

## Access to Dihydropyrano[3,2-b]pyrrol-5-ones Skeletons by *N*- Heterocyclic Carbene-Catalyzed [3 + 3] Annulations

Ya-Tong Wu,<sup>a,†</sup> Rui Zhang,<sup>a,†</sup> Xiao-Yong Duan,<sup>\*, a, b</sup> Hai-Fei Yu,<sup>a</sup> Bo-Yu Sun,<sup>a</sup> and Jing Qi<sup>\*, a, b</sup>

<sup>a</sup>Key Laboratory of Chemical Biology of Hebei Province, College of Chemistry and Environmental Science, Hebei University, Baoding 071002, People's Republic of China.

<sup>b</sup>Key Laboratory of Medicinal Chemistry and Molecular Diagnosis of the Ministry of Education, Hebei University, Baoding 071002, People's Republic of China.

\* Email: [qjjinghbu2013@126.com](mailto:qjjinghbu2013@126.com); [duanxy05@126.com](mailto:duanxy05@126.com).

† These authors contributed equally.

### Table of Contents

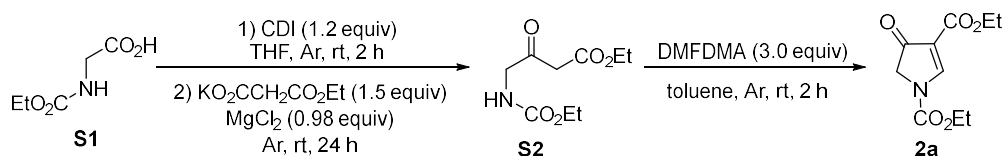
<b>Part 1:</b> General Information.....	2
<b>Part 2:</b> Experimental Section.....	2
<b>Part 3:</b> Characterization of Products.....	7
<b>Part 4:</b> HPLC spectra for all products.....	20
<b>Part 5:</b> <sup>1</sup> HNMR and <sup>13</sup> CNMR spectra.....	50

## Part 1: General Information

Unless otherwise specified, all reactions were carried out under a nitrogen atmosphere in an oven-dried sealed tube, with dry, freshly distilled solvents in anhydrous conditions. The solvents were distilled by standard methods. Reagents were obtained from commercial suppliers and used without further purification unless otherwise noted. The silica gel (200-300 meshes) was used for column chromatography, and the distillation range of petroleum was 60-90 °C. <sup>1</sup>H and <sup>13</sup>C NMR spectra were recorded on Bruker 600 or 400 MHz instrument in CDCl<sub>3</sub>, and spectral data were reported in ppm relative to tetramethylsilane (TMS) as internal standard. The high resolution mass spectra (HRMS) were measured on a Bruker Daltonics Apex Ultra spectrometer by ESI. The determination of enantiomeric excess was performed via chiral HPLC analysis Thermo Ulti Mate 3000 HPLC workstation. Optical rotations were measured by Rudolph Research Analytical Autopol-I instrument.

## Part 2: Experimental Section

### 1. General procedure for the synthesis of pyrrol-4-one **2** (**2a** as an example).

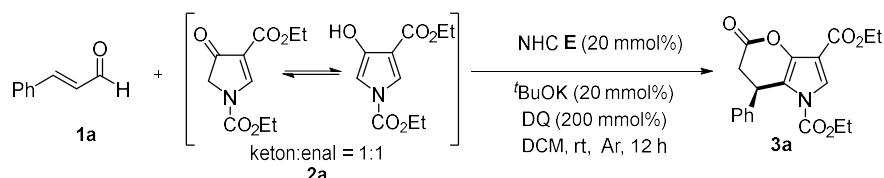


To a solution of **S1** (10 mmol) in anhydrous THF (50 mL) under argon was added CDI (2.01 g, 12 mmol) and the resulting reaction mixture was stirred at room temperature for 2 hours, followed by the addition of a solid mixture of MgCl<sub>2</sub> (0.95 g, 9.80 mmol) and ethyl potassium malonate (2.37 g, 15.00 mmol). The reaction mixture was stirred at room temperature for additional 24 h. Volatile components were evaporated in vacuo, the residue was dissolved in EtOAc (150 mL) and washed with NaHSO<sub>4</sub> (1 M in H<sub>2</sub>O, 50 mL), saturated NaCl (50 mL), saturated NaHCO<sub>3</sub> (20 mL), and saturated NaCl (50 mL). The organic phase was dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>, filtered, and volatile components evaporated in vacuo. The residue was purified by column chromatography on silica gel eluting with Petroleum ether/EtOAc (3:1) to give the desired product **S2** as a white solid (1.6 g, 75% yield).

To a solution **S2** (5 mmol) in anhydrous toluene (10 mL) under argon was added DMFDMA (15

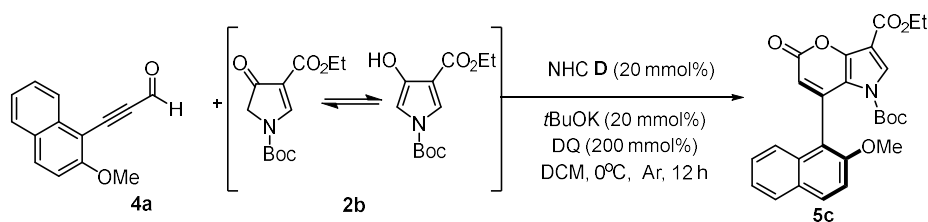
mol) and the resulting reaction mixture was stirred at room temperature or at elevated temperature until completion of the reaction judging by TLC-analysis. Volatile components were evaporated in vacuo and the residue was as quickly as possible purified by column chromatography on silica gel eluting with Petroleum ether/EtOAc (3:1) to give the desired product **2** as a yellow oil (1.6 g, 70% yield). The products were characterized as soon as isolated and stored under argon. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.60 (d, *J* = 1.2 Hz, 1H), 7.43 (s, 1H), 6.77 (s, 1H), 4.45-4.29 (m, 8H), 4.22 (s, 2H), 1.43-1.32 (m, 12H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 191.6, 166.1, 163.1, 161.3, 149.8, 146.3, 121.0, 113.8, 108.5, 101.5, 64.2, 60.6, 55.6, 14.2, 14.1.

**2.** General procedure for the catalytic reactions of enal **1** with pyrrol-4-one **2** to synthesis dihydropyrano[3,2-*b*]pyrrol-5-ones **3** (**3a** as an example).



A dry 25 mL Schlenk tube with stir bar was charged with **2a** (34 mg, 0.15 mmol, 1.5 equiv), NHC **E** (8.4 mg, 0.01 mmol, 0.2 equiv), <sup>t</sup>BuOK (2 mg, 0.02 mmol, 0.2 equiv), DQ (82 mg, 2.0 equiv). The tube was evacuated, and refilled with argon. Then enals **1a** (13 mg, 0.1 mmol, 1.0 equiv) was added and the mixture was dissolved with newly distilled solvent DCM (1 mL). The mixture was stirred at room temperature for 12 hours when the substrate was consumed completely (monitored by TLC). The reaction mixture was concentrated under vacuum and purified by column chromatography on silica gel using Petroleum ether/EtOAc (3:1) as eluent to afford desired product **3a** as yellow oil (32.8 mg, 92% yield).

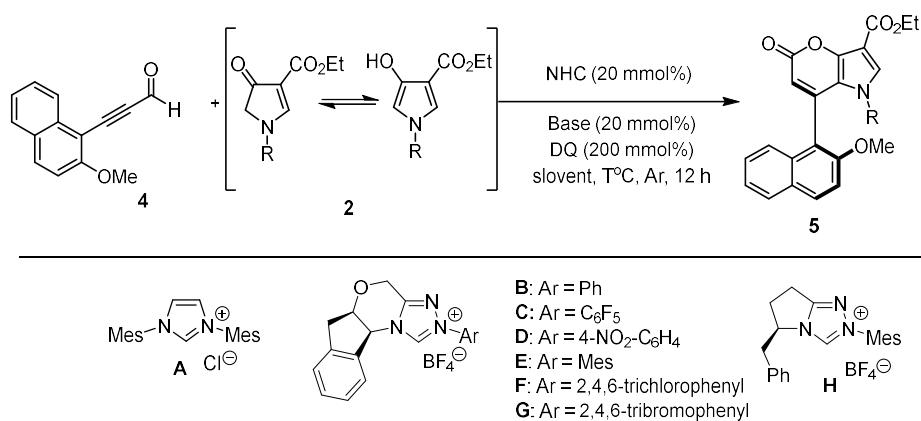
**3.** General procedure for the catalytic reactions of enal **4** with pyrrol-4-one **2** to synthesis pyrano[3,2-*b*]pyrrol-5-ones **5** (**5b** as an example).



A dry 25 mL Schlenk tube with stir bar was charged with **2a** (34 mg, 0.15 mmol, 1.5 equiv), NHC **D** (8.4 mg, 0.01 mmol, 0.2 equiv), <sup>t</sup>BuOK (2 mg, 0.02 mmol, 0.2 equiv), DQ (82 mg, 2.0

equiv). The tube was evacuated, and refilled with argon. Then ynals **4a** (13 mg, 0.1 mmol, 1.0 equiv) was added and the mixture was dissolved with newly distilled solvent DCM (1 mL). The mixture was stirred at 0°C for 12 hours when the substrate was consumed completely (monitored by TLC). The reaction mixture was concentrated under vacuum and purified by column chromatography on silica gel using Petroleum ether/EtOAc (3:1) as eluent to afford desired product **5c** as yellow solid (25.5 mg, 55% yield).

Scheme 1. Optimization of [3+3] atroposelective annulation reaction conditions<sup>a</sup>

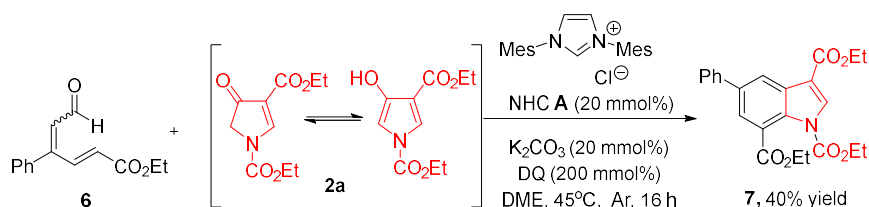


entry	NHC	base	solvent	T/°C	Yield (%)	ee (%)
1	<b>A</b>	<sup>t</sup> BuOK	DCM	rt	54	0
2	<b>B</b>	<sup>t</sup> BuOK	DCM	rt	45	10
3	<b>C</b>	<sup>t</sup> BuOK	DCM	rt	trace	-
4	<b>D</b>	<sup>t</sup> BuOK	DCM	rt	71	60
5	<b>E</b>	<sup>t</sup> BuOK	DCM	rt	32	24
6	<b>F</b>	<sup>t</sup> BuOK	DCM	rt	20	36
7	<b>G</b>	<sup>t</sup> BuOK	DCM	rt	12	31
8	<b>H</b>	<sup>t</sup> BuOK	DCM	rt	58	45
9	<b>D</b>	<sup>t</sup> BuOK	DCM	0	55	70
10	<b>D</b>	<sup>t</sup> BuOK	THF	0	12	-
11	<b>D</b>	Cs <sub>2</sub> CO <sub>3</sub>	DCM	0	78	42
12	<b>D</b>	K <sub>2</sub> CO <sub>3</sub>	DCM	0	73	35
13	<b>D</b>	DBU	DCM	0	28	60
14	<b>D</b>	DIPEA	DCM	0	39	56

15	<b>D</b>	Et <sub>3</sub> N	DCM	0	trace	-
16	<b>D</b>	TBD	DCM	0	28	54
17	<b>D</b>	DMAP	DCM	0	49	60
18	<b>D</b>	Na <sub>2</sub> CO <sub>3</sub>	DCM	0	30	31
19	<b>D</b>	NaOAc	DCM	0	24	42
20	<b>D</b>	<sup>t</sup> BuOK	CH <sub>3</sub> CN	0	68	40
21	<b>D</b>	<sup>t</sup> BuOK	toluene	0	24	30
22	<b>D</b>	<sup>t</sup> BuOK	PhCl	0	58	45
23	<b>D</b>	<sup>t</sup> BuOK	PhCF <sub>3</sub>	0	trace	-
24	<b>D</b>	<sup>t</sup> BuOK	1,4-dioxane	0	trace	-
25	<b>D</b>	<sup>t</sup> BuOK	CHCl <sub>3</sub>	0	58	55
26	<b>D</b>	<sup>t</sup> BuOK	DCM	0	62	53

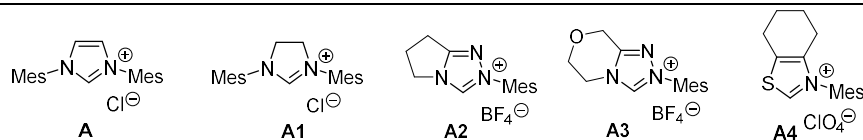
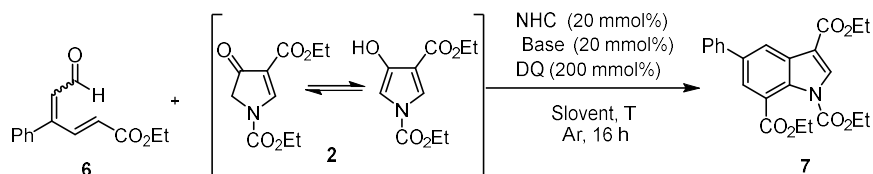
<sup>a</sup>Reaction conditions: **4** (0.1 mmol, 1.0 equiv), **2** (0.15 mmol, 1.5 equiv), solvent (1.0 mL); For entries 1-25, R = Boc; For entry 26, R = CO<sub>2</sub>Et. <sup>b</sup>Isolated yield after flash chromatography. <sup>c</sup>Determined by chiral-phase HPLC analysis. TBD = 1,5,7-Triazabicyclo[4.4.0]dec-5-ene, DBU = 1,8-diazabicyclo[5.4.0]-undec-7-ene, Mes = mesityl

#### 4. Reaction procedure for the catalytic reactions of $\alpha,\beta\text{-}\gamma,\delta\text{-}$ diunsaturated aldehyde **6** with pyrrol-4-one **2a** to synthesis polysubstituted indole **7**.



A dry 25 mL Schlenk tube with stir bar was charged with **2a** (34 mg, 0.15 mmol, 1.5 equiv), NHC **A** (6.8 mg, 0.01 mmol, 0.2 equiv), K<sub>2</sub>CO<sub>3</sub> (3 mg, 0.02 mmol, 0.2 equiv), DQ (82 mg, 2.0 equiv). The tube was evacuated, and refilled with nitrogen. Then  $\alpha,\beta\text{-}\gamma,\delta\text{-}$ diunsaturated aldehyde **6** (23 mg, 0.1 mmol, 1.0 equiv) was added and the mixture was dissolved with newly distilled solvent DME (1 mL). The mixture was stirred at 25°C for 16 hours when the substrate was consumed completely (monitored by TLC). The reaction mixture was concentrated under vacuum and purified by column chromatography on silica gel using Petroleum ether/EtOAc (8:1) as eluent to afford desired product **7** as white solid (16.4mg, 40% yield).

Scheme 2. Optimization of the cascade reaction conditions<sup>a</sup>

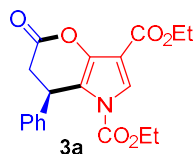


entry	NHC	base	solvent	T/°C	Yield (%)
1	<b>A</b>	K <sub>2</sub> CO <sub>3</sub>	THF	rt	28
2	<b>A1</b>	K <sub>2</sub> CO <sub>3</sub>	THF	rt	21
3	<b>A2</b>	K <sub>2</sub> CO <sub>3</sub>	THF	rt	trace
4	<b>A3</b>	K <sub>2</sub> CO <sub>3</sub>	THF	rt	trace
5	<b>A4</b>	K <sub>2</sub> CO <sub>3</sub>	THF	rt	trace
6	<b>A</b>	DBU	THF	rt	12
7	<b>A</b>	Cs <sub>2</sub> CO <sub>3</sub>	THF	rt	15
8	<b>A</b>	Na <sub>2</sub> CO <sub>3</sub>	THF	rt	23
9	<b>A</b>	<sup>t</sup> BuOK	THF	rt	trace
10	<b>A</b>	K <sub>3</sub> PO <sub>4</sub>	THF	rt	18
11	<b>A</b>	NaOAc	THF	rt	26
12	<b>A</b>	NaOAc	THF	rt	25
13	<b>A</b>	CsOAc	THF	rt	21
14	<b>A</b>	LiOAc	THF	rt	trace
15	<b>A</b>	PhCO <sub>2</sub> Na	THF	rt	10
16	<b>A</b>	PhCO <sub>2</sub> K	THF	rt	14
17	<b>A</b>	DABCO	THF	rt	8
18	<b>A</b>	KHMDS	THF	rt	18
19	<b>A</b>	DMAP	THF	rt	15
20	<b>A</b>	DIPEA	THF	rt	24
21	<b>A</b>	TMEDA	THF	rt	22

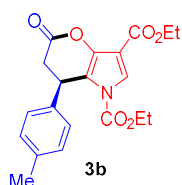
22	A	K <sub>2</sub> CO <sub>3</sub>	DCM	rt	trace
23	A	K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> CN	rt	trace
24	A	K <sub>2</sub> CO <sub>3</sub>	1,4-dioxane	rt	25
25	A	K <sub>2</sub> CO <sub>3</sub>	EtOAc	rt	20
26	A	K <sub>2</sub> CO <sub>3</sub>	toluene	rt	26
27	A	K <sub>2</sub> CO <sub>3</sub>	DME	rt	35
28	A	K <sub>2</sub> CO <sub>3</sub>	PhCF <sub>3</sub>	rt	6
29	A	K <sub>2</sub> CO <sub>3</sub>	DME	45	40
30	A	K <sub>2</sub> CO <sub>3</sub>	DME	60	32
31	A	K <sub>2</sub> CO <sub>3</sub>	DME	50	36

<sup>a</sup>Reaction conditions: **4** (0.1 mmol, 1.0 equiv), **2** (0.15 mmol, 1.5 equiv), solvent (1.0 mL); <sup>b</sup>Isolated yield after flash chromatography. TBD = 1,5,7-Triazabicyclo[4.4.0]dec-5-ene, DBU = 1,8-diazabicyclo[5.4.0]-undec-7-ene, DABCO = 1,4-Diazabicyclo[2.2.2]octane, TMEDA = N,N,N',N'-Tetramethylethylenediamine, DME = 1,2-Dimethoxyethane, Mes = mesityl.

### Part 3: Characterization of Products.



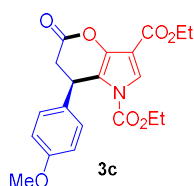
**3a**, Prepared according to the general procedure in 0.1 mmol scale, 92% yield, 32.9 mg, colorless oil. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.82 (s, 1H), 7.31-7.22 (m, 3H), 7.07 (d, *J* = 7.2 Hz, 2H), 4.82 (d, *J* = 8.0 Hz, 1H), 4.39-4.26 (m, 4H), 3.24 (dd, *J*<sub>1</sub> = 16.0 Hz, *J*<sub>2</sub> = 8.0 Hz, 1H), 2.95 (d, *J* = 16.0 Hz, 1H), 1.39 (t, *J* = 7.2 Hz, 3H), 1.26 (t, *J* = 7.2 Hz, 3H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ 165.9, 162.0, 149.1, 140.6, 140.2, 129.1, 127.6, 126.5, 124.4, 115.7, 109.2, 64.5, 60.8, 37.8, 36.8, 14.3, 14.0; HRMS (ESI): calculated for C<sub>19</sub>H<sub>23</sub>N<sub>2</sub>O<sub>6</sub><sup>+</sup>, [M+NH<sub>4</sub>]<sup>+</sup> 375.1551, Found 375.1547. [α]<sub>D</sub><sup>25</sup> = -98.8 (c = 1.0 in CHCl<sub>3</sub>); HPLC analysis: 92% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 12.4 min (minor), 14.0 min (major)].



**3b**, Prepared according to the general procedure in 0.1 mmol scale, 66% yield, 24.5 mg, light yellow oil. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.82 (s, 1H), 7.09 (d, *J* = 7.6 Hz, 2H), 6.96 (d, *J* = 8.0 Hz, 2H),

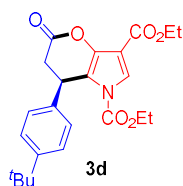
4.78 (d,  $J = 8.0$  Hz, 1H), 4.40-4.30 (m, 4H), 3.22 (dd,  $J_1 = 15.6$  Hz,  $J_2 = 8.0$  Hz, 1H), 2.92 (d,  $J = 15.6$  Hz, 1H), 2.90 (s, 3H), 1.39 (t,  $J = 7.2$  Hz, 3H), 1.29 (t,  $J = 7.2$  Hz, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  166.0, 162.1, 149.1, 140.1, 137.6, 137.3, 129.8, 129.2, 126.4, 126.3, 124.3, 116.1, 109.2, 64.5, 60.8, 38.0, 36.4, 21.0, 14.3, 14.0; **HRMS** (ESI): calculated for  $\text{C}_{20}\text{H}_{22}\text{NO}_6^+$ ,  $[\text{M}+\text{H}]^+$  372.1442, Found 372.1440.

$[\alpha]_D^{25} = -99.8$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis**: 94% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 11.2 min (minor), 12.5 min (major)].



**3c**, Prepared according to the general procedure in 0.1 mmol scale, 57% yield, 22.1 mg, colorless oil;  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.81 (s, 1H), 6.99 (d,  $J = 8.4$  Hz, 2H), 6.81 (d,  $J = 8.8$  Hz, 2H), 4.77 (d,  $J = 7.2$  Hz, 1H), 4.39-4.28 (m, 4H), 3.76 (s, 3H), 3.21 (dd,  $J_1 = 15.6$  Hz,  $J_2 = 8.0$  Hz, 1H), 2.91 (d,  $J = 15.6$  Hz, 1H), 1.39 (t,  $J = 7.2$  Hz, 3H), 1.29 (t,  $J = 7.2$  Hz, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  166.1, 162.0, 158.9, 149.1, 140.0, 132.7, 127.6, 124.3, 116.2, 114.4, 109.2, 64.5, 60.8, 55.2, 38.1, 36.0, 14.3, 14.0; **HRMS** (ESI): calculated for  $\text{C}_{20}\text{H}_{22}\text{NO}_7^+$ ,  $[\text{M}+\text{H}]^+$  388.1391, Found 388.1388.

$[\alpha]_D^{25} = -112.8$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis**: 90% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 16.3 min (minor), 18.8 min (major)].

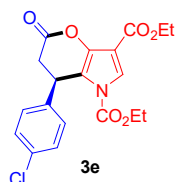


**3d**, Prepared according to the general procedure in 0.1 mmol scale, 70% yield, 28.9 mg, colorless oil;  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.81 (s, 1H), 7.27 (d,  $J = 8.4$  Hz, 2H), 7.01 (d,  $J = 8.4$  Hz, 2H), 4.79 (d,  $J = 7.6$  Hz, 1H), 4.39-4.29 (m, 2H), 3.21 (dd,  $J_1 = 16.0$  Hz,  $J_2 = 8.0$  Hz, 1H), 2.94 (d,  $J = 15.6$  Hz, 1H), 1.39 (t,  $J = 7.2$  Hz, 3H), 1.27 (t,  $J = 7.2$  Hz, 3H), 1.27 (s, 9H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  166.2, 162.1, 150.4, 149.1, 140.1, 137.5, 126.1, 126.0, 124.3, 116.2, 109.2, 64.5, 60.8, 37.9, 36.3, 34.4, 31.2, 14.3, 14.0; **HRMS** (ESI): calculated for  $\text{C}_{23}\text{H}_{27}\text{NNaO}_6^+$ ,  $[\text{M}+\text{Na}]^+$  436.1731,



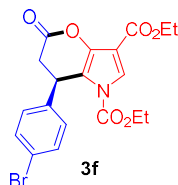
Found 436.1728.

$[\alpha]^{25}_{\text{D}} = -117.6$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis:** 95% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 8.5 min (minor), 10.1 min (major)].



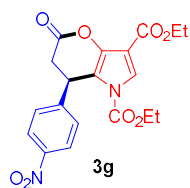
**3e**, Prepared according to the general procedure in 0.1 mmol scale, 82% yield, 32.1 mg, light yellow oil;  **$^1\text{H NMR}$**  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.82 (s, 1H), 7.27 (d,  $J = 8.0$  Hz, 2H), 7.02 (d,  $J = 8.4$  Hz, 2H), 4.81 (d,  $J = 8.0$  Hz, 1H), 4.37-4.28 (m, 4H), 3.24 (dd,  $J_1 = 16.0$  Hz,  $J_2 = 8.0$  Hz, 1H), 2.92 (d,  $J = 16.0$  Hz, 1H), 1.39 (t,  $J = 7.2$  Hz, 3H), 1.30 (t,  $J = 7.1$  Hz, 3H);  **$^{13}\text{C NMR}$**  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  165.6, 161.9, 149.0, 140.3, 139.2, 133.5, 129.3, 128.0, 124.5, 115.3, 109.3, 64.6, 60.8, 37.7, 36.2, 14.3, 14.0; **HRMS (ESI):** calculated for  $\text{C}_{19}\text{H}_{18}\text{ClNNaO}_6^+$ ,  $[\text{M}+\text{Na}]^+$  414.0715, Found 414.0712.

$[\alpha]^{25}_{\text{D}} = -101.6$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis:** 94% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 80:20; retention times: 7.7 min (minor), 8.5 min (major)].

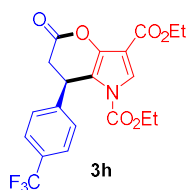


**3f**, Prepared according to the general procedure in 0.1 mmol scale, 78% yield, 34.0 mg, light yellow oil.  **$^1\text{H NMR}$**  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.82 (s, 1H), 7.42 (d,  $J = 8.0$  Hz, 2H), 6.97 (d,  $J = 8.0$  Hz, 2H), 4.80 (d,  $J = 8.0$  Hz, 1H), 4.36-4.29 (m, 4H), 3.24 (dd,  $J_1 = 16.0$  Hz,  $J_2 = 8.0$  Hz, 1H), 2.92 (d,  $J = 16.0$  Hz, 1H), 1.39 (t,  $J = 7.2$  Hz, 3H), 1.30 (t,  $J = 7.2$  Hz, 3H);  **$^{13}\text{C NMR}$**  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  165.5, 161.9, 149.0, 140.3, 139.7, 132.2, 128.3, 124.5, 121.5, 115.2, 109.3, 64.6, 60.8, 37.6, 36.3, 14.3, 14.0; **HRMS (ESI):** calculated for  $\text{C}_{19}\text{H}_{18}\text{BrNNaO}_6^+$ ,  $[\text{M}+\text{Na}]^+$  458.0210, Found 458.0203.

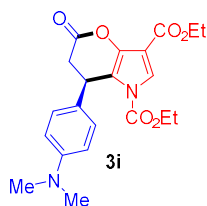
$[\alpha]^{25}_{\text{D}} = -103.6$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis:** 94% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 13.5 min (minor), 15.4 min (major)].



**3g**, Prepared according to the general procedure in 0.1 mmol scale, 90% yield, 36.2 mg, light yellow oil; **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ 8.18 (d, *J* = 8.8 Hz, 2H), 7.84 (s, 1H), 7.28 (d, *J* = 8.8 Hz, 2H), 4.97 (d, *J* = 8.0 Hz, 1H), 4.32 (m, 4H), 3.31 (dd, *J*<sub>1</sub> = 16.0 Hz, *J*<sub>2</sub> = 8.0 Hz, 1H), 2.95 (d, *J* = 16.0 Hz, 1H), 1.40 (t, *J* = 7.2 Hz, 3H), 1.32 (t, *J* = 7.2 Hz, 3H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>) δ 165.0, 161.7, 148.9, 147.9, 147.4, 140.7, 127.7, 124.7, 124.5, 114.3, 109.4, 64.8, 60.9, 37.1, 36.5, 14.3, 14.0; **HRMS** (ESI): calculated for C<sub>19</sub>H<sub>18</sub>N<sub>2</sub>NaO<sub>8</sub><sup>+</sup>, [M+Na]<sup>+</sup> 425.0955, Found 425.0955. [α]<sub>D</sub><sup>25</sup> = -131.4 (c = 1.0 in CHCl<sub>3</sub>); **HPLC analysis**: 99% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 13.2 min (minor), 18.2 min (major)].

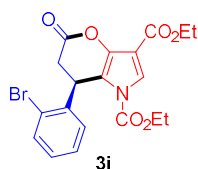


**3h**, Prepared according to the general procedure in 0.1 mmol scale, 81% yield, 34.5 mg, light yellow oil. **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ 7.83 (s, 1H), 7.57 (d, *J* = 8.0 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 4.91 (d, *J* = 8.0 Hz, 1H), 4.40-4.31 (m, 4H), 3.28 (dd, *J*<sub>1</sub> = 16.0 Hz, *J*<sub>2</sub> = 8.0 Hz, 1H), 2.94 (d, *J* = 16.0 Hz, 1H), 1.40 (t, *J* = 7.2 Hz, 3H), 1.30 (t, *J* = 7.2 Hz, 3H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>) δ 165.4, 161.9, 149.0, 144.6, 140.5, 129.9 (q, *J* = 35.0 Hz), 127.9, 126.17, 126.13, 124.6, 123.9 (q, *J* = 270.0 Hz), 114.9, 109.3, 64.7, 60.9, 37.4, 36.6, 14.3, 14.0; **HRMS** (ESI): calculated for C<sub>20</sub>H<sub>18</sub>F<sub>3</sub>NNaO<sub>6</sub><sup>+</sup>, [M+Na]<sup>+</sup> 448.0978, Found 448.0974. [α]<sub>D</sub><sup>25</sup> = -99.6 (c = 1.0 in CHCl<sub>3</sub>); **HPLC analysis**: 95% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 11.6 min (minor), 13.4 min (major)].



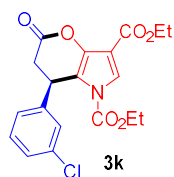
**3i**, Prepared according to the general procedure in 0.1 mmol scale, 85% yield, 34.0 mg, brown oil; **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ 7.79 (s, 1H), 6.93 (d, *J* = 8.8 Hz, 2H), 6.62 (d, *J* = 8.4 Hz, 2H), 4.72

(d,  $J = 7.6$  Hz, 1H), 4.38-4.29 (m, 4H), 3.19 (dd,  $J_1 = 16.0$  Hz,  $J_2 = 8.0$  Hz, 1H), 2.93 (d,  $J = 4.0$  Hz, 1H), 2.90 (s, 6H), 1.39 (t,  $J = 7.2$  Hz, 3H), 1.30 (t,  $J = 7.2$  Hz, 3H).  **$^{13}\text{C}$  NMR** (100 MHz,  $\text{CDCl}_3$ )  $\delta$  166.3, 162.1, 149.9, 149.2, 139.8, 128.2, 127.2, 124.1, 116.8, 112.9, 109.1, 64.4, 60.7, 40.5, 38.2, 36.0, 14.3, 14.0; **HRMS** (ESI): calculated for  $\text{C}_{21}\text{H}_{25}\text{N}_2\text{O}_6^+$ ,  $[\text{M}+\text{H}]^+$  401.1707, Found 401.1702.  $[\alpha]_D^{25} = -92.2$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis**: 90% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 15.3 min (minor), 18.7 min (major)].



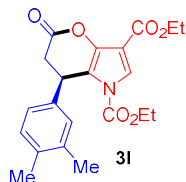
**3j**, Prepared according to the general procedure in 0.1 mmol scale, 63% yield, 27.5 mg, light yellow oil.  **$^1\text{H}$  NMR** (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.90 (s, 1H), 7.61 (d,  $J = 7.6$  Hz, 1H), 7.20-7.11 (m, 2H), 6.72 (d,  $J = 7.6$  Hz, 1H), 5.23 (d,  $J = 8.0$  Hz, 1H), 4.40-4.25 (m, 4H), 3.21 (dd,  $J_1 = 16.0$  Hz,  $J_2 = 8.4$  Hz, 1H), 3.04 (d,  $J = 16.0$  Hz, 1H), 1.40 (t,  $J = 7.2$  Hz, 3H), 1.18 (t,  $J = 7.2$  Hz, 3H);  **$^{13}\text{C}$  NMR** (100 MHz,  $\text{CDCl}_3$ )  $\delta$  165.6, 161.9, 149.1, 141.3, 138.9, 133.5, 129.3, 128.2, 127.4, 124.9, 123.1, 113.9, 109.2, 64.7, 60.8, 36.3, 35.8, 14.3, 13.8; **HRMS** (ESI): calculated for  $\text{C}_{19}\text{H}_{18}\text{BrNNaO}_6^+$ ,  $[\text{M}+\text{Na}]^+$  458.0210, Found 458.0205.

$[\alpha]_D^{25} = -120.4$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis**: 98% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 95:5; retention times: 17.2 min (minor), 18.4 min (major)].



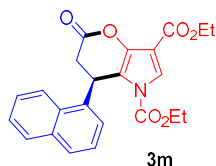
**3k**, Prepared according to the general procedure in 0.1 mmol scale, 63% yield, 24.7 mg, light yellow oil.  **$^1\text{H}$  NMR** (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.84 (s, 1H), 7.24 (d,  $J = 4.0$  Hz, 2H), 7.06 (s, 1H), 6.96 (d,  $J = 3.2$  Hz, 1H), 4.81 (d,  $J = 8.0$  Hz, 1H), 4.40-4.30 (m, 4H), 3.21 (dd,  $J_1 = 16.0$  Hz,  $J_2 = 8.0$  Hz, 1H), 2.94 (d,  $J = 16.0$  Hz, 1H), 1.40 (t,  $J = 7.2$  Hz, 3H), 1.30 (t,  $J = 7.2$  Hz, 3H);  **$^{13}\text{C}$  NMR** (100 MHz,  $\text{CDCl}_3$ )  $\delta$  165.5, 161.9, 149.0, 142.7, 140.5, 135.0, 13-0.5, 128.0, 126.8, 124.7, 124.6, 114.9, 109.3, 64.6, 60.9, 37.6, 36.5, 14.3, 14.0; **HRMS** (ESI): calculated for  $\text{C}_{19}\text{H}_{18}\text{ClNNaO}_6^+$ ,  $[\text{M}+\text{Na}]^+$  414.0715, Found 414.0711.

$[\alpha]_D^{25} = -120.4$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis:** 95% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/i-PrOH = 90:10; retention times: 14.0 min (minor), 17.3 min (major)].



**3l**, Prepared according to the general procedure in 0.1 mmol scale, 75% yield, 28.9 mg, light yellow oil. **<sup>1</sup>H NMR** (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.81 (s, 1H), 7.04 (d,  $J = 7.6$  Hz, 2H), 6.80 (d,  $J = 8.0$  Hz, 2H), 4.75 (d,  $J = 7.6$  Hz, 1H), 4.40-4.27 (m, 4H), 3.21 (dd,  $J_1 = 16.0$  Hz,  $J_2 = 8.0$  Hz, 1H), 2.91 (d,  $J = 16.0$  Hz, 1H), 2.20 (s, 6H), 1.39 (t,  $J = 7.2$  Hz, 3H), 1.30 (t,  $J = 7.2$  Hz, 3H); **<sup>13</sup>C NMR** (100 MHz,  $\text{CDCl}_3$ )  $\delta$  166.1, 162.1, 149.1, 140.1, 138.0, 137.4, 135.9, 130.3, 127.6, 124.3, 123.9, 116.1, 109.2, 64.4, 60.8, 38.0, 36.4, 19.8, 19.4, 14.3, 14.0; **HRMS** (ESI): calculated for  $\text{C}_{21}\text{H}_{23}\text{NNaO}_6^+$ ,  $[\text{M}+\text{Na}]^+$  408.1418, Found 408.1414.

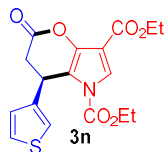
$[\alpha]_D^{25} = -124.4$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis:** 90% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/i-PrOH = 90:10; retention times: 10.1 min (minor), 11.5 min (major)].



**3m**, Prepared according to the general procedure in 0.1 mmol scale, 65% yield, 26.5 mg, light yellow oil. **<sup>1</sup>H NMR** (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.04 (d,  $J = 8.4$  Hz, 1H), 7.93 (s, 1H), 7.90 (d,  $J = 8.4$  Hz, 1H), 7.75 (d,  $J = 8.4$  Hz, 2H), 7.61 (t,  $J = 7.6$  Hz, 1H), 7.54 (t,  $J = 7.6$  Hz, 2H), 7.30 (t,  $J = 7.6$  Hz, 1H), 6.86 (d,  $J = 7.2$  Hz, 2H), 5.66 (d,  $J = 8.0$  Hz, 1H), 4.40 (dd,  $J_1 = 6.8$  Hz,  $J_2 = 2.4$  Hz, 2H), 4.11 (dd,  $J_1 = 6.8$  Hz,  $J_2 = 2.4$  Hz, 2H), 3.36 (dd,  $J_1 = 15.6$  Hz,  $J_2 = 8.0$  Hz, 1H), 3.11 (d,  $J = 15.6$  Hz, 1H), 1.41 (t,  $J = 7.2$  Hz, 3H), 0.91 (t,  $J = 7.2$  Hz, 3H); **<sup>13</sup>C NMR** (100 MHz,  $\text{CDCl}_3$ )  $\delta$  165.6, 162.0, 149.1, 141.3, 135.6, 134.3, 130.2, 129.4, 128.4, 126.8, 125.9, 125.5, 124.8, 123.4, 131.9, 114.8, 109.3, 64.4, 60.8, 36.6, 32.6, 14.3, 13.6; **HRMS** (ESI): calculated for  $\text{C}_{23}\text{H}_{21}\text{NNaO}_6^+$ ,  $[\text{M}+\text{Na}]^+$  430.1261, Found 430.1255.

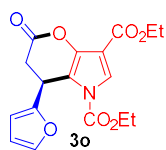
$[\alpha]_D^{25} = -235.0$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis:** 99% ee, [CHIRALPAK AD column; 1.0

mL/min; solvent system: hexane/i-PrOH = 90:10; retention times: 14.9 min (minor), 20.2 min (major)].



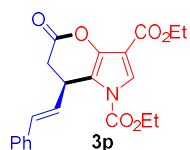
**3n**, Prepared according to the general procedure in 0.1 mmol scale, 67% yield, 24.3 mg, light yellow oil.  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.80 (s, 1H), 7.27 (dd,  $J_1 = 5.2$  Hz,  $J_2 = 3.2$  Hz, 1H), 6.92 (dd,  $J_1 = 5.2$  Hz,  $J_2 = 3.2$  Hz, 2H), 4.95 (d,  $J = 7.2$  Hz, 1H), 4.39-4.32 (m, 4H), 3.36 (dd,  $J_1 = 16.0$  Hz,  $J_2 = 7.6$  Hz, 1H), 3.00 (dd,  $J_1 = 16.0$  Hz,  $J_2 = 1.2$  Hz, 1H), 1.38 (t,  $J = 7.2$  Hz, 3H), 1.32 (t,  $J = 7.2$  Hz, 3H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  166.1, 161.9, 149.2, 141.1, 139.5, 127.0, 125.9, 124.2, 121.3, 1116.3, 109.3, 64.5, 60.7, 37.1, 32.0, 14.3, 14.0; **HRMS** (ESI): calculated for  $\text{C}_{17}\text{H}_{17}\text{NNaO}_6\text{S}^+$ ,  $[\text{M}+\text{Na}]^+$  386.0669, Found 386.0666.

$[\alpha]_D^{25} = -101.8$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis**: 86% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/i-PrOH = 93:7; retention times: 13.7 min (minor), 15.7 min (major)].



**3o**, Prepared according to the general procedure in 0.1 mmol scale, 72% yield, 25.0 mg, light yellow oil.  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.80 (s, 1H), 7.30 (s, 1H), 6.25 (d,  $J = 2.0$  Hz, 1H), 6.01 (d,  $J = 3.2$  Hz, 1H), 4.95 (t,  $J = 4.0$  Hz, 1H), 4.43-4.31 (m, 4H), 3.13-3.11 (m, 2H), 3.00 (dd,  $J_1 = 16.0$  Hz,  $J_2 = 1.2$  Hz, 1H), 1.39-1.34 (m, 6H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  165.7, 161.9, 152.7, 149.2, 142.4, 140.0, 124.3, 113.3, 110.3, 109.3, 106.1, 64.3, 60.7, 34.7, 30.6, 14.3, 14.0; **HRMS** (ESI): calculated for  $\text{C}_{17}\text{H}_{17}\text{NNaO}_7^+$ ,  $[\text{M}+\text{Na}]^+$  370.0897, Found 370.0892.

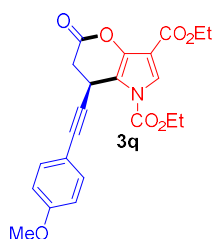
$[\alpha]_D^{25} = -60.6$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis**: 90% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/i-PrOH = 90:10; retention times: 12.2 min (minor), 13.7 min (major)].



**3p**, Prepared according to the general procedure in 0.1 mmol scale, 50% yield, 19.2mg, light yellow oil.  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.80 (s, 1H), 7.80 (s, 1H), 7.31-7.22 (m, 5H), 6.33 (d,  $J = 16.0$

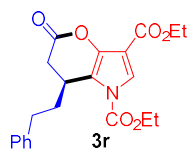
Hz, 1H), 6.21 (dd,  $J_1 = 16.0$  Hz,  $J_2 = 6.4$  Hz, 1H), 4.48-4.40 (m, 3H), 4.37-4.32 (m, 2H), 3.08 (dd,  $J_1 = 15.6$  Hz,  $J_2 = 7.6$  Hz, 1H), 2.98 (d,  $J = 15.6$  Hz, 1H), 1.41 (t,  $J = 7.2$  Hz, 3H), 1.38 (t,  $J = 7.2$  Hz, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  166.3, 162.0, 149.2, 139.5, 136.1, 131.3, 128.5, 127.9, 127.3, 126.4, 124.2, 115.5, 109.3, 64.6, 60.8, 35.2, 33.6, 14.3, 14.2; **HRMS** (ESI): calculated for  $\text{C}_{21}\text{H}_{21}\text{NNaO}_6^+$ ,  $[\text{M}+\text{Na}]^+$  402.1261, Found 402.1260.

$[\alpha]_D^{25} = -84.6$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis**: 83% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 21.2 min (minor), 24.1 min (major)].



**3q**, Prepared according to the general procedure in 0.1 mmol scale, 55% yield, 22.6mg, light yellow oil.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.81 (s, 1H), 7.28 (d,  $J = 8.8$  Hz, 1H), 6.79 (d,  $J = 8.8$  Hz, 1H), 4.71 (dd,  $J_1 = 7.2$  Hz,  $J_2 = 1.2$  Hz, 1H), 4.55-4.43 (m, 4H), 4.34 (q,  $J = 7.2$  Hz, 1H), 3.79 (s, 3H), 3.17 (dd,  $J_1 = 15.6$  Hz,  $J_2 = 1.6$  Hz, 1H), 3.05 (dd,  $J_1 = 15.6$  Hz,  $J_2 = 1.6$  Hz, 1H), 1.47 (t,  $J = 7.2$  Hz, 3H), 1.37 (t,  $J = 7.2$  Hz, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  165.3, 161.9, 159.7, 149.2, 139.3, 133.2, 124.3, 114.4, 113.8, 113.1, 109.4, 105.6, 84.4, 83.2, 64.8, 60.8, 55.3, 24.1, 14.3, 14.1; **HRMS** (ESI): calculated for  $\text{C}_{22}\text{H}_{21}\text{NNaO}_7^+$ ,  $[\text{M}+\text{Na}]^+$  434.1210, Found 434.1211.

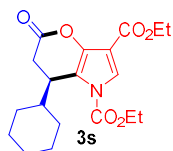
$[\alpha]_D^{25} = -24.4$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis**: 81% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 36.6 min (minor), 46.5 min (major)].



**3r**, Prepared according to the general procedure in 0.1 mmol scale, 65% yield, 25.1 mg, light yellow oil.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.74 (s, 1H), 7.28-7.25 (m, 2H), 7.20-7.13 (m, 3H), 6.33 (d,  $J = 16.0$  Hz, 1H), 6.21 (dd,  $J_1 = 16.0$  Hz,  $J_2 = 6.4$  Hz, 1H), 4.40 (q,  $J = 7.2$  Hz, 2H), 4.33 (q,  $J = 7.2$  Hz, 2H), 3.68 (s, 1H), 2.97-2.86 (m, 2H), 2.75-2.68 (m, 1H), 2.64-2.57 (m, 1H), 2.06-1.97 (m, 1H), 1.90-1.80 (m, 1H), 1.40 (t,  $J = 7.2$  Hz, 3H), 1.37 (t,  $J = 7.2$  Hz, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  167.1, 162.0, 149.4, 140.7, 139.1, 128.4, 128.2, 126.1, 123.9, 117.5, 109.2, 64.5, 60.7, 35.7, 33.8, 32.3, 30.5, 14.3, 14.2; **HRMS** (ESI): calculated for  $\text{C}_{21}\text{H}_{24}\text{NO}_6^+$ ,  $[\text{M}+\text{H}]^+$  386.1598, Found

386.1592.

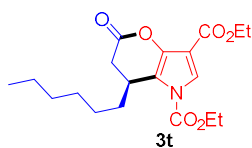
$[\alpha]_D^{25} = -15.4$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis:** 93% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 31.8 min (minor), 37.1 min (major)].



**3s**, Prepared according to the general procedure in 0.1 mmol scale, 67% yield, 24.3mg, colorless oil.

**$^1\text{H NMR}$**  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.77 (d,  $J = 1.2$  Hz, 1H), 4.50-4.41 (m, 2H), 4.36-4.30 (m, 2H), 3.49 (dd,  $J_1 = 8.0$  Hz,  $J_2 = 4.0$  Hz, 1H), 2.91 (d,  $J = 16.8$  Hz, 1H), 2.75 (dd,  $J_1 = 16.4$  Hz,  $J_2 = 8.0$  Hz, 1H), 1.75-1.54 (m, 7H), 1.44 (t,  $J = 7.2$  Hz, 3H), 1.36 (t,  $J = 7.2$  Hz, 3H), 1.23 (t,  $J = 9.6$  Hz, 2H), 1.11 (t,  $J = 10.4$  Hz, 2H);  **$^{13}\text{C NMR}$**  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  1167.9, 162.1, 149.5, 135.6, 124.0, 116.8, 109.1, 64.4, 60.6, 41.8, 36.2, 31.1, 30.4, 27.7, 26.4, 26.2, 26.0, 14.3, 14.1; **HRMS** (ESI): calculated for  $\text{C}_{19}\text{H}_{25}\text{NNaO}_6^+$ ,  $[\text{M}+\text{Na}]^+$  386.1574, Found 386.1570.

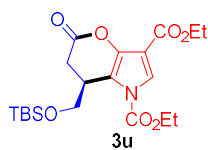
$[\alpha]_D^{25} = -11.0$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis:** 96% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 95:5; retention times: 11.6 min (minor), 12.6 min (major)].



**3t**, Prepared according to the general procedure in 0.1 mmol scale, 55% yield, 20.1mg, colorless oil.

**$^1\text{H NMR}$**  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.74 (s, 1H), 4.45 (q,  $J = 7.2$  Hz, 2H), 4.33 (q,  $J = 7.2$  Hz, 2H), 3.62-3.57 (m, 1H), 2.86 (d,  $J = 4.0$  Hz, 2H), 1.69-1.62 (m, 1H), 1.52-1.50 (m, 1H), 1.44 (t,  $J = 7.2$  Hz, 3H), 1.36 (t,  $J = 7.2$  Hz, 3H), 1.25 (bs, 8H), 0.86 (t,  $J = 5.6$  Hz, 3H);  **$^{13}\text{C NMR}$**  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  167.3, 162.1, 149.4, 139.0, 123.7, 118.1, 123.7, 118.1, 109.2, 64.5, 60.7, 34.3, 33.9, 31.6, 30.8, 26.0, 22.6, 14.3, 14.2, 14.0; **HRMS** (ESI): calculated for  $\text{C}_{19}\text{H}_{27}\text{NNaO}_6^+$ ,  $[\text{M}+\text{Na}]^+$  388.1731, Found 388.1730.

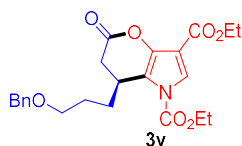
$[\alpha]_D^{25} = -7.8$  ( $c = 1.0$  in  $\text{CHCl}_3$ ); **HPLC analysis:** 98% ee, [CHIRALPAK AD column; 0.8 mL/min; solvent system: hexane/*i*-PrOH = 98:2; retention times: 33.4 min (minor), 3.8 min (major)].



**3u**, Prepared according to the general procedure in 0.1 mmol scale, 85% yield, 36.2 mg, light yellow

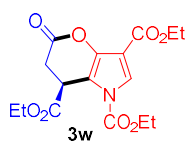
oil. **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ 7.76 (s, 1H), 4.48-4.43 (m, 2H), 4.38-4.28 (m, 2H), 3.75 (d, *J* = 2.0 Hz, 2H), 3.69-3.67 (m, 1H), 2.87 (d, *J* = 6.4 Hz, 2H), 1.44 (t, *J* = 7.2 Hz, 3H), 1.35 (t, *J* = 7.2 Hz, 3H), 0.81 (s, 9H), -0.06 (s, 3H), -0.14 (s, 3H). **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>) δ 166.9, 162.1, 149.5, 140.9, 123.8, 114.2, 109.4, 65.0, 64.4, 60.6, 34.2, 32.7, 25.6, 18.1, 14.3, 14.1, -5.9, -6.1; **HRMS** (ESI): calculated for C<sub>20</sub>H<sub>31</sub>NNaO<sub>7</sub>Si<sup>+</sup>, [M+Na]<sup>+</sup> 448.1762, Found 448.1758.

[α]<sub>D</sub><sup>25</sup> = -15.0 (c = 1.0 in CHCl<sub>3</sub>); **HPLC analysis**: 97% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 80:20; retention times: 5.0 min (minor), 6.3 min (major)].



**3v**, Prepared according to the general procedure in 0.1 mmol scale, 64% yield, 27.5 mg, light yellow oil; **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ 7.74 (s, 1H), 7.35 – 7.26 (m, 5H), 4.46-4.40 (m, 4H), 4.33 (q, *J* = 7.2 Hz, 2H), 3.66 – 3.65 (m, 1H), 3.44 (t, *J* = 5.6 Hz, 2H), 2.92-2.83 (m, 2H), 1.81-1.73 (m, 1H), 1.72-1.56 (m, 3H), 1.41 (t, *J* = 7.2 Hz, 3H), 1.36 (t, *J* = 7.2 Hz, 3H). **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>) δ 167.2, 162.0, 149.3, 139.0, 138.3, 128.3, 127.6, 127.5, 123.8, 117.6, 109.2, 72.9, 69.8, 64.5, 60.7, 34.0, 31.1, 30.6, 26.2, 14.3, 14.1; **HRMS** (ESI): calculated for C<sub>23</sub>H<sub>27</sub>NNaO<sub>7</sub><sup>+</sup>, [M+Na]<sup>+</sup> 452.1680, Found 452.1677.

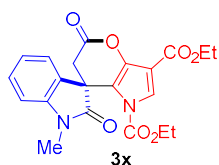
[α]<sub>D</sub><sup>25</sup> = -24.2 (c = 1.0 in CHCl<sub>3</sub>); **HPLC analysis**: 96% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 29.0 min (minor), 50.6 min (major)].



**3w**, Prepared according to the general procedure in 0.1 mmol scale, 65% yield, 23.0 mg, light yellow oil; **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ 7.81 (s, 1H), 4.48-4.43 (m, 3H), 4.34 (q, *J* = 7.2 Hz, 2H), 4.17 (q, *J* = 7.2 Hz, 2H), 3.18 (dd, *J*<sub>1</sub> = 16.4, *J*<sub>2</sub> = 2.0 Hz, 1H), 3.05 (dd, *J*<sub>1</sub> = 16.4, *J*<sub>2</sub> = 8.4 Hz, 1H), 1.43 (t, *J* = 7.2 Hz, 3H), 1.37 (t, *J* = 7.2 Hz, 3H), 1.24 (t, *J* = 7.2 Hz, 3H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>) δ 170.0, 164.8, 161.8, 149.3, 140.6, 124.6, 110.6, 109.2, 64.8, 62.0, 60.8, 37.1, 31.7, 14.3, 14.1, 14.0; **HRMS** (ESI): calculated for C<sub>16</sub>H<sub>19</sub>NNaO<sub>8</sub><sup>+</sup>, [M+Na]<sup>+</sup> 376.1003, Found 376.1005.

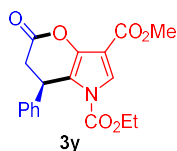
[α]<sub>D</sub><sup>25</sup> = 24.6 (c = 1.0 in CHCl<sub>3</sub>); **HPLC analysis**: 97% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 15.7 min (minor), 17.7 min (major)].





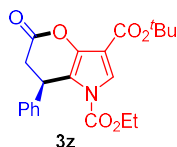
**3x**, Prepared according to the general procedure in 0.1 mmol scale, 64% yield, 26.4 mg, brown oil; **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.77 (s, 1H), 7.36-7.31 (m, 1H), 7.02 (d,  $J$  = 4.0 Hz, 2H), 6.93 (d,  $J$  = 8.0 Hz, 1H), 4.40-4.35 (m, 2H), 4.30-4.12 (m, 2H), 3.36 (d,  $J$  = 15.6 Hz, 1H), 3.30 (s, 3H), 2.66 (d,  $J$  = 16.0 Hz, 1H), 1.39 (t,  $J$  = 7.2 Hz, 3H), 1.25 (t,  $J$  = 7.2 Hz, 3H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  175.7, 164.8, 148.5, 142.8, 142.6, 129.5, 129.4, 125.3, 123.1, 122.7, 109.3, 108.8, 64.7, 60.9, 47.5, 39.8, 26.9, 14.3, 13.9; **HRMS** (ESI): calculated for C<sub>21</sub>H<sub>20</sub>N<sub>2</sub>NaO<sub>7</sub><sup>+</sup>, [M+Na]<sup>+</sup> 435.1163, Found 435.1160.

[ $\alpha$ ]<sub>D</sub><sup>25</sup> = 170.4 (c = 1.0 in CHCl<sub>3</sub>); **HPLC analysis**: 90% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 24.1 min (minor), 29.9 min (major)].



**3y**, Prepared according to the general procedure in 0.1 mmol scale, 79% yield, 27.1 mg, light yellow oil; **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.85 (s, 1H), 7.32-7.22 (m, 3H), 7.07 (d,  $J$  = 7.2 Hz, 2H), 4.83 (d,  $J$  = 7.2 Hz, 1H), 4.35-4.27 (m, 2H), 3.90 (s, 3H), 3.24 (dd,  $J_1$  = 16.0 Hz,  $J_2$  = 8.0 Hz, 1H), 2.95 (dd,  $J_1$  = 16.0 Hz,  $J_2$  = 1.6 Hz, 1H), 1.27 (t,  $J$  = 7.2 Hz, 3H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  161.2, 161.0, 149.1, 148.2, 147.8, 136.9, 131.6, 129.6, 128.9, 126.4, 115.5, 110.2, 109.1, 65.1, 61.2, 14.4, 13.5; **HRMS** (ESI): calculated for C<sub>18</sub>H<sub>18</sub>NO<sub>6</sub><sup>+</sup>, [M+H]<sup>+</sup> 344.1129, Found 344.1127.

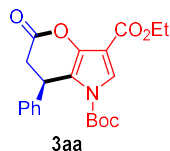
[ $\alpha$ ]<sub>D</sub><sup>25</sup> = -101 (c = 1.0 in EtOAc); **HPLC analysis**: 95% ee, [CHIRALPAK IA column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 13.1 min (minor), 14.9 min (major)].



**3z**, Prepared according to the general procedure in 0.1 mmol scale, 81% yield, 31.2 mg, light yellow oil; **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.73 (s, 1H), 7.31-7.21 (m, 3H), 7.07 (d,  $J$  = 7.2 Hz, 2H), 4.80 (d,  $J$  = 7.6 Hz, 1H), 4.34-4.25 (m, 2H), 3.23 (dd,  $J_1$  = 16.0 Hz,  $J_2$  = 8.0 Hz, 1H), 2.95 (dd,  $J_1$  = 16.0 Hz,  $J_2$  = 0.8 Hz, 1H), 1.59 (s, 9H), 1.25 (t,  $J$  = 7.2 Hz, 3H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  165.8, 161.2, 149.2, 140.7, 140.5, 129.1, 127.5, 126.5, 124.0, 81.5, 64.4, 37.8, 36.8, 28.2, 13.9; **HRMS**

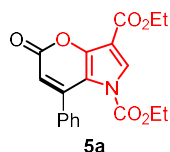
(ESI): calculated for  $C_{21}H_{24}NO_6^+$ ,  $[M+H]^+$  386.1598, Found 386.1594.

$[\alpha]_D^{25} = -65$  ( $c = 1.0$  in EtOAc); **HPLC analysis:** 96% ee, [CHIRALPAK IA column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 13.5 min (minor), 14.5 min (major)].

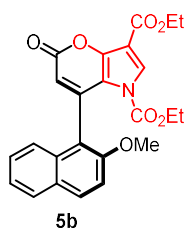


**3aa**, Prepared according to the general procedure in 0.1 mmol scale, 83% yield, 32.0 mg, light yellow oil;  **$^1H$  NMR** (400 MHz,  $CDCl_3$ )  $\delta$  7.80 (s, 1H), 7.30-7.21 (m, 3H), 7.04 (d,  $J = 7.6$  Hz, 2H), 4.82 (d,  $J = 7.6$  Hz, 1H), 4.39-4.32 (m, 2H), 3.25 (dd,  $J_1 = 16.0$  Hz,  $J_2 = 8.0$  Hz, 1H), 2.98 (d,  $J = 16.0$  Hz, 1H), 1.43 (s, 9H), 1.39 (t,  $J = 7.2$  Hz, 3H);  **$^{13}C$  NMR** (100 MHz,  $CDCl_3$ )  $\delta$  166.0, 162.2, 147.6, 140.6, 140.1, 129.0, 127.5, 126.6, 124.6, 115.2, 108.6, 86.0, 60.7, 38.0, 36.7, 27.7, 14.3; **HRMS** (ESI): calculated for  $C_{21}H_{24}NO_6^+$ ,  $[M+H]^+$  386.1598, Found 386.1596.

$[\alpha]_D^{25} = -83$  ( $c = 1.0$  in EtOAc); **HPLC analysis:** 93% ee, [CHIRALPAK AD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 90:10; retention times: 7.9 min (minor), 9.3 min (major)].



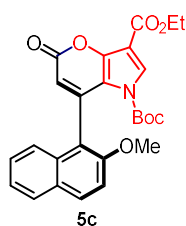
**5a**, Prepared according to the general procedure in 0.1 mmol scale, 88% yield, 31.3 mg, white solid, m.p. 165.2-167.4 °C;  **$^1H$  NMR** (400 MHz,  $CDCl_3$ )  $\delta$  8.11 (s, 1H), 7.48-7.47 (m, 3H), 7.39-7.37 (m, 2H), 6.13 (s, 1H), 4.42 (q,  $J = 7.2$  Hz, 2H), 3.81 (q,  $J = 7.2$  Hz, 2H), 1.42 (t,  $J = 7.2$  Hz, 3H), 0.94 (t,  $J = 7.2$  Hz, 3H);  **$^{13}C$  NMR** (100 MHz,  $CDCl_3$ )  $\delta$  165.9, 162.5, 149.1, 140.6, 140.1, 129.2, 127.7, 126.5, 124.6, 115.8, 108.9, 64.5, 51.9, 37.8, 36.8, 14.0; **HRMS** (ESI): calculated for  $C_{19}H_{18}NO_6^+$ ,  $[M+H]^+$  356.1129, Found 356.1126.



**5b**, Prepared according to the general procedure in 0.1 mmol scale, 62% yield, 27.0 mg, white solid, m.p. 101.4-103.3 °C;  **$^1H$  NMR** (400 MHz,  $CDCl_3$ )  $\delta$  8.07 (s, 1H), 7.94 (d,  $J = 9.2$  Hz, 1H), 7.85 (d,  $J = 8.0$  Hz, 1H), 7.67 (d,  $J = 8.4$  Hz, 1H), 7.45-7.41 (m, 1H), 7.39-7.37 (m, 1H), 7.31 (d,  $J = 8.8$  Hz,

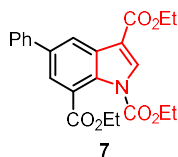
1H), 6.18 (s, 1H), 4.44 (q,  $J = 7.2$  Hz, 2H), 3.83 (s, 3H), 3.80-3.72 (m, 1H), 3.31-3.23 (m, 1H), 1.43 (t,  $J = 7.2$  Hz, 3H), 0.60 (t,  $J = 7.2$  Hz, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  161.5, 161.1, 152.7, 148.7, 147.3, 144.3, 131.6, 130.7, 130.6, 128.9, 128.2, 127.6, 124.1, 124.0, 119.5, 117.1, 113.2, 112.3, 108.3, 64.6, 61.1, 56.4, 14.4; **HRMS** (ESI): calculated for  $\text{C}_{24}\text{H}_{22}\text{NO}_7^+$ ,  $[\text{M}+\text{H}]^+$  436.1391, Found 436.1388.

$[\alpha]^{25}_{\text{D}} = -54$  ( $c = 1.0$  in EtOAc); **HPLC analysis**: 53% ee, [CHIRALPAK OD column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 80:20; retention times: 23.7 min (minor), 26.5 min (major)].



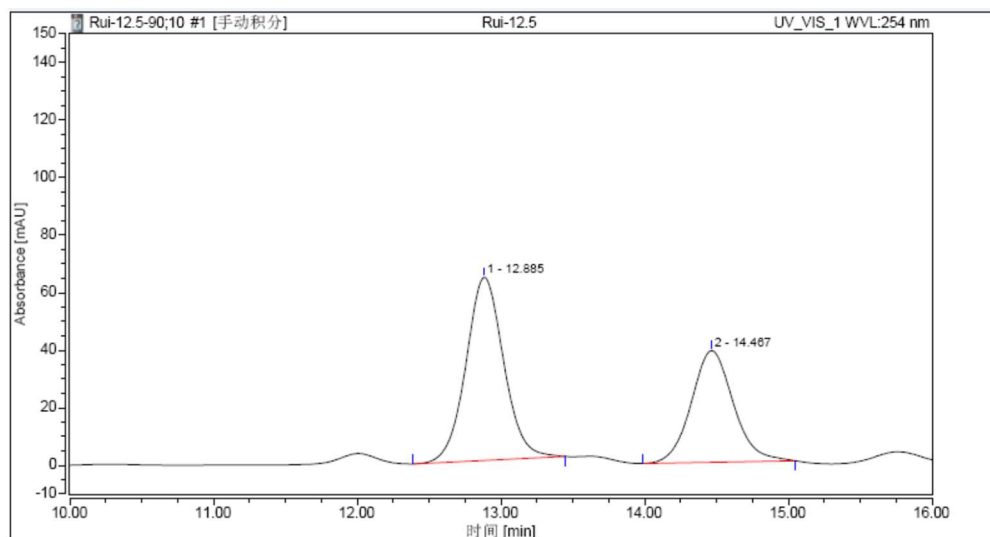
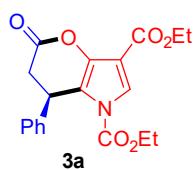
**5c**, Prepared according to the general procedure in 0.1 mmol scale, 55% yield, 25.4 mg, white solid, m.p. 59.6-61.2 °C;  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.95 (s, 1H), 7.93 (d,  $J = 9.2$  Hz, 1H), 7.83 (d,  $J = 7.2$  Hz, 1H), 7.61 (d,  $J = 8.4$  Hz, 1H), 7.45-7.41 (m, 1H), 7.39-7.35 (d,  $J = 9.2$  Hz, 1H), 6.20 (s, 1H), 4.44 (q,  $J = 7.2$  Hz, 2H), 3.86 (s, 3H), 1.44 (t,  $J = 7.2$  Hz, 3H), 1.02 (s, 9H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  161.8, 161.4, 153.1, 147.1, 146.5, 144.2, 131.6, 130.8, 130.5, 129.0, 128.3, 127.5, 124.0, 119.1, 117.1, 113.0, 112.5, 86.0, 61.0, 56.3, 27.0, 14.4; **HRMS** (ESI): calculated for  $\text{C}_{26}\text{H}_{26}\text{NO}_7^+$ ,  $[\text{M}+\text{H}]^+$  464.1704, Found 464.1701.

$[\alpha]^{25}_{\text{D}} = -119$  ( $c = 1.0$  in EtOAc); **HPLC analysis**: 70% ee, [CHIRALPAK IA column; 1.0 mL/min; solvent system: hexane/*i*-PrOH = 97:3; retention times: 60.3 min (minor), 65.3 min (major)].

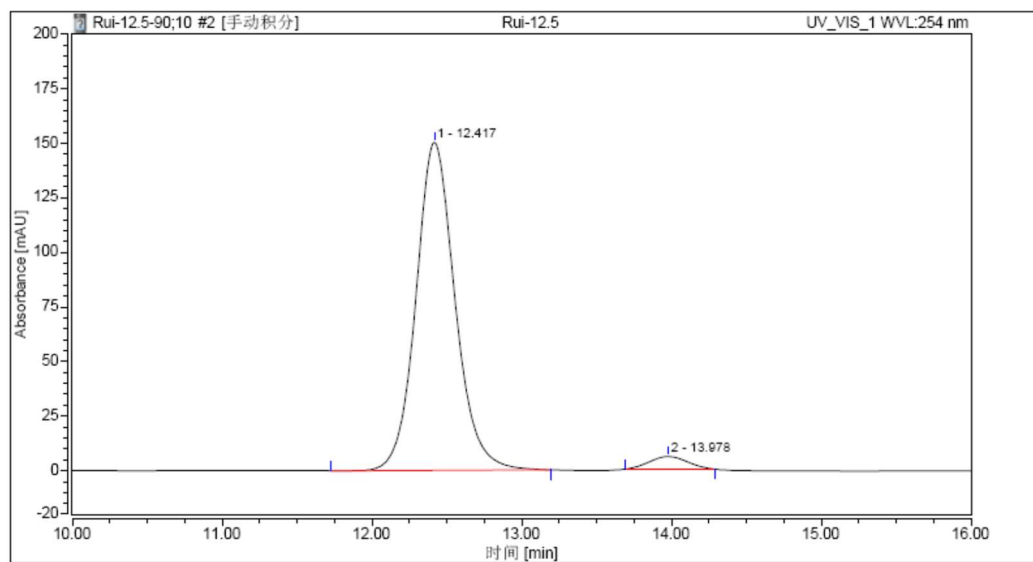


**7**, Prepared according to the general procedure in 0.1 mmol scale, 40% yield, 16.4 mg, yellow solid, m.p. 109.1-109.5 °C;  $^1\text{H}$  NMR (600 MHz,  $\text{CDCl}_3$ )  $\delta$  8.56 (d,  $J = 1.2$  Hz, 1H), 8.30 (s, 1H), 7.89 (d,  $J = 1.2$  Hz, 1H), 7.69 (d,  $J = 1.8$  Hz, 2H), 7.46 (t,  $J = 7.8$  Hz, 2H), 7.37 (t,  $J = 7.2$  Hz, 1H), 4.48 (q,  $J = 7.2$  Hz, 2H), 4.44-4.39 (m, 4H), 1.45 (q,  $J = 7.2$  Hz, 6H), 1.38 (t,  $J = 7.2$  Hz, 3H);  $^{13}\text{C}$  NMR (150 MHz,  $\text{CDCl}_3$ )  $\delta$  167.6, 163.6, 150.1, 140.2, 137.5, 133.9, 131.1, 129.6, 128.8, 127.4, 127.38, 125.4, 122.9, 121.6, 113.2, 64.5, 61.3, 60.5, 14.4, 14.2, 14.1; **HRMS** (ESI): calculated for  $\text{C}_{23}\text{H}_{24}\text{NO}_6^+$ ,  $[\text{M}+\text{H}]^+$  410.1598, Found 410.1584.

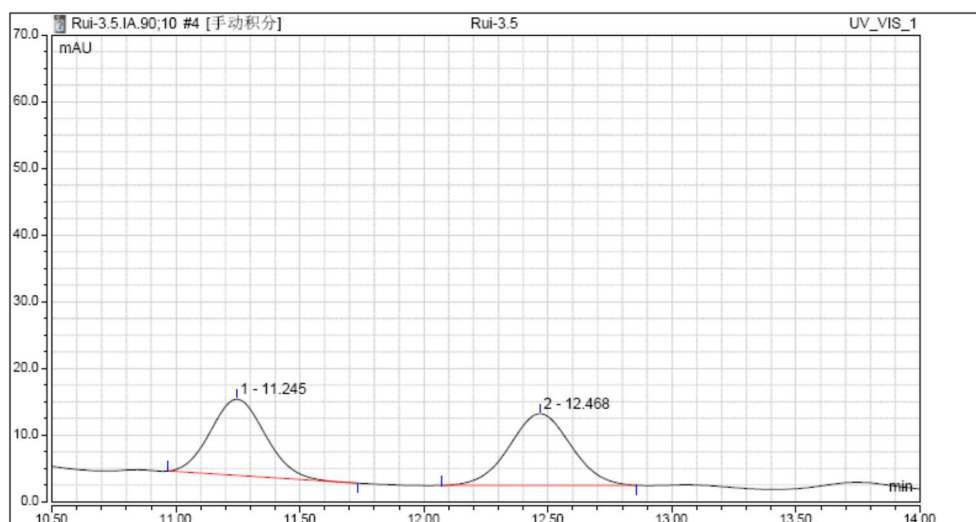
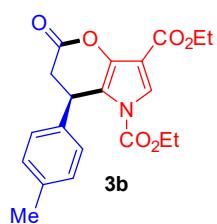
#### Part 4: HPLC spectra for all products



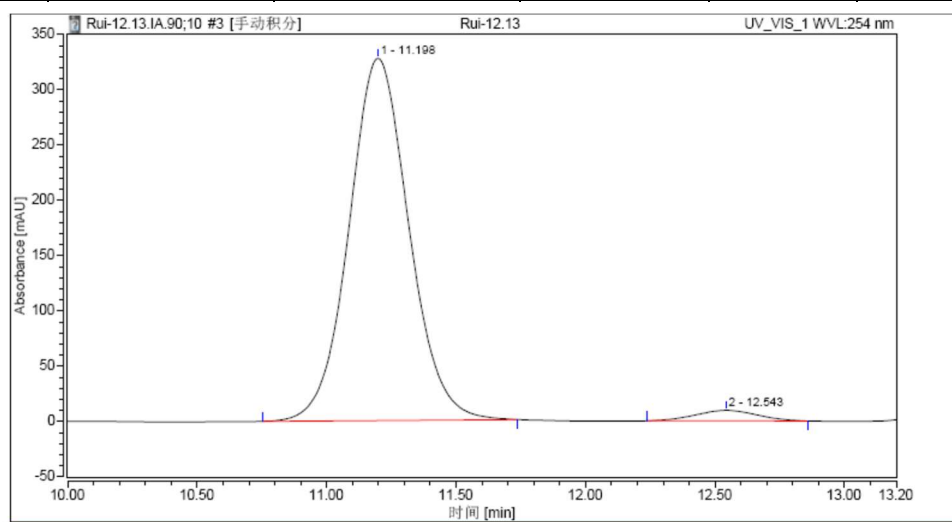
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	12.885	19.385	63.651	59.56	62.12
2	14.467	13.160	38.806	40.44	37.88
Total		32.546	102.458	100.00	100.0



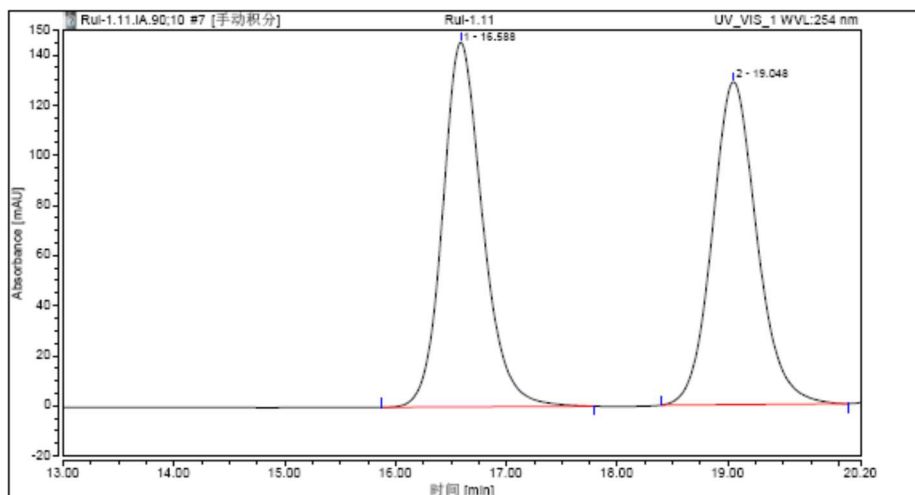
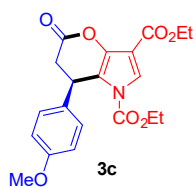
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	12.417	45.512	150.357	96.36	96.28
2	13.978	1.719	5.82	3.64	3.72
Total		47.231	156.159	100.00	100.0



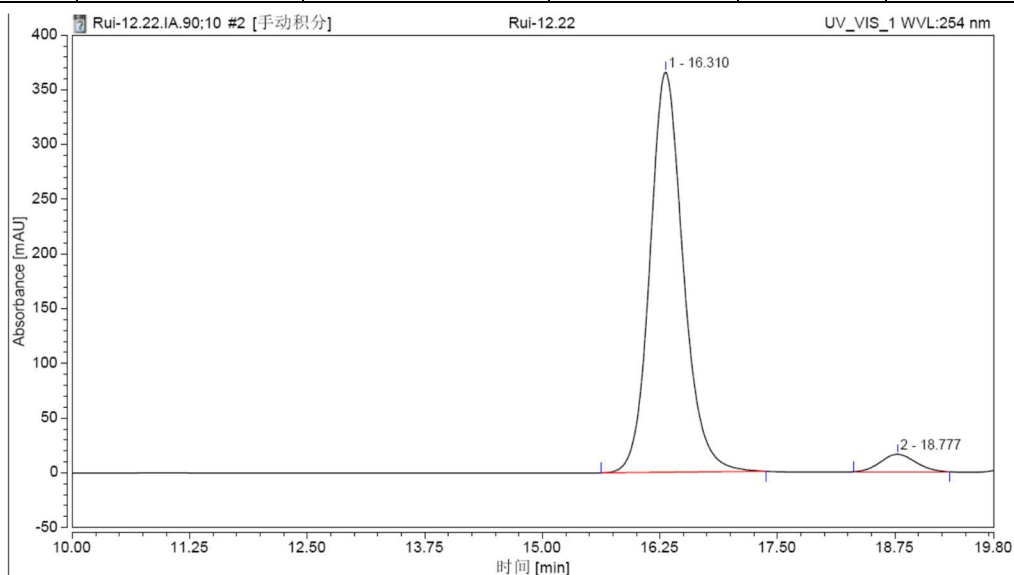
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	11.254	2.935	11.420	48.64	51.53
2	12.468	3.100	10.742	51.36	48.47
Total		6.035	22.161	100.00	100.0



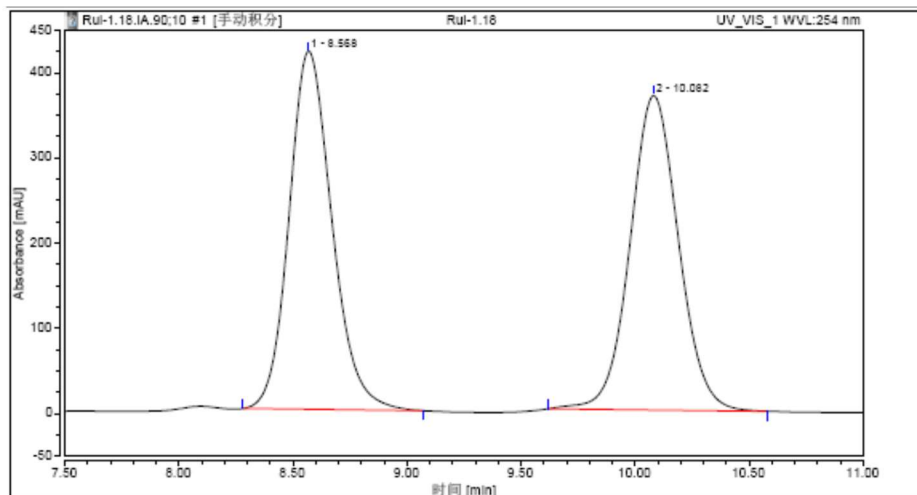
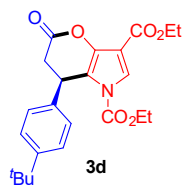
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	11.198	87.789	327.357	97.10	97.19
2	12.543	2.621	9.456	2.9	2.81
Total		90.410	336.813	100.00	100.0



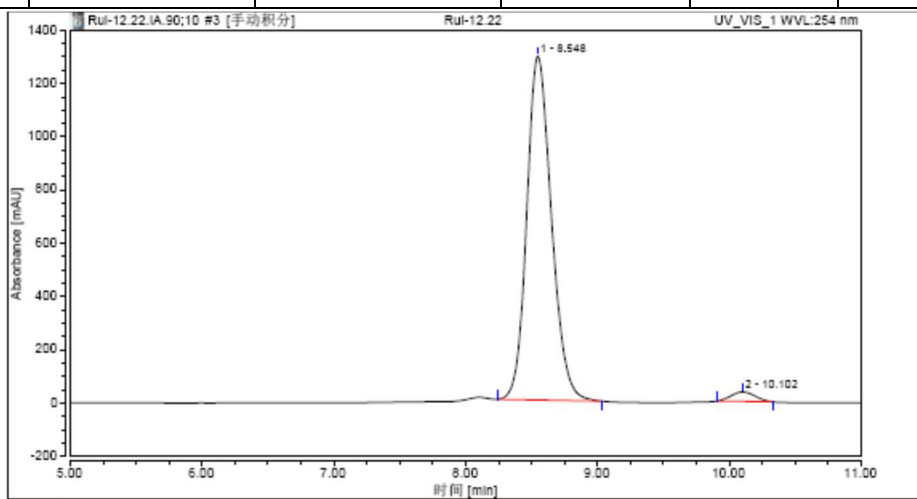
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	16.588	61.104	145.509	50.38	53.04
2	19.048	60.176	128.812	49.62	46.96
Total		121.279	274.321	100.00	100.00



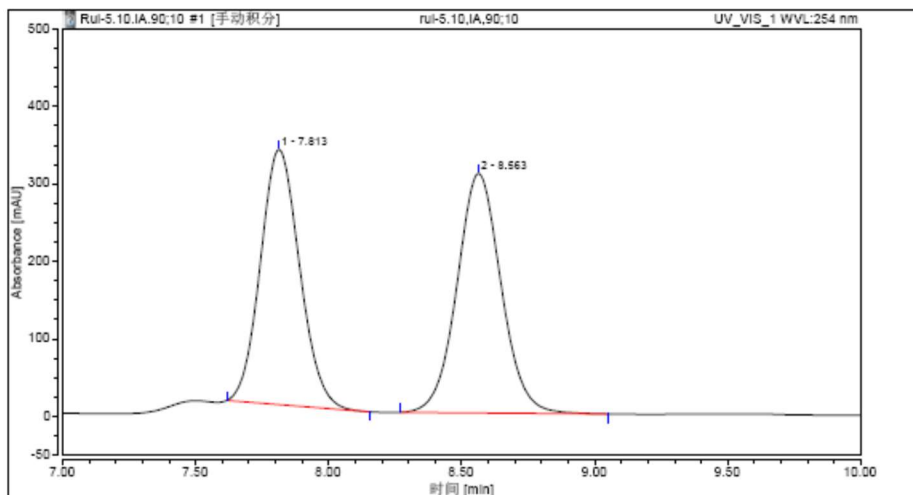
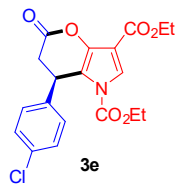
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	16.310	150.109	365.732	95.58	95.80
2	18.777	6.936	16.024	4.42	4.20
Total		157.044	381.756	100.00	100.00



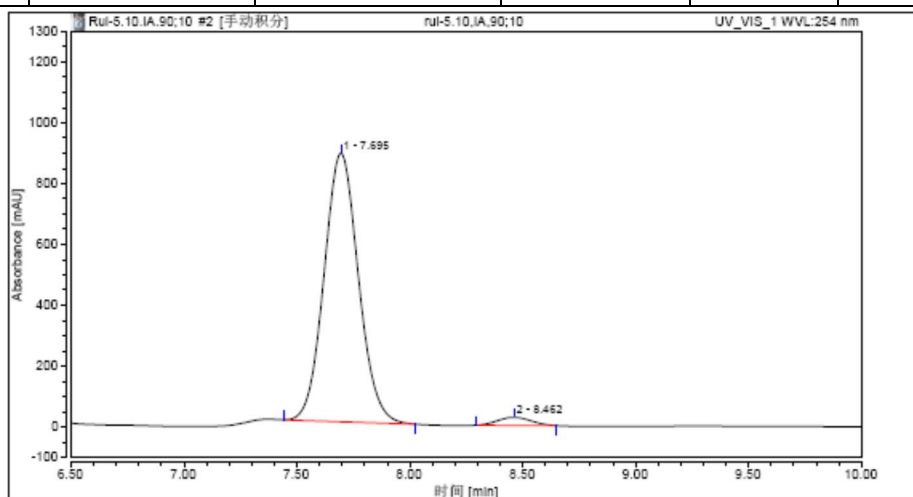
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	8.568	91.710	420.637	50.22	53.25
2	10.082	90.908	369.245	49.78	46.75
Total		182.617	789.882	100.00	100.00



Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	8.548	280.159	1292.906	97.40	97.33
2	10.102	7.472	35.494	2.60	2.67
Total		287.631	1328.400	100.00	100.00

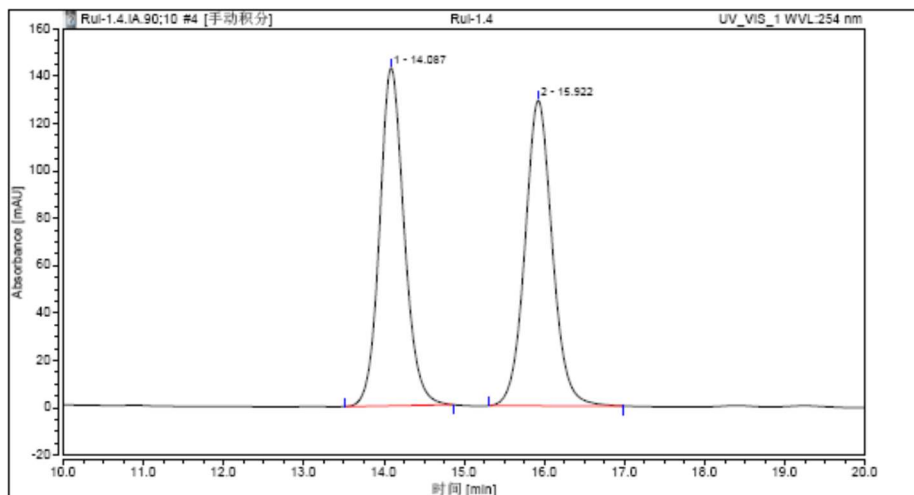
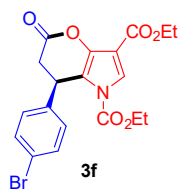


Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	7.813	56.316	329.314	48.66	51.58
2	8.563	59.421	309.197	51.34	48.42
Total		115.737	638.511	100.00	100.00

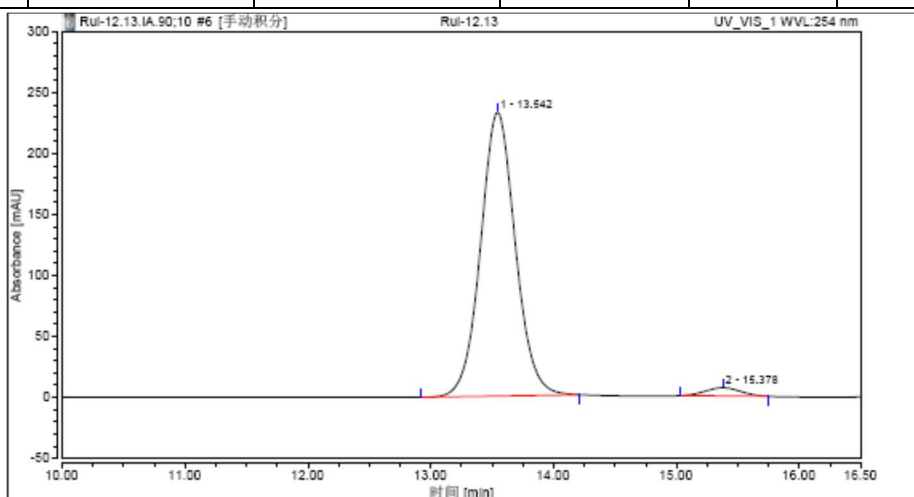


Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	7.695	155.420	882.974	97.16	97.08
2	8.462	4.547	26.524	2.84	2.92
Total		159.967	909.498	100.00	100.00

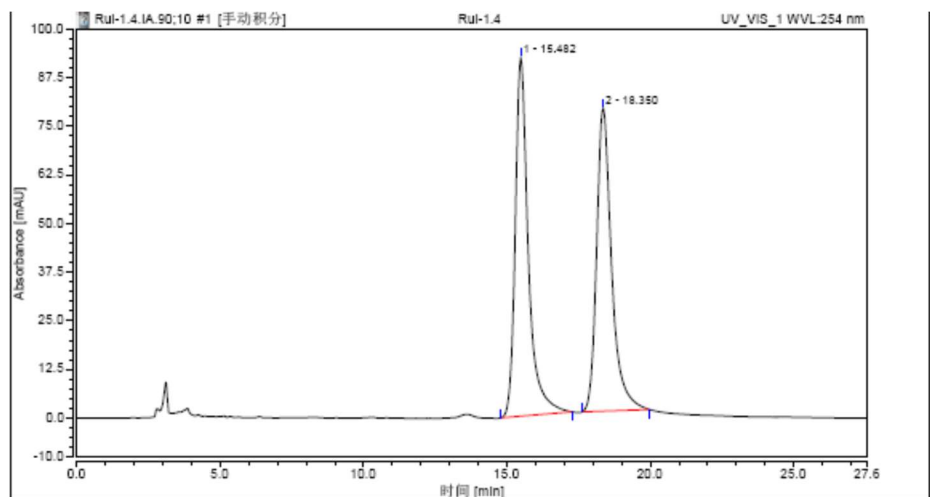
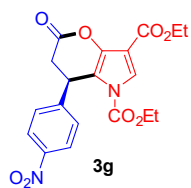




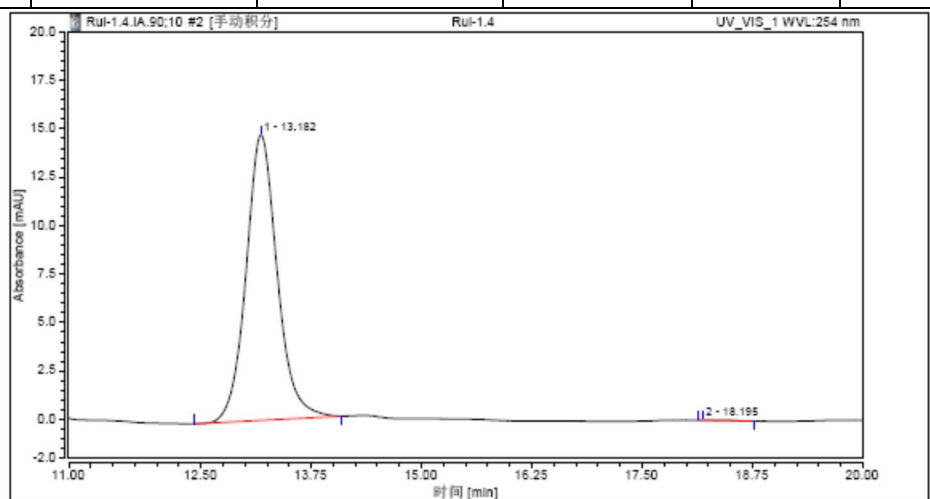
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	14.087	50.717	142.891	49.89	52.54
2	15.922	50.947	129.084	50.11	47.46
Total		101.663	271.976	100.00	100.00



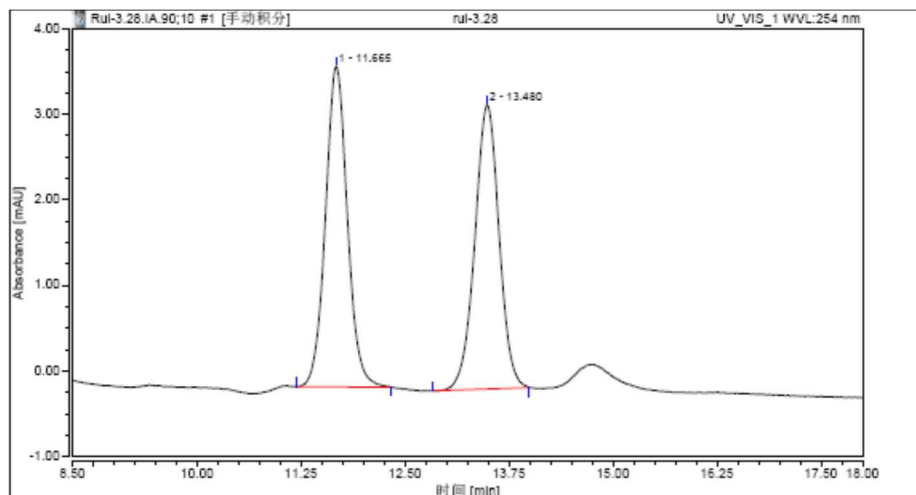
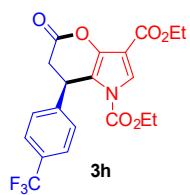
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	13.542	76.274	232.732	97.15	97.18
2	15.378	2.234	5.742	2.85	2.82
Total		78.508	239.474	100.00	100.00



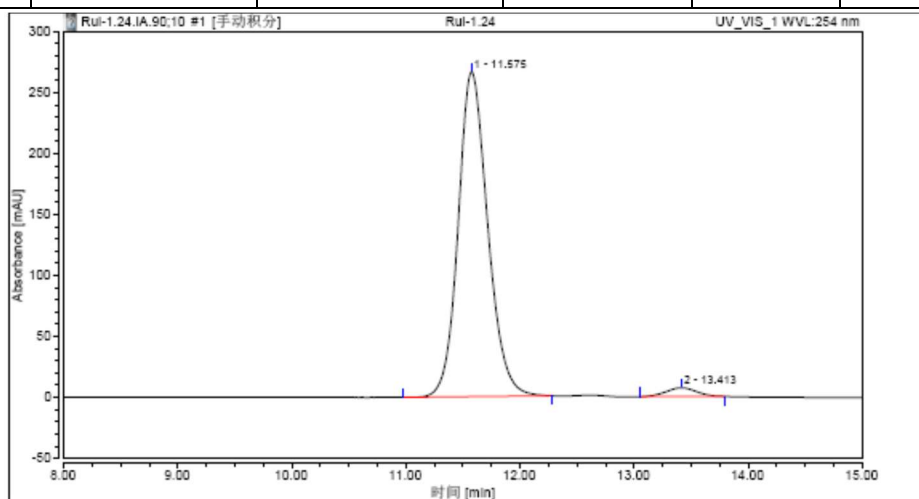
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	15.482	48.671	92.335	50.84	54.22
2	18.350	47.068	77.973	49.16	45.78
Total		95.739	170.307	100.00	100.00



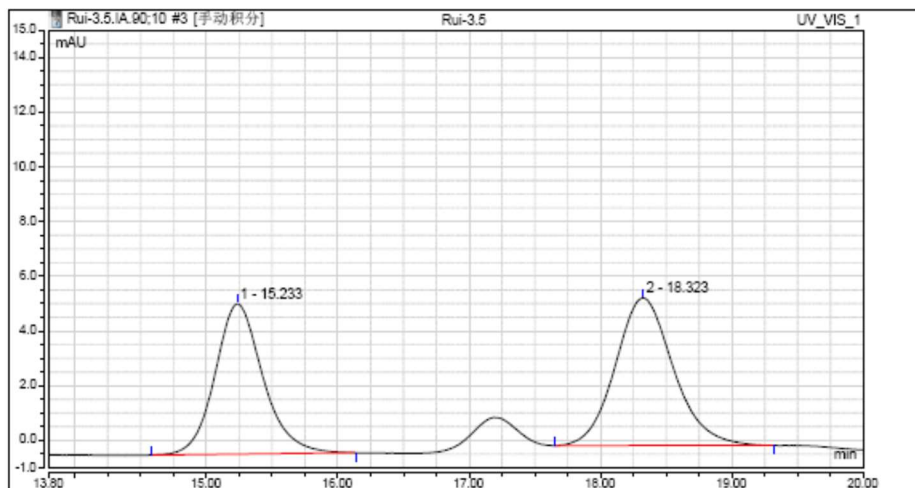
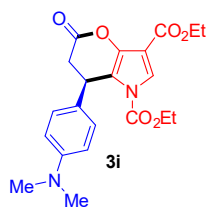
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	13.182	6.033	14.757	99.92	99.94
2	18.195	0.005	0.009	0.08	0.06
Total		6.038	14.766	100.00	100.00



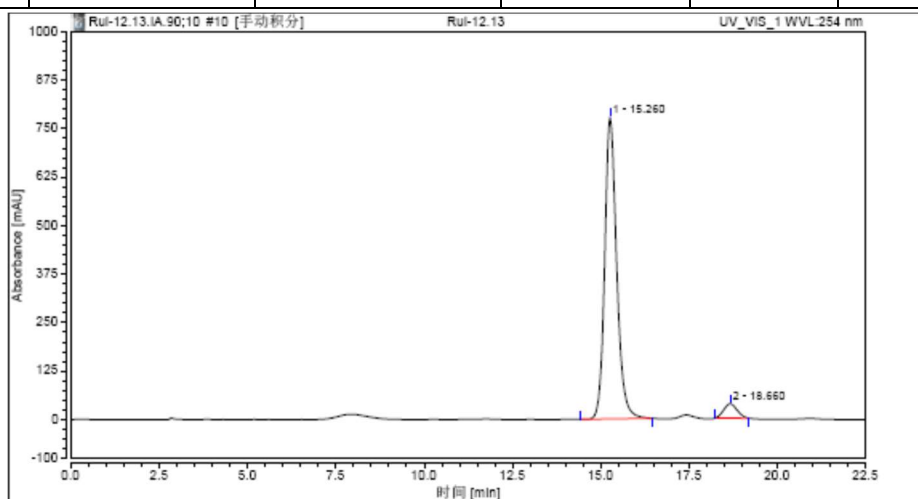
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	11.665	1.145	3.751	50.51	52.98
2	13.480	1.122	3.328	49.49	47.02
Total		2.268	7.079	100.00	100.00



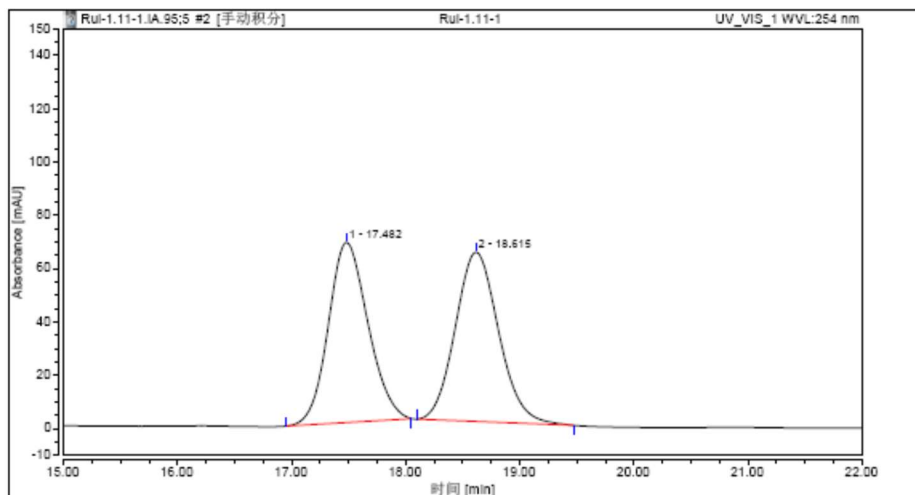
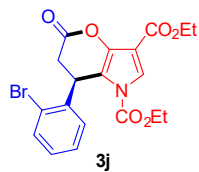
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	11.575	79.987	266.461	97.30	97.40
2	13.413	2.222	7.118	2.70	2.60
Total		82.209	273.579	100.00	100.00



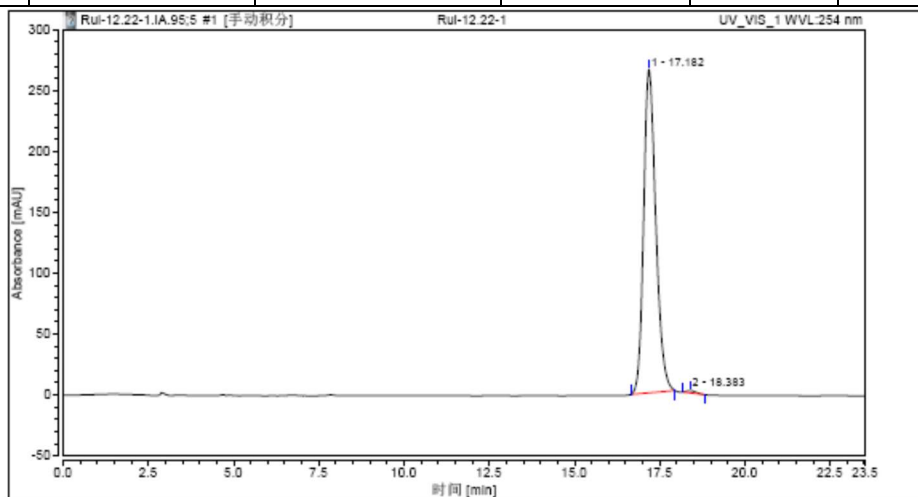
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	15.233	2.321	5.493	45.64	50.44
2	18.323	2.765	5.397	54.36	49.56
Total		5.086	10.890	100.00	100.00



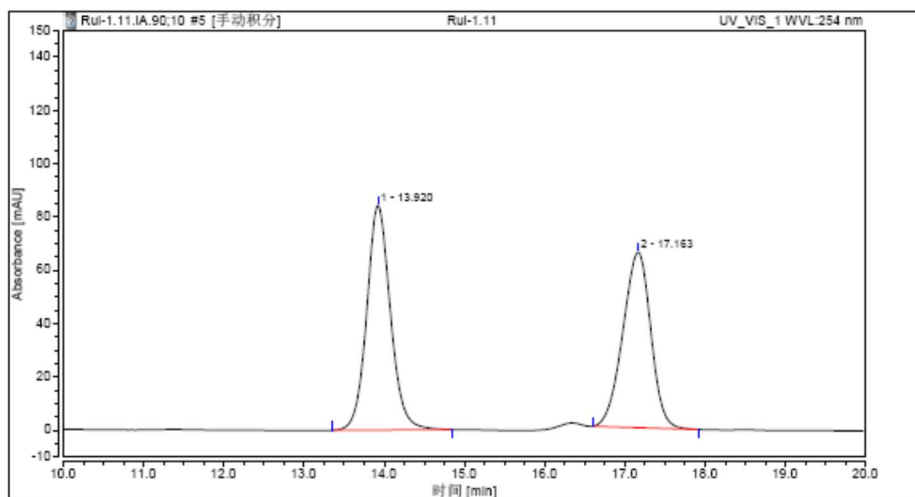
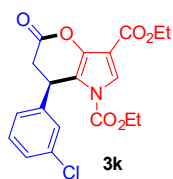
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	15.260	304.683	777.452	94.93	95.45
2	18.660	16.289	37.034	5.07	4.55
Total		320.971	814.486	100.00	100.00



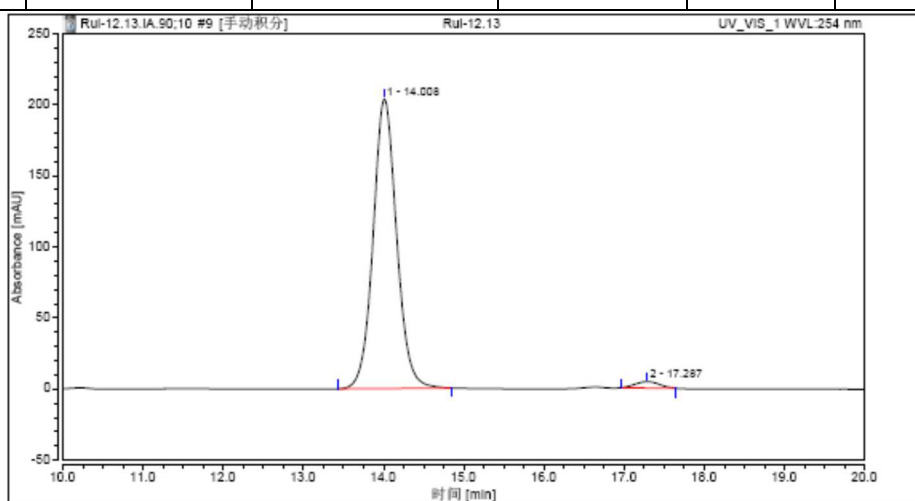
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	17.482	27.211	67.630	49.35	51.56
2	18.615	27.929	63.544	50.65	48.44
Total		55.141	131.174	100.00	100.00



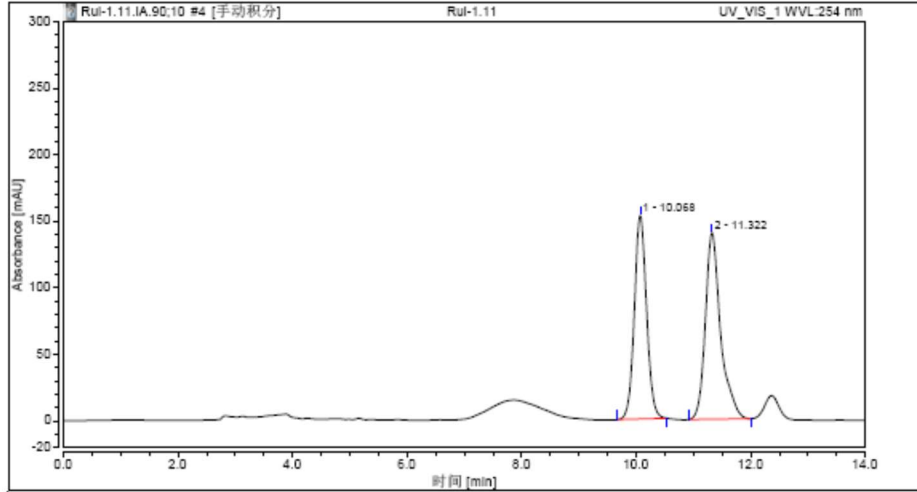
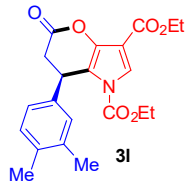
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	17.182	109.881	265.998	99.45	99.32
2	18.383	0.608	1.827	0.55	0.68
Total		110.489	267.824	100.00	100.00



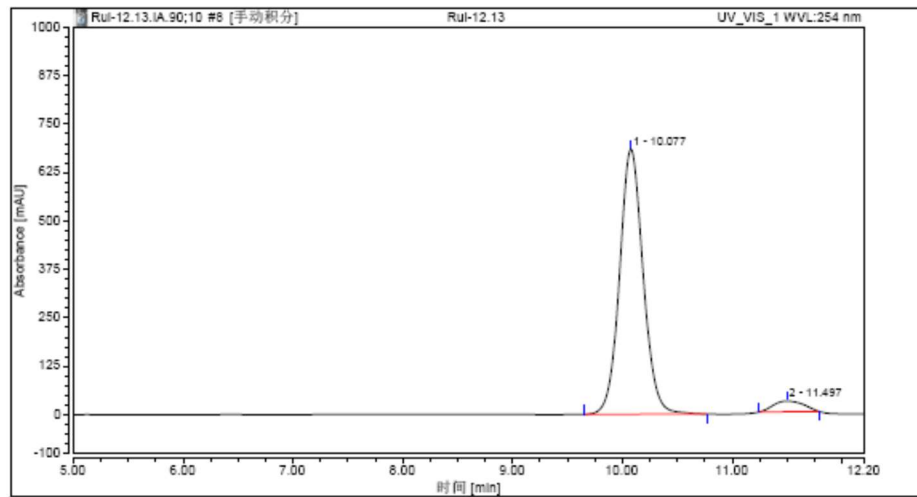
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	13.920	28.810	84.242	52.04	56.14
2	17.163	26.555	65.817	47.96	43.86
Total		55.365	150.059	100.00	100.00



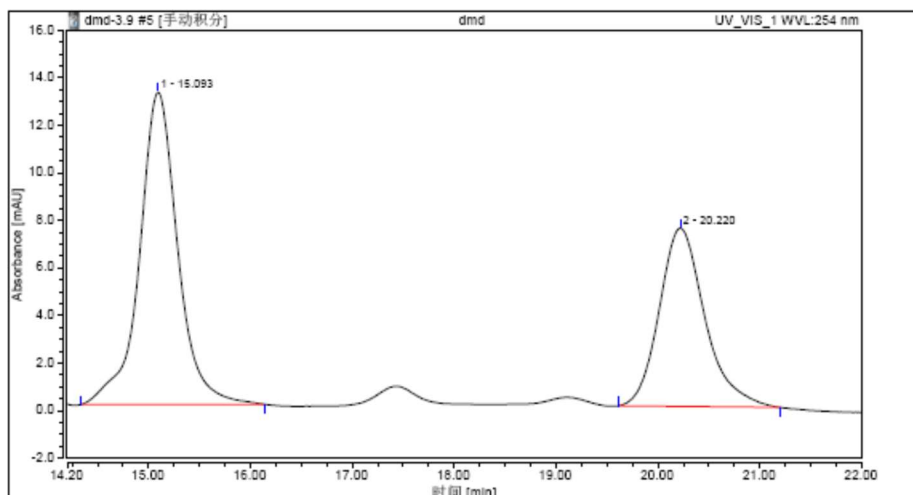
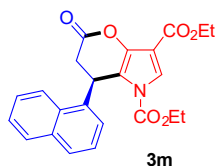
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	14.008	69.105	203.698	97.82	97.85
2	17.287	1.540	4.470	2.18	2.15
Total		70.645	208.168	100.00	100.00



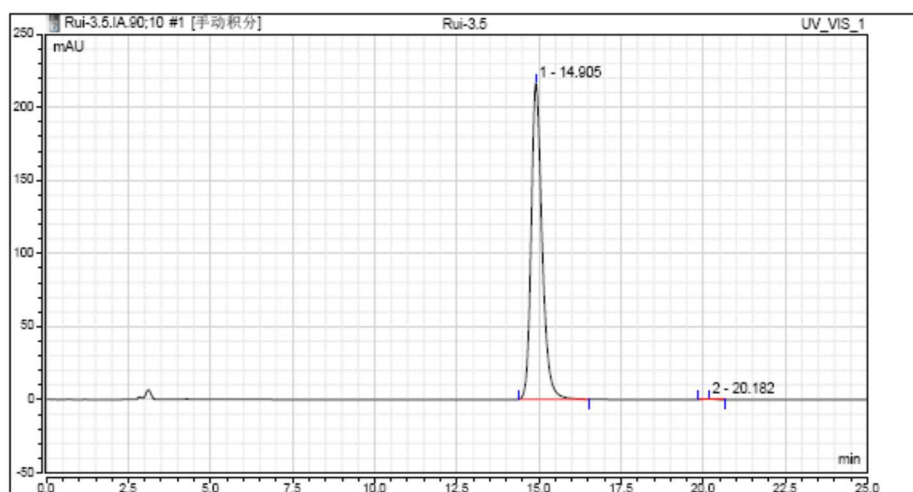
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	10.068	37.681	153.237	46.57	52.22
2	11.322	43.239	140.227	53.43	47.78
Total		80.920	293.464	100.00	100.00



Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	10.077	170.350	685.008	95.05	96.14
2	11.497	8.864	27.477	4.95	3.86
Total		179.214	712.485	100.00	100.00

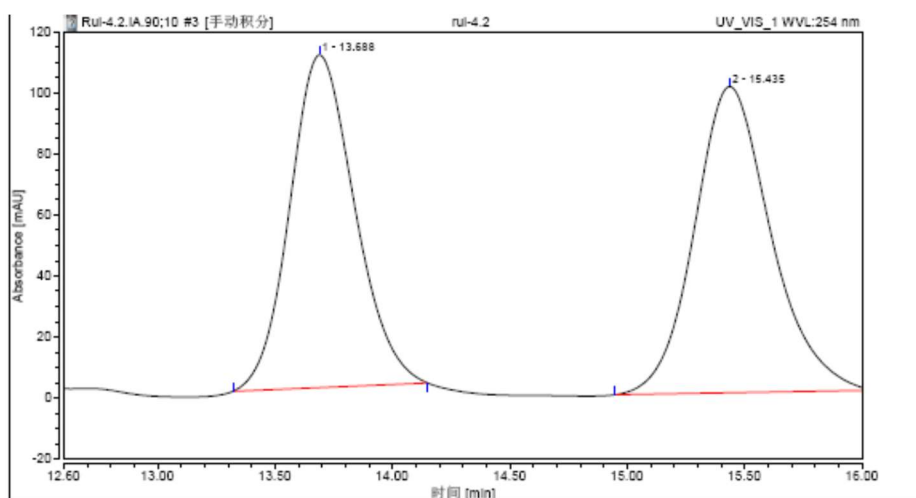
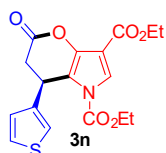


Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	15.093	5.722	13.142	59.51	63.65
2	20.220	3.893	7.506	40.49	36.35
Total		9.615	20.648	100.00	100.00

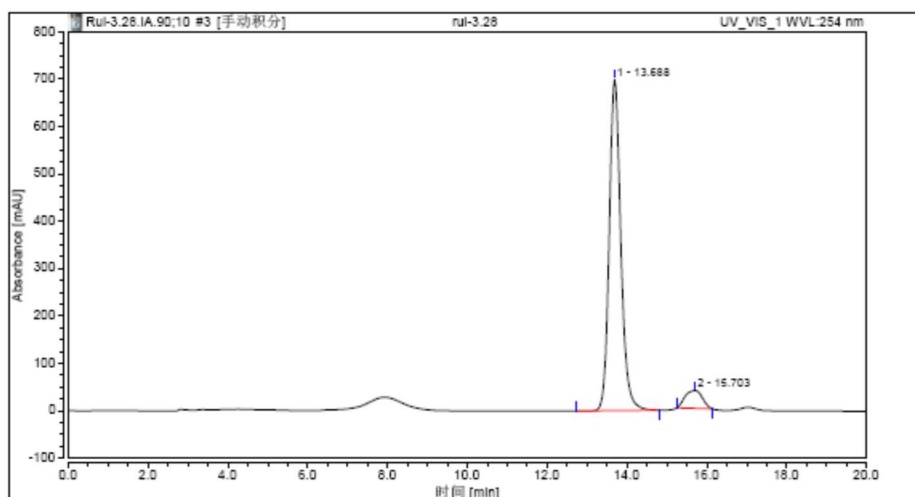


Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	14.905	83.147	216.596	99.70	99.72
2	20.182	0.254	0.604	0.30	0.28
Total		83.401	217.200	100.00	100.00

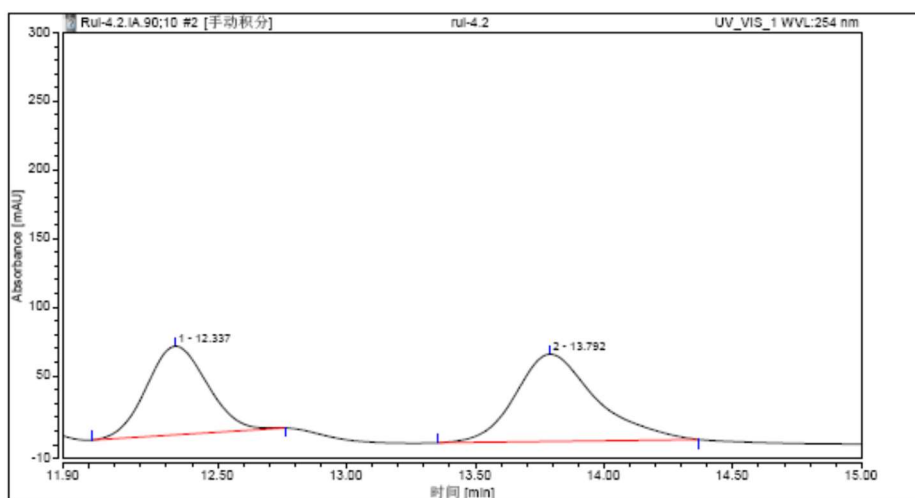
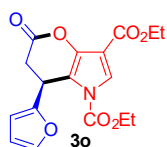




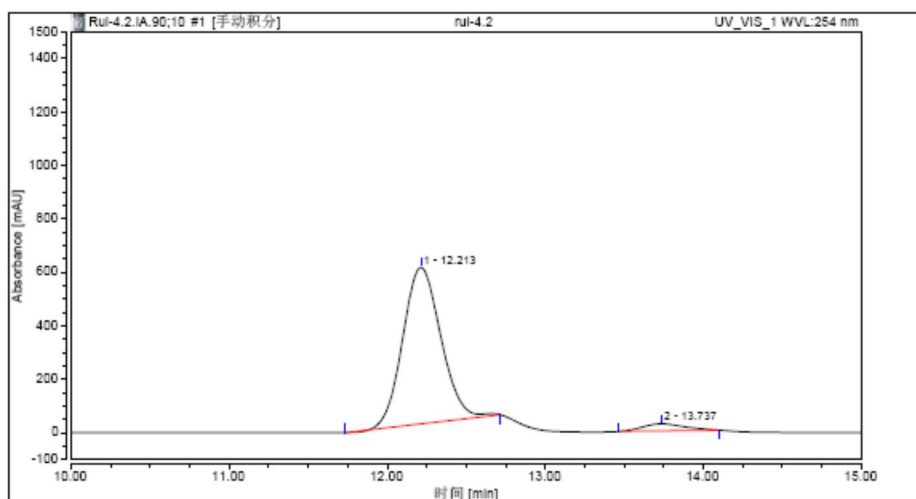
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	13.688	34.912	109.057	47.96	52.07
2	15.435	37.885	100.405	52.04	47.93
Total		72.796	209.462	100.00	100.00



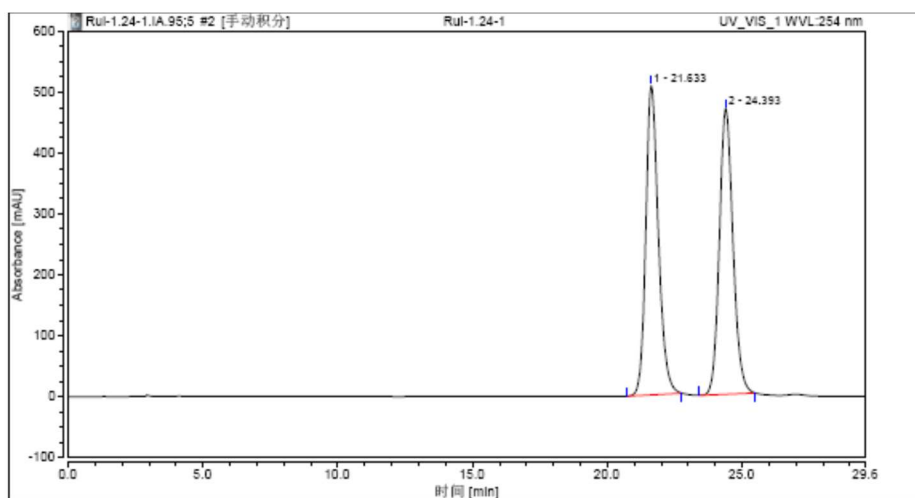
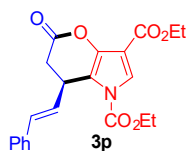
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	13.688	234.651	699.088	92.61	94.88
2	15.703	18.726	37.715	7.39	5.12
Total		253.377	736.803	100.00	100.00



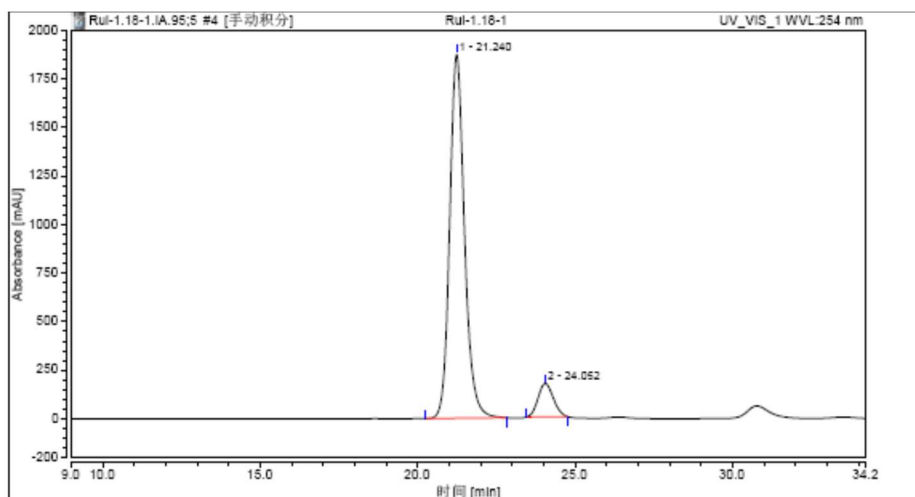
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	12.337	17.570	64.474	43.43	50.41
2	13.792	22.887	63.634	56.57	49.59
Total		40.457	127.908	100.00	100.00



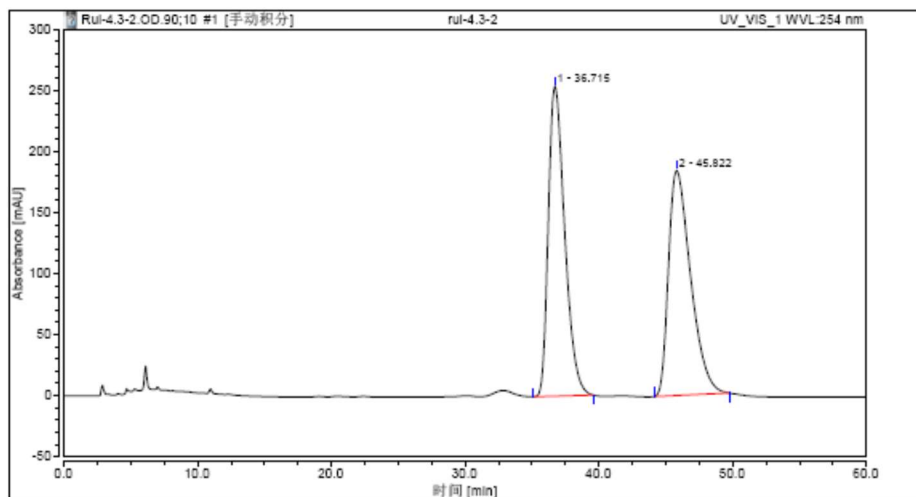
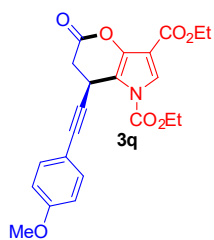
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	12.213	163.528	585.775	95.23	95.70
2	13.737	8.187	26.334	4.77	4.30
Total		171.714	612.109	100.00	100.00



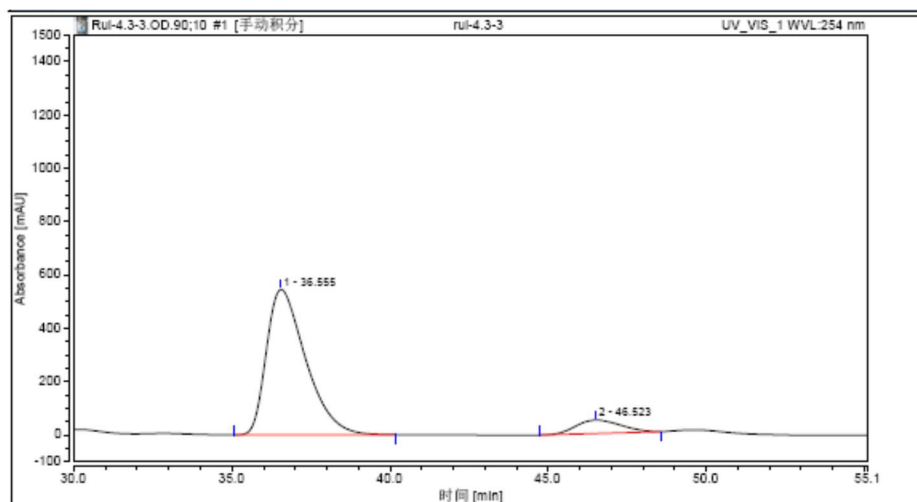
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	21.633	275.333	508.943	50.07	52.00
2	24.393	274.565	469.791	49.93	48.00
Total		549.898	978.734	100.00	100.00



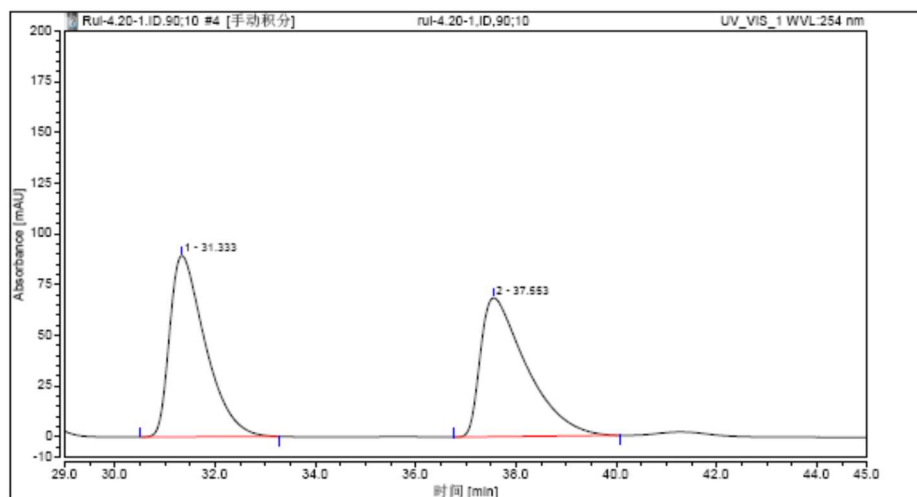
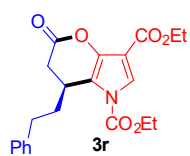
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	21.240	1019.536	1875.520	91.29	91.55
2	24.052	97.308	173.017	8.71	8.45
Total		1116.844	2048.536	100.00	100.00



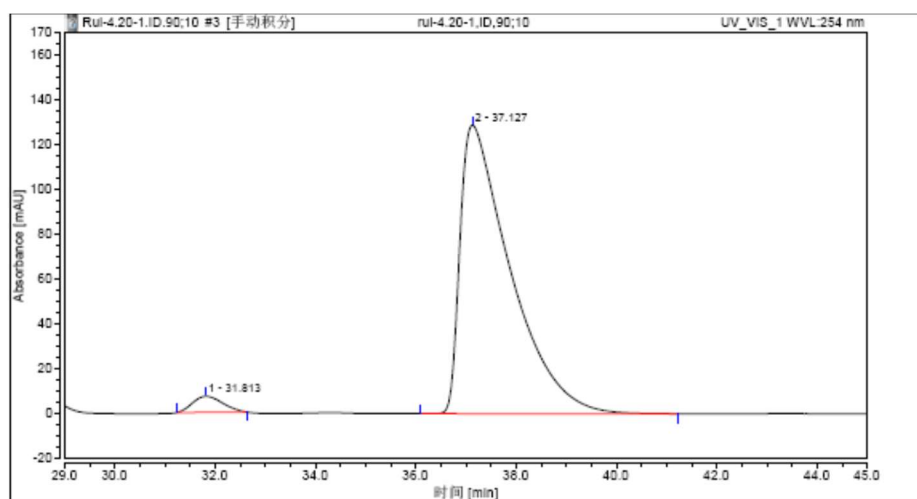
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	36.715	360.488	254.355	50.57	57.97
2	45.822	352.354	184.413	49.43	42.03
Total		712.842	438.768	100.00	100.00



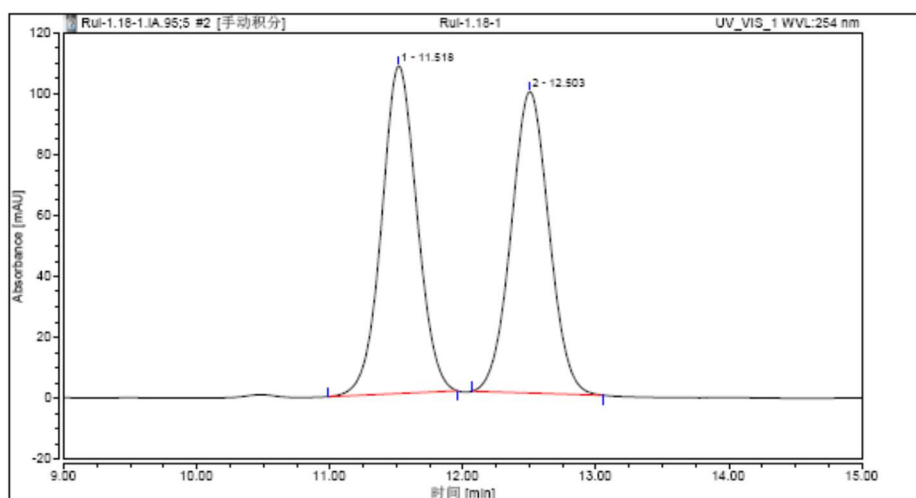
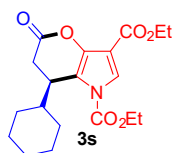
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	36.555	785.543	454.677	90.60	91.62
2	46.523	81.532	49.913	9.40	8.38
Total		867.075	595.590	100.00	100.00



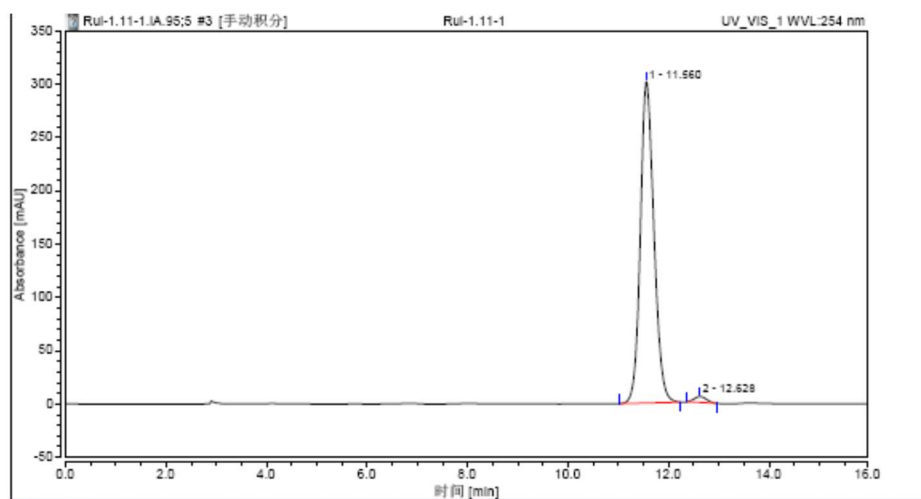
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	31.333	73.409	89.304	50.27	56.62
2	37.553	72.621	68.409	49.73	43.38
Total		146.030	157.713	100.00	100.00



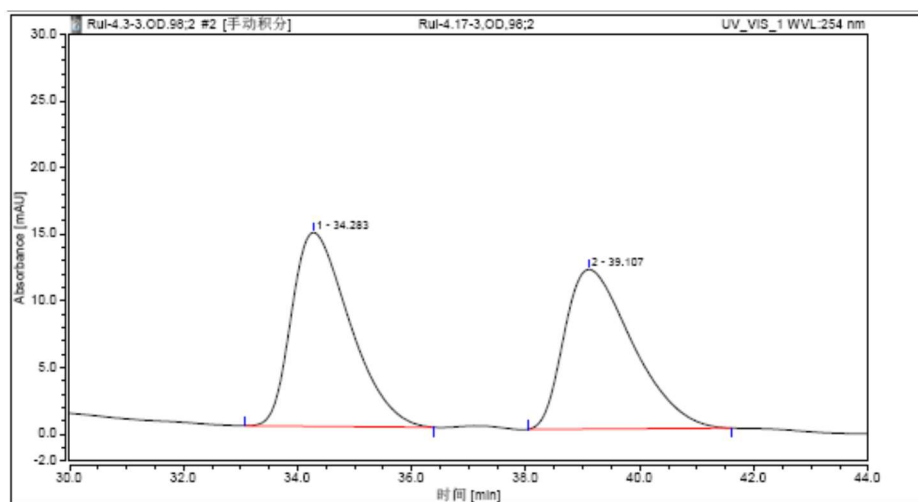
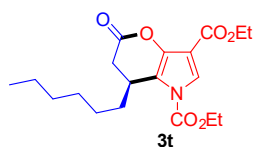
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	31.813	4.964	7.169	3.23	5.28
2	37.127	148.750	128.661	96.77	94.72
Total		153.714	135.830	100.00	100.00



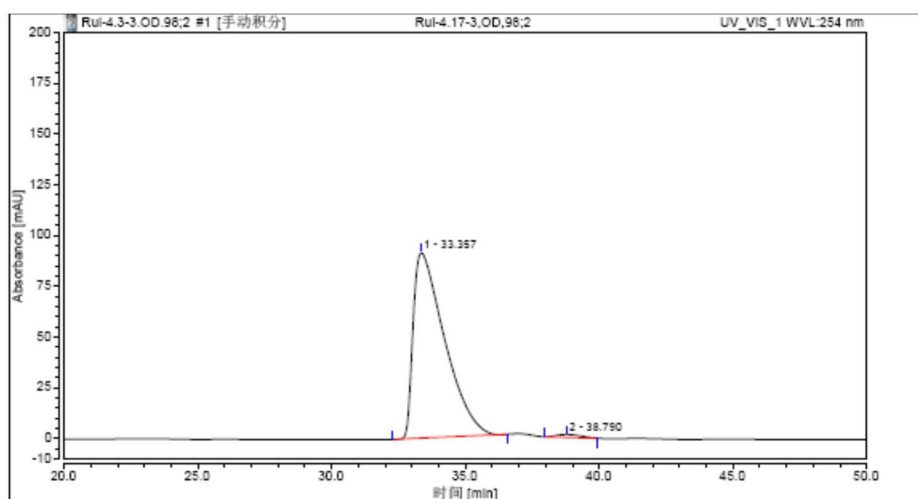
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	11.518	33.206	107.684	50.41	52.08
2	12.503	32.661	99.070	49.59	47.92
Total		65.867	206.755	100.00	100.00



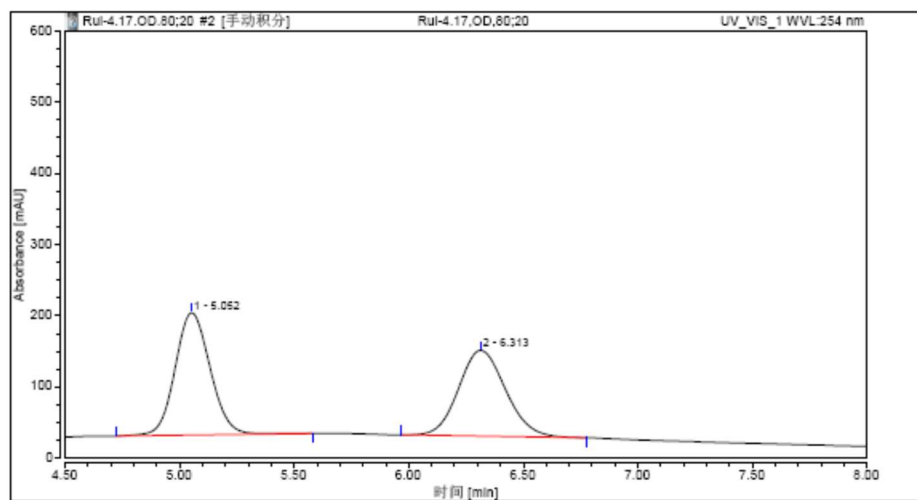
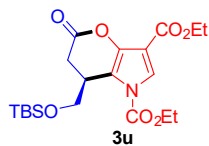
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	11.560	94.186	301.554	98.38	98.20
2	12.628	1.552	5.522	1.62	1.82
Total		95.738	307.076	100.00	100.00



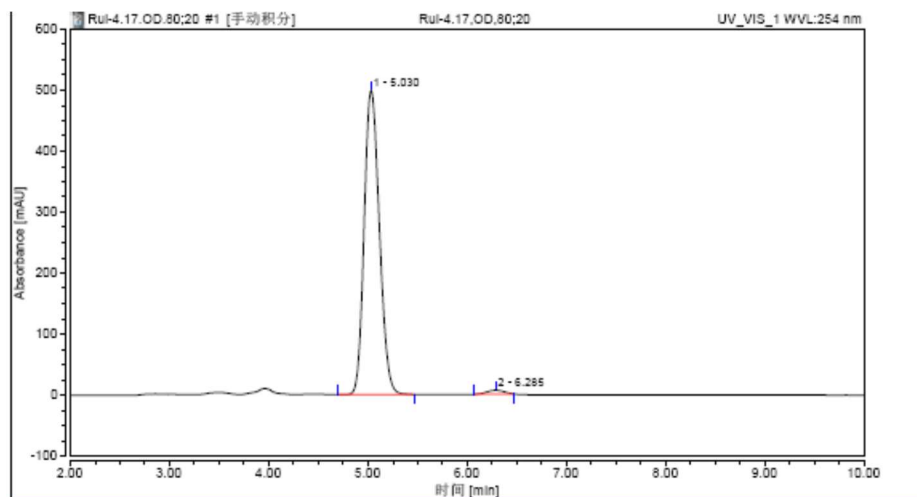
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	34.283	17.182	14.537	50.91	54.85
2	39.107	16.567	11.968	49.09	45.15
Total		33.750	26.505	100.00	100.00



Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	33.357	123.956	91.215	98.80	98.46
2	38.790	1.509	1.429	1.20	1.54
Total		125.466	92.644	100.00	100.00

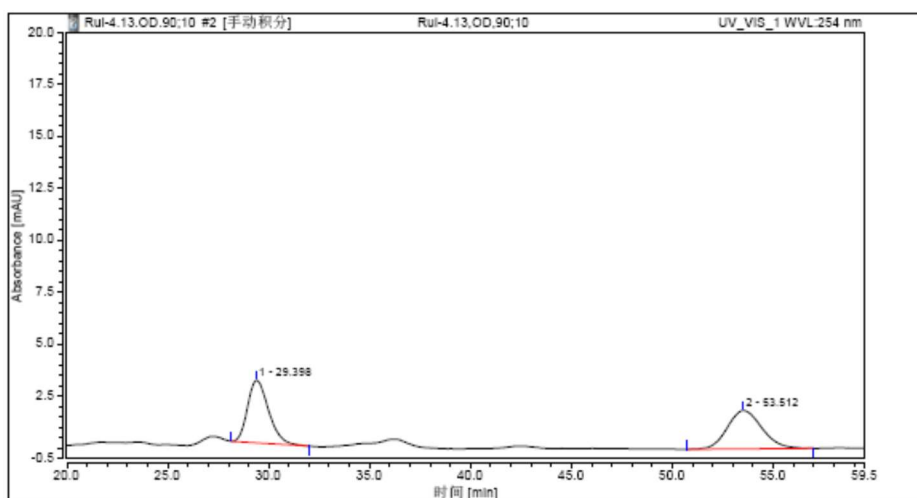
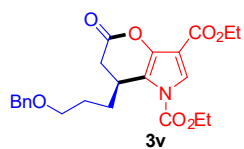


Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	5.052	30.552	171.800	51.57	58.77
2	6.313	28.689	120.526	48.43	41.23
Total		59.240	292.326	100.00	100.00

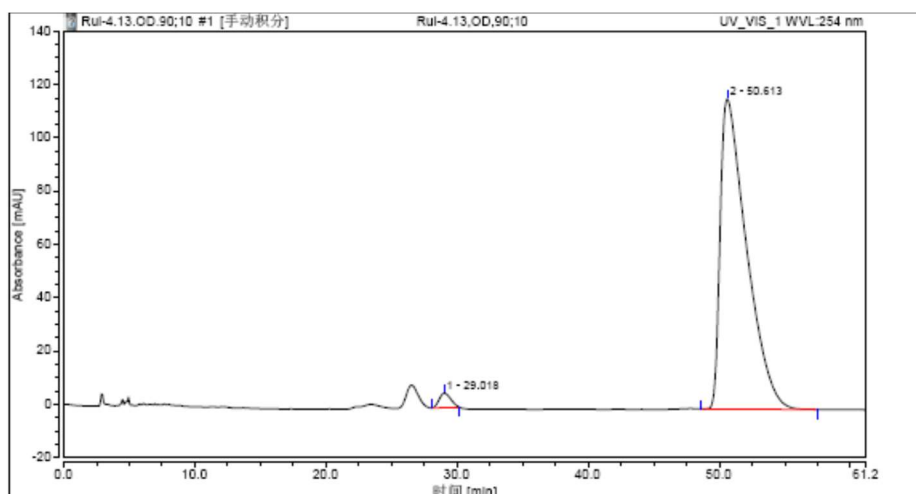


Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	5.030	88.323	499.293	98.65	98.72
2	6.285	1.300	6.476	1.45	1.28
Total		89.623	505.769	100.00	100.00

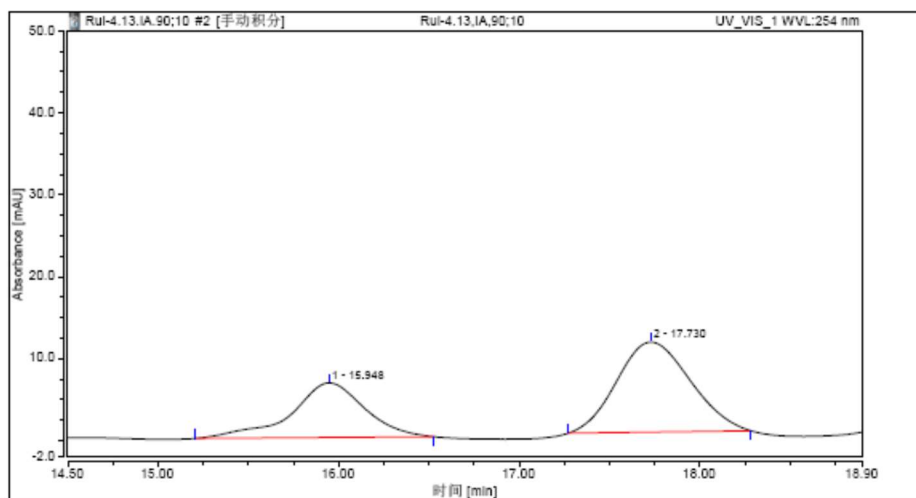
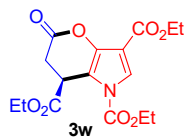




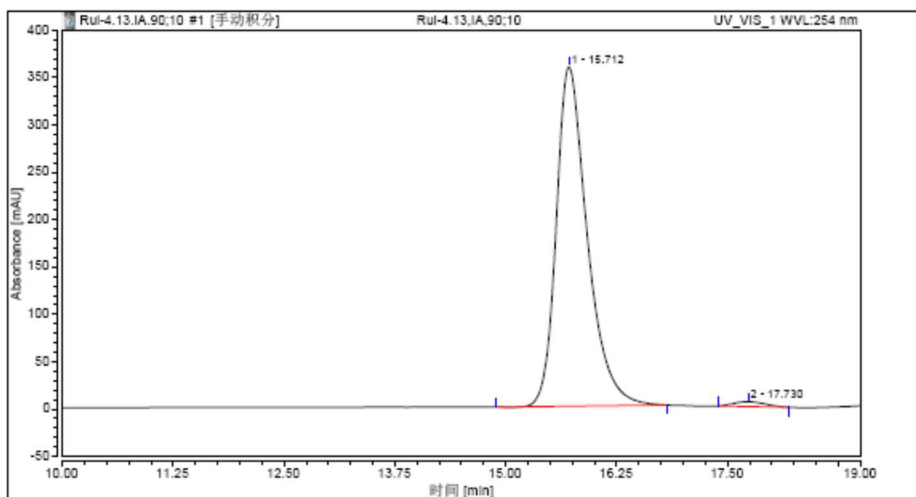
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	29.398	3.626	3.014	49.56	61.92
2	53.512	3.691	1.854	50.44	38.08
Total		7.317	4.868	10.00	100.00



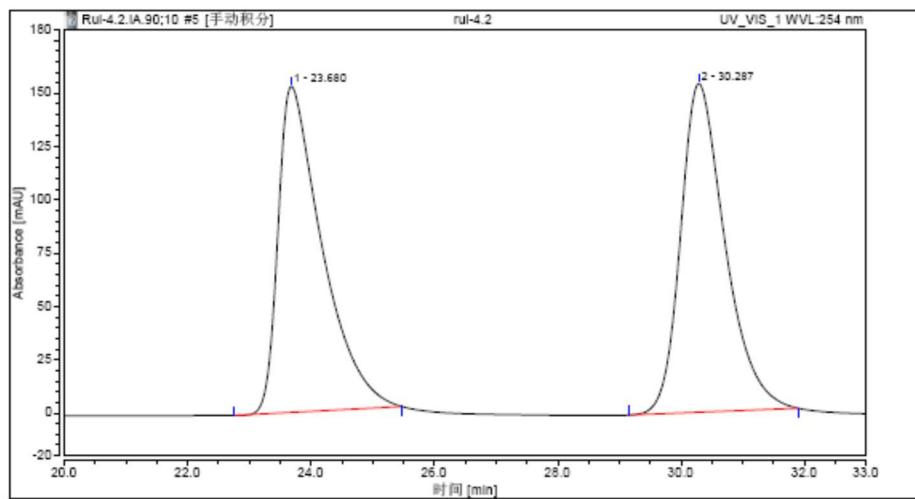
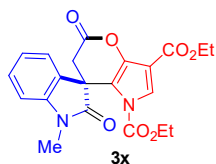
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	29.018	5.565	5.432	2.01	4.45
2	50.613	271.016	116.504	97.99	95.55
Total		276.581	121.936	100.00	100.00



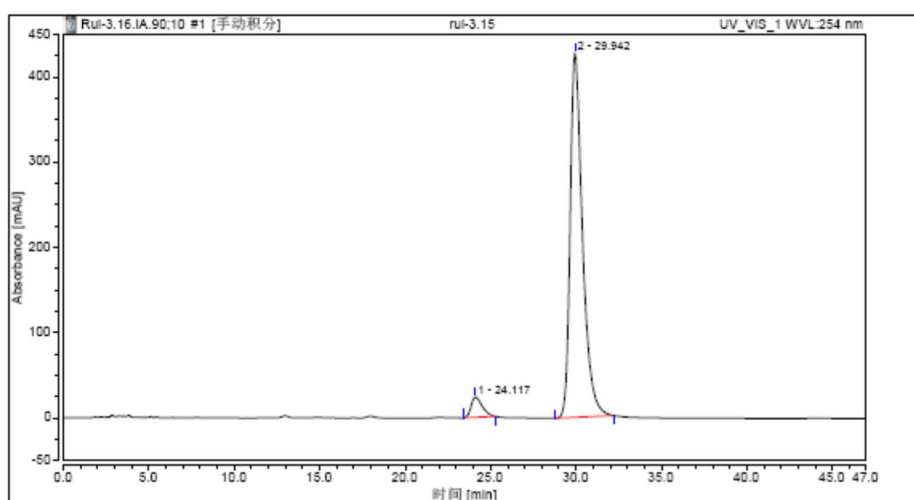
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	15.948	3.140	6.668	37.71	37.76
2	17.730	5.187	10.993	62.29	62.24
Total		8.326	17.661	100.00	100.00



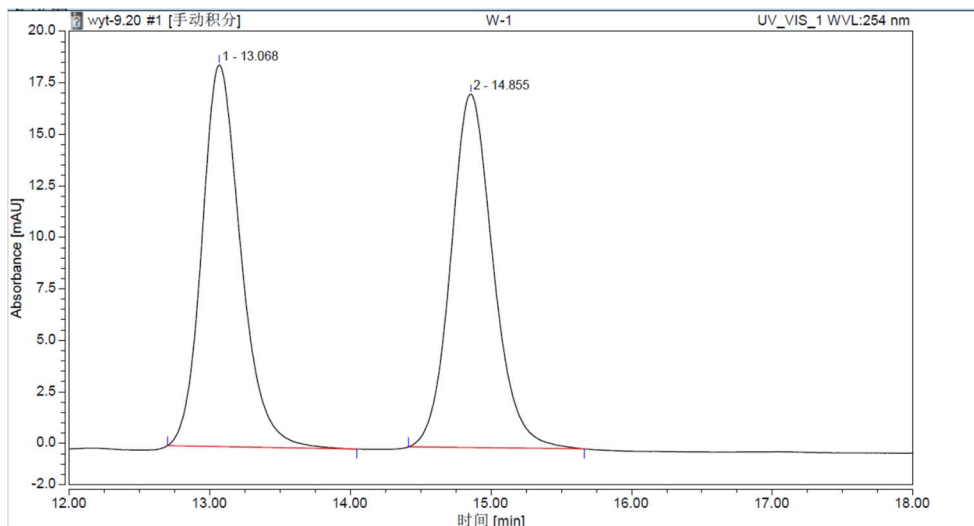
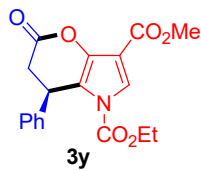
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	15.712	145.383	358.422	98.59	98.58
2	17.730	2.072	5.150	1.41	1.42
Total		147.455	363.572	100.00	100.00



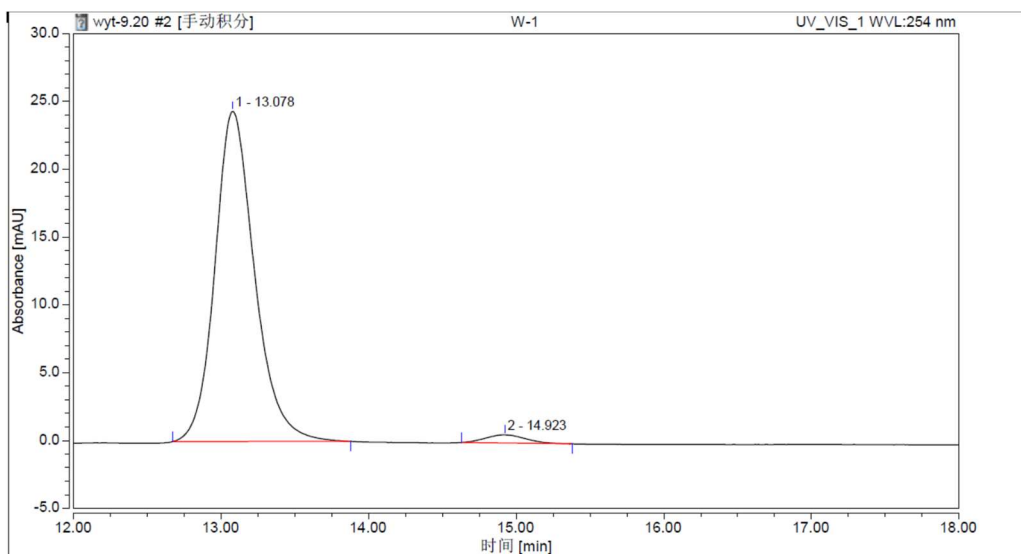
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	23.680	126.488	153.053	49.53	49.80
2	30.287	128.875	154.307	50.47	50.20
Total		255.363	307.360	100.00	100.00



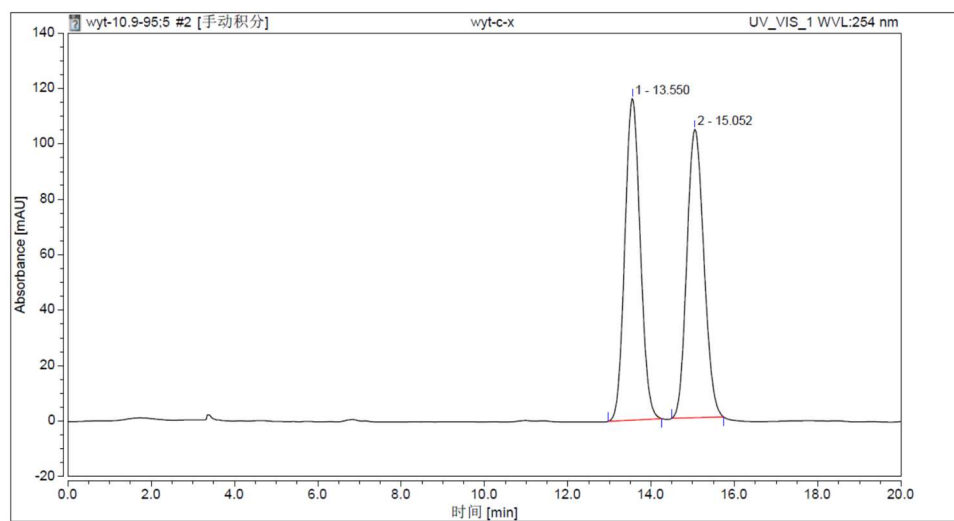
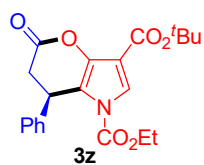
Peak	Ret. Time (min)	Area (mAu*min)	Height (mAu)	Area (%)	Height (%)
1	24.117	17.802	23.734	4.75	5.26
2	29.942	356.888	427.555	95.25	94.74
Total		374.691	451.289	100.00	100.00



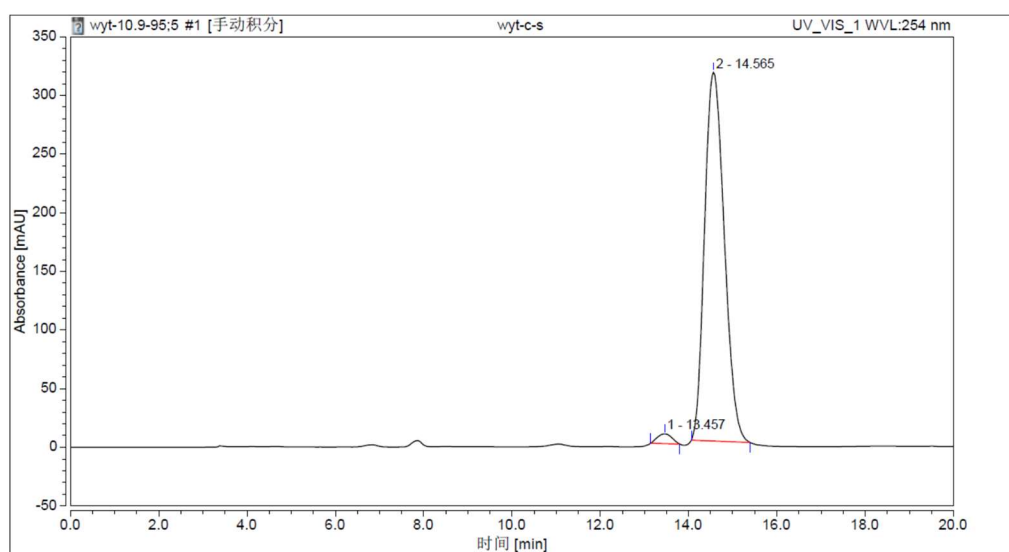
Peak#	Ret. Time (min)	Area (mAU)	Height (mAU)	Area %	Height %
1	13.068	5.945	18.536	49.83	51.92
2	14.855	5.986	17.167	50.17	48.08
Total		<b>11.931</b>	<b>35.703</b>	100.00	100.00



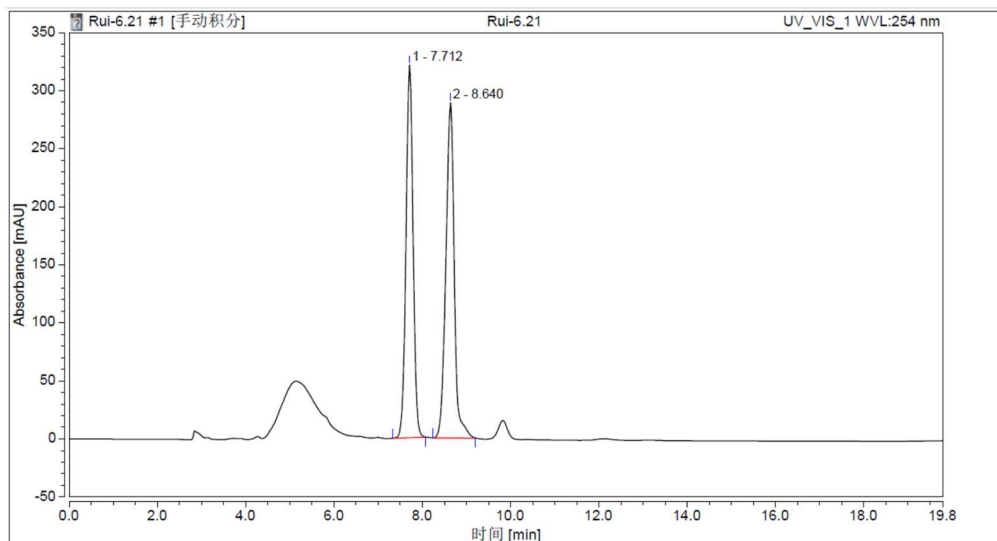
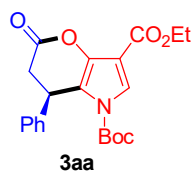
Peak#	Ret. Time (min)	Area (mAU)	Height (mAU)	Area %	Height %
1	13.078	7.588	24.351	97.61	97.56
2	14.923	0.186	0.609	2.39	2.44
Total		<b>7.773</b>	<b>24.960</b>	100.00	100.00



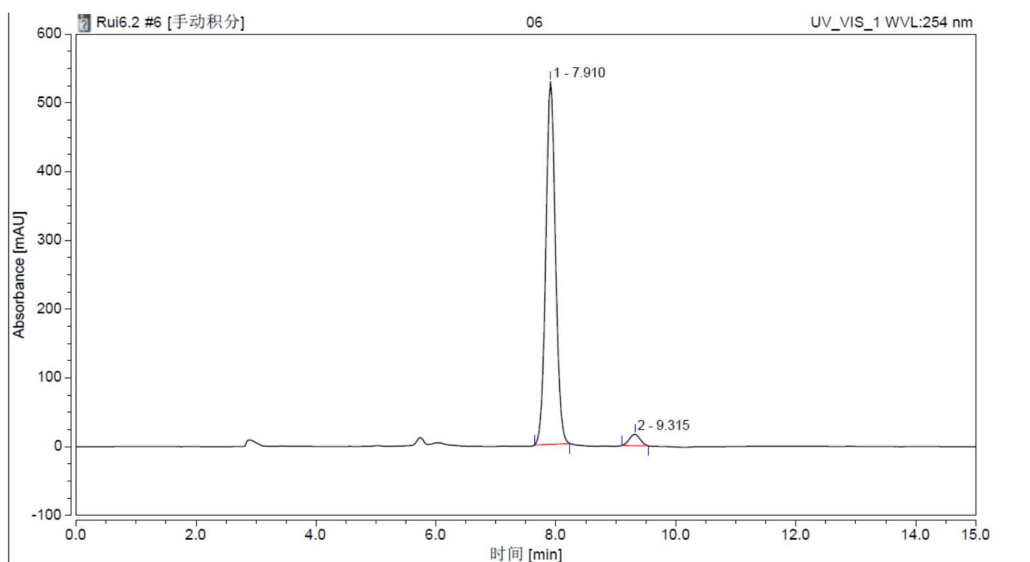
Peak#	Ret. Time (min)	Area (mAU)	Height (mAU)	Area %	Height %
1	13.550	49.859	116.152	50.38	52.73
2	15.052	49.105	104.110	49.62	47.27
Total		<b>98.964</b>	<b>220.262</b>	100.00	100.00



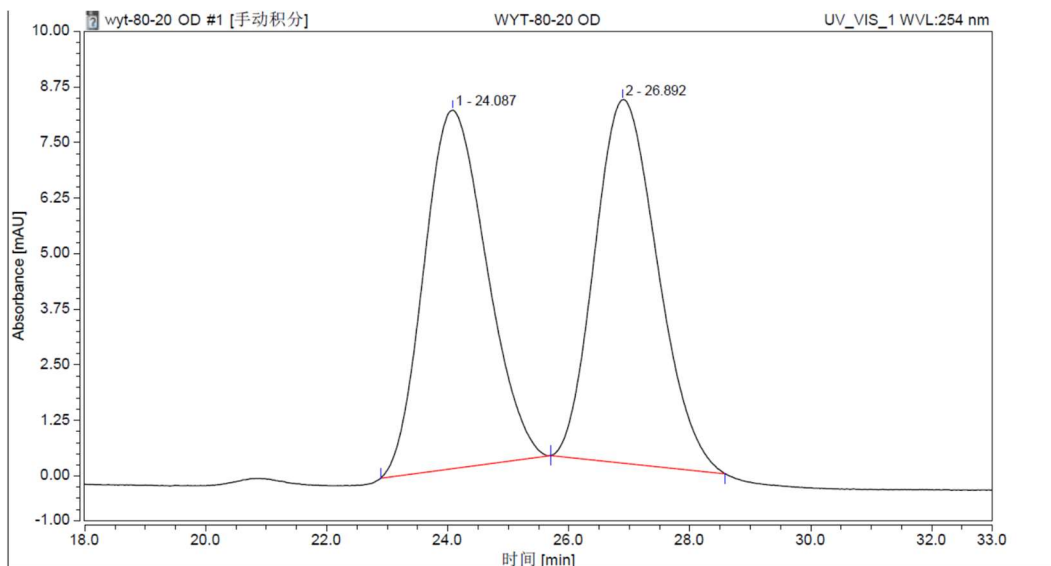
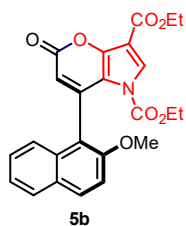
Peak#	Ret. Time (min)	Area (mAU)	Height (mAU)	Area %	Height %
1	13.457	3.230	8.451	1.95	2.62
2	14.565	162.228	314.475	98.05	97.38
Total		<b>165.457</b>	<b>322.927</b>	100.00	100.00



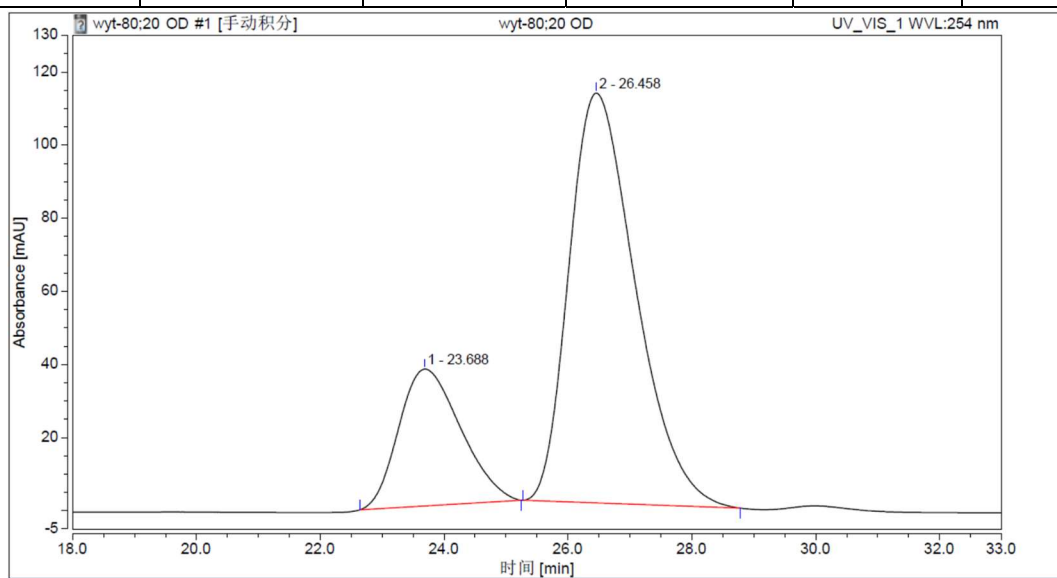
Peak#	Ret. Time (min)	Area (mAU)	Height (mAU)	Area %	Height %
1	7.712	59.658	320.981	48.49	52.64
2	8.640	63.379	288.839	51.51	47.36
<b>Total</b>		<b>123.037</b>	<b>609.820</b>	<b>100.00</b>	<b>100.00</b>



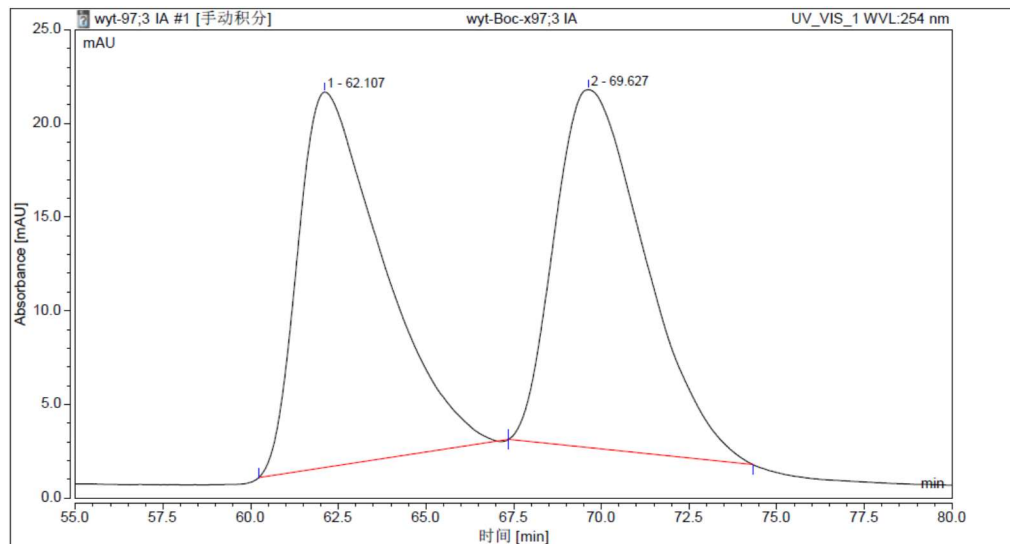
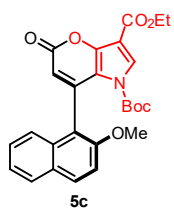
Peak#	Ret. Time (min)	Area (mAU)	Height (mAU)	Area %	Height %
1	7.910	98.411	527.786	96.64	96.97
2	9.315	3.423	16.471	3.36	3.03
<b>Total</b>		<b>101.833</b>	<b>544.257</b>	<b>100.00</b>	<b>100.00</b>



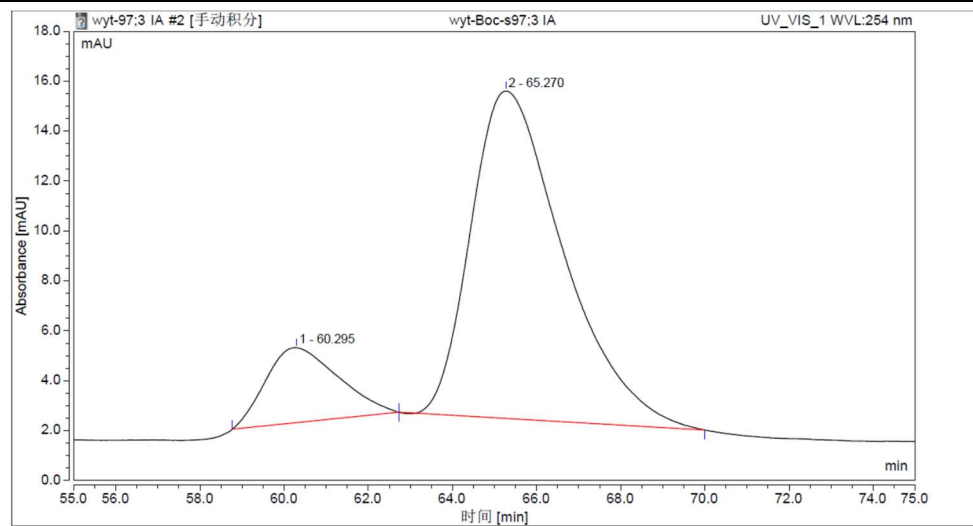
Peak#	Ret. Time (min)	Area (mAU)	Height (mAU)	Area %	Height %
1	24.087	9.666	8.064	49.52	49.63
2	26.892	9.853	8.183	50.48	50.37
<b>Total</b>		<b>19.519</b>	<b>16.246</b>	<b>100.00</b>	<b>100.00</b>



Peak#	Ret. Time (min)	Area (mAU)	Height (mAU)	Area %	Height %
1	23.688	43.228	37.444	23.67	25.03
2	26.458	139.391	112.141	76.33	74.97
<b>Total</b>		<b>182.619</b>	<b>149.586</b>	<b>100.00</b>	<b>100.00</b>



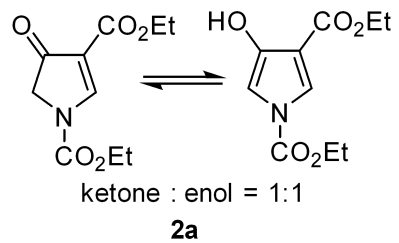
Peak#	Ret. Time (min)	Area (mAU)	Height (mAU)	Area %	Height %
1	62.107	56.286	20.043	49.52	51.21
2	69.627	57.378	19.099	50.48	48.79
Total		<b>113.665</b>	<b>39.142</b>	100.00	100.00



Peak#	Ret. Time (min)	Area (mAU)	Height (mAU)	Area %	Height %
1	60.295	5.981	3.007	15.15	18.64
2	65.270	33.496	13.127	84.85	81.36
Total		<b>39.476</b>	<b>16.134</b>	100.00	100.00

**Part 5:**  $^1\text{H}$ NMR and  $^{13}\text{C}$ NMR spectra

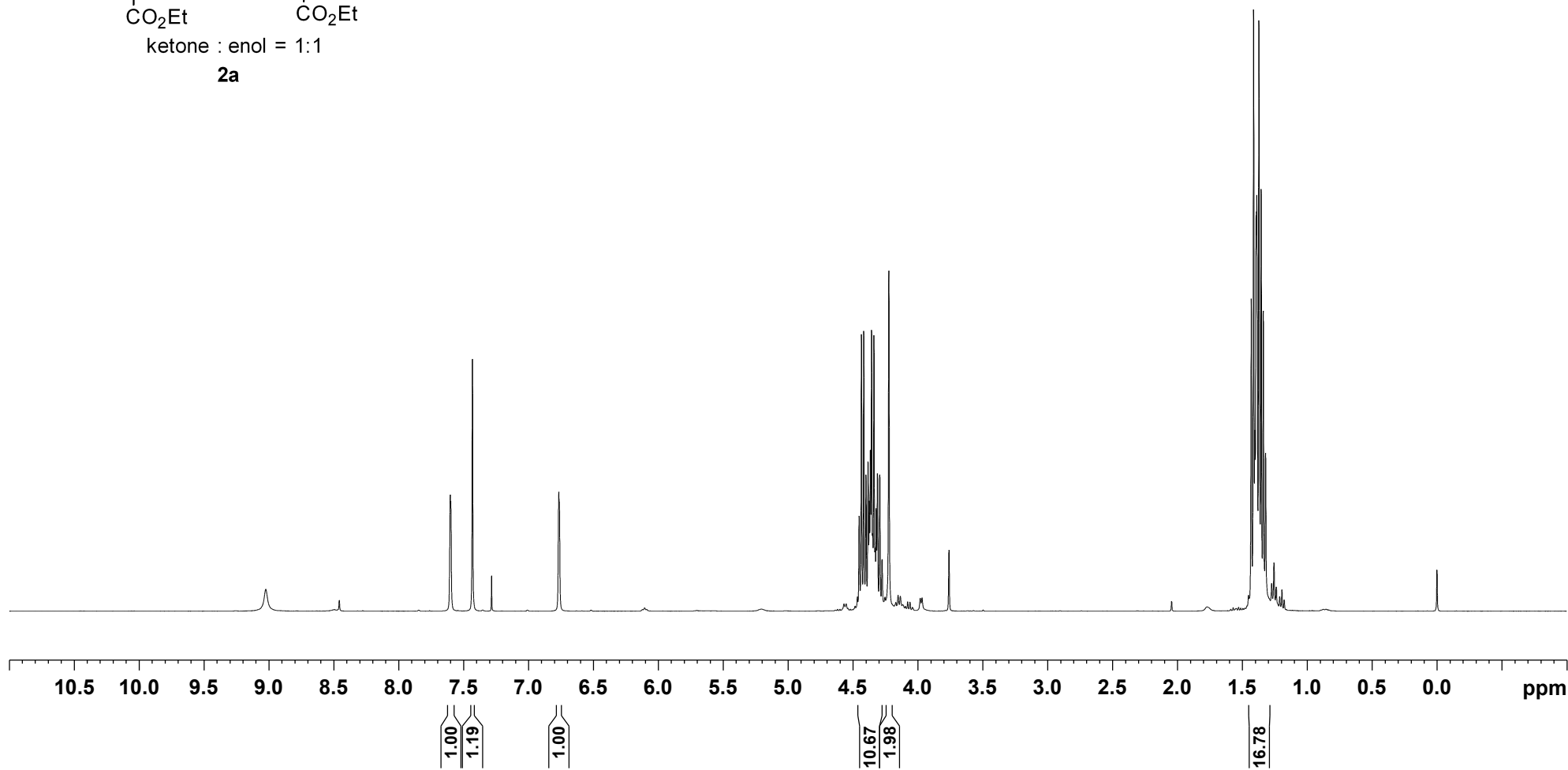




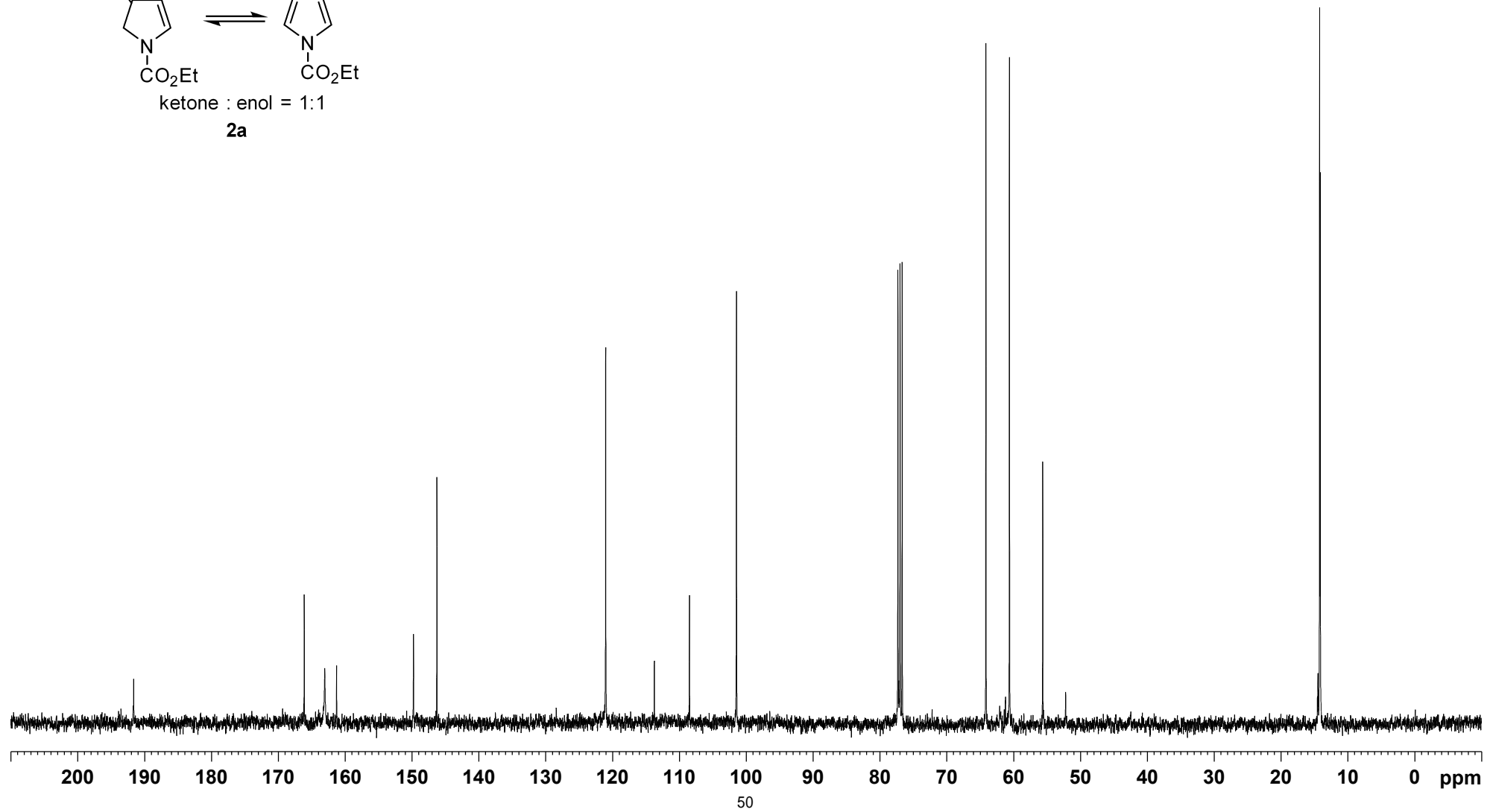
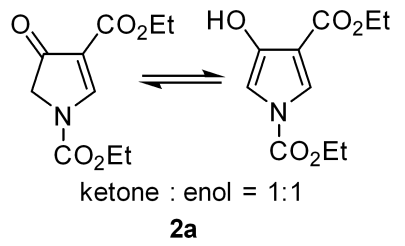
7.602  
 7.599  
 7.432  
 7.284  
 — 6.766

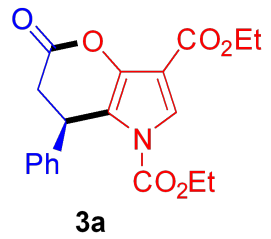
4.452  
 4.435  
 4.417  
 4.399  
 4.384  
 4.374  
 4.372  
 4.366  
 4.356  
 4.348  
 4.339  
 4.321  
 4.311  
 4.293  
 4.223

1.431  
 1.413  
 1.403  
 1.393  
 1.390  
 1.388  
 1.372  
 1.370  
 1.354  
 1.338  
 1.320  
 — 0.000



191.65  
 166.14  
 163.08  
 161.29  
 149.80  
 146.29  
 121.04  
 113.76  
 108.50  
 101.47  
 77.32  
 77.00  
 76.68  
 64.16  
 60.64  
 55.65  
 14.21  
 14.13



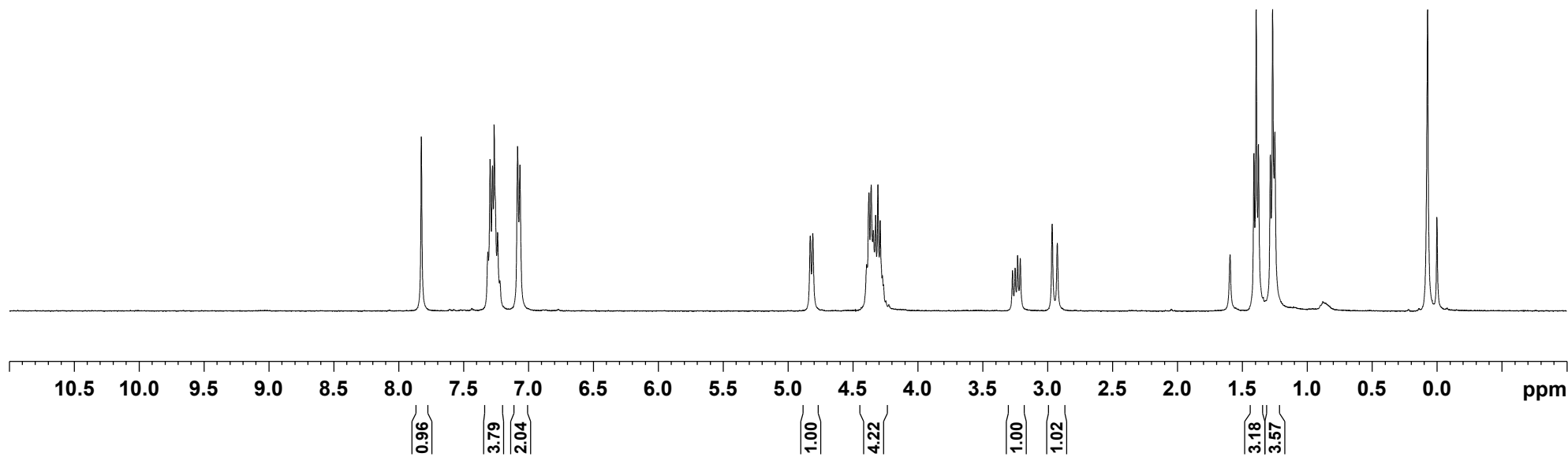


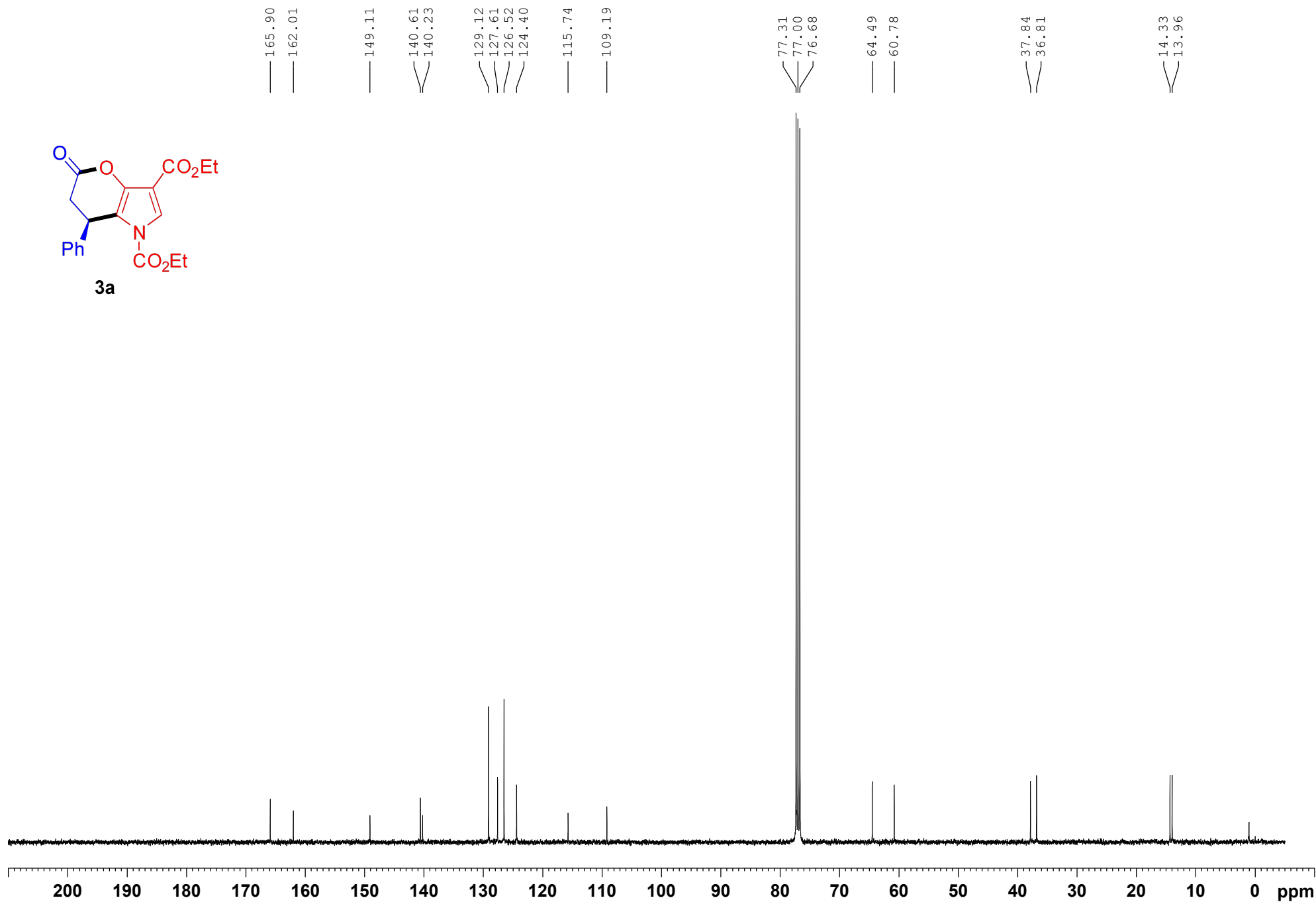
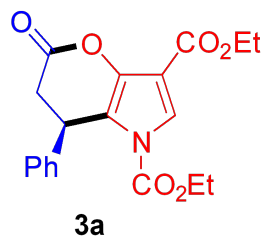
7.824  
7.312  
7.294  
7.276  
7.263  
7.237  
7.219  
7.082  
7.064

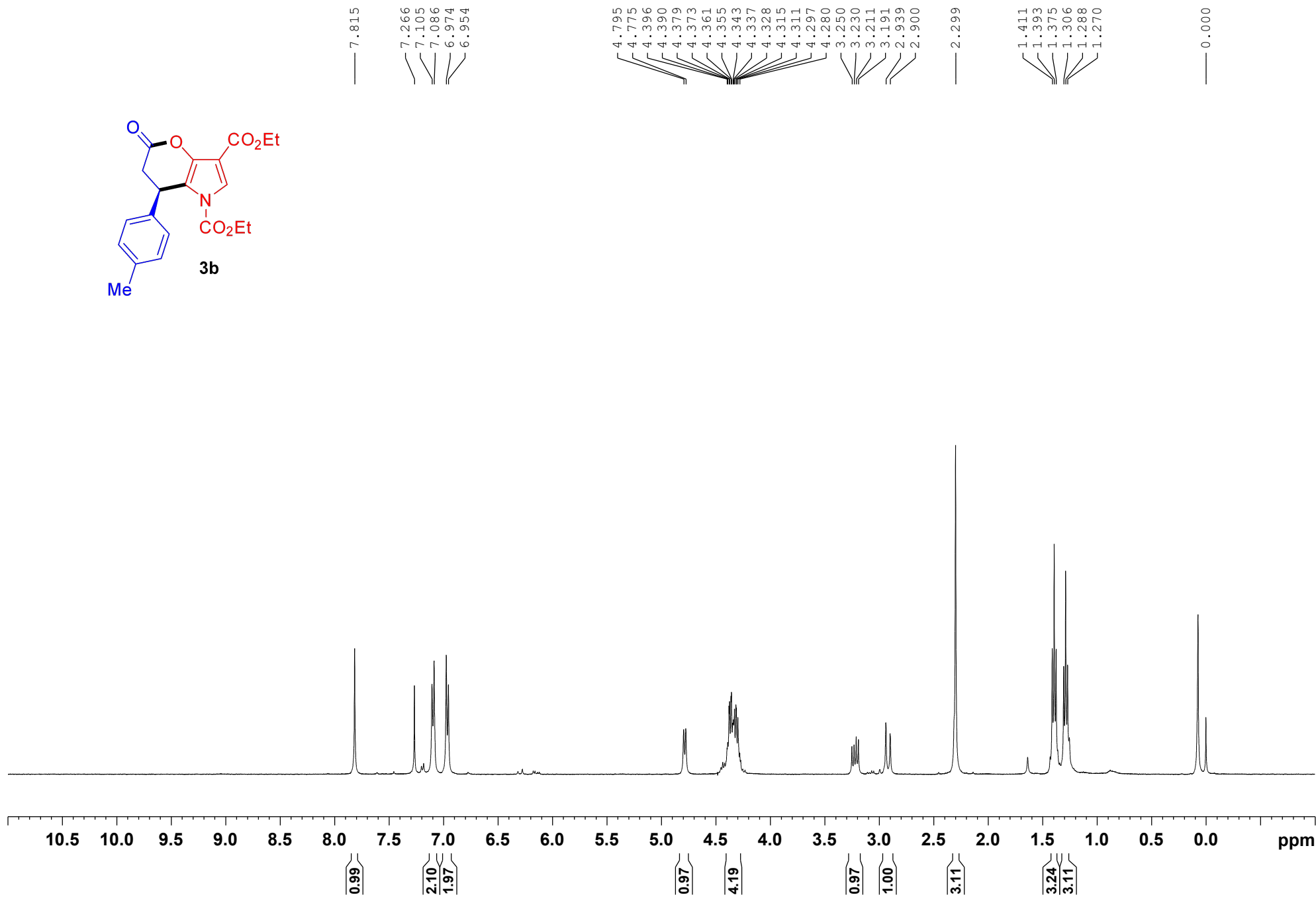
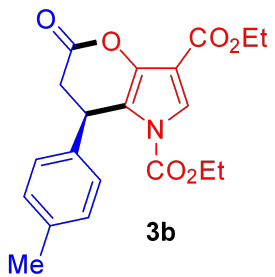
4.827  
4.808  
4.393  
4.376  
4.358  
4.342  
4.324  
4.306  
4.289  
4.272  
4.263  
3.270  
3.249  
3.230  
3.210  
2.964  
2.924

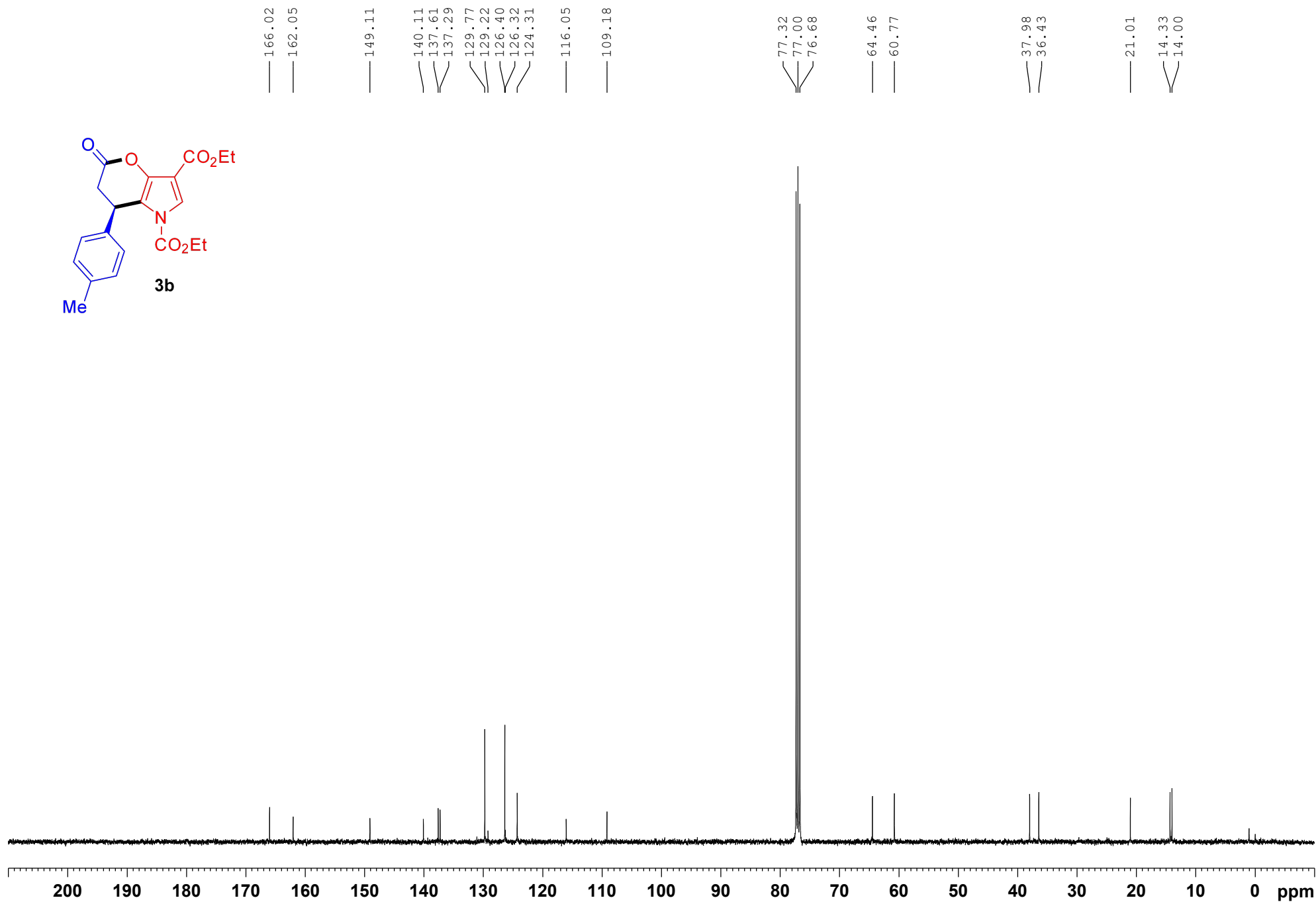
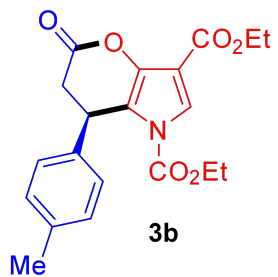
1.410  
1.392  
1.375  
1.283  
1.266  
1.248

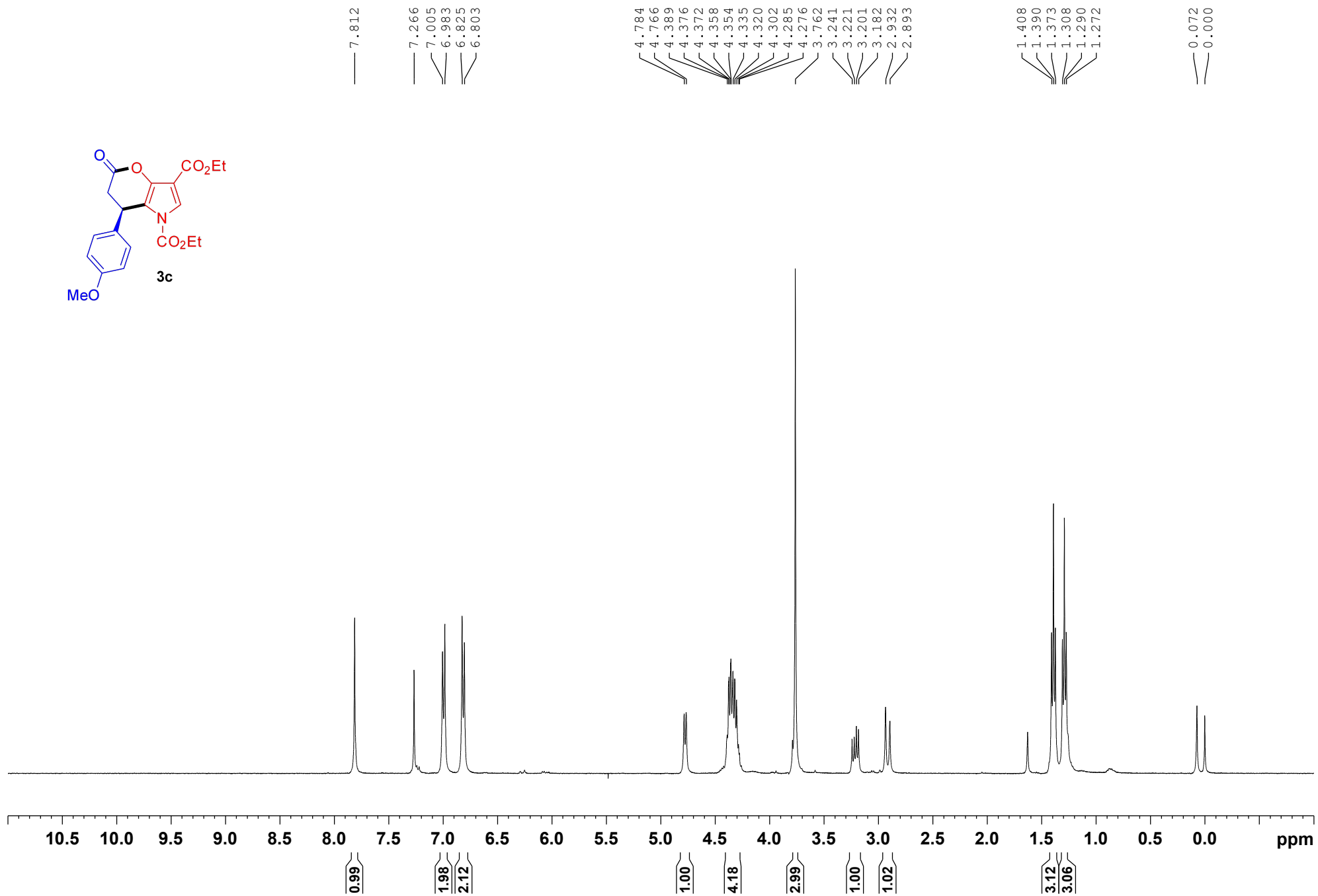
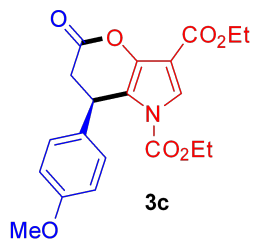
0.000

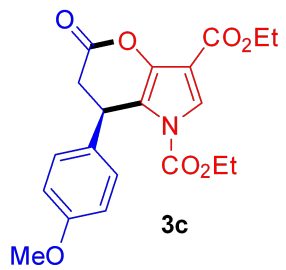












166.05  
162.02  
158.92

149.10

140.01

132.68

127.61

124.30

116.22

114.42

109.18

77.31  
77.00  
76.68

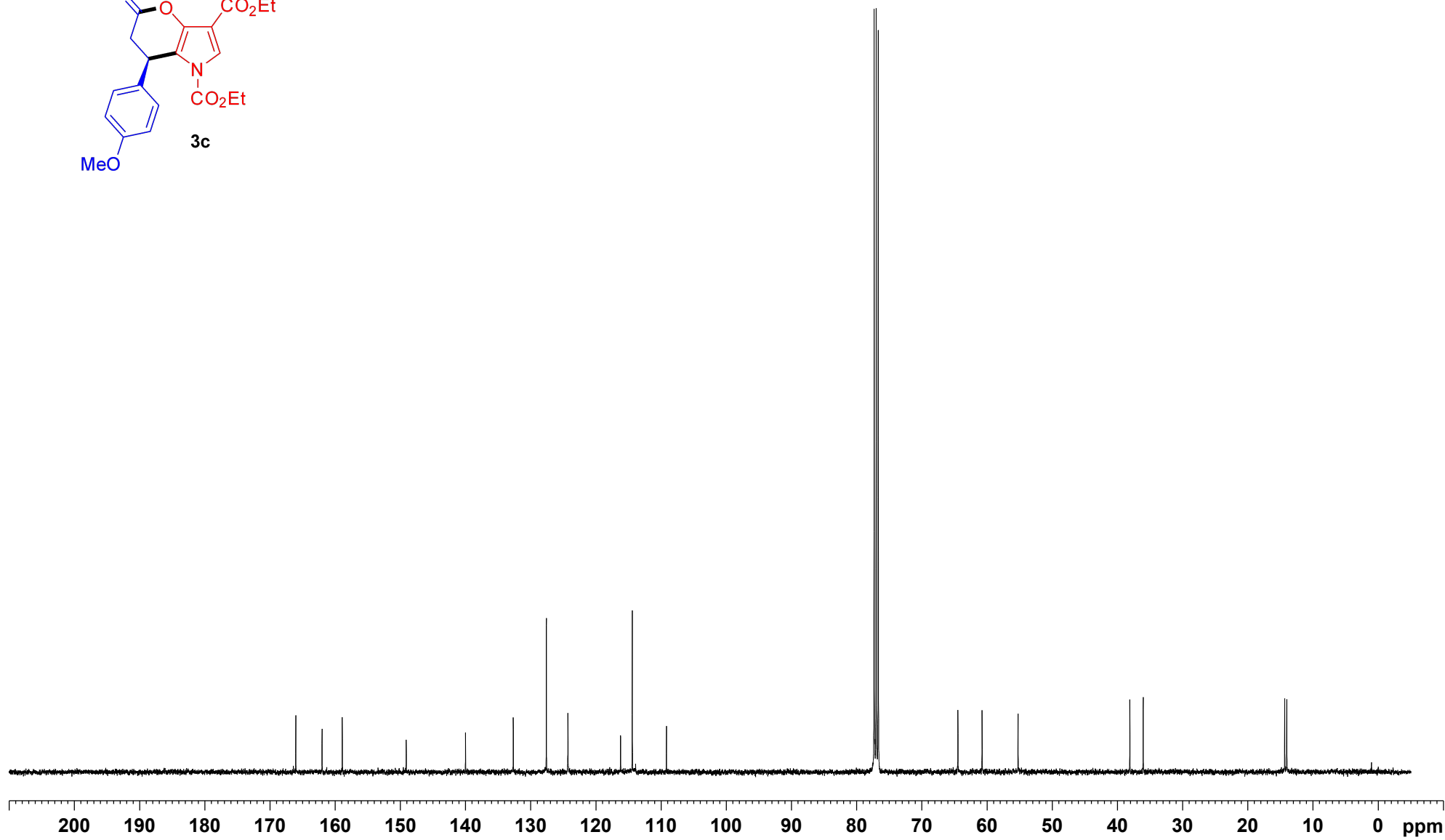
64.46

60.75

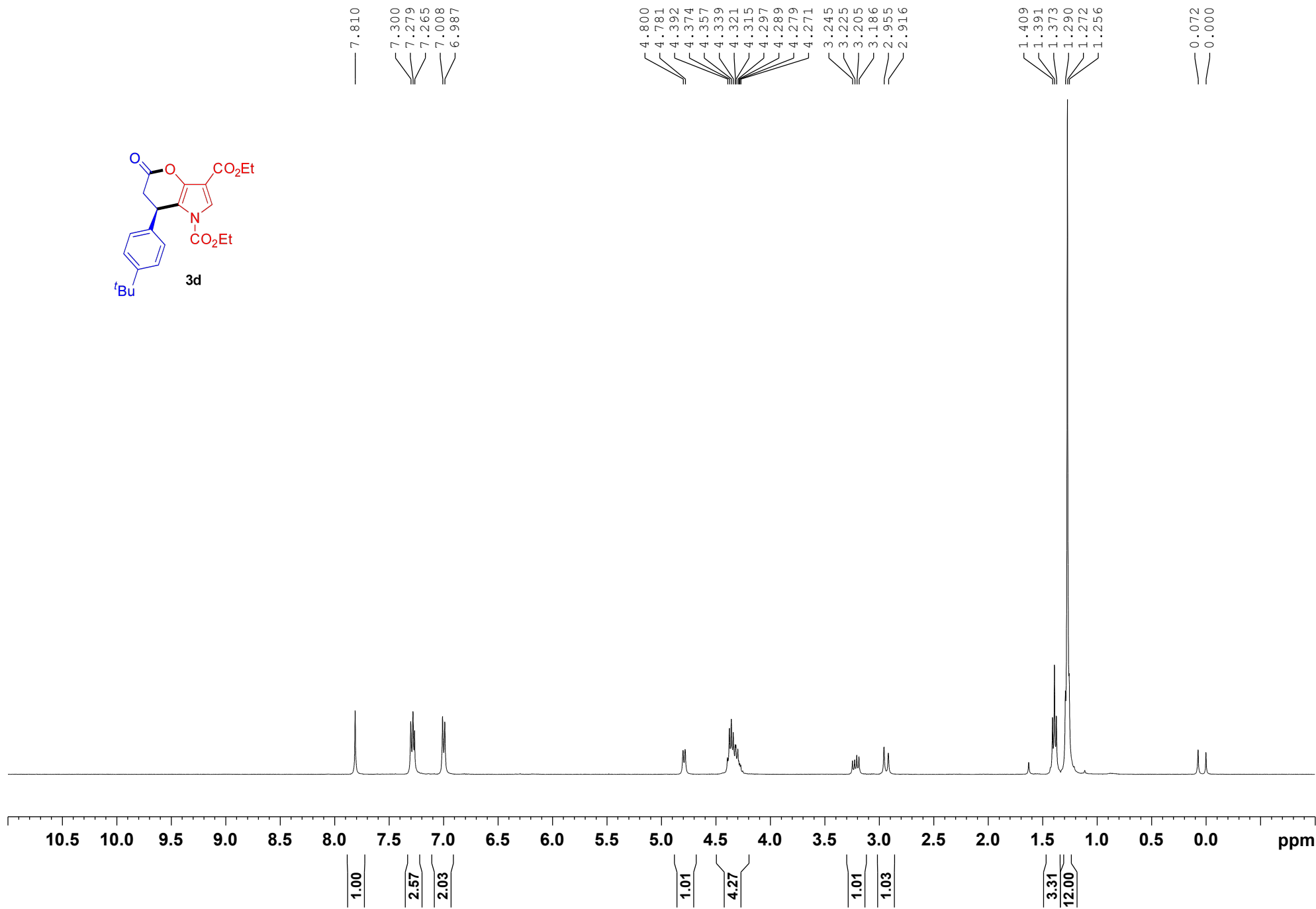
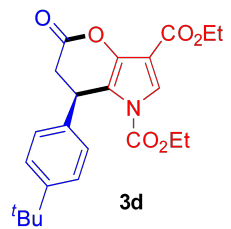
55.23

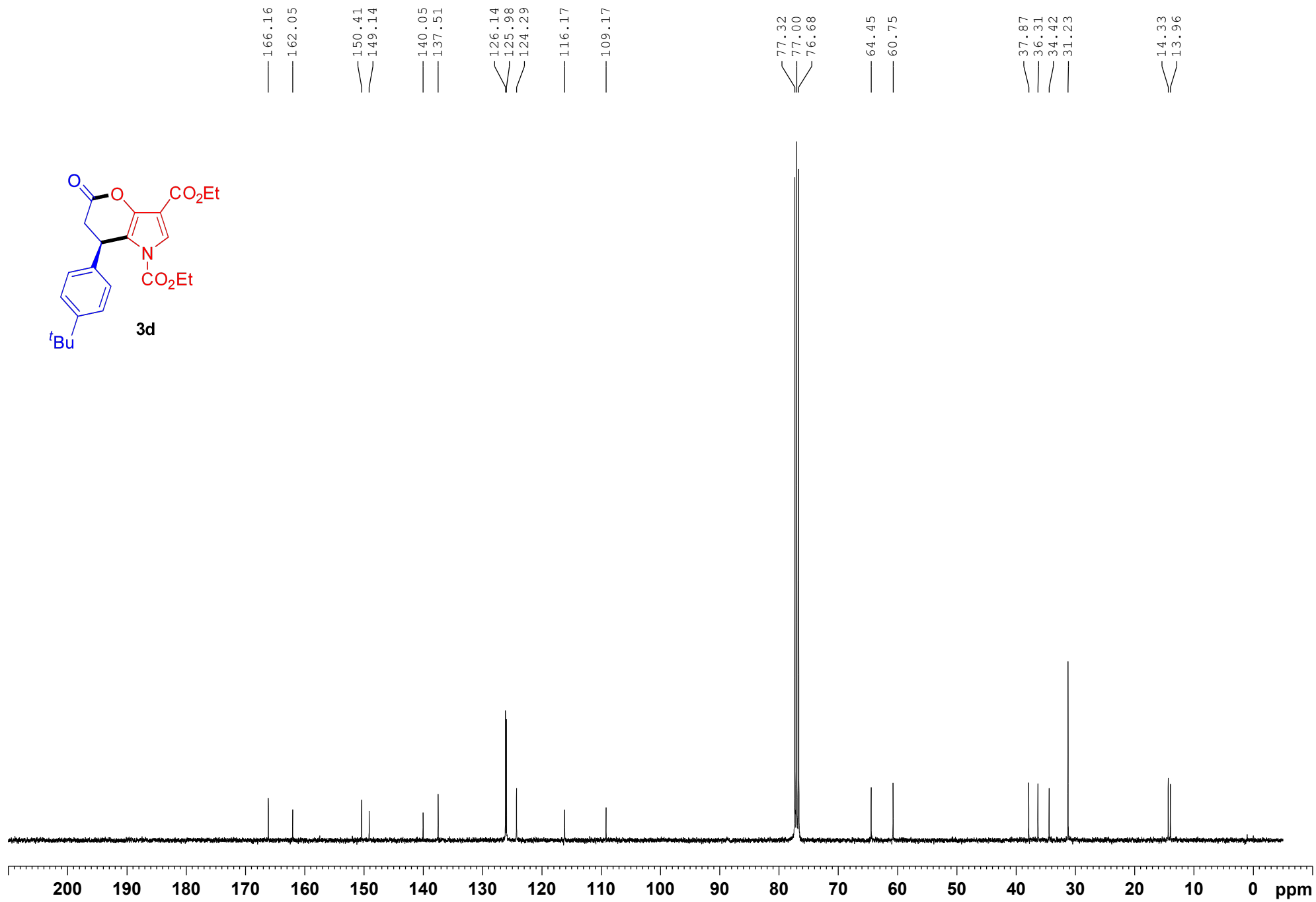
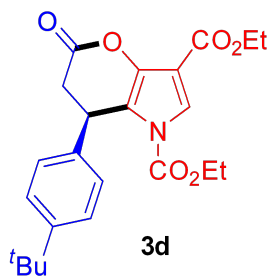
38.08  
36.03

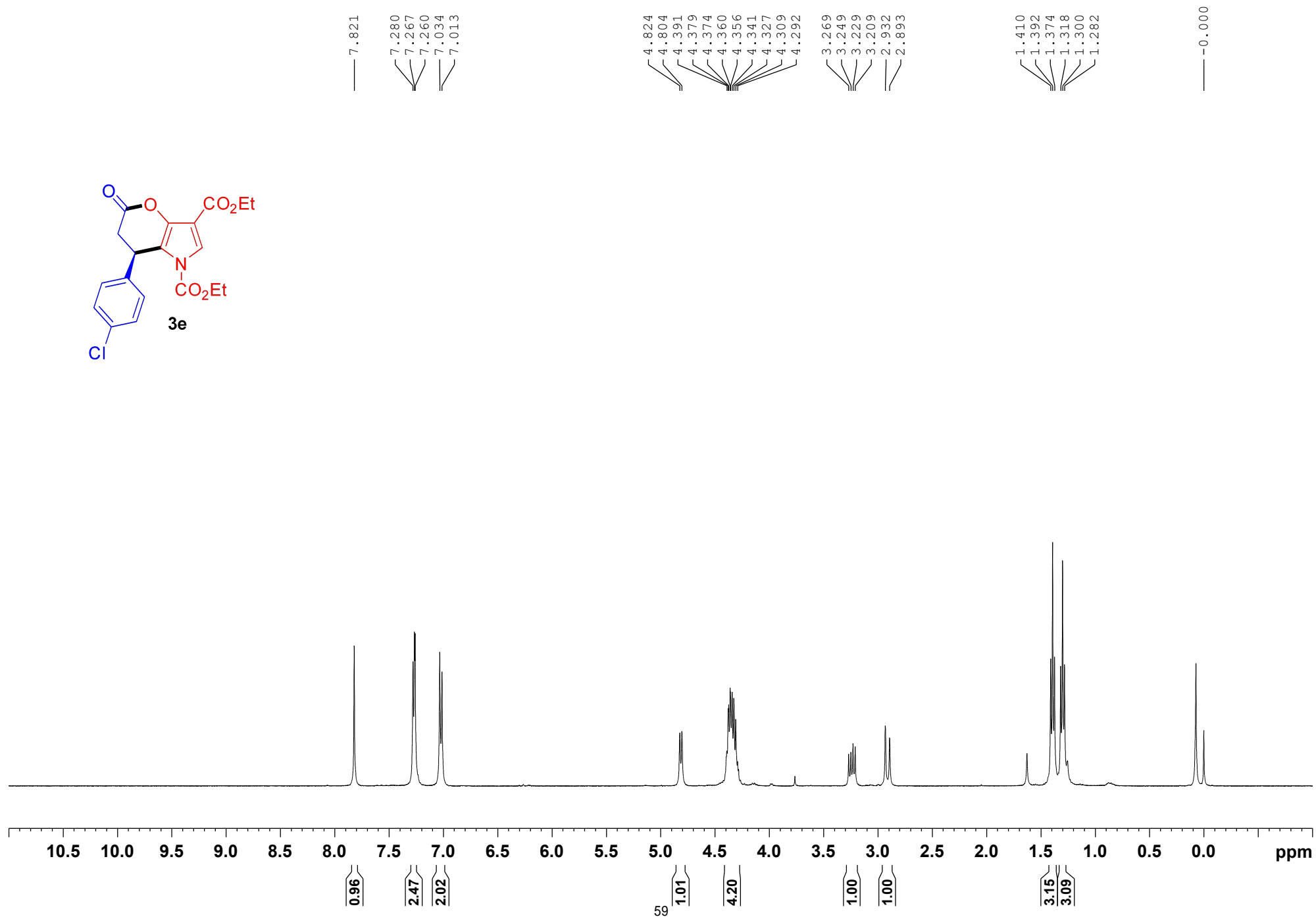
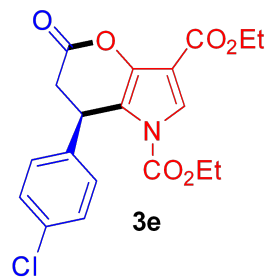
14.32  
14.00

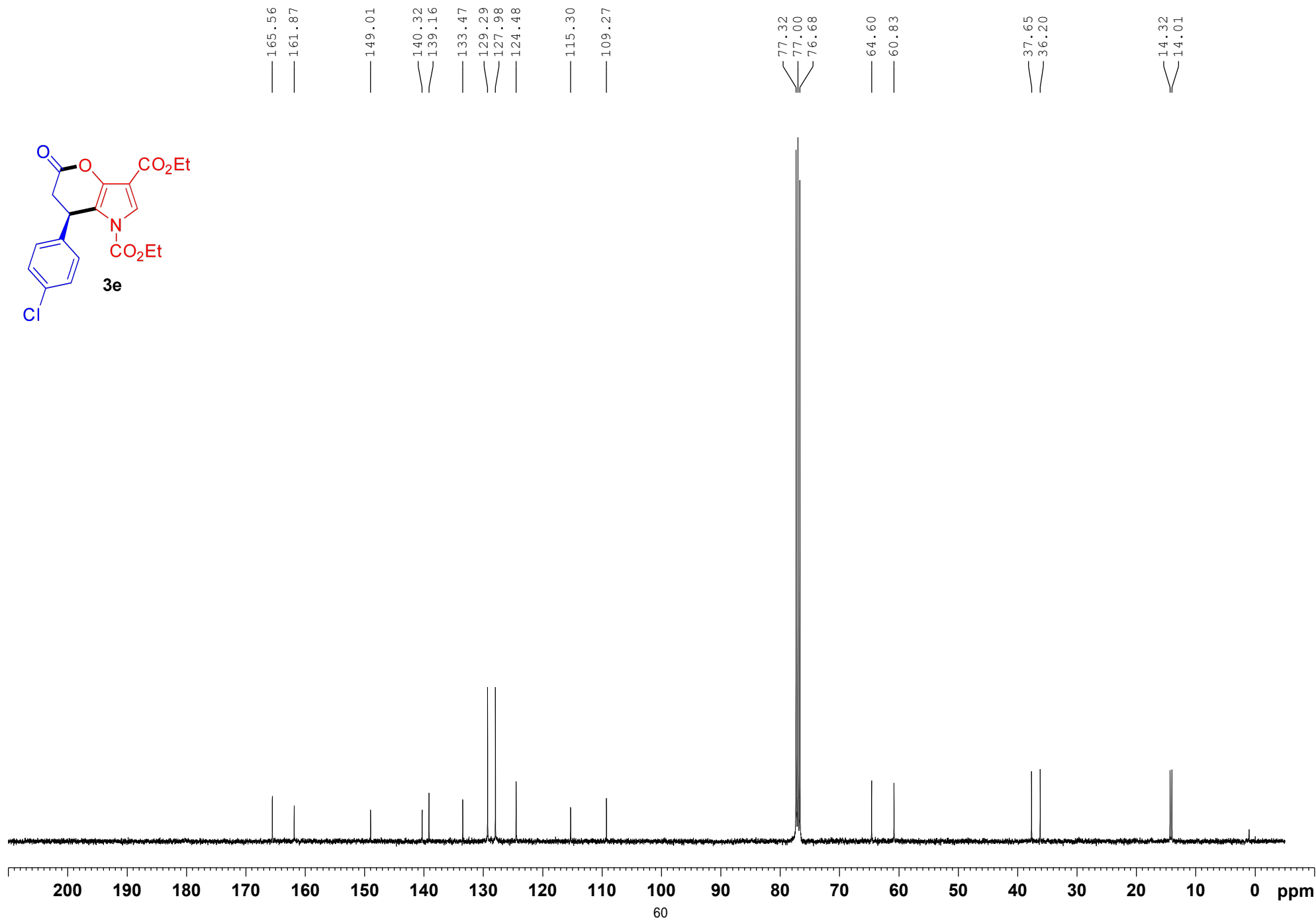
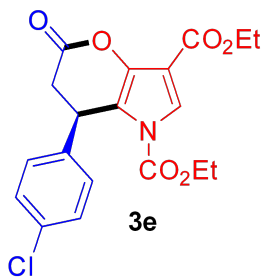


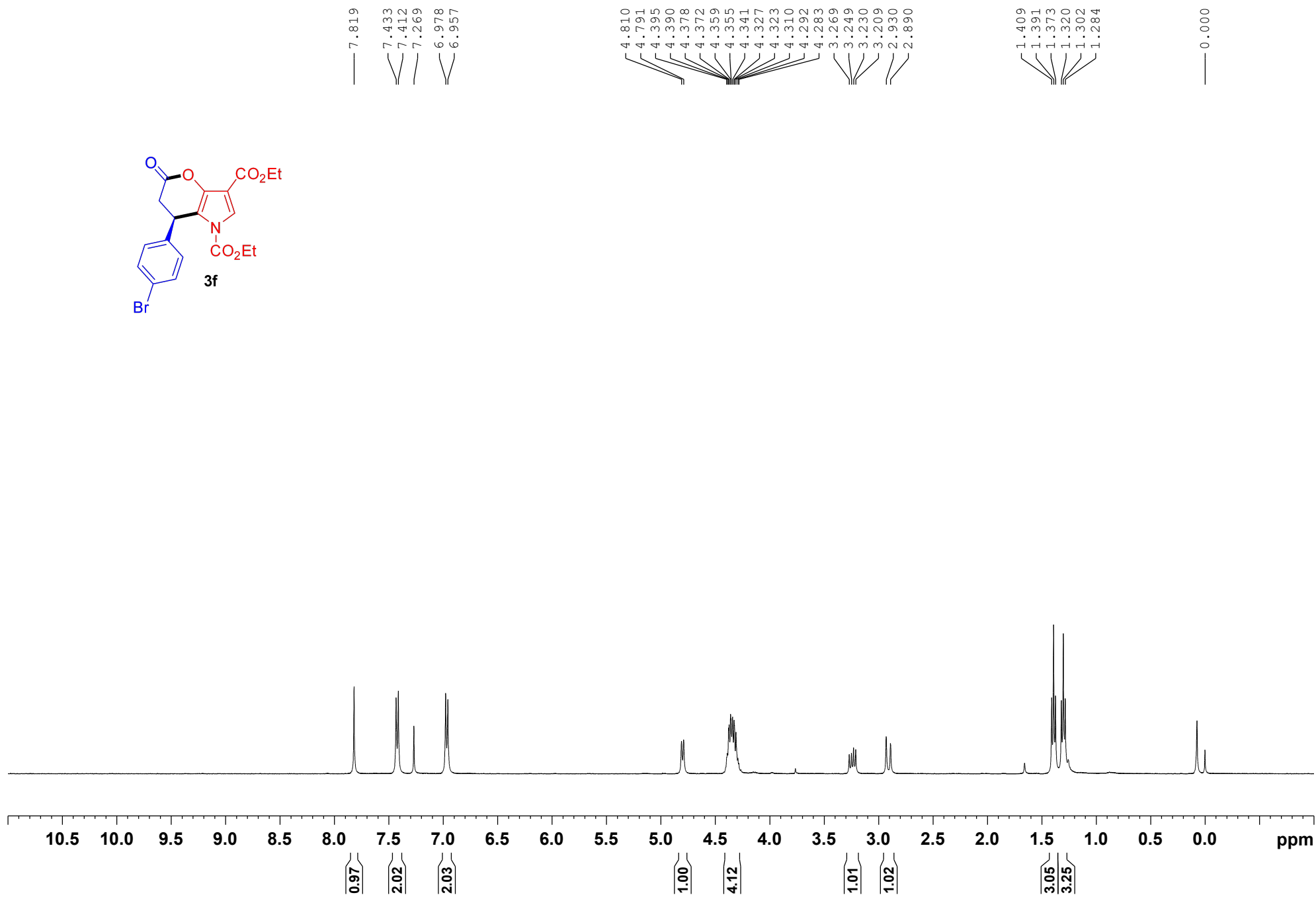
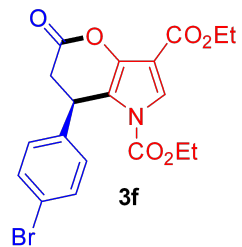


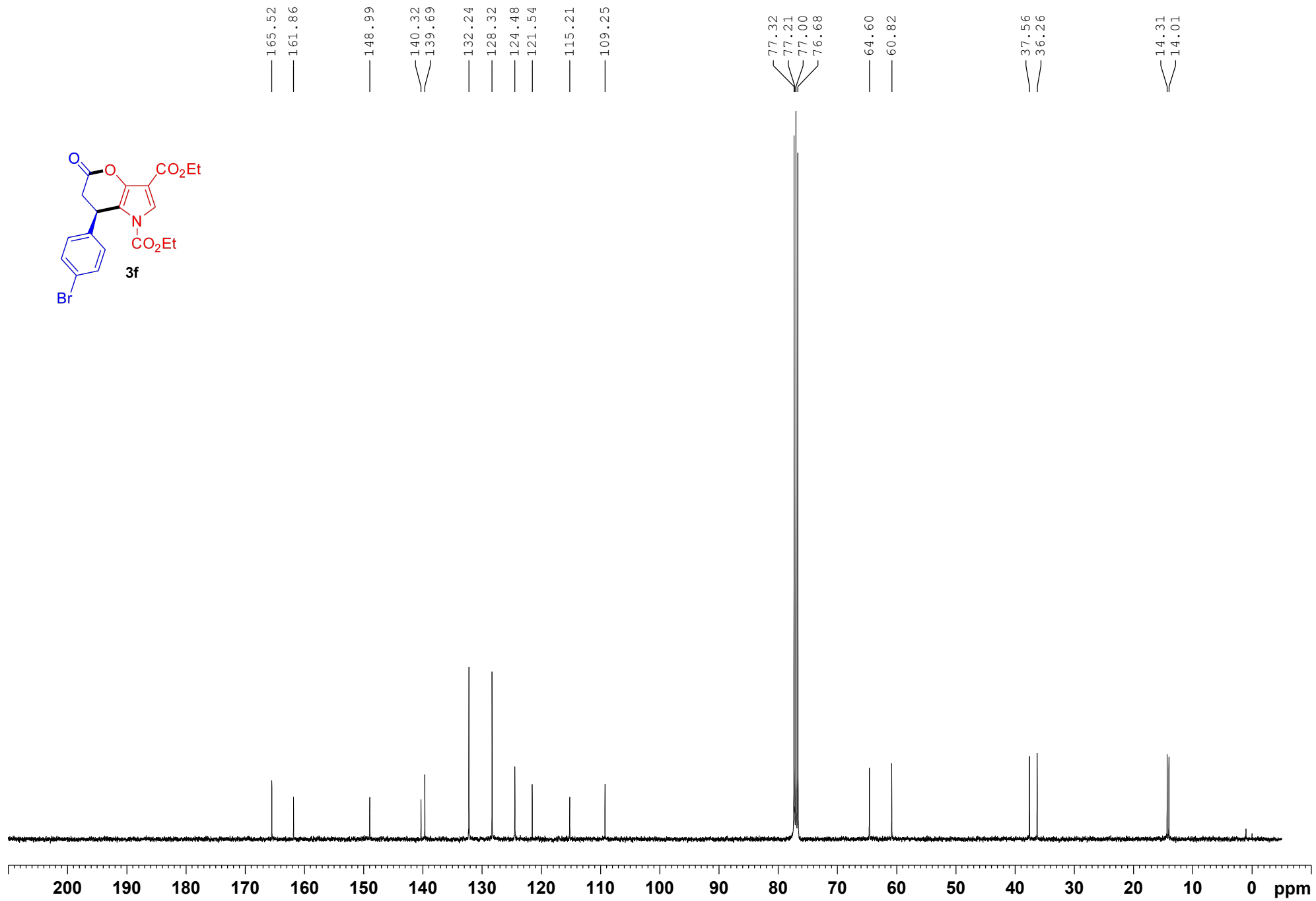
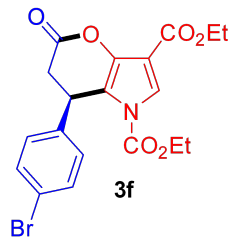


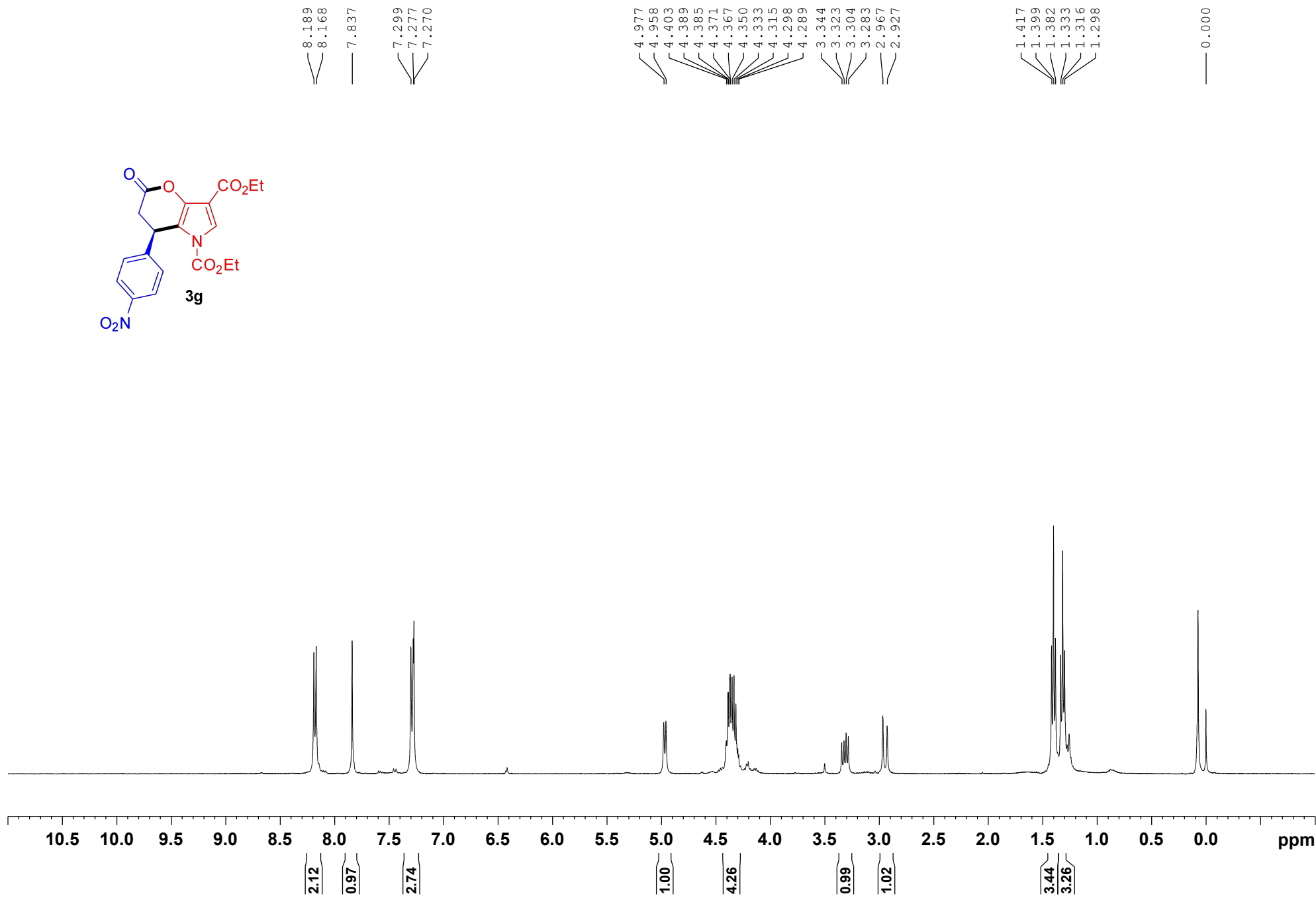
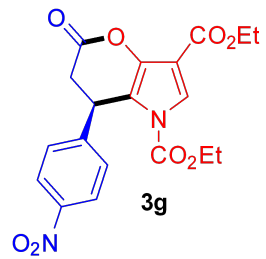


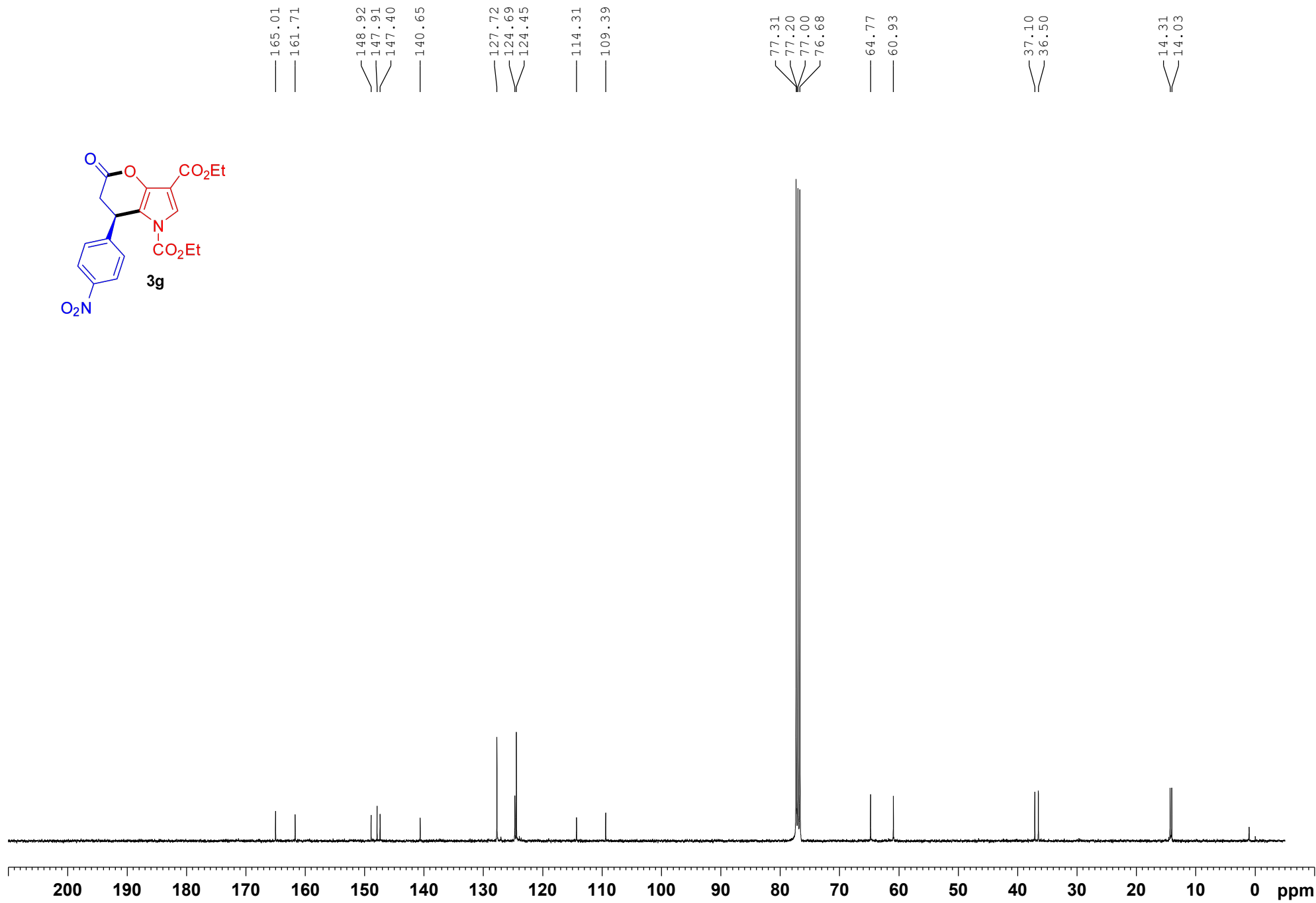
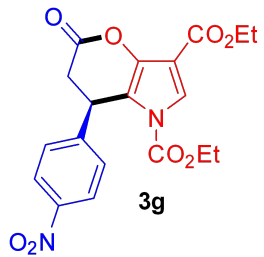




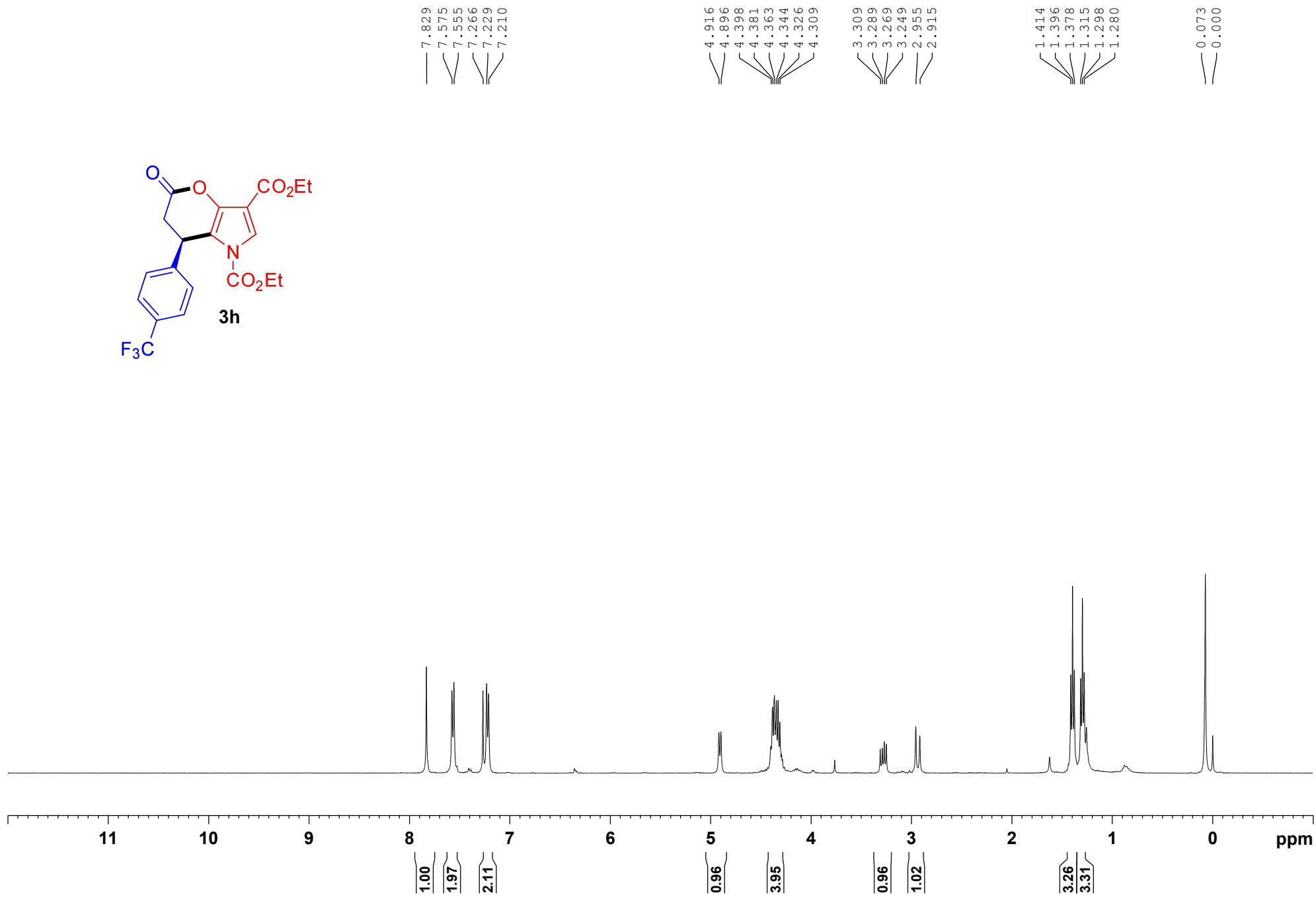
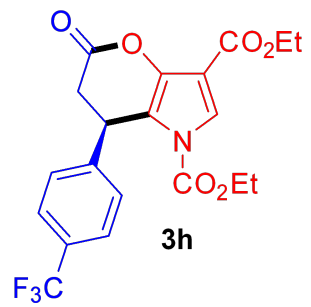


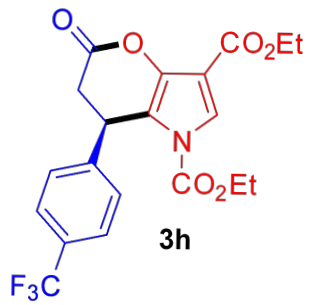












— 165.42  
 — 161.81  
 — 148.99  
 — 144.64  
 — 140.46  
 — 130.42  
 — 130.12  
 — 129.77  
 — 129.42  
 — 127.90  
 — 127.12  
 — 126.18  
 — 125.22  
 — 124.56  
 — 122.52  
 — 119.86  
 — 114.90  
 — 109.29

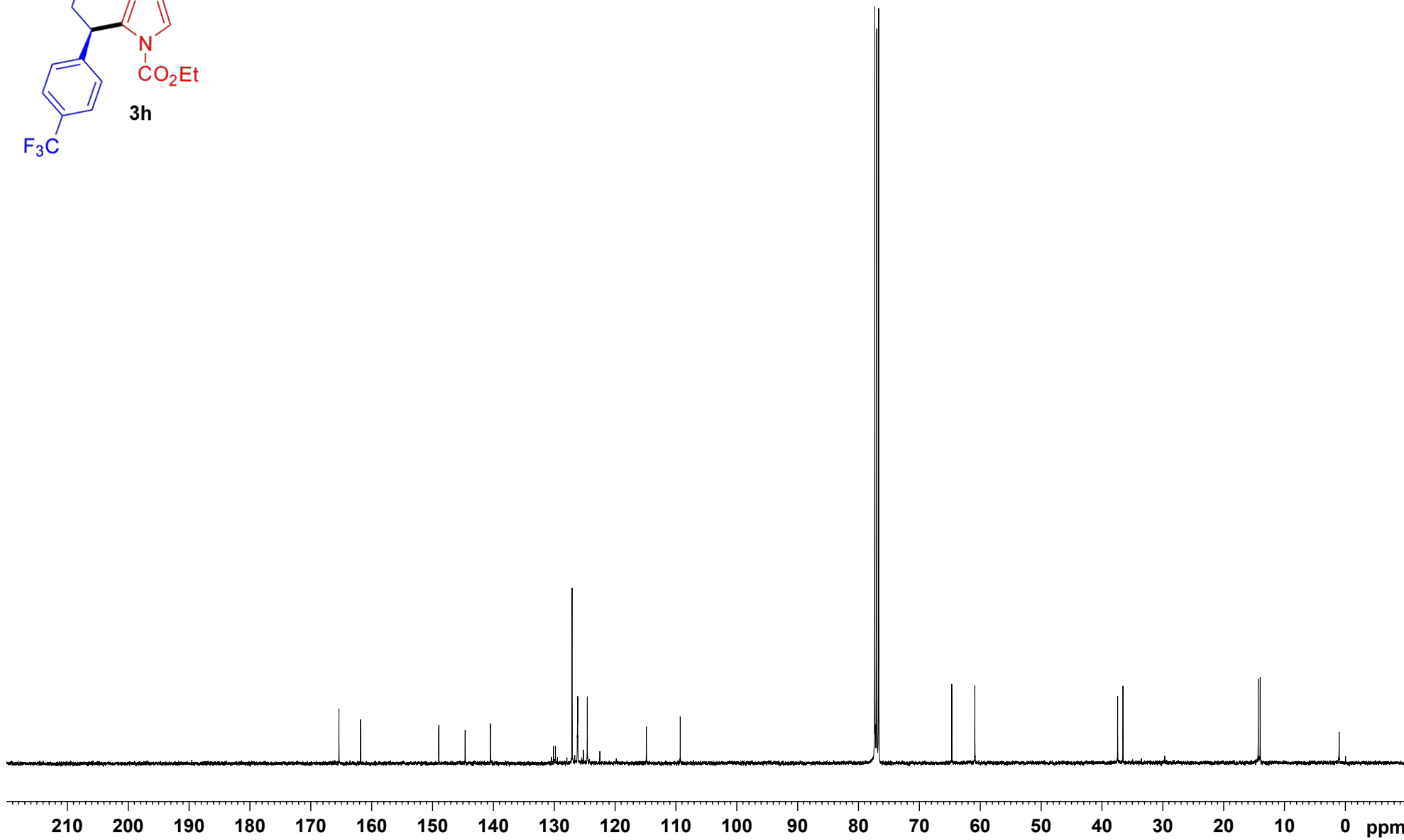
77.32  
 77.01  
 76.69

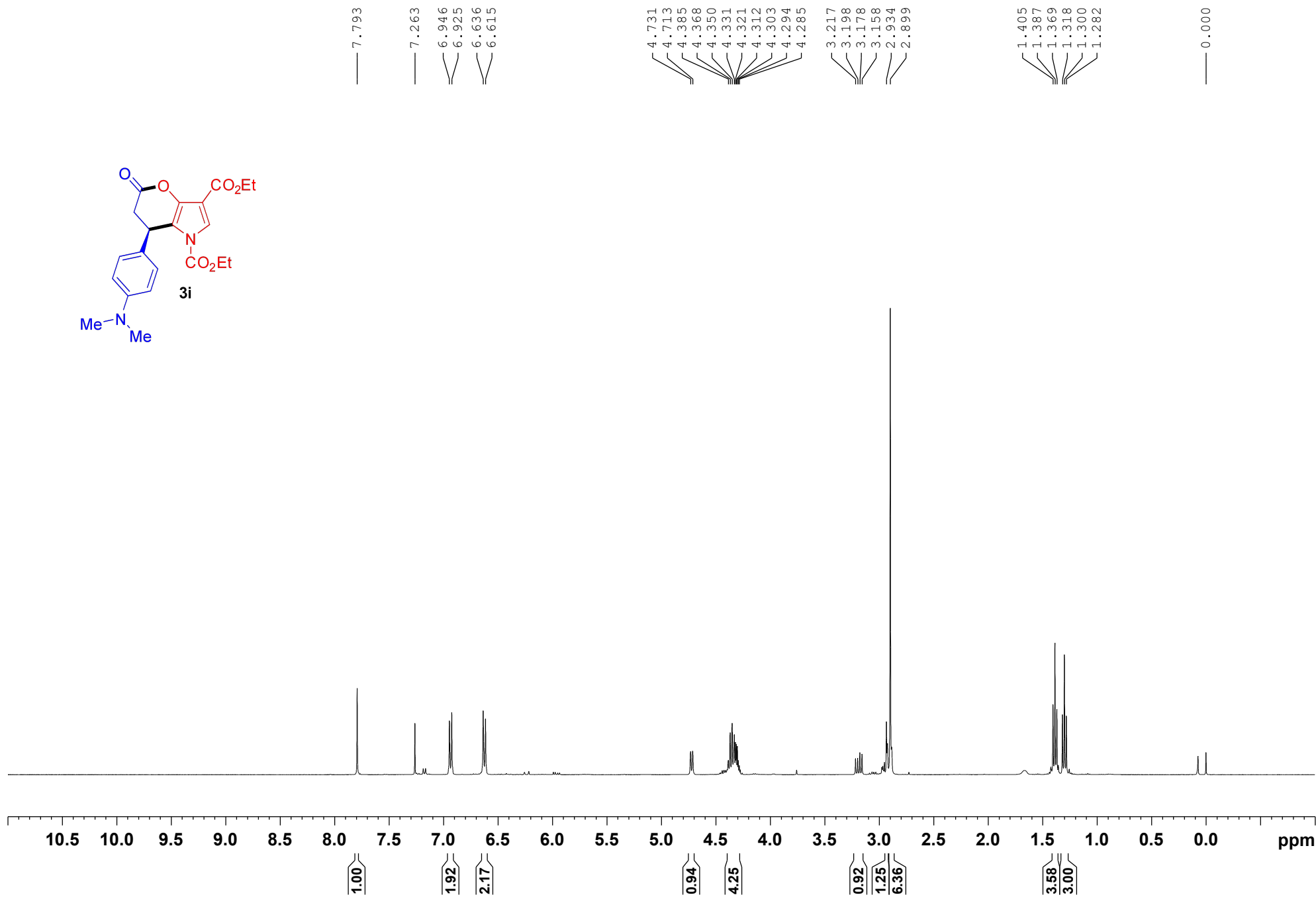
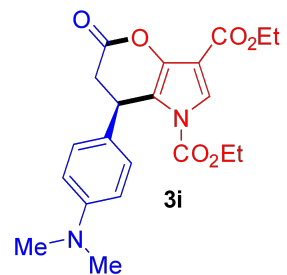
— 64.68  
 — 60.89

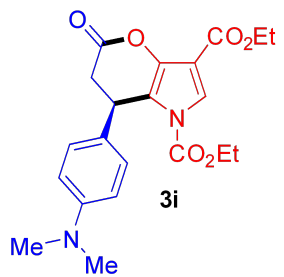
37.43  
 36.54

14.32  
 14.01

1.00  
 -0.01







— 166.32  
— 162.10

∨ 149.86  
149.15

— 139.80

— 127.22  
— 124.14

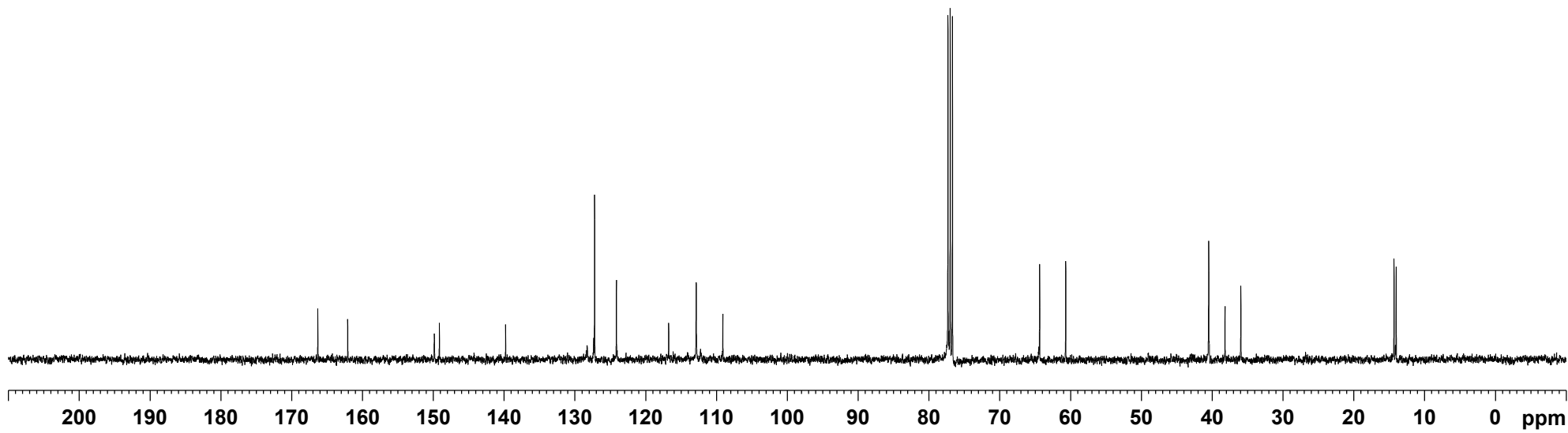
— 116.77  
— 112.87  
— 109.11

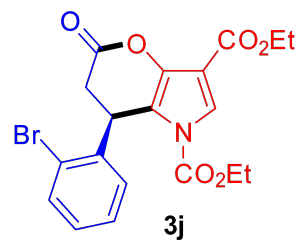
∨ 77.32  
77.00  
76.68

— 64.37  
— 60.68

— 40.48  
— 38.18  
— 35.95

∨ 14.31  
14.01



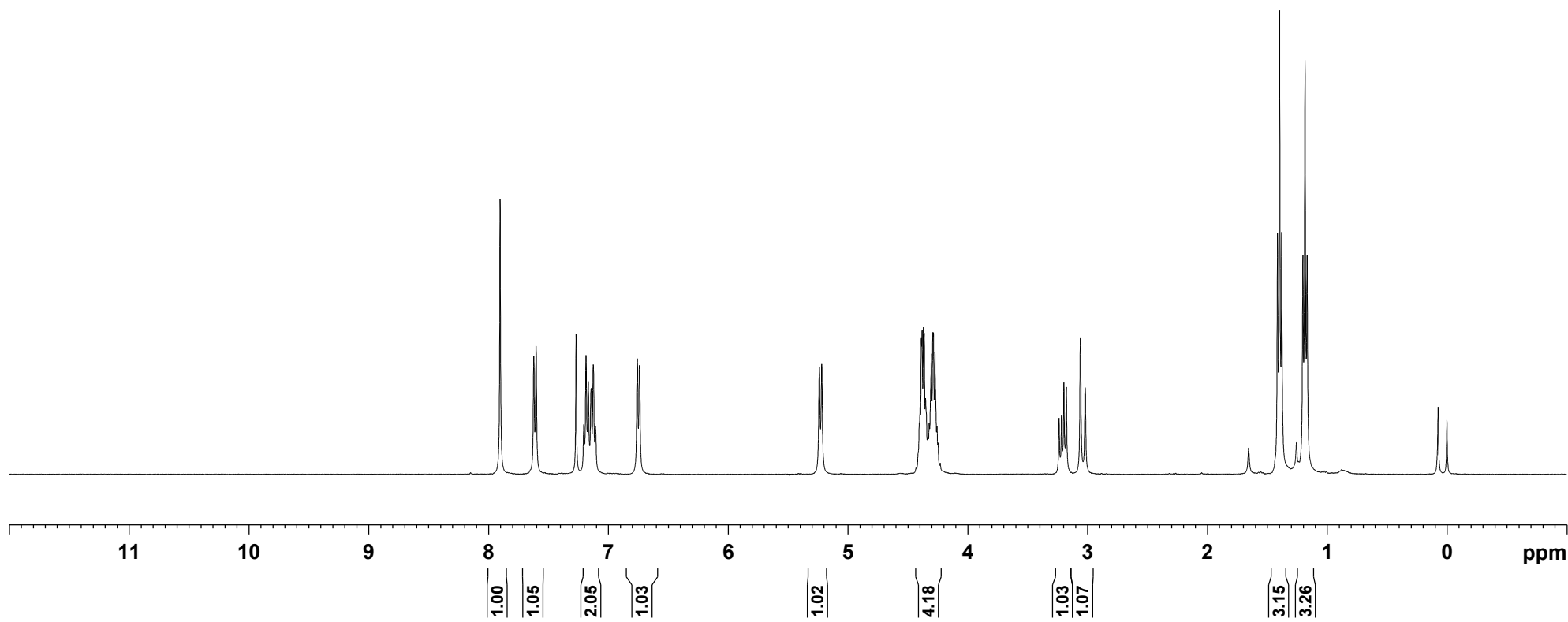


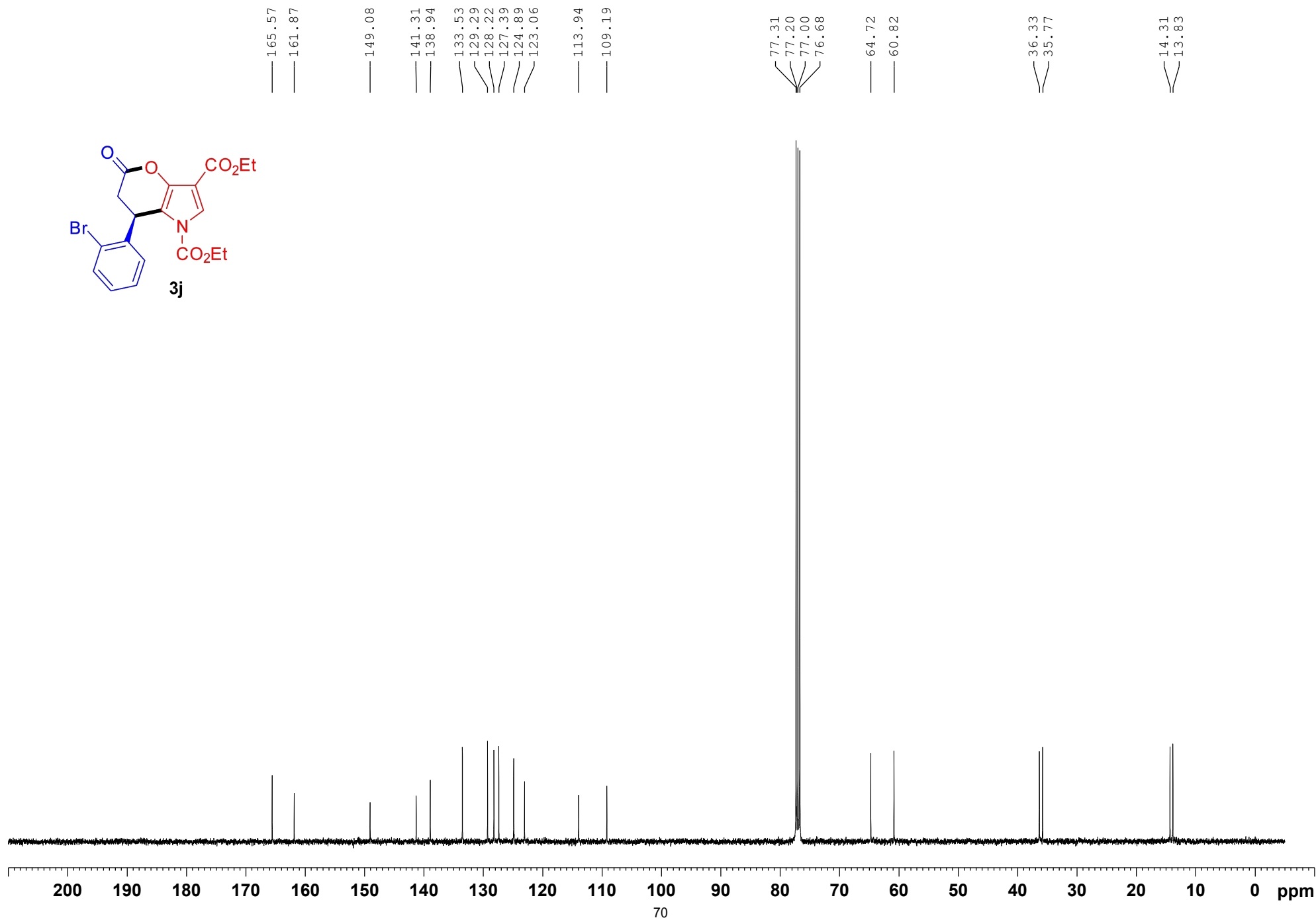
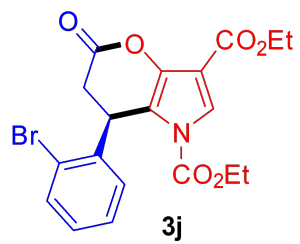
7.902  
7.621  
7.602  
7.268  
7.203  
7.185  
7.167  
7.142  
7.125  
7.107  
6.758  
6.740

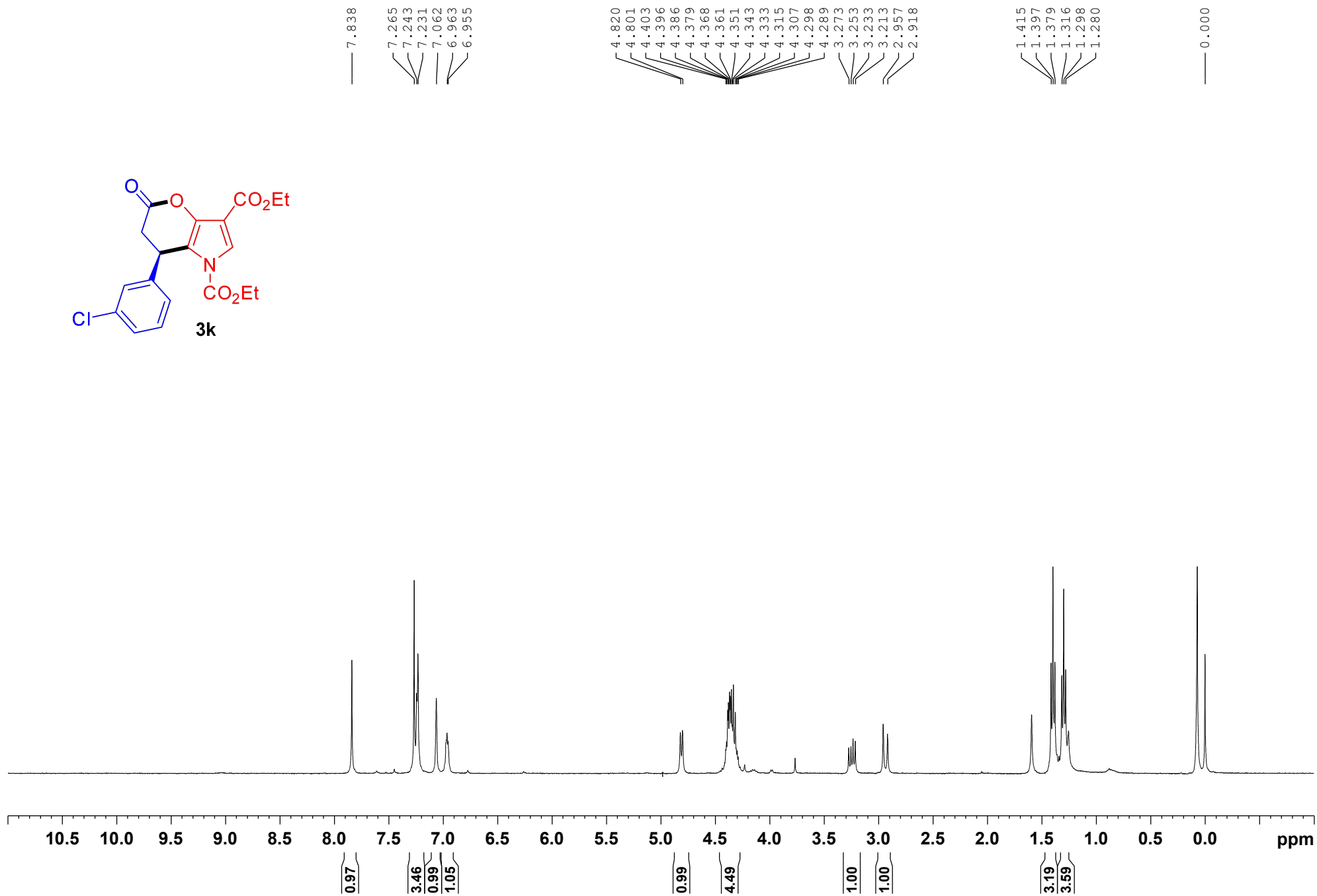
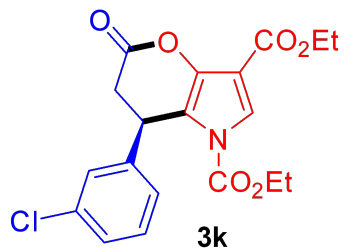
5.238  
5.218  
5.218  
4.397  
4.386  
4.380  
4.369  
4.363  
4.351  
4.330  
4.321  
4.303  
4.290  
4.286  
4.273  
4.256  
3.237  
3.216  
3.197  
3.176  
3.059  
3.019

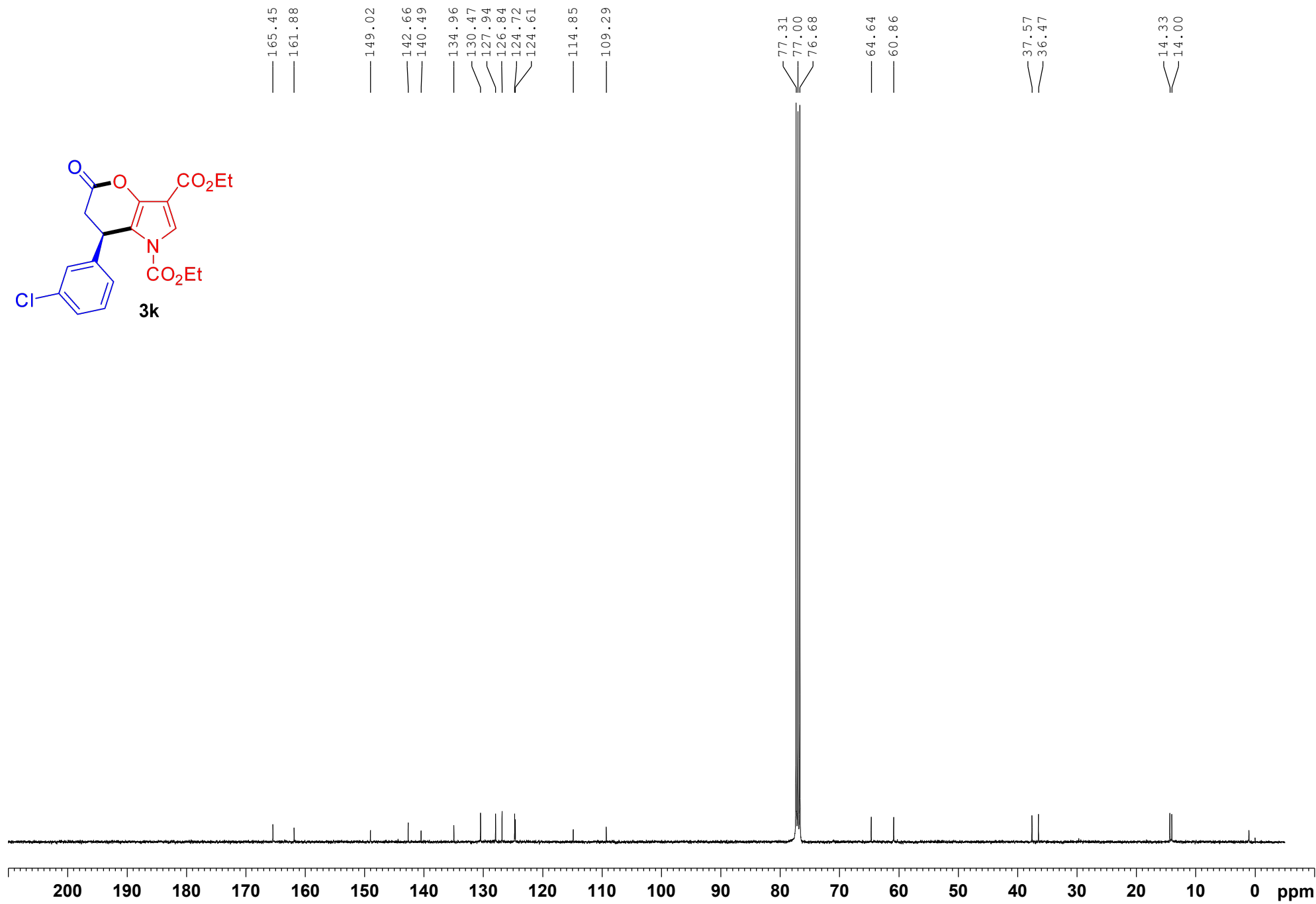
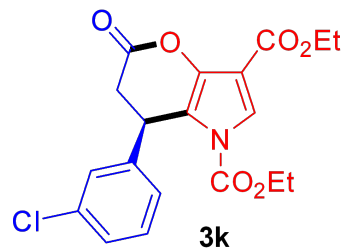
1.414  
1.396  
1.378  
1.202  
1.184  
1.166

0.073  
-0.000

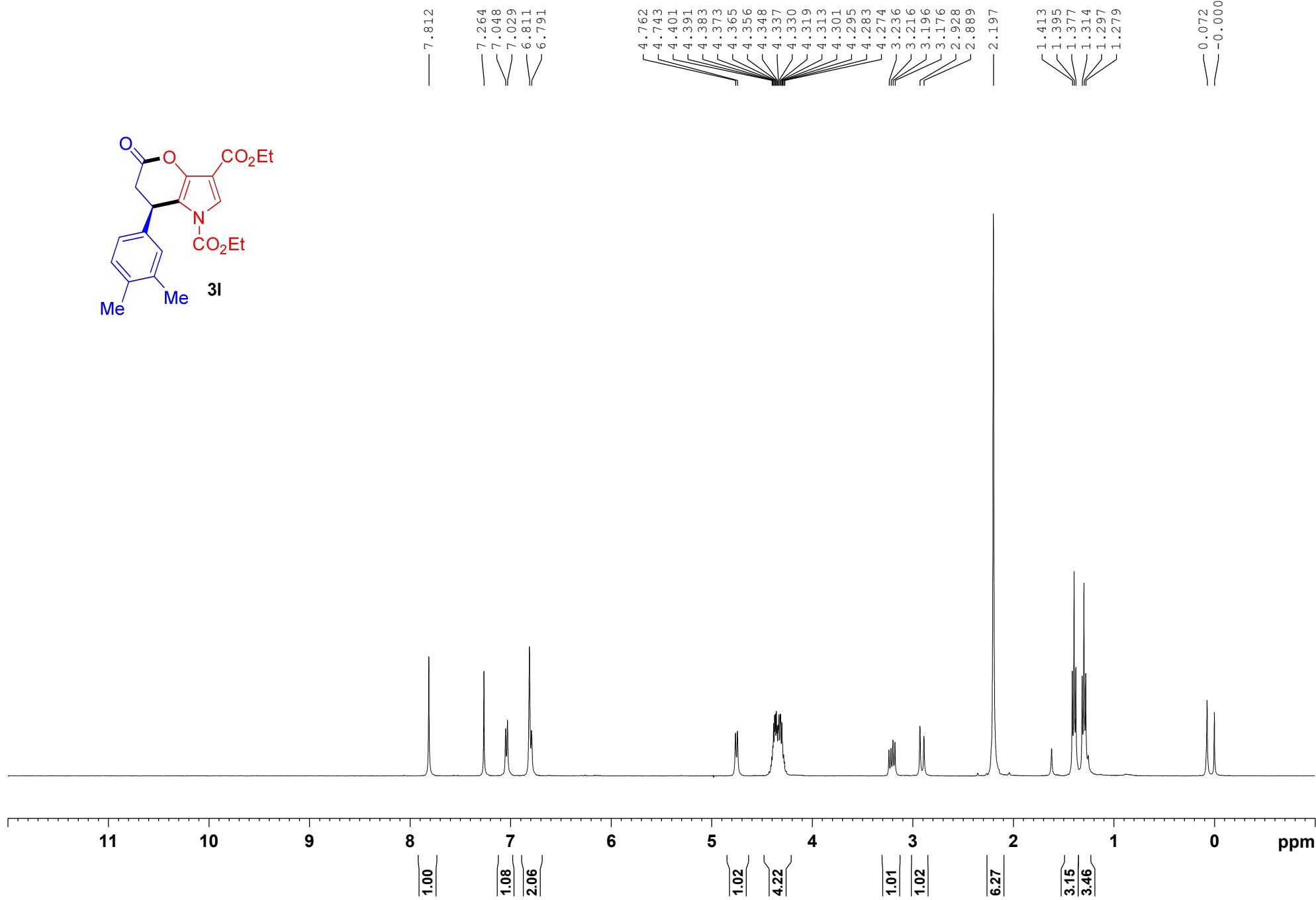
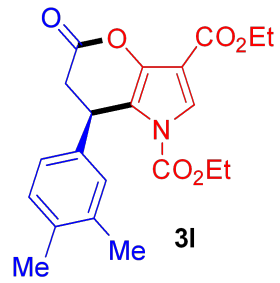


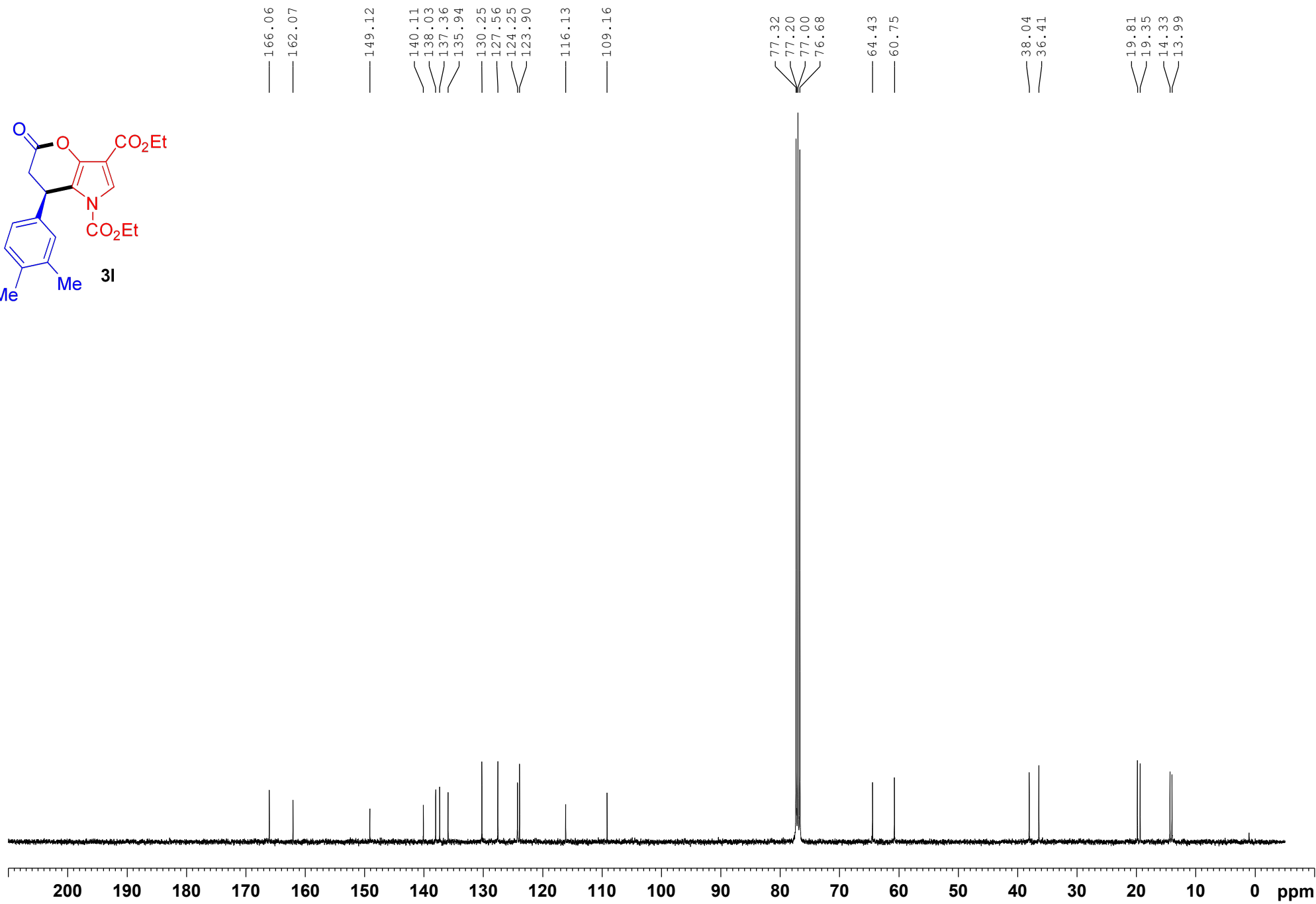
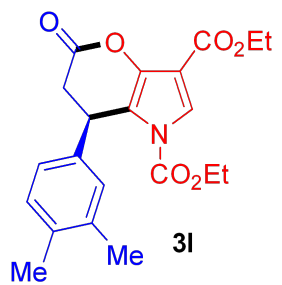


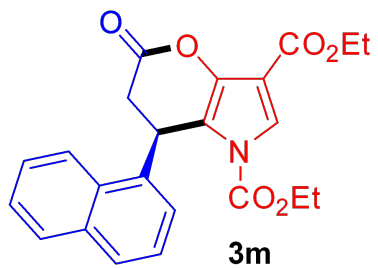












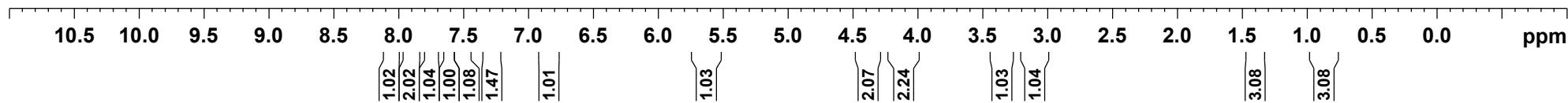
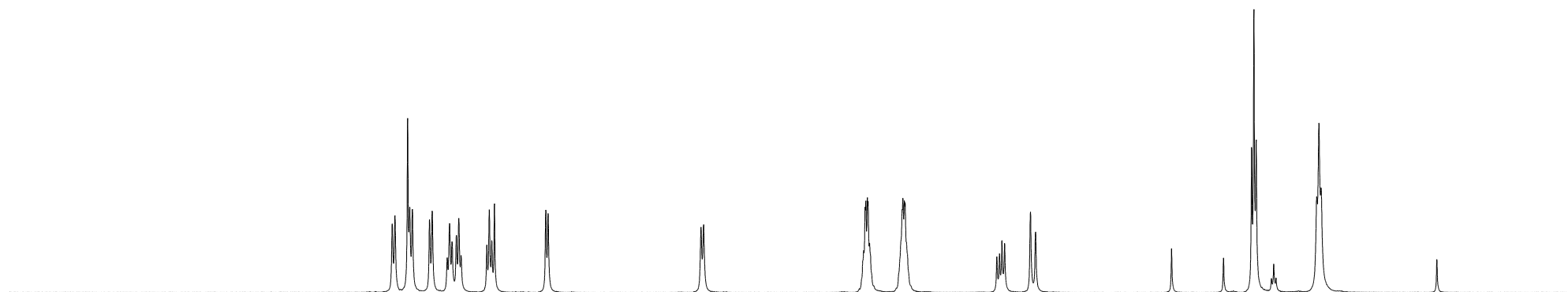
8.048  
8.027  
7.930  
7.914  
7.893  
7.761  
7.740  
7.624  
7.607  
7.587  
7.554  
7.535  
7.518  
7.319  
7.300  
7.281  
7.261  
6.865  
6.847

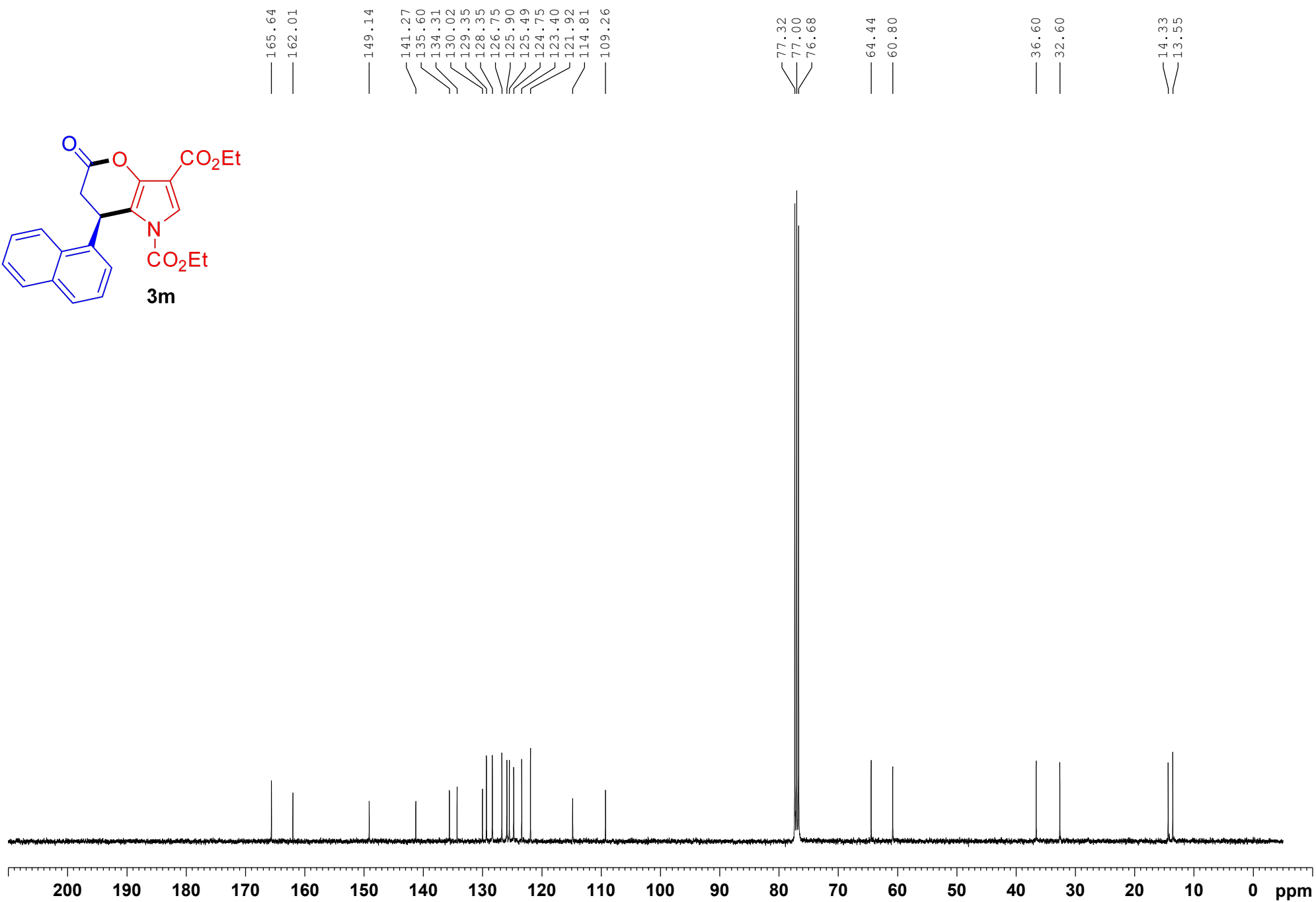
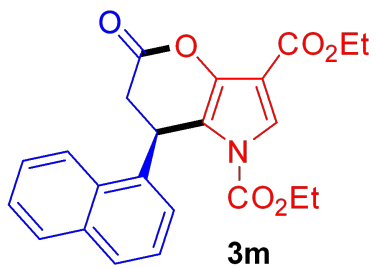
5.669  
5.649

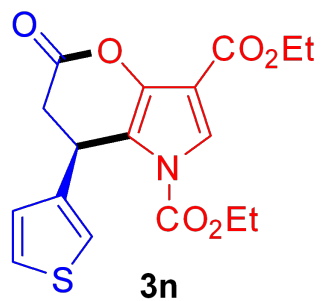
4.405  
4.399  
4.388  
4.382  
4.120  
4.114  
4.103  
4.097  
3.390  
3.370  
3.351  
3.330  
3.131  
3.092

1.428  
1.410  
1.392  
0.925  
0.909  
0.892

0.000





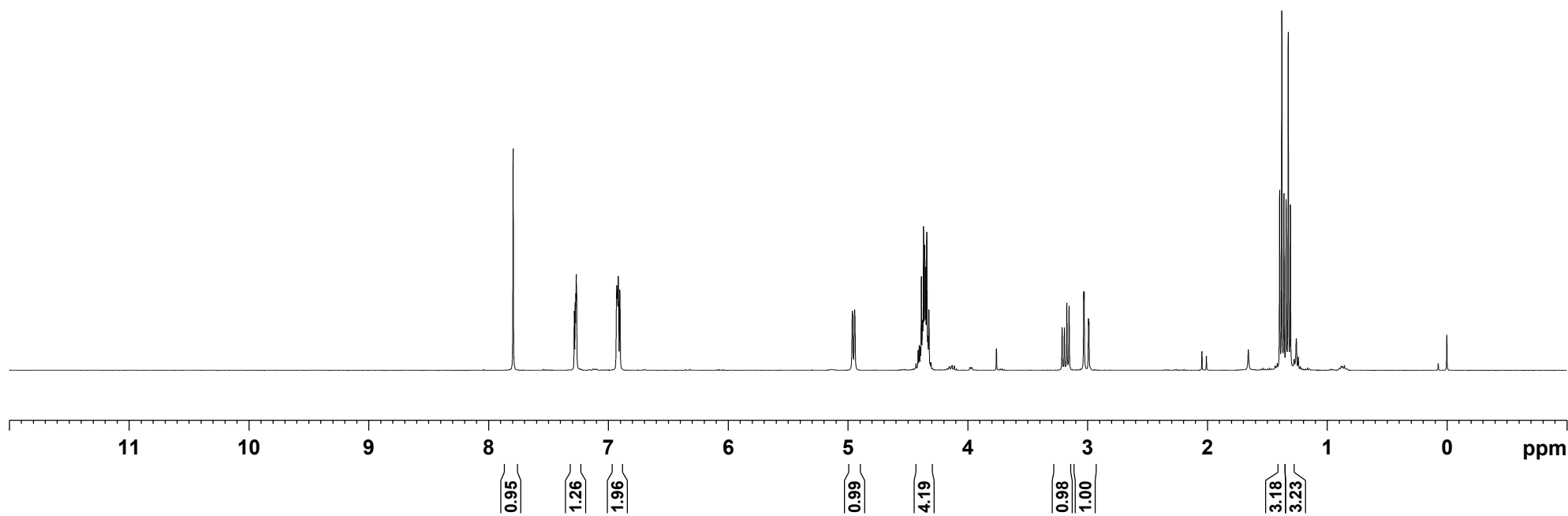


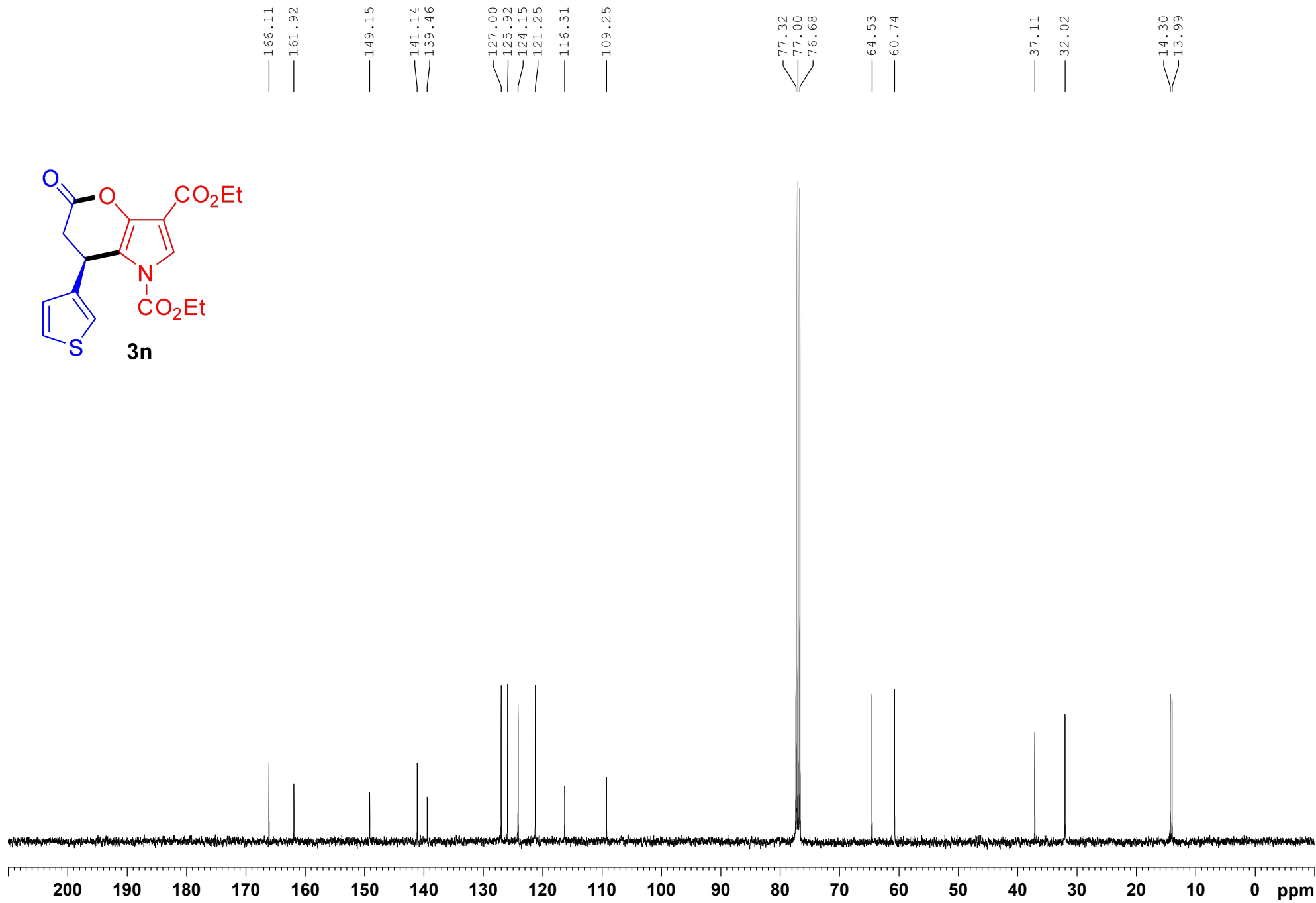
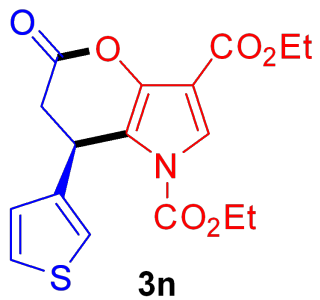
7.795  
7.284  
7.276  
7.271  
7.267  
6.930  
6.923  
6.917  
6.905

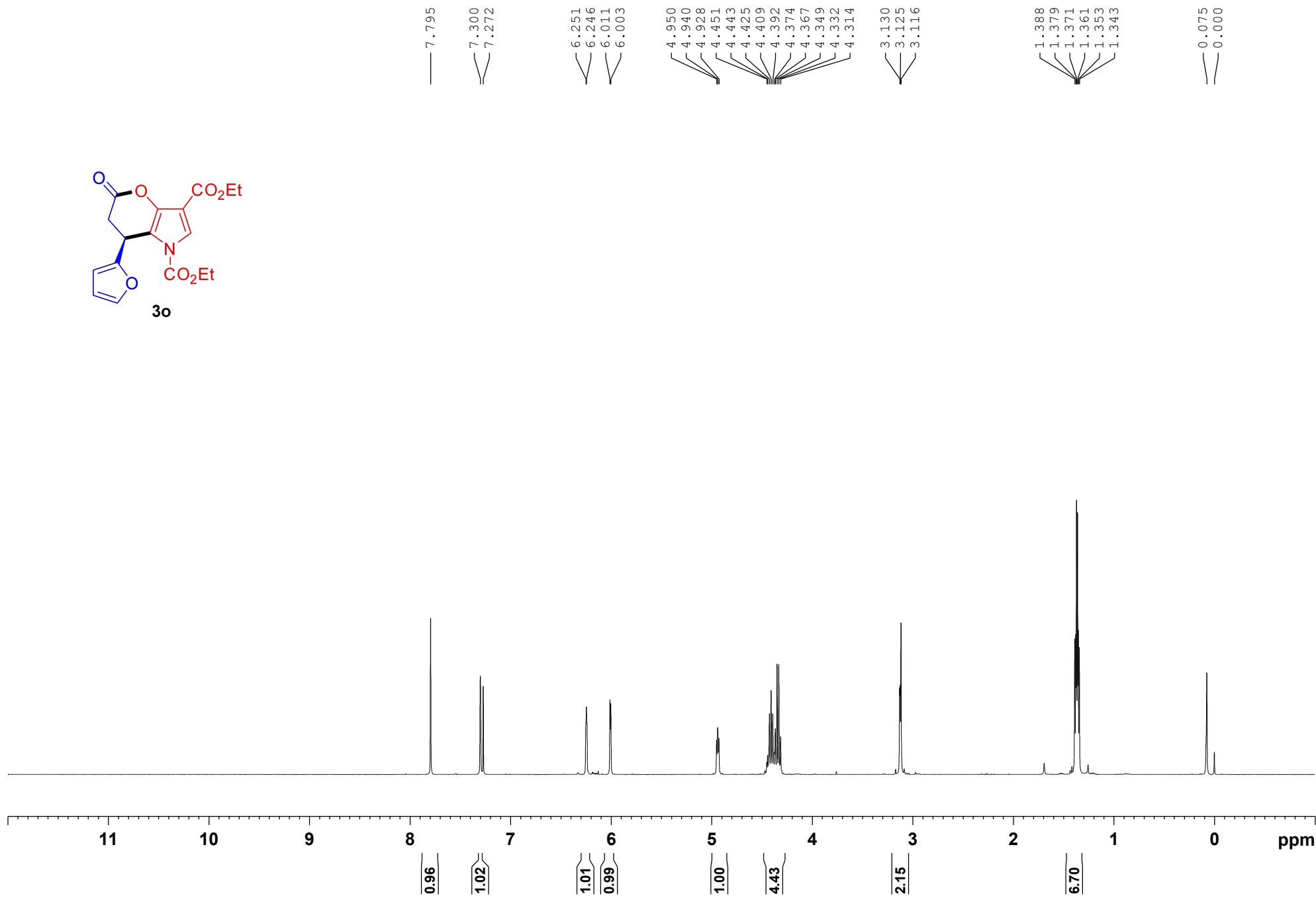
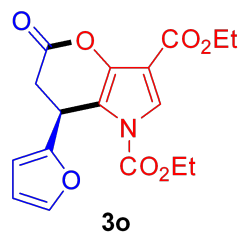
4.962  
4.944  
4.387  
4.378  
4.369  
4.360  
4.351  
4.342  
4.333  
4.324  
3.212  
3.193  
3.172  
3.153  
3.031  
3.028  
2.991  
2.988

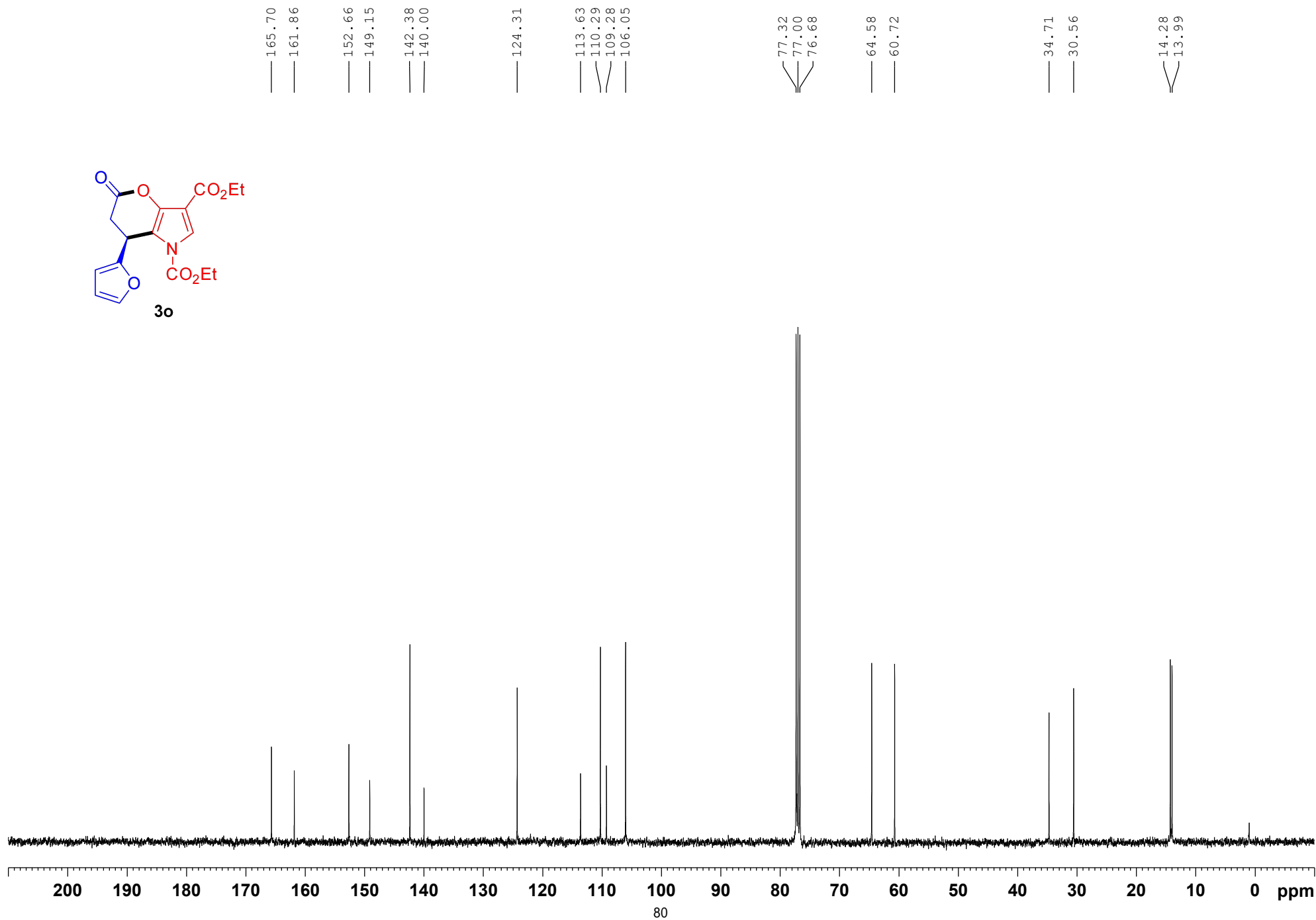
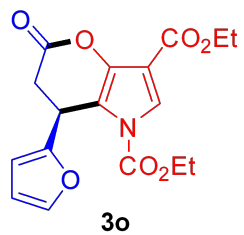
1.396  
1.378  
1.360  
1.342  
1.324  
1.306

0.000

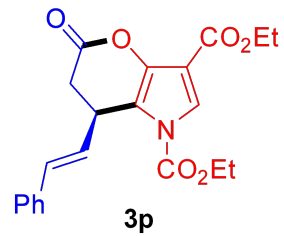










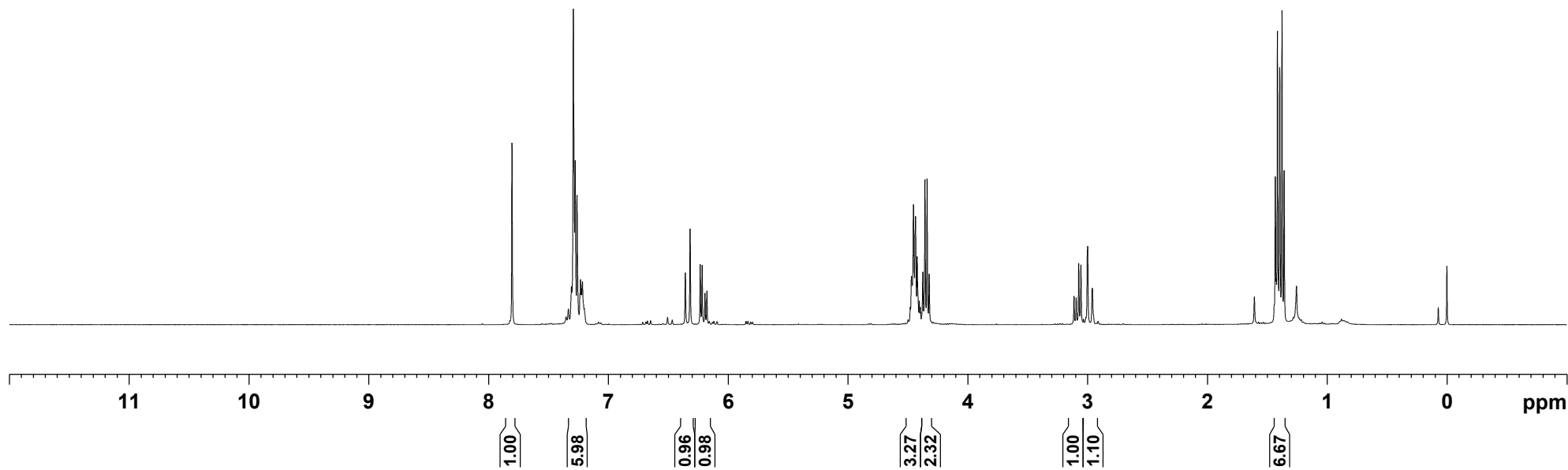


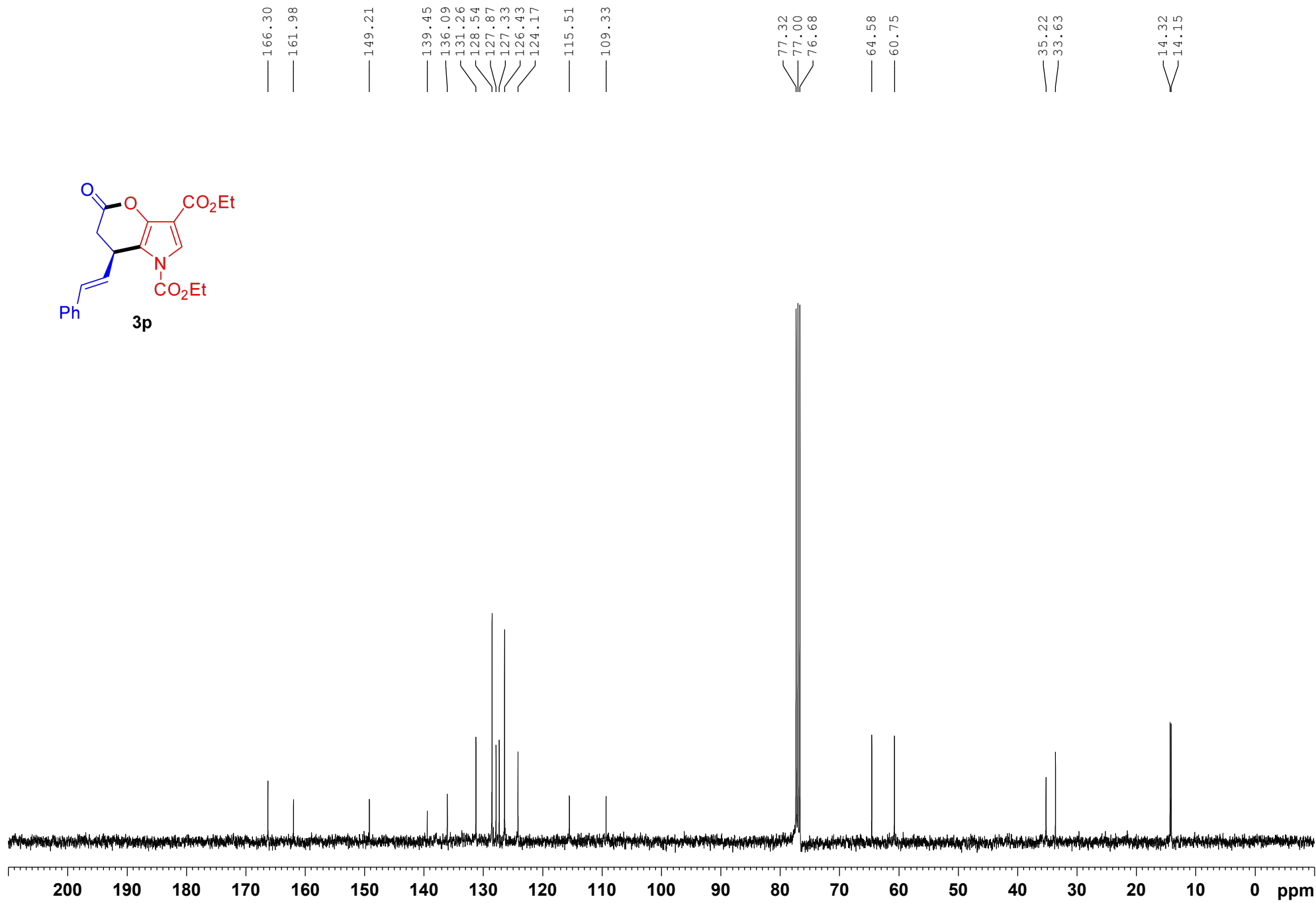
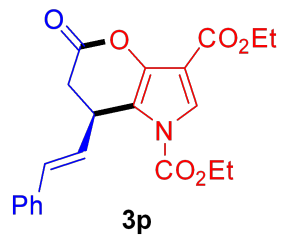
7.804  
 7.308  
 7.293  
 7.277  
 7.261  
 7.232  
 7.225  
 7.216  
 6.357  
 6.317  
 6.233  
 6.217  
 6.193  
 6.177

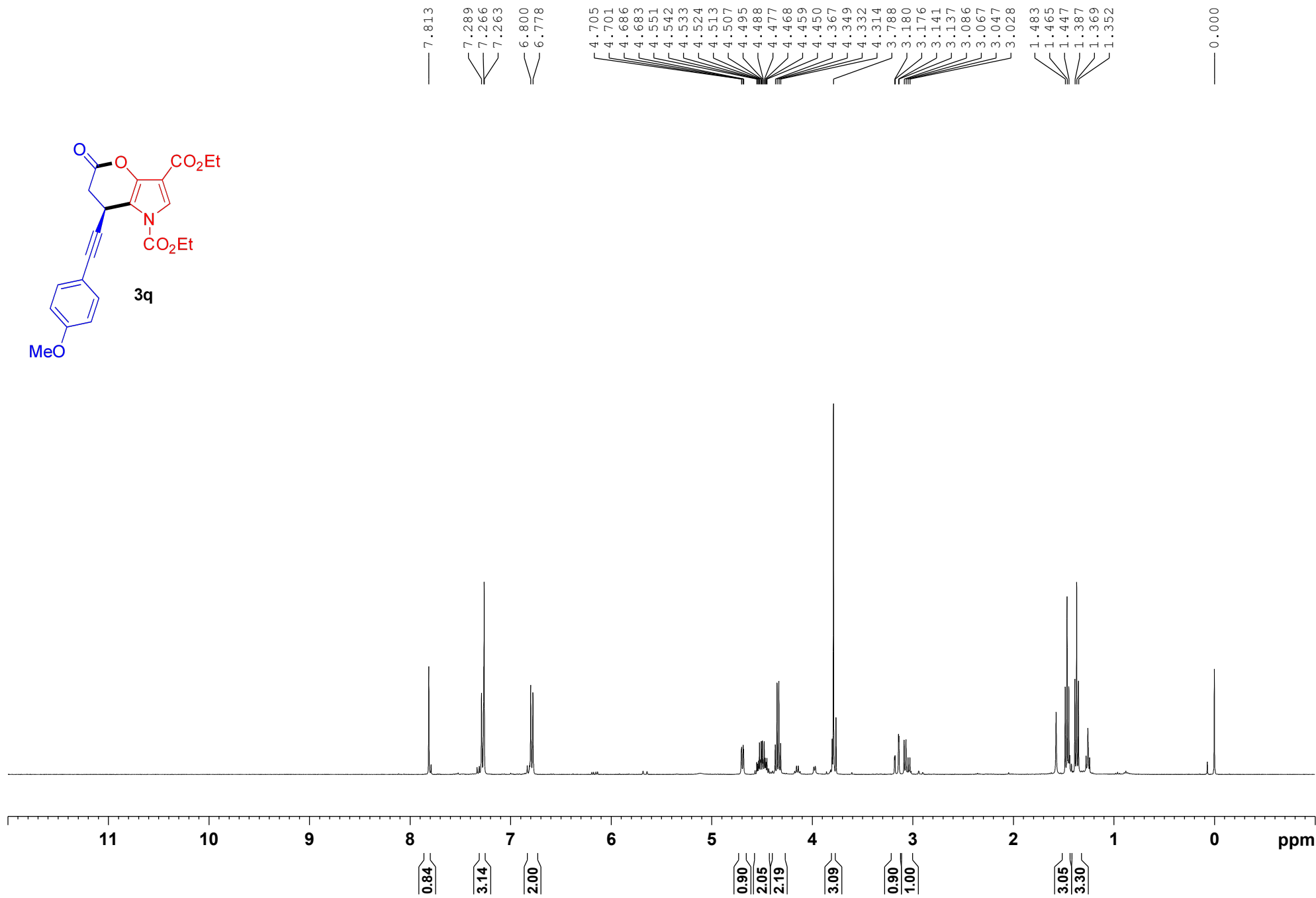
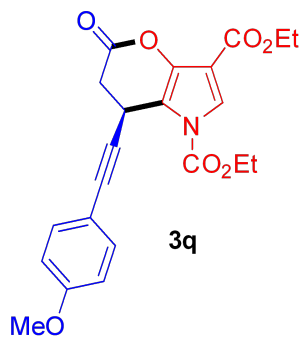
4.470  
 4.463  
 4.453  
 4.436  
 4.422  
 4.404  
 4.375  
 4.357  
 4.339  
 4.321  
 3.113  
 3.094  
 3.073  
 3.055  
 2.998  
 2.962  
 2.959

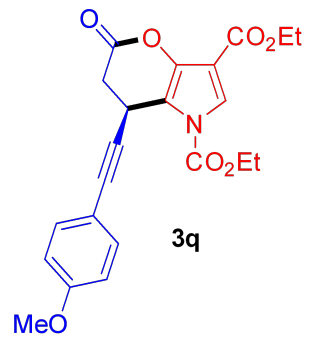
1.432  
 1.414  
 1.395  
 1.376  
 1.359

0.000









165.27  
161.87  
159.68

149.23

139.33

133.20

124.26

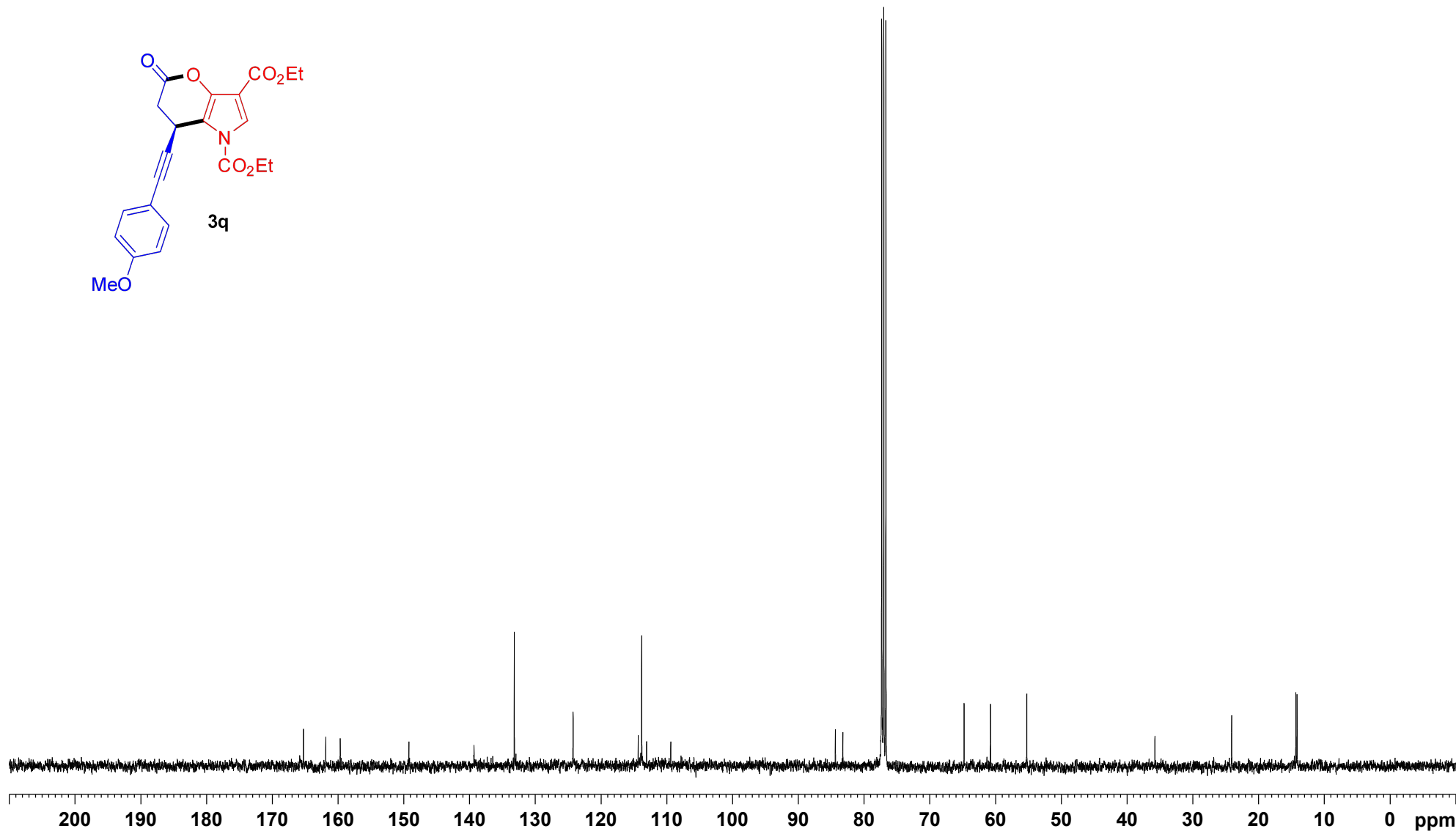
114.35  
113.83  
113.08  
109.40  
105.58

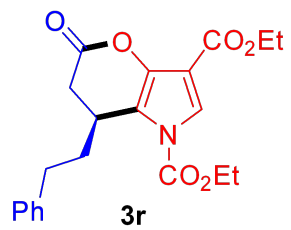
84.37  
83.23  
77.32  
77.00  
76.68

64.79  
60.77  
55.25

24.08

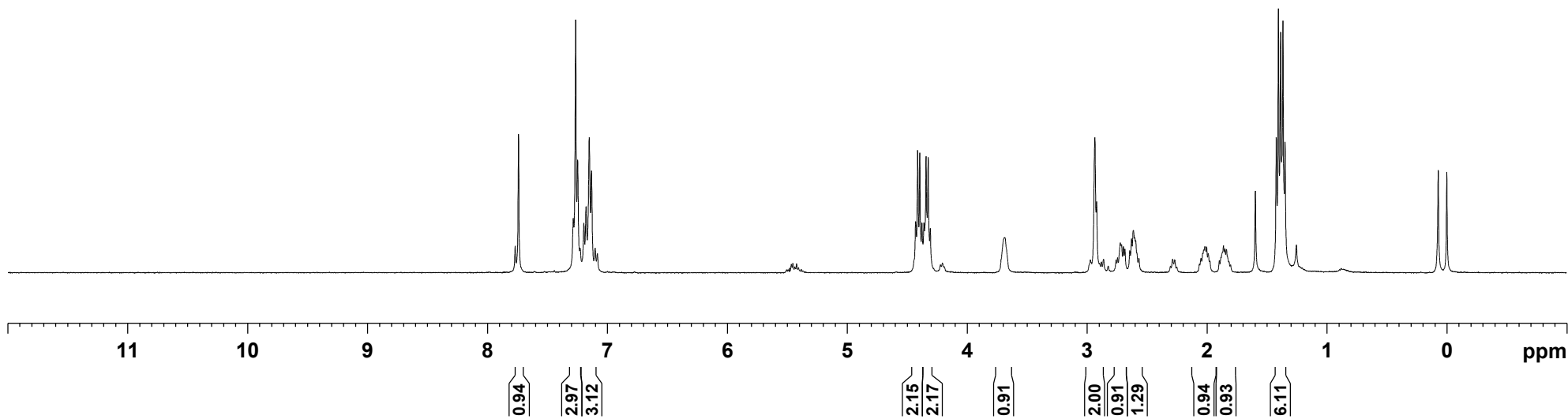
14.32  
14.14

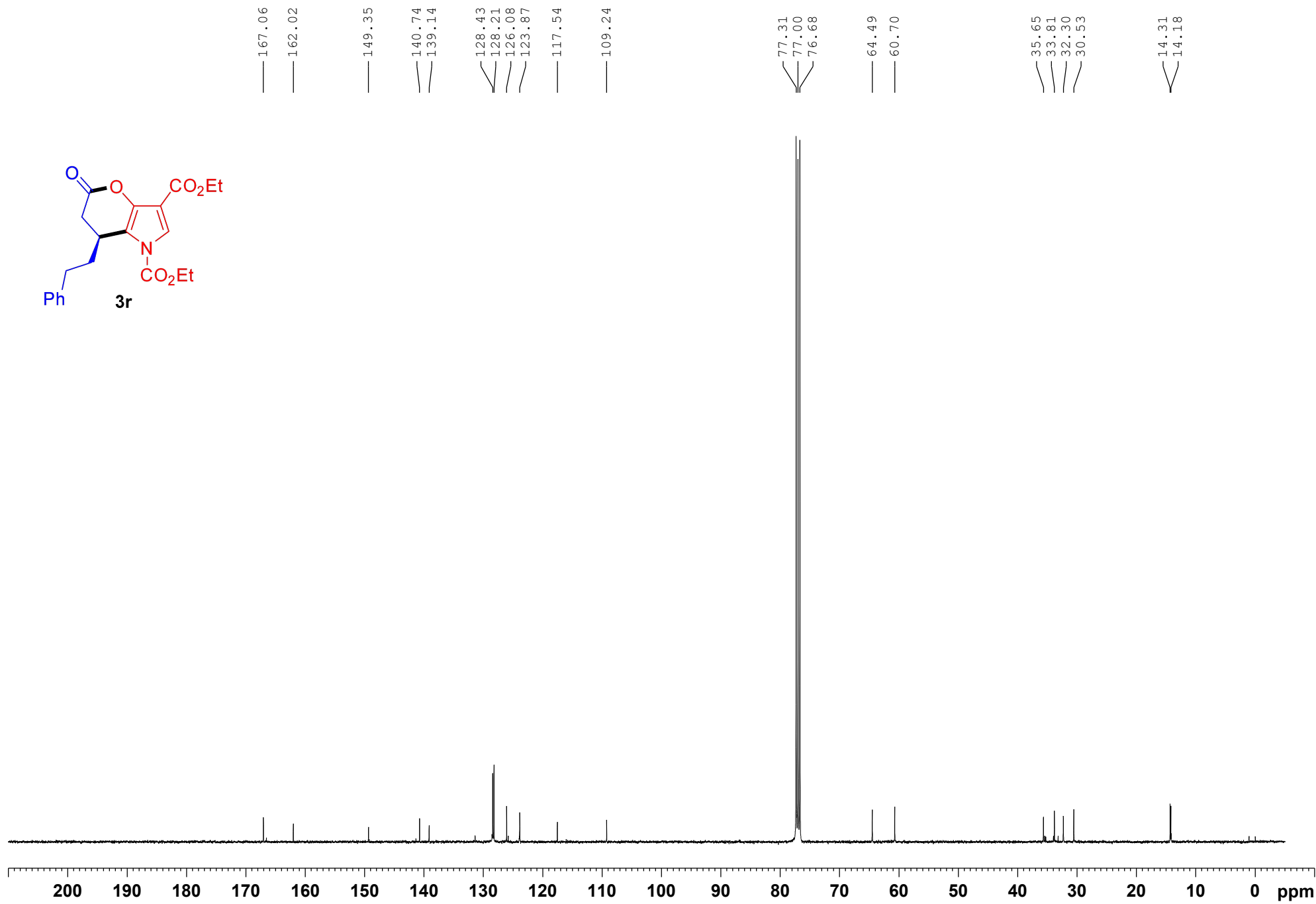
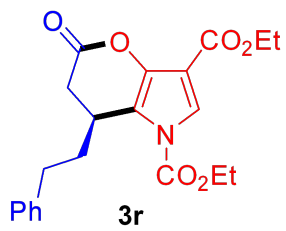


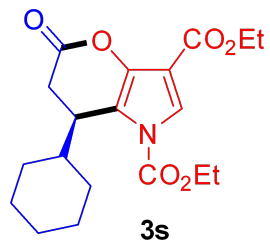


7.739  
7.283  
7.263  
7.247  
7.195  
7.177  
7.150  
7.131

4.429  
4.412  
4.394  
4.376  
4.359  
4.342  
4.324  
4.306  
3.688  
2.934  
2.919  
2.757  
2.745  
2.722  
2.711  
2.696  
2.684  
2.643  
2.628  
2.613  
2.602  
2.593  
2.567  
2.062  
2.048  
2.035  
2.017  
2.002  
1.989  
1.975  
1.897  
1.883  
1.861  
1.849  
1.836  
1.802  
1.421  
1.404  
1.384  
1.366  
1.348  
0.071  
-0.000



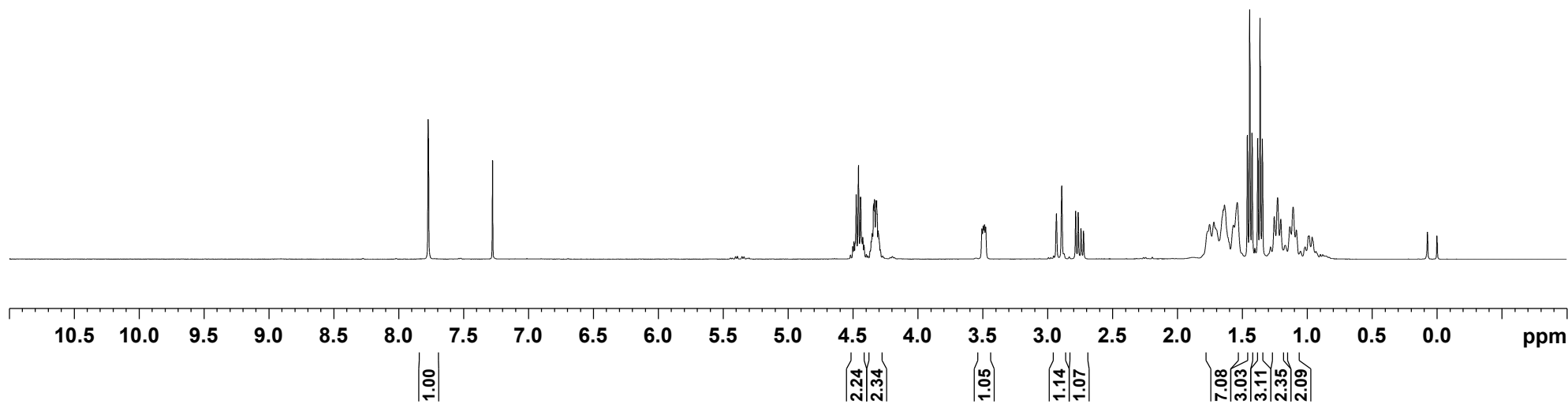


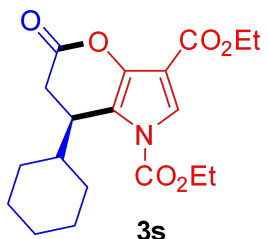


7.773  
7.770

7.277

4.501  
4.492  
4.483  
4.475  
4.457  
4.441  
4.439  
4.430  
4.424  
4.415  
4.359  
4.352  
4.348  
4.342  
4.337  
4.334  
4.330  
4.324  
4.320  
4.316  
4.313  
4.306  
4.303  
4.299  
3.506  
3.496  
3.486  
3.477  
2.932  
2.890  
2.784  
2.764  
2.743  
2.723  
1.752  
1.718  
1.646  
1.637  
1.567  
1.538  
1.461  
1.443  
1.425  
1.381  
1.363  
1.345  
1.254  
1.227  
1.203  
1.133  
1.108  
1.083  
0.073  
0.000





— 167.88

— 162.05

— 149.47

— 139.60

— 124.02

— 116.78

— 109.06

77.32  
77.00  
76.68

— 64.42

— 60.63

— 41.79

36.23

31.09

30.36

27.67

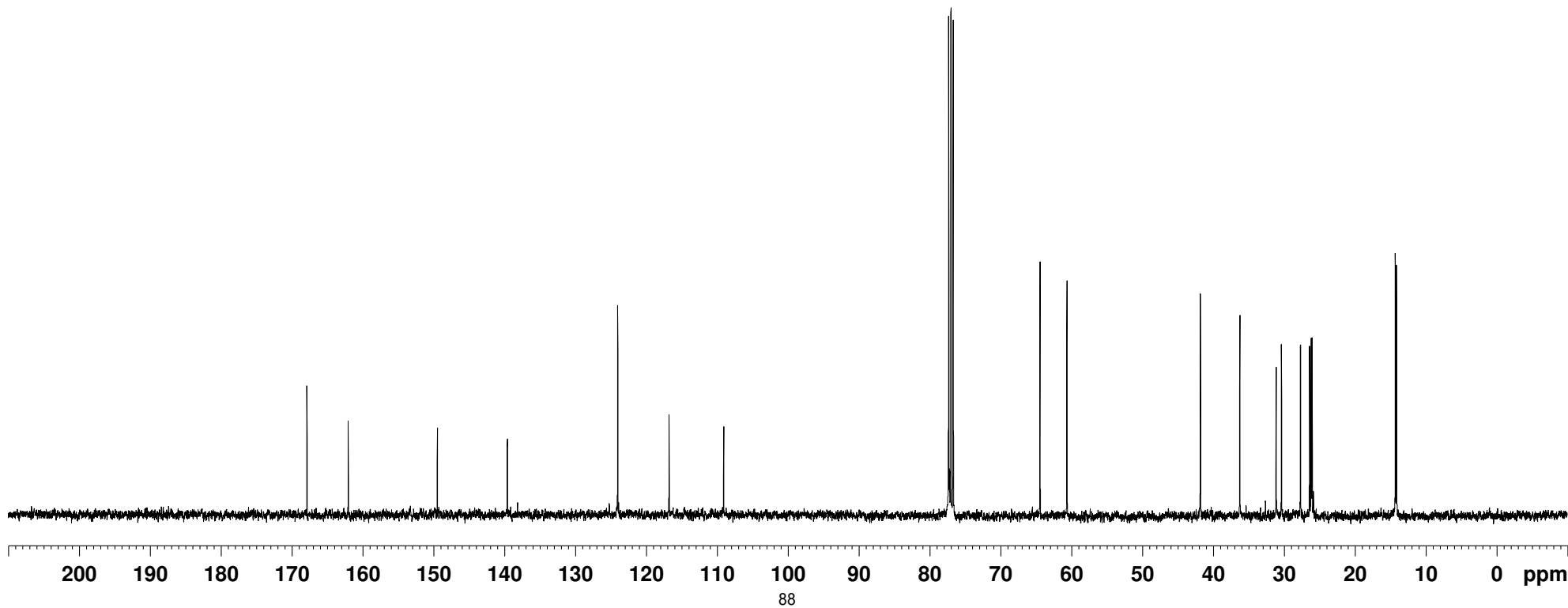
26.39

26.15

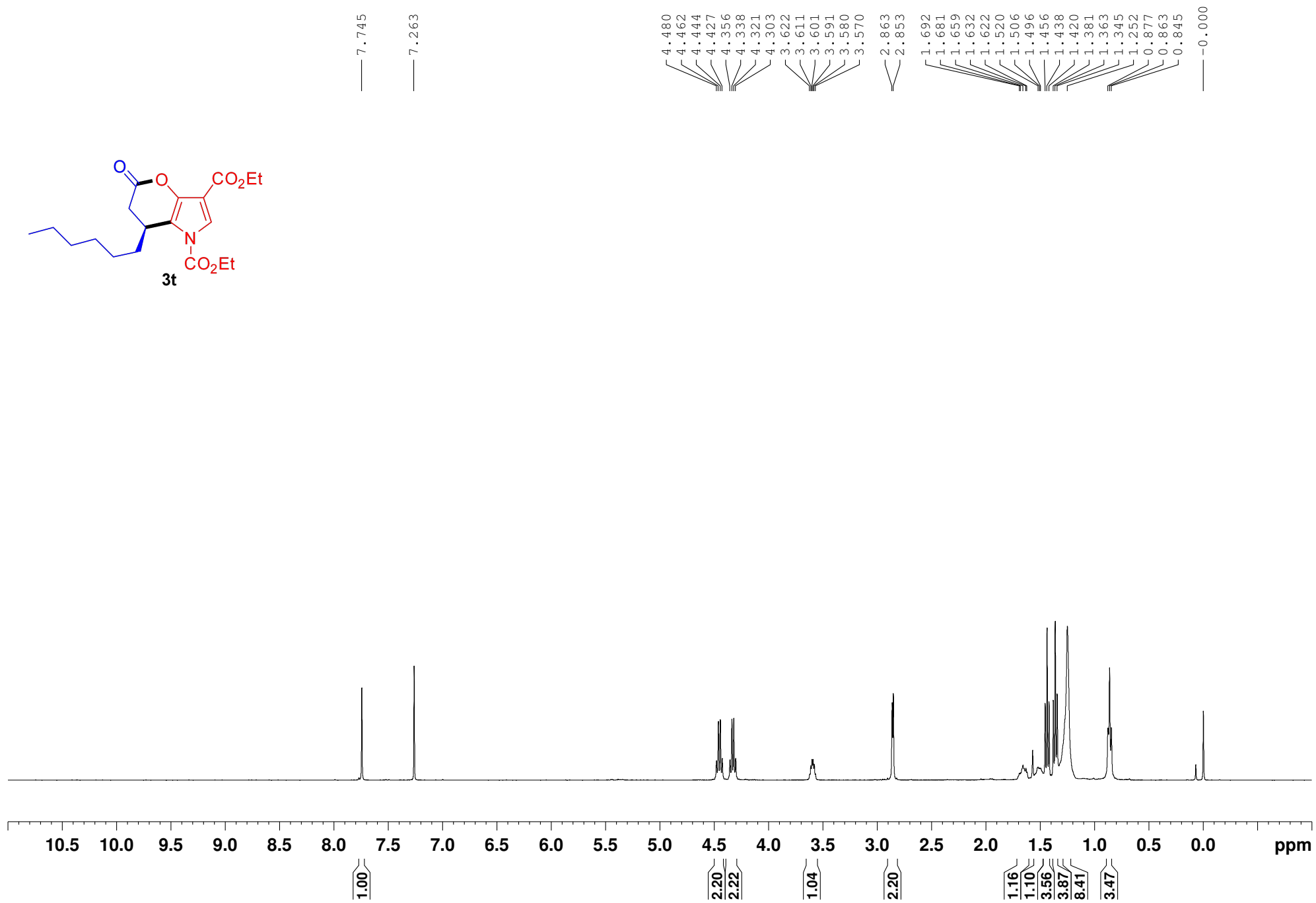
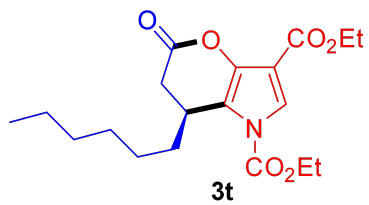
26.02

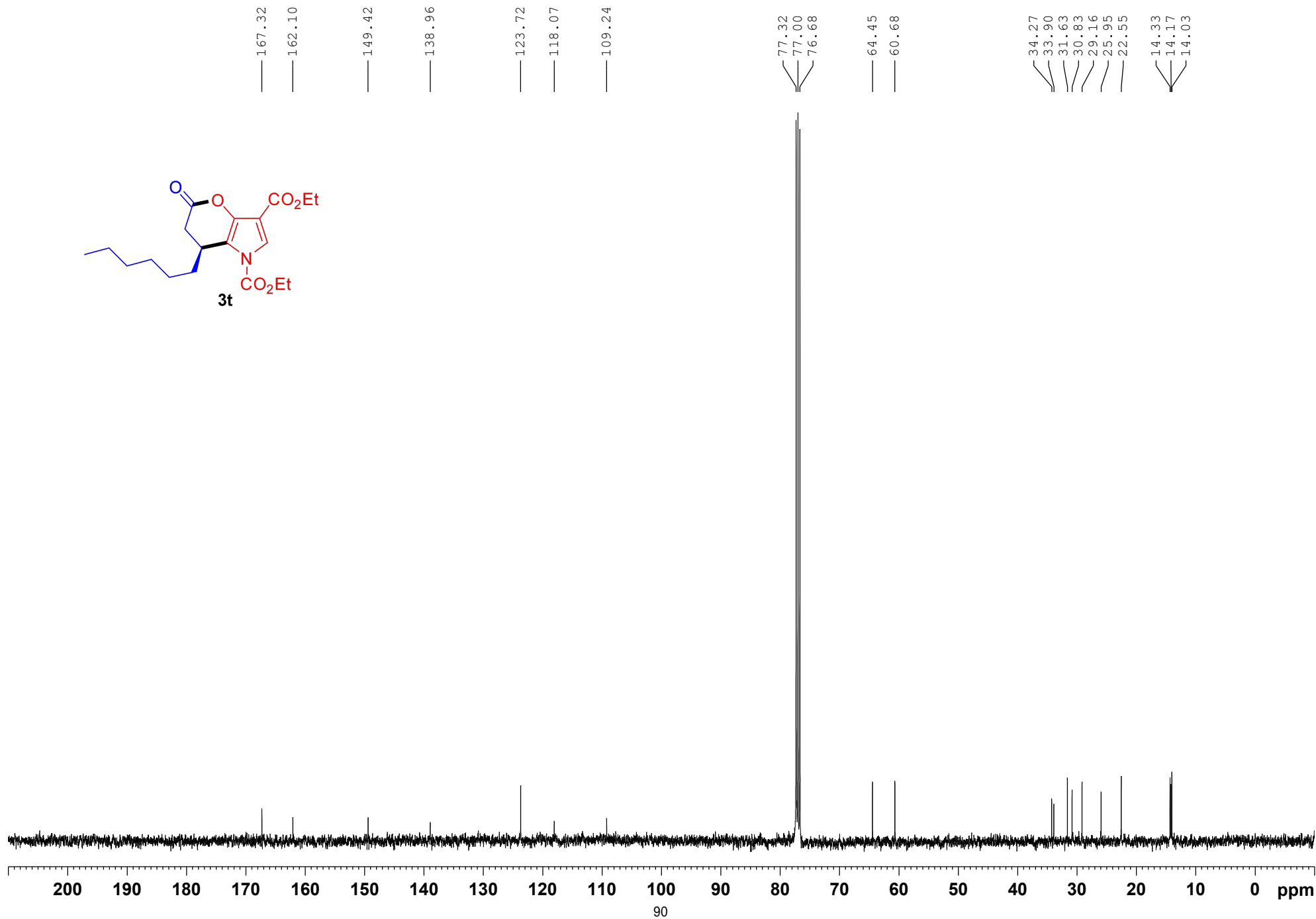
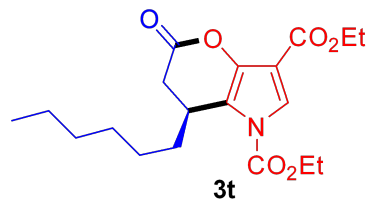
14.28

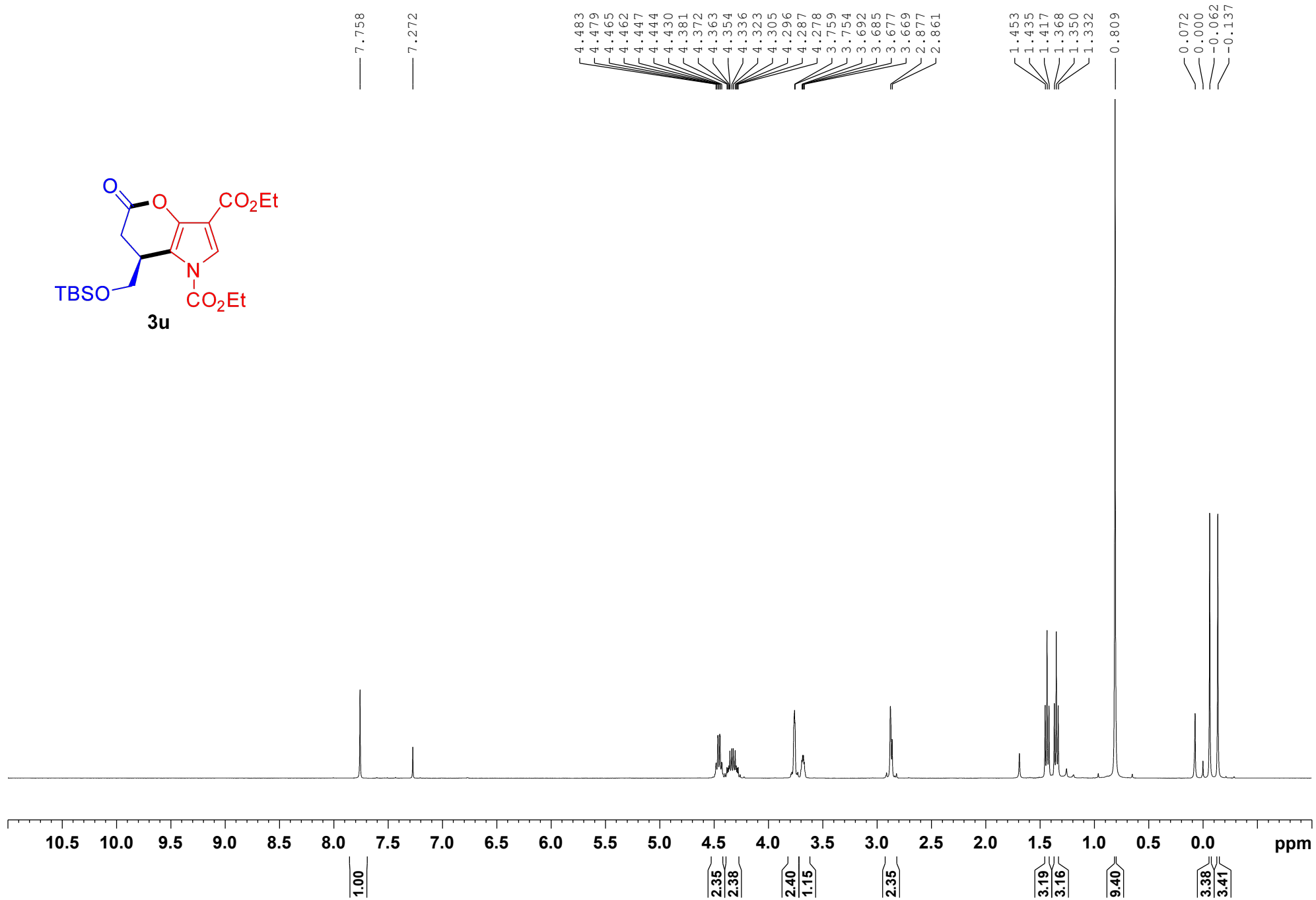
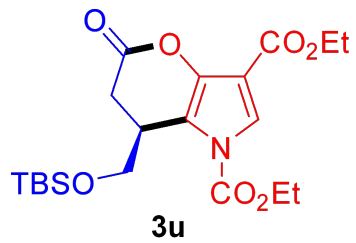
14.11

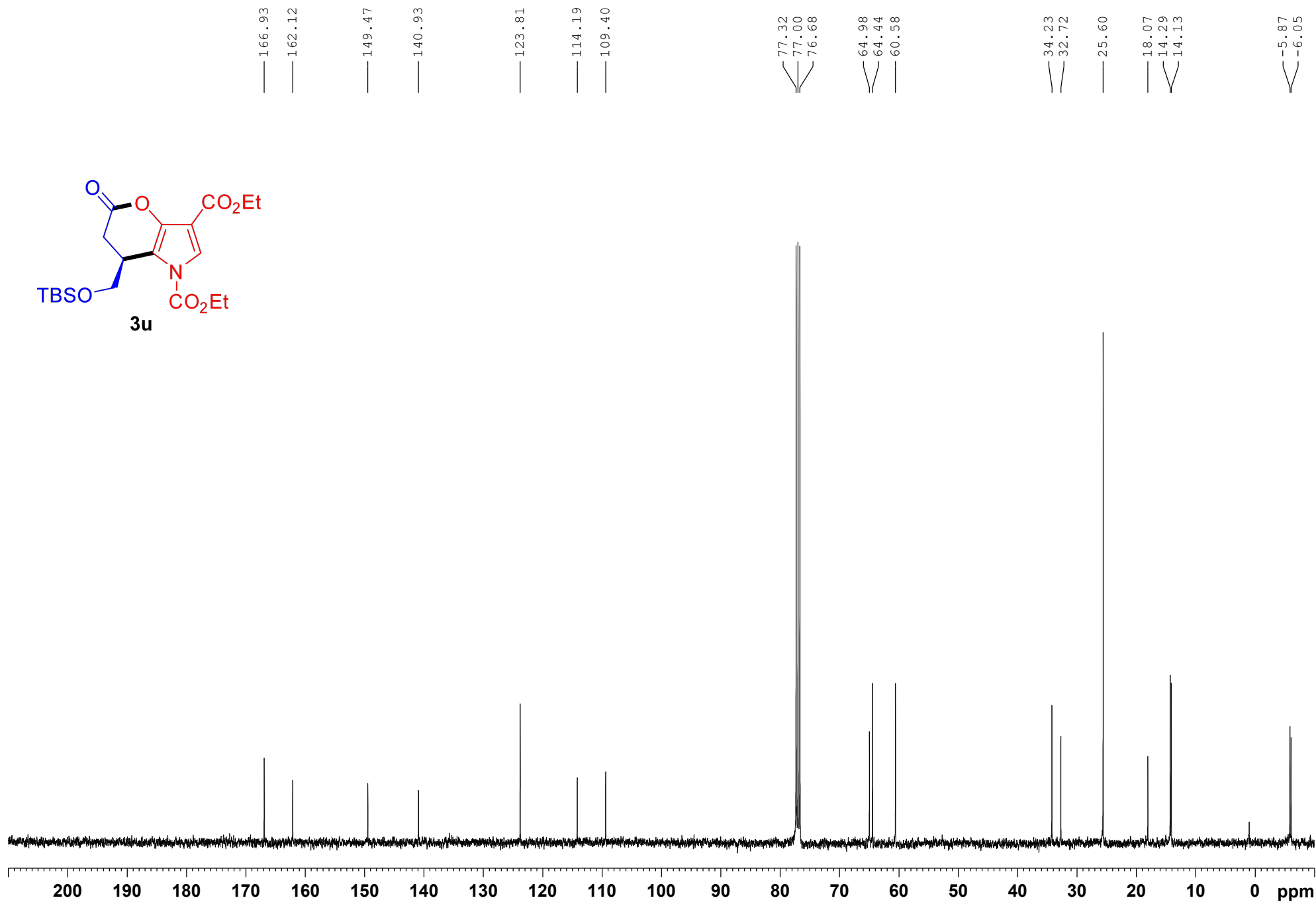
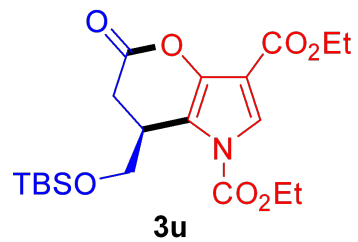


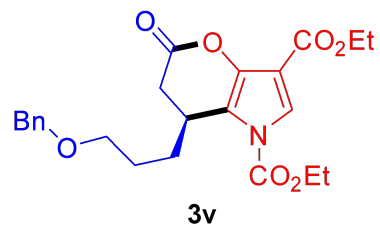






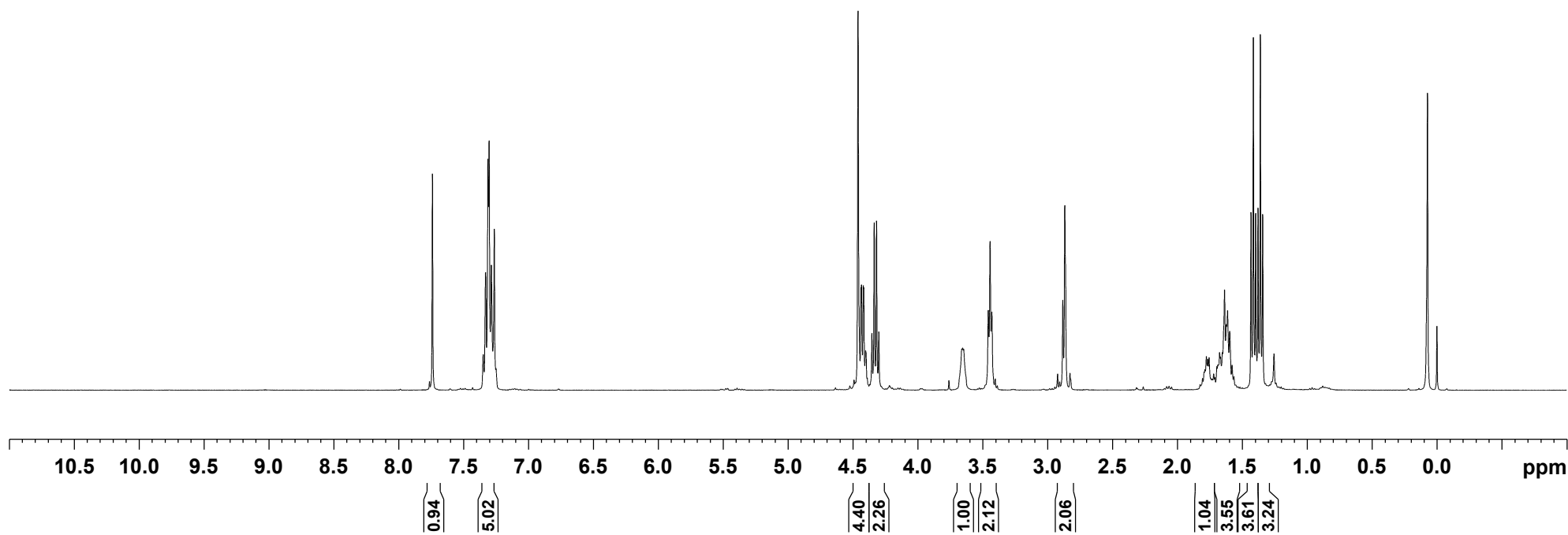


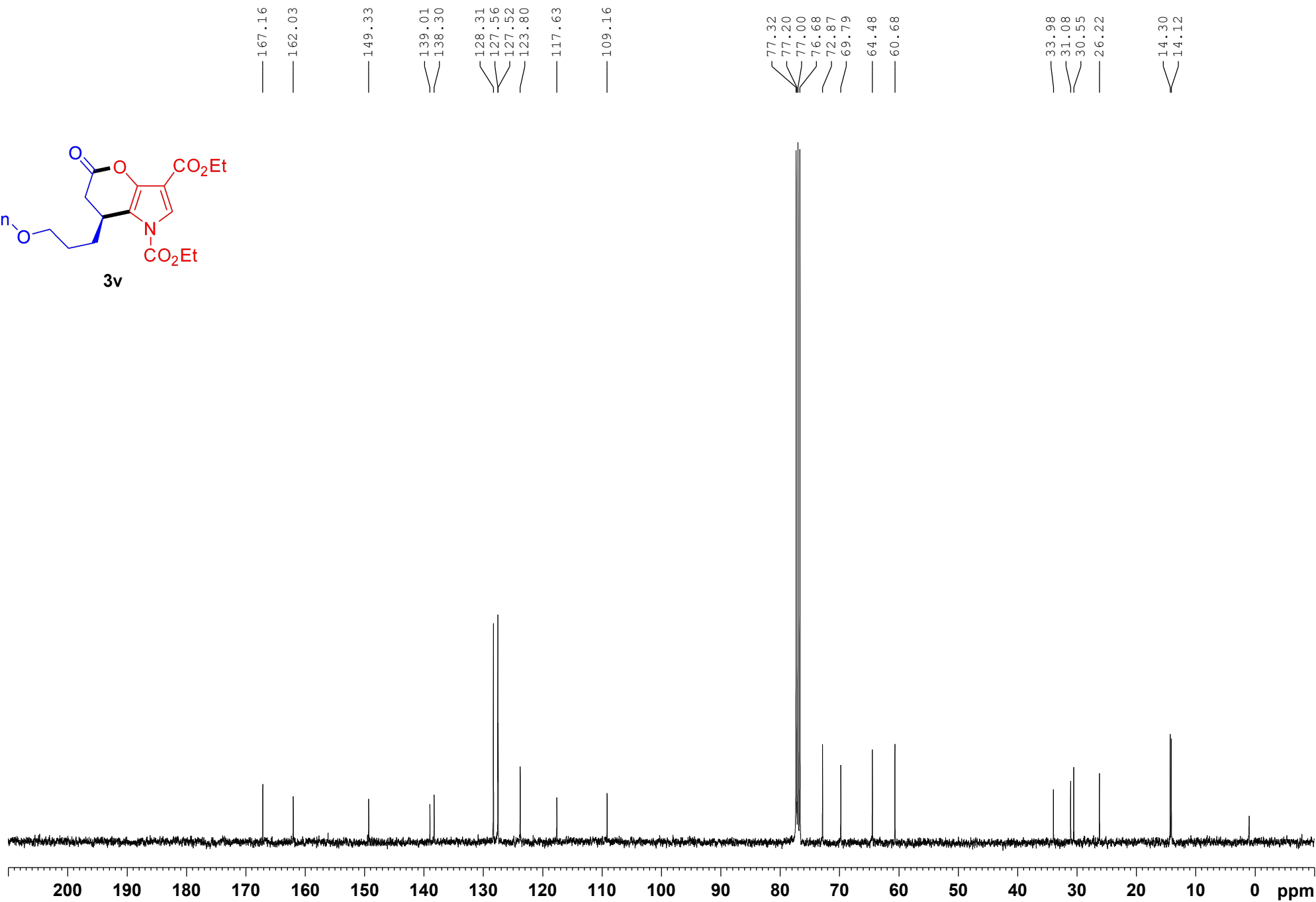
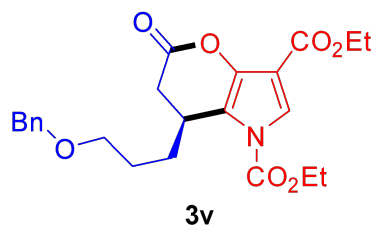


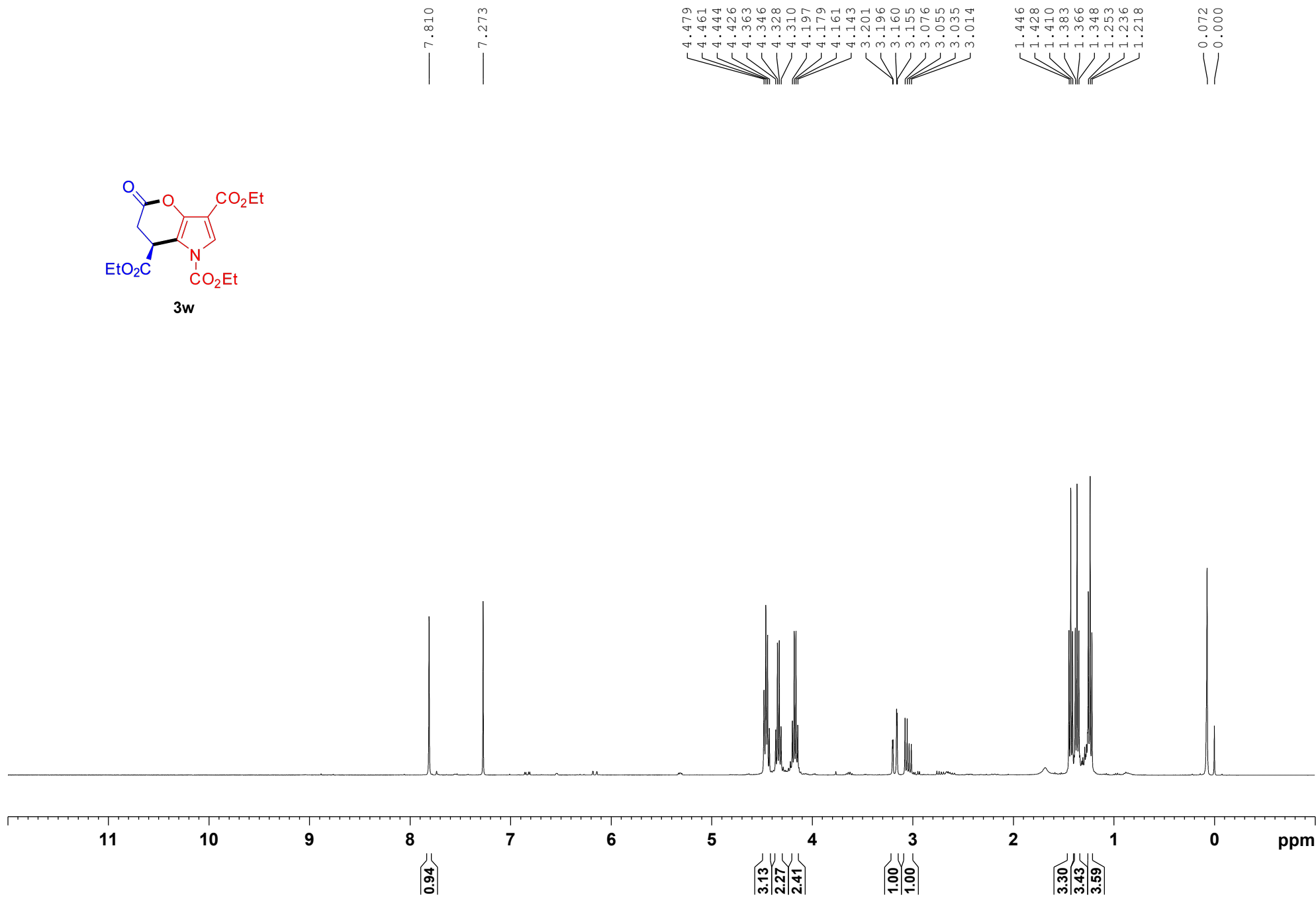
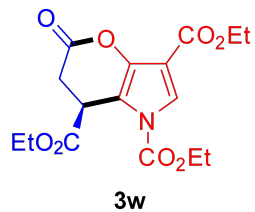


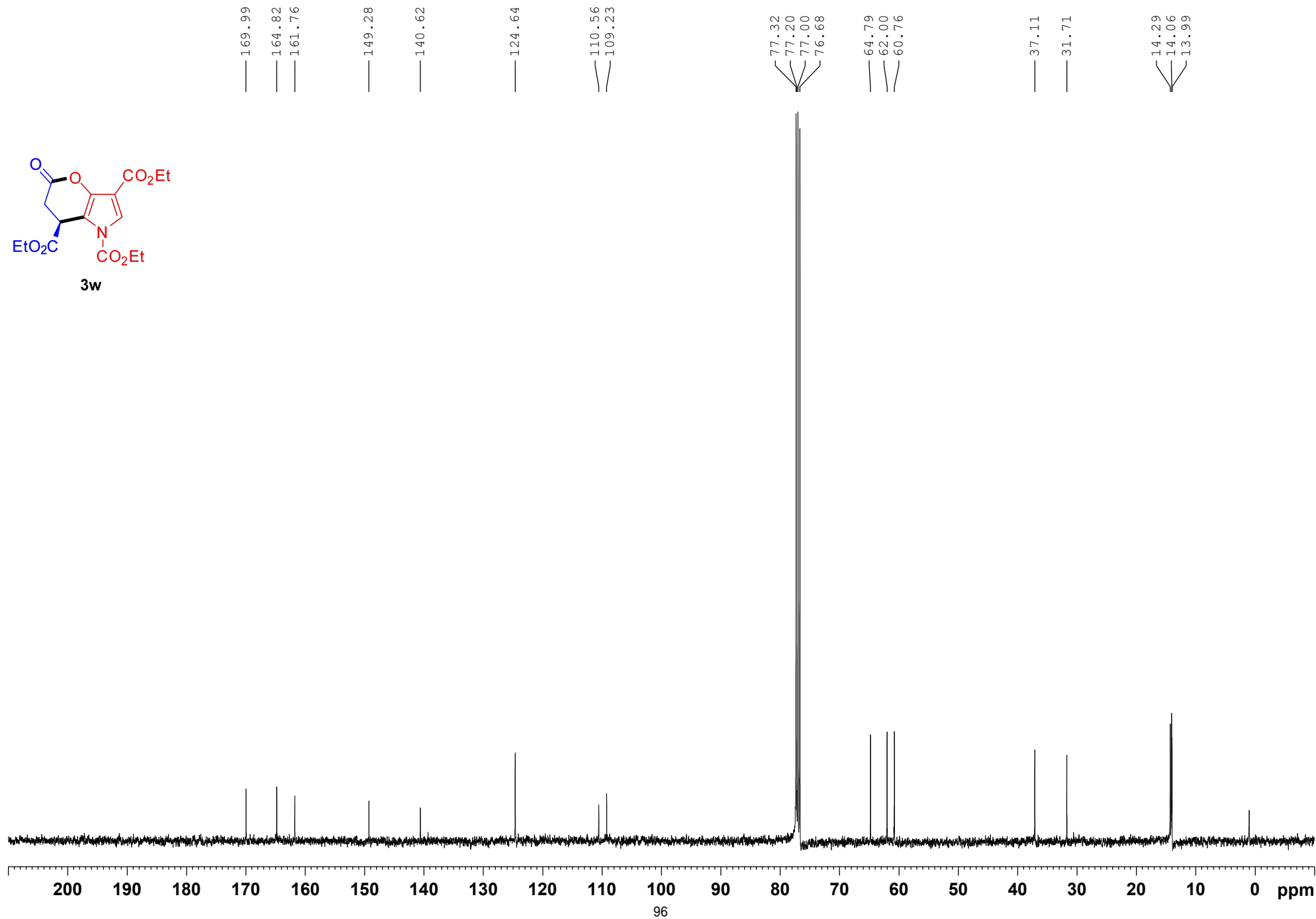
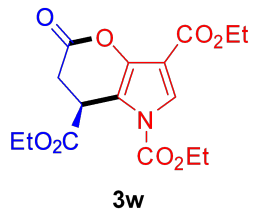
7.740  
7.349  
7.330  
7.312  
7.303  
7.286  
7.263

4.460  
4.437  
4.434  
4.420  
4.417  
4.402  
4.354  
4.336  
4.318  
4.300  
3.661  
3.654  
3.647  
3.457  
3.443  
3.429  
2.882  
2.867  
1.794  
1.788  
1.776  
1.766  
1.756  
1.720  
1.695  
1.688  
1.675  
1.668  
1.653  
1.636  
1.623  
1.613  
1.432  
1.414  
1.397  
1.378  
1.361  
1.343  
0.000

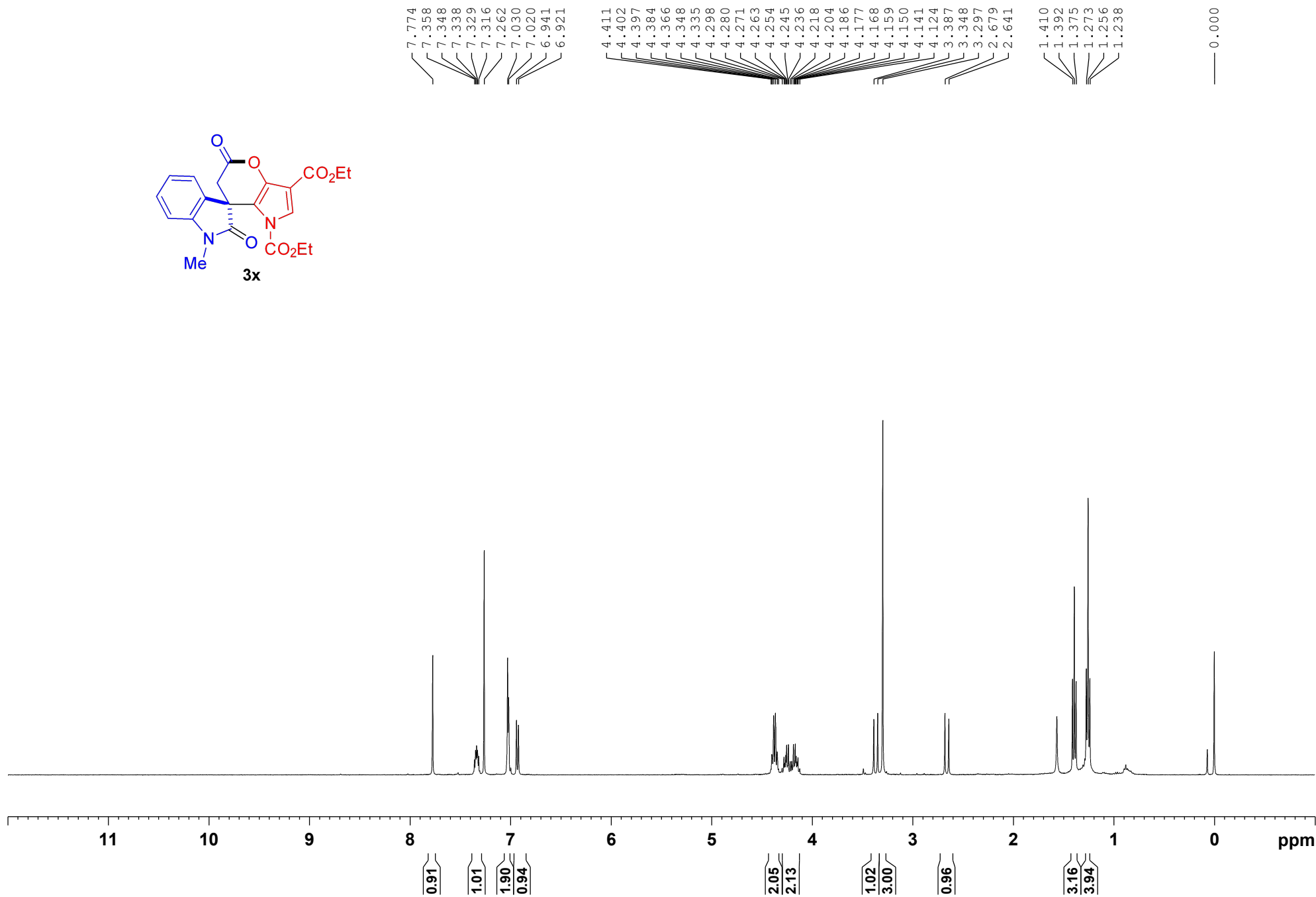
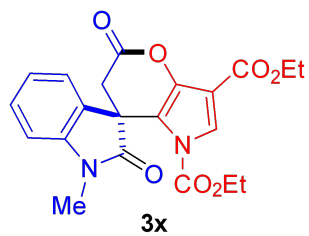


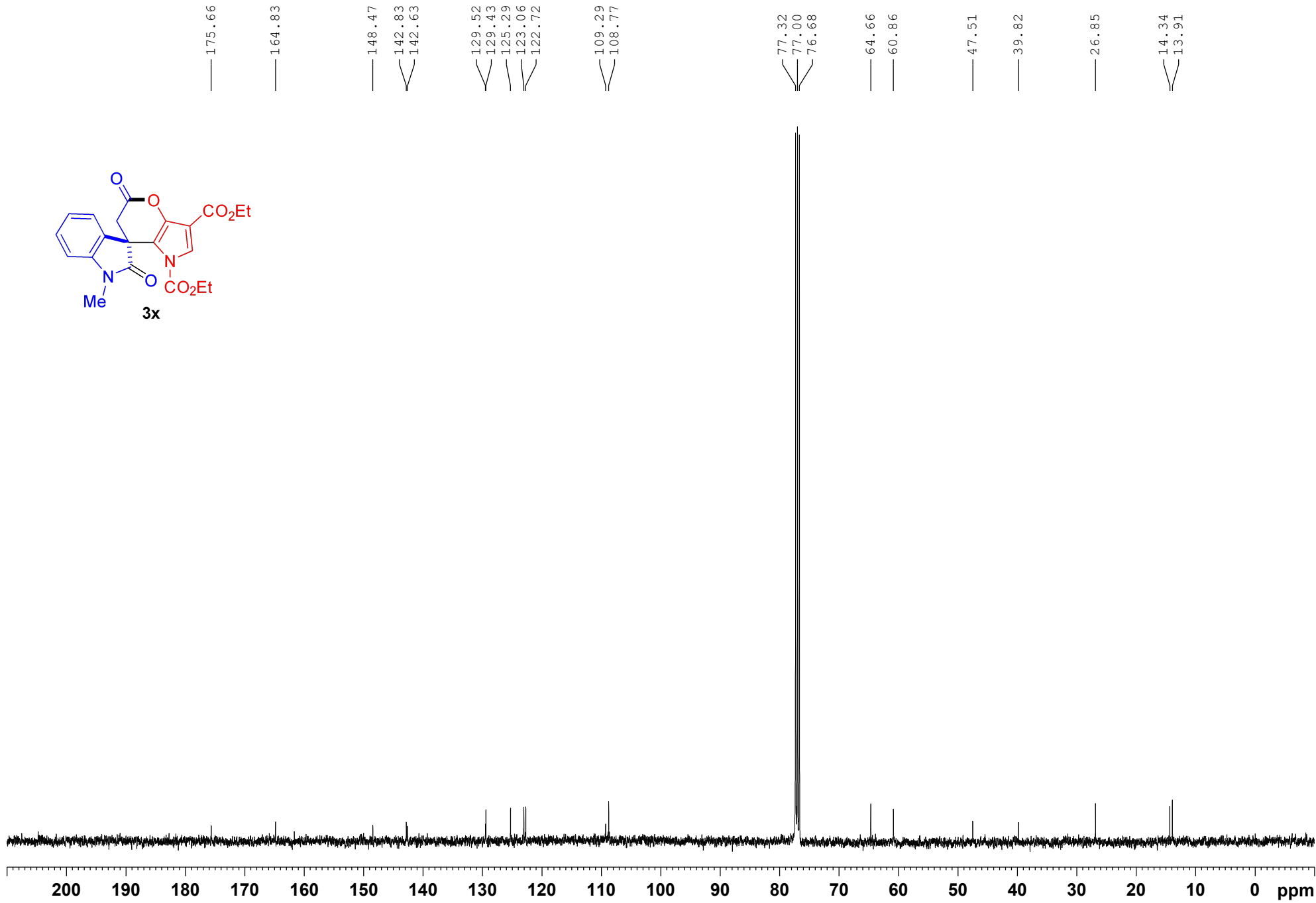
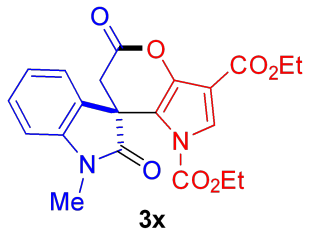


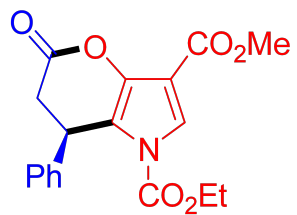












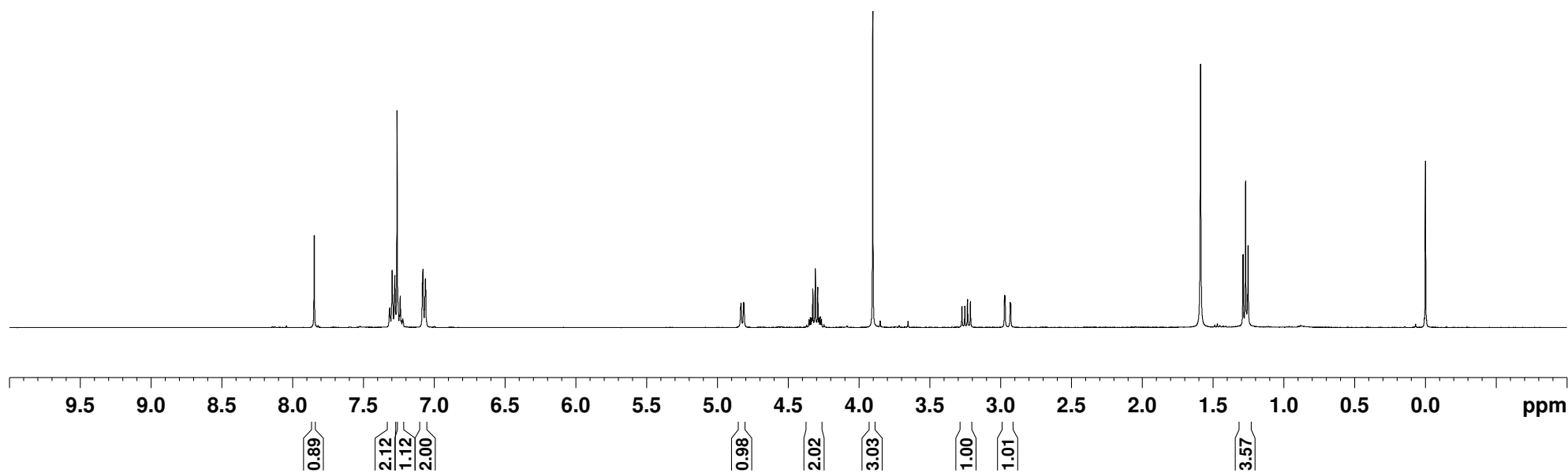
3y

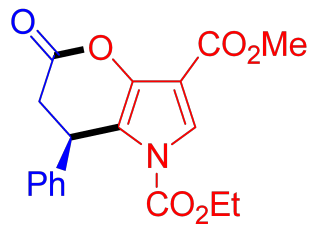
7.848  
7.315  
7.298  
7.279  
7.264  
7.247  
7.241  
7.234  
7.223  
7.084  
7.081  
7.063

4.834  
4.816  
4.354  
4.345  
4.336  
4.327  
4.317  
4.310  
4.301  
4.292  
4.283  
4.274  
4.266  
3.904  
3.274  
3.254  
3.234  
3.214  
2.973  
2.969  
2.933  
2.929

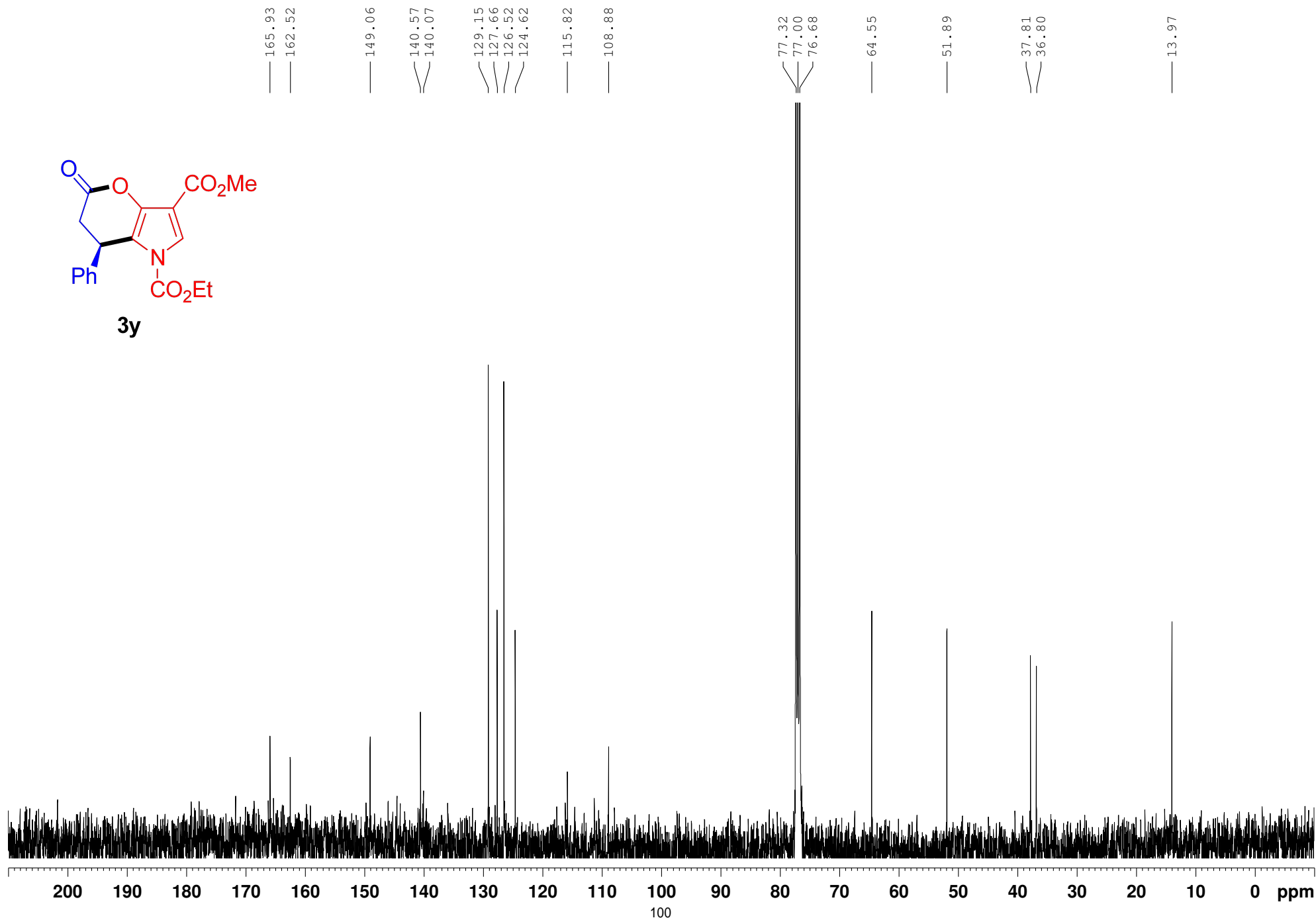
1.288  
1.271  
1.253

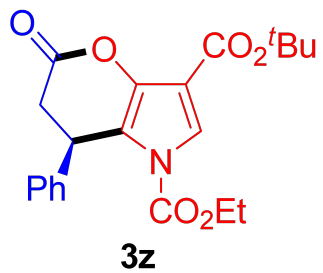
0.000





3y





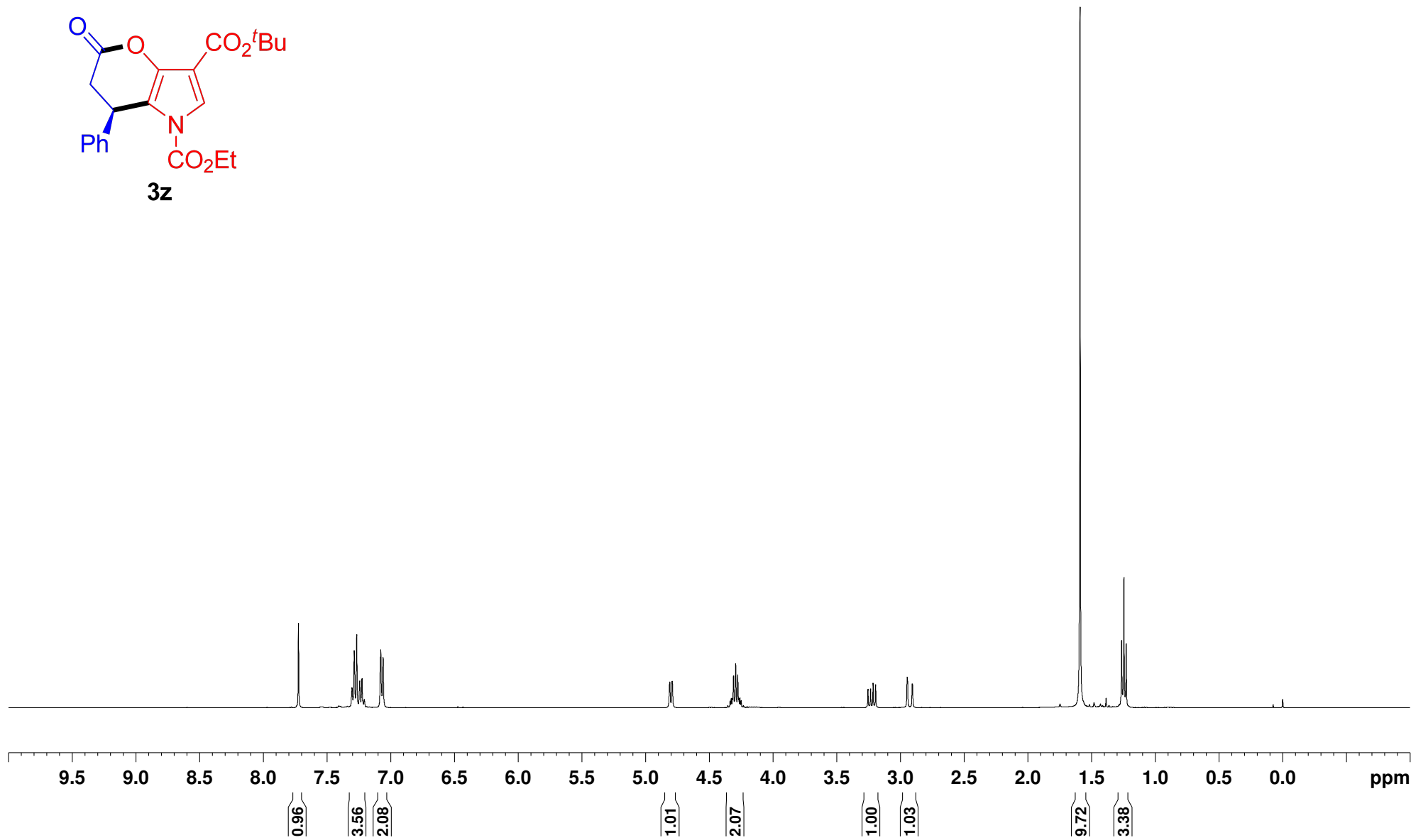
7.725  
7.305  
7.288  
7.268  
7.244  
7.227  
7.208  
7.079  
7.061

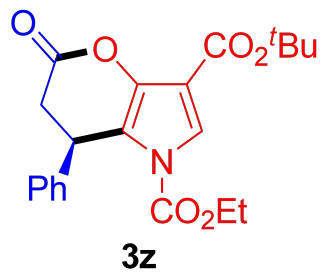
4.811  
4.792  
4.337  
4.328  
4.319  
4.311  
4.294  
4.277  
4.269  
4.260  
4.251

3.255  
3.235  
3.216  
3.195  
2.948  
2.946  
2.909  
2.906

1.591  
1.265  
1.247  
1.229

0.000





— 165.84

— 161.17

— 149.21

— 140.72

— 140.46

— 129.05

— 127.52

— 126.52

— 123.96

— 115.50

— 110.58

— 81.49

— 77.32

— 77.00

— 76.68

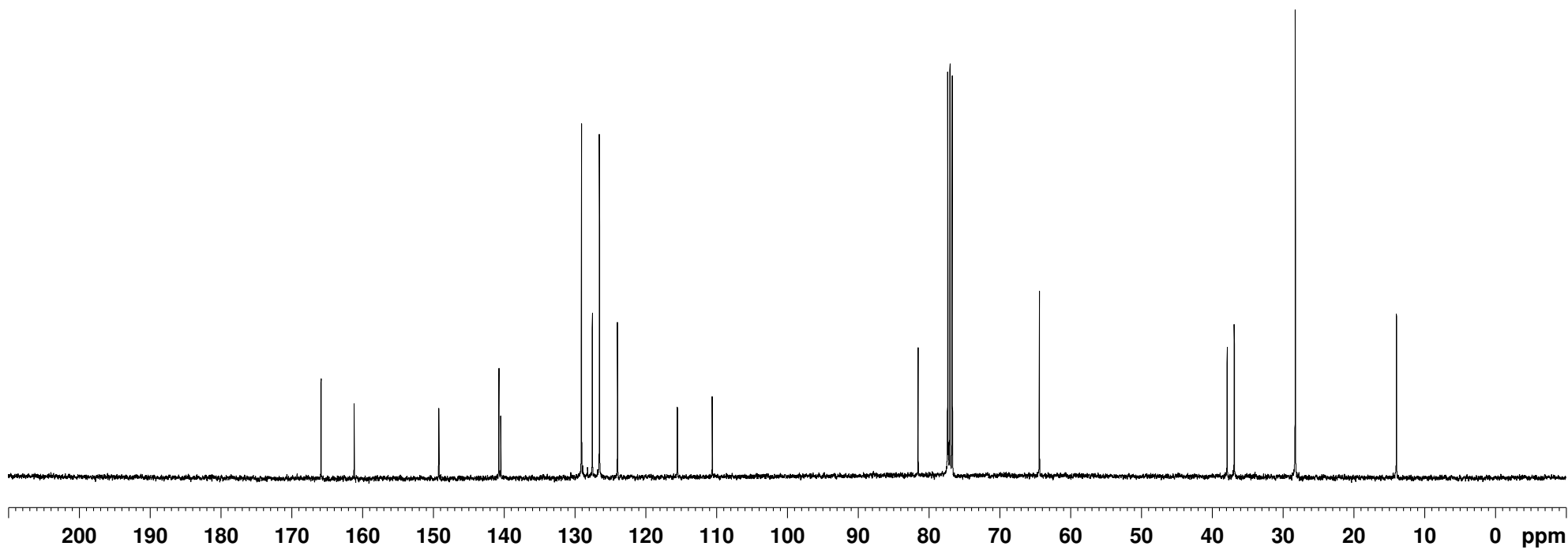
— 64.36

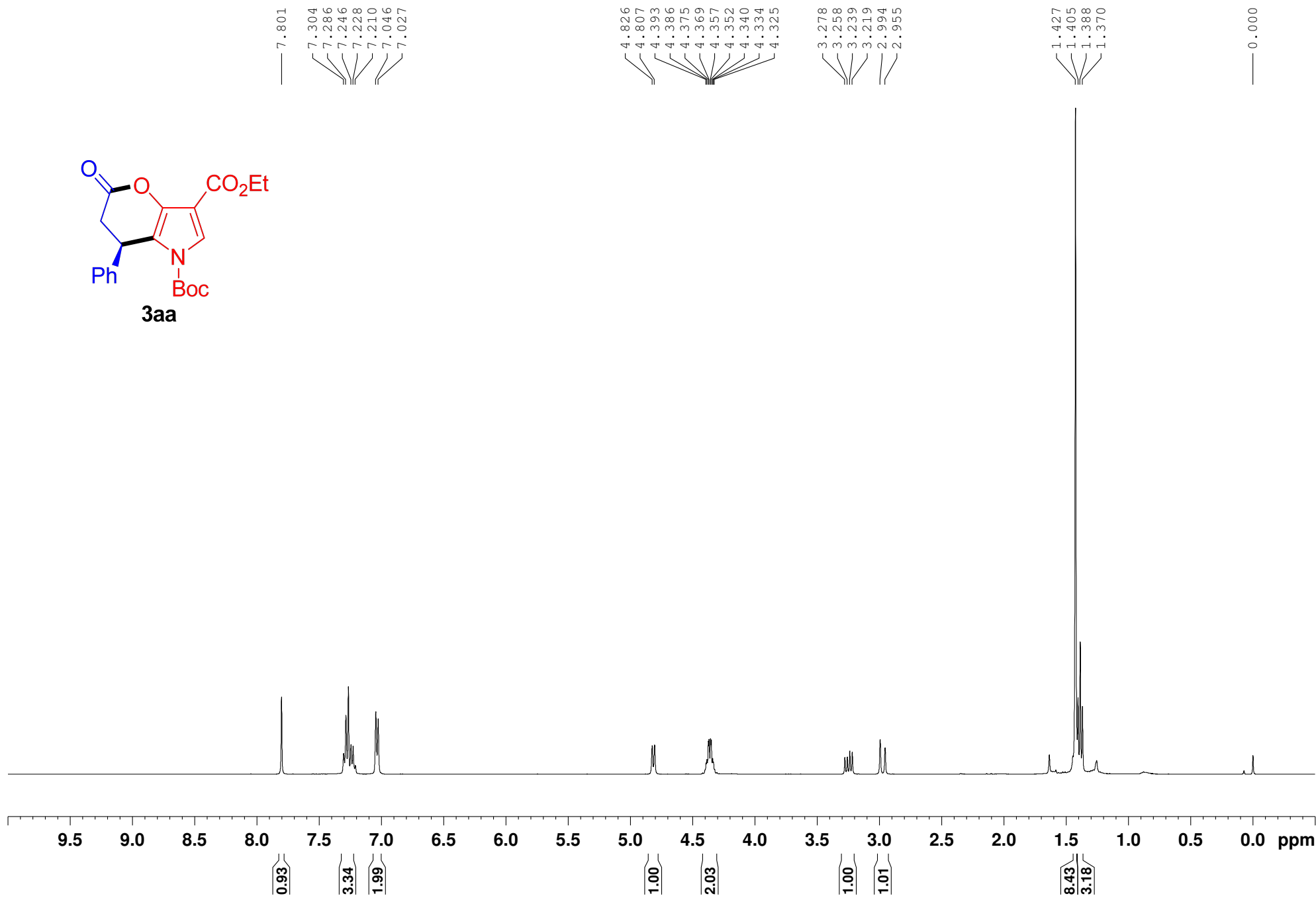
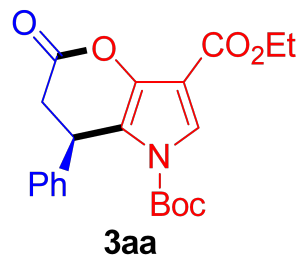
— 37.84

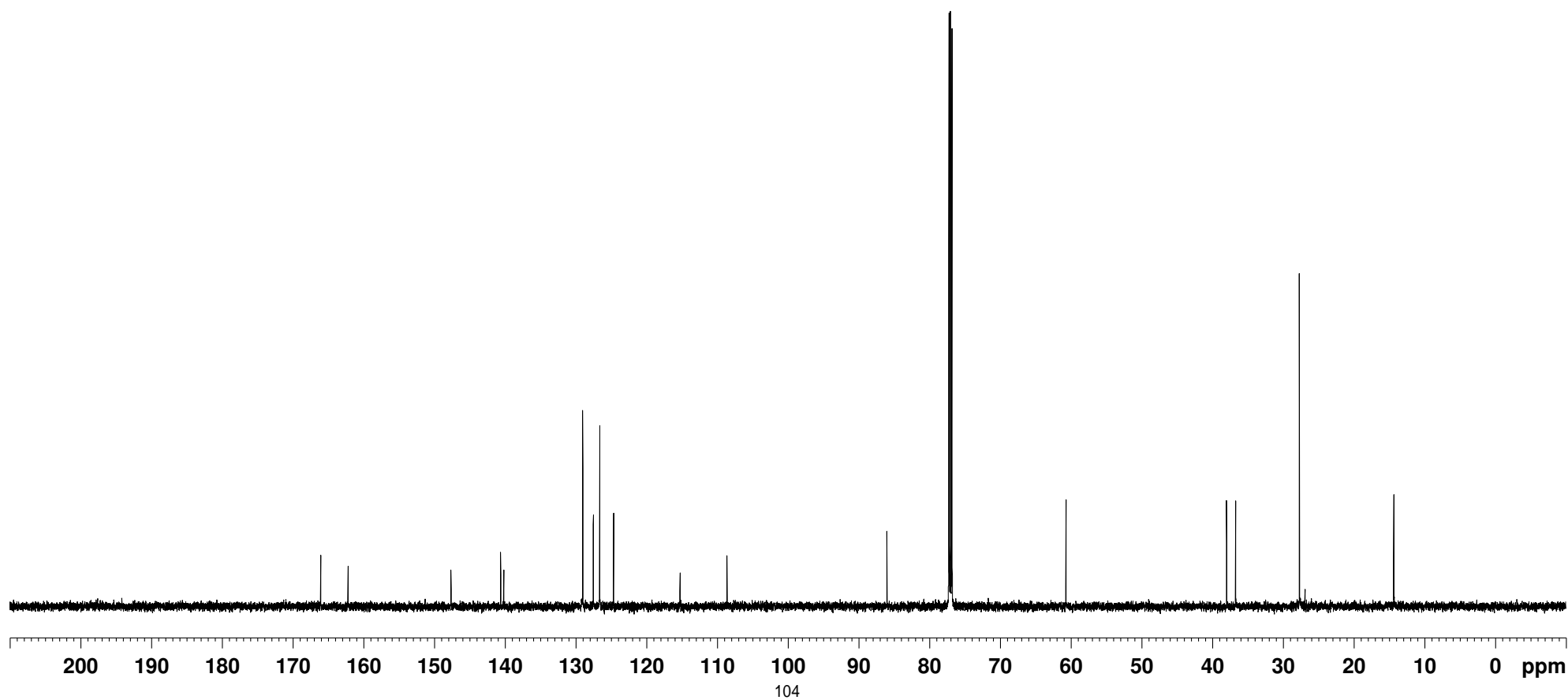
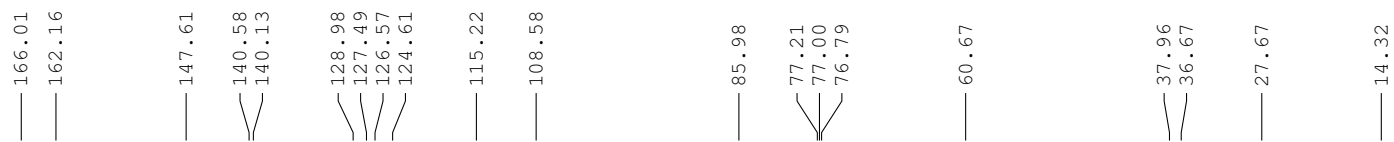
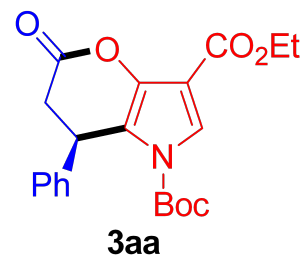
— 36.84

— 28.21

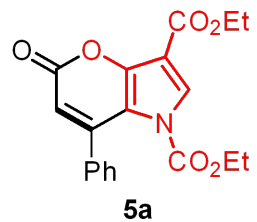
— 13.92











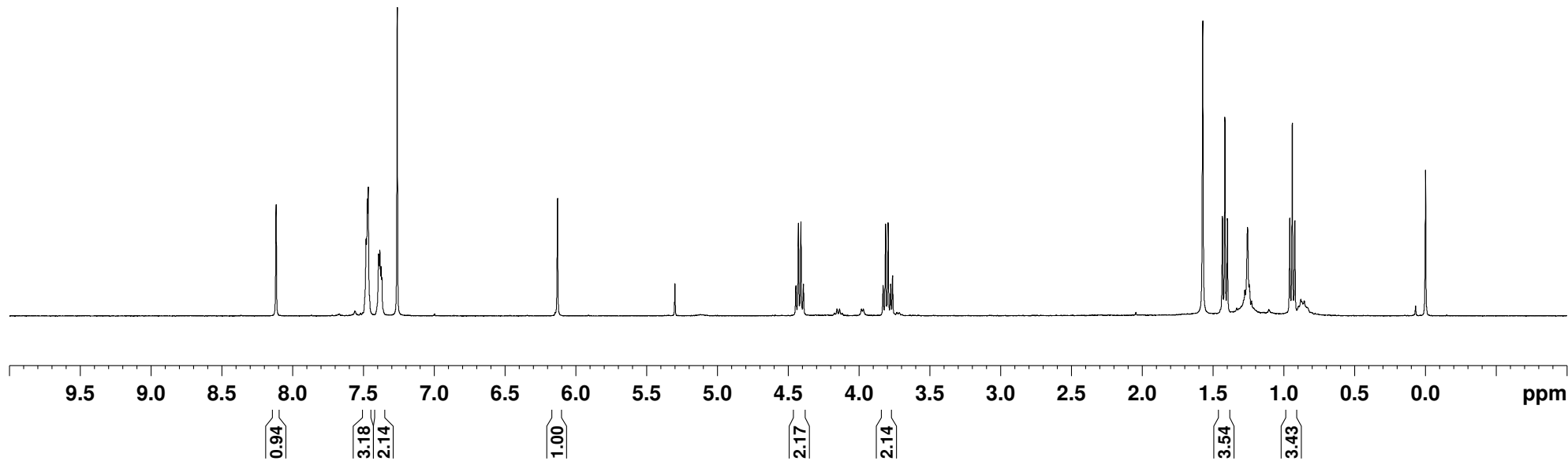
8.115  
7.482  
7.473  
7.467  
7.394  
7.386  
7.376  
7.371  
7.262

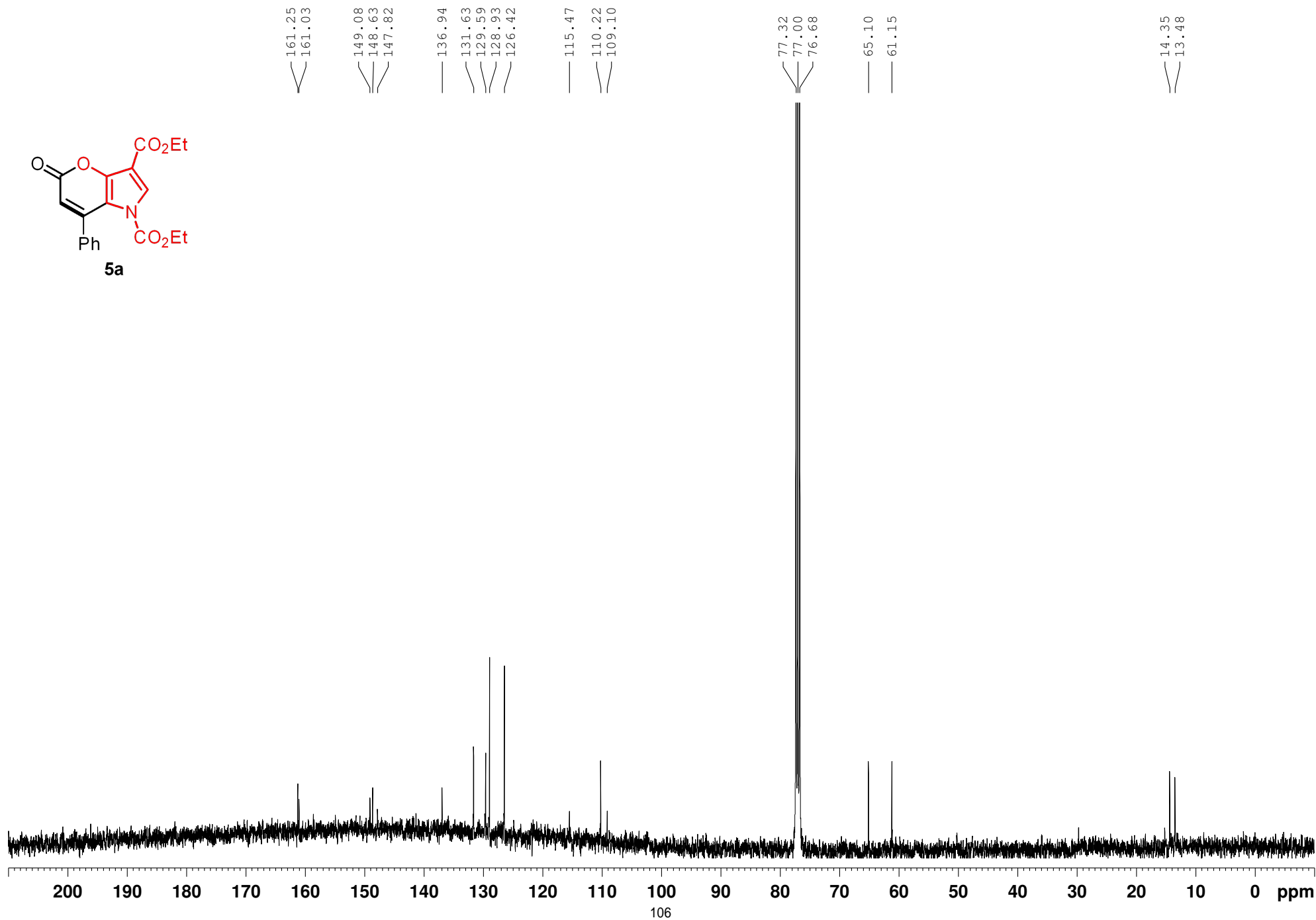
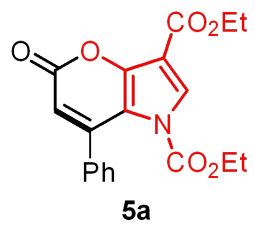
6.130

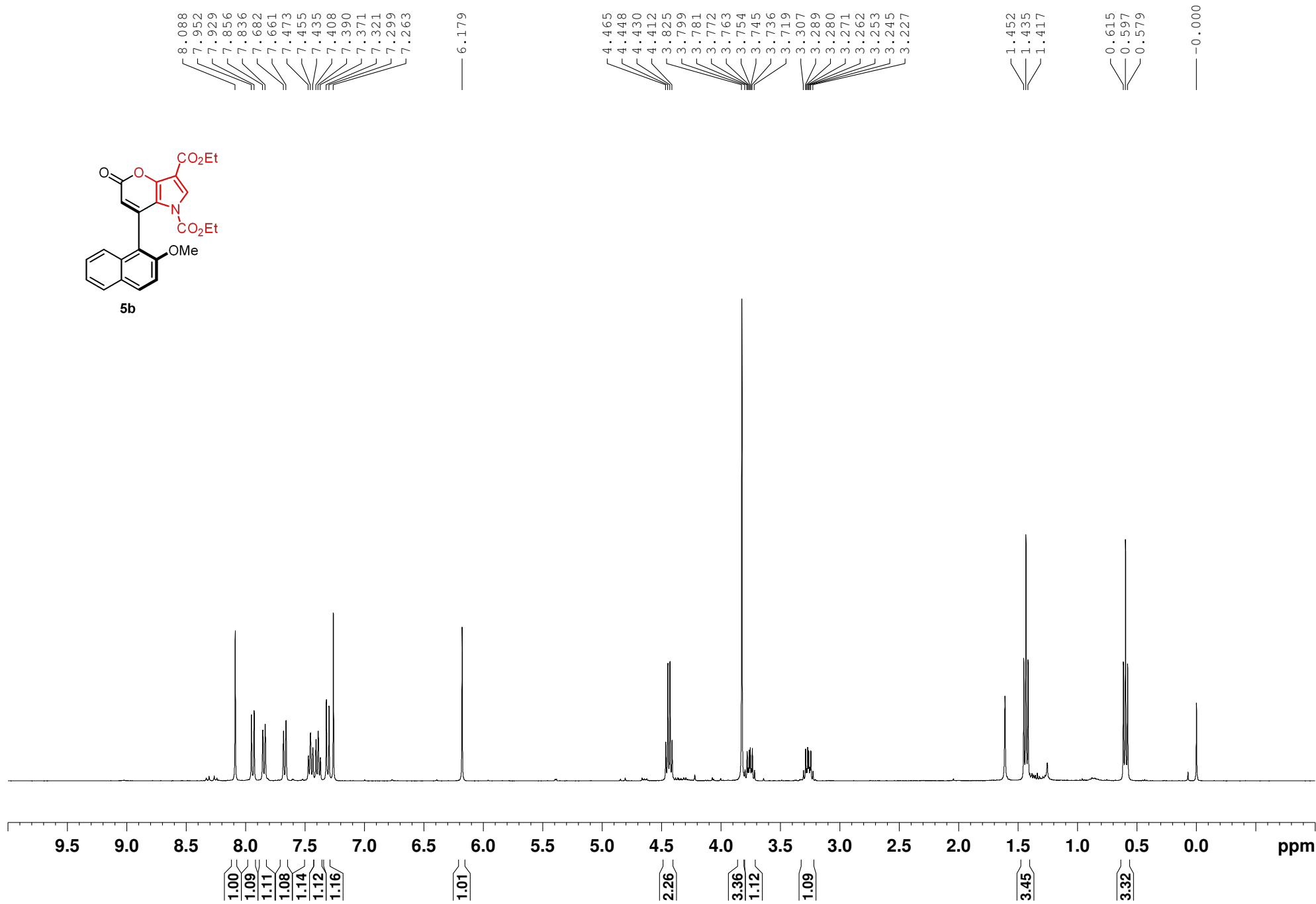
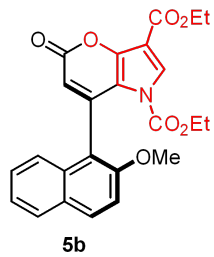
4.447  
4.429  
4.411  
4.393  
3.831  
3.813  
3.795  
3.777

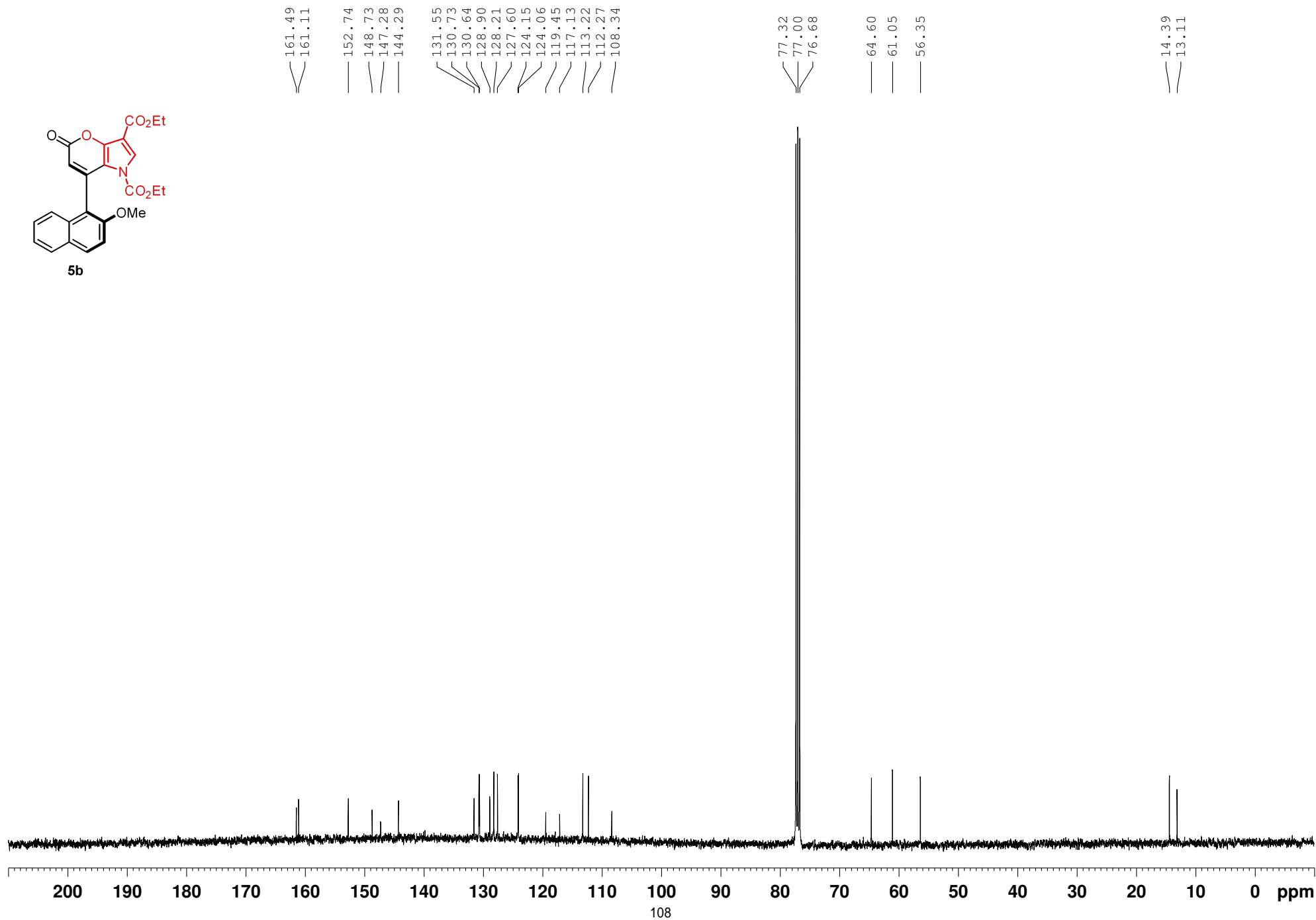
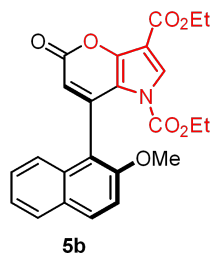
1.435  
1.417  
1.399  
0.959  
0.941  
0.923

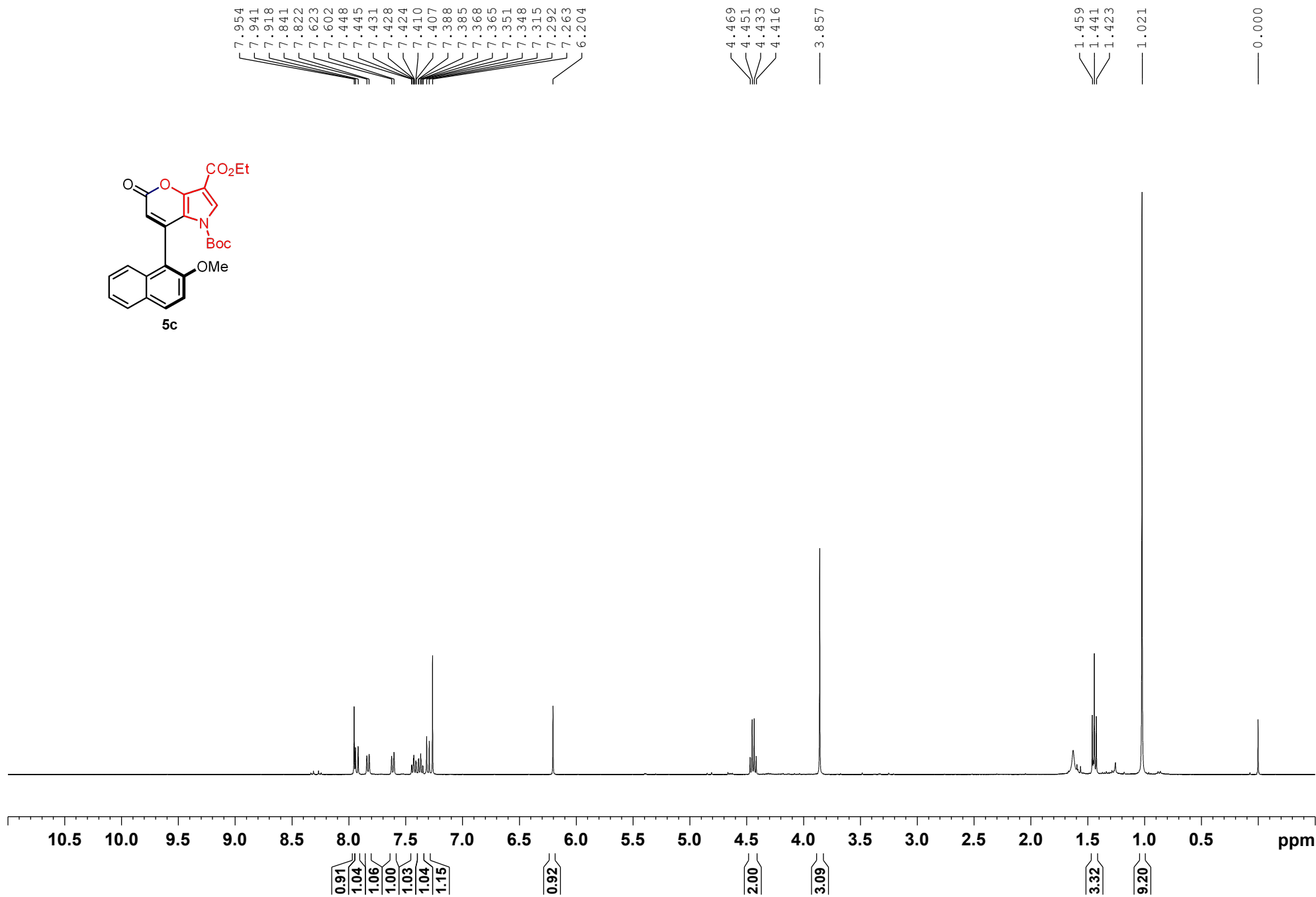
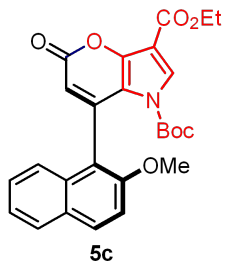
0.000

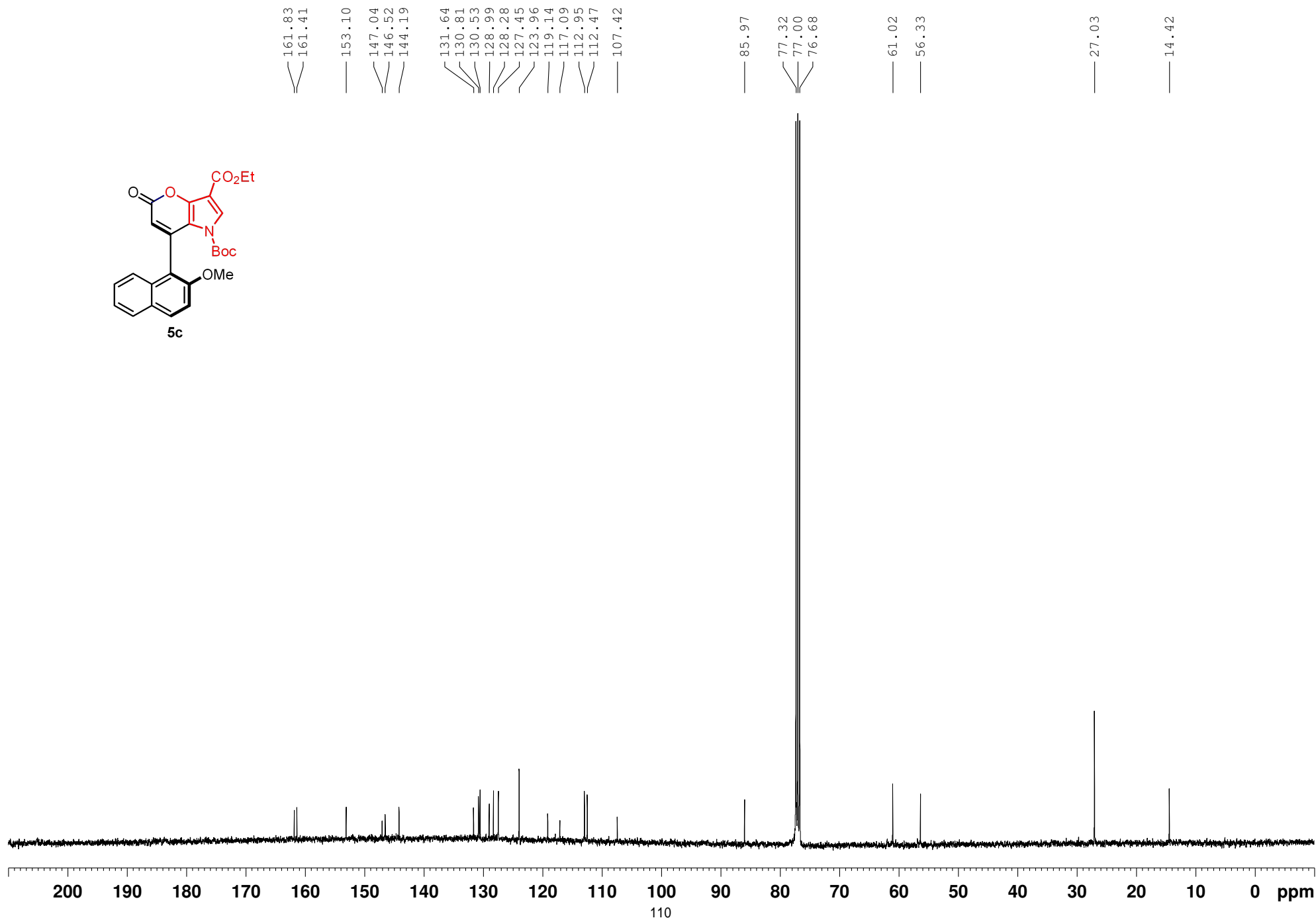
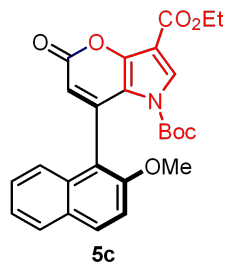


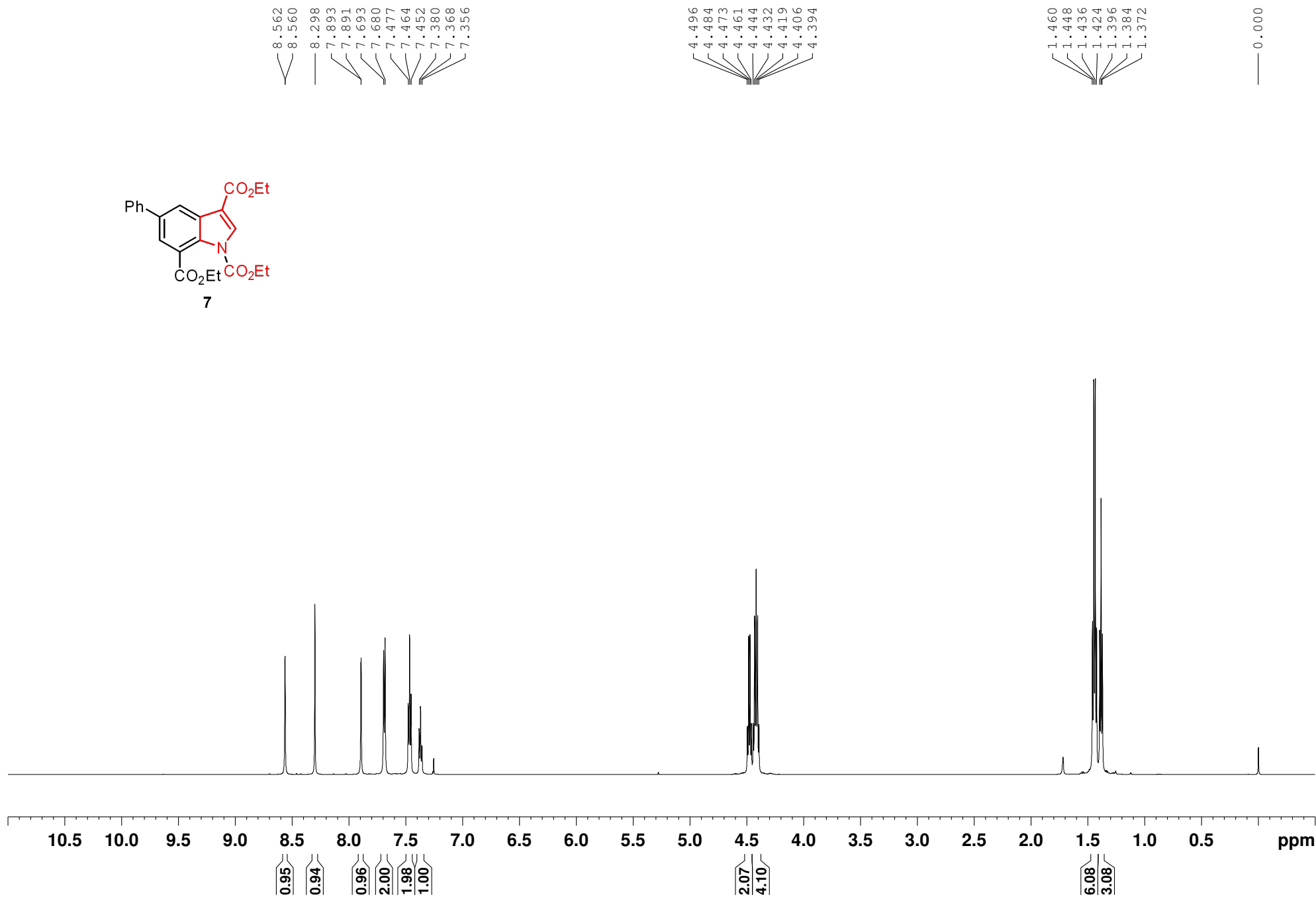
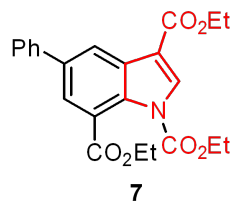


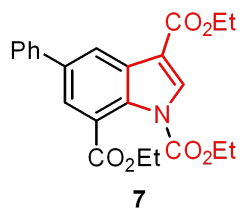












— 167.56  
— 163.64

— 150.15

— 140.23  
— 137.46  
— 133.92  
— 131.13  
— 129.62  
— 128.79  
— 127.43  
— 127.38  
— 125.39  
— 122.90  
— 121.59  
— 113.17

— 77.21  
— 77.00  
— 76.79

— 64.48  
— 61.30  
— 60.50

— 14.38  
— 14.17  
— 14.11

