

# Copper-Catalyzed Asymmetric Dearomative [3+2] Cycloaddition of Nitroheteroarenes with Azomethines

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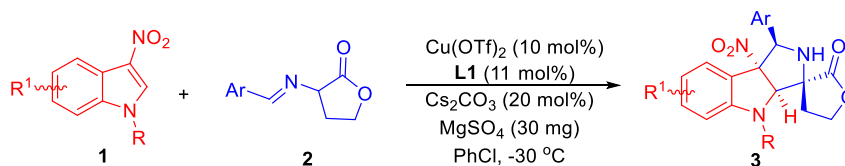
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## Supporting Information

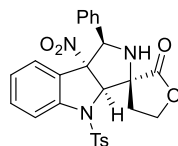
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## 1. Characterization data for compounds 3



(1'*R*,3*S*,3*a'**R*,8*b'**R*)-8*b'*-nitro-1'-phenyl-4'-tosyl-1',3*a'*,4,4',5,8*b'*-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3*a*)



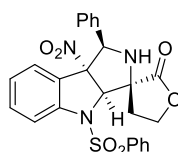
100 mg, 99% yield for the sum of the diastereomers, 61% yield for the major isomer. white solid, 62:18:20:0 dr, 98% ee, mp 182.5-183.1 °C; **The ee was determined by HPLC** (Chiralpak AD-H, EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 11.6 min,  $t_{\text{major}}$  = 24.4 min);  $[\alpha]_{\text{D}}^{20}$  = +104.2 (*c* 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 7.69 (d,  $J$  = 8.2 Hz, 1H), 7.52 – 7.44 (m, 3H), 7.40 – 7.33 (m, 1H), 7.28 (dd,  $J$  = 13.4, 7.9 Hz, 4H), 7.06 (d,  $J$  = 7.5 Hz, 2H), 6.86 – 6.80 (m, 1H), 5.78 (d,  $J$  = 8.1 Hz, 1H), 5.51 (s, 1H), 5.33 (d,  $J$  = 5.8 Hz, 1H), 4.65 (d,  $J$  = 5.8 Hz, 1H), 4.59 (td,  $J$  = 8.5, 3.9 Hz, 1H), 4.45 (m,  $J$  = 8.3 Hz, 1H), 3.04 (dt,  $J$  = 13.6, 8.2 Hz, 1H), 2.36 – 2.29 (m, 1H), 2.27 (s, 3H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 177.1, 145.4, 143.5, 134.7, 132.1, 131.8, 130.0, 129.0, 128.6, 127.8, 127.6, 127.5, 124.34, 124.29, 116.2, 101.1, 73.9, 66.9, 66.6, 66.5, 31.6, 21.0.

**HRMS** (ESI-TOF)  $m/z$ :  $[M + H]^+$  calcd for C<sub>26</sub>H<sub>24</sub>N<sub>3</sub>O<sub>6</sub>S, 506.1380; found, 506.1383.

(1'*R*,3*S*,3*a'**R*,8*b'**R*)-8*b'*-nitro-1'-phenyl-4'-(phenylsulfonyl)-1',3*a'*,4,4',5,8*b'*-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3*b*)

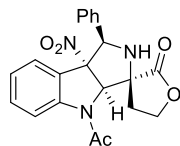


71.5 mg, 73% yield for the sum of the diastereomers, 45% yield for the major isomer, white solid, 61:19:20:0 dr; 85% ee, mp 103.9-104.6 °C; **The ee was determined by HPLC** (Chiralpak AS-H, EtOH/hexane = 10/90, flow rate 1.0 mL/min,  $\lambda$  = 220 nm, major diastereomer:  $t_{\text{minor}}$  = 14.1 min,  $t_{\text{major}}$  = 28.9 min);  $[\alpha]_{\text{D}}^{20}$  = +36.3 (*c* 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer)  $\delta$  7.72 (d,  $J$  = 8.2 Hz, 1H), 7.65 – 7.60 (m, 3H), 7.50 – 7.44 (m, 3H), 7.37 (d,  $J$  = 7.2 Hz, 1H), 7.32 – 7.27 (m, 2H), 7.06 (d,  $J$  = 7.5 Hz, 2H), 6.88 – 6.83 (m, 1H), 5.79 (d,  $J$  = 6.6 Hz, 1H), 5.50 (s, 1H), 5.32 (d,  $J$  = 5.4 Hz, 1H), 4.67 (d,  $J$  = 6.2 Hz, 1H), 4.60 (td,  $J$  = 8.5, 3.9 Hz, 1H), 4.46 (td,  $J$  = 8.5, 6.8 Hz, 1H), 3.05 (dt,  $J$  = 13.6, 8.3 Hz, 1H), 2.32 (ddd,  $J$  = 13.6, 6.8, 3.8 Hz, 1H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 177.0, 143.4, 134.7, 134.61, 134.57, 132.2, 129.6, 129.1, 128.6, 127.8, 127.7, 127.4, 124.5, 124.3, 116.3, 101.0, 73.8, 66.9, 66.6, 66.5, 31.7. **HRMS** (ESI-TOF)  $m/z$ :  $[M + H]^+$  calcd for C<sub>25</sub>H<sub>22</sub>N<sub>3</sub>O<sub>6</sub>S, 492.1224; found, 492.1226.

**(1'*R*,3*S*,3*a'**R*,8*b'**R*)-4'-acetyl-8*b'*-nitro-1'-phenyl-1',3*a'*,4,4',5,8*b'*-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3c)**



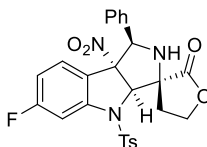
46.4 mg, 59% yield for the sum of the diastereomers, 47% yield for the major isomer, white solid, 80:20:0:0 dr, 93% ee, m.p.:98.6-98.9 °C; **The ee was determined by HPLC** (Chiralpak AD-H, EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 20.6 min,  $t_{\text{major}}$  = 27.6 min);  $[\alpha]_{\text{D}}^{20}$  = +23.9 ( $c$  1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 7.41 (dd,  $J$  = 6.6, 3.4 Hz, 2H), 7.38 – 7.32 (m, 3H), 7.10 (d,  $J$  = 7.3 Hz, 2H), 6.78 – 6.71 (m, 1H), 5.93 (d,  $J$  = 7.8 Hz, 1H), 5.59 (s, 1H), 5.03 (d,  $J$  = 5.1 Hz, 1H), 4.65 – 4.54 (m, 1H), 4.51 – 4.43 (m, 1H), 3.75 (d,  $J$  = 5.0 Hz, 1H), 3.05 (ddd,  $J$  = 12.8, 6.1, 2.1 Hz, 1H), 2.41 – 2.28 (m, 4H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  175.8, 174.3, 169.9, 168.9, 143.8, 142.4, 136.0, 135.3, 131.4, 130.9, 129.2, 129.0, 128.80, 128.77, 128.52, 128.45, 127.9, 127.7, 127.5, 127.2, 123.8, 122.8, 121.6, 113.8, 102.0, 99.1, 74.4, 73.9, 71.2, 69.5, 68.8, 66.7, 65.9, 64.7, 36.4, 33.8, 24.5, 24.2.

**HRMS** (ESI-TOF)  $m/z$ :  $[M + H]^+$  calcd for C<sub>21</sub>H<sub>20</sub>N<sub>3</sub>O<sub>5</sub>, 394.1397; found, 394.1409.

**(1'*R*,3*S*,3*a'**R*,8*b'**R*)-6'-fluoro-8*b'*-nitro-1'-phenyl-4'-tosyl-1',3*a'*,4,4',5,8*b'*-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3d)**



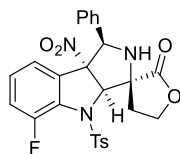
73.0 mg, 70% yield for the sum of the diastereomers, 42% yield for the major isomer, white solid, 60:19:21:0 dr, 92% ee, m.p. 87.6-89.2 °C; **The ee was determined by HPLC** (Chiralpak AD-H, EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 10.3 min,  $t_{\text{major}}$  = 23.9 min);  $[\alpha]_{\text{D}}^{20}$  = +45.6 ( $c$  1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 7.55 (d,  $J$  = 8.2 Hz, 2H), 7.43 (dd,  $J$  = 9.6, 2.5 Hz, 1H), 7.37 (d,  $J$  = 7.3 Hz, 1H), 7.31 (dd,  $J$  = 8.0, 3.8 Hz, 4H), 7.07 (d,  $J$  = 7.5 Hz, 2H), 6.75 (m,  $J$  = 8.8, 2.4 Hz, 1H), 5.76 (dd,  $J$  = 8.7, 5.5 Hz, 1H), 5.53 (s, 1H), 5.30 (d,  $J$  = 6.0 Hz, 1H), 4.69 (d,  $J$  = 6.0 Hz, 1H), 4.58 (td,  $J$  = 8.5, 3.8 Hz, 1H), 4.45 (m,  $J$  = 8.2 Hz, 1H), 3.01 (dt,  $J$  = 13.6, 8.3 Hz, 1H), 2.38 – 2.31 (m, 1H), 2.30 (s, 3H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 176.9, 165.4, 163.0, 145.8, 145.2 (d,  $J$  = 12.3 Hz), 134.4, 131.5, 129.5 (d,  $J$  = 10.7 Hz), 129.2, 128.9 (d,  $J$  = 262.8 Hz), 128.5, 128.0, 120.4 (d,  $J$  = 2.4 Hz), 111.9 (d,  $J$  = 23.4 Hz), 103.9 (d,  $J$  = 28.0 Hz), 100.4, 74.7, 66.9, 66.6, 66.5, 31.6, 21.0.

**HRMS** (ESI-TOF)  $m/z$ :  $[M + H]^+$  calcd for C<sub>26</sub>H<sub>23</sub>FN<sub>3</sub>O<sub>6</sub>S, 524.1286; found, 524.1288.

**(1'*R*,3*S*,3*a'**R*,8*b'**R*)-5'-fluoro-8*b'*-nitro-1'-phenyl-4'-tosyl-1',3*a'*,4,4',5,8*b'*-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3e)**



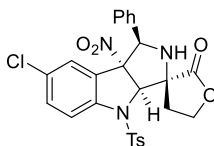
94.2 mg, 90% yield for the sum of the diastereomers, 65% yield for the major isomer, white solid, 72:28:0:0 dr, 93% ee, m.p. 88.4-89.3 °C; **The ee was determined by HPLC** (Chiralpak AD-H, EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 220 nm, major diastereomer:  $t_{\text{minor}}$  = 14.6 min,  $t_{\text{major}}$  = 31.5 min);  $[\alpha]_{\text{D}}^{20}$  = +22.9 ( $c$  1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 7.41 (dd,  $J$  = 8.5, 2.1 Hz, 3H), 7.38 – 7.35 (m, 2H), 7.31 – 7.27 (m, 4H), 6.99 – 6.89 (m, 3H), 5.60 (d,  $J$  = 7.8 Hz, 1H), 5.58 (s, 1H), 5.32 (d,  $J$  = 6.5 Hz, 1H), 4.62 (d,  $J$  = 6.5 Hz, 1H), 4.53 (dd,  $J$  = 8.4, 4.5 Hz, 1H), 4.46 – 4.40 (m, 1H), 2.85 (dt,  $J$  = 13.6, 7.9 Hz, 1H), 2.39 – 2.32 (m, 1H), 2.31 (s, 3H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 176.9, 152.7, 150.2, 145.7, 132.7 (d,  $J$  = 264.1 Hz), 130.2, 129.2, 128.4 (d,  $J$  = 2.0 Hz), 128.3, 128.1, 127.8 (d,  $J$  = 44.9 Hz), 127.5 (d,  $J$  = 52.4 Hz), 126.7 (d,  $J$  = 6.9 Hz), 124.2, 119.8 (d,  $J$  = 19.7 Hz), 100.7, 75.3, 67.9, 66.9, 66.4, 31.8, 21.1.

**HRMS (ESI-TOF)**  $m/z$ :  $[M + H]^+$  calcd for C<sub>26</sub>H<sub>23</sub>FN<sub>3</sub>O<sub>6</sub>S, 524.1286; found, 524.1291.

**(1'*R*,3*S*,3a'*R*,8b'*R*)-7'-chloro-8b'-nitro-1'-phenyl-4'-tosyl-1',3a',4,4',5,8b'-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3f)**



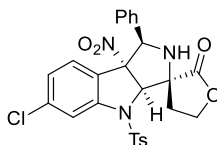
97.2 mg, 90% yield for the sum of the diastereomers, 55% yield for the major isomer, white solid, 61:15:24:0 dr, 95% ee, m.p.: 93.8-94.2 °C; **The ee was determined by HPLC** (Chiralpak AD-H, EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 11.0 min,  $t_{\text{major}}$  = 19.0 min);  $[\alpha]_{\text{D}}^{20}$  = +83.4 ( $c$  1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 7.70 (d,  $J$  = 8.8 Hz, 1H), 7.55 (dd,  $J$  = 8.8, 2.3 Hz, 1H), 7.49 (d,  $J$  = 8.2 Hz, 2H), 7.41 (d,  $J$  = 7.3 Hz, 1H), 7.34 (d,  $J$  = 7.6 Hz, 2H), 7.29 (d,  $J$  = 8.2 Hz, 2H), 7.06 (d,  $J$  = 7.6 Hz, 2H), 5.57 (d,  $J$  = 2.2 Hz, 1H), 5.49 (s, 1H), 5.33 (d,  $J$  = 5.9 Hz, 1H), 4.71 (d,  $J$  = 5.9 Hz, 1H), 4.59 (td,  $J$  = 8.5, 4.0 Hz, 1H), 4.47 – 4.43 (m, 1H), 2.99 (dt,  $J$  = 13.6, 8.2 Hz, 1H), 2.35 – 2.30 (m, 1H), 2.29 (s, 3H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 176.9, 145.7, 142.5, 134.3, 132.2, 131.5, 130.2, 129.3, 128.38, 128.36, 128.0, 127.6, 127.5, 125.9, 117.9, 100.6, 74.3, 67.1, 66.8, 66.6, 31.6, 21.0.

**HRMS (ESI-TOF)**  $m/z$ :  $[M + H]^+$  calcd for C<sub>26</sub>H<sub>23</sub><sup>35</sup>ClN<sub>3</sub>O<sub>6</sub>S, 540.0991; found, 540.0991.  $[M + H]^+$  calcd for C<sub>26</sub>H<sub>23</sub><sup>37</sup>ClN<sub>3</sub>O<sub>6</sub>S, 542.0972; found, 542.0972.

**(1'*R*,3*S*,3a'*R*,8b'*R*)-6'-chloro-8b'-nitro-1'-phenyl-4'-tosyl-1',3a',4,4',5,8b'-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3g)**





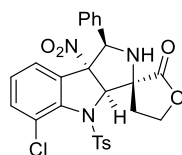
85.4 mg, 79% yield for the sum of the diastereomers, 54% yield for the major isomer, white solid, 68:11:21:0 dr, 92% ee, m.p. 83.6-84.5 °C; **The ee was determined by HPLC** (Chiralpak AD-H, EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 9.2 min,  $t_{\text{major}}$  = 24.5 min);  $[\alpha]_{\text{D}}^{20}$  = +96.7 ( $c$  1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 7.66 (d,  $J$  = 2.0 Hz, 1H), 7.52 (d,  $J$  = 8.3 Hz, 2H), 7.38 (d,  $J$  = 7.4 Hz, 1H), 7.31 (m,  $J$  = 7.2, 3.3 Hz, 4H), 7.07 (d,  $J$  = 7.5 Hz, 2H), 6.97 (dd,  $J$  = 8.4, 2.0 Hz, 1H), 5.74 (d,  $J$  = 8.5 Hz, 1H), 5.51 (s, 1H), 5.32 (d,  $J$  = 6.2 Hz, 1H), 4.69 (d,  $J$  = 6.2 Hz, 1H), 4.58 (td,  $J$  = 8.5, 3.9 Hz, 1H), 4.45 (td,  $J$  = 8.5, 6.8 Hz, 1H), 3.00 (dt,  $J$  = 13.6, 8.3 Hz, 1H), 2.36 – 2.31 (m, 1H), 2.30 (s, 3H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 176.8, 145.8, 144.7, 136.8, 134.2, 131.5, 130.2, 129.24, 129.17, 128.4, 128.0, 127.5, 124.7, 123.2, 116.1, 100.5, 74.4, 67.0, 66.7, 66.6, 31.6, 21.0.

**HRMS (ESI-TOF)**  $m/z$ :  $[M + H]^+$  calcd for C<sub>26</sub>H<sub>23</sub><sup>35</sup>ClN<sub>3</sub>O<sub>6</sub>S, 540.0991; found, 540.0993.  $[M + H]^+$  calcd for C<sub>26</sub>H<sub>23</sub><sup>37</sup>ClN<sub>3</sub>O<sub>6</sub>S, 542.0972; found, 542.0973.

**(1'*R*,3*S*,3*a'**R*,8*b'**R*)-5'-chloro-8*b'*-nitro-1'-phenyl-4'-tosyl-1',3*a'*,4,4',5,8*b'*-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3h)**



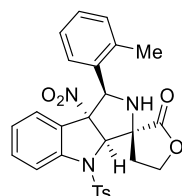
68.1 mg, 63% yield for the sum of the diastereomers, 49% yield for the major isomer, white solid, 77:23:0:0 dr, 96% ee, m.p.:90.5-91.5 °C; **The ee was determined by HPLC** (Chiralpak AD-H, EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 11.9 min,  $t_{\text{major}}$  = 30.3 min);  $[\alpha]_{\text{D}}^{20}$  = +1.6 ( $c$  0.10, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 7.65 (dd,  $J$  = 8.0, 1.2 Hz, 1H), 7.43 – 7.40 (m, 1H), 7.35 – 7.28 (m, 7H), 7.10 – 7.01 (m, 1H), 6.86 (d,  $J$  = 7.2 Hz, 2H), 5.73 (d,  $J$  = 6.7 Hz, 1H), 5.43 (s, 1H), 5.30 (d,  $J$  = 6.6 Hz, 1H), 4.52 (d,  $J$  = 6.6 Hz, 1H), 4.38 – 4.32 (m, 2H), 2.60 (dt,  $J$  = 14.1, 7.3 Hz, 1H), 2.35 (s, 3H), 2.22 (dt,  $J$  = 13.0, 5.9 Hz, 1H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 177.0, 145.9, 140.4, 133.6, 133.5, 131.4, 130.3, 130.2, 129.4, 128.7, 128.2, 127.7, 127.6, 127.4, 125.1, 100.5, 74.5, 69.0, 66.5, 66.0, 31.9, 21.1.

**HRMS (ESI-TOF)**  $m/z$ :  $[M + H]^+$  calcd for C<sub>26</sub>H<sub>23</sub><sup>35</sup>ClN<sub>3</sub>O<sub>6</sub>S, 540.0991; found, 540.0994.  $[M + H]^+$  calcd for C<sub>26</sub>H<sub>23</sub><sup>37</sup>ClN<sub>3</sub>O<sub>6</sub>S, 542.0972; found, 540.0975.

**(1'*R*,3*S*,3*a'**R*,8*b'**R*)-8*b'*-nitro-1'-(*o*-tolyl)-4'-tosyl-1',3*a'*,4,4',5,8*b'*-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3i)**



95.5 mg, 92% yield for the sum of the diastereomers, 56% yield for the major isomer, white solid, 61:18:21:0 dr, 78% ee, m.p. :116.8-117.4 °C; **The ee was determined by HPLC** (Chiralpak AD,

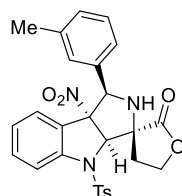
EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 9.0 min,  $t_{\text{major}}$  = 21.1 min);  $[\alpha]_{\text{D}}^{20}$  = +29.1 ( $c$  1.00,  $\text{CH}_2\text{Cl}_2$ ) for major diastereomer;

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ )**  $\delta$  (major diastereomer) 7.71 (d,  $J$  = 8.2 Hz, 1H), 7.55 – 7.50 (m, 1H), 7.42 (d,  $J$  = 8.3 Hz, 2H), 7.24 (d,  $J$  = 8.8 Hz, 4H), 7.02 – 6.92 (m, 2H), 6.72 (d,  $J$  = 8.5 Hz, 1H), 6.04 (s, 1H), 5.62 (d,  $J$  = 5.6 Hz, 1H), 5.55 (s, 1H), 4.58 (td,  $J$  = 8.4, 4.2 Hz, 1H), 4.53 (d,  $J$  = 5.6 Hz, 1H), 4.45 – 4.40 (m, 1H), 2.98 (dt,  $J$  = 13.5, 8.1 Hz, 1H), 2.31 – 2.28 (m, 1H), 2.26 (s, 3H), 2.12 (s, 3H).

**$^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ )**  $\delta$  (major diastereomer) 181.2, 145.4, 143.5, 137.0, 132.3, 132.2, 131.6, 130.5, 130.0, 129.4, 129.3, 128.6, 127.3, 124.8, 124.3, 123.7, 116.3, 100.5, 73.7, 66.6, 66.4, 62.9, 31.8, 21.0, 18.6.

**HRMS** (ESI-TOF)  $m/z$ :  $[\text{M} + \text{H}]^+$  calcd for  $\text{C}_{27}\text{H}_{26}\text{N}_3\text{O}_6\text{S}$ , 520.1537; found, 520.1541.

**(1'*R*,3*S*,3*a'**R*,8*b'**R*)-8*b'*-nitro-1'-(*m*-tolyl)-4'-tosyl-1',3*a'*,4,4',5,8*b'*-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3j)**



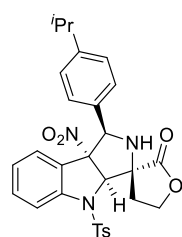
101.8 mg, 98% yield for the sum of the diastereomers, 61% yield for the major isomer, white solid, 62:18:20:0 dr, 90% ee, m.p.:190.2-190.8 °C; **The ee was determined by HPLC** (Chiralpak AD, EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 12.1 min,  $t_{\text{major}}$  = 30.9 min);  $[\alpha]_{\text{D}}^{20}$  = +30.7 ( $c$  1.00,  $\text{CH}_2\text{Cl}_2$ )

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ )**  $\delta$  (major diastereomer) 7.69 (d,  $J$  = 8.2 Hz, 1H), 7.48 (m,  $J$  = 8.4 Hz, 3H), 7.26 (d,  $J$  = 8.2 Hz, 2H), 7.18 (d,  $J$  = 4.6 Hz, 2H), 6.89 – 6.83 (m, 2H), 6.82 – 6.78 (m, 1H), 5.80 (d,  $J$  = 6.6 Hz, 1H), 5.48 (s, 1H), 5.28 (d,  $J$  = 5.6 Hz, 1H), 4.58 (td,  $J$  = 8.3, 3.9 Hz, 2H), 4.48 – 4.41 (m, 1H), 3.01 (dt,  $J$  = 13.6, 8.2 Hz, 1H), 2.34 – 2.29 (m, 1H), 2.28 (s, 3H), 2.19 (s, 3H).

**$^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ )**  $\delta$  (major diastereomer) 177.1, 145.4, 143.5, 136.9, 134.5, 132.1, 131.8, 130.0, 129.6, 129.1, 127.9, 127.7, 127.5, 125.8, 124.3, 124.2, 116.3, 101.1, 73.9, 67.0, 66.7, 66.6, 31.6, 21.0, 20.9.

**HRMS** (ESI-TOF)  $m/z$ :  $[\text{M} + \text{H}]^+$  calcd for  $\text{C}_{27}\text{H}_{26}\text{N}_3\text{O}_6\text{S}$ , 520.1537; found, 520.1538.

**(1'*R*,3*S*,3*a'**R*,8*b'**R*)-1'-(4-isopropylphenyl)-8*b'*-nitro-4'-tosyl-1',3*a'*,4,4',5,8*b'*-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3k)**



108.4 mg, 99% yield for the sum of the diastereomers, 55% yield for the major isomer, white solid, 56:18:16:0 dr, 90% ee, m.p.:109.8-110.3 °C; **The ee was determined by HPLC** (Chiralpak IC,

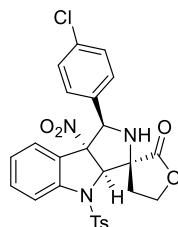
EtOH/hexane = 10/90, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 12.4 min,  $t_{\text{major}}$  = 14.0 min);  $[\alpha]_{\text{D}}^{20}$  = +18.4 ( $c$  1.00,  $\text{CH}_2\text{Cl}_2$ ) for major diastereomer;

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ )**  $\delta$  (major diastereomer) 7.68 (d,  $J$  = 8.2 Hz, 1H), 7.51 – 7.44 (m, 3H), 7.26 (d,  $J$  = 8.3 Hz, 2H), 7.15 (d,  $J$  = 7.9 Hz, 2H), 6.96 (d,  $J$  = 8.0 Hz, 2H), 6.86 – 6.78 (m, 1H), 5.80 (d,  $J$  = 7.9 Hz, 1H), 5.50 (s, 1H), 5.28 (d,  $J$  = 5.6 Hz, 1H), 4.61 – 4.56 (m, 2H), 4.47 – 4.40 (m, 1H), 3.03 (dt,  $J$  = 13.6, 8.2 Hz, 1H), 2.92 – 2.84 (m, 1H), 2.33 – 2.29 (m, 1H), 2.27 (s, 3H), 1.18 (dd,  $J$  = 6.9, 3.1 Hz, 6H).

**$^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ )**  $\delta$  (major diastereomer) 177.1, 149.4, 145.3, 143.5, 132.10, 132.05, 131.8, 129.9, 128.6, 127.7, 127.5, 125.6, 124.32, 124.27, 116.1, 101.1, 73.8, 66.9, 66.6, 66.4, 33.1, 31.6, 23.9, 23.8, 21.0.

**HRMS** (ESI-TOF)  $m/z$ :  $[\text{M} + \text{H}]^+$  calcd for  $\text{C}_{29}\text{H}_{30}\text{N}_3\text{O}_6\text{S}$ , 548.1850; found, 548.1852.

**(1'*R*,3*S*,3*a'**R*,8*b'**R*)-1'-(4-chlorophenyl)-8*b'*-nitro-4'-tosyl-1',3*a'*,4,4',5,8*b'*-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3l)**



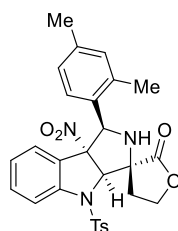
88.6 mg, 82% yield for the sum of the diastereomers, 38% yield for the major isomer, white solid, 47:23:30:0 dr, 88% ee m.p.: 109.6–110.2 °C; **The ee was determined by HPLC** (Chiralpak AD, EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 14.6 min,  $t_{\text{major}}$  = 47.9 min);  $[\alpha]_{\text{D}}^{20}$  = +20.9 ( $c$  1.00,  $\text{CH}_2\text{Cl}_2$ ) for major diastereomer.

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ )**  $\delta$  (major diastereomer) 7.70 (d,  $J$  = 8.2 Hz, 1H), 7.52 (d,  $J$  = 8.4 Hz, 2H), 7.50 – 7.46 (m, 1H), 7.36 (d,  $J$  = 8.7 Hz, 2H), 7.27 (d,  $J$  = 8.1 Hz, 2H), 7.09 (d,  $J$  = 8.1 Hz, 2H), 6.92 – 6.86 (m, 1H), 5.88 (d,  $J$  = 9.1 Hz, 1H), 5.50 (s, 1H), 5.32 (d,  $J$  = 5.5 Hz, 1H), 4.70 (d,  $J$  = 4.3 Hz, 1H), 4.59 (td,  $J$  = 8.5, 3.9 Hz, 1H), 4.49 – 4.42 (m, 1H), 3.07 (dt,  $J$  = 13.6, 8.3 Hz, 1H), 2.30 (dd,  $J$  = 6.8, 3.9 Hz, 1H), 2.28 (s, 3H).

**$^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ )**  $\delta$  (major diastereomer) 177.0, 145.4, 143.5, 134.0, 133.5, 132.3, 131.7, 130.7, 130.0, 127.8, 127.6, 127.2, 124.5, 124.2, 116.3, 100.8, 73.6, 66.8, 66.7, 65.5, 31.6, 21.0.

**HRMS** (ESI-TOF)  $m/z$ :  $[\text{M} + \text{H}]^+$  calcd for  $\text{C}_{26}\text{H}_{23}^{35}\text{ClN}_3\text{O}_6\text{S}$ , 540.0991; found, 540.0993.  $[\text{M} + \text{H}]^+$  calcd for  $\text{C}_{26}\text{H}_{23}^{37}\text{ClN}_3\text{O}_6\text{S}$ , 542.0972; found, 542.0975.

**(1'*R*,3*S*,3*a'**R*,8*b'**R*)-1'-(2,4-dimethylphenyl)-8*b'*-nitro-4'-tosyl-1',3*a'*,4,4',5,8*b'*-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3m)**



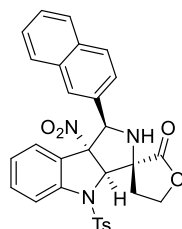
87.5 mg, 82% yield for the sum of the diastereomers, 48% yield for the major isomer, white solid, 59:15:26:0 dr, 80% ee, m.p.:84.6-85.1 °C; **The ee was determined by HPLC** (Chiralpak IC, EtOH/hexane = 15/85, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 9.9 min,  $t_{\text{major}}$  = 12.7 min);  $[\alpha]_{\text{D}}^{20}$  = +28.3 (*c* 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 7.69 (d, *J* = 8.2 Hz, 1H), 7.48 (dd, *J* = 7.9, 3.1 Hz, 3H), 7.26 (d, *J* = 8.1 Hz, 2H), 7.05 (d, *J* = 7.8 Hz, 1H), 6.90 – 6.84 (m, 1H), 6.79 – 6.72 (m, 2H), 5.86 (d, *J* = 7.1 Hz, 1H), 5.48 (s, 1H), 5.24 (d, *J* = 6.2 Hz, 1H), 4.58 (dd, *J* = 8.5, 4.0 Hz, 1H), 4.53 (d, *J* = 6.2 Hz, 1H), 4.43 (m, *J* = 8.0 Hz, 1H), 3.00 (dt, *J* = 13.6, 8.2 Hz, 1H), 2.34 – 2.29 (m, 1H), 2.27 (s, 3H), 2.21 (s, 3H), 2.11 (s, 3H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 177.1, 145.4, 143.5, 136.9, 135.6, 132.1, 131.84, 131.76, 130.2, 130.0, 129.6, 128.9, 128.1, 127.4, 126.0, 124.3, 116.2, 101.1, 73.9, 66.9, 66.7, 66.6, 31.6, 21.0, 19.3, 19.2.

**HRMS (ESI-TOF)** *m/z*: [M + H]<sup>+</sup> calcd for C<sub>28</sub>H<sub>28</sub>N<sub>3</sub>O<sub>6</sub>S, 534.1693; found, 534.1696.

**(1'*R*,3*S*,3*a'**R*,8*b'**R*)-1'-(naphthalen-2-yl)-8*b'*-nitro-4'-tosyl-1',3*a'*,4,4',5,8*b'*-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3n)**



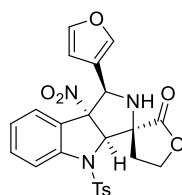
106.6 mg, 96% yield for the sum of the diastereomers, 67% yield for the major isomer, white solid, 70:15:15:0 dr, 69% ee, m.p.:117.4-117.9 °C; **The ee was determined by HPLC** (Chiralpak AS, EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 16.9 min,  $t_{\text{major}}$  = 23.2 min);  $[\alpha]_{\text{D}}^{20}$  = +23.5 (*c* 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 7.91 (d, *J* = 7.7 Hz, 1H), 7.81 (d, *J* = 8.3 Hz, 2H), 7.71 (d, *J* = 8.3 Hz, 1H), 7.64 (d, *J* = 4.4 Hz, 1H), 7.51 (d, *J* = 7.6 Hz, 4H), 7.44 (d, *J* = 8.2 Hz, 1H), 7.27 (d, *J* = 8.2 Hz, 2H), 7.13 (d, *J* = 8.5 Hz, 1H), 6.74 – 6.67 (m, 1H), 5.73 (d, *J* = 8.1 Hz, 1H), 5.54 (s, 1H), 5.51 (d, *J* = 5.5 Hz, 1H), 4.77 (d, *J* = 5.7 Hz, 1H), 4.64 – 4.58 (m, 1H), 4.48 (q, *J* = 7.6 Hz, 1H), 3.08 (dt, *J* = 12.6, 8.0 Hz, 1H), 2.38 – 2.34 (m, 1H), 2.27 (s, 3H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 177.2, 145.4, 143.6, 133.1, 132.3, 132.24, 132.19, 131.8, 130.0, 128.1, 127.60, 127.56, 127.2, 127.1, 126.8, 126.6, 126.4, 126.2, 124.38, 124.35, 116.3, 101.0, 73.9, 67.0, 66.6, 31.7, 26.4, 21.0.

**HRMS (ESI-TOF)** *m/z*: [M + H]<sup>+</sup> calcd for C<sub>30</sub>H<sub>26</sub>N<sub>3</sub>O<sub>6</sub>S, 556.1537; found, 556.1540.

**(1'*R*,3*S*,3*a'**R*,8*b'**R*)-1'-(furan-3-yl)-8*b'*-nitro-4'-tosyl-1',3*a'*,4,4',5,8*b'*-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (3o)**

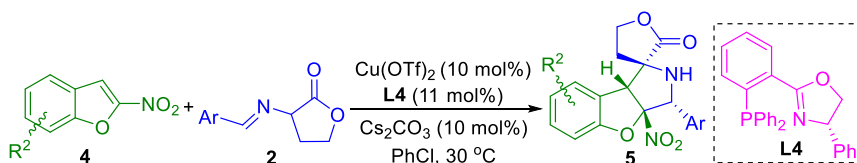




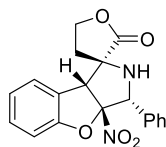
20	<b>L4</b>	Et <sub>3</sub> N	PhCl	25	82	13	22:78:nd	20/40
21	<b>L4</b>	DABCO	PhCl	25	82	22	26:74:nd	7/55
22	<b>L4</b>	TMG	PhCl	25	82	61	94:6:nd	3/46
23	<b>L4</b>	Cs <sub>2</sub> CO <sub>3</sub>	PhCl	50	72	70	17:83:nd	20/80
24	<b>L4</b>	Cs <sub>2</sub> CO <sub>3</sub>	PhCl	30	72	68	18:82:nd	12,/84
25	<b>L4</b>	Cs <sub>2</sub> CO <sub>3</sub>	PhCl	0	72	53	11:89:nd	11/89
26	<b>L4</b>	Cs <sub>2</sub> CO <sub>3</sub>	PhCl	-30	72	41	12:88:nd	12/88
<b>27 [d]</b>	<b>L4</b>	<b>Cs<sub>2</sub>CO<sub>3</sub></b>	<b>PhCl</b>	<b>30</b>	<b>45</b>	<b>81</b>	<b>24:76:nd</b>	<b>11/96</b>

[a] Isolated yield of the mixture of diastereomers. [b] Determined by <sup>1</sup>H NMR. [c] Determined by chiral HPLC analysis after purification of the diastereomers. [d] 10 mol% Cs<sub>2</sub>CO<sub>3</sub> was added.

### 3. Characterization data for compounds 5



#### (1*R*,3*R*,3*aR*,8*bR*)-3*a*-nitro-3-phenyl-2,3,3*a*,4',5',8*b*-hexahydro-2'*H*-spiro[benzofuro[2,3-*c*]pyrrole-1,3'-furan]-2'-one(5*a*)



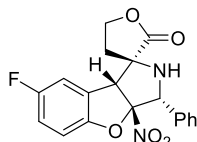
57.1 mg, 81% yield for the sum of the diastereomers, 61% yield for the major isomer, white solid, 74:26 dr, 96% ee, m.p.: 160.9-161.4 °C; **The ee was determined by HPLC** (Chiralpak IB, *i*-PrOH/hexane = 20/80, flow rate 1.0 mL/min, λ = 220 nm, major diastereomer: *t*<sub>minor</sub> = 12.7 min, *t*<sub>major</sub> = 9.9 min); [α]<sub>D</sub><sup>20</sup> = -91.2 (c 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)** δ (major diastereomer) 7.43 – 7.38 (m, 3H), 7.34 (dd, *J* = 7.2, 2.9 Hz, 2H), 7.29 – 7.24 (m, 1H), 7.07 (d, *J* = 7.2 Hz, 1H), 7.02 (dd, *J* = 12.7, 7.6 Hz, 2H), 5.23 (d, *J* = 6.6 Hz, 1H), 4.85 (s, 1H), 4.67 – 4.57 (m, 2H), 3.83 (d, *J* = 7.0 Hz, 1H), 2.95 (dd, *J* = 12.3, 4.9 Hz, 1H), 2.45 (dd, *J* = 11.7, 8.5 Hz, 1H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)** δ (major diastereomer) 173.6, 157.9, 133.9, 129.7, 128.8, 128.3, 128.0, 125.5, 123.8, 122.8, 122.7, 109.6, 68.4, 68.1, 64.6, 60.5, 36.2.

**HRMS (ESI-TOF)** *m/z*: [M + H]<sup>+</sup> calcd for C<sub>19</sub>H<sub>17</sub>N<sub>2</sub>O<sub>5</sub>, 353.1132; found, 353.1136.

#### (1*R*,3*R*,3*aS*,8*bR*)-7-fluoro-3*a*-nitro-3-phenyl-2,3,3*a*,4',5',8*b*-hexahydro-2'*H*-spiro[benzofuro[2,3-*c*]pyrrole-1,3'-furan]-2'-one(5*b*)



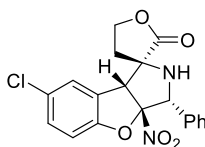
60.7 mg, 82% yield for the major isomer, white solid, >99:1 dr, 95% ee, m.p.: 70.2-70.8 °C; **The ee was determined by HPLC** (Chiralpak AD, *i*-PrOH/hexane = 20/80, flow rate 1.0 mL/min, λ = 254 nm, major diastereomer: *t*<sub>minor</sub> = 10.2 min, *t*<sub>major</sub> = 11.8 min); [α]<sub>D</sub><sup>20</sup> = -96.2 (c 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)** δ (major diastereomer) 7.44 – 7.38 (m, 3H), 7.29 – 7.26 (m, 2H), 7.02 – 6.95 (m, 1H), 6.93 (dd, *J* = 8.8, 4.1 Hz, 1H), 6.78 – 6.73 (m, 1H), 5.15 (d, *J* = 13.0 Hz, 1H), 4.75 – 4.68 (m, 1H), 4.48 (td, *J* = 10.8, 5.2 Hz, 1H), 4.41 (s, 1H), 3.29 (d, *J* = 13.4 Hz, 1H), 3.05 (dd, *J* = 12.7, 5.3 Hz, 1H), 2.64 (td, *J* = 12.1, 8.6 Hz, 1H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)** δ (major diastereomer) 173.6, 157.8 (d, *J* = 237.6 Hz), 154.1, 133.8, 128.8, 128.2 (d, *J* = 24.3 Hz), 125.7 (d, *J* = 9.5 Hz), 123.2, 116.2 (d, *J* = 24.5 Hz), 112.7 (d, *J* = 25.9 Hz), 110.5 (d, *J* = 8.8 Hz), 68.4, 68.1, 64.7, 60.51, 60.49, 36.1.

**HRMS (ESI-TOF)** *m/z*: [M + H]<sup>+</sup> calcd for C<sub>19</sub>H<sub>16</sub>FN<sub>2</sub>O<sub>5</sub>, 371.1038; found, 371.0147.

**(1*R*,3*R*,3*aS*,8*bR*)-7-chloro-3*a*-nitro-3-phenyl-2,3,3*a*,4',5',8*b*-hexahydro-2'*H*-spiro[benzofuro[2,3-*c*]pyrrole-1,3'-furan]-2'-one(5c)**



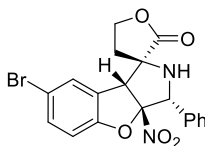
66.5 mg, 86% yield for the major isomer, white solid, >99:1 dr, 94% ee, m.p.: 90.6-90.9 °C; **The ee was determined by HPLC** (Chiralpak IB, EtOH/hexane = 5/95, flow rate 1.0 mL/min, λ = 220 nm, major diastereomer: *t*<sub>minor</sub> = 22.9 min, *t*<sub>major</sub> = 19.6 min); [α]<sub>D</sub><sup>20</sup> = -83.7 (*c* 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)** δ (major diastereomer) 7.43 – 7.37 (m, 3H), 7.37 – 7.30 (m, 3H), 7.12 (s, 1H), 7.06 (d, *J* = 8.6 Hz, 1H), 5.20 (d, *J* = 6.4 Hz, 1H), 4.84 (s, 1H), 4.63 (dd, *J* = 10.7, 5.3 Hz, 1H), 4.61 – 4.53 (m, 1H), 3.93 (d, *J* = 6.4 Hz, 1H), 2.94 (dd, *J* = 12.6, 5.1 Hz, 1H), 2.49 – 2.43 (m, 1H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)** δ (major diastereomer) 173.6, 156.8, 133.8, 129.6, 128.9, 128.3, 128.1, 126.4, 126.3, 125.5, 122.9, 111.1, 68.4, 68.2, 64.8, 60.2, 36.1.

**HRMS (ESI-TOF)** *m/z*: [M + H]<sup>+</sup> calcd for C<sub>19</sub>H<sub>16</sub><sup>35</sup>ClN<sub>2</sub>O<sub>5</sub>, 387.0742; found, 387.0754. [M + H]<sup>+</sup> calcd for C<sub>19</sub>H<sub>16</sub><sup>37</sup>ClN<sub>2</sub>O<sub>5</sub>, 389.0721; found, 387.0731.

**(1*R*,3*R*,3*aS*,8*bR*)-7-bromo-3*a*-nitro-3-phenyl-2,3,3*a*,4',5',8*b*-hexahydro-2'*H*-spiro[benzofuro[2,3-*c*]pyrrole-1,3'-furan]-2'-one(5d)**



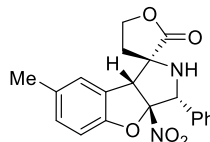
69.0 mg, 80% yield for the major isomer, white solid, >99:1 dr, 98% ee, m.p.: 68.4-68.8 °C; **The ee was determined by HPLC** (Chiralpak IA, *i*-PrOH/hexane = 10/90, flow rate 1.0 mL/min, λ = 254 nm, major diastereomer: *t*<sub>minor</sub> = 18.4 min, *t*<sub>major</sub> = 24.8 min), ee 98%; [α]<sub>D</sub><sup>20</sup> = -84.6 (*c* 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)** δ (major diastereomer) 7.45 (dd, *J* = 8.6, 2.0 Hz, 1H), 7.42 – 7.37 (m, 3H), 7.37 – 7.31 (m, 2H), 7.24 (d, *J* = 2.4 Hz, 1H), 7.02 (s, 1H), 5.20 (d, *J* = 6.4 Hz, 1H), 4.84 (s, 1H), 4.64 (td, *J* = 10.6, 10.2, 5.4 Hz, 1H), 4.60 – 4.53 (m, 1H), 3.93 (d, *J* = 6.4 Hz, 1H), 2.94 (dd, *J* = 12.5, 5.1 Hz, 1H), 2.49 – 2.42 (m, 1H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)** δ (major diastereomer) 173.6, 157.3, 133.8, 132.5, 128.9, 128.3, 128.1, 126.7, 122.8, 114.0, 111.7, 68.3, 68.1, 64.7, 60.1, 36.0.

**HRMS** (ESI-TOF)  $m/z$ :  $[M + H]^+$  calcd for  $C_{19}H_{16}^{79}BrN_2O_5$ , 431.0237; found, 431.0242.  $[M + H]^+$  calcd for  $C_{19}H_{16}^{81}BrN_2O_5$ , 433.0219; found, 433.0224.

**(1*R*,3*R*,3*aS*,8*bR*)-7-methyl-3*a*-nitro-3-phenyl-2,3,3*a*,4',5',8*b*-hexahydro-2'*H*-spiro[benzofuro[2,3-*c*]pyrrole-1,3'-furan]-2'-one(5e)**



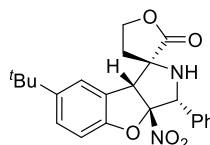
65.9 mg, 90% yield for the sum of the diastereomers, 60% yield for the major isomer, white solid, 67:33 dr, 97% ee, m.p.: 105.5-106.0 °C; **The ee was determined by HPLC** (Chiralpak AD, *i*-PrOH/hexane = 10/90, flow rate 1.0 mL/min,  $\lambda$  = 220 nm, major diastereomer:  $t_{\text{minor}}$  = 13.3 min,  $t_{\text{major}}$  = 20.8 min);  $[\alpha]_D^{20}$  = -89.3 (*c* 1.00,  $CH_2Cl_2$ ) for major diastereomer;

**$^1H$  NMR (400 MHz, DMSO- $d_6$ )**  $\delta$  (major diastereomer) 7.42 – 7.32 (m, 5H), 7.06 (d,  $J$  = 8.2 Hz, 1H), 6.91 – 6.83 (m, 2H), 5.21 (s, 1H), 4.79 (s, 1H), 4.61 (dd,  $J$  = 14.2, 7.0 Hz, 2H), 3.82 (s, 1H), 2.94 (dd,  $J$  = 12.4, 4.7 Hz, 1H), 2.48 – 2.40 (m, 1H), 2.23 (s, 3H).

**$^{13}C$  NMR (101 MHz, DMSO- $d_6$ )**  $\delta$  (major diastereomer) 173.7, 156.1, 134.0, 131.8, 130.1, 128.8, 128.3, 128.0, 125.7, 123.9, 123.0, 109.2, 68.4, 68.1, 64.7, 60.7, 36.3, 20.4.

**HRMS** (ESI-TOF)  $m/z$ :  $[M + H]^+$  calcd for  $C_{20}H_{19}N_2O_5$ , 367.1288; found, 367.1303.

**(1*R*,3*R*,3*aS*,8*bR*)-7-(tert-butyl)-3*a*-nitro-3-phenyl-2,3,3*a*,4',5',8*b*-hexahydro-2'*H*-spiro[benzofuro[2,3-*c*]pyrrole-1,3'-furan]-2'-one(5f)**



80.1 mg, 98% yield for the sum of the diastereomers, 86% yield for the major isomer, white solid, 88:12 dr, 93% ee, m.p.: 96.8-97.2 °C; **The ee was determined by HPLC** (Chiralpak IA, *i*-PrOH/hexane = 15/85, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 7.7 min,  $t_{\text{major}}$  = 10.2 min);  $[\alpha]_D^{20}$  = -218.8 (*c* 1.00,  $CH_2Cl_2$ ) for major diastereomer;

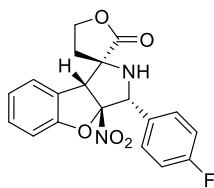
**$^1H$  NMR (400 MHz, DMSO- $d_6$ )**  $\delta$  (major diastereomer) 7.42 – 7.37 (m, 3H), 7.37 – 7.33 (m, 2H), 7.28 (d,  $J$  = 10.0 Hz, 1H), 7.07 (s, 1H), 6.90 (d,  $J$  = 8.5 Hz, 1H), 5.21 (d,  $J$  = 7.1 Hz, 1H), 4.80 (s, 1H), 4.68 (td,  $J$  = 10.3, 5.2 Hz, 1H), 4.58 (t,  $J$  = 8.8 Hz, 1H), 3.82 (d,  $J$  = 7.1 Hz, 1H), 2.96 (dd,  $J$  = 12.4, 5.1 Hz, 1H), 2.46 (dd,  $J$  = 11.6, 8.4 Hz, 1H), 1.23 (s, 9H).

**$^{13}C$  NMR (101 MHz, DMSO- $d_6$ )**  $\delta$  (major diastereomer) 173.6, 155.8, 145.2, 134.0, 128.7, 128.3, 128.0, 126.4, 123.4, 123.0, 122.4, 108.7, 68.4, 68.3, 64.6, 60.9, 36.2, 34.1, 31.2.

**HRMS** (ESI-TOF)  $m/z$ :  $[M + H]^+$  calcd for  $C_{23}H_{25}N_2O_5$ , 409.1758; found, 409.1767.

**(1*R*,3*R*,3*aR*,8*bR*)-3-(4-fluorophenyl)-3*a*-nitro-2,3,3*a*,4',5',8*b*-hexahydro-2'*H*-spiro[benzofuro[2,3-*c*]pyrrole-1,3'-furan]-2'-one(5g)**





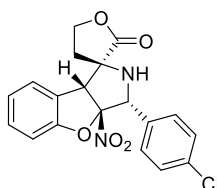
65.9 mg, 89% yield for the sum of the diastereomers, 64% yield for the major isomer, white solid, 72:28 dr, 80% ee, m.p.:147.6-148.2 °C; **The ee was determined by HPLC** (Chiralpak AD, *i*-PrOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 220 nm, major diastereomer:  $t_{\text{minor}}$  = 11.7 min,  $t_{\text{major}}$  = 9.7 min);  $[\alpha]_{\text{D}}^{20}$  = -110.5 (*c* 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 7.45 – 7.40 (m, 2H), 7.25 (q, *J* = 9.3, 8.5 Hz, 3H), 7.07 (d, *J* = 7.2 Hz, 1H), 7.02 (dd, *J* = 11.5, 7.7 Hz, 2H), 5.24 (s, 1H), 4.86 (s, 1H), 4.66 – 4.54 (m, 2H), 3.82 (s, 1H), 2.95 (dd, *J* = 12.3, 4.9 Hz, 1H), 2.49 – 2.41 (m, 1H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 173.5, 162.4 (*d*, *J* = 244.9 Hz), 157.9, 130.3, 130.0 (*d*, *J* = 49.8 Hz), 128.1 (*d*, *J* = 3.3 Hz), 125.5, 123.9, 122.9, 122.5, 115.1 (*d*, *J* = 21.5 Hz), 109.6, 68.3, 67.4, 64.6, 60.2, 36.1.

**HRMS (ESI-TOF)** *m/z*: [M + Na]<sup>+</sup> calcd for C<sub>19</sub>H<sub>15</sub>FN<sub>2</sub>O<sub>5</sub>Na, 393.0857; found, 393.0876.

**(1R,3R,3aR,8bR)-3-(4-chlorophenyl)-3a-nitro-2,3,3a,4',5',8b-hexahydro-2'H-spiro[benzofuro[2,3-c]pyrrole-1,3'-furan]-2'-one(5h)**



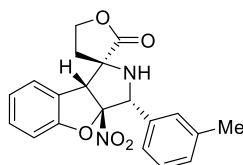
67.3 mg, 87% yield for the sum of the diastereomers, 85% yield for the major isomer, white solid, 98:2 dr, 87% ee, m.p.:200.2-200.8 °C; **The ee was determined by HPLC** (Chiralpak IA, *i*-PrOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 16.8 min,  $t_{\text{major}}$  = 11.6 min);  $[\alpha]_{\text{D}}^{20}$  = -32.6 (*c* 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 7.48 (d, *J* = 8.7 Hz, 2H), 7.39 (d, *J* = 8.2 Hz, 2H), 7.29 – 7.23 (m, 1H), 7.09 – 6.97 (m, 3H), 5.24 (d, *J* = 6.3 Hz, 1H), 4.86 (s, 1H), 4.66 – 4.54 (m, 2H), 3.93 (d, *J* = 6.3 Hz, 1H), 2.94 (dd, *J* = 12.3, 4.8 Hz, 1H), 2.49 – 2.40 (m, 1H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 173.5, 157.9, 133.5, 133.3, 130.0, 129.8, 128.3, 125.6, 123.8, 122.9, 122.4, 109.6, 68.3, 67.3, 64.6, 60.2, 36.1.

**HRMS (ESI-TOF)** *m/z*: [M + H]<sup>+</sup> calcd for C<sub>19</sub>H<sub>16</sub><sup>35</sup>ClN<sub>2</sub>O<sub>5</sub>, 387.0742; found, 387.0754. [M + H]<sup>+</sup> calcd for C<sub>19</sub>H<sub>16</sub><sup>37</sup>ClN<sub>2</sub>O<sub>5</sub>, 389.0721; found, 389.0728.

**(1R,3R,3aR,8bR)-3a-nitro-3-(*m*-tolyl)-2,3,3a,4',5',8b-hexahydro-2'H-spiro[benzofuro[2,3-c]pyrrole-1,3'-furan]-2'-one(5i)**



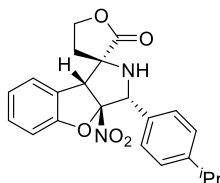
60.1 mg, 82% yield for the sum of the diastereomers, 53% yield for the major isomer, white solid, 65:35 dr, 90% ee, m.p.: 227.6–228.1 °C; **The ee was determined by HPLC** (Chiralpak AD, *i*-PrOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 220 nm, major diastereomer:  $t_{\text{minor}}$  = 15.9 min,  $t_{\text{major}}$  = 7.8 min);  $[\alpha]_{\text{D}}^{20}$  = -42.3 (*c* 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 7.27 (q, *J* = 8.2, 7.8 Hz, 2H), 7.20 (d, *J* = 7.7 Hz, 1H), 7.16 (s, 1H), 7.11 (d, *J* = 7.7 Hz, 1H), 7.06 (d, *J* = 7.3 Hz, 1H), 7.05 – 6.99 (m, 2H), 5.18 (d, *J* = 7.1 Hz, 1H), 4.84 (s, 1H), 4.68 – 4.55 (m, 2H), 3.79 (d, *J* = 7.2 Hz, 1H), 2.95 (dd, *J* = 12.4, 4.9 Hz, 1H), 2.44 (dd, *J* = 11.9, 8.7 Hz, 1H), 2.32 (s, 3H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 173.6, 157.9, 137.5, 133.8, 129.7, 129.4, 128.4, 128.2, 125.5, 125.1, 123.9, 122.84, 122.75, 109.6, 68.4, 68.1, 64.7, 60.6, 36.2, 21.0.

**HRMS** (ESI-TOF) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>20</sub>H<sub>19</sub>N<sub>2</sub>O<sub>5</sub>, 367.1288; found, 367.1298.

**(1*R*,3*R*,3*aR*,8*bR*)-3-(4-isopropylphenyl)-3*a*-nitro-2,3,3*a*,4',5',8*b*-hexahydro-2'*H*-spiro[benzofuro[2,3-*c*]pyrrole-1,3'-furan]-2'-one(5j)**



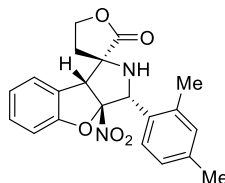
71.0 mg, 90% yield for the sum of the diastereomers, 73% yield for the major isomer, white solid, 81:19 dr, 93% ee, m.p.: 144.9–145.3 °C; **The ee was determined by HPLC** (Chiralpak IA, *i*-PrOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 16.7 min,  $t_{\text{major}}$  = 9.0 min);  $[\alpha]_{\text{D}}^{20}$  = -88.8 (*c* 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 7.27 (s, 5H), 7.07 (d, *J* = 7.5 Hz, 1H), 7.03 (dd, *J* = 7.9, 5.4 Hz, 2H), 5.18 (s, 1H), 4.85 (s, 1H), 4.68 – 4.54 (m, 2H), 3.76 (s, 1H), 2.99 – 2.87 (m, 2H), 2.48 – 2.40 (m, 1H), 1.22 (d, *J* = 6.9 Hz, 6H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 173.6, 157.9, 149.0, 131.2, 129.7, 128.1, 126.2, 125.5, 123.9, 122.84, 122.79, 109.6, 68.4, 68.1, 64.7, 60.6, 36.2, 33.2, 23.8, 23.8.

**HRMS** (ESI-TOF) *m/z*: [M + H]<sup>+</sup> calcd for C<sub>22</sub>H<sub>23</sub>N<sub>2</sub>O<sub>5</sub>, 395.1601; found, 395.1601.

**(1*R*,3*R*,3*aR*,8*bR*)-3-(2,4-dimethylphenyl)-3*a*-nitro-2,3,3*a*,4',5',8*b*-hexahydro-2'*H*-spiro[benzofuro[2,3-*c*]pyrrole-1,3'-furan]-2'-one(5k)**



44.1 mg, 58% yield for the sum of the diastereomers, 51% yield for the major isomer, white solid, 88:12 dr, 70% ee, m.p.: 229.8–230.2 °C; **The ee was determined by HPLC** (Chiralpak AD, *i*-PrOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 220 nm, major diastereomer:  $t_{\text{minor}}$  = 27.2 min,  $t_{\text{major}}$  = 8.5 min);  $[\alpha]_{\text{D}}^{20}$  = -41.9 (*c* 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

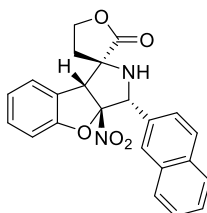
**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  (major diastereomer) 7.26 (d, *J* = 7.2 Hz, 1H), 7.15 (d, *J* = 7.8 Hz, 1H), 7.11 – 7.08 (m, 1H), 7.08 – 6.98 (m, 4H), 5.14 (d, *J* = 7.4 Hz, 1H), 4.83 (s, 1H), 4.68 –

4.54 (m, 2H), 3.72 (d,  $J = 7.5$  Hz, 1H), 2.98 – 2.90 (m, 1H), 2.48 – 2.40 (m, 1H), 2.23 (d,  $J = 3.4$  Hz, 6H).

$^{13}\text{C}$  NMR (101 MHz, DMSO- $d_6$ )  $\delta$  (major diastereomer) 173.7, 157.9, 136.8, 136.1, 131.1, 129.7, 129.4, 128.8, 125.5, 125.3, 123.8, 122.9, 122.8, 109.6, 68.4, 68.1, 64.7, 60.7, 36.3, 19.4, 19.1.

HRMS (ESI-TOF)  $m/z$ :  $[\text{M} + \text{H}]^+$  calcd for  $\text{C}_{21}\text{H}_{21}\text{N}_2\text{O}_5$ , 381.1445; found, 381.1446.

**(1R,3S,3aS,8bS)-3-(naphthalen-2-yl)-3a-nitro-2,3,3a,4',5',8b-hexahydro-2'H-spiro[benzofuro[2,3-c]pyrrole-1,3'-furan]-2'-one(5l)**



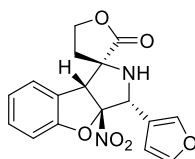
52.3 mg, 65% yield for the sum of the diastereomers, 64% yield for the major isomer, white soild, 92:8 dr, 82% ee, m.p.:210.4-210.8 °C; **The ee was determined by HPLC** (Chiralpak IA, *i*-PrOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda = 220$  nm, major diastereomer:  $t_{\text{minor}} = 32.7$  min,  $t_{\text{major}} = 13.5$  min);  $[\alpha]_{\text{D}}^{20} = -48.7$  (*c* 1.00,  $\text{CH}_2\text{Cl}_2$ ) for major diastereomer;

$^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ )  $\delta$  7.96 (dd,  $J = 9.3, 4.4$  Hz, 4H), 7.59 – 7.52 (m, 2H), 7.47 (d,  $J = 8.7$  Hz, 1H), 7.30 – 7.23 (m, 1H), 7.10 (d,  $J = 7.4$  Hz, 1H), 7.07 – 7.01 (m, 1H), 6.99 (d,  $J = 8.1$  Hz, 1H), 5.43 (d,  $J = 6.7$  Hz, 1H), 4.91 (s, 1H), 4.71 – 4.58 (m, 2H), 4.01 (d,  $J = 6.9$  Hz, 1H), 3.02 (dd,  $J = 12.3, 4.9$  Hz, 1H), 2.54 (dd,  $J = 11.6, 8.6$  Hz, 1H).

$^{13}\text{C}$  NMR (101 MHz, DMSO- $d_6$ )  $\delta$  173.6, 158.0, 133.1, 132.6, 131.7, 129.8, 128.0, 127.8, 127.5, 127.2, 126.5, 126.4, 125.61, 125.57, 123.8, 122.9, 122.8, 109.6, 68.5, 68.3, 64.7, 60.6, 36.2.

HRMS (ESI-TOF)  $m/z$ :  $[\text{M} + \text{H}]^+$  calcd for  $\text{C}_{23}\text{H}_{19}\text{N}_2\text{O}_5$ , 403.1288; found, 403.1294.

**(1R,3R,3aR,8bR)-3-(furan-3-yl)-3a-nitro-2,3,3a,4',5',8b-hexahydro-2'H-spiro[benzofuro[2,3-c]pyrrole-1,3'-furan]-2'-one(5m)**



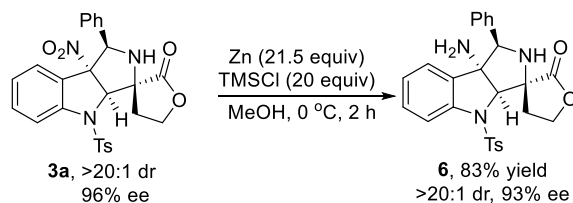
37.7 mg, 55% yield for the sum of the diastereomers, 36% yield for the major isomer, white soild, 66:34 dr, 91% ee, m.p.:199.8-200.3 °C; **The ee was determined by HPLC** (Chiralpak AD-H, EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda = 254$  nm, major diastereomer:  $t_{\text{minor}} = 12.0$  min,  $t_{\text{major}} = 18.1$  min);  $[\alpha]_{\text{D}}^{20} = -56.9$  (*c* 1.00,  $\text{CH}_2\text{Cl}_2$ ) for major diastereomer;

$^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ )  $\delta$  (major diastereomer) 7.81 (s, 1H), 7.75 – 7.67 (m, 1H), 7.34 – 7.24 (m, 1H), 7.11 – 7.00 (m, 3H), 6.54 (d,  $J = 1.9$  Hz, 1H), 5.12 (d,  $J = 9.8$  Hz, 1H), 4.86 (s, 1H), 4.67 – 4.56 (m, 2H), 3.64 (d,  $J = 9.8$  Hz, 1H), 2.94 – 2.86 (m, 1H), 2.43 (td,  $J = 11.6, 8.7$  Hz, 1H).

$^{13}\text{C}$  NMR (101 MHz, DMSO- $d_6$ )  $\delta$  (major diastereomer) 173.5, 157.9, 143.7, 141.9, 129.8, 125.5, 123.8, 123.2, 123.0, 118.2, 110.3, 109.8, 69.0, 65.0, 61.7, 61.1, 36.5.

HRMS (ESI-TOF)  $m/z$ :  $[\text{M} + \text{H}]^+$  calcd for  $\text{C}_{17}\text{H}_{15}\text{N}_2\text{O}_6$ , 343.0925; found, 343.0931.

#### 4. Characterization data for compounds 6-9



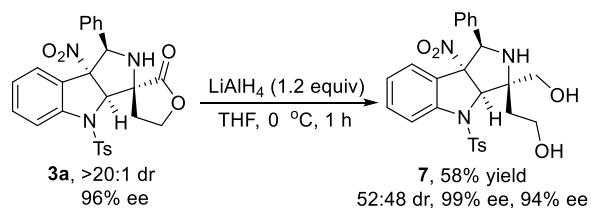
**(1'*R*,3*S*,3*a*'*S*,8*b*'*R*)-8*b*'-amino-1'-phenyl-4'-tosyl-1',3*a*',4,4',5,8*b*'-hexahydro-2*H*,2'*H*-spiro[furan-3,3'-pyrrolo[3,4-*b*]indol]-2-one (6).**

39.5 mg, 83% yield, white solid,  $>20:1$  dr, 93% ee, m.p.: 120.7–121.1 °C; **The ee was determined by HPLC** (Chiralpak IA, *i*-PrOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 25.1 min,  $t_{\text{major}}$  = 28.4 min);  $[\alpha]_{\text{D}}^{20}$  = +25.6 (*c* 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  7.57 (d, *J* = 7.0 Hz, 3H), 7.42 (d, *J* = 8.1 Hz, 1H), 7.23 (dd, *J* = 8.1, 3.5 Hz, 5H), 7.19 – 7.13 (m, 3H), 6.60 – 6.53 (m, 1H), 5.43 (d, *J* = 7.6 Hz, 1H), 5.00 (s, 1H), 4.95 (d, *J* = 4.7 Hz, 1H), 4.55 (q, *J* = 7.2 Hz, 1H), 4.41 (q, *J* = 7.6 Hz, 1H), 4.33 (s, 1H), 3.95 (d, *J* = 4.9 Hz, 1H), 2.93 (dt, *J* = 13.8, 7.2 Hz, 1H), 2.27 (s, 3H), 2.22 (dt, *J* = 13.3, 6.5 Hz, 1H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  178.4, 144.4, 143.0, 138.4, 133.2, 130.5, 129.5, 129.2, 127.9, 127.6, 127.4, 127.3, 126.6, 123.2, 114.8, 80.2, 71.0, 66.1, 65.9, 61.5, 32.6, 21.0.

**HRMS (ESI-TOF)** *m/z*:  $[\text{M} + \text{H}]^+$  calcd for C<sub>26</sub>H<sub>26</sub>N<sub>3</sub>O<sub>4</sub>S, 476.1639; found, 476.1633.



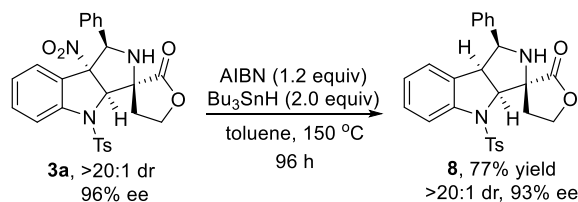
**2-(3-(hydroxymethyl)-8*b*-nitro-1-phenyl-4-tosyl-1,2,3,3*a*,4,8*b*-hexahydropyrrolo[3,4-*b*]indol-3-yl)ethan-1-ol(7)**

29.6 mg, 58% yield, white solid, 52:48 dr, 99%, 94% ee, m.p.: 130.1–130.5 °C; **The ee was determined by HPLC** (Chiralpak AD-H, EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 16.7 min,  $t_{\text{major}}$  = 9.0 min);  $[\alpha]_{\text{D}}^{20}$  = +21.3 (*c* 1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  7.73 (d, *J* = 7.9 Hz, 1H), 7.61 (dd, *J* = 20.5, 7.8 Hz, 3H), 7.45 (d, *J* = 8.1 Hz, 2H), 7.41 – 7.38 (m, 2H), 7.38 – 7.32 (m, 8H), 7.30 – 7.18 (m, 7H), 7.08 – 7.00 (m, 2H), 6.80 – 6.69 (m, 1H), 5.69 (s, 1H), 5.64 (d, *J* = 7.6 Hz, 1H), 5.43 (t, 1H), 5.35 (s, 1H), 5.31 (t, 1H), 5.23 (d, *J* = 6.1 Hz, 1H), 4.57 (d, *J* = 12.4 Hz, 1H), 4.48 (t, *J* = 5.0 Hz, 1H), 4.36 (t, *J* = 5.1 Hz, 1H), 3.87 (d, *J* = 6.0 Hz, 2H), 3.73 (d, *J* = 5.5 Hz, 2H), 3.64 – 3.55 (m, 2H), 3.53 (d, *J* = 13.1 Hz, 1H), 3.47 – 3.41 (m, 2H), 2.27 (s, 3H), 2.23 (s, 3H), 2.16 – 2.07 (m, 1H), 1.87 – 1.76 (m, 1H), 1.61 – 1.50 (m, 1H), 1.29 – 1.25 (m, 1H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  144.8, 144.7, 143.9, 142.7, 136.6, 134.9, 132.8, 132.3, 131.6, 129.9, 129.8, 128.9, 128.8, 128.6, 128.43, 128.35, 128.3, 128.2, 127.8, 127.7, 127.3, 127.2, 126.8, 125.9, 124.9, 123.7, 117.1, 115.9, 105.7, 102.1, 75.5, 73.2, 71.6, 68.5, 67.8, 66.0, 65.4, 61.4, 57.2, 56.7, 37.5, 31.4, 21.0, 20.9.

**HRMS (ESI-TOF)** *m/z*:  $[\text{M} + \text{H}]^+$  calcd for C<sub>26</sub>H<sub>25</sub>N<sub>2</sub>O<sub>4</sub>S, 510.1693; found, 510.1688.



**(1'S,3S,3a'S,8b'S)-1'-phenyl-4'-tosyl-1',3a',4,4',5,8b'-hexahydro-2H,2'H-spiro[furan-3,3'-pyrrolo[3,4-b]indol]-2-one (8)**

35.5 mg, 77% yield, white solid, >20:1 dr, 93% ee, m.p.:220.1-220.4 °C; **The ee was determined by HPLC** (Chiralpak IC, EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 10.0 min,  $t_{\text{major}}$  = 10.7 min);  $[\alpha]_{\text{D}}^{20}$  = +24.3 ( $c$  1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  7.51 – 7.42 (m, 3H), 7.30 – 7.22 (m, 5H), 7.18 (s, 2H), 7.14 – 7.08 (m, 1H), 6.63 – 6.53 (m, 1H), 5.39 (d,  $J$  = 7.6 Hz, 1H), 4.95 (t,  $J$  = 6.0 Hz, 1H), 4.85 (d,  $J$  = 8.2 Hz, 1H), 4.52 (td,  $J$  = 8.4, 4.3 Hz, 1H), 4.42 (q,  $J$  = 8.4, 7.8 Hz, 1H), 4.02 (d,  $J$  = 5.6 Hz, 1H), 3.94 (t,  $J$  = 7.4 Hz, 1H), 2.89 (dt,  $J$  = 13.4, 8.0 Hz, 1H), 2.29 (s, 3H), 2.26 – 2.16 (m, 1H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  178.6, 144.7, 142.4, 138.3, 133.2, 131.4, 130.3, 130.0, 128.0, 127.9, 127.4, 127.1, 126.0, 124.0, 115.8, 69.9, 67.8, 66.4, 61.7, 50.4, 32.5, 21.0.

**HRMS (ESI-TOF)**  $m/z$ :  $[M + H]^+$  calcd for C<sub>26</sub>H<sub>25</sub>N<sub>2</sub>O<sub>4</sub>S, 461.1530; found, 461.1540.



**(1'R,3S,3a'S,8b'S)-2'-bromo-8b'-nitro-1'-phenyl-4'-tosyl-1',3a',4,4',5,8b'-hexahydro-2H,2'H-spiro[furan-3,3'-pyrrolo[3,4-b]indol]-2-one (9)**

54.4 mg, 93% yield, white solid, >20:1 dr, 92% ee; m.p.:153.4-153.8 °C; **The ee was determined by HPLC** (Chiralpak IC, EtOH/hexane = 20/80, flow rate 1.0 mL/min,  $\lambda$  = 254 nm, major diastereomer:  $t_{\text{minor}}$  = 7.1 min,  $t_{\text{major}}$  = 7.9 min);  $[\alpha]_{\text{D}}^{20}$  = +34.5 ( $c$  1.00, CH<sub>2</sub>Cl<sub>2</sub>) for major diastereomer;

**<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  7.68 (d,  $J$  = 8.2 Hz, 1H), 7.47 (dd,  $J$  = 14.0, 8.0 Hz, 3H), 7.39 – 7.33 (m, 1H), 7.31 – 7.23 (m, 4H), 7.05 (d,  $J$  = 7.6 Hz, 2H), 6.87 – 6.79 (m, 1H), 5.78 (d,  $J$  = 7.8 Hz, 1H), 5.50 (s, 1H), 5.33 (s, 1H), 4.58 (td,  $J$  = 8.5, 4.0 Hz, 1H), 4.45 (q,  $J$  = 8.0 Hz, 1H), 3.03 (dt,  $J$  = 13.6, 8.2 Hz, 1H), 2.35 – 2.28 (m, 1H), 2.27 (s, 3H).

**<sup>13</sup>C NMR (101 MHz, DMSO-*d*<sub>6</sub>)**  $\delta$  177.1, 145.4, 143.5, 134.7, 132.2, 131.8, 130.0, 129.0, 128.6, 127.8, 127.6, 127.5, 124.4, 124.3, 116.2, 101.1, 73.9, 66.9, 66.6, 66.5, 31.6, 21.0.

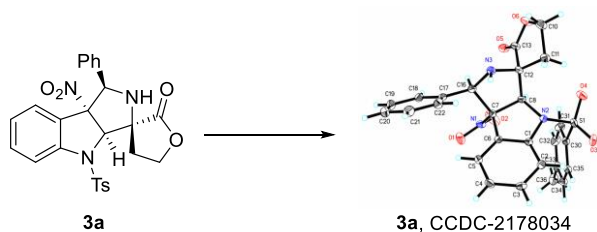
**HRMS (ESI-TOF)**  $m/z$ :  $[M + H]^+$  calcd for C<sub>26</sub>H<sub>23</sub><sup>79</sup>BrN<sub>3</sub>O<sub>6</sub>S, 584.0485; found, 584.0492.  $[M + H]^+$  calcd for C<sub>26</sub>H<sub>23</sub><sup>81</sup>BrN<sub>3</sub>O<sub>6</sub>S, 586.0468; found, 586.0472.

## 5. X-ray crystal structure of compounds 3a and 5c

Single crystal of compound **3a** was prepared from the mixture solvent of ethyl acetate/petroleum ether (1/2) at room temperature by slow evaporation of solvent. A suitable crystal was selected for structure determination on a XtaLAB AFC12 (RINC): Kappa single diffractometer. The crystal was kept at 150.00(10) K during data collection. Using Olex2 [1], the

structure was solved with the SHELXT [2] structure solution program using Intrinsic Phasing and refined with the SHELXL [3] refinement package using Least Squares minimisation.

- [1] Dolomanov, O. V.; Bourhis, L. J.; Gildea, R. J, Howard, J. A. K.; Puschmann, H. *J. Appl. Cryst.* **2009**, 42, 339-341.  
 [2] Sheldrick, G. M. *Acta Cryst.* **2008**, A64, 112-122.  
 [3] Sheldrick, G. M. *Acta Cryst.* **2015**, C71, 3-8.

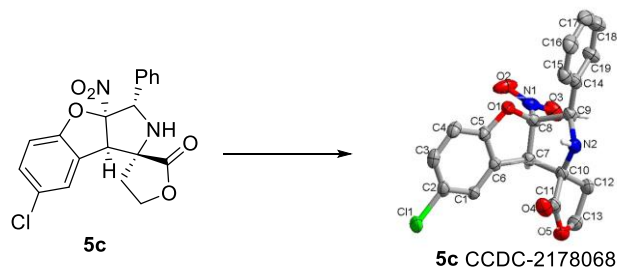


**Table 1 Crystal data and structure refinement for 3a.**

Identification code	<b>3a</b>
Empirical formula	$C_{26}H_{23}N_3O_6S$
Formula weight	505.53
Temperature/K	150.00(10)
Crystal system	orthorhombic
Space group	$P2_12_12_1$
$a/\text{\AA}$	9.1955(2)
$b/\text{\AA}$	12.9582(3)
$c/\text{\AA}$	19.8231(5)
$\alpha/^\circ$	90
$\beta/^\circ$	90
$\gamma/^\circ$	90
Volume/ $\text{\AA}^3$	2362.06(10)
Z	4
$\rho_{\text{calc}}/\text{g cm}^{-3}$	1.422
$\mu/\text{mm}^{-1}$	1.637
F(000)	1056.0
Crystal size/ $\text{mm}^3$	$0.14 \times 0.11 \times 0.09$
Radiation	Cu $K\alpha$ ( $\lambda = 1.54184$ )
$2\theta$ range for data collection/ $^\circ$	8.152 to 144.48
Index ranges	$-11 \leq h \leq 10, -15 \leq k \leq 12, -21 \leq l \leq 24$
Reflections collected	10706
Independent reflections	4529 [ $R_{\text{int}} = 0.0301, R_{\text{sigma}} = 0.0279$ ]
Data/restraints/parameters	4529/0/330
Goodness-of-fit on $F^2$	1.045
Final R indexes [ $I \geq 2\sigma(I)$ ]	$R_1 = 0.0426, wR_2 = 0.1115$
Final R indexes [all data]	$R_1 = 0.0431, wR_2 = 0.1120$
Largest diff. peak/hole / $e \text{\AA}^{-3}$	0.45/-0.41

Flack/Hoof parameter	-0.005(14)/-0.005(6)
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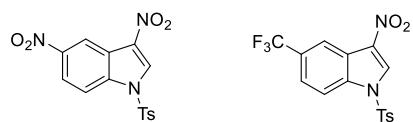
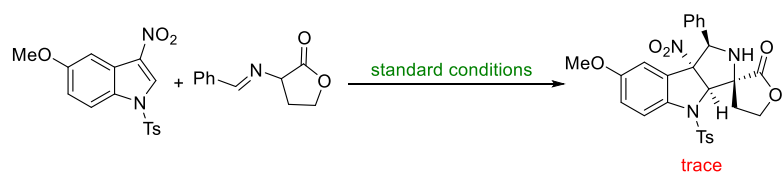
Single crystal of compound **5c** was prepared from the mixture solvent of dichloromethane/EtOH (1/5) at room temperature by slow evaporation of solvent.



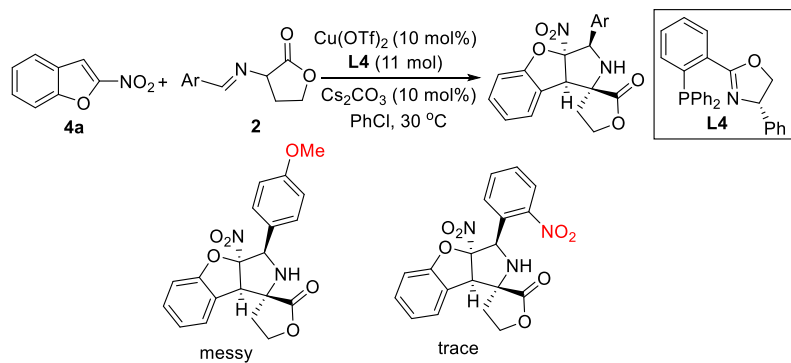
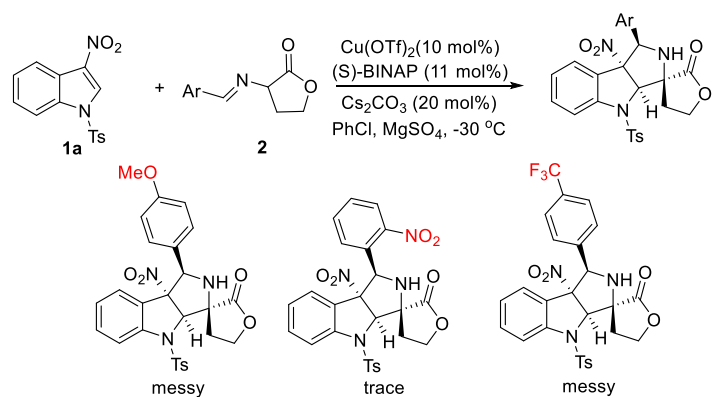
**Table 1 Crystal data and structure refinement for 5c.**

Identification code	<b>5c</b>
Empirical formula	C <sub>19</sub> H <sub>15</sub> ClN <sub>2</sub> O <sub>5</sub>
Formula weight	386.78
Temperature/K	293(2)
Crystal system	orthorhombic
Space group	P2 <sub>1</sub> 2 <sub>1</sub> 2 <sub>1</sub>
a/Å	9.9074(6)
b/Å	13.3728(8)
c/Å	13.4556(9)
α/°	90
β/°	90
γ/°	90
Volume/Å <sup>3</sup>	1782.7(2)
Z	4
ρ <sub>calc</sub> /g/cm <sup>3</sup>	1.441
μ/mm <sup>-1</sup>	2.204
F(000)	800.0
Crystal size/mm <sup>3</sup>	0.15 × 0.1 × 0.09
Radiation	CuKα (λ = 1.54184)
2θ range for data collection/°	9.324 to 144.02
Index ranges	-12 ≤ h ≤ 11, -16 ≤ k ≤ 16, -15 ≤ l ≤ 16
Reflections collected	13126
Independent reflections	3409 [R <sub>int</sub> = 0.0373, R <sub>sigma</sub> = 0.0308]
Data/restraints/parameters	3409/1/259
Goodness-of-fit on F <sup>2</sup>	1.056
Final R indexes [I ≥ 2σ (I)]	R <sub>1</sub> = 0.0444, wR <sub>2</sub> = 0.1191
Final R indexes [all data]	R <sub>1</sub> = 0.0528, wR <sub>2</sub> = 0.1288
Largest diff. peak/hole / e Å <sup>-3</sup>	0.31/-0.30
Flack parameter	-0.014(13)

## 6. Unsuccessful examples



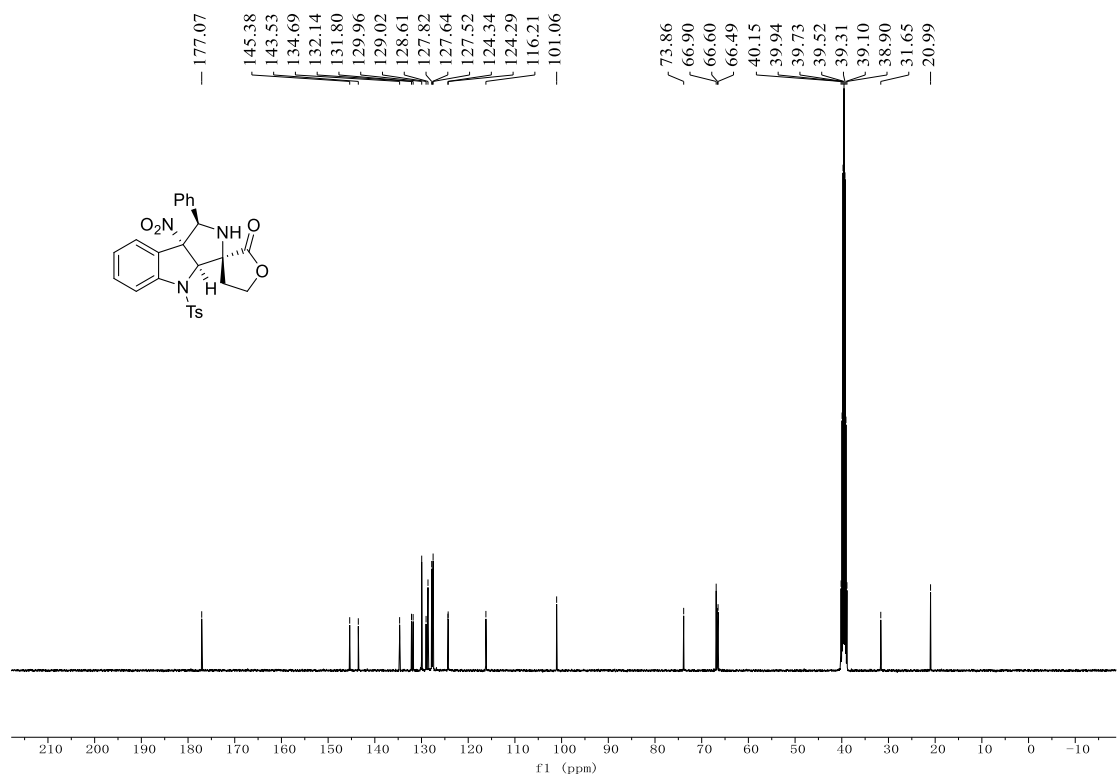
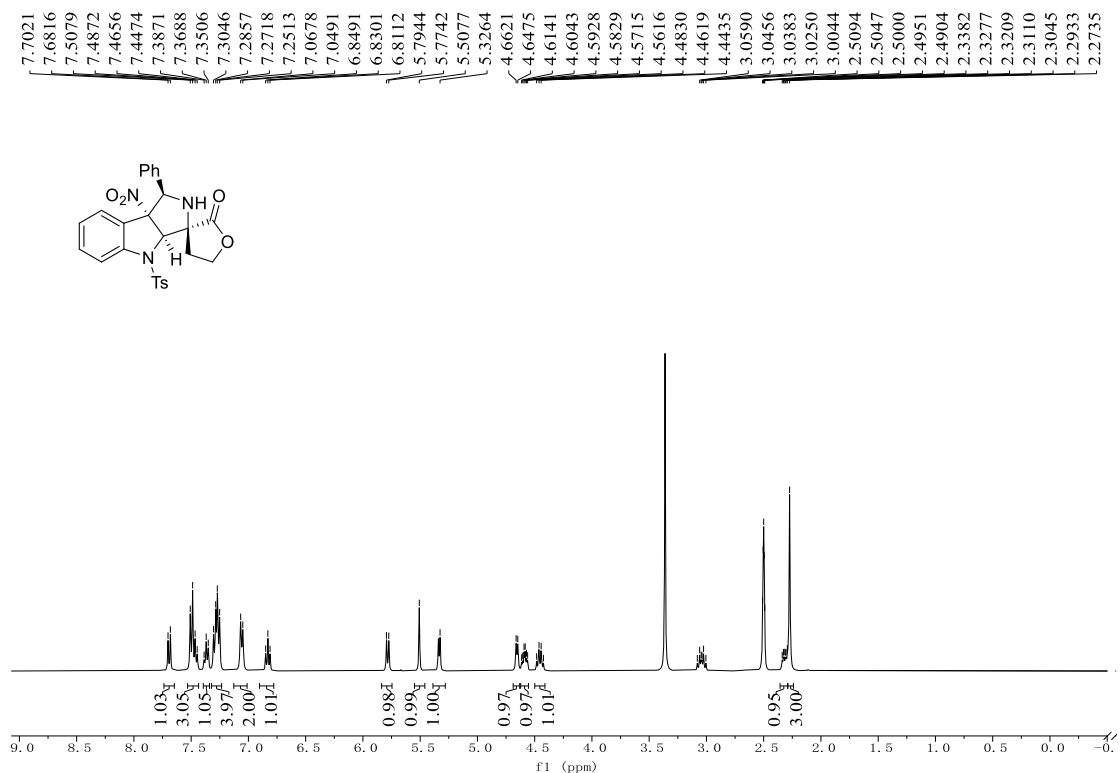
These two substrates are not available at present



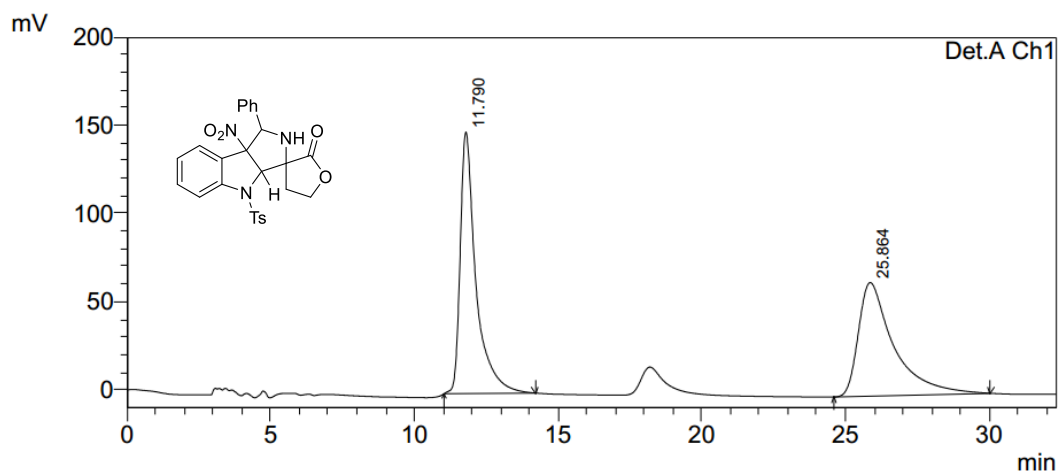


## 7. $^1\text{H}$ NMR, $^{13}\text{C}$ NMR and HPLC spectra for compounds 3,5 and 6-9

$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ ) of 3a



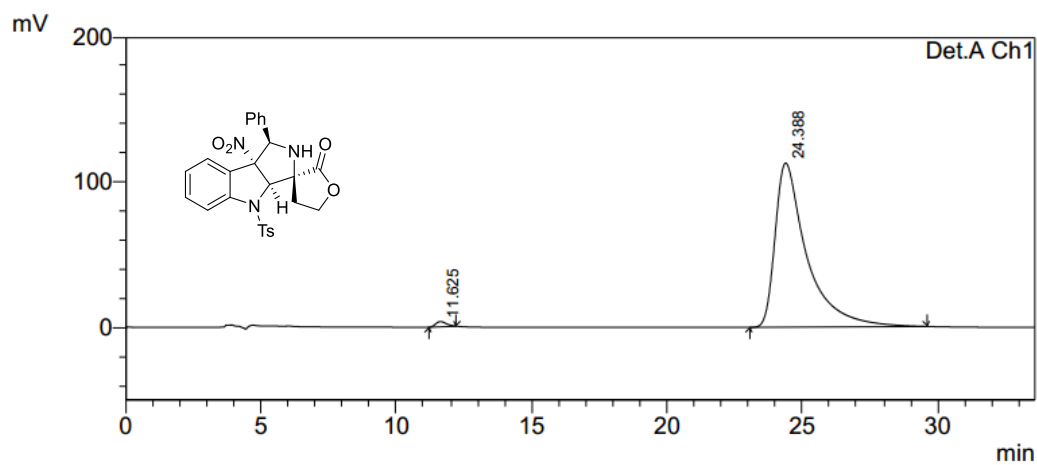
# HPLC spectra of 3a



1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm				
Peak#	Ret. Time	Area	Height	Area %
1	11.790	5624264	148086	50.483
2	25.864	5516663	64333	49.517
Total		11140927		100.000

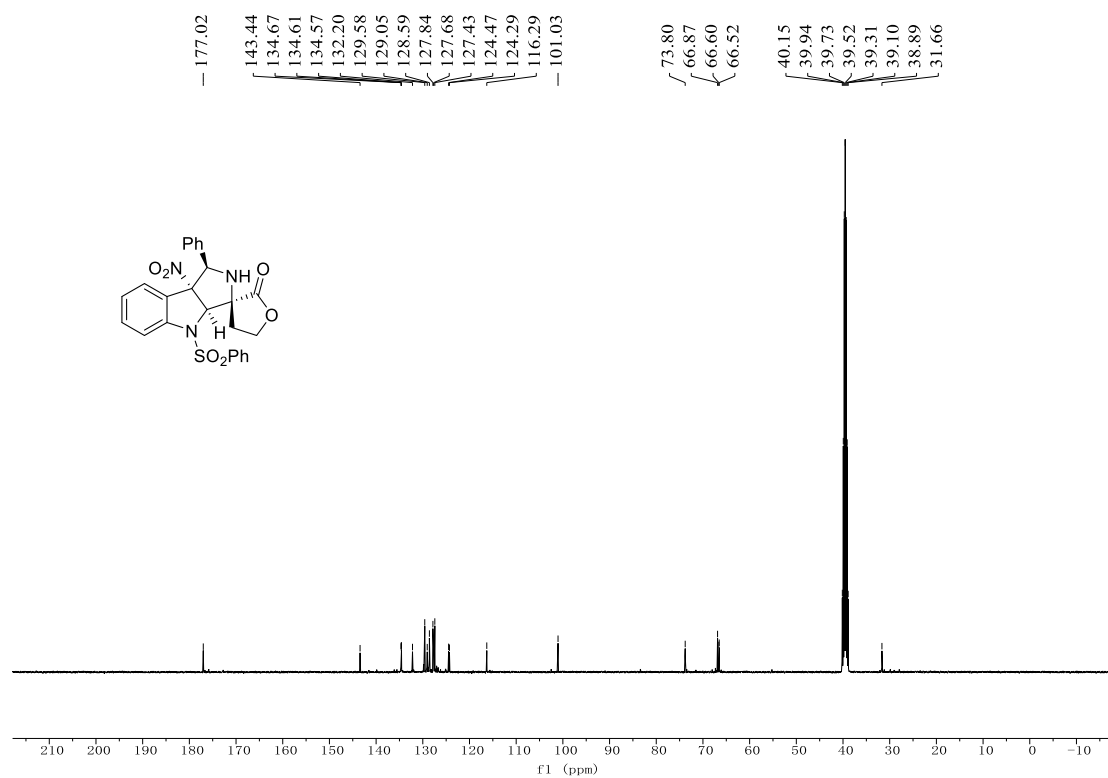
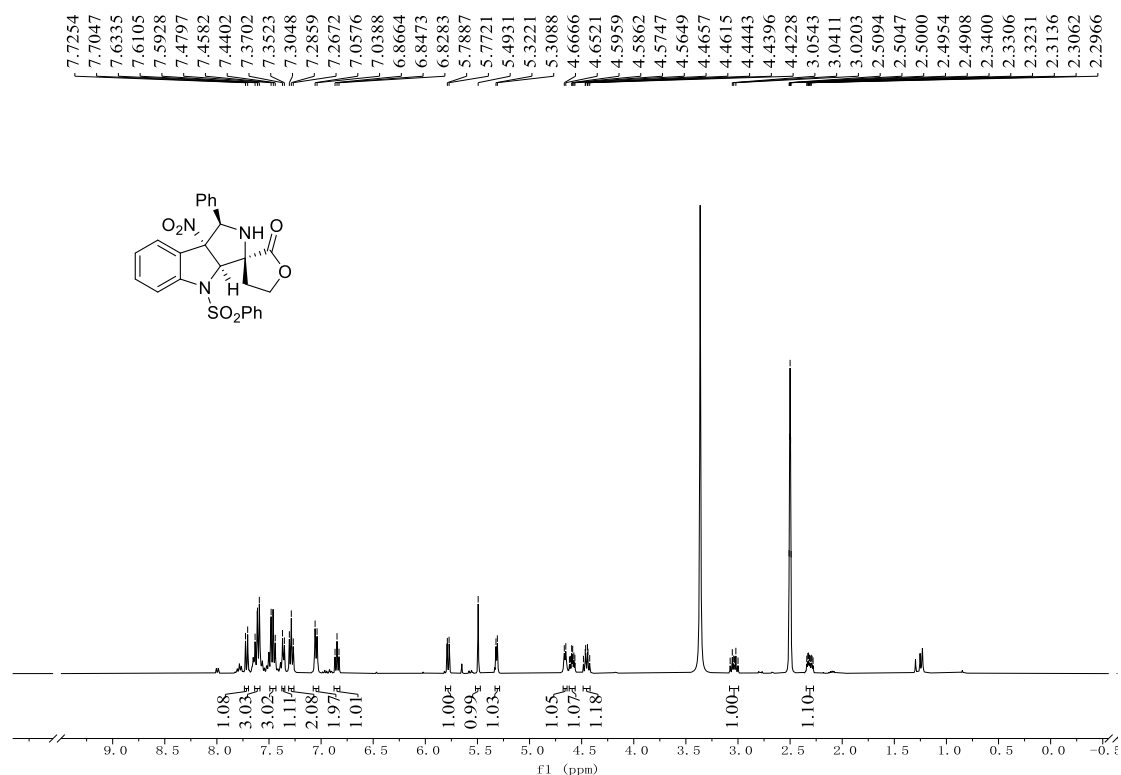


1 Det.A Ch1/254nm

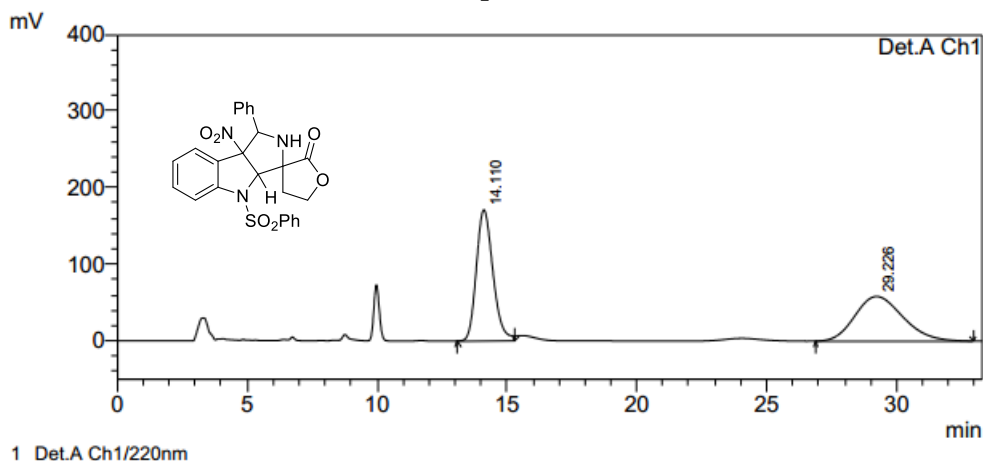
PeakTable

Detector A Ch1 254nm				
Peak#	Ret. Time	Area	Height	Area %
1	11.625	100348	3610	1.076
2	24.388	9229724	113106	98.924
Total		9330072		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ ) of 3b**



# HPLC spectra of 3b

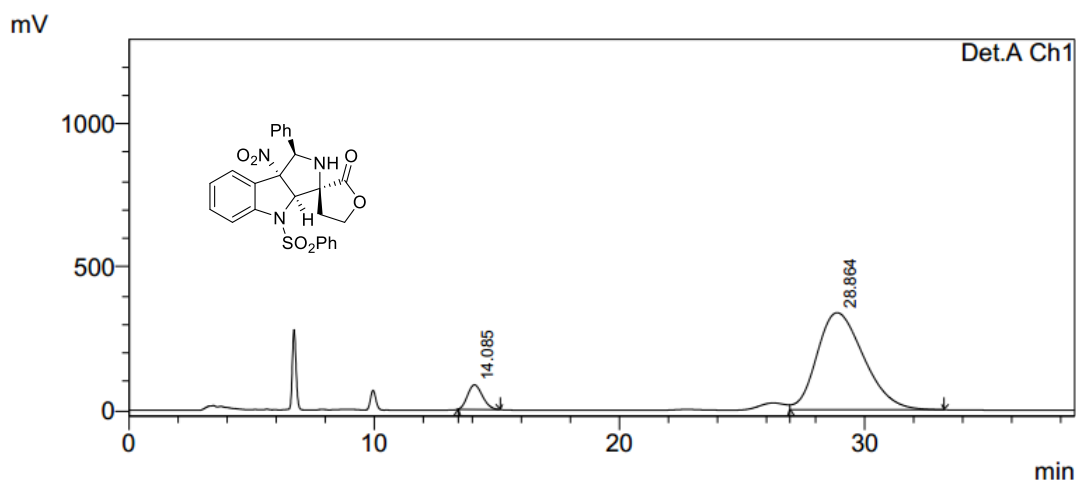


1 Det.A Ch1/220nm

PeakTable

Detector A Ch1 220nm

Peak#	Ret. Time	Area	Height	Area %
1	14.110	7664788	171374	50.085
2	29.226	7638637	58684	49.915
Total		15303425		100.000



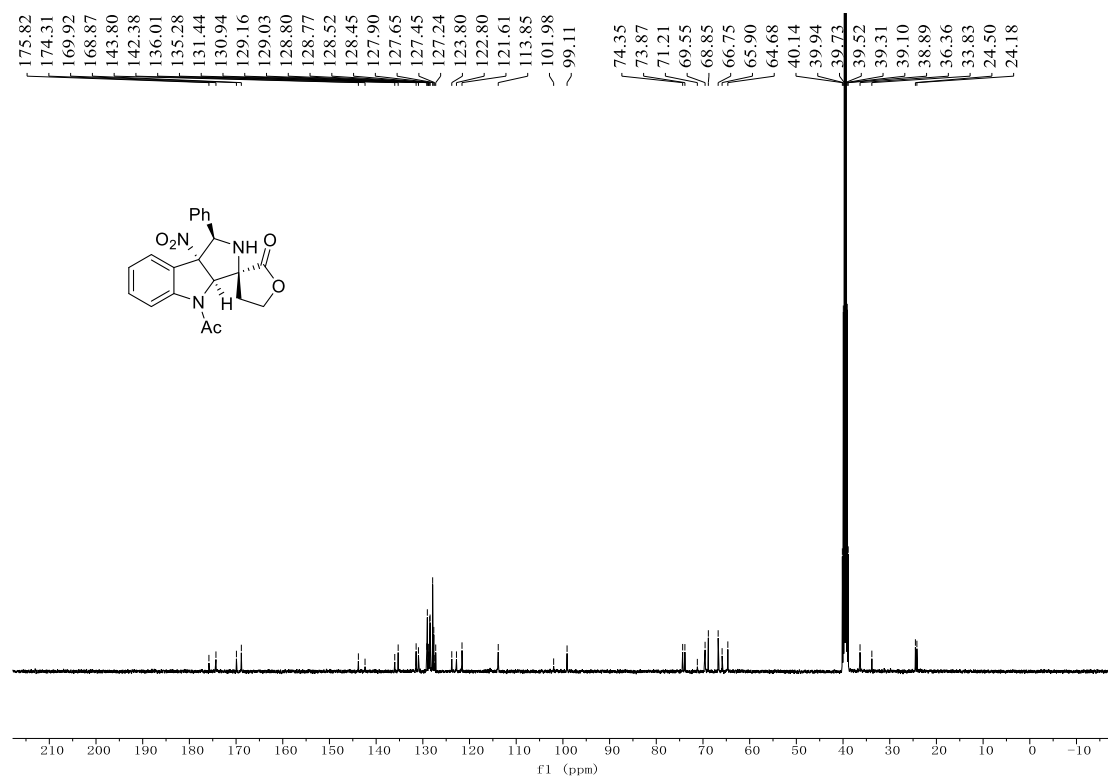
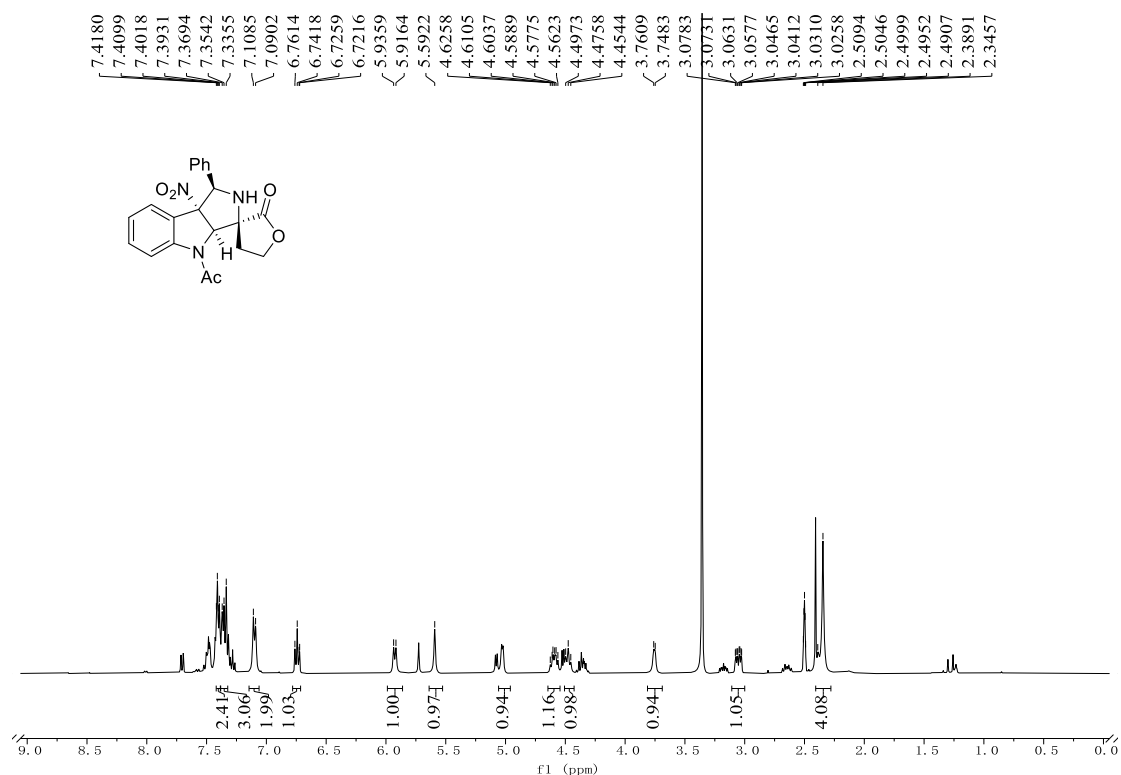
1 Det.A Ch1/220nm

PeakTable

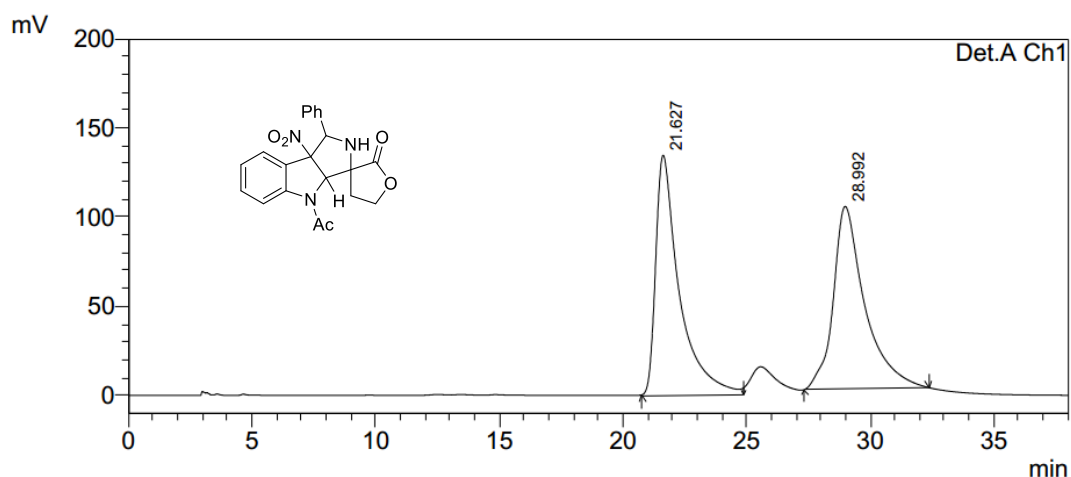
Detector A Ch1 220nm

Peak#	Ret. Time	Area	Height	Area %
1	14.085	3658641	86526	7.513
2	28.864	45036347	339465	92.487
Total		48694988		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-}d_6$ ) of 3c**



# HPLC spectra of 3c

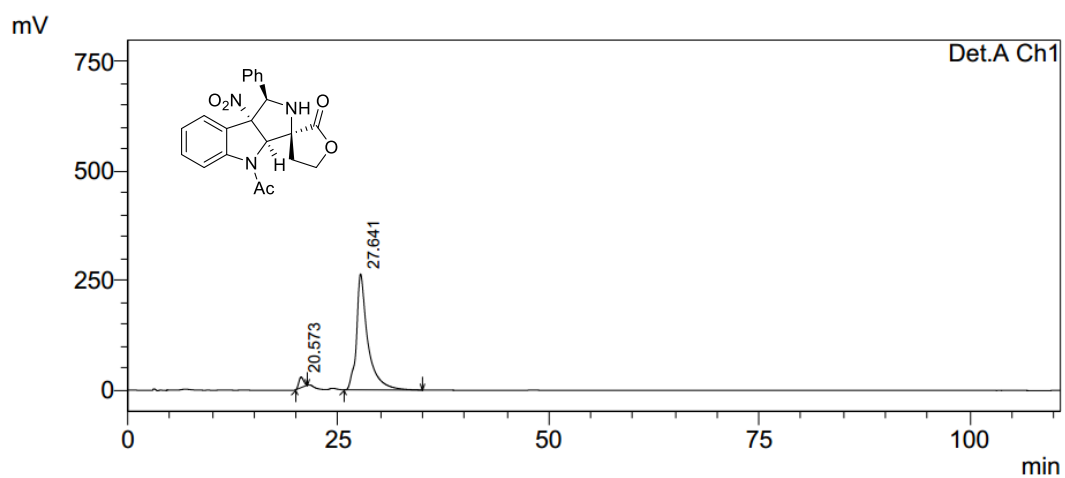


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	21.627	8980846	134713	49.803
2	28.992	9051775	102136	50.197
Total		18032621		100.000



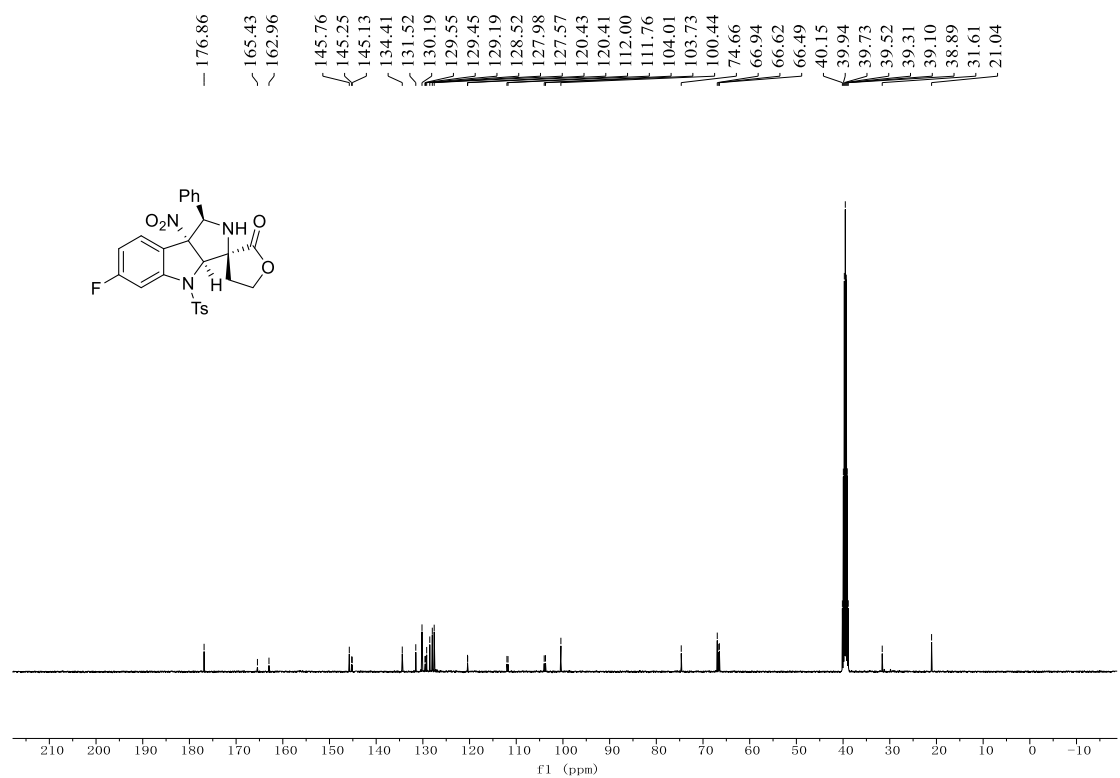
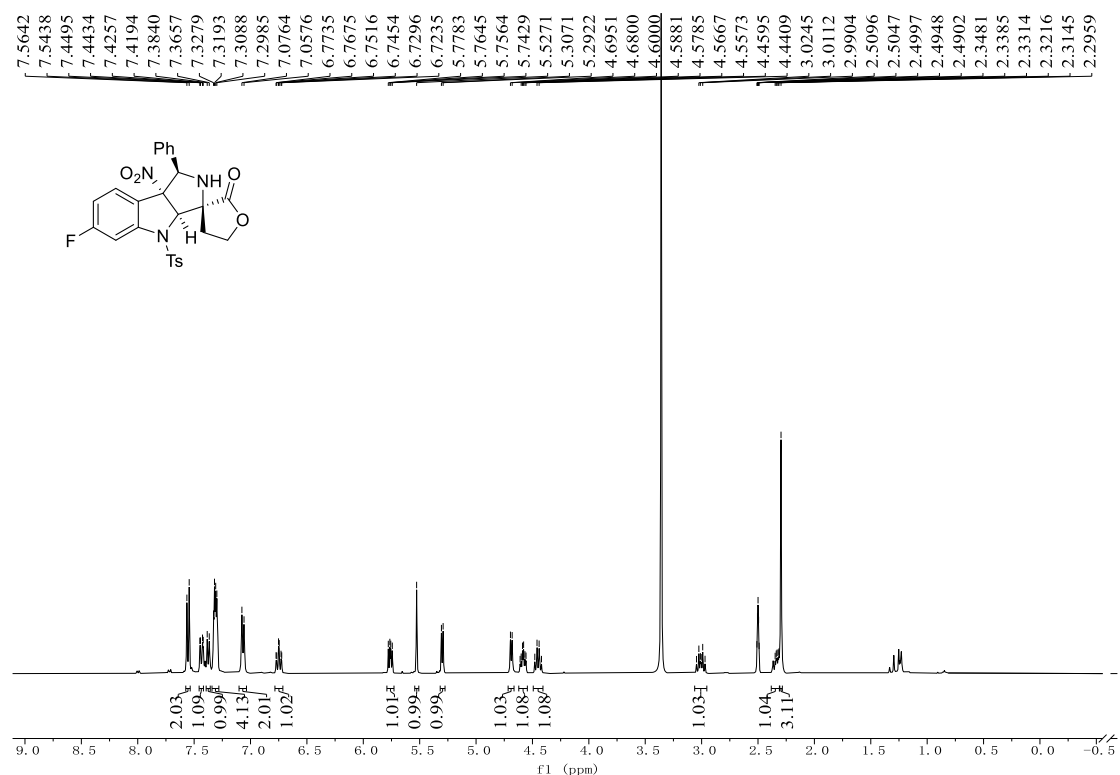
1 Det.A Ch1/254nm

PeakTable

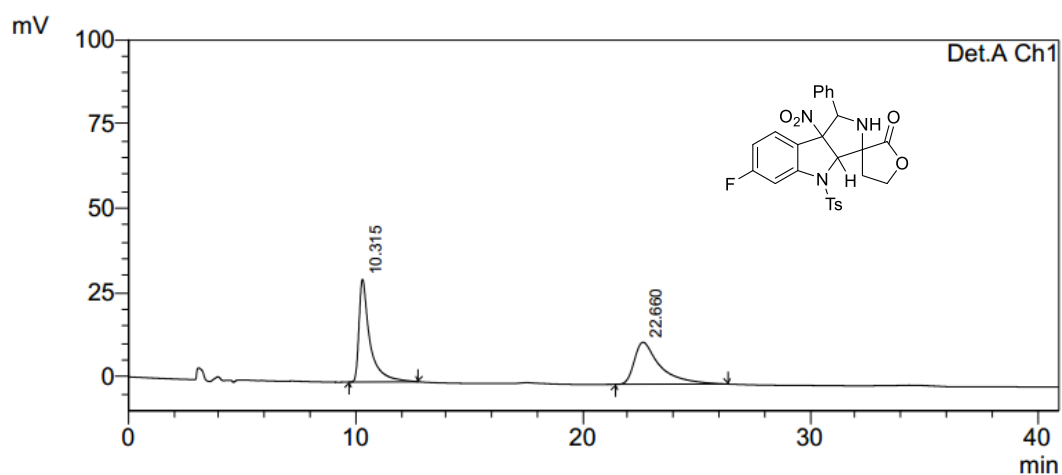
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	20.573	958003	24408	3.705
2	27.641	24896678	264828	96.295
Total		25854682		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ ) of 3d**



# HPLC spectra of 3d

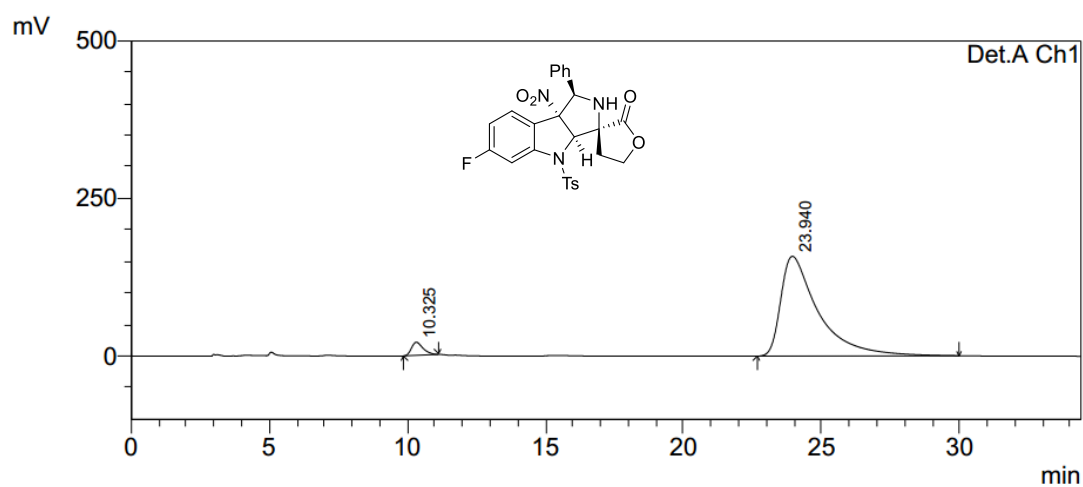


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	10.315	1016807	30426	50.776
2	22.660	985716	12448	49.224
Total		2002522		100.000



1 Det.A Ch1/254nm

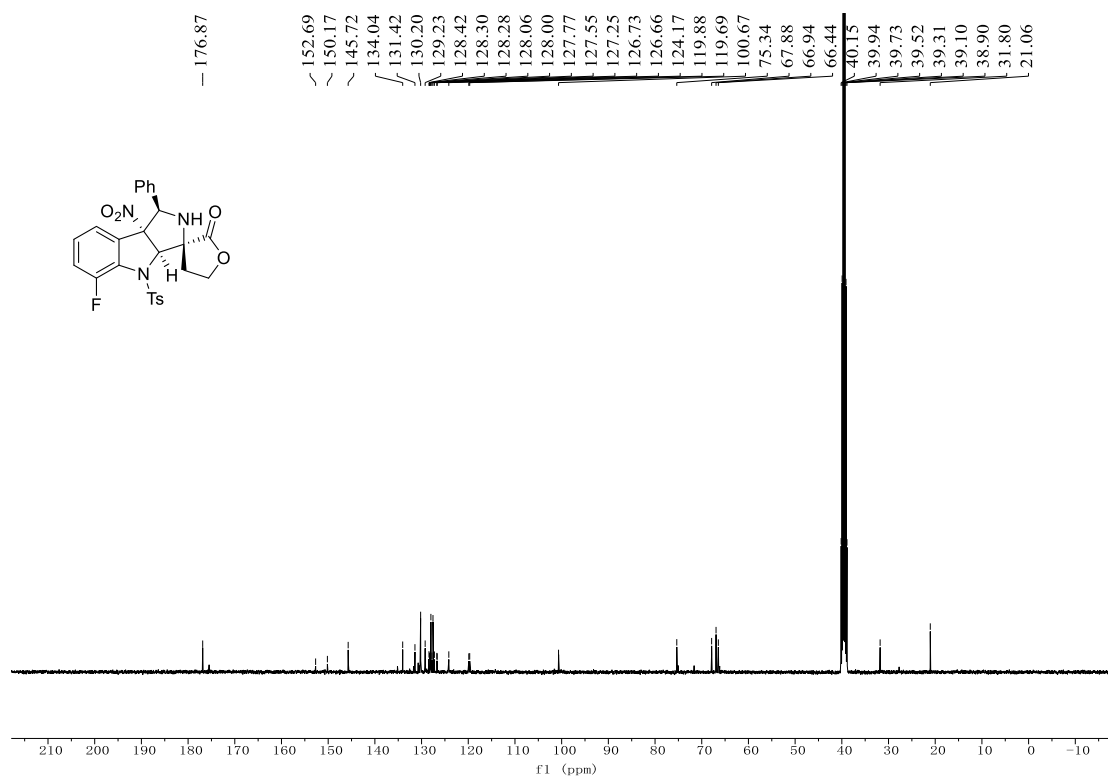
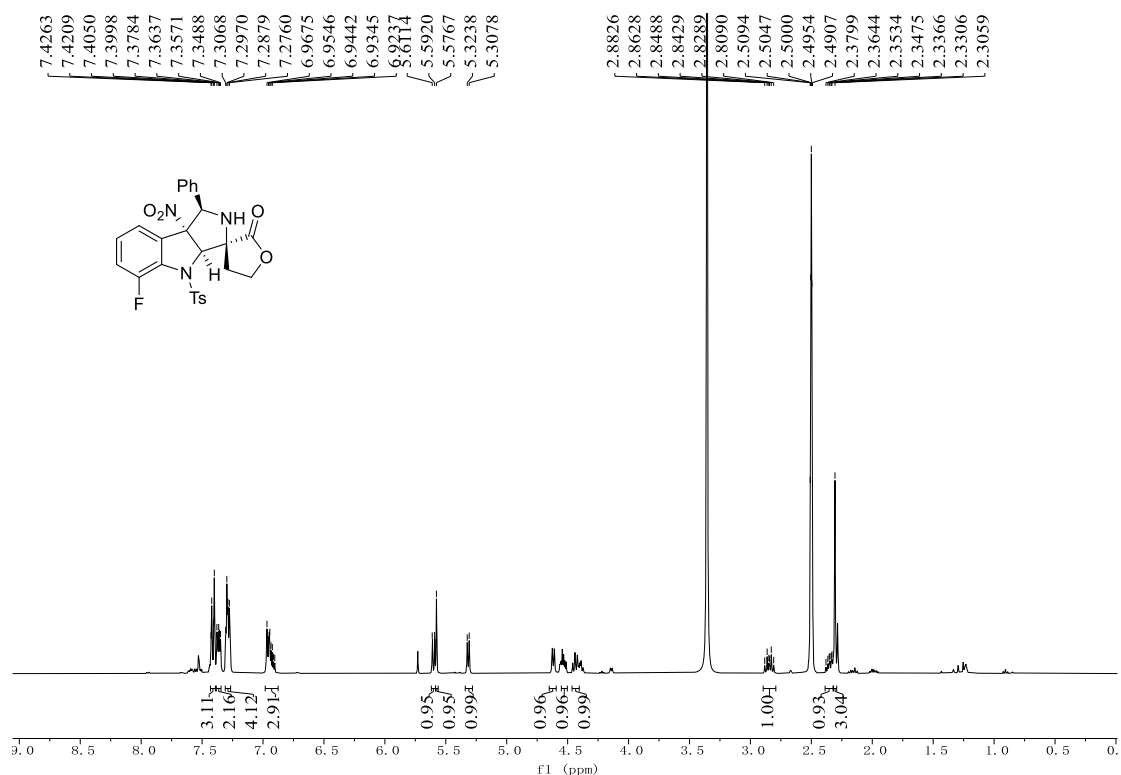
PeakTable

Detector A Ch1 254nm

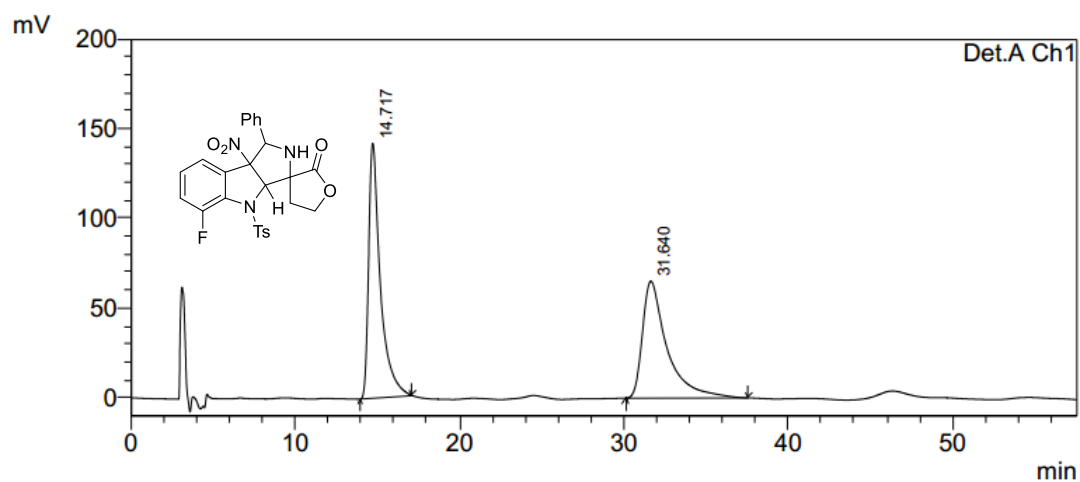
Peak#	Ret. Time	Area	Height	Area %
1	10.325	604156	20761	3.893
2	23.940	14916849	157860	96.107
Total		15521005		100.000



**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-}d_6$ ) of **3e****



# HPLC spectra of 3e

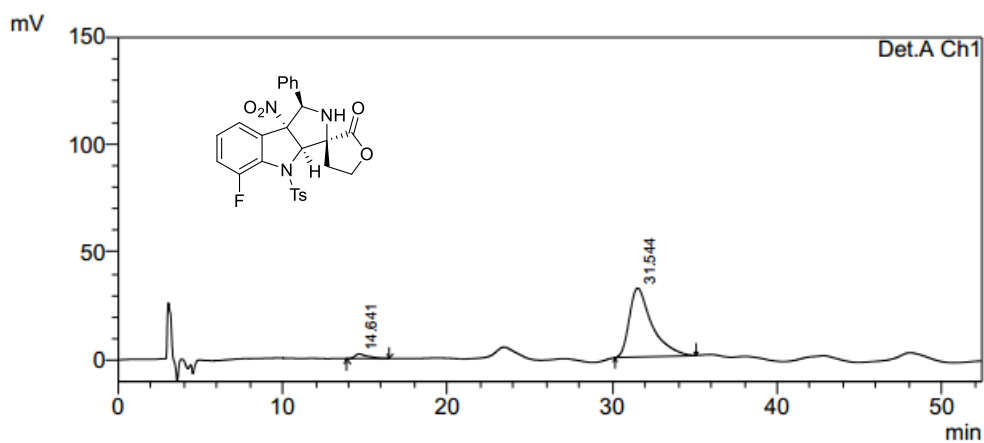


1 Det.A Ch1/220nm

PeakTable

Detector A Ch1 220nm

Peak#	Ret. Time	Area	Height	Area %
1	14.717	7019346	142067	50.829
2	31.640	6790249	65175	49.171
Total		13809594		100.000



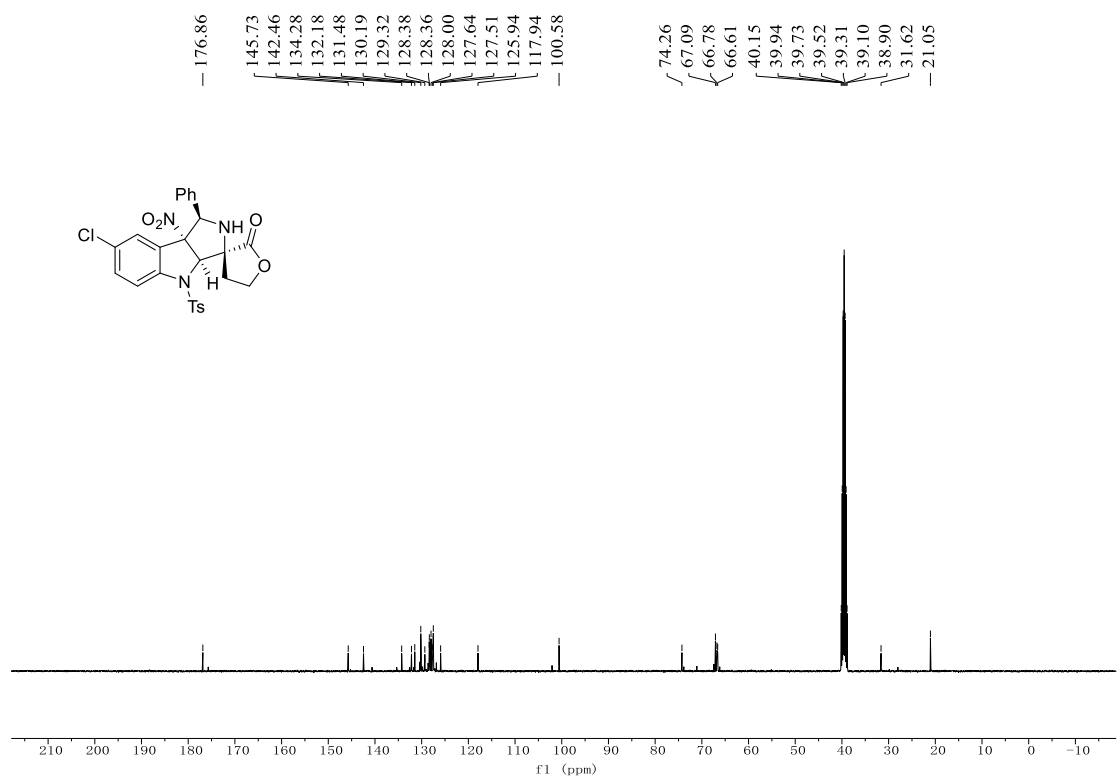
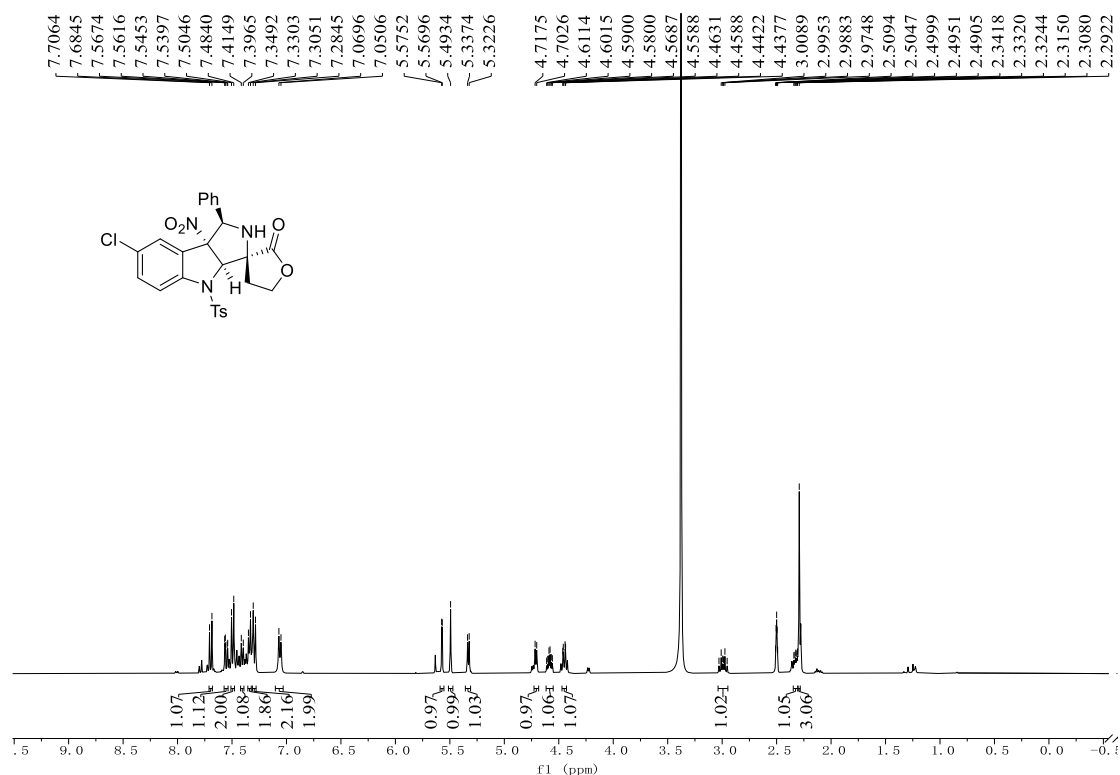
1 Det.A Ch1/220nm

PeakTable

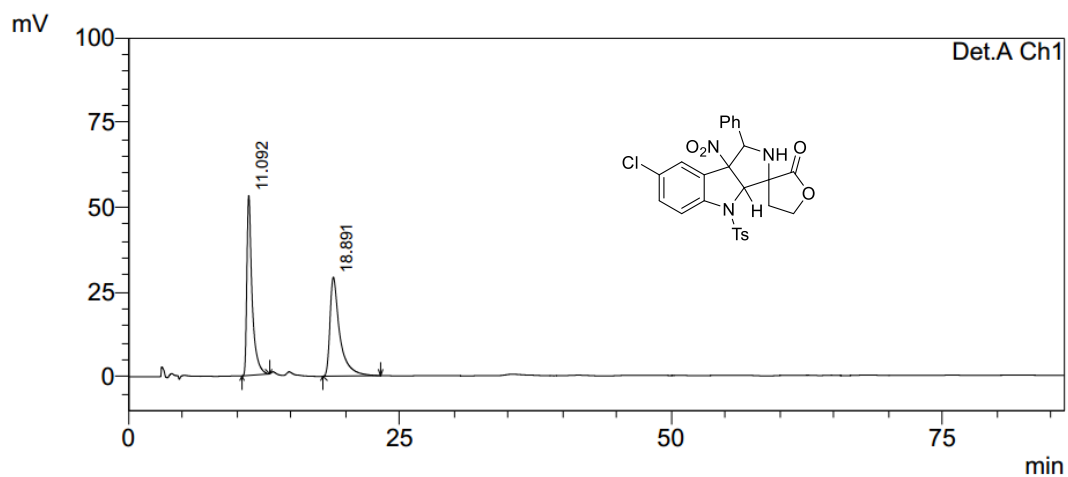
Detector A Ch1 220nm

Peak#	Ret. Time	Area	Height	Area %
1	14.641	113057	2153	3.546
2	31.544	3075118	32006	96.454
Total		3188175		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-}d_6$ ) of 3f**



# HPLC spectra of 3f

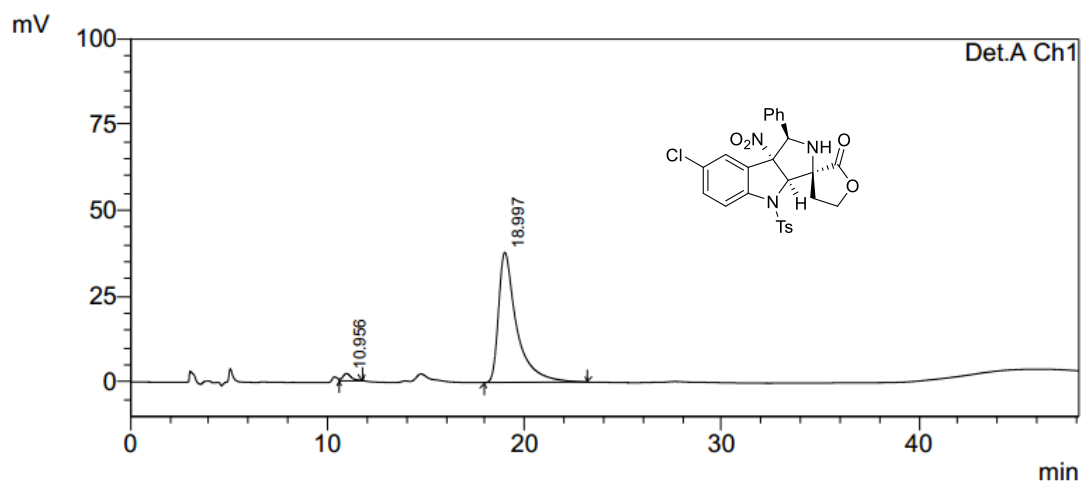


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	11.092	1787960	53036	49.422
2	18.891	1829766	29162	50.578
Total		3617726		100.000



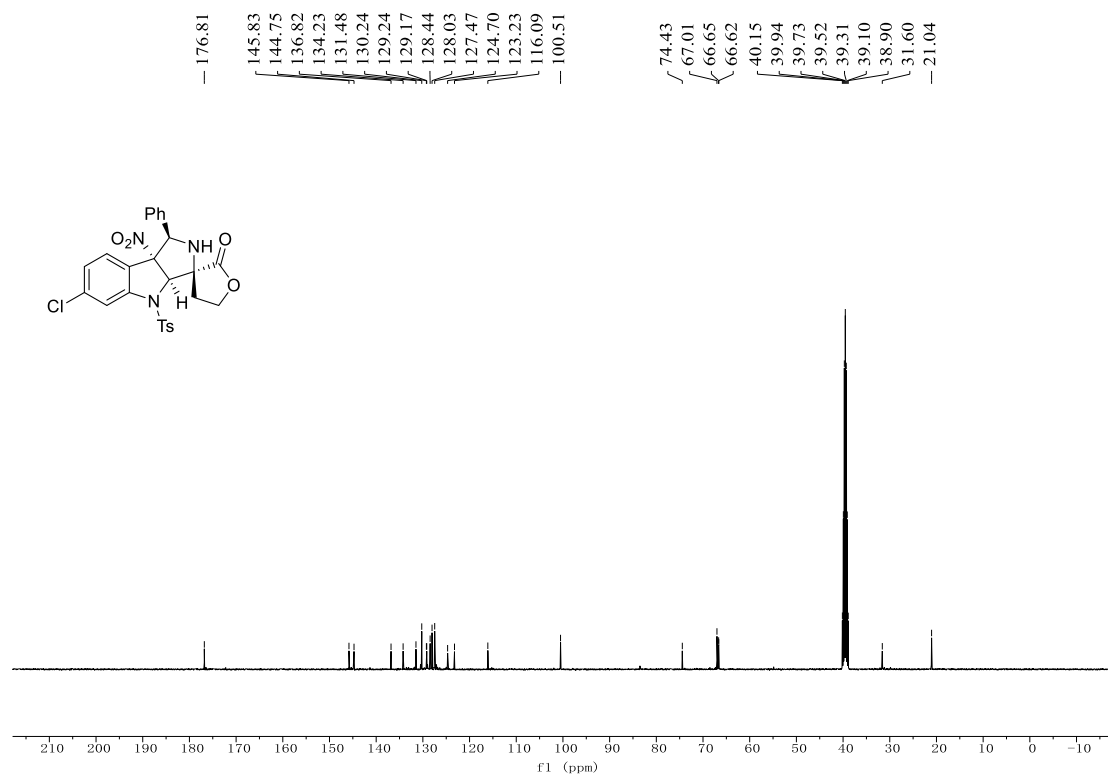
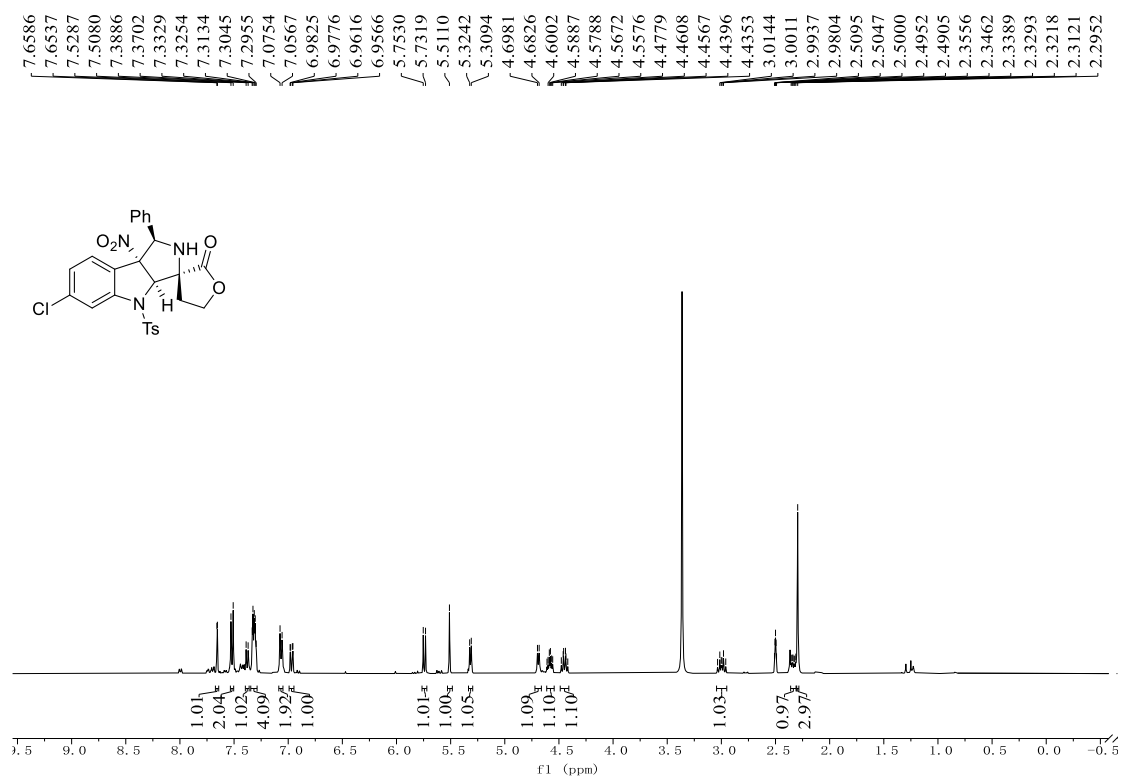
1 Det.A Ch1/254nm

PeakTable

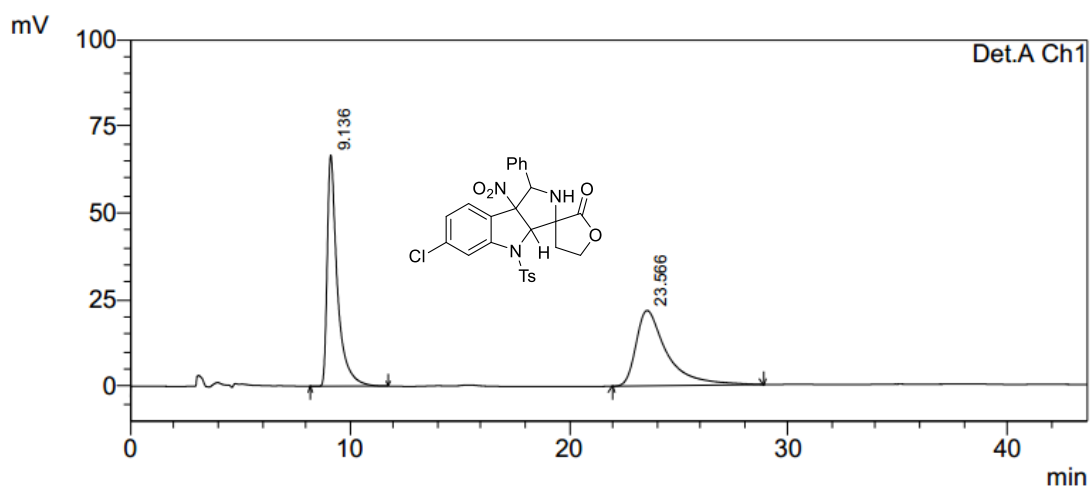
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	10.956	63225	2136	2.539
2	18.997	2427051	37896	97.461
Total		2490276		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-}d_6$ ) of **3g****



# HPLC spectra of 3g

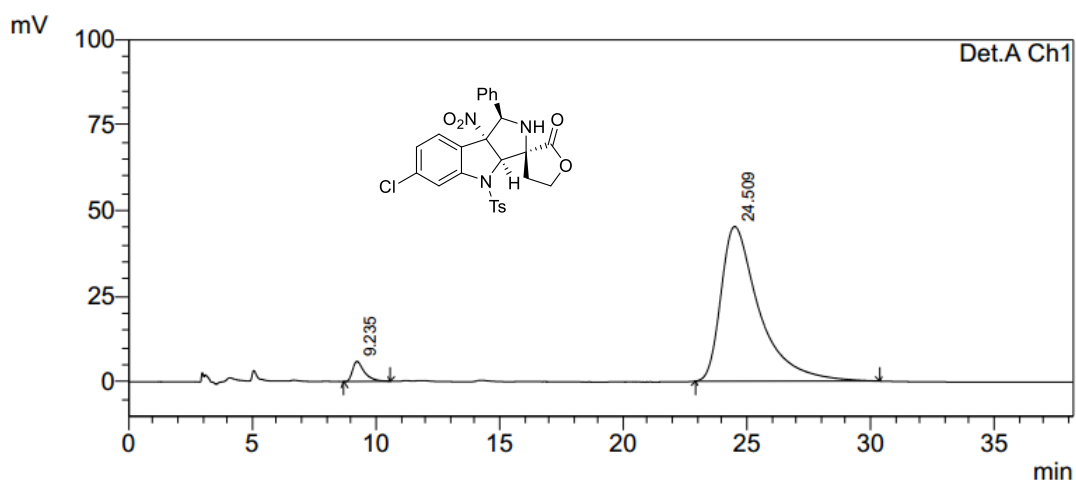


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	9.136	2139465	66667	50.197
2	23.566	2122697	21718	49.803
Total		4262162		100.000



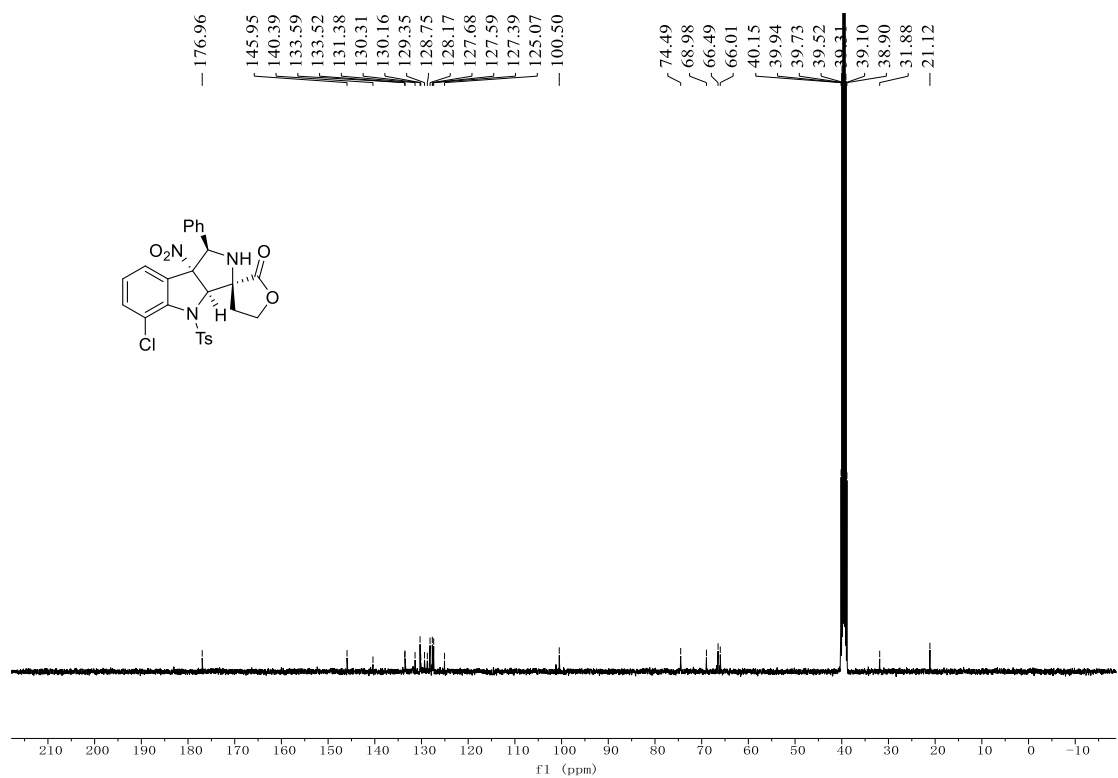
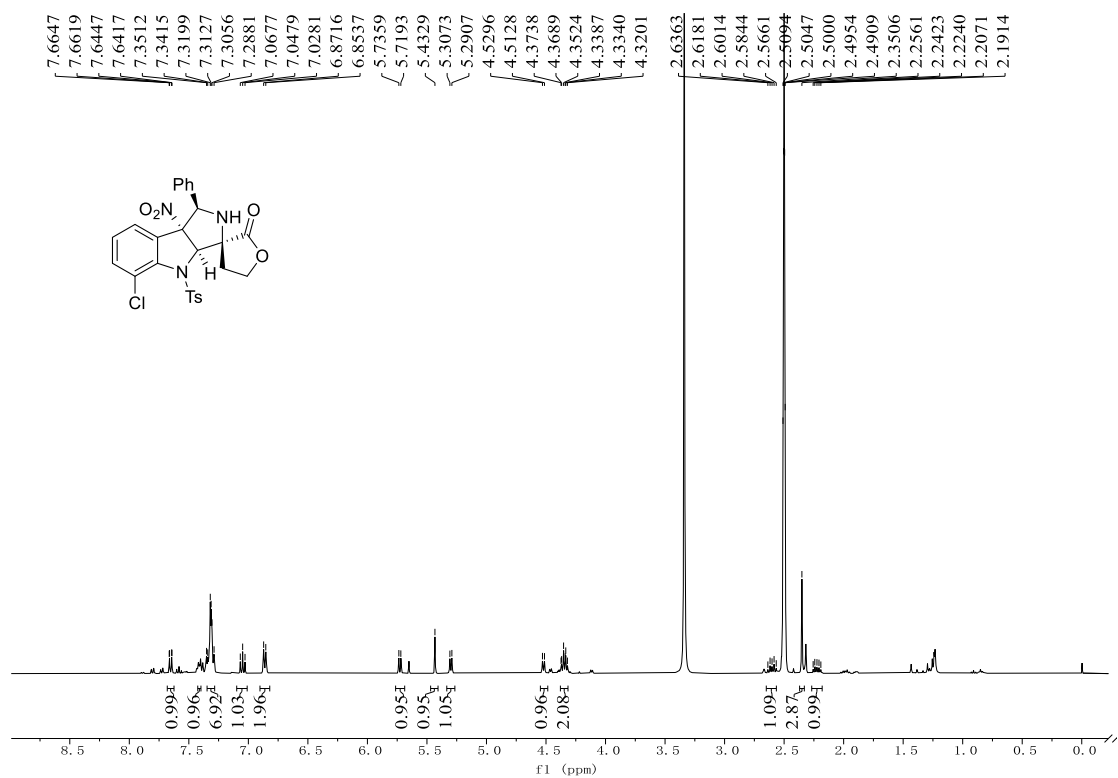
1 Det.A Ch1/254nm

PeakTable

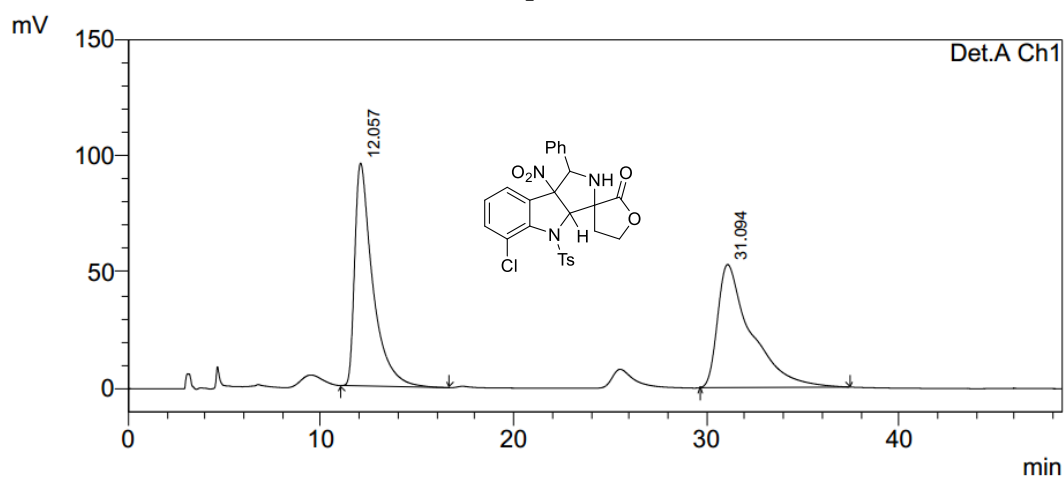
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	9.235	197435	5885	3.892
2	24.509	4875199	45129	96.108
Total		5072634		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ ) of 3h**



# HPLC spectra of 3h

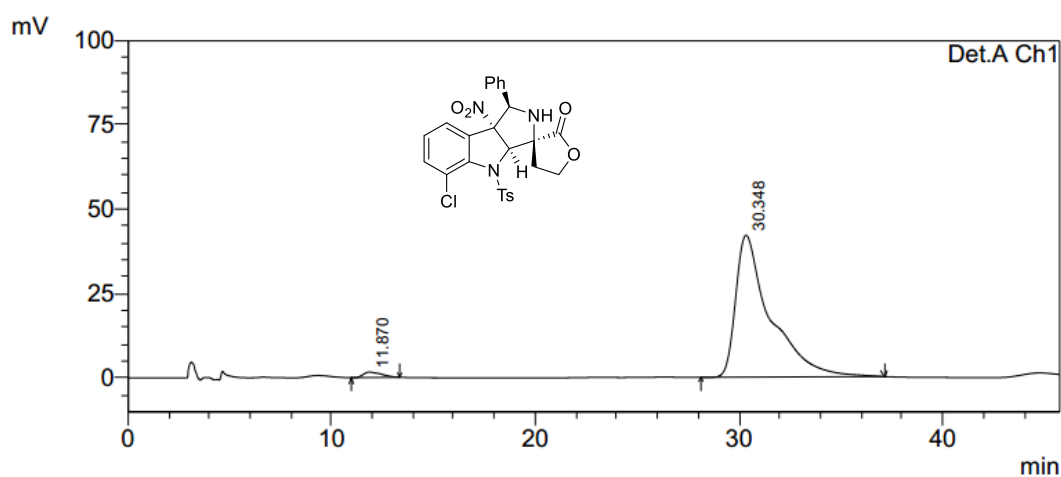


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	12.057	6189274	95583	49.261
2	31.094	6374966	52778	50.739
Total		12564239		100.000



1 Det.A Ch1/254nm

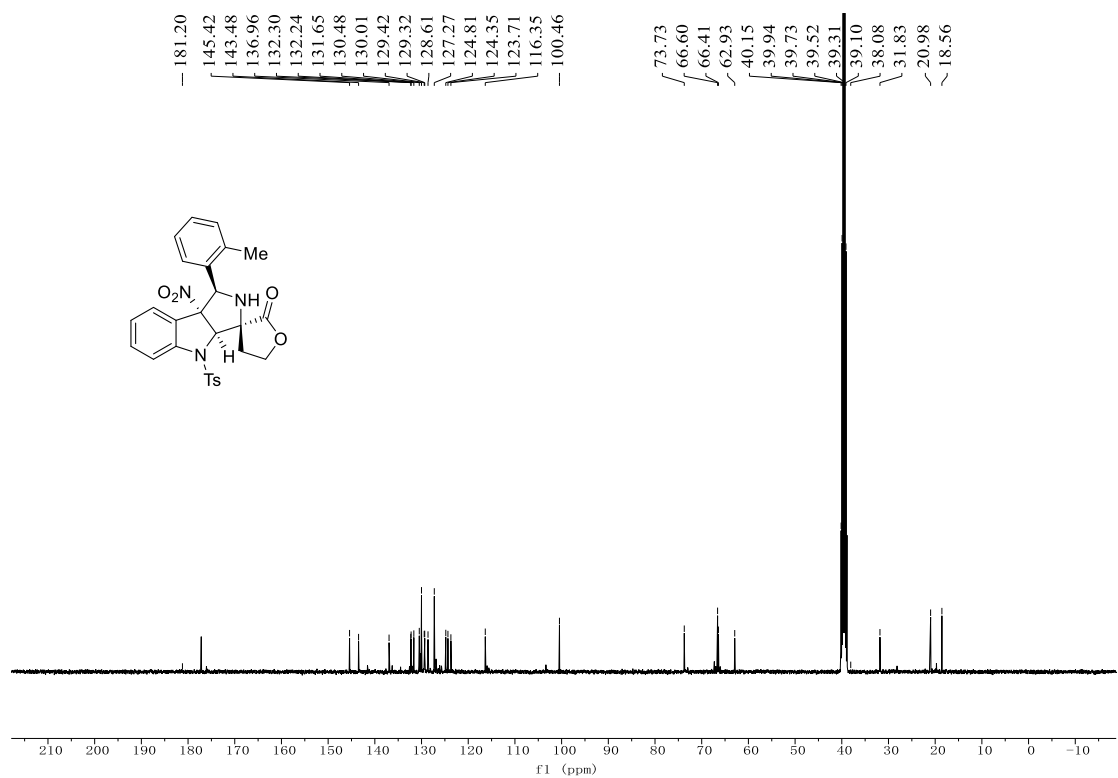
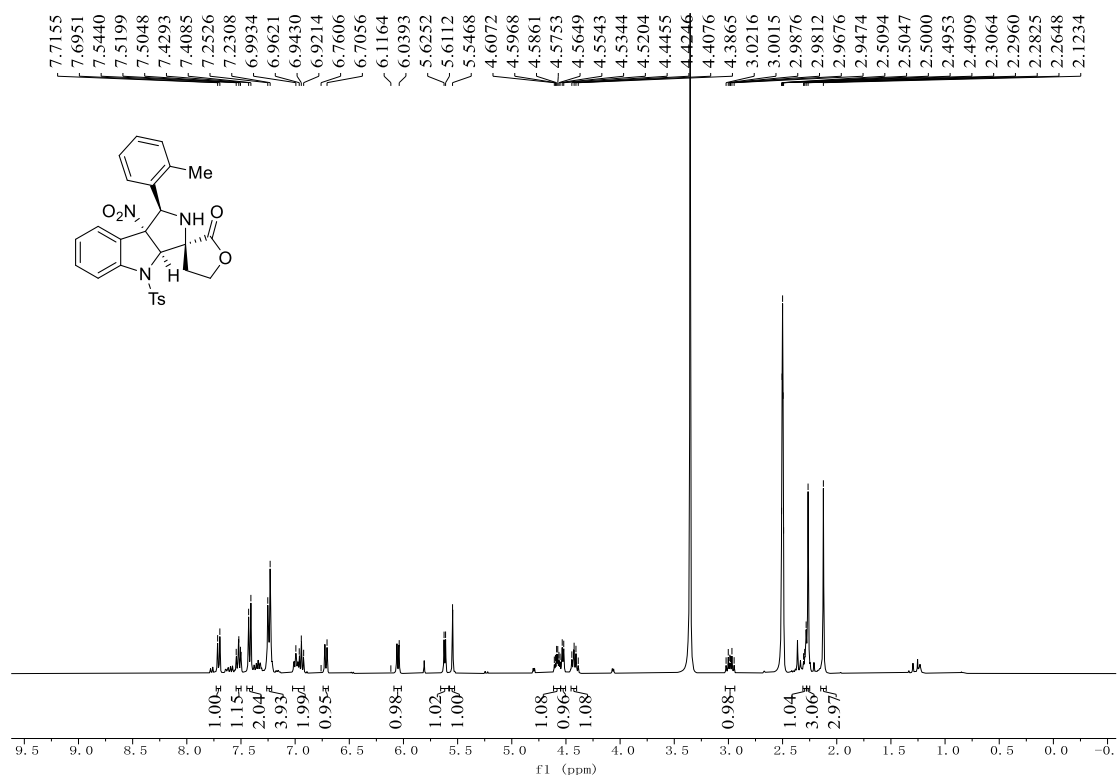
PeakTable

Detector A Ch1 254nm

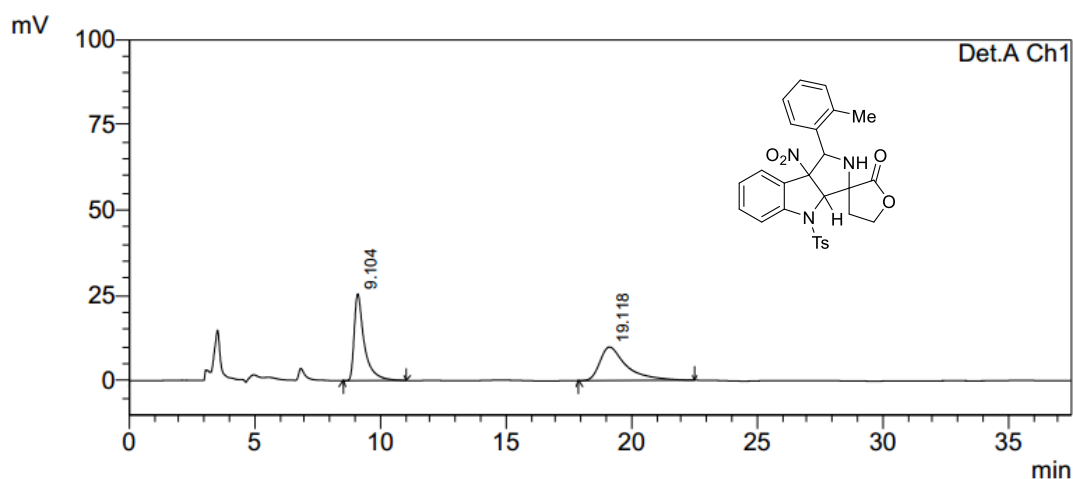
Peak#	Ret. Time	Area	Height	Area %
1	11.870	99525	1607	1.962
2	30.348	4973741	42034	98.038
Total		5073266		100.000



**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ ) of 3i**



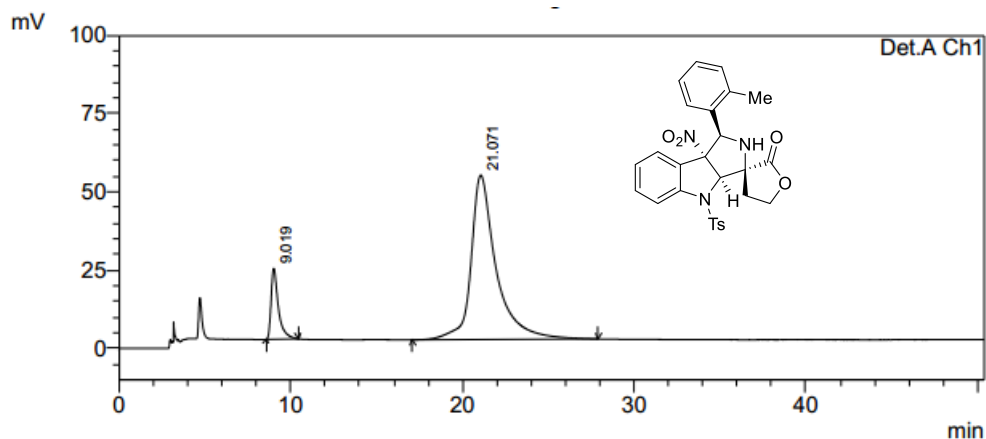
# HPLC spectra of 3i



1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm				
Peak#	Ret. Time	Area	Height	Area %
1	9.104	711498	25428	49.721
2	19.118	719476	9815	50.279
Total		1430974		100.000

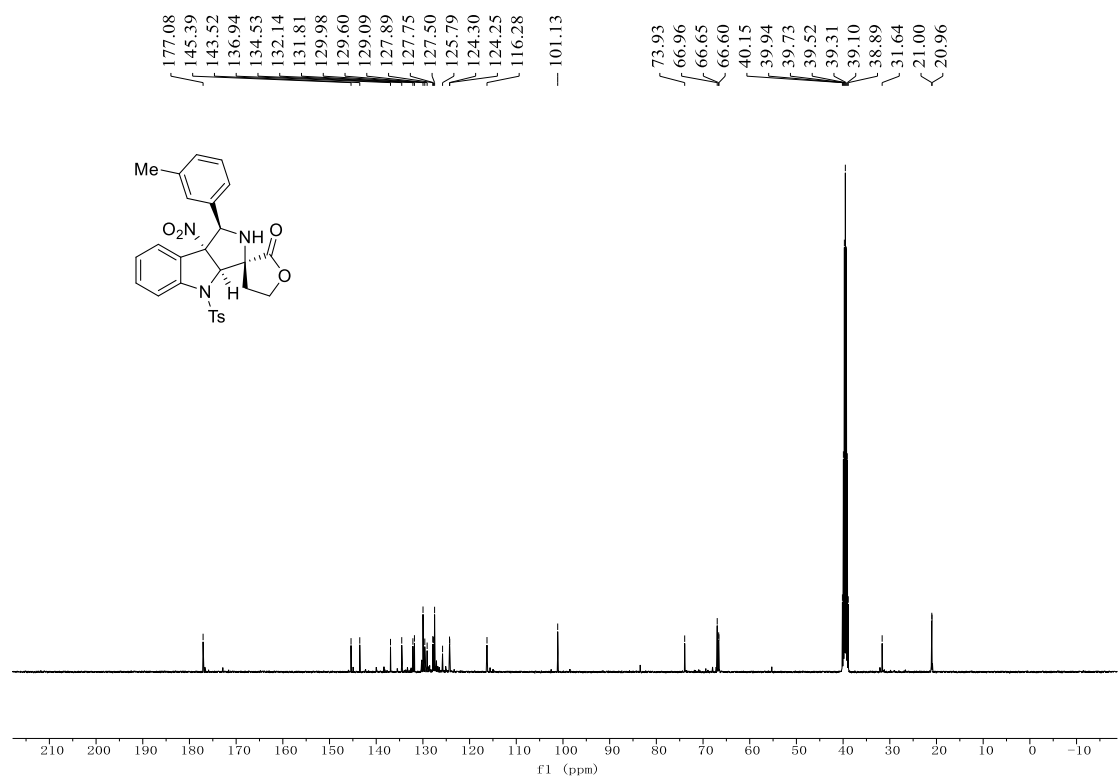
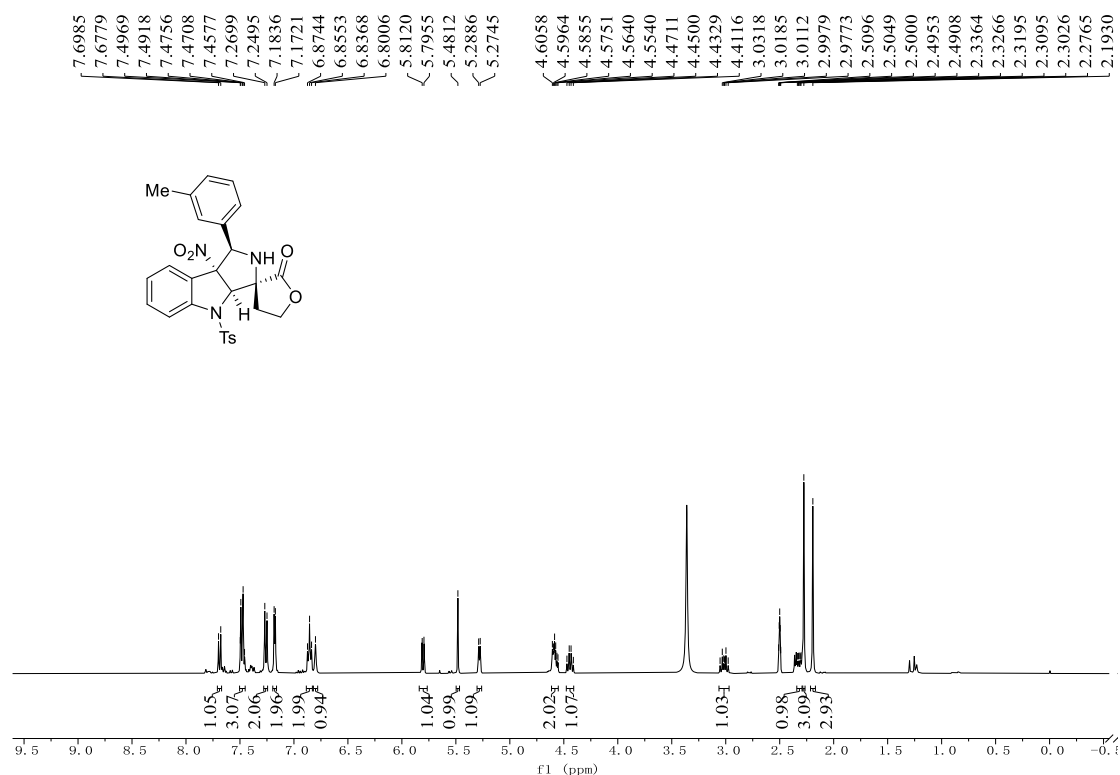


1 Det.A Ch1/254nm

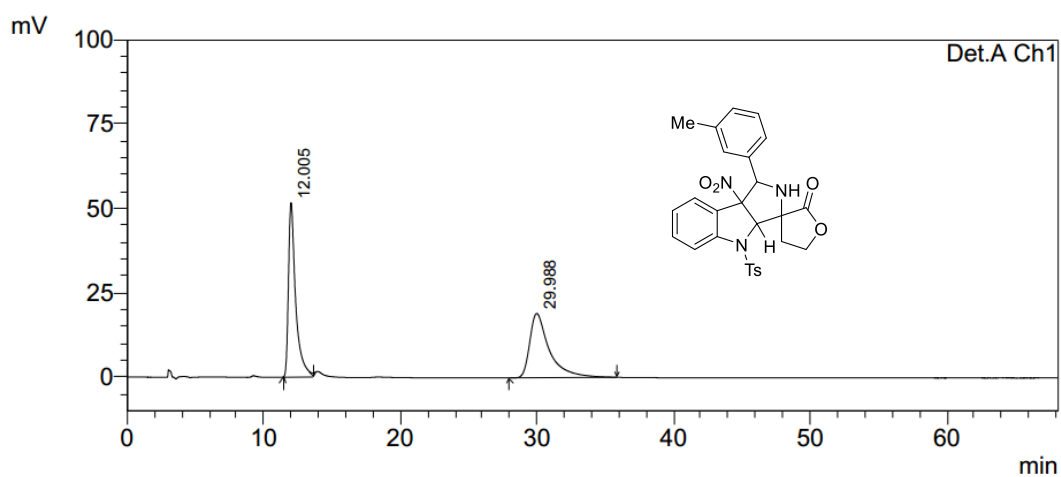
PeakTable

Detector A Ch1 254nm				
Peak#	Ret. Time	Area	Height	Area %
1	9.019	668440	22664	11.091
2	21.071	5358264	52426	88.909
Total		6026704		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ ) of 3j**



# HPLC spectra of 3j

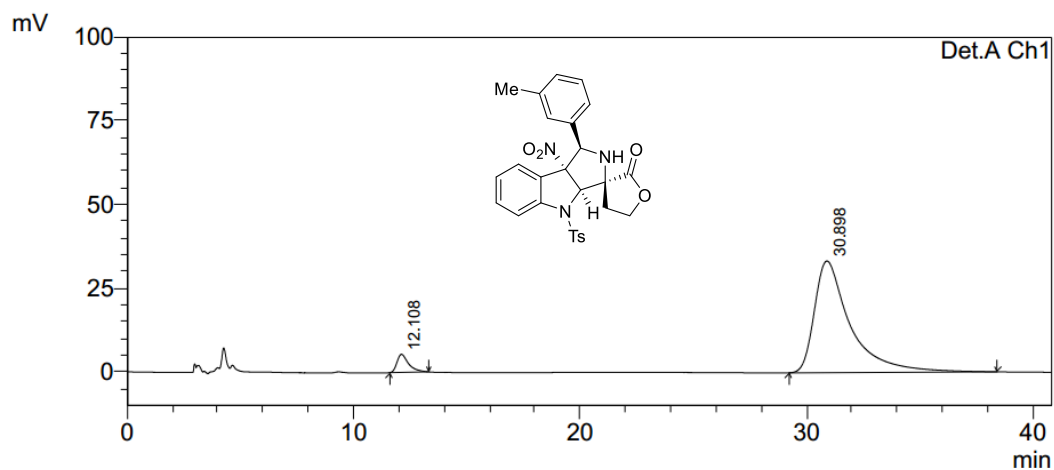


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	12.005	1897125	51641	50.041
2	29.988	1894024	19032	49.959
Total		3791149		100.000



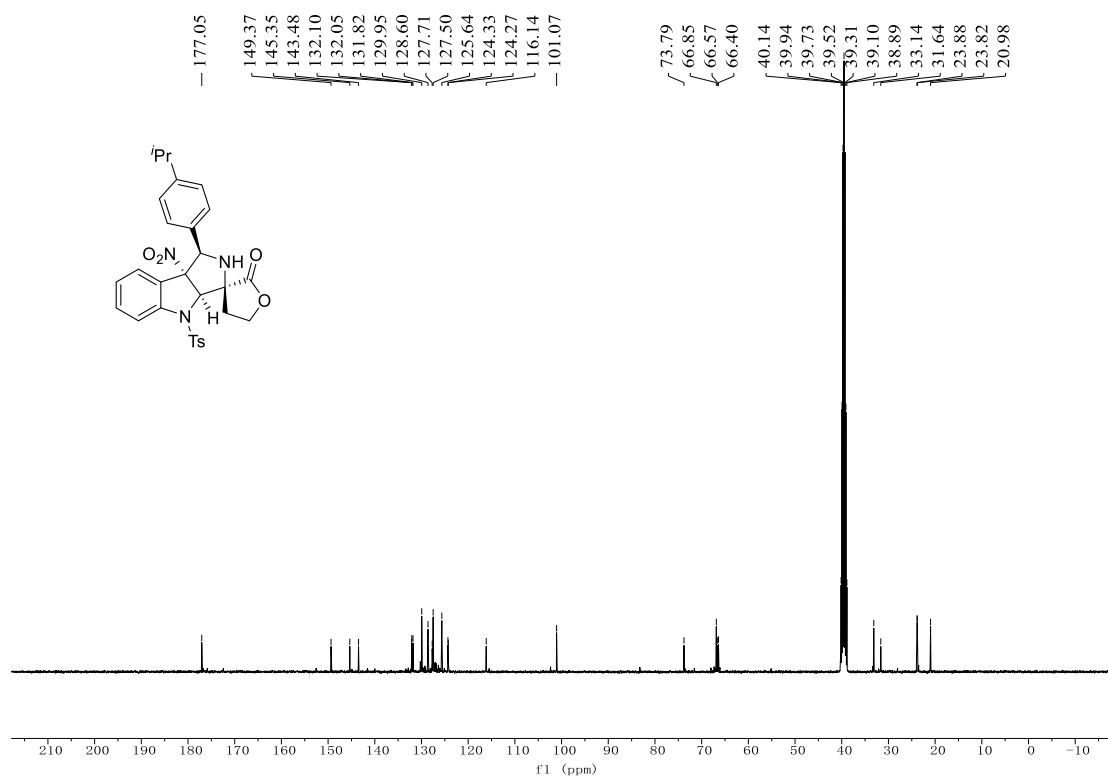
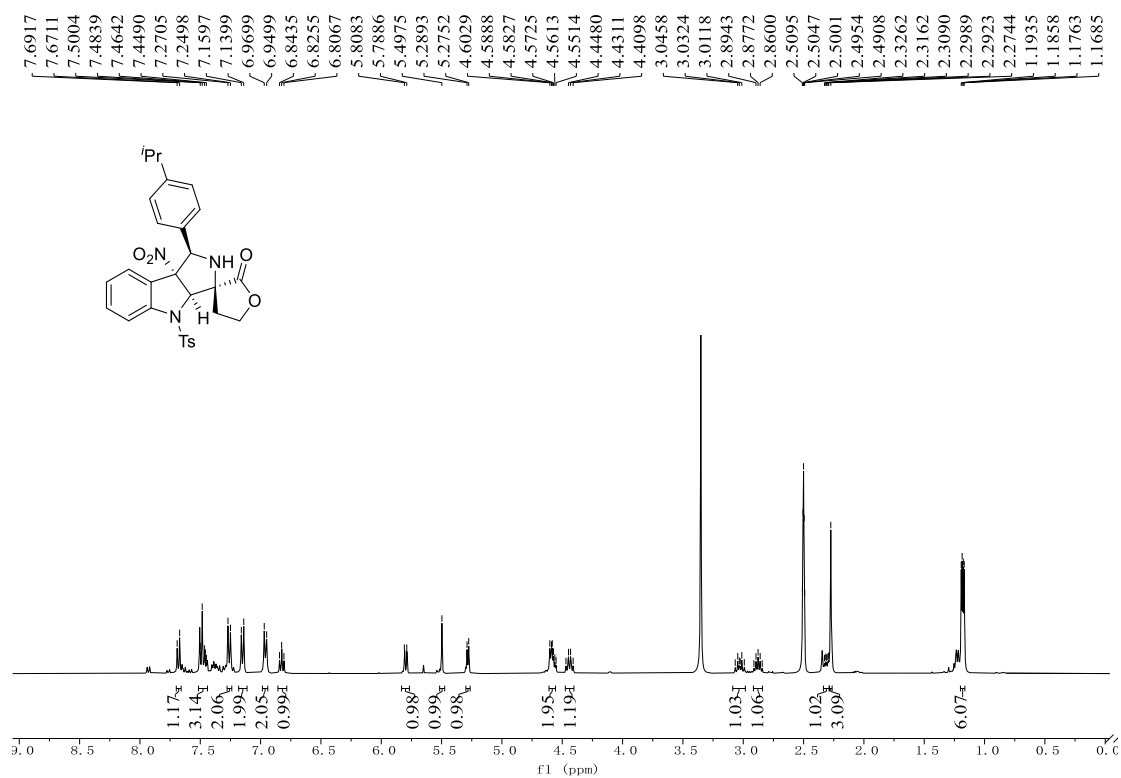
1 Det.A Ch1/254nm

PeakTable

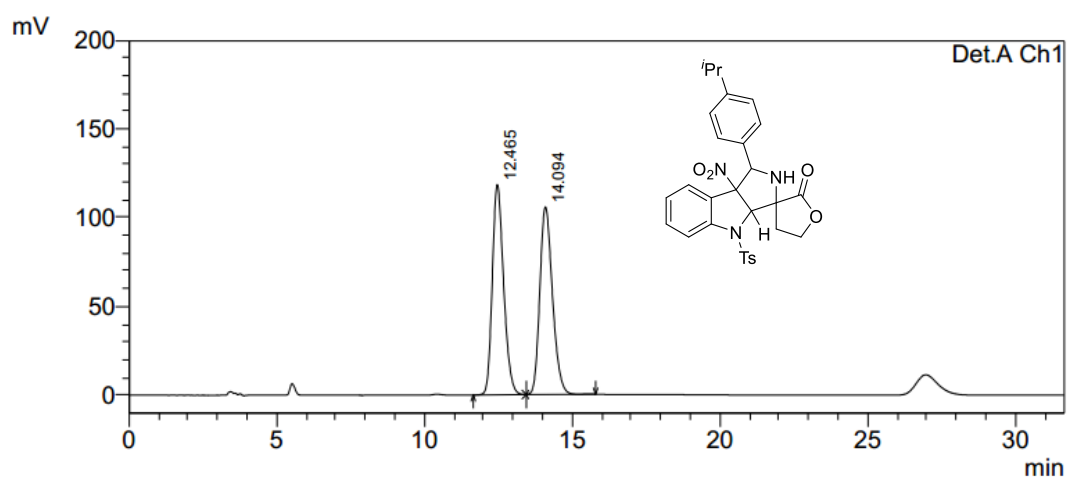
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	12.108	194276	5420	5.024
2	30.898	3672663	33306	94.976
Total		3866938		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-}d_6$ ) of 3k**



# HPLC spectra of 3k

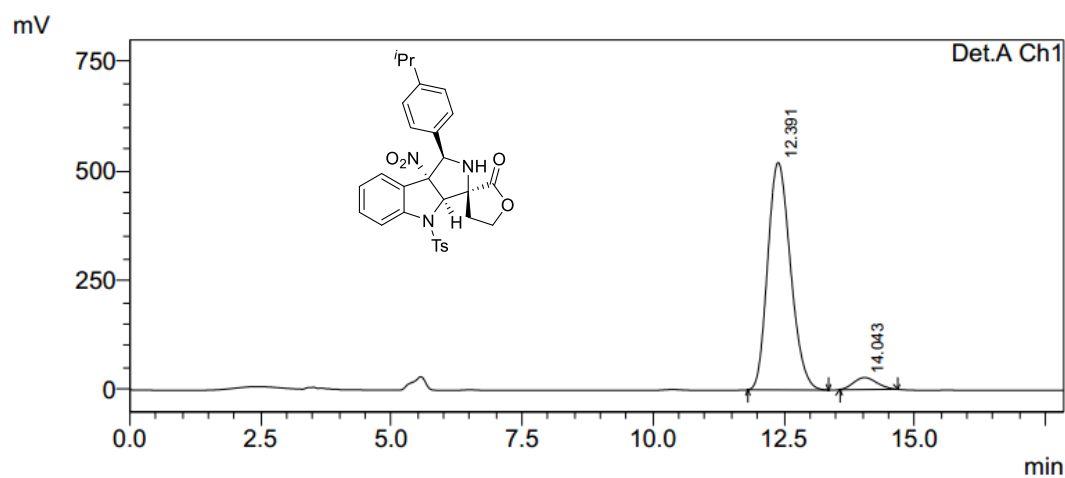


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	12.465	3155874	118369	50.061
2	14.094	3148129	105744	49.939
Total		6304002		100.000



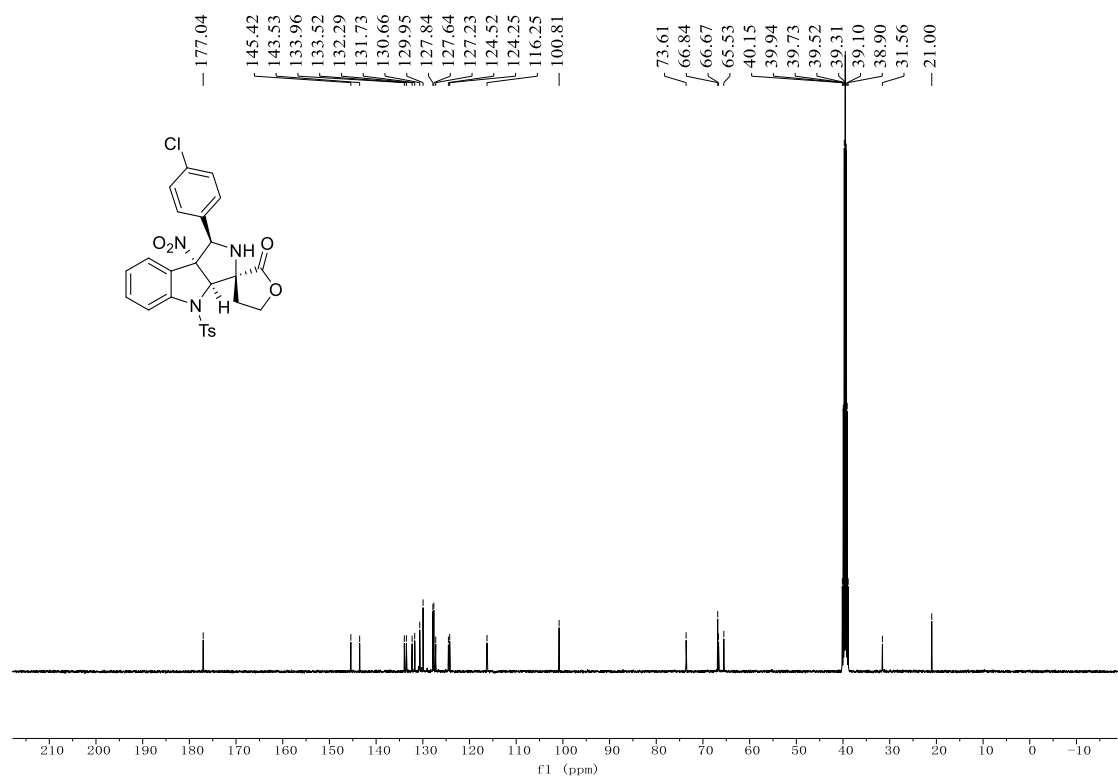
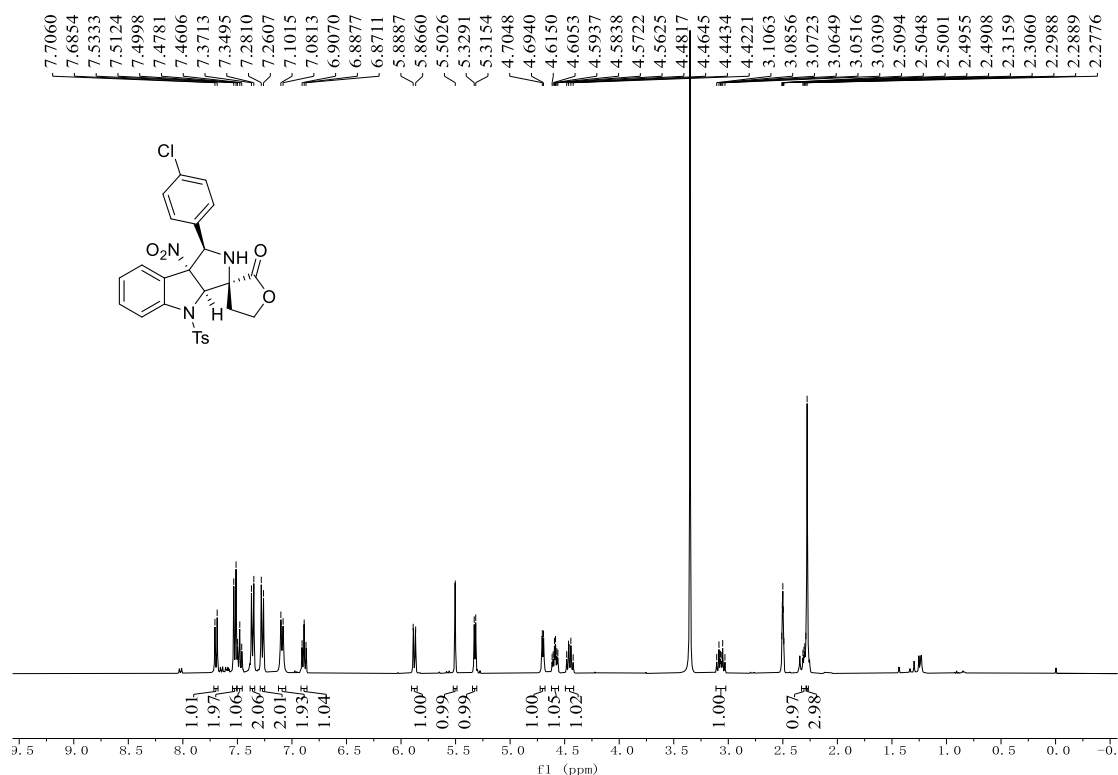
1 Det.A Ch1/254nm

PeakTable

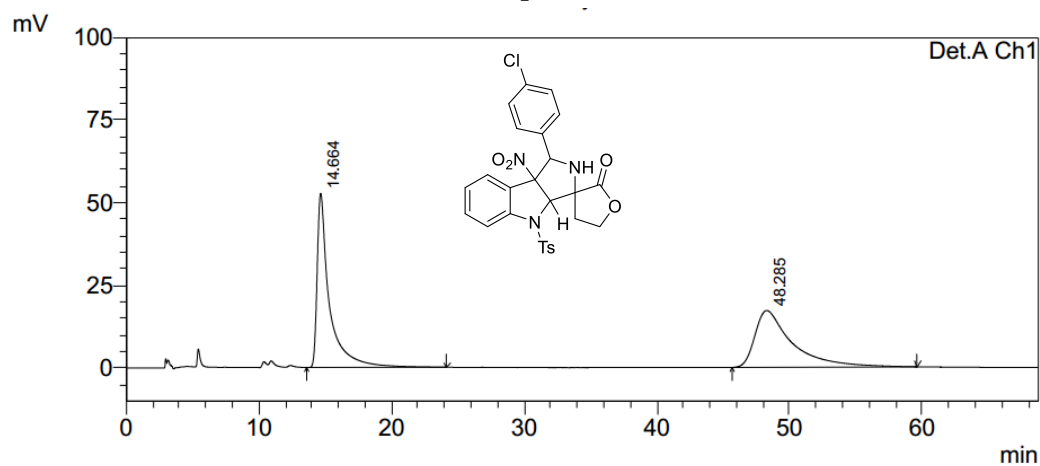
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	12.391	15719711	518659	94.942
2	14.043	837408	27133	5.058
Total		16557120		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ ) of 3l**



# HPLC spectra of 3l

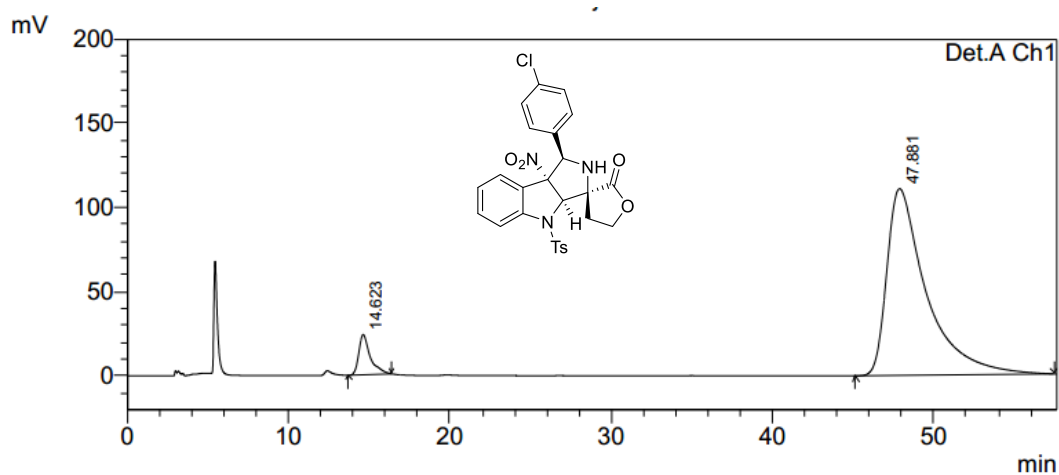


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	14.664	3396511	52588	50.343
2	48.285	3350258	17127	49.657
Total		6746769		100.000



1 Det.A Ch1/254nm

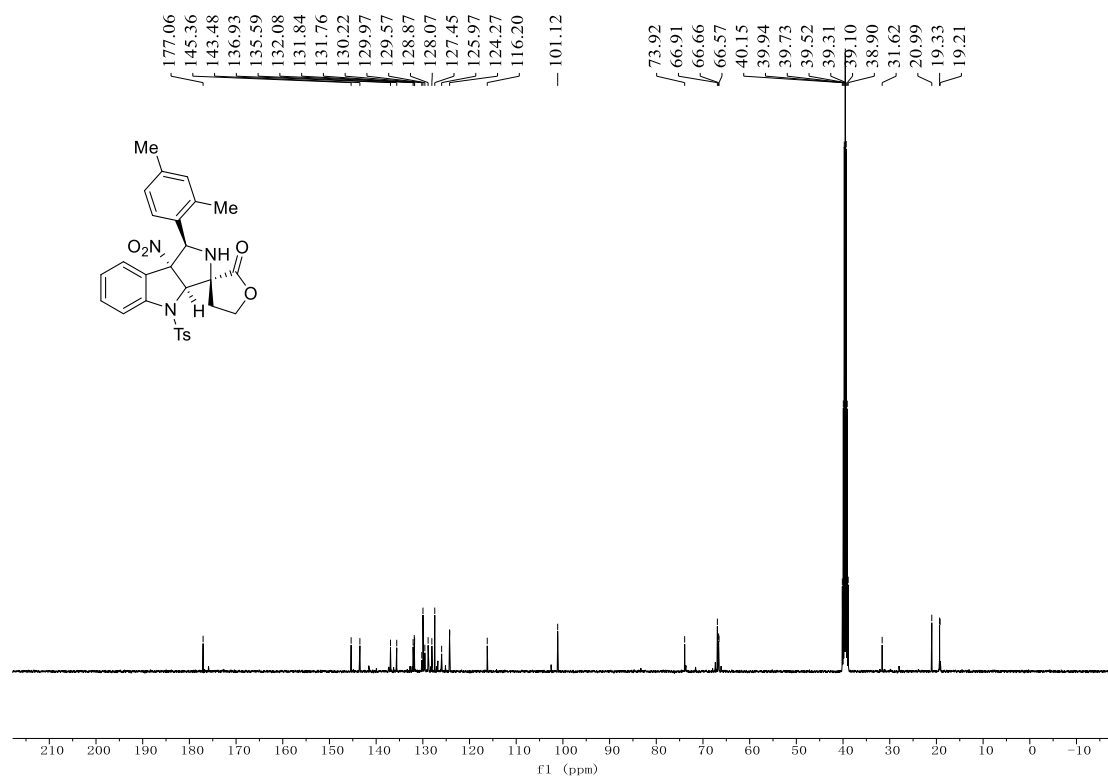
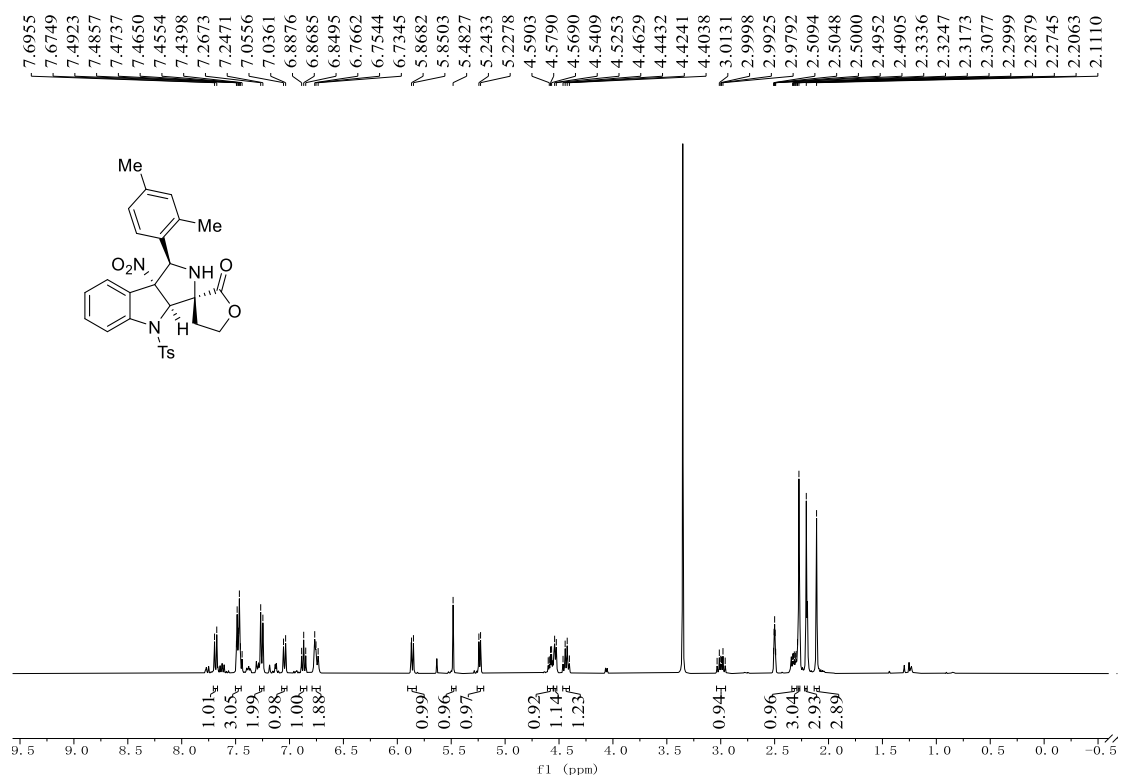
PeakTable

Detector A Ch1 254nm

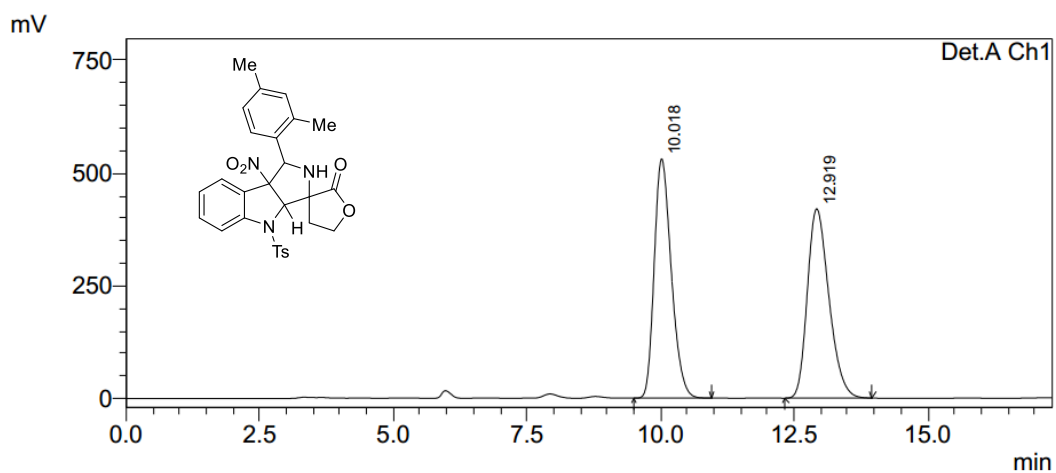
Peak#	Ret. Time	Area	Height	Area %
1	14.623	1182802	23923	5.908
2	47.881	18837911	110717	94.092
Total		20020712		100.000



**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-}d_6$ ) of 3m**



# HPLC spectra of 3m

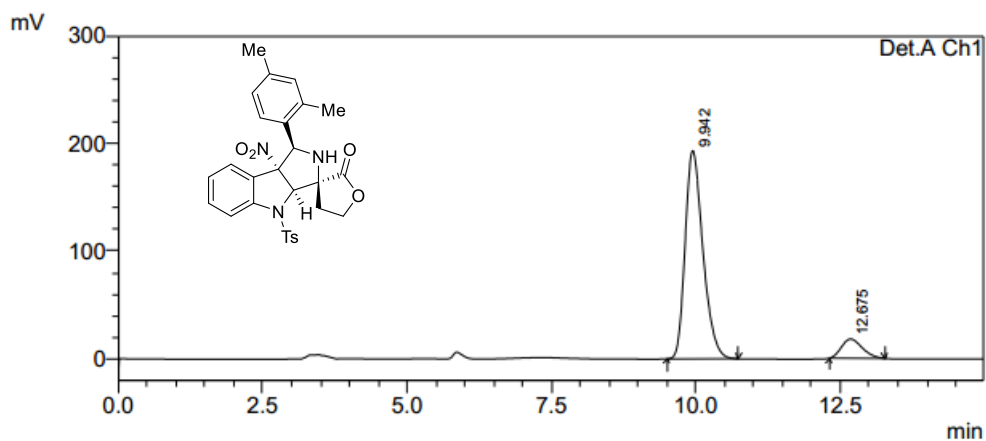


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	10.018	11783053	530770	49.944
2	12.919	11809406	419987	50.056
Total		23592459		100.000



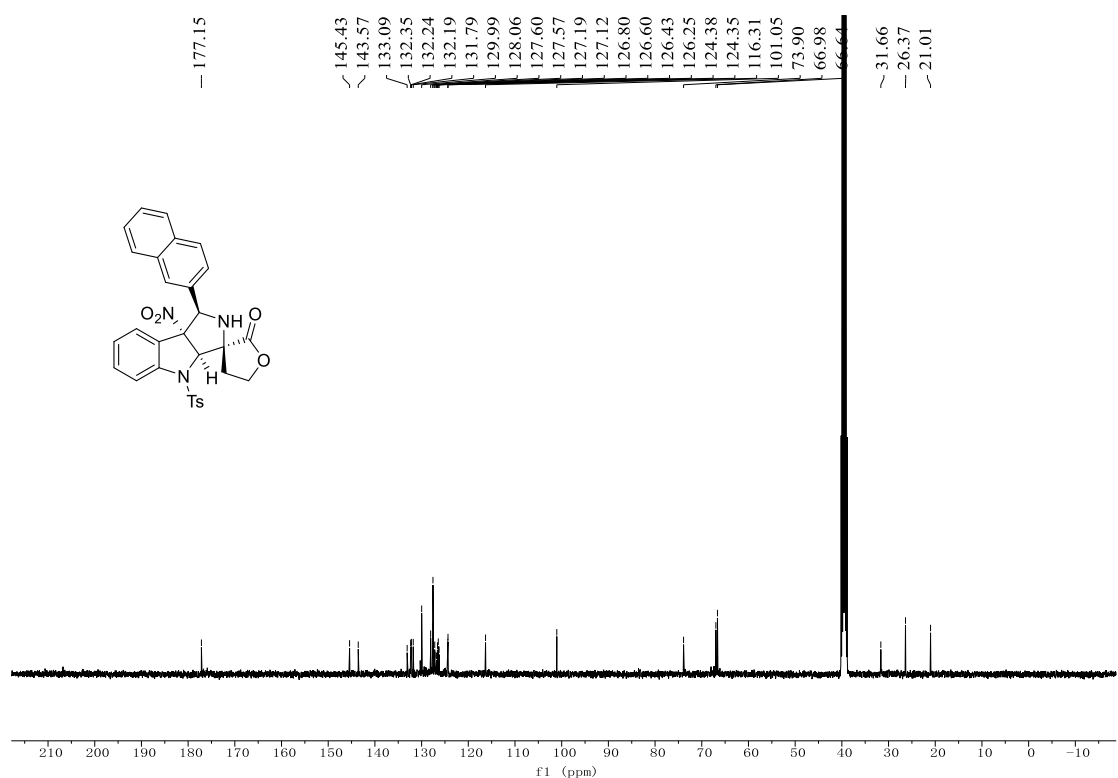
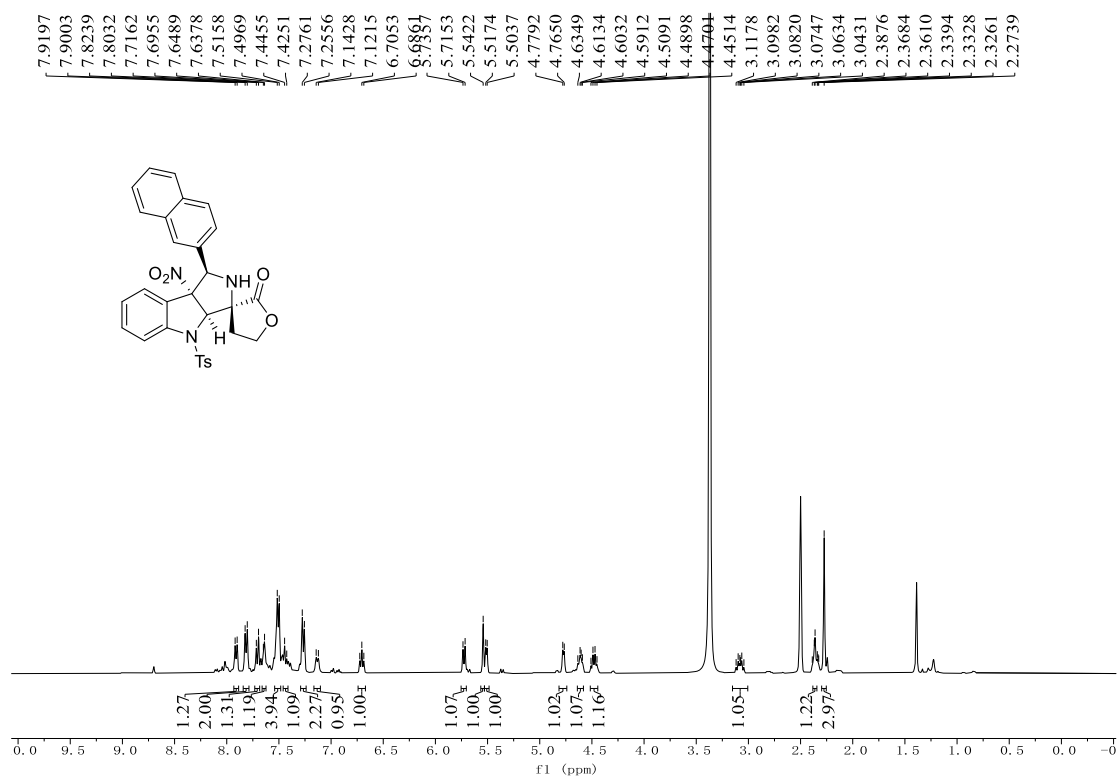
1 Det.A Ch1/254nm

PeakTable

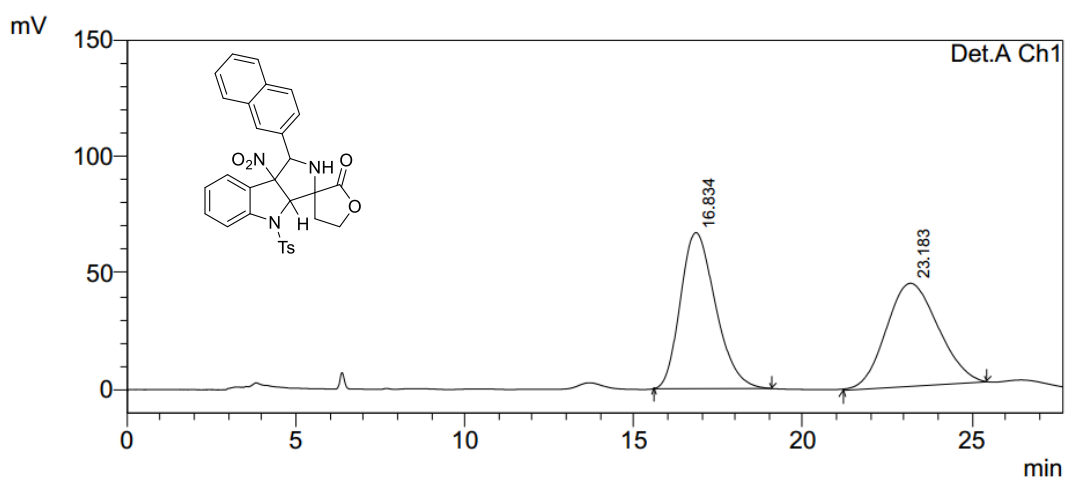
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	9.942	4138827	193173	90.233
2	12.675	448019	17857	9.767
Total		4586845		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ ) of 3n**



# HPLC spectra of 3n

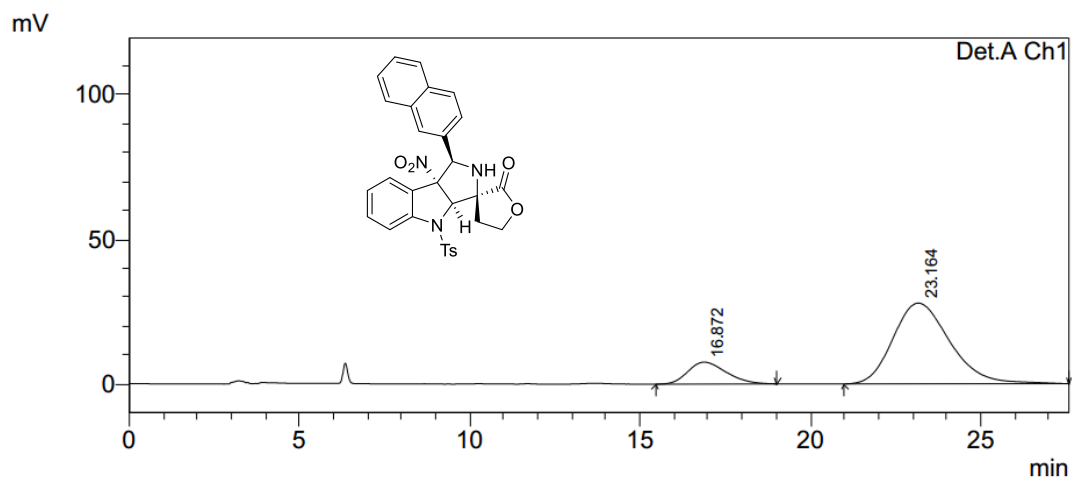


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	16.834	4847732	66825	50.576
2	23.183	4737280	44168	49.424
Total		9585012		100.000



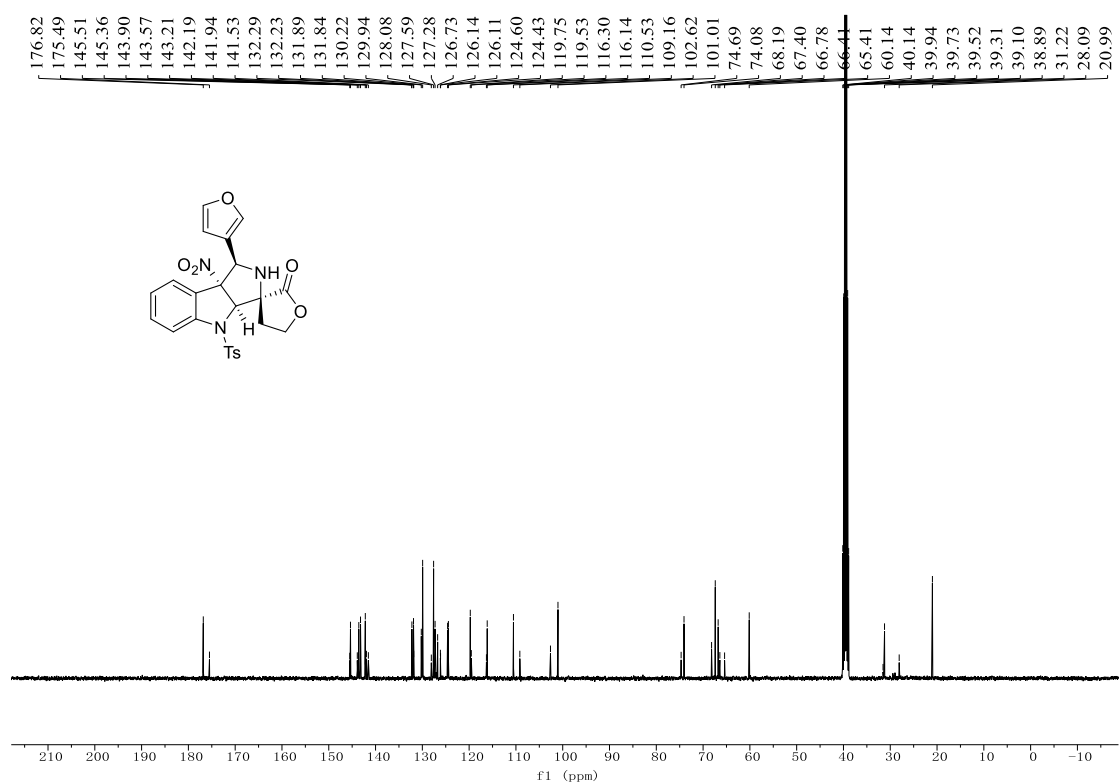
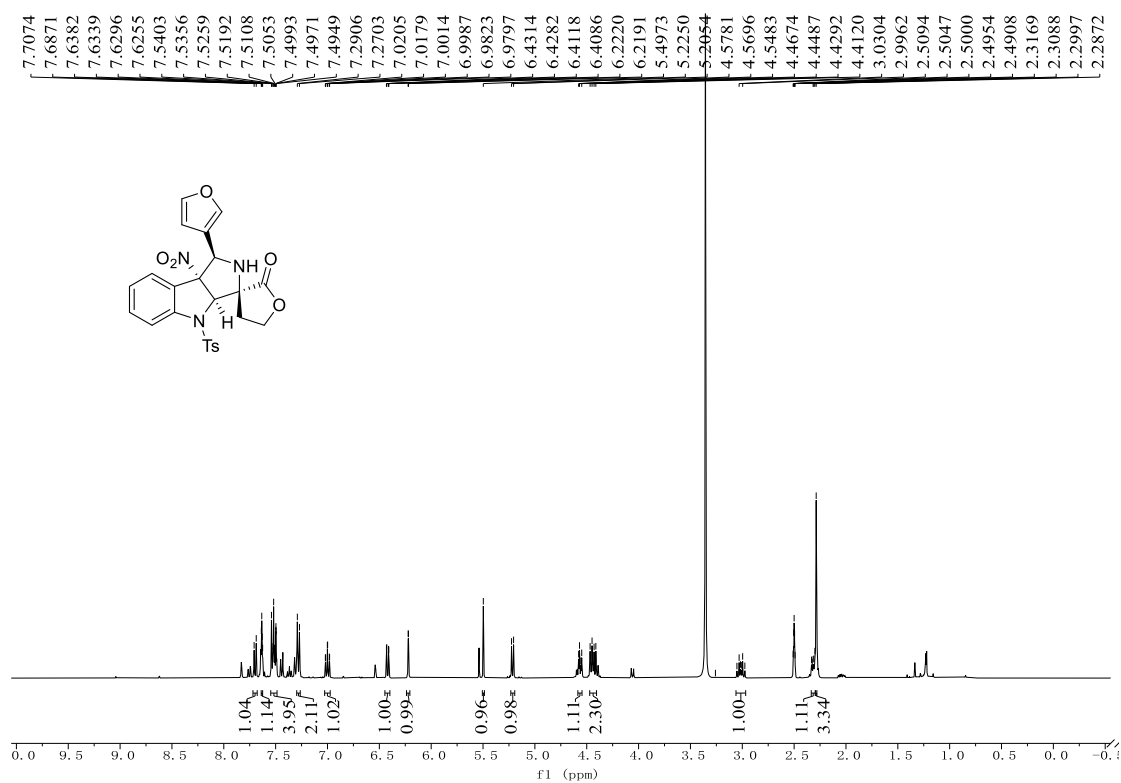
1 Det.A Ch1/254nm

PeakTable

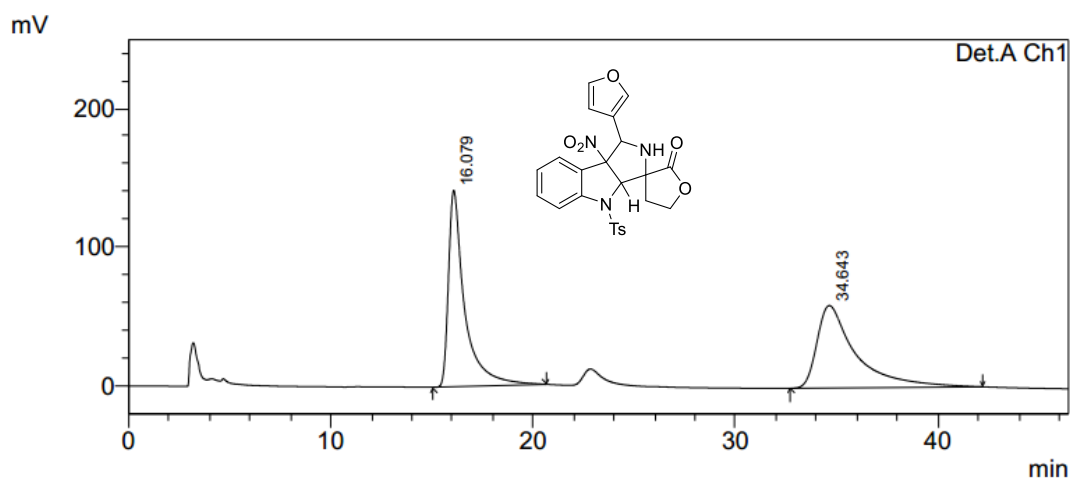
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	16.872	592993	7578	15.449
2	23.164	3245321	27962	84.551
Total		3838315		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-}d_6$ ) of **3o****



# HPLC spectra of 3o

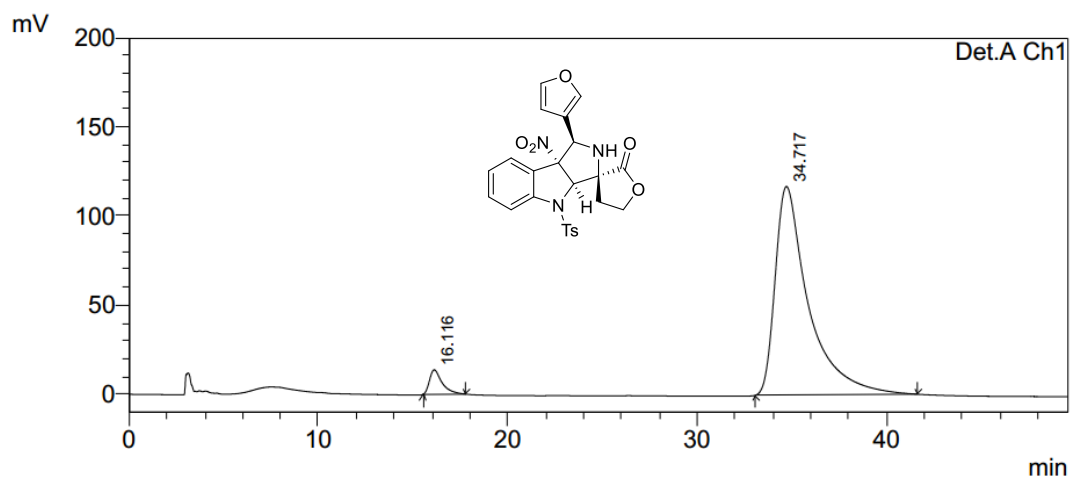


1 Det.A Ch1/220nm

PeakTable

Detector A Ch1 220nm

Peak#	Ret. Time	Area	Height	Area %
1	16.079	7884641	141286	49.830
2	34.643	7938419	59360	50.170
Total		15823060		100.000



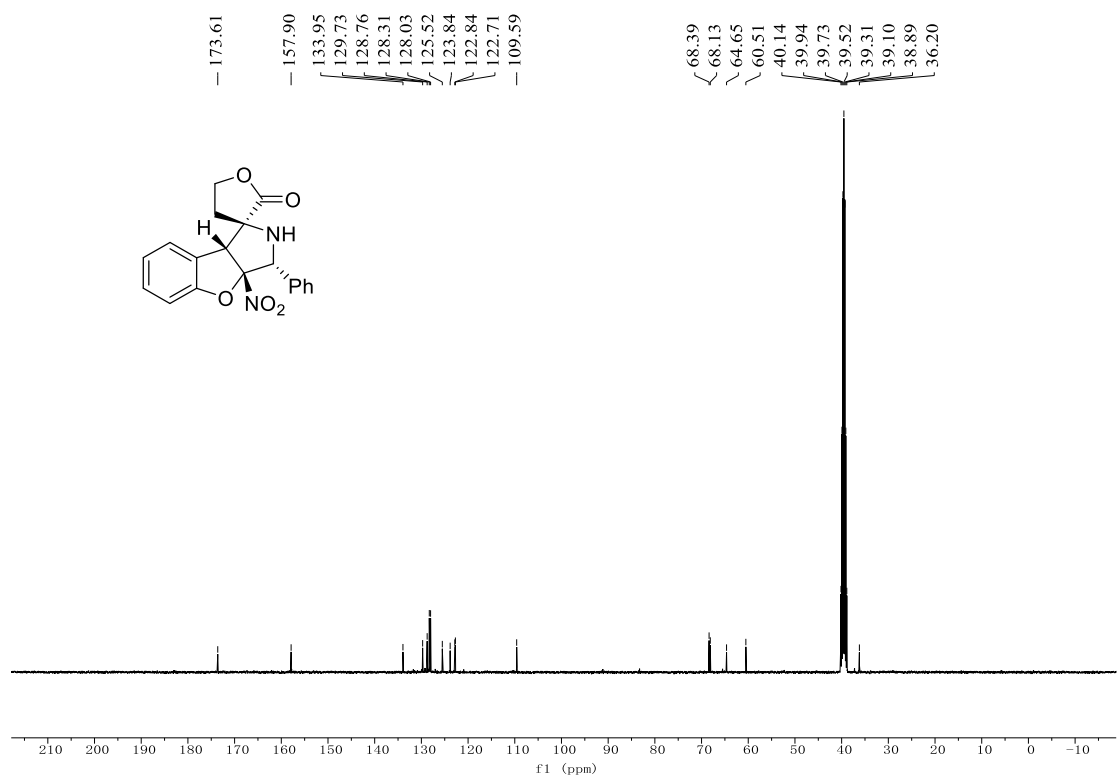
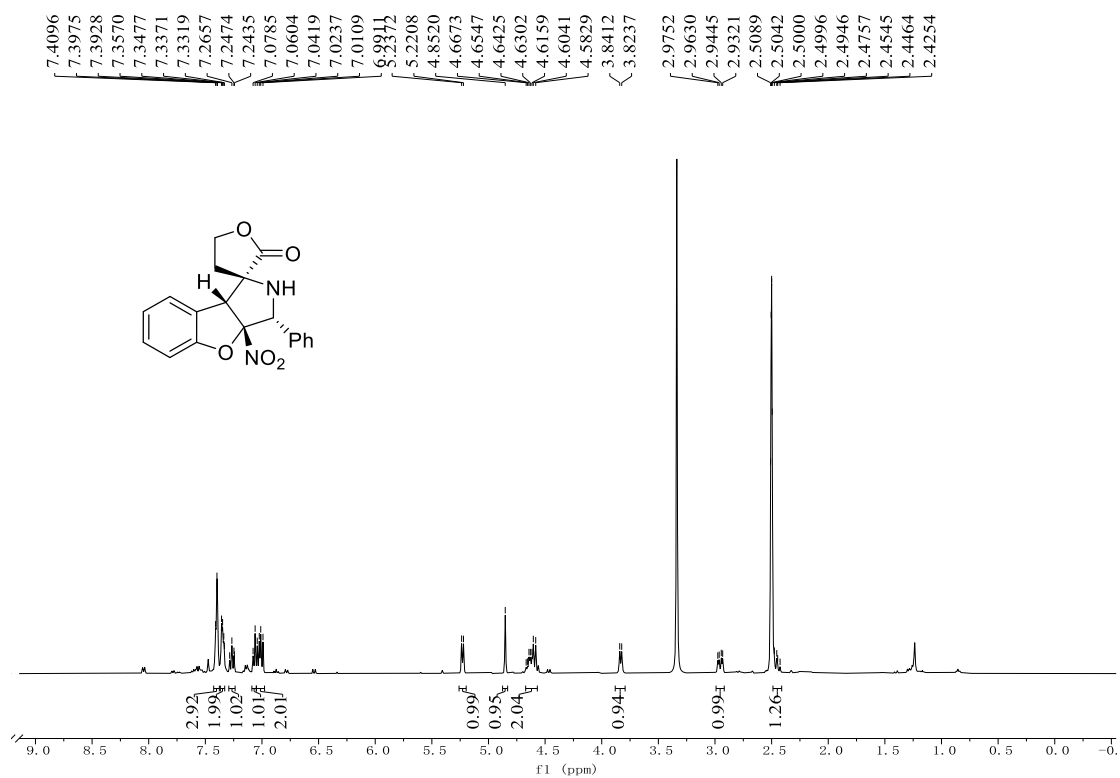
1 Det.A Ch1/220nm

PeakTable

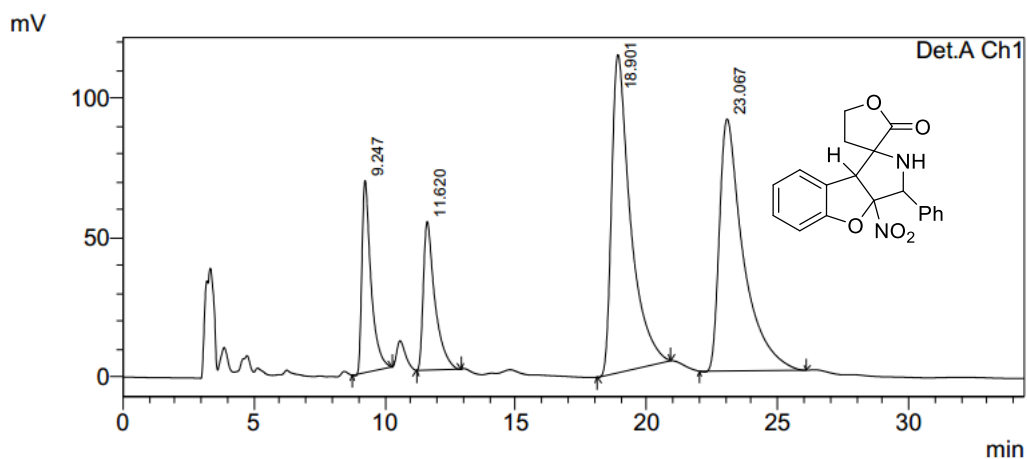
Detector A Ch1 220nm

Peak#	Ret. Time	Area	Height	Area %
1	16.116	644937	13822	4.320
2	34.717	14284340	116887	95.680
Total		14929277		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ ) of 5a**



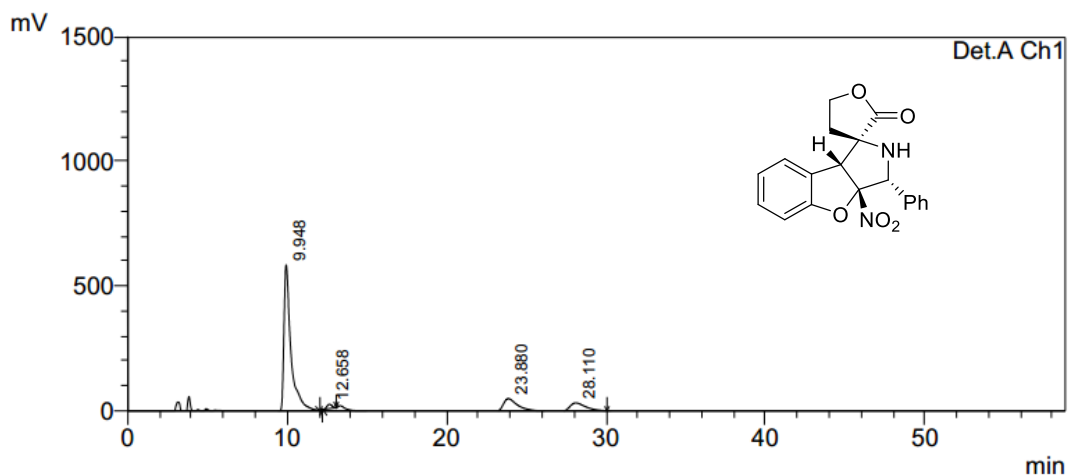
# HPLC spectra of 5a



PeakTable

Detector A Ch1 220nm

Peak#	Ret. Time	Area	Height	Area %
1	9.247	1666777	69011	11.276
2	11.620	1636389	53384	11.070
3	18.901	5738022	114193	38.818
4	23.067	5740620	90490	38.836
Total		14781808		100.000



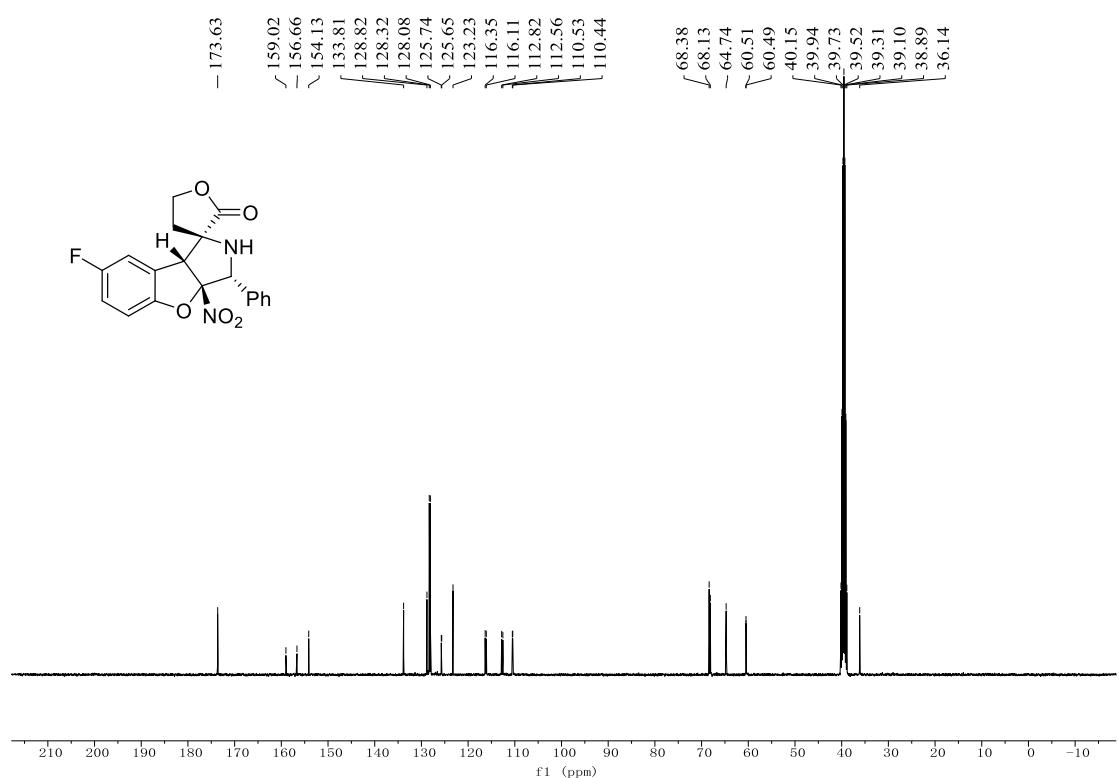
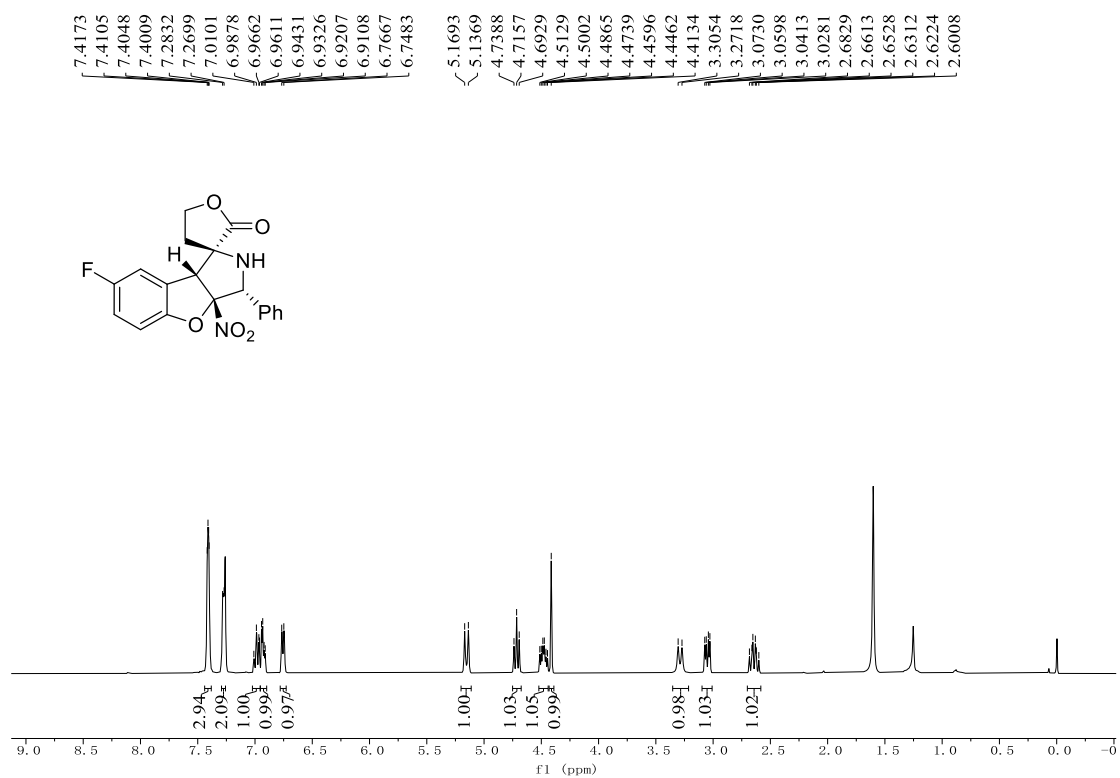
PeakTable

Detector A Ch1 220nm

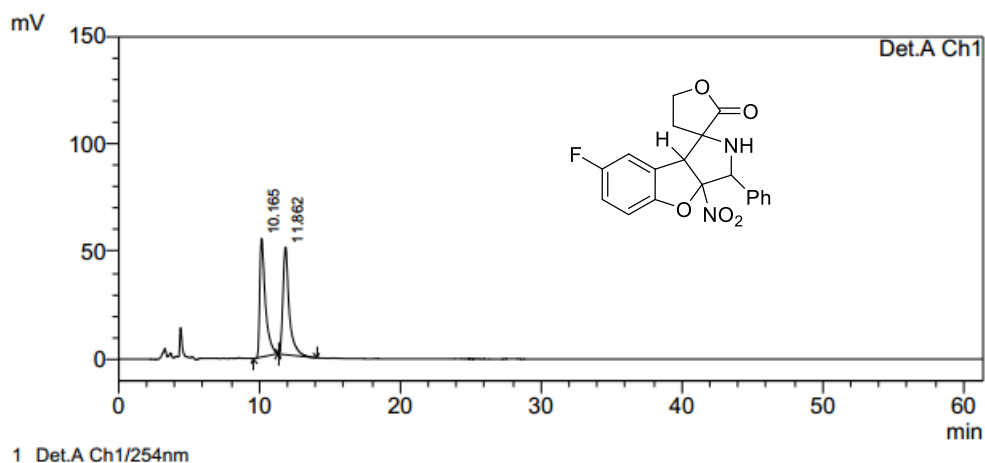
Peak#	Ret. Time	Area	Height	Area %
1	9.948	17986169	585911	74.694
2	12.658	374132	17478	1.554
3	23.880	3349278	52267	13.909
4	28.110	2370149	33695	9.843
Total		24079728		100.000



**$^1\text{H}$  NMR (400 MHz, Chloroform- $d$ ) and  $^{13}\text{C}$  NMR (101 MHz, DMSO- $d_6$ ) of 5b**



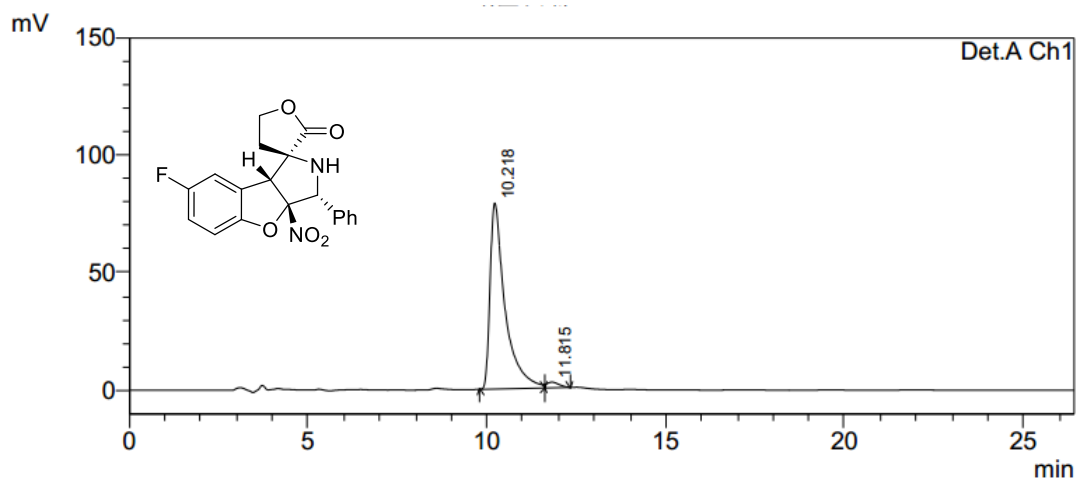
# HPLC spectra of 5b



PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	10.165	1525355	55085	49.631
2	11.862	1548020	49958	50.369
Total		3073375		100.000

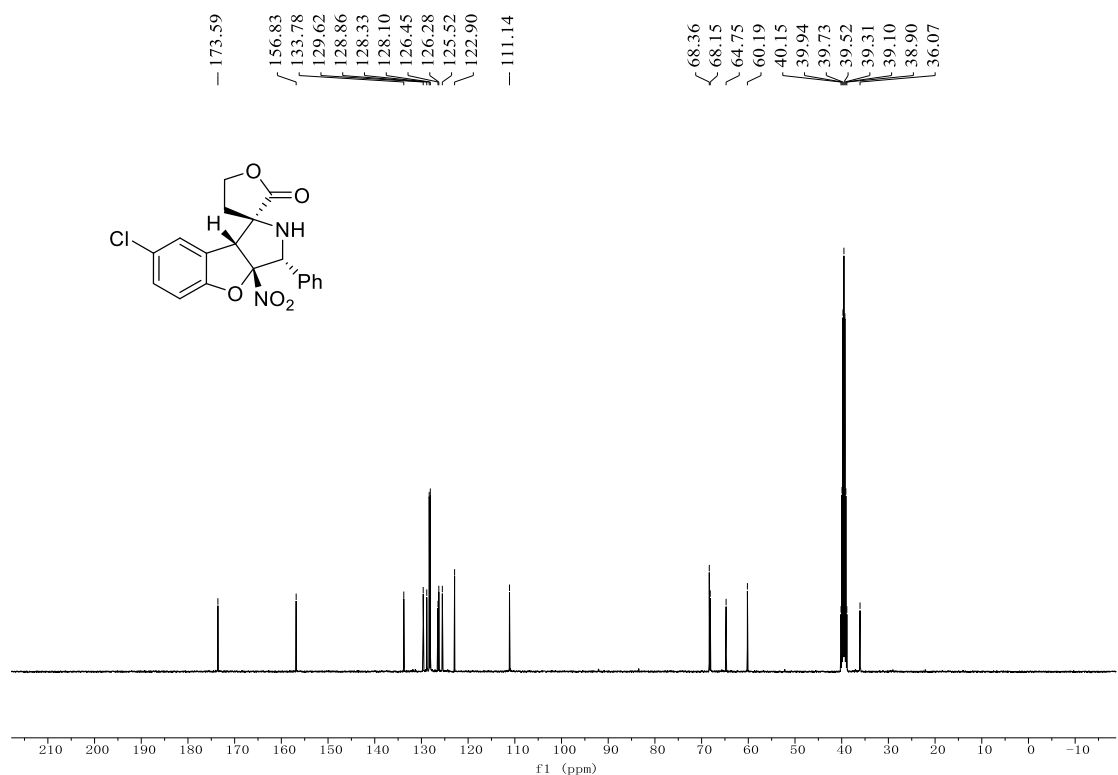
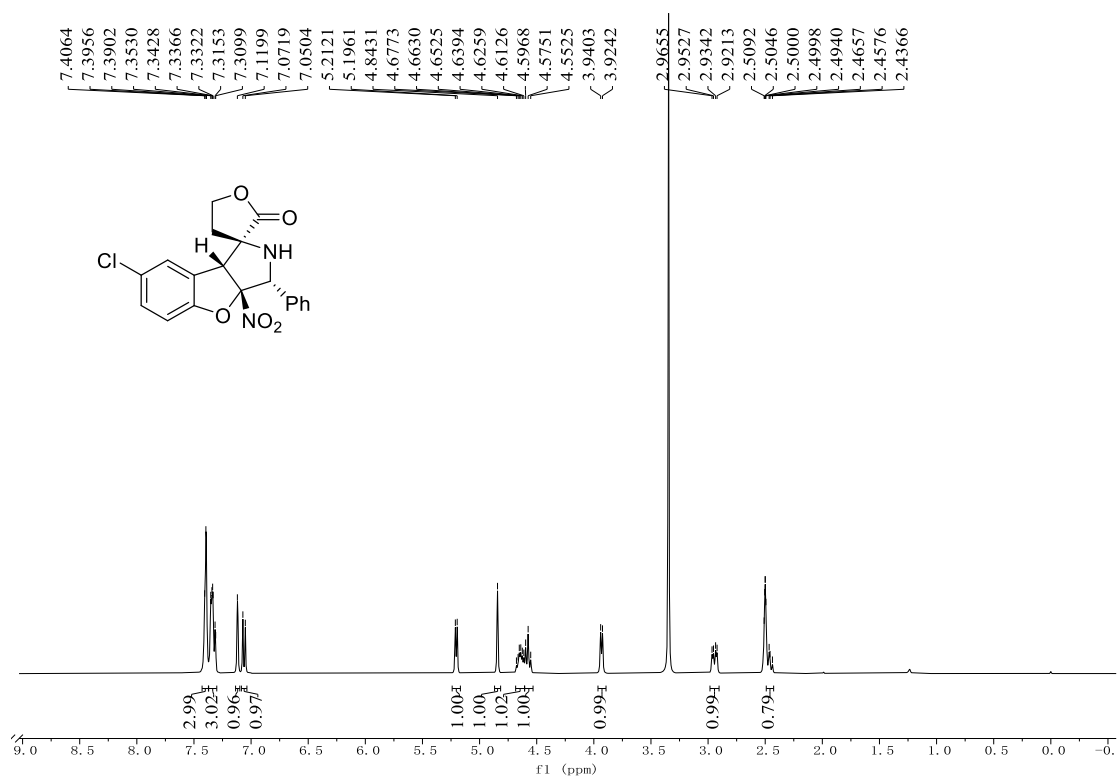


PeakTable

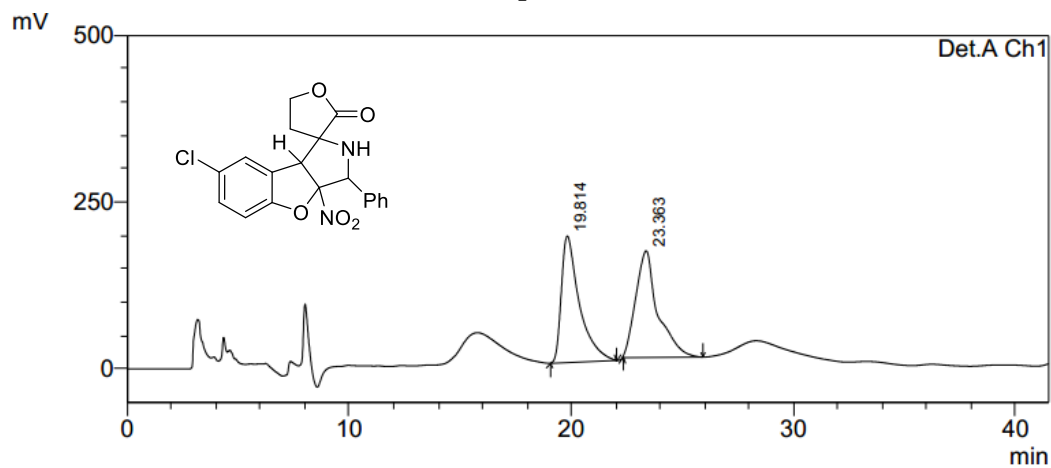
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	10.218	2305886	79013	97.469
2	11.815	59875	2411	2.531
Total		2365761		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ ) of **5c****



# HPLC spectra of 5c

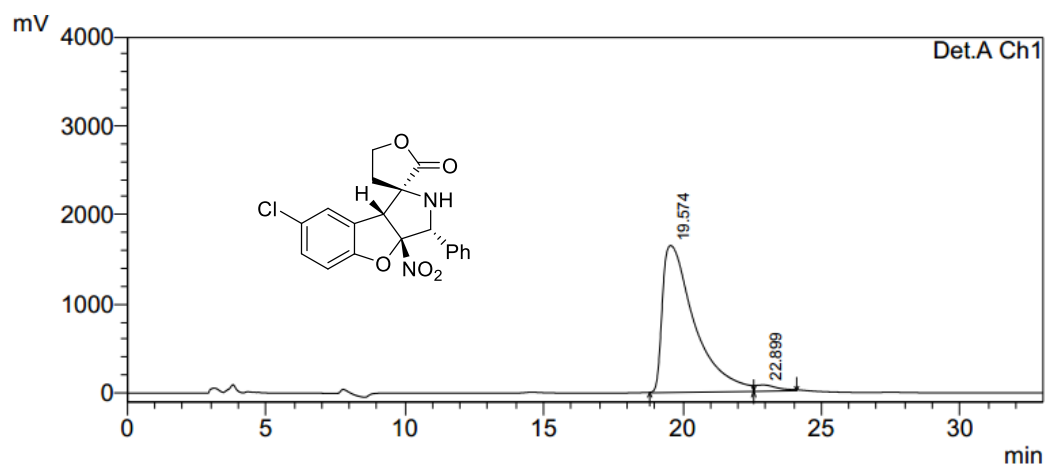


1 Det.A Ch1/220nm

PeakTable

Detector A Ch1 220nm

Peak#	Ret. Time	Area	Height	Area %
1	19.814	10708569	189445	49.268
2	23.363	11026718	159489	50.732
Total		21735287		100.000



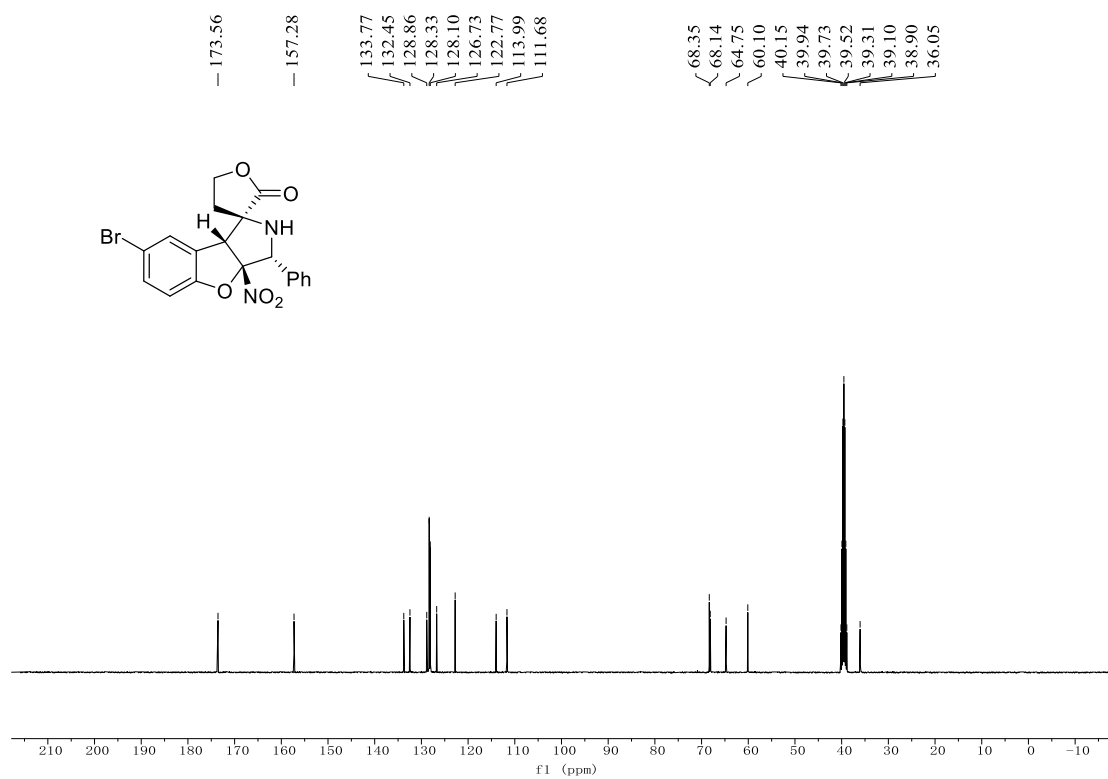
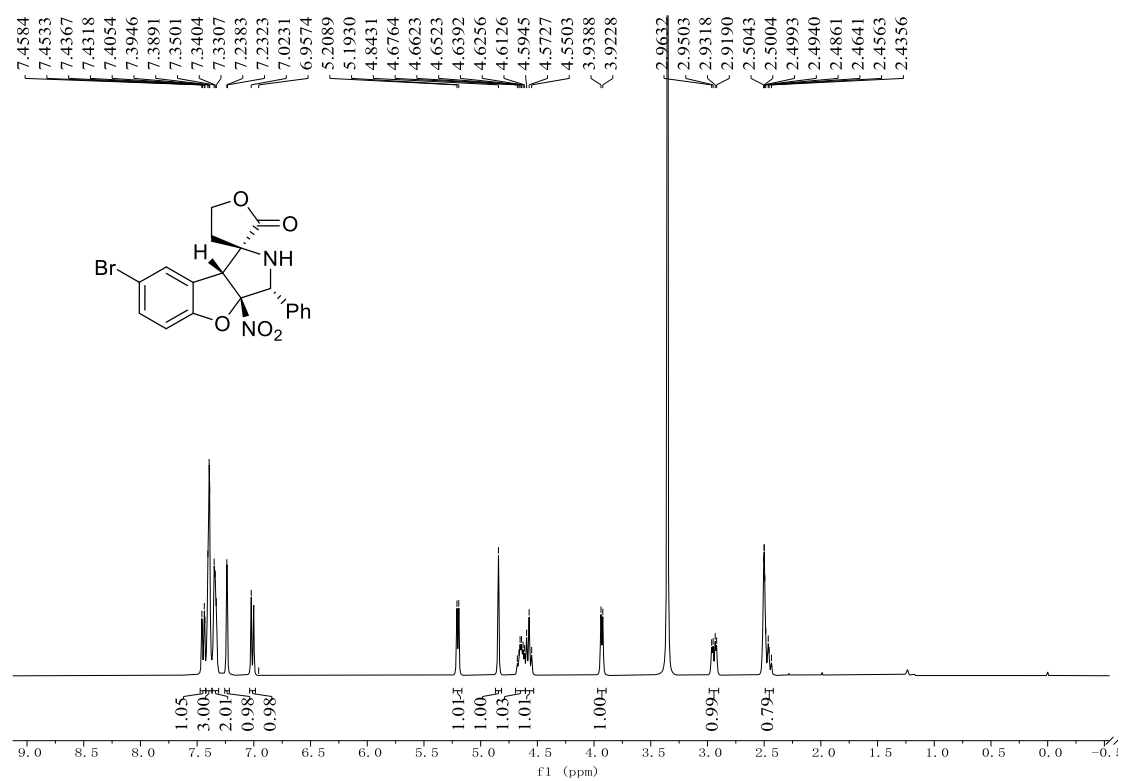
1 Det.A Ch1/220nm

PeakTable

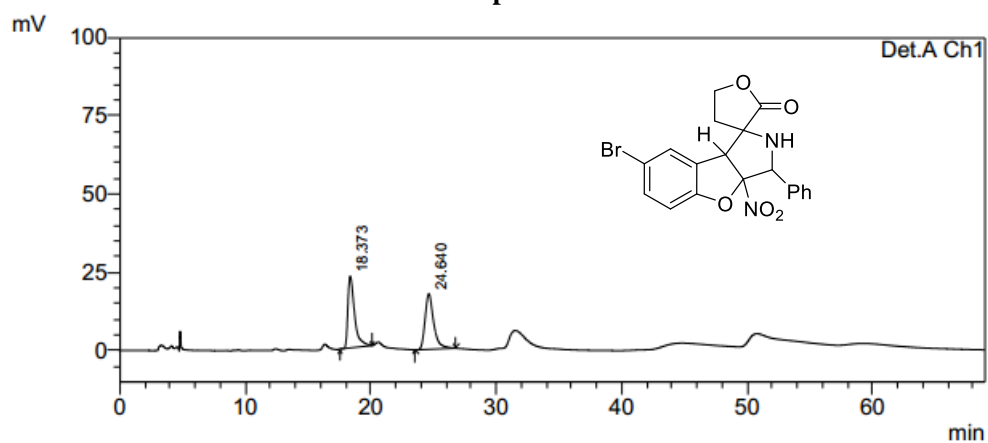
Detector A Ch1 220nm

Peak#	Ret. Time	Area	Height	Area %
1	19.574	133099290	1650021	97.102
2	22.899	3972764	70192	2.898
Total		137072054		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ ) of 5d**



# HPLC spectra of 5d

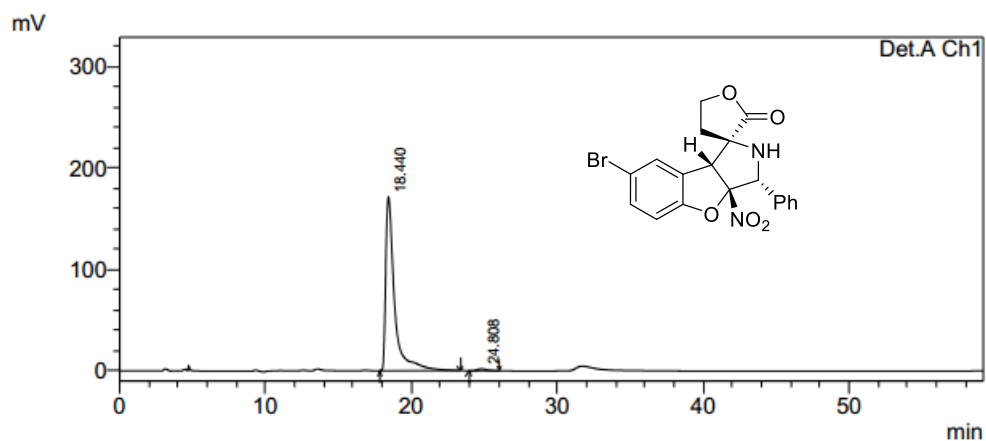


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	18.373	848889	22893	50.076
2	24.640	846308	17761	49.924
Total		1695197		100.000



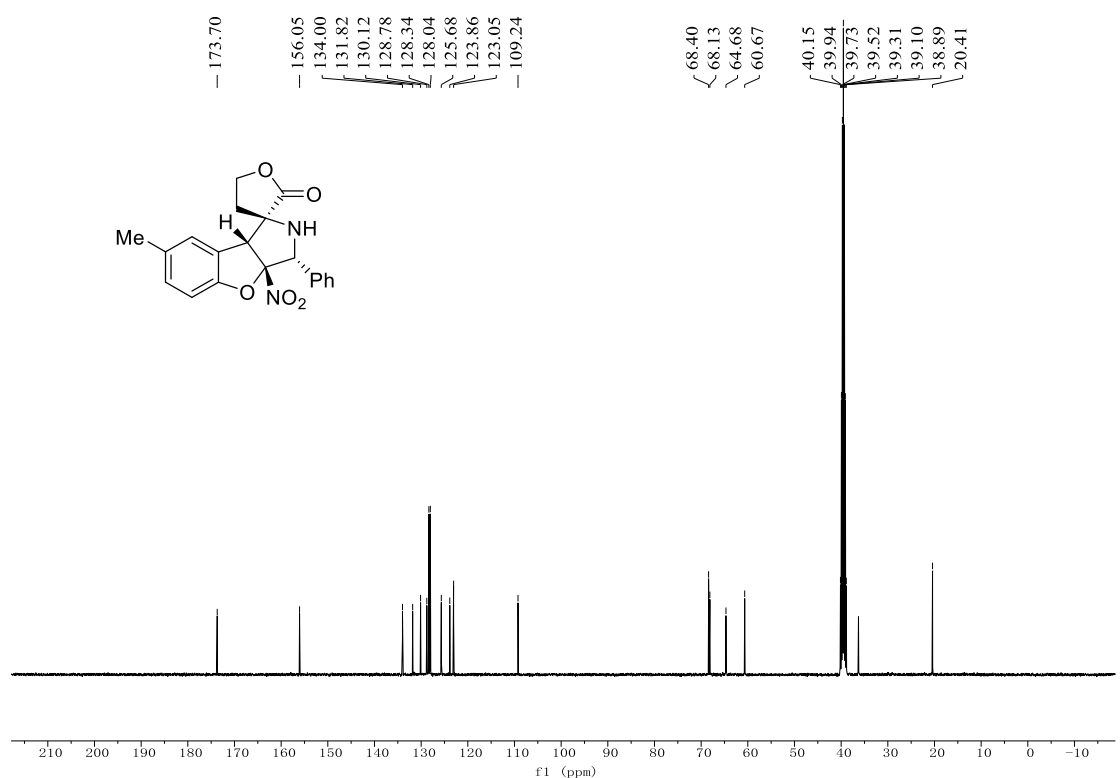
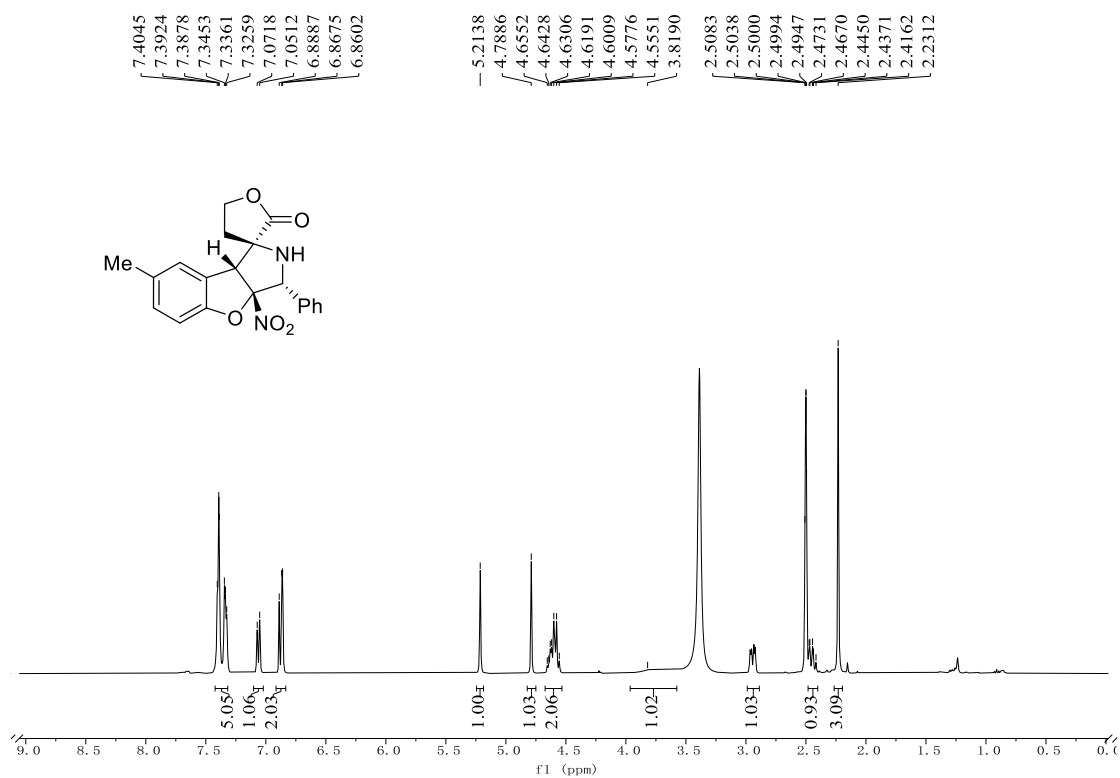
1 Det.A Ch1/254nm

PeakTable

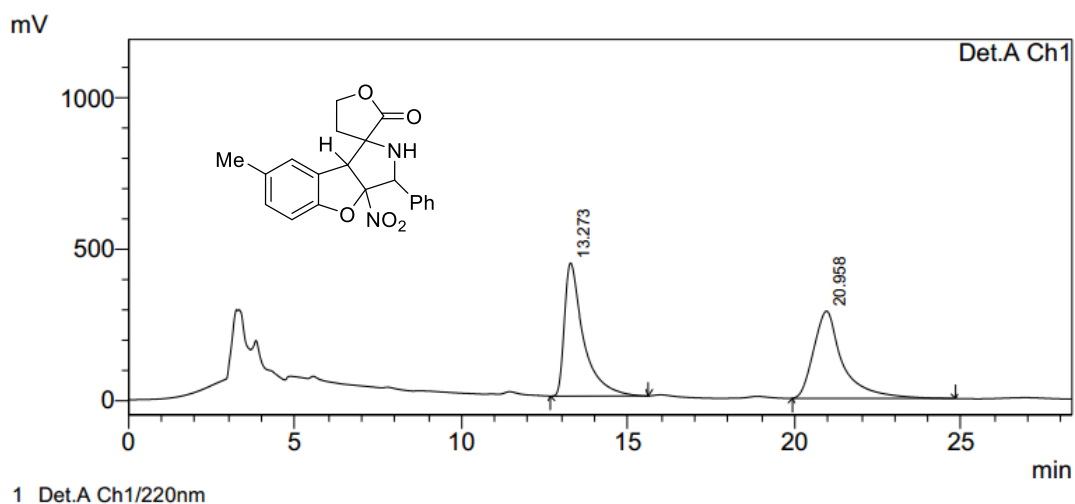
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	18.440	7226885	171478	98.842
2	24.808	84673	1891	1.158
Total		7311558		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-}d_6$ ) of **5e****



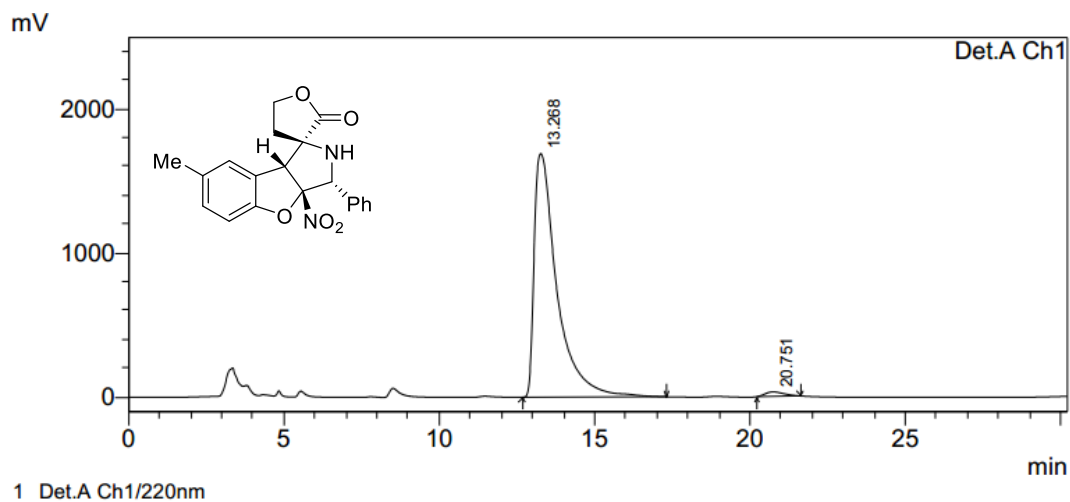
# HPLC spectra of 5e



PeakTable

Detector A Ch1 220nm

Peak#	Ret. Time	Area	Height	Area %
1	13.273	17555802	441957	49.835
2	20.958	17671785	290162	50.165
Total		35227587		100.000



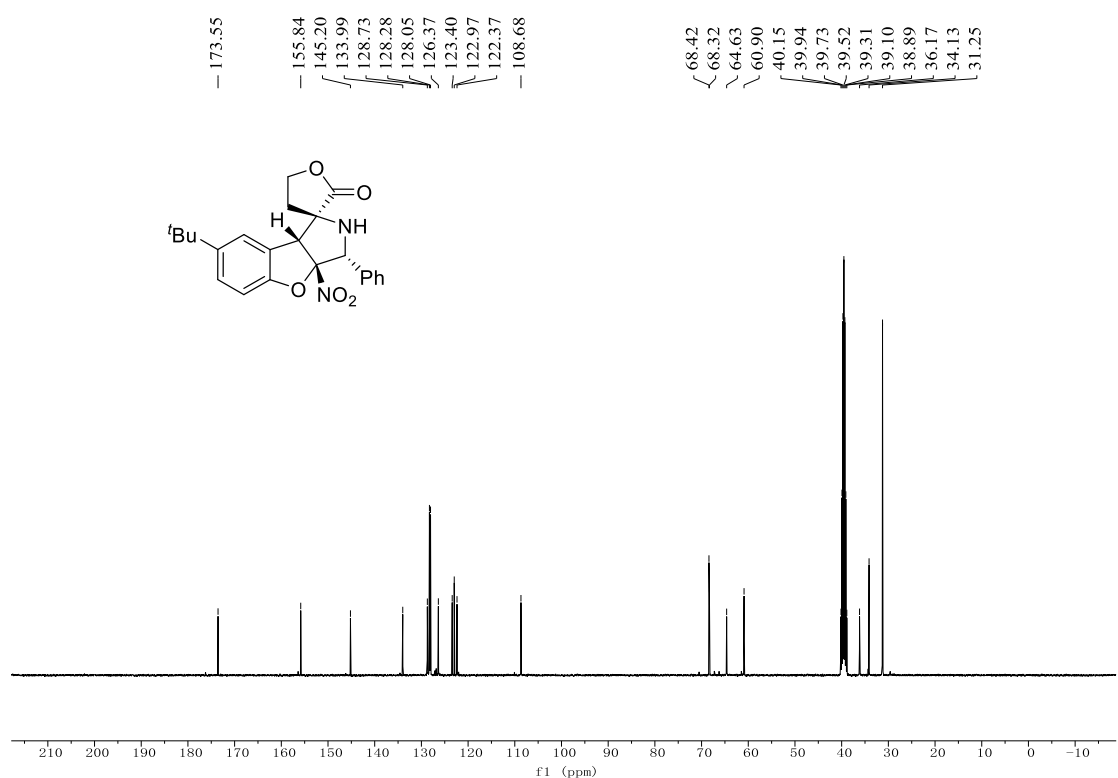
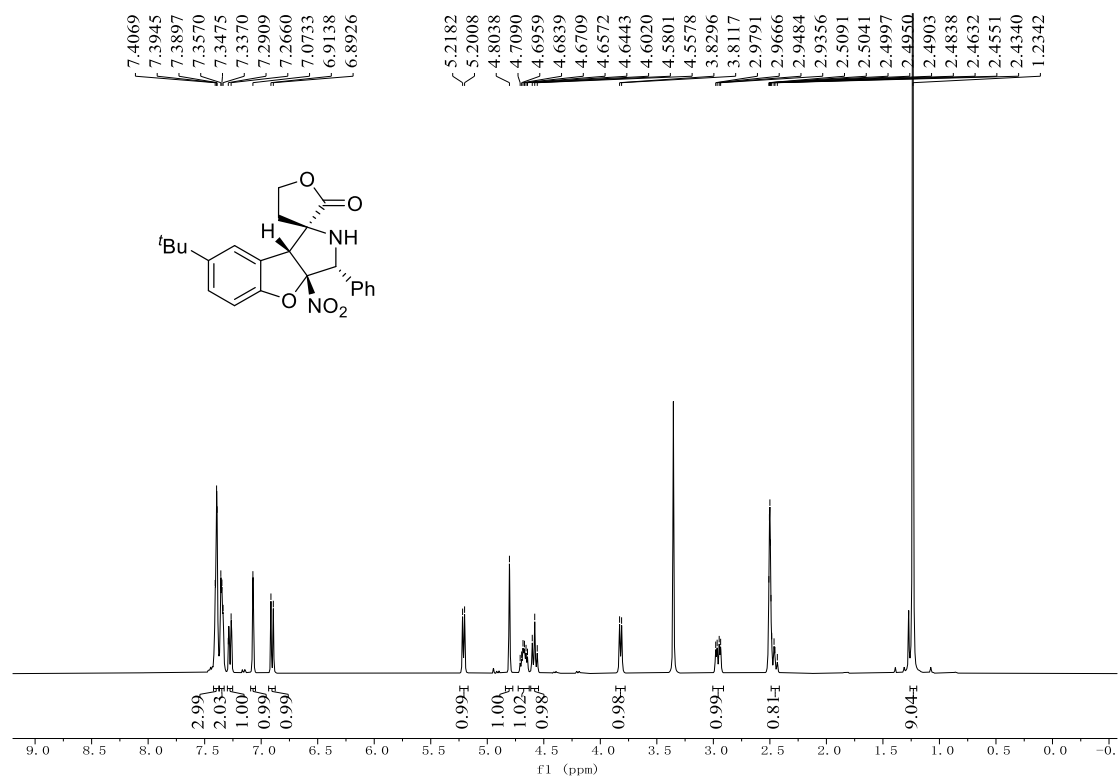
PeakTable

Detector A Ch1 220nm

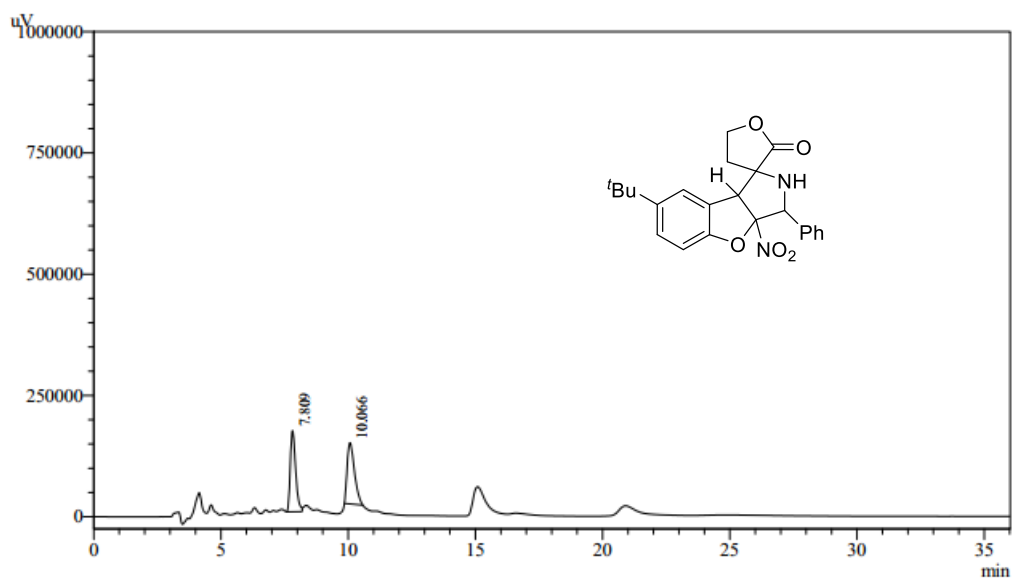
Peak#	Ret. Time	Area	Height	Area %
1	13.268	86122036	1689286	98.489
2	20.751	1321531	31410	1.511
Total		87443567		100.000



**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-}d_6$ ) of 5f**



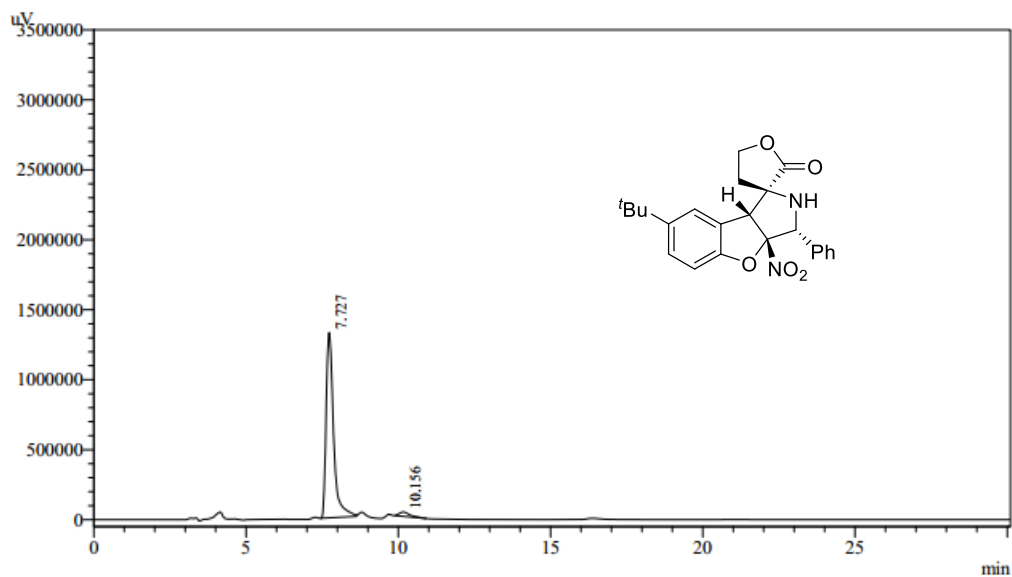
# HPLC spectra of 5f



1 Det.A Ch1 / 254nm

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	7.809	2453116	167288	49.261	57.038
2	10.066	2526767	126003	50.739	42.962
Total		4979884	293291	100.000	100.000

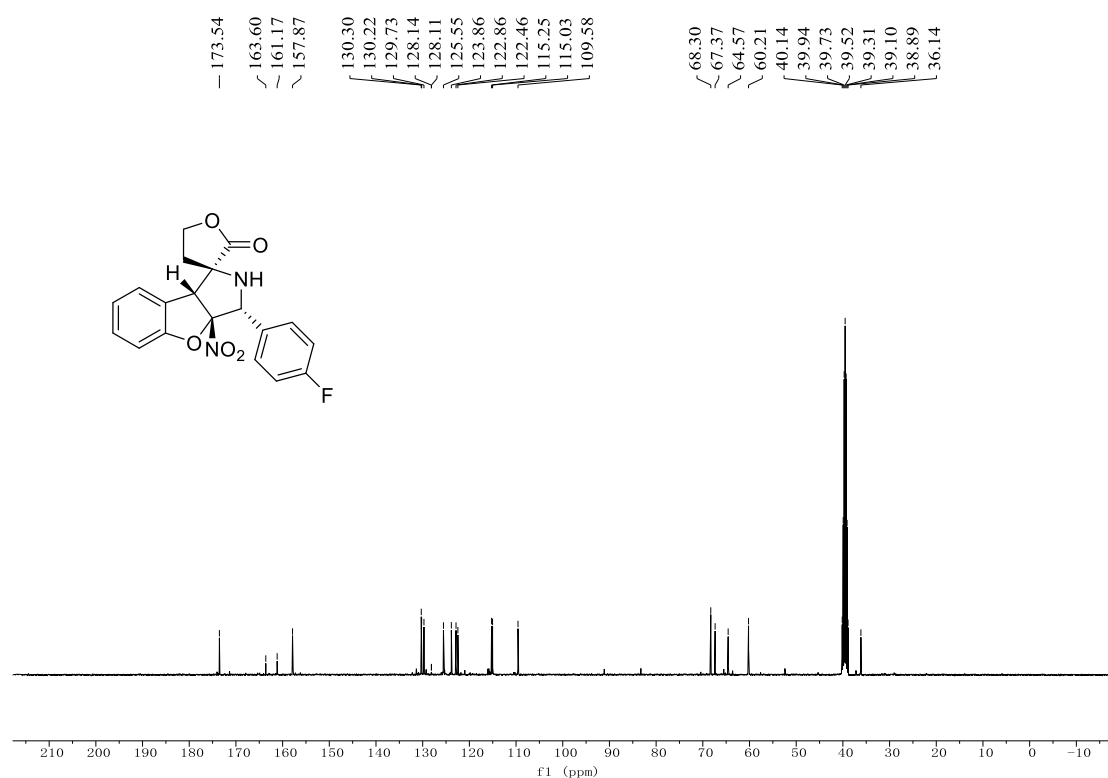
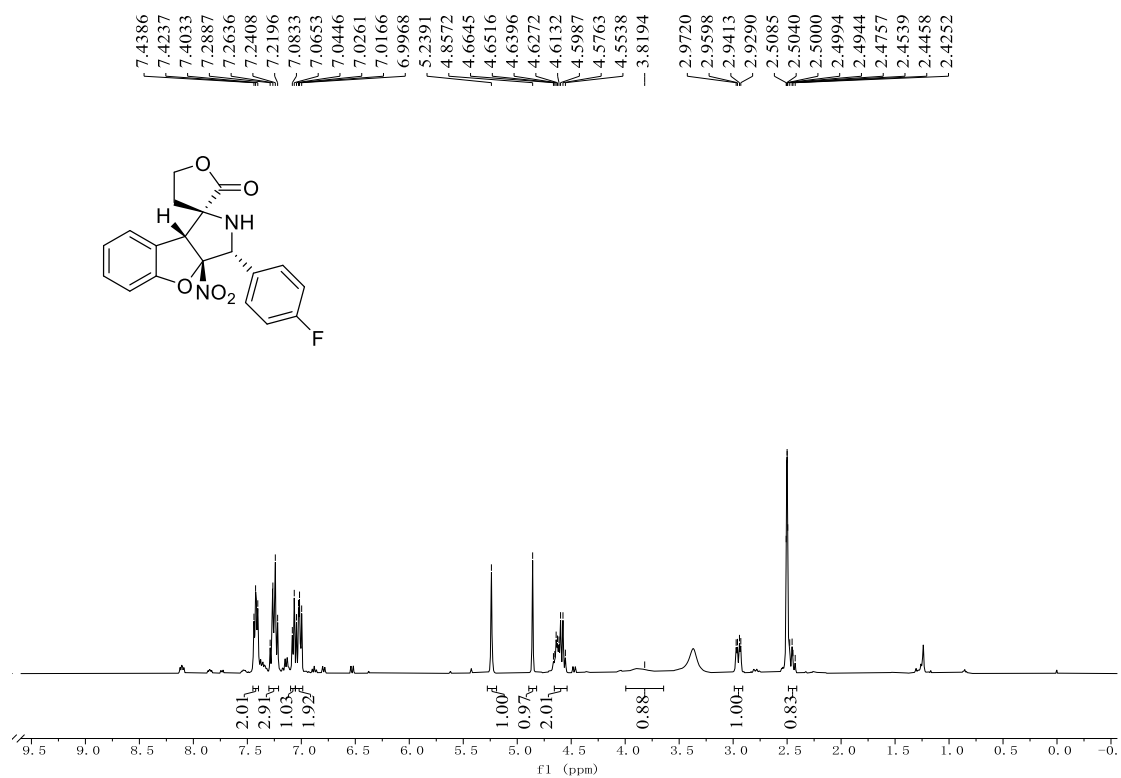


1 Det.A Ch1 / 254nm

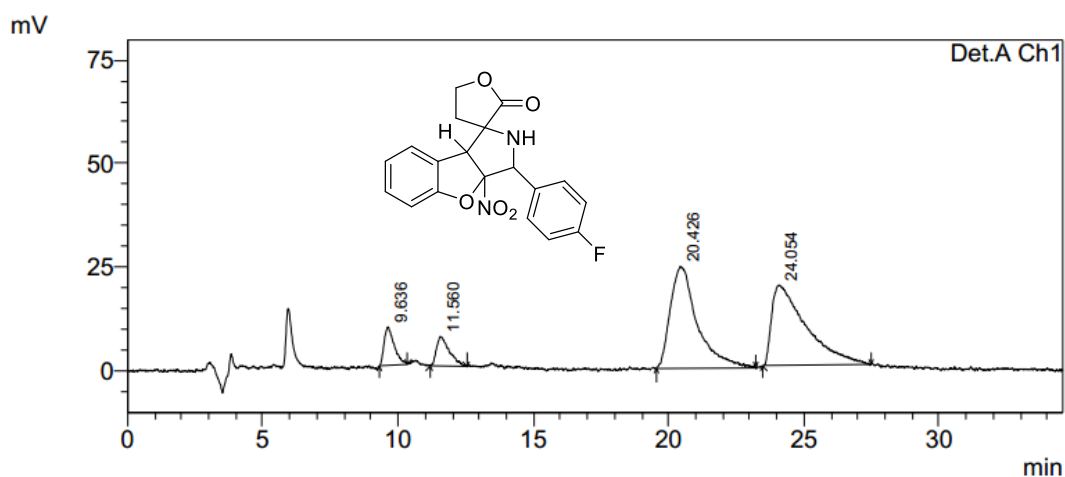
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	7.727	22679021	1324659	96.750	97.743
2	10.156	761948	30585	3.250	2.257
Total		23440969	1355243	100.000	100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO}-d_6$ ) of 5g**



# HPLC spectra of 5g

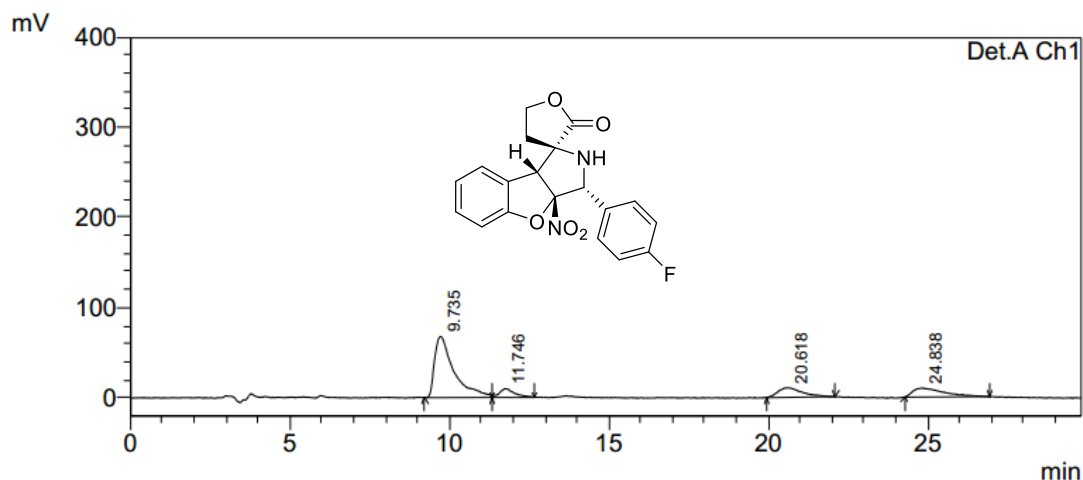


1 Det.A Ch1/220nm

PeakTable

Detector A Ch1 220nm

Peak#	Ret. Time	Area	Height	Area %
1	9.636	238985	9296	6.142
2	11.560	233494	7062	6.001
3	20.426	1711645	24610	43.992
4	24.054	1706658	19330	43.864
Total		3890783		100.000



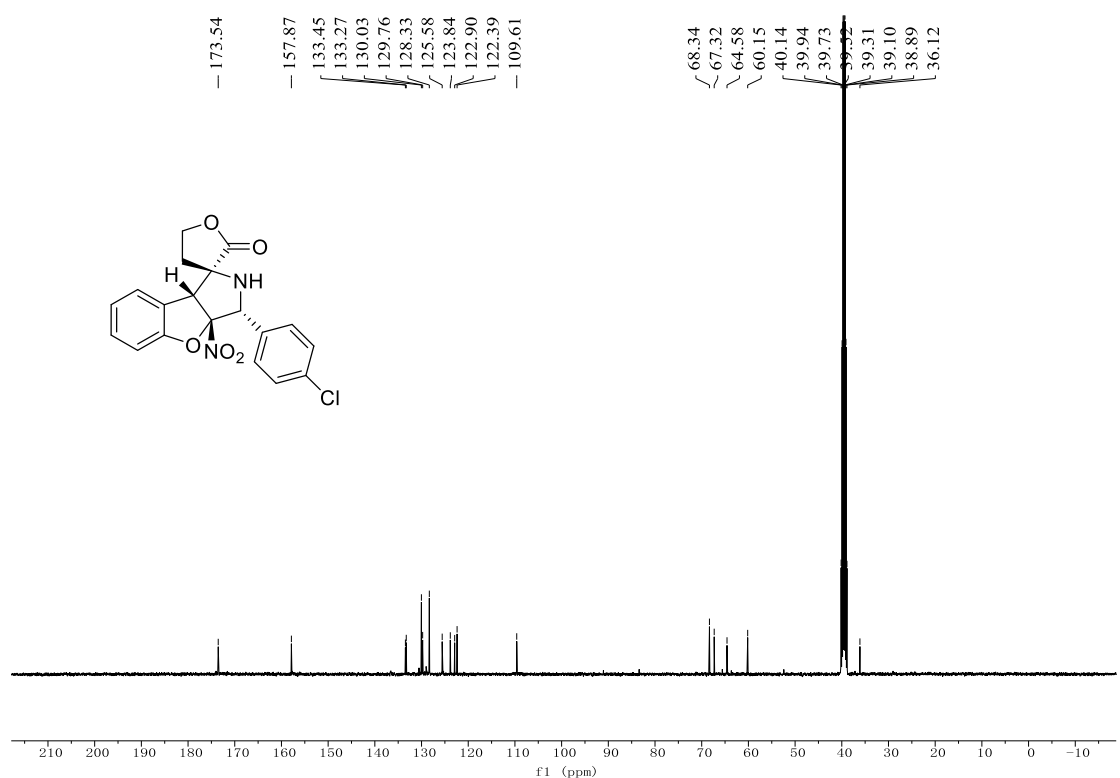
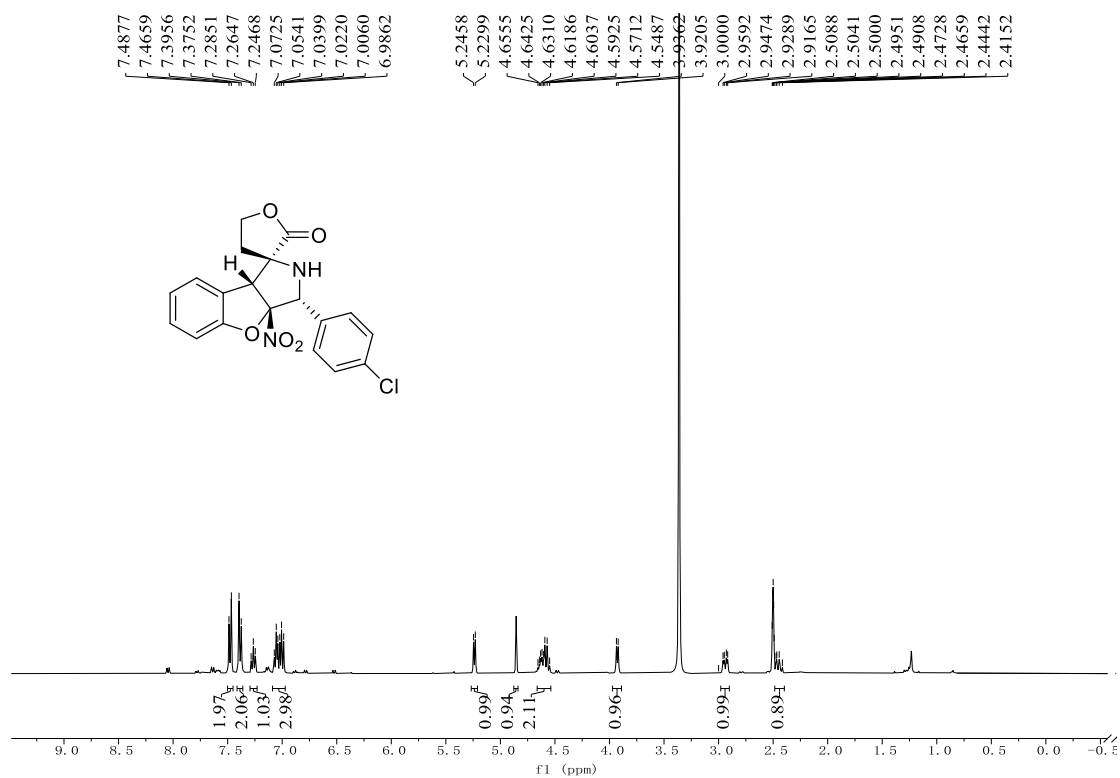
1 Det.A Ch1/220nm

PeakTable

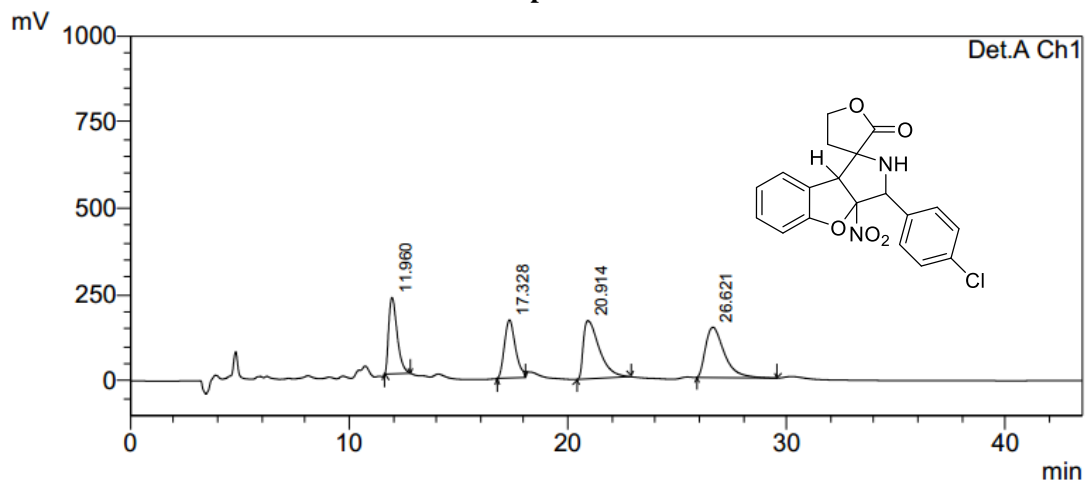
Detector A Ch1 220nm

Peak#	Ret. Time	Area	Height	Area %
1	9.735	2865620	67686	64.614
2	11.746	328069	9600	7.397
3	20.618	560612	10571	12.641
4	24.838	680706	10088	15.348
Total		4435006		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-}d_6$ ) of 5h**



# HPLC spectra of 5h

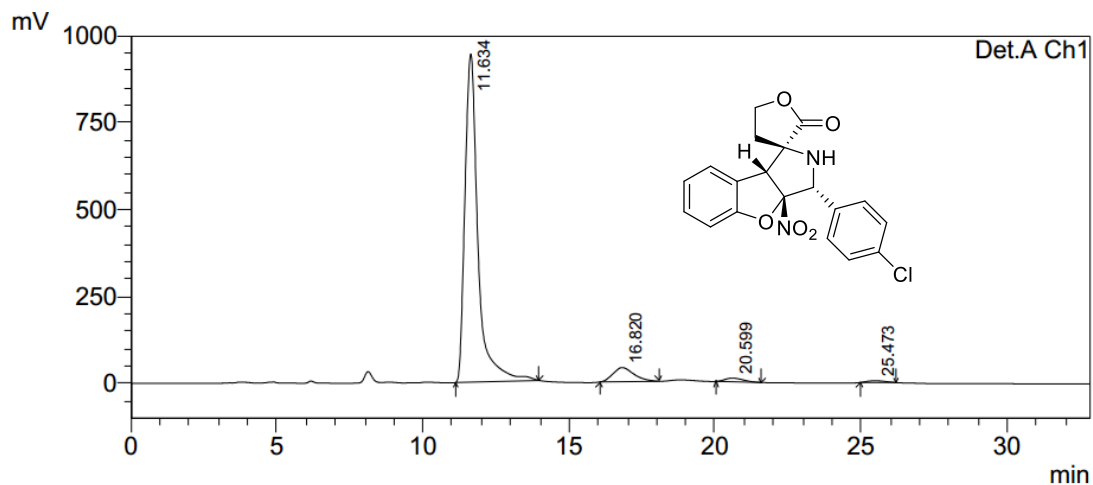


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	11.960	5990811	221406	20.575
2	17.328	5885122	168221	20.212
3	20.914	8564342	168395	29.414
4	26.621	8676051	145642	29.798
Total		29116327		100.000



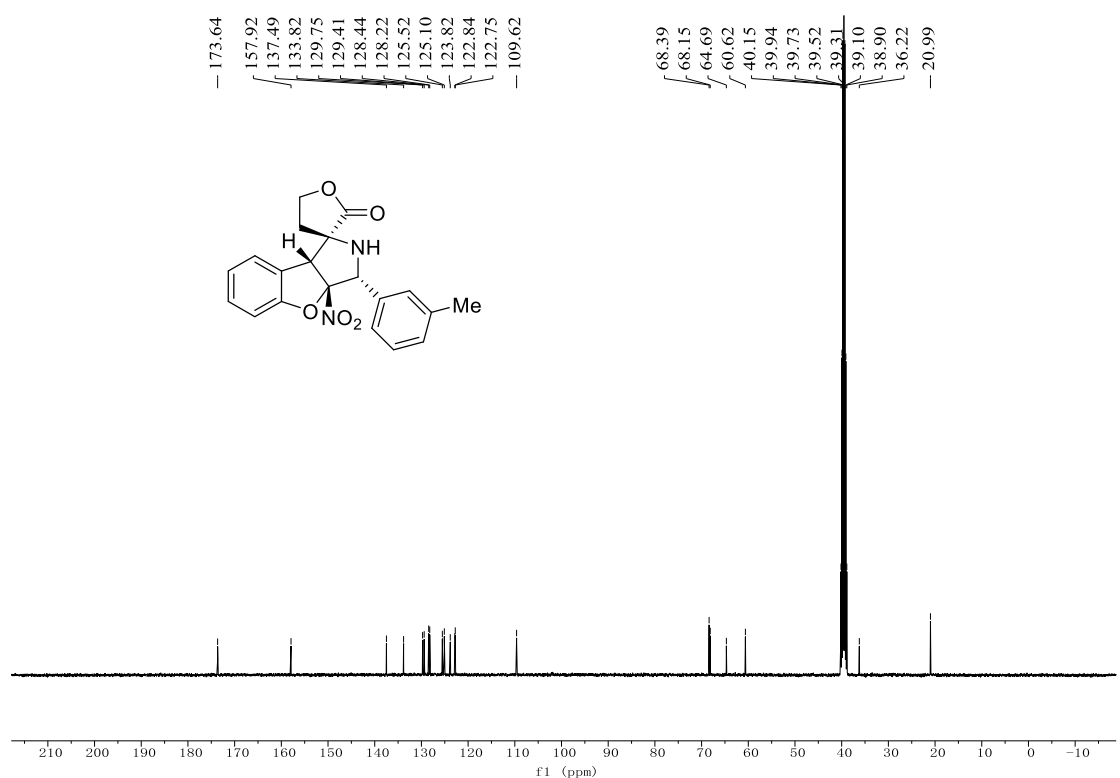
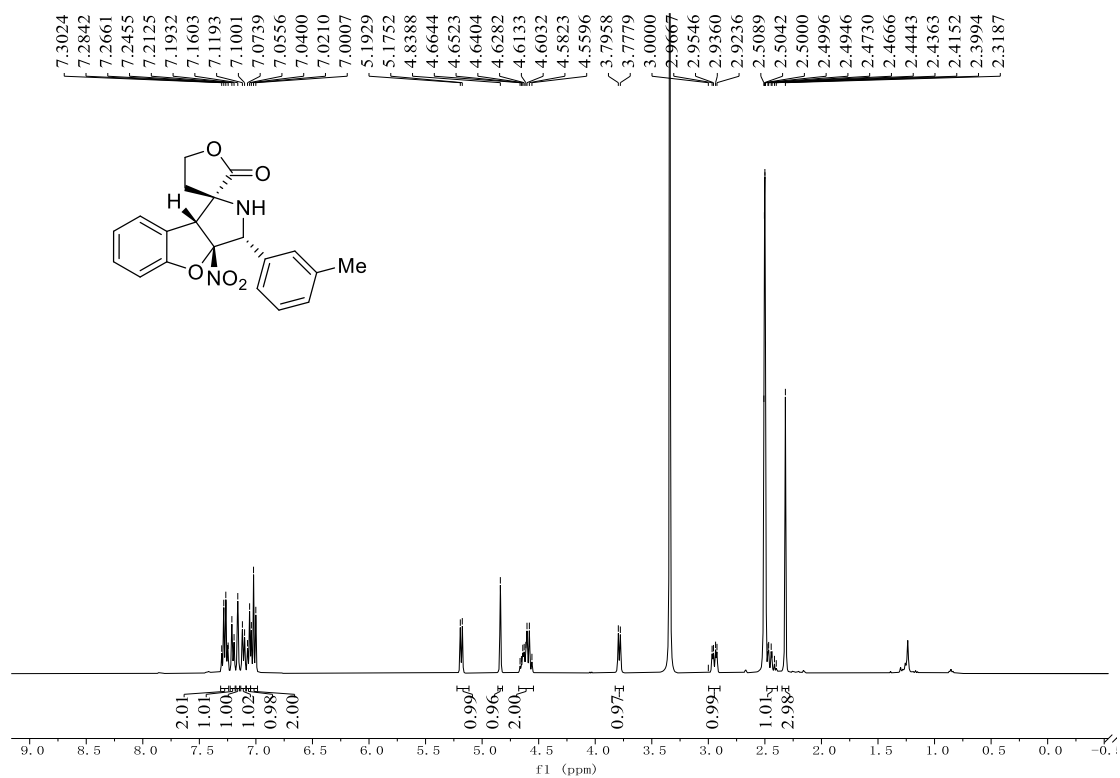
1 Det.A Ch1/254nm

PeakTable

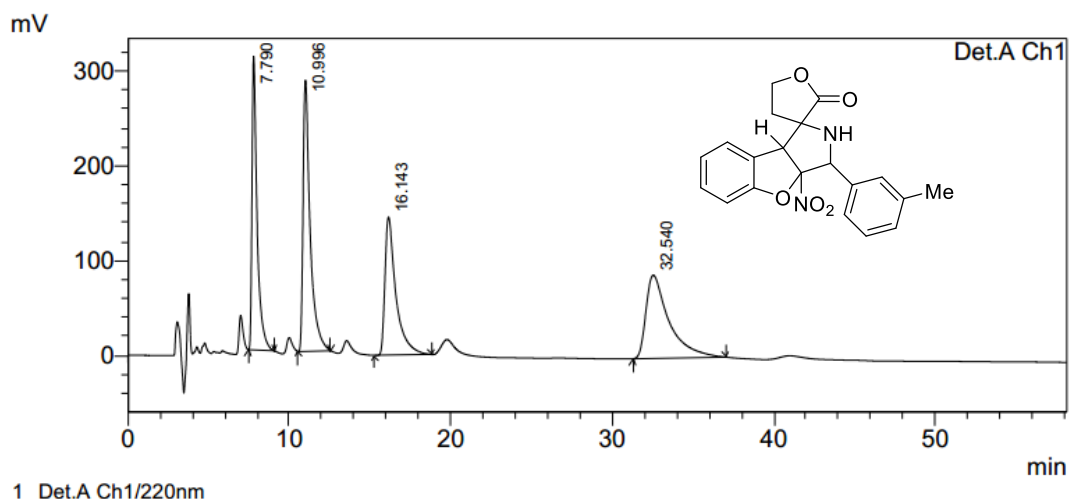
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	11.634	29274414	942273	91.489
2	16.820	2022844	40709	6.322
3	20.599	470313	10734	1.470
4	25.473	230147	5326	0.719
Total		31997718		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-}d_6$ ) of 5i**

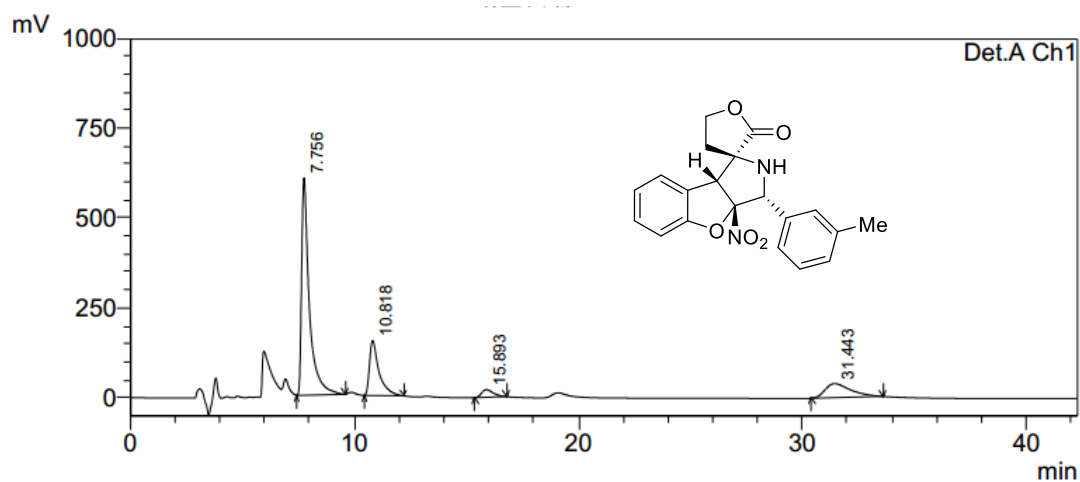


# HPLC spectra of 5i



PeakTable

Detector A Ch1 220nm				
Peak#	Ret. Time	Area	Height	Area %
1	7.790	6816273	310225	21.888
2	10.996	8744705	286499	28.080
3	16.143	6863027	145949	22.038
4	32.540	8718174	87998	27.995
Total		31142180		100.000

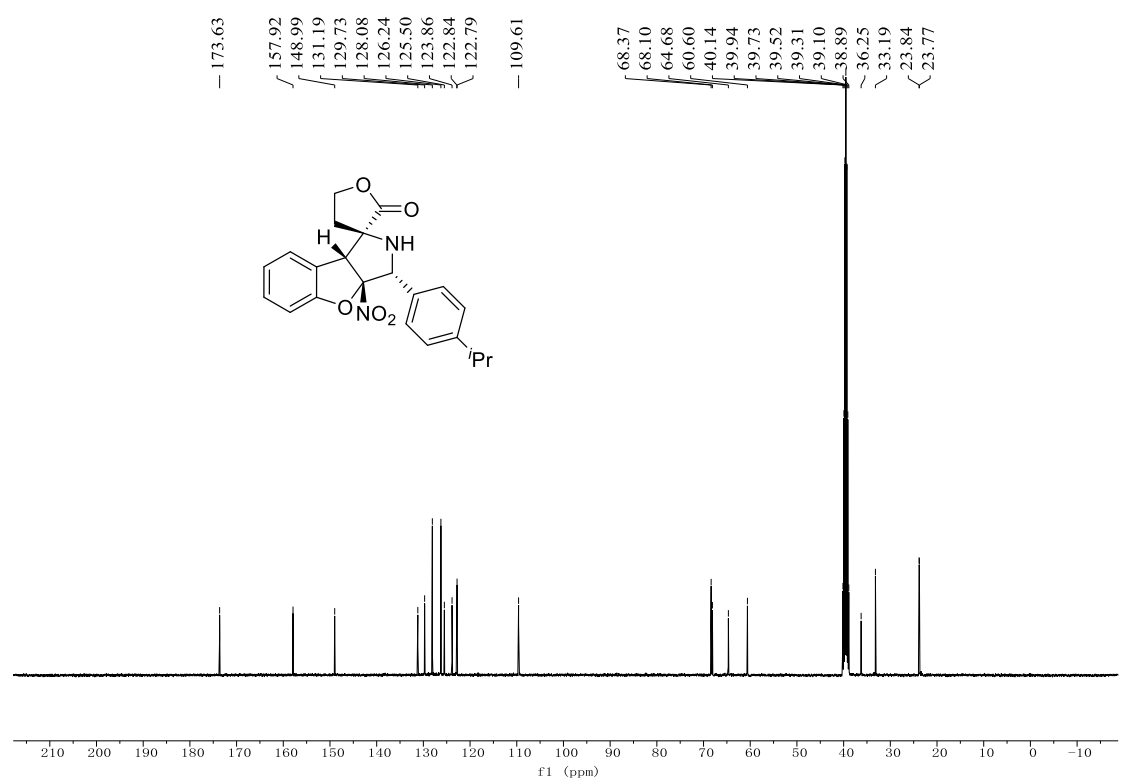
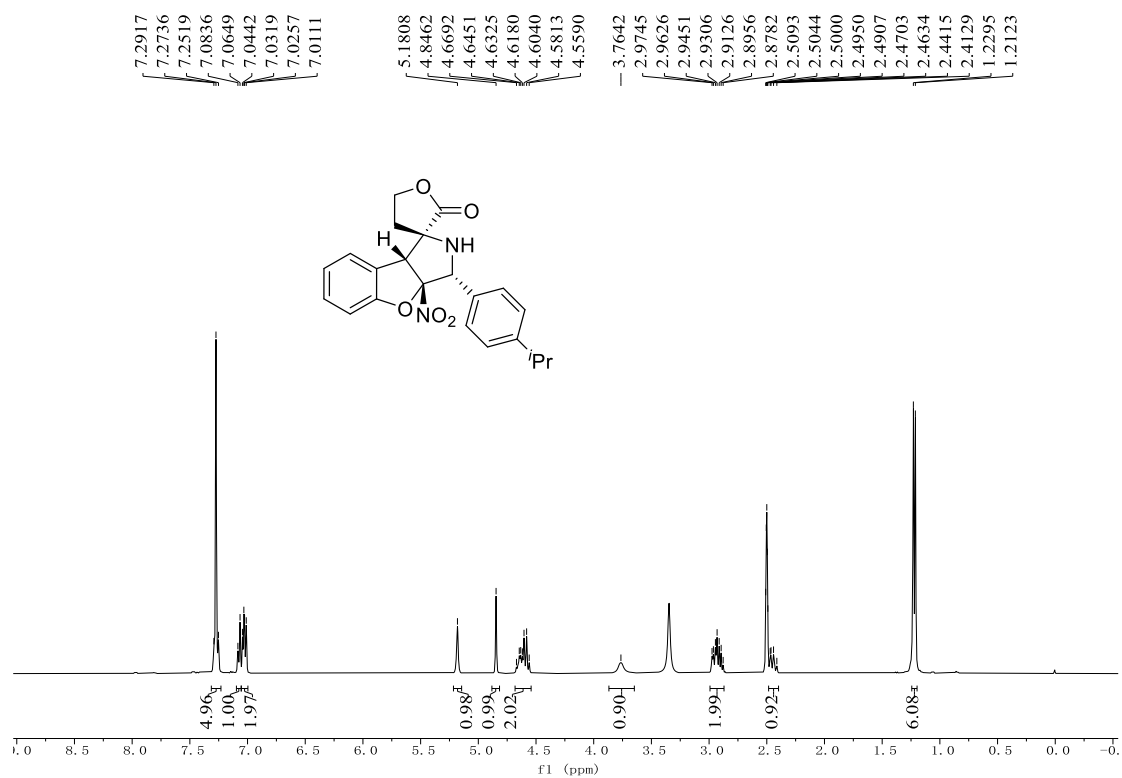


PeakTable

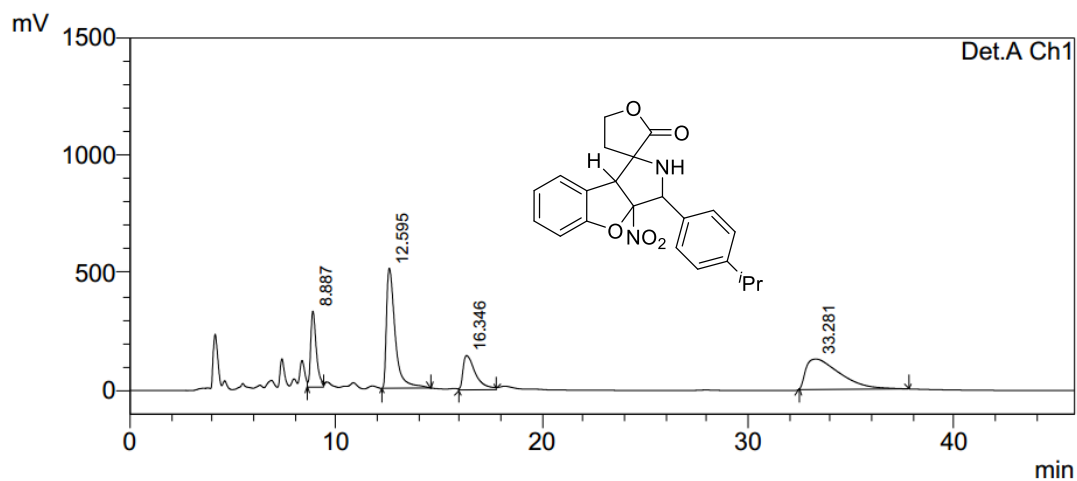
Detector A Ch1 220nm				
Peak#	Ret. Time	Area	Height	Area %
1	7.756	14458743	604517	63.301
2	10.818	4492765	152979	19.669
3	15.893	769588	21286	3.369
4	31.443	3120191	39135	13.660
Total		22841288		100.000



**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-d}_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-d}_6$ ) of 5j**



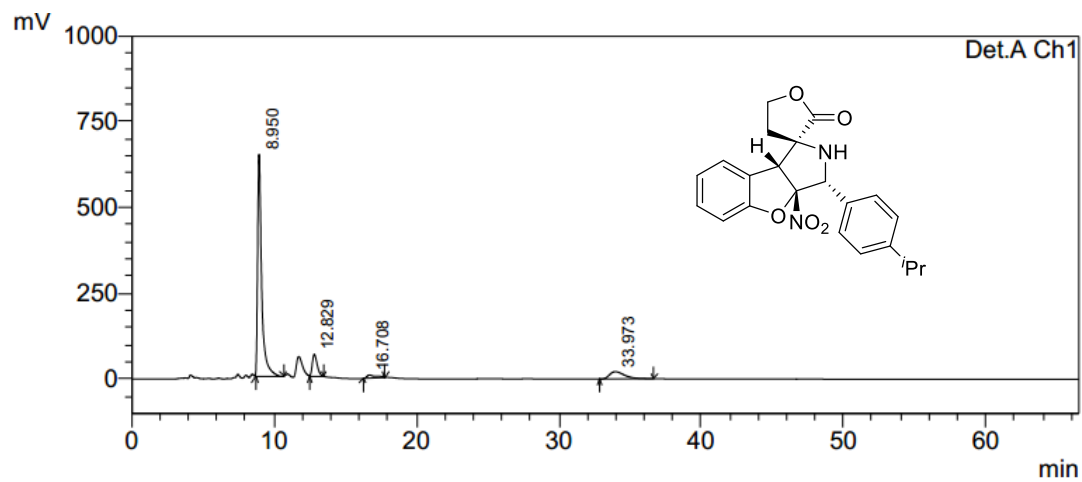
# HPLC spectra of 5j



1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm				
Peak#	Ret. Time	Area	Height	Area %
1	8.887	6199662	322244	14.657
2	12.595	14964963	509226	35.380
3	16.346	6178162	145436	14.606
4	33.281	14955240	129398	35.357
Total		42298027		100.000

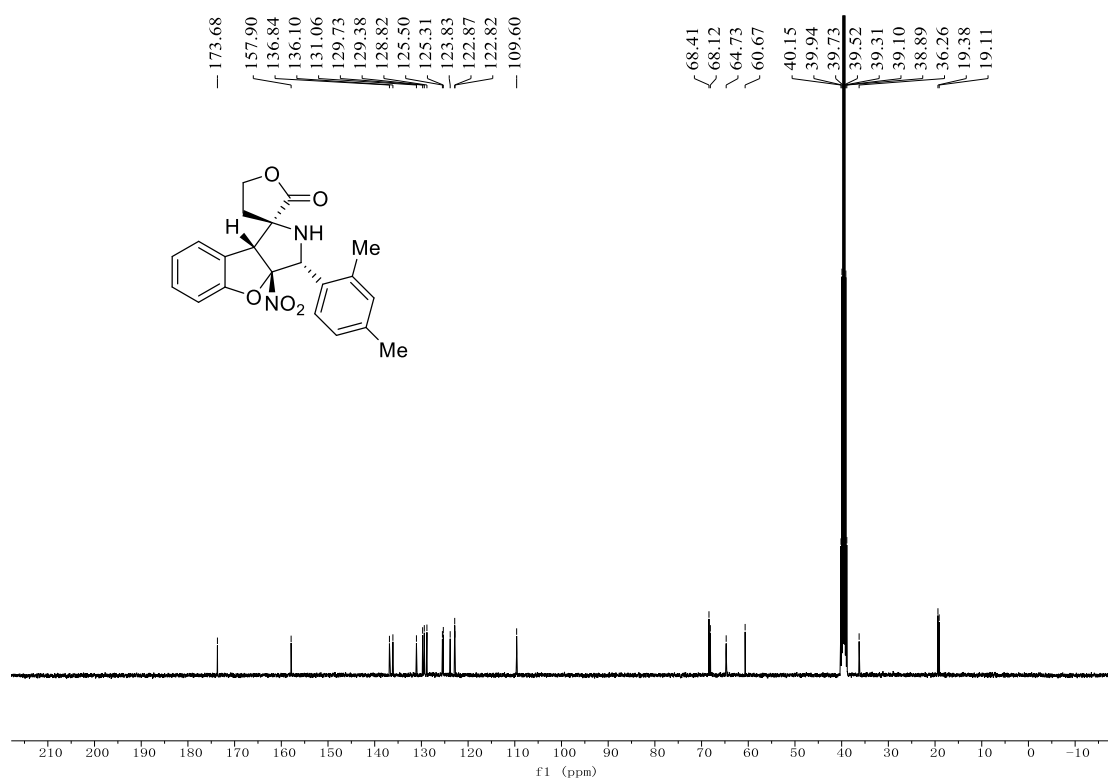
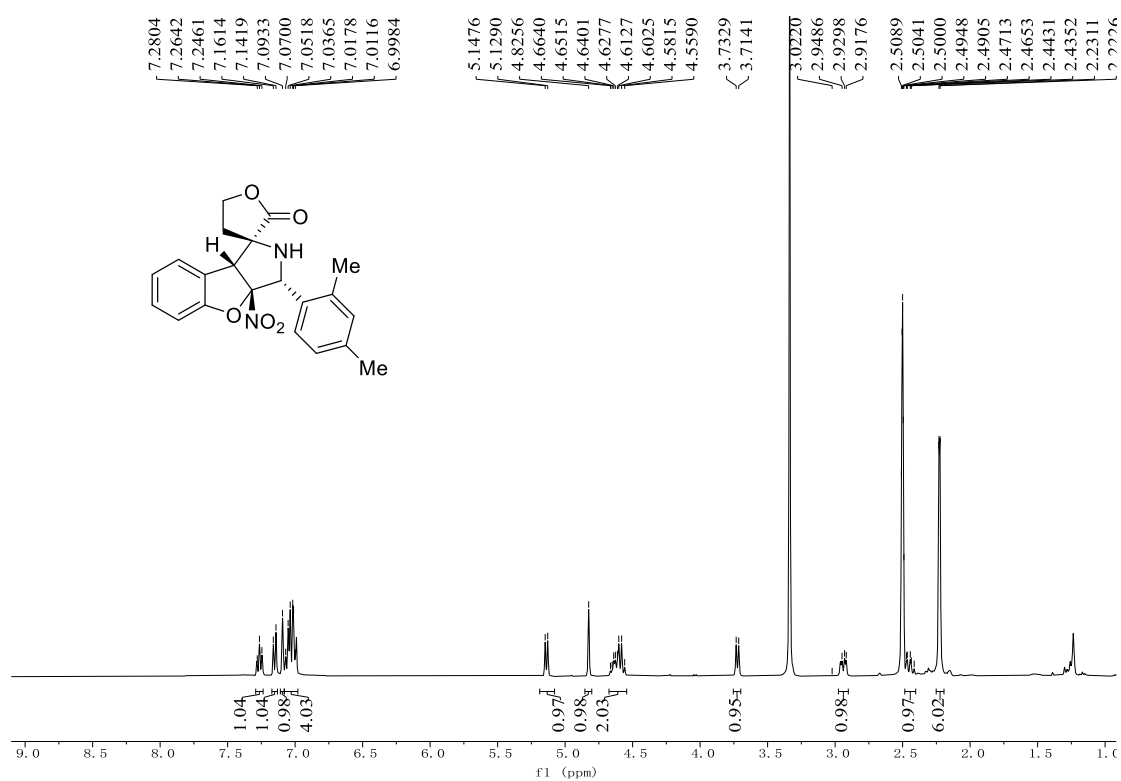


1 Det.A Ch1/254nm

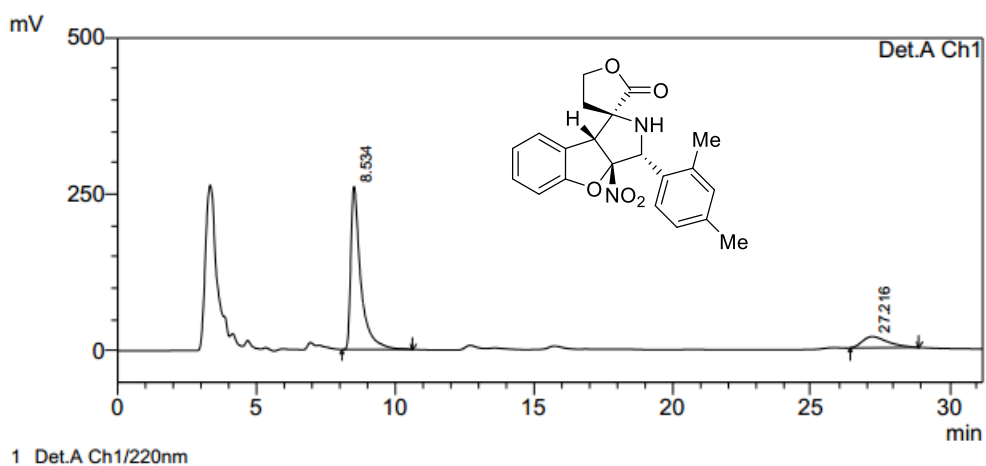
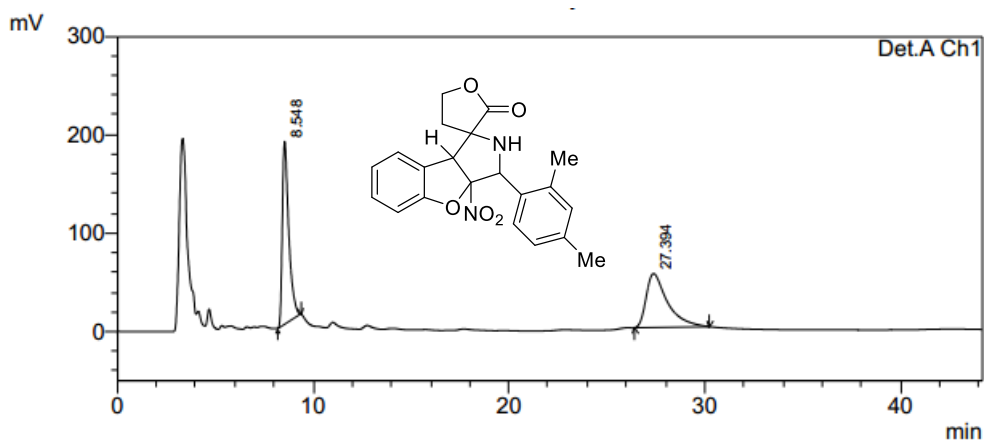
PeakTable

Detector A Ch1 254nm				
Peak#	Ret. Time	Area	Height	Area %
1	8.950	12934559	646595	78.503
2	12.829	1548732	64334	9.400
3	16.708	436236	9232	2.648
4	33.973	1557025	21089	9.450
Total		16476552		100.000

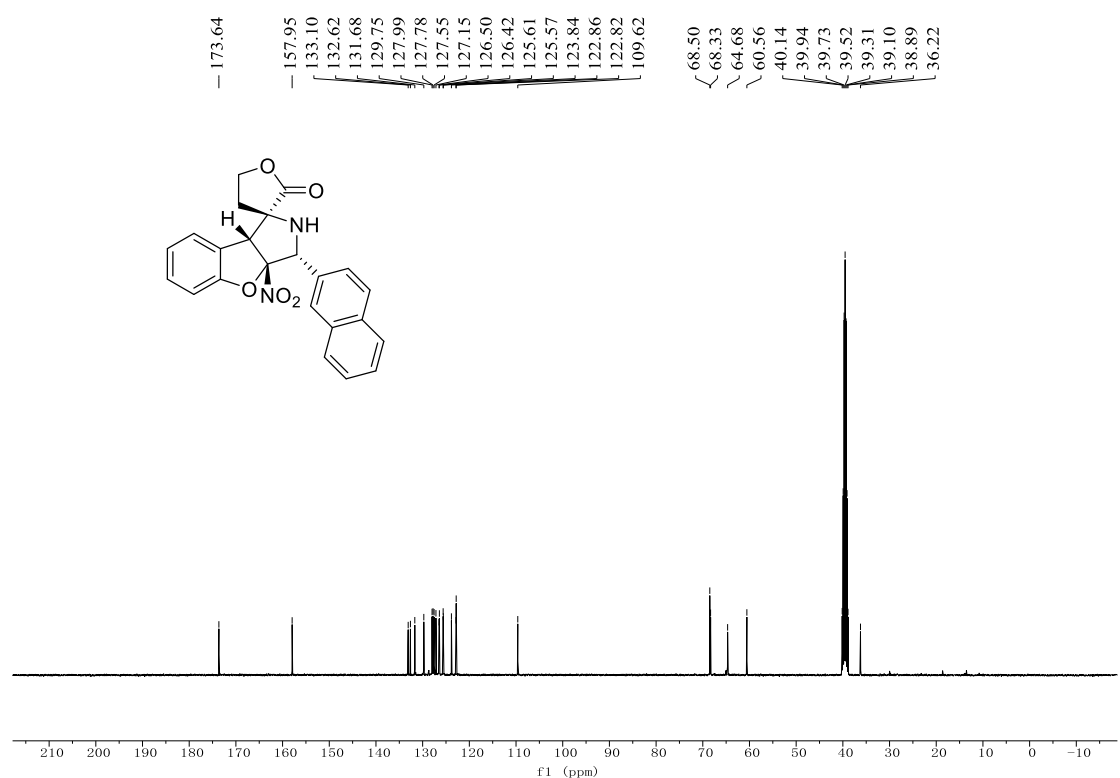
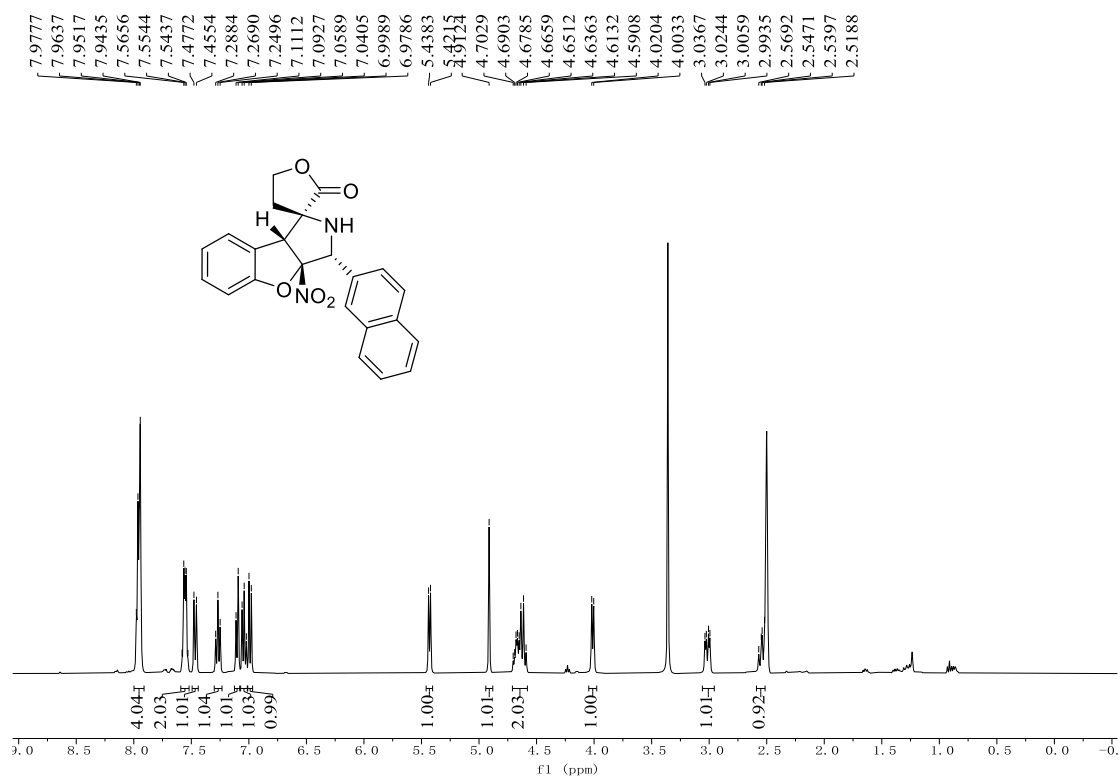
**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-d}_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-d}_6$ ) of 5k**



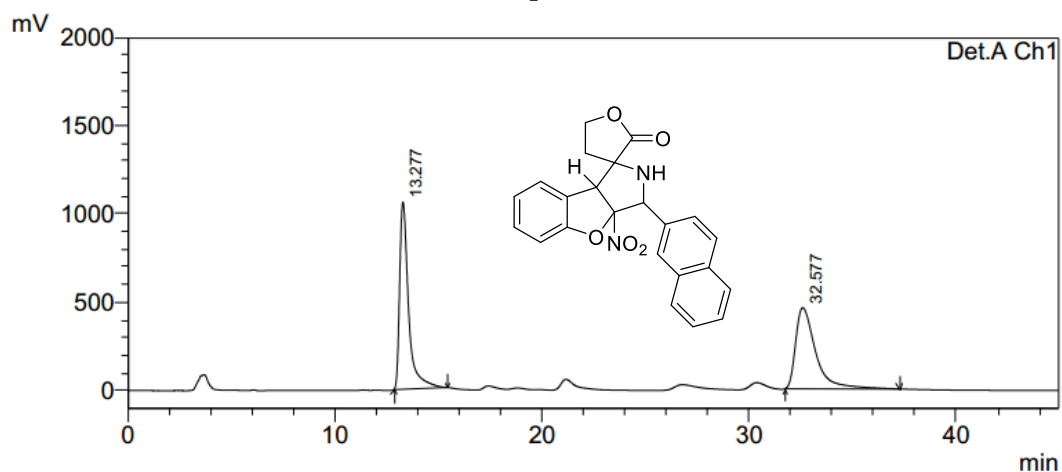
# HPLC spectra of 5k



**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-d}_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-d}_6$ ) of 5l**



# HPLC spectra of 5l

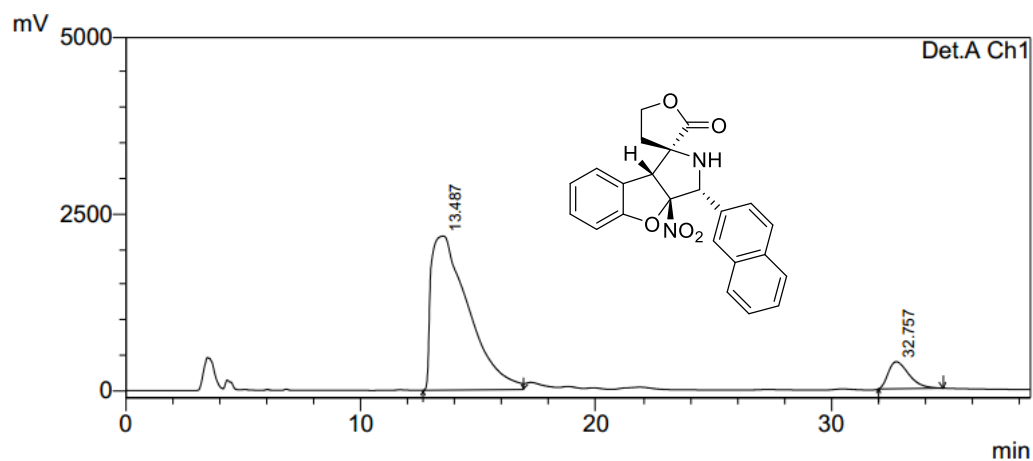


1 Det.A Ch1/220nm

PeakTable

Detector A Ch1 220nm

Peak#	Ret. Time	Area	Height	Area %
1	13.277	31836970	1059176	50.826
2	32.577	30802253	458913	49.174
Total		62639222		100.000



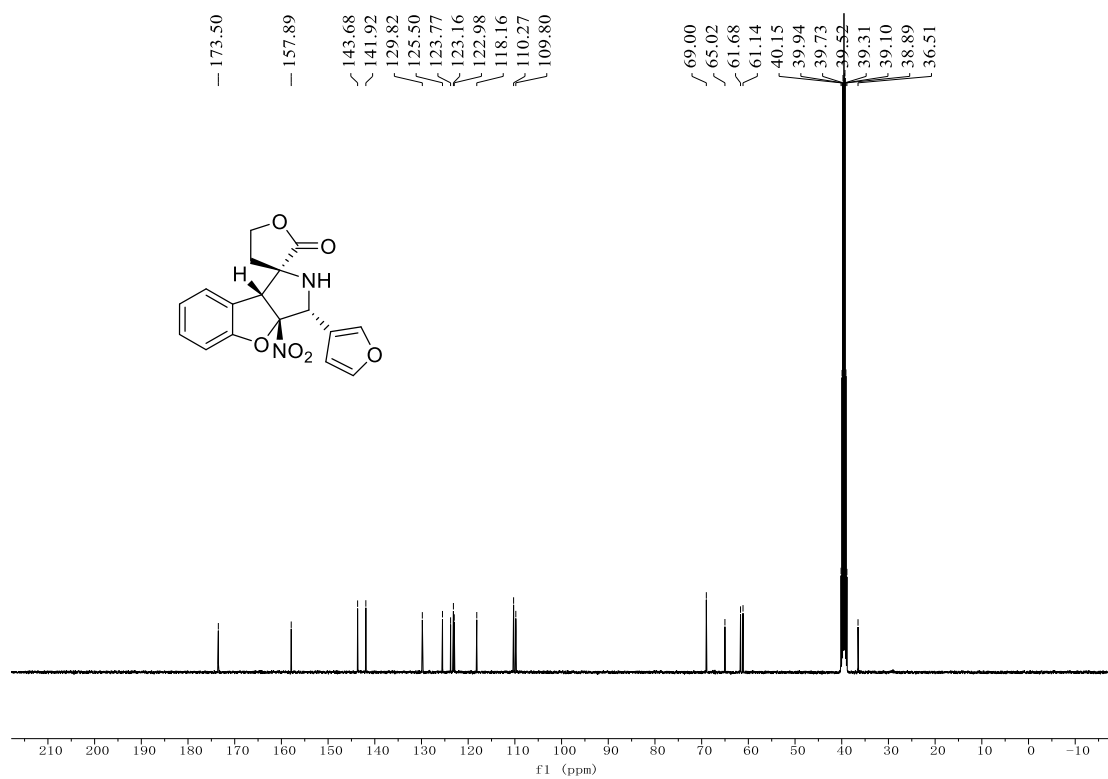
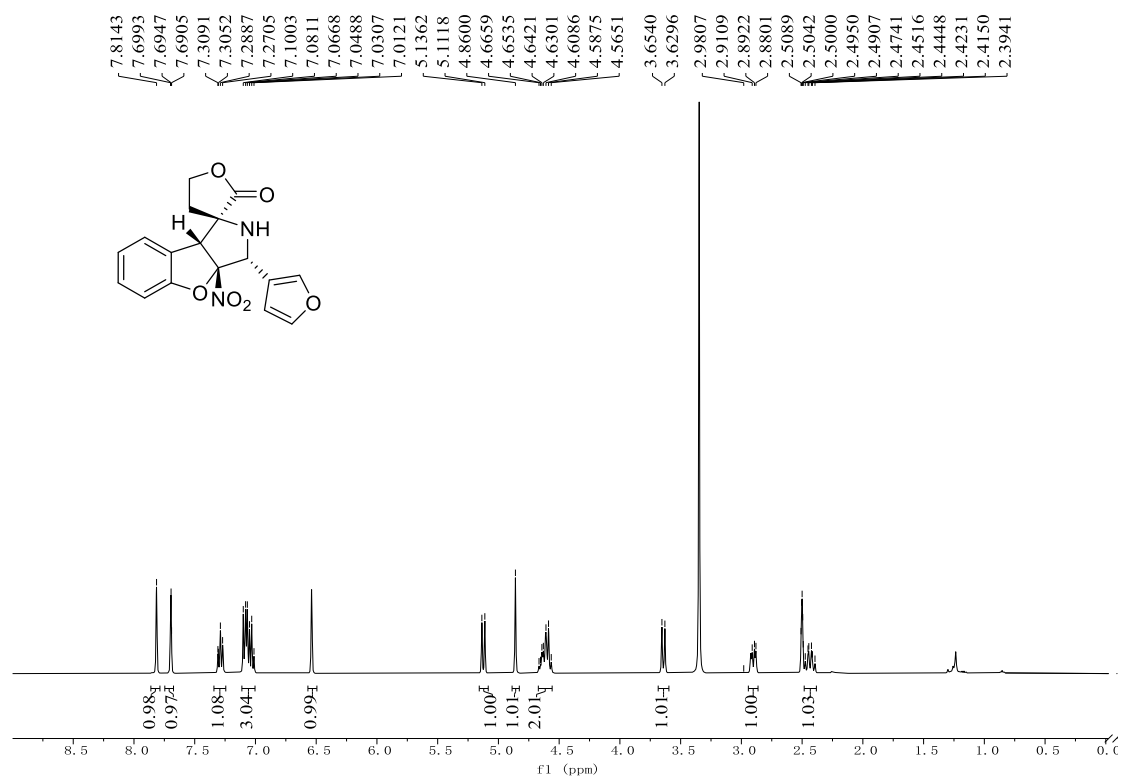
1 Det.A Ch1/220nm

PeakTable

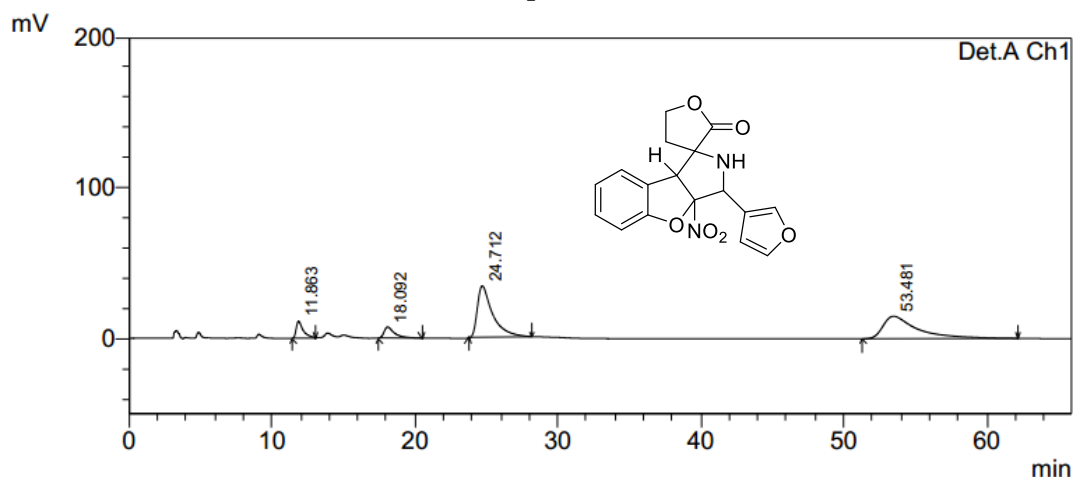
Detector A Ch1 220nm

Peak#	Ret. Time	Area	Height	Area %
1	13.487	241466470	2178456	91.216
2	32.757	23252657	381101	8.784
Total		264719127		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-d}_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-d}_6$ ) of 5m**



# HPLC spectra of 5m

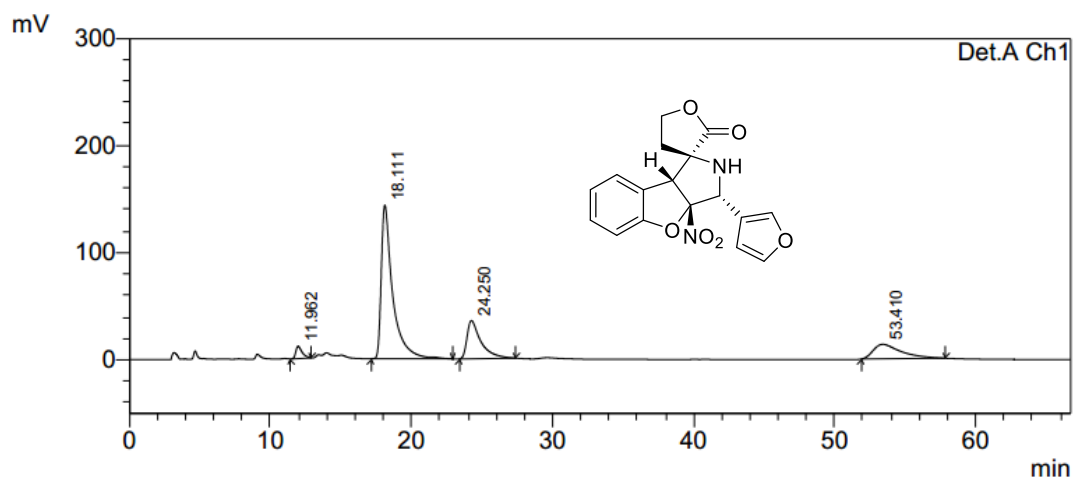


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	11.863	385790	11203	6.696
2	18.092	365807	7320	6.349
3	24.712	2516724	34129	43.683
4	53.481	2493059	14877	43.272
Total		5761380		100.000



1 Det.A Ch1/254nm

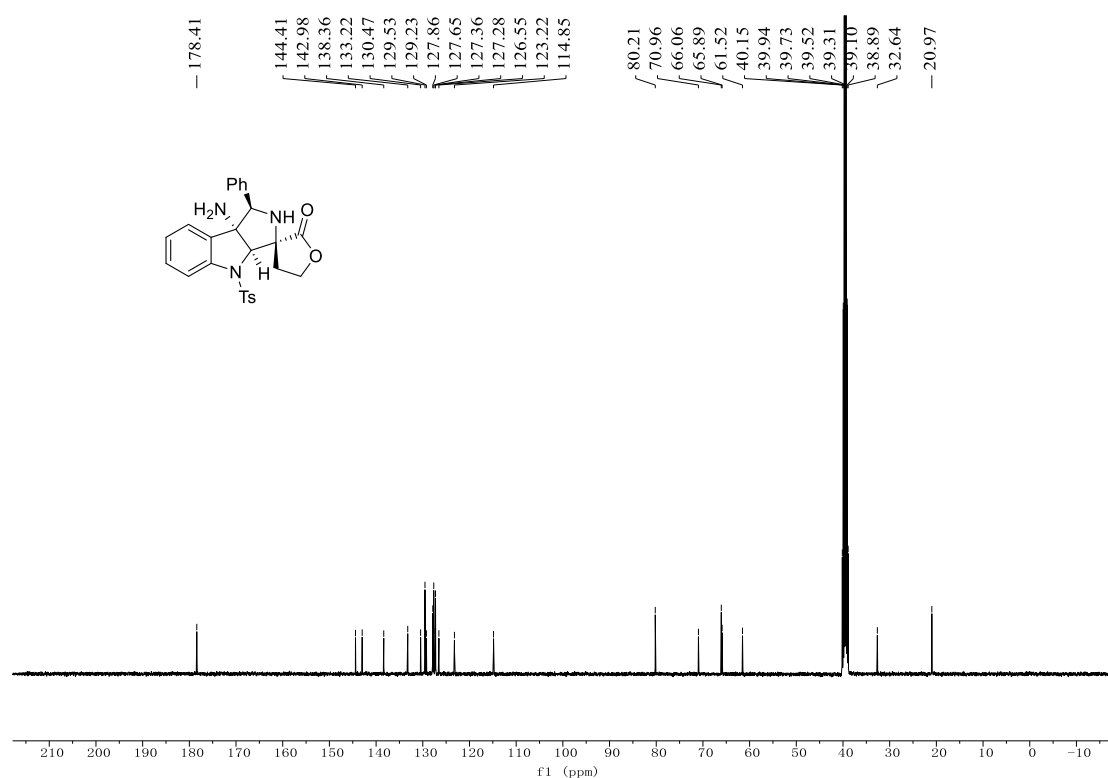
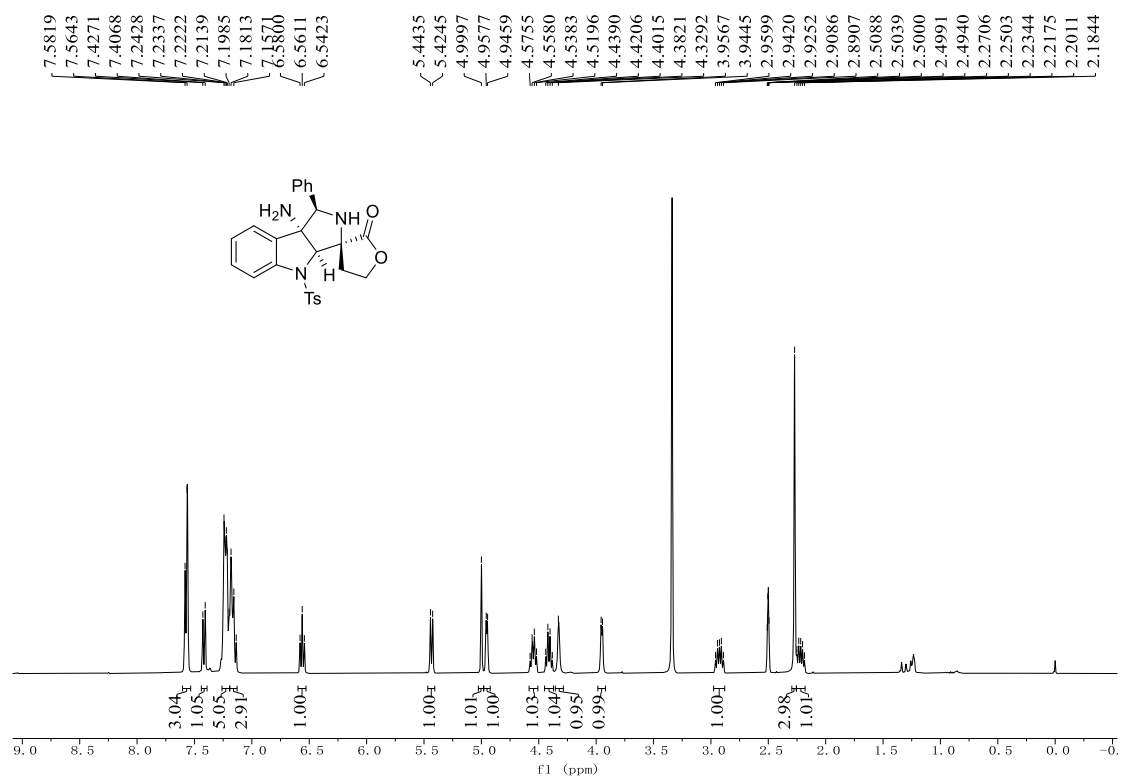
PeakTable

Detector A Ch1 254nm

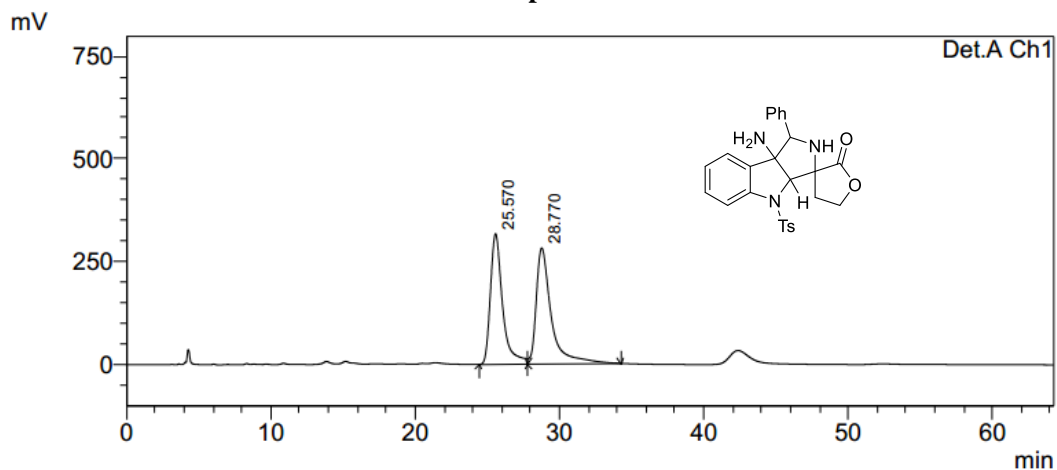
Peak#	Ret. Time	Area	Height	Area %
1	11.962	360315	11527	2.827
2	18.111	8050330	143178	63.165
3	24.250	2444755	35613	19.182
4	53.410	1889505	13576	14.826
Total		12744905		100.000



**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-d}_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-d}_6$ ) of 6**



# HPLC spectra of 6

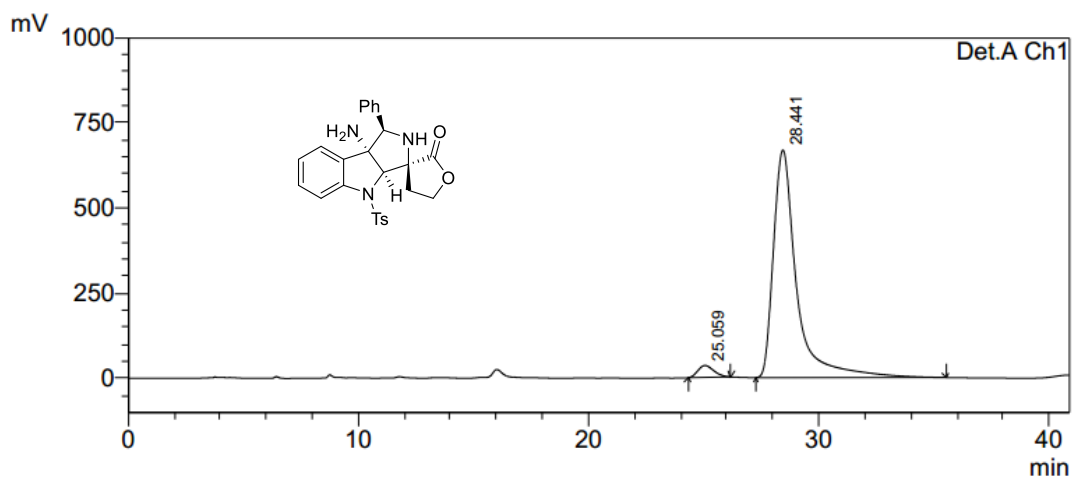


1 Det.A Ch1/254nm

PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	25.570	18684948	317684	47.597
2	28.770	20571504	282228	52.403
Total		39256452		100.000



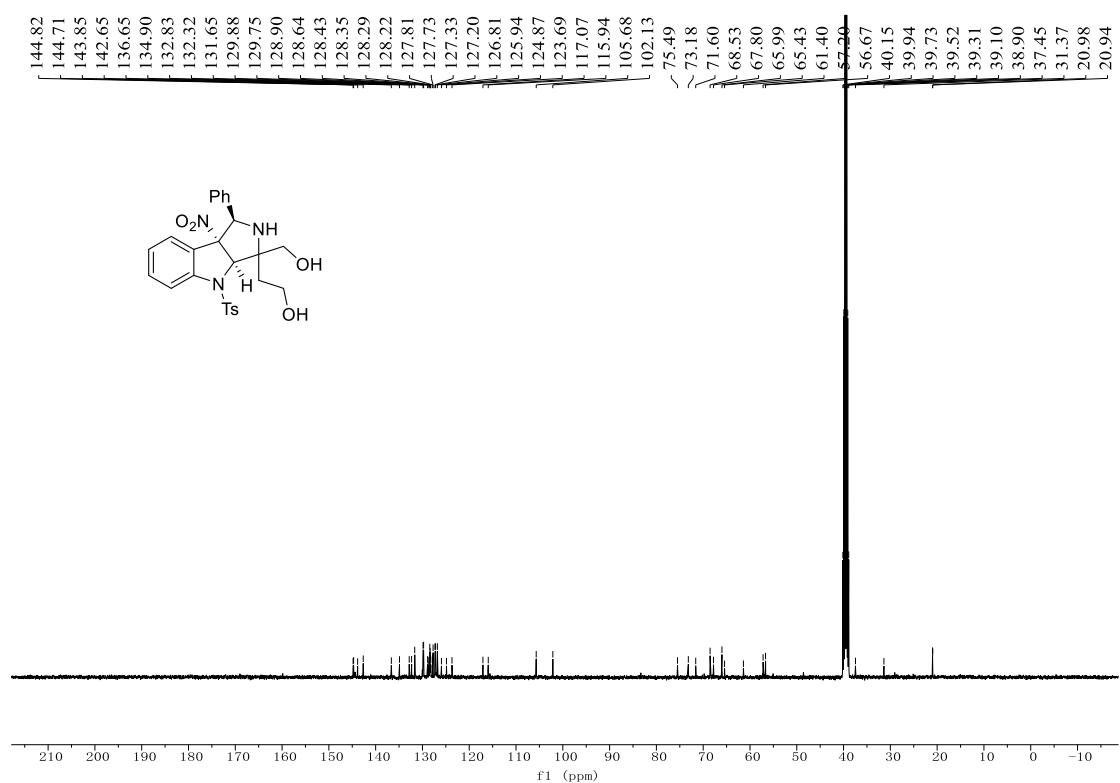
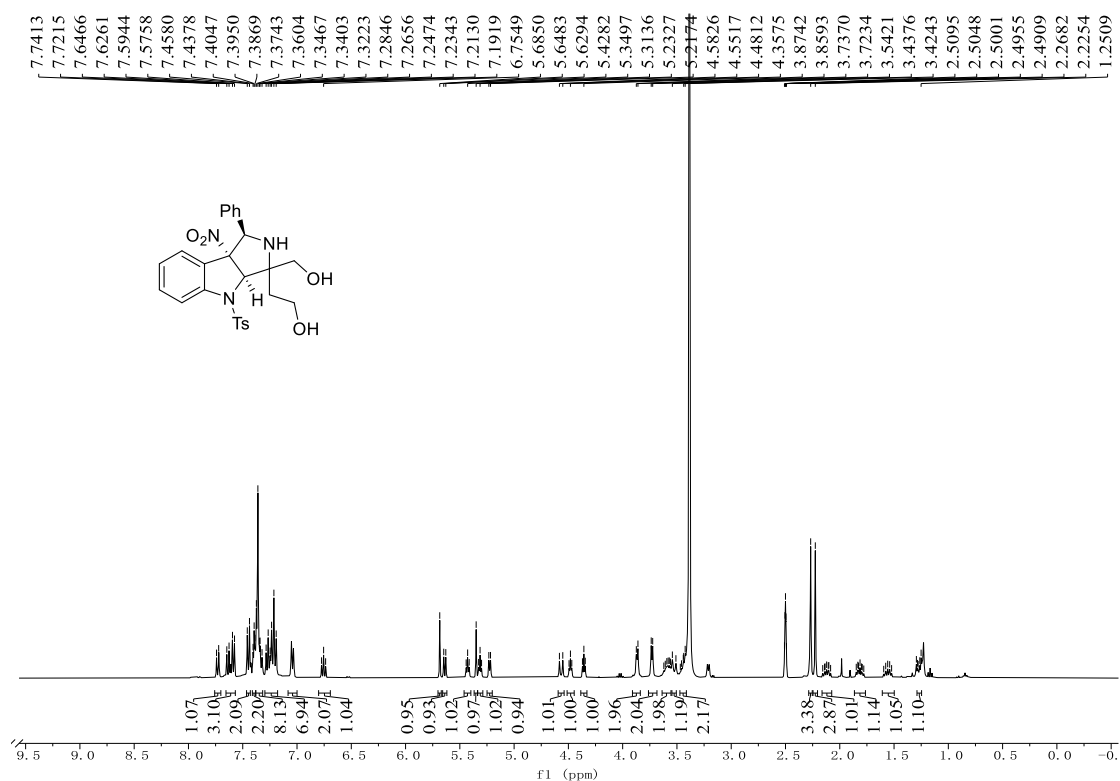
1 Det.A Ch1/254nm

PeakTable

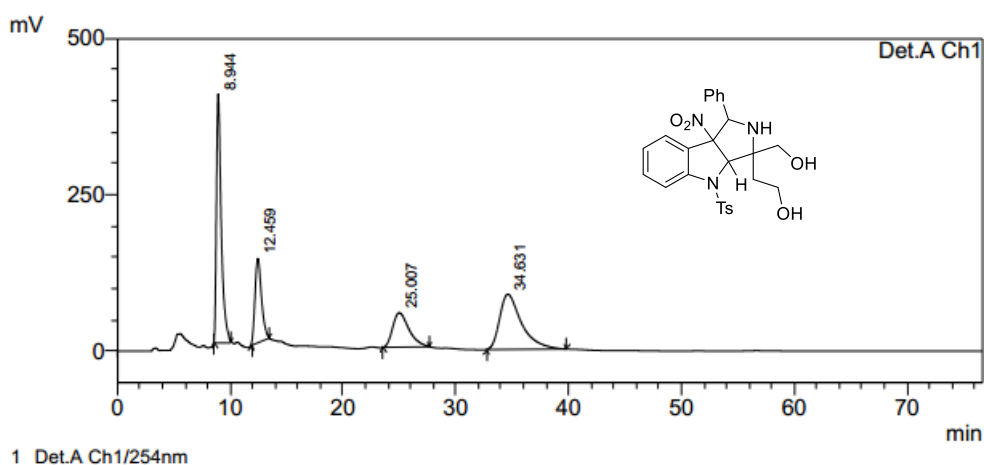
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	25.059	1698956	35151	3.499
2	28.441	46858420	667243	96.501
Total		48557376		100.000

**<sup>1</sup>H NMR (400 MHz, DMSO-d<sub>6</sub>) and <sup>13</sup>C NMR (101 MHz, DMSO-d<sub>6</sub>) of 7**



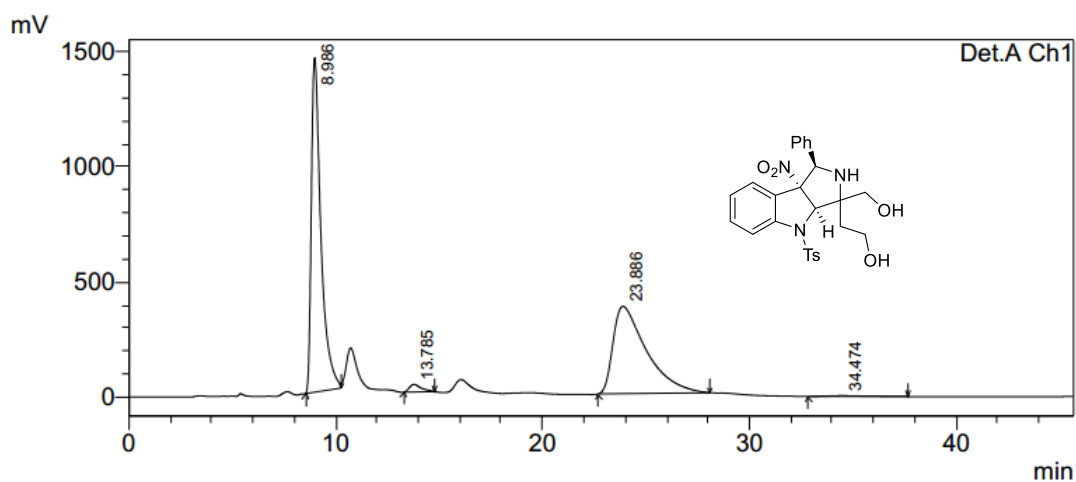
# HPLC spectra of 7



PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	8.944	11863673	397535	34.221
2	12.459	5395629	134414	15.564
3	25.007	5509068	54933	15.891
4	34.631	11899582	88181	34.324
Total		34667953		100.000

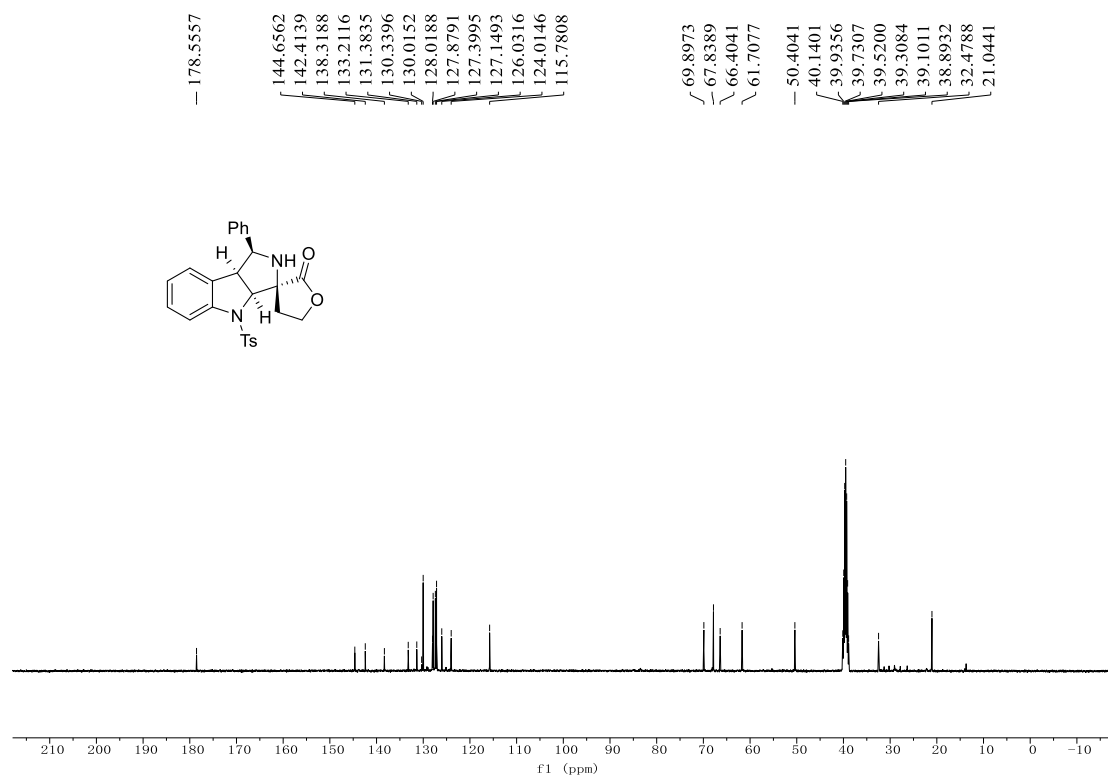
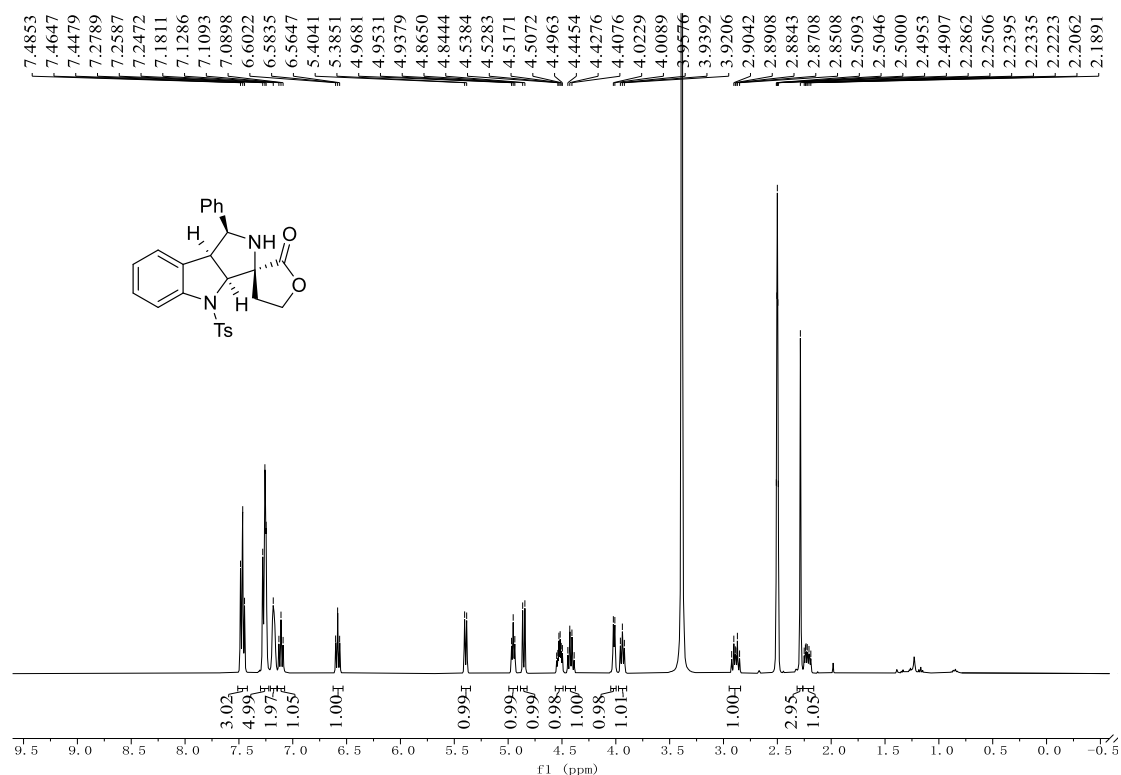


PeakTable

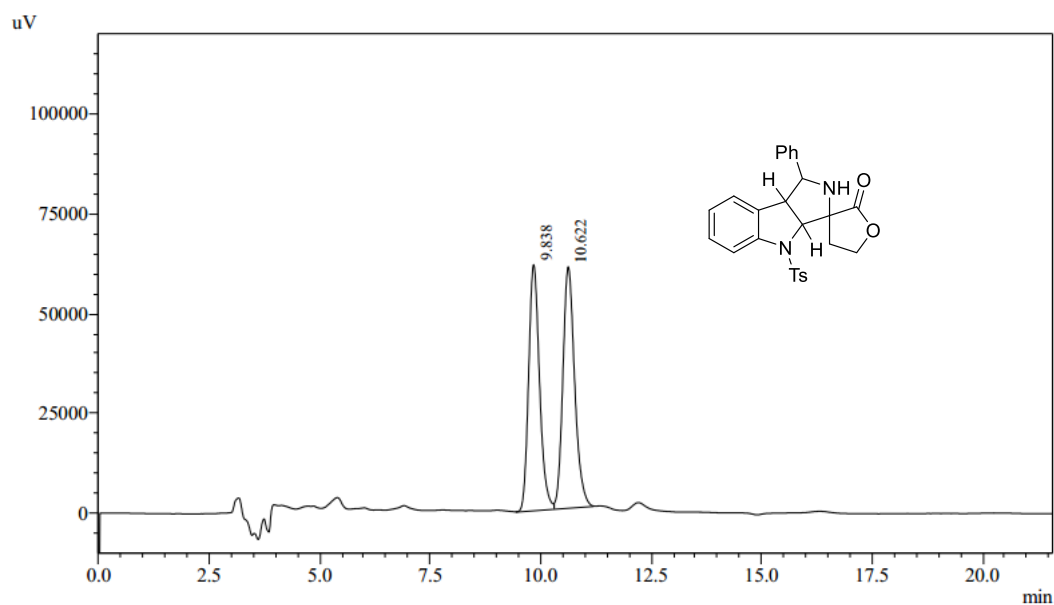
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	8.986	46798281	1454539	51.457
2	13.785	1360330	33236	1.496
3	23.886	42368173	378878	46.586
4	34.474	420003	3258	0.462
Total		90946787		100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-d}_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-d}_6$ ) of 8**



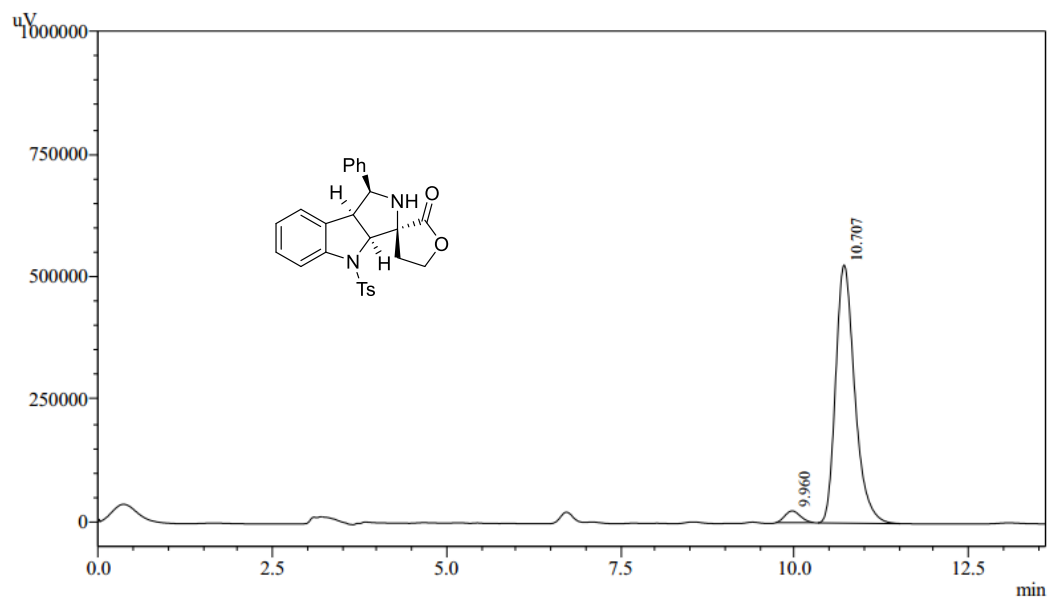
# HPLC spectra of 8



1 Det.A Ch1 / 254nm

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	9.838	1058308	61659	48.371	50.460
2	10.622	1129602	60535	51.629	49.540
Total		2187911	122194	100.000	100.000

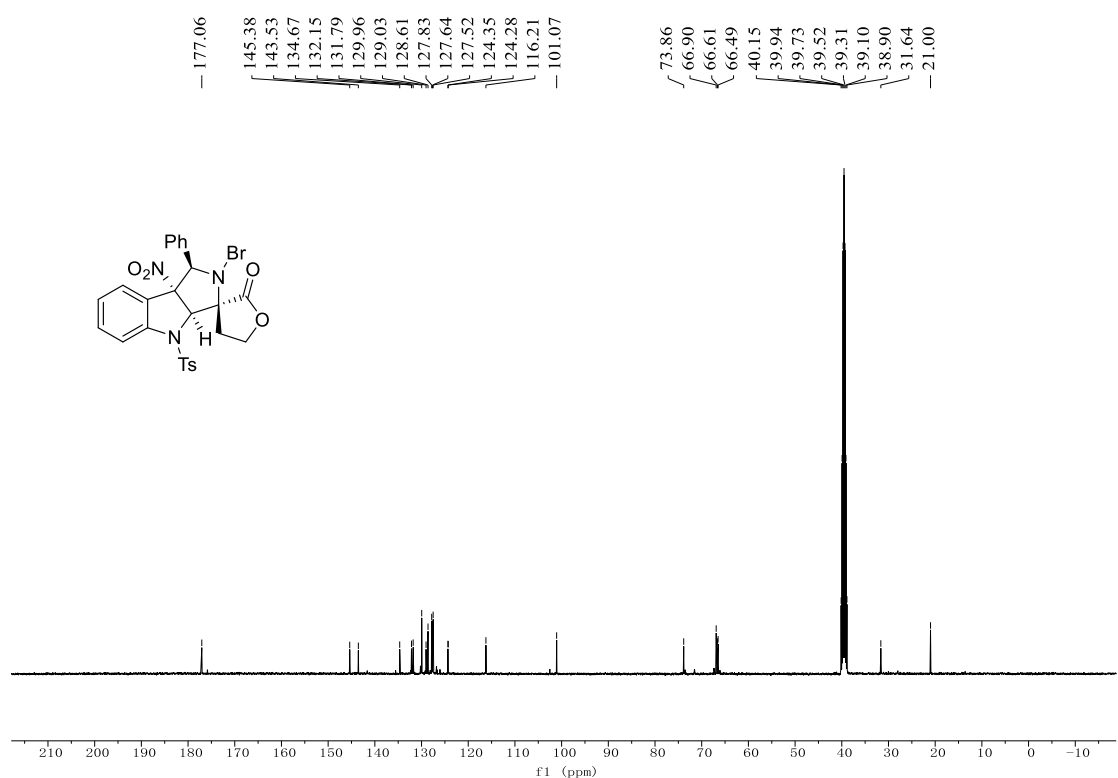
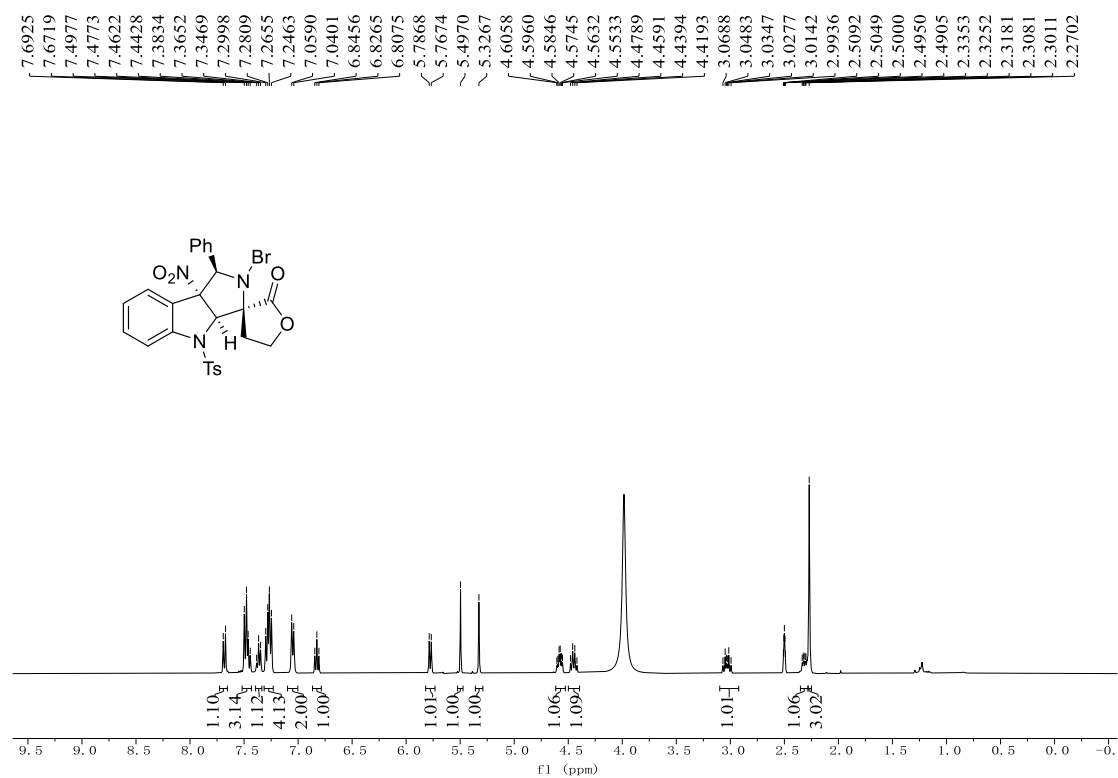


1 Det.A Ch1 / 254nm

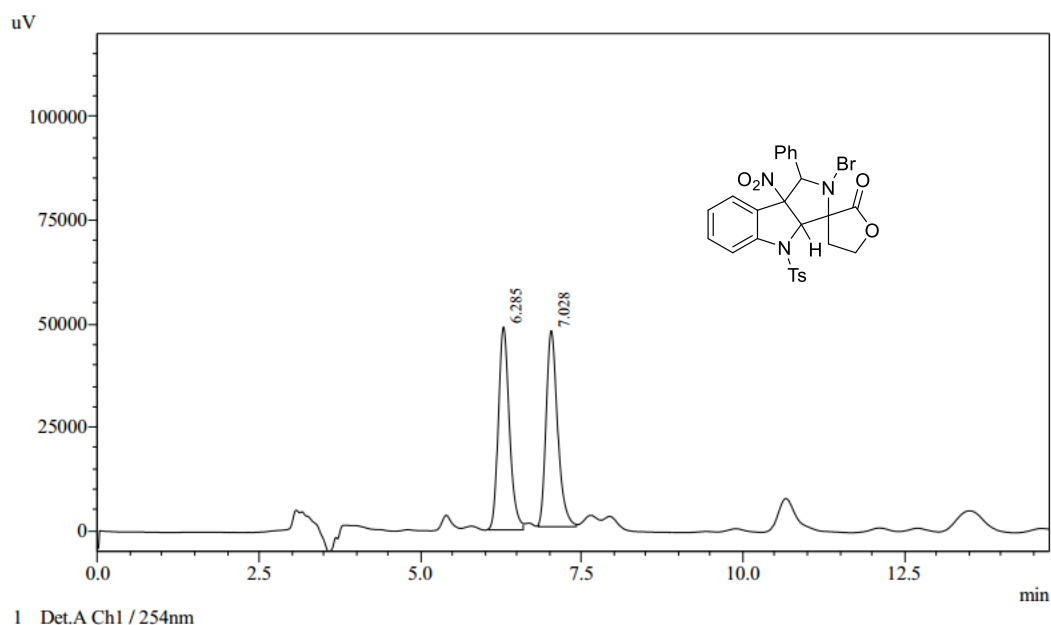
Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	9.960	365455	23760	3.507	4.317
2	10.707	10054332	526620	96.493	95.683
Total		10419787	550381	100.000	100.000

**$^1\text{H}$  NMR (400 MHz,  $\text{DMSO-d}_6$ ) and  $^{13}\text{C}$  NMR (101 MHz,  $\text{DMSO-d}_6$ ) of 9**

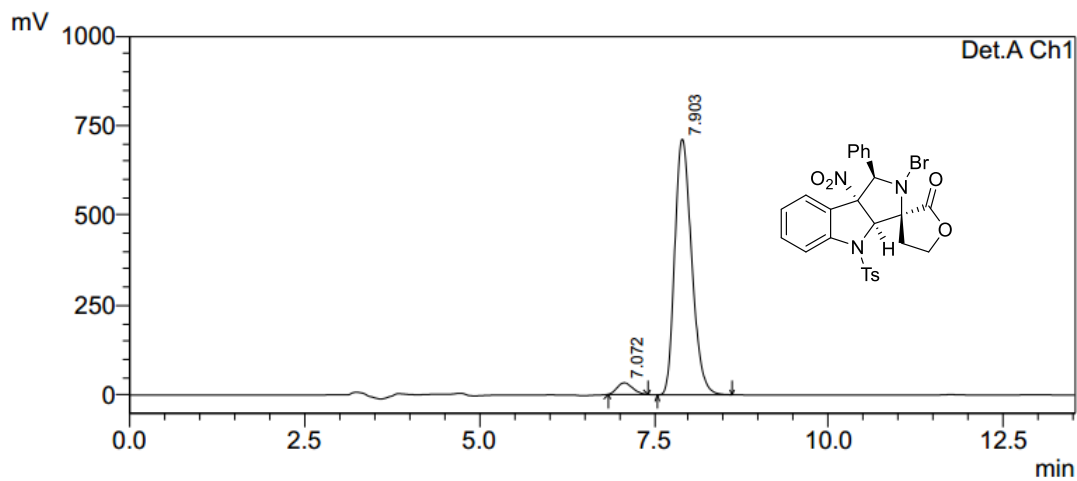


# HPLC spectra of 9



Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %	Height %
1	6.285	586234	49004	49.899	50.855
2	7.028	588599	47357	50.101	49.145
Total		1174833	96361	100.000	100.000



PeakTable

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Height	Area %
1	7.072	489816	32126	3.928
2	7.903	11980998	711253	96.072
Total		12470814		100.000