

Dinuclear Zinc Catalyzed Desymmetric Intramolecular Aldolization: An Enantioselective Construction of Spiro[Cyclohexanone-Oxindole] Derivatives

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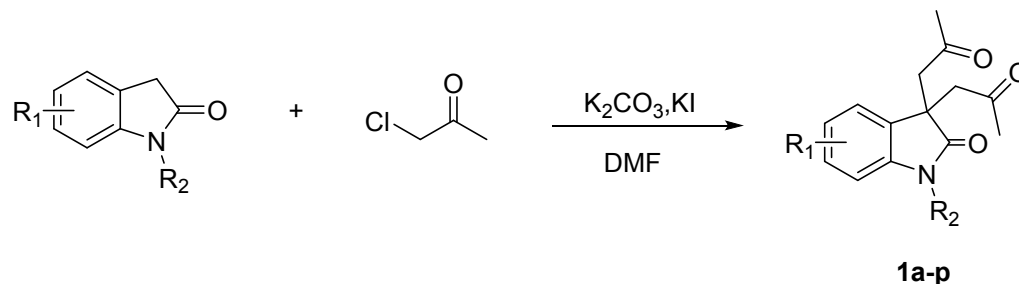
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1. General methods

Unless otherwise stated, all reagents were purchased from commercial suppliers and used without further purification. All solvents employed in the reactions were distilled from appropriate drying agent prior to use. Molecular Sieves were flame-dried under high vacuum before use. Substrates **1a-p** were prepared in air without any precautions to exclude moisture unless otherwise noted. The other reactions were carried out under nitrogen protection by the use of distilled solvents. Organic solutions were concentrated under reduced pressure on an EYELA N-1001 rotary evaporator. Reactions were monitored by thin-layer chromatography (TLC) on silica gel precoated glass plates (0.2 ± 0.03 mm thickness, GF-254, particle size 0.01–0.04 mm) from Yantai Chemical Industry Research Institute, P. R. China. Chromatograms were visualized by fluorescence quenching with UV light at 254 nm. Flash column chromatography was performed using silica gel (particle size 0.04 – 0.05 mm) from Yantai Chemical Industry Research Institute, P. R. China. ^1H , ^{13}C NMR and ^{31}F NMR spectra were recorded in CDCl_3 on Varian Inova (400 MHz, 101 MHz and 162 MHz, respectively) spectrometer. Chemical shifts (δ ppm) are relative to the resonance of the deuterated solvent as the internal standard (CDCl_3 , δ 7.26 ppm for proton NMR, δ 77.23 ppm for carbon NMR). ^1H NMR data are reported as follows: chemical shift (δ , ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br. s = broad singlet, dd = double-doublet, td = triple-doublet, ddd = double-double-doublet), coupling constants (J) and assignment. Data for ^{13}C NMR are reported in terms of coupling constants (J) and chemical shift (δ , ppm). IR Spectra were recorded on Thermo Fisher Nicolet 6700. Melting points measured with melting point detector. High-resolution mass spectra were recorded on a commercial apparatus (ESI Source). High performance liquid chromatography (HPLC) was performed on an Agilent 1200 Series chromatographs using Daicel Chiralpak OJ-H or AD-H column (0.46cm x 25 cm). X-ray data were recorded on a Rigaku Mercury CCD/AFC diffractometer with Cu $K\alpha$ radiation ($\lambda=1.54178$ Å). Optical rotations are reported as follows: $[\alpha]_{\text{D}}^{20}$ (c in g per 100 mL, solvent).

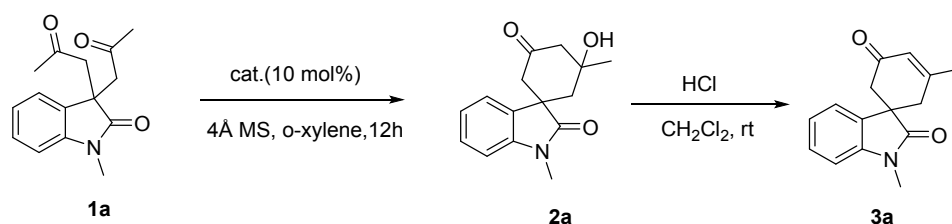
2. Typical experimental procedure

2.1 General procedure for the preparation of oxindolyl diketone derivatives 1a–p



In an ordinary tube equipped with a magnetic stirring bar, the mixture of indolin-2-one (2.0 mmol), K₂CO₃ (6.0 mmol) and KI (0.2 mmol) in DMF (5.0 mL) was stirred at room temperature for 10 minutes, and 1-chloropropan-2-one (6 mmol) was added. Then, the reaction was stirred for 12 hours at rt. After the reaction was completed, H₂O (35 mL) was added. Afterwards, the mixture was extracted by CH₂Cl₂ (3 × 10 mL). The combined organic layers were dried over anhydrous Na₂SO₄ and concentrated *in vacuo*. The residue was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 2:1) to afford the desired products **1a–p**.

2.2 General procedure and spectroscopic data for dinuclear zinc catalyzed asymmetric intramolecular aldolization of oxindole dione derivatives:



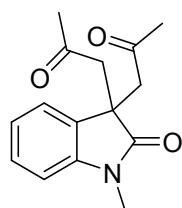
Under an argon atmosphere, a solution of diethylzinc (20 μL, 1.0 M in hexane, 0.02 mmol) was added to a stirred solution of **L9** (7.5 mg, 0.01 mmol) in o-xylene (1.0 mL) at room temperature. After the addition, the resulting solution was allowed to stir at rt for 30 min. Then **1a** (25 mg, 0.1 mmol) and 4 Å MS (30 mg) was added. The reaction was stirred for 12 h at 40 °C, then the reaction mixture was directly loaded onto a silica gel and purified by flash chromatography (eluent: petroleum ether/ethyl acetate = 2:1) to give desired products **2a**. Then **2a** was dissolved in CH₂Cl₂ (1 mL) and HCl (1 mmol) was added and the solution was well stirred for 12 h at room temperature. After the

reaction was complete (monitored by TLC), 10% NaHCO₃ was added. The pH was adjusted to around 7.0. The mixture was extracted with CH₂Cl₂ (3 × 5 mL). The organic layer was washed by H₂O (5 mL) and dried over anhydrous Na₂SO₄. The solvent was evaporated *in vacuo* and the residue was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 2:1) to afford the desired product **3a**. The reaction procedures for the preparation of **2b-e** are identical with the above described for the preparation of **2a**.

The reaction procedures for the preparation of **3b-p**: Under an argon atmosphere, a solution of diethylzinc (20 μL, 1.0 M in hexane, 0.02 mmol) was added to a stirred solution of **L9** (7.5 mg, 0.01 mmol) in *o*-xylene (1.0 mL). After the addition, the resulting solution was allowed to stir at rt for 30 min. Then **1a** (25 mg, 0.1 mmol) and 4 Å MS (30 mg) was added. The reaction was stirred for 12 h at 40 °C, then HCl (1 mmol) was added and the solution was well stirred for another 12 h at rt. After the reaction was complete (monitored by TLC), 10% NaHCO₃ was added. The pH was adjusted to around 7.0. The mixture was extracted with CH₂Cl₂ (3 × 5 mL). The organic layer was washed by H₂O (5 mL) and dried over anhydrous Na₂SO₄. The solvent was evaporated *in vacuo* and the residue was purified by flash column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 2:1) to afford the desired product **3b-p**.

3. Experimental Data

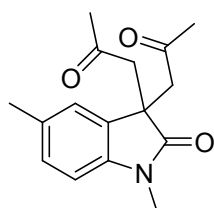
1,1'-(1-methyl-2-oxoindoline-3,3-diyl)bis(propan-2-one) (1a)



1a

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 90% yield. White solid, mp 76 – 77 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.39 (d, *J* = 7.4 Hz, 1H), 7.31 (dd, *J* = 15.4, 1.0 Hz, 1H), 7.03 (t, *J* = 7.5 Hz, 1H), 6.91 (d, *J* = 7.8 Hz, 1H), 3.40 (d, *J* = 17.7 Hz, 2H), 3.32 (s, 3H), 2.88 (d, *J* = 17.7 Hz, 2H), 2.06 (s, 6H). ¹³C NMR (101 MHz, CDCl₃) δ 204.50, 178.78, 143.88, 130.47, 127.82, 123.34, 121.78, 107.72, 48.20, 46.55, 30.07, 26.04. ESI-MS: *m/z* calcd for [C₁₅H₁₇NO₃, M + Na]⁺ : 282.1101, found: 282.1111. IR ν (cm⁻¹) 1704, 1610, 1470, 1426, 1168, 765.

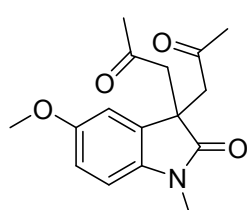
1,1'-(1,5-dimethyl-2-oxoindoline-3,3-diyl)bis(propan-2-one) (1b)



1b

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 90% yield. White solid, mp 136 – 137 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.16 (s, 1H), 7.06 (dd, *J* = 7.9, 0.9 Hz, 1H), 6.75 (d, *J* = 7.9 Hz, 1H), 3.33 (d, *J* = 17.7 Hz, 2H), 3.25 (s, 3H), 2.82 (d, *J* = 17.7 Hz, 2H), 2.29 (s, 3H), 2.01 (s, 6H). ¹³C NMR (101 MHz, CDCl₃) δ 204.59, 178.70, 141.48, 131.24, 130.53, 128.07, 124.25, 107.41, 48.24, 46.61, 30.06, 26.06, 20.69. ESI-MS: *m/z* calcd for [C₁₆H₁₉NO₃, M + Na]⁺ : 296.1257, found: 296.1262. IR ν (cm⁻¹) 1712, 1501, 1403, 1167, 805, 622.

1,1'-(5-methoxy-1-methyl-2-oxoindoline-3,3-diyl)bis(propan-2-one) (1c)

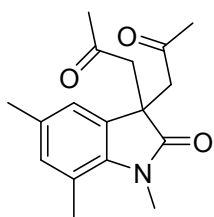


1c

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 88% yield. Light yellow solid, mp 100 – 101 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.01 (d, *J* = 1.8 Hz, 1H), 6.76 (t, *J* = 5.8 Hz, 2H), 3.75 (s, 3H), 3.33 (d, *J* = 17.8 Hz, 2H), 3.24 (s, 3H), 2.82 (d, *J* = 17.8 Hz, 2H), 2.02 (s, 6H). ¹³C NMR (101 MHz, CDCl₃) δ 204.42, 178.36, 155.18, 137.44, 131.89, 111.63, 111.29, 107.84, 55.20, 48.16, 46.91, 30.02, 26.10. ESI-MS: *m/z* calcd for [C₁₆H₁₉NO₄, M +

$\text{Na}]^+$: 312.1206, found: 312.1212. IR ν (cm^{-1}) 1704, 1498, 1346, 1261, 1112, 805, 629.

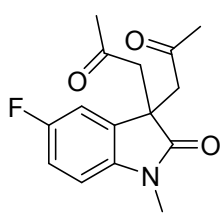
1,1'-(1,5,7-trimethyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1d)



1d

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 85% yield. Light yellow solid, mp 109 – 110 °C. ^1H NMR (400 MHz, CDCl_3) δ 6.95 (s, 1H), 6.79 (s, 1H), 3.52 (s, 3H), 3.26 (d, $J = 17.5$ Hz, 2H), 2.83 (d, $J = 17.5$ Hz, 2H), 2.54 (s, 3H), 2.23 (s, 3H), 2.00 (s, 6H). ^{13}C NMR (101 MHz, CDCl_3) δ 204.62, 179.41, 139.17, 132.11, 131.18, 131.04, 121.61, 118.92, 48.60, 46.11, 30.17, 29.45, 20.35, 18.50. ESI-MS: m/z calcd for $[\text{C}_{17}\text{H}_{21}\text{NO}_3, \text{M} + \text{Na}]^+$: 310.1414, found: 310.1421. IR ν (cm^{-1}) 1709, 1601, 1475, 1373, 1167, 1101, 858, 643.

1,1'-(5-fluoro-1-methyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1e)

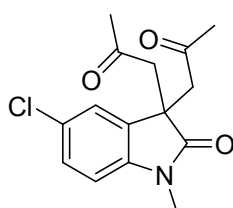


1e

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 80% yield. White solid, mp 156 – 157 °C. ^1H NMR (400 MHz, CDCl_3) δ 7.16 (dd, $J = 8.3, 2.6$ Hz, 1H), 6.95 (td, $J = 8.9, 2.6$ Hz, 1H), 6.77 (dd, $J = 8.5, 4.2$ Hz, 1H), 3.37 (d, $J = 18.0$ Hz, 2H), 3.25 (s, 3H), 2.82 (d, $J = 18.0$ Hz, 2H), 2.03 (s, 6H). ^{13}C NMR (101 MHz, CDCl_3) δ 204.26, 178.49, 158.47 (d, $J = 240.5$ Hz), 139.93 (d, $J = 1.8$ Hz), 132.15 (d, $J = 8.3$ Hz), 113.75 (d, $J = 23.3$ Hz), 111.97 (d, $J = 25.2$ Hz), 107.96 (d, $J = 8.2$ Hz), 48.05, 46.83 (d, $J = 1.7$ Hz), 29.87, 26.15. ^{19}F NMR (376 MHz, CDCl_3) δ -120.89. ESI-MS: m/z calcd for $[\text{C}_{15}\text{H}_{16}\text{FNO}_3, \text{M} + \text{Na}]^+$: 300.1006, found: 300.1011. IR ν (cm^{-1}) 1706, 1620, 1495, 1389, 1170, 1109, 824, 627.

1,1'-(5-chloro-1-methyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1f)

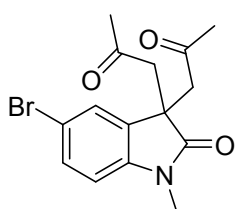
The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 85% yield. White solid, mp 100 – 101 °C. ^1H NMR (400 MHz, CDCl_3) δ 7.36 (d, $J = 2.0$ Hz, 1H), 7.23 (dd, $J = 8.3, 2.1$ Hz, 1H), 6.78 (d, $J = 8.3$ Hz, 1H), 3.36 (d, $J = 18.1$ Hz, 2H), 3.25 (s, 3H), 2.82 (d, $J = 18.1$ Hz, 2H), 2.04 (s, 6H). ^{13}C NMR (101 MHz,



1f

CDCl₃) δ 204.20, 178.42, 142.63, 132.28, 127.67, 124.05, 108.52, 99.50, 48.14, 46.57, 29.86, 26.15. ESI-MS: m/z calcd for [C₁₅H₁₆ClNO₃, M + Na]⁺ : 316.0711, found: 316.0722. IR ν (cm⁻¹) 1706, 1610, 1493, 1343, 1167, 1104, 826, 620.

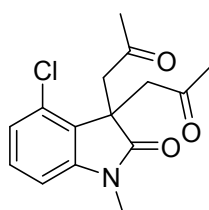
1,1'-(5-bromo-1-methyl-2-oxoindoline-3,3-diyl)bis(propan-2-one) (1g)



1g

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 87% yield. White solid, mp 158 – 159 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.49 (d, J = 1.8 Hz, 1H), 7.38 (dd, J = 8.3, 1.9 Hz, 1H), 6.74 (d, J = 8.3 Hz, 1H), 3.35 (d, J = 18.1 Hz, 2H), 3.24 (s, 3H), 2.82 (d, J = 18.1 Hz, 2H), 2.04 (s, 6H). ¹³C NMR (101 MHz, CDCl₃) δ 204.18, 178.32, 143.13, 132.68, 130.60, 126.71, 114.44, 109.06, 48.17, 46.51, 29.86, 26.13. ESI-MS: m/z calcd for [C₁₅H₁₆BrNO₃, M + Na]⁺ : 360.0206, found: 360.0213. IR ν (cm⁻¹) 1706, 1607, 1491, 1352, 1166, 1105, 823, 617.

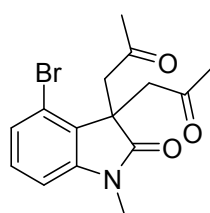
1,1'-(4-chloro-1-methyl-2-oxoindoline-3,3-diyl)bis(propan-2-one) (1h)



1h

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 85% yield. White solid, mp 99 – 100 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.20 (t, J = 8.0 Hz, 1H), 6.89 (d, J = 8.2 Hz, 1H), 6.77 (d, J = 7.8 Hz, 1H), 3.49 (d, J = 16.8 Hz, 2H), 3.28 (s, 3H), 2.98 (d, J = 16.9 Hz, 2H), 1.97 (s, 6H). ¹³C NMR (101 MHz, CDCl₃) δ 203.47, 177.36, 146.81, 129.24, 128.38, 125.93, 122.26, 106.31, 47.28, 47.21, 29.78, 26.28. ESI-MS: m/z calcd for [C₁₅H₁₆ClNO₃, M + Na]⁺ : 316.0711, found: 316.0721. IR ν (cm⁻¹) 1708, 1605, 1457, 1300, 1206, 1100, 793, 625.

1,1'-(4-bromo-1-methyl-2-oxoindoline-3,3-diyl)bis(propan-2-one) (1i)

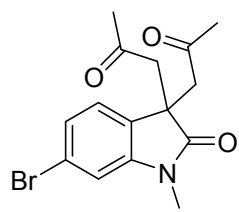


1i

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 82% yield. Light yellow solid, mp 101 – 102 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.12 (d, J = 7.9 Hz, 1H), 7.05 (dd, J = 8.2, 0.7 Hz, 1H), 6.81 (d, J = 7.7 Hz, 1H),

3.60 (d, $J = 16.9$ Hz, 2H), 3.28 (s, 3H), 2.94 (d, $J = 16.9$ Hz, 2H), 1.98 (s, 6H). ^{13}C NMR (101 MHz, CDCl_3) δ 203.45, 177.39, 147.14, 129.49, 127.63, 125.33, 116.67, 106.80, 48.03, 47.07, 29.79, 26.21. ESI-MS: m/z calcd for $[\text{C}_{15}\text{H}_{16}\text{BrNO}_3, \text{M} + \text{Na}]^+$: 360.0206, found: 360.0212. IR ν (cm^{-1}) 1704, 1601, 1455, 1298, 1167, 790, 766.

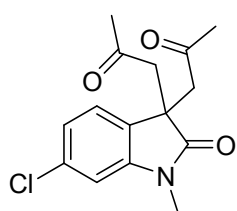
1,1'-(6-bromo-1-methyl-2-oxoindoline-3,3-diyl)bis(propan-2-one) (1j)



1j

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 83% yield. White solid, mp 112 – 113 °C. ^1H NMR (400 MHz, CDCl_3) δ 7.22 (d, $J = 7.9$ Hz, 1H), 7.10 (dd, $J = 7.9, 0.9$ Hz, 1H), 7.00 (d, $J = 1.4$ Hz, 1H), 3.35 (d, $J = 18.0$ Hz, 2H), 3.24 (s, 3H), 2.81 (d, $J = 18.0$ Hz, 2H), 2.02 (s, 6H). ^{13}C NMR (101 MHz, CDCl_3) δ 204.28, 178.66, 145.34, 129.48, 124.78, 124.47, 121.42, 111.21, 48.08, 46.20, 29.93, 26.14. ESI-MS: m/z calcd for $[\text{C}_{15}\text{H}_{16}\text{BrNO}_3, \text{M} + \text{Na}]^+$: 360.0206, found: 360.0213. IR ν (cm^{-1}) 1703, 1605, 1496, 1397, 1172, 1115, 819, 656.

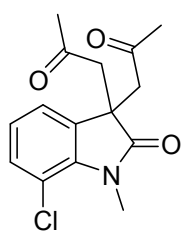
1,1'-(6-chloro-1-methyl-2-oxoindoline-3,3-diyl)bis(propan-2-one) (1k)



1k

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 81% yield. Light yellow solid, mp 125 – 126 °C. ^1H NMR (400 MHz, CDCl_3) δ 7.28 (d, $J = 6.9$ Hz, 1H), 6.94 (dd, $J = 7.9, 1.6$ Hz, 1H), 6.85 (d, $J = 1.7$ Hz, 1H), 3.35 (d, $J = 18.0$ Hz, 2H), 3.25 (s, 3H), 2.81 (d, $J = 18.0$ Hz, 2H), 2.02 (s, 6H). ^{13}C NMR (101 MHz, CDCl_3) δ 204.30, 178.80, 145.20, 133.59, 128.91, 124.39, 121.52, 108.46, 48.14, 46.15, 29.93, 26.14. ESI-MS: m/z calcd for $[\text{C}_{15}\text{H}_{16}\text{ClNO}_3, \text{M} + \text{Na}]^+$: 316.0711, found: 316.0721. IR ν (cm^{-1}) 1703, 1609, 1498, 1365, 1172, 878, 819, 785.

1,1'-(7-chloro-1-methyl-2-oxoindoline-3,3-diyl)bis(propan-2-one) (1l)

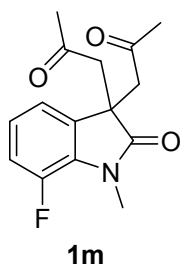


1l

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 85% yield. White solid, mp

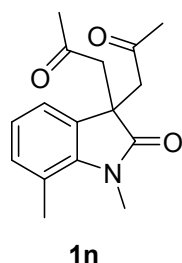
130 – 131 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.22 (dd, *J* = 7.4, 0.9 Hz, 1H), 7.17 (dd, *J* = 8.2, 0.9 Hz, 1H), 6.87 (dd, *J* = 8.1, 7.5 Hz, 1H), 3.64 (s, 3H), 3.33 (d, *J* = 17.8 Hz, 2H), 2.85 (d, *J* = 17.8 Hz, 2H), 2.02 (s, 6H). ¹³C NMR (101 MHz, CDCl₃) δ 204.20, 179.13, 139.86, 133.39, 130.14, 122.46, 121.59, 115.18, 48.41, 46.27, 29.99, 29.49. ESI–MS: *m/z* calcd for [C₁₅H₁₆ClNO₃, M + Na]⁺ : 316.0711, found: 316.0715. IR ν (cm⁻¹) 1711, 1606, 1468, 1337, 1167, 1063, 761.

1,1'-(7-fluoro-1-methyl-2-oxoindoline-3,3-diyl)bis(propan-2-one) (1m)



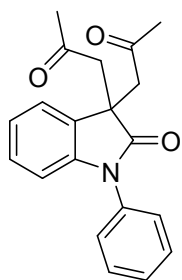
The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 81% yield. Light yellow solid, mp 91 – 92 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.15 – 7.06 (m, 1H), 6.98 (dd, *J* = 11.0, 8.3 Hz, 1H), 6.93 – 6.84 (m, 1H), 3.48 (d, *J* = 2.7 Hz, 3H), 3.33 (d, *J* = 17.8 Hz, 2H), 2.85 (d, *J* = 17.8 Hz, 2H), 2.02 (s, 6H). ¹³C NMR (101 MHz, CDCl₃) δ 204.20, 178.44, 147.37 (d, *J* = 244.4 Hz), 133.46 (d, *J* = 3.4 Hz), 130.60 (d, *J* = 8.1 Hz), 122.18 (d, *J* = 6.4 Hz), 118.99 (d, *J* = 3.1 Hz), 115.82 (d, *J* = 19.2 Hz), 48.37, 46.72 (d, *J* = 2 Hz), 29.97, 28.51 (d, *J* = 5.9 Hz). ¹⁹F NMR (376 MHz, CDCl₃) δ -136.59. ESI–MS: *m/z* calcd for [C₁₅H₁₆FNO₃, M + Na]⁺ : 300.1006, found: 300.1002. IR ν (cm⁻¹) 1704, 1629, 1483, 1355, 1297, 1116, 791, 735.

1,1'-(1,7-dimethyl-2-oxoindoline-3,3-diyl)bis(propan-2-one) (1n)



The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 92% yield. White solid, mp 125 – 126 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.14 (d, *J* = 7.2 Hz, 1H), 6.98 (d, *J* = 7.5 Hz, 1H), 6.85 (t, *J* = 7.5 Hz, 1H), 3.55 (s, 3H), 3.28 (d, *J* = 17.4 Hz, 2H), 2.84 (d, *J* = 17.4 Hz, 2H), 2.59 (s, 3H), 1.99 (s, 6H). ¹³C NMR (101 MHz, CDCl₃) δ 204.49, 179.46, 141.65, 131.61, 131.04, 121.64, 120.81, 119.28, 48.56, 46.01, 30.18, 29.48, 18.68. ESI–MS: *m/z* calcd for [C₁₆H₁₉NO₃, M + Na]⁺ : 296.1257, found: 296.1262. IR ν (cm⁻¹) 1709, 1598, 1476, 1368, 1243, 1073, 744.

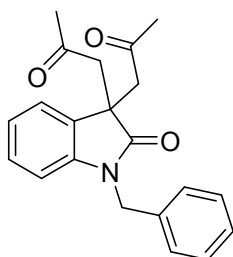
1,1'-(2-oxo-1-phenylindoline-3,3-diyl)bis(propan-2-one) (1o)



1o

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 89% yield. White solid, mp 173 – 174 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.57 – 7.48 (m, 4H), 7.46 – 7.39 (m, 1H), 7.37 (dd, *J* = 7.5, 0.8 Hz, 1H), 7.17 (td, *J* = 7.8, 1.3 Hz, 1H), 7.00 (td, *J* = 7.6, 1.0 Hz, 1H), 6.77 (d, *J* = 7.8 Hz, 1H), 3.42 (d, *J* = 17.7 Hz, 2H), 2.98 (d, *J* = 17.7 Hz, 2H), 2.05 (d, *J* = 4.0 Hz, 6H). ¹³C NMR (101 MHz, CDCl₃) δ 204.33, 178.35, 144.36, 134.44, 130.13, 129.13, 127.73, 127.64, 126.51, 123.27, 122.10, 108.96, 48.87, 46.58, 30.03. ESI-MS: *m/z* calcd for [C₂₀H₁₉NO₃, M + Na]⁺ : 344.1257, found: 344.1268. IR ν (cm⁻¹) 1702, 1594, 1481, 1404, 1180, 1167, 763, 643.

1,1'-(1-benzyl-2-oxoindoline-3,3-diyl)bis(propan-2-one) (1p)

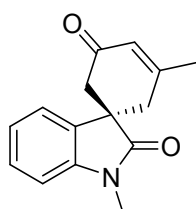


1p

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 4:1) in 95% yield. White solid, mp 97 – 98 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.43 (d, *J* = 7.2 Hz, 2H), 7.37 – 7.25 (m, 4H), 7.11 (td, *J* = 7.7, 1.1 Hz, 1H), 6.94 (td, *J* = 7.6, 0.8 Hz, 1H), 6.69 (d, *J* = 7.8 Hz, 1H), 4.97 (s, 2H), 3.40 (d, *J* = 17.7 Hz, 2H), 2.88 (d, *J* = 17.7 Hz, 2H), 2.02 (s, 6H). ¹³C NMR (101 MHz, CDCl₃) δ 204.36, 178.85, 143.01, 135.59, 130.50, 128.25, 127.67, 126.98, 126.84, 123.35, 121.81, 108.87, 48.33, 46.65, 43.77, 30.10. ESI-MS: *m/z* calcd for [C₂₁H₂₁NO₃, M + Na]⁺ : 358.1414, found: 358.1435. IR ν (cm⁻¹) 1701, 1609, 1464, 1404, 1361, 1167, 743, 643.

(*R*)-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3a)

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 68% yield. White solid, mp 109 – 110 °C, 93% *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 80/20, flow rate: 1.0 mL·min⁻¹, λ = 254.4 nm, *t* (minor) =

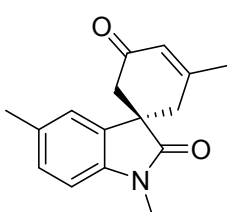


3a

6.939, *t* (major) = 8.564], [α]_D²⁰ = +78.8 (c 0.25, CHCl₃). ¹H NMR (400 MHz, CDCl₃) δ 7.30 (td, *J* = 7.8, 1.0 Hz, 1H), 7.24 (d, *J* = 7.4 Hz,

1H), 6.98 (td, $J = 7.6, 0.7$ Hz, 1H), 6.88 (d, $J = 7.8$ Hz, 1H), 6.17 (s, 1H), 3.25 (s, 3H), 3.01 (dd, $J = 18.2, 1.0$ Hz, 1H), 2.91 (d, $J = 16.2$ Hz, 1H), 2.27 (dd, $J = 26.1, 17.3$ Hz, 2H), 2.01 (s, 3H). ^{13}C NMR (101 MHz, CDCl_3) δ 195.78, 177.15, 158.39, 141.92, 132.37, 128.27, 126.19, 122.48, 122.45, 108.07, 48.52, 42.40, 37.67, 26.04, 24.00. ESI-MS: m/z calcd for $[\text{C}_{15}\text{H}_{15}\text{NO}_2, \text{M} + \text{Na}]^+$: 264.0995, found: 264.0991. IR ν (cm^{-1}) 3053, 2945, 2917, 2905, 1702, 1665, 1611, 1493, 1376, 758.

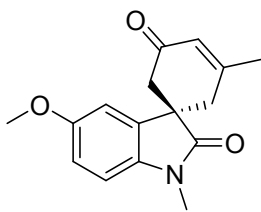
(R)-1',3,5'-trimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3b)



3b

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 60% yield. White solid, mp 119 – 120 °C, 87% *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 80/20, flow rate: 1.0 mL·min⁻¹, $\lambda = 254.4$ nm, t (minor) = 6.200, t (major) = 7.720], $[\alpha]_{\text{D}}^{20} = +196.92$ (c 0.26, CHCl_3). ^1H NMR (400 MHz, CDCl_3) δ 7.09 (d, $J = 7.9$ Hz, 1H), 7.03 (s, 1H), 6.77 (d, $J = 7.9$ Hz, 1H), 6.17 (s, 1H), 3.22 (s, 3H), 3.00 (dd, $J = 18.3, 1.0$ Hz, 1H), 2.90 (d, $J = 16.2$ Hz, 1H), 2.31 (s, 1H), 2.27 (s, 3H), 2.23 (d, $J = 18.5$ Hz, 1H), 2.02 (s, 3H). ^{13}C NMR (101 MHz, CDCl_3) δ 195.95, 177.10, 158.50, 139.52, 132.48, 132.09, 128.48, 126.16, 123.24, 107.81, 48.56, 42.42, 37.69, 26.05, 24.02, 20.64. ESI-MS: m/z calcd for $[\text{C}_{16}\text{H}_{17}\text{NO}_2, \text{M} + \text{Na}]^+$: 278.1151, found: 278.1148. IR ν (cm^{-1}) 3059, 2959, 2921, 2849, 1707, 1699, 1662, 1633, 1618, 1602, 1501, 1365, 1094, 824.

(R)-5'-methoxy-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3c)



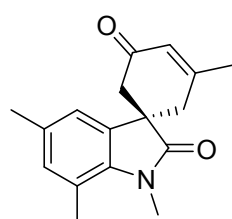
3c

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 64% yield. Light yellow solid, mp 144 – 145 °C, 85% *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 80/20, flow rate: 1.0 mL·min⁻¹, $\lambda = 254.4$ nm, t (minor) = 8.098, t (major) = 9.290], $[\alpha]_{\text{D}}^{20} = +365.71$ (c 0.18, CHCl_3). ^1H NMR (400 MHz, CDCl_3) δ 6.86-6.77 (m, 3H), 6.16 (s, 1H), 3.74 (s, 3H), 3.22 (s, 3H), 3.01 (d, $J = 18.3$ Hz, 1H), 2.91 (d, $J = 16.3$ Hz, 1H), 2.27 (dd, $J = 28.3, 17.4$ Hz, 2H), 2.01 (s, 3H). ^{13}C NMR (101 MHz, CDCl_3) δ 195.65, 176.79, 158.41, 155.60,

135.42, 133.69, 126.15, 111.81, 110.64, 108.28, 55.33, 48.86, 42.38, 37.57, 26.11, 24.01. ESI-MS: m/z calcd for $[C_{16}H_{17}NO_3, M + Na]^+$: 294.1101, found: 294.1097. IR ν (cm^{-1}) 3024, 2959, 2919, 2836, 1697, 1659, 1628, 1597, 1500, 1046, 809.

(R)-1',3,5',7'-tetramethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3d)

The title compound was isolated by column chromatography (petroleum ether/ethyl



3d

acetate = 2:1) in 78% yield. White solid, mp 191 – 192 °C, 92% *ee*

[Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 90/10, flow rate: 1.0

$mL \cdot min^{-1}$, $\lambda = 254.4$ nm, t (minor) = 10.058, t (major) = 13.931],

$[\alpha]_D^{20} = +244.0$ (c 0.08, $CHCl_3$). 1H NMR (400 MHz, $CDCl_3$) δ 6.85

(d, $J = 18.0$ Hz, 2H), 6.15 (s, 1H), 3.49 (s, 3H), 2.96 (dd, $J = 18.3$,

1.1 Hz, 1H), 2.87 (d, $J = 16.3$ Hz, 1H), 2.54 (s, 3H), 2.31-2.25 (m, 2H), 2.21 (s, 3H),

2.00 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 196.09, 178.00, 158.38, 133.33, 132.42,

131.94, 126.10, 120.92, 119.39, 47.82, 42.63, 37.99, 29.41, 24.00, 20.31, 18.49. ESI-

MS: m/z calcd for $[C_{17}H_{19}NO_2, M + Na]^+$: 292.1308, found: 292.1300. IR ν (cm^{-1})

2959, 2919, 2850, 1698, 1666, 1601, 1477, 1348, 1085, 800.

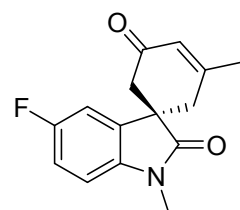
(R)-5'-fluoro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3e)

The title compound was isolated by column chromatography (petroleum ether/ethyl

acetate = 2:1) in 63% yield. Light yellow solid, mp 112 – 113 °C, 71% *ee* [Daicel

Chiralpak AD-H, hexanes/*i*-PrOH = 80/20, flow rate: 1.0 $mL \cdot min^{-1}$,

$\lambda = 254.4$ nm, t (minor) = 7.664, t (major) = 9.271], $[\alpha]_D^{20} = +86.7$



3e

(c 0.45, $CHCl_3$). 1H NMR (400 MHz, $CDCl_3$) δ 7.06 – 6.95 (m,

2H), 6.80 (dd, $J = 8.2, 4.1$ Hz, 1H), 6.18 (s, 1H), 3.23 (s, 3H), 3.03

(d, $J = 19.3$ Hz, 1H), 2.92 (d, $J = 16.3$ Hz, 1H), 2.31 (d, $J = 6.5$

Hz, 1H), 2.25 – 2.18 (m, 1H), 2.03 (s, 3H). ^{13}C NMR (101 MHz,

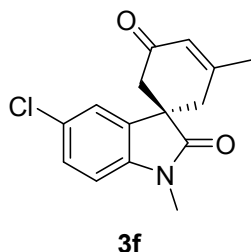
$CDCl_3$) δ 195.22, 176.79, 158.67 (d, $J = 240.1$ Hz), 158.20, 137.90, 133.71 (d, $J = 7.9$

Hz), 126.23, 114.48 (d, $J = 23.3$ Hz), 110.89 (d, $J = 25.1$ Hz), 108.56 (d, $J = 8.2$ Hz),

48.89, 42.23, 37.42, 26.18, 24.00. ^{19}F NMR (376 MHz, $CDCl_3$) δ -119.46. ESI-MS:

m/z calcd for $[C_{15}H_{14}FNO_2, M + Na]^+$: 282.0901, found: 282.0911. IR ν (cm^{-1}) 3008, 2918, 2849, 1710, 1669, 1495, 1469, 1353, 752.

(R)-5'-chloro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3f)

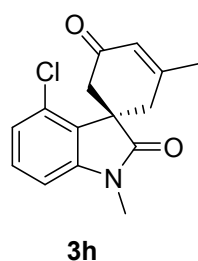


The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 70% yield. White solid, mp 108 – 109 °C, 80% *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 80/20, flow rate: 1.0 mL·min⁻¹, λ = 254.4 nm, t (minor) = 7.771, t (major) = 9.414], $[\alpha]_D^{20}$ = +262.5 (c 0.16, CHCl₃). ¹H NMR (400 MHz, CDCl₃) δ 7.28 (dd, *J* = 6.7, 1.5 Hz, 1H), 7.19 (d, *J* = 2.0 Hz, 1H), 6.81 (d, *J* = 8.3 Hz, 1H), 6.18 (s, 1H), 3.23 (s, 3H), 2.99 (d, *J* = 16.3 Hz, 1H), 2.90 (d, *J* = 16.3 Hz, 1H), 2.29 (d, *J* = 16.3 Hz, 1H), 2.23 (d, *J* = 18.4 Hz, 1H), 2.03 (s, 3H). ¹³C NMR (101 MHz, CDCl₃) δ 195.10, 176.67, 158.14, 140.54, 133.88, 128.27, 127.84, 126.27, 123.01, 109.00, 48.68, 42.16, 37.40, 26.17, 24.02. ESI-MS: m/z calcd for $[C_{15}H_{14}ClNO_2, M + Na]^+$: 298.0605, found: 298.0599. IR ν (cm^{-1}) 2955, 2921, 2851, 1711, 1662, 1609, 1492, 1284, 1101, 824.

(R)-5'-bromo-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3g)

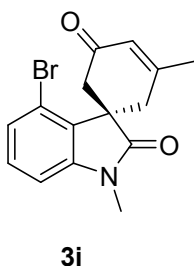
The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 58% yield. White solid, mp 123 – 124 °C, 63% *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 80/20, flow rate: 1.0 mL·min⁻¹, λ = 254.4 nm, t (minor) = 8.011, t (major) = 9.917], $[\alpha]_D^{20}$ = +230.5 (c 0.20, CHCl₃). ¹H NMR (400 MHz, CDCl₃) δ 7.44 (dd, *J* = 8.3, 1.9 Hz, 1H), 7.32 (d, *J* = 1.9 Hz, 1H), 6.76 (d, *J* = 8.3 Hz, 1H), 6.19 (s, 1H), 3.23 (s, 3H), 3.00 (dd, *J* = 18.3, 1.0 Hz, 1H), 2.90 (d, *J* = 16.3 Hz, 1H), 2.30 (d, *J* = 16.5 Hz, 1H), 2.23 (d, *J* = 18.4 Hz, 1H), 2.04 (s, 3H). ¹³C NMR (101 MHz, CDCl₃) δ 195.12, 176.59, 158.21, 141.02, 134.26, 131.22, 126.26, 125.67, 115.17, 109.53, 48.63, 42.14, 37.39, 26.16, 24.05. ESI-MS: m/z calcd for $[C_{15}H_{14}BrNO_2, M + Na]^+$: 342.0100, found: 342.0101. IR ν (cm^{-1}) 2959, 2920, 2850, 1709, 1665, 1635, 1607, 1488, 1364, 1100, 806.

(R)-4'-chloro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3h)



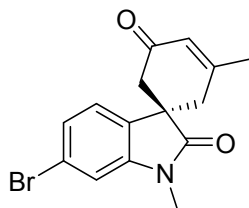
The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 45% yield. White solid, mp 55 – 56 °C, 82% *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 80/20, flow rate: 1.0 mL·min⁻¹, λ = 254.4 nm, t (major) = 7.908, t (minor) = 8.472], [α]_D²⁰ = -53.2 (c 0.50, CHCl₃). ¹H NMR (400 MHz, CDCl₃) δ 7.31 – 7.26 (m, 1H), 7.04 (d, *J* = 8.2 Hz, 1H), 6.78 (d, *J* = 7.8 Hz, 1H), 6.12 (s, 1H), 3.37 (dd, *J* = 17.6, 9.9 Hz, 2H), 3.17 (s, 3H), 2.39 – 2.22 (m, 2H), 2.01 (s, 3H). ¹³C NMR (101 MHz, CDCl₃) δ 195.84, 177.43, 155.81, 144.34, 130.13, 129.65, 126.54, 125.89, 123.68, 106.56, 48.49, 38.48, 33.77, 25.92, 23.70. ESI-MS: *m/z* calcd for [C₁₅H₁₄ClNO₂, M + Na]⁺ : 298.0605, found: 298.0613. IR ν (cm⁻¹) 3060, 2919, 2849, 1713, 1666, 1606, 1458, 1112, 775.

(R)-4'-bromo-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3i)



The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 53% yield. White solid, mp 92 – 93 °C, 88% *ee* [Daicel Chiralcel OJ-H, hexanes/*i*-PrOH = 90/10, flow rate: 1.0 mL·min⁻¹, λ = 254.4 nm, t (minor) = 37.503, t (major) = 45.901], [α]_D²⁰ = -38.3 (c 0.18, CHCl₃). ¹H NMR (400 MHz, CDCl₃) δ 7.24 – 7.14 (m, 2H), 6.81 (dd, *J* = 7.0, 1.6 Hz, 1H), 6.12 (s, 1H), 3.54 (d, *J* = 16.6 Hz, 1H), 3.47 (dd, *J* = 18.8, 1.2 Hz, 1H), 3.16 (s, 3H), 2.30 (d, *J* = 16.6 Hz, 1H), 2.23 (d, *J* = 18.8 Hz, 1H), 2.00 (s, 3H). ¹³C NMR (101 MHz, CDCl₃) δ 195.78, 177.52, 155.57, 144.61, 129.85, 127.85, 126.83, 125.95, 118.50, 107.06, 49.08, 38.22, 33.56, 25.83, 23.72. ESI-MS: *m/z* calcd for [C₁₅H₁₄BrNO₂, M + H]⁺ : 320.0281, found: 320.0272. IR ν (cm⁻¹) 2919, 2850, 1712, 1666, 1601, 1577, 1455, 1340, 1103, 773, 732.

(R)-6'-bromo-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3j)

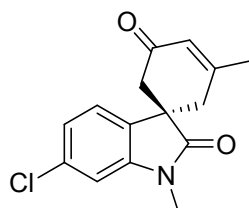


3j

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 68 % yield. White solid, mp 124 – 125 °C, 73 % *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 80/20, flow rate: 1.0 mL·min⁻¹, λ = 254.4 nm, t (minor) = 7.593, t (major) = 8.522], [α]_D²⁰ = +225.0 (c 0.30, CHCl₃). ¹H NMR (400 MHz, CDCl₃) δ 7.11 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.08 (d, *J* = 7.9 Hz, 1H), 7.03 (d, *J* = 1.3 Hz, 1H), 6.16 (s, 1H), 3.22 (s, 3H), 3.00 (dd, *J* = 18.2, 1.1 Hz, 1H), 2.90 (d, *J* = 16.3 Hz, 1H), 2.28 (d, *J* = 16.2 Hz, 1H), 2.20 (d, *J* = 18.4 Hz, 1H), 2.01 (s, 3H). ¹³C NMR (101 MHz, CDCl₃) δ 195.27, 176.93, 158.13, 143.35, 131.17, 126.23, 125.19, 123.74, 121.95, 111.63, 48.33, 42.18, 37.52, 26.15, 23.99. ESI-MS: *m/z* calcd for [C₁₅H₁₄BrNO₂, M + H]⁺ : 320.0281, found: 320.0272. IR ν (cm⁻¹) 3059, 2961, 2921, 2851, 1707, 1661, 1602, 1370, 1248, 1091, 805.

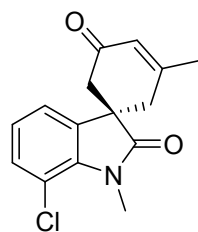
(R)-6'-chloro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3k)

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 55 % yield. Light yellow solid, mp 155 – 156 °C, 75 % *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 80/20, flow rate: 1.0 mL·min⁻¹, λ = 254.4 nm, t (minor) = 7.337, t (major) = 8.232], [α]_D²⁰ = +300.6 (c 0.16, CHCl₃). ¹H NMR (400 MHz, CDCl₃) δ 7.14 (d, *J* = 8.0 Hz, 1H), 6.95 (dd, *J* = 8.0, 1.9 Hz, 1H), 6.88 (d, *J* = 1.8 Hz, 1H), 6.17 (s, 1H), 3.23 (s, 3H), 3.01 (dd, *J* = 18.2, 1.1 Hz, 1H), 2.90 (d, *J* = 16.2 Hz, 1H), 2.28 (d, *J* = 16.6 Hz, 1H), 2.20 (d, *J* = 18.4 Hz, 1H), 2.01 (s, 3H). ¹³C NMR (101 MHz, CDCl₃) δ 195.34, 177.08, 158.20, 143.22, 134.21, 130.61, 126.22, 123.38, 122.23, 108.86, 48.28, 42.26, 37.59, 26.15, 23.99. ESI-MS: *m/z* calcd for [C₁₅H₁₄ClNO₂, M + Na]⁺ : 298.0605, found: 298.0596. IR ν (cm⁻¹) 3061, 2959, 2919, 2850, 1705, 1662, 1606, 1493, 1372, 1092, 799.



3k

(R)-7'-chloro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3l)



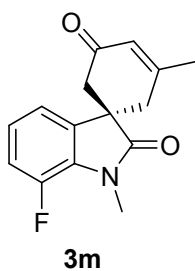
3l

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 68 % yield. White solid, mp

92 – 93 °C, 75 % *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 80/20, flow rate: 1.0 mL·min⁻¹, λ = 254.4 nm, t (minor) = 7.337, t (major) = 8.232], [α]_D²⁰ = +300.6 (c 0.16, CHCl₃). ¹H NMR (400 MHz, CDCl₃) δ 7.22 (dd, *J* = 8.2, 1.1 Hz, 1H), 7.14 (dd, *J* = 7.5, 1.1 Hz, 1H), 6.93 – 6.84 (m, 1H), 6.16 (s, 1H), 3.62 (s, 3H), 2.99 (dd, *J* = 18.3, 1.1 Hz, 1H), 2.89 (d, *J* = 16.3 Hz, 1H), 2.30 (d, *J* = 16.3 Hz, 1H), 2.28 – 2.22 (d, *J* = 18.3 Hz, 1H), 2.01 (s, 3H). ¹³C NMR (101 MHz, CDCl₃) δ 195.30, 177.50, 158.01, 137.88, 135.09, 130.62, 126.16, 123.29, 120.83, 115.54, 48.13, 42.36, 37.77, 29.53, 23.96. ESI-MS: *m/z* calcd for [C₁₅H₁₄ClNO₂, M + H]⁺ : 276.0786, found: 276.0778. IR ν (cm⁻¹) 2951, 2918, 2887, 2849, 1712, 1669, 1603, 1462, 789.

(*R*)-7'-fluoro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3m)

The title compound was isolated by column chromatography (petroleum ether/ethyl



acetate = 2:1) in 55 % yield. White solid, mp 110 – 111 °C, 82%

ee [Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 80/20, flow rate:

1.0 mL·min⁻¹, λ = 254.4 nm, t (minor) = 6.404, t (major) = 7.493],

[α]_D²⁰ = +132.2 (c 0.09, CHCl₃). ¹H NMR (400 MHz, CDCl₃) δ

7.07 – 6.99 (m, 2H), 6.90 (ddd, *J* = 8.6, 7.5, 4.6 Hz, 1H), 6.17 (s,

1H), 3.46 (d, *J* = 2.9 Hz, 3H), 3.00 (dd, *J* = 18.3, 1.1 Hz, 1H), 2.91 (d, *J* = 16.3 Hz, 1H),

2.34 – 2.21 (m, 2H), 2.01 (s, 3H). ¹³C NMR (101 MHz, CDCl₃) δ 195.35, 176.79,

158.08, 148.68, 146.25, 135.16 (d, *J* = 2.8 Hz), 126.18, 123.14 (d, *J* = 6.3 Hz), 118.26 (d,

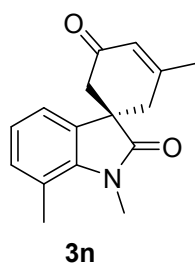
J = 7.2 Hz), 116.25 (d, *J* = 19 Hz), 48.77, 42.38, 37.69, 28.54 (d, *J* = 5.9 Hz), 23.97.

¹⁹F NMR (376 MHz, CDCl₃) δ -135.69. ESI-MS: *m/z* calcd for [C₁₅H₁₄FNO₂, M +

Na]⁺ : 282.0901, found: 282.0905. IR ν (cm⁻¹) 2955, 2920, 2850, 1707, 1667, 1629,

1479, 1241, 1124, 788.

(*R*)-1',3,7'-trimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3n)



The title compound was isolated by column chromatography

(petroleum ether/ethyl acetate = 2:1) in 79% yield. White solid, mp

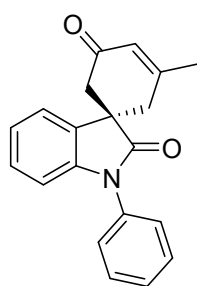
173 – 174 °C, 86% *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH =

80/20, flow rate: 1.0 mL·min⁻¹, λ = 254.4 nm, t (major) = 7.207, t

(minor) = 8.642], $[\alpha]_D^{20} = +148.9$ (c 0.65, CHCl_3). $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.08 (d, $J = 7.4$ Hz, 1H), 7.02 (d, $J = 7.7$ Hz, 1H), 6.86 (t, $J = 7.6$ Hz, 1H), 6.15 (s, 1H), 3.52 (s, 3H), 2.97 (dd, $J = 18.3, 1.1$ Hz, 1H), 2.88 (d, $J = 16.3$ Hz, 1H), 2.59 (s, 3H), 2.32–2.26 (m, 2H), 2.00 (s, 3H). $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ 195.95, 178.05, 158.32, 139.62, 133.13, 131.98, 126.11, 122.42, 120.25, 119.72, 47.76, 42.61, 37.96, 29.46, 23.98, 18.67. ESI–MS: m/z calcd for $[\text{C}_{16}\text{H}_{17}\text{NO}_2, \text{M} + \text{Na}]^+$: 278.1151, found: 278.1152. IR ν (cm^{-1}) 3010, 2981, 2948, 2923, 1698, 1672, 1598, 1459, 1367, 745.

(*R*)-3-methyl-1'-phenylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3o)

The title compound was isolated by column chromatography (petroleum ether/ethyl



3o

acetate = 2:1) in 63% yield. White solid, mp 128 – 129 °C, 95% *ee*

[Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 95/5, flow rate: 1.0

$\text{mL} \cdot \text{min}^{-1}$, $\lambda = 254.4$ nm, t (minor) = 24.440, t (major) = 26.415],

$[\alpha]_D^{20} = +122.8$ (c 0.50, CHCl_3). $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 7.54

(t, $J = 7.7$ Hz, 2H), 7.47 – 7.38 (m, 3H), 7.31 (d, $J = 7.2$ Hz, 1H),

7.22 (td, $J = 7.8, 1.0$ Hz, 1H), 7.01 (t, $J = 7.6$ Hz, 1H), 6.86 (d, $J =$

7.9 Hz, 1H), 6.21 (s, 1H), 3.13 (d, $J = 18.2$ Hz, 1H), 3.02 (d, $J = 16.2$

Hz, 1H), 2.44 (dd, $J = 22.8, 17.4$ Hz, 2H), 2.05 (s, 3H). $^{13}\text{C NMR}$ (101 MHz, CDCl_3) δ

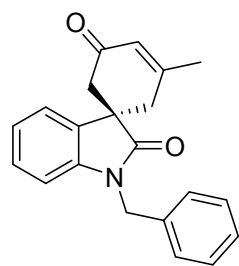
195.58, 176.64, 158.28, 141.88, 133.61, 132.20, 129.23, 128.18, 127.85, 126.25,

126.04, 122.95, 122.76, 109.43, 48.71, 42.72, 37.96, 24.04. ESI–MS: m/z calcd for

$[\text{C}_{20}\text{H}_{17}\text{NO}_2, \text{M} + \text{Na}]^+$: 326.1151, found: 326.1155. IR ν (cm^{-1}) 3060, 2981, 2917,

2822, 1715, 1676, 1633, 1608, 1592, 1453, 1203, 698.

(*R*)-1'-benzyl-3-methylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3p)



3p

The title compound was isolated by column chromatography

(petroleum ether/ethyl acetate = 2:1) in 60% yield. White solid, mp

43 – 44 °C, 89% *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH =

85/15, flow rate: 1.0 $\text{mL} \cdot \text{min}^{-1}$, $\lambda = 254.4$ nm, t (minor) = 10.105, t

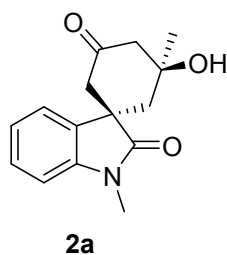
(major) = 11.644], $[\alpha]_D^{20} = +232.3$ (c 0.64, CHCl_3). $^1\text{H NMR}$ (400

MHz, CDCl_3) δ 7.32–7.17 (m, 7H), 6.93 (t, $J = 7.3$ Hz, 1H), 6.76

(d, $J = 7.6$ Hz, 1H), 6.19 (s, 1H), 4.93 (s, 2H), 3.04 (dd, $J = 40.3, 17.3$ Hz, 2H), 2.34 (dd, $J = 24.4, 13.0$ Hz, 2H), 2.03 (s, 3H). ^{13}C NMR (101 MHz, CDCl_3) δ 195.68, 177.31, 158.38, 140.98, 135.01, 132.35, 128.43, 128.20, 127.31, 126.64, 126.24, 122.54, 122.51, 109.14, 48.55, 43.39, 42.62, 37.73, 24.03. ESI-MS: m/z calcd for $[\text{C}_{21}\text{H}_{19}\text{NO}_2, \text{M} + \text{Na}]^+$: 340.1308, found: 340.1310. IR ν (cm^{-1}) 3058, 3031, 2915, 2854, 1708, 1666, 1637, 1609, 1486, 1410, 1377, 730.

(1R,3S)-3-hydroxy-1',3-dimethylspiro[cyclohexane-1,3'-indoline]-2',5-dione (2a)

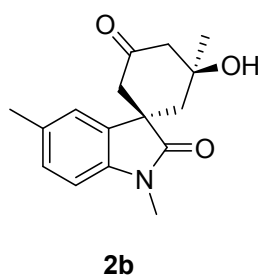
The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 68% yield. White solid, mp 195 – 196 °C, 1:20 *dr*, 99% *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 80/20, flow rate: 1.0 $\text{mL} \cdot \text{min}^{-1}$, $\lambda = 254.4$ nm, t (minor) = 9.559, t (major) = 11.949], $[\alpha]_{\text{D}}^{20} = +74.4$ (c 0.25, CHCl_3).



MHz, CDCl_3) δ 7.34 (td, $J = 7.7, 1.0$ Hz, 1H), 7.23 (d, $J = 6.9$ Hz, 1H), 7.16 (t, $J = 7.5$ Hz, 1H), 6.89 (d, $J = 7.8$ Hz, 1H), 5.84 (s, 1H), 3.22 (s, 3H), 2.80 (dt, $J = 14.8, 2.1$ Hz, 1H), 2.74 – 2.65 (m, 2H), 2.42 (dt, $J = 14.4, 1.9$ Hz, 1H), 2.31 (d, $J = 14.9$ Hz, 1H), 2.07 (dt, $J = 15.0, 2.0$ Hz, 1H), 1.41 (s, 3H). ^{13}C NMR (101 MHz, CDCl_3) δ 205.73, 180.48, 141.86, 131.51, 128.53, 123.31, 121.90, 108.51,

73.05, 54.02, 50.70, 46.65, 42.54, 30.77, 26.11. ESI-MS: m/z calcd for $[\text{C}_{15}\text{H}_{17}\text{NO}_3, \text{M} + \text{Na}]^+$: 282.1104, found: 282.1100. IR ν (cm^{-1}) 3345, 3059, 2961, 2923, 2873, 1712, 1683, 1609, 1492, 1471, 1377, 1360, 753.

(1R,3S)-3-hydroxy-1',3,5'-trimethylspiro[cyclohexane-1,3'-indoline]-2',5-dione (2b)

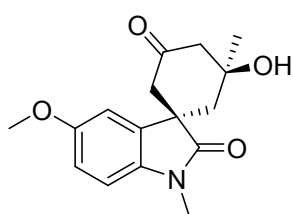


The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 56% yield. White solid, mp 199 – 200 °C, 1:11 *dr*, 95% *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 90/10, flow rate: 1.0 $\text{mL} \cdot \text{min}^{-1}$, $\lambda = 254.4$ nm, t (minor) = 15.554, t (major) = 20.370], $[\alpha]_{\text{D}}^{20} = +584.0$ (c 0.15,

CHCl_3). ^1H NMR (400 MHz, CDCl_3) δ 7.13 (dd, $J = 7.9, 0.7$ Hz, 1H), 7.05 (s, 1H), 6.77 (d, $J = 7.9$ Hz, 1H), 5.88 (s, 1H), 3.20 (s, 3H), 2.83 – 2.76 (m, 1H), 2.67 (t, $J = 14.8$ Hz,

2H), 2.42 (dt, $J = 14.4, 1.9$ Hz, 1H), 2.37 (s, 3H), 2.30 (d, $J = 3.8$ Hz, 1H), 2.06 (dt, $J = 14.9, 2.1$ Hz, 1H), 1.41 (d, $J = 0.8$ Hz, 3H). ^{13}C NMR (101 MHz, CDCl_3) δ 205.81, 180.38, 139.47, 133.01, 131.55, 128.71, 122.75, 108.22, 72.98, 54.03, 50.73, 46.72, 42.63, 30.79, 26.11, 20.70. ESI-MS: m/z calcd for $[\text{C}_{16}\text{H}_{19}\text{NO}_3, \text{M} + \text{Na}]^+$: 296.1257, found: 296.1258. IR ν (cm^{-1}) 3395, 3331, 2964, 2920, 2850, 1711, 1677, 1604, 1501, 1433, 1370, 1261, 1099, 815.

(1R,3S)-3-hydroxy-5'-methoxy-1',3-dimethylspiro[cyclohexane-1,3'-indoline]-2',5-dione (2c)

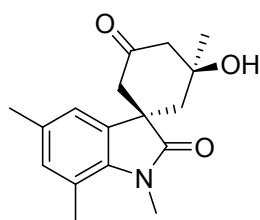


2c

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 59% yield. White solid, mp 193 – 194 °C, 1:3 *dr*, 82% *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 80/20, flow rate: 1.0 mL·min⁻¹, $\lambda = 254.4$ nm, t (minor) = 10.348, t (major) = 16.768], $[\alpha]_{\text{D}}^{20} = +363.2$ (c 0.30, CHCl_3). ^1H NMR (400 MHz, CDCl_3) δ 6.87 – 6.77 (m, 3H), 5.93 (s, 1H), 3.82 (s, 3H), 3.19 (s, 3H), 2.82 – 2.75 (m, 1H), 2.67 (dd, $J = 22.7, 14.6$ Hz, 2H), 2.45 – 2.39 (m, 1H), 2.27 (d, $J = 15.2$ Hz, 1H), 2.07 (dd, $J = 14.9, 1.9$ Hz, 1H), 1.41 (s, 3H). ^{13}C NMR (101 MHz, CDCl_3) δ 205.64, 180.04, 156.44, 135.18, 132.82, 112.34, 109.68, 108.90, 72.96, 55.40, 54.02, 51.05, 46.71, 42.63, 30.76, 26.17. ESI-MS: m/z calcd for $[\text{C}_{16}\text{H}_{19}\text{NO}_4, \text{M} + \text{Na}]^+$: 312.1206, found: 312.1208. IR ν (cm^{-1}) 3318, 2961, 2922, 2850, 2833, 1709, 1672, 1603, 1500, 1032, 803.

(1R,3S)-3-hydroxy-1',3,5',7'-tetramethylspiro[cyclohexane-1,3'-indoline]-2',5-dione (2d)

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 80% yield. White solid, mp 196 – 197 °C, 1:20 *dr*, 93% *ee* [Daicel Chiralpak AD-H, hexanes/*i*-PrOH = 85/15, flow rate: 1.0 mL·min⁻¹, $\lambda = 254.4$ nm, t (minor) = 8.447, t (major) = 9.225], $[\alpha]_{\text{D}}^{20} = +166.2$ (c 0.23, CHCl_3). ^1H NMR (400 MHz, CDCl_3) δ 6.87 (d, $J = 2.9$ Hz, 2H), 5.97 (s, 1H), 3.45 (s, 3H), 2.78 (dt, $J = 14.6, 2.2$ Hz, 1H), 2.65 (dd, $J = 26.3, 14.5$ Hz,

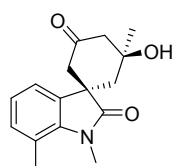


2d

2H), 2.53 (s, 3H), 2.38 (dt, $J = 14.4$, 2.0 Hz, 1H), 2.31 (s, 3H), 2.27 – 2.22 (m, 1H), 2.02 (dt, $J = 14.9$, 2.1 Hz, 1H), 1.40 (d, $J = 0.7$ Hz, 3H). ^{13}C NMR (101 MHz, CDCl_3) δ 205.81, 180.38, 139.47, 133.01, 131.55, 128.71, 122.75, 108.22, 72.98, 54.03, 50.73, 46.72, 42.63, 30.79, 26.11, 20.70. ESI–MS: m/z calcd for $[\text{C}_{17}\text{H}_{21}\text{NO}_3, \text{M} + \text{Na}]^+$: 310.1414, found: 310.1418. IR ν (cm^{-1}) 3331, 2968, 2920, 2850, 1716, 1671, 1603, 1365, 1224, 1134, 919, 645.

(1R,3S)-3-hydroxy-1',3,7'-trimethylspiro[cyclohexane-1,3'-indoline]-2',5-dione

(2e)



2e

The title compound was isolated by column chromatography (petroleum ether/ethyl acetate = 2:1) in 81% yield. White solid, mp 173 – 174 °C, 1:20 *dr*, 86% *ee* [Daicel Chiralcel AD-H, hexanes/*i*-PrOH = 80/20, flow rate: 1.0 mL·min⁻¹, $\lambda = 254.4$ nm, t (minor) = 8.437, t (major) = 9.320], $[\alpha]_{\text{D}}^{20} = +38.3$ (c 0.35, CHCl_3). ^1H NMR (400 MHz, CDCl_3) δ 7.10 – 6.98 (m, 3H), 5.90 (s, 1H), 3.48 (s, 3H), 2.79 (dt, $J = 14.6$, 2.0 Hz, 1H), 2.73 – 2.59 (m, 2H), 2.58 (s, 3H), 2.40 (dd, $J = 16.2$, 1.9 Hz, 1H), 2.25 (d, $J = 14.8$ Hz, 1H), 2.04 (d, $J = 14.8$ Hz, 1H), 1.40 (s, 3H). ^{13}C NMR (101 MHz, CDCl_3) δ 205.80, 181.11, 139.60, 132.18, 132.16, 123.12, 120.21, 119.82, 72.97, 54.02, 50.03, 46.97, 42.87, 30.80, 29.45, 18.35. ESI–MS: m/z calcd for $[\text{C}_{16}\text{H}_{19}\text{NO}_3, \text{M} + \text{Na}]^+$: 296.1257, found: 296.1266. IR ν (cm^{-1}) 3383, 3260, 2989, 2920, 2850, 1709, 1674, 1458, 1374, 743.

4. Single-Crystal X-ray Crystallography of 2a

Crystal data and structure refinement for **2a**

Empirical formula	$\text{C}_{15} \text{H}_{18} \text{N} \text{O}_3$
Formula weight	260.30
Temperature	140(2) K
Wavelength	1.54178 Å
Crystal system	Triclinic
Space group	P 1

Unit cell dimensions	a = 5.9370(3) Å	α = 105.428(4)°.
	b = 5.9425(3) Å	β = 101.284(4)°.
	c = 10.0505(7) Å	γ = 99.757(3)°.
Volume	325.87(3) Å ³	
Z	1	
Density (calculated)	1.326 Mg/m ³	
Absorption coefficient	0.750 mm ⁻¹	
F(000)	139	
Crystal size	0.320 x 0.200 x 0.150 mm ³	
Theta range for data collection	4.718 to 65.989°.	
Index ranges	-7 ≤ h ≤ 7, -6 ≤ k ≤ 7, -11 ≤ l ≤ 11	
Reflections collected	2435	
Independent reflections	1466 [R(int) = 0.0296]	
Completeness to theta = 67.679°	89.8 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.753 and 0.594	
Refinement method	Full-matrix least-squares on F ²	
Data / restraints / parameters	1466 / 3 / 175	
Goodness-of-fit on F ²	1.156	
Final R indices [I > 2σ(I)]	R ₁ = 0.0508, wR ₂ = 0.1544	
R indices (all data)	R ₁ = 0.0509, wR ₂ = 0.1544	
Absolute structure parameter	0.29(17)	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.337 and -0.309 e.Å ⁻³	

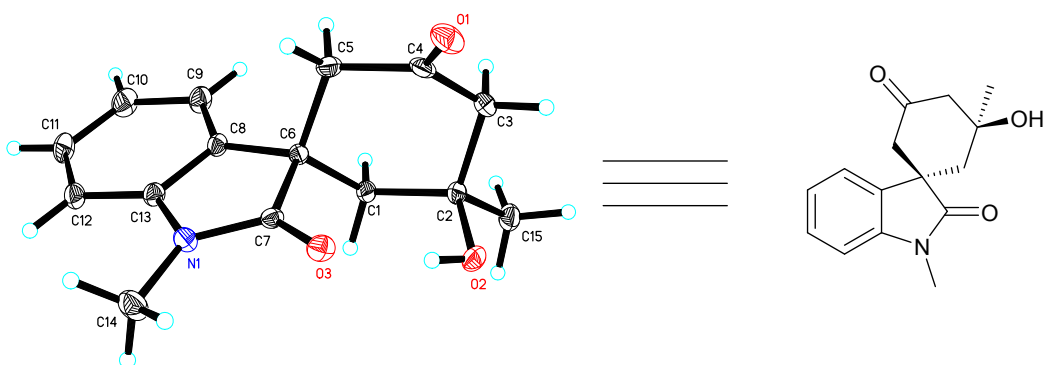


Figure S1. X-ray structure of compound **2a**.

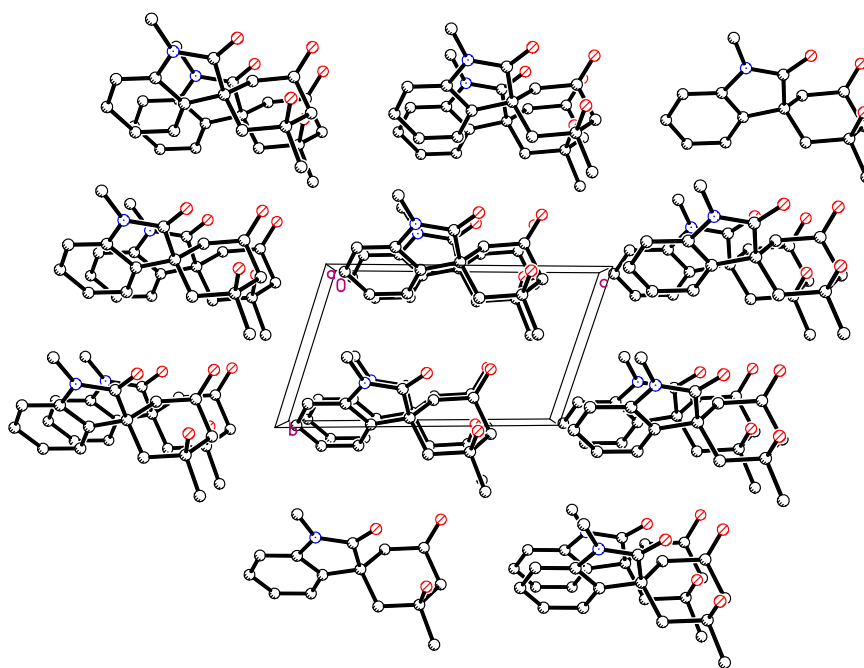
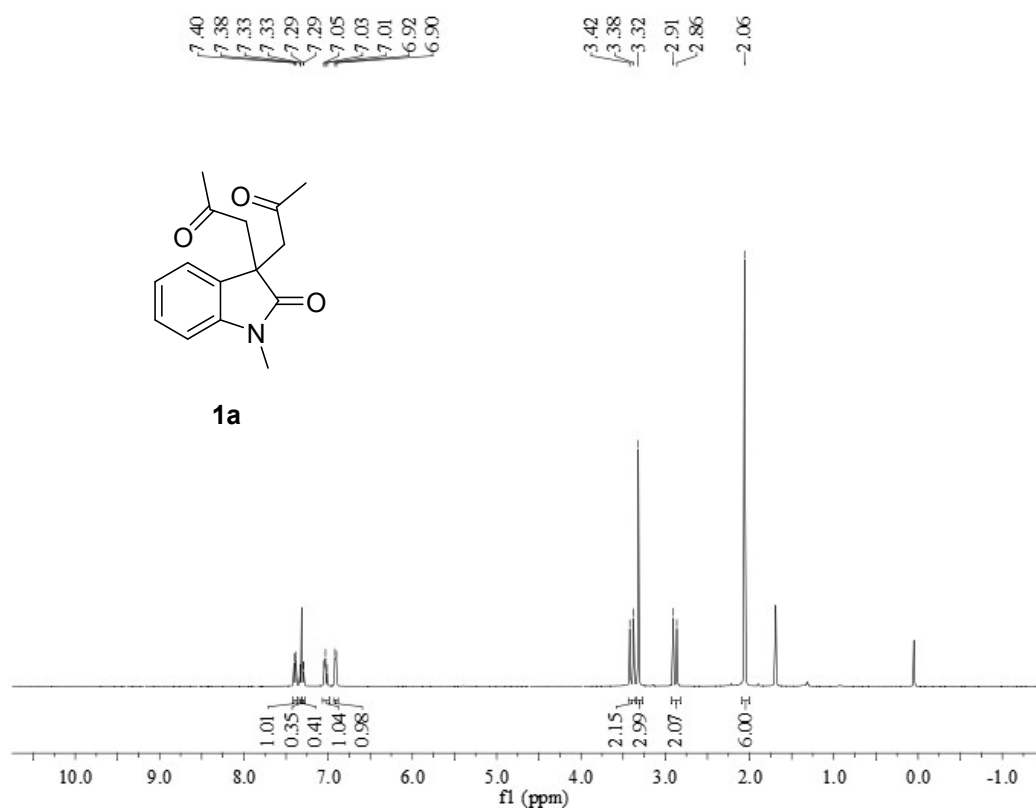


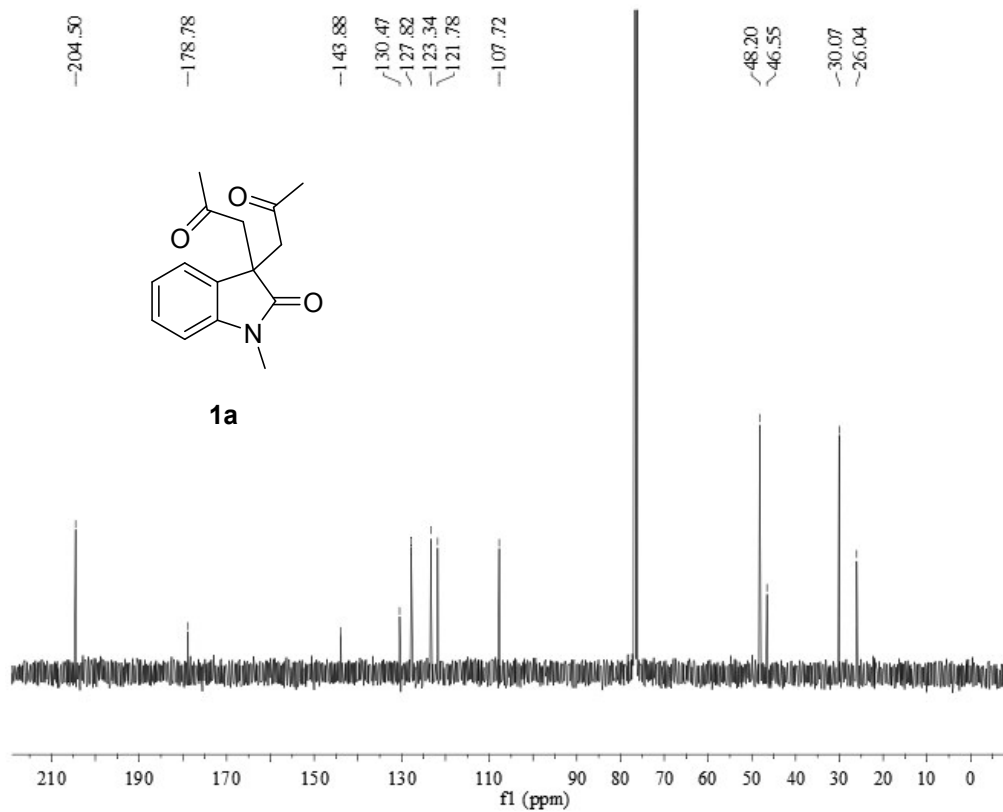
Figure S2. Packing of molecules in a unit cell for **2a**.

The crystal was prepared from the solution of **2a** in ethyl acetate and n-hexane. CCDC 1011578 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

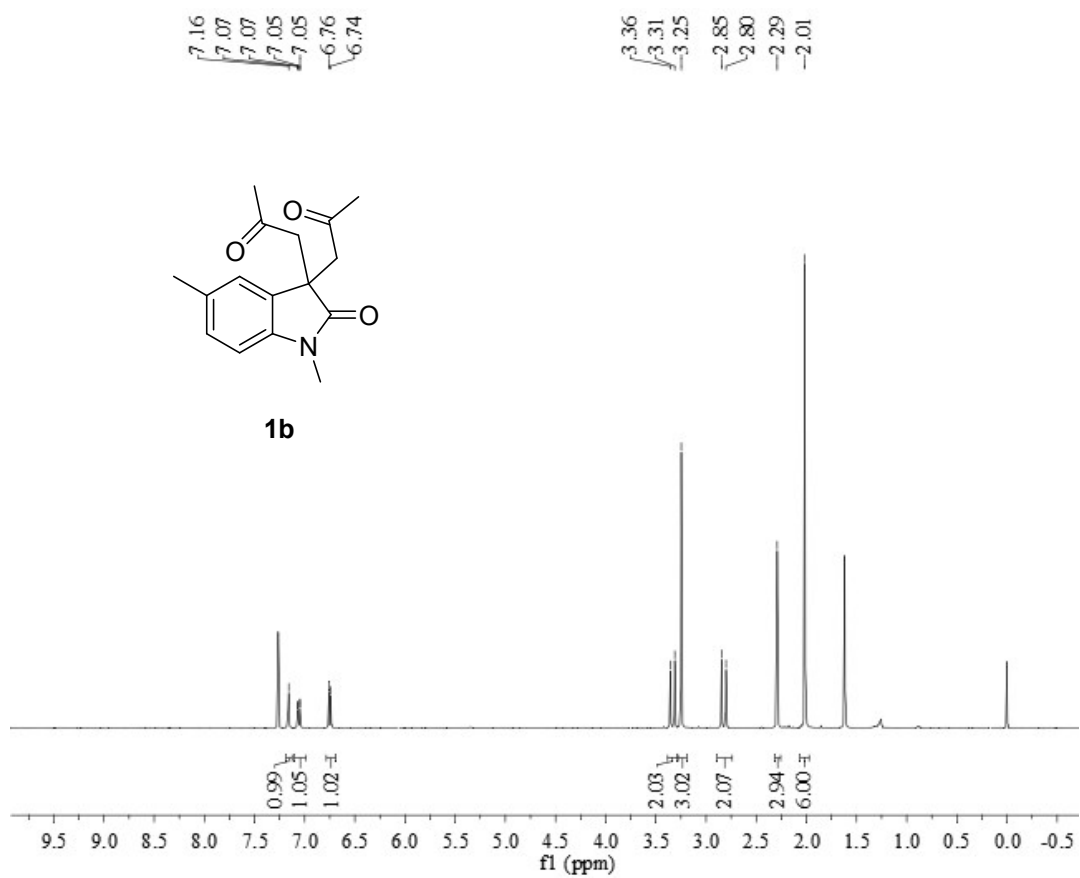
5. ¹H NMR and ¹³C NMR spectra

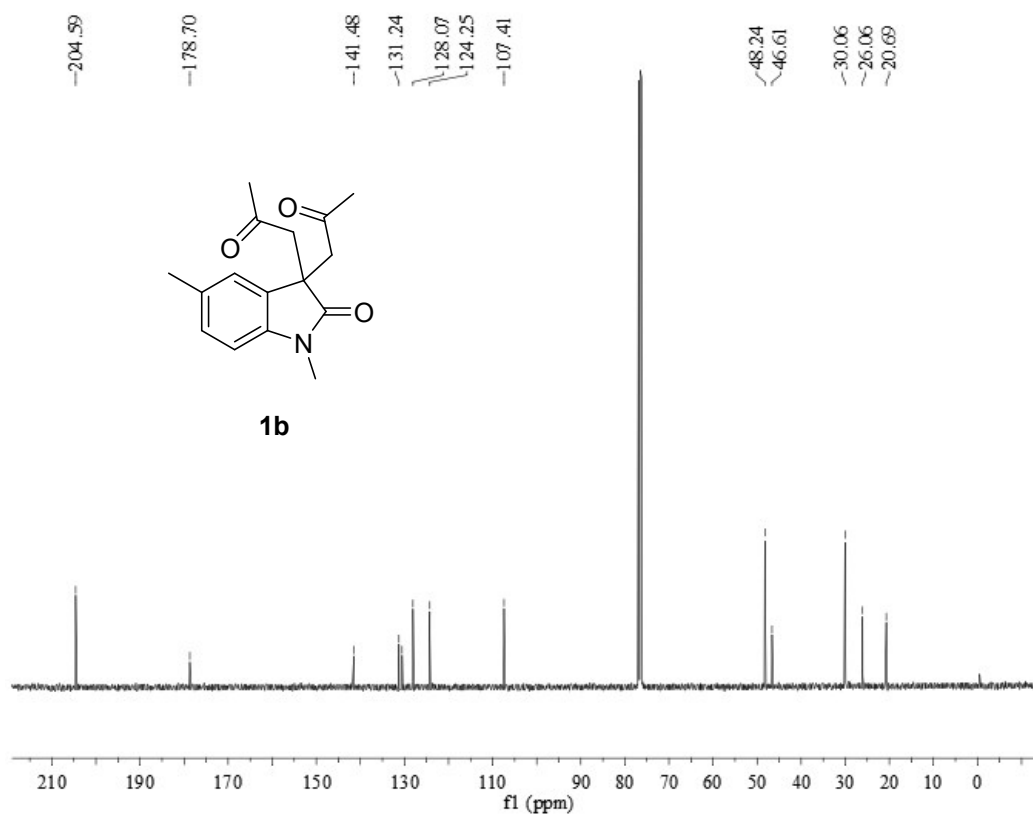
1,1'-(1-methyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1a)



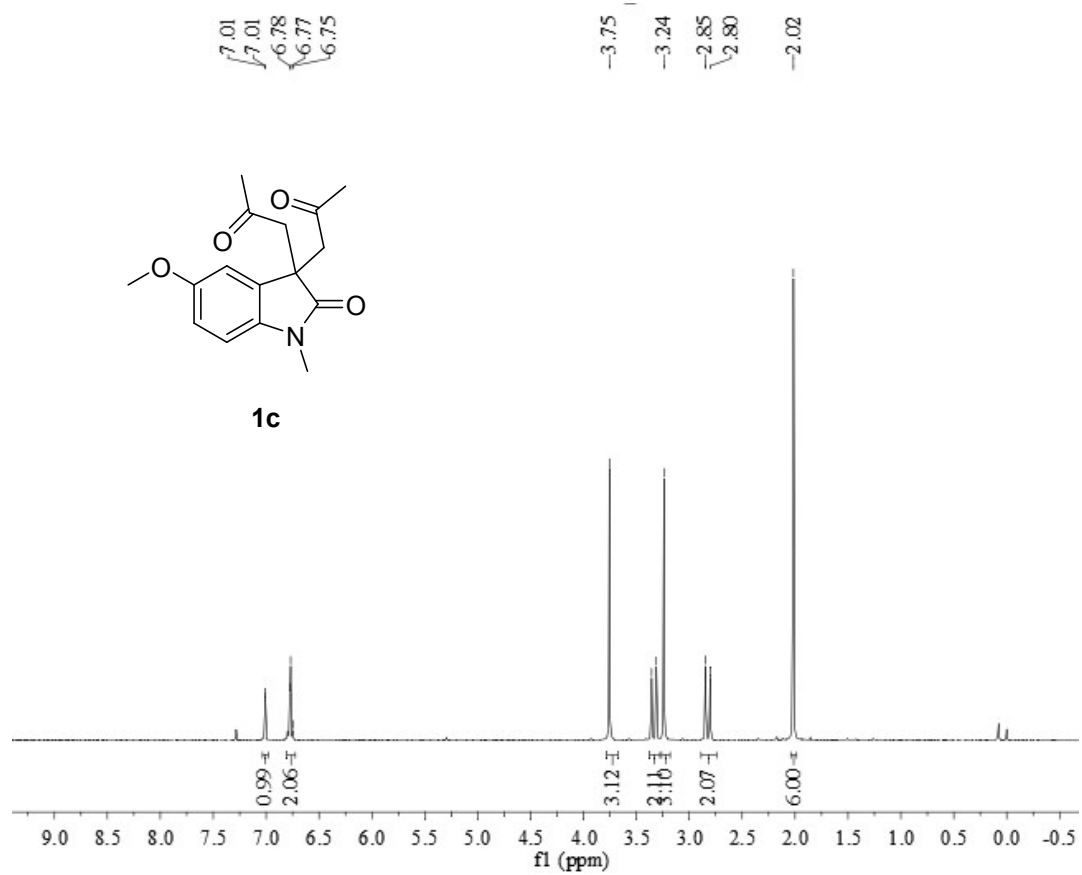


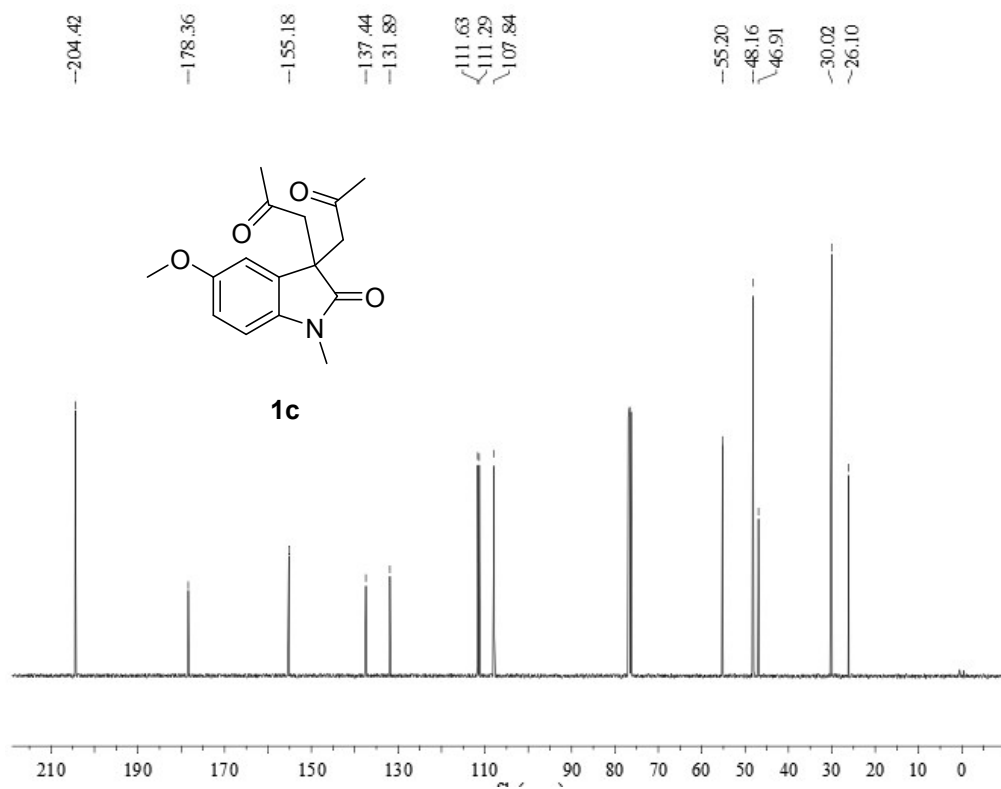
1,1'-(1,5-dimethyl-2-oxoindoline-3,3-diyl)bis(propan-2-one) (1b)



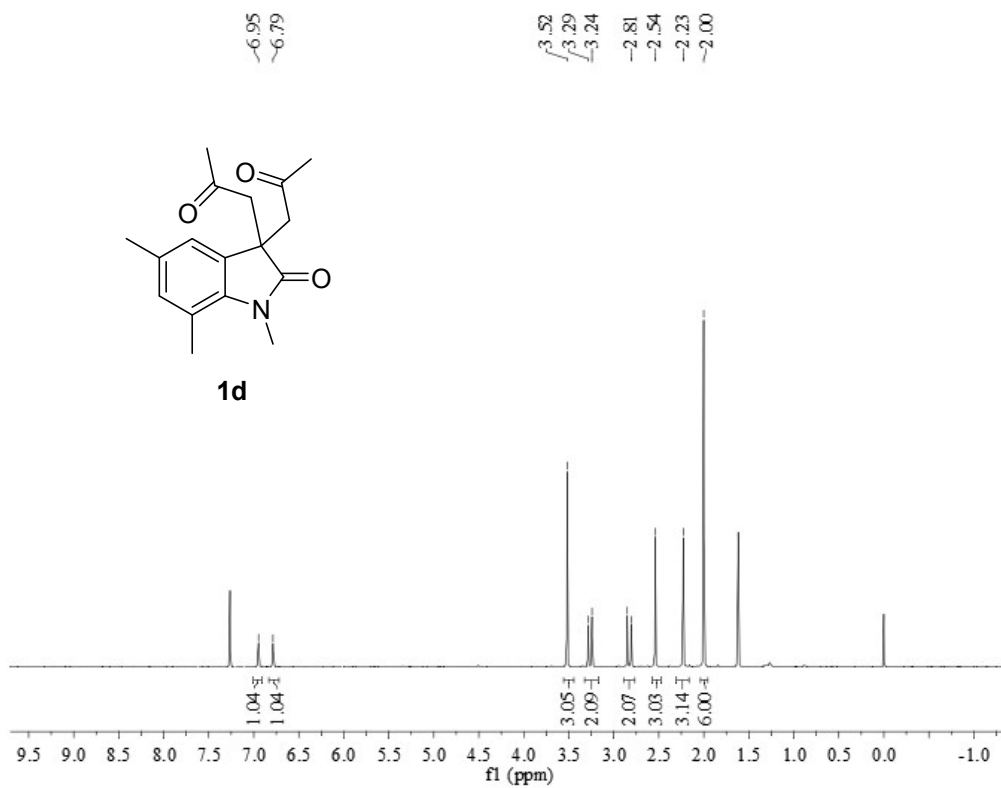


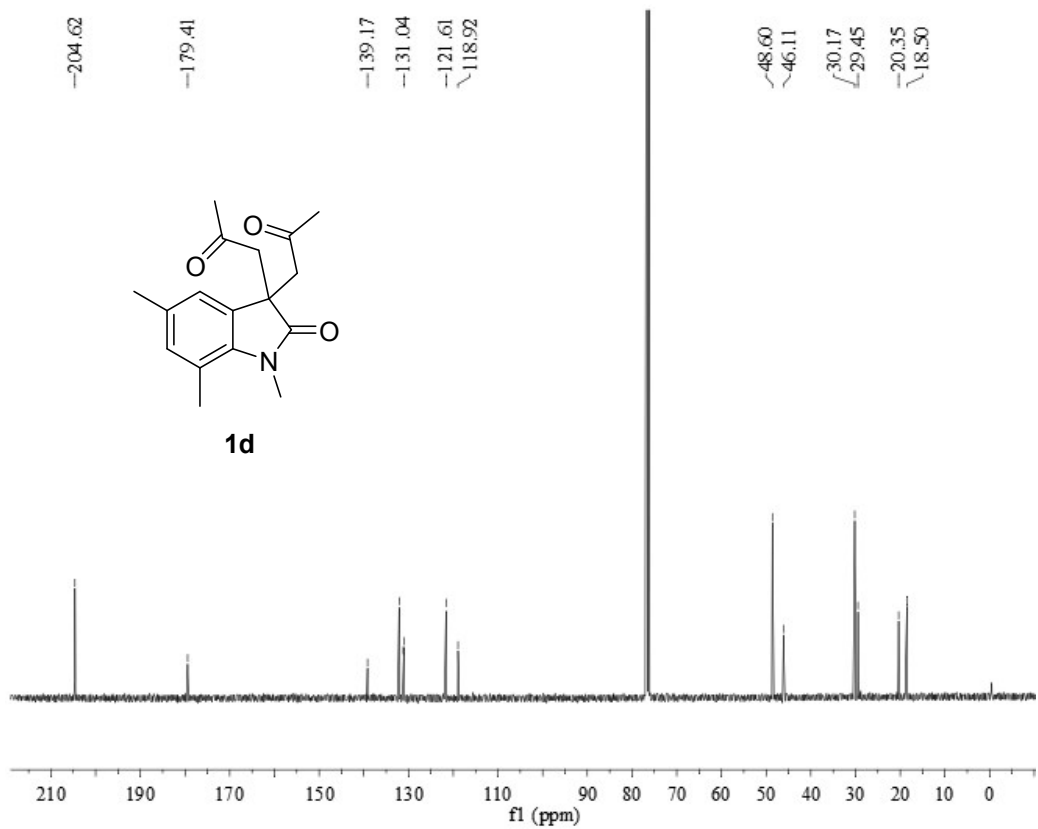
1,1'-(5-methoxy-1-methyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1c)



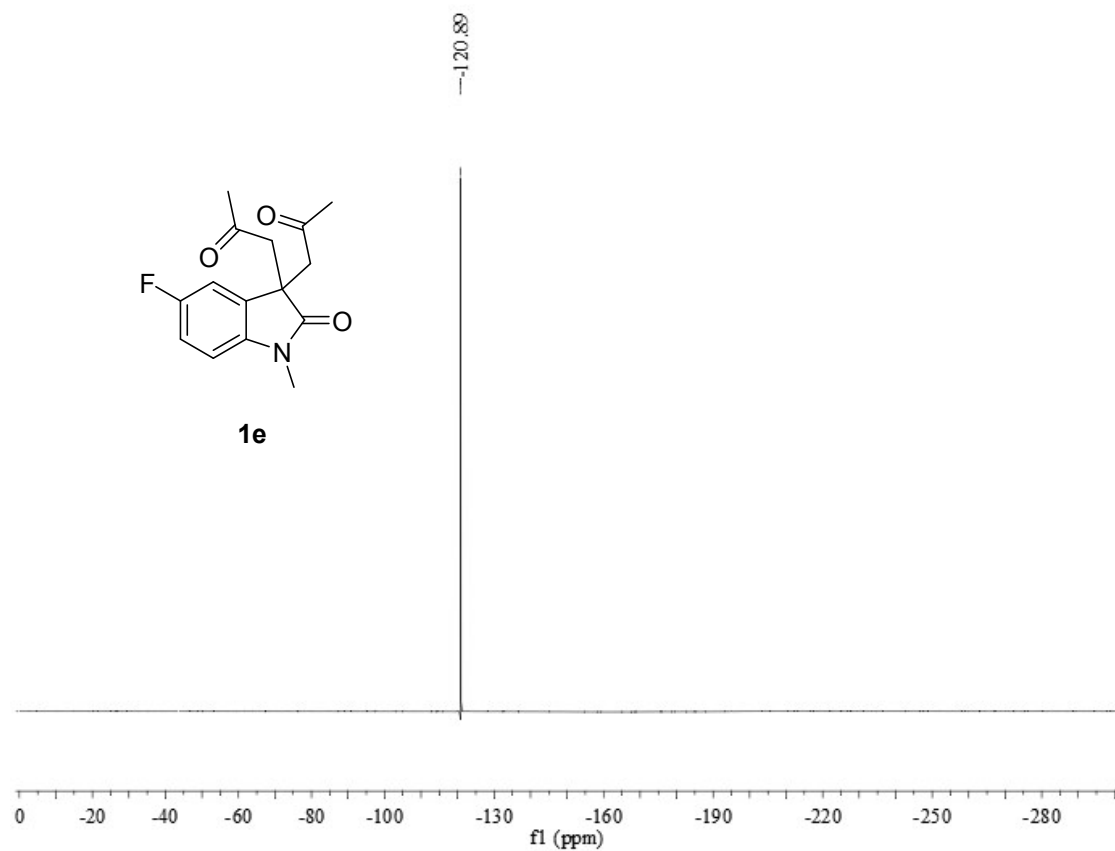
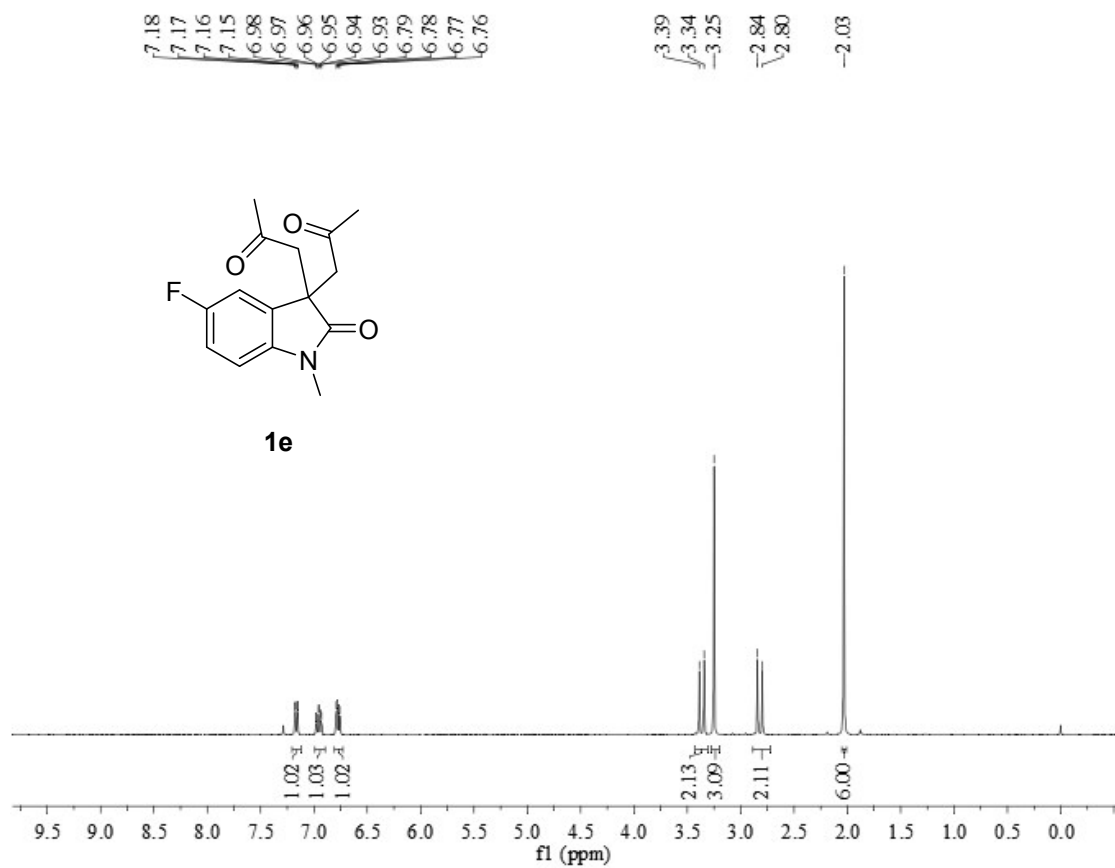


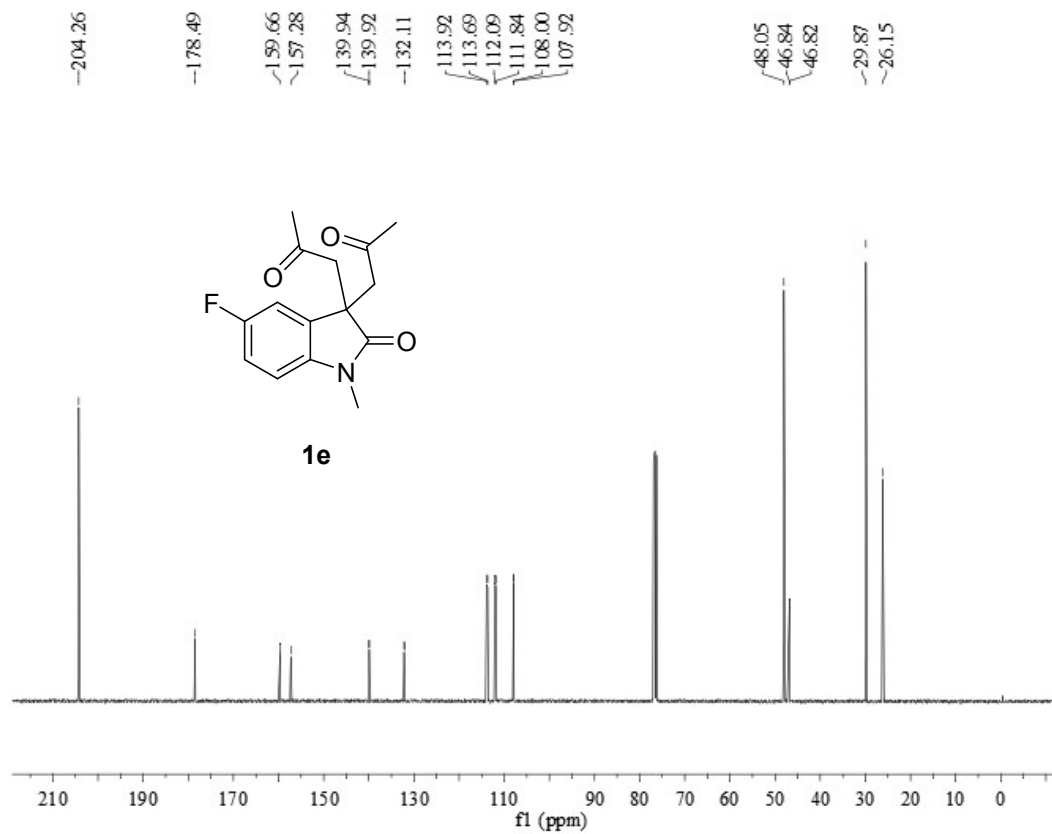
1,1'-(1,5,7-trimethyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1d)



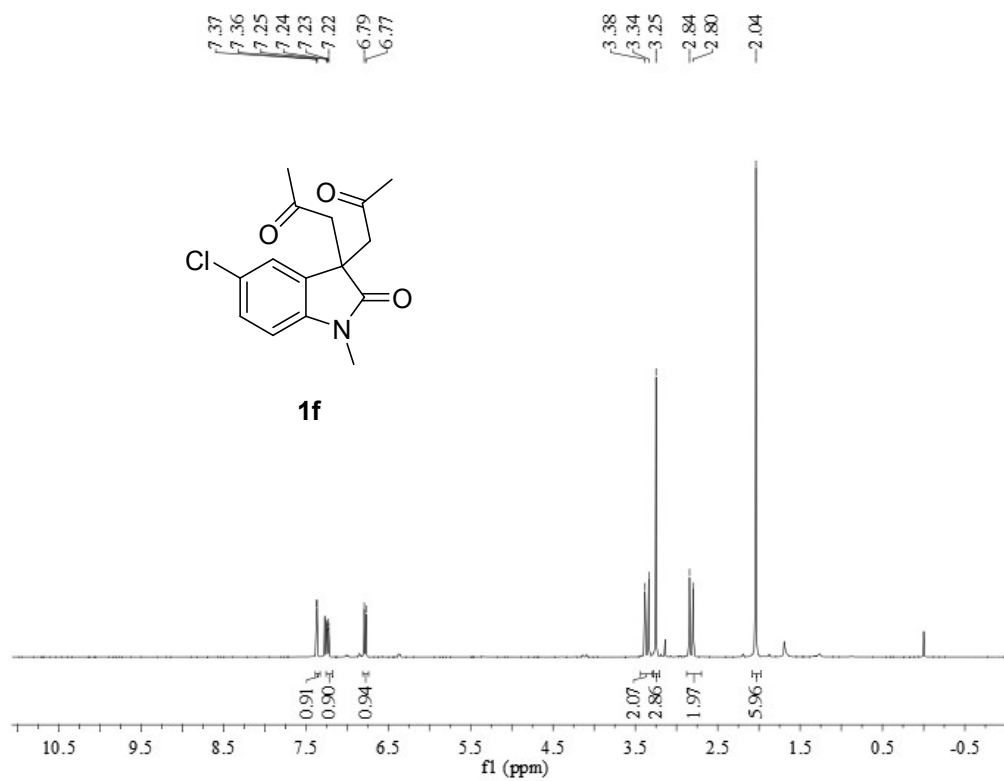


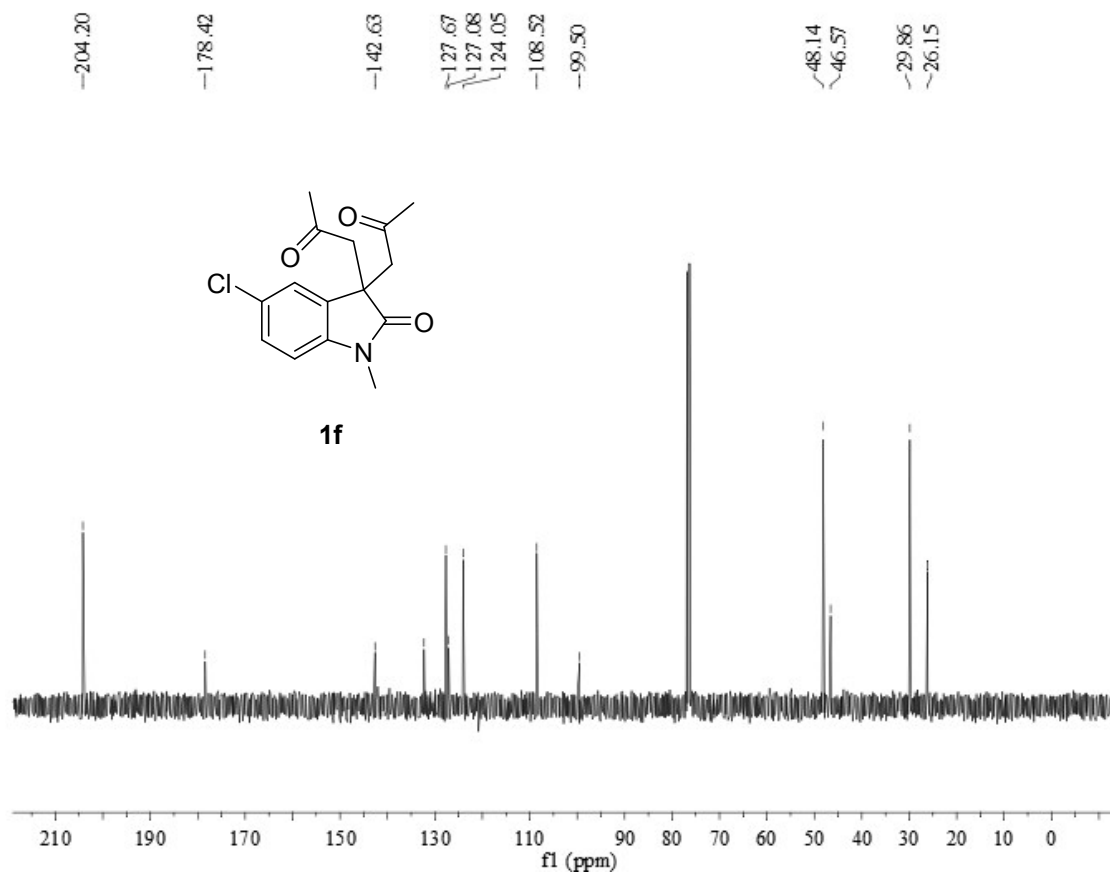
1,1'-(5-fluoro-1-methyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1e)



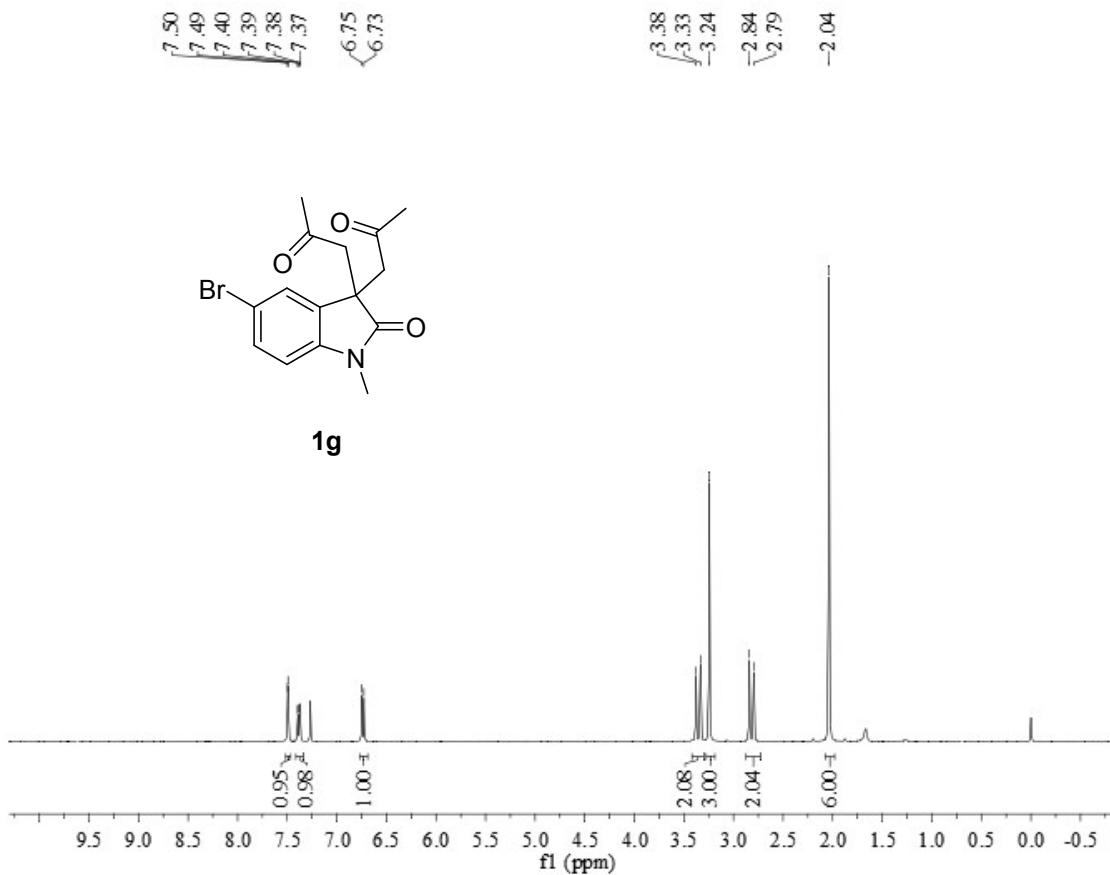


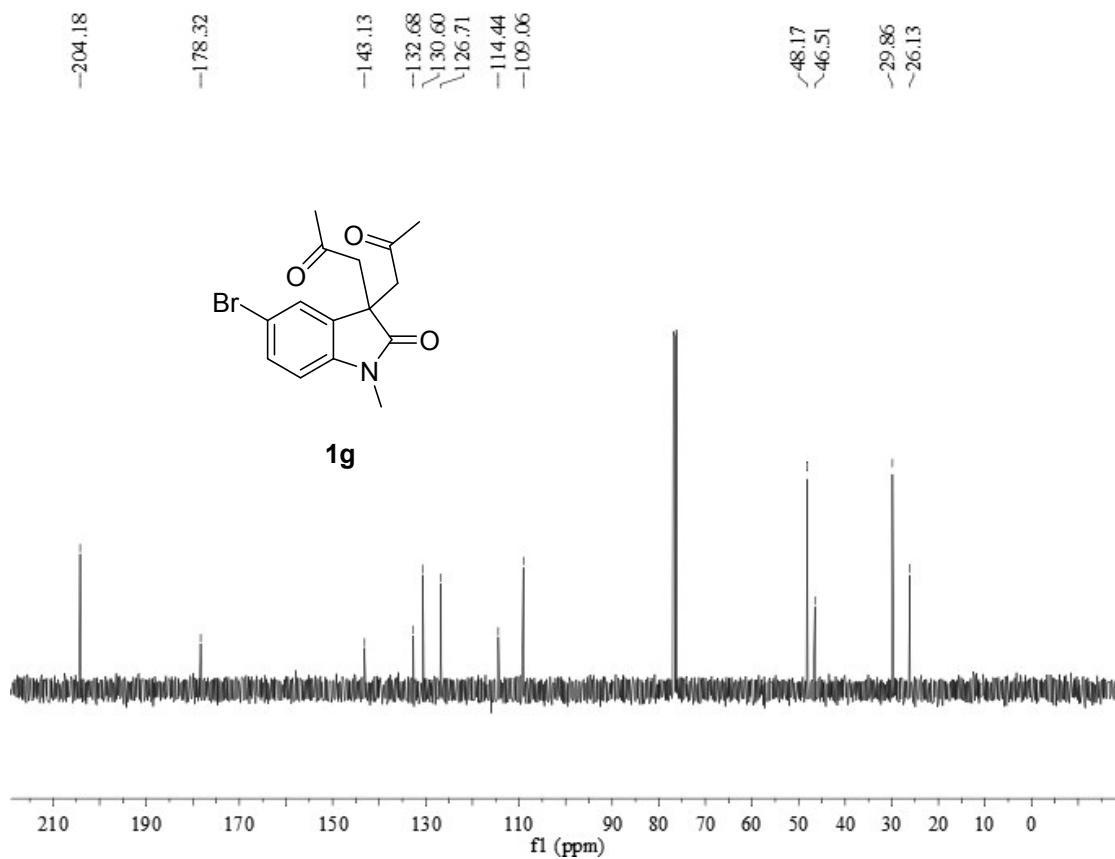
1,1'-(5-chloro-1-methyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1f)



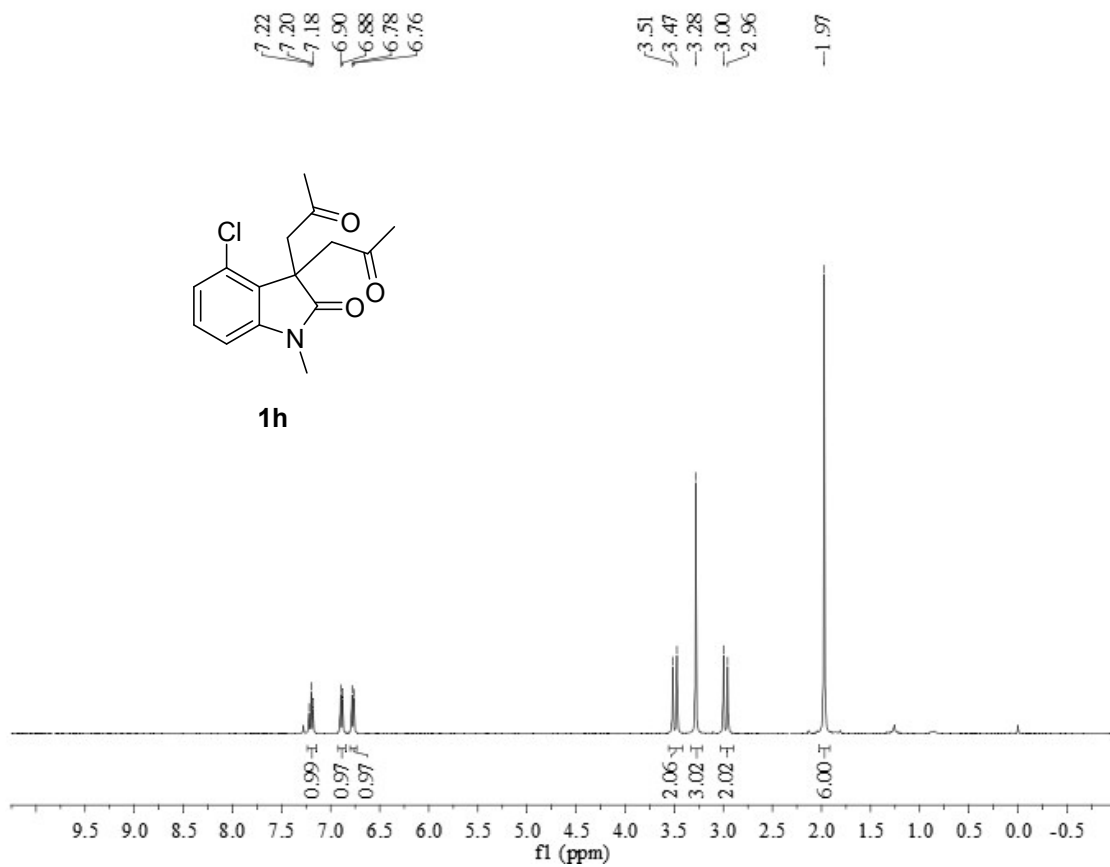


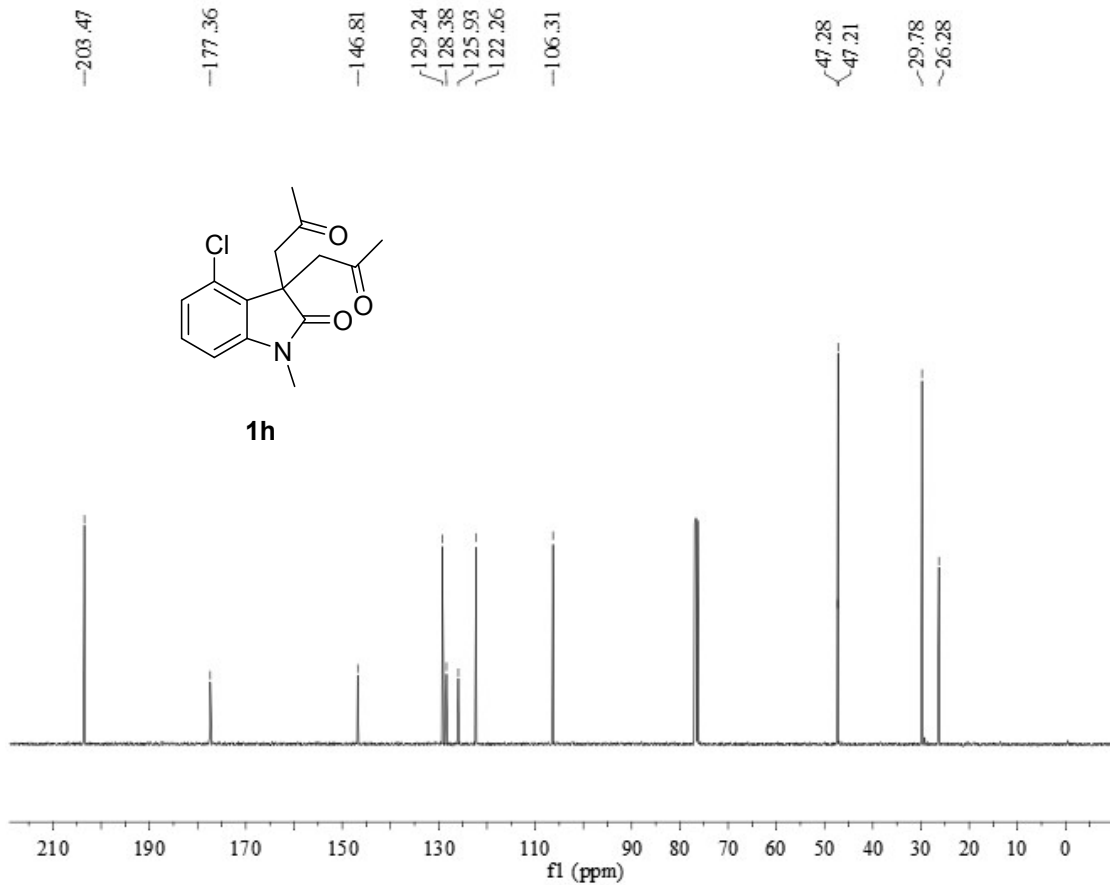
1,1'-(5-bromo-1-methyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1g)



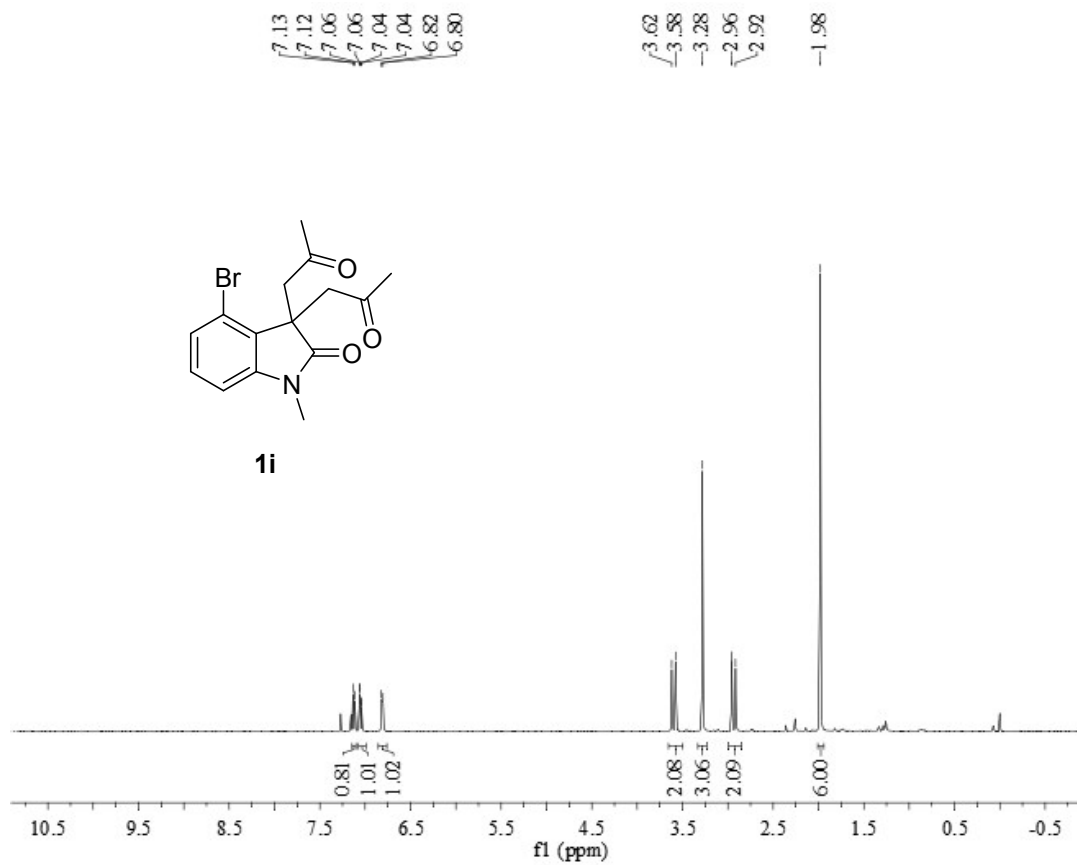


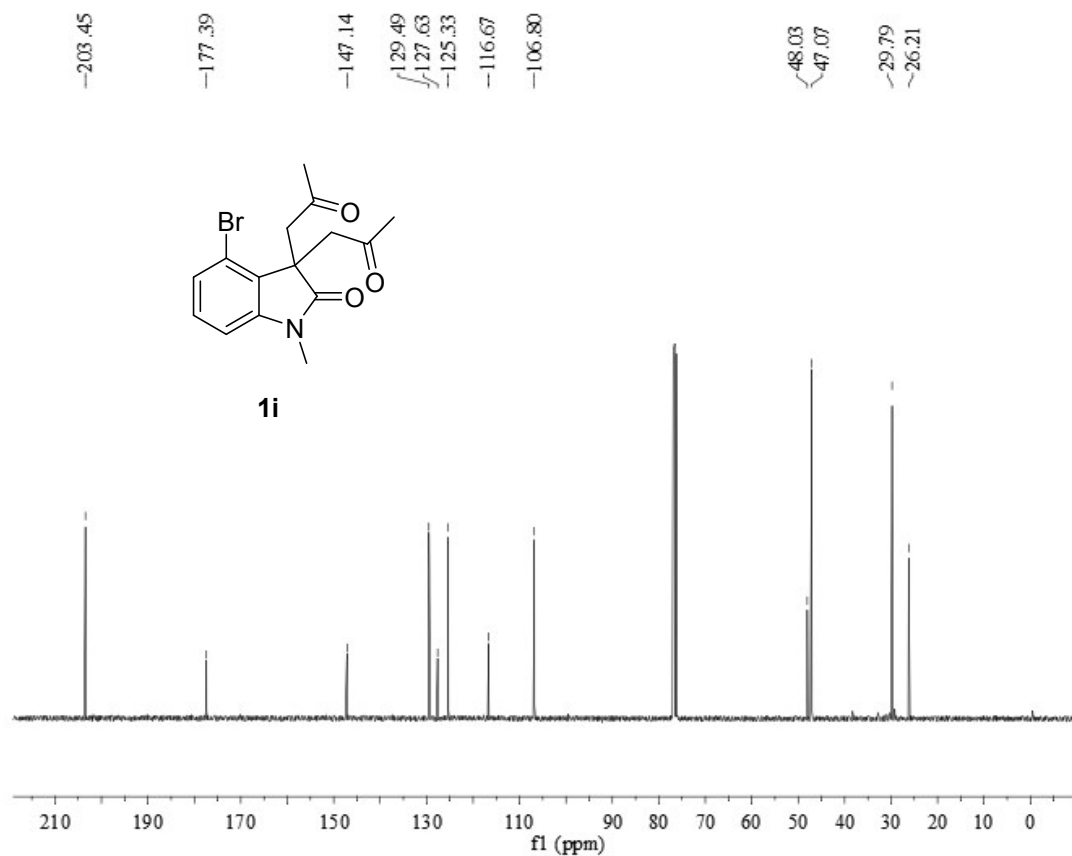
1,1'-(4-chloro-1-methyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1h)



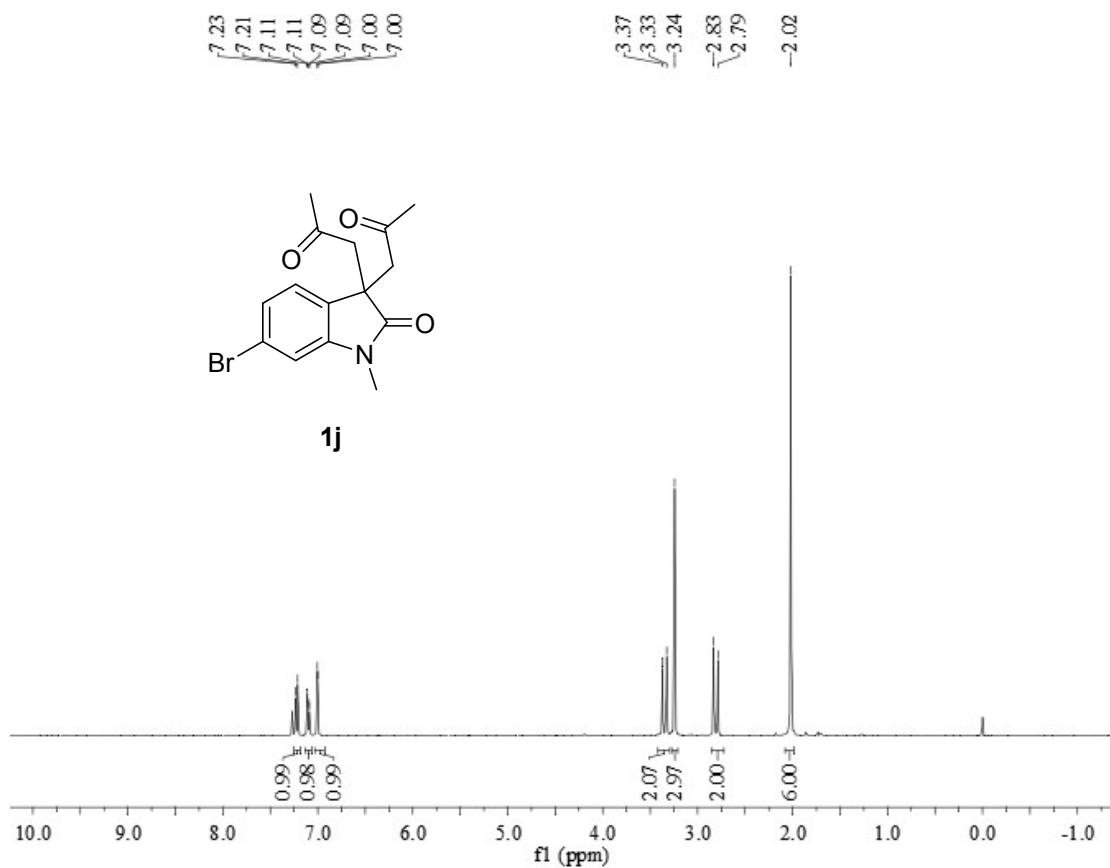


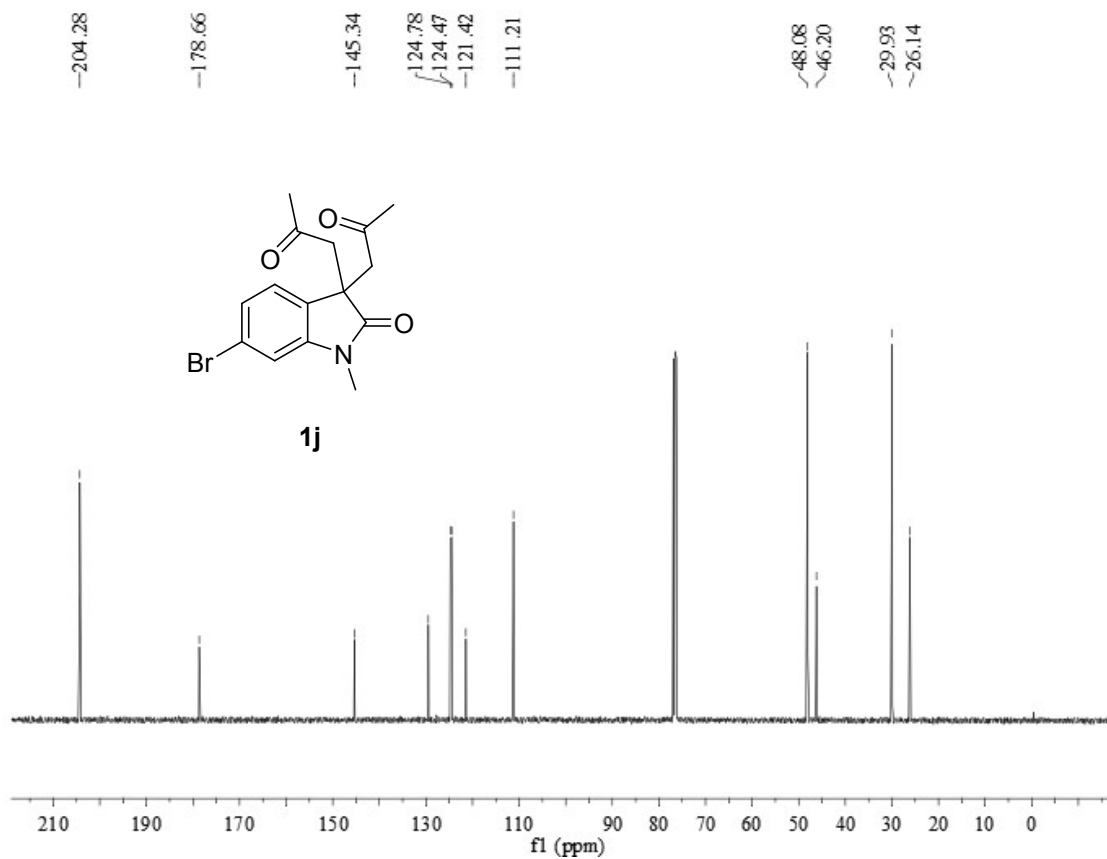
1,1'-(4-bromo-1-methyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1i)



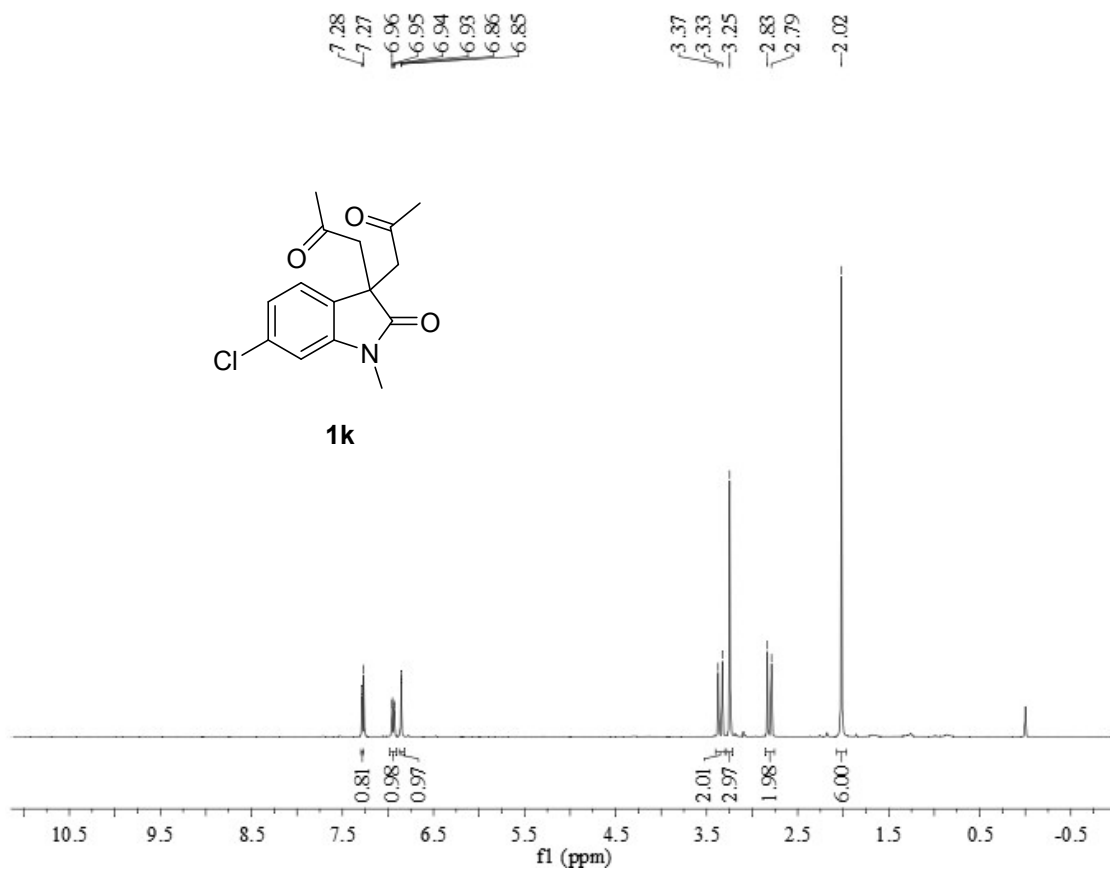


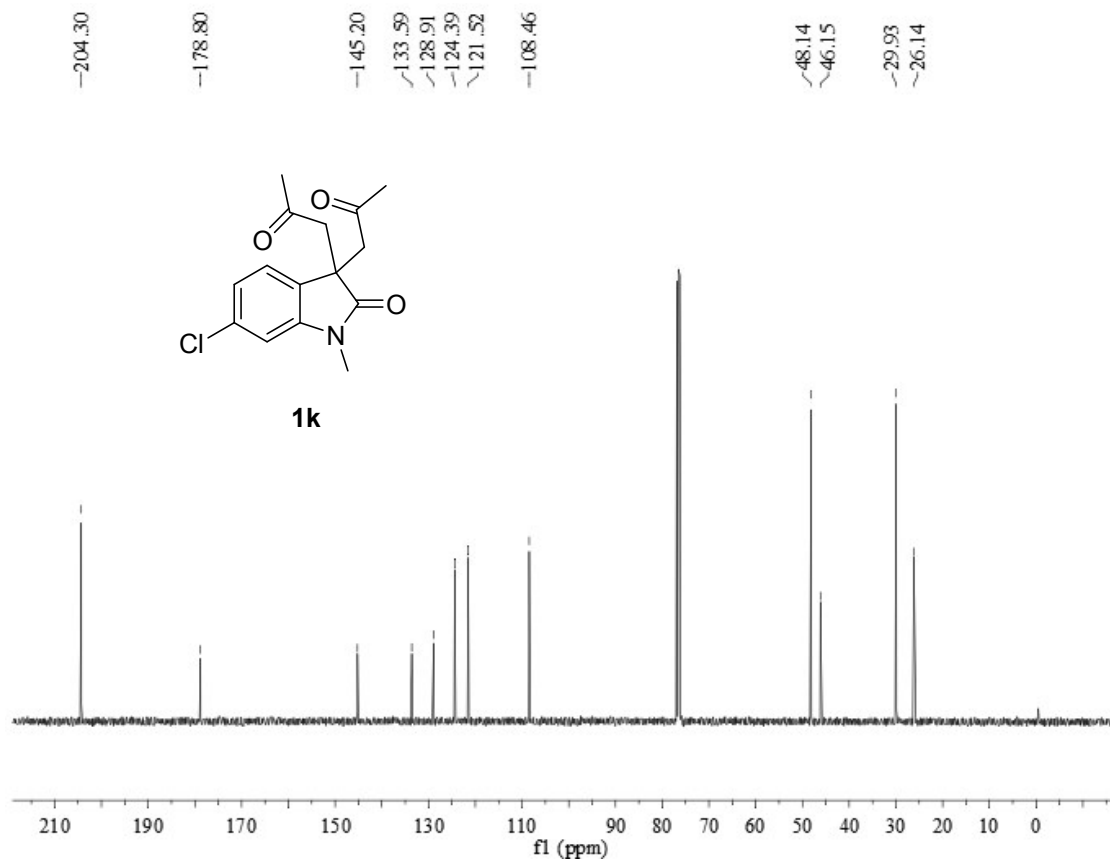
1,1'-(6-bromo-1-methyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1j)



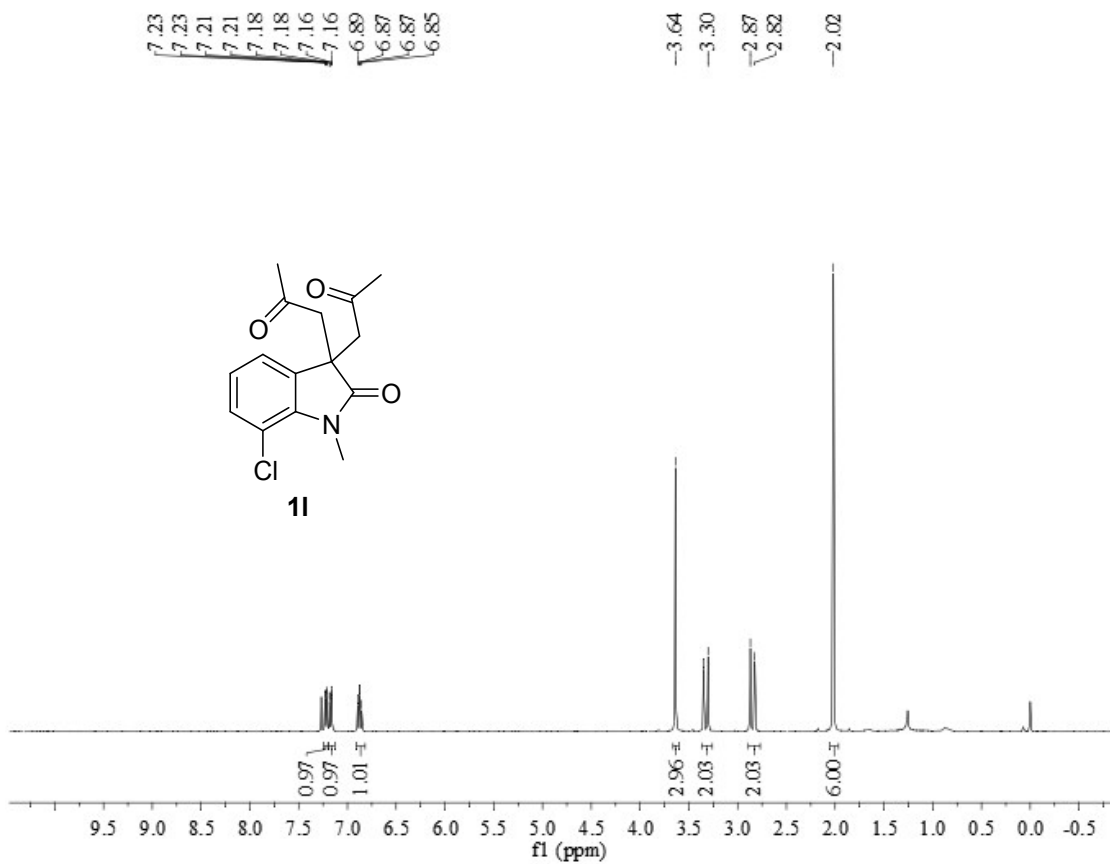


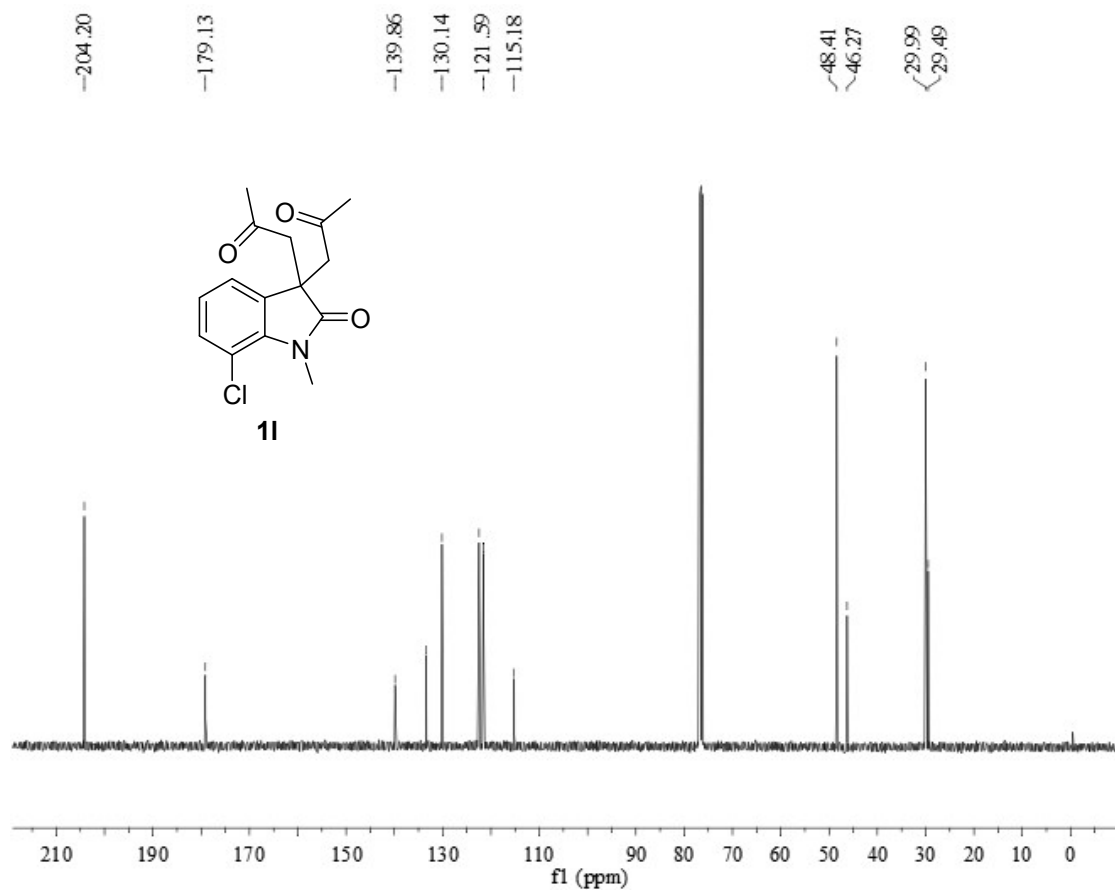
1,1'-(6-chloro-1-methyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1k)



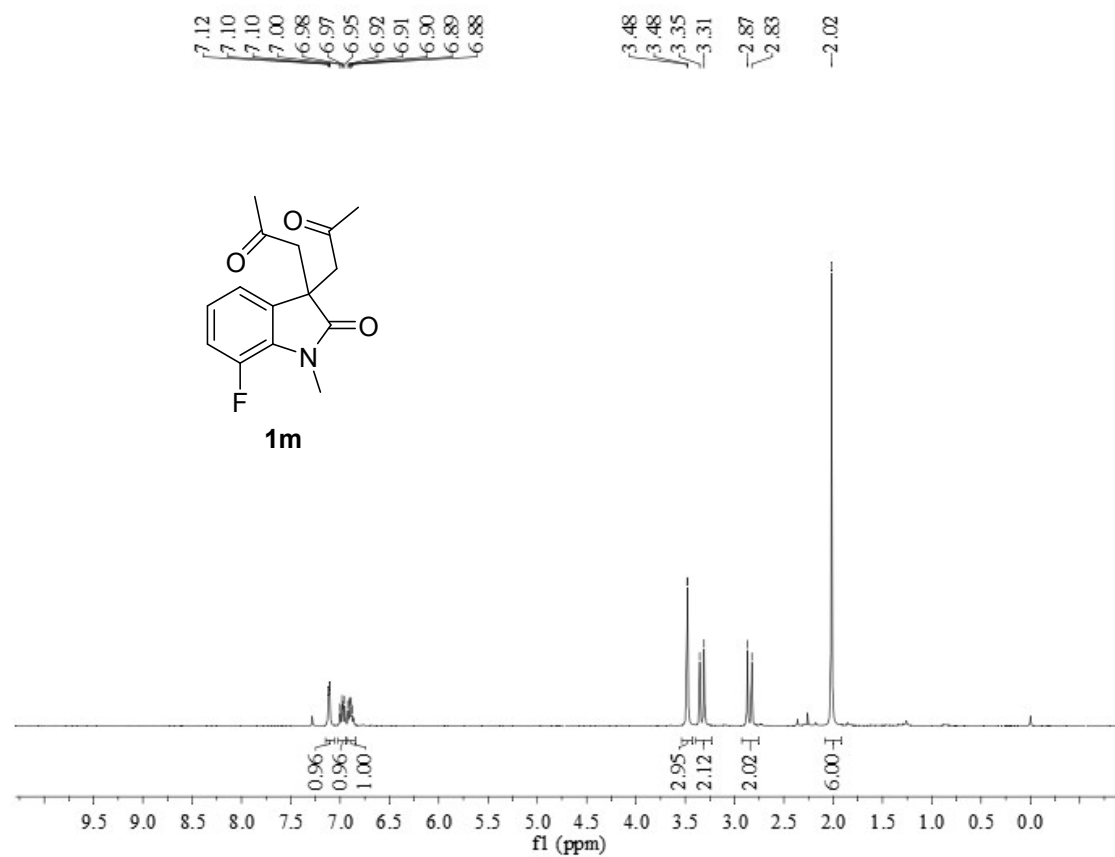


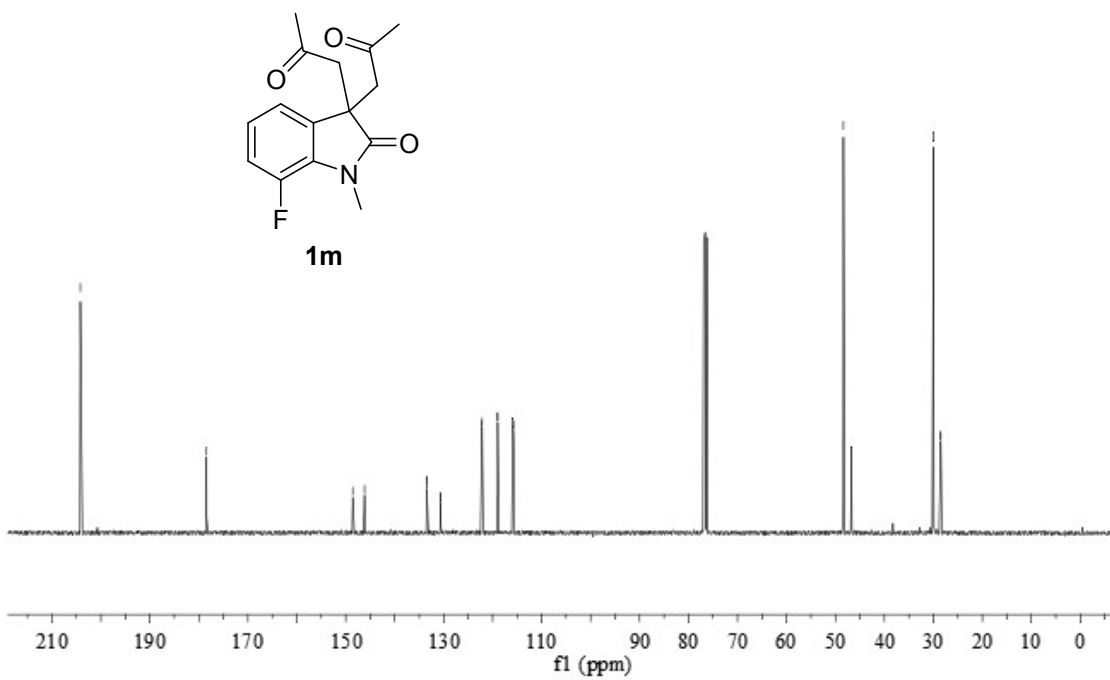
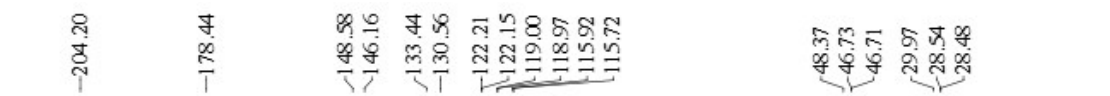
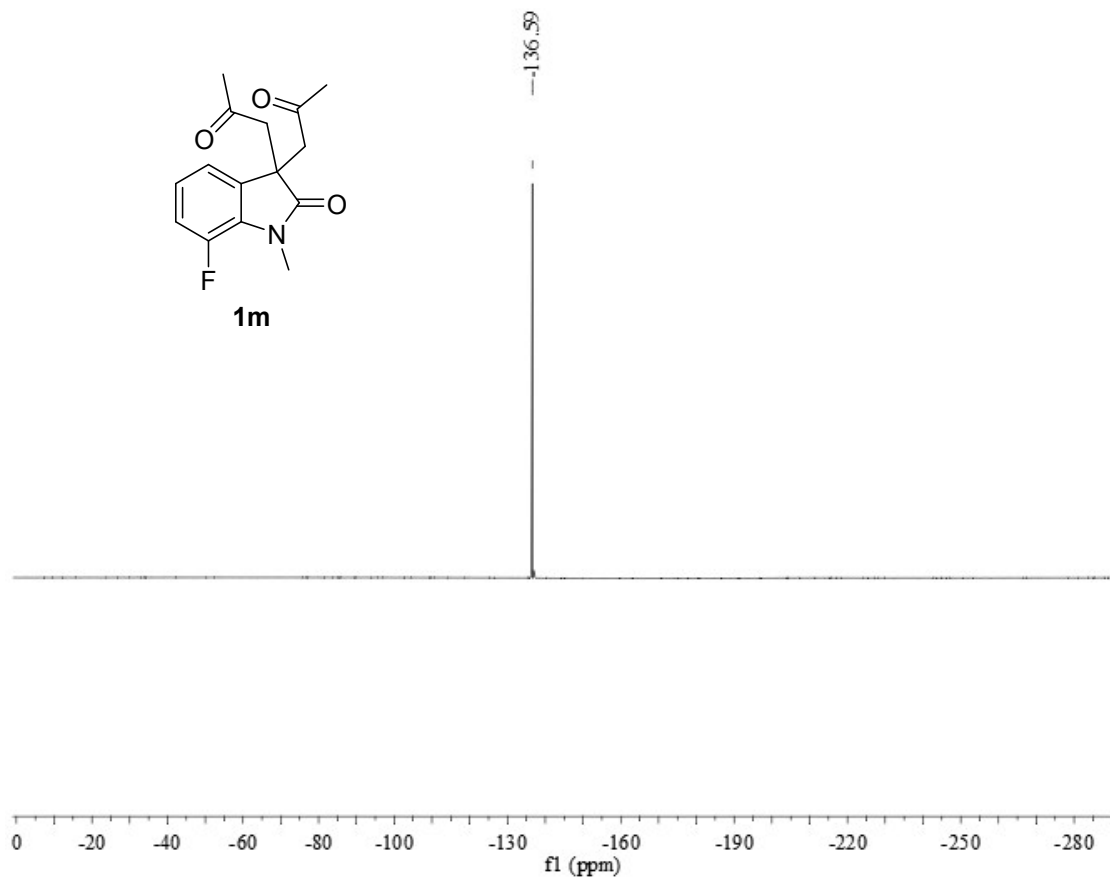
1,1'-(7-chloro-1-methyl-2-oxindole-3,3-diyl)bis(propan-2-one) (1l)



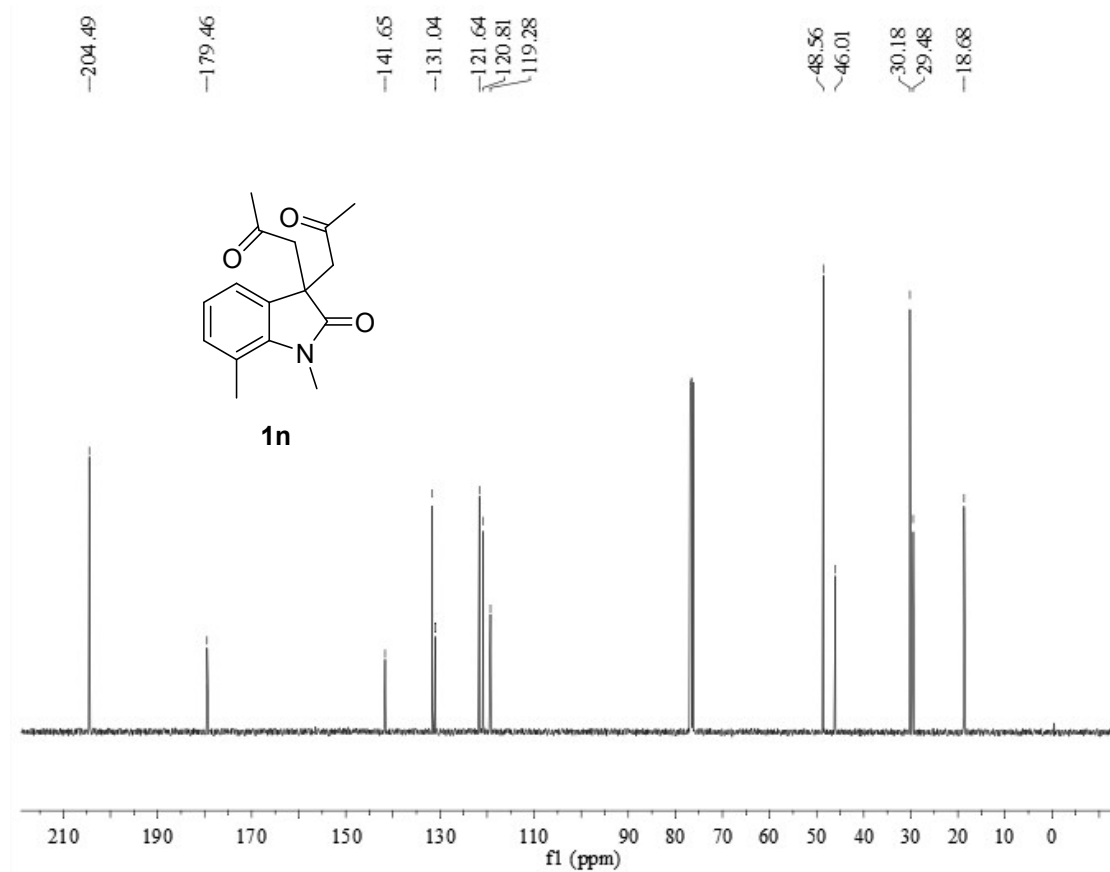
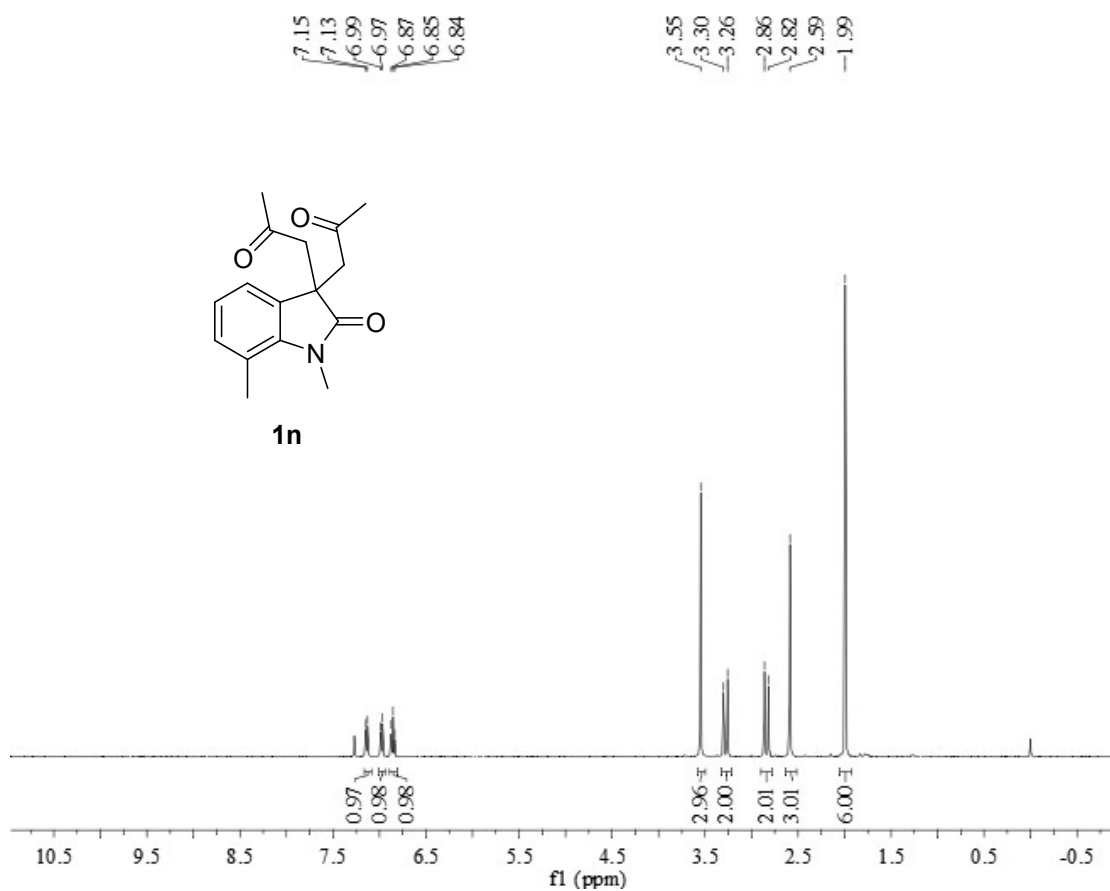


1,1'-(7-fluoro-1-methyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1m)

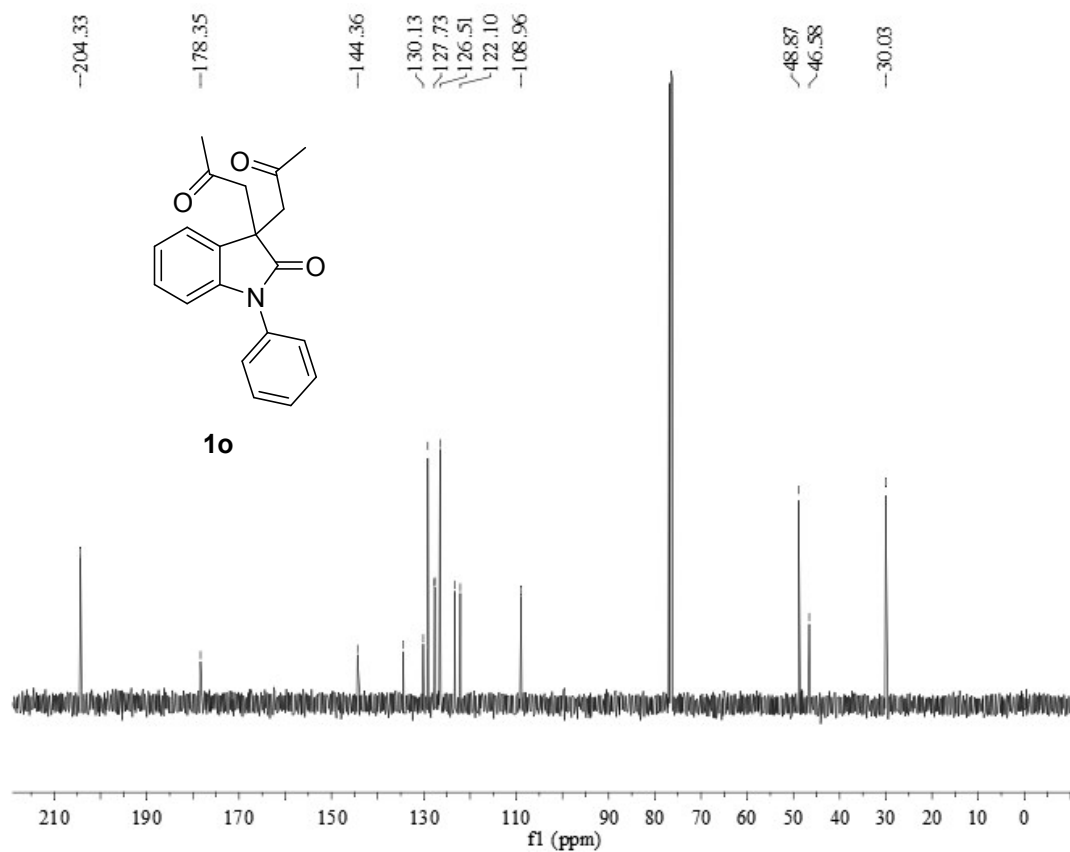
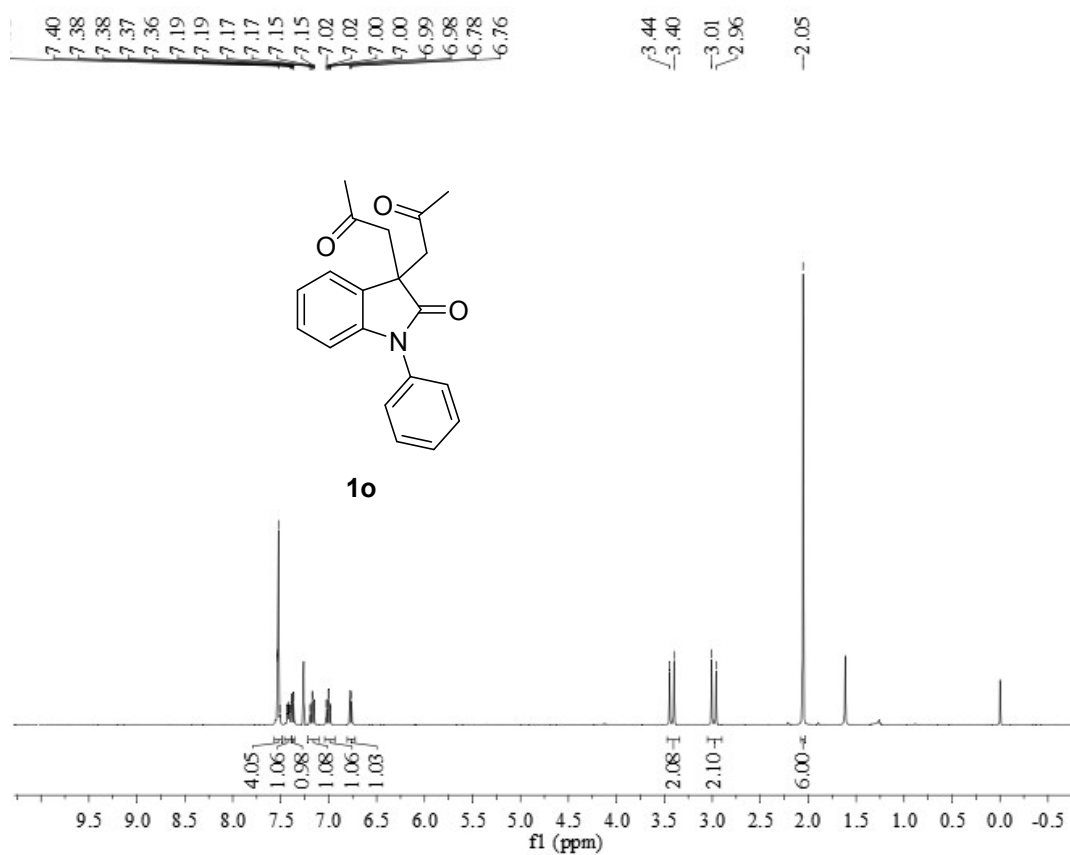




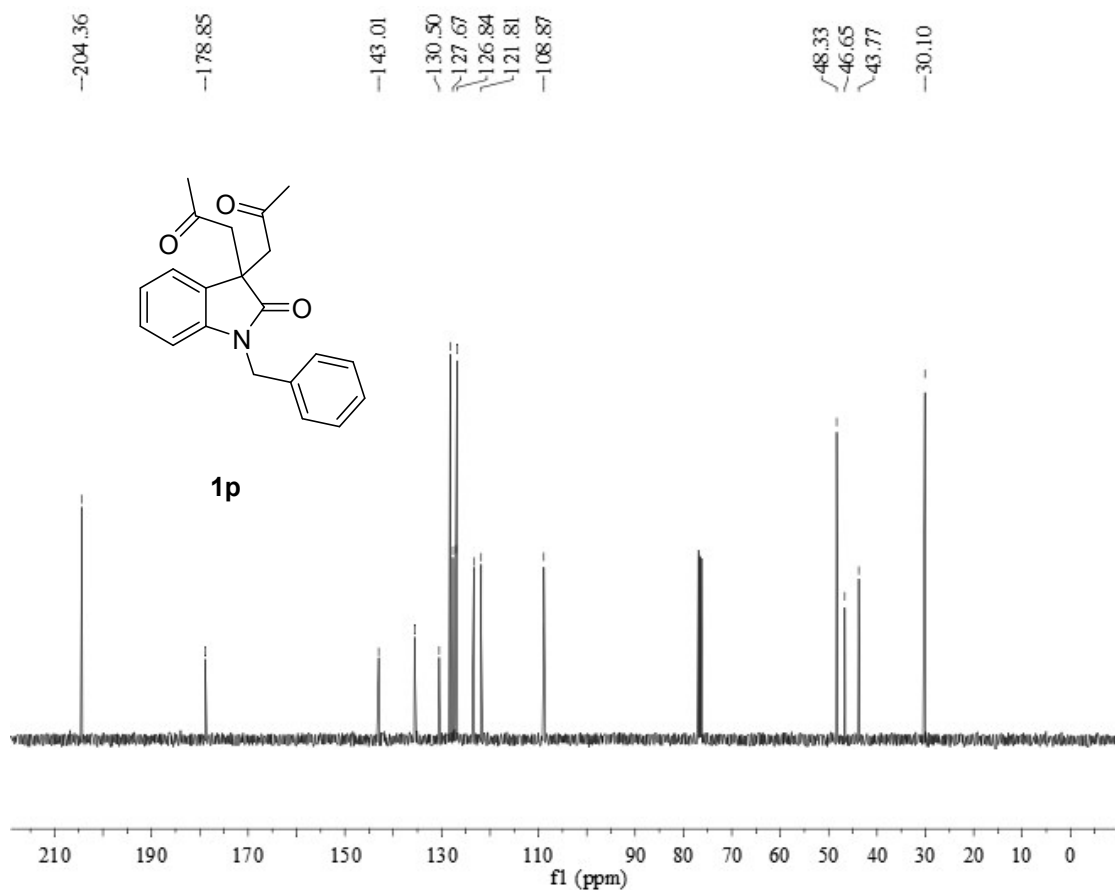
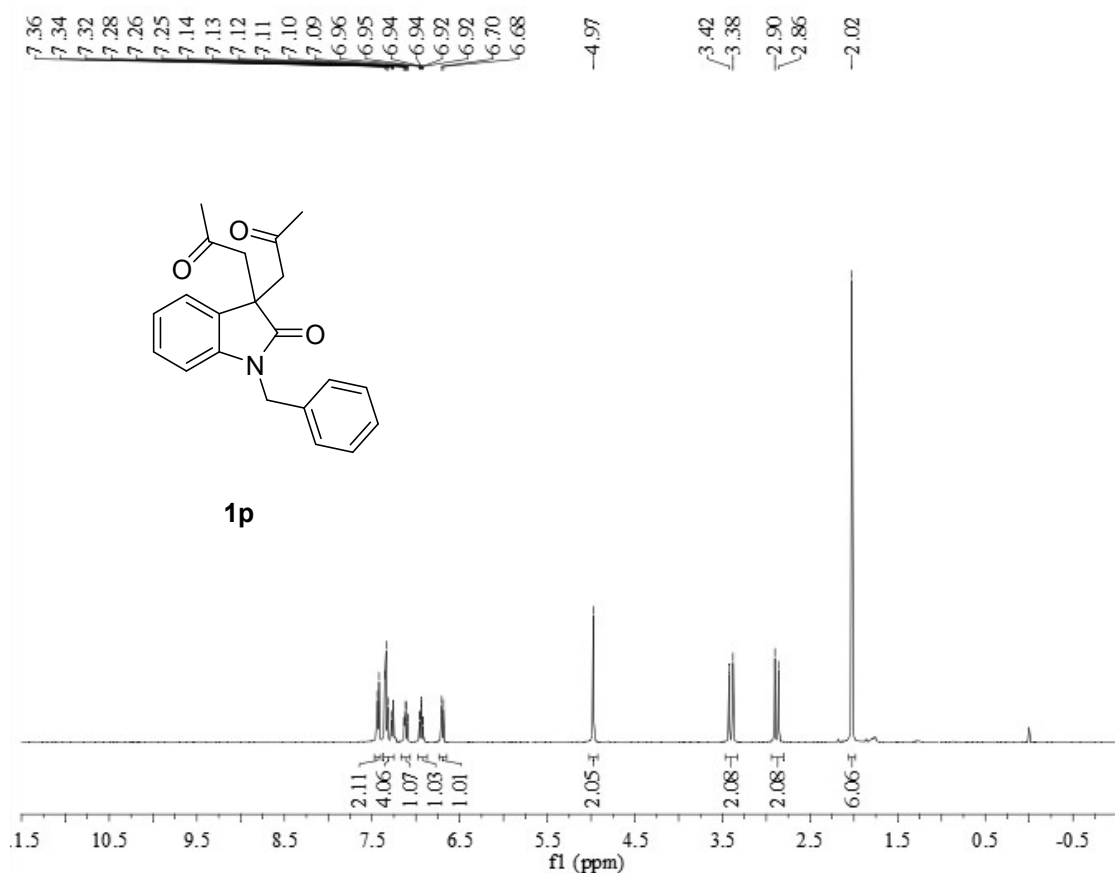
1,1'-(1,7-dimethyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1n)



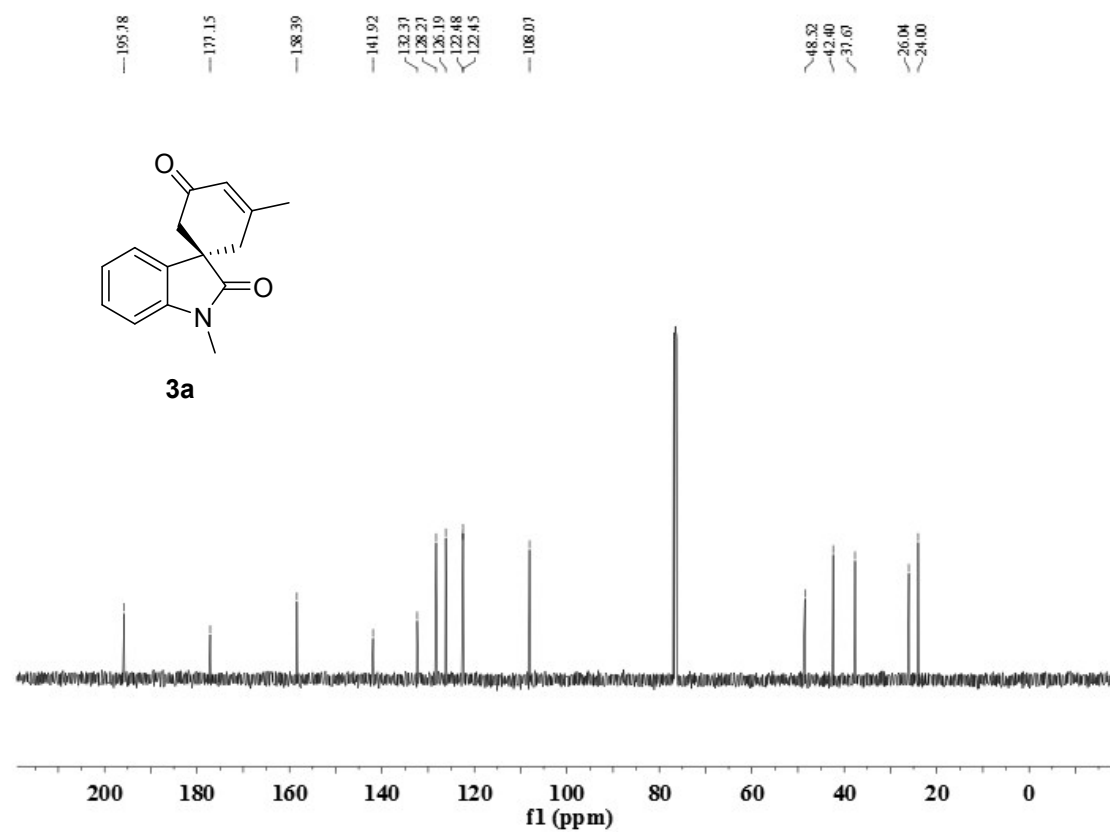
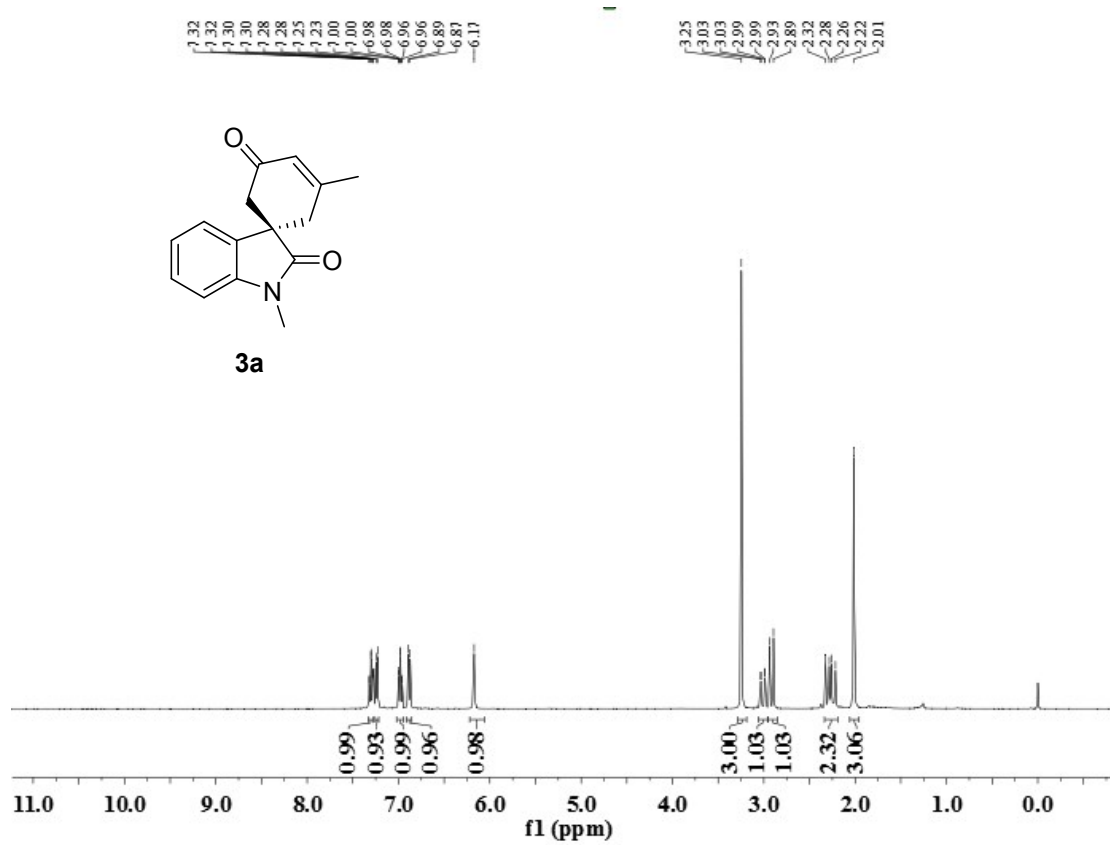
1,1'-(2-oxo-1-phenylindoline-3,3-diyl)bis(propan-2-one) (1o)



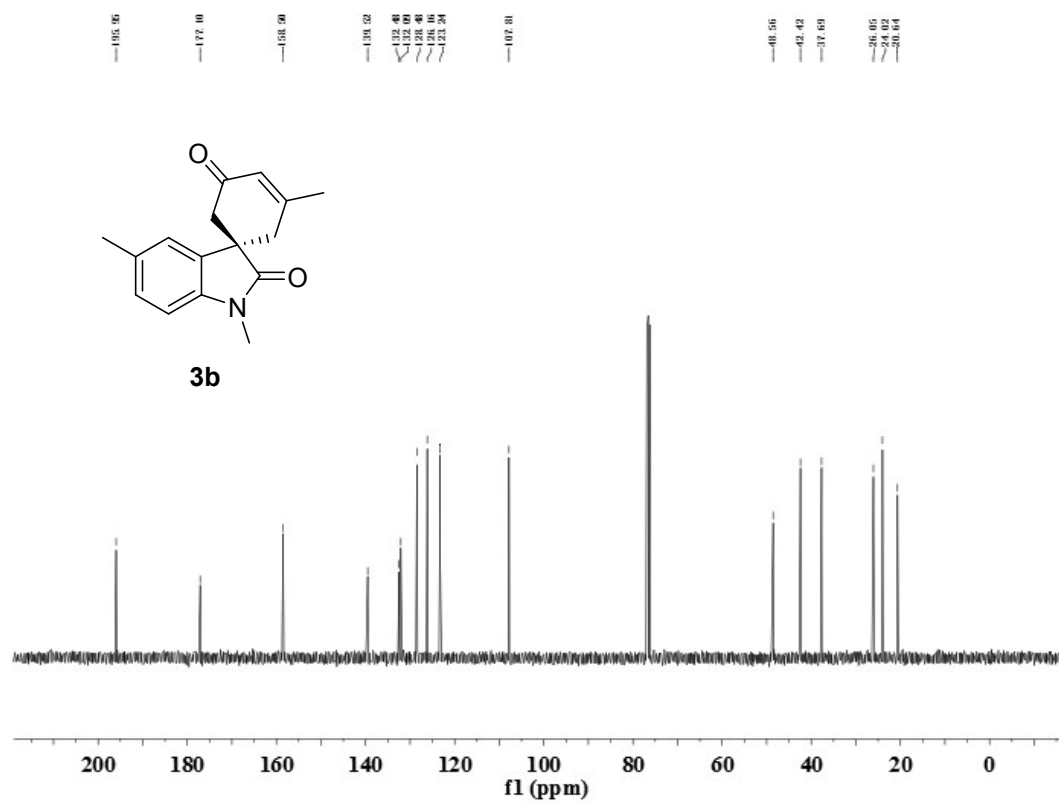
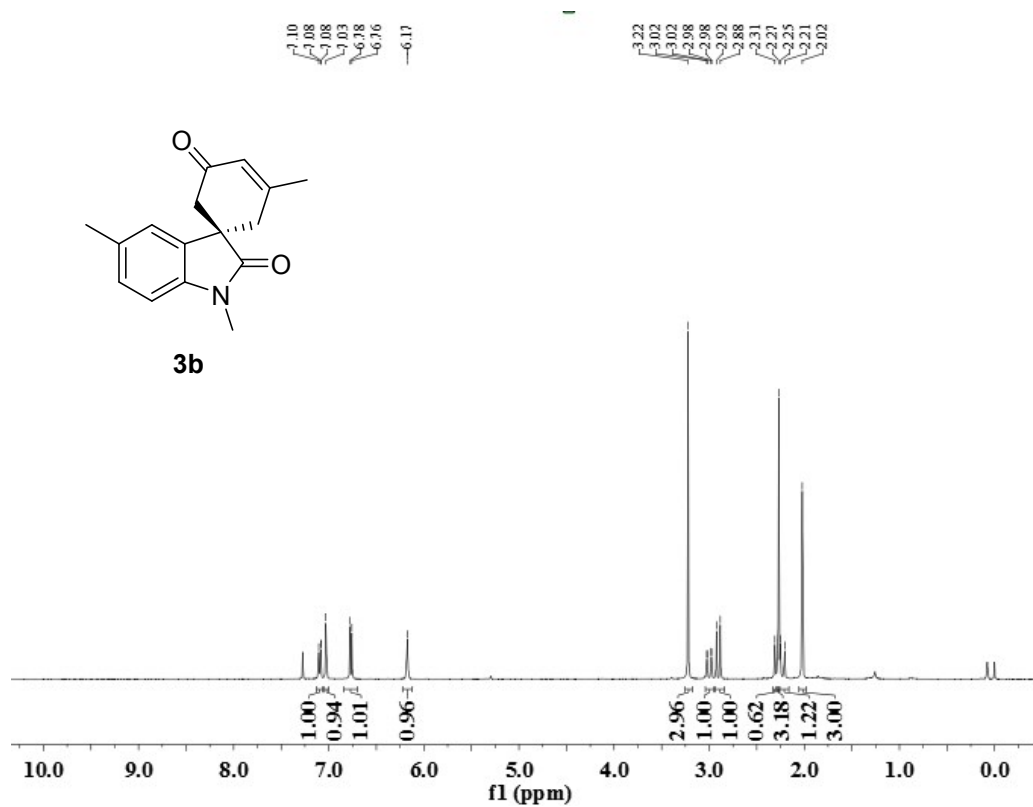
1,1'-(1-benzyl-2-oxindoline-3,3-diyl)bis(propan-2-one) (1p)



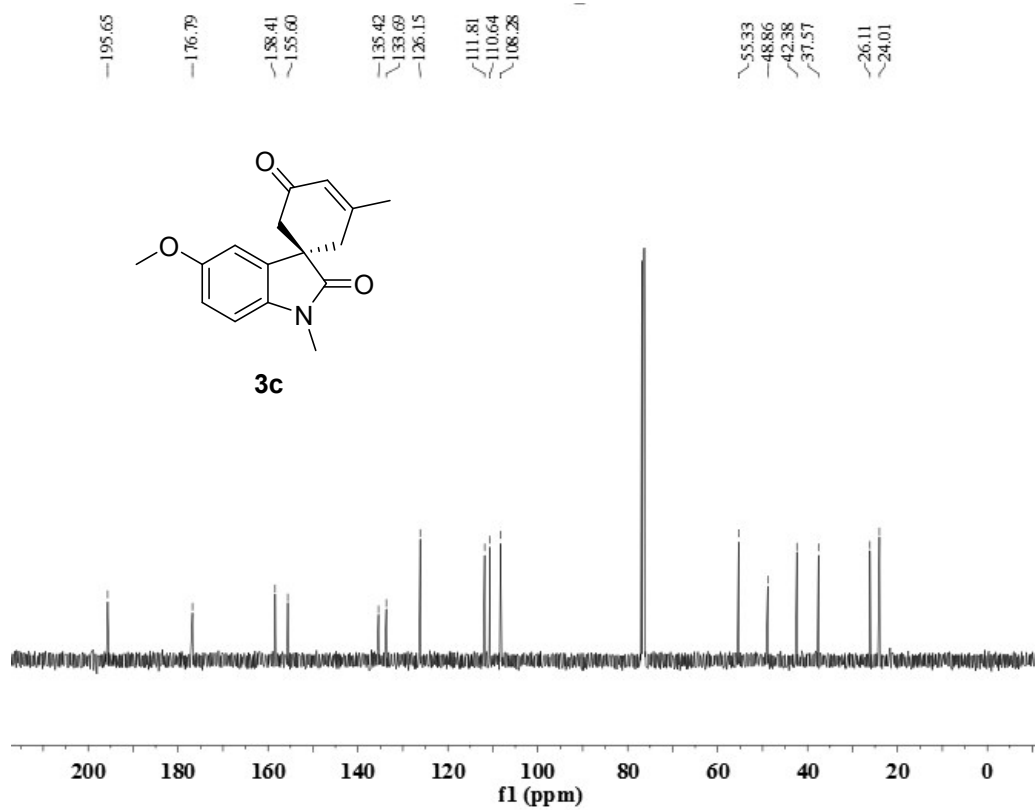
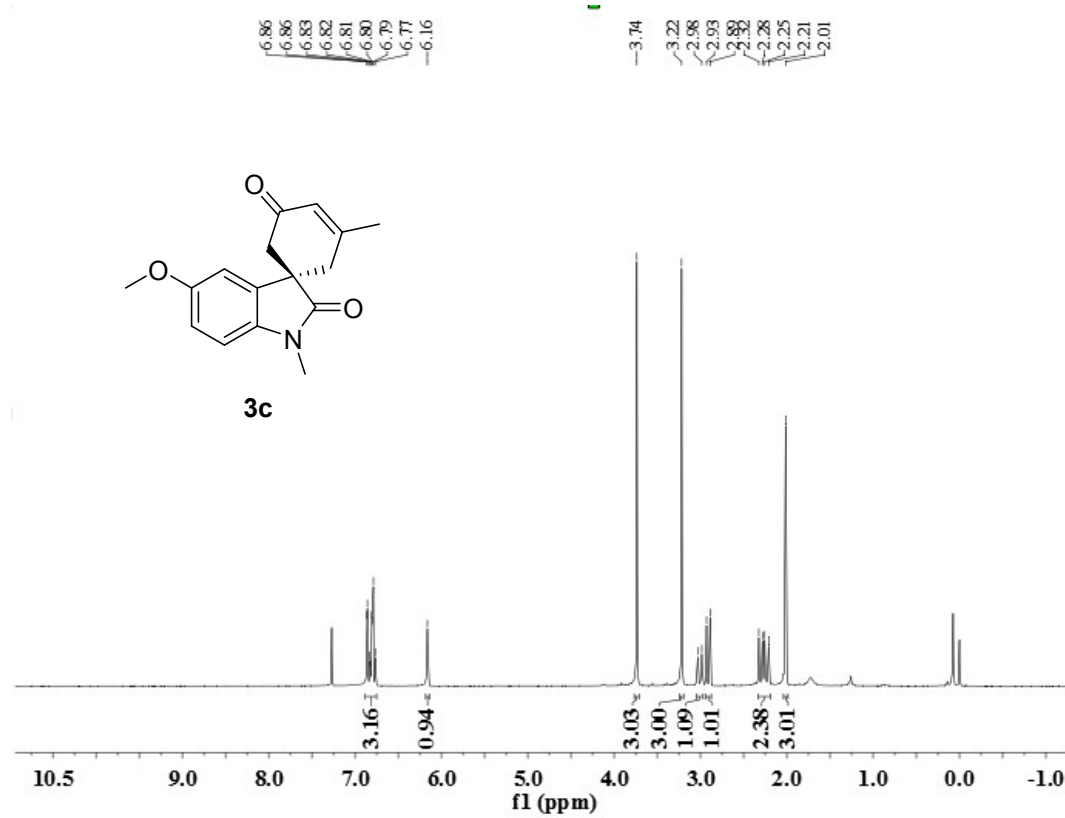
(R)-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3a)



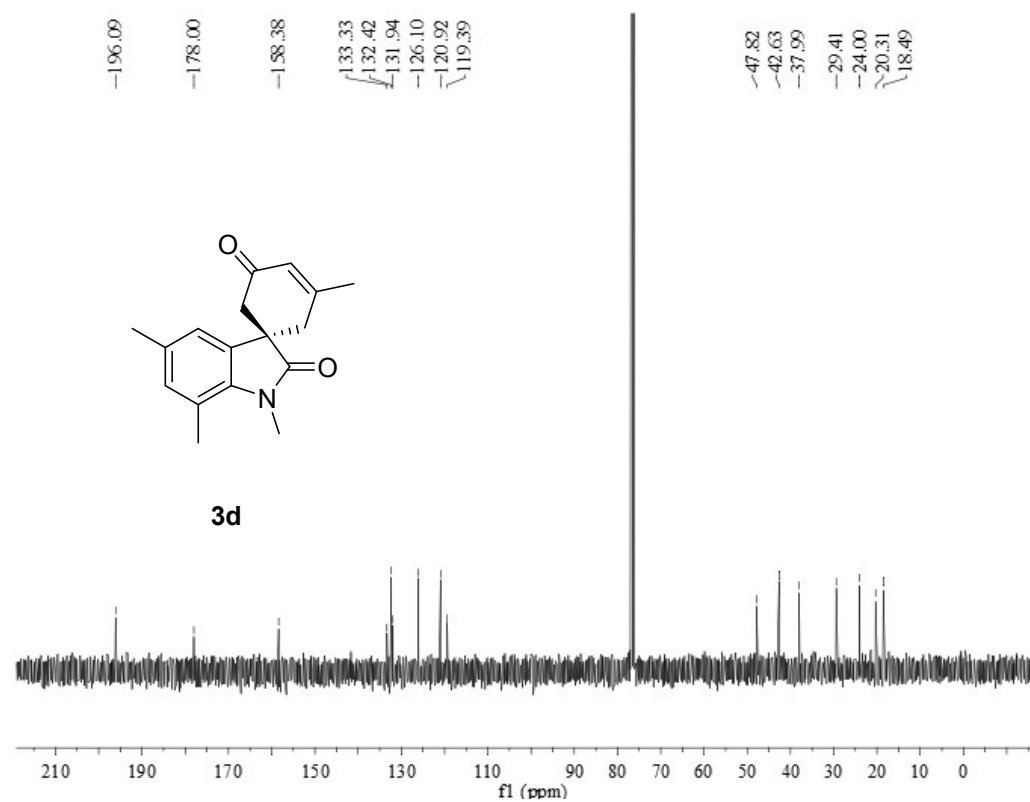
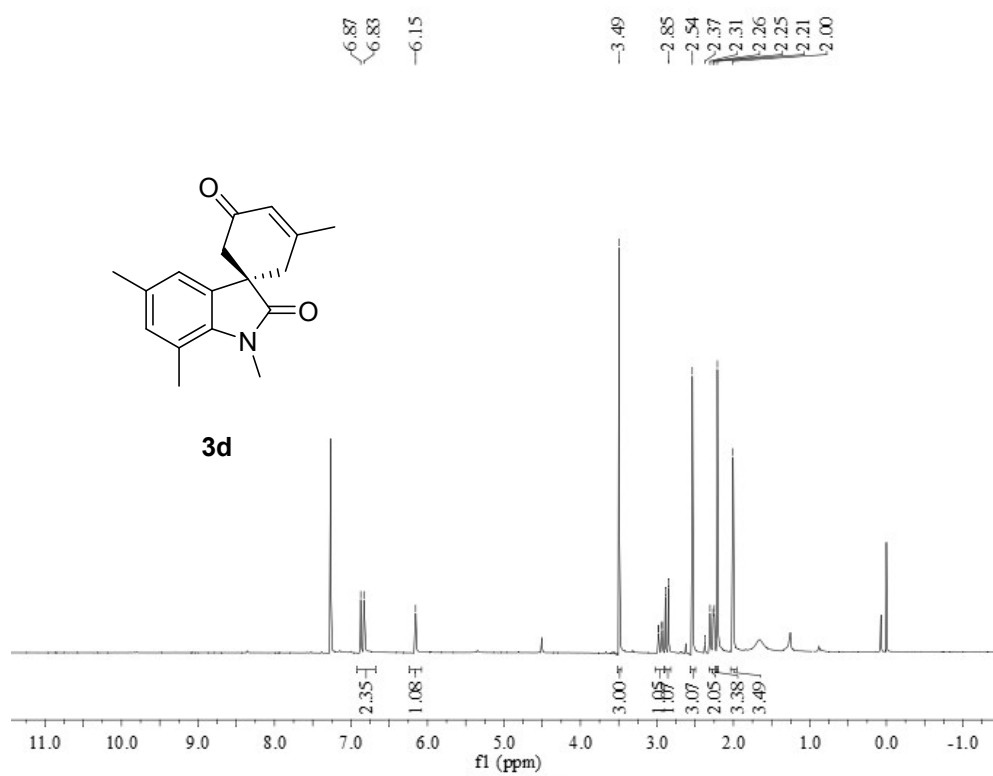
(R)-1',3,5'-trimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3b)



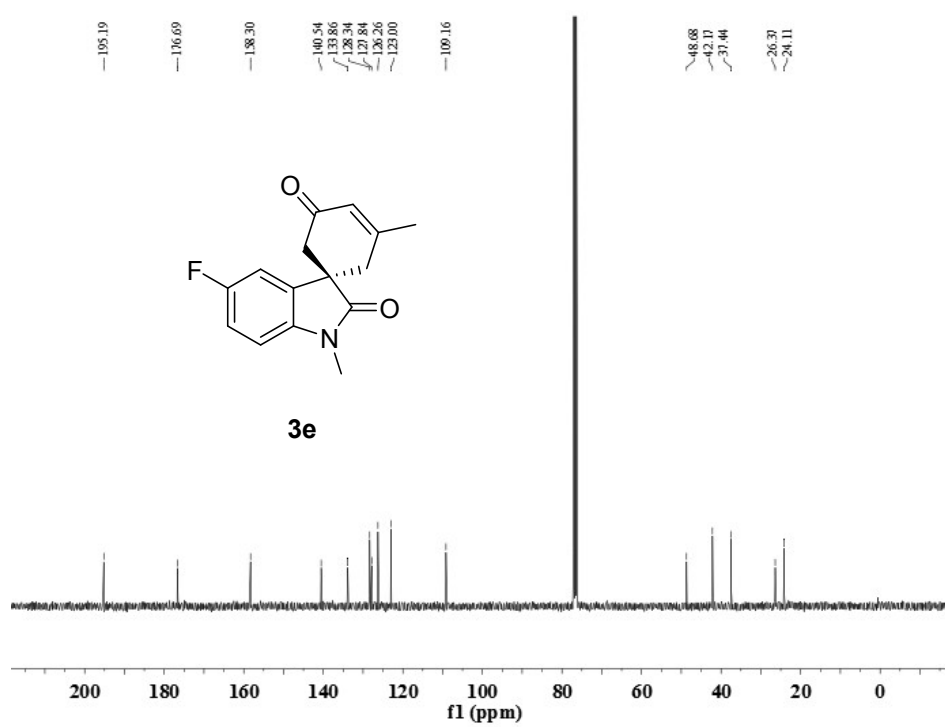
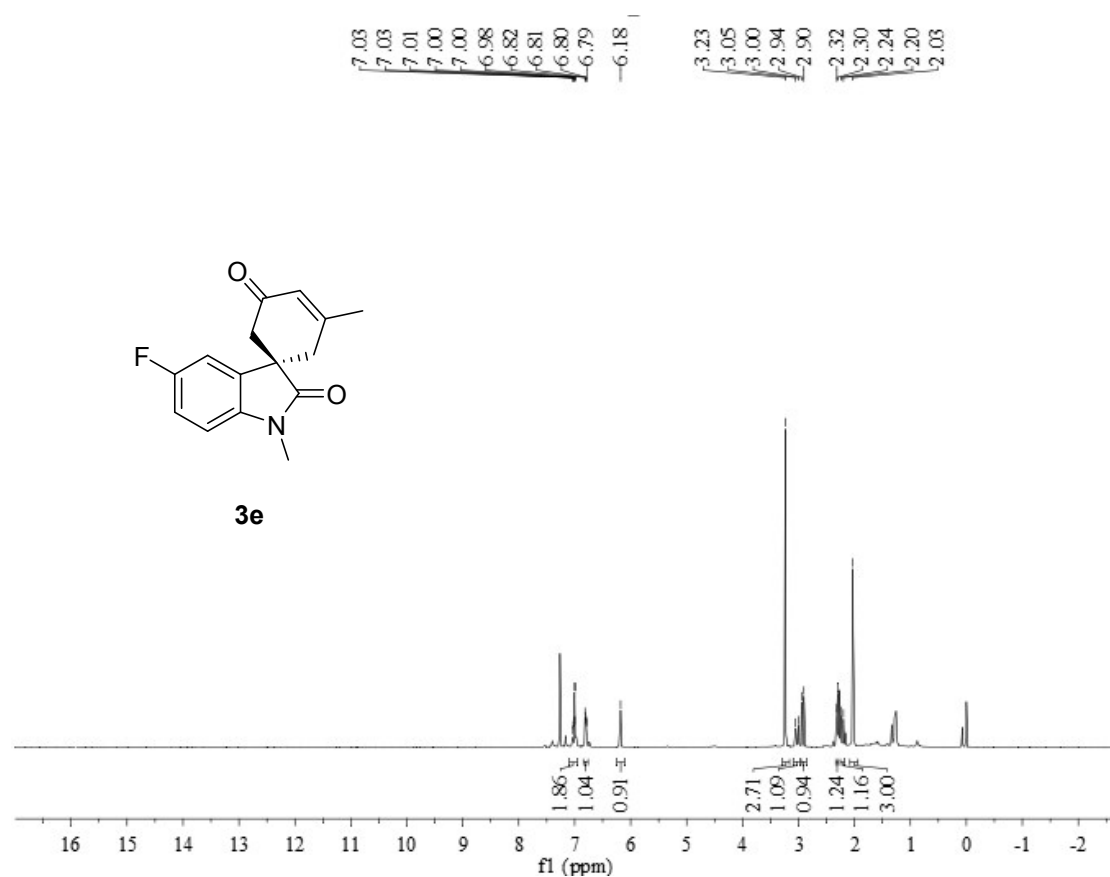
(R)-5'-methoxy-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3c)

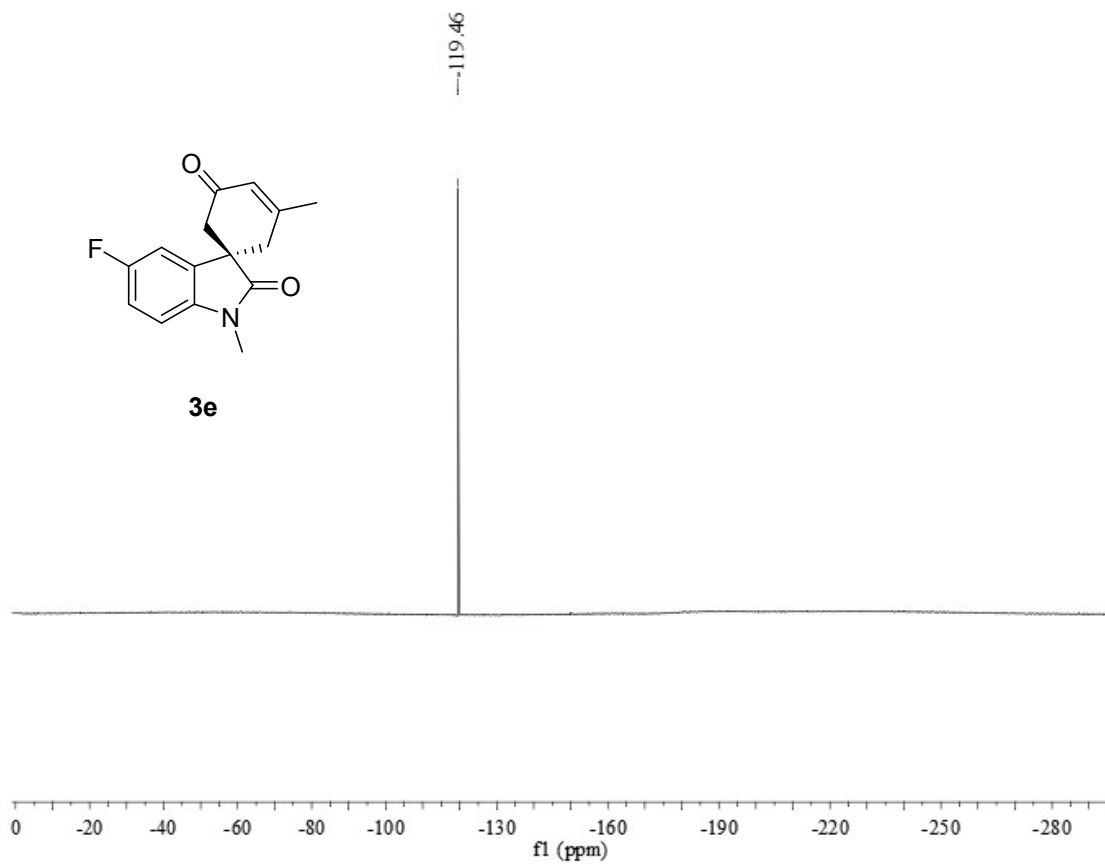


(R)-1',3,5',7'-tetramethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3d)

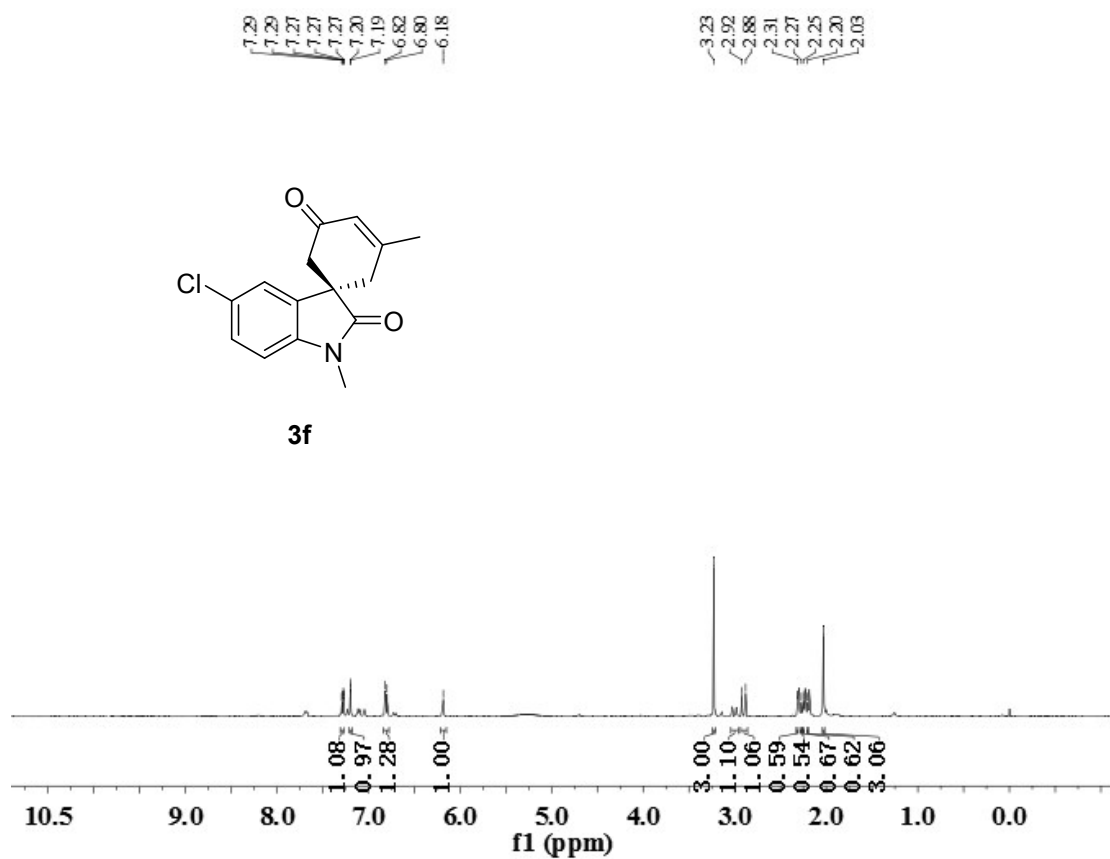


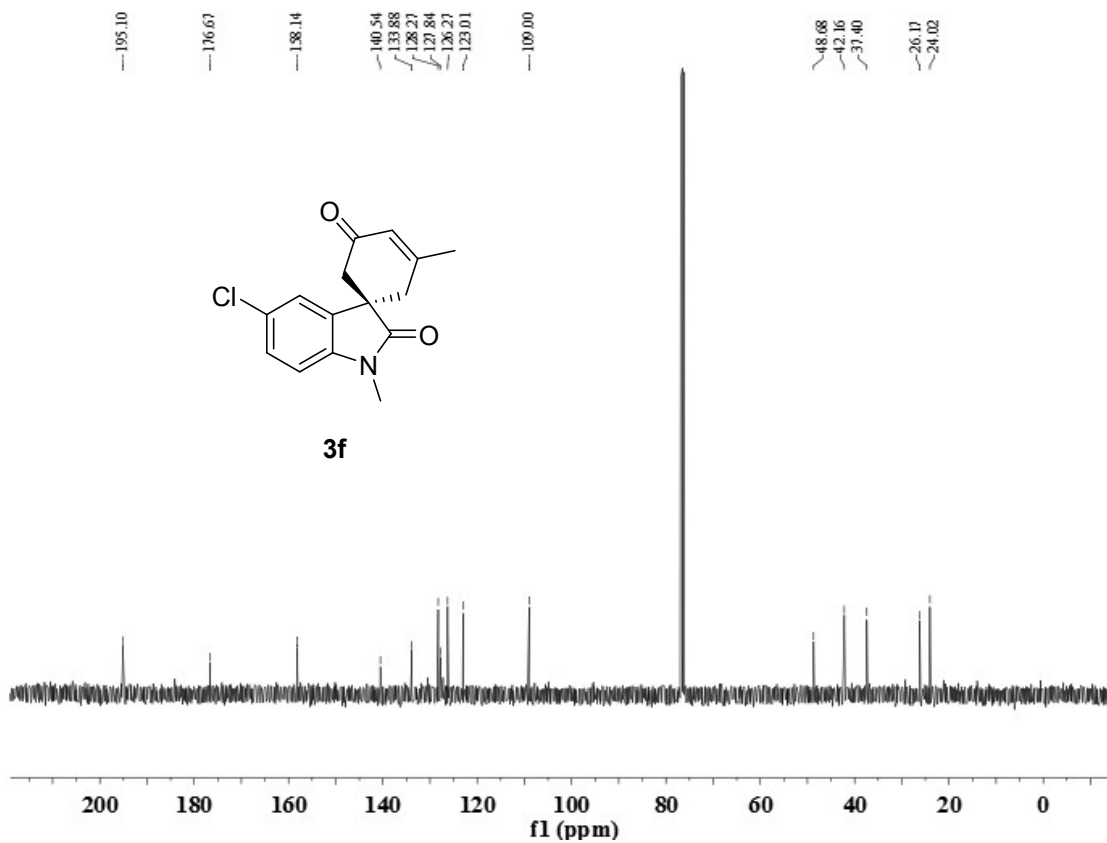
(R)-5'-fluoro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3e)



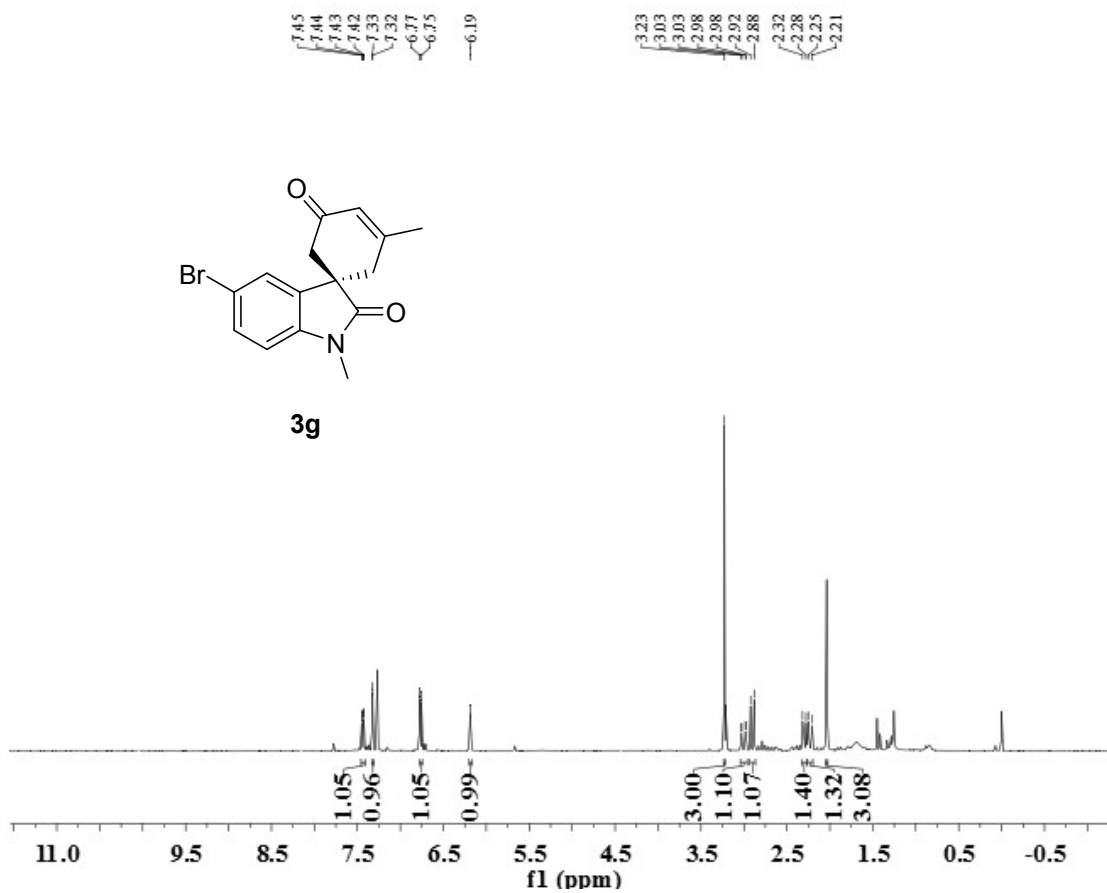


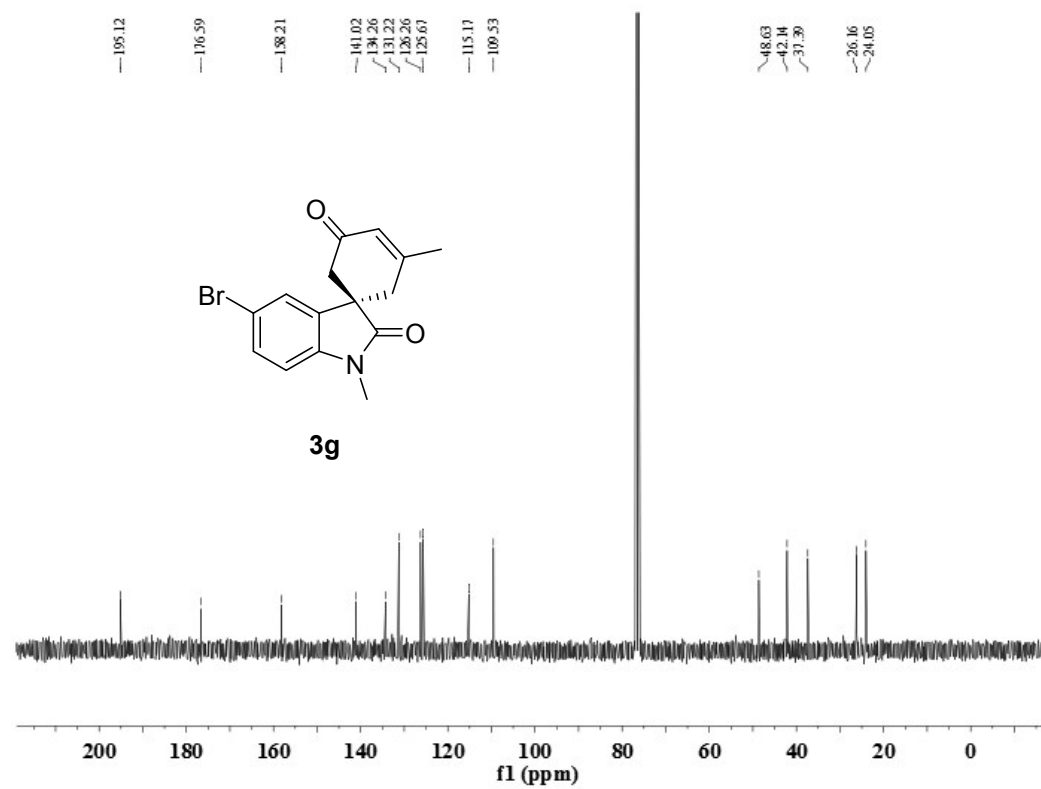
(R)-5'-chloro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3f)



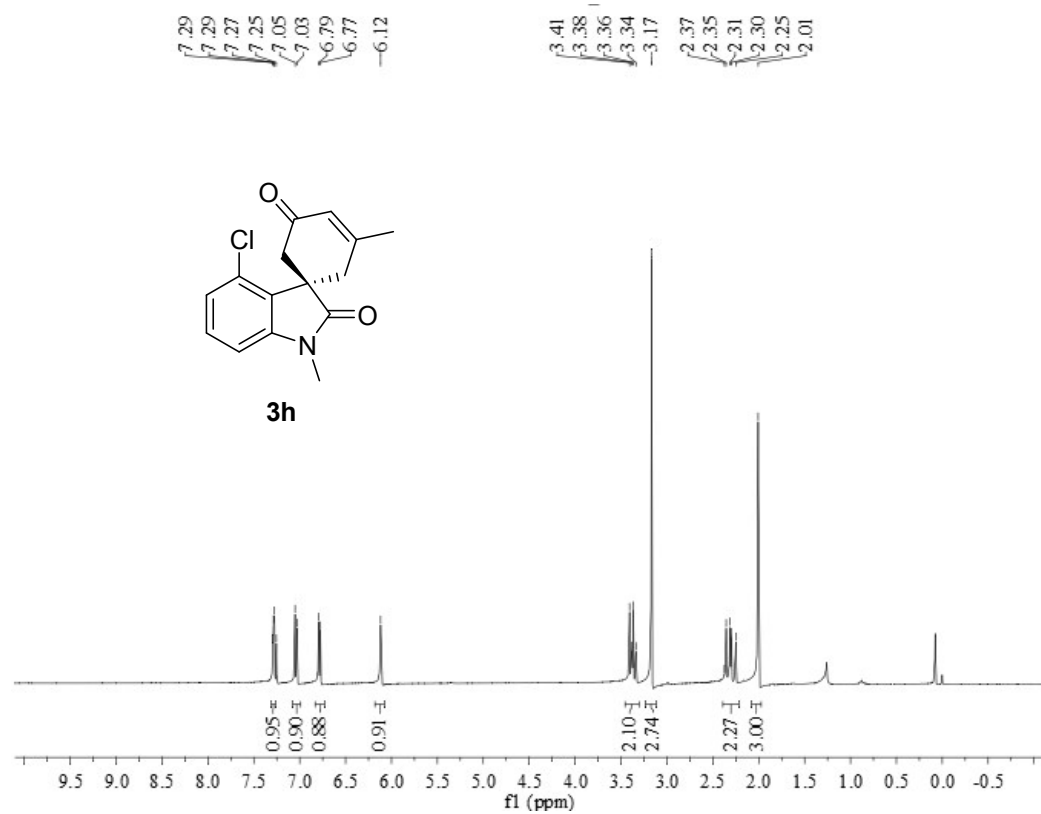


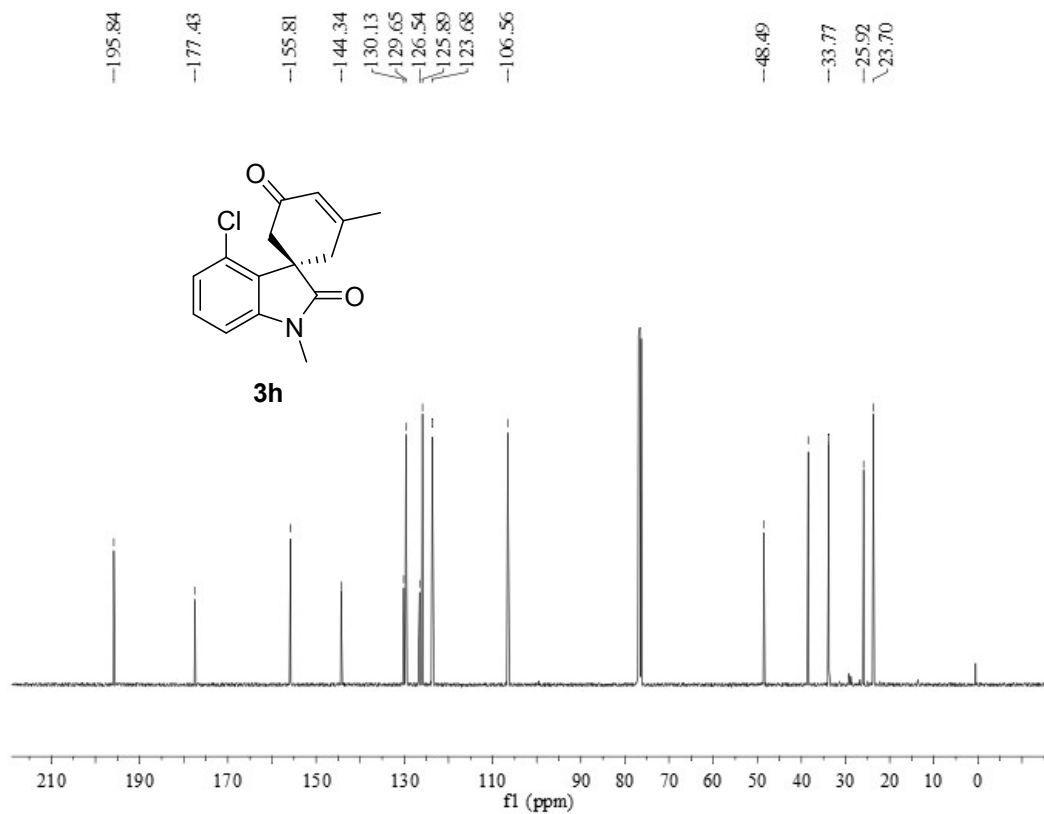
(R)-5'-bromo-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3g)



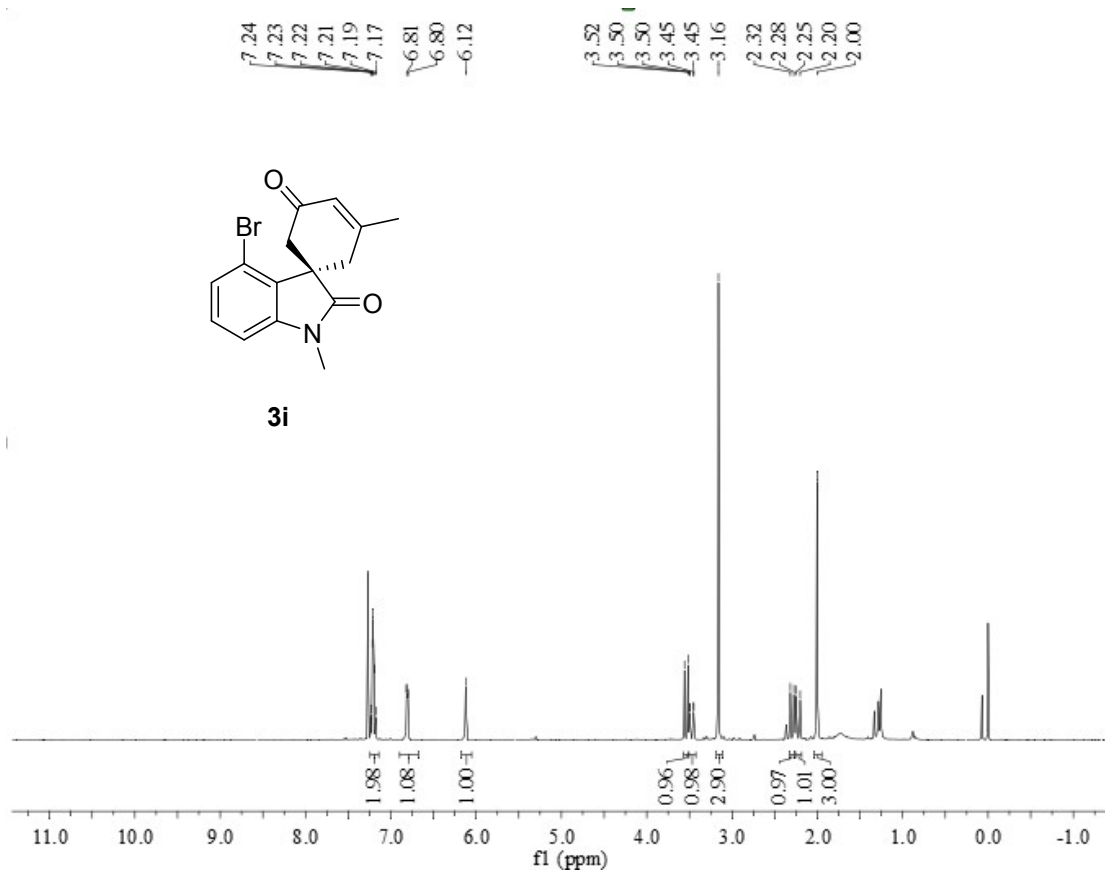


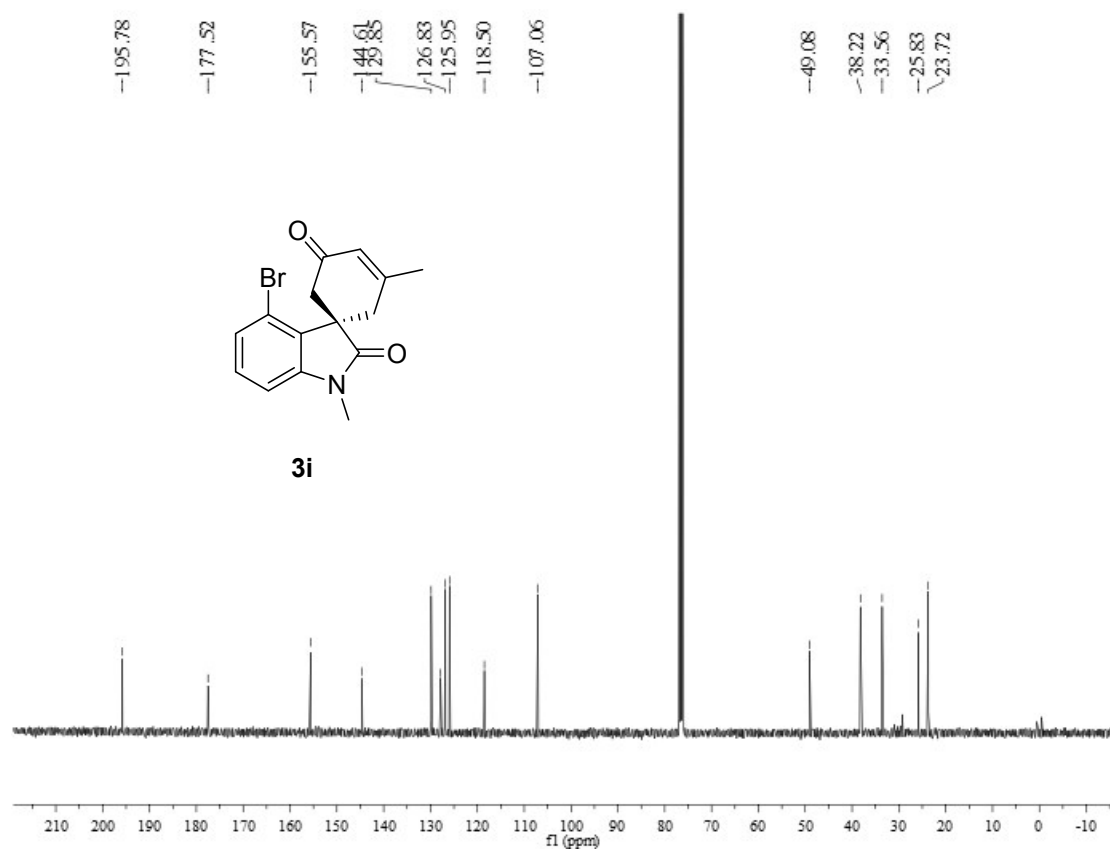
(R)-4'-chloro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3h)



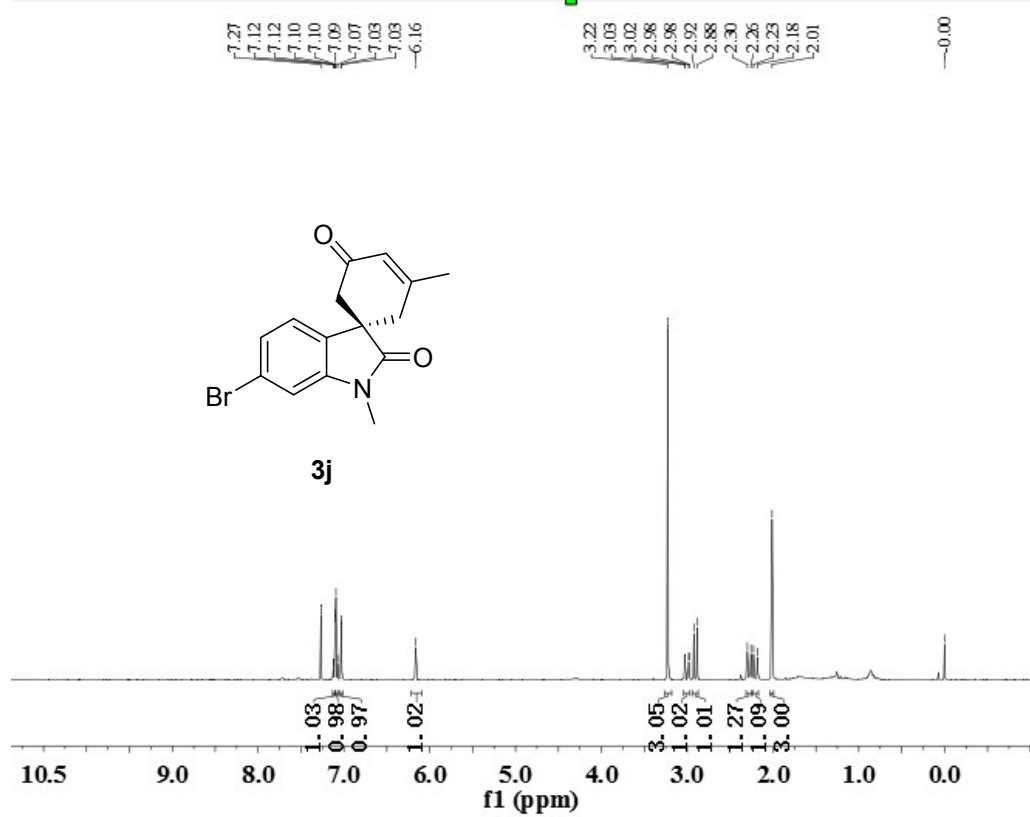


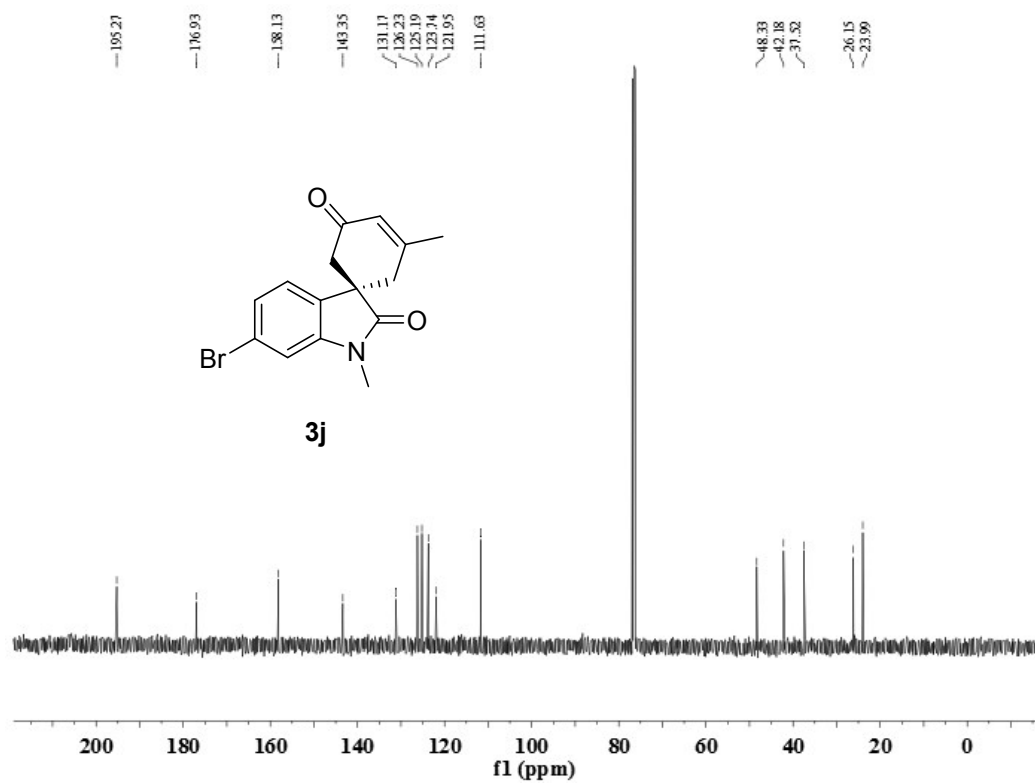
(R)-4'-bromo-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3i)



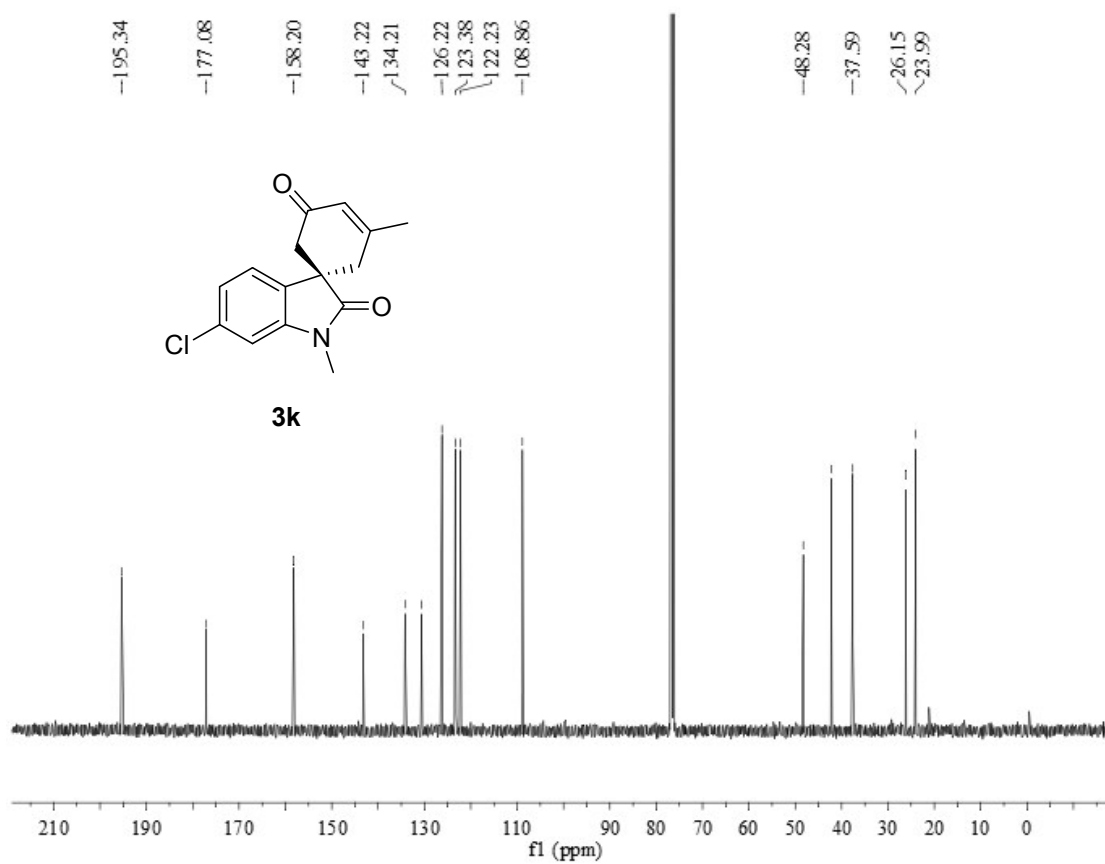
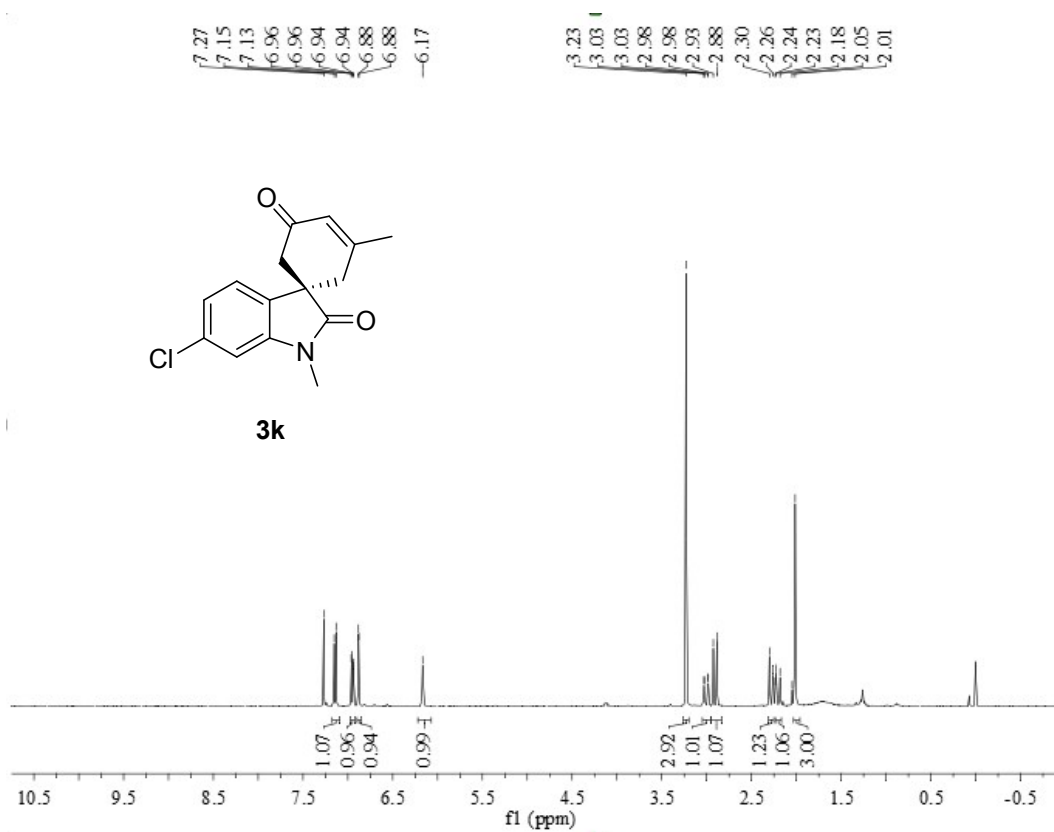


(R)-6'-bromo-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3j)

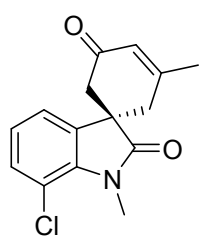
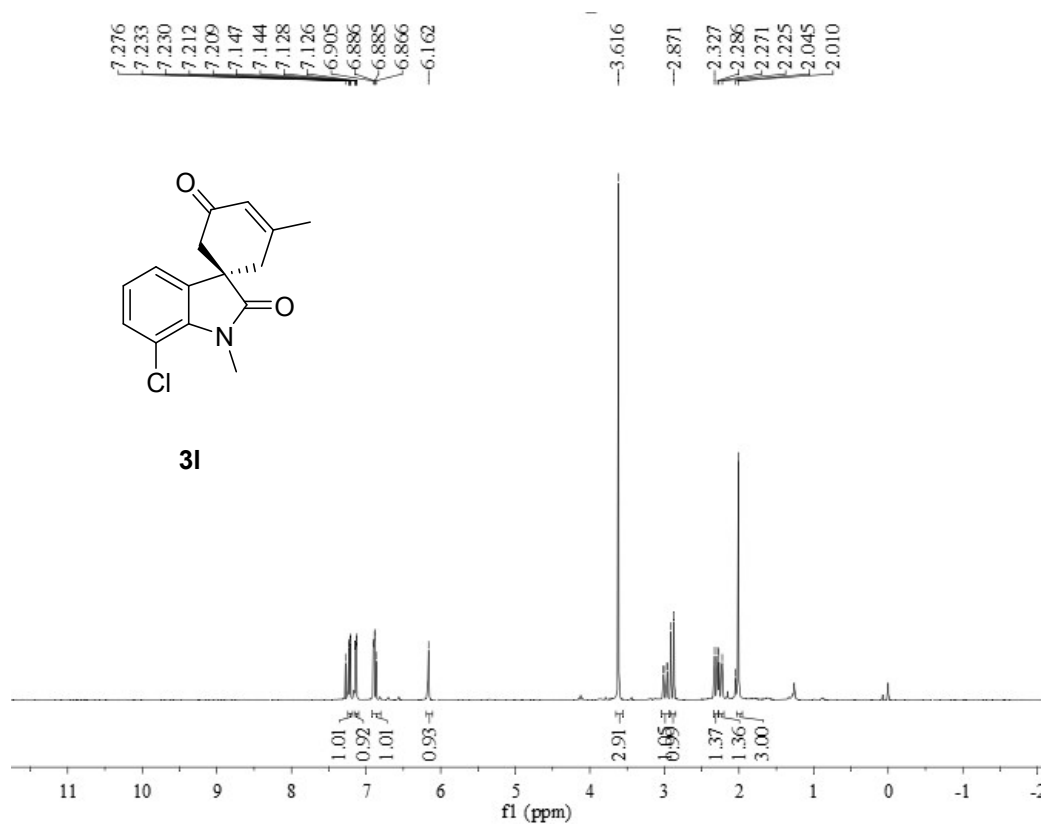




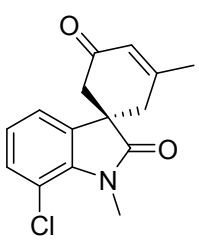
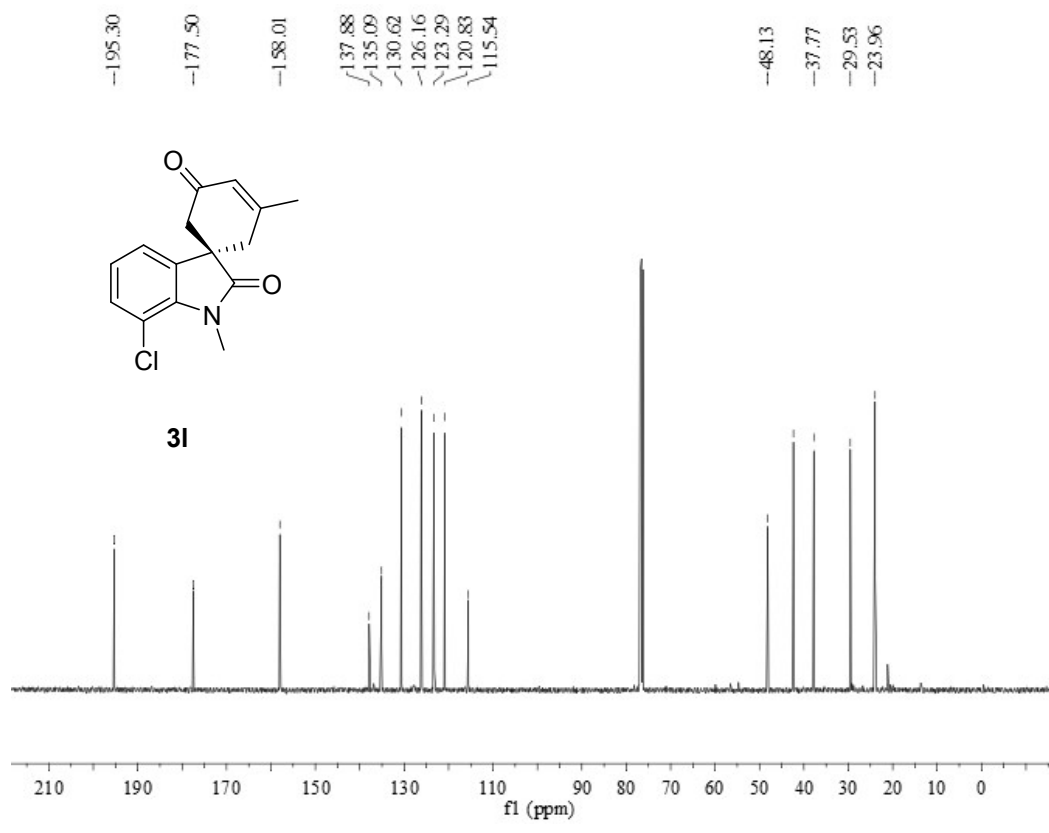
(R)-6'-chloro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3k)



(R)-7'-chloro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3l)

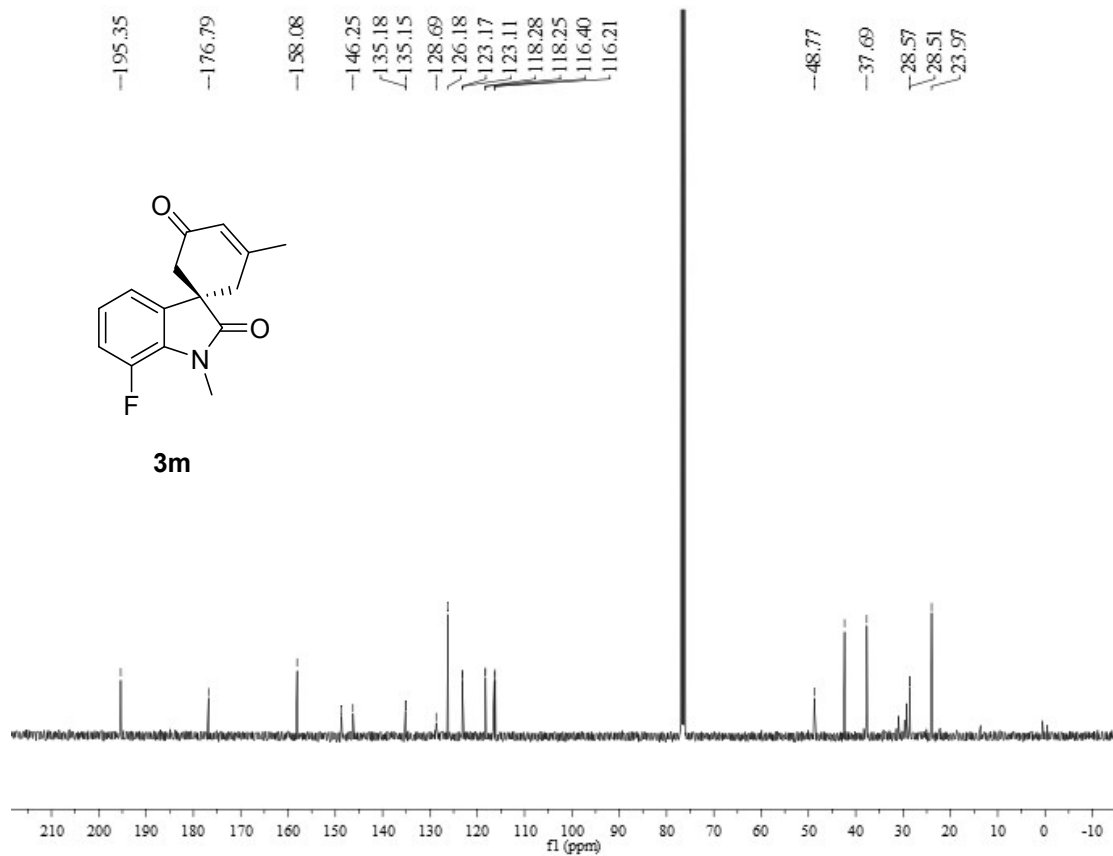
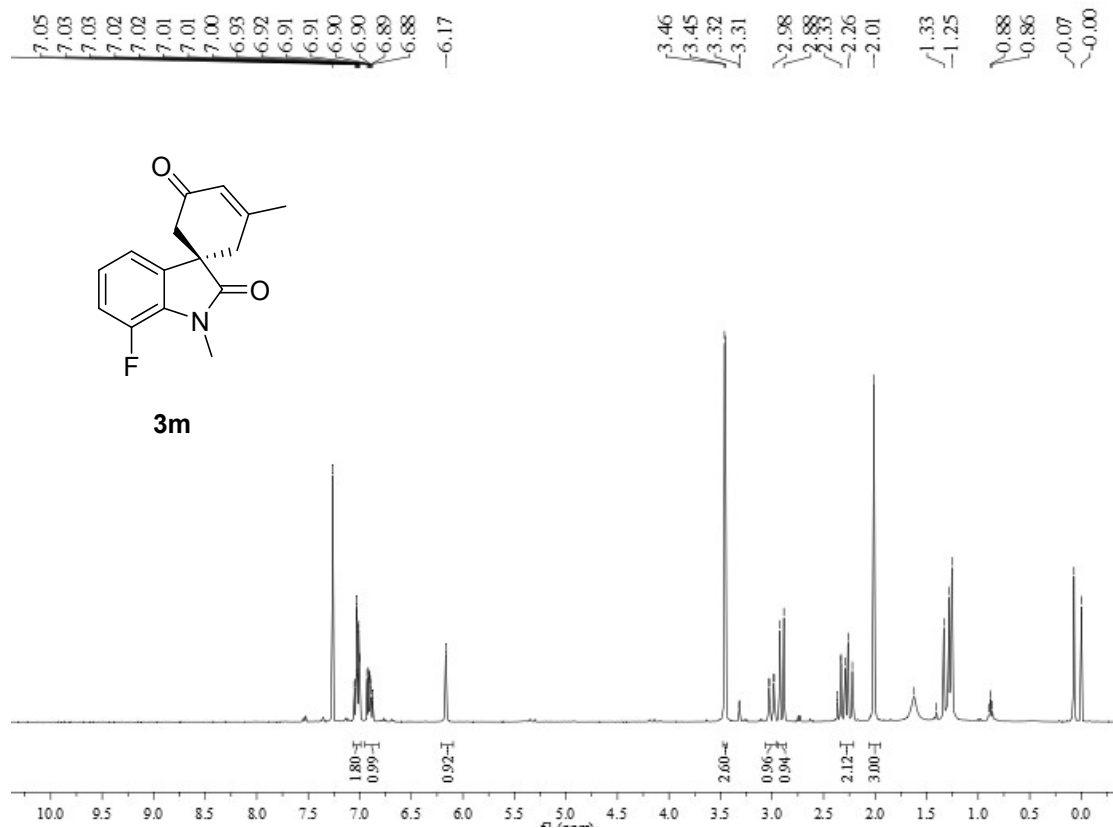


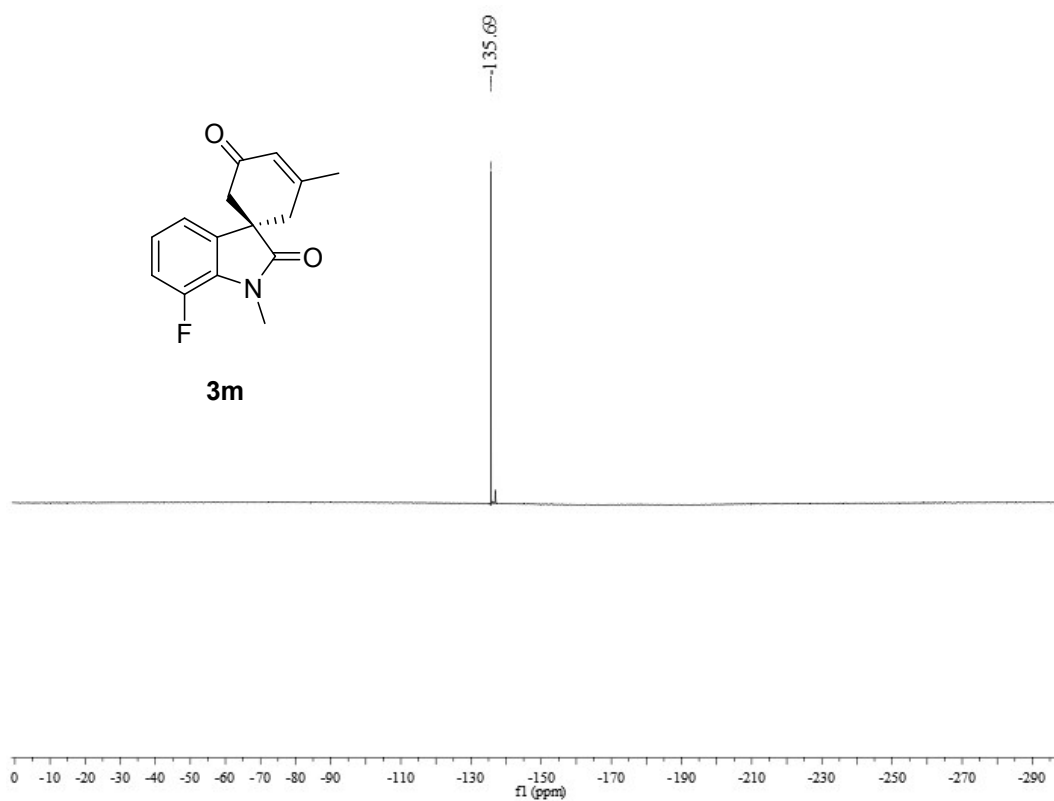
31



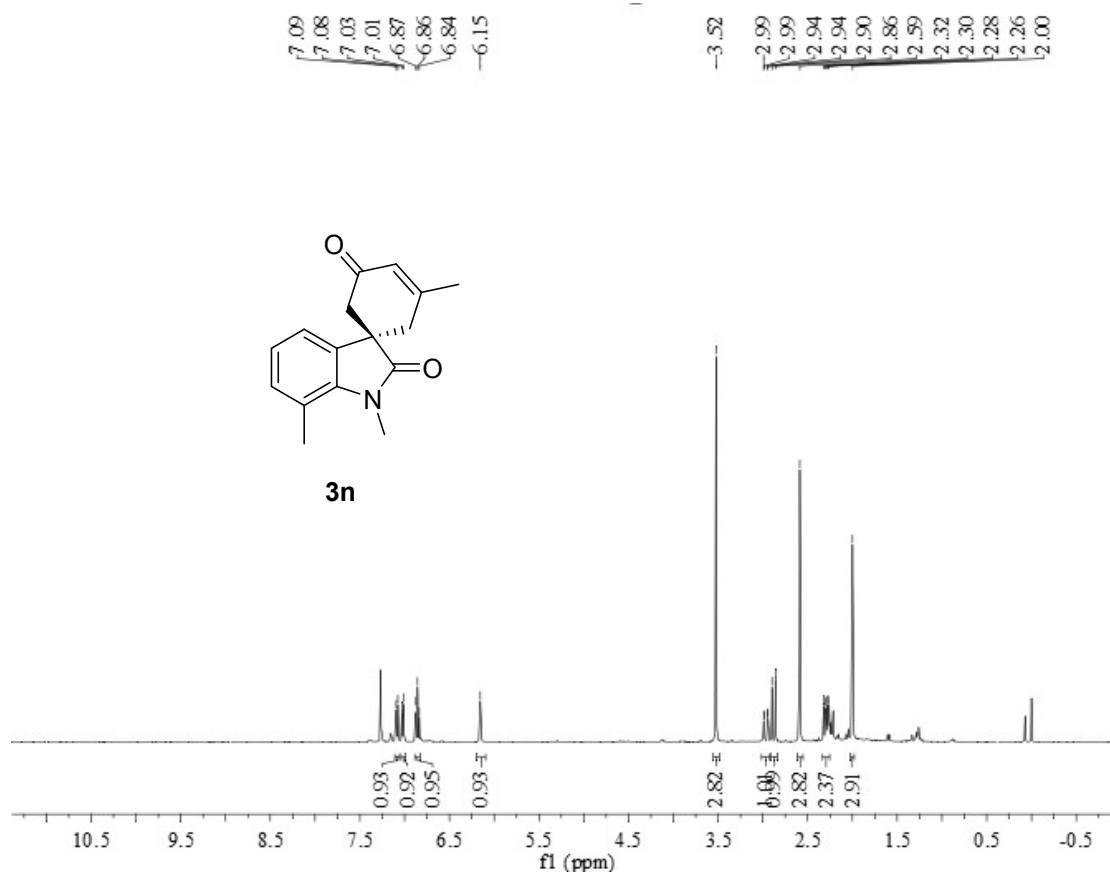
31

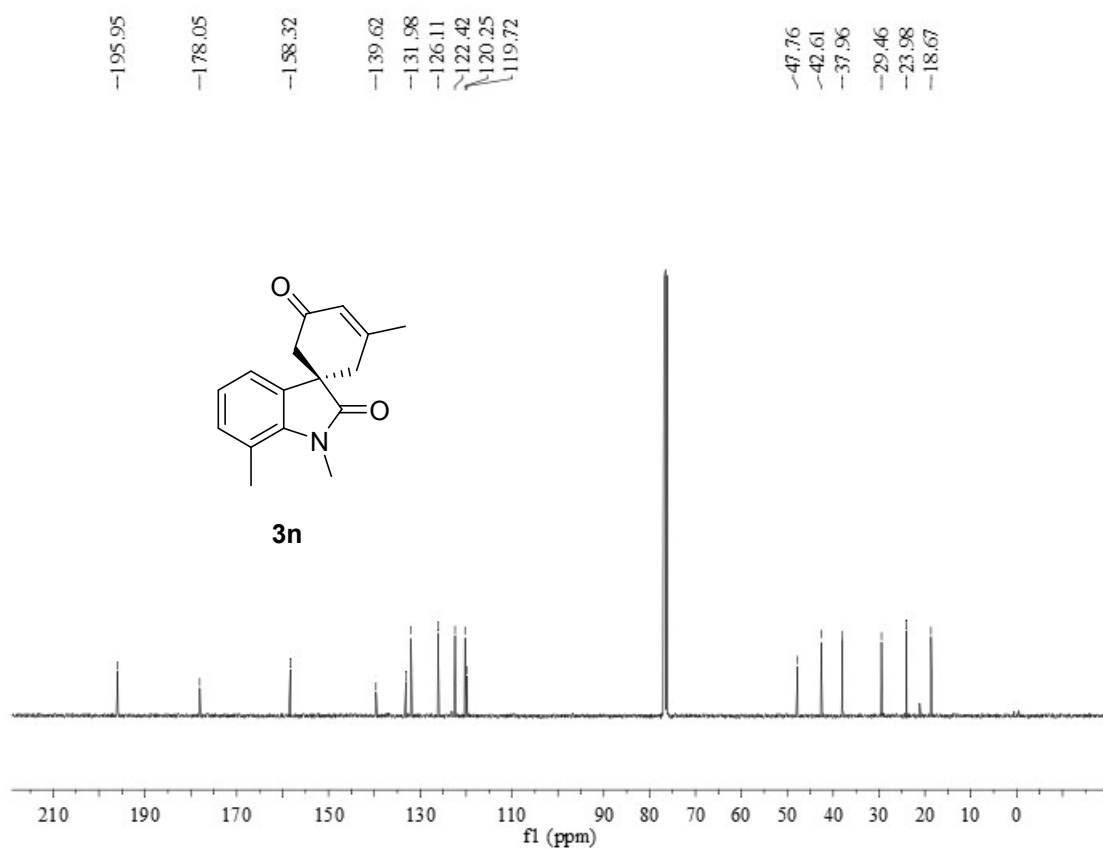
(R)-7'-fluoro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3m)



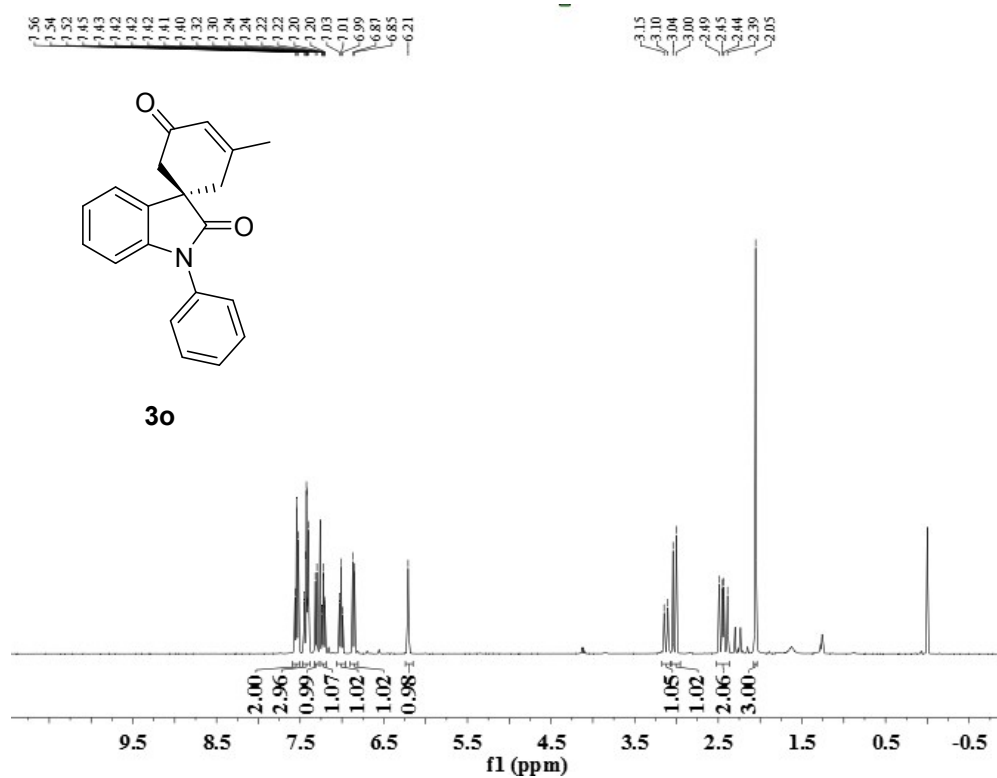


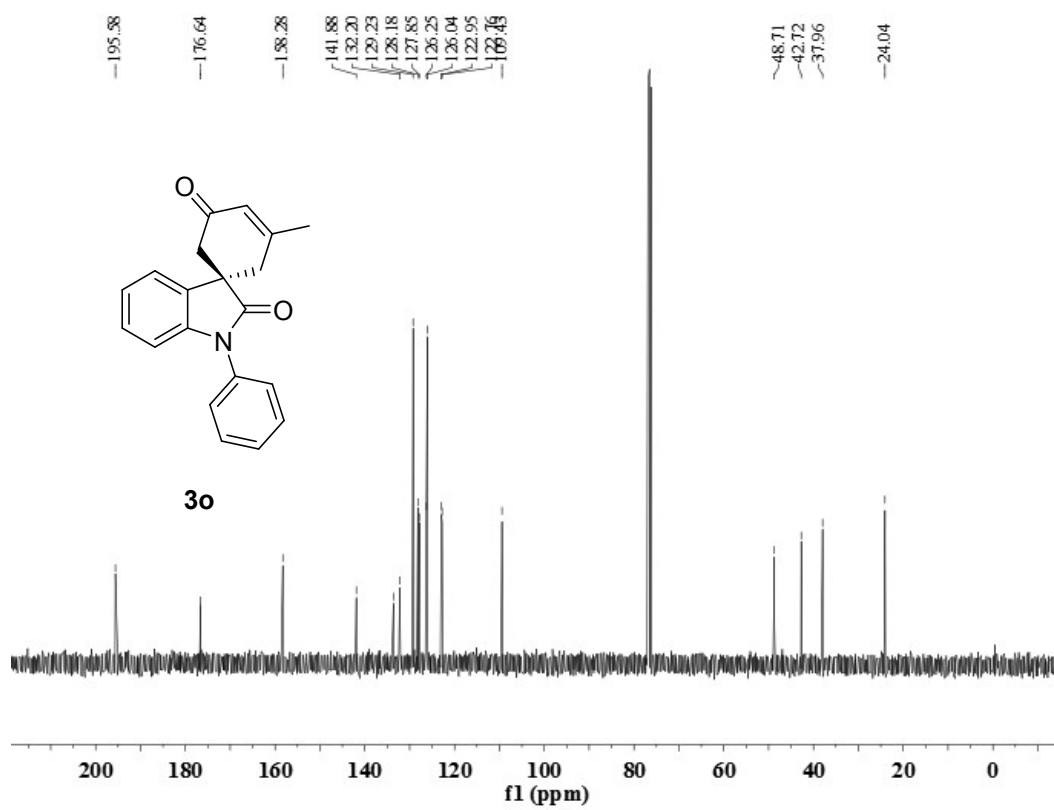
(R)-1',3,7'-trimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3n)



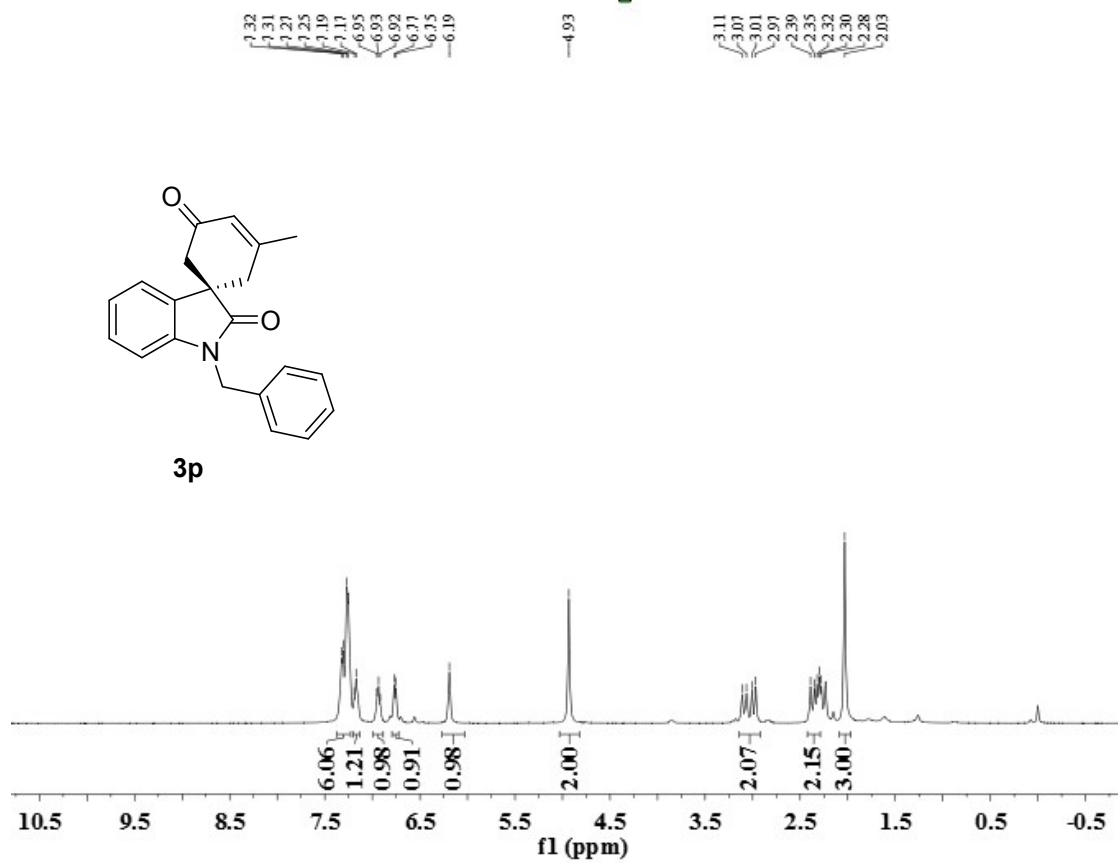


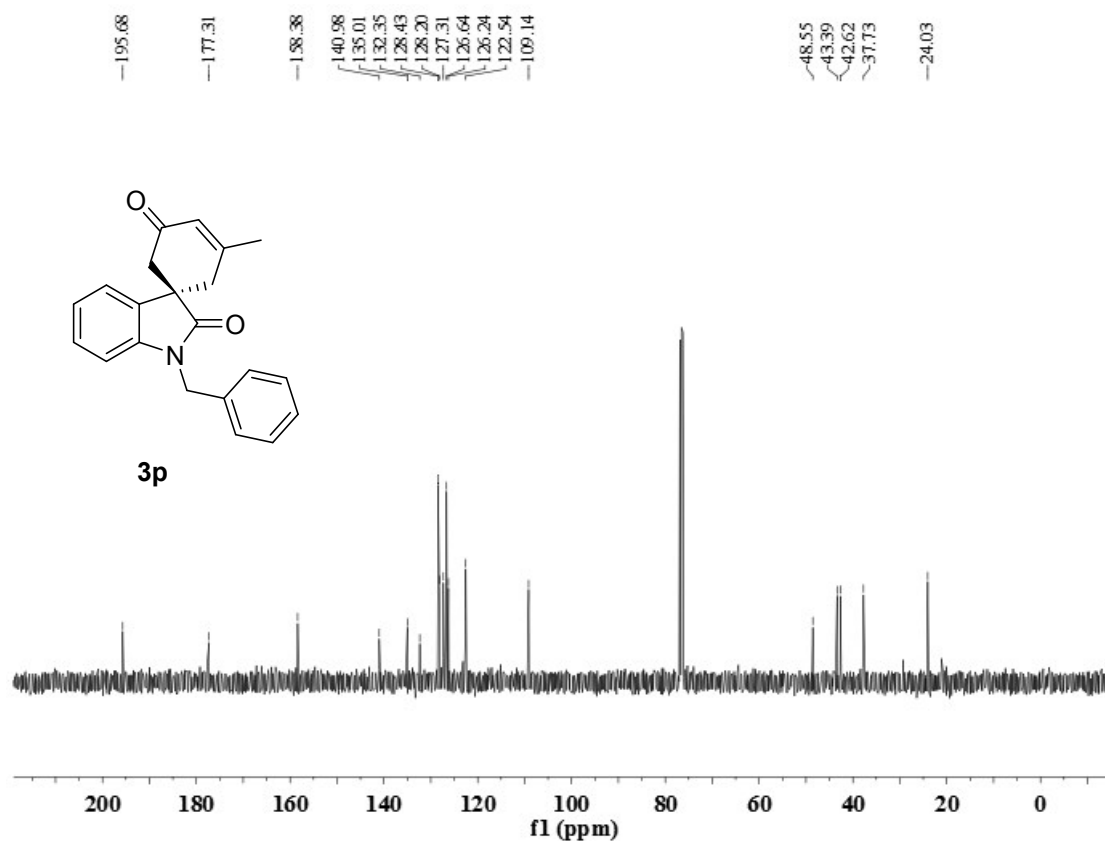
(R)-3-methyl-1'-phenylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3o)



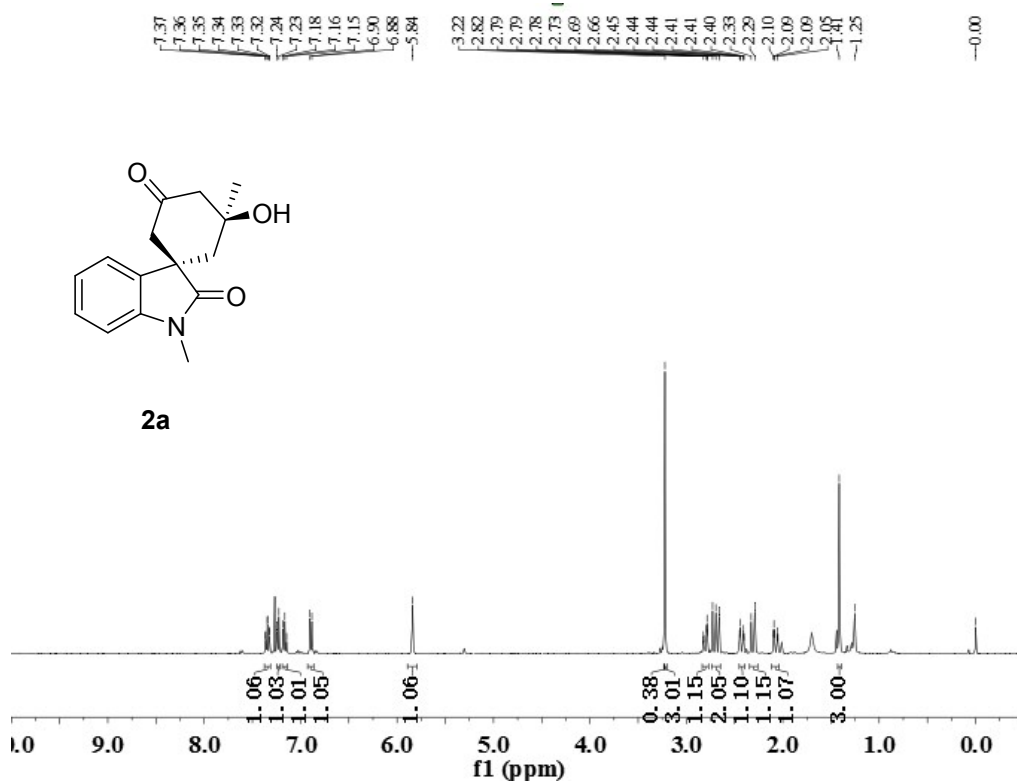


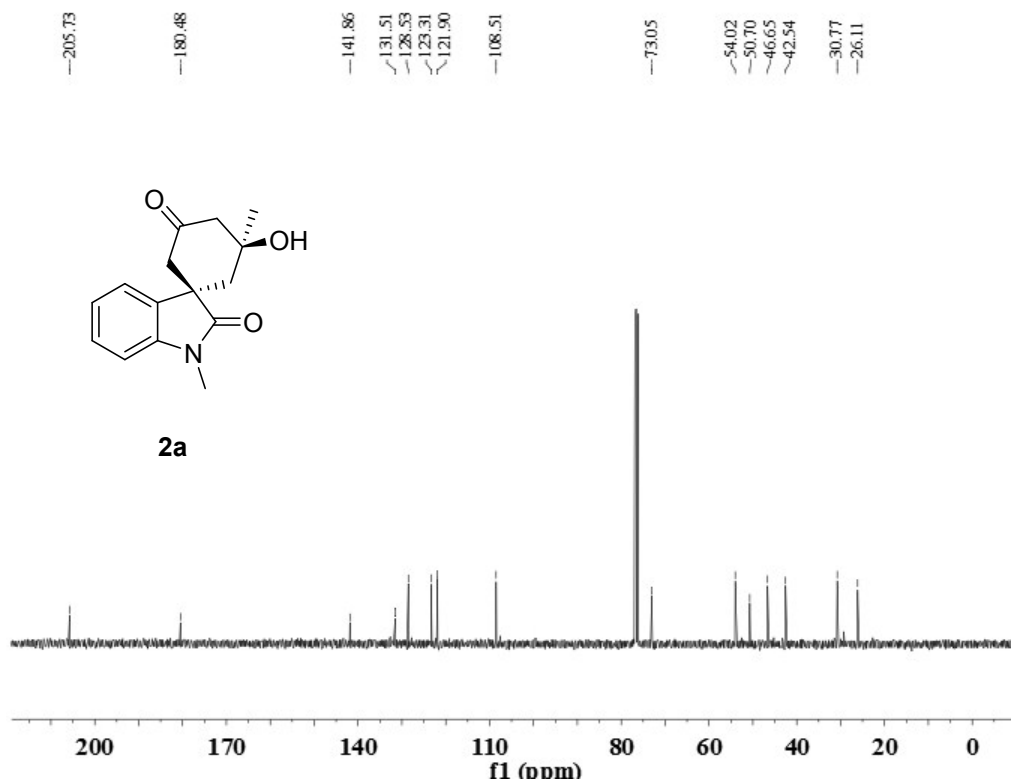
(R)-1'-benzyl-3-methylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3p)



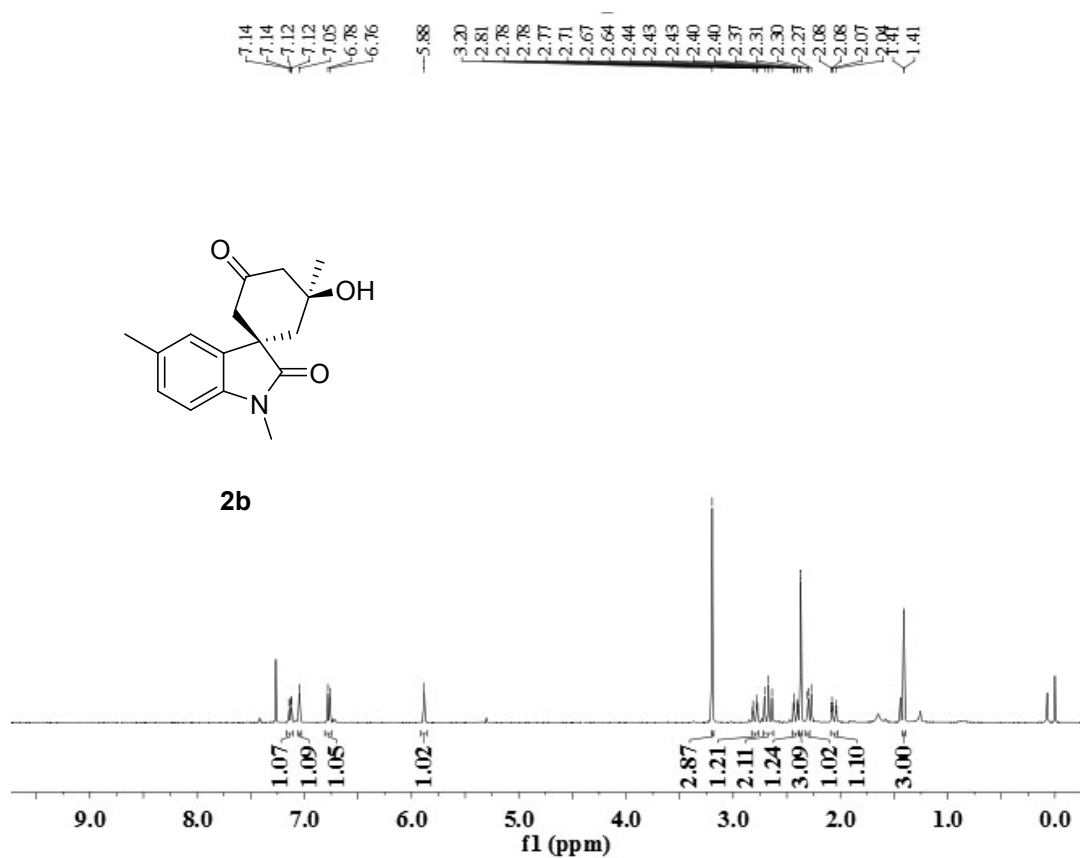


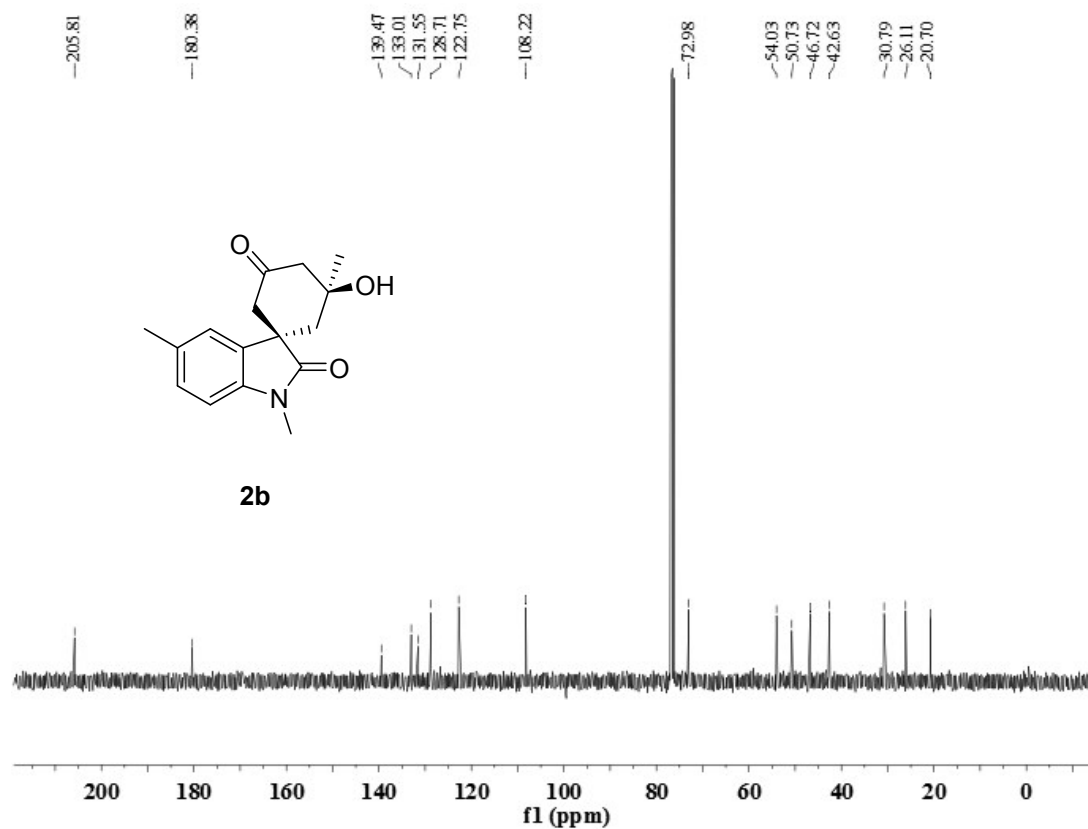
(1*R*,3*S*)-3-hydroxy-1',3-dimethylspiro[cyclohexane-1,3'-indoline]-2',5-dione (**2a**)



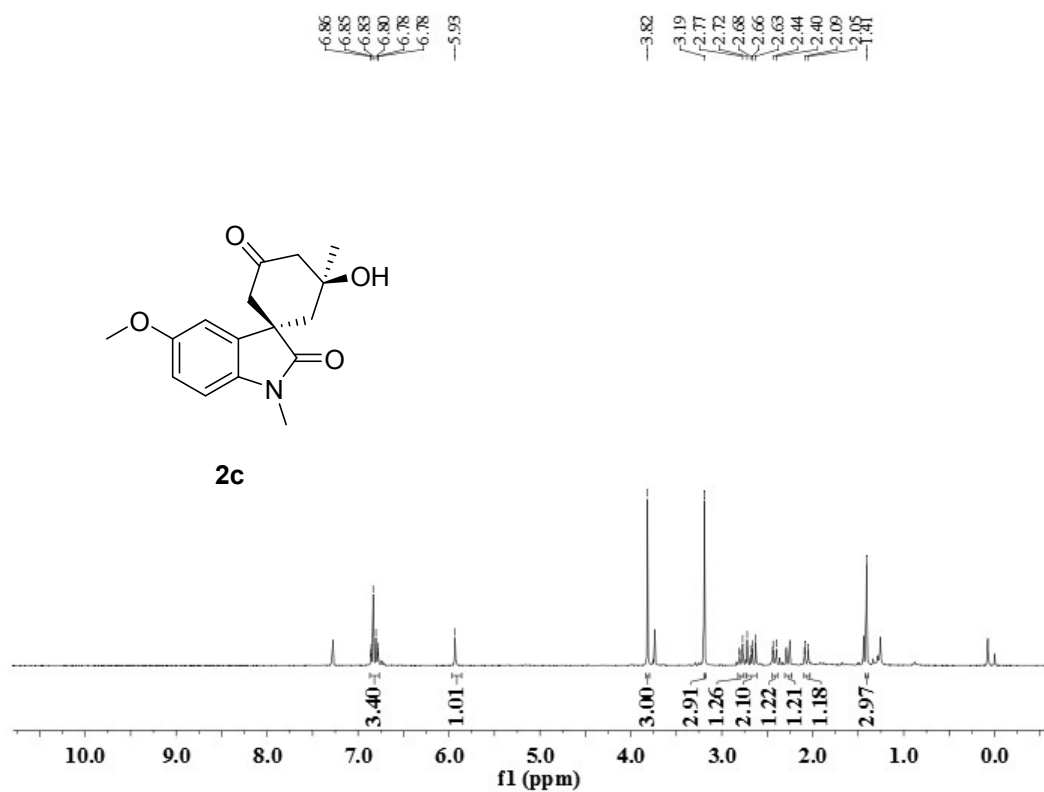


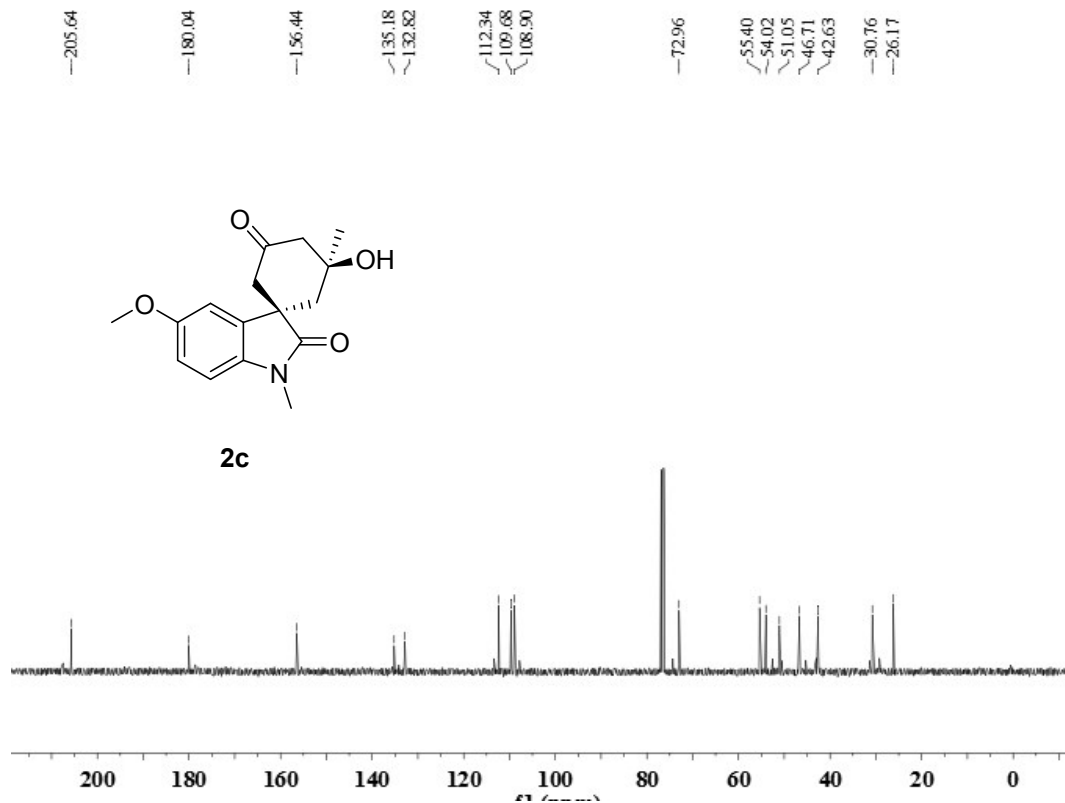
(1*R*,3*S*)-3-hydroxy-1',3,5'-trimethylspiro[cyclohexane-1,3'-indoline]-2',5-dione (2b)



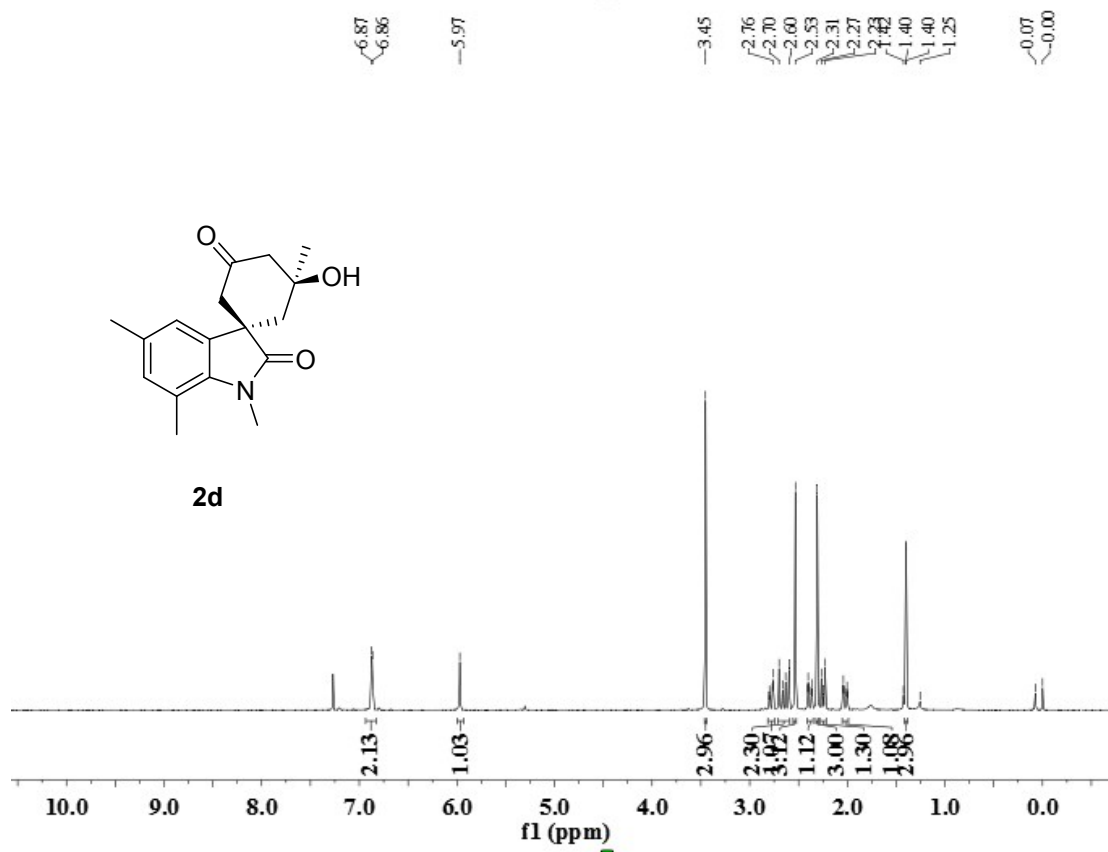


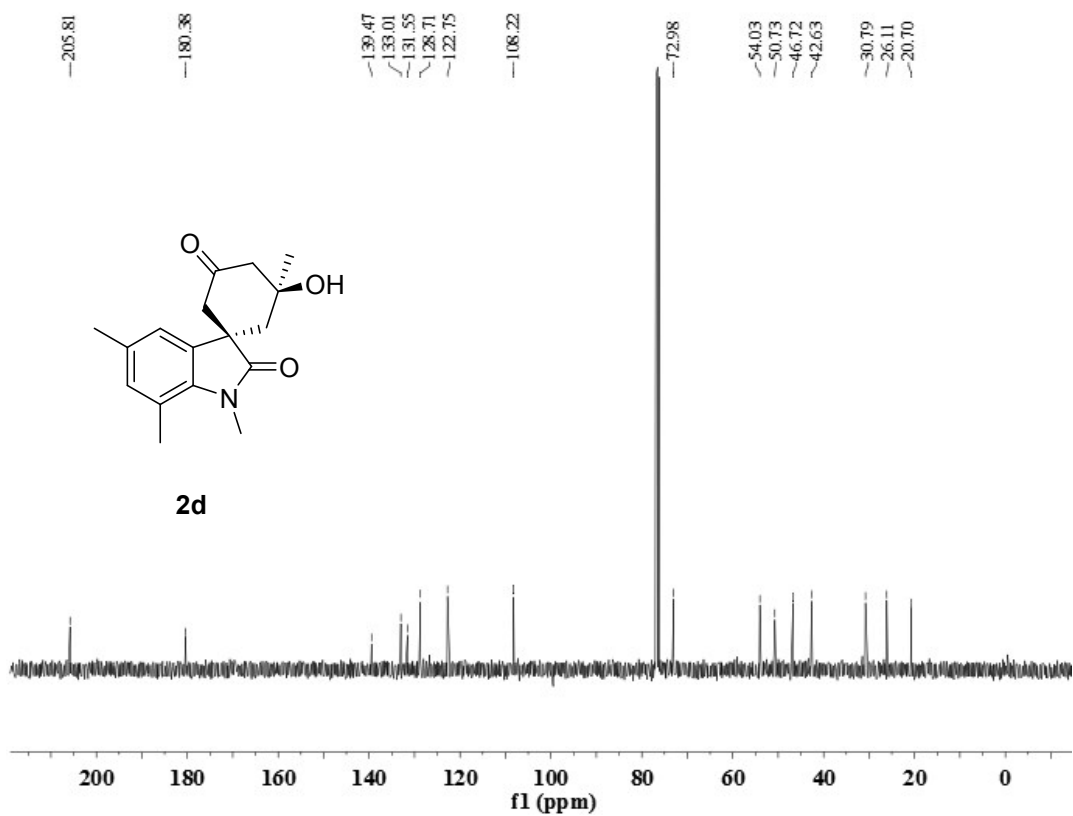
(1*R*,3*S*)-3-hydroxy-5'-methoxy-1',3-dimethylspiro[cyclohexane-1,3'-indoline]-2',5-dione (2c)





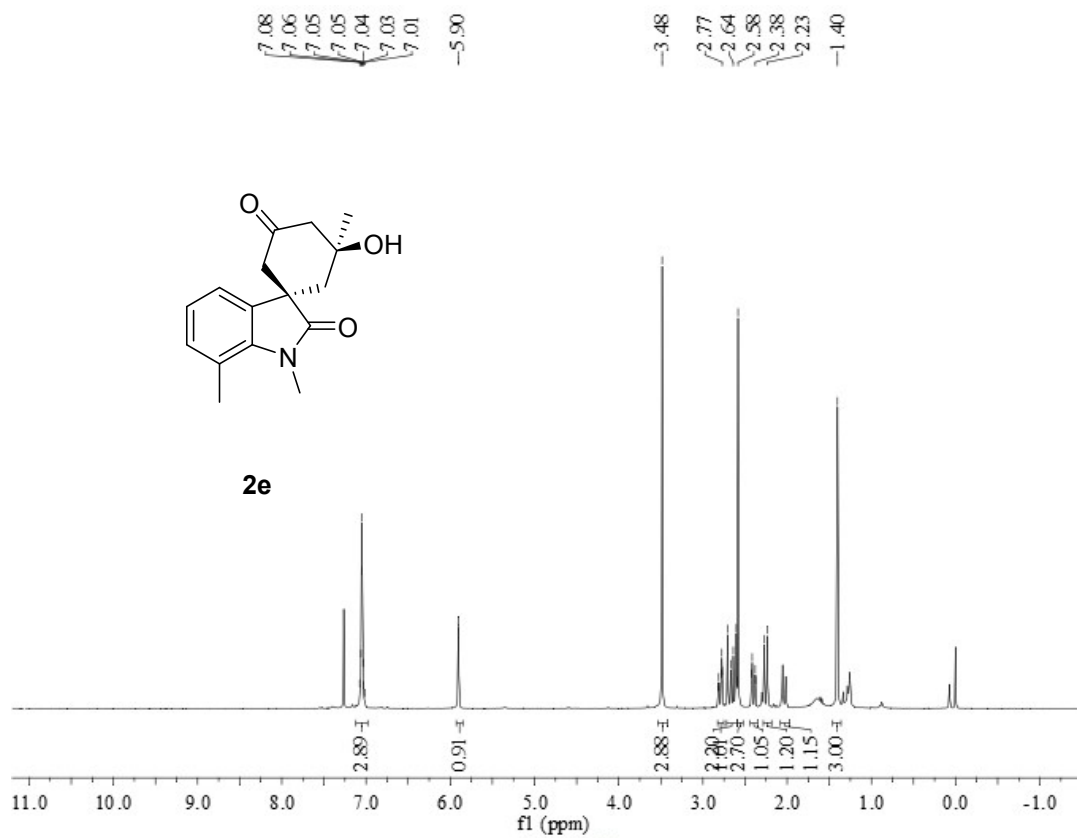
(1*R*,3*S*)-3-hydroxy-1',3,5',7'-tetramethylspiro[cyclohexane-1,3'-indoline]-2',5-dione (2d)

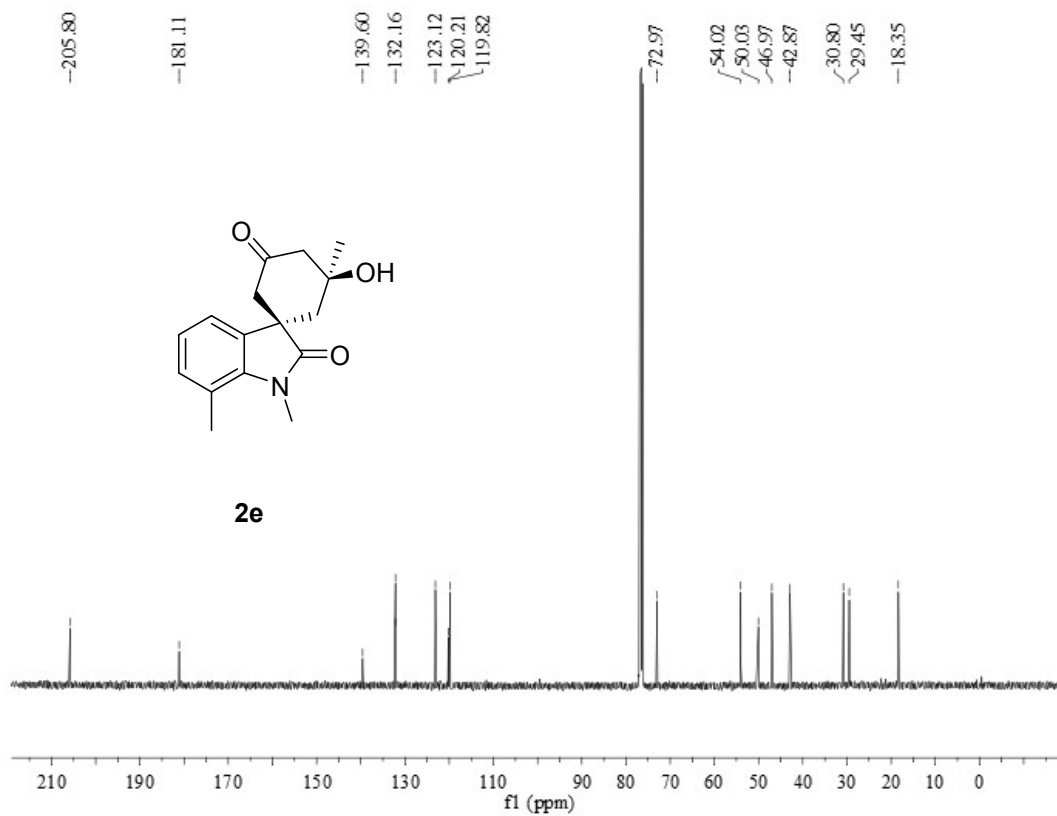




(1*R*,3*S*)-3-hydroxy-1',3,7'-trimethylspiro[cyclohexane-1,3'-indoline]-2',5-dione

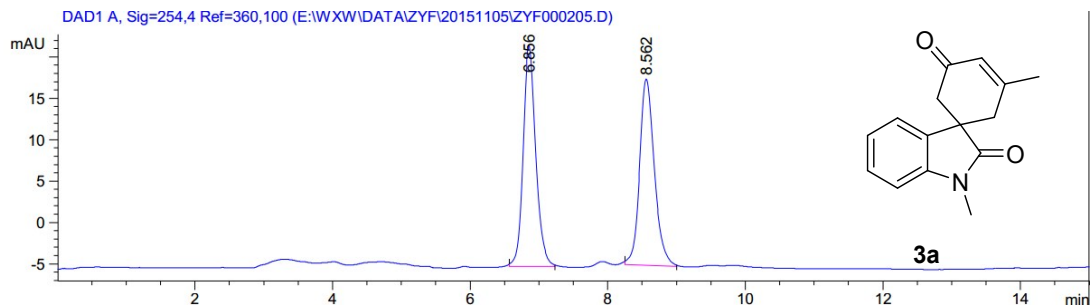
(2e)



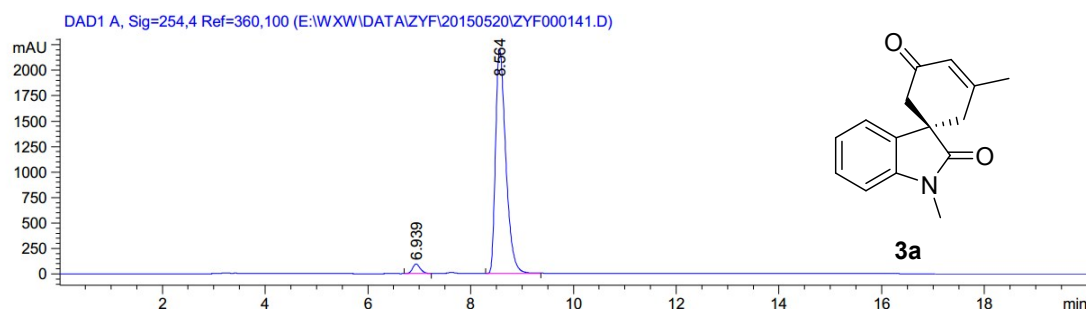


6. HPLC spectra

(*R*)-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (**3a**)

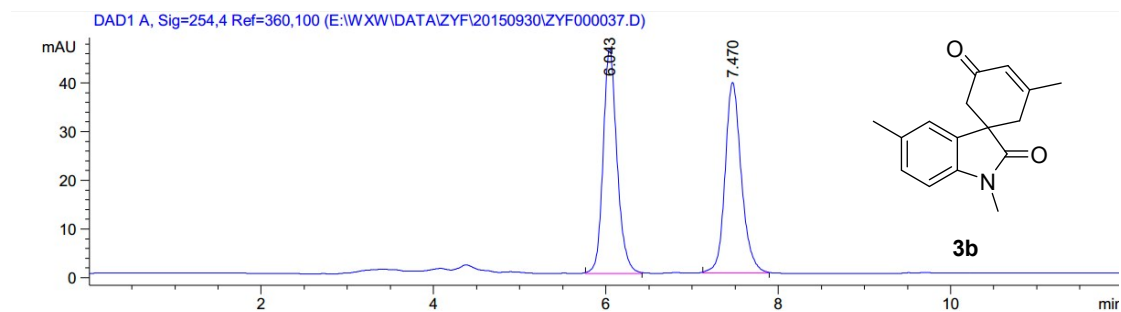


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.856	BB	0.1943	339.72488	26.73346	50.4525
2	8.562	BB	0.2252	333.63165	22.46773	49.5475

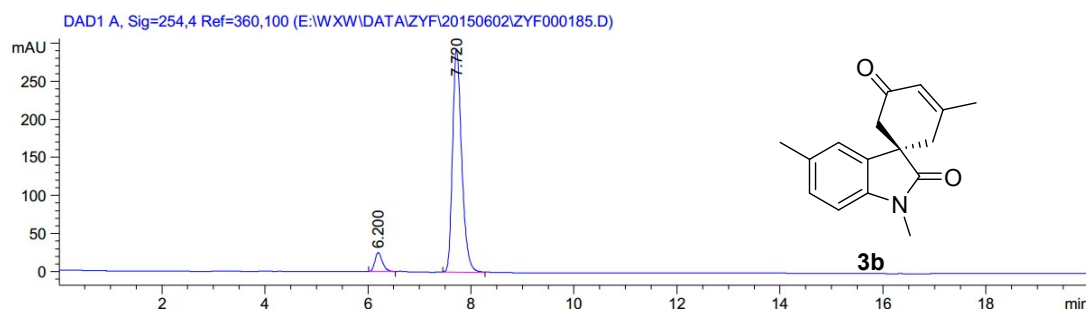


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.939	BV	0.1646	1014.26379	94.94855	3.2142
2	8.564	BB	0.2140	3.05414e4	2199.68384	96.7858

1',3,5'-trimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3b)

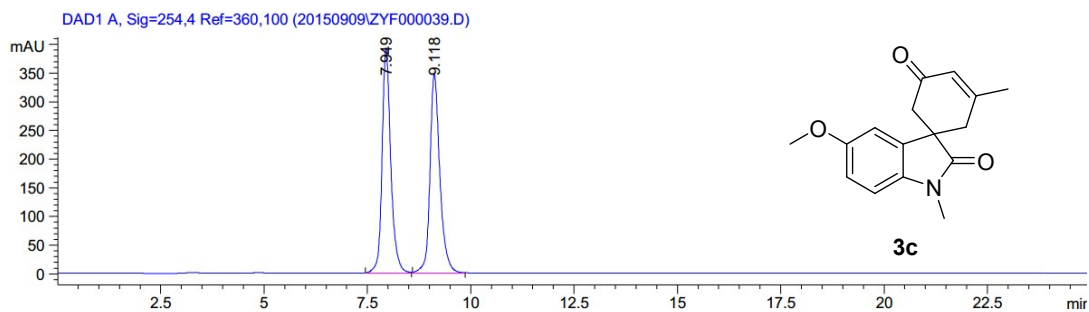


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.043	BB	0.1705	516.59576	46.18646	50.0381
2	7.470	BB	0.1996	515.80853	39.16749	49.9619

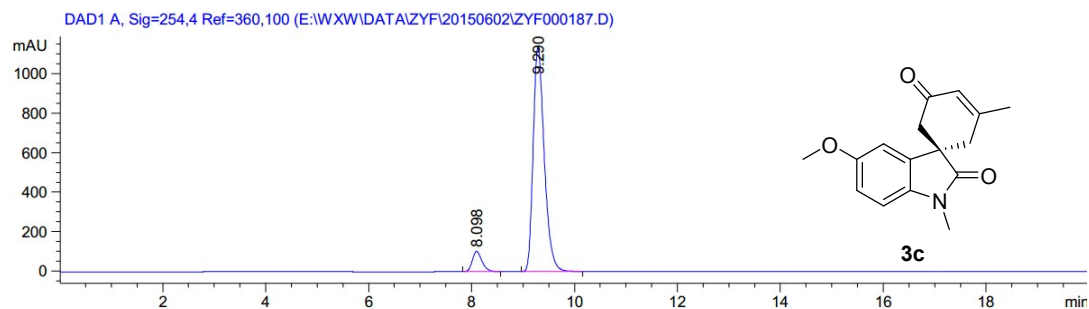


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.200	BB	0.1548	252.23119	24.77690	6.5184
2	7.720	BB	0.1881	3617.31421	292.84329	93.4816

5'-methoxy-1',3'-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3c)

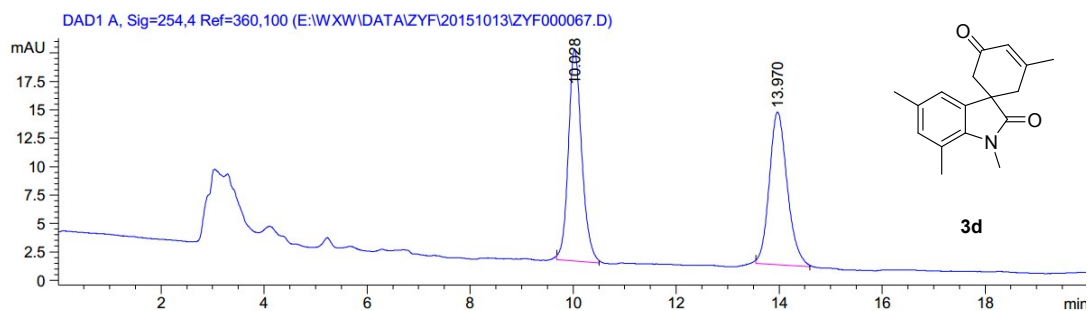


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.949	BB	0.2212	5756.07813	392.14700	49.9389
2	9.118	BB	0.2503	5770.16260	346.52817	50.0611

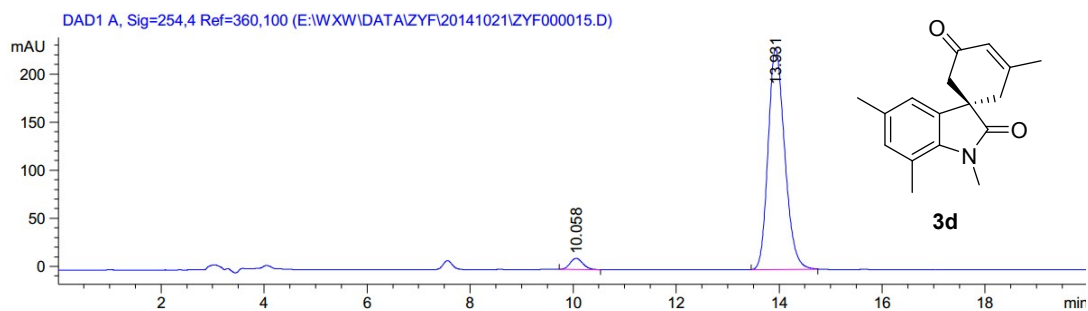


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.098	BB	0.1988	1349.75977	103.09045	7.3296
2	9.290	BB	0.2295	1.70653e4	1134.64465	92.6704

1',3',5',7'-tetramethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3d)

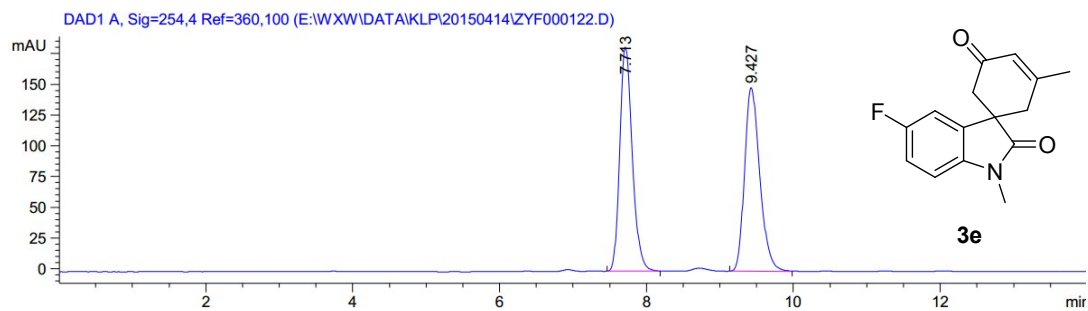


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.028	BB	0.2736	334.70117	18.62933	50.6620
2	13.970	BB	0.3671	325.95453	13.43311	49.3380

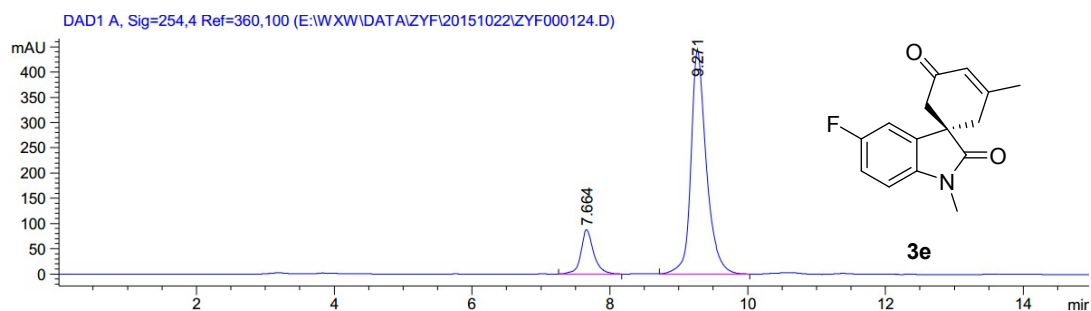


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.058	BB	0.2664	200.94386	11.70000	3.7485
2	13.931	BB	0.3458	5159.68555	229.92014	96.2515

5'-fluoro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3e)

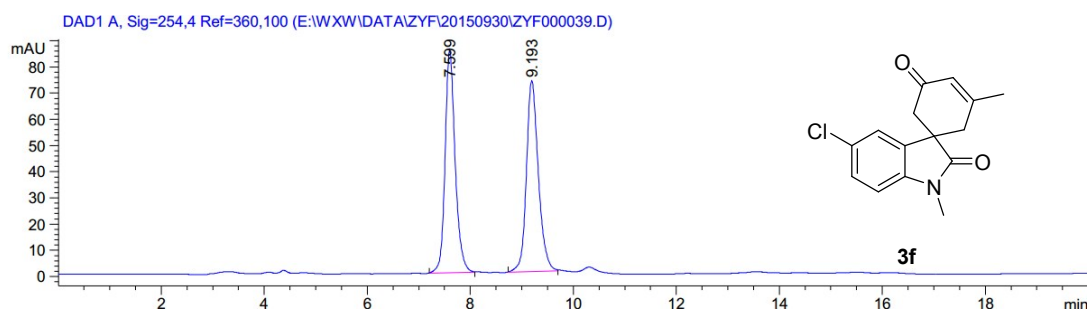


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.713	BB	0.1819	2151.73926	182.07396	49.9154
2	9.427	BB	0.2207	2159.03638	149.33194	50.0846

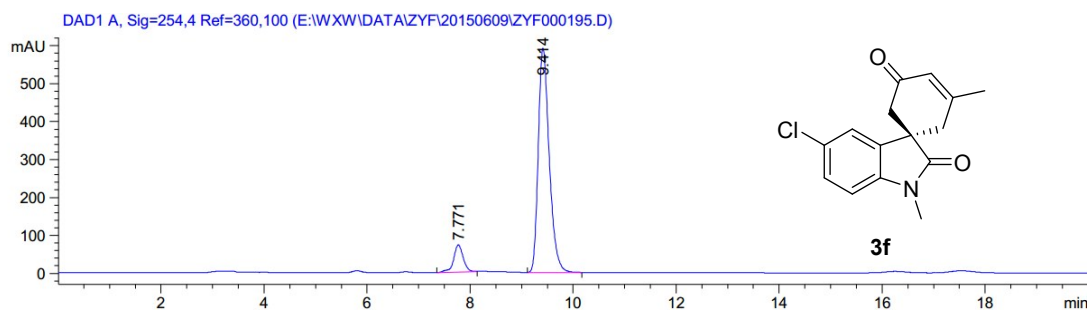


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.664	BB	0.1949	1157.51880	88.30658	14.2208
2	9.271	VB	0.2328	6982.08838	445.63812	85.7792

5'-chloro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3f)

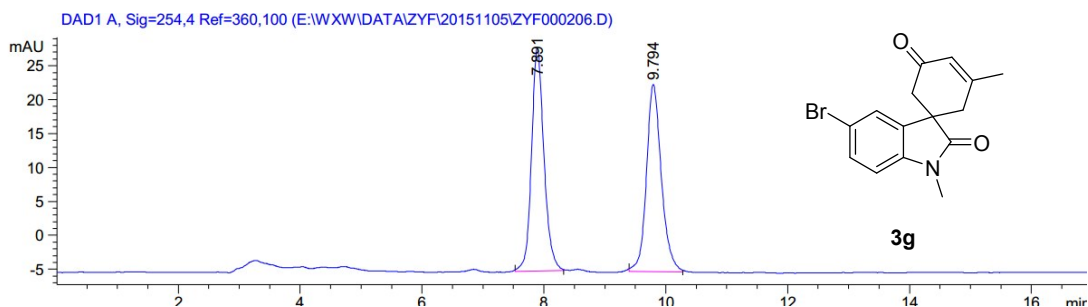


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.599	BB	0.2064	1153.37305	84.92987	49.6039
2	9.193	BB	0.2418	1171.79517	72.79231	50.3961

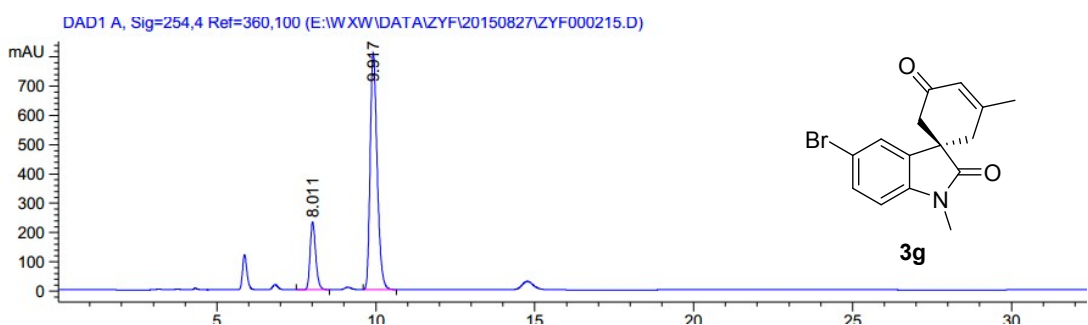


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.771	BB	0.1971	927.12891	71.60761	9.5893
2	9.414	BB	0.2267	8741.28516	590.51465	90.4107

5'-bromo-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3g)

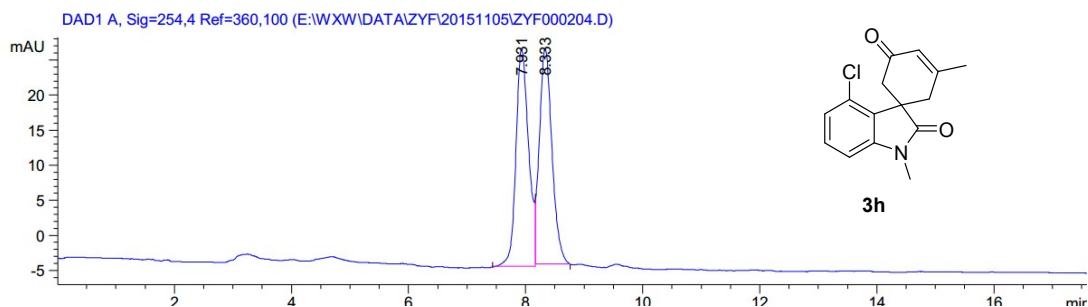


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.891	BB	0.2162	467.76627	32.84144	49.9543
2	9.794	BB	0.2562	468.62155	27.57841	50.0457

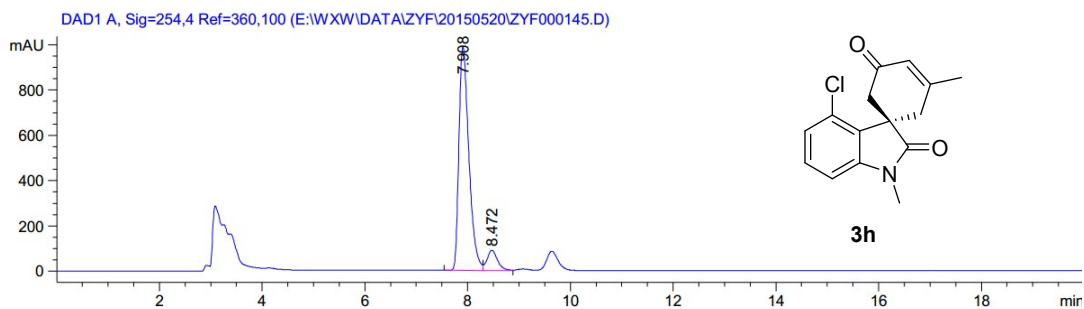


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.011	BB	0.1876	2852.27100	231.77048	18.7534
2	9.917	BB	0.2342	1.23570e4	809.18121	81.2466

5'-chloro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3h)

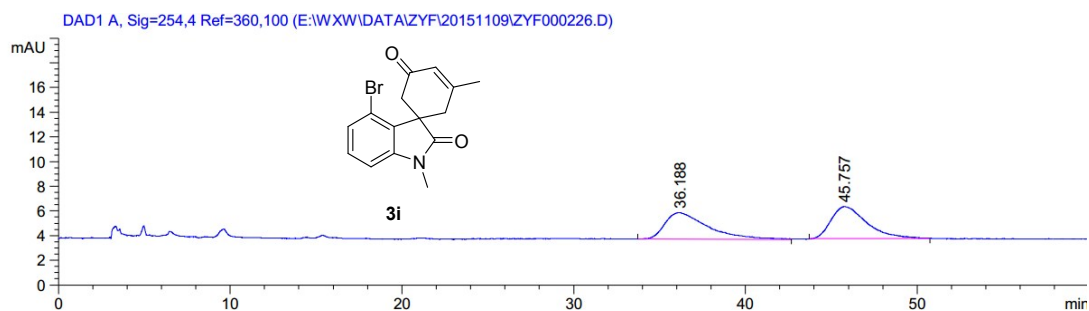


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.931	MM R	0.2528	469.52280	30.95194	50.6795
2	8.333	MM R	0.2476	456.93179	30.76304	49.3205

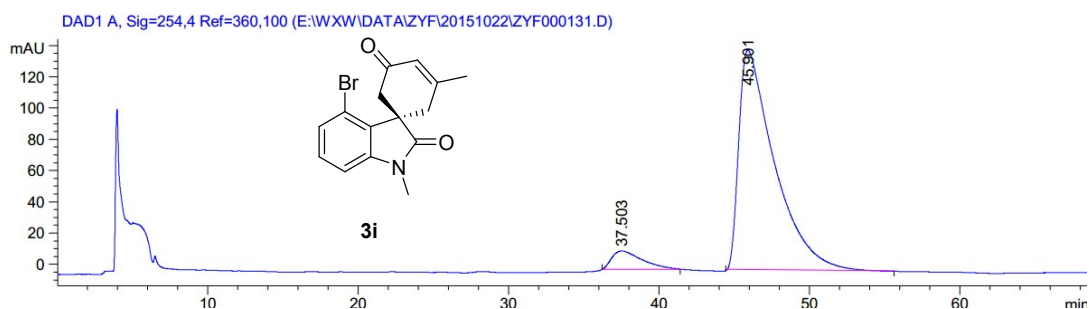


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.908	BV	0.2070	1.32535e4	985.13147	91.3312
2	8.472	VV	0.2128	1257.97449	89.04173	8.6688

4'-bromo-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3i)

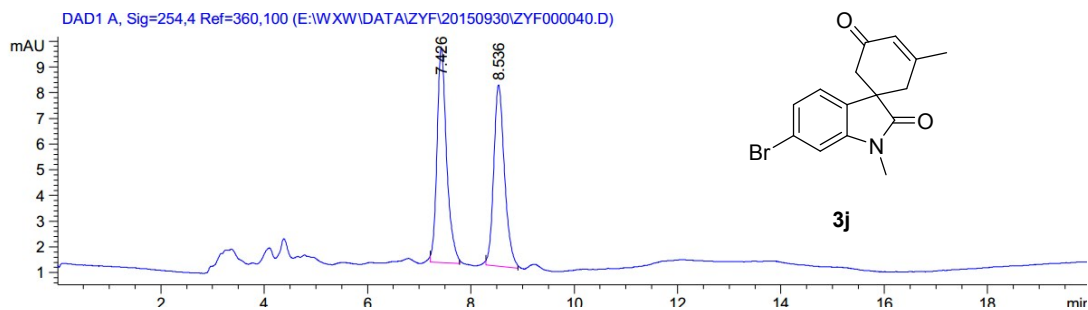


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	36.188	MM R	2.8788	370.32443	2.14394	49.5123
2	45.757	MM R	2.4214	377.62030	2.59920	50.4877

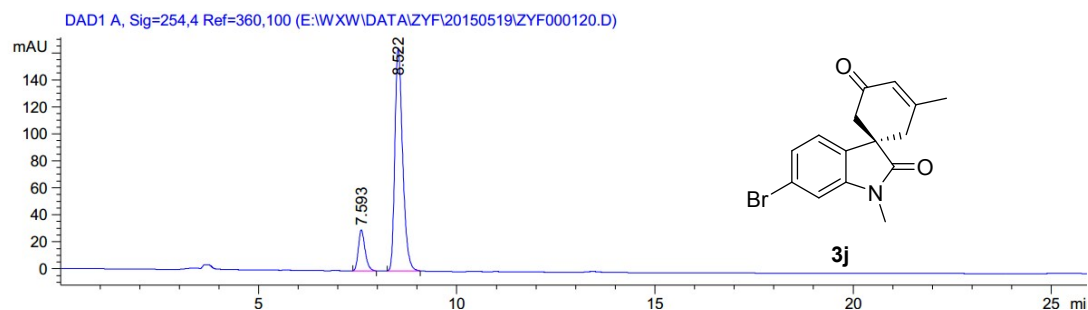


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	37.503	BB	1.3751	1301.24658	11.10434	5.6072
2	45.901	BB	2.1621	2.19057e4	140.10556	94.3928

6'-bromo-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3j)

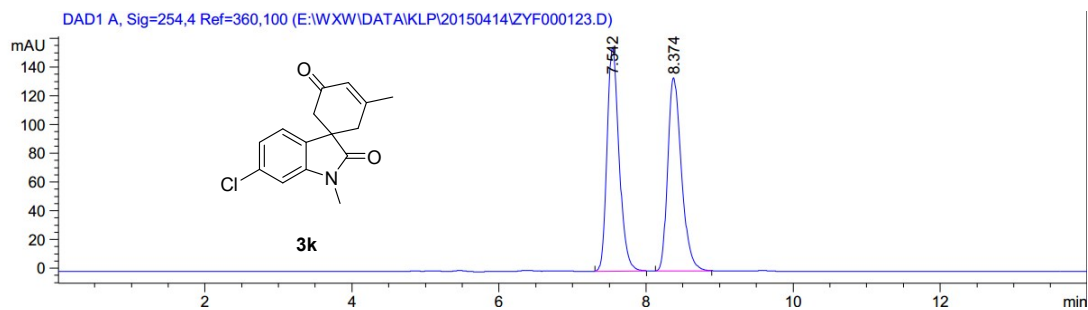


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.426	BB	0.1923	107.73447	8.36507	51.3815
2	8.536	BB	0.2187	101.94128	7.04884	48.6185

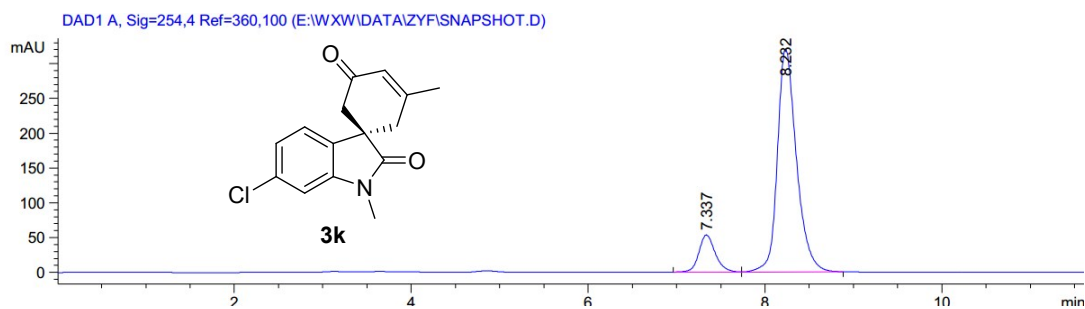


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.593	BB	0.1793	357.39322	30.37880	13.6885
2	8.522	BB	0.2094	2253.50781	164.96368	86.3115

6'-chloro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3k)

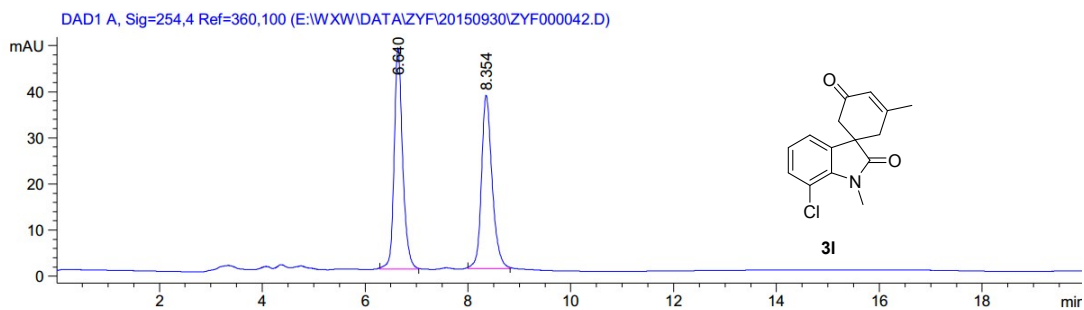


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.542	BB	0.1727	1773.67383	155.96324	50.4038
2	8.374	BB	0.1993	1745.25220	134.53914	49.5962

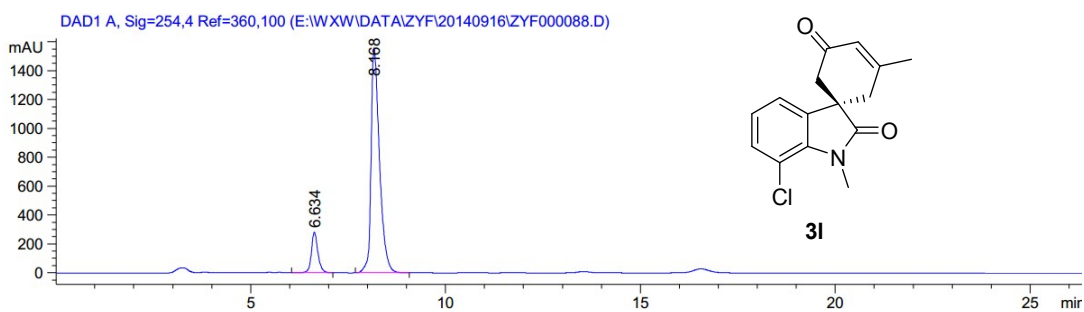


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.337	BV	0.1971	693.66931	53.56949	12.6004
2	8.232	VB	0.2272	4811.44678	320.31149	87.3996

7'-chloro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3I)

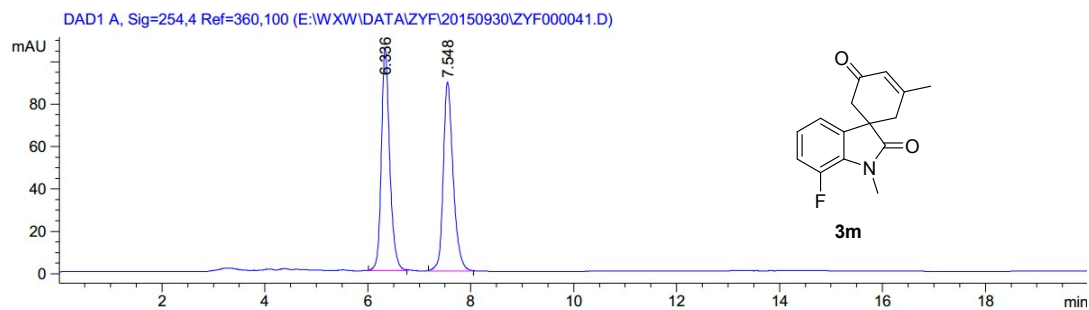


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.640	BB	0.1721	551.96350	48.01515	50.3766
2	8.354	BB	0.2163	543.71136	37.68377	49.6234

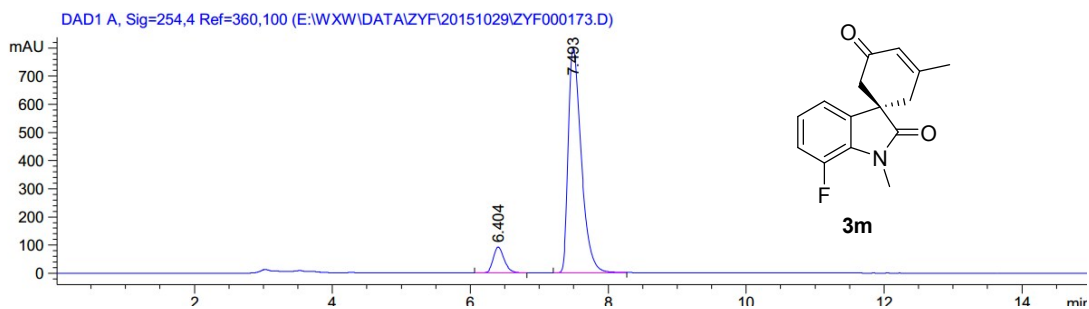


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.634	VB	0.1714	3276.45117	282.23920	12.2829
2	8.168	BB	0.2262	2.33984e4	1549.07703	87.7171

7'-fluoro-1',3-dimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3m)

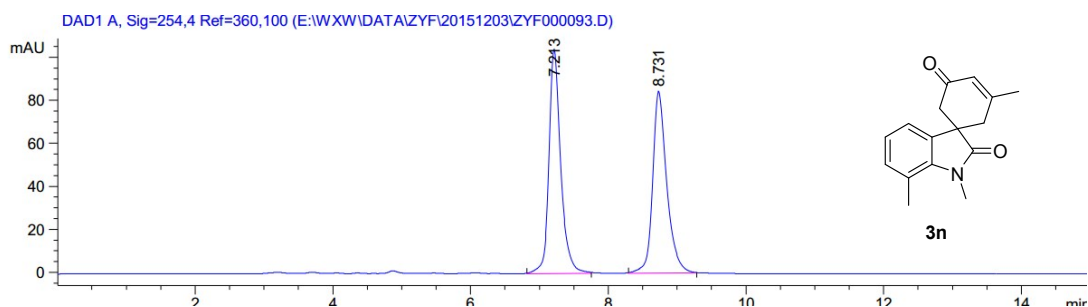


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.336	BB	0.1696	1184.29163	104.96521	49.9159
2	7.548	BB	0.2016	1188.28357	89.09842	50.0841

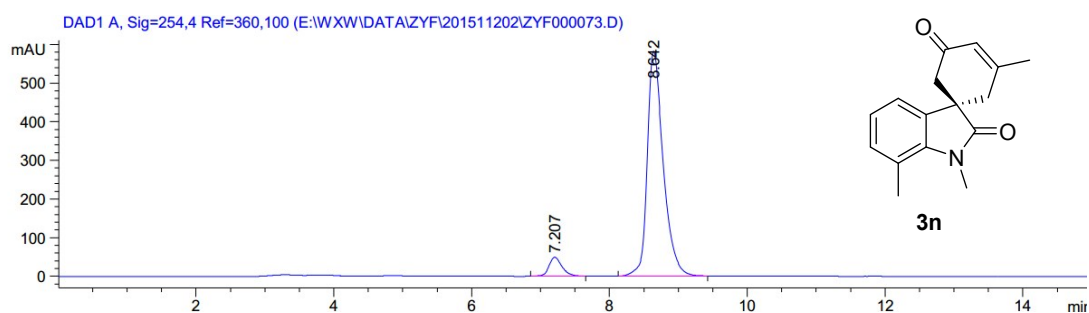


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.404	BB	0.1686	1014.88550	92.09166	8.8784
2	7.493	BB	0.1983	1.04161e4	797.77057	91.1216

1',3,7'-trimethylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3n)

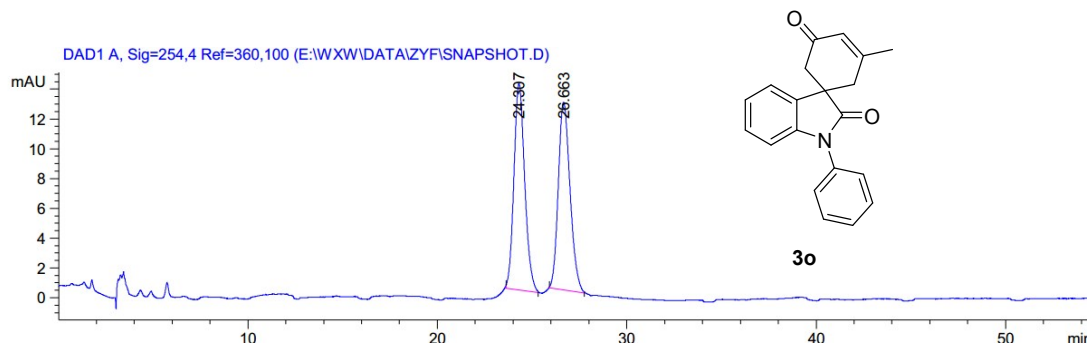


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.213	BB	0.1732	1225.34460	104.18589	50.2411
2	8.731	BB	0.2152	1213.58630	84.69070	49.7589

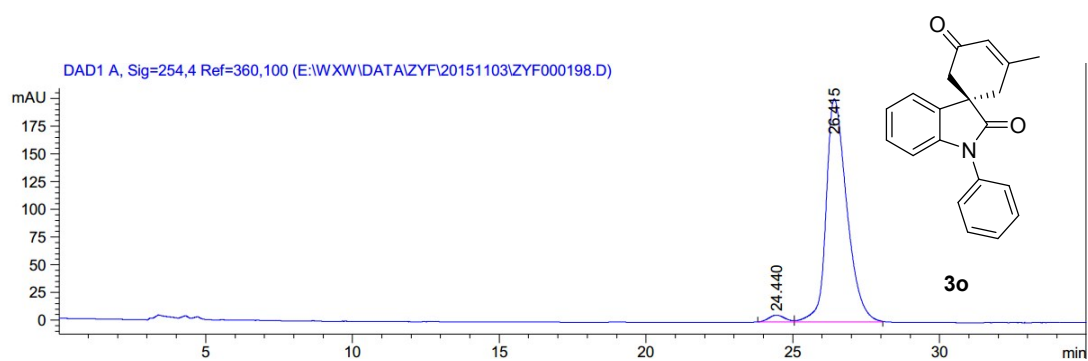


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.207	BB	0.1985	651.96814	49.24111	6.5212
2	8.642	BB	0.2413	9345.73340	582.23889	93.4788

3-methyl-1'-phenylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3o)

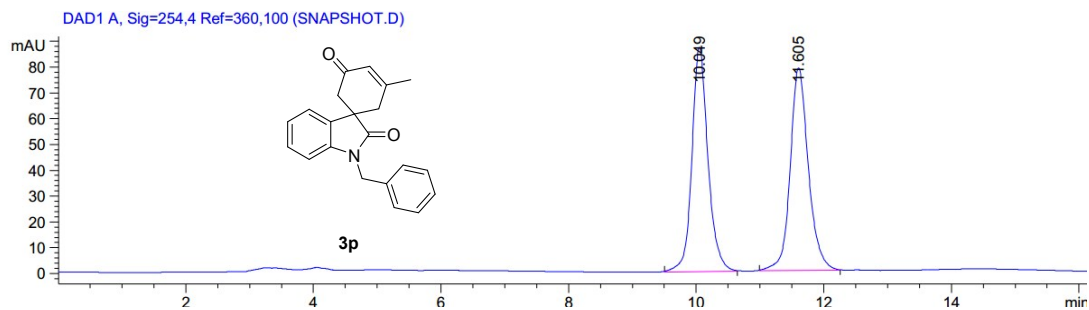


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	24.307	BB	0.6029	547.71802	13.86528	50.2490
2	26.663	BB	0.6406	542.28992	12.58837	49.7510

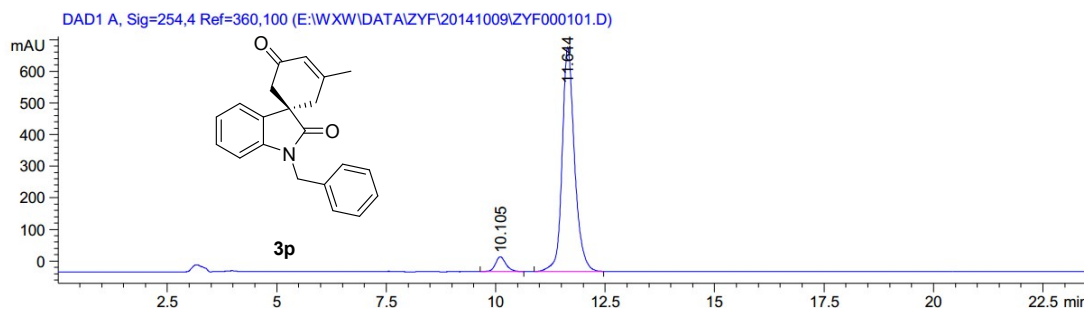


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	24.440	BV	0.5628	234.82584	6.13196	2.3278
2	26.415	VB	0.7419	9852.85938	200.98625	97.6722

1'-benzyl-3-methylspiro[cyclohexane-1,3'-indolin]-3-ene-2',5-dione (3p)



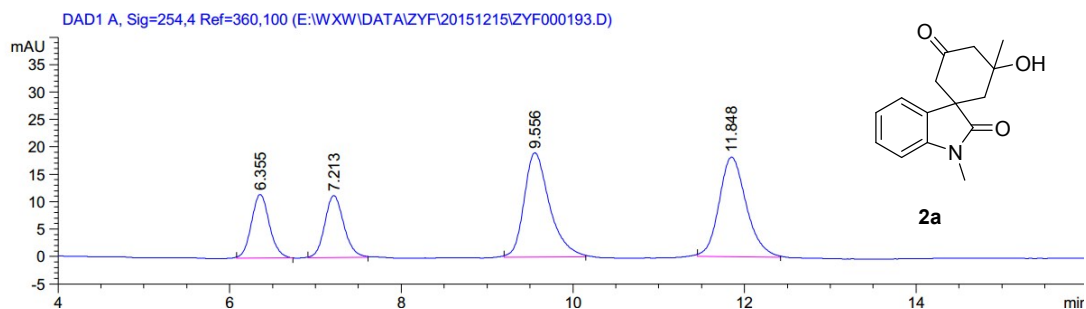
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.049	BB	0.2643	1521.46082	86.89236	49.4092
2	11.605	BB	0.2995	1557.84839	78.52006	50.5908



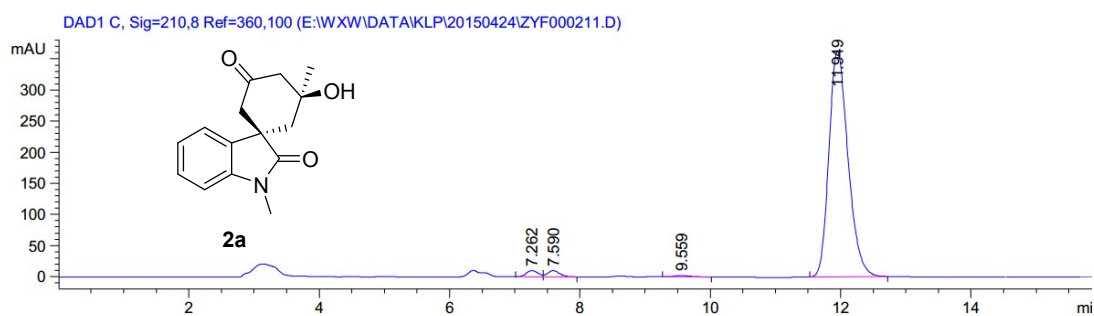
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.105	BB	0.2567	807.36365	47.40277	5.4641
2	11.644	BB	0.2960	1.39683e4	708.40112	94.5359

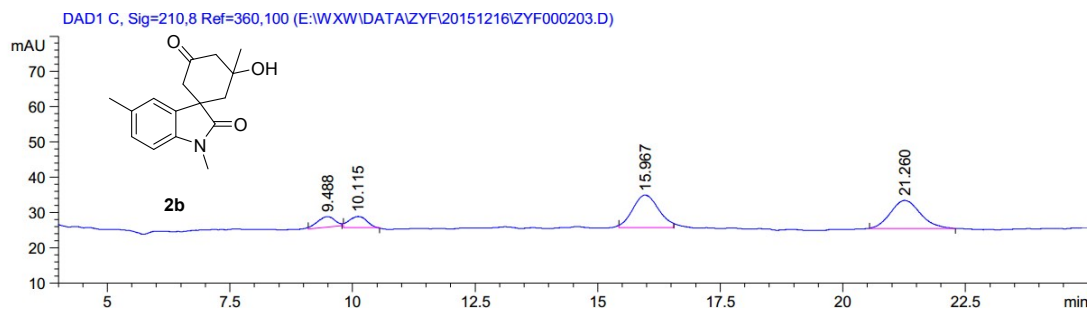
3-hydroxy-1',3'-dimethylspiro[cyclohexane-1,3'-indoline]-2',5-dione (2a)



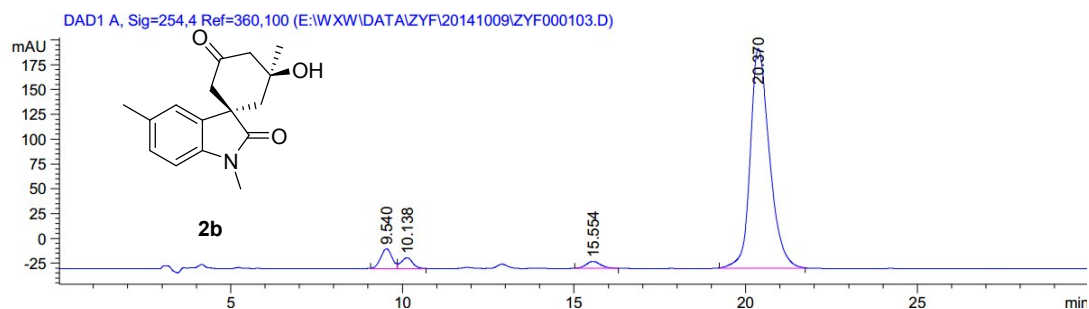
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.355	BB	0.2240	169.32706	11.62207	14.8749
2	7.213	BB	0.2374	173.42807	11.27518	15.2352
3	9.556	BB	0.3130	393.67847	19.05595	34.5835
4	11.848	BB	0.3358	401.90729	18.18920	35.3064



3-hydroxy-1',3,5'-trimethylspiro[cyclohexane-1,3'-indoline]-2',5-dione (2b)



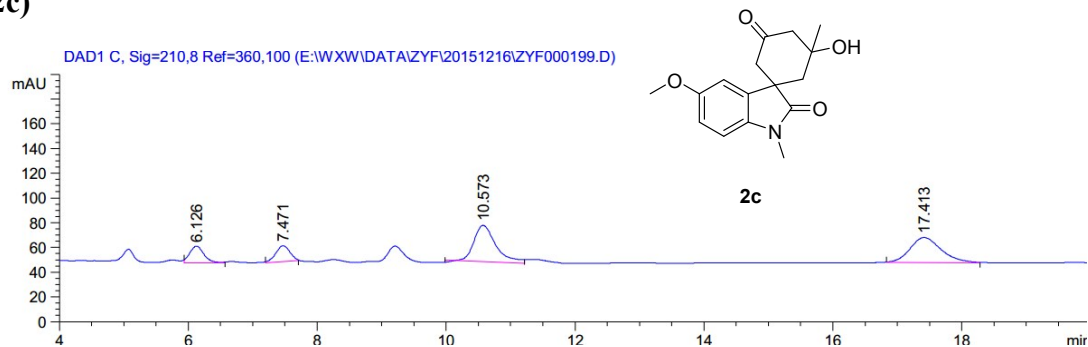
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.488	MM R	0.4188	74.67024	2.97153	9.0823
2	10.115	MM R	0.4116	76.29781	3.08954	9.2802
3	15.967	MM R	0.6074	333.84363	9.16007	40.6059
4	21.260	BB	0.5916	337.34375	7.94187	41.0316



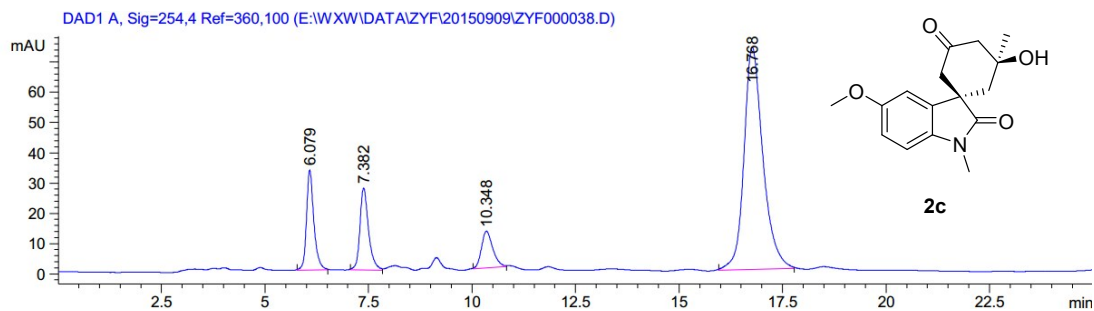
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.540	BV	0.3554	454.96243	19.84818	4.7709
2	10.138	VB	0.3531	250.33028	10.77384	2.6251
3	15.554	BB	0.4426	202.23689	6.92706	2.1207
4	20.370	BB	0.5887	8628.59277	221.41458	90.4832

3-hydroxy-5'-methoxy-1',3'-dimethylspiro[cyclohexane-1,3'-indoline]-2',5-dione

(2c)

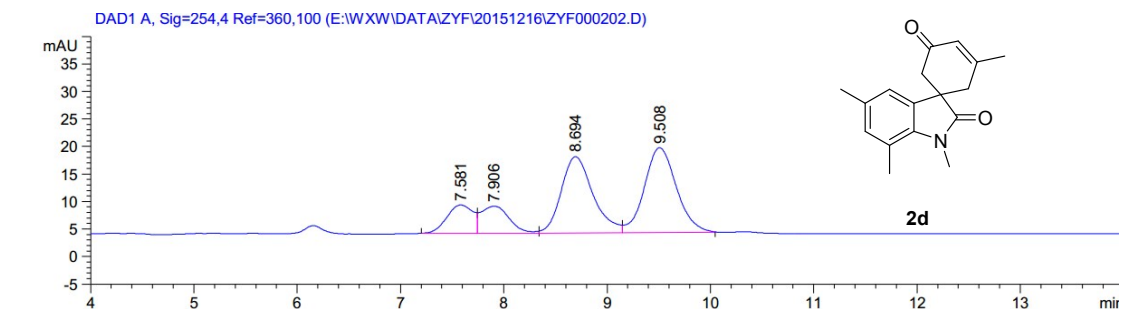


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.126	MM R	0.2592	211.28902	13.58677	11.7765
2	7.471	MM R	0.2579	200.43352	12.95466	11.1714
3	10.573	MM R	0.3964	697.37708	29.32057	38.8693
4	17.413	BB	0.5086	685.05927	20.25360	38.1828

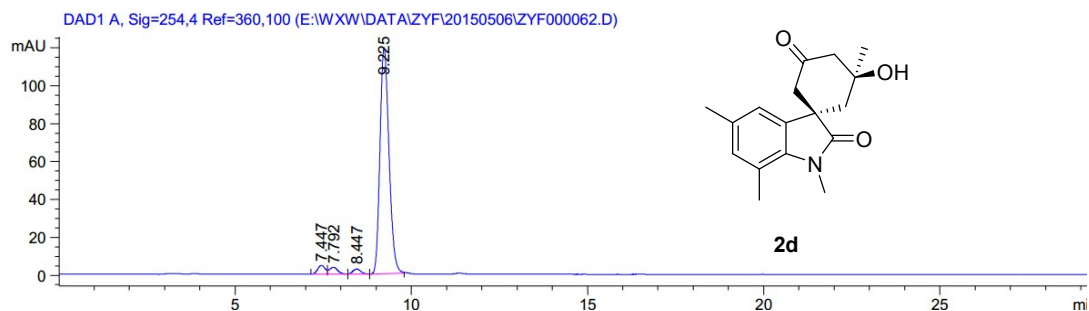


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.079	BB	0.1848	410.39178	33.06650	12.1403
2	7.382	BB	0.2166	392.30612	27.14191	11.6053
3	10.348	BB	0.2881	231.64247	12.16704	6.8525
4	16.768	BB	0.4807	2346.05615	73.44314	69.4018

3-hydroxy-1',3,5',7'-tetramethylspiro[cyclohexane-1,3'-indoline]-2',5-dione (2d)

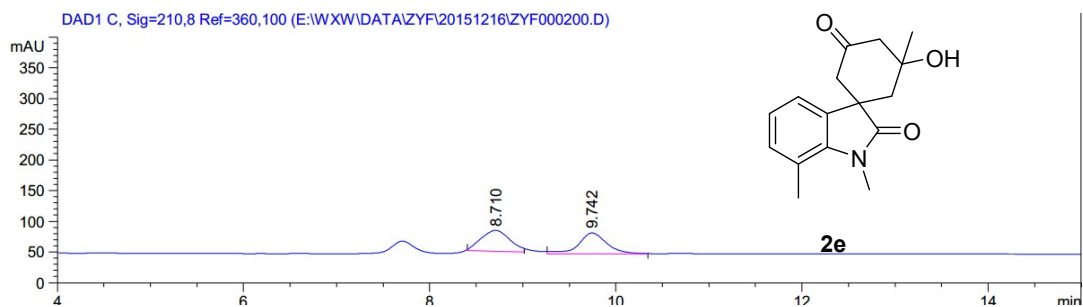


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.581	BV	0.2723	91.04388	5.14811	13.2392
2	7.906	VB	0.2841	92.92494	4.92458	13.5127
3	8.694	MM R	0.3203	248.44904	12.92640	36.1283
4	9.508	MM R	0.3099	255.26665	13.72624	37.1197

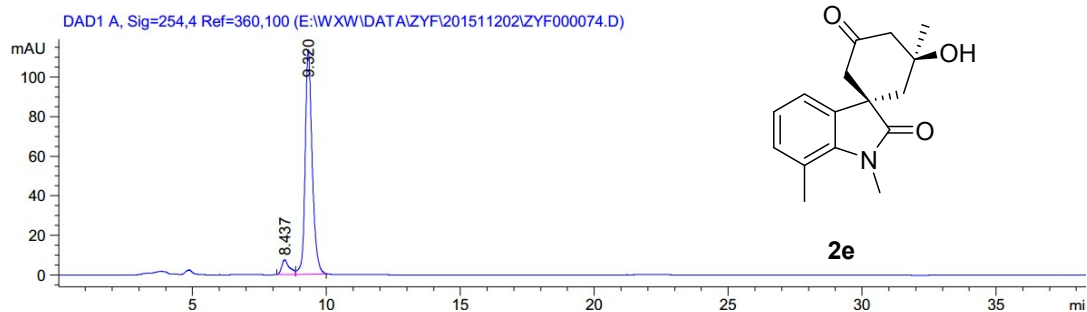


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.447	BV	0.2295	69.22902	4.65602	3.0301
2	7.792	VB	0.2469	59.12953	3.65111	2.5880
3	8.447	BV	0.2470	41.70429	2.65889	1.8253
4	9.225	VB	0.2751	2114.68530	119.10801	92.5566

3-hydroxy-1',3,7'-trimethylspiro[cyclohexane-1,3'-indoline]-2',5-dione (2e)



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.710	MM R	0.3557	721.89343	33.82203	50.5678
2	9.742	VB	0.3121	705.68286	33.73236	49.4322



Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.437	BV	0.2859	150.69177	7.51488	6.7816
2	9.320	VB	0.2752	2071.37817	113.33819	93.2184