Supporting Information

Access to the Benzene-modified 2nd generation Strigolactam and GR24 Analogues by Merging of C–H Olefination with Decarboxylative Giese Cyclization

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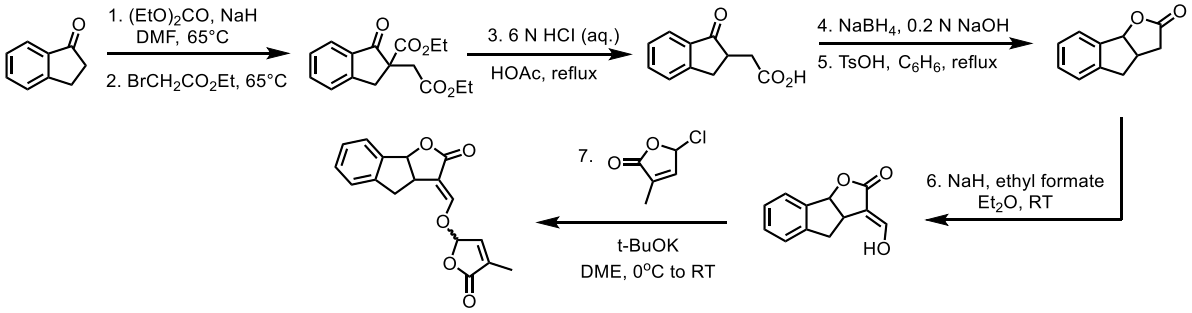
1. General Information

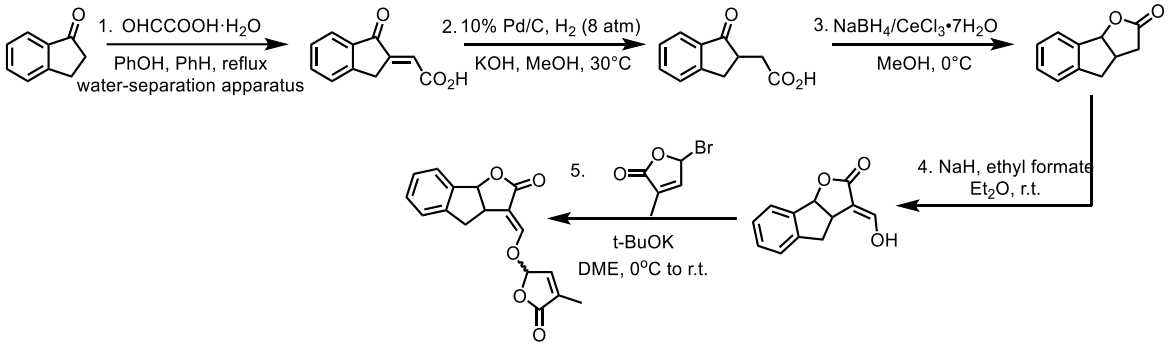
All the chemicals were purchased commercially and used without further purification. General reagents were obtained from Adamas, Leyan, Innochem and Bidepharm. Anhydrous solvents were obtained from J&K. Analytical thin layer chromatography was performed on 0.25 mm silica gel 60-F254. Visualization was carried out with UV light and Vogel's permanganate. ^{1}H NMR spectra were recorded on Bruker-400 MHz and Bruker-500 MHz instruments. When the ^{1}H NMR solvent was $CDCl_3$, chemical shifts were quoted in parts per million (ppm) referenced to 7.26 ppm for solvent $CDCl_3$; When the ^{1}H NMR solvent was DMSO-*d*-6, chemical shifts were quoted in parts per million (ppm) referenced to 2.50 ppm for solvent DMSO-*d*-6. When the ^{1}H NMR solvent was Methanol-*d*-4, chemical shifts were quoted in parts per million (ppm) referenced to 3.31 ppm for solvent Methanol-*d*-4. The following abbreviations (or combinations thereof) were used to explain multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, m = multiple, br = broad. Coupling constants, *J*, were reported in Hertz unit (Hz). ^{13}C NMR spectra were recorded on Bruker-400 instrument (100 MHz) and Bruker-500instrument (125 MHz), and were fully decoupled by broad band proton decoupling. When the ^{13}C NMR solvent was $CDCl_3$, chemical shifts were reported in ppm referenced to 77.00 ppm for $CDCl_3$; When the ^{13}C NMR solvent was DMSO-*d*-6, chemical shifts were quoted in parts per million (ppm) referenced to 39.52 ppm for solvent DMSO-*d*-6. When the ^{13}C NMR solvent was Methanol-*d*-4, chemical shifts were quoted in parts per million (ppm) referenced to 49.00 ppm for solvent Methanol-*d*-4. High-resolution mass spectra (HRMS) were recorded on an Agilent Mass spectrometer using ESI-TOF (electrospray ionization-time of flight). Optical rotations were measured on an Anton Paar MCP100 automatic polarimeter using a 100 mm path-length cell at 589 nm. Melting points were measured with microscope WRX-4 (Shanghai Yice).

Scheme S1-1. Previous synthetic route of strigolactone analogues [1]

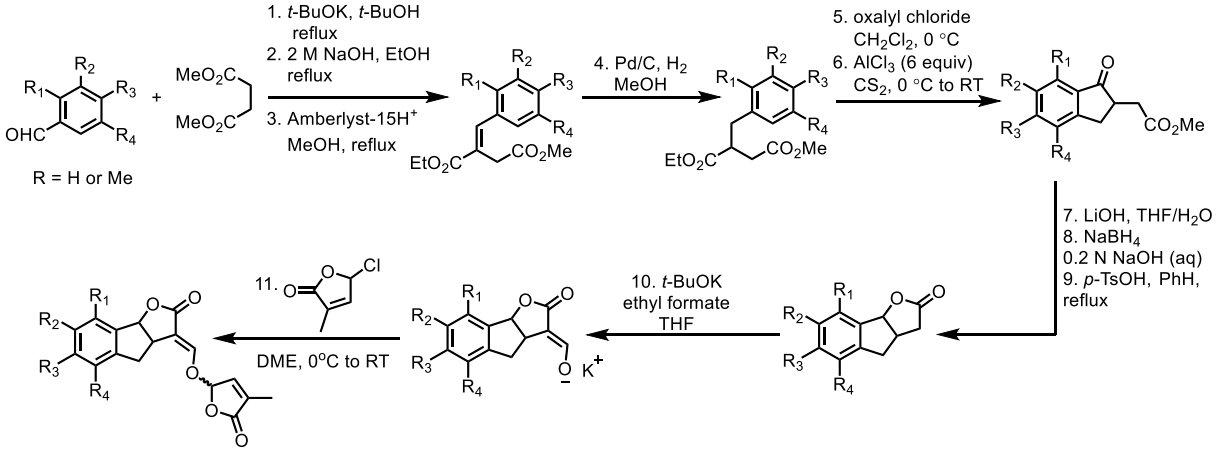
Binne Zwanenburg and coworkers, synthesis of GR24
J. Agrie. Food Chem., 1992, **40**, 1230.



Jiayang Li and coworkers, synthesis of GR24
Nature, 2020, **583**, 277.

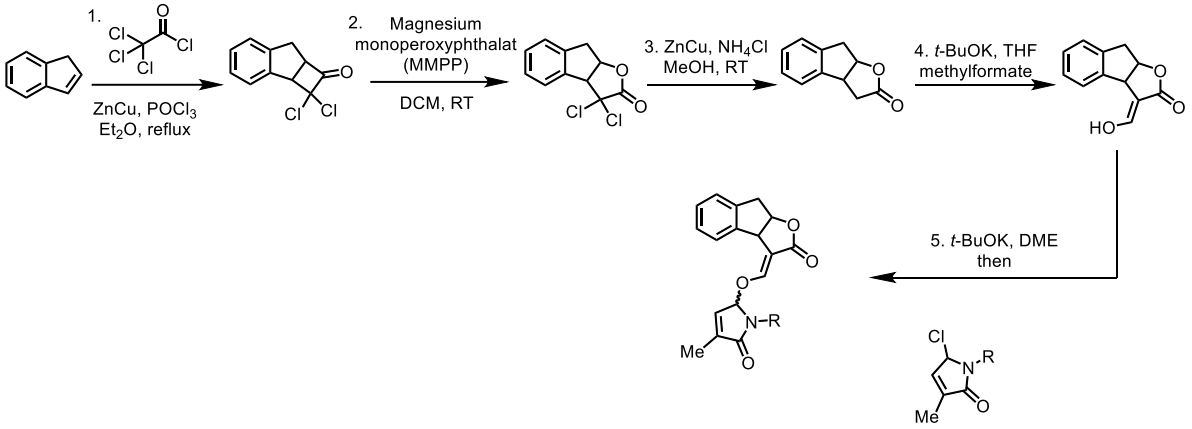


Binne Zwanenburg and coworkers, synthesis of diversified GR-24 analogues
Tetrahedron, 2010, **66**, 7198.



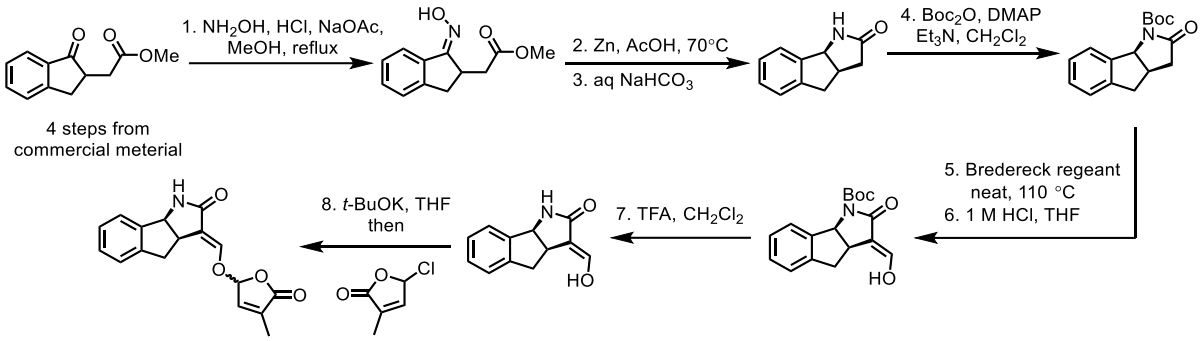
Alain De Mesmaeker and coworkers, synthesis of 2nd generation GR24

WO 2018/145979



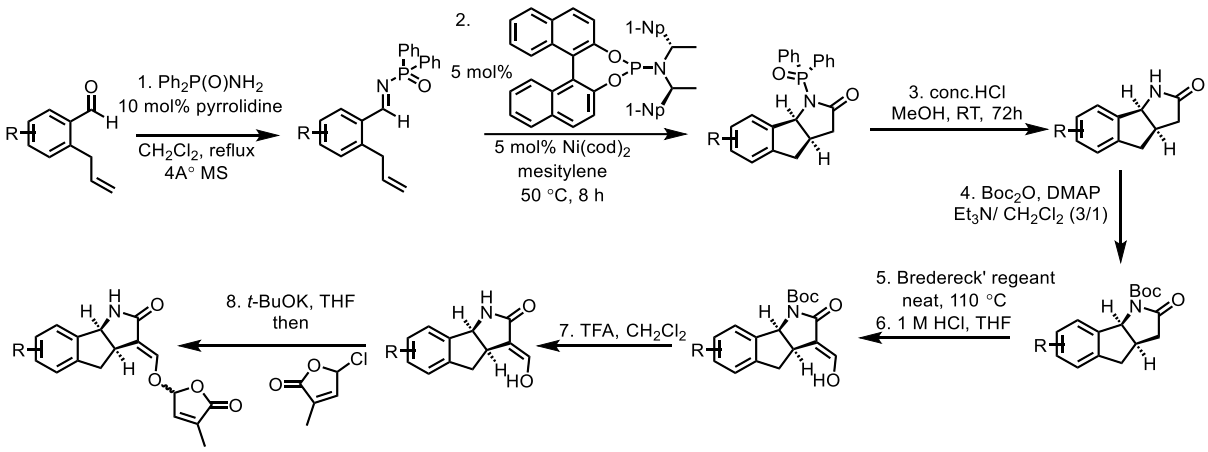
Alain De Mesmaeker and coworkers, synthesis of 1st generation strigolactams

Bioorg. Med. Chem. Lett., 2015, **25**, 2184.



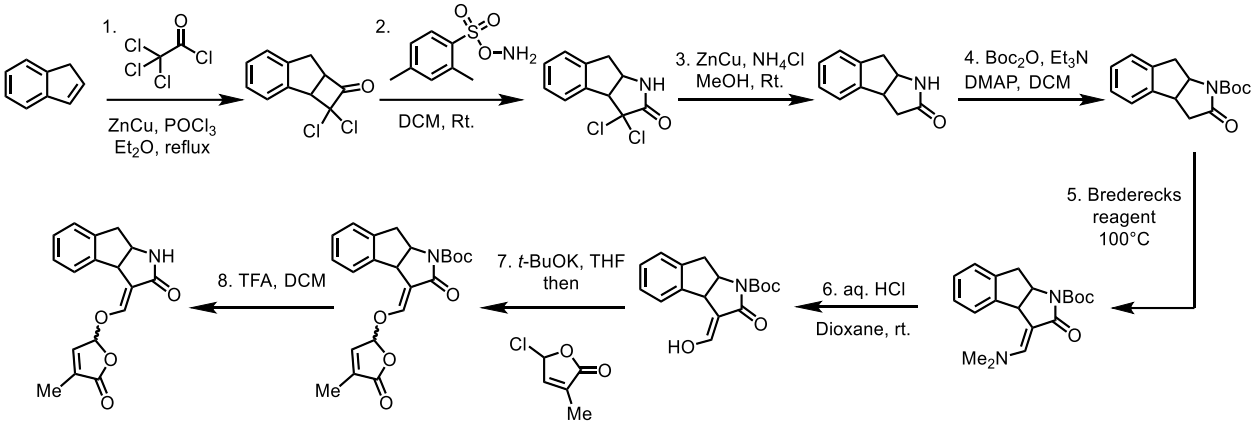
Sensuke Ogoshi and coworkers, synthesis of 1st generation strigolactams

J. Am. Chem. Soc., 2020, **142**, 1594.



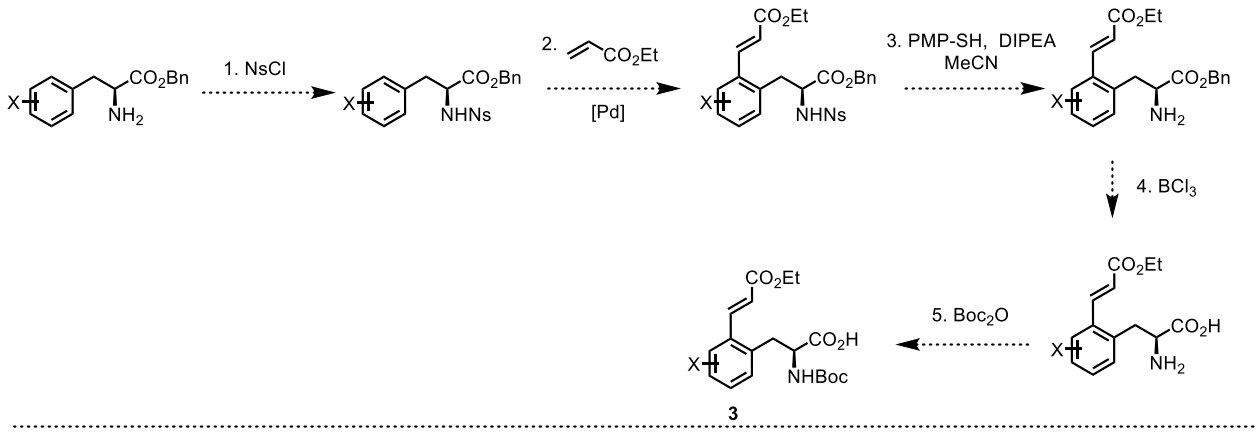
Alain De Mesmaeker and coworkers, synthesis of 2nd generation strigolactams

WO 2019/175025

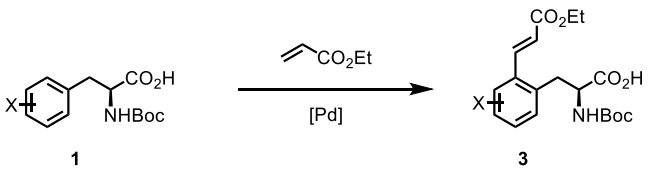


Scheme S1-2. Synthetic strategies of substrates 3

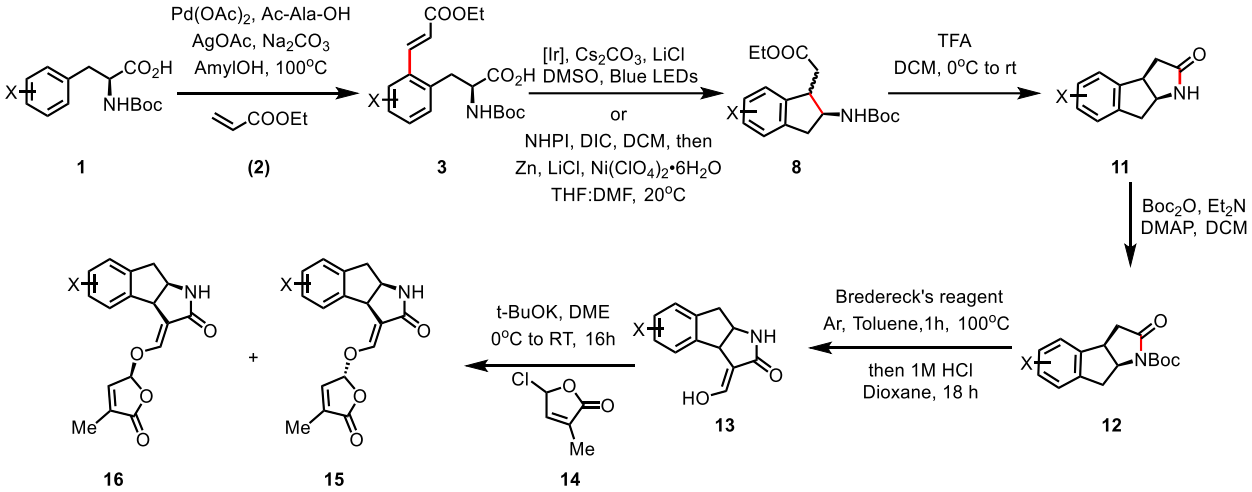
5-step synthetic route using -NHNs as a directing group (previous strategy):



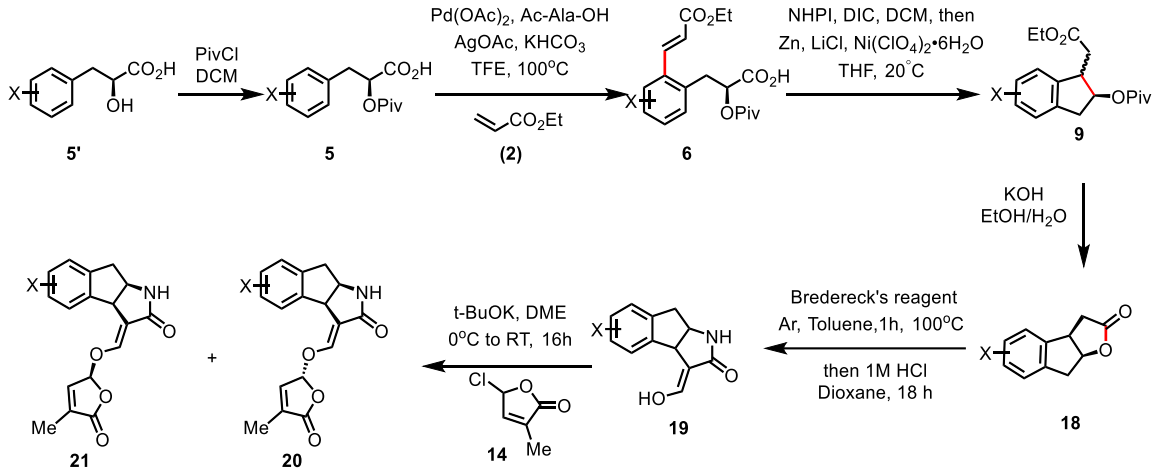
1-step synthetic route using -CO_2H as a directing group (this work):



Scheme S2. Our synthetic route of 2nd generation strigolactams



Scheme S3. Our synthetic route of 2nd generation GR24



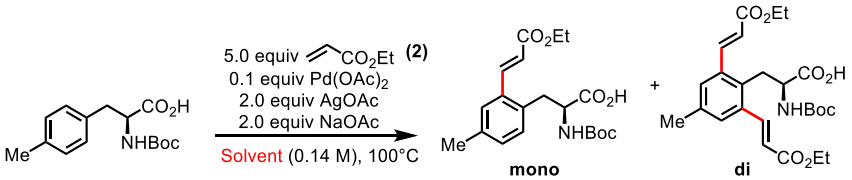
2. Experimental Procedure and Spectroscopic Data

2.1 C–H Olefination of N-Boc L-phenylalanine and O-Piv L-phenyllactic acid

All L-phenylalanine analogues in this work are commercially available.

Table S1. Optimization of C–H olefination of N-Boc L-phenylalanine [2]

Solvent screening[a]:

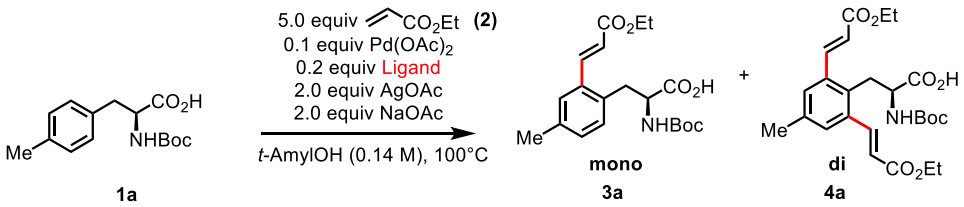


1a **3a** **4a**

Entry	Solvent	Yield	mono:di
1	DCE	11%	10:1
2	Toluene	11%	3:1
3	EtOAc	0%	/
4	THF	11%	10:1
5	MeCN	5%	1:0
6	*t*-AmylOH	34%	16:1
7	DMSO	N. D.	/

[a] Reaction conditions: Boc-L-4-Me-Phe-OH (0.1 mmol), Ethyl acrylate (0.5 mmol), $Pd(OAc)_2$ (0.01 mmol), AgOAc (0.2 mmol), NaOAc (0.2 mmol), Solvent (0.7 mL), 100 °C, 12 h; The yields were determined by ^1H NMR analysis of the crude product using 1,3,5-Trimethoxybenzene as an internal standard. DCE = 1,2-Dichloroethane; *t*-AmylOH = 2-Methyl-2-butanol; HFIP = 1,1,1,3,3,3-Hexafluoro-2-propanol; THF = Tetrahydrofuran.

Ligand screening using *t*-AmylOH as solvent[a]:

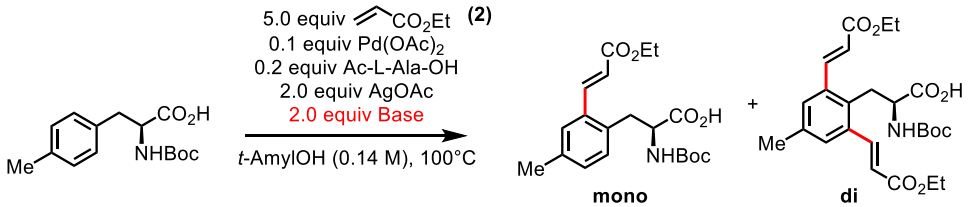


1a 3a 4a

Entry	Ligand	Yield	mono:di
1	Ac-L-Ala-OH	37%	>20:1
2	Ac-L-Leu-OH	32%	15:1
3	Ac-L-Phe-OH	31%	>20:1
4	Ac-L-Val-OH	25%	12:1
5	Ac-L-Gly-OH	34%	16:1
6	Fmoc-L-Ala-OH	25%	>20:1
7	Boc-L-Ala-OH	27%	17:1
8	Pyridine	10%	6:1
9	2-Picoline	20%	9:1
10	4-(Trifluoromethyl)pyridine	25%	9:1
11	4-Methoxypyridine	N.D.	/

[a] Reaction conditions: Boc-L-4-Me-Phe-OH (0.1 mmol), Ethyl acrylate (0.5 mmol), $Pd(OAc)_2$ (0.01 mmol), Ligand (0.02 mmol), AgOAc (0.2 mmol), NaOAc (0.2 mmol), AmylOH (0.7 mL), 100 °C, 12 h; The yields were determined by ^{1}H NMR analysis of the crude product using 1,3,5-Trimethoxybenzene as an internal standard.

Base screening using Ac-L-Ala-OH as a ligand[a]:

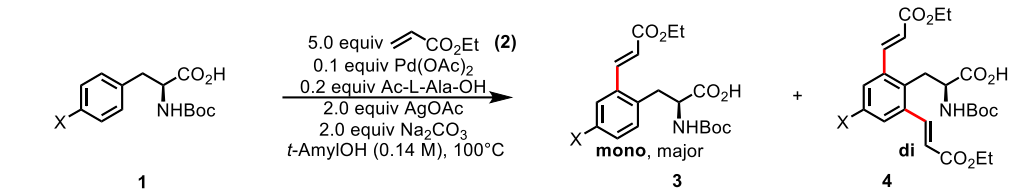


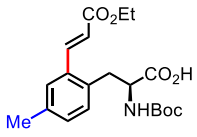
1a 3a 4a

Entry	Base	Yield	mono:di	Entry	Base	Yield	mono:di
1	NaOMe	33%	11:1	8	$KHCO_3$	51%	7:1
2	NaOH	32%	11:1	9	KF	30%	20:1
3	Na_2CO_3	51%	10:1	10	KOAc	30%	10:1
4	$NaHCO_3$	30%	10:1	11	KTFA	51%	7:1
5	NaOAc	38%	7:1	12	KH_2PO_4	33%	10:1
6	KOH	25%	8:1	13	Cs_2CO_3	17%	> 20:1
7	K_2CO_3	38%	19:1	14	$LiOH·H_2O$	10%	> 20:1

[a] Reaction conditions: Boc-L-4-Me-Phe-OH (0.1 mmol), Ethyl acrylate (0.5 mmol), $Pd(OAc)_2$ (0.01 mmol), Ac-L-Ala-OH (0.02 mmol), AgOAc (0.2 mmol), Base (0.2 mmol), *t*-AmylOH (0.7 mL), 100 °C, 12 h; The yields were determined by ^{1}H NMR analysis of the crude product using 1,3,5-Trimethoxybenzene as an internal standard.

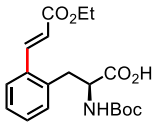
Table S2. Substrate scope of C–H olefination of N-Boc L-phenylalanine





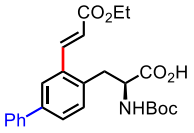
3a

52% (mono:di = 8:1)
Gram scale:
50% (mono:di = 8:1)



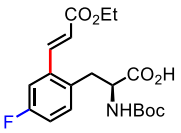
3b

52% (mono:di = 8:1)
Gram scale:
45% (mono:di = 14:1)



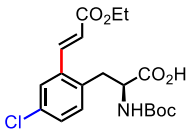
3c

45% (mono:di = 8:1)
Gram scale:
43% (mono:di = 8:1)



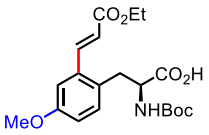
3d

32% (mono:di = 10:1)
Gram scale:
35% (mono:di = 11:1)



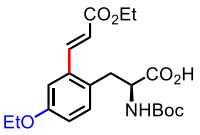
3e

38% (mono:di = 18:1)
Gram scale:
40% (mono:di = 9:1)



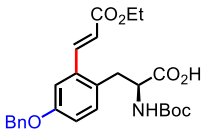
3f

52% (mono:di = 8:1)
Gram scale:
47% (mono:di = 15:1)



3g

51% (mono:di = 6:1)
Gram scale:
46% (mono:di = 6:1)



3h

48% (mono:di = 7:1)
Gram scale:
40% (mono:di = 12:1)

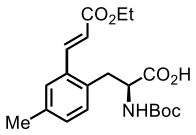
Reaction conditions: Substrate (0.1 mmol), Ethyl acrylate (0.5 mmol), $Pd(OAc)_2$ (0.01 mmol), Ac-L-Ala-OH (0.02 mmol), AgOAc (0.2 mmol), Na_2CO_3 (0.2 mmol), *t*-AmylOH (0.14 M), 100 °C, 12 h.

General procedure A (0.1 mmol scale): Substrate **1a-h** (0.1mmol, 1.0 equiv), $Pd(OAc)_2$ (2.3 mg, 0.01 mmol, 0.1 equiv), Ac-L-Ala-OH (2.6 mg, 0.02 mmol, 0.2 equiv), AgOAc (33.2 mg, 0.2 mmol, 2 equiv), Na_2CO_3 (21.2 mg, 0.2 mmol, 2 equiv) and Ethyl acrylate (54 μL,0.5 mmol, 5.0 equiv) were dissolved in 0.7 mL *t*-AmylOH. The tube was sealed and the reaction mixture was then placed to a pre-heated oil bath maintaining at 100 ℃ for 12h. The reaction mixture was then cooled to room temperature, and was filtered through celite. The filtrate was concentrated under reduced pressure and the residue was purified by PTLC (hexane:EtOAc = 75:25 with 0.2% HOAc).) to give the pure products **3a-h**.

General procedure B (gram scale): Substrate 1**a-h** (1.0 equiv), $Pd(OAc)_2$ (0.1 equiv), Ac-L-Ala-OH (0.2 equiv), AgOAc (2.0 equiv), Na_2CO_3 (2 equiv) and Ethyl acrylate (5.0 equiv) were dissolved in *t*-AmylOH (0.14 M). The tube was sealed and then placed to a pre-heated oil bath maintaining at 100 ℃ for 12 h. the reaction mixture was stirred at 100 ℃ (oil bath) for 12h. *Caution: The tube was carefully capped and covered with safety shield.* The reaction mixture was then cooled to room temperature, and was filtered through celite. The filtrate was

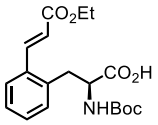
concentrated under vacuum and the residue was purified by column chromatography (C18 Spherical silica) using H_2O/MeOH as the eluent to give the products **3a-h**.

(*S*,*E*)-2-((*tert*-butoxycarbonyl)amino)-3-(2-(3-ethoxy-3-oxoprop-1-en-1-yl)-4-methylphenyl)propanoic acid (3a)



Substrate **1a** was olefinated following the general procedure **A** on 0.1 mmol scale (17.3 mg, 46%, mono:di = 20:1) and the general procedure **B** on gram scale (6.0 mmol scale; mono: 1.012 g, 44%; di: 0.155 g, 6%) to provide compound **3a**. Yellow solid, mp 120.8-121.4 ℃; $[\alpha]_D^{25}$ +74.50 (c 0.4, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, a mixture of rotational isomers 1.5:1) δ 8.69 (br s, 1H), 8.10–7.96 (m, 1H), 7.44–7.35 (m, 1H), 7.13 (s, 2H), 6.69 (d, *J* = 8.4 Hz, 0.4H), 6.42–6.30 (m, 1H), 5.08 (d, *J* = 8.4 Hz, 0.6H), 4.62–4.31 (m, 1H), 4.26 (q, *J* = 7.2 Hz, 2H), 3.53–3.27 (m, 1H), 3.18–2.88 (m, 1H), 2.33 (d, *J* = 5.3 Hz, 3H), 1.38–1.26 (m, 9H), 1.13 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 175.4, 175.1 (minor), 167.3, 166.9 (minor), 156.2 (minor), 155.2, 142.1, 141.5 (minor), 137.1, 133.8 (minor), 133.7, 133.6 (minor), 133.0, 131.5, 131.0, 127.3, 127.2 (minor), 119.9 (minor), 119.8, 81.2 (minor), 80.0, 60.7, 60.6 (minor), 55.6 (minor), 54.2, 36.9 (minor), 34.7, 28.2, 27.7 (minor), 21.0, 14.2. HRMS-ESI m/z Calcd for $C_{20}H_{27}NNaO_6$ $[M+Na]^+$: 400.1731; found 400.1731.

(*S*,*E*)-2-((*tert*-butoxycarbonyl)amino)-3-(2-(3-ethoxy-3-oxoprop-1-en-1-yl)phenyl)propanoic acid (3b)



Substrate **1b** was olefinated following the general procedure **A** on 0.1 mmol scale (mono: 16.8mg, 46%; di: 2.9 mg, 6%) and the general procedure **B** on gram scale (10.0 mmol scale; mono: 1.510 g, 42%; di: 0.121g, 3%) to provide compound **3b**. Yellow solid, mp 61.5-62.8 ℃; $[\alpha]_D^{25}$ +73.00 (c 0.4, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, a mixture of rotational isomers 1.2:1) δ 8.14–8.00 (m, 1H), 7.82 (br s, 1H), 7.61–7.56 (m, 1H), 7.37–7.21 (m, 3H), 6.84–6.66 (m, 0.45H), 6.43–6.31 (m, 1H), 5.11 (d, *J* = 8.0 Hz, 0.55H), 4.62–4.37 (m, 1H), 4.26 (q, *J* = 7.2 Hz, 2H), 3.53–3.31 (m, 1H), 3.20–2.85 (m, 1H), 1.38–1.22 (m, 9H), 1.11 (s, 3H). ^{13}C NMR (125

MHz, $CDCl_3$) δ 175.1, 167.3, 166.9 (minor), 156.3 (minor), 155.2, 142.0, 141.4 (minor), 136.9 (minor), 136.1, 134.0, 133.9 (minor), 131.6 (minor), 131.1, 130.1, 127.6, 126.9, 126.8 (minor), 120.3 (minor), 120.2, 81.3 (minor), 80.1, 60.8, 60.7 (minor), 55.6 (minor), 54.2, 37.5 (minor), 35.2, 28.2, 27.8 (minor), 14.3. >99% ee as determined by HPLC (Chiralpak ADH, 85:15 hexane/*i*-PrOH, 0.5 mL/min, 25 °C, λ = 250 nm), tr (minor) = 16.5 min, tr (major) = 30.2 min. HRMS-ESI m/z Calcd for $C_{19}H_{25}NNaO_6$ $[M+Na]^+$: 386.1574; found 386.1573.

Area % Report (racemic)

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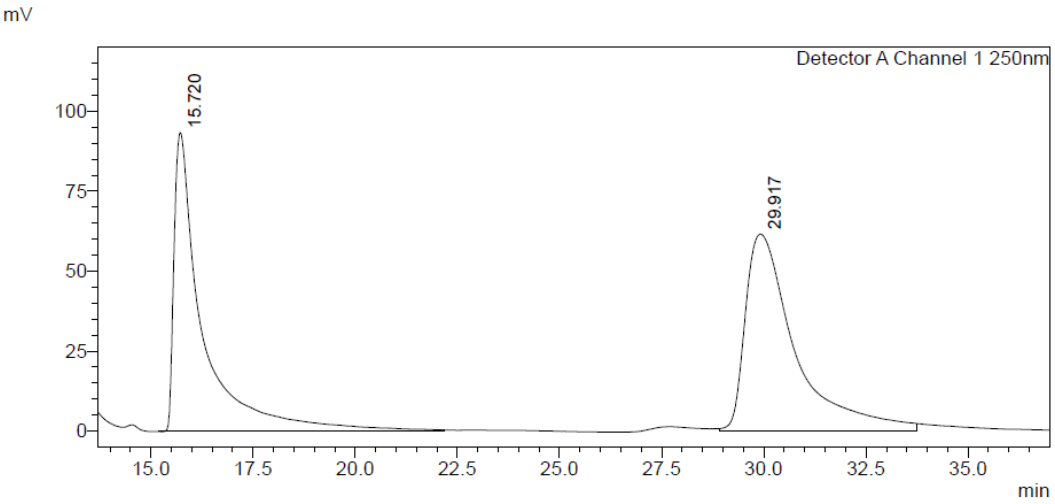

<Peak Table>

Detector A Channel 1 250nm

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Area % Report (chiral)

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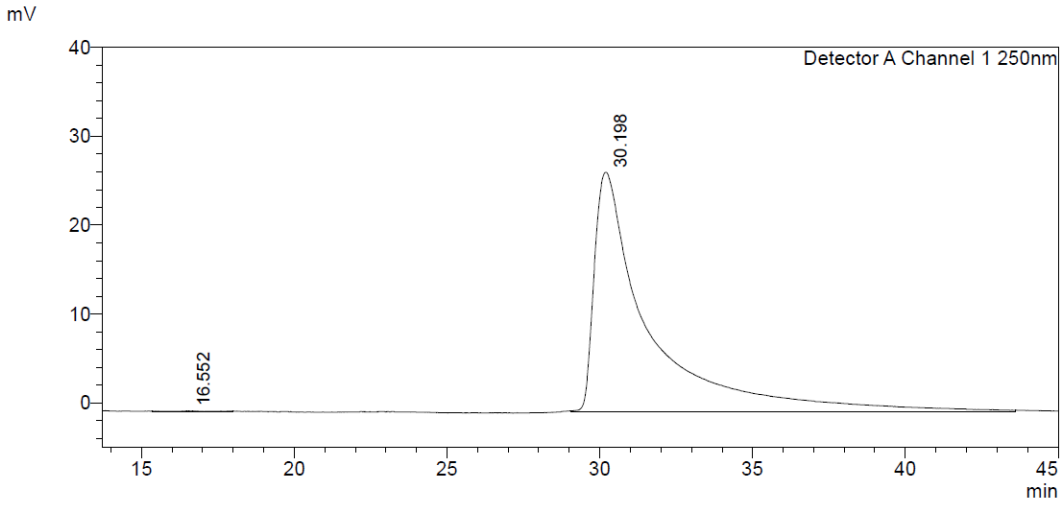

<Peak Table>

Detector A Channel 1 250nm

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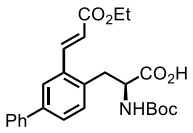
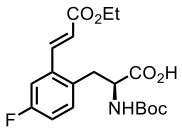
2	30.198	27002	3453380	99.578
Total		27138	3468015	100.000

(*S,E*)-2-((*tert*-butoxycarbonyl)amino)-3-(3-(3-ethoxy-3-oxoprop-1-en-1-yl)-[1,1'-biphenyl]-4-yl)propanoic acid (3c)



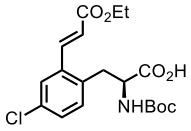
Substrate **1c** was olefinated following the general procedure **A** on 0.1 mmol scale (mono: 17.6 mg, 40%; di: 2.6 mg, 5%) and the general procedure **B** on gram scale (12.0 mmol scale; mono: 2.003 g, 38%; di: 0.306 g, 5%) to provide compound **3c**. Yellow solid, mp 81.2-83.7 ℃; $[\alpha]_D^{25}$ +66.00 (c 0.4, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$, a mixture of rotational isomers 1.5:1) δ 8.16–8.07(m, 1H), 7.83–7.74 (m, 1H), 7.59–7.49 (m, 3H), 7.49–7.40 (m, 2H), 7.40–7.27 (m, 2H), 6.86 (s, 0.4H), 6.54–6.42 (m, 1H), 5.70 (br s, 1H), 5.14 (s, 0.6H), 4.76–4.41 (m, 1H), 4.28 (q, *J* = 6.7 Hz, 2H), 3.64–3.38 (m, 1H), 3.35–3.02 (m, 1H), 1.42–1.23 (m, 9H), 1.11 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 175.0, 166.8, 156.3, 155.2, 142.1, 141.4, 140.5, 140.1, 135.8, 134.9, 134.3, 132.1, 131.6, 128.8, 128.7, 127.6, 127.0, 125.4, 120.4, 81.3, 80.1, 60.9, 60.7, 55.5, 54.2, 37.3, 34.8, 28.2, 27.7, 14.2. HRMS-ESI m/z Calcd for $C_{25}H_{29}NNaO_6$ $[M+Na]^+$: 462.1887; found 462.1885.

(*S,E*)-2-((*tert*-butoxycarbonyl)amino)-3-(2-(3-ethoxy-3-oxoprop-1-en-1-yl)-4-fluorophenyl)propanoic acid (3d)



Substrate **1d** was olefinated following the general procedure **A** on 0.1 mmol scale (11.1 mg, 29%; di: 1.2 mg, 3%) and the general procedure **B** on gram scale (16.0 mmol scale; mono: 1.951 g, 32%; di: 0.240 g, 3%) to provide compound **3d**. Yellow solid, mp 83.6-84.5 °C; $[\alpha]_D^{25}$ +76.50 (c 0.4, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, a mixture of rotational isomers 1.5:1) δ 8.05–7.93 (m, 1H), 7.31–7.18 (m, 2H), 7.07–6.99 (m, 1H), 6.82 (d, *J* = 8.0 Hz, 0.4H), 6.40–6.29 (m, 1H), 5.13 (d, *J* = 8.5 Hz, 0.6H), 4.61–4.32 (m, 1H), 4.27 (q, *J* = 7.1 Hz, 2H), 3.48–3.32 (m, 1H), 3.20–2.87 (m, 1H), 1.38–1.29 (m, 9H), 1.15 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$, a mixture of rotational isomers) δ 174.9, 174.7 (minor), 167.0, 166.5 (minor), 161.9 (d, *J* = 246.5 Hz), 156.3 (minor), 155.2, 140.9, 140.2 (minor), 135.7, 133.20 (minor), 132.8, 131.9, 121.5 (minor), 121.2, 117.0 (d, *J* = 21.4 Hz), 113.2 (d, *J* = 22.2 Hz), 81.5 (minor), 80.2, 60.9, 60.8 (minor), 55.5 (minor), 54.1, 36.7 (minor), 34.6, 28.2, 27.8 (minor), 14.2. ^{19}F NMR (375 MHz, $CDCl_3$) δ -114.7, -115.0. HRMS-ESI m/z Calcd for $C_{19}H_{24}FNNaO_6$ $[M+Na]^+$: 404.1480; found 404.1483.

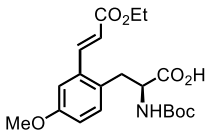
(*S*,*E*)-2-((*tert*-butoxycarbonyl)amino)-3-(4-chloro-2-(3-ethoxy-3-oxoprop-1-en-1-yl)phenyl)propanoic acid (3e)



Substrate **1e** was olefinated following the general procedure A on 0.1 mmol scale (mono: 14.4 mg, 36%; di: 3.2 mg, 2%) and the general procedure **B** on gram scale (15.0 mmol scale; mono: 2.144 g, 36%; di: 0.262 g, 4%) to provide compound **3e**. Yellow solid, mp 118.5-120.2 ℃; $[\alpha]_D^{25}$ +62.75 (c 0.4, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, a mixture of rotational isomers 1.5:1) δ 8.23 (br s, 1H), 8.03–7.93 (m, 1H), 7.60–7.52 (m, 1H), 7.33–7.27 (m, 2H), 7.22–7.16 (m, 1H), 6.93 (d, *J* = 8.1 Hz, 0.4H), 6.43–6.30 (m, 1H), 5.15 (d, *J* = 8.5 Hz, 0.6H), 4.63–4.32 (m, 1H), 4.27 (q, *J* = 7.1 Hz, 2H), 3.50–3.29 (m, 1H), 3.18–2.87 (m, 1H), 1.46–1.25 (m, 9H), 1.15 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 174.9, 174.6 (minor), 166.9, 166.4 (minor), 156.4 (minor), 155.2, 140.7, 140.0 (minor), 135.6, 135.6 (minor), 135.2 (minor), 134.5, 133.4, 132.8 (minor), 132.4, 129.8, 126.7, 126.5 (minor), 121.6 (minor), 121.4, 81.7 (minor), 80.2, 60.9,

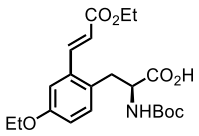
60.8 (minor), 55.3 (minor), 53.9, 36.9 (minor), 34.7, 28.2, 27.7 (minor), 14.2. HRMS-ESI m/z Calcd for $C_{19}H_{24}ClNNaO_6$ $[M+Na]^+$: 420.1184; found 420.1190.

(*S,E*)-2-((*tert*-butoxycarbonyl)amino)-3-(2-(3-ethoxy-3-oxoprop-1-en-1-yl)-4-methoxyphenyl)propanoic acid (3f)



Substrate **1f** was olefinated following the general procedure **A** on 0.1 mmol scale (mono: 18.0 mg, 46%; di: 2.7 mg, 6%) and the general procedure **F** on gram scale (10.0 mmol scale; mono: 1.730 g, 44%; di: 0.134 g, 3%) to provide compound **3f**. Yellow solid, mp 90.5-91.9 °C; $[\alpha]_D^{25}$ +74.50 (c 0.4, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, a mixture of rotational isomers 2.3:1) δ 8.00 (d, *J* = 15.5 Hz, 1H), 7.18–7.11 (m, 1H), 7.07 (s, 1H), 6.92–6.85 (m, 1H), 6.35 (d, *J* = 15.3 Hz, 1H), 6.02–5.85 (m, 0.3H), 5.08 (s, 0.7H), 4.49–4.28(m, 1H), 4.26 (q, *J* = 6.9 Hz, 2H), 3.80 (s, 3H), 4.34–3.25 (m, 1H), 3.19–2.80 (m, 1H), 1.39–1.29 (m, 9H), 1.26–1.22 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 174.0, 167.5, 158.6, 155.4, 142.3, 134.7, 132.5, 129.1, 119.8, 116.3, 111.2, 79.7, 60.8, 55.3, 47.6, 34.7, 28.3, 28.0 (minor), 14.3. HRMS-ESI m/z Calcd for $C_{20}H_{27}NNaO_7$ $[M+Na]^+$: 416.1680; found 416.1680.

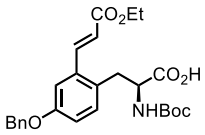
(*S,E*)-2-((*tert*-butoxycarbonyl)amino)-3-(4-ethoxy-2-(3-ethoxy-3-oxoprop-1-en-1-yl)phenyl)propanoic acid (3g)



Substrate **1g** was olefinated following the general procedure **A** on 0.1 mmol scale (mono: 18.1 mg, 44%; di: 3.5 mg, 7%) and the general procedure **B** on gram scale (12.0 mmol scale; mono: 1.905 g, 39%; di: 0.391 g, 7%) to provide compound **3g**. Yellow solid, mp 113.0-116.2 ℃; $[\alpha]_D^{25}$ +76.75 (c 0.4, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, a mixture of rotational isomers 2.3:1) δ 8.00 (d, *J* = 15.5 Hz, 1H), 7.17–7.03 (m, 2H), 6.89–6.80 (m, 1H), 6.33 (d, *J* = 15.7 Hz, 1H), 6.05–5.89 (m, 0.3H), 5.68 (br s, 1H), 5.13–5.07 (m, 0.7H), 4.55–4.39 (m, 1H), 4.24 (q, *J* = 7.0 Hz, 2H), 4.07–3.93 (m, 2H), 3.41–3.21 (m, 1H), 3.19–2.83 (m, 1H), 1.45–1.35 (m, 9H), 1.32 (t, *J* = 7.1 Hz, 3H), 1.27–1.19 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 175.5, 167.6, 158.0,

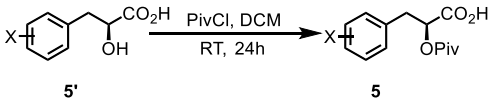
155.2, 142.3, 134.7, 132.5, 128.5, 119.6, 116.8, 111.8, 79.8, 63.5, 60.8, 54.7, 34.5, 28.3, 14.8, 14.2. HRMS-ESI m/z Calcd for $C_{21}H_{29}NNaO_7$ $[M+Na]^+$: 430.1836; found 430.1836.

(*S*,*E*)-3-(4-(benzyloxy)-2-(3-ethoxy-3-oxoprop-1-en-1-yl)phenyl)-2-((*tert*-butoxycarbonyl)amino)propanoic acid (3h)



Substrate **1h** was olefinated following the general procedure **A** on 0.1 mmol scale (mono: 19.7 mg, 42%; di: 3.5mg, 6%) and the general procedure **B** on gram scale (12.0 mmol scale; mono: 2.080 g, 37%; di: 0.208 g, 3%) to provide compound **3h**. Yellow solid, mp 80.7-86.5 °C; $[\alpha]_D^{25}$ +56.750 (c 0.4, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$, a mixture of rotational isomers 2.3:1) δ 7.08–7.95 (m, 1H), 7.49–7.30 (m, 5H), 7.20–7.12 (m, 2H), 6.99–6.92 (m, 1H), 6.69 (d, *J* = 8.2 Hz, 0.3H), 6.38–6.29 (m, 1H), 5.17 –5.09 (m, 0.7H), 5.09–5.00 (m, 2H), 4.61–4.30 (m, 1H), 4.26 (q, *J* = 7.1 Hz, 2H), 3.44–3.26 (m, 1H), 3.21–2.83 (m, 1H), 1.43–1.25 (m, 9H), 1.16 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 175.0, 167.2, 158.0, 155.2, 141.8, 136.6, 135.0, 132.3, 128.6, 128.1, 127.5, 127.4, 120.3, 117.0, 112.5, 80.1, 70.1, 60.8, 54.2, 34.3, 28.2, 27.8 (minor), 14.2. HRMS-ESI m/z Calcd for $C_{26}H_{31}NNaO_7$ $[M+Na]^+$: 492.1993; found 492.1993.

Synthesis of O-Piv-L-phenyllactic acid analogues: [3]

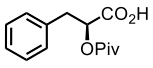


5' **5**

General Procedure C

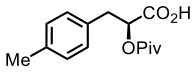
The phenyllactic acid substrate (1 equiv) and pivaloyl chloride (1.5 equiv) were stirred in DCM (1M) at RT for 24 h. The reaction mixture was then concentrated in vacuum and the resulting residue was purified by column chromatography (hexane:EtOAc = 75:25 with 0.2% HOAc).

(*S*)-3-phenyl-2-(pivaloyloxy)propanoic acid (5a)



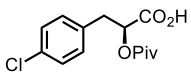
Substrate **5a** was obtained following general procedure **C** from L-phenyllactic acid (commercial available, 20.0 mmol, 3.3 g). After purification by column chromatography, **5a** was obtained as a colorless oil (4.2g, 84%), colorless oil; $[\alpha]_D^{25}$ -13.50 (c 0.4, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 10.10 (br s, 1H), 7.35–7.22 (m, 5H), 5.21 (dd, *J* = 9.4, 3.9 Hz, 1H), 3.26 (dd, *J* = 14.3, 3.9 Hz, 1H), 3.13 (dd, *J* = 14.3, 9.4 Hz, 1H), 1.16 (s, 9H). HRMS-ESI m/z Calcd for $C_{14}H_{18}NaO_4$ $[M+Na]^+$: 273.1097; found 273.1086.

(*S*)-2-(pivaloyloxy)-3-(*p-tolyl*)propanoic acid (5b)



Substrate **5b** was obtained following general procedure **C** from 4-Methyl-L-phenyllactic acid (commercial available, 12.6 mmol, 2.3 g). After purification by column chromatography, **5b** was obtained as a white solid (2.3 g, 70%), white solid, mp 86.0-86.6 ℃; $[\alpha]_D^{25}$ -11.25 (c 0.4, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 7.15–7.08 (m, 4H), 5.18 (dd, *J* = 9.0, 4.2 Hz, 1H), 3.20 (dd, *J* = 14.3, 4.2 Hz, 1H), 3.09 (dd, *J* = 14.3, 9.0 Hz, 1H), 2.32 (s, 3H), 1.17 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 177.8, 174.7, 136.6, 132.7, 129.3, 129.1, 72.3, 38.6, 36.8, 26.9, 21.1. HRMS-ESI m/z Calcd for $C_{15}H_{20}NaO_4$ $[M+Na]^+$: 287.1254; found 287.1250.

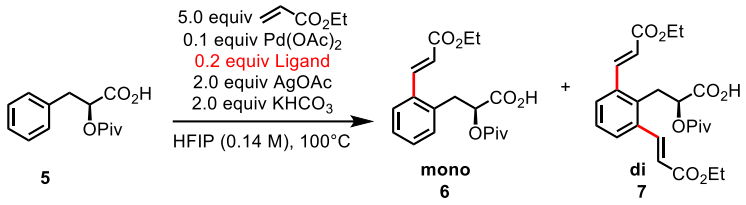
(*S*)-3-(4-chlorophenyl)-2-(pivaloyloxy)propanoic acid (5c)



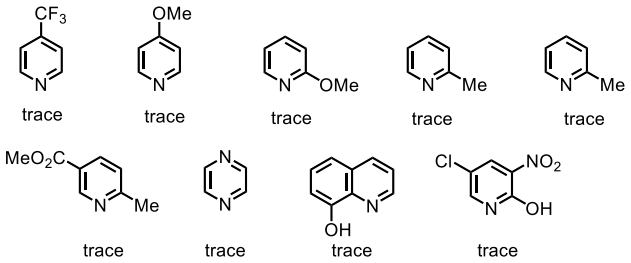
Substrate **5c** was obtained following general procedure **C** from 4-chloro-L-phenyllactic acid (commercial available, 16.0 mmol, 3.2 g). After purification by column chromatography, **5c** was obtained as a white solid (2.7 g, 59%), mp 110.6-113.9 ℃; $[\alpha]_D^{25}$ -13.50 (c 0.4, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 8.53 (br s, 1H), 7.28 (d, *J* = 8.1 Hz, 2H), 7.18 (d, *J* = 8.2 Hz, 2H), 5.18 (dd, *J* = 9.0, 3.9 Hz, 1H), 3.22 (dd, *J* = 14.4, 4.0 Hz, 1H), 3.11 (dd, *J* = 14.4, 9.0 Hz, 1H), 1.16 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 177.7, 174.9, 134.2, 133.1, 130.7, 128.6, 71.8, 38.6, 36.5, 26.9. HRMS-ESI m/z Calcd for $C_{14}H_{17}NaClO_4$ $[M+Na]^+$:307.0708; found 307.0716.

Table S3. Optimization of C–H olefination of O-Piv L-phenyllactic acid [2]

Ligand screening



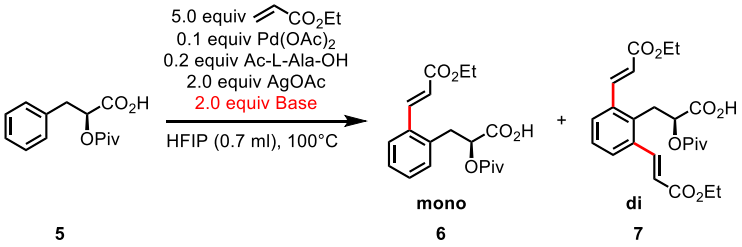
Entry	Ligand	Yield	mono:di
1	Ac-L-Ala-OH	51%	19:1
2	Fmoc-L-Ala-OH	24%	N.D.
3	Bz-L-Ala-OH	21%	N.D.
4	Ac-L-Leu-OH	40%	>20:1
5	Ac-L-Phe-OH	43%	>20:1
6	Ac-L-Val-OH	27%	>20:1
7	Ac-L-Gly-OH	47%	>20:1
8	Ac-L-Cys-OH	trace	N.D.



trace trace trace trace trace trace trace trace trace

[a] Reaction conditions: O-Piv L-phenyllactic acid (0.1 mmol), Ethyl acrylate (0.5 mmol), $Pd(OAc)_2$ (0.01 mmol), Ligand (0.02 mmol), AgOAc (0.2 mmol), $KHCO_3$ (0.2 mmol), HFIP (0.7 mL), 100 °C, 12 h; The yields were determined by ^1H NMR analysis of the crude product using 1,3,5-Trimethoxybenzene as an internal standard.

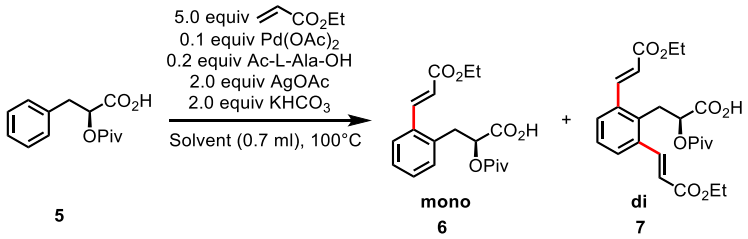
Base screening



Entry	Base	Yield	mono:di
1	$KHCO_3$	51%	19:1
2	K_2CO_3	25%	N.D.
3	KOAc	35%	>20:1
4	K_2HPO_4	27%	>20:1
5	KH_2PO_4	42%	20:1
6	Na_2CO_3	40%	>20:1
7	Li_2CO_3	46%	>20:1
8	Cs_2CO_3	32%	>20:1
9	$NaHCO_3$	45%	>20:1

[a] Reaction conditions: O-Piv L-phenyllactic acid (0.1 mmol), Ethyl acrylate (0.5 mmol), $Pd(OAc)_2$ (0.01 mmol), Ac-L-Ala-OH (0.02 mmol), AgOAc (0.2 mmol), Base (0.2 mmol), HFIP (0.7 mL), 100 °C, 12 h; The yields were determined by ^1H NMR analysis of the crude product using 1,3,5-Trimethoxybenzene as an internal standard.

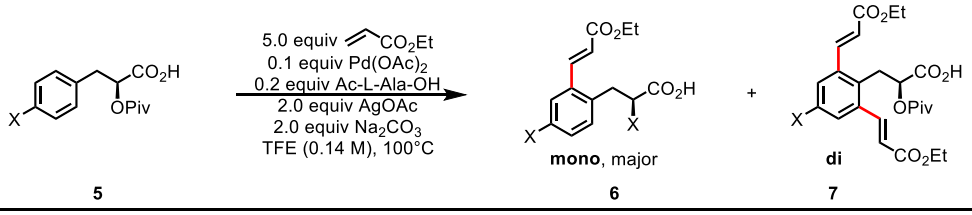
Solvent screening

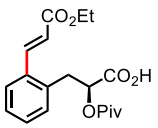


Entry	Solvent	Yield	mono:di
1	HFIP	51%	19:1
2	TFE	57%	15:1
3	Toluene	15%	9:1
4	DCE	14%	13:1
5	Dioxane	trace	N.D.
6	AmylOH	35%	>20:1
7	AcOH	decomposed	N.D.

[a] Reaction conditions: O-Piv L-phenyllactic acid (0.1 mmol), Ethyl acrylate (0.5 mmol), $Pd(OAc)_2$ (0.01 mmol), Ac-L-Ala-OH (0.02 mmol), AgOAc (0.2 mmol), $KHCO_3$ (0.2 mmol), Solvent (0.7 mL), 100 °C, 12 h; The yields were determined by ^1H NMR analysis of the crude product using 1,3,5-Trimethoxybenzene as an internal standard. TFE = 2,2,2-Trifluoroethanol; HFIP = 1,1,1,3,3,3-Hexafluoro-2-propanol.

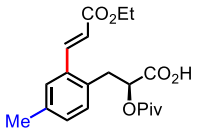
Table S4. Substrate scope of C–H olefination of O-Pv L-phenyllactic acid





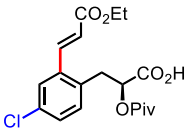
6a

57% (mono:di = 13:1)
Gram scale:
50% (mono:di = 12:1)[b]



6
b

59% (mono:di = 7:1)
Gram scale:
58% (mono:di = 6:1)



6c

41% (mono:di = 5:1)
Gram scale:
39% (mono:di = 12:1)

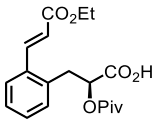
[a] Reaction conditions: Substrate (0.1 mmol), Ethyl acrylate (0.5 mmol), $Pd(OAc)_2$ (0.01 mmol), Ac-L-Ala-OH (0.02 mmol), AgOAc (0.2 mmol), $KHCO_3$ (0.2 mmol), TFE (2,2,2-Trifluoroethanol, 0.7 mL), 100 °C, 12 h; [b] using HFIP instead of TFE

General procedure D (0.1 mmol scale): Substrate **5a-c** (0.1 mmol, 1.0 equiv), $Pd(OAc)_2$ (2.3 mg, 0.01 mmol, 0.1 equiv), Ac-L-Ala-OH (2.6mg, 0.02 mmol, 0.2 equiv), AgOAc (33.2 mg, 0.2 mmol, 2 equiv), $KHCO_3$ (21.2 mg, 0.2 mmol, 2.0 equiv) and Ethyl acrylate (54 μL, 0.5 mmol, 5.0 equiv) were dissolved in 0.7 mL TFE. The tube was sealed and the reaction mixture was then placed to a pre-heated oil bath maintaining at 100 ℃ for 12 h. The reaction mixture was then cooled to room temperature, and was filtered through celite. The filtrate was

concentrated under reduced pressure and the residue was purified by PTLC (hexane:EtOAc:HOAc = 75:25 with 0.2% HOAc) to give the pure products **6a-c**.

General procedure E (gram scale): Substrate **5a-c** (1.0 equiv), $Pd(OAc)_2$ (0.1 equiv), Ac-L-Ala-OH (0.2 equiv), AgOAc (2.0 equiv), $KHCO_3$ (2 equiv) and Ethyl acrylate (5.0 equiv) were dissolved in TFE (0.14 M). The tube was sealed and then placed to a pre-heated oil bath maintaining at 100 ℃ for 12 h. (*Caution: The tube was carefully capped and covered with safety shield.)* The reaction mixture was then cooled to room temperature, and was filtered through celite. The filtrate was concentrated under vacuum and the residue was purified by column chromatography (C18 Spherical silica) using H_2O/MeOH as the eluent to give the products **6a-c**.

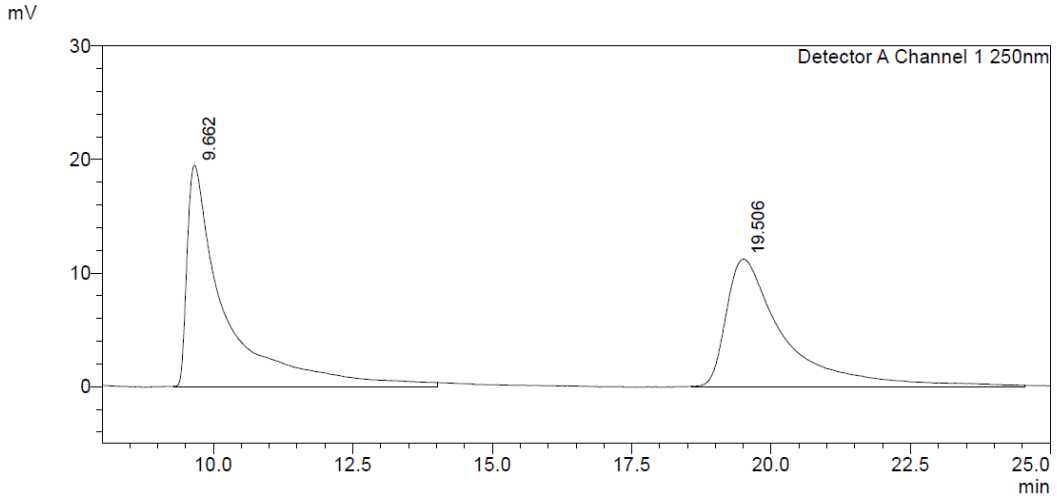
(*S,E*)-3-(2-(3-ethoxy-3-oxoprop-1-en-1-yl)phenyl)-2-(pivaloyloxy)propanoic acid (6a)



Substrate **5a** was olefinated following the general procedure **D** on 0.1 mmol scale (mono: 18.4 mg, 53%; di: 2.8 mg, 4%) and the general procedure **E** on gram scale (using HFIP instead of TFE; 20.0 mmol scale; mono: 3.123 g, 46%; di: 0.340 g, 4%) to provide compound **6a**. Colourless oil; $[\alpha]_D^{25}$ +56.75(c 0.4, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.10 (d, *J* = 15.8 Hz, 1H), 7.62–7.57 (m, 1H), 7.38–7.25 (m, 3H), 6.40 (d, *J* = 15.8 Hz, 1H), 5.37 (br s, 1H), 5.15 (dd, *J* = 9.8, 3.8 Hz, 1H), 4.28 (q, *J* = 7.1 Hz, 2H), 3.44 (dd, *J* = 14.6, 3.8 Hz, 1H), 3.31 (dd, *J* = 14.6, 9.8 Hz, 1H), 1.34 (t, *J* = 7.1 Hz, 3H), 1.12 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 177.8, 173.8, 166.8, 141.6, 135.5, 133.9, 131.0, 130.0, 127.7, 126.7, 120.6, 72.2, 60.7, 38.5, 33.9, 26.8, 14.3. >99% ee as determined by HPLC (Chiralpak ADH, 85:15 hexane/*i*-PrOH, 1.0 mL/min, 25 °C, λ = 250 nm), tr (major) = 9.4 min, tr (minor) = 18.5 min. HRMS-ESI m/z Calcd for $C_{19}H_{24}NaO_6$ $[M+H]^+$: 371.1465; found 371.1474.

Area % Report (racemic)

<Chromatogram>



<Peak Table>

Detector A Channel 1 250nm

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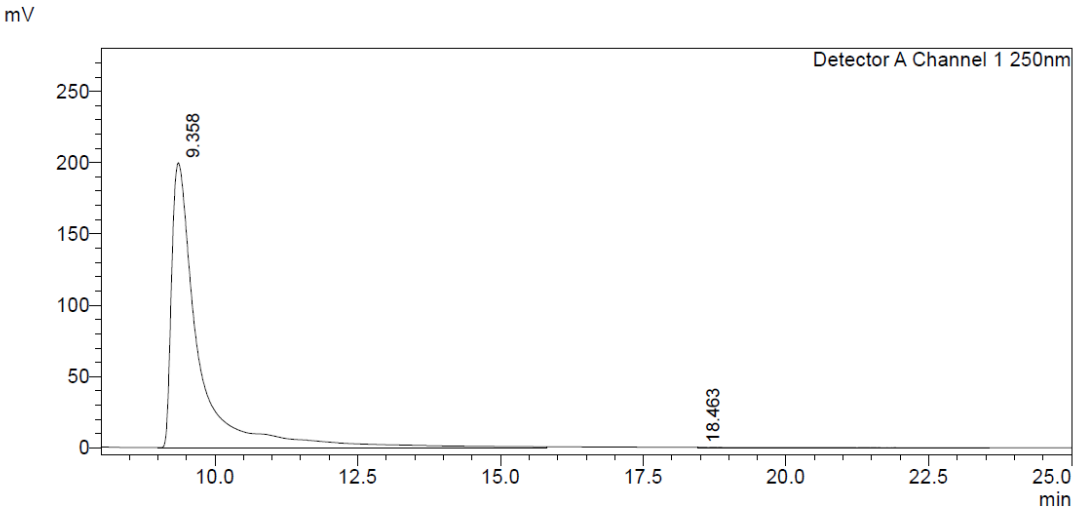
Total		30783	1764402	100.000

Area % Report (chiral)

<Chromatogram>

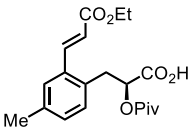


<Peak Table>

Detector A Channel 1 250nm

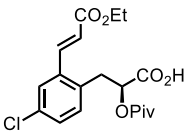
Peak#	Ret. Time	Height	Area	Area%
1	9.358	199776	6626967	99.499
2	18.463	296	33355	0.501
Total		200072	6660322	100.000

(*S,E*)-3-(2-(3-ethoxy-3-oxoprop-1-en-1-yl)-4-methylphenyl)-2-(pivaloyloxy)propanoic acid (6b)



Substrate **5b** was olefinated following the general procedure **D** on 0.1 mmol scale (mono: 18.8 mg, 52%; di: 3.0 mg, 7%) and the general procedure **E** on gram scale (8 mmol scale; mono: 1.448 g, 50% ;di: 0.284 g, 8%) to provide compound **6b**. Yellow oil; $[\alpha]_D^{25}$ +14.75 (c 0.4, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 8.07 (d, *J* = 15.8 Hz, 1H), 7.71 (br s, 1H), 7.40 (s, 1H), 7.20–7.10 (m, 2H), 6.39 (d, *J* = 15.8 Hz, 1H), 5.11 (dd, *J* = 9.5, 3.8 Hz, 1H), 4.27 (q, *J* = 7.2 Hz, 2H), 3.38 (dd, *J* = 14.6, 3.9 Hz, 1H), 3.26 (dd, *J* = 14.6, 9.6 Hz, 1H), 2.33 (s, 3H), 1.33 (t, *J* = 7.2 Hz, 3H), 1.12 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 177.9, 174.3, 167.0, 141.8, 137.2, 133.5, 132.7, 130.9, 130.9, 127.2, 120.0, 72.4, 60.6, 38.5, 33.5, 26.8, 21.0, 14.2. HRMS-ESI m/z Calcd for $C_{20}H_{26}NaO_6$ $[M+Na]^+$: 385.1622; found 385.1614.

(*S*,*E*)-3-(4-chloro-2-(3-ethoxy-3-oxoprop-1-en-1-yl)phenyl)-2-(pivaloyloxy)propanoic acid (6c)

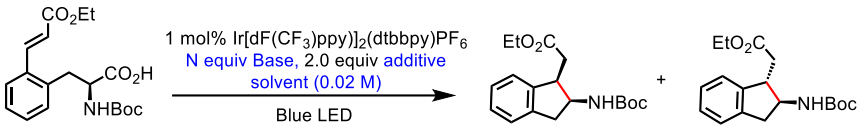


Substrate **5c** was olefinated following the general procedure **D** on 0.1 mmol scale (mono:12.8 mg, 34%;di: 3.3 mg, 7%) and the general procedure **E** on gram scale (9.6 mmolscale;mono:1.310 g, 36%; di: 0.147 g, 3%) to provide compound **6c**. Yellow oil; $[\alpha]_D^{25}$ +12.25 (c 0.4, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 8.12 (d, *J* = 16.1 Hz, 1H), 7.49 (s, 1H), 7.24–7.13 (m, 2H), 6.33 (d, *J* = 15.7 Hz, 1H), 4.86 (d, *J*=9.8 Hz, 1H), 4.18–4.07 (m, 2H), 3.43 (d, *J* = 14.7 Hz, 1H), 3.10 (t, *J* = 12.4 Hz, 1H), 1.23 (t, *J* = 7.1 Hz, 3H), 1.01 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 179.5, 176.0, 167.2, 141.7, 137.2, 135.0, 132.6, 132.5, 129.7, 125.9, 120.2, 60.8, 38.6, 34.1, 29.7, 26.9, 14.1. HRMS-ESI m/z Calcd for $C_{19}H_{24}ClO_6$ $[M+H]^+$ 383.1256; found 383.1264.

2.2 B-Ring formation *via* decarboxylative giese cyclization

Table S5. Optimization of Ir-catalyzed photo-redox decarboxylative coupling [4]

Screening of bases and solvents [a]:

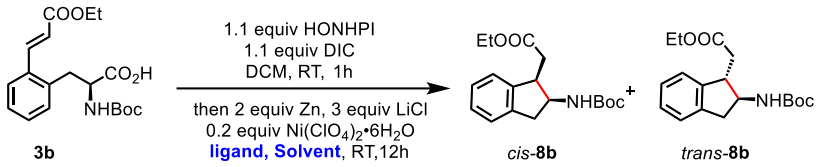


3b *cis*-**8b** *trans*-**8b**

Entry	Solvent	N equiv	Base	Additive	Yield	cis- : trans[c]
1	DMSO	2	DBU	/	0%	/
2	DMSO	2	DIPEA	/	25%[b]	/
3	DMSO	2	DMAP	/	0%	/
4	DMSO	2	DABCO	/	19%[b]	/
5	DMSO	1	Li_2CO_3	/	90%	1:1
6	DMSO	1	$LiOH•H_2O$	/	90%	1:1
7	DMSO	1	Cs_2CO_3	/	90%	1:1
8	DMSO	1	Cs_2CO_3	$MgBr_2•OEt_2$	0%	/
9	DMSO	1	Cs_2CO_3	LiCl	95% (90%[b])	1:1
10	DMSO	2	Cs_2CO_3	LiCl	90%	1:1
11	DMF	1	Cs_2CO_3	LiCl	65%[b]	1:0.9
12	MeCN	1	Cs_2CO_3	LiCl	24%	1:1
13	THF	1	Cs_2CO_3	LiCl	17%	/
14	NMP	1	Cs_2CO_3	LiCl	16%	/

[a] Conditions: $[IrdF(CF_3)ppy)_2(dtbbpy)]PF_6$ (0.001 mmol, 0.01 equiv), substrate (0.1 mmol, 1.0 equiv), Base (0.2 mmol, 2.0 equiv), and 5 mL of DMSO (0.02 M). The yield was determined by ^1H NMR using 1,3,5-trimethoxybenzene as an internal standard. [b] isolated yield. [c] The dr value was determined by ^1H NMR. DBU = 1,8-Diazabicyclo[5.4.0]undec-7-ene.

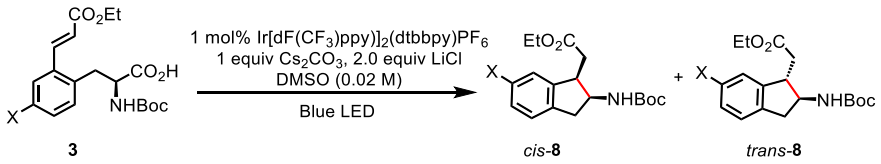
Table S6. Optimization of Ni-catalyzed decarboxylative coupling *via* RAEs [5]

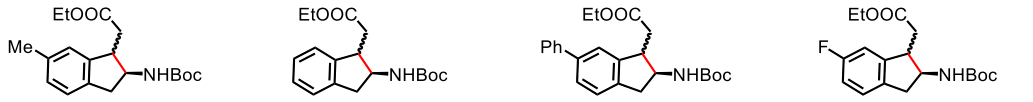


Entry	Ligand	Solvent	Yield [b]	cis : trans [c]
1	/	MeCN	73%	1:1.7
2	/	DMF	70%	1:2.3
3	/	DMA	60%	1:1.9
4	/	NMP	77%	1:2.3
5	/	DMSO	62%	1:2.4
6	/	THF	72%	1:1.5
7	/	1,4 - Dioxane	53%	1:1.1
8	/	THF:DMF = 2:1	86%	1:1.5
9	/	DMI	80%	1:2.5
10 [d]	/	DMI	80%	1:2.9
11	Dtbbpy	DMI	68%	1:2.5
12	Bphen	DMI	74%	1:2.9
13	Tpy	DMI	72%	1:3.2

[a] Reaction conditions: Substrate **3b** (0.1 mmol), DIC (0.11 mmol), NHPI (0.11 mmol), DCM (0.5 mL), solvent removed after 2 h, then $Ni(ClO_4)_2{\cdot}6H_2O$ (0.02 mmol), Zn (0.2 mmol), LiCl (0.3 mmol), ligand (0.2 equiv), solvent (0.5 mL), 20°C, 12 h. [b] Isolated yields. [c] *dr* value determined by ^{1}H NMR. [d] The reaction was performed at 0 °C. DMF = N,N-Dimethylformamide, DMA = N,N-Dimethylacetamide, NMP = N-Methyl-2-pyrrolidinone, DMSO = Methyl sulfoxide, THF = Tetrahydrofuran, DMI = 1,3-Dimethyl-2-imidazolidinone. Dtbbpy = 4,4'-Di-tert-butyl-2,2'-bipyridine, Bphen = 4,7-Diphenyl-1,10-phenanthroline, Tpy = 2''-Terpyridine

Table S7. Decarboxylative cyclization reaction of substrates 3a-h



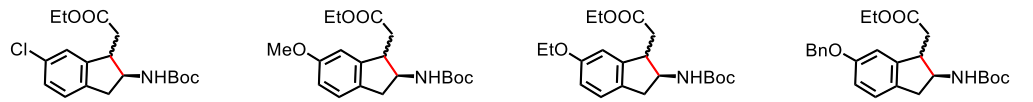


8a
89% (1:1.2 dr)
92% (1:1.2 dr) [1 mmol scale]

8b
90% (1:1 dr)
72% (1:1 dr) [1 mmol scale]

8c
95% (1:1.3 dr)
85% (1:1.3 dr) [1 mmol scale]

8d
91% (1:1.2 dr)
87% (1:1.2 dr) [1 mmol scale]



8e
87% (1:1.2 dr)
75% (1:1.2 dr) [1 mmol scale]

8f
75% (1:1.2 dr)
65% (1:1.2 dr) [1 mmol scale]

8g
80% (1:1.2 dr)
85% (1:1.2 dr) [1 mmol scale]

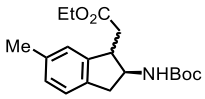
8h
83% (1:1.3 dr)
85% (1:1.3dr) [1 mmol scale]

[a] Reaction conditions: Substract (0.1 mmol), Ir (1 mol%), Cs_2CO_3 (0.1 mmol), LiCl (0.2mmol), DMSO (0.02M), Blue LED, RT. [b] Isolated yields. [c] dr value determined by ^{1}H NMR; dr ration refers to cis versus trans.

General procedure F (0.1 mmol scale): An oven-dried 25 mL Schlenck-type tube with a magnetic stir bar was charged with Ir[dF(CF_3)ppy)]$_2$(dtbbpy)PF_6 (1.1 mg, 0.001 mmol, 0.01 equiv), substract **3a-h** (0.1 mmol, 1.0 equiv), Cs_2CO_3 (32.6 mg, 0.1 mmol, 1.0equiv),LiCl (8.4 mg, 0.2 mmol, 2.0 equiv) as additive and DMSO (5 mL). The reaction mixture was cooled to -78 ℃ under vacuum for 5 min and then back filled with nitrogen while being allowed to rt. This process was repeated 3 times, then the reaction mixture was irradiated with blue LEDs (2 cm away from two 20W blue LED strips). After 12 h, the reaction mixture was diluted with saturated aqueous 1 M HCl solution, extracted with EtOAc (4 ×50 mL). The combined organic extracts were washed with water and brine, dried over Na_2SO_4 and concentrated *in vacuo*. The crude product was purified by silica gel flash column chromatography or PTLC (hexane:EtOAc = 90:10) to yield pure compound, and the dr value was determined by ^{1}H NMR.

General procedure G (1.0 mmol scale): An oven-dried 100 mL Schlenck-type tube with a magnetic stir bar was charged with Ir[dF(CF_3)ppy)]$_2$(dtbbpy)PF_6 (11 mg, 0.01 mmol, 0.01 equiv), substract **3a-h** (1.0 mmol, 1.0 equiv), Cs_2CO_3 (325.8mg, 1.0 mmol, 1.0equiv), LiCl (84 mg, 2.0 mmol, 2.0 equiv.) as additive and DMSO (50 mL). The reaction mixture was cooled to -78 ℃ under vacuum for 5 min and then backfilled with nitrogen while being allowed to rt. This process was repeated 3 times, then the reaction mixture was irradiated with blue LEDs (2 cm away from two 20W blue LED strips). After 24 h, the reaction mixture was diluted with saturated aqueous 1 M HCl solution, extracted with EtOAc (4 × 100 mL). The combined organic extracts were washed with water and brine, dried over Na_2SO_4 and concentrated *in vacuo*. The residue was purified by flash column chromatography on silica gel (eluted with hexane:EtOAc = 90:10) to furnish the desired product.

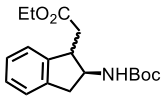
Ethyl 2-((2*S*)-2-((*tert*-butoxycarbonyl)amino)-6-methyl-2,3-dihydro-1*H*-inden-1-yl)acetate (8a)



Substrate **3a** was cyclized following the general procedure **F** on 0.1 mmol scale (29.6 mg, 89%, 1:1.2 d.r.) and the general procedure **G** on 1 mmol scale (0.307 g, 92%, 1:1.2 d.r.) to provide compound **8a**. Yellow oil, ^{1}H NMR (400 MHz, $CDCl_3$, 1:1.2 d.r.) δ 7.11–7.06 (m, 1H), 7.03–6.93 (m, 2H), 4.90–4.62 (m, 1H), 4.28–4.00 (m, 2H), 3.71 (q, *J* = 7.0 Hz, 0.45H), 3.39 (q, *J* = 7.0 Hz, 0.55H), 3.30 (dd, *J* = 15.6, 7.6 Hz, 0.55H), 3.15 (dd, *J* = 16.6, 6.7 Hz, 0.45H), 2.78–2.64 (m, 2H), 2.67–2.57 (m, 1H), 2.31 (m, 3H), 1.45–1.38 (m, 9H), 1.31–1.23 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 172.5, 155.6, 155.5, 143.4, 143.0, 137.4, 137.2, 136.6, 136.5, 128.1,

127.9, 124.7, 124.5, 124.5, 124.3, 79.3,79.2, 60.6, 60.5, 58.2, 54.6, 47.4, 44.2, 38.4, 38.4, 37.9, 34.0, 28.4, 28.3, 21.4, 21.3, 14.2, 14.2. HRMS-ESI m/z Calcd for $C_{19}H_{27}NNaO_4$ $[M+Na]^+$: 356.1832; found 356.1830.

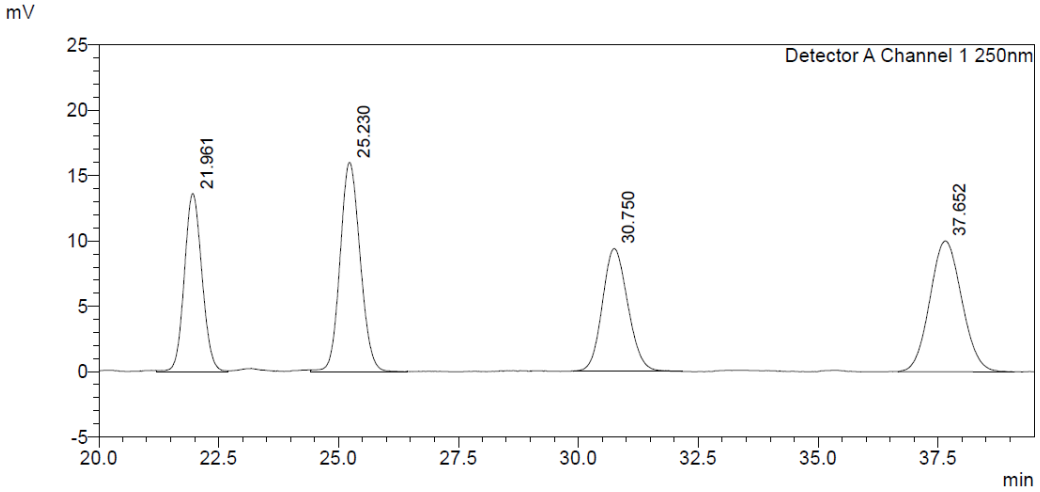
Ethyl 2-((2*S*)-2-((*tert*-butoxycarbonyl)amino)-2,3-dihydro-1*H*-inden-1-yl)acetate (8b)



Substrate **3b** was cyclized following the general procedure **F** on 0.1 mmol scale (28.7 mg, 90%, 1:1 d.r.) and the general procedure **G** on 1 mmol scale (0.229 g, 72%, 1:1 d.r.) to provide compound **8b**. Colorless oil,^{1}H NMR (400 MHz, $CDCl_3$, 1:1 d.r.) δ 7.25–7.10 (m, 4H), 4.91–4.65 (m, 1H), 4.25–4.07 (m, 2H), 3.75 (q, *J* = 6.8 Hz, 0.5H), 3.44 (q, *J* = 7.0 Hz, 0.5H), 3.35 (dd, *J* = 15.7, 7.4 Hz, 0.5H), 3.20 (dd, *J* = 16.0, 6.9 Hz, 0.5H), 2.83–2.67 (m, 2H), 2.66–2.61 (m, 1H), 1.45–1.43 (m, 9H), 1.30–1.22 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 172.5, 155.6, 155.5, 143.3, 142.9, 140.5, 140.3, 127.3, 127.2, 126.9, 126.9, 124.8, 124.7, 124.1, 123.6, 79.3, 60.7, 60.6, 58.0, 54.4, 47.5, 44.3, 38.8, 37.8, 34.0, 31.4, 28.4, 28.3, 14.2, 14.1. <5% ee as determined by HPLC (Chiralcel OZH, 85:15 hexane/*i*-PrOH, 0.5 mL/min, 25 °C, λ = 250 nm), tr = 22.0 min, tr = 25.2 min, tr = 30.7 min, tr = 37.3 min. HRMS-ESI m/z Calcd for $C_{18}H_{25}NNaO_4$ $[M+Na]^+$: 342.1676; found 342.1683.

Area % Report (racemic)

<Chromatogram>



<Peak Table>

Detector A Channel 1 250nm

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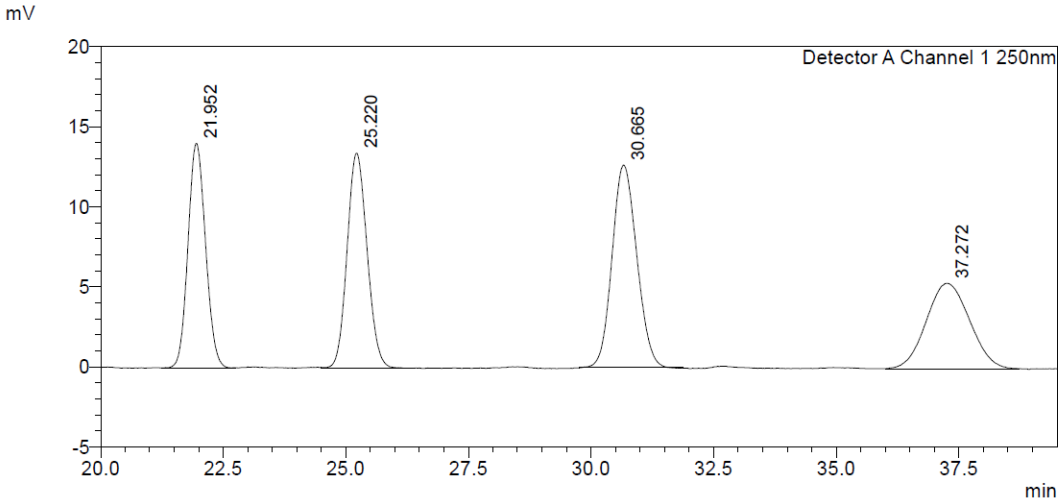
2	25.230	16037	469326	28.769
3	30.750	9393	347708	21.314
4	37.652	10015	463898	28.436
Total		49103	1631374	100.000

Area % Report (chiral)

<Chromatogram>

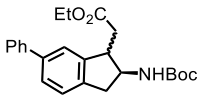


<Peak Table>

Detector A Channel 1 250nm

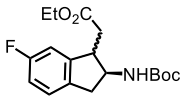
Peak#	Ret. Time	Height	Area	Area%
1	21.952	14039	350759	23.339
2	25.220	13419	380773	25.336
3	30.665	12653	443789	29.529
4	37.272	5337	327590	21.797
Total		45448	1502910	100.000

Ethyl 2-((2*S*)-2-((*tert*-butoxycarbonyl)amino)-6-phenyl-2,3-dihydro-1*H*-inden-1-yl)acetate (8c)



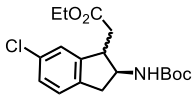
Substrate **3c** was cyclized following the general procedure **F** on 0.1 mmol scale (37.5 mg, 95%, 1:1.3 d.r.) and the general procedure **G** on 1 mmol scale (0.336 g, 85%, 1:1.3 d.r.) to provide compound **8c**. Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$, 1:1.3 d.r.) δ 7.58–7.50 (m, 2H), 7.46–7.38 (m, 3H), 7.38–7.22 (m, 3H), 5.05–4.63 (m, 1H), 4.28–4.08 (m, 2H), 3.82 (q, *J* = 6.9 Hz, 0.43H), 3.50 (q, *J* = 7.0 Hz, 0.57H), 3.39 (dd, *J* = 16.0, 7.3 Hz, 0.57H), 3.25 (dd, *J* = 16.1, 6.9 Hz, 0.43H), 2.88–2.64 (m, 3H), 1.47–1.44 (m, 9H), 1.30–1.21 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 172.5, 155.6, 155.5, 144.0, 143.6, 141.3, 141.3, 140.3, 140.3, 139.6, 139.5, 128.7, 128.7, 127.1, 127.1, 127.1, 127.1, 126.5, 126.3, 125.1, 125.0, 122.9, 122.5, 79.4, 60.7, 60.6, 58.2, 54.6, 47.6, 44.4, 38.5, 37.9, 34.1, 29.7, 28.4, 28.3, 14.2, 14.1. HRMS-ESI m/z Calcd for $C_{24}H_{29}NNaO_4$ $[M+Na]^+$: 418.1989; found 418.1991.

Ethyl 2-((2*S*)-2-((*tert*-butoxycarbonyl)amino)-6-fluoro-2,3-dihydro-1*H*-inden-1-yl)acetate (8d)



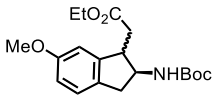
Substrate **3d** was cyclized following the general procedure **F** on 0.1 mmol scale (30.7 mg, 91%, 1:1.2 d.r.) and the general procedure **G** on 1 mmol scale (0.293 g, 87%, 1:1.2 d.r.) to provide compound **8d**. Colorless oil;^{1}H NMR (400 MHz, $CDCl_3$, 1:1.2 d.r.) δ 7.16– 7.10 (m, 1H), 6.90–6.83 (m, 2H), 4.97–4.57 (m, 1H), 4.27–4.07 (m, 2H), 3.73 (q, *J* = 6.8 Hz, 0.44H), 3.41 (q, *J* = 6.8 Hz, 0.56H), 3.29 (dd, *J* = 15.9, 7.6 Hz, 0.56H), 3.15 (dd, *J* = 16.1, 7.5 Hz, 0.44H), 2.81–2.47 (m, 3H), 1.49–1.42 (m, 9H), 1.30–1.22 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 172.3, 162.2 (d, *J* = 244.0 Hz), 155.5, 155.4 (minor), 145.5, 145.0 (minor), 135.7 (minor), 135.6, 125.7, 114.20 (d, *J* = 22.4 Hz), 110.0 (d, J = 22.5 Hz), 79.5, 60.8, 60.7 (minor), 58.3, 54.8 (minor), 47.6, 44.4 (minor), 38.0, 37.9 (minor), 37.6, 33.9 (minor), 28.4, 28.3 (minor), 14.2, 14.1 (minor). ^{19}F NMR (375 MHz, $CDCl_3$) δ -115.8, -115.9. HRMS-ESI m/z Calcd for $C_{18}H_{24}FNNaO_4$ $[M+Na]^+$: 360.1586; found 360.1578.

Ethyl 2-((2*S*)-2-((*tert*-butoxycarbonyl)amino)-6-chloro-2,3-dihydro-1*H*-inden-1-yl)acetate (8e)



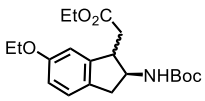
Substrate **3e** was cyclized following the general procedure **F** on 0.1 mmol scale (30.7 mg, 87%, 1:1.2 d.r.) and the general procedure **G** on 1 mmol scale (0.253 g, 75%, 1:1.2 d.r.) to provide compound **8e**. Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$, 1:1.2 d.r.) δ 7.20–7.11 (m, 3H), 5.03–4.61 (m, 1H), 4.30–4.08 (m, 2H), 3.74 (t, *J* = 6.9 Hz, 0.45H), 3.44 (q, *J* = 7.1 Hz, 0.55H), 3.31 (dd, *J* = 15.9, 7.4 Hz, 0.55H), 3.18 (dd, *J* = 16.0, 6.9 Hz, 0.45H), 2.86–2.47 (m, 3H), 1.46–1.44 (m, 9H), 1.33–1.24 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 172.2, 155.5, 155.4, 145.3, 144.9, 138.9, 138.7, 132.6, 132.6, 127.5, 127.3, 125.9, 125.8, 124.5, 124.1, 79.5, 60.8, 60.7, 58.1, 54.5, 47.4, 44.3, 38.2, 37.6, 33.8, 28.4, 28.3, 14.2, 14.1. HRMS-ESI m/z Calcd for $C_{18}H_{24}ClNNaO_4$ $[M+Na]^+$: 376.1286; found 376.1286.

Ethyl 2-((2*S*)-2-((*tert*-butoxycarbonyl)amino)-6-methoxy-2,3-dihydro-1*H*-inden-1-yl)acetate (8f)



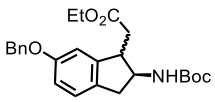
Substrate **3f** was cyclized following the general procedure **F** on 0.1 mmol scale (26.3 mg, 75%, 1:1.2 d.r.) and the general procedure **G** on 1 mmol scale (0.227 g, 65%, 1:1.2 d.r.) to provide compound **8f**. Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$, 1:1.2 d.r.) δ 7.14–7.07 (m, 1H), 6.75–6.70 (m, 2H), 4.98–4.57 (m, 1H), 4.27–4.07 (m, 2H), 3.77 (s,3H), 3.72 (q, *J* = 7.0, 6.5 Hz, 0.45H), 3.40 (q, *J* = 7.2 Hz, 0.55H), 3.27 (dd, *J* = 15.5, 7.5 Hz, 0.55H), 3.13 (dd, *J* = 15.7, 7.0 Hz, 0.45H), 2.72–2.54 (m, 3H), 1.48–1.37 (m, 9H), 1.35–1.23 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 172.5, 159.1, 159.1, 155.6, 155.5, 144.9, 144.4, 132.3, 132.2, 125.4, 125.3, 113.0, 112.9, 109.9, 109.5, 79.3, 60.7, 60.6, 58.3, 55.4, 55.4, 54.8, 47.8, 44.5, 38.0, 37.9, 34.0, 33.7, 28.4, 28.3, 14.2, 14.2. HRMS-ESI m/z Calcd for $C_{19}H_{27}NNaO_5$ $[M+Na]^+$: 372.1781; found 372.1788.

Ethyl 2-((2*S*)-2-((*tert*-butoxycarbonyl)amino)-6-ethoxy-2,3-dihydro-1*H*-inden-1-yl)acetate (8g)



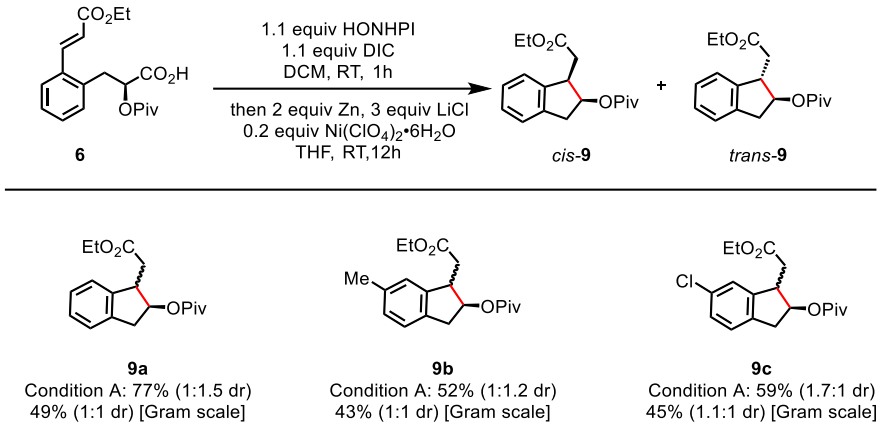
Substrate **3g** was cyclized following the general procedure **F** on 0.1 mmol scale (29.0 mg, 80%, 1:1.2 d.r.) and the general procedure **G** on 1 mmol scale (0.309 g, 85%, 1:1.2 d.r.) to provide compound **8g**. Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$, 1:1.2 d.r.) δ 7.10–7.05 (m, 1H), 6.74–6.69 (m, 2H), 4.94–4.57 (m, 1H), 4.25–4.04 (m, 2H), 4.01–3.95 (m, 2H), 3.70 (q, *J* = 6.8 Hz, 0.44H), 3.39 (q, *J* = 7.1 Hz, 0.56H), 3.26 (dd, *J* = 15.5, 7.4 Hz, 0.56H), 3.12 (dd, *J* = 15.2, 7.0 Hz, 0.44H), 2.74–2.55 (m, 3H), 1.45–1.42 (m, 9H), 1.41–1.36 (m, 3H), 1.30–1.20 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 172.5, 158.4, 158.4, 155.6, 155.5, 144.8, 144.3, 132.1, 132.0, 125.3, 125.3, 113.6, 113.5, 110.5, 110.1, 79.3, 63.6, 63.6, 60.7, 60.6, 58.3, 54.8, 47.7, 44.5, 38.0, 37.9, 34.0, 28.4, 28.3, 14.8, 14.2, 14.2. HRMS-ESI m/z Calcd for $C_{20}H_{29}NNaO_5$ $[M+Na]^+$: 386.1938; found 386.1940.

Ethyl 2-((2*S*)-6-(benzyloxy)-2-((*tert*-butoxycarbonyl)amino)-2,3-dihydro-1*H*-inden-1-yl)acetate (8h)



Substrate **3h** was cyclized following the general procedure **F** on 0.1 mmol scale (35.3 mg, 83%, 1:1.25 d.r.) and the general procedure **G** on 1 mmol scale (0.361 g, 85%, 1:1.2 d.r.) to provide compound **8h**. Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$, 1:1.2 d.r.) δ 7.50–7.26 (m, 5H), 7.12–7.07 (m, 1H), 6.85–6.77 (m, 2H), 5.02 (d, *J* = 2.3 Hz, 2H), 4.93–4.63 (m, 1H), 4.26–4.07 (m, 2H), 3.72 (q, *J* = 6.9 Hz, 0.45H), 3.40 (q, *J* = 7.1 Hz, 0.55H), 3.27 (dd, *J* = 15.5, 7.4 Hz, 0.55H), 3.14 (dd, *J* = 15.6, 6.9 Hz, 0.45H), 2.80–2.50 (m, 3H), 1.51–1.43 (m, 9H), 1.30–1.21 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 172.4, 158.3, 158.3, 155.6, 155.4, 144.9, 144.4, 137.0, 132.6, 132.5, 128.5, 127.9, 127.4, 125.4, 125.3, 113.9, 113.7, 110.9, 110.5, 79.3, 70.2, 60.7, 60.6, 58.3, 54.8, 47.7, 44.5, 38.0, 37.9, 37.8, 34.0, 28.4, 28.3, 14.2, 14.1. HRMS-ESI m/z Calcd for $C_{25}H_{31}NNaO_5$ $[M+Na]^+$: 448.2094; found 448.2090.

Table S8. Decarboxylative cyclization reactions of substrates 6a-c



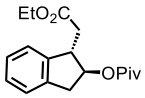
[a] Reaction conditions: Substrate **6a-c** (0.1 mmol), DIC (0.11 mmol), NHPI (0.11 mmol), DCM (0.5 mL), solvent removed after 2 h, then $Ni(ClO_4)_2 \cdot 6H_2O$ (0.02 mmol), Zn (0.2 mmol), LiCl (0.3 mmol), THF (0.5 mL), 20°C, 12 h. [b] dr ration refers to cis versus trans.

General procedure H (Condition B, 0.1 mmol scale): A culture tube was charged with substrate **6a-c** (0.1 mmol, 1.0 equiv) and NHPI (0.11 mmol, 1.1 equiv). DCM (0.5 mL, anhydrous, 0.2 M) was added, and DIC (0.11 mmol, 17 μL) was added drop wise. The reactions were monitored by TLC (typical time was 1 h). After consumption of all starting material, the solvent was removed on a rotary evaporator at 40 ℃ under reduced pressure and dried on a high-vacuum line for at least 5 minutes to remove residue of DCM. Then, the culture tube was charged with LiCl (12.7 mg, 0.3 mmol, 3.0 equiv), Zn powder (13.1 mg, 0.2 mmol, 2.0 equiv), and $Ni(ClO_4)_2 \cdot 6H_2O$ (7.4 mg, 0.04 mmol, 0.2 equiv), and the culture tube was evacuated and backfilled with argon from a balloon. To the reaction mixture was added THF (0.2 M), and the mixture was stirred overnight at room temperature. After 12 hours, sat. aq. NH_4Cl solution was added. The mixture was extracted with EtOAc three times, and the organic layer was dried over Na_2SO_4. The crude product was purified by silica gel flash column chromatography or PTLC (hexane:EtOAc = 90:10) to yield pure compound, and the dr value was determined by ^1H NMR.

General procedure I (Condition B, 1.0 mmol scale): A culture tube was charged with substrate **6a-c** (1.0 equiv) and NHPI (1.1 equiv). DCM (0.2 M) was added, and DIC (1.1 mmol) was added drop wise. The reactions were monitored by TLC (typical time was 1 h). After consumption of all starting material, the solvent was removed on a rotary evaporator at 40 ℃ under reduced pressure and dried on a high-vacuum line for at least 5 minutes to remove residue of DCM. Then, the culture tube was charged with LiCl (12.7 mg, 0.3 mmol, 3.0 equiv), Zn powder (13.1 mg, 0.2 mmol, 2.0 equiv), and $Ni(ClO_4)_2 \cdot 6H_2O$ (7.4 mg, 0.04 mmol, 0.2 equiv), and the culture tube was evacuated and backfilled with argon from a balloon. To the reaction mixture was added THF (0.2 M), and the mixture was stirred overnight at room temperature.

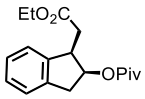
After 12 hours, sat. aq. NH_4Cl solution were added. The mixture was extracted with EtOAc three times, and the organic layer was dried over Na_2SO_4. The crude product was purified by silica gel flash column chromatography (hexane:EtOAc = 90:10) to yield pure compound, and the dr value was determined by ^1H NMR.

(1*S*,2*S*)-1-(2-ethoxy-2-oxoethyl)-2,3-dihydro-1H-inden-2-yl pivalate (*trans*-9a)



Substrate **6a** as cyclized following the general procedure **H** on 0.1 mmol scale (20.3 mg, 67%, cis:trans = 1:1.6) and the general procedure **I** on gram scale (gram scale: 4.35 mmol, 0.404 g, 42%, cis:trans = 1:1.1) to provide compound **9a.** The trans isomer ***trans*-9a** was separated by PTLC (preparative TLC) (Hexane: EtOAc = 9:1). Colorless oil; ^1H NMR (400 MHz, $CDCl_3$) δ 7.21–7.19 (m, 4H), 5.24 (dt, *J* = 6.9, 4.5 Hz, 1H), 4.23–4.09 (m, 2H), 3.66 (td, *J* = 7.0, 4.4 Hz, 1H), 3.43 (dd, *J* = 16.8, 7.0 Hz, 1H), 2.86 (dd, *J* = 16.8, 4.5 Hz, 1H), 2.66 (d, *J* = 7.0 Hz, 2H), 1.25 (t, *J* = 7.1 Hz, 3H), 1.18 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 178.5, 171.8, 142.5, 139.9, 127.4, 127.0, 124.7, 123.9, 79.5, 60.6, 47.4, 38.6, 38.0, 38.0, 27.1, 14.2. <5% ee as determined by HPLC (Chiralcel OZH, 95:5 hexane/*i*-PrOH, 0.5 mL/min, 25 °C, λ = 250 nm), tr = 8.7 min, tr = 9.4 min, tr = 9.8 min, tr = 11.0 min. HRMS-ESI m/z Calcd for $C_{18}H_{24}NaO_4$ $[M+Na]^+$: 327.1567; found 327.1570.

(1*R*,2*S*)-1-(2-ethoxy-2-oxoethyl)-2,3-dihydro-1*H*-inden-2-yl pivalate (*cis*-9a)



The cis isomer ***cis*-9a** was separated by PTLC (preparative TLC) (Hexane: EtOAc = 9:1). Colorless oil; ^1H NMR (400 MHz, $CDCl_3$) δ 7.24–7.15 (m, 4H), 5.61 (td, *J* = 5.9, 2.8 Hz, 1H), 4.25–4.11 (m, 2H), 3.83 (dt, *J* = 8.5, 6.4 Hz, 1H), 2.89 (dd, *J* = 17.0, 2.8 Hz, 1H), 2.81–2.68 (m, 2H), 1.28 (t, *J* = 7.2 Hz, 3H), 1.14 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 177.9, 172.2, 142.8, 140.2, 127.2, 126.8, 124.7, 123.4, 75.9, 60.6, 44.2, 38.9, 38.7, 33.4, 27.0, 14.2. HRMS-ESI m/z Calcd for $C_{18}H_{24}NaO_4$ $[M+H]^+$: 327.1567; found 327.1572.

Area % Report (racemic)

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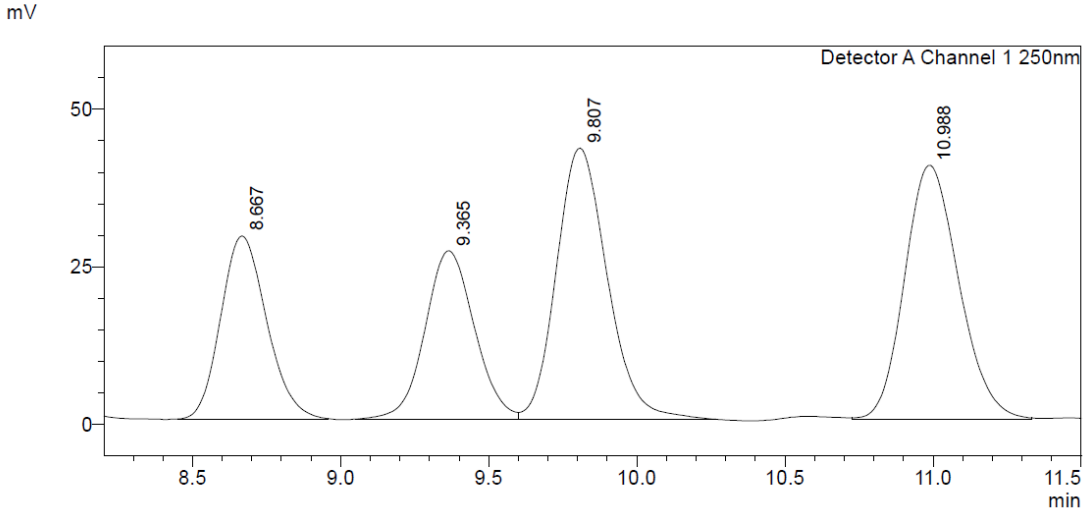

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Detector A Channel 1 250nm

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3	9.807	43036	512367	31.085
4	10.988	40246	512709	31.106
Total		139114	1648279	100.000

Area % Report (chiral)

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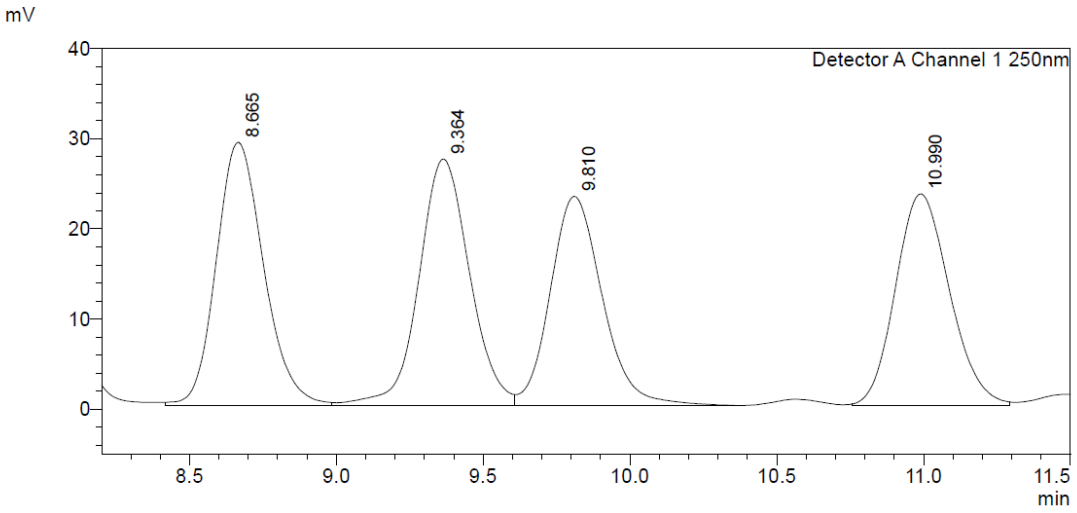

<Peak Table>

Detector A Channel 1 250nm

Peak#	Ret. Time	Height	Area	Area%
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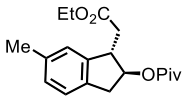
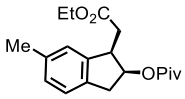
2	9.364	27400	330375	26.439
3	9.810	23252	287708	23.024
4	10.990	23520	301745	24.147
Total		103425	1249597	100.000

(1*S*,2*S*)-1-(2-ethoxy-2-oxoethyl)-6-methyl-2,3-dihydro-1*H*-inden-2-yl pivalate (*trans*-9b)



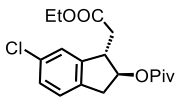
Substrate **6b** as cyclized following the general procedure **H** on 0.1 mmol scale (16.4 mg, 52%, cis:trans = 1:1.2) and the general procedure **I** on gram scale (gram scale: 3.0 mmol, 0.415 g, 43%, cis:trans = 1:1.2) to provide compound **9b.** The trans isomer ***trans*-9b** was separated by PTLC (preparative TLC) (Hexane: EtOAc = 9:1). Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.11–7.06 (m, 1H), 7.05–6.98 (m, 2H), 5.22 (dt, *J* = 7.0, 4.5 Hz, 1H), 4.22–4.10 (m, 2H), 3.62 (td, *J* = 7.1, 4.2 Hz, 1H), 4.42–4.32 (m, 1H), 3.84–3.76 (m, 1H), 2.64 (d, *J* = 7.1 Hz, 2H), 2.32 (s, 3H), 1.25 (t, *J* = 7.2 Hz, 3H), 1.17 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 178.5, 171.9, 142.6, 136.8, 136.6, 128.2, 124.5, 124.4, 79.7, 60.6, 47.3, 38.6, 38.0, 37.6, 27.0, 21.4, 14.2. HRMS-ESI m/z Calcd for $C_{19}H_{26}NaO_4$ $[M+Na]^+$: 341.1723; found 341.1727.

(1*R*,2*S*)-1-(2-ethoxy-2-oxoethyl)-6-methyl-2,3-dihydro-1*H*-inden-2-yl pivalate (*cis*-9b)



The cis isomer ***cis*-9b** was separated by PTLC (preparative TLC) (Hexane: EtOAc = 9:1). Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.12–7.07 (m, 1H), 7.07–6.95 (m, 2H), 5.60 (td, *J* = 6.0, 2.9 Hz, 1H), 4.26–4.10 (m, 2H), 3.79 (q, *J* = 6.5 Hz, 1H), 3.27–3.18 (m, 1H), 2.87–2.79 (m, 1H), 2.78–2.68 (m, 2H), 2.33 (s, 3H), 1.28 (t, *J* = 7.2 Hz, 3H), 1.14 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 177.9, 172.3, 142.9, 137.1, 136.5, 128.0, 124.4, 124.1, 76.1, 60.6, 44.1, 38.9, 38.3, 33.5, 27.0, 21.4, 14.2. HRMS-ESI m/z Calcd for $C_{19}H_{26}NaO_4$ $[M+Na]^+$: 341.1723; found 341.1717.

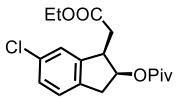
(1*S*,2*S*)-6-chloro-1-(2-ethoxy-2-oxoethyl)-2,3-dihydro-1*H*-inden-2-yl pivalate (*trans*-9c)



Substrate **6c** as cyclized following the general procedure **H** on 0.1 mmol scale (23.8 mg, 59%, cis:trans = 1.7:1) and the general procedure **I** on gram scale (gram scale: 3.43 mmol, 0.480 g, 45%, cis:trans = 1.1:1) to provide compound **9c.** The trans isomer ***trans*-9c** was separated by PTLC (preparative TLC) (Hexane: EtOAc = 9:1). Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.17–7.10 (m, 3H), 5.24–5.21 (m, 1H), 4.21–4.10 (m, 2H), 3.61 (td, *J* = 7.0, 4.1 Hz, 1H), 3.37 (dd, *J* = 16.9, 6.9 Hz, 1H), 2.81 (dd, *J* = 17.0, 4.2 Hz, 1H), 2.69–2.57 (m, 2H), 1.24 (t, *J*

= 7.1 Hz, 3H), 1.16 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 178.3, 171.4, 144.6, 138.4, 132.6, 127.6, 125.8, 124.4, 79.4, 60.7, 47.4, 38.5, 37.6, 37.4, 27.0, 14.1. HRMS-ESI m/z Calcd for $C_{18}H_{24}ClO_4$ $[M+H]^+$: 339.1358; found 339.1352.

(1*R*,2*S*)-6-chloro-1-(2-ethoxy-2-oxoethyl)-2,3-dihydro-1*H*-inden-2-yl pivalate (*cis*-9c)

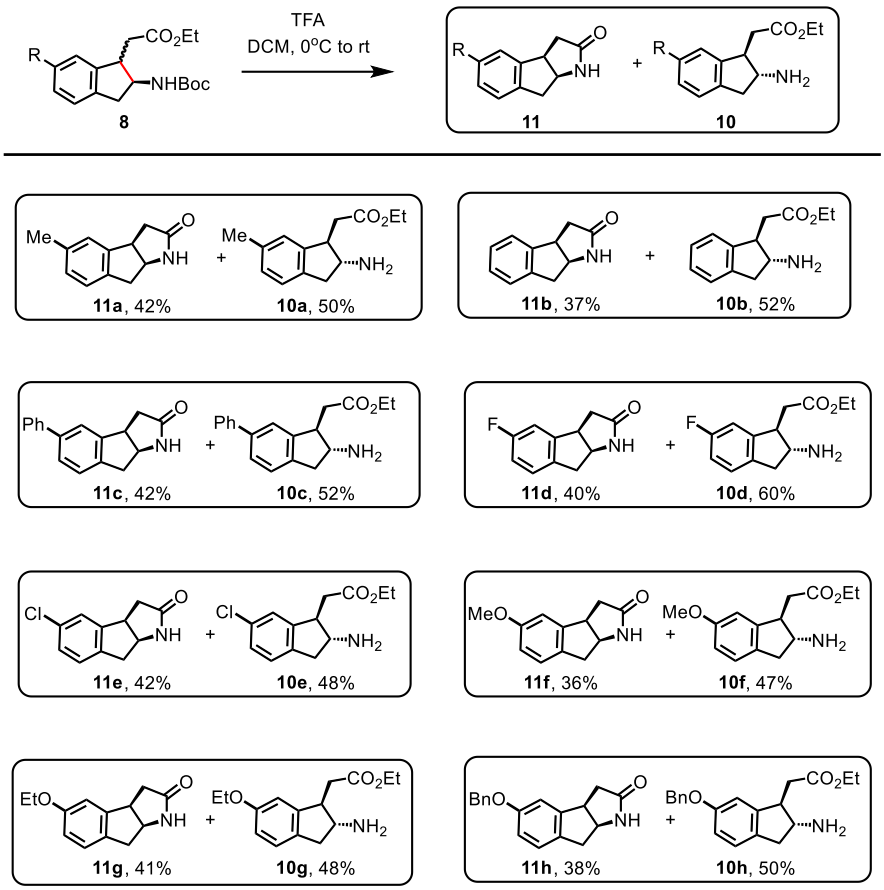


The cis isomer ***trans*-9c** was separated by PTLC (preparative TLC) (Hexane: EtOAc = 9:1). Yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.18-7.12 (m, 3H), 5.59 (td, *J* = 5.8, 2.6 Hz, 1H), 4.24-4.12 (m, 2H), 3.79 (q, *J* = 7.1 Hz, 1H), 3.22 (dd, *J* = 17.1, 5.7 Hz, 1H), 2.84 (dd, *J* = 17.1, 2.6 Hz, 1H), 2.72 (d, *J* =7.7 Hz, 2H), 1.27 (t, *J* = 7.1 Hz, 3H), 1.12 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 177.8, 171.9, 144.9, 138.7, 132.6, 127.4, 125.8, 123.8, 76.0, 60.7, 44.2, 38.9, 38.2, 33.1, 27.0, 14.2. HRMS-ESI m/z Calcd for $C_{18}H_{24}ClO_4$ $[M+H]^+$: 339.1358; found 339.1366.

2.3 C-Ring formation *via* intramolecular cyclization

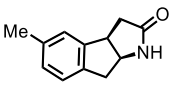
2.3.1 Synthetic route of compounds 11 from 8a-h (NHBoc series)

Table S9. C-Ring formation from substrates 8a-h



General Procedure J: To a stirred solution of substrate **8a-h** (1.0 equiv) in DCM (10 mL/ mmol) was added TFA (10.0 equiv) at 0℃. When the addition was complete, the reaction mixture was warmed to room temperature (RT) and stirred for an additional 2h. The mixture was quenched with saturated aqueous $NaHCO_3$ followed by the addition of EtOAc. The organic layer was separated, and the aqueous phase was further extracted with EtOAc (2 times). The combined organic phase was dried over Na_2SO_4. After removal of the solvent *in vacuo*, the residue was stirred with silica gel (400 mesh, RT, 6 h) in DCM immediately before purified by column chromatography on silica gel to give the products **10a-h** and **11a-h**.

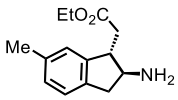
(3a*R*,8a*S*)-5-methyl-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (11a)



Compound **11a** was obtained following general procedure **J** from **8a** (0.922 mmol, 0.307g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **11a** was obtained as a white solid (0.072 g, 42%); mp 202.3-203.1 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.12–7.01 (m, 3H), 5.96 (s, 1H), 4.48 (t, *J* = 6.3 Hz, 1H), 3.90 (t, *J* = 7.9 Hz,

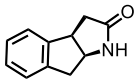
1H), 3.18 (dd, *J* = 16.7, 6.3 Hz, 1H), 2.94–2.79 (m, 2H), 2.49 (dd, *J* = 17.1, 1.8 Hz, 1H), 2.34 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 177.0, 144.1, 137.2, 137.1, 128.7, 125.2, 124.9, 58.1, 44.8, 39.2, 36.9, 21.2. HRMS-ESI m/z Calcd for $C_{12}H_{13}NNaO$ $[M+Na]^+$: 210.0889; found 210.0886.

Ethyl 2-((1*S*,2*S*)-2-amino-6-methyl-2,3-dihydro-1*H*-inden-1-yl)acetate (10a)



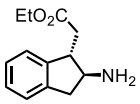
Compound **10a** was obtained following general procedure **J** from **8a** (0.922 mmol, 0.307g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **10a** was obtained as a colorless oil(0.107 g, 50%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.11–6.94 (m, 3H), 4.20 (q, *J* = 7.2 Hz, 2H), 3.43 (br s, 2H), 3.24–3.14 (m, 2H), 2.73–2.50 (m, 3H), 2.31 (s, 3H), 1.29 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.0, 144.0, 137.9, 136.3, 127.9, 124.6, 124.5, 60.6, 59.8, 50.9, 41.1, 38.3, 21.4, 14.3. HRMS-ESI m/z Calcd for $C_{14}H_{20}NO_2$ $[M+H]^+$: 234.1489; found 234.1490.

(3a*R*,8a*S*)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (11b)



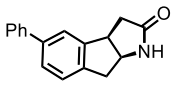
Compound **11b** was obtained following general procedure **J** from **8b** (2.187 mmol, 0.698g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **11b** was obtained as a white solid (0.155 g, 41%); mp 177.2-178.5 ℃;^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25-7.16 (m, 4H), 6.99 (br s, 1H), 4.47 (t, *J* = 6.4 Hz, 1H), 3.91 (dd, *J* = 9.0, 6.8 Hz, 1H), 3.19 (dd, *J* = 16.9, 6.3 Hz, 1H), 2.96 (d, *J* = 16.9 Hz, 1H), 2.86 (dd, *J* = 17.1, 9.3 Hz, 1H), 2.48 (dd, *J* = 17.1, 1.7 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 177.3, 144.0, 140.3, 127.7, 127.3, 125.2, 124.6, 58.0, 44.8, 39.5, 37.1. HRMS-ESI m/z Calcd for $C_{11}H_{11}NNaO$ $[M+Na]^+$: 196.0733; found 196.0736.

Ethyl 2-((1*S*,2*S*)-2-amino-2,3-dihydro-1*H*-inden-1-yl)acetate (10b)



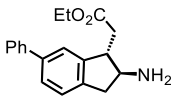
Compound **11b** was obtained following general procedure **J** from **8b** (2.187 mmol, 0.698g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **11b** was obtained as a yellow oil (0.280 g, 58%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21-7.12 (m, 4H), 4.19 (q, *J* = 7.2 Hz, 2H), 3.54–3.46 (m, 1H), 3.37–3.22 (m, 2H), 2.95 (br s, 2H), 2.76 (td, *J* = 16.2, 6.3 Hz, 2H), 2.59 (dd, *J* = 16.0, 8.1 Hz, 1H), 1.28 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.0, 143.4, 140.7, 127.2, 126.8, 124.8, 123.8, 60.7, 59.2, 49.9, 40.6, 38.2, 14.2. HRMS-ESI m/z Calcd for $C_{13}H_{17}NNaO_2$ $[M+Na]^+$: 242.1151; found 242.1147.

(3a*R*,8a*S*)-5-phenyl-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (11c)



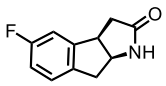
Compound **11c** was obtained following general procedure **J** from **8c** (2.199 mmol, 0.871 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **11c** was obtained as a white solid (0.231g, 42%); mp 182.2-183.0 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58–7.53 (m, 2H), 7.48–7.40 (m, 4H), 7.37–7.31 (m, 1H), 7.30–7.26 (m, 1H), 6.27 (br s, 1H), 4.54 (t, *J* = 6.3 Hz, 1H), 4.00 (t, *J* = 7.9 Hz, 1H), 3.26 (dd, *J* = 17.0, 6.3 Hz, 1H), 3.00 (d, *J* = 17.0 Hz, 1H), 2.91 (dd, *J* = 17.1, 9.3 Hz, 1H), 2.57 (dd, *J* = 17.1, 1.8 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 176.9, 144.7, 141.1, 140.9, 139.4, 128.8, 127.2, 127.1, 127.1, 125.5, 123.4, 58.1, 45.0, 39.3, 37.0. HRMS-ESI m/z Calcd for $C_{17}H_{15}NNaO$ $[M+Na]^+$: 272.1046; found 272.1086.

Ethyl 2-((1*S*,2*S*)-2-amino-6-phenyl-2,3-dihydro-1H-inden-1-yl)acetate (10c)



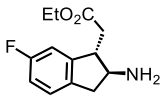
Compound **10c** was obtained following general procedure **J** from **8c** (2.199 mmol, 0.871 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **10c** was obtained as a colorless oil (0.378g, 58%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57–7.50 (m, 2H), 7.45–7.39 (m, 3H), 7.38–7.30 (m, 2H), 7.28–7.24 (m, 1H), 4.29 (br s, 2H), 4.25–4.13 (m, 2H), 3.64 (q, *J* = 6.9 Hz, 1H), 3.52–3.44 (m, 1H), 3.34 (dd, *J* = 16.1, 7.5 Hz, 1H), 2.96–2.85 (m, 2H), 2.63 (dd, *J* = 16.4, 8.9 Hz, 1H), 1.28 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.3, 143.4, 141.2, 140.4, 139.3, 128.7, 127.1, 127.1, 126.6, 125.1, 122.6, 61.0, 59.0, 48.6, 39.3, 38.3, 14.1. HRMS-ESI m/z Calcd for $C_{19}H_{22}NO_2$ $[M+H]^+$: 296.1645; found 296.1644.

(3a*R*,8a*S*)-5-fluoro-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (11d)



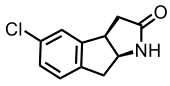
Compound **11d** was obtained following general procedure **J** from **8d** (1.792 mmol, 0.604 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **11d** was obtained as a white solid (0.140g, 41%); mp 193.8-194.5 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.17–7.10 (m, 1H), 6.96–6.87 (m, 2H), 6.51 (s, 1H), 4.51 (t, *J* = 6.3 Hz, 1H), 3.91 (t, *J* = 7.8 Hz, 1H), 3.22–3.11 (m, 1H), 2.95–2.80 (m, 2H), 2.45 (dd, *J* = 17.1, 2.1 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 176.7, 162.7 (d, *J* = 244.1 Hz), 146.2 (d, *J* = 7.6 Hz), 135.6 (d, *J* = 2.4 Hz), 126.3 (d, *J* = 8.6 Hz), 115.0 (d, *J* = 22.4 Hz), 111.5 (d, *J* = 21.9 Hz), 58.4, 45.0 (d, *J* = 2.4 Hz), 38.9, 36.8. ^{19}F NMR (375 MHz, $CDCl_3$) δ -115.7. HRMS-ESI m/z Calcd for $C_{11}H_{10}FNNaO$ $[M+Na]^+$: 214.0639; found 214.0640.

Ethyl 2-((1*S*,2*S*)-2-amino-6-fluoro-2,3-dihydro-1*H*-inden-1-yl)acetate (10d)



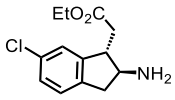
Compound **10d** was obtained following general procedure **J** from **8d** (1.792 mmol, 0.604 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **10d** was obtained as a colourless oil (0.247 g, 58%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.15–7.07 (m, 1H), 6.91–6.80 (m, 2H), 4.19 (q, *J* = 7.1 Hz, 2H), 3.48 (q, *J* = 6.4 Hz, 1H), 3.28–3.13 (m, 2H), 2.77–2.53 (m, 3H), 1.86 (br s, 2H), 1.28 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 172.6, 162.2 (d, *J* = 243.2 Hz), 145.9 (d, *J* = 7.6 Hz), 136.2 (d, *J* = 2.4 Hz), 125.7 (d, *J* = 8.6 Hz), 114.0 (d, *J* = 21.9 Hz), 111.1 (d, *J* = 22.4 Hz), 60.7, 59.8, 50.7, 40.5, 37.9, 14.2.^{19}F NMR (375 MHz, $CDCl_3$) δ -116.3. HRMS-ESI m/z Calcd for $C_{13}H_{16}FNNaO_2$ $[M+Na]^+$: 238.1238; found 238.1235.

(3a*R*,8a*S*)-5-chloro-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (11e)



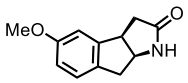
Compound **11e** was obtained following general procedure **J** from **8e** (2.078 mmol, 0.734 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **11e** was obtained as a white solid (0.181g, 42%); mp 192.1-193.4 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20–7.18 (m, 2H), 7.15–7.10 (m, 1H), 6.32 (br s, 1H), 4.50 (t, *J* = 6.4 Hz, 1H), 3.92 (t, *J* = 8.0 Hz, 1H), 3.18 (dd, *J* = 17.0, 6.3 Hz, 1H), 2.96–2.80 (m, 2H), 2.46 (dd, *J* = 17.1, 1.8 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 176.6, 146.0, 138.7, 133.1, 128.1, 126.4, 124.9, 58.1, 44.9, 39.1, 36.7. HRMS-ESI m/z Calcd for $C_{11}H_{10}ClNNaO$ $[M+Na]^+$: 230.0343; found 230.0339.

Ethyl 2-((1*S*,2*S*)-2-amino-5-chloro-2,3-dihydro-1*H*-inden-1-yl)acetate (10e)



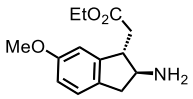
Compound **10e** was obtained following general procedure **J** from **8e** (2.078 mmol, 0.734 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **10e** was obtained as a colorless oil (0.252g, 48%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.18–7.07 (m, 3H), 4.24–4.14 (m, 2H), 3.50 (q, *J* = 6.6 Hz, 1H), 3.27 (q, *J* = 6.7 Hz, 1H), 3.20 (dd, *J* = 16.0, 7.1 Hz, 1H), 2.77 (br s, 2H), 2.68 (dd, *J* = 15.8, 6.4 Hz, 2H), 2.58 (dd, *J* = 16.1, 7.9 Hz, 1H), 1.28 (t, *J* = 7.1 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 172.6, 145.5, 139.2, 132.4, 127.4, 125.9, 124.3, 60.8, 59.4, 50.1, 40.3, 37.9, 14.2. HRMS-ESI m/z Calcd for $C_{13}H_{17}ClNO_2$ $[M+H]^+$: 254.0942; found 254.0932.

(3a*R*,8a*S*)-5-methoxy-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (11f)



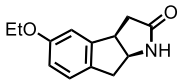
Compound **11f** was obtained following general procedure **J** from **8f** (1.449 mmol, 0.506 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **11f** was obtained as a white solid (0.106g, 36%); mp 188.9-190.0 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.12–7.07 (m, 1H), 6.82–6.72 (m, 2H), 6.27 (br s, 1H), 4.49 (t, *J* = 6.3 Hz, 1H), 3.90 (t, *J* = 7.9 Hz, 1H), 3.79 (s, 3H), 3.16 (dd, *J* = 16.5, 6.3 Hz, 1H), 2.92–2.79 (m, 2H), 2.48 (dd, *J* = 17.1, 1.8 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 176.9, 159.5, 145.5, 132.0, 125.8, 114.0, 109.7, 58.4, 55.5, 45.1, 38.8, 36.9. HRMS-ESI m/z Calcd for $C_{12}H_{13}NNaO_2$ $[M+Na]^+$: 226.0838; found 226.0829.

Ethyl 2-((1*S*,2*S*)-2-amino-6-methoxy-2,3-dihydro-1*H*-inden-1-yl)acetate (10f)



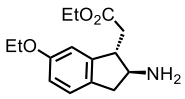
Compound **11f** was obtained following general procedure **J** from **8f** (1.449 mmol, 0.506 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **11f** was obtained as a colorless oil (0.169g, 47%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.13–7.02 (m, 1H), 6.82–6.62 (m, 2H), 6.22 (br s, 2H), 4.25–4.10 (m, 2H), 3.76 (s, 3H), 3.71–3.64 (m, 1H), 3.60–3.47 (m, 1H), 3.28–3.26 (m, 1H), 3.03–2.85 (m, 2H), 2.61–2.52 (m, 1H), 1.28 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.6, 159.3, 143.1, 131.3, 125.4, 113.6, 109.3, 61.3, 58.6, 55.4, 46.8, 38.2, 37.2, 14.1. HRMS-ESI m/z Calcd for $C_{14}H_{19}NNaO_3$ $[M+Na]^+$:272.1257; found 272.1258.

(3a*R*,8a*S*)-5-ethoxy-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (11g)



Compound **11g** was obtained following general procedure **J** from **8g** (1.826 mmol, 0.663 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **11g** was obtained as a white solid (0.162g, 41%); mp 201.2-201.6 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.11–7.05 (m, 1H), 6.80–6.72 (m, 2H), 6.34–6.10 (m, 1H), 4.48 (t, *J* = 6.3 Hz, 1H), 4.01 (q, *J* = 7.0 Hz, 2H), 3.89 (t, *J* = 7.9 Hz, 1H), 3.15 (dd, *J* = 16.6, 6.2 Hz, 1H), 2.91–2.78 (m, 2H), 2.47 (dd, *J* = 17.1, 1.9 Hz, 1H), 1.40 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 176.9, 158.9, 145.5, 131.9, 125.8, 114.6, 110.4, 63.7, 58.4, 45.1, 38.8, 36.8, 14.9. HRMS-ESI m/z Calcd for $C_{13}H_{15}NNaO_2$ $[M+Na]^+$: 240.0995; found 240.0995.

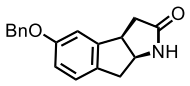
Ethyl 2-((1*S*,2*S*)-2-amino-6-ethoxy-2,3-dihydro-1*H*-inden-1-yl)acetate (10g)



Compound **10g** was obtained following general procedure **J** from **8g** (1.826 mmol, 0.663 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **10g** was obtained as a colorless oil (0.226g, 48%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.11–7.03 (m, 1H), 6.77–6.67 (m, 2H), 4.19 (q, *J* = 7.1 Hz, 2H), 3.98 (q, *J* = 7.0 Hz, 2H), 3.48 (q, *J* = 6.5 Hz, 1H), 3.31–3.23 (m, 1H), 3.18 (dd, *J* = 15.6, 7.2 Hz, 1H), 2.91 (br s, 2H), 2.94–2.63

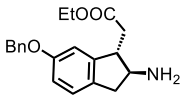
(m, 2H), 2.55 (dd, *J* = 16.0, 8.3 Hz, 1H), 1.38 (t, *J* = 7.0 Hz, 3H), 1.28 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.0, 158.4, 144.8, 132.4, 125.4, 113.7, 110.3, 63.6, 60.8, 59.6, 50.2, 39.9, 38.2, 14.9, 14.2. HRMS-ESI m/z Calcd for $C_{15}H_{21}NNaO_3$ $[M+Na]^+$: 286.1414; found 286.1411.

(3a*R*,8a*S*)-5-(benzyloxy)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (11h)



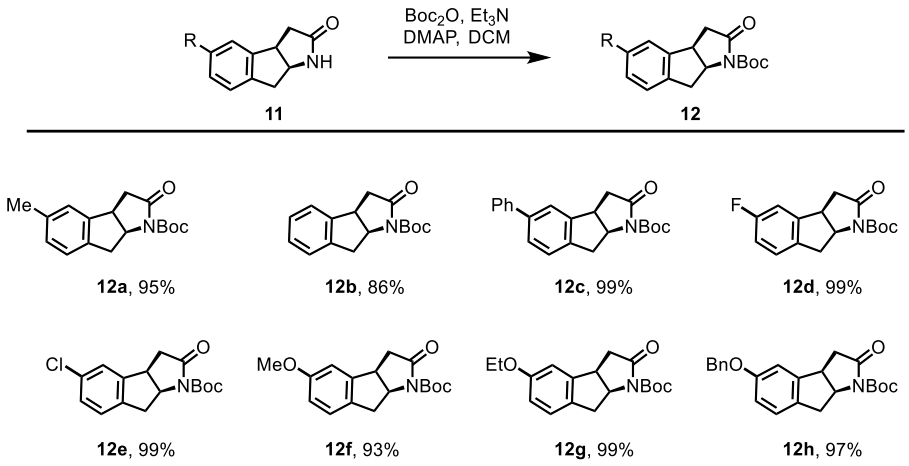
Compound **11h** was obtained following general procedure **J** from **8h** (1.598 mmol, 0.679 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **11h** was obtained as a white solid (0.169g, 38%); mp 177.4-178.2 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48–7.29 (m, 5H), 7.10 (d, *J* = 8.2 Hz, 1H), 6.89–6.80 (m, 2H), 6.27 (br s, 1H), 5.04 (s, 2H), 4.48 (t, *J* = 6.4 Hz, 1H), 3.89 (t, *J* = 8.0 Hz, 1H), 3.15 (dd, *J* = 16.6, 6.4 Hz, 1H), 2.92–2.78 (m, 2H), 2.46 (dd, *J* = 17.1, 1.8 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 176.9, 158.7, 145.5, 137.0, 132.4, 128.6, 127.9, 127.4, 125.8, 114.9, 110.9, 70.3, 58.4, 45.1, 38.8, 36.8. HRMS-ESI m/z Calcd for $C_{18}H_{17}NNaO_2$ $[M+Na]^+$: 302.1151; found 302.1147.

Ethyl 2-((1*S*,2*S*)-2-amino-6-(benzyloxy)-2,3-dihydro-1*H*-inden-1-yl)acetate (10h)



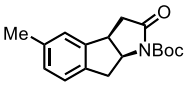
Compound **10h** was obtained following general procedure **J** from **8h** (1.598 mmol, 0.679 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **10h** was obtained as a colorless oil (0.249g, 48%); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44–7.29 (m, 5H), 7.08 (d, J = 8.3 Hz, 1H), 6.89–6.75 (m, 2H), 5.01 (s, 2H), 4.23–4.14 (m, 2H), 4.11 (br s, 2H), 3.57 (q, *J* = 6.8 Hz, 1H), 3.44–3.34 (m, 1H), 3.23 (dd, *J* = 15.7, 7.5 Hz, 1H), 2.87–2.75 (m, 2H), 2.56 (dd, *J* = 16.6, 8.9 Hz, 1H), 1.28 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.3, 158.4, 144.1, 137.0, 132.3, 128.5, 127.9, 127.4, 125.4, 114.2, 110.5, 70.2, 61.1, 59.1, 48.6, 38.6, 38.2, 14.1. HRMS-ESI m/z Calcd for $C_{20}H_{23}NNaO_3$ $[M+Na]^+$: 348.1570; found 348.1563.

Table S10. Boc-protection of substrates 11a-h



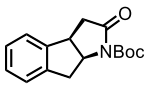
General Procedure K: To a solution of **11a-h** (1.0 equiv), NEt_3 (3.0 equiv) and DMAP (0.5 equiv) in DCM (10 mL/1 mmol) was added $(Boc)_2O$ (3.0 equiv) at RT, and the resultant mixture was stirred for 16 h. After dilution with EtOAc, the organic phase was washed successively with 1M HCl, saturated $NaHCO_3$ and brine. After drying over Na_2SO_4, and removing all volatiles, a crude mixture was obtained, which was purified by flash chromatography on silica gel to quantitatively afford **12a-h**.

***Tert*-butyl (3a*S*,8a*R*)-5-methyl-2-oxo-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrole-1(2*H*)-carboxylate (12a)**



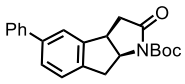
Compound **12a** was obtained following general procedure **K** from **11a** (0.76 mmol, 0.142 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **12a** was obtained as a colorless oil (0.207g,95%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.10–6.99 (m, 3H), 4.86 (td, *J* = 7.5, 2.6 Hz, 1H), 3.83–3.74 (m, 1H), 3.39 (dd, *J* = 17.5, 7.2 Hz, 1H), 3.12 (dd, *J* = 17.4, 2.6 Hz, 1H), 3.01 (dd, *J* = 17.9, 10.1 Hz, 1H), 2.65 (dd, *J* = 17.9, 3.7 Hz, 1H), 2.33 (s, 3H), 1.56 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.7, 150.1, 143.4, 137.3, 137.2, 128.8, 124.9, 124.7, 83.1, 62.3, 39.8, 39.7, 38.9, 28.1, 21.2. HRMS-ESI m/z Calcd for $C_{17}H_{21}NNaO_3$ $[M+Na]^+$: 310.1414; found 310.1418.

***Tert*-butyl (3a*S*,8a*R*)-2-oxo-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrole-1(2*H*)-carboxylate (12b)**



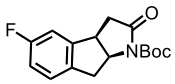
Compound **12b** was obtained following general procedure **K** from **11b** (0.86 mmol, 0.148 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **12b** was obtained as a colorless oil (0.199g, 86%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27–7.16 (m, 4H), 4.87 (td, *J* = 7.4, 2.6 Hz, 1H), 3.87–3.79 (m, 1H), 3.44 (dd, *J* = 17.7, 7.2 Hz, 1H), 3.18 (dd, *J* = 17.7, 2.6 Hz, 1H), 3.03 (dd, *J* = 17.9, 10.1 Hz, 1H), 2.67 (dd, *J* = 17.9, 3.6 Hz, 1H), 1.56 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.4, 149.8, 143.0, 140.1, 127.7, 127.2, 124.7, 124.1, 82.9, 61.8, 39.7, 39.6, 38.6, 27.8. HRMS-ESI m/z Calcd for $C_{16}H_{19}NNaO_3$ $[M+Na]^+$: 296.1257; found 296.1264.

Tert-butyl (3a*R*,8a*S*)-2-oxo-5-phenyl-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrole-1(2*H*)-carboxylate (12c)



Compound **12c** was obtained following general procedure **K** from **11c** (0.963 mmol, 0.241 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **12c** was obtained as a colorless oil (0.334 g, 99%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58–7.51 (m, 2H), 7.50–7.40 (m, 4H), 7.38–7.32 (m, 1 H), 7.28 (d, *J* = 7.8 Hz,1H), 4.92 (td, *J* = 7.3, 2.6 Hz, 1H), 3.93–3.85 (m, 1H), 3.48 (dd, *J* = 18.6, 7.2 Hz, 1H), 3.22 (dd, *J* = 17.8, 2.8 Hz, 1H), 3.07 (dd, *J* = 17.9, 10.1 Hz, 1H), 2.73 (dd, *J* = 18.0, 3.7 Hz, 1H), 1.58 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.5, 150.1, 144.0, 141.1, 141.1, 139.5, 128.8, 127.3, 127.2, 127.1, 125.3, 123.1, 83.2, 62.3, 40.0, 39.8, 38.9, 28.1. HRMS-ESI m/z Calcd for $C_{22}H_{23}NNaO_3$ $[M+Na]^+$: 372.1570; found 372.1561.

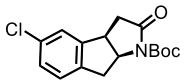
Tert-butyl (3a*R*,8a*S*)-5-fluoro-2-oxo-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrole-1(2*H*)-carboxylate (12d)



Compound **12d** was obtained following general procedure **K** from **11d** (0.710 mmol, 0.135 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **12d** was obtained as a colorless oil (0.690g, 97%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.14 (dd, *J* = 8.3, 5.1 Hz, 1H), 6.99–6.85 (m, 2H), 4.90 (td, *J* = 7.3, 2.5 Hz, 1H), 3.82 (ddd, *J* = 11.0, 7.6, 3.7 Hz, 1H), 3.86–3.77 (m, 1H), 3.18–3.08 (m, 1H), 3.03 (dd, *J* = 17.9, 10.2 Hz, 1H), 2.63 (dd, *J* = 17.9, 3.7 Hz, 1H), 1.56 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.1, 162.6 (d, *J* =

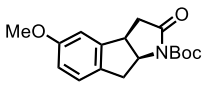
244.6 Hz), 145.0, 145.3 (d, *J* = 8.1 Hz), 135.7 (d, *J* = 2.9 Hz), 126.1 (d, *J* = 8.6 Hz), 115.2 (d, *J* = 22.4 Hz), 111.2 (d, *J* = 22.4 Hz), 83.3, 62.5, 40.0 (d, *J* = 2.4 Hz), 39.3, 38.6, 28.1. ^{19}F NMR (375 MHz, $CDCl_3$) δ -115.4. HRMS-ESI m/z Calcd for $C_{16}H_{18}FNNaO_3$ $[M+Na]^+$: 314.1163; found 314.1157.

Tert-butyl (3a*R*,8a*S*)-5-chloro-2-oxo-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrole-1(2*H*)-carboxylate (12e)



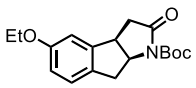
Compound **12e** was obtained following general procedure **K** from **11e** (0.804 mmol, 0.166 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **12e** was obtained as a colorless oil (0.244 g, 99%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24–7.10 (m, 3H), 4.88 (td, *J* = 7.4, 2.5 Hz, 1H), 3.86–3.77 (m, 1H), 3.40 (dd, *J* = 17.8, 7.1 Hz, 1H), 3.14 (dd, *J* = 17.8, 2.5 Hz, 1H), 3.03 (dd, *J* = 17.9, 10.2 Hz, 1H), 2.63 (dd, *J* = 17.9, 3.6 Hz, 1H), 1.55 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.1, 149.9, 145.2, 138.8, 133.2, 128.2, 126.1, 124.6, 83.4, 62.2, 39.9, 39.5, 38.6, 28.1. HRMS-ESI m/z Calcd for $C_{16}H_{18}ClNNaO_3$ $[M+Na]^+$: 330.0867; found 330.0862.

Tert-butyl (3a*R*,8a*S*)-5-methoxy-2-oxo-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrole-1(2*H*)-carboxylate (12f)



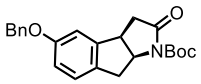
Compound **12f** was obtained following general procedure **K** from **11f** (0.492 mmol, 0.092 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **12f** was obtained as a colorless oil (0.131g, 93%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.10 (d, *J* = 8.3 Hz, 1H), 6.78 (dd, *J* = 8.3, 2.4 Hz, 1H), 6.72 (d, *J* = 2.4 Hz, 1H), 4.87 (td, *J* = 7.5, 2.6 Hz, 1H), 3.82–3.77 (m, 4H), 3.38 (dd, *J* = 17.2, 7.2 Hz, 1H), 3.09 (dd, *J* = 17.2, 2.7 Hz, 1H), 3.01 (dd, *J* = 17.9, 10.2 Hz, 1H), 2.65 (dd, *J* = 17.9, 3.8 Hz, 1H), 1.56 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.6, 159.6, 150.0, 144.7, 132.2, 125.6, 114.2, 109.4, 83.1, 62.6, 55.5, 40.1, 39.3, 38.8, 28.1. HRMS-ESI m/z Calcd for $C_{17}H_{21}NNaO_4$ $[M+Na]^+$: 326.1363; found 326.1366.

***Tert*-butyl (3a*S*,8a*R*)-5-ethoxy-2-oxo-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrole-1(2*H*)-carboxylate (12g)**



Compound **12g** was obtained following general procedure **K** from **11g** (0.700 mmol, 0.152 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **12g** was obtained as a colorless oil (0.220g, 99%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.08 (d, *J* = 8.3 Hz, 1H), 6.77 (dd, *J* = 8.3, 2.5 Hz, 1H), 6.71 (d, *J* = 2.8 Hz, 1H), 4.86 (td, *J* = 7.3, 2.7 Hz, 1H), 4.00 (q, *J* = 7.0 Hz, 2H), 3.83–3.74 (m, 1H), 3.37 (dd, *J* = 17.2, 7.2, 1H), 3.08 (dd, *J* = 17.2, 2.8 Hz, 1H), 3.00 (dd, *J* = 17.9, 10.2 Hz, 1H), 2.64 (dd, *J* = 17.9, 3.8 Hz, 1H), 1.55 (s, 9H), 1.40 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.3, 158.6, 149.8, 144.4, 131.7, 125.3, 114.5, 109.9, 82.8, 63.4, 62.3, 39.8, 39.0, 38.5, 27.8, 14.6. HRMS-ESI m/z Calcd for $C_{18}H_{23}NNaO_4$ $[M+Na]^+$: 340.1519; found 340.1515.

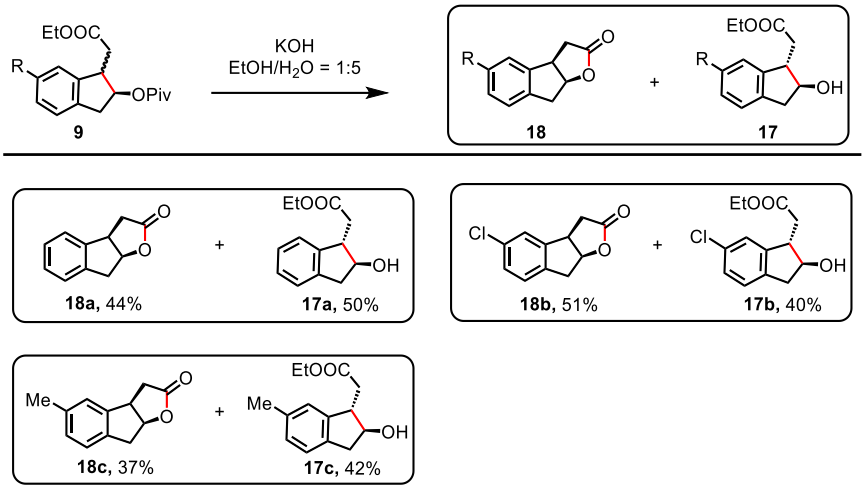
***Tert*-butyl (3a*R*,8a*S*)-5-(benzyloxy)-2-oxo-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrole-1(2*H*)-carboxylate (12h)**



Compound **12h** was obtained following general procedure **K** from **11h** (0.541 mmol, 0.151 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **12h** was obtained as a colorless oil (0.198g, 97%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45–7.28 (m, 5H), 7.10 (d, *J* = 8.3 Hz, 1H), 6.86 (dd, *J* = 8.3, 2.8 Hz, 1H), 6.80 (d, *J* = 2.7 Hz, 1H), 5.04 (s, 2H), 4.87 (td, *J* = 7.5, 2.9 Hz, 1H), 3.79 (ddd, *J* = 11.0, 7.8, 3.9 Hz, 1H), 3.38 (dd, *J* = 17.2, 7.1 Hz, 1H), 3.09 (dd, *J* = 17.2, 2.9 Hz, 1H), 3.00 (dd, *J* = 17.9, 10.2 Hz, 1H), 2.63 (dd, *J* = 17.9, 3.8 Hz, 1H), 1.56 (s, 9H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 173.5, 158.7, 150.0, 144.7, 136.9, 132.5, 128.6, 128.0, 127.4, 125.6, 115.1, 110.6, 83.1, 70.3, 62.5, 40.1, 39.3, 38.8, 28.1. HRMS-ESI m/z Calcd for $C_{23}H_{25}NNaO_4$ $[M+Na]^+$: 402.1676; found 402.1677.

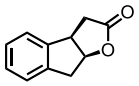
2.3.2 Synthetic route from compound 9a-c (O-Piv series)

Table S11. C-Ring formation from substrates 9a-c



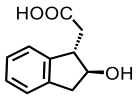
General Procedure L: To solution of **9a-c** (1.0 equiv) in EtOH (5 mL/1 mmol) was added 10% aqueous KOH (5 equiv). The reaction mixture was stirred at room temperature and was monitored by TLC (typical time was 12 h). After consumption of all starting material, 1 M aqueous HCl solution was used to carefully adjust the pH to ~ 4. Then the mixture was extracted with EtOAc three times, and the organic layer was dried over Na_2SO_4. The crude product was placed under 40℃ (neat) over night before purified by silica gel flash column chromatography to afford compound **18a-c** and **17a-c**.

(3a*R*,8a*S*)-3,3a,8,8a-tetrahydro-2*H*-indeno[*2,1-b*]furan-2-one (18a)



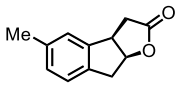
Compound **18a** was obtained following general procedure **L** from **9a** (1.073 mmol, 0.326 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **18a** was obtained as a white solid (0.080g, 43%). mp 67.3-70.0 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28–7.25 (m, 3H), 7.23–7.21 (m, 1H), 5.30 (dt, *J* = 6.2, 3.2 Hz, 1H), 4.01 (dd, *J* = 9.3, 5.8 Hz, 1H), 3.32 (d, *J* = 3.2 Hz, 2H), 3.04 (dd, *J* = 17.8, 9.3 Hz, 1H), 2.74 (dd, *J* = 17.7, 1.5 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 176.3, 142.0, 140.0, 128.3, 127.7, 125.3, 124.6, 84.3, 45.4, 38.9, 35.3. HRMS-ESI m/z Calcd for $C_{11}H_{10}NaO_2$ $[M+Na]^+$: 197.0573; found 197.0574.

2-((1R,2*R*)-2-hydroxy-2,3-dihydro-1*H*-inden-1-yl)acetic acid (17a)



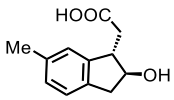
Compound **17a** was obtained following general procedure **L** from **9a** (1.073 mmol, 0.326 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **17a** was obtained as a white solid (0.091 g, 44%). mp 128.6-132.4 ℃; ^{1}H NMR (400 MHz, CD_3OD) δ 7.25-7.10 (m, 4H), 4.25 (q, *J* = 5.7 Hz, 1H), 3.39 (q, *J* = 6.9 Hz, 1H), 3.20 (dd, *J* = 15.9, 6.5 Hz, 1H), 2.81 (dd, *J* = 16.0, 5.6 Hz, 1H), 2.60 (m, 2H). ^{13}C NMR (125 MHz, CD_3OD) δ 176.5, 144.7, 141.5, 128.2, 127.8, 125.7, 125.0, 79.1, 50.8, 40.9, 38.4. HRMS-ESI m/z Calcd for $C_{11}H_{12}NaO_3$ $[M+Na]^+$: 215.0679; found 215.0684.

(3a*R*,8a*S*)-5-methyl-3,3a,8,8a-tetrahydro-2*H*-indeno[*2,1-b*]furan-2-one (18b)



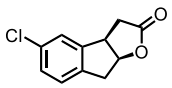
Compound **18b** was obtained following general procedure **L** from **9b** (1.198 mmol, 0.381 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **18b** was obtained as a white solid (0.091g, 37%). mp 95.8-97.0 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.14 (d, *J* = 7.7 Hz, 1H), 7.07 (d, *J* = 7.8 Hz, 1H), 7.02 (s, 1H), 5.29 (dt, *J* = 6.0, 3.2 Hz, 1H), 3.96 (dd, *J* = 9.5, 5.6 Hz, 1H), 3.27 (d, *J* = 3.5 Hz, 2H), 3.02 (dd, *J* = 17.7, 9.3 Hz, 1H), 2.73 (dd, *J* = 17.8, 1.5 Hz, 1H), 2.35 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 176.4, 142.1, 137.5, 136.9, 129.2, 125.2, 124.9, 84.6, 45.3, 38.5, 35.3, 21.2. HRMS-ESI m/z Calcd for $C_{12}H_{12}NaO_2$ $[M+Na]^+$: 211.0730; found 211.0735.

2-((1*S*,2*S*)-2-hydroxy-6-methyl-2,3-dihydro-1*H*-inden-1-yl)acetic acid (17b)



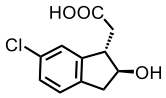
Compound **17b** was obtained following general procedure **L** from **9b** (1.198 mmol, 0.381 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **17b** was obtained as a white solid (0.110g, 42%). mp ℃; ^{1}H NMR (400 MHz, CD_3OD) δ 5.52–5.38 (m, 3H), 2.67 (q, *J* = 5.9 Hz, 1H), 1.59 (dd, *J* = 15.7, 6.7 Hz, 1H), 1.20 (dd, *J* = 15.7, 5.7 Hz, 1H), 1.10–0.94 (m, 2H), 0.73 (s, 3H). ^{13}C NMR (125 MHz, CD_3OD) δ 178.8, 145.8, 139.2, 138.2, 129.7, 126.4, 126.3, 80.6, 51.7, 41.3, 40.4, 22.3. HRMS-ESI m/z Calcd for $C_{12}H_{14}NaO_3$ $[M+Na]^+$: 229.0835; found 229.0830.

(3a*R*,8a*S*)-5-chloro-3,3a,8,8a-tetrahydro-2*H*-indeno[*2,1-b*]furan-2-one (18c)



Compound **18c** was obtained following general procedure **L** from **9c** (1.120 mmol, 0.379 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **18c** was obtained as a yellow solid (0.119 g, 51%). mp 123.1-125.2 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.26- 7.18 (m, 3H), 5.31-5.28 (m, 1H), 4.00 (dd, *J* = 9.4, 5.8 Hz, 1H), 3.28 (s, 2H), 3.04 (dd, *J* = 17.9, 9.3 Hz, 1H), 2.71 (d, *J* = 17.8 Hz, 1H). ^{13}C NMR (125 MHz, $CDCl_3$)δ 175.7, 144.0, 138.5, 133.4, 128.6, 126.4, 124.9, 84.2, 45.4, 38.4, 35.0. HRMS-ESI m/z Calcd for $C_{11}H_9ClO_2$ $[M+Na]^+$: 231.0183; found 231.0192.

2-((1*S*,2*S*)-6-chloro-2-hydroxy-2,3-dihydro-1*H*-inden-1-yl)acetic acid (17c)

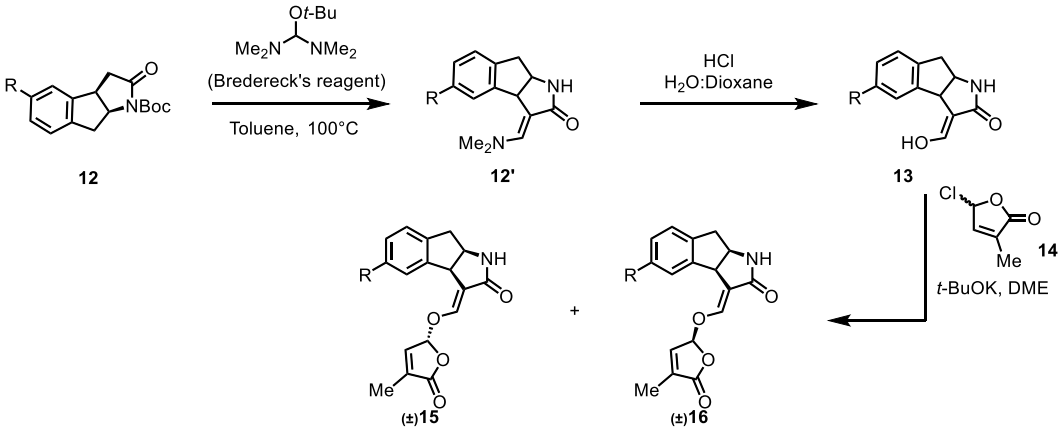


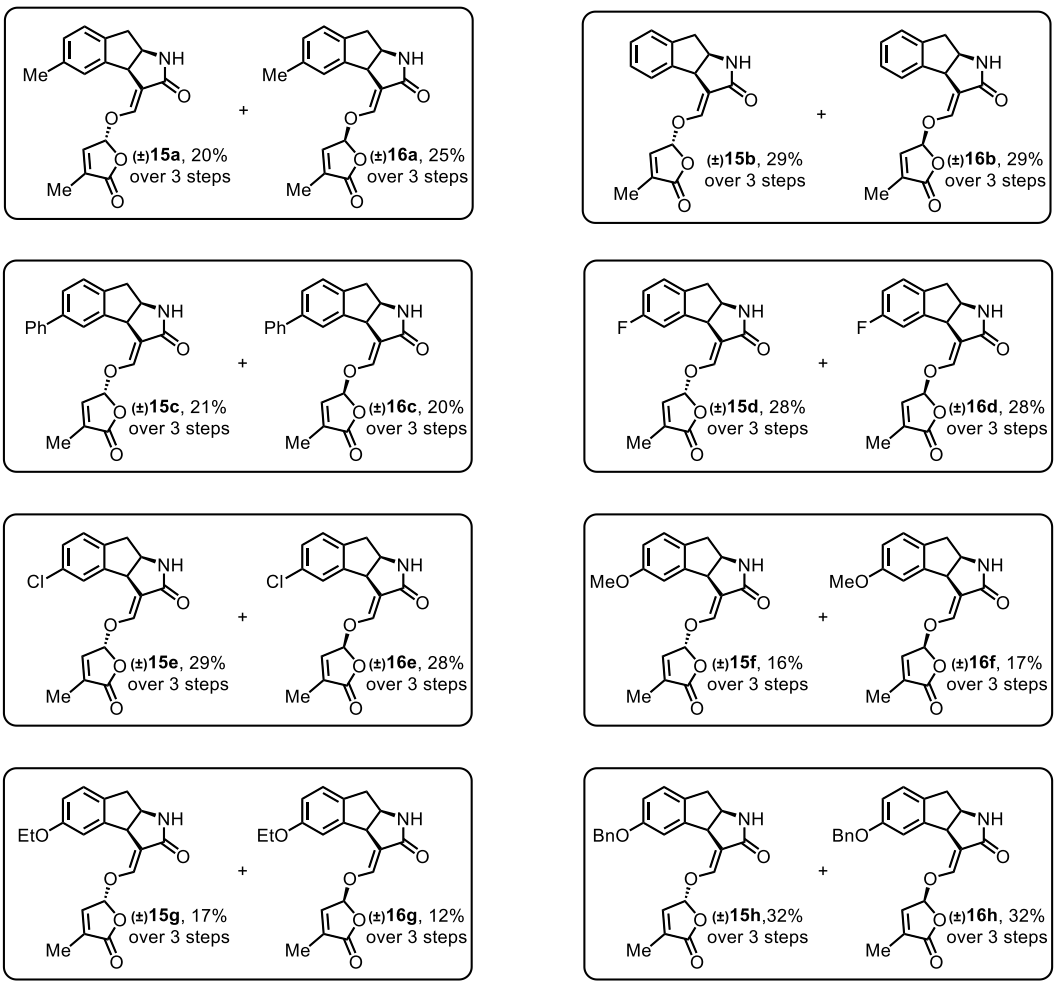
Compound **17c** was obtained following general procedure **L** from **9c** (1.120 mmol, 0.379 g). After purification by column chromatography using DCM:MeOH (1/0 to 40/1 to 20/1) as the eluent, **17c** was obtained as a white solid (0.081 g, 40%). mp 150.1-151.8 ℃; ^{1}H NMR (400 MHz, CD_3OD) δ 7.21 (s, 1H), 7.18 (s, 2H), 4.27 (q, *J* = 5.6 Hz, 1H), 3.4–3.3 (m, 1H), 3.18 (dd, *J* = 16.1, 6.5 Hz, 1H), 2.77 (dd, *J* = 16.1, 5.4 Hz, 1H), 2.67 (dd, *J* = 16.1, 6.5 Hz, 1H), 2.54 (dd, *J* = 16.1, 7.7 Hz, 1H).^{13}C NMR (125 MHz, CD_3OD) δ 176.1, 147.1, 140.4, 133.4, 128.2, 127.2, 125.4, 79.0, 50.9, 40.4, 38.0. HRMS-ESI m/z Calcd for $C_{11}H_{11}NaClO_3$ $[M+Na]^+$: 249.0289; found 249.0287.

2.4 Final synthetic route of 2nd generation strigolactams and GR24

2.4.1 Synthesis of (±)-Strigolactams and (±)-*Epi*-Strigolactams [6]

Table S12. Final synthetic route of 2nd generation strigolactams



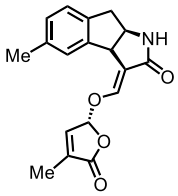


General Procedure M: To a solution of **12a-h** (1.0 equiv) in toluene (10 mL/1 mmol) was added Bredereck's reagent (5.0 equiv) at RT and the solution was refluxed and was monitored by TLC (typical time was 8 h). It was then cooled to rt and diluted with EtOAc. The solution was washed with water. After drying over Na_2SO_4, and removing all volatiles, enamine was obtained as a crude product.

The obtained enamine was dissolved in dioxane (20 mL/1 mmol) and 1M HCl (20 mL/1 mmol), and the resultant mixture was stirred at rt for 12 h. The solution was neutralized with saturated $NaHCO_3$ and then diluted with EtOAc, further washed with water followed by brine, and dried over Na_2SO_4. After removal of volatiles under reduced pressure, the crude product was obtained.

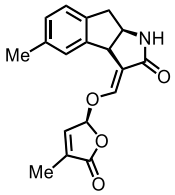
The obtained enamine was then dissolved in dioxane (5 mL/1 mmol) was added KO^{t}Bu (1.5 equiv) at 0 ℃. After 10 min, a solution of chlorobutenolidine (1.5 equiv) in DME was added dropwise. The reaction mixture was then allowed to warm slowly to rt and stirred for 16 h. The reaction mixture was diluted with EtOAc and washed with water and brine, and then dried over Na_2SO_4. After removal of volatiles under reduced pressure, the mixture of **15a-h** and **16a-h** was obtained. These compounds were separated by flash chromatography on silica gel.

(3a*S*,8a*R*,*E*)-5-methyl-3-((((*R*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±15a)



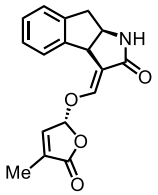
Compound **15a** was obtained following general procedure **M** from **12a** (0.697 mmol, 0.200 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **15a** was obtained as a white solid (43.5 mg, 20%). mp 138.8-140.4 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (d, *J* = 1.8 Hz, 1H), 7.16 (s, 1H), 7.10–6.98 (m, 3H), 6.66 (br s, 1H), 6.26–6.21 (m, 1H), 4.61 (d, *J* = 6.6 Hz, 1H), 4.44 (t, *J* = 6.7 Hz, 1H), 3.22 (dd, *J* = 16.9, 6.8 Hz, 1H), 2.92 (d, *J* = 16.9 Hz, 1H), 2.32 (s, 3H), 2.07–2.03 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.7, 170.6, 145.6, 142.8, 141.2, 136.9, 136.9, 135.8, 128.7, 126,1 124.9, 117.3, 100.7, 56.1, 47.3, 39.0, 21.4, 10.8. HRMS-ESI m/z Calcd for $C_{18}H_{17}NNaO_4$ $[M+Na]^+$: 334.1050; found 334.1059.

(3a*S*,8a*R*,*E*)-5-methyl-3-((((*S*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±16a)



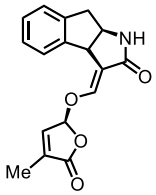
Compound **16a** was obtained following general procedure **M** from **12a** (0.697 mmol, 0.200 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **16a** was obtained as a white solid (54.0 mg, 25%). mp 270.5-271.2 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 (d, *J* = 1.8 Hz, 1H), 7.16 (s, 1H), 7.09–6.98 (m, 3H), 6.26 (br s, 1H), 6.24–6.20 (m, 1H), 4.62 (d, *J* = 6.6 Hz, 1H), 4.44 (t, *J* = 6.7 Hz, 1H), 3.23 (dd, *J* = 16.9, 6.8 Hz, 1H), 2.92 (d, *J* = 16.9 Hz, 1H), 2.29 (s, 3H), 2.07–2.03 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.5, 170.5, 145.4, 142.7, 141.4, 137.2, 136.6, 135.8, 128.8, 126.2, 124.8, 117.3, 100.7, 56.1, 47.2, 39.0, 21.3, 10.8. HRMS-ESI m/z Calcd for $C_{18}H_{17}NNaO_4$ $[M+Na]^+$: 334.1050; found 334.1054.

(3a*S*,8a*R*,*E*)-3-(((*R*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±15b)



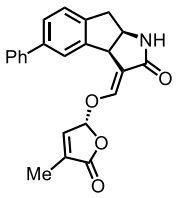
Compound **15b** was obtained following general procedure **M** from **12b** (0.502 mmol, 0.137 g). After purification by column chromatography using Hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **15b** was obtained as a white solid (43.0 mg, 29%). mp 176.5-177.3 ℃;^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40–7.32 (m,2H), 7.23–7.16 (m, 3H), 7.04 (t, *J* = 1.6 Hz, 1H), 6.64 (br s, 1H), 6.25–6.20 (m, 1H), 4.66 (d, *J* = 6.6 Hz, 1H), 4.46 (t, *J* = 6.7 Hz, 1H), 3.28 (dd, *J* = 17.0, 6.8 Hz, 1H), 2.98 (d, *J* = 17.0 Hz, 1H), 2.05 (t, *J* = 1.6 Hz, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.7, 170.6, 145.9, 142.7, 141.2, 139.9, 135.8, 127.8, 127.3, 125.6, 125.2, 117.1, 100.7, 55.8, 47.4, 39.5, 10.8. HRMS-ESI m/z Calcd for $C_{17}H_{15}NNaO_4$ $[M+Na]^+$: 320.0893; found 320.0898.

(3a*S*,8a*R*,*E*)-3-((((*S*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±16b)



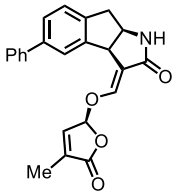
Compound **16b** was obtained following general procedure **M** from **12b** (0.502 mmol, 0.137 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **16b** was obtained as a white solid (43.0 mg, 29%). mp 260.1-262.2 ℃;^{1}H NMR (400 MHz, $CDCl_3$) δ7.41–7.31 (m, 2H), 7.27–7.16 (m, 3H), 7.02 (t, *J* = 1.6 Hz, 1H), 6.46 (br s, 1H), 6.27–6.22 (m, 1H), 4.69 (d, *J* = 6.6 Hz, 1H), 4.48 (t, *J* = 6.7 Hz, 1H), 3.30 (dd, *J* = 17.0, 6.8 Hz, 1H), 3.00 (d, *J* = 17.0 Hz, 1H), 2.08 (t, *J* = 1.6 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.6, 170.5, 145.3, 142.6, 141.4, 139.7, 135.8, 127.8, 127.4, 125.7, 125.1, 117.1, 100.6, 55.8, 47.3, 39.4, 10.8. HRMS-ESI m/z Calcd for $C_{17}H_{15}NNaO_4$ $[M+Na]^+$: 320.0893; found 320.089.

(3a*R*,8a*R*,*E*)-3-((((*R*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-5-phenyl-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±15c)



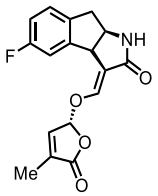
Compound **15c** was obtained following general procedure **M** from **12c** (0.700 mmol, 0.245 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **15c** was obtained as a white solid (55.2 mg, 21%). mp 107.3-108.9 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (s, 1H), 7.53–7.48 (m, 2H), 7.46–7.37 (m, 4H), 7.37–7.31 (m, 1H), 7.22 (d, *J* = 7.9 Hz, 1H), 6.98–6.80 (m, 2H), 6.20 (br s, 1H), 4.62 (d, *J* = 6.8 Hz, 1H), 4.42 (s, 1H), 3.27 (dd, *J* = 17.2, 6.9 Hz, 1H), 2.99 (d, *J* = 17.1 Hz, 1H), 1.99 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.8, 170.4, 146.8, 143.1, 141.1, 141.0, 140.4, 138.9, 135.2, 128.5, 126.9, 126.7, 126.7, 125.2, 124.2, 116.2, 100.7, 56.1, 47.1, 38.8, 10.4. HRMS-ESI m/z Calcd for $C_{23}H_{19}NNaO_4$ $[M+Na]^+$: 396.1206; found 396.1208.

(3a*R*,8a*R*,*E*)-3-((((*S*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-5-phenyl-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±16c)



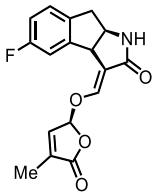
Compound **16c** was obtained following general procedure **M** from **12c** (0.697 mmol, 0.200 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **16c** was obtained as a white solid (52.1 mg, 20%). mp 216.7-217.4 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (s, 1H), 7.51 (d, *J* = 7.6 Hz, 2H), 7.44 (t, *J* = 7.6 Hz, 3H), 7.40–7.36 (m, 1H), 7.33 (t, *J* = 7.4 Hz, 1H), 7.24 (d, *J* = 7.8 Hz, 1H), 6.97 (s, 1H), 6.55 (br s, 1H), 6.23 (s, 1H), 4.72 (d, *J* = 6.6 Hz, 1H), 4.51 (t, *J* = 6.8 Hz, 1H), 3.32 (dd, *J* = 17.1, 6.8 Hz, 1H), 3.01 (d, *J* = 17.1 Hz, 1H), 1.99 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.3, 170.0, 145.8, 143.1, 140.9, 140.7, 140.5, 138.6, 135.5, 128.6, 126.9, 126.7, 126.6, 125.1, 124.2, 116.5, 100.6, 55.7, 47.0, 39.0, 10.5. HRMS-ESI m/z Calcd for $C_{23}H_{19}NNaO_4$ [M+Na]$^+$: 396.1206; found 396.1209.

(3a*S*,8a*R*,*E*)-5-fluoro-3-((((*R*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±15d)



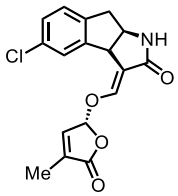
Compound **15d** was obtained following general procedure **M** from **12d** (0.660 mmol, 0.193 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **15d** was obtained as a white solid (60.3 mg, 29%). mp 178.0-179.2 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 (d, *J* = 2.0 Hz, 1H), 7.31 (s, 1H), 7.10 (dd, *J* = 8.4, 5.1 Hz, 1H), 7.08–6.97 (m, 2H), 6.89 (td, *J* = 8.6, 2.6 Hz, 1H), 6.25–6.20 (m, 1H), 4.61 (d, *J* = 6.7 Hz, 1H), 4.47 (t, *J* = 6.7 Hz, 1H), 3.21 (dd, *J* = 16.8, 6.8 Hz, 1H), 2.93 (d, *J* = 16.9 Hz, 1H), 2.07–2.01 (m, 3H).^{13}C NMR (125 MHz, $CDCl_3$) δ 170.7, 170.5, 162.4 (d, *J* = 243.7 Hz), 146.2, 144.7, 141.2, 135.7, 135.4 (d, *J* = 2.4 Hz), 126.2 (d, *J* = 8.6 Hz), 116.6, 114.9 (d, *J* = 22.9 Hz), 112.4 (d, *J* = 22.9 Hz), 100.7, 56.5, 47.3 (d, *J* = 2.4 Hz), 38.7, 10.7. ^{19}F NMR (375 MHz, $CDCl_3$) δ -115.9. HRMS-ESI m/z Calcd for $C_{17}H_{14}FNNaO_4$ [M+Na]$^+$: 338.0799; found 338.0798.

(3a*S*,8a*R*,*E*)-5-fluoro-3-((((*S*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±16d)



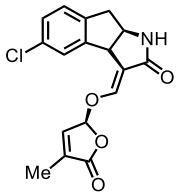
Compound **16d** was obtained following general procedure **M** from **12d** (0.660 mmol, 0.193 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **16d** was obtained as a white solid (58.9 mg, 28%). mp 232.7-233.9 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 (d, *J* = 2.1 Hz, 1H), 7.12 (dd, *J* = 8.4, 5.1 Hz, 1H), 7.08–6.99 (m, 2H), 6.90 (td, *J* = 8.6, 2.7 Hz, 1H), 6.82 (s, 1H), 6.23 (d, *J* = 1.3 Hz, 1H), 4.63 (d, *J* = 6.5 Hz, 1H), 4.49 (t, *J* = 6.8 Hz, 1H), 3.23 (dd, *J* = 16.2, 7.2 Hz, 1H), 2.94 (d, *J* = 16.9 Hz, 1H), 2.06–2.03(m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.4, 170.2, 162.5 (d, *J* = 244.6 Hz), 145.3, 144.5 (d, *J* = 8.8 Hz), 141.2, 136.2, 135.1, 126.1 (d, *J* = 8.6 Hz), 116.4, 115.1 (d, *J* = 22.9 Hz), 112.6 (d, *J* = 22.9 Hz), 100.3, 56.4, 47.4, 38.8, 10.8. ^{19}F NMR (375 MHz, CDCl3) δ -115.4. HRMS-ESI m/z Calcd for $C_{17}H_{14}FNNaO_4$ $[M+Na]^+$: 338.0799; found 338.0799.

(3a*S*,8a*R*,*E*)-5-chloro-3-((((*R*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±15e)

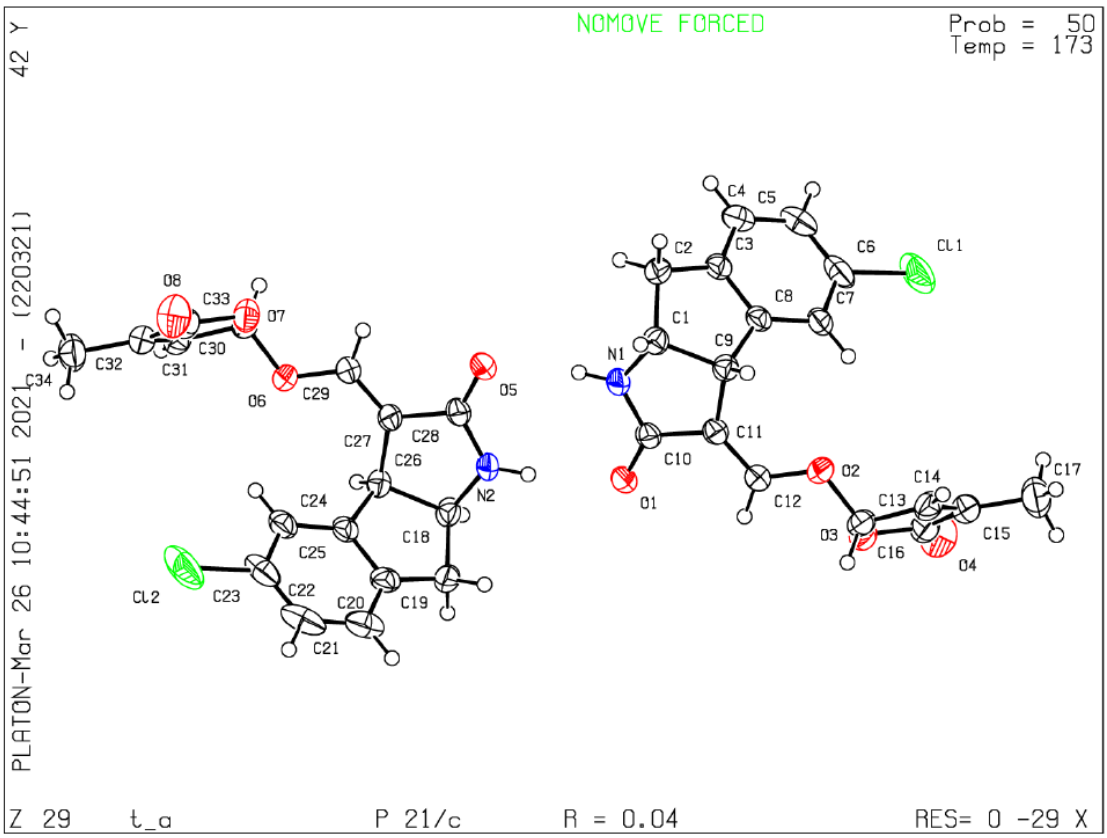


Compound **15e** was obtained following general procedure **M** from **12e** (0.766 mmol, 0.235 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **15e** was obtained as a white solid (79.9 mg, 31%). mp 190.1-191.2 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 (d, *J* = 1.9 Hz, 1H), 7.33–7.30 (m, 1H), 7.18 (dd, *J* = 8.1, 2.0 Hz, 1H), 7.11 (d, *J* = 8.1 Hz, 1H), 7.08–7.04 (m, 1H), 6.78 (br s, 1H), 6.23 (t, *J* = 1.5 Hz, 1H), 4.64 (d, *J* = 6.7 Hz, 1H), 4.50 (t, *J* = 6.8 Hz, 1H), 3.24 (dd, *J* = 17.2, 6.9 Hz, 1H), 2.95 (d, *J* = 17.2 Hz, 1H), 2.08–2.04 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.7, 170.5, 146.7, 144.5, 141.1, 138.4, 135.8, 132.8, 128.1, 126.3, 125.9, 116.2, 100.8, 56.2, 47.3, 39.0, 10.7. HRMS-ESI m/z Calcd for $C_{17}H_{14}ClNNaO_4$ $[M+Na]^+$: 354.0504; found 354.0497.

(3a*S*,8a*R*,*E*)-5-chloro-3-((((*S*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±16e)



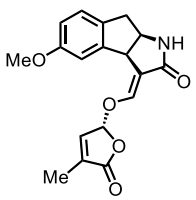
Compound **16e** was obtained following general procedure **M** from **12e** (0.766 mmol, 0.235 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **16e** was obtained as a white solid (57.4 mg, 23%). mp 257.6-258.1 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35–7.32 (m, 1H), 7.31 (d, *J* = 1.9, 1H), 7.18 (dd, *J* = 8.0, 2.0 Hz, 1H), 7.10 (d, *J* = 8.1 Hz, 1H), 7.03-7.00 (m, 1H), 6.39 (br s, 1H), 6.27–6.22 (m, 1H), 4.65 (d, *J* = 6.8 Hz, 1H), 4.50 (t, *J* = 6.7 Hz, 1H), 3.25 (dd, *J* = 17.1, 6.8 Hz, 1H), 2.95 (d, *J* = 17.2 Hz, 1H), 2.09–2.04 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.6, 170.2, 145.5, 144.4, 141.1, 138.2, 136.2, 133.1, 128.2, 126.2, 126.0, 116.3, 100.4, 56.2, 47.2, 39.0, 10.9. HRMS-ESI m/z Calcd for $C_{17}H_{14}ClNNaO_4$ $[M+Na]^+$: 354.0504; found 354.0510.



Crystal	Data
Empirical formula	$C_{17}H_{14}ClNO_4$
Formula weight	331.74

Crystal system	Monoclinic
Space group	P2(1)/c
Z	8
a/ Å	11.168(2)
b/ Å	15.730(2)
c/ Å	18.350(3)
α/°	90 deg
β/°	105.575(13) deg
γ/°	90 deg
V/Å^3	3105.2(9)
Density/Mg/m^3	1.419
F(000)	1376
Absorption coefficient/mm^{-1}	2.362
Theta range for data collection/ °	3.761 to 68.567
Reflections collected	47550
Independent reflections	5696
No. of parameters	417
Goodness-of-fit on F^2	1.051
Largest diff. peak and hole/$e/Å^3$	0.466 and -0.495
R_1, wR_2(I > 2σ(I))	R_1 = 0.0446, wR_2 = 0.1200
R_1, wR_2(all data)	R_1 = 0.0595, wR_2 = 0.1303

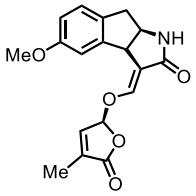
(3a*R*,8a*R*,*E*)-5-methoxy-3-((((*R*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±15f)



Compound **15f** was obtained following general procedure **M** from **12f** (0.405 mmol, 0.123 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the

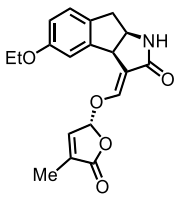
eluent, **15f** was obtained as a white solid (20.6 mg, 16%). mp 155.6-157.1 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (d, *J* = 1.8 Hz, 1H), 7.08 (d, *J* = 8.3 Hz, 1H), 7.05–6.99 (m, 1H), 6.92 (d, *J* = 2.5 Hz, 1H), 6.77 (dd, *J* = 8.4, 2.5 Hz, 1H), 6.52 (br s, 1H), 6.26–6.20 (m, 1H), 4.63 (d, *J* = 6.6 Hz, 1H), 4.46 (t, *J* = 6.6 Hz, 1H), 3.78 (s, 3H), 3.21 (dd, *J* = 16.7, 6.8 Hz, 1H), 2.90 (d, *J* = 16.7 Hz, 1H), 2.07–2.02 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.5, 170.5, 159.4, 145.7, 144.2, 141.1, 135.9, 131.8, 125.7, 117.0, 113.6, 111.2, 100.6, 56.4, 55.4, 47.5, 38.7,10.8. HRMS-ESI m/z Calcd for $C_{18}H_{17}NNaO_5$ $[M+Na]^+$: 350.0999; found 350.1003.

(3a*S*,8a*R*,*E*)-5-methoxy-3-((((*S*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±16f)



Compound **16f** was obtained following general procedure **M** from **12f** (0.405 mmol, 0.123 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **16f** was obtained as a white solid (16.9 mg, 17%). mp 250.4-251.7 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (d, *J* = 1.8 Hz, 1H), 7.06 (d, *J* = 8.4 Hz, 1H), 7.02–6.98 (m, 1H), 6.94–6.89 (m, 1H), 6.77 (dd, *J* = 8.3, 2.5 Hz, 1H), 6.25–6.20 (m, 1H), 6.17 (br s, 1H), 4.64 (d, *J* = 6.6 Hz, 1H), 4.46 (t, *J* = 6.7 Hz, 1H), 3.73 (s, 3H), 3.22 (dd, *J* = 16.6, 6.7 Hz, 1H), 2.90 (d, *J* = 16.6 Hz, 1H), 2.07–2.02 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.5, 170.4, 159.5, 145.8, 143.9, 141.4 135.7, 131.4, 125.6, 116.9, 115.0, 109.1, 100.9, 56.4, 55.4, 47.5, 38.6, 10.8. HRMS-ESI m/z Calcd for $C_{18}H_{17}NNaO_5$ $[M+Na]^+$: 350.0999; found 350.0992.

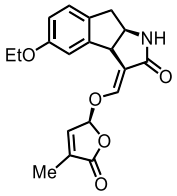
(3a*R*,8a*R*,*E*)-5-ethoxy-3-((((*R*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±15g)



Compound **15g** was obtained following general procedure **M** from **12g** (0.611 mmol, 0.208 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **15g** was obtained as a white solid (35.3 mg, 17%). mp 144.8-146.2 ℃; ^{1}H NMR (400

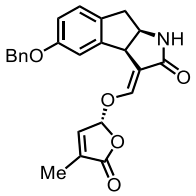
MHz, $CDCl_3$) δ 7.32 (d, *J* = 1.8 Hz, 1H), 7.06 (d, *J* = 8.3 Hz, 1H), 7.03–6.99 (m, 1H), 6.90 (d, *J* = 2.7 Hz, 1H), 6.75 (dd, *J* = 8.3, 2.6 Hz, 1H), 6.69 (br s, 1H), 6.26–6.20 (t, *J* = 1.5 Hz, 1H), 4.61 (d, *J* = 6.6 Hz, 1H), 4.45 (t, *J* = 6.6 Hz, 1H), 3.99 (q, *J* = 7.0 Hz, 2H), 3.20 (dd, *J* = 16.7, 6.8 Hz, 1H), 2.89 (d, *J* = 16.6 Hz, 1H), 2.04 (s, 3H), 1.40 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.7, 170.5, 158.7, 145.7, 144.1, 141.2, 135.8, 131.7, 125.7, 117.1, 114.2, 111.8, 100.6, 63.6, 56.5, 47.5, 38.6, 14.9, 10.7. HRMS-ESI m/z Calcd for $C_{19}H_{19}NNaO_5$ $[M+Na]^+$: 364.1155; found 364.1153.

(3a*S*,8a*R*,*E*)-5-ethoxy-3-((((*S*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±16g)



Compound **16g** was obtained following general procedure **M** from **12g** (0.611 mmol, 0.208 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **16g** was obtained as a white solid (24.3 mg, 12%). mp 214.7-215.4 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32 (d, *J* = 1.8 Hz, 1H), 7.04 (d, *J* = 8.3 Hz, 1H), 7.00 (s, 1H), 6.90 (d, *J* = 2.7 Hz, 1H), 6.75 (dd, *J* = 8.3, 2.6 Hz, 1H), 6.41 (br s, 1H), 6.22 (s, 1H), 4.61 (d, *J* = 6.5 Hz, 1H), 4.45 (t, *J* = 6.7 Hz, 1H), 3.96–3.87 (m, 1H), 3.20 (dd, *J* = 16.6, 6.8 Hz, 1H), 2.88 (d, *J* = 16.8 Hz, 1H), 2.07–2.01 (m, 3H), 1.38 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.6, 170.4, 158.8, 145.8, 143.9, 141.4, 135.6, 131.2, 125.6, 117.0, 115.6, 110.4, 101.0, 63.6, 56.4, 47.4, 38.6, 14.8, 10.7. HRMS-ESI m/z Calcd for $C_{19}H_{19}NNaO_5$ $[M+Na]^+$: 364.1155; found 364.1152.

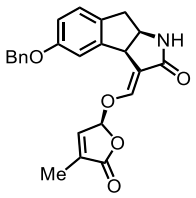
(3a*R*,8a*R*,*E*)-5-(benzyloxy)-3-((((*R*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±15h)



Compound **15h** was obtained following general procedure **M** from **12h** (0.474 mmol, 0.180 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the

eluent, **15h** was obtained as a white solid (60.1 mg, 32%). mp 107.3-108.9 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47–7.29 (m, 6H), 7.08 (d, *J* = 8.1 Hz, 1H), 6.99 (s, 1H), 6.95–6.81 (m, 2H), 6.28 (s, 1H), 6.17 (s, 1H), 5.10–5.02 (m, 2H), 4.62 (s, 1H), 4.54–4.39 (m, 1H), 3.30–3.16 (m, 1H), 2.90 (d, *J* = 16.8 Hz, 1H), 2.08–1.97 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.5, 170.4, 158.7, 145.7, 144.2, 141.2, 137.2, 135.8, 132.1, 128.6, 127.9, 127.4, 125.7, 117.0, 114.7, 112.1, 100.6, 70.3, 56.4, 47.6, 38.7, 10.7. HRMS-ESI m/z Calcd for $C_{24}H_{21}NNaO_5$ $[M+Na]^+$: 426.1312; found 426.1307.

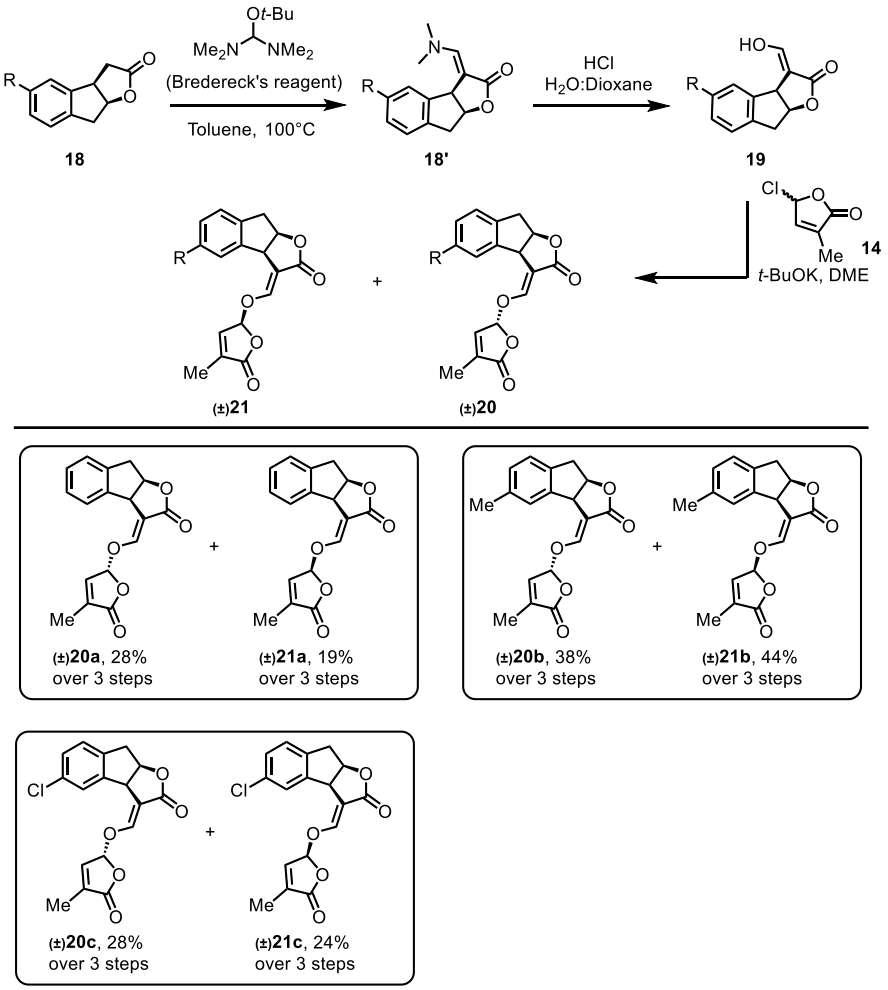
(3a*R*,8a*R*,*E*)-5-(benzyloxy)-3-((((*S*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydroindeno[*2,1-b*]pyrrol-2(1*H*)-one (±16h)



Compound **16h** was obtained following general procedure **M** from **12h** (0.474 mmol, 0.180 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **16h** was obtained as a white solid (60.5 mg, 32%). mp 216.7-217.4 ℃;^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 (d, *J* = 7.7 Hz, 2H), 7.38 (t, *J* = 7.4 Hz, 2H), 7.35–7.28 (m, 2H), 7.07 (d, *J* = 8.3 Hz, 1H), 7.03–6.99 (m, 1H), 6.97–6.93 (m, 1H), 6.88–6.81 (m, 1H), 6.38 (s, 1H), 6.20 (s, 1H), 4.98 (s, 2H), 4.64 (d, *J* = 7.2 Hz, 1H), 4.47 (t, *J* = 6.6 Hz, 1H), 3.22 (dd, *J* = 16.6, 6.6 Hz, 1H), 2.90 (d, *J* = 16.8 Hz, 1H), 2.01–1.98 (m, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.5, 170.3, 158.7, 145.3, 144.0, 141.4, 137.1, 135.8, 131.8, 128.5, 127.8, 127.5, 125.7, 117.0, 115.6, 111.1, 100.7, 70.0, 56.4, 47.5, 38.7, 10.8. HRMS-ESI m/z Calcd for $C_{24}H_{21}NNaO_5$ $[M+Na]^+$: 426.1312; found 426.1320.

2.4.2 Synthesis of (±)-Strigolactones and (±)-*Epi*-Strigolactones

Table S13. Final synthetic route of 2nd generation GR24



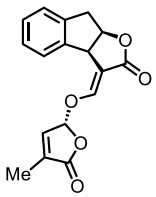
General Procedure N: To a solution of **18a-c** (1.0 equiv) in toluene (10 mL/1 mmol) was added Bredereck's reagent (5.0 equiv) at rt and the solution was refluxed and was monitored by TLC (typical time was 8 h). It was then cooled to rt and diluted with EtOAc. The solution was washed with water. After drying over Na_2SO_4, and removing all volatiles, enamine was obtained as a crude product.

The obtained enamine was then dissolved in dioxane (20 mL/1 mmol) and 1M HCl (20 mL/1 mmol), and the resultant mixture was stirred at rt for 12 h. The solution was neutralized with saturated $NaHCO_3$ and then diluted with EtOAc, washed with water and brine, and dried over Na_2SO_4. After removal of volatiles under reduced pressure, the crude product was obtained.

The obtained enamine was then dissolved in dioxane (5 mL/1 mmol) was added KO^{t}Bu ((1.5 equiv) at 0 ℃. After 10 min, a solution of chlorobutenolidine (1.5 equiv) in DME was added drop wise. The reaction mixture was then allowed to warm slowly to rt and stirred for 16 h. The reaction mixture was diluted with EtOAc and washed with water and brine, and then dried

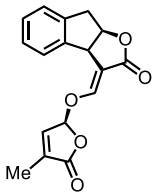
over Na_2SO_4. After removal of volatiles under reduced pressure, the mixture of **20a-c** and **21a-c** was obtained. These compounds were separated by flash chromatography on silica gel.

(3a*R*,8a*R*,*E*)-3-(((®-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydro-2*H*-indeno[*2,1-b*]furan-2-one (±20a)



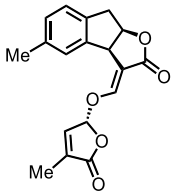
Compound **20a** was obtained following general procedure **N** from **18a** (0.382 mmol, 0.066 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **20a** was obtained as a white solid (31.4 mg, 28%). mp 133.6-136.5 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 (s, 1H), 7.33 (d, *J* = 7.1 Hz, 1H), 7.24-7.20 (m, 3H), 7.05 (s, 1H), 6.26 (s, 1H), 5.26 (t, *J* = 6.2 Hz, 1H), 4.71 (d, *J* = 6.3 Hz, 1H), 3.41 (dd, *J* = 18.0, 6.1 Hz, 1H), 3.33 (d, *J* = 17.9 Hz, 1H), 2.07 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.9, 170.2, 150.3, 141.4, 140.7, 139.6, 136.2, 128.3, 127.6, 125.4, 125.2, 112.2, 100.7, 82.0, 47.9, 38.9, 10.8. HRMS-ESI m/z Calcd for $C_{17}H_{14}NaO_5$ $[M+Na]^+$: 321.0733; found 321.0730.

(3a*R*,8a*R*,*E*)-3-((((*S*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydro-2*H*-indeno[*2,1-b*]furan-2-one (±21a)



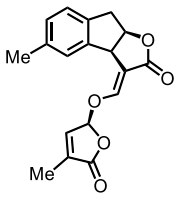
Compound **21a** was obtained following general procedure **N** from **18a** (0.382 mmol, 0.066 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **21a** was obtained as a white solid (21.2 mg, 19%). mp 209.5-212.5 ℃;^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (s, 1H), 7.31 (d, *J* = 7.0 Hz, 1H), 7.24-7.18 (m, 3H), 7.01 (s, 1H), 6.25 (s, 1H), 5.25 (t, *J* = 6.1 Hz, 1H), 4.71 (d, *J* = 6.3 Hz, 1H), 3.40 (dd, *J* = 18.0, 5.9 Hz, 1H), 3.32 (d, *J* = 18.0 Hz, 1H), 2.08 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$)δ 170.9, 170.1, 149.8, 141.3, 140.9, 139.5, 136.2, 128.3, 127.8, 125.5, 125.1, 112.3, 100.6, 82.1, 47.8, 38.9, 10.8. HRMS-ESI m/z Calcd for $C_{17}H_{14}NaO_5$ $[M+Na]^+$: 321.0733; found 321.0736.

(3a*R*,8a*R*,*E*)-5-methyl-3-(((®-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydro-2*H*-indeno[*2,1-b*]furan-2-one (±20b)



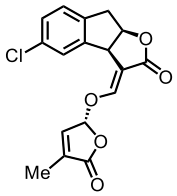
Compound **20b** was obtained following general procedure **N** from **18b** (0.397 mmol, 0.075 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **20b** was obtained as a white solid (47.2 mg, 38%). mp116.7-118.7 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 (d, *J* = 1.8 Hz, 1H), 7.13–7.11 (m, 2H), 7.08–7.03 (m, 2H), 6.30–6.24 (m, 1H), 5.25 (td, *J* = 6.2, 1.5 Hz, 1H), 4.66 (dd, *J* = 6.3, 1.9 Hz, 1H), 3.42–3.20 (m, 2H), 2.33 (s, 3H), 2.07 (t, *J* = 1.6 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.9, 170.2, 150.1, 141.5, 140.8, 137.3, 136.6, 136.2, 129.2, 125.9, 124.9, 112.4, 100.7, 82.4, 47.8, 38.5, 21.4, 10.8. HRMS-ESI m/z Calcd for $C_{18}H_{16}NaO_5$ $[M+Na]^+$: 335.0890; found 335.0892.

(3a*R*,8a*R*,*E*)-5-methyl-3-((((*S*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydro-2*H*-indeno[*2,1-b*]furan-2-one (±21b)



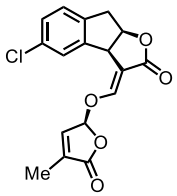
Compound **21b** was obtained following general procedure **N** from **18b** (0.397 mmol, 0.075 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **21b** was obtained as a white solid (54.4 mg, 44%). mp 225.5-227.0 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (d, *J* = 2.0 Hz, 1H), 7.12–7.09 (m, 2H), 7.06–6.98 (m, 2H), 6.27–6.26 (m, 1H), 5.24 (td, *J* = 6.1, 1.5 Hz, 1H), 4.69–4.63 (m, 1H), 3.40–3.18 (m, 2H), 2.29 (s, 3H), 2.08 (t, *J* = 1.6 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.9, 170.1, 149.8, 141.4, 141.0, 137.5, 136.4, 136.1, 129.2, 126.0, 124.8, 112.6, 100.7, 82.4, 47.7, 38.5, 21.3, 10.8. HRMS-ESI m/z Calcd for $C_{18}H_{16}NaO_5$ $[M+Na]^+$: 335.0890; found 335.0884.

(3a*R*,8a*R*,*E*)-5-chloro-3-(((®-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydro-2*H*-indeno[*2,1-b*]furan-2-one (±20c)

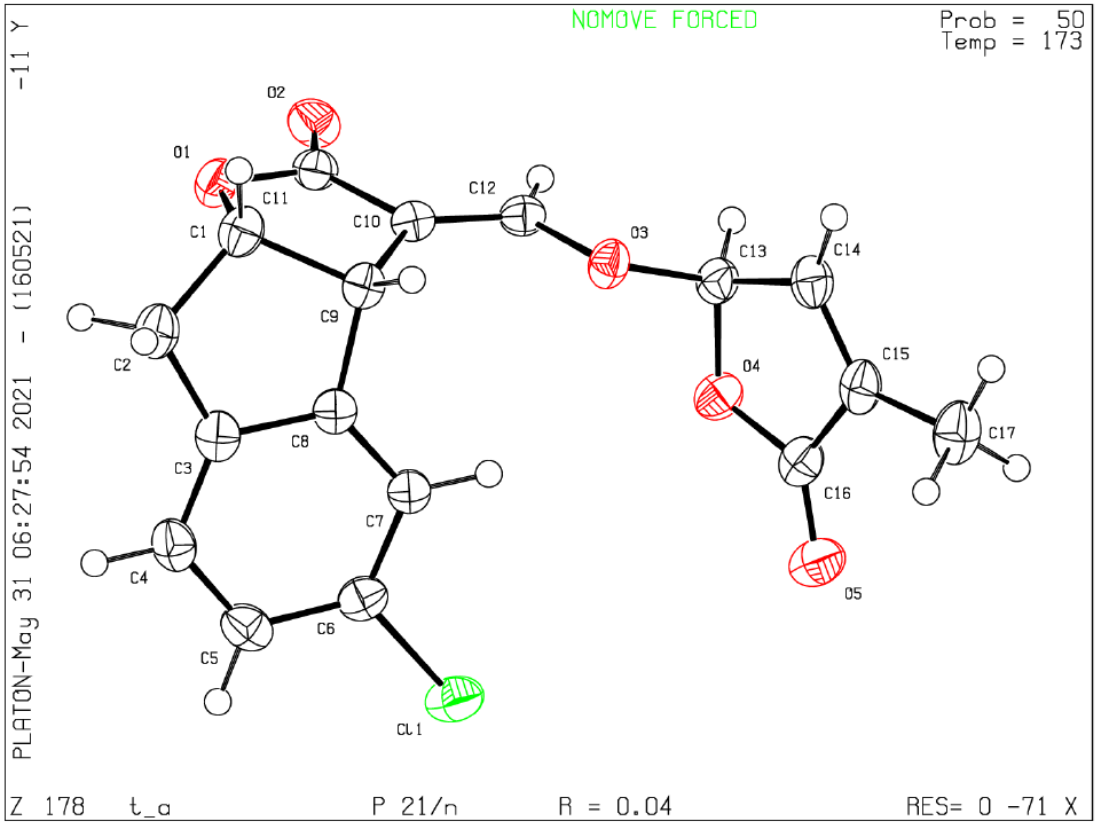


Compound **20c** was obtained following general procedure **N** from **18c** (0.389 mmol, 0.081 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **20c** was obtained as a white solid (36.1 mg, 28%). mp 165.6-169.1 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (s, 1H), 7.29 (s, 1H), 7.22 (d, *J* = 6.3 Hz, 1H), 7.16 (d, *J* = 8.2 Hz, 1H), 7.07 (s, 1H), 6.26 (s, 1H), 5.27 (t, *J* = 6.3 Hz, 1H), 4.69 (d, *J* = 6.5 Hz, 1H), 3.4 (dd, *J* = 18.1, 6.1 Hz, 1H), 3.3 (d, *J* = 18.1 Hz, 1H), 2.08 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.4, 170.1, 151.0, 143.3, 140.7, 138.2, 136.2, 133.1, 128.5, 126.3, 125.7, 111.4, 100.8, 82.0, 47.8, 38.5, 10.8. HRMS-ESI m/z Calcd for$C_{17}H_{13}NaClO_5$ $[M+Na]^+$: 355.0344; found 355.0347.

(3a*R*,8a*R*,*E*)-5-chloro-3-((((*S*)-4-methyl-5-oxo-2,5-dihydrofuran-2-yl)oxy)methylene)-3,3a,8,8a-tetrahydro-2*H*-indeno[*2,1-b*]furan-2-one (±21c)



Compound **21c** was obtained following general procedure **N** from **18c** (0.389 mmol, 0.081 g). After purification by column chromatography using hexane:EtOAc (1/0 to 4/1 to 1/1) as the eluent, **21c** was obtained as a white solid (30.6 mg, 24%). mp 218.3-221.4 ℃; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (s, 1H), 7.28 (s, 1H), 7.21 (d, *J* = 8.1 Hz, 1H), 7.15 (d, *J* = 8.1 Hz, 1H), 7.03 (s, 1H), 6.29 (s, 1H), 5.27 (t, *J* = 6.3 Hz, 1H), 4.69 (d, *J* = 6.5 Hz, 1H), 3.4 (dd, *J* = 18.1, 6.2 Hz, 1H), 3.3 (d, *J* = 18.0 Hz, 1H), 2.08 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 170.5, 169.8, 149.8, 143.1, 140.8, 138.0, 136.5, 133.3, 128.5, 126.2, 125.7, 111.6, 100.3, 82.0, 47.6, 38.5, 10.8. HRMS-ESI m/z Calcd for $C_{17}H_{13}NaClO_5$ $[M+Na]^+$: 355.0344; found 355.0351.

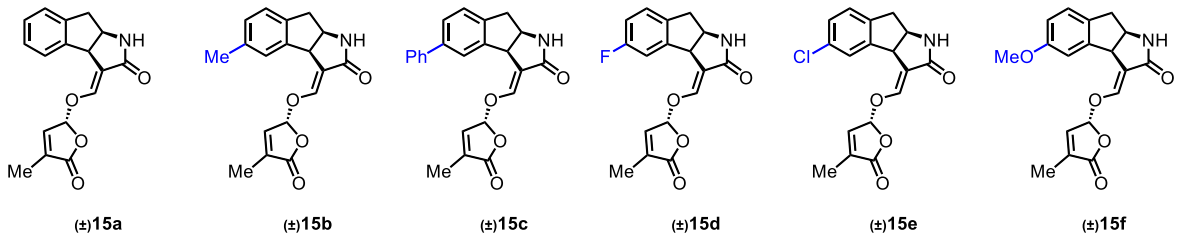


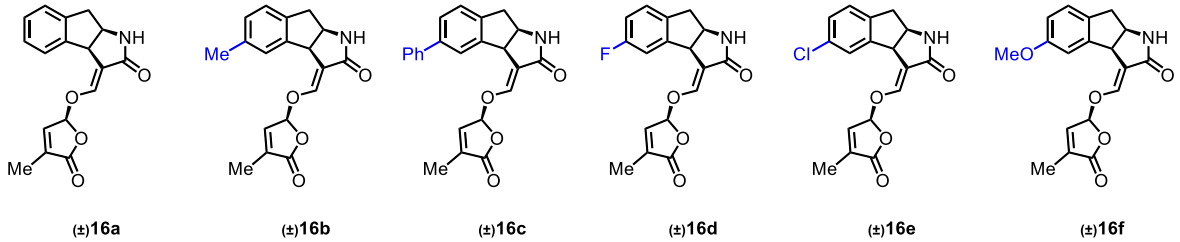
Crystal	Data
Empirical formula	$C_{17}H_{13}ClNO_5$
Formula weight	332.72
Crystal system	Monoclinic
Space group	P2(1)/n
Z	4
a/ Å	12.588(3)
b/ Å	7.415(2)
c/ Å	16.351(4)
α/°	90 deg
β/°	100.998(18) deg
γ/°	90 deg
V/Å^3	3105.2(9)
Density/Mg/m^3	11.475
F(000)	688
Absorption coefficient/mm^{-1}	Semi-empirical from equivalents

Theta range for data collection/ °	4.915 to 68.215 deg
Reflections collected	10523
Independent reflections	2735
No. of parameters	209
Goodness-of-fit on F^2	1.036
Largest diff. peak and hole/$e/Å^3$	0.276 and -0.235
R_1, $wR_2(I > 2\sigma(I))$	R_1 = 0.0359, wR_2 = 0.0950
R_1, wR_2(all data)	R_1 = 0.0422, wR_2 = 0.1000

2.5 The germination efficacy assay of strigolactams and strigolactones [7]

The Orobanche aegyptiaca seeds used in this study was kindly provided by Prof. Yong-Qing Ma from College of Forestry, Northwest A & F University. The strigolactone analogues was dissolved in DMSO at the concentration of 10 mM and used as a stock solution. First soak the seeds in 1% NaCIO for 3 min. and washed with autoclaved distilled water and then soak in 75% alcohol for 2 min. and then thoroughly washed with autoclaved distilled water and air-dried in clean bench. The seeds conditioned in the dark at room temperature for 1 weeks. The conditioned seeds suspended in milliQ water were aliquoted in 96-well plates at the volume of 100 μL, to which 1μL of the diluted stock solution was added to the final concentration indicated in the text. The number of germinated seeds were counted and divided by the total number of seeds to indicate germination rate. The experiments were repeated three times and averages with standard deviations were presented.





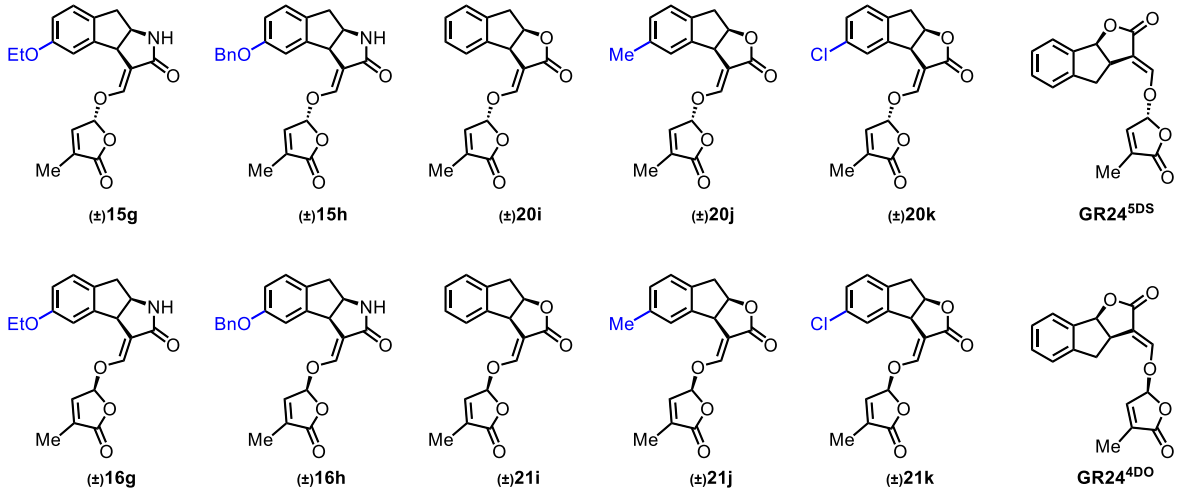
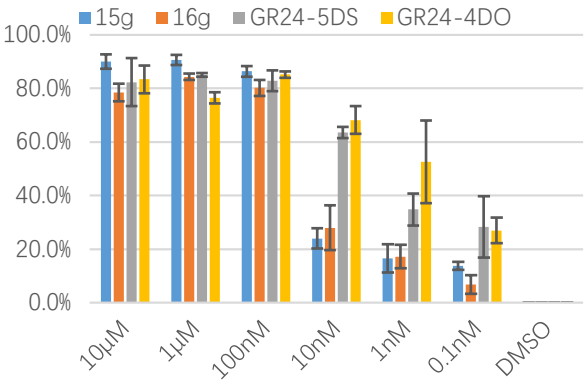
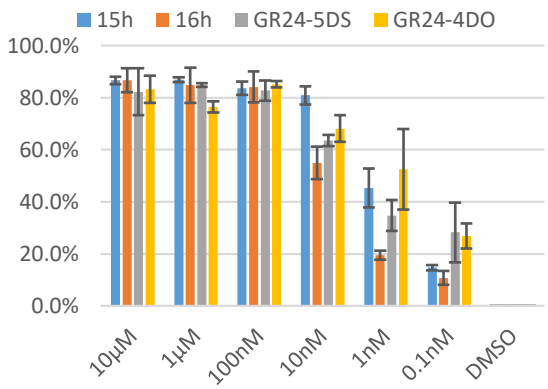


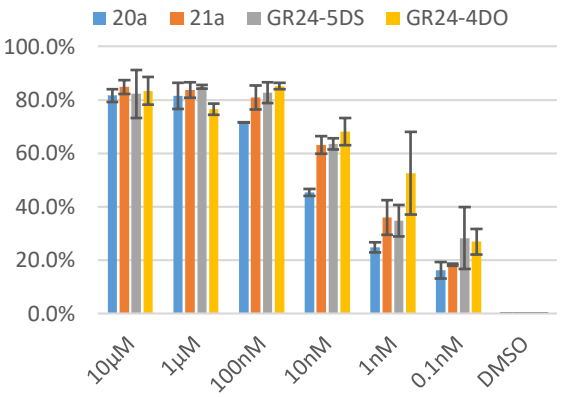
Table S14. Numeric data for the assay

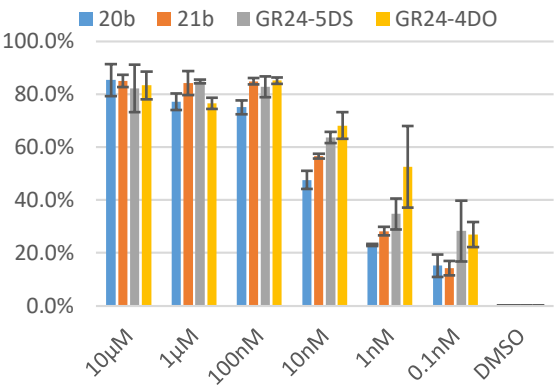
Orobanche aegyptiaca germination							
	10µM	1µM	100nM	10nM	1nM	0.1nM	DMSO
(±)15a	87.8% ± 0.0%	85.0% ± 2.1%	90% ± 1.3%	58.5% ± 1.1%	46.7% ± 2.3%	22.9% ± 5.7%	0.0% ± 0.0%
(±)16a	78.5% ± 0.6%	85.0% ± 5.5%	85.9% ± 1.1%	70.4% ± 1.5%	46.7% ± 3.3%	21.7% ± 2.8%	0.0% ± 0.0%
(±)15b	87.9% ± 1.1%	89.5% ± 2.6%	89.4% ± 1.1%	73.4% ± 3.9%	33.9% ± 4.3%	20.3% ± 2.0%	0.0% ± 0.0%
(±)16b	83.9% ± 0.6%	87.4% ± 0.8%	90.5% ± 1.1%	71.8% ± 4.9%	53.1% ± 7.3%	34.0% ± 1.5%	0.0% ± 0.0%
(±)15c	90% ± 0.9%	90.5% ± 2.0%	86.3% ± 1.3%	24.0% ± 0.6%	16.5% ± 2.0%	13.7% ± 3.0%	0.0% ± 0.0%
(±)16c	78.4% ± 2.6%	84.2% ± 2.9%	80.1% ± 0.5%	27.9% ± 2.7%	17.2% ± 8.1%	6.8% ± 0.8%	0.0% ± 0.0%
(±)15d	86.6% ± 5.8%	86.0% ± 4.6%	75.1% ± 13.1%	54.5% ± 6.4%	32.5% ± 2.3%	17.2% ± 3.2%	0.0% ± 0.0%
(±)16d	86.6% ± 3.9%	84.4% ± 2.0%	81.7% ± 4.5%	66.6% ± 5.2%	33.7% ± 10.8%	13.5% ± 1.0%	0.0% ± 0.0%
(±)15e	84.9% ± 1.4%	81.2% ± 5.3%	84.3% ± 4.4%	51.7% ± 3.3%	24.2% ± 2.3%	18.8% ± 2.2%	0.0% ± 0.0%
(±)16e	83.8% ± 5.2%	86.8% ± 1.7%	82.0% ± 5.2%	49.4% ± 7.4%	18.6% ± 0.5%	8.4% ± 1.2%	0.0% ± 0.0%
(±)15f	83.1% ± 3.3%	88.6% ± 3.2%	87.8% ± 1.5%	75.5% ± 5.3%	73.4% ± 7.8%	28.5% ± 1.6%	0.0% ± 0.0%
(±)16f	85.2% ± 4.0%	81.7% ± 4.6%	87.7% ± 3.3%	73.6% ± 5.0%	41.6% ± 1.6%	16.8% ± 1.1%	0.0% ± 0.0%
(±)15g	88.5% ± 2.7%	83.5% ± 1.9%	86.4% ± 1.9%	76.0% ± 3.8%	50.2% ± 5.2%	15.9% ± 1.4%	0.0% ± 0.0%
(±)16g	83.7% ± 3.2%	87.3% ± 1.2%	88.6% ± 3.0%	77.7% ± 8.3%	22.6% ± 4.4%	15.8% ± 3.4%	0.0% ± 0.0%
(±)15h	86.6% ± 1.4%	86.9% ± 0.9%	83.7% ± 2.5%	80.9% ± 3.5%	45.3% ± 7.5%	14.7% ± 1.0%	0.0% ± 0.0%
(±)16h	86.7% ± 4.6%	84.8% ± 6.8%	84.1% ± 5.9%	55.0% ± 6.3%	19.6% ± 1.7%	10.8% ± 2.7%	0.0% ± 0.0%
(±)20a	81.7% ± 2.4%	81.4% ± 4.9%	71.7% ± 0.0%	45.4% ± 1.3%	24.8% ± 1.9%	16.2% ± 3.1%	0.0% ± 0.0%
(±)21a	84.8% ± 2.6%	83.7% ± 2.9%	81.0% ± 4.5%	63.0% ± 3.3%	36.0% ± 6.5%	18.2% ± 0.4%	0.0% ± 0.0%
(±)20b	85.3% ± 6.1%	77.2% ± 3.1%	75.1% ± 2.6%	47.6% ± 3.4%	23.1% ± 0.4%	15.2% ± 4.3%	0.0% ± 0.0%
(±)21b	85.0% ± 2.4%	84.2% ± 4.6%	84.9% ± 1.2%	56.5% ± 0.9%	28.2% ± 1.6%	14.2% ± 2.7%	0.0% ± 0.0%
(±)20c	87.9% ± 4.9%	85.0% ± 2.4%	66.9% ± 1.0%	31.3% ± 4.4%	19.0% ± 0.3%	15.3% ± 6.7%	0.0% ± 0.0%
(±)21c	69.6% ± 4.7%	77.5% ± 8.1%	84.8% ± 1.3%	64.9% ± 3.8%	26.4% ± 9.7%	11.9% ± 0.4%	0.0% ± 0.0%
GR24^{5DS}	82.3% ± 9.0%	84.9% ± 0.7%	82.8% ± 3.9%	63.6% ± 2.1%	34.7% ± 5.9%	28.3% ± 11.5%	0.0% ± 0.0%
GR24^{4DO}	83.3% ± 5.2%	76.5% ± 2.1%	85.1% ± 1.2%	68.2% ± 5.1%	52.6% ± 15.5%	26.9% ± 4.8%	0.0% ± 0.0%

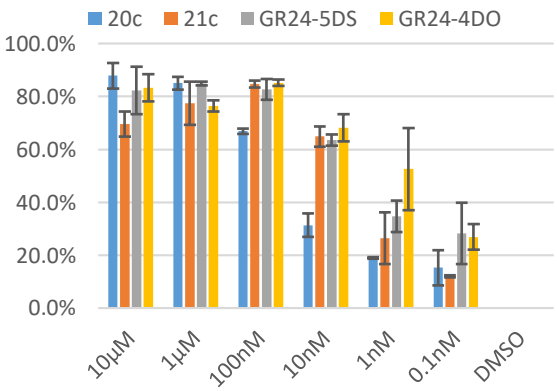
Figure S1. Orobanche aegyptiaca seeds germination


15g
16g
GR24-5DS
GR24-4DO
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
10μM
1μM
100nM
10nM
1nM
0.1nM
DMSO


15h
16h
GR24-5DS
GR24-4DO
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
10μM
1μM
100nM
10nM
1nM
0.1nM
DMSO


20a
21a
GR24-5DS
GR24-4DO
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
10μM
1μM
100nM
10nM
1nM
0.1nM
DMSO


20b
21b
GR24-5DS
GR24-4DO
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
10μM
1μM
100nM
10nM
1nM
0.1nM
DMSO


20c
21c
GR24-5DS
GR24-4DO
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
10μM
1μM
100nM
10nM
1nM
0.1nM
DMSO

Reference:

1. (a) E. M. Mangnus, F. J. Dommerholt, R. L. P. d. Jong and B. Zwanenburg, *J. Agric. Food Chem.*, 1992, **40**, 1230; (b) L. Wang, B. Wang, H. Yu, H. Guo, T. Lin, L. Kou, A. Wang, N. Shao, H. Ma, G. Xiong, X. Li, J. Yang, J. Chu and J. Li, *Nature*, 2020, **583**, 277; (c) H. Malik, F. P. J.T. Rutjes and B. Zwanenburg, *Tetrahedron*, 2010, **66**, 7198; (d) M. Lachia, H. C. Wolf, P. J. M. Jung, C. Screpanti and A. D. Mesmaeker, *Bioorg. Med. Chem. Lett.*, 2015, **25**, 2184; (e) K. Ashida, Y. Hoshimoto, N. Tohnai, D. E. Scott, M. Ohashi, H. Imaizumi, Y. Tsuchiya and S. Ogoshi, *J. Am. Chem. Soc.*, 2020, **142**, 1594; (f) WO. Pat., 145979, 2018; (g) WO. Pat., 175025, 2019.

2. For optimization of C-H olefination, see: (a) K. M. Engle, D.-H. Wang and J.-Q. Yu, *Angew. Chem. Int. Ed.*, 2010, **49**, 6169; (b) P. S. Thuy-Boun, G. Villa, D. Dang, P. Richardson, S. Su and J.-Q. Yu, *J. Am. Chem. Soc.*, 2013, **135**, 17508; (c) D. Nandi, D. Ghosh, S.-J. Chen, B.-C. Kuo, N. M. Wang and H. M. Lee, *J. Org. Chem.*, 2013, **78**, 3445.

3. For the introduction of Piv group, see: N. Dastbaravardeh, T. Toba, M. E. Farmer and J.-Q. Yu, *J. Am. Chem. Soc.*, 2015, **137**, 9877.

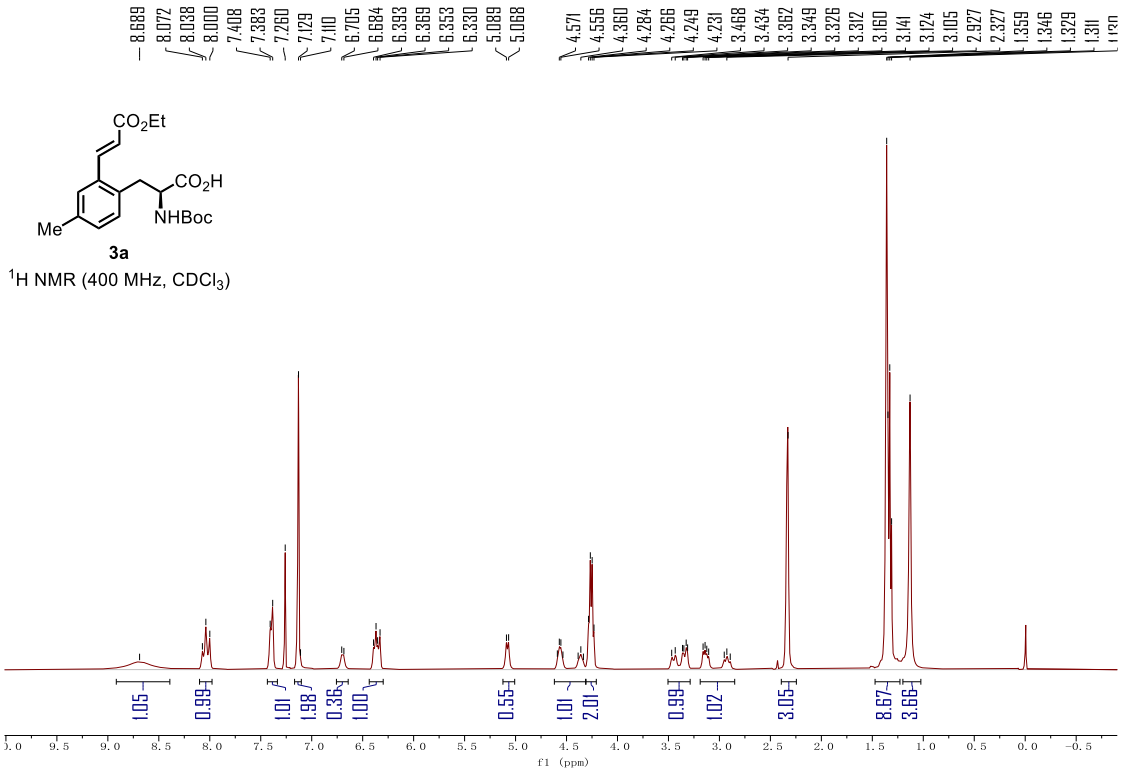
4. For Ir-catalyzed decarboxylative Giese reaction, see: L. Chu, C. Ohta, Z. Zuo and D. W. C. MacMillan, *J. Am. Chem. Soc.*, 2014, **136**, 10886.

5. For Ni-catalyzed decarboxylative Giese reaction, see: T. Qin, L. R. Malins, J. T. Edwards, R. R. Merchant, A. J. E. Novak, J. Z. Zhong, R. B. Mills, M. Yan, C. Yuan, M. D. Eastgate and P. S. Baran, A*ngew. Chem. Int. Ed.*, 2017, **56**, 260.

6. For the synthesis of Strigolactone analogues, see: (a) K. Ashida, Y. Hoshimoto, N. Tohnai, D. E. Scott, M. Ohashi, H. Imaizumi, Y. Tsuchiya and S. Ogoshi, *J. Am. Chem. Soc.*, 2020, **142**, 1594; (b) M. Lachia, H. C. Wolf, P. J. M. Jung, C. Screpanti and A. D. Mesmaeker, *Bioorg. Med. Chem. Lett.*, 2015, **25**, 2184.

7. For the research on bioactivity Strigolactone analogues: M. Lachia, H. C. Wolf, P. J. M. Jung, C. Screpanti and A. D. Mesmaeker, *Bioorg. Med. Chem. Lett.*, 2015, **25**, 2184.

NMR Spectra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8.072
8.038
8.000
7.408
7.383
7.260
7.129
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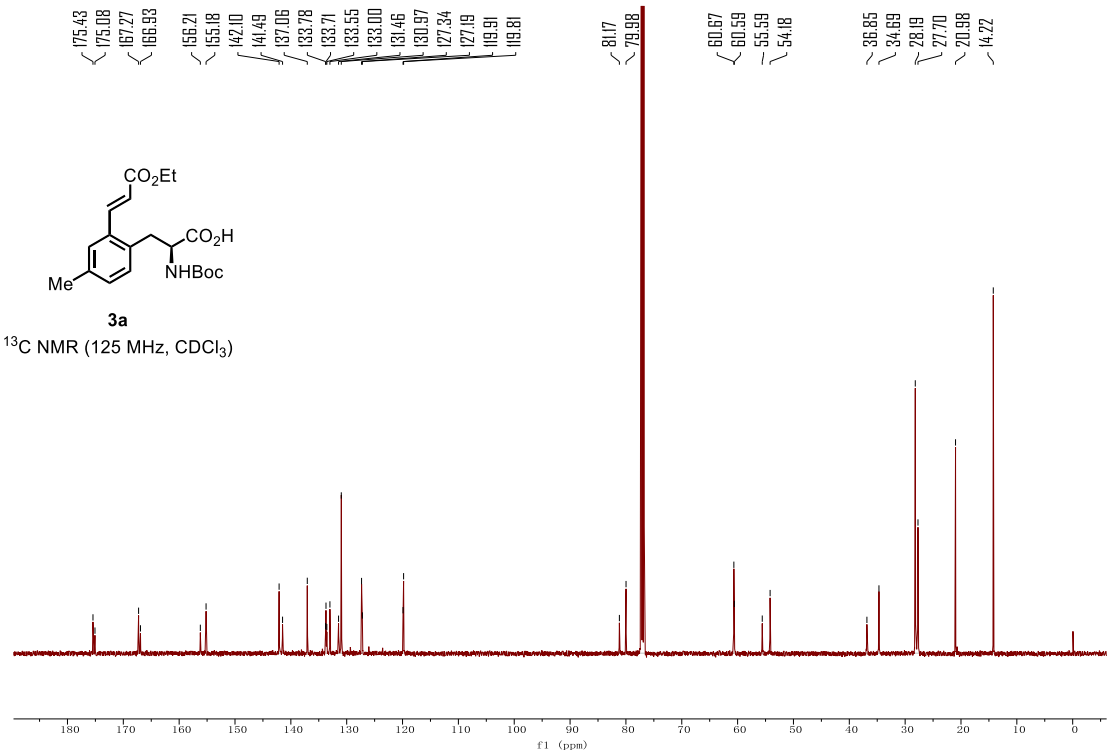
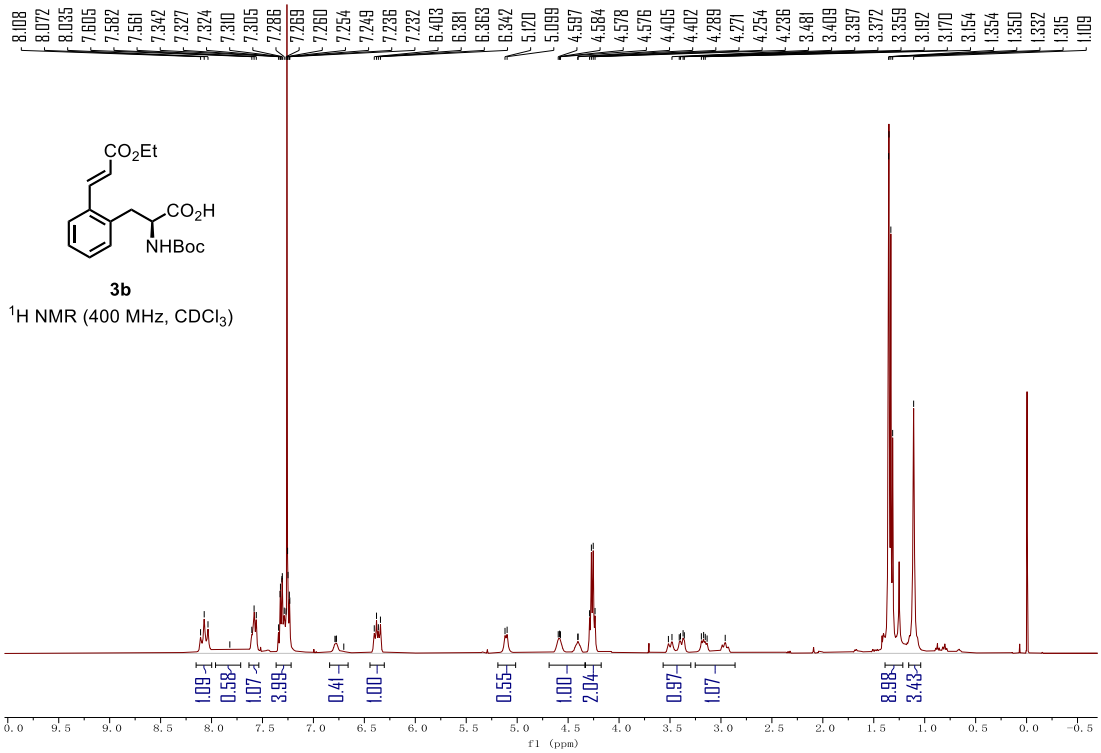
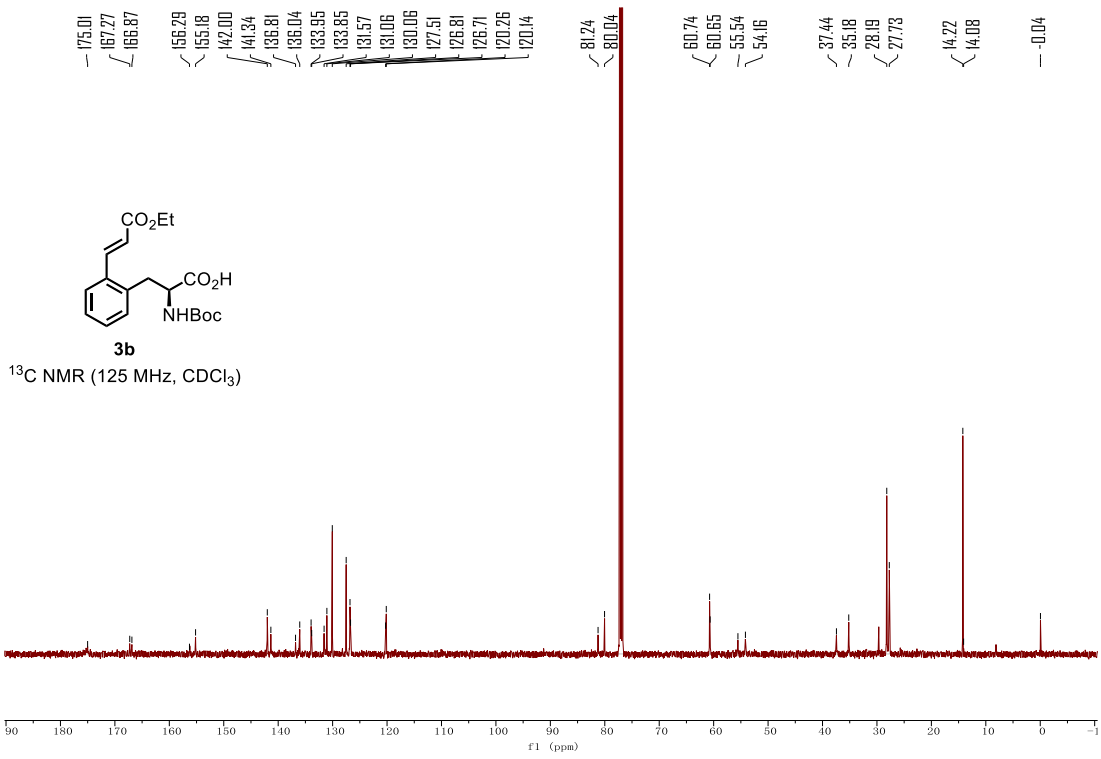
6.705
6.684
6.393
6.369
6.353
6.330
5.089
5.068
4.571
4.556
4.380
4.284
4.266
4.249
4.231
3.468
3.434
3.382
3.349
3.326
3.312
3.160
3.141
3.124
3.105
2.927
2.327
1.359
1.346
1.329
1.311
CO2Et
CO2H
NHBoc
Me
3a
1H NMR (400 MHz, CDCl3)
1.05
0.99
1.01
1.98
0.36
1.00
0.55
1.01
2.01
0.99
1.02
3.05
8.67
3.66
f1 (ppm)


175.43
175.08
167.27
166.93
156.21
155.18
142.10
141.49
137.06
133.78
133.71
133.55
133.00
131.46
130.97
127.34
127.19
119.91
119.81
81.17
79.98
60.67
60.59
55.59
54.18
36.85
34.69
28.19
27.70
20.98
14.22
CO2Et
CO2H
NHBoc
Me
3a
13C NMR (125 MHz, CDCl3)
f1 (ppm)



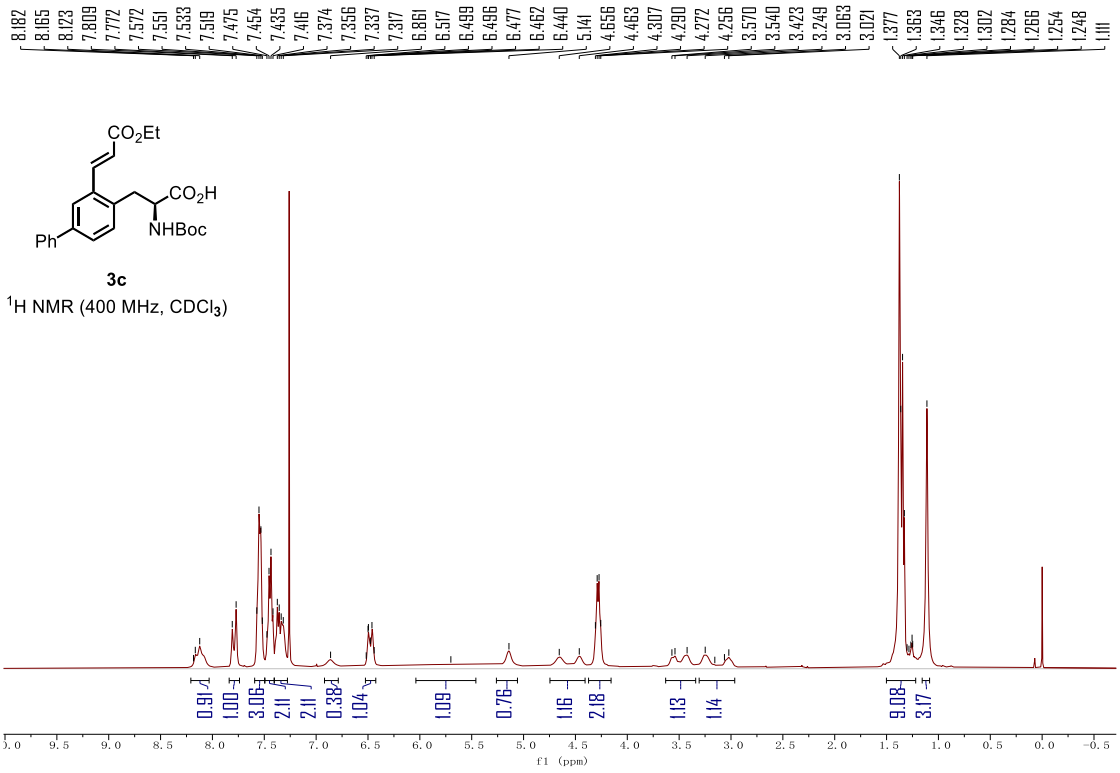
3b

^{1}H NMR (400 MHz, $CDCl_3$)



3b

^{13}C NMR (125 MHz, $CDCl_3$)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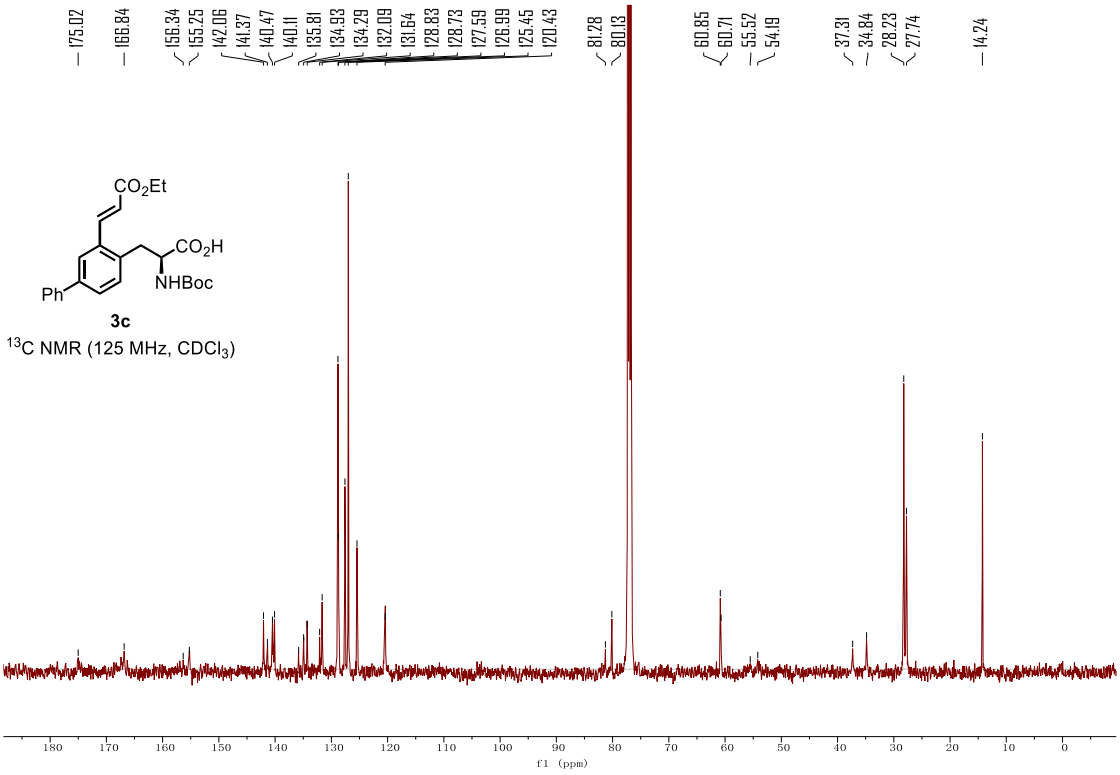
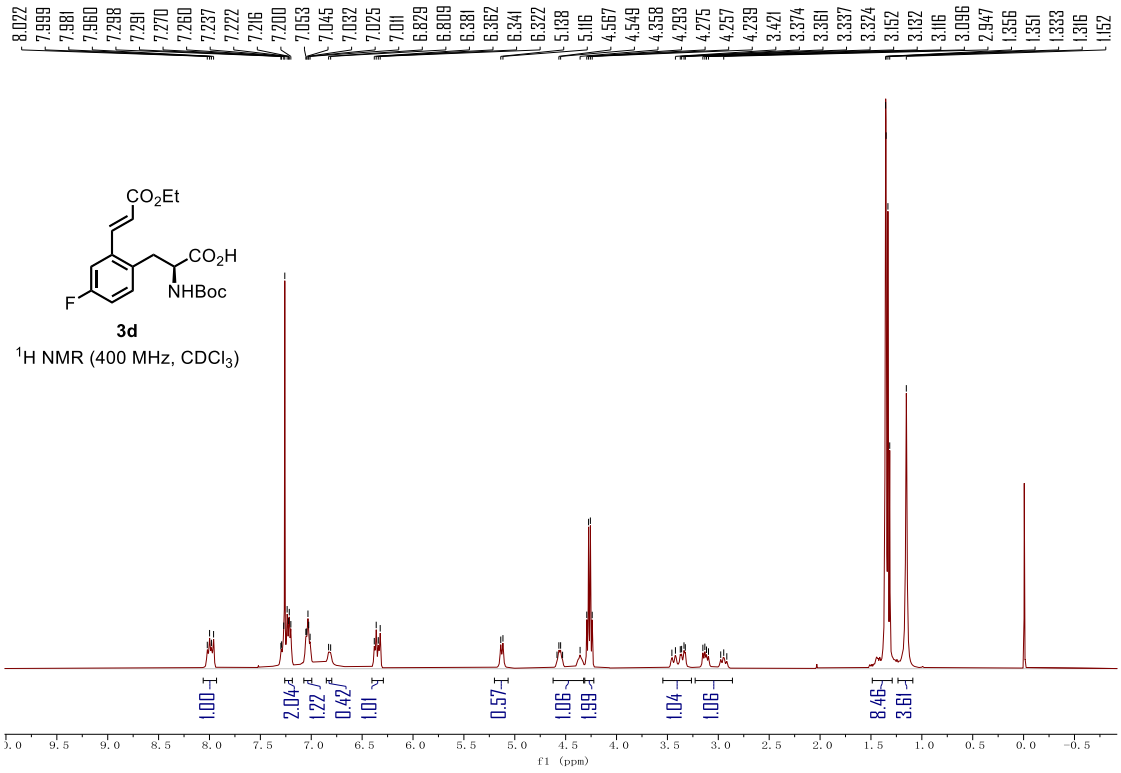
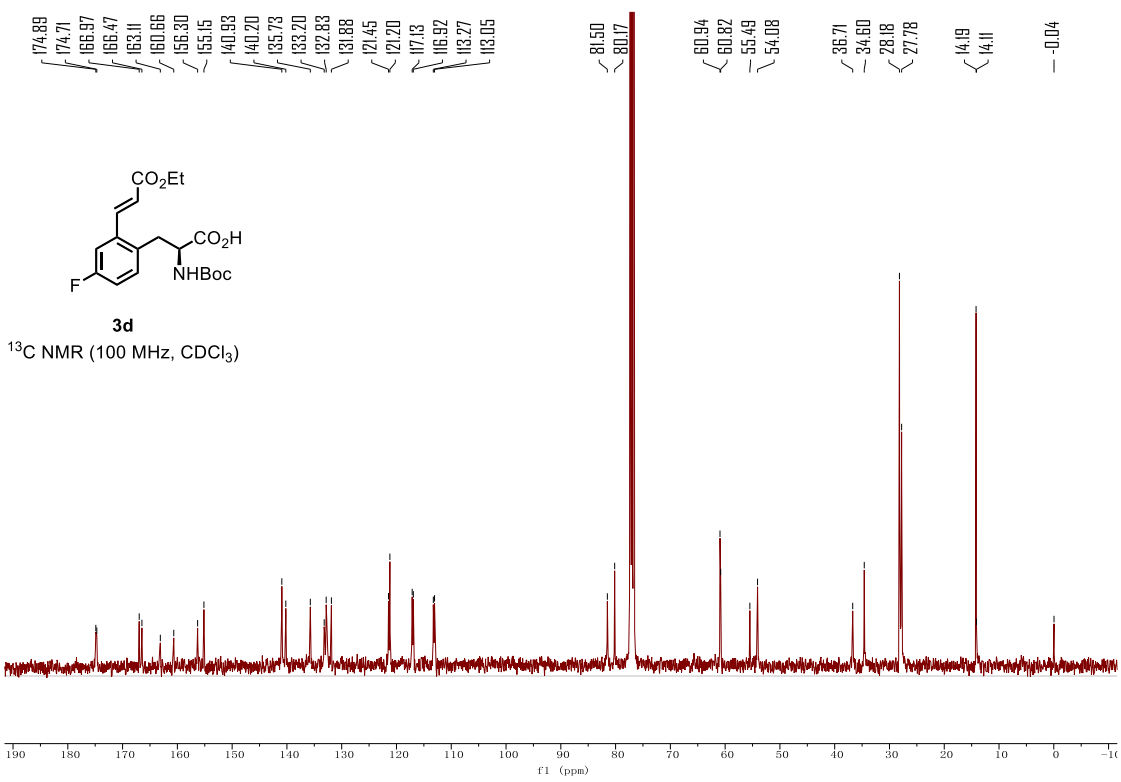
8.123
7.809
7.772
7.572
7.551
7.533
7.519
7.475
7.454
7.435
7.416
7.374
7.356
7.337
7.317
6.861
6.517
6.499
6.496
6.477
6.462
6.440
5.141
4.656
4.463
4.307
4.290
4.272
4.256
3.570
3.540
3.423
3.249
3.063
3.021
1.377
1.363
1.346
1.328
1.302
1.284
1.266
1.254
1.248
1.111
CO2Et
CO2H
NHBoc
Ph
3c
1H NMR (400 MHz, CDCl3)
0.91
1.00
3.06
2.11
2.11
0.38
1.04
1.09
0.78
1.16
2.18
1.13
1.14
9.08
3.17
f1 (ppm)


175.02
166.84
156.34
155.25
142.06
141.37
140.47
140.11
135.81
134.93
134.29
132.09
131.64
128.83
128.73
127.59
126.99
125.45
120.43
81.28
80.13
60.85
60.71
55.52
54.19
37.31
34.84
28.23
27.74
14.24
CO2Et
CO2H
NHBoc
Ph
3c
13C NMR (125 MHz, CDCl3)
f1 (ppm)



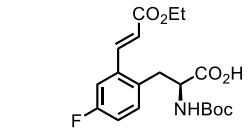
3d

^{1}H NMR (400 MHz, $CDCl_3$)



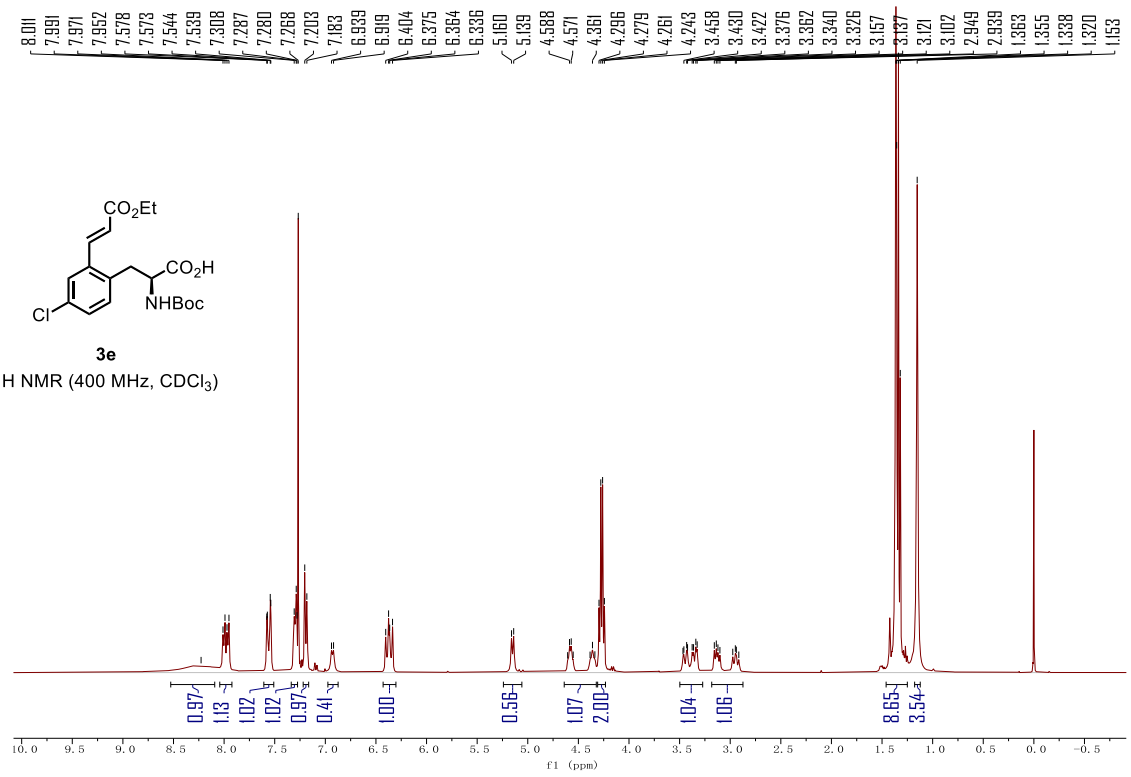
3d

^{13}C NMR (100 MHz, $CDCl_3$)



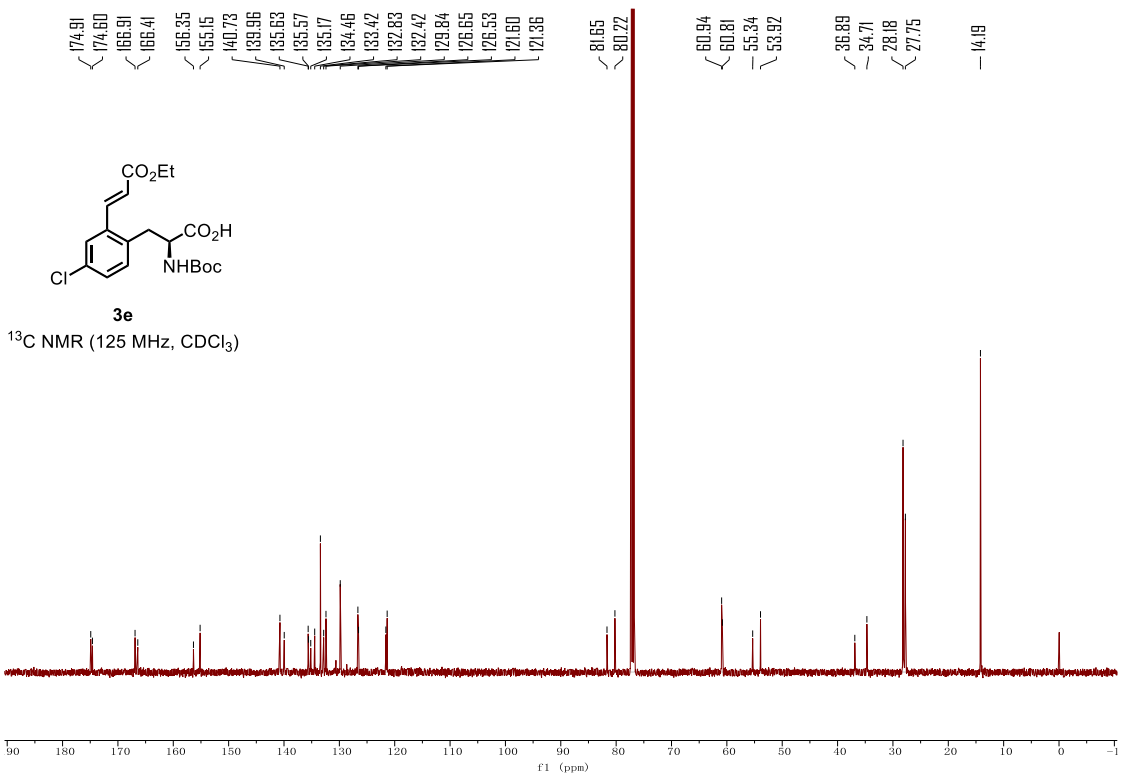
3d

^{19}F NMR (375 MHz, $CDCl_3$)



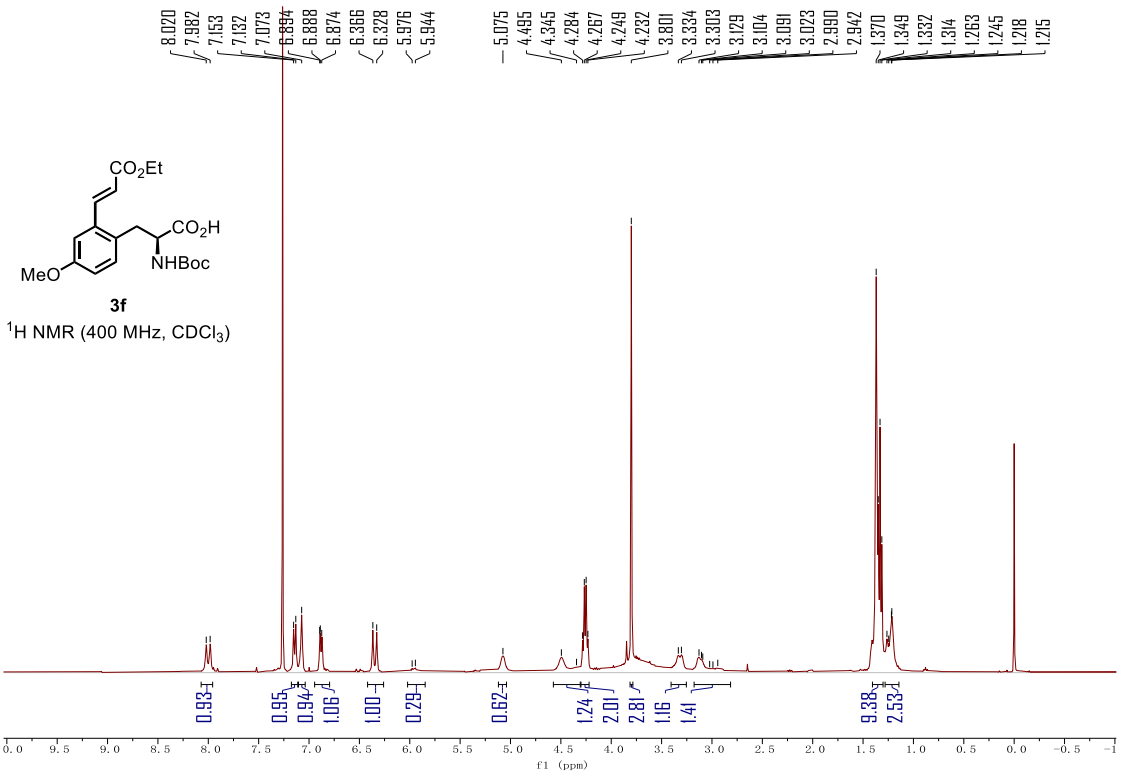
3e

^{1}H NMR (400 MHz, $CDCl_3$)



3e

^{13}C NMR (125 MHz, $CDCl_3$)



3f

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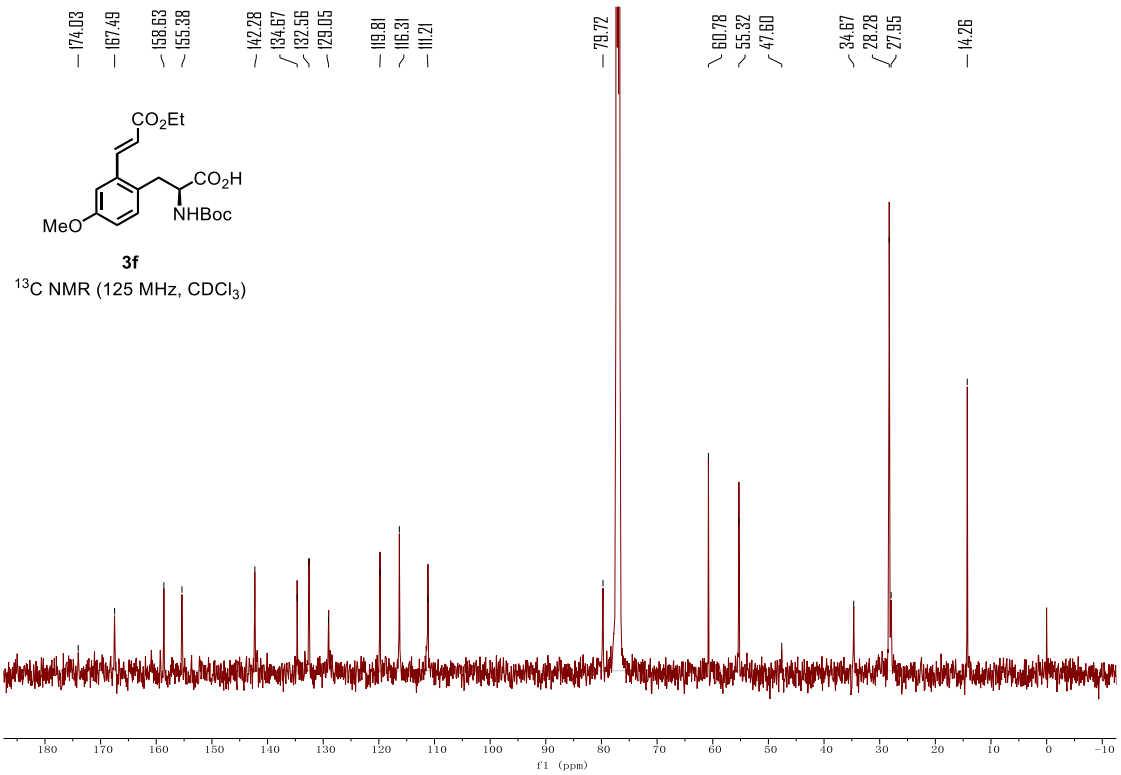

3f

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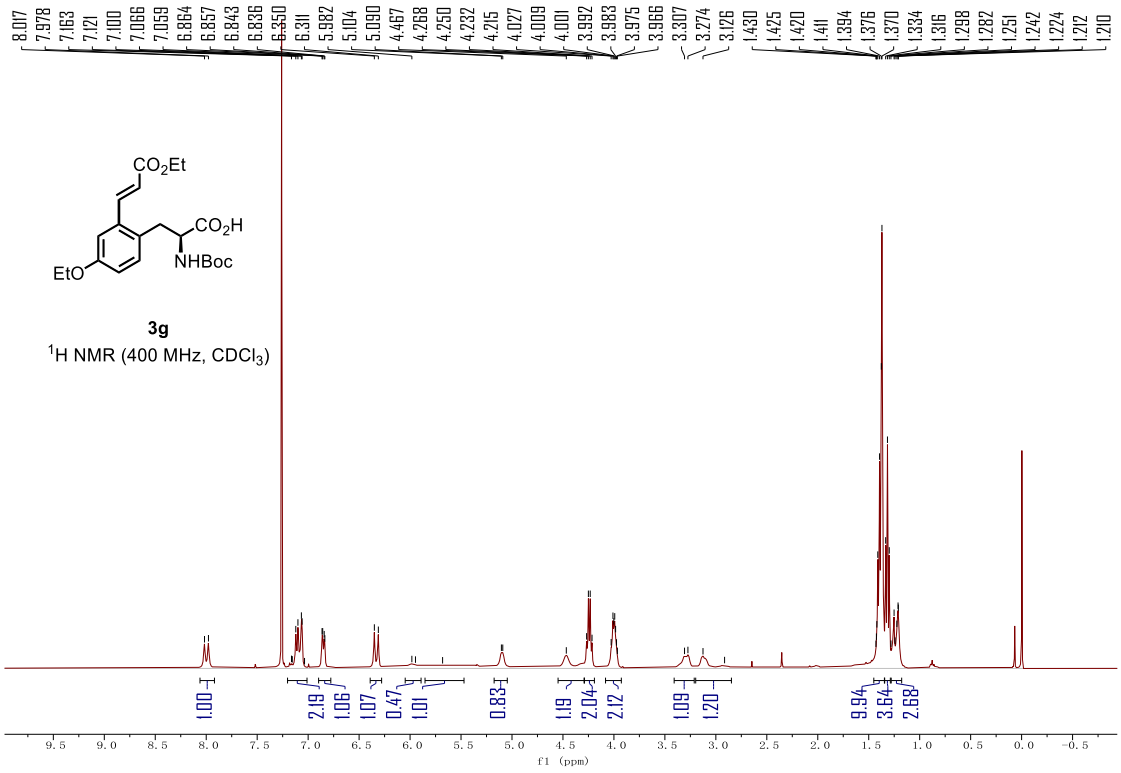

3g

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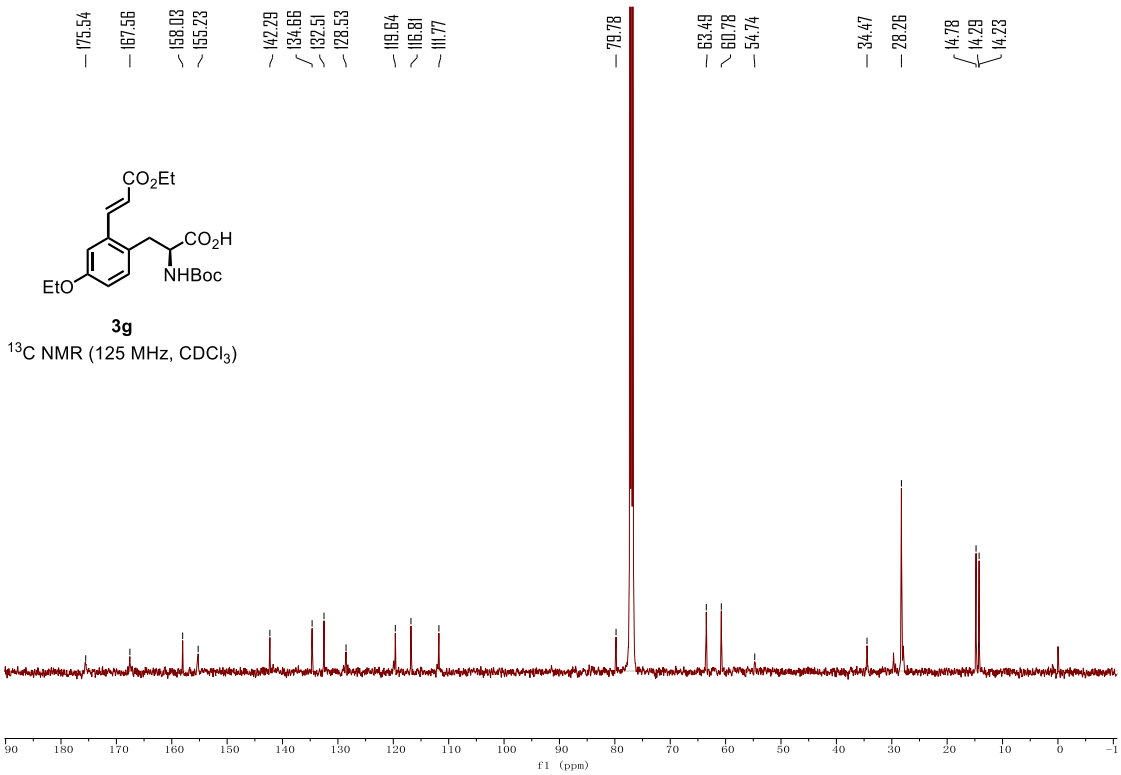
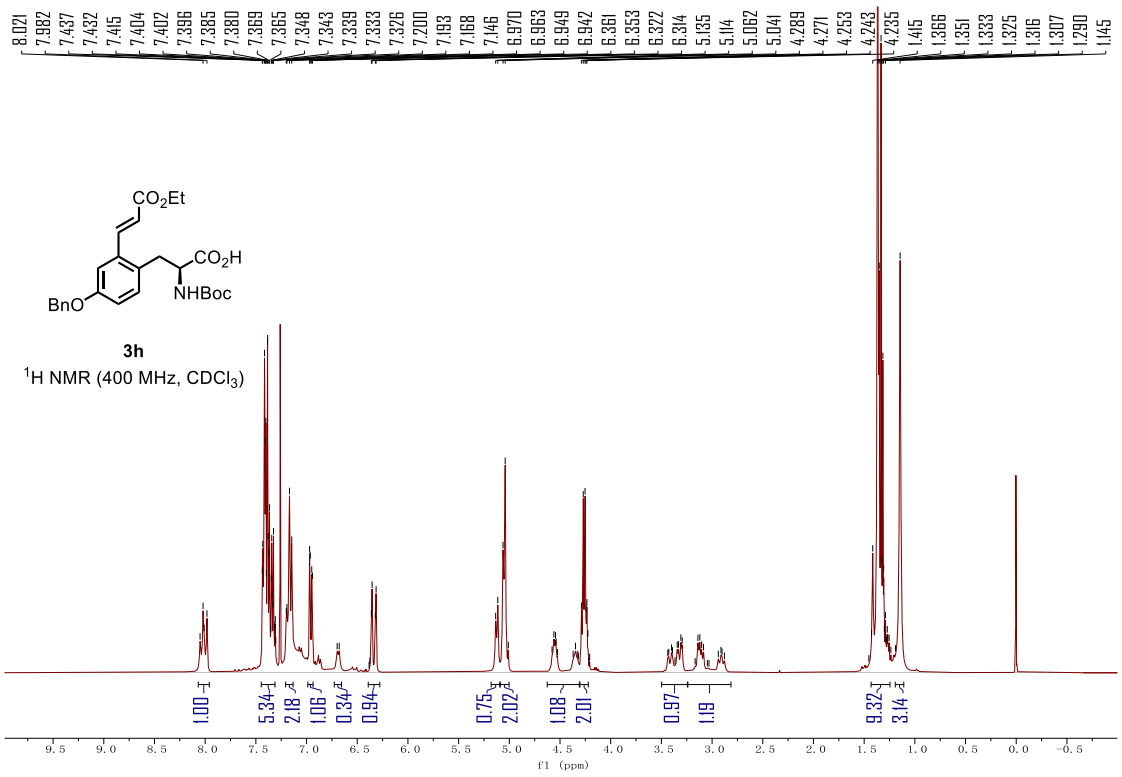


3g

^{13}C NMR (125 MHz, $CDCl_3$)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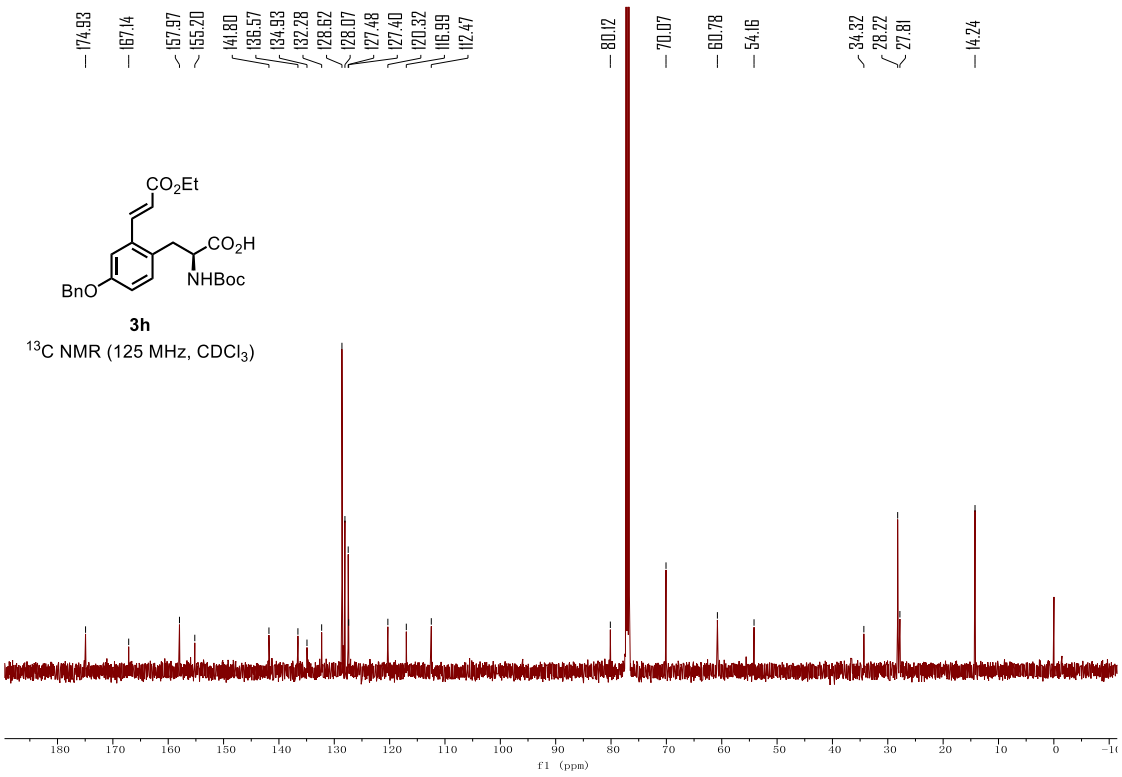
7.432
7.415
7.404
7.402
7.396
7.385
7.380
7.369
7.365
7.348
7.343
7.339
7.333
7.326
7.200
7.193
7.168
7.146
6.970
6.963
6.949
6.942
6.361
6.353
6.322
6.314
5.135
5.114
5.062
5.041
4.289
4.271
4.253
4.243
4.235
1.415
1.366
1.351
1.333
1.325
1.316
1.307
1.280
1.145
CO2Et
CO2H
NHBoc
BnO
3h
1H NMR (400 MHz, CDCl3)
1.00
5.34
2.18
1.06
0.34
0.94
0.75
2.02
1.08
2.01
0.97
1.19
9.32
3.14
f1 (ppm)


174.93
167.14
157.97
155.20
141.80
136.57
134.93
132.28
128.62
128.07
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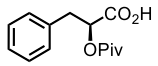
120.32
116.99
112.47
80.12
70.07
60.78
54.16
34.32
28.22
27.81
14.24
CO2Et
CO2H
NHBoc
BnO
3h
13C NMR (125 MHz, CDCl3)
f1 (ppm)



5a

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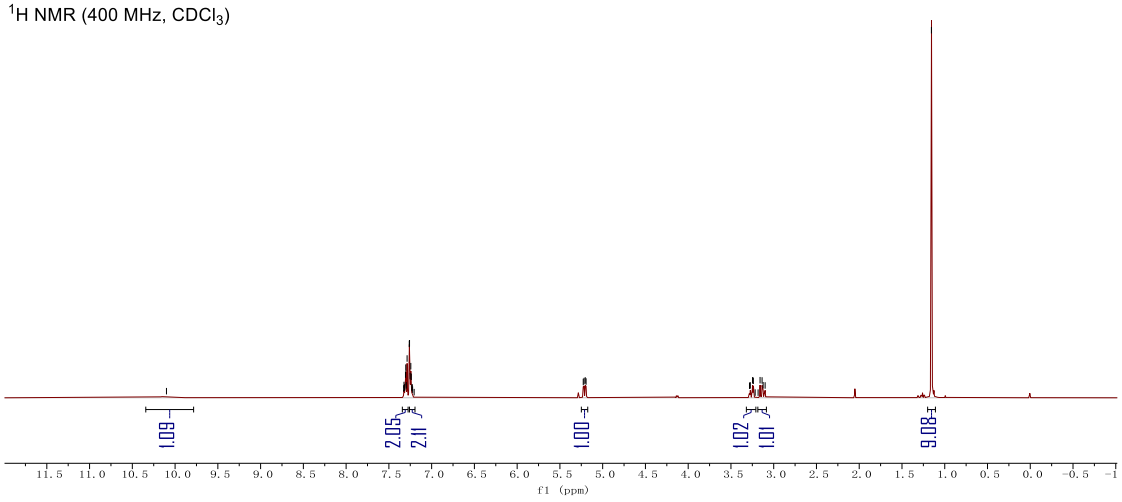
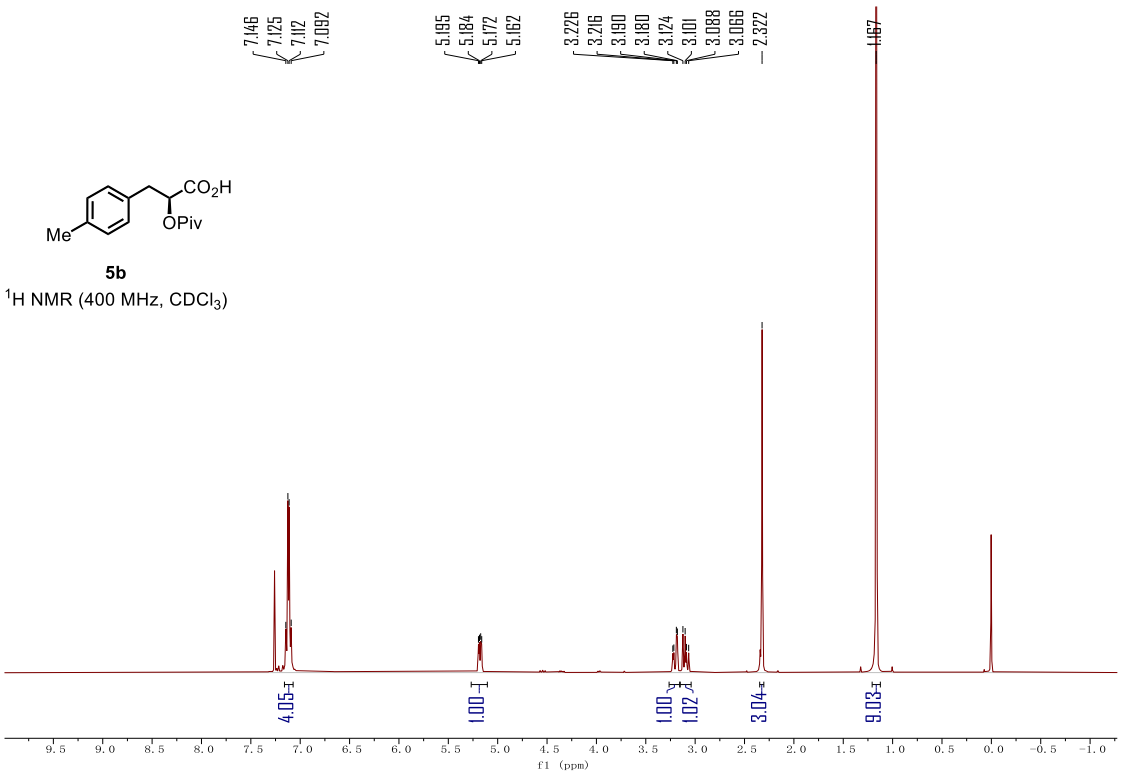
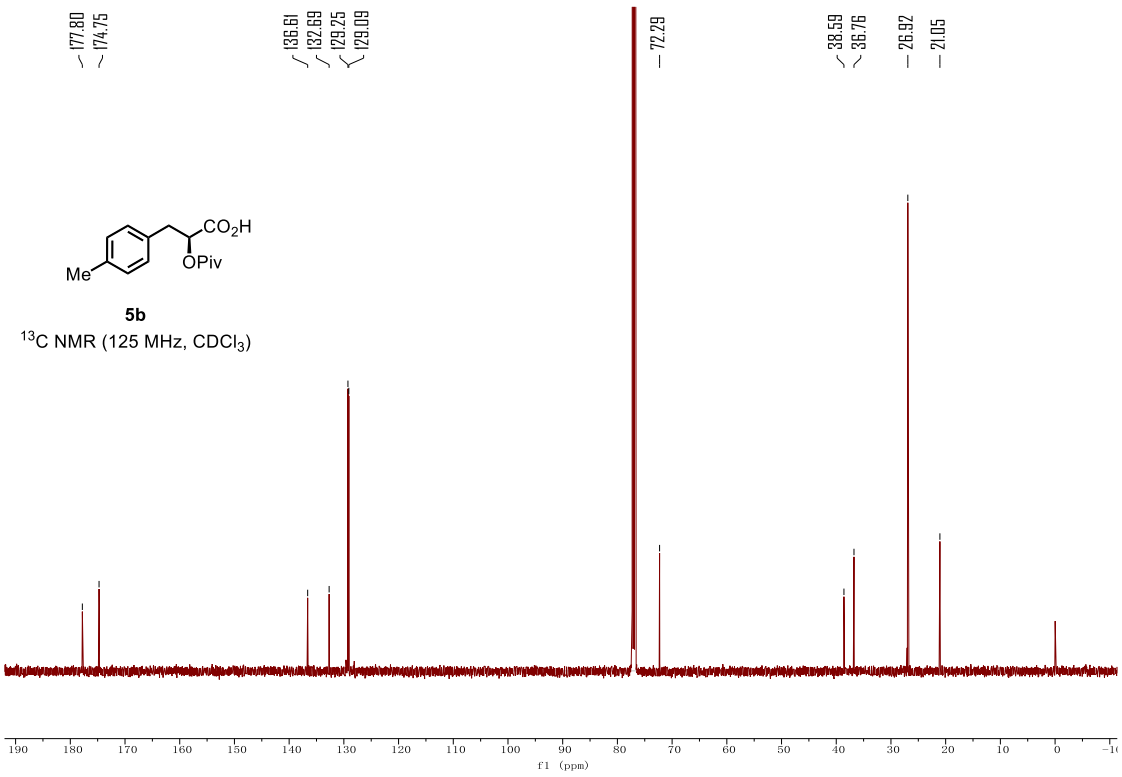




5b

^{1}H NMR (400 MHz, $CDCl_3$)



5b

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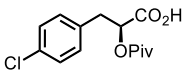

5c

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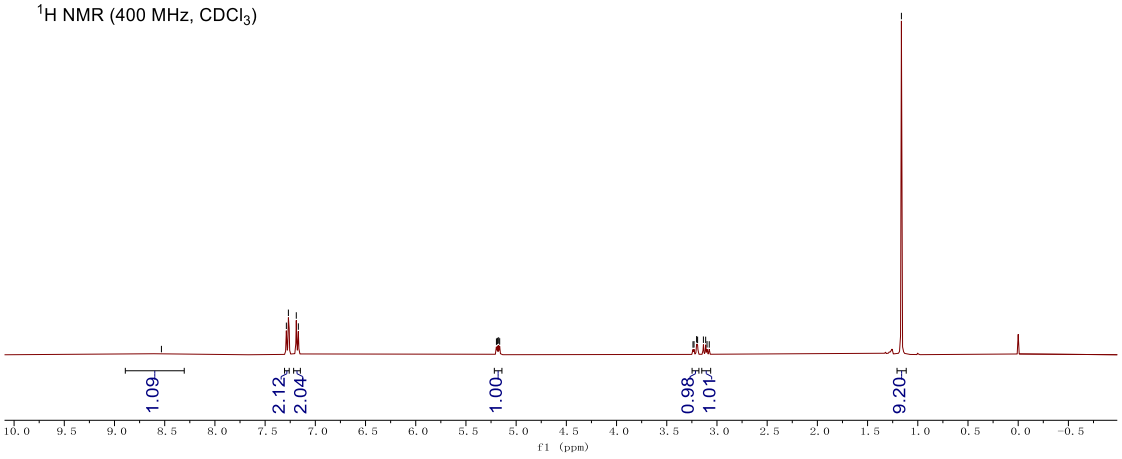

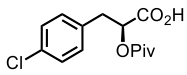

5c

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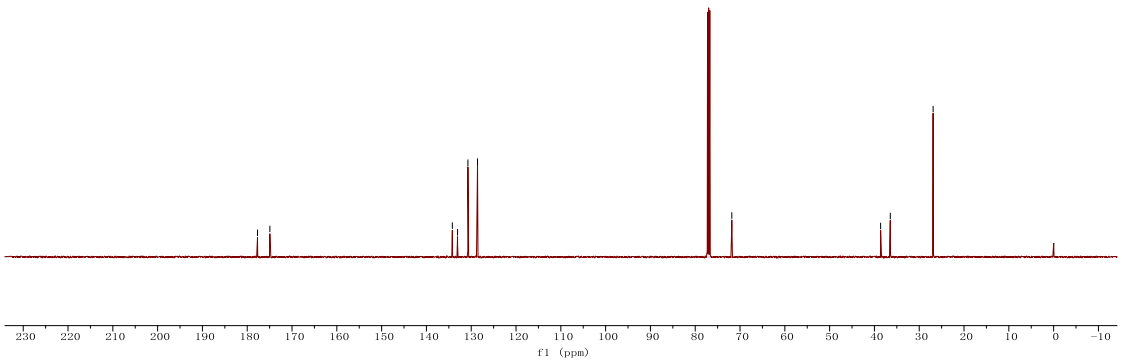

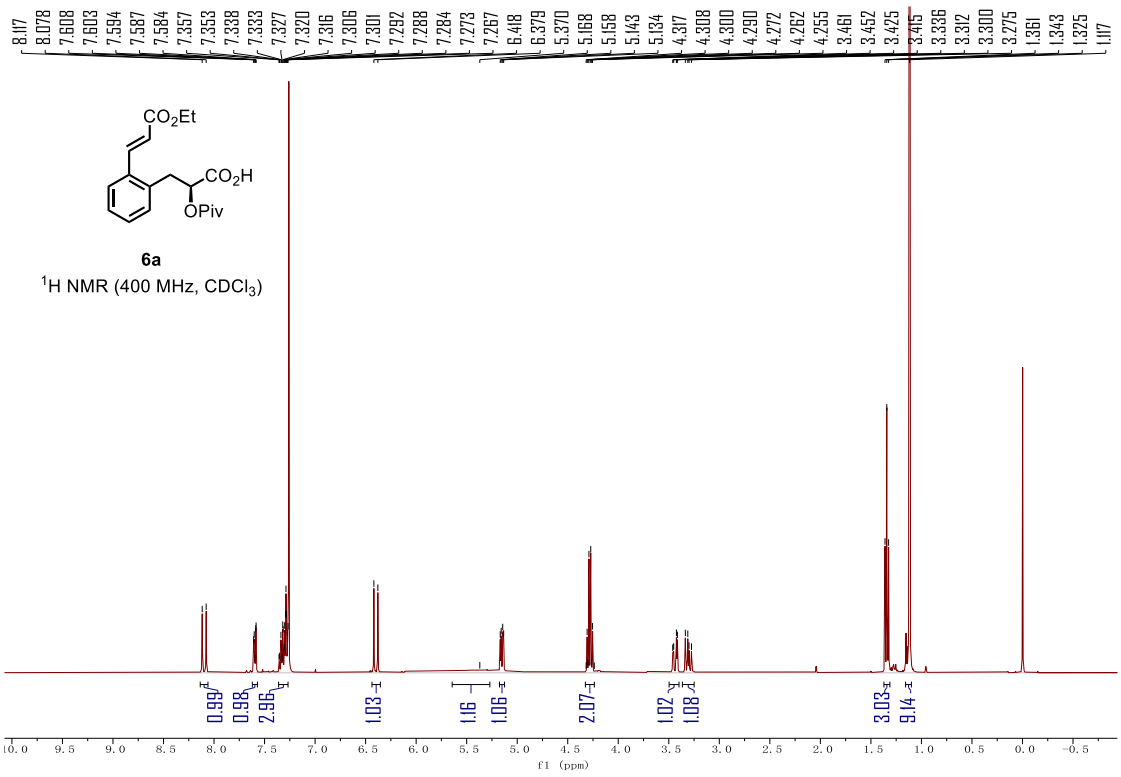

6a

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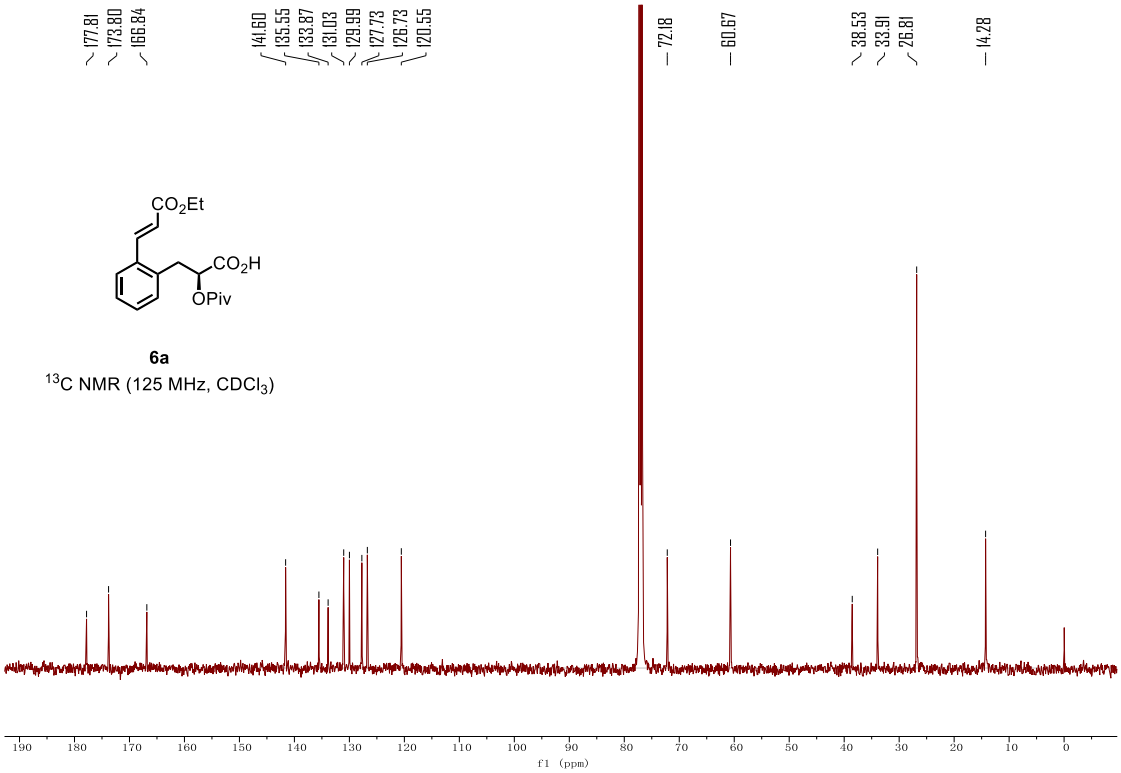

6a

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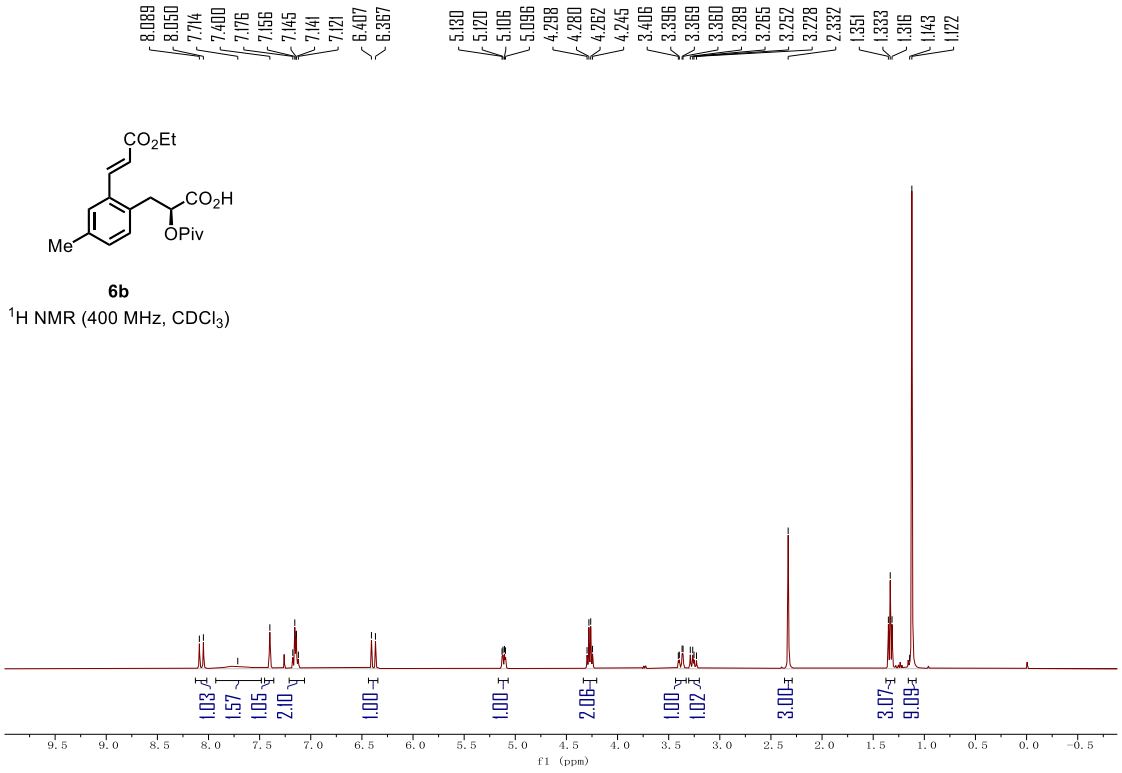

6b

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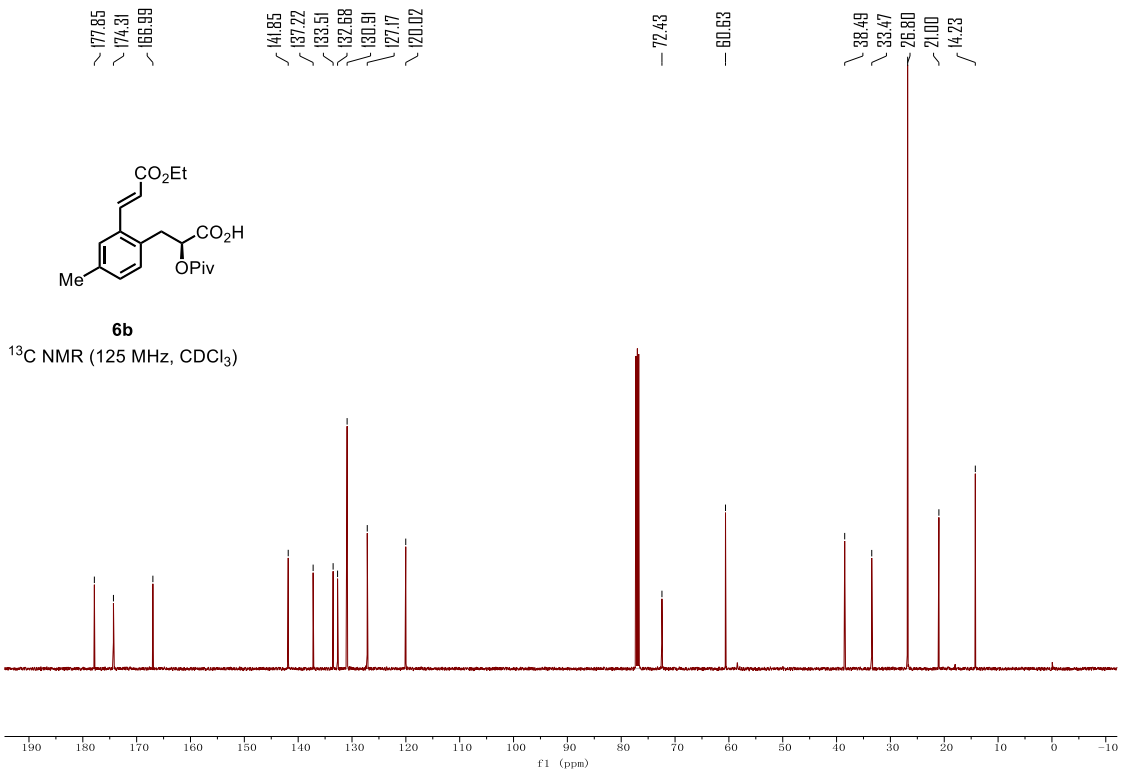

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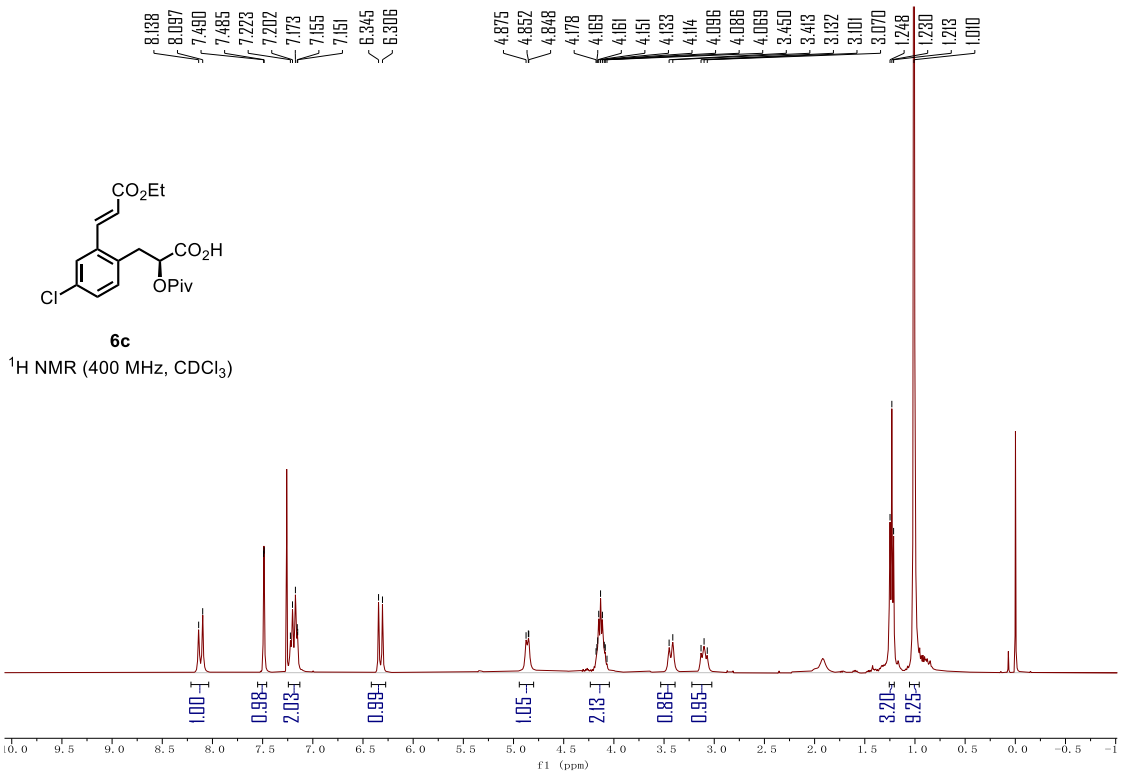

6c

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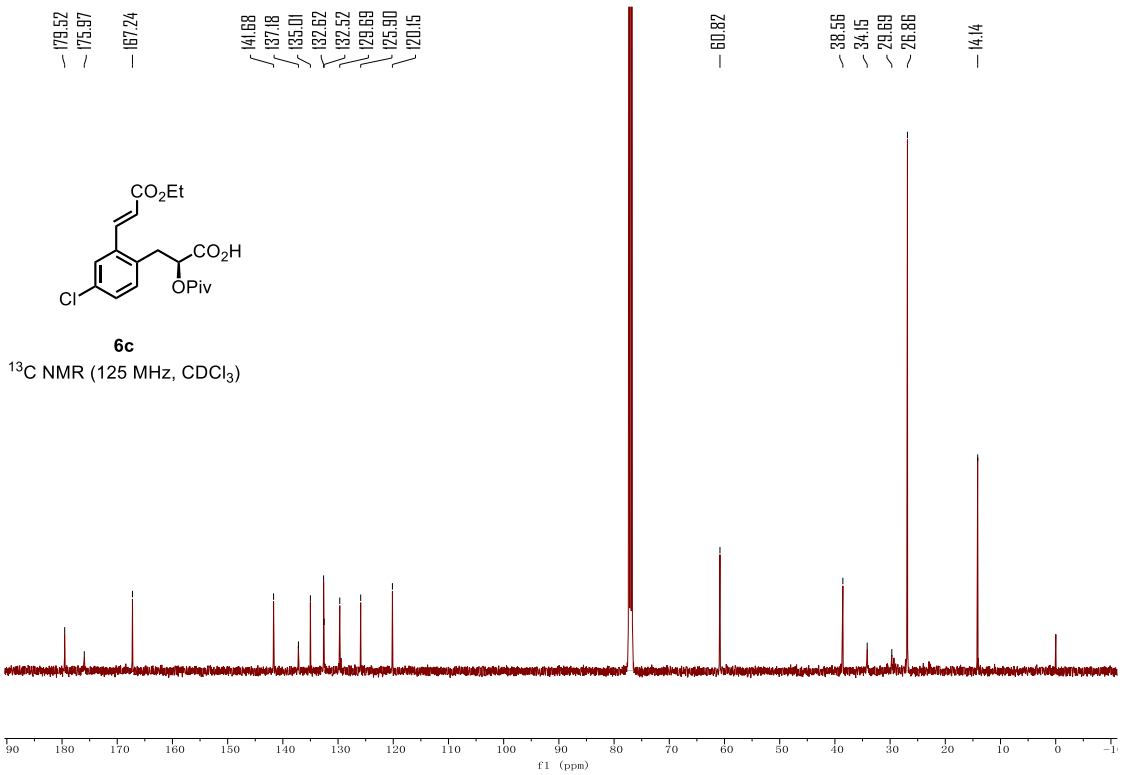

6c

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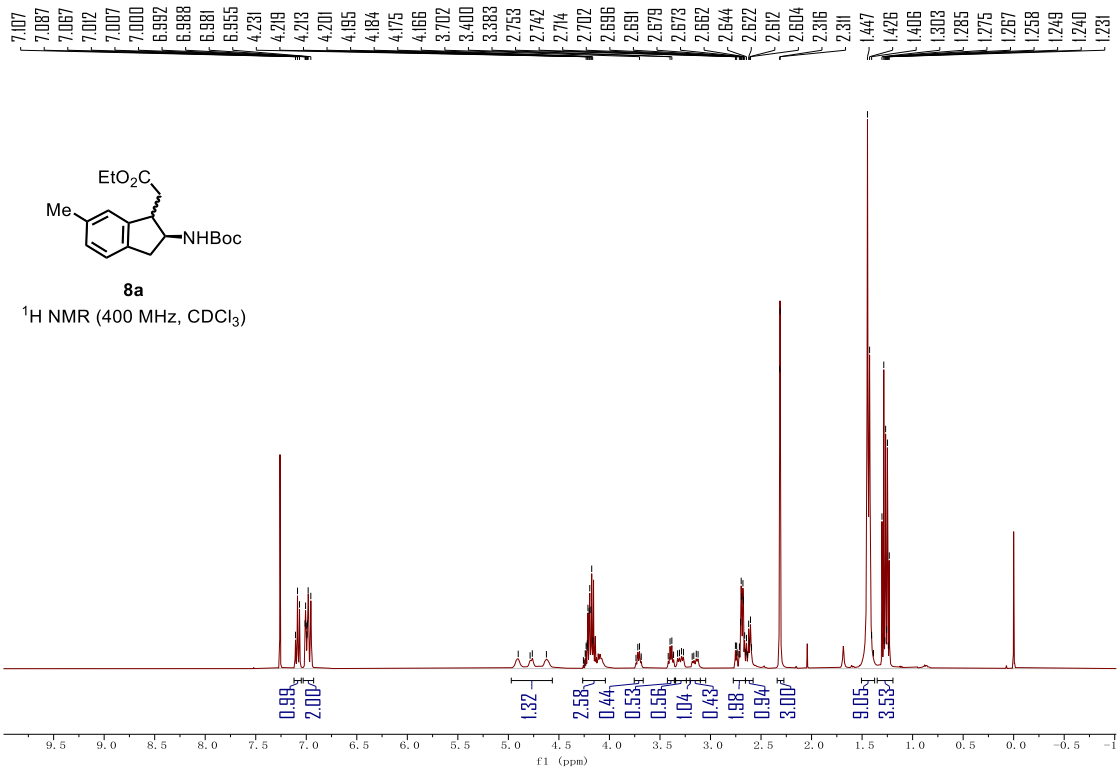

8a

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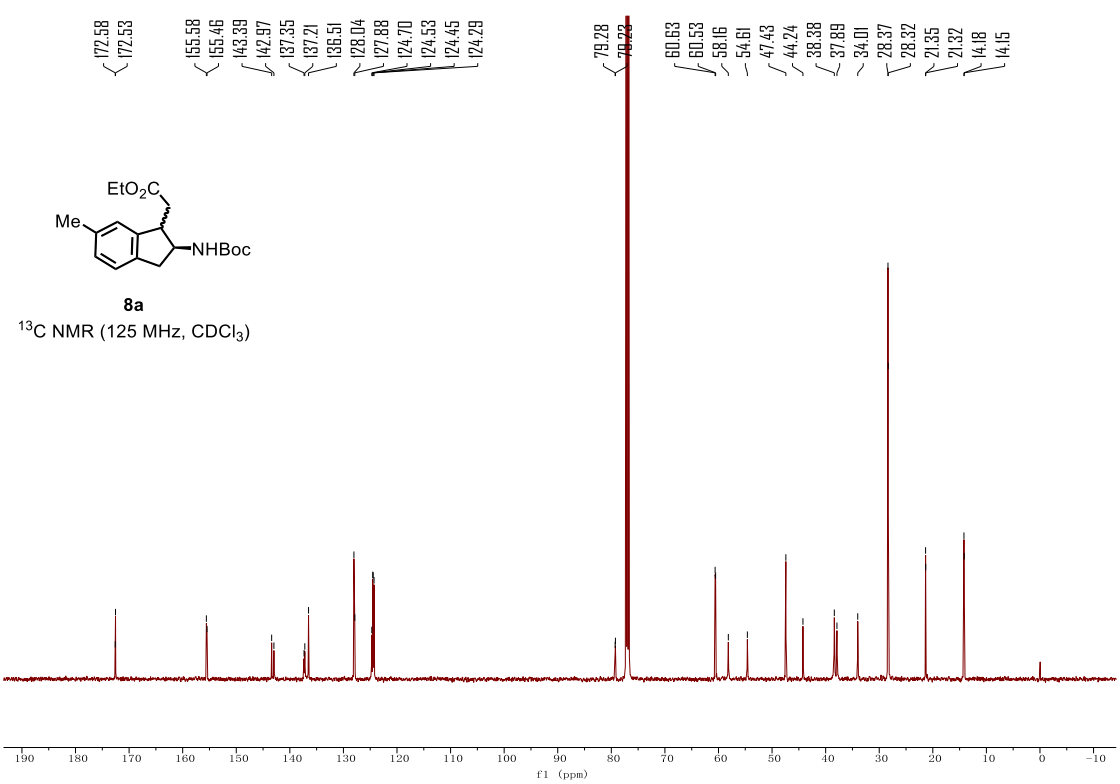

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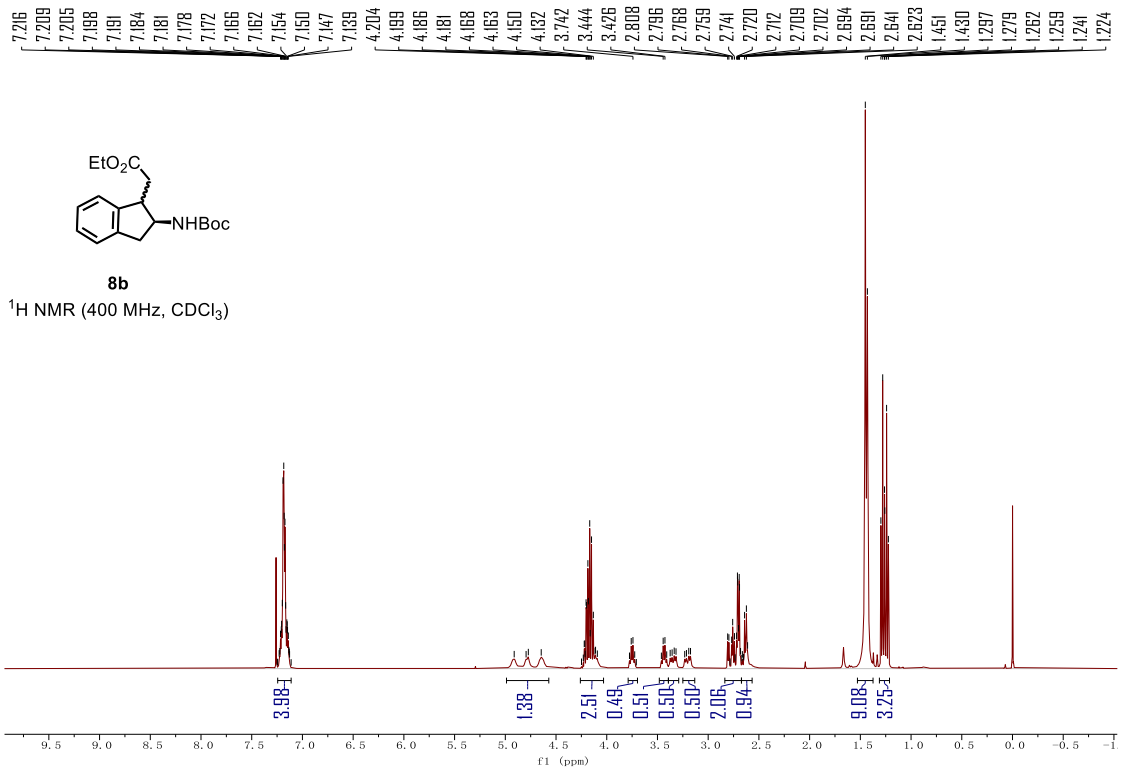

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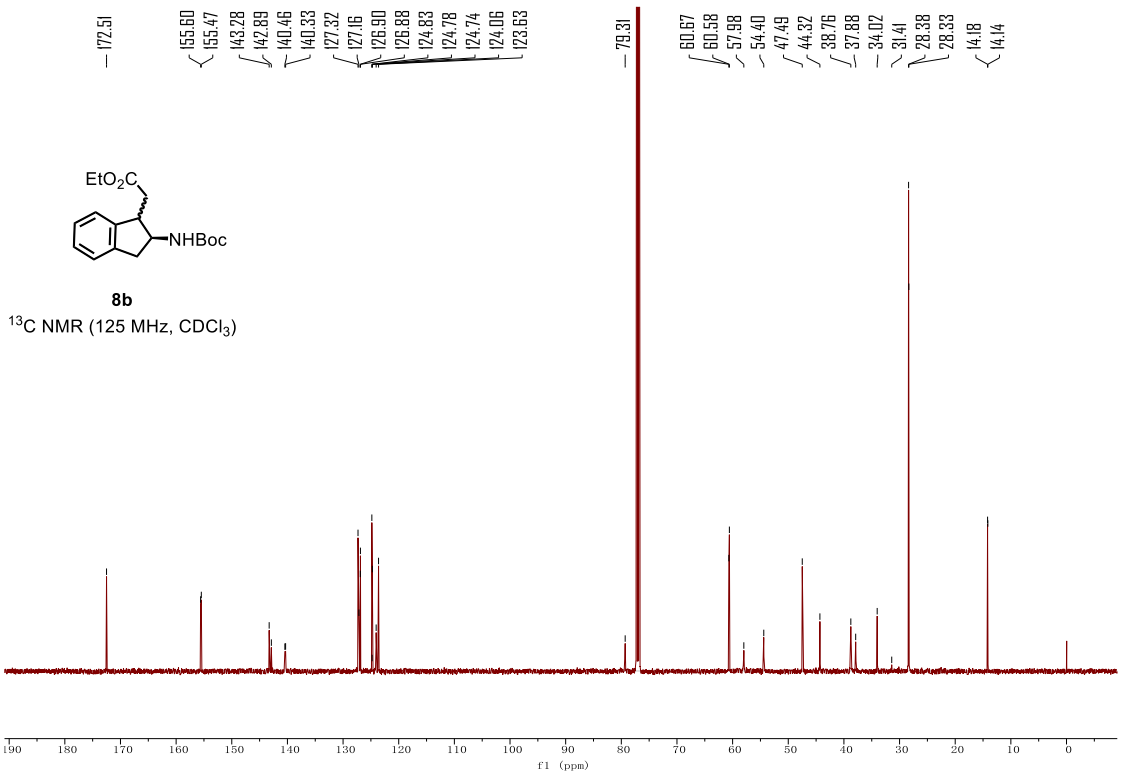

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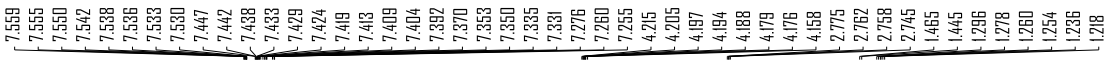

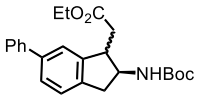

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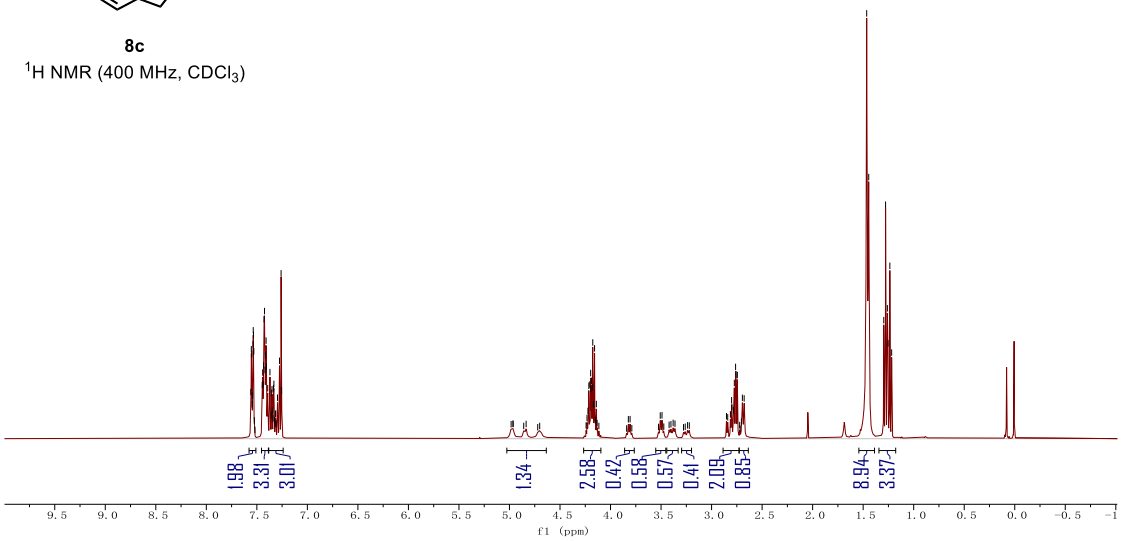
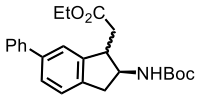
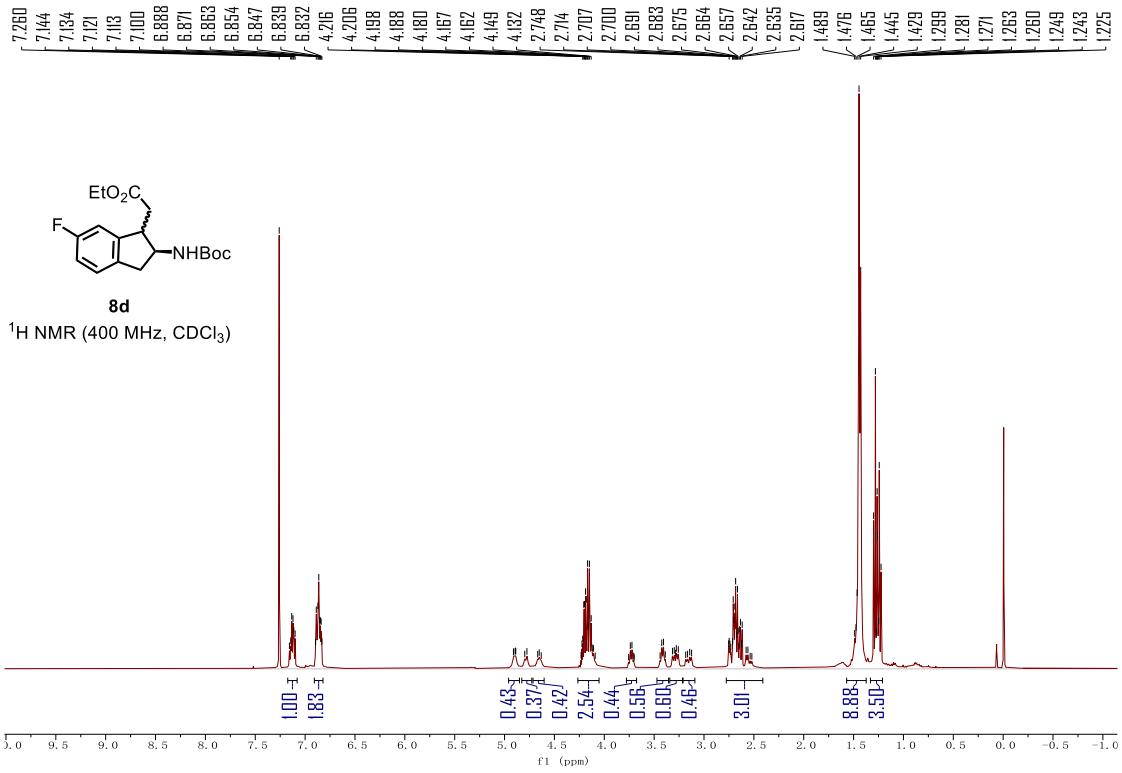




8c

^{13}C NMR (125 MHz, $CDCl_3$)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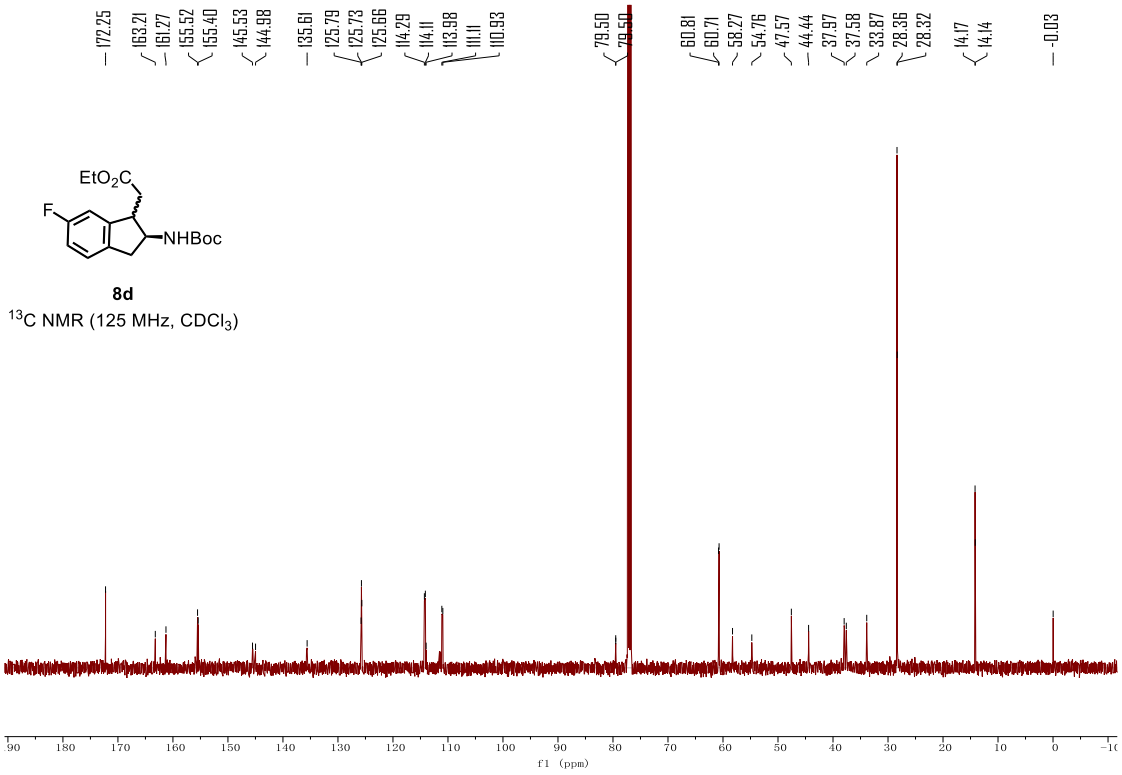
6.847
6.839
6.832
4.216
4.206
4.198
4.188
4.180
4.167
4.162
4.149
4.132
2.748
2.714
2.707
2.700
2.691
2.683
2.675
2.664
2.657
2.642
2.635
2.617
1.489
1.476
1.465
1.445
1.429
1.299
1.281
1.271
1.263
1.260
1.249
1.243
1.225
EtO2C
F
NHBoc
8d
1H NMR (400 MHz, CDCl3)
1.00
1.83
0.43
0.37
0.42
2.54
0.44
0.56
0.60
0.46
3.01
8.88
3.50
f1 (ppm)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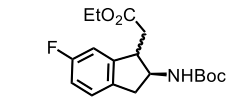
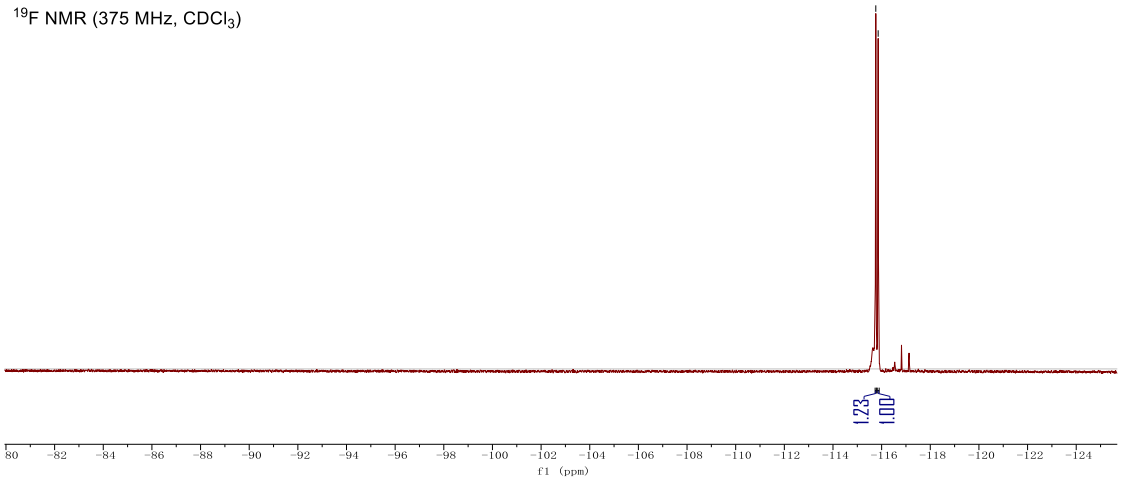
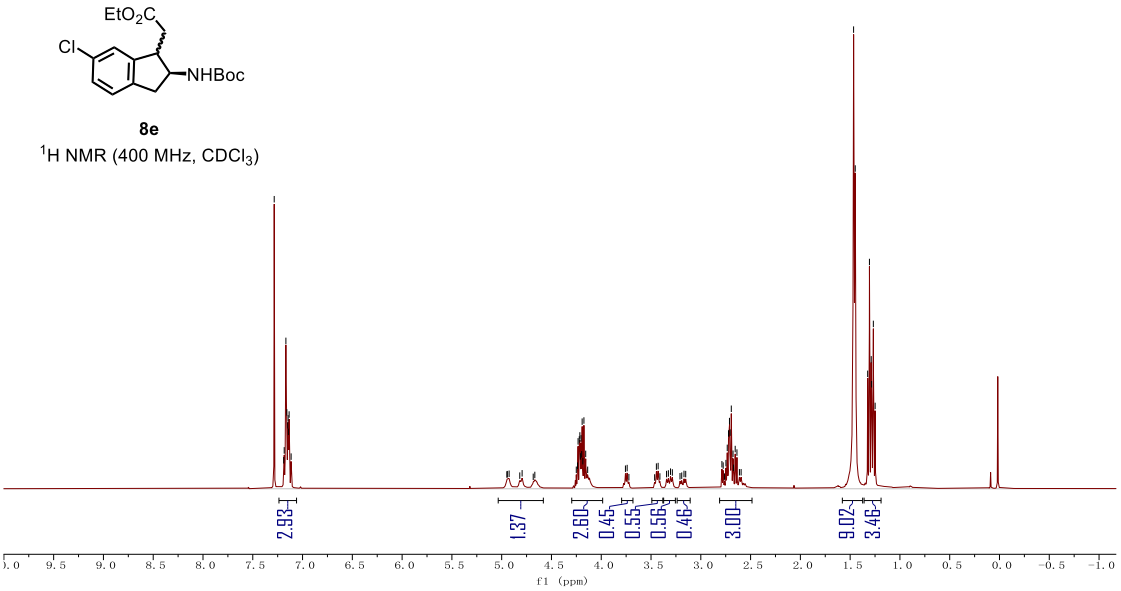
113.98
111.11
110.93
79.50
79.50
60.81
60.71
58.27
54.76
47.57
44.44
37.97
37.58
33.87
28.36
28.32
14.17
14.14
-0.03
EtO2C
F
NHBoc
8d
13C NMR (125 MHz, CDCl3)
f1 (ppm)



8d

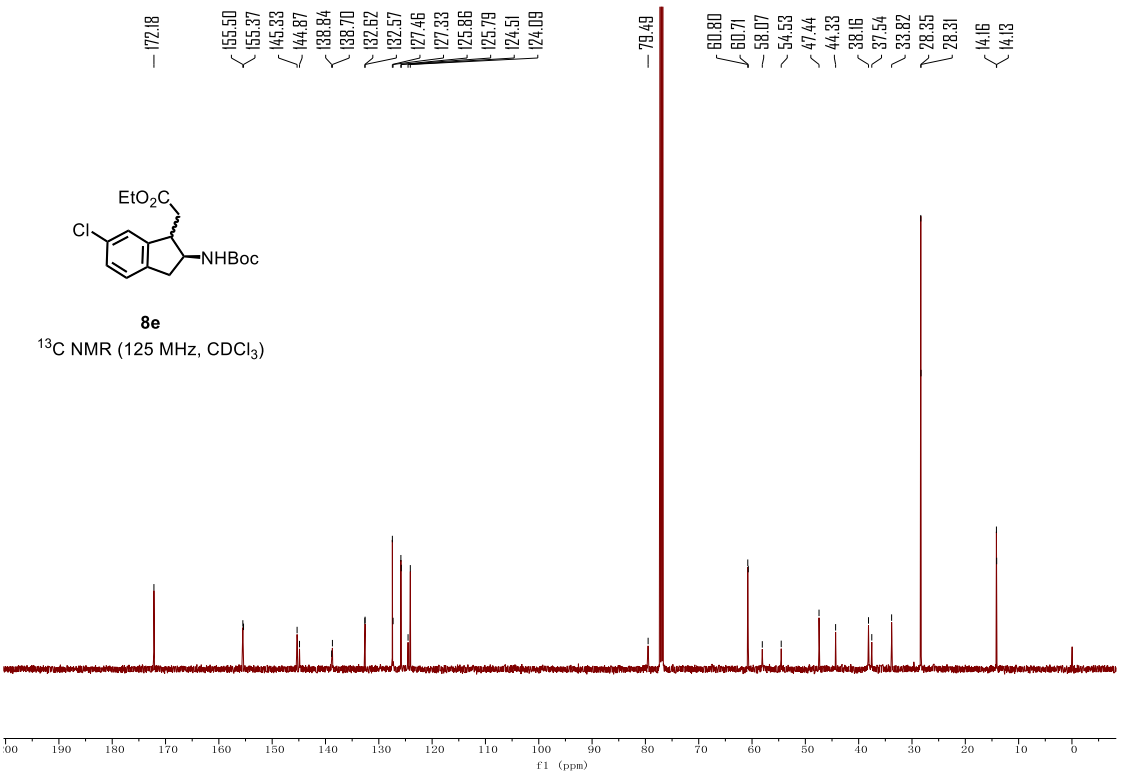
^{19}F NMR (375 MHz, $CDCl_3$)





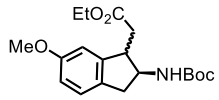
8e

^{1}H NMR (400 MHz, $CDCl_3$)



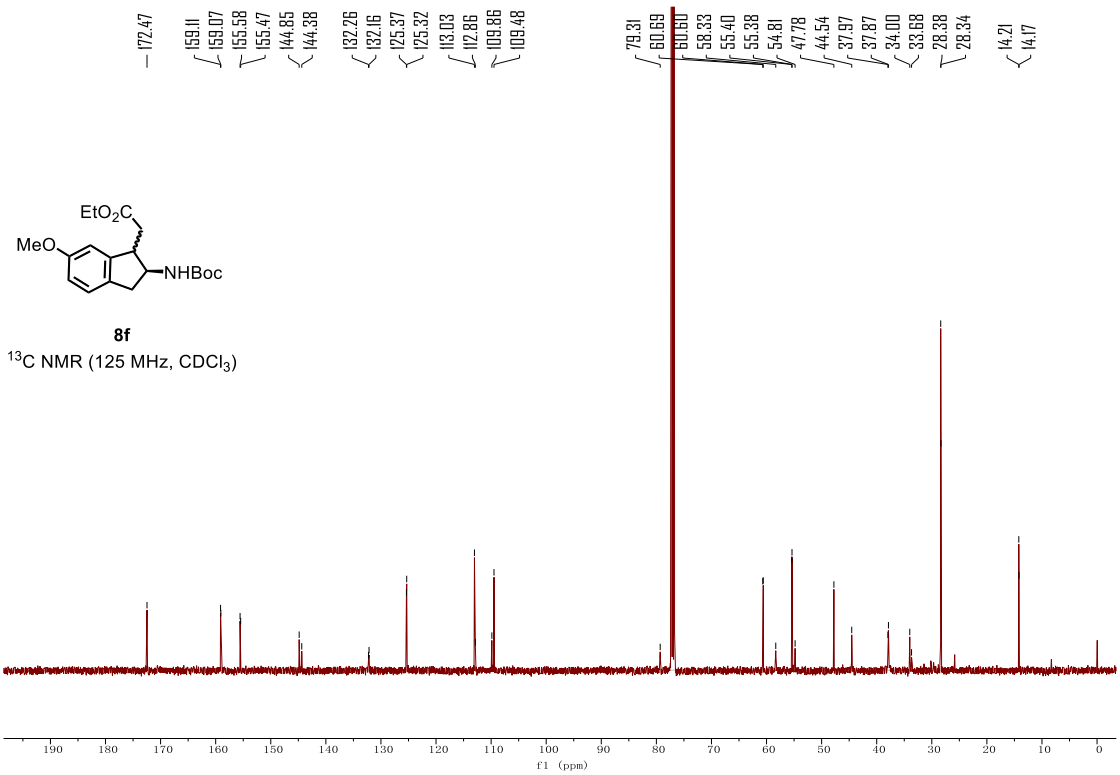
8e

^{13}C NMR (125 MHz, $CDCl_3$)



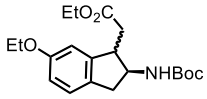
8f

^{1}H NMR (400 MHz, $CDCl_3$)



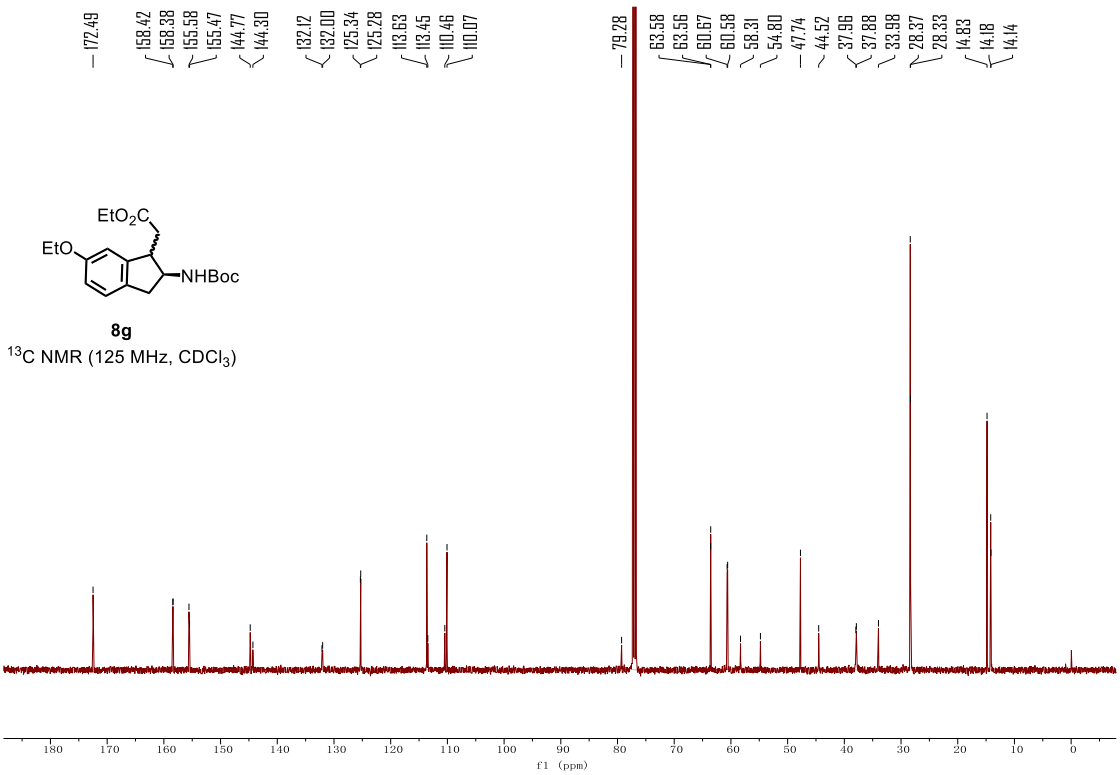
8f

^{13}C NMR (125 MHz, $CDCl_3$)



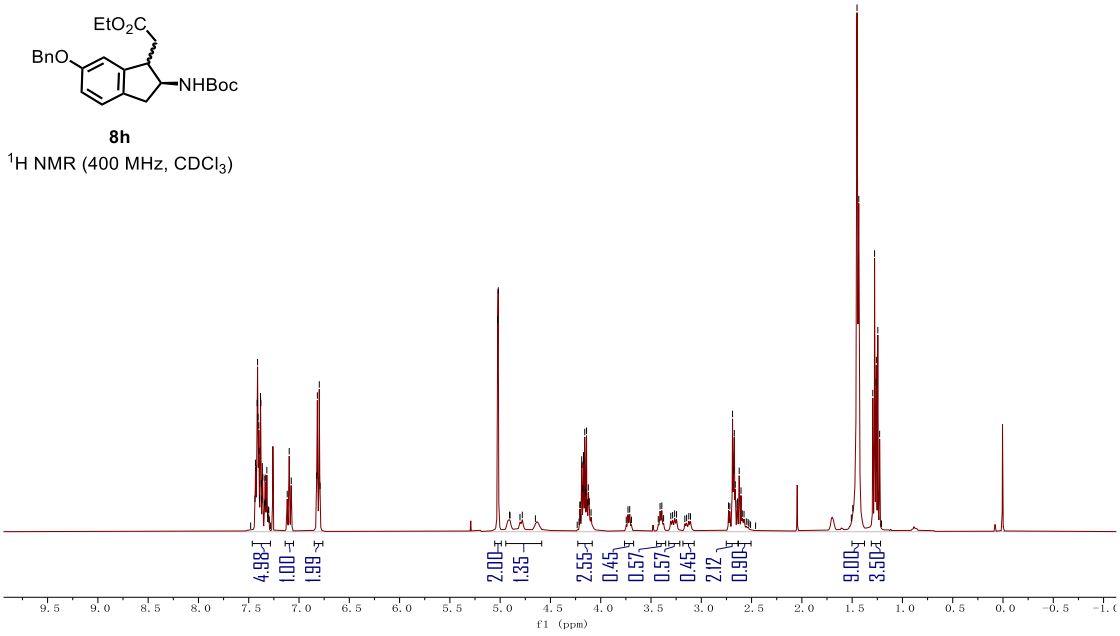
8g

^{1}H NMR (400 MHz, $CDCl_3$)



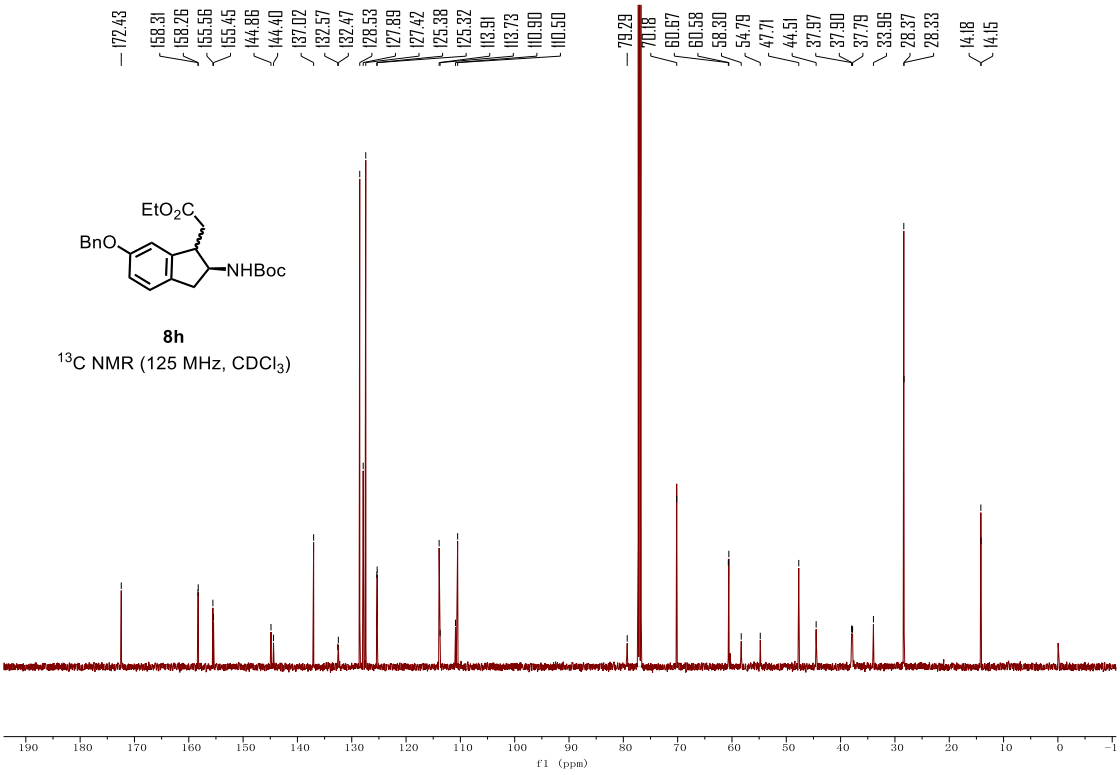
8g

^{13}C NMR (125 MHz, $CDCl_3$)



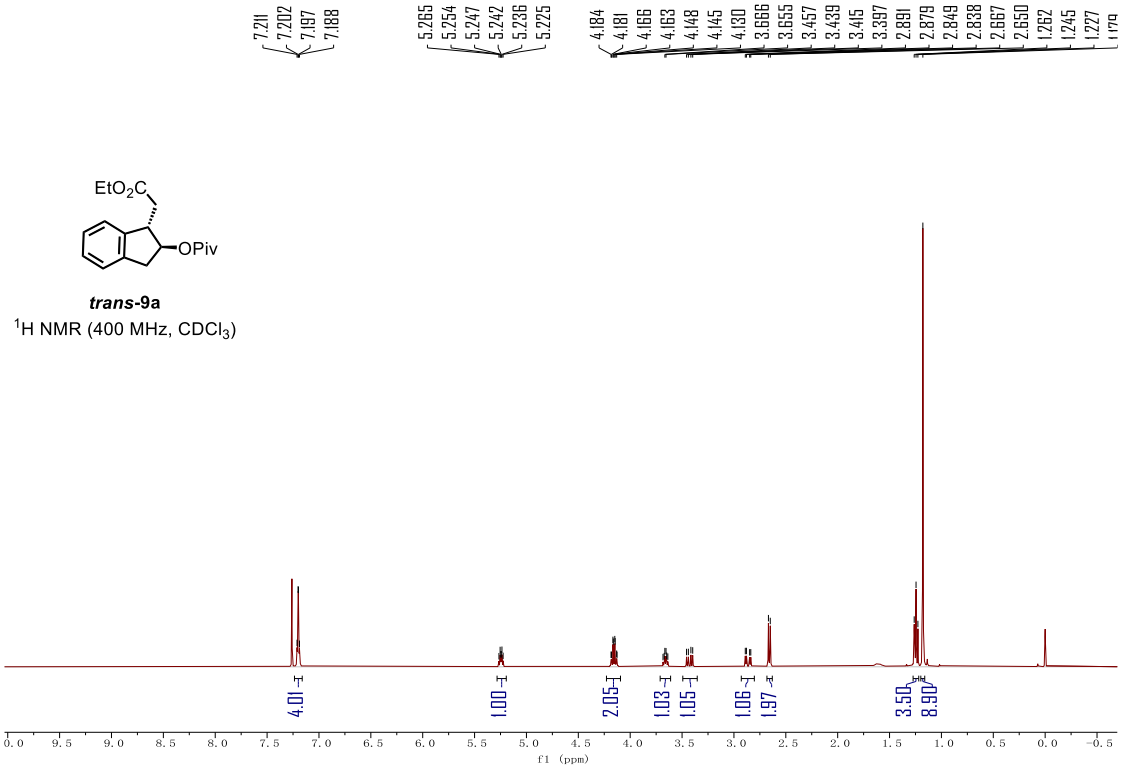
8h

^{1}H NMR (400 MHz, $CDCl_3$)



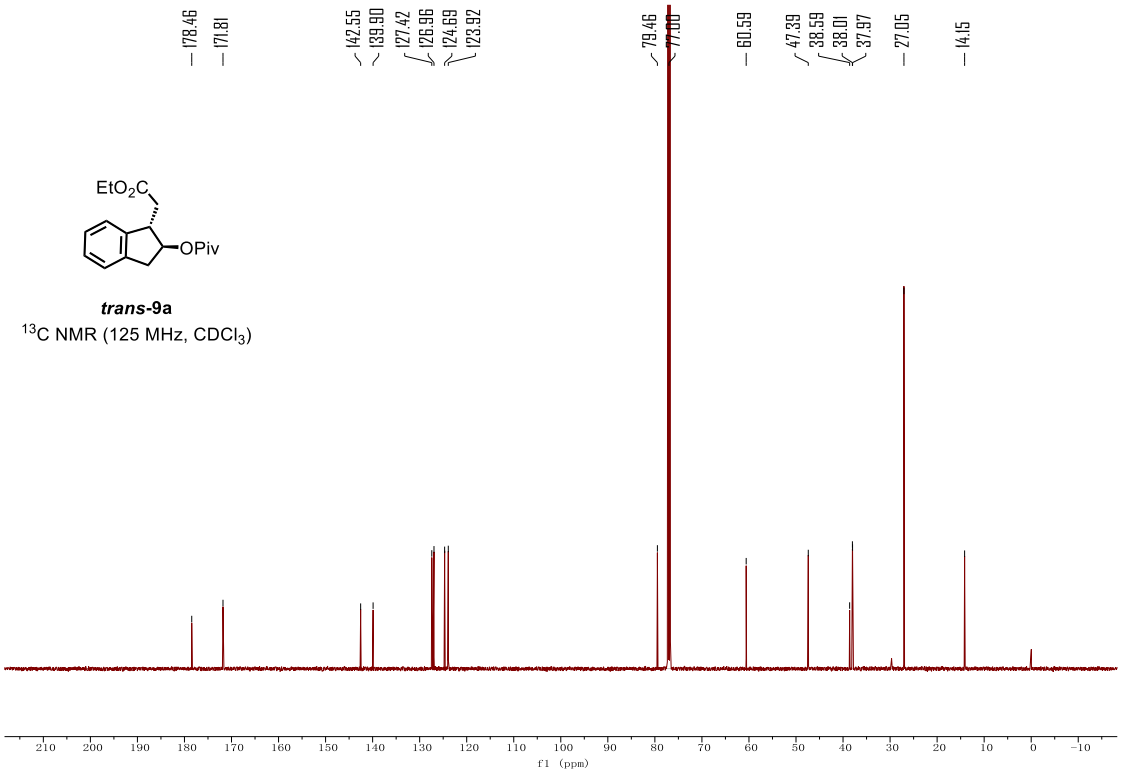
8h

^{13}C NMR (125 MHz, $CDCl_3$)



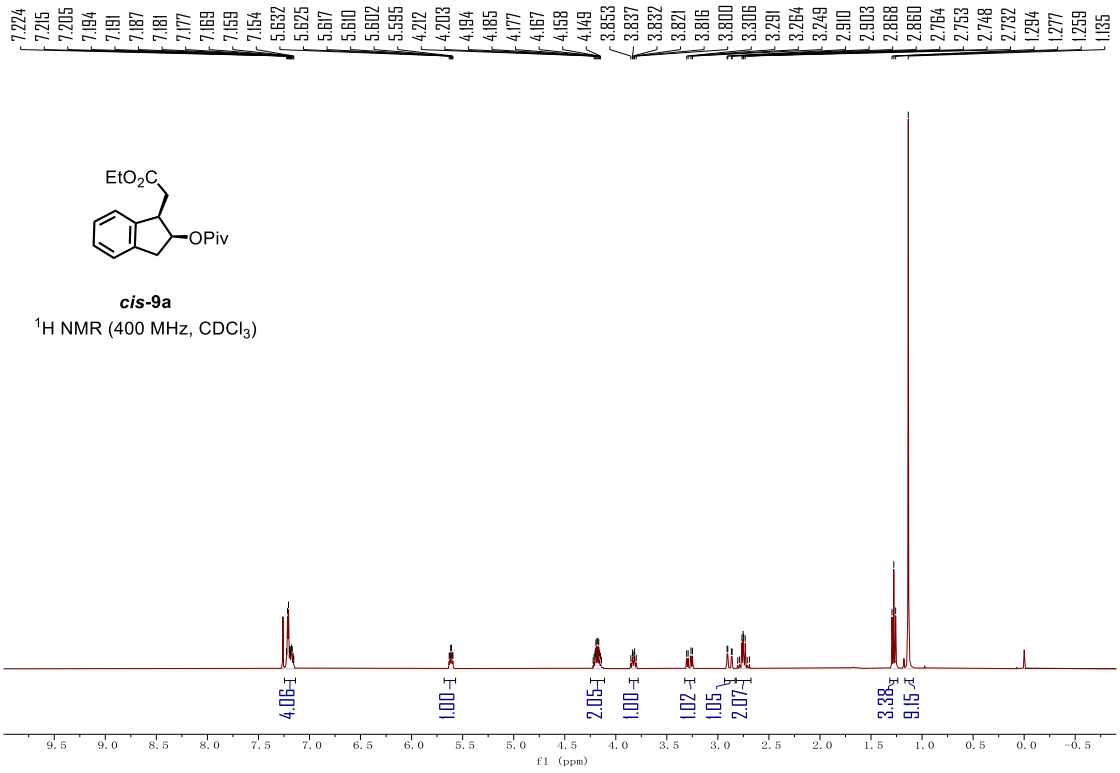
***trans*-9a**

^{1}H NMR (400 MHz, $CDCl_3$)



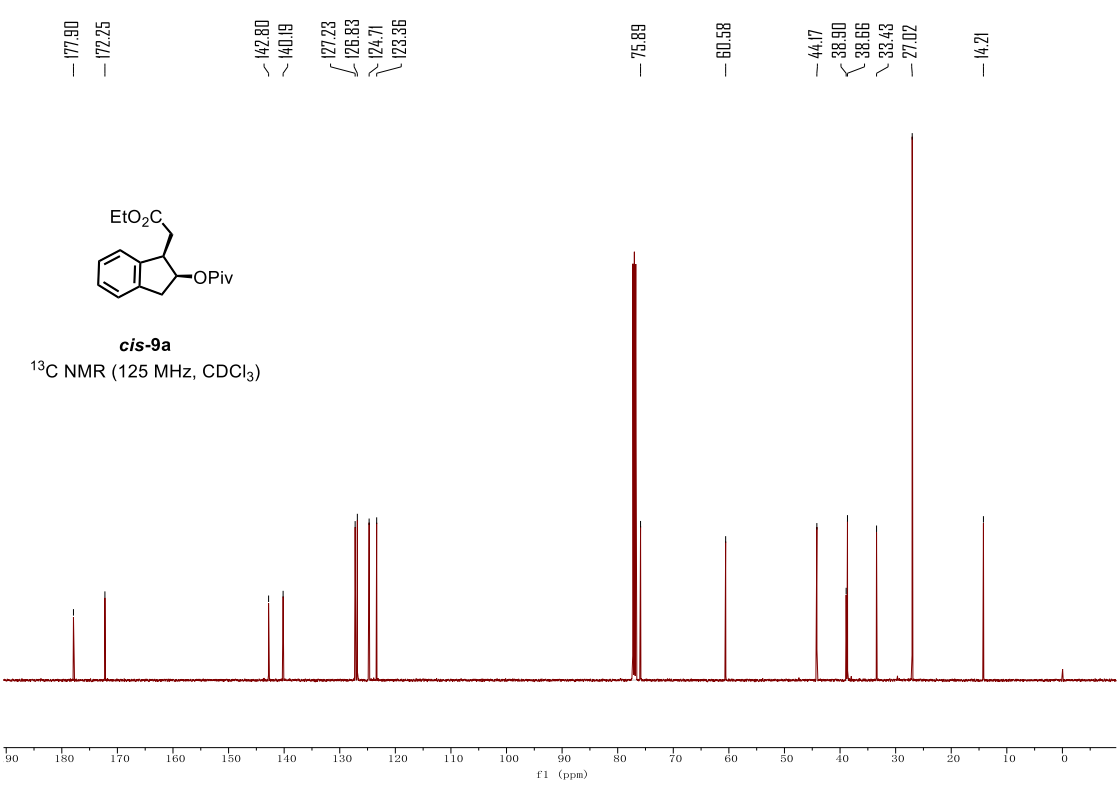
***trans*-9a**

^{13}C NMR (125 MHz, $CDCl_3$)



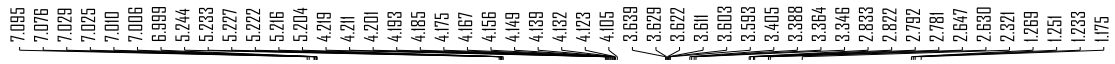
***cis*-9a**

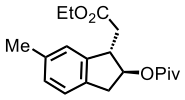
^{1}H NMR (400 MHz, $CDCl_3$)



***cis*-9a**

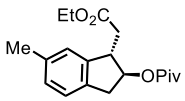
^{13}C NMR (125 MHz, $CDCl_3$)





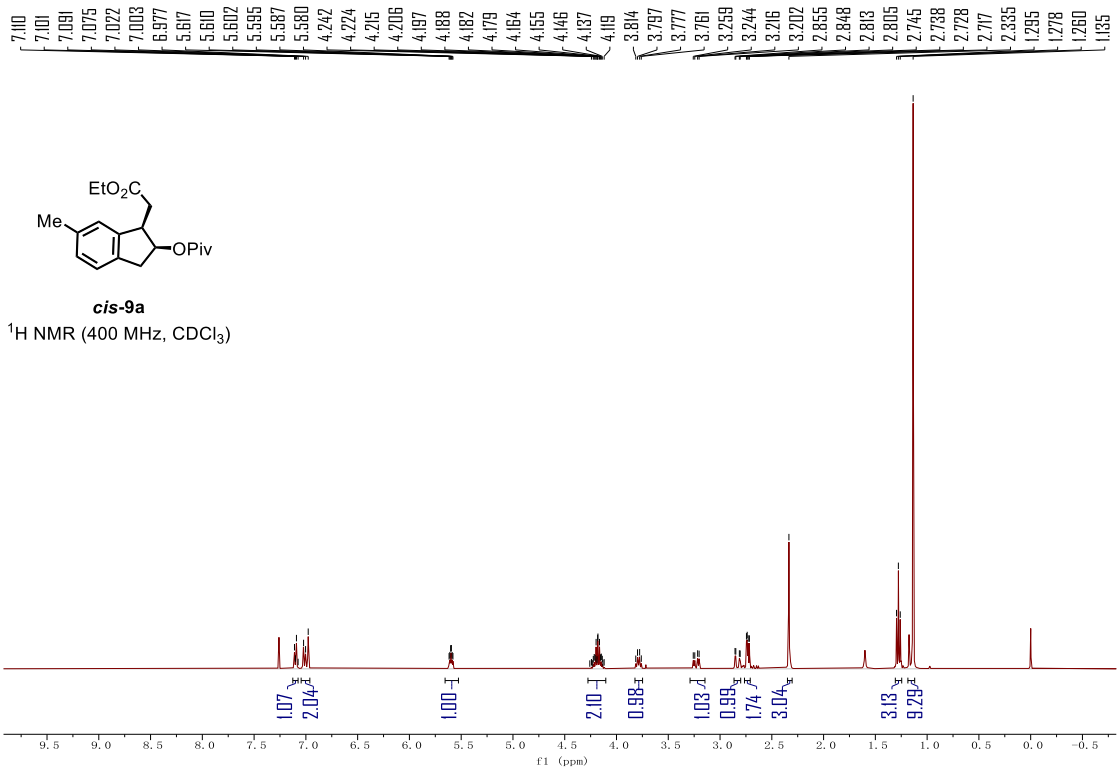
***trans*-9b**

^{1}H NMR (400 MHz, $CDCl_3$)



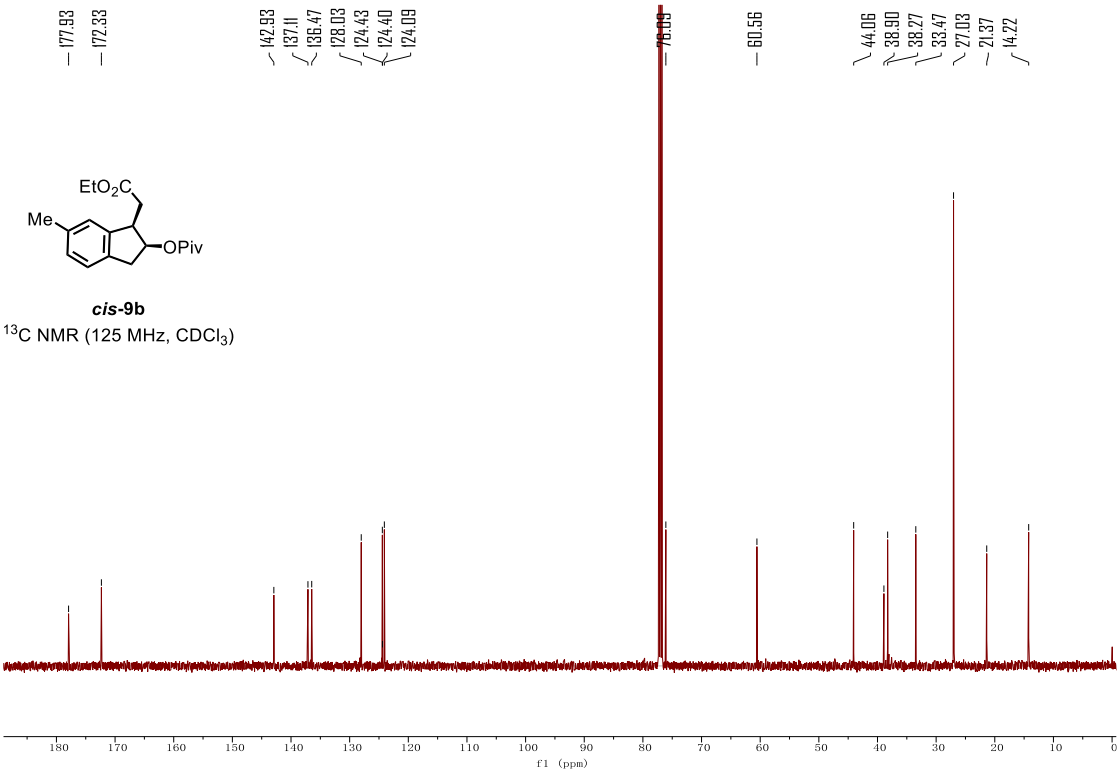
***trans*-9b**

^{13}C NMR (125 MHz, $CDCl_3$)



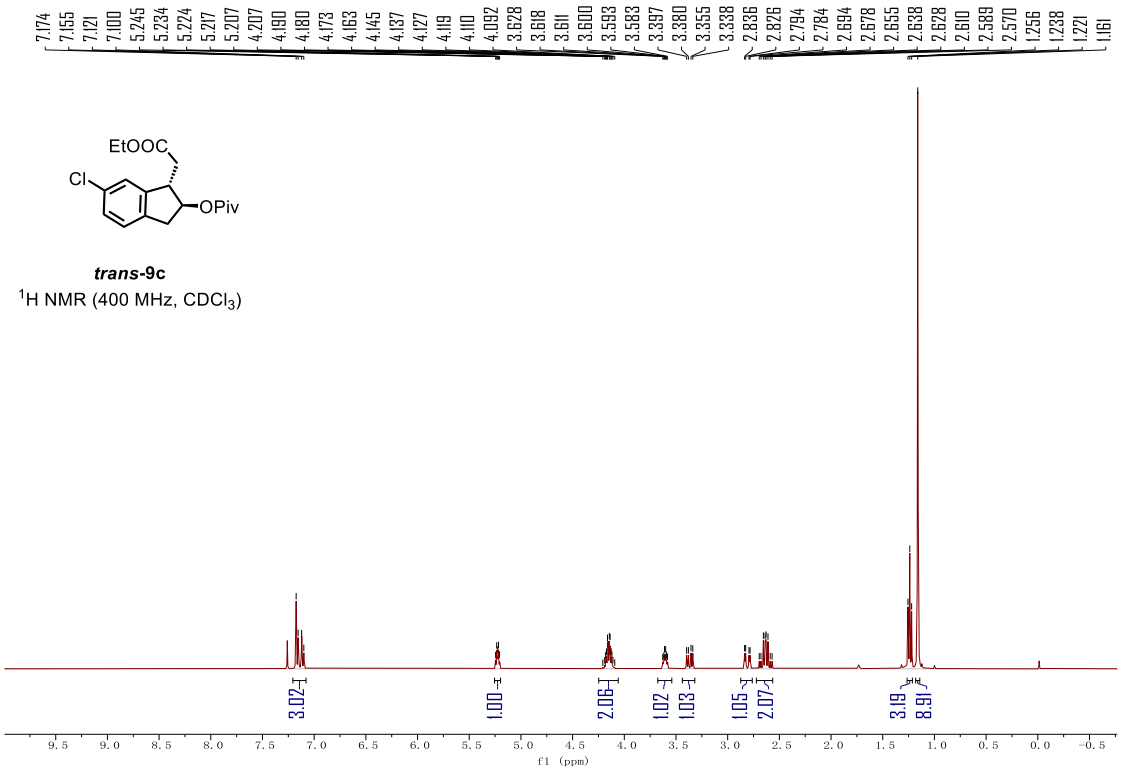
***cis*-9a**

^{1}H NMR (400 MHz, $CDCl_3$)



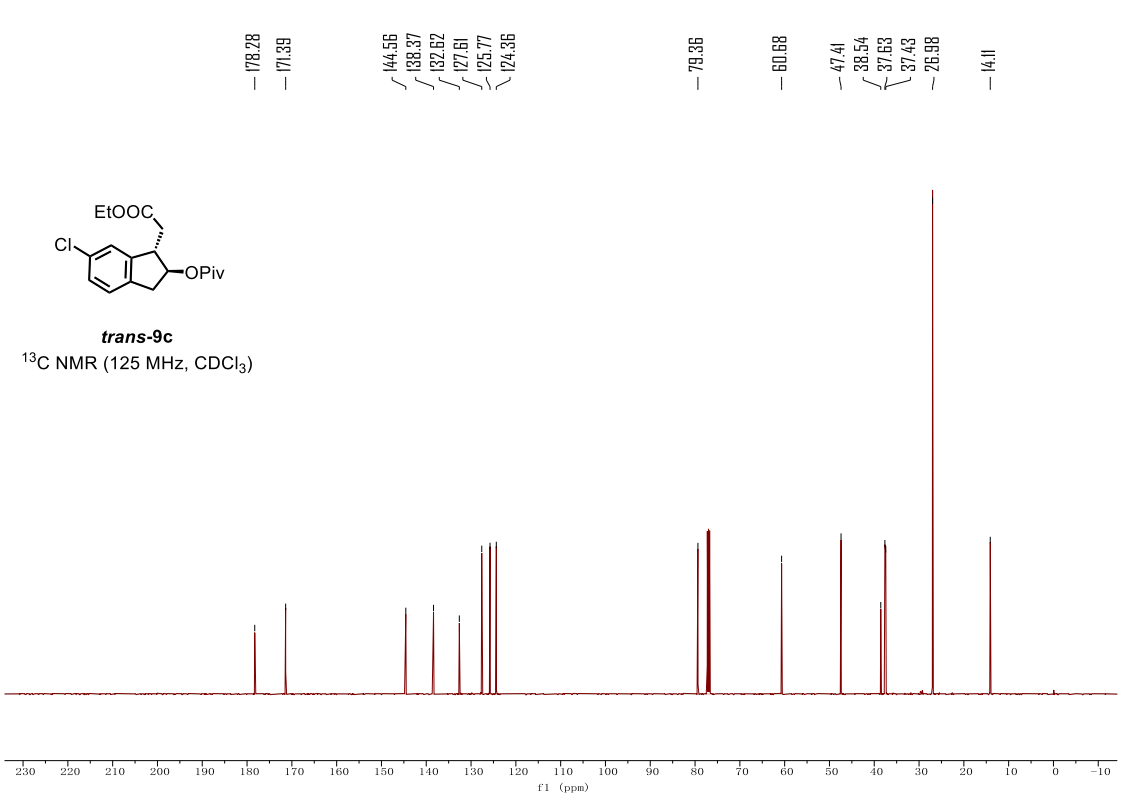
***cis*-9b**

^{13}C NMR (125 MHz, $CDCl_3$)



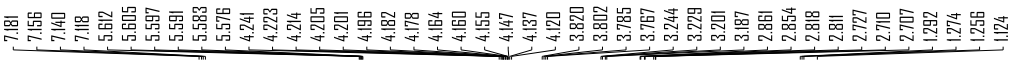
***trans*-9c**

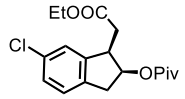
^{1}H NMR (400 MHz, $CDCl_3$)



***trans*-9c**

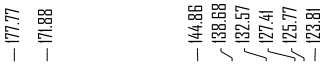
^{13}C NMR (125 MHz, $CDCl_3$)

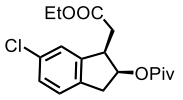




***cis*-9c**

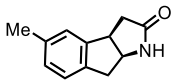
^{1}H NMR (400 MHz, $CDCl_3$)





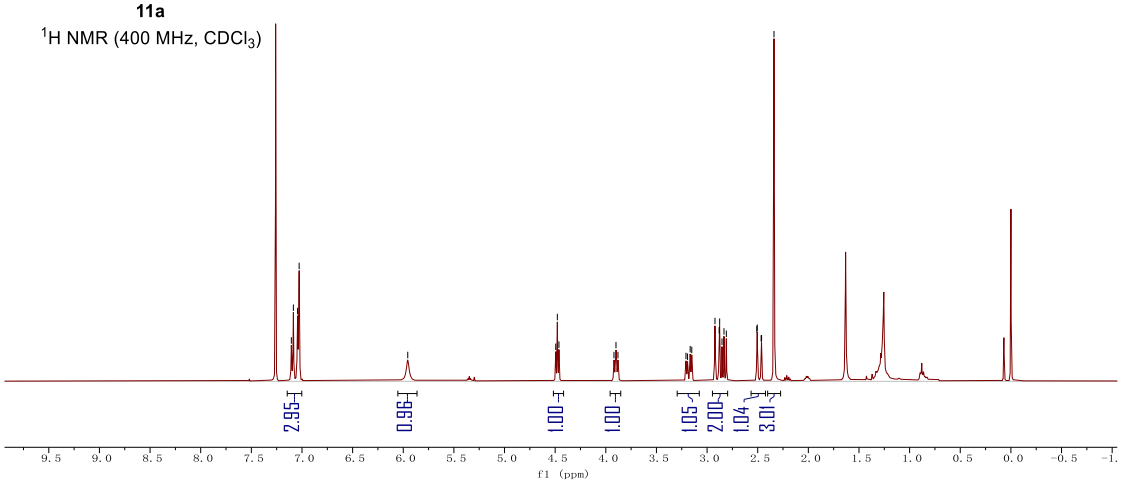
***cis*-9c**

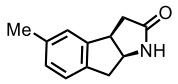
^{13}C NMR (125 MHz, $CDCl_3$)



11a

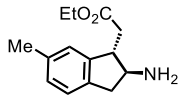
^{1}H NMR (400 MHz, $CDCl_3$)





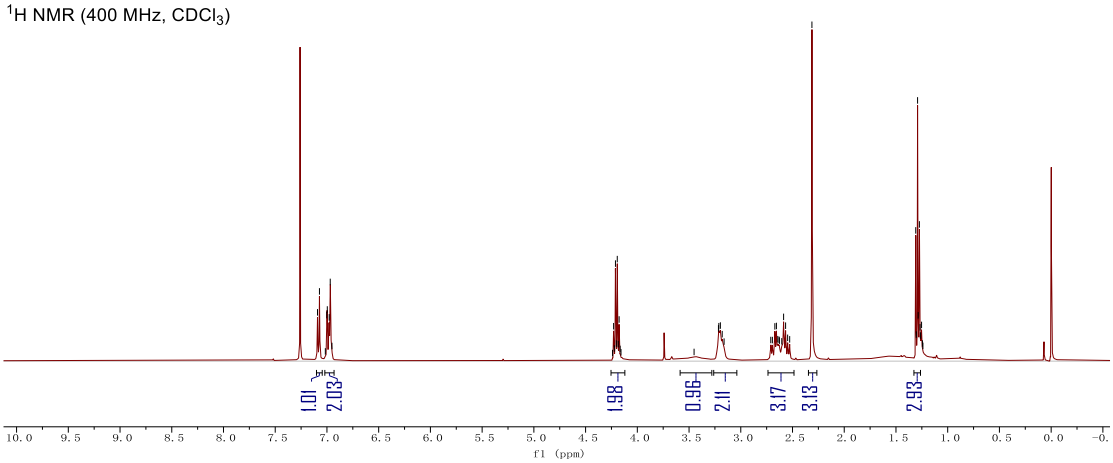
11a

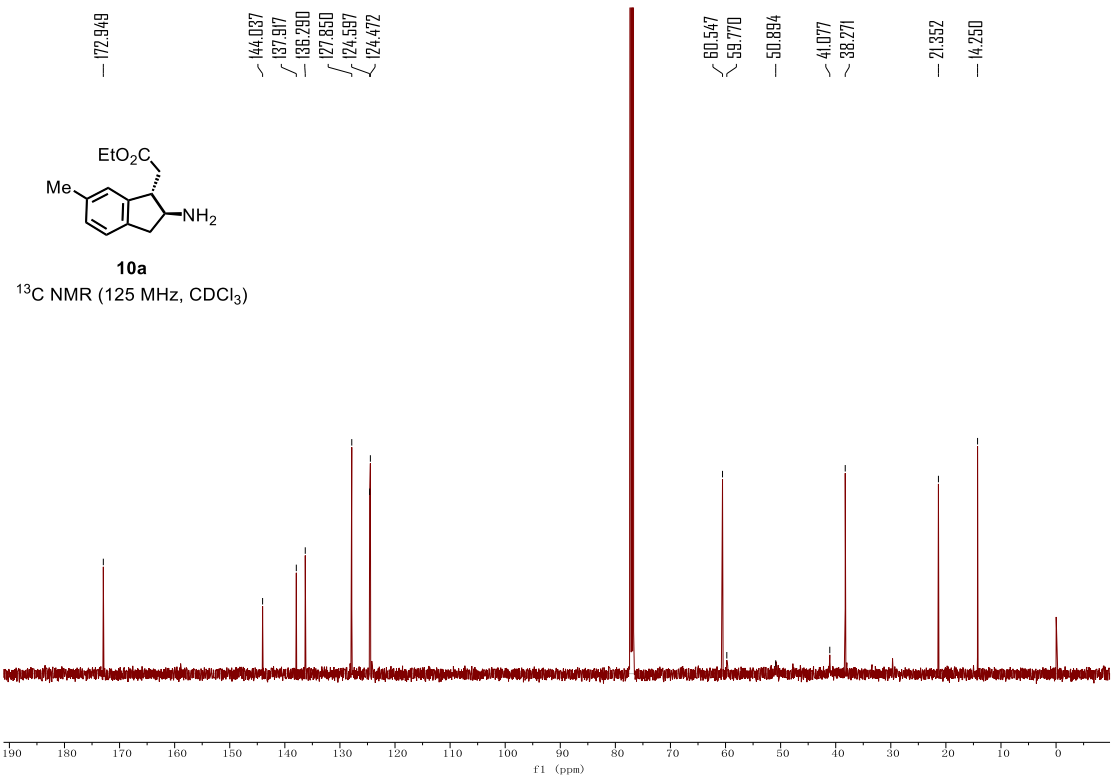
^{13}C NMR (125 MHz, $CDCl_3$)



10a

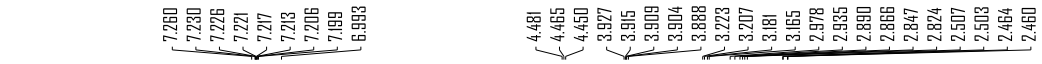
^{1}H NMR (400 MHz, $CDCl_3$)

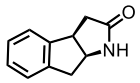




10a

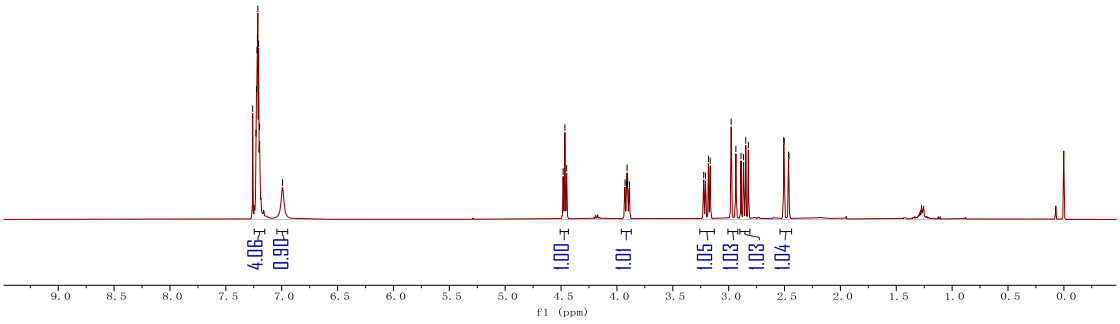
^{13}C NMR (125 MHz, $CDCl_3$)

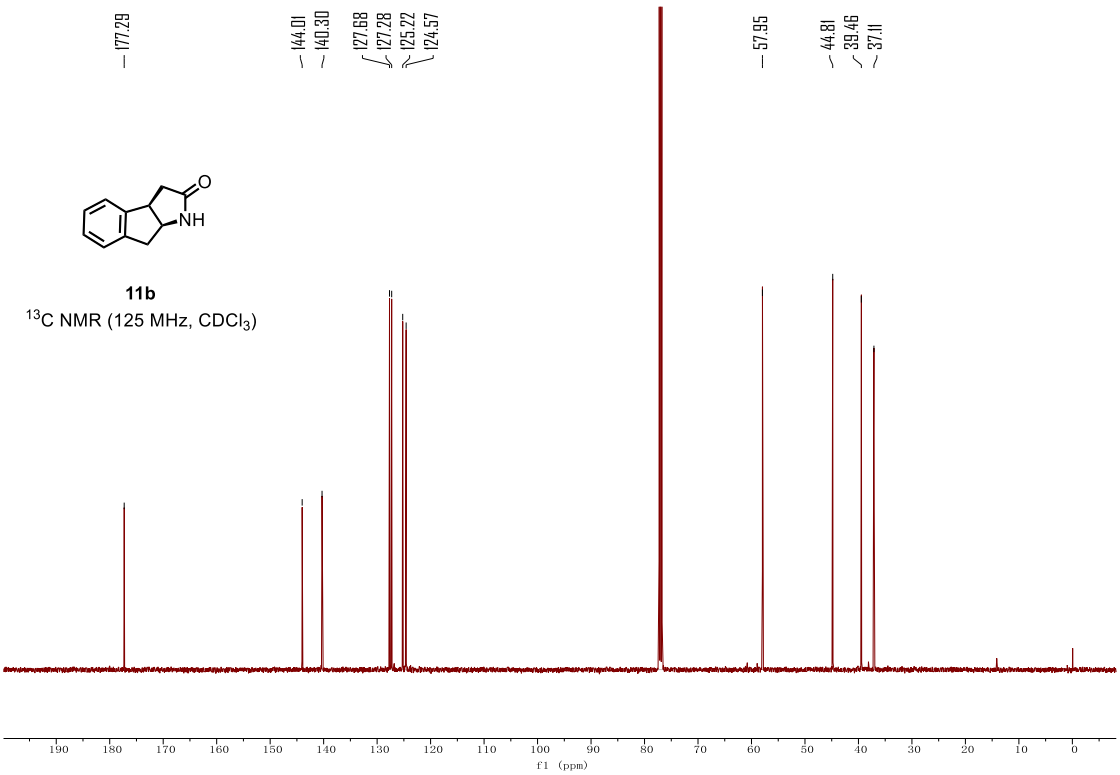




11b

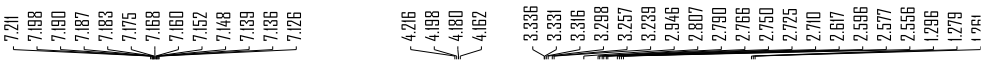
^{1}H NMR (400 MHz, $CDCl_3$)

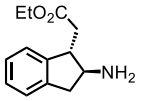




11b

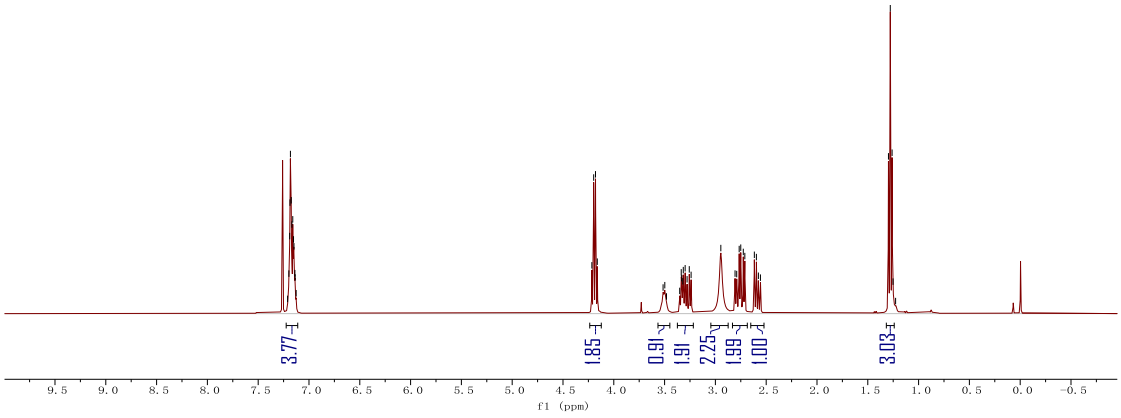
^{13}C NMR (125 MHz, $CDCl_3$)

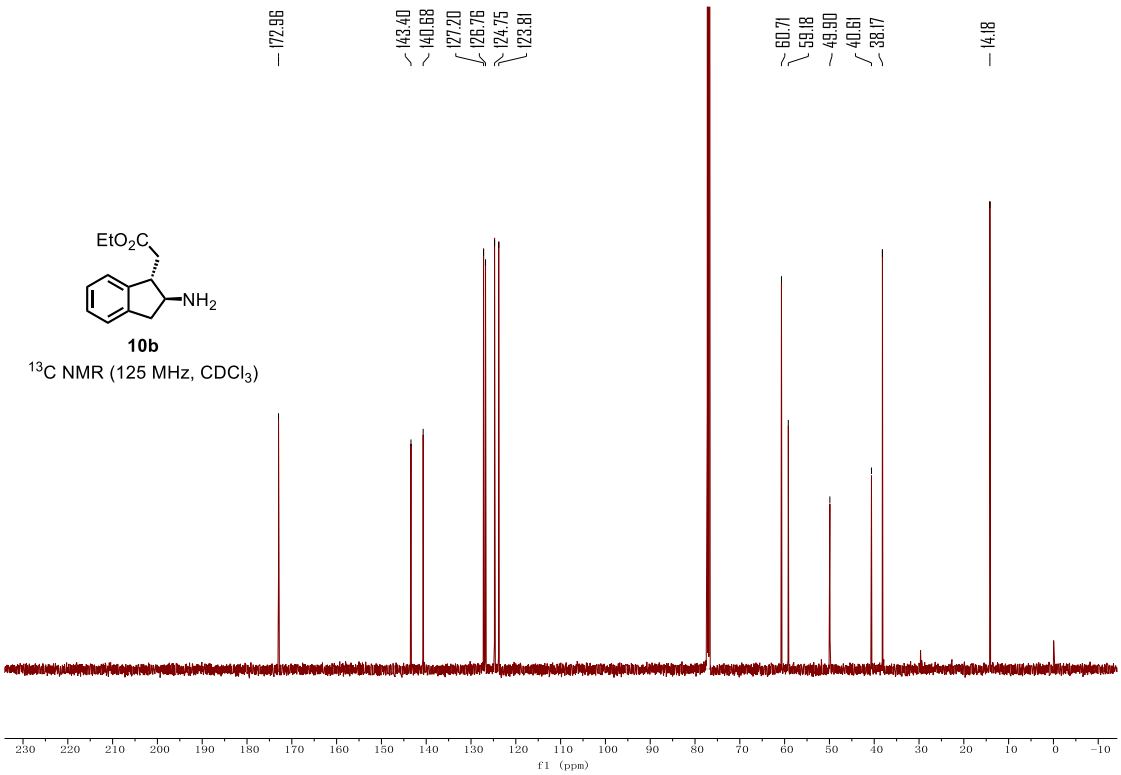




10b

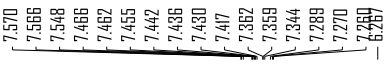
^{1}H NMR (400 MHz, $CDCl_3$)

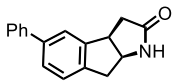




10b

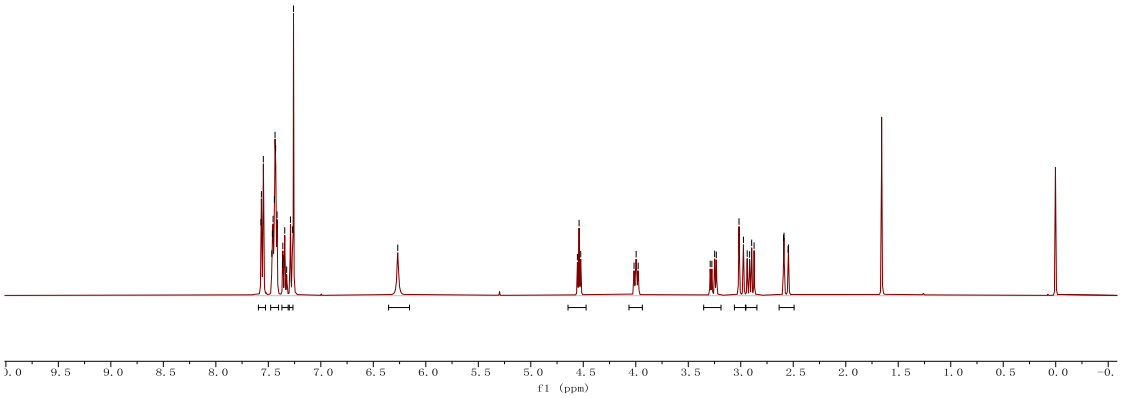
^{13}C NMR (125 MHz, $CDCl_3$)

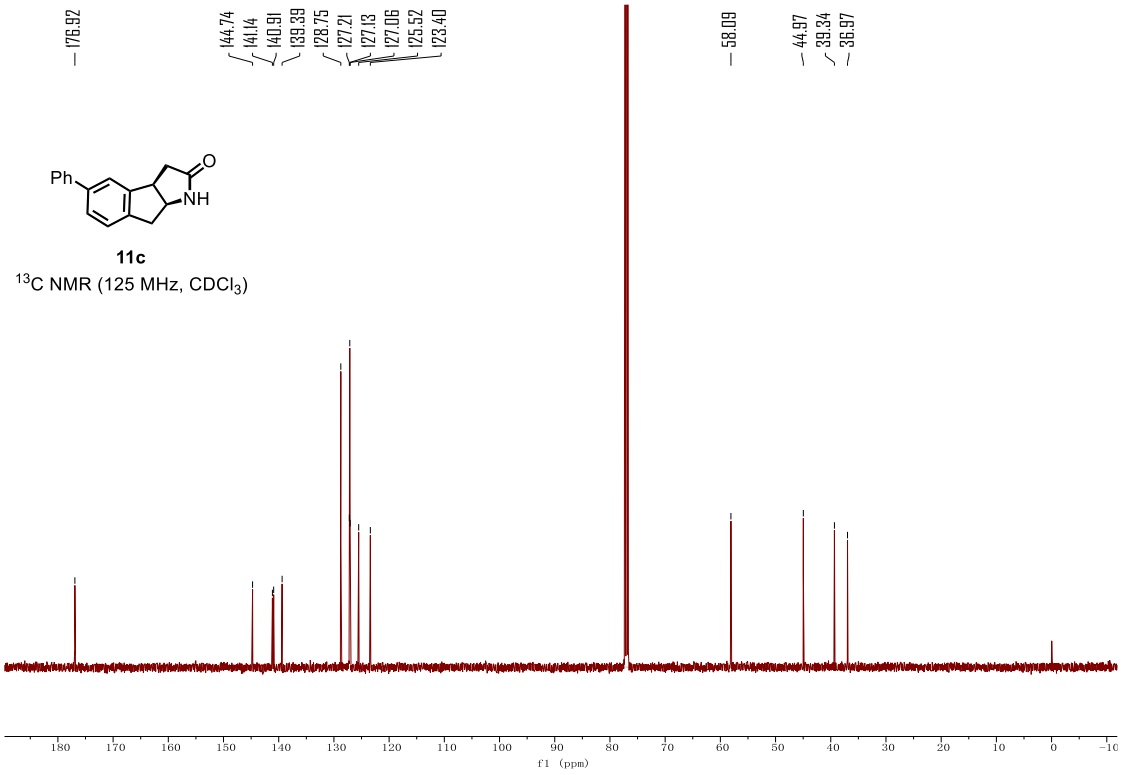




11c

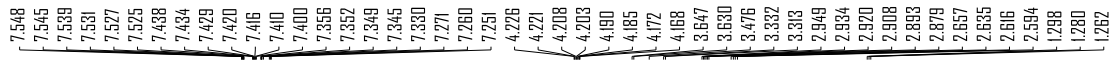
^{1}H NMR (400 MHz, $CDCl_3$)





11c

^{13}C NMR (125 MHz, $CDCl_3$)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7.400
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7.352
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7.345
7.330
7.271
7.260
7.251
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4.221
4.208
4.203
4.190
4.185
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3.647
3.630
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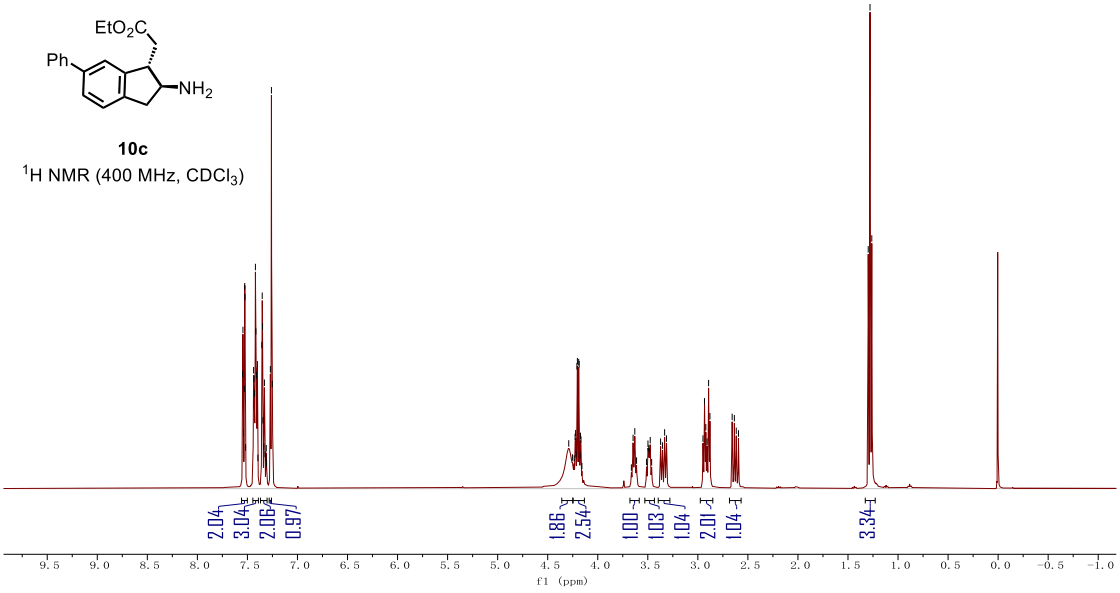
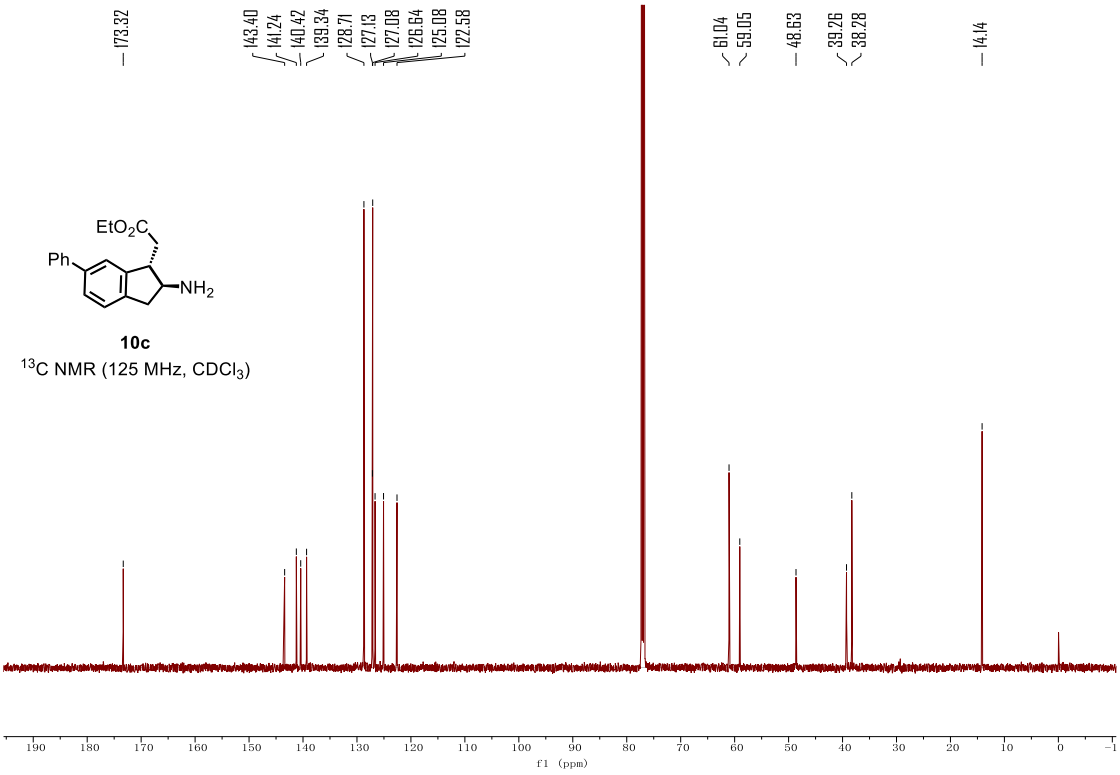
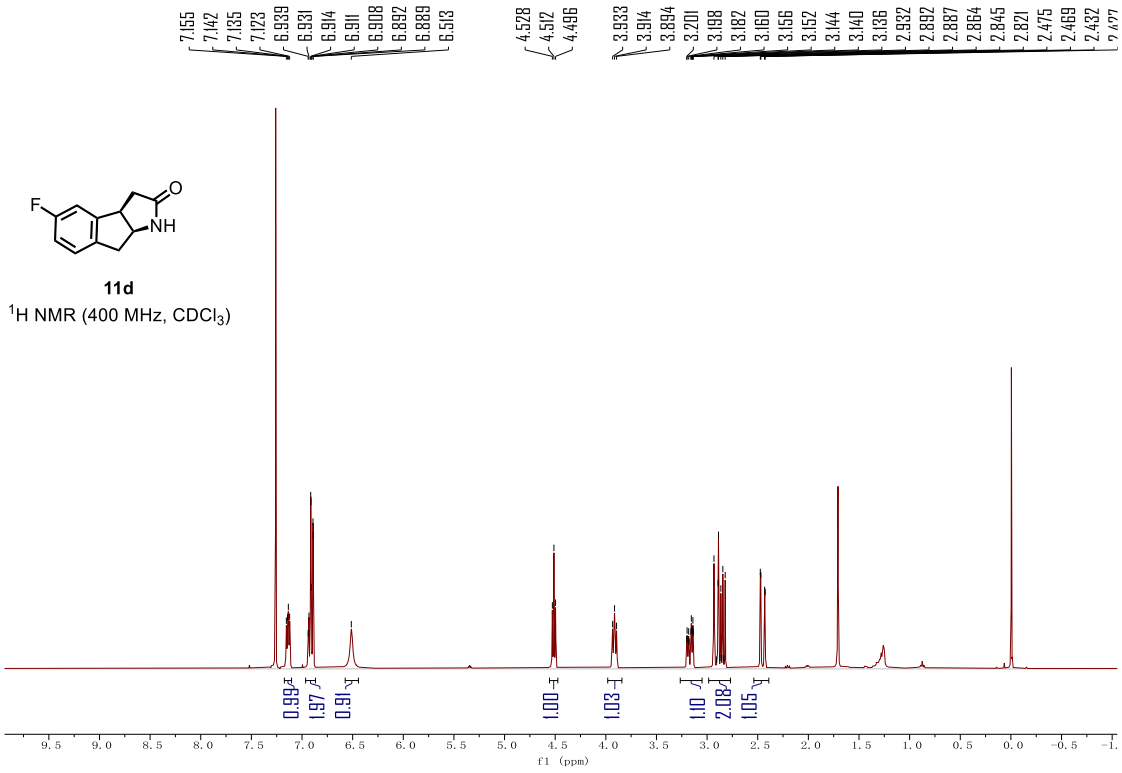
1.280
1.262


EtO2C
Ph
NH2
10c
1H NMR (400 MHz, CDCl3)
2.04
3.04
2.06
0.97
1.86
2.54
1.00
1.03
1.04
2.01
1.04
3.34
f1 (ppm)


173.32
143.40
141.24
140.42
139.34
128.71
127.13
127.08
126.64
125.08
122.58
61.04
59.05
48.63
39.26
38.28
14.14
EtO2C
Ph
NH2
10c
13C NMR (125 MHz, CDCl3)
f1 (ppm)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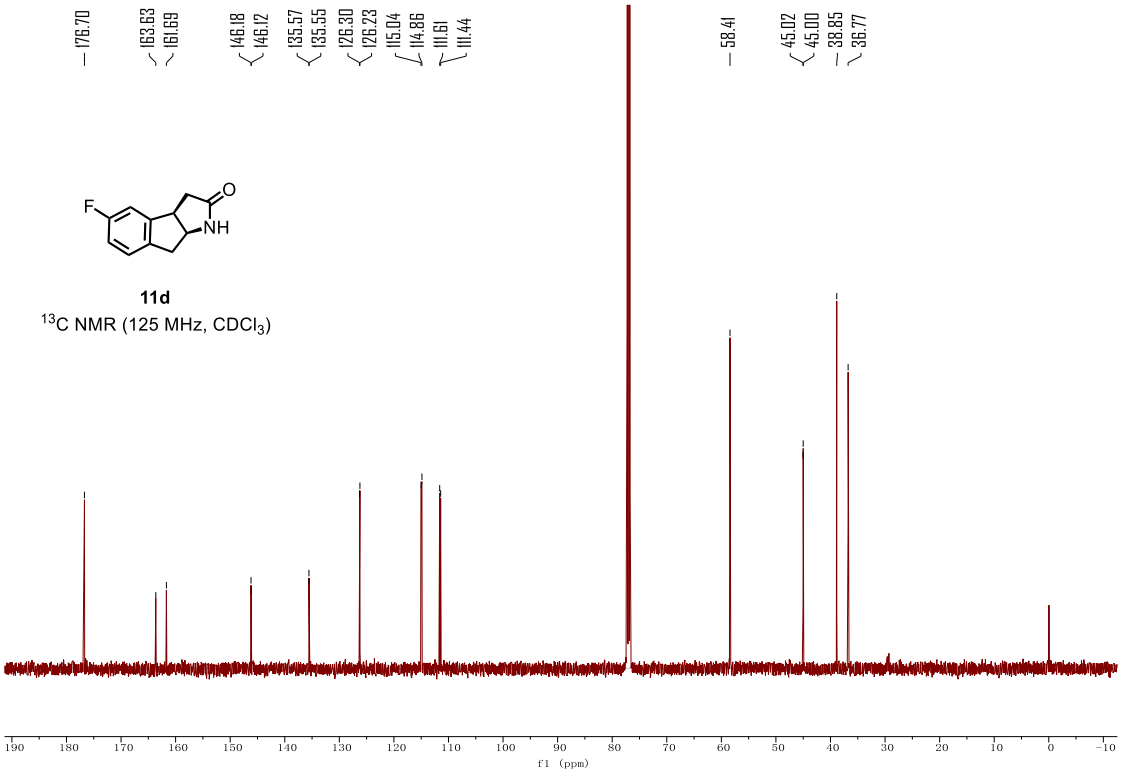
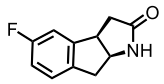
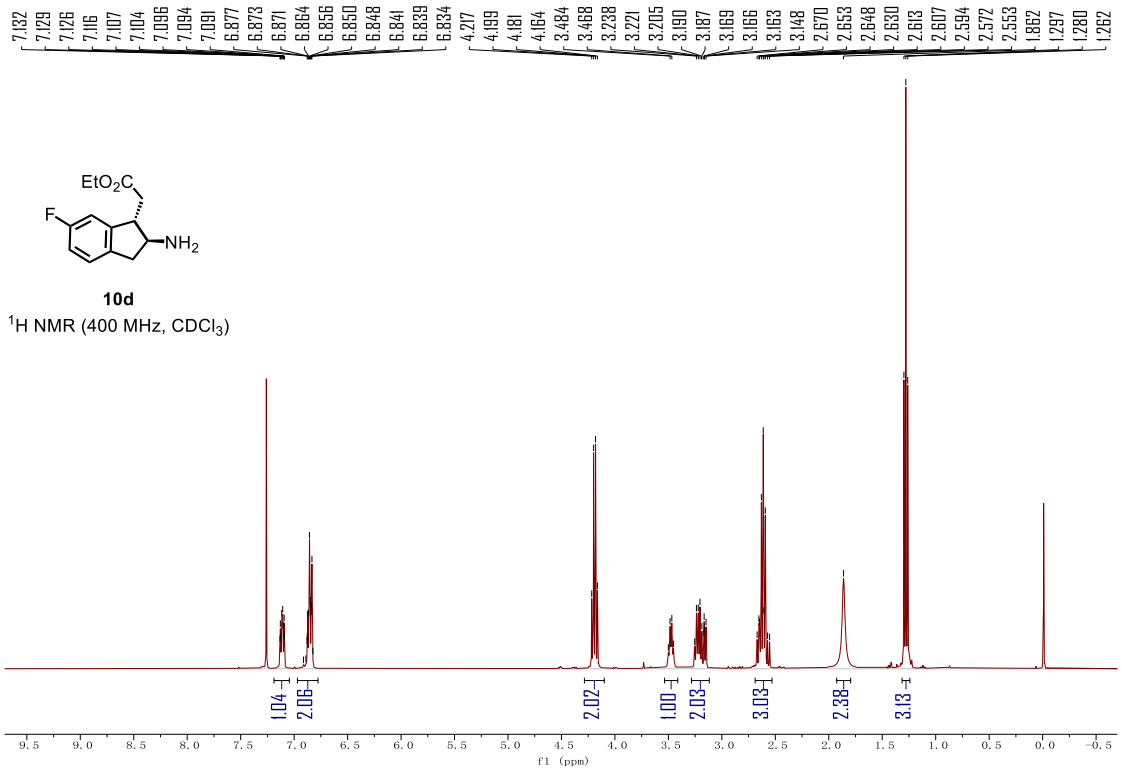
7.142
7.135
7.123
6.939
6.931
6.914
6.911
6.908
6.892
6.889
6.513
4.528
4.512
4.496
3.933
3.914
3.894
3.201
3.198
3.182
3.160
3.156
3.152
3.144
3.140
3.136
2.932
2.892
2.887
2.864
2.845
2.821
2.475
2.469
2.432
F
O
NH
11d
1H NMR (400 MHz, CDCl3)
0.99
1.97
0.91
1.00
1.03
1.10
2.08
1.05
f1 (ppm)

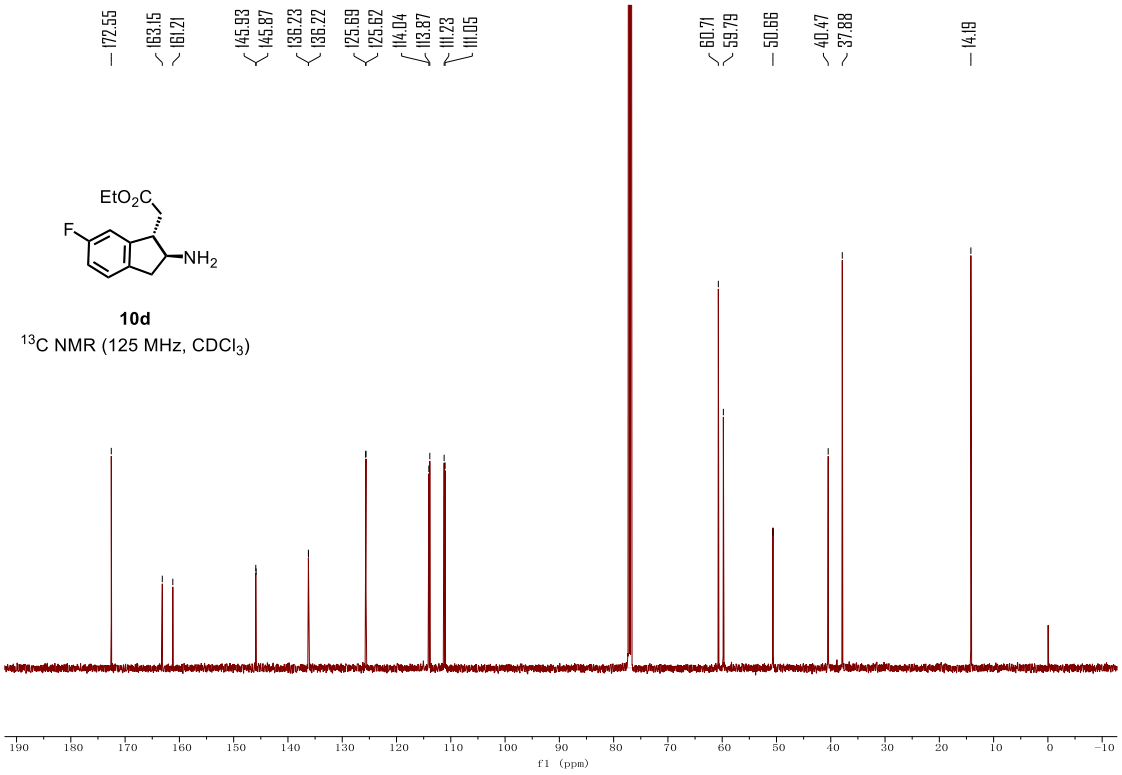

176.70
163.63
161.69
146.18
146.12
135.57
135.55
128.30
128.23
115.04
114.86
111.61
111.44
58.41
45.02
45.00
38.85
38.77
F
O
NH
11d
13C NMR (125 MHz, CDCl3)
f1 (ppm)

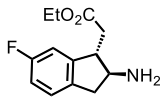


11d

^{19}F NMR (375 MHz, $CDCl_3$)

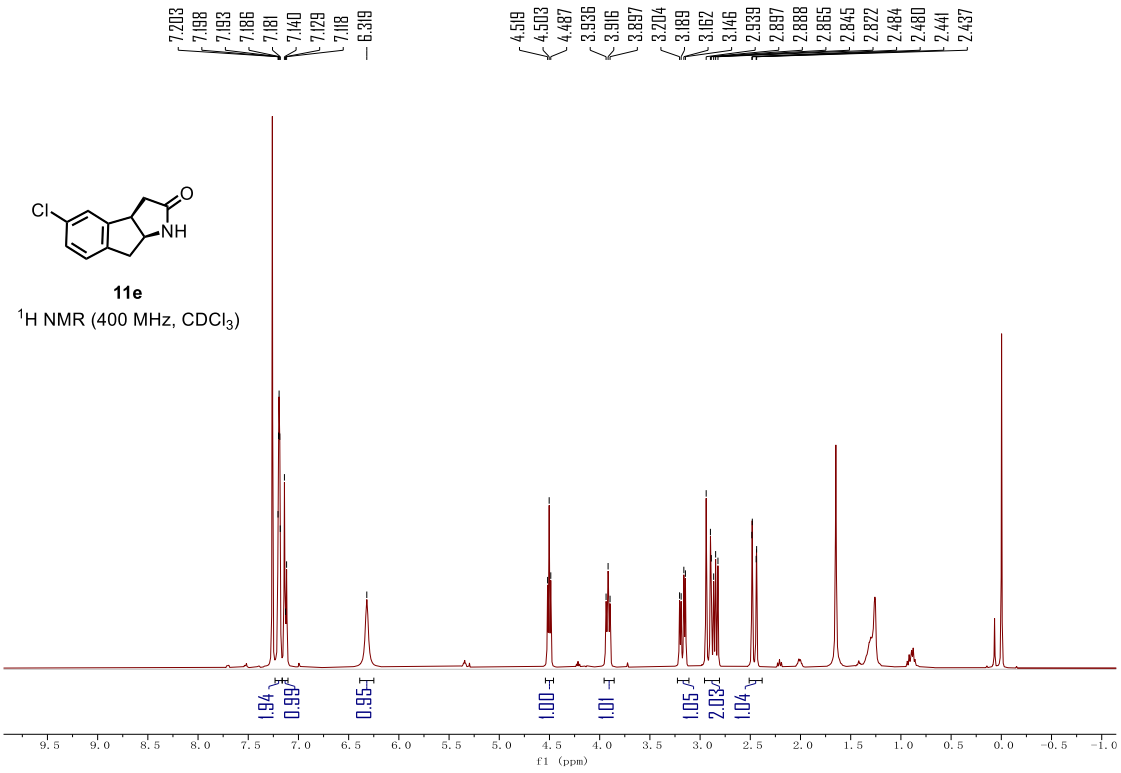

7.132
7.129
7.126
7.116
7.107
7.104
7.096
7.094
7.091
6.877
6.873
6.871
6.864
6.856
6.850
6.848
6.841
6.839
6.834
4.217
4.199
4.181
4.164
3.484
3.468
3.238
3.221
3.205
3.190
3.187
3.169
3.166
3.163
3.148
2.670
2.653
2.648
2.630
2.613
2.607
2.594
2.572
2.553
1.862
1.297
1.280
1.262
EtO2C
F
NH2
10d
1H NMR (400 MHz, CDCl3)
1.04
2.06
2.02
1.00
2.03
3.03
2.88
3.13
f1 (ppm)

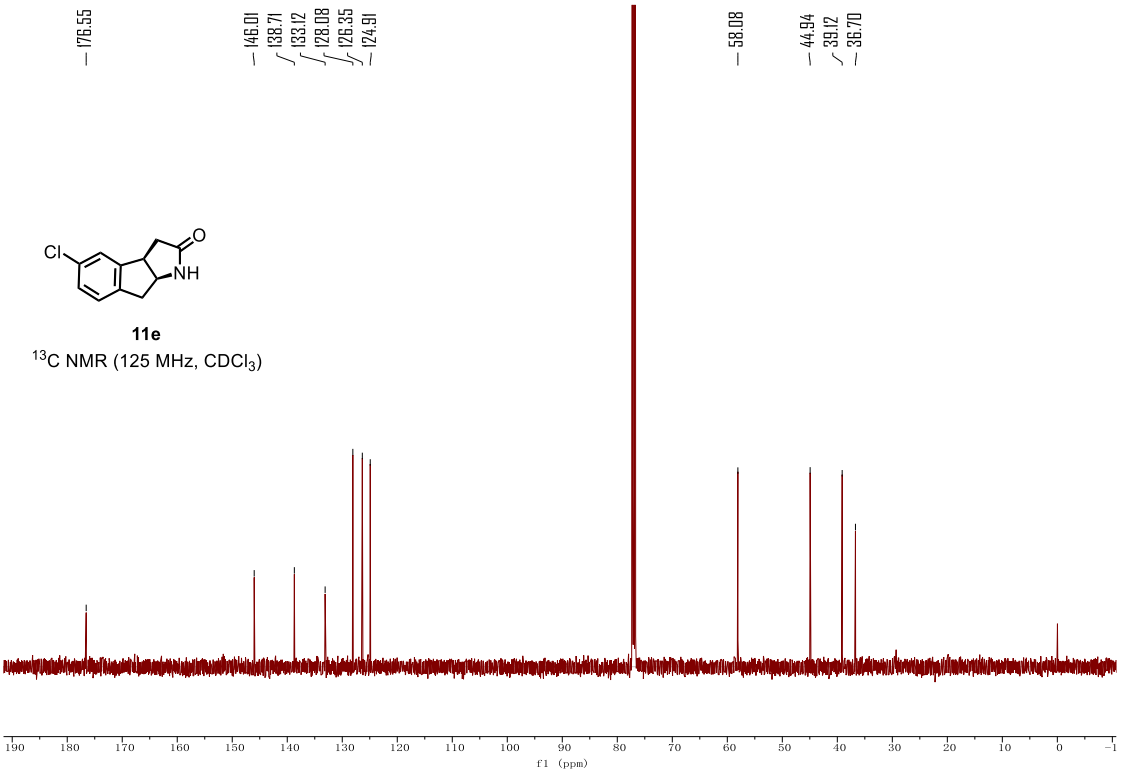

172.55
163.15
161.21
145.93
145.87
136.23
136.22
125.69
125.62
114.04
113.87
111.23
111.05
60.71
59.79
50.66
40.47
37.88
14.19
EtO2C
F
NH2
10d
13C NMR (125 MHz, CDCl3)
f1 (ppm)

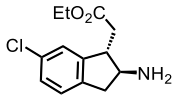


10d

^{19}F NMR (375 MHz, $CDCl_3$)

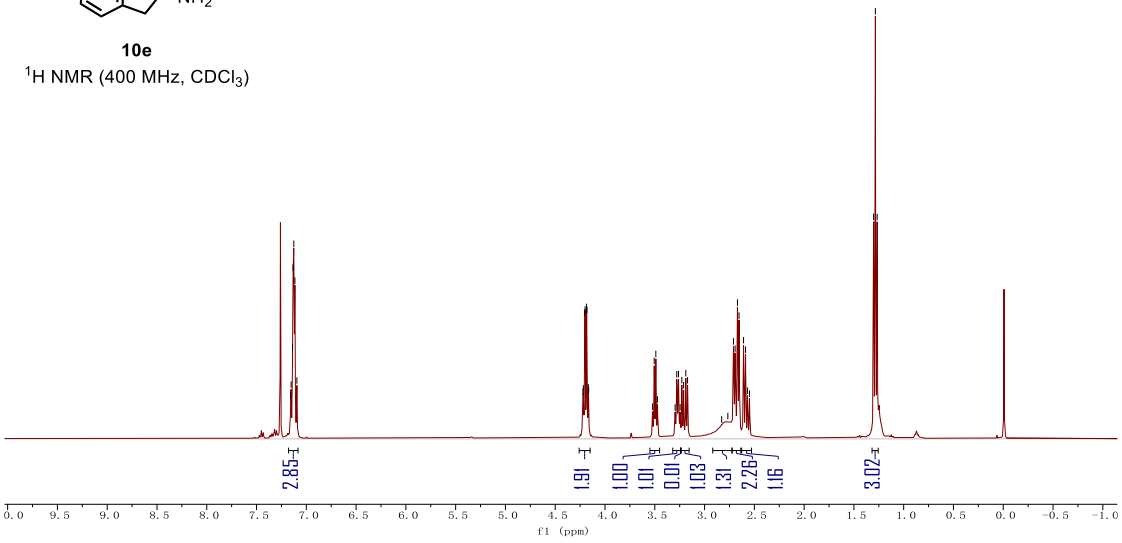

7.203
7.198
7.193
7.186
7.181
7.140
7.129
7.118
6.319
4.519
4.503
4.487
3.936
3.916
3.897
3.204
3.189
3.162
3.146
2.939
2.897
2.888
2.865
2.845
2.822
2.484
2.480
2.441
2.437
Cl
O
NH
11e
1H NMR (400 MHz, CDCl3)
1.94
0.99
0.95
1.00
1.01
1.05
2.03
1.04
f1 (ppm)

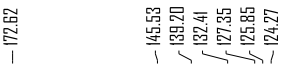

176.55
146.01
138.71
133.12
128.08
126.35
124.91
58.08
44.94
39.12
36.70
Cl
O
NH
11e
13C NMR (125 MHz, CDCl3)
f1 (ppm)

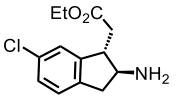


10e

^{1}H NMR (400 MHz, $CDCl_3$)

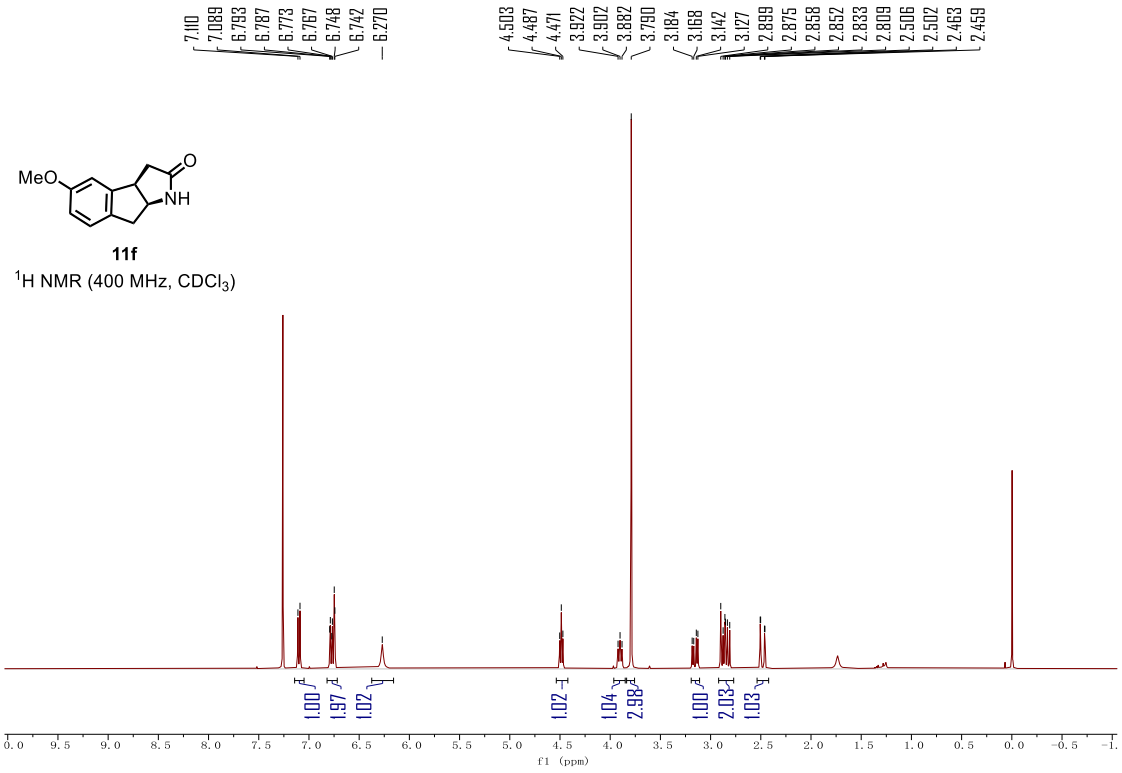






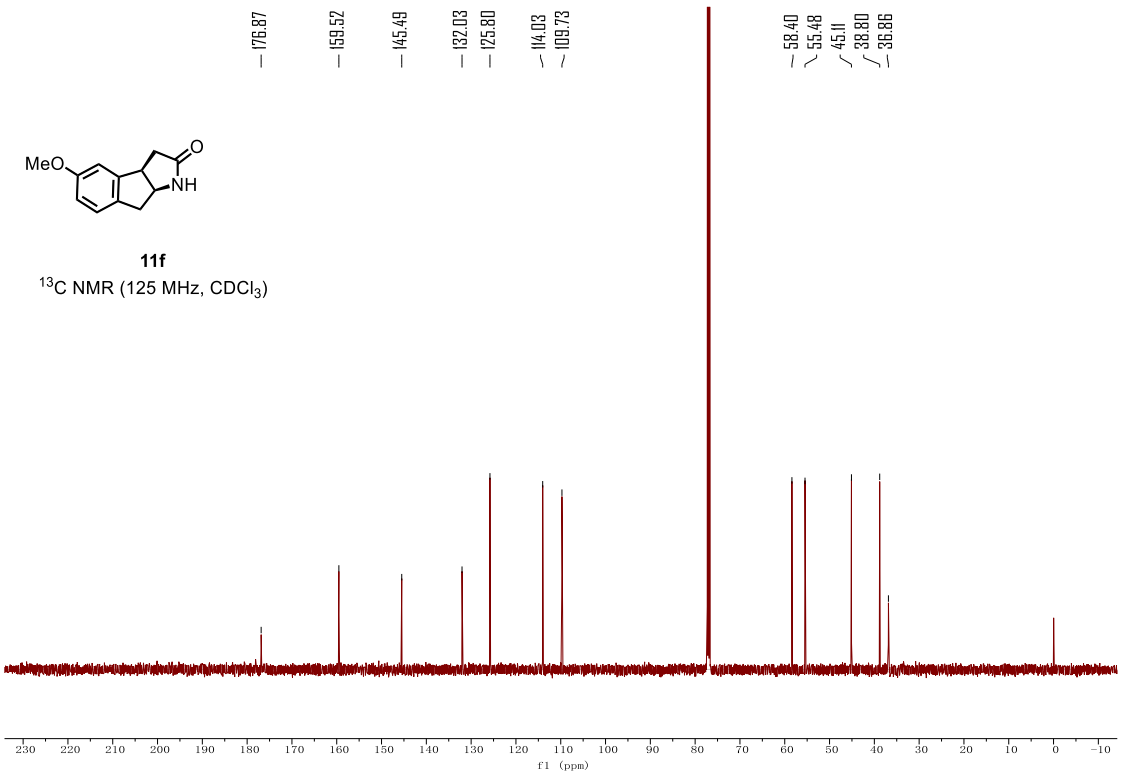
10e

^{13}C NMR (125 MHz, $CDCl_3$)



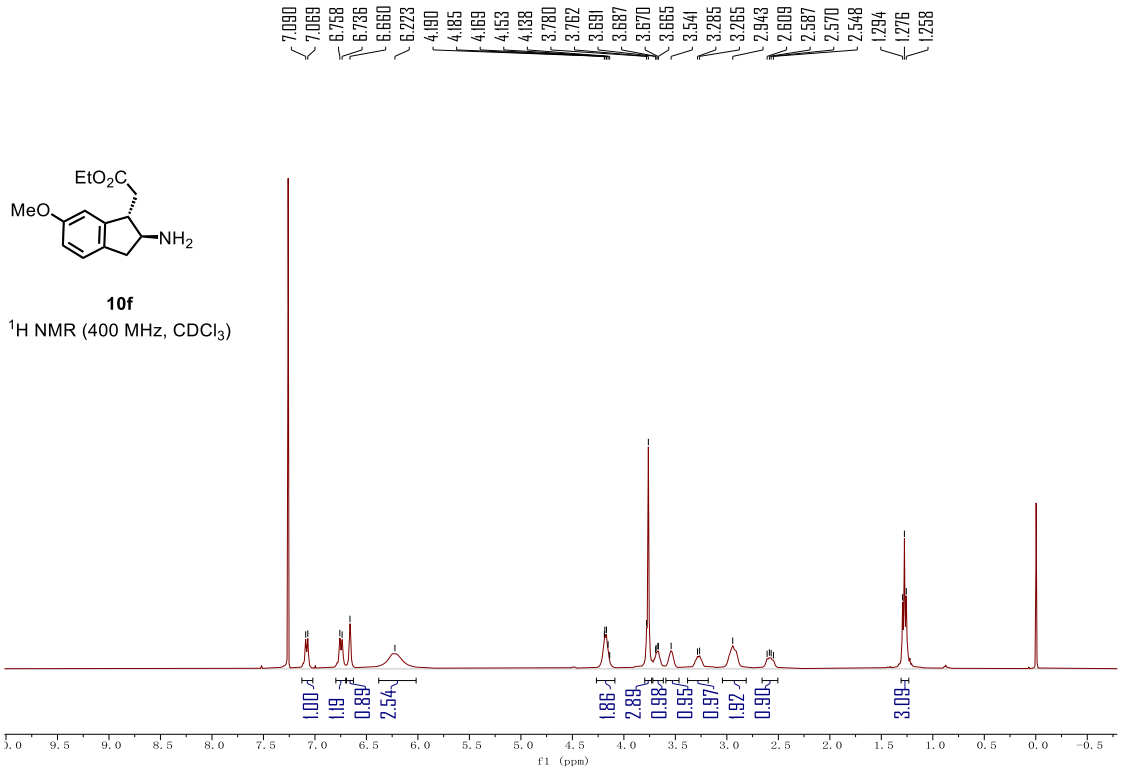
11f

^{1}H NMR (400 MHz, $CDCl_3$)



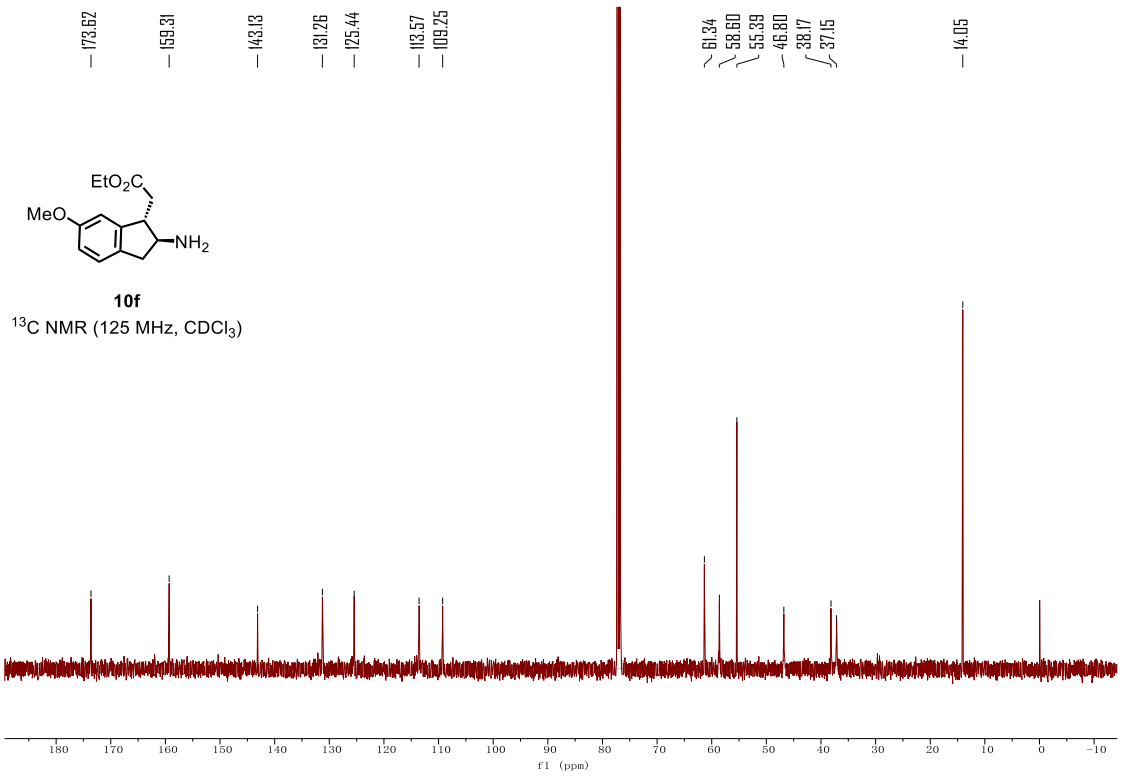
11f

^{13}C NMR (125 MHz, $CDCl_3$)



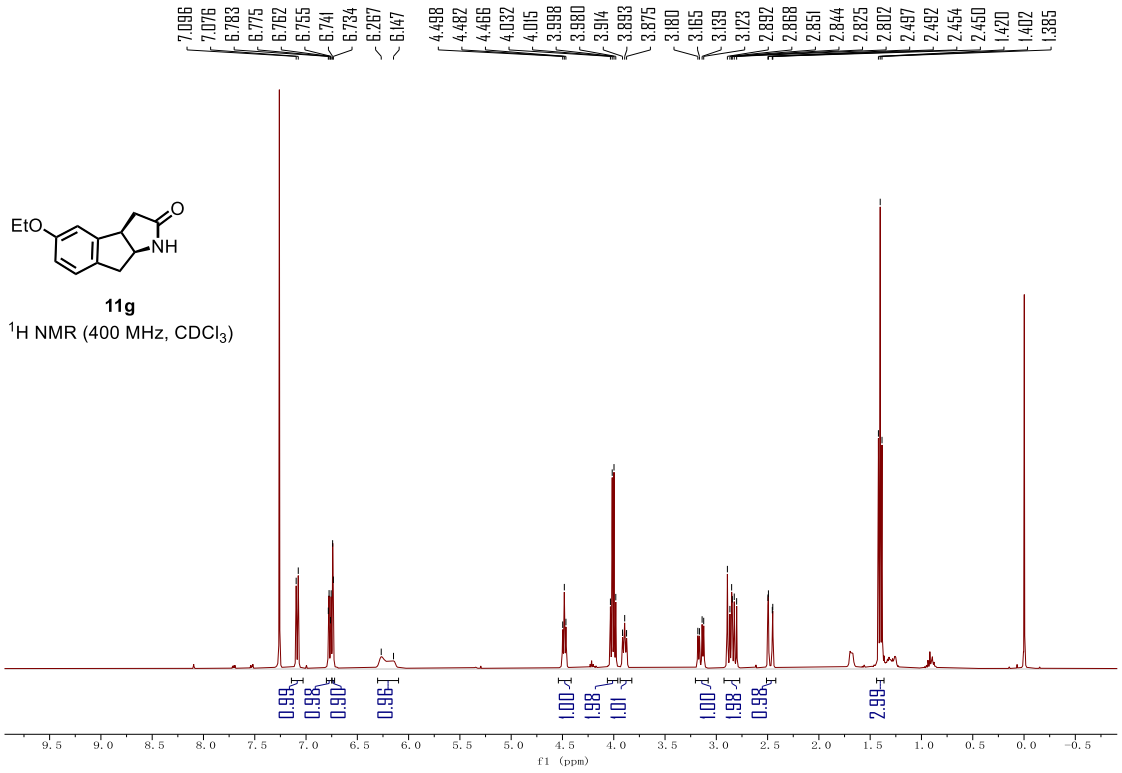
10f

^{1}H NMR (400 MHz, $CDCl_3$)



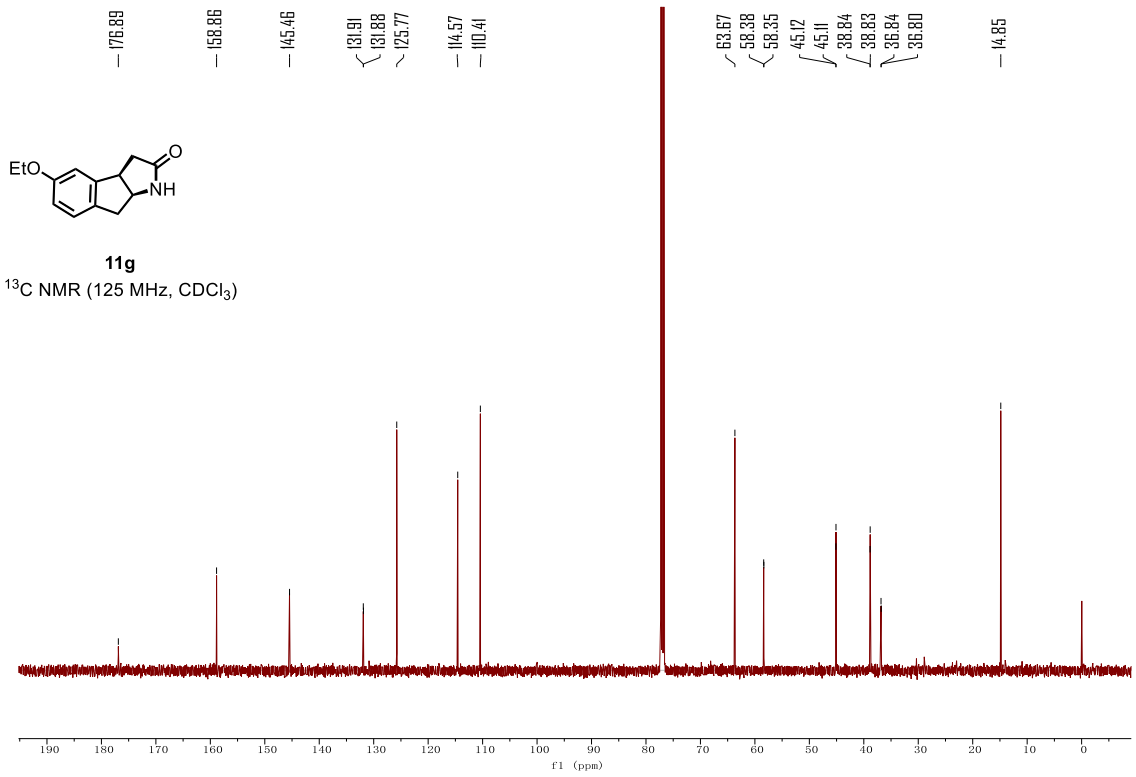
10f

^{13}C NMR (125 MHz, $CDCl_3$)



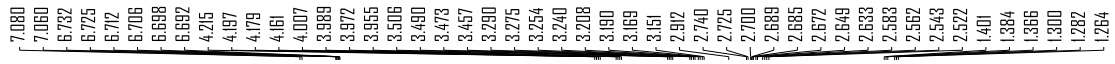
11g

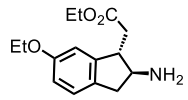
^{1}H NMR (400 MHz, $CDCl_3$)



11g

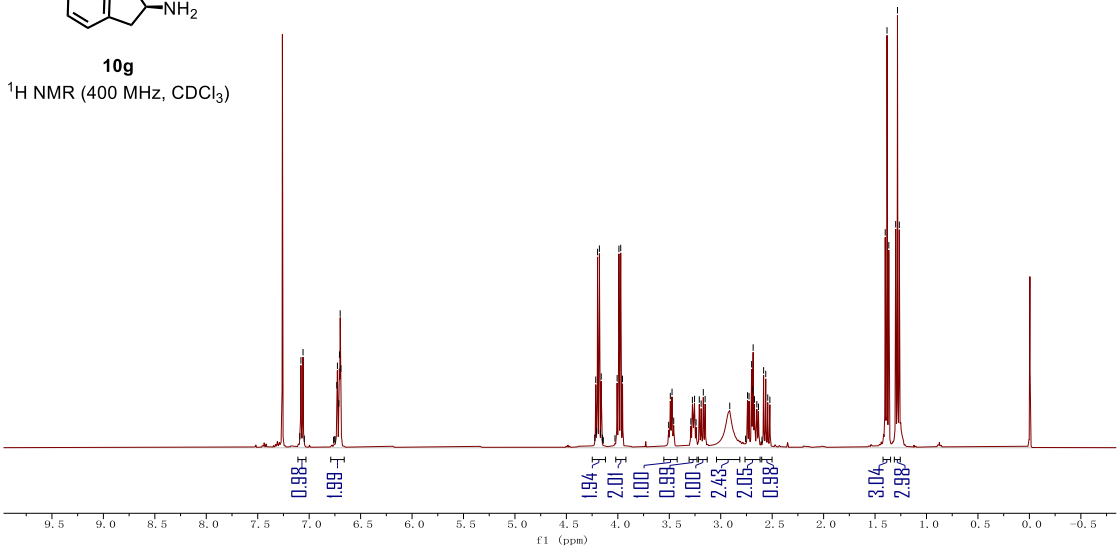
^{13}C NMR (125 MHz, $CDCl_3$)

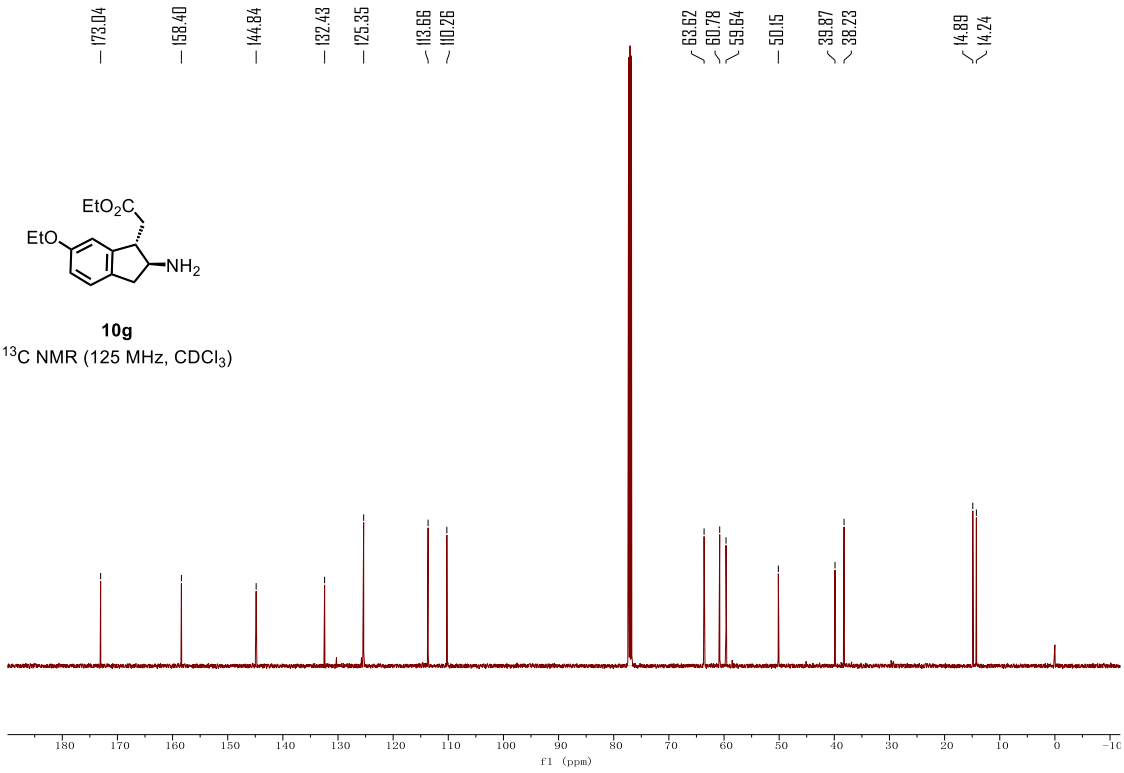




10g

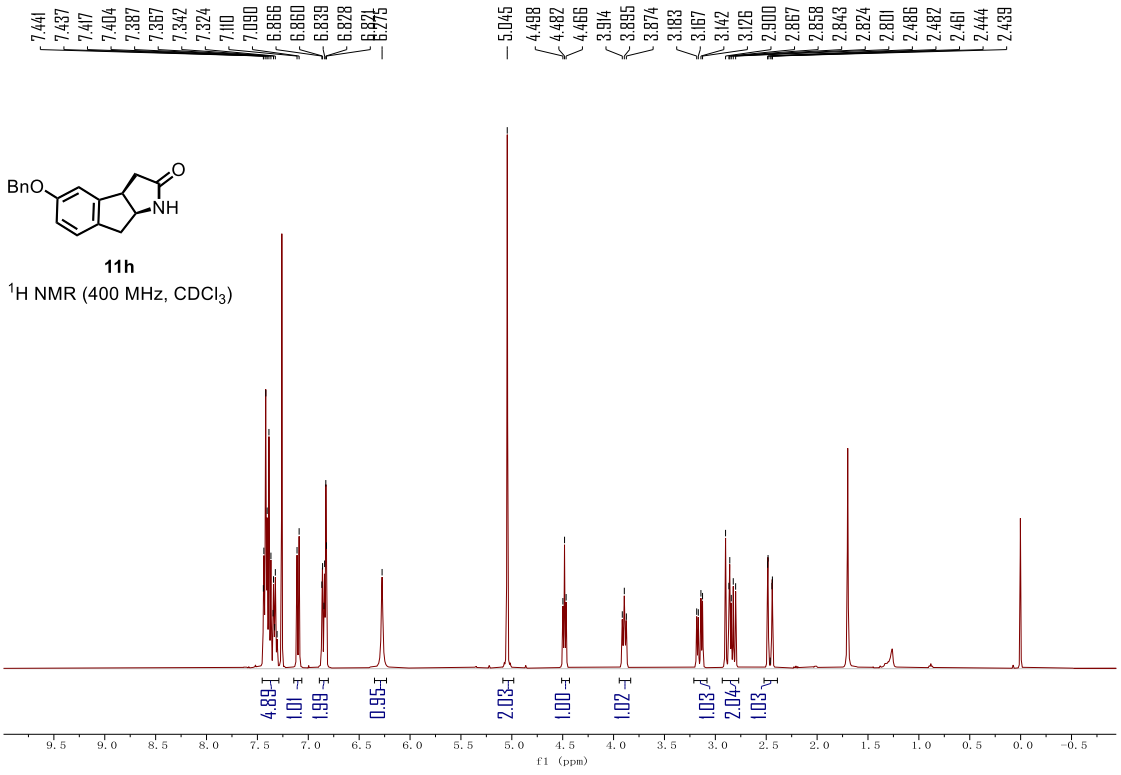
^{1}H NMR (400 MHz, $CDCl_3$)





10g

^{13}C NMR (125 MHz, $CDCl_3$)


7.441
7.437
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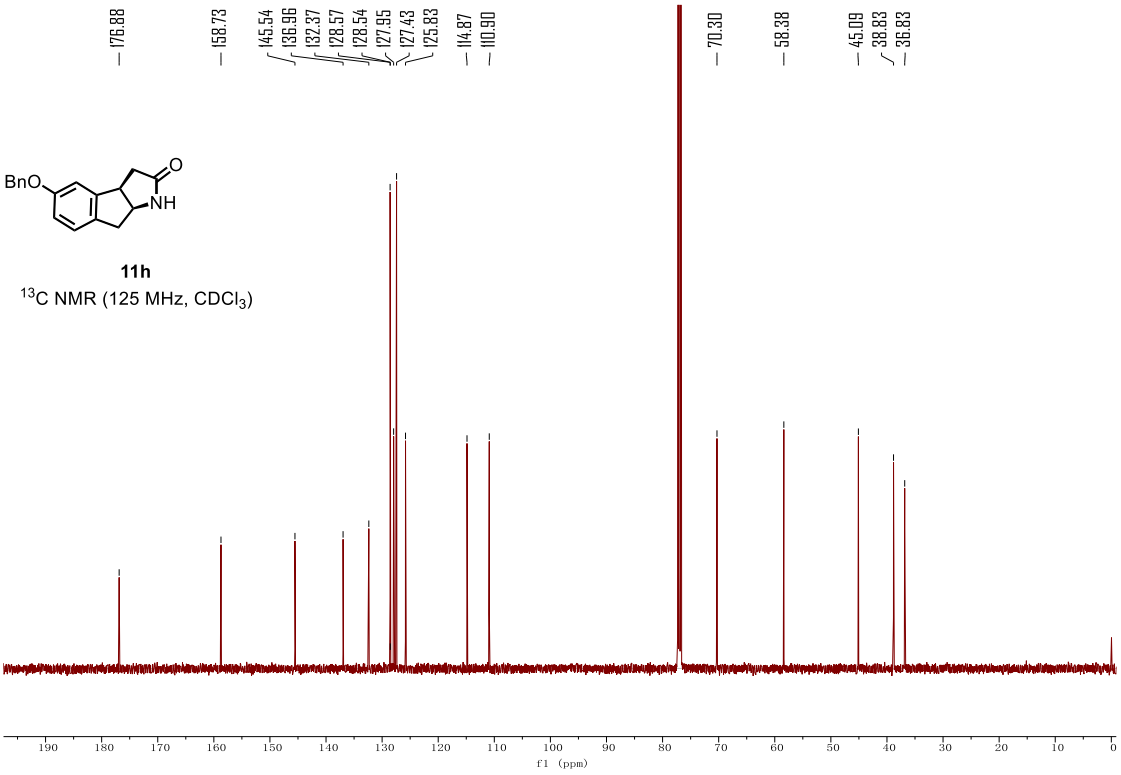
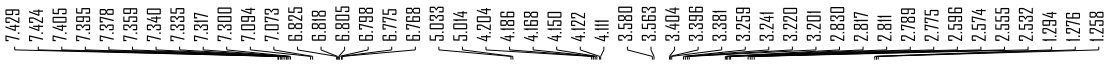
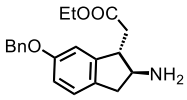
7.404
7.387
7.367
7.342
7.324
7.110
7.090
6.866
6.860
6.839
6.828
6.821
6.275
5.045
4.498
4.482
4.466
3.914
3.895
3.874
3.183
3.167
3.142
3.126
2.900
2.867
2.858
2.843
2.824
2.801
2.488
2.482
2.461
2.444
2.439
BnO
O
NH
11h
1H NMR (400 MHz, CDCl3)
4.89
1.01
1.99
0.95
2.03
1.00
1.02
1.03
2.04
1.03
f1 (ppm)

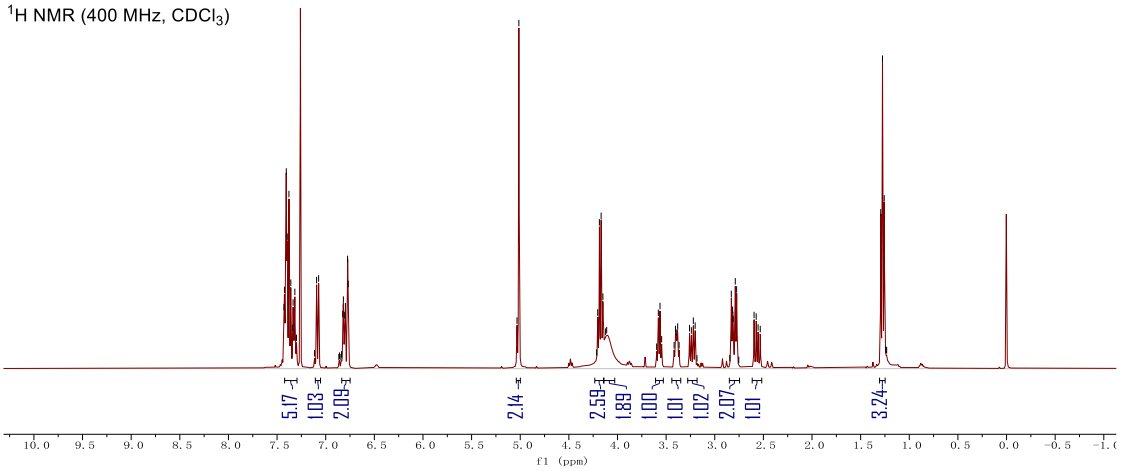

176.88
158.73
145.54
136.96
132.37
128.57
128.54
127.95
127.43
125.83
114.87
110.90
70.30
58.38
45.09
38.83
36.83
BnO
O
NH
11h
13C NMR (125 MHz, CDCl3)
f1 (ppm)

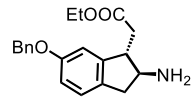




10h

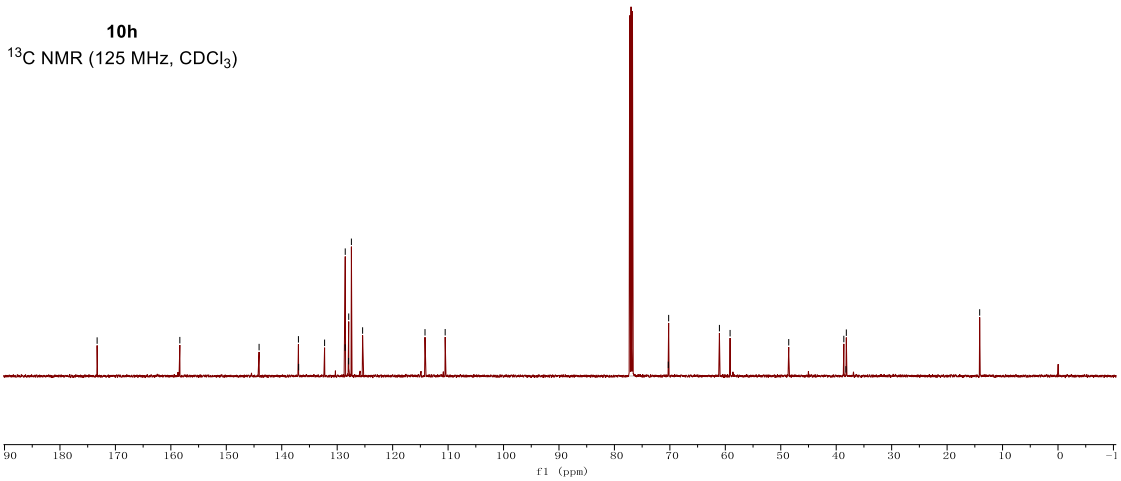
^{1}H NMR (400 MHz, $CDCl_3$)

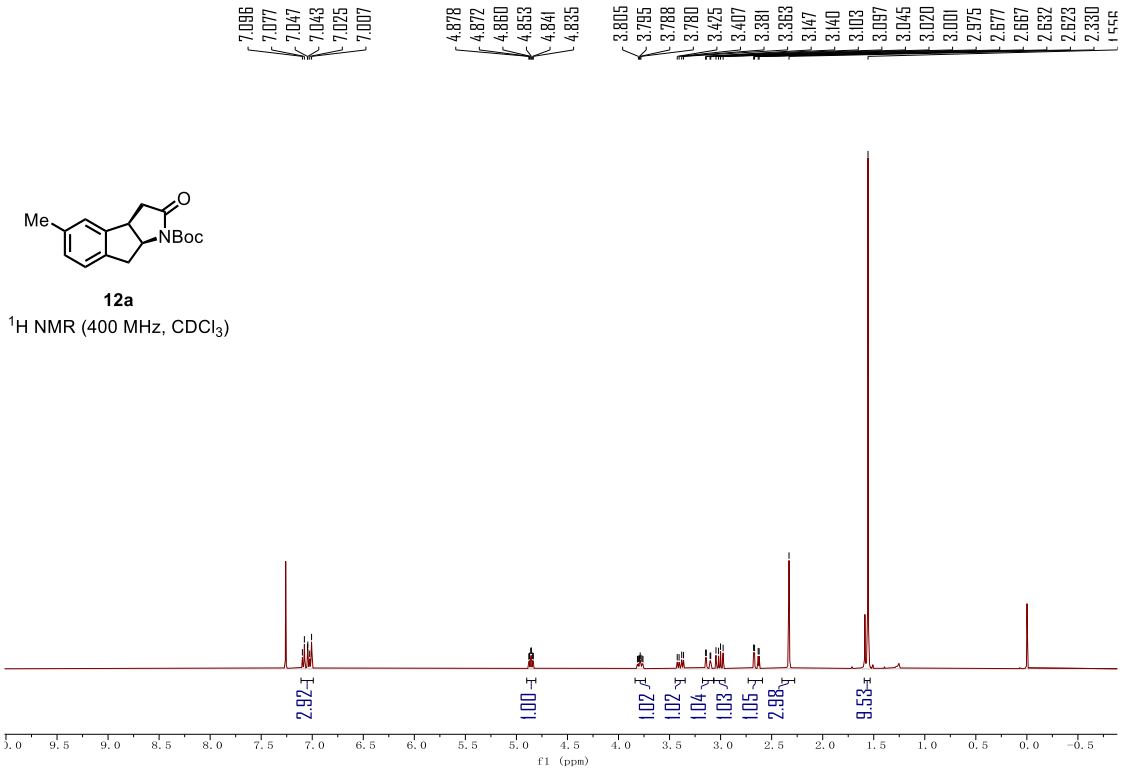




10h

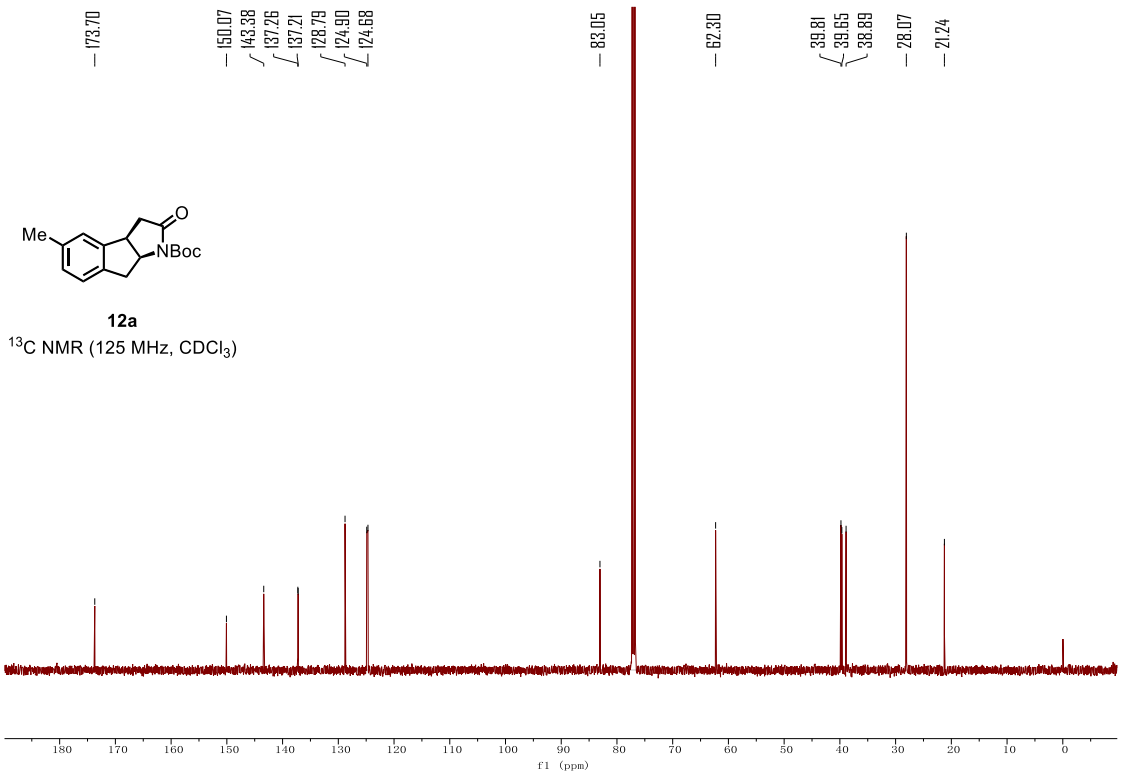
^{13}C NMR (125 MHz, $CDCl_3$)





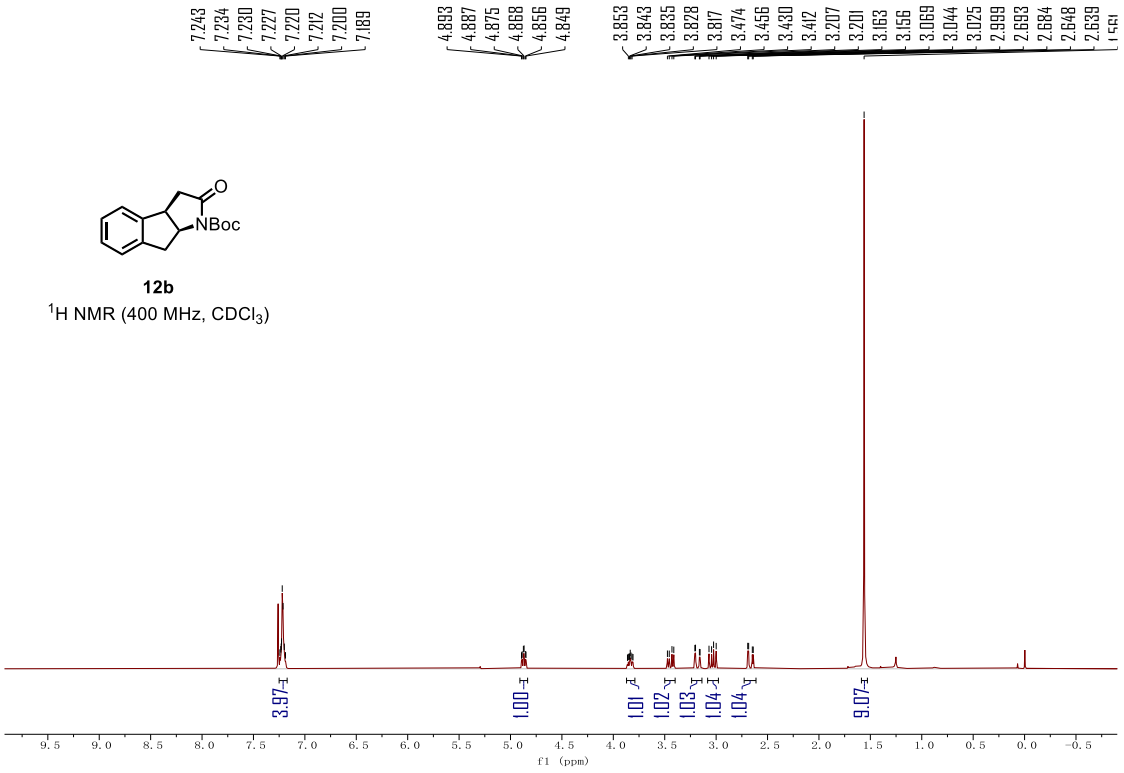
12a

^{1}H NMR (400 MHz, $CDCl_3$)



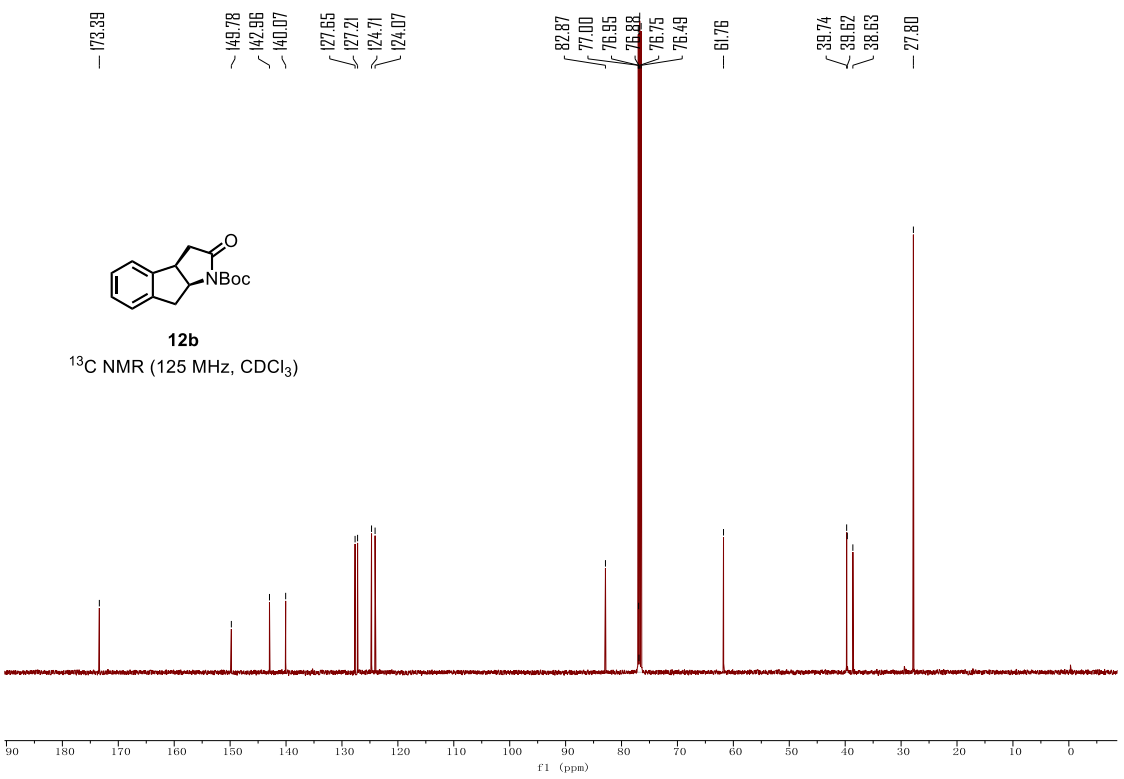
12a

^{13}C NMR (125 MHz, $CDCl_3$)



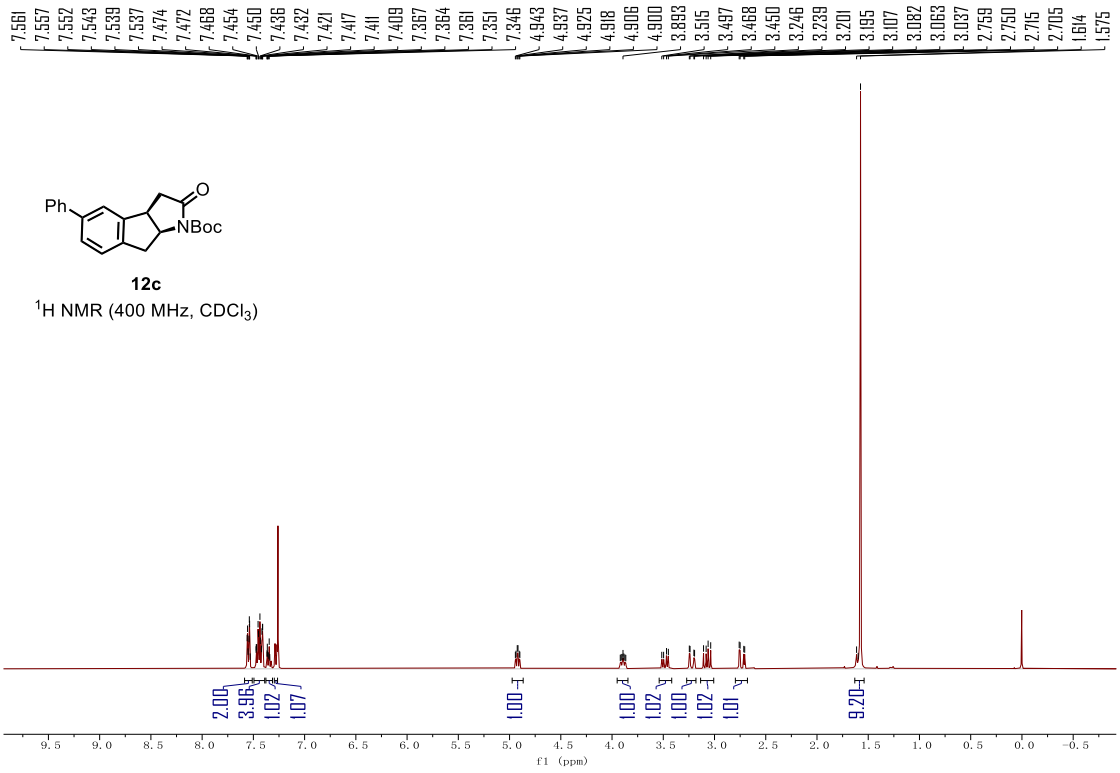
12b

^{1}H NMR (400 MHz, $CDCl_3$)



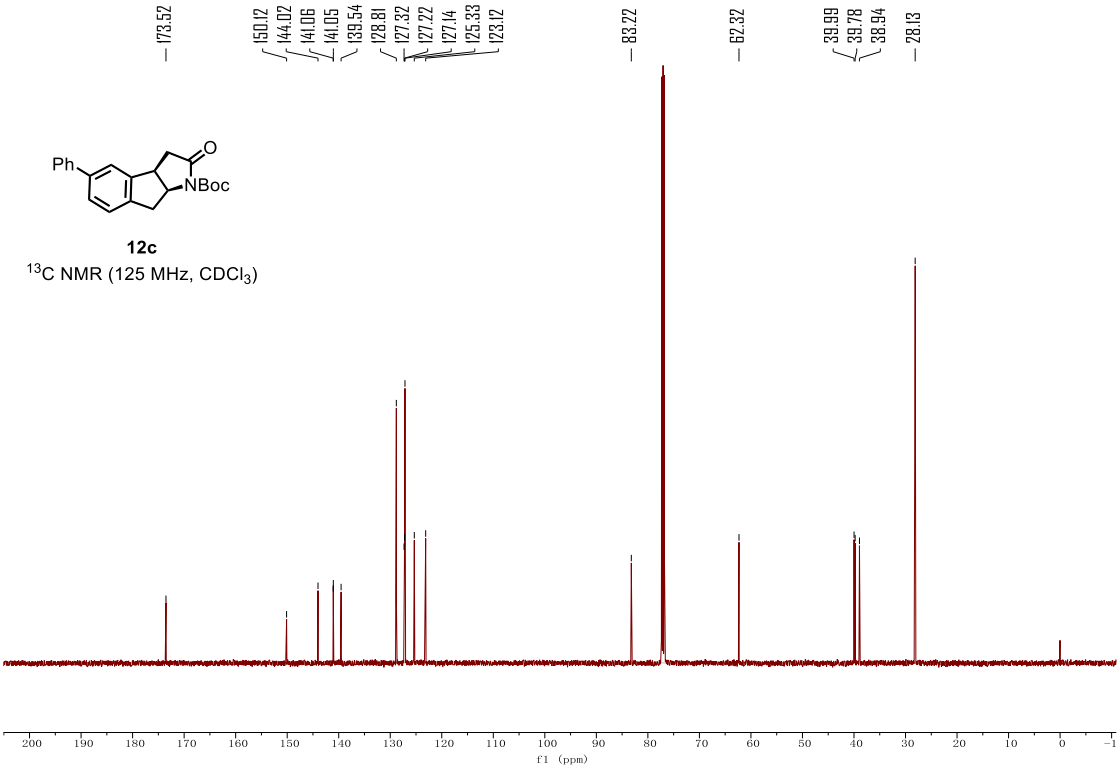
12b

^{13}C NMR (125 MHz, $CDCl_3$)



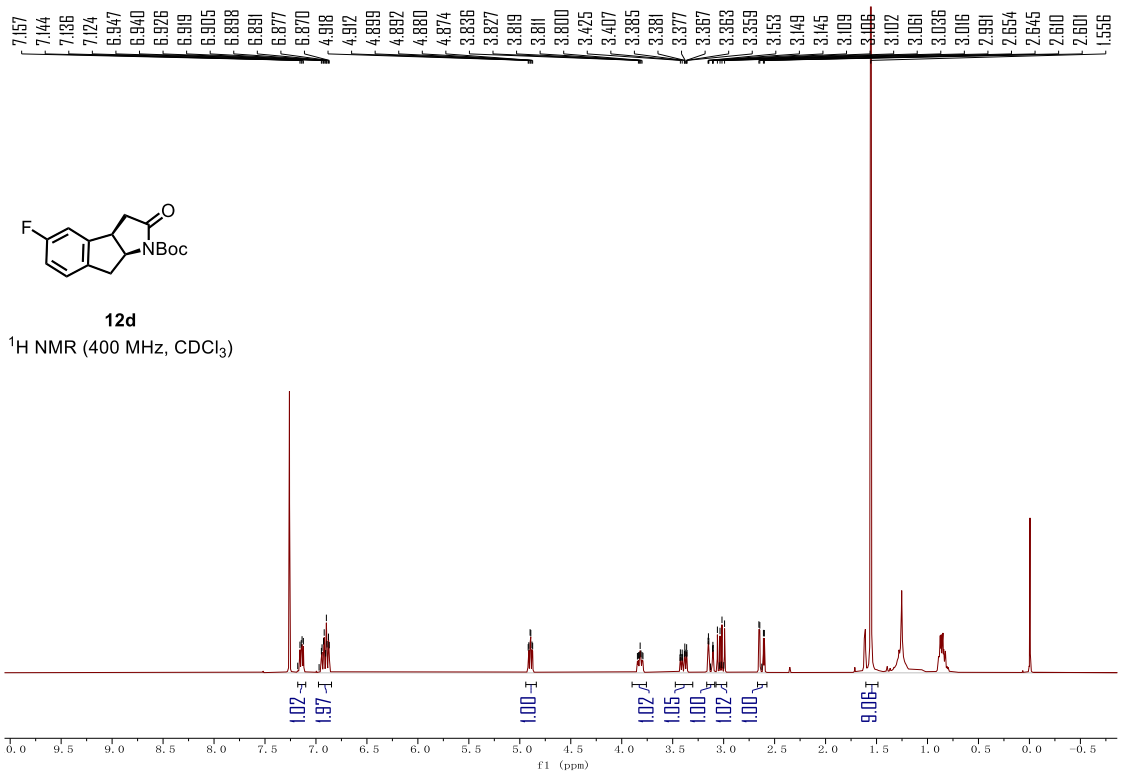
12c

^{1}H NMR (400 MHz, $CDCl_3$)



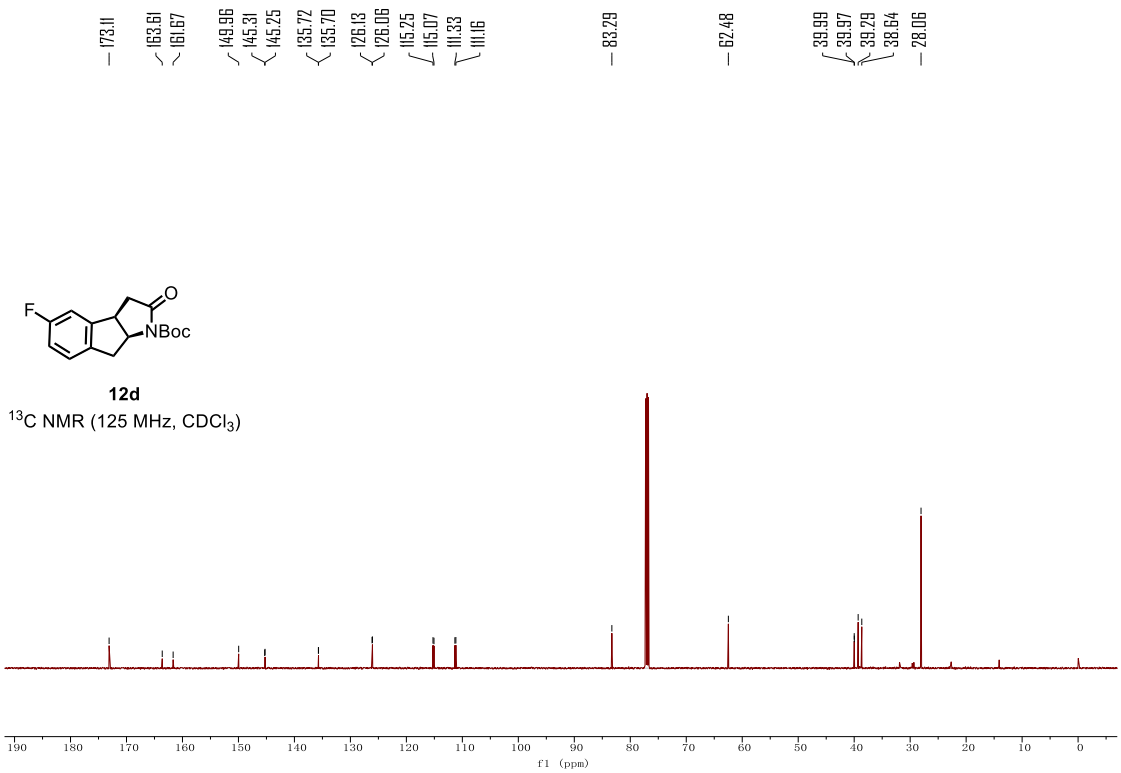
12c

^{13}C NMR (125 MHz, $CDCl_3$)



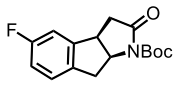
12d

^{1}H NMR (400 MHz, $CDCl_3$)



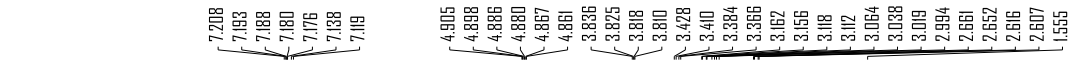
12d

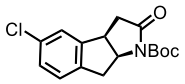
^{13}C NMR (125 MHz, $CDCl_3$)



12d

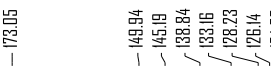
^{19}F NMR (375 MHz, $CDCl_3$)

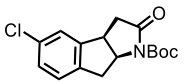




12e

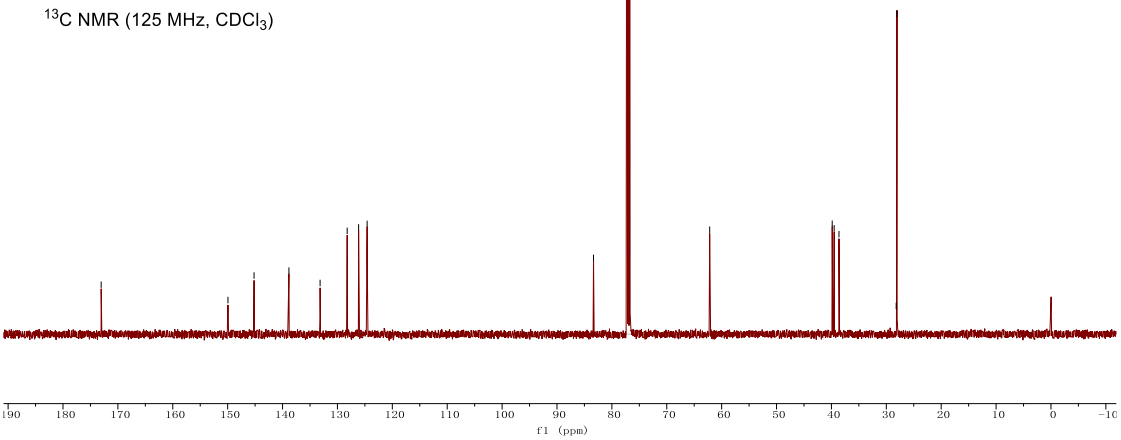
^{1}H NMR (400 MHz, $CDCl_3$)

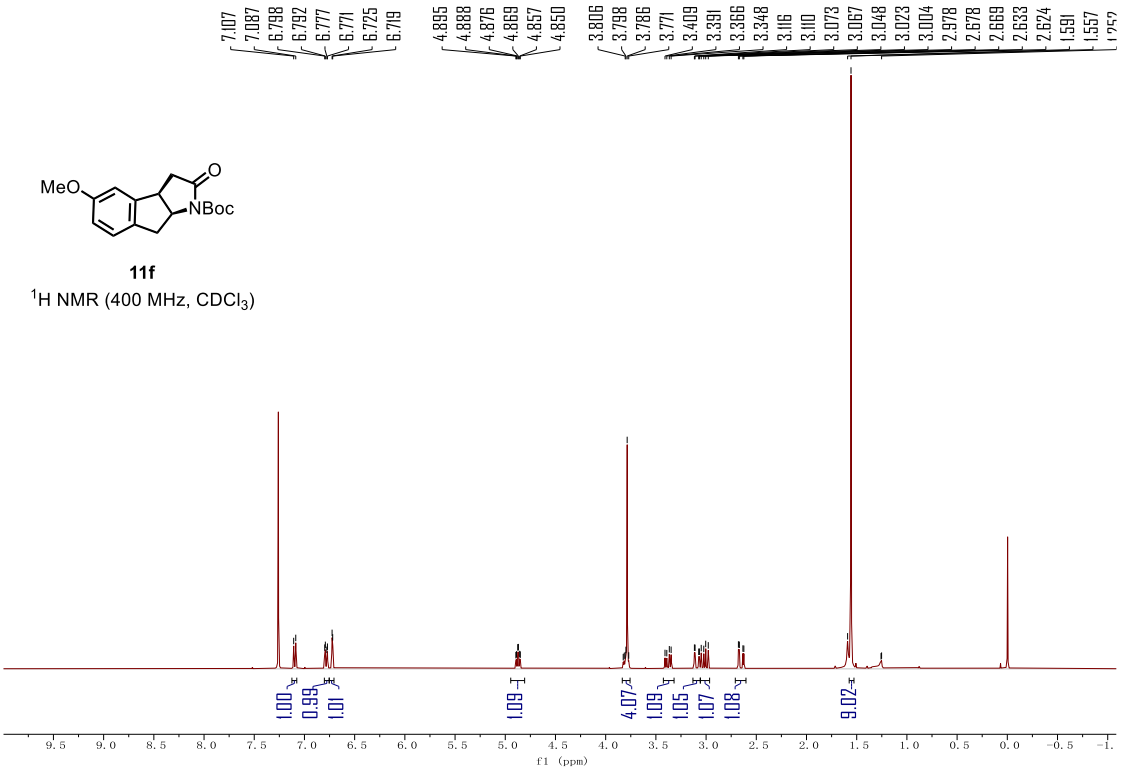




12e

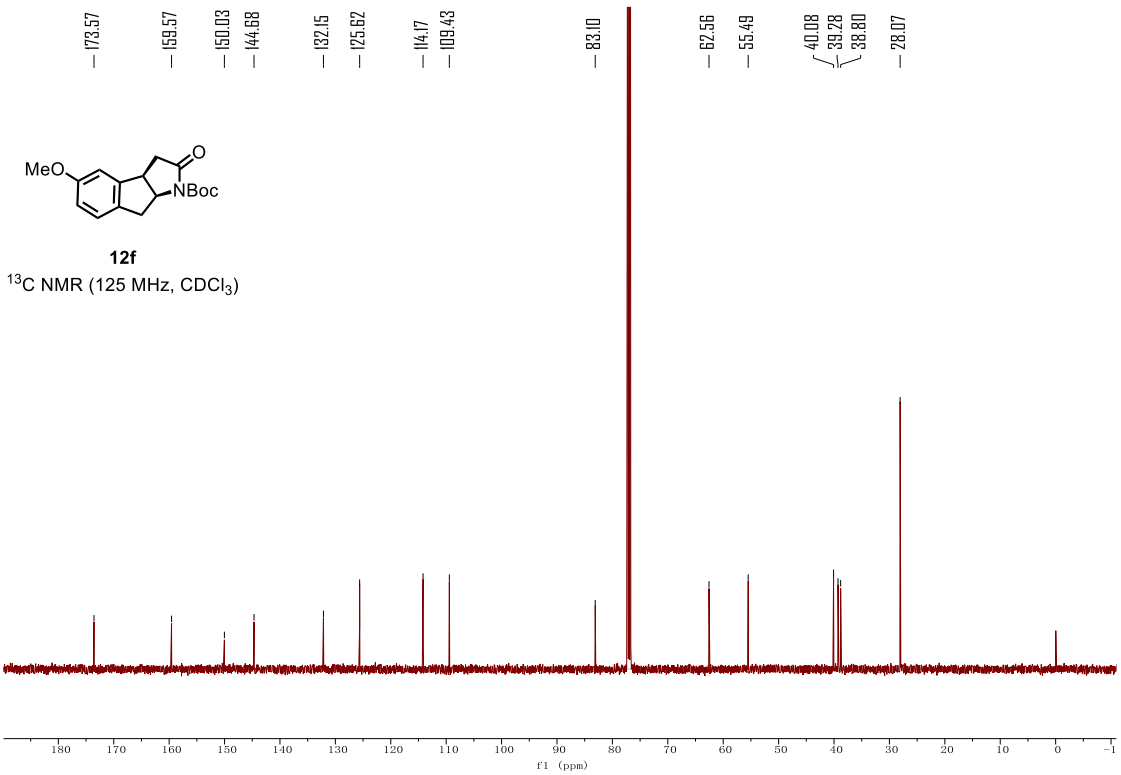
^{13}C NMR (125 MHz, $CDCl_3$)





11f

^{1}H NMR (400 MHz, $CDCl_3$)

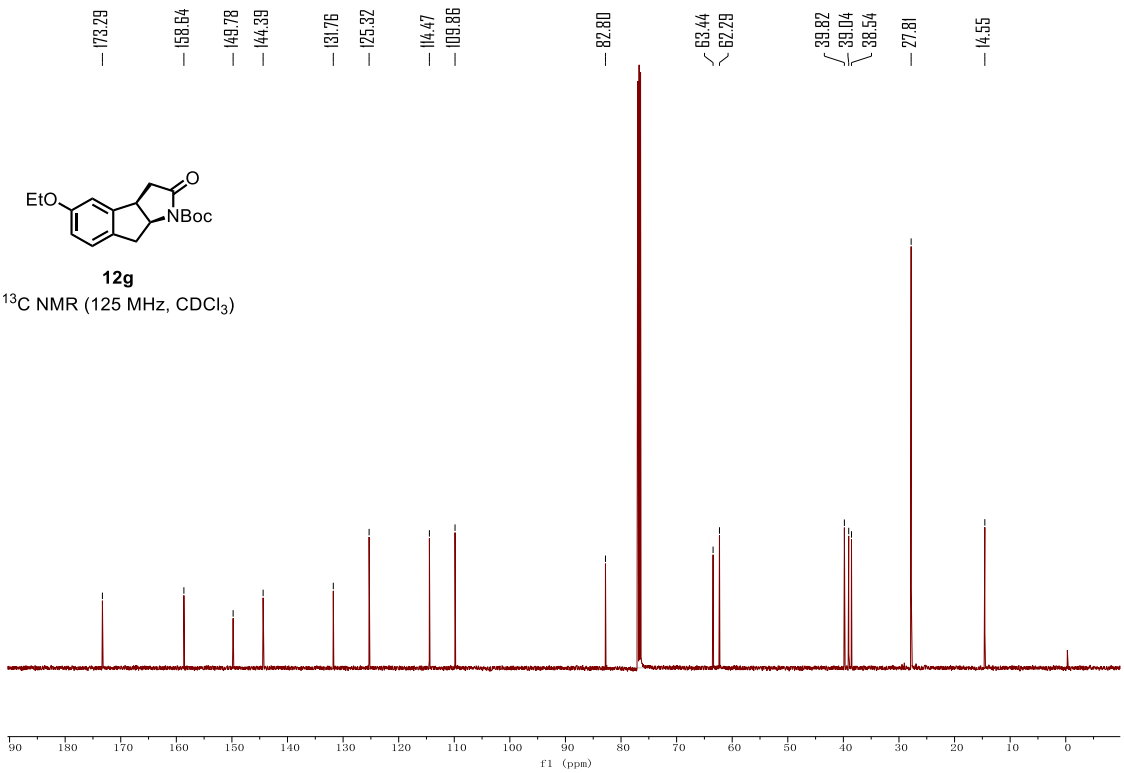


12f

^{13}C NMR (125 MHz, $CDCl_3$)

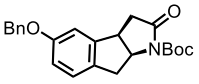
11g

^{1}H NMR (400 MHz, $CDCl_3$)



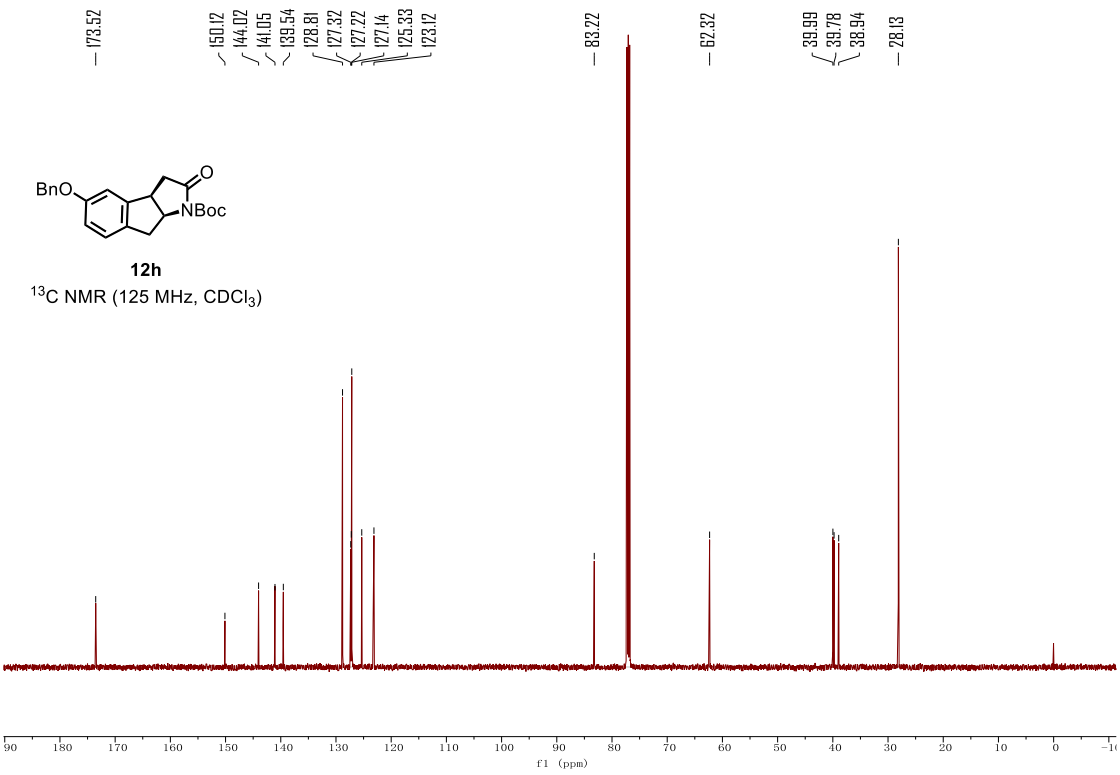
12g

^{13}C NMR (125 MHz, $CDCl_3$)



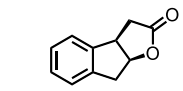
11h

^{1}H NMR (400 MHz, $CDCl_3$)



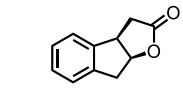
12h

^{13}C NMR (125 MHz, $CDCl_3$)



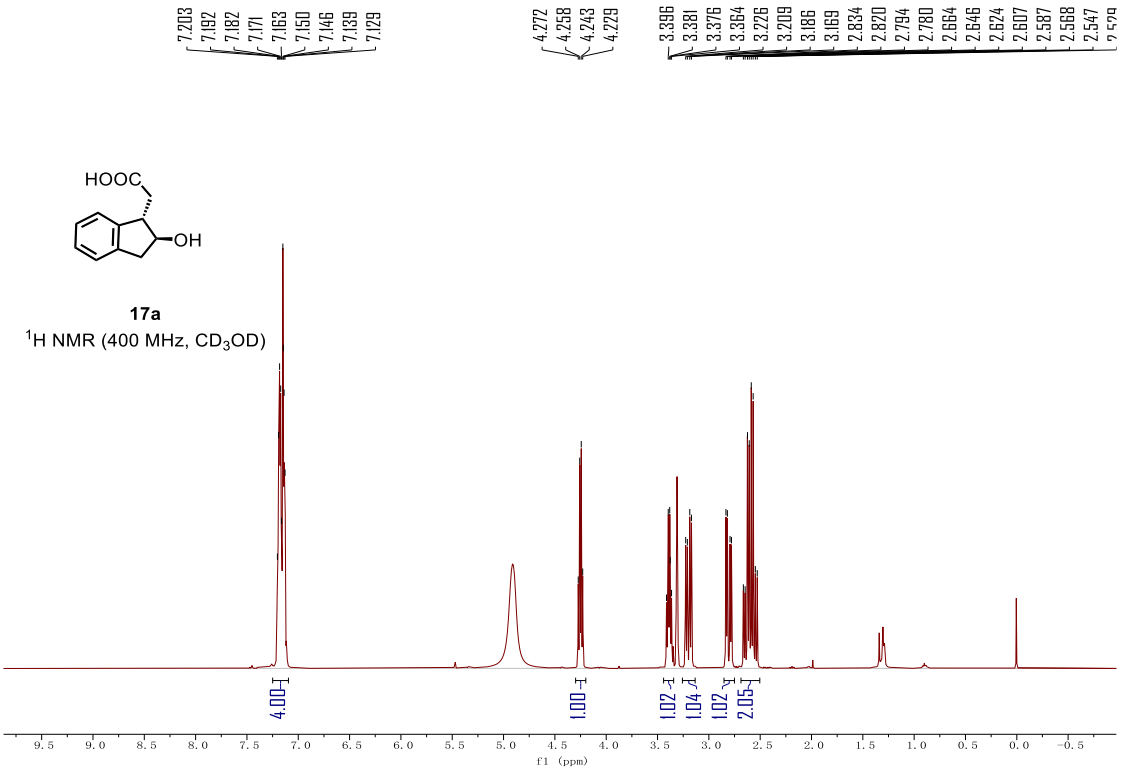
18a

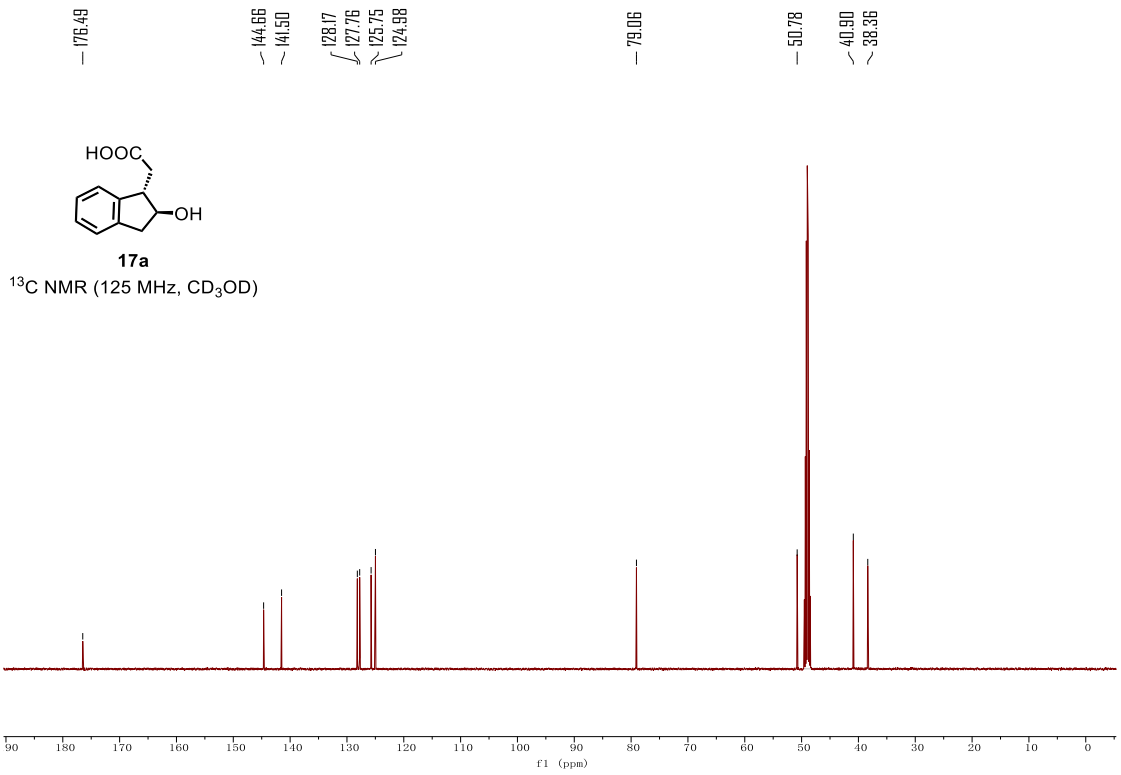
^{1}H NMR (400 MHz, $CDCl_3$)

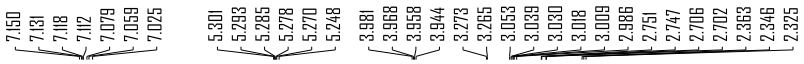


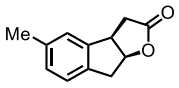
18a

^{13}C NMR (125 MHz, $CDCl_3$)


7.203
7.192
7.182
7.171
7.163
7.150
7.146
7.139
7.129
4.272
4.258
4.243
4.229
3.396
3.381
3.376
3.364
3.226
3.209
3.186
3.169
2.834
2.820
2.794
2.780
2.664
2.646
2.624
2.607
2.587
2.568
2.547
HOOC
OH
17a
1H NMR (400 MHz, CD3OD)
4.00
1.00
1.02
1.04
1.02
2.05
f1 (ppm)

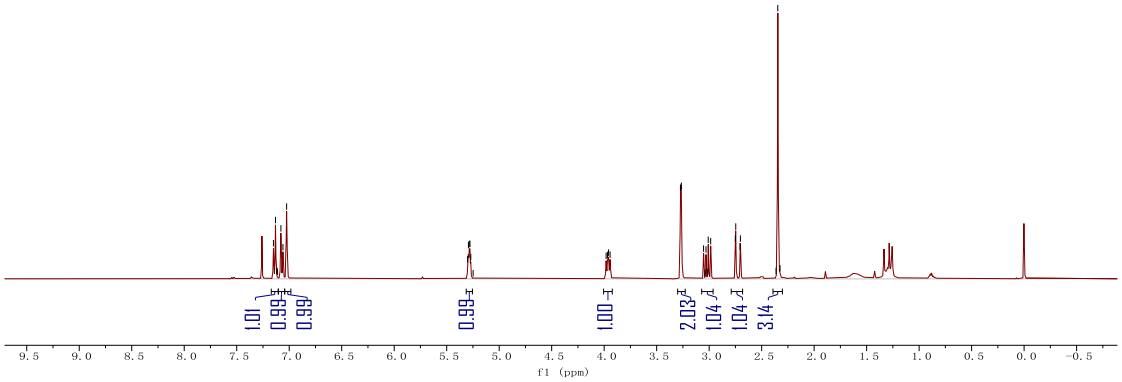

176.49
144.66
141.50
128.17
127.76
125.75
124.98
79.06
50.78
40.90
38.36
HOOC
OH
17a
13C NMR (125 MHz, CD3OD)
f1 (ppm)

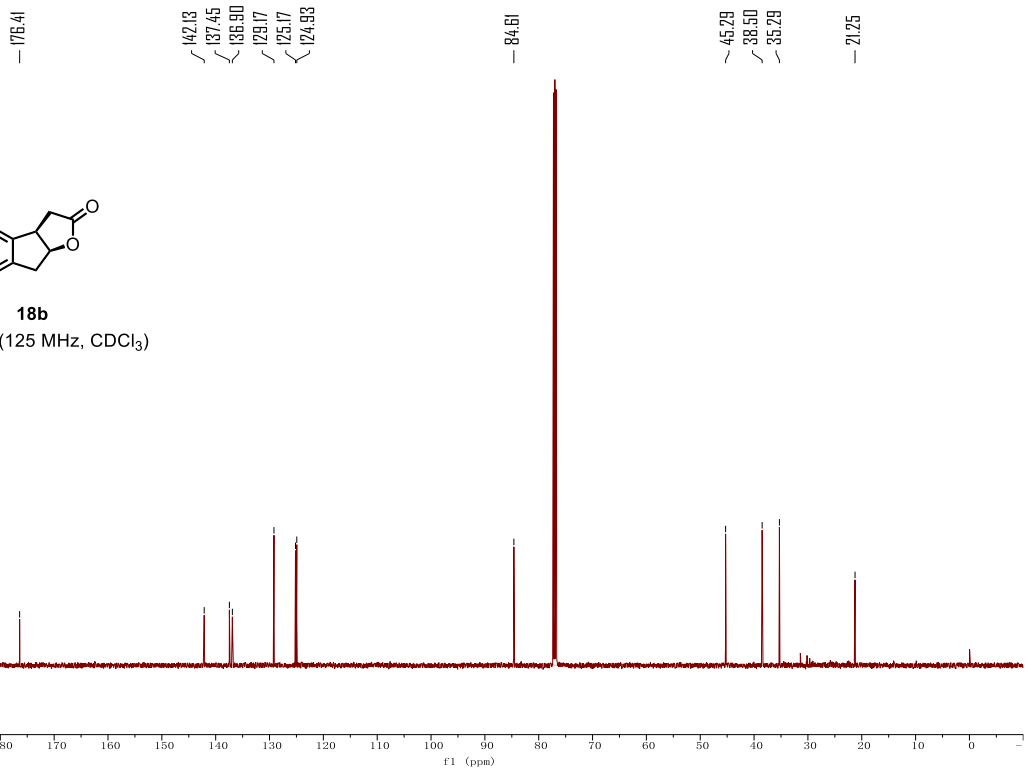




18b

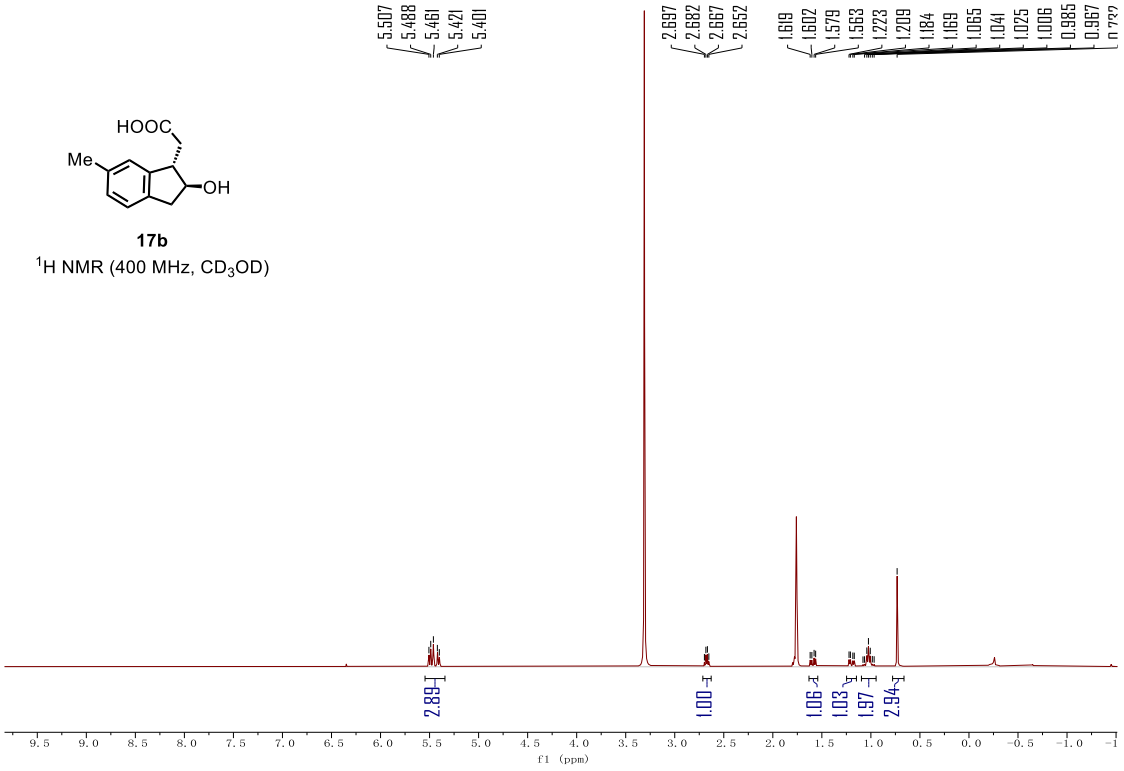
^{1}H NMR (400 MHz, $CDCl_3$)





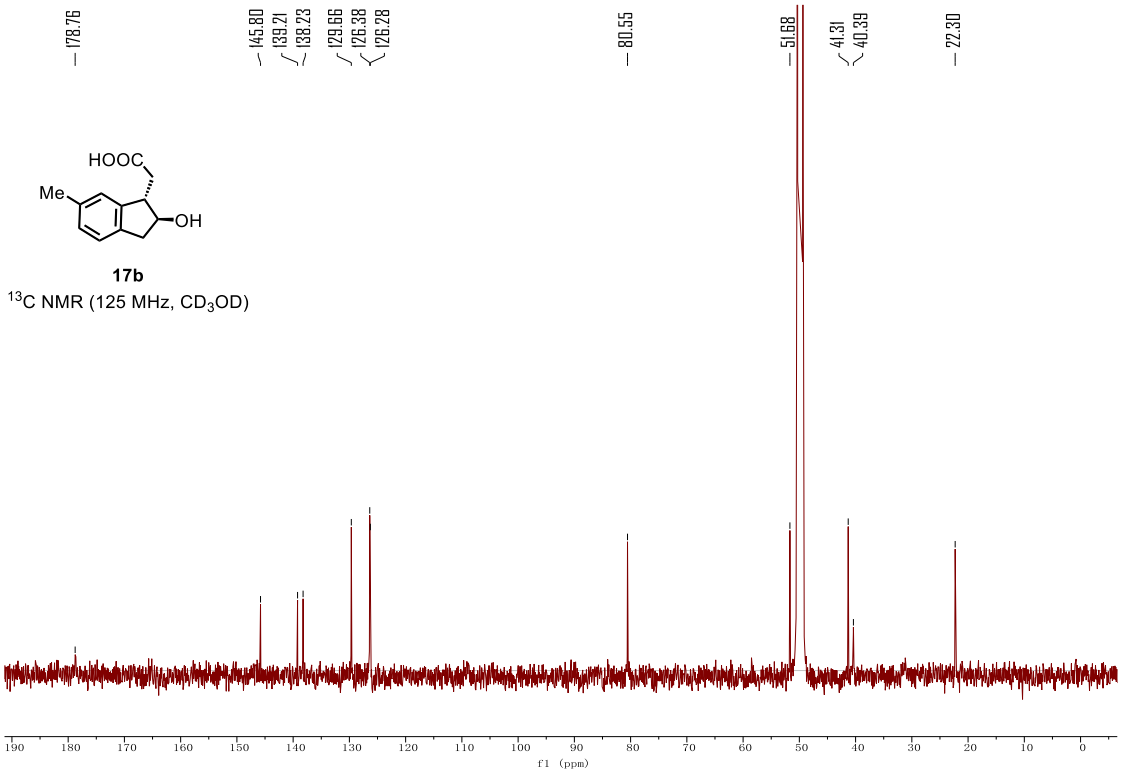
18b

^{13}C NMR (125 MHz, $CDCl_3$)



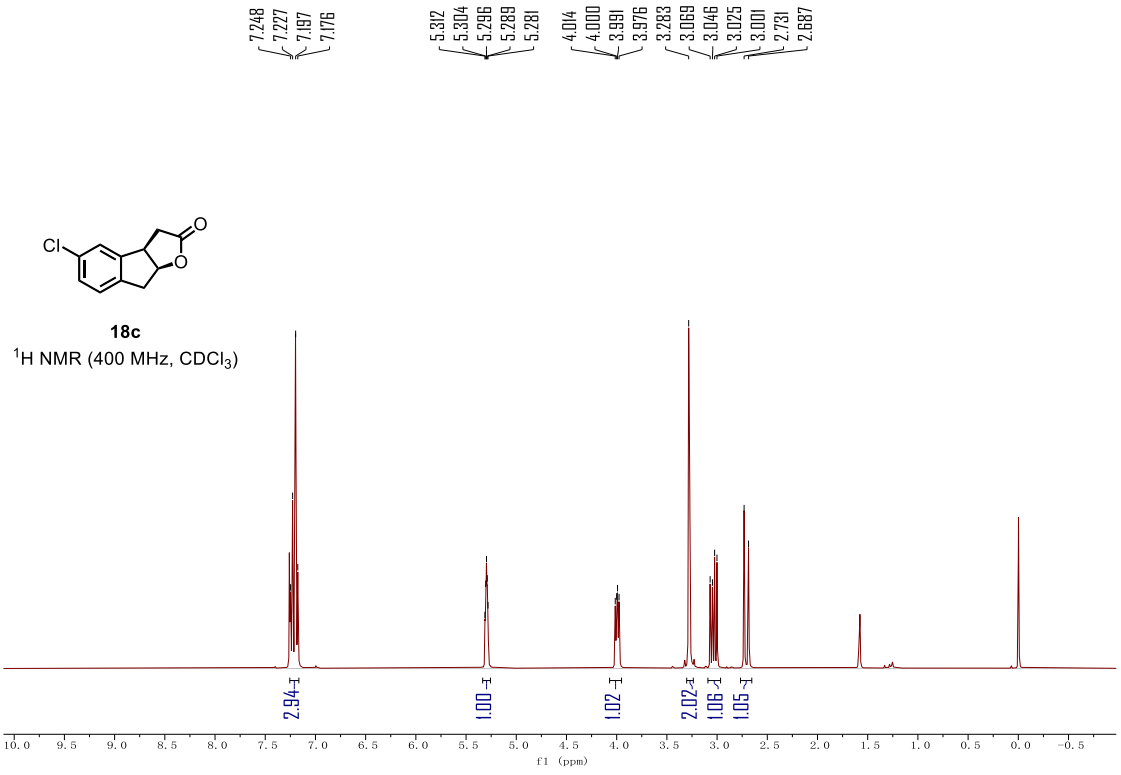
17b

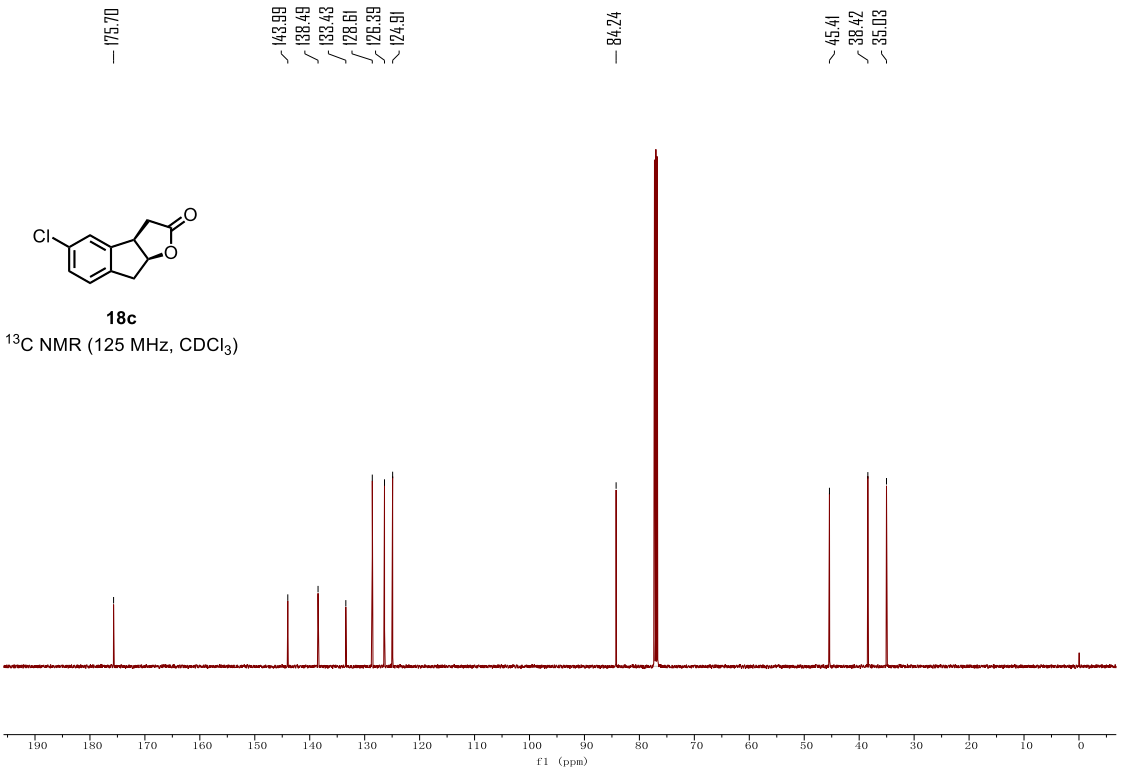
^{1}H NMR (400 MHz, CD_3OD)

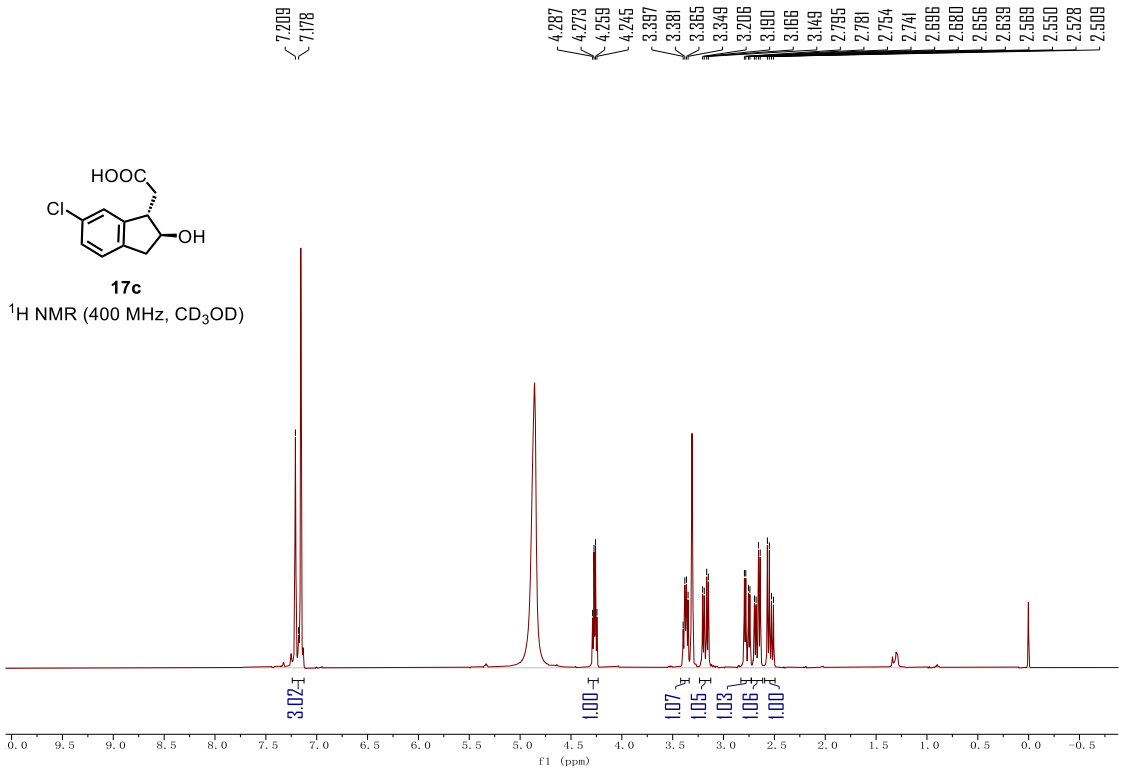


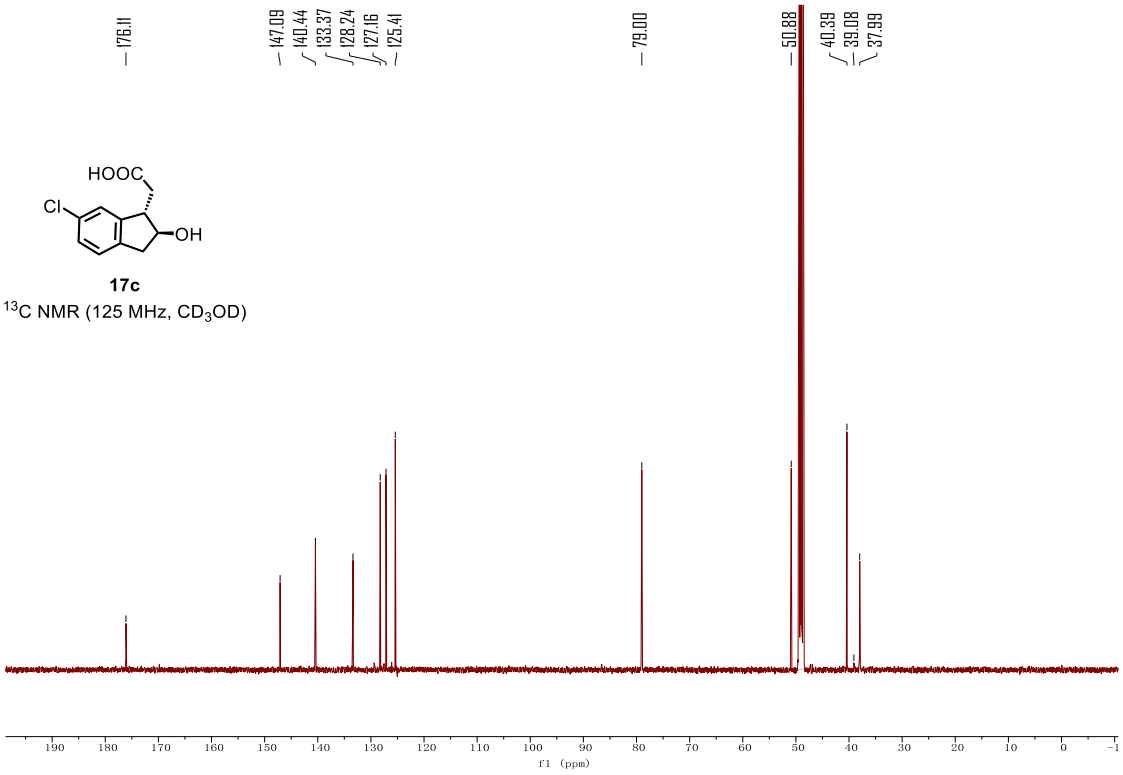
17b

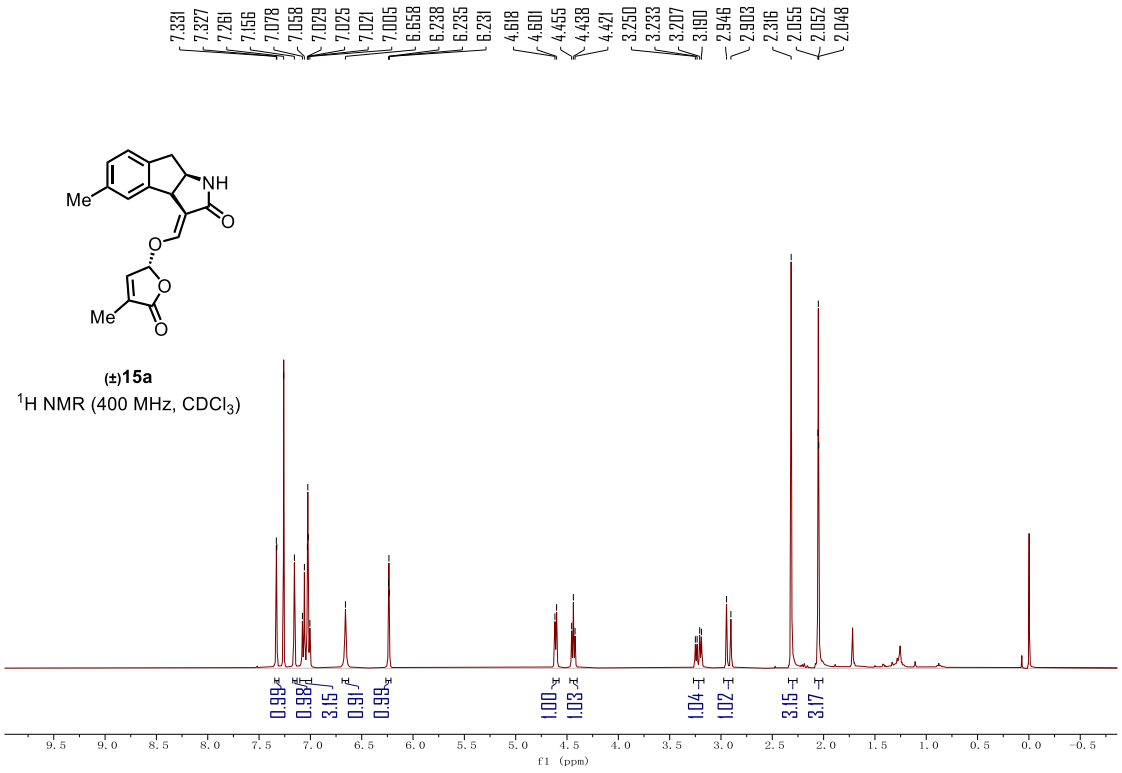
^{13}C NMR (125 MHz, CD_3OD)


7.248
7.227
7.197
7.176
5.312
5.304
5.296
5.289
5.281
4.014
4.000
3.991
3.976
3.283
3.069
3.046
3.025
3.001
2.731
2.687
Cl
O
O
18c
1H NMR (400 MHz, CDCl3)
2.94
1.00
1.02
2.02
1.06
1.05
f1 (ppm)


175.70
143.99
138.49
133.43
128.61
126.39
124.91
84.24
45.41
38.42
35.03
Cl
O
O
18c
13C NMR (125 MHz, CDCl3)
f1 (ppm)

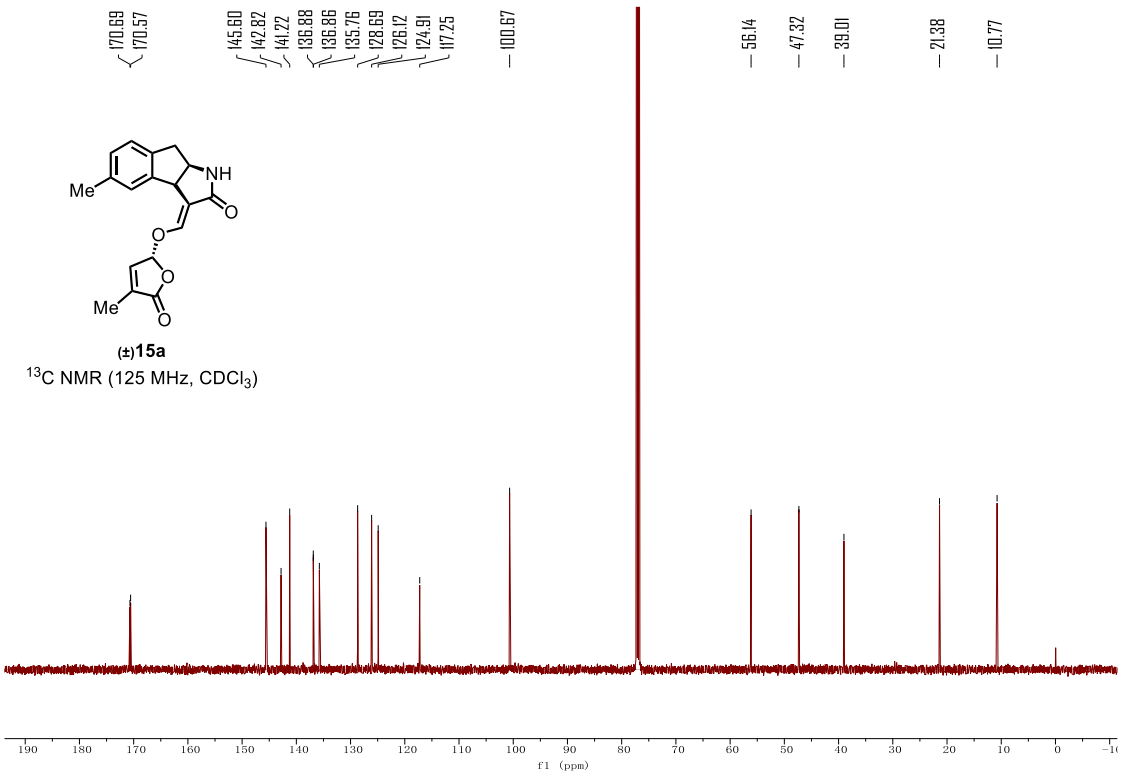

7.209
7.178
4.287
4.273
4.259
4.245
3.397
3.381
3.365
3.349
3.206
3.190
3.166
3.149
2.795
2.781
2.754
2.741
2.696
2.680
2.656
2.639
2.569
2.550
2.528
2.509
HOOC
Cl
OH
17c
1H NMR (400 MHz, CD3OD)
3.02
1.00
1.07
1.05
1.03
1.06
1.00
f1 (ppm)


176.11
147.09
140.44
133.37
128.24
127.16
125.41
79.00
50.88
40.39
39.08
37.99
HOOC
Cl
OH
17c
13C NMR (125 MHz, CD3OD)
f1 (ppm)



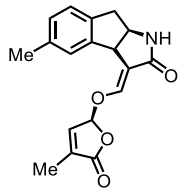
(±)15a

^{1}H NMR (400 MHz, $CDCl_3$)



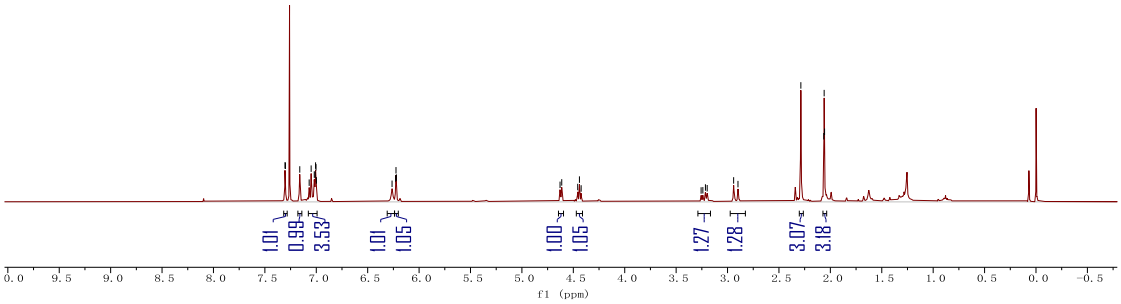
(±)15a

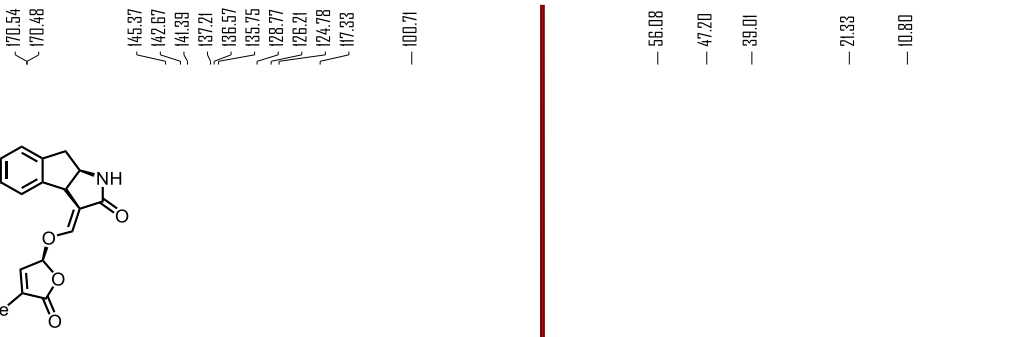
^{13}C NMR (125 MHz, $CDCl_3$)



(±)16a

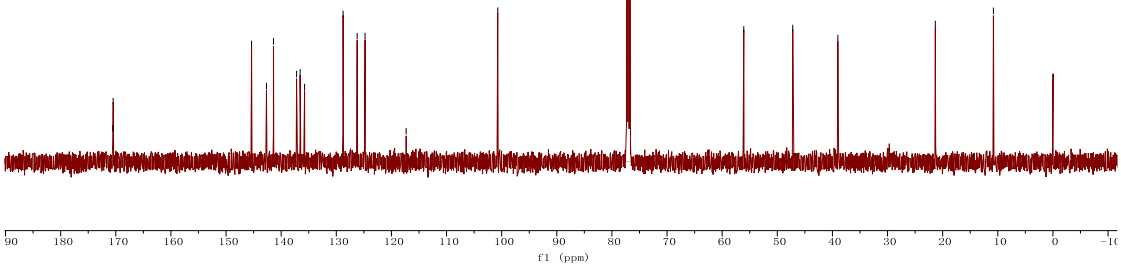
^{1}H NMR (400 MHz, $CDCl_3$)

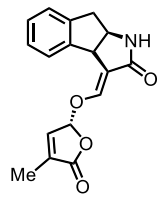




(±)16a

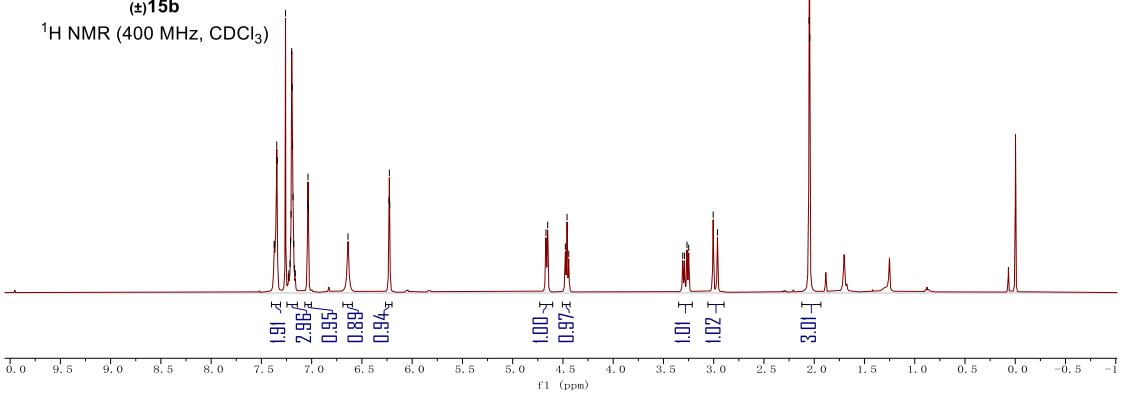
^{13}C NMR (125 MHz, $CDCl_3$)

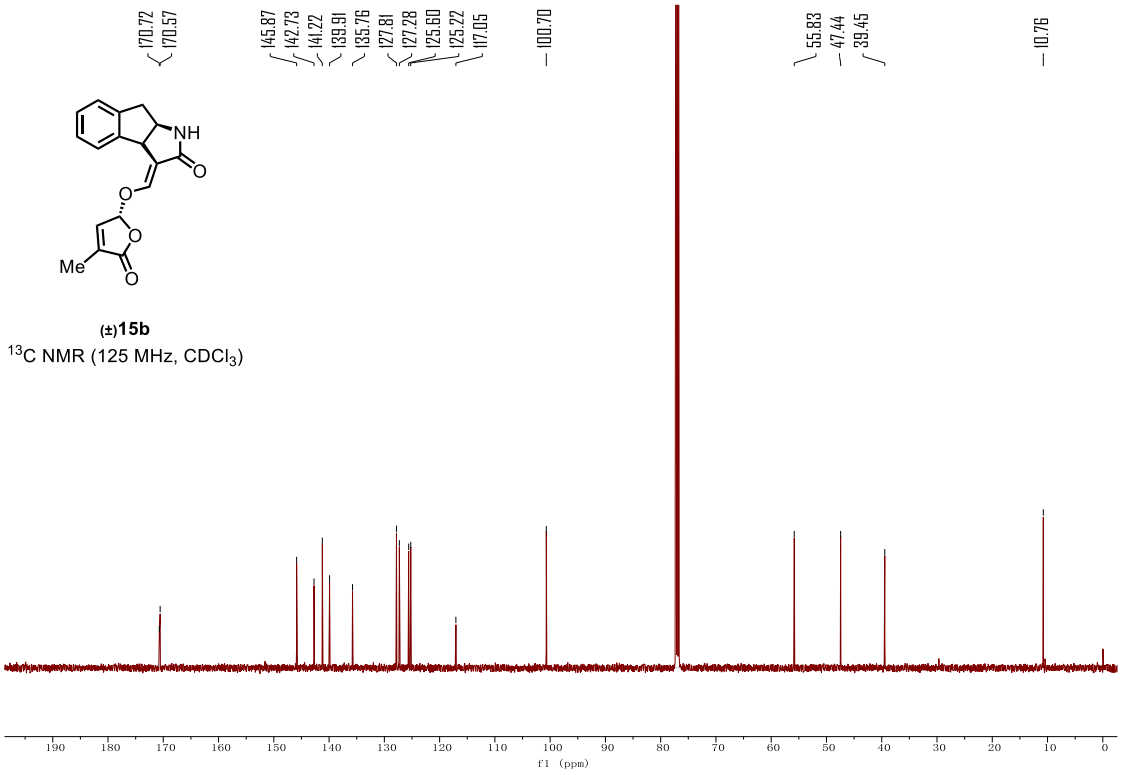




(±)15b

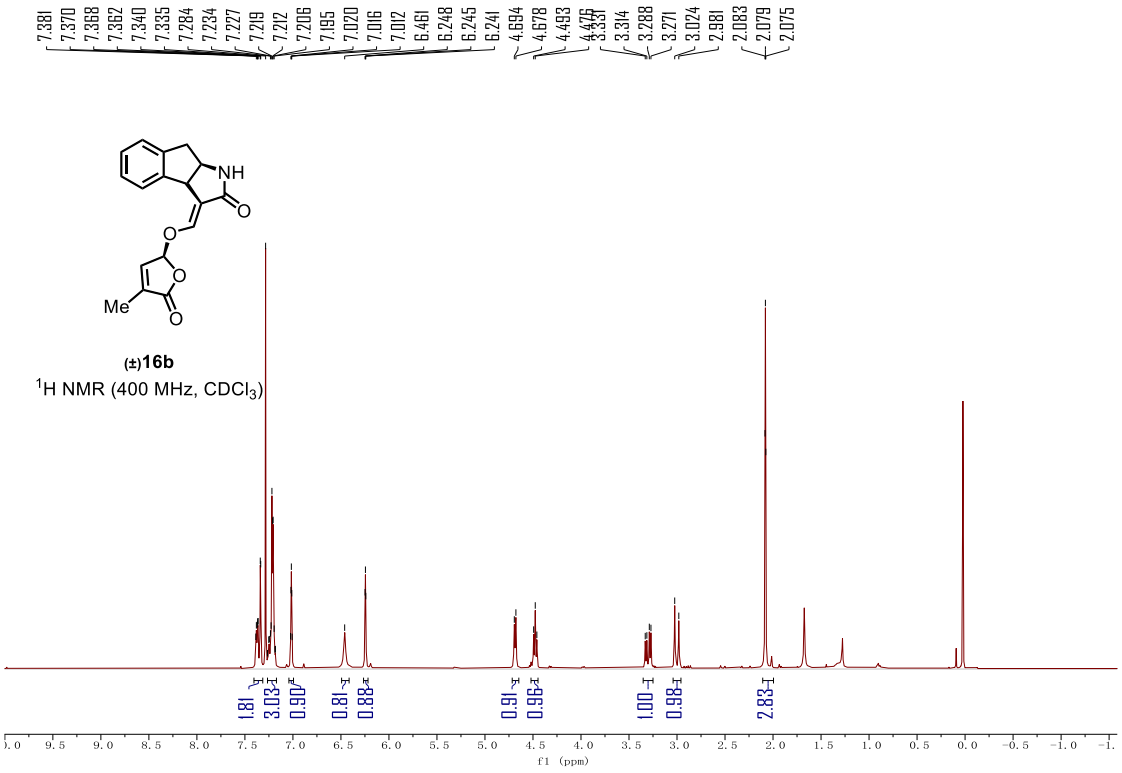
^{1}H NMR (400 MHz, $CDCl_3$)

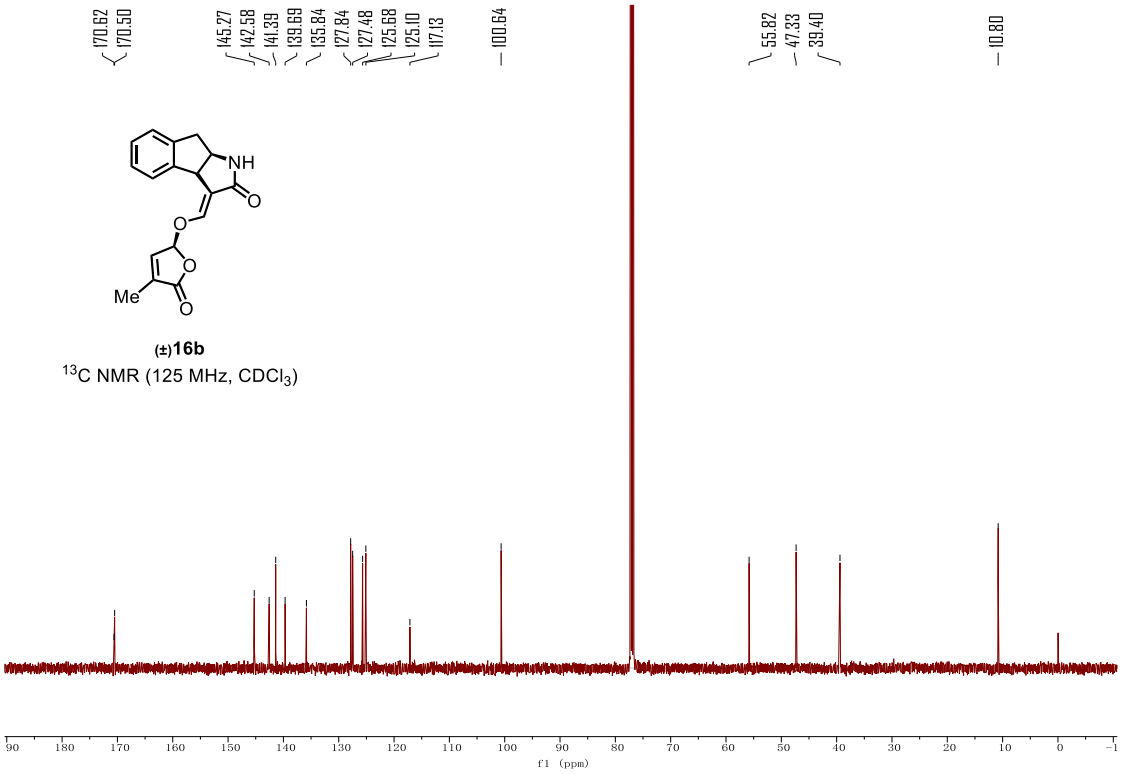


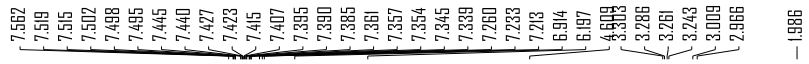


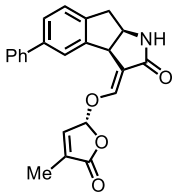
(±)15b

^{13}C NMR (125 MHz, $CDCl_3$)


7.381
7.370
7.368
7.362
7.340
7.335
7.284
7.234
7.227
7.219
7.212
7.206
7.195
7.020
7.016
7.012
6.461
6.248
6.245
6.241
4.694
4.678
4.493
4.476
3.331
3.314
3.288
3.271
3.024
2.981
2.083
2.079
2.075
NH
O
O
O
Me
O
(±)16b
1H NMR (400 MHz, CDCl3)
1.81
3.03
0.90
0.81
0.88
0.91
0.96
1.00
0.98
2.83
f1 (ppm)

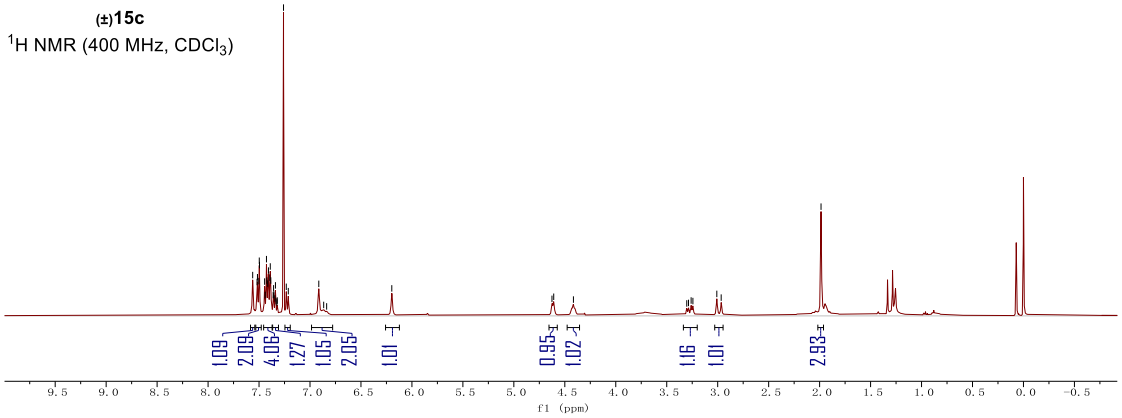

170.62
170.50
145.27
142.58
141.39
139.69
135.84
127.84
127.48
125.68
125.10
117.13
100.64
55.82
47.33
39.40
10.80
NH
O
O
O
Me
O
(±)16b
13C NMR (125 MHz, CDCl3)
f1 (ppm)

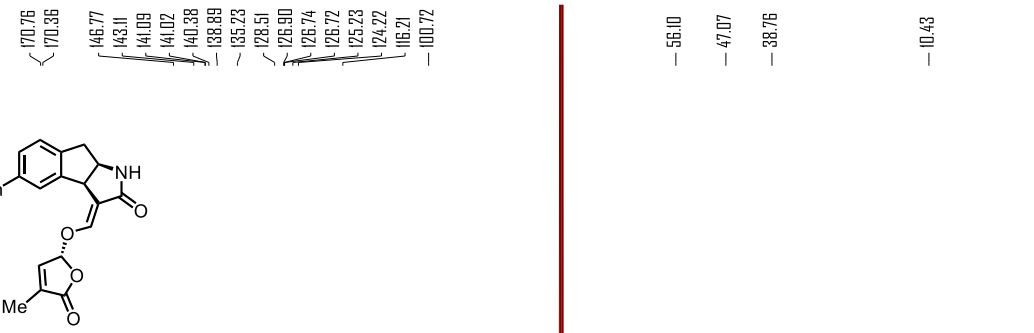




(±)15c

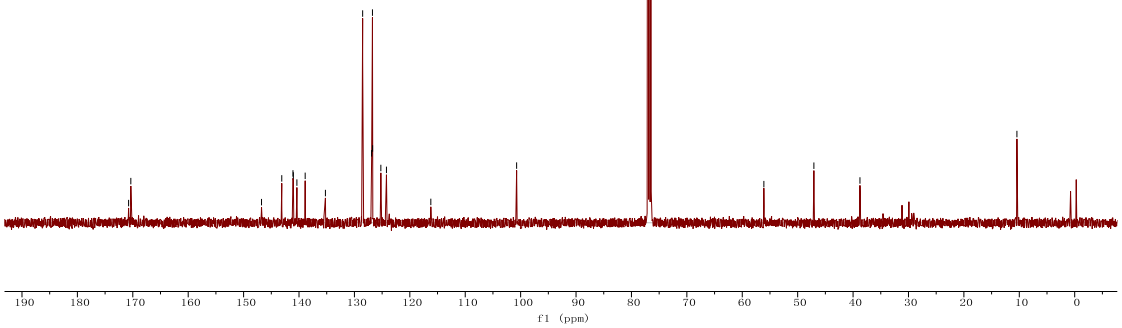
^{1}H NMR (400 MHz, $CDCl_3$)

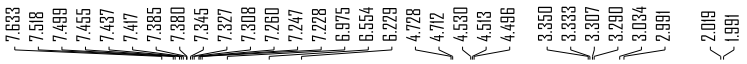


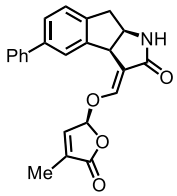


(±)15c

^{13}C NMR (125 MHz, $CDCl_3$)

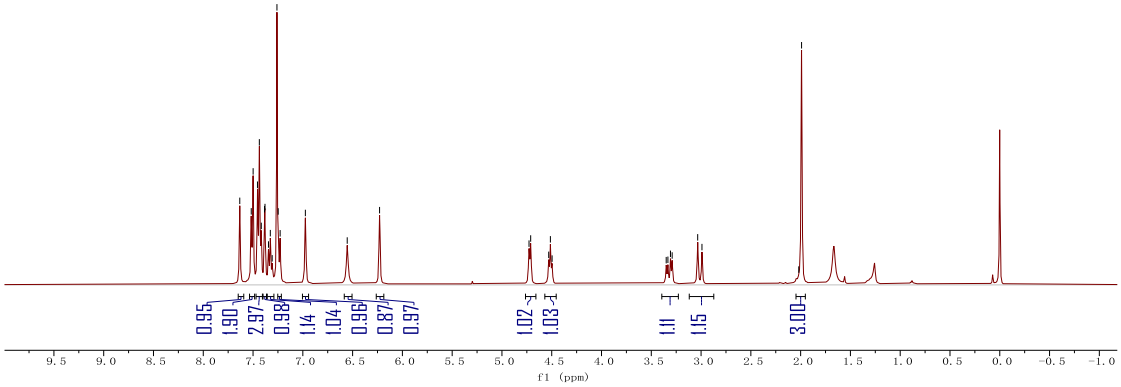


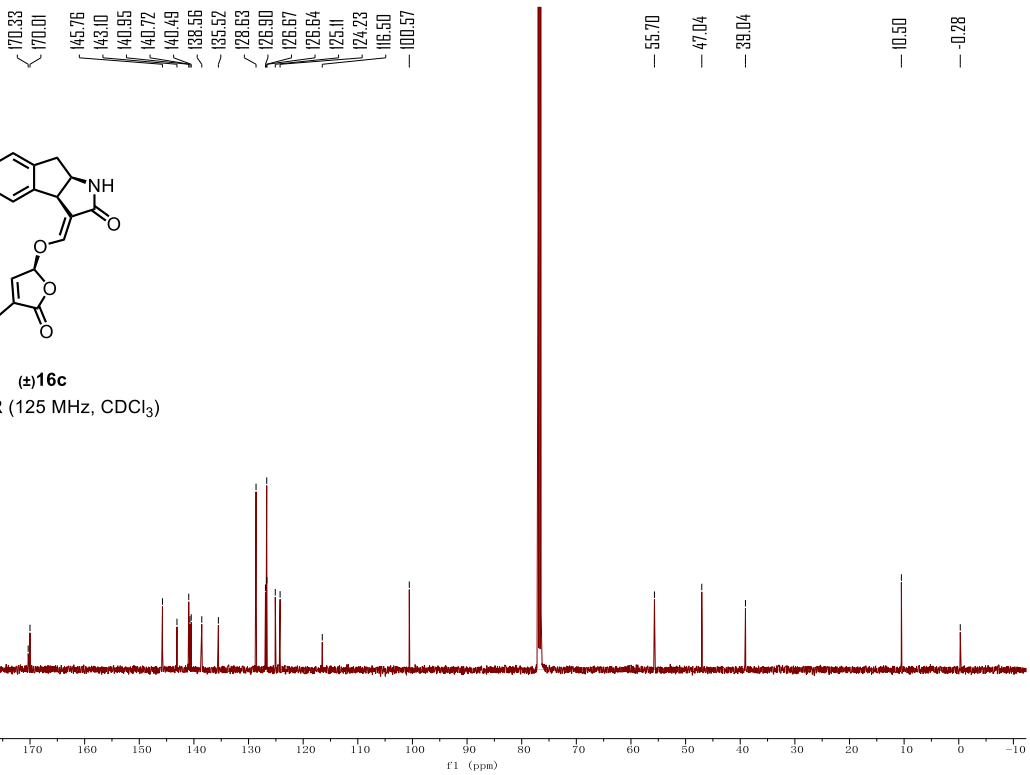




(±)16c

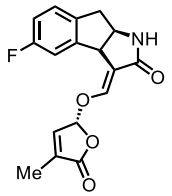
^{1}H NMR (400 MHz, $CDCl_3$)





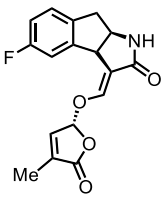
(±)16c

^{13}C NMR (125 MHz, $CDCl_3$)



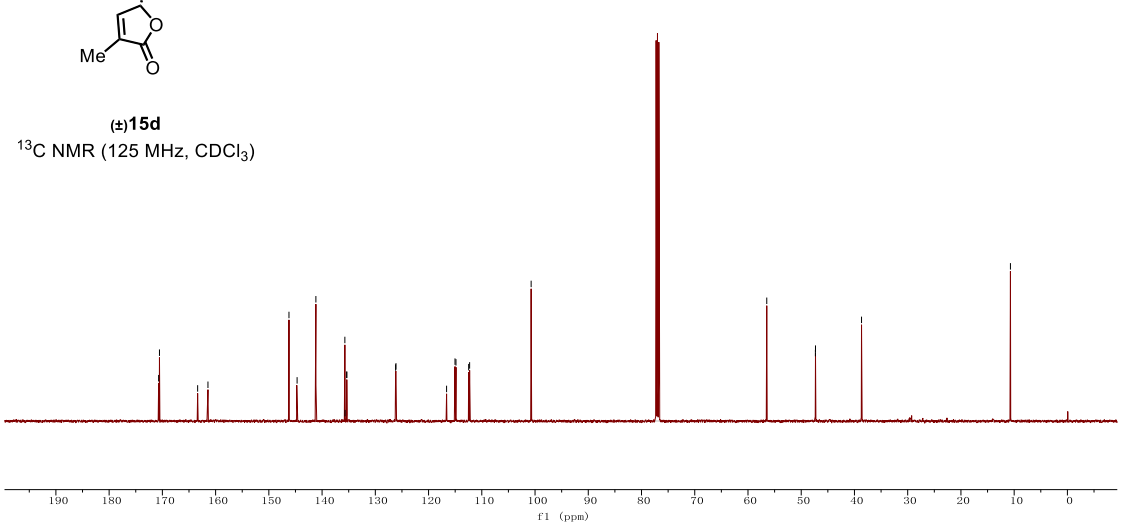
(±)15d

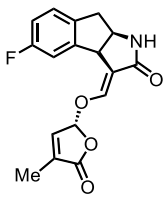
^{1}H NMR (400 MHz, $CDCl_3$)



(±)15d

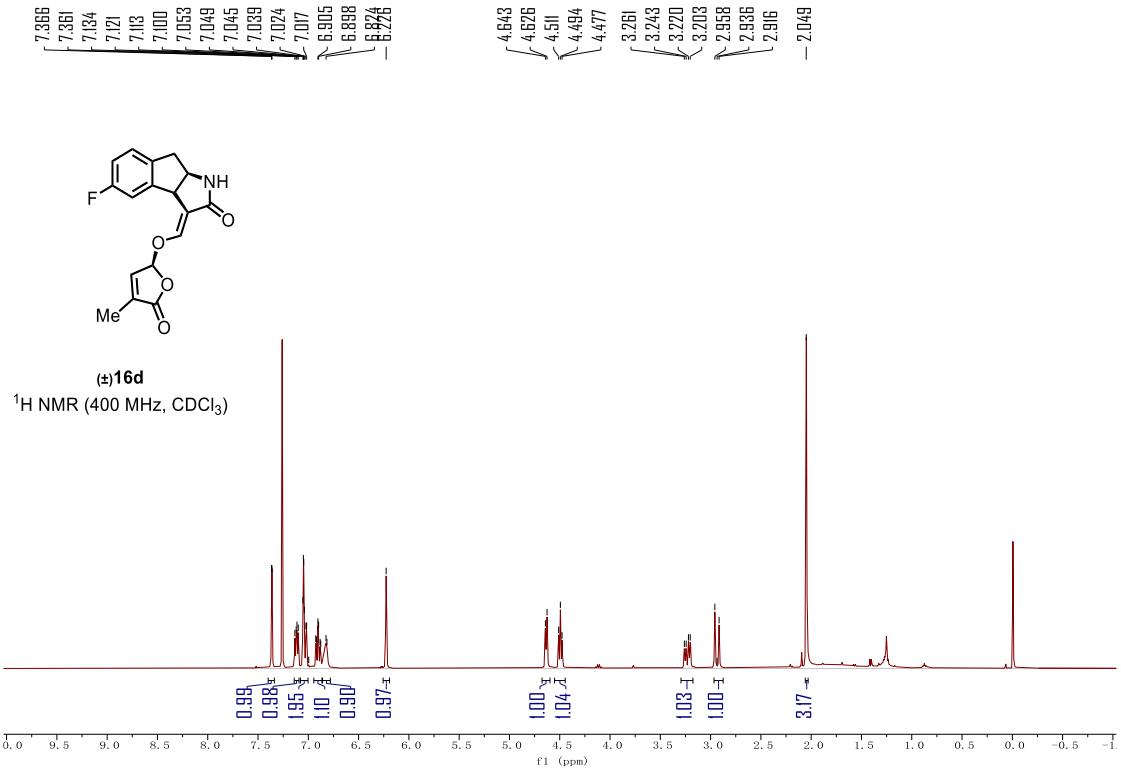
^{13}C NMR (125 MHz, $CDCl_3$)





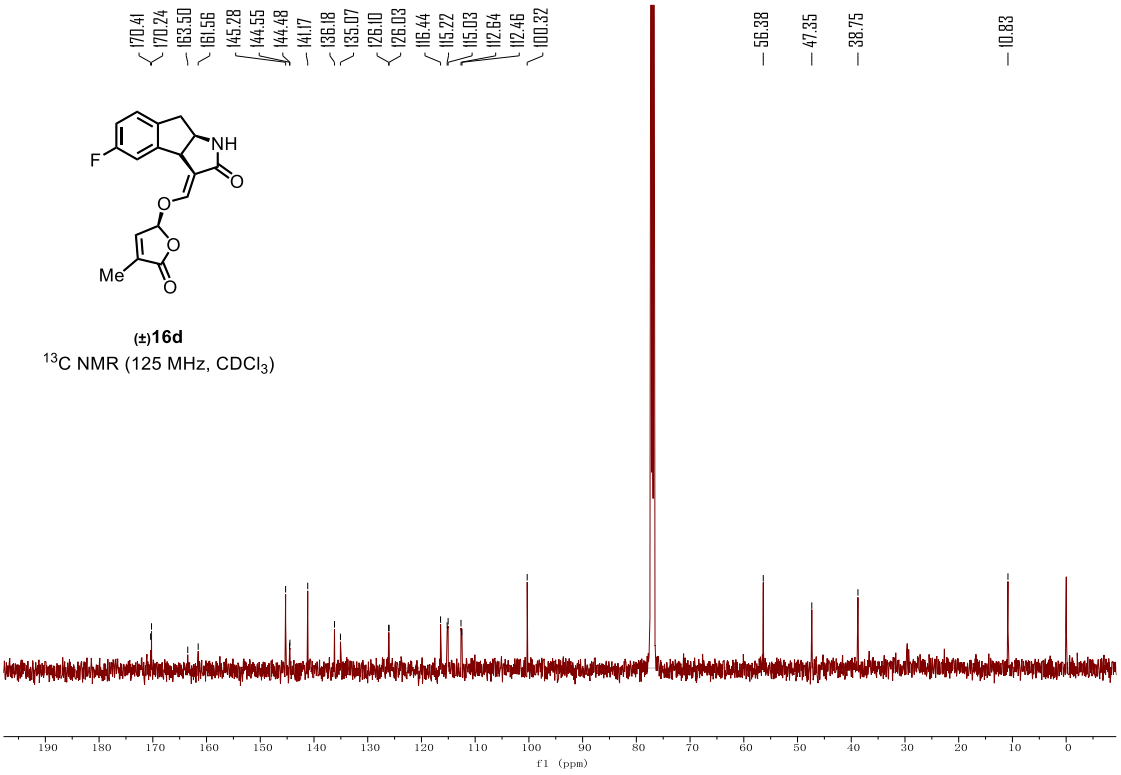
(±)15d

^{19}F NMR (375 MHz, $CDCl_3$)



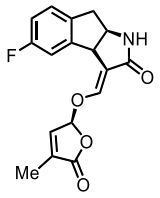
(±)16d

^{1}H NMR (400 MHz, $CDCl_3$)



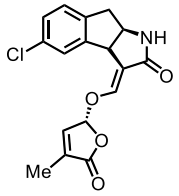
(±)16d

^{13}C NMR (125 MHz, $CDCl_3$)



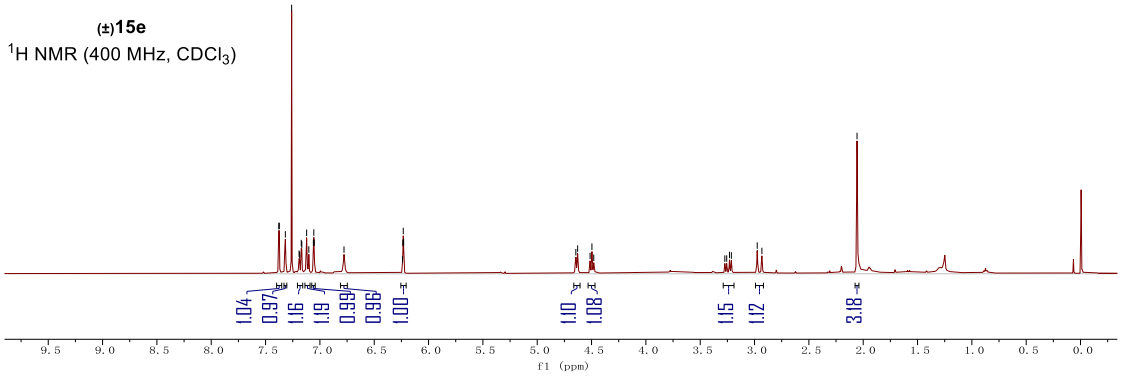
(±)16d

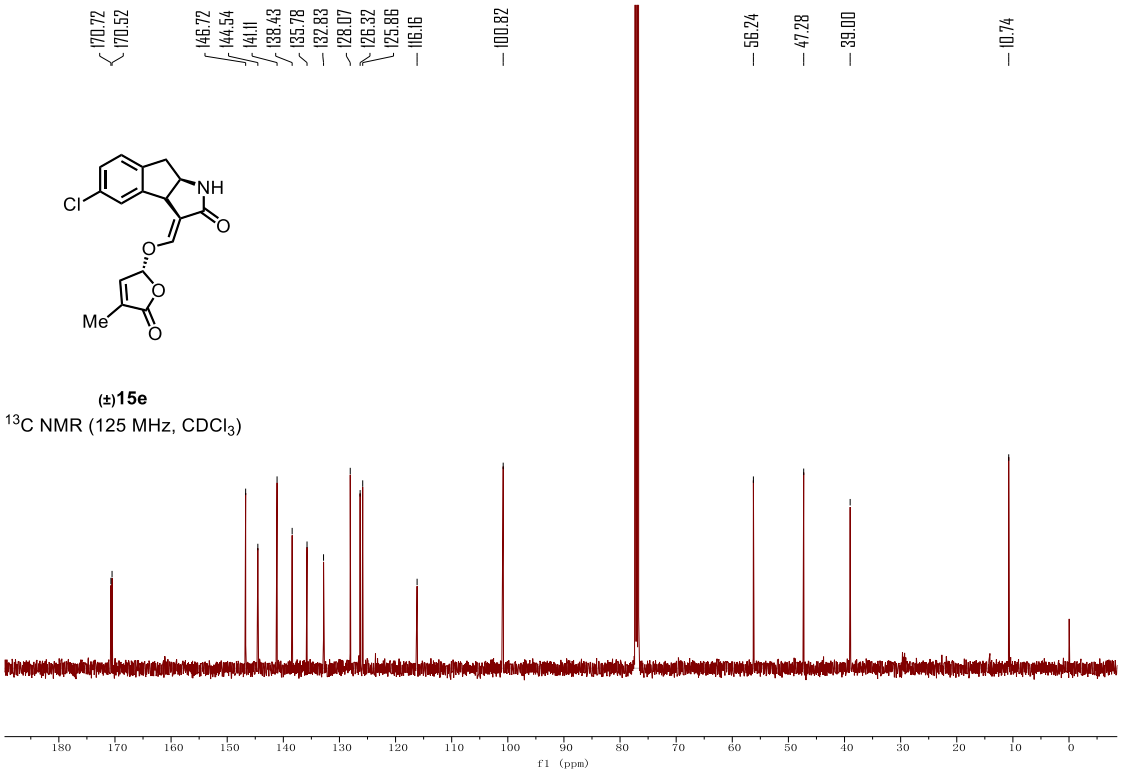
^{19}F NMR (375 MHz, $CDCl_3$)



(±)15e

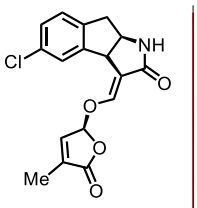
^{1}H NMR (400 MHz, $CDCl_3$)





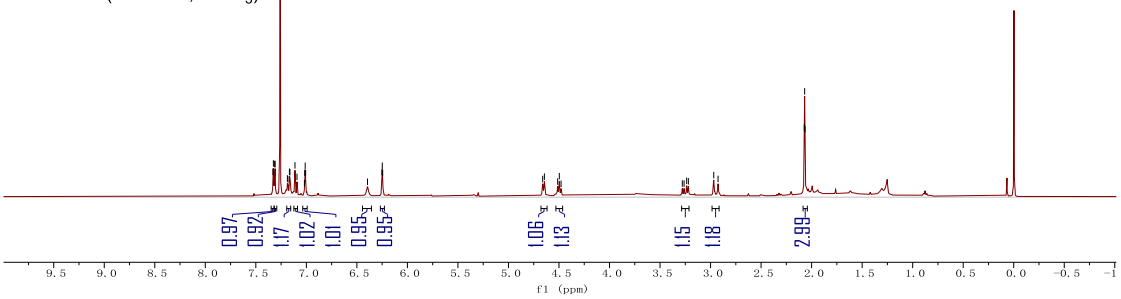
(±)15e

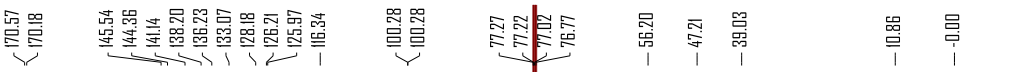
^{13}C NMR (125 MHz, $CDCl_3$)

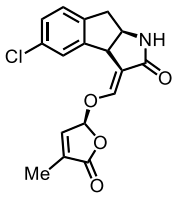


(±)16e

^{1}H NMR (400 MHz, $CDCl_3$)

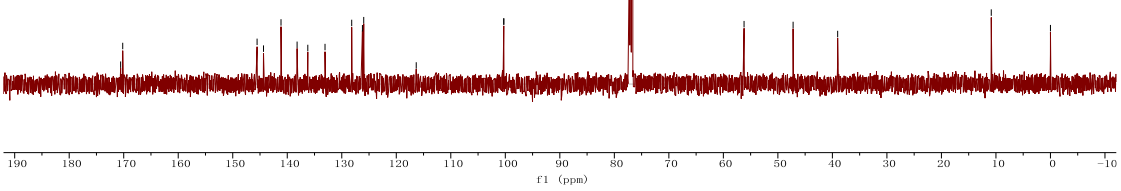


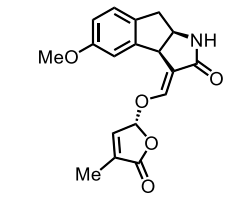




(±)16e

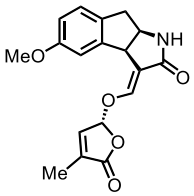
^{13}C NMR (125 MHz, $CDCl_3$)





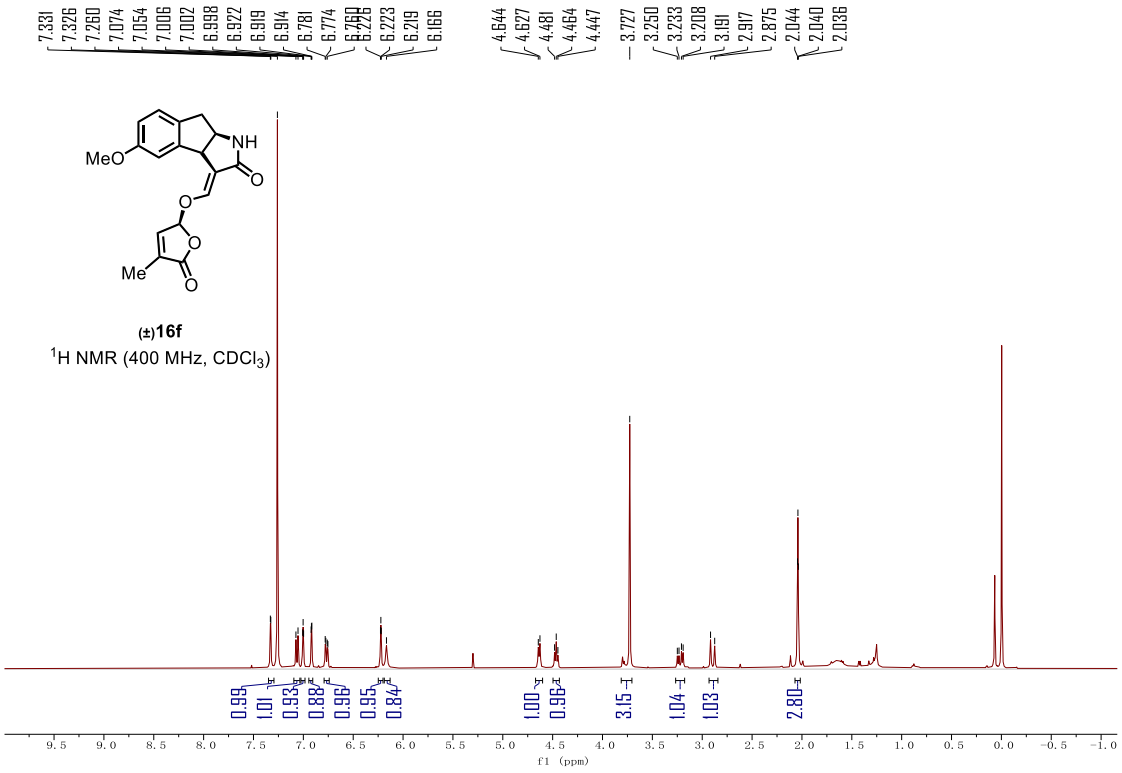
(±)15f

^{1}H NMR (400 MHz, $CDCl_3$)



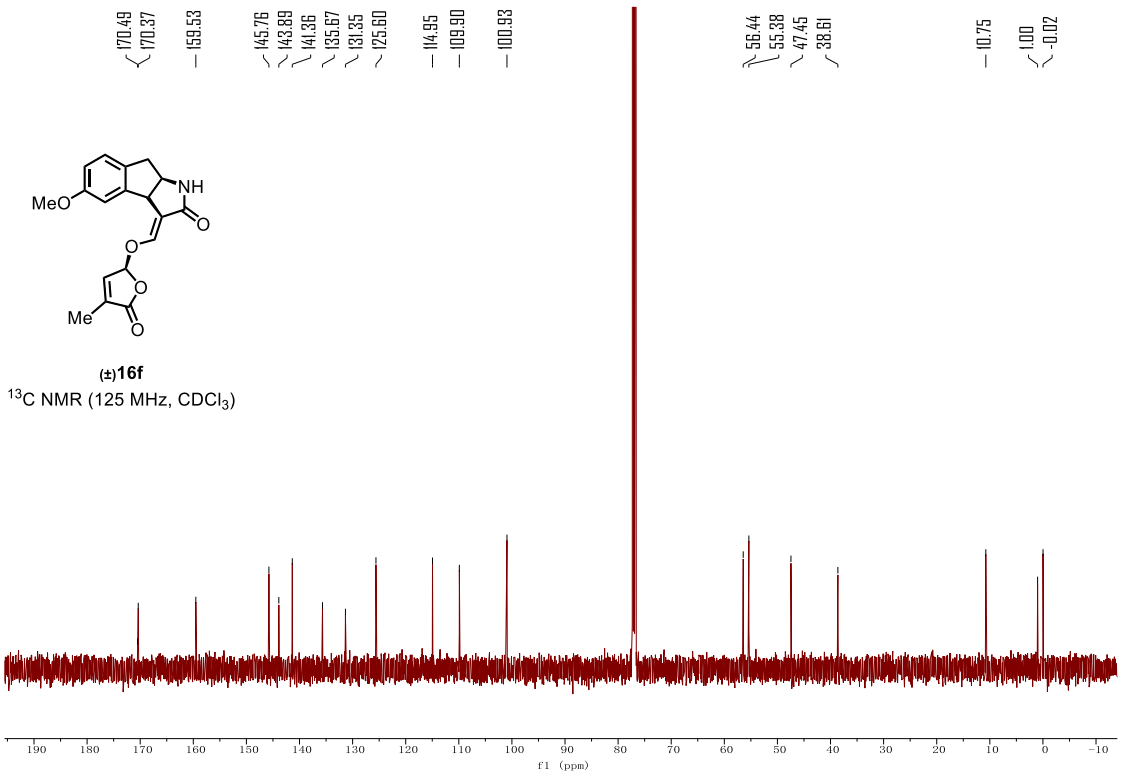
(±)15f

^{13}C NMR (125 MHz, $CDCl_3$)



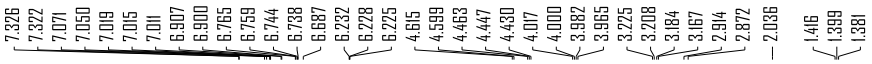
(±)16f

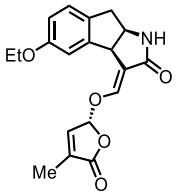
^{1}H NMR (400 MHz, $CDCl_3$)



(±)16f

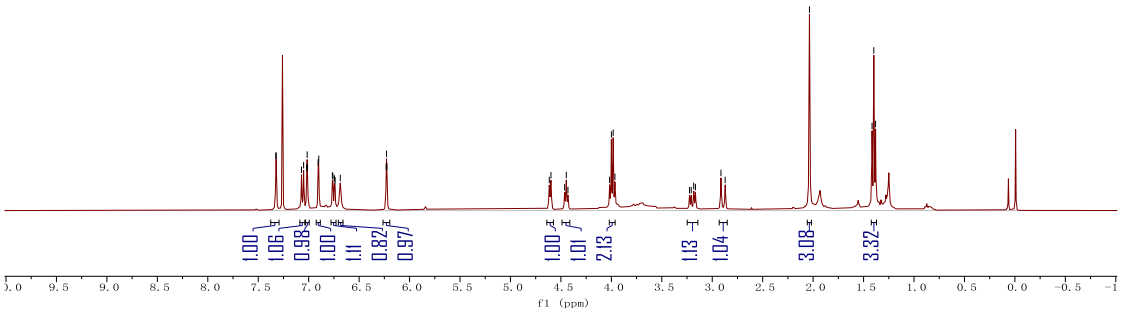
^{13}C NMR (125 MHz, $CDCl_3$)

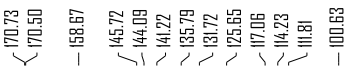


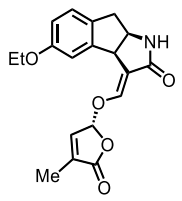


(±)15g

^{1}H NMR (400 MHz, $CDCl_3$)

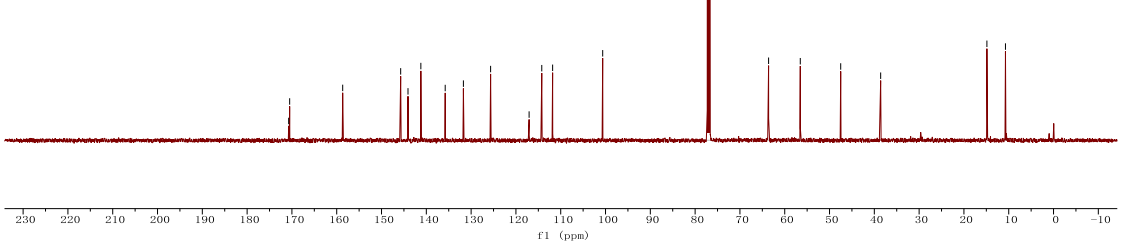


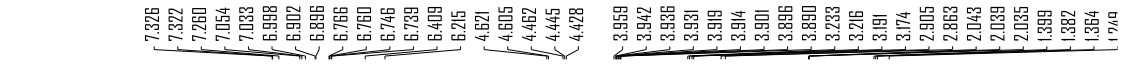


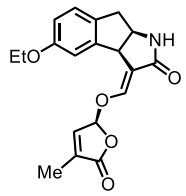


(±)15g

^{13}C NMR (125 MHz, $CDCl_3$)

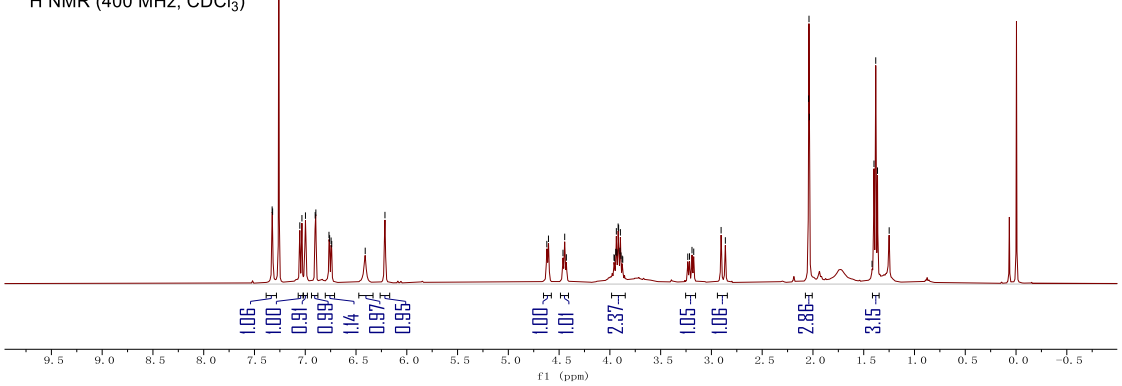


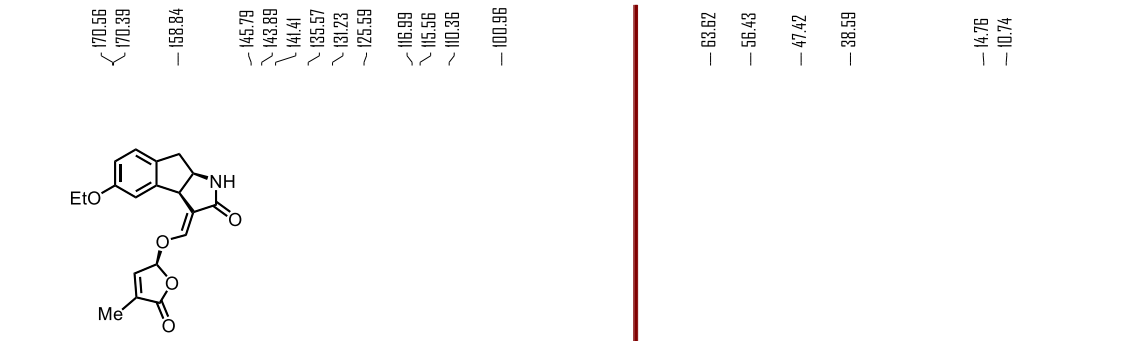




(±)16g

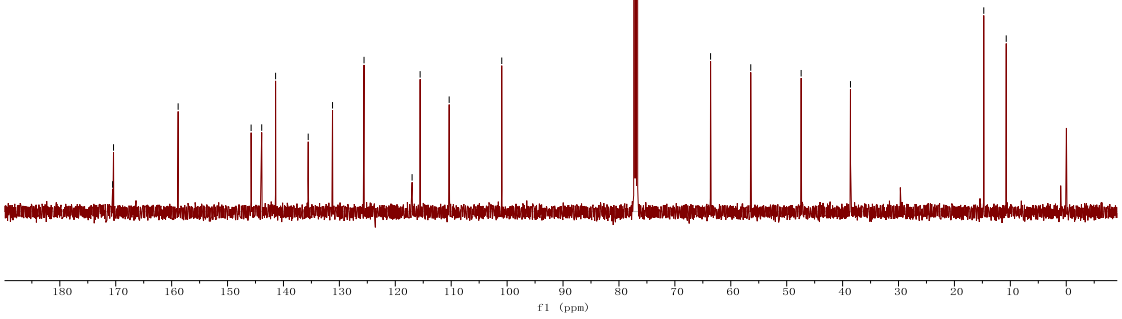
^{1}H NMR (400 MHz, $CDCl_3$)

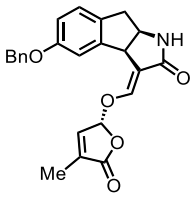




(±)16g

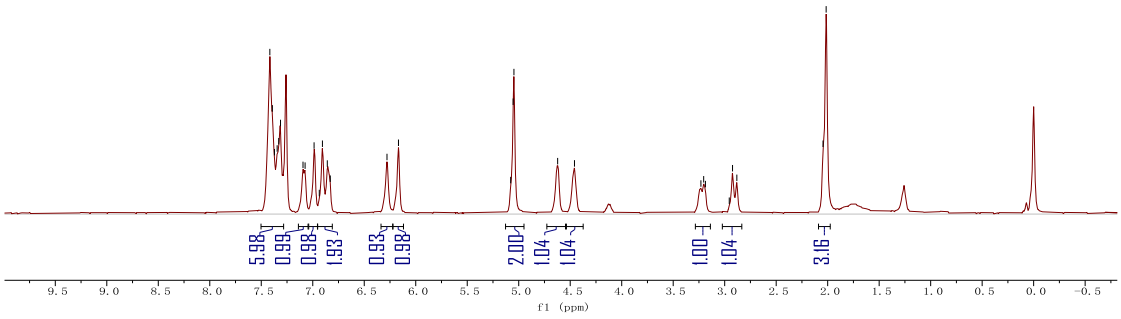
^{13}C NMR (125 MHz, $CDCl_3$)

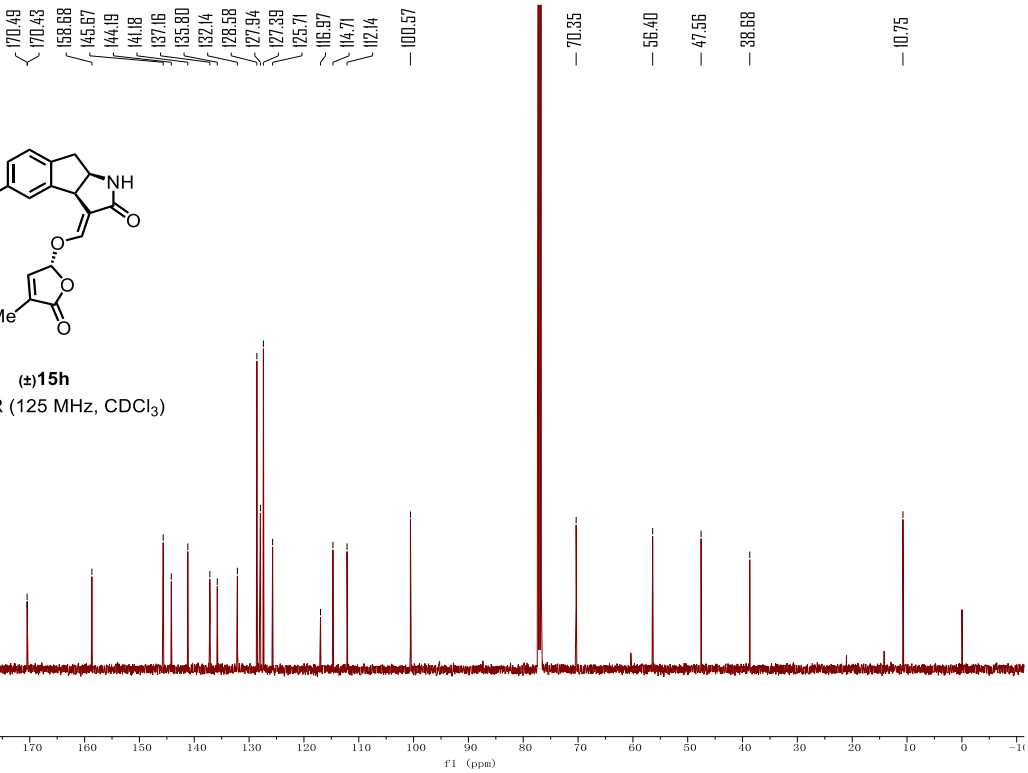




(±)15h

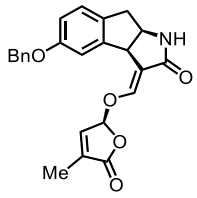
^{1}H NMR (400 MHz, $CDCl_3$)





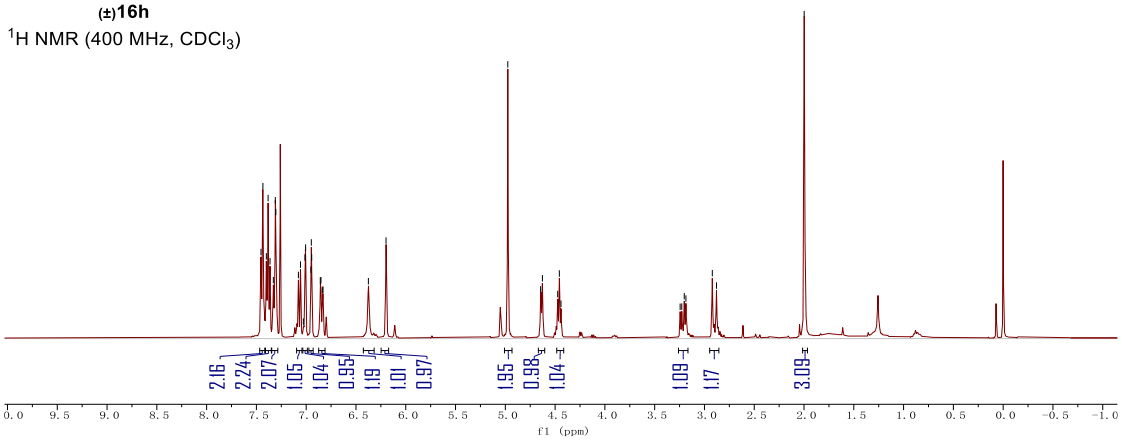
(±)15h

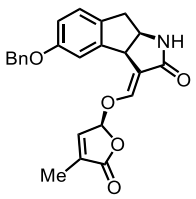
^{13}C NMR (125 MHz, $CDCl_3$)



(±)16h

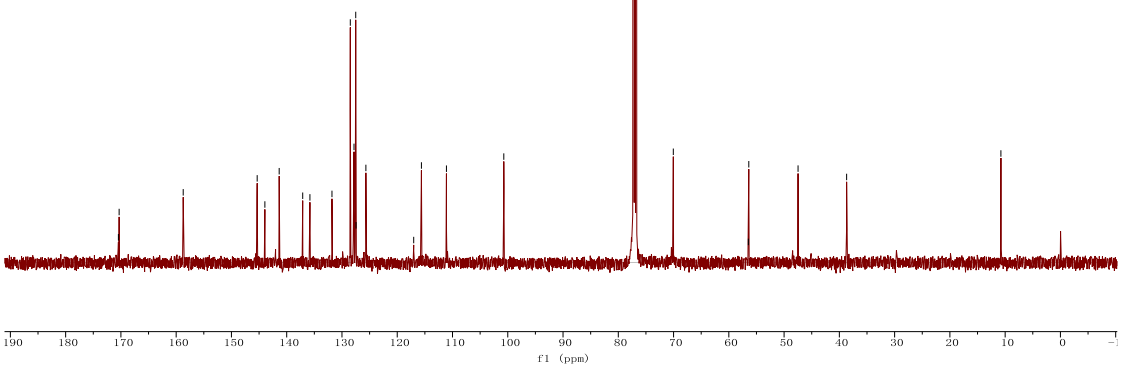
^{1}H NMR (400 MHz, $CDCl_3$)

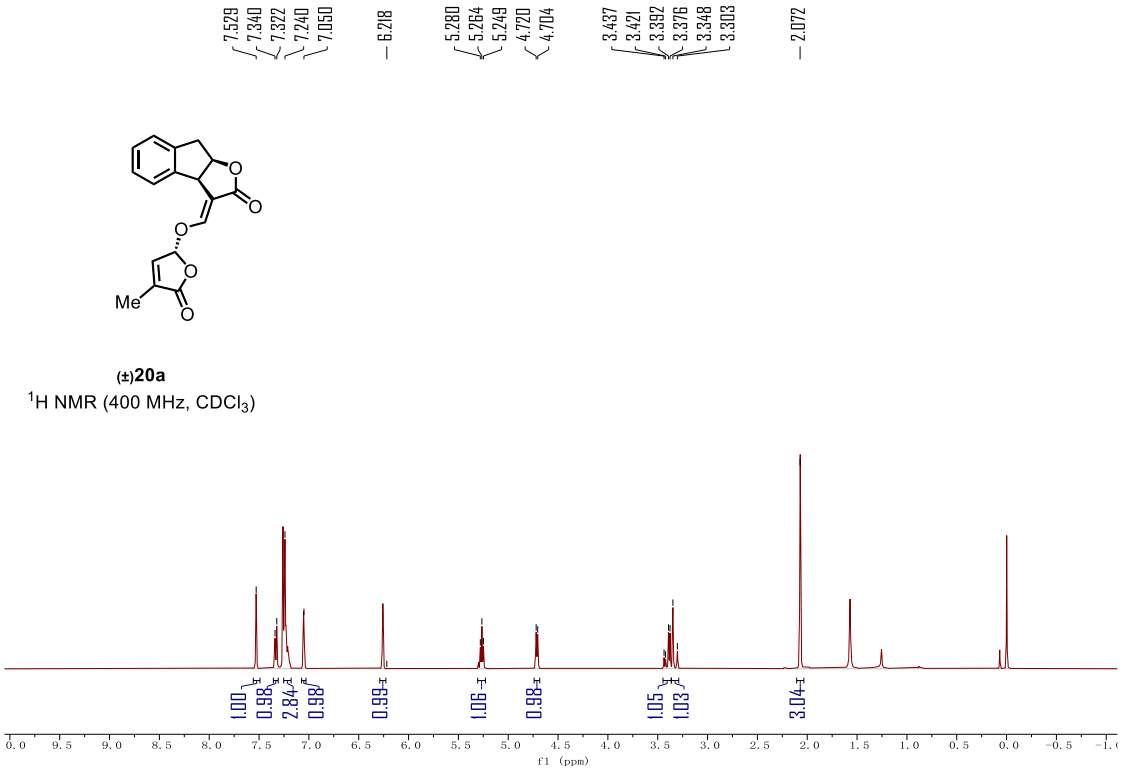




(±)16h

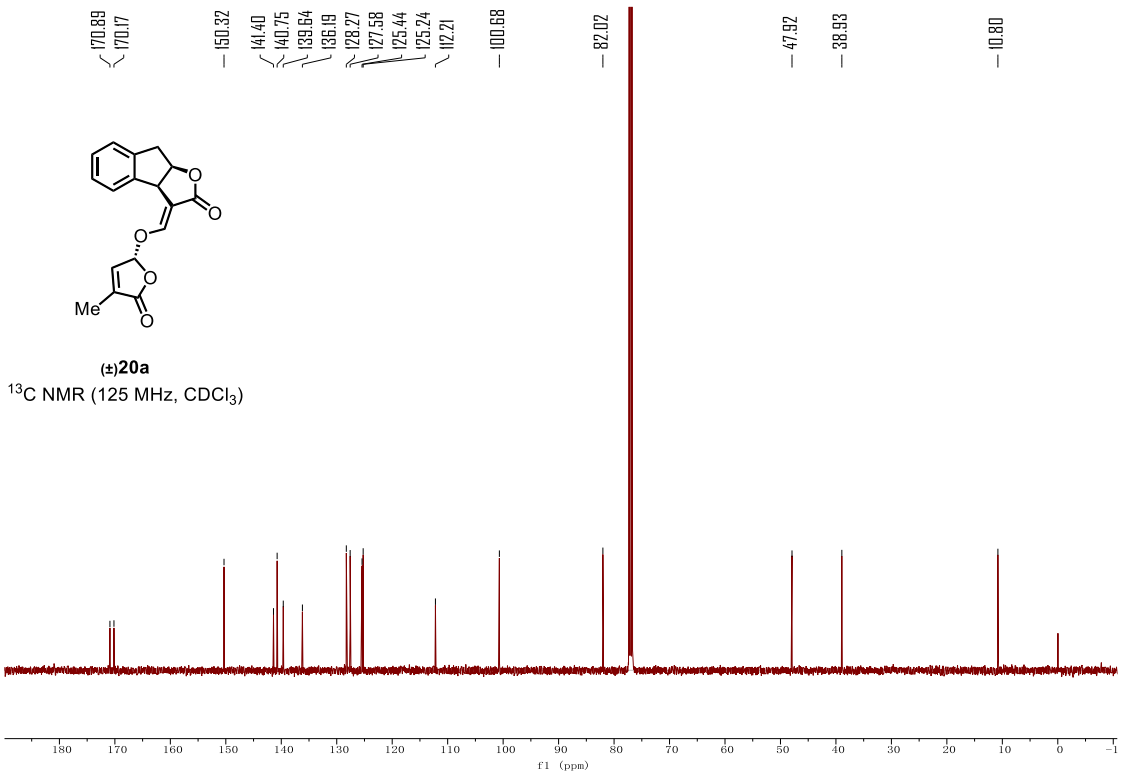
^{13}C NMR (125 MHz, $CDCl_3$)





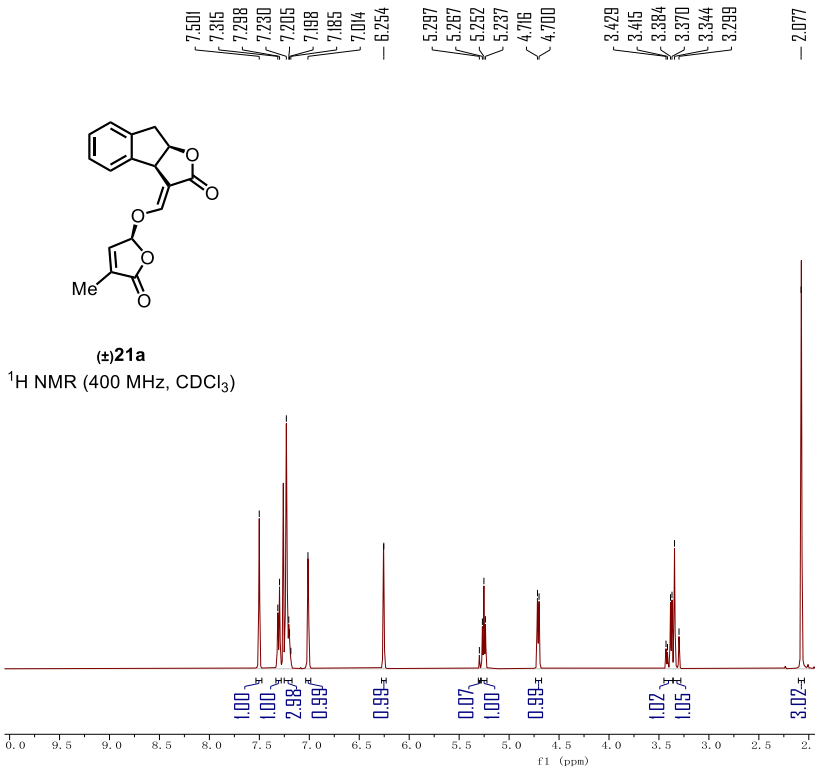
(±)20a

^{1}H NMR (400 MHz, $CDCl_3$)



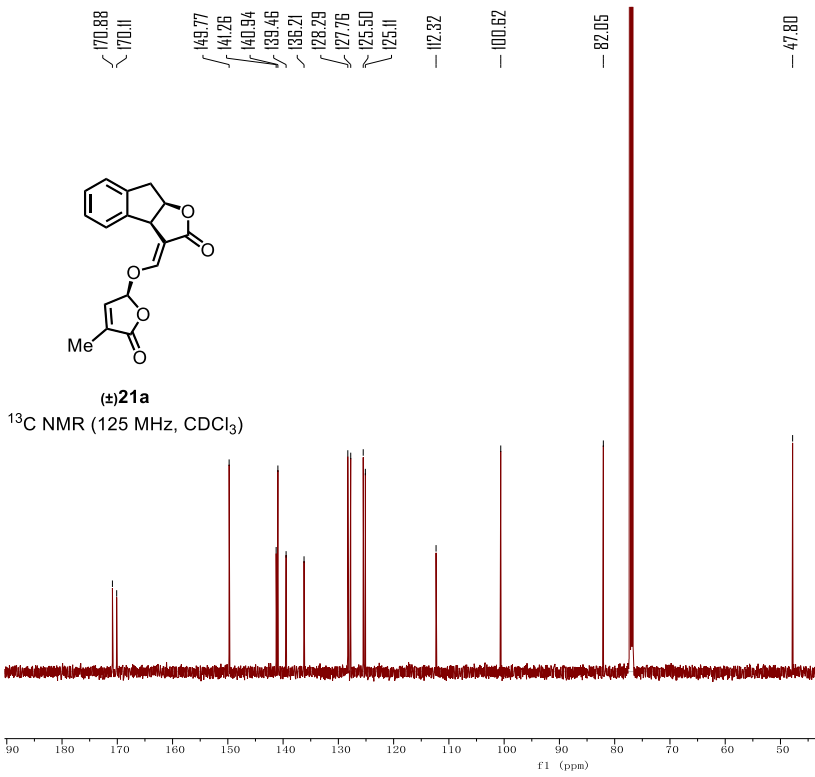
(±)20a

^{13}C NMR (125 MHz, $CDCl_3$)



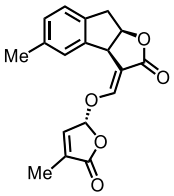
(±)21a

^{1}H NMR (400 MHz, $CDCl_3$)



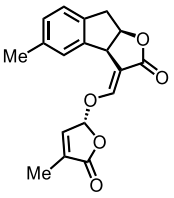
(±)21a

^{13}C NMR (125 MHz, $CDCl_3$)



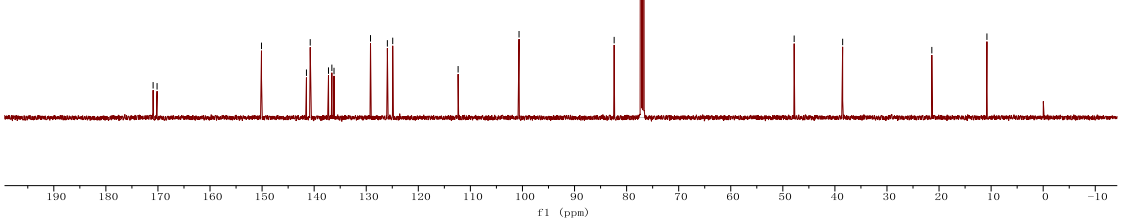
(±)20b

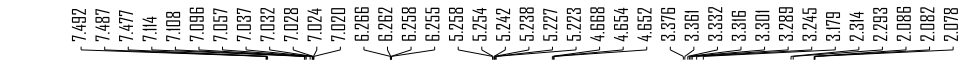
^{1}H NMR (400 MHz, $CDCl_3$)

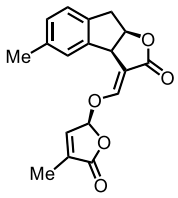


(±)20b

^{13}C NMR (125 MHz, $CDCl_3$)

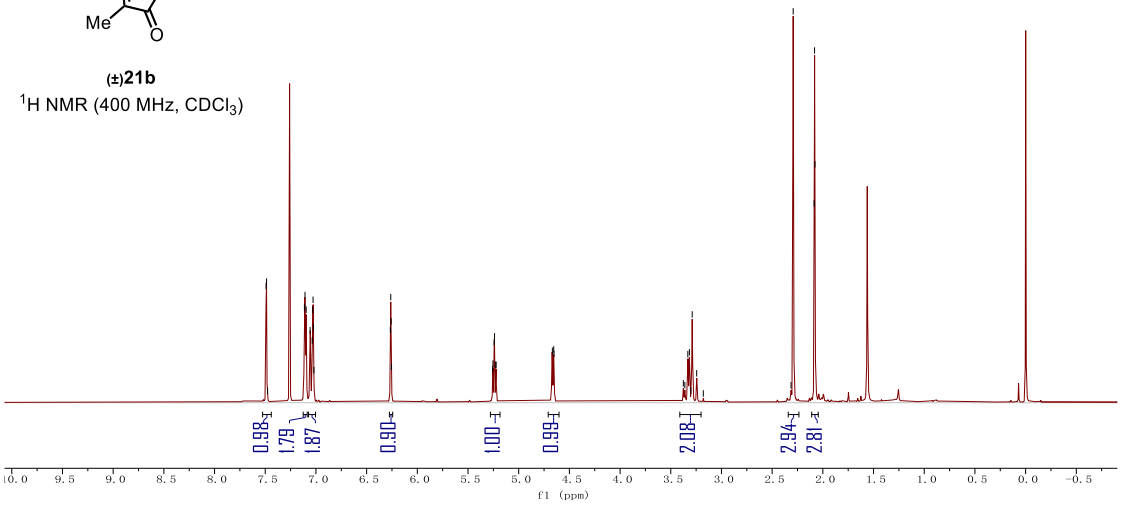


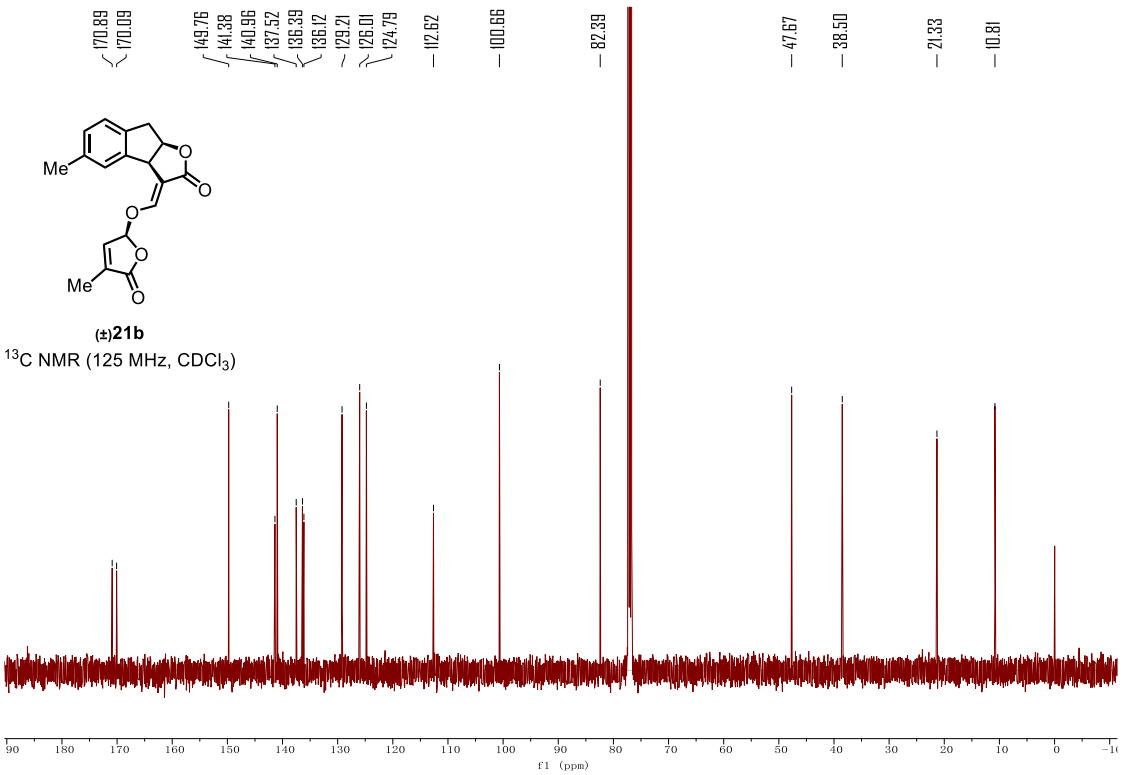




(±)21b

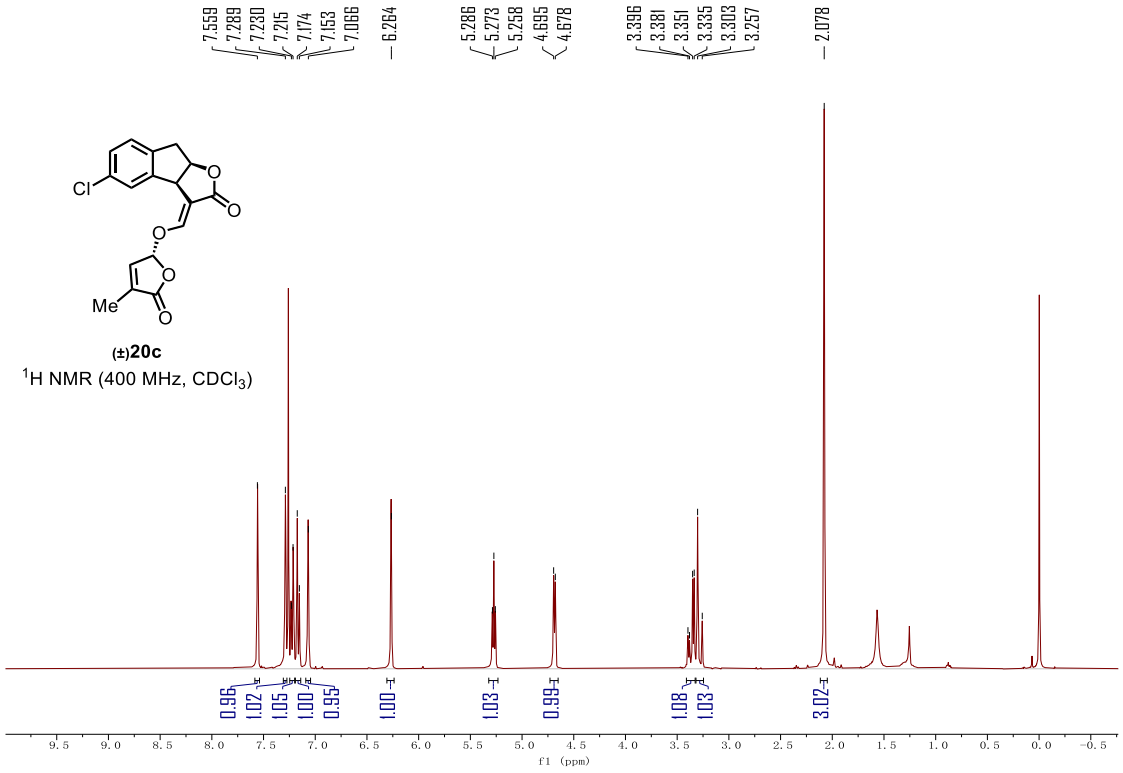
^{1}H NMR (400 MHz, $CDCl_3$)





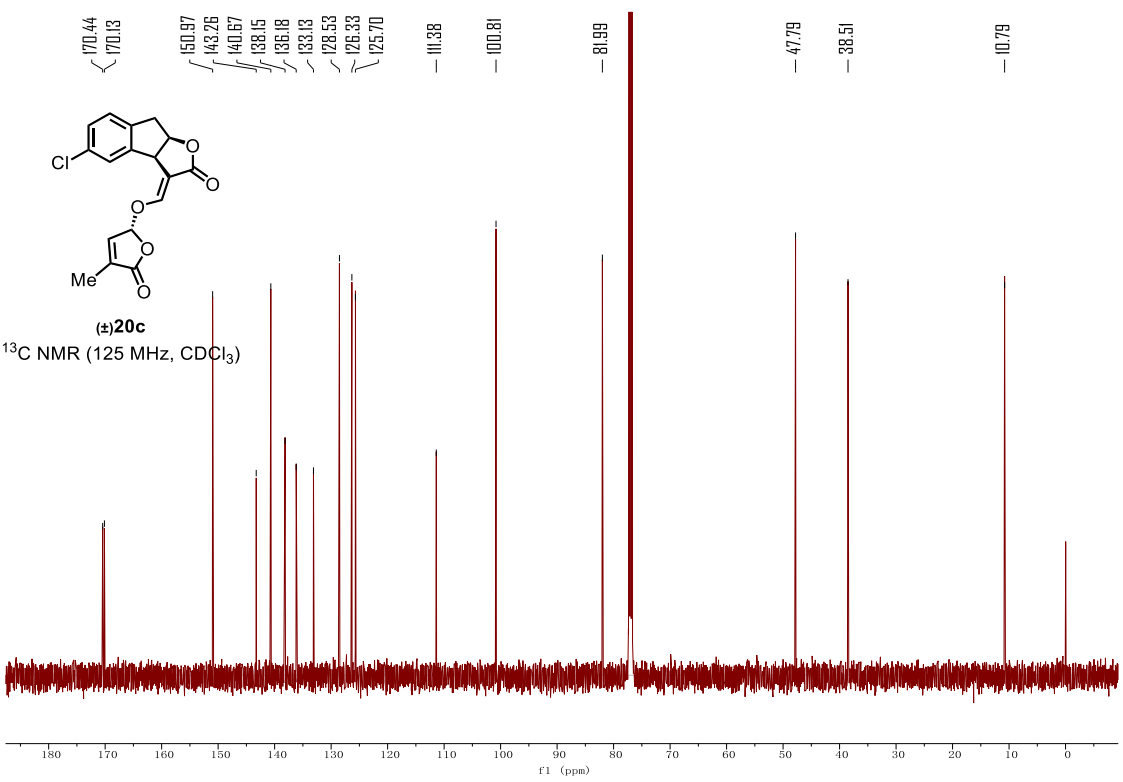
(±)21b

^{13}C NMR (125 MHz, $CDCl_3$)



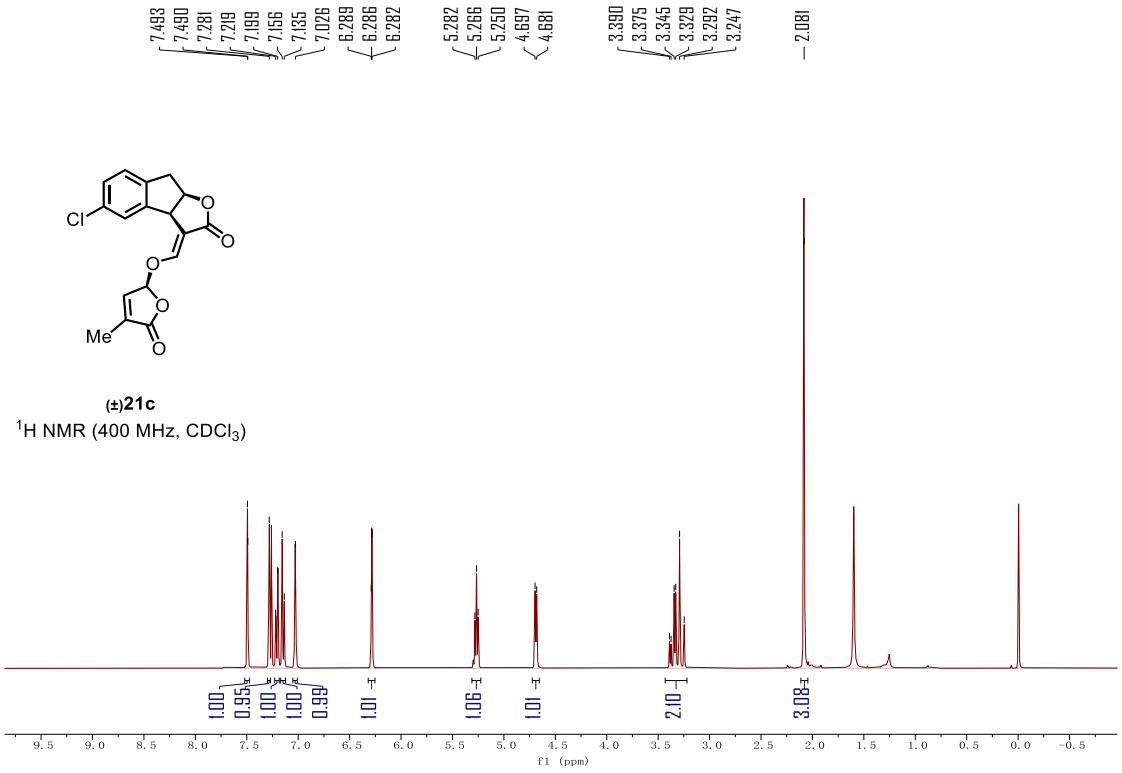
(±)20c

^{1}H NMR (400 MHz, $CDCl_3$)



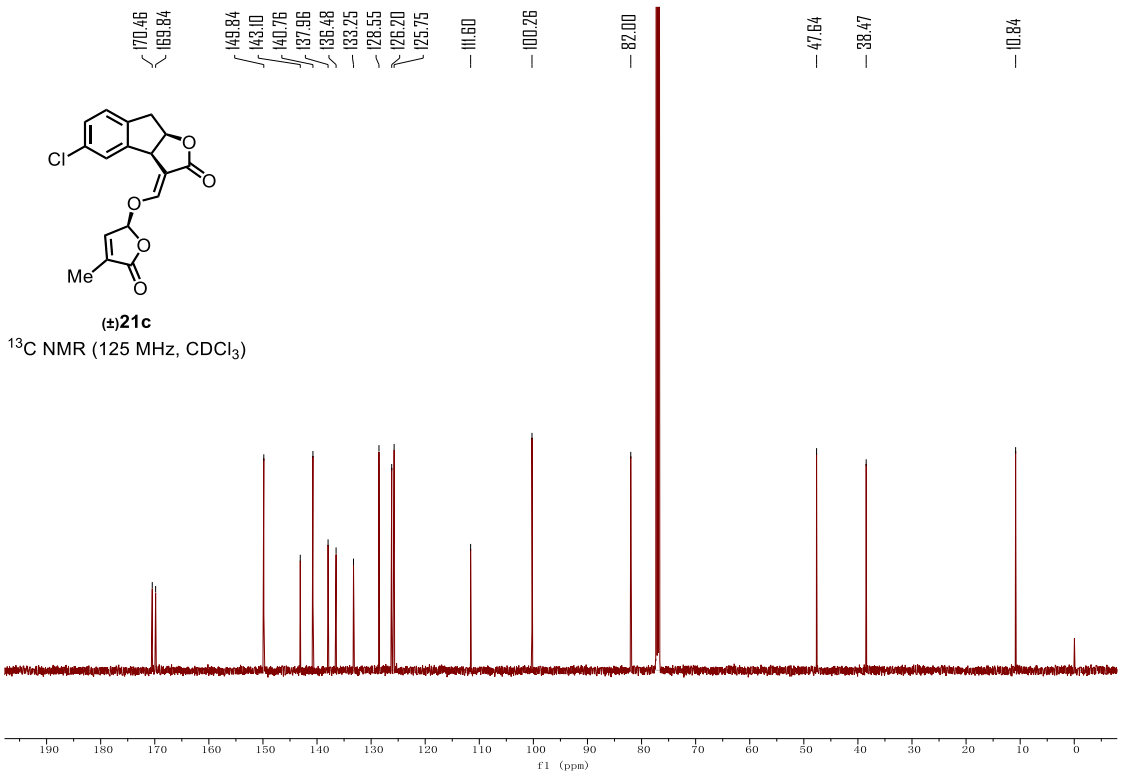
(±)20c

^{13}C NMR (125 MHz, $CDCl_3$)



(±)21c

^{1}H NMR (400 MHz, $CDCl_3$)



(±)21c

^{13}C NMR (125 MHz, $CDCl_3$)