

*Supporting Information*

**Oxidative NHCs catalysis: direct activation of  $\beta$   $sp^3$  carbons of saturated  
acid chlorides**

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**Contents**

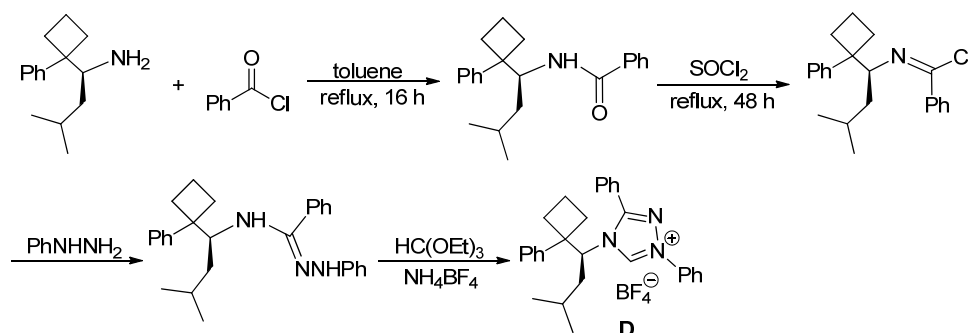
1. General information.....	S2
2. General procedures.....	S2
2.1 Synthesis of N-heterocyclic carbene catalyst <b>D</b> .....	S2
2.2 General procedure for the synthesis of compounds <b>3a–3f</b> and <b>3h–3p</b> .....	S3
2.3 General procedure for the synthesis of compounds <b>5a–5i</b> .....	S3
2.4 General procedure for the synthesis of compound <b>7a–7b</b> .....	S4
3. Characterization of compounds <b>3a–3f</b> and <b>3h–3p</b> .....	S4
4. Characterization of compounds <b>5a–5i</b> and <b>7a–7b</b> .....	S10
5. X-Ray crystal structure of compound <b>3b</b> .....	S14
6. NMR spectra of compounds <b>3a–3f</b> , <b>3h–3p</b> , <b>5a–5i</b> and <b>7a–7b</b> .....	S15
7. HPLC spectra of compounds <b>3a–3f</b> , <b>3h–3p</b> , <b>5a–5i</b> and <b>7a–7b</b> .....	S41

## 1. General information

$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR spectra were recorded on a Bruker AVANCE III 400 spectrometer using tetramethylsilane as internal reference, and chemical shifts ( $\delta$ ) and coupling constants ( $J$ ) were expressed in ppm and Hz, respectively. The HRMS analysis was obtained on a Bruker Apex II FT-ICR mass spectrometer with ESI ionization method. The *ee* value determination was carried out using HPLC with chiral Chirapak column on Agilent 1260 with a UV-detector. Optical rotation was measured by the Perkin Elmer 341 polarimeter. Melting points were taken on an X-4 melting point apparatus and were uncorrected. Dichloromethane was freshly distilled from phosphorous pentoxide. Toluene was freshly distilled from a deep-blue solution of sodium-benzophenone under nitrogen. DBU, TBD,  $\text{K}_2\text{CO}_3$ ,  $\text{Cs}_2\text{CO}_3$ , DIPEA and DABCO were purchased from commercial suppliers and used directly. All syntheses and manipulations were carried out under dry nitrogen atmosphere. Flash column chromatography was carried out utilizing 200–300 mesh silica gel.

## 2. General procedures

### 2.1 Synthesis of *N*-heterocyclic carbene catalyst **D**



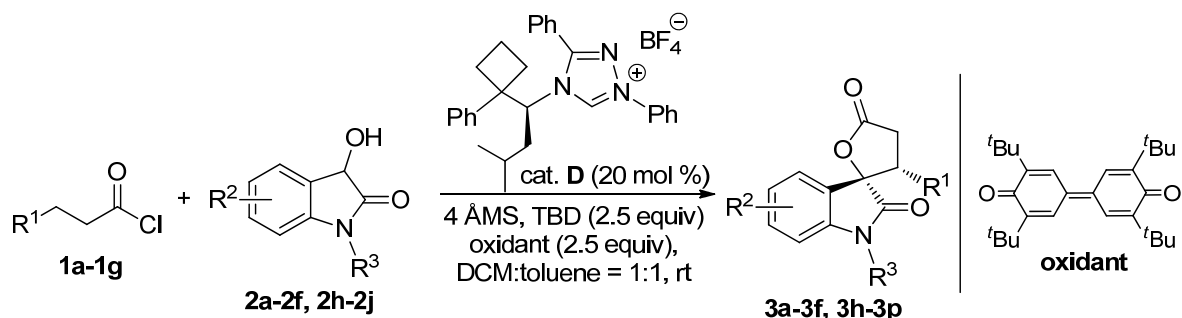
A flame-dried 100 mL round-bottom flask was charged with (*S*)-3-methyl-1-(1-phenylcyclobutyl)butan-1-amine (10 mmol) and reprocessed toluene (40 mL). Then benzoyl chloride (10 mmol) was added slowly. After that, the reaction mixture was refluxed and stirred for 16 h. Upon cooling, thionyl chloride (30 mmol) was added to the reaction, the reaction mixture was stirred at 85 °C for 48 h. After the reaction completed, the solvent was removed *in vacuo* and the remains was dissolved in THF. Keeping the solution stirred at 0 °C for 15 min before  $\text{NEt}_3$  (30 mmol) and phenylhydrazine (10 mmol) was added in one portion. The reaction mixture was stirred for 16 h at room temperature and then reflux for 5 h. The solvent was removed *in vacuo* and a solution of acetic acid (2%, 20 mL) was added. The mixture was heated to 75 °C and stirred for 1 h. After the reaction completed, the product was precipitated at an ice-water bath.

To a 50 mL round bottom flask equipped with a magnetic stir bar was added (*S*)-*N*-(3-methyl-1-(1-phenylcyclobutyl)butyl)-*N'*-phenylbenzohydrazonamide (5 mmol),  $\text{NH}_4^+\text{BF}_4^-$  (10 mmol) and of triethoxymethane (30 mmol). The reaction was carried out at 125 °C for 18 h. After the reaction was completed, the

clear dark solution was concentrated. The residue was purified by column chromatography using MeOH/DCM = 1/20 as eluent to yield the desired product **D** in 32% yield as light yellow solid.

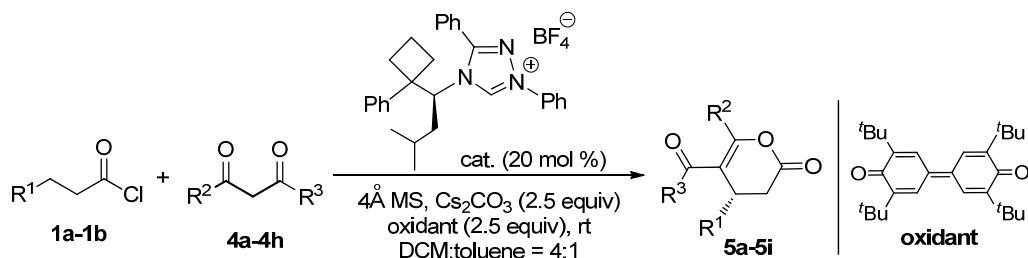
$^1\text{H}$  NMR (300 MHz, DMSO- $d_6$ )  $\delta$  10.33 (s, 1H), 7.96 – 7.47 (m, 10H), 7.38 – 7.28 (m, 3H), 7.09 – 6.96 (m, 2H), 4.74 (d,  $J$  = 10.1 Hz, 1H), 2.33 (d,  $J$  = 6.5 Hz, 2H), 2.13 (d,  $J$  = 5.5 Hz, 1H), 1.99 (t,  $J$  = 11.9 Hz, 1H), 1.92 – 1.65 (m, 3H), 1.59 – 1.42 (m, 2H), 0.92 (dd,  $J$  = 9.3, 6.1 Hz, 6H).  $^{13}\text{C}$  NMR (75 MHz, DMSO- $d_6$ )  $\delta$  155.11, 142.17, 140.04, 134.86, 132.48, 130.86, 130.05, 129.84, 129.57, 128.46, 127.52, 127.38, 122.68, 121.05, 65.14, 51.13, 31.29, 30.97, 23.35, 23.22, 21.31, 15.52.

## 2.2 Procedure for the synthesis of compounds 3a–3f and 3h–3p



A stirred mixture of 3-substituted propanoyl chloride (**1**) (0.25 mmol), oxidant (0.25 mmol, 102.2 mg), 4 Å MS (100 mg), *N*-heterocyclic carbene catalyst **D** (0.02 mmol, 10.2 mg), TBD (0.25 mmol, 34.8 mg), and anhydrous DCM:toluene (1:1) (1 mL) was stirred for 0.5 h under nitrogen atmosphere. Then, a solution of substrate **2** (0.1 mmol) in DCM:toluene (1:1) (0.5 mL) was added and stirred at room temperature. The reaction was monitored by TLC. When the substrate **2** was disappeared, the reaction was quenched by water (2 mL) and the aqueous layer was extracted with ethyl acetate (5 mL×3). The combined organic layer was dried over anhydrous MgSO<sub>4</sub>. After removal of the solvent under reduced pressure, the crude residue was purified by flash column chromatography on silica gel using PE/EA (5:1) to afford the desired products **3**.

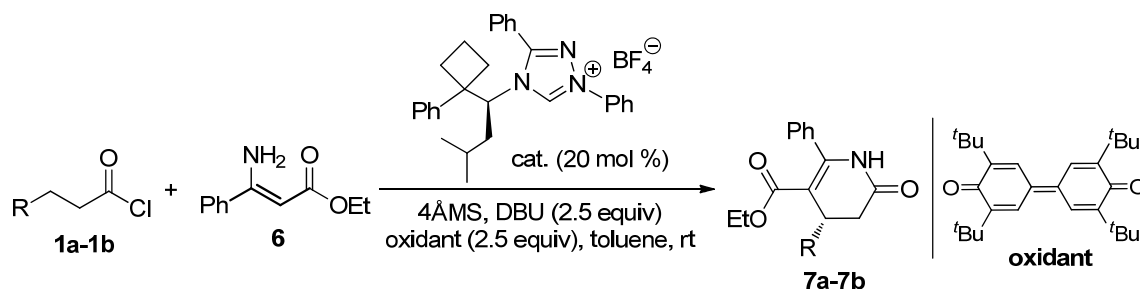
## 2.3 Procedure for the synthesis of compounds 5a–5i



A stirred mixture of 3-substituted propanoyl chloride (**1a**) (0.25 mmol, 42.2 mg), oxidant (0.25 mmol, 102.2 mg), 4 Å MS (100 mg), *N*-heterocyclic carbene catalyst **D** (0.02 mmol, 10.2 mg), Cs<sub>2</sub>CO<sub>3</sub> (0.25 mmol, 81.5 mg), and anhydrous DCM:toluene (4:1) (1 mL) was stirred for 0.5 h under nitrogen atmosphere. Then,

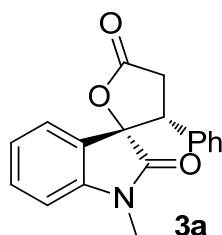
a solution of substrate **4** (0.1 mmol) in DCM:toluene (4:1) (0.5 mL) was added, and the reaction was stirred for 48 h at room temperature. The reaction was quenched by water (2 mL), and the aqueous layer was extracted with ethyl acetate (5 mL×3). The combined organic layer was dried over anhydrous MgSO<sub>4</sub>. After removal of the solvent under reduced pressure, the crude residue was purified by flash column chromatography on silica gel using PE/EA (5:1) to afford the desired products **5**.

## 2.4 Procedure for the synthesis of compound 7a–7b



A stirred mixture of 3-phenylpropanoyl chloride (**1a**) (0.25 mmol, 42.2 mg), oxidant (0.25 mmol, 102.2 mg), 4Å MS (100 mg), *N*-heterocyclic carbene catalyst **D** (0.02 mmol, 10.2 mg), DBU (0.25 mmol, 37.4 μL), and anhydrous toluene (1 mL) was stirred for 0.5 h under nitrogen atmosphere. Then, a solution of enamine **6** (0.1 mmol, 19.1 mg) in toluene (0.5 mL) was added, and the reaction was stirred for 36 h at room temperature. The reaction was quenched by water (2 mL), and the aqueous layer was extracted with ethyl acetate (5 mL×3). The combined organic layer was dried over anhydrous MgSO<sub>4</sub>. After removal of the solvent under reduced pressure, the crude residue was purified by flash column chromatography on silica gel using PE/EA (5:1) to afford the desired product **7a**.

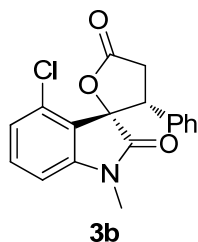
## 3. Characterization of compounds 3a–3f and 3h–3p



### (2*S*, 3*R*)-1'-methyl-3-phenyl-3,4-dihydro-5*H*-spiro[furan-2,3'-indoline]-2',5-dione (**3a**)

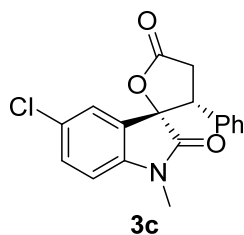
white solid, mp 148–151 °C,  $[\alpha]_D^{20}$  –99 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.54 (d, *J* = 7.2 Hz, 1H), 7.41–7.37 (m, 1H), 7.22–7.14 (m, 4H), 6.93 (d, *J* = 7.2 Hz, 2H), 6.67 (d, *J* = 7.6 Hz, 1H), 4.07 (dd, *J* = 14.0, 8.0 Hz, 1H), 3.82 (dd, *J* = 16.8, 13.6 Hz, 1H), 2.91 (dd, *J* = 16.8, 8.0 Hz, 1H), 2.82 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 174.79, 172.57, 144.32, 132.07, 131.27, 128.42, 128.26, 127.54, 124.73, 124.12, 123.47, 108.58, 86.43, 50.99, 32.18, 25.78. HRMS (ESI): Exact Mass Calcd. for C<sub>18</sub>H<sub>16</sub>NO<sub>3</sub>

(M+H)<sup>+</sup>: 294.1125, Found: 294.1128. HPLC (Chiralpak AD–H column, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, retention time:  $t_{\text{major}} = 18.122$  min,  $t_{\text{minor}} = 36.708$  min, 96% ee).



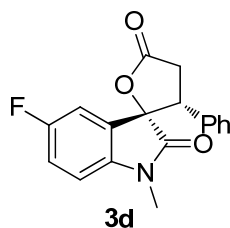
**(2S, 3R)-4'-chloro-1'-methyl-3-phenyl-3,4-dihydro-5H-spiro[furan-2,3'-indoline]-2',5-dione (3b)**

White solid, mp 127 – 130 °C,  $[\alpha]_{\text{D}}^{20} -95$  (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.32 (t,  $J = 8.4$  Hz, 1H), 7.22 – 7.16 (m, 3H), 7.13 (d,  $J = 8.0$  Hz, 1H), 6.96 (d,  $J = 8.0$  Hz, 2H), 6.57 (d,  $J = 7.6$  Hz, 1H), 4.70 (dd,  $J = 13.6, 8.4$  Hz, 1H), 3.80 (dd,  $J = 16.8, 13.6$  Hz, 1H), 2.92 (dd,  $J = 16.8, 8.0$  Hz, 1H), 2.78 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  174.35, 171.95, 146.00, 132.36, 132.20, 131.96, 128.46, 128.31, 127.59, 124.50, 120.70, 107.06, 86.73, 46.06, 31.33, 25.92. HRMS (ESI): Exact Mass Calcd. for C<sub>18</sub>H<sub>15</sub>ClNO<sub>3</sub> (M+H)<sup>+</sup>: 328.0735, Found: 328.0731. HPLC (Chiralpak AD–H column, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, retention time:  $t_{\text{major}} = 27.951$  min,  $t_{\text{minor}} = 46.048$  min, 95% ee).



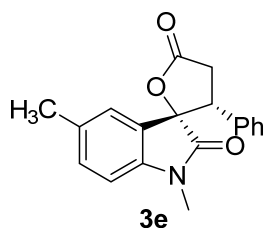
**(2S, 3R)-5'-chloro-1'-methyl-3-phenyl-3,4-dihydro-5H-spiro[furan-2,3'-indoline]-2',5-dione (3c)**

white solid, mp 133 – 135 °C,  $[\alpha]_{\text{D}}^{20} -110$  (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.53 (d,  $J = 2.0$  Hz, 1H), 7.37 – 7.35 (d,  $J = 8.4, 2.0$  Hz, 1H), 7.24 – 7.16 (m, 3H), 6.95 (d,  $J = 7.2$  Hz, 2H), 6.60 (d,  $J = 8.4$  Hz, 1H), 4.04 (dd,  $J = 13.6, 8.0$  Hz, 1H), 3.79 (dd,  $J = 16.8, 14.0$  Hz, 1H), 2.92 (dd,  $J = 16.8, 8.0$  Hz, 1H), 2.80 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  174.24, 172.22, 142.84, 131.67, 131.19, 128.93, 128.54, 128.48, 127.54, 126.47, 124.64, 109.61, 86.07, 51.13, 32.01, 25.91. HRMS (ESI): Exact Mass Calcd. for C<sub>18</sub>H<sub>15</sub>ClNO<sub>3</sub> (M+H)<sup>+</sup>: 328.0735, Found: 328.0740. HPLC (Chiralpak AD–H column, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, retention time:  $t_{\text{major}} = 8.943$  min,  $t_{\text{minor}} = 14.912$  min, 92% ee).



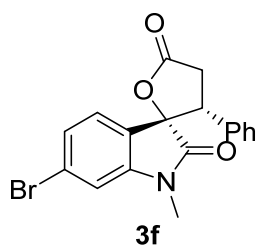
**(2S, 3R)-5'-fluoro-1'-methyl-3-phenyl-3,4-dihydro-5H-spiro[furan-2,3'-indoline]-2',5-dione (3d)**

white solid, mp 99 – 102 °C,  $[\alpha]_D^{20}$  -119 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.30 (dd,  $J$  = 7.2, 2.4 Hz, 1H), 7.24 – 7.16 (m, 3H), 7.12 – 7.07 (m, 1H), 6.95 (d,  $J$  = 7.2 Hz, 2H), 6.60 (dd,  $J$  = 8.8, 4.0 Hz, 1H), 4.03 (dd,  $J$  = 13.6, 8.0 Hz, 1H), 3.81 (dd,  $J$  = 16.8, 13.6 Hz, 1H), 2.92 (dd,  $J$  = 16.8, 7.6 Hz, 1H), 2.80 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 174.34, 172.38, 160.70, 158.29, 140.25, 131.70, 128.52, 128.46, 127.54, 126.35, 126.27, 117.74, 117.51, 112.44, 112.19, 109.40, 109.32, 86.27, 51.23, 32.05, 25.93. HRMS (ESI): Exact Mass Calcd. for C<sub>18</sub>H<sub>15</sub>FNO<sub>3</sub> (M+H)<sup>+</sup>: 312.1035, Found: 312.1037. HPLC (Chiralpak AD–H column, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, retention time:  $t_{\text{major}}$  = 18.068 min,  $t_{\text{minor}}$  = 24.745 min, 93% ee).



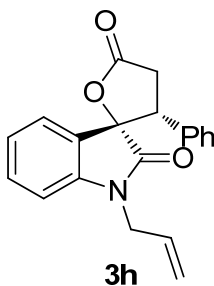
**(2*S*, 3*R*)-1',5'-dimethyl-3-phenyl-3,4-dihydro-5*H*-spiro[furan-2,3'-indoline]-2',5-dione (3e)**

white solid, mp 127 – 130 °C,  $[\alpha]_D^{20}$  -132 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.36 (s, 1H), 7.22 – 7.14 (m, 4H), 6.93 (d,  $J$  = 7.2 Hz, 2H), 6.55 (d,  $J$  = 8.0 Hz 1H), 4.06 (dd,  $J$  = 13.6, 8.0 Hz, 1H), 3.81 (dd,  $J$  = 16.8, 13.6 Hz, 1H), 2.90 (dd,  $J$  = 16.8, 8.0 Hz, 1H), 2.79 (s, 3H), 2.41 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 174.80, 172.51, 141.94, 133.17, 132.24, 131.50, 128.38, 128.19, 127.52, 124.81, 124.74, 108.33, 86.55, 50.87, 32.21, 25.78, 21.10. HRMS (ESI): Exact Mass Calcd. for C<sub>19</sub>H<sub>18</sub>NO<sub>3</sub> (M+H)<sup>+</sup>: 308.1281, Found: 308.1277. HPLC (Chiralpak AD–H column, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, retention time:  $t_{\text{major}}$  = 18.146 min,  $t_{\text{minor}}$  = 36.620 min, 97% ee).



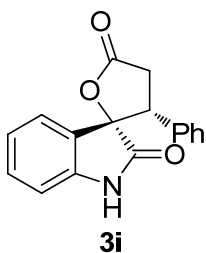
**(2*S*, 3*R*)-6'-bromo-1'-methyl-3-phenyl-3,4-dihydro-5*H*-spiro[furan-2,3'-indoline]-2',5-dione (3f)**

white solid, mp 189 – 192 °C,  $[\alpha]_D^{20}$  -131 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.40 (d,  $J$  = 8.0 Hz, 1H), 7.35 (dd,  $J$  = 8.0, 1.6 Hz, 1H), 7.23 – 7.17 (m, 3H), 6.94 (d,  $J$  = 8.0 Hz, 2H), 6.83 (d,  $J$  = 1.6 Hz, 1H), 4.04 (dd,  $J$  = 13.6, 8.0 Hz, 1H), 3.80 (dd,  $J$  = 16.8, 13.6 Hz, 1H), 2.92 (dd,  $J$  = 16.8, 8.0 Hz, 1H), 2.80 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 174.44, 172.44, 145.51, 131.65, 128.58, 128.47, 127.50, 126.35, 125.38, 125.11, 123.63, 112.24, 85.95, 50.90, 32.04, 25.92. HRMS (ESI): Exact Mass Calcd. for C<sub>18</sub>H<sub>15</sub>BrNO<sub>3</sub> (M+H)<sup>+</sup>: 372.0230, Found: 372.0238. HPLC (Chiralpak AD–H column, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, retention time:  $t_{\text{major}}$  = 8.964 min,  $t_{\text{minor}}$  = 12.685 min, 97% ee).



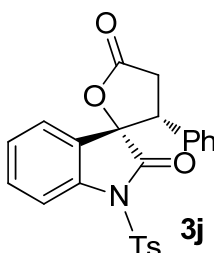
**(2S, 3R)-1'-allyl-3-phenyl-3,4-dihydro-5H-spiro[furan-2,3'-indoline]-2',5-dione (3h)**

white solid, mp 163 – 165 °C,  $[\alpha]_D^{20}$  –113 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.56 (d, *J* = 7.2 Hz, 1H), 7.35 (t, *J* = 7.6 Hz, 1H), 7.23 – 7.15 (m, 4H), 6.95 (d, *J* = 7.2 Hz, 2H), 6.63 (d, *J* = 8.0 Hz, 1H), 5.26 – 5.16 (m, 1H), 4.82 (d, *J* = 10.4 Hz, 1H), 4.35 (d, *J* = 17.2 Hz, 1H), 4.28 (dd, *J* = 4.0, 2.0 Hz, 1H), 4.24 (dd, *J* = 4.0, 2.0 Hz, 1H), 4.11 (dd, *J* = 14.0, 8.0 Hz, 1H), 3.85 (dd, *J* = 16.8, 14.0 Hz, 1H), 3.71 (dd, *J* = 16.8, 5.6 Hz, 1H), 2.92 (dd, *J* = 16.8, 8.0 Hz, 1H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): δ 174.78, 172.33, 143.57, 131.94, 131.16, 129.96, 128.54, 128.30, 127.76, 124.61, 124.17, 123.41, 116.98, 109.52, 86.41, 51.10, 41.95, 32.06. HRMS (ESI): Exact Mass Calcd. for C<sub>20</sub>H<sub>18</sub>NO<sub>3</sub> (M+H)<sup>+</sup>: 320.1281, Found: 320.1285. HPLC (Chiralpak AD–H column, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, retention time: *t*<sub>minor</sub> = 15.607 min, *t*<sub>major</sub> = 17.554 min, 94% ee).



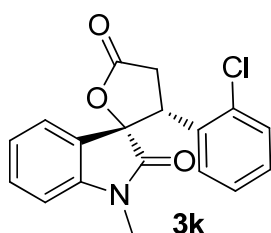
**(2S, 3R)-3-phenyl-3,4-dihydro-5H-spiro[furan-2,3'-indoline]-2',5-dione (3i)**

white solid, mp 111 – 114 °C,  $[\alpha]_D^{20}$  –89 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.54 (d, *J* = 7.2 Hz, 1H), 7.35 – 7.31 (m, 1H), 7.23 – 7.16 (m, 4H), 7.04 (br s, 1H), 6.97 (d, *J* = 7.2 Hz, 2H), 6.71 (d, *J* = 7.6 Hz, 1H), 4.09 (dd, *J* = 13.6, 8.0 Hz, 1H), 3.79 (dd, *J* = 16.8, 13.6 Hz, 1H), 2.92 (dd, *J* = 16.8, 8.0 Hz, 1H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 174.67, 173.98, 141.28, 132.00, 131.31, 128.62, 128.37, 127.65, 125.07, 124.67, 123.58, 110.38, 86.32, 50.94, 32.11. HRMS (ESI): Exact Mass Calcd. for C<sub>17</sub>H<sub>14</sub>NO<sub>3</sub> (M+H)<sup>+</sup>: 280.0968, Found: 280.0964. HPLC (Chiralpak AD–H column, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, retention time: *t*<sub>major</sub> = 8.706 min, *t*<sub>minor</sub> = 24.000 min, 95% ee).



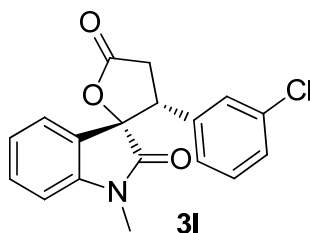
**(2*S*, 3*R*)-3-phenyl-1'-tosyl-3,4-dihydro-5*H*-spiro[furan-2,3'-indoline]-2',5-dione (3j)**

white solid, mp 202 – 204 °C,  $[\alpha]_D^{20}$  –102 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.75 (d, *J* = 8.0 Hz, 1H), 7.72 (d, *J* = 8.4 Hz, 2H), 7.55 (d, *J* = 7.6 Hz, 1H), 7.49 – 7.45 (m, 1H), 7.34 (t, *J* = 7.6 Hz, 1H), 7.23 (d, *J* = 8.4 Hz, 2H), 7.19 (d, *J* = 7.6 Hz, 1H), 7.11 (t, *J* = 7.6 Hz, 2H), 6.81 (d, *J* = 7.6 Hz, 2H), 4.01 (dd, *J* = 13.6, 8.0 Hz, 1H), 3.67 (dd, *J* = 17.2, 13.6 Hz, 1H), 2.90 (dd, *J* = 17.2, 8.0 Hz, 1H), 2.42 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 173.80, 171.40, 145.87, 139.94, 134.46, 131.97, 130.57, 129.90, 128.81, 128.68, 127.77, 127.29, 125.67, 124.52, 123.89, 113.79, 85.77, 51.94, 31.66, 21.70. HRMS (ESI): Exact Mass Calcd. for C<sub>24</sub>H<sub>20</sub>NO<sub>5</sub>S (M+H)<sup>+</sup>: 434.1057, Found: 434.1066. HPLC (Chiralpak AD–H column, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, retention time: *t*<sub>major</sub> = 13.383 min, *t*<sub>minor</sub> = 18.311 min, 87% ee).



**(2*S*, 3*R*)-3-(2-chlorophenyl)-1'-methyl-3,4-dihydro-5*H*-spiro[furan-2,3'-indoline]-2',5-dione (3k)**

white solid, mp 122 – 125 °C,  $[\alpha]_D^{20}$  –141 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.63 (d, *J* = 8.0 Hz, 1H), 7.57 (d, *J* = 7.6 Hz, 1H), 7.36 – 7.32 (m, 1H), 7.25 – 7.21 (m, 1H), 7.19 – 7.12 (m, 3H), 6.65 (d, *J* = 7.6 Hz, 1H), 4.83 (dd, *J* = 13.6, 8.4 Hz, 1H), 3.66 (dd, *J* = 16.8, 13.6 Hz, 1H), 2.97 (dd, *J* = 16.8, 8.4 Hz, 1H), 2.91 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 174.31, 172.93, 143.91, 134.91, 131.23, 130.18, 129.83, 129.34, 129.03, 126.98, 125.67, 123.82, 123.22, 108.47, 86.37, 45.24, 34.21, 25.98. HRMS (ESI): Exact Mass Calcd. for C<sub>18</sub>H<sub>15</sub>ClNO<sub>3</sub> (M+H)<sup>+</sup>: 328.0735, Found: 328.0739. HPLC (Chiralpak AD–H column, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, retention time: *t*<sub>minor</sub> = 6.835 min, *t*<sub>major</sub> = 10.468 min, 90% ee).

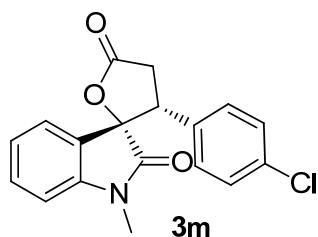


**(2*S*, 3*R*)-3-(3-chlorophenyl)-1'-methyl-3,4-dihydro-5*H*-spiro[furan-2,3'-indoline]-2',5-dione (3l)**

white solid, mp 134 – 137 °C,  $[\alpha]_D^{20}$  –127 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>),  $[\alpha]_D^{20}$  –97 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.53 (d, *J* = 7.2 Hz, 1H), 7.42 (t, *J* = 8.0 Hz, 1H), 7.24 – 7.18 (m, 2H), 7.11 (t, *J* = 8.0 Hz, 1H), 6.89 (s, 1H), 6.84 (d, *J* = 7.6 Hz, 1H), 6.72 (d, *J* = 7.6 Hz, 1H), 4.04 (dd, *J* = 14.0, 7.6 Hz, 1H), 3.77 (dd, *J* = 16.8, 14.0 Hz, 1H), 2.92 (dd, *J* = 16.8, 8.0 Hz, 1H), 2.87 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 174.20, 172.31, 144.28, 134.39, 134.35, 131.55, 129.70, 128.50, 127.83, 125.67, 124.35, 124.12, 123.68, 108.77, 86.05, 50.42, 32.17, 25.90. HRMS (ESI): Exact Mass Calcd. for C<sub>18</sub>H<sub>15</sub>ClNO<sub>3</sub> (M+H)<sup>+</sup>: 328.0735, Found:

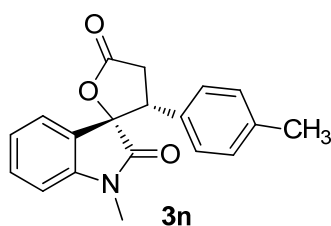


328.0732. HPLC (Chiralpak AD-H column, *n*-hexane/*i*-PrOH = 90/10, flow rate = 1.0 mL/min, retention time:  $t_{\text{major}} = 47.098$  min,  $t_{\text{minor}} = 52.457$  min, 94% ee).



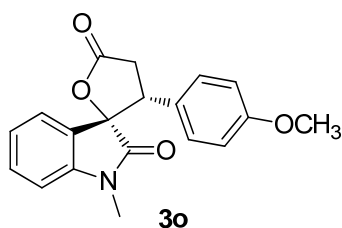
**(2S, 3R)-3-(4-chlorophenyl)-1'-methyl-3,4-dihydro-5H-spiro[furan-2,3'-indoline]-2',5-dione (3m)**

white solid, mp 193 – 196 °C,  $[\alpha]_{\text{D}}^{20} -133$  (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.53 (d,  $J = 7.2$  Hz, 1H), 7.42 – 7.38 (m, 1H), 7.21 (t,  $J = 7.6$  Hz, 1H), 7.14 (d,  $J = 8.8$  Hz, 2H), 6.87 (d,  $J = 8.4$  Hz, 2H), 6.70 (d,  $J = 8.0$  Hz, 1H), 4.04 (dd,  $J = 13.6, 8.0$  Hz, 1H), 3.76 (dd,  $J = 16.8, 14.0$  Hz, 1H), 2.91 (dd,  $J = 16.8, 8.0$  Hz, 1H), 2.86 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 174.31, 172.40, 144.27, 134.23, 131.46, 130.67, 128.96, 128.64, 124.36, 124.12, 123.60, 108.76, 86.11, 50.31, 32.27, 25.90. HRMS (ESI): Exact Mass Calcd. for C<sub>18</sub>H<sub>15</sub>ClNO<sub>3</sub> (M+H)<sup>+</sup>: 328.0735, Found: 328.0730. HPLC (Chiralpak AD-H column, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, retention time:  $t_{\text{major}} = 25.633$  min,  $t_{\text{minor}} = 38.990$  min, 94% ee).



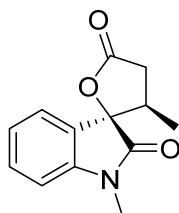
**(2S, 3R)-1'-methyl-3-(*p*-tolyl)-3,4-dihydro-5H-spiro[furan-2,3'-indoline]-2',5-dione (3n)**

white solid, mp 148 – 151 °C,  $[\alpha]_{\text{D}}^{20} -143$  (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.52 (d,  $J = 7.2$  Hz, 1H), 7.40 – 7.36 (m, 1H), 7.21 – 7.17 (m, 1H), 6.96 (d,  $J = 8.0$  Hz, 2H), 6.81 (d,  $J = 8.4$  Hz, 2H), 6.67 (d,  $J = 8.0$  Hz, 1H), 4.04 (dd,  $J = 13.6, 8.0$  Hz, 1H), 3.79 (dd,  $J = 16.8, 13.6$  Hz, 1H), 2.89 (dd,  $J = 16.8, 8.0$  Hz, 1H), 2.84 (s, 3H), 2.24 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 174.89, 172.67, 144.36, 137.98, 131.19, 129.10, 128.99, 127.39, 124.84, 124.11, 123.41, 108.57, 86.41, 50.63, 32.36, 25.82, 20.97. HRMS (ESI): Exact Mass Calcd. for C<sub>19</sub>H<sub>18</sub>NO<sub>3</sub> (M+H)<sup>+</sup>: 308.1281, Found: 308.1288. HPLC (Chiralpak AD-H column, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, retention time:  $t_{\text{major}} = 8.964$  min,  $t_{\text{minor}} = 12.685$  min, 97% ee).



**(2S, 3R)-3-(4-methoxyphenyl)-1'-methyl-3,4-dihydro-5H-spiro[furan-2,3'-indoline]-2',5-dione (3o)**

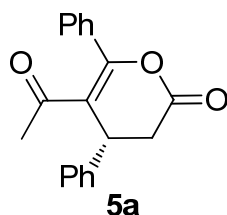
white solid, mp 172 – 174 °C,  $[\alpha]_D^{20}$  –101 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.52 (d, *J* = 7.6 Hz, 1H), 7.40 – 7.36 (m, 1H), 7.19 (t, *J* = 7.6 Hz, 1H), 6.85 (d, *J* = 8.8 Hz, 2H), 6.69 – 6.66 (m, 3H), 4.02 (dd, *J* = 14.0, 8.0 Hz, 1H), 3.80 – 3.72 (m, 4H), 2.91 – 2.85 (m, 4H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 174.86, 172.71, 159.39, 144.34, 131.20, 128.68, 124.81, 124.09, 123.92, 123.42, 113.77, 108.57, 86.44, 55.15, 50.36, 32.46, 25.85. HRMS (ESI): Exact Mass Calcd. for C<sub>19</sub>H<sub>18</sub>NO<sub>4</sub> (M+H)<sup>+</sup>: 324.1230, Found: 324.1233. HPLC (Chiralpak AD–H column, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, retention time: *t*<sub>major</sub> = 13.343 min, *t*<sub>minor</sub> = 18.061 min, 95% ee).



**(2R, 3R)-1',3-dimethyl-3H-spiro[furan-2,3'-indoline]-2',5(4H)-dione (3p)**

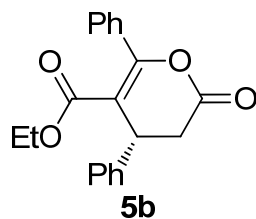
Off-white solid,  $[\alpha]_D^{20}$  +107 (c 0.31, CHCl<sub>3</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.42 (td, *J* = 8.0, 1.2 Hz, 1H), 7.35 (d, *J* = 7.6 Hz, 1H), 7.14 (td, *J* = 7.6, 0.4 Hz, 1H), 6.86 (d, *J* = 8.0 Hz, 1H), 3.20 (s, 3H), 3.03 (dd, *J* = 16.4, 12.8 Hz, 1H), 2.94 – 2.84 (m, 1H), 2.72 (dd, *J* = 16.4, 8.0 Hz, 1H), 1.00 (d, *J* = 6.4 Hz, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 175.40, 173.05, 144.57, 131.15, 124.84, 124.22, 123.49, 108.60, 86.07, 40.26, 34.98, 26.18, 12.58. HRMS (ESI): Exact Mass Calcd. for C<sub>13</sub>H<sub>13</sub>NO<sub>3</sub>Na (M+Na)<sup>+</sup>: 254.0788, Found: 254.0791. HPLC (Chiralpak AD–H column, *n*-hexane/*i*-PrOH = 70/30, flow rate = 1.0 mL/min, retention time: *t*<sub>minor</sub> = 19.954 min, *t*<sub>major</sub> = 22.269 min, 95% ee).

**4. Characterization of compounds 5a–5i and 7a–7b**



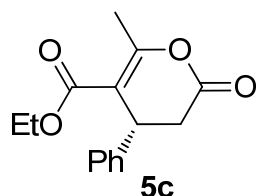
**(R)-5-acetyl-4,6-diphenyl-3,4-dihydro-2H-pyran-2-one (5a)**

white solid, mp 136 – 140 °C,  $[\alpha]_D^{20}$  –176 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.62 (d, *J* = 8.4 Hz, 2H), 7.54 – 7.50 (m, 1H), 7.39 (t, *J* = 7.6 Hz, 2H), 7.29 – 7.20 (m, 3H), 7.14 (d, *J* = 8.4 Hz, 2H), 4.32 (dd, *J* = 7.2, 3.2 Hz, 1H), 3.07 (dd, *J* = 16.0, 7.6 Hz, 1H), 2.93 (dd, *J* = 16.0, 3.6 Hz, 1H), 1.90 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 195.78, 166.49, 154.74, 139.97, 138.42, 133.06, 129.13, 128.78, 128.71, 127.62, 126.76, 117.75, 39.41, 36.19, 18.99. HRMS (ESI): Exact Mass Calcd. for C<sub>19</sub>H<sub>17</sub>O<sub>3</sub> (M+H)<sup>+</sup>: 293.1172, Found: 293.1181. HPLC (Chiralpak OD–H column, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, retention time: *t*<sub>minor</sub> = 10.650 min, *t*<sub>major</sub> = 12.607 min, 95% ee).



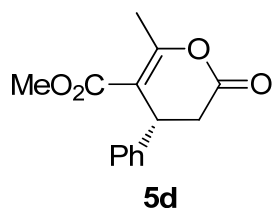
**ethyl (*R*)-2-oxo-4,6-diphenyl-3,4-dihydro-2*H*-pyran-5-carboxylate (5b)**

white solid, mp 131–134 °C,  $[\alpha]_D^{20}$   $-134$  (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.52 – 7.50 (m, 2H), 7.47 – 7.39 (m, 3H), 7.36 – 7.32 (m, 2H), 7.29 – 7.28 (m, 2H), 7.27 – 7.25 (m, 1H), 4.41 (dd,  $J = 7.6$ , 2.4 Hz, 1H), 3.93 (q,  $J = 2.8$  Hz, 2H), 3.10 (dd,  $J = 16.0$ , 7.6 Hz, 1H), 2.94 (dd,  $J = 16.0$ , 2.4 Hz, 1H), 0.88 (t,  $J = 7.2$  Hz, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  166.35, 165.96, 158.50, 139.90, 133.11, 130.11, 129.19, 128.63, 127.97, 127.73, 126.75, 111.71, 60.98, 38.87, 36.30, 13.43. HRMS (ESI): Exact Mass Calcd. for C<sub>20</sub>H<sub>19</sub>O<sub>4</sub> (M+H)<sup>+</sup>: 323.1278, Found: 323.1273. HPLC (Chiralpak OD–H column, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, retention time:  $t_{\text{minor}} = 12.276$  min,  $t_{\text{major}} = 13.809$  min, 91% ee).



**ethyl (*R*)-6-methyl-2-oxo-4-phenyl-3,4-dihydro-2*H*-pyran-5-carboxylate (5c)**

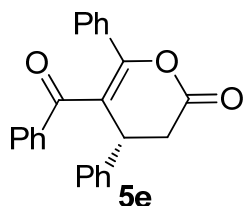
brown solid, mp 111 – 114 °C,  $[\alpha]_D^{20}$   $-170$  (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.31 – 7.28 (m, 2H), 7.25 – 7.21 (m, 1H), 7.14 (d,  $J = 7.2$  Hz, 2H), 4.26 (d,  $J = 7.2$  Hz, 1H), 4.13 (q,  $J = 7.2$  Hz, 2H), 2.95 (dd,  $J = 15.6$ , 7.6 Hz, 1H), 2.82 (dd,  $J = 15.6$ , 2.4 Hz, 1H), 2.47 (s, 3H), 1.19 (t,  $J = 7.2$  Hz, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  166.09, 165.93, 161.27, 140.63, 128.99, 127.46, 126.57, 110.00, 60.82, 37.82, 36.34, 18.84, 14.02. HRMS (ESI): Exact Mass Calcd. for C<sub>15</sub>H<sub>17</sub>O<sub>4</sub> (M+H)<sup>+</sup>: 261.1121, Found: 261.1127. HPLC (Chiralpak OD–H column, *n*-hexane/*i*-PrOH = 80/20), flow rate = 1.0 mL/min, retention time:  $t_{\text{minor}} = 9.105$  min,  $t_{\text{major}} = 16.704$  min, 95% ee).



**methyl (*R*)-6-methyl-2-oxo-4-phenyl-3,4-dihydro-2*H*-pyran-5-carboxylate (5d)**

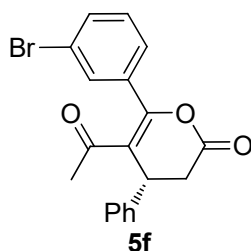
white solid, mp 99 – 102 °C,  $[\alpha]_D^{20}$   $-183$  (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.32 – 7.22 (m, 3H), 7.13 (d,  $J = 7.2$  Hz, 2H), 4.26 (d,  $J = 7.2$  Hz, 1H), 3.68 (s, 3H), 2.94 (dd,  $J = 16.0$ , 7.6 Hz, 1H), 2.83 (dd,  $J = 16.0$ , 2.4 Hz, 1H), 2.48 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  166.42, 165.98, 161.72, 140.39, 129.06, 127.54, 126.55, 109.71, 51.89, 37.73, 36.44, 18.90. HRMS (ESI): Exact Mass Calcd. for C<sub>14</sub>H<sub>15</sub>O<sub>4</sub>

(M+H)<sup>+</sup>: 247.0965, Found: 247.0972. HPLC (Chiralpak OD–H column, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, retention time:  $t_{\text{minor}} = 7.831$  min,  $t_{\text{major}} = 16.611$  min, 91% ee).



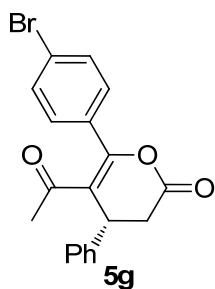
**(R)-5-benzoyl-4,6-diphenyl-3,4-dihydro-2H-pyran-2-one (5e)**

brown solid, mp 201 – 203 °C,  $[\alpha]_{\text{D}}^{20} -86$  (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.49 (d,  $J = 7.2$  Hz, 2H), 7.37 (d,  $J = 6.8$  Hz, 2H), 7.30 – 7.21 (m, 6H), 7.18 – 7.06 (m, 5H), 4.56 (dd,  $J = 7.6, 2.4$  Hz, 1H), 3.21 (dd,  $J = 16.0, 7.6$  Hz, 1H), 3.06 (dd,  $J = 16.0, 2.4$  Hz, 1H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  195.91, 166.65, 154.79, 139.70, 137.08, 132.57, 131.97, 130.27, 129.22, 128.98, 128.04, 127.98, 127.77, 126.84, 118.28, 40.38, 35.93. HRMS (ESI): Exact Mass Calcd. for C<sub>24</sub>H<sub>19</sub>O<sub>3</sub> (M+H)<sup>+</sup>: 355.1329, Found: 355.1334. HPLC (Chiralpak OD–H column, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, retention time:  $t_{\text{minor}} = 19.703$  min,  $t_{\text{major}} = 28.502$  min, 91% ee).



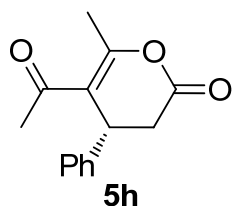
**(R)-5-acetyl-6-(3-bromophenyl)-4-phenyl-3,4-dihydro-2H-pyran-2-one (5f)**

brown solid, mp 131 – 134 °C,  $[\alpha]_{\text{D}}^{20} -98$  (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.53 (d,  $J = 8.4$  Hz, 2H), 7.48 (d,  $J = 8.4$  Hz, 2H), 7.28 – 7.21 (m, 3H), 7.11 (d,  $J = 8.4$  Hz, 2H), 4.29 (dd,  $J = 7.2, 3.6$  Hz, 1H), 3.06 (dd,  $J = 16.0, 7.2$  Hz, 1H), 2.93 (dd,  $J = 16.0, 4.0$  Hz, 1H), 1.91 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  194.37, 166.16, 155.52, 140.22, 139.76, 135.82, 131.56, 130.25, 129.24, 127.78, 127.22, 126.73, 122.97, 117.46, 39.47, 36.19, 19.09. HRMS (ESI): Exact Mass Calcd. for C<sub>19</sub>H<sub>16</sub>BrO<sub>3</sub> (M+H)<sup>+</sup>: 372.0277, Found: 372.0281. HPLC (Chiralpak OD–H column, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, retention time:  $t_{\text{minor}} = 15.840$  min,  $t_{\text{major}} = 19.112$  min, 87% ee).



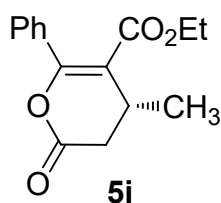
**(R)-5-acetyl-6-(4-bromophenyl)-4-phenyl-3,4-dihydro-2H-pyran-2-one (5g)**

brown solid, mp 142 – 145 °C,  $[\alpha]_D^{20}$  –109 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.53 (q, *J* = 8.8 Hz, 2H), 7.48 (q, *J* = 8.4 Hz, 2H), 7.28 – 7.20 (m, 3H), 7.11 (d, *J* = 8.4 Hz, 2H), 4.28 (dd, *J* = 7.2, 3.6 Hz, 1H), 3.06 (dd, *J* = 16.0, 7.2 Hz, 1H), 2.93 (dd, *J* = 16.0, 4.0 Hz, 1H), 1.91 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 194.72, 166.25, 154.81, 139.84, 137.10, 132.07, 130.25, 129.21, 128.29, 127.74, 126.69, 117.46, 39.46, 36.10, 19.06. HRMS (ESI): Exact Mass Calcd. for C<sub>19</sub>H<sub>16</sub>BrO<sub>3</sub> (M+H)<sup>+</sup>: 372.0277, Found: 372.0274. HPLC (Chiralpak OD–H column, *n*-hexane/*i*-PrOH = 80/20), flow rate = 1.0 mL/min, retention time: *t*<sub>minor</sub> = 16.105 min, *t*<sub>major</sub> = 21.732 min, 87% ee).



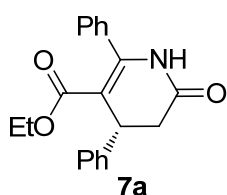
**(R)-5-acetyl-6-methyl-4-phenyl-3,4-dihydro-2H-pyran-2-one (5h)**

white solid, mp 109 – 112 °C,  $[\alpha]_D^{20}$  –182 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.36 – 7.32 (m, 2H), 7.29 – 7.28 (m, 1H), 7.15 (d, *J* = 7.2 Hz, 2H), 4.15 (d, *J* = 6.0 Hz, 1H), 2.97 (dd, *J* = 15.6, 7.2 Hz, 1H), 2.84 (dd, *J* = 15.6, 2.4 Hz, 1H), 2.43 (s, 3H), 2.12 (s, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 197.88, 165.56, 160.23, 139.70, 129.43, 127.94, 126.65, 117.28, 38.86, 37.16, 29.75, 19.06. HRMS (ESI): Exact Mass Calcd. for C<sub>14</sub>H<sub>15</sub>O<sub>3</sub> (M+H)<sup>+</sup>: 231.1016, Found: 231.1019. HPLC (Chiralpak OD–H column, *n*-hexane/*i*-PrOH = 80/20, flow rate = 1.0 mL/min, retention time: *t*<sub>minor</sub> = 10.954 min, *t*<sub>major</sub> = 13.941 min, 88% ee).



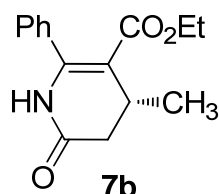
**ethyl (R)-4-methyl-2-oxo-6-phenyl-3,4-dihydro-2H-pyran-5-carboxylate (5i)**

colorless oil,  $[\alpha]_D^{20}$  –101 (c 1.0, CHCl<sub>3</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.44 – 7.35 (m, 5H), 4.05 (q, *J* = 7.2 Hz, 2H), 3.24 – 3.17 (m, 1H), 2.85 (dd, *J* = 15.6, 6.8 Hz, 1H), 2.66 (dd, *J* = 15.6, 2.4 Hz, 1H), 1.25 (d, *J* = 6.8 Hz, 3H), 0.99 (t, *J* = 6.8 Hz, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 166.92, 166.66, 157.35, 133.19, 129.88, 128.50, 113.91, 60.88, 35.55, 28.25, 19.17, 13.56. HRMS (ESI): Exact Mass Calcd. for C<sub>15</sub>H<sub>17</sub>O<sub>4</sub> (M+H)<sup>+</sup>: 261.1121, Found: 261.1123. HPLC (Chiralpak OD–H column, *n*-hexane/*i*-PrOH = 95/5, flow rate = 1.0 mL/min, retention time: *t*<sub>minor</sub> = 11.237 min, *t*<sub>major</sub> = 14.681 min, 83% ee).



### ethyl (*R*)-6-oxo-2,4-diphenyl-1,4,5,6-tetrahydropyridine-3-carboxylate (**7a**)

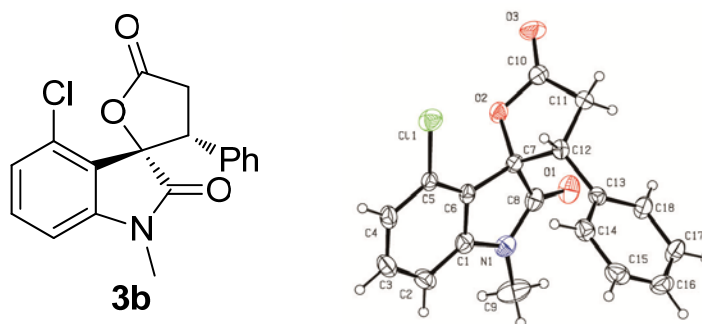
white solid, mp 122 – 124 °C,  $[\alpha]_D^{20}$  –144 (c 1.0, CH<sub>2</sub>Cl<sub>2</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.42 – 7.30 (m, 9H), 7.25 – 7.23 (m, 1H), 7.19 (br s, 1H), 4.34 (dd, *J* = 8.0, 2.4 Hz, 1H), 3.86 (q, *J* = 7.2 Hz, 2H), 3.06 (dd, *J* = 16.4, 8.0 Hz, 1H), 2.80 (dd, *J* = 16.4, 2.4 Hz, 1H), 0.83 (t, *J* = 7.2 Hz, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 169.53, 166.58, 146.50, 141.71, 135.76, 129.51, 128.87, 128.44, 127.82, 127.11, 126.73, 108.73, 60.16, 38.59, 38.01, 13.49. HRMS (ESI): Exact Mass Calcd. for C<sub>20</sub>H<sub>20</sub>NO<sub>3</sub> (M+H)<sup>+</sup>: 322.1438, Found: 322.3844. HPLC (Chiralpak AD–H column, *n*-hexane/*i*-PrOH = 80/20), flow rate = 1.0 mL/min, retention time: *t*<sub>major</sub> = 15.822 min, *t*<sub>minor</sub> = 29.715 min, 86% ee).



### ethyl (*R*)-4-methyl-6-oxo-2-phenyl-1,4,5,6-tetrahydropyridine-3-carboxylate (**7b**)

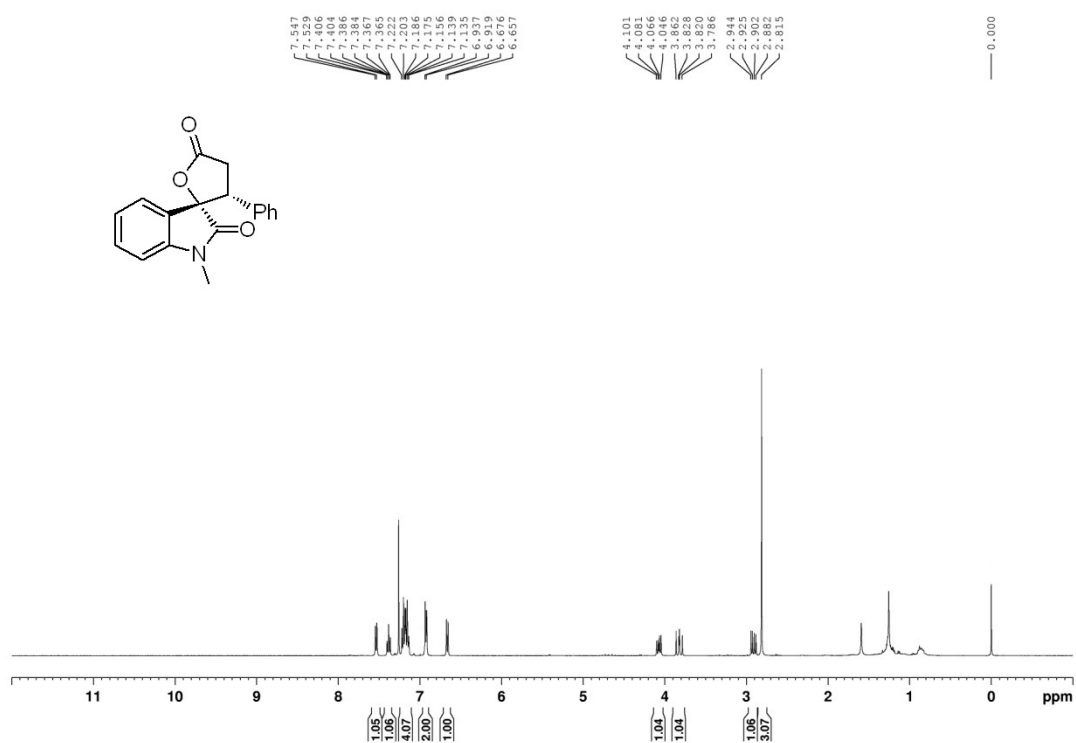
white solid, mp 141 – 144 °C,  $[\alpha]_D^{20}$  –128 (c 1.0, CHCl<sub>3</sub>). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.41 – 7.37 (m, 3H), 7.30 – 7.28 (m, 2H), 7.06 (br s, 1H), 3.95 (q, *J* = 6.8 Hz, 2H), 3.18 – 3.10 (m, 1H), 2.79 (dd, *J* = 16.4, 6.8 Hz, 1H), 2.43 (dd, *J* = 16.4, 0.8 Hz, 1H), 1.25 (d, *J* = 6.8 Hz, 3H), 0.91 (t, *J* = 6.8 Hz, 3H). <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 170.16, 166.90, 144.83, 135.86, 129.35, 128.38, 127.77, 111.06, 60.03, 37.56, 28.48, 18.72, 13.60. HRMS (ESI): Exact Mass Calcd. for C<sub>15</sub>H<sub>17</sub>NO<sub>3</sub>Na (M+Na)<sup>+</sup>: 282.1101, Found: 282.1102. HPLC (Chiralpak AD–H column, *n*-hexane/*i*-PrOH = 95/5, flow rate = 1.0 mL/min, retention time: *t*<sub>minor</sub> = 13.041 min, *t*<sub>major</sub> = 11.553 min, 75% ee).

## 5. X-Ray crystal structure of compound **3b**

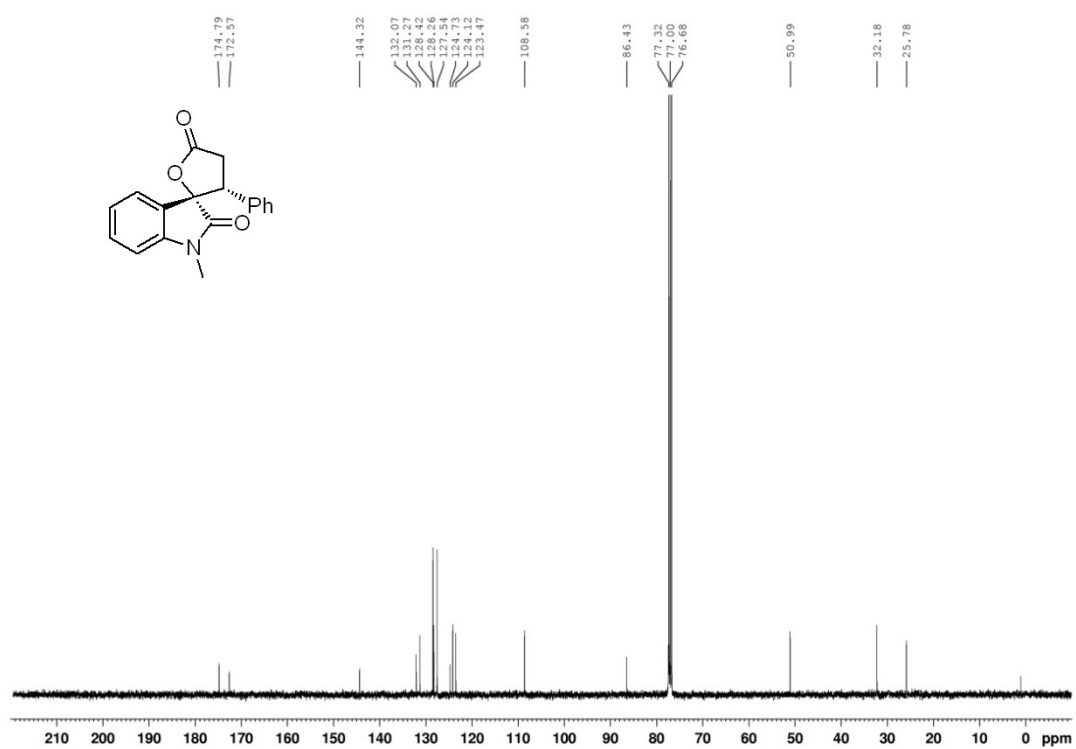


## 6. NMR spectra of compounds 3a–3f, 3h–3p, 5a–5i and 7a–7b

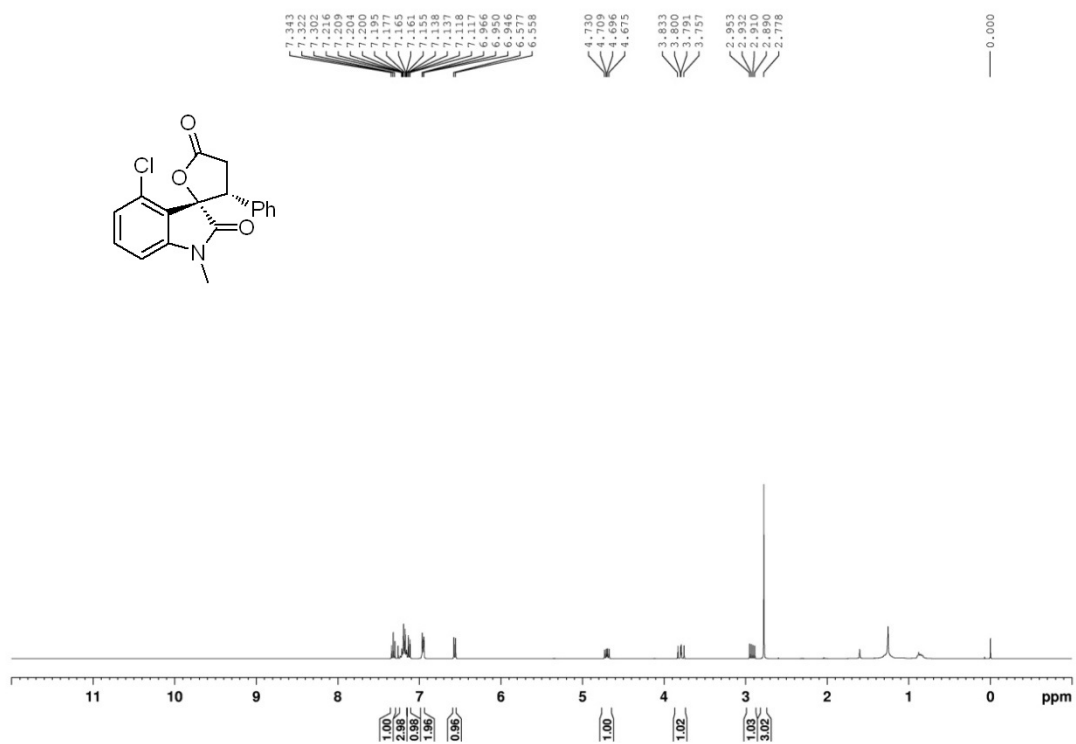
$^1\text{H}$  NMR spectrum of compound **3a** ( $\text{CDCl}_3$ , 400 MHz)



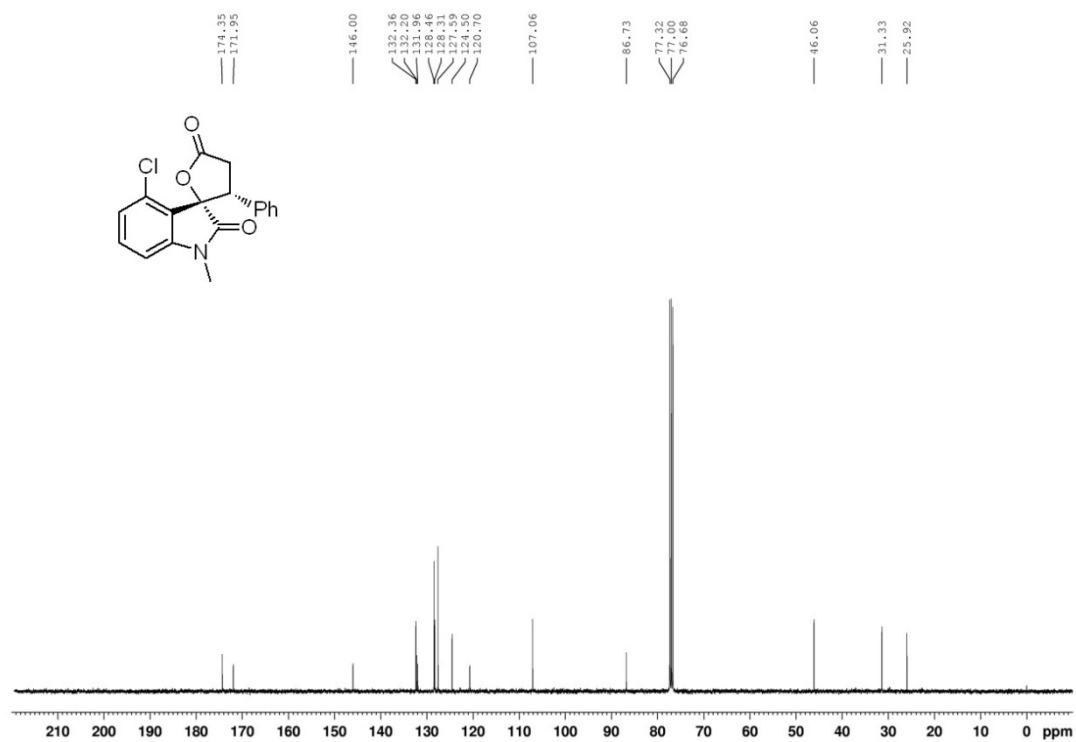
$^{13}\text{C}$  NMR spectrum of compound **3a** ( $\text{CDCl}_3$ , 100 MHz)



$^1\text{H}$  NMR spectrum of compound **3b** ( $\text{CDCl}_3$ , 400 MHz)

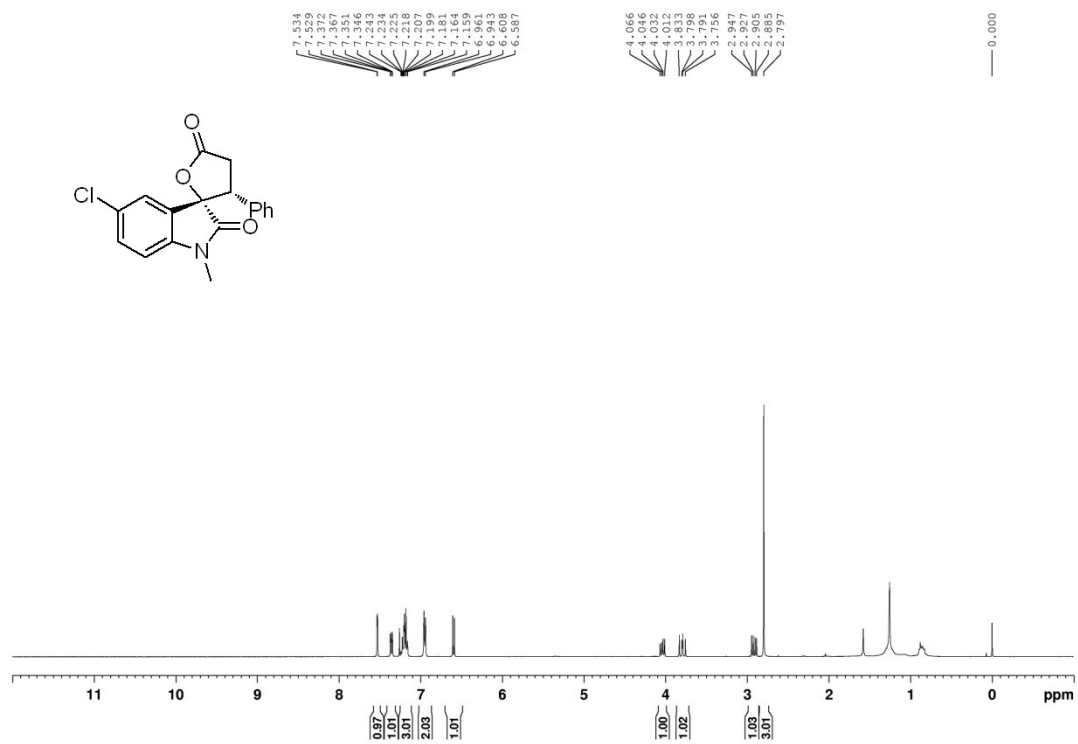


$^{13}\text{C}$  NMR spectrum of compound **3b** ( $\text{CDCl}_3$ , 100 MHz)

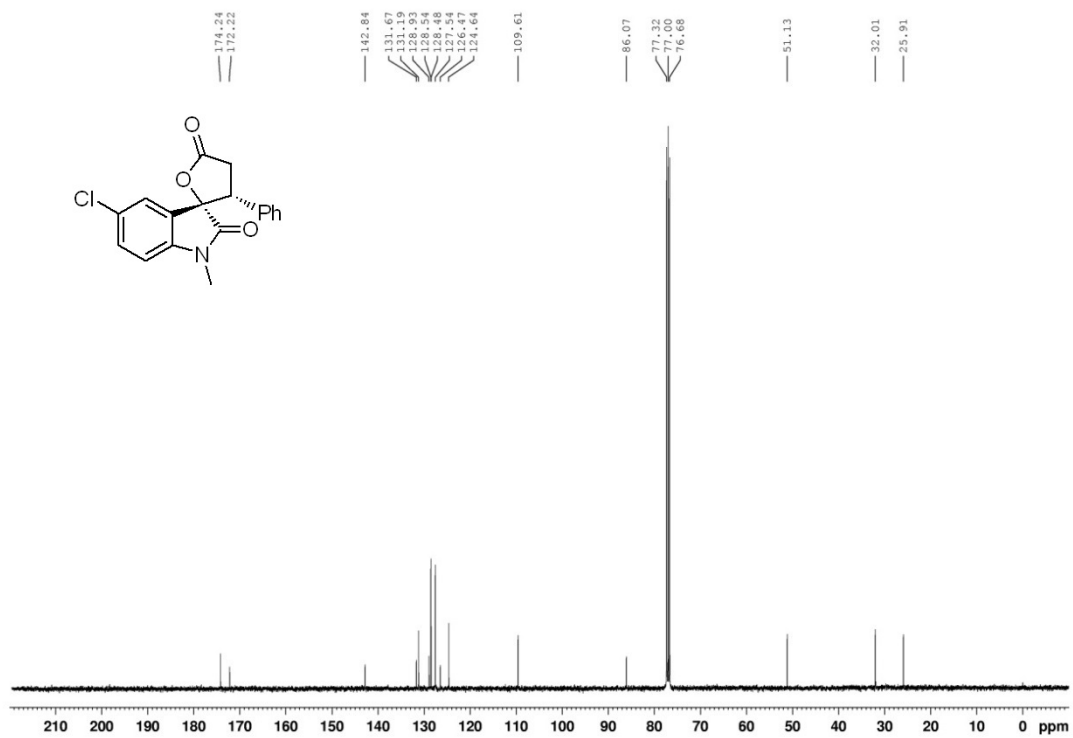




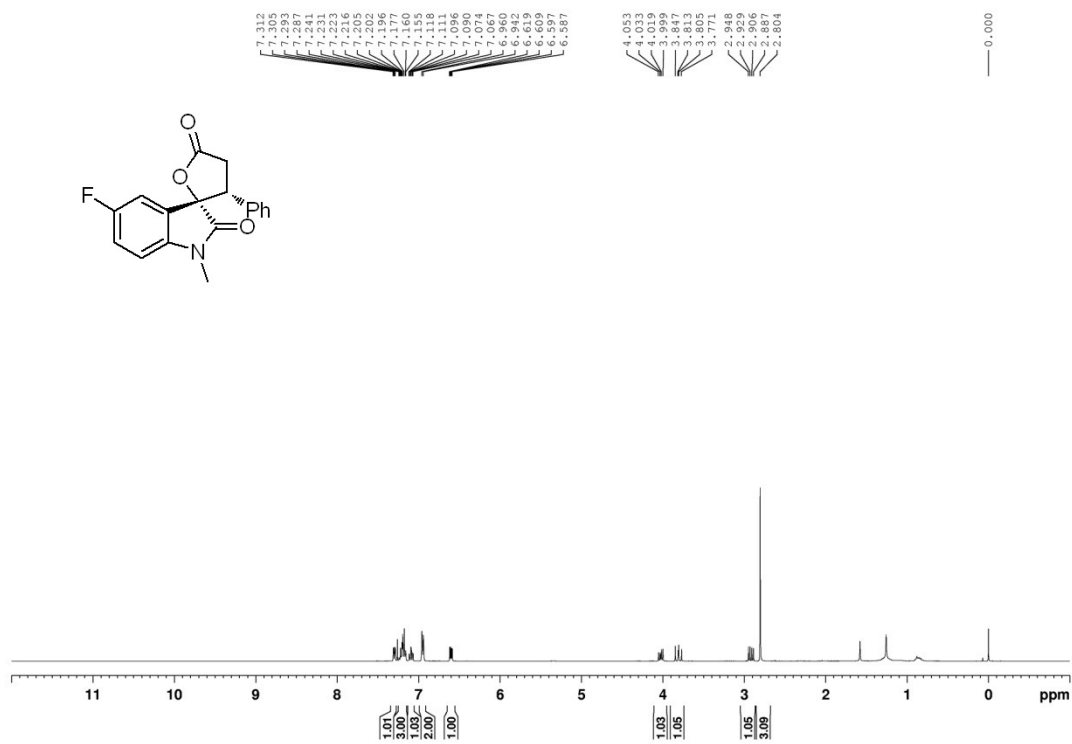
$^1\text{H}$  NMR spectrum of compound **3c** ( $\text{CDCl}_3$ , 400 MHz)



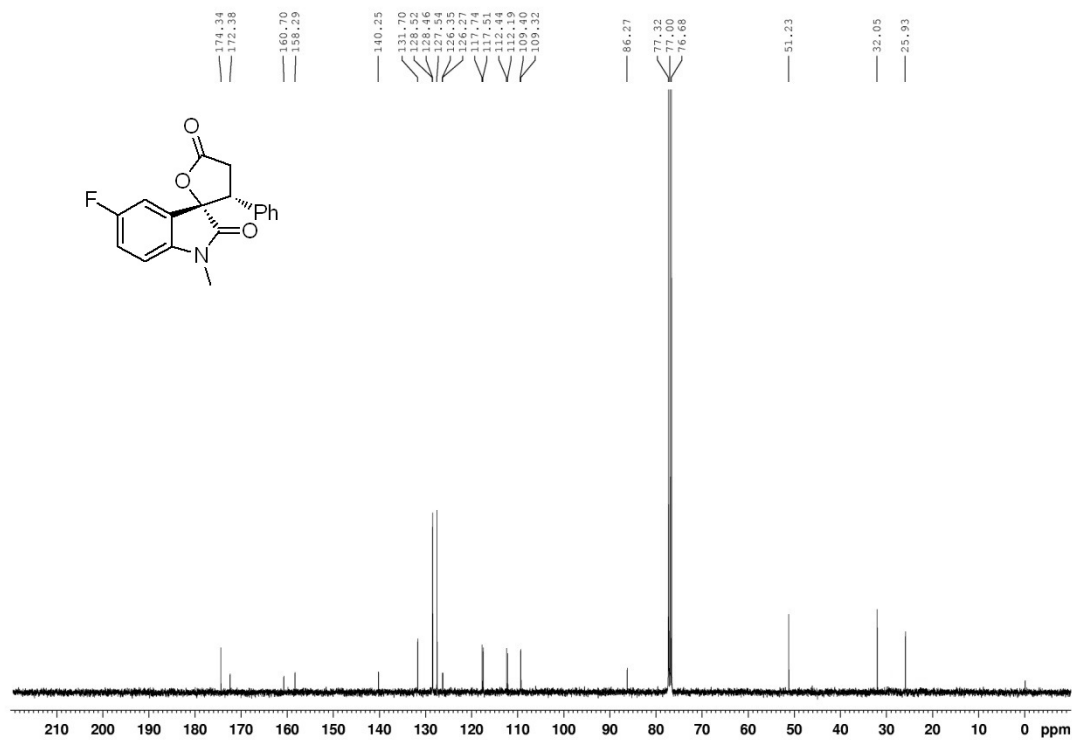
$^{13}\text{C}$  NMR spectrum of compound **3c** ( $\text{CDCl}_3$ , 100 MHz)



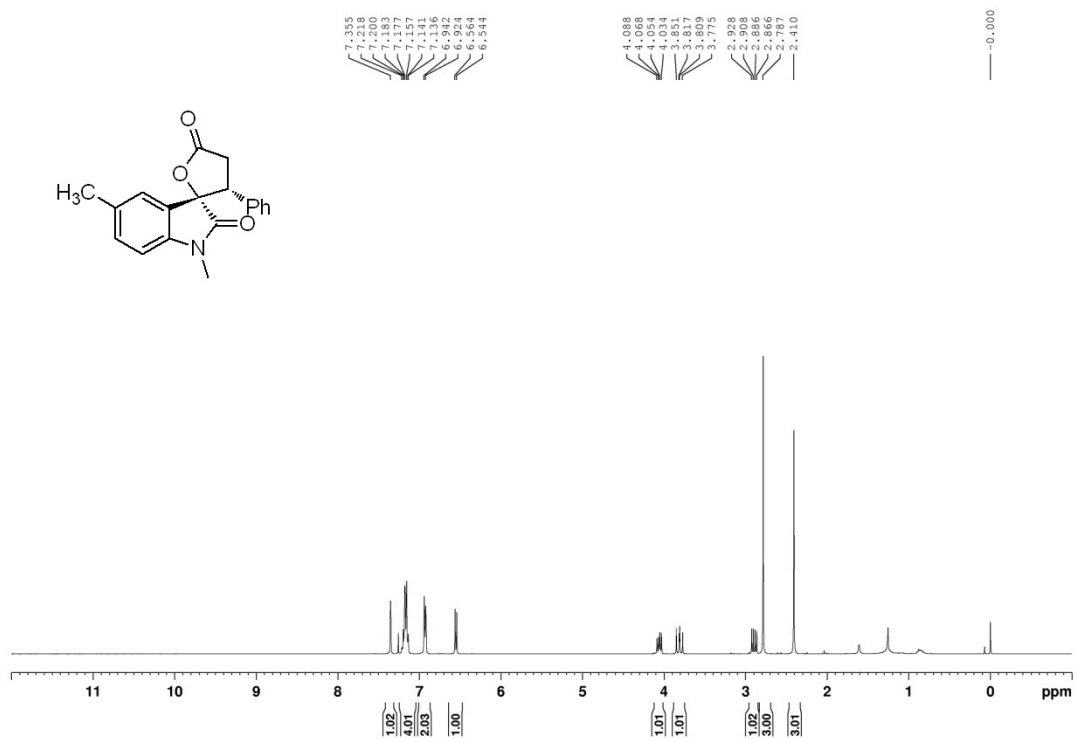
$^1\text{H}$  NMR spectrum of compound **3d** ( $\text{CDCl}_3$ , 400 MHz)



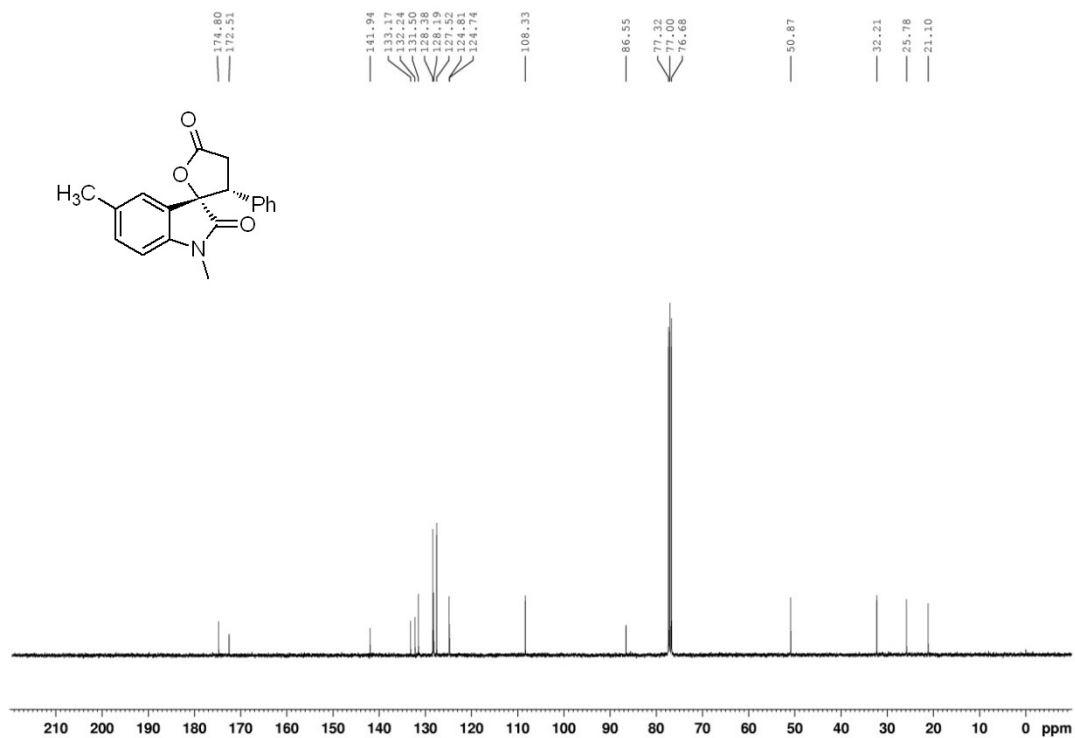
$^{13}\text{C}$  NMR spectrum of compound **3d** ( $\text{CDCl}_3$ , 100 MHz)



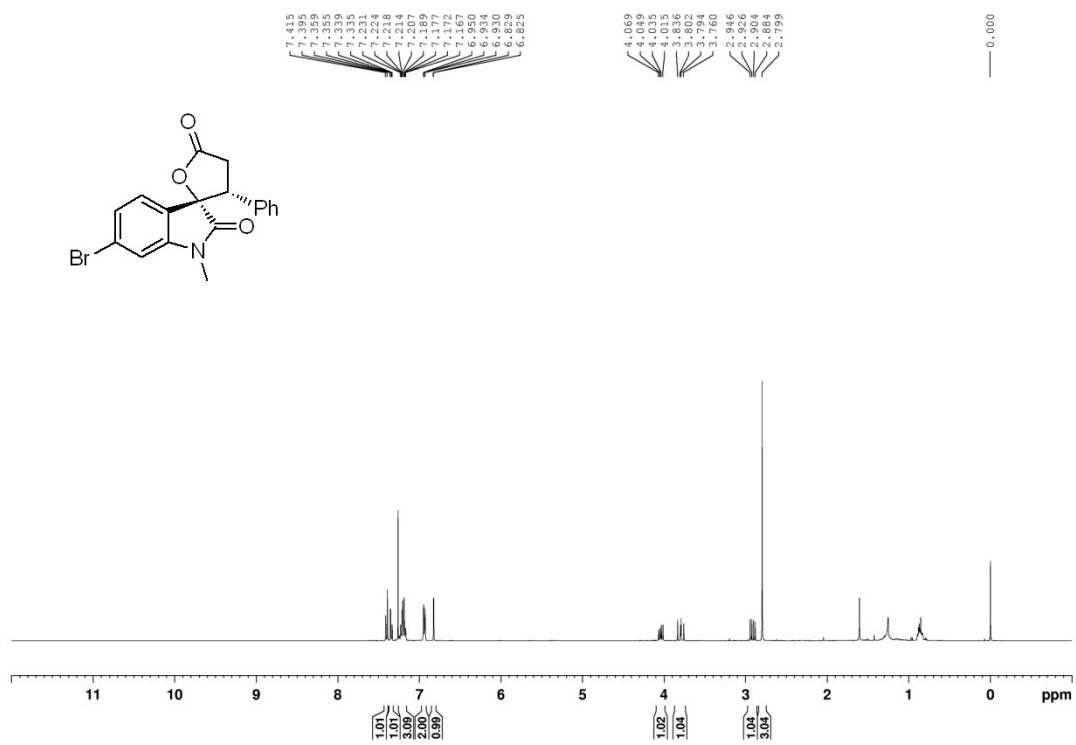
<sup>1</sup>H NMR spectrum of compound **3e** (CDCl<sub>3</sub>, 400 MHz)



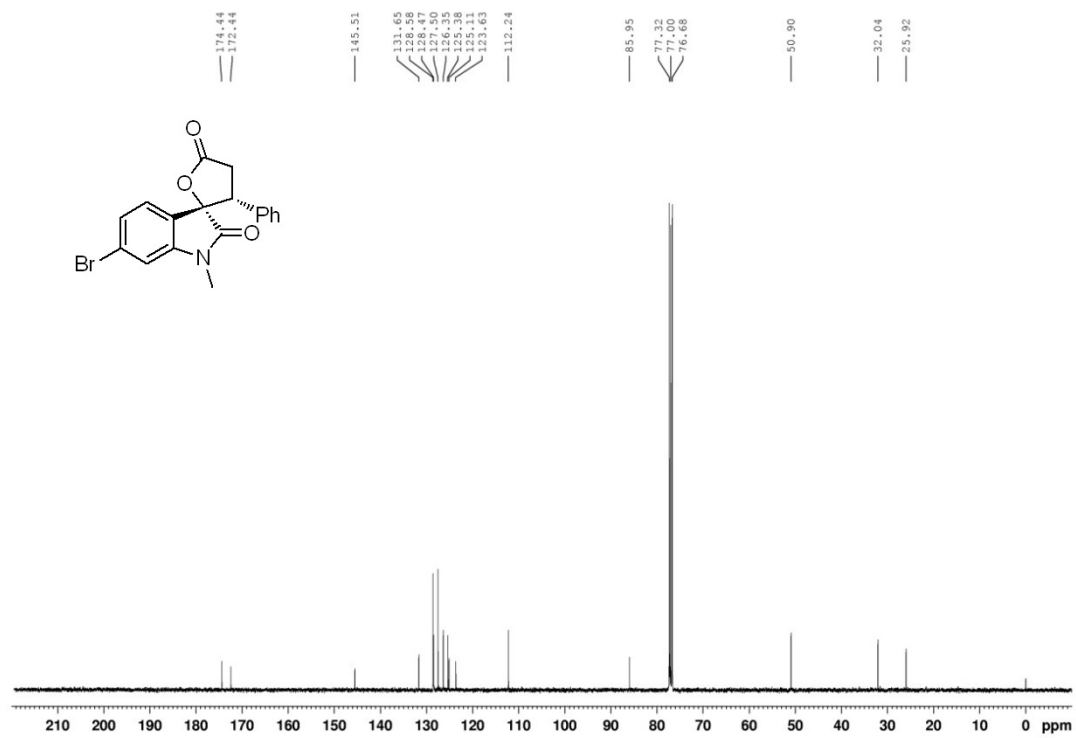
<sup>13</sup>C NMR spectrum of compound **3e** (CDCl<sub>3</sub>, 100 MHz)



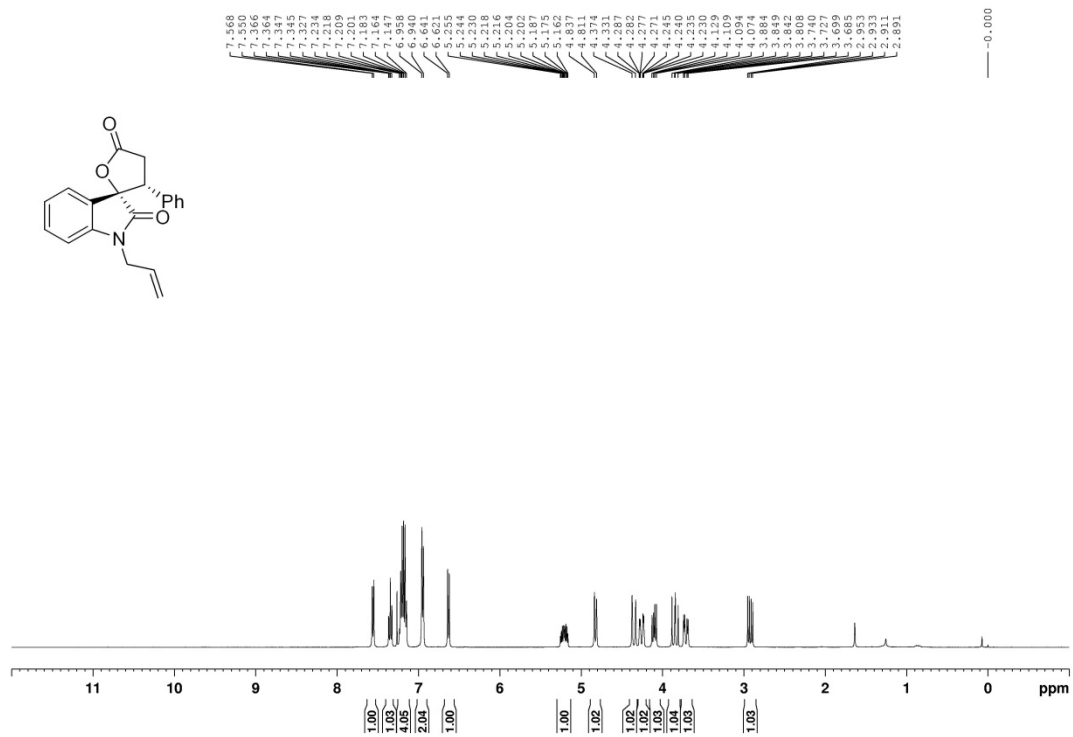
$^1\text{H}$  NMR spectrum of compound **3f** ( $\text{CDCl}_3$ , 400 MHz)



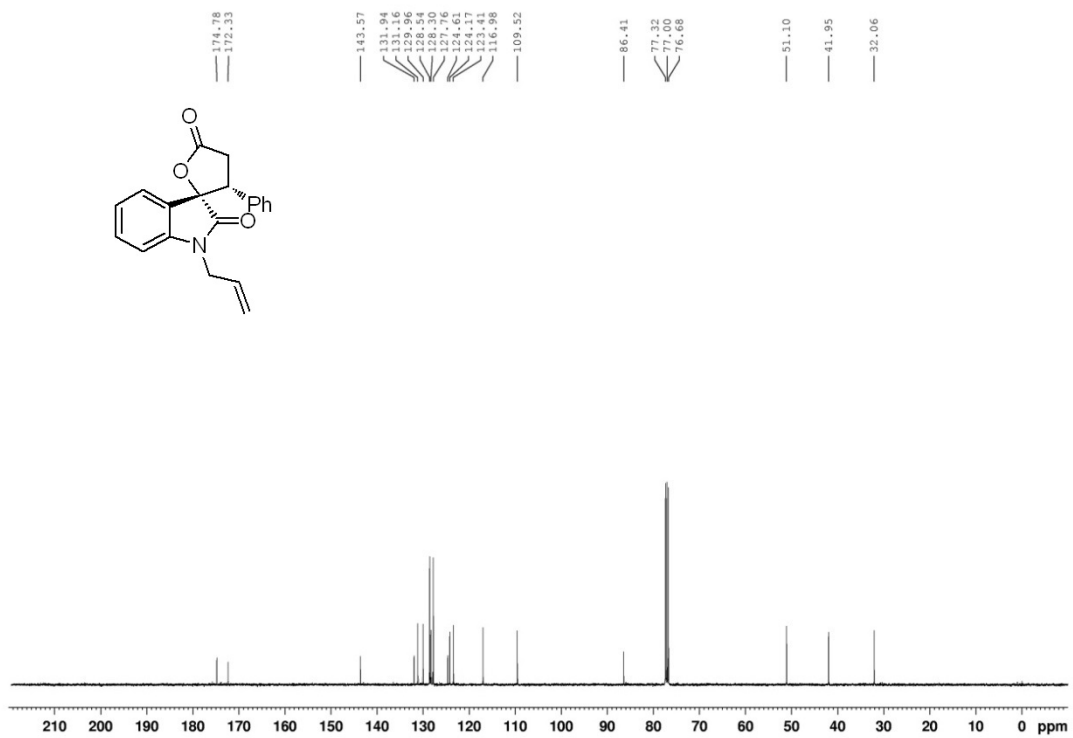
$^{13}\text{C}$  NMR spectrum of compound **3f** ( $\text{CDCl}_3$ , 100 MHz)



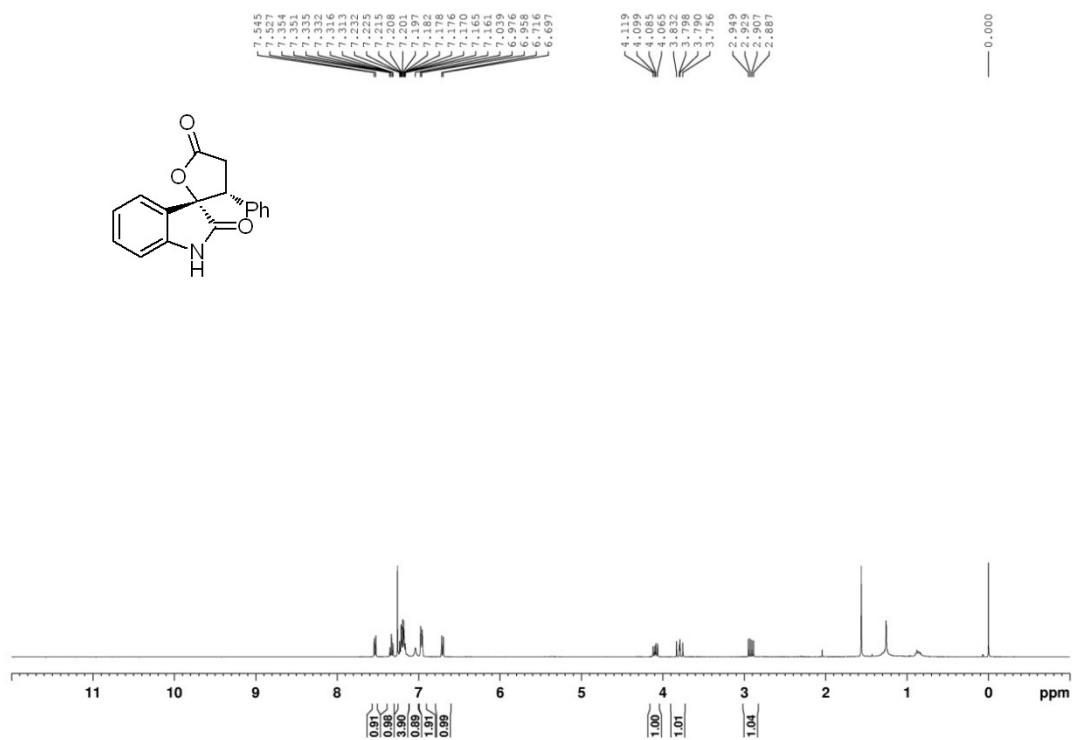
$^1\text{H}$  NMR spectrum of compound **3h** ( $\text{CDCl}_3$ , 400 MHz)



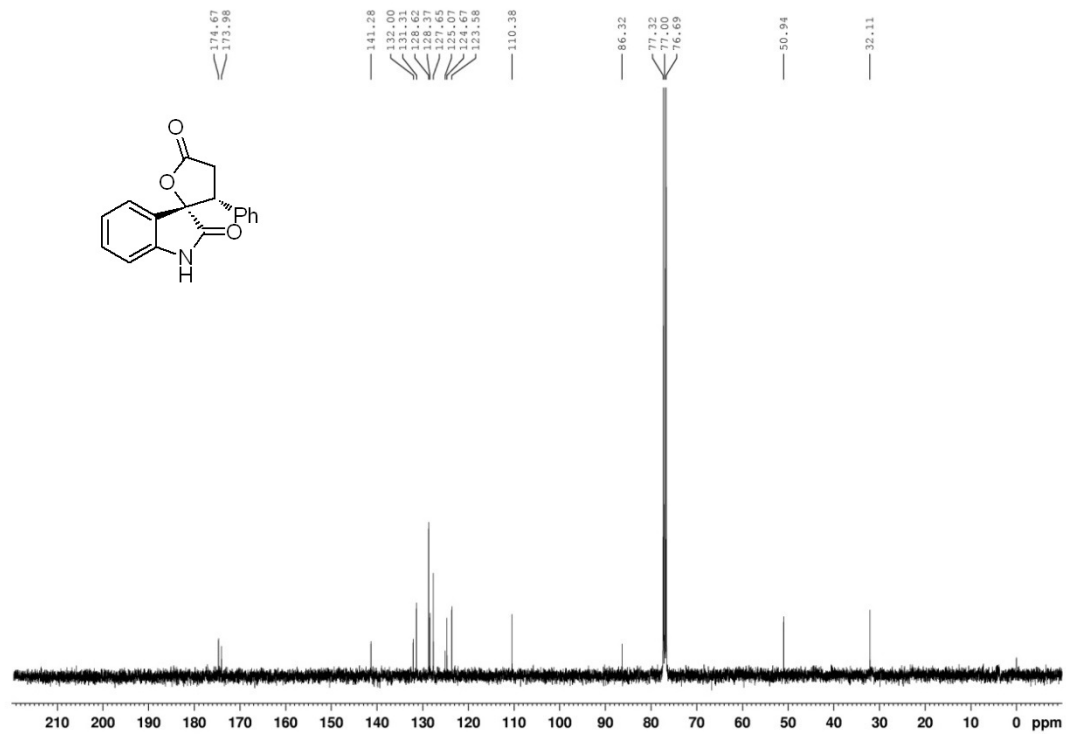
$^{13}\text{C}$  NMR spectrum of compound **3h** ( $\text{CDCl}_3$ , 100 MHz)



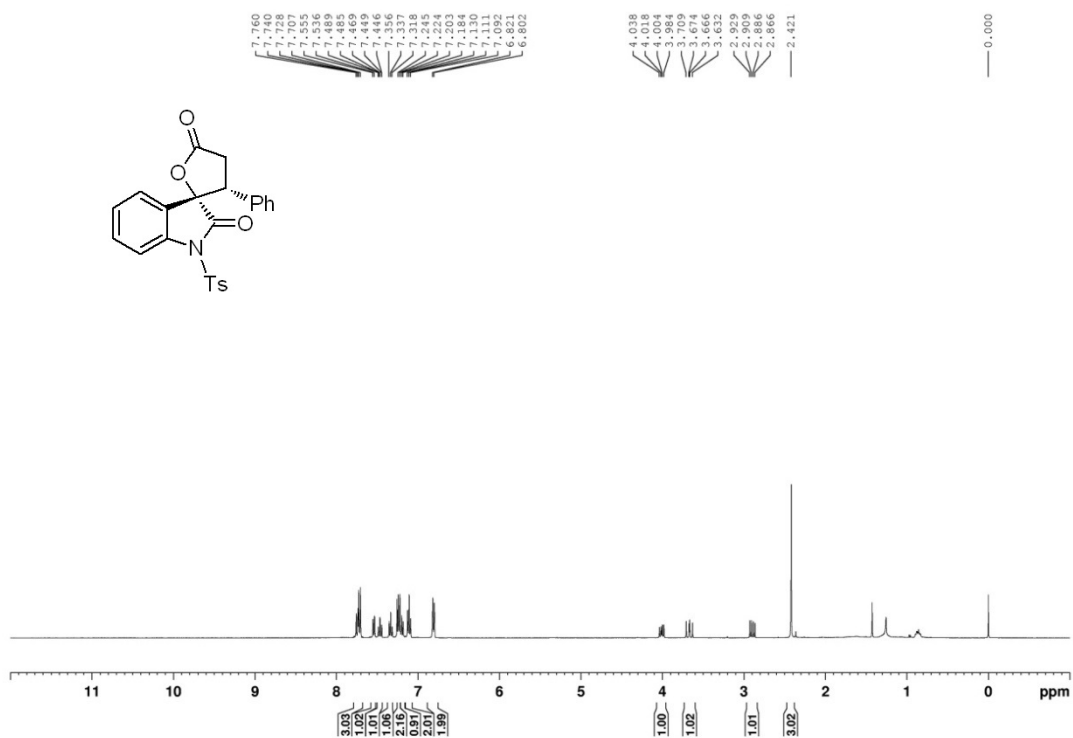
$^1\text{H}$  NMR spectrum of compound **3i** ( $\text{CDCl}_3$ , 400 MHz)



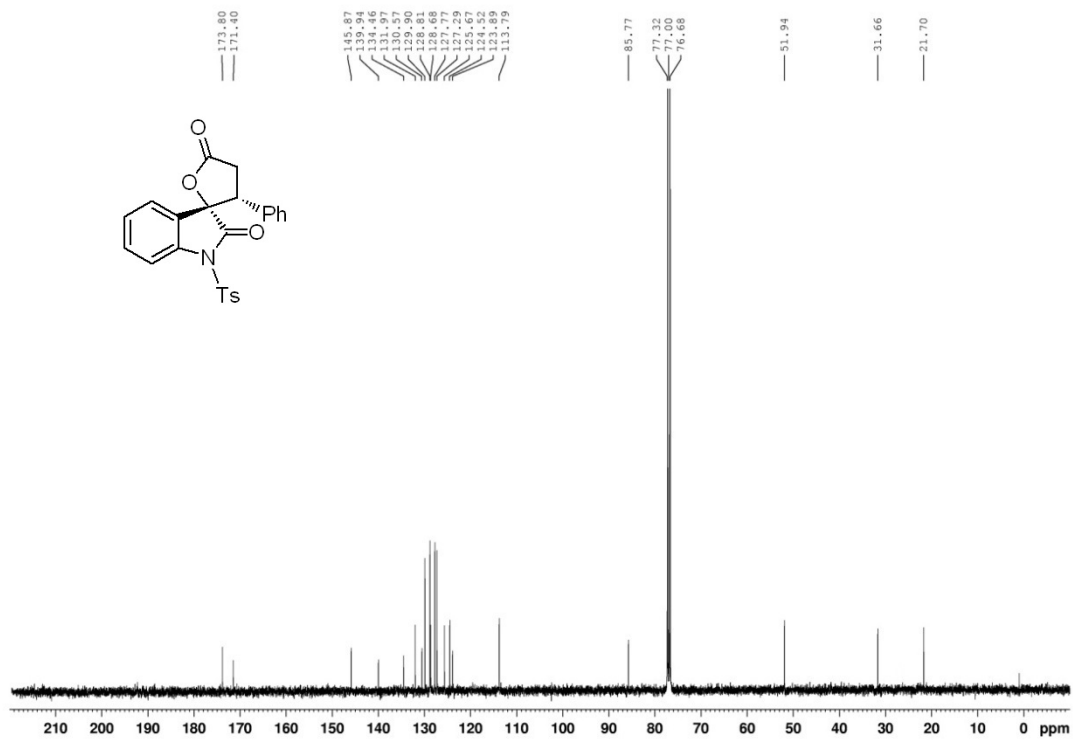
$^{13}\text{C}$  NMR spectrum of compound **3i** ( $\text{CDCl}_3$ , 100 MHz)



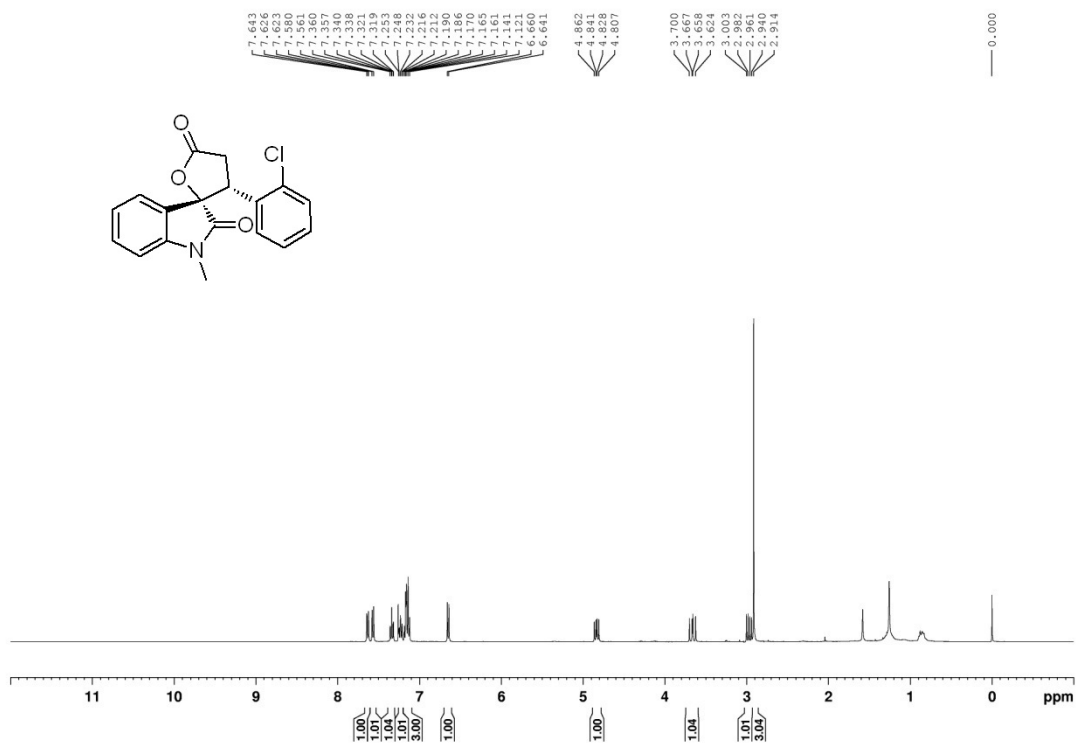
$^1\text{H}$  NMR spectrum of compound **3j** ( $\text{CDCl}_3$ , 400 MHz)



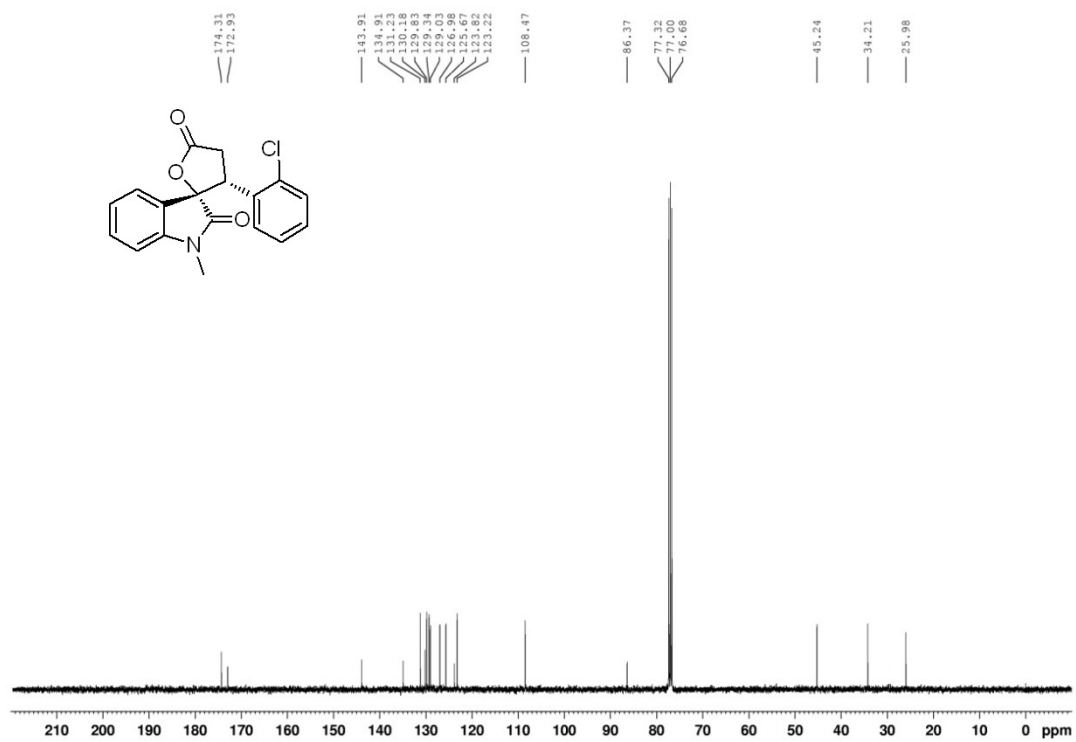
$^{13}\text{C}$  NMR spectrum of compound **3j** ( $\text{CDCl}_3$ , 100 MHz)



$^1\text{H}$  NMR spectrum of compound **3k** ( $\text{CDCl}_3$ , 400 MHz)

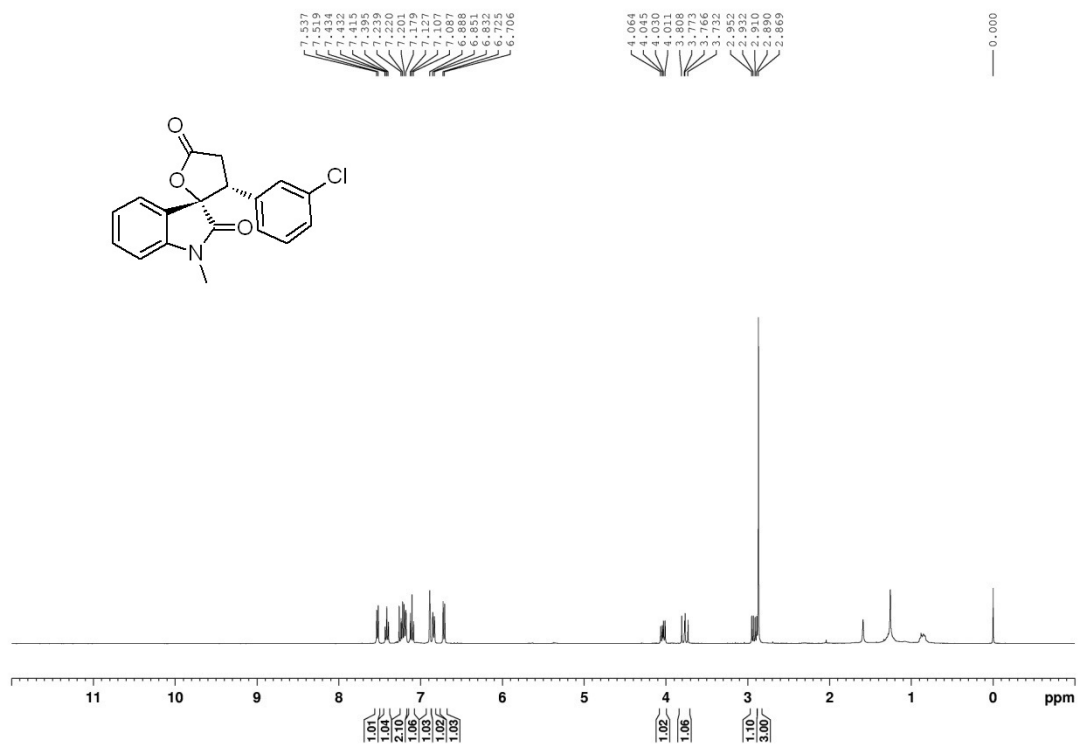


$^{13}\text{C}$  NMR spectrum of compound **3k** ( $\text{CDCl}_3$ , 100 MHz)

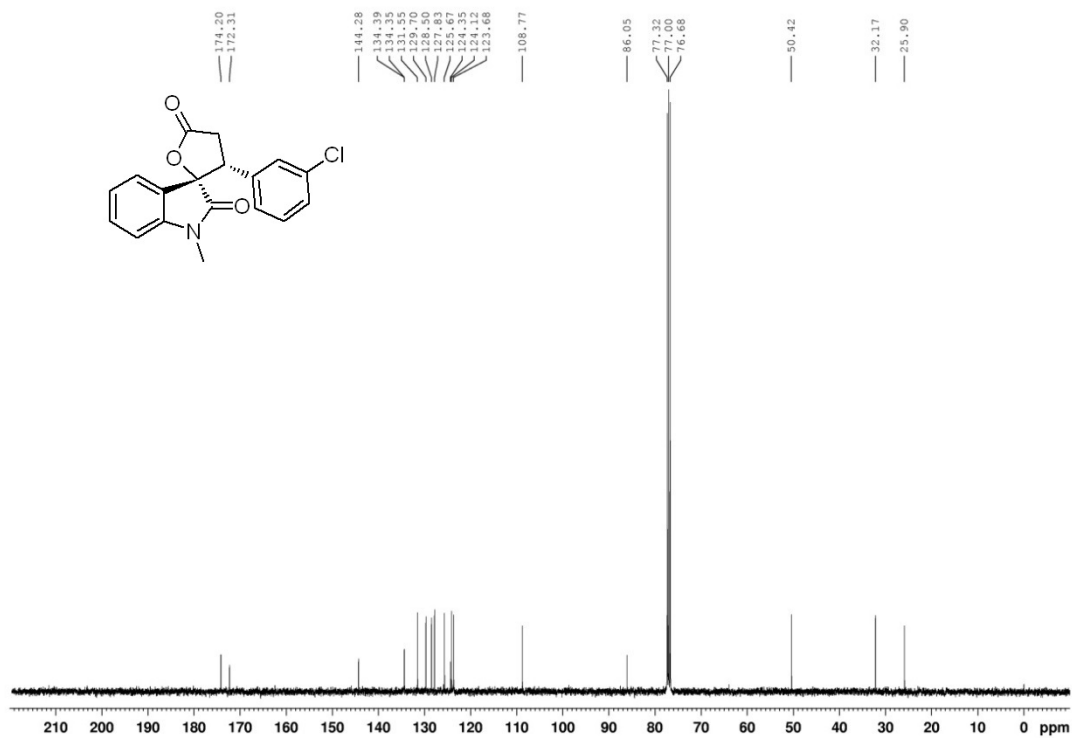




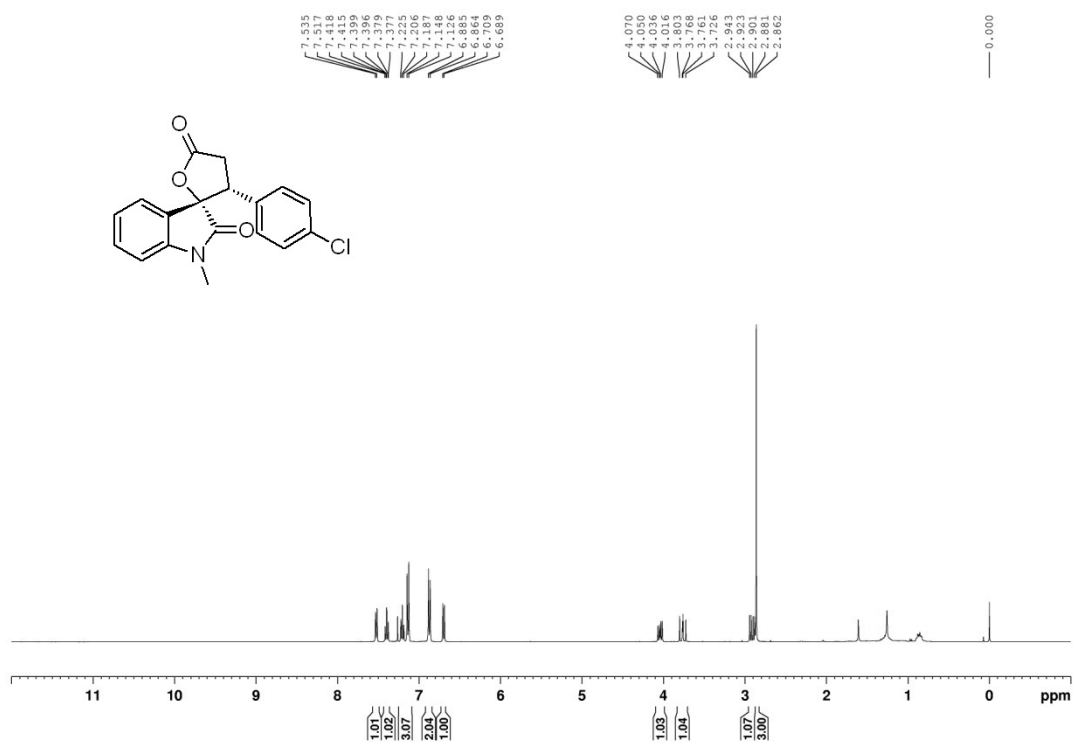
<sup>1</sup>H NMR spectrum of compound **31** (CDCl<sub>3</sub>, 400 MHz)



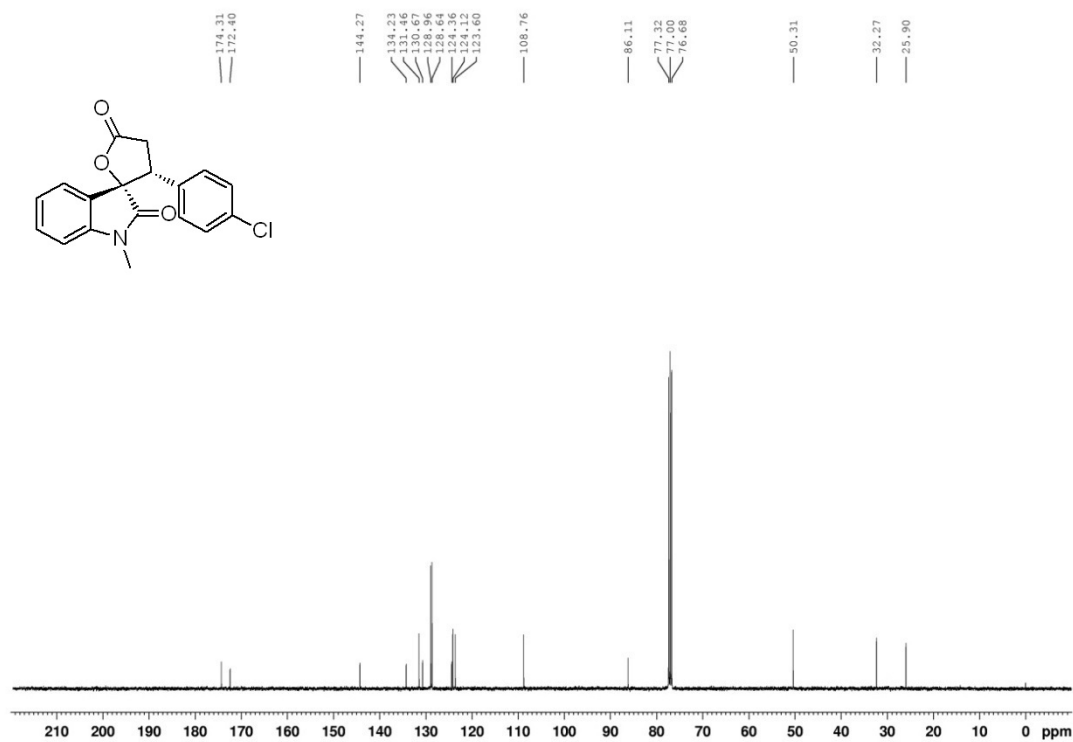
<sup>13</sup>C NMR spectrum of compound **31** (CDCl<sub>3</sub>, 100 MHz)



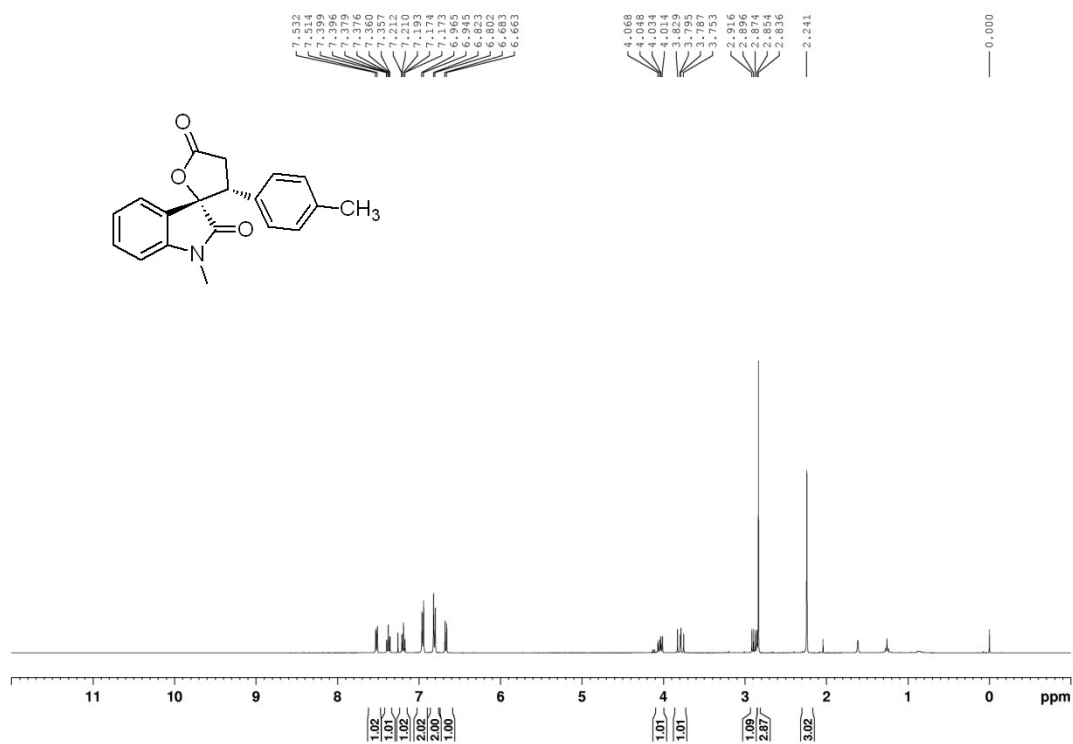
$^1\text{H}$  NMR spectrum of compound **3m** ( $\text{CDCl}_3$ , 400 MHz)



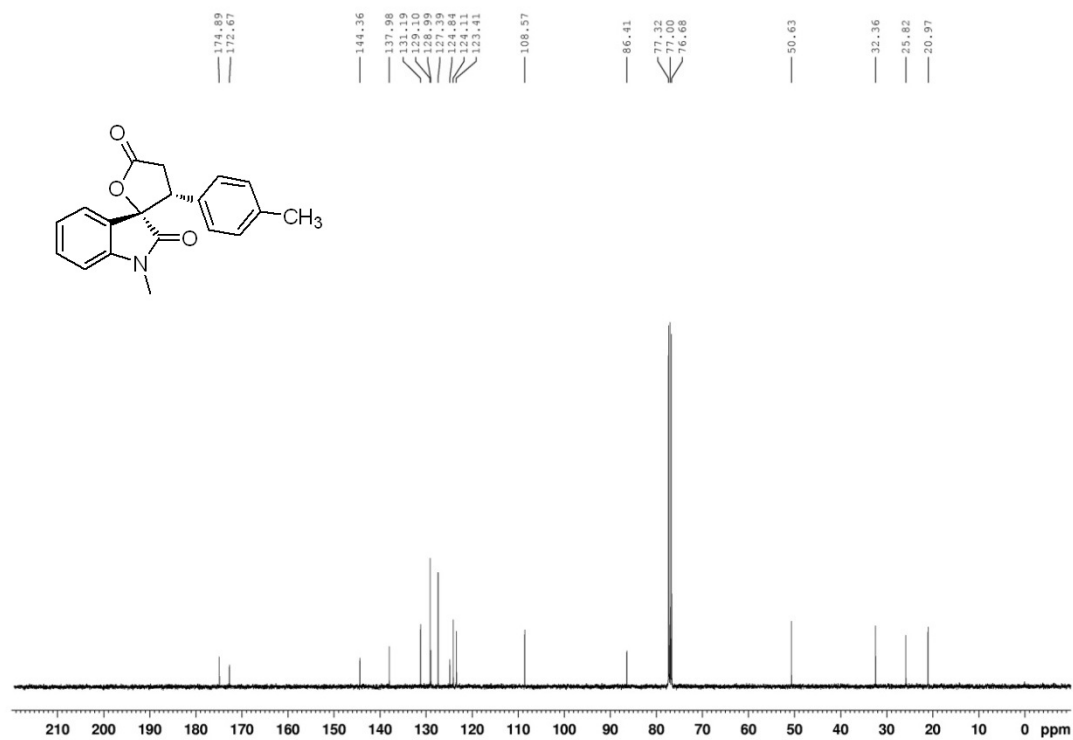
$^{13}\text{C}$  NMR spectrum of compound **3m** ( $\text{CDCl}_3$ , 100 MHz)



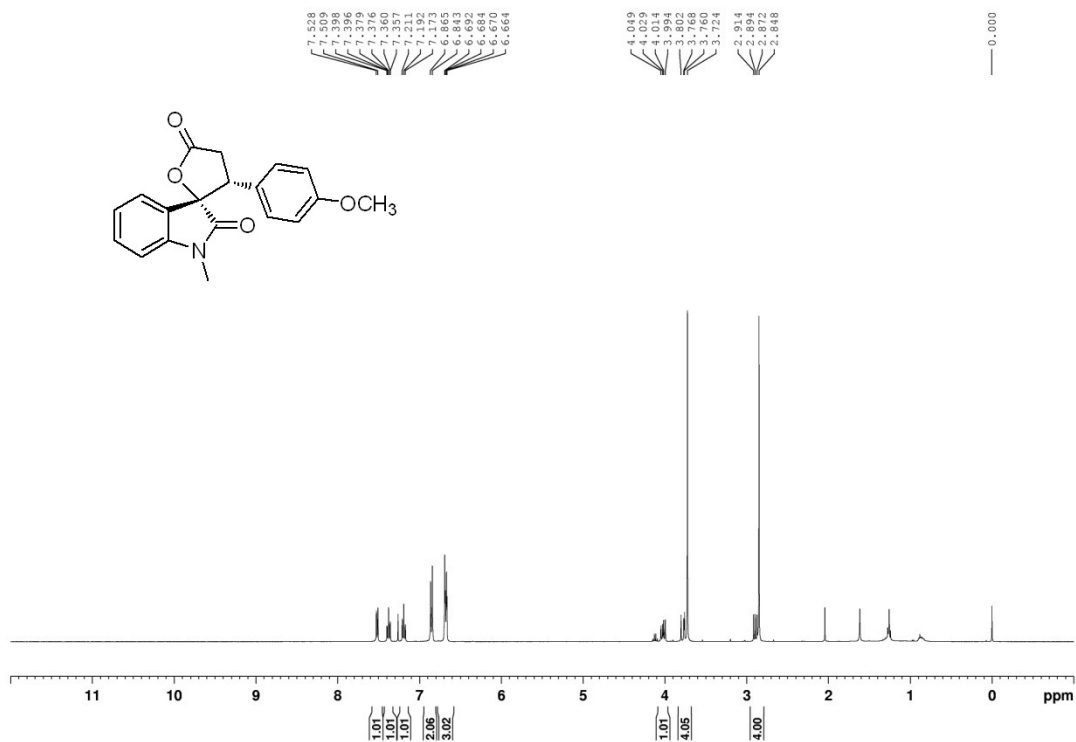
$^1\text{H}$  NMR spectrum of compound **3n** ( $\text{CDCl}_3$ , 400 MHz)



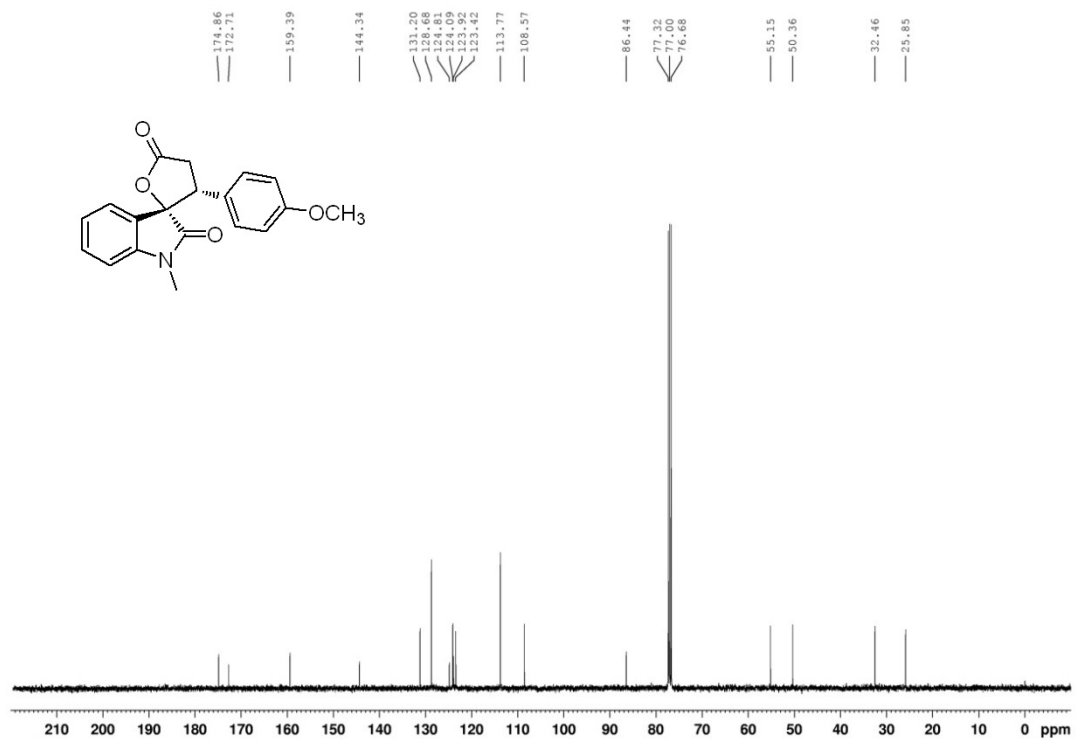
$^{13}\text{C}$  NMR spectrum of compound **3n** ( $\text{CDCl}_3$ , 100 MHz)



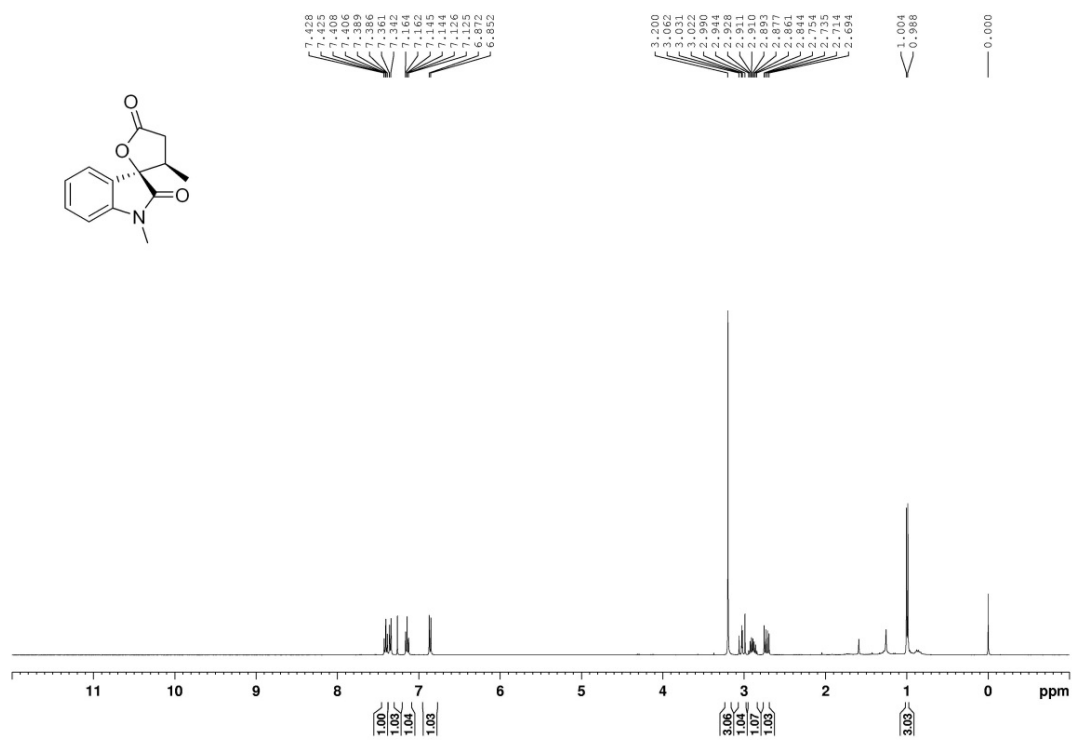
$^1\text{H}$  NMR spectrum of compound **3o** ( $\text{CDCl}_3$ , 400 MHz)



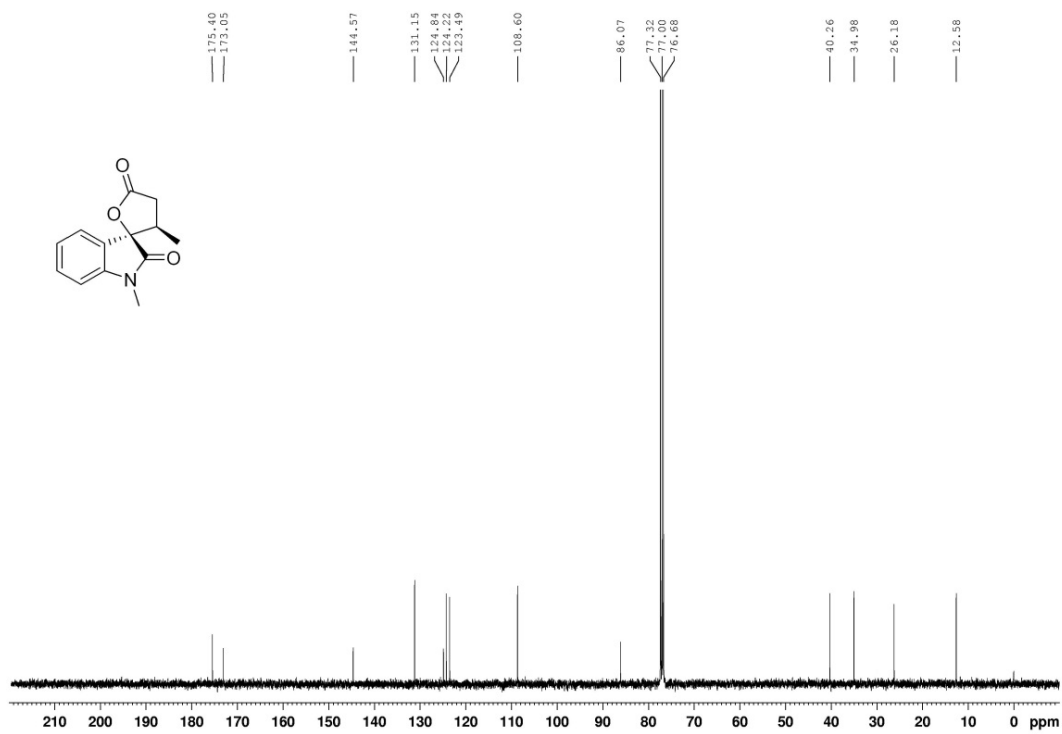
$^{13}\text{C}$  NMR spectrum of compound **3o** ( $\text{CDCl}_3$ , 100 MHz)



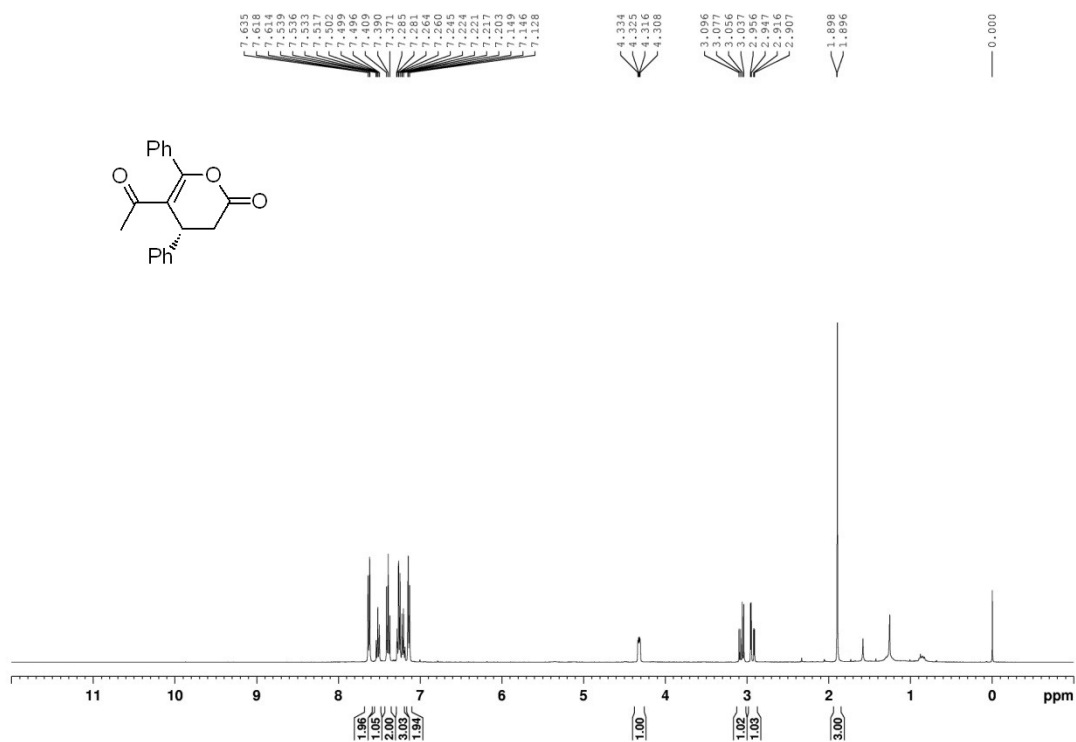
### $^1\text{H}$ NMR spectrum of compound **3p**



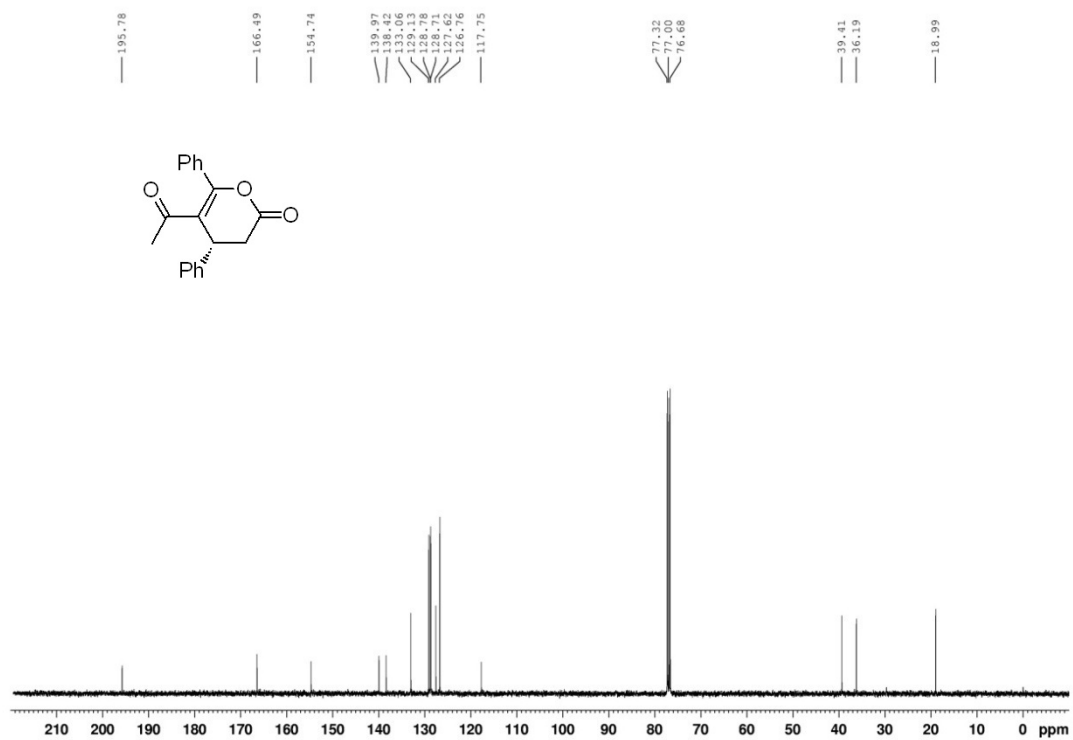
### $^{13}\text{C}$ NMR spectrum of compound **3p**



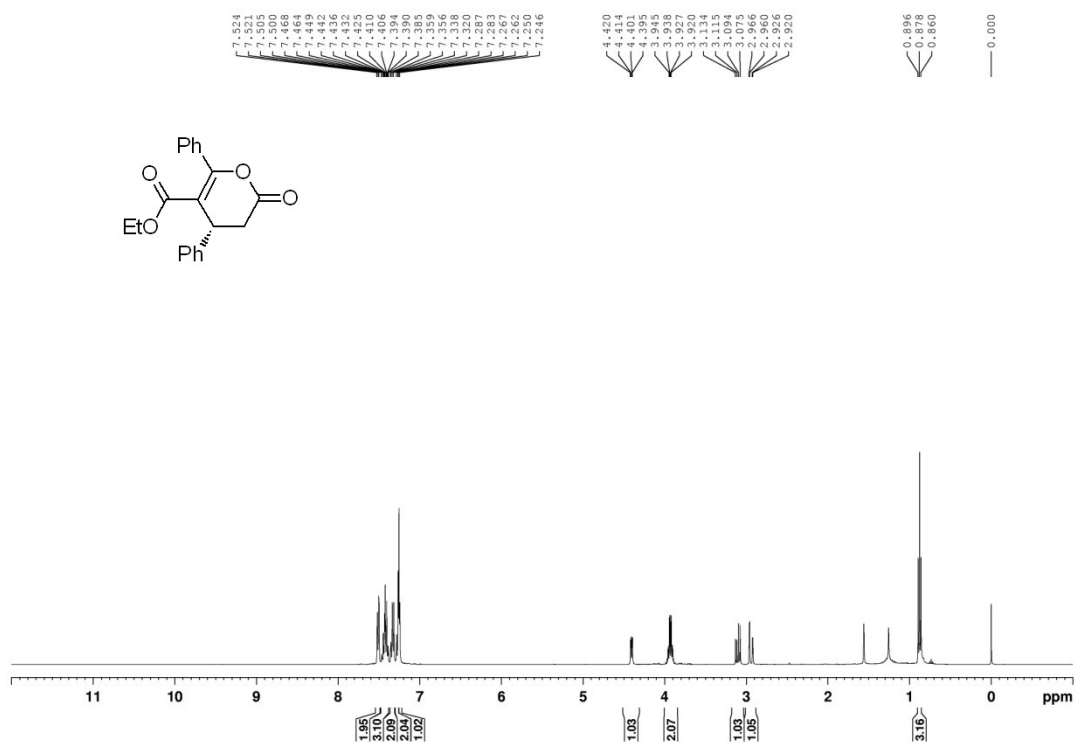
$^1\text{H}$  NMR spectrum of compound **5a** ( $\text{CDCl}_3$ , 400 MHz)



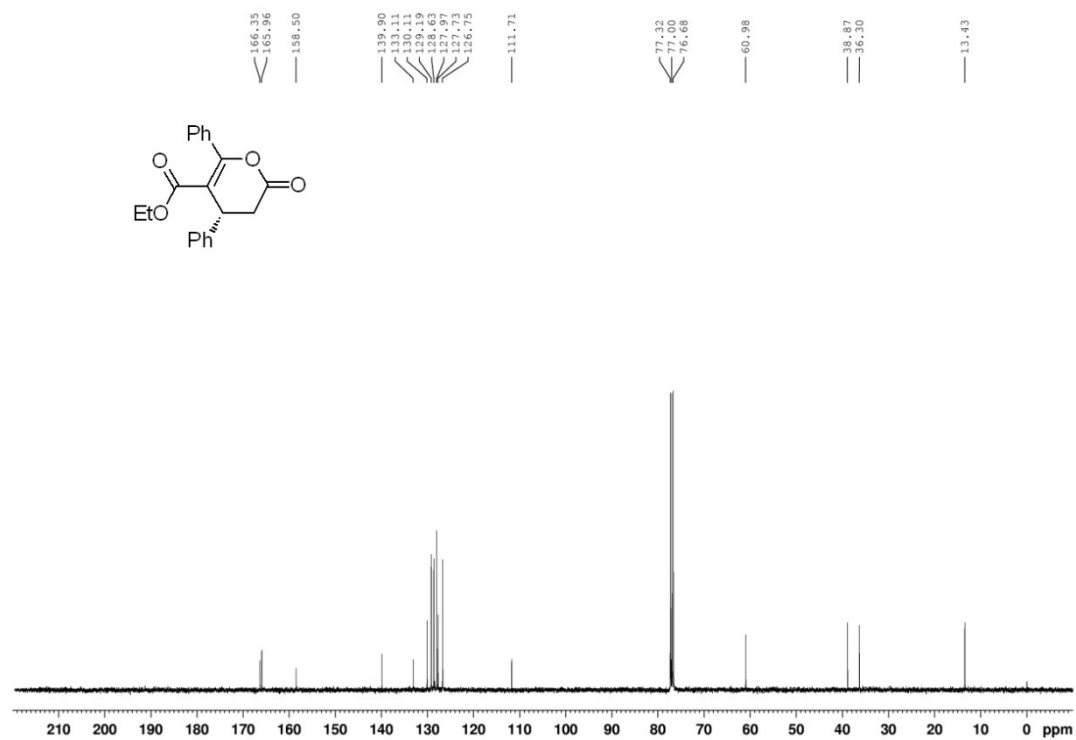
$^{13}\text{C}$  NMR spectrum of compound **5a** ( $\text{CDCl}_3$ , 100 MHz)



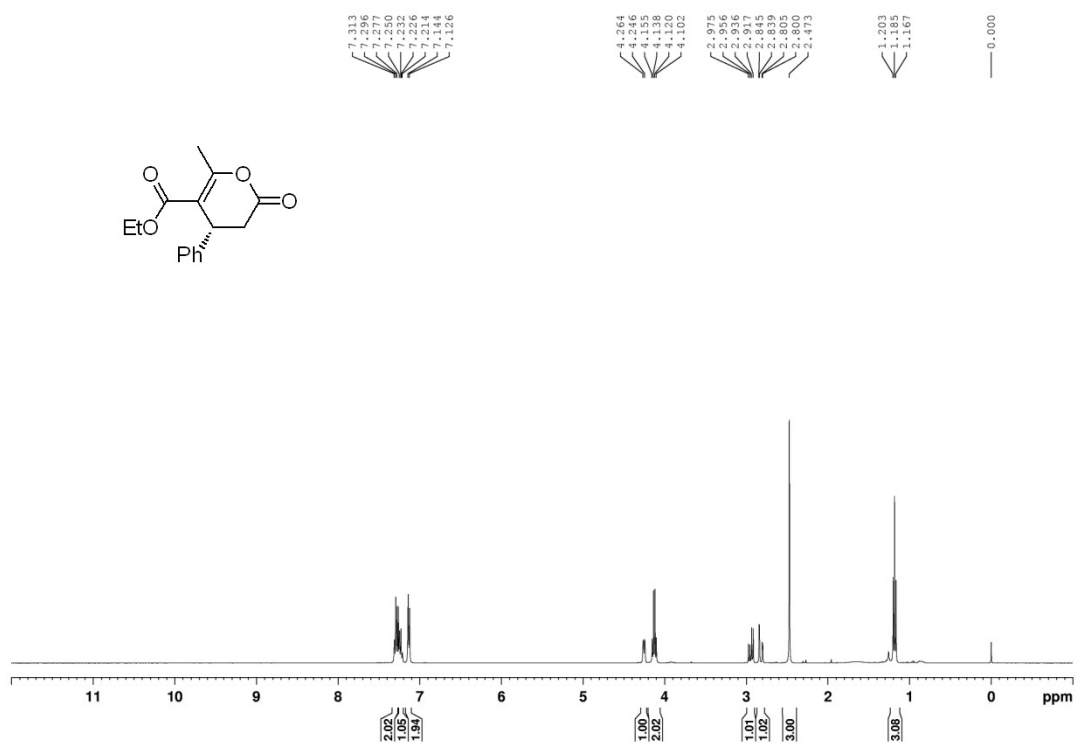
$^1\text{H}$  NMR spectrum of compound **5b** ( $\text{CDCl}_3$ , 400 MHz)



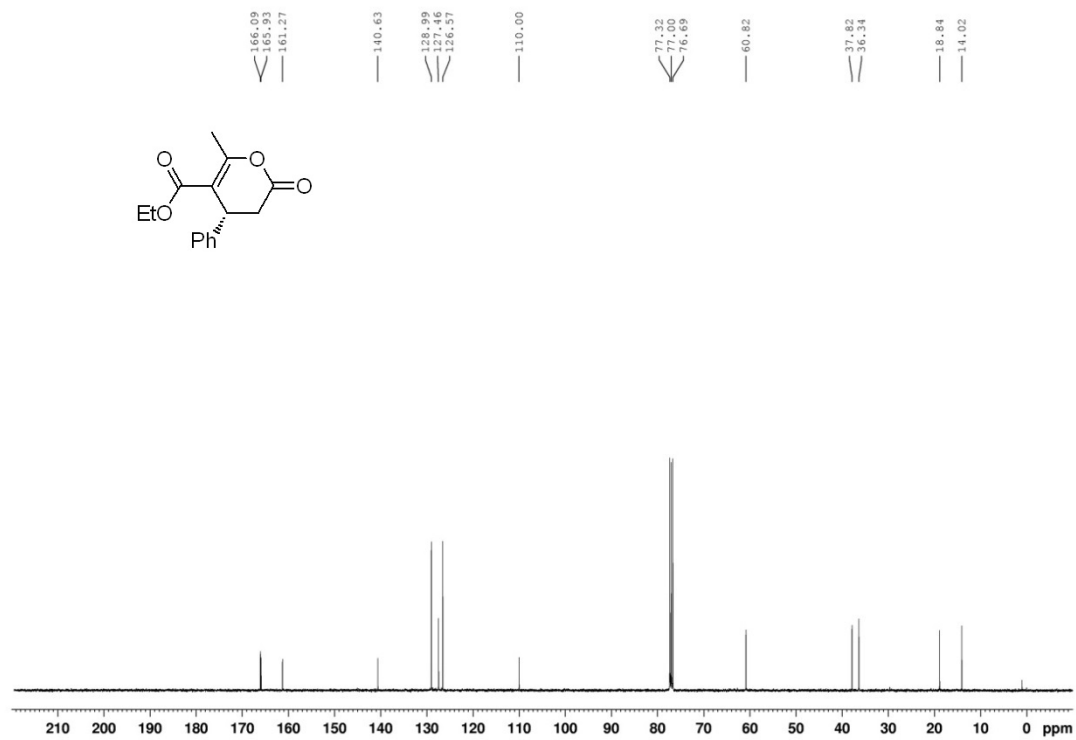
$^{13}\text{C}$  NMR spectrum of compound **5b** ( $\text{CDCl}_3$ , 100 MHz)



$^1\text{H}$  NMR spectrum of compound **5c** ( $\text{CDCl}_3$ , 400 MHz)

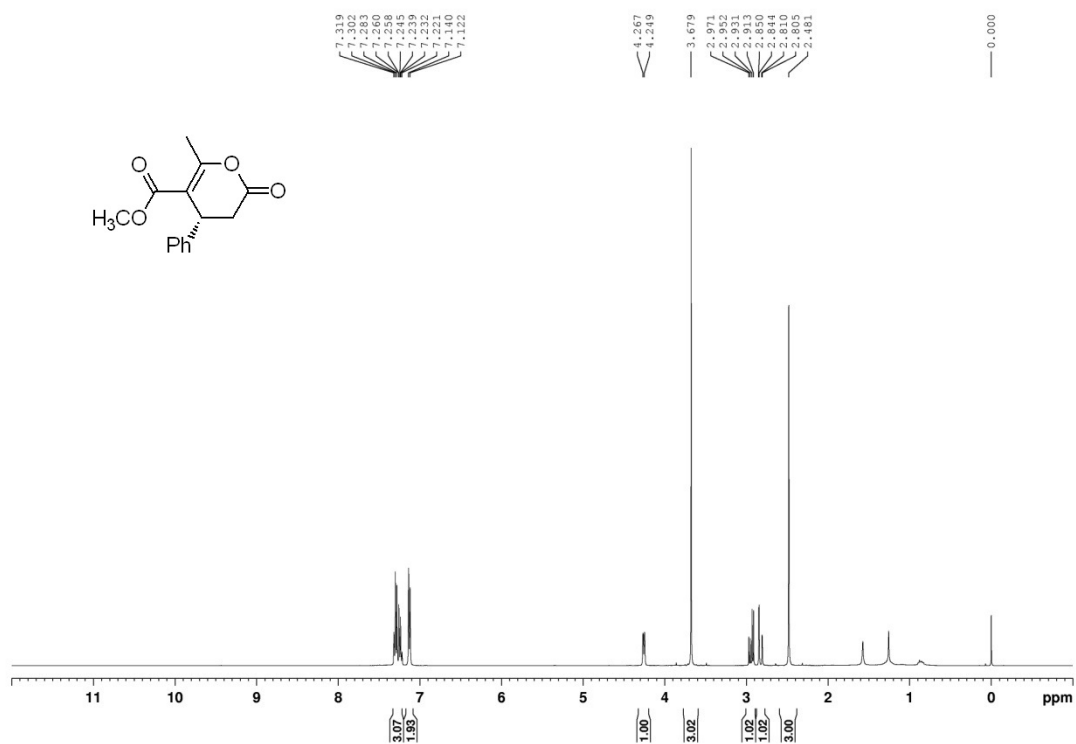


$^{13}\text{C}$  NMR spectrum of compound **5c** ( $\text{CDCl}_3$ , 100 MHz)

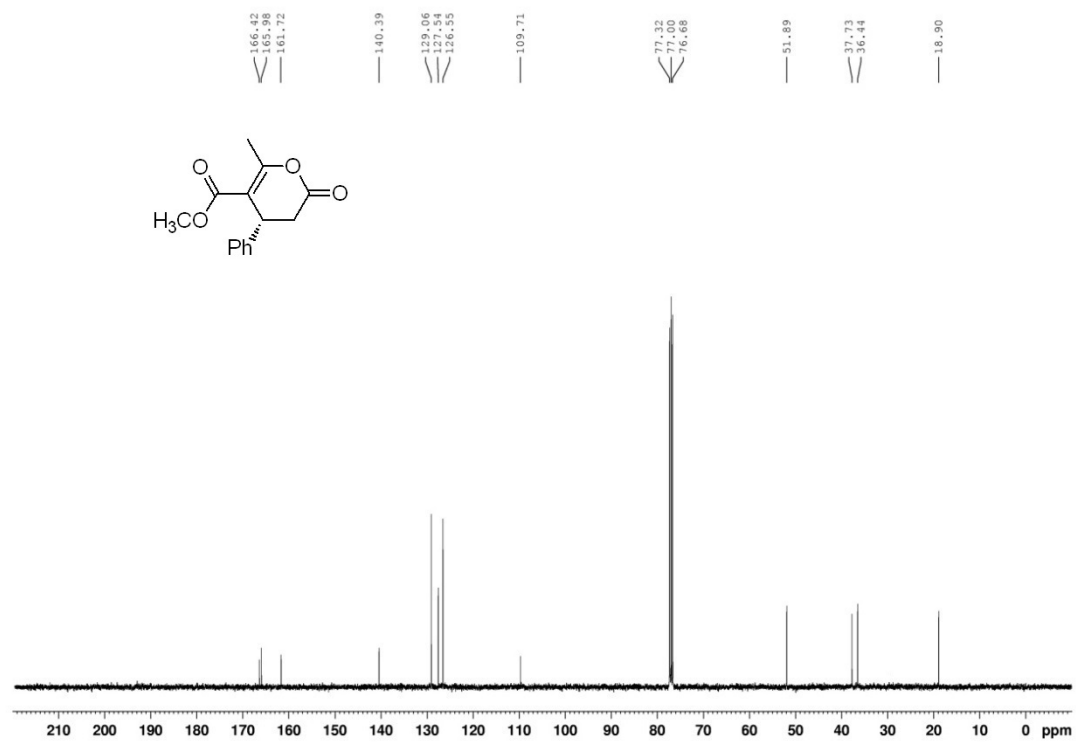




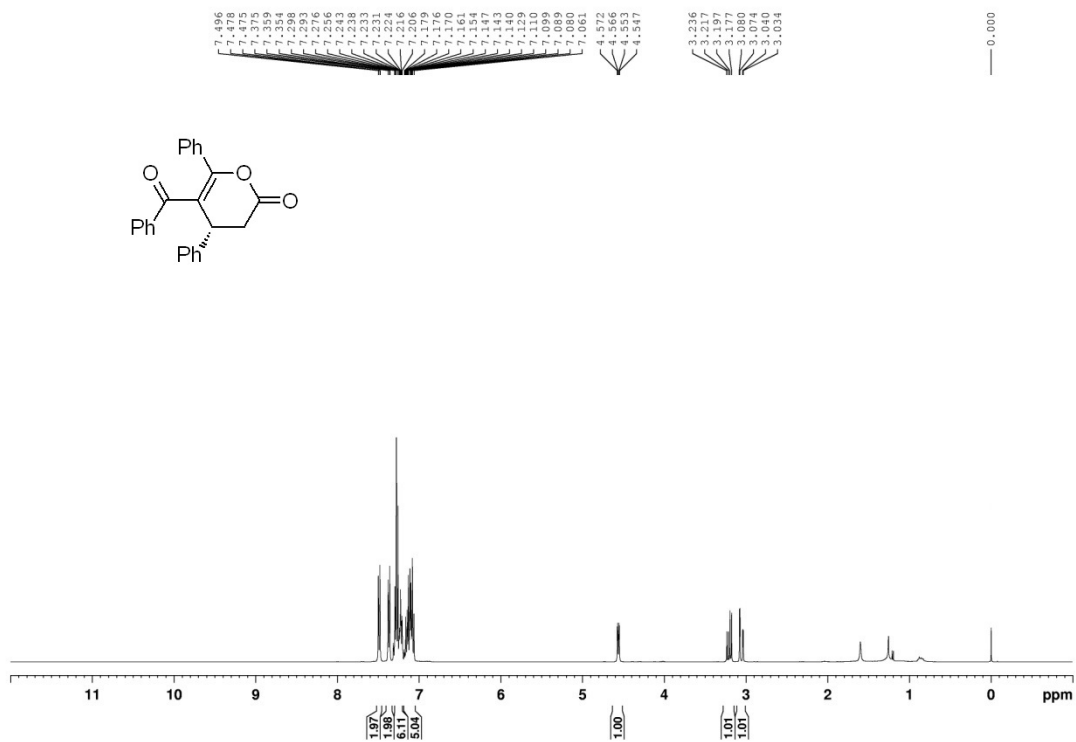
$^1\text{H}$  NMR spectrum of compound **5d** ( $\text{CDCl}_3$ , 400 MHz)



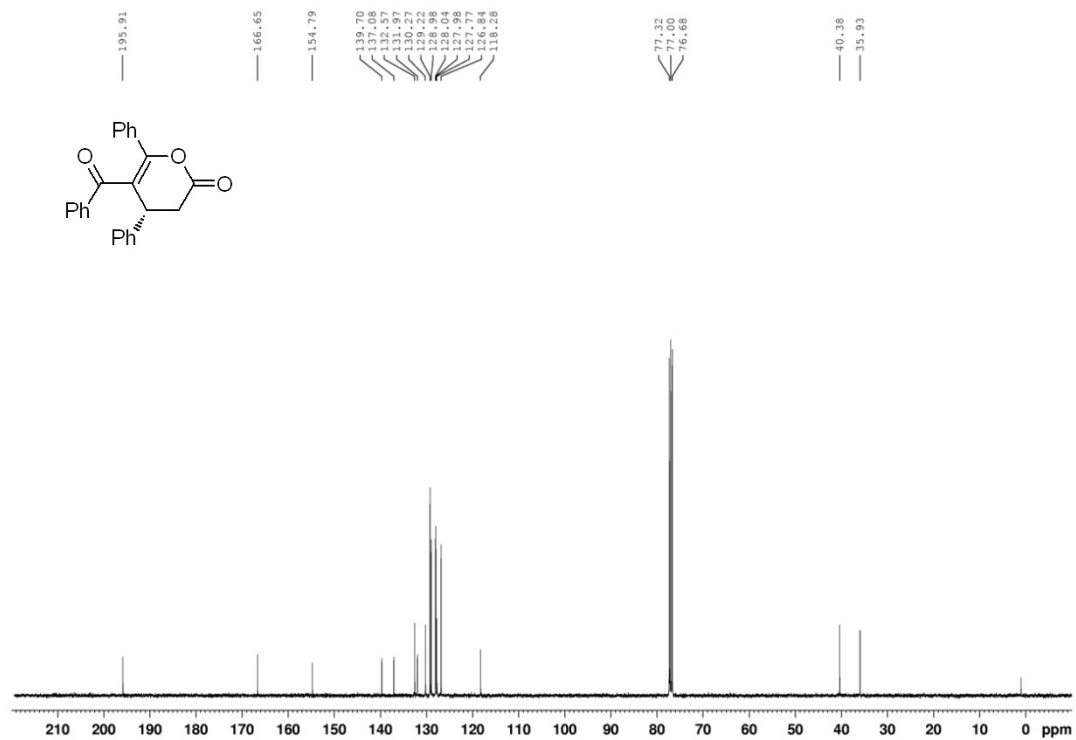
$^{13}\text{C}$  NMR spectrum of compound **5d** ( $\text{CDCl}_3$ , 100 MHz)



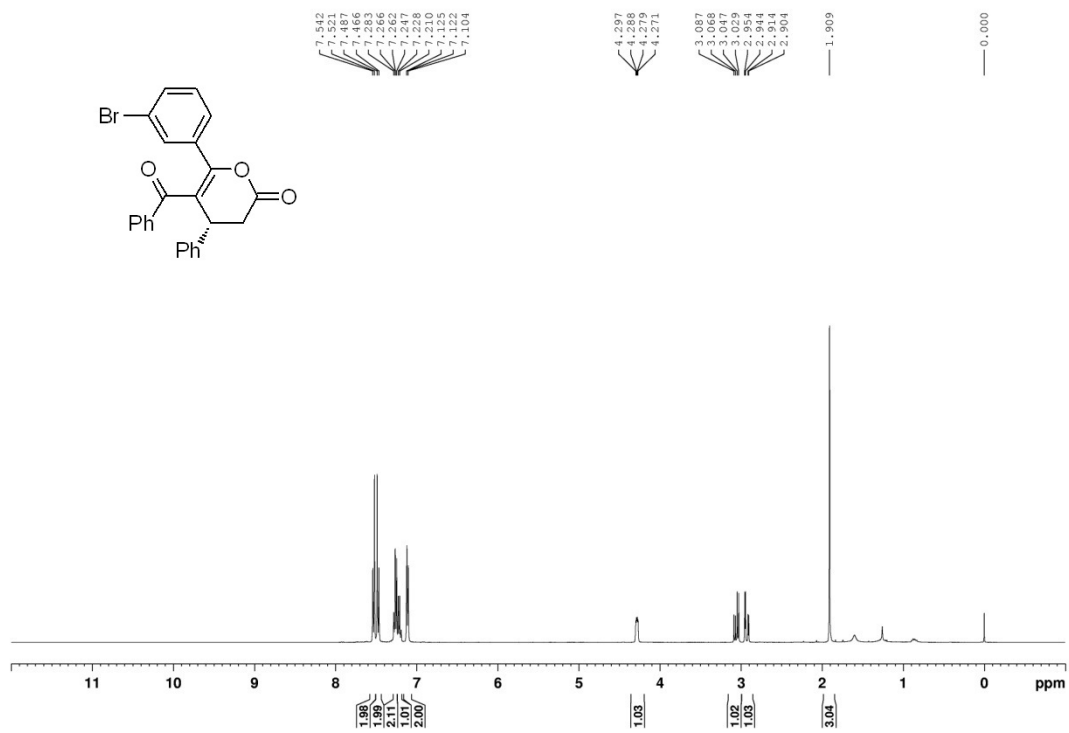
$^1\text{H}$  NMR spectrum of compound **5e** ( $\text{CDCl}_3$ , 400 MHz)



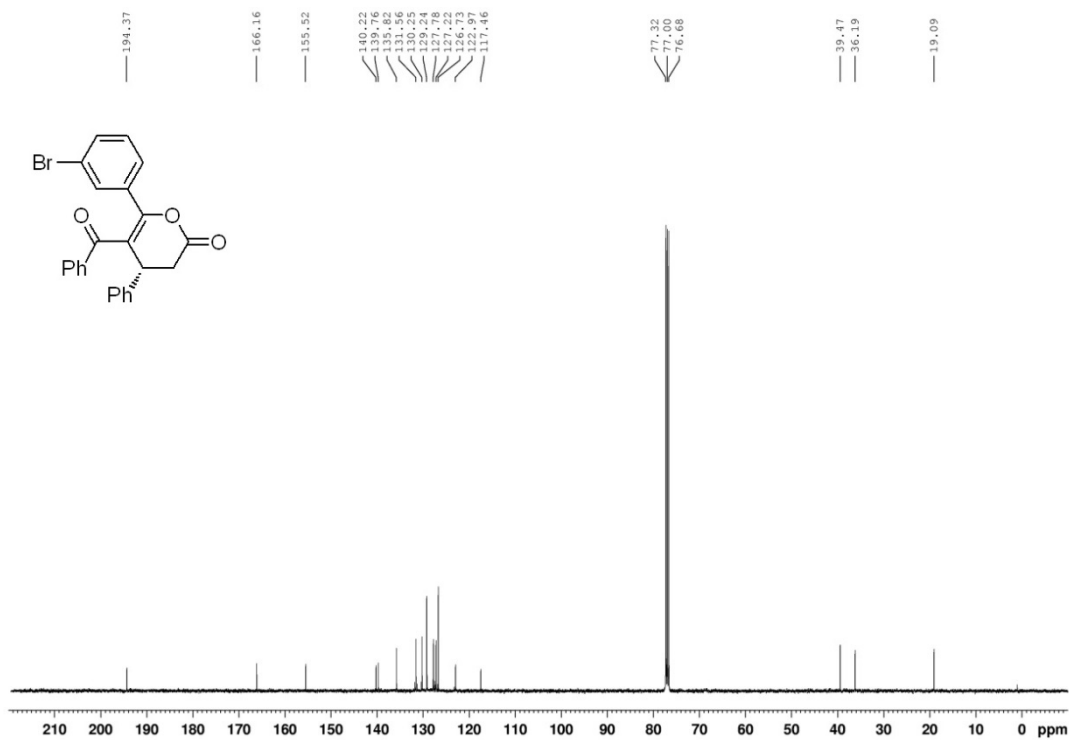
$^{13}\text{C}$  NMR spectrum of compound **5e** ( $\text{CDCl}_3$ , 100 MHz)



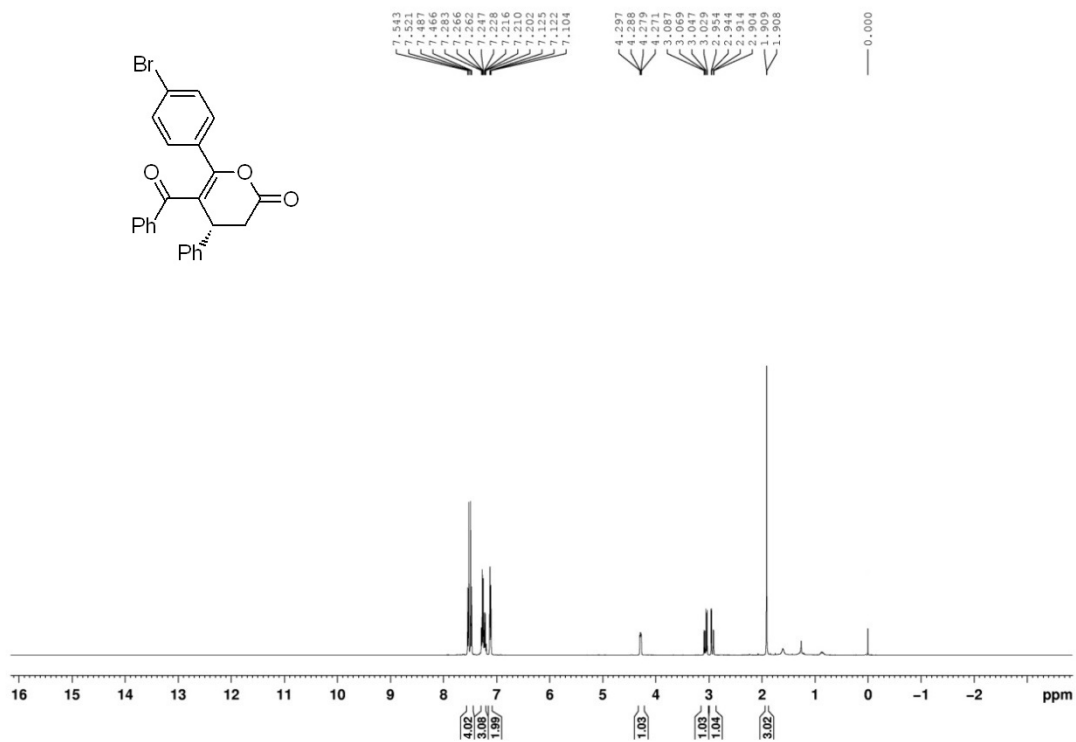
$^1\text{H}$  NMR spectrum of compound **5f** ( $\text{CDCl}_3$ , 400 MHz)



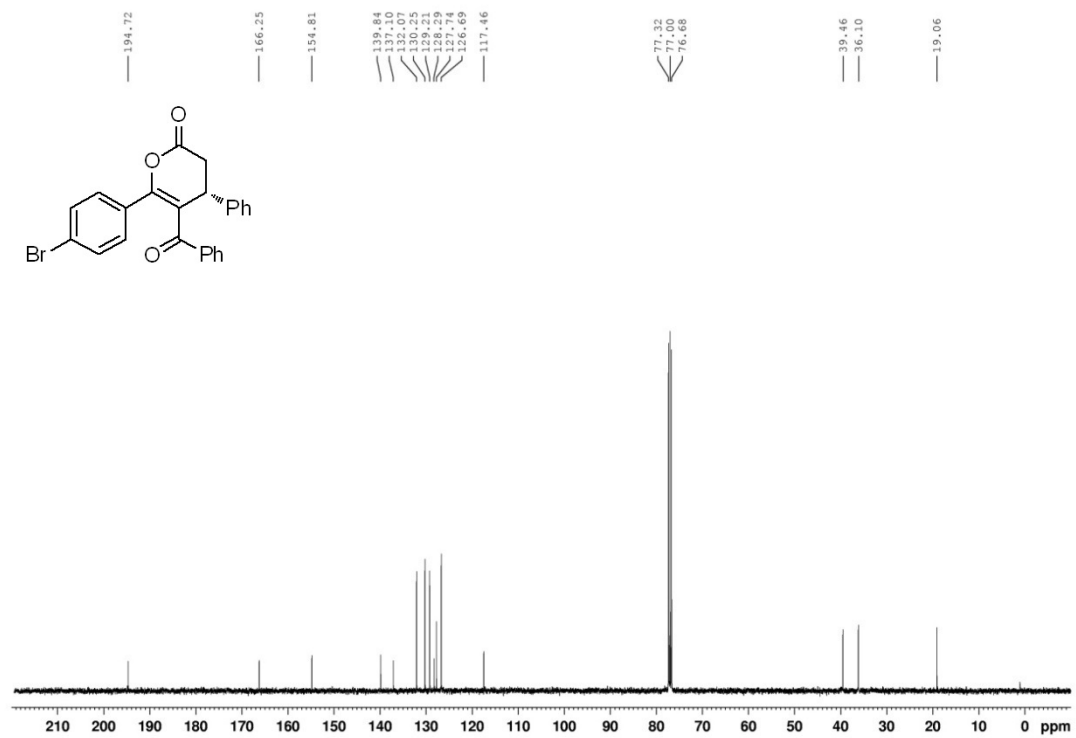
$^{13}\text{C}$  NMR spectrum of compound **5f** ( $\text{CDCl}_3$ , 100 MHz)



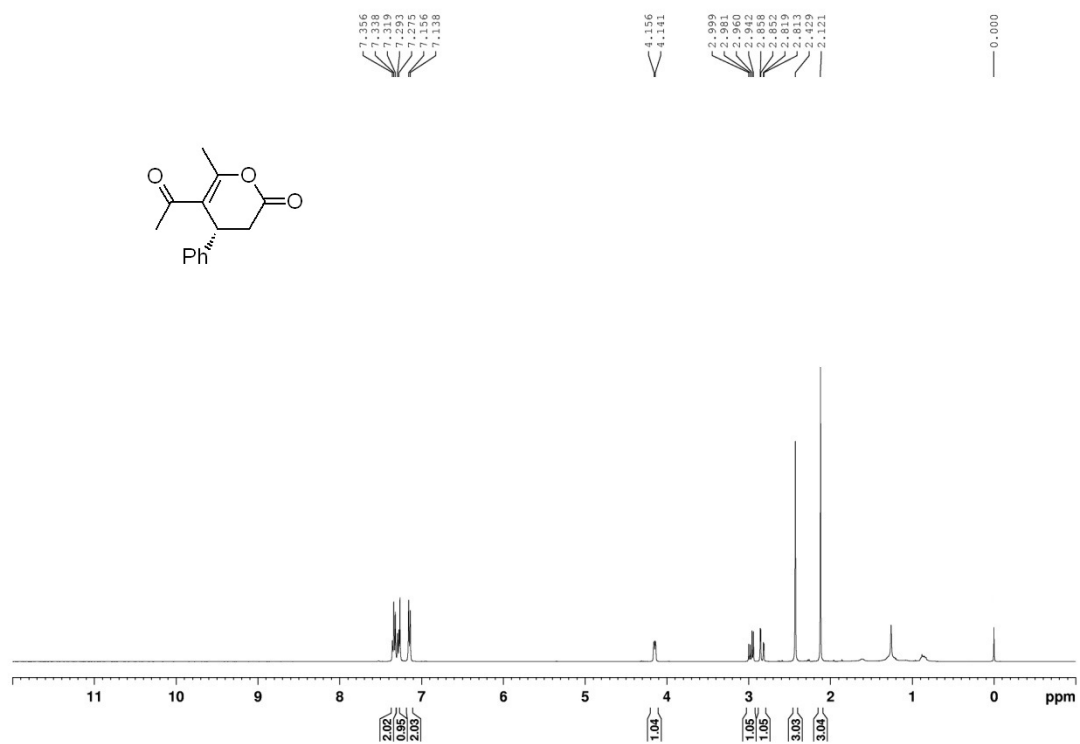
$^1\text{H}$  NMR spectrum of compound **5g** ( $\text{CDCl}_3$ , 400 MHz)



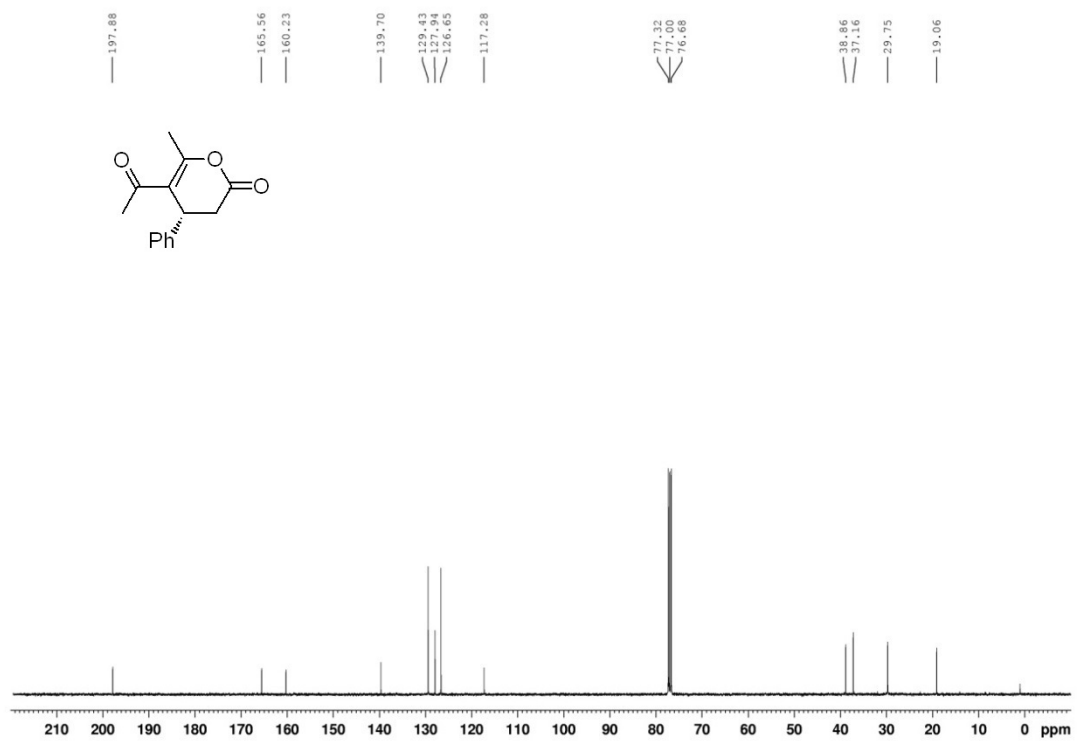
$^{13}\text{C}$  NMR spectrum of compound **5g** ( $\text{CDCl}_3$ , 100 MHz)



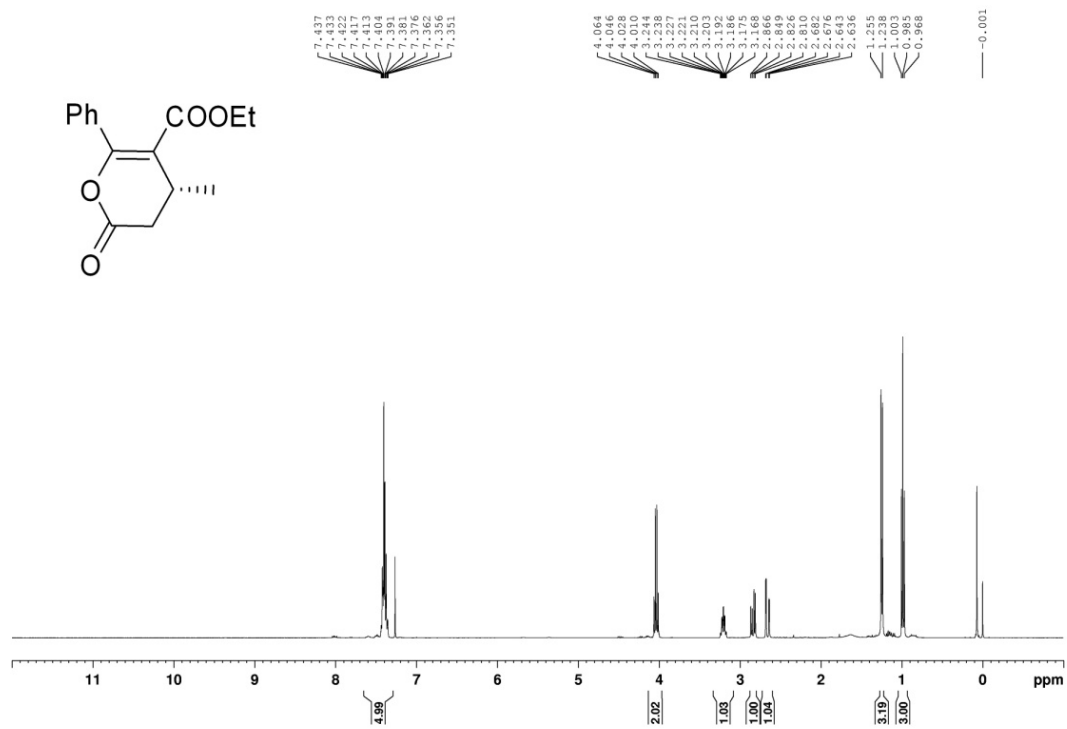
$^1\text{H}$  NMR spectrum of compound **5h** ( $\text{CDCl}_3$ , 400 MHz)



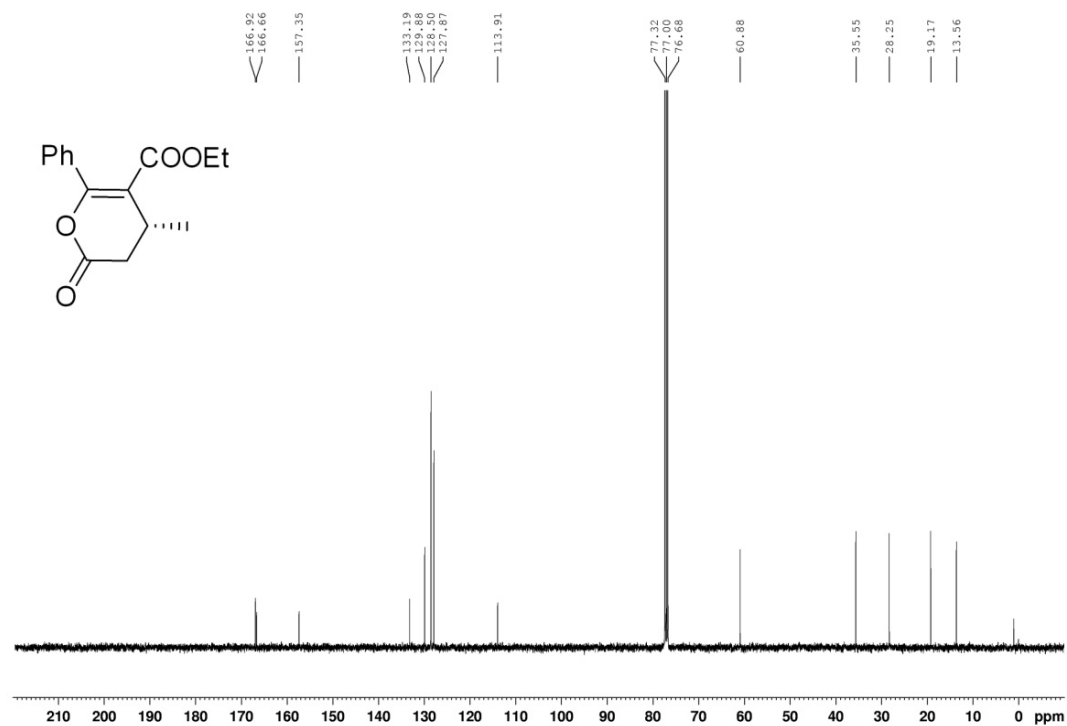
$^{13}\text{C}$  NMR spectrum of compound **5h** ( $\text{CDCl}_3$ , 100 MHz)



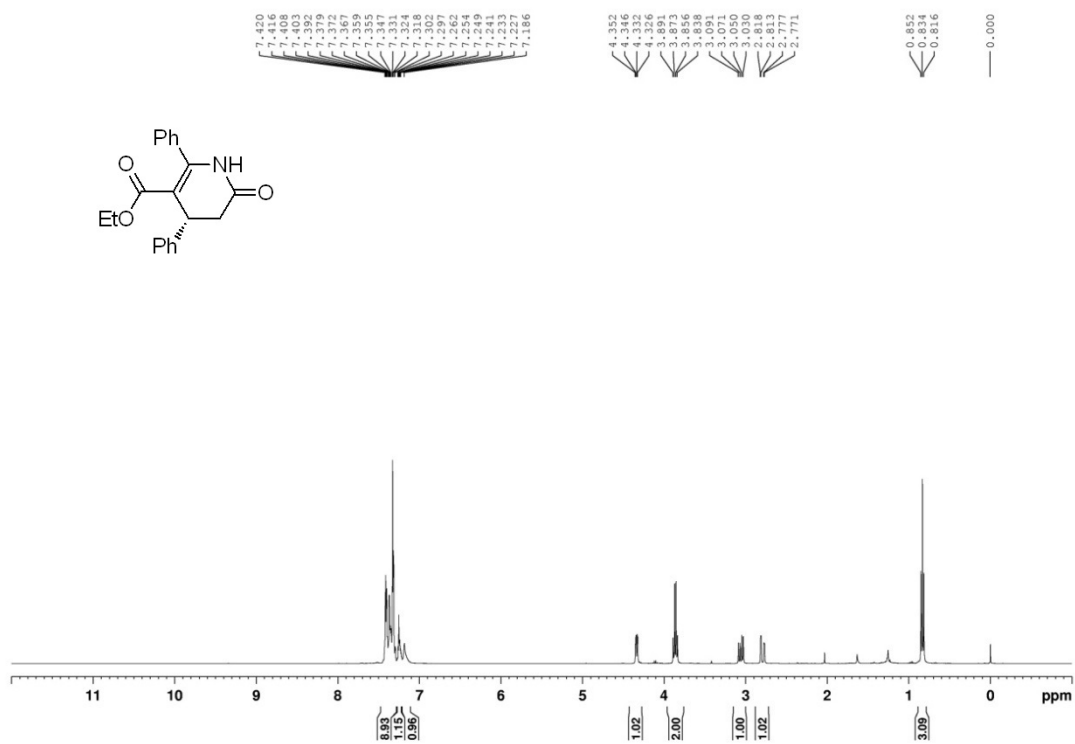
$^1\text{H}$  NMR spectrum of compound **5i** ( $\text{CDCl}_3$ , 400 MHz)



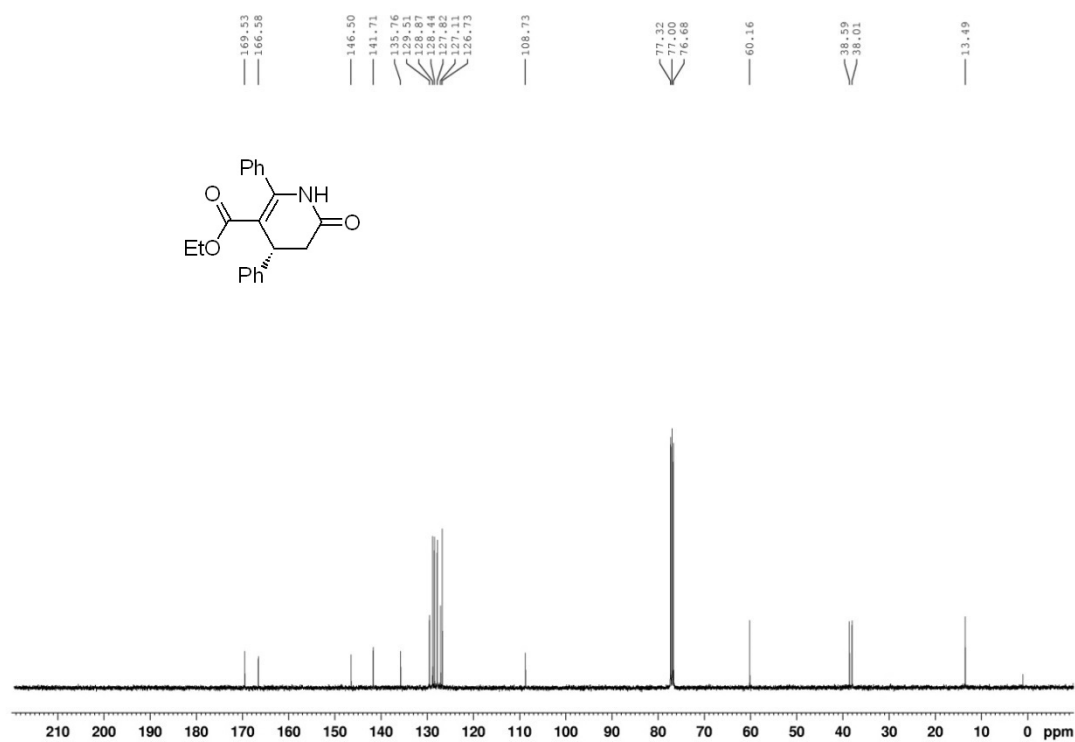
$^{13}\text{C}$  NMR spectrum of compound **5i** ( $\text{CDCl}_3$ , 100 MHz)



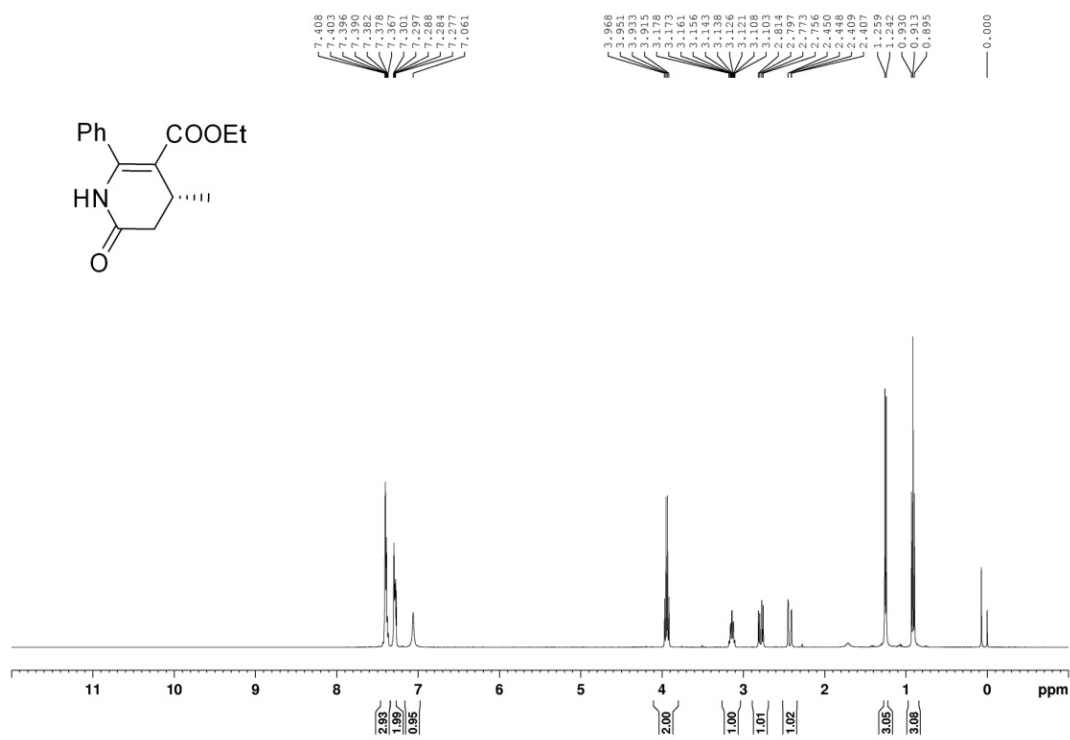
$^1\text{H}$  NMR spectrum of compound **7a** ( $\text{CDCl}_3$ , 400 MHz)



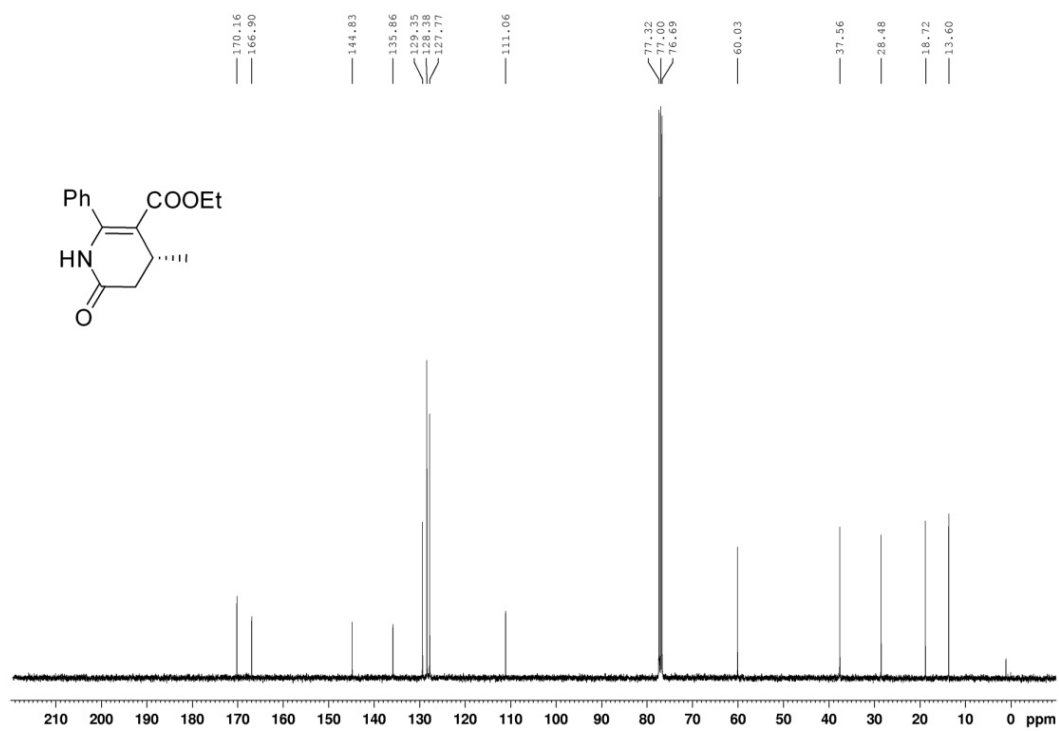
$^{13}\text{C}$  NMR spectrum of compound **7a** ( $\text{CDCl}_3$ , 100 MHz)



$^1\text{H}$  NMR spectrum of compound **7b** ( $\text{CDCl}_3$ , 400 MHz)

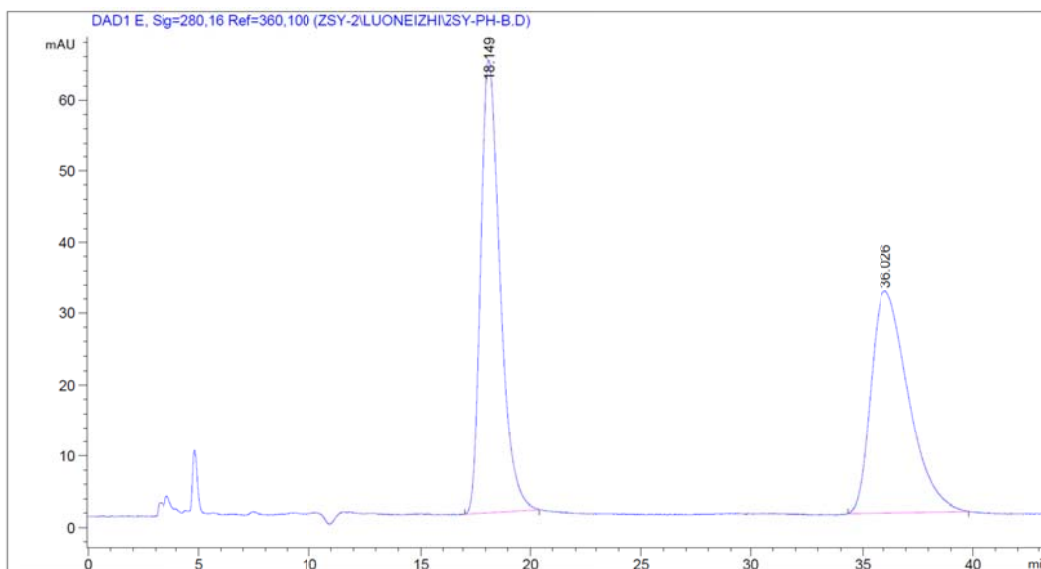
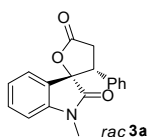


$^{13}\text{C}$  NMR spectrum of compound **7b** ( $\text{CDCl}_3$ , 100 MHz)

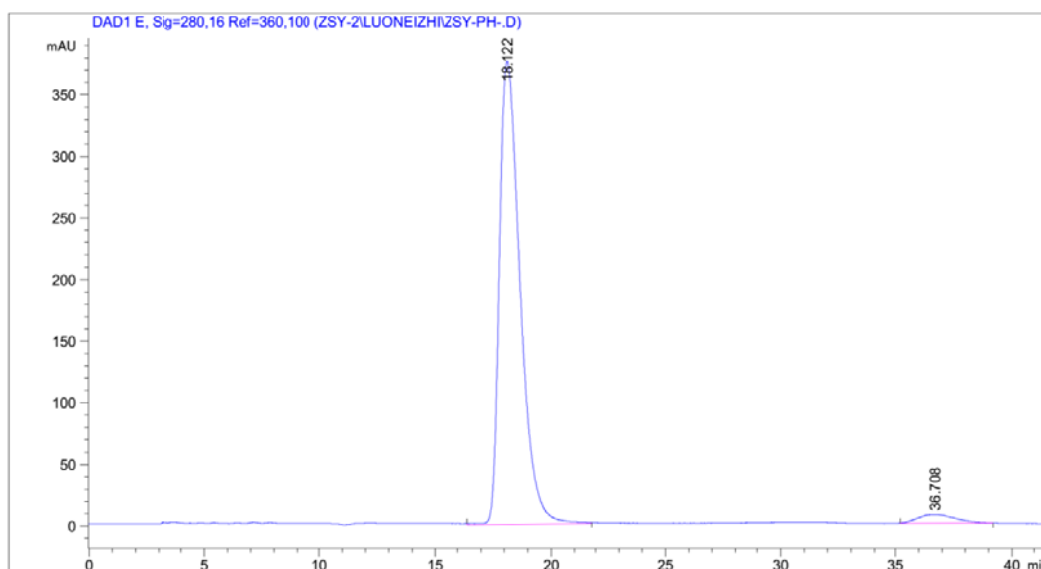
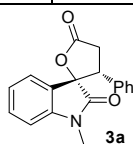




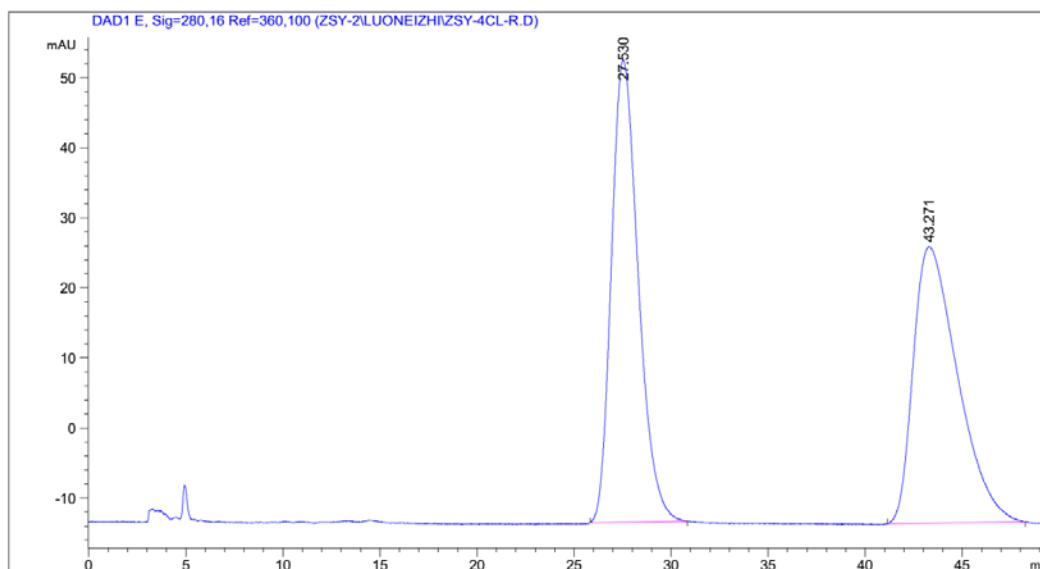
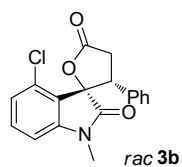
## 7. HPLC spectra for compounds 3a–3f, 3h–3p, 5a–5i and 7a–7b



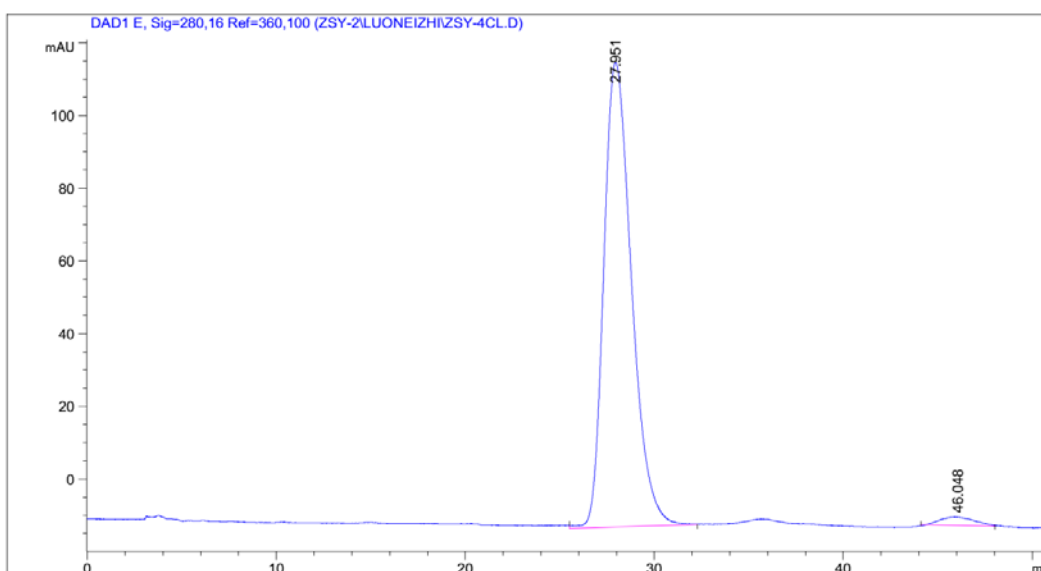
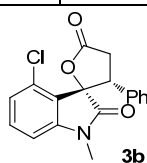
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 280.16 nm	18.149	3813.47461	63.44444	50.64
2	PDA 280.16 nm	36.026	3717.01733	31.01186	49.36



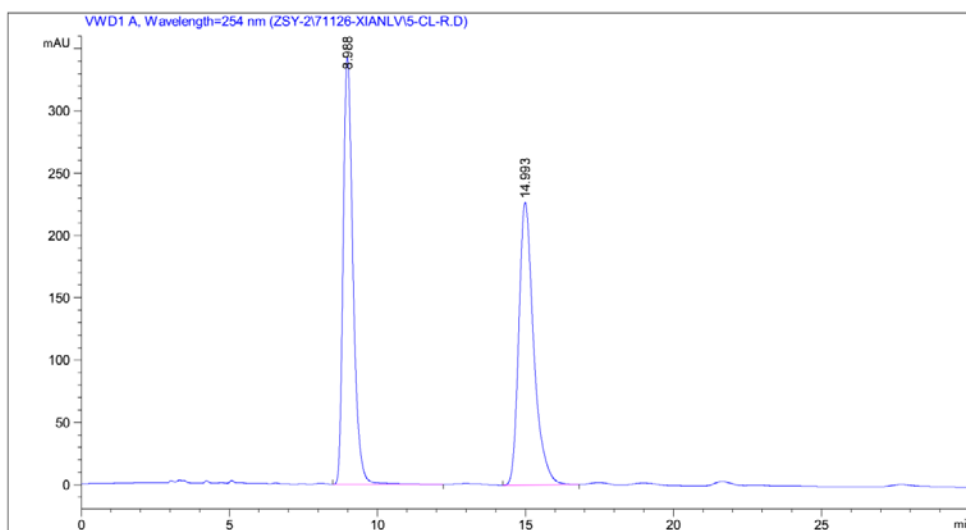
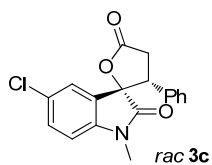
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 280.16 nm	18.122	2.31660e4	376.05981	97.76
2	PDA 280.16 nm	36.708	763.95637	7.03376	2.24



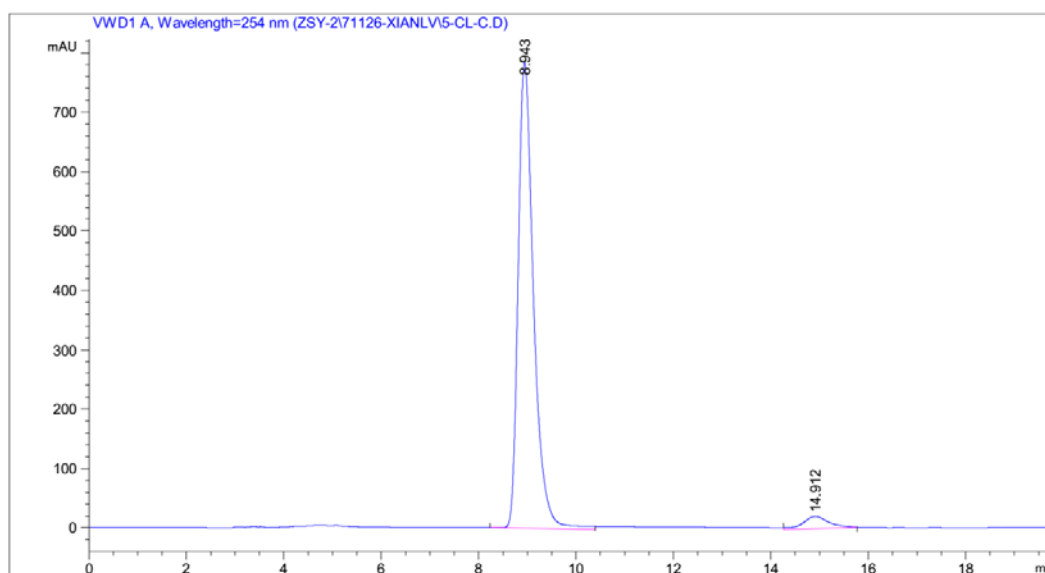
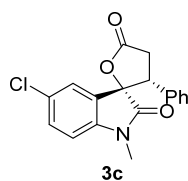
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 280.16 nm	27.530	6358.36572	66.00119	50.38
2	PDA 280.16 nm	43.271	6261.76416	39.47338	49.62



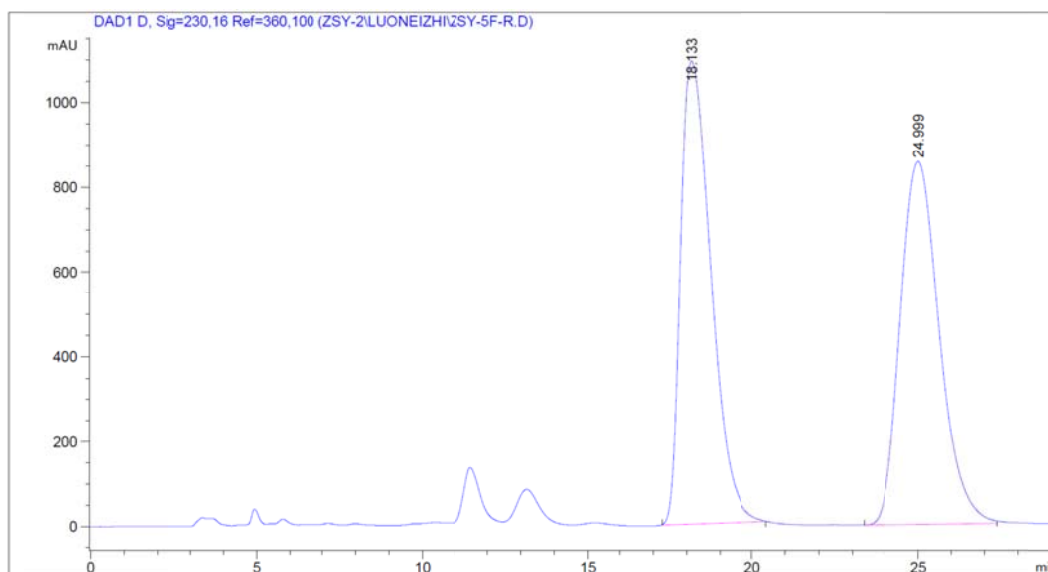
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 280.16 nm	27.951	1.30335 e4	127.79919	97.72
2	PDA 280.16 nm	46.048	304.04662	2.38757	2.28



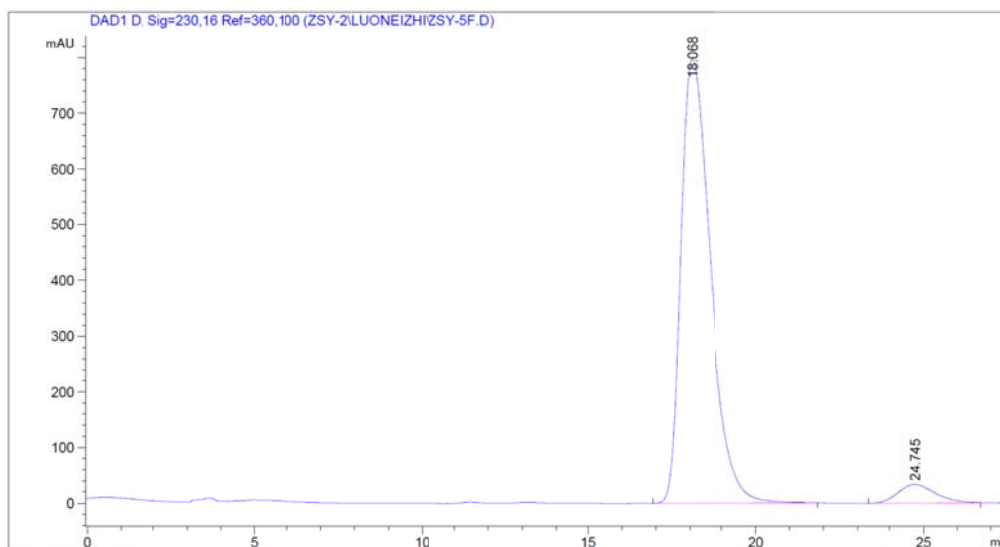
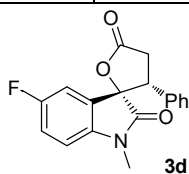
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	8.988	7917.94434	342.60480	49.99
2	PDA 254 nm	14.993	7918.29199	226.89465	50.01



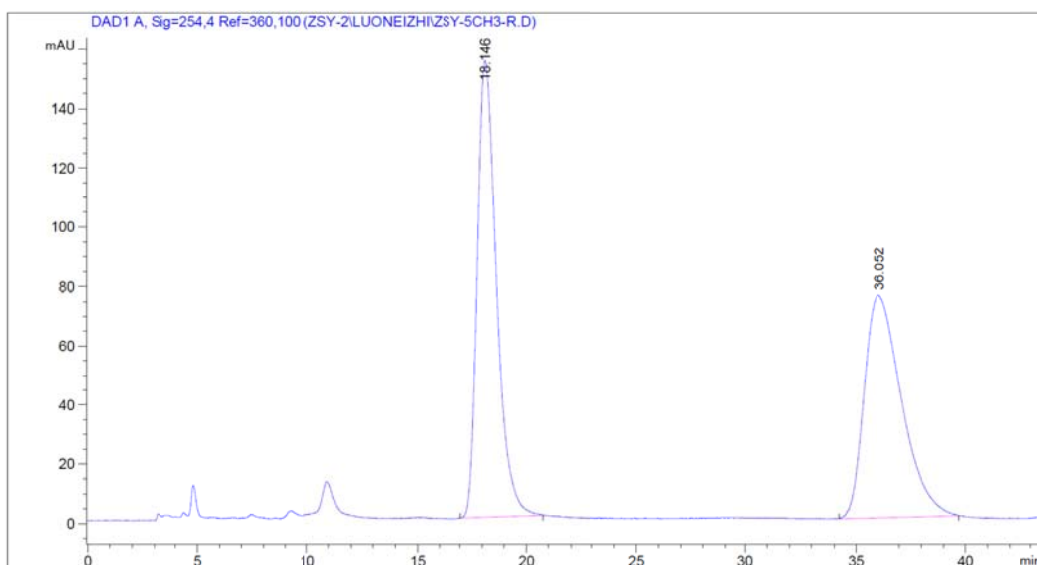
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	8.943	1.72543e4	785.07922	95.84
2	PDA 254 nm	14.912	749.80920	20.46606	4.16



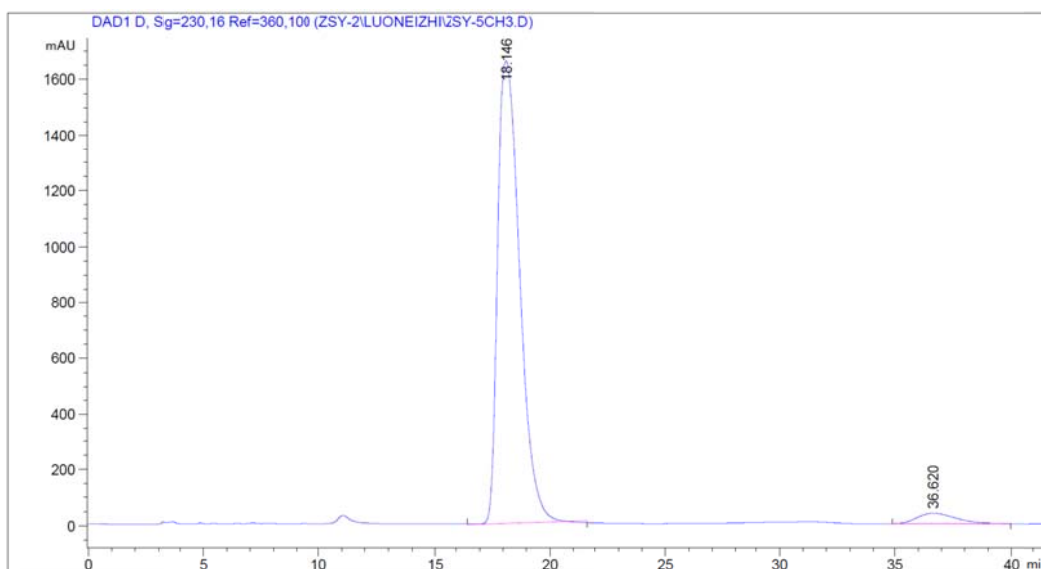
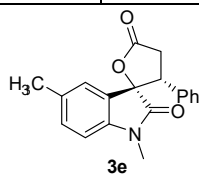
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 230.16 nm	18.133	6.92980e4	1092.24377	49.70
2	PDA 230.16nm	24.999	7.01397e4	856.33618	50.30



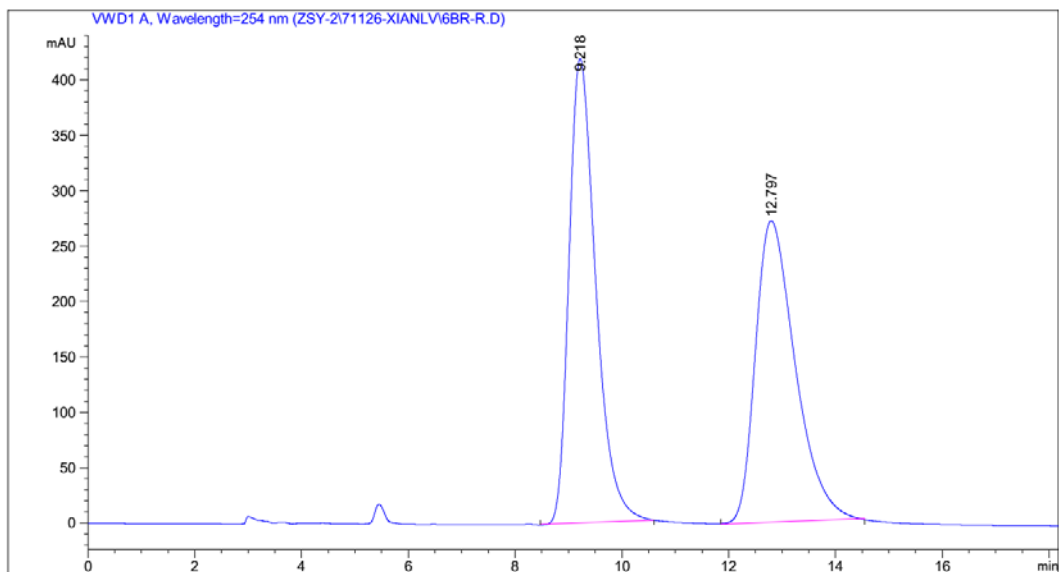
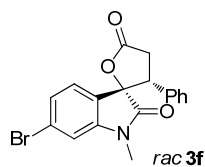
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 230.16 nm	18.068	4.95033e4	798.68909	96.36
2	PDA 230.16 nm	24.745	2567.60522	33.54792	3.64



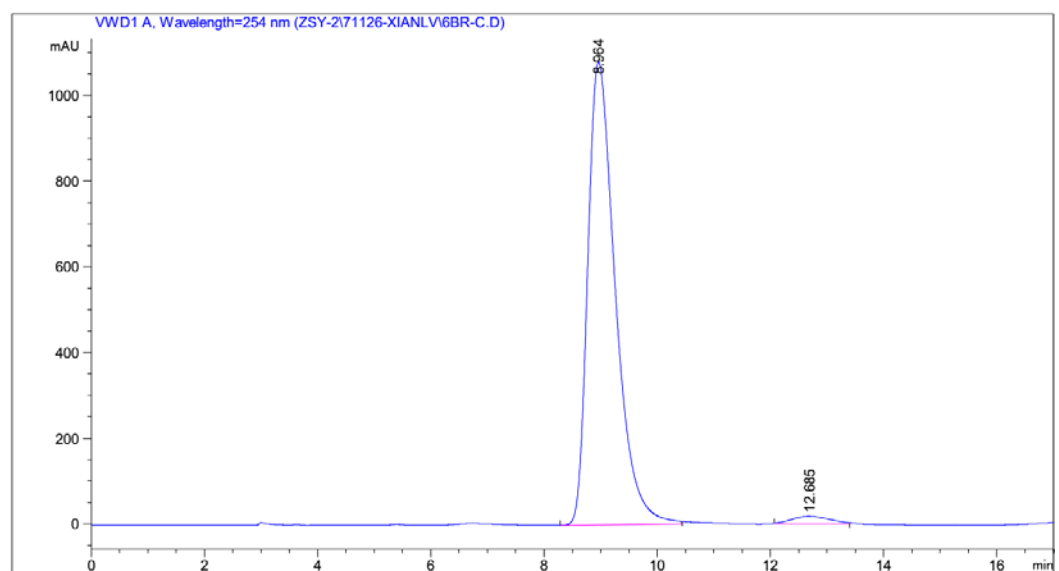
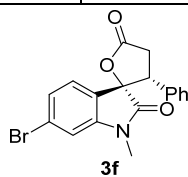
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	18.146	9285.13867	154.11418	50.76
2	PDA 254 nm	36.052	9008.18945	75.27971	49.24



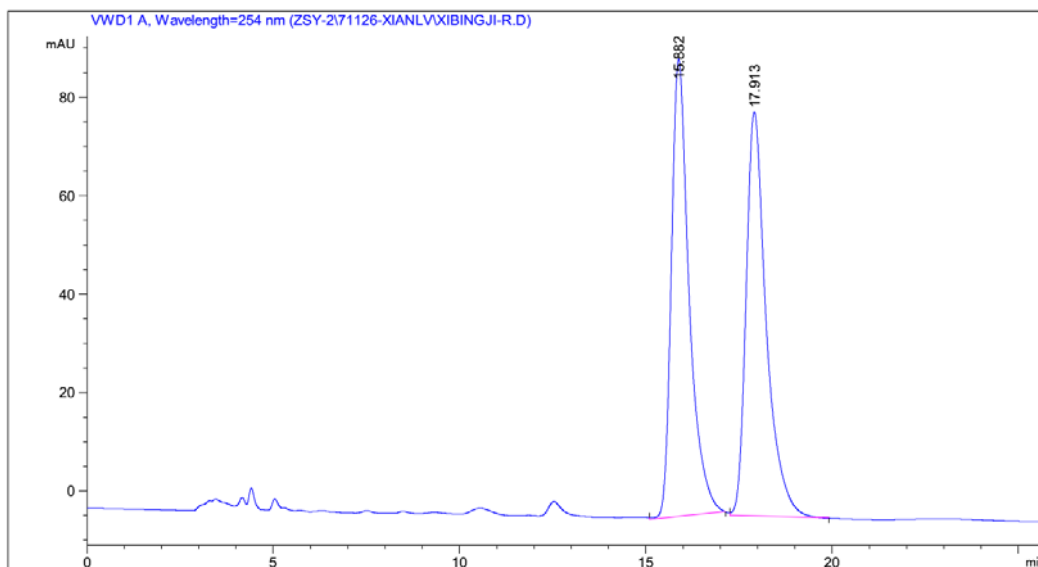
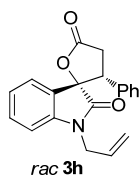
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	18.146	1.07854e5	1655.87183	98.65
2	PDA 254 nm	36.620	4413.67285	37.71472	1.35



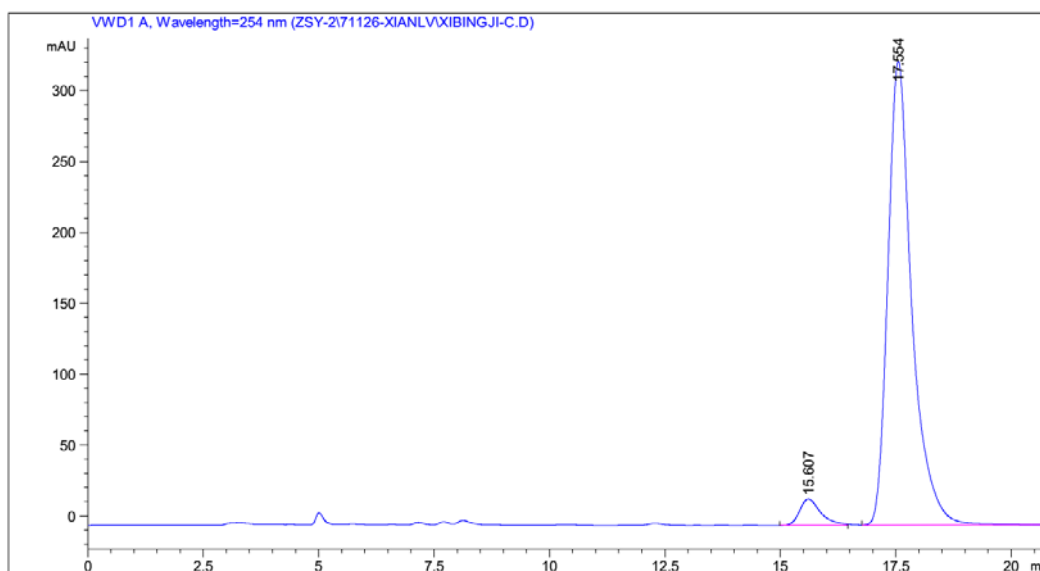
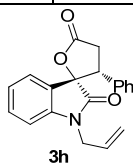
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	9.218	1.45982e4	419.09821	50.89
2	PDA 254 nm	12.797	1.40889e4	272.19839	49.11



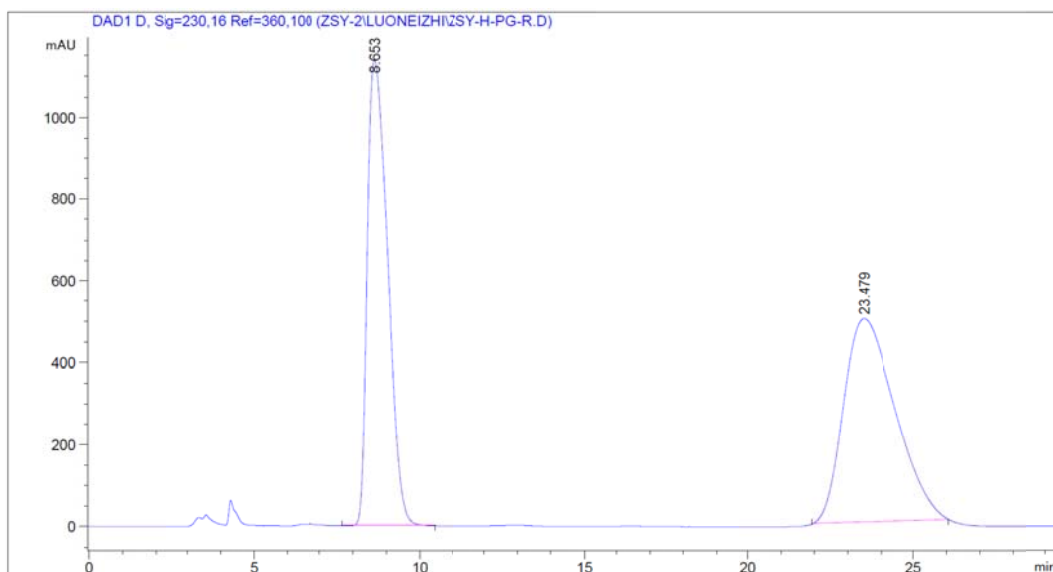
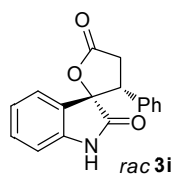
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	8.964	3.65524e4	1081.66357	98.35
2	PDA 254 nm	12.685	829.90753	18.17889	1.65



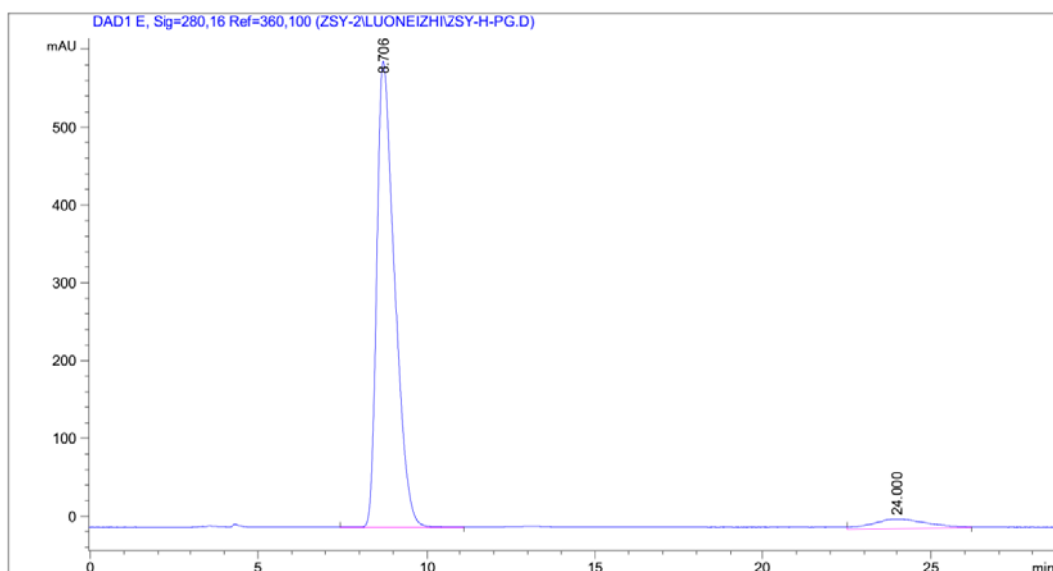
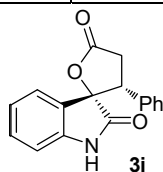
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	15.882	3081.38013	92.98299	49.96
2	PDA 254 nm	17.913	3086.50464	82.17327	50.04



Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	15.607	579.02112	18.36727	3.48
2	PDA 254 nm	17.554	1.18044e4	327.30682	97.52

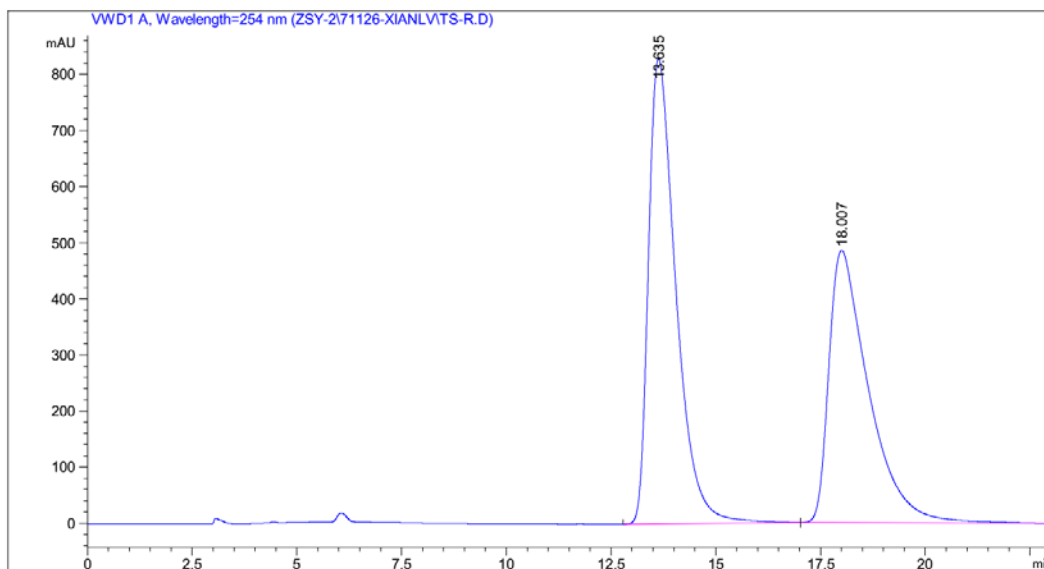
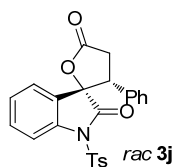


Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 230 nm	8.653	4.77599e4	1134.67993	48.86
2	PDA 230nm	23.479	5.41531e4	495.64865	51.14

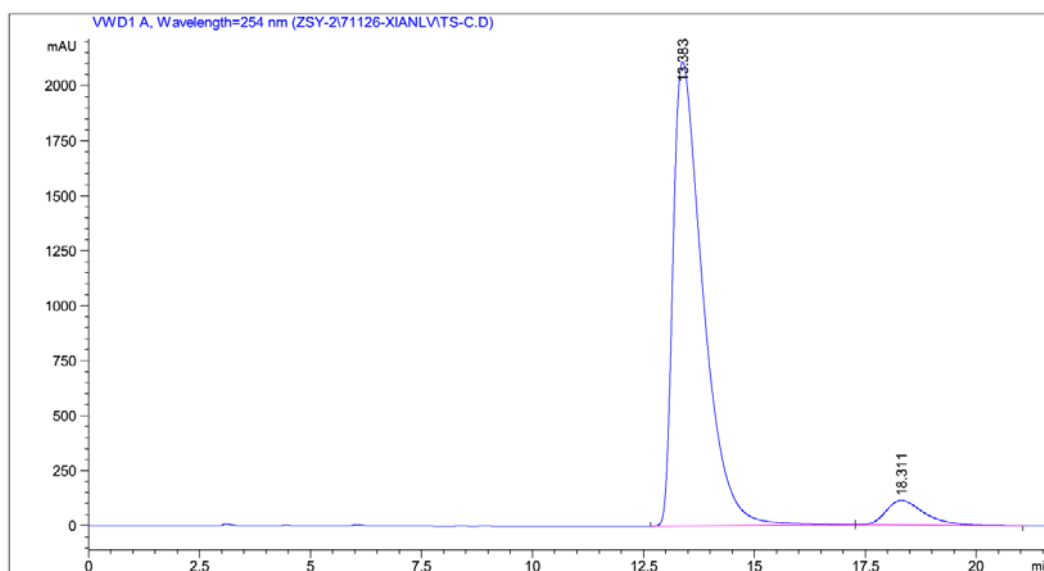
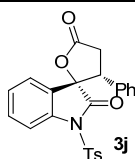


Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254nm	8.706	2.19020e4	599.54016	97.41
2	PDA 254nm	24.000	536.45471	7.34325	2.59

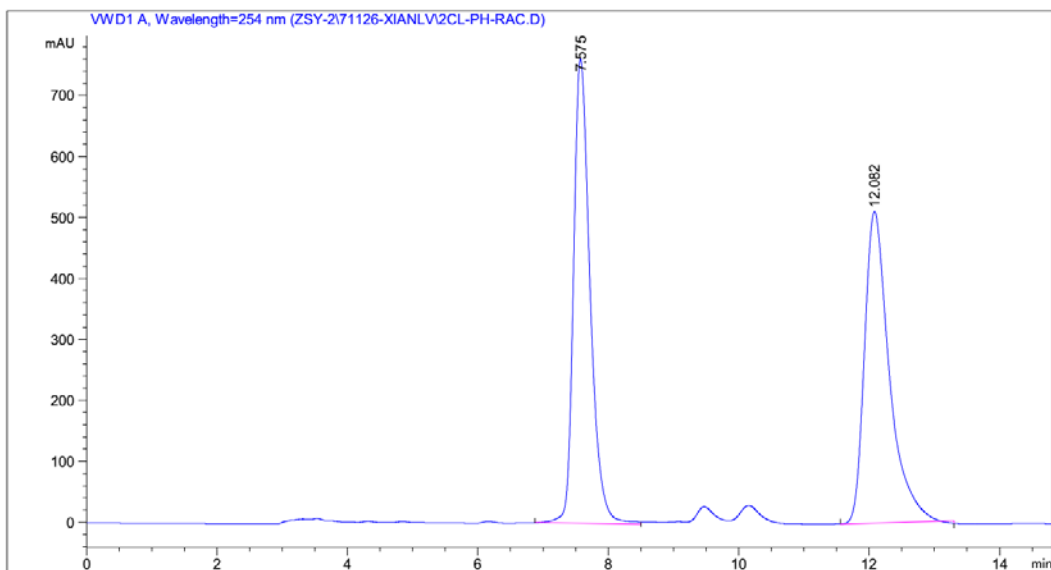
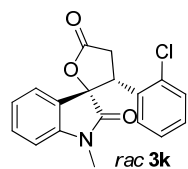




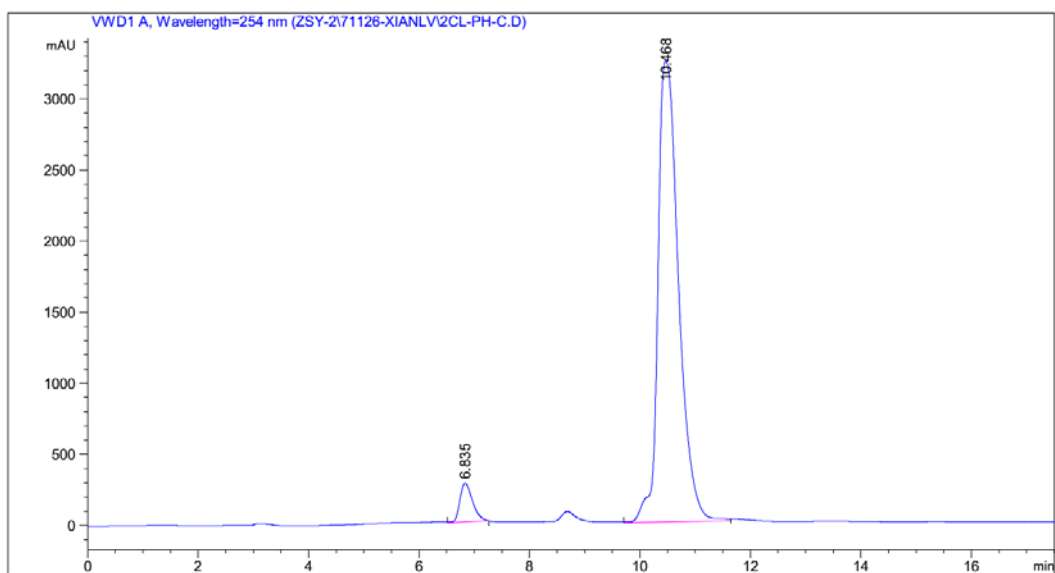
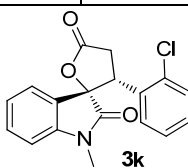
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	13.635	3.77319e4	828.47968	52.17
2	PDA 254 nm	18.007	3.19220e4	485.59973	47.83



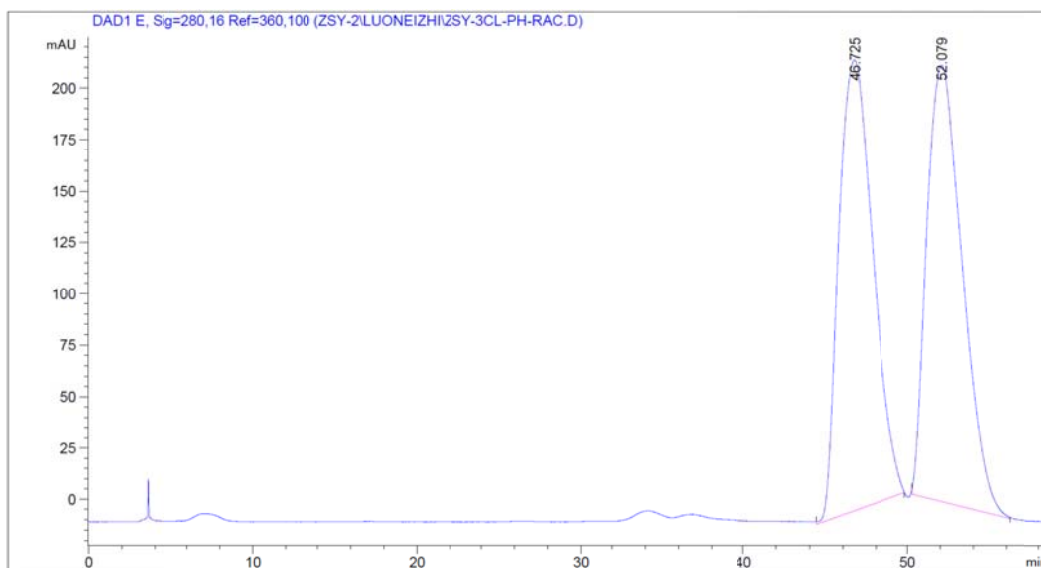
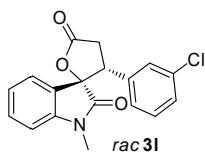
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	13.383	9.87124e4	2109.53125	93.55
2	PDA 254 nm	18.311	6810.26416	111.99897	6.45



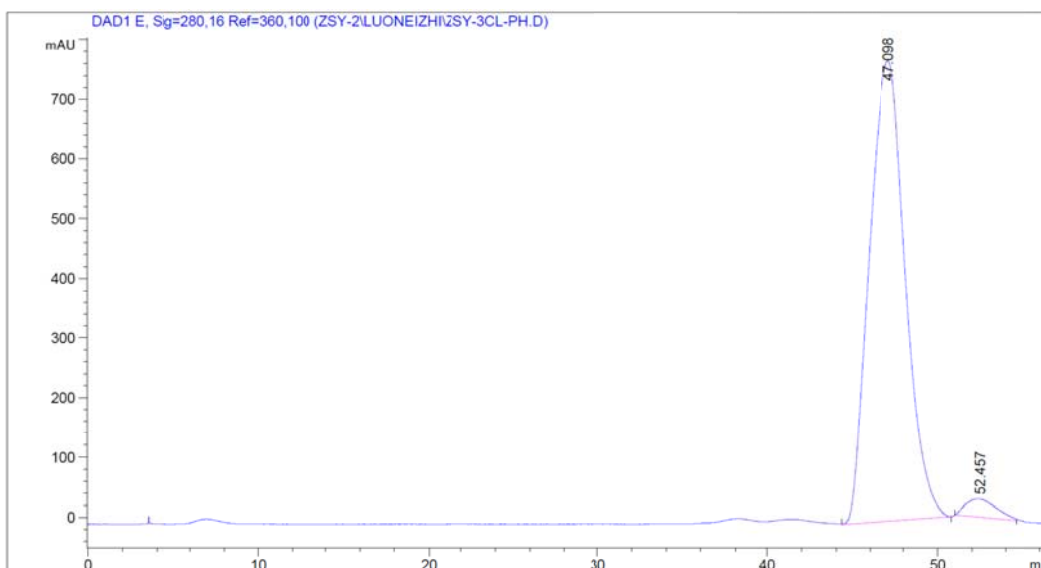
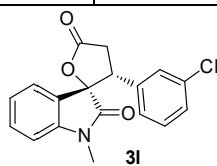
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA254 nm	7.575	1.34514e4	761.84167	49.81
2	PDA254 nm	12.082	1.35545e4	511.35513	50.19



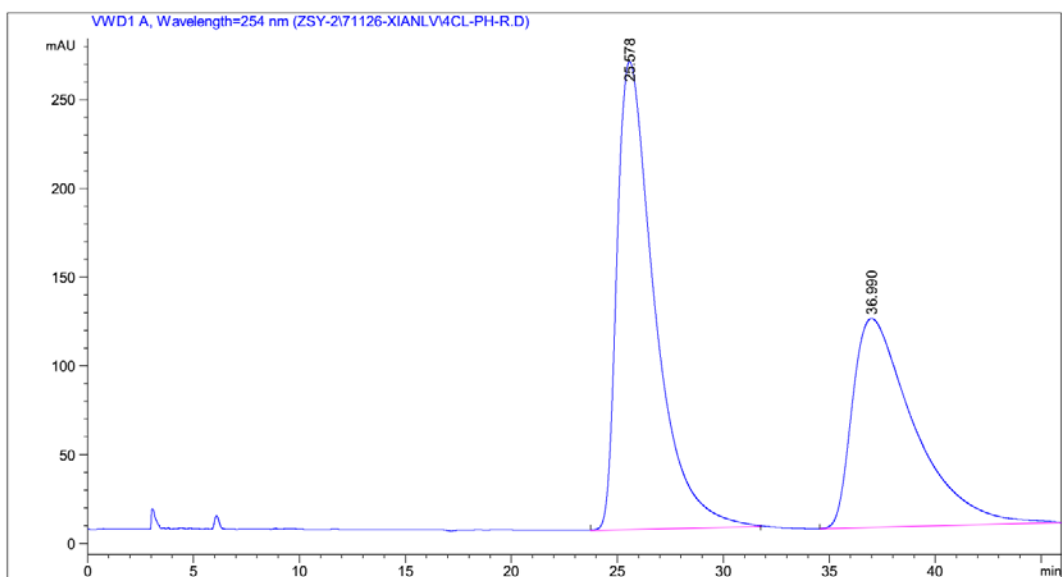
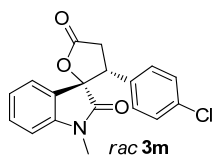
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	6.835	4330.88037	272.07785	4.88
2	PDA 254 nm	10.468	8.43472e4	3241.88672	95.11



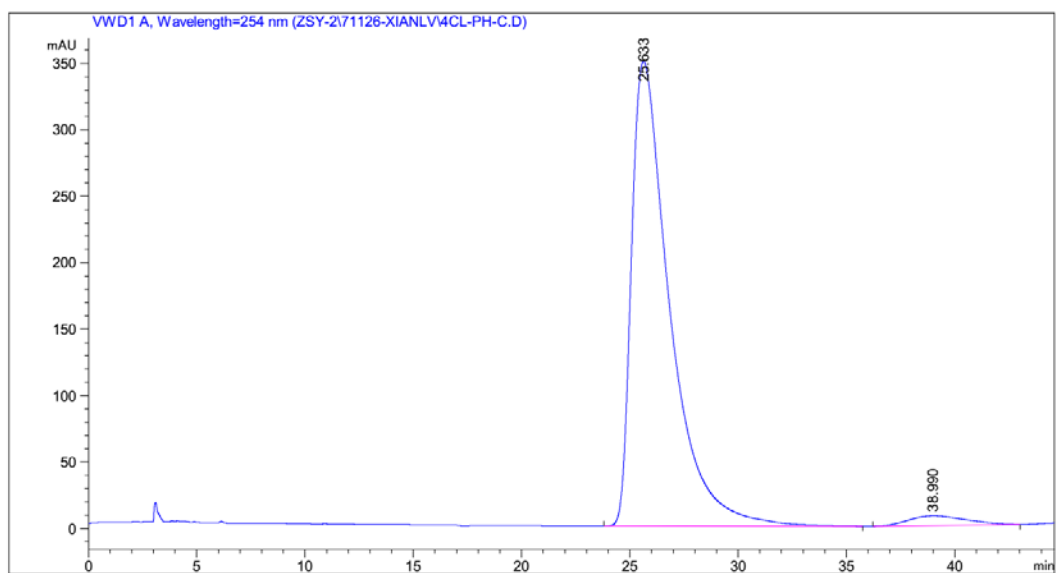
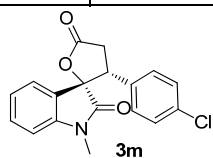
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 280 nm	46.725	3.16768e4	219.19832	49.92
2	PDA 280 nm	52.079	3.17813e4	212.05476	50.08



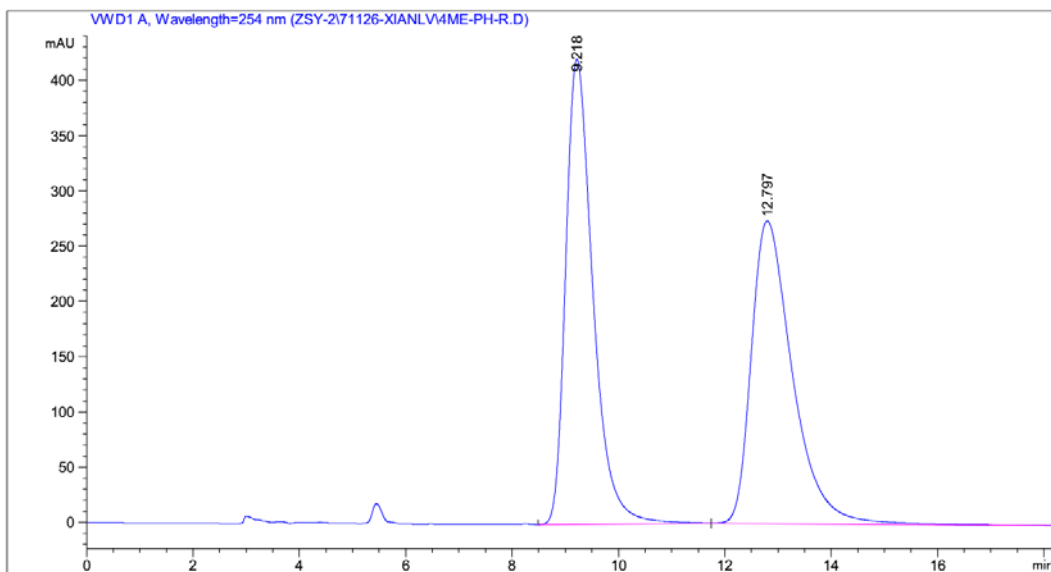
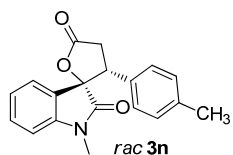
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 280 nm	47.098	1.15041e5	771.53644	96.84
	PDA 280 nm	52.457	3761.53516	30.25532	3.16



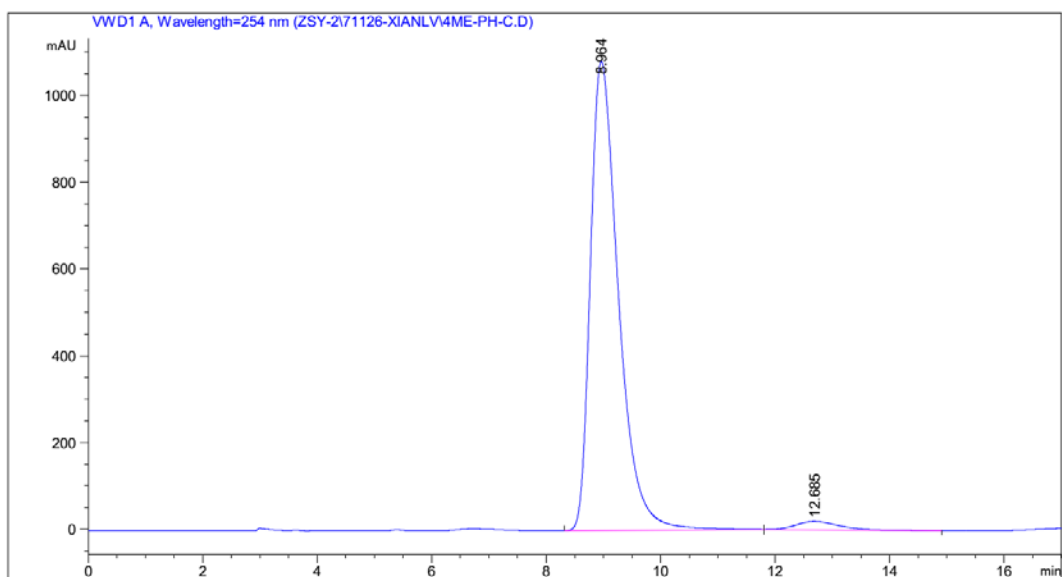
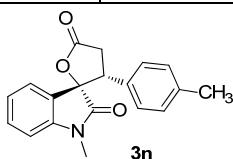
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	25.578	3.24891e4	263.87503	54.85
2	PDA 254 nm	36.990	2.36690e4	117.73990	45.15



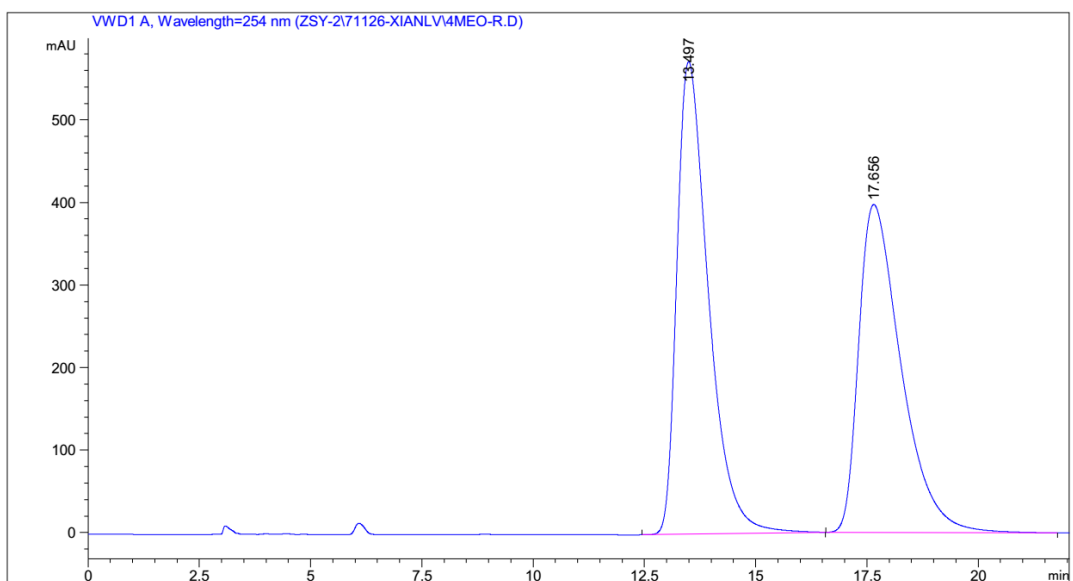
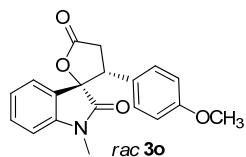
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	25.633	4.27842e4	349.75385	97.03
2	PDA 254 nm	38.990	1309.70886	7.17981	2.97



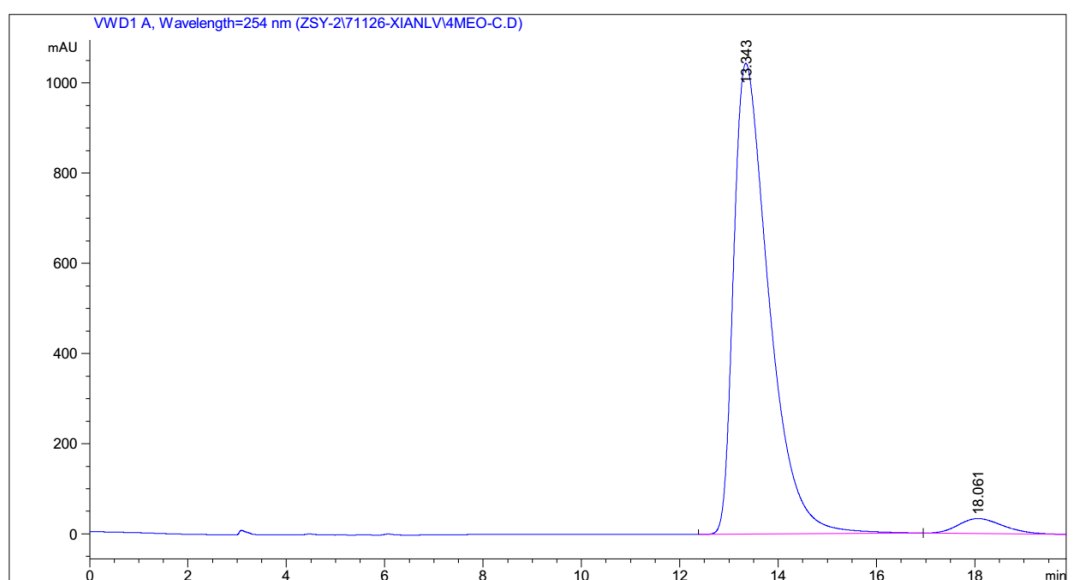
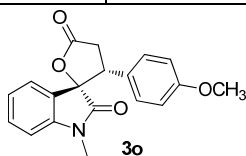
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	9.218	1.49308e4	420.64984	50.44
2	PDA 254 nm	12.797	1.46730e4	273.82755	49.56



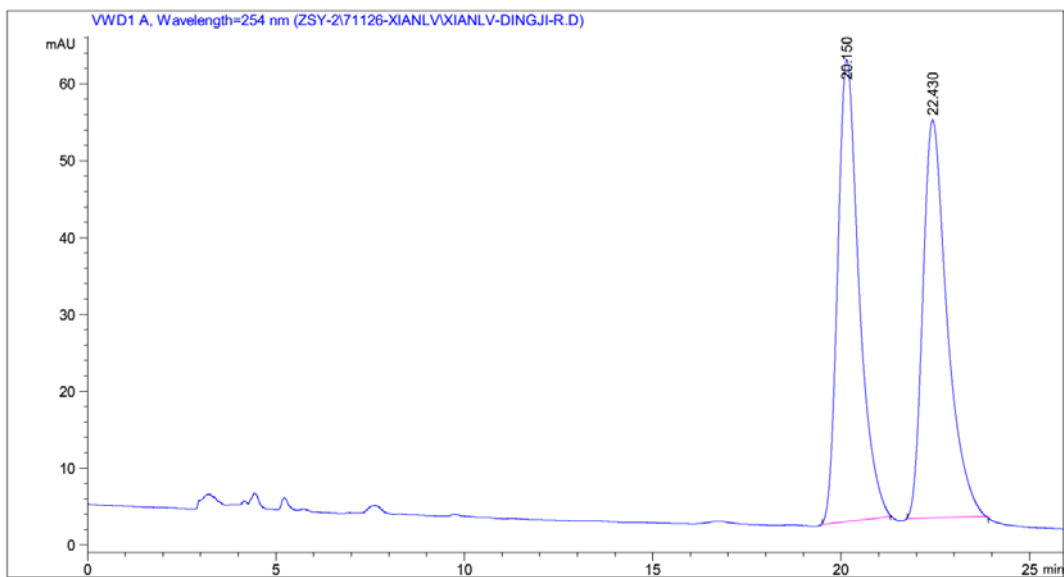
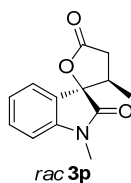
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	8.964	3.67620e4	1081.23206	98.62
2	PDA 254 nm	12.685	987.95496	19.28213	1.38



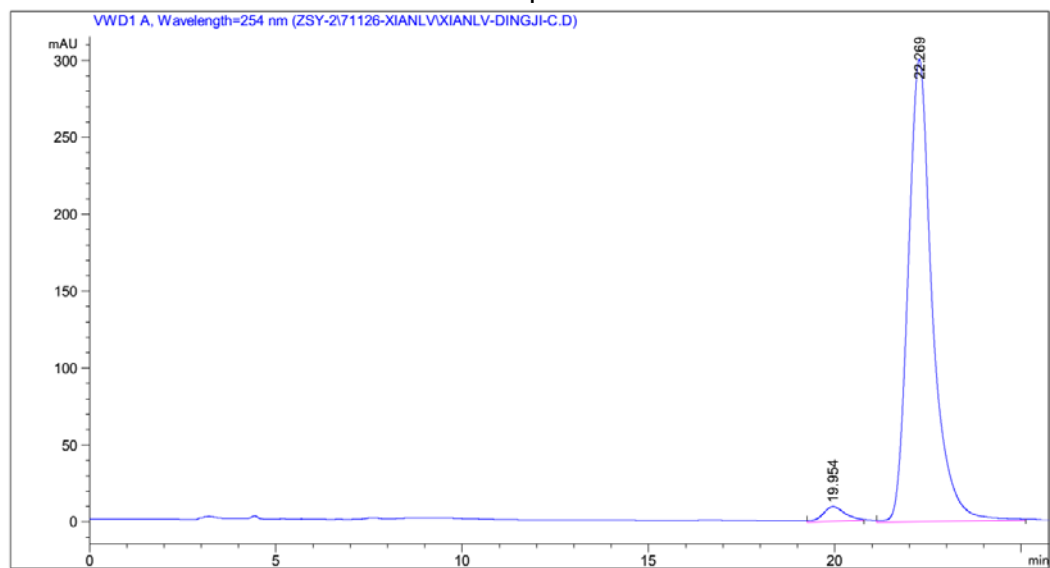
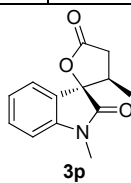
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	13.497	2.82043e4	572.54382	51.74
2	PDA 254 nm	17.656	2.63089e4	397.30475	48.26



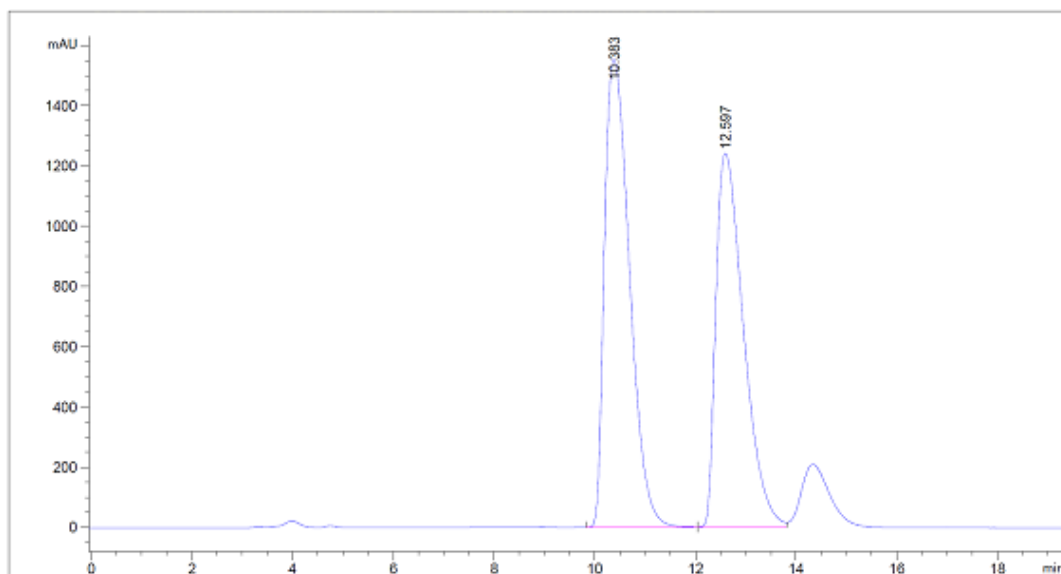
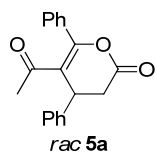
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	13.443	5.19571e4	1044.12244	97.66
2	PDA 254 nm	18.061	2105.10522	33.10919	2.34



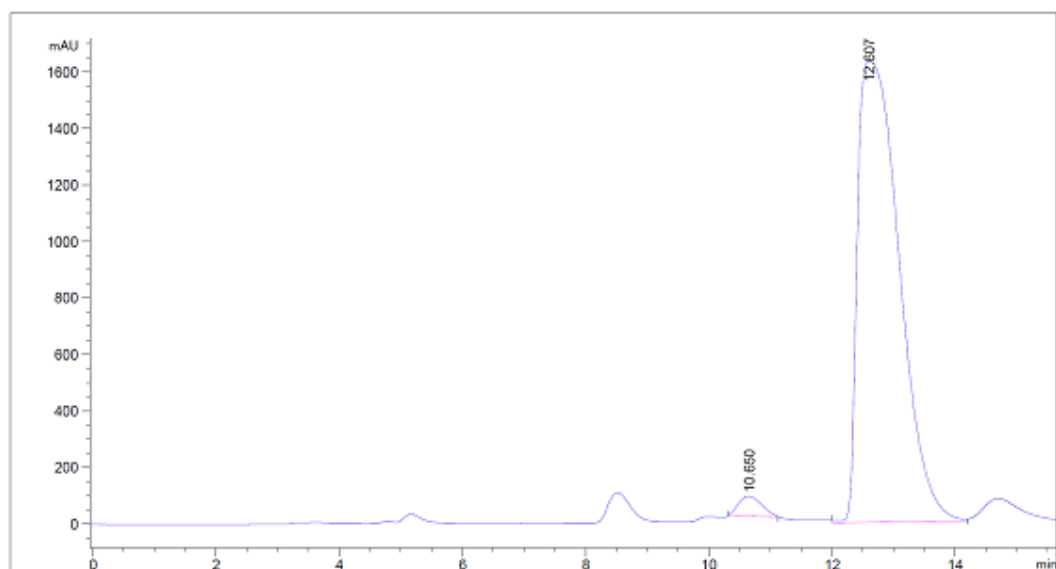
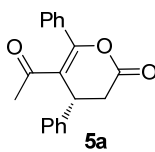
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	20.150	2371.76123	60.13734	50.52
2	PDA 254 nm	22.430	2322.74219	51.78837	49.48



Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	19.954	395.56198	9.58714	2.63
2	PDA 254 nm	22.269	1.35730e4	300.62967	97.37

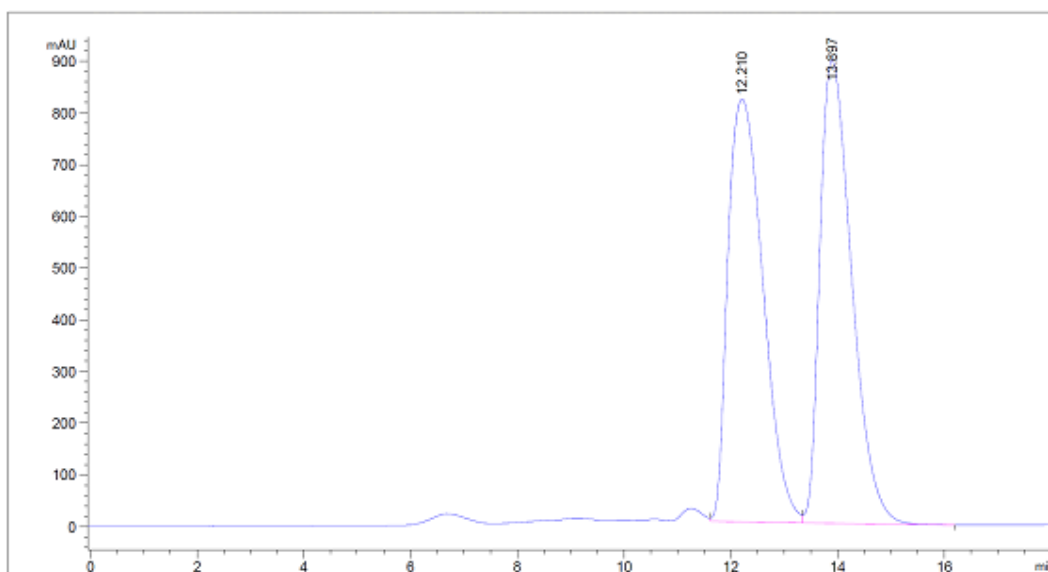
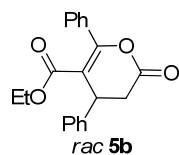


Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 280 nm	10.383	5.35277e4	1552.80420	53.07
2	PDA 280 nm	12.597	4.73409e4	1240.23083	46.93

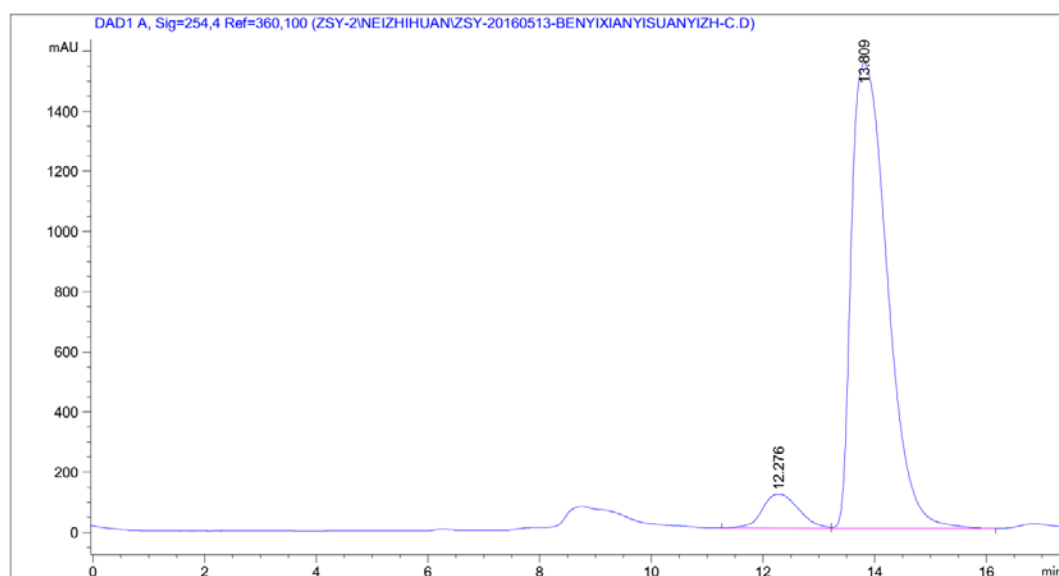
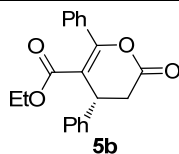


Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 280 nm	10.650	1852.39600	70.20706	2.36
2	PDA 280 nm	12.607	7.65690e4	1633.32336	97.64

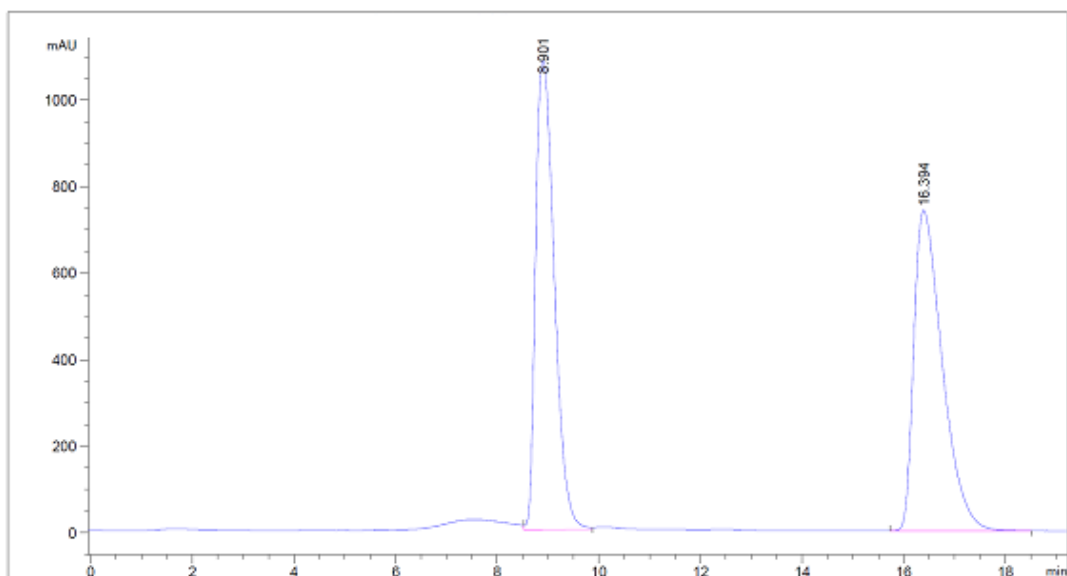
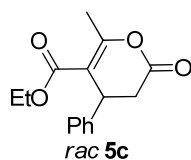




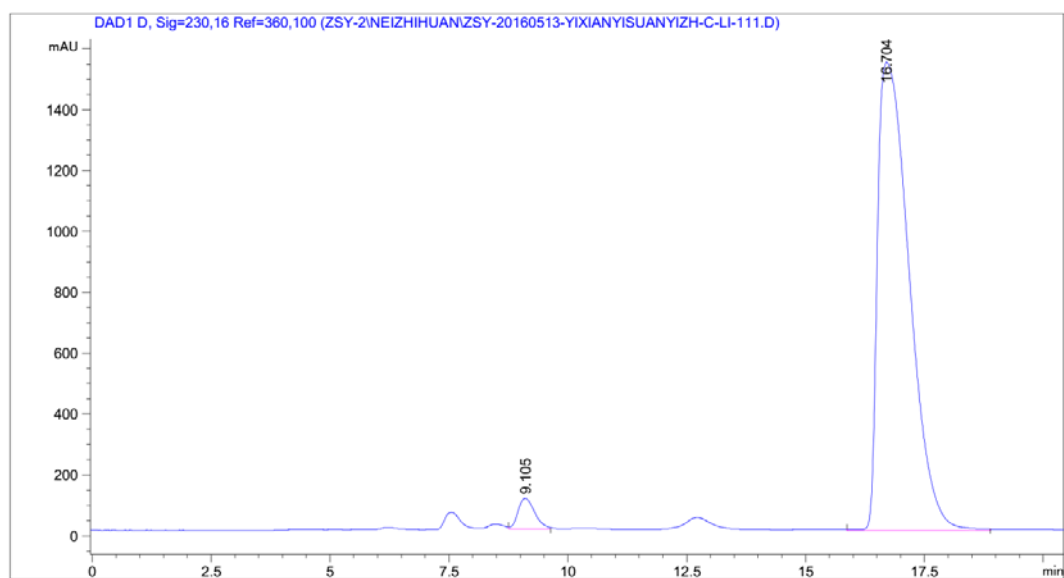
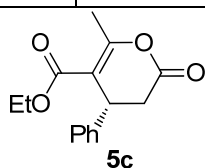
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 280 nm	12.210	3.72243e4	817.08600	50.08
2	PDA 280 nm	13.897	3.71014e4	894.90759	49.92



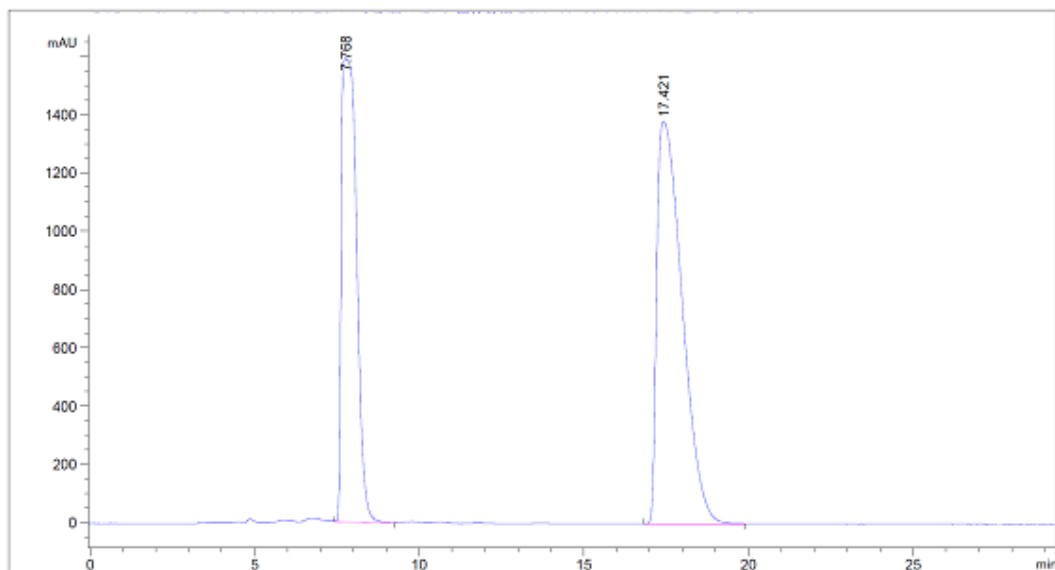
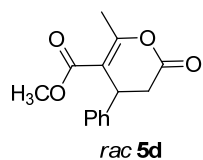
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 280 nm	12.276	2582.92065	69.47312	4.35
2	PDA 280 nm	13.809	5.46270e4	1304.64160	95.65



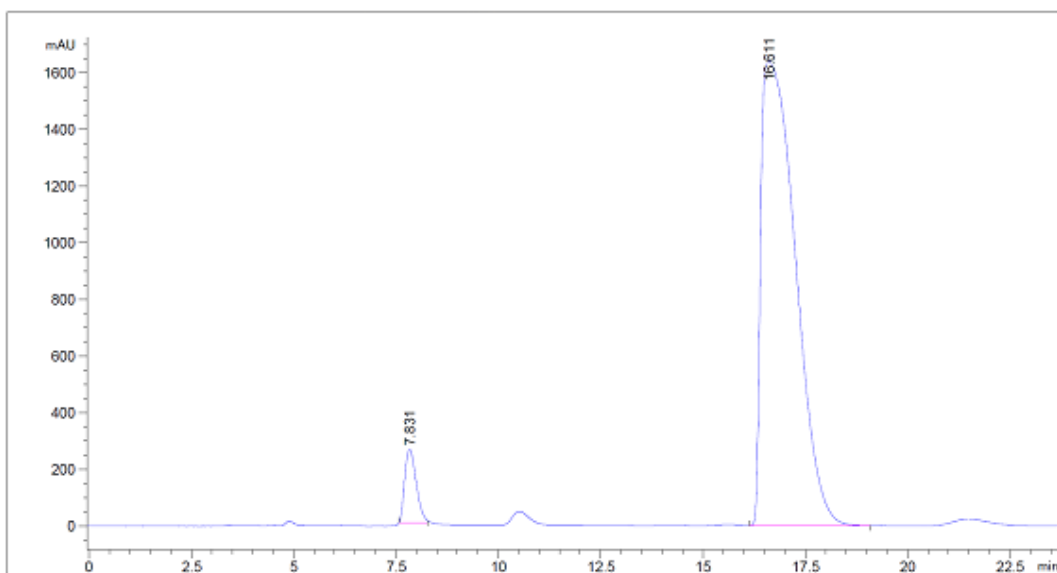
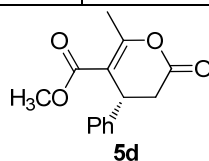
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 230 nm	8.901	2.76678e4	1083.27173	48.95
2	PDA 230 nm	16.394	2.88580e4	740.59827	51.05



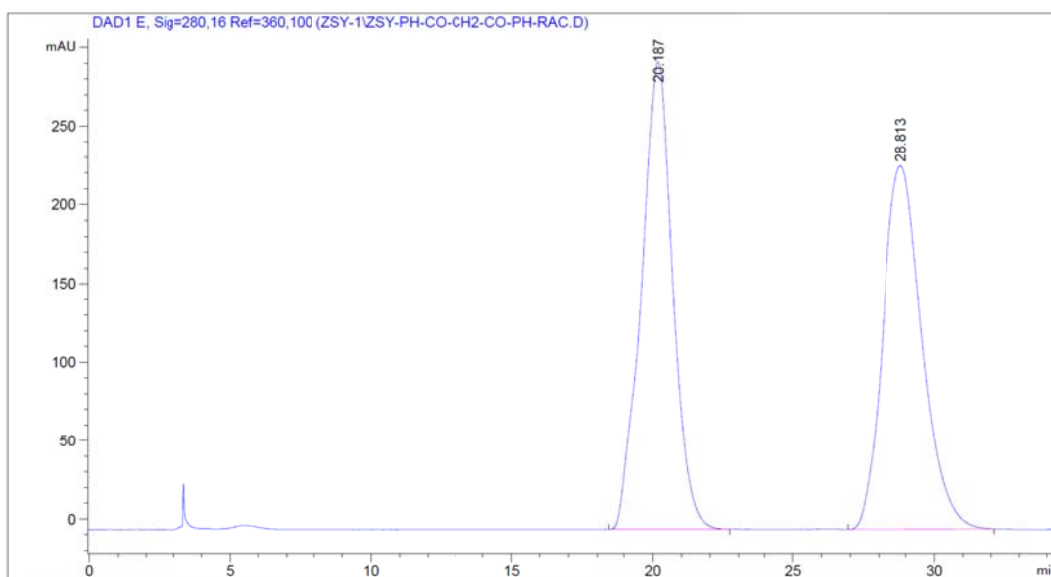
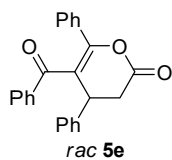
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 230 nm	9.105	1835.94568	86.06533	2.44
2	PDA 230 nm	16.704	7.05180e4	1534.99316	97.56



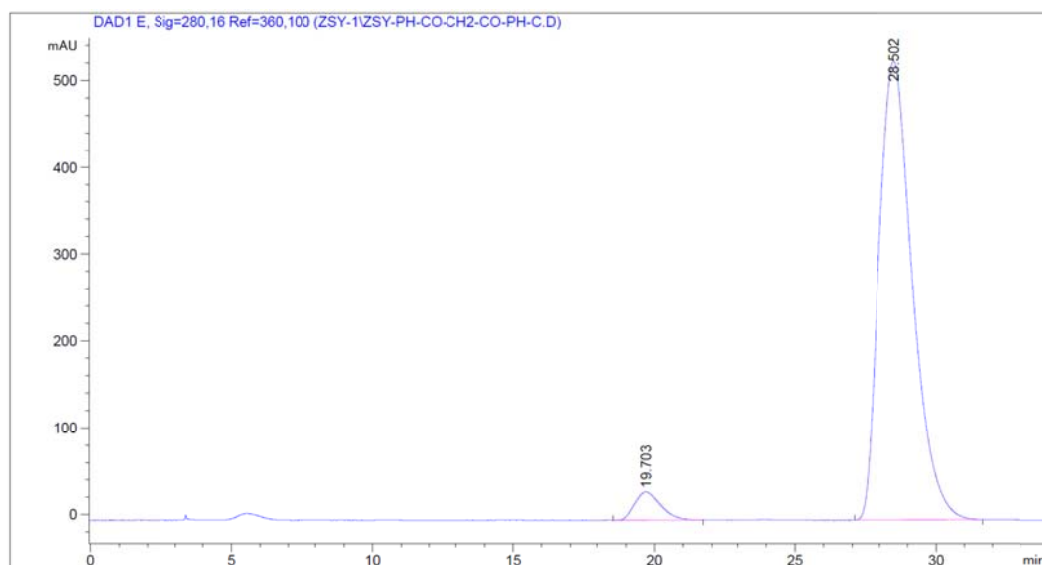
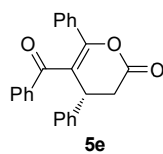
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	7.768	5.08243e4	1589.94666	45.87
2	PDA 254 nm	17.421	7.35177e4	1381.68469	54.13



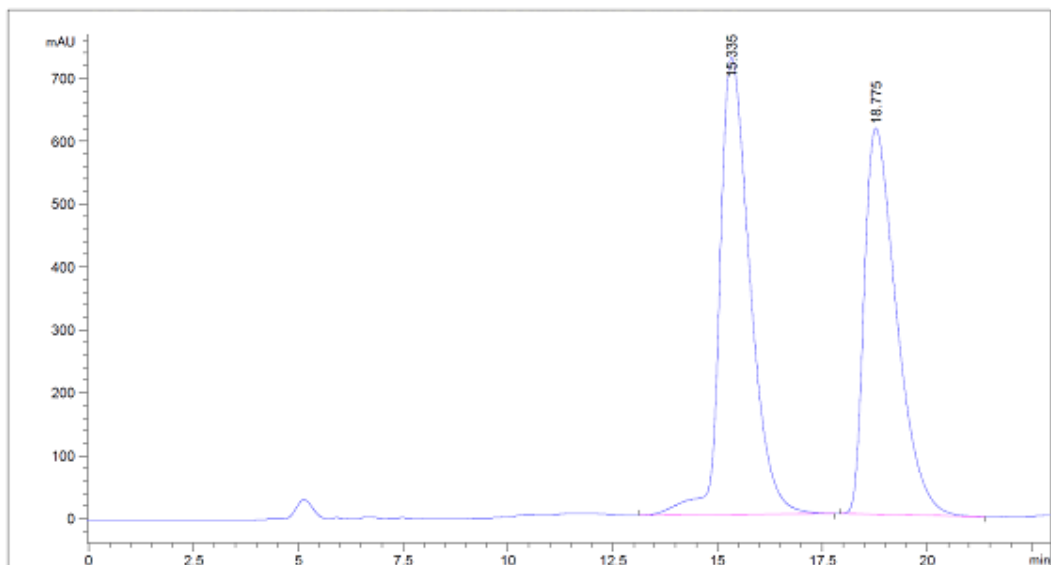
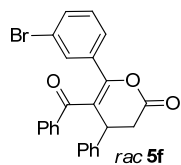
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	7.831	5082.59863	258.62338	4.46
2	PDA 254 nm	16.611	9.53986e4	1641.20764	95.54



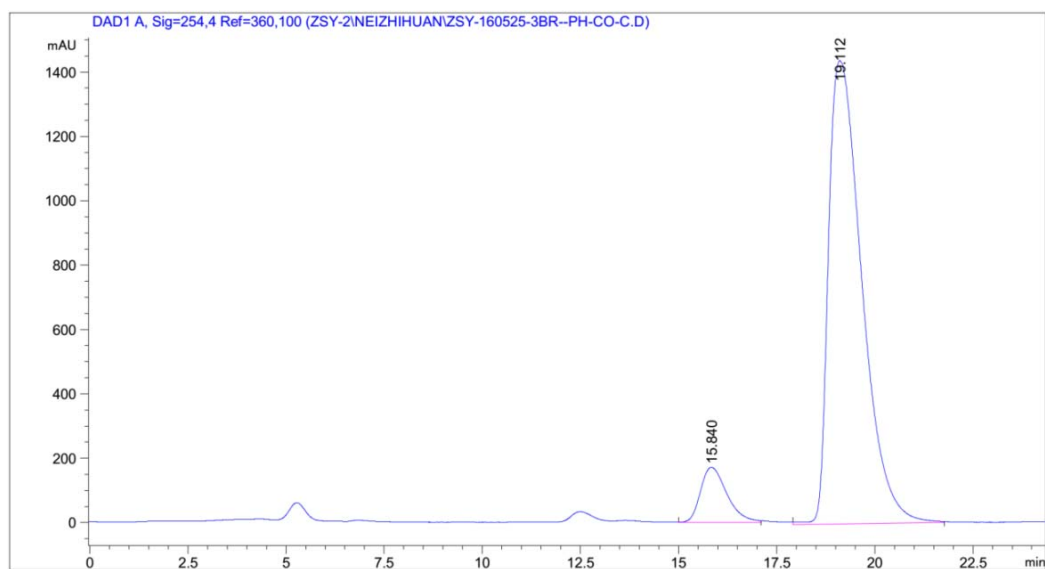
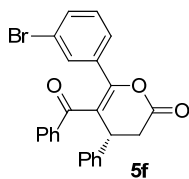
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	20.187	2.25771 e4	297.19433	50.03
2	PDA 254 nm	28.813	2.25511 e4	228.92552	49.97



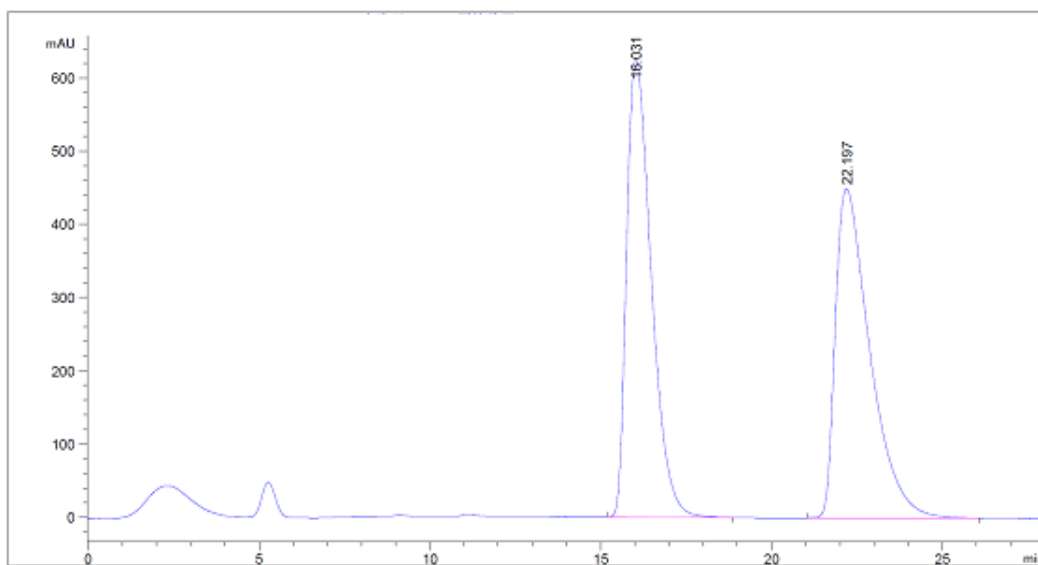
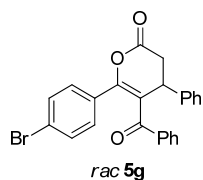
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	19.703	2042.74182	32.60457	4.57
2	PDA 254 nm	28.502	4.36587e4	528.56146	95.43



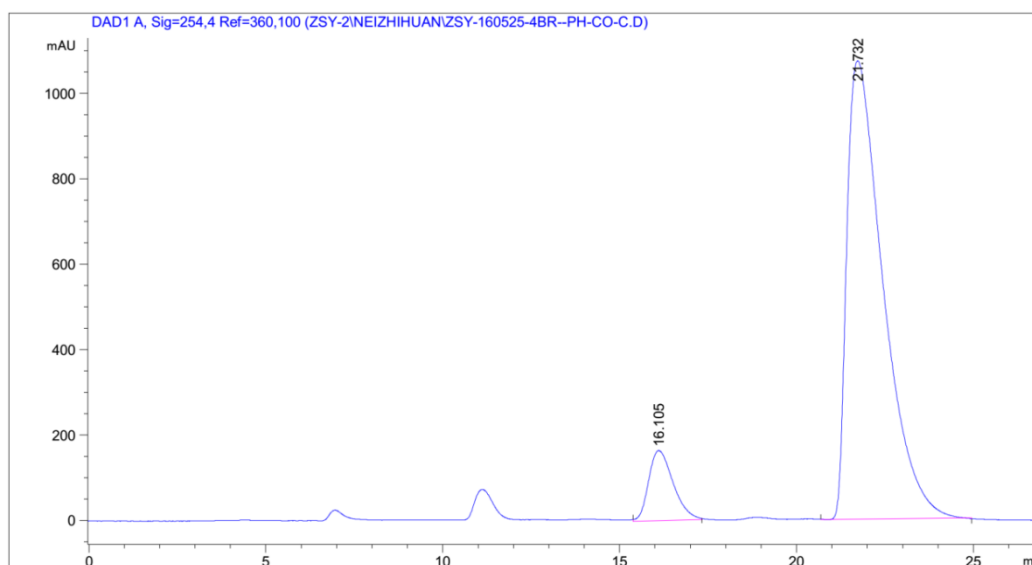
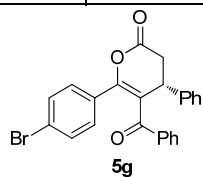
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	15.335	3.65230e4	726.63184	52.6592
2	PDA 254 nm	18.775	3.28342e4	614.07043	47.3408



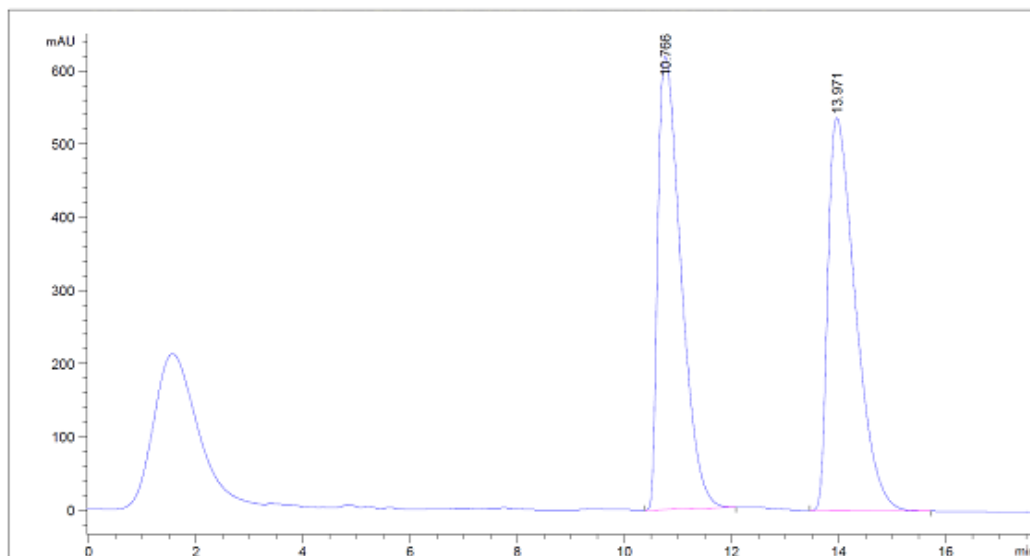
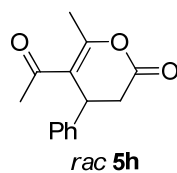
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	15.840	2850.69312	70.71241	6.46
2	PDA 254 nm	19.112	4.06294e4	742.55450	93.54



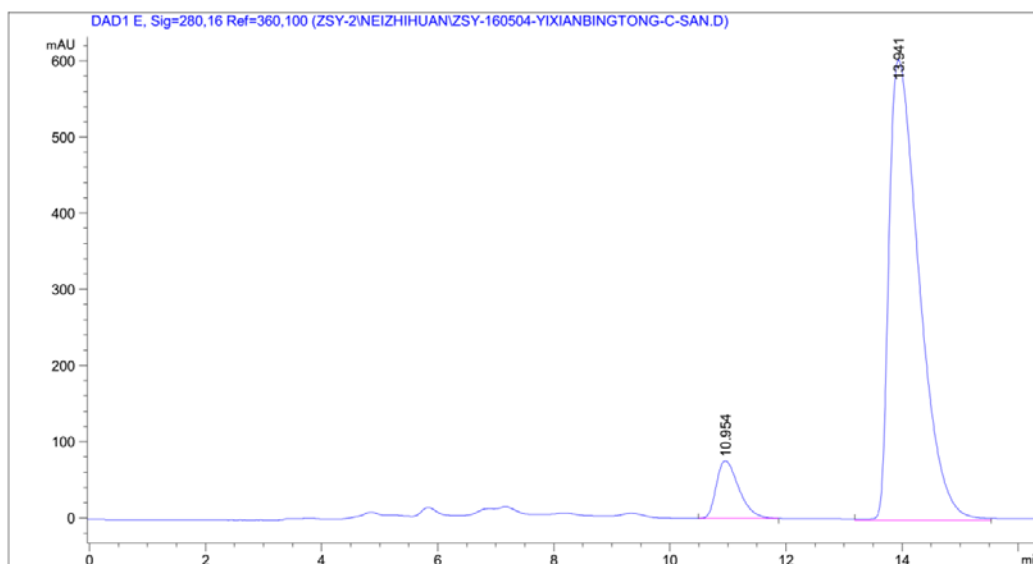
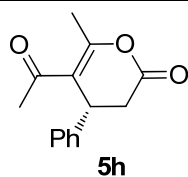
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	16.031	3.13770e4	625.71527	49.82
2	PDA 254 nm	22.197	3.16042e4	449.75967	50.18



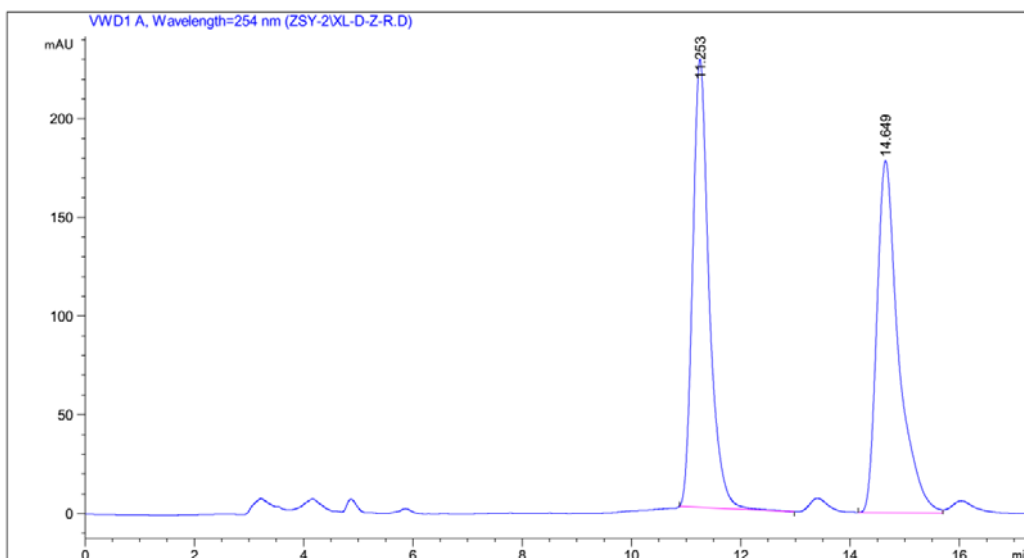
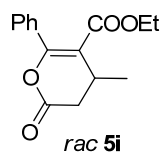
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	16.105	5375.09473	125.85065	6.44
2	PDA 254 nm	21.732	6.49187e4	920.04065	93.56



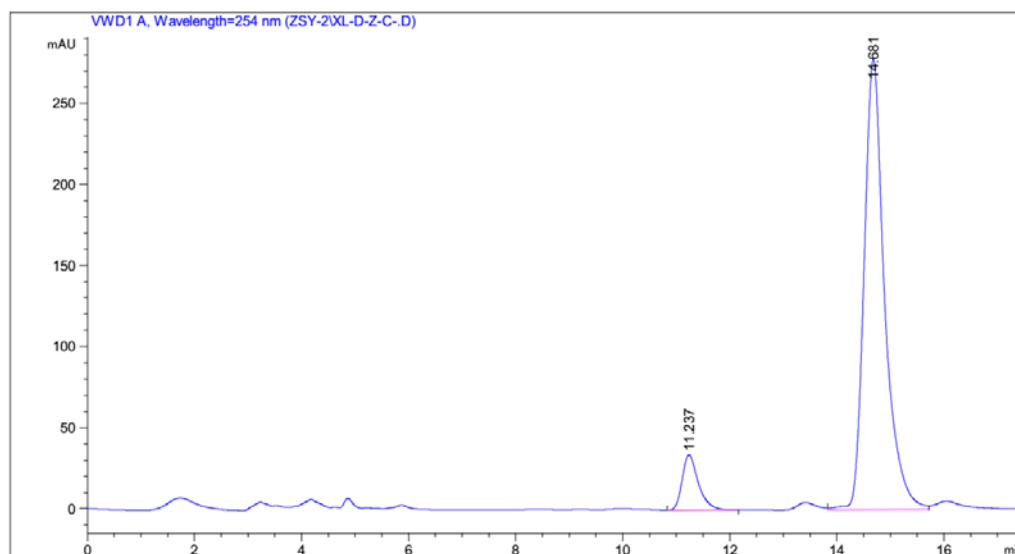
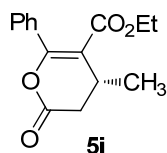
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	10.766	1.85695e4	617.98260	49.23
2	PDA 254 nm	13.971	1.91513e4	535.67426	50.77



Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	10.954	1669.51978	70.43662	5.19
2	PDA 254 nm	13.941	2.15267e4	602.72693	92.81

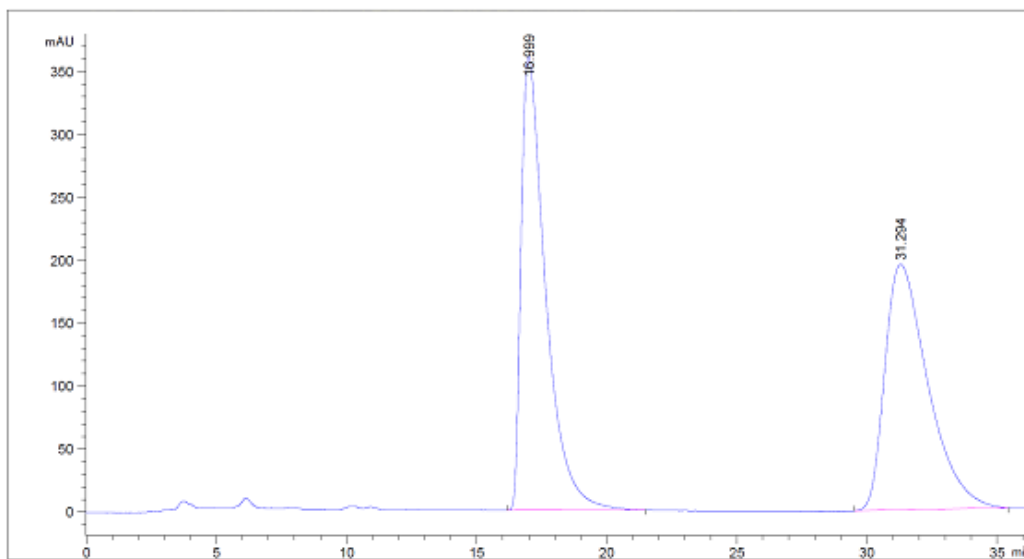
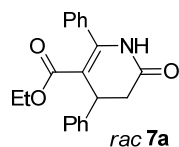


Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	11.253	4749.16016	227.04272	49.10
2	PDA 254 nm	14.649	4923.09961	178.28705	50.90

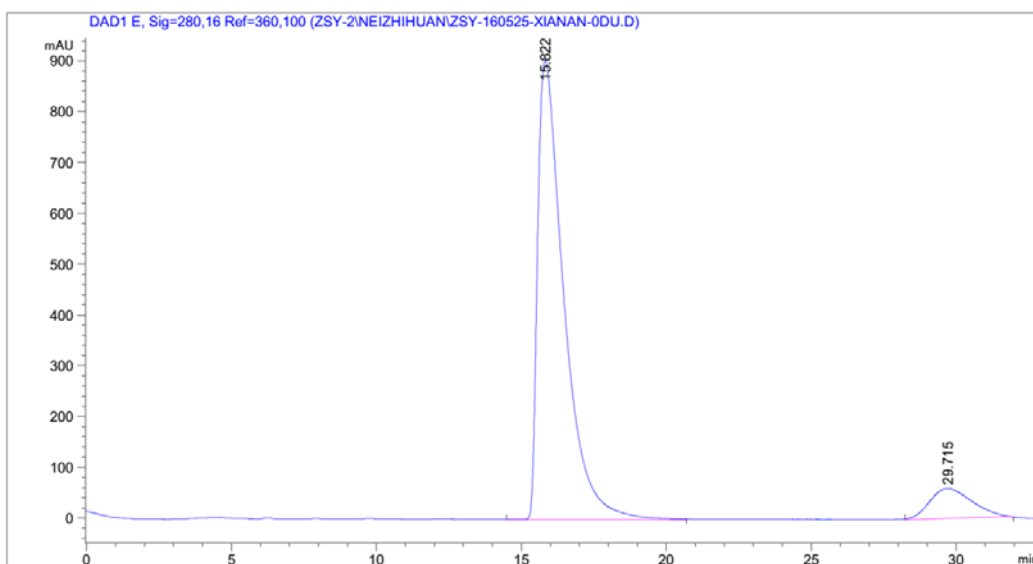
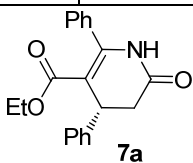


Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	11.237	713.41681	34.10785	8.41
2	PDA 254 nm	14.681	7382.97266	278.02084	91.59

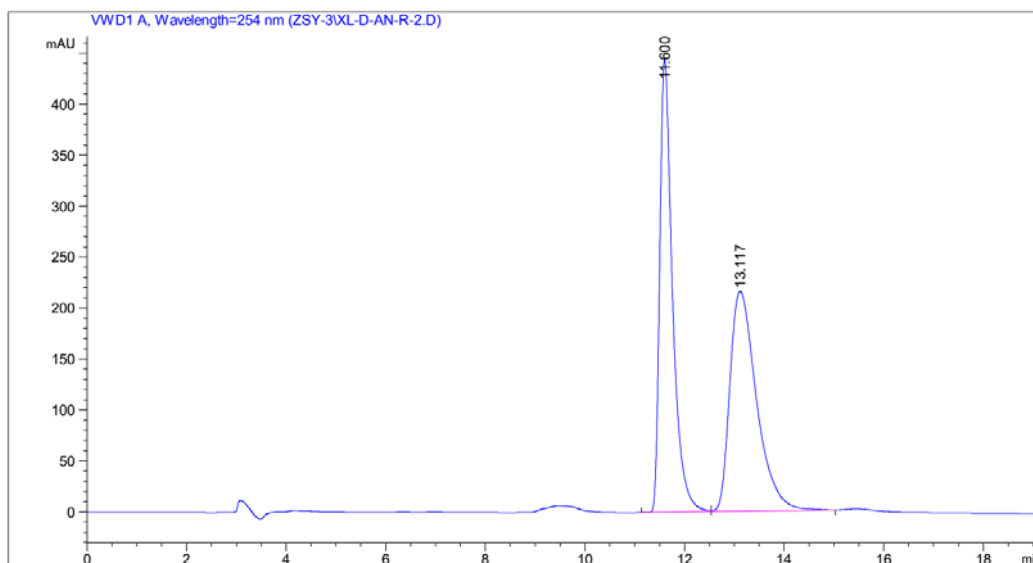
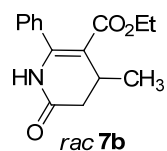




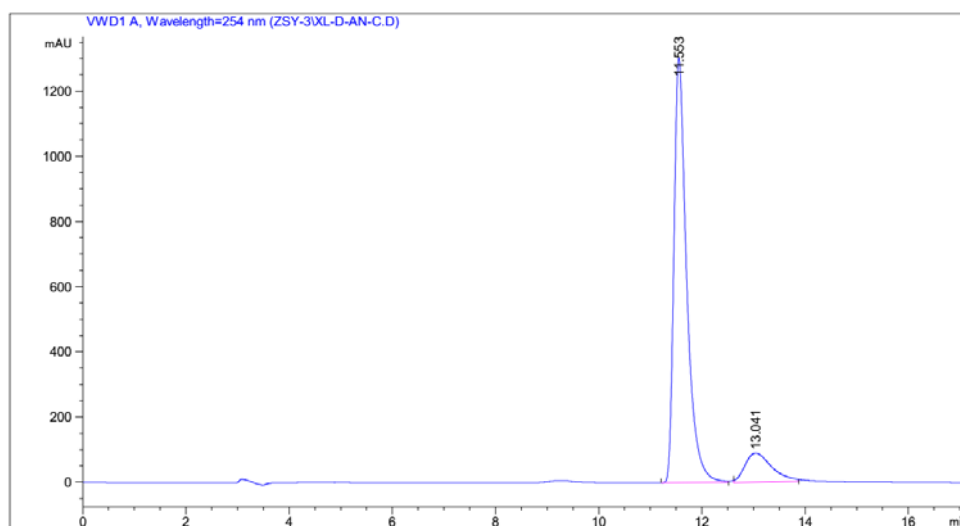
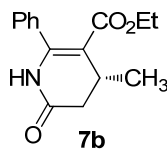
Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	16.999	2.35951e4	360.10287	51.26
2	PDA 254 nm	31.294	2.24315e4	195.12534	48.74



Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	15.822	5.64948e4	903.24915	92.77
2	PDA 254 nm	29.715	4742.16846	53.55134	7.23



Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	11.600	7892.28906	444.20700	49.56
2	PDA 254 nm	13.117	8032.83691	215.71977	50.44



Peak	Processed channel	Retention time (min)	Peak area (mAU*s)	Peak height (mAU)	Peak area (%)
1	PDA 254 nm	11.553	2.23191e4	1303.38452	87.67
2	PDA 254 nm	13.041	3240.26709	89.55066	12.33