Copper-catalyzed [4+1]-annulation of 2-alkenylindoles with diazoacetates: a facile access to dihydrocyclopenta[*b*]indoles

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General Information

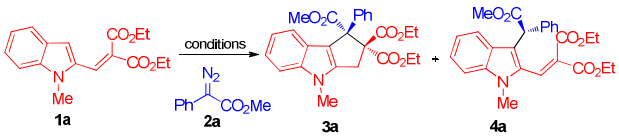
All reactions were performed in 10 ml oven-dried glassware under atmosphere of argon. Solvents were dried and distilled by following the standard methods before using. Analytical thin-layer chromatography was performed using glass plates pre-coated with 200-300 mesh silica gel impregnated with a fluorescent indicator (254 nm). Flash column chromatography was performed using silica gel (300-400 mesh). ^{1}H NMR and ^{13}C NMR spectra were recorded in $CDCl_3$ on a 400 MHz spectrometer; chemical shifts are reported in ppm with the solvent signals as reference and coupling constants (*J*) are given in Hertz. The peak information is described as: br = broad, s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, comp = composite. Enantioselectivity was determined on HPLC using Chiralpak IC-3. High-resolution mass spectra (HRMS) were recorded on a commercial apparatus (ESI Source) and (CI Source). Starting materials **1**[1] and **2**[2] were prepared according to the reported reference.

Condition Optimization

The initial exploration was carried out with 2-alkenylindole **1a** and methyl phenyldiazoacetate **2a** as model substrates in dichloromethane (DCM) at 25 ^{o}C (Table S1). Instead of giving the annulation product **3a**, only decomposition of **2a** was observed when the reaction was catalyzed by Rh-, Pd-, or Ag-catalysts (entries 1-4), and most of the material **1a** remained intact. The desired product **3a** was obtained in moderate to high yields contaminated with C-H insertion product **4a** when the copper-catalysts were explored (entries 5-14), and $Cu(CH_3CN)_4PF_6$ gave the superior results in terms of both the yield and selectivity (entry 12, 85% yield, **3a**:**4a** = 91:9). Control experiment in the presence of Lewis acid, such as $Sc(OTf)_3$, was conducted and no reaction occurred (entry 15).[17] Further optimization of solvents, reaction temperature, and the concentration of reaction mixture showed that only trace amount of **3a** was formed when the reaction was conducted in tetrahydrofuran (entry 18) or acetonitrile (entry 19), and the best results were obtained by conducting the reaction

in DCM at 35 °C, giving **3a** as a single product in 86% yield (entry 21).

Table S1 Condition optimization[a]

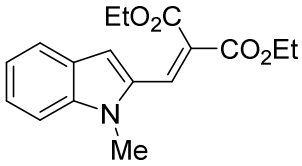


Entry	Cat (x mol %)	Solvent	Yield[b] (%) (**3a**+**4a**)	Ratio[c] **3a** : **4a**
1[d]	$Rh_2(OAc)_4$ (1.0)	DCM	-	-
2[d]	$Rh_2(esp)_2$ (1.0)	DCM	-	-
3[d]	$[PdCl(\eta^3\text{-}C_3H_5)]_2$ (5.0)	DCM	-	-
4[d]	AgOTf (5.0)	DCM	-	-
5	$Cu(OTf)_2$ (5.0)	DCM	61	83:17
6	$Cu(hfacac)_2$ (5.0)	DCM	48	67:33
7	$CuBr_2$ (5.0)	DCM	37	71:29
8	$Cu(CH_3CN)_4BF_4$ (5.0)	DCM	78	85:15
9	$Cu(TFA)_2$ (5.0)	DCM	57	66:34
10	Copper(II)acrylate (5.0)	DCM	61	54:46
11	CuTC (5.0)	DCM	55	73:27
12	$Cu(CH_3CN)_4PF_6$ (5.0)	DCM	85	91:9
13	$[CuOTf]_2$.benzene (5.0)	DCM	60	63:37
14	$Cu(acac)_2$ (5.0)	DCM	49	77:23
15	$Sc(OTf)_3$ (5.0)	DCM	NR	-
16	$Cu(CH_3CN)_4PF_6$ (5.0)	DCE	88	81:13
17	$Cu(CH_3CN)_4PF_6$ (5.0)	toluene	84	71:29
18[d]	$Cu(CH_3CN)_4PF_6$ (5.0)	THF	<5	-
19[d]	$Cu(CH_3CN)_4PF_6$ (5.0)	CH_3CN	<5	-
20	$Cu(CH_3CN)_4PF_6$ (5.0)	TBME	43	55:45
21[e]	$Cu(CH_3CN)_4PF_6$ (5.0)	DCM	86	>95:5

[a] Reaction conditions: to the catalyst and **1a** (30.0 mg, 0.1 mmol) in 1.0 mL of solvent, was added **2a** (35.0 mg, 0.2 mmol) in 1.0 mL of the same solvent *via* syringe pump over 2 h under argon atmosphere at 25 °C. [b] Isolated yields, [c] The ratio was determined by proton NMR of the crude reaction mixture. [d] Most of material **1a** was recovered and **2a** was decomposed. [e] The reaction was carried at 35 °C in 3.0 mL DCM. CuTC = Copper(I) thiophene-2-carboxylate.

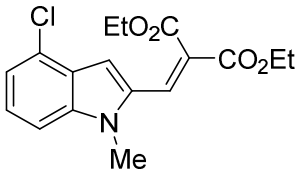
General Procedure for the Preparation of 2-Alkenylindoles 1

2-Alkenylindoles **1**were prepared according to the reported reference.[1]



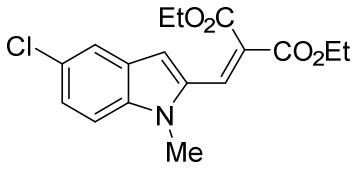
Diethyl 2-[(1-methyl-1*H*-indol-2-yl)methylene]malonate (1a)

^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.82 (s, 1H), 7.61 (d, *J* = 8.0 Hz, 1H), 7.32 – 7.27 (m, 2H), 7.14– 7.10 (m, 1H), 6.96 (s, 1H), 4.43 (q, *J* = 7.1 Hz, 2H), 4.34 (q, *J* = 7.1 Hz, 2H), 3.80 (s, 3H), 1.36 (comp, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 166.8, 164.2, 138.8, 131.9, 129.4, 127.6, 124.8, 124.4, 121.9, 120.6, 109.8, 106.5, 61.9, 61.7, 29.9, 14.3, 14.0; HRMS (TOF MS ESI$^+$) calculated for $C_{17}H_{19}NNaO_4$ [M + Na]$^+$, 324.1206; found, 324.1201.



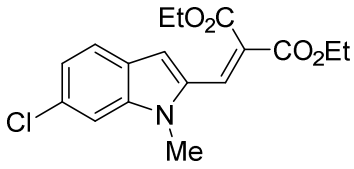
Diethyl 2-((4-chloro-1-methyl-1H-indol-2-yl)methylene)malonate (1n)

^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.76 (s, 1H), 7.22 – 7.13 (m, 2H), 7.12 – 7.07 (m, 1H), 6.98 (s, 1H), 4.44 (q, *J* = 7.1 Hz, 2H), 4.33 (q, *J* = 7.1 Hz, 2H), 3.79 (s, 3H), 1.37 (dt, *J* = 16.7, 7.1 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 166.5, 164.0, 139.3, 132.5, 128.7, 127.1, 126.6, 126.1, 124.7, 120.3, 108.5, 104.7, 62.2, 61.9, 30.4, 14.3, 14.1; HRMS (TOF MS ESI$^+$) calculated for $C_{17}H_{18}ClNNaO_4$ [M + Na]$^+$, 358.0817; found, 358.0825.



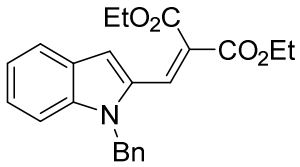
Diethyl 2-[(5-chloro-1-methyl-1H-indol-2-yl)methylene]malonate (1o)

^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.75 (s, 1H), 7.54 (t, *J* = 1.2 Hz, 1H), 7.20 (d, *J* = 1.2 Hz, 2H), 6.83 (s, 1H), 4.41 (q, *J* = 7.1 Hz, 2H), 4.32 (q, *J* = 7.1 Hz, 2H), 3.77 (s, 3H), 1.34 (td, *J* = 7.1, 1.8 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 166.6, 164.0, 137.1, 133.1, 128.9, 128.4, 126.3, 125.9, 124.7, 121.0, 110.9, 105.6, 62.1, 61.9, 30.2, 14.3, 14.1; HRMS (TOF MS ESI$^+$) calculated for $C_{17}H_{18}ClNNaO_4$ $[M + Na]^+$, 358.0817; found, 358.0813.



Diethyl 2-[(6-chloro-1-methyl-1H-indol-2-yl)methylene]malonate (1p)

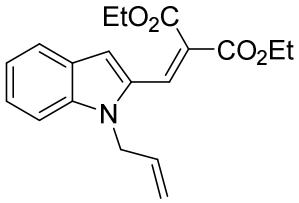
^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.74 (s, 1H), 7.48 (d, *J* = 8.5 Hz, 1H), 7.28 (d, *J* = 0.7 Hz, 1H), 7.08 – 7.03 (m, 1H), 6.89 (s, 1H), 4.41 (q, *J* = 7.1 Hz, 2H), 4.32 (q, *J* = 7.1 Hz, 2H), 3.74 (s, 3H), 1.34 (td, *J* = 7.1, 2.8 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 166.7, 164.0, 139.1, 132.7, 130.4, 128.8, 126.1, 125.4, 122.8, 121.5, 109.8, 106.4, 62.0, 61.8, 30.0, 14.2, 14.1; HRMS (TOF MS ESI$^+$) calculated for $C_{17}H_{18}ClNNaO_4$ $[M + Na]^+$, 358.0817; found, 358.0809.



Diethyl 2-[(1-benzyl-1*H*-indol-2-yl)methylene]malonate (1q)

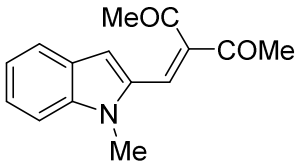
^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.78 (s, 1H), 7.69 – 7.64 (m, 1H), 7.33 – 7.23 (comp, 5H), 7.18 – 7.12 (m, 1H), 7.08 – 7.01 (comp, 3H), 5.45 (s, 2H), 4.44 (q, *J* = 7.1 Hz, 2H), 4.29 (q, *J* = 7.1 Hz, 2H), 1.37 (t, *J* = 7.1 Hz, 3H), 1.32 (t, *J* = 7.1 Hz, 3H);

^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 166.6, 164.0, 138.6, 137.1, 131.9, 129.5, 129.0, 127.84, 127.77, 126.2, 125.3, 124.7, 122.0, 120.9, 110.2, 107.0, 61.9, 61.6, 46.9, 14.2, 14.0; HRMS (TOF MS ESI$^+$) calculated for $C_{23}H_{23}NNaO_4$ [M + Na]$^+$, 400.1519; found, 400.1528.



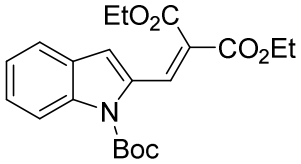
Diethyl 2-[(1-allyl-1*H*-indol-2-yl)methylene]malonate (1r)

^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.75 (s, 1H), 7.62 (d, *J* = 8.0 Hz, 1H), 7.30 – 7.25 (m, 2H), 7.15 – 7.09 (m, 1H), 6.98 (s, 1H), 6.02 – 5.90 (m, 1H), 5.17 (dd, *J* = 10.4, 0.7 Hz, 1H), 4.90 (dd, *J* = 17.1, 0.6 Hz, 1H), 4.85 – 4.79 (m, 2H), 4.42 (q, *J* = 7.1 Hz, 2H), 4.32 (q, *J* = 7.1 Hz, 2H), 1.35 (td, *J* = 7.1, 4.0 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 166.8, 164.1, 138.3, 132.8, 131.7, 129.5, 127.8, 125.1, 124.5, 122.0, 120.8, 117.1, 110.0, 106.8, 62.0, 61.7, 45.5, 14.3, 14.1; HRMS (TOF MS ESI$^+$) calculated for $C_{19}H_{21}NNaO_4$ [M + Na]$^+$, 350.1363; found, 350.1347.



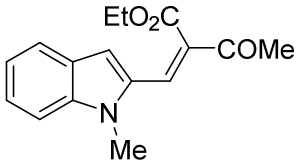
3-[(1-Methyl-1H-indol-2-yl)methylene]pentane-2,4-dione (1s)

^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.60 – 7.55 (comp, 2H), 7.31 – 7.30 (m, 2H), 7.14 – 7.11 (m, 1H), 6.79 (s, 1H), 3.81 (s, 3H), 2.41 (s, 3H), 2.40 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ205.8, 195.0, 141.1, 139.2, 131.6, 127.6, 126.7, 124.8, 122.0, 120.9, 109.8, 107.9, 77.5, 77.2, 76.8, 31.1, 29.9, 26.7; HRMS (TOF MS ESI$^+$) calculated for $C_{15}H_{15}NNaO_2$ [M + Na]$^+$, 264.0995; found, 264.1007.



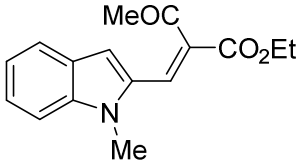
Diethyl 2-{[1-(tert-butoxycarbonyl)-1*H*-indol-2-yl]methylene}malonate (1t)

^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 8.26 – 8.16 (comp, 2H), 7.56 (d, *J* = 7.7 Hz, 1H), 7.43 – 7.35 (m, 1H), 7.29 – 7.22 (m, 1H), 6.96 (s, 1H), 4.33 (qd, *J* = 7.1, 5.8 Hz, 4H), 1.71 (s, 9H), 1.36 (t, *J* = 7.1 Hz, 3H), 1.28 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 166.5, 163.9, 150.0, 137.4, 134.1, 132.9, 128.8, 126.2, 125.7, 123.5, 121.6, 115.8, 113.1, 85.2, 61.8, 61.7, 28.3, 14.3, 14.0; HRMS (TOF MS ESI$^+$) calculated for C21H25NO6 $[M + Na]^+$, 387.1682; found, 387.1689.



Ethyl (*Z*)-2-[(1-methyl-1*H*-indol-2-yl)methylene]-3-oxobutanoate (*Z*-1u)

^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.74 (s, 1H), 7.48 (d, *J* = 8.5 Hz, 1H), 7.28 (d, *J* = 0.7 Hz, 1H), 7.08 – 7.03 (m, 1H), 6.89 (s, 1H), 4.41 (q, *J* = 7.1 Hz, 2H), 4.32 (q, *J* = 7.1 Hz, 2H), 3.83 (s, 3H), 2.46 (s, 3H), 1.35 (td, *J* = 7.1, 0.5 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 166.7, 164.0, 139.1, 132.7, 130.4, 128.8, 126.1, 125.4, 122.8, 121.5, 109.8, 106.4, 62.0, 61.8, 30.0, 14.2, 14.1; HRMS (TOF MS ESI$^+$) calculated for $C_{16}H_{17}NNaO_3$ $[M + Na]^+$, 294.1101; found, 294.1092.



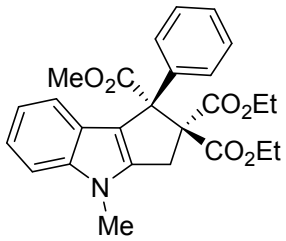
Ethyl (*E*)-2[(1-methyl-1*H*-indol-2-yl)methylene]-3-oxobutanoate (*E*-1u)

^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.67 (s, 1H), 7.60 (d, *J* = 8.0 Hz, 1H), 7.32 – 7.27 (m, 2H), 7.15 – 7.08 (m, 1H), 6.96 (s, 1H), 4.44 (q, *J* = 7.1 Hz, 2H), 3.78 (s, 3H), 2.41 (s, 3H), 1.37 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 193.4,

168.3, 139.1, 132.4, 131.9, 128.2, 127.6, 124.7, 122.0, 120.7, 109.8, 107.0, 62.0, 29.8, 26.9, 14.0; HRMS (TOF MS ESI$^+$) calculated for $C_{16}H_{17}NNaO_3$ [M + Na]$^+$, 294.1101; found, 294.1110.

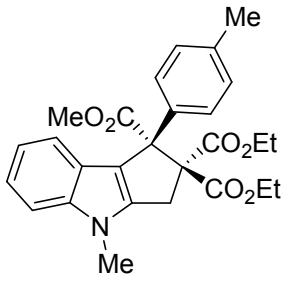
General Procedure for [4 + 1]-Annulation Reaction

To a 10-mL oven-dried vial containing a magnetic stirring bar, $Cu(CH_3CN)_4PF_6$ (1.9 mg, 5.0 mol %), compound **1** (0.1 mmol) in DCM (2.0 mL), diazo compound **1** (0.2 mmol) in DCM (1.0 mL) was added as a solution *via* a syringe pump over 2 h under argon atmosphere at 35 ^{o}C. After addition, the reaction mixture was stirred overnight under these conditions until consumption of the material (monitored by TLC). Then the reaction mixture was purified by column chromatography on silica gel without any additional treatment (Hexanes : EtOAc = 15:1 to 10:1) to give the pure products **3**.



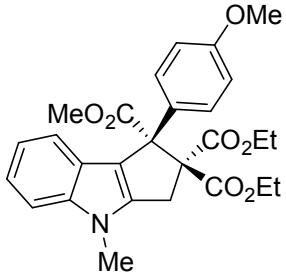
2,2-Diethyl 1-methyl 4-methyl-1-phenyl-3,4-dihydrocyclopenta[*b*]indole-1,2,2 (1*H*)-tricarboxylate (3a)

White solid, 38.6 mg, 86% yield, mp: 134.5-135.9 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.66 (d, *J* = 3.4 Hz, 2H), 7.30 (t, *J* = 6.9 Hz, 4H), 7.20 – 7.12 (m, 2H), 7.02 (t, *J* = 7.5 Hz, 1H), 4.40 – 4.28 (m, 2H), 3.82 (d, *J* = 15.5 Hz, 1H), 3.78 (s, 3H), 3.65 (d, *J* = 15.5 Hz, 1H), 3.62 – 3.56 (m, 1H), 3.55 (s, 3H), 3.32 – 3.18 (m, 1H), 1.37 (t, *J* = 7.1 Hz, 3H), 0.73 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 173.4, 170.4, 169.6, 145.6, 141.4, 136.7, 130.8, 127.7, 127.3, 123.7, 120.9, 119.9, 119.2, 114.6, 109.8, 74.1, 66.2, 61.8, 61.7, 52.3, 34.3, 31.1, 14.2, 13.4; HRMS (TOF MS ESI$^+$) calculated for $C_{26}H_{27}NNaO_6$ [M + Na]$^+$, 472.1731; found, 472.1743.



2,2-Diethyl 1-methyl 4-methyl-1-(*p*-tolyl)-3,4-dihydrocyclopenta[*b*]indole-1,2,2(1*H*)-tricarboxylate (3b)

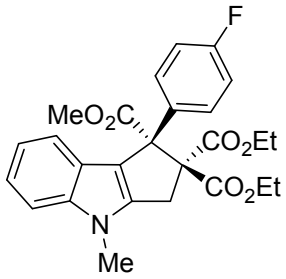
White solid, 41.7 mg, 90% yield, mp: 111.2-113.0 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.53 (d, *J* = 8.0 Hz, 2H), 7.32 – 7.27 (m, 1H), 7.19 – 7.13 (m, 2H), 7.09 (d, *J* = 8.0 Hz, 2H), 7.04 – 6.97 (m, 1H), 4.40 – 4.26 (m, 2H), 3.80 (d, *J* = 15.5 Hz, 1H), 3.77 (s, 3H), 3.63 (d, *J* = 15.5 Hz, 1H), 3.61 – 3.56 (m, 1H), 3.54 (s, 3H), 3.38 – 3.24 (m, 1H), 2.34 (s, 3H), 1.36 (t, *J* = 7.1 Hz, 3H), 0.74 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 173.5, 170.4, 169.7, 145.6, 141.4, 137.3, 133.7, 130.7, 128.0, 123.8, 120.8, 119.8, 119.2, 114.8, 109.8, 74.2, 67.0, 61.8, 61.6, 52.3, 34.3, 31.1, 21.2, 14.2, 13.3; HRMS (TOF MS ESI^{+}) calculated for $C_{27}H_{29}NNaO_6$ $[M + Na]^{+}$, 486.1887; found, 486.1893.



2,2-Diethyl 1-methyl 1-(4-methoxyphenyl)-4-methyl-3,4-dihydrocyclopenta[*b*] indole-1,2,2(1*H*)-tricarboxylate (3c)

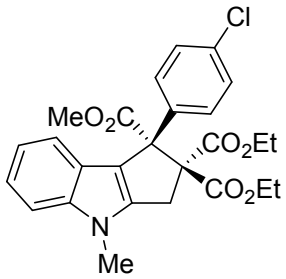
White solid, 35.0 mg, 73% yield, mp: 159.2-161.3 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.56 (d, *J* = 8.3 Hz, 2H), 7.29 (d, *J* = 8.5 Hz, 1H), 7.20 – 7.11 (m, 2H), 7.01 (t, *J* = 7.5 Hz, 1H), 6.81 (d, *J* = 8.6 Hz, 2H), 4.38 – 4.26 (m, 2H), 3.84 – 3.77 (comp, 4H), 3.77 (s, 3H), 3.65 – 3.57 (m, 2H), 3.53 (s, 3H), 3.39 – 3.28 (m, 1H), 1.36 (t, *J* = 7.1 Hz, 3H), 0.77 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 173.6, 170.5, 169.8, 159.2, 145.5, 141.4, 132.1, 128.8, 123.8, 120.8, 119.9, 119.2, 114.9,

112.6, 109.8, 74.2, 65.7, 61.8, 61.7, 55.4, 52.4, 34.3, 31.1, 14.2, 13.5; HRMS (TOF MS ESI$^+$) calculated for $C_{27}H_{29}NNaO_7$ [M + Na]$^+$, 502.1836; found, 502.1831.



2,2-Diethyl 1-methyl 1-(4-fluorophenyl)-4-methyl-3,4-dihydrocyclopenta[*b*] indole-1,2,2(1*H*)-tricarboxylate (3d)

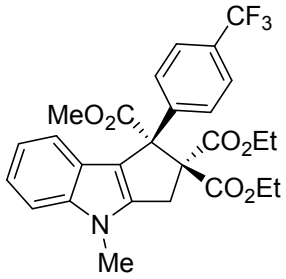
White solid, 40.2 mg, 86% yield, mp: 116.2-117.5 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.70 – 7.60 (m, 2H), 7.31 (d, *J* = 8.2 Hz, 1H), 7.21 – 7.15 (m, 1H), 7.13 (d, *J* = 7.8 Hz, 1H), 7.07 – 6.93 (m, 3H), 4.40 – 4.25 (m, 2H), 3.81 (d, *J* = 15.5 Hz, 1H), 3.77 (s, 3H), 3.67 – 3.58 (m, 2H), 3.54 (s, 3H), 3.40 – 3.25 (m, 1H), 1.36 (t, *J* = 7.1 Hz, 3H), 0.79 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 173.2, 170.3, 169.6, 162.5 (d, *J* = 246.5 Hz), 145.6, 141.4, 132.8 (d, *J* = 8.0 Hz), 132.5 (d, *J* = 3.2 Hz), 123.5, 121.0, 120.0, 119.0, 114.5, 114.1 (d, *J* = 21.1 Hz), 110.0, 74.1, 65.5, 61.9, 61.8, 52.4, 34.3, 31.1, 14.2, 13.5; ^{19}F NMR (376 MHz, $CDCl_3$) (δ, ppm) δ -115.2; HRMS (TOF MS ESI$^+$) calculated for $C_{26}H_{26}FNNaO_6$ [M + Na]$^+$, 490.1636; found, 490.1641.



2,2-Diethyl 1-methyl 1-(4-chlorophenyl)-4-methyl-3,4-dihydrocyclopenta[*b*] indole-1,2,2(1*H*)-tricarboxylate (3e)

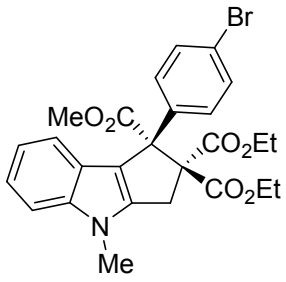
White solid, 39.2 mg, 81% yield, mp: 171.6-172.9 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.61 (d, *J* = 8.2 Hz, 2H), 7.31 (d, *J* = 8.2 Hz, 1H), 7.28 – 7.25 (m, 2H), 7.21 –

7.15 (m, 1H), 7.11 (d, J = 7.8 Hz, 1H), 7.02 (t, J = 7.2 Hz, 1H), 4.39 – 4.26 (m, 2H), 3.80 (d, J = 15.6 Hz, 1H), 3.77 (s, 3H), 3.67 – 3.58 (m, 2H), 3.54 (s, 3H), 3.40 – 3.30 (m, 1H), 1.36 (t, J = 7.1 Hz, 3H), 0.78 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 173.0, 170.2, 169.5, 145.7, 141.4, 135.4, 133.7, 132.4, 127.4, 123.5, 121.0, 120.1, 119.0, 114.2, 109.9, 77.5, 77.2, 76.8, 74.1, 65.6, 62.0, 61.8, 52.4, 34.3, 31.2, 14.2, 13.4; HRMS (TOF MS ESI$^+$) calculated for $C_{26}H_{26}ClNNaO_6$ [M + Na]$^+$, 506.1341; found, 506.1333.



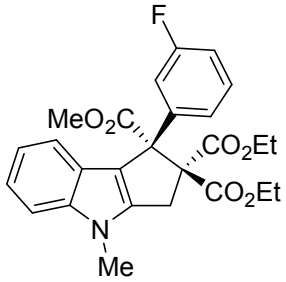
2,2-Diethyl 1-methyl 4-methyl-1-(4-(trifluoromethyl)phenyl)-3,4-dihydrocyclopenta[*b*]indole-1,2,2(1*H*)-tricarboxylate (3f)

Yellow oil, 41.4 mg, 80% yield, ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.84 (d, J = 7.9 Hz, 2H), 7.58 (d, J = 8.3 Hz, 2H), 7.35 (d, J = 8.3 Hz, 1H), 7.24 – 7.19 (m, 1H), 7.14 – 7.02 (m, 2H), 4.41 – 4.29 (m, 2H), 3.85 (d, J = 15.5 Hz, 1H), 3.81 (s, 3H), 3.68 (d, J = 15.5 Hz, 1H), 3.65 – 3.58 (m, 1H), 3.58 (s, 3H), 3.34 – 3.21 (m, 1H), 1.38 (t, J = 7.1 Hz, 3H), 0.72 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 172.8, 170.1, 169.4, 145.8, 141.5, 141.0, 131.4, 129.9 (q, J = 32.3 Hz), 124.2 (q, J = 241.6 Hz), 124.2 (q, J = 3.7 Hz), 123.4, 121.1, 120.2, 118.9, 113.9, 110.0, 74.1, 65.8, 62.0, 61.9, 52.5, 34.4, 31.2, 14.2, 13.2; ^{19}F NMR (376 MHz, $CDCl_3$) (δ, ppm) δ -62.6; HRMS (TOF MS ESI$^+$) calculated for $C_{27}H_{26}F_3NNaO_6$ [M + Na]$^+$, 540.1604; found, 540.1618.



2,2-Diethyl 1-methyl 1-(4-bromophenyl)-4-methyl-3,4-dihydrocyclopenta[*b*] indole-1,2,2(1*H*)-tricarboxylate (3g)

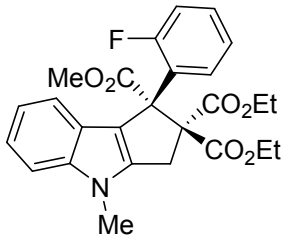
White solid, 43.9 mg, 83% yield, mp: 199.2-200.3 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.55 (d, *J* = 8.2 Hz, 2H), 7.41 (d, *J* = 8.7 Hz, 2H), 7.31 (d, *J* = 8.2 Hz, 1H), 7.18 (t, *J* = 7.6 Hz, 1H), 7.11 (d, *J* = 7.8 Hz, 1H), 7.02 (t, *J* = 7.4 Hz, 1H), 4.40 – 4.26 (m, 2H), 3.80 (d, *J* = 15.6 Hz, 1H), 3.77 (s, 3H), 3.67 – 3.58 (m, 2H), 3.54 (s, 3H), 3.41 – 3.30 (m, 1H), 1.35 (t, *J* = 7.1 Hz, 3H), 0.78 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 172.9, 170.2, 169.5, 145.7, 141.4, 135.9, 132.8, 130.4, 123.5, 122.1, 121.0, 120.1, 119.0, 114.1, 109.9, 74.0, 65.6, 62.0, 61.8, 52.4, 34.3, 31.2, 14.2, 13.4; HRMS (TOF MS ESI$^+$) calculated for $C_{26}H_{26}BrNNaO_6$ $[M + Na]^+$, 550.0836; found, 550.0829.



2,2-Diethyl 1-methyl 1-(3-fluorophenyl)-4-methyl-3,4-dihydrocyclopenta[*b*] indole-1,2,2(1*H*)-tricarboxylate (3h)

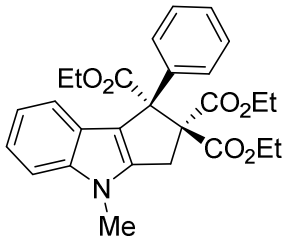
White solid, 37.0 mg, 79% yield, mp: 184.1-185.9 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.54 – 7.36 (m, 2H), 7.31 (d, *J* = 8.2 Hz, 1H), 7.26 – 7.10 (m, 3H), 7.07 – 6.93 (m, 2H), 4.40 – 4.26 (m, 2H), 3.85 – 3.75 (comp, 4H), 3.68 – 3.59 (m, 2H), 3.54 (s, 3H), 3.39 – 3.27 (m, 1H), 1.37 (t, *J* = 7.1 Hz, 3H), 0.78 (t, *J* = 7.1 Hz, 3H) ; ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 172.9, 169.8 (d, *J* = 71.5 Hz), 162.2 (d, *J* = 243.6 Hz), 145.7, 141.4, 139.5 (d, *J* = 7.5 Hz), 128.6 (d, *J* = 8.0 Hz), 126.4, 123.5, 121.0, 120.1,

119.0, 118.3 (d, J = 23.1 Hz), 114.8, 114.6, 114.2, 109.9, 74.1, 65.8 (d, J = 1.8 Hz), 62.0, 61.9, 52.5, 34.4, 31.2, 14.2, 13.4; ^{19}F NMR (376 MHz, $CDCl_3$) (δ, ppm) δ -114.4; HRMS (TOF MS ESI$^+$) calculated for $C_{26}H_{267}FNO_6$ $[M + H]^+$, 468.1817; found, 468.1797.



2,2-Diethyl 1-methyl 1-(2-fluorophenyl)-4-methyl-3,4-dihydrocyclopenta[*b*] indole-1,2,2(1*H*)-tricarboxylate (3i)

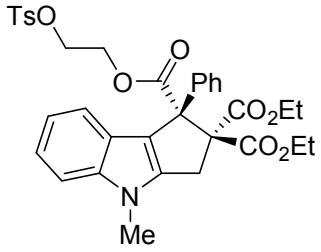
White solid, 34.6 mg, 74% yield, mp: 170.4-171.8 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.35 – 7.29 (m, 2H), 7.24 – 7.09 (comp, 3H), 7.05 – 6.93 (comp, 3H), 4.39 – 4.22 (m, 2H), 3.85 – 3.78 (comp, 4H), 3.75 – 3.64 (comp, 2H), 3.59 (s, 3H), 3.41 – 3.30 (m, 1H), 1.33 (td, J = 7.1, 0.5 Hz, 3H), 0.81 – 0.68 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 171.6, 169.5 (d, J = 3.2 Hz), 161.5 (d, J = 252.4 Hz), 145.7, 141.4, 131.8 (d, J = 3.3 Hz), 129.9 (d, J = 8.8 Hz), 124.9 (d, J = 12.3 Hz), 123.5, 123.1 (d, J = 3.4 Hz), 120.8, 119.9, 119.0, 116.4, 116.1, 114.0, 109.9, 74.3, 62.8, 61.9, 61.5, 52.4, 33.6, 31.1, 14.0, 13.4; ^{19}F NMR (376 MHz, $CDCl_3$) (δ, ppm) δ -104.8; HRMS (TOF MS ESI$^+$) calculated for $C_{26}H_{26}FNNaO_6$ $[M + Na]^+$, 490.1636; found, 490.1646.



Triethyl 4-methyl-1-phenyl-3,4-dihydrocyclopenta[*b*]indole-1,2,2(1*H*) -tricarboxylate (3j)

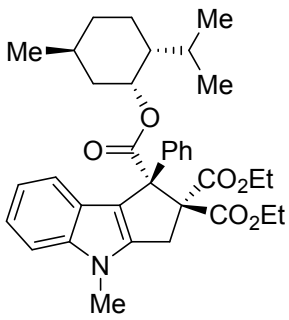
Yellow oil, 40.8 mg, 88% yield; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.70 – 7.59 (m, 2H), 7.32 – 7.26 (comp, 4H), 7.18 – 7.11 (m, 2H), 7.03 – 6.97 (m, 1H), 4.38 – 4.27 (m,

2H), 4.01 (q, *J* = 7.1 Hz, 2H), 3.81 (d, *J* = 15.5 Hz, 1H), 3.77 (s, 3H), 3.64 (d, *J* = 15.5 Hz, 1H), 3.61 – 3.53 (m, 1H), 3.30 – 3.17 (m, 1H), 1.36 (t, *J* = 7.1 Hz, 3H), 1.03 (t, *J* = 7.1 Hz, 3H), 0.72 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 172.7, 170.4, 169.7, 145.6, 141.4, 136.8, 130.9, 127.6, 127.2, 123.8, 120.8, 119.8, 119.3, 114.8, 109.8, 74.1, 66.3, 61.8, 61.6, 61.3, 34.4, 31.1, 14.2, 14.1, 13.4; HRMS (TOF MS ESI$^+$) calculated for $C_{27}H_{29}NNaO_6$ $[M + Na]^+$, 486.1887; found, 486.1878.



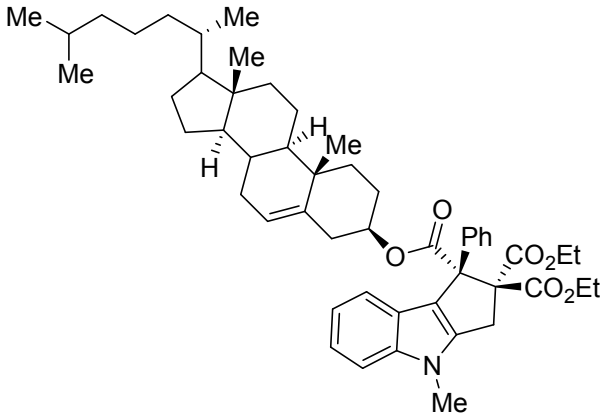
2,2-Diethyl 1-[2-(tosyloxy)ethyl] 4-methyl-1-phenyl-3,4-dihydrocyclopenta[*b*] indole-1,2,2(1*H*)-tricarboxylate (3k)

White solid, 52.6 mg, 83% yield, mp: 161.3-162.8 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.69 – 7.62 (m, 2H), 7.59 (d, *J* = 8.3 Hz, 2H), 7.37 – 7.30 (comp, 4H), 7.26 (s, 2H), 7.21 – 7.15 (m, 1H), 6.99 – 6.92 (m, 2H), 4.40 – 4.31 (m, 2H), 4.17 – 4.09 (m, 1H), 4.05 – 3.98 (m, 1H), 3.95 (t, *J* = 4.6 Hz, 2H), 3.84 – 3.75 (m, 4H), 3.68 (d, *J* = 15.6 Hz, 1H), 3.65 – 3.57 (m, 1H), 3.29 – 3.18 (m, 1H), 2.45 (s, 3H), 1.37 (t, *J* = 7.1 Hz, 3H), 0.75 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 172.2, 170.2, 169.5, 146.0, 145.0, 141.4, 136.3, 132.6, 130.9, 130.0, 128.0, 127.8, 127.3, 123.5, 120.9, 119.9, 119.0, 114.1, 109.9, 74.2, 67.5, 65.8, 62.2, 61.9, 61.8, 34.3, 31.1, 21.8, 14.2, 13.4; HRMS (TOF MS ESI$^+$) calculated for $C_{34}H_{35}NNaO_9S$ $[M + Na]^+$, 656.1925; found, 656.1929.



2,2-Diethyl 1-[(1*R*, 2*R*, 5*S*)-2-Isopropyl-5-methylcyclohexyl] (*S*)-4-methyl-1-phenyl-3,4-dihydrocyclopenta[*b*]indole-1,2,2(1*H*)-tricarboxylate (3l)

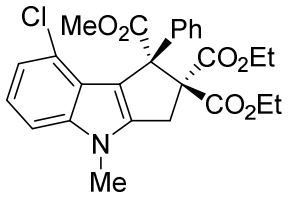
White oil, 39.0 mg, 68% yield; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.64 (d, *J* = 3.0 Hz, 2H), 7.27 – 7.30 (comp, 3H), 7.22 – 7.26 (m, 1H), 7.14 – 7.07 (m, 2H), 7.00 – 6.93 (m, 1H), 4.58 – 4.51 (m, 1H), 4.36 – 4.26 (m, 2H), 3.81 (d, *J* = 15.4 Hz, 1H), 3.76 (s, 3H), 3.68 – 3.55 (m, 3H), 3.21 – 3.51 (m, 1H), 1.76 (d, *J* = 11.4 Hz, 1H), 1.51 – 1.44 (m, 1H), 1.36 – 1.31 (m, 3H), 1.12 – 1.05 (m, 1H), 0.94 – 0.83 (m, 2H), 0.80 (d, *J* = 6.6 Hz, 4H), 0.77 – 0.67 (m, 5H), 0.46 (d, *J* = 7.0 Hz, 3H), 0.27 (d, *J* = 6.9 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 172.8, 170.4, 169.8, 145.6, 141.4, 136.9, 131.0, 127.5, 127.1, 123.8, 120.7, 119.6, 119.5, 115.0, 109.6, 75.7, 74.2, 66.7, 61.7, 61.5, 46.9, 40.4, 34.3, 34.2, 31.4, 31.1, 25.0, 22.6, 22.1, 20.8, 15.3, 14.2, 13.4; HRMS (TOF MS ESI$^+$) calculated for $C_{35}H_{43}NNaO_6$ $[M + Na]^+$, 596.2983; found, 596.2989.



1-[(3*R*, 9*R*, 10*S*, 13*S*, 14*R*)-10,13-Dimethyl-17-((*S*)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta[*a*]phenanthren-3-yl] 2,2-diethyl (1*S*)-4-methyl-1-phenyl-

3,4-dihydrocyclopenta[*b*]indole-1,2,2(1*H*)-tricarboxylate (3m)

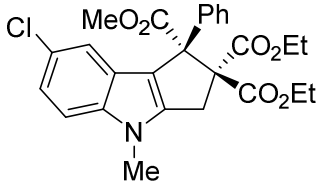
White oil, 34.5 mg, 43% yield; ^{1}H NMR (400 MHz, $CDCl_3$) of the two isomers (δ, ppm) 7.68-7.51 (m, 2H), 7.35-7.31 (comp, 3H), 7.30 – 7.24 (m, 2H), 7.20 (m, 1H), 7.04 (t, *J* = 7.5 Hz, 1H), 5.44 – 5.17 (m, 1H), 4.48-4.74 (m, 1H), 4.43 – 4.15 (m, 2H), 3.89 – 3.74 (m, 4H), 3.68 – 3.51 (m, 2H), 3.31 – 3.25 (m, 1H), 2.45 – 2.13 (m, 2H), 2.06 – 1.94 (m, 2H), 1.73 – 1.52 (m, 6H), 1.48 – 1.36 (m, 8H), 1.33 – 1.25 (m, 4H), 1.18 – 1.09 (m, 6H), 1.06 – 1.01 (m, 3H), 0.96 – 0.85 (m, 11H), 0.81 – 0.74 (m, 2H), 0.73 – 0.64 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) of the two isomers (δ, ppm) 172.4, 172.1, 171.4, 170.4, 169.8, 168.7, 145.6, 141.4, 139.8, 139.6, 139.6, 138.9, 137.0, 136.9, 134.7, 130.9, 128.39, 128.37, 128.3, 127.6, 127.2, 126.7, 126.6, 123.8, 123.77, 122.7, 122.66, 122.6, 121.6, 121.5, 121.4, 120.8, 120.75, 119.7, 119.68, 119.5, 119.4, 115.0, 109.8, 109.1, 75.2, 75.1, 74.9, 74.02, 74.00, 66.59, 66.55, 62.0, 61.9, 61.8, 61.6, 56.81, 56.78, 56.75, 56.3, 52.4, 50.1, 50.06, 50.03, 48.8, 48.7, 42.44, 42.41, 39.9, 39.8, 39.7, 38.0, 37.8, 37.1, 37.06, 37.00, 36.9, 36.7, 36.6, 36.3, 35.9, 34.4, 34.3, 32.0, 31.9, 31.1, 30.1, 28.4, 28.2, 24.4, 24.0, 23.7, 23.0, 22.7, 21.2, 21.14, 21.12, 21.1, 19.5, 19.4, 18.9, 18.8, 14.2, 14.1, 14.0, 13.4, 11.99, 11.97; HRMS (TOF MS ESI^{+}) calculated for $C_{52}H_{69}NNaO_6$ $[M + Na]^{+}$, 826.5017; found, 826.5029.



2,2-Diethyl 1-methyl 8-chloro-4-methyl-1-phenyl-3,4-dihydrocyclopenta[*b*] indole-1,2,2(1*H*)-tricarboxylate (3n)

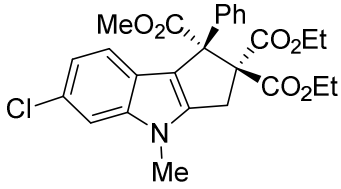
White solid, 34.4 mg, 71% yield, mp: 121.4-122.8 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.58-7.69 (m, 2H), 7.25 – 7.15 (m, 4H), 7.08 – 6.96 (m, 2H), 4.35 – 4.25 (m, 2H), 3.85 – 3.73 (m, 4H), 3.68 – 3.53 (m, 5H), 3.17 – 3.07 (m, 1H), 1.35 (td, *J* = 7.1, 1.6 Hz, 3H), 0.75 (td, *J* = 7.1, 1.5 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 173.6, 170.4, 169.8, 147.2, 142.3, 138.1, 131.3, 127.5, 126.7, 125.1, 122.5, 121.6, 121.2, 114.6, 108.2, 75.1, 66.3, 62.0, 61.8, 52.4, 34.1, 31.4, 14.2, 13.4; HRMS (TOF

MS ESI$^+$) calculated for $C_{26}H_{26}ClNNaO_6$ [M + Na]$^+$, 506.1341, found, 506.1334.



2,2-Diethyl 1-methyl 7-chloro-4-methyl-1-phenyl- 3,4-dihydrocyclopenta[*b*]indole -1,2,2(1*H*)-tricarboxylate (3o)

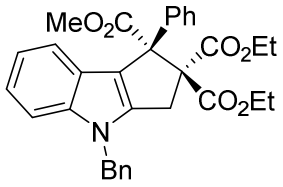
White solid, 38.2 mg, 79% yield, mp: 144.1-142.2 ^oC; ^1H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.62 – 7.55 (m, 2H), 7.33 – 7.27 (m, 3H), 7.19 (d, J = 9.3 Hz, 1H), 7.12 – 7.08 (m, 2H), 4.37 – 4.27 (m, 2H), 3.78 (d, J = 15.7 Hz, 1H), 3.75 (s, 3H), 3.64 (d, J = 7.3 Hz, 1H), 3.61 – 3.57 (m, 1H), 3.56 (s, 3H), 3.28 – 3.17 (m, 1H), 1.35 (t, J = 7.1 Hz, 3H), 0.72 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 173.2, 170.2, 169.6, 147.1, 139.8, 136.3, 130.7, 127.9, 127.5, 125.9, 124.6, 121.2, 118.5, 114.4, 110.8, 74.0, 66.1, 61.9, 61.7, 52.5, 34.3, 31.3, 14.2, 13.4; HRMS (TOF MS ESI$^+$) calculated for $C_{26}H_{26}ClNNaO_6$ [M + Na]$^+$, 506.1341, found, 506.1347.



2,2-Diethyl 1-methyl 6-chloro-4-methyl-1-phenyl-3,4-dihydrocyclopenta[*b*]indole -1,2,2(1*H*)-tricarboxylate (3p)

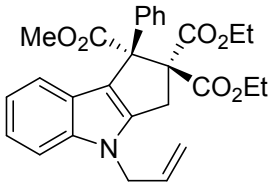
White solid, 36.3 mg, 75% yield, mp: 163.3-164.5 ^oC; ^1H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.63 – 7.55 (m, 2H), 7.33 – 7.26 (m, 4H), 7.07 – 6.95 (m, 2H), 4.39 – 4.25 (m, 2H), 3.78 (d, J = 15.7 Hz, 1H), 3.74 (s, 3H), 3.63 (d, J = 15.5 Hz, 1H), 3.60 – 3.55 (m, 1H), 3.54 (s, 3H), 3.29 – 3.17 (m, 1H), 1.35 (t, J = 7.1 Hz, 3H), 0.72 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 173.2, 170.2, 169.5, 146.4, 141.8, 136.4, 130.7, 127.9, 127.4, 127.0, 122.2, 120.6, 119.9, 115.0, 110.1, 74.1, 66.1, 61.9, 61.8, 52.4, 34.3, 31.3, 14.2, 13.4; HRMS (TOF MS ESI$^+$) calculated for $C_{26}H_{26}ClNNaO_6$

$[M + Na]^+$, 506.1341, found, 506.1344.



2,2-Diethyl 1-methyl 4-benzyl-1-phenyl-3,4-dihydrocyclopenta[*b*]indole -1,2,2(1*H*)-tricarboxylate (3q)

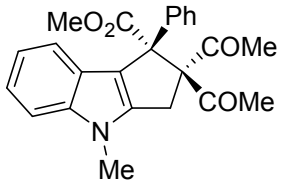
White solid, 43.6 mg, 83% yield, mp: 163.3-164.5 ^oC; ^1H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.73 – 7.63 (m, 2H), 7.36 – 7.28 (comp, 5H), 7.26 – 7.21 (m, 2H), 7.18 (d, *J* = 7.4 Hz, 3H), 7.10 (t, *J* = 7.4 Hz, 1H), 7.01 (t, *J* = 7.4 Hz, 1H), 5.40 – 5.26 (m, 2H), 4.31 (q, *J* = 7.1 Hz, 2H), 3.77 (d, *J* = 15.6 Hz, 1H), 3.62 – 3.55 (comp, 4H), 3.54 – 3.47 (m, 1H), 3.35 – 3.23 (m, 1H), 1.34 (t, *J* = 7.1 Hz, 3H), 0.74 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 173.3, 170.4, 169.6, 145.6, 140.8, 137.3, 136.6, 130.9, 129.0, 127.8, 127.7, 127.3, 126.7, 124.0, 121.1, 120.2, 119.4, 115.5, 110.5, 74.3, 66.1, 61.8, 61.7, 52.4, 48.6, 34.6, 14.2, 13.5; HRMS (TOF MS ESI^+) calculated for $C_{32}H_{31}NO_6$ $[M + H]^+$, 525.2151; found, 525.2147.



2,2-Diethyl 1-methyl 4-allyl-1-phenyl-3,4-dihydrocyclopenta[*b*]indole-1,2,2(1*H*) -tricarboxylate (3r)

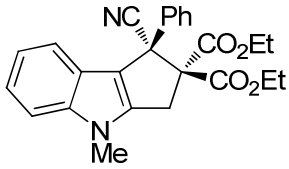
White oil, 40.0 mg, 89% yield; ^1H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.70 – 7.62 (m, 2H), 7.34 – 7.27 (comp, 4H), 7.15 (t, *J* = 8.4 Hz, 2H), 7.02 (t, *J* = 7.5 Hz, 1H), 6.13 – 5.97 (m, 1H), 5.22 (dd, *J* = 10.3, 1.0 Hz, 1H), 5.07 (dd, *J* = 17.1, 1.0 Hz, 1H), 4.84 – 4.66 (m, 2H), 4.33 (q, *J* = 7.1 Hz, 2H), 3.79 (d, *J* = 15.6 Hz, 1H), 3.61 (d, *J* = 15.6 Hz, 1H), 3.58 – 3.49 (comp, 4H), 3.33 – 3.23 (m, 1H), 1.36 (t, *J* = 7.1 Hz, 3H), 0.74 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 173.3, 170.4, 169.6, 145.5,

140.7, 136.6, 133.1, 130.9, 127.8, 127.3, 123.8, 121.0, 120.0, 119.3, 117.1, 115.3, 110.2, 74.3, 66.0, 61.8, 61.7, 52.3, 47.1, 34.5, 14.2, 13.4; HRMS (TOF MS ESI$^+$) calculated for $C_{28}H_{29}NNaO_6$ [M + Na]$^+$, 498.1887, found, 498.1892.



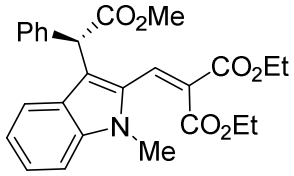
Methyl 2,2-diacetyl-4-methyl-1-phenyl-1,2,3,4- tetrahydrocyclopenta[*b*]indole-1-carboxylate (3s)

White solid, 32.3 mg, 83% yield, mp: 163.3-164.5 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.54 – 7.47 (m, 2H), 7.34 – 7.26 (m, 4H), 7.22 – 7.15 (m, 2H), 7.02 (t, *J* = 7.5 Hz, 1H), 3.83 – 3.73 (comp, 4H), 3.64 – 3.52 (comp, 4H), 2.27 (s, 3H), 1.51 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 206.2, 203.9, 174.0, 144.4, 141.6, 136.8, 130.6, 128.1, 128.0, 123.6, 121.2, 120.1, 119.6, 115.5, 109.9, 85.2, 66.5, 52.5, 32.3, 31.2, 29.3, 27.9; HRMS (TOF MS ESI$^+$) calculated for $C_{24}H_{23}NNaO_4$ [M + Na]$^+$, 412.1519, found, 412.1523.



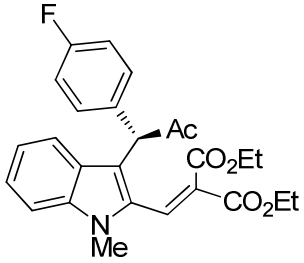
Diethyl 1-cyano-4-methyl-1-phenyl-3,4-dihydrocyclopenta[*b*]indole-2,2(1*H*)-dicarboxylate (3ao). 36.0 mg, 87% yield; ^{1}H NMR (500 MHz, $CDCl_3$) (δ, ppm) 7.71 – 7.54 (m, 2H), 7.43 – 7.30 (comp, 4H), 7.21 (t, *J* = 7.6 Hz, 1H), 7.10 (d, *J* = 7.8 Hz, 1H), 7.04 (t, *J* = 7.5 Hz, 1H), 4.51 – 4.25 (m, 2H), 3.88 – 3.67 (comp, 5H), 3.57 (d, *J* = 16.0 Hz, 1H), 3.36 – 3.33 (m, 1H), 1.36 (t, *J* = 7.1 Hz, 3H), 0.79 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (125 MHz, CDCl3) (δ, ppm) 168.4, 167.6, 144.0, 141.7, 134.9, 128.9, 128.7, 128.3, 122.6, 121.8, 120.5, 120.3, 118.8, 113.2, 110.1, 74.7, 62.5, 62.3, 53.7, 32.8, 31.2, 14.108, 13.4. HRMS (TOF MS ESI$^+$) calculated for $C_{25}H_{25}N_2O_4$ [M + H]$^+$,

417.1809; found, 417.1810.



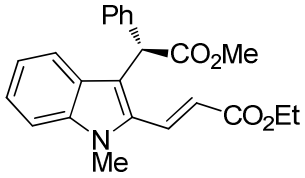
Diethyl 2-{[3-(2-methoxy-2-oxo-1-phenylethyl)-1-methyl-1*H*-indol-2-yl] methylene}malonate 4a

Yellow solid, mp: 121.1-122.4 °C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.79 (s, 1H), 7.51 (d, *J* = 8.1 Hz, 1H), 7.30 – 7.21 (comp, 7H), 7.10 – 7.02 (m, 1H), 5.31 (s, 1H), 4.39 – 4.26 (m, 2H), 3.93 – 3.84 (m, 1H), 3.74 (t, *J* = 3.5 Hz, 1H), 3.70 (s, 3H), 3.65 (s, 3H), 1.35 (t, *J* = 7.1 Hz, 3H), 0.93 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 173.0, 164.8, 163.6, 138.8, 138.0, 134.1, 132.0, 131.9, 128.6, 128.4, 127.1, 126.8, 123.5, 121.7, 120.3, 113.1, 109.7, 62.1, 61.6, 52.4, 48.6, 31.5, 14.2, 13.8; HRMS (TOF MS ESI$^+$) calculated for $C_{26}H_{27}NNaO_6$ $[M + Na]^+$, 472.1731; found, 472.1743.

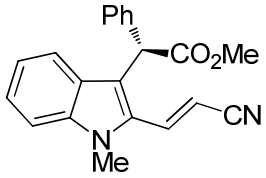


Diethyl 2-((3-(1-(4-fluorophenyl)-2-oxopropyl)-1-methyl-1*H*-indol-2-yl)methylene) malonate (4an). 29.2 mg, 65% yield; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) 7.79 (s, 1H), 7.39 – 7.26 (comp, 3H), 7.15 – 7.05 (comp, 3H), 6.99 – 6.91 (m, 2H), 5.24 (s, 1H), 4.37 – 4.31 (m, 2H), 3.91 – 4.83 (m, 1H), 3.74 – 3.66 (comp, 4H), 2.12 (s, 3H), 1.35 (t, *J* = 7.1 Hz, 3H), 0.97 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) 206.1, 164.8, 163.5, 163.1, 160.7, 139.0, 133.4, 132.4, 132.3, 130.9, 130.8, 126.5, 123.8, 121.0 (d, *J* = 32.5 Hz), 115.1 (d, *J* = 21.2 Hz), 112.4, 110.0, 62.3, 61.7, 55.8, 31.6, 29.4, 14.2, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) (δ, ppm) -116.10. HRMS

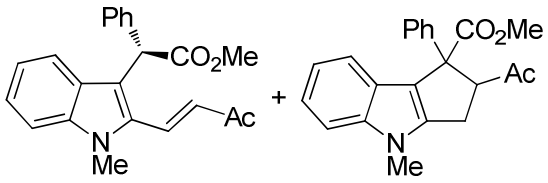
(TOF MS ESI$^+$) calculated for $C_{26}H_{26}FNNaO_5$ [M + Na]$^+$, 474.1687; found, 474.1670.



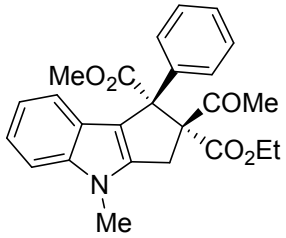
Ethyl (*E*)-3-(3-(2-methoxy-2-oxo-1-phenylethyl)-1-methyl-1*H*-indol-2-yl)acrylate (4ha). 30.6 mg, 81% yield; ^{1}H NMR (500 MHz, $CDCl_3$) (δ, ppm) 7.88 (d, *J* = 16.2 Hz, 1H), 7.55 (d, *J* = 8.1 Hz, 1H), 7.41 – 7.20 (comp, 6H), 7.09 – 7.05 (m, 1H), 6.27 (d, *J* = 16.2 Hz, 1H), 5.49 (s, 1H), 4.28 (q, *J* = 7.1 Hz, 2H). 3.84 (s, 3H), 3.74 (s, 3H), 1.35 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, CDCl3) (δ, ppm) 173.1, 166.8, 138.9, 138.3, 133.0, 132.3, 128.6, 128.5, 127.2, 126.6, 124.1, 121.6, 121.2, 120.5, 115.2, 109.7, 60.9, 52.5, 48.6, 31.5, 14.5. HRMS (TOF MS ESI$^+$) calculated for $C_{23}H_{24}NO_4$ [M + H]$^+$, 378.1700; found, 378.1717.



Methyl (*E*)-2-(2-(2-cyanovinyl)-1-methyl-1*H*-indol-3-yl)-2-phenylacetate (4ia). 22.2 mg, 67% yield; ^{1}H NMR (500 MHz, $CDCl_3$) (δ, ppm) 7.56 – 7.54 (m, 1H), 7.51 (d, *J* = 16.7 Hz, 1H), 7.35 – 7.27 (comp, 5H), 7.23 – 7.17 (m, 2H), 7.12 – 7.08 (m, 1H), 5.68 (d, *J* = 16.7 Hz, 1H), 5.40 (s, 1H), 3.81 (s, 3H), 3.74 (s, 3H); ^{13}C NMR (100 MHz, CDCl3) (δ, ppm) 172.7, 138.9, 138.2, 137.7, 132.1, 128.8, 128.3, 127.5, 126.7, 124.9, 121.6, 121.0, 118.2, 115.9, 109.9, 99.1, 52.7, 48.5, 31.4. HRMS (TOF MS ESI$^+$) calculated for $C_{21}H_{19}N_2O_2$ [M + H]$^+$, 331.1441; found, 331.1449.



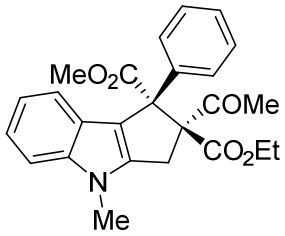
Methyl (*E*)-2-(1-methyl-2-(3-oxobut-1-en-1-yl)-1*H*-indol-3-yl)-2-phenylacetate (4ja) and Methyl 2-acetyl-4-methyl-1-phenyl-1,2,3,4-tetrahydrocyclopenta[*b*]-indole-1-carboxylate (3ja). 27.1 mg, **4xa** : **3xa** = 4.8 : 1, 78% total yield; **4xa**: ^{1}H NMR (500 MHz, $CDCl_3$) (δ, ppm) 7.74 (d, *J* = 16.4 Hz, 1H), 7.66 – 7.56 (m, 1H), 7.38 – 7.26 (comp, 7H), 7.16 – 7.08 (m, 1H), 6.56 (d, *J* = 16.4 Hz, 1H), 5.56 (s, 1H), 3.83 (s, 3H), 3.76 (s, 3H), 2.33 (s, 3H); ^{13}C NMR (100 MHz, CDCl3) (δ, ppm) 197.6, 172.9, 139.1, 138.2, 132.8, 131.0, 128.8, 128.5, 128.3, 127.2, 126.7, 124.3, 121.0, 120.5, 116.0, 109.8, 52.4, 48.4, 31.5, 28.0. **3xa**: ^{1}H NMR (500 MHz, $CDCl_3$) (δ, ppm) 7.54 – 7.49 (m, 2H), 7.41 – 7.28 (comp, 3H), 7.25 – 7.17 (m, 3H), 7.07 – 7.03 (m, 1H), 3.85 – 3.81 (m, 1H), 3.74 (s, 3H), 3.64 (s, 3H), 3.53 (dd, *J* = 15.3, 8.4 Hz, 1H), 3.24 (dd, *J* = 15.3, 8.4 Hz, 1H), 2.22 (s, 3H); ^{13}C NMR (100 MHz, CDCl3) (δ, ppm) 205.9, 173.6, 144.2, 142.3, 141.3, 128.2, 128.1, 127.2, 123.6, 120.9, 119.8, 119.5, 116.9, 109.6, 69.6, 62.8, 52.1, 30.8, 29.6, 27.3. HRMS (TOF MS ESI^{+}) calculated for $C_{22}H_{21}NNaO_3$ $[M + Na]^{+}$, 370.1414; found, 370.1400.



2-Ethyl 1-methyl (1*S, 2*R**)-2-acetyl-4-methyl-1-phenyl-1,2,3,4-tetrahydrocyclopenta[*b*]indole-1,2-dicarboxylate (7)**

Yellow solid, 32.3 mg, 77% yield, mp: 133.7-134.5 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.61 – 7.54 (m, 2H), 7.34 – 7.28 (comp, 4H), 7.20 – 7.10 (m, 2H), 7.03 – 6.98 (m, 1H), 4.40 – 4.28 (m, 2H), 3.78 (d, *J* = 4.9 Hz, 3H), 3.70 (d, *J* = 15.8 Hz, 1H), 3.58 – 3.51 (comp, 4H), 1.47 (s, 3H), 1.38 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 202.7, 173.5, 172.0, 145.8, 141.5, 136.3, 130.8, 128.1, 128.0,

123.7, 121.0, 120.0, 119.3, 114.4, 109.9, 78.9, 66.4, 61.8, 52.4, 32.9, 31.2, 27.7, 14.2; HRMS (TOF MS ESI$^+$) calculated for $C_{25}H_{25}NNaO_5$ [M + Na]$^+$, 442.1625, found, 442.1629.

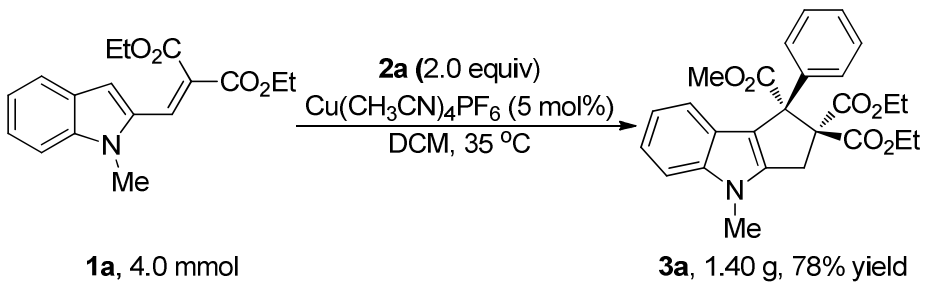


2-Ethyl 1-methyl (1*S, 2*S**)-2-acetyl-4-methyl-1-phenyl-1,2,3,4-tetrahydrocyclopenta[*b*]indole-1,2-dicarboxylate (8)**

Yellow solid, 33.1 mg, 79% yield, mp: 133.7-134.5 ^oC; ^1H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.63 – 7.54 (m, 2H), 7.32 – 7.27 (m, 2H), 7.26 (d, *J* = 1.6 Hz, 2H), 7.19 – 7.12 (m, 2H), 7.04 – 6.97 (m, 1H), 3.79 (s, 3H), 3.76 – 3.66 (m, 2H), 3.65 – 3.58 (m, 1H), 3.55 (s, 3H), 3.26 – 3.15 (m, 1H), 2.30 (s, 3H), 0.74 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 202.1, 173.7, 169.7, 144.4, 141.5, 137.1, 130.8, 127.6, 127.5, 123.7, 121.0, 120.0, 119.4, 115.4, 109.8, 80.3, 65.6, 62.0, 52.4, 33.7, 31.2, 28.5, 13.4; HRMS (TOF MS ESI$^+$) calculated for $C_{25}H_{25}NNaO_5$ [M + Na]$^+$, 442.1625, found, 442.1626.

General Procedure of the Scale Up and Synthesis of 5 and 6.

General Procedure of the Scale Up:

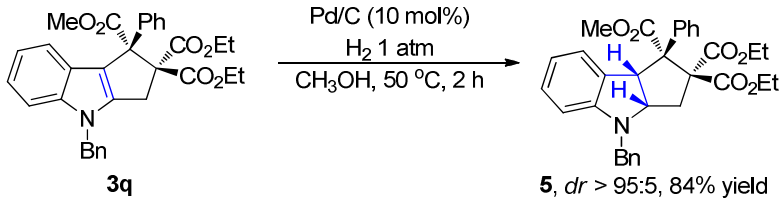


1a, 4.0 mmol **3a**, 1.40 g, 78% yield

To a 50-mL oven-dried vial containing a magnetic stirring bar, $Cu(CH_3CN)_4PF_6$ (74.5 mg, 5.0 mol %), compound **1a** (1.20 g, 4.0 mmol) in DCM (20.0 mL), diazo

compound **2a** (1.41 g, 8.0 mmol) in DCM (10.0 mL) was added as a solution *via* a syringe pump over 2 h under argon atmosphere at 35 °C. After addition, the reaction mixture was stirred overnight under these conditions until consumption of the material (monitored by TLC). Then the reaction mixture was purified by column chromatography on silica gel after evaporate most of the solvent in *vacuo* (Hexanes : EtOAc = 15:1 to 10:1) to give the pure products 1.40 g of **3** (78% yield).

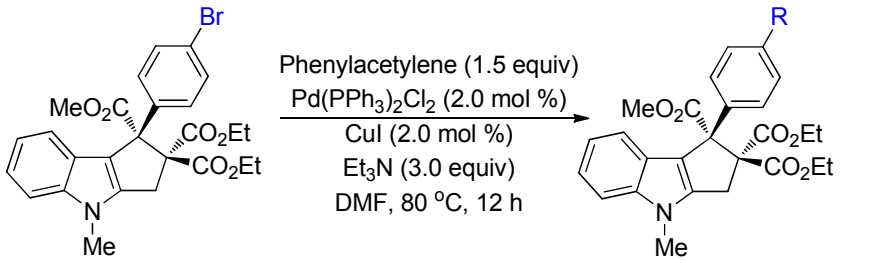
Synthesis of 5.[3]



3q **5**, *dr* > 95:5, 84% yield

To a 10-mL oven-dried vial containing a magnetic stirring bar, **3q** (52.6 mg, 0.1 mmol), Pd/C (1.1 mg, 0.01 mmol, 0.1 equiv), was added MeOH (3.0 mL) under H_2 atmosphere. Then the reaction mixture was stirred at 50 °C for 2 h with a H_2 balloon. After the reaction was complete, the reaction mixture was cooled to room temperature and concentrated under reduced pressure. The obtained residue was purified by flash column chromatography on silica gel (Hexanes: EtOAc = 15:1) to give 44.3 mg pure product **5** as white solid (84% yield). mp: 137.2-138.9 °C, ^{1}H NMR (400 MHz, $CDCl_3$) (δ, ppm)7.49 (d, *J* = 7.9 Hz, 1H), 7.30 – 7.26 (comp, 3H), 7.26 – 7.18 (comp, 6H), 7.15 – 7.09 (m, 1H), 7.06 – 6.99 (m, 1H), 6.97 – 6.91 (m, 2H), 5.45 (s, 2H), 5.42 (s, 1H), 4.21 – 4.05 (m, 2H), 4.00 – 3.84 (m, 2H), 3.73 (s, 3H), 3.56 (t, *J* = 7.3 Hz, 1H), 3.42 (d, *J* = 7.0 Hz, 2H), 1.19 (t, *J* = 7.1 Hz, 3H), 1.11 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 173.6, 168.7, 168.6, 138.6, 137.7, 137.3, 134.8, 129.0, 128.5, 128.4, 127.5, 126.9, 126.0, 122.0, 121.1, 120.0, 110.4, 109.9, 61.9, 61.8, 52.3, 52.3, 48.2, 46.8, 29.9, 23.8, 14.07, 14.0. HRMS (TOF MS ESI$^+$) calculated for $C_{32}H_{33}NNaO_6$ $[M + Na]^+$, 550.2200; found, 550.2196.

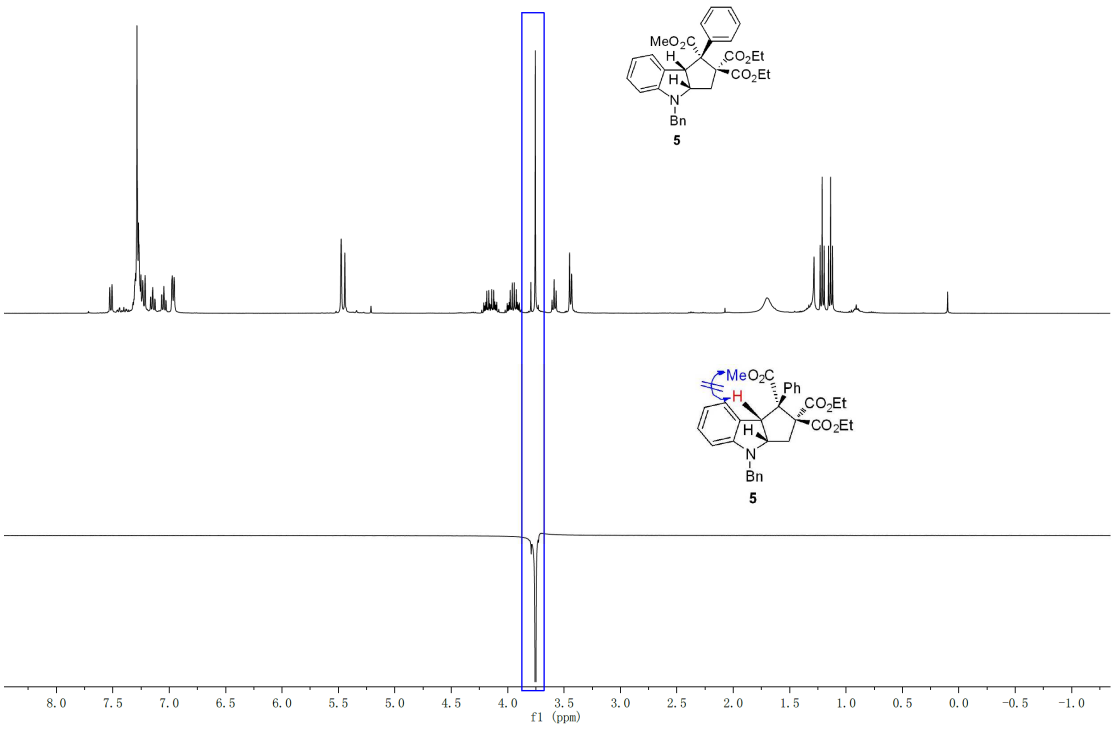
Synthesis of 6.[4]



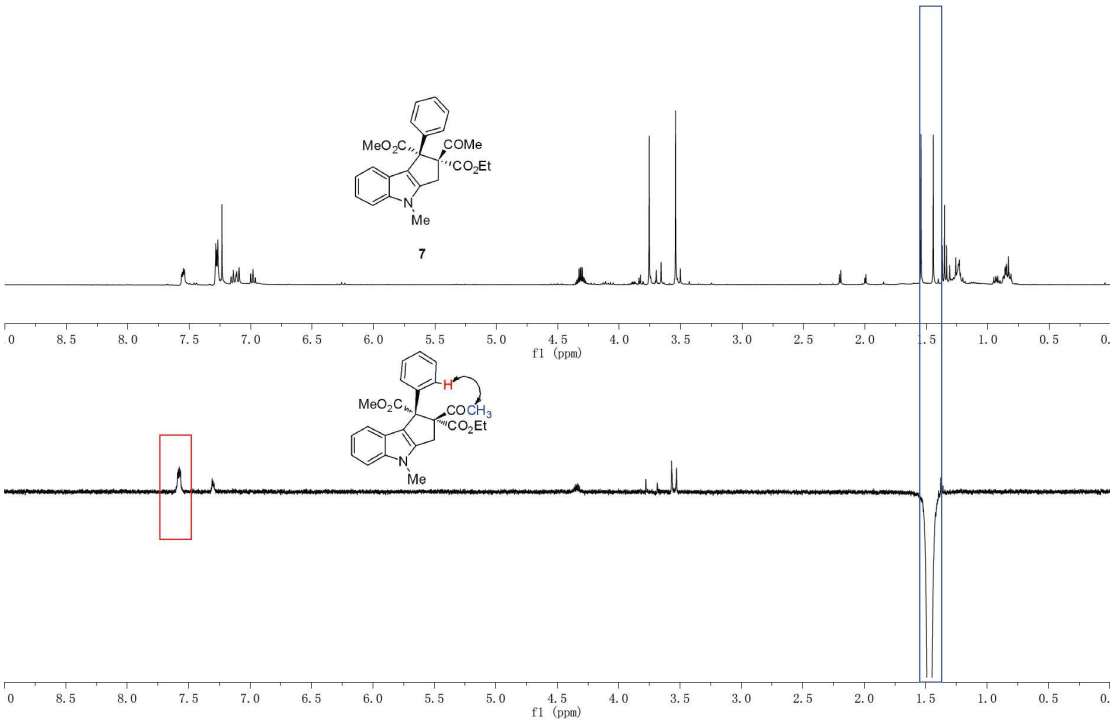
3g **6**, R = phenylethynyl, 92% yield

To a 10-mL oven-dried vial containing a magnetic stirring bar, **3g** (52.8 mg, 0.1 mmol), Phenylacetylene (15.3 mg, 0.15 mmol, 1.5 equiv), Et_3N (30.3 mg, 0.3 mmol, 3.0 equiv), $Pd(PPh_3)_2Cl_2$ (1.4 mg, 2.0 mol%), and CuI (0.4 mg, 2.0 mol%), was added DMF (2.0 mL) under argon atmosphere. Then the reaction mixture was stirred at 80 ^oC for 12 h. After the reaction was complete, the reaction mixture was cooled to room temperature and quenched with water (10 mL) and extracted with EtOAc (10 mL). The organic layer was dried over anhydrous Na_2SO_4 and concentrated under reduced pressure after filtration. The obtained residue was purified by flash column chromatography on silica gel (Hexanes: EtOAc = 10:1) to give 50.6 mg pure product **6** as yellow solid (92% yield). mp: 178.8-179.3 ^oC, ^1H NMR (400 MHz, $CDCl_3$) (δ, ppm) δ 7.66 (d, J = 8.0 Hz, 2H), 7.57 – 7.51 (m, 2H), 7.46 (d, J = 8.7 Hz, 2H), 7.38 – 7.29 (comp, 4H), 7.21 – 7.11 (m, 2H), 7.06 – 6.99 (m, 1H), 4.42 – 4.27 (m, 2H), 3.85 – 3.73 (comp, 4H), 3.69 – 3.58 (comp, 2H), 3.55 (s, 3H), 3.40 – 3.27 (m, 1H), 1.37 (t, J = 7.1 Hz, 3H), 0.79 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) (δ, ppm) δ 173.1, 170.3, 169.5, 145.7, 141.4, 137.1, 131.7, 130.9, 130.5, 128.5, 128.3, 123.6, 123.5, 122.6, 121.0, 120.0, 119.1, 114.3, 109.9, 89.7, 89.6, 74.2, 66.0, 62.0, 61.8, 52.4, 34.3, 31.2, 14.2, 13.5; HRMS (TOF MS ESI$^+$) calculated for $C_{34}H_{31}NNaO_6$ $[M + Na]^+$, 572.2044; found, 572.2048.

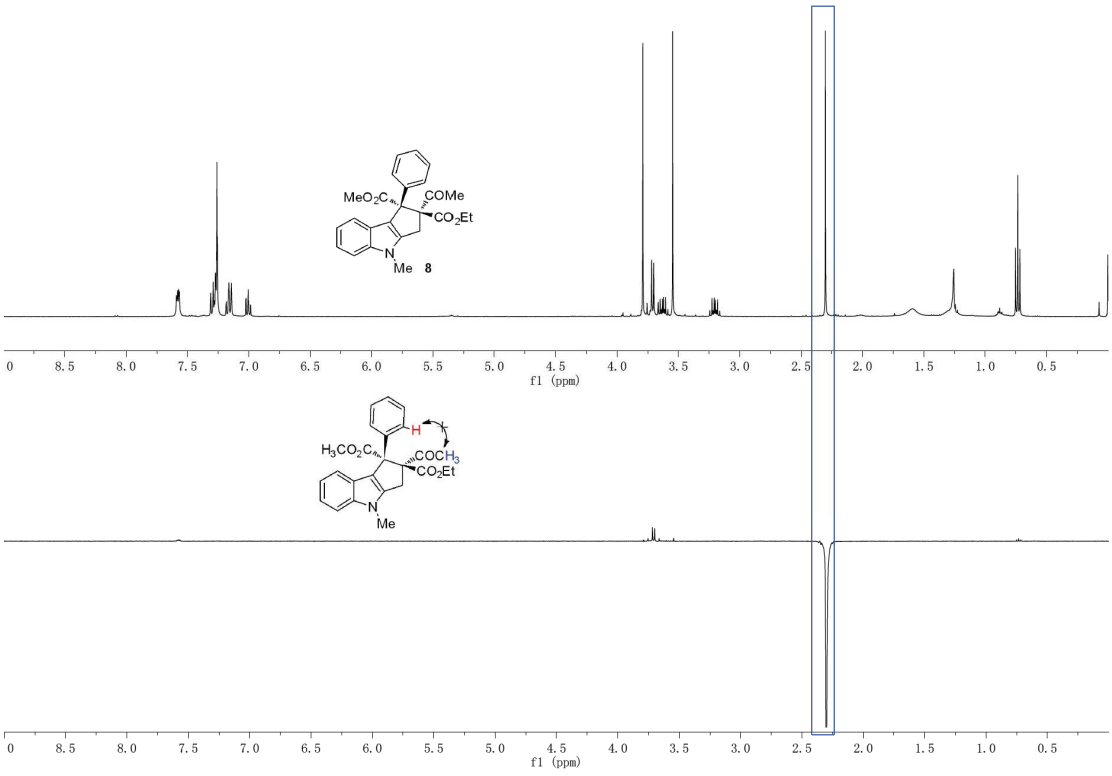
1D-Noe Study of 5



1D-Noe Study of 7



1D-Noe Study of 8



References

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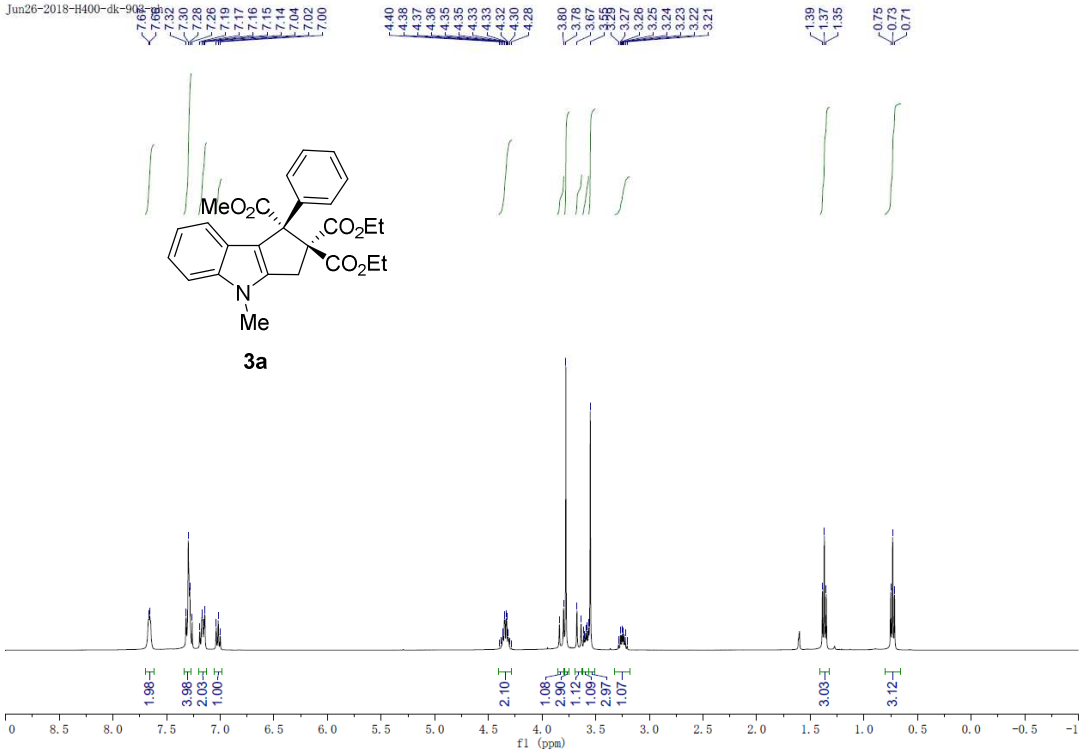
2 (a) X. Zhang, Y. Zheng, L. Qiu and X. Xu, *Org. Biomol. Chem*., 2018, **16**, 70; (b) K. Zhang, X. Xu, J. Zhang, H. Zheng and A. Lin, *Org. Lett.*, 2017, **19**, 2596.

3 D. S. Roman, Y. Takahashi and A. B. Charette, *Org. Lett*., 2011, **13**, 3242.

4 R. Yao, G. Rong, B. Yan, L. Qiu and X. Xu, *ACS Catal*., 2016, **6**, 1024.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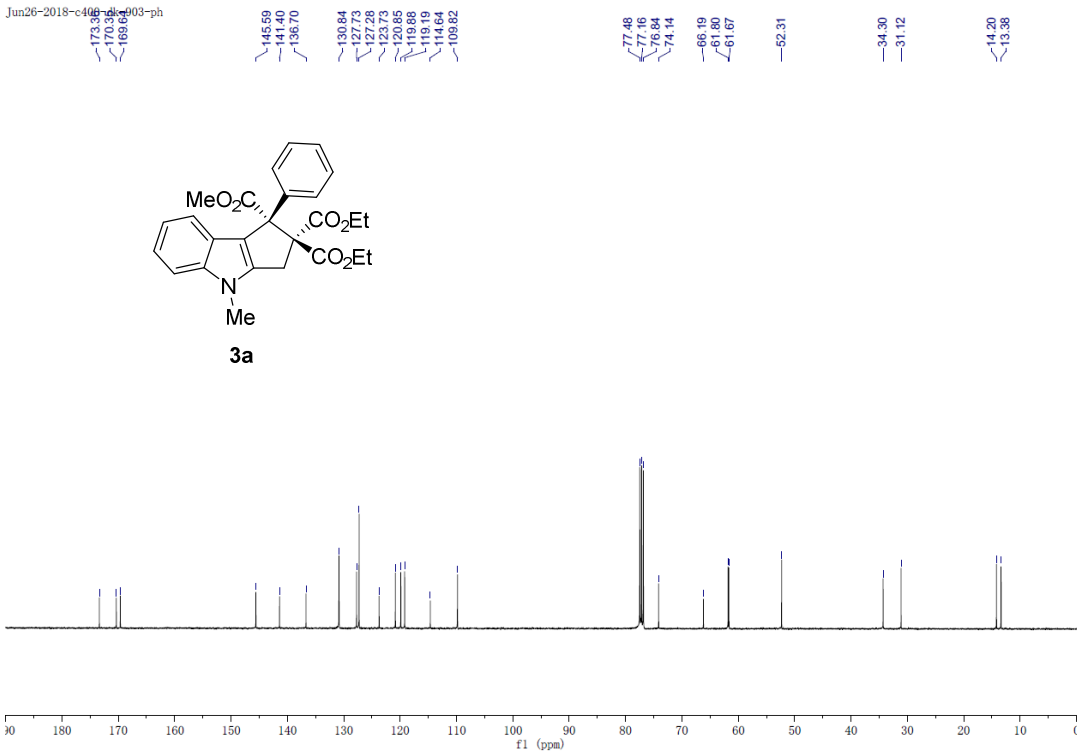
CO2Et
N
Me
3a
f1 (ppm)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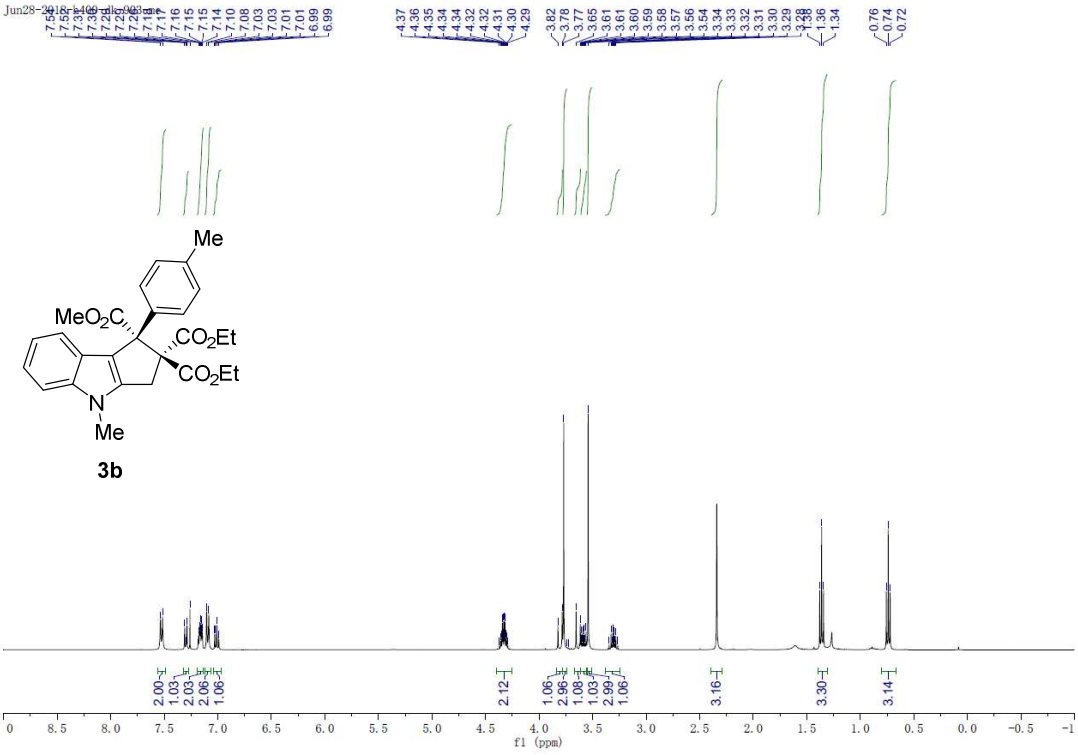
CO2Et
CO2Et
N
Me
3a
f1 (ppm)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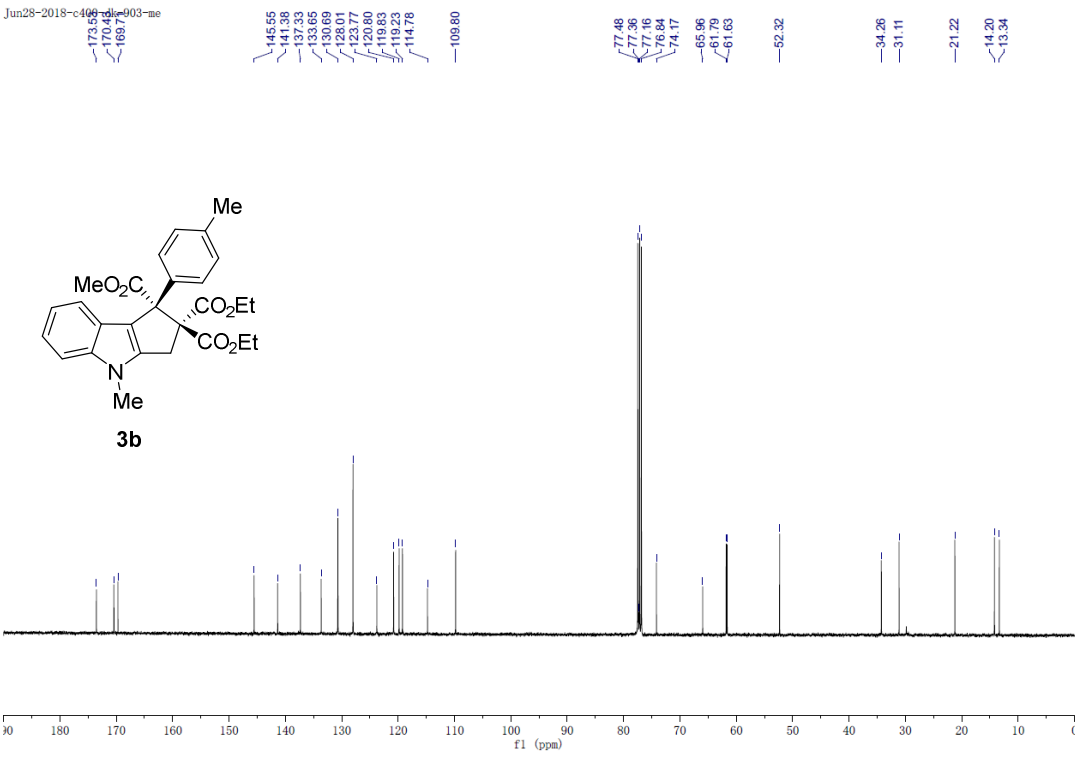
CO2Et
CO2Et
N
Me
3b
f1 (ppm)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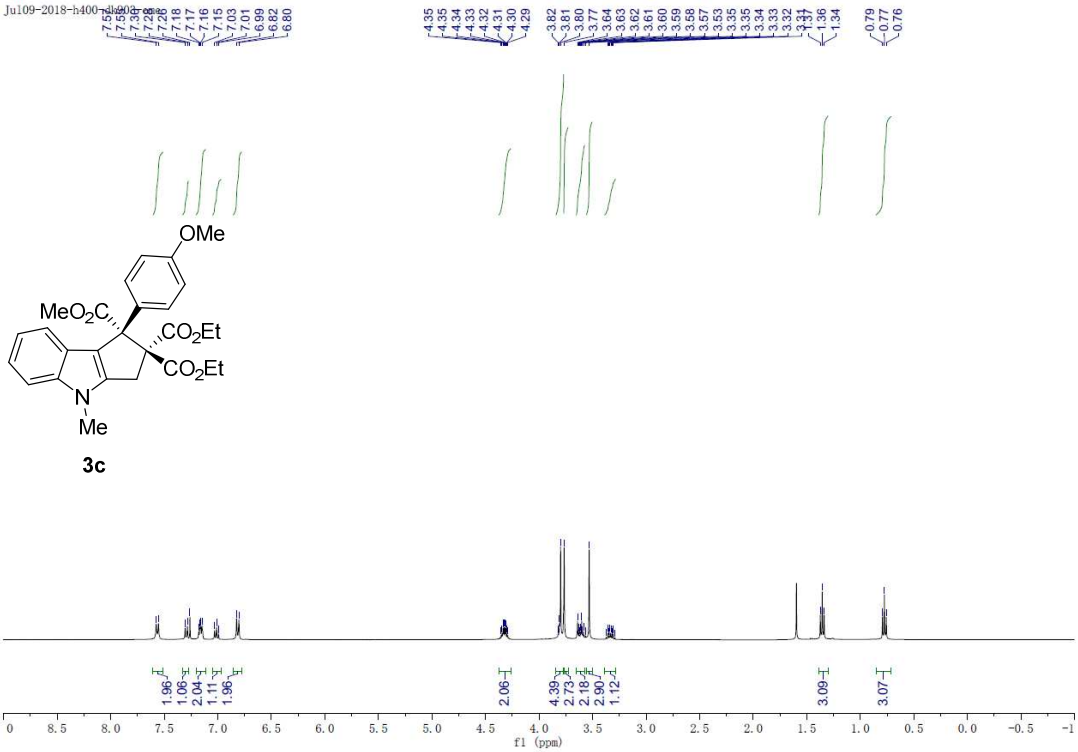
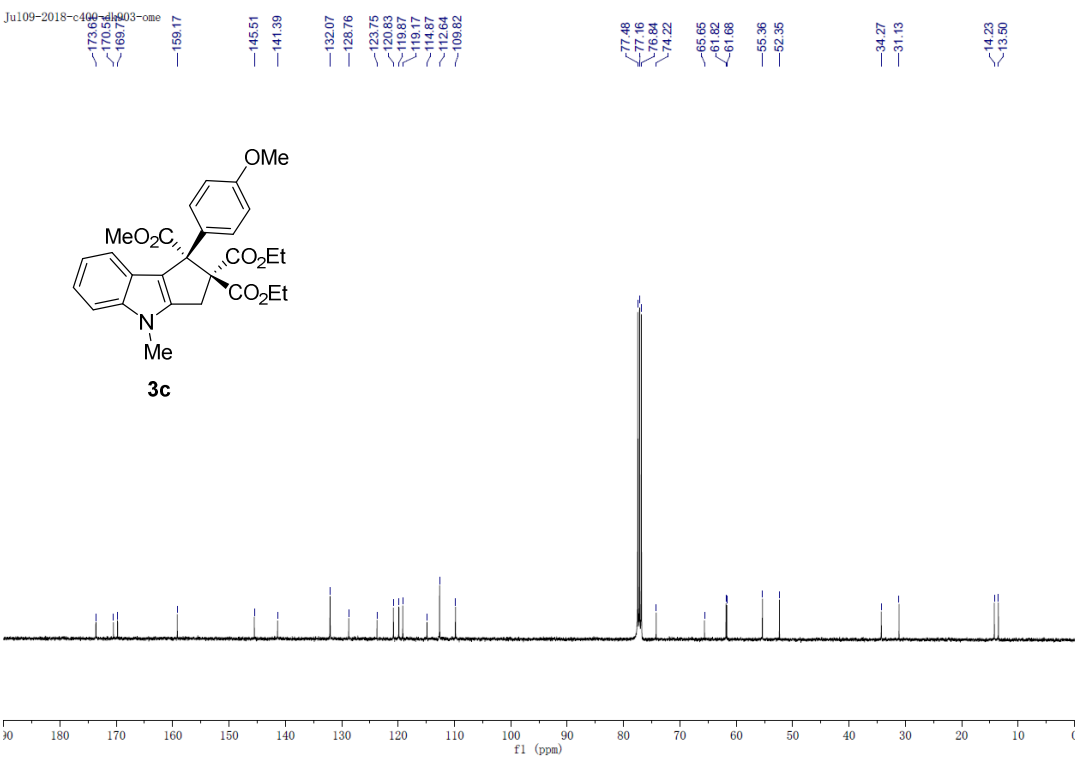
MeO2C
CO2Et
CO2Et
N
Me
3b
f1 (ppm)



3c



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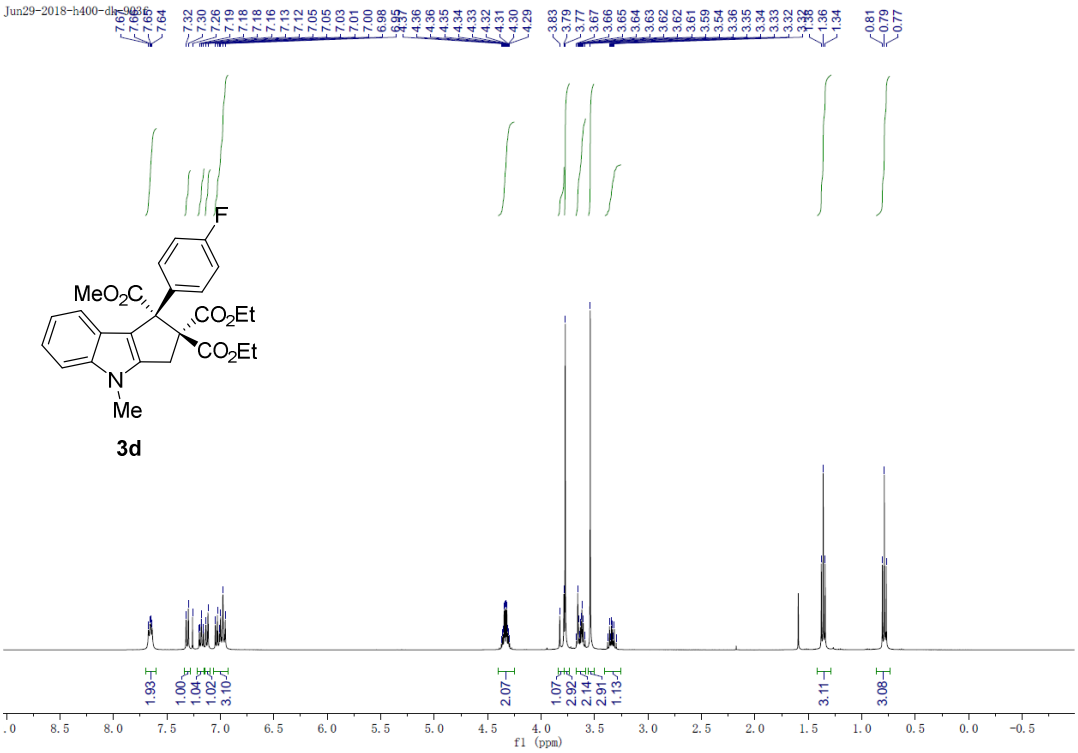
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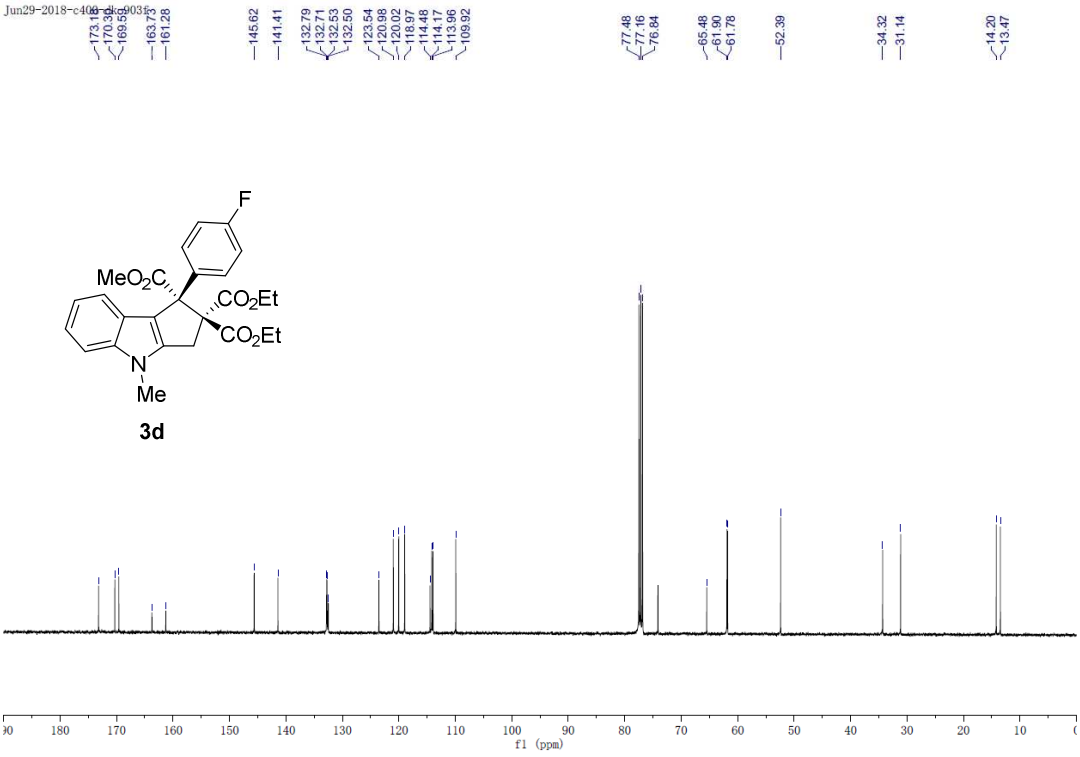
CO2Et
CO2Et
N
Me
3d
f1 (ppm)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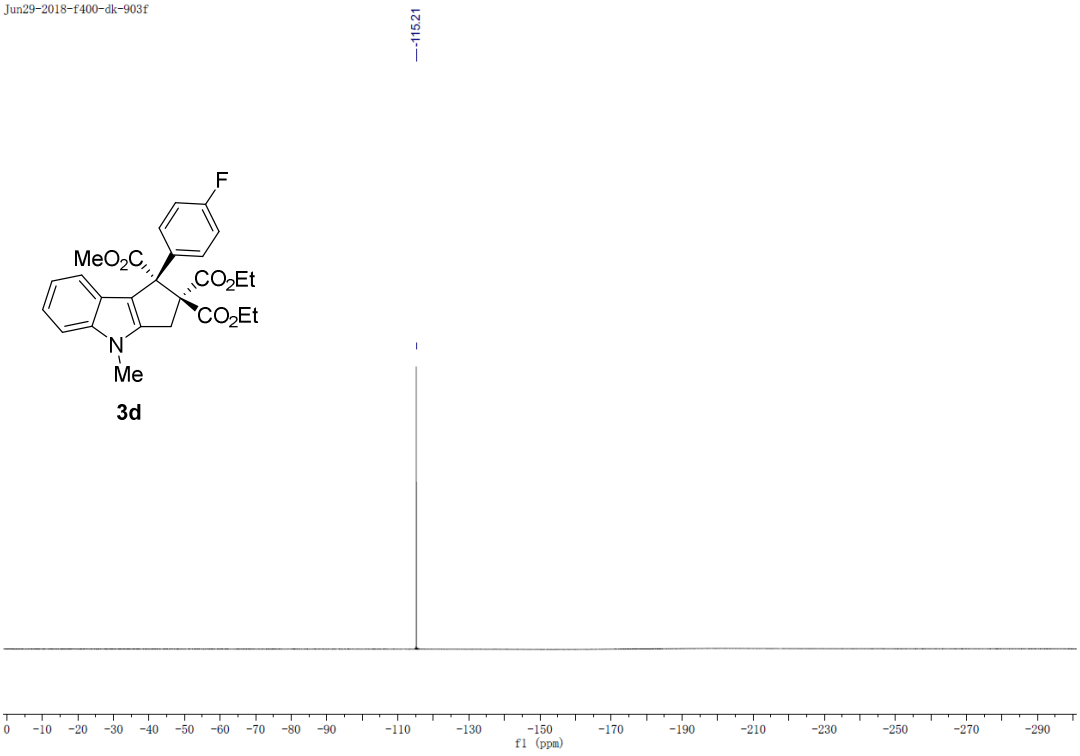
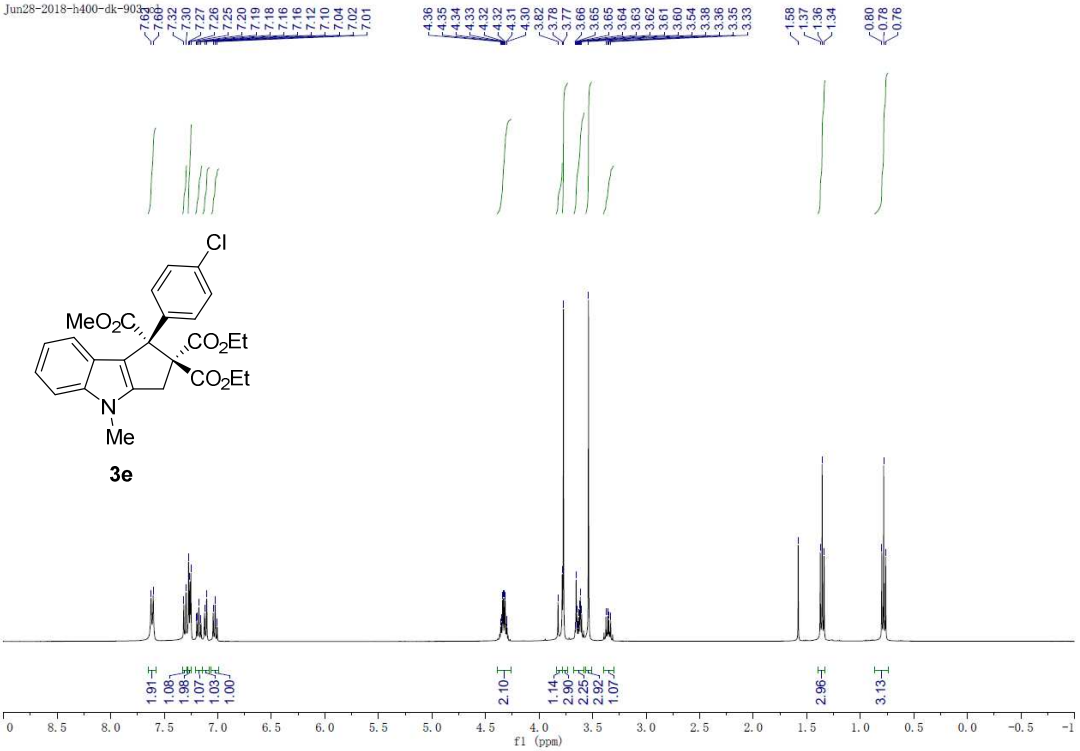
CO2Et
CO2Et
N
Me
3d
f1 (ppm)

Jun29-2018-f400-dk-903f



3d

Jun28-2018-h400-dk-903



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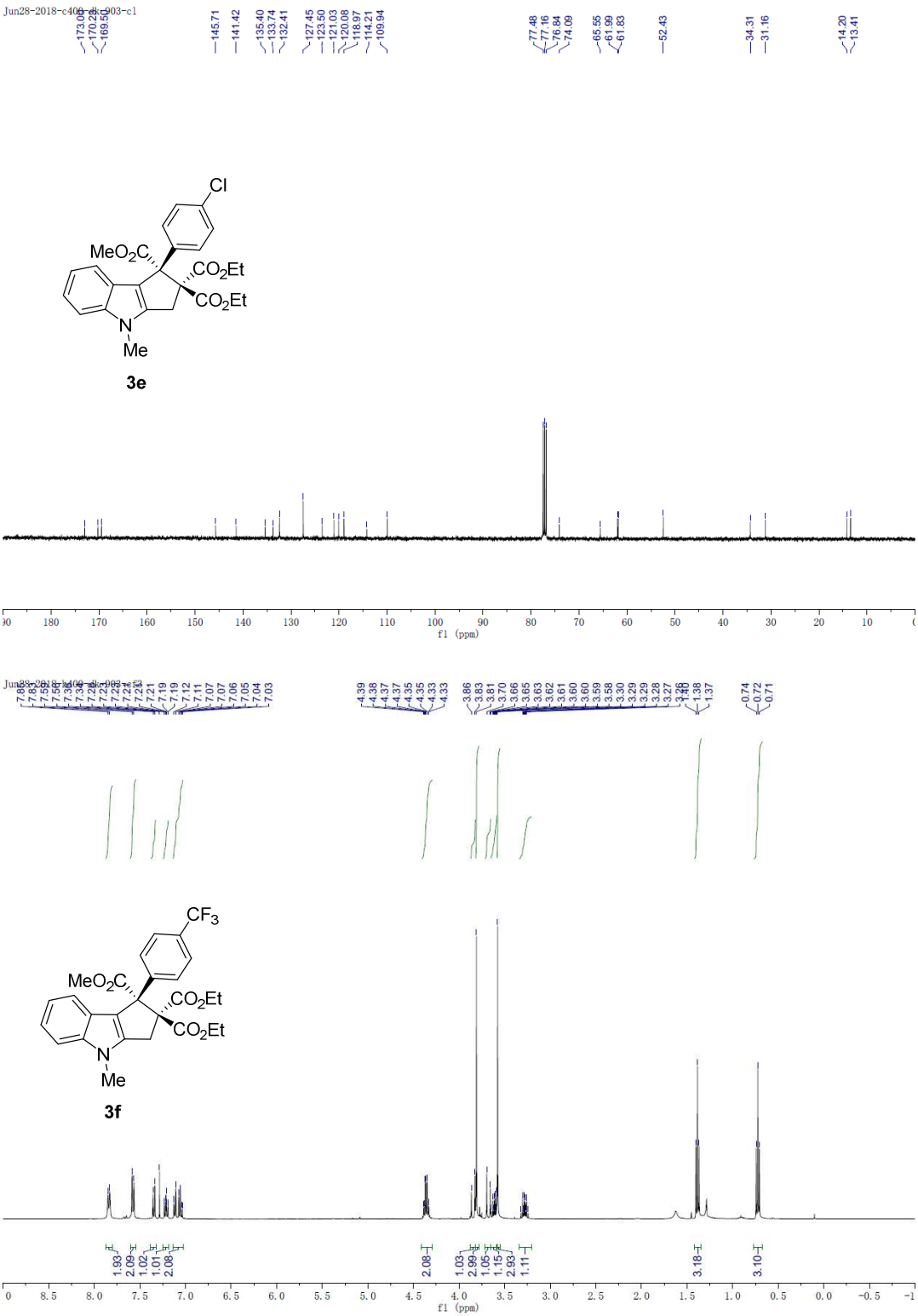
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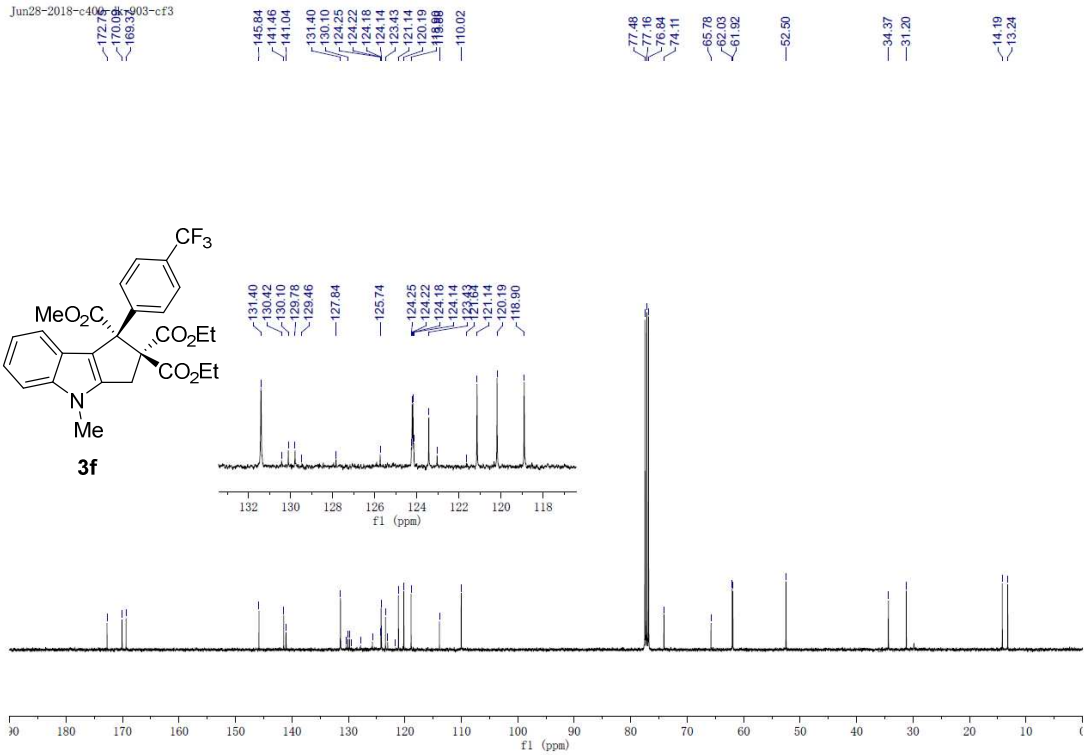
135.40
133.74
132.41
127.45
123.50
121.03
120.08
116.97
114.21
109.94
77.48
77.16
76.84
74.09
65.55
61.99
61.83
52.43
34.31
31.16
14.20
13.41
Cl
MeO2C
CO2Et
CO2Et
N
Me
3e
f1 (ppm)
CF3
MeO2C
CO2Et
CO2Et
N
Me
3f
f1 (ppm)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124.25
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124.18
124.14
123.43
121.14
120.19
110.02
77.48
77.16
76.84
74.11
65.78
62.03
61.92
52.50
34.37
31.20
14.19
13.24
CF3
MeO2C
CO2Et
CO2Et
N
Me
3f
131.40
130.42
130.10
129.78
129.46
127.64
125.74
124.25
124.22
124.18
124.14
121.14
120.19
118.90
132
130
128
126
124
122
120
118
f1 (ppm)
90
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140
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120
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100
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80
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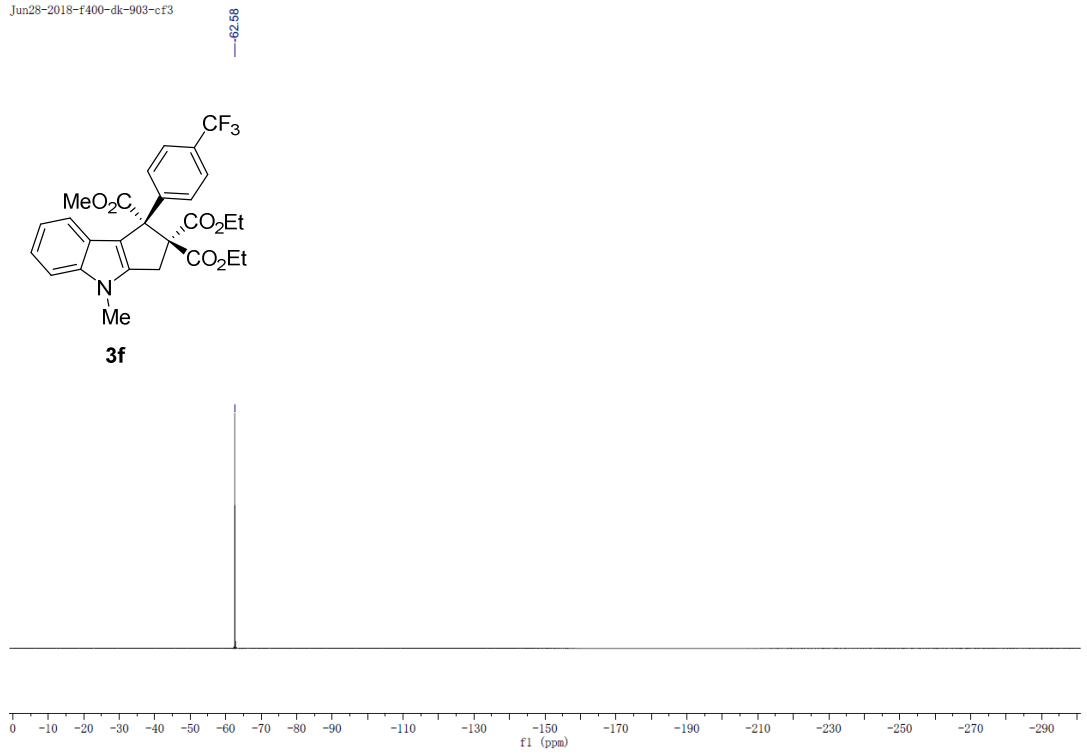
60
50
40
30
20
10
f1 (ppm)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CO2Et
N
Me
3f
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-10
-20
-30
-40
-50
-60
-70
-80
-90
-110
-130
-150
-170
-190
-210
-230
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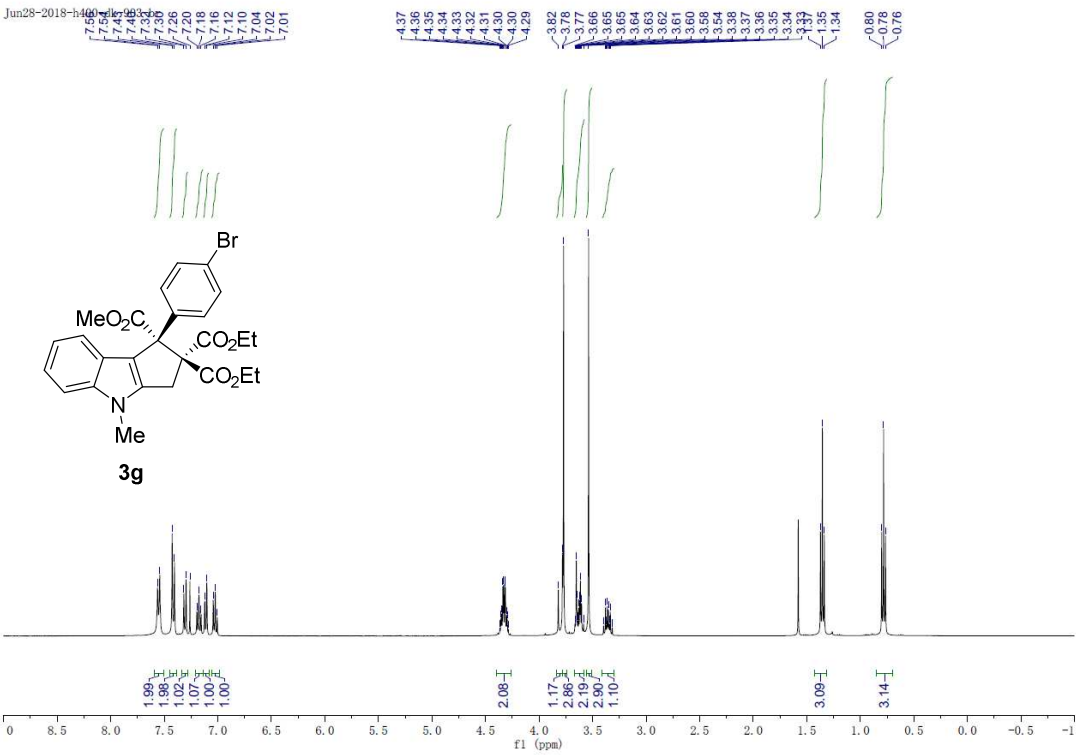
-270
-290
f1 (ppm)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CO2Et
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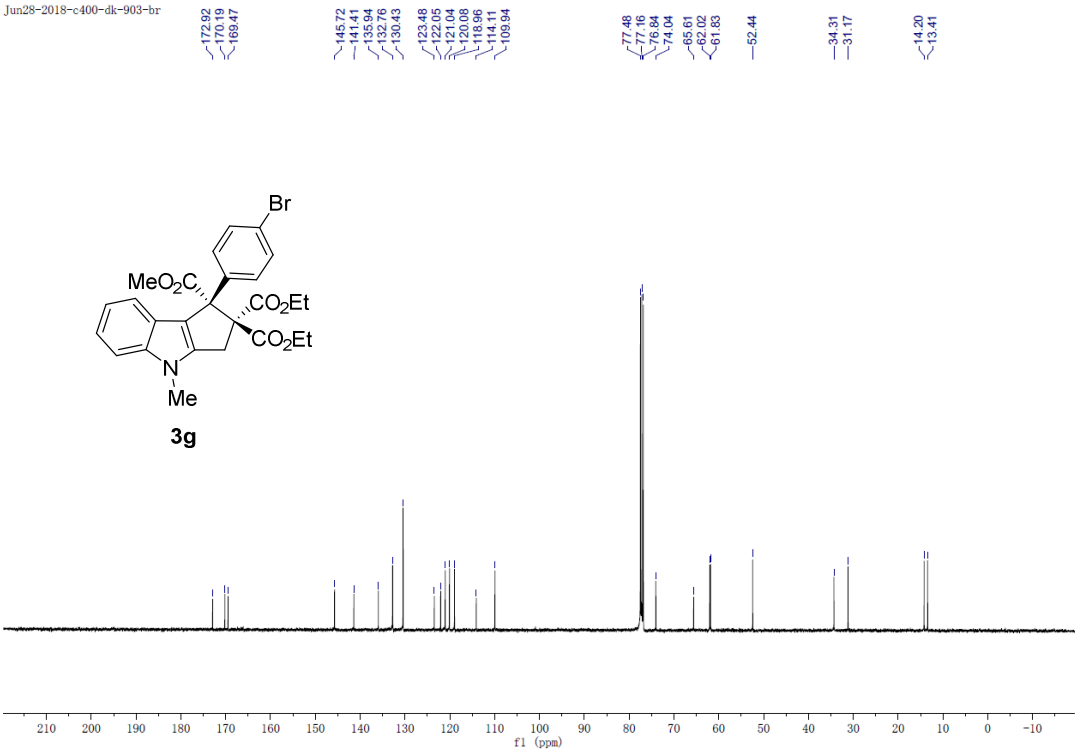
N
Me
3g
f1 (ppm)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CO2Et
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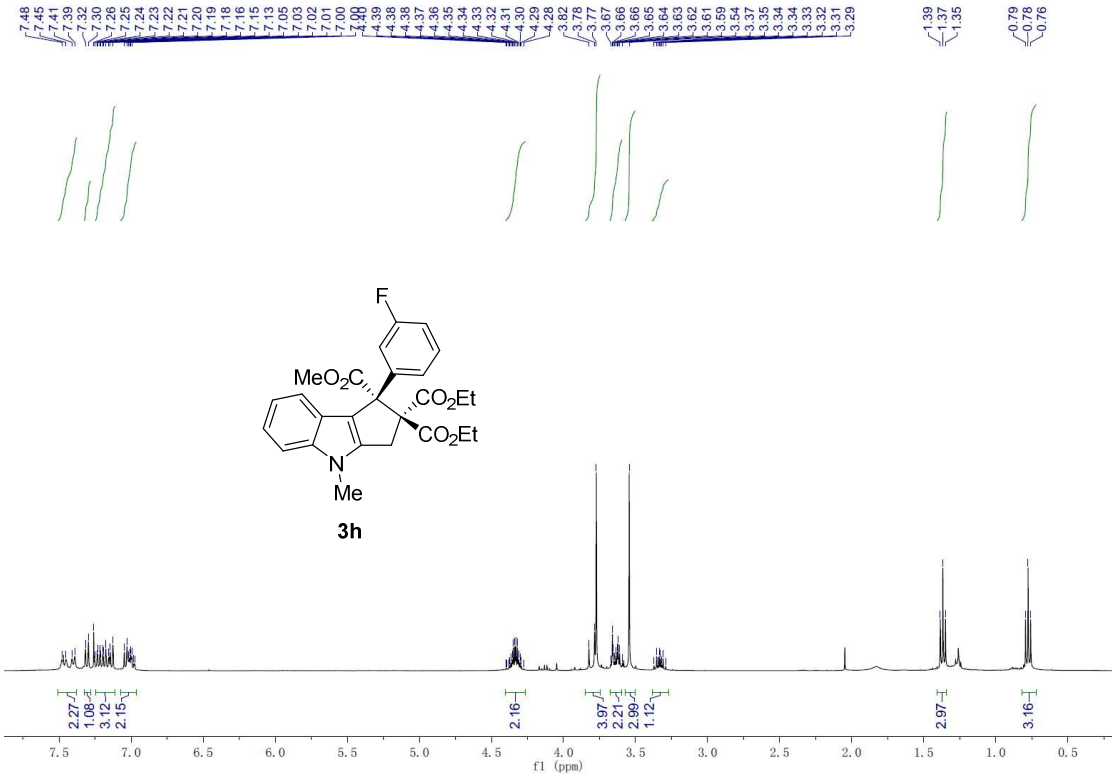
f1 (ppm)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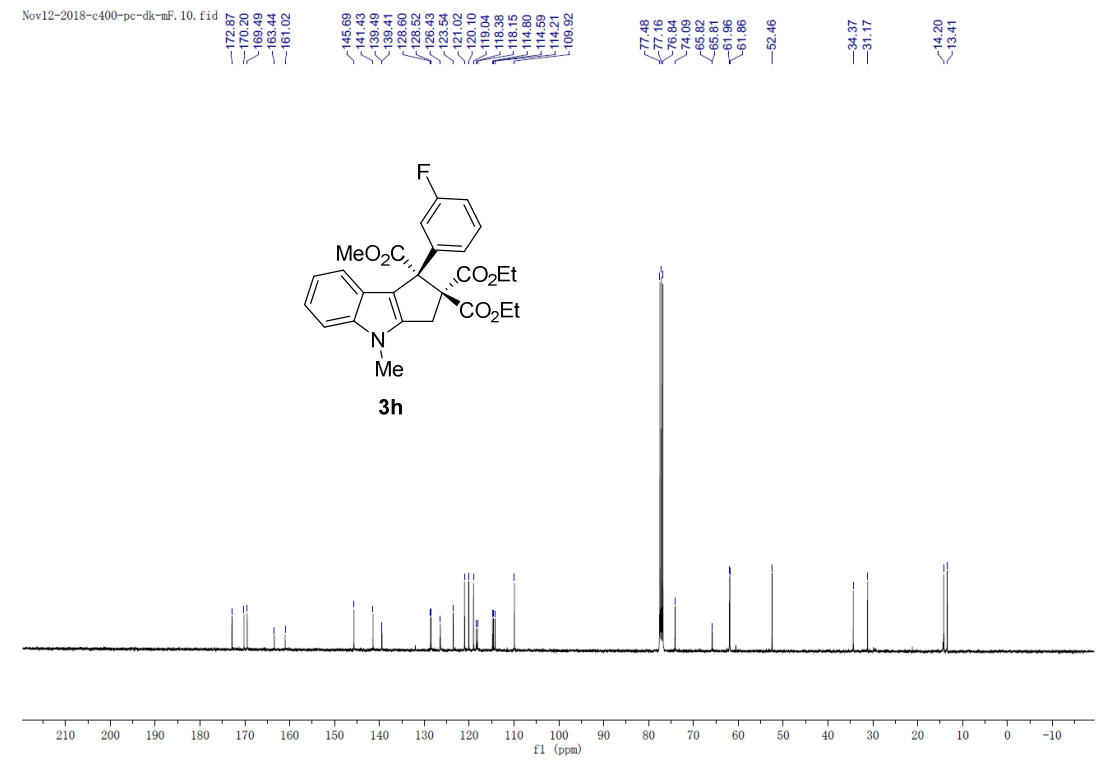
CO2Et
CO2Et
N
Me
3h
f1 (ppm)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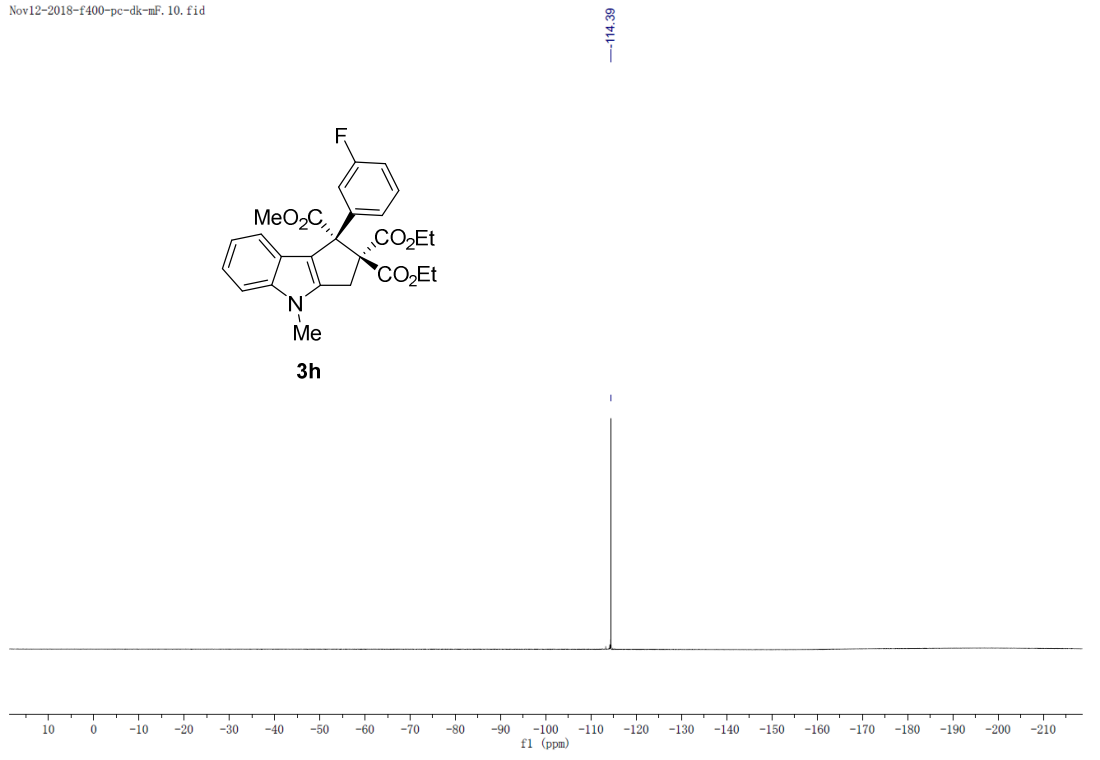
N
Me
3h
f1 (ppm)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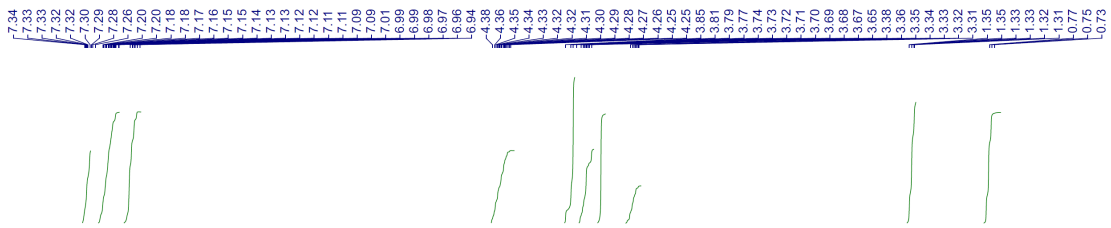
CO2Et
CO2Et
N
Me
3h
f1 (ppm)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7.20
7.18
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7.09
7.01
6.99
6.99
6.98
6.97
6.96
6.94
4.38
4.36
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4.27
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3.77
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3.70
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3.36
3.35
3.34
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1.32
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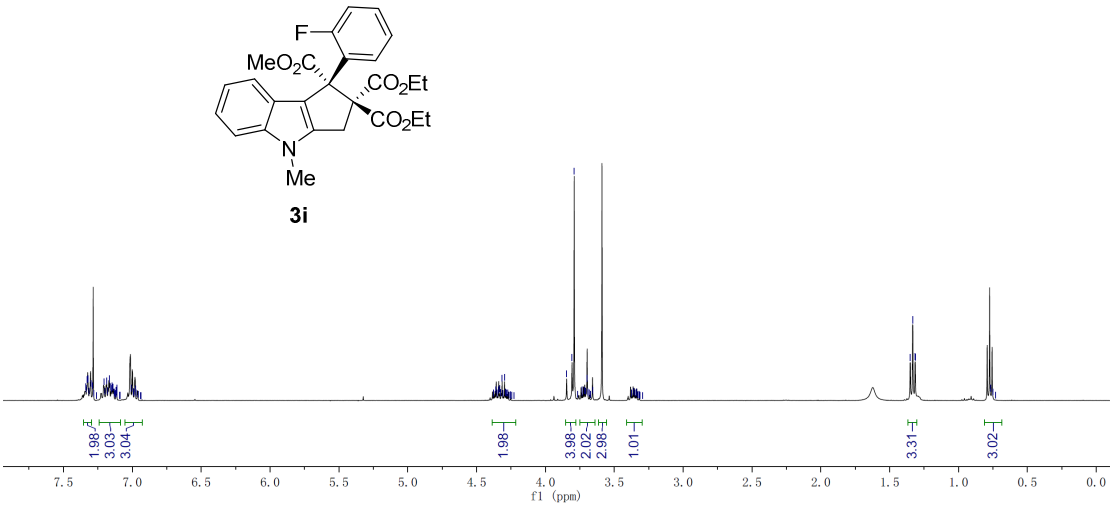
0.75
0.73


F
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CO2Et
CO2Et
N
Me
3i
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3.04
1.98
3.98
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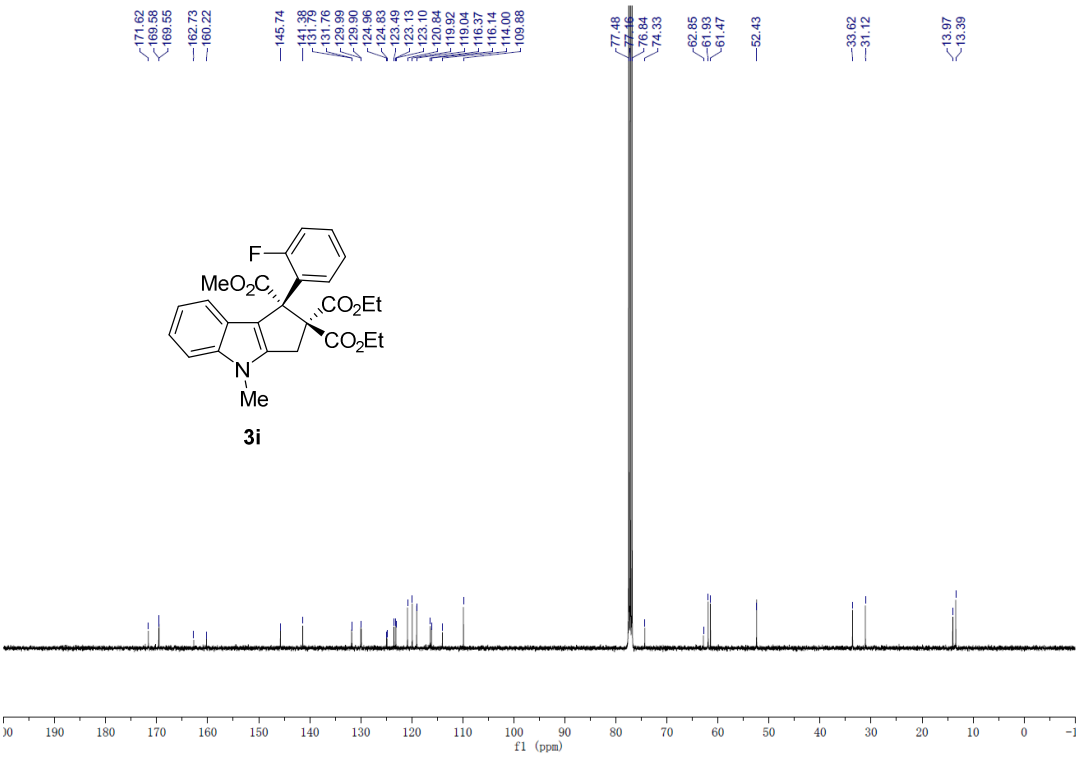
2.98
1.01
3.31
3.02
f1 (ppm)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124.83
123.49
123.13
123.10
120.84
119.92
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116.14
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77.48
77.16
76.84
74.33
62.85
61.93
61.47
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33.62
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F
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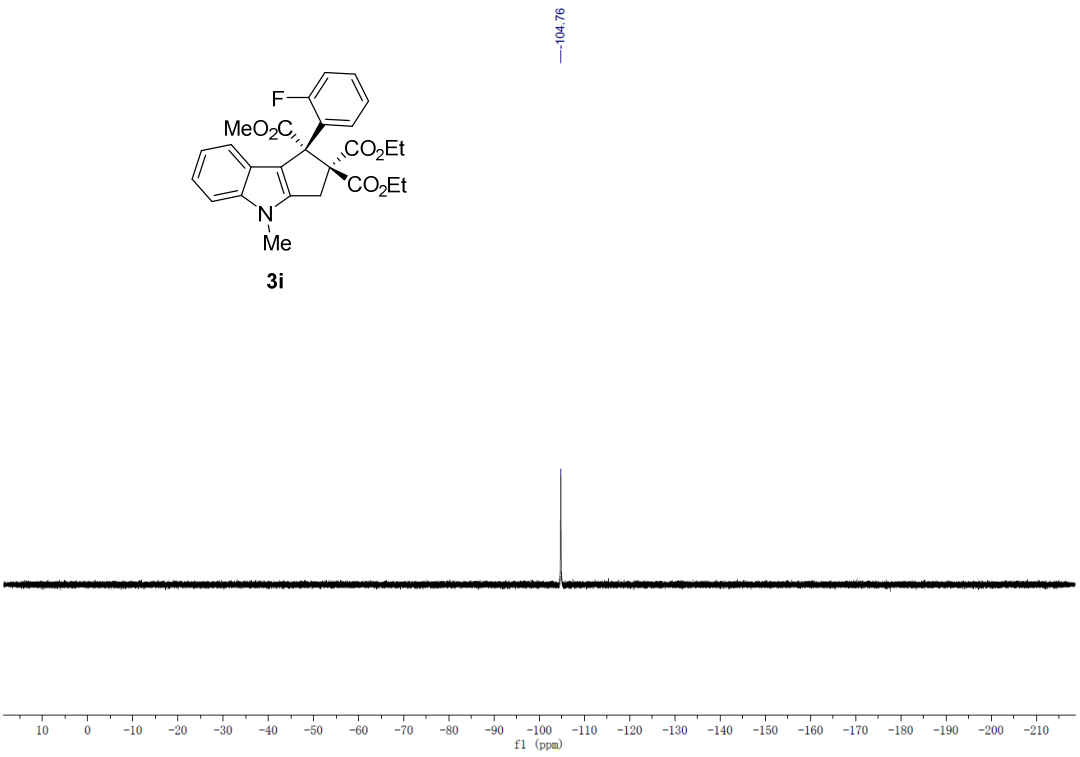
CO2Et
CO2Et
N
Me
f1 (ppm)

3i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Me
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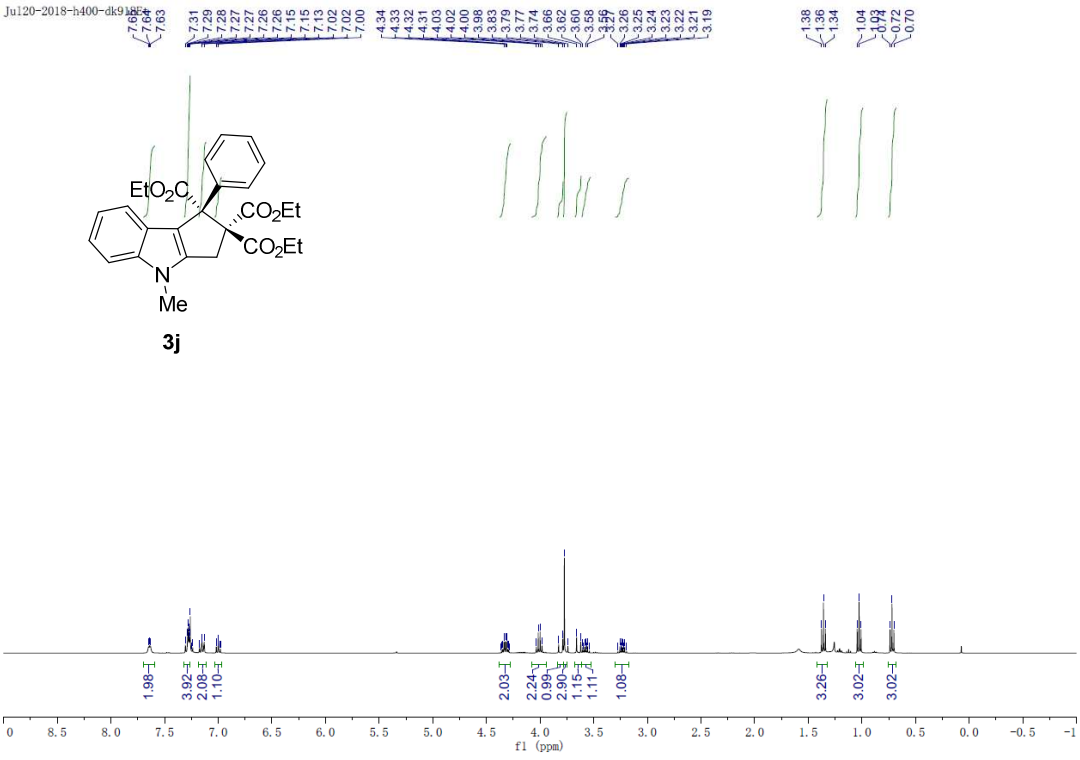
3i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7.15
7.13
7.02
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4.32
4.31
4.03
4.02
4.00
3.98
3.83
3.79
3.77
3.74
3.66
3.62
3.60
3.58
3.26
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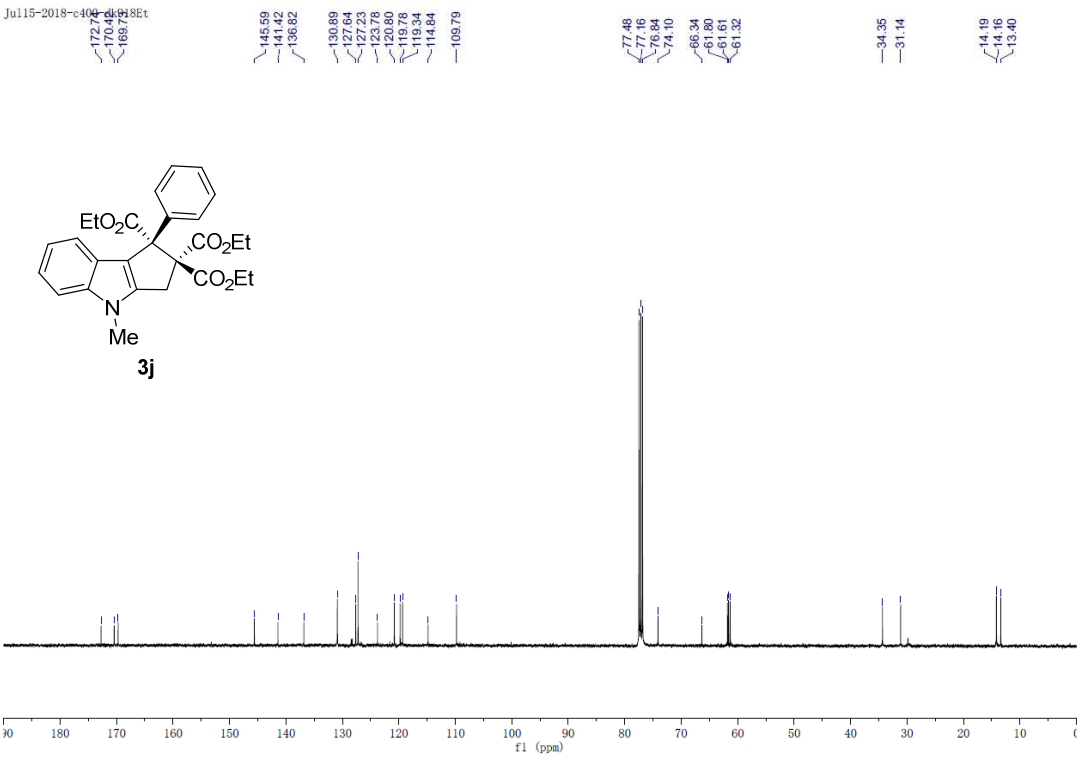
3.24
3.23
3.22
3.21
3.19
1.38
1.36
1.34
1.04
1.03
0.74
0.72
0.70
EtO2C
CO2Et
CO2Et
N
Me
1.98
3.92
2.08
1.10
2.03
2.24
0.99
2.90
1.15
1.11
1.08
3.26
3.02
3.02
f1 (ppm)

3j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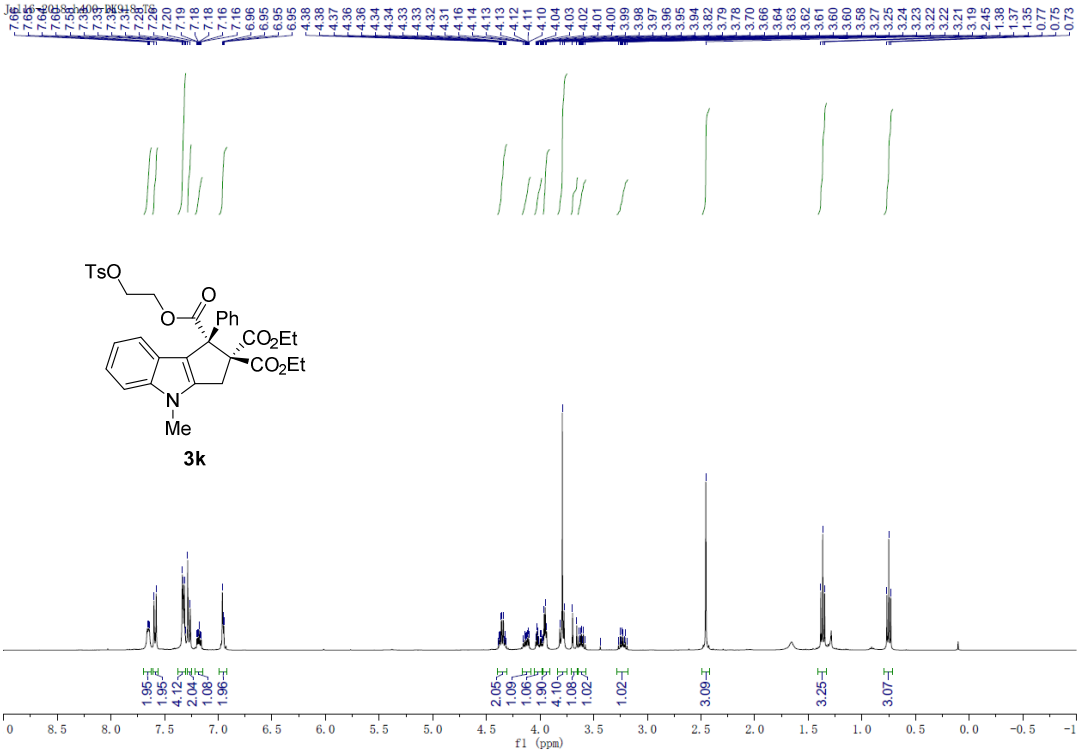
130.89
127.64
127.23
123.78
120.80
119.78
119.34
114.84
109.79
77.48
77.16
76.84
74.10
66.34
61.80
61.61
61.32
34.35
31.14
14.19
14.16
13.40
EtO2C
CO2Et
CO2Et
N
Me
f1 (ppm)

3j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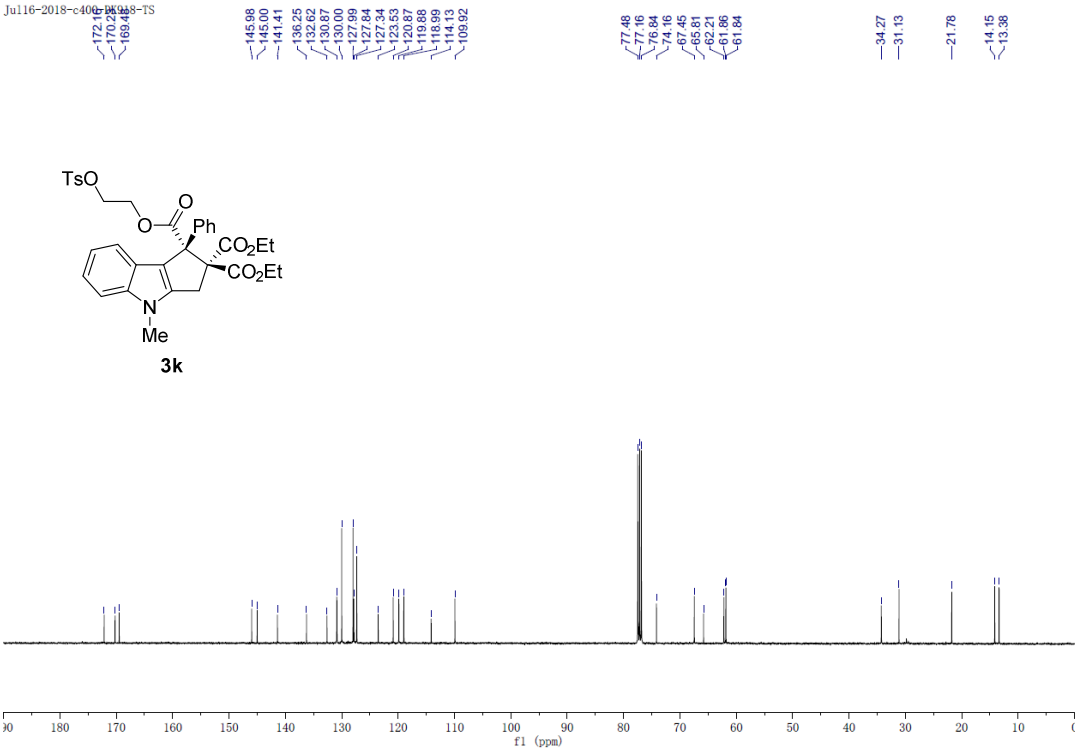
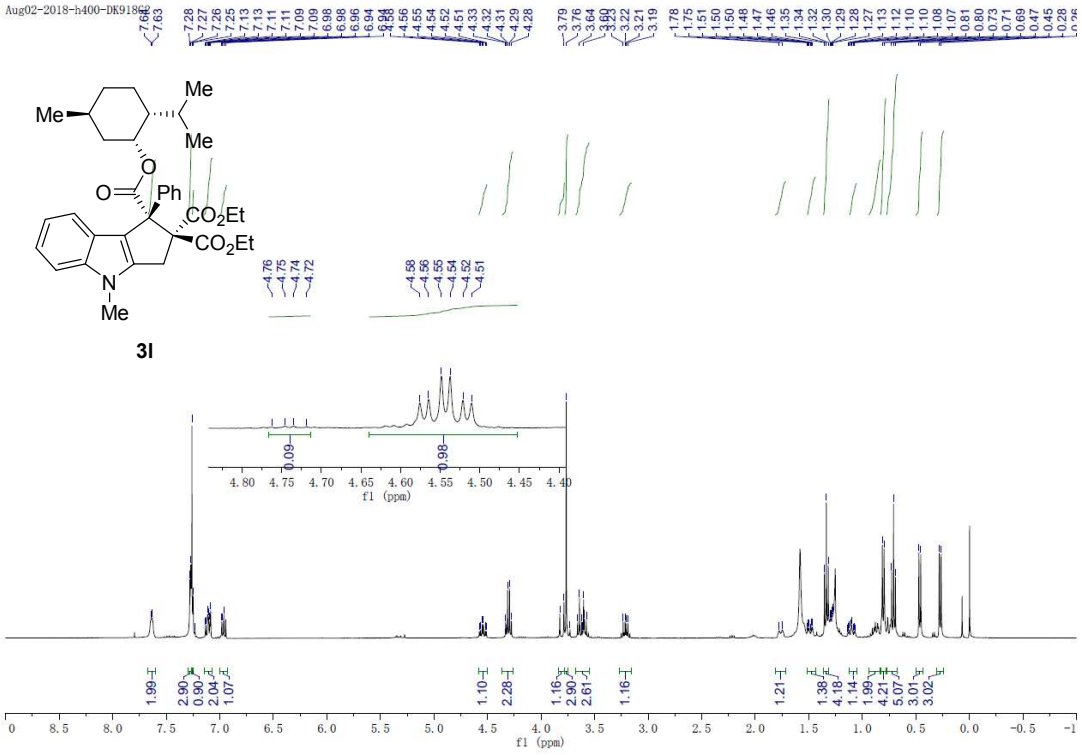
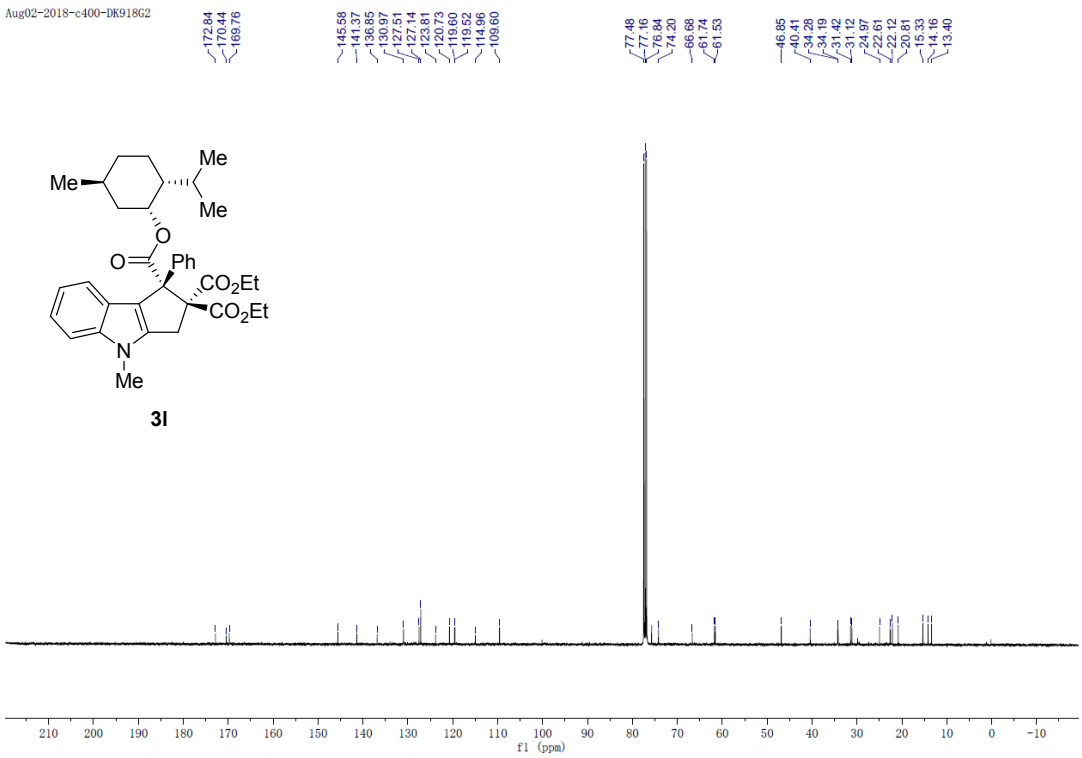
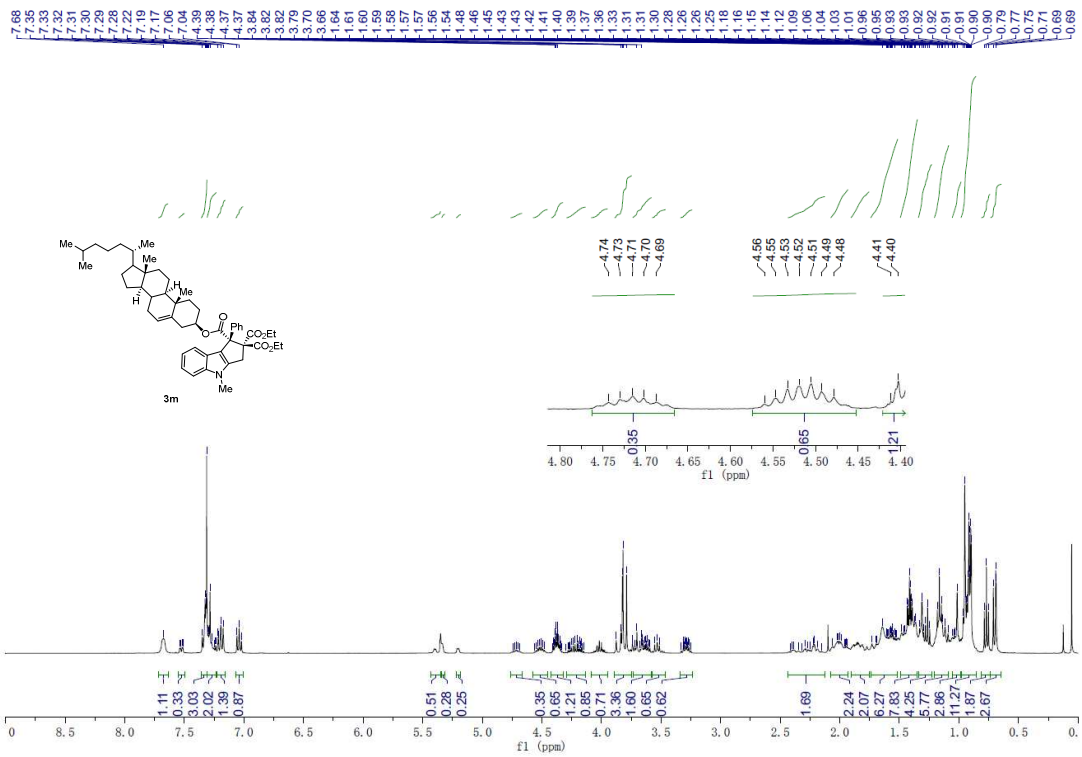
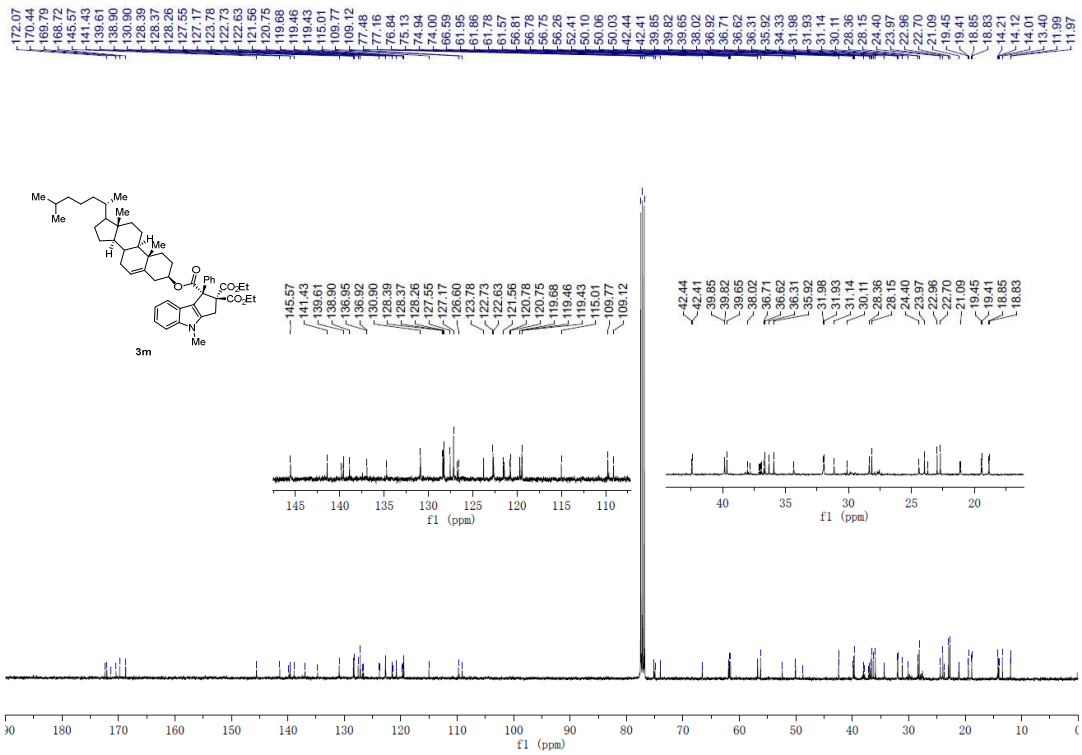
O
O
Ph
CO2Et
CO2Et
N
Me
3k
f1 (ppm)

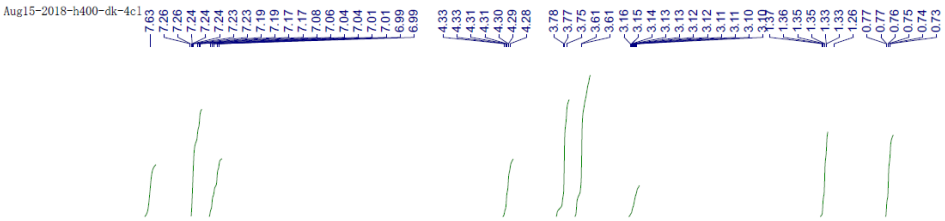

TsO
O
O
Ph
CO2Et
CO2Et
N
Me
3k
f1 (ppm)

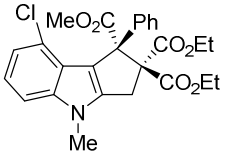

Aug02-2018-h400-DK918G2
Me
Me
Me
O
O
Ph
CO2Et
CO2Et
N
Me
3l
4.80 4.75 4.70 4.65 4.60 4.55 4.50 4.45 4.40
f1 (ppm)
0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)


Aug02-2018-c400-DK918G2
Me
Me
Me
O
O
Ph
CO2Et
CO2Et
N
Me
3l
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

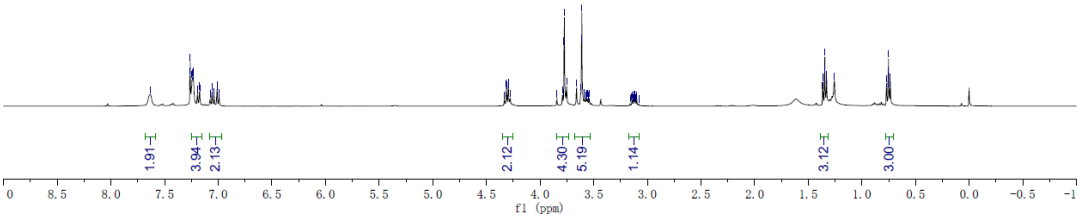

3m
f1 (ppm)


3m
f1 (ppm)

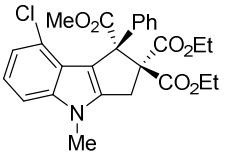

Aug15-2018-h400-dk-4cl
7.63
7.26
7.24
7.24
7.24
7.23
7.23
7.19
7.19
7.17
7.17
7.08
7.06
7.04
7.04
7.01
7.01
6.99
6.99
4.33
4.33
4.31
4.31
4.30
4.29
4.28
3.78
3.77
3.75
3.61
3.61
3.16
3.15
3.14
3.13
3.13
3.12
3.12
3.11
3.11
3.10
3.10
1.37
1.36
1.35
1.35
1.33
1.33
1.26
0.77
0.77
0.76
0.75
0.74
0.73


Cl
MeO2C
Ph
CO2Et
CO2Et
N
Me

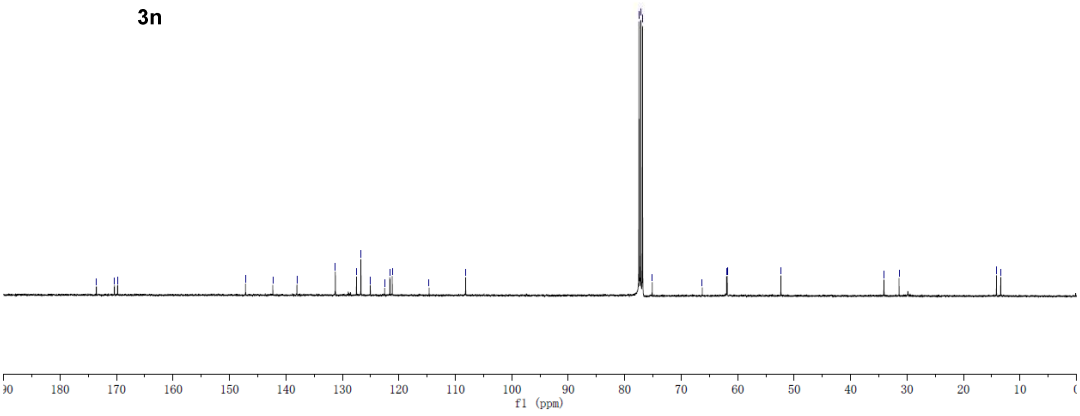
3n

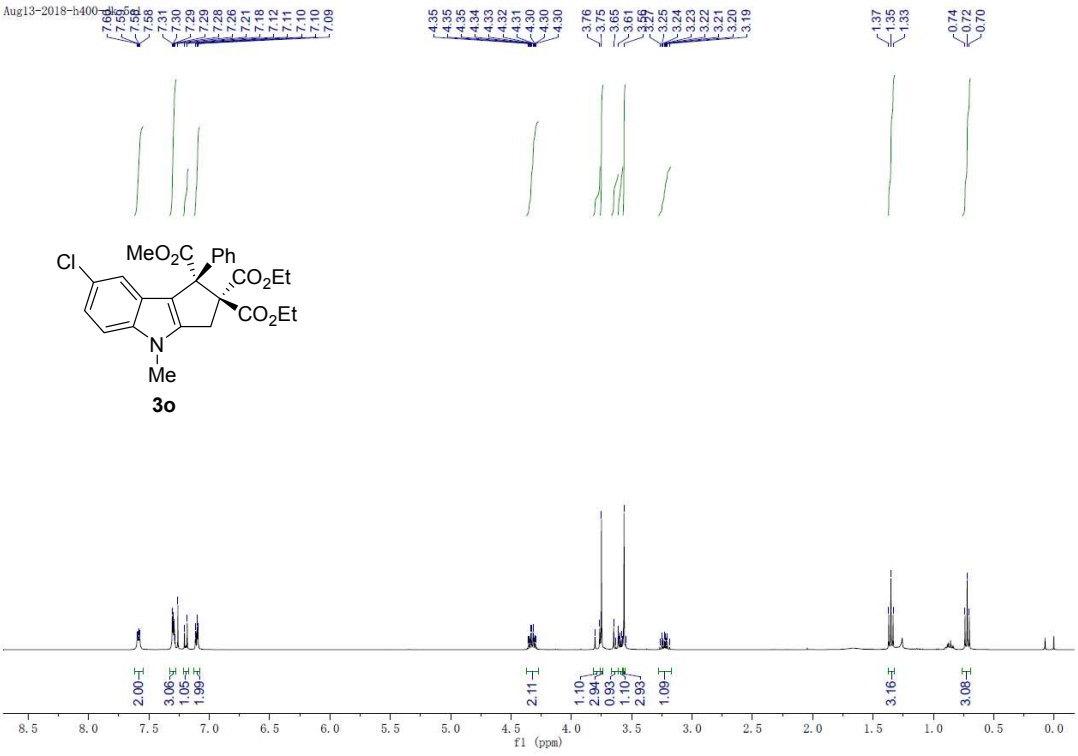

1.91
3.94
2.13
2.12
4.30
5.19
1.14
3.12
3.00
f1 (ppm)

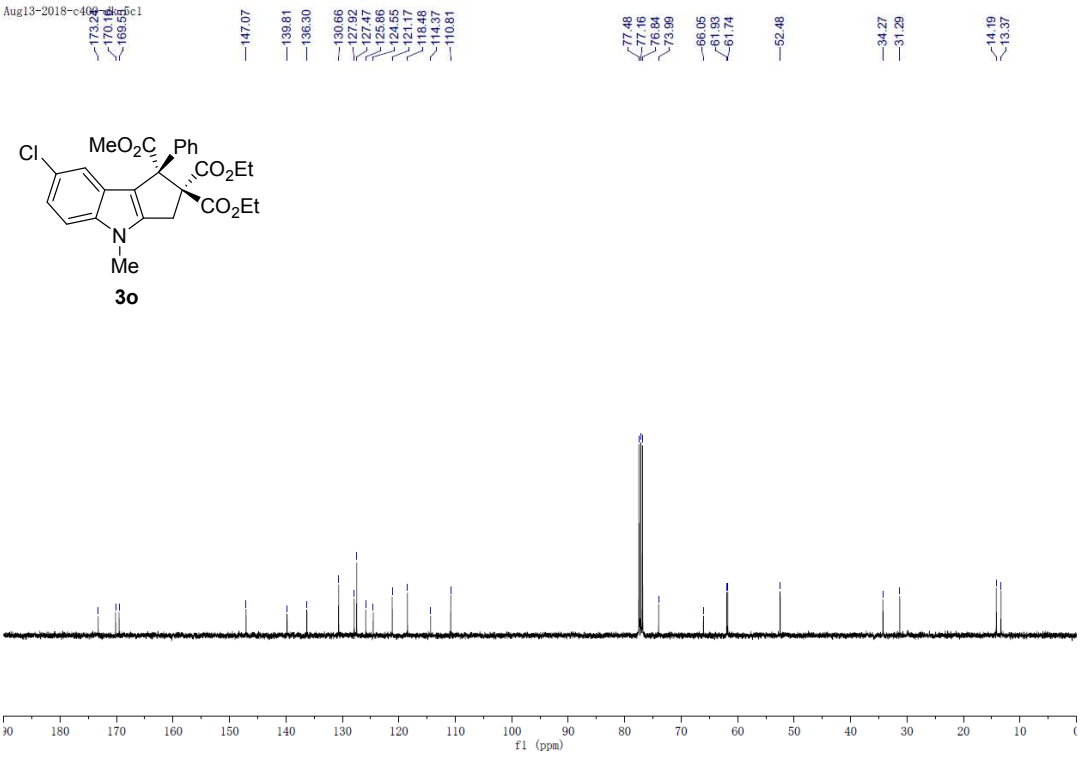

Aug15-2018-c400-dk-4cl
173.56
170.38
169.83
147.16
142.32
138.05
131.25
127.51
126.73
125.06
122.52
121.59
121.18
114.64
108.18
77.48
77.16
76.84
75.13
66.27
61.96
61.84
52.35
34.09
31.41
14.17
13.41

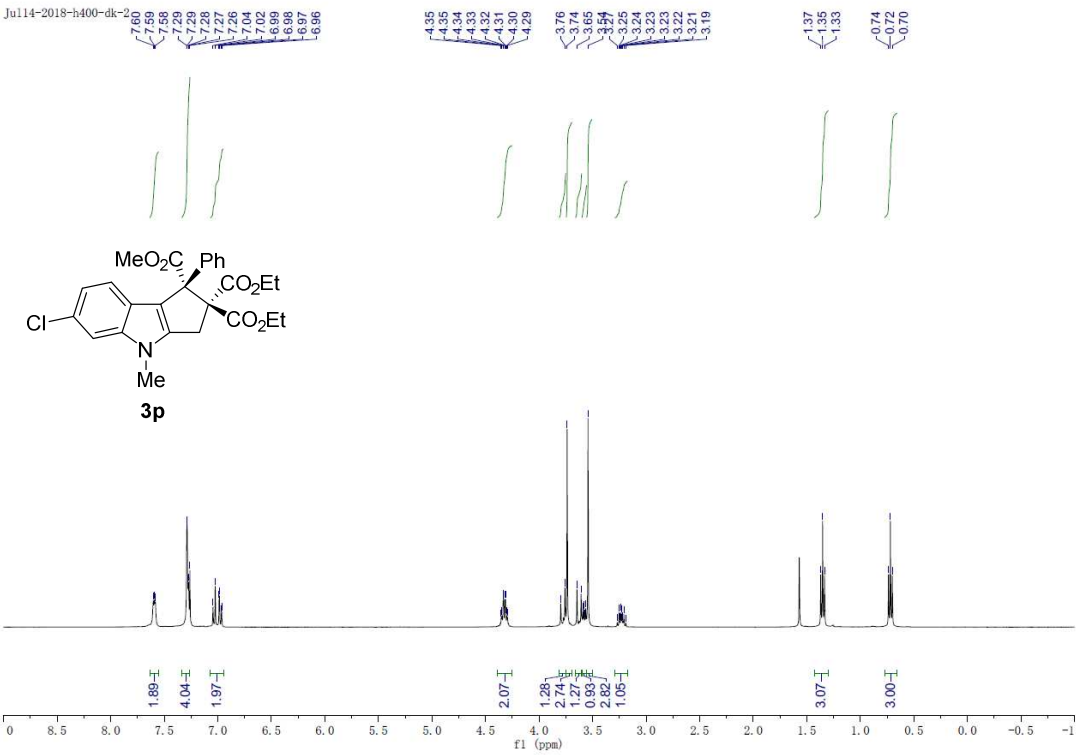

Cl
MeO2C
Ph
CO2Et
CO2Et
N
Me

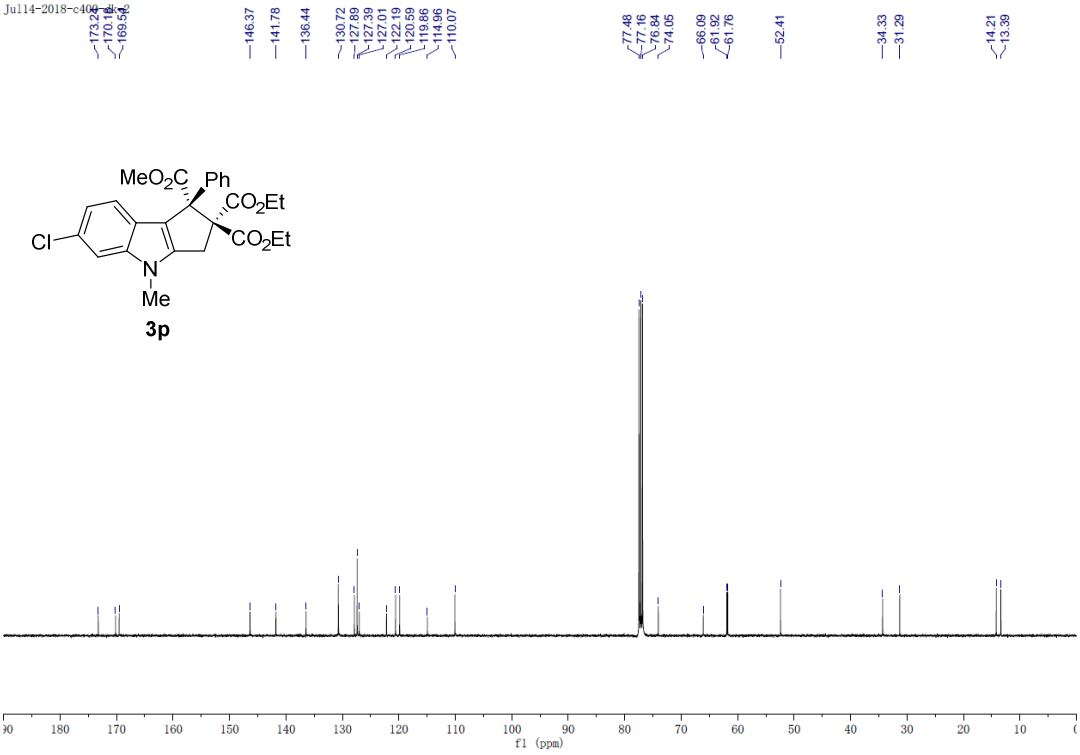
3n

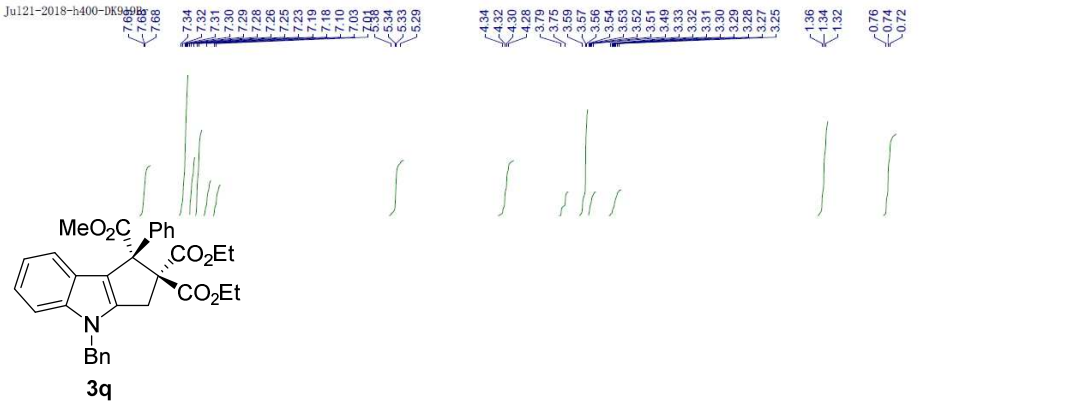

f1 (ppm)


Aug13-2018-h400-dkc5c1
7.66
7.56
7.56
7.56
7.31
7.30
7.29
7.29
7.28
7.26
7.21
7.18
7.12
7.11
7.10
7.10
7.09
4.35
4.35
4.35
4.34
4.33
4.32
4.31
4.30
4.30
4.30
3.76
3.75
3.65
3.61
3.25
3.24
3.23
3.22
3.21
3.20
3.19
1.37
1.35
1.33
0.74
0.72
0.70
Cl
MeO2C
Ph
CO2Et
CO2Et
N
Me
3o
2.00
3.06
1.05
1.99
2.11
1.10
2.94
0.93
1.10
2.93
1.09
3.16
3.08
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

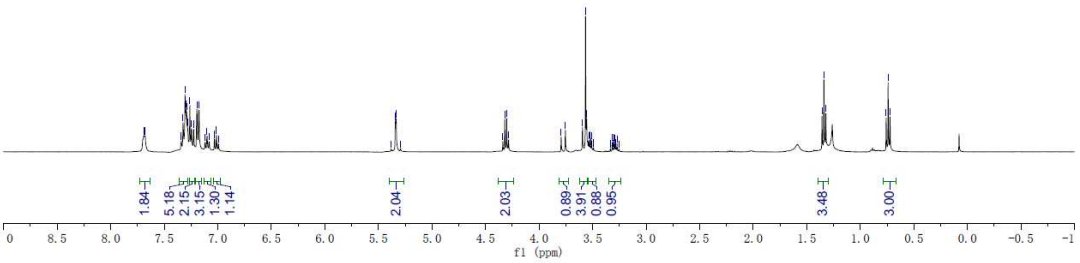

Aug13-2018-c400-dkc5c1
173.26
170.14
169.55
147.07
139.81
136.30
130.66
127.92
127.47
125.86
124.55
121.17
118.48
114.37
110.81
77.48
77.16
76.84
73.99
66.05
61.93
61.74
52.48
34.27
31.29
14.19
13.37
Cl
MeO2C
Ph
CO2Et
CO2Et
N
Me
3o
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

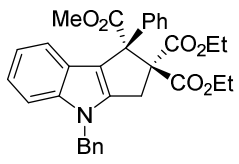

Jul14-2018-h400-dk-2
MeO2C
Ph
CO2Et
CO2Et
Cl
N
Me
3p
f1 (ppm)


Jul14-2018-c400
MeO2C
Ph
CO2Et
CO2Et
Cl
N
Me
3p
f1 (ppm)

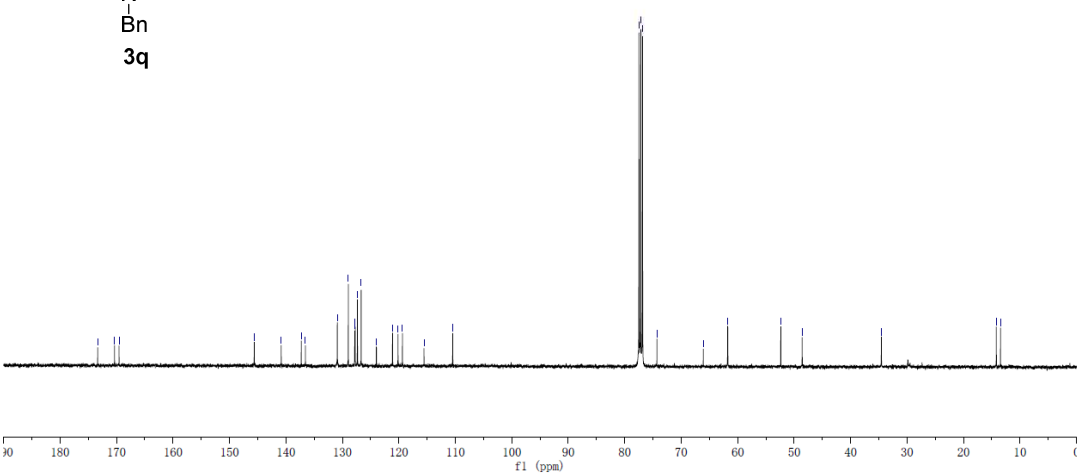

MeO2C
Ph
CO2Et
CO2Et
N
Bn

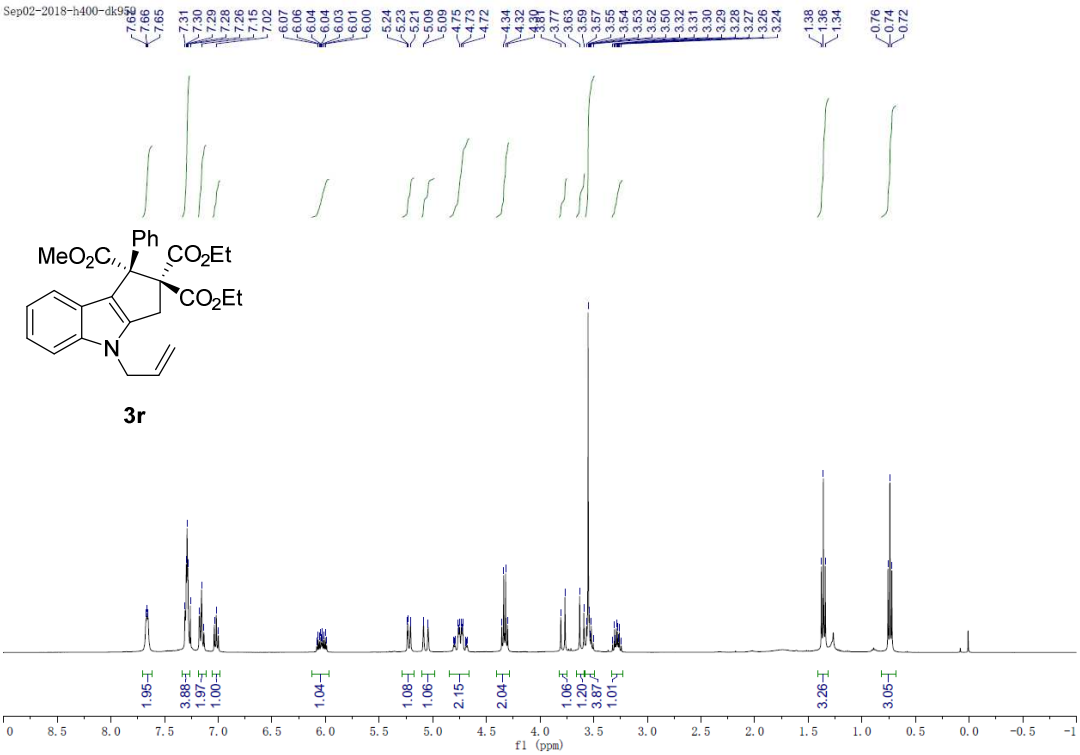
3q


f1 (ppm)

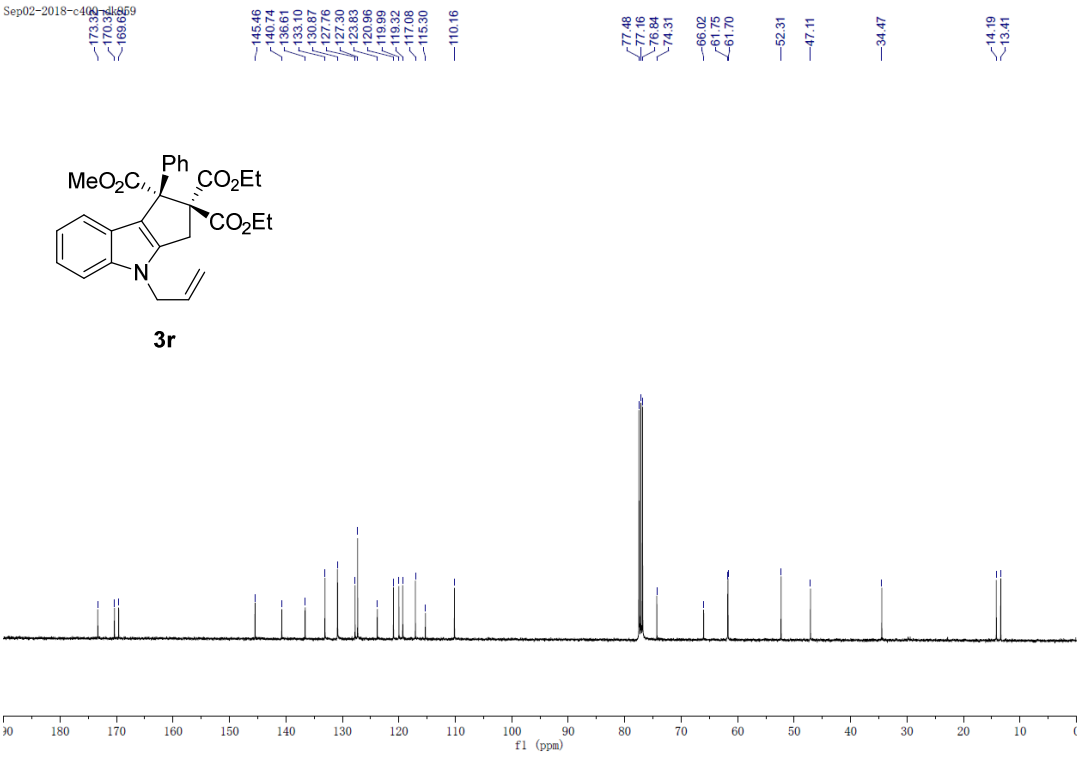

MeO2C
Ph
CO2Et
CO2Et
N
Bn

3q

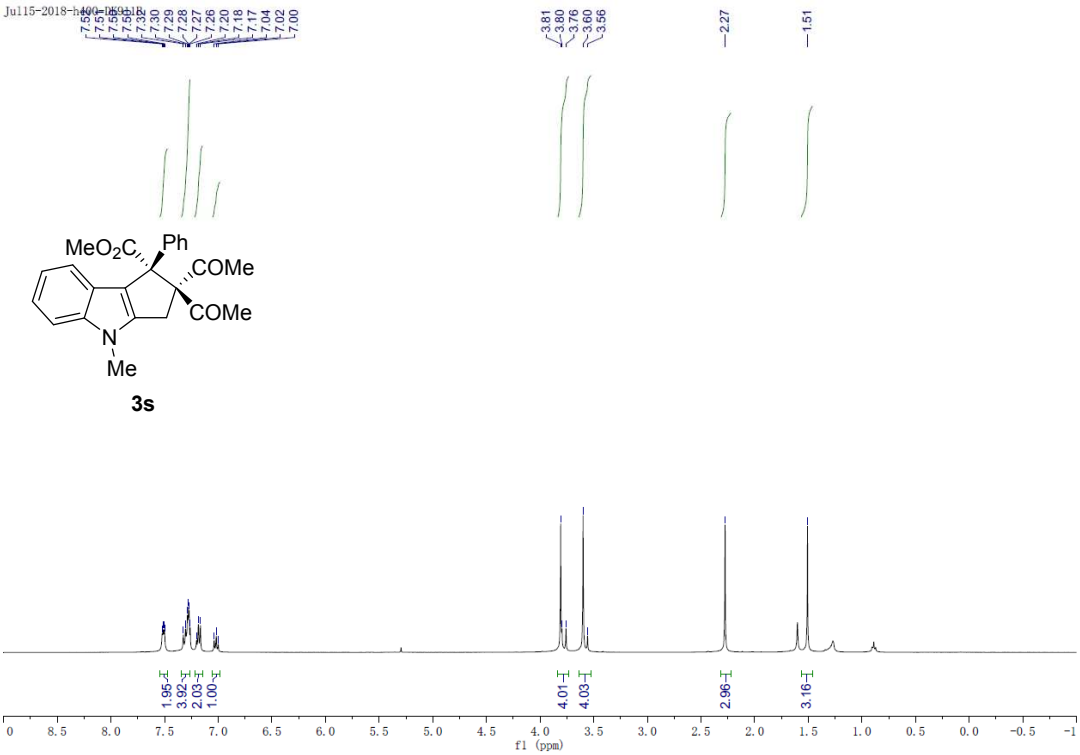

f1 (ppm)


Sep02-2018-h400-dk950
MeO2C
Ph
CO2Et
CO2Et
N
f1 (ppm)

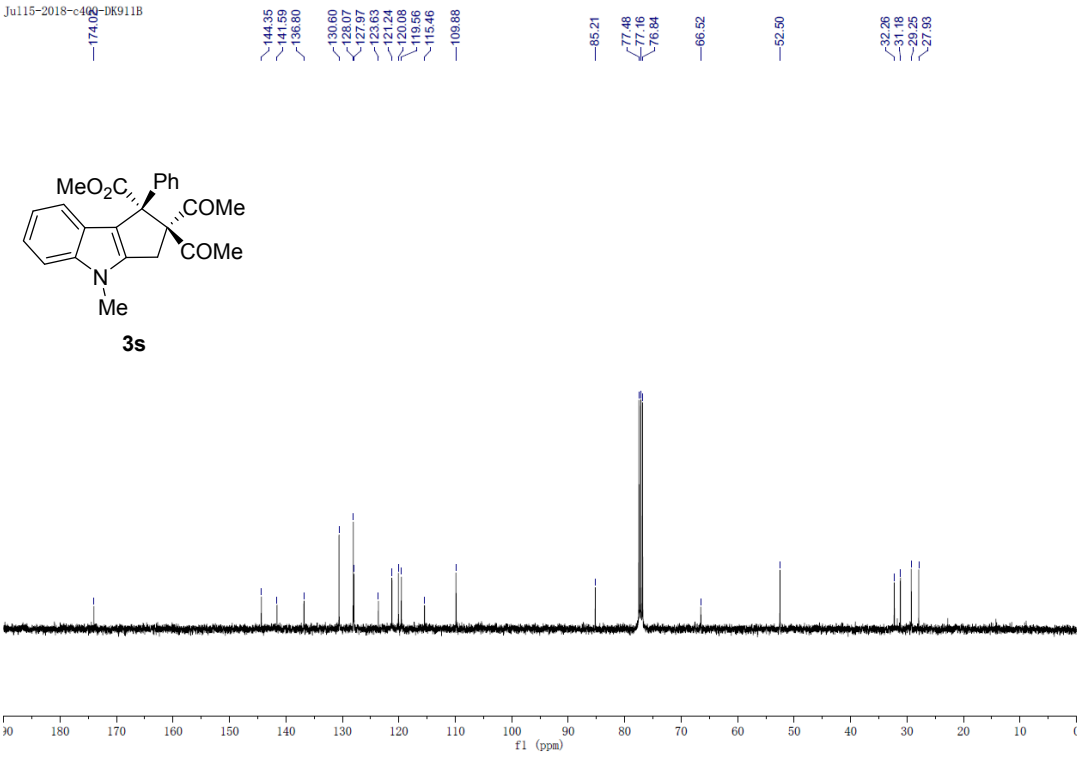
3r


Sep02-2018-c400-dk859
MeO2C
Ph
CO2Et
CO2Et
N
f1 (ppm)

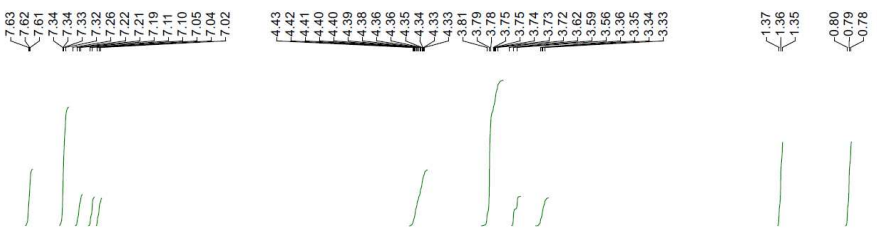
3r

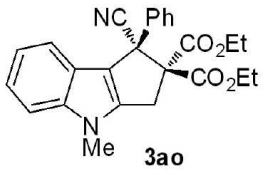

Jul15-2018-h400-DK911B
7.52
7.51
7.50
7.49
7.48
7.32
7.30
7.29
7.28
7.27
7.26
7.20
7.18
7.17
7.04
7.02
7.00
3.81
3.80
3.76
3.60
3.56
2.27
1.51
MeO2C
Ph
COMe
COMe
N
Me
1.95
3.92
2.03
1.00
4.01
4.03
2.96
3.16
f1 (ppm)

3s

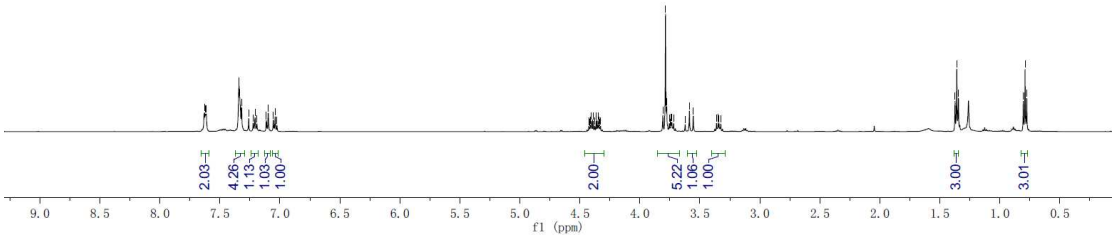

Jul15-2018-c400-DK911B
174.02
144.35
141.59
136.80
130.60
128.07
127.97
123.63
121.24
120.08
119.56
115.46
109.88
85.21
77.48
77.16
76.84
66.52
52.50
32.26
31.18
29.25
27.93
MeO2C
Ph
COMe
COMe
N
Me
f1 (ppm)

3s

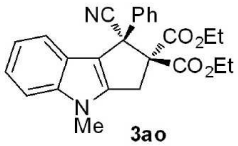

7.63
7.62
7.61
7.34
7.33
7.32
7.26
7.22
7.21
7.19
7.11
7.10
7.05
7.04
7.02
4.43
4.42
4.41
4.40
4.39
4.38
4.36
4.36
4.35
4.34
4.33
3.81
3.79
3.78
3.75
3.74
3.73
3.72
3.62
3.59
3.56
3.36
3.35
3.34
3.33
1.37
1.36
1.35
0.80
0.79
0.78


NC
Ph
CO2Et
CO2Et
N
Me

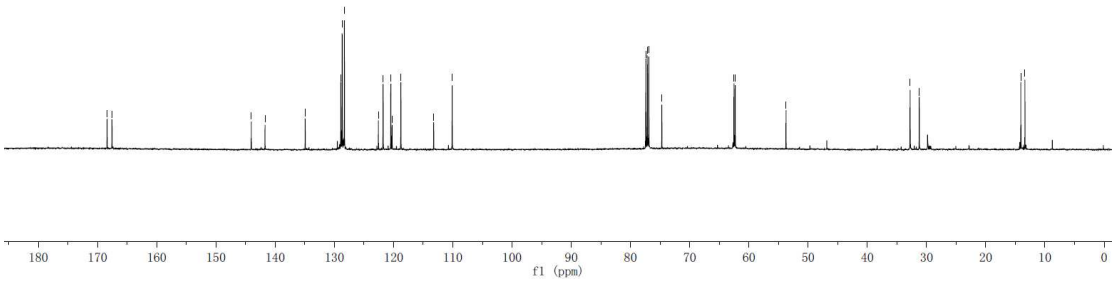
3ao

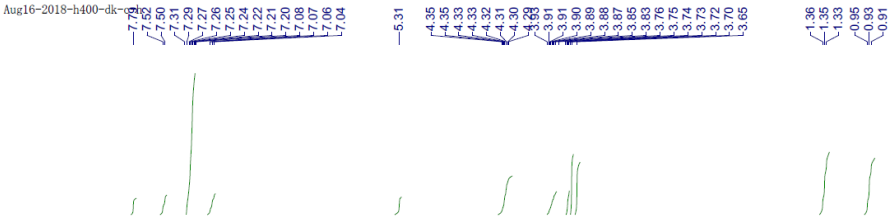

2.03
4.26
1.13
1.03
1.00
2.00
5.22
1.06
1.00
3.00
3.01
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

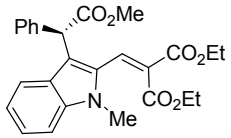

168.38
167.56
144.03
141.72
134.93
128.91
128.69
128.31
122.57
121.78
120.47
110.10
77.41
77.16
76.91
74.70
62.52
62.31
53.73
32.78
31.23
14.08
13.38


NC
Ph
CO2Et
CO2Et
N
Me

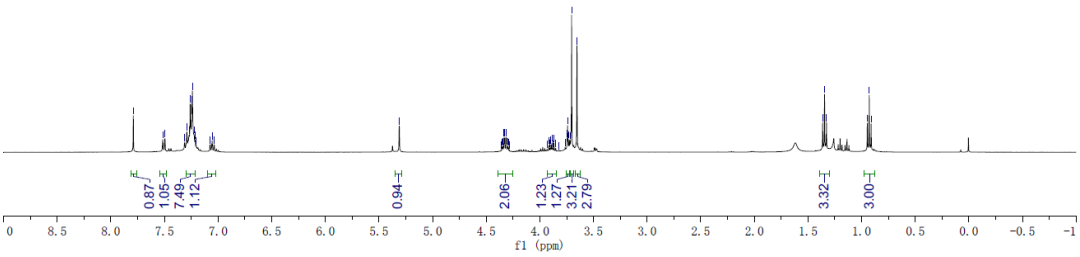
3ao

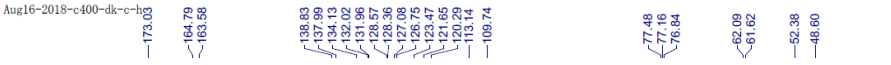

180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

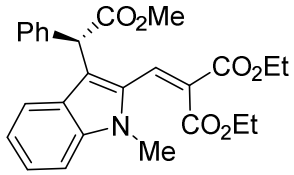




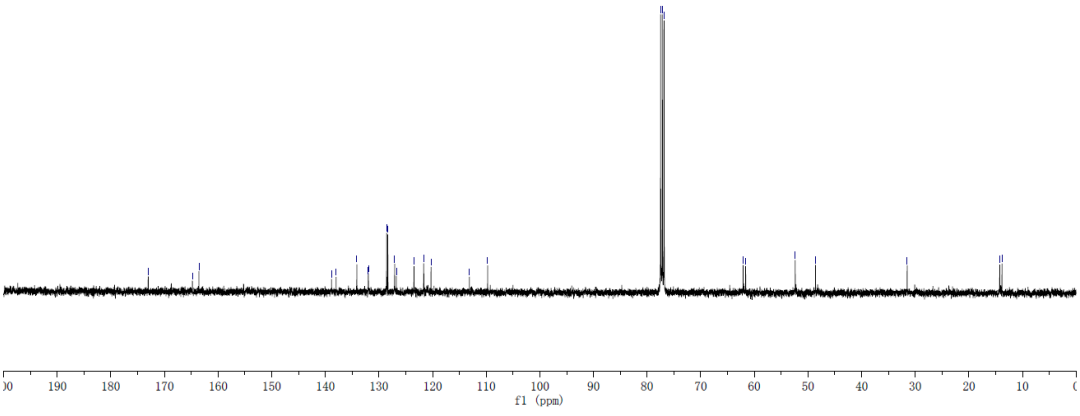
4a

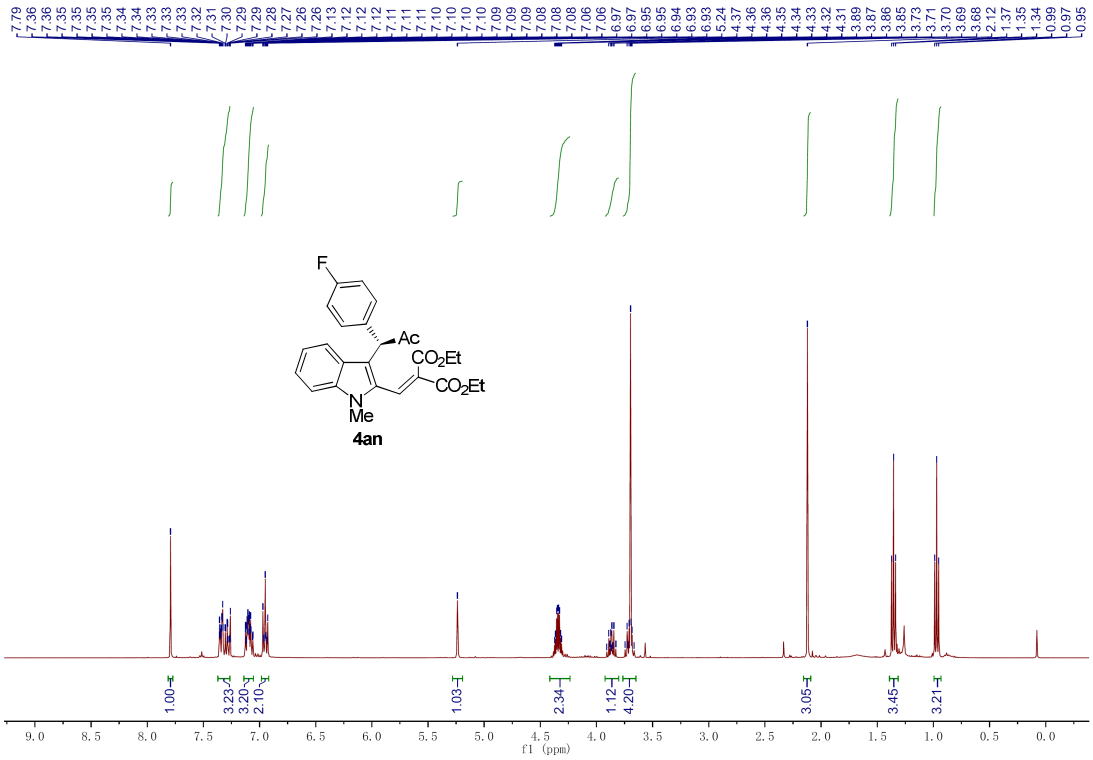


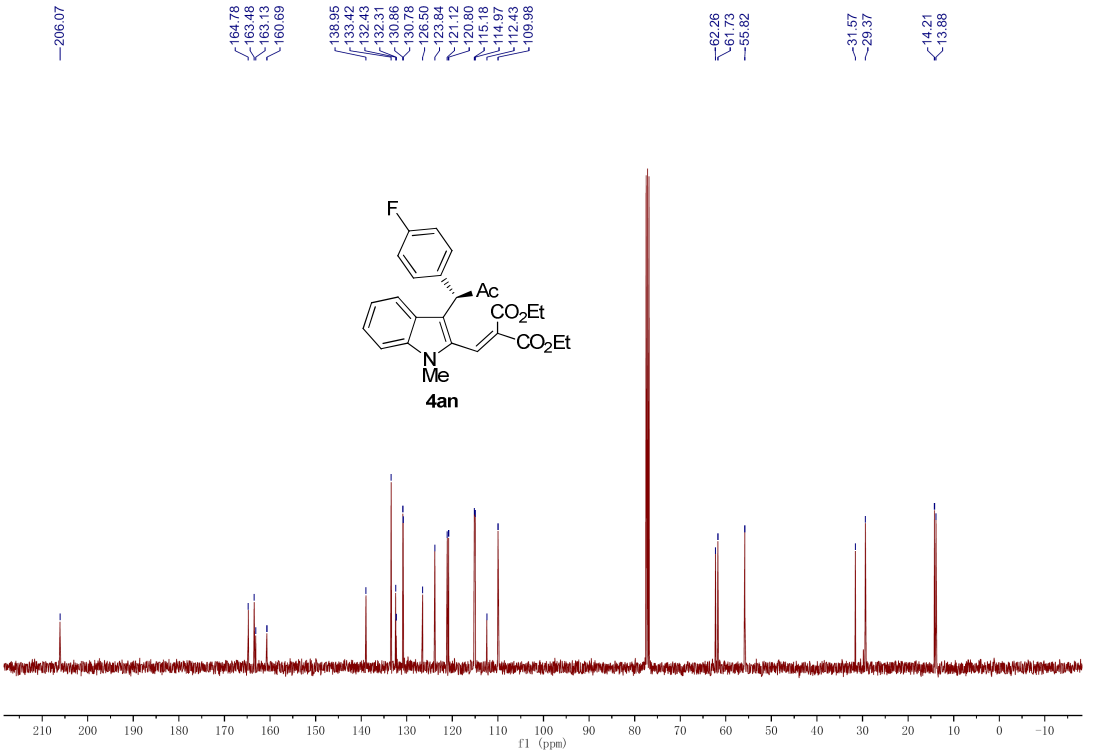


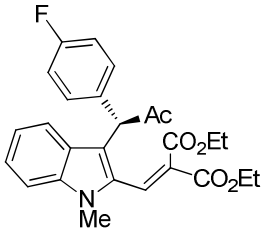


4a

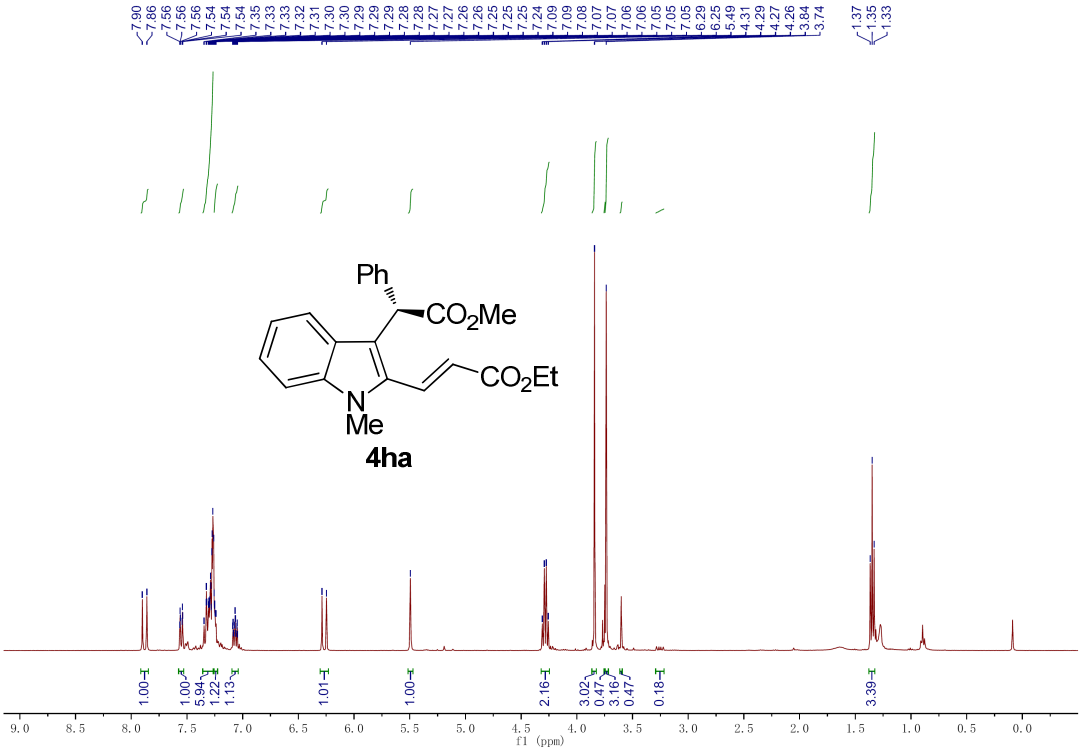



7.79 7.36 7.36 7.35 7.35 7.35 7.35 7.34 7.34 7.33 7.33 7.33 7.32 7.31 7.30 7.29 7.29 7.28 7.27 7.26 7.26 7.13 7.12 7.12 7.12 7.11 7.11 7.11 7.10 7.10 7.10 7.10 7.09 7.09 7.09 7.08 7.08 7.08 7.08 7.06 7.06 6.97 6.97 6.95 6.95 6.94 6.93 6.93 5.24 4.37 4.36 4.36 4.35 4.34 4.33 4.32 4.31 3.89 3.87 3.86 3.85 3.73 3.71 3.70 3.69 3.68 2.12 1.37 1.35 1.34 0.99 0.97 0.95
F
Ac
CO2Et
CO2Et
N
Me
4an
1.00 3.23 3.20 2.10 1.03 2.34 1.12 4.20 3.05 3.45 3.21
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

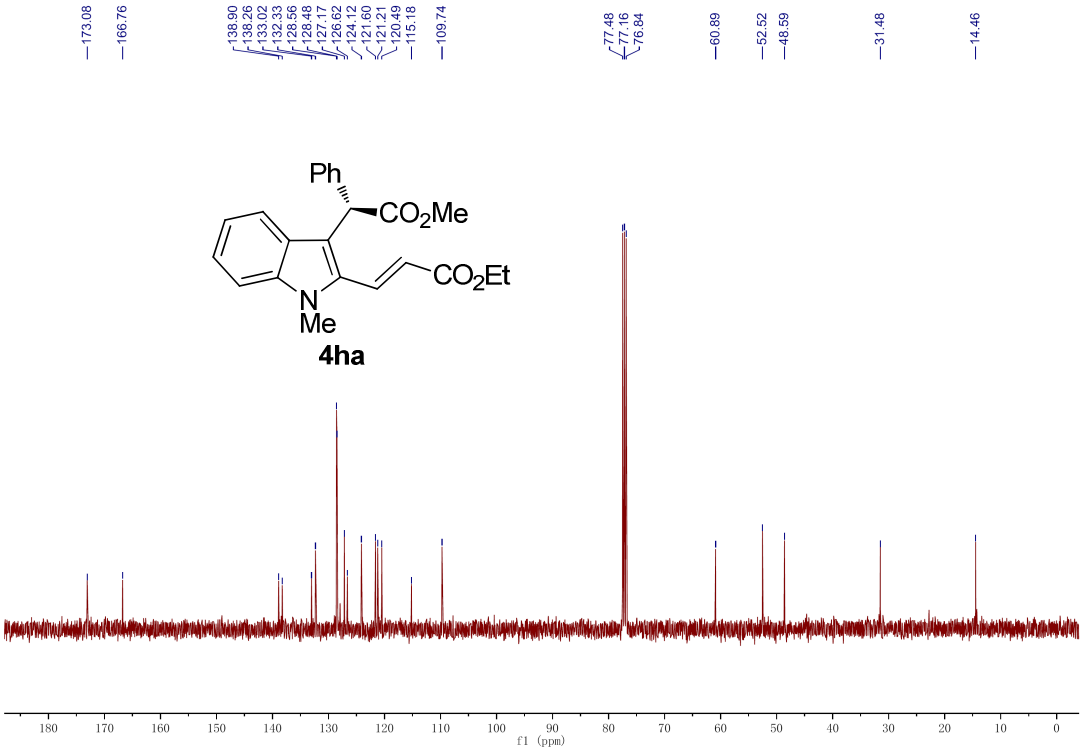

206.07
164.78 163.48 163.13 160.69 138.95 133.42 132.43 132.31 130.86 130.78 126.50 123.84 121.12 120.80 115.18 114.97 112.43 109.98
62.26 61.73 55.82
31.57 29.37
14.21 13.88
F
Ac
CO2Et
CO2Et
N
Me
4an
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

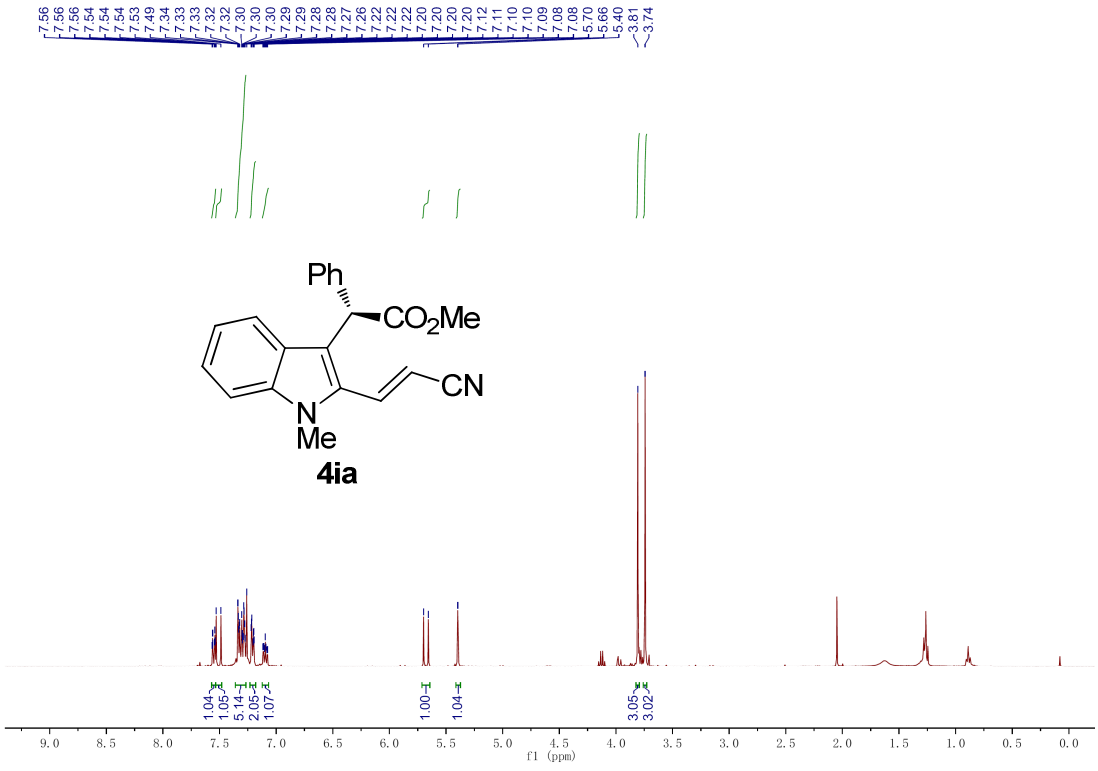


4an



4ha


173.08
166.76
138.90
138.26
133.02
132.33
128.56
128.48
127.17
126.62
124.12
121.60
121.21
120.49
115.18
109.74
77.48
77.16
76.84
60.89
52.52
48.59
31.48
14.46
Ph
CO2Me
CO2Et
N
Me
4ha
f1 (ppm)


7.56
7.56
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7.33
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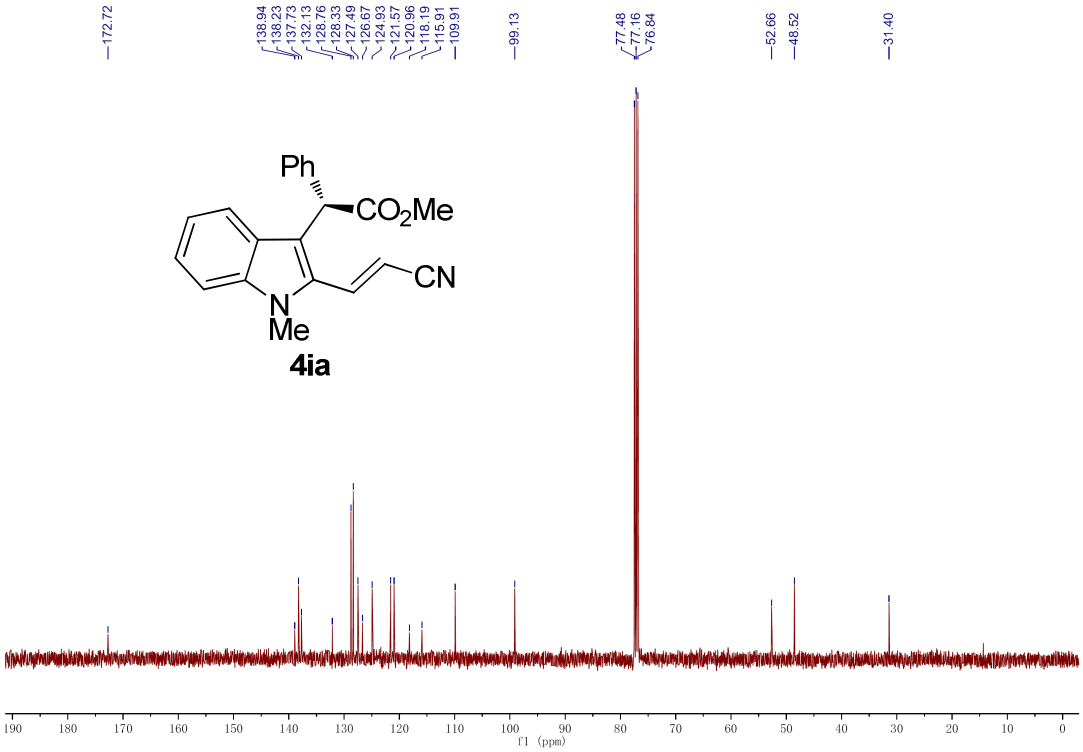
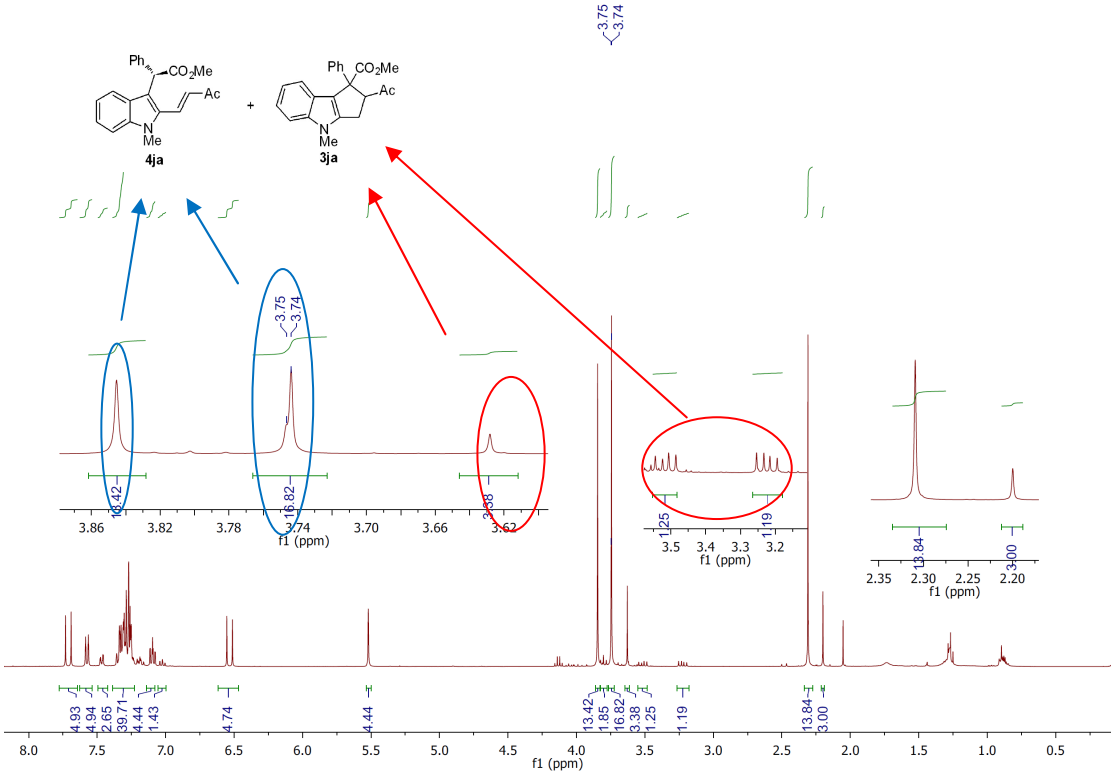
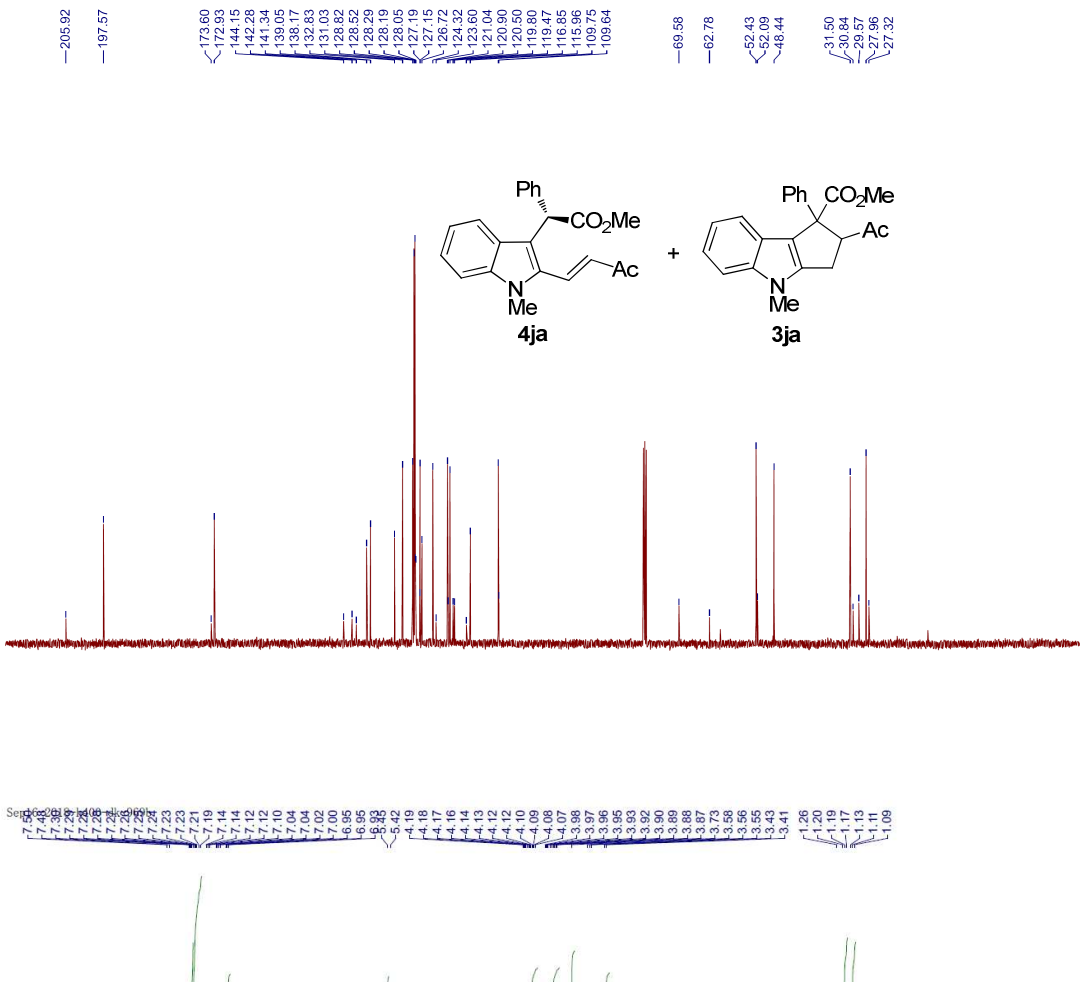
7.30
7.30
7.30
7.29
7.29
7.28
7.28
7.27
7.26
7.22
7.22
7.22
7.20
7.20
7.20
7.20
7.12
7.11
7.10
7.10
7.09
7.08
7.08
5.70
5.66
5.40
3.81
3.74
Ph
CO2Me
CN
N
Me
4ia
1.04
1.05
5.14
2.05
1.07
1.00
1.04
3.05
3.02
f1 (ppm)


172.72
138.94
138.23
137.73
132.13
128.76
128.33
127.49
126.67
124.93
121.57
120.96
118.19
115.91
109.91
99.13
77.48
77.16
76.84
52.66
48.52
31.40
Ph
CO2Me
CN
N
Me
4ia
f1 (ppm)


3.75
3.74
Ph
CO2Me
Ac
N
Me
4ja
3ja
f1 (ppm)


205.92
197.57
173.60
172.93
144.15
142.28
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139.05
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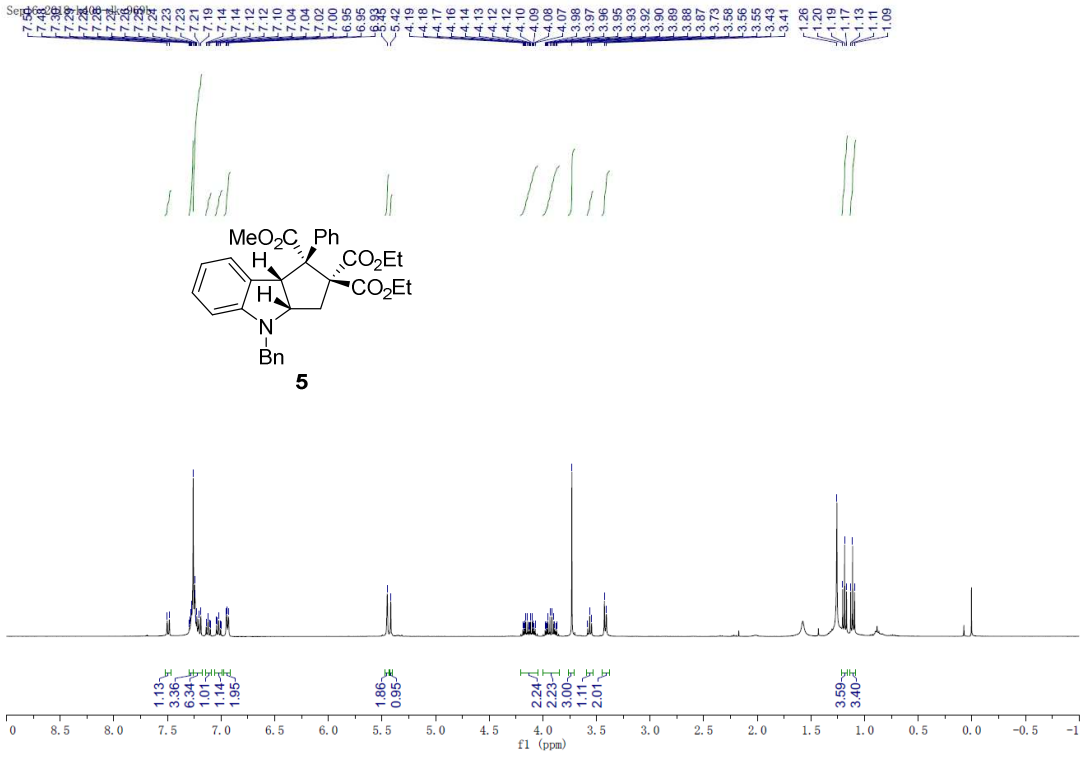
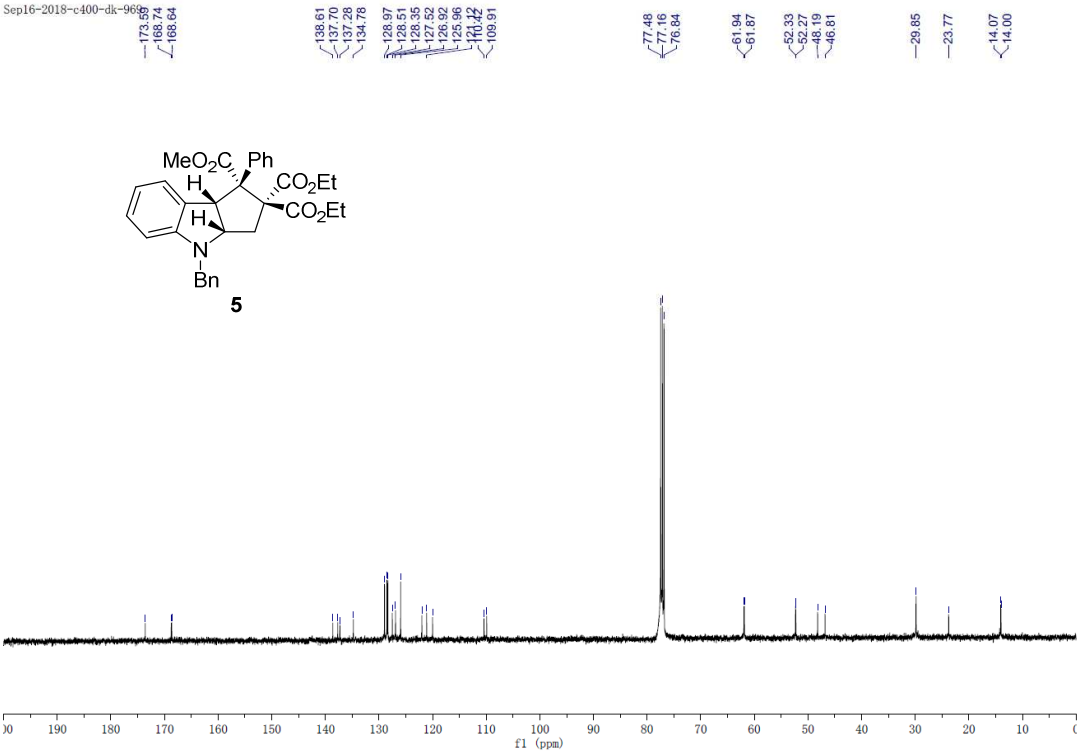
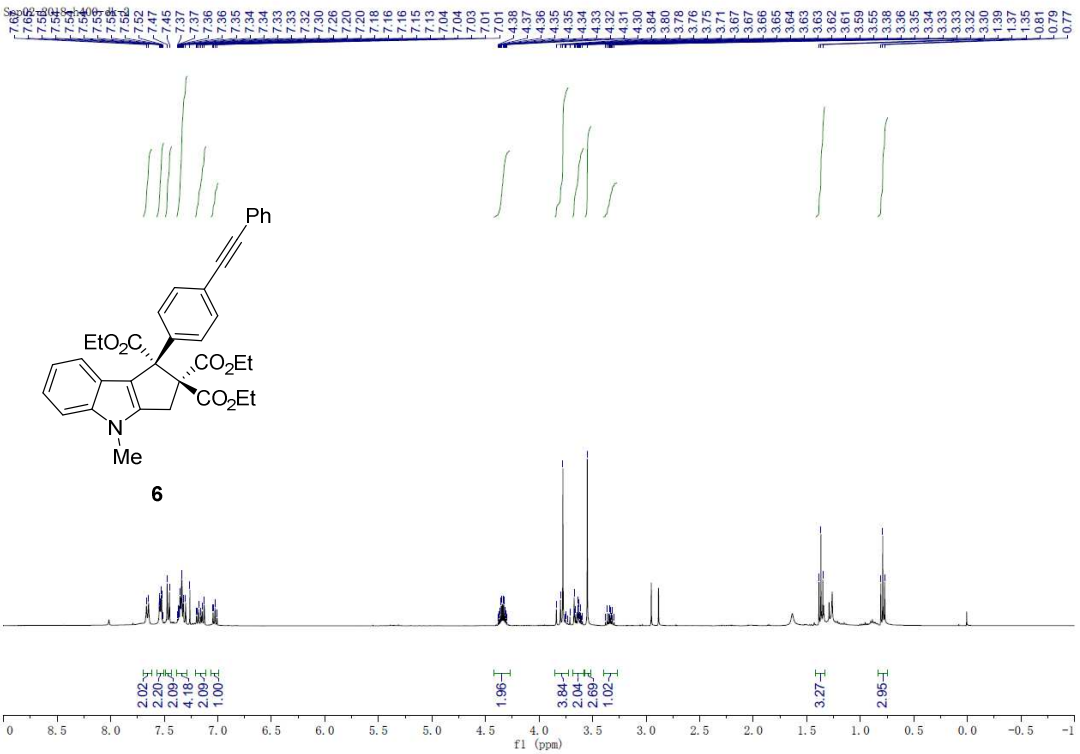
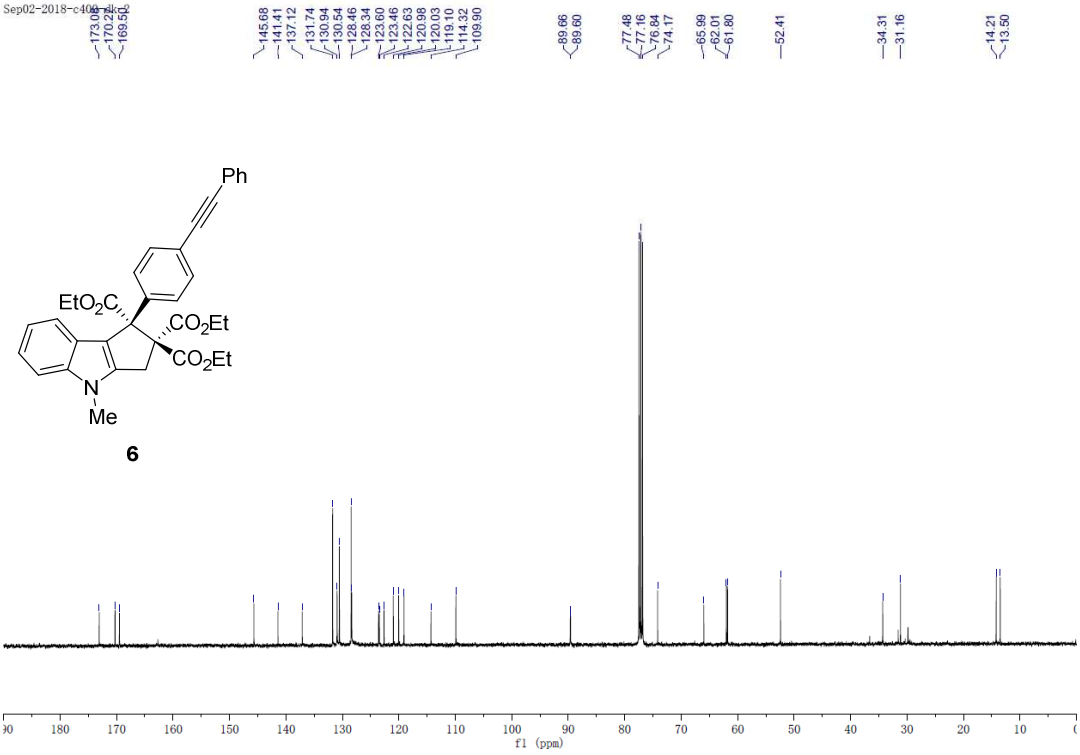
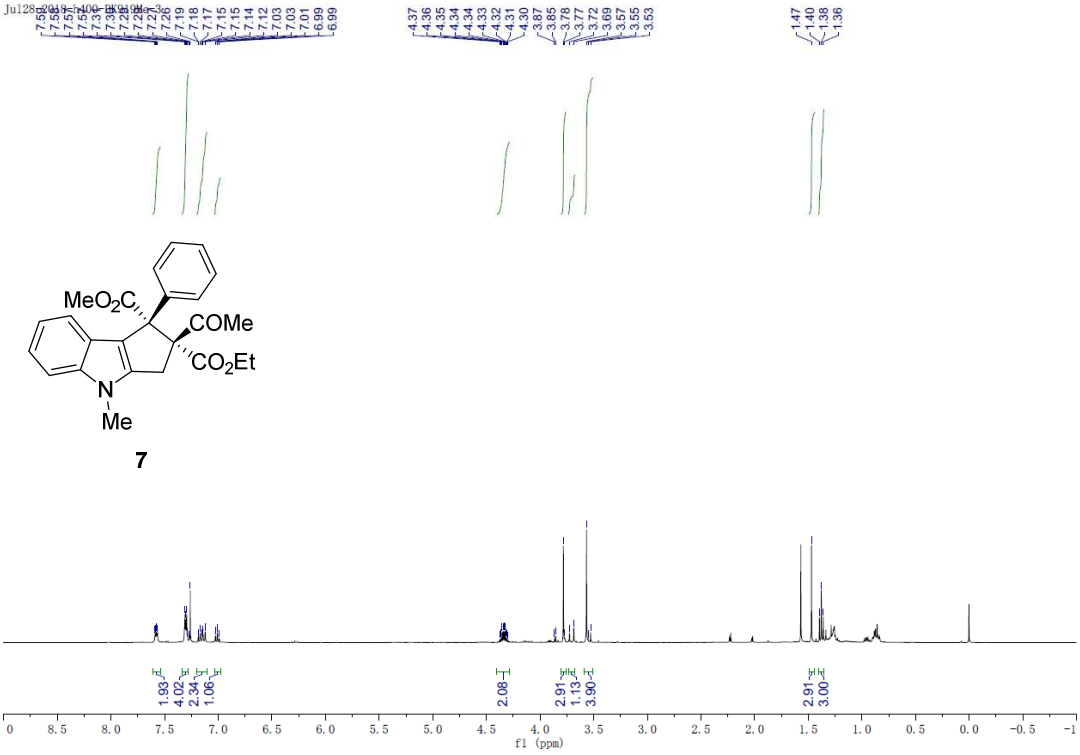
132.83
131.03
128.82
128.52
128.29
128.19
128.05
127.19
127.15
126.72
124.32
123.60
121.04
120.90
120.50
119.80
119.47
116.85
115.96
109.75
109.64
69.58
62.78
52.43
52.09
48.44
31.50
30.84
29.57
27.96
27.32
Ph
CO2Me
Ac
N
Me
4ja
+
Ph
CO2Me
Ac
N
Me
3ja

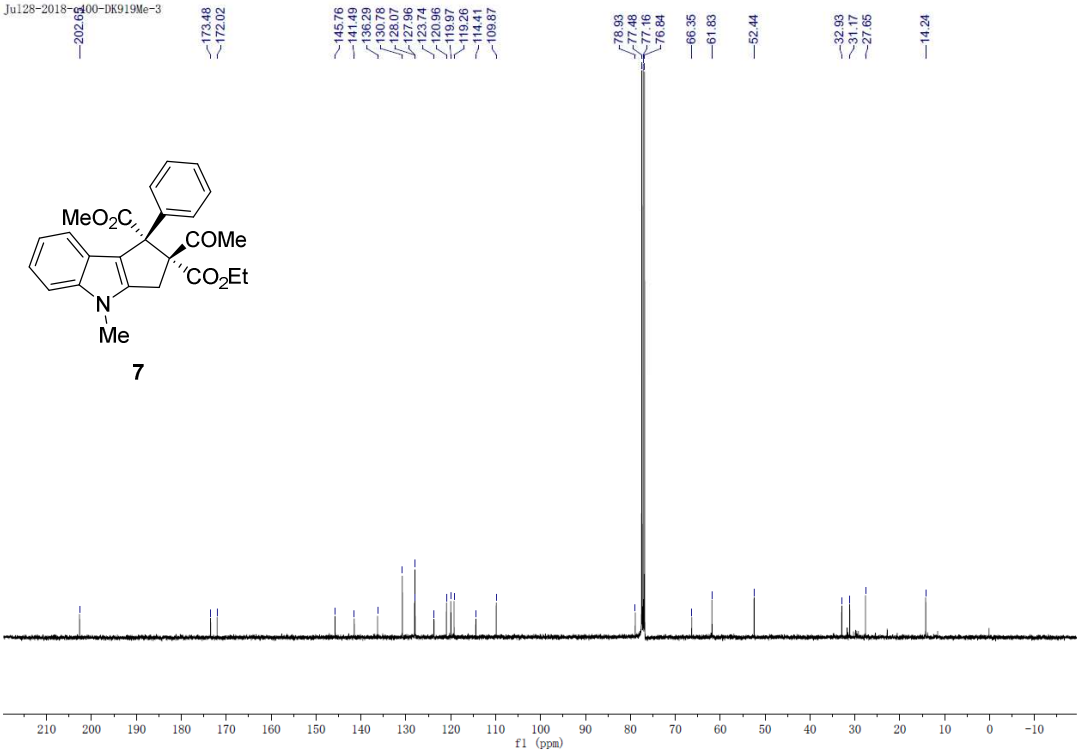

MeO2C
Ph
H
CO2Et
CO2Et
H
N
Bn
5
1.13
3.36
6.34
1.01
1.14
1.95
1.86
0.95
2.24
2.23
3.00
1.11
2.01
3.59
3.40
f1 (ppm)


Sep16-2018-c400-dk-968
MeO2C
Ph
H
CO2Et
CO2Et
H
N
Bn
5
f1 (ppm)


Ph
EtO2C
CO2Et
CO2Et
N
Me
6
f1 (ppm)


Ph
EtO2C
CO2Et
CO2Et
N
Me
6
f1 (ppm)


MeO2C
COMe
CO2Et
N
Me
7
f1 (ppm)


Jul28-2018-400-DK919Me-3
202.65
173.48
172.02
145.76
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136.29
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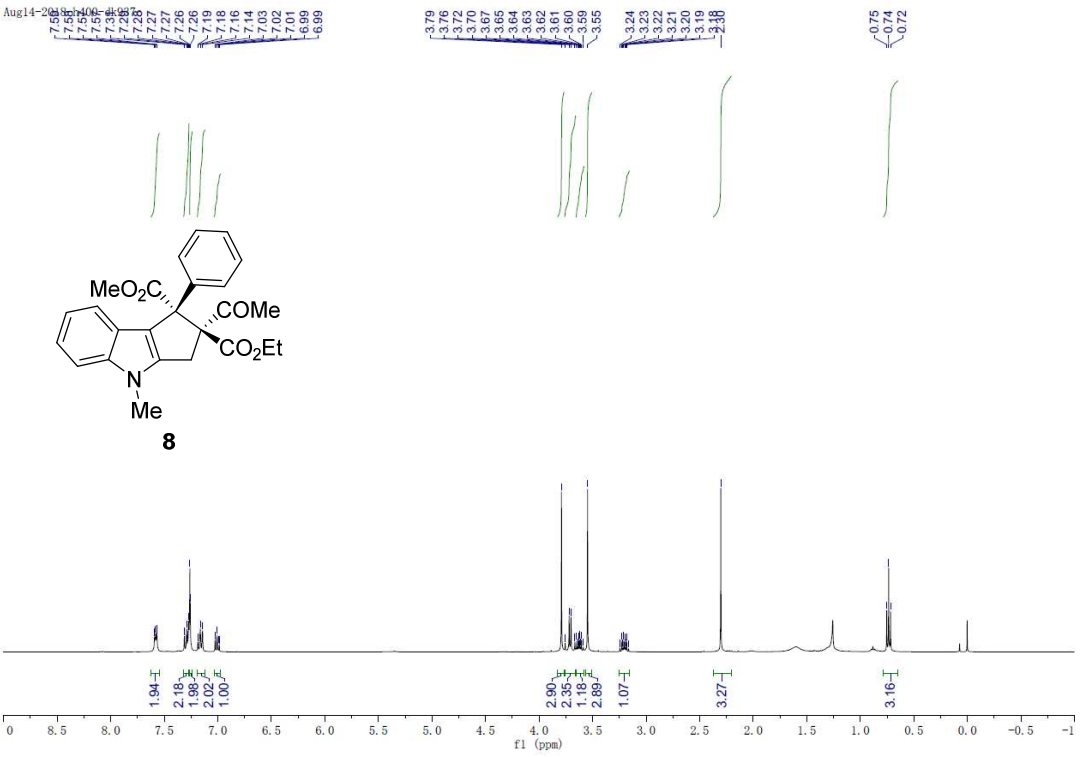
128.07
127.96
123.74
120.96
119.97
119.26
114.41
109.87
78.93
77.48
77.16
76.84
66.35
61.83
52.44
32.93
31.17
27.65
14.24
MeO2C
COMe
CO2Et
N
Me
7
f1 (ppm)


Aug14-2018-400
7.56
7.55
7.55
7.55
7.54
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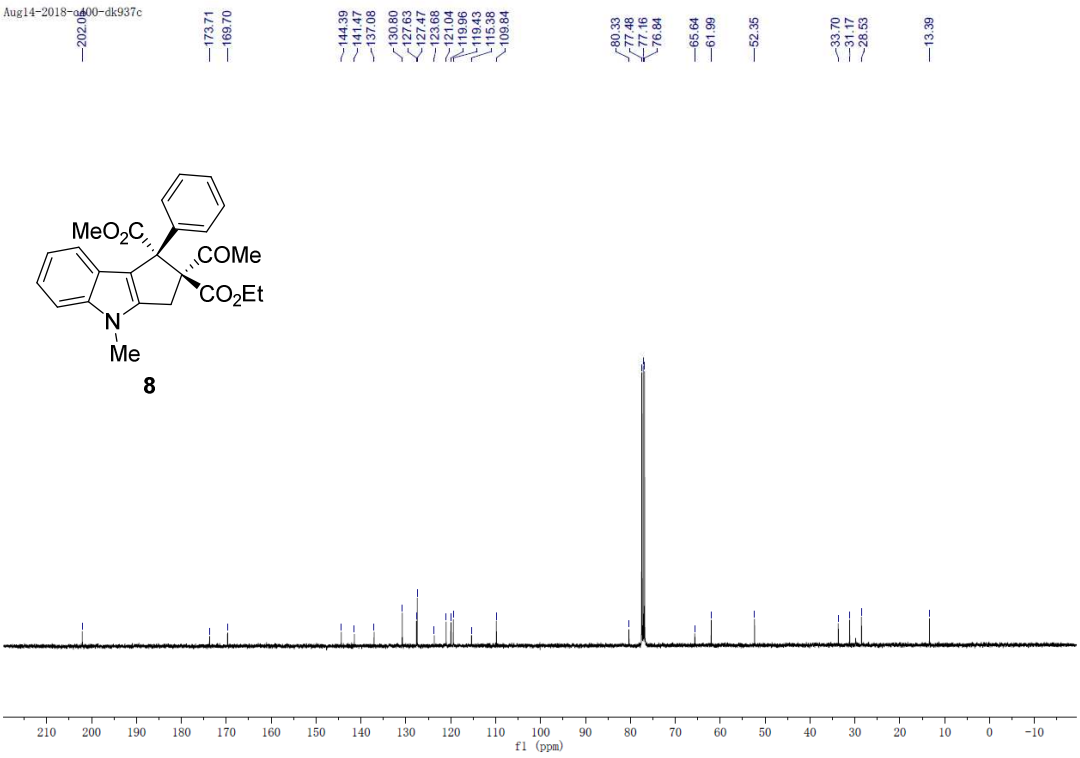
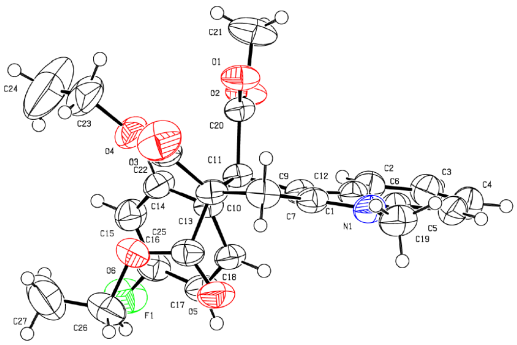
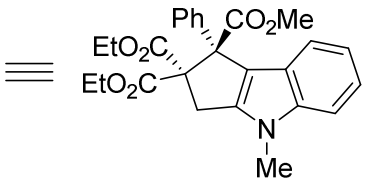
7.27
7.27
7.27
7.26
7.26
7.19
7.18
7.16
7.14
7.03
7.02
7.01
6.99
6.99
3.79
3.76
3.72
3.70
3.67
3.65
3.64
3.63
3.62
3.61
3.60
3.59
3.55
3.24
3.23
3.22
3.21
3.20
3.19
2.38
2.38
0.75
0.74
0.72
MeO2C
COMe
CO2Et
N
Me
8
1.94
2.18
1.98
2.02
1.00
2.90
2.35
1.18
2.89
1.07
3.27
3.16
f1 (ppm)


Aug14-2018-a400-dk937c
202.08
173.71
169.70
144.39
141.47
137.08
130.80
127.63
127.47
123.68
121.04
119.96
119.43
115.38
109.84
80.33
77.48
77.16
76.84
65.64
61.99
52.35
33.70
31.17
28.53
13.39
MeO2C
COMe
CO2Et
N
Me
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

8





3d (CCDC 1855321)

No syntax errors found. CIF dictionary Interpreting this report

Datablock: s180711a

Bond precision: C-C = 0.0037 A Wavelength=0.71073

Cell: a=9.936(7) b=11.476(9) c=12.791(10)
alpha=112.421(8) beta=91.811(11) gamma=111.934(8)
Temperature: 293 K

	Calculated	Reported
Volume	1224.6(16)	1224.58(10)
Space group	P -1	P -1
Hall group	-P 1	-P 1
Moiety formula	C26 H26 F N O6	?
Sum formula	C26 H26 F N O6	C26 H26 F N O6
Mr	467.48	467.48
Dx,g cm-3	1.268	1.268
Z	2	2
Mu (mm-1)	0.095	0.095
F000	492.0	492.0
F000'	492.28	
h,k,lmax	15,18,20	15,18,19
Nref	10657	9035
Tmin,Tmax		
Tmin'		

Correction method= Not given

Data completeness= 0.848 Theta(max)= 34.830

R(reflections)= 0.0933(6826) wR2(reflections)= 0.2820(9035)

S = 1.152 Npar= 311

The following ALERTS were generated. Each ALERT has the format
test-name_ALERT_alert-type_alert-level.
Click on the hyperlinks for more details of the test.