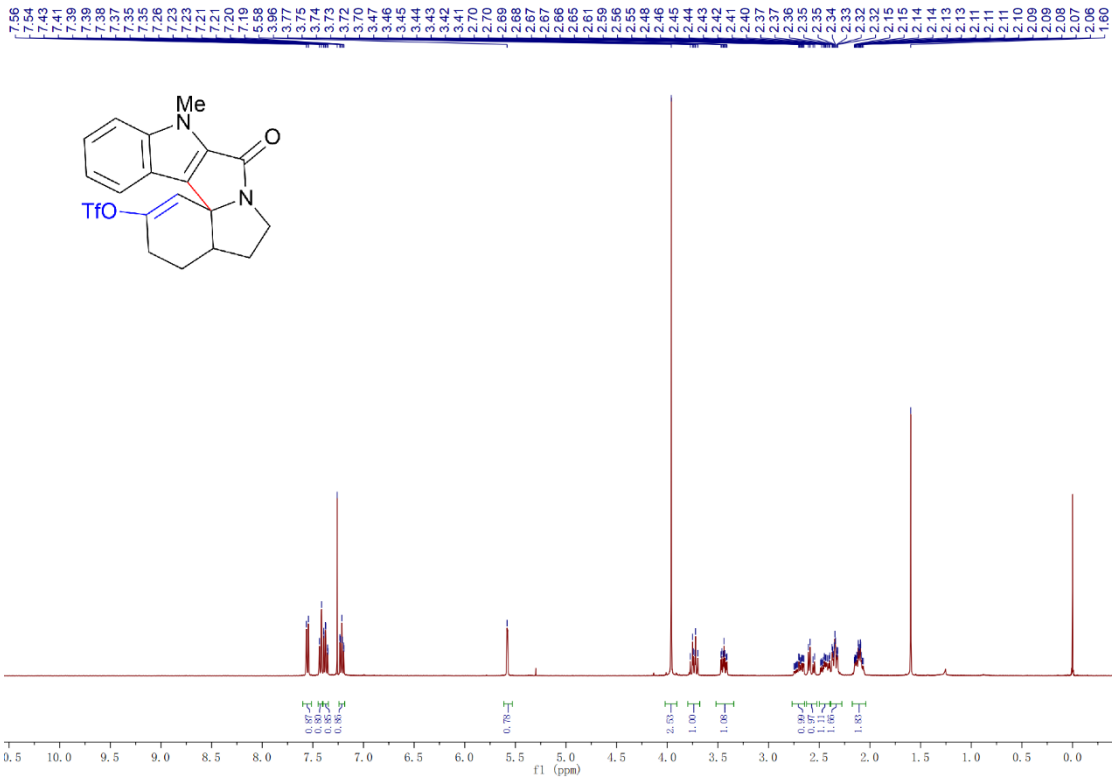
Compound **19o**, ^{13}C NMR, 100 MHz, $CDCl_3$



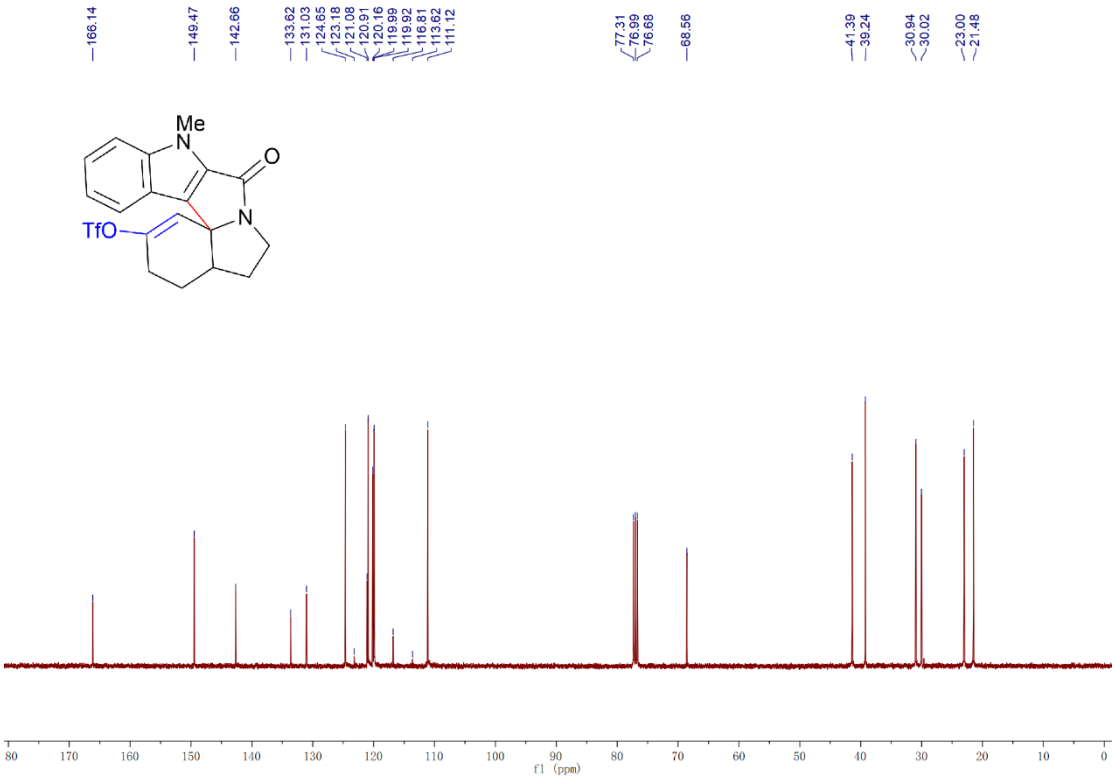
Compound **19o**, ^{19}F NMR, 376 MHz, $CDCl_3$



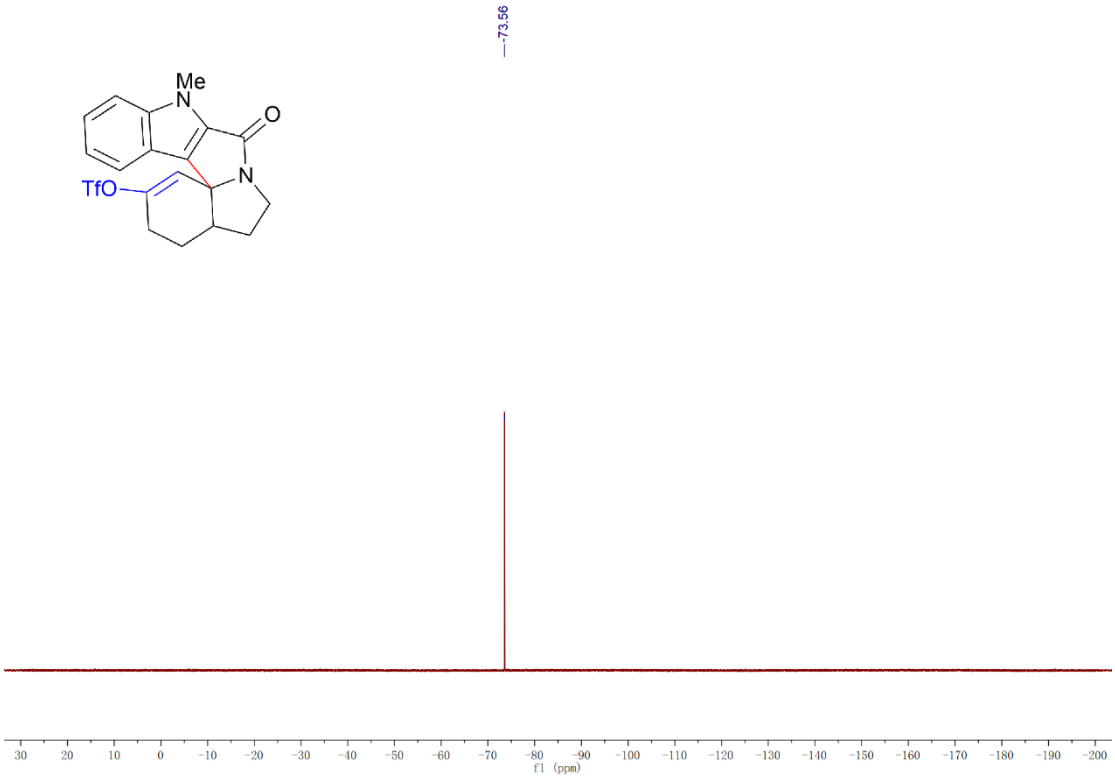
Compound **19p**, ^{1}H NMR, 400 MHz, $CDCl_3$



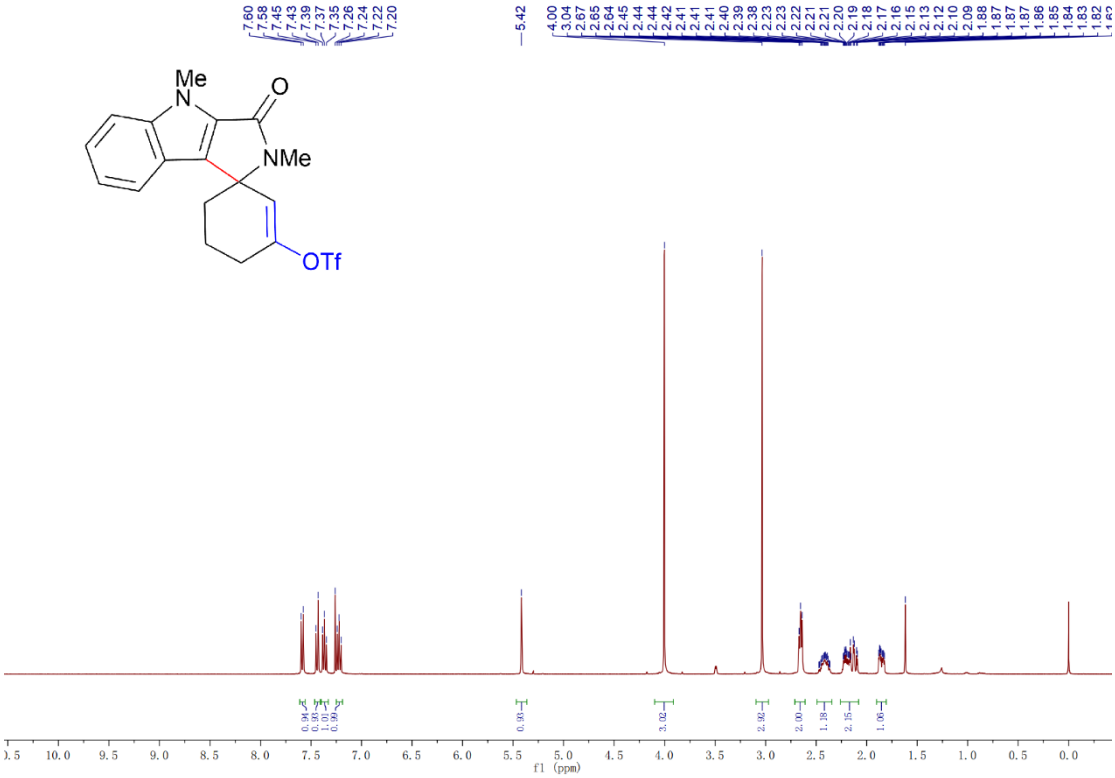
Compound **19p**, ^{13}C NMR, 100 MHz, $CDCl_3$



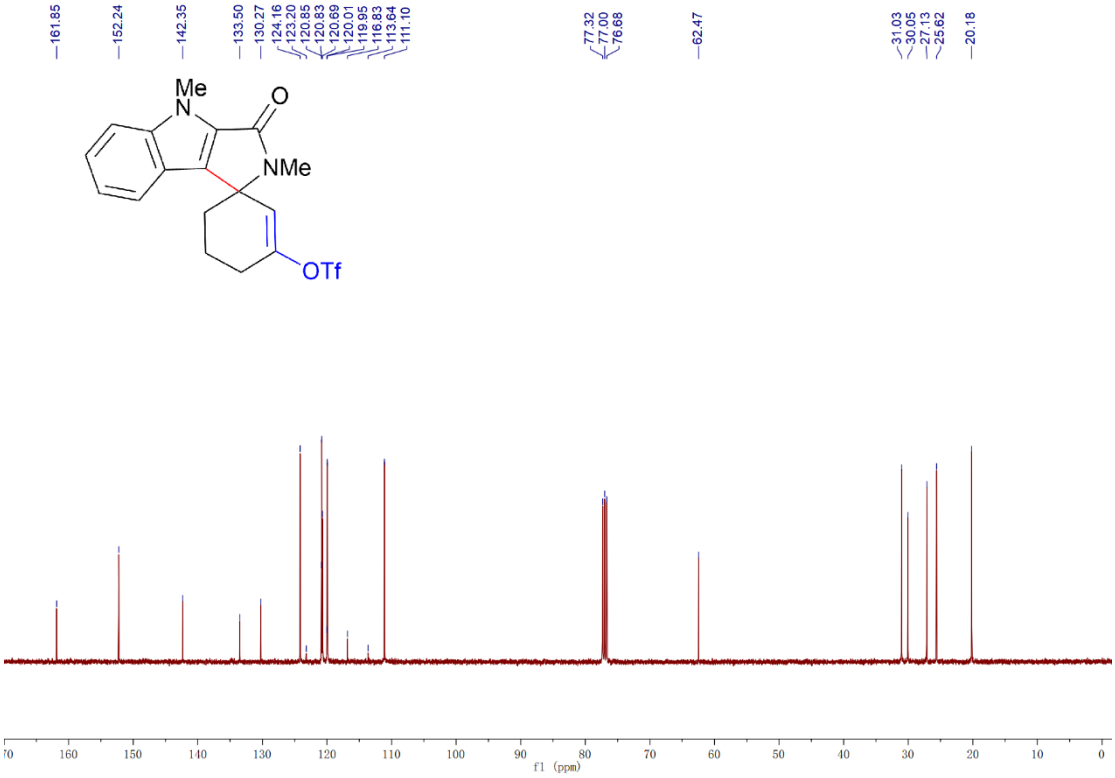
Compound **19p**, ^{19}F NMR, 376 MHz, $CDCl_3$



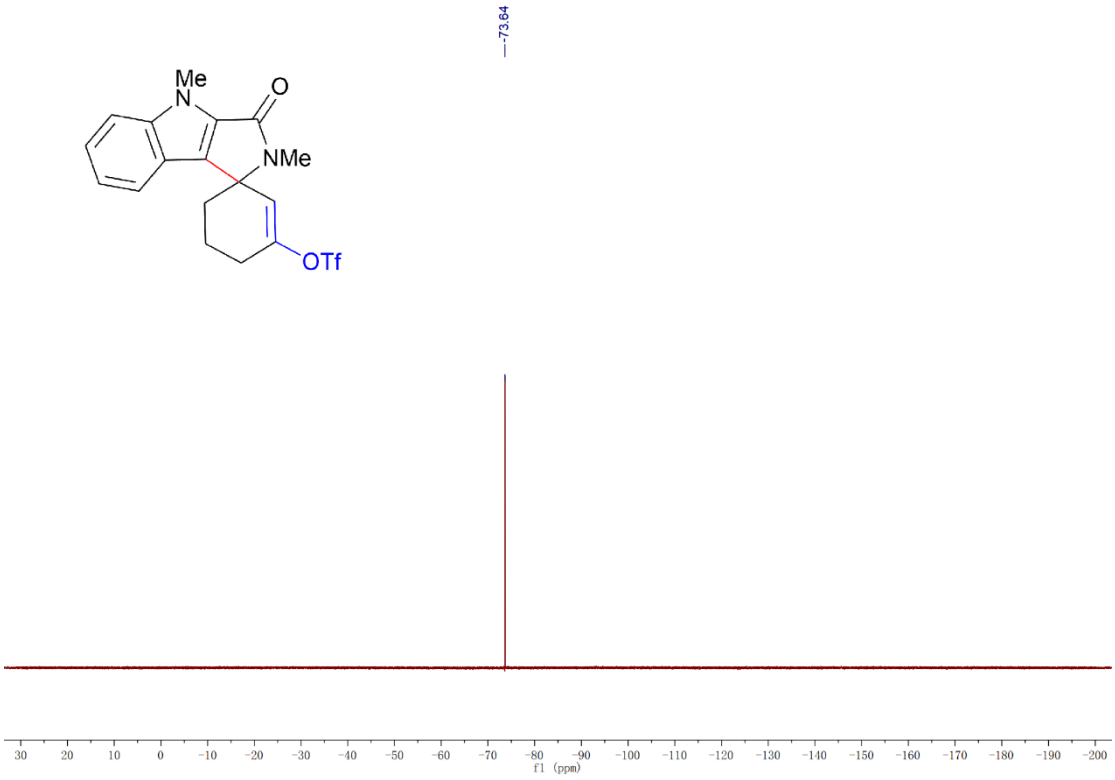
Compound **19q**, ^{1}H NMR, 400 MHz, $CDCl_3$



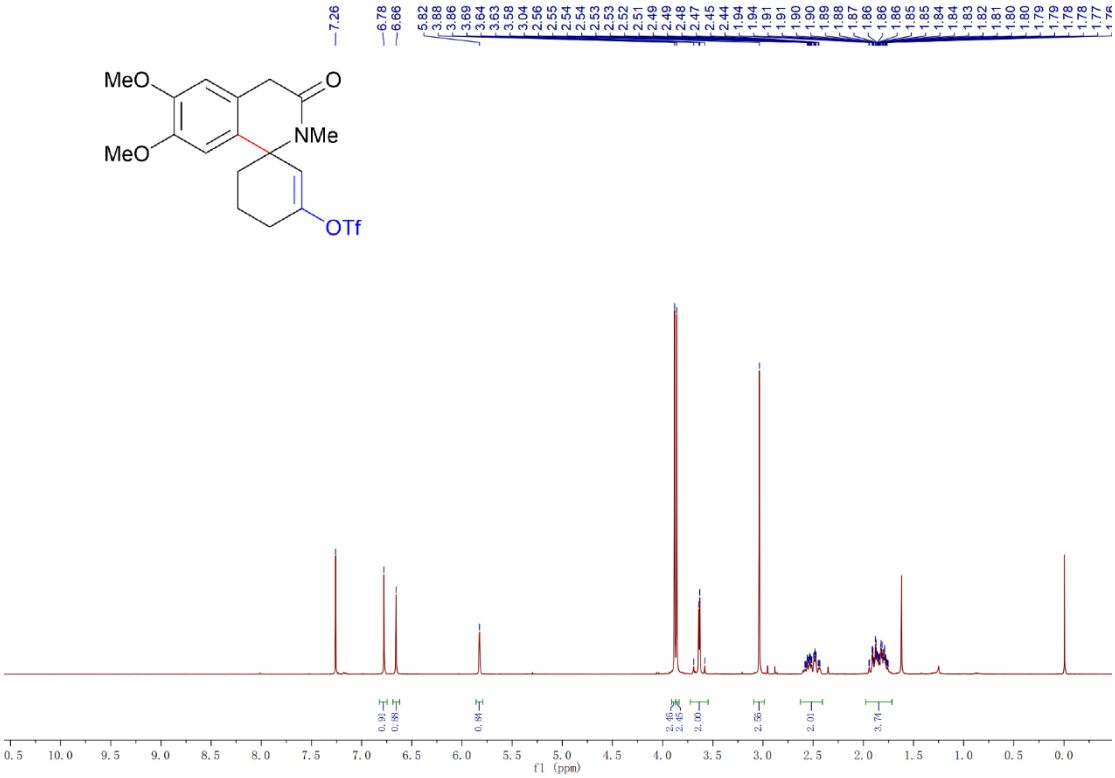
Compound **19q**, ^{13}C NMR, 100 MHz, $CDCl_3$



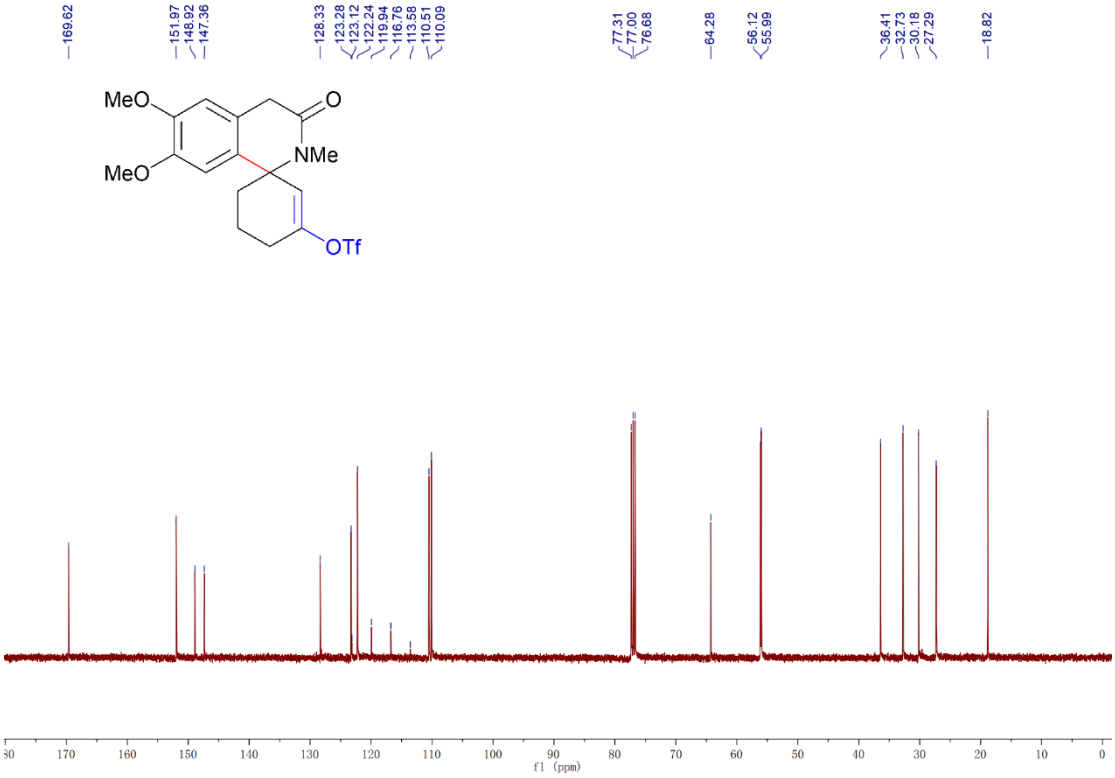
Compound **19q**, ^{19}F NMR, 376 MHz, $CDCl_3$



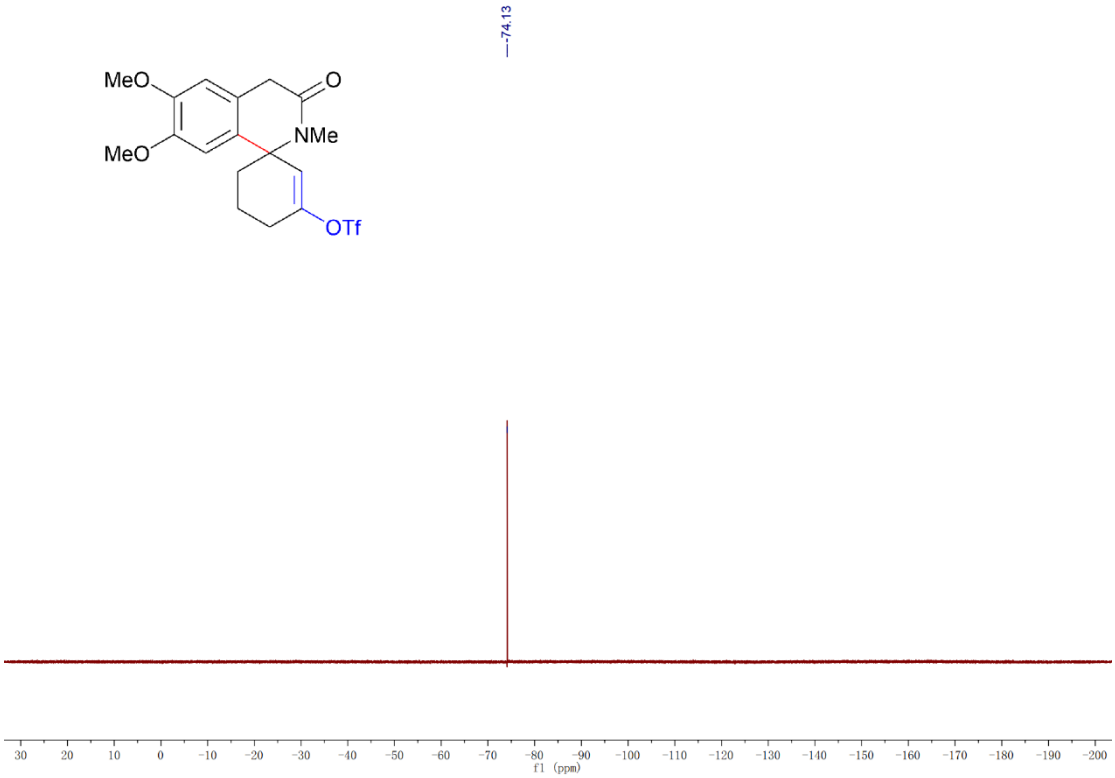
Compound **19r**, ^{1}H NMR, 400 MHz, $CDCl_3$



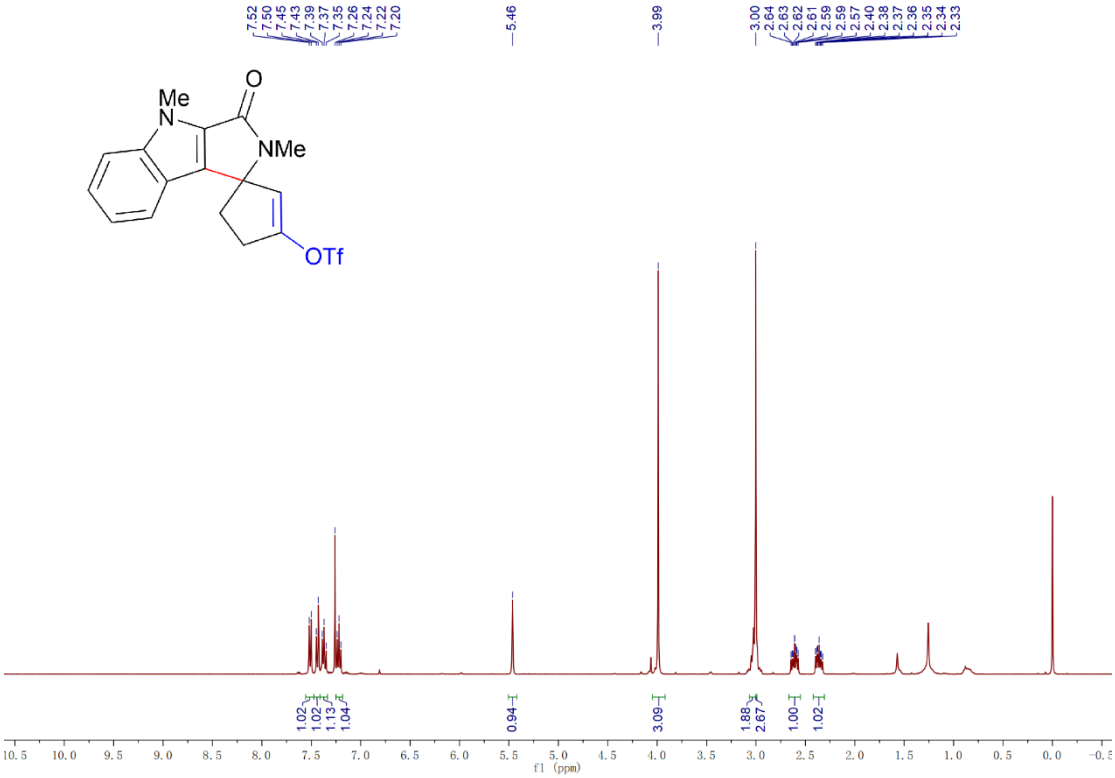
Compound **19r**, ^{13}C NMR, 100 MHz, $CDCl_3$



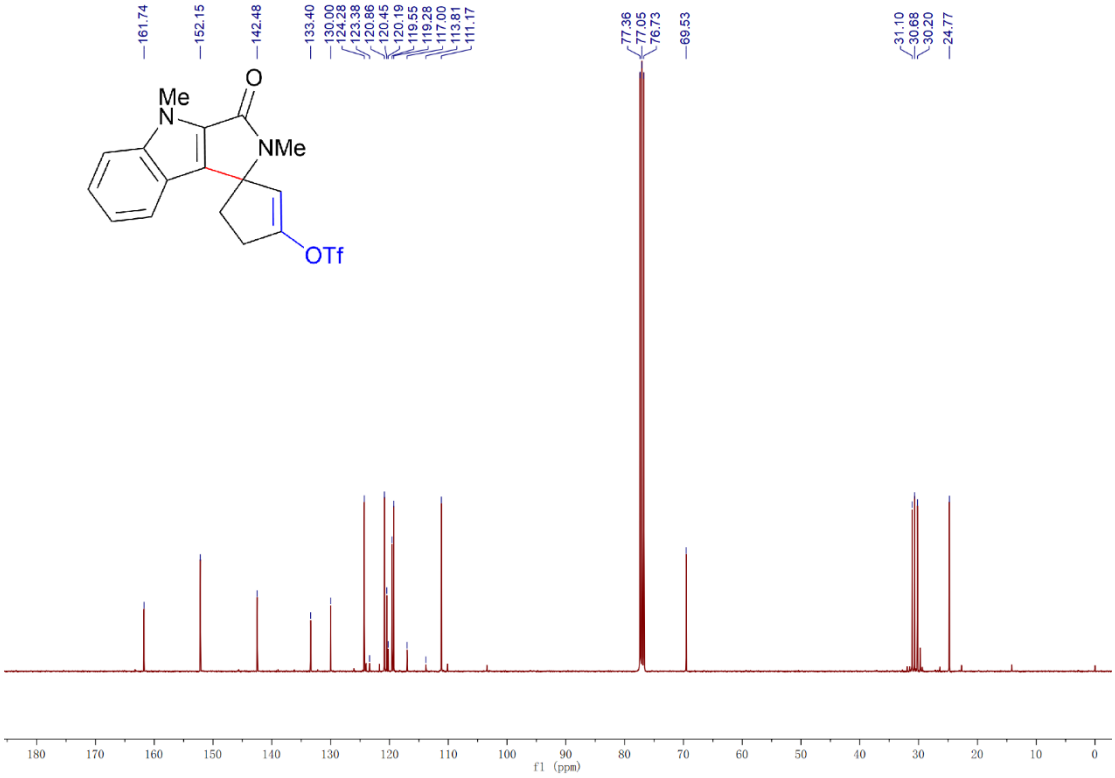
Compound **19r**, ^{19}F NMR, 376 MHz, $CDCl_3$



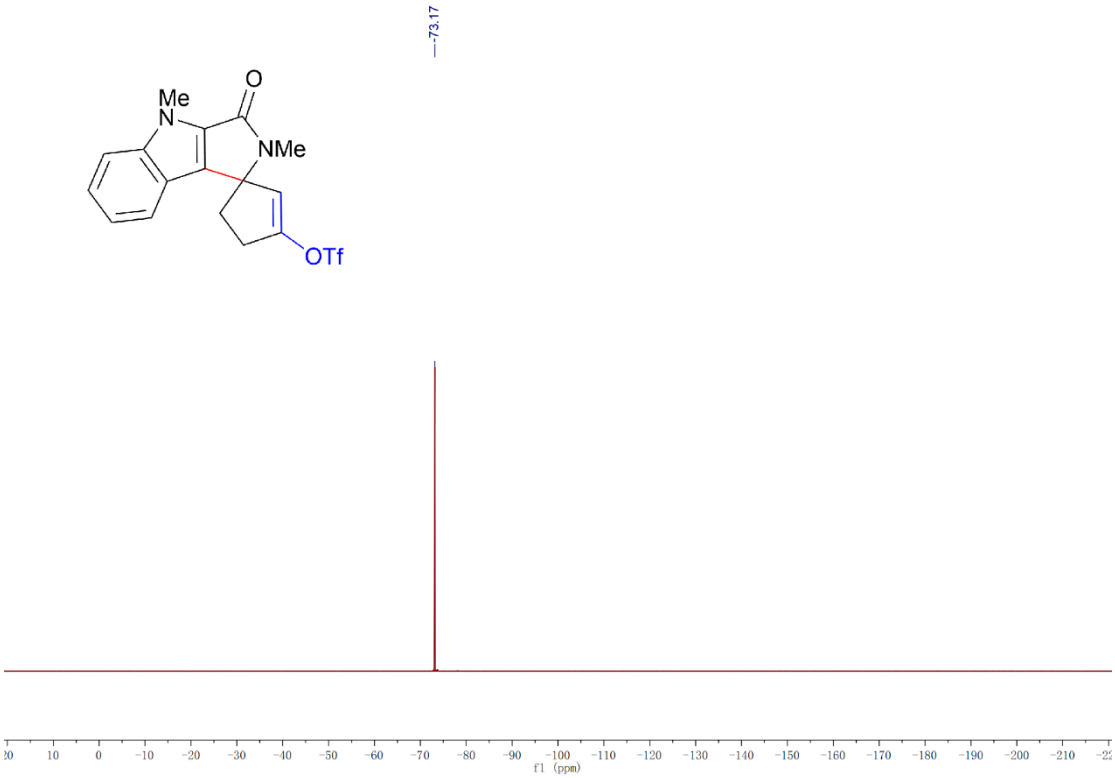
Compound **19s**, ^{1}H NMR, 400 MHz, $CDCl_3$



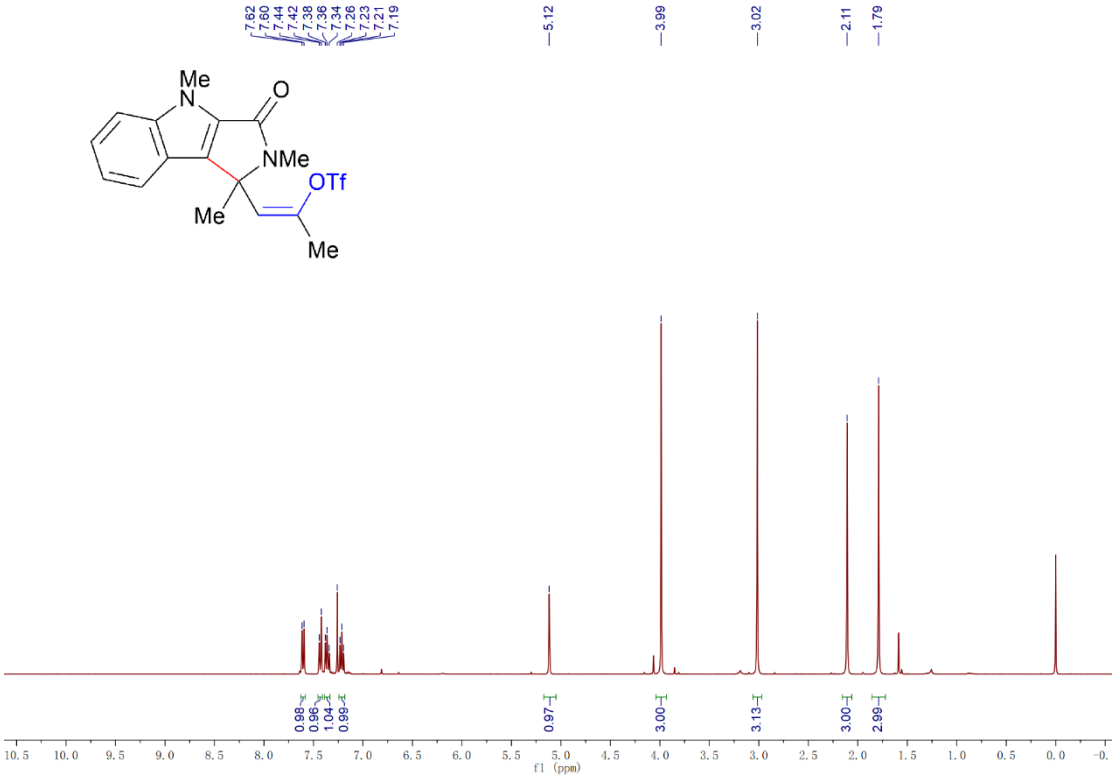
Compound **19s**, ^{13}C NMR, 100 MHz, $CDCl_3$



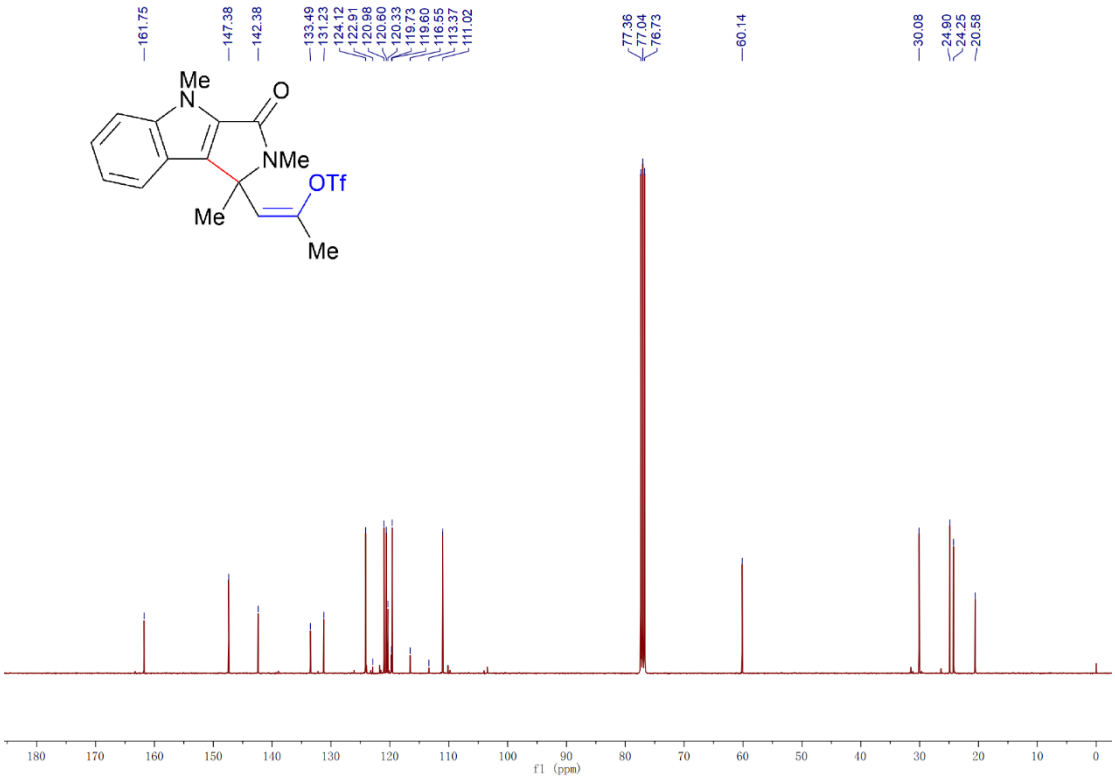
Compound **19s**, ^{19}F NMR, 376 MHz, $CDCl_3$



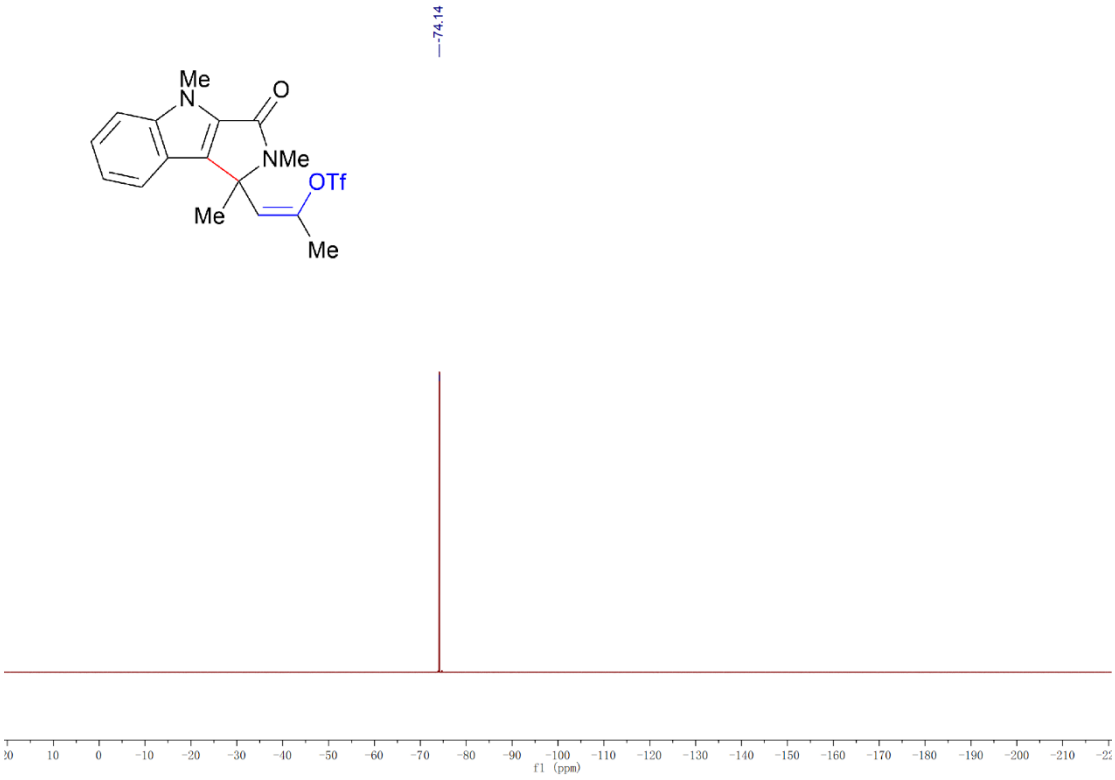
Compound **19t**, ^{1}H NMR, 400 MHz, $CDCl_3$



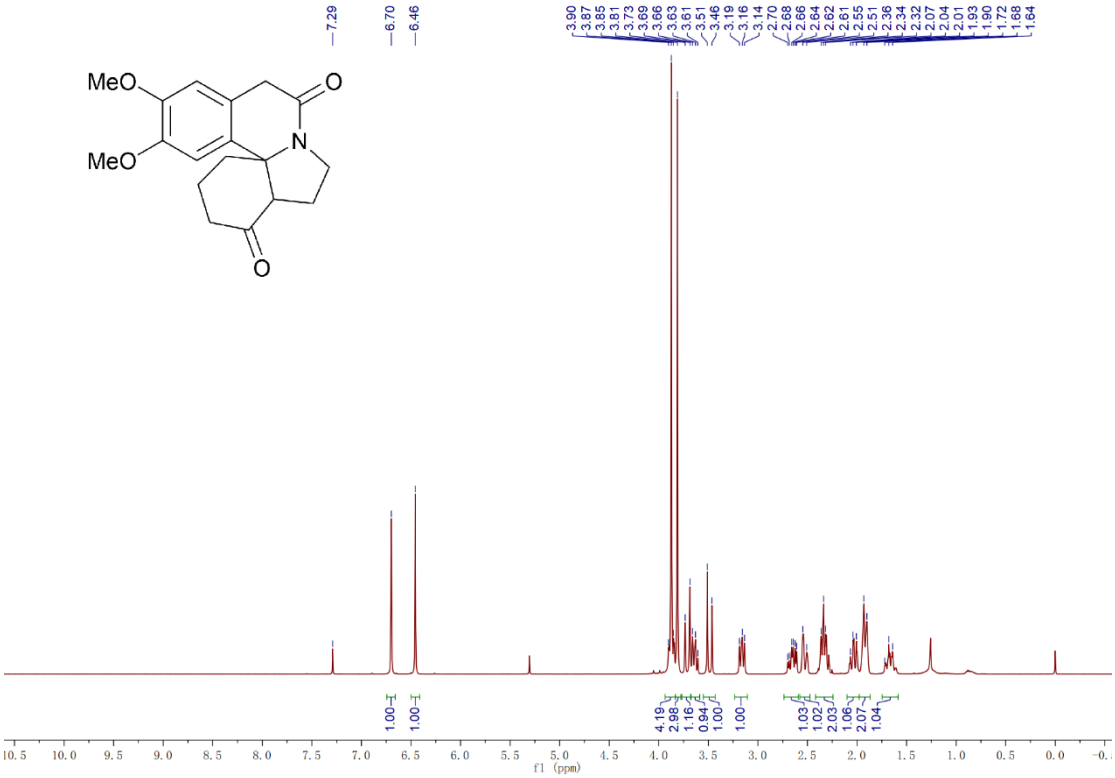
Compound **19t**, ^{13}C NMR, 100 MHz, $CDCl_3$



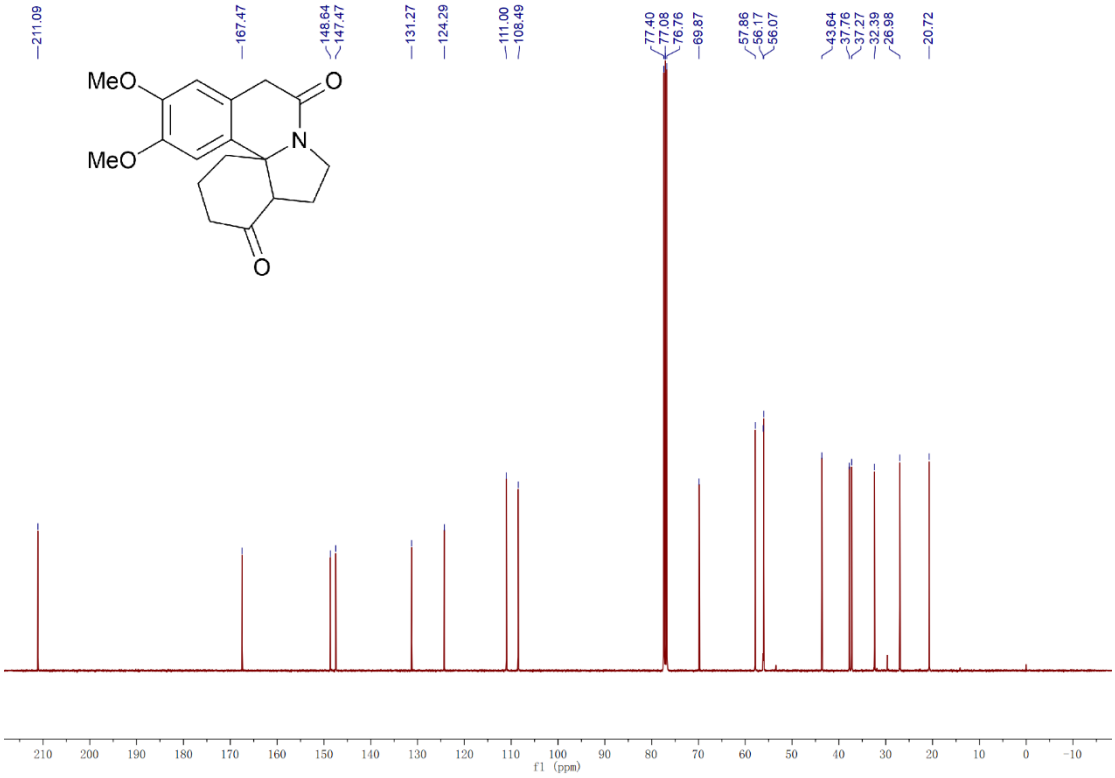
Compound **19t**, ^{19}F NMR, 376 MHz, $CDCl_3$



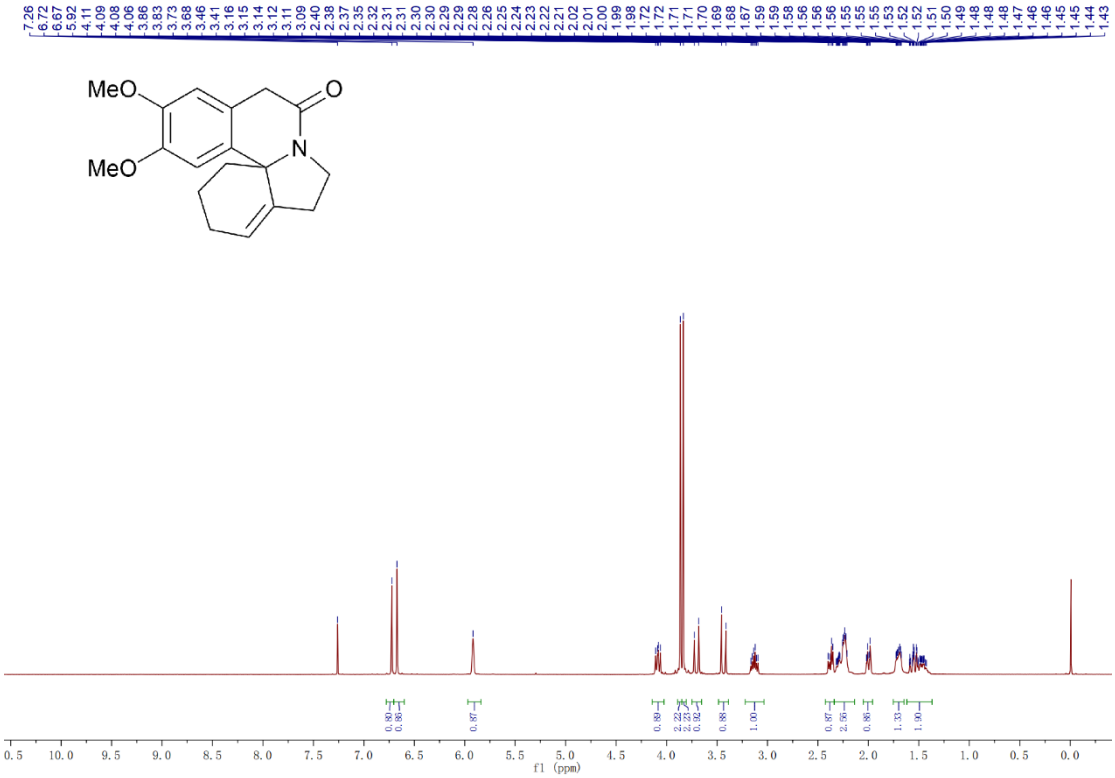
Compound **20**, ^{1}H NMR, 400 MHz, $CDCl_3$



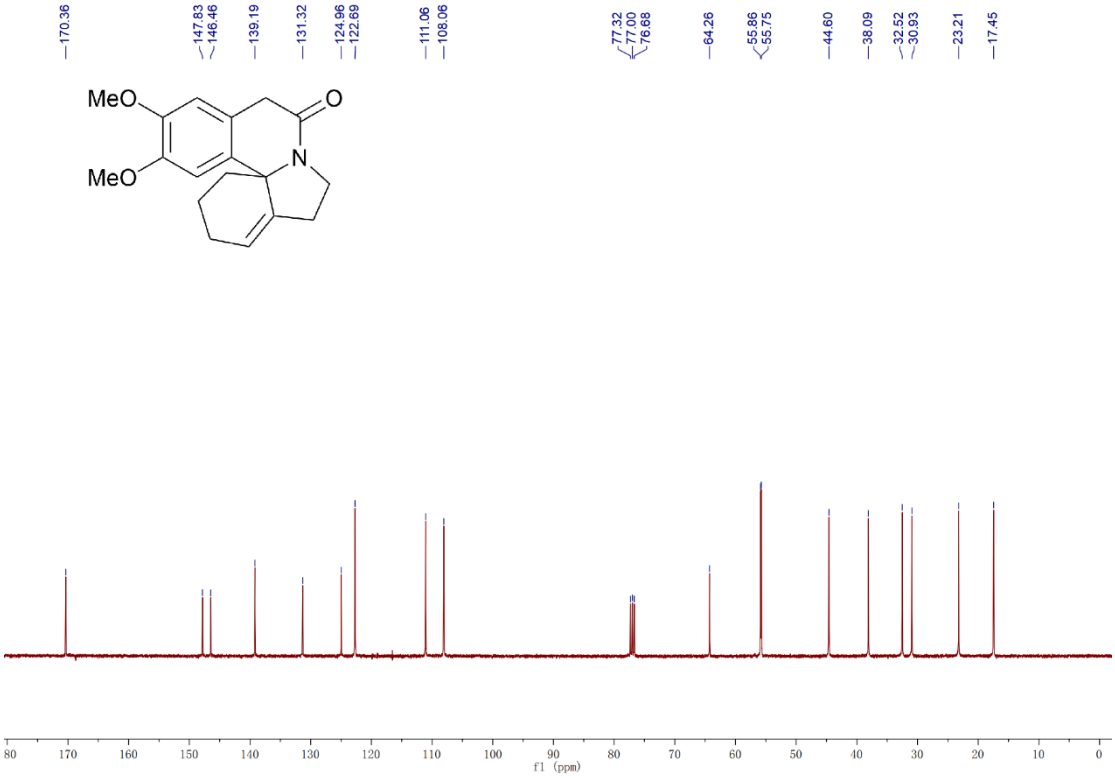
Compound **20**, ^{13}C NMR, 100 MHz, $CDCl_3$



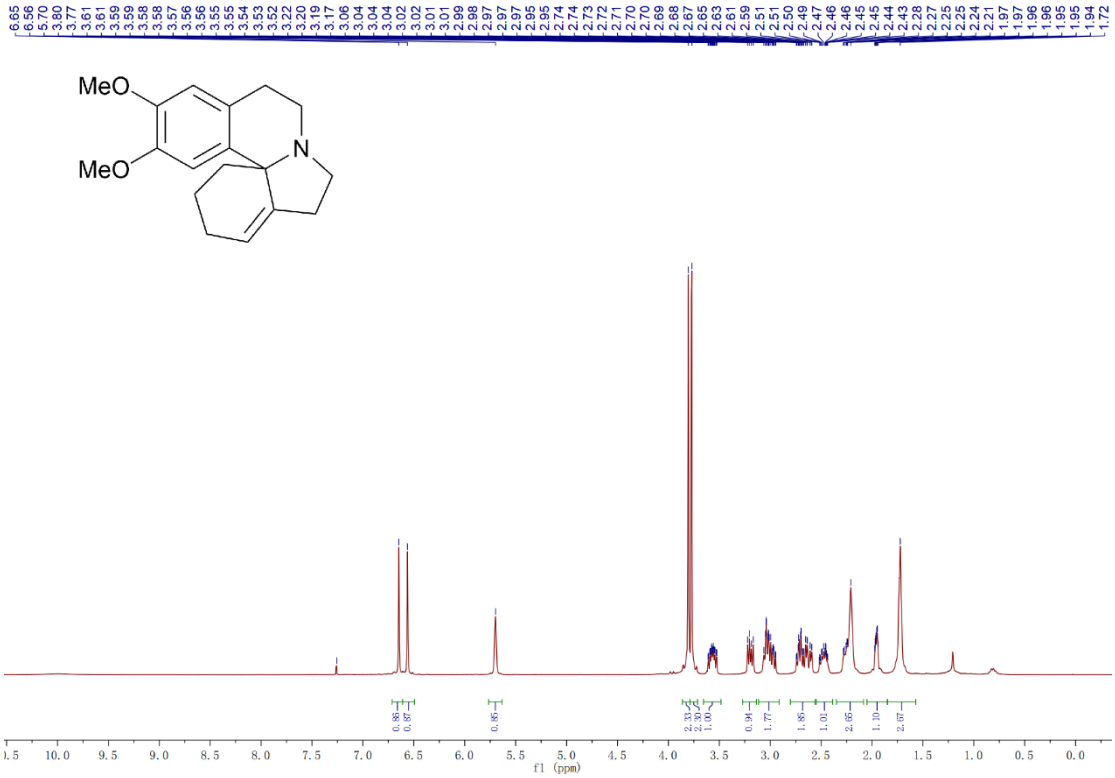
Compound **21**, ^{1}H NMR, 400 MHz, $CDCl_3$



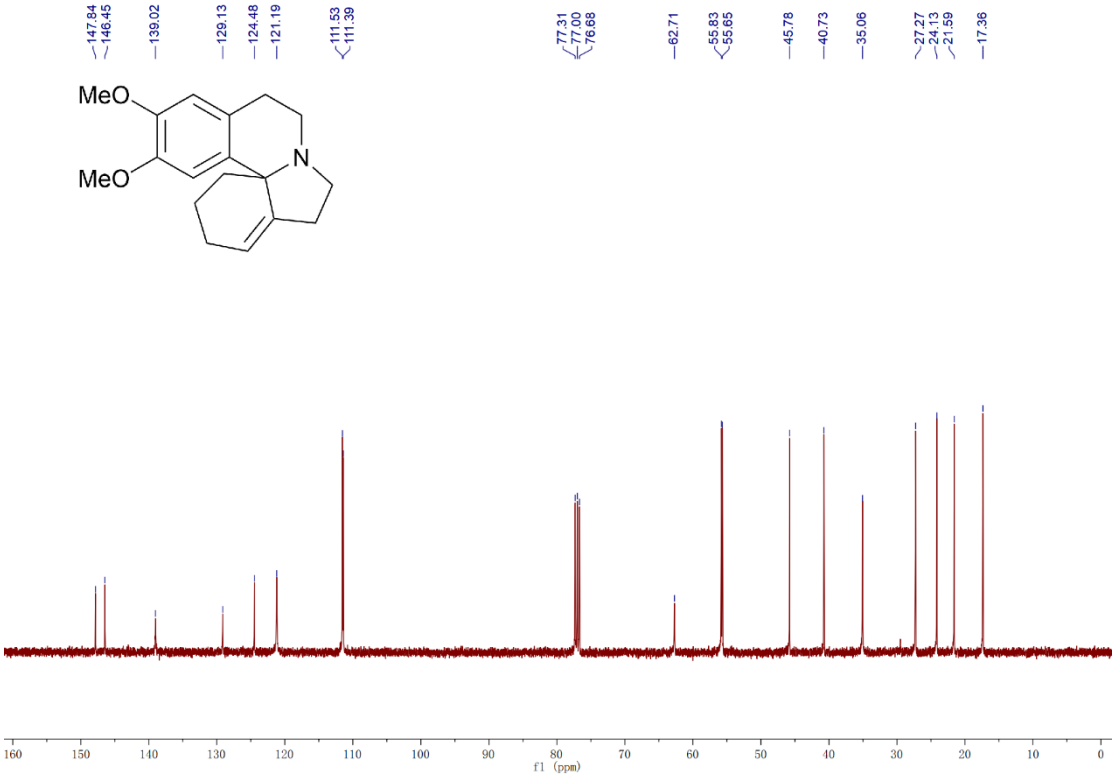
Compound **21**, ^{13}C NMR, 100 MHz, $CDCl_3$



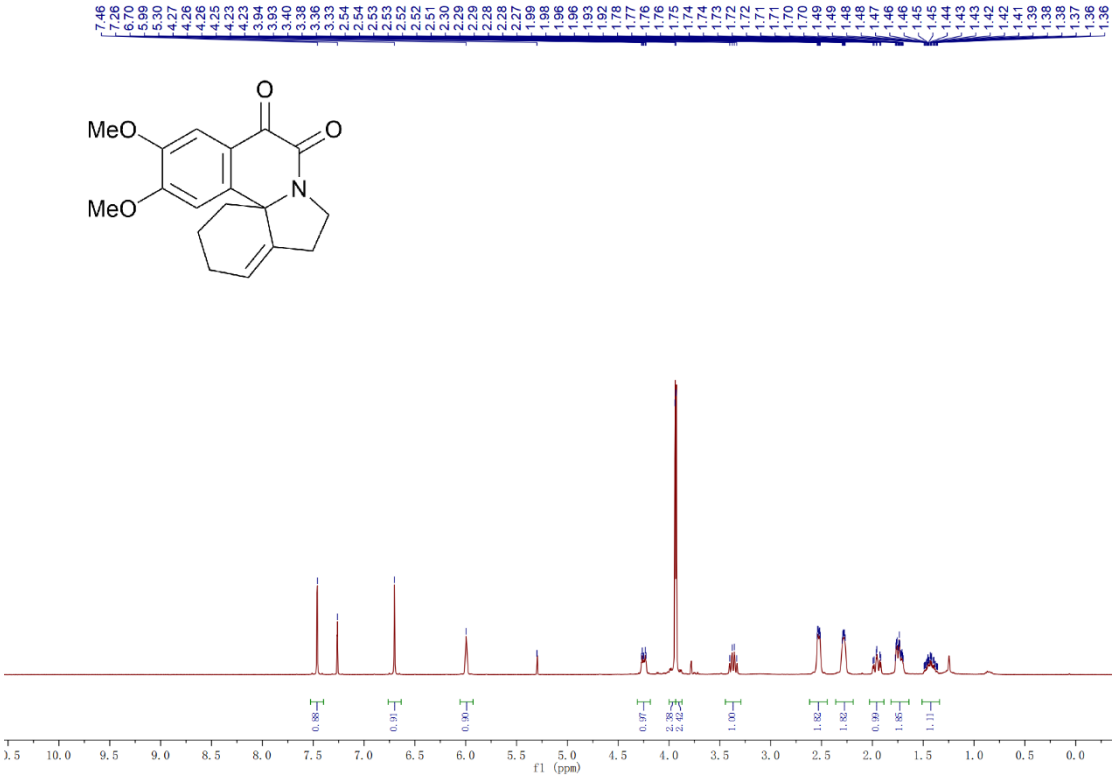
Compound **22**, ^{1}H NMR, 400 MHz, $CDCl_3$



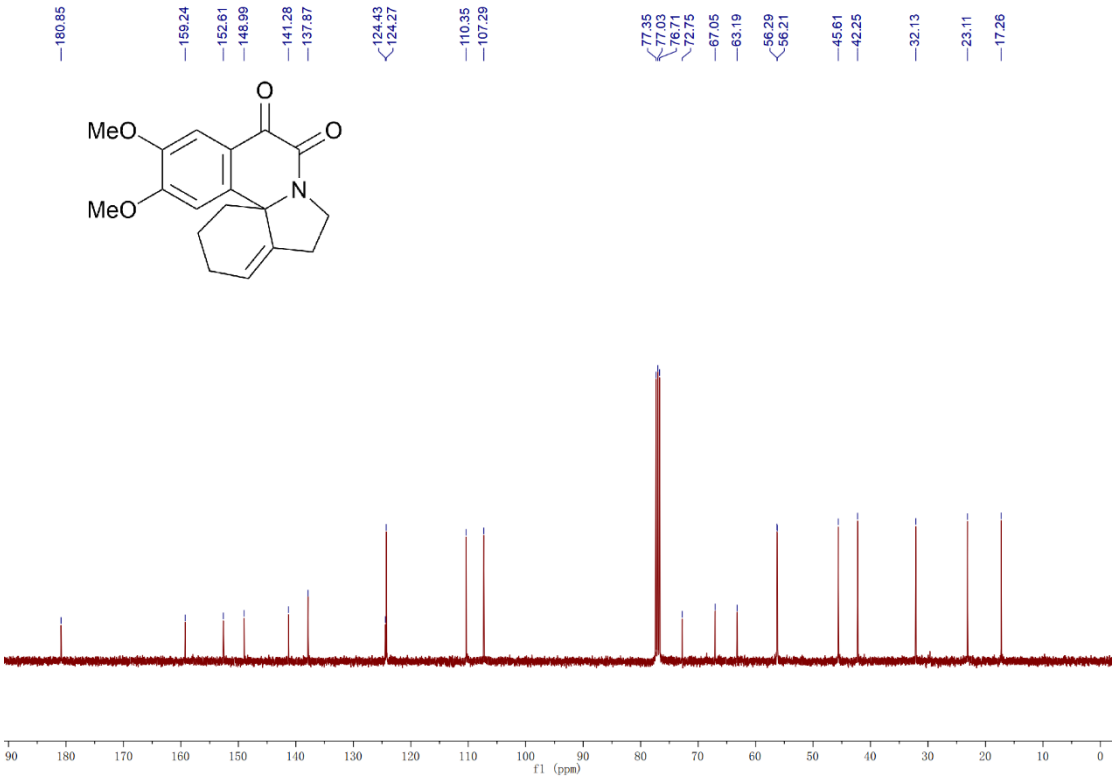
Compound **22**, ^{13}C NMR, 100 MHz, $CDCl_3$



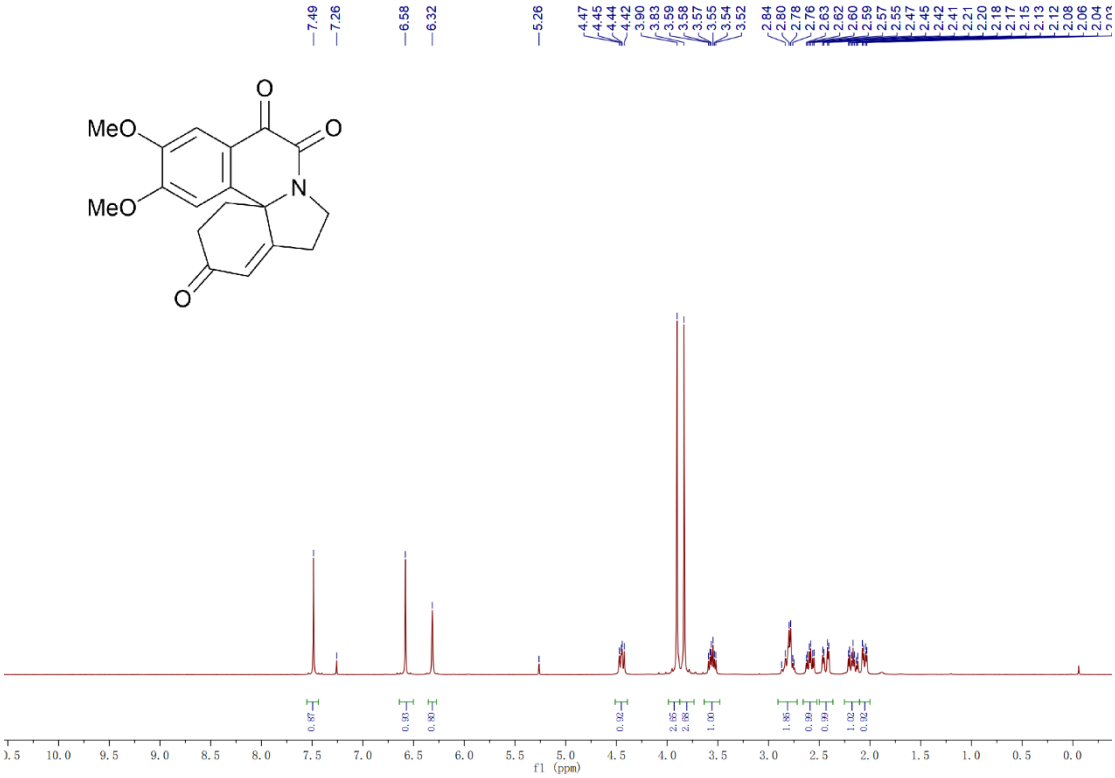
Compound **23**, ^{1}H NMR, 400 MHz, $CDCl_3$



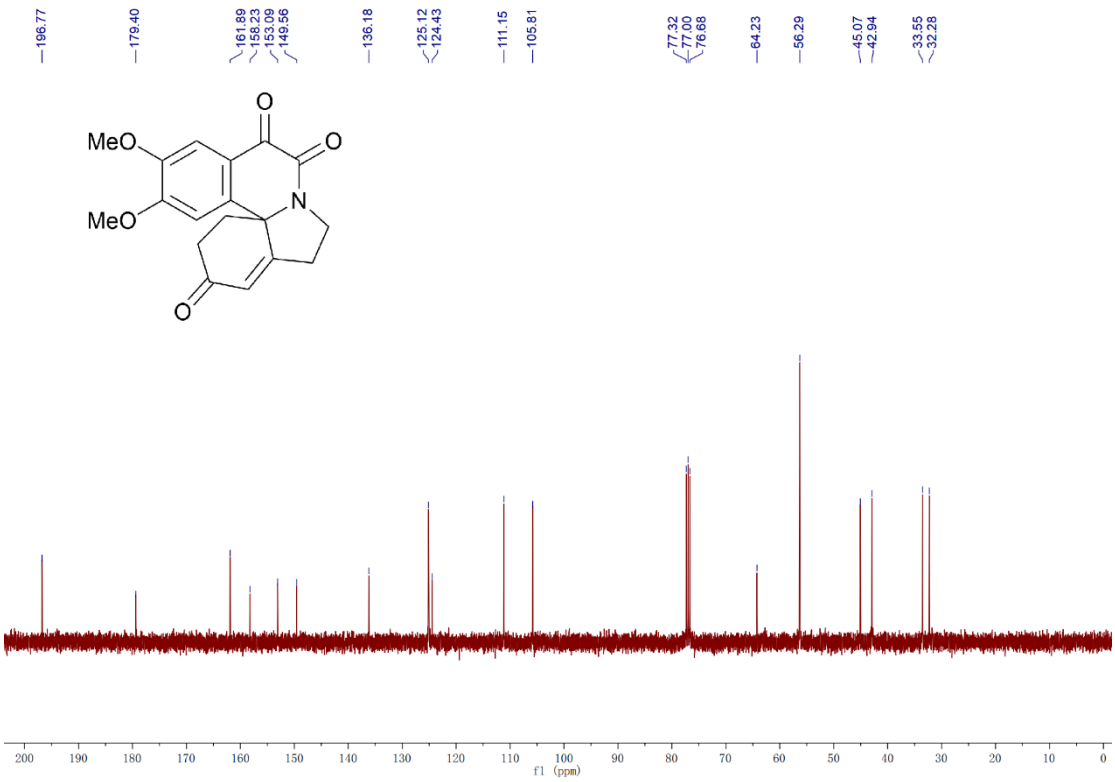
Compound **23**, ^{13}C NMR, 100 MHz, $CDCl_3$



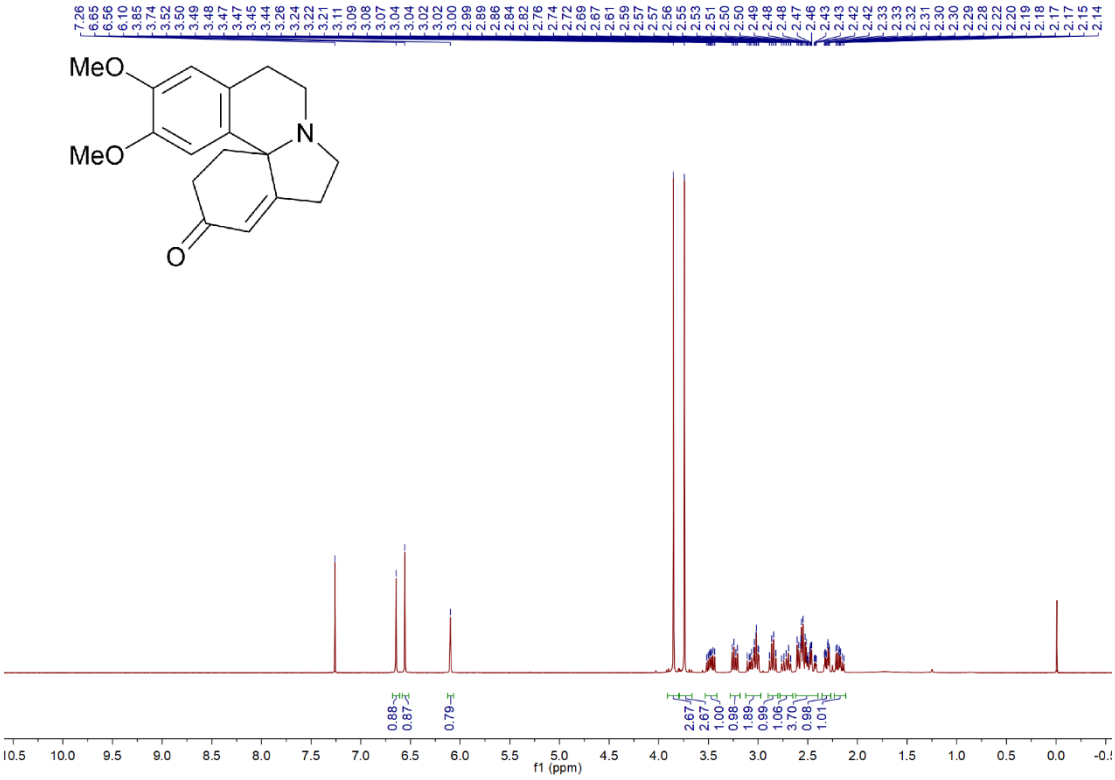
Compound **24**, ^{1}H NMR, 400 MHz, $CDCl_3$



Compound **24**, ^{13}C NMR, 100 MHz, $CDCl_3$



3-demethoxyerythratidinone (**3**), ^{1}H NMR, 400 MHz, $CDCl_3$



3-demethoxyerythratidinone (**3**), ^{13}C NMR, 100 MHz, $CDCl_3$