Supporting Information

Gold-Catalyzed Intermolecular [4+1] Spiroannulation by Aromatic C(sp^2)-H Functionalization and Dearomatization of Phenol Derivatives

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Table of Contents

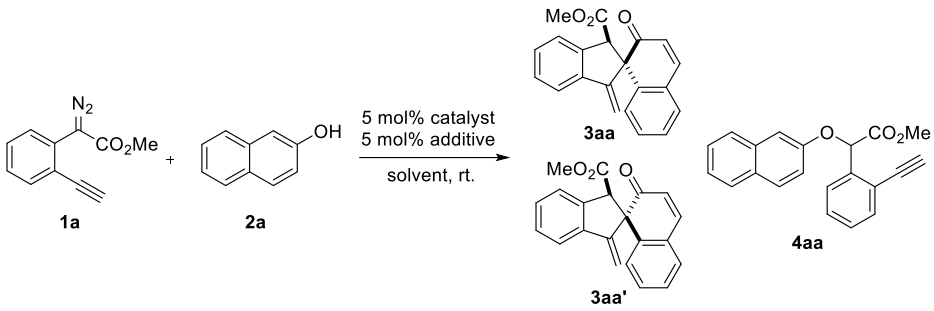
1. General Information

Unless otherwise noted, all air- and moisture-sensitive manipulations were carried out with standard Schlenk techniques under nitrogen or in a glove box under nitrogen. All reactions were carried out under a nitrogen atmosphere; materials obtained from commercial suppliers were used directly without further purification. Solvents were distilled following standard procedures before use. Reactions were monitored by thin layer chromatography (TLC) using silicycle pre-coated silica gel plates. Flash column chromatography was performed on silica gel 60 (particle size 300-400 mesh ASTM, purchased from Yantai, China) and eluted with petroleum ether/ethyl acetate. The substrates **1** were synthesized according to the reported methods.[1] All reagents and solvents were used as received from commercial sources without further purification.

Trichloromethane ($CHCl_3$), dichloromethane, dichloroethane and ethyl acetate were freshly distilled from CaH_2; tetrahydrofuran (THF), toluene and ether were dried with sodium benzophenone and distilled before use.

^1H NMR spectra, ^{13}C NMR spectra were recorded on a Bruker 500 MHz in chloroform-d_3. Chemical shifts (in ppm) were referenced to tetramethylsilane (0 ppm) in $CDCl_3$ as an internal standard. ^{13}C-NMR spectra were obtained by using the same NMR spectrometers and were calibrated with $CDCl_3$ (77.00 ppm). The data is being reported as (s = singlet, d = doublet, dd = doublet of doublet, t = triplet, m = multiplet or unresolved, br = broad signal, coupling constant(s) in Hz, integration).

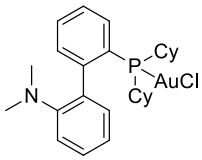
2. Optimization of conditions



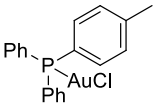
Entry	Catalyst	Additive	Solvent	3aa/3aa'/4aa [a]
1	Ph_3PAuCl	$AgNTf_2$	CH_2Cl_2	Messy
2	$(2,4\text{-}^tBu_2C_6H_3O)_3PAuCl$	$AgNTf_2$	CH_2Cl_2	Messy
3	JohnPhosAuCl	$AgNTf_2$	CH_2Cl_2	51/24/6
4	XPhosAuCl	$AgNTf_2$	CH_2Cl_2	Trace
5	IPrAuCl	$AgNTf_2$	CH_2Cl_2	Trace
6	$PicAuCl_2$	$AgNTf_2$	CH_2Cl_2	Trace
7	*S*PhosAuCl	$AgNTf_2$	CH_2Cl_2	36/19/20
8	DavaPhosAuCl	$AgNTf_2$	CH_2Cl_2	20/11/19
9	^{t}BuDavaPhosAuCl	$AgNTf_2$	CH_2Cl_2	Messy
10	$^tBu_3PAuCl$	$AgNTf_2$	CH_2Cl_2	59/16/5
11	Cy_3PAuCl	$AgNTf_2$	CH_2Cl_2	54/19/6
12	$Ph_2MePAuCl$	$AgNTf_2$	CH_2Cl_2	56/16/8
13	L1AuCl	$AgNTf_2$	CH_2Cl_2	Trace
14	L2AuCl	$AgNTf_2$	CH_2Cl_2	15/45/5
15	L3AuCl	$AgNTf_2$	CH_2Cl_2	48/24/6
16	L3AuCl	-	CH_2Cl_2	NR
17	L3AuCl	AgOTf	CH_2Cl_2	8/49/3
18	L3AuCl	$AgSbF_6$	CH_2Cl_2	9/47/4
19	L3AuCl	AgOMs	CH_2Cl_2	Trace
20	L3AuCl	$AgBF_4$	CH_2Cl_2	Trace
21	L4AuCl	$AgNTf_2$	CH_2Cl_2	39/17/13
22	L5AuCl	$AgNTf_2$	CH_2Cl_2	Trace
23	L6AuCl	$AgNTf_2$	CH_2Cl_2	32/8/12
24	L7AuCl	$AgNTf_2$	CH_2Cl_2	46/24/9
25	L8AuCl	$AgNTf_2$	CH_2Cl_2	59/12/5
26	L9AuCl	$AgNTf_2$	CH_2Cl_2	77/17/2 (66/15/0)
27	L9AuCl	$AgBF_4$	CH_2Cl_2	36/18/9
28	L9AuCl	$NaBAr_F$	CH_2Cl_2	85/11/2 (75/9/0)
29	L10AuCl	$NaBAr_F$	CH_2Cl_2	79/11/3

30	L11AuCl	$NaBAr_F$	CH_2Cl_2	55/16/3
31	L12AuCl	$NaBAr_F$	CH_2Cl_2	80/17/2 (70/14/0)
32	L9AuCl	$NaBAr_F$	1,2-dichlorethane	61/10/0
33	L9AuCl	$NaBAr_F$	THF	NR
34	L9AuCl	$NaBAr_F$	Toluene	45/14/3
35	L9AuCl	$NaBAr_F$	Et_2O	Messy
36	L9AuCl	$NaBAr_F$	1,4-dioxane	Trace
37	L9AuCl	$NaBAr_F$	CH_3CN	Trace
38	L9AuCl	$NaBAr_F$	DMF	Trace
39	L9AuCl	$NaBAr_F$	PhCl	54/13/5
40	L9AuCl	$NaBAr_F$	$CHCl_3$	59/10/6
41	L9AuCl	$NaBAr_F$	CCl_4	Messy
42	L9AuCl	$NaBAr_F$	CH_2Br_2	(66/8/3)
43	L9AuCl	$NaBAr_F$	$PhCF_3$	55/14/5
44[b]	L9AuCl	$NaBAr_F$	CH_2Cl_2	72/14/2 (65/10/0)
45[c]	L9AuCl	$NaBAr_F$	CH_2Cl_2	80/12/2 (67/11/0)
46	CuCl	-	CH_2Cl_2	Messy
47	$Cu(CH_3CN)_4BF_4$	-	CH_2Cl_2	25/15/8
48	$Cu(OTf)_2$	-	CH_2Cl_2	Messy
49	$(C_6F_5)_3B$	-	CH_2Cl_2	Trace
50	AgOTf	-	CH_2Cl_2	Trace
51	$In(OTf)_3$	-	CH_2Cl_2	Trace

Reaction Conditions: **1a** (0.4 mmol), **2a** (0.6 mmol), catalyst (5 mol%), solvent (5 mL), r.t, 6 hours. The dr ratio was determined by ^1H NMR of the crude reaction mixture. [a] Determined by ^1H NMR analysis, CH_2Br_2 as internal standard. The number in parenthesis is isolated yield. [b]1.0 equiv. 2,6-dibromopyridine was added, isolated yield. [c]1.0 equiv. benzoic acid was added, isolated yield.



L1AuCl



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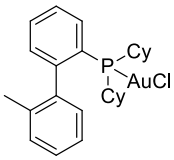

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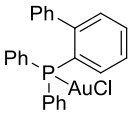

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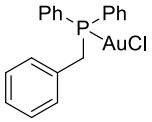
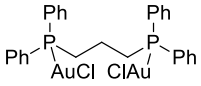
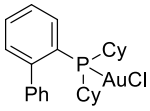


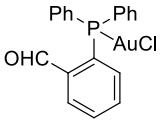
L5AuCl



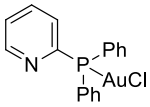
L6AuCl



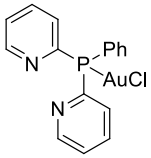
L7AuCl



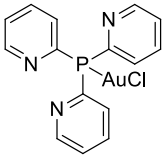
L8AuCl



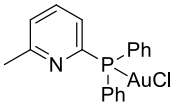
L9AuCl



L10 AuCl

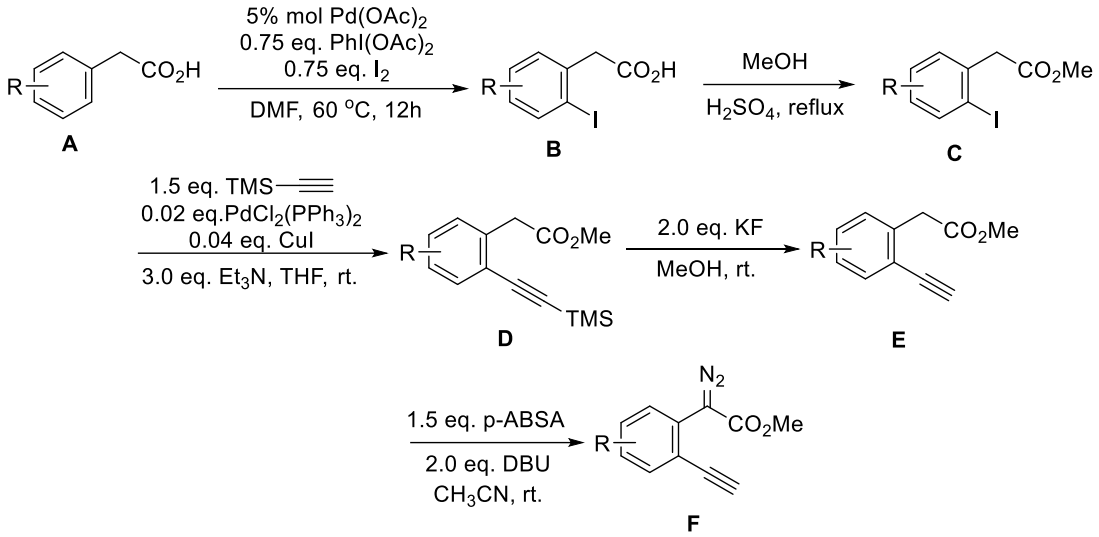


L11 AuCl



L12 AuCl

3. Synthesis of diazo compound 1



In a 250 mL bottom reaction flask, phenylacetic acid **A**, $Pd(OAc)_2$ (5 mol%), $PhI(OAc)_2$ (0.75 equiv.), I_2 (0.75 equiv.) were dissolved in 80 mL anhydrous DMF under air. Wrapped by aluminum foil to keep the system in the dark. The reaction mixture was then stirred at 60 °C for 12 h. After cooled to room temperature, the mixture was concentrated under vacuum and the residue was either subjected to column chromatography using hexanes : ethyl acetate : acetic acid / 2:1:0.05 to get the acids or converted to methyl esters as follows to get the compound **B**.

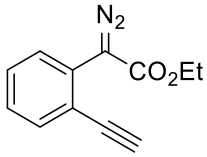
Then a 100 mL round bottom flask was taken, followed by the addition of the substituted *o*-iodophenylacetic acid **B**, anhydrous methanol solution, concentrated sulfuric acid, and reflux at 90 °C for 6 hours. The solution was cooled, reduced pressure remove the solvent, quenched with water and extracted with ethyl acetate three times, combined organic layers were dried over Na_2SO_4, filtrated and concentrated under reduced pressure. The residue was purified via flash chromatography to afford methyl *o*-iodophenylacetate **C**.

To a stirred solution of 2-iodophenylacetic acid methyl ester in THF was added CuI, $Pd(PPh_3)_2Cl_2$, and trimethylamine, trimethylsilylacetylene was slow dropped. This mixture was stirred at room temperature for 12h, then the reaction was quenched

by addition of water, followed by extraction with EtOAc. The organic phase was washed with sat. aq. NaCl, dried over Na_2SO_4 and concentrated under reduced pressure to yield crude product that was purified via silica gel chromatography to get the **D**. To remove the TMS-group the (2-ethynyl-phenyl)-acetic acid methyl ester was dissolved in 50 mL anhydrous methanol. Potassium fluoride was added to this mixture and stirred for 1 h at room temperature. Then the mixture was washed with water, $NaHCO_3$ solution and NaCl solution, dried over Na_2SO_4 and concentrated under reduced pressure to yield crude product that was purified via silica gel chromatography.

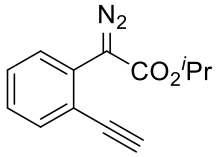
Finally, compound **E** was dissolved in anhydrous acetonitrile and *p*-ABSA, DBU was added, Stir overnight in the dark at room temperature, the reaction was quenched by addition of water, followed by extraction with Et_2O. The organic phase was washed with sat. aq. NaCl, dried over Na_2SO_4 and concentrated under reduced pressure to yield crude product that was purified via silica gel chromatography to get the diazo compound **1**.

1) Ethyl 2-diazo-2-(2-ethynylphenyl)acetate (1b)



^{1}H NMR (500 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.0 Hz, 1H), 7.53 (dd, *J* = 7.8, 1.1 Hz, 1H), 7.42-7.38 (m, 1H), 7.29-7.21 (m, 1H), 4.32 (q, *J* = 7.1 Hz, 2H), 3.48 (s, 1H), 1.33 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 165.6, 133.4, 133.0, 129.1, 127.7, 127.4, 120.1, 84.3, 80.8, 61.2, 14.5; HRMS (ESI) m/z calculated for $C_{12}H_{10}N_2NaO_2$ $[M+Na]^+$ = 237.0634, found 237.0635;

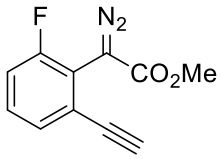
2) Isopropyl 2-diazo-2-(2-ethynylphenyl)acetate (1c)



^{1}H NMR (500 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.0 Hz, 1H), 7.52 (d, *J* = 7.8 Hz, 1H), 7.40 (dd, *J* = 11.2, 4.3 Hz, 1H), 7.25 (t, *J* = 7.6 Hz, 1H), 5.18 (hept, *J* = 6.2 Hz, 1H), 3.48

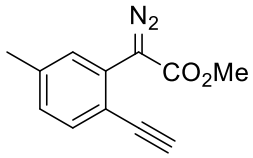
(s, 1H), 1.31 (d, *J* = 6.3 Hz, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 165.1, 133.4, 129.9, 129.1, 127.8, 127.3, 120.0, 84.3, 80.8, 68.8, 22.0; HRMS (ESI) m/z calculated for $C_{13}H_{12}N_2NaO_2$ $[M+Na]^+$ = 251.0791, found 251.0784;

3) Methyl 2-diazo-2-(2-ethynyl-6-fluorophenyl)acetate (1d)



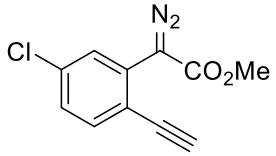
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.39-7.30 (m, 2H), 7.20-7.11 (m, 1H), 3.83 (s, 3H), 3.43 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 161.2, 159.2, 130.5, 130.4, 128.9 (d, *J* = 3.5 Hz), 124.6 (d, *J* = 3.2 Hz), 116.8 (d, *J* = 22.1 Hz), 116.1 (d, *J* = 16.4 Hz), 83.8, 79.9 (d, *J* = 4.3 Hz), 52.3; HRMS (ESI) m/z calculated for $C_{11}H_7FN_2NaO_2$ $[M+Na]^+$ = 241.0384, found 241.0379;

4) Methyl 2-diazo-2-(2-ethynyl-5-methylphenyl)acetate (1f)



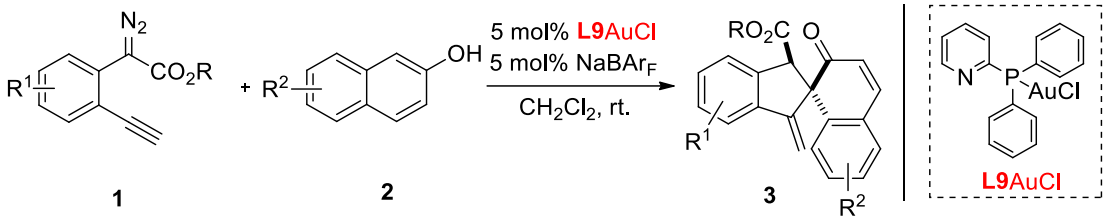
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.46-7.38 (m, 1H), 7.08 (d, *J* = 7.9 Hz, 1H), 3.85 (s, 3H), 3.43 (s, 1H), 2.37 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 166.1, 139.5, 133.3, 130.5, 128.6, 127.2, 117.3, 83.6, 80.9, 52.1, 21.5; HRMS (ESI) m/z calculated for $C_{12}H_{10}N_2NaO_2$ $[M+Na]^+$ = 237.0634, found 237.0635;

5) Methyl 2-(5-chloro-2-ethynylphenyl)-2-diazoacetate (1g)



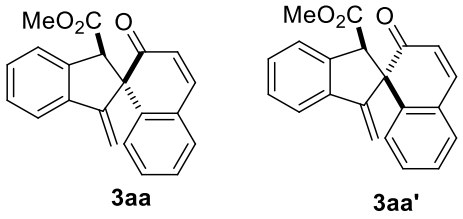
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.65 (d, *J* = 1.9 Hz, 1H), 7.45 (d, *J* = 8.4 Hz, 1H), 7.23 (dd, *J* = 8.4, 2.1 Hz, 1H), 3.86 (s, 3H), 3.52 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 165.5, 135.3, 134.5, 129.6, 129.2, 127.6, 118.1, 85.4, 79.8, 52.3. HRMS (ESI) m/z calculated for $C_{11}H_{17}ClN_2NaO_2$ $[M+Na]^+$ = 257.0088, found 257.0089;

4. Synthesis of compound 3 and 6



In a dried glass tube, a mixture of **L9**AuCl (0.02 mmol), additive (5 mol%) in solvent (3 mL) was stirred at room temperature for 15 mins. Subsequently, naphthalenol **2** (0.6 mmol) was added to the reaction mixture at room temperature. Then a solution of diazo compounds **1** (0.4 mmol) in solvent (1 mL) was introduced into the reaction mixture by a syringe in 20 mins. Then the resulting mixture was continually stirred at room temperature for 6-12 hours and **1** was consumed completely determined by TLC analysis. The mixture was concentrated under reduced pressure and the residue was purified by column chromatography on silica gel (PE/EA = 10:1 to 5:1 or PE/EA = 20:1 to 10:1) to afford the desired product.

1) Methyl 3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene] -1-carboxylate (3aa)

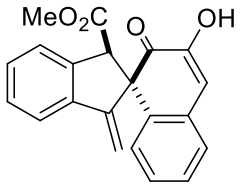


3aa, *cis*-isomer, 94.9 mg, 75% yield (isolated yield of single isomer), yellow solid, m.p. = 172-174 °C, ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.88 (d, *J* = 7.7 Hz, 1H), 7.51 (d, *J* = 9.9 Hz, 1H), 7.47 (d, *J* = 7.7 Hz, 1H), 7.44-7.39 (m, 2H), 7.38 (dd, *J* = 7.4, 1.9 Hz, 1H), 7.35 (dt, *J* = 12.6, 4.5 Hz, 2H), 7.22 (d, *J* = 7.6 Hz, 1H), 6.13 (d, *J* = 9.9 Hz, 1H), 5.39 (s, 1H), 4.82 (s, 1H), 4.50 (s, 1H), 3.60 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.7, 171.0, 150.6, 145.1, 144.6, 141.4, 137.7, 130.4, 130.2, 129.5, 129.3, 128.1, 127.5, 127.4, 126.2, 123.9, 121.5, 105.6, 65.5, 60.5, 51.9; HRMS (ESI) m/z calculated

for $C_{21}H_{16}NaO_3$ $[M+Na]^+$ = 339.0992, found 339.0995;

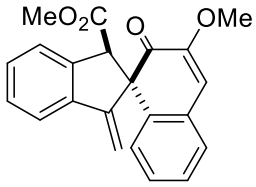
3aa', *trans*-isomer, 11.4 mg, 9% yield (isolated yield of single isomer), light yellow solid, m.p. = 208~210 ºC ; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.75-7.68 (m, 1H), 7.59 (d, J = 9.9 Hz, 1H), 7.50 (d, J = 7.7 Hz, 1H), 7.44 (dd, J = 10.8, 4.1 Hz, 1H), 7.39-7.31 (m, 2H), 7.23 (td, J = 7.5, 1.1 Hz, 1H), 7.12 (td, J = 7.7, 1.3 Hz, 1H), 6.84 (d, J = 7.9 Hz, 1H), 6.41 (d, J = 9.9 Hz, 1H), 5.40 (d, J = 0.8 Hz, 1H), 5.23 (s, 1H), 4.86 (d, J = 0.7 Hz, 1H), 3.21 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 200.6, 170.6, 154.0, 146.6, 144.2, 140.7, 139.1, 130.2, 129.7, 129.6, 128.3, 128.0, 127.4, 126.8, 125.5, 125.3, 121.3, 104.6, 64.5, 59.2, 51.4; HRMS (ESI) m/z calculated for $C_{21}H_{16}NaO_3$ $[M+Na]^+$ = 339.0992, found 339.0984

2) *cis*-Methyl 3'-hydroxy-3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3ab)



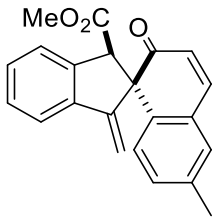
71.1 mg, 68% yield (isolated yield of single isomer), dr = 7.5:1, yellow oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.85 (d, *J* = 7.7 Hz, 1H), 7.49 (d, *J* = 7.7 Hz, 1H), 7.43 (t, *J* = 7.4 Hz, 1H), 7.36 (t, *J* = 7.5 Hz, 1H), 7.30 (d, *J* = 4.3 Hz, 2H), 7.24 (dd, *J* = 7.6, 4.5 Hz, 1H), 7.13 (d, *J* = 7.7 Hz, 1H), 6.88 (s, 1H), 6.23 (s, 1H), 5.40 (s, 1H), 4.90 (s, 1H), 4.53 (s, 1H), 3.60 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 194.8, 170.4, 150.8, 144.3, 140.8, 140.4, 138.0, 131.2, 129.5, 128.3, 128.2, 127.8, 127.7, 127.3, 126.2, 121.6, 117.2, 106.2, 64.3, 61.5, 52.1; HRMS (ESI) m/z calculated for $C_{21}H_{16}NaO_4$ $[M+Na]^+$ = 355.0941, found 355.0934;

3) *cis*-Methyl 3'-methoxy-3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3ac)



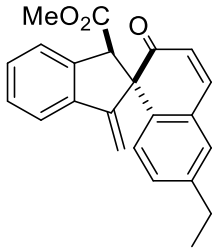
71.3 mg, 63% yield (isolated yield of single isomer), dr = 4.3:1, yellow oil, ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.87 (d, *J* = 7.7 Hz, 1H), 7.45 (d, *J* = 7.7 Hz, 1H), 7.41 (t, *J* = 7.5 Hz, 1H), 7.35-7.27 (m, 3H), 7.25-7.21 (m, 1H), 7.13 (d, *J* = 7.7 Hz, 1H), 6.61 (s, 1H), 5.39 (s, 1H), 4.86 (s, 1H), 4.56 (s, 1H), 3.80 (s, 3H), 3.62 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 192.4, 170.8, 150.2, 148.6, 141.3, 140.5, 137.5, 131.0, 129.3, 128.1, 127.9, 127.7, 127.6, 126.9, 126.1, 121.6, 115.3, 105.9, 66.6, 60.5, 55.5, 52.0; HRMS (ESI) m/z calculated for $C_{22}H_{18}NaO_4$ $[M+Na]^+$ = 369.1097, found 369.1093;

4) *cis*-Methyl 6'-methyl-3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3ad)



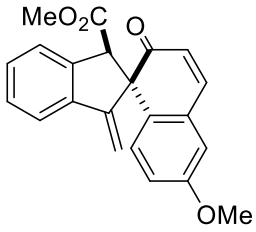
89.0 mg, 74% yield (isolated yield of single isomer), dr = 7.7:1, yellow oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.92 (d, *J* = 7.7 Hz, 1H), 7.50 (d, *J* = 9.7 Hz, 2H), 7.45 (t, *J* = 7.5 Hz, 1H), 7.36 (t, *J* = 7.5 Hz, 1H), 7.26-7.21 (m, 2H), 7.14 (d, *J* = 7.9 Hz, 1H), 6.14 (d, *J* = 9.9 Hz, 1H), 5.42 (s, 1H), 4.84 (s, 1H), 4.55 (s, 1H), 3.63 (s, 3H), 2.43 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.8, 171.0, 150.6, 145.3, 141.5, 141.4, 137.6, 137.1, 131.2, 130.0, 129.9, 129.2, 128.0, 127.2, 126.1, 123.8, 121.4, 105.4, 65.2, 60.3, 51.8, 20.8; HRMS (ESI) m/z calculated for $C_{22}H_{18}NaO_3$ $[M+Na]^+$ = 353.1148, found 353.1146;

5) *cis*-Methyl 6'-ethyl-3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3ae)



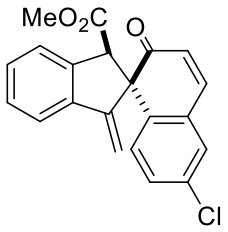
107.2 mg, 71% yield (isolated yield of single isomer), dr = 7:1; yellow oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.87 (d, *J* = 7.8 Hz, 1H), 7.47 (t, *J* = 8.2 Hz, 2H), 7.41 (td, *J* = 7.6, 1.0 Hz, 1H), 7.33 (t, *J* = 7.5 Hz, 1H), 7.24-7.18 (m, 2H), 7.16-7.08 (m, 1H), 6.11 (d, *J* = 9.9 Hz, 1H), 5.38 (s, 1H), 4.80 (s, 1H), 4.51 (s, 1H), 3.60 (s, 3H), 2.70 (q, *J* = 7.6 Hz, 2H), 1.29 (t, *J* = 7.6 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 198.1, 171.1, 150.8, 145.5, 143.4, 141.8, 141.5, 137.8, 130.1, 130.1, 129.3, 128.9, 128.1, 127.4, 126.2, 123.8, 121.5, 105.5, 65.3, 60.5, 51.9, 28.2, 15.2; HRMS (ESI) m/z calculated for $C_{23}H_{20}NaO_3$ $[M+Na]^+$ = 367.1305, found 367.1306;

6) *cis*-Methyl 6'-methoxy-3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3af)



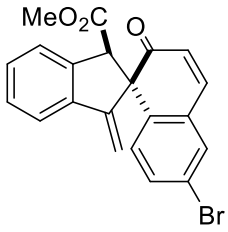
80.1 mg, 58% yield (isolated yield of single isomer), dr = 7.8:1, light yellow solid; m.p. = 215-217 ^{o}C, ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.86 (d, *J* = 7.7 Hz, 1H), 7.45 (t, *J* = 8.4 Hz, 2H), 7.41 (t, *J* = 7.5 Hz, 1H), 7.33 (t, *J* = 7.5 Hz, 1H), 7.13 (d, *J* = 8.5 Hz, 1H), 6.99-6.87 (m, 2H), 6.13 (d, *J* = 9.9 Hz, 1H), 5.38 (s, 1H), 4.77 (s, 1H), 4.51 (s, 1H), 3.86 (s, 3H), 3.60 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.9, 171.1, 158.6, 150.8, 145.0, 141.4, 137.8, 136.4, 131.2, 129.3, 128.6, 128.1, 126.2, 124.4, 121.5, 116.3, 114.1, 105.5, 65.1, 60.5, 55.4, 51.9; HRMS (ESI) m/z calculated for $C_{22}H_{18}NaO_4$ $[M+Na]^+$ = 369.1097, found 369.1090;

7) *cis*-Methyl 6'-chloro-3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3ag)



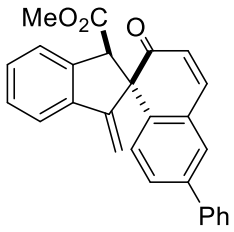
75.2 mg, 54% yield (isolated yield of single isomer), dr = 5.1:1, light yellow solid, m.p. = 196-198 ºC, ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.87 (d, *J* = 7.7 Hz, 1H), 7.48-7.42 (m, 2H), 7.42-7.39 (m, 2H), 7.34 (dd, *J* = 11.2, 4.6 Hz, 2H), 7.16 (d, *J* = 8.4 Hz, 1H), 6.16 (d, *J* = 9.9 Hz, 1H), 5.40 (s, 1H), 4.76 (s, 1H), 4.50 (s, 1H), 3.60 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 196.9, 170.7, 150.2, 143.5, 142.7, 141.2, 137.4, 133.3, 131.8, 130.1, 129.5, 129.0, 129.0, 128.3, 126.2, 125.1, 121.6, 105.8, 65.2, 60.5, 52.0; HRMS (ESI) m/z calculated for $C_{21}H_{15}ClNaO_3$ $[M+Na]^+$ = 373.0602, found 373.0609;

8) *cis*-Methyl 6'-bromo-3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3ah)



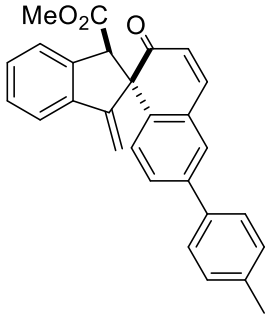
98.1 mg, 59% yield (isolated yield of single isomer), dr = 5.4:1, yellow oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.72 (d, *J* = 7.7 Hz, 1H), 7.54 (d, *J* = 10.0 Hz, 1H), 7.51 (d, *J* = 7.4 Hz, 2H), 7.47 (t, *J* = 7.4 Hz, 1H), 7.40 (t, *J* = 7.5 Hz, 1H), 7.25 (dd, *J* = 8.4, 1.5 Hz, 1H), 6.74 (d, *J* = 8.4 Hz, 1H), 6.48 (d, *J* = 9.9 Hz, 1H), 5.42 (s, 1H), 5.25 (s, 1H), 4.87 (s, 1H), 3.30 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 199.8, 170.4, 153.6, 144.9, 142.8, 140.4, 138.8, 132.8, 132.2, 130.0, 129.7, 128.4, 127.1, 126.8, 126.5, 121.3, 121.1, 104.9, 64.3, 59.0, 51.6; HRMS (ESI) m/z calculated for $C_{21}H_{15}BrNaO_3$ $[M+Na]^+$ = 417.0097, found 417.0102;

9) *cis*-Methyl 3-methylene-2'-oxo-6'-phenyl-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3ai)



94.2 mg, 53% yield (isolated yield of single isomer), dr = 5.4:1, yellow solid, m.p. = 222-224 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89 (d, *J* = 7.7 Hz, 1H), 7.61 (dd, *J* = 13.1, 5.7 Hz, 4H), 7.57 (d, *J* = 9.9 Hz, 1H), 7.50-7.32 (m, 6H), 7.28 (d, *J* = 8.2 Hz, 1H), 6.17 (d, *J* = 9.9 Hz, 1H), 5.42 (s, 1H), 4.86 (s, 1H), 4.57 (s, 1H), 3.62 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.6, 171.0, 150.6, 145.1, 143.3, 141.4, 140.4, 139.7, 137.7, 130.6, 129.3, 129.0, 128.9, 128.2, 128.0, 127.9, 127.8, 127.0, 126.2, 124.3, 121.5, 105.8, 65.3, 60.5, 52.0; HRMS (ESI) m/z calculated for $C_{27}H_{20}NaO_3$ $[M+Na]^+$ = 415.1305, found 415.1297;

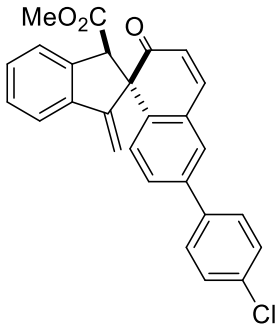
10) *cis*-Methyl 3-methylene-2'-oxo-6'-(p-tolyl)-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3aj)



94.7 mg, 49% yield (isolated yield of single isomer), dr = 5.2:1, light yellow solid, m.p. = 216-218 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89 (d, *J* = 7.7 Hz, 1H), 7.60-7.57 (m, 2H), 7.56 (d, *J* = 10.0 Hz, 1H), 7.52 (d, *J* = 8.1 Hz, 2H), 7.48 (d, *J* = 7.7 Hz, 1H), 7.42 (d, *J* = 7.4 Hz, 1H), 7.34 (t, *J* = 7.5 Hz, 1H), 7.27-7.23 (m, 2H), 6.16 (d, *J* = 9.9 Hz, 1H), 5.41 (s, 1H), 4.85 (s, 1H), 4.57 (s, 1H), 3.61 (s, 3H), 2.41 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.7, 171.0, 150.6, 145.2, 143.0, 141.4, 140.4, 137.7, 137.6, 136.8, 130.5, 129.6, 129.3, 128.8, 128.2, 127.9, 127.8, 126.8, 126.2, 124.2, 121.5,

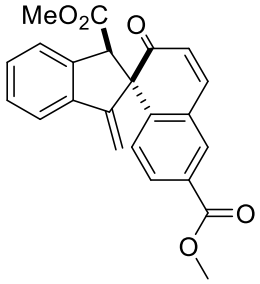
105.7, 65.3, 60.5, 51.9, 21.1; HRMS (ESI) m/z calculated for $C_{28}H_{22}NaO_3$ $[M+Na]^+$ = 429.1461, found 429.1464;

11) *cis*-Methyl 6'-(4-chlorophenyl)-3-methylene-2'-oxo-1,3-dihydro-2'H-spiro [indene-2,1'-naphthalene]-1-carboxylate (3ak)



96.4 mg, 48% yield (isolated yield of single isomer), dr = 5:1, white solid, m.p. = 230-232 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89 (d, *J* = 7.7 Hz, 1H), 7.58-7.56 (m, 3H), 7.55 (d, *J* = 2.8 Hz, 2H), 7.48 (d, *J* = 7.7 Hz, 1H), 7.46-7.40 (m, 3H), 7.35 (t, *J* = 7.5 Hz, 1H), 7.29 (d, *J* = 7.9 Hz, 1H), 5.42 (s, 1H), 4.85 (s, 1H), 4.56 (s, 1H), 3.62 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.5, 171.0, 150.5, 144.8, 143.7, 141.3, 139.2, 138.2, 137.6, 133.9, 130.8, 129.4, 129.1, 128.8, 128.2, 128.1, 127.8, 126.2, 124.5, 121.6, 105.8, 65.3, 60.6, 52.0; HRMS (ESI) m/z calculated for $C_{27}H_{19}ClNaO_3$ $[M+Na]^+$ = 449.0915, found 449.0903;

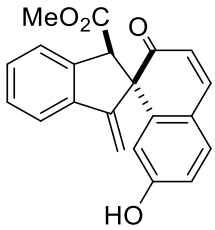
12) *cis*-Dimethyl 3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1,6'-dicarboxylate (3al)



71.8 mg, 41% yield (isolated yield of single isomer), dr = 5:1, white solid, 157-158 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.09 (d, *J* = 1.7 Hz, 1H), 8.03 (dd, *J* = 8.2, 1.8 Hz, 1H), 7.88 (d, *J* = 7.6 Hz, 1H), 7.56 (d, *J* = 9.9 Hz, 1H), 7.49-7.40 (m, 2H), 7.38-7.29 (m,

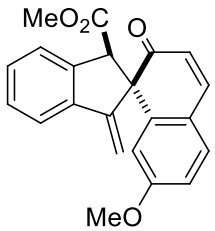
2H), 6.19 (d, *J* = 9.9 Hz, 1H), 5.40 (d, *J* = 0.8 Hz, 1H), 4.84 (s, 1H), 4.48 (d, *J* = 0.6 Hz, 1H), 3.96 (s, 3H), 3.60 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 196.8, 170.7, 166.1, 150.1, 149.3, 144.1, 141.2, 137.4, 131.1, 130.5, 130.5, 129.6, 129.5, 128.3, 127.8, 126.2, 124.8, 121.6, 105.9, 65.7, 60.5, 52.4, 52.0; HRMS (ESI) m/z calculated for $C_{23}H_{18}NaO_5$ $[M+Na]^+$ = 397.1046, found 397.1045;

13) *cis*-Methyl 7'-hydroxy-3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3am)

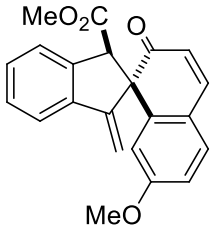


62.8 mg (0.3 mmol scale), 55% yield (isolated yield of single isomer), dr = 6:1, yellow oil liquid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.81 (d, *J* = 7.8 Hz, 1H), 7.41 (dd, *J* = 8.7, 4.3 Hz, 2H), 7.37 (dd, *J* = 10.8, 4.2 Hz, 1H), 7.29 (t, *J* = 7.5 Hz, 1H), 7.21 (d, *J* = 8.3 Hz, 1H), 6.70 (d, *J* = 8.3 Hz, 1H), 6.60 (d, *J* = 2.3 Hz, 1H), 6.42 (s, 1H), 5.92 (d, *J* = 9.8 Hz, 1H), 5.34 (s, 1H), 4.71 (s, 1H), 4.50 (s, 1H), 3.54 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 198.7, 171.3, 158.5, 150.4, 146.9, 146.1, 141.3, 137.6, 131.4, 129.3, 128.1, 126.2, 123.0, 121.5, 120.6, 114.8, 105.7, 65.7, 60.5, 51.9; HRMS (ESI) m/z calculated for $C_{21}H_{16}NaO_4$ $[M+Na]^+$ = 355.0941, found 355.0937;

14) Methyl 7'-methoxy-3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3an and 3an')



3an



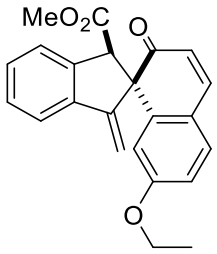
3an'

3an, major, 68.5 mg, 49% yield (isolated yield of single isomer), dr = 3.5:1, light

yellow oil liquid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.88 (d, *J* = 7.7 Hz, 1H), 7.46 (dd, *J* = 8.7, 5.6 Hz, 2H), 7.42 (t, *J* = 7.5 Hz, 1H), 7.33 (dd, *J* = 8.0, 5.6 Hz, 2H), 6.87 (dd, *J* = 8.4, 2.4 Hz, 1H), 6.73 (d, *J* = 2.3 Hz, 1H), 5.99 (d, *J* = 9.8 Hz, 1H), 5.39 (s, 1H), 4.76 (s, 1H), 4.54 (s, 1H), 3.78 (s, 3H), 3.60 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.7, 171.0, 161.5, 150.7, 146.7, 145.1, 141.4, 137.6, 131.1, 129.3, 128.1, 126.2, 123.6, 121.5, 121.3, 113.7, 112.5, 105.6, 65.7, 60.6, 55.4, 51.9; HRMS (ESI) m/z calculated for $C_{22}H_{18}NaO_4$ $[M+Na]^+$ = 369.1097, found 369.1087;

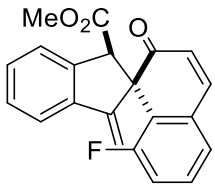
3an', minor, 19.5 mg, 14% yield, light yellow oil, ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89 (d, *J* = 7.7 Hz, 1H), 7.51-7.40 (m, 3H), 7.38-7.31 (m, 2H), 6.88 (dd, *J* = 8.4, 2.4 Hz, 1H), 6.74 (d, *J* = 2.4 Hz, 1H), 6.00 (d, *J* = 9.8 Hz, 1H), 5.40 (s, 1H), 4.77 (s, 1H), 4.55 (s, 1H), 3.80 (s, 3H), 3.61 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.7, 171.0, 161.5, 150.7, 146.8, 145.1, 141.4, 137.7, 131.1, 129.3, 128.1, 126.2, 123.6, 121.5, 121.3, 113.7, 112.6, 105.6, 65.7, 60.6, 55.5, 51.9, 29.7. HRMS (ESI) m/z calculated for $C_{22}H_{18}NaO_4$ $[M+Na]^+$ = 369.1097, found 369.1099;

15) *cis*-Methyl 7'-ethoxy-3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3ao)



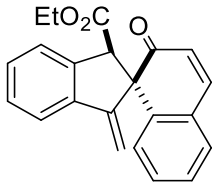
61.6 mg, 31% yield (isolated yield of single isomer), dr = 2.6:1, yellow oil liquid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.87 (d, *J* = 7.7 Hz, 1H), 7.45 (dd, *J* = 8.7, 5.2 Hz, 2H), 7.41 (t, *J* = 7.5 Hz, 1H), 7.35-7.30 (m, 2H), 6.85 (dd, *J* = 8.4, 2.4 Hz, 1H), 6.73 (d, *J* = 2.3 Hz, 1H), 5.99 (d, *J* = 9.8 Hz, 1H), 5.39 (s, 1H), 4.76 (s, 1H), 4.54 (s, 1H), 4.02-3.96 (m, 2H), 3.60 (s, 3H), 1.36 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.7, 171.0, 160.9, 150.8, 146.8, 145.1, 141.4, 137.6, 131.1, 129.2, 128.1, 126.2, 123.4, 121.4, 121.1, 114.3, 112.7, 105.5, 65.6, 63.7, 60.6, 51.8, 14.6; HRMS (ESI) m/z calculated for $C_{21}H_{16}NaO_3$ $[M+Na]^+$ = 383.1254, found 383.1244;

16) *cis*-Methyl 8'-fluoro-3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3ap)



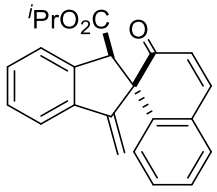
50.3 mg, 30% yield (isolated yield of single isomer), dr = 4:1, yellow solid, m.p. = 182-184 ºC; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.85 (d, *J* = 7.7 Hz, 1H), 7.50 (dd, *J* = 12.9, 4.6 Hz, 2H), 7.44-7.30 (m, 3H), 7.23 (d, *J* = 7.4 Hz, 1H), 7.09 (dd, *J* = 10.8, 8.6 Hz, 1H), 6.17 (d, *J* = 9.9 Hz, 1H), 5.38 (s, 1H), 5.00 (d, *J* = 1.7 Hz, 1H), 4.51 (s, 1H), 3.61 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 196.8, 171.3, 160.1 (d, *J* = 249.2 Hz), 149.8, 144.1 (d, *J* = 3.6 Hz), 141.4, 138.3, 132.5 (d, *J* = 4.3 Hz), 130.5 (d, *J* = 10.4 Hz), 129.3 (d, *J* = 9.4 Hz), 129.2, 127.8, 126.3, 125.5 (d, *J* = 2.8 Hz), 125.0, 121.4, 118.0 (d, *J* = 23.0 Hz), 103.8, 61.5 (d, *J* = 2.3 Hz), 59.3 (d, *J* = 6.8 Hz), 51.9; HRMS (ESI) m/z calculated for $C_{21}H_{15}FNaO_3$ $[M+Na]^+$ = 357.0897, found 357.0903;

17) *cis*-Ethyl 3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene] -1-carboxylate (3ba)



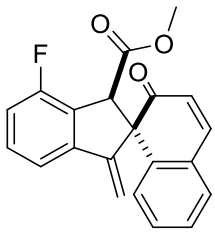
83.3 mg, 63% yield (isolated yield of single isomer), dr = 5.8:1, yellow solid, m.p. = 163-165 ºC , ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89 (d, *J* = 7.7 Hz, 1H), 7.48 (dd, *J* = 17.8, 8.8 Hz, 2H), 7.45-7.30 (m, 5H), 7.23 (d, *J* = 7.5 Hz, 1H), 6.13 (d, *J* = 9.9 Hz, 1H), 5.38 (s, 1H), 4.79 (s, 1H), 4.49 (s, 1H), 4.16-3.96 (m, 2H), 1.10 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.6, 170.4, 150.7, 145.0, 144.7, 141.6, 137.7, 130.3, 130.2, 129.4, 129.3, 128.1, 127.5, 127.4, 126.2, 124.1, 121.5, 105.5, 65.5, 60.9, 60.5, 13.8; HRMS (ESI) m/z calculated for $C_{22}H_{18}NaO_3$ $[M+Na]^+$ = 355.1148, found 355.1153;

18) *cis*-Isopropyl 3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3ca)



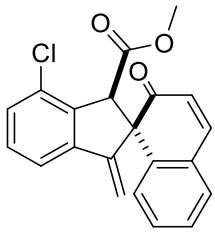
82.8 mg, 60% yield (isolated yield of single isomer), dr = 5.5:1, light yellow solid, m.p. = 122-123 °C, ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.90 (d, *J* = 7.7 Hz, 1H), 7.47 (dd, *J* = 17.4, 8.8 Hz, 2H), 7.43-7.29 (m, 5H), 7.22 (d, *J* = 7.4 Hz, 1H), 6.12 (d, *J* = 9.9 Hz, 1H), 5.37 (s, 1H), 5.01-4.87 (m, 1H), 4.76 (s, 1H), 4.48 (s, 1H), 1.09 (d, *J* = 6.2 Hz, 3H), 1.06 (d, *J* = 6.2 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.4, 169.9, 150.79, 144.9, 144.8, 141.9, 137.7, 130.3, 130.3, 129.3, 129.3, 128.0, 127.5, 127.3, 126.1, 124.2, 121.5, 105.4, 68.7, 65.5, 60.6, 21.6, 21.3; HRMS (ESI) m/z calculated for $C_{23}H_{20}NaO_3$ $[M+Na]^+$ = 367.1305, found 367.1305;

19) *cis*-Methyl 4-fluoro-1-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-3-carboxylate (3da)



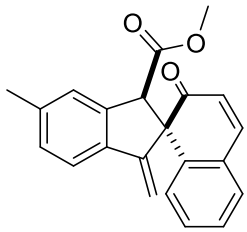
83.0 mg, 59% yield (isolated yield of single isomer), dr = 7:1, light yellow solid, m.p. = 173-175 °C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.54 (d, *J* = 9.9 Hz, 1H), 7.42-7.29 (m, 5H), 7.09 (dd, *J* = 11.5, 5.9 Hz, 2H), 6.18 (d, *J* = 9.9 Hz, 1H), 5.49 (s, 1H), 4.77 (s, 1H), 4.64 (s, 1H), 3.60 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 198.3, 169.4, 160.6, 158.6, 152.5 (d, *J* = 2.4 Hz), 145.8, 142.4 (d, *J* = 5.1 Hz), 130.8, 130.7 (d, *J* = 7.5 Hz), 129.5, 129.0, 127.7, 127.3 (d, *J* = 16.6 Hz), 127.2, 124.5, 117.0 (d, *J* = 3.6 Hz), 116.2, 116.0, 107.4, 64.8, 60.6 (d, *J* = 2.4 Hz), 52.1; HRMS (ESI) m/z calculated for $C_{21}H_{15}FNaO_3$ $[M+Na]^+$ = 357.0898, found 357.0897;

20) *cis*-Methyl 4-chloro-1-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-3-carboxylate (3ea)



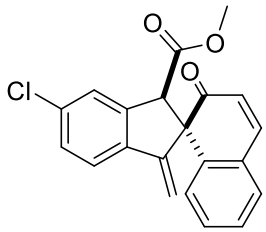
82.8 mg, 58% yield (isolated yield of single isomer), dr = 7:1, yellow oil liquid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.55 (d, *J* = 9.9 Hz, 1H), 7.47 (d, *J* = 7.5 Hz, 1H), 7.40-7.27 (m, 5H), 6.23 (d, *J* = 9.9 Hz, 1H), 5.57 (s, 1H), 4.74 (s, 1H), 4.58 (s, 1H), 3.63 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 199.1, 169.2, 153.6, 146.3, 145.8, 142.5, 138.7, 132.6, 130.8, 130.2, 129.8, 129.5, 128.4, 127.8, 126.7, 125.2, 119.6, 108.0, 64.2, 63.4, 52.2; HRMS (ESI) m/z calculated for $C_{21}H_{15}ClNaO_3$ $[M+Na]^+$ = 373.0595, found 373.0602;

21) *cis*-Methyl 5-methyl-1-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-3-carboxylate (3fa)



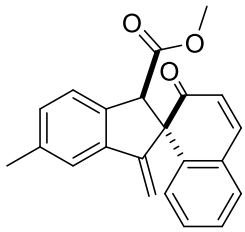
92.5 mg, 74% yield (isolated yield of single isomer), dr = 8:1, yellow solid, m.p. = 220-222 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.69 (s, 1H), 7.49 (d, *J* = 9.9 Hz, 1H), 7.40-7.31 (m, 4H), 7.20 (d, *J* = 7.5 Hz, 1H), 7.15 (d, *J* = 7.8 Hz, 1H), 6.12 (d, *J* = 9.9 Hz, 1H), 5.31 (s, 1H), 4.78 (s, 1H), 4.44 (s, 1H), 3.59 (s, 3H), 2.45 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.7, 171.1, 150.4, 145.1, 144.7, 141.5, 139.5, 135.1, 130.3, 130.2, 129.4, 129.2, 127.4, 127.4, 126.7, 124.0, 121.3, 104.5, 65.7, 60.3, 51.8, 21.7; HRMS (ESI) m/z calculated for $C_{22}H_{18}NaO_3$ $[M+Na]^+$ = 353.1154, found 353.1148;

22) *cis*-Methyl 5-chloro-1-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-3-carboxylate (3ga)



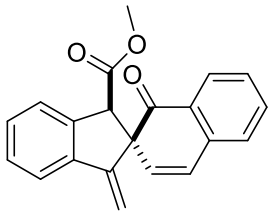
73.4 mg, 53% yield (isolated yield of single isomer), dr = 4.5:1, light yellow solid, m.p. = 197-198 ºC; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.88 (s, 1H), 7.51 (d, *J* = 9.9 Hz, 1H), 7.44-7.34 (m, 4H), 7.30 (dd, *J* = 8.2, 1.0 Hz, 1H), 7.20 (d, *J* = 7.5 Hz, 1H), 6.11 (d, *J* = 9.9 Hz, 1H), 5.36 (s, 1H), 4.79 (s, 1H), 4.51 (s, 1H), 3.61 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.4, 170.4, 149.3, 145.3, 143.9, 143.0, 136.2, 135.2, 130.5, 130.2, 129.6, 128.5, 127.6, 127.4, 126.5, 123.7, 122.4, 106.3, 65.6, 59.9, 52.1; HRMS (ESI) m/z calculated for $C_{21}H_{15}ClNaO_3$ $[M+Na]^+$ = 373.0595, found 373.0602;

23) *cis*-Methyl 5-methyl-3-methylene-2'-oxo-1,3-dihydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (3ha)

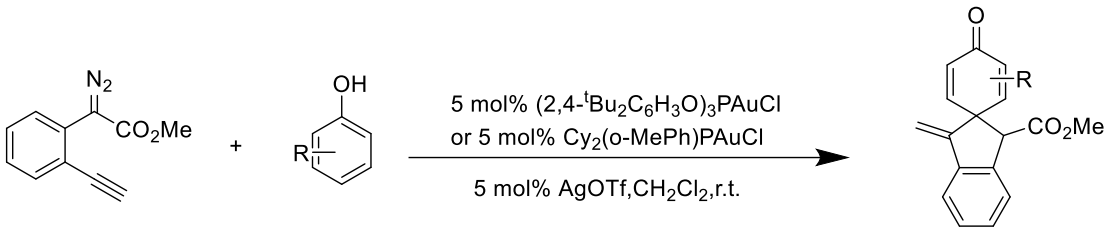


73.2 mg, 69% yield (isolated yield of single isomer), dr = 7.2:1, yellow oil liquid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.74 (d, *J* = 7.9 Hz, 1H), 7.49 (d, *J* = 9.9 Hz, 1H), 7.42-7.30 (m, 3H), 7.27 (s, 1H), 7.22 (dd, *J* = 17.6, 7.9 Hz, 2H), 6.12 (d, *J* = 9.9 Hz, 1H), 5.36 (s, 1H), 4.77 (s, 1H), 4.47 (s, 1H), 3.59 (s, 3H), 2.38 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.7, 171.1, 150.7, 145.1, 144.7, 138.7, 137.9, 137.7, 130.4, 130.3, 130.1, 129.4, 127.5, 127.4, 125.9, 124.0, 121.8, 105.2, 65.7, 60.4, 51.8, 21.3; HRMS (ESI) m/z calculated for $C_{22}H_{18}NaO_3$ $[M+Na]^+$ = 353.1148, found 353.1142;

24) *cis*-Methyl 3-methylene-1'-oxo-1,3-dihydro-1'H-spiro[indene-2,2'-naphthalene]-1-carboxylate (3aq)



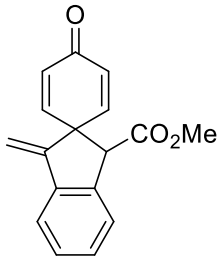
59.2 mg, 50% yield (isolated yield of single isomer), dr = 6:1, yellow liquid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.91 (d, *J* = 7.6 Hz, 1H), 7.87 (d, *J* = 7.7 Hz, 1H), 7.57 (td, *J* = 7.5, 1.1 Hz, 1H), 7.47 (d, *J* = 7.6 Hz, 1H), 7.38 (t, *J* = 7.5 Hz, 1H), 7.33 (t, *J* = 7.7 Hz, 1H), 7.29 (t, *J* = 7.7 Hz, 2H), 6.84 (d, *J* = 9.7 Hz, 1H), 6.27 (d, *J* = 9.7 Hz, 1H), 5.42 (s, 1H), 4.96 (s, 1H), 4.35 (s, 1H), 3.61 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 196.5, 171.1, 145.3, 141.5, 137.9, 137.8, 136.6, 134.3, 129.2, 128.2, 127.9, 127.8, 127.2, 126.1, 125.9, 121.9, 105.6, 64.2, 58.2, 51.9. HRMS (ESI) m/z calculated for $C_{21}H_{16}NaO_3$ $[M+Na]^+$ = 339.0993, found 339.0992;



1a **5** **6**

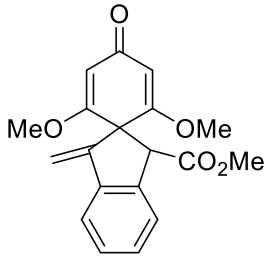
In a dried glass tube, a mixture of LAuCl (0.015 mmol), additive (5 mol%) in solvent (4 mL) was stirred at room temperature for 15 mins. Subsequently, phenol (0.45 mmol) was added to the reaction mixture at room temperature. Then a solution of diazo compounds (0.3 mmol) in solvent (1 mL) was introduced into the reaction mixture by a syringe in 15 mins. Then the resulting mixture was continually stirred at room temperature for 6 hours and diazo compound was consumed completely determined by TLC analysis. The mixture was concentrated under reduced pressure and the residue was purified by column chromatography on silica gel (PE/EA = 10:1 to 5:1 or PE/EA = 20:1 to 10:1) to afford the desired product.

25) Methyl 3'-methylene-4-oxo-1',3'-dihydrospiro[cyclohexane-1,2'-indene]-2,5-diene-1'-carboxylate (6a)



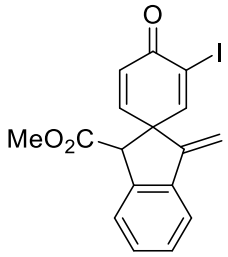
50.1 mg, 45% yield, yellow solid, m.p = 131-132 ^{o}C; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.60-7.52 (m, 1H), 7.47-7.33 (m, 3H), 6.93 (dd, *J* = 10.0, 3.0 Hz, 1H), 6.79 (dd, *J* = 10.1, 3.0 Hz, 1H), 6.52-6.40 (m, 1H), 6.30-6.16 (m, 1H), 5.58 (d, *J* = 0.6 Hz, 1H), 5.19-4.92 (m, 1H), 4.34 (s, 1H), 3.68 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 185.8, 170.3, 150.6, 148.3, 147.7, 139.4, 138.8, 129.8, 129.4, 128.7, 128.4, 126.7, 121.9, 107.3, 57.3, 55.8, 52.3; HRMS (ESI) m/z calculated for $C_{17}H_{14}NaO_3$ $[M+Na]^+$ = 289.0835, found 289.0827;

26) Methyl 3,5-dimethoxy-3'-methylene-4-oxo-1',3'-dihydrospiro[cyclohexane-1,2'-indene]-2,5-diene-1'-carboxylate (6b)



57.2 mg, 57% yield, colorless solid, m.p. = 178-180 ^{o}C , ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.65 (d, *J* = 7.7 Hz, 1H), 7.44 (d, *J* = 7.7 Hz, 1H), 7.34 (t, *J* = 7.4 Hz, 1H), 7.28 (d, *J* = 7.5 Hz, 1H), 5.48 (s, 1H), 5.47 (s, 1H), 5.17 (d, *J* = 1.7 Hz, 1H), 5.09 (s, 1H), 5.06 (s, 1H), 3.87 (s, 3H), 3.67 (s, 3H), 3.48 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 197.2, 175.8, 172.4, 170.7, 150.7, 141.4, 138.1, 129.1, 127.7, 126.5, 120.7, 103.9, 93.9, 91.1, 65.2, 56.3, 56.2, 55.9, 51.7; HRMS (ESI) m/z calculated for $C_{19}H_{18}NaO_5$ $[M+Na]^+$ = 349.1040, found 349.1046;

27) Methyl 2-iodine-3'-methylene-4-oxo-1',3'-dihydrospiro[cyclohexane-1,2'-indene]-2,5-diene-1'-carboxylate (6c and 6c')

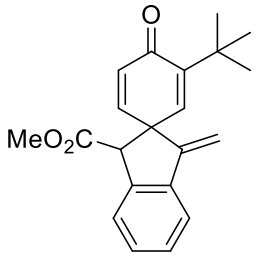


dr = 2:1

Major: 44.9 mg, 38% yield, yellow liquid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.65 (d, *J* = 2.7 Hz, 1H), 7.57 – 7.55 (m, 1H), 7.44 – 7.39 (m, 3H), 6.88 (dd, *J* = 9.9, 2.7 Hz, 1H), 6.36 (d, *J* = 9.9 Hz, 1H), 5.61 (d, *J* = 0.9 Hz, 1H), 5.03 (d, *J* = 0.8 Hz, 1H), 4.36 (s, 1H), 3.68 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 179.4, 170.0, 158.4, 148.6, 146.5, 139.1, 138.4, 129.9, 128.9, 126.6, 125.5, 122.0, 107.8, 104.5, 59.5, 56.7, 52.5; HRMS (ESI) m/z calculated for $C_{17}H_{13}INaO_3$ $[M+Na]^+$ =414.9807, found 414.9800;

Minor: 22.5 mg, 19% yield, yellow liquid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.57 – 7.56 (m, 1H), 7.54 (d, *J* = 2.6 Hz, 1H), 7.45– 7.39 (m, 3H), 6.99 (dd, *J* = 9.8, 2.6 Hz, 1H), 6.54 (d, *J* = 9.8 Hz, 1H), 5.61 (s, 1H), 5.04 (s, 1H), 4.36 (s, 1H), 3.71 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 179.5, 169.8, 156.2, 150.7, 146.3, 139.0, 138.3, 130.0, 128.9, 126.7, 126.5, 122.0, 107.9, 103.5, 59.8, 57.0, 52.6; HRMS (ESI) m/z calculated for $C_{17}H_{13}INaO_3$ $[M+Na]^+$ =414.9807, found 414.9793;

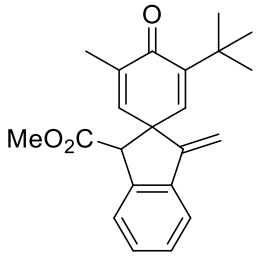
28) Methyl 2-tert-butyl-3'-methylene-4-oxo-1',3'-dihydrospiro[cyclohexane-1,2'-indene]-2,5-diene-1'-carboxylate (6d)



64.1 mg, 66% yield, dr = 1.4:1, yellow liquid; ^{1}H NMR (500 MHz, $CDCl_3$) δ ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.68-7.55 (m, 1 H), 7.43-7.37 (m, 3H), [6.81 (dd, *J* = 9.8,

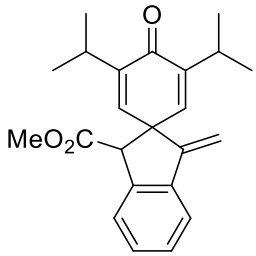
2.8 Hz, 0.6H), 6.70 (d, *J* =2.8 Hz, 0.4H)], [6.64 (dd, *J* = 9.8, 2.8 Hz, 0.4H), 6.52 (d, *J* = 2.8 Hz, 0.6H)], [6.35 (d, *J* = 9.7 Hz, 0.6H), 6.15 (d, *J* = 9.8 Hz, 0.4H)], 5.53 (d, *J* = 4.9 Hz, 1H), 4.93 (d, *J* = 6.5 Hz, 1H), 4.31 (s, 1H), 3.64 (d, *J* = 1.6 Hz, 3H), [1.29 (s, 3.8H), 1.17 (s, 5.3H)]; ^{13}C NMR (125 MHz, $CDCl_3$) δ [186.0, 185.9], 170.4, [148.6, 148.5], [148.2, 146.6], [145.7, 145.4], [144.1, 141.7], [139.6, 139.5], [139.1, 138.9], [131.1, 130.1], [129.7, 129.6], 128.5, [126.8, 126.7], 121.8, [106.7, 106.6], [57.6, 57.3], [56.0, 55.6], [52.0, 51.9], [34.6, 34.5], [29.1, 29.0]. HRMS (ESI) m/z calculated for $C_{21}H_{22}NaO_3$ $[M+Na]^+$ = 345.1467, found 345.1460;

29) Methyl 2-tert-butyl-6-methyl-3'-methylene-4-oxo-1',3'-dihydrospiro [cyclohexane-1,2'-indene]-2,5-diene-1'-carboxylate (6e)



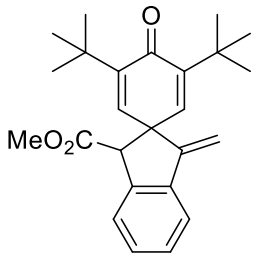
70.3 mg, 70% yield, dr = 1.4:1, yellow liquid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.56 (dd, *J* = 7.9, 4.4 Hz, 1H), 7.43-7.35 (m, 3H), [6.69 (d, *J* = 3.0 Hz, 0.4H), 6.62 (dd, *J* = 2.7, 1.3 Hz, 0.6H)], [6.51 (d, *J* = 3.0 Hz, 0.6H), 6.46 (dd, *J* = 2.7, 1.3 Hz, 0.4H)], 5.50 (d, *J* = 4.9 Hz, 1H), 4.91 (d, *J* = 2.3 Hz, 1H), 4.28 (d, *J* = 1.8 Hz, 1H), [3.63 (s, 1.7H), 3.60 (s, 1.3H)], [1.97 (d, *J* = 1.2 Hz, 1.7H), 1.83 (d, *J* = 1.2 Hz, 1.3H)], [1.29 (s, 3.7H), 1.17 (s, 5.2H)]; ^{13}C NMR (125 MHz, $CDCl_3$) δ [186.5, 186.4], [170.7, 170.6], [149.1, 149.0], [146.2, 145.0], [144.1, 144.0], [141.4, 141.1], [139.8, 139.6], [139.2, 139.1], [136.6, 136.0], [129.5, 129.4], [128.5, 128.4], [126.8, 126.7], [121.8, 121.7], [106.3, 106.1], [57.5, 57.4], [55.5, 55.1], [51.9, 51.8], [34.6, 34.5], [29.2, 29.1], [16.4, 16.3]; HRMS (ESI) m/z calculated for $C_{22}H_{24}NaO_3$ $[M+Na]^+$ = 359.1623, found 359.1609;

30) Methyl 2,6-diisopropyl-3'-methylene-4-oxo-1',3'-dihydrospiro[cyclohexane-1,2'-indene]-2,5-diene-1'-carboxylate (6f)



66.8 mg (0.5 mmol scale), 41% yield, yellow liquid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.58-7.56 (m, 1H), 7.43-7.37 (m, 3H), 6.59 (d, *J* = 2.4 Hz, 1H), 6.41 (dd, *J* = 2.8, 0.6 Hz, 1H), 5.49 (s, 1H), 4.87 (s, 1H), 4.30 (s, 1H), 3.60 (s, 3H), 3.11 (hept, *J* = 6.8 Hz, 1H), 3.01 ((hept, *J* = 6.8 Hz, 1H), 1.12 (d, *J* = 6.9 Hz, 6H), 0.97 (dd, *J* = 6.9, 4.7 Hz, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 185.0, 170.5, 149.1, 145.5, 144.6, 142.3, 139.7, 139.6, 139.2, 129.5, 128.4, 126.7, 121.8, 106.2, 57.5, 54.9, 51.8, 26.4, 26.2, 22.1, 22.0, 21.7, 21.6; HRMS (ESI) m/z calculated for $C_{23}H_{26}NaO_3$ $[M+Na]^+$ = 373.1780, found 373.1768;

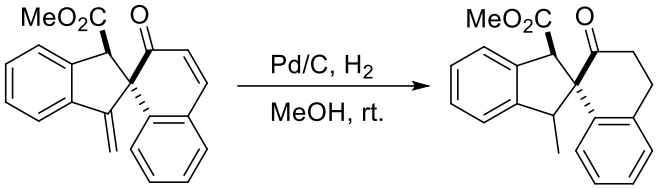
31) Methyl 2,6-di-tert-butyl-3'-methylene-4-oxo-1',3'-dihydrospiro[cyclohexane -1,2'-indene]-2,5-diene-1'-carboxylate (6g)



33.3 mg, 30% yield, yellow oil; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.56 (dd, *J* = 5.7, 2.9 Hz, 1H), 7.43 – 7.35 (m, 3H), 6.61 (d, *J* = 2.9 Hz, 1H), 6.39 (d, *J* = 2.9 Hz, 1H), 5.49 (s, 1H), 4.88 (s, 1H), 4.27 (s, 1H), 3.61 (s, 3H), 1.29 (s, 9H), 1.16 (s, 9H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 186.4 170.6, 149.7, 147.8, 146.6, 141.9, 139.7, 139.3, 139.2, 129.5, 128.4, 126.8, 121.8, 106.1, 57.7, 55.0, 51.8, 34.9, 34.8, 29.5, 29.4; HRMS (ESI) m/z calculated for $C_{25}H_{30}NaO_3$ $[M+Na]^+$ = 401.2093, found 401.2086.

5. Transformations of products

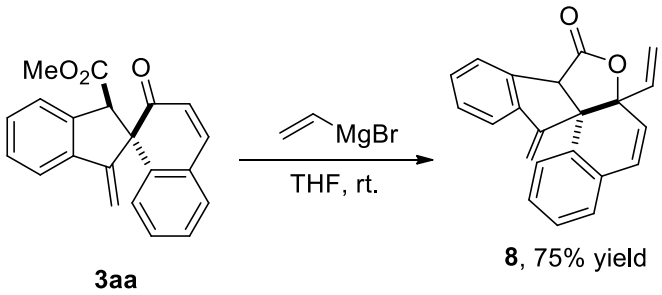
1) Methyl 3-methyl-2'-oxo-1,3,3',4'-tetrahydro-2'H-spiro[indene-2,1'-naphthalene]-1-carboxylate (7)



3aa **7**, 74% yield

In a dried Schlenk tube, Pd/C (16.0 mg, palladium on activated carbon, 10% Pd basis, 0.1 equiv.) was added to a solution of **3aa** (63.3 mg, 0.2 mmol) in MeOH (3.0 mL). The reaction mixture was stirred under H_2 atmosphere (1 atm) at rt for 12 h. After the reaction was complete (monitored by TLC), the crude reaction mixture was filtered with celite and washed with EtOAc. The solvent was removed under reduced pressure. Then the residue was purified by silica gel column chromatography (PE/EA = 10:1) to afford the desired product **7** (47.4 mg, 74% yield) as a colorless liquid; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.69 (d, *J* = 7.1 Hz, 1H), 7.45 (d, *J* = 7.5 Hz, 1H), 7.34-7.20 (m, 5H), 7.07 (d, *J* = 6.9 Hz, 1H), 4.53 (s, 1H), 3.80 (q, *J* = 7.1 Hz, 1H), 3.65 (s, 3H), 3.43-3.26 (m, 1H), 3.11 (ddd, *J* = 15.7, 6.2, 3.9 Hz, 1H), 2.81-2.57 (m, 2H), 1.26 (d, *J* = 7.2 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 210.5, 171.7, 143.2, 140.9, 138.6, 137.7, 128.3, 127.5, 127.3, 126.9, 126.7, 126.7, 124.0, 122.3, 64.8, 62.3, 52.9, 51.9, 41.2, 29.2, 14.0; HRMS (ESI) m/z calculated for $C_{21}H_{20}NaO_3$ $[M+Na]^+$ = 343.1298, found 343.1305.

2) 13-methylene-6a-vinyl-8a,13-dihydro-6aH,8H-indeno[2,1-c]naphtho[2,1-b] furan-8-one (8)



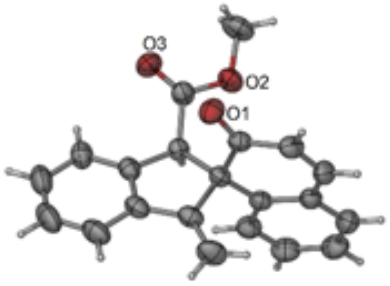
3aa **8**, 75% yield

To a solution of **3aa** (63.3 mg, 0.2 mmol) in THF (2 mL) was added vinyl magnesium bromide (0.6 mmol, 3.0 equiv) slowly, and the reaction was then stirred at room temprerature. After the reaction was complete (monitored by TLC), the reaction was quenched with saturated aqueous $NaHCO_3$, and extracted with ethyl acetate. The organic layers were combined and dried over Na_2SO_4, filtered and concentrated by rotary evaporation. Then the residue was purified by silica gel column chromatography (petroleum ether / ethyl acetate = 20/1) to afford product **8** as a yellow oil, 46.9 mg, 75% yield; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.58 (d, *J* = 7.5 Hz, 1H), 7.35 (dd, *J* = 14.3, 7.3 Hz, 2H), 7.27 (dd, *J* = 13.8, 6.3 Hz, 1H), 7.21 (d, *J* = 4.3 Hz, 2H), 7.02 (s, 1H), 6.68 (d, *J* = 7.4 Hz, 1H), 6.63 (d, *J* = 9.7 Hz, 1H), 6.42 (d, *J* = 9.7 Hz, 1H), 6.16 (s, 1H), 5.90 (dd, *J* = 17.0, 10.7 Hz, 1H), 5.50 (d, *J* = 17.0 Hz, 1H), 5.39 (s, 1H), 5.15 (d, *J* = 10.7 Hz, 1H), 4.19 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 175.4, 149.4, 140.7, 139.1, 138.6, 137.7, 132.5, 129.6, 129.6, 128.8, 128.5, 128.4, 127.8, 127.6, 125.0, 123.0, 121.6, 116.3, 107.8, 87.2, 63.5, 53.4; RMS (ESI) m/z calculated for $C_{22}H_{16}NaO_2$ $[M+Na]^+$ = 335.1045, found 335.1043;

6. Reference

[1] (a) T. Mei, D. Wang, J. Yu, *Org. Lett.* **2010**, *12*, 3140-3143; (b) P. Wessig, C. Glombitza, G. Müller, J. Teubner, *J. Org. Chem.* **2004**, *69*, 7582-7591; (c) F. J. Reboredo, M. Treus, J. C.Estévez, L. Castedo, R. J. Estévez, *Synlett*, **2003**, *11*, 1603-1606; (d) C. Peng, J. Cheng, J. Wang, *Adv. Synth. Catal.*. **2008**, *350*, 2359-2364.

7. X-ray Crystal data for 3aa, 3aa' and 3aq.



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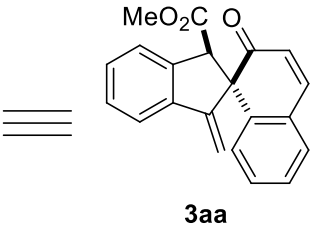
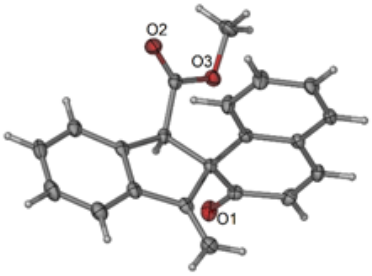


3aa



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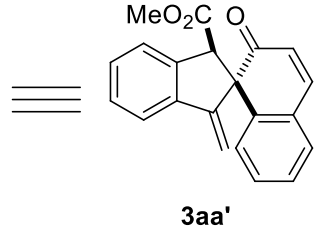
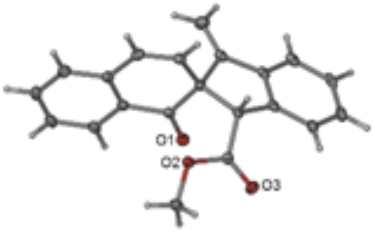


3aa'



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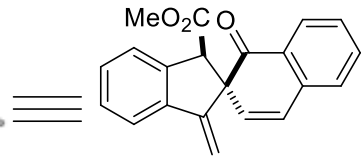
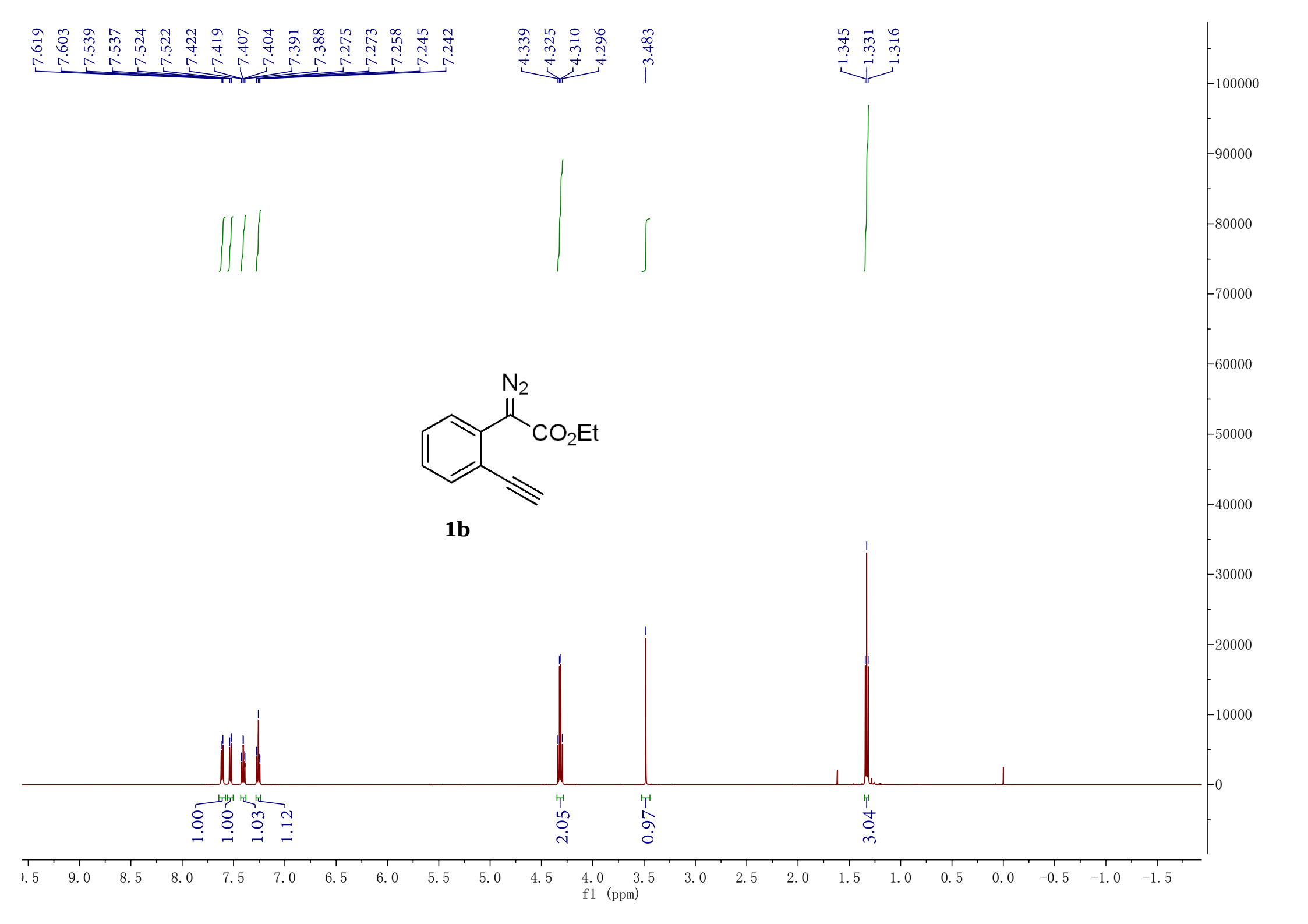


3aq

8. NMR Spectra of new compounds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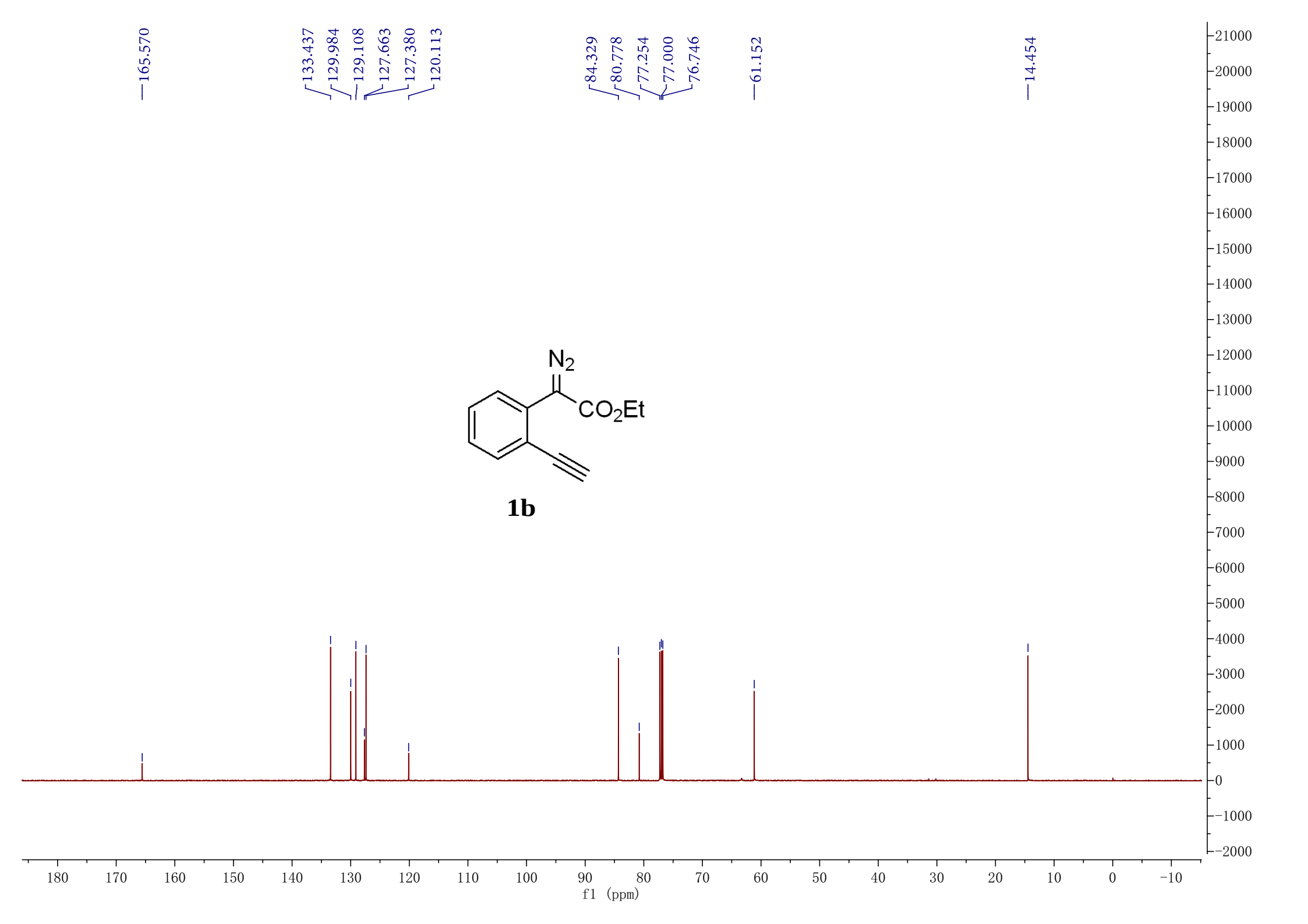
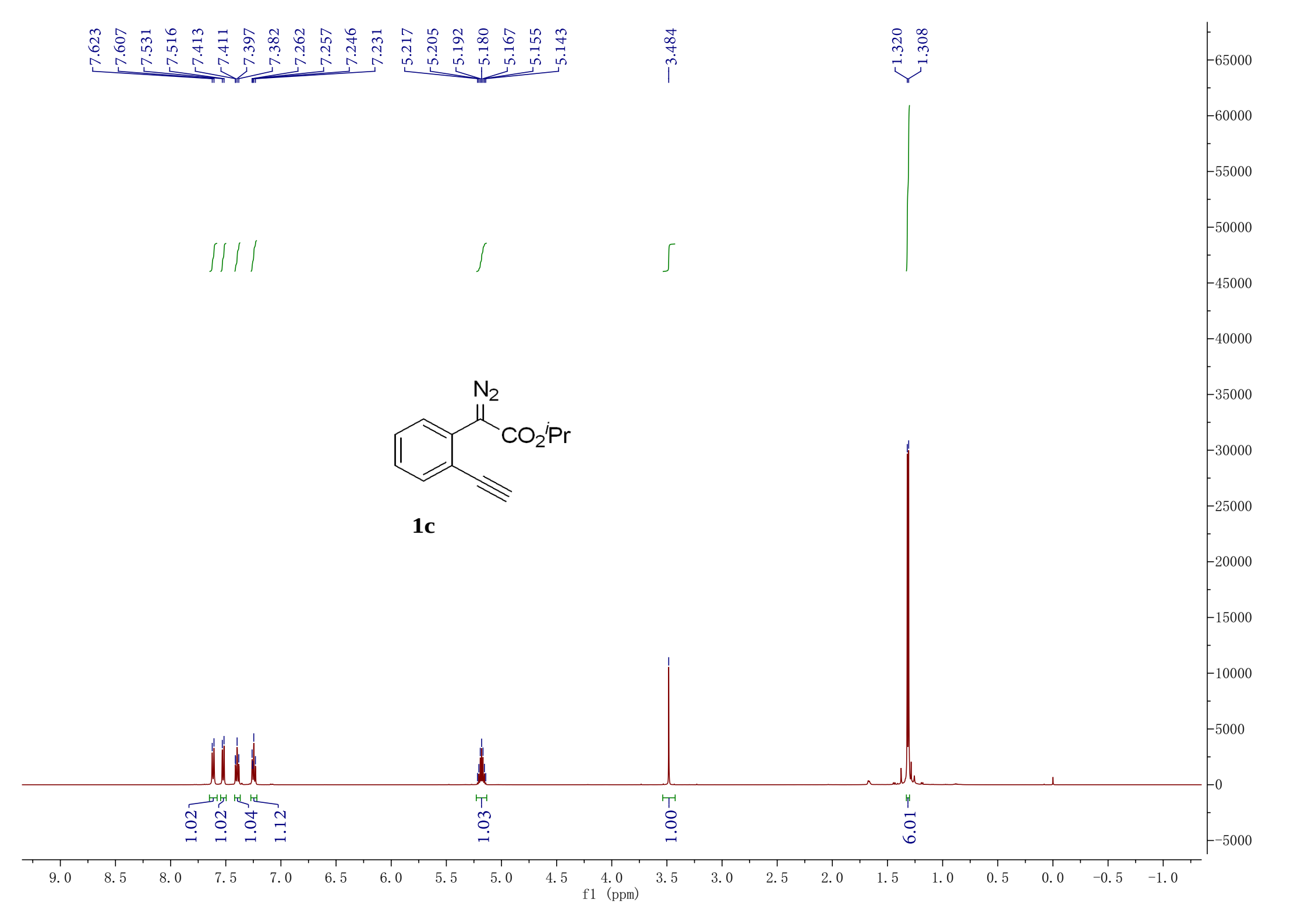
7.603
7.539
7.537
7.524
7.522
7.422
7.419
7.407
7.404
7.391
7.388
7.275
7.273
7.258
7.245
7.242
4.339
4.325
4.310
4.296
3.483
1.345
1.331
1.316
N2
CO2Et
1b
1.00
1.00
1.03
1.12
2.05
0.97
3.04
f1 (ppm)


165.570
133.437
129.984
129.108
127.663
127.380
120.113
84.329
80.778
77.254
77.000
76.746
61.152
14.454
N2
CO2Et
1b
f1 (ppm)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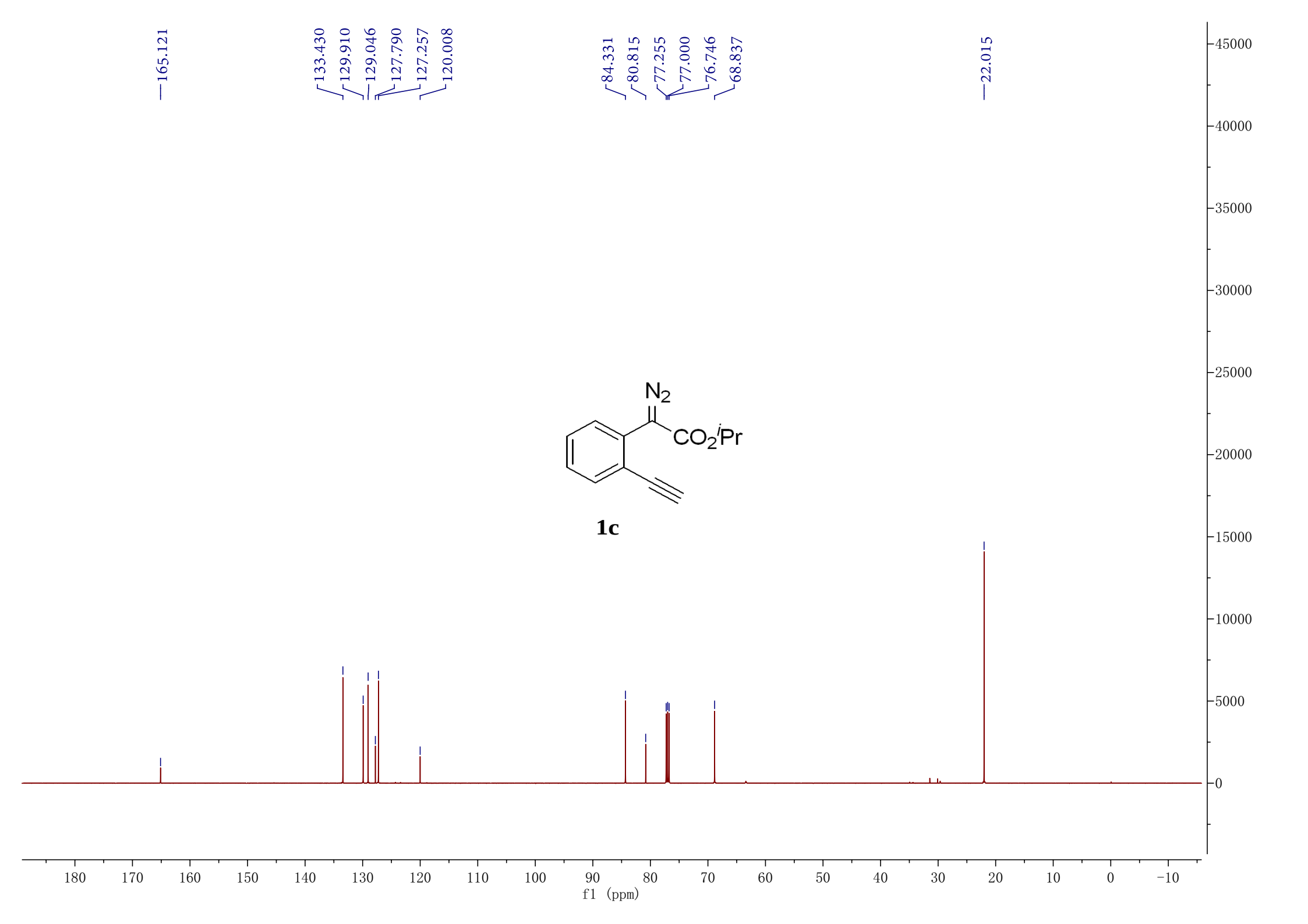
7.607
7.531
7.516
7.413
7.411
7.397
7.382
7.262
7.257
7.246
7.231
5.217
5.205
5.192
5.180
5.167
5.155
5.143
3.484
1.320
1.308
N2
CO2iPr
1c
1.02
1.02
1.04
1.12
1.03
1.00
6.01
f1 (ppm)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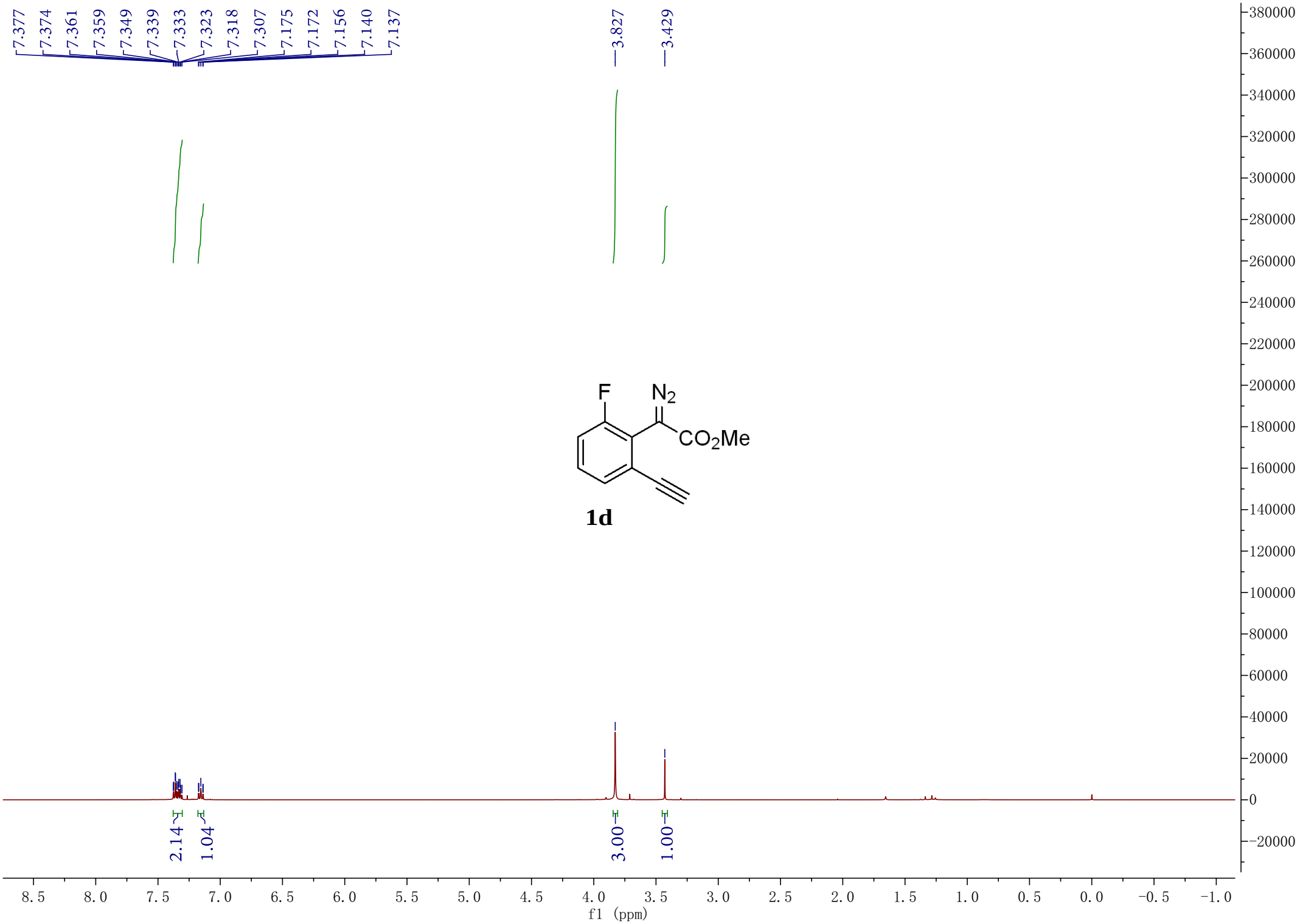
133.430
129.910
129.046
127.790
127.257
120.008
84.331
80.815
77.255
77.000
76.746
68.837
22.015
N2
CO2iPr
1c
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)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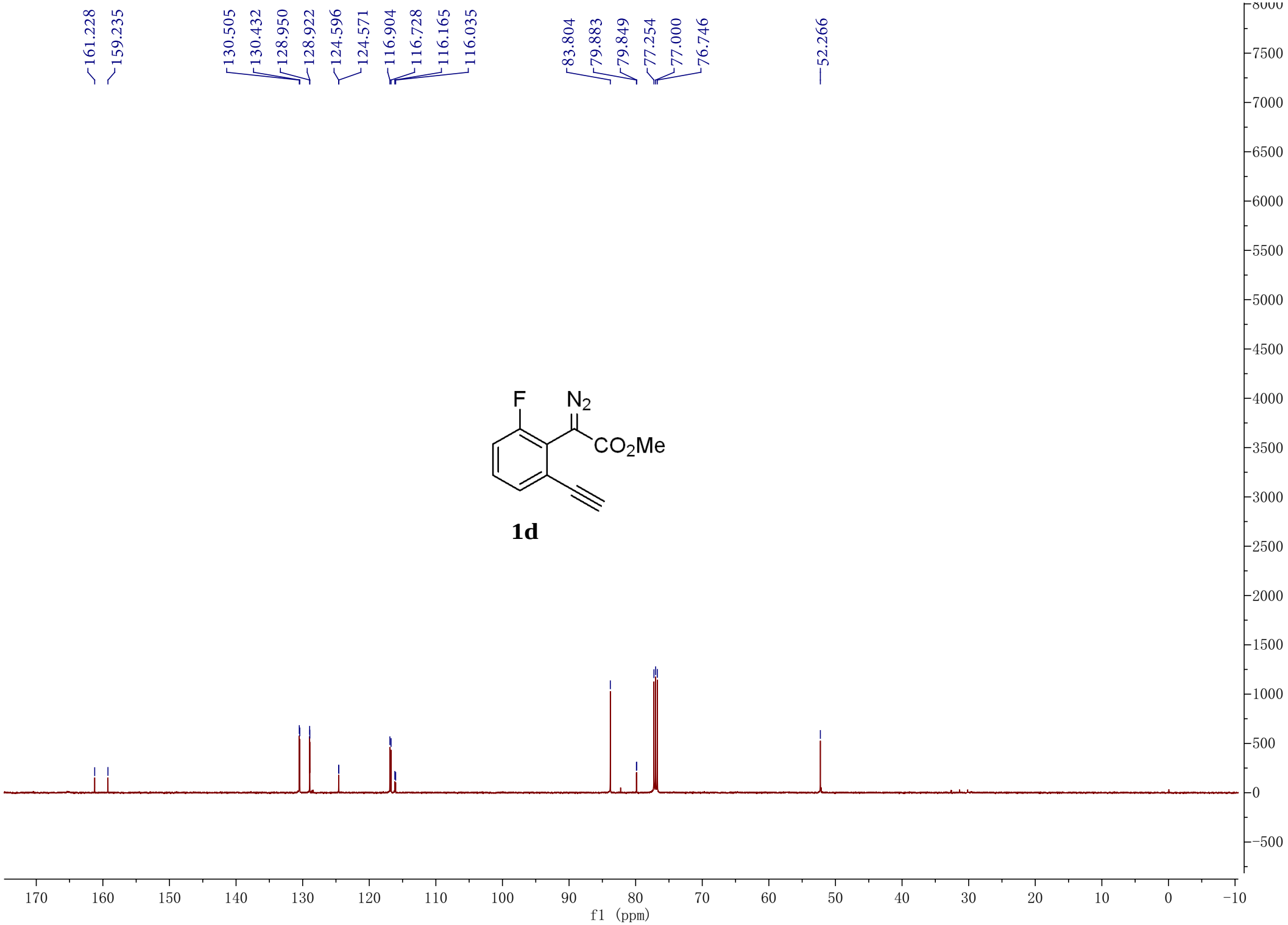
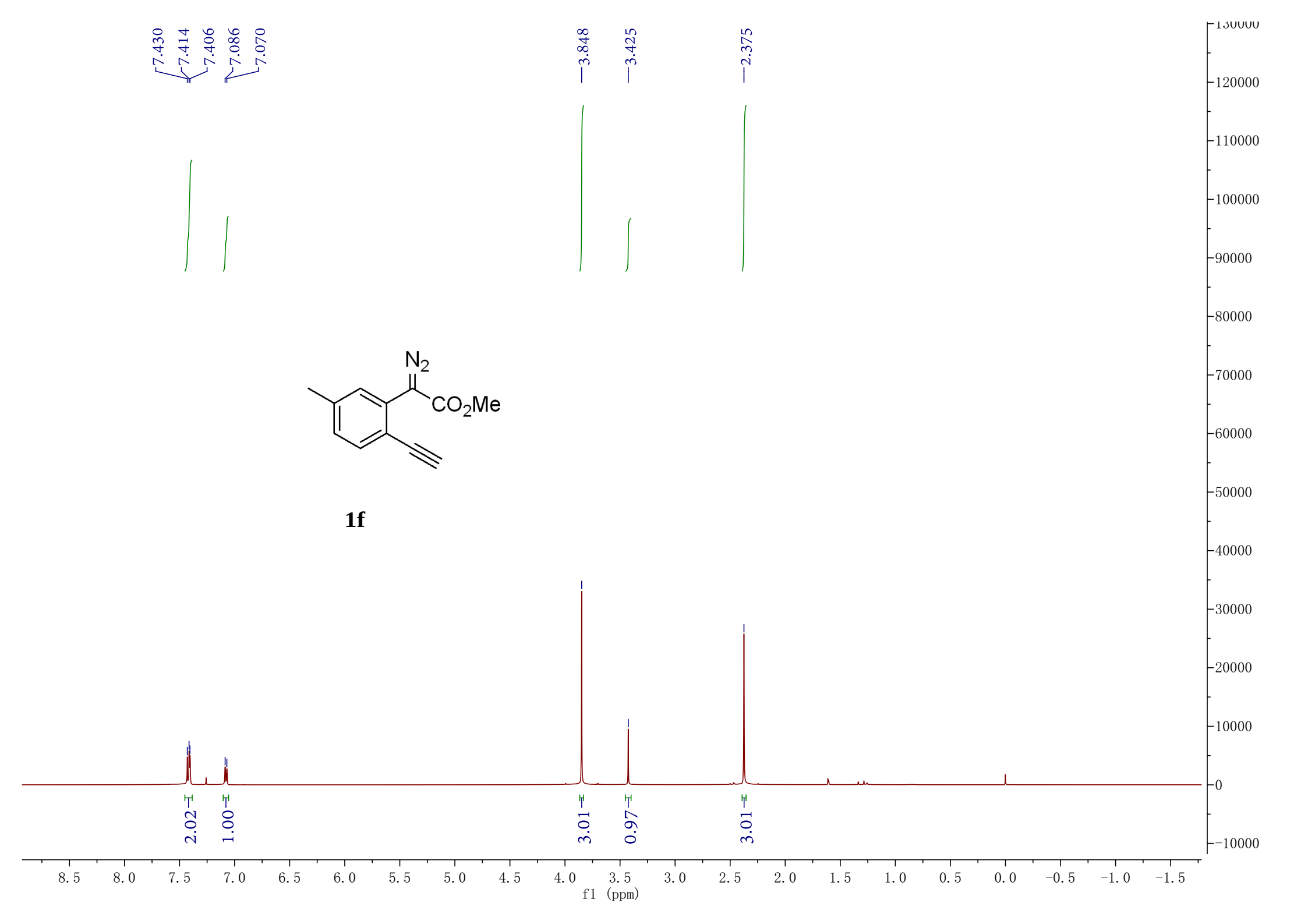
7.374
7.361
7.359
7.349
7.339
7.333
7.323
7.318
7.307
7.175
7.172
7.156
7.140
7.137
3.827
3.429
F
N2
CO2Me
2.14
1.04
3.00
1.00
f1 (ppm)

1d


161.228
159.235
130.505
130.432
128.950
128.922
124.596
124.571
116.904
116.728
116.165
116.035
83.804
79.883
79.849
77.254
77.000
76.746
52.266
F
N2
CO2Me
1d
f1 (ppm)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7.086
7.070
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2.375
N2
CO2Me
1f
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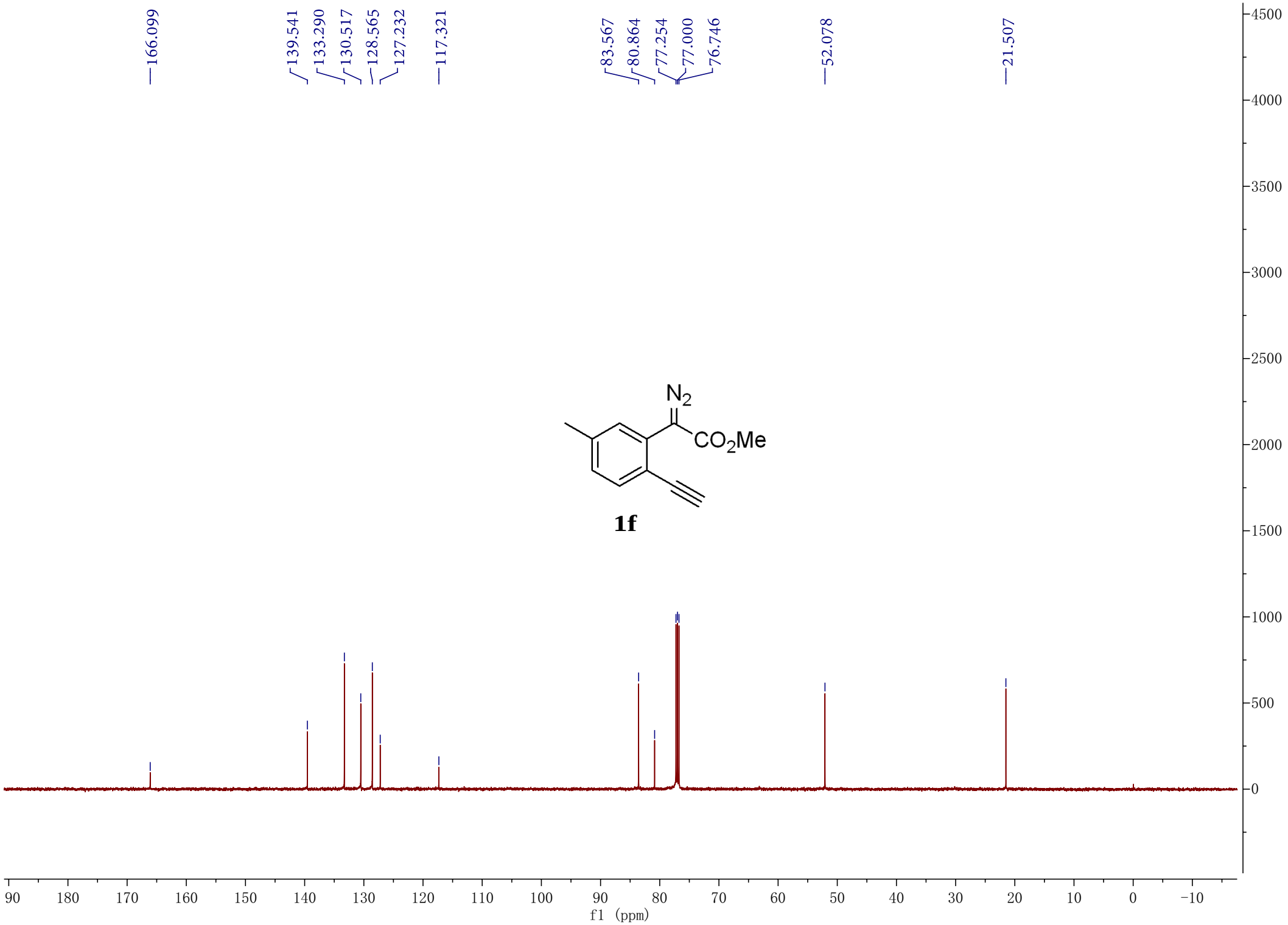
1.00
3.01
0.97
3.01
f1 (ppm)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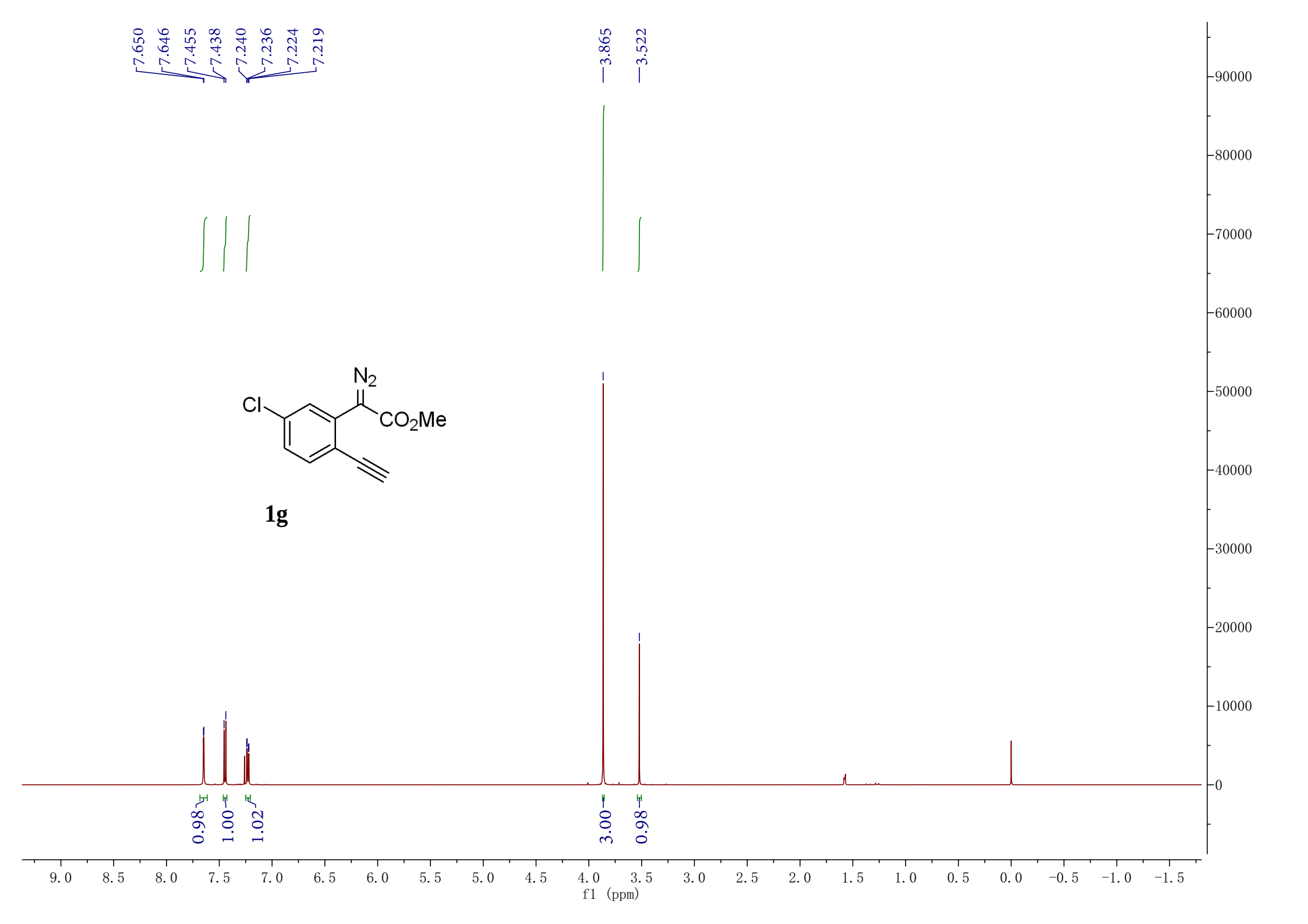
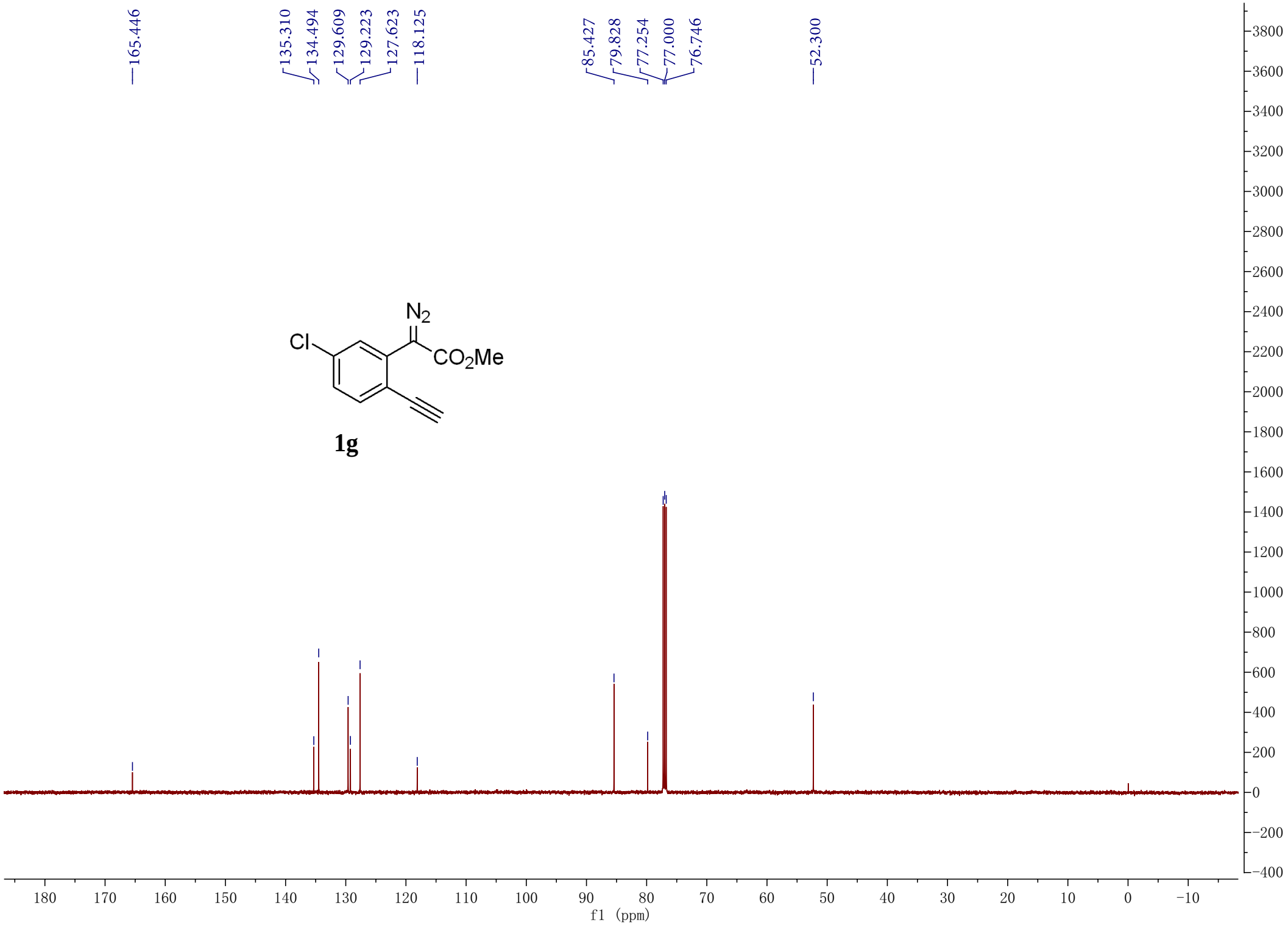
139.541
133.290
130.517
128.565
127.232
117.321
83.567
80.864
77.254
77.000
76.746
52.078
21.507
N2
CO2Me
1f
4500
4000
3500
3000
2500
2000
1500
1000
500
0
90
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


7.650
7.646
7.455
7.438
7.240
7.236
7.224
7.219
3.865
3.522
N2
Cl
CO2Me
1g
0.98
1.00
1.02
3.00
0.98
f1 (ppm)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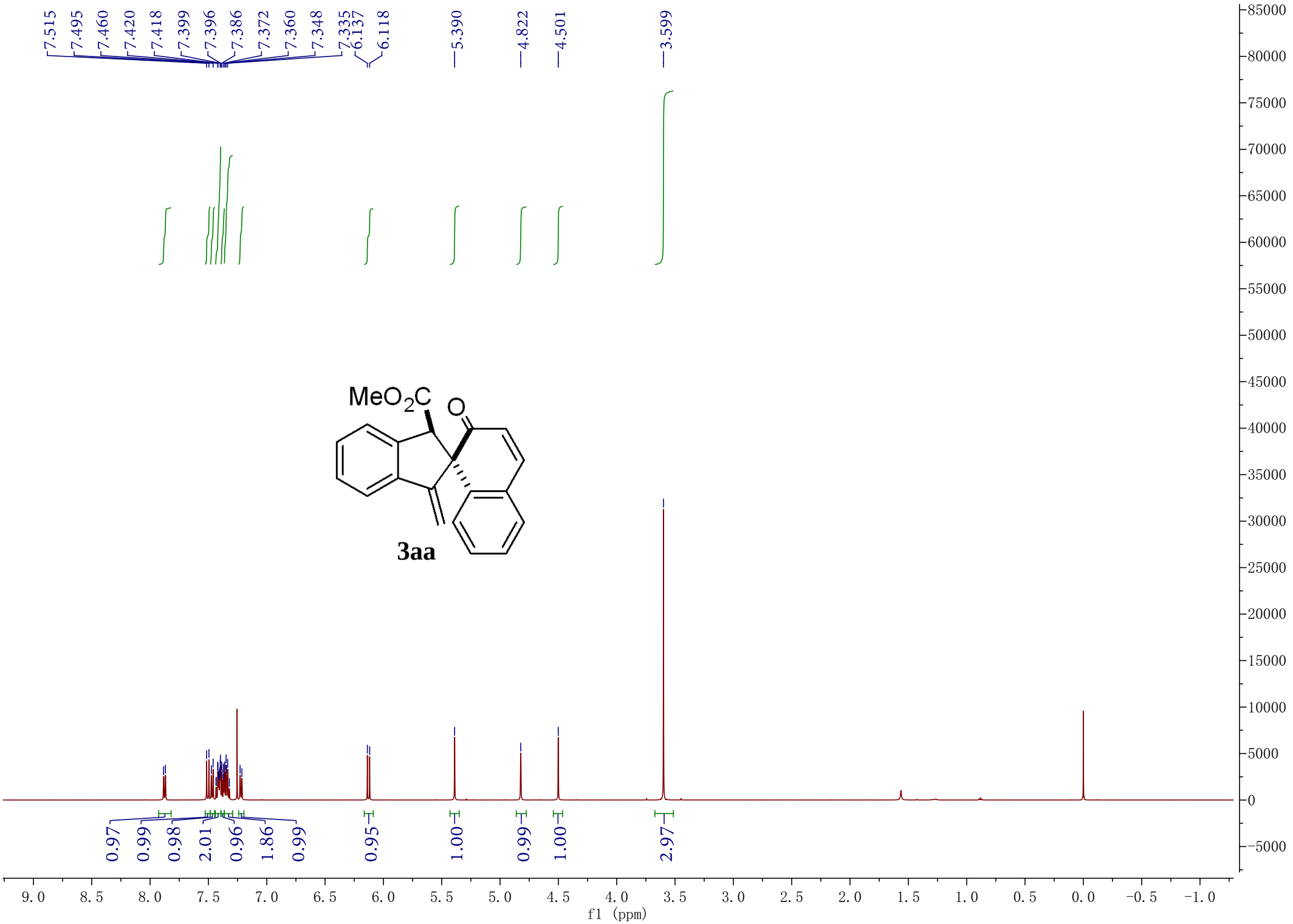
52.300
N2
Cl
CO2Me
1g
f1 (ppm)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7.495
7.460
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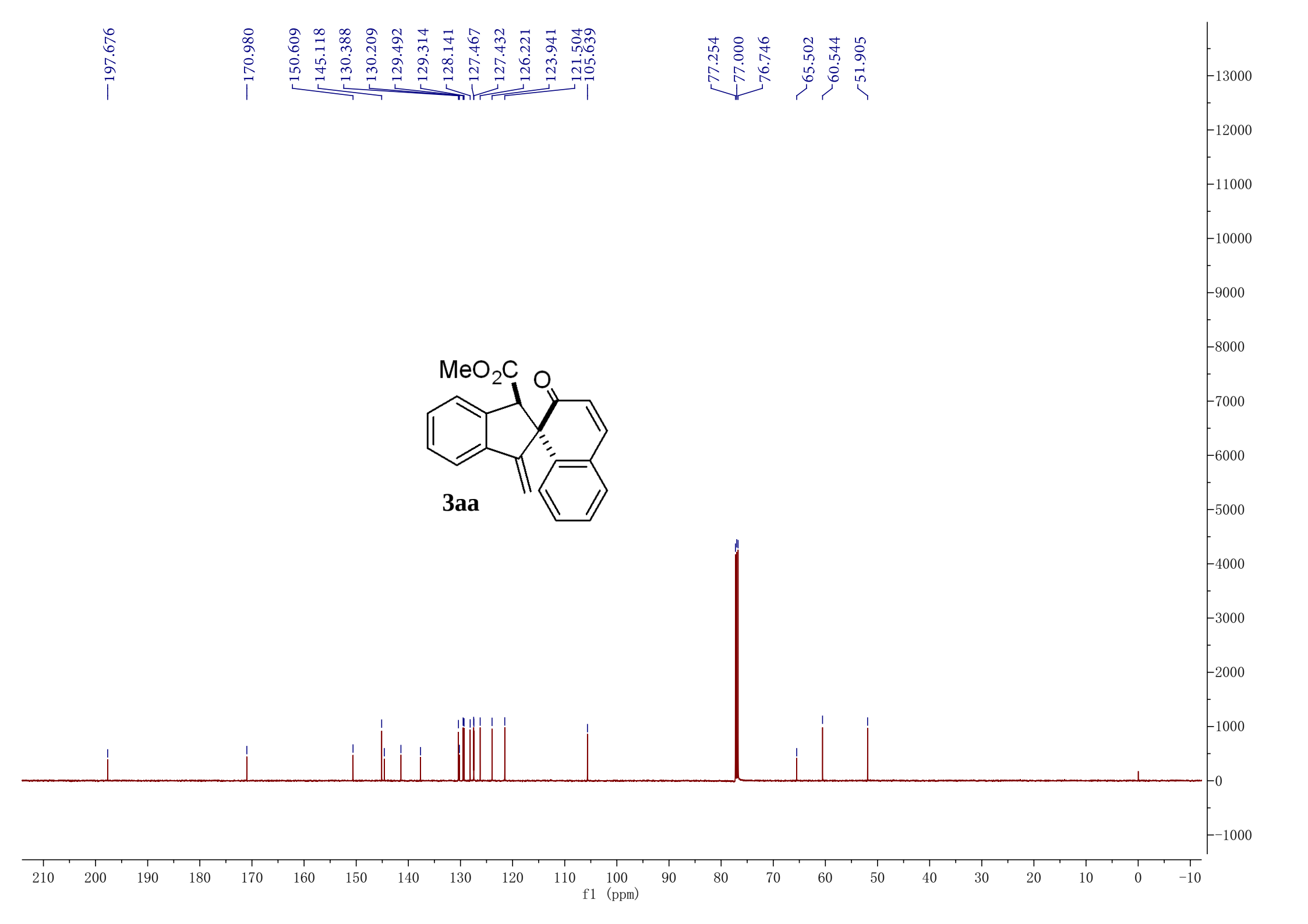
7.418
7.399
7.396
7.386
7.372
7.360
7.348
7.335
6.137
6.118
5.390
4.822
4.501
3.599
MeO2C
O
3aa
0.97
0.99
0.98
2.01
0.96
1.86
0.99
0.95
1.00
0.99
1.00
2.97
f1 (ppm)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130.209
129.492
129.314
128.141
127.467
127.432
126.221
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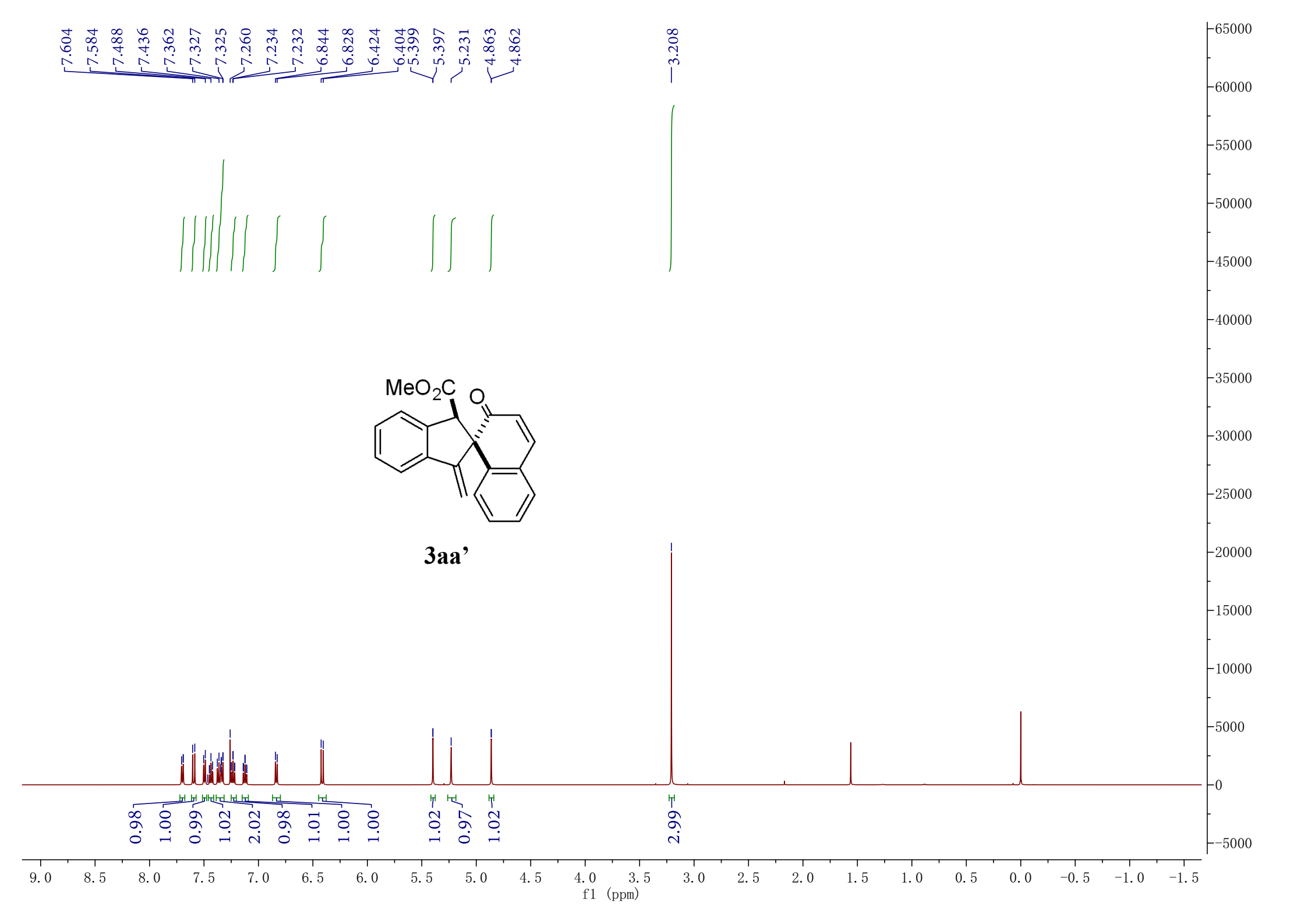
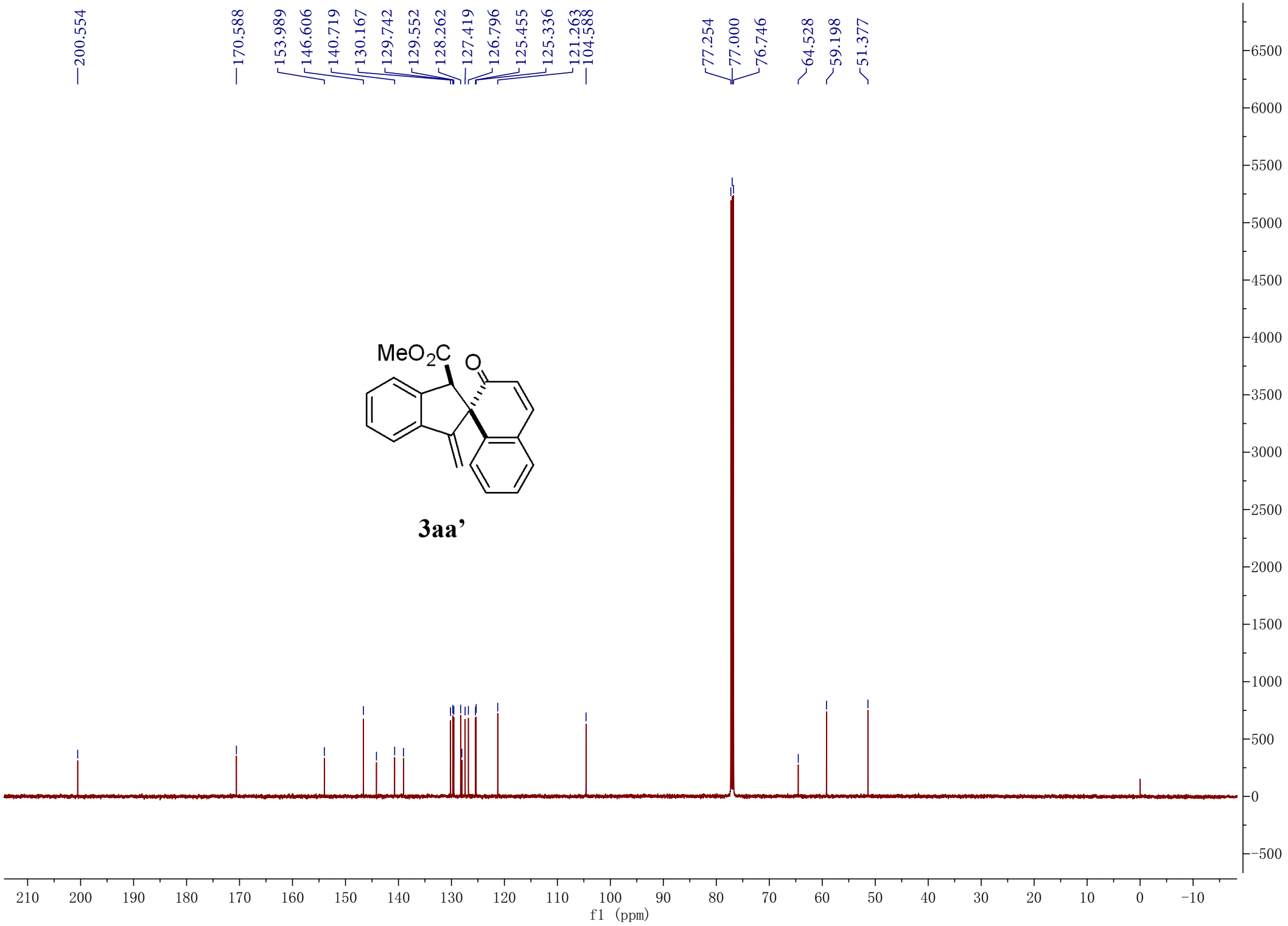
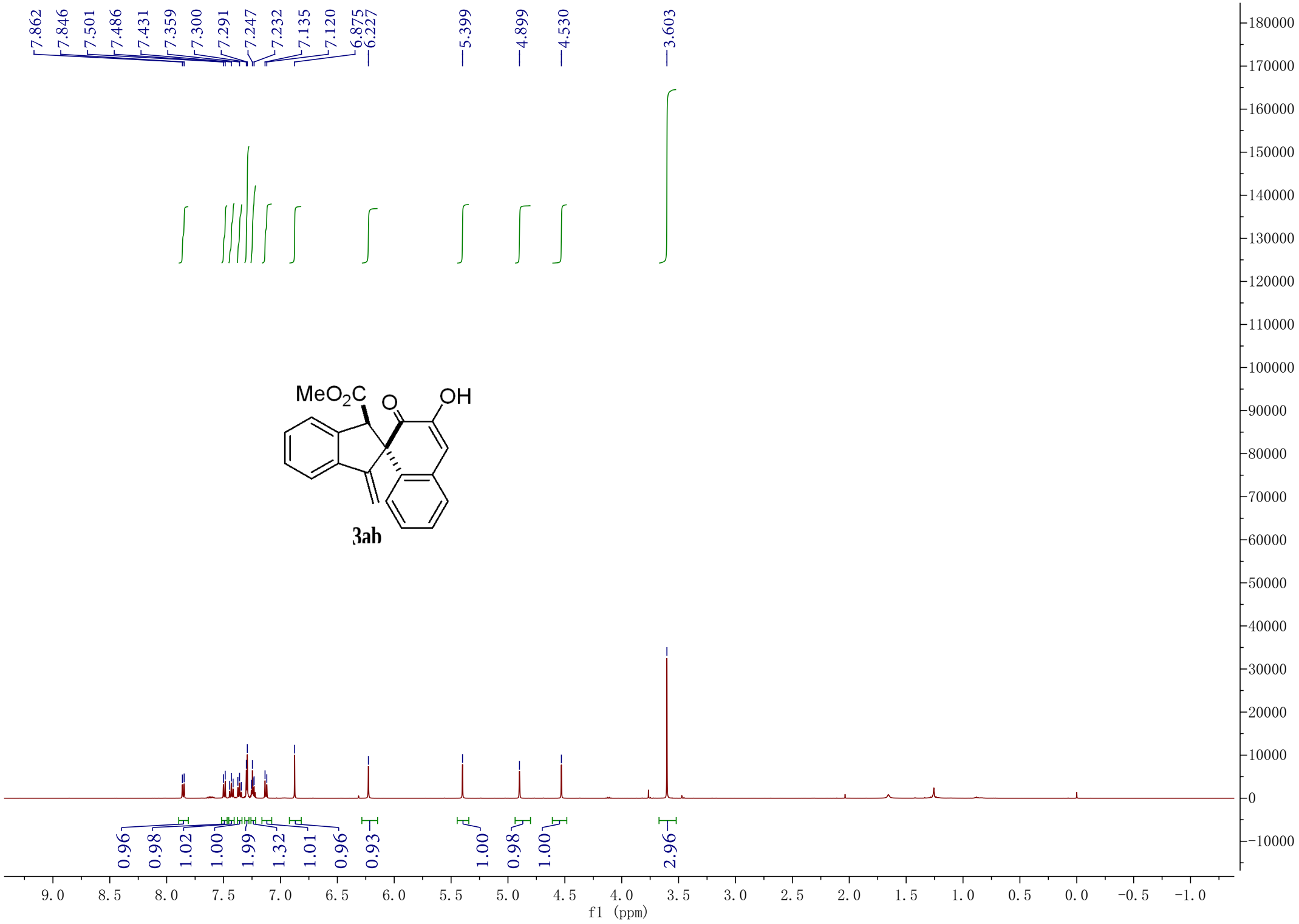
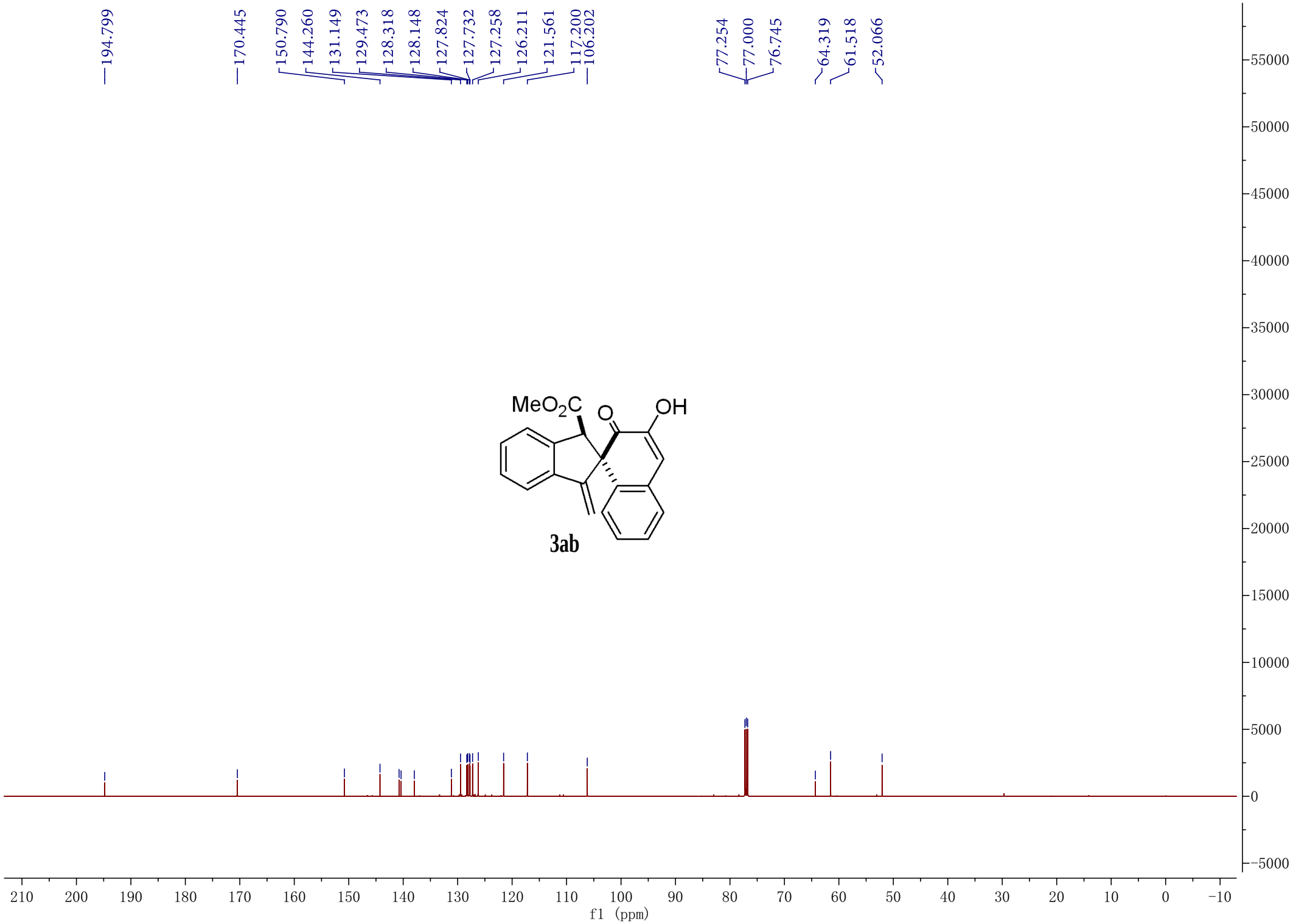
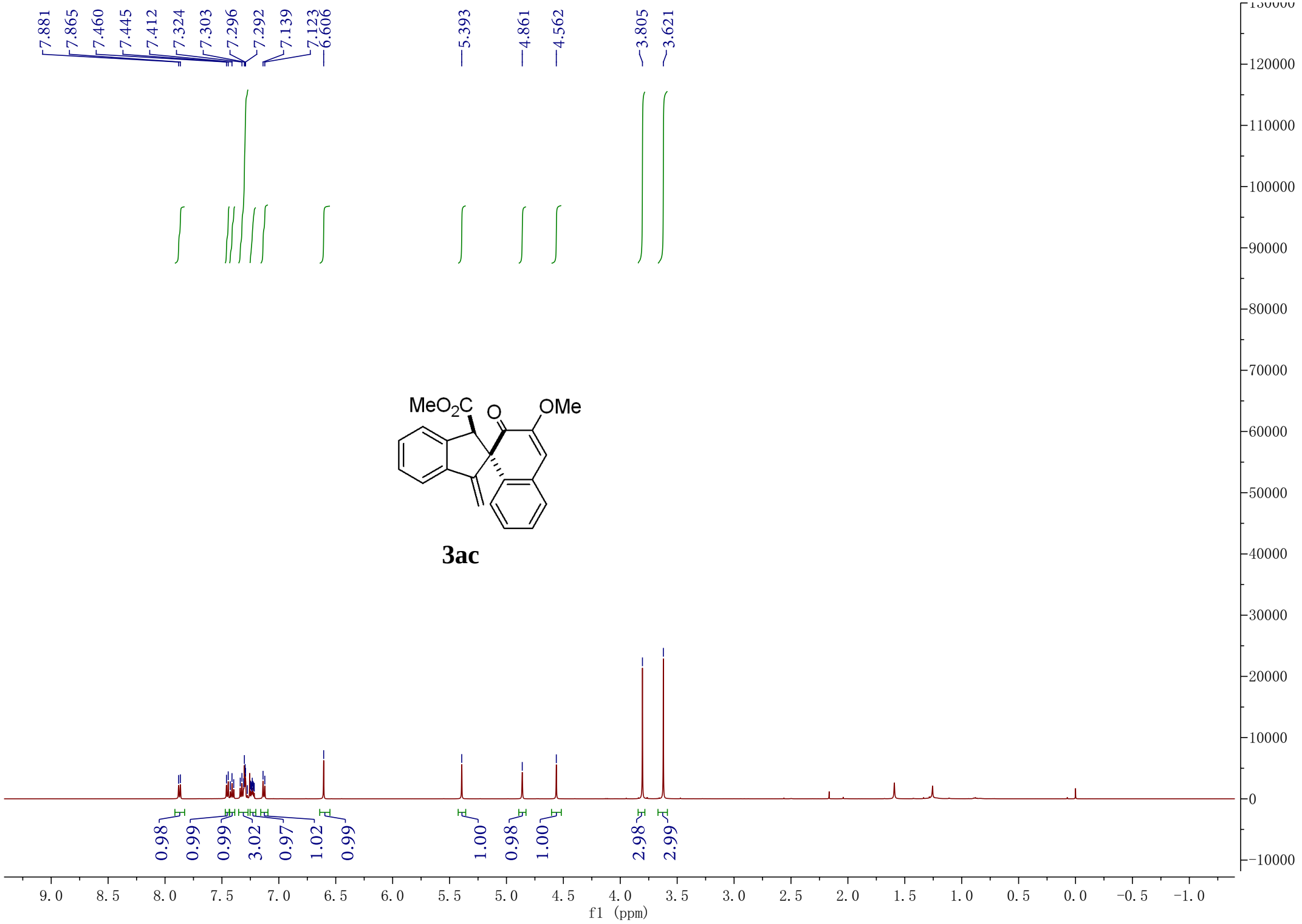
121.504
105.639
77.254
77.000
76.746
65.502
60.544
51.905
MeO2C
O
3aa
f1 (ppm)


7.604
7.584
7.488
7.436
7.362
7.327
7.325
7.260
7.234
7.232
6.844
6.828
6.424
6.404
5.399
5.397
5.231
4.863
4.862
3.208
MeO2C
O
3aa'
0.98
1.00
0.99
1.02
2.02
0.98
1.01
1.00
1.00
1.02
0.97
1.02
2.99
f1 (ppm)

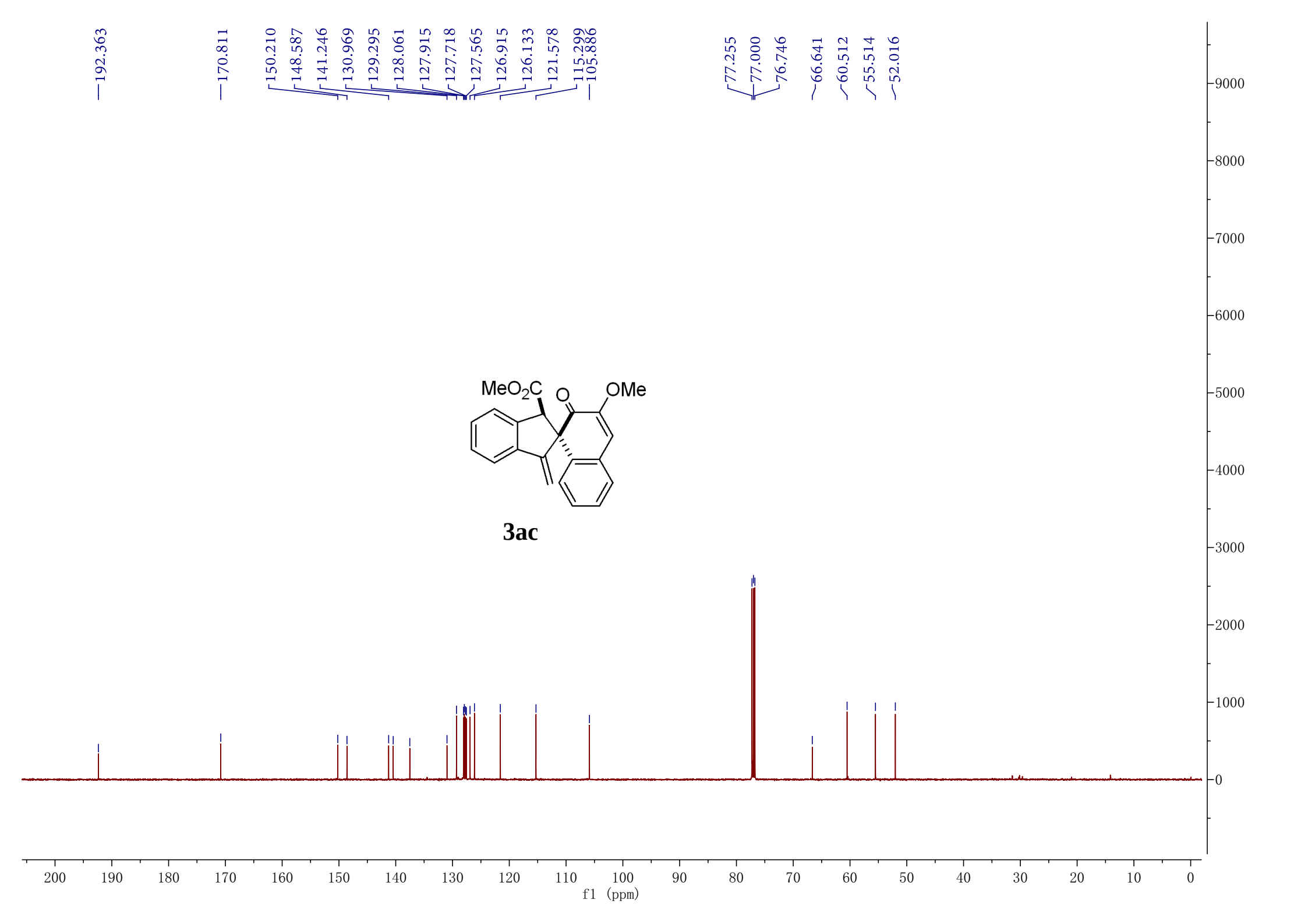

200.554
170.588
153.989
146.606
140.719
130.167
129.742
129.552
128.262
127.419
126.796
125.455
125.336
121.263
104.588
77.254
77.000
76.746
64.528
59.198
51.377
MeO2C
O
3aa'
f1 (ppm)

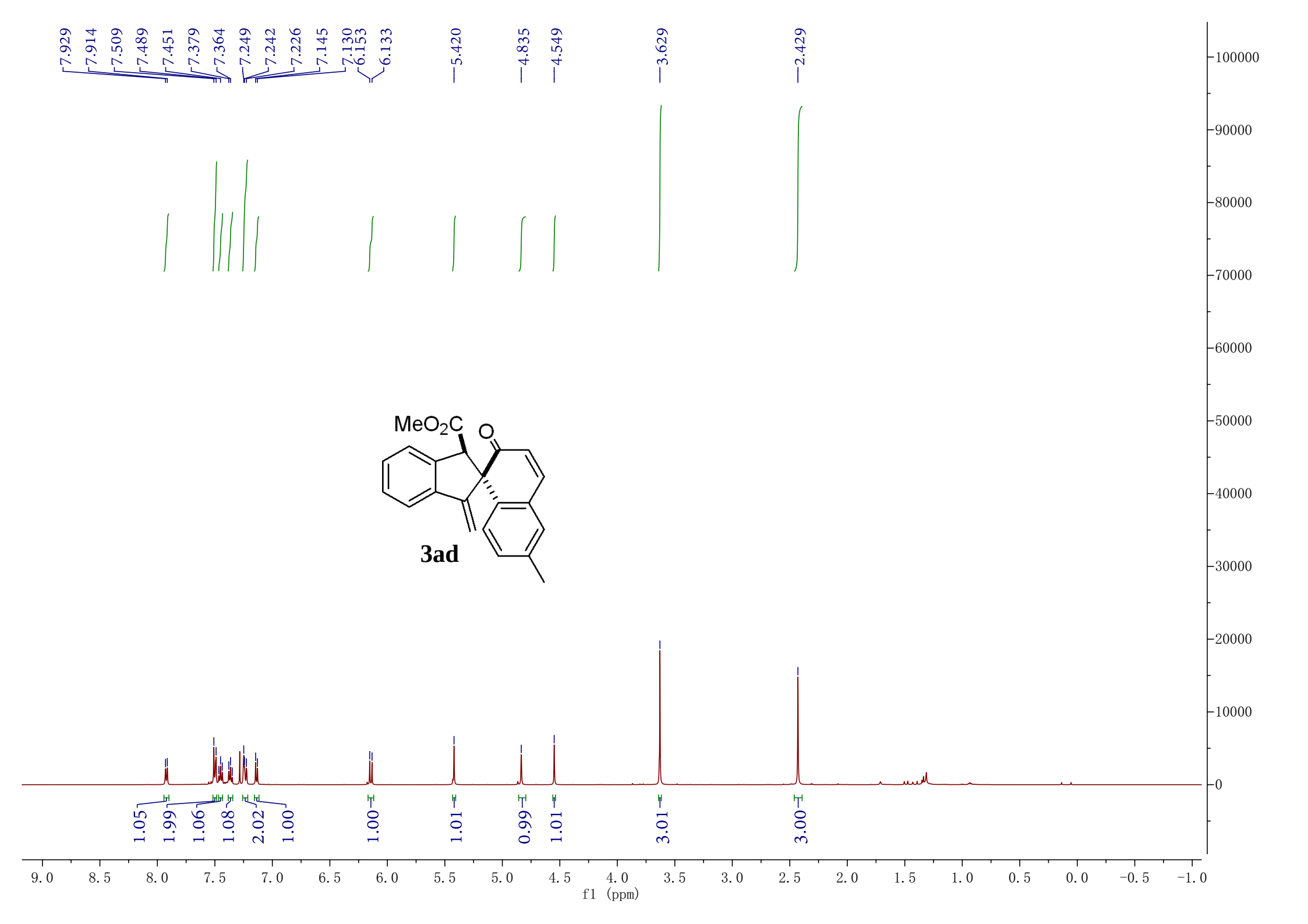

7.862
7.846
7.501
7.486
7.431
7.359
7.300
7.291
7.247
7.232
7.135
7.120
6.875
6.227
5.399
4.899
4.530
3.603
MeO2C
O
OH
3ab
0.96
0.98
1.02
1.00
1.99
1.32
1.01
0.96
0.93
1.00
0.98
1.00
2.96
f1 (ppm)

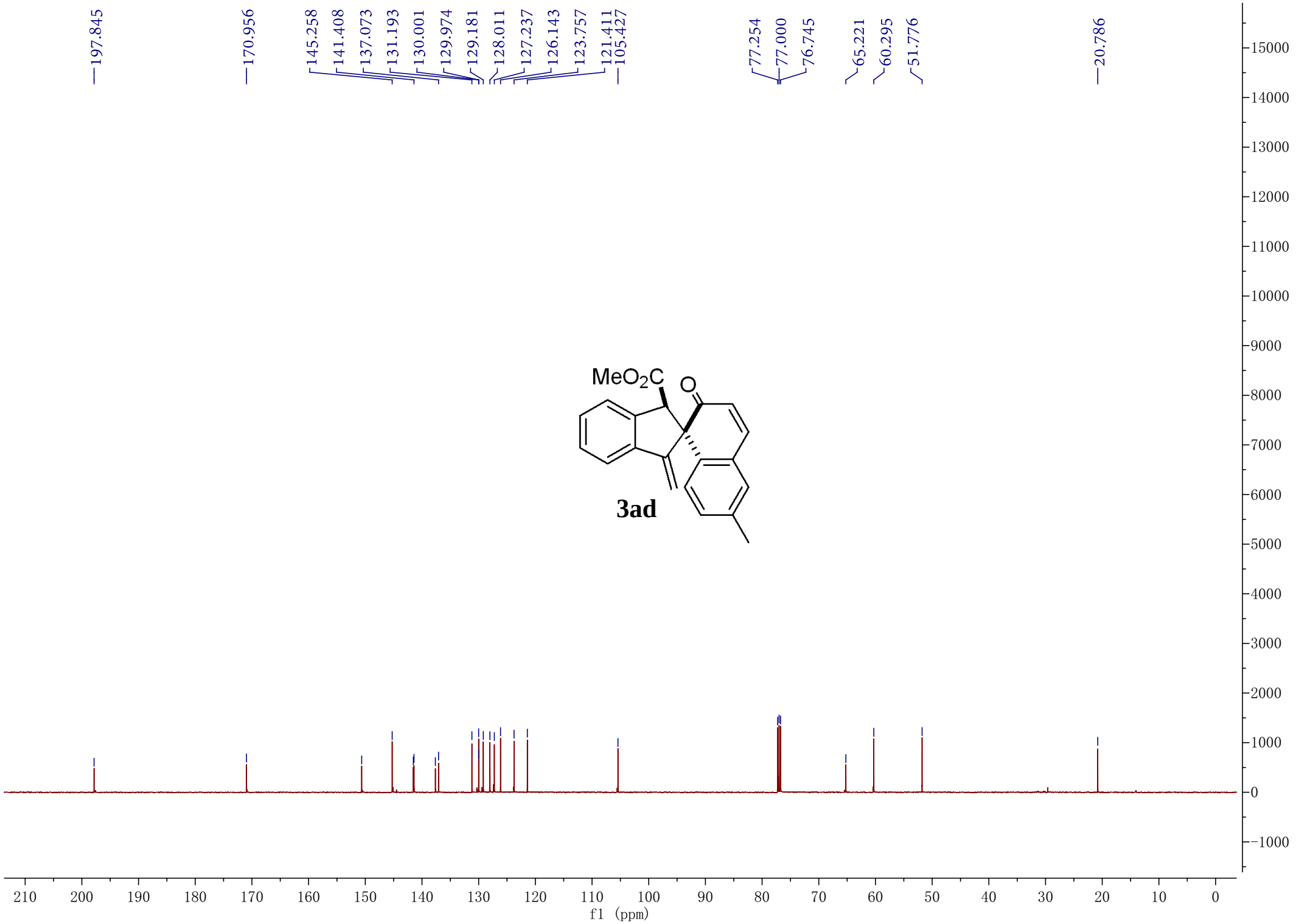

194.799
170.445
150.790
144.260
131.149
129.473
128.318
128.148
127.824
127.732
127.258
126.211
121.561
117.200
106.202
77.254
77.000
76.745
64.319
61.518
52.066
MeO2C
O
OH
3ab
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

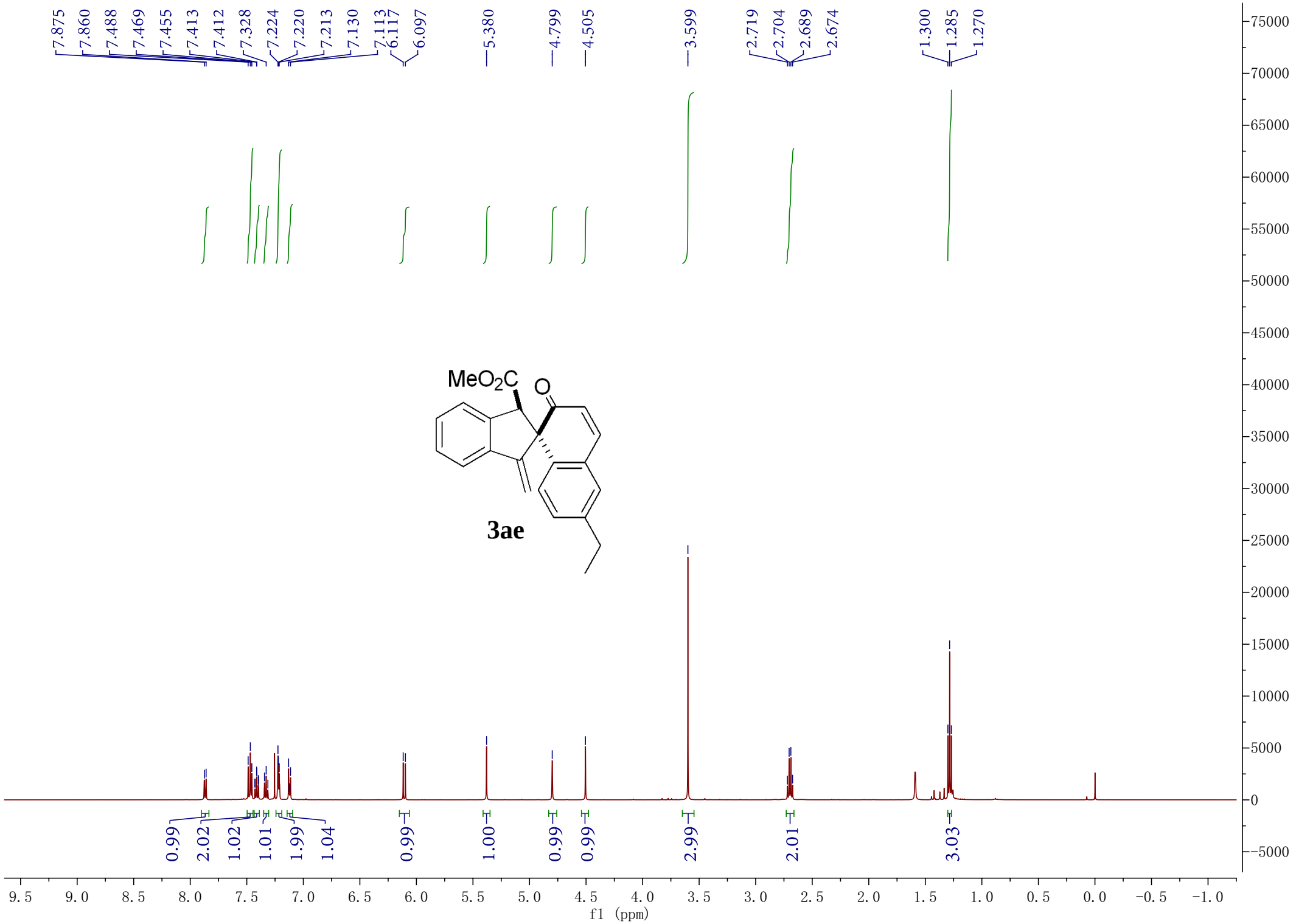

7.881
7.865
7.460
7.445
7.412
7.324
7.303
7.296
7.292
7.139
7.123
6.606
5.393
4.861
4.562
3.805
3.621
MeO2C
O
OMe
0.98
0.99
0.99
3.02
0.97
1.02
0.99
1.00
0.98
1.00
2.98
2.99
f1 (ppm)

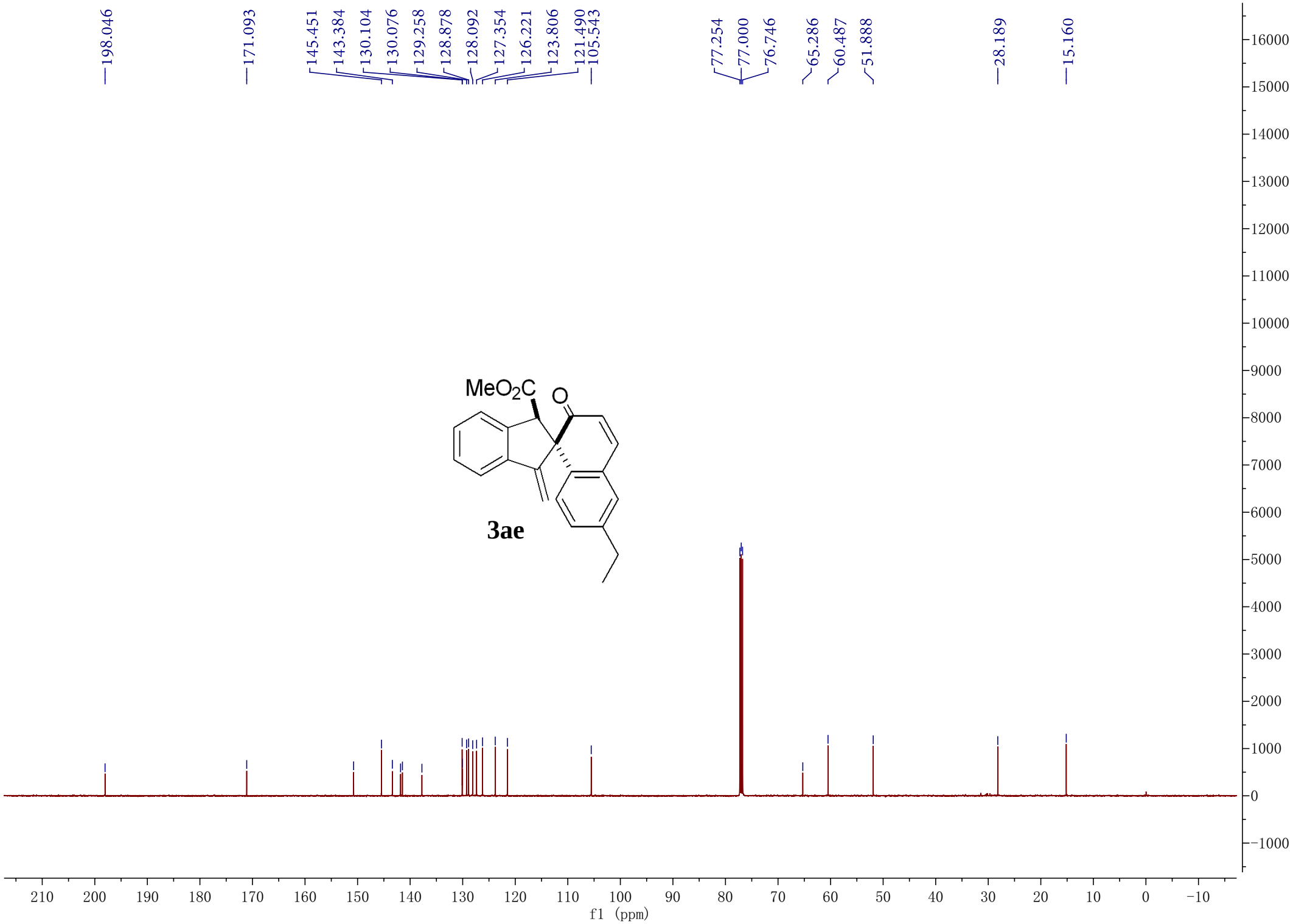
3ac

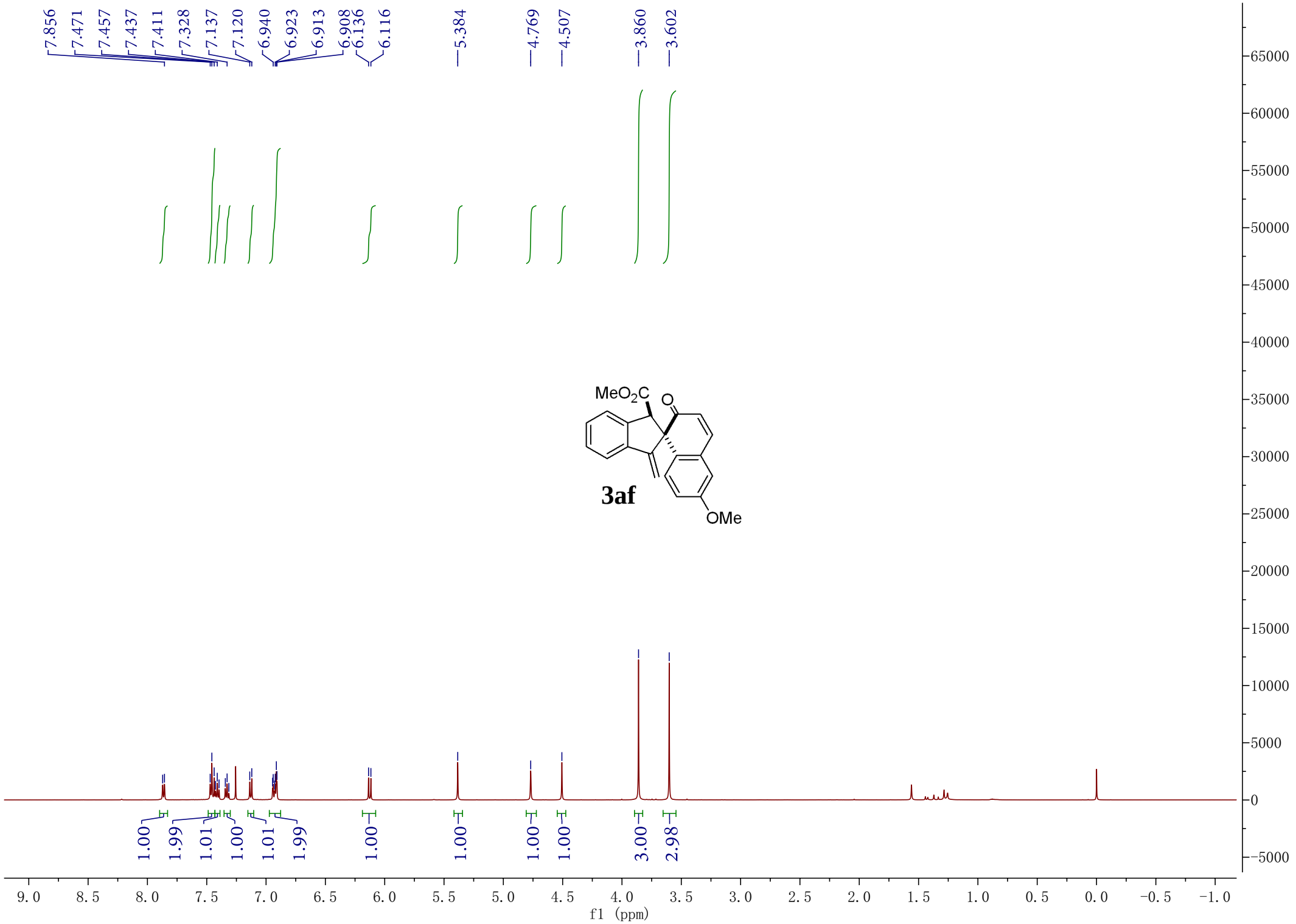

192.363
170.811
150.210
148.587
141.246
130.969
129.295
128.061
127.915
127.718
127.565
126.915
126.133
121.578
115.299
105.886
77.255
77.000
76.746
66.641
60.512
55.514
52.016
MeO2C
O
OMe
3ac
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

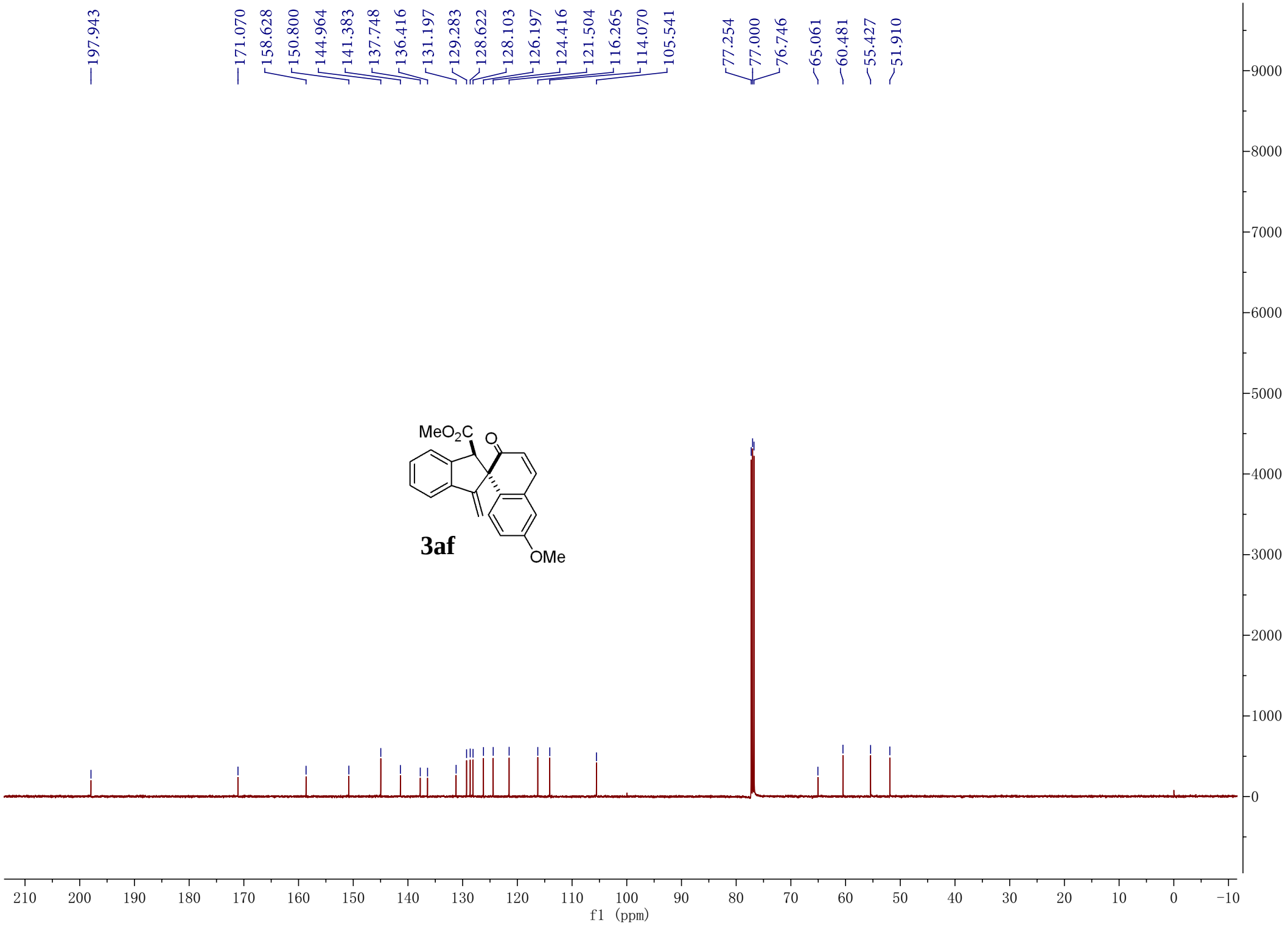

7.929
7.914
7.509
7.489
7.451
7.379
7.364
7.249
7.242
7.226
7.145
7.130
6.153
6.133
5.420
4.835
4.549
3.629
2.429
MeO2C
O
3ad
1.05
1.99
1.06
1.08
2.02
1.00
1.00
1.01
0.99
1.01
3.01
3.00
f1 (ppm)

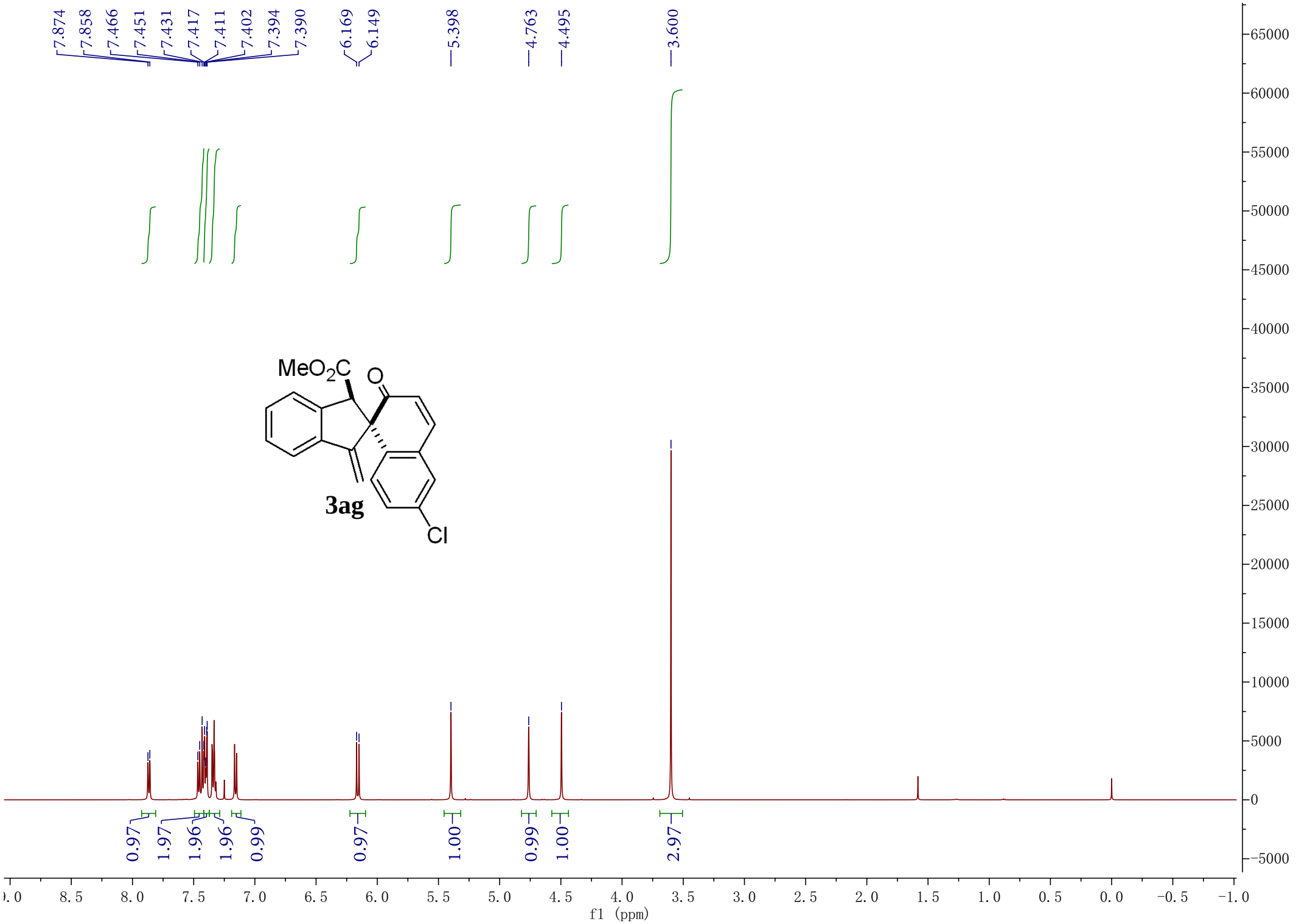

197.845
170.956
145.258
141.408
137.073
131.193
130.001
129.974
129.181
128.011
127.237
126.143
123.757
121.411
105.427
77.254
77.000
76.745
65.221
60.295
51.776
20.786
MeO2C
O
3ad
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

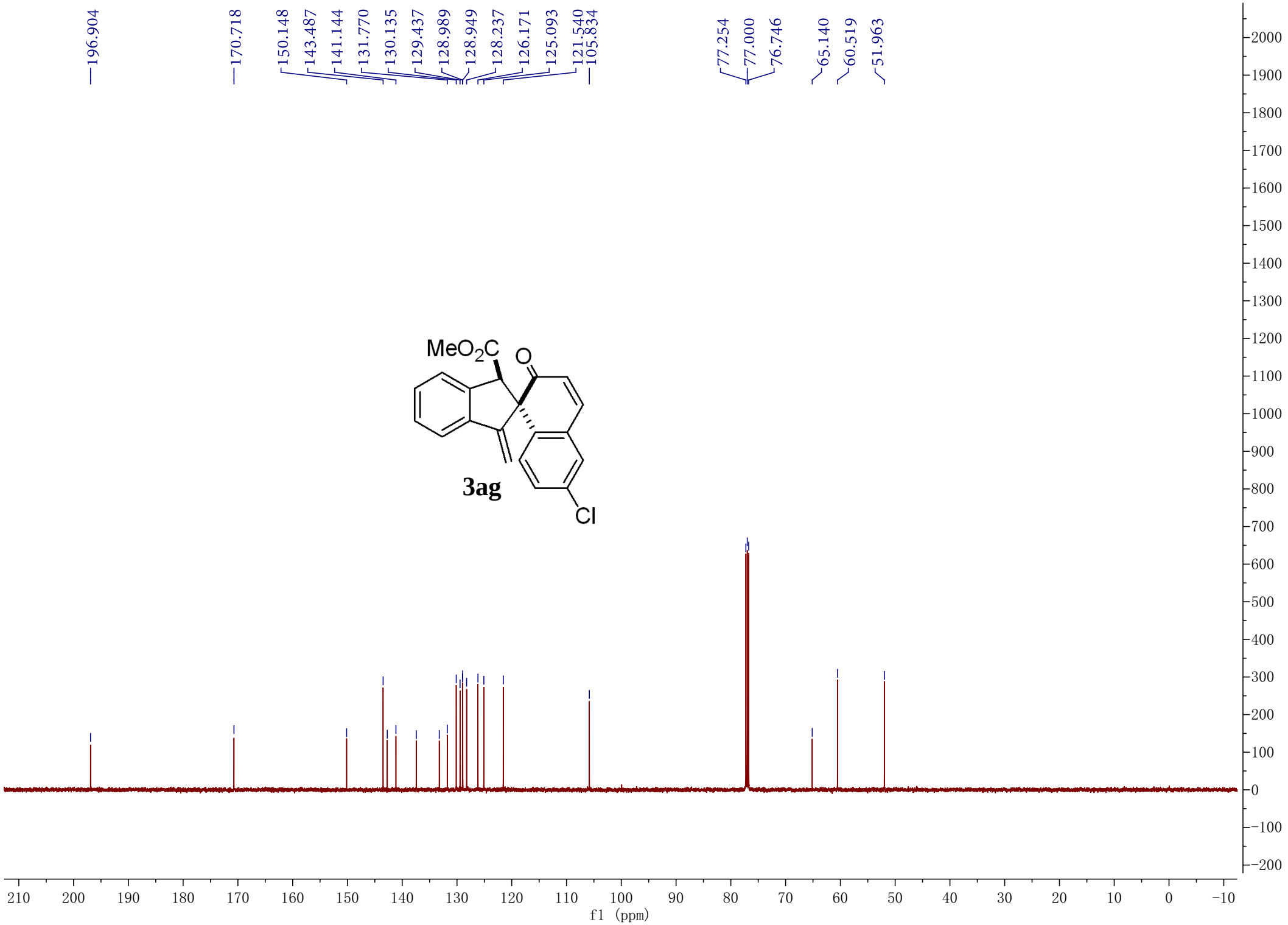

7.875
7.860
7.488
7.469
7.455
7.413
7.412
7.328
7.224
7.220
7.213
7.130
7.113
6.117
6.097
5.380
4.799
4.505
3.599
2.719
2.704
2.689
2.674
1.300
1.285
1.270
MeO2C
O
3ae
0.99
2.02
1.02
1.01
1.99
1.04
0.99
1.00
0.99
0.99
2.99
2.01
3.03
f1 (ppm)

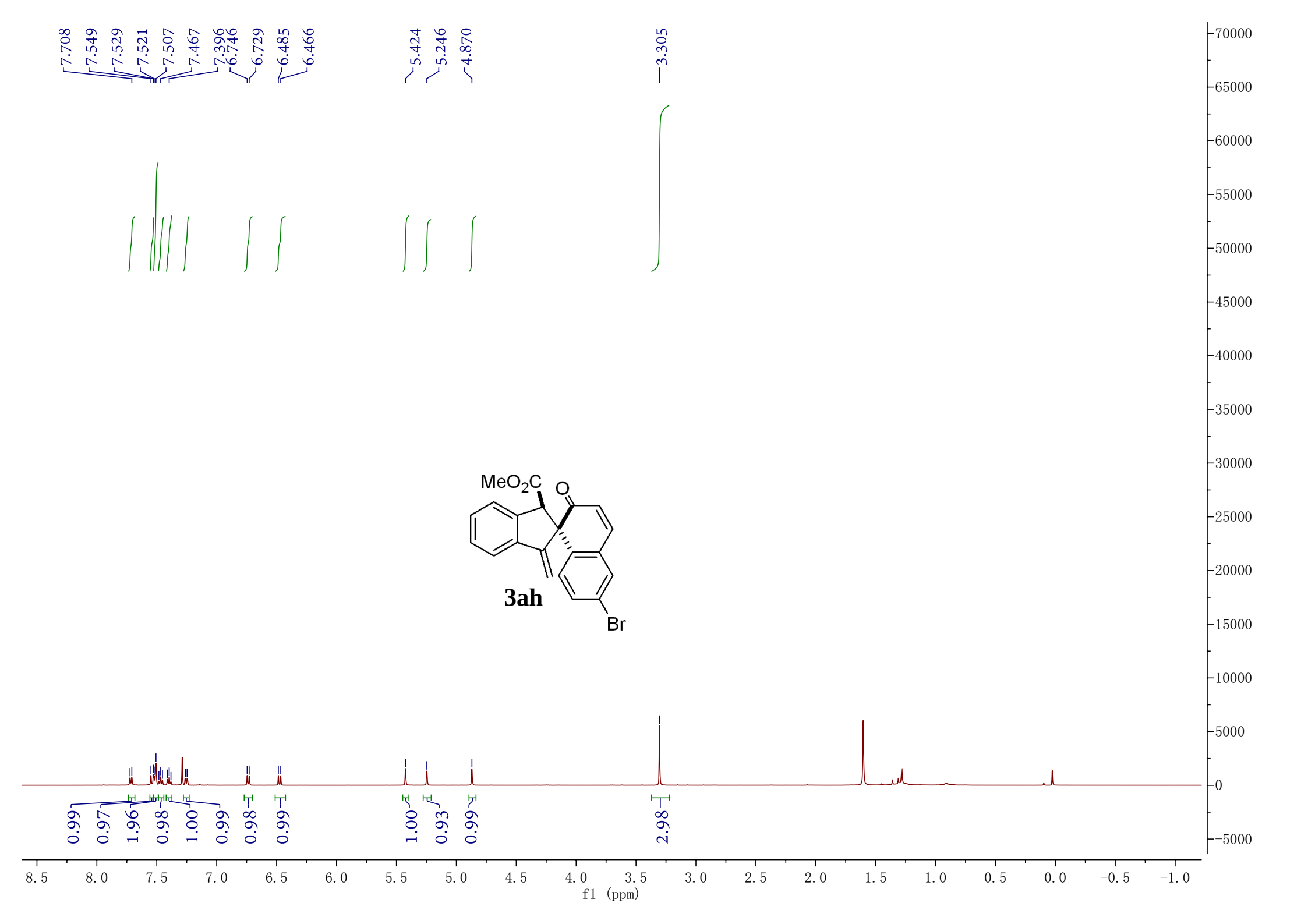

198.046
171.093
145.451
143.384
130.104
130.076
129.258
128.878
128.092
127.354
126.221
123.806
121.490
105.543
77.254
77.000
76.746
65.286
60.487
51.888
28.189
15.160
MeO2C
O
3ae
f1 (ppm)

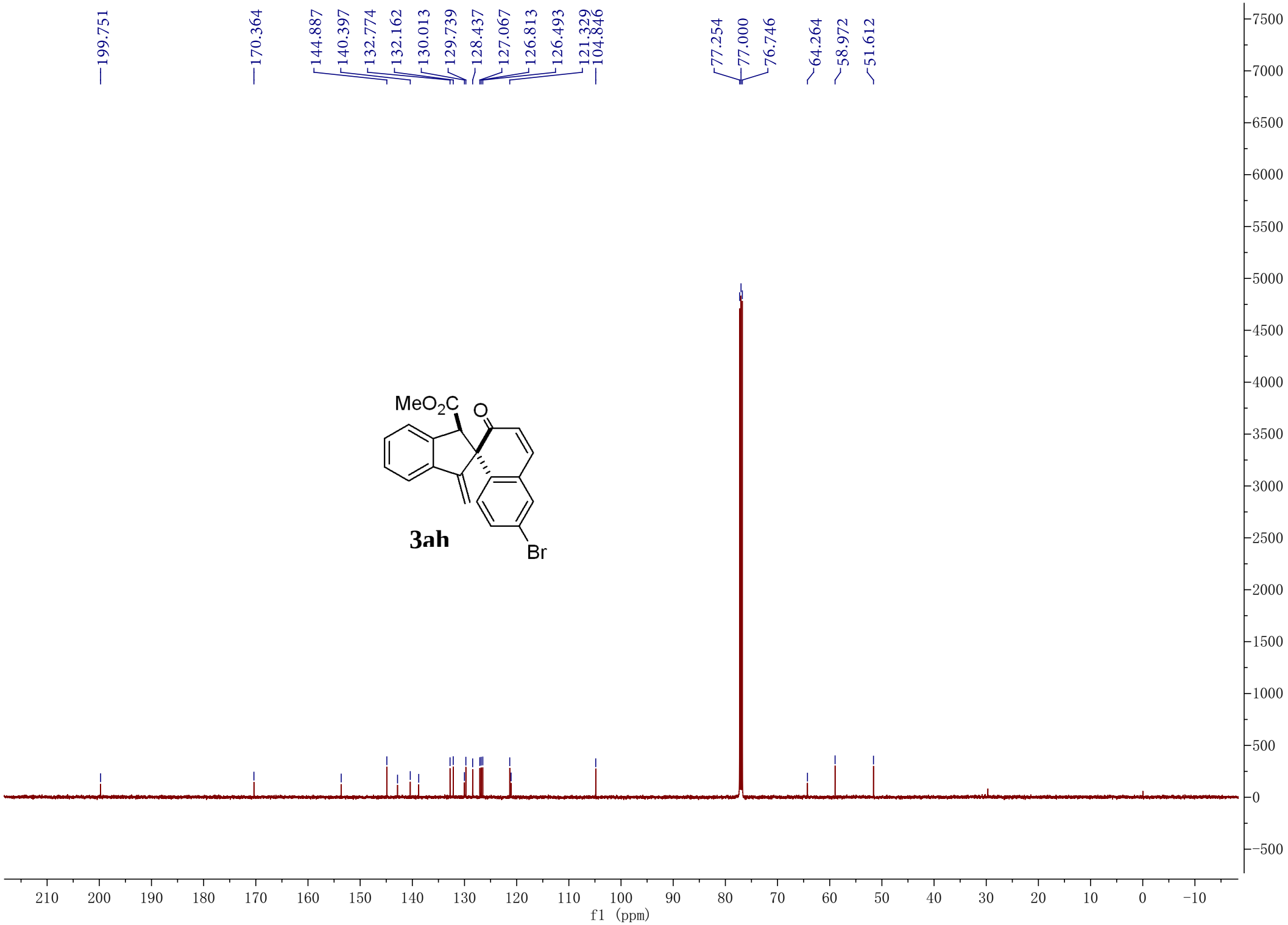

7.856
7.471
7.457
7.437
7.411
7.328
7.137
7.120
6.940
6.923
6.913
6.908
6.136
6.116
5.384
4.769
4.507
3.860
3.602
MeO2C
O
OMe
3af
1.00
1.99
1.01
1.00
1.01
1.99
1.00
1.00
1.00
1.00
3.00
2.98
f1 (ppm)

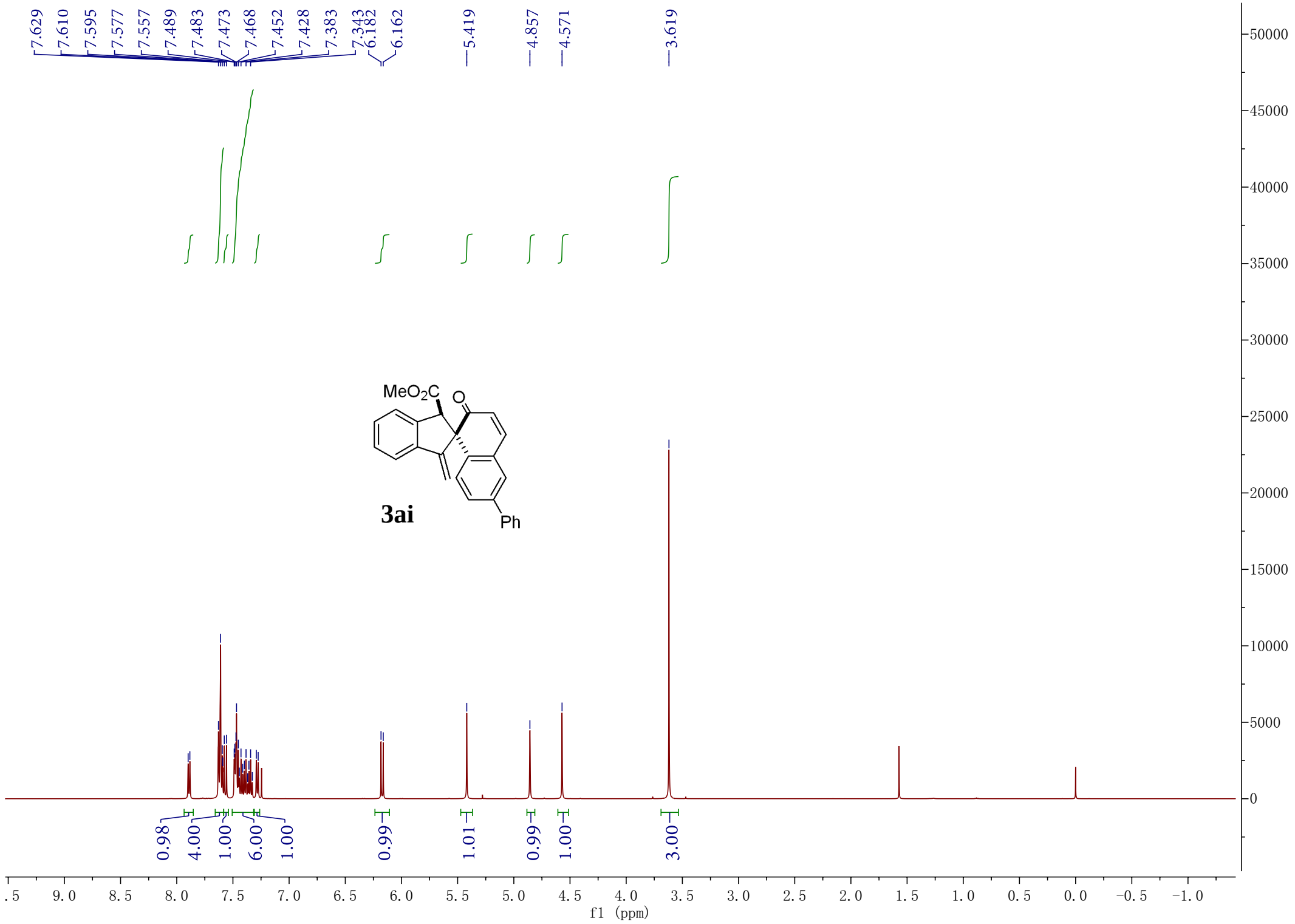

197.943
171.070
158.628
150.800
144.964
141.383
137.748
136.416
131.197
129.283
128.622
128.103
126.197
124.416
121.504
116.265
114.070
105.541
77.254
77.000
76.746
65.061
60.481
55.427
51.910
MeO2C
O
OMe
3af
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

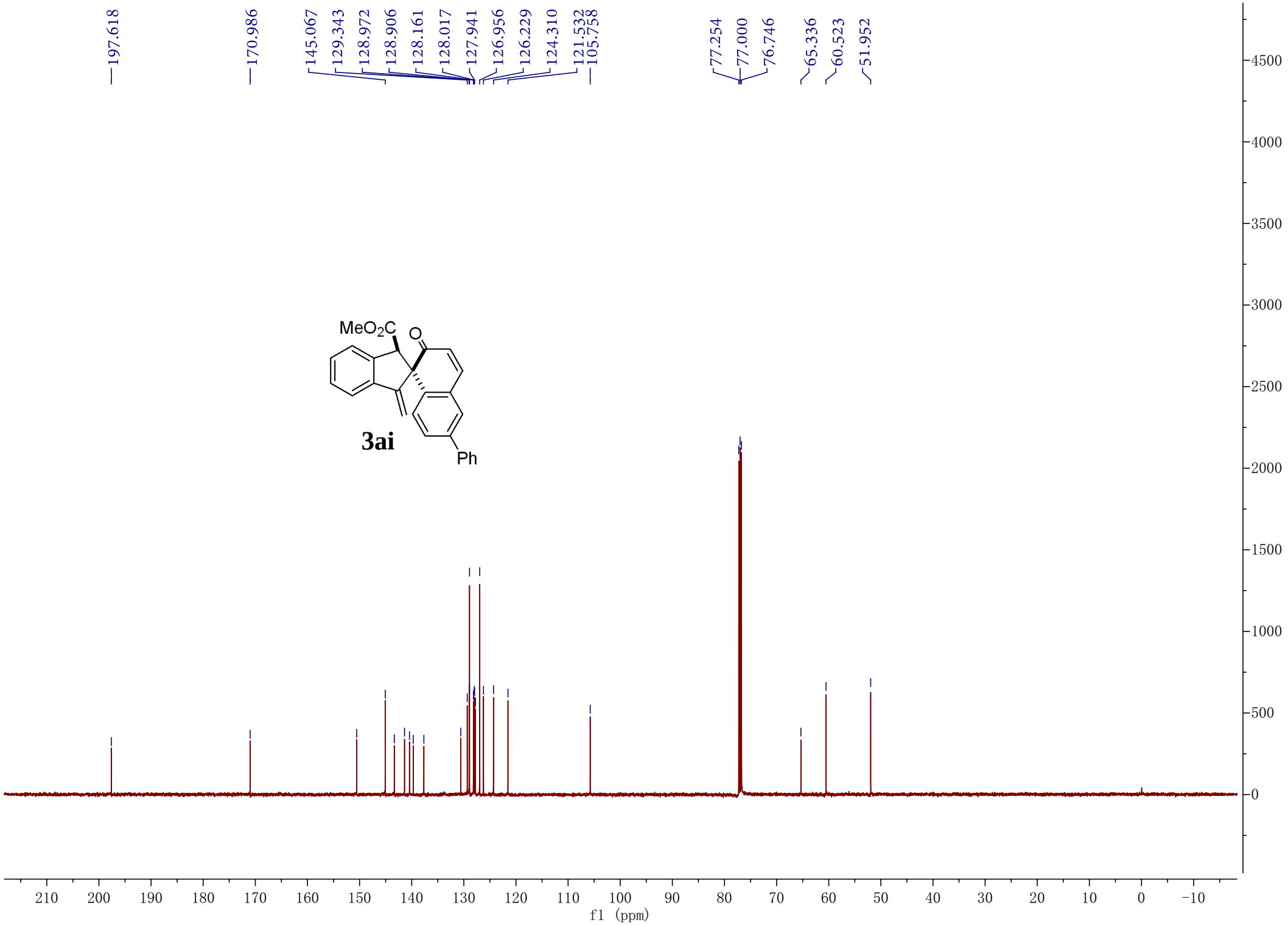

7.874
7.858
7.466
7.451
7.431
7.417
7.411
7.402
7.394
7.390
6.169
6.149
5.398
4.763
4.495
3.600
MeO2C
O
Cl
3ag
0.97
1.97
1.96
1.96
0.99
0.97
1.00
0.99
1.00
2.97
f1 (ppm)


196.904
170.718
150.148
143.487
141.144
131.770
130.135
129.437
128.989
128.949
128.237
126.171
125.093
121.540
105.834
77.254
77.000
76.746
65.140
60.519
51.963
MeO2C
O
Cl
3ag
f1 (ppm)


7.708
7.549
7.529
7.521
7.507
7.467
7.396
6.746
6.729
6.485
6.466
5.424
5.246
4.870
3.305
MeO2C
O
Br
3ah
0.99
0.97
1.96
0.98
1.00
0.99
0.98
0.99
1.00
0.93
0.99
2.98
f1 (ppm)


199.751
170.364
144.887
140.397
132.774
132.162
130.013
129.739
128.437
127.067
126.813
126.493
121.329
104.846
77.254
77.000
76.746
64.264
58.972
51.612
MeO2C
O
Br
3ah
f1 (ppm)


7.629
7.610
7.595
7.577
7.557
7.489
7.483
7.473
7.468
7.452
7.428
7.383
7.343
6.182
6.162
5.419
4.857
4.571
3.619
MeO2C
O
Ph
3ai
0.98
4.00
1.00
6.00
1.00
0.99
1.01
0.99
1.00
3.00
f1 (ppm)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145.067
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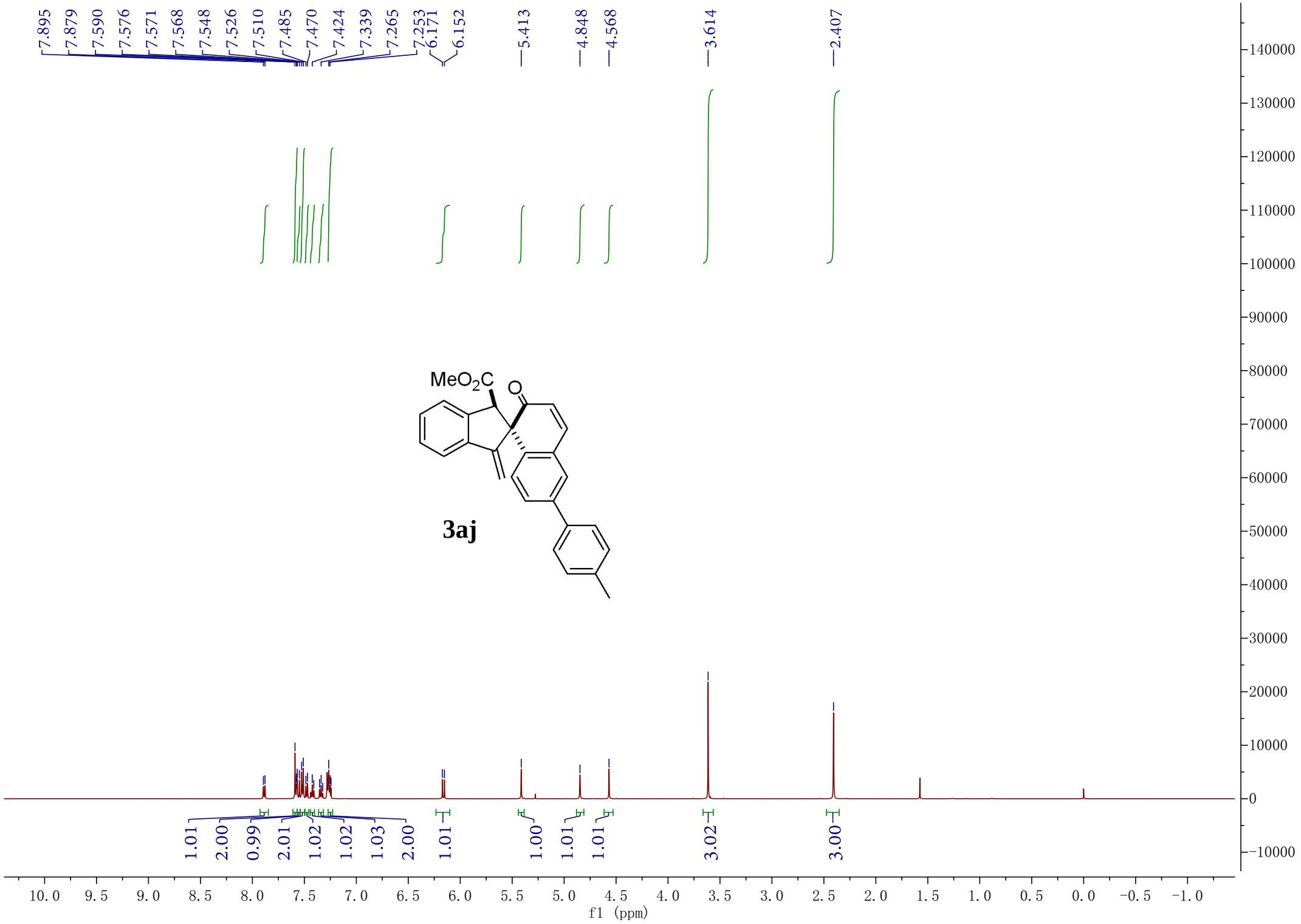
128.972
128.906
128.161
128.017
127.941
126.956
126.229
124.310
121.532
105.758
77.254
77.000
76.746
65.336
60.523
51.952
MeO2C
O
Ph
3ai
4500
4000
3500
3000
2500
2000
1500
1000
500
0
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)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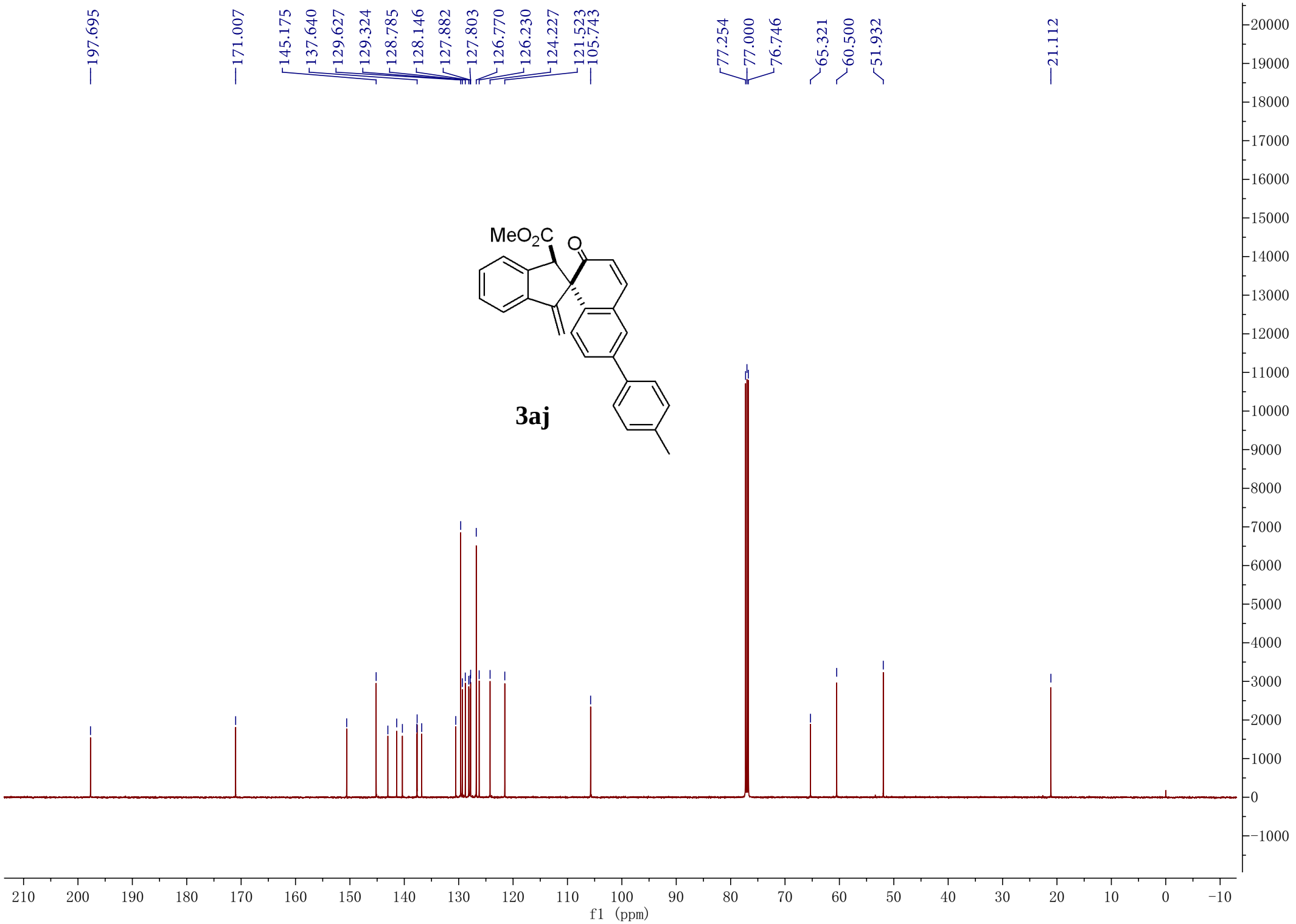
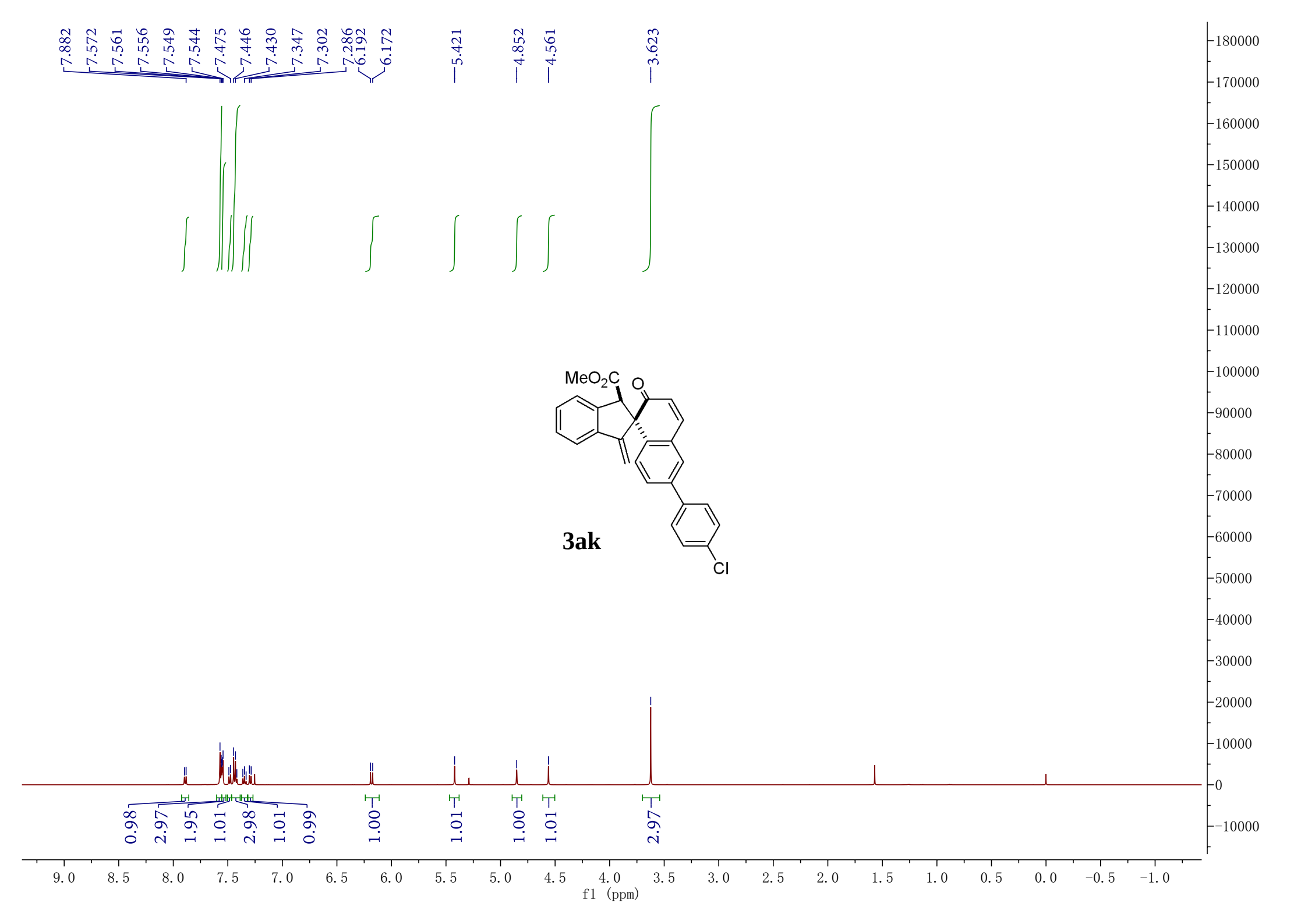
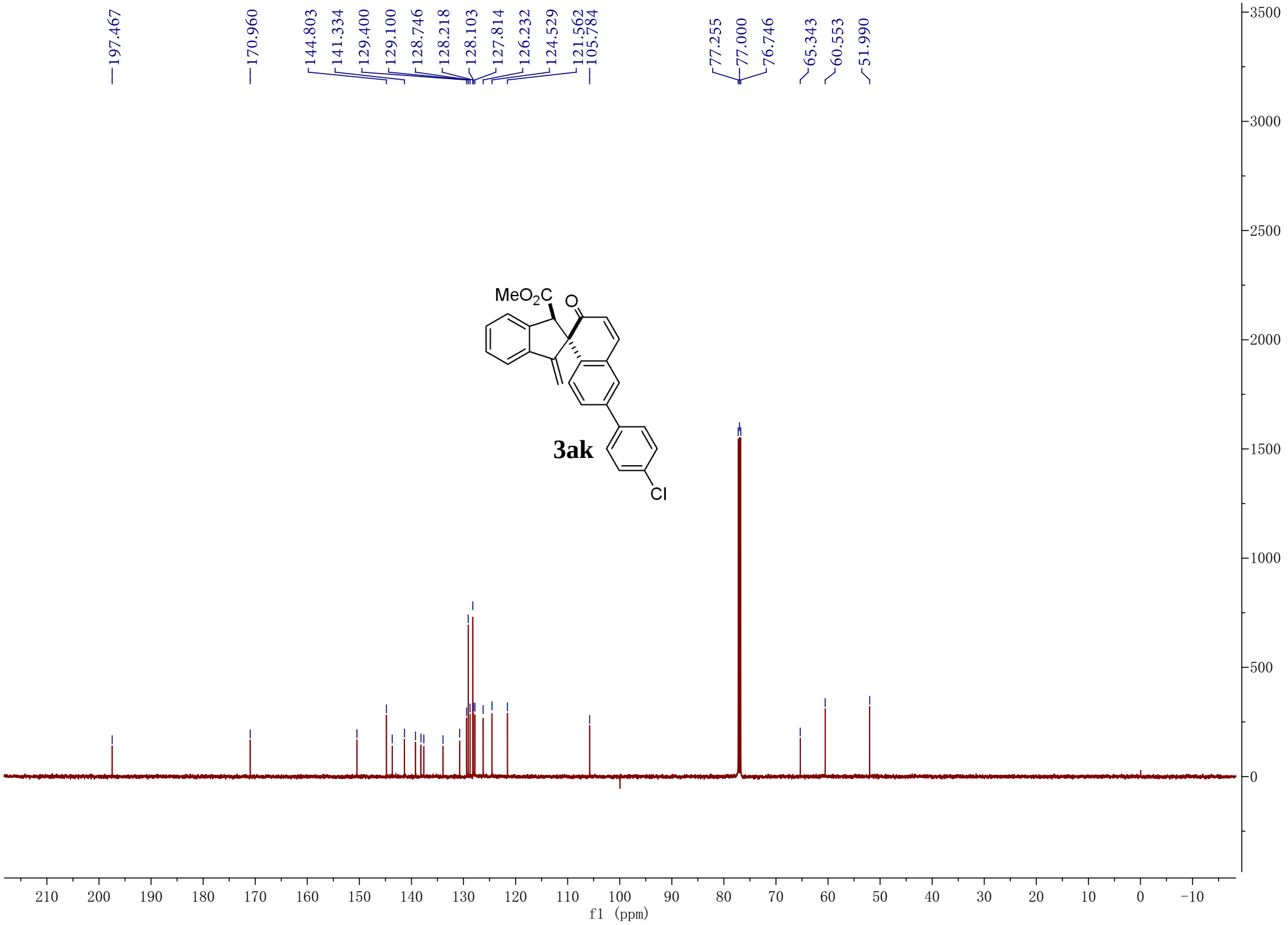
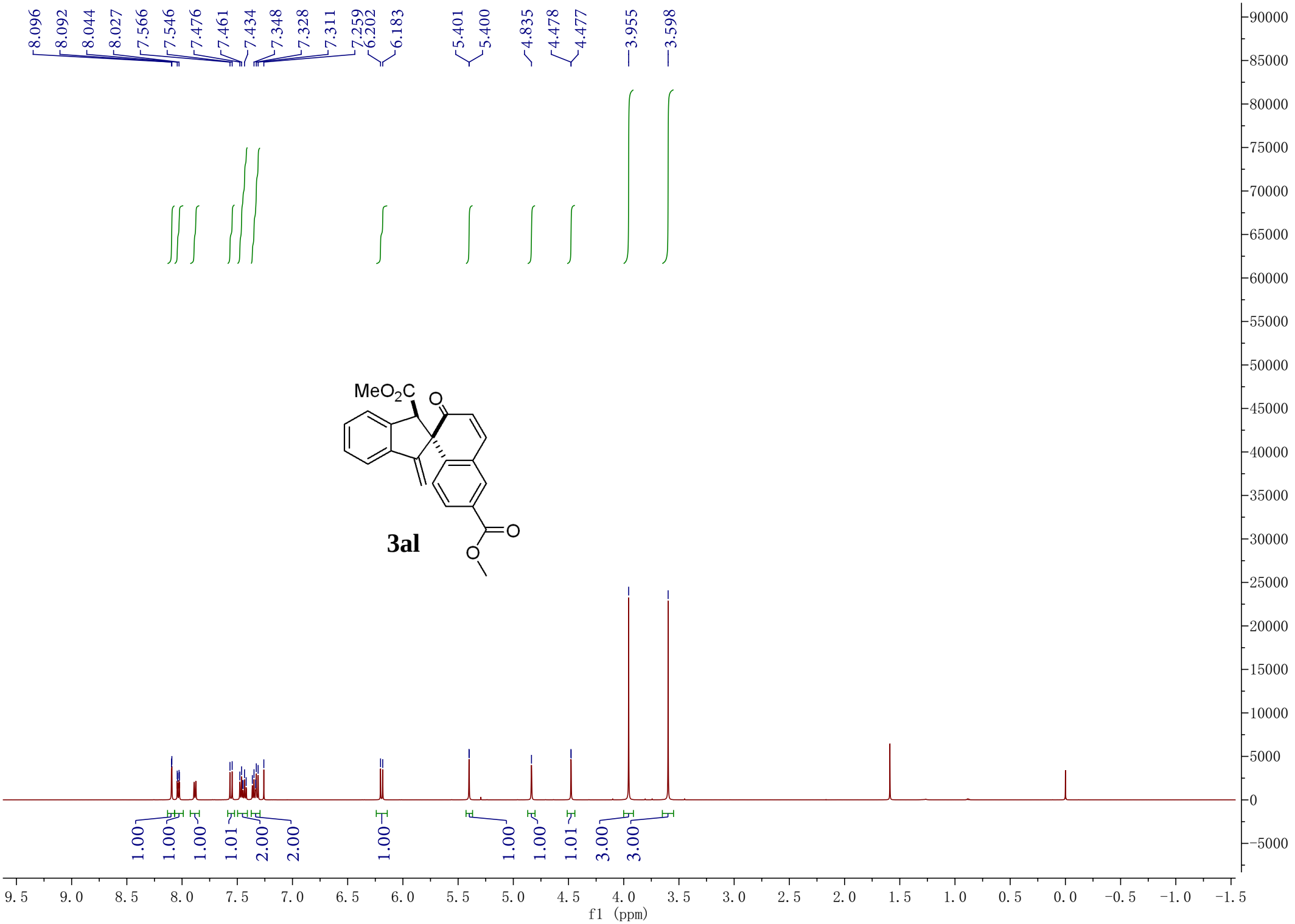
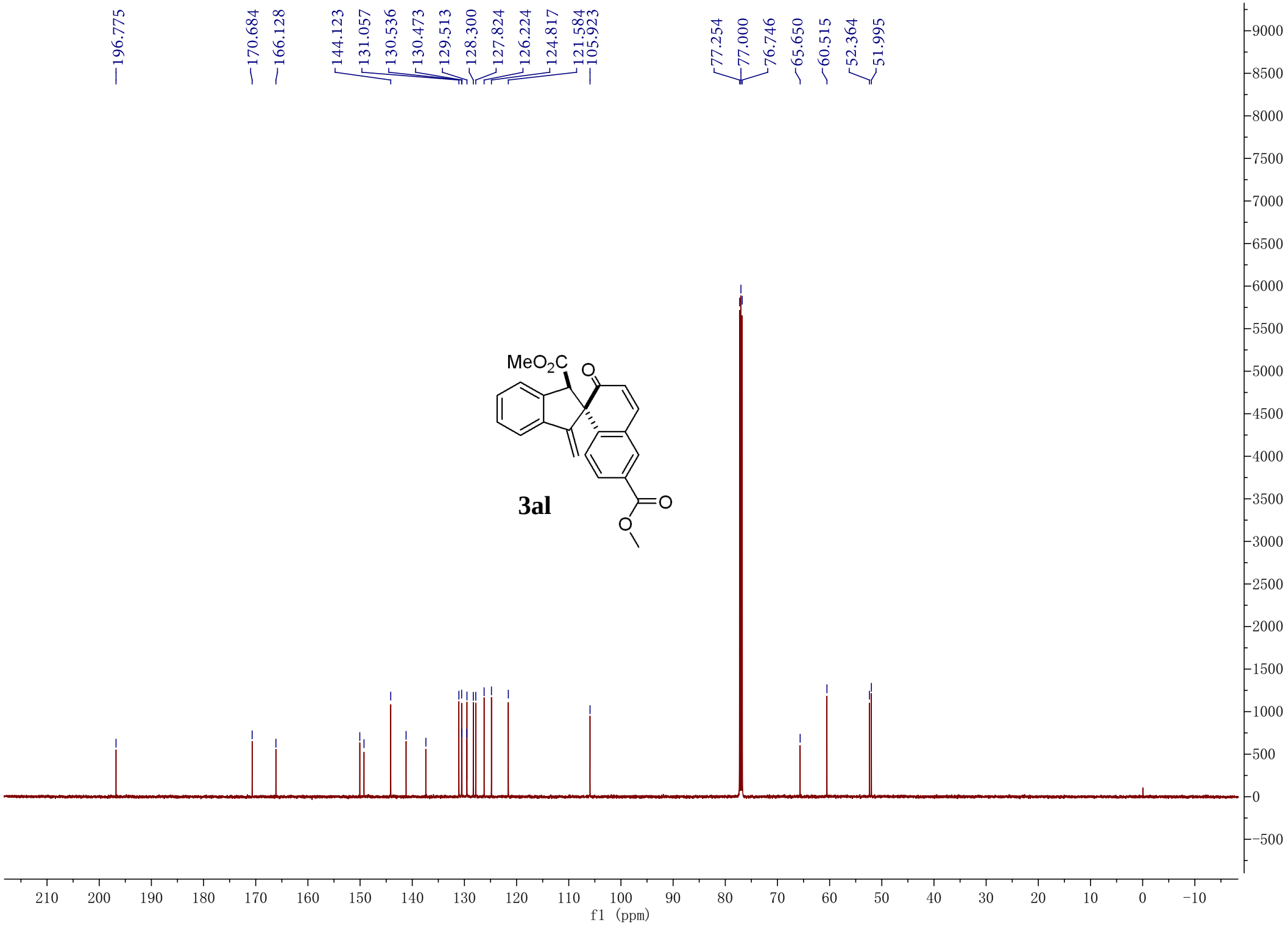
7.590
7.576
7.571
7.568
7.548
7.526
7.510
7.485
7.470
7.424
7.339
7.265
7.253
6.171
6.152
5.413
4.848
4.568
3.614
2.407
MeO2C
O
3aj
1.01
2.00
0.99
2.01
1.02
1.02
1.03
2.00
1.01
1.00
1.01
1.01
3.02
3.00
f1 (ppm)

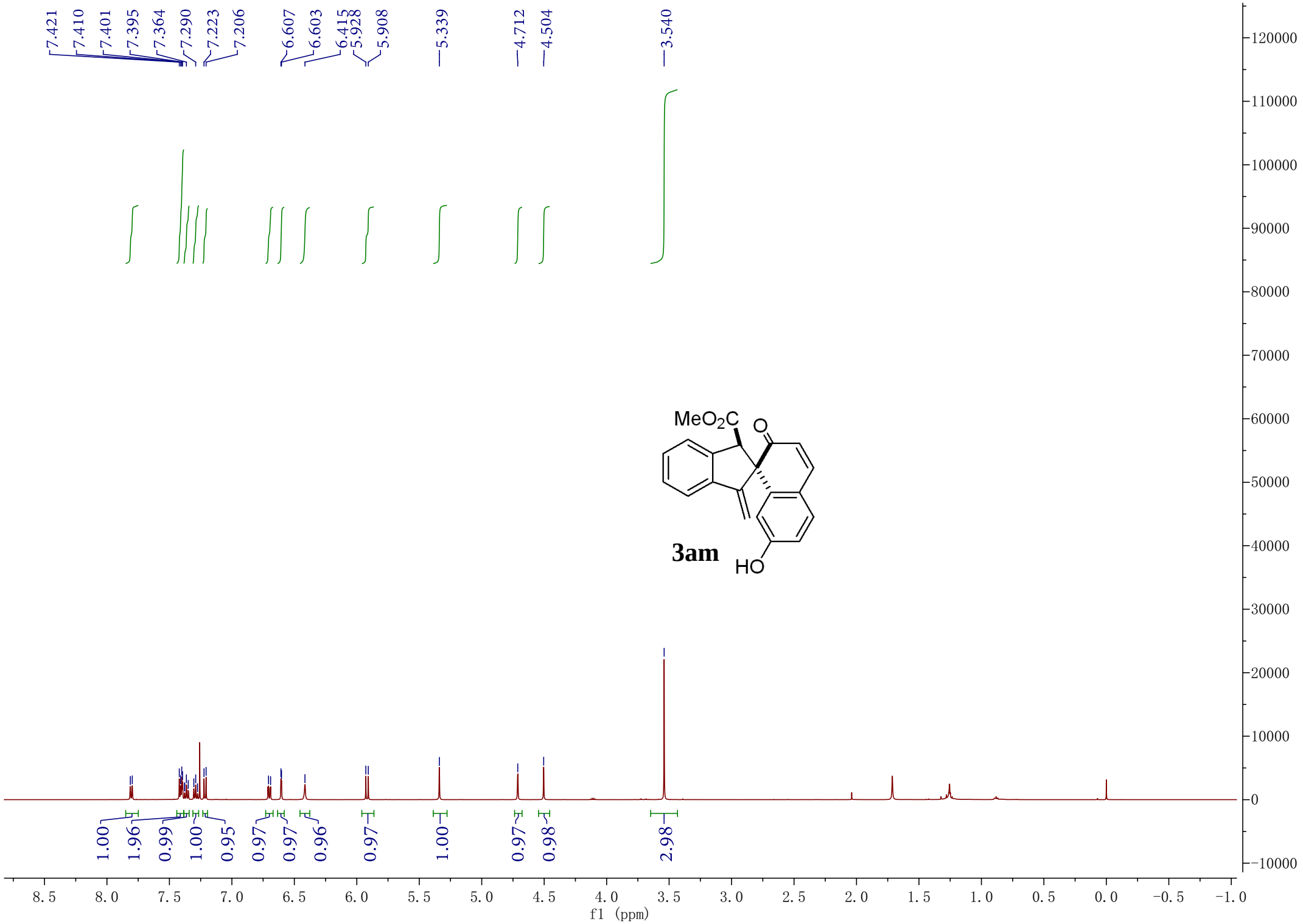

197.695
171.007
145.175
137.640
129.627
129.324
128.785
128.146
127.882
127.803
126.770
126.230
124.227
121.523
105.743
77.254
77.000
76.746
65.321
60.500
51.932
21.112
MeO2C
O
3aj
f1 (ppm)

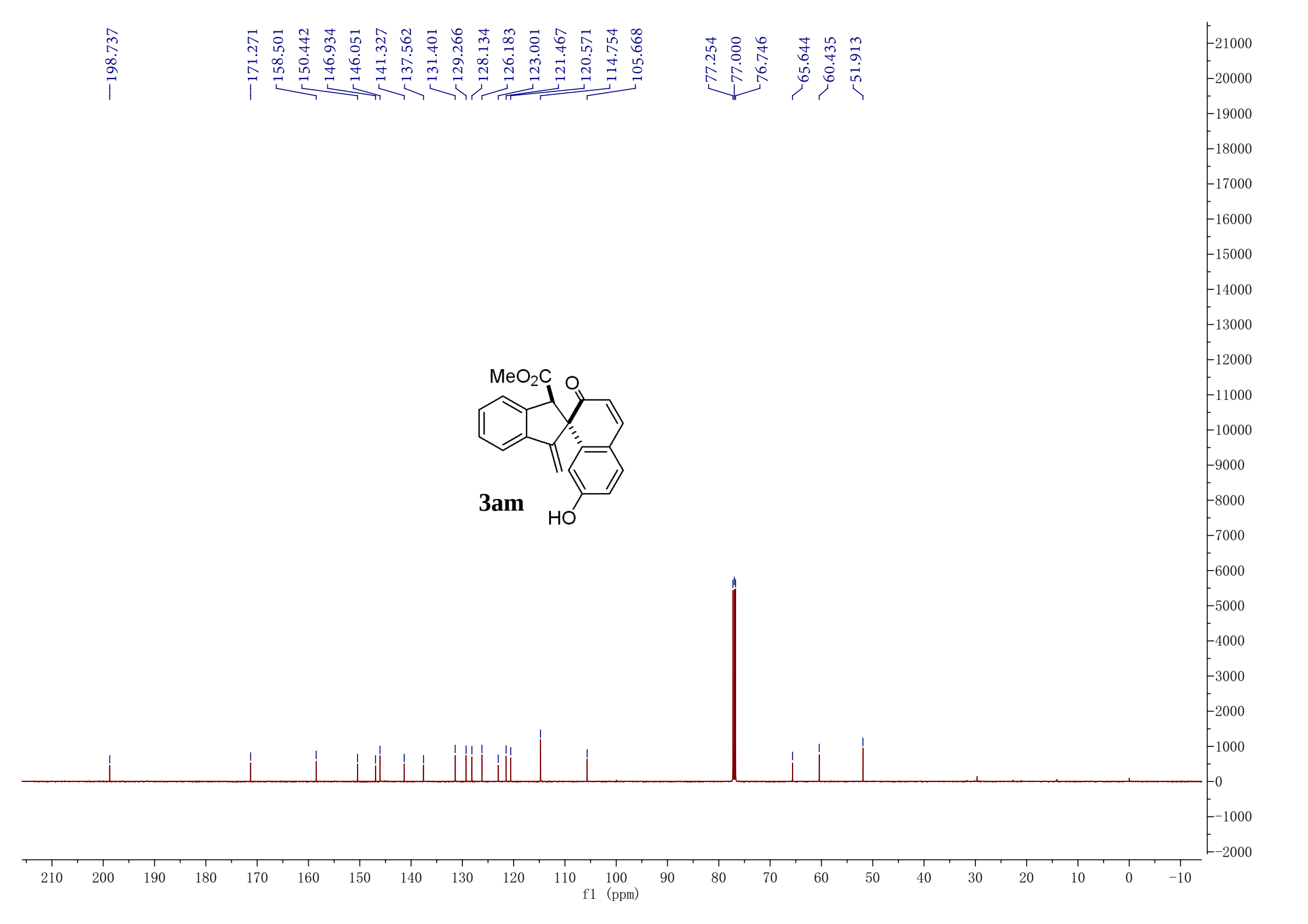

7.882
7.572
7.561
7.556
7.549
7.544
7.475
7.446
7.430
7.347
7.302
7.286
6.192
6.172
5.421
4.852
4.561
3.623
MeO2C
O
Cl
3ak
0.98
2.97
1.95
1.01
2.98
1.01
0.99
1.00
1.01
1.00
1.01
2.97
f1 (ppm)


197.467
170.960
144.803
141.334
129.400
129.100
128.746
128.218
128.103
127.814
126.232
124.529
121.562
105.784
77.255
77.000
76.746
65.343
60.553
51.990
MeO2C
O
Cl
3ak
3500
3000
2500
2000
1500
1000
500
0
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)


8.096
8.092
8.044
8.027
7.566
7.546
7.476
7.461
7.434
7.348
7.328
7.311
7.259
6.202
6.183
5.401
5.400
4.835
4.478
4.477
3.955
3.598
MeO2C
O
O
O
3al
1.00
1.00
1.00
1.01
2.00
2.00
1.00
1.00
1.00
1.01
3.00
3.00
f1 (ppm)


196.775
170.684
166.128
144.123
131.057
130.536
130.473
129.513
128.300
127.824
126.224
124.817
121.584
105.923
77.254
77.000
76.746
65.650
60.515
52.364
51.995
MeO2C
O
O
O
3al
9000
8500
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
−500
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)


7.421
7.410
7.401
7.395
7.364
7.290
7.223
7.206
6.607
6.603
6.415
5.928
5.908
5.339
4.712
4.504
3.540
MeO2C
O
HO
3am
1.00
1.96
0.99
1.00
0.95
0.97
0.97
0.96
0.97
1.00
0.97
0.98
2.98
f1 (ppm)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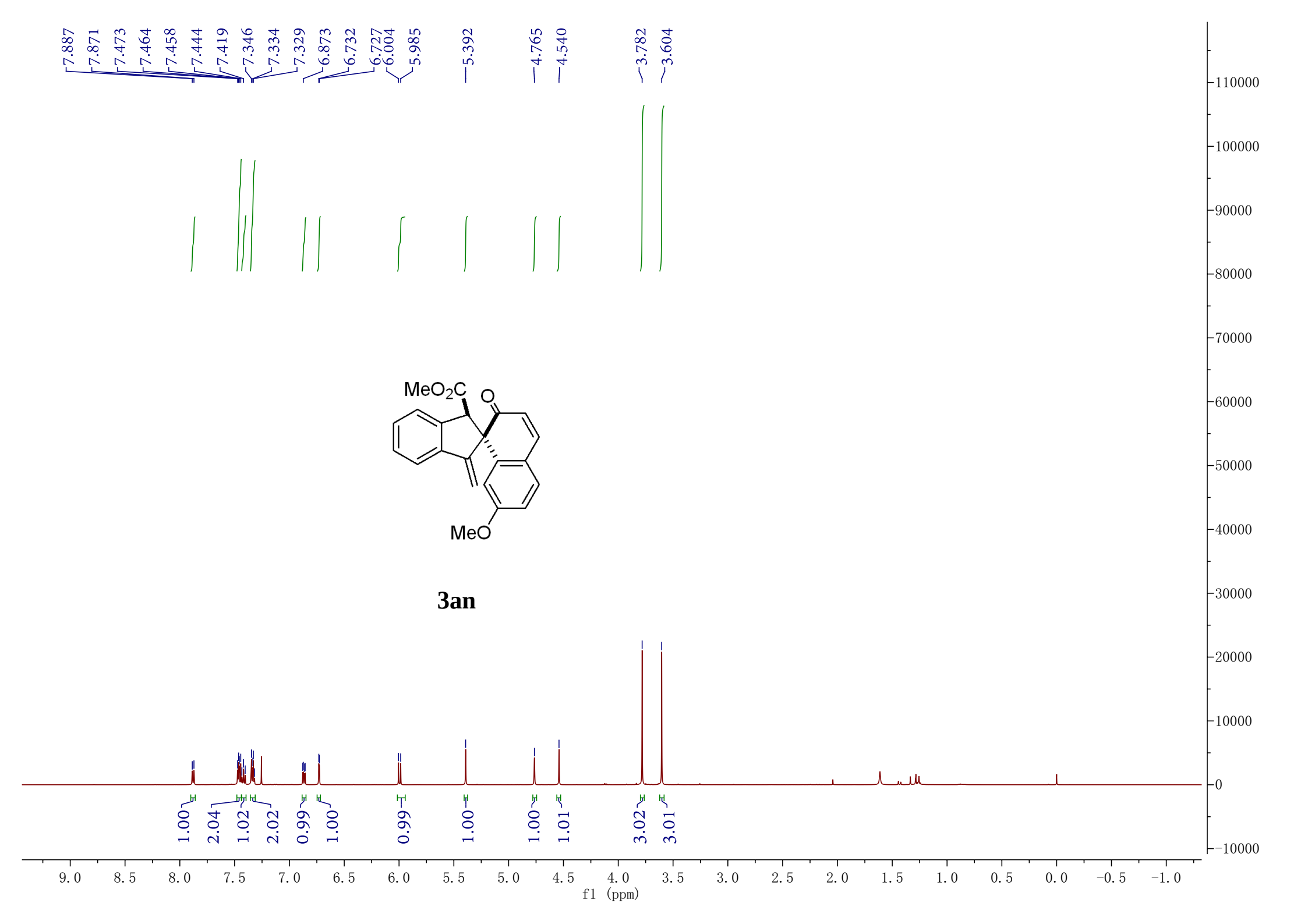
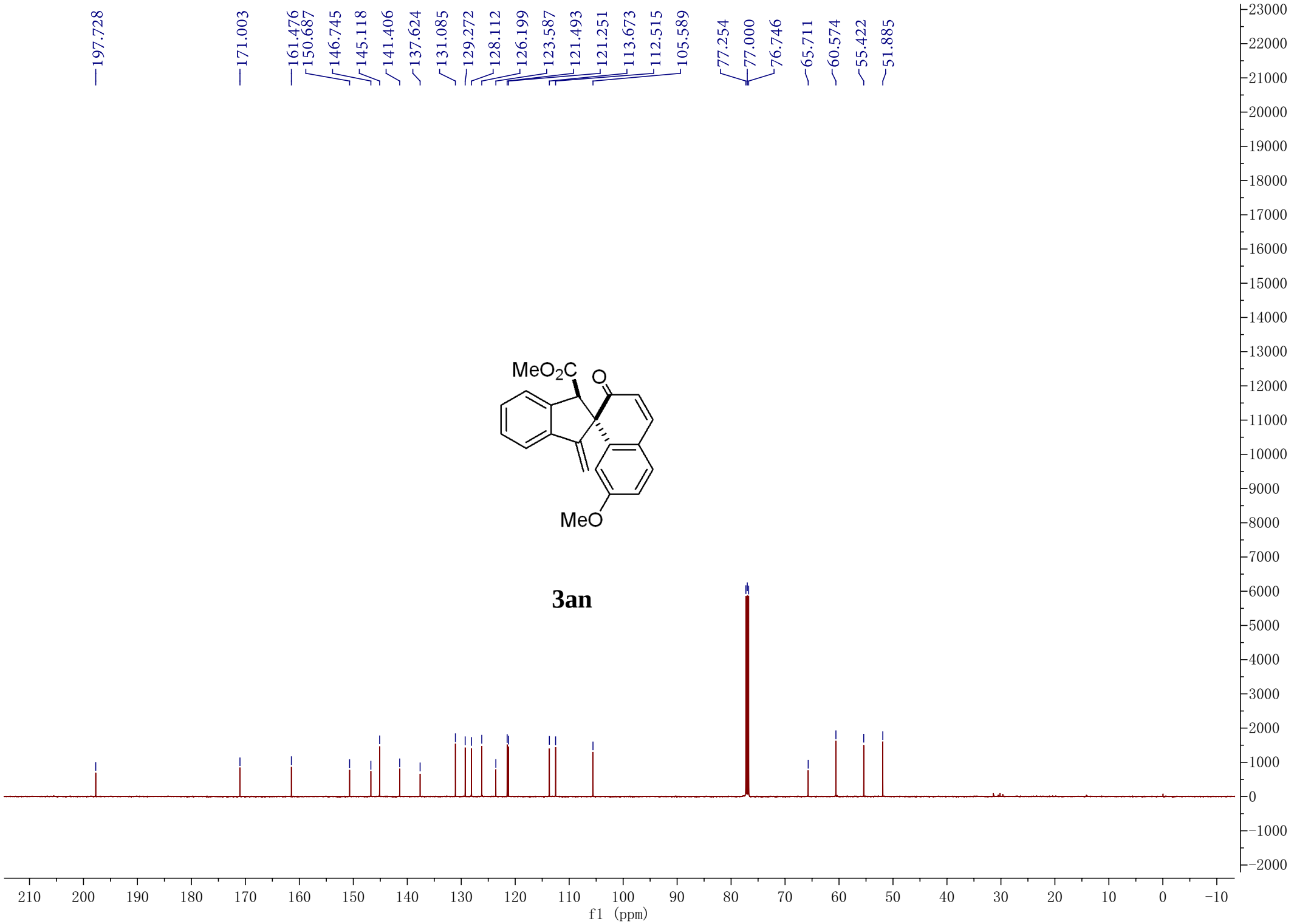
171.271
158.501
150.442
146.934
146.051
141.327
137.562
131.401
129.266
128.134
126.183
123.001
121.467
120.571
114.754
105.668
77.254
77.000
76.746
65.644
60.435
51.913
MeO2C
O
HO
3am
f1 (ppm)


7.887
7.871
7.473
7.464
7.458
7.444
7.419
7.346
7.334
7.329
6.873
6.732
6.727
6.004
5.985
5.392
4.765
4.540
3.782
3.604
MeO2C
O
MeO
3an
1.00
2.04
1.02
2.02
0.99
1.00
0.99
1.00
1.00
1.01
3.02
3.01
f1 (ppm)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161.476
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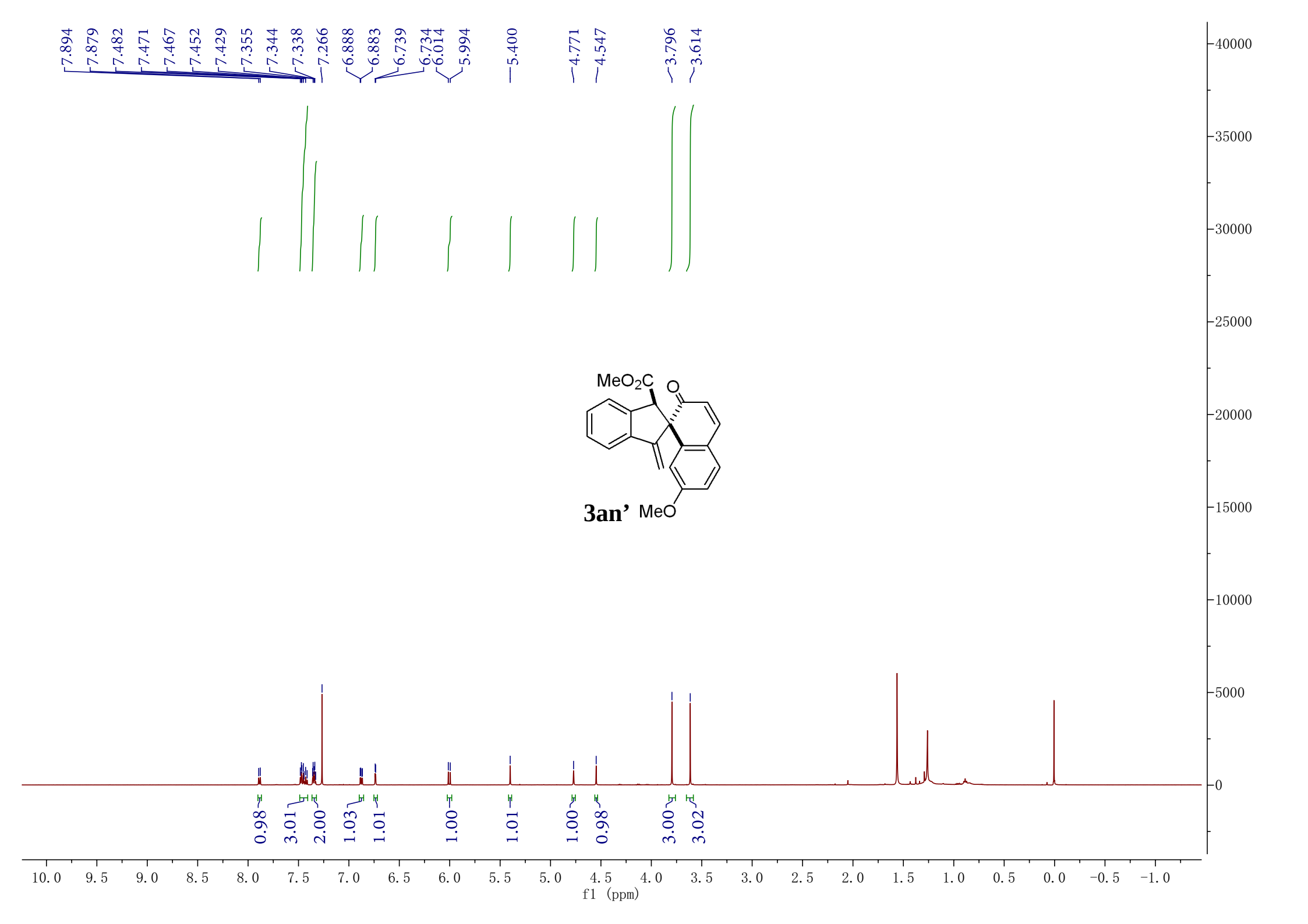
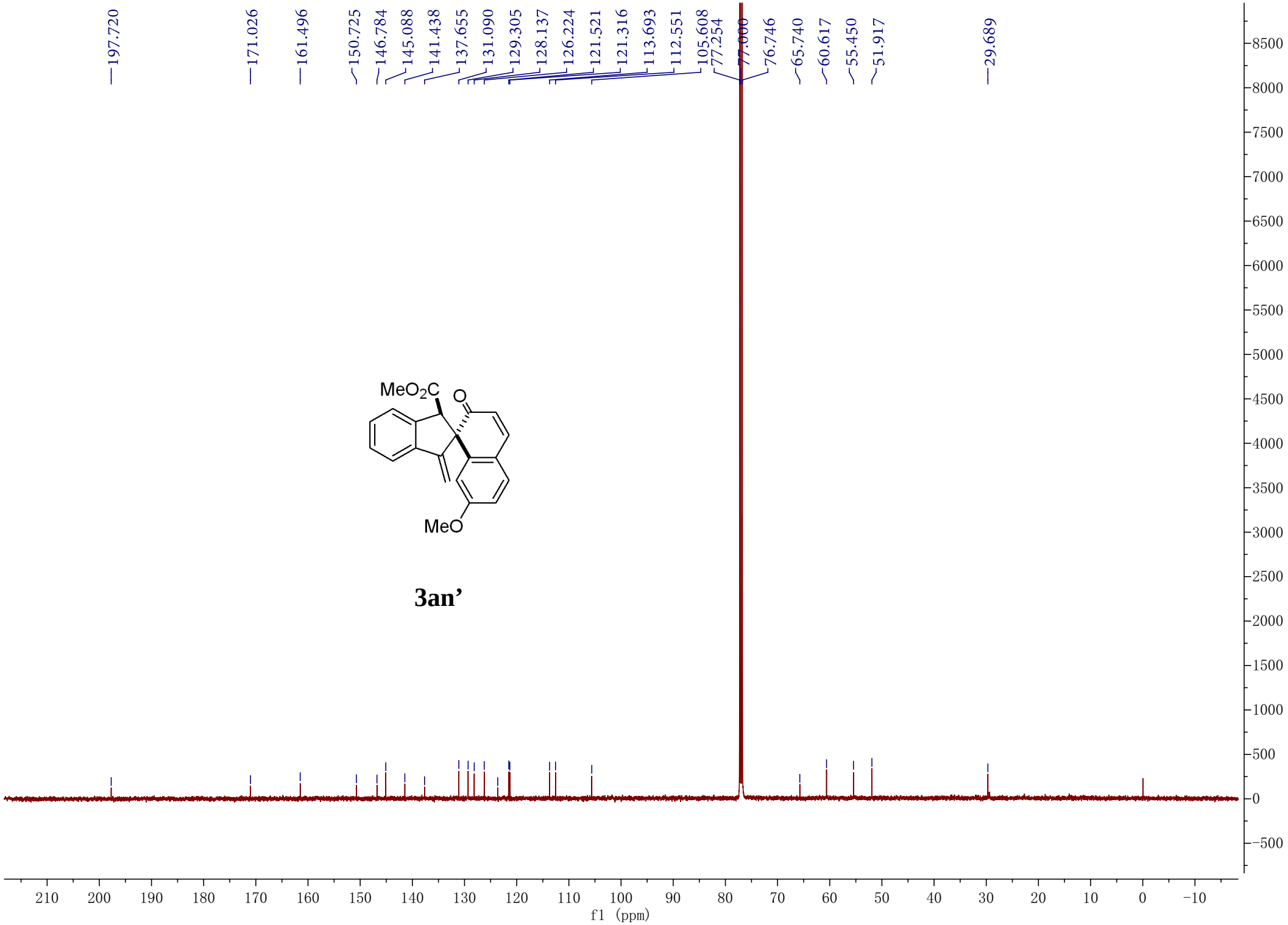
146.745
145.118
141.406
137.624
131.085
129.272
128.112
126.199
123.587
121.493
121.251
113.673
112.515
105.589
77.254
77.000
76.746
65.711
60.574
55.422
51.885
MeO2C
O
MeO
3an
f1 (ppm)


7.894
7.879
7.482
7.471
7.467
7.452
7.429
7.355
7.344
7.338
7.266
6.888
6.883
6.739
6.734
6.014
5.994
5.400
4.771
4.547
3.796
3.614
MeO2C
O
MeO
3an'
0.98
3.01
2.00
1.03
1.01
1.00
1.01
1.00
0.98
3.00
3.02
40000
35000
30000
25000
20000
15000
10000
5000
0
10.0
9.5
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
-0.5
-1.0
f1 (ppm)


197.720
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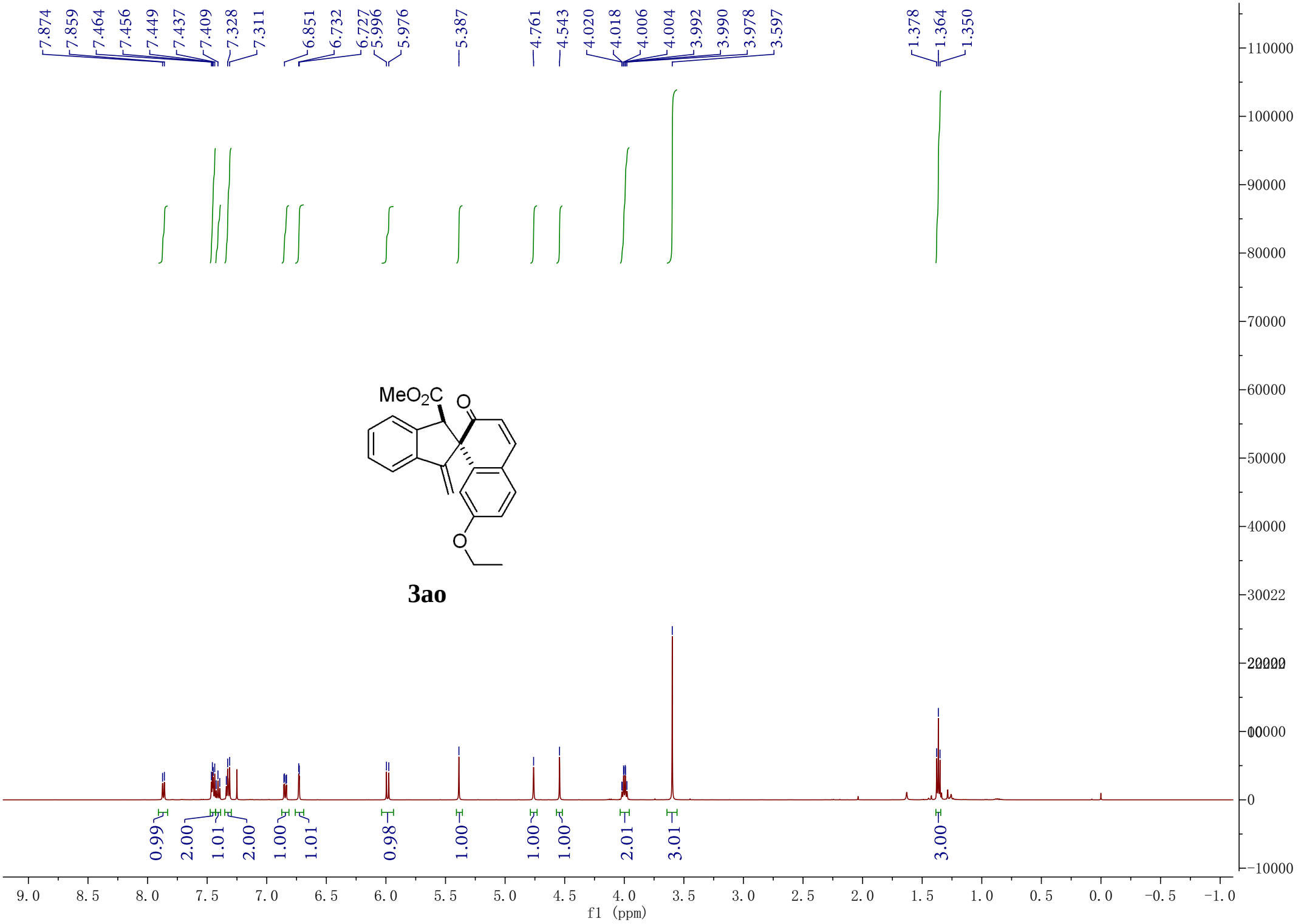
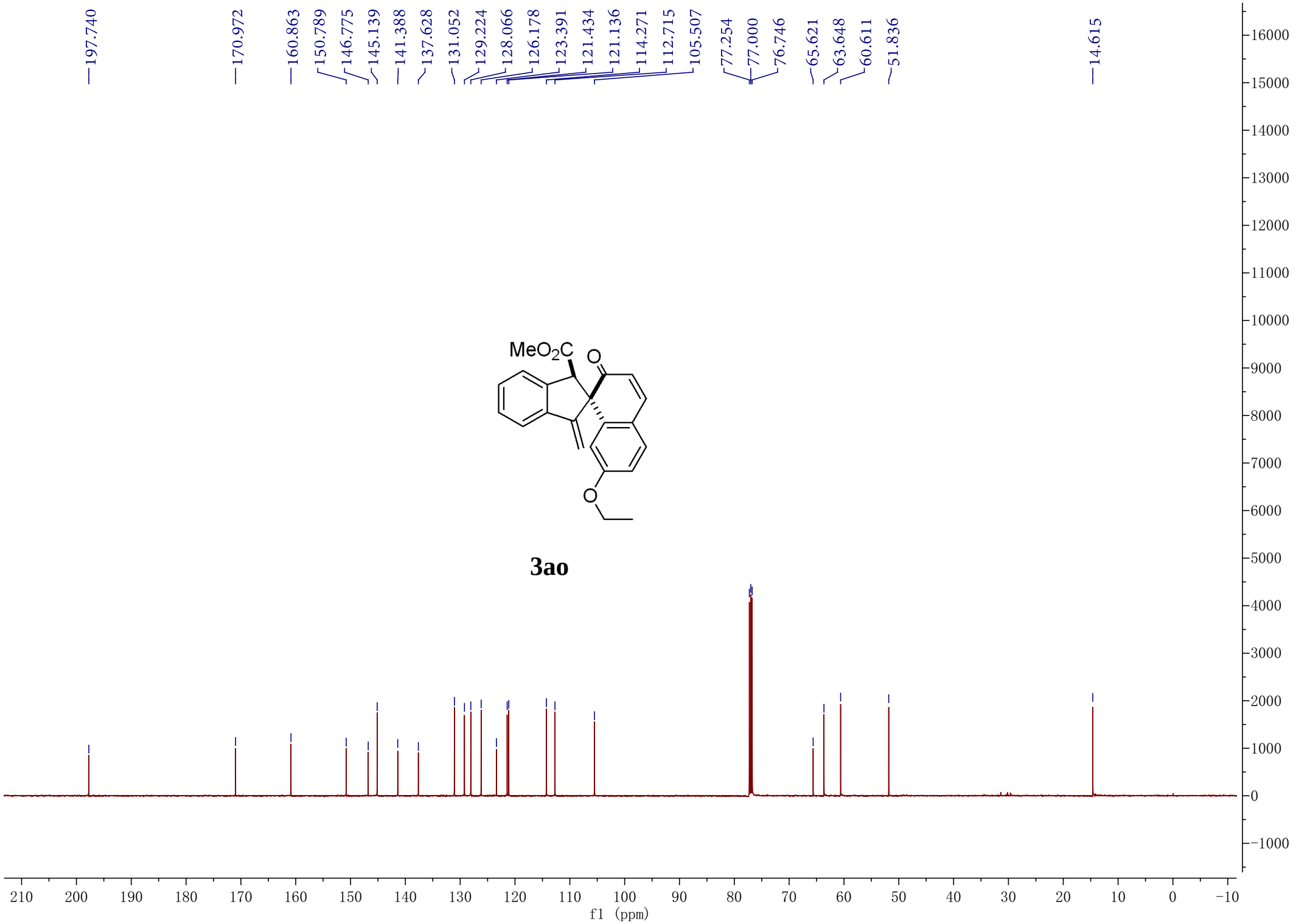
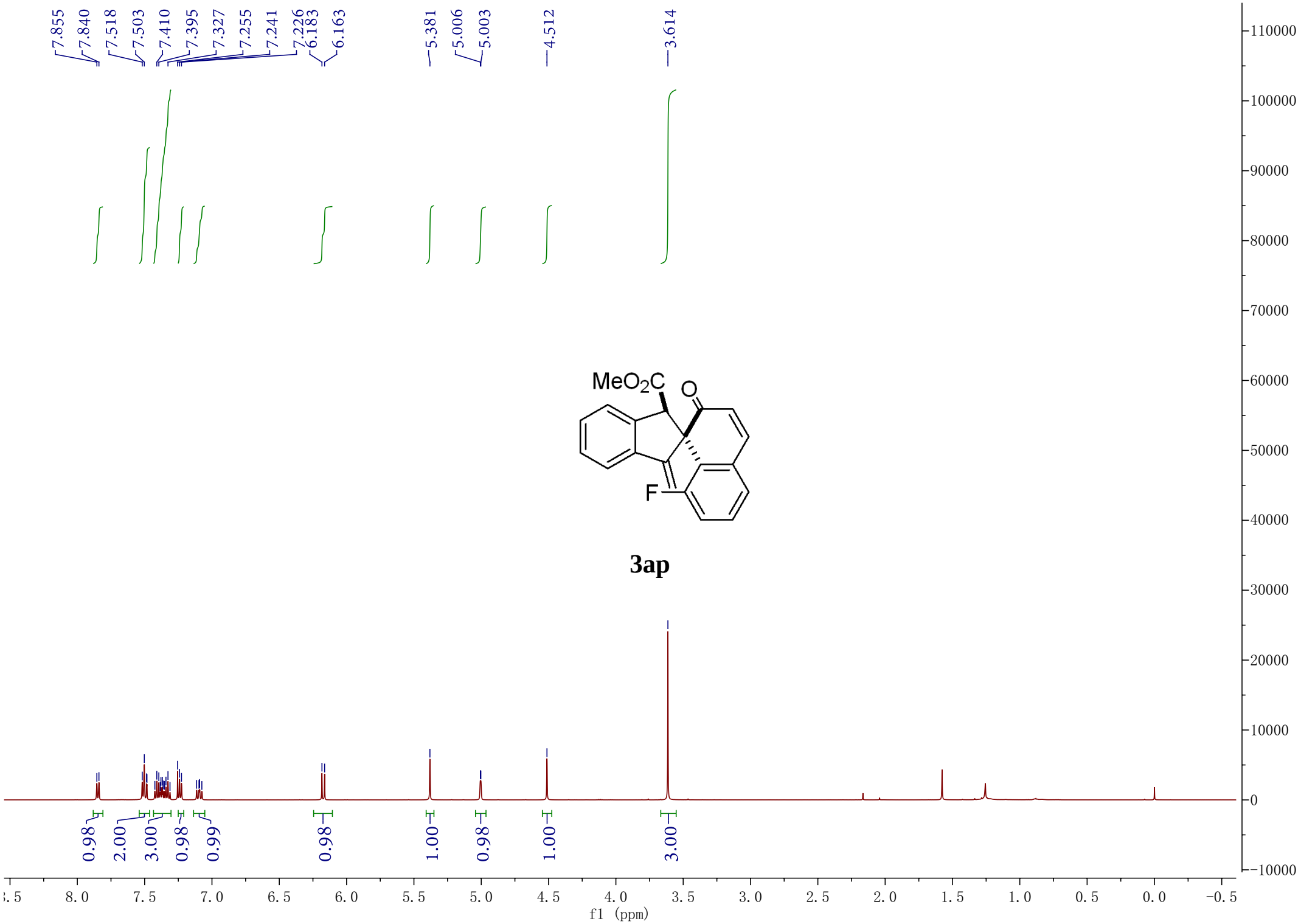
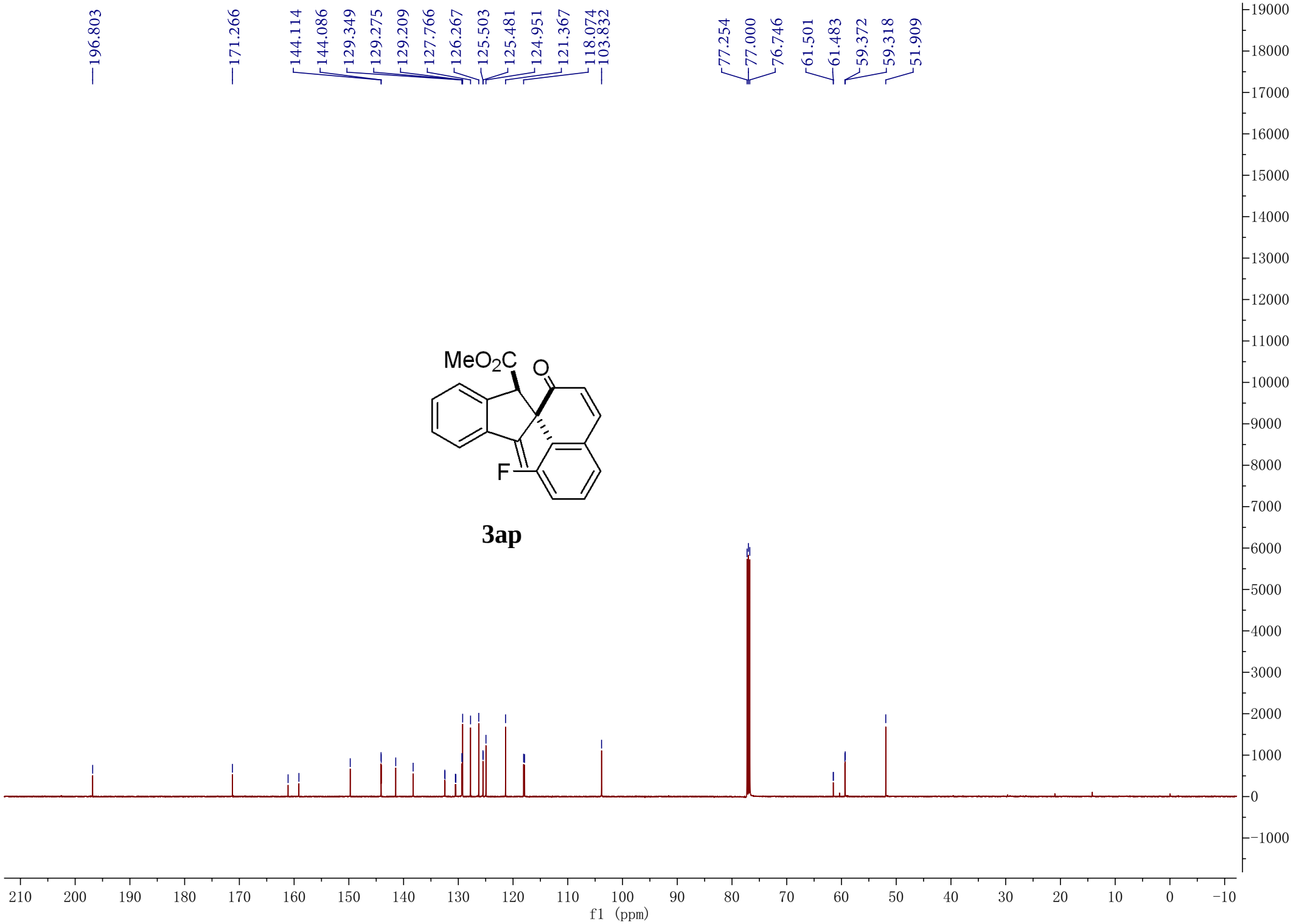
161.496
150.725
146.784
145.088
141.438
137.655
131.090
129.305
128.137
126.224
121.521
121.316
113.693
112.551
105.608
77.254
77.000
76.746
65.740
60.617
55.450
51.917
29.689
MeO2C
O
MeO
3an'
f1 (ppm)

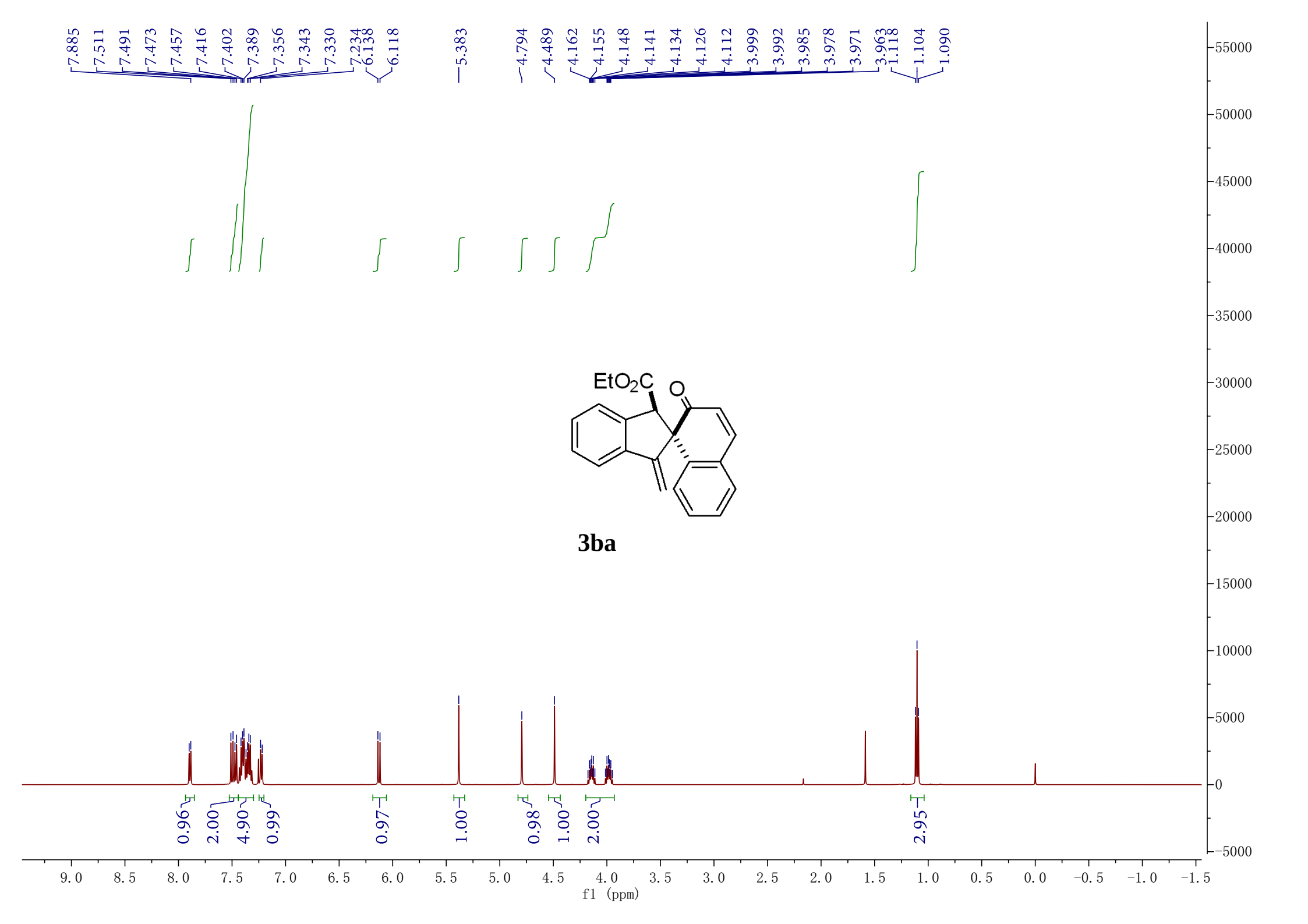

7.874
7.859
7.464
7.456
7.449
7.437
7.409
7.328
7.311
6.851
6.732
6.727
5.996
5.976
5.387
4.761
4.543
4.020
4.018
4.006
4.004
3.992
3.990
3.978
3.597
1.378
1.364
1.350
MeO2C
O
O
3ao
0.99
2.00
1.01
2.00
1.00
1.01
0.98
1.00
1.00
1.00
2.01
3.01
3.00
f1 (ppm)

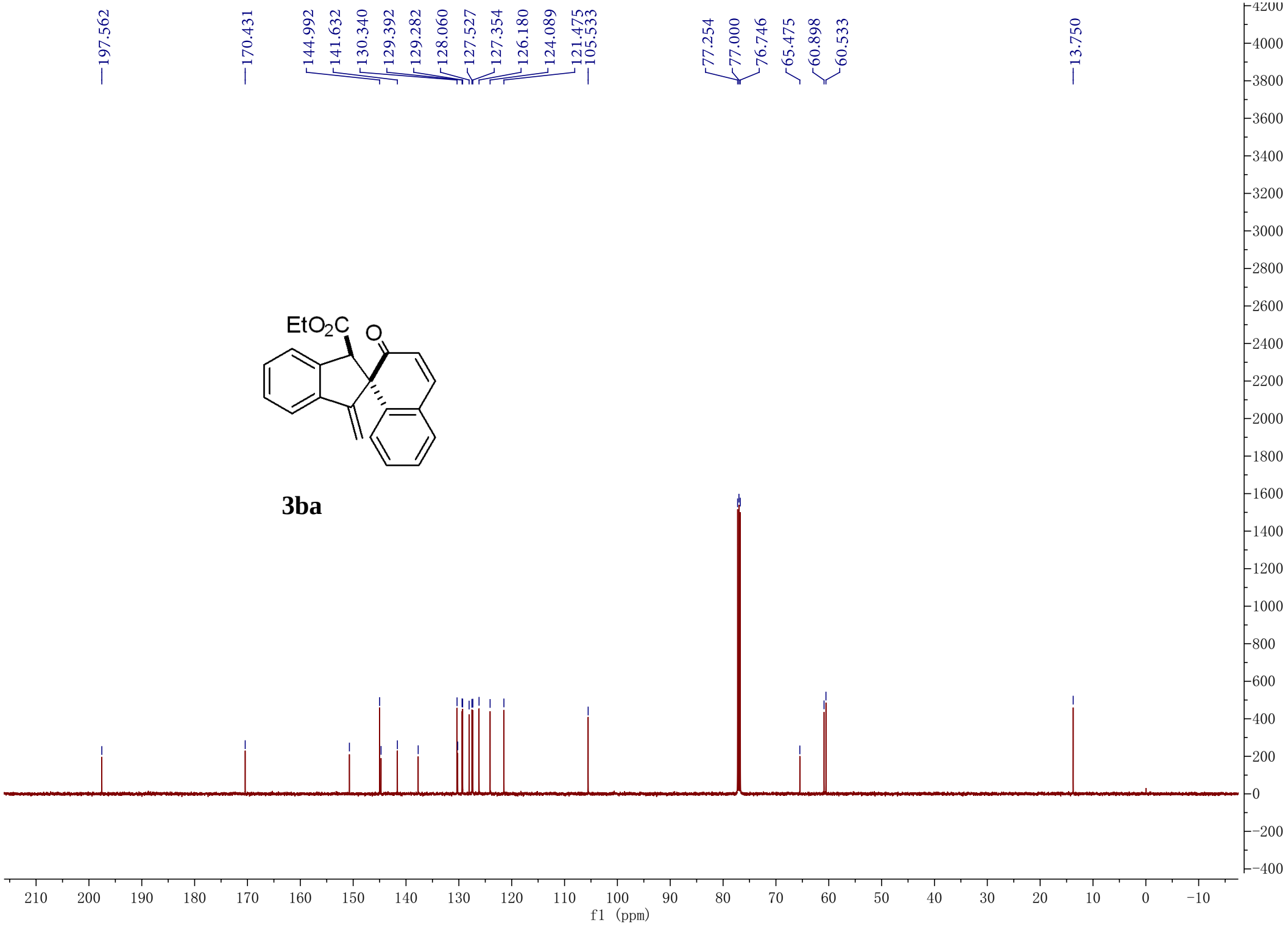

197.740
170.972
160.863
150.789
146.775
145.139
141.388
137.628
131.052
129.224
128.066
126.178
123.391
121.434
121.136
114.271
112.715
105.507
77.254
77.000
76.746
65.621
63.648
60.611
51.836
14.615
MeO2C
O
O
3ao
f1 (ppm)

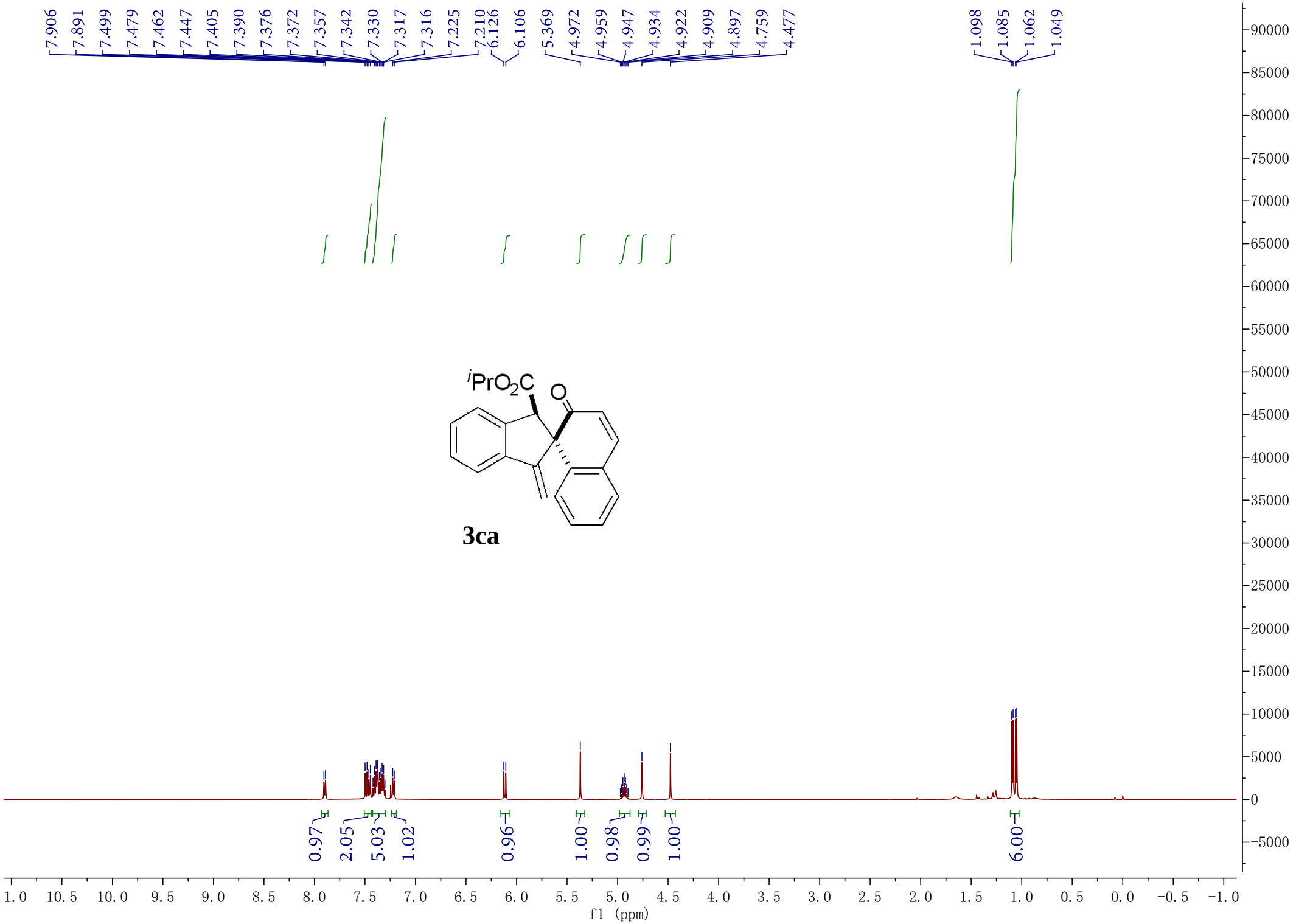

7.855
7.840
7.518
7.503
7.410
7.395
7.327
7.255
7.241
7.226
6.183
6.163
5.381
5.006
5.003
4.512
3.614
MeO2C
O
F
0.98
2.00
3.00
0.98
0.99
0.98
1.00
0.98
1.00
3.00
f1 (ppm)

3ap


196.803
171.266
144.114
144.086
129.349
129.275
129.209
127.766
126.267
125.503
125.481
124.951
121.367
118.074
103.832
77.254
77.000
76.746
61.501
61.483
59.372
59.318
51.909
MeO2C
O
F
3ap
f1 (ppm)


7.885
7.511
7.491
7.473
7.457
7.416
7.402
7.389
7.356
7.343
7.330
7.234
6.138
6.118
5.383
4.794
4.489
4.162
4.155
4.148
4.141
4.134
4.126
4.112
3.999
3.992
3.985
3.978
3.971
3.963
1.118
1.104
1.090
EtO2C
O
3ba
0.96
2.00
4.90
0.99
0.97
1.00
0.98
1.00
2.00
2.95
f1 (ppm)


197.562
170.431
144.992
141.632
130.340
129.392
129.282
128.060
127.527
127.354
126.180
124.089
121.475
105.533
77.254
77.000
76.746
65.475
60.898
60.533
13.750
EtO2C
O
3ba
f1 (ppm)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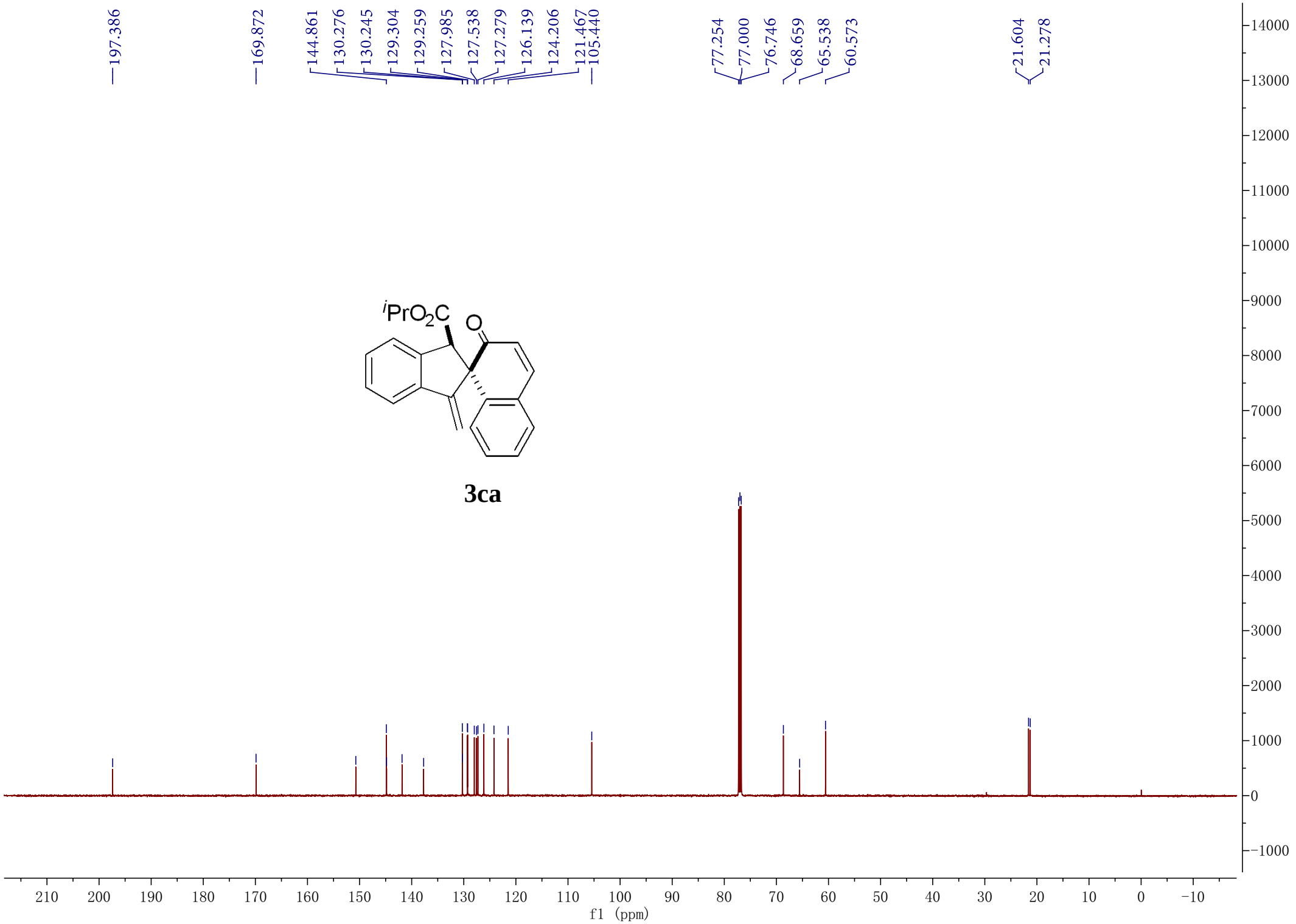
7.891
7.499
7.479
7.462
7.447
7.405
7.390
7.376
7.372
7.357
7.342
7.330
7.317
7.316
7.225
7.210
6.126
6.106
5.369
4.972
4.959
4.947
4.934
4.922
4.909
4.897
4.759
4.477
1.098
1.085
1.062
1.049
iPrO2C
O
3ca
0.97
2.05
5.03
1.02
0.96
1.00
0.98
0.99
1.00
6.00
f1 (ppm)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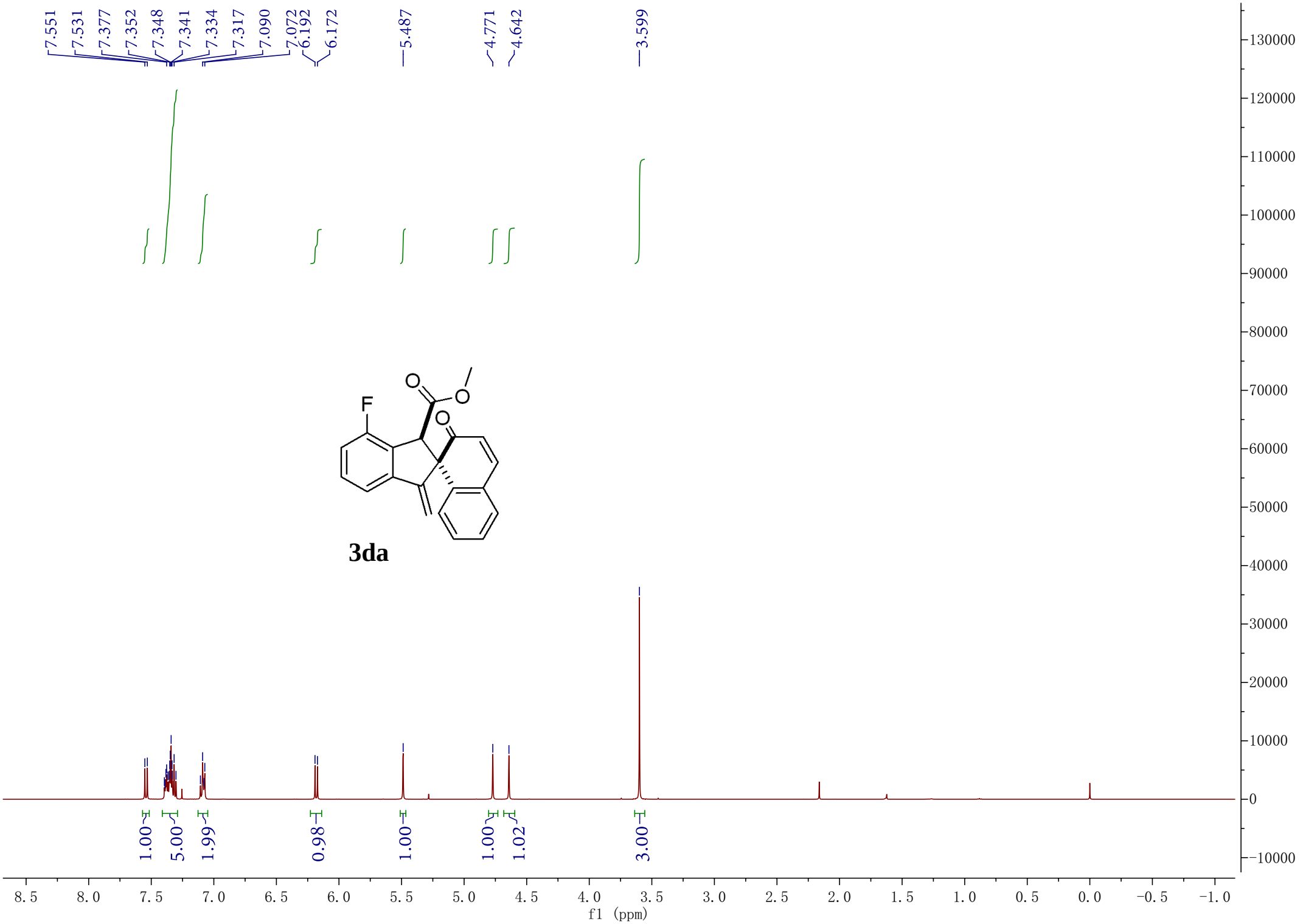
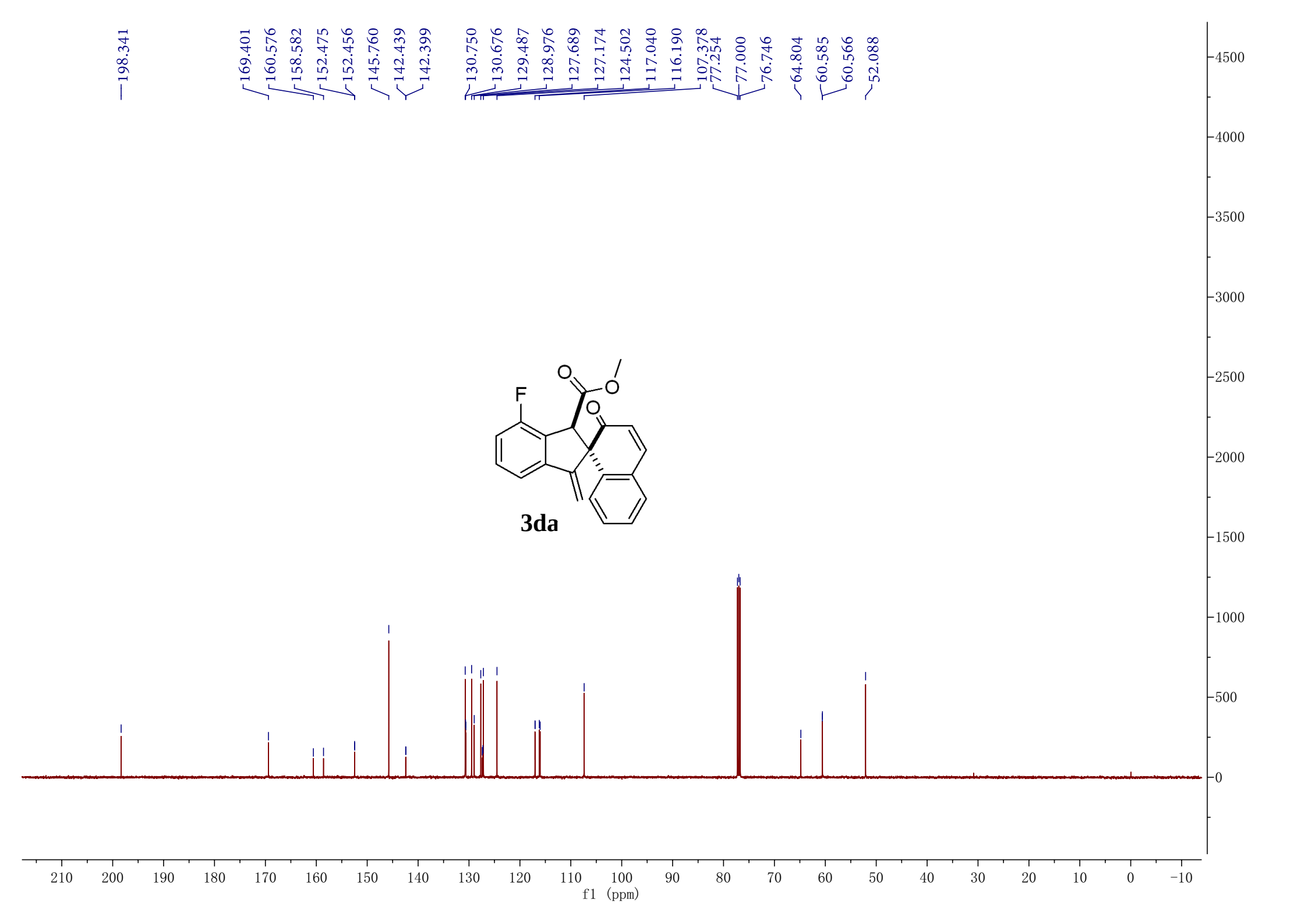
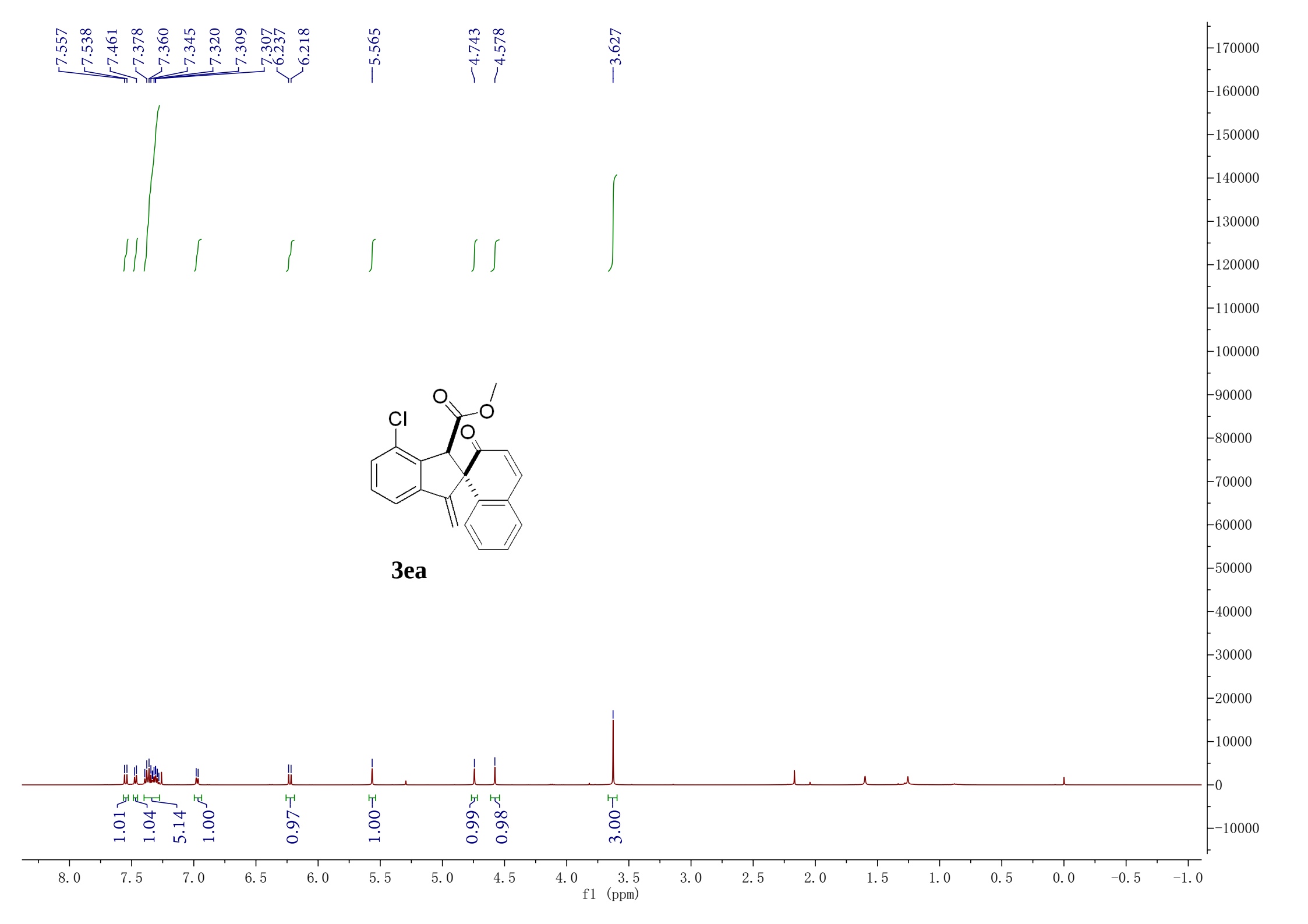
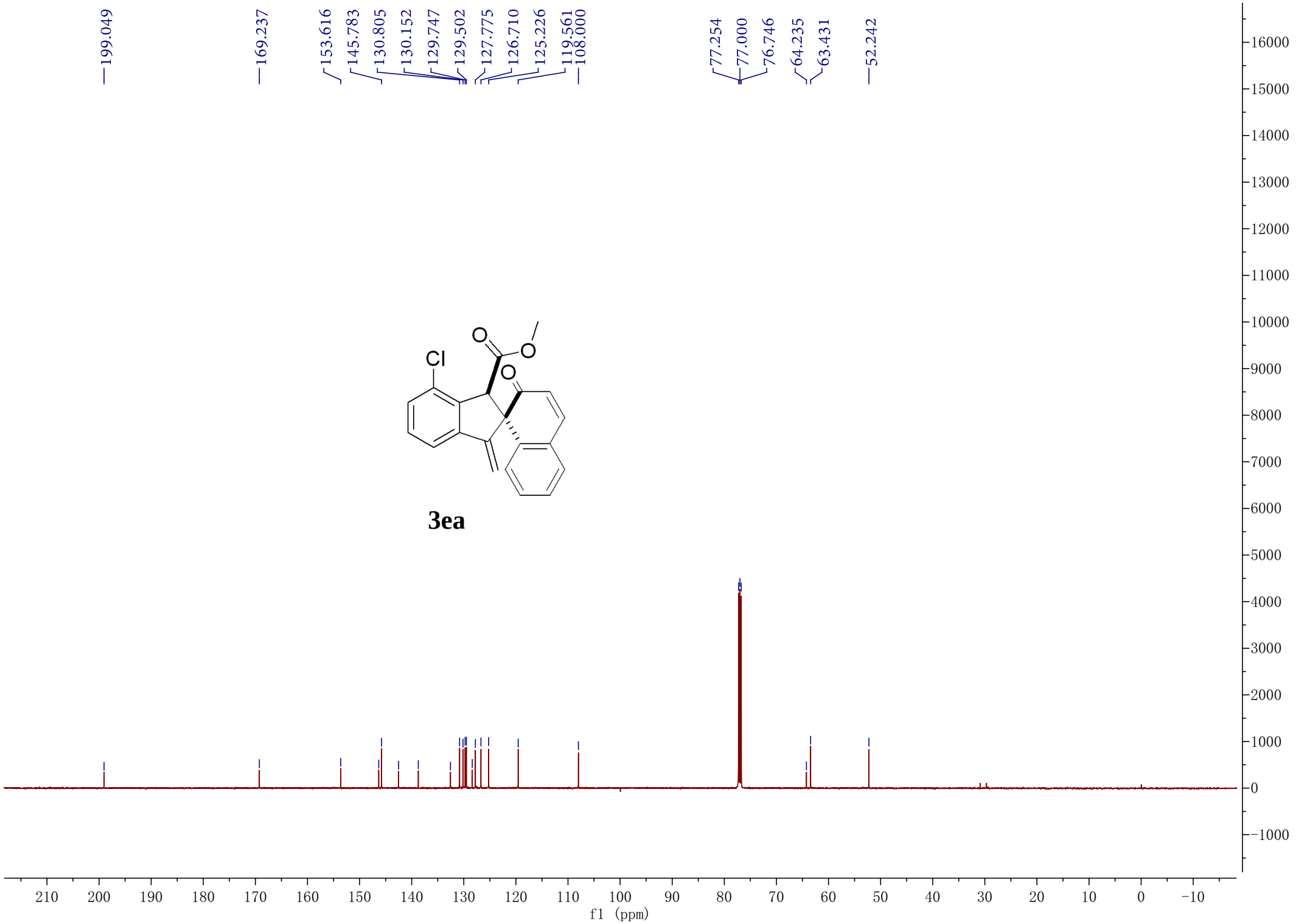
144.861
130.276
130.245
129.304
129.259
127.985
127.538
127.279
126.139
124.206
121.467
105.440
77.254
77.000
76.746
68.659
65.538
60.573
21.604
21.278
iPrO2C
O
3ca
f1 (ppm)


7.551
7.531
7.377
7.352
7.348
7.341
7.334
7.317
7.090
7.072
6.192
6.172
5.487
4.771
4.642
3.599
F
O
O
O
3da
1.00
5.00
1.99
0.98
1.00
1.00
1.02
3.00
f1 (ppm)

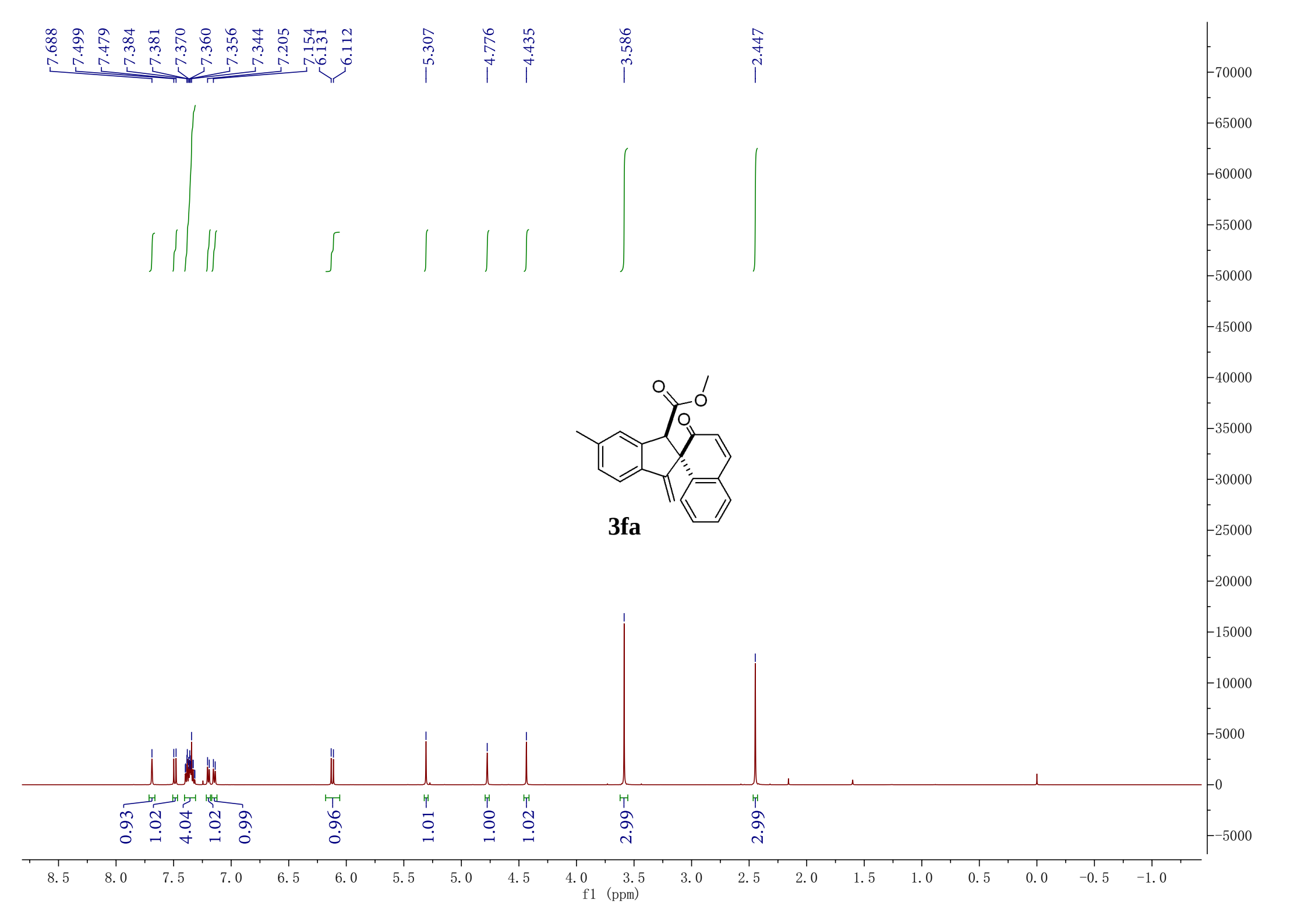

198.341
169.401
160.576
158.582
152.475
152.456
145.760
142.439
142.399
130.750
130.676
129.487
128.976
127.689
127.174
124.502
117.040
116.190
107.378
77.254
77.000
76.746
64.804
60.585
60.566
52.088
F
O
O
O
3da
4500
4000
3500
3000
2500
2000
1500
1000
500
0
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


7.557
7.538
7.461
7.378
7.360
7.345
7.320
7.309
7.307
6.237
6.218
5.565
4.743
4.578
3.627
Cl
O
O
O
1.01
1.04
5.14
1.00
0.97
1.00
0.99
0.98
3.00
f1 (ppm)

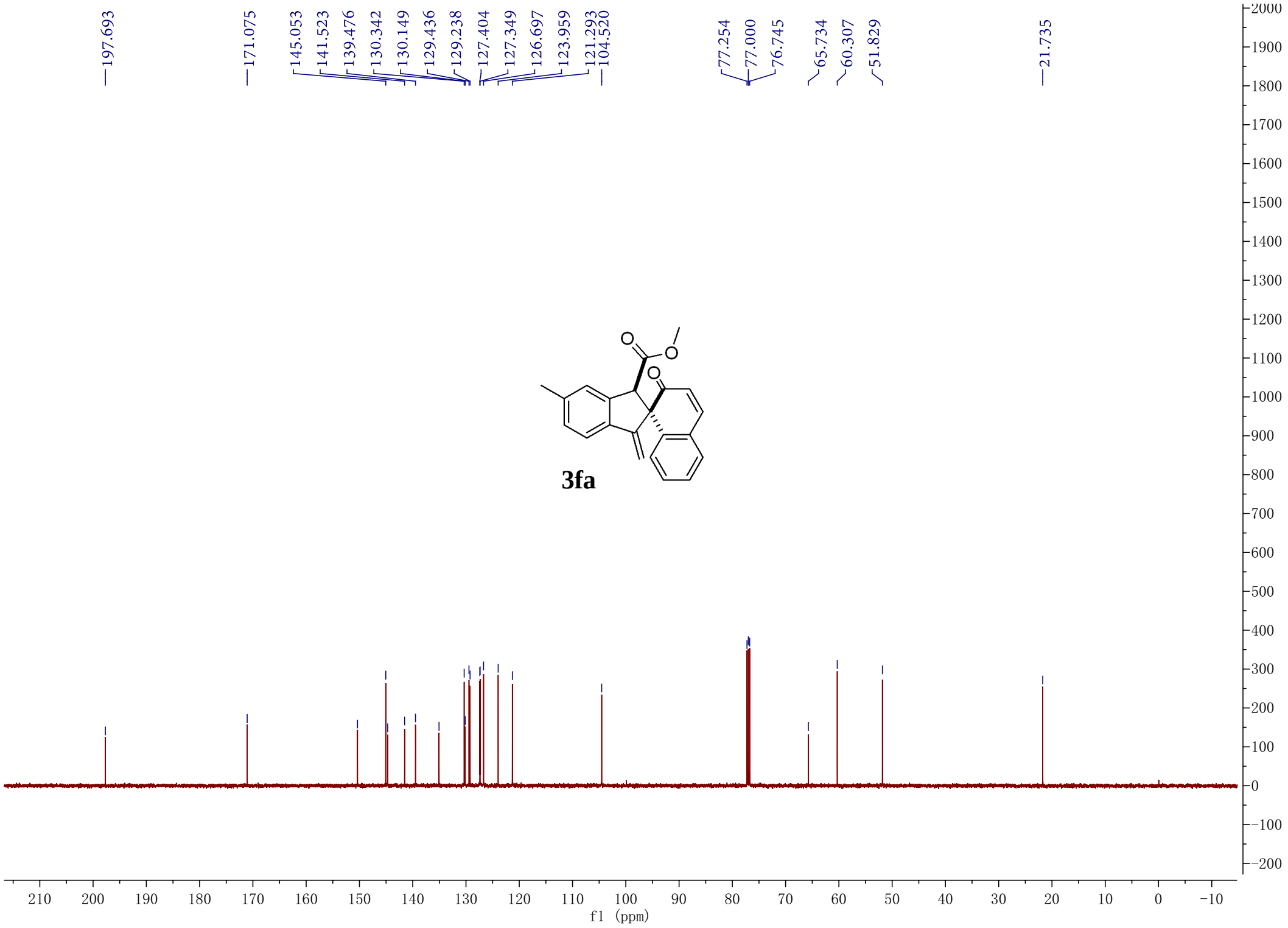
3ea

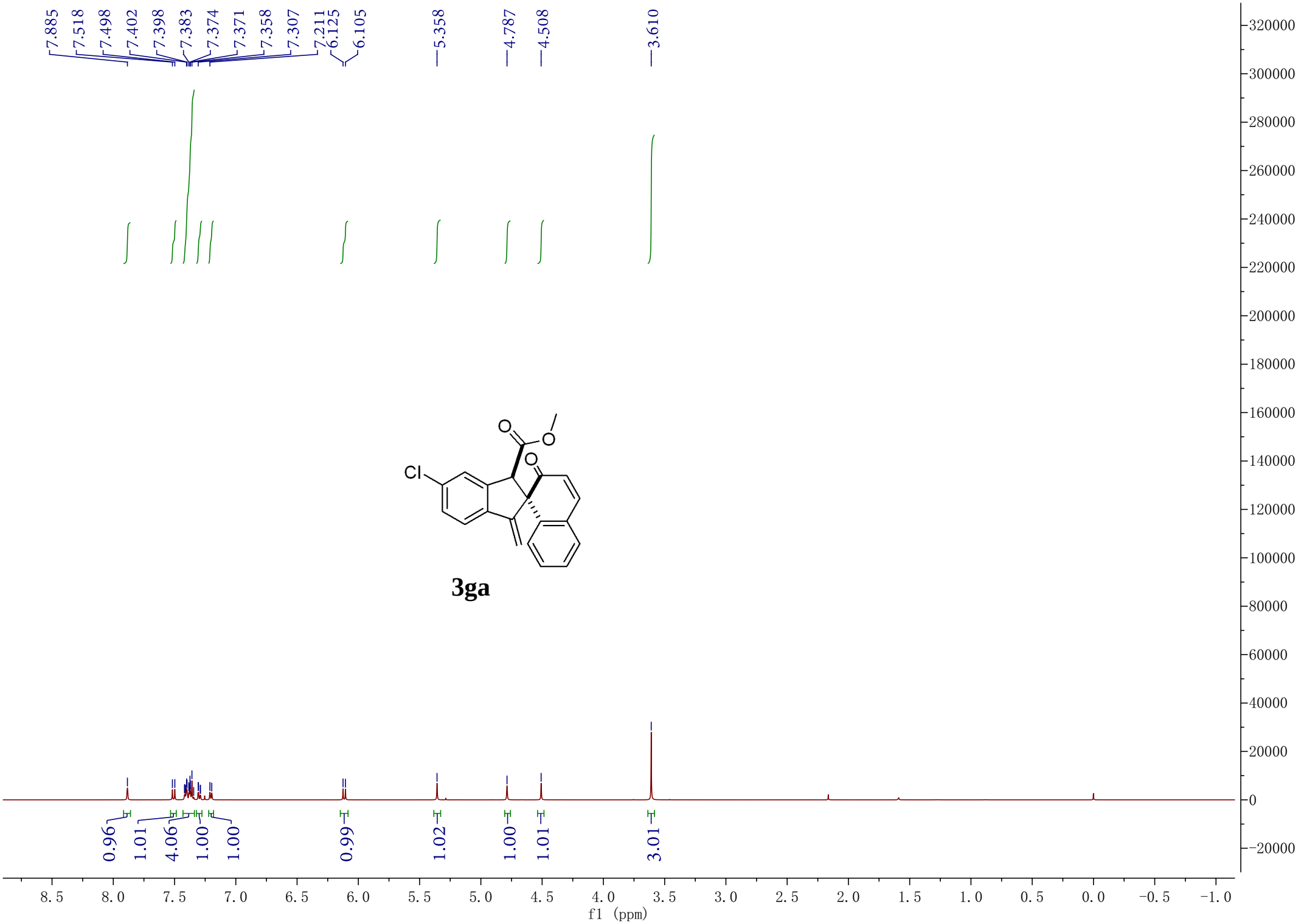

199.049
169.237
153.616
145.783
130.805
130.152
129.747
129.502
127.775
126.710
125.226
119.561
108.000
77.254
77.000
76.746
64.235
63.431
52.242
Cl
O
O
O
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

3ea

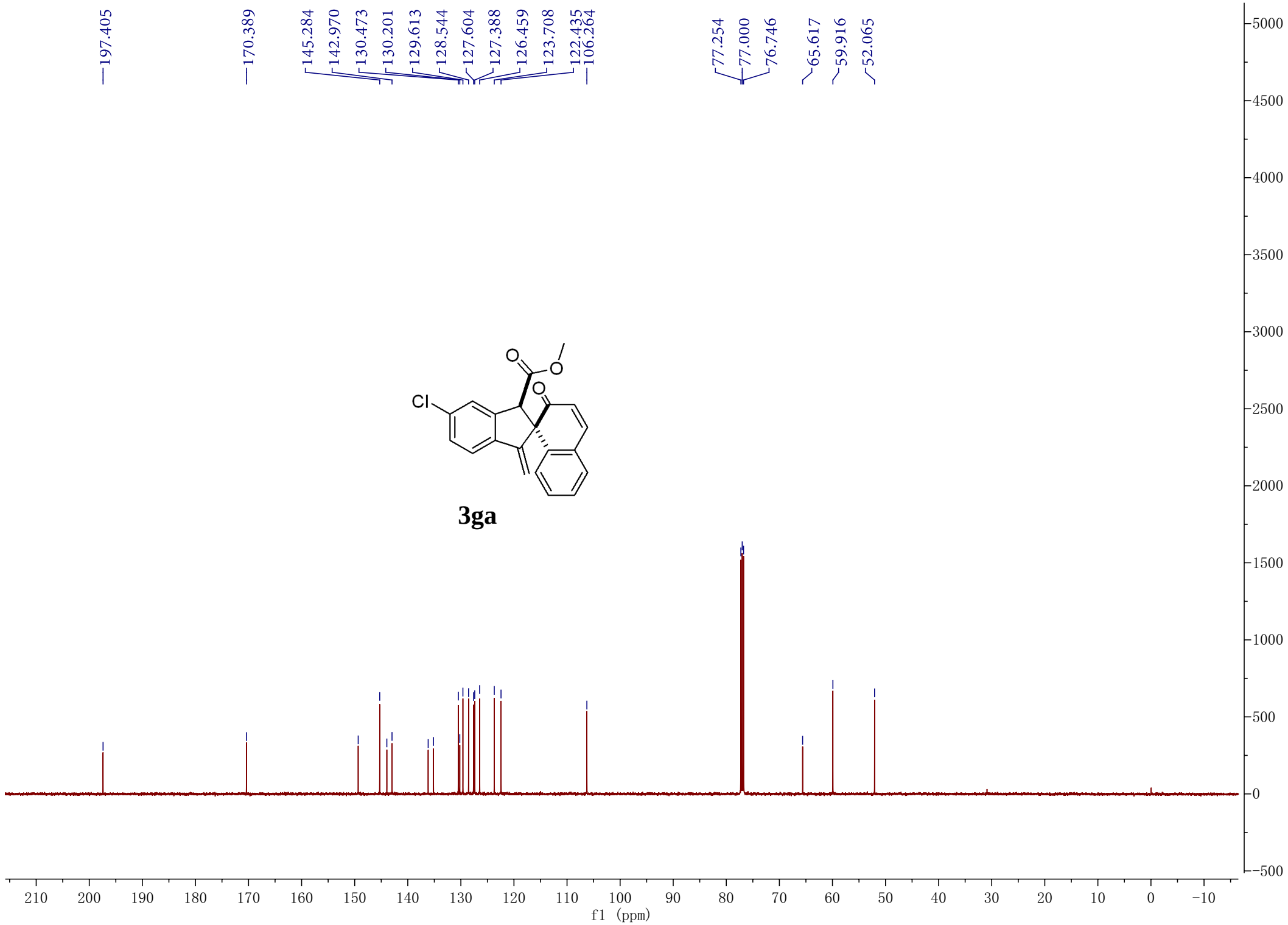

7.688
7.499
7.479
7.384
7.381
7.370
7.360
7.356
7.344
7.205
7.154
6.131
6.112
5.307
4.776
4.435
3.586
2.447
0.93
1.02
4.04
1.02
0.99
0.96
1.01
1.00
1.02
2.99
2.99
f1 (ppm)

3fa

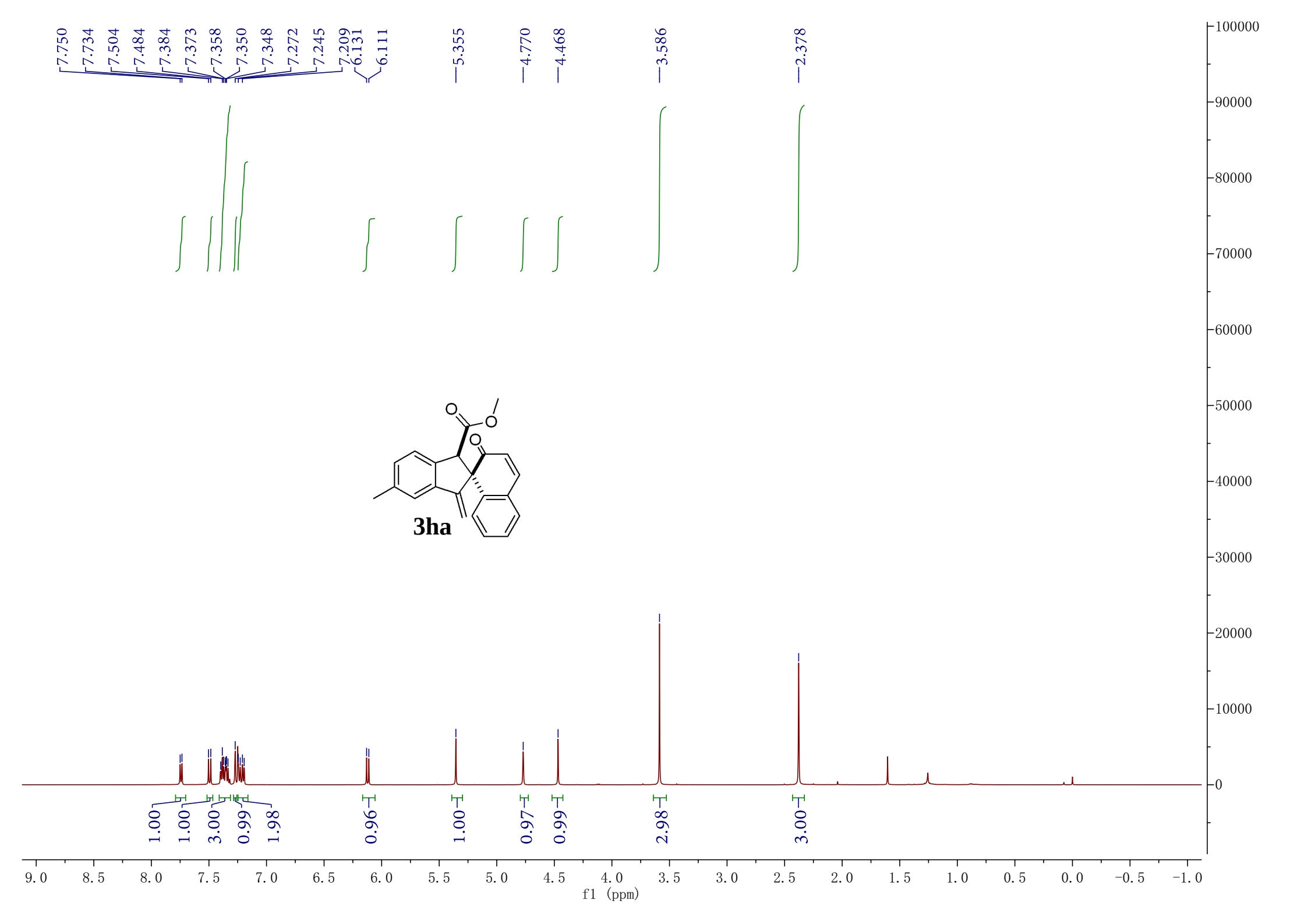

197.693
171.075
145.053
141.523
139.476
130.342
130.149
129.436
129.238
127.404
127.349
126.697
123.959
121.293
104.520
77.254
77.000
76.745
65.734
60.307
51.829
21.735
3fa
f1 (ppm)


7.885
7.518
7.498
7.402
7.398
7.383
7.374
7.371
7.358
7.307
7.211
6.125
6.105
5.358
4.787
4.508
3.610
Cl
O
O
O
0.96
1.01
4.06
1.00
1.00
0.99
1.02
1.00
1.01
3.01
f1 (ppm)

3ga


197.405
170.389
145.284
142.970
130.473
130.201
129.613
128.544
127.604
127.388
126.459
123.708
122.435
106.264
77.254
77.000
76.746
65.617
59.916
52.065
Cl
O
O
O
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
−500
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)

3ga


7.750
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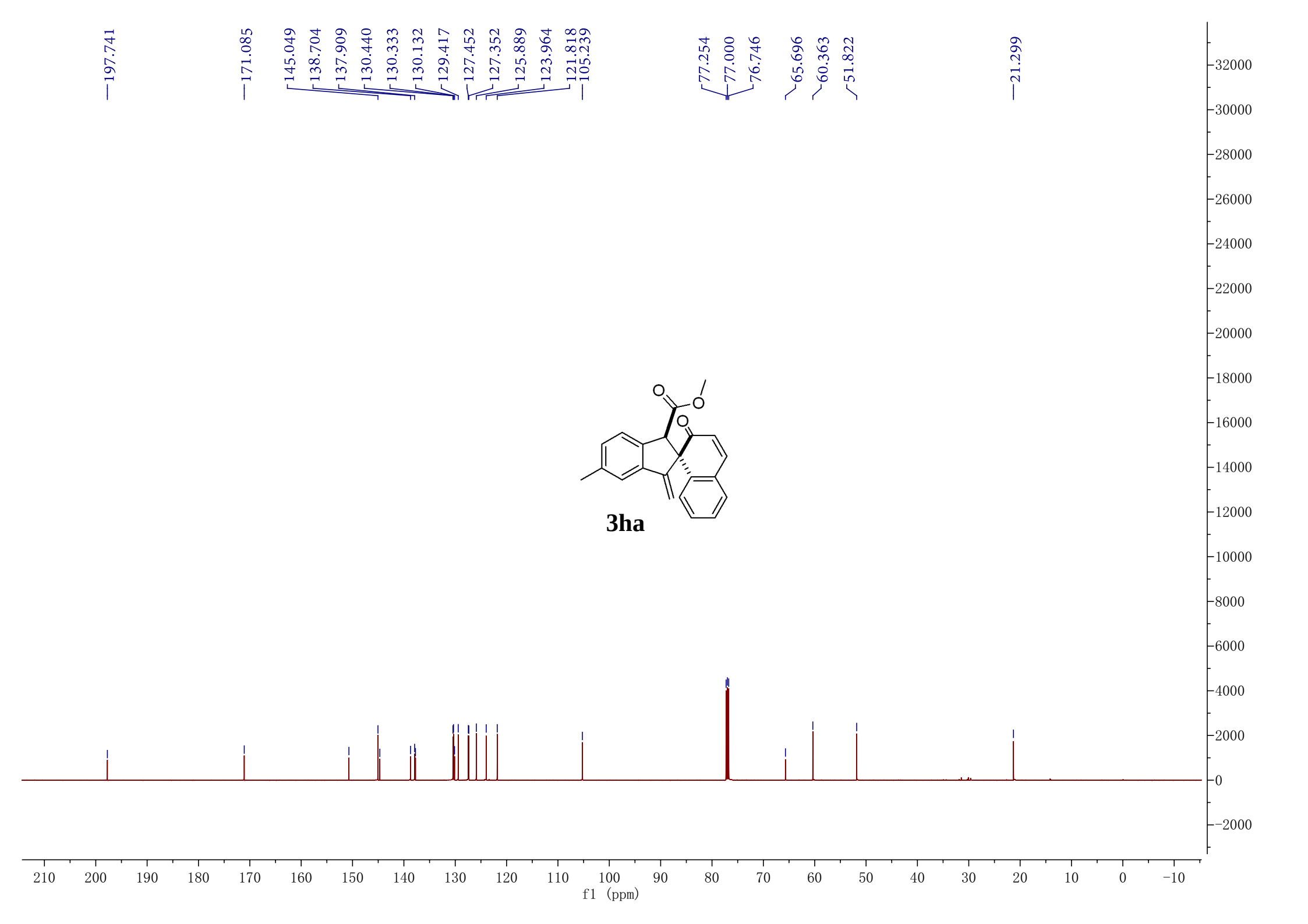
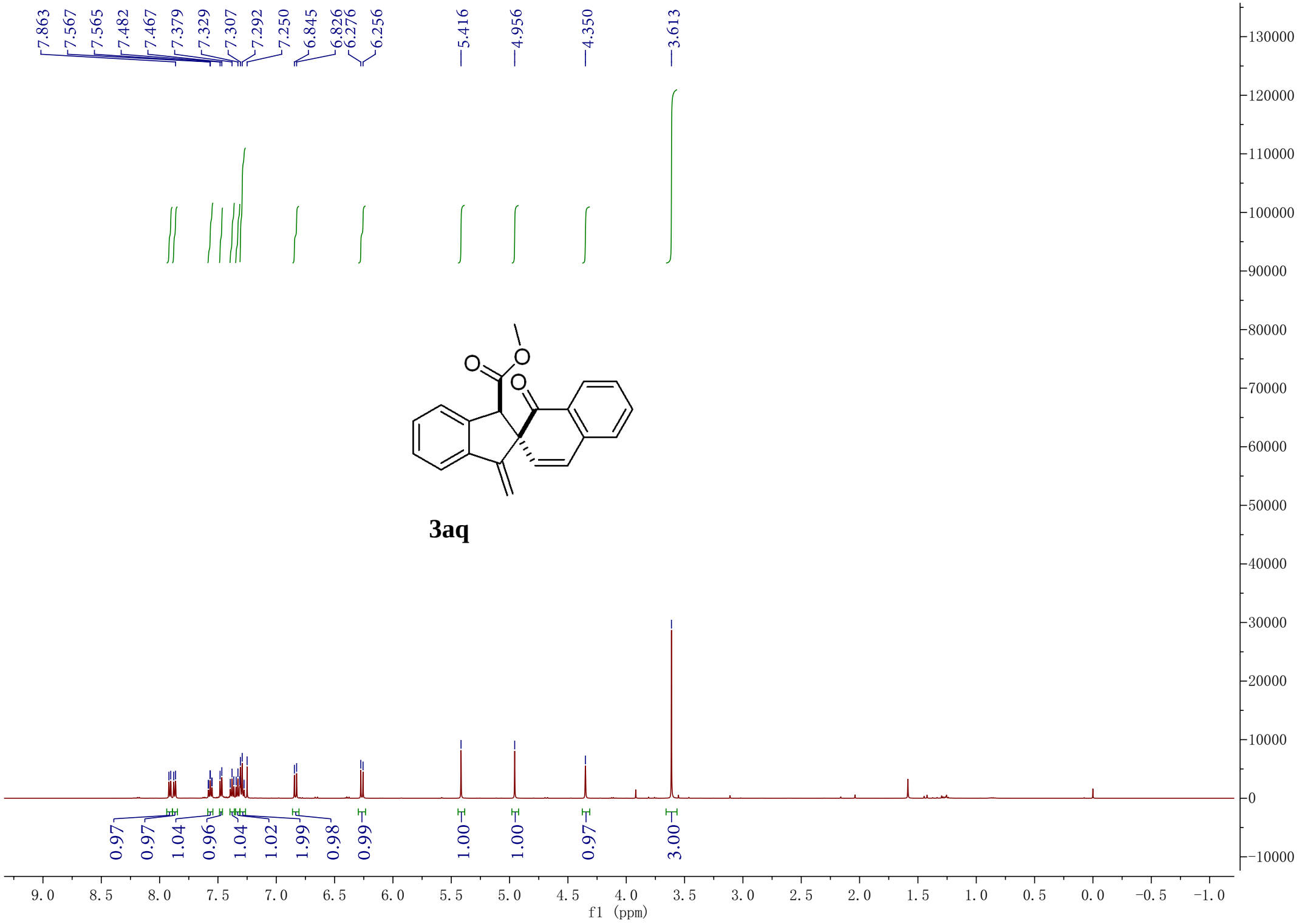
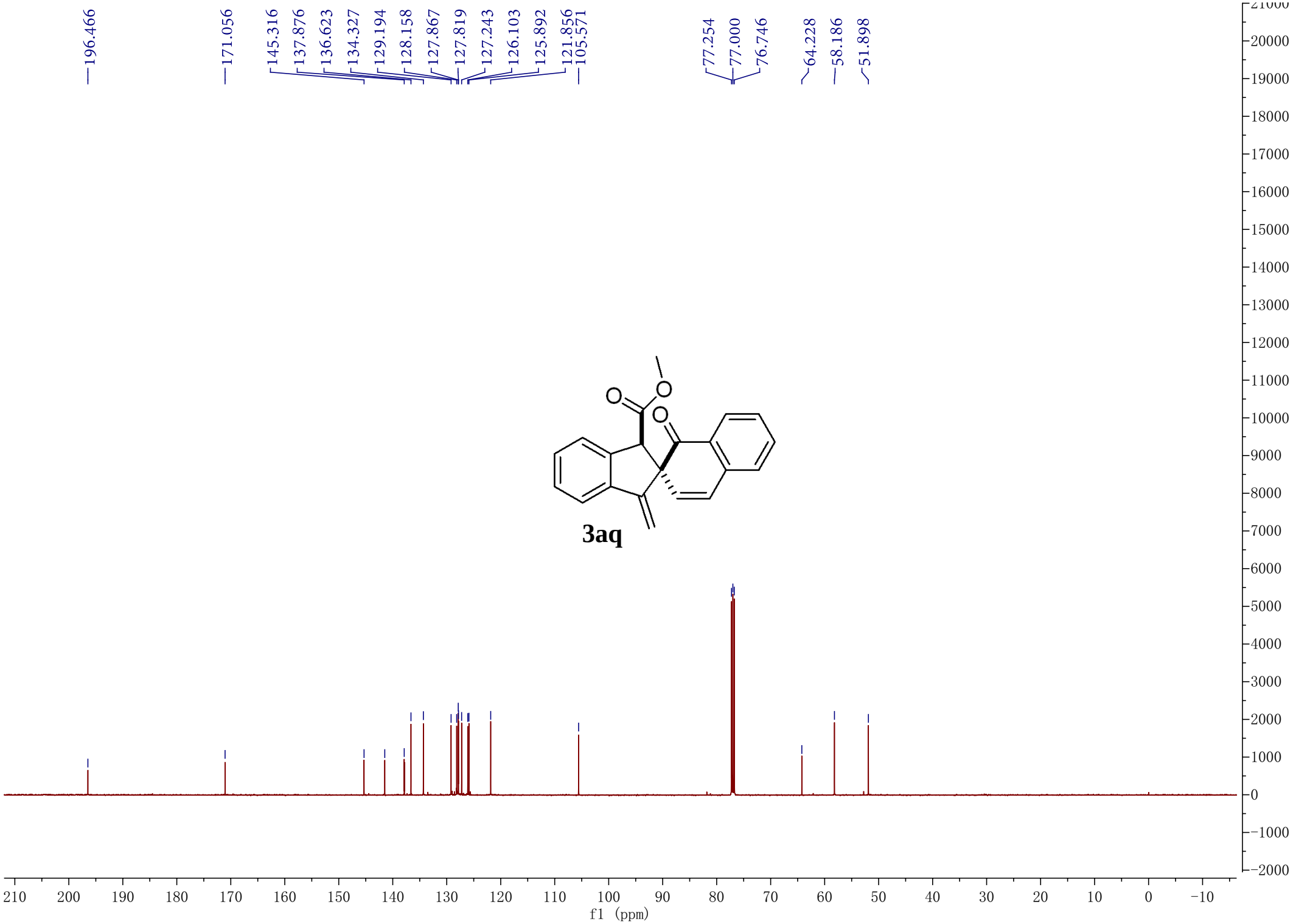
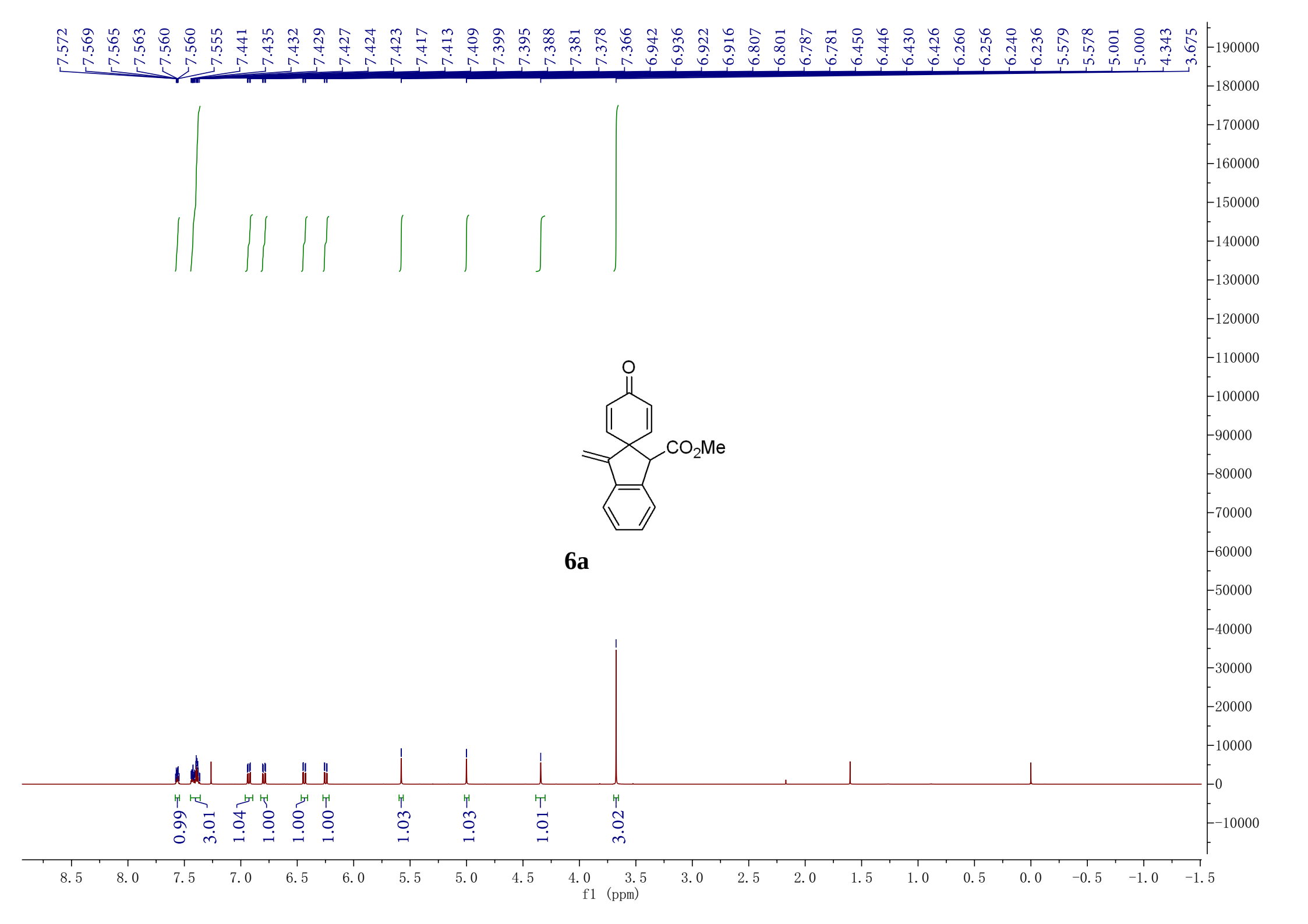
7.504
7.484
7.384
7.373
7.358
7.350
7.348
7.272
7.245
7.209
6.131
6.111
5.355
4.770
4.468
3.586
2.378
3ha
1.00
1.00
3.00
0.99
1.98
0.96
1.00
0.97
0.99
2.98
3.00
f1 (ppm)


197.741
171.085
145.049
138.704
137.909
130.440
130.333
130.132
129.417
127.452
127.352
125.889
123.964
121.818
105.239
77.254
77.000
76.746
65.696
60.363
51.822
21.299
3ha
f1 (ppm)

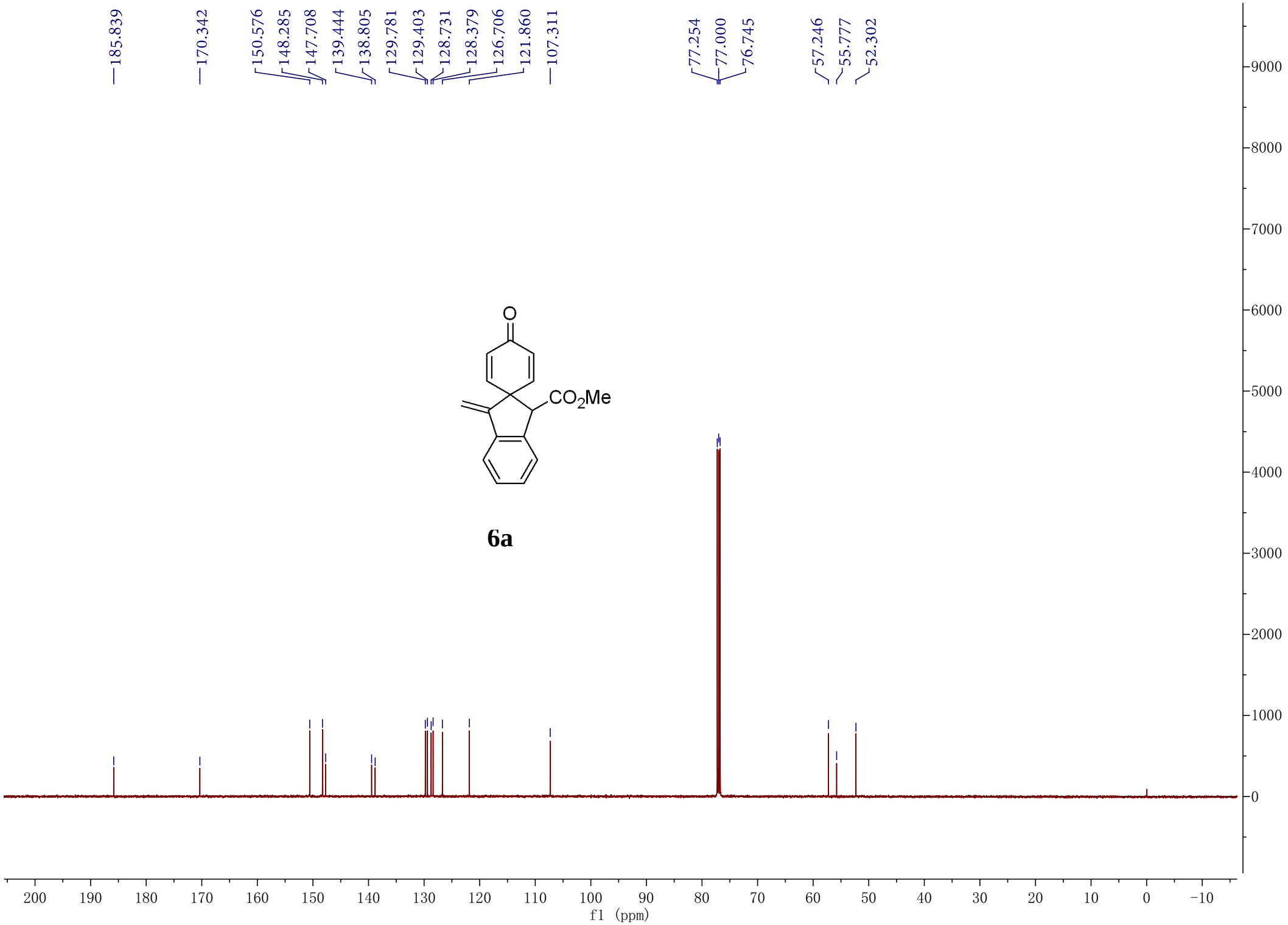

7.863
7.567
7.565
7.482
7.467
7.379
7.329
7.307
7.292
7.250
6.845
6.826
6.276
6.256
5.416
4.956
4.350
3.613
0.97
0.97
1.04
0.96
1.04
1.02
1.99
0.98
0.99
1.00
1.00
0.97
3.00
f1 (ppm)

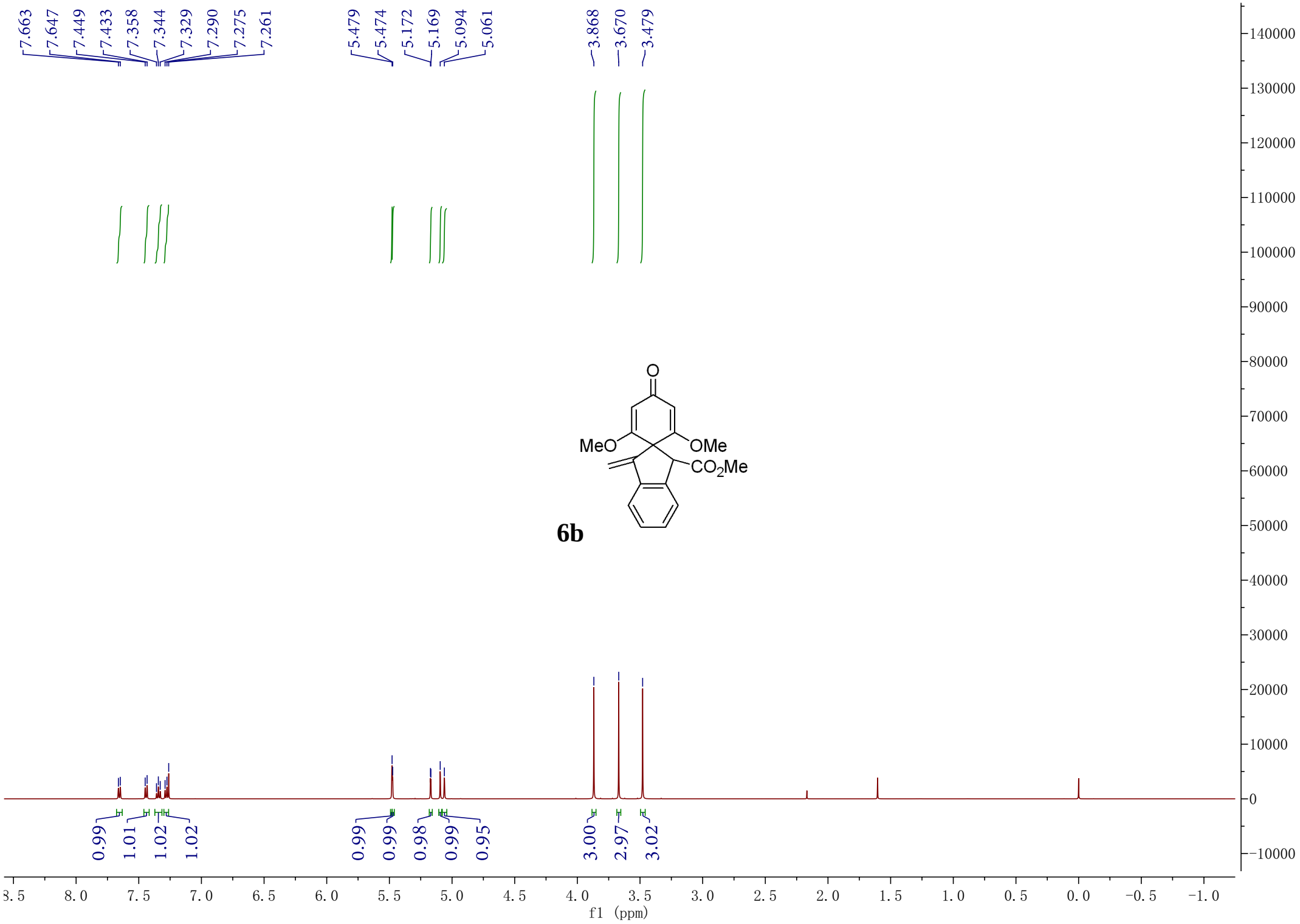
3aq


196.466
171.056
145.316
137.876
136.623
134.327
129.194
128.158
127.867
127.819
127.243
126.103
125.892
121.856
105.571
77.254
77.000
76.746
64.228
58.186
51.898
3aq
f1 (ppm)


7.572
7.569
7.565
7.563
7.560
7.560
7.555
7.441
7.435
7.432
7.429
7.427
7.424
7.423
7.417
7.413
7.409
7.399
7.395
7.388
7.381
7.378
7.366
6.942
6.936
6.922
6.916
6.807
6.801
6.787
6.781
6.450
6.446
6.430
6.426
6.260
6.256
6.240
6.236
5.579
5.578
5.001
5.000
4.343
3.675
O
CO2Me
0.99
3.01
1.04
1.00
1.00
1.00
1.03
1.03
1.01
3.02
f1 (ppm)

6a


185.839
170.342
150.576
148.285
147.708
139.444
138.805
129.781
129.403
128.731
128.379
126.706
121.860
107.311
77.254
77.000
76.745
57.246
55.777
52.302
O
CO2Me
6a
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)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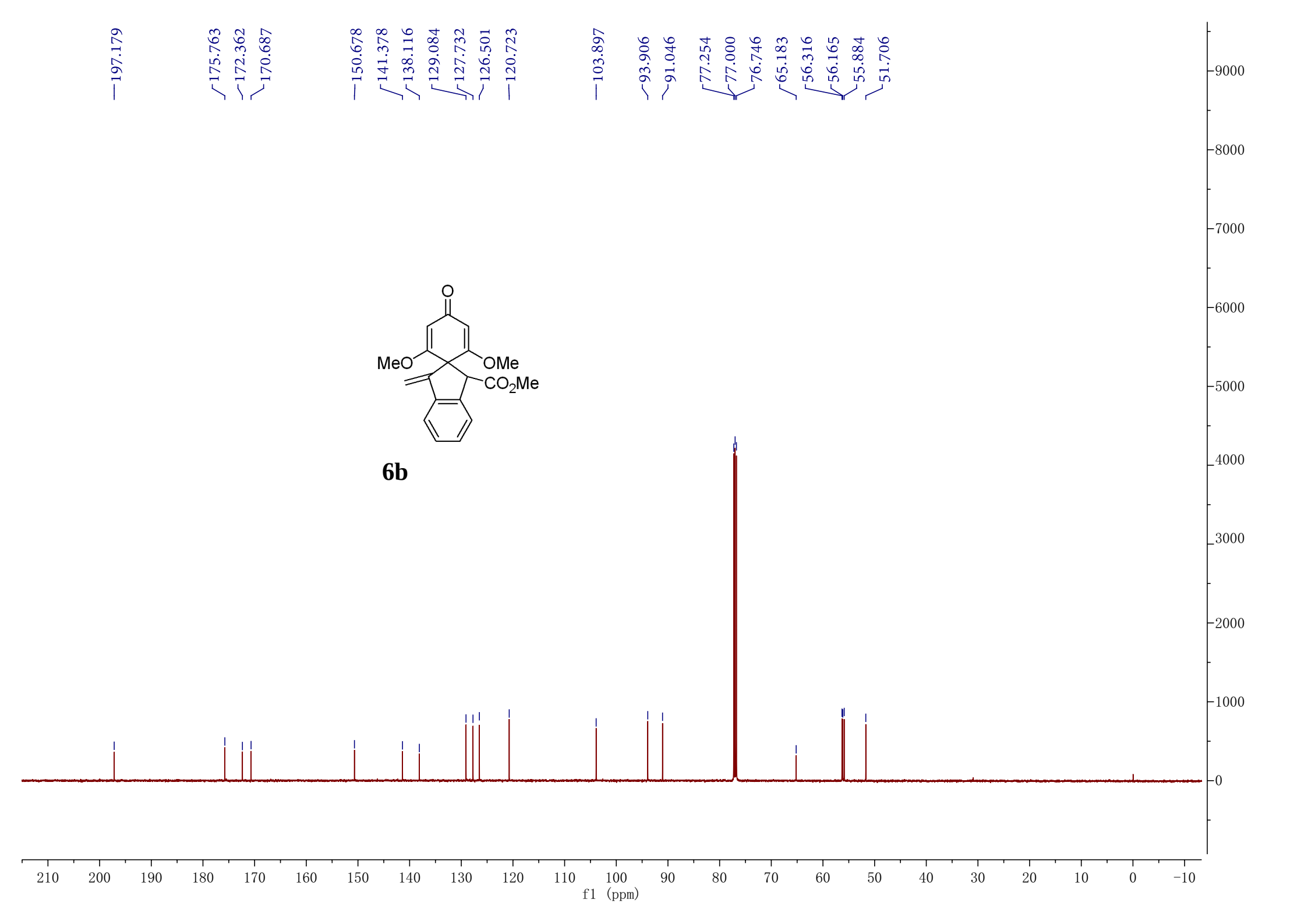
7.647
7.449
7.433
7.358
7.344
7.329
7.290
7.275
7.261
5.479
5.474
5.172
5.169
5.094
5.061
3.868
3.670
3.479
MeO
OMe
CO2Me
6b
0.99
1.01
1.02
1.02
0.99
0.99
0.98
0.99
0.95
3.00
2.97
3.02
f1 (ppm)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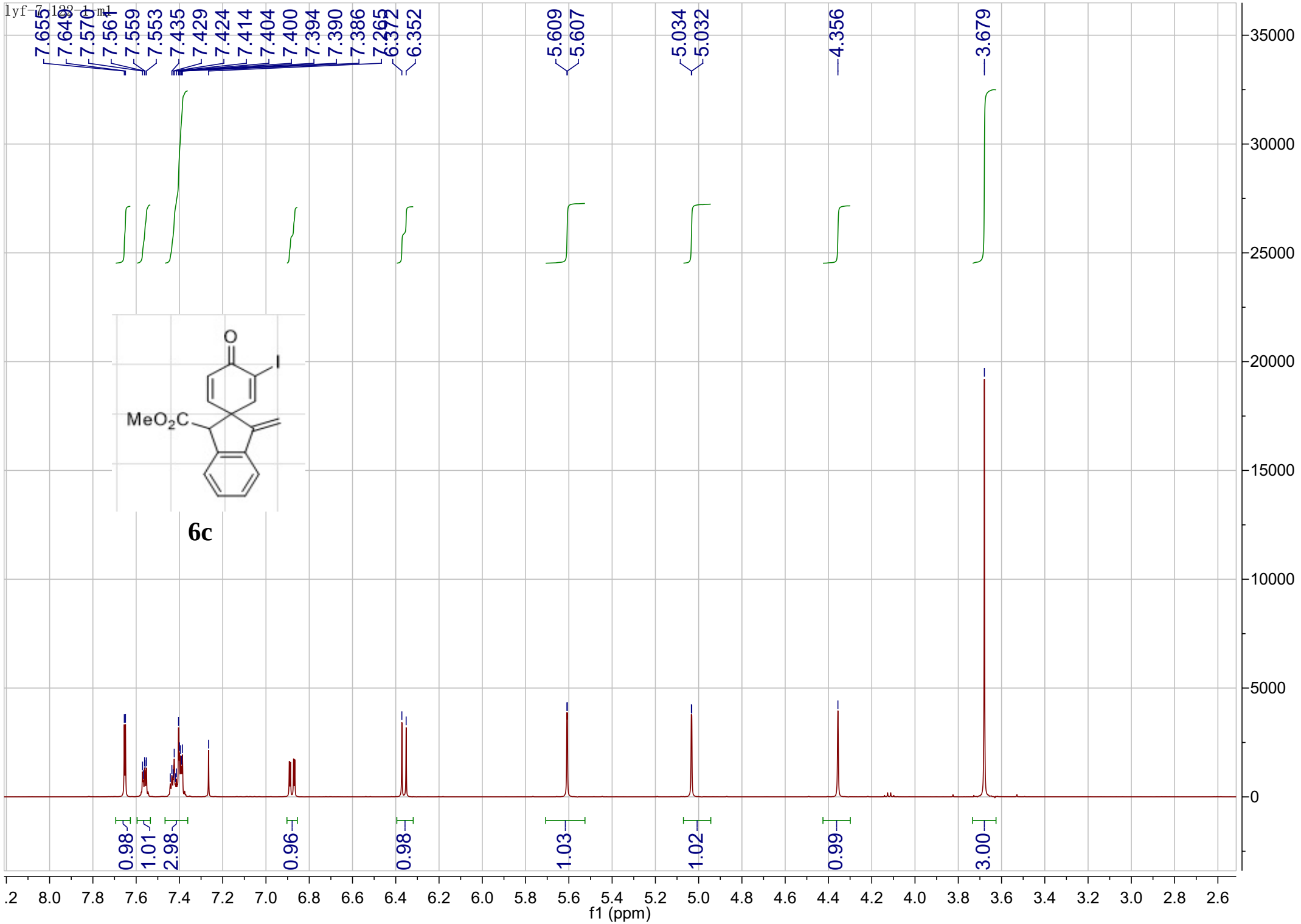
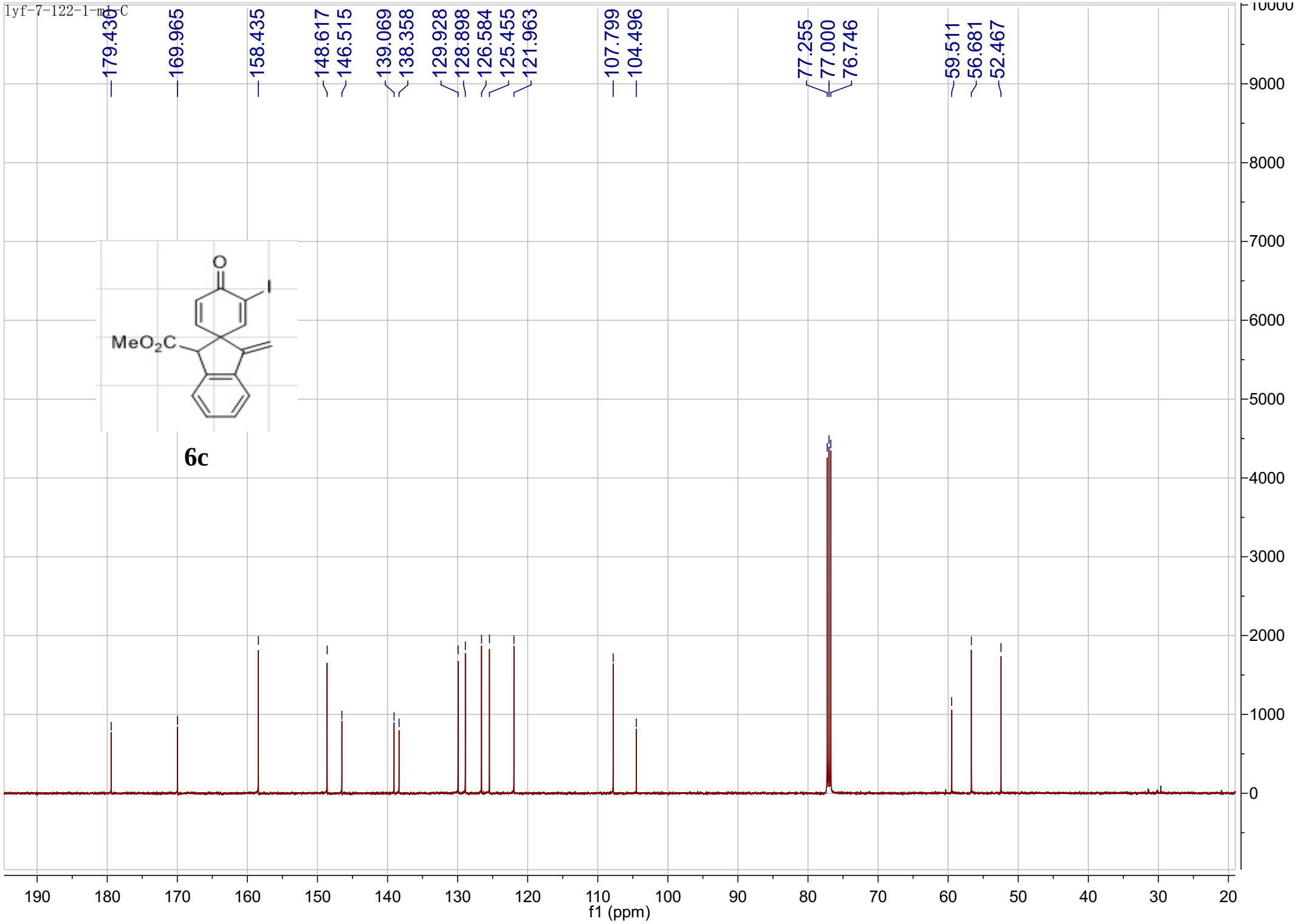
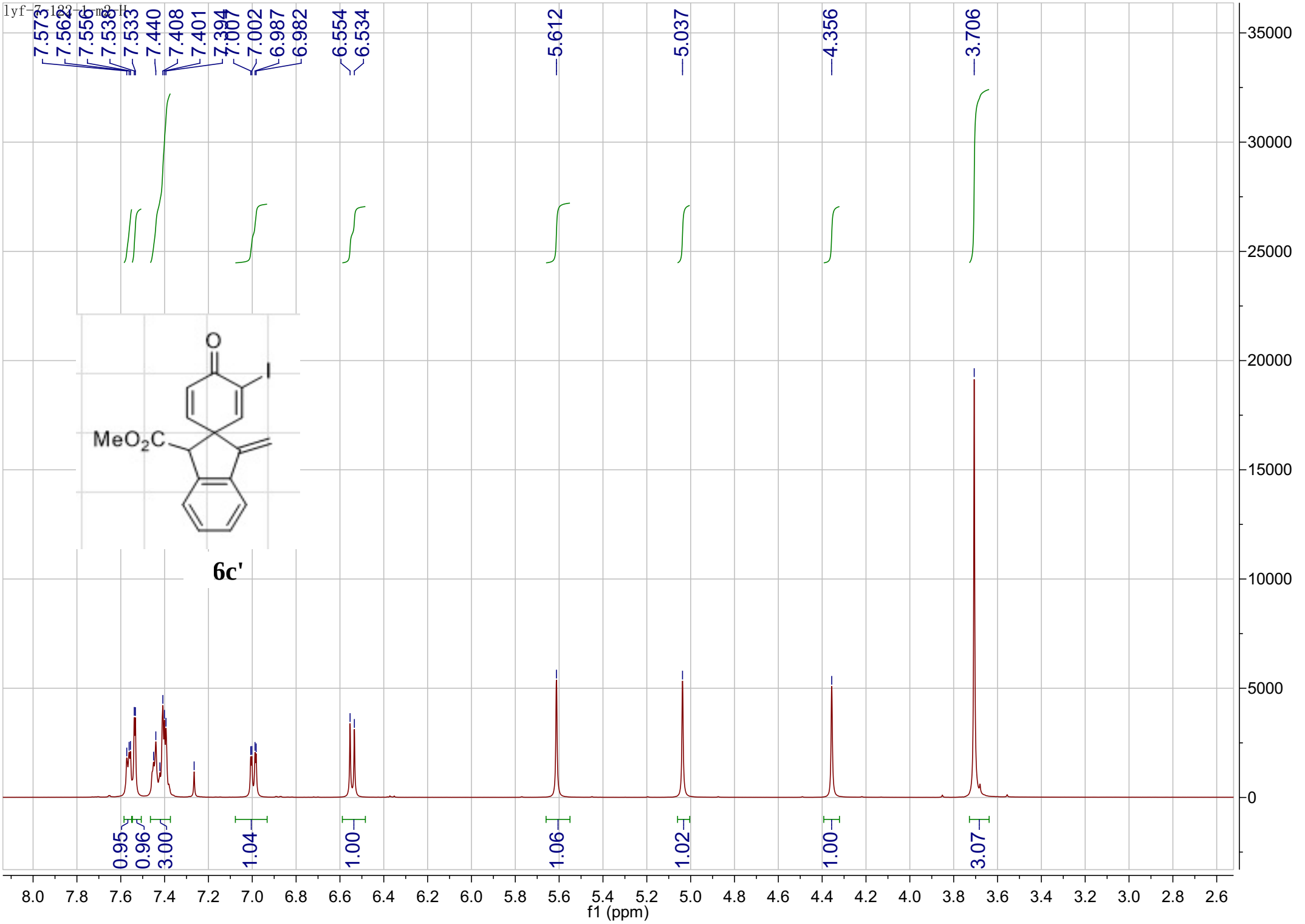
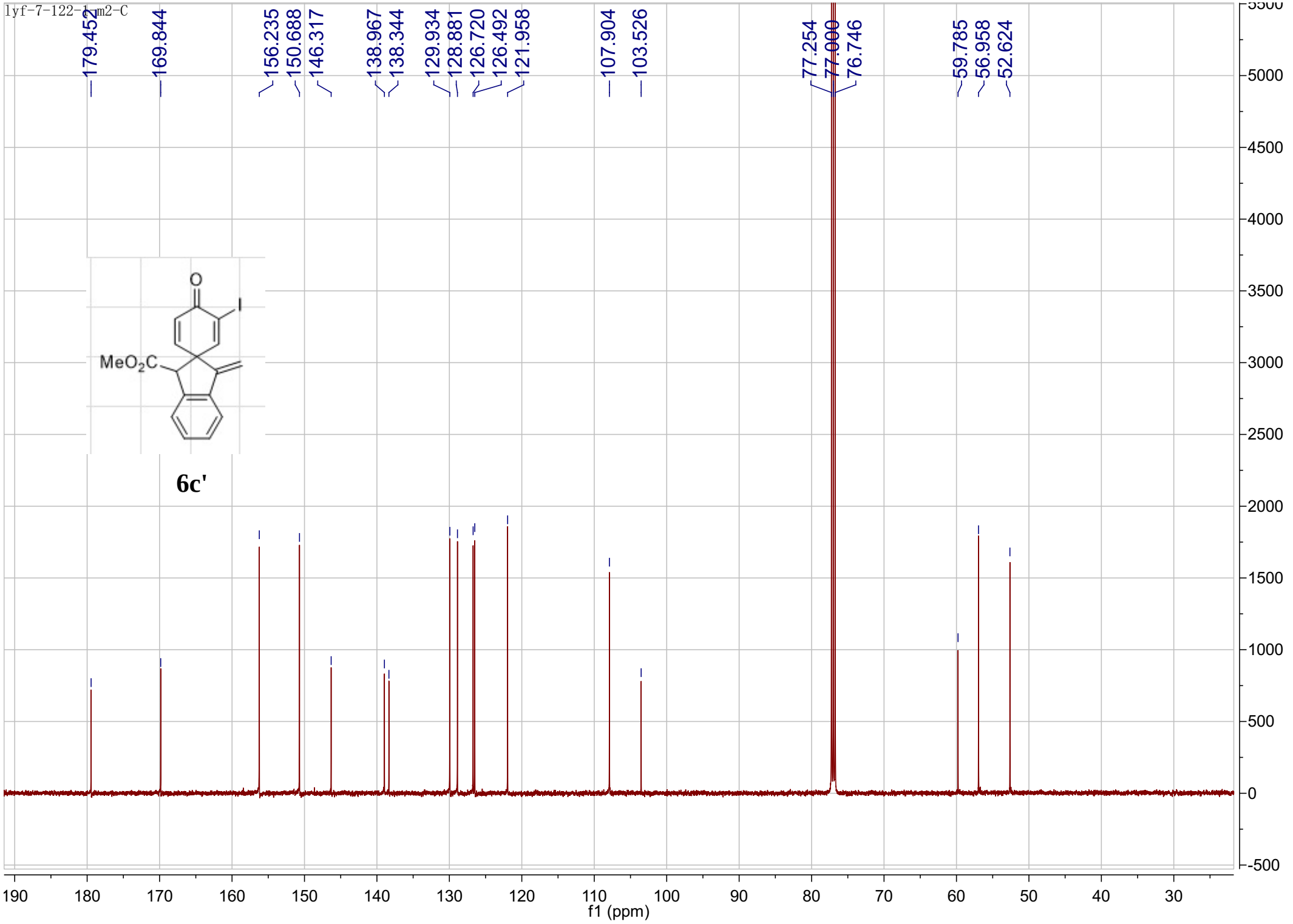
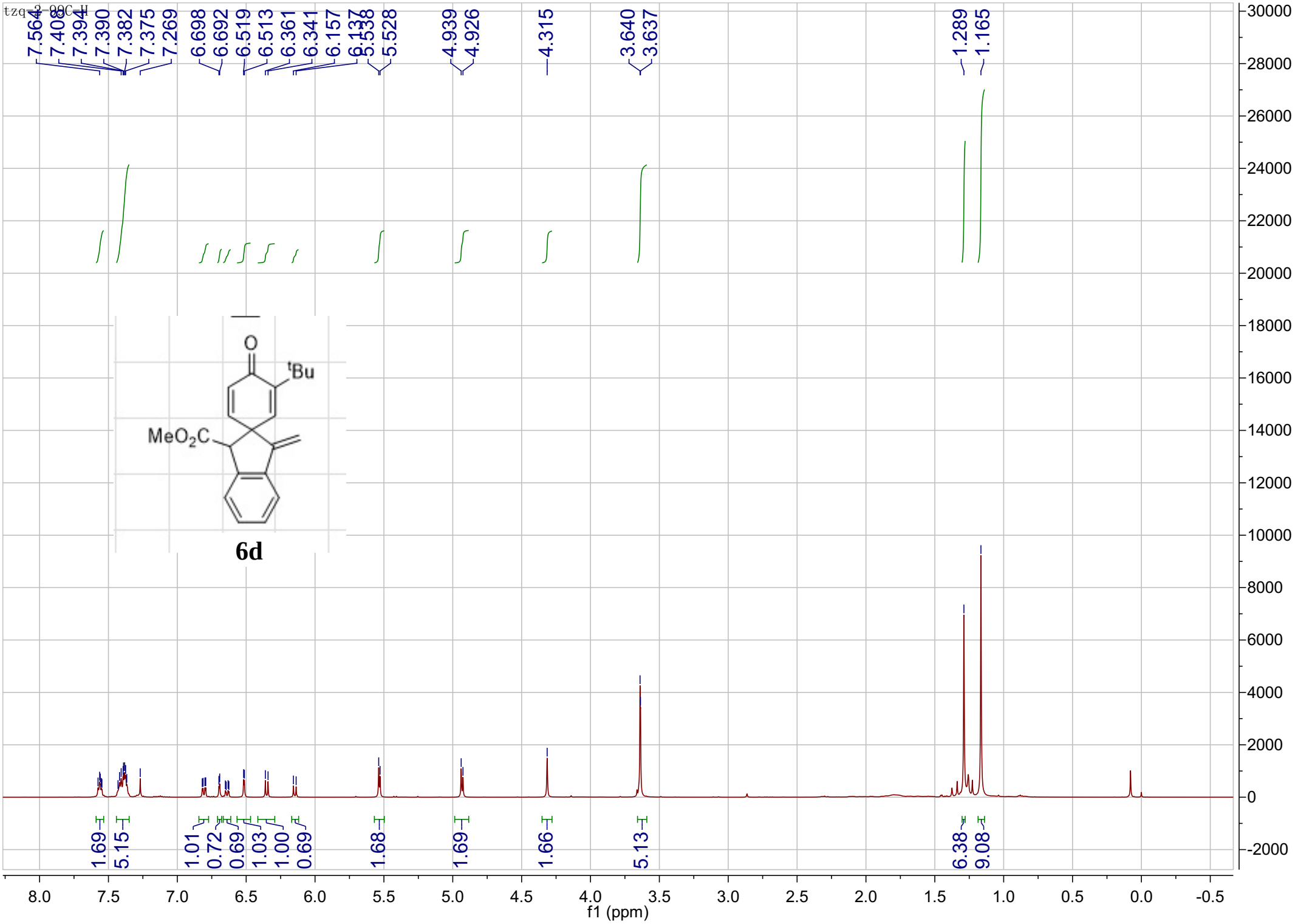
175.763
172.362
170.687
150.678
141.378
138.116
129.084
127.732
126.501
120.723
103.897
93.906
91.046
77.254
77.000
76.746
65.183
56.316
56.165
55.884
51.706
O
MeO
OMe
CO2Me
6b
f1 (ppm)

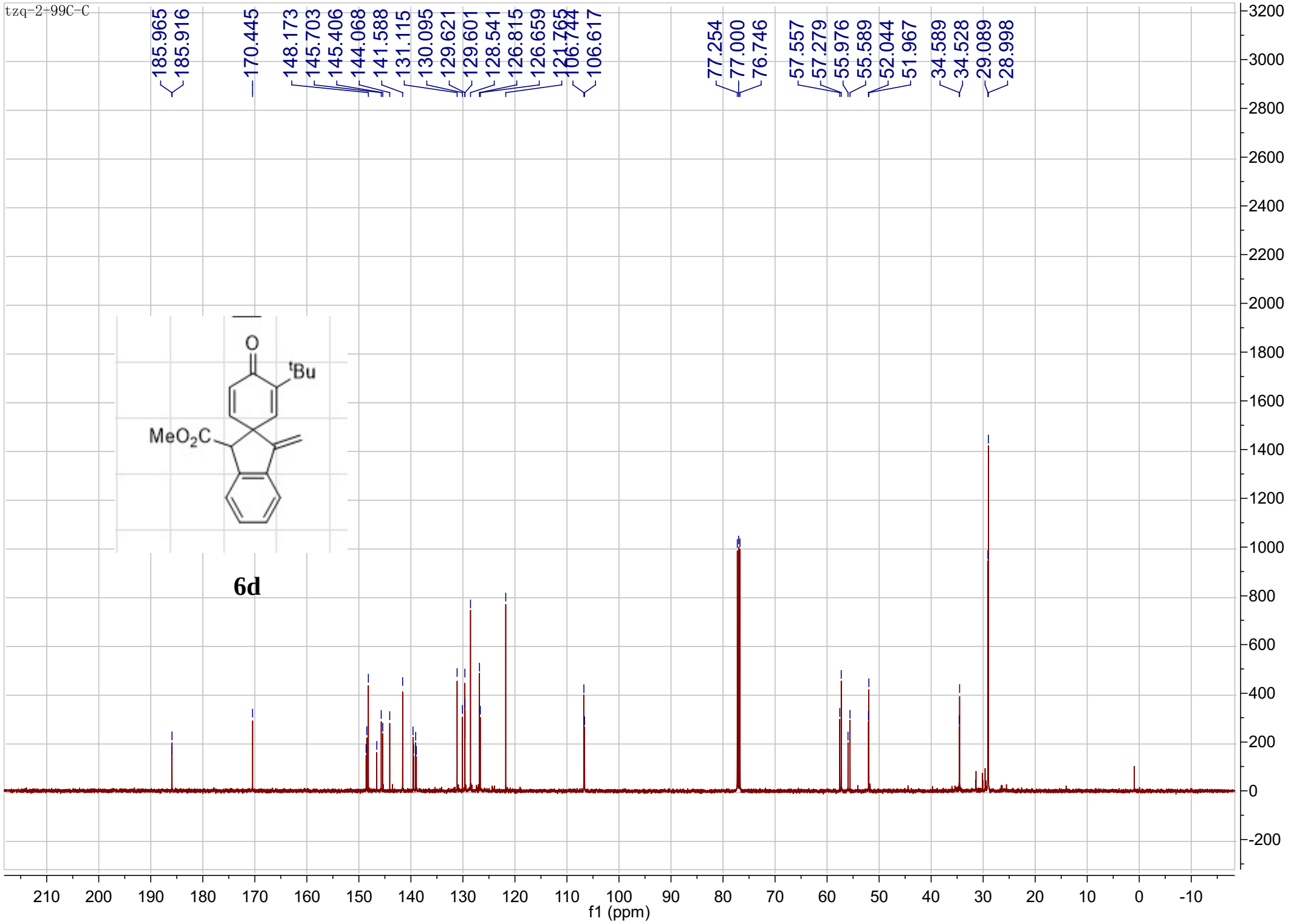

lyf-7-123-1-ml
7.655
7.643
7.570
7.561
7.559
7.553
7.435
7.429
7.424
7.414
7.404
7.400
7.394
7.390
7.386
7.265
7.372
6.352
5.609
5.607
5.034
5.032
4.356
3.679
O
I
MeO2C
6c
0.98
1.01
2.98
0.96
0.98
1.03
1.02
0.99
3.00
35000
30000
25000
20000
15000
10000
5000
0
.2 8.0 7.8 7.6 7.4 7.2 7.0 6.8 6.6 6.4 6.2 6.0 5.8 5.6 5.4 5.2 5.0 4.8 4.6 4.4 4.2 4.0 3.8 3.6 3.4 3.2 3.0 2.8 2.6
f1 (ppm)

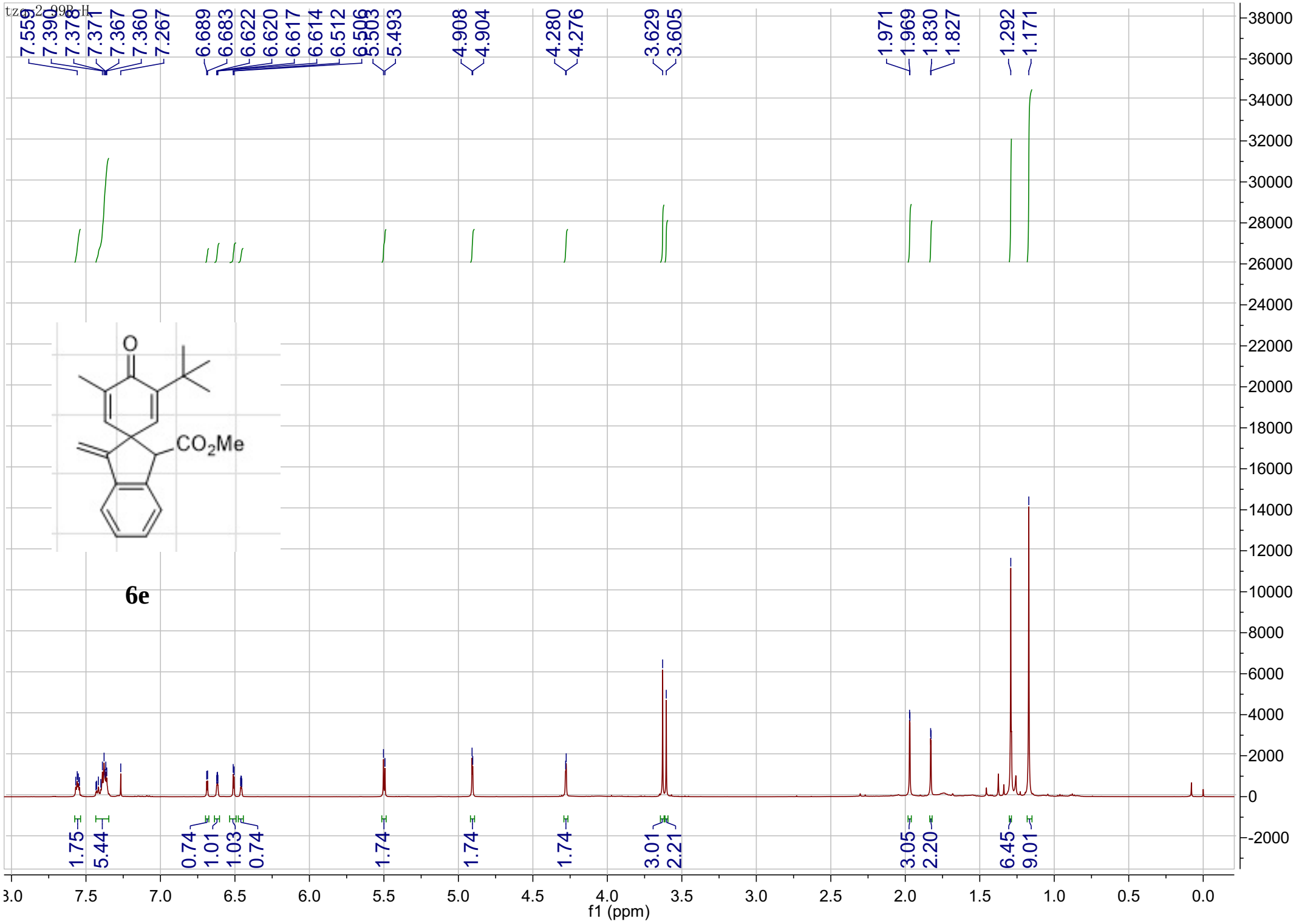

lyf-7-122-1-m1-C
179.430
169.965
158.435
148.617
146.515
139.069
138.358
129.928
128.898
126.584
125.455
121.963
107.799
104.496
77.255
77.000
76.746
59.511
56.681
52.467
O
I
MeO2C
6c
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
f1 (ppm)

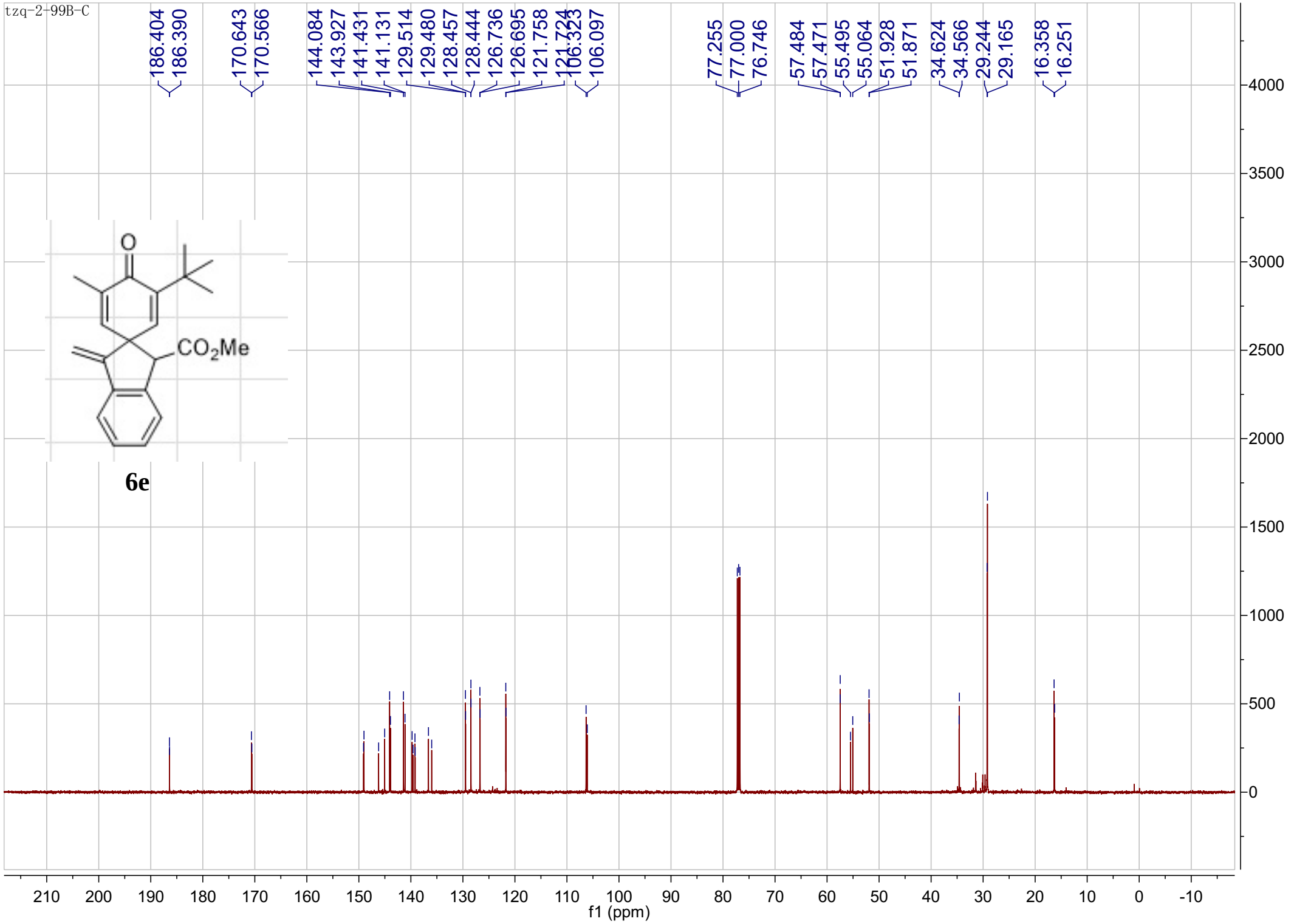

lyf-7-122-1-m2-H
7.573
7.564
7.556
7.538
7.533
7.440
7.408
7.401
7.394
7.007
7.002
6.987
6.982
6.554
6.534
5.612
5.037
4.356
3.706
O
I
MeO2C
6c'
0.95
0.96
3.00
1.04
1.00
1.06
1.02
1.00
3.07
35000
30000
25000
20000
15000
10000
5000
0
8.0
7.8
7.6
7.4
7.2
7.0
6.8
6.6
6.4
6.2
6.0
5.8
5.6
5.4
5.2
5.0
4.8
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
f1 (ppm)


lyf-7-122-1-m2-C
179.452
169.844
156.235
150.688
146.317
138.967
138.344
129.934
128.881
126.720
126.492
121.958
107.904
103.526
77.254
77.000
76.746
59.785
56.958
52.624
O
I
MeO2C
6c'
f1 (ppm)


tzq-3-09C-H
7.564
7.408
7.394
7.390
7.382
7.375
7.269
6.698
6.692
6.519
6.513
6.361
6.341
6.157
6.137
5.538
5.528
4.939
4.926
4.315
3.640
3.637
1.289
1.165
O
tBu
MeO2C
6d
1.69
5.15
1.01
0.72
0.69
1.03
1.00
0.69
1.68
1.69
1.66
5.13
6.38
9.08
f1 (ppm)


tzq-2-99C-C
185.965
185.916
170.445
148.173
145.703
145.406
144.068
141.588
131.115
130.095
129.621
129.601
128.541
126.815
126.659
121.765
106.744
106.617
77.254
77.000
76.746
57.557
57.279
55.976
55.589
52.044
51.967
34.589
34.528
29.089
28.998
O
tBu
MeO2C
6d
f1 (ppm)


7.559
7.390
7.378
7.371
7.367
7.360
7.267
6.689
6.683
6.622
6.620
6.617
6.614
6.512
6.506
6.503
5.493
4.908
4.904
4.280
4.276
3.629
3.605
1.971
1.969
1.830
1.827
1.292
1.171
O
CO2Me
6e
1.75
5.44
0.74
1.01
1.03
0.74
1.74
1.74
1.74
3.01
2.21
3.05
2.20
6.45
9.01
f1 (ppm)


tzq-2-99B-C
186.404
186.390
170.643
170.566
144.084
143.927
141.431
141.131
129.514
129.480
128.457
128.444
126.736
126.695
121.758
121.724
106.323
106.097
77.255
77.000
76.746
57.484
57.471
55.495
55.064
51.928
51.871
34.624
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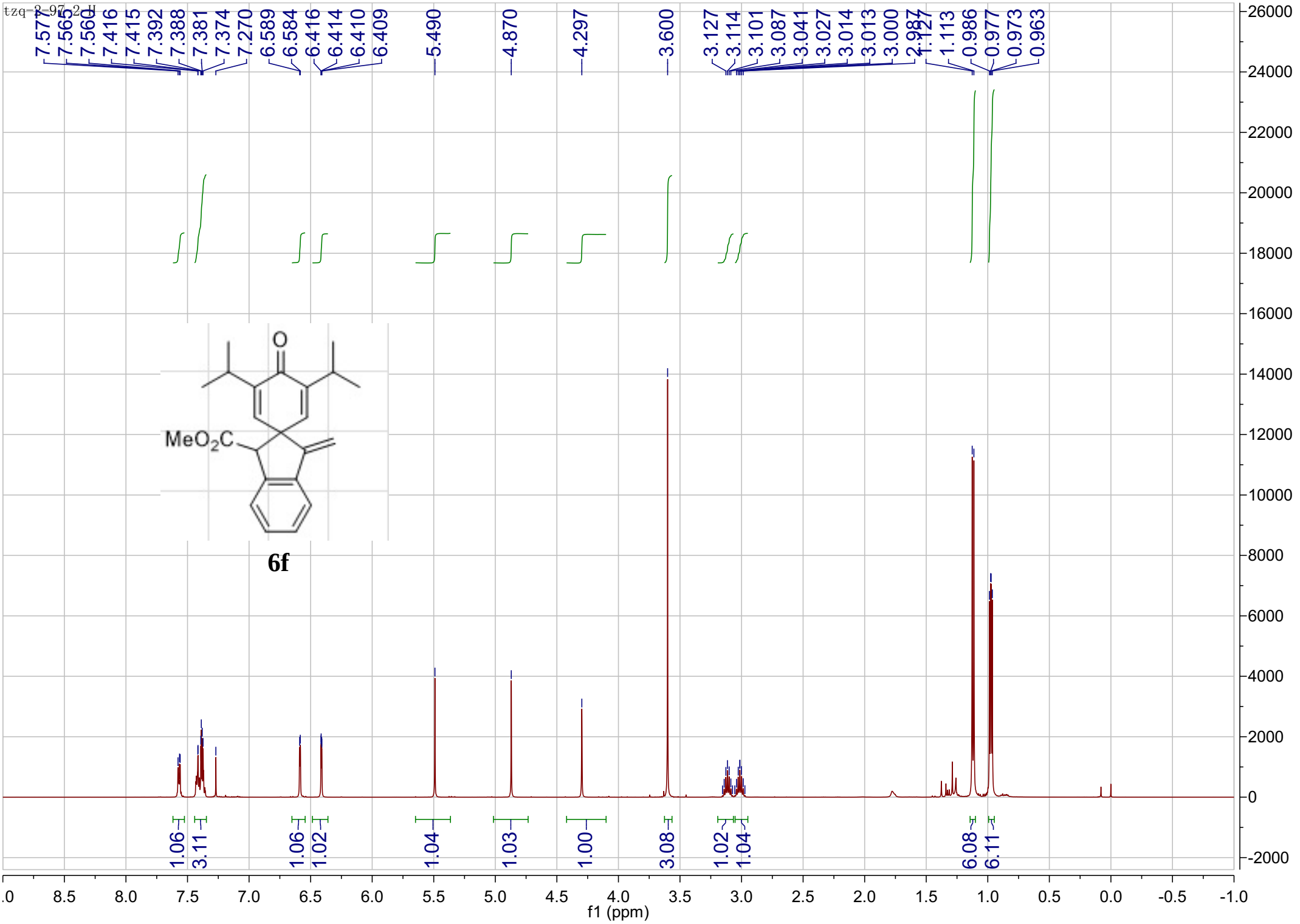
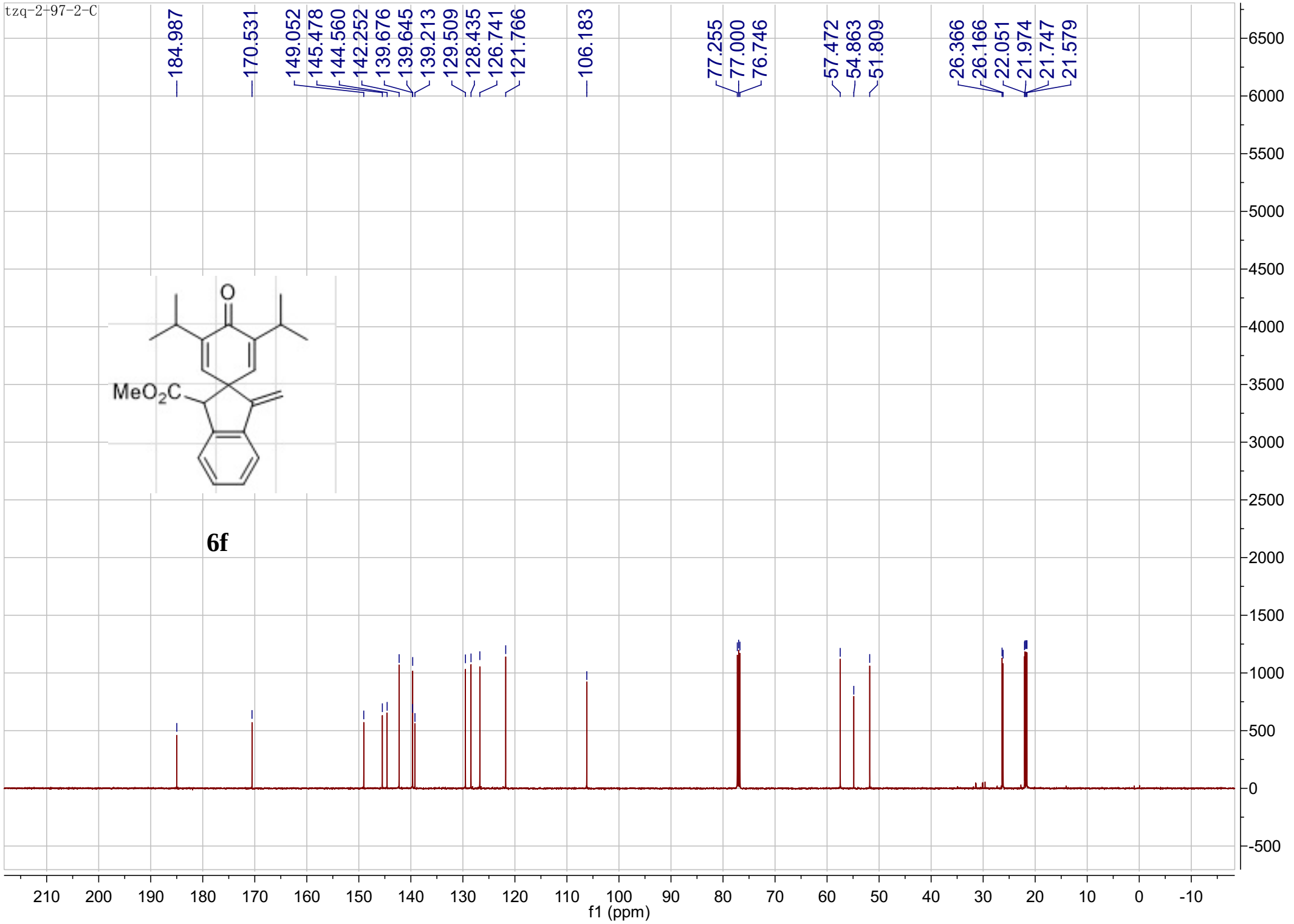
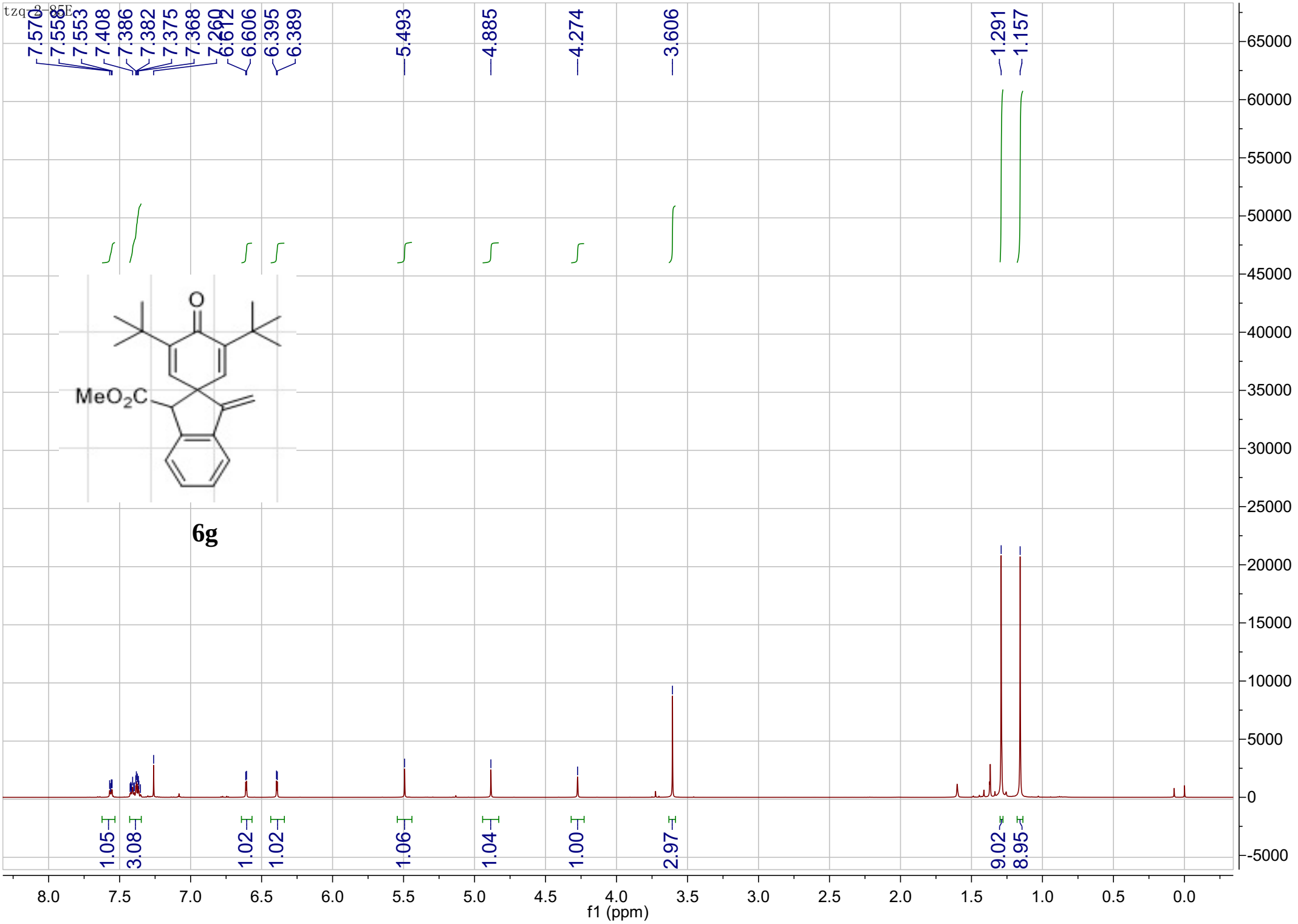
16.358
16.251
O
CO2Me
6e
f1 (ppm)


tzq-3-97-2-H
7.577
7.565
7.560
7.416
7.415
7.392
7.388
7.381
7.374
7.270
6.589
6.584
6.416
6.414
6.410
6.409
5.490
4.870
4.297
3.600
3.127
3.114
3.101
3.087
3.041
3.027
3.014
3.013
3.000
2.987
2.127
1.113
0.986
0.977
0.973
0.963
O
MeO2C
1.06
3.11
1.06
1.02
1.04
1.03
1.00
3.08
1.02
1.04
6.08
6.11
f1 (ppm)

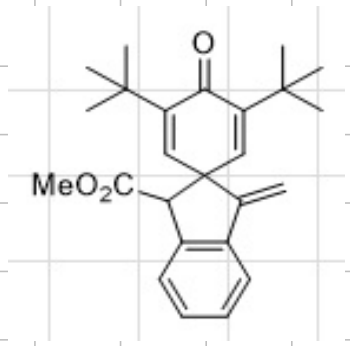
6f


tzq-2-97-2-C
184.987
170.531
149.052
145.478
144.560
142.252
139.676
139.645
139.213
129.509
128.435
126.741
121.766
106.183
77.255
77.000
76.746
57.472
54.863
51.809
26.366
26.166
22.051
21.974
21.747
21.579
O
MeO2C
6f
f1 (ppm)


tzq-3-85E
7.570
7.558
7.553
7.408
7.386
7.382
7.375
7.368
7.260
6.612
6.606
6.395
6.389
5.493
4.885
4.274
3.606
1.291
1.157
O
MeO2C
1.05
3.08
1.02
1.02
1.06
1.04
1.00
2.97
9.02
8.95
f1 (ppm)

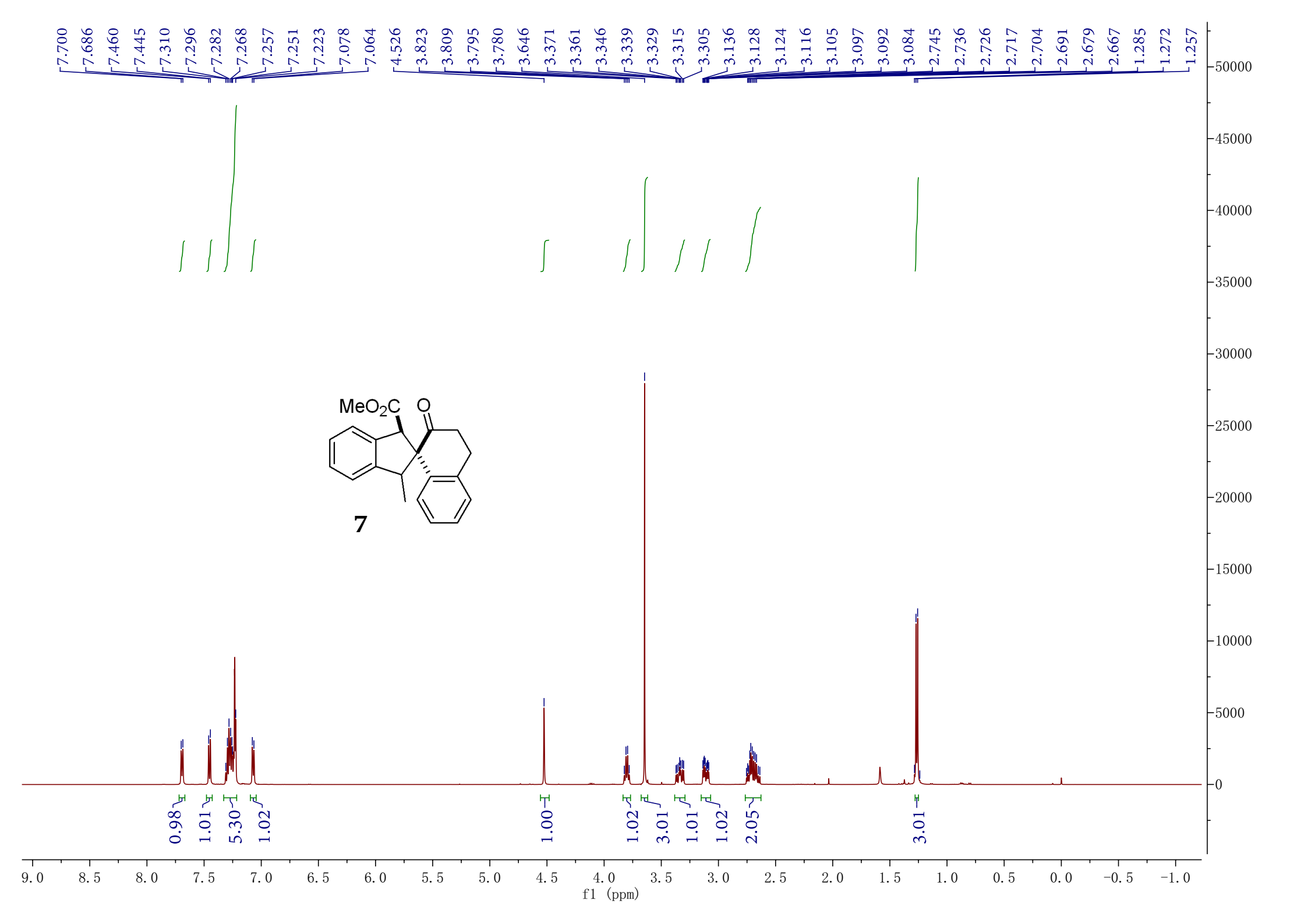
6g

tzq-2-85E-C



6g

f1 (ppm)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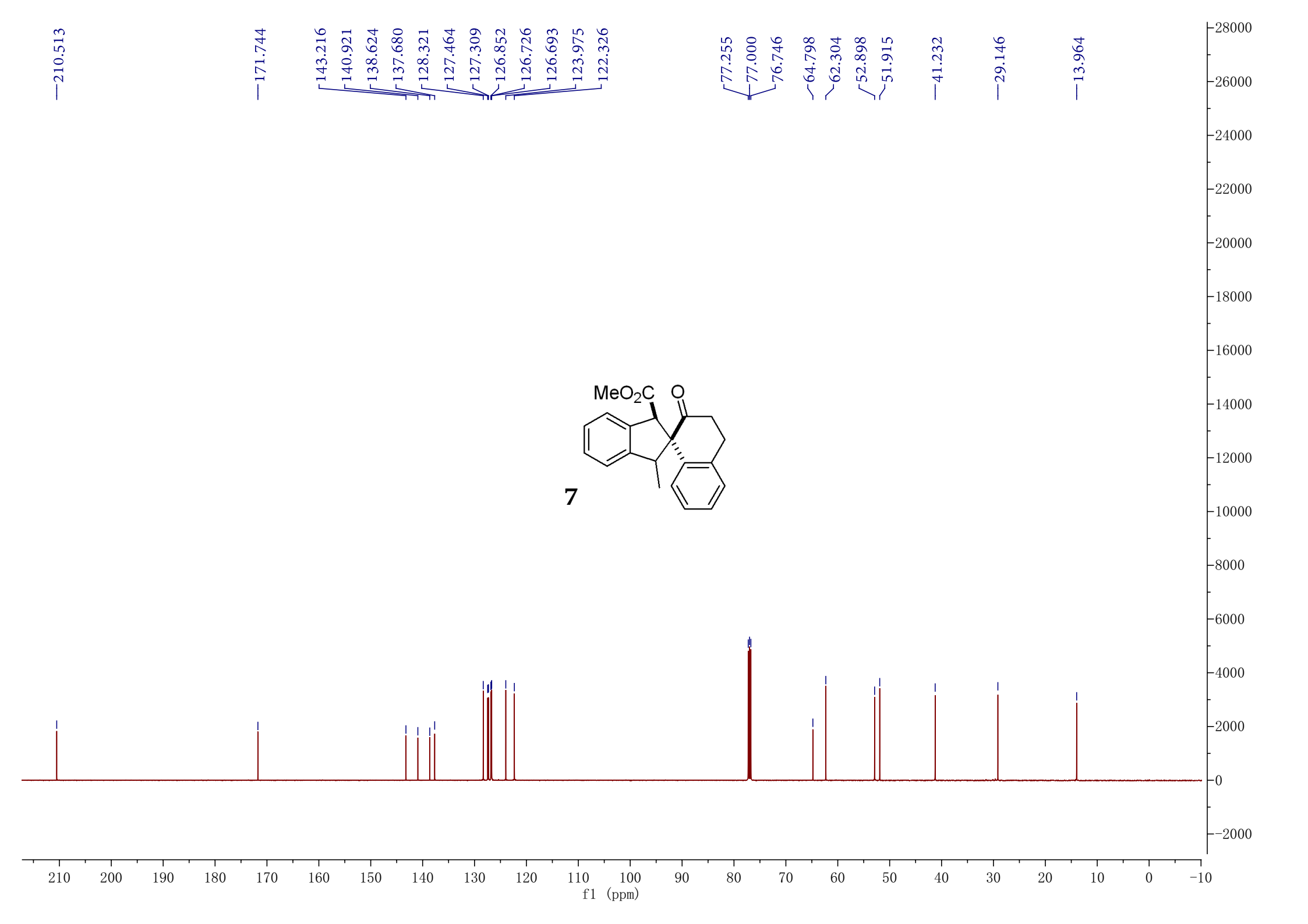
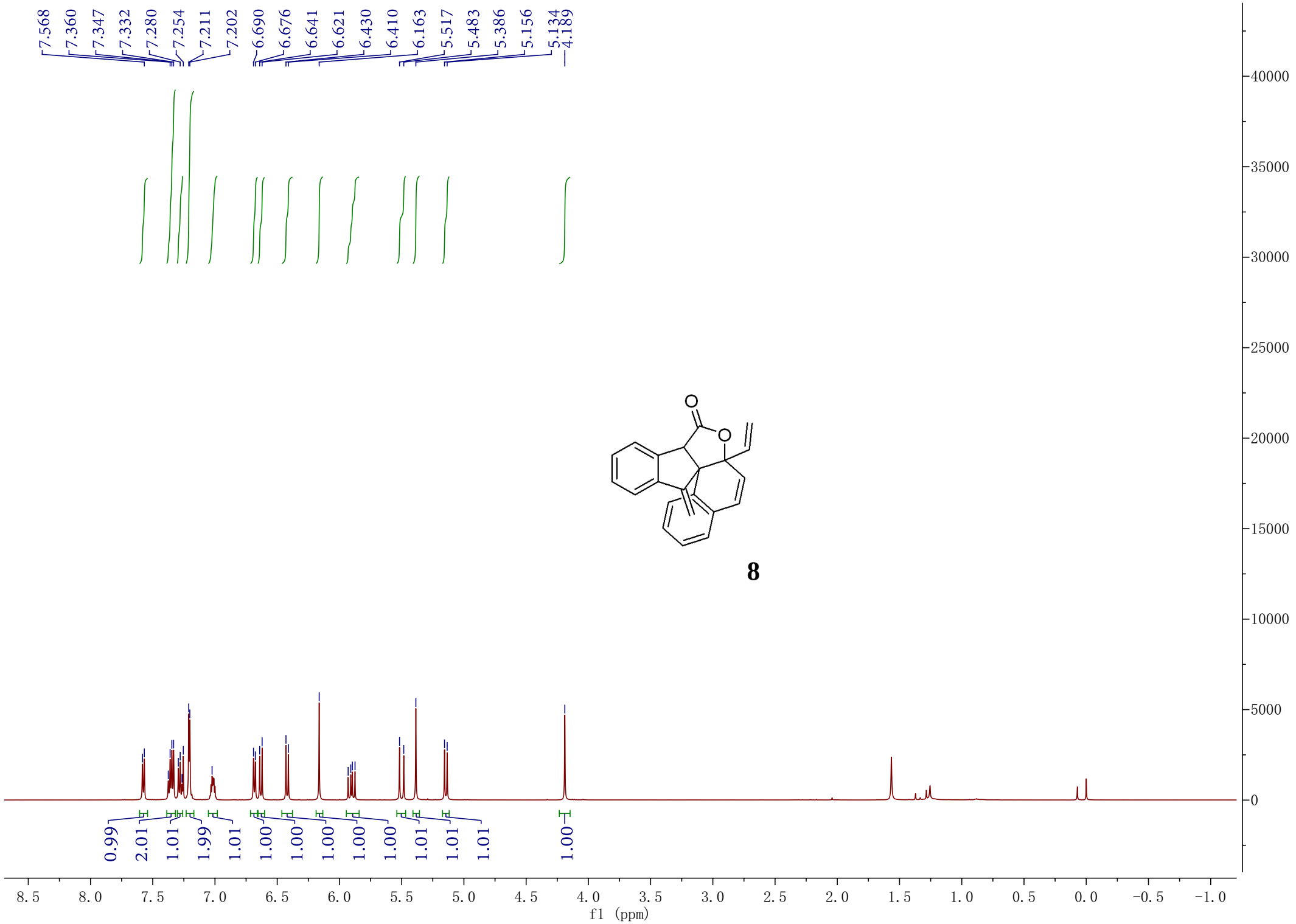
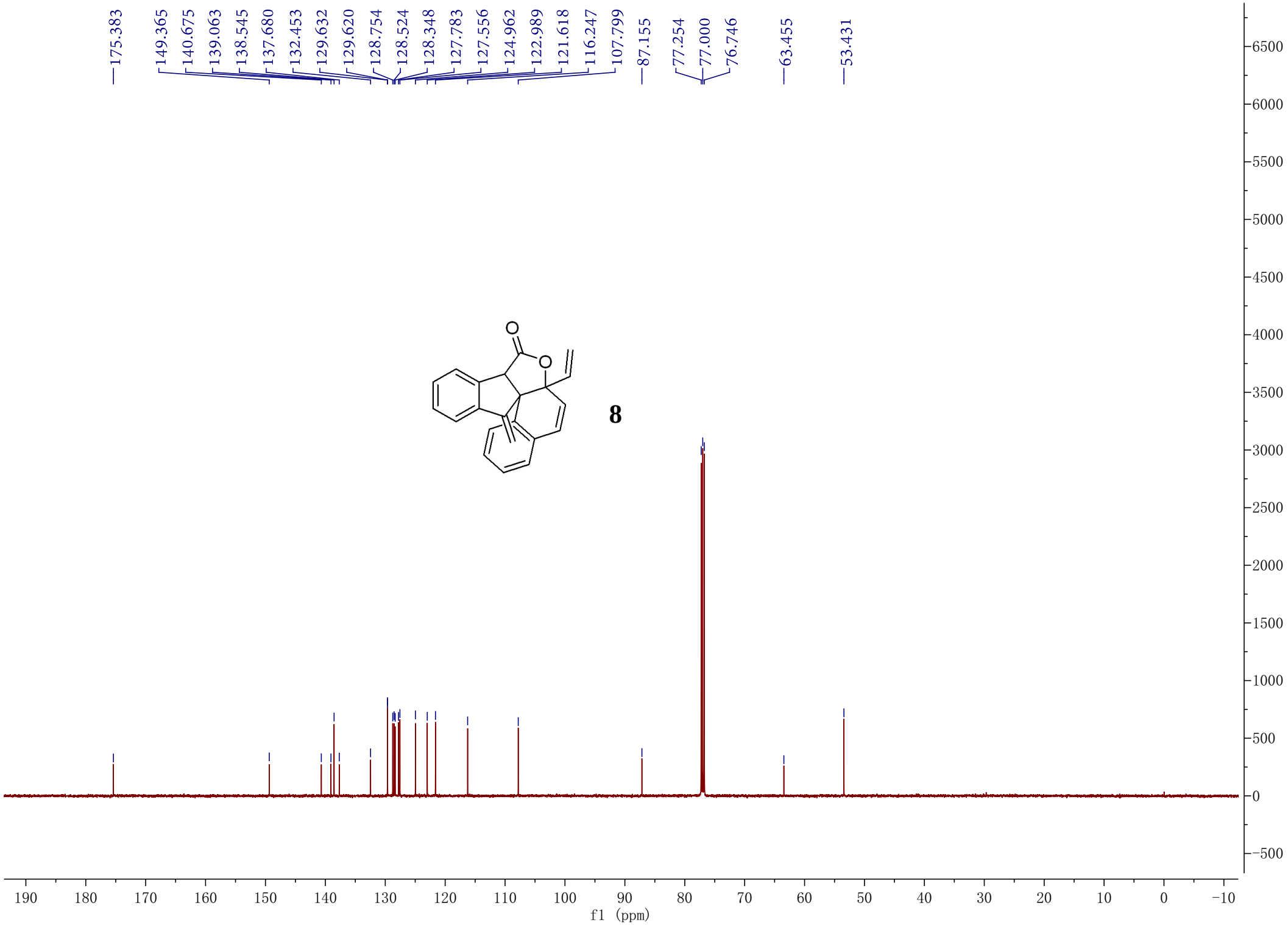
7.445
7.310
7.296
7.282
7.268
7.257
7.251
7.223
7.078
7.064
4.526
3.823
3.809
3.795
3.780
3.646
3.371
3.361
3.346
3.339
3.329
3.315
3.305
3.136
3.128
3.124
3.116
3.105
3.097
3.092
3.084
2.745
2.736
2.726
2.717
2.704
2.691
2.679
2.667
1.285
1.272
1.257
MeO2C
O
7
0.98
1.01
5.30
1.02
1.00
1.02
3.01
1.01
1.02
2.05
3.01
f1 (ppm)


210.513
171.744
143.216
140.921
138.624
137.680
128.321
127.464
127.309
126.852
126.726
126.693
123.975
122.326
77.255
77.000
76.746
64.798
62.304
52.898
51.915
41.232
29.146
13.964
MeO2C
O
7
f1 (ppm)


7.568
7.360
7.347
7.332
7.280
7.254
7.211
7.202
6.690
6.676
6.641
6.621
6.430
6.410
6.163
5.517
5.483
5.386
5.156
5.134
4.189
40000
35000
30000
25000
20000
15000
10000
5000
0
0.99
2.01
1.01
1.99
1.01
1.00
1.00
1.00
1.00
1.00
1.01
1.01
1.01
1.00
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
-1.0
f1 (ppm)

8


175.383
149.365
140.675
139.063
138.545
137.680
132.453
129.632
129.620
128.754
128.524
128.348
127.783
127.556
124.962
122.989
121.618
116.247
107.799
87.155
77.254
77.000
76.746
63.455
53.431
8
f1 (ppm)