Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.


**Supporting Information**

# N-Heterocyclic carbene-catalyzed [4+2] cyclization of 2-bromo-2-enal with 3-alkylenyloxindoles: an efficient assembly of spirocarbocyclic oxindole

**Yuanwei Xie, Yonglei Que, Tuanjie Li, Ling Zhu, Chenxia Yu and Changsheng Yao***

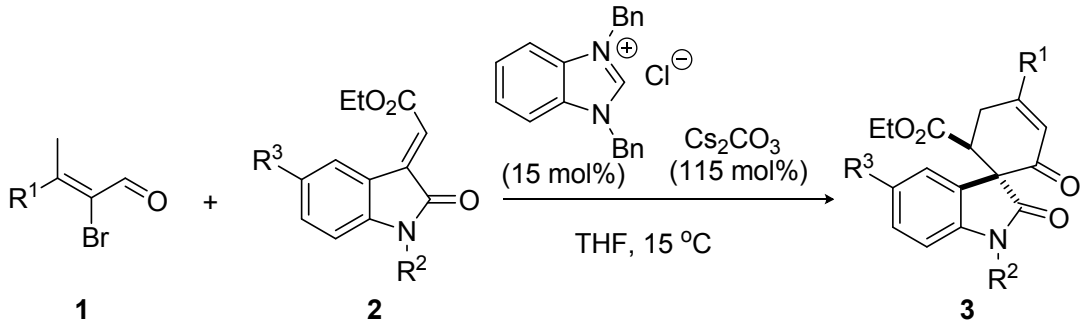
## 1. General methods

Common reagents and materials were purchased from commercial sources and purified by recrystallization or distillation. Melting points were determined in open capillaries and were uncorrected. IR spectra were taken on a FT-IR-Tensor 27 spectrometer in KBr pellets and reported in $cm^{-1}$. $^1H$ NMR spectra were measured on a Bruker DPX 400 MHz spectrometer in $CDCl_3$ (100 MHz, $^{13}C$ NMR) or DMSO-$d_6$ with chemical shift ($\delta$) given in ppm relative to TMS as internal standard. High-resolution mass spectra (HRMS) were obtained on a micrOTOF-QⅡ HRMS/MS instrument (Bruker) with the technique of electrospray ionization.

## 2. Abstract

A NHC-catalyzed [4+2] cyclization of 2-bromo-2-enal bearing γ-H with 3-alkylenyloxindoles under mild reaction conditions give spirocarbocyclic oxindoles containing one quaternary carbon in moderate to good yields with high diastereoselectivies. The easy availability of the starting materials, the concise assembly and the potential utilization value of the products make this strategy attractive in molecular biology and pharmacy.

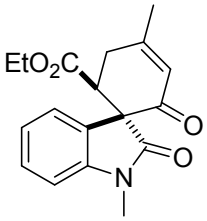
## 3. Experimental section



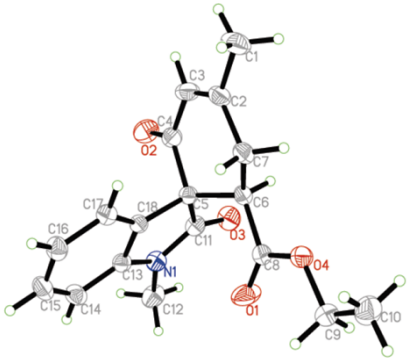

1 2 3

To an oven-dried 25 mL vial equipped with a stir bar, precatalyst **4C** (49 mg, 0.15 mmol) and anhydrous $Cs_2CO_3$ (374 mg) were added in. Freshly distilled THF (10 mL) was added to the mixture. The mixture was stirred at room temperature for 5 mins. Then 2-bromo-2-enal, 3-alkylenyloxindole 2 (1 mmol) was successively added. The mixture was stirred at 15 °C until completion (monitored by TLC). The solvent was removed under reduced pressure and the crude product was purified by chromatography on silica gel (mixtures of petroleum ether/ethyl acetate, 3:1, v/v).

## 4. X-ray structures of 3a

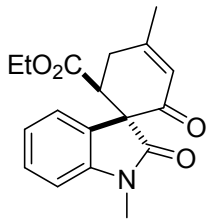



**3a**



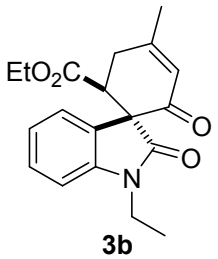

The crystal of compounds **3a** was prepared from the solution in petroleum ether/ethyl acetate/ ethyl alcohol with trace of acetone. Crystallographic data (excluding structure factors) for the structures in this paper have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication no. CCDC 1016169. Copies of the data can be obtained, free of charge, on application to CCDC, 12 Union Road, CambridgeCB21EZ, UK (fax: +44 1223 336033 or email: deposit@ccdc.cam.ac.uk).

## 5. Spectral data for all compounds



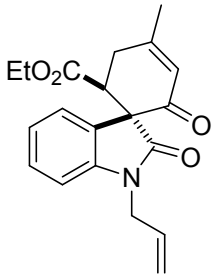

**3a**

White solid; M.P: 158-160 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.31 (d, $J$ = 7.6 Hz, 1H, ArH), 7.05 (d, $J$ = 7.2 Hz, 1H, ArH), 6.97 (t, $J$ = 7.2 Hz, 1H, ArH), 6.88 (d, $J$ = 7.6 Hz, 1H, ArH), 6.06 (s, 1H, CH=), 3.98 - 3.82 (m, 3H, $CH_2$, CH), 3.31 (s, 3H, $CH_3$), 3.09-2.99 (m, 1H, $CH_2$), 2.88 (dd, $J$ = 19.6, 6.0 Hz, 1H, $CH_2$), 2.17 (s, 3H, $CH_3$), 2.07 (s, 1H, $CH_3$), 0.97 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 192.1, 175.7, 170.0, 160.5, 145.1, 129.2, 126.6, 125.4, 123.1, 122.3, 108.7, 61.1, 60.2, 44.3, 30.4, 26.7, 24.4, 13.8; IR (potassium bromide) ($v$, cm$^{-1}$): 1731, 1713, 1660, 1606, 1493, 1470, 1377, 1251, 1209, 1130, 1025, 969, 777, 695, 541; HRMS (ESI) m/z: Calcd. for $[M+Na]^+C_{18}H_{19}NNaO_4$: 336.1212; found: 336.1212.



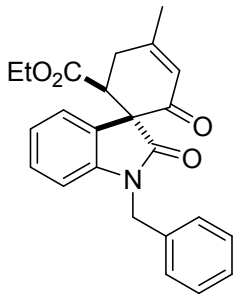

**3b**

White solid; M.P: 163.9-164.8 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.27 (t, $J$ = 7.6 Hz, 1H, ArH), 7.03 (d, $J$ = 7.6 Hz, 1H, ArH), 6.93 (t, $J$ = 7.6 Hz, 1H, ArH), 6.87 (d, $J$ = 8.0 Hz, 1H, ArH), 6.02 (s, 1H, CH=), 3.98 - 3.81 (m, 5H, $CH_2$, $CH_2$, CH), 3.03 (dd, $J$ = 19.6, 11.6 Hz, 1H, $CH_2$), 2.86 (dd, $J$ = 19.6, 6.4 Hz, 1H, $CH_2$), 2.14 (s, 3H, $CH_3$), 1.32 (t, $J$ = 7.2 Hz, 3H, $CH_3$ ), 0.93 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 192.0, 175.3, 170.0, 160.4, 144.2, 129.1, 126.9, 125.3, 123.2, 122.0, 108.8, 61.0, 60.1, 44.2, 35.1, 30.4, 24.4, 13.7, 12.4; IR (potassium bromide) ($v$, cm$^{-1}$): 2982, 1727, 1654, 1607, 1469, 1374, 1244, 987, 759, 550; HRMS (ESI) m/z: Calcd. for $[M+Na]^+$ $C_{19}H_{21}NNaO_4$: 350.1368 found: 350.1366.



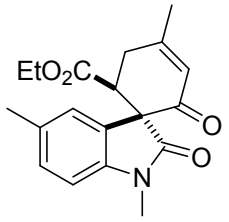

**3c**

White solid; M.P: 131.1-132.7 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.24 (t, $J$ = 7.6 Hz, 1H, ArH), 7.03 (d, $J$ = 7.6 Hz, 1H, ArH), 6.94 (t, $J$ = 7.6 Hz, 1H, ArH), 6.84 (d, $J$ = 8.0 Hz, 1H, ArH), 6.03 (s, 1H, CH=), 5.94 - 5.85 (m, 1H, CH=), 5.43 (d, $J$ = 17.2 Hz, 1H, $CH_2$=), 5.25 (d, $J$ = 10.4 Hz, 1H,$CH_2$=), 4.51 (dd, $J$ = 16.4, 4.4 Hz, 1H, $CH_2$), 4.31 (dd, $J$ = 16.8, 5.2 Hz, 1H, $CH_2$), 4.01 - 3.83 (m, 3H, $CH_2$, CH), 3.04 (dd, $J$ = 20.0, 11.6 Hz, 1H,$CH_2$), 2.88 (dd, $J$ = 19.6, 6.4 Hz, 1H, $CH_2$), 2.15 (s, 3H, $CH_3$), 0.95 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 191.9, 175.4, 170.0, 160.4, 144.3, 130.9, 129.1, 126.8, 125.3, 123.1, 122.2, 117.8, 109.6, 61.1, 60.3, 44.2, 42.7, 30.5, 24.4, 13.8; IR (potassium bromide) ($v$, cm$^{-1}$): 2980, 1726, 1655, 1364, 1245, 1000, 942, 761, 582; HRMS (ESI) m/z: Calcd. for $[M+Na]^+$ $C_{20}H_{21}NNaO_4$: 362.1368 found: 362.1352.



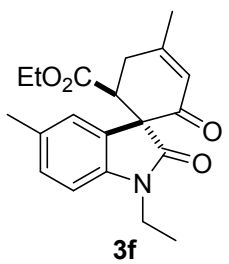
**3d**

White solid; M.P: 118.7-120.0 $^{o}$C; $^{1}$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.50 (d, $J$ = 7.6 Hz, 2H, ArH), 7.36 (t, $J$ = 7.6 Hz, 2H, ArH), 7.28 (t, $J$ = 6.0 Hz, 1H, ArH), 7.16 (t, $J$ = 7.6 Hz, 1H, ArH ), 7.06 (d, $J$ = 7.6 Hz, 1H, ArH), 6.93 (t, $J$ = 7.6 Hz, 1H, ArH), 6.71 (d, $J$ = 8.0 Hz, 1H, ArH), 6.08 (s, 1H, CH=), 5.27 (d, $J$ = 15.6 Hz, 1H, $CH_2$), 4.78 (d, $J$ = 15.6 Hz, 1H, $CH_2$), 4.02 - 3.92 (m, 2H, $CH_2$), 3.87 - 3.79 (m, 1H, CH), 3.09 (dd, $J$ = 19.6, 11.6 Hz, 1H, $CH_2$), 2.92 (dd, $J$ = 19.6, 6.0 Hz, 1H, $CH_2$), 2.18 (s, 3H, $CH_3$), 0.91 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 192.0, 175.9, 170.1, 160.6, 144.2, 135.5, 129.1, 128.7, 127.5, 127.4, 126.9, 125.3, 123.1, 122.3, 109.8, 61.1, 60.3, 44.2, 44.1, 30.5, 24.4, 13.7; IR (potassium bromide) ($\nu$, cm$^{-1}$): 2938, 1731, 1655, 1486, 1346, 1240, 1184, 747, 705, 572; HRMS (ESI) m/z: Calcd. for [M-H]$^{-}$ $C_{24}H_{22}NO_4$: 388.1549 found: 388.1577.



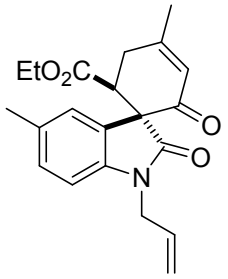
**3e**

White solid; M.P: 171.3-172.5$^{o}$C; $^{1}$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.07 (d, $J$ = 8.0 Hz, 1H, ArH), 6.81 (s, 1H, ArH), 6.74 (d, $J$ = 8.0 Hz, 1H, ArH), 6.03 (s, 1H, CH=), 3.98 - 3.81 (m, 3H, $CH_2$,CH), 3.26 (s, 3H, $CH_3$), 3.03 (dd, $J$ = 20.0, 12.4 Hz, 1H, $CH_2$), 2.84 (dd, $J$ = 20.0, 6.4 Hz, 1H, $CH_2$), 2.27 (s, 3H, $CH_3$), 2.16 (s, 3H, $CH_3$), 0.95 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 192.1, 175.6, 170.1, 160.5, 142.7, 131.7, 129.5, 126.7, 125.4, 123.9, 108.4, 61.0, 60.3, 44.3, 30.4, 26.6, 24.4, 21.2, 13.8; IR (potassium bromide) ($\nu$, cm$^{-1}$): 2920, 1730, 1662, 1499, 1368, 1277, 1224, 1039, 832, 557; HRMS (ESI) m/z: Calcd. for [M-H]$^{-}$ $C_{19}H_{2O}NO_4$: 326.1392 found: 326.1431.



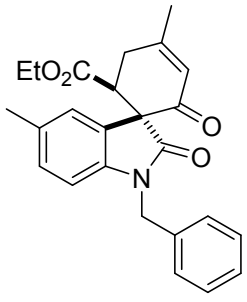
**3f**

White solid; M.P: 101-104 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.08 (d, $J$ = 7.6 Hz, 1H, ArH), 6.83 (s, 1H, ArH), 6.78 (d, $J$ = 8.0 Hz, 1H, ArH), 6.04 (s, 1H, CH=), 4.02 - 3.80 (m, 5H, $CH_2$, $CH_2$, CH), 3.05 (dd, $J$ = 19.6, 11.6 Hz, 1H, $CH_2$), 2.86 (dd, $J$ = 19.6, 6.0 Hz, 1H, $CH_2$), 2.28 (s, 3H, $CH_3$), 2.17 (s, 3H, $CH_3$), 1.32 (t, $J$ = 7.2 Hz, 3H, $CH_3$), 0.96 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 192.2, 175.2, 170.1, 160.3, 141.8, 131.4, 129.4, 127.0, 125.4, 124.0, 108.5, 61.0, 60.2, 44.2, 35.1, 30.4, 24.4, 21.1, 13.8, 12.4; IR (potassium bromide) ($v$, cm$^{-1}$): 2978, 1739, 1719, 1661, 1496, 1368, 1187, 824, 641, 595; HRMS (ESI) m/z: Calcd. for $[M+H]^+$ $C_{20}H_{24}NO_4$: 342.1705 found: 342.1684.




**3g**

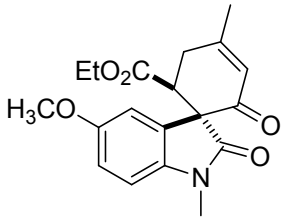
White solid; M.P: 123.9-124.4 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.04 (d, $J$ = 7.6 Hz, 1H, ArH), 6.82 (s, 1H, ArH), 6.73 (d, $J$ = 8.0 Hz, 1H, ArH), 6.03 (s, 1H, CH=), 5.93-5.83 (m, 1H, CH=), 5.42 (d, $J$ = 17.2 Hz, 1H, CH=), 5.24 (d, $J$ = 10.4 Hz, 1H, CH=), 4.49 (dd, $J$ = 16.8, 4.0 Hz, 1H, $CH_2$), 4.28 (dd, $J$ = 16.8, 4.0 Hz, 1H, $CH_2$), 4.01 - 3.84 (m, 3H,$CH_2$), 3.04 (dd, $J$ = 19.6, 11.6 Hz, 1H, $CH_2$), 2.87 (dd, $J$ = 19.6, 6.4 Hz, 1H, $CH_2$), 2.26 (s, 3H, $CH_3$), 2.17 (s, 3H, $CH_3$), 0.96 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 192.0, 175.4, 170.1, 160.4, 141.8, 131.6, 131.0, 129.3, 126.9, 125.3, 123.9, 117.6, 109.3, 61.1, 60.3, 44.2, 42.7, 30.4, 24.4, 21.1, 13.8; IR (potassium bromide) ($v$, cm$^{-1}$): 1735, 1720, 1662, 1495, 1363, 1212, 1187, 931, 826, 633; HRMS (ESI) m/z: Calcd. for $[M+Na]^+$ $C_{21}H_{23}NNaO_4$: 376.1525 found: 376.1545.




**3h**

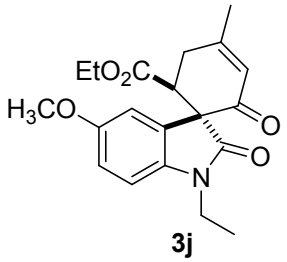
White solid; M.P: 158.9-159.3 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.49 (d, $J$ = 7.6 Hz, 2H, ArH), 7.35 (t, $J$ = 7.6 Hz, 2H, ArH), 7.29 - 7.25 (m, 1H, ArH), 6.96 (d, $J$ = 8.0 Hz, 1H, ArH ), 6.85 (s, 1H, ArH), 6.59 (d, $J$ = 8.0 Hz, 1H, ArH ), 6.07 (s, 1H, CH=), 5.26 (d, $J$ = 16.0 Hz, 1H, $CH_2$), 4.74 (d, $J$ = 16.0 Hz, 1H, $CH_2$), 4.01 - 3.93(m, 2H, $CH_2$), 3.88 - 3.80 (m, 1H, CH), 3.09 (dd, $J$ = 19.6, 11.6 Hz, 1H, $CH_2$), 2.91 (dd, $J$ = 19.6, 6.0 Hz, 1H, $CH_2$), 2.25 (s, 3H, $CH_3$), 2.20 (s, 3H, $CH_3$), 0.92 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 192.1, 175.8, 170.2, 160.6, 141.71, 135.6, 131.7, 129.4,

128.7, 127.4, 127.4, 126.9, 125.3, 123.9, 109.5, 61.1, 60.4, 44.2, 44.1, 30.5, 24.5, 21.1, 13.8; IR (potassium bromide) ($\nu$, $cm^{-1}$): 1726, 1661, 1368, 1215, 1187, 1027, 824, 724, 583; HRMS (ESI) m/z: Calcd. for $[M+Na]^+$ $C_{25}H_{25}NNaO_4$: 426.1681 found: 426.1680.



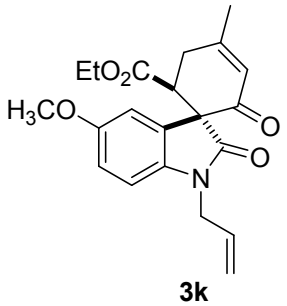

**3i**

White solid; M.P: 139.2-140.2 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 6.81 - 6.75 (m, 2H, ArH), 6.65 (s, 1H, ArH), 6.03 (s, 1H, CH=), 4.00 - 3.83 (m, 3H, $CH_2$, CH), 3.75 (s, 3H, $OCH_3$), 3.26 (s, 3H, $CH_3$), 3.00 (dd, $J$ = 19.6, 11.6 Hz, 1H, $CH_2$), 2.86 (dd, $J$ = 19.7, 6.0 Hz, 1H, $CH_2$), 2.14 (s, 3H, $CH_3$), 0.98 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 191.9, 175.3, 170.0, 160.5, 155.5, 138.7, 127.9, 125.3, 112.0, 108.7, 61.1, 60.5, 55.8, 44.2, 30.3, 26.7, 24.4, 13.8; IR (potassium bromide) ($\nu$, $cm^{-1}$): 2978, 1740, 1715, 1655, 1498, 1363, 1252, 1034, 808, 589; HRMS (ESI) m/z: Calcd. for $[M+Na]^+$ $C_{19}H_{21}NNaO_5$: 366.1317 found: 366.1302.




**3j**

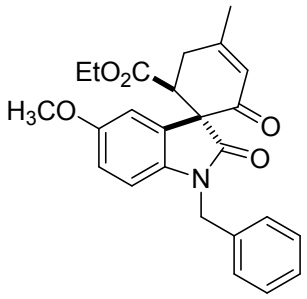
White solid; M.P: 114.2-115.4 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 6.80 (s, 2H, ArH), 6.67 (s, 1H, ArH), 6.03 (s, 1H, CH=), 4.03 - 3.95 (m, 1H, CH), 3.94 - 3.88 (m, 2H, $CH_2$), 3.85 - 3.78 (m, 2H, $CH_2$), 3.75 (s, 3H, $OCH_3$), 3.01 (dd, $J$ = 19.6, 11.6 Hz, 1H, $CH_2$), 2.87 (dd, $J$ = 19.6, 6.4 Hz, 1H, $CH_2$), 2.15 (s, 3H, $CH_3$), 1.32 (t, $J$ = 7.2 Hz, 3H, $CH_3$), 0.99 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 191.9, 174.8, 170.0, 160.5, 155.2, 137.7, 128.2, 125.3, 112.1, 111.8, 108.8, 61.1, 60.3, 55.8, 44.1, 35.2, 30.4, 24.4, 13.8, 12.4; IR (potassium bromide) ($\nu$, $cm^{-1}$): 2975, 1737, 1655, 1495, 1353, 1176, 1037, 802, 762, 590; HRMS (ESI) m/z: Calcd. for $[M+Na]^+$ $C_{20}H_{23}NNaO_5$: 380.1474 found: 380.1474.




**3k**

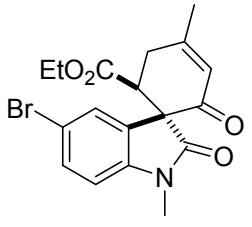
White solid; M.P: 101.7-102.2 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 6.77 (s, 2H, ArH), 6.67 (s, 1H, ArH), 6.04 (s, 1H, CH=), 5.94 -5.84 (m, 1H, CH=), 5.44 (d, $J$ = 17.6 Hz,

1H, CH=), 5.26 (d, $J$ = 10.3 Hz, 1H, $CH_2$=), 4.50 (dd, $J$ = 16.4, 3.2 Hz, 1H, $CH_2$), 4.31 (dd, $J$ = 16.4, 4.0 Hz, 1H, $CH_2$), 4.05 - 3.87 (m, 3H, $CH_2$, CH), 3.75 (t, 3H, $OCH_3$), 3.02 (dd, $J$ = 19.6, 11.6 Hz, 1H, $CH_2$), 2.89 (dd, $J$ = 19.6, 6.4 Hz, 1H, $CH_2$), 2.15 (s, 3H, $CH_3$), 1.00 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 191.8, 175.1, 170.0, 160.6, 155.3, 137.7, 131.0, 128.1, 125.2, 117.7, 111.9, 111.8, 109.6, 61.1, 60.4, 55.8, 44.1, 42.8, 30.4, 24.4, 13.8; IR (potassium bromide) ($v$, cm$^{-1}$): 2987, 1716, 1651, 1488, 1361, 1185, 930, 827, 742, 592; HRMS (ESI) m/z: Calcd. for $[M+Na]^+$ $C_{21}H_{23}NNaO_5$: 392.1474 found: 392.1446.



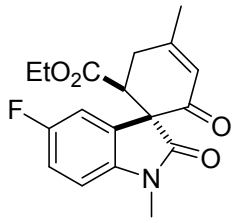

**3l**

White solid; M.P: 125.3-126.1 $^o$C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.49 (d, $J$ = 7.6 Hz, 2H, ArH), 7.36 (t, $J$ = 7.6 Hz, 2H, ArH), 7.29 - 7.26 (m, 1H, ArH), 6.68 - 6.65 (m, 2H, ArH), 6.59 (d, $J$ = 8.0 Hz, 1H, ArH ), 6.07 (s, 1H, CH=), 5.26 (d, $J$ = 15.6 Hz, 1H, $CH_2$), 4.74 (d, $J$ = 15.8 Hz, 1H, $CH_2$), 4.05 - 3.94 (m, 2H, $CH_2$), 3.91 - 3.82 (m, 1H, CH), 3.71 (s, 3H, $OCH_3$), 3.05 (dd, $J$ = 19.6, 11.6 Hz, 1H, $CH_2$), 2.92 (dd, $J$ = 19.6, 6.4 Hz, 1H, $CH_2$), 2.18 (s, 3H, $CH_3$), 0.96 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 191.8, 175.5, 170.0, 160.6, 155.4, 137.6, 135.5, 128.7, 128.1, 127.5, 127.4, 125.21, 112.0, 111.8, 109.8, 61.1, 60.5, 55.7, 44.3, 44.0, 30.5, 24.4, 13.8.; IR (potassium bromide) ($v$, cm$^{-1}$): 1719, 1657, 1495, 1436, 1224, 1194, 1023, 858, 780, 627; HRMS (ESI) m/z: Calcd. for $[M+Na]^+$ $C_{25}H_{25}NNaO_5$: 442.1630 found: 442.1613.



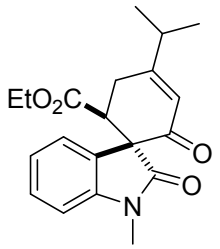

**3m**

White solid; M.P: 180.5-181.8 $^o$C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.47 (dd, $J$ = 8.4, 2.0 Hz, 1H, ArH), 7.10 (d, $J$ = 2.0 Hz, 1H, ArH), 6.77 (d, $J$ = 8.4 Hz, 1H, ArH), 4.74 - 4.67 (m, 1H, CH), 4.00 -3.90 (m, 2H, $CH_2$), 3.42 (dd, $J$ = 11.2, 7.2 Hz, 1H, CH), 3.26 (s, 3H, $CH_3$), 2.83 - 2.68 (m, 2H, $CH_2$), 2.07 (s, 3H, $CH_3$), 1.07 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 177.1, 169.9, 144.7, 133.9, 131.8, 128.2, 127.7, 122.2, 115.0, 109.5, 73.9, 61.1, 54.6, 43.4, 32.6, 26.7, 23.2, 13.9; IR (potassium bromide) ($v$, cm$^{-1}$): 1733, 1694, 1605, 1488, 1367, 1181, 1085, 1026, 821, 618; HRMS (ESI) m/z: Calcd. for $[M-H]^-$ $C_{18}H_{17}BrNO_5$: 390.0341 found: 390.0368.




**3n**

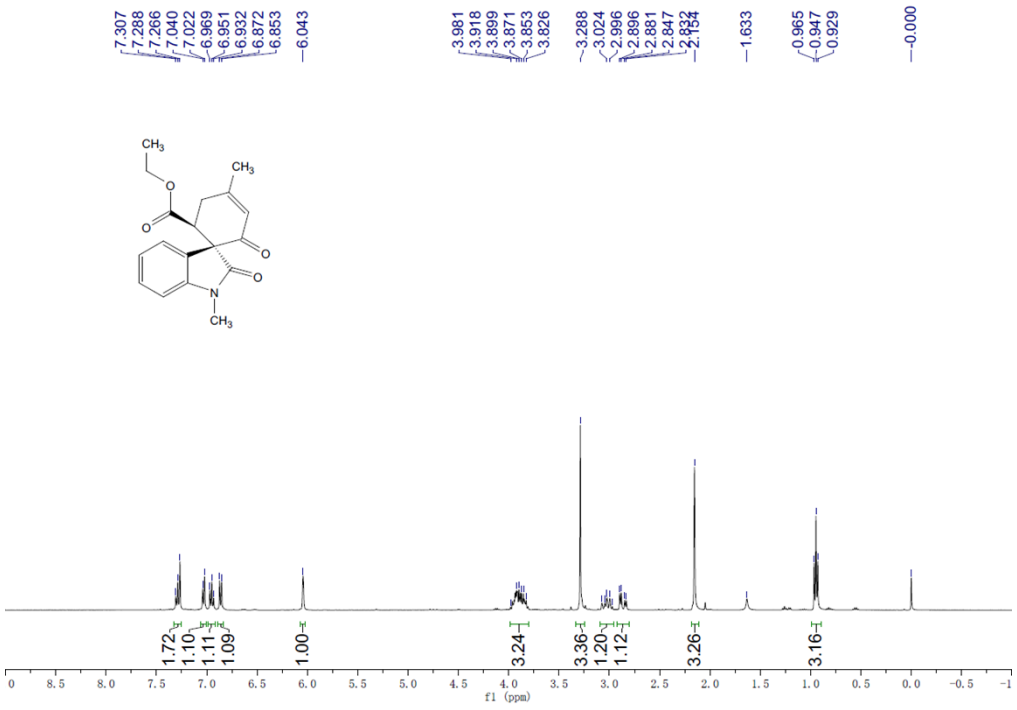
White solid; M.P: 152.7-153.3 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.04 - 6.99 (m, 1H, ArH), 6.82 - 6.78 (m, 2H, ArH), 6.06 (s, 1H, CH=), 4.01 - 3.88 (m, 3H, $CH_2$, CH), 3.29 (s, 3H, $CH_3$), 3.03 - 2.87 (m, 2H, $CH_2$), 2.18 (s, 3H, $CH_3$), 1.01 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 191.4, 175.3, 169.8, 160.7, 158.6 ($J_{CF}$ = 240.0 Hz), 141.2 ($J_{CF}$ = 2.0 Hz), 127.8 ($J_{CF}$ = 8.0 Hz), 125.3, 115.3 ($J_{CF}$ = 23.3 Hz), 111.5 ($J_{CF}$ = 25.0 Hz), 109.0 ($J_{CF}$ = 8.0 Hz), 61.2, 60.4 ($J_{CF}$ = 1.6 Hz), 44.2, 30.3, 26.8, 24.4, 13.8; IR (potassium bromide) ($v$, cm$^{-1}$): 1726, 1664, 1630, 1495, 1335, 1174, 1122, 1058, 1026, 818; HRMS (ESI) m/z: Calcd. for $[M+H]^+$ $C_{18}H_{19}FNO_5$: 332.1298 found: 332.1287.



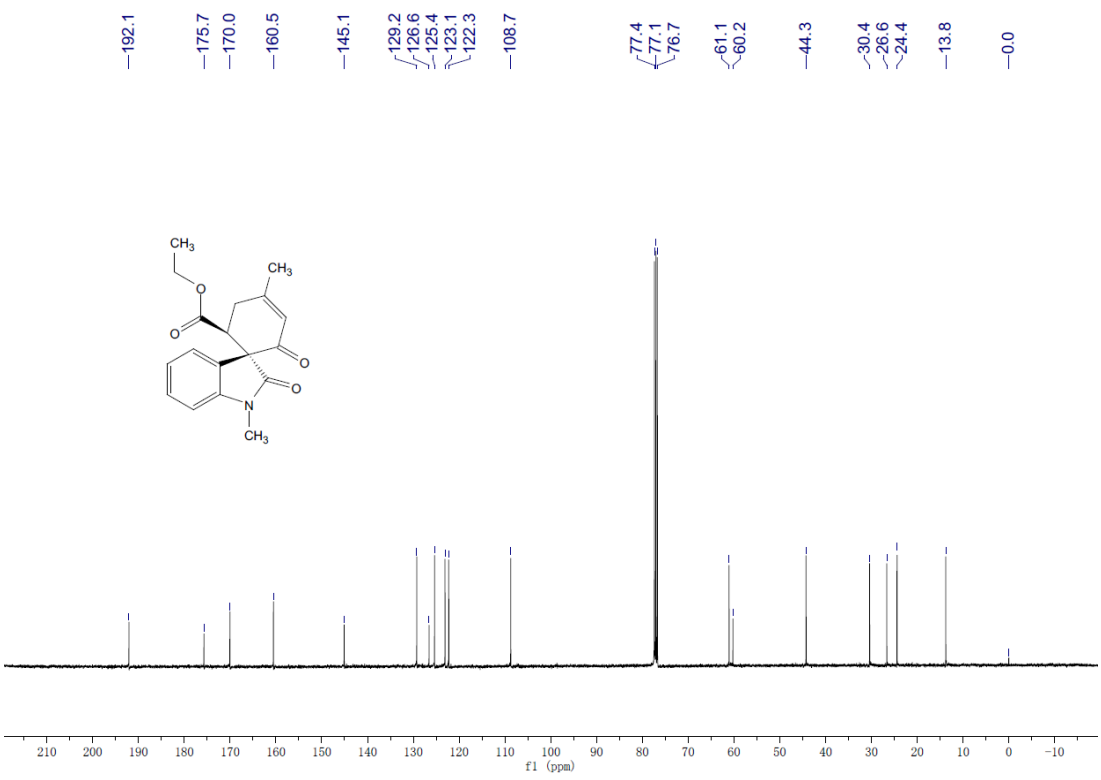

**3o**

White solid; M.P: 141.2-142.6 °C; $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ 7.31-7.27 (m, 1H, ArH), 7.01 (dd, $J$ = 7.6, 1.2 Hz, 1H, ArH), 6.95 (td, $J$ = 7.2, 0.8 Hz, 1H, ArH), 6.86 (d, $J$ = 7.6 Hz, 1H, ArH), 6.05 (t, $J$ = 1.2 Hz, 1H, CH=), 4.00 - 3.81 (m, 3H, $CH_2$, CH), 3.29 (s, 3H, $NCH_3$), 3.08-2.99 (m, 1H, $CH_2$) 2.90 (dd, $J$ = 19.2, 6.0 Hz, 1H, $CH_2$), 2.64-2.57 (m, 1H, CH), 1.25 (t, $J$ = 6.6 Hz, 6H, $CH_3$), 0.95 (t, $J$ = 7.2 Hz, 3H, $CH_3$); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ 192.7, 175.7, 170.2, 169.7, 145.1, 129.2, 126.6, 123.0, 122.6, 122.3, 108.7, 61.1, 60.7, 44.5, 35.9, 27.2, 26.6, 21.0, 20.6, 13.8; IR (potassium bromide) ($v$, cm$^{-1}$): 2963, 1724, 1715, 1655, 1606, 1493, 1346, 1249, 1189, 1093, 759; HRMS (ESI) m/z: Calcd. for $[M+Na]^+$ $C_{20}H_{23}NNaO_4$: 364.1525 found: 364.1545.

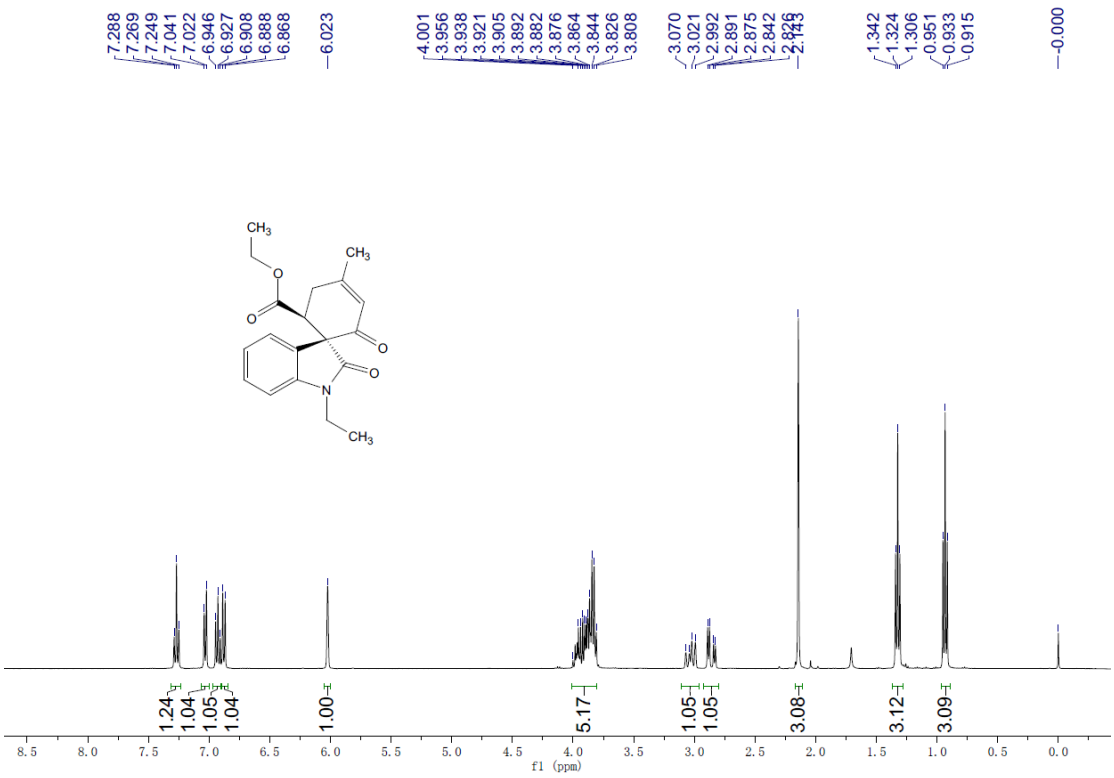
**4. Spectures**



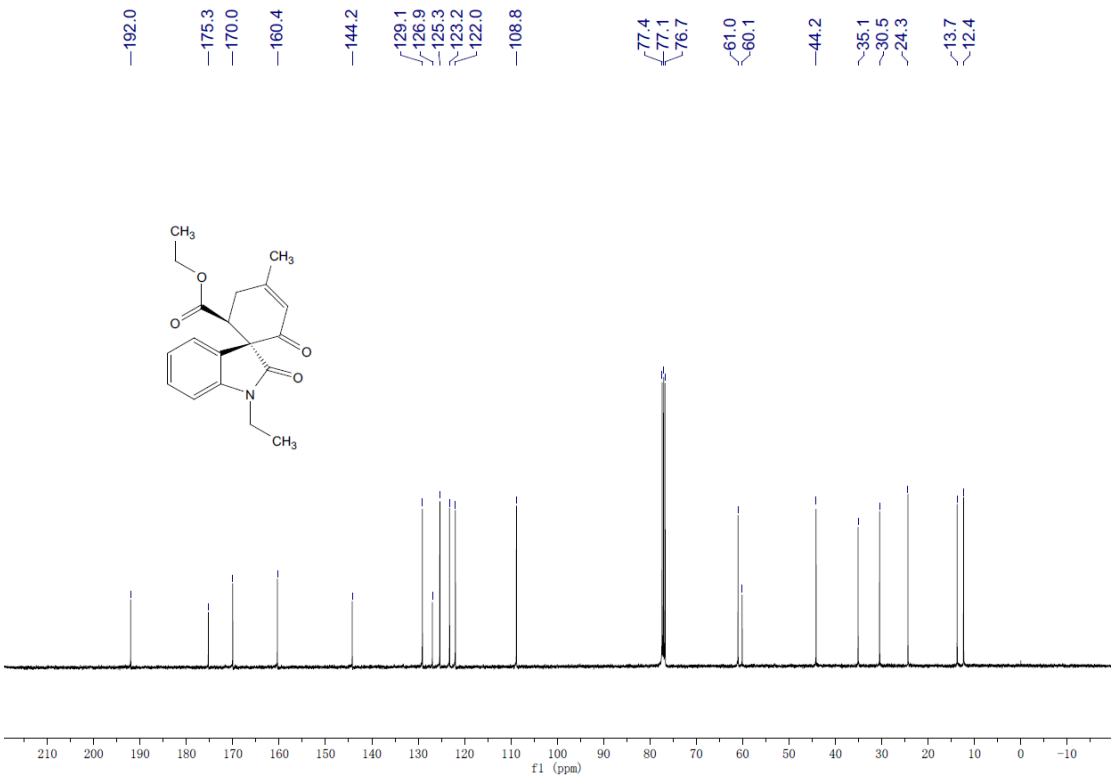

**$^{1}$H NMR Spectrum of Compound (3a)**



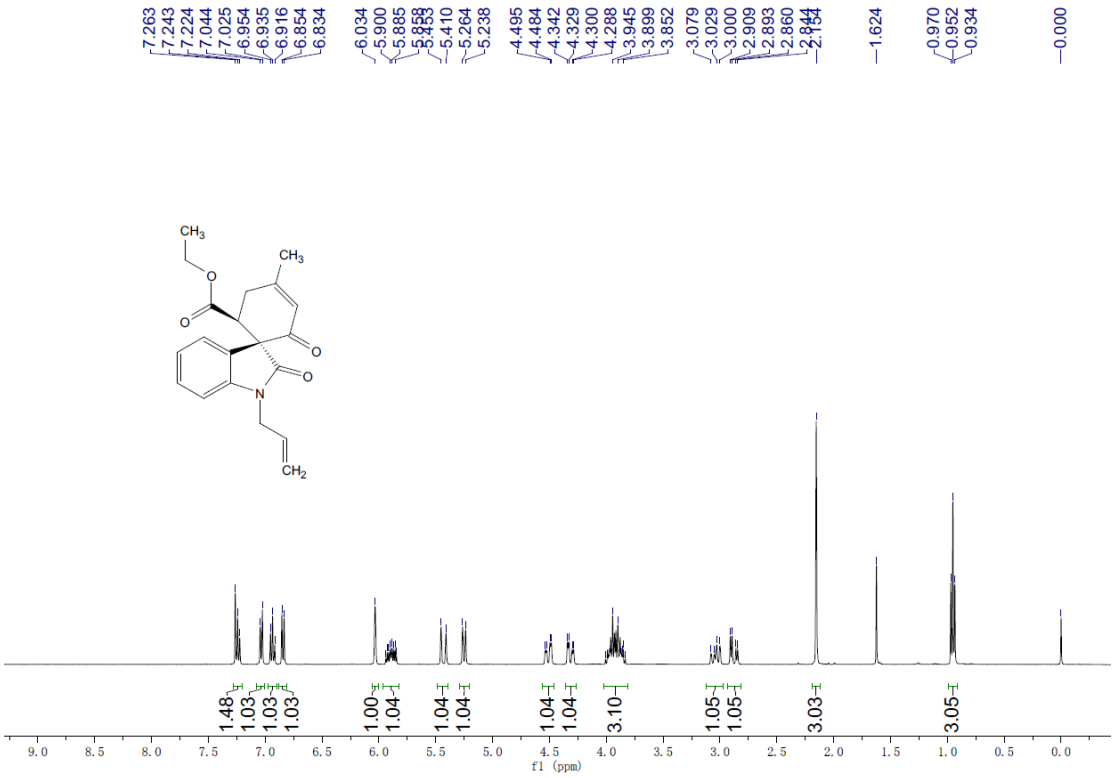

**$^{13}$C NMR Spectrum of Compound (3a)**



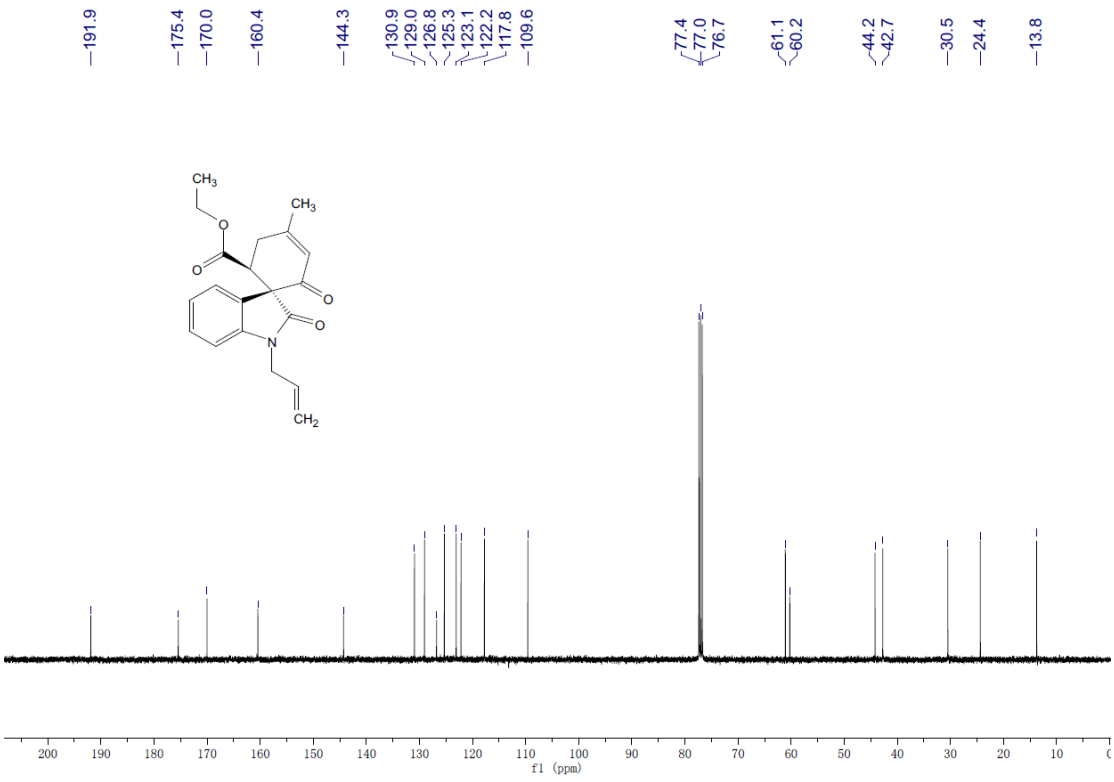

**$^{1}$H NMR Spectrum of Compound (3b)**



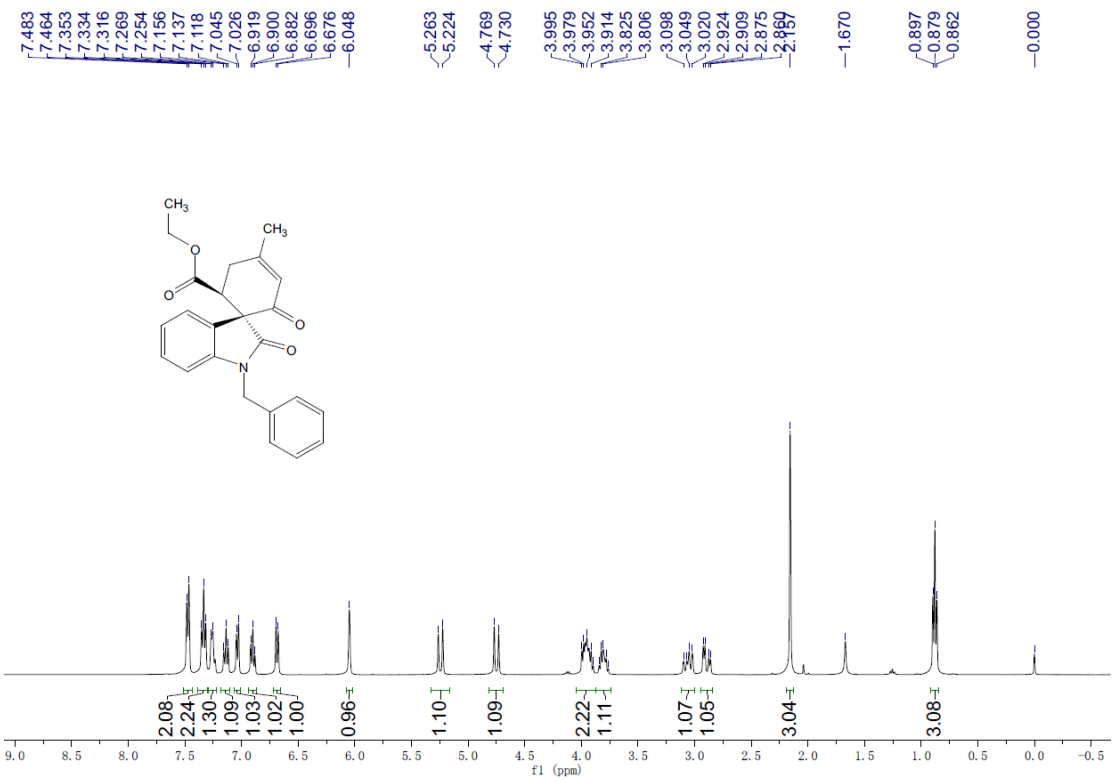

**$^{13}$C NMR Spectrum of Compound (3b)**



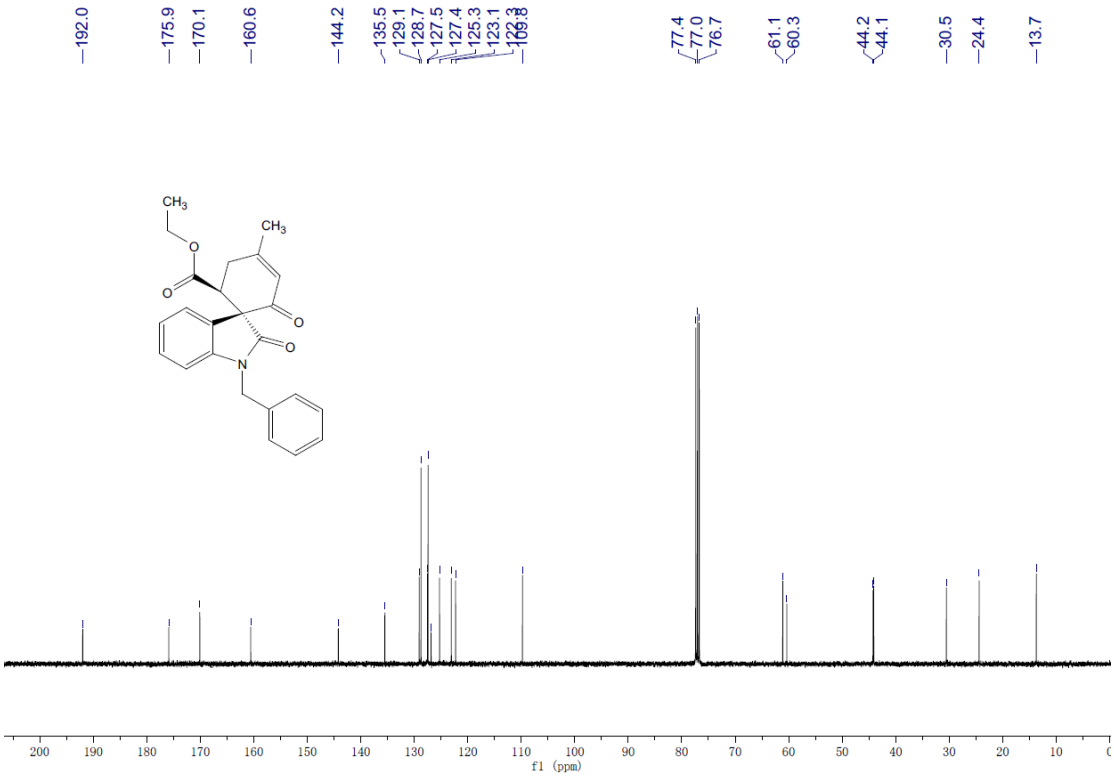

**$^{1}$H NMR Spectrum of Compound (3c)**



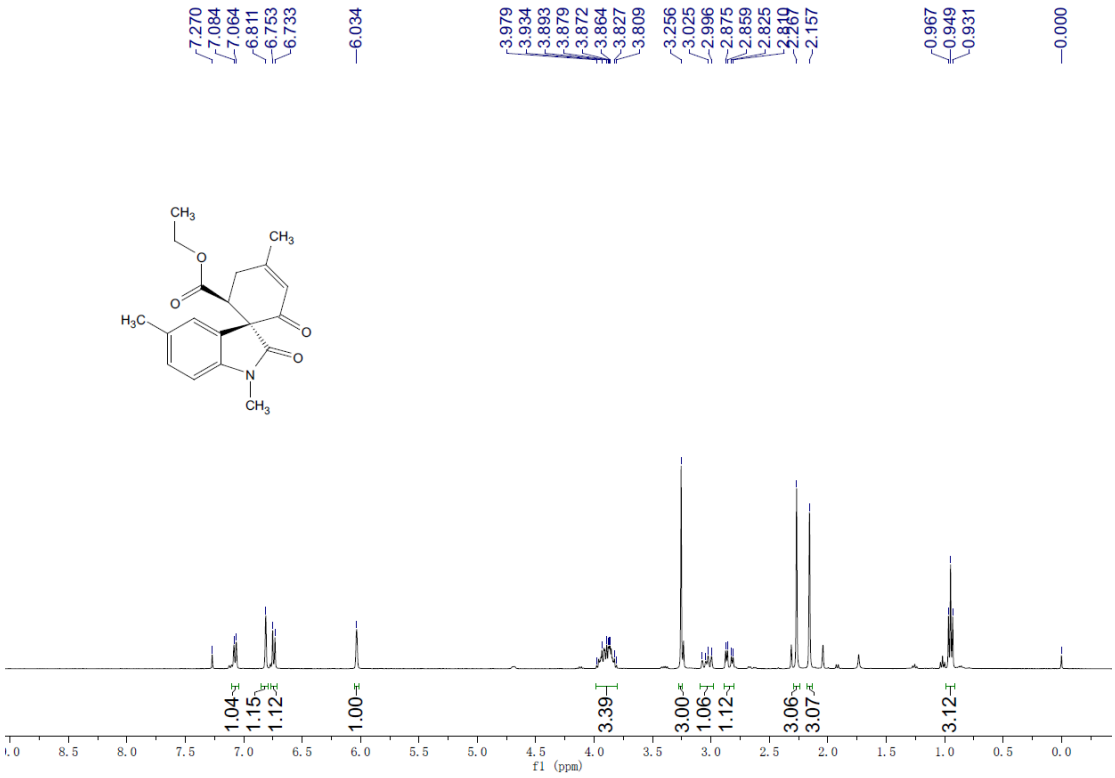

**$^{13}$C NMR Spectrum of Compound (3c)**



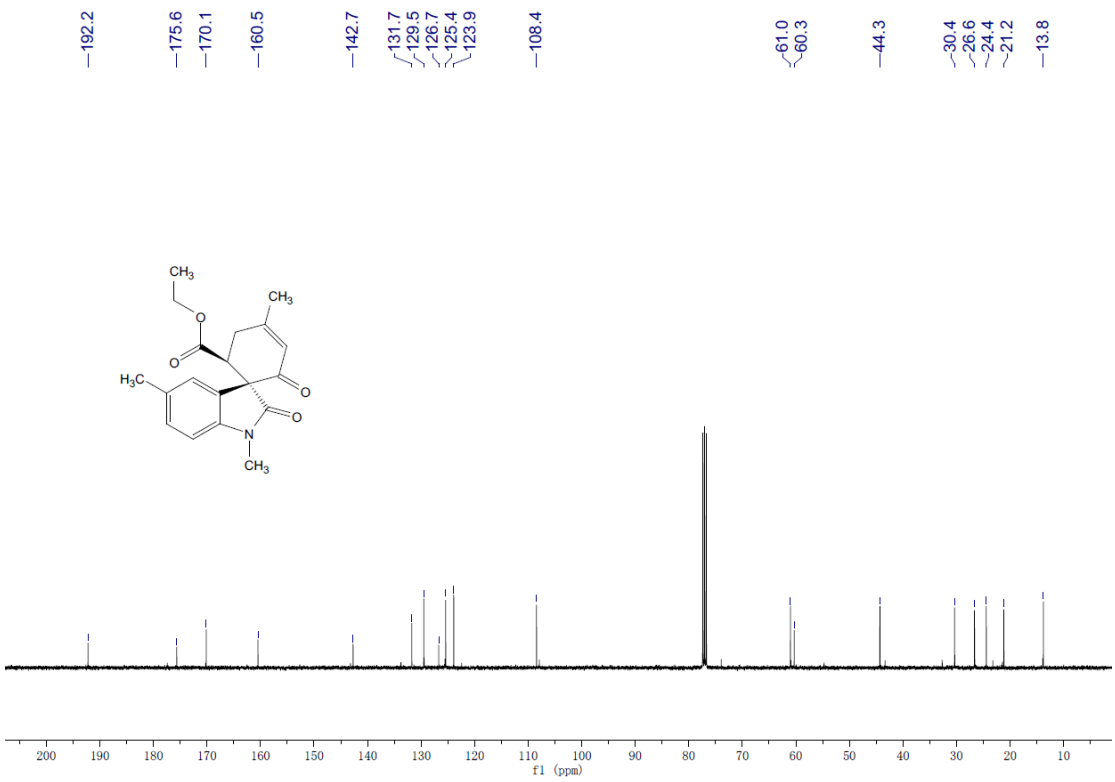

**$^{1}$H NMR Spectrum of Compound (3d)**



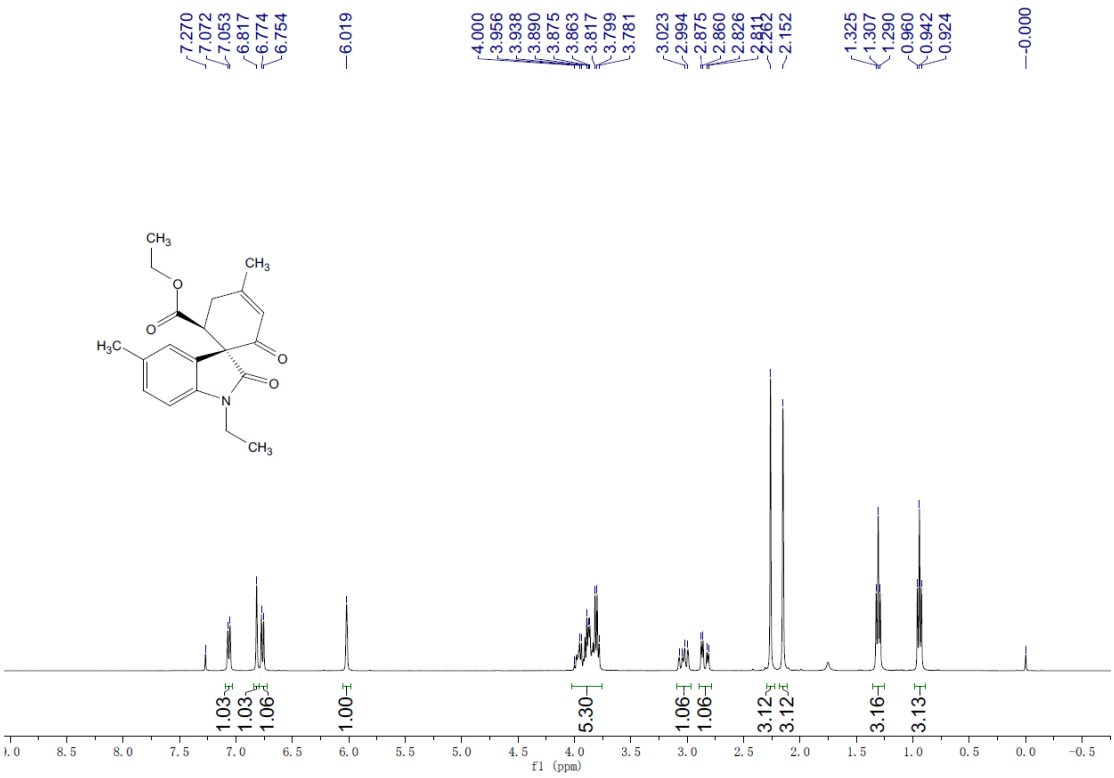

**$^{13}$C NMR Spectrum of Compound (3d)**



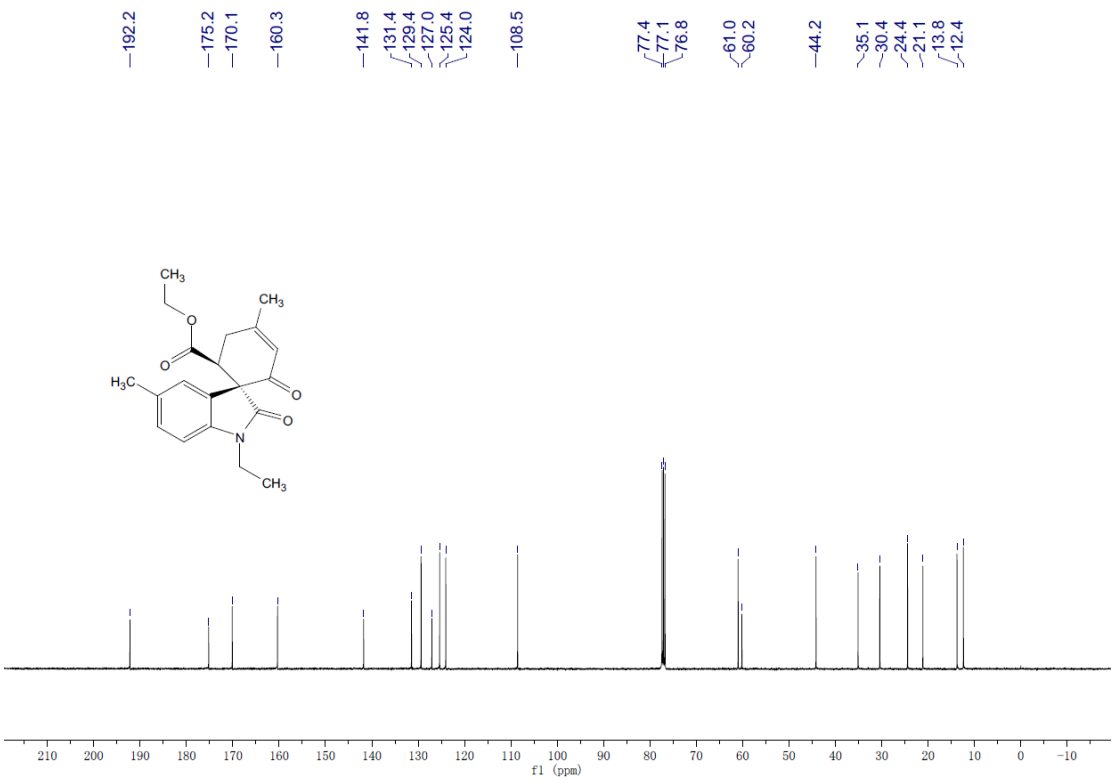

**$^{1}$H NMR Spectrum of Compound (3e)**



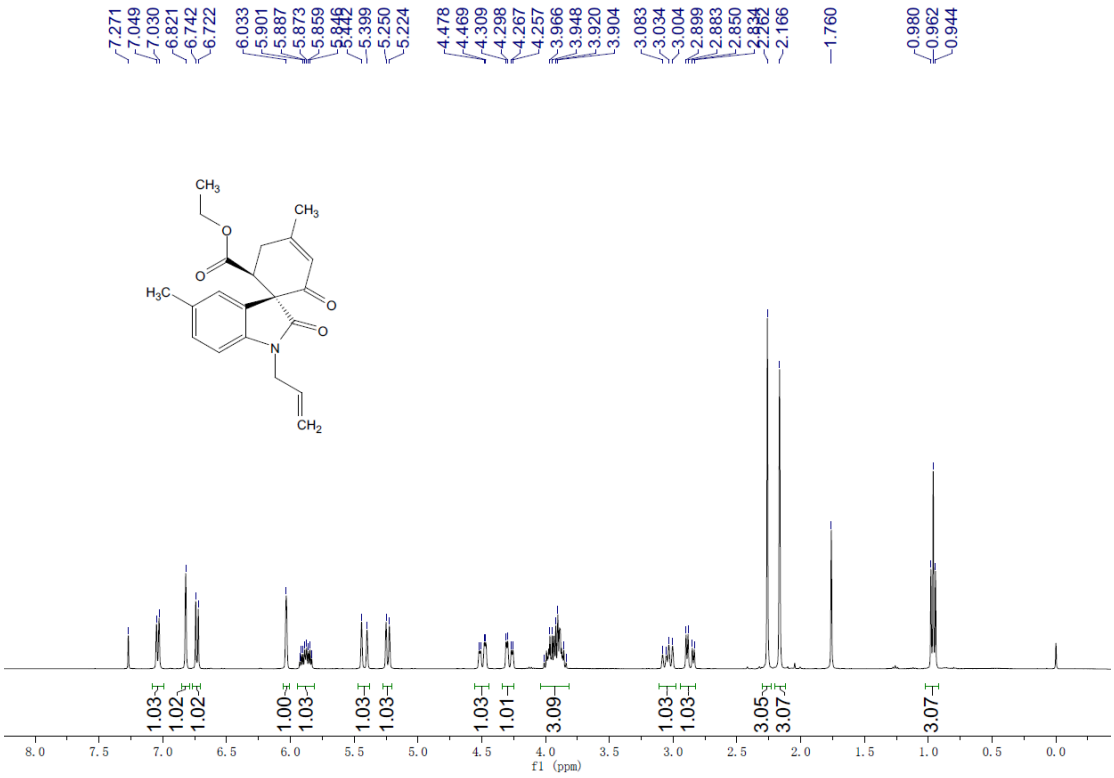

**$^{13}$C NMR Spectrum of Compound (3e)**



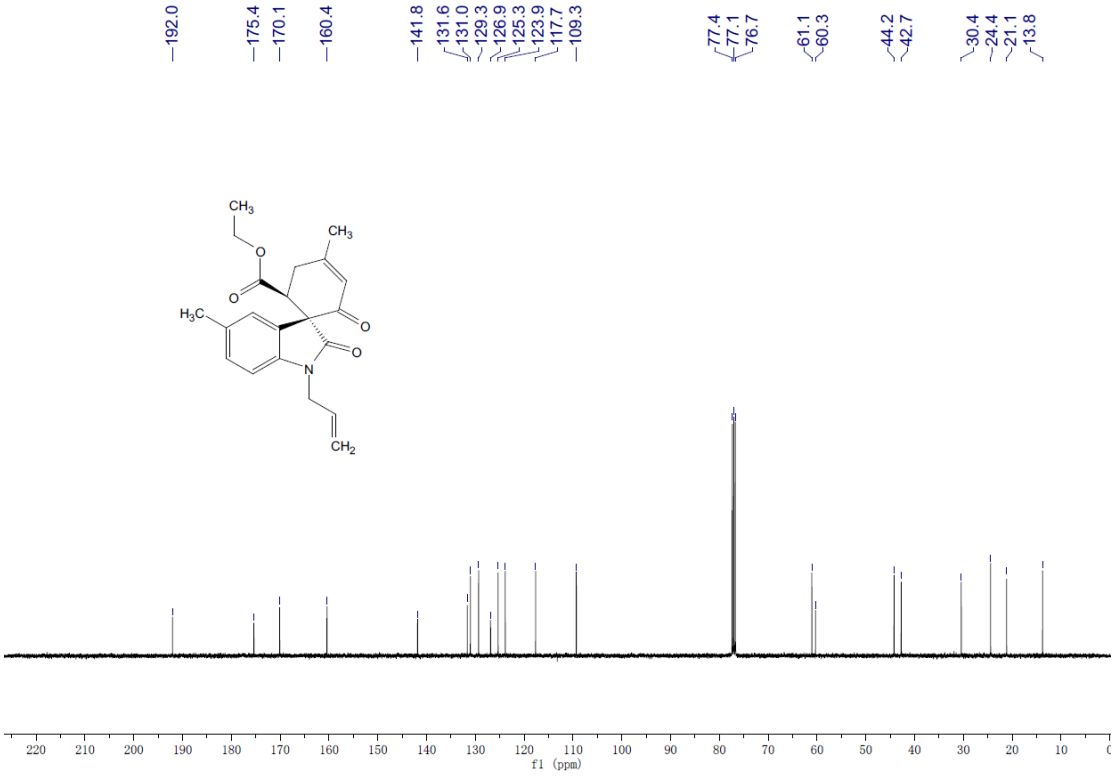

**$^{1}$H NMR Spectrum of Compound (3f)**



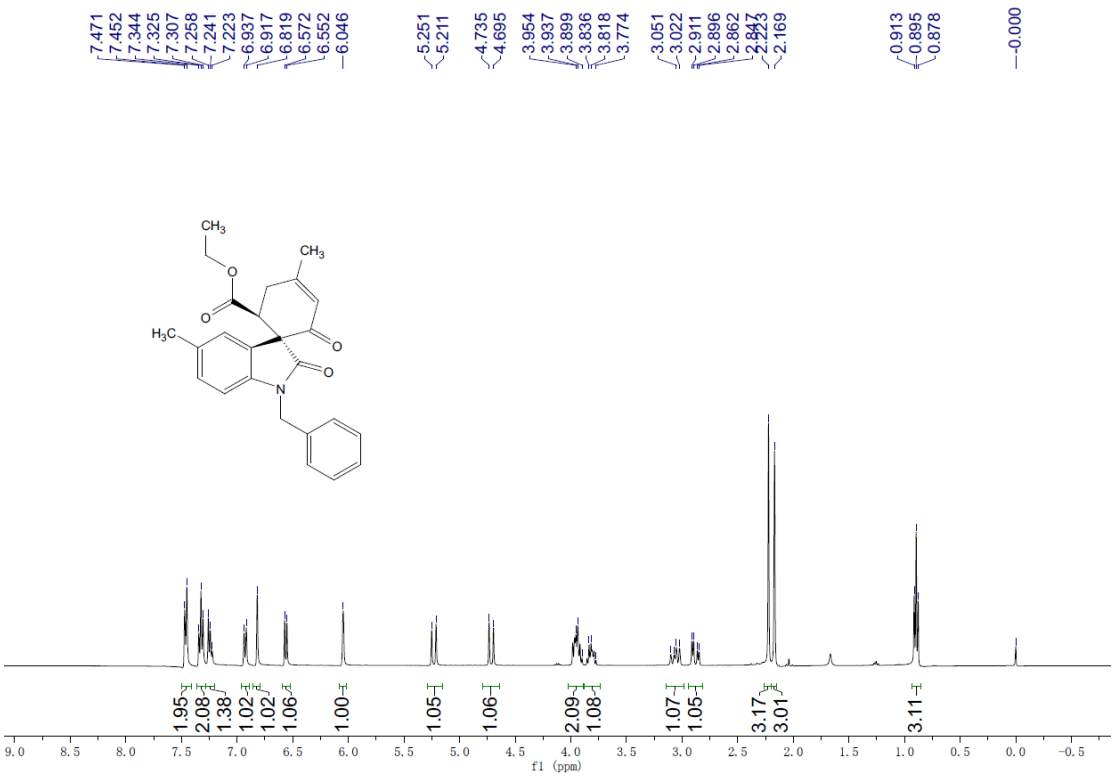

**$^{13}$C NMR Spectrum of Compound (3f)**



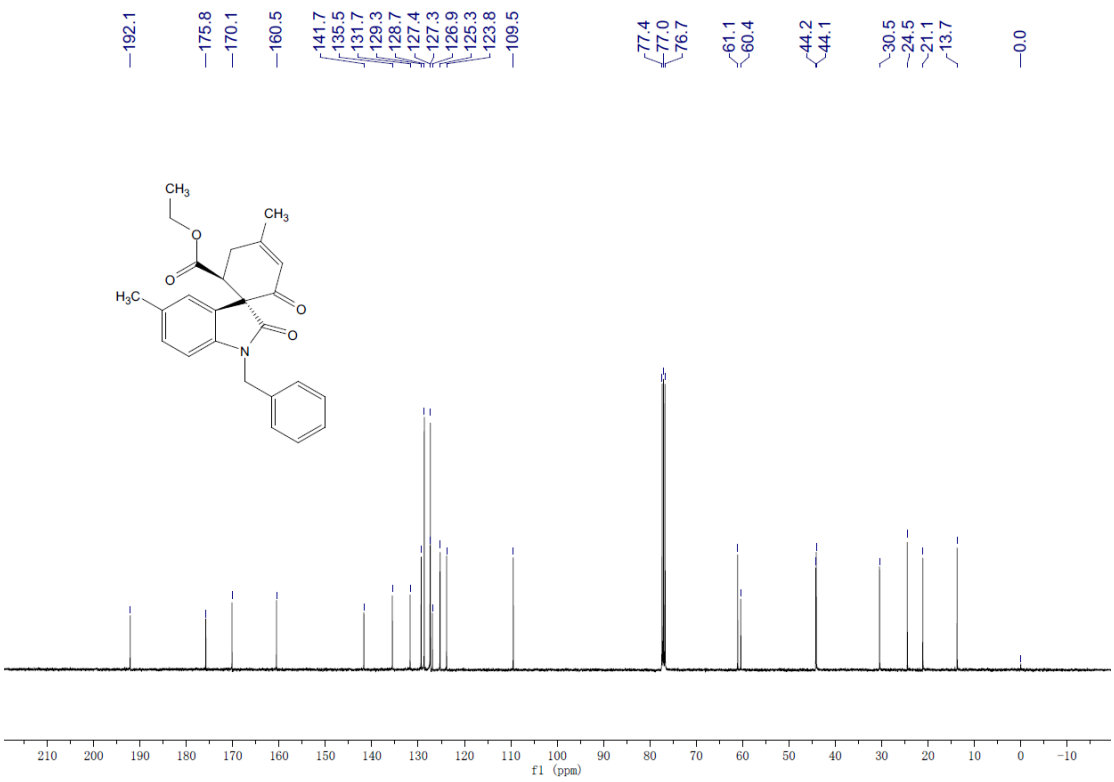

**[1]H NMR Spectrum of Compound (3g)**



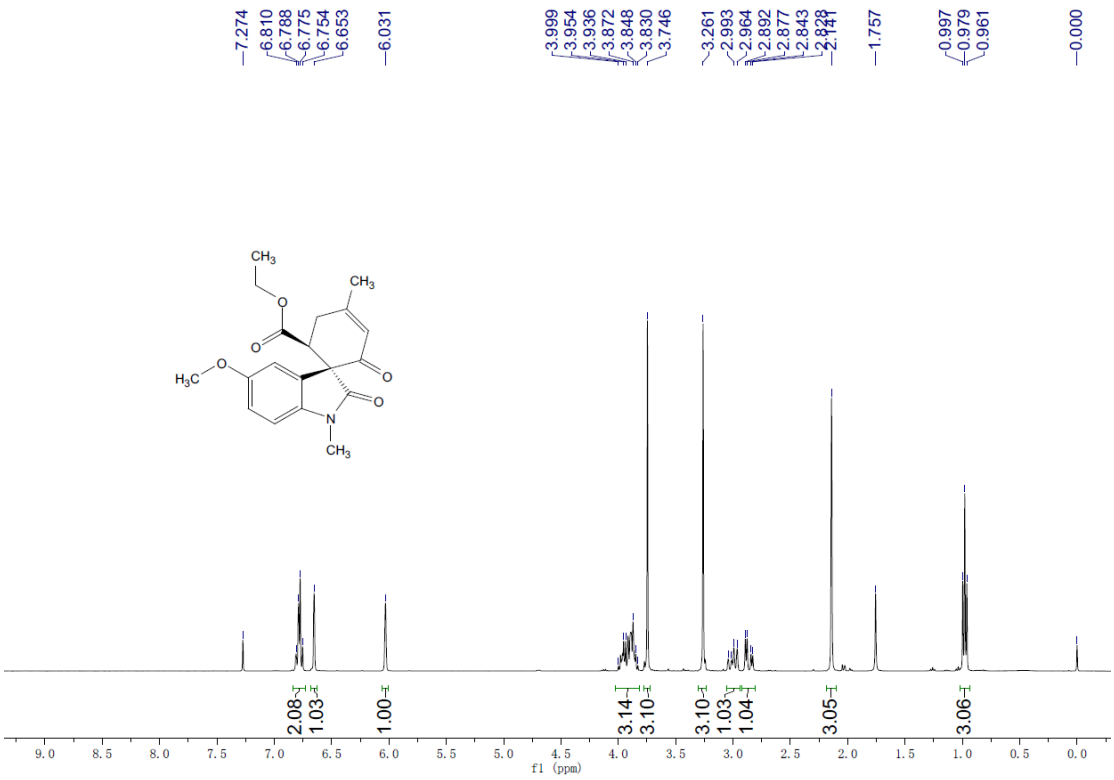

**[13]C NMR Spectrum of Compound (3g)**



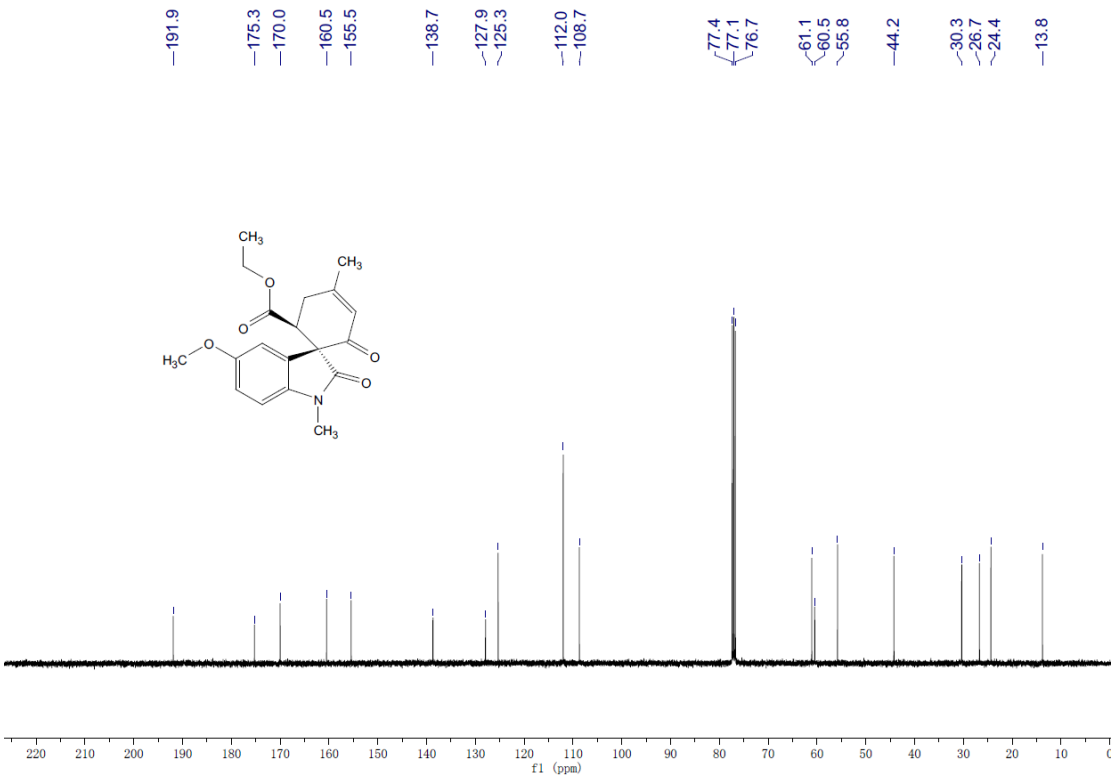

**$^{1}$H NMR Spectrum of Compound (3h)**



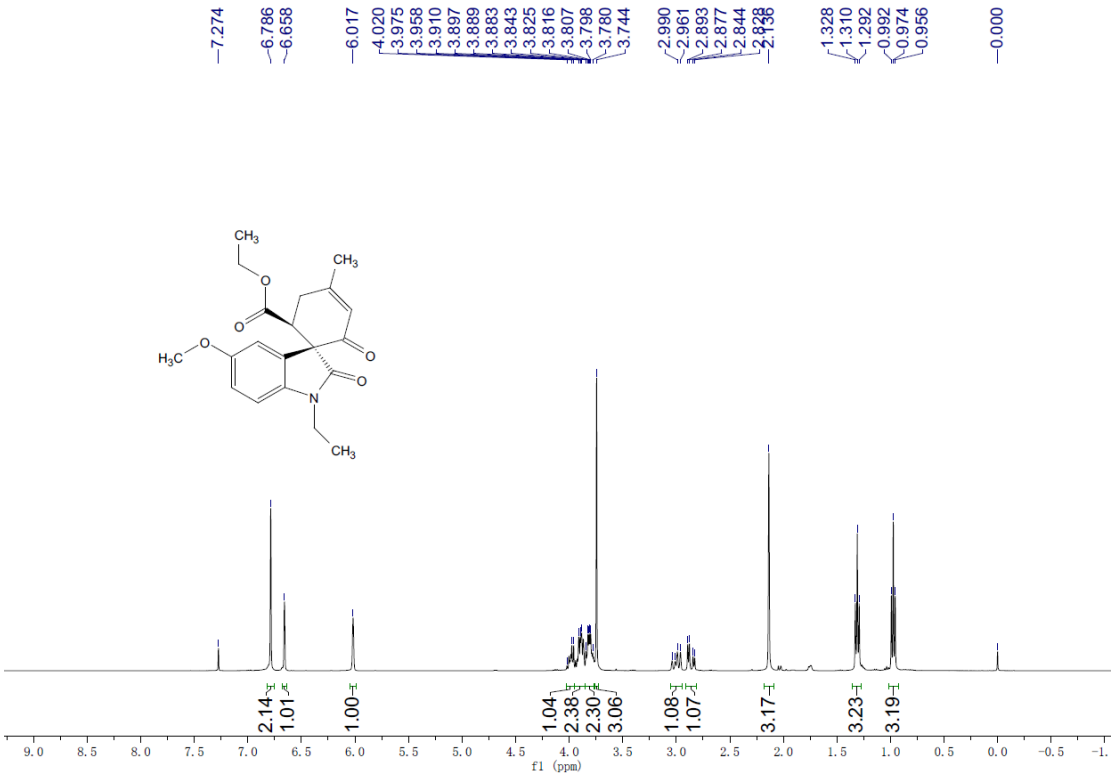

**$^{13}$C NMR Spectrum of Compound (3h)**



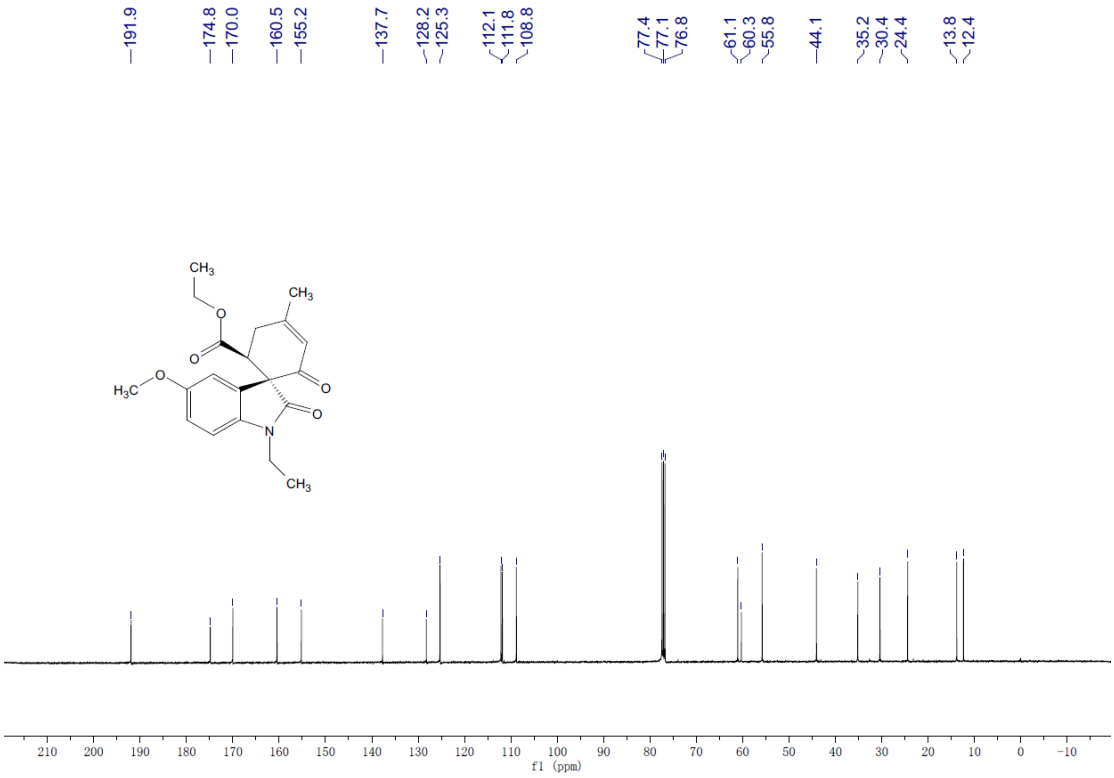

**$^{1}$H NMR Spectrum of Compound (3i)**



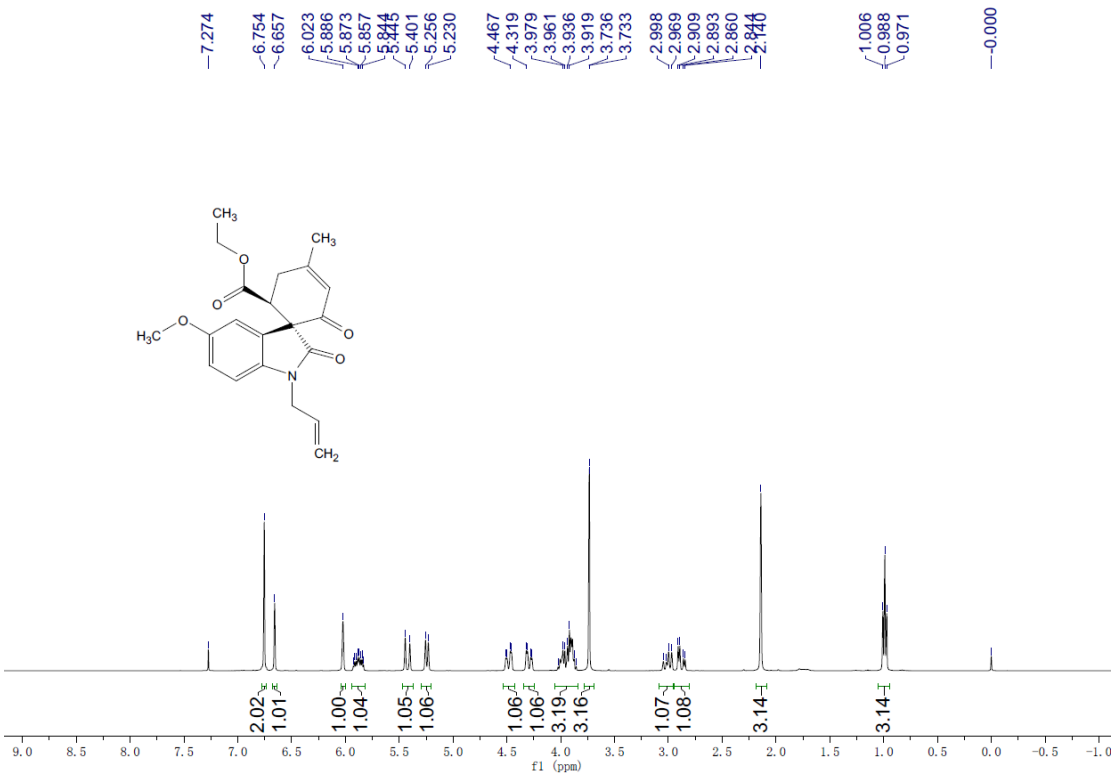

**$^{13}$C NMR Spectrum of Compound (3i)**



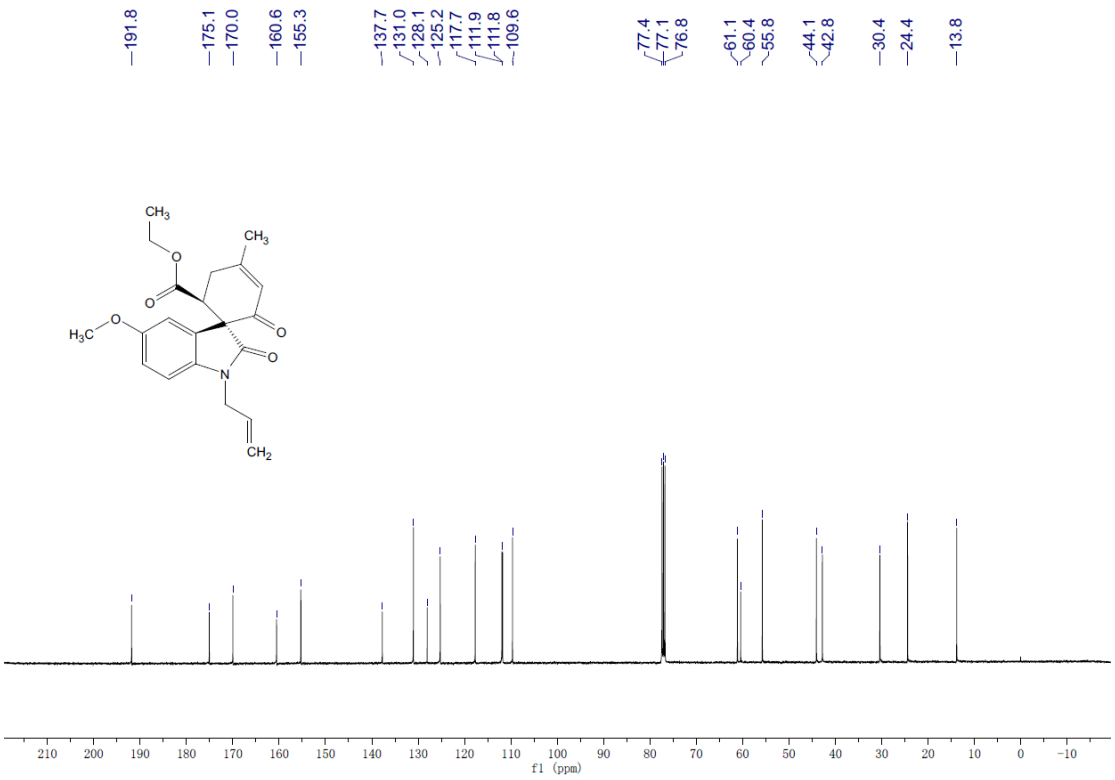

**$^{1}$H NMR Spectrum of Compound (3j)**



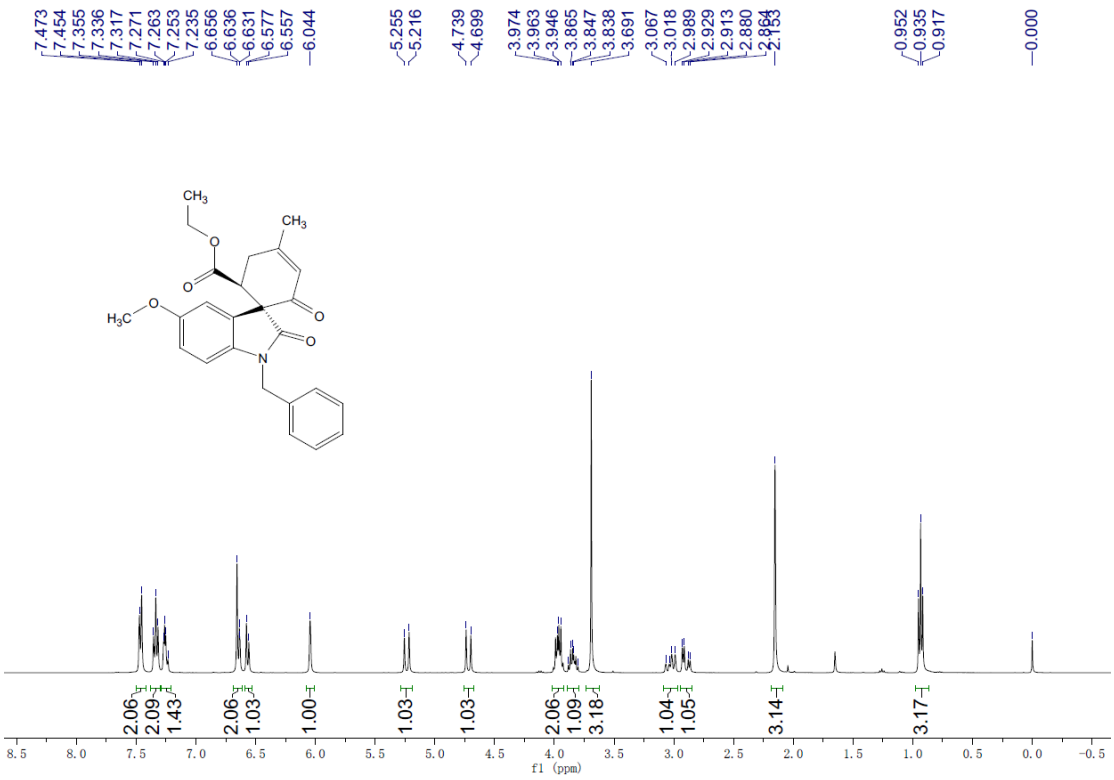

**$^{13}$C NMR Spectrum of Compound (3j)**



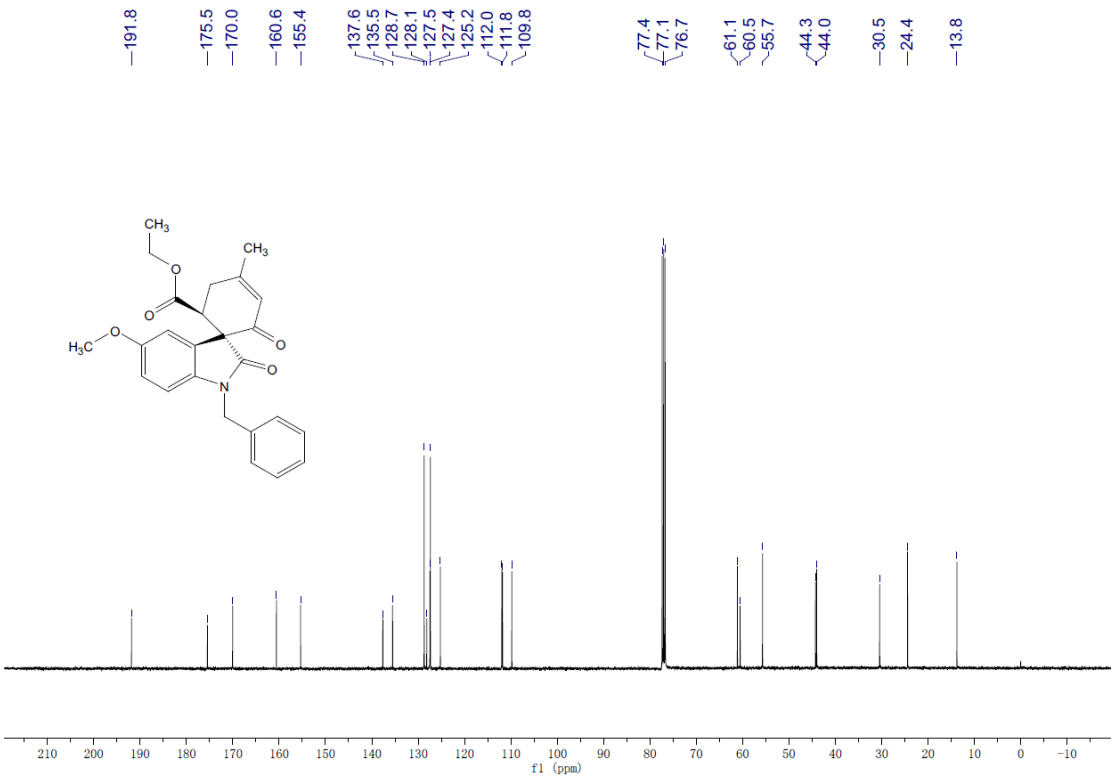

**$^{1}$H NMR Spectrum of Compound (3k)**



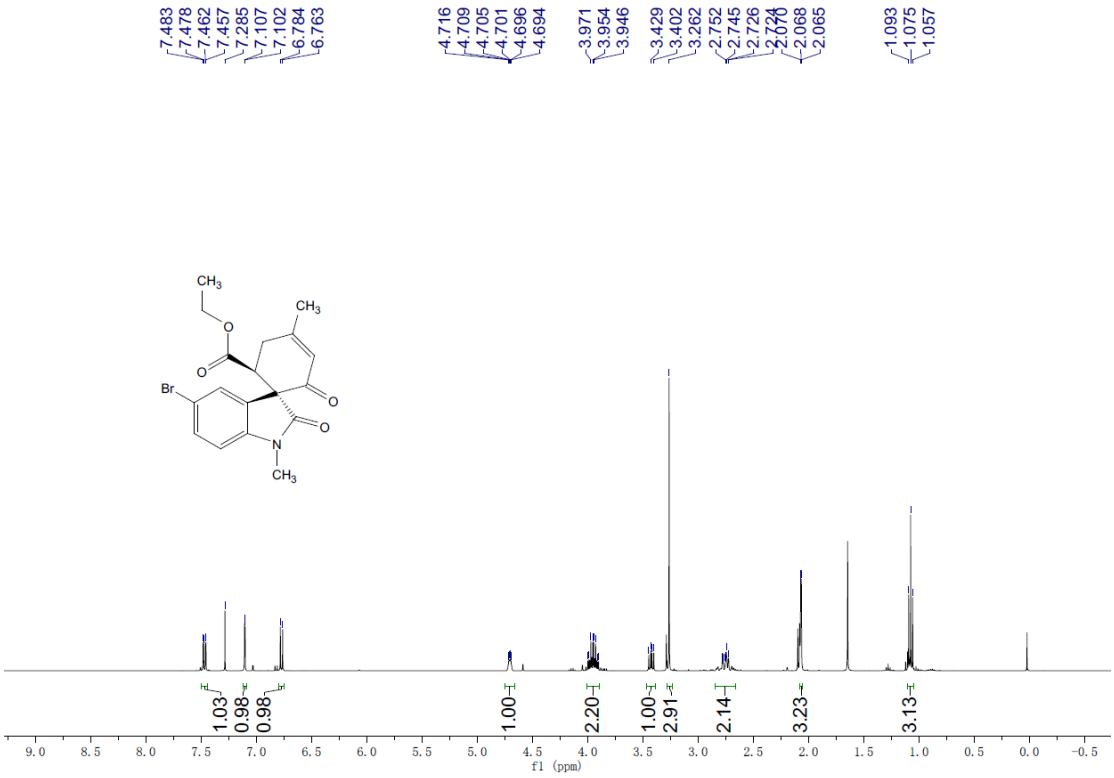

**$^{13}$C NMR Spectrum of Compound (3k)**



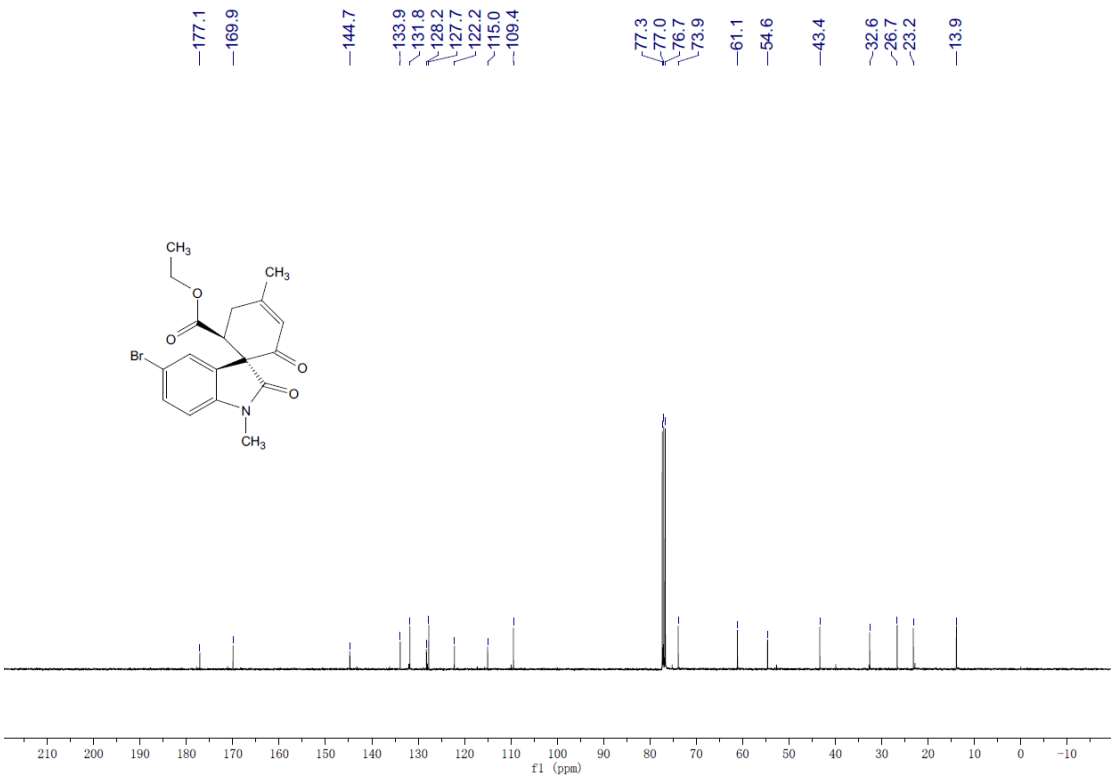

**$^{1}$H NMR Spectrum of Compound (3l)**



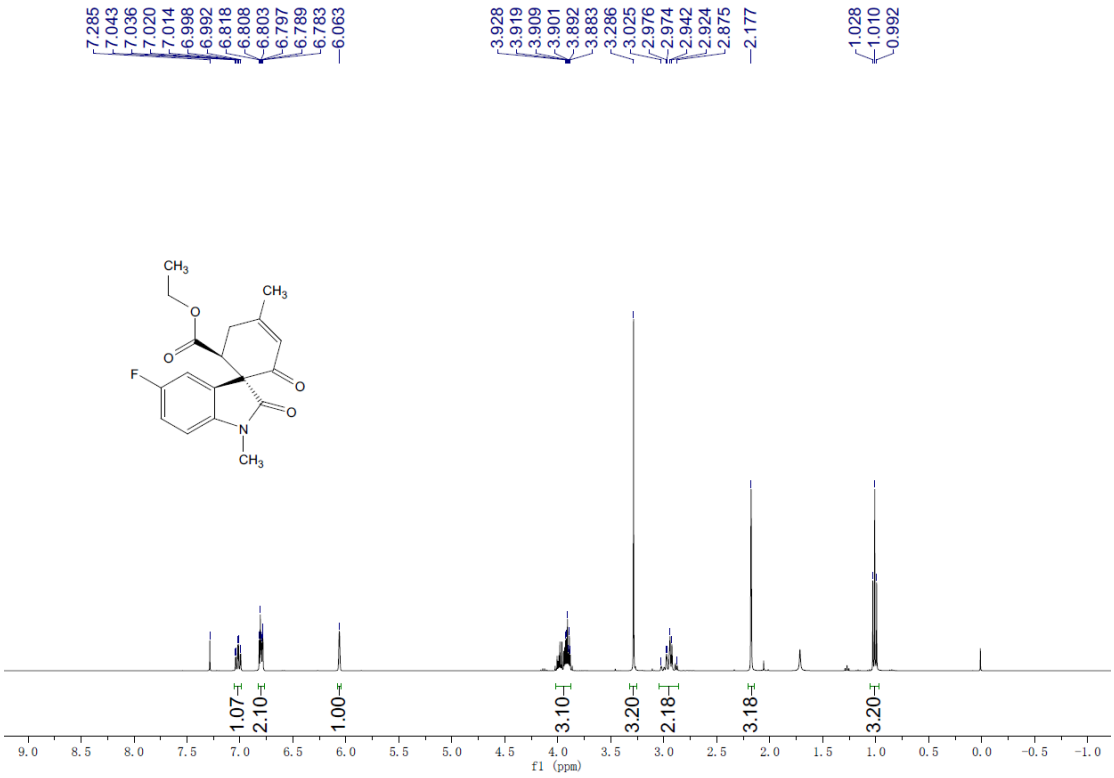

**$^{13}$C NMR Spectrum of Compound (3l)**



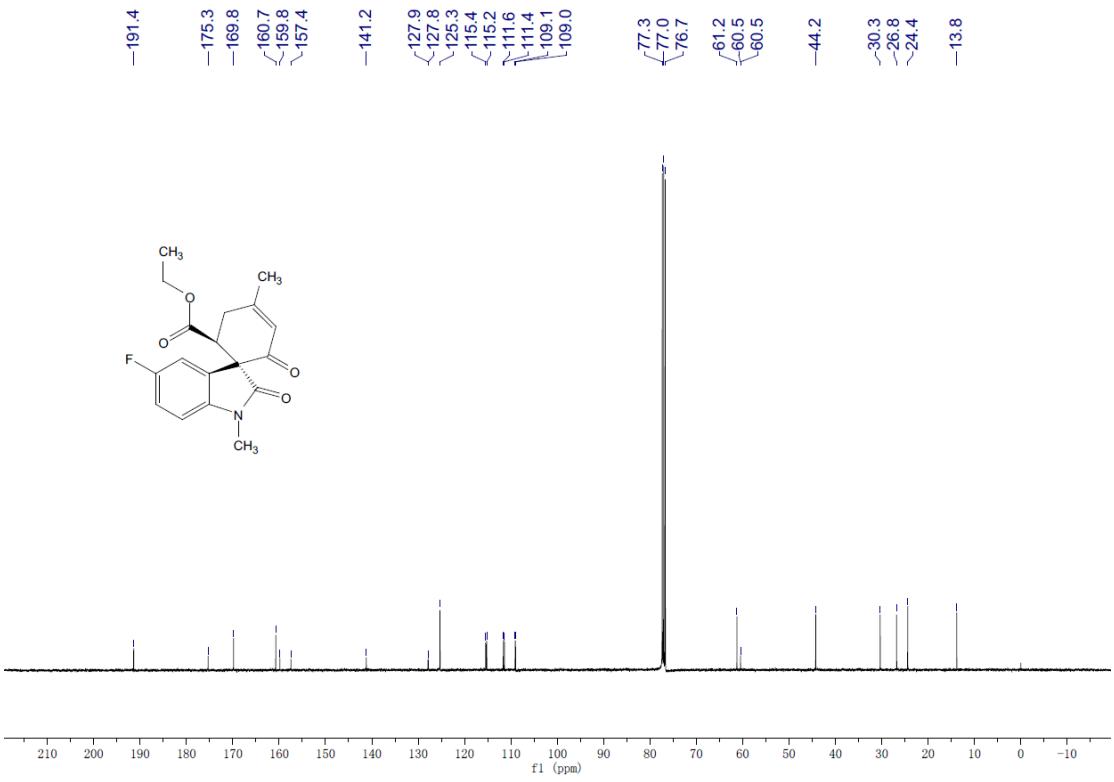

**$^{1}$H NMR Spectrum of Compound (3m)**



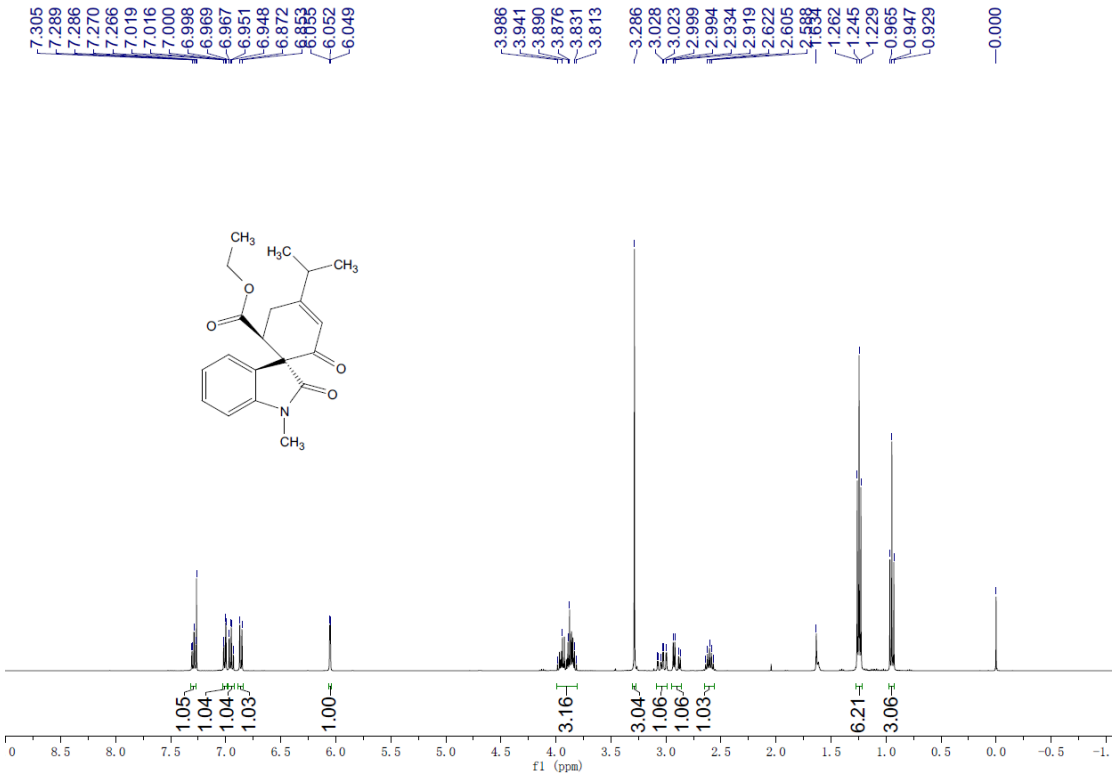

**$^{13}$C NMR Spectrum of Compound (3m)**



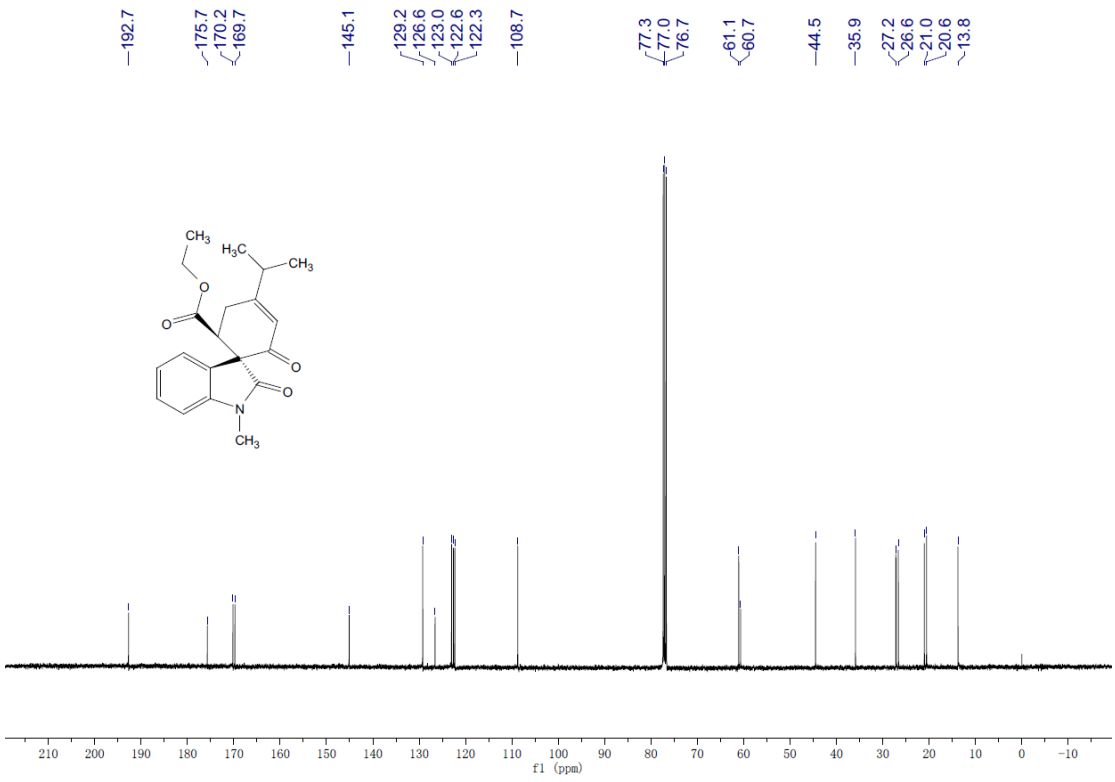

**$^{1}$H NMR Spectrum of Compound (3n)**




**$^{13}$C NMR Spectrum of Compound (3n)**




**$^{1}$H NMR Spectrum of Compound (3o)**




**$^{13}$C NMR Spectrum of Compound (3o)**