Electronic Supplementary Material (ESI) for Green Chemistry.

Supporting Information

Stepwise Benzylic Oxygenation via Uranyl-Photocatalysis

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I. General Information

NMR Spectrum:

^{1}H and ^{13}C spectra were collected on 400 MHz or 500 MHz NMR spectrometers (Bruker AVANCE). Chemical shifts for protons are reported in parts per million (ppm) downfield and are referenced to residual protium in the NMR solvent ($CHCl_3$ = δ 7.26, DMSO = δ 2.50, Acetone = δ 2.05). Chemical for carbon are reported in parts per million downfield and are referenced to the carbon resonances of solvent ($CHCl_3$ = δ 77.0, DMSO = δ 39.52, Acetone = δ 206.26, 29.84). Date are represented as follows: chemical shift, multiplicity (br = broad, s = singlet, d = double, t = triplet, q = quartet, m = multiplet), coupling constants in Hertz (Hz), integration.

Mass Spectroscopy:

Mass spectra were in general recorded on a Waters Synapt G2 (HRMS) and Waters Acquity H (LCMS).

Chromatography:

Column chromatography was performed with silica gel (300 – 400 mesh ASTM).

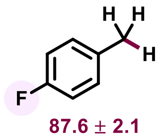
IR:

SHIMADZU IR Tracer-100 Spectrometers.

Solvent:

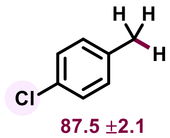
Acetone was bought and used without further purification.

II. Bond Dissociation Energy[1] and Oxidative Potential[2] of Typical Toluenes.



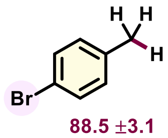
87.6 ± 2.1

E^{ox} = 2.24 vs SCE



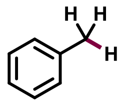
87.5 ±2.1

E^{ox} = 2.12 vs SCE



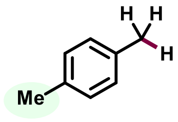
88.5 ±3.1

E^{ox} = 2.68 vs Ag/AgCl, KCl (sat.)



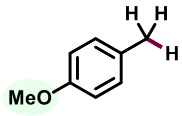
88.1 ±2.1

E^{ox} = 2.20 vs SCE



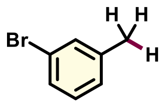
87.7

E^{ox} = 1.93 vs SCE



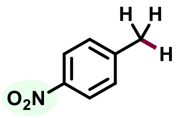
86.6

E^{ox} = 1.72 vs SCE



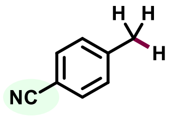
90.1 ± 3.1

E^{ox} = 2.68 vs Ag/AgCl, KCl (sat.)



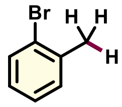
86.5

E^{ox} > 2.80 vs SCE



88.0

E^{ox} > 2.80 vs $AgClO_4$/Ag



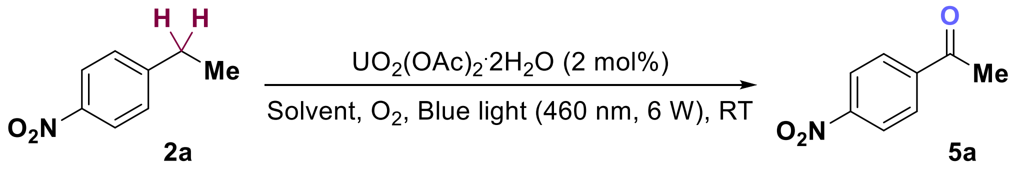
90.2±3.1

*E*ox = 2.69 vs Ag/AgCl, KCl (sat.)

III. Conditions Optimization

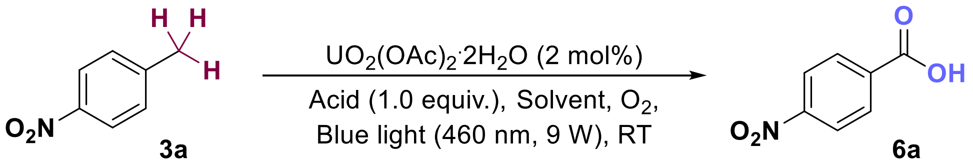
Entry	Solvent	**4a** (%)[b]	**5a** (%)
1	acetone	44	43
2	CH_3CN	24	25
3	**CH_3OH**	**63 (60)[c]**	**trace**
4	THF	trace	ND
5	DCM	15	trace
6	1,4-Dioxane	trace	ND
7	EA	51	35
8[d]	CH_3OH	ND	ND

[a]General Conditions: **1a** (0.2 mmol), $UO_2(OAc)_2·2H_2O$ (2 mol%) and solvent (1 mL) were stirred with blue light (460 nm, 9 W) under O_2 (1 atm) for 30 hours. [b]^{1}H NMR yields with CH_2Br_2 as the internal standard. [c]Yields of isolated products. [d]Without $UO_2(OAc)_2·2H_2O$, or light, or O_2. ND means no detected.



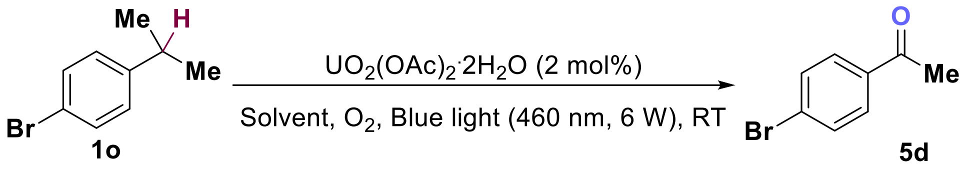
Entry	Solvent	**5a** (%)[b]
1	**acetone**	**84 (81)[c]**
2	CH_3CN	24
3	CH_3OH	12
4	THF	trace
5	DCM	trace
6	1,4-Dioxane	trace
7	EA	trace
8[d]	acetone	ND

[a]General Conditions: **2a** (0.2 mmol), $UO_2(OAc)_2{\cdot}2H_2O$ (2 mol%) and solvent (1 mL) were stirred with blue light (460 nm, 6 W) under O_2 (1 atm) for 24 hours. [b]^{1}H NMR yields with CH_2Br_2 as the internal standard. [c]Yields of isolated products. [d]Without $UO_2(OAc)_2{\cdot}2H_2O$, or light, or O_2. ND means no detected.



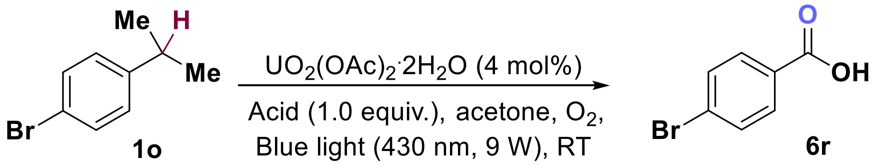
Entry	Acid	Solvent	**6a** (%)[b]
1	HCO_2H	acetone	26
2	CH_3CO_2H	acetone	28
3	CCl_3COOH	acetone	60
4	CF_3CO_2H	acetone	18
5	$MeSO_3H$	acetone	30
6	HBr/HOAc	acetone	48
7	**HCl (2 N)**	**acetone**	**85 (81)**[c]
8	$Zn(OAc)_2{\cdot}2H_2O$	acetone	61
9	HCl (1 N)	acetone	66
10	HCl (3 N)	acetone	76
11	HCl (2 N)	CH_3CN	58
12	HCl (2 N)	DCM	31
13	HCl (2 N)	MeOH	trace
14	HCl (2 N)	THF	trace
15[d]	HCl (2 N)	acetone	78
16	without HCl (2 N)	acetone	3
17[e]	HCl (2 N)	acetone	ND

[a]General Conditions: **3a** (0.2 mmol), $UO_2(OAc)_2{\cdot}2H_2O$ (2 mol%), acid (0.2 mmol) and solvent (1 mL) were stirred with blue light (460 nm, 9 W) under O_2 (1 atm) for 36 hours. [b]^1H NMR yields with CH_2Br_2 as the internal standard. [c]Yields of isolated products. [d]$UO_2(NO_3)_2{\cdot}6H_2O$ (2 mol%). [e]Without $UO_2(OAc)_2{\cdot}2H_2O$, or light, or O_2. ND means no detected.



Entry	Solvent	**5d** (%)[b]
1	CH_3OH	trace
2	acetone	56%
3	CH_3CN	52%
4	THF	ND
5	DCM	19%
6	1,4-Dioxane	ND
7	EA	48%
8[c]	**acetone**	**63% (60%)[d]**

[a]General Conditions: **1o** (0.2 mmol), $UO_2(OAc)_2·2H_2O$ (2 mol%), acid (0.2 mmol) and solvent (1.2 mL) were stirred with blue light (460 nm, 6 W) under O_2 (1 atm) for 30 hours. [b]^{1}H NMR yields with CH_2Br_2 as the internal standard. [c]Blue light (460 nm, 9 W). [d]Yields of isolated products. ND means no detected.



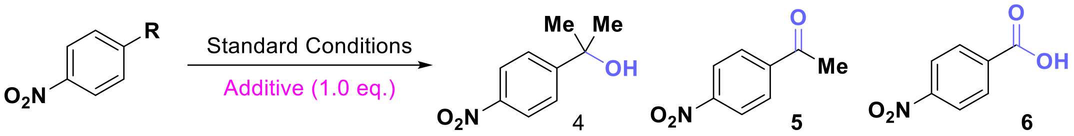
Entry	Acid	**6r** (%)[b]
1	H_2SO_4 (2 N)	13
2	HCl (2 N)	trace
3	CCl_3COOH	trace
4	AcOH	ND
5[c]	**H_2SO_4 (2 N)**	**47%**

[a]General Conditions: **1o** (0.2 mmol), $UO_2(OAc)_2·2H_2O$ (4 mol%), acid (0.2 mmol) and solvent (1.2 mL) were stirred with blue light (430 nm, 9 W) under O_2 (1 atm) for 5 days. [b] Yields of isolated products. [c]Blue light (430 nm, 12 W), 5 days. Trace means less than 5%. ND means no detected.

IV. Mechanistic Studies

1) Radical Quenching Experiments

All reactions were operated under standard conditions with extra TEMPO (1.0 equiv.) or BHT (1.0 equiv.). The result was detected by GC.



Entry	R	Additive	Result
1	Me	TEMPO	No 4
2	Me	BHT	4 (trace)
3	Et	TEMPO	No 5
4	Et	BHT	5 (trace)
5	^{i}Pr	TEMPO	No 6
6	^{i}Pr	BHT	6 (trace)

Radical trapping experiments revealed that 2,2,6,6-tertramethylpiperidine-1-oxyl (TEMPO), or 2,6-Di-tert-butyl-4-methylphenol (BHT) could efficiently quench the process of the oxygenation of benzylic molecules. The results in the above indicated that the radical process might be involved in the oxygenation of benzylic molecules.

2) Ultraviolet-Visible Absorption Experiments

Ultraviolet-visible absorption experiments were performed using a Shimadzu UV-2700 UV-visible spectrophotometer. In each experiment, the varying samples were combined in acetone in screw-top 1.0 cm quartz cuvettes. The concentration of each component under standard conditions [$UO_2(OAc)_2 \cdot 2H_2O$, 2.0 x 10^{-4} M, 4-NO_2Ph^iPr, 4-NO_2PhEt, 4-NO_2PhMe, 0.2 M].

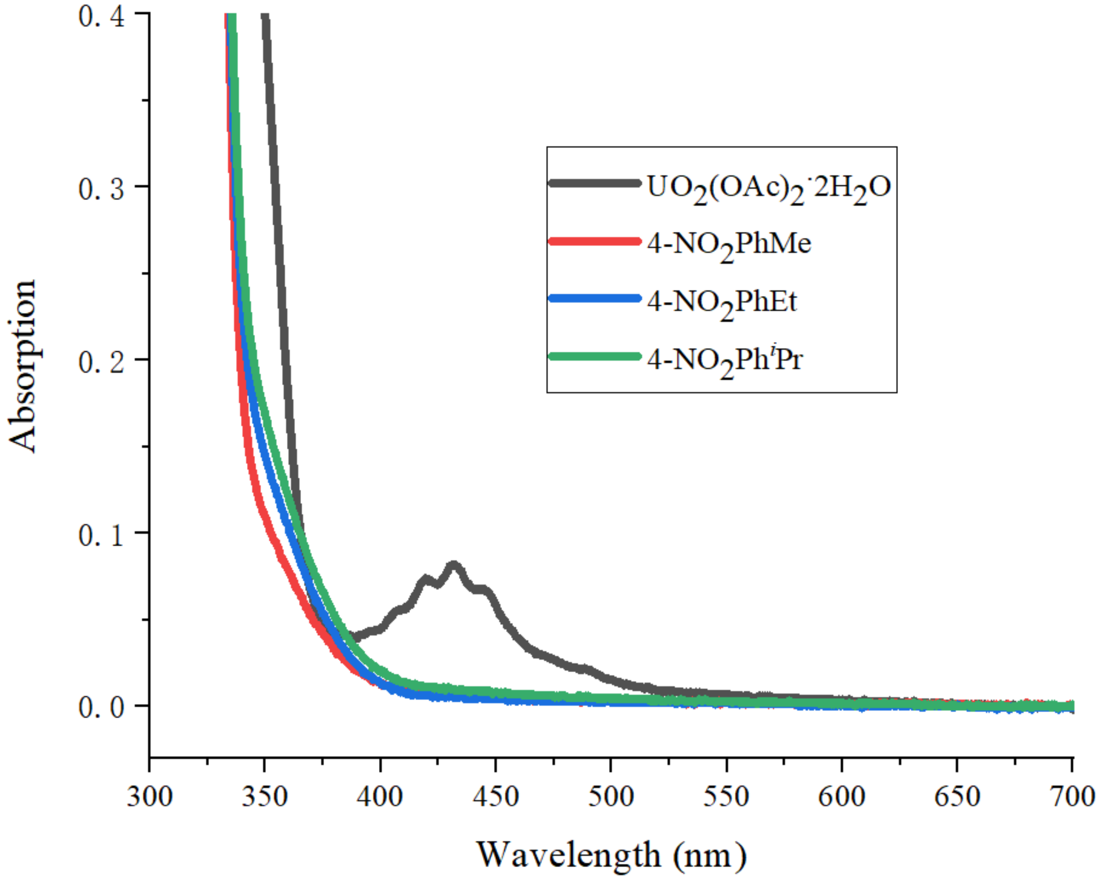


Figure S1: Ultraviolet-Visible Absorption of Each Reaction Component.

Ultraviolet-visible absorption of each reaction component indicated that $UO_2(OAc)_2 \cdot 2H_2O$ served as photocatalyst in system.

3) Fluorescence Quenching Experiments

a) Stern–Volmer analysis between alkylbenzenes and $UO_2(OAc)_2 \cdot 2H_2O$

Fluorescence quenching studies were performed using a Shimadzu RF-6000 Fluorescence Spectrophotometer. In each experiment, the photocatalyst and varying concentrations of quencher were combined in acetone in screw-top 1.0 cm quartz cuvettes. For the emission quenching of $UO_2(OAc)_2 \cdot 2H_2O$, the photocatalyst concentration was 2×10^{-4} M, the solution was irradiated at 432 nm, and the emission intensity was observed at 520 nm.

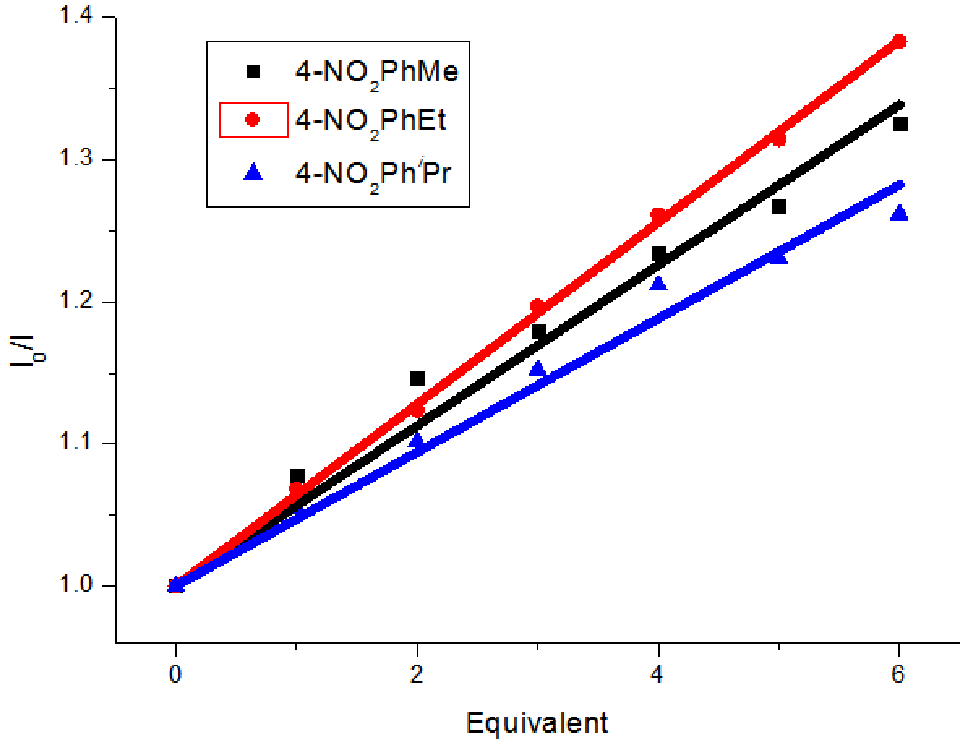


Figure S2: Stern–Volmer analysis between alkylbenzenes and $UO_2(OAc)_2 \cdot 2H_2O$.

Stern–Volmer analysis between alkylbenzenes and $UO_2(OAc)_2 \cdot 2H_2O$ *indicated that the excited state of* $UO_2(OAc)_2 \cdot 2H_2O$ *was efficiently quenched by alkylbenzenes in acetone at room temperature.*

b) Fluorescence quenching experiments between MeOH/^{t}BuOH/HCl and $UO_2(OAc)_2 \cdot 2H_2O$

Fluorescence quenching studies were performed using a Shimadzu RF-6000

Fluorescence Spectrophotometer. In each experiment, the photocatalyst and varying concentrations of quencher were combined in acetone in screw-top 1.0 cm quartz cuvettes. For the emission quenching of $UO_2(OAc)_2{\cdot}2H_2O$, the photoredox catalyst concentration was $2{*}10^{-3}$ M, the solution was irradiated at 432 nm.

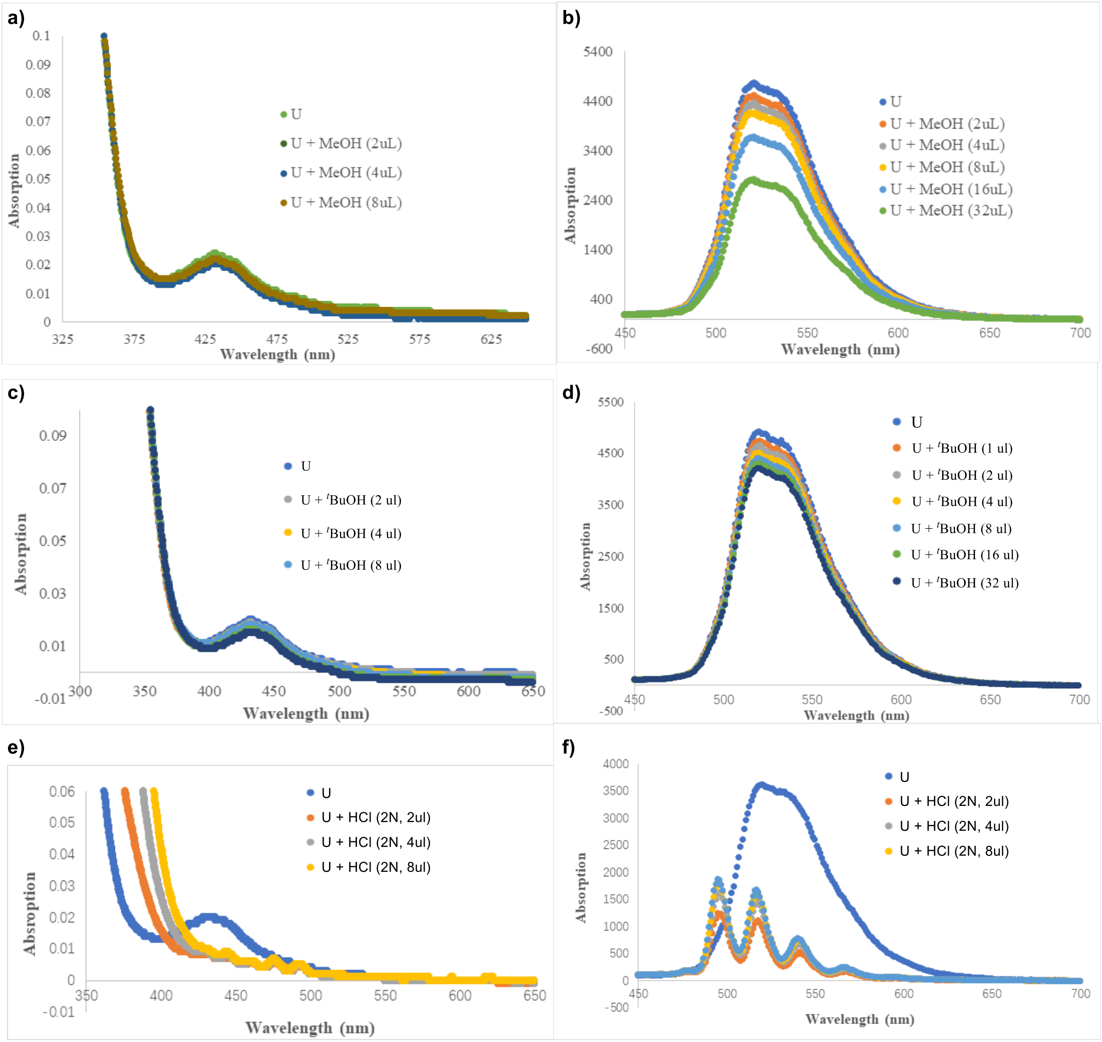


Figure S3: a), c), e) Ultraviolet-visible absorption experiments of $UO_2(OAc)_2{\cdot}2H_2O$ with varied [MeOH]/[^{t}BuOH]/[HCl] in acetone. **b), d), f)** Fluorescence quenching of $UO_2(OAc)_2{\cdot}2H_2O$ with varied [MeOH]/[^{t}BuOH]/[HCl] in acetone.

Fluorescence quenching studies revealed that the excited state of $UO_2(OAc)_2{\cdot}2H_2O$ *was efficiently quenched by ethanol or HCl in acetone at room temperature.*

4) Reaction Rate Constant Experiments

All reactions were operated under standard conditions. The time interval of methylarenes oxygenation is 1 hours, and the corresponding yields were calculated by NMR with CH_2Br_2 as internal standard. Take 4 or 5 dates for each methylarenes to form a liner curve and obtained the reaction rate constant of it.

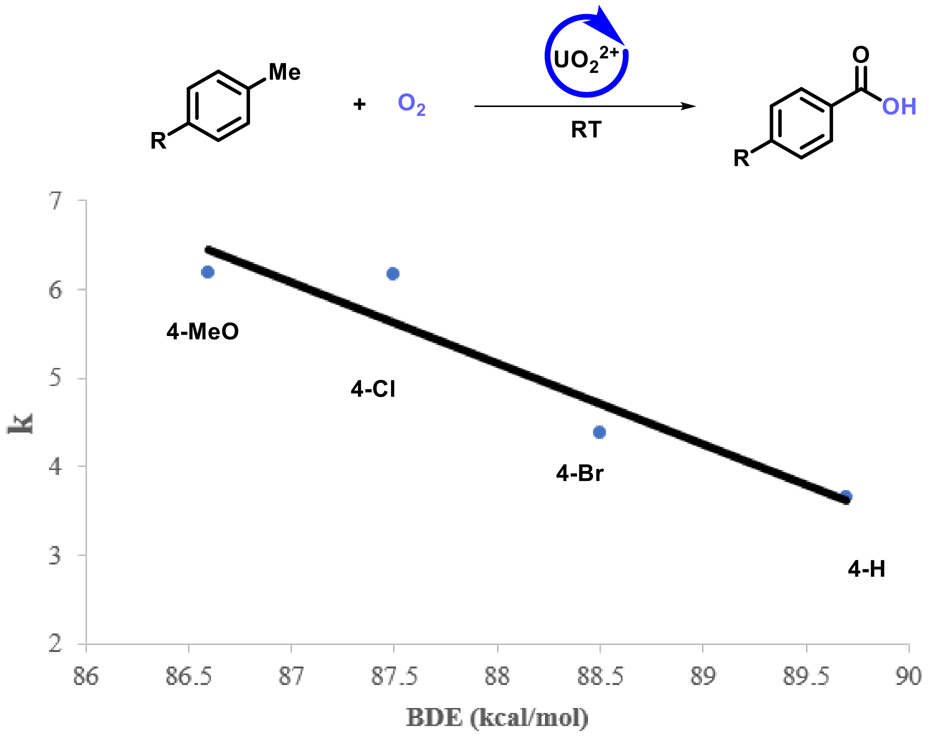
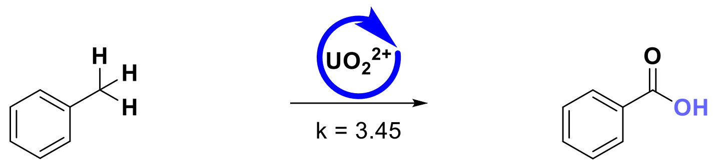


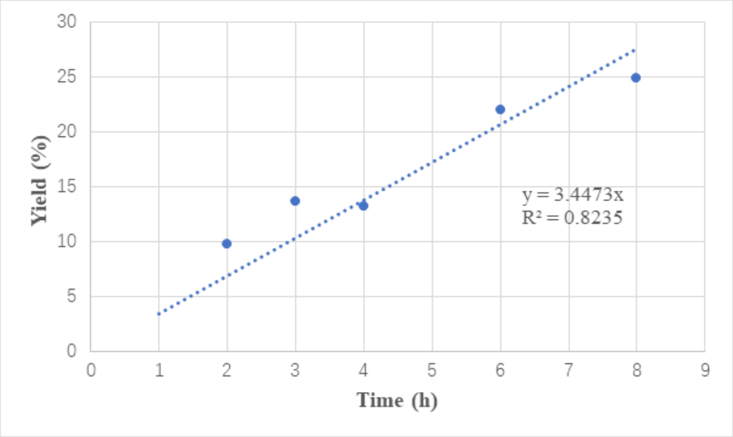
Figure S4: Reaction Rate Constant Experiments of Methylarenes.

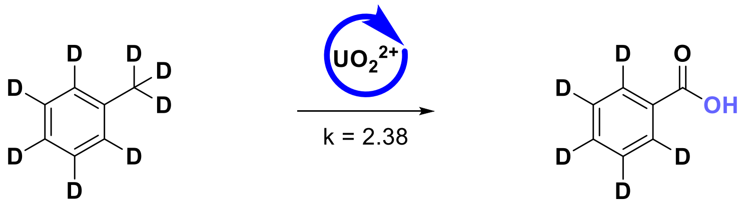
It was discovered that the reaction ratio of alkylbenzenes with different substitutions shows the first order response to the bond dissociation energy of the benzylic C-H bonds.[3]

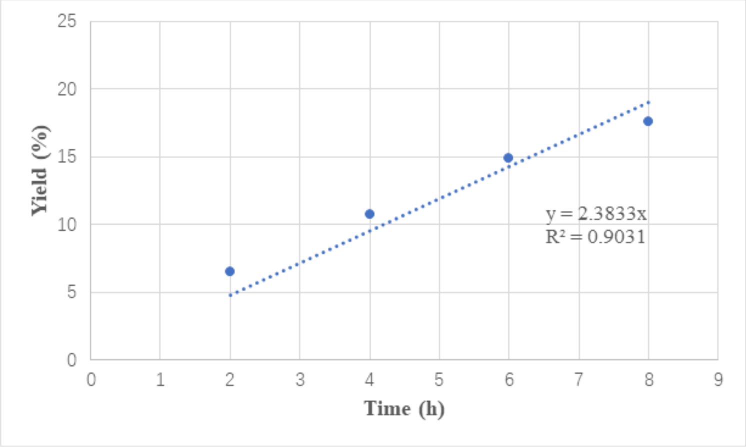
5) Kinetic Studies

The reactions were conducted under standard conditions with acetone-*d6* and acetone as solvents separately, which were irradiated for certain reaction times. The corresponding yields were calculated by NMR with CH_2Br_2 as internal standard.









The result of kinetic isotope effects was determined to be 3.45 and 2.38, respectively, suggesting that the HAT process might not be the rate-determining step.

V. General Procedures

A. Paralleled Photoreactor

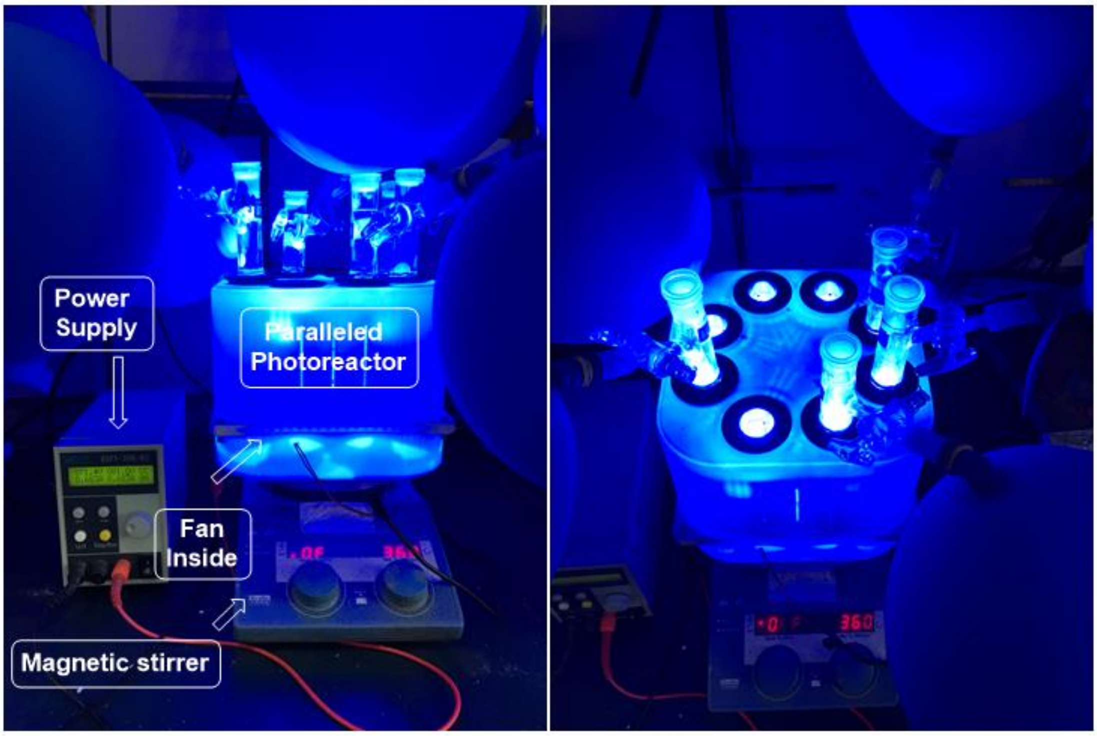
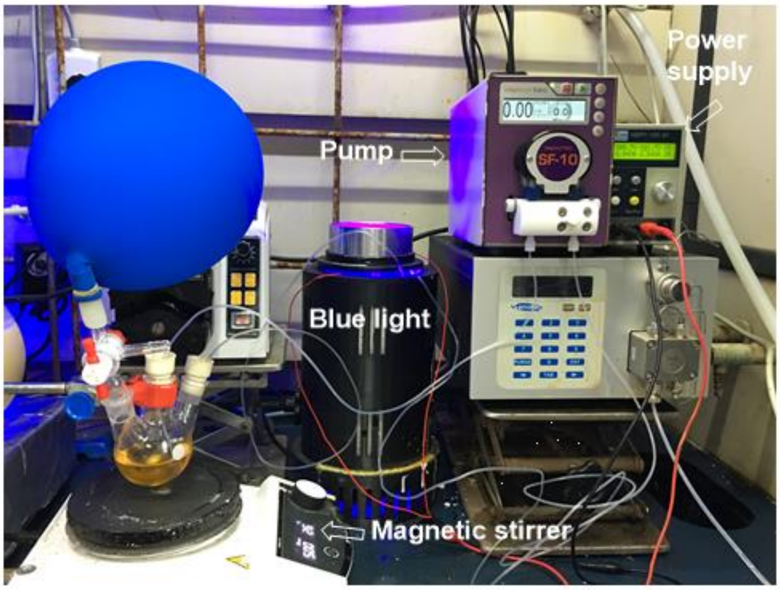


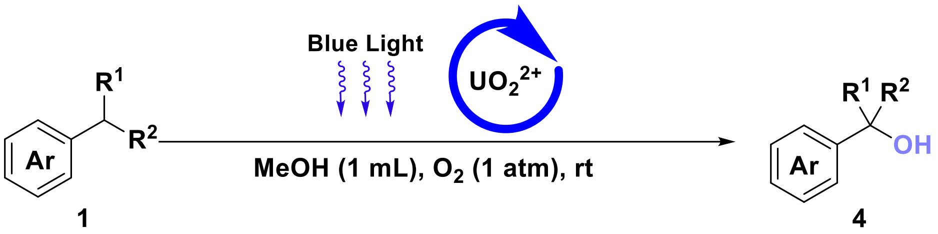
Figure S10: Parallel Photoreactor

[a]There are three LEDs in each cell. The second LED is on the opposite side of shown LED, the third one is on the bottom part of the cell.

B. Flow reactor

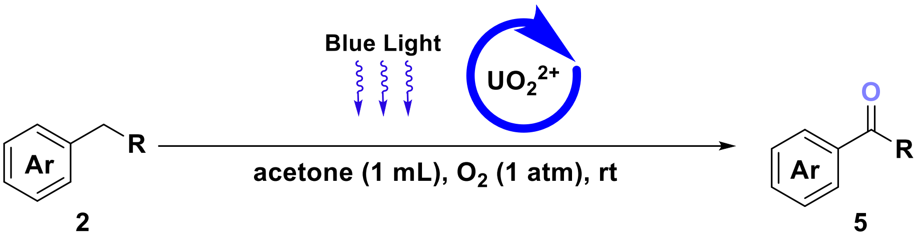


C. General Procedures for Aryl Alcohols



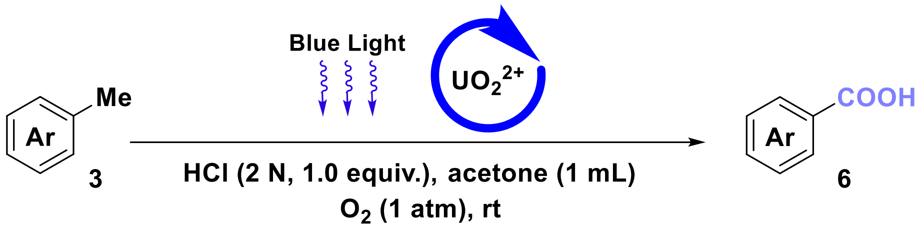
To a 50 mL Schlenk tube, **1** (0.2 mmol), $UO_2(OAc)_2 \cdot 2H_2O$ (2mol%, 1.7 mg), MeOH (1 mL) were added, then an oxygen balloon was linked and the system was vacuumed and refilled with oxygenation for 3 times with water pump (CAUTION: the pressure of water pump shouldn't be too high to avoid solvent removing). Subsequently, the reaction was irradiated by blue light (460 nm, 9 W) in paralleled reactor. Dichloromethane (DCM) was added to the reaction mixture to quench it, then removed solvent and purified by column chromatography. For detailed modification, please see the corresponding procedure.

D. General Procedures for Aromatic Ketone



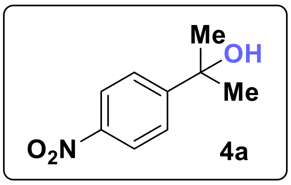
To a 50 mL Schlenk tube, **2** (0.2 mmol), $UO_2(OAc)_2 \cdot 2H_2O$ (2mol%, 1.7 mg), acetone (1 mL) were added, then an oxygen balloon was linked and the system was vacuumed and refilled with oxygenation for 3 times with water pump (CAUTION: the pressure of water pump shouldn't be too high to avoid solvent removing). Subsequently, the reaction was irradiated by blue light (460 nm, 6 W) in paralleled reactor. Dichloromethane (DCM) was added to the reaction mixture to quench it, then removed solvent and purified by column chromatography. For detailed modification, please see the corresponding procedure.

E. General Procedures for Aromatic Acids

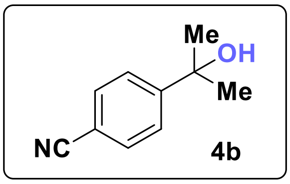


To a 50 mL Schlenk tube, **3** (0.2 mmol), $UO_2(OAc)_2 \cdot 2H_2O$ (2mol%, 1.7 mg), HCl (2 N, 1.0 equiv., 100 ul), acetone (1 mL) were added, then an oxygen balloon was linked and the system was vacuumed and refilled with oxygenation for 3 times with water pump (CAUTION: the pressure of water pump shouldn't be too high to avoid solvent removing). Subsequently, the reaction was irradiated by blue light (460 nm, 9 W) in paralleled reactor. Dichloromethane (DCM) was added to the reaction mixture to quench it, then removed solvent and purified by column chromatography. For detailed modification, please see the corresponding procedure.

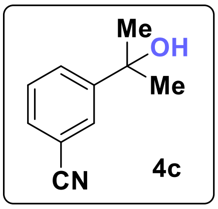
VI. Procedures and Data for Fig. 3, 4, and 5.



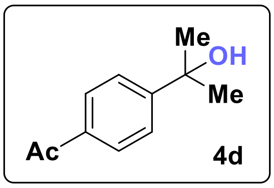
2-(4-Nitrophenyl)propan-2-ol 4a: 1-isopropyl-4-nitrobenzene **1a** (0.2 mmol, 33.0 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (0.004 mmol, 1.7 mg), MeOH (1.0 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 30 hours under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **4a**[4] (21.7 mg, 60%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1) as a yellow liquid. ^{1}**H NMR** (400 MHz, $CDCl_3$) δ 8.09 (d, *J* = 8.0 Hz, 2H), 7.61 (d, *J* = 8.0 Hz, 2H), 2.62 (brs, 1H), 1.57 (s, 6H). ^{13}**C NMR** (100 MHz, $CDCl_3$) δ 156.5, 146.4, 125.4, 123.3, 72.3, 31.5. **IR** (neat) 3396, 1599, 1514, 1346, 1175, 1107, 1092. GCMS (EI) m/z, $[M]^+$ = 181.



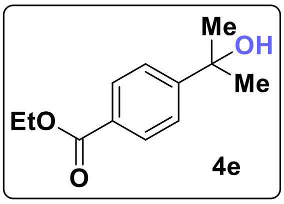
4-(2-Hydroxypropan-2-yl)benzonitrile 4b: 4-isopropylbenzonitrile **1b** (0.2 mmol, 29.0 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (0.004 mmol, 1.7 mg) and MeOH (1.0 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **4b**[4] (16.4 mg, 51%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1) as a faint yellow liquid. ^{1}**H NMR** (400 MHz, $CDCl_3$) δ 7.62-7.58 (m, 4H), 2.00 (brs, 1H), 1.57 (s, 6H). ^{13}**C NMR** (100 MHz, $CDCl_3$) δ 154.4, 132.0, 125.3, 118.9, 110.4, 72.4, 31.6. **IR** (neat) 2956, 1691, 1402, 1363, 1261, 1186, 1080. GCMS (EI) m/z, $[M]^+$ = 161.



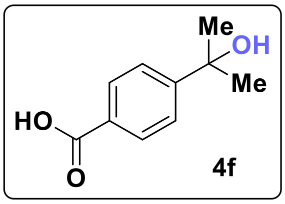
3-(2-Hydroxypropan-2-yl)benzonitrile 4c: 3-isopropylbenzonitrile **1c** (0.2 mmol, 29.0 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (0.004 mmol, 1.7 mg) and MeOH (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **4c** (15.5 mg, 48%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1) as a brown liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.80 (s, 1H), 7.72 (d, *J* = 8.0 Hz, 1H), 7.52 (d, *J* = 8.0 Hz, 1H), 7.44 (t, *J* = 8.0 Hz, 1H), 1.99 (brs, 1H), 1.58 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 150.5, 130.3, 129.1, 129.0, 128.3, 119.0, 112.1, 72.1, 31.7. **IR** (neat) 3442, 2229, 1419, 1366, 1263, 1173, 1090. GCMS (EI) m/z, $[M]^+$ = 161.



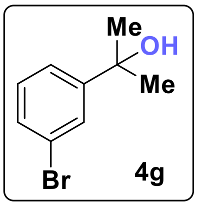
1-(4-(2-Hydroxypropan-2-yl)phenyl)ethan-1-one 4d: 1-(4-isopropylphenyl)ethan-1-one **1d** (0.2 mmol, 32.4 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (0.008 mmol, 3.4 mg), MeOH (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 3 days under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **4d**[4] (20.6 mg, 58%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1 to 2/1) as a faint yellow liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.92 (d, *J* = 8.0 Hz, 2H), 7.58 (d, *J* = 8.0 Hz, 2H), 2.59 (s, 3H), 2.03 (brs, 1H), 1.59 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 197.9, 154.4, 135.6, 128.4, 124.6, 72.5, 31.7, 26.6. **IR** (neat) 3447, 1676, 1607, 1406, 1358, 1271, 1176. GCMS (EI) m/z, $[M]^+$ = 178.



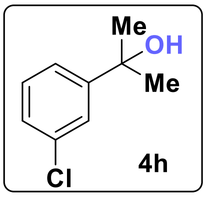
Ethyl 4-(2-hydroxypropan-2-yl)benzoate 4e: ethyl 4-isopropylbenzoate **1e** (0.2 mmol, 38.4 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (0.004 mmol, 1.7 mg), HBr (40 wt% in H_2O, 2 N) (0.01 mmol, 5 ul), MeOH (1.0 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 3 W blue light (460 nm) in a paralleled reactor. **4e**[5] (30.4 mg, 73%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1) as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 8.0 Hz, 2H), 7.54 (d, *J* = 8.0 Hz, 2H), 4.35 (q, *J* = 8.0 Hz, 2H), 2.06 (s, 1H), 1.58 (s, 6H), 1.38 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 166.5, 154.1, 129.5, 128.8, 124.4, 72.5, 60.8, 31.6, 14.3. **IR** (neat) 3462, 2976, 1717, 1697, 1408, 1367, 1173. GCMS (EI) m/z, $[M]^+$ = 208.



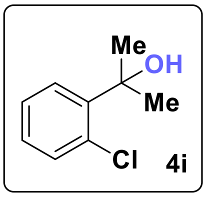
4-(2-Hydroxypropan-2-yl)benzoic acid 4f: 4-isopropylbenzoic acid **1f** (0.2 mmol, 32.8 mg), $UO_2(OAc)_2·2H_2O$ (0.008 mmol, 3.4 mg), MeOH (1.0 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 3 W blue light (460 nm) in a paralleled reactor. **4f**[6] (19.8 mg, 55%) was obtained through column chromatography (V_{PE}/V_{EA} = 1/1) as a white solid. **^{1}H NMR** (400 MHz, *d6*-DMSO) δ 7.88 (d, *J* = 8.0 Hz, 2H), 7.57 (d, *J* = 8.0 Hz, 2H), 5.18 (brs, 1H), 1.43 (s, 6H). **^{13}C NMR** (100 MHz, *d6*-DMSO) δ 167.4, 155.7, 129.0, 128.5, 124.8, 70.9, 31.8. **IR** (neat) 2976, 1647, 1423, 1315, 1167, 1089, 1051. GCMS (EI) m/z, $[M]^+$ = 180.



2-(3-Bromophenyl)propan-2-ol 4g: 1-bromo-3-isopropylbenzene **1g** (0.2 mmol, 39.6 mg), $UO_2(OAc)_2·2H_2O$ (0.004 mmol, 1.7 mg), TFA (0.2 mmol, 22.8 mg), and MeOH (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **4g**[7] (27.4 mg, 64%) was obtained through column chromatography (V_{PE}/V_{EA} = 10/1) as a colorless liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.65 (t, *J* = 2.0 Hz, 1H), 7.40-7.35 (m, 2H), 7.19 (t, *J* = 8.0 Hz, 1H), 2.02 (brs, 1H), 1.55 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 151.4, 129.8, 129.7, 127.8, 123.1, 122.4, 72.2, 31.6. **IR** (neat) 3383, 2976, 1412, 1364, 1248, 1171, 1142. GCMS (EI) m/z, $[M]^+$ = 214.

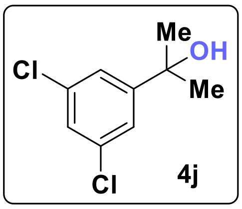


2-(3-Chlorophenyl)propan-2-ol 4h: 1-chloro-3-isopropylbenzene **1h** (0.2 mmol, 30.8 mg), $UO_2(OAc)_2·2H_2O$ (0.004 mmol, 1.7 mg), HBr (40 wt% in H_2O, 2 N) (0.01 mmol, 5 ul) and MeOH (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 12 hours under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **4h** (26.5 mg, 78%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1) as a colorless liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.49 (t, *J* = 1.6 Hz, 1H), 7.36 (d, *J* = 8.0 Hz, 1H), 7.27 (t, *J* = 8.0 Hz, 1H), 7.22 (d, *J* = 8.0 Hz, 1H), 1.72 (brs, 1H), 1.57 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 151.2, 134.1, 129.5, 126.8, 124.9, 122.6, 72.3, 31.7. **IR** (neat) 3447, 2978, 1772, 1683, 1362, 1252, 1173. GCMS (EI) m/z, $[M]^+$ = 170.



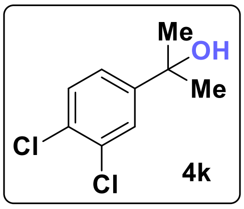
4i

2-(2-Chlorophenyl)propan-2-ol 4i: 1-chloro-2-isopropylbenzene **1i** (0.2 mmol, 30.8 mg), $UO_2(OAc)_2\cdot 2H_2O$ (0.004 mmol, 1.7 mg), HBr (40 wt% in H_2O, 2 N) (0.01 mmol, 5 ul) and MeOH (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 12 hours under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **4i**[8] (20.7 mg, 61%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1) as a colorless liquid. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.69 (d, *J* = 7.5 Hz, 1H), 7.38 (d, *J* = 7.5 Hz, 1H), 7.28 (t, *J* = 7.5 Hz, 1H), 7.21 (t, *J* = 7.5 Hz, 1H), 2.68 (brs, 1H), 1.76 (s, 6H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 144.7, 131.3, 131.2, 128.2, 126.9 (2C), 73.1, 29.3. **IR** (neat) 2936, 2249, 1682, 1595, 1290, 1211, 746. GCMS (EI) m/z, $[M]^+$ = 170.



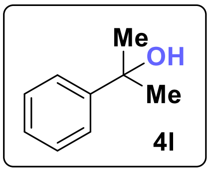
4j

2-(3,5-Dichlorophenyl)propan-2-ol 4j: 1,3-dichloro-5-isopropylbenzene **1j** (0.2 mmol, 37.6 mg), $UO_2(OAc)_2\cdot 2H_2O$ (0.004 mmol, 1.7 mg), HBr (40 wt% in H_2O, 2 N) (0.01 mmol, 5 ul) and MeOH (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 24 hours under the irradiation of 3 W blue light (460 nm) in a paralleled reactor. **4j**[5] (29.4 mg, 72%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1) as a colorless liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36 (d, *J* = 1.6 Hz, 1H), 7.23 (t, *J* = 1.6 Hz, 1H), 1.84 (brs, 1H), 1.55 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 152.5, 134.8, 126.7, 123.3, 72.2, 31.6. **IR** (neat) 3392, 1472, 1431, 1364, 1273, 1172, 1034. GCMS (EI) m/z, $[M]^+$ = 204.



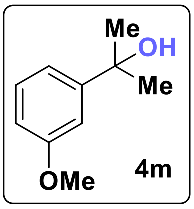
4k

2-(3,4-Dichlorophenyl)propan-2-ol 4k: cumene **1j** (0.2 mmol, 24.0 mg), $UO_2(OAc)_2·2H_2O$ (0.004 mmol, 1.7 mg), HBr (40 wt% in H_2O, 2 N) (0.01 mmol, 5 ul) and MeOH (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 24 hours under the irradiation of 3 W blue light (460 nm) in a paralleled reactor. **4k** (27.7 mg, 68%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1) as a colorless liquid. ^{1}**H NMR** (400 MHz, $CDCl_3$) δ 7.58 (d, J = 4.0 Hz, 1H), 7.39 (d, J = 8.0 Hz, 1H), 7.30 (dd, J_1 = 8.0 Hz, J_2 = 4.0 Hz, 1H), 1.80 (brs, 1H), 1.56 (s, 6H). ^{13}**C NMR** (100 MHz, $CDCl_3$) δ 149.4, 132.2, 130.5, 130.1, 126.8, 124.0, 72.0, 31.7. **IR** (neat) 3381, 2976, 1469, 1385, 1242, 1173, 1139. GCMS (EI) m/z, $[M]^+$ = 204.



4l

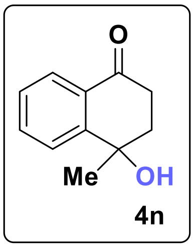
2-Phenylpropan-2-ol 4l: 1,2-dichloro-4-isopropylbenzene **1j** (0.2 mmol, 37.6 mg), $UO_2(OAc)_2·2H_2O$ (0.004 mmol, 1.7 mg), and MeOH (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **4l**[9] (12.2 mg, 45%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1) as a colorless liquid. ^{1}**H NMR** (400 MHz, $CDCl_3$) δ 7.50 (d, J = 8.0 Hz, 2H), 7.36 (t, J = 8.0 Hz, 2H), 7.26 (t, J = 8.0 Hz, 1H), 1.88 (brs, 1H), 1.60 (s, 6H). ^{13}**C NMR** (100 MHz, $CDCl_3$) δ 149.1, 128.2, 126.6, 124.3, 72.5, 31.7. **IR** (neat) 3394, 1688, 1495, 1447, 1362, 1259, 1175. GCMS (EI) m/z, $[M]^+$ = 136.



4m

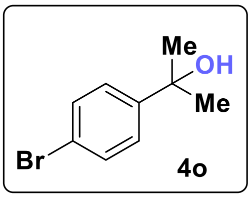
2-(3-Methoxyphenyl)propan-2-ol 4m: 1-isopropyl-3-methoxybenzene **1m** (0.2 mmol, 30.0 mg), $UO_2(OAc)_2·2H_2O$ (0.004 mmol, 1.7 mg), HBr (40 wt% in H_2O, 2 N) (0.01 mmol, 5 ul) and MeOH (1.0 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 24 hours under the irradiation of 3 W blue light (460 nm) in a paralleled reactor. **4l**[10] (17.6 mg, 53%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1) as a colorless liquid. ^{1}**H NMR** (400 MHz, $CDCl_3$) δ 7.27 (d, J = 8.0

Hz, 1H), 7.07 (t, *J* = 8.0 Hz, 2H), 6.80 (dd, J_1 = 8.0 Hz, J_2 = 2.4 Hz, 1H), 3.82 (s, 3H), 2.15 (brs, 1H), 1.58 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 159.4, 150.9, 129.1, 116.8, 111.7, 110.5, 72.4, 55.1, 31.6. **IR** (neat) 2963, 1601, 1487, 1431, 1288, 1267, 1230. GCMS (EI) m/z, $[M]^+$ = 166.



4n

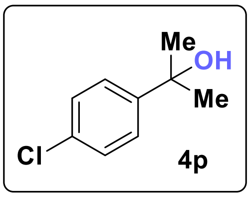
4-Hydroxy-4-methyl-3,4-dihydronaphthalen-1(2H)-one 4n: 4-methyl-3,4-dihydronaphthalen-1(2H)-one **1n** (0.2 mmol, 32.0 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (0.004 mmol, 1.7 mg) and MeOH (1.0 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **4n** (21.1 mg, 60%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1 to 2/1) as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.98 (d, *J* = 12.0 Hz, 1H), 7.71 (t, *J* = 12.0 Hz, 2H), 7.60 (t, *J* = 8.0 Hz, 1H), 7.39 (t, J = 8.0 Hz, 1H), 2.92-2.82 (m, 1H), 2.75-2.64 (m, 1H), 2.31-2.26 (m, 2H), 1.85 (brs, 1H), 1.64 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 197.3, 149.5, 134.3, 130.5, 127.8, 127.0, 125.2, 70.2, 38.3, 35.8, 29.0. **IR** (neat) 3416, 2970, 1599, 1450, 1287, 1194, 1089. GCMS (EI) m/z, $[M]^+$ = 176.



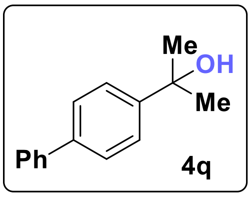
4o

2-(4-Bromophenyl)propan-2-ol 4o: 1-bromo-4-isopropylbenzene **1o** (0.2 mmol, 39.6 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (0.004 mmol, 1.7 mg) and MeOH (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 21 hours under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **4o**[11] (34.2 mg, 80%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1) as a brown liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.44 (d, *J* = 8.0 Hz, 2H), 7.34 (d, *J* = 8.0 Hz, 2H), 2.14 (brs, 1H), 1.54 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 148.1, 131.1, 126.3, 120.5, 72.2, 31.6. **IR** (neat) 3379, 1481, 1396, 1364, 1169, 1142, 1107. GCMS (EI) m/z, $[M]^+$ = 214.

Flow Chemistry: To a 100 mL three-necked flask, a solution of 1-bromo-4-isopropylbenzene **1o** (20.0 mmol, 3.96 g), $UO_2(NO_3)_2 \cdot 6H_2O$ (0. 4 mmol, 200 mg) and MeOH (60 mL) were stirred under oxygen atmosphere. The solution was pumped into a flow micro tube by a pump (0.5 mL/min), which was made of PTFE tubing (O.D. = 2 mm, I.D. = 1 mm, length = 31.4 m, volume = 24.65 mL), and returned to Schlenk tube with the same pump. This circulatory system was irradiated by blue light (435 nm, 90 W) about 92 hours (the temperature was below 30 °C). After the reaction, DCM (10 mL) was pumped into a flow micro tube to quench it and wash the tube. The solvent was removed in vacuo. Purify the crude residue by column chromatography on silica gel using PE/EA (5/1 to 2/1) to afford **4o** (51%, 2.19 g, 0.111 mmol/h) with brown liquid.

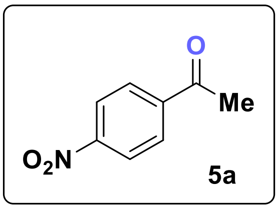


2-(4-Chlorophenyl)propan-2-ol 4p: 1-Chloro-4-isopropylbenzene **1p** (0.2 mmol, 30.8 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (0.004 mmol, 1.7 mg), HBr (40 wt% in H_2O, 2 N) (0.01 mmol, 5 ul) and MeOH (1.0 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 12 hours under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **4p**[8] (20.7 mg, 61%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1) as a colorless liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.41 (d, *J* = 8.0 Hz, 2H), 7.29 (d, *J* = 8.0 Hz, 2H), 1.89 (brs, 1H), 1.56 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 147.6, 132.5, 128.3, 125.9, 72.3, 31.8. **IR** (neat) 2961, 1491, 1398, 1363, 1209, 1188. GCMS (EI) m/z, $[M]^+$ = 170.



2-([1,1'-biphenyl]-4-yl)propan-2-ol 4q: 4-isopropyl-1,1'-biphenyl **1q** (0.2 mmol, 39.2 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (0.004 mmol, 1.7 mg), MeOH (1.0 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 24 hours under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **4q**[12] (21.2 mg, 50%) was obtained through column chromatography (V_{PE}/V_{EA} = 10/1) as a white solid.

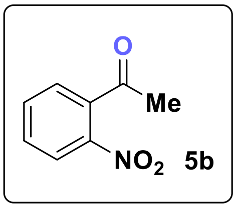
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62-7.58 (m, 6H), 7.45 (t, *J* = 8.0 Hz, 2H), 7.36 (t, *J* = 7.6 Hz, 1H), 1.82 (brs, 1H), 1.64 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 148.1, 140.8, 139.6, 128.7, 127.2, 127.0, 126.9, 124.8, 72.4, 31.7. **IR** (neat) 3408, 1487, 1398, 1265, 1167, 1117, 1097. GCMS (EI) m/z, $[M]^+$ = 212.



5a

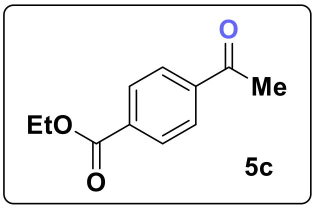
1-(4-Nitrophenyl)ethanone 5a: 1-ethyl-4-nitrobenzene **2a** (0.2 mmol, 30.2 mg), $UO_2(OAc)_2{\cdot}2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 24 hours under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5a**[13] (26.7 mg, 81%) was obtained through column chromatography (V_{PE}/V_{EA} = 10/1) as a yellow solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.29 (d, *J* = 8.0 Hz, 2H), 8.10 (d, *J* = 8.0 Hz, 1H), 2.67 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 196.3, 150.3, 141.3, 129.3, 123.8, 26.9. **IR** (neat) 3107, 1708, 1693, 1602, 1527, 1346, 1242.

Flow Chemistry: To a 100 mL three-necked flask, a solution of 1-ethyl-4-nitrobenzene **2a** (20.0 mmol, 3.02 g), $UO_2(NO_3)_2{\cdot}6H_2O$ (0. 4 mmol, 200 mg) and acetone (60 mL) were stirred under oxygen atmosphere. The solution was pumped into a flow micro tube by a pump (0.5 mL/min), which was made of PTFE tubing (O.D. = 2 mm, I.D. = 1 mm, length = 31.4 m, volume = 24.65 mL), and returned to Schlenk tube with the same pump. This circulatory system was irradiated by blue light (435 nm, 90 W) about 96 hours (the temperature was below 30 ºC). After the reaction, DCM (10 mL) was pumped into a flow micro tube to quench it and wash the tube. The solvent was removed in vacuo. Purify the crude residue by column chromatography on silica gel using PE/EA (10/1) to afford **5a** (65%, 2.15 g, 0.135 mmol/h) with yellow solid.



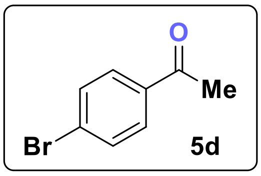
5b

1-(2-Nitrophenyl)ethanone 5b: 1-ethyl-2-nitrobenzene **2b** (0.2 mmol, 30.2 mg), $UO_2(OAc)_2{\cdot}2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **3b** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5b**[14] (17.8 mg, 54%) was obtained through column chromatography (V_{PE}/V_{EA} = 10/1) as a yellow liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.06-8.03 (m, 1H), 7.72-7.68 (m, 1H), 7.61-7.56 (m, 1H), 7.42 (d, *J* = 8.0 Hz, 1H), 2.53 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 199.7, 145.7, 137.7 (d, *J* = 4 Hz), 134.1, 130.6, 127.2, 124.2, 30.0. **IR** (neat) 3007, 1710, 1575, 1529, 1348, 1222, 1001.



5c

Ethyl 4-acetylbenzoate 5c: ethyl 4-ethylbenzoate **2c** (0.2 mmol, 35.6 mg), $UO_2(OAc)_2{\cdot}2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **3c** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5c**[15] (31.1 mg, 81%) was obtained through column chromatography (V_{PE}/V_{EA} = 10/1) as a white liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.08 (d, *J* = 8.8 Hz, 2H), 7.95 (d, *J* = 8.8 Hz, 2H), 4.37 (q, *J* = 7.2 Hz, 2H), 2.60 (s, 3H), 1.37 (t, *J* = 7.2 Hz, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 197.4, 165.6, 140.0, 134.1, 129.6, 128.0, 61.3, 26.7, 14.2. **IR** (neat) 2959, 1718, 1676, 1435, 1277, 1111, 955.

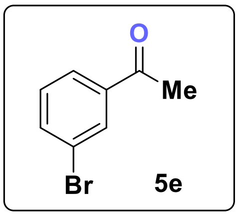


5d

1-(4-Bromophenyl)ethanone 5d: 1-bromo-4-ethylbenzene **2d** (0.2 mmol, 36.8 mg), $UO_2(OAc)_2{\cdot}2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5d**[16] (26.9 mg, 68%) was obtained through column chromatography (V_{PE}/V_{EA} = 10/1) as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.79 (d, *J* = 8.0 Hz, 2H), 7.57 (d, *J* = 8.0 Hz, 2H), 2.56 (s, 3H). **^{13}C NMR**

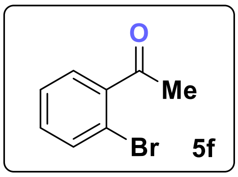
(100 MHz, CDCl$_3$) δ 196.9, 135.7, 131.8, 129.7, 128.2, 26.5. **IR** (neat) 1683, 1583, 1230, 1070, 1008, 821, 590.

1-(4-Bromophenyl)ethanone 5d: 1-bromo-4-isopropylbenzene **1o** (0.2 mmol, 39.6 mg), UO$_2$(OAc)$_2$·2H$_2$O (1.7 mg, 0.004 mmol), acetone (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 30 hours under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **5d** (23.8 mg, 60%) was obtained through column chromatography (V$_{PE}$/V$_{EA}$ = 10/1) as a white solid.



5e

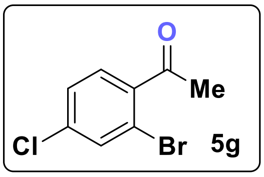
1-(3-Bromophenyl)ethanone 5e: 1-bromo-3-ethylbenzene **2e** (0.2 mmol, 36.8 mg), UO$_2$(OAc)$_2$·2H$_2$O (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2e** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5e**[17] (31.7 mg, 80%) was obtained through column chromatography (V$_{PE}$/V$_{EA}$ = 10/1) as a yellow liquid. **^{1}H NMR** (400 MHz, CDCl$_3$) δ 8.06 (t, *J* = 2.0 Hz, 1H), 7.87-7.84 (m, 1H), 7.68-7.65 (m, 1H), 7.33 (t, *J* = 8.0 Hz, 1H), 2.57 (s, 3H). **^{13}C NMR** (100 MHz, CDCl$_3$) δ 196.6, 138.7, 135.9, 131.3, 130.1, 126.8, 122.9, 26.6. **IR** (neat) 1685, 1566, 1419, 1246, 997, 781, 680.



5f

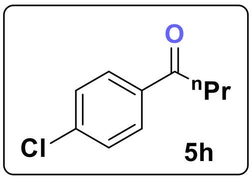
1-(2-Bromophenyl)ethanone 5f: 1-bromo-2-ethylbenzene **2f** (0.2 mmol, 36.8 mg), UO$_2$(OAc)$_2$·2H$_2$O (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2f** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5f**[14] (27.7 mg, 70%) was obtained through column chromatography (V$_{PE}$/V$_{EA}$ = 10/1) as a yellow liquid. **^{1}H NMR** (400 MHz, CDCl$_3$) δ 7.61 (d, *J* = 8.0 Hz, 1H), 7.46 (d, *J* = 8.0 Hz, 1H), 7.37 (t, *J* = 8.0 Hz, 1H), 7.29 (t, *J* = 8.0 Hz, 1H), 2.63 (s, 3H). **^{13}C NMR** (100 MHz,

$CDCl_3$) δ 201.3, 141.5, 133.8, 131.8, 128.9, 127.4, 118.9, 30.3. **IR** (neat) 1737, 1697, 1425, 1357, 1242, 1026, 758.



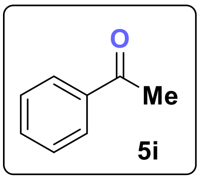
5g

1-(2-Bromo-4-chlorophenyl)ethan-1-one 5g: 2-bromo-4-chloro-1-ethylbenzene **2g** (0.2 mmol, 43.6 mg), $UO_2(OAc)_2\cdot 2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2g** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5g** (32.5 mg, 70%) was obtained through column chromatography (V_{PE}/V_{EA} = 10/1) as a yellow liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.63-7.61 (m, 1H), 7.44-7.42 (m, 1H), 7.36-7.33 (m, 1H), 2.61 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 199.8, 139.4, 137.3, 133.6, 130.1, 127.7, 119.7, 30.2. **IR** (neat) 1697, 1578, 1466, 1356, 1269, 1234, 1101.



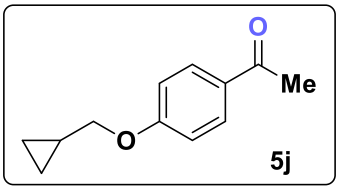
5h

1-(4-Chlorophenyl)butan-1-one 5h: 1-butyl-4-chlorobenzene **2h** (0.2 mmol, 33.6 mg), $UO_2(OAc)_2\cdot 2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2h** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5h**[18] (24.7 mg, 68%) was obtained through column chromatography (V_{PE}/V_{EA} = 10/1) as a yellow liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.87 (d, J = 8.0 Hz, 2H), 7.39 (d, J = 8.0 Hz, 2H), 2.89 (t, J = 7.6 Hz, 2H), 1.78-1.69 (m, 2H), 0.98 (t, J = 7.2 Hz, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 198.9, 139.2, 135.3, 129.4, 128.7, 40.4, 17.6, 13.7. **IR** (neat) 1716, 1684, 1213, 1155, 1091, 1024, 1003.



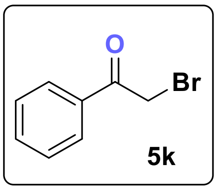
5i

Acetophenone 5i: ethylbenzene **2i** (0.2 mmol, 21.2 mg), $UO_2(OAc)_2\cdot 2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2i** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5i**[13] (18.5 mg, 77%) was obtained through column chromatography (V_{PE}/V_{EA} = 20/1) as a yellow liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.97-7.95 (m, 2H), 7.58-7.54 (m, 1H), 7.48-7.44 (m, 2H), 2.61 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 198.1, 137.1, 133.1, 128.5, 128.3, 26.6. **IR** (neat) 1712, 1683, 1448, 1423, 1359, 1222, 761.



5j

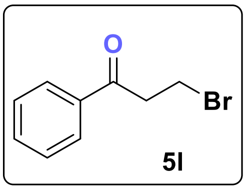
1-(4-(Cyclopropylmethoxy)phenyl)ethanone 5j: 1-(cyclopropylmethoxy)-4-ethylbenzene **2j** (0.2 mmol, 35.2 mg), $UO_2(OAc)_2·2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2j** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5j** (19.8 mg, 52%) was obtained through column chromatography (V_{PE}/V_{EA} = 10/1) as a yellow liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 12.0 Hz, 2H), 6.91 (d, *J* = 12.0 Hz, 2H), 3.86 (d, *J* = 8.0 Hz, 2H), 2.54 (s, 3H), 1.32-1.24 (m, 1H), 0.69-0.64 (m, 2H), 0.38-0.34 (m, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 196.8, 162.9, 130.5, 130.1, 114.1, 72.9, 26.3, 10.1, 3.2. **IR** (neat) 1674, 1598, 1247, 1168, 1002, 835, 588. **HRMS** (EI) Calcd for $C_{12}H_{14}O_2$ 190.0994, Found 190.0995.



5k

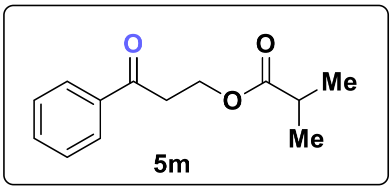
2-Bromo-1-phenylethanone 5k: (2-bromoethyl)benzene **2k** (0.2 mmol, 36.8 mg), $UO_2(OAc)_2·2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2k** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5k** (27.7 mg, 70%) was obtained through column chromatography (V_{PE}/V_{EA} = 20/1) as a brown solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.00-7.98 (m, 2H), 7.61 (t, *J* = 6.0 Hz, 1H), 7.50 (t, *J* = 8.0 Hz, 2H), 4.46 (s, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 191.3, 133.9, 128.9, 128.8, 30.9. **IR** (neat) 1685, 1579, 1448, 1388, 1280, 991, 744. **HRMS** (EI) Calcd for C_8H_7BrO

197.9680, Found 197.9678.



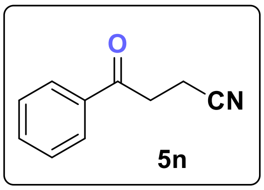
5l

3-Bromo-1-phenylpropan-1-one 5l: (3-bromopropyl)benzene **2l** (0.2 mmol, 39.6 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2l** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5l** (28.8 mg, 68%) was obtained through column chromatography ($V_{PE}/V_{EA} = 10/1$) as a brown solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.95 (d, J = 8.0 Hz, 2H), 7.59 (t, J = 8.0 Hz, 1H), 7.48 (t, J = 8.0 Hz, 2H), 3.74 (t, J = 8.0 Hz, 2H), 3.57 (t, J = 6.0 Hz, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 196.9, 136.2, 133.5, 128.7, 128.0, 41.5, 25.7. **IR** (neat) 1681, 1361, 1228, 1112, 974, 756, 688. **HRMS** (EI) Calcd for C_9H_9BrO 211.9837, Found 211.9835.



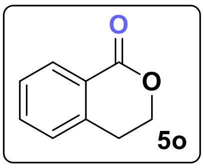
5m

3-Oxo-3-phenylpropyl isobutyrate 5m: 3-phenylpropyl isobutyrate **2m** (0.2 mmol, 41.2 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol) and acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5m** (22.0 mg, 50%) was obtained through column chromatography ($V_{PE}/V_{EA} = 10/1$) as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.95 (d, J = 12.0 Hz, 2H), 7.58 (t, J = 8.0 Hz, 1H), 7.48 (t, J = 8.0 Hz, 2H), 4.52 (t, J = 8.0 Hz, 2H), 3.31 (t, J = 6.0 Hz, 2H), 2.56-2.47 (m, 1H), 1.13 (d, J = 8.0 Hz, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 197.1, 177.1, 136.6, 133.3, 128.7, 128.1, 59.6, 37.4, 33.9, 18.9. **IR** (neat) 2974, 1734, 1686, 1389, 1265, 1157, 746.

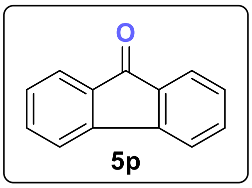


5n

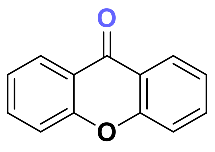
4-Oxo-4-phenylbutanenitrile 5n: 4-phenylbutanenitrile **2n** (0.2 mmol, 29.0 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol) and acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2n** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5n**[19] (16.2 mg, 51%) was obtained through column chromatography ($V_{PE}/V_{EA} = 5/1$) as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.92 (d, *J* = 8.0 Hz, 2H), 7.59 (t, *J* = 8.0 Hz, 1H), 7.44 (t, *J* = 8.0 Hz, 2H), 3.34 (t, *J* = 8.0 Hz, 2H), 2.73 (t, *J* = 8.0 Hz, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 195.3, 135.4, 133.7, 128.7, 127.8, 119.2, 34.0, 11.6. **IR** (neat) 1682, 1447, 1369, 1284, 1207, 1053, 976.



Isochroman-1-one 5o: isochroman **2o** (0.2 mmol, 26.8 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2o** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5o**[20] (17.2 mg, 58%) was obtained through column chromatography ($V_{PE}/V_{EA} = 10/1$) as a colorless liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.09 (dd, J_1 = 8.0 Hz, J_2 = 0.8 Hz, 1H), 7.53 (td, J_1 = 8.0 Hz, J_2 = 1.6 Hz, 1H), 7.39 (t, *J* = 8.0 Hz, 1H), 7.26 (d, *J* = 8.0 Hz, 1H), 4.53 (t, *J* = 6.0 Hz, 2H), 3.06 (t, *J* = 6.0 Hz, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 165.1, 139.5, 133.6, 130.4, 127.7, 127.2, 125.3, 67.3, 27.8. **IR** (neat) 1716, 1678, 1602, 1392, 1292, 1118, 1028.

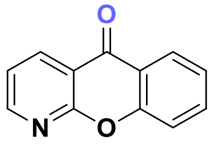


***9H*-fluoren-9-one 5p**: *9H*-fluorene **2p** (0.2 mmol, 33.2 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2p** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5p**[21] (27.7 mg, 77%) was obtained through column chromatography ($V_{PE}/V_{EA} = 10/1$) as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.65 (d, *J* = 8.0 Hz, 2H), 7.51-7.44 (m, 4H), 7.28 (t, *J* = 8.0 Hz, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 193.8, 144.3, 134.6, 134.0, 128.9, 124.2, 120.2. **IR** (neat) 1717, 1612, 1452, 1300, 1192, 1148, 737.



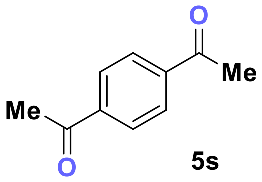
5q

***9H*-xanthen-9-one 5q**: *9H*-xanthene **2p** (0.2 mmol, 36.4 mg), $UO_2(OAc)_2\cdot 2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2q** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5q**[22] (33.3 mg, 85%) was obtained through column chromatography (V_{PE}/V_{EA} = 10/1) as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.33 (d, *J* = 8.0 Hz, 2H), 7.71 (t, *J* = 8.0 Hz, 2H), 7.48 (t, *J* = 8.0 Hz, 2H), 7.37 (t, *J* = 8.0 Hz, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 177.2, 156.1, 134.8, 126.7, 123.9, 121.8, 117.9. **IR** (neat) 1674, 1589, 1304, 1283, 968, 746, 690.



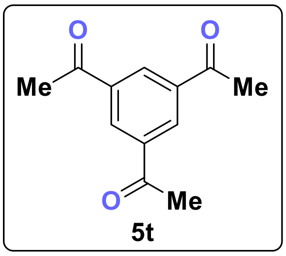
5r

***5H*-chromeno[2,3-b]pyridin-5-one 5r**: *5H*-chromeno[2,3-b]pyridine **2r** (0.2 mmol, 36.6 mg), $UO_2(OAc)_2\cdot 2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2r** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5r**[23] (32.7 mg, 83%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1) as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.73-8.68 (m, 2H), 8.28 (d, *J* = 8.0 Hz, 1H), 7.76 (t, *J* = 8.0 Hz, 1H), 7.69 (d, *J* = 8.0 Hz, 1H), 7.44-7.38 (m, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 177.5, 160.3, 155.6, 154.1, 137.3, 135.6, 126.6, 124.6, 121.4, 121.0, 118.4, 116.7. **IR** (neat) 1670, 1614, 1418, 1348, 1199, 937, 760.



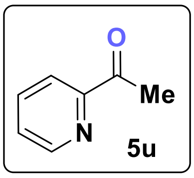
5s

1,1'-(1,4-Phenylene)diethanone 5s: 1,4-diethylbenzene **2s** (0.2 mmol, 26.8 mg), $UO_2(OAc)_2\cdot 2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2s** under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5s**[24] (25.9 mg, 80%) was obtained through column chromatography (V_{PE}/V_{EA} = 5/1) as a colorless liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.98 (s, 4H), 2.60 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 197.3, 140.0, 128.4, 26.8. **IR** (neat) 1676, 1566, 1423, 1348, 1246, 1166, 1010.



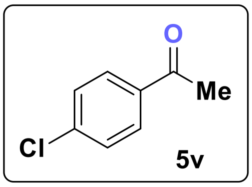
5t

1,1',1''-(Benzene-1,3,5-triyl)triethanone 5t: 1,3,5-triethylbenzene **2t** (0.1 mmol, 16.2 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (0.85 mg, 0.002 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2t** under the irradiation of 6W blue LEDs in a paralleled reactor. **5t** (15.7 mg, 77%) was obtained through column chromatography ($V_{PE}/V_{EA} = 10/1$) as a colorless liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.70 (s, 3H), 2.71 (s, 9H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 196.7, 137.9, 131.7, 26.8. **IR** (neat) 1683, 1419, 1361, 1226, 1022, 904, 684. **HRMS** (EI) Calcd for $C_{12}H_{12}O_3$ 204.0786, Found 204.0789.



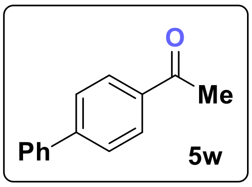
5u

1-(Pyridin-2-yl)ethanone 5u: 2-ethylpyridine **2u** (0.2 mmol, 21.4 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **2u** under the irradiation of 6W blue LEDs in a paralleled reactor. **5u**[25] (16.2 mg, 67%) was obtained through column chromatography ($V_{PE}/V_{EA} = 5/1$) as a colorless liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.65 (d, J = 4.0 Hz, 1H), 8.00 (d, J = 8.0 Hz, 1H), 7.79 (td, J_1 = 8.0 Hz, J_2 = 1.6 Hz, 1H), 7.45-7.41 (m, 1H), 2.69 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 200.0, 153.5, 148.9, 136.7, 127.0, 121.5, 25.7. **IR** (neat) 1697, 1355, 1280, 1238, 1043, 777, 588.



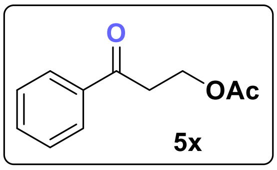
5v

1-(4-Chlorophenyl)ethan-1-one 5v: 1-chloro-4-isopropylbenzene **1p** (0.2 mmol, 30.8 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol) and acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **5v**[21] (22.5 mg, 73%) was obtained through column chromatography (V_{PE}/V_{EA} = 20/1) as a colorless liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.0 Hz, 2H), 7.43 (d, *J* = 8.0 Hz, 2H), 2.59 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 196.8, 139.5, 135.4, 129.7, 128.9, 26.5. **IR** (neat) 1684, 1587, 1396, 1356, 1258, 1093, 1012.



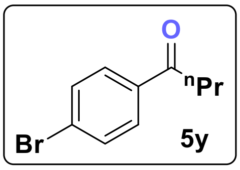
5w

1-([1,1'-Biphenyl]-4-yl)ethan-1-one 5w: 4-isopropyl-1,1'-biphenyl **1q** (0.2 mmol, 39.2 mg), $UO_2(OAc)_2·2H_2O$ (1.7 mg, 0.004 mmol) and acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **5w**^{26} (21.2 mg, 54%) was obtained through column chromatography (V_{PE}/V_{EA} = 10/1) as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.04 (d, *J* = 8.0 Hz, 2H), 7.69 (d, *J* = 8.0 Hz, 2H), 7.63 (d, *J* = 8.0 Hz, 2H), 7.48 (t, *J* = 8.0 Hz, 2H), 7.41 (t, *J* = 8.0 Hz, 1H), 2.65 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 197.8, 145.8, 139.9, 135.8, 128.94, 128.90, 128.2, 127.3, 127.2, 26.7. **IR** (neat) 1676, 1600, 1359, 1261, 1004, 677, 592.

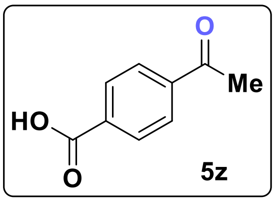


5x

3-Oxo-3-phenylpropyl acetate 5x: 3-phenylpropyl acetate **2x** (0.2 mmol, 35.6 mg), $UO_2(OAc)_2·2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5x** (23.4 mg, 61%) was obtained through column chromatography (V_{PE}/V_{EA} = 10/1) as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.96 (d, *J* = 8.0 Hz, 2H), 7.59 (t, *J* = 6.0 Hz, 1H), 7.48 (t, *J* = 8.0 Hz, 2H), 4.52 (t, *J* = 6.0 Hz, 2H), 3.32 (t, *J* = 6.0 Hz, 2H), 2.03 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 197.0, 171.0, 136.6, 133.4, 128.7, 128.1, 59.7, 37.4, 20.9. **IR** (neat) 2926, 1728, 1670, 1249, 1176, 1049, 744. **HRMS** (EI) Calcd for $C_{11}H_{12}O_3$ 192.0786, Found 192.0787.

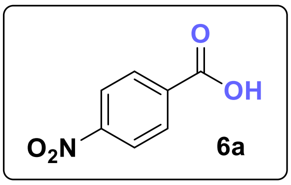


1-(4-bromophenyl)butan-1-one 5y: 1-bromo-4-butylbenzene **2y** (0.2 mmol, 42.4 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature under the irradiation of 6 W blue light (460 nm) in a paralleled reactor. **5x**[27] (28.5 mg, 63%) was obtained through column chromatography (V_{PE}/V_{EA} = 20/1) as a brown liquid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.80 (d, *J* = 8.0 Hz, 2H), 7.58 (d, *J* = 8.0 Hz, 2H), 2.89 (t, *J* = 8.0 Hz, 2H), 1.79-1.70 (m, 2H), 0.99 (t, *J* = 8.0 Hz, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 199.2, 135.8, 131.8, 129.5, 127.9, 40.4, 17.6, 13.8. **IR** (neat) 1686, 1587, 1379, 1271, 1091, 1045, 879.



4-acetylbenzoic acid 5z: 4-ethylbenzoic acid **2z** (0.2 mmol, 30.0 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature under the irradiation of 6W blue light (460 nm) in a paralleled reactor. **5z**[28] (32.5 mg, 99%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 13.31 (brs, 1H), 8.05 (s, 4H), 2.62 (s, 3H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 197.7, 166.6, 139.9, 134.5, 129.5, 128.3, 27.0. **IR** (neat) 3005, 1716, 1670, 1570, 1425, 1288, 1224.

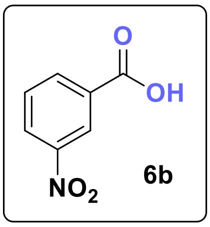
4-acetylbenzoic acid 5z: 1-p-tolylethanone **3g** (0.2 mmol, 26.8 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), HCl (2 N, 0.2 mmol, 100 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **5z** (19.7 mg, 60%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid.



6a

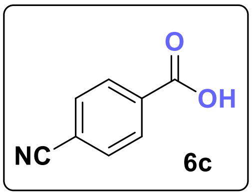
4-Nitrobenzoic acid 6a: 1-methyl-4-nitrobenzene **3a** (0.2 mmol, 27.4 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (0.004 mmol, 1.7 mg), HCl (2 N, 0.2 mmol, 100 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 36 hours under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6a**[29] (27.0 mg, 81%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a yellow solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 13.66 (brs, 1H), 8.31 (d, *J* = 8.0 Hz, 2H), 8.16 (d, *J* = 8.0 Hz, 2H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 165.8, 150.0, 136.4, 130.7, 123.7. **IR** (neat) 3392, 1685, 1598, 1539, 1425, 1350, 1278.

Flow Chemistry: To a 100 mL three-necked flask, a solution of 1-ethyl-4-nitrobenzene **3a** (20.0 mmol, 2.74 g), $UO_2(NO_3)_2 \cdot 6H_2O$ (0. 4 mmol, 200 mg), HCl (2N, 20.0 mmol, 10 mL) and acetone (60 mL) were stirred under oxygen atmosphere. The solution was pumped into a flow micro tube by a pump (0.5 mL/min), which was made of PTFE tubing (O.D. = 2 mm, I.D. = 1 mm, length = 31.4 m, volume = 24.65 mL), and returned to Schlenk tube with the same pump. This circulatory system was irradiated by blue light (435 nm, 90 W) about 5 days (the temperature was below 30 °C). After the reaction, DCM (10 mL) was pumped into a flow micro tube to quench it and wash the tube. The solvent was removed in vacuo. Purify the crude residue by column chromatography on silica gel using DCM/MeOH (20/1) to afford **6a** (80%, 2.67 g, 0.133 mmol/h) with yellow solid.



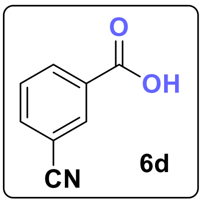
6b

3-Nitrobenzoic acid 6b: 1-methyl-3-nitrobenzene **3b** (0.2 mmol, 27.4 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (0.004 mmol, 1.7 mg), HCl (2 N, 0.2 mmol, 100 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **3b** under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6b**[30] (25.4 mg, 76%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a yellow solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 13.66 (brs, 1H), 8.61 (s, 1H), 8.46 (d, *J* = 8.0 Hz, 1H), 8.34 (d, *J* = 8.0 Hz, 1H), 7.81 (t, *J* = 8.0 Hz, 1H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 165.5, 147.9, 135.4, 132.5, 130.5, 127.3, 123.7. **IR** (neat) 3367, 1705, 1618, 1527, 1417, 1350, 1228.



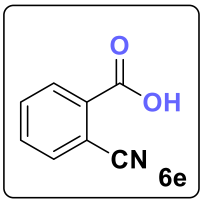
6c

4-Cyanobenzoic acid 6c: 4-methylbenzonitrile **3c** (0.2 mmol, 23.4 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), CCl_3COOH (0.2 mmol, 32.4 mg), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **3c** under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6c**[31] (20.0 mg, 68%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 13.56 (brs, 1H), 8.08 (d, *J* = 8.0 Hz, 2H), 7.98 (d, *J* = 8.0 Hz, 2H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 166.3, 135.0, 132.9, 130.1, 118.4, 115.2. **IR** (neat) 3410, 2231, 1714, 1566, 1429, 1286, 927.



6d

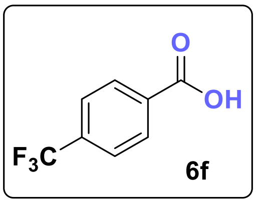
3-Cyanobenzoic acid 6d: 3-methylbenzonitrile **3d** (0.2 mmol, 23.4 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), HCl (2 N, 0.2 mmol, 100 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **3d** under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6d**[29] (15.3 mg, 52%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 13.74 (brs, 1H), 8.48-8.45 (m, 1H), 8.36-8.33 (m, 1H), 7.81 (t, *J* = 8.0 Hz, 1H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 165.5, 147.9, 135.4, 132.5, 130.6, 127.4, 123.7. **IR** (neat) 2924, 2233, 1689, 1616, 1435, 1298, 675.



6e

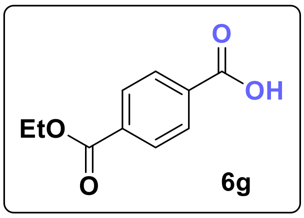
2-Cyanobenzoic acid 6e: 2-methylbenzonitrile **3e** (0.2 mmol, 23.4 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), HCl (2 N, 0.2 mmol, 100 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **3e** under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6e**[32] (21.5 mg, 73%)

was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 8.09 (d, *J* = 8.0 Hz, 1H), 7.95-7.94 (m, 1H), 7.79-7.78 (m, 2H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 165.3, 135.1, 133.24, 133.16, 133.1, 131.0, 117.8, 111.8. **IR** (neat) 2976, 1697, 1417, 1275, 1093, 1082, 1051.



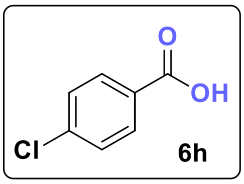
6f

4-(trifluoromethyl)benzoic acid 6f: 1-methyl-4-(trifluoromethyl)benzene **3f** (0.2 mmol, 32.0 mg), $UO_2(OAc)_2·2H_2O$ (1.7 mg, 0.004 mmol), HCl (2 N, 0.2 mmol, 100 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **3f** under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6f**[29] (26.2 mg, 69%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (500 MHz, acetone-*d6*) δ 11.58 (brs, 1H), 8.24 (d, *J* = 8.0 Hz, 2H), 7.87 (d, *J* = 8.0 Hz, 2H). **^{13}C NMR** (126 MHz, acetone-*d6*) δ 166.5, 135.1 (d, *J* = 1.26 Hz), 134.5 (q, *J* = 32.76 Hz), 131.2, 126.4 (q, *J* = 3.90 Hz), 124.9 (q, *J* = 272.16 Hz). **^{19}F NMR** (376 MHz, acetone-*d6*) δ -63.59. **IR** (neat) 2926, 1689, 1583, 1425, 1284, 1166, 700.



6g

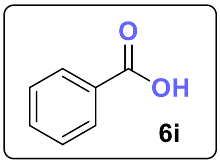
4-(ethoxycarbonyl)benzoic acid 6g: ethyl 4-methylbenzoate **3h** (0.2 mmol, 32.8 mg), $UO_2(OAc)_2·2H_2O$ (1.7 mg, 0.004 mmol), CCl_3COOH (0.2 mmol, 32.4 mg), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 3 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6g**[31] (24.8 mg, 64%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 13.33 (brs, 1H), 8.05 (s, 4H), 4.34 (q, *J* = 6.7 Hz, 2H), 1.33 (t, *J* = 8.0 Hz, 3H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 166.6, 165.1, 134.8, 133.4, 129.6, 129.3, 61.2, 14.1. **IR** (neat) 3005, 1712, 1573, 1427, 1224, 1014, 729.



6h

4-chlorobenzoic acid 6h: 1-chloro-4-methylbenzene **3i** (0.2 mmol, 25.2 mg), $UO_2(OAc)_2\cdot 2H_2O$ (1.7 mg, 0.004 mmol), HCl (2 N, 0.2 mmol, 100 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6h**[28] (24.0 mg, 77%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 13.16 (brs, 1H), 7.93 (d, *J* = 8.0 Hz, 2H), 7.54 (d, *J* = 8.0 Hz, 2H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 166.5, 137.8, 131.2, 129.7, 128.8. **IR** (neat) 3008, 1716, 1678, 1423, 1365, 1224, 1091.

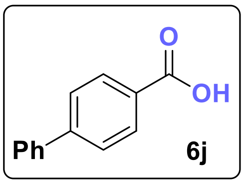
4-chlorobenzoic acid 6h: 1-chloro-4-isopropylbenzene **1p** (0.2 mmol, 30.8 mg), $UO_2(OAc)_2\cdot 2H_2O$ (1.7 mg, 0.004 mmol), H_2SO_4 (2 N, 0.2 mmol, 100 ul), acetone (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 5 days under the irradiation of 12 W blue light (430 nm) in a paralleled reactor. **6h** (18.4 mg, 59%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid.



6i

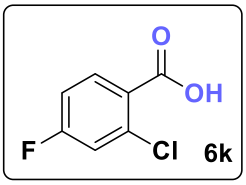
Benzoic acid 6i: toluene **3j** (0.2 mmol, 18.4 mg), $UO_2(OAc)_2\cdot 2H_2O$ (1.7 mg, 0.004 mmol), HCl (2 N, 0.2 mmol, 100 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6i**[30] (16.3 mg, 67%) was obtained through column chromatography (V_{PE}/V_{EA} = 2/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 12.96 (brs, 1H), 7.96-7.94-7.98 (m, 2H), 7.63-7.59 (m, 1H), 7.51-7.48 (m, 2H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 167.4, 132.9, 130.8, 129.3, 128.6. **IR** (neat) 3007, 1716, 1681, 1421, 1224, 923, 704.

Benzoic acid 6i: 3-phenylpropyl acetate **2x** (0.2 mmol, 35.6 mg), $UO_2(OAc)_2\cdot 2H_2O$ (1.7 mg, 0.004 mmol), ^{t}BuOH (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 5 days under the irradiation of 12 W blue light (430 nm) in a paralleled reactor. **6i** (15.9 mg, 65%) was obtained through column chromatography (V_{PE}/V_{EA} = 2/1) as a white solid.

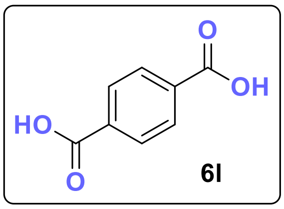


Biphenyl-4-carboxylic acid 6j: 4-methylbiphenyl **3k** (0.2 mmol, 33.6 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), HCl (2 N, 0.2 mmol, 100 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature until the total consumption of **3k** under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6j**[33] (36.4 mg, 92%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 12.99 (brs, 1H), 8.03 (d, *J* = 8.0 Hz, 2H), 7.79 (d, *J* = 8.0 Hz, 2H), 7.72 (d, *J* = 8.0 Hz, 2H), 7.49 (t, *J* = 8.0 Hz, 2H), 7.42 (t, *J* = 8.0 Hz, 1H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 167.2, 144.3, 139.0, 129.9, 129.6, 129.1, 128.3, 126.9, 126.8. **IR** (neat) 2547, 1712, 1674, 1421, 1298, 1286, 746.

Biphenyl-4-carboxylic acid 6j: 4-isopropyl-1,1'-biphenyl **1q** (0.2 mmol, 39.2 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), H_2SO_4 (2 N, 0.2 mmol, 100 ul), acetone (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 4 days under the irradiation of 12 W blue light (430 nm) in a paralleled reactor. **6j** (24.1 mg, 61%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid.



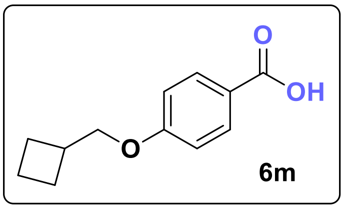
2-chloro-4-fluorobenzoic acid 6k: 2-chloro-4-fluoro-1-methylbenzene **3l** (0.2 mmol, 28.8 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), HCl (2 N, 0.2 mmol, 100 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 3 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6k**[34] (21.2 mg, 61%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 7.91-7.88 (m, 1H), 7.54-7.51 (m, 1H), 7.33-7.28 (m, 1H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 165.8, 163.22 (d, *J* = 251 Hz), 133.7 (d, *J* = 22 Hz), 133.4 (d, *J* = 10 Hz), 127.7 (d, *J* = 3 Hz), 118.2 (d, *J* = 25 Hz), 114.7 (d, *J* = 21 Hz). **^{19}F NMR** (376 MHz, DMSO-*d6*) δ -106.72. **IR** (neat) 2955, 1703, 1599, 1500, 1427, 1294, 1269.



6l

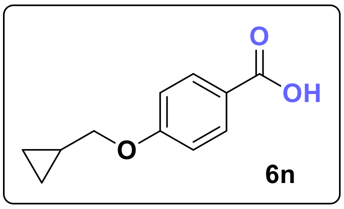
Terephthalic acid 6l: p-xylene **3m** (0.2 mmol, 28.8 mg), $UO_2(OAc)_2\cdot 2H_2O$ (1.7 mg, 0.004 mmol), HCl (2 N, 0.2 mmol, 100 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 4 days under the irradiation of 9 W blue light (430 nm) in a paralleled reactor. The solvent was removed by vacuum distillation. The residue was dissolved in $NaHCO_3$ (aq), then EA added. Extract the solution with EA three times. Collect the aqueous layer and treat it with HCl (2 N). Filter the formed precipitate and wash it with water and ether, then dry the white precipitate **6l** (18.9 mg, 57%). **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 8.03 (s, 4H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 166.9, 134.6, 129.6. **IR** (neat) 2820, 2534, 2359, 1670, 1508, 1419, 1279.

Terephthalic acid 6l: 4-ethylbenzoic acid (0.2 mmol, 30.0 mg), $UO_2(OAc)_2\cdot 2H_2O$ (1.7 mg, 0.004 mmol), ^{t}BuOH (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 3 days under the irradiation of 12 W blue light (460 nm) in a paralleled reactor. **6l** (17.3 mg, 52%) was obtained as a white solid.

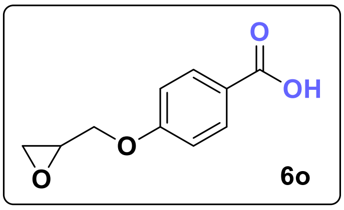


6m

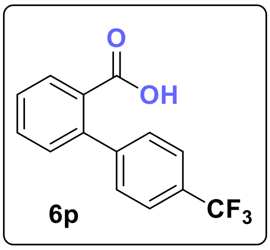
4-(cyclobutylmethoxy)benzoic acid 6m: 1-(cyclobutylmethoxy)-4-methylbenzene **3n** (0.2 mmol, 35.2 mg), $UO_2(OAc)_2\cdot 2H_2O$ (1.7 mg, 0.004 mmol), CH_3COOH (0.2 mmol, 12.0 mg), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 36 hours under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6m** (21.0 mg, 51%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 12.60 (brs, 1H), 7.87 (d, *J* = 8.0 Hz, 2H), 7.00 (d, *J* = 8.0 Hz, 2H), 4.01 (d, *J* = 8.0 Hz, 2H), 2.76-2.68 (m, 1H), 2.10-2.03 (m, 2H), 1.93-1.79 (m, 4H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 167.0, 162.4, 131.3, 122.8, 114.3, 71.7, 33.8, 24.3, 18.1. **IR** (neat) 2922, 1674, 1600, 1423, 1286, 1238, 1166. **HRMS** (EI) Calcd for $C_{12}H_{14}O_3$ 206.0943, Found 206.0947.



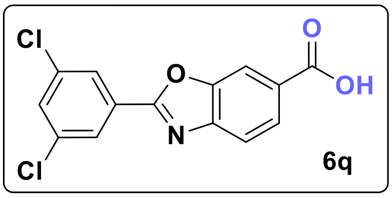
4-(cyclopropylmethoxy)benzoic acid 6n: 1-(cyclopropylmethoxy)-4-methylbenzene **3o** (0.2 mmol, 32.4 mg), $UO_2(OAc)_2·2H_2O$ (1.7 mg, 0.004 mmol), CH_3COOH (0.2 mmol, 12.0 mg), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 36 hours under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6n** (20.7 mg, 54%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.05 (d, *J* = 8.0 Hz, 2H), 6.94 (d, *J* = 8.0 Hz, 2H), 3.88 (d, *J* = 4.0 Hz, 2H), 1.32-1.26 (m, 1H), 0.70-0.65 (m, 2H), 0.39-0.36 (m, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 171.6, 163.5, 132.3, 121.4, 114.2, 73.0, 10.1, 3.2. **IR** (neat) 2924, 1741, 1672, 1575, 1406, 1242, 1001. **HRMS** (EI) Calcd for $C_{11}H_{12}O_3$ 192.0786, Found 192.0788.



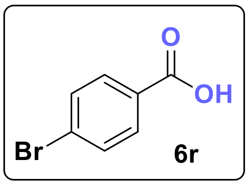
4-(oxiran-2-ylmethoxy)benzoic acid 6o: 2-(p-tolyloxymethyl)oxirane **3p** (0.2 mmol, 32.8 mg), $UO_2(OAc)_2·2H_2O$ (1.7 mg, 0.004 mmol), CH_3COOH (0.2 mmol, 12.0 mg), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 36 hours under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6o** (23.3 mg, 60%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 12.66 (brs, 1H), 7.89 (d, *J* = 8.0 Hz, 2H), 7.04 (d, *J* = 8.0 Hz, 2H), 4.43-4.40 (m, 1H), 3.92-3.88 (m, 1H), 3.37-3.34 (m, 2H), 2.86-2.84 (m, 1H), 2.73-2.71 (m, 1H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 167.0, 161.8, 131.4, 123.3, 114.4, 69.2, 49.6, 43.8. **IR** (neat) 2920, 1674, 1602, 1425, 1246, 1170, 916. **HRMS** (EI) Calcd for $C_{10}H_{10}O_4$ 194.0579, Found 194.0582.



4'-(trifluoromethyl)biphenyl-2-carboxylic acid 6p: 2-methyl-4'-(trifluoromethyl)biphenyl **3q** (0.1 mmol, 23.6 mg), $UO_2(OAc)_2{\cdot}2H_2O$ (0.85 mg, 0.002 mmol), HCl (2 N, 0.2 mmol, 100 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 3 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6p** (30.9 mg, 58%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 12.86 (brs, 1H), 7.83 (dd, J_1 = 7.6 Hz, J_2 = 1.2 Hz, 1H), 7.76 (d, J = 8.0 Hz, 2H), 7.63 (dt, J_1 = 7.6 Hz, J_2 = 1.6 Hz, 1H), 7.55-7.51 (m, 3H), 7.42-7.40 (m, 1H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 168.9, 145.3, 140.0, 131.8, 131.3, 130.6, 129.6, 129.2, 128.1, 127.6 (d, J = 31 Hz), 124.9 (q, J = 4 Hz), 124.4 (d, J = 270 Hz). **^{19}F NMR** (376 MHz, DMSO-*d6*) δ -60.81. **IR** (neat) 2926, 1697, 1404, 1290, 1155, 1107, 1006. **HRMS** (EI) Calcd for $C_{14}H_9F_3O_2$ 266.0555, Found 266.0552.



2-(3,5-dichlorophenyl)benzo[d]oxazole-6-carboxylic acid 6q: 2-(3,5-dichlorophenyl)-6-methylbenzo[d]oxazole **3r** (0.1 mmol, 27.7 mg), $UO_2(OAc)_2{\cdot}2H_2O$ (0.85 mg, 0.002 mmol), HCl (2 N, 0.1 mmol, 50 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6q** (15.4 mg, 50%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 8.29 (d, J = 1.2 Hz, 1H), 8.17 (d, J = 1.6 Hz, 2H), 8.05 (dd, J_1 = 8.4 Hz, J_2 = 1.6 Hz, 1H), 7.96 (t, J = 2.0 Hz, 1H), 7.93 (d, J = 8.4 Hz, 1H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 166.8, 162.1, 150.2, 144.7, 135.2, 131.8, 129.3, 126.6, 126.0, 120.0, 112.3. **IR** (neat) 2924, 1743, 1703, 1267, 1242, 1049, 1004. **HRMS** (EI) Calcd for $C_{14}H_7Cl_2NO_3$ 306.9803, Found 306.9807.

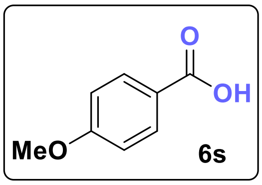


6r

4-Bromobenzoic acid 6r: 1-bromo-4-isopropylbenzene **1o** (0.2 mmol, 39.6 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), H_2SO_4 (2 N, 0.2 mmol, 100 ul), acetone (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 3 days under the irradiation of 12 W blue light (460 nm) in a paralleled reactor. **6r**[30] (18.8 mg, 47%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 13.21 (brs, 1H), 7.86 (d, *J* = 8.0 Hz, 2H), 7.71 (d, *J* = 8.0 Hz, 2H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 166.7, 131.7, 131.3, 130.1, 126.9. **IR** (neat) 2546, 1670, 1570, 1421, 1234, 925, 754.

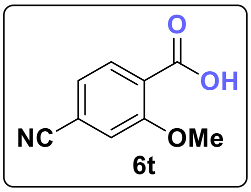
4-Bromobenzoic acid 6r: 1-bromo-4-butylbenzene **2y** (0.2 mmol, 42.4 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), ^{t}BuOH (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 3 days under the irradiation of 12 W blue light (460 nm) in a paralleled reactor. **6r** (22.4 mg, 56%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid.

4-Bromobenzoic acid 6r: 1-bromo-4-methylbenzene **3s** (0.2 mmol, 34.0 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), HCl (2 N, 0.2 mmol, 100 ul), acetone (1.2 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 3 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6r** (22.0 mg, 55%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid.



6s

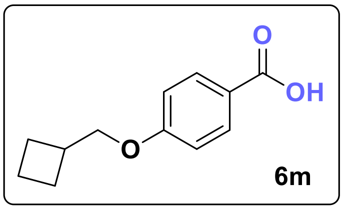
4-methoxybenzoic acid 6s: 1-methoxy-4-methylbenzene **3t** (0.2 mmol, 24.4 mg), $UO_2(OAc)_2 \cdot 2H_2O$ (1.7 mg, 0.004 mmol), HCl (2 N, 0.2 mmol, 100 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 2 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6s**[30] (24.6 mg, 81%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 12.62 (brs, 1H), 7.89 (d, *J* = 8.0 Hz, 2H), 7.01 (d, *J* = 8.0 Hz, 2H), 3.82 (s, 3H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 167.0, 162.9, 131.4, 123.0, 113.8, 55.4. **IR** (neat) 2926, 1705, 1678, 1575, 1425, 1230, 1022.



6t

4-Cyano-2-methoxybenzoic acid 6t: 3-methoxy-4-methylbenzonitrile **3u** (0.2 mmol, 29.4 mg), $UO_2(OAc)_2·2H_2O$ (1.7 mg, 0.004 mmol), HCl (2 N, 0.2 mmol, 100 ul), acetone (1 mL) were stirred under oxygen atmosphere (1 atm, ballon) at room temperature about 3 days under the irradiation of 9 W blue light (460 nm) in a paralleled reactor. **6t** (24.8 mg, 70%) was obtained through column chromatography (V_{DCM}/V_{MeOH} = 20/1) as a white solid. **^{1}H NMR** (400 MHz, DMSO-*d6*) δ 7.89 (d, *J* = 8.0 Hz, 1H), 7.62 (d, *J* = 0.8 Hz, 1H), 7.46 (dd, J_1 = 8.0 Hz, J_2 = 1.6 Hz, 1H), 3.87 (s, 3H). **^{13}C NMR** (100 MHz, DMSO-*d6*) δ 166.5, 157.4, 130.8, 126.6, 124.1, 118.2, 116.0, 114.6, 56.4. **IR** (neat) 2951, 1458, 1375, 1169, 1092, 1051, 881.

VII. X-ray Crystallography Analysis of Compounds



6m

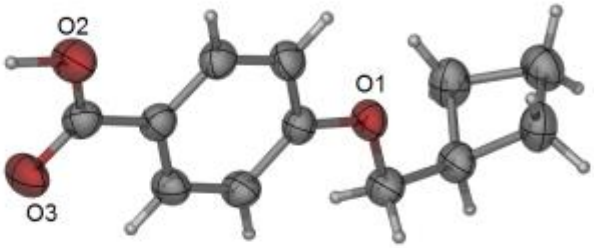
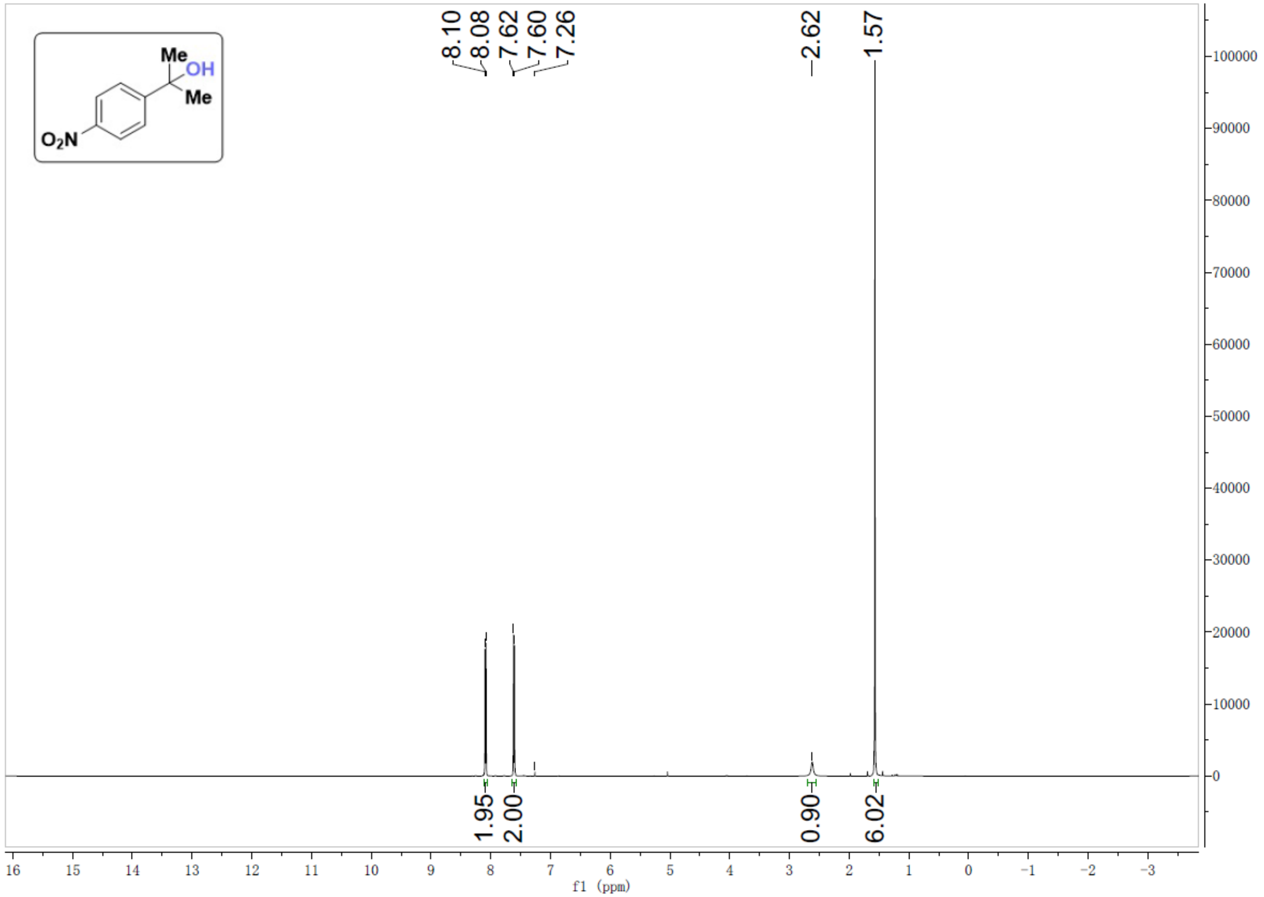


Table S8. Crystal Data and Structure Refinement for Complex **6m** **(CCDC1962911)**

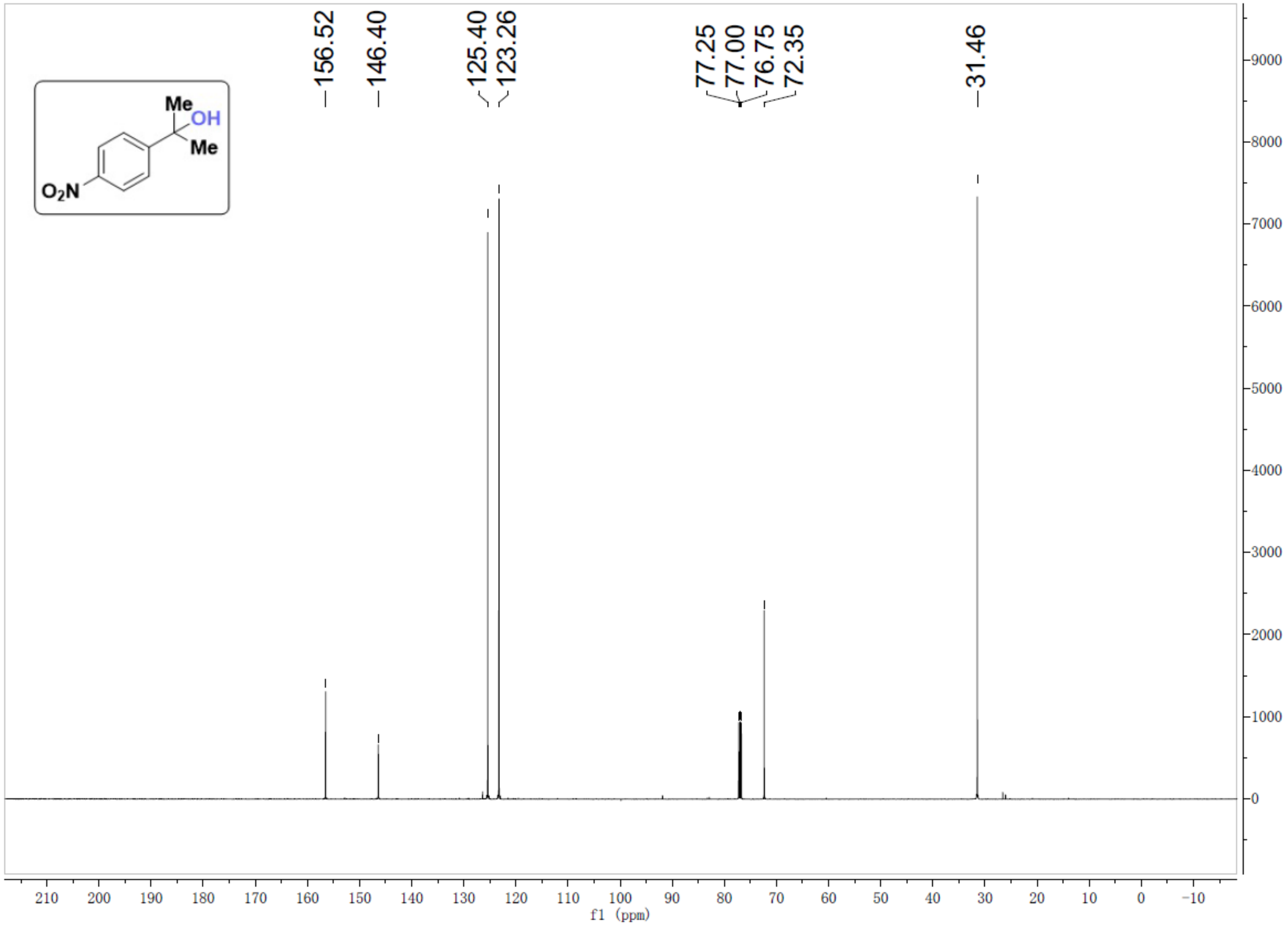
Complex	**6m**
Empirical formula	$C_{12}H_{14}O_3$
Formula weight	206.23
Crystal system	monoclinic
Space group	$P2_1/c$
a, Å	17.7291(6)
b, Å	7.5614(2)
c, Å	8.1518(2)
α, °	90
β, °	102.867(3)
γ, °	90
V, Å^3	1065.36(5)
Z	4
ρ_{calcd} (g cm^{-3})	1.286
μ/mm^{-1}	0.751
F(000)	440.0
2θ range for data collection/°	10.236 to 148.668
R_{int}	0.1087
Final R indices [$I > 2\sigma(I)$]	$R_1 = 0.0499$ $wR_2 = 0.1432$
Final R indexes [all data]	$R_1 = 0.0559$, $wR_2 = 0.1488$

VIII. NMR Spectra

^{1}H NMR of 4a



^{13}C NMR of 4a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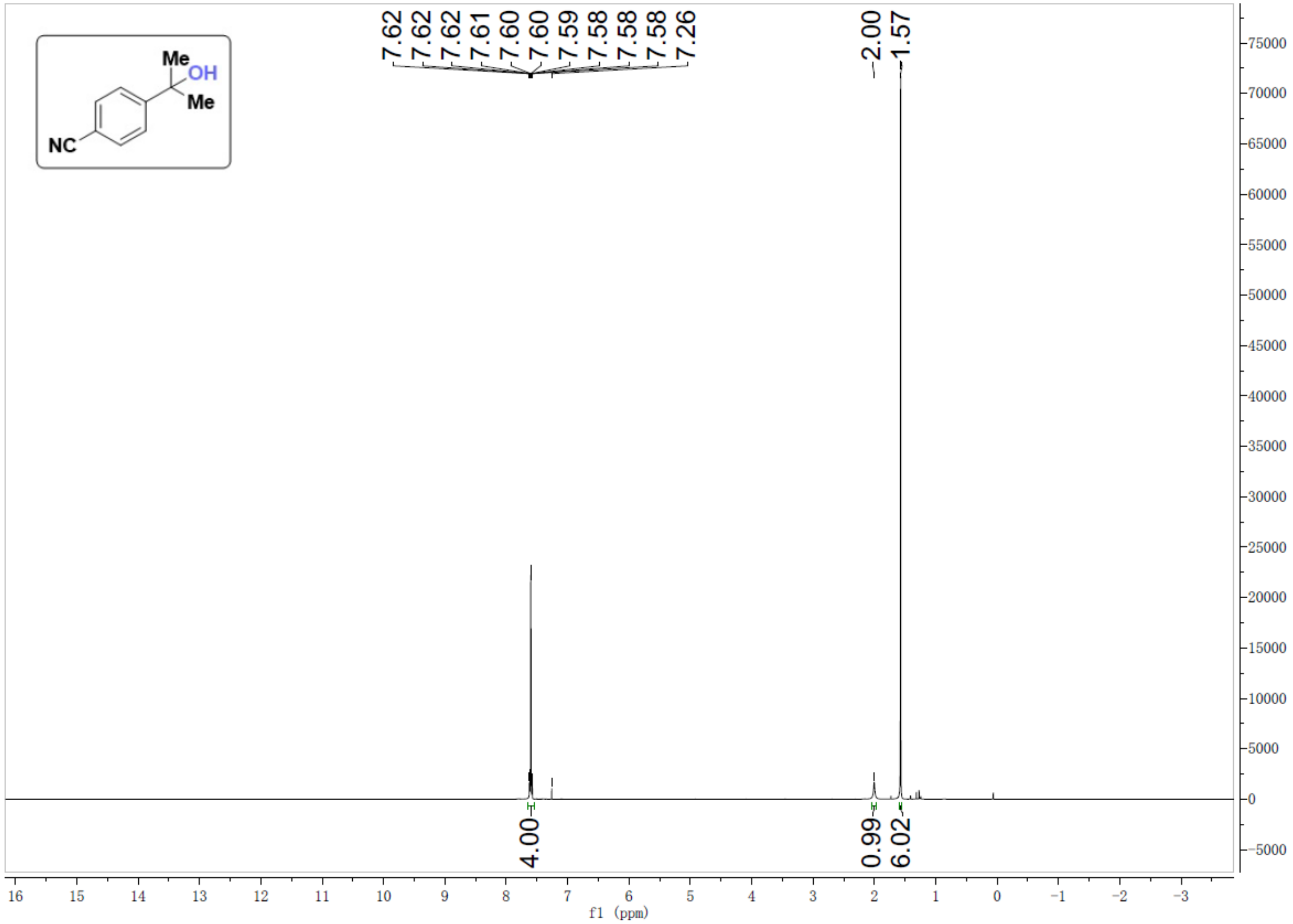
125.40
123.26
77.25
77.00
76.75
72.35
31.46
Me
OH
Me
O₂N
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 4b


Me
OH
Me
NC
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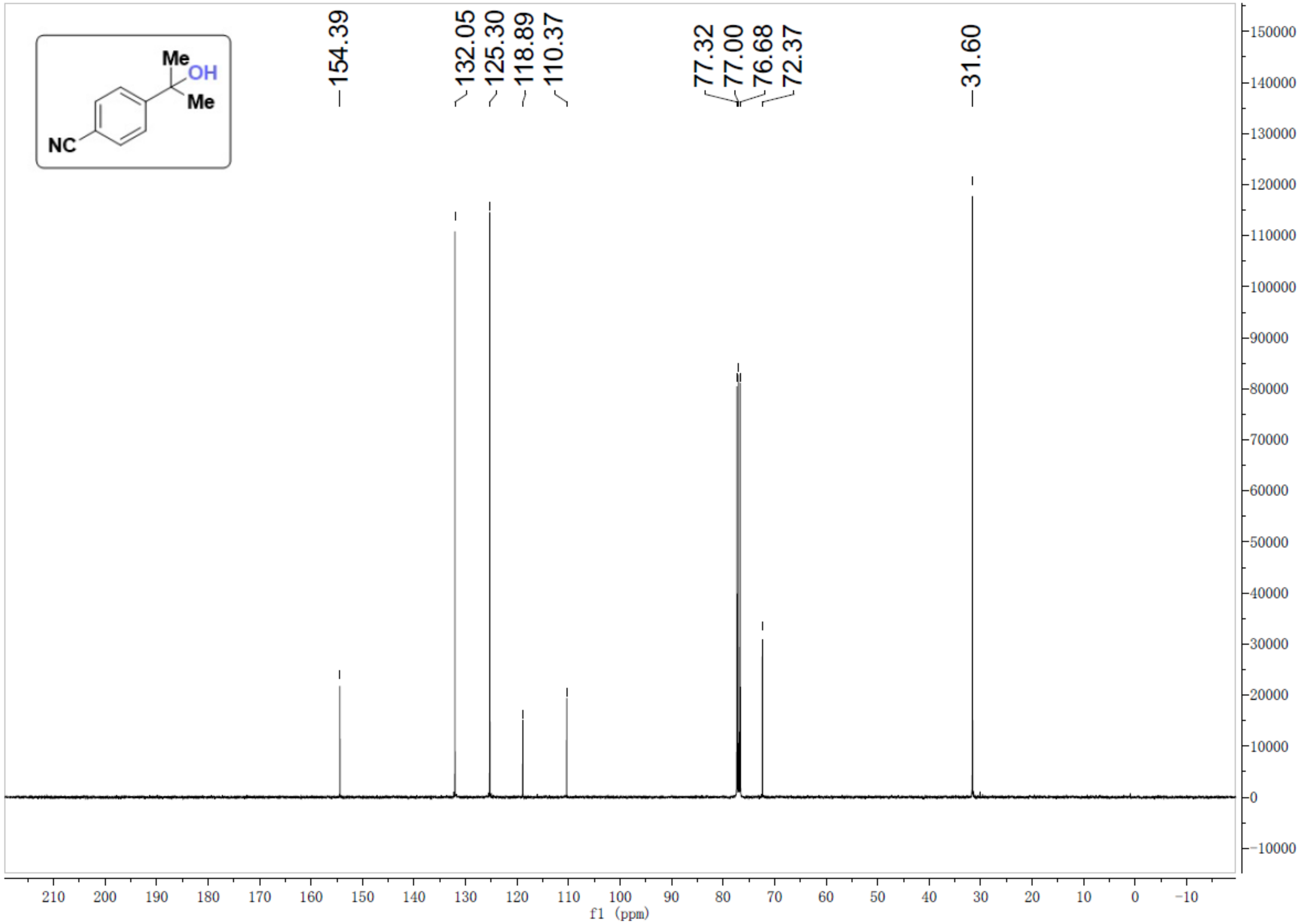
7.62
7.62
7.61
7.60
7.60
7.59
7.58
7.58
7.58
7.26
2.00
1.57
4.00
0.99
6.02
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 4b



Me
OH
Me
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77.00
76.68
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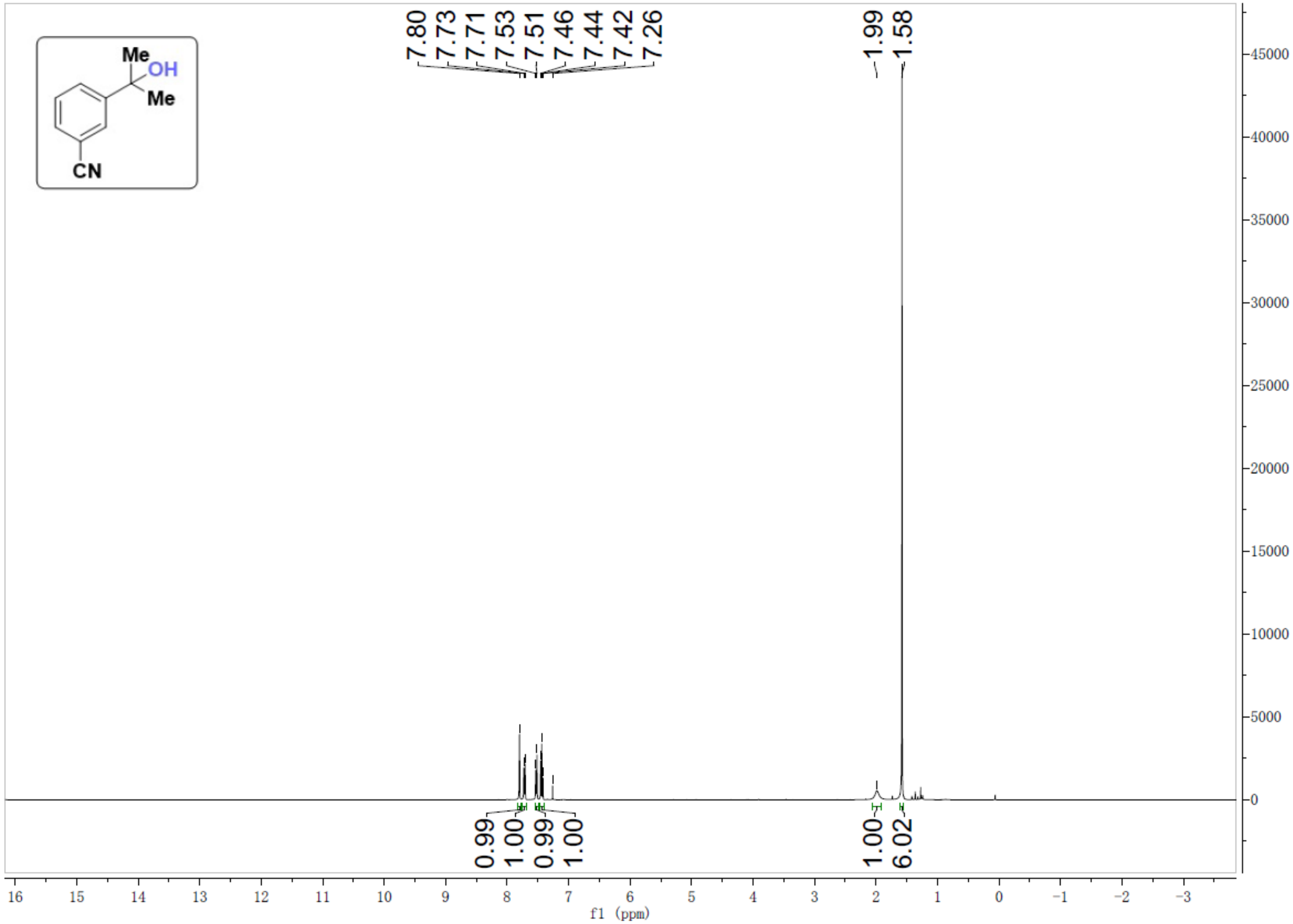
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 4c



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OH
Me
CN
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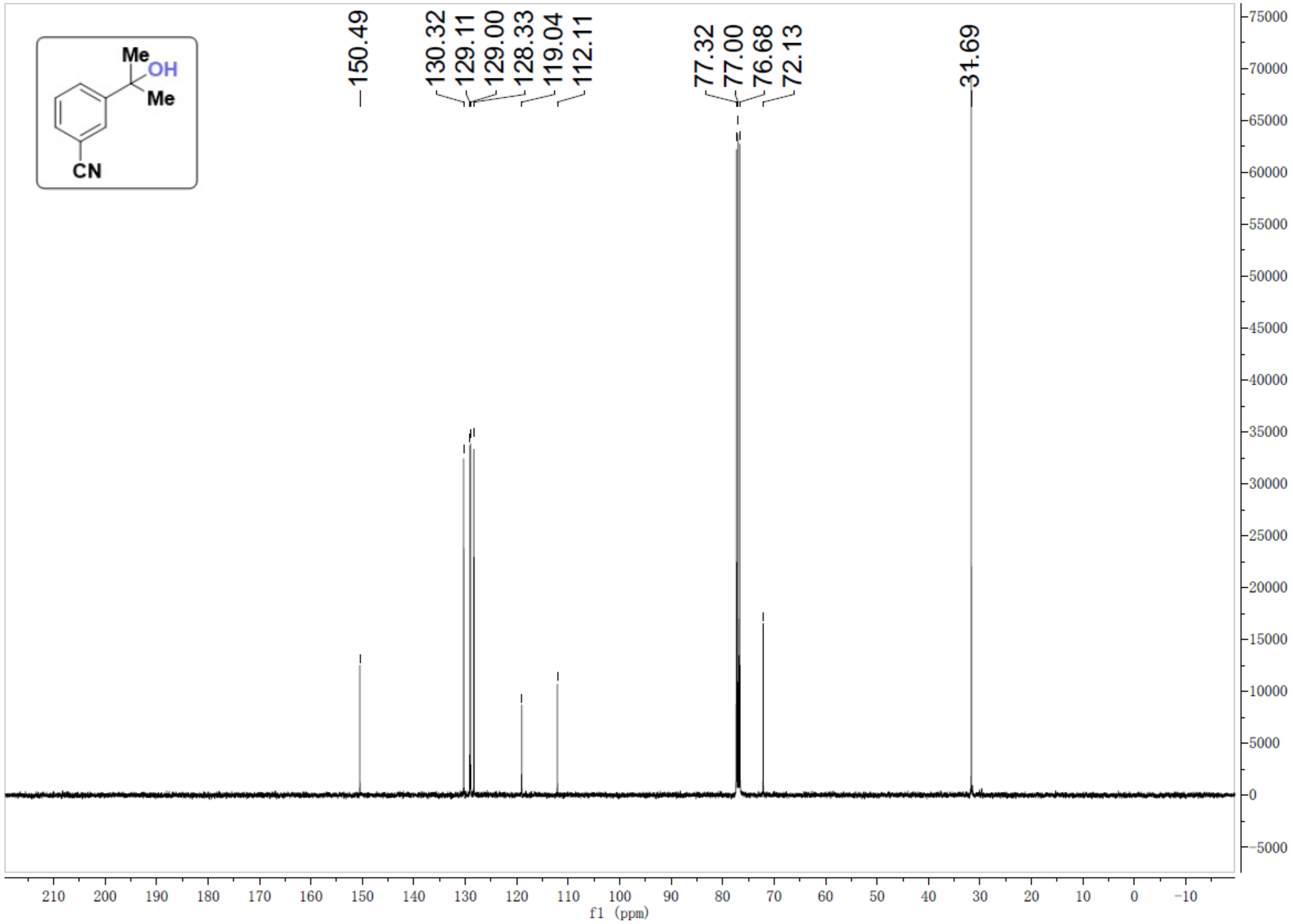
7.71
7.53
7.51
7.46
7.44
7.42
7.26
1.99
1.58
0.99
1.00
0.99
1.00
1.00
6.02
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 4c



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Me
CN
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129.00
128.33
119.04
112.11
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77.00
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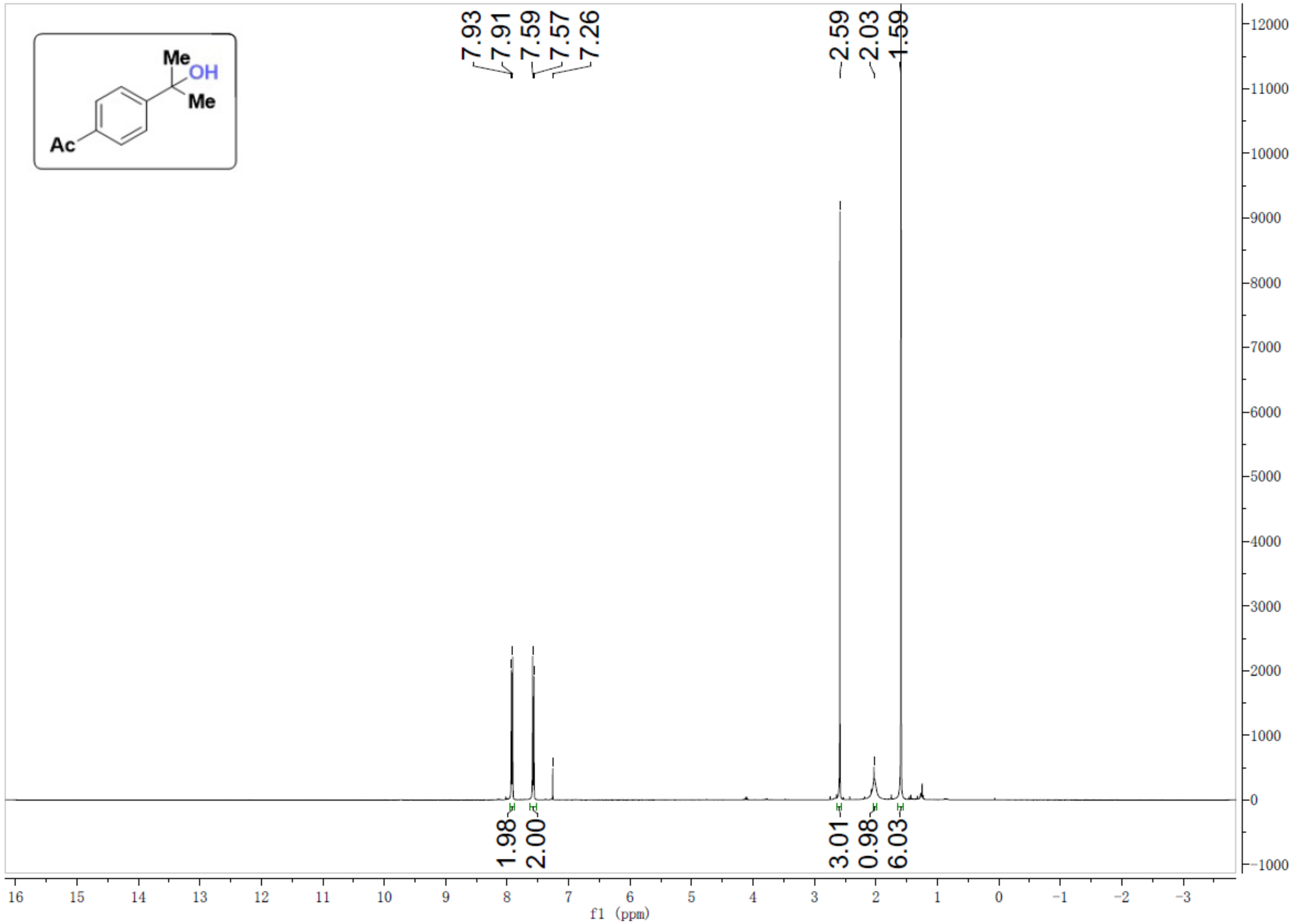
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 4d



Me
OH
Me
Ac
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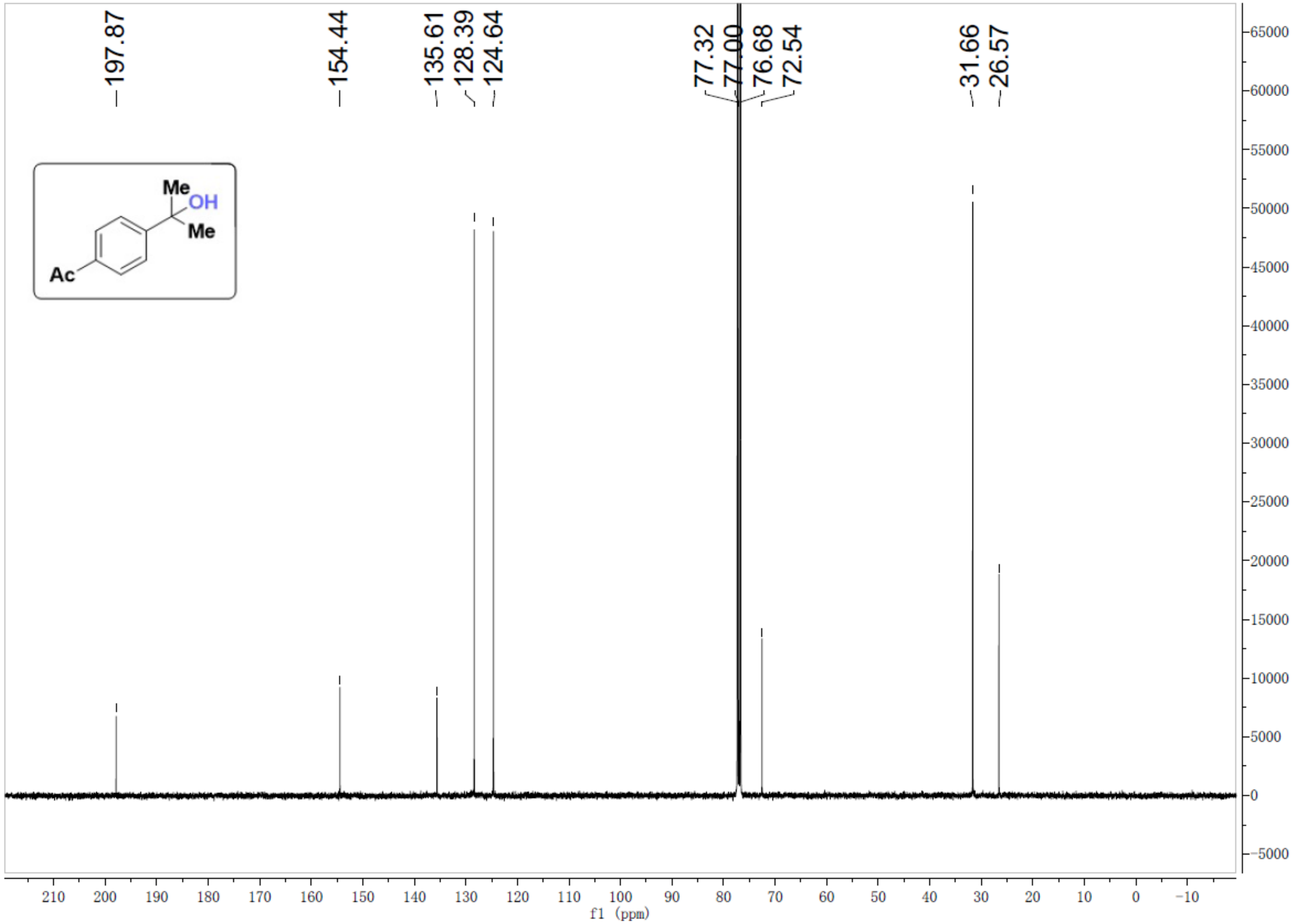
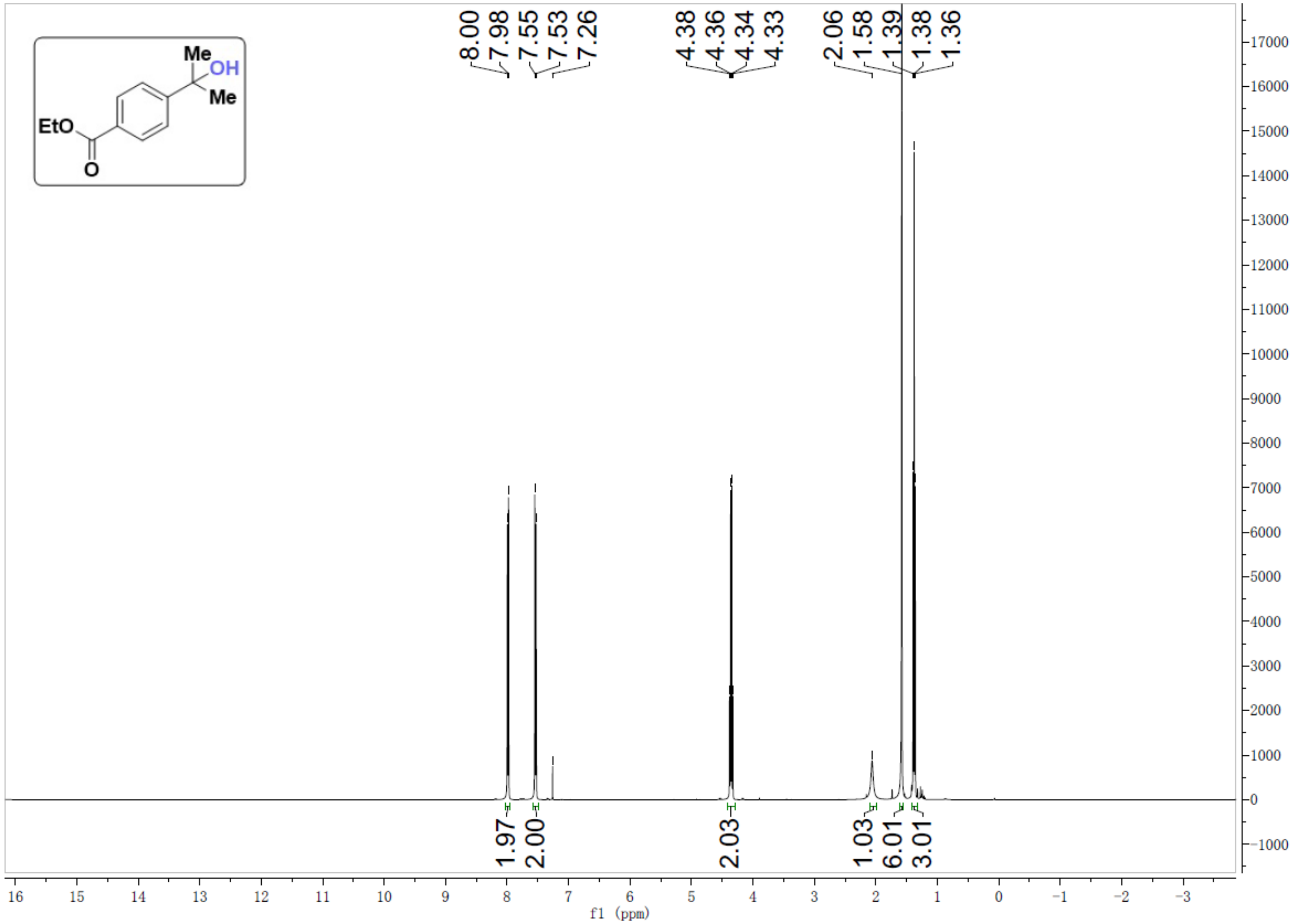
7.91
7.59
7.57
7.26
2.59
2.03
1.59
1.98
2.00
3.01
0.98
6.03
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 4d



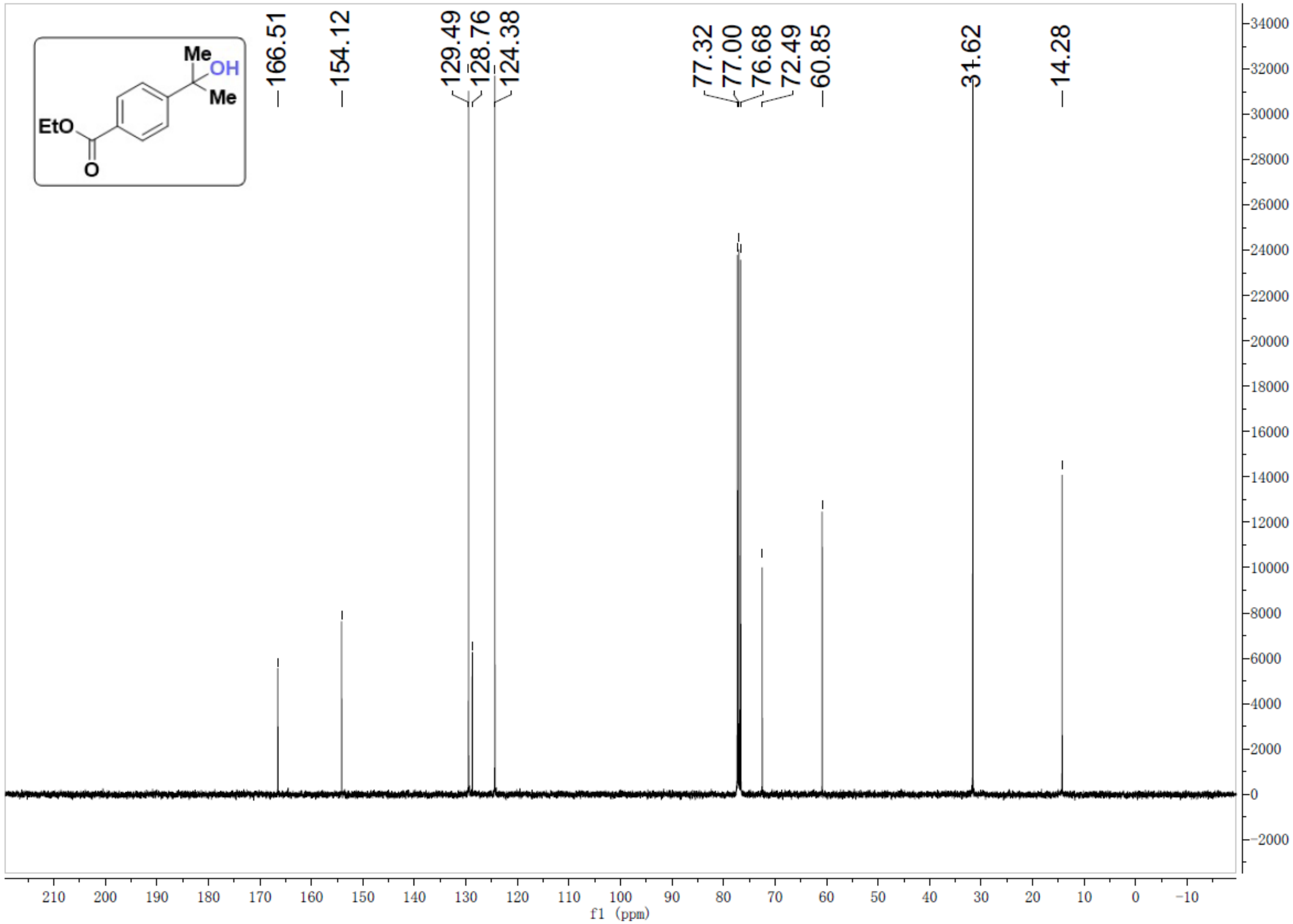
197.87
154.44
135.61
128.39
124.64
77.32
77.00
76.68
72.54
31.66
26.57
Me
OH
Me
Ac
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 4e

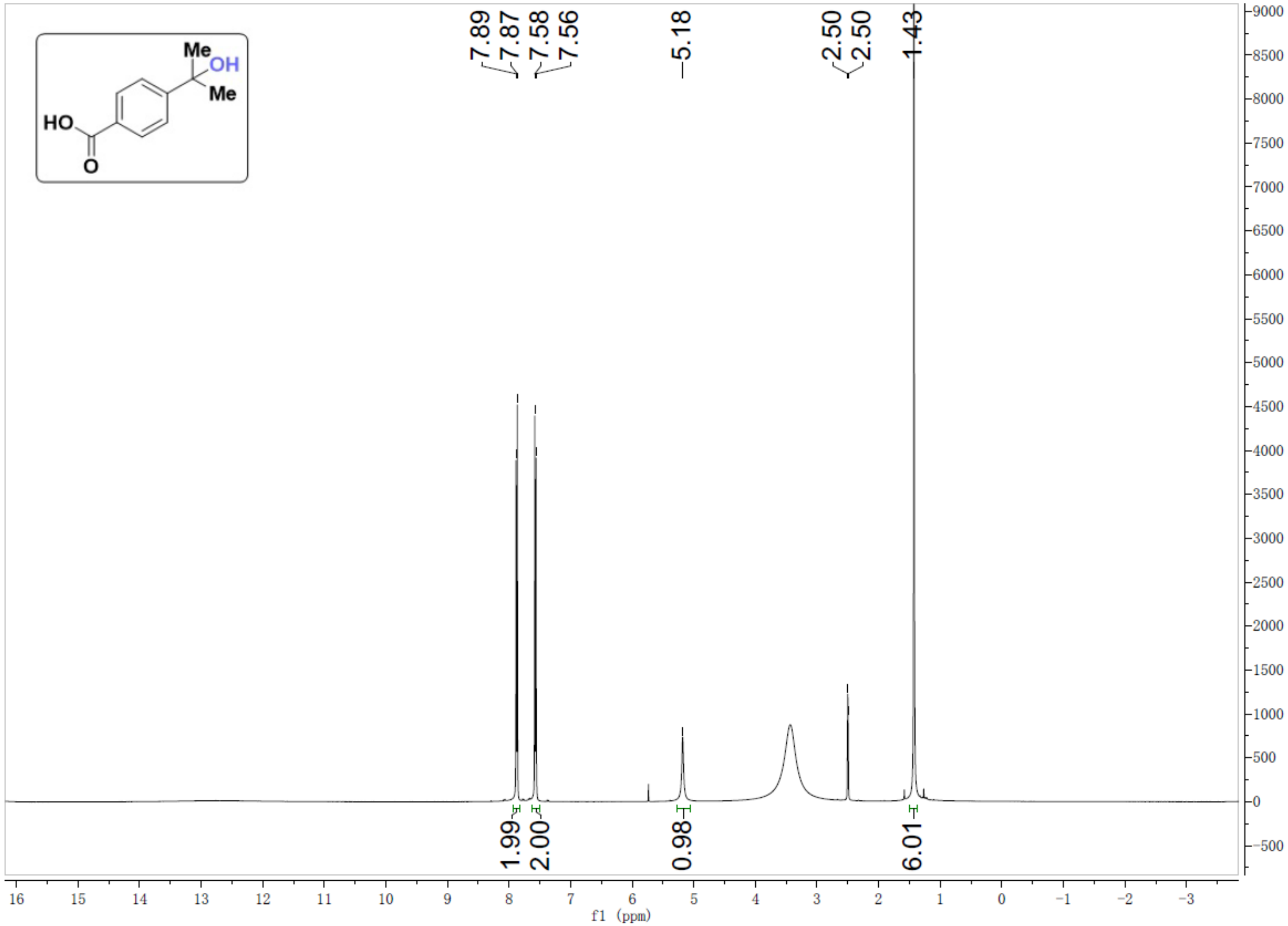


Me
OH
Me
EtO
O
8.00
7.98
7.55
7.53
7.26
4.38
4.36
4.34
4.33
2.06
1.58
1.39
1.38
1.36
1.97
2.00
2.03
1.03
6.01
3.01
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 4e

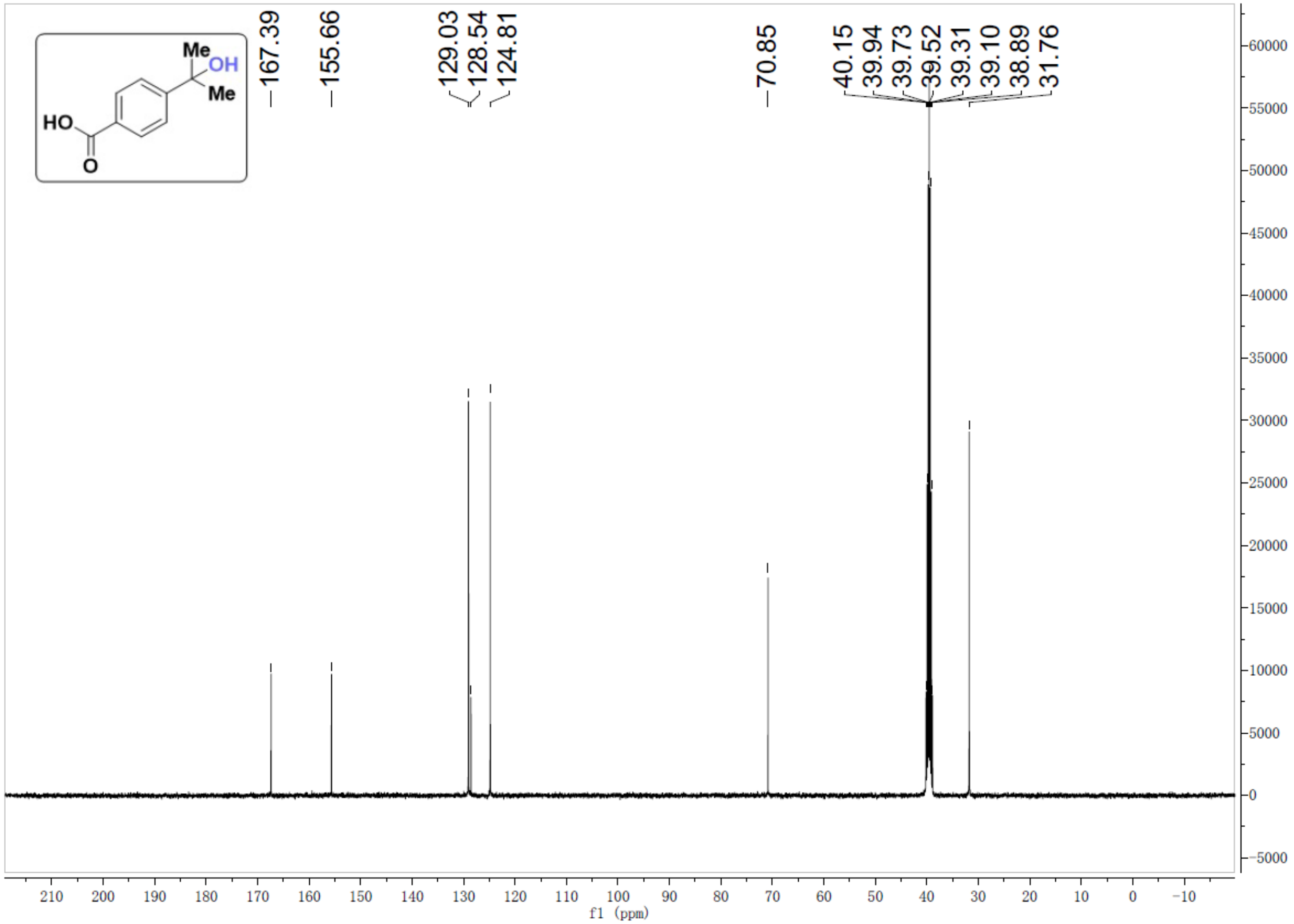

Me
OH
Me
EtO
O
166.51
154.12
129.49
128.76
124.38
77.32
77.00
76.68
72.49
60.85
31.62
14.28
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
−2000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

^{1}H NMR of 4f

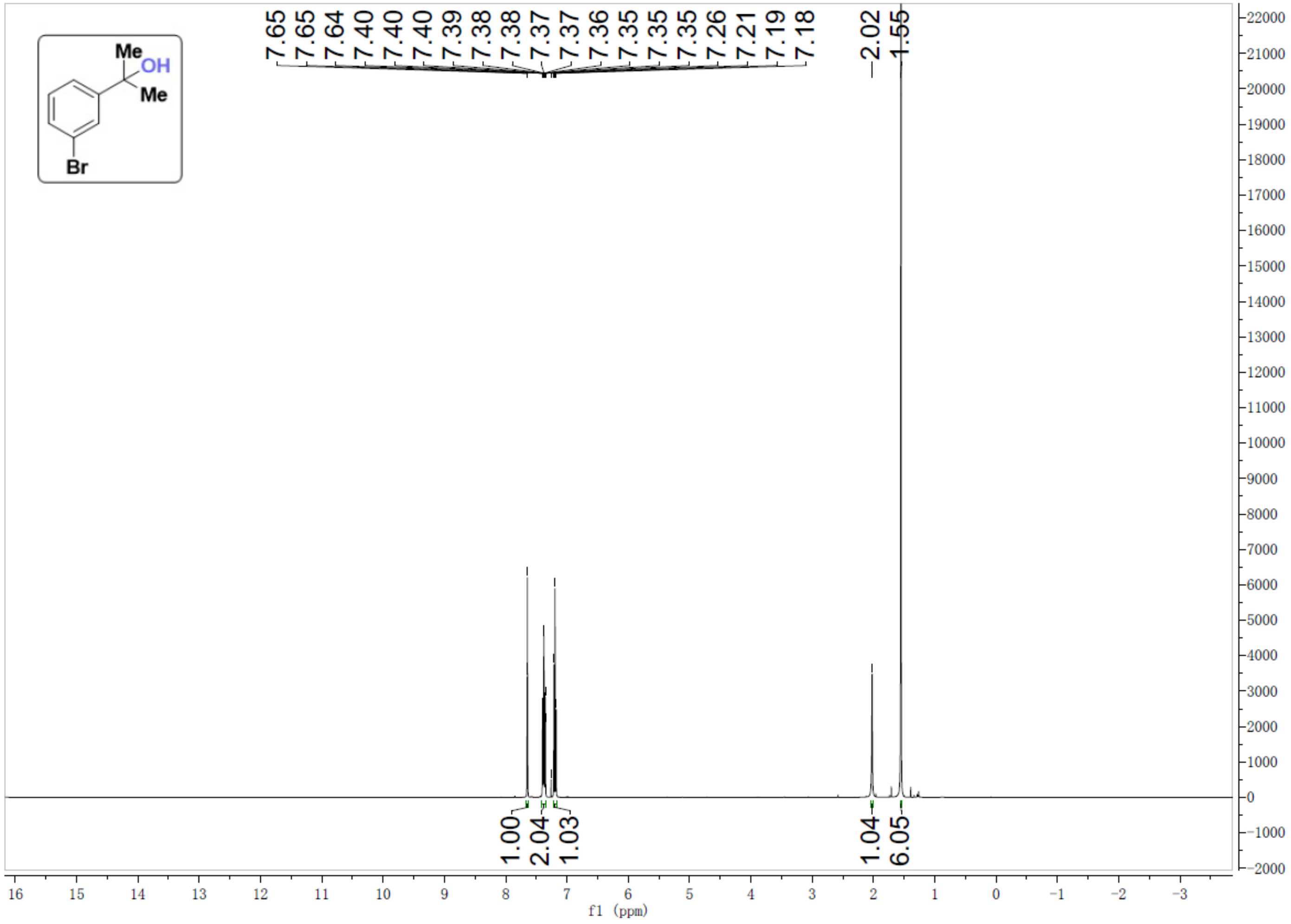


Me
OH
Me
HO
O
7.89
7.87
7.58
7.56
5.18
2.50
2.50
1.43
1.99
2.00
0.98
6.01
f1 (ppm)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
9000
8500
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500

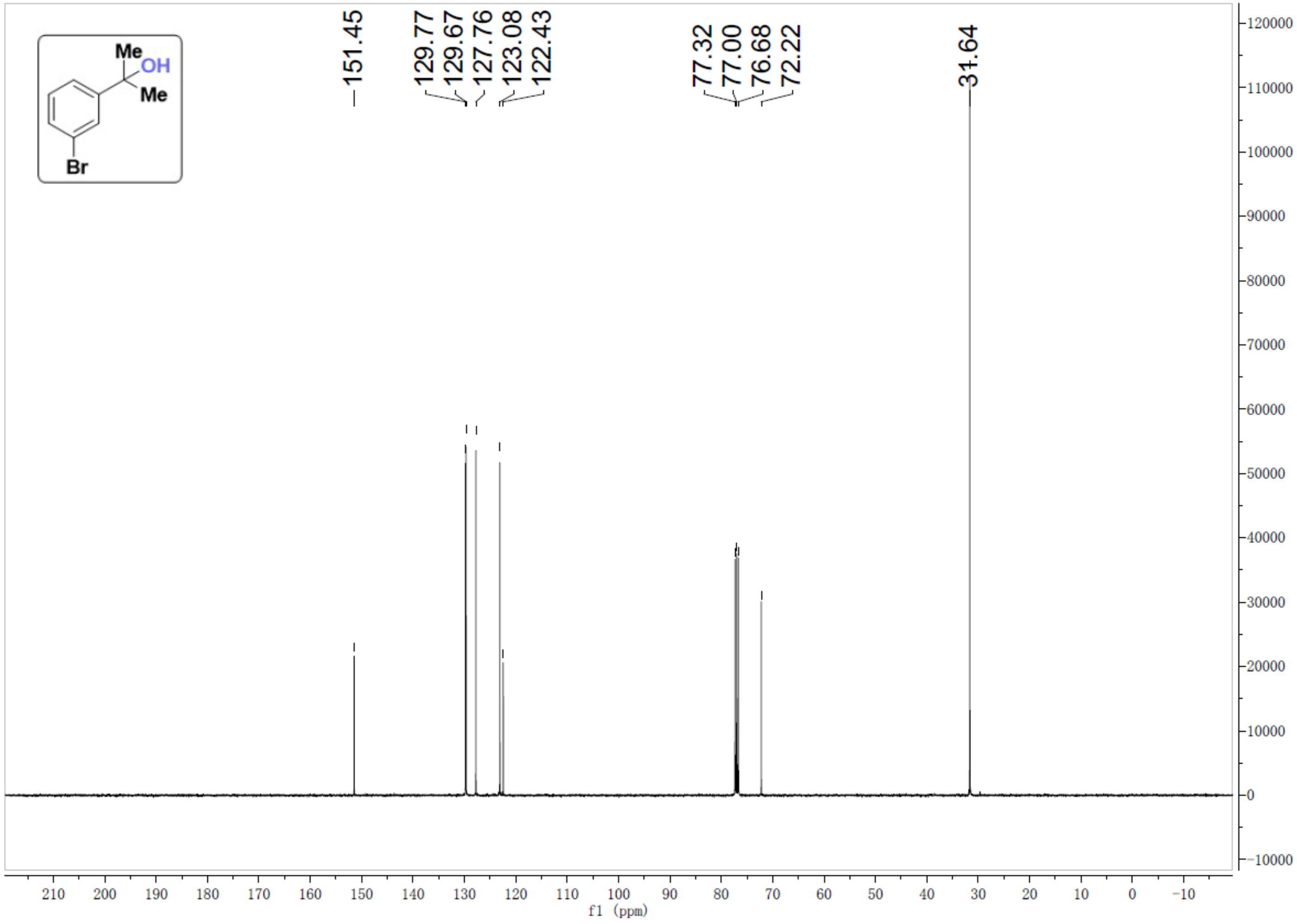
^{13}C NMR of 4f


Me
OH
Me
HO
O
167.39
155.66
129.03
128.54
124.81
70.85
40.15
39.94
39.73
39.52
39.31
39.10
38.89
31.76
60000
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)

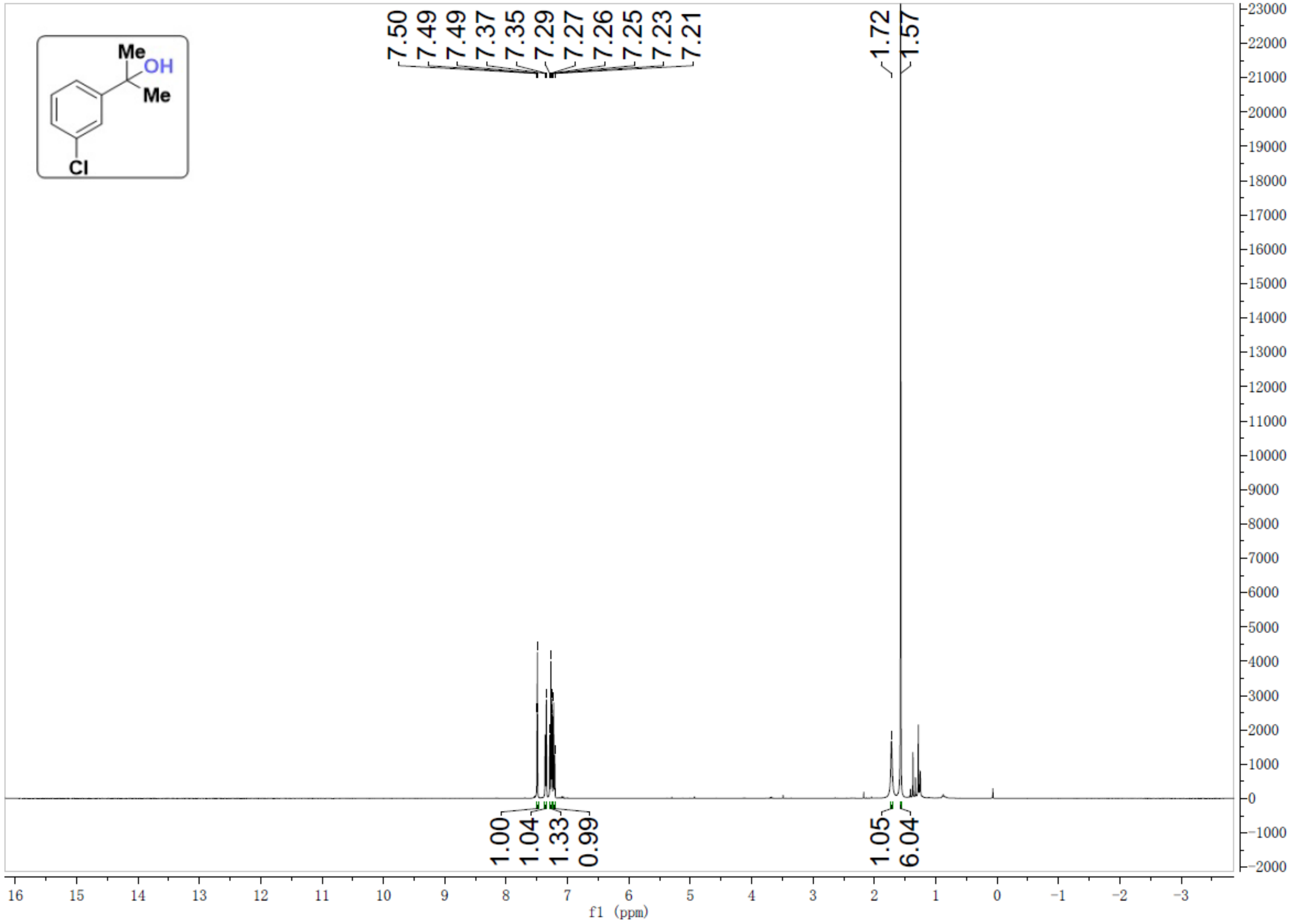
^{1}H NMR of 4g


Me
OH
Me
Br
7.65
7.65
7.64
7.40
7.40
7.40
7.39
7.38
7.38
7.37
7.37
7.36
7.35
7.35
7.35
7.26
7.21
7.19
7.18
2.02
1.55
1.00
2.04
1.03
1.04
6.05
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
−2000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−2
−3
f1 (ppm)

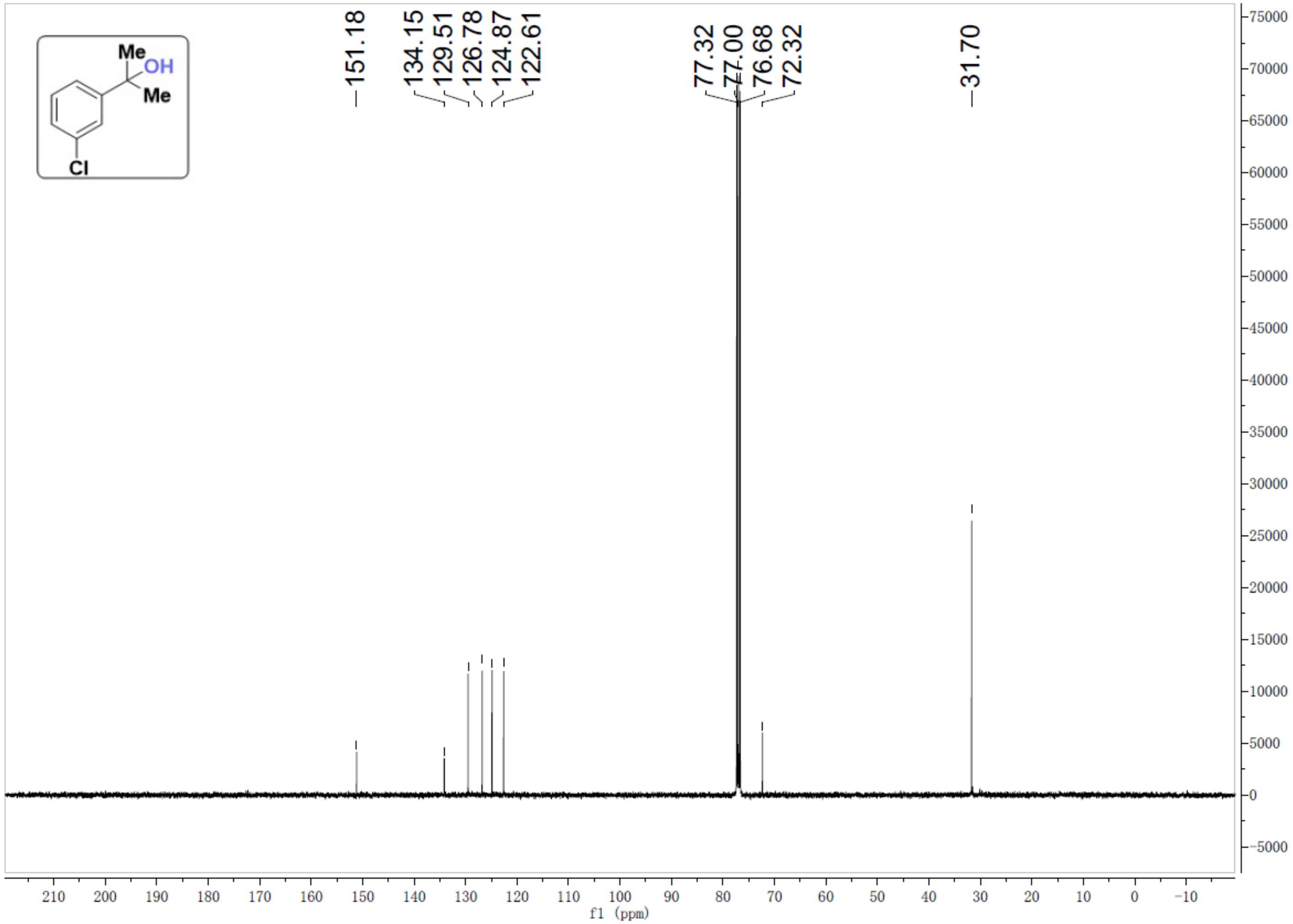
^{13}C NMR of 4g


Me
OH
Me
Br
151.45
129.77
129.67
127.76
123.08
122.43
77.32
77.00
76.68
72.22
31.64
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
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)

^{1}H NMR of 4h

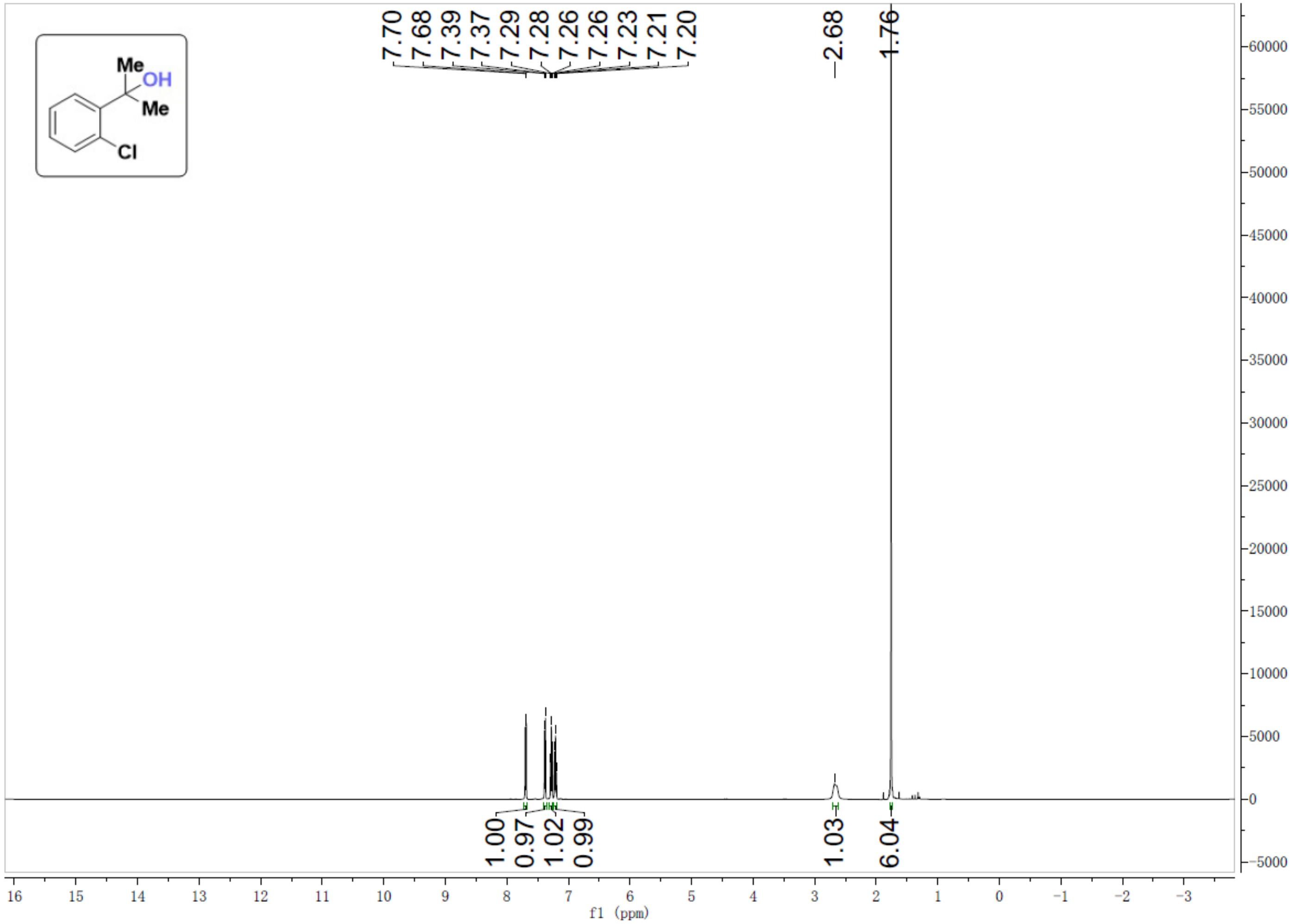

Me
OH
Me
Cl
7.50
7.49
7.49
7.37
7.35
7.29
7.27
7.26
7.25
7.23
7.21
1.72
1.57
1.00
1.04
1.33
0.99
1.05
6.04
f1 (ppm)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000

^{13}C NMR of 4h



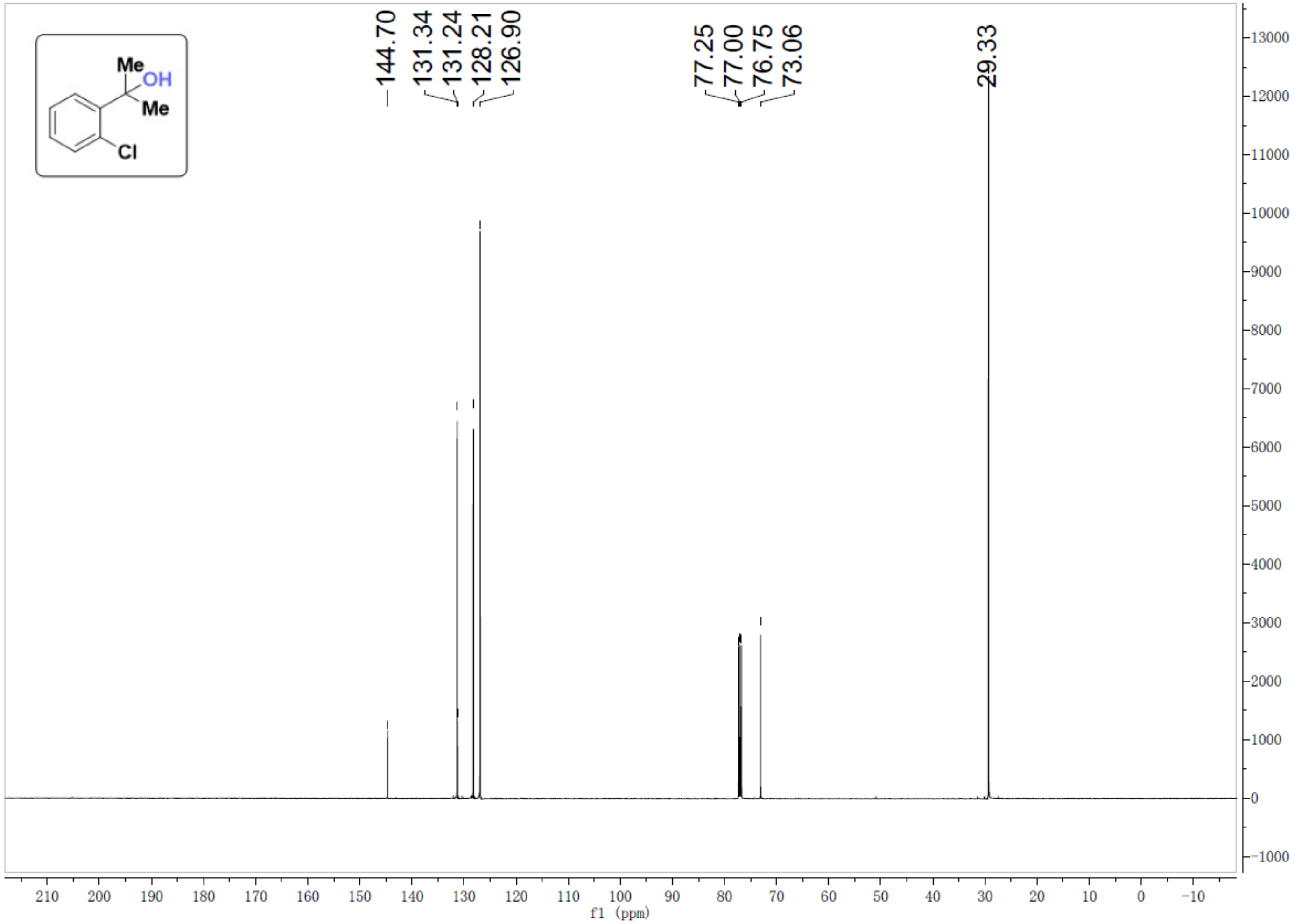
Me
OH
Me
Cl
151.18
134.15
129.51
126.78
124.87
122.61
77.32
77.00
76.68
72.32
31.70
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 4i

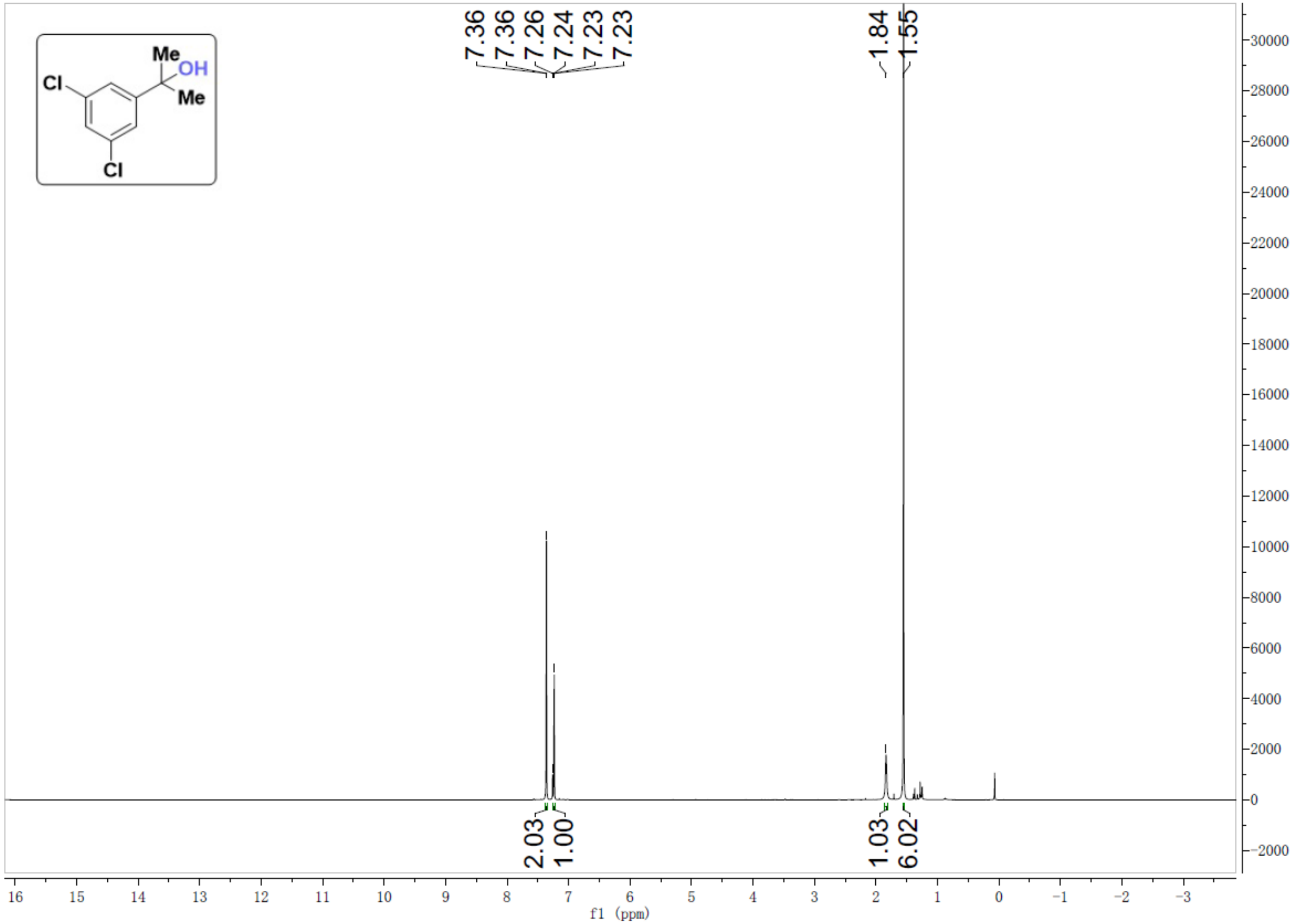


Me
OH
Me
Cl
7.70
7.68
7.39
7.37
7.29
7.28
7.26
7.26
7.23
7.21
7.20
2.68
1.76
1.00
0.97
1.02
0.99
1.03
6.04
f1 (ppm)

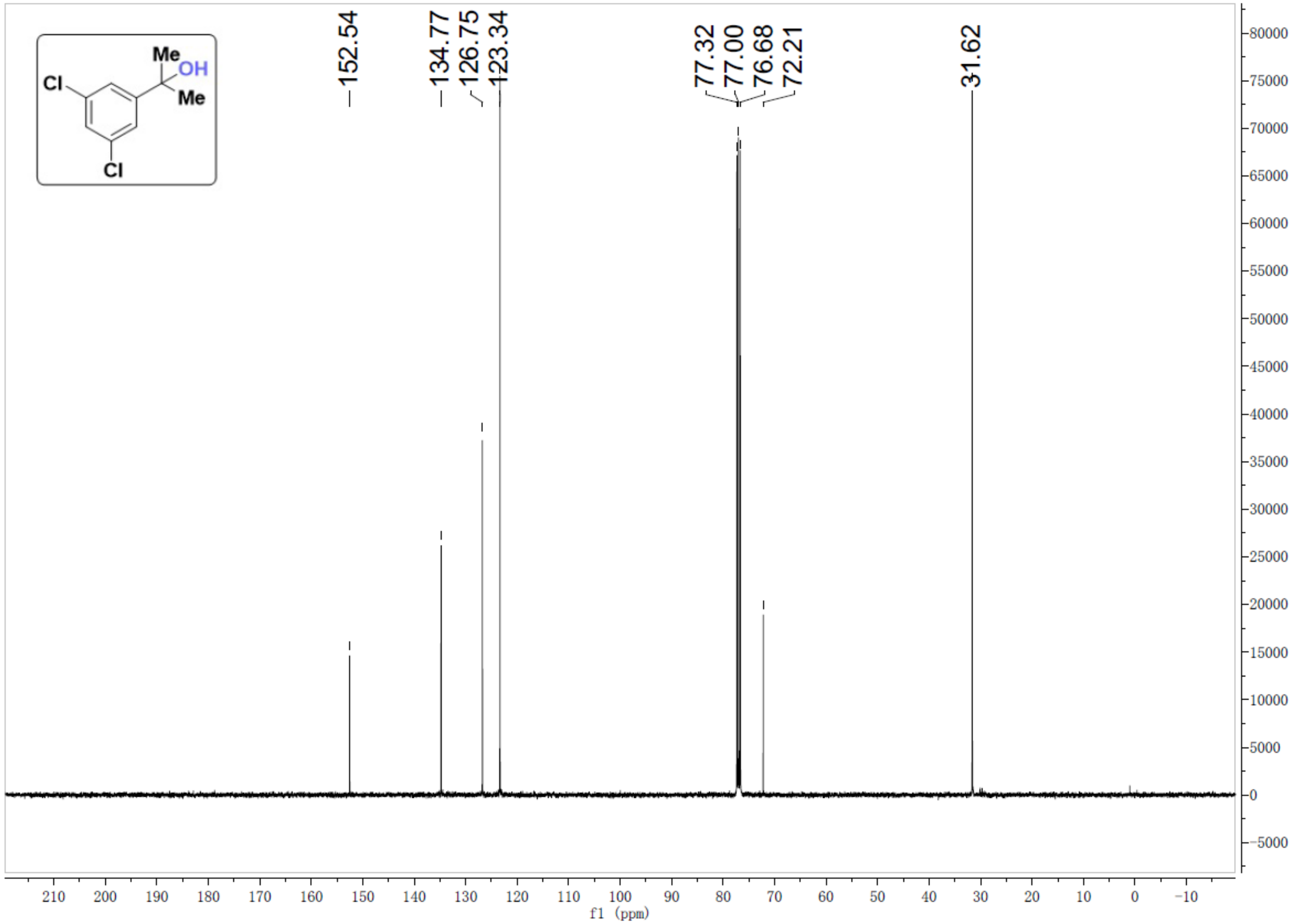
^{13}C NMR of 4i


Me
OH
Me
Cl
144.70
131.34
131.24
128.21
126.90
77.25
77.00
76.75
73.06
29.33
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)

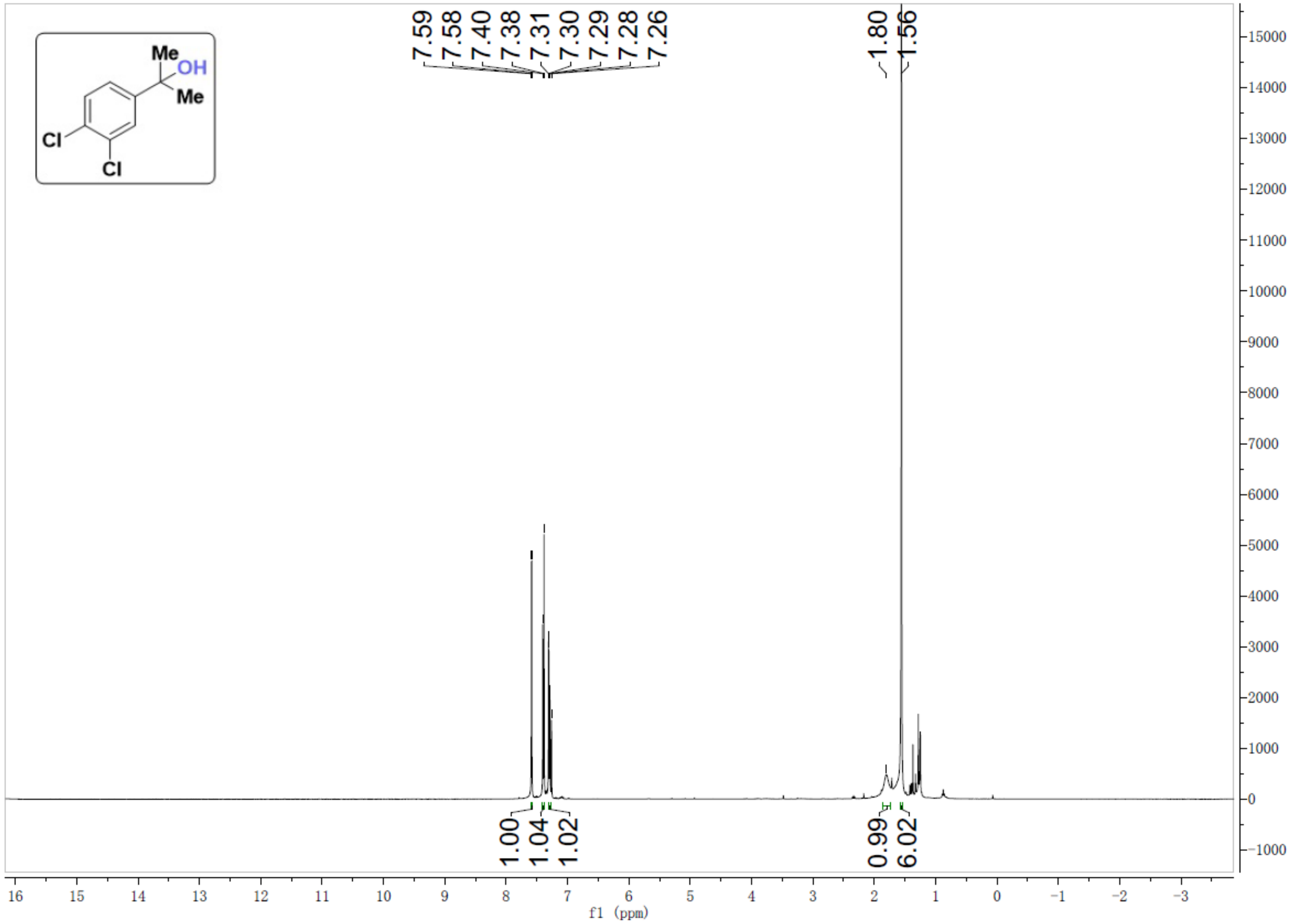
^{1}H NMR of 4j


Me
OH
Me
Cl
Cl
7.36
7.36
7.26
7.24
7.23
7.23
1.84
1.55
2.03
1.00
1.03
6.02
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 4j

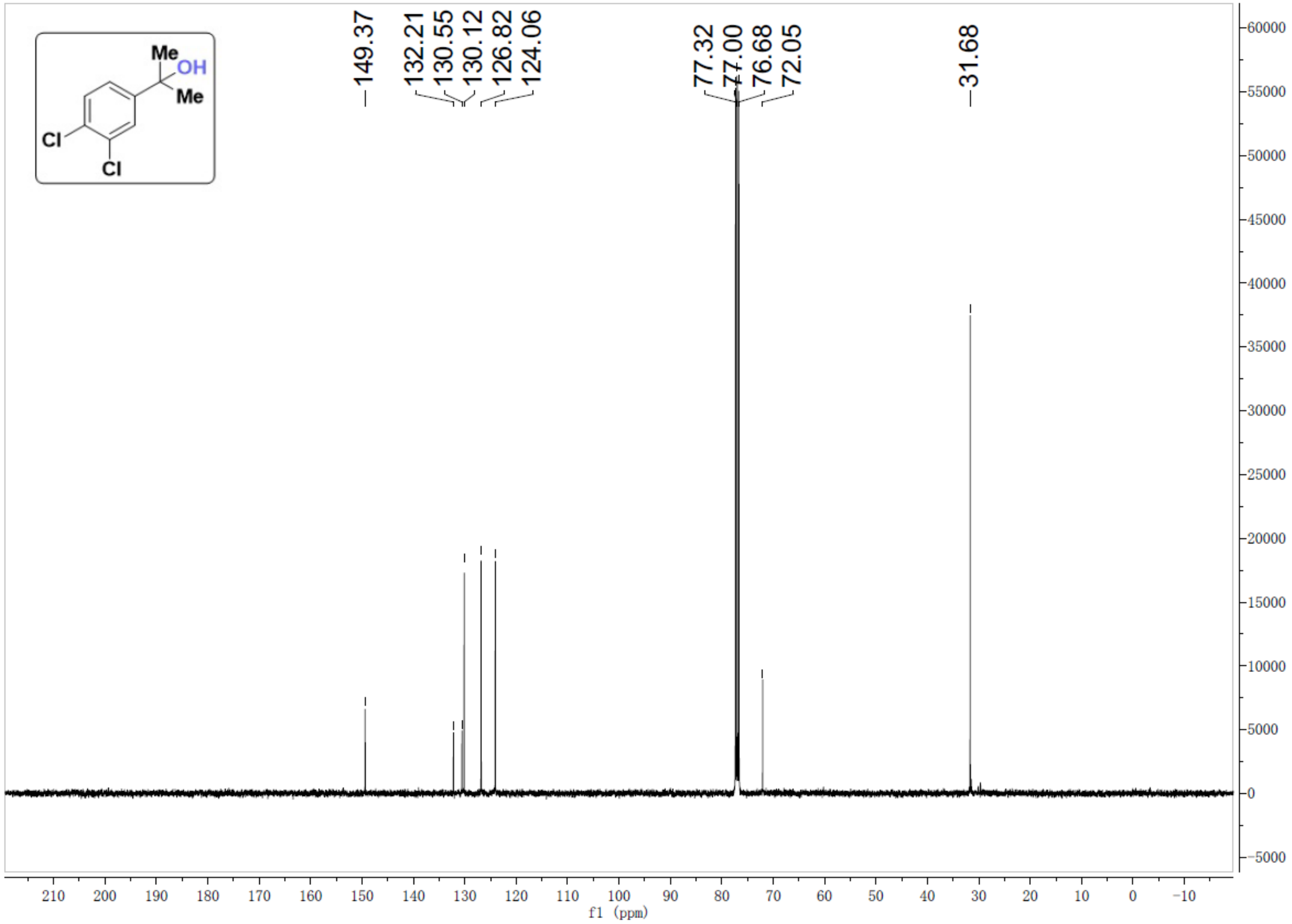

Cl
Cl
Me
OH
Me
152.54
134.77
126.75
123.34
77.32
77.00
76.68
72.21
31.62
80000
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 4k

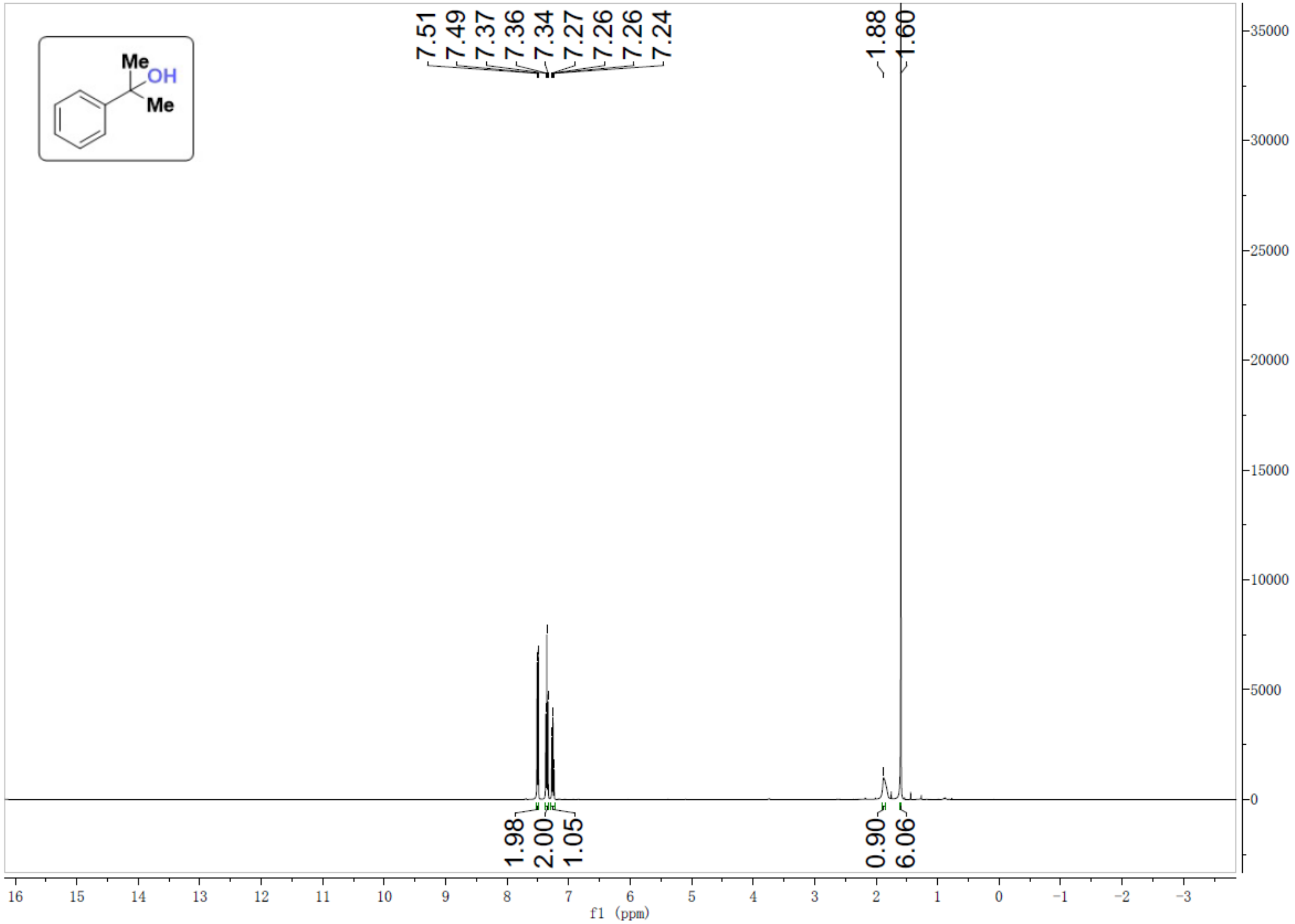


Me
OH
Me
Cl
Cl
7.59
7.58
7.40
7.38
7.31
7.30
7.29
7.28
7.26
1.80
1.56
1.00
1.04
1.02
0.99
6.02
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000

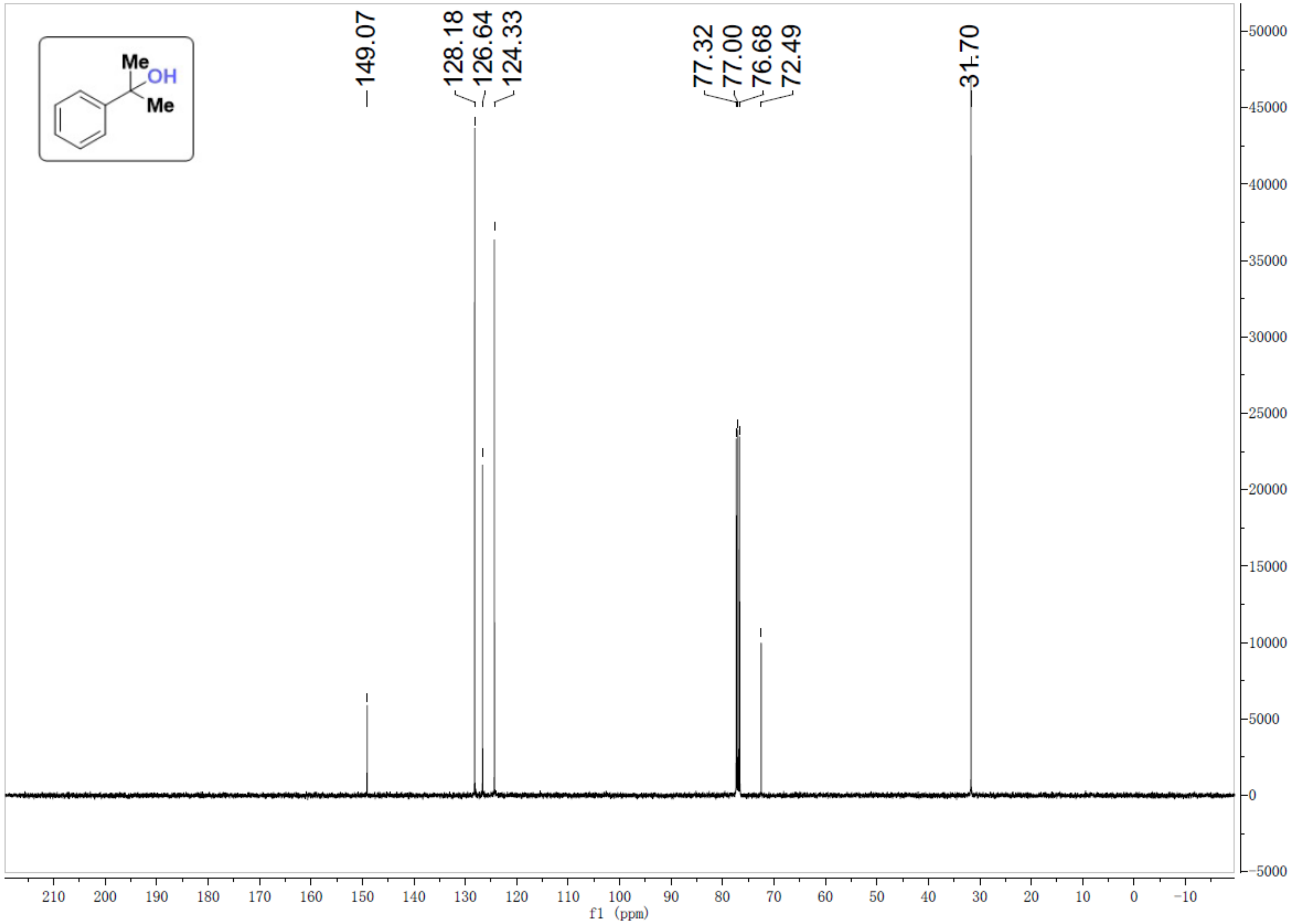
^{13}C NMR of 4k


Me
OH
Me
Cl
Cl
149.37
132.21
130.55
130.12
126.82
124.06
77.32
77.00
76.68
72.05
31.68
60000
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)

^1H NMR of 4l

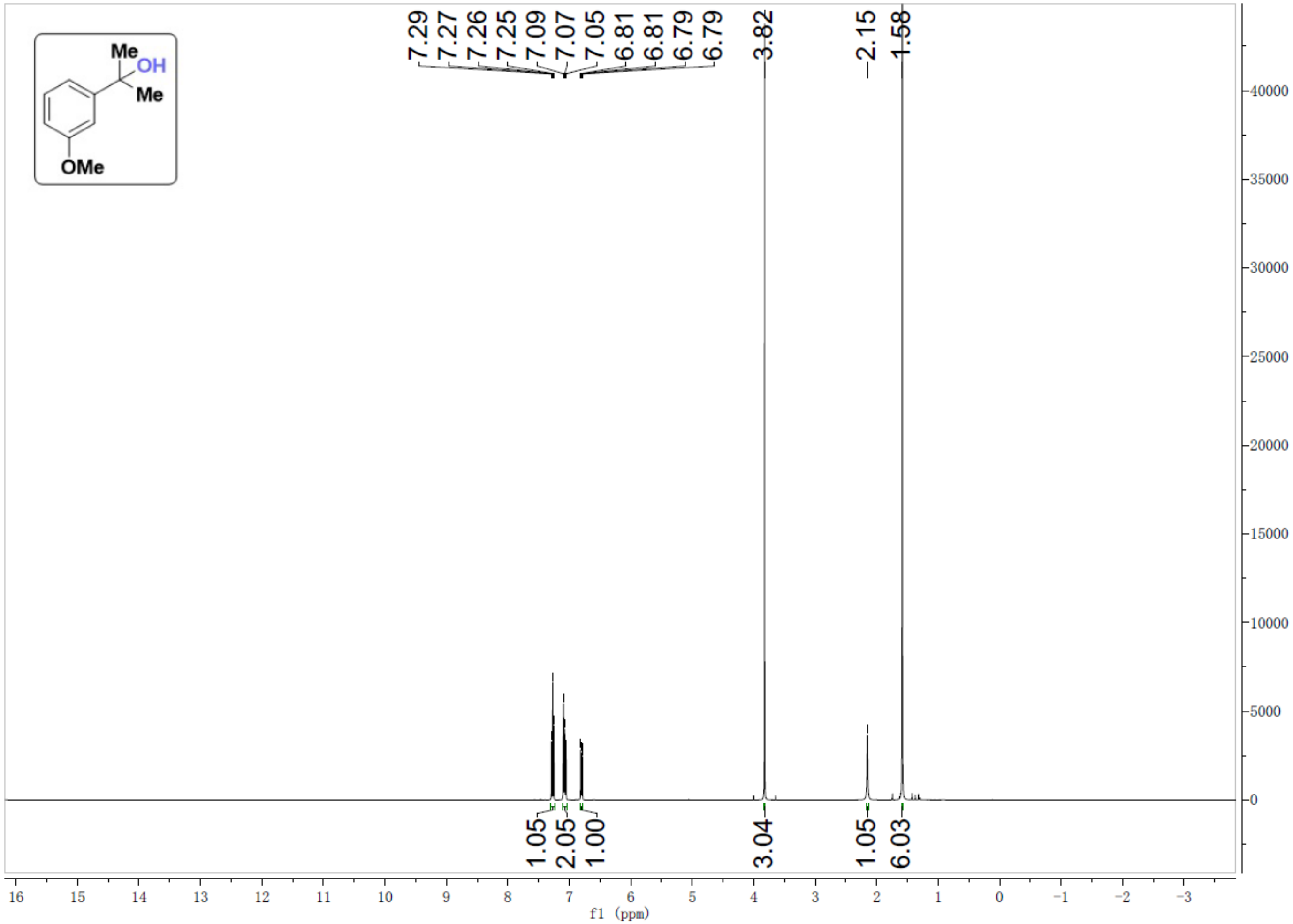

Me
OH
Me
7.51
7.49
7.37
7.36
7.34
7.27
7.26
7.26
7.24
1.88
1.60
1.98
2.00
1.05
0.90
6.06
35000
30000
25000
20000
15000
10000
5000
0
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 4l

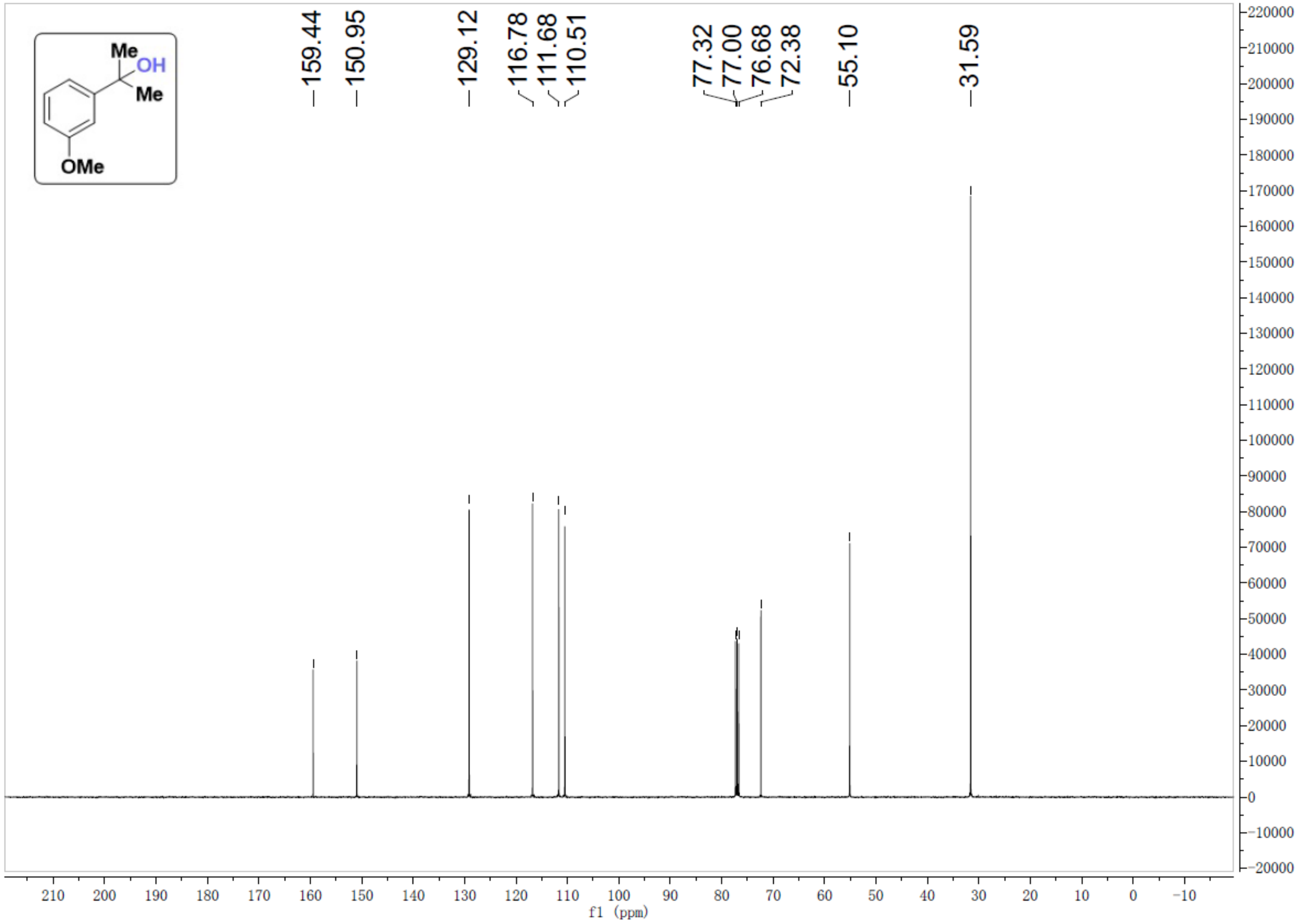


Me
OH
Me
149.07
128.18
126.64
124.33
77.32
77.00
76.68
72.49
31.70
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

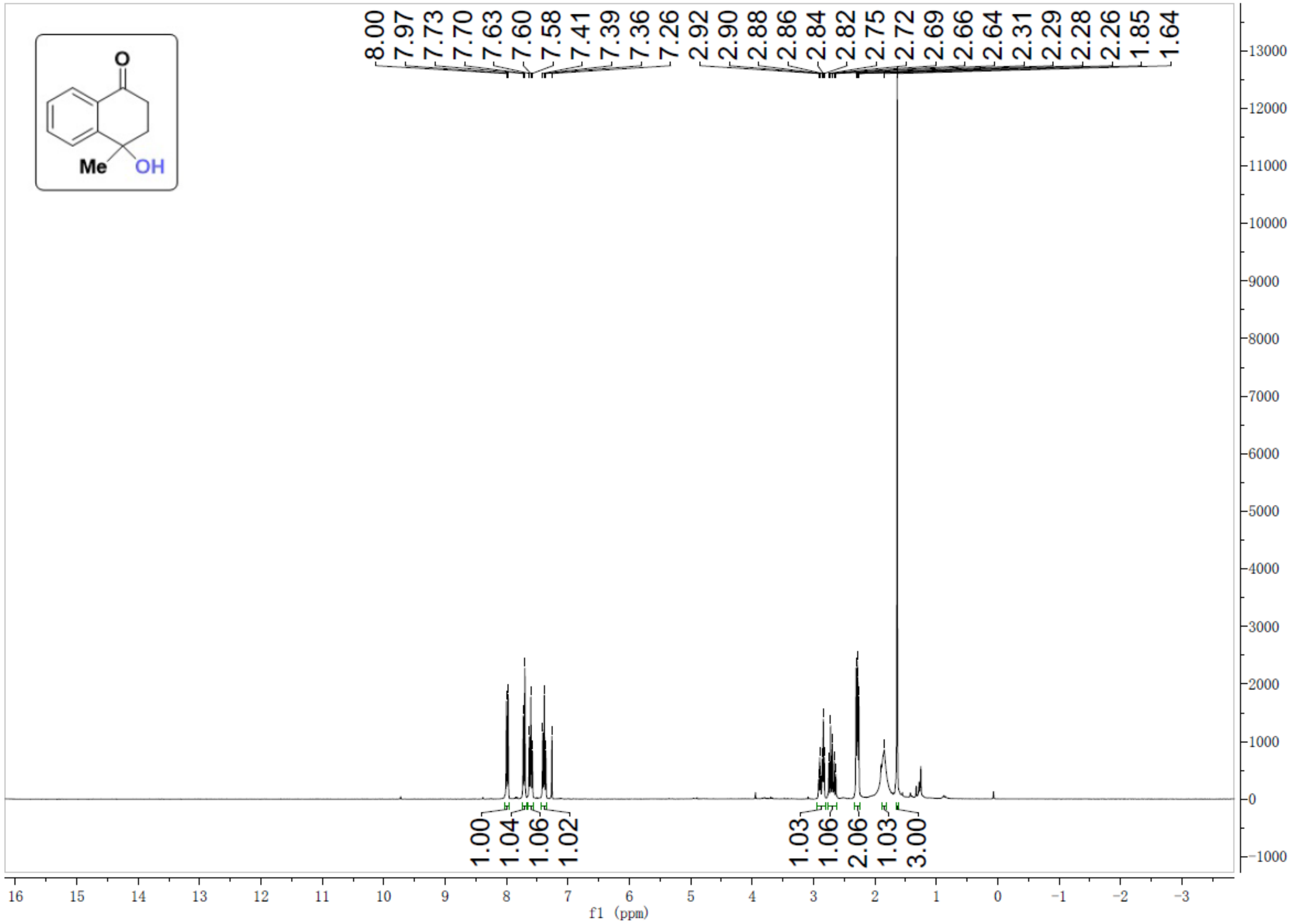
^{1}H NMR of 4m


Me
OH
Me
OMe
7.29
7.27
7.26
7.25
7.09
7.07
7.05
6.81
6.81
6.79
6.79
3.82
2.15
1.58
1.05
2.05
1.00
3.04
1.05
6.03
40000
35000
30000
25000
20000
15000
10000
5000
0
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 4m

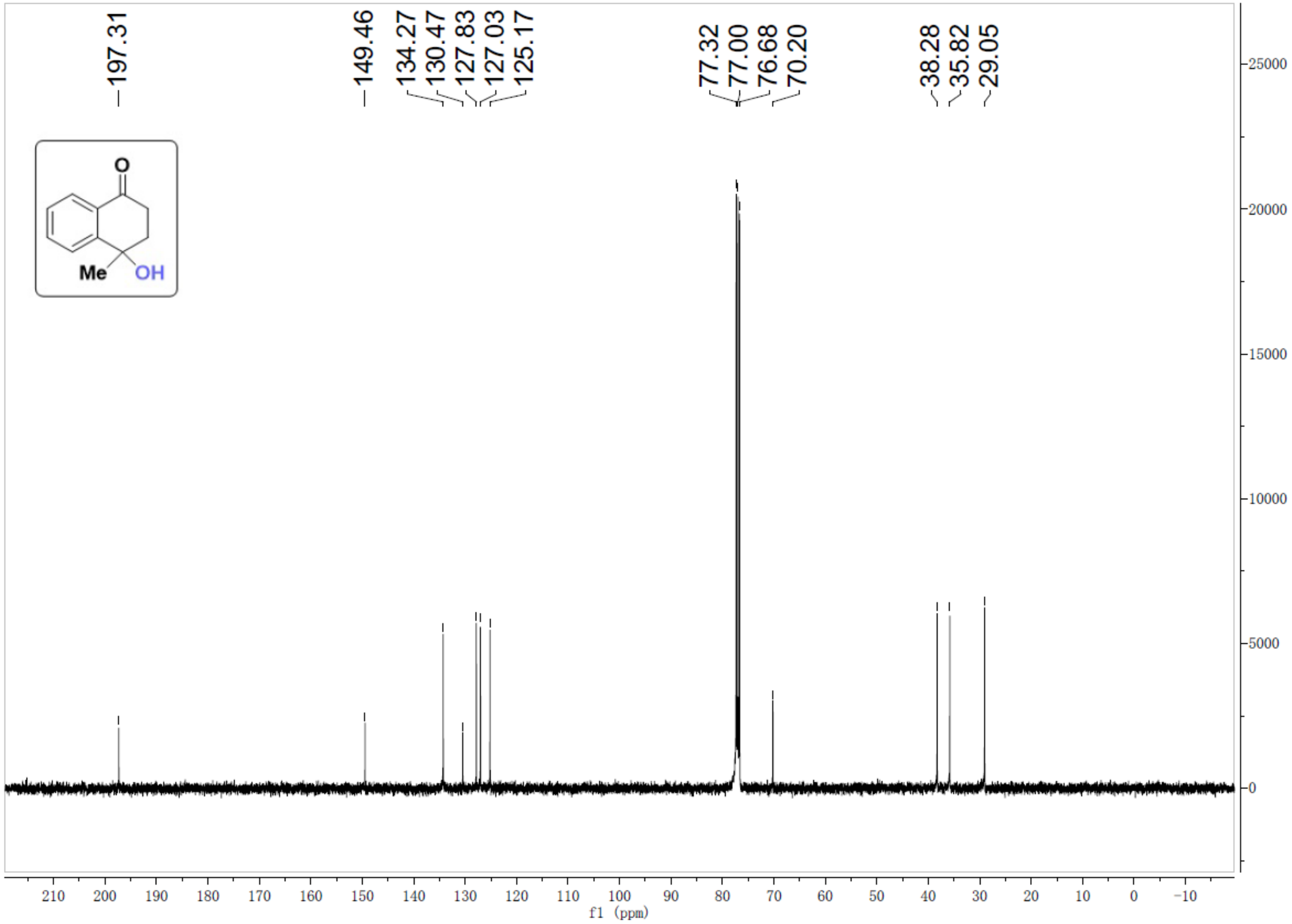

Me
OH
Me
OMe
159.44
150.95
129.12
116.78
111.68
110.51
77.32
77.00
76.68
72.38
55.10
31.59
220000
210000
200000
190000
180000
170000
160000
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
-20000
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

^{1}H NMR of 4n



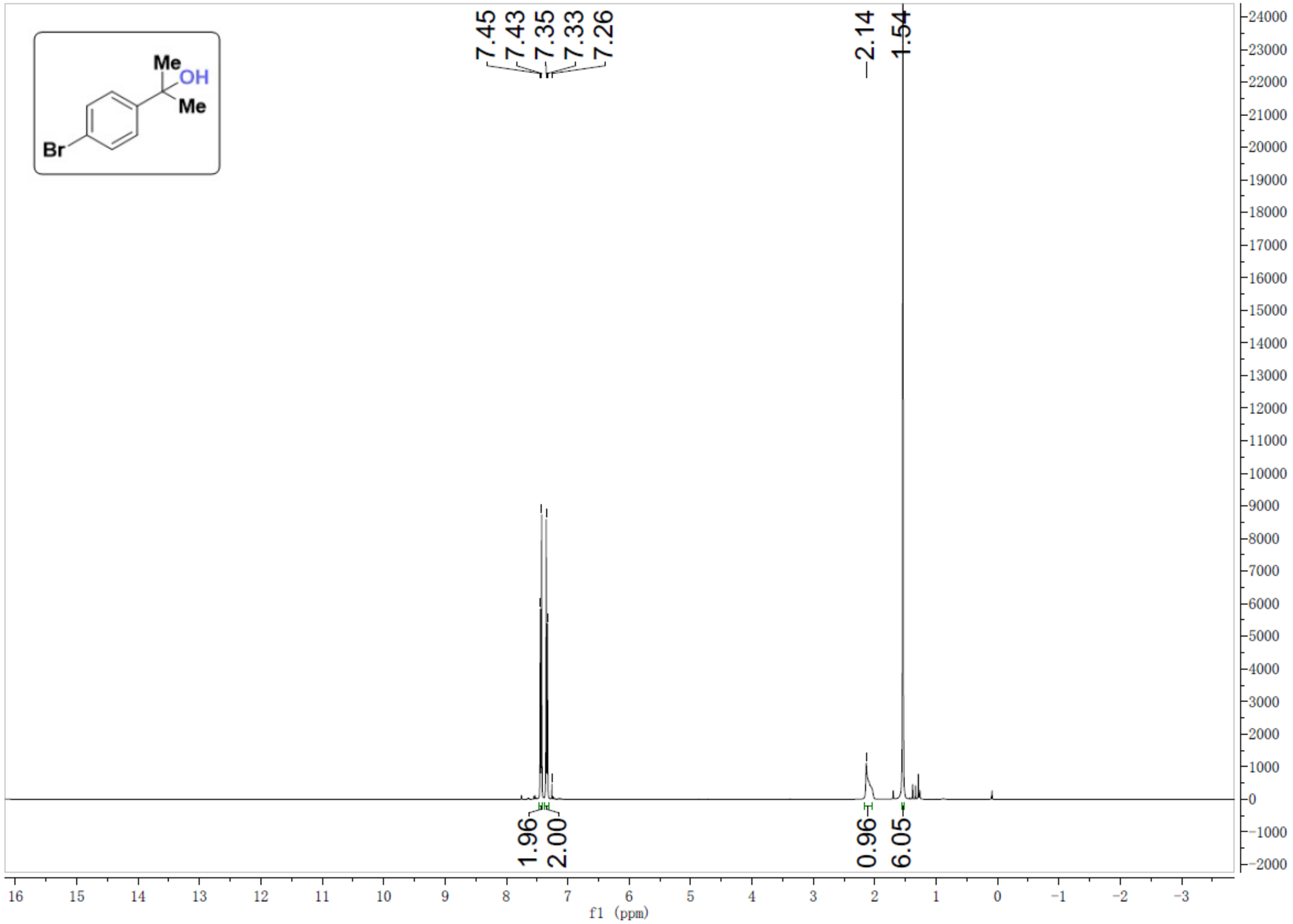
O
Me
OH
8.00
7.97
7.73
7.70
7.63
7.60
7.58
7.41
7.39
7.36
7.26
2.92
2.90
2.88
2.86
2.84
2.82
2.75
2.72
2.69
2.66
2.64
2.31
2.29
2.28
2.26
1.85
1.64
1.00
1.04
1.06
1.02
1.03
1.06
2.06
1.03
3.00
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 4n



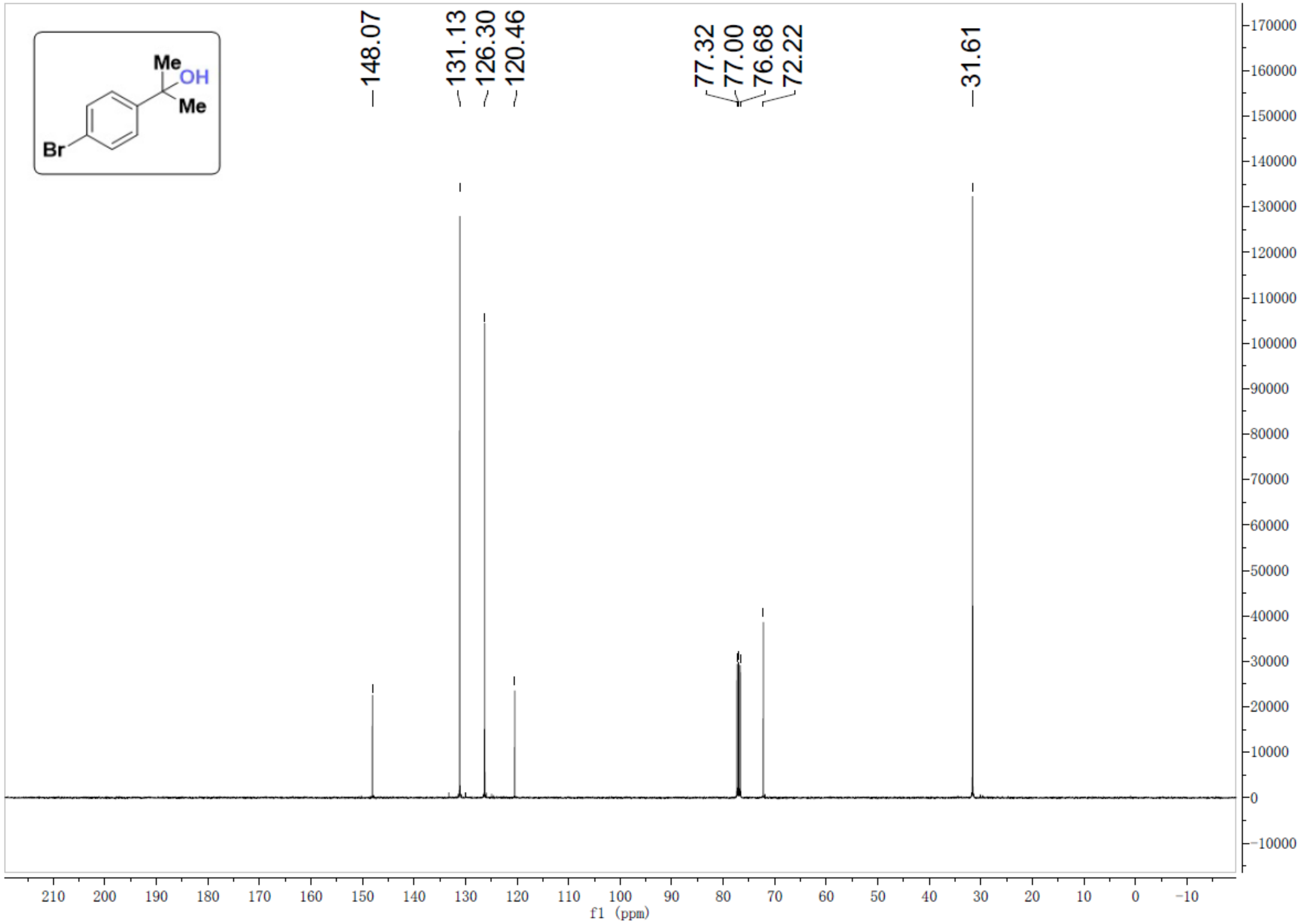
197.31
149.46
134.27
130.47
127.83
127.03
125.17
77.32
77.00
76.68
70.20
38.28
35.82
29.05
O
Me
OH
25000
20000
15000
10000
5000
0
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 4o

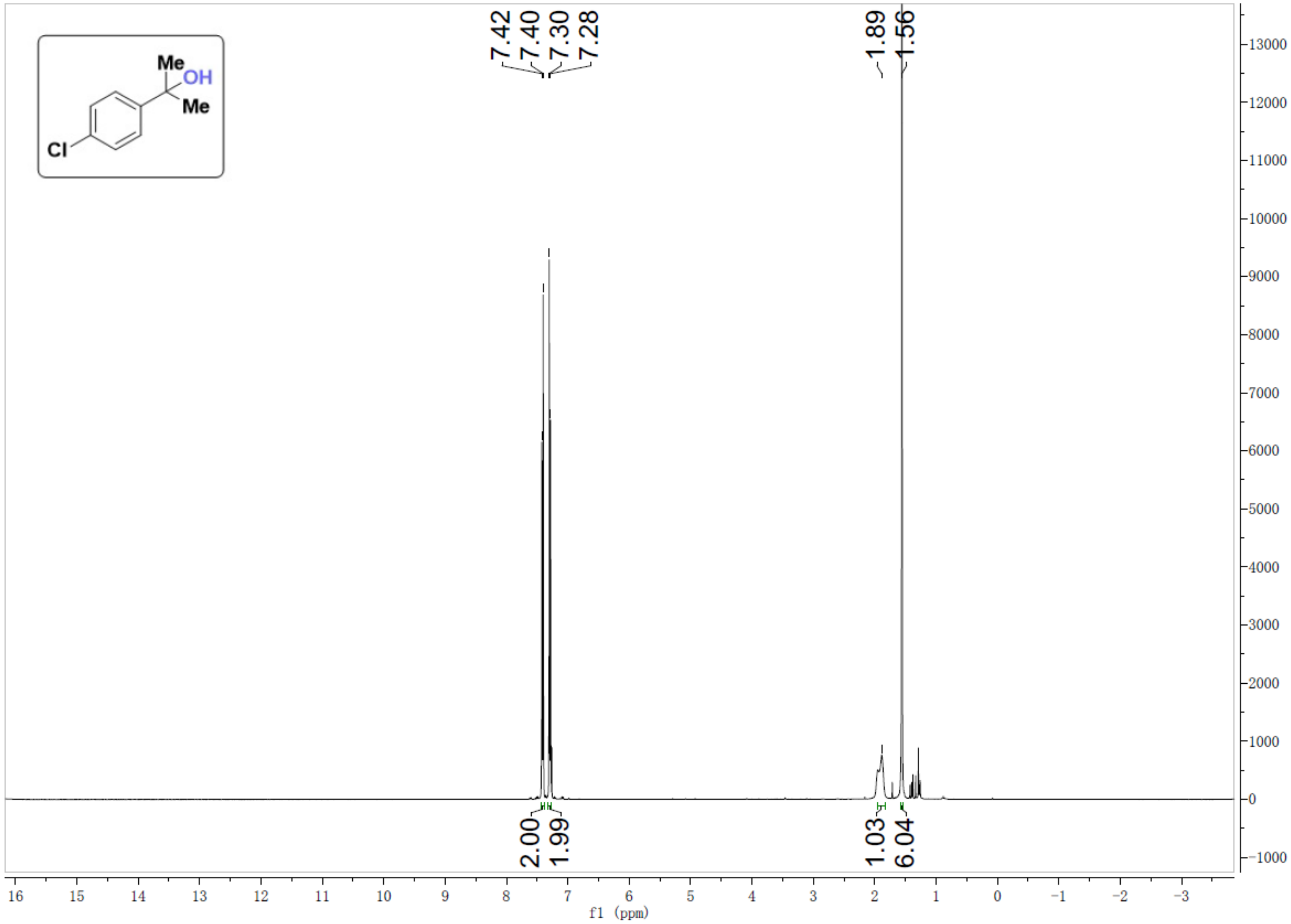


Me
OH
Me
Br
7.45
7.43
7.35
7.33
7.26
2.14
1.54
1.96
2.00
0.96
6.05
24000
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

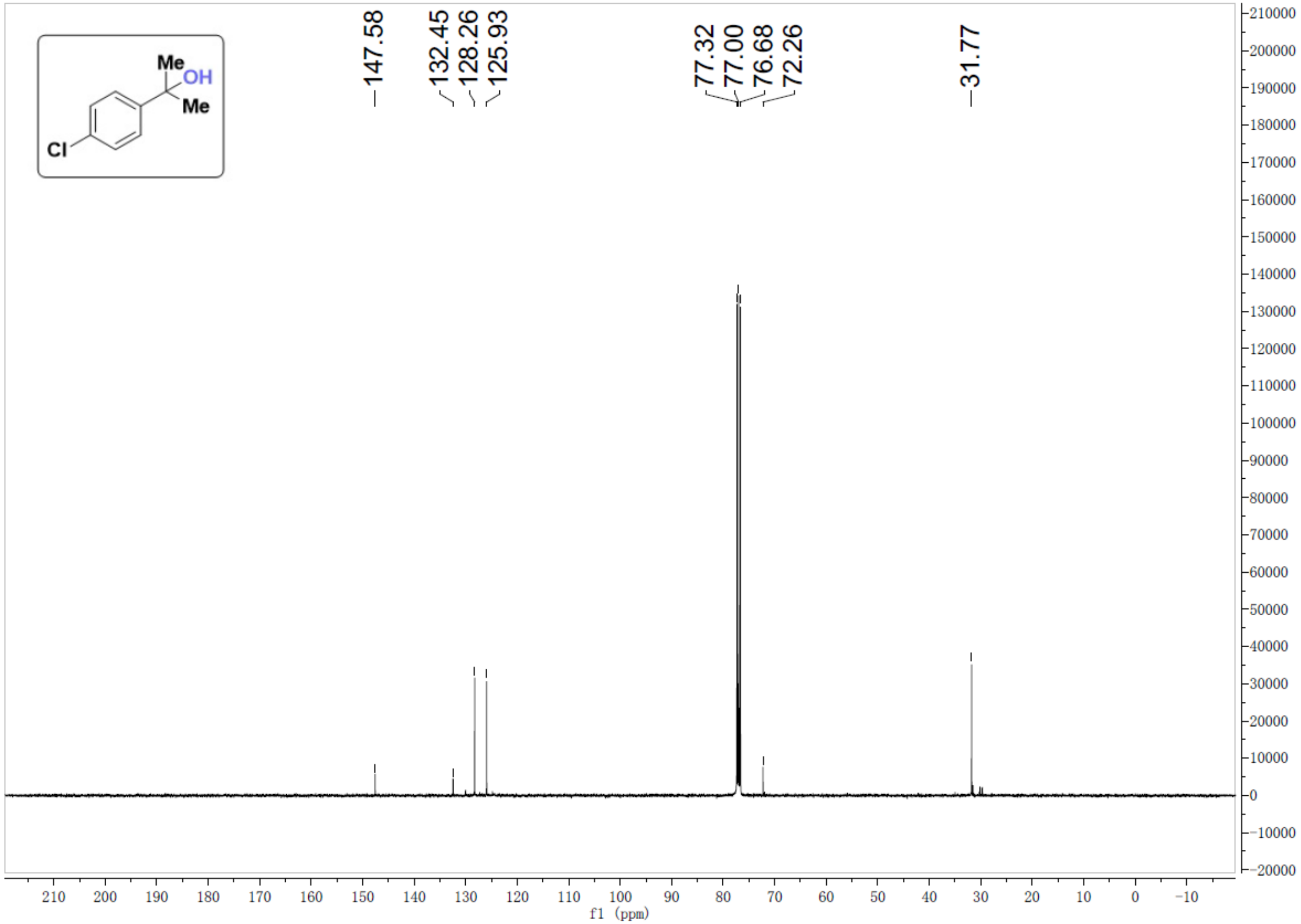
^{13}C NMR of 4o


Me
OH
Me
Br
148.07
131.13
126.30
120.46
77.32
77.00
76.68
72.22
31.61
170000
160000
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
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)

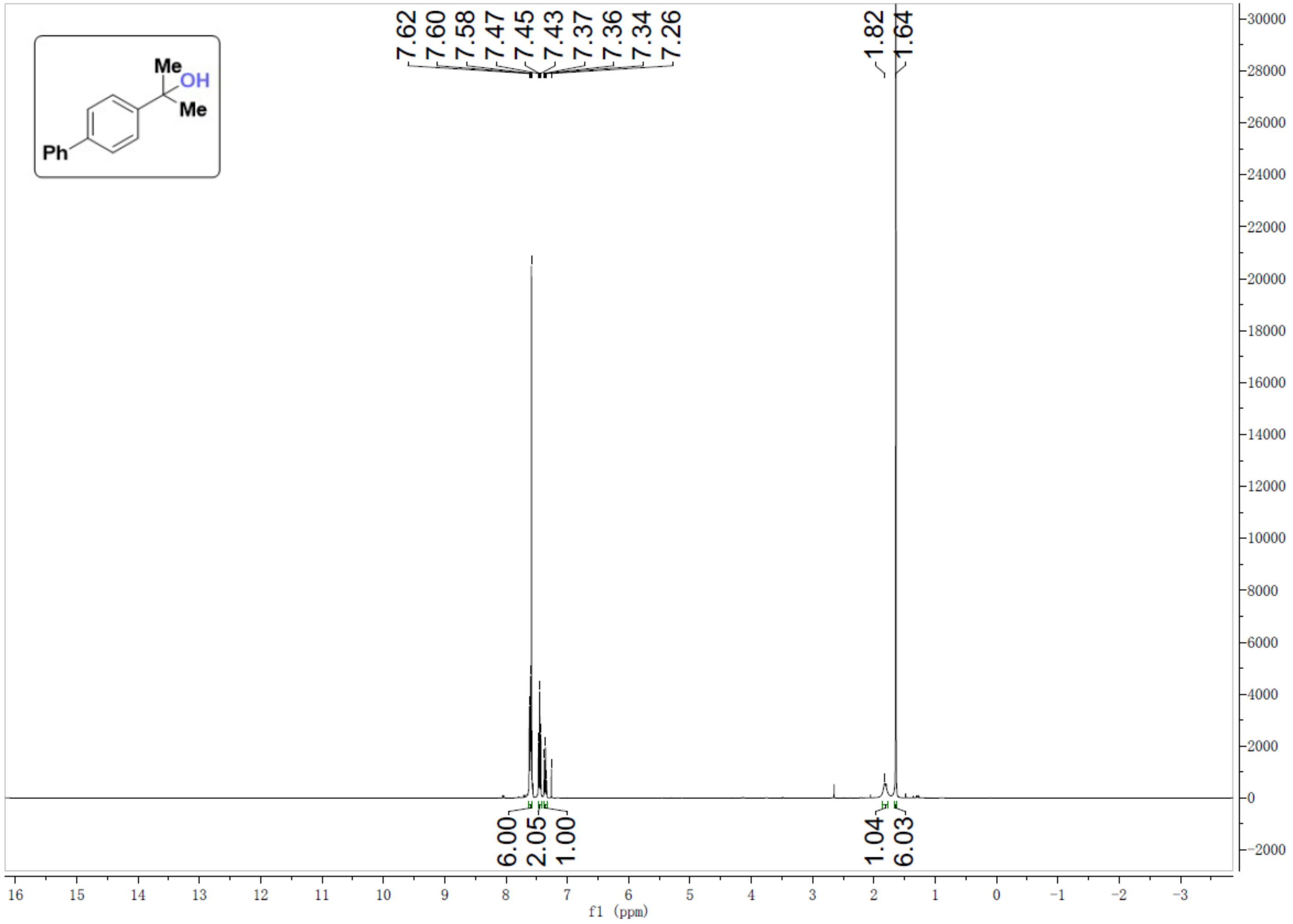
^1H NMR of 4p


Me
OH
Me
Cl
7.42
7.40
7.30
7.28
1.89
1.56
2.00
1.99
1.03
6.04
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000

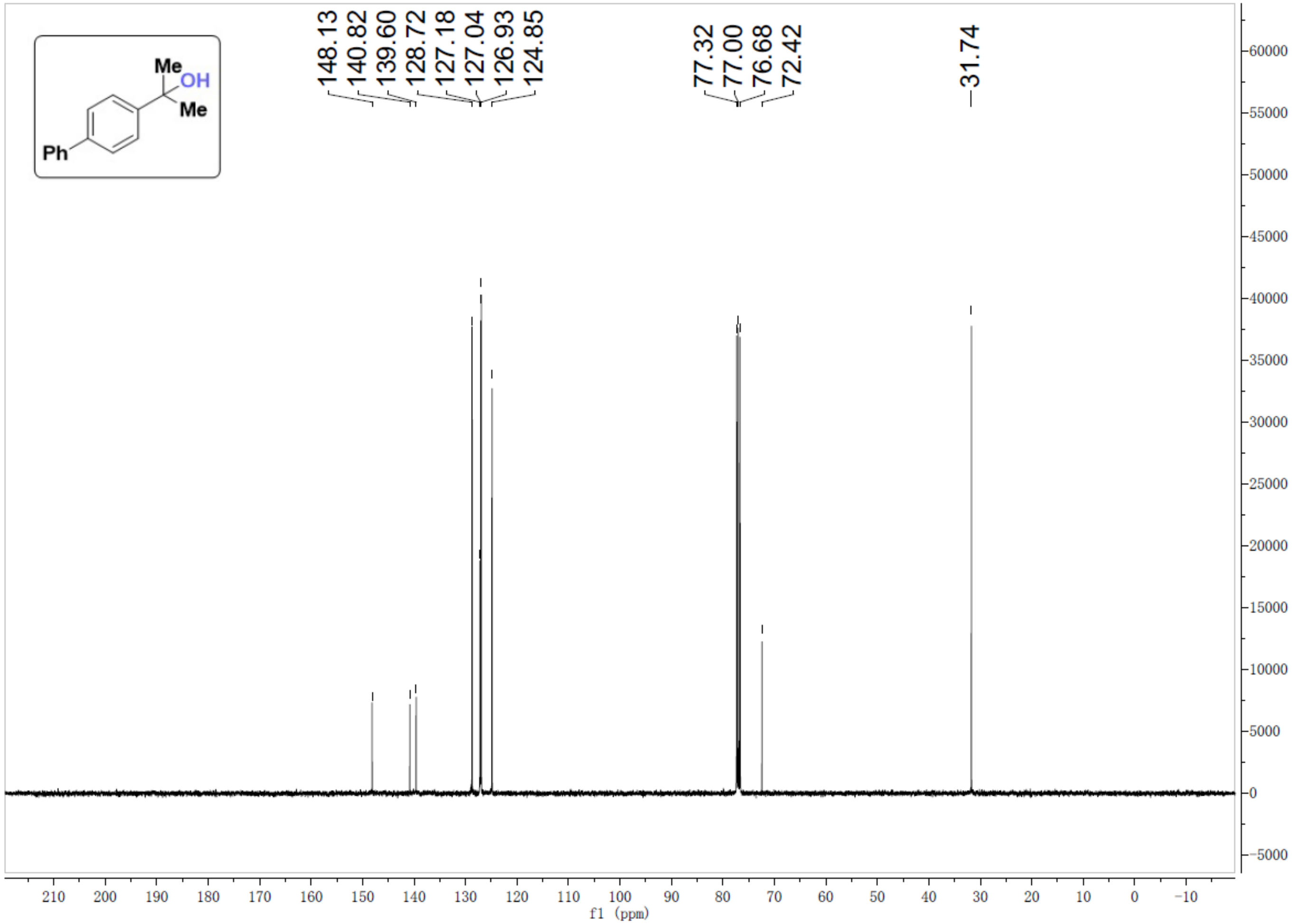
^{13}C NMR of 4p


Me
OH
Me
Cl
147.58
132.45
128.26
125.93
77.32
77.00
76.68
72.26
31.77
210000
200000
190000
180000
170000
160000
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
-20000
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)

^{1}H NMR of 4q

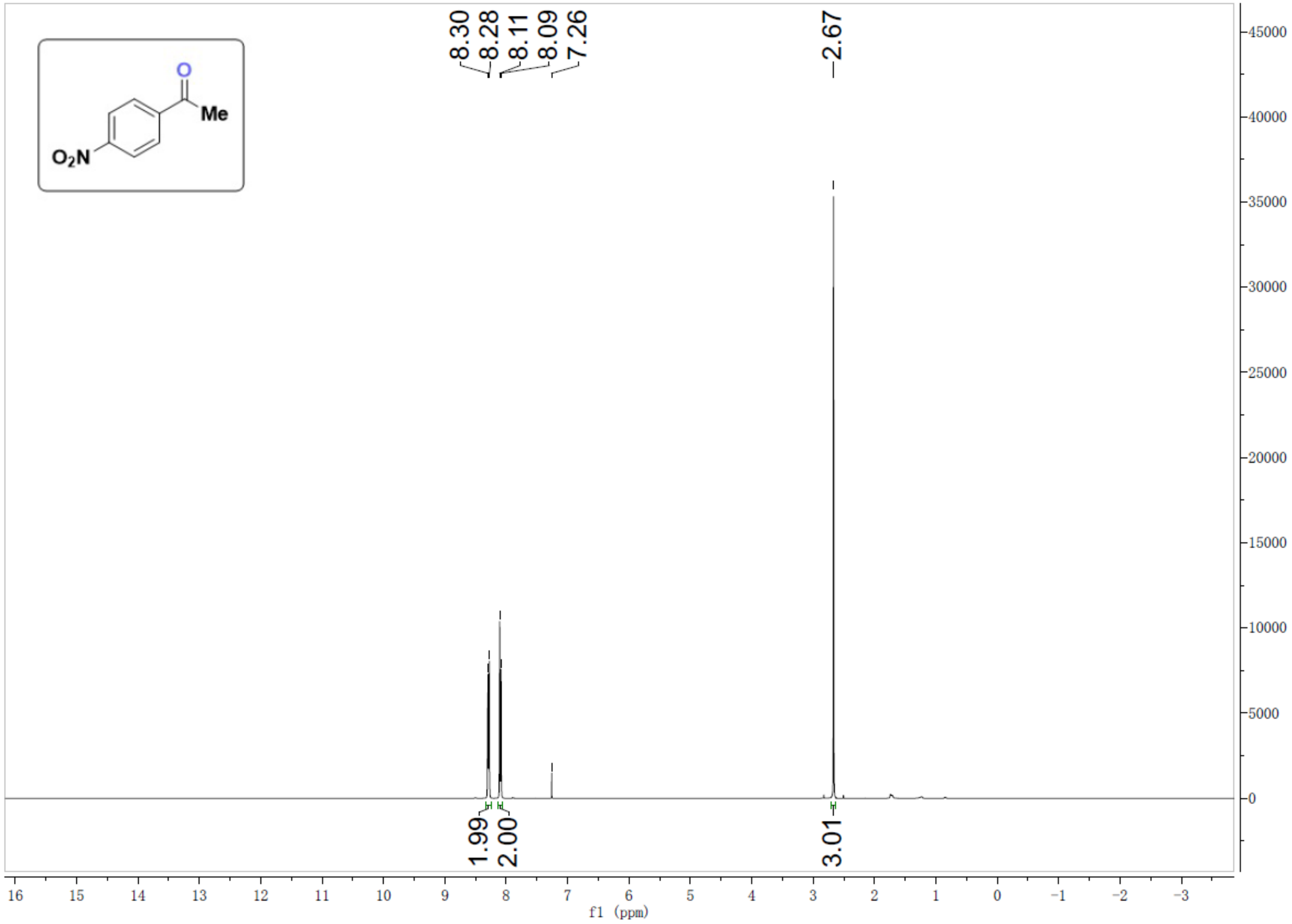

Me
OH
Me
Ph
7.62
7.60
7.58
7.47
7.45
7.43
7.37
7.36
7.34
7.26
1.82
1.64
6.00
2.05
1.00
1.04
6.03
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000

^{13}C NMR of 4q

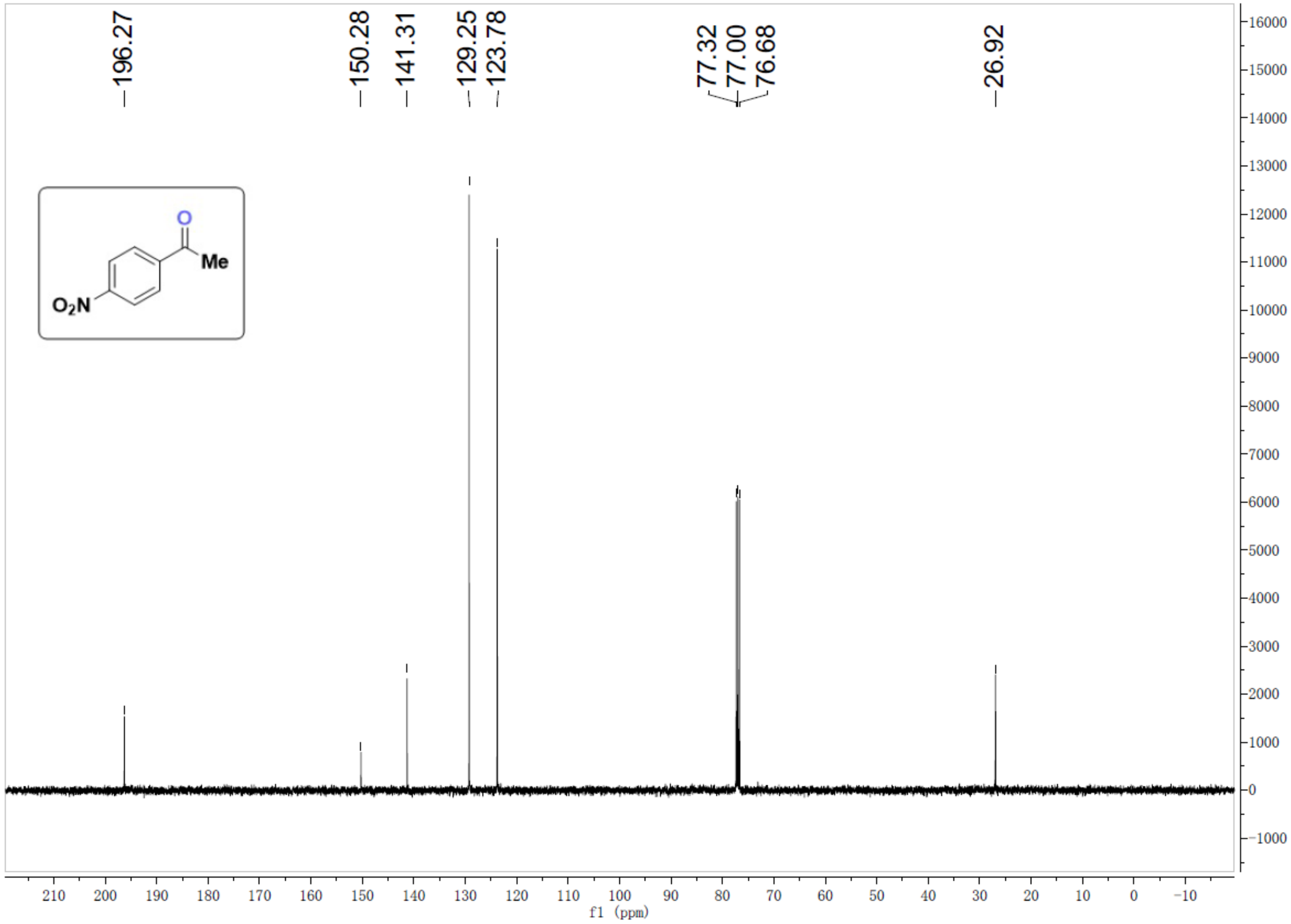


148.13
140.82
139.60
128.72
127.18
127.04
126.93
124.85
77.32
77.00
76.68
72.42
31.74
Me
OH
Me
Ph
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
−5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

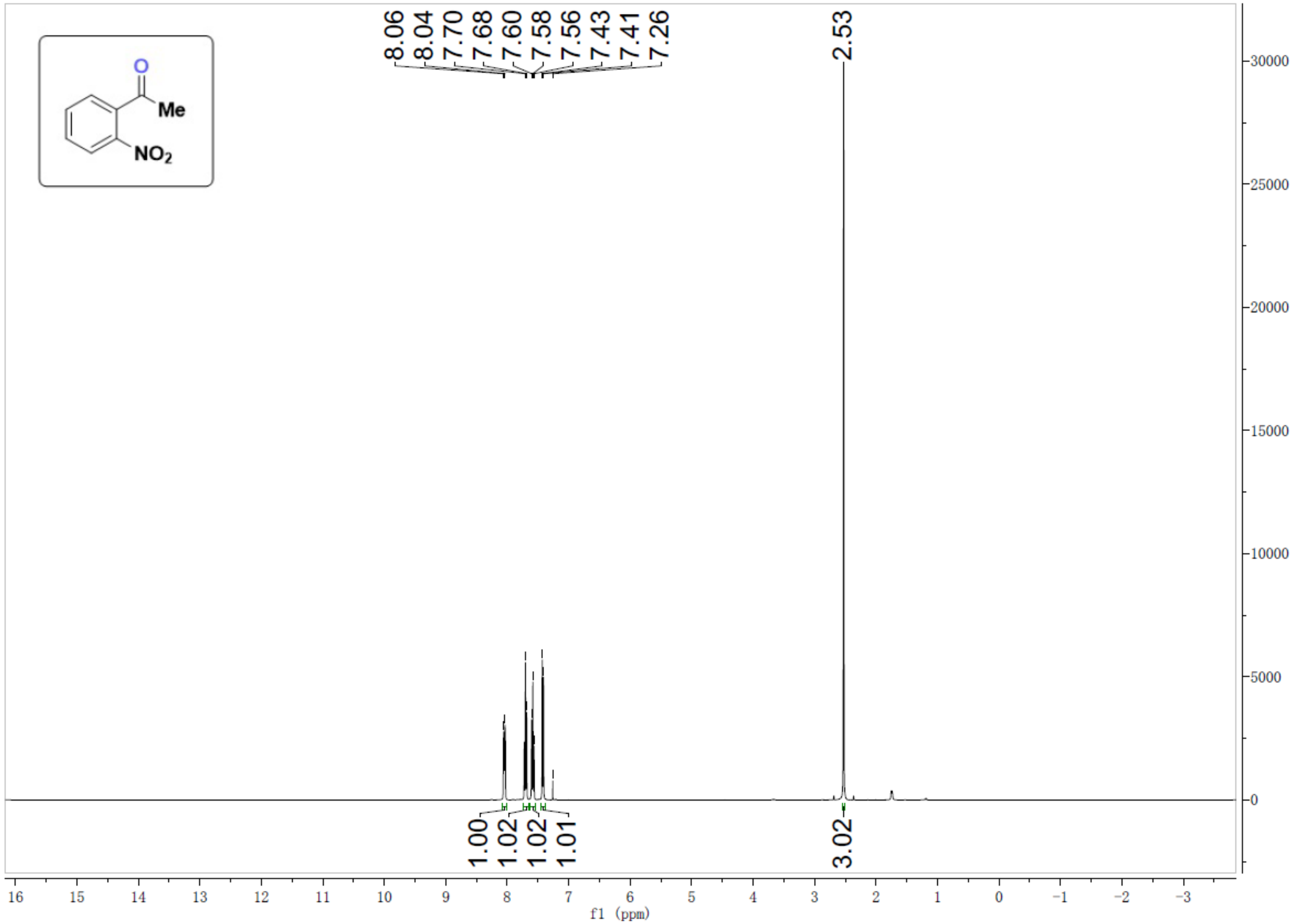
^{1}H NMR of 5a


8.30
8.28
8.11
8.09
7.26
2.67
O
Me
O2N
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1.99
2.00
3.01
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 5a

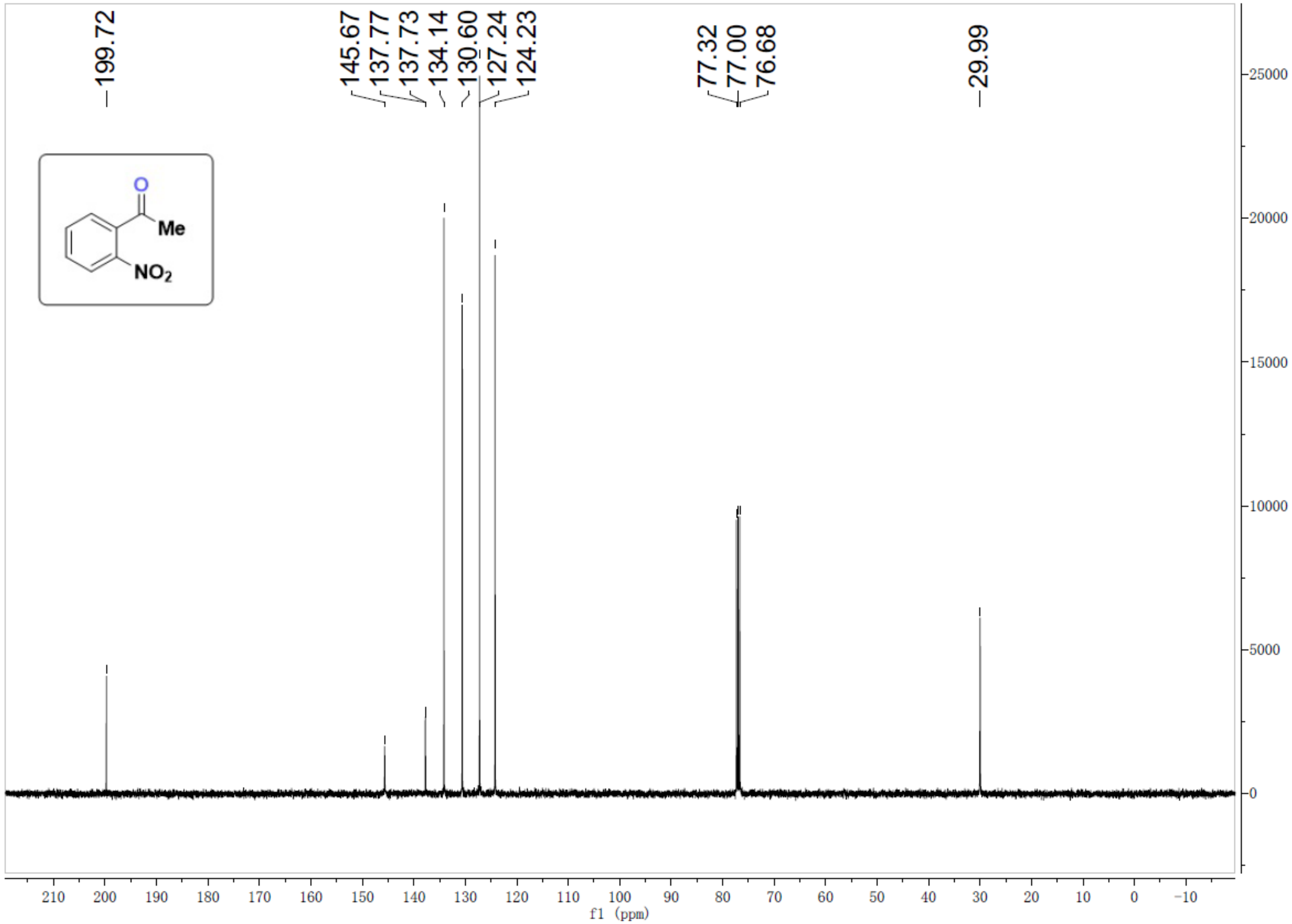

196.27
150.28
141.31
129.25
123.78
77.32
77.00
76.68
26.92
O
Me
O2N
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

^{1}H NMR of 5b

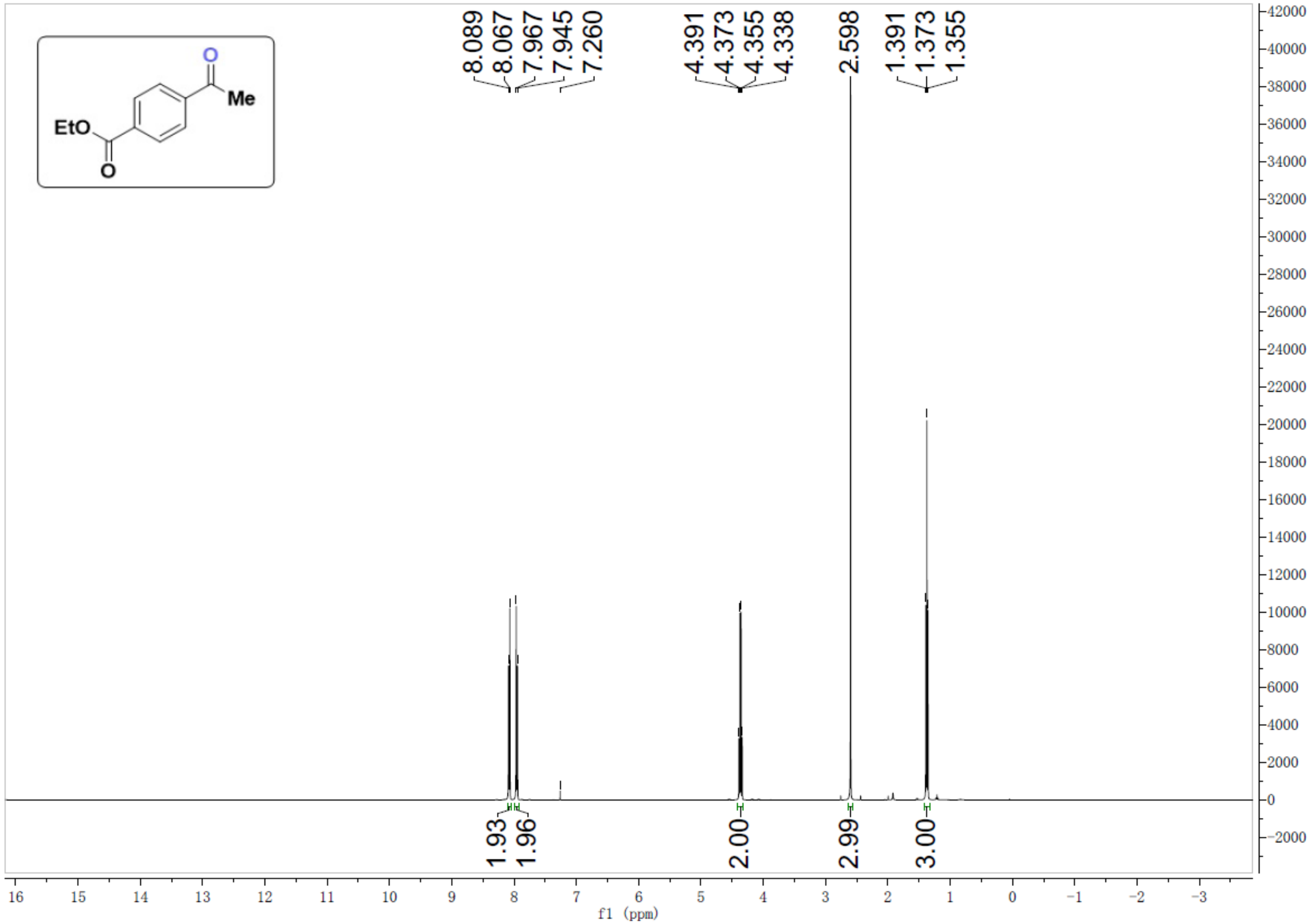


O
Me
NO2
8.06
8.04
7.70
7.68
7.60
7.58
7.56
7.43
7.41
7.26
2.53
1.00
1.02
1.02
1.01
3.02
30000
25000
20000
15000
10000
5000
0
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 5b

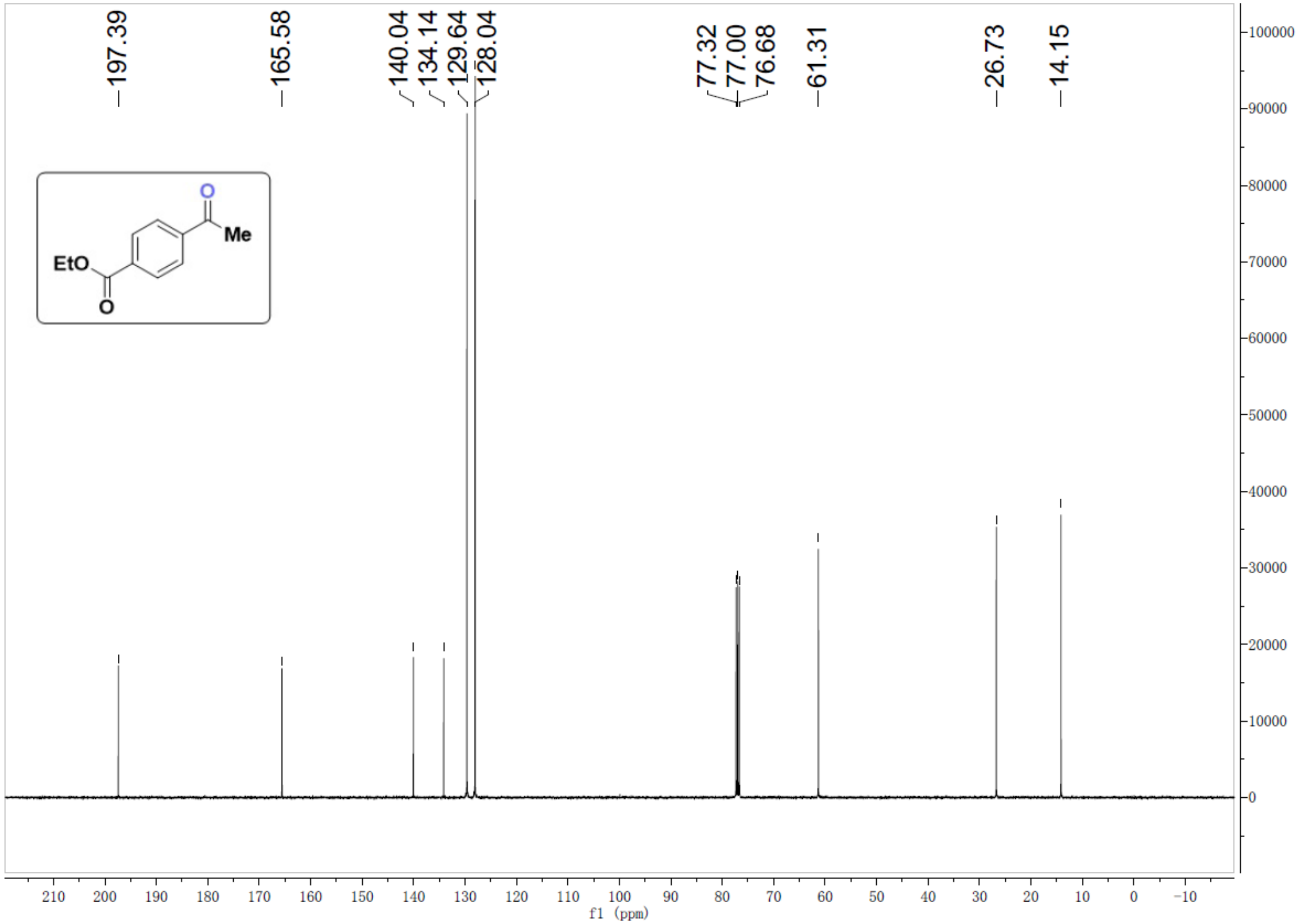

199.72
145.67
137.77
137.73
134.14
130.60
127.24
124.23
77.32
77.00
76.68
29.99
O
Me
NO2
25000
20000
15000
10000
5000
0
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 5c

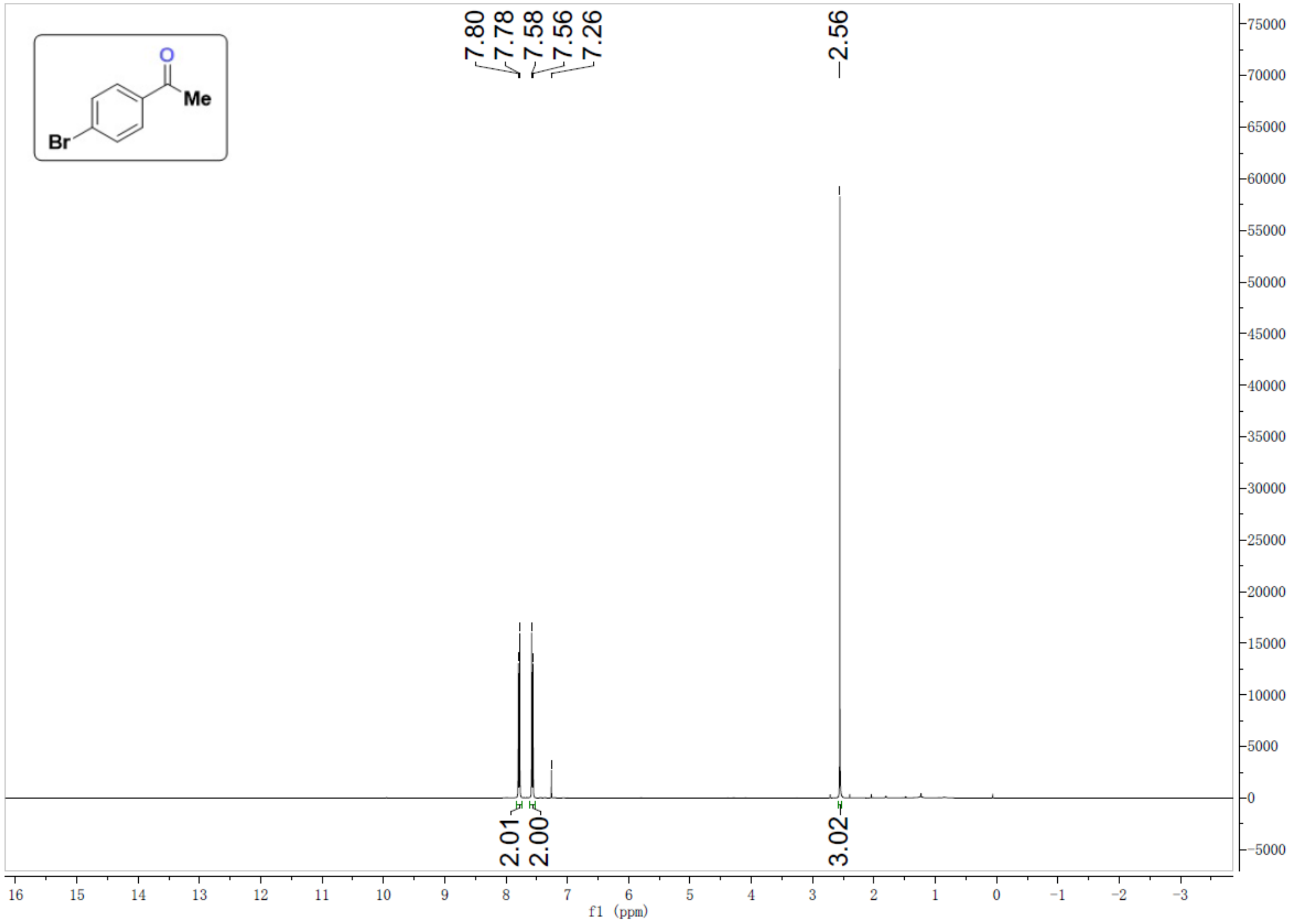


EtO
O
O
Me
8.089
8.067
7.967
7.945
7.260
4.391
4.373
4.355
4.338
2.598
1.391
1.373
1.355
1.93
1.96
2.00
2.99
3.00
42000
40000
38000
36000
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

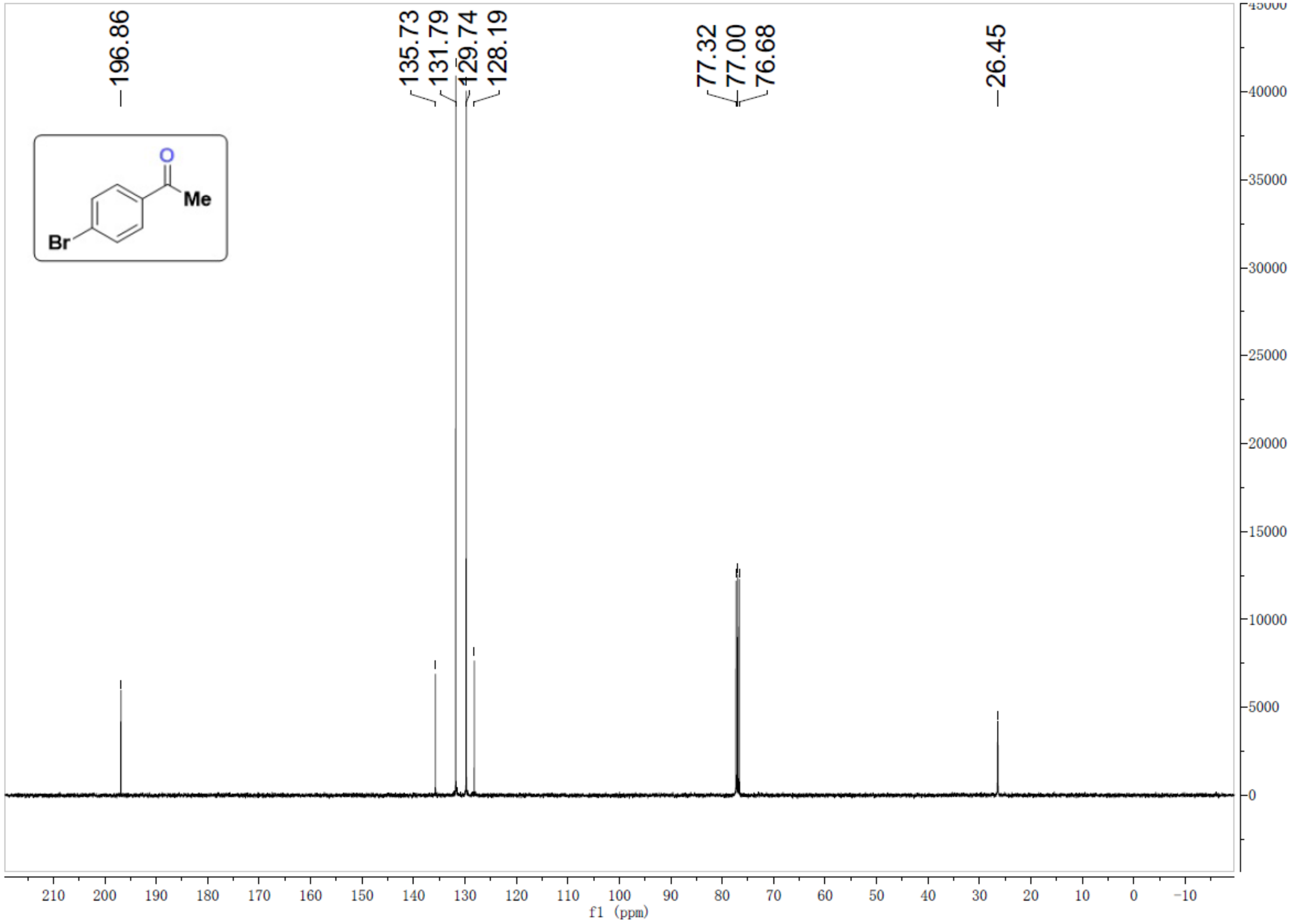
^{13}C NMR of 5c


197.39
165.58
140.04
134.14
129.64
128.04
77.32
77.00
76.68
61.31
26.73
14.15
EtO
O
O
Me
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
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)

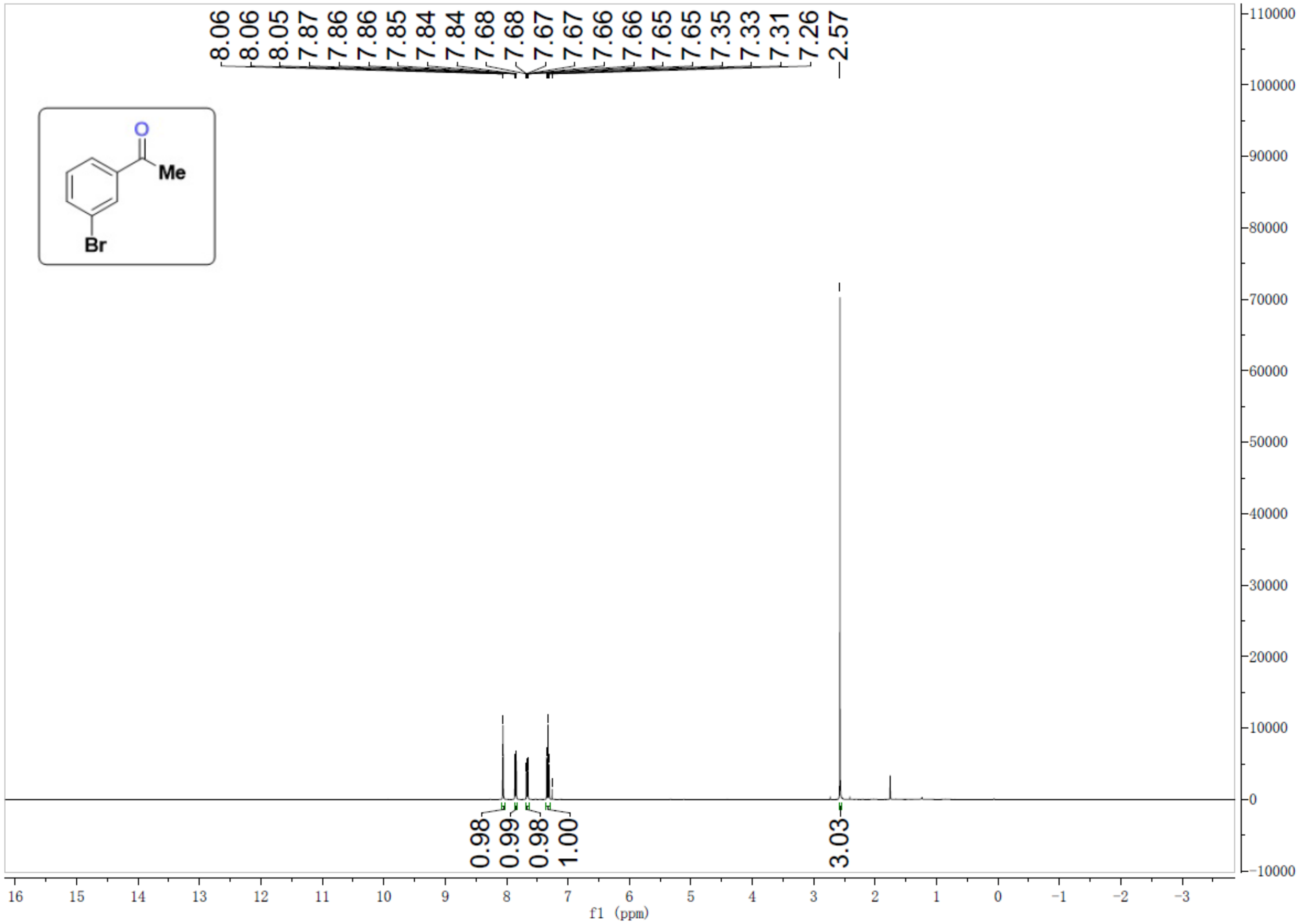
^{1}H NMR of 5d


O
Me
Br
7.80
7.78
7.58
7.56
7.26
2.56
2.01
2.00
3.02
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

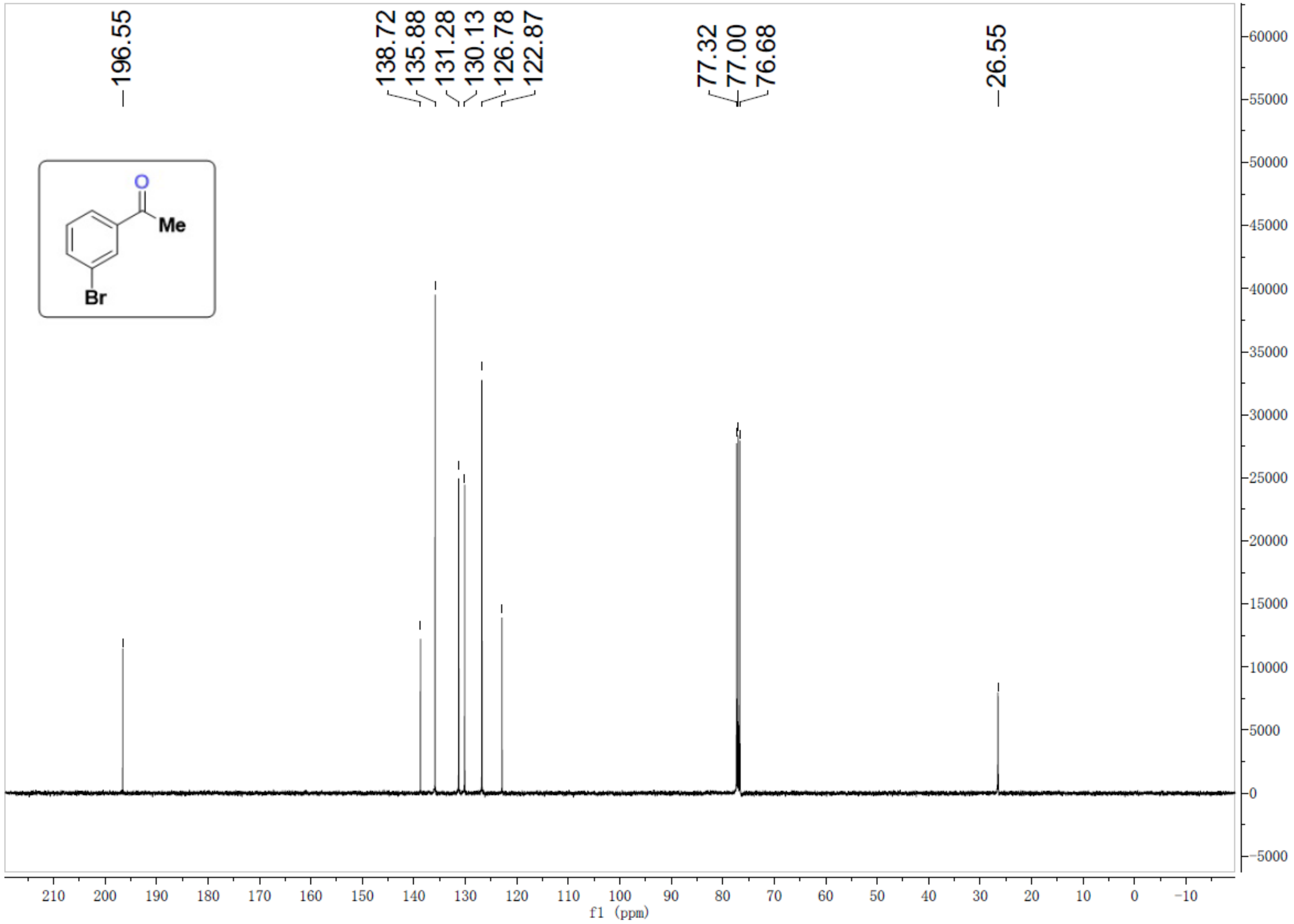
^{13}C NMR of 5d


196.86
135.73
131.79
129.74
128.19
77.32
77.00
76.68
26.45
Br
O
Me
45000
40000
35000
30000
25000
20000
15000
10000
5000
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)

^{1}H NMR of 5e

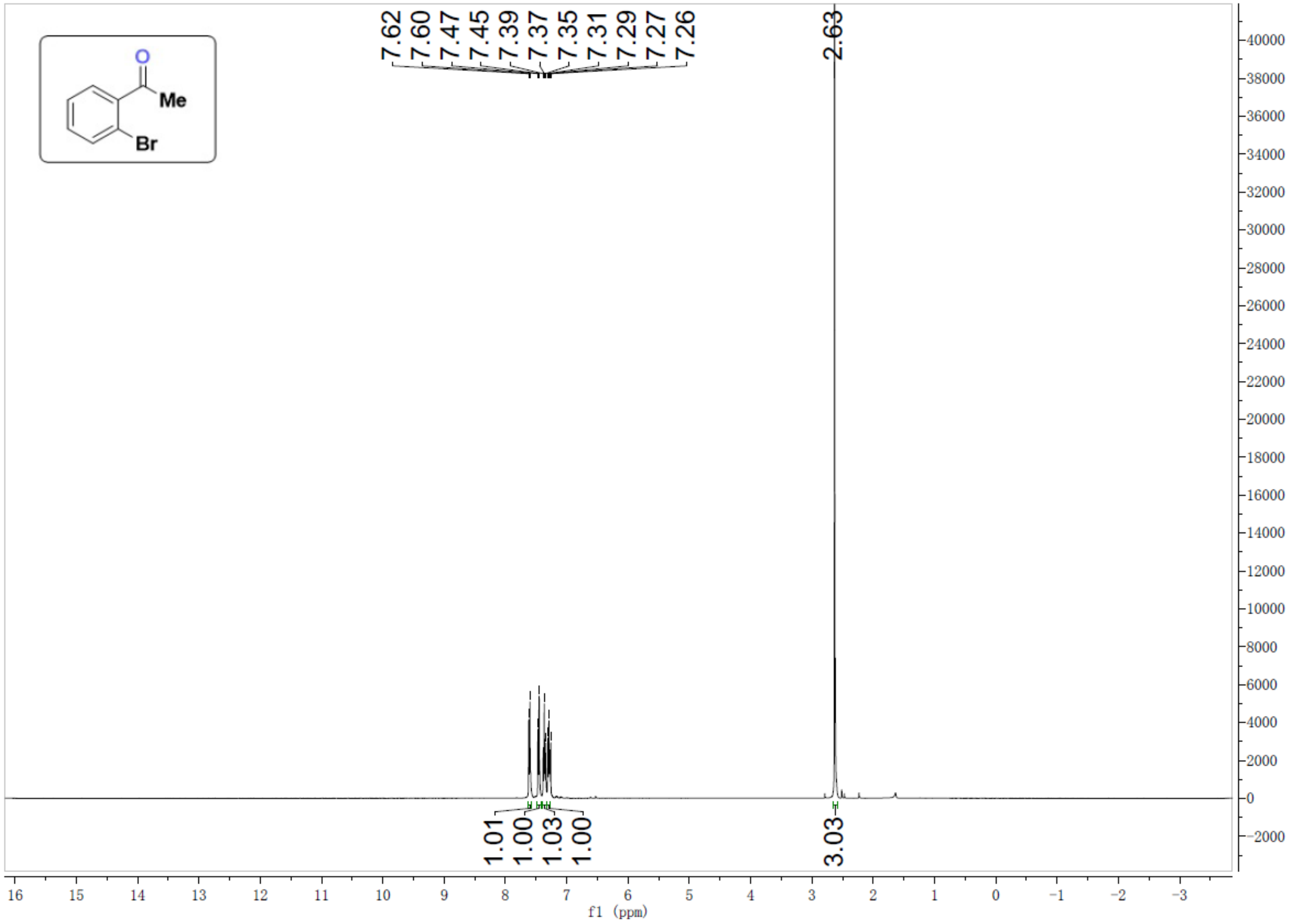

8.06
8.06
8.05
7.87
7.86
7.86
7.85
7.84
7.84
7.68
7.68
7.67
7.67
7.66
7.66
7.65
7.65
7.35
7.33
7.31
7.26
2.57
O
Me
Br
0.98
0.99
0.98
1.00
3.03
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 5e

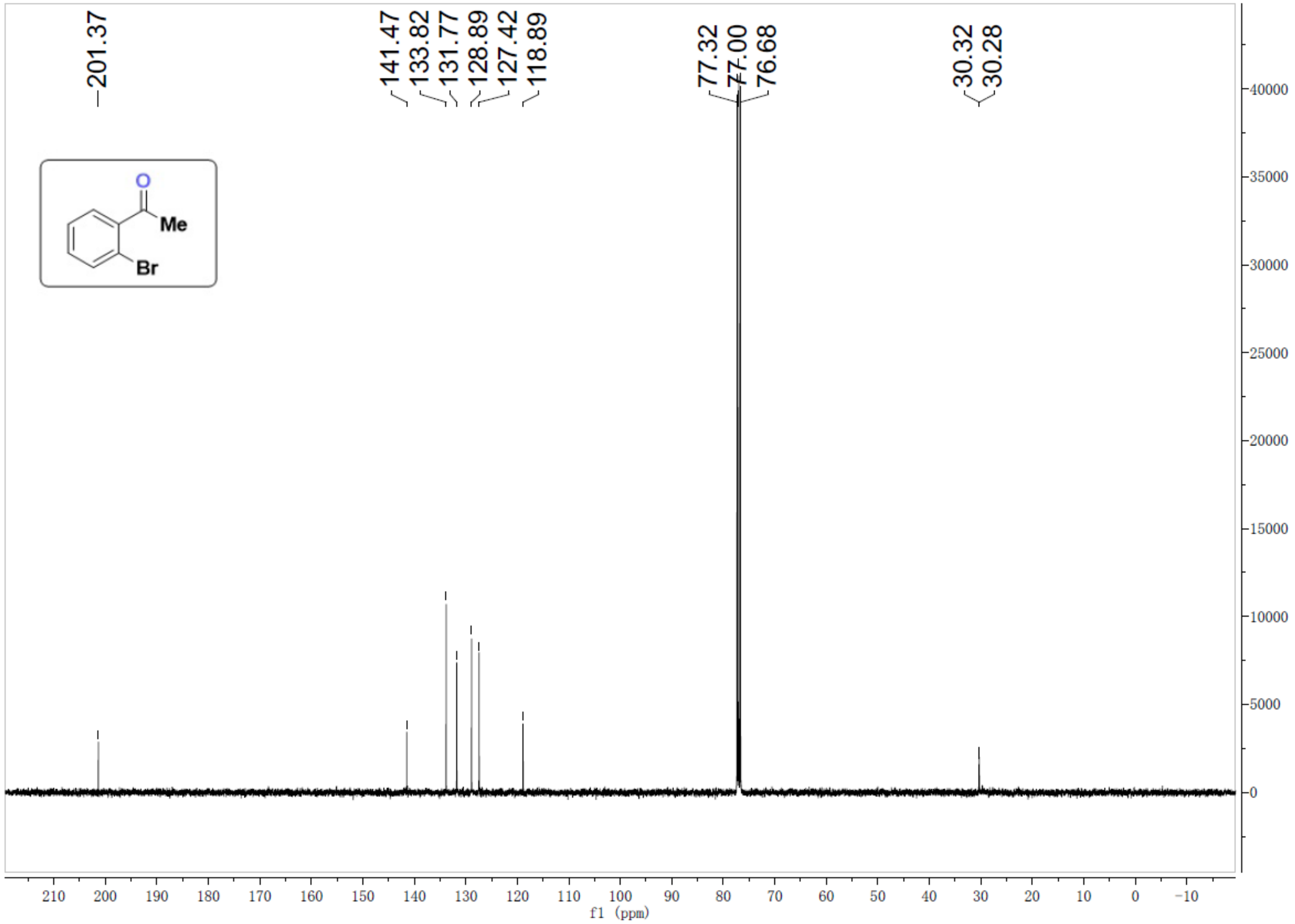


196.55
138.72
135.88
131.28
130.13
126.78
122.87
77.32
77.00
76.68
26.55
O
Me
Br
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
−5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

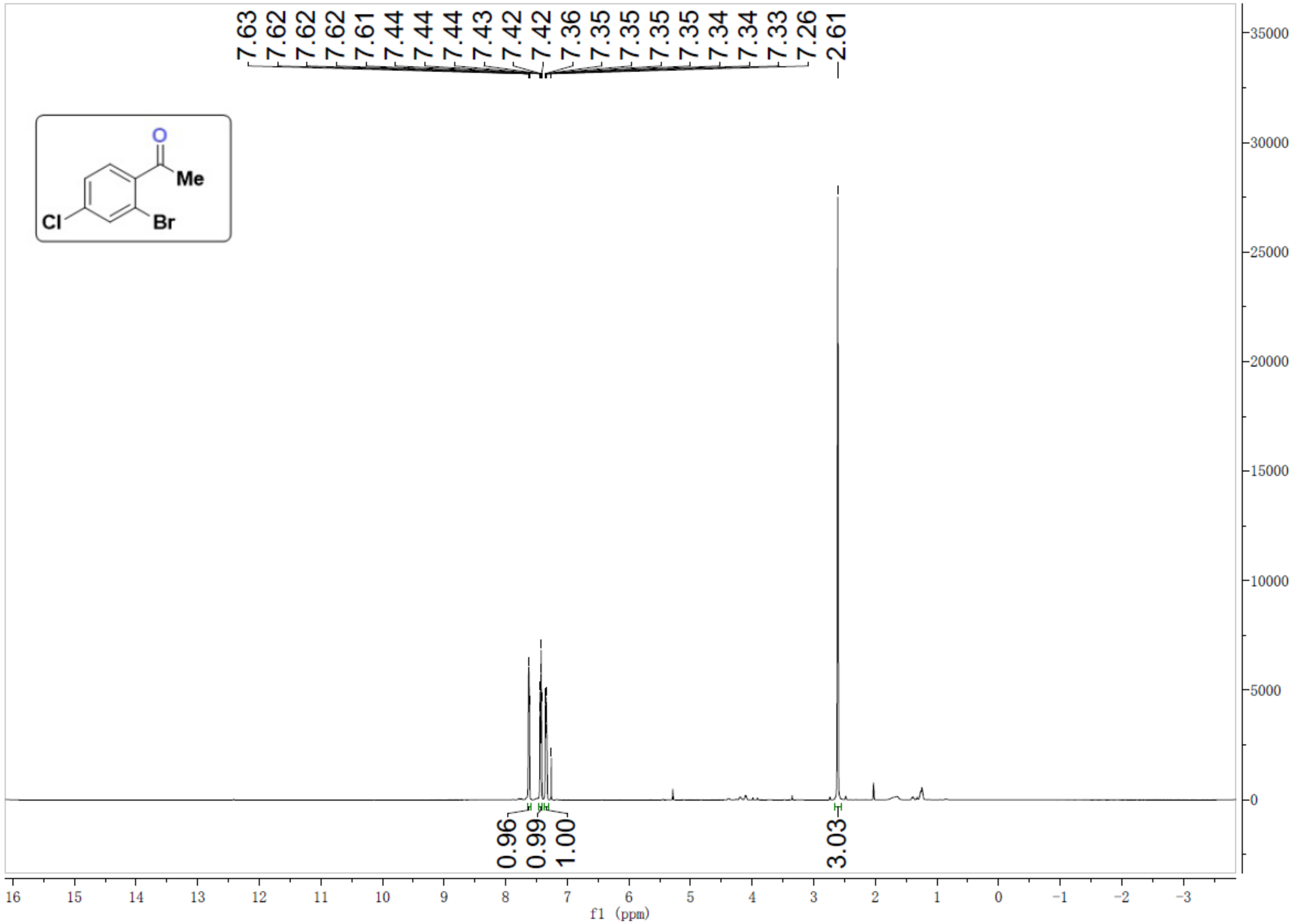
^{1}H NMR of 5f


7.62
7.60
7.47
7.45
7.39
7.37
7.35
7.31
7.29
7.27
7.26
2.63
O
Me
Br
1.01
1.00
1.03
1.00
3.03
40000
38000
36000
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

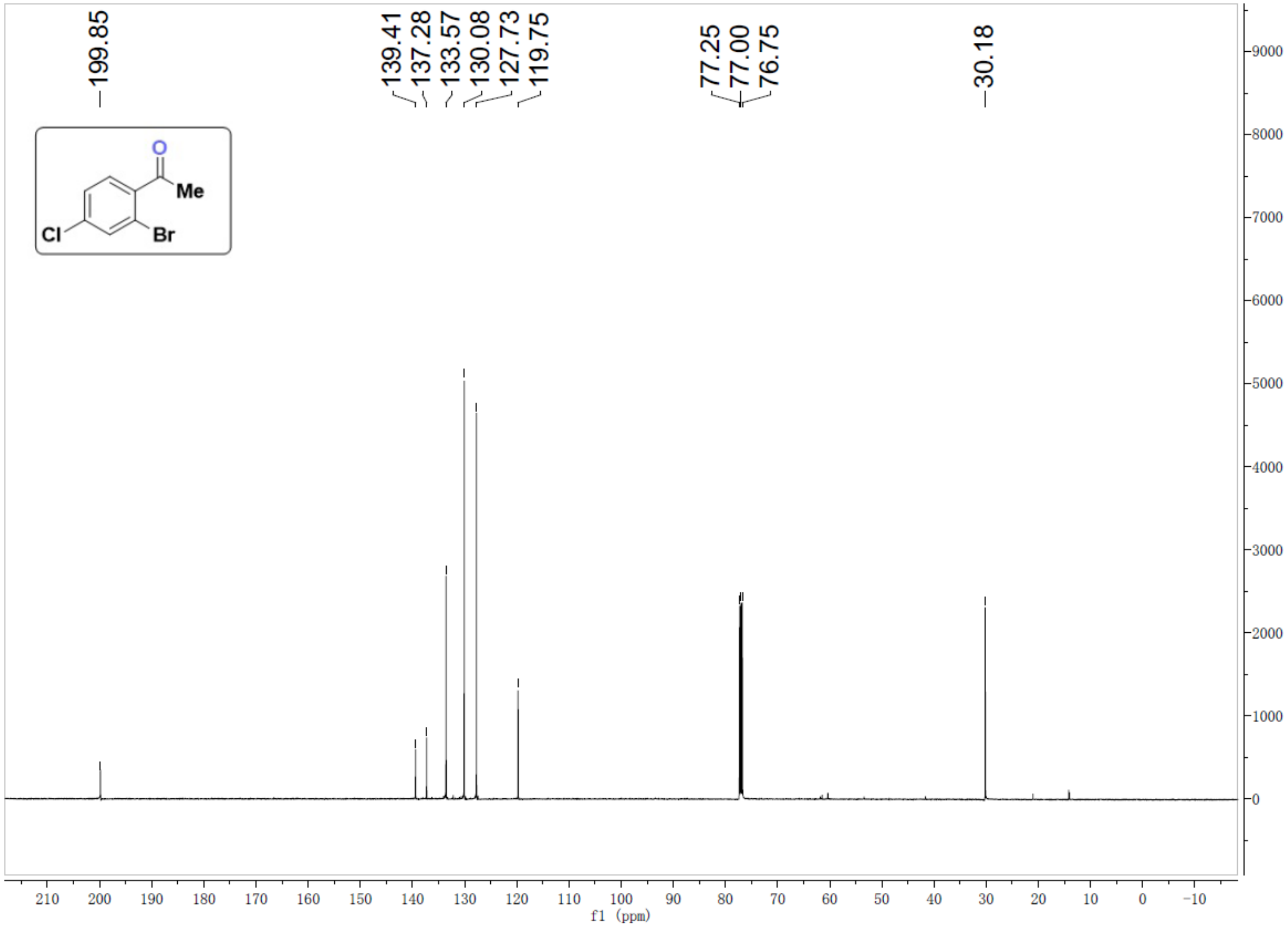
^{13}C NMR of 5f


201.37
141.47
133.82
131.77
128.89
127.42
118.89
77.32
77.00
76.68
30.32
30.28
O
Me
Br
40000
35000
30000
25000
20000
15000
10000
5000
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)

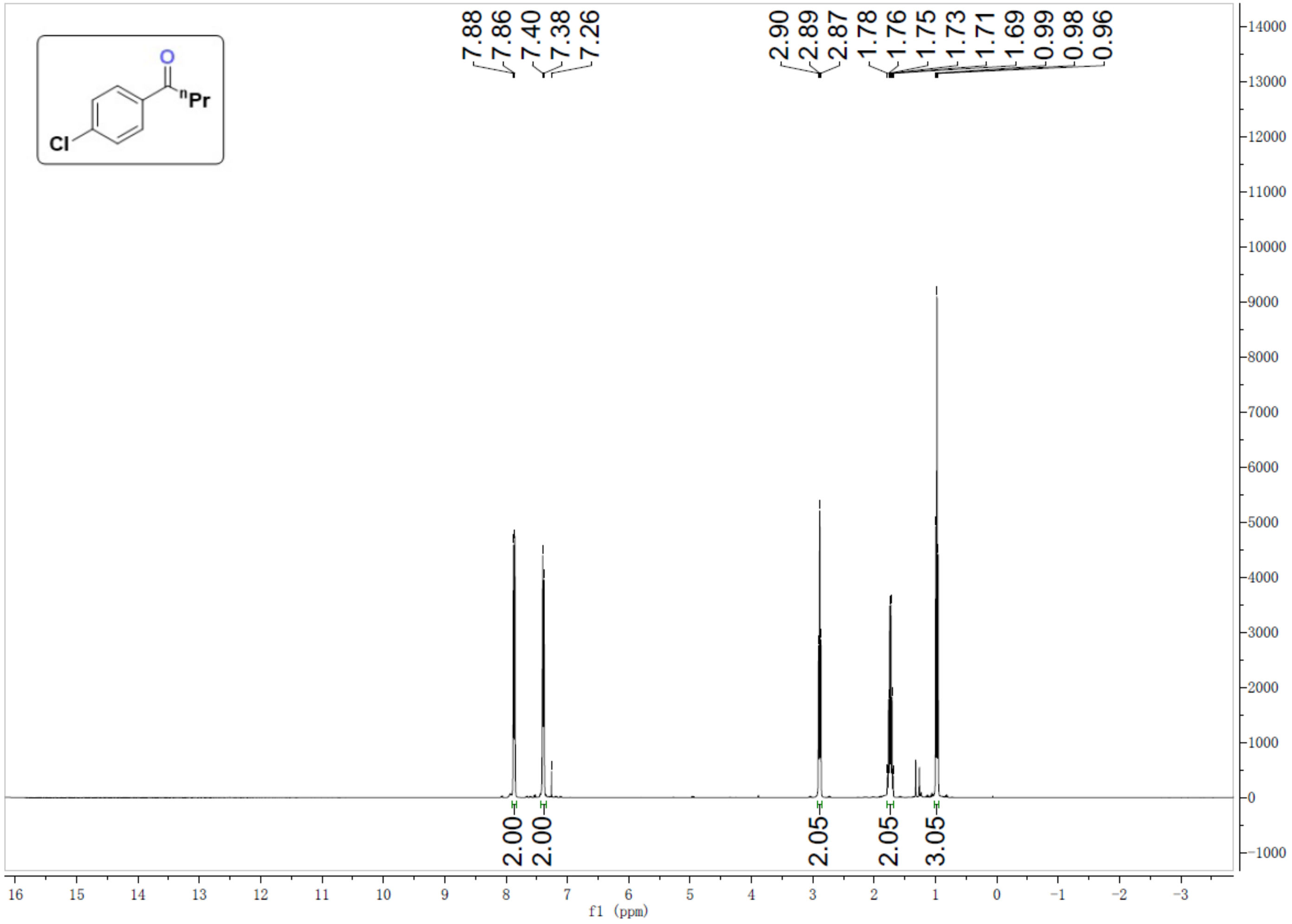
^{1}H NMR of 5g


7.63
7.62
7.62
7.62
7.61
7.44
7.44
7.44
7.43
7.42
7.42
7.36
7.35
7.35
7.35
7.35
7.34
7.34
7.33
7.26
2.61
O
Me
Cl
Br
0.96
0.99
1.00
3.03
35000
30000
25000
20000
15000
10000
5000
0
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

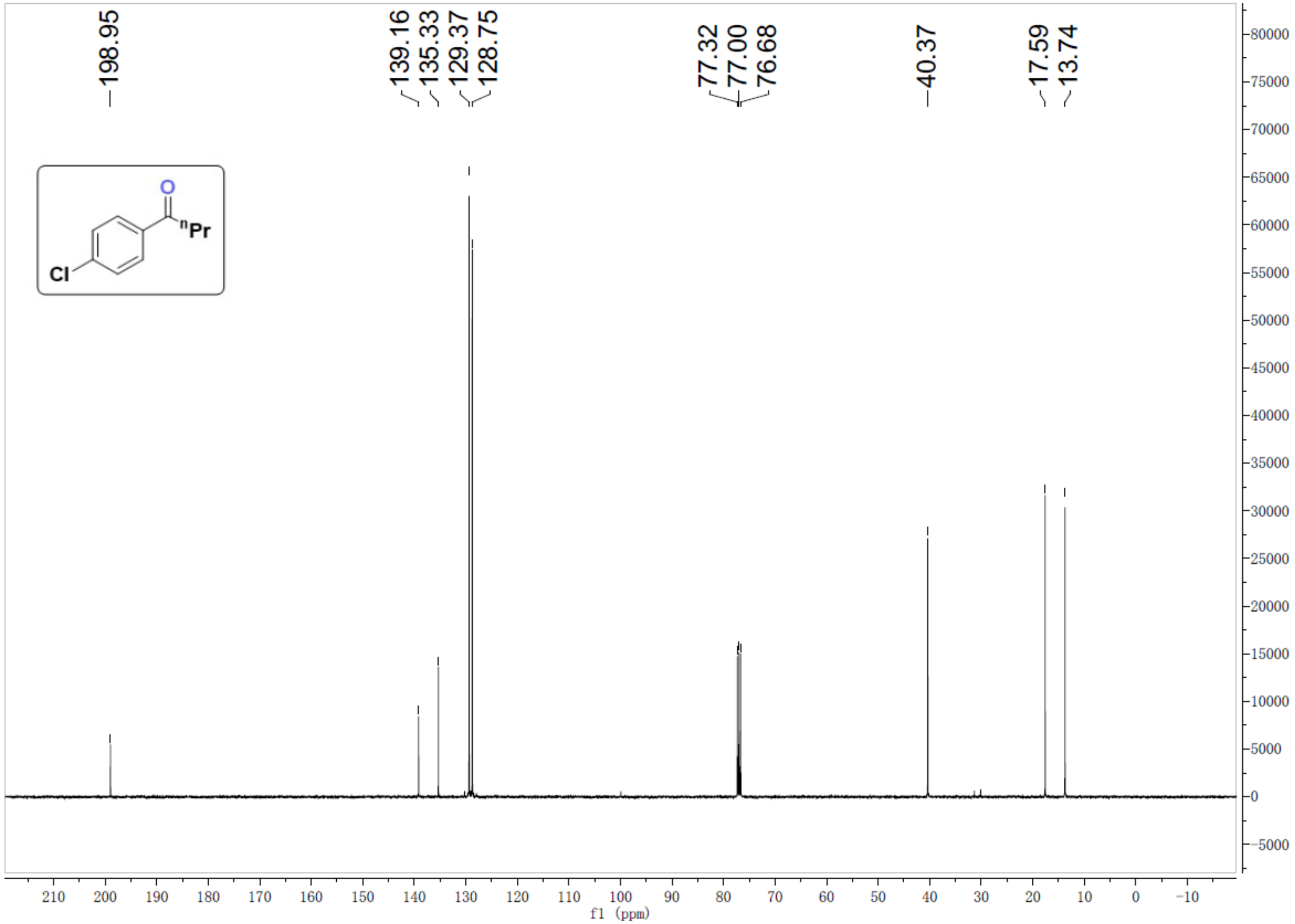
^{13}C NMR of 5g


199.85
139.41
137.28
133.57
130.08
127.73
119.75
77.25
77.00
76.75
30.18
O
Me
Cl
Br
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)

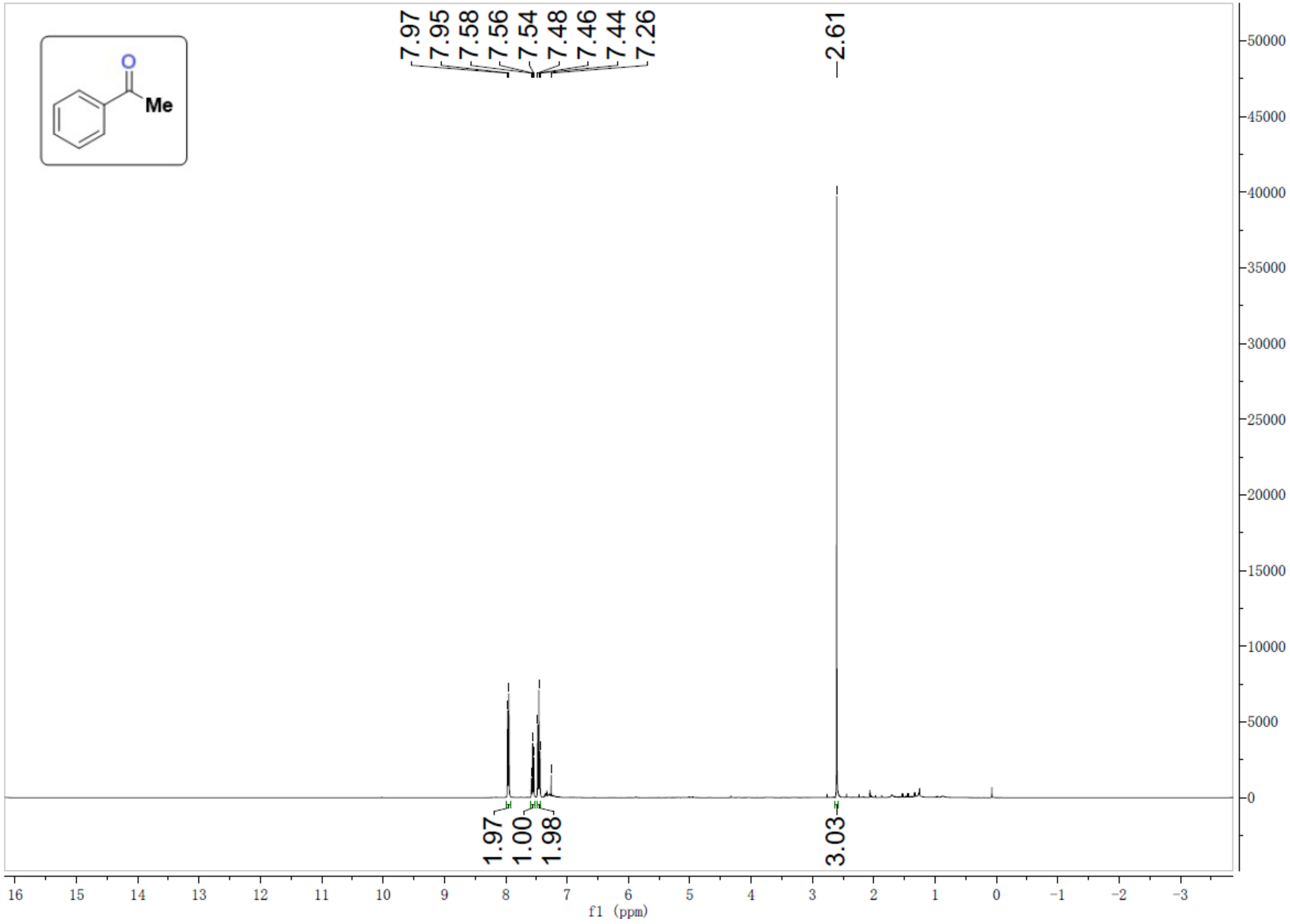
^{1}H NMR of 5h


Cl
O
nPr
7.88
7.86
7.40
7.38
7.26
2.90
2.89
2.87
1.78
1.76
1.75
1.73
1.71
1.69
0.99
0.98
0.96
2.00
2.00
2.05
2.05
3.05
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 5h

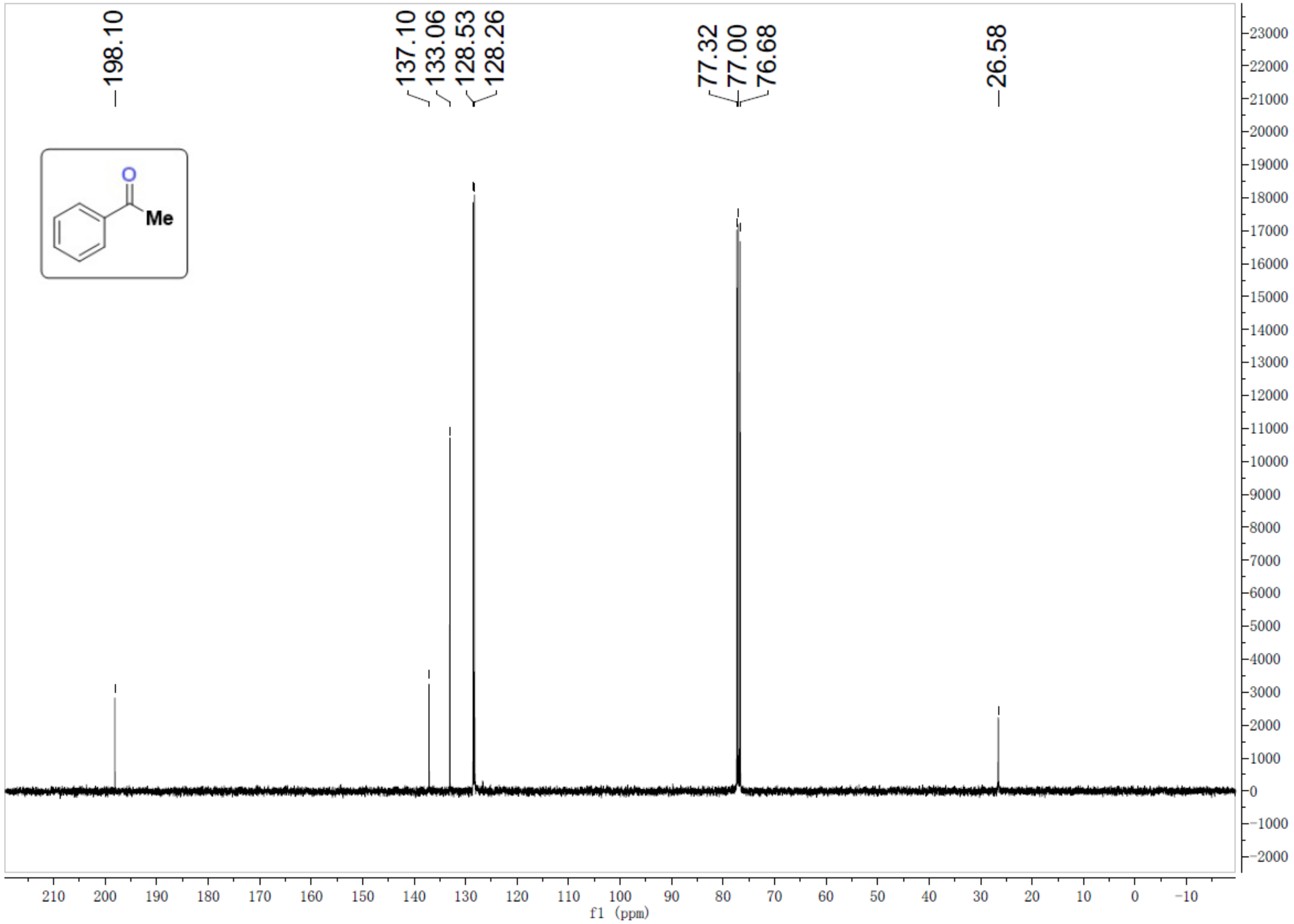

198.95
139.16
135.33
129.37
128.75
77.32
77.00
76.68
40.37
17.59
13.74
O
^{n}Pr
Cl
80000
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 5i



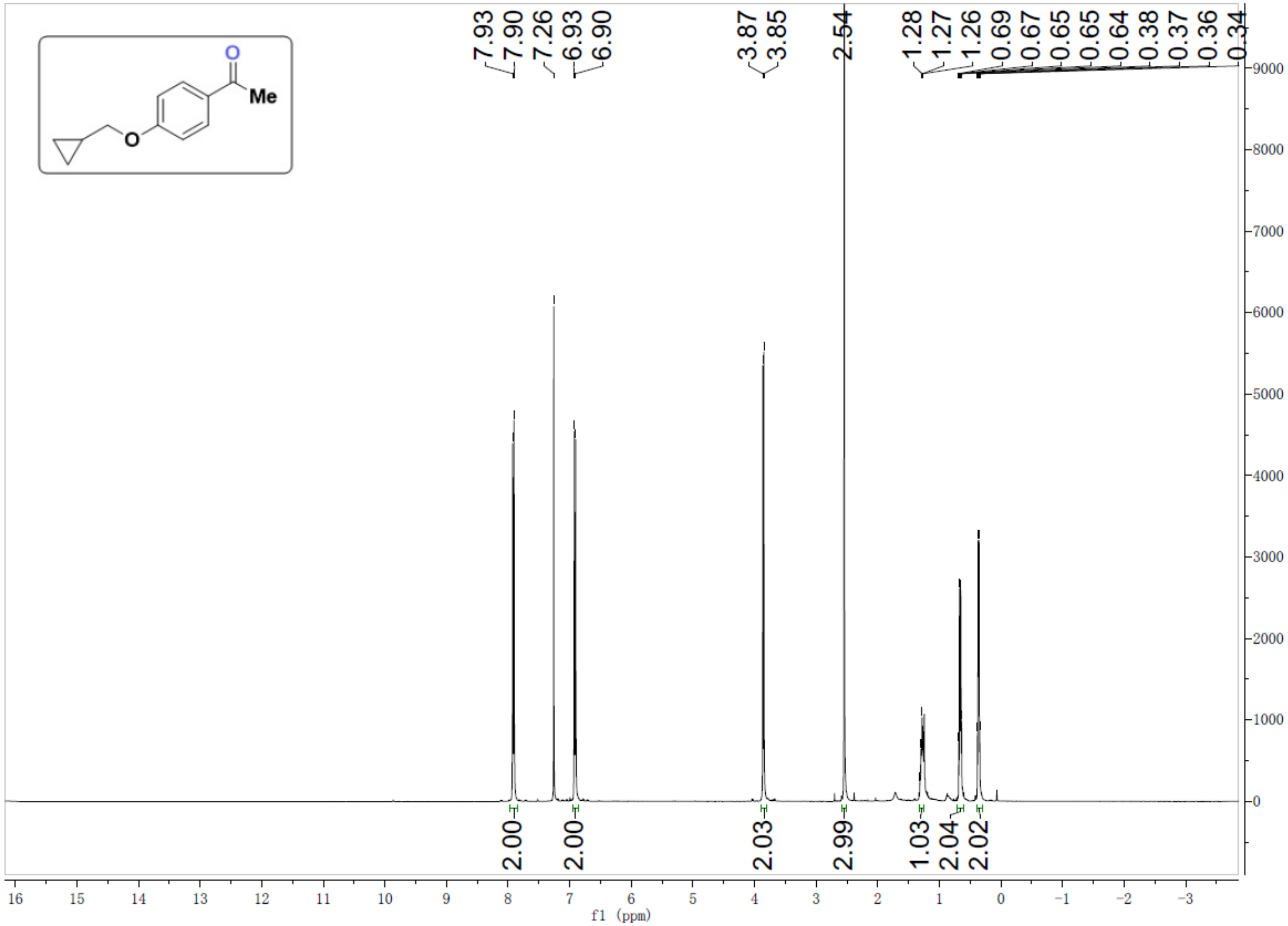
O
Me
7.97
7.95
7.58
7.56
7.54
7.48
7.46
7.44
7.26
2.61
1.97
1.00
1.98
3.03
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 5i



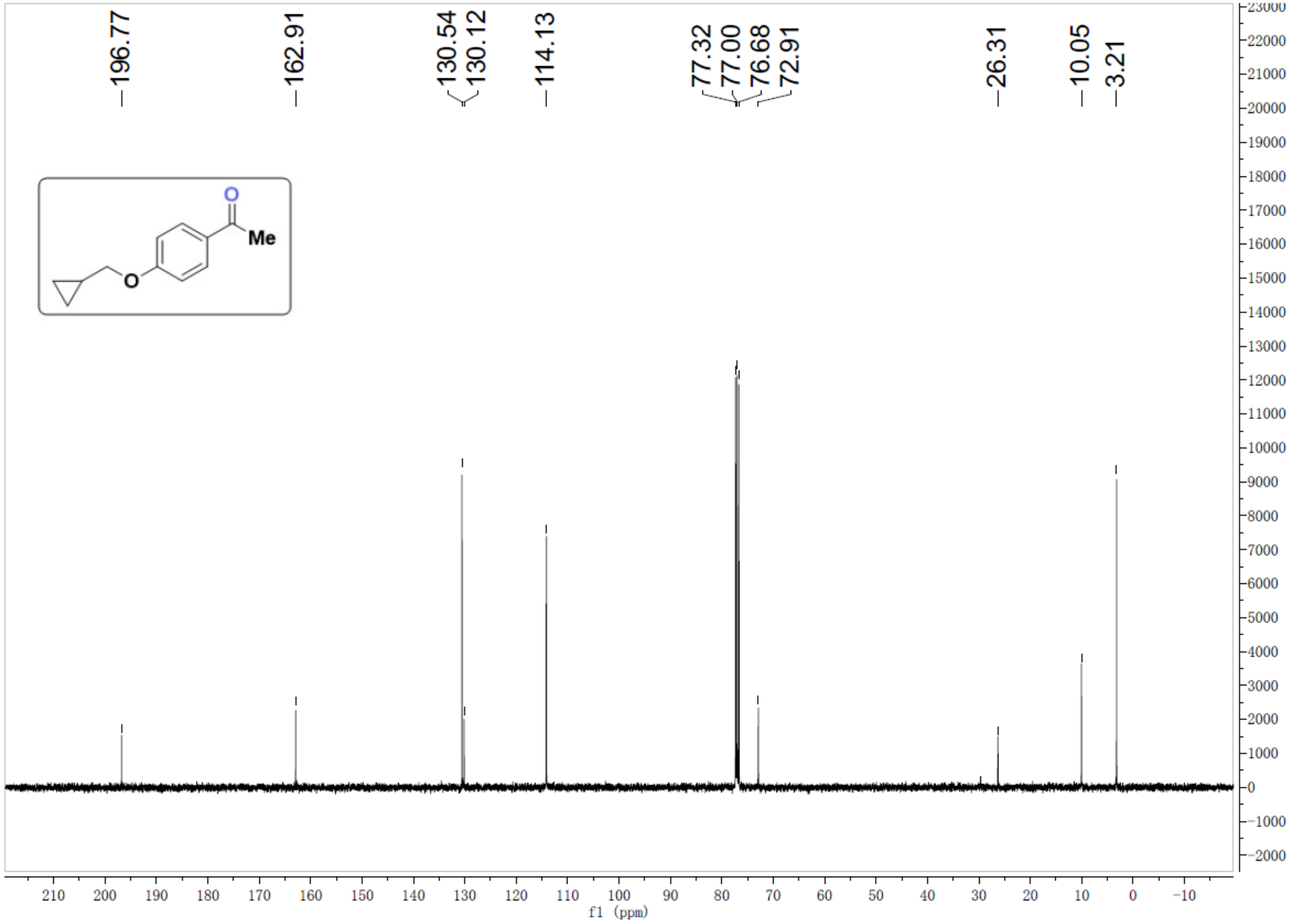
198.10
137.10
133.06
128.53
128.26
77.32
77.00
76.68
26.58
Me
O
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000

^{1}H NMR of 5j



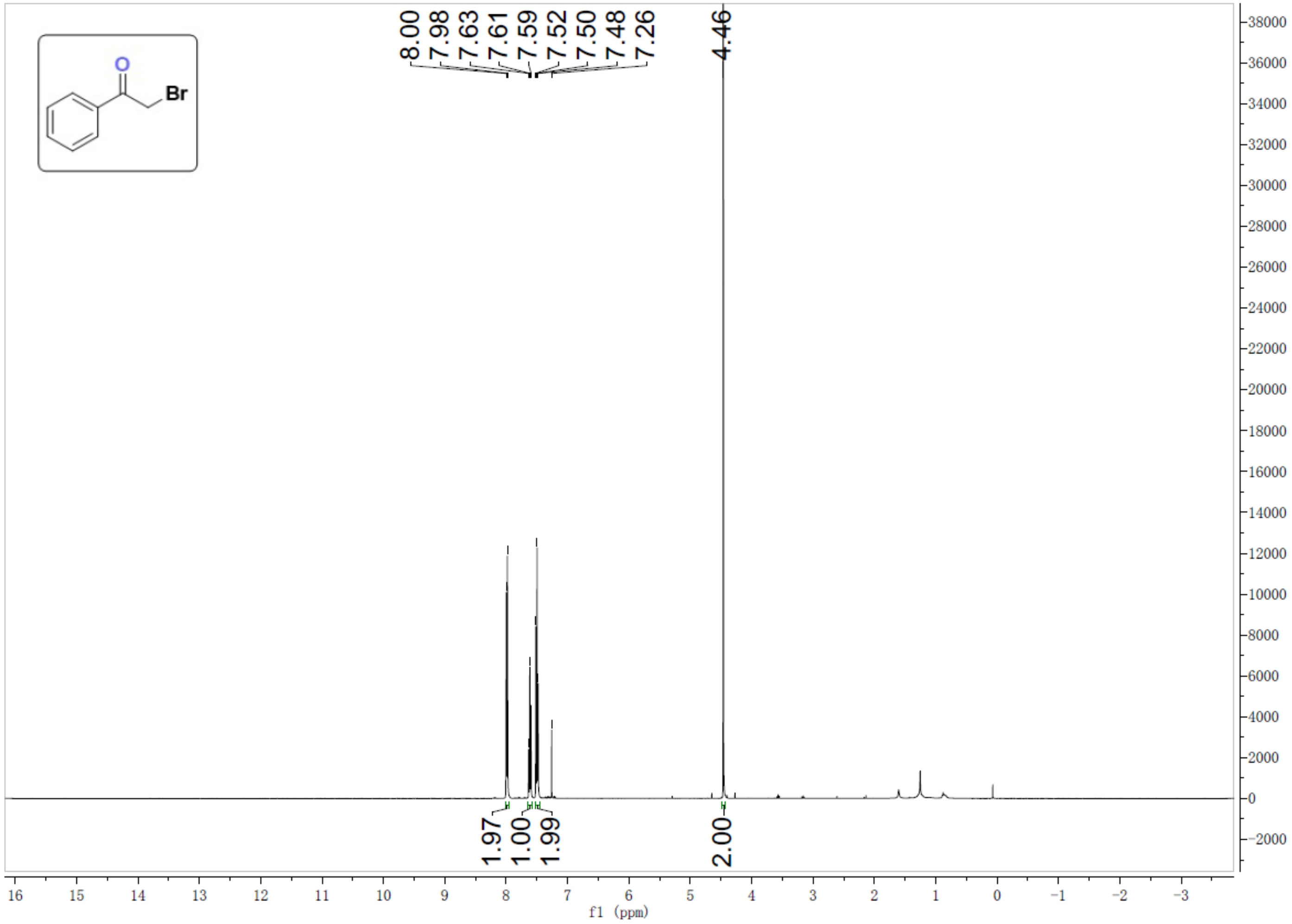
O
Me
O
7.93
7.90
7.26
6.93
6.90
3.87
3.85
2.54
1.28
1.27
1.26
0.69
0.67
0.65
0.65
0.64
0.38
0.37
0.36
0.34
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
2.00
2.00
2.03
2.99
1.03
2.04
2.02
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 5j



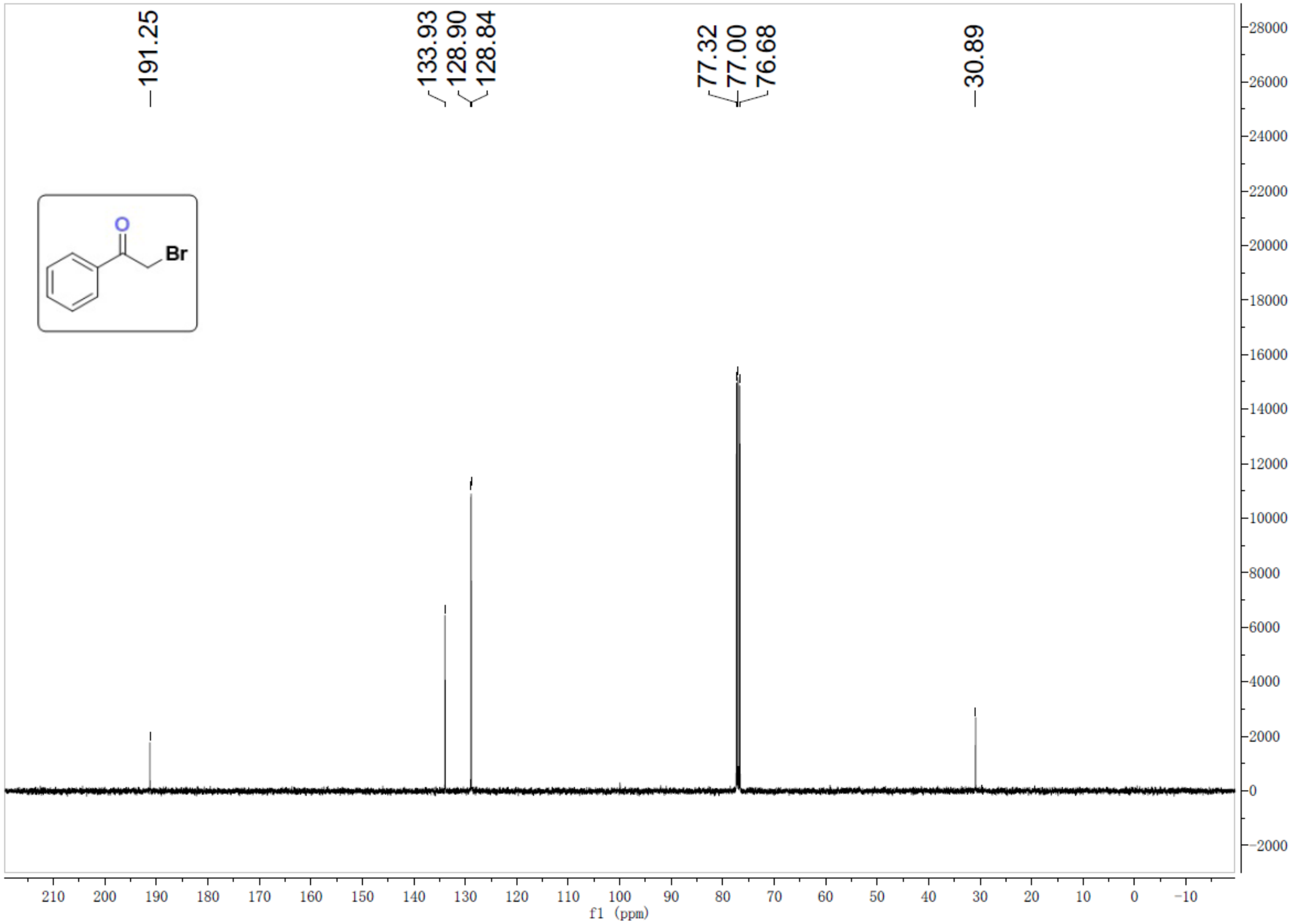
196.77
162.91
130.54
130.12
114.13
77.32
77.00
76.68
72.91
26.31
10.05
3.21
O
Me
O
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)
23000 22000 21000 20000 19000 18000 17000 16000 15000 14000 13000 12000 11000 10000 9000 8000 7000 6000 5000 4000 3000 2000 1000 0 -1000 -2000

^{1}H NMR of 5k

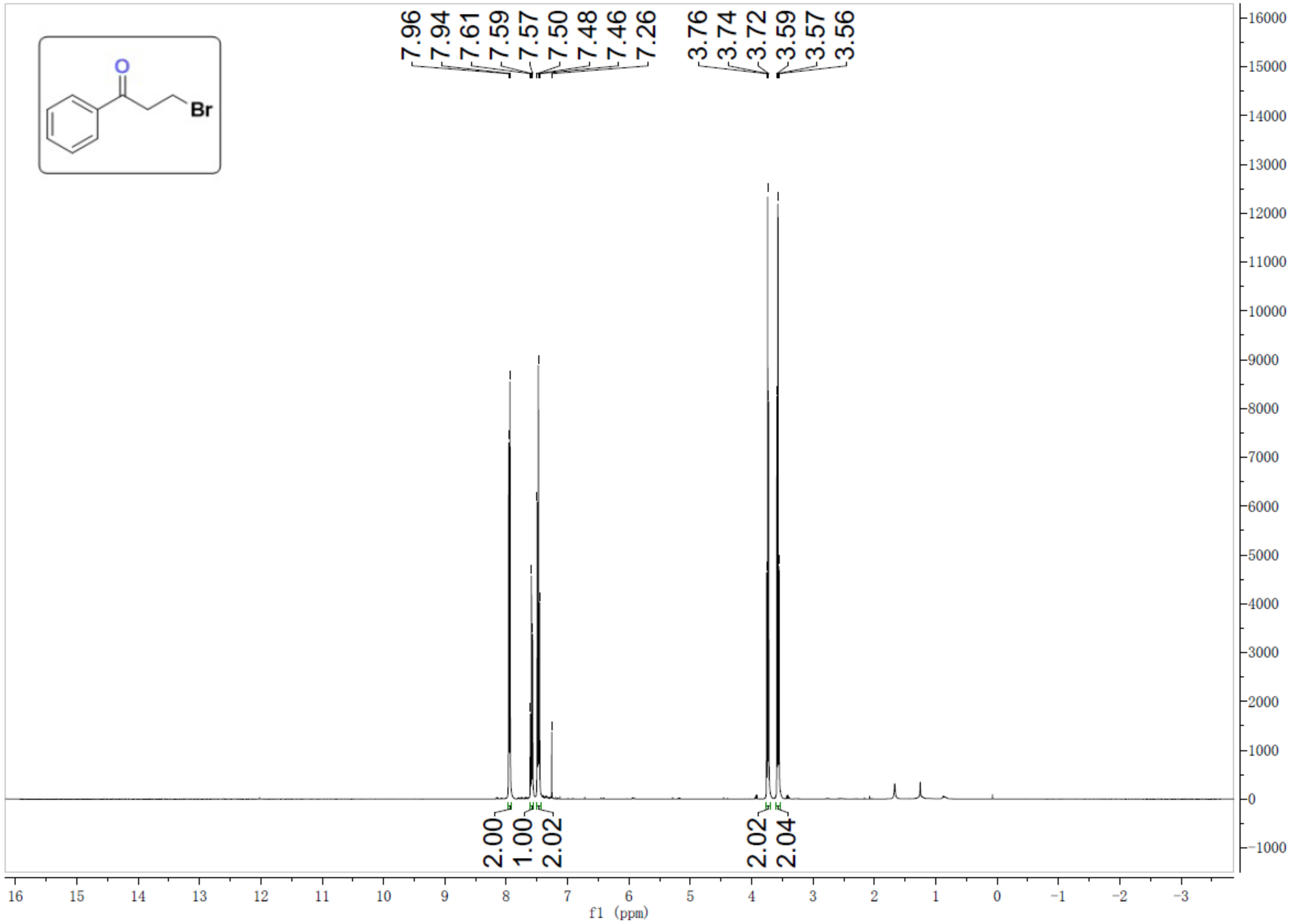


Br
O
8.00
7.98
7.63
7.61
7.59
7.52
7.50
7.48
7.26
4.46
1.97
1.00
1.99
2.00
38000
36000
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 5k

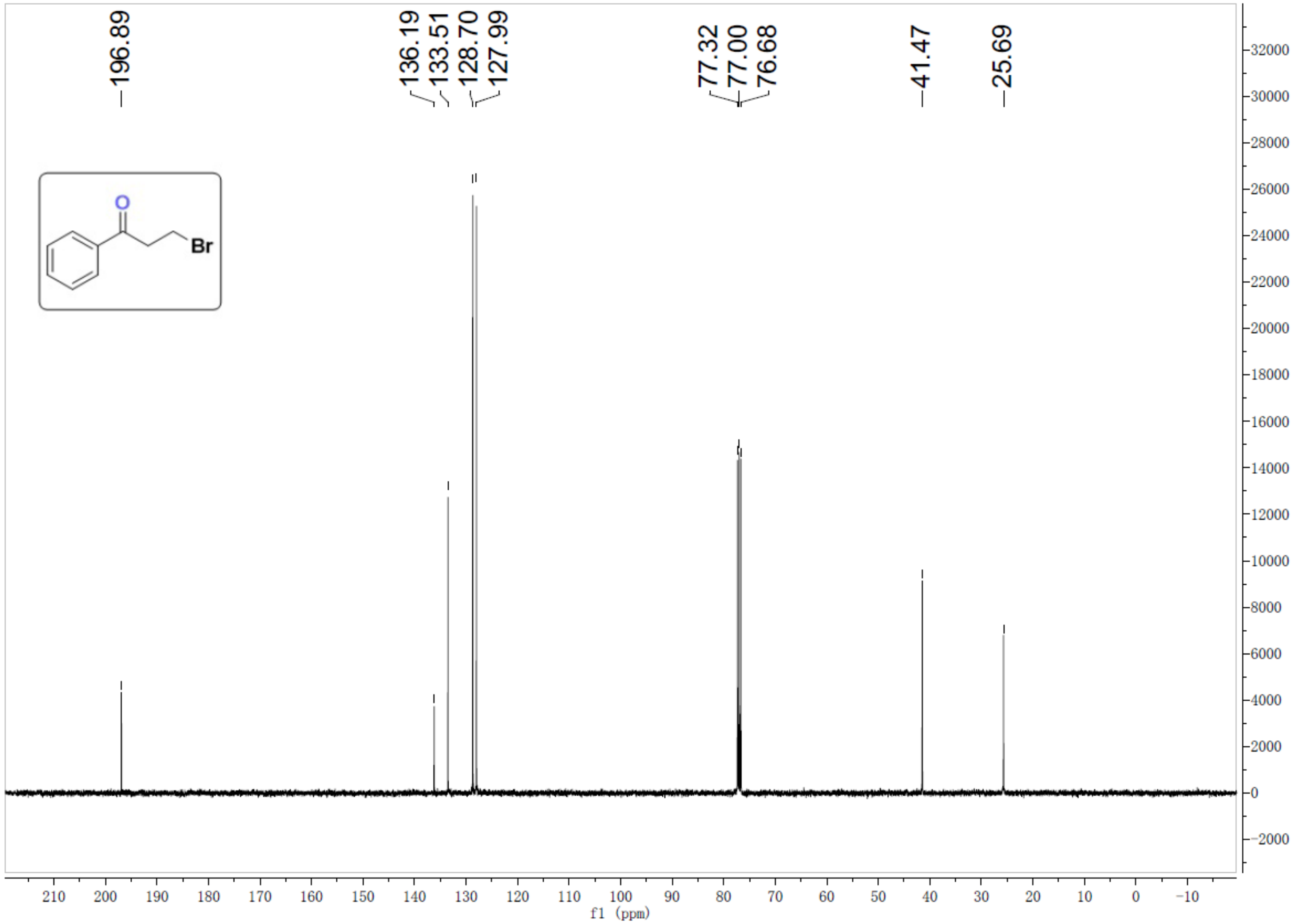

191.25
133.93
128.90
128.84
77.32
77.00
76.68
30.89
O
Br
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 5l

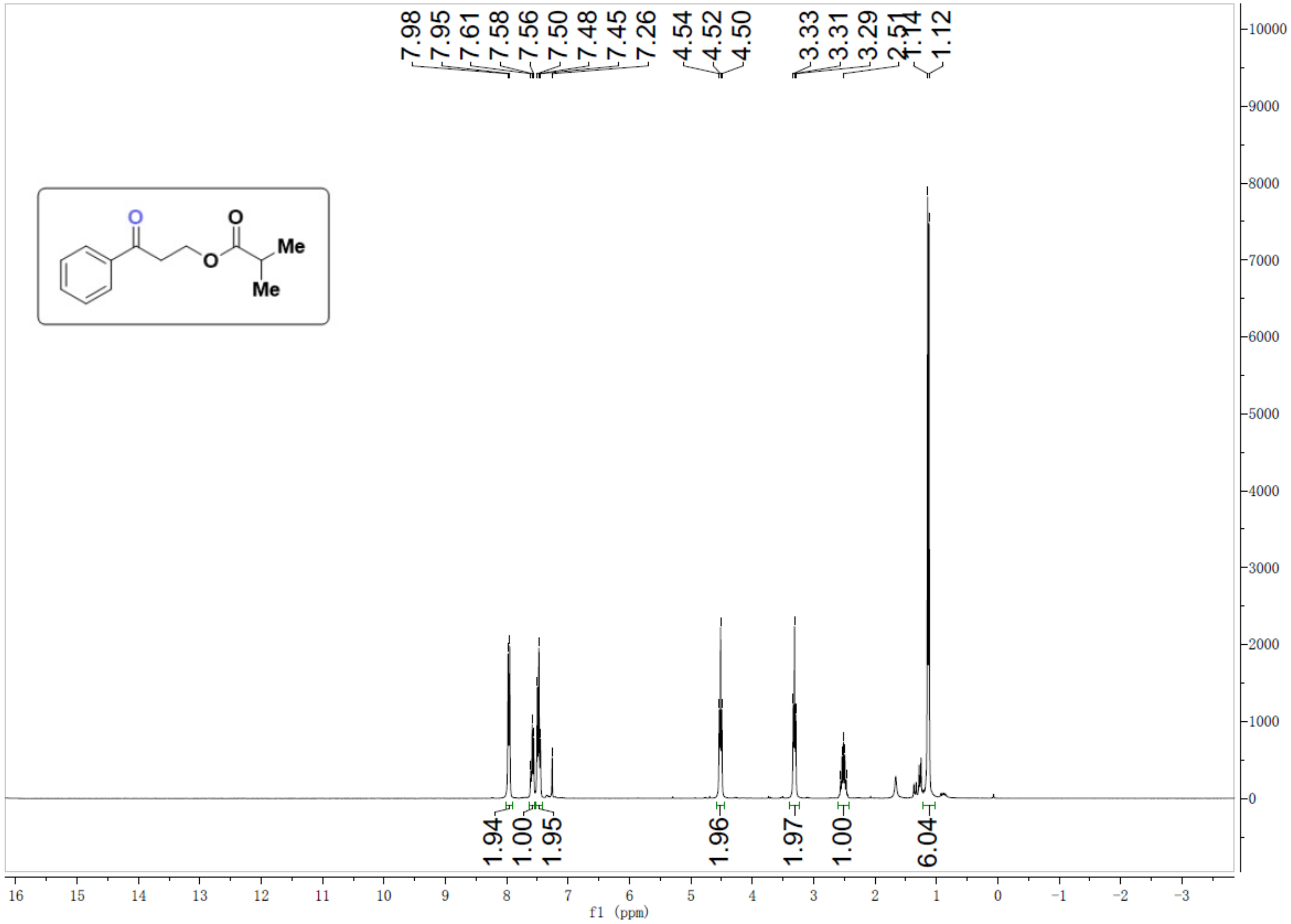


O
Br
7.96
7.94
7.61
7.59
7.57
7.50
7.48
7.46
7.26
3.76
3.74
3.72
3.59
3.57
3.56
2.00
1.00
2.02
2.02
2.04
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

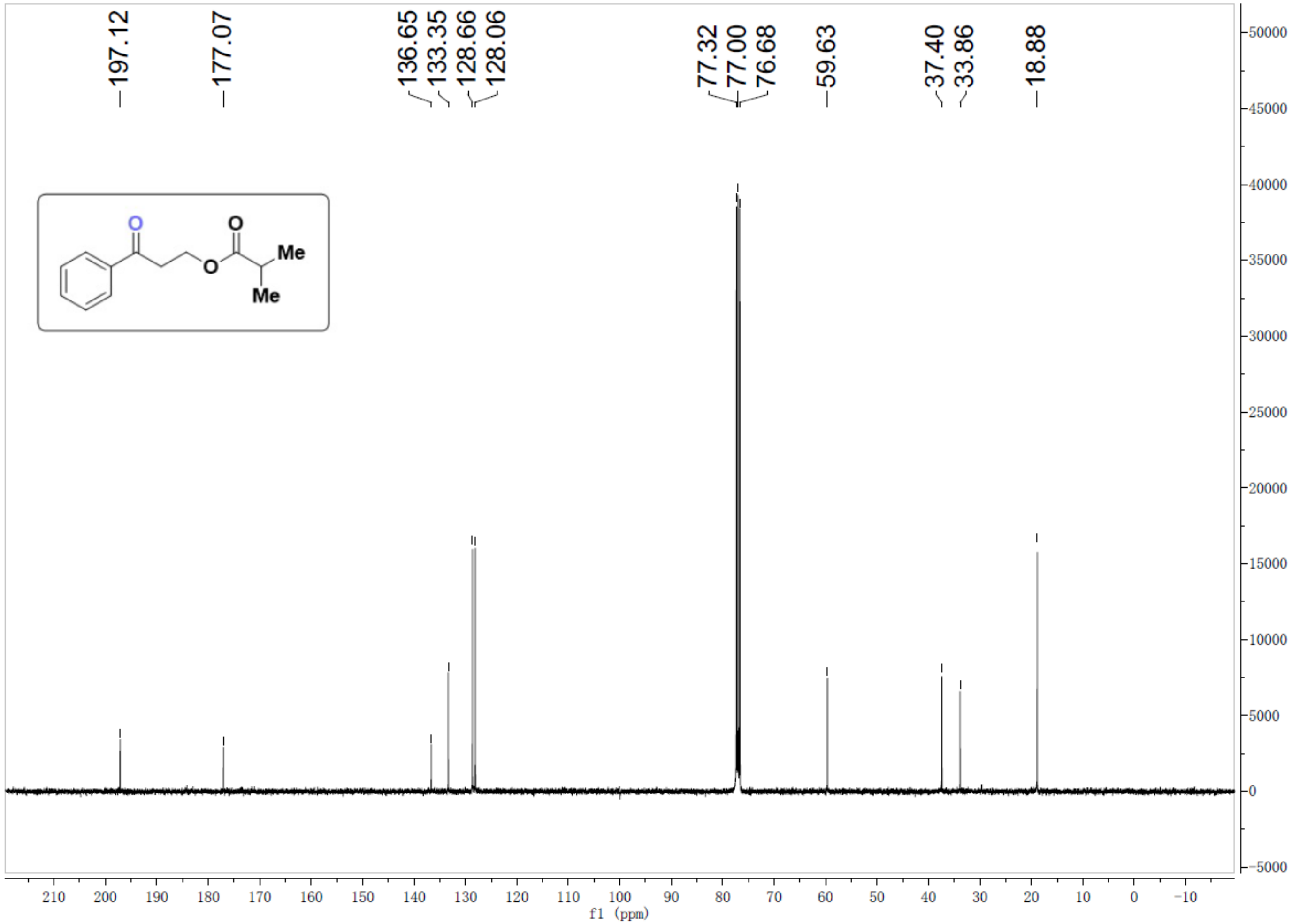
^{13}C NMR of 5l


196.89
136.19
133.51
128.70
127.99
77.32
77.00
76.68
41.47
25.69
O
Br
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
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)

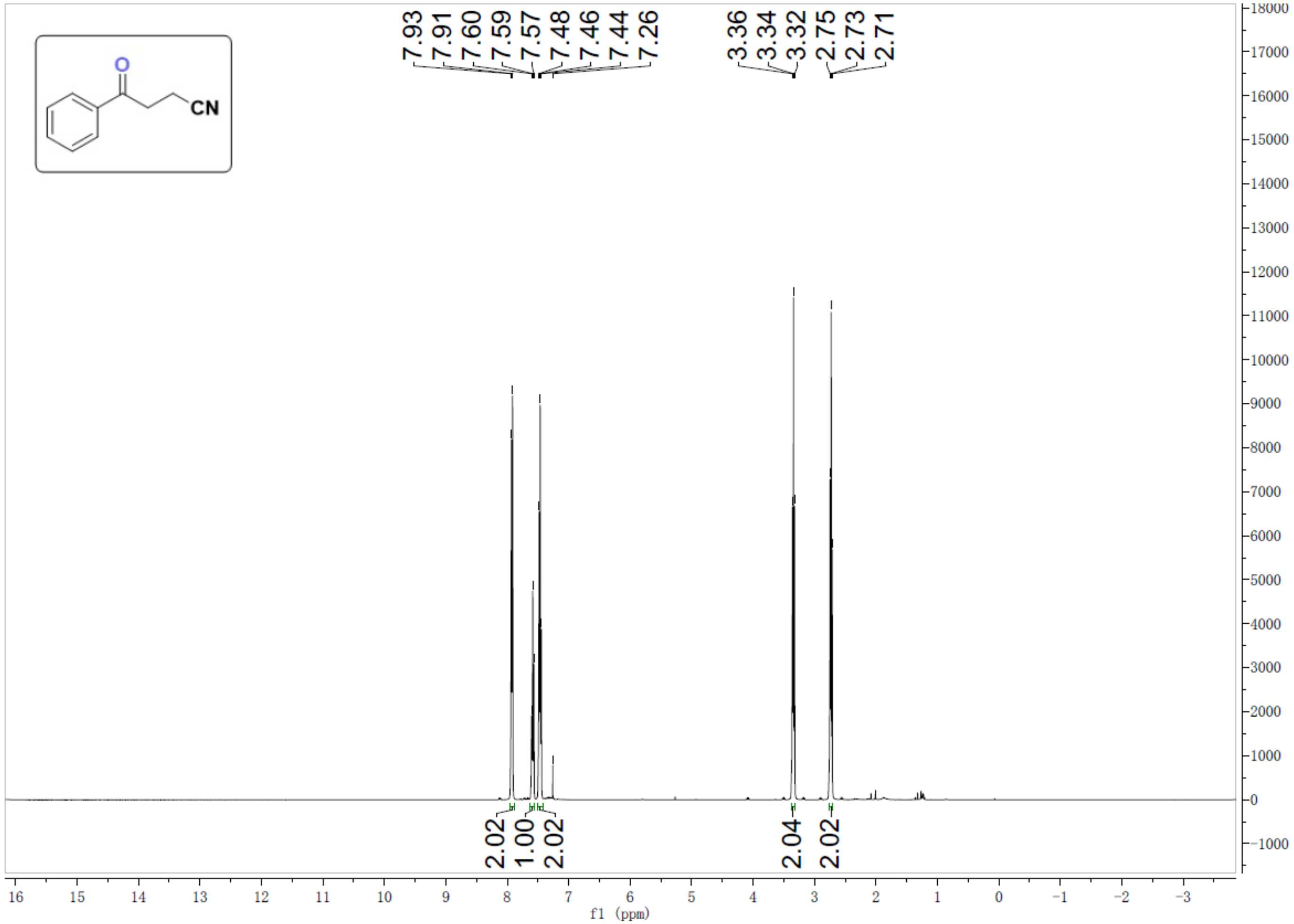
^{1}H NMR of 5m


7.98
7.95
7.61
7.58
7.56
7.50
7.48
7.45
7.26
4.54
4.52
4.50
3.33
3.31
3.29
2.51
1.14
1.12
O
O
O
Me
Me
1.94
1.00
1.95
1.96
1.97
1.00
6.04
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−2
−3
f1 (ppm)

^{13}C NMR of 5m

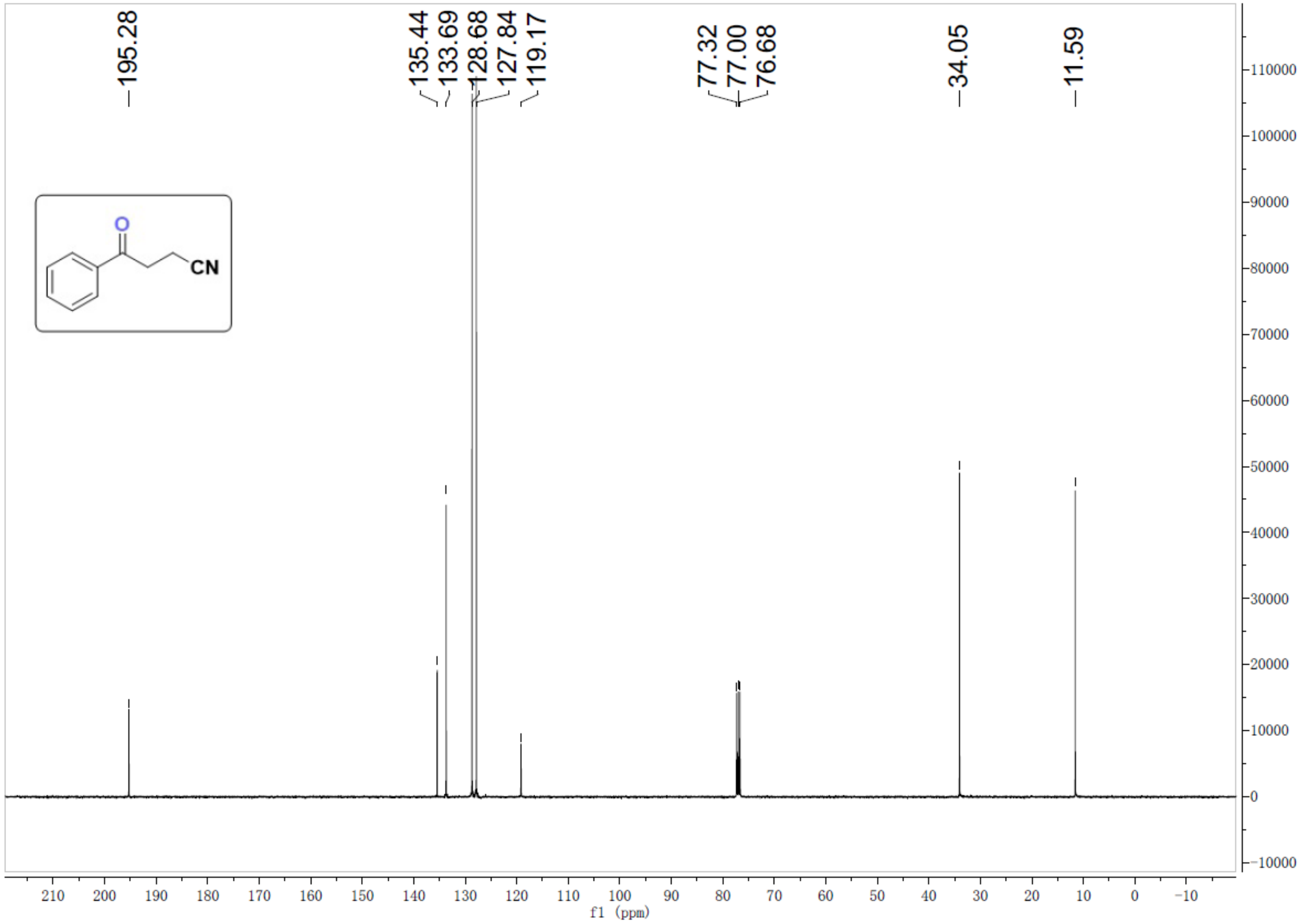

197.12
177.07
136.65
133.35
128.66
128.06
77.32
77.00
76.68
59.63
37.40
33.86
18.88
O
O
O
Me
Me
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 5n

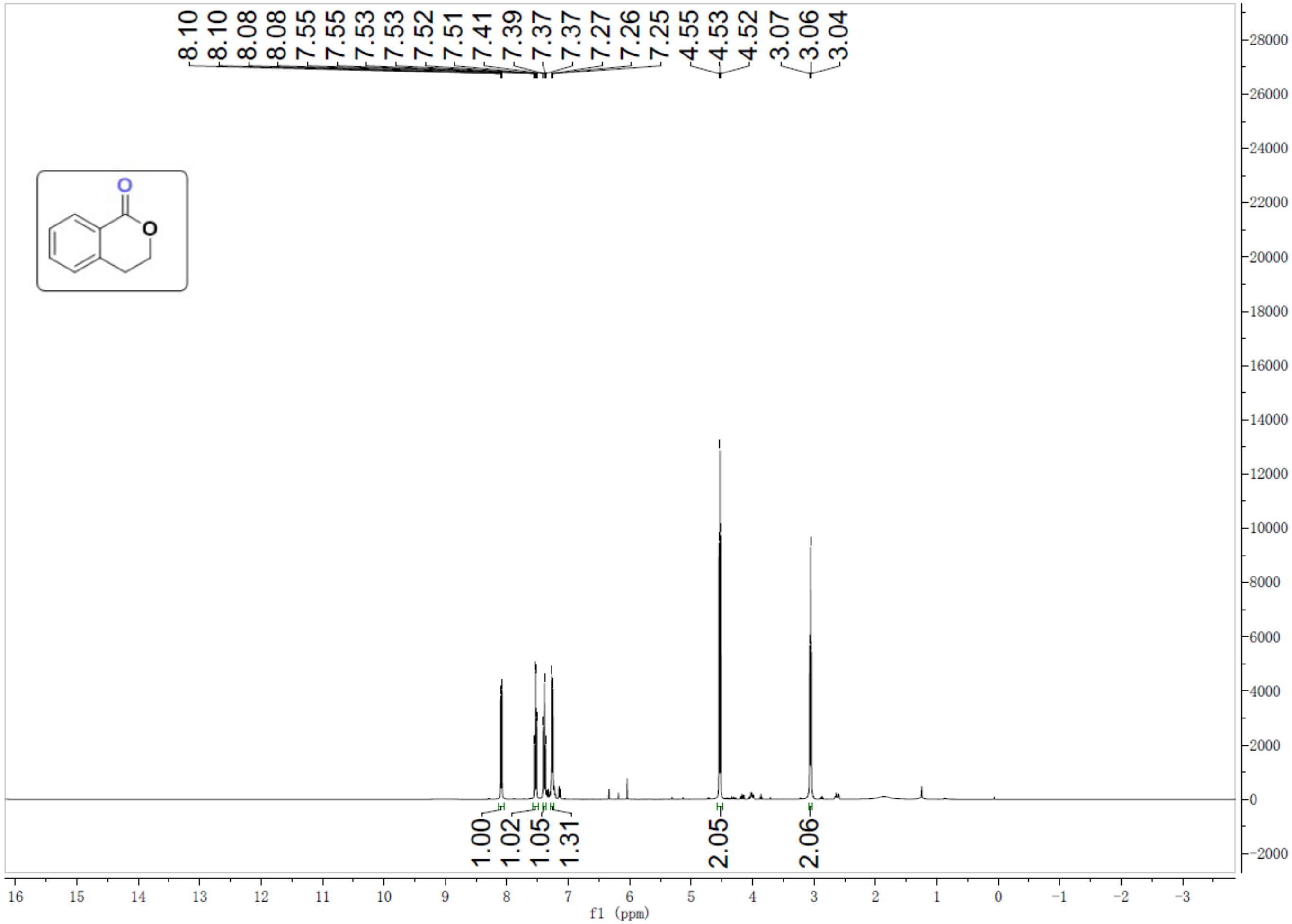


CN
O
7.93
7.91
7.60
7.59
7.57
7.48
7.46
7.44
7.26
3.36
3.34
3.32
2.75
2.73
2.71
2.02
1.00
2.02
2.04
2.02
f1 (ppm)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000

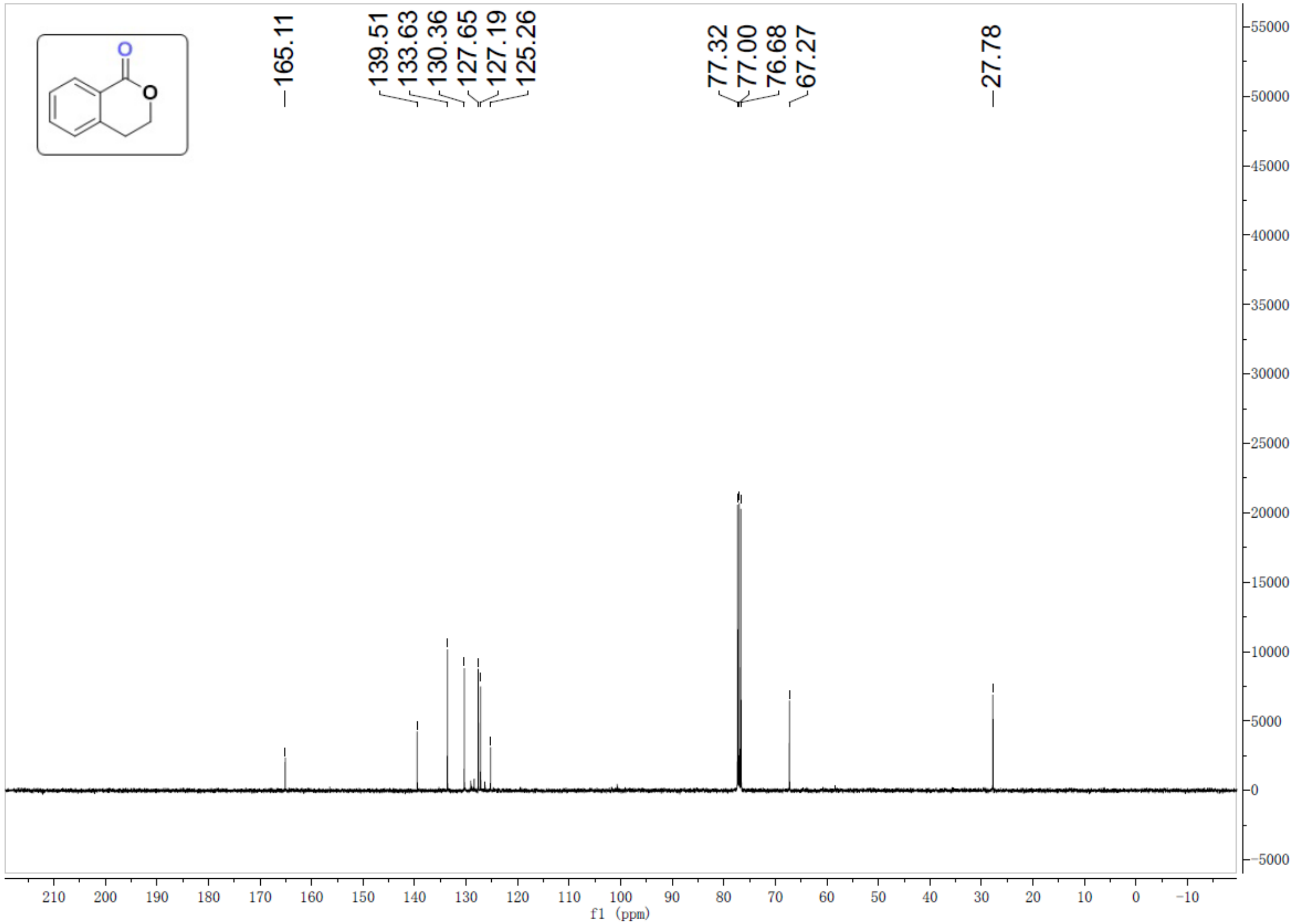
^{13}C NMR of 5n


195.28
135.44
133.69
128.68
127.84
119.17
77.32
77.00
76.68
34.05
11.59
O
CN
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
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)

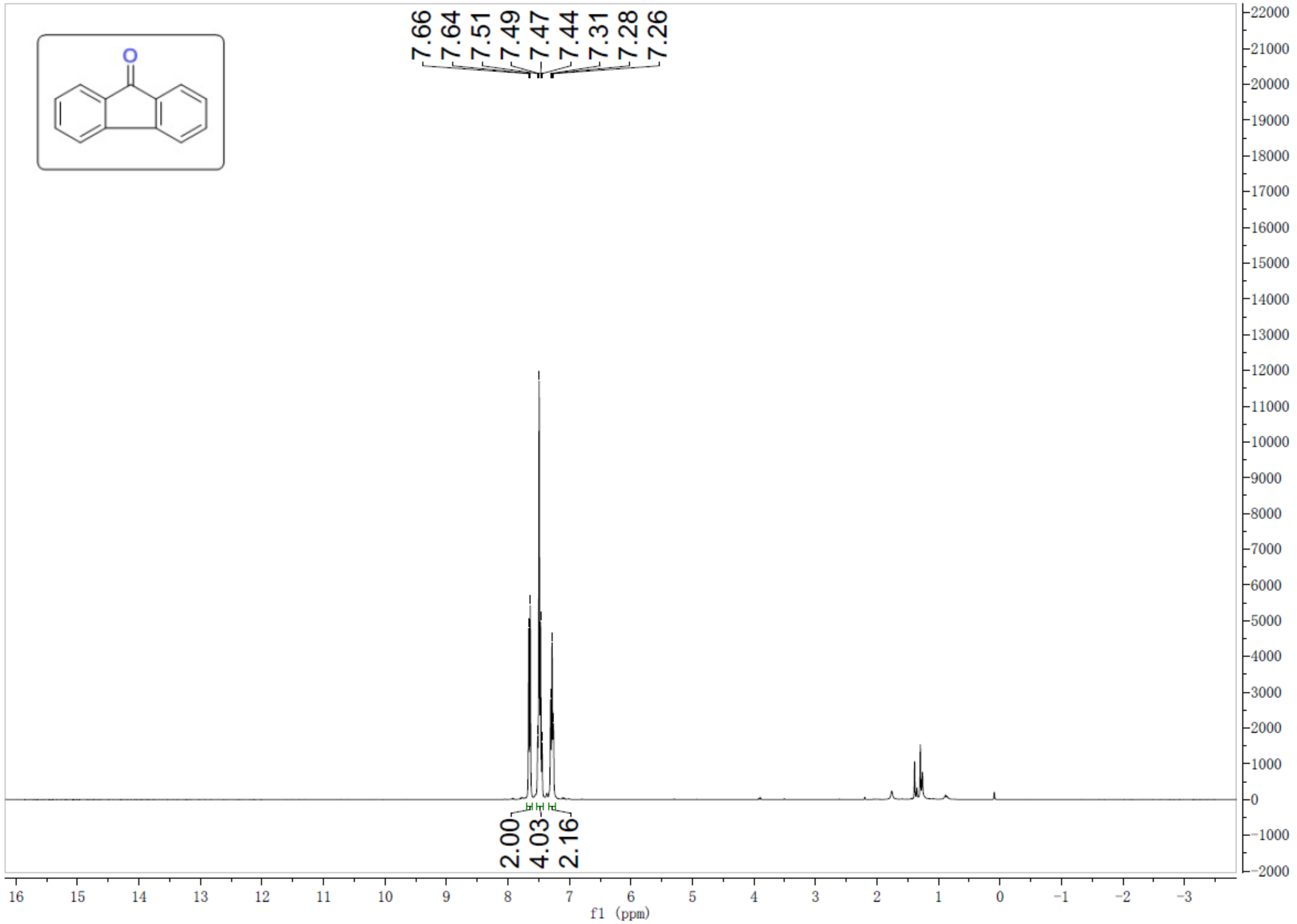
^1H NMR of 5o


8.10
8.10
8.08
8.08
7.55
7.55
7.53
7.53
7.52
7.51
7.41
7.39
7.37
7.37
7.27
7.26
7.25
4.55
4.53
4.52
3.07
3.06
3.04
1.00
1.02
1.05
1.31
2.05
2.06
f1 (ppm)

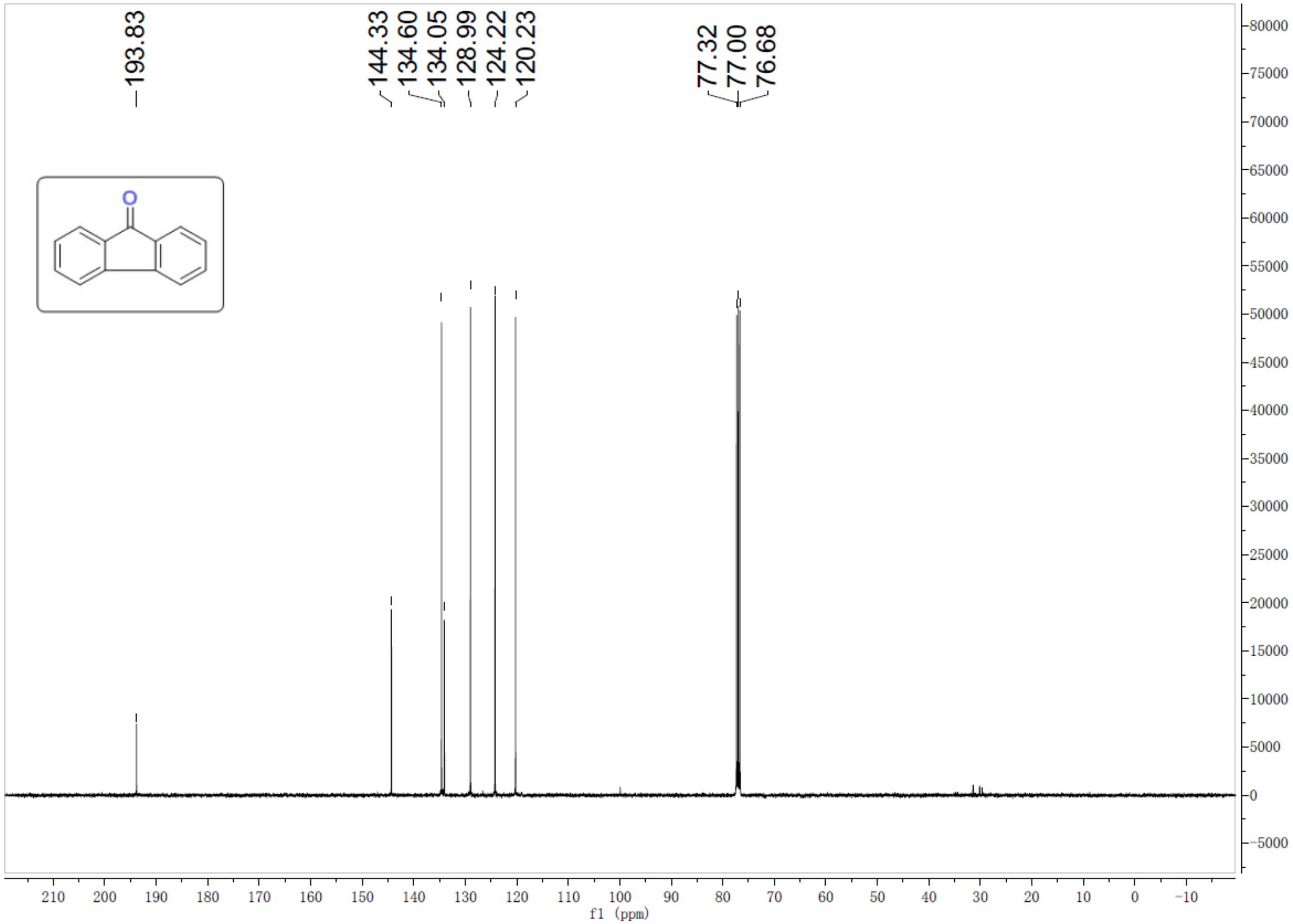
^{13}C NMR of 5o


165.11
139.51
133.63
130.36
127.65
127.19
125.26
77.32
77.00
76.68
67.27
27.78
O
O
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)

^{1}H NMR of 5p

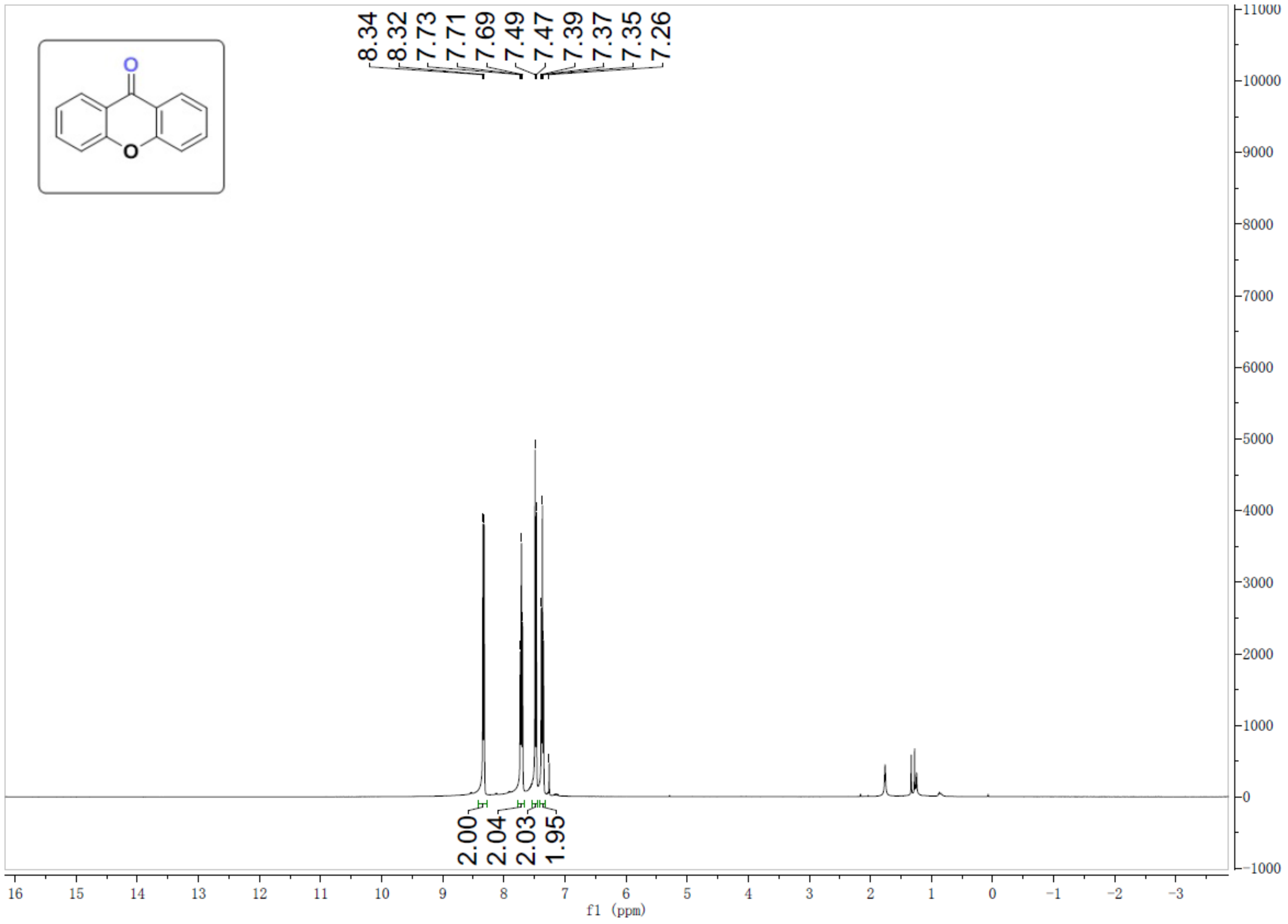

7.66
7.64
7.51
7.49
7.47
7.44
7.31
7.28
7.26
2.00
4.03
2.16
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
O

^{13}C NMR of 5p

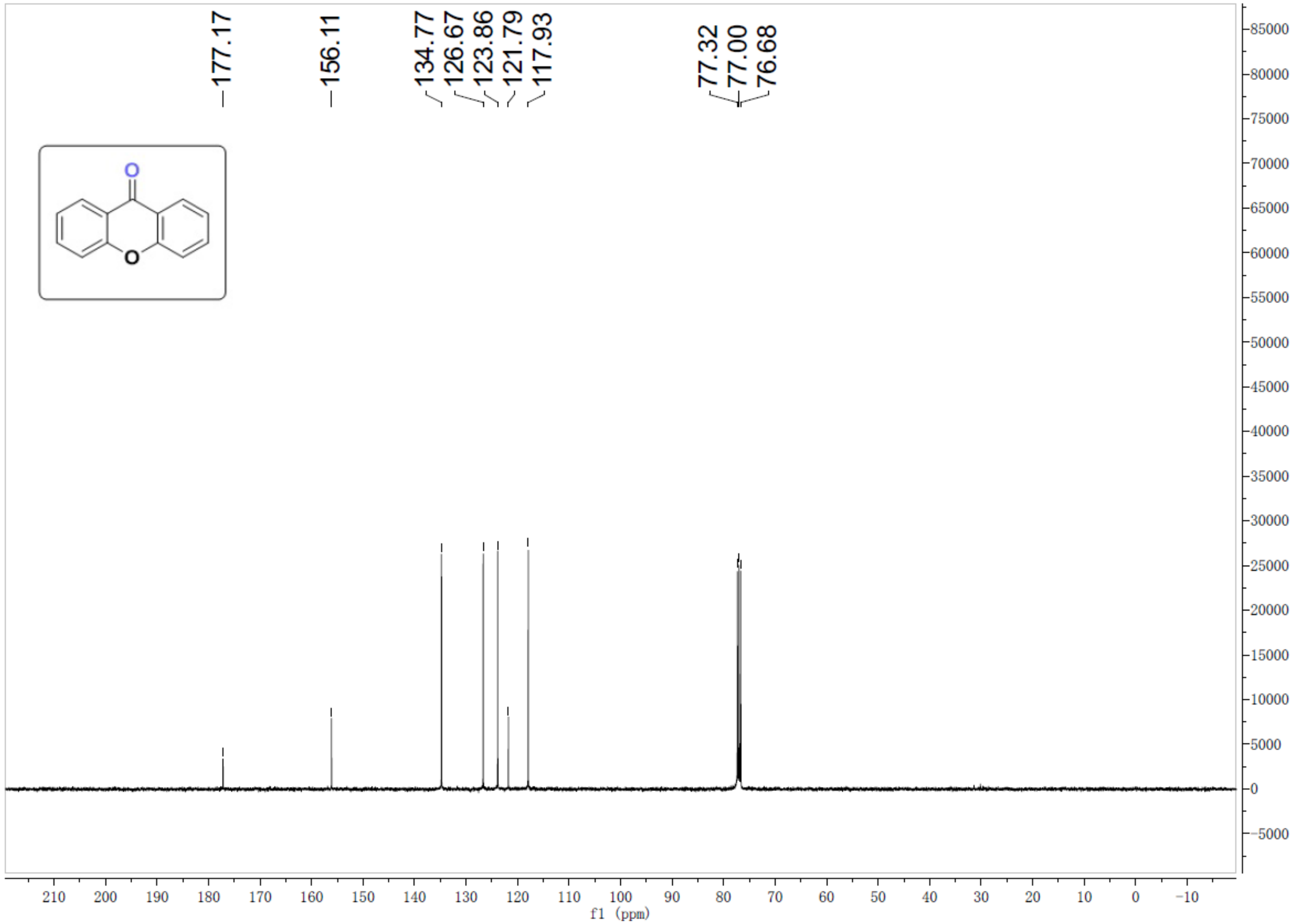


193.83
144.33
134.60
134.05
128.99
124.22
120.23
77.32
77.00
76.68
O
80000
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 5q

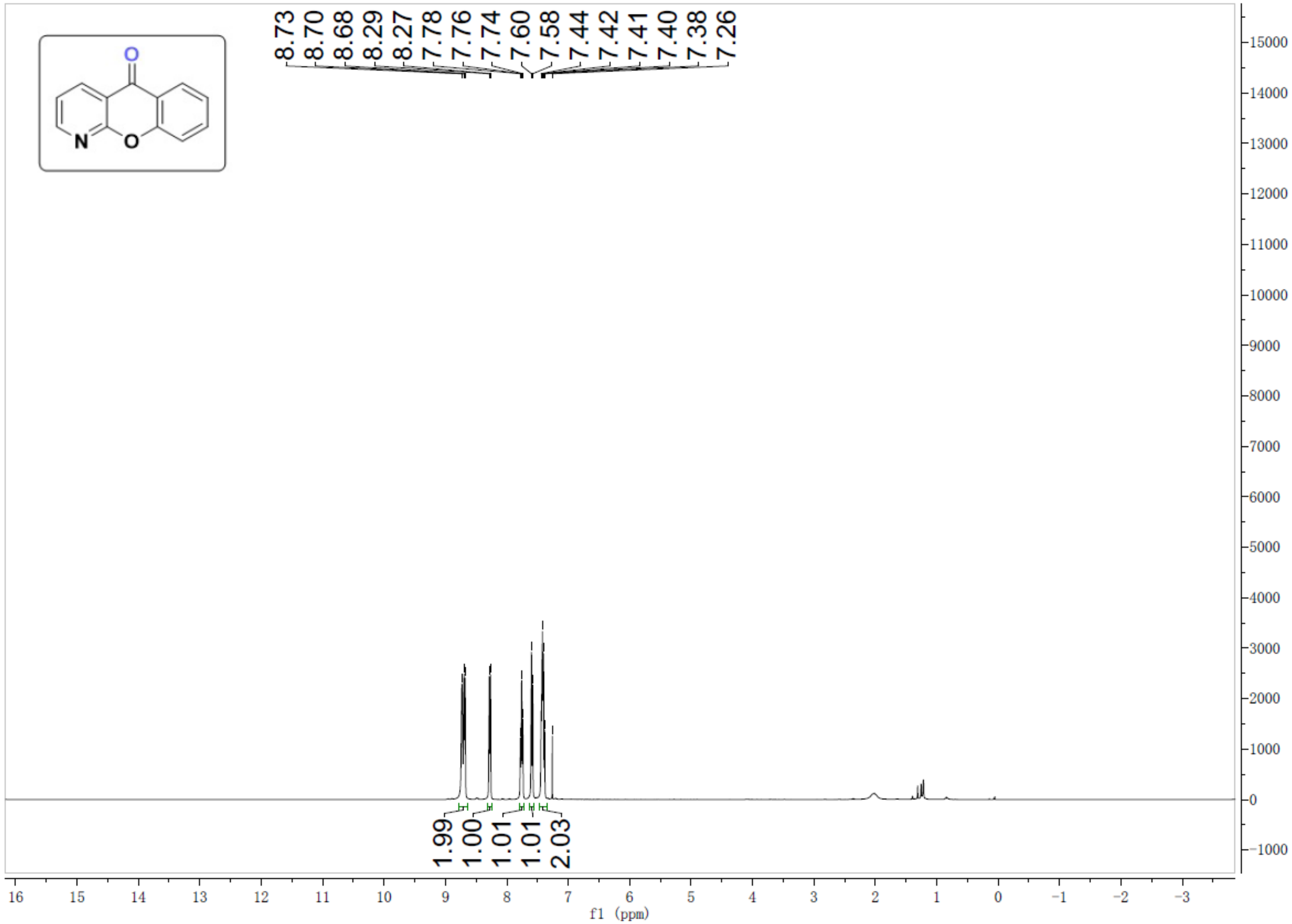

8.34
8.32
7.73
7.71
7.69
7.49
7.47
7.39
7.37
7.35
7.26
2.00
2.04
2.03
1.95
O
O
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−2
−3
f1 (ppm)
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000

^{13}C NMR of 5q

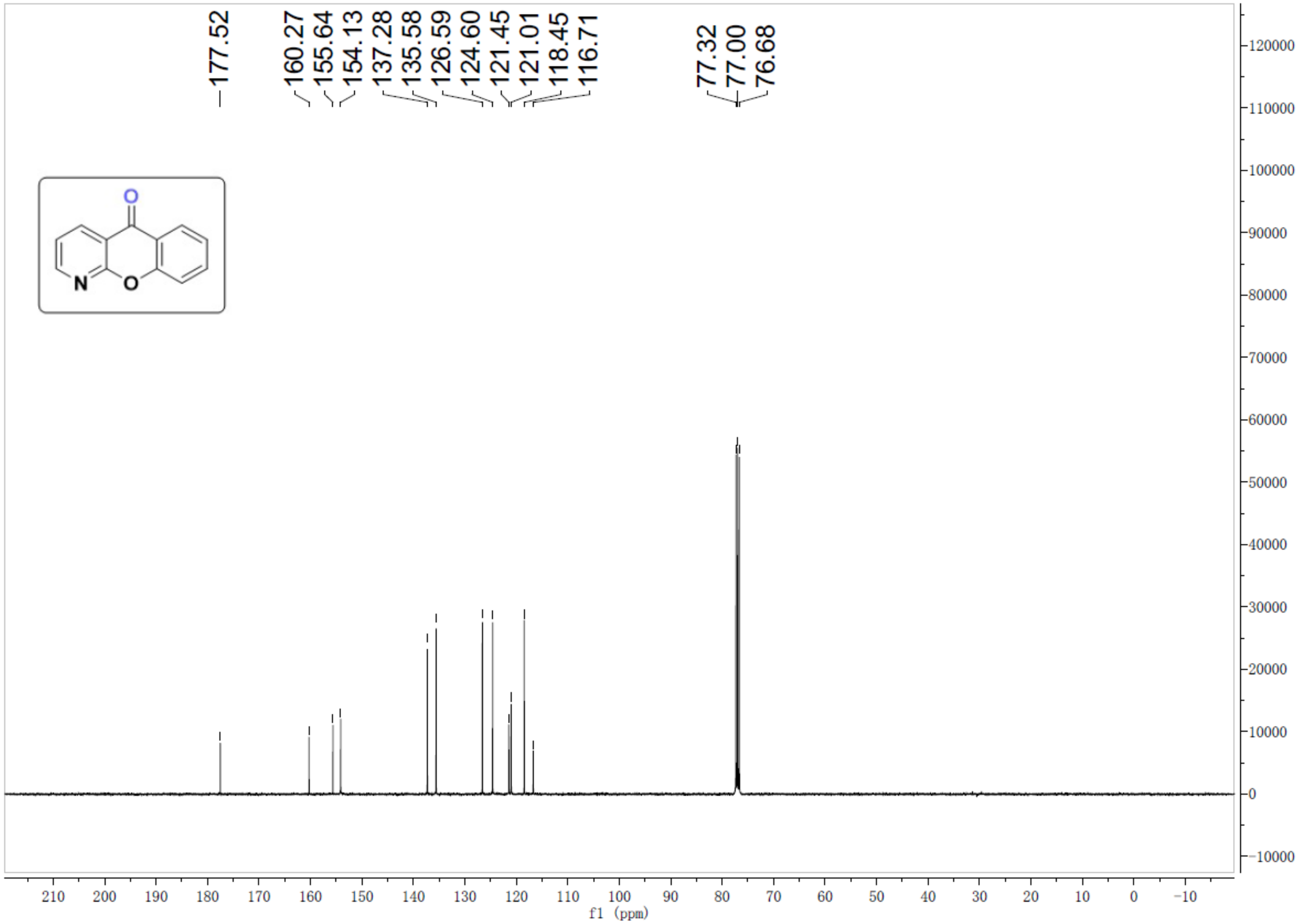


177.17
156.11
134.77
126.67
123.86
121.79
117.93
77.32
77.00
76.68
O
O
85000
80000
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

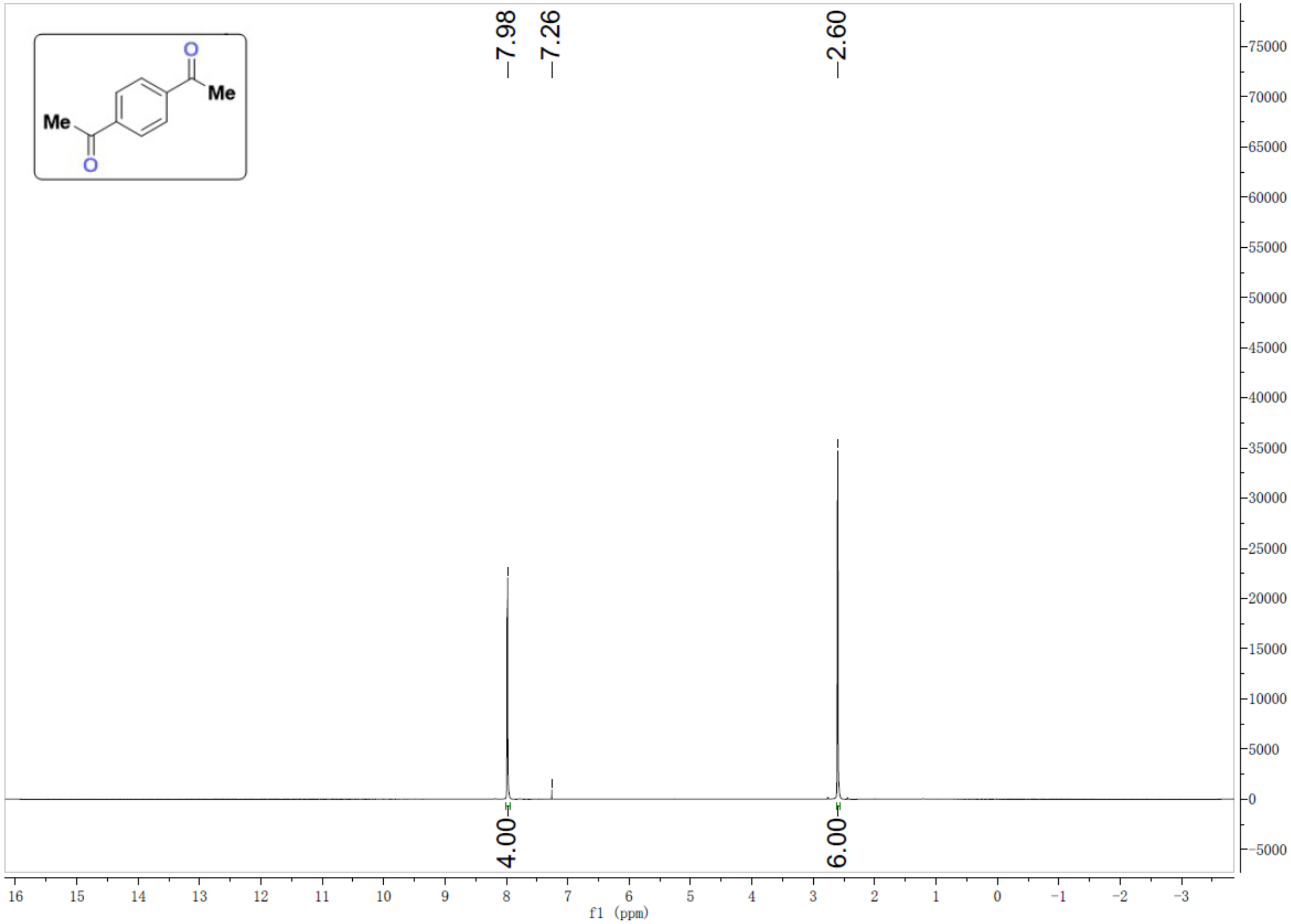
^{1}H NMR of 5r


8.73
8.70
8.68
8.29
8.27
7.78
7.76
7.74
7.60
7.58
7.44
7.42
7.41
7.40
7.38
7.26
N
O
1.99
1.00
1.01
1.01
2.03
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 5r

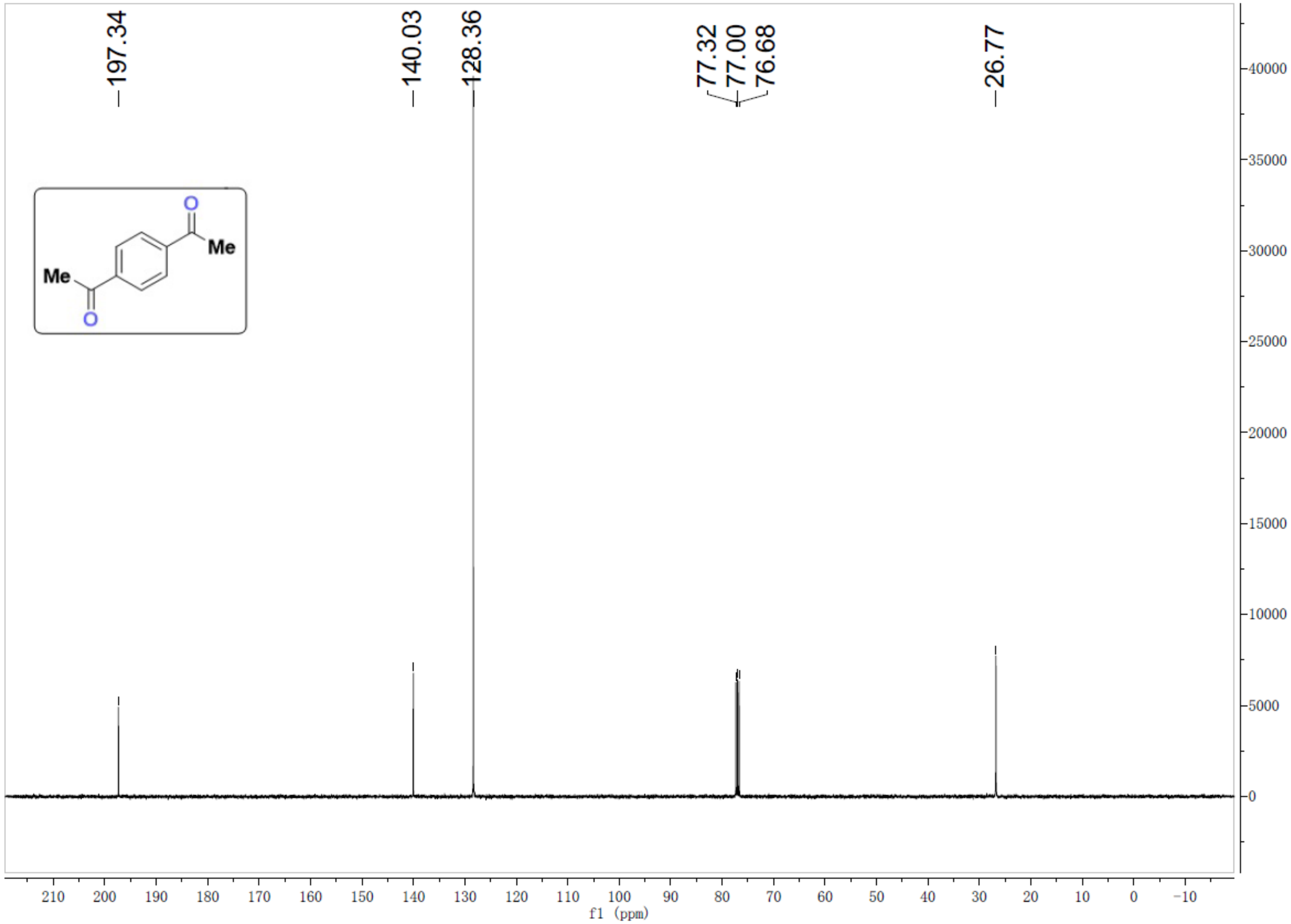

177.52
160.27
155.64
154.13
137.28
135.58
126.59
124.60
121.45
121.01
118.45
116.71
77.32
77.00
76.68
N
O
O
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 5s



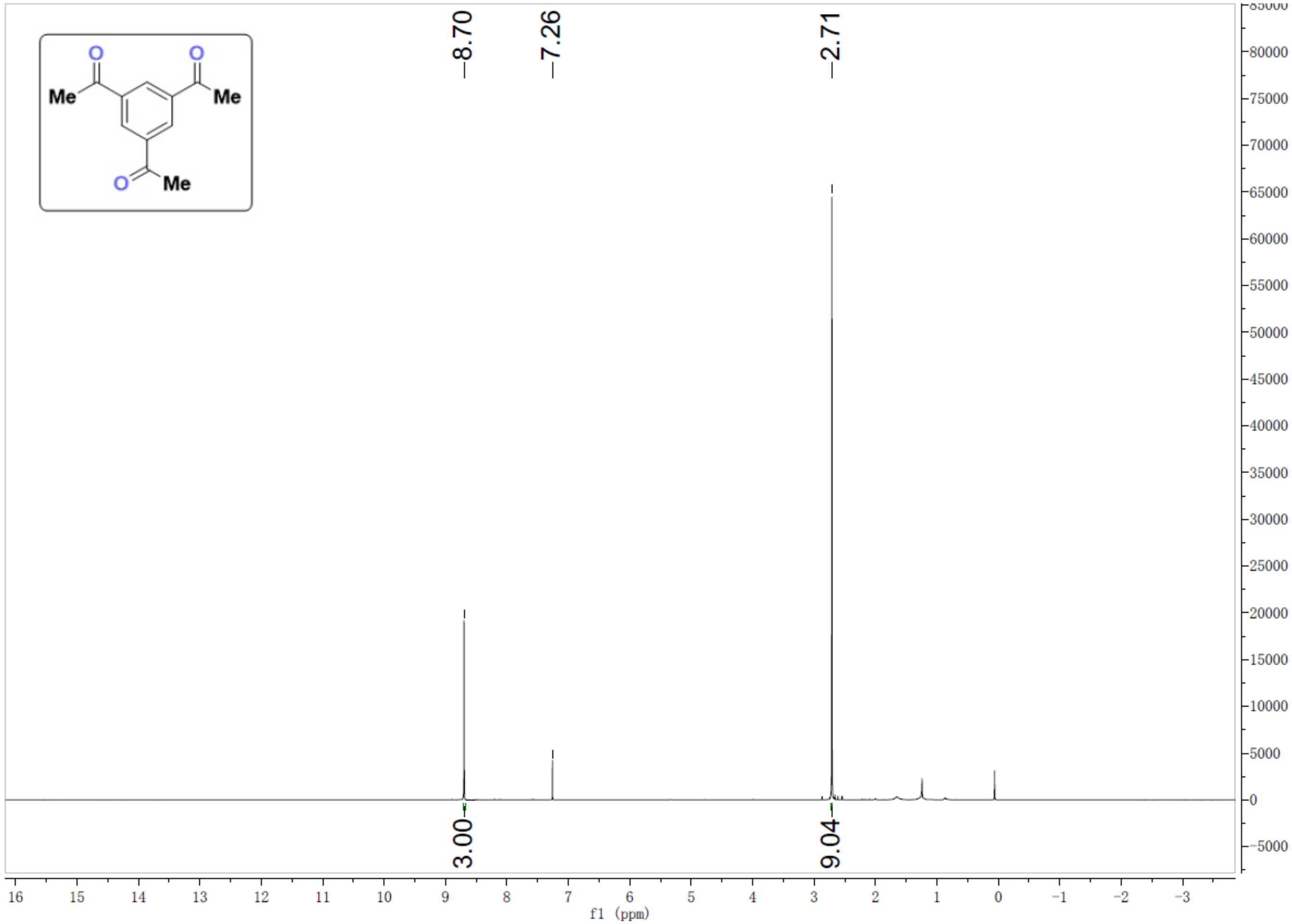
7.98
7.26
2.60
Me
Me
O
O
4.00
6.00
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 5s



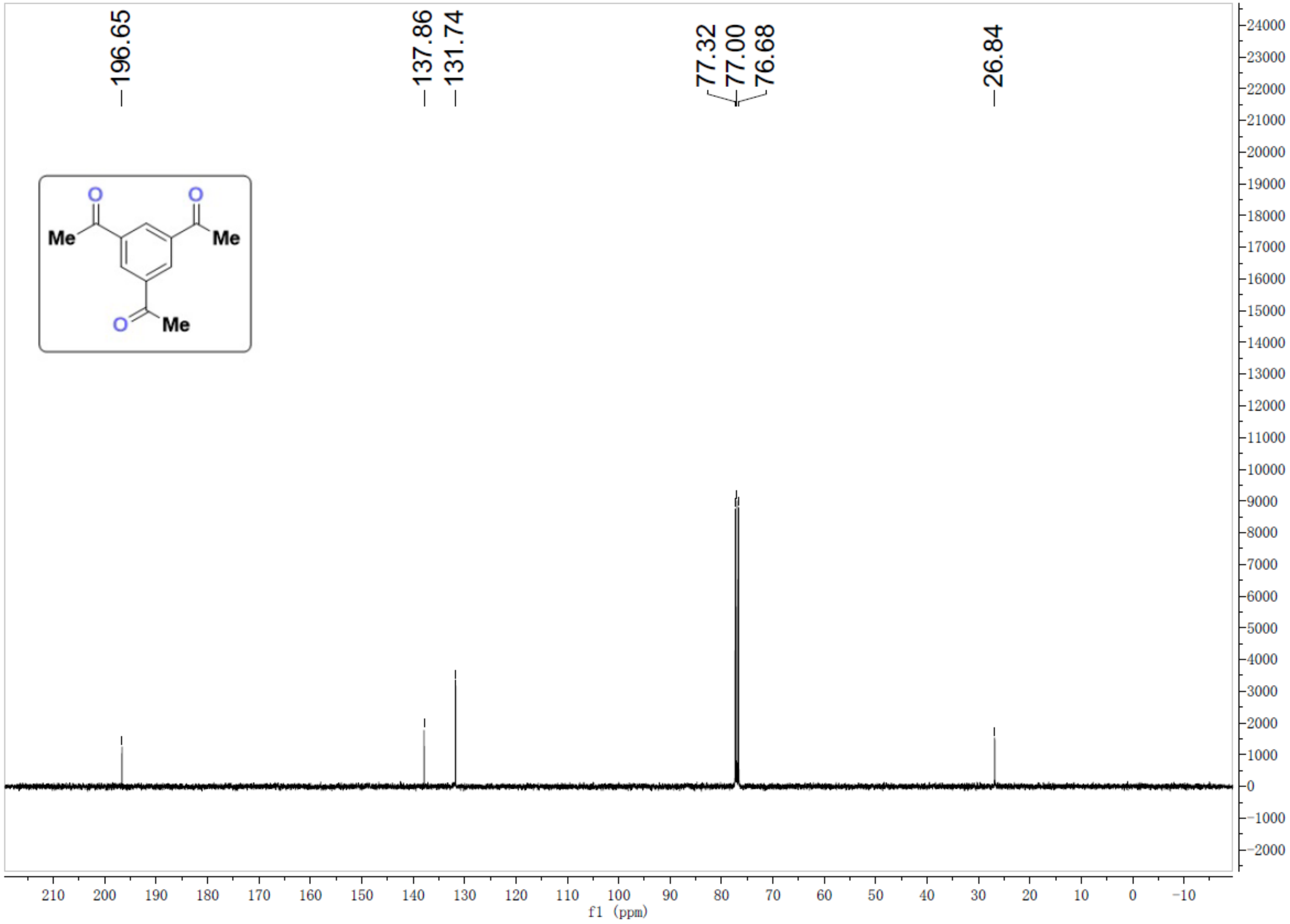
197.34
140.03
128.36
77.32
77.00
76.68
26.77
Me
O
Me
O
40000
35000
30000
25000
20000
15000
10000
5000
0
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

^{1}H NMR of 5t

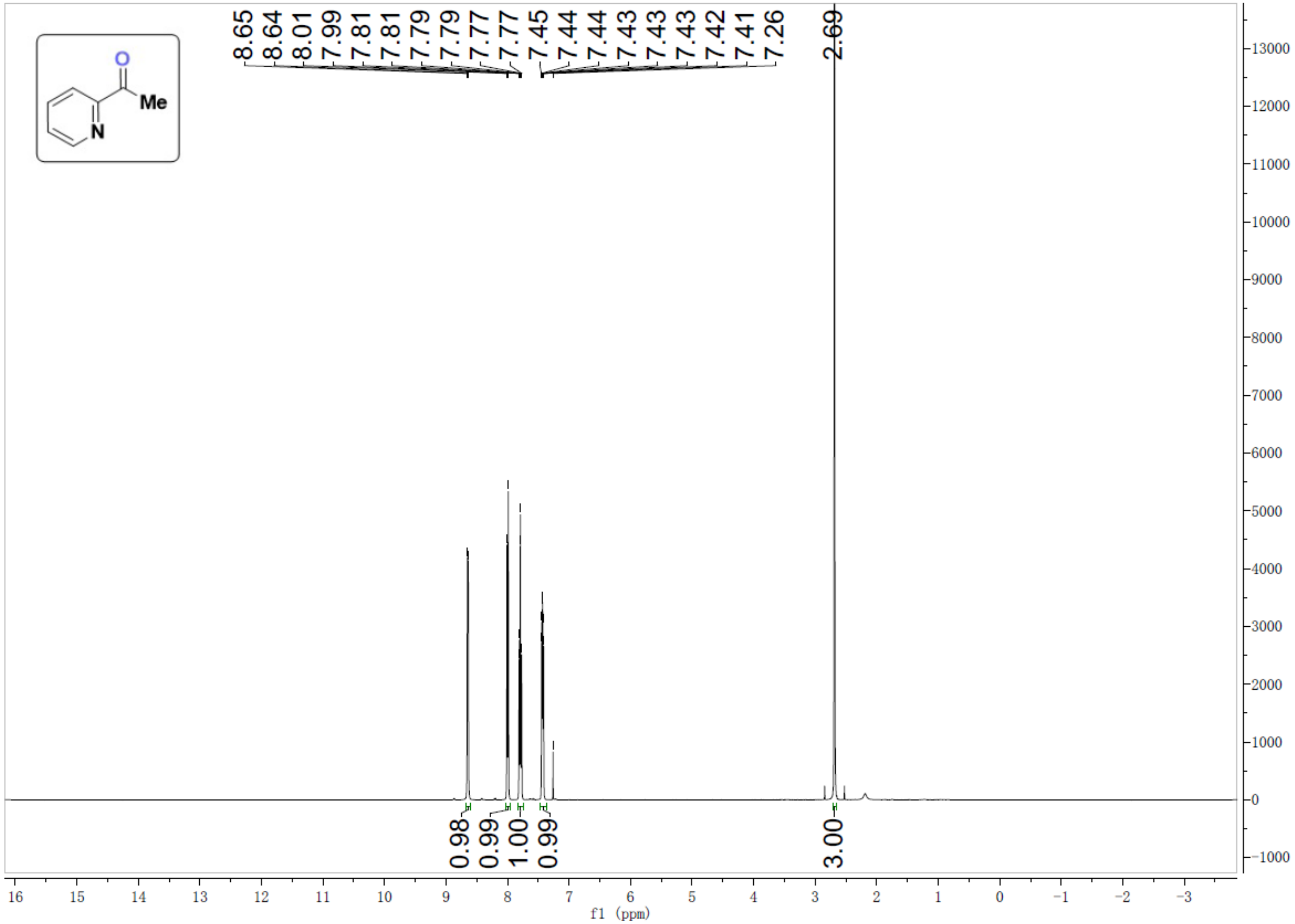


Me
Me
Me
O
O
O
8.70
7.26
2.71
3.00
9.04
85000
80000
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 5t

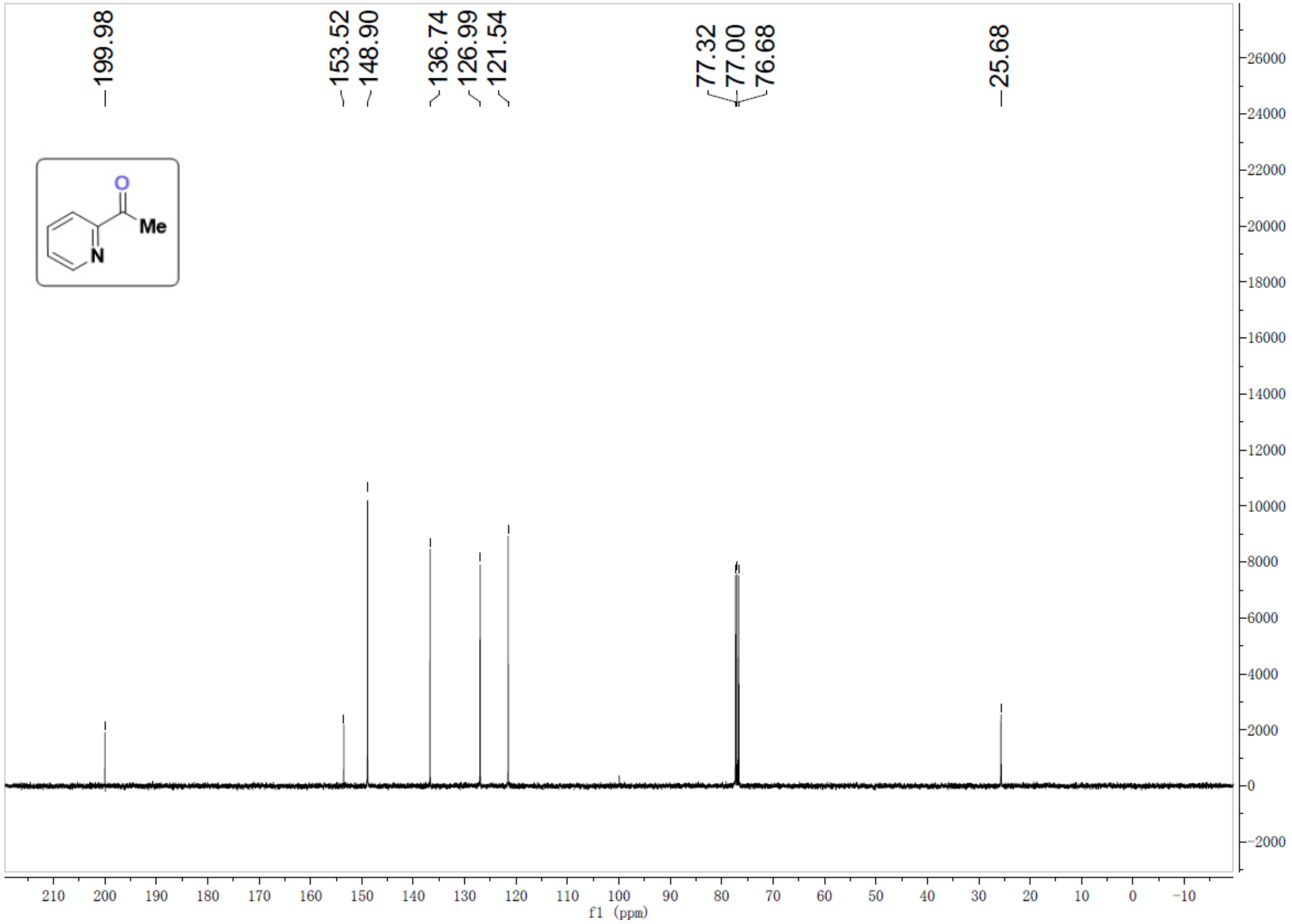

196.65
137.86
131.74
77.32
77.00
76.68
26.84
Me
Me
Me
O
O
O
24000
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
−2000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

^{1}H NMR of 5u

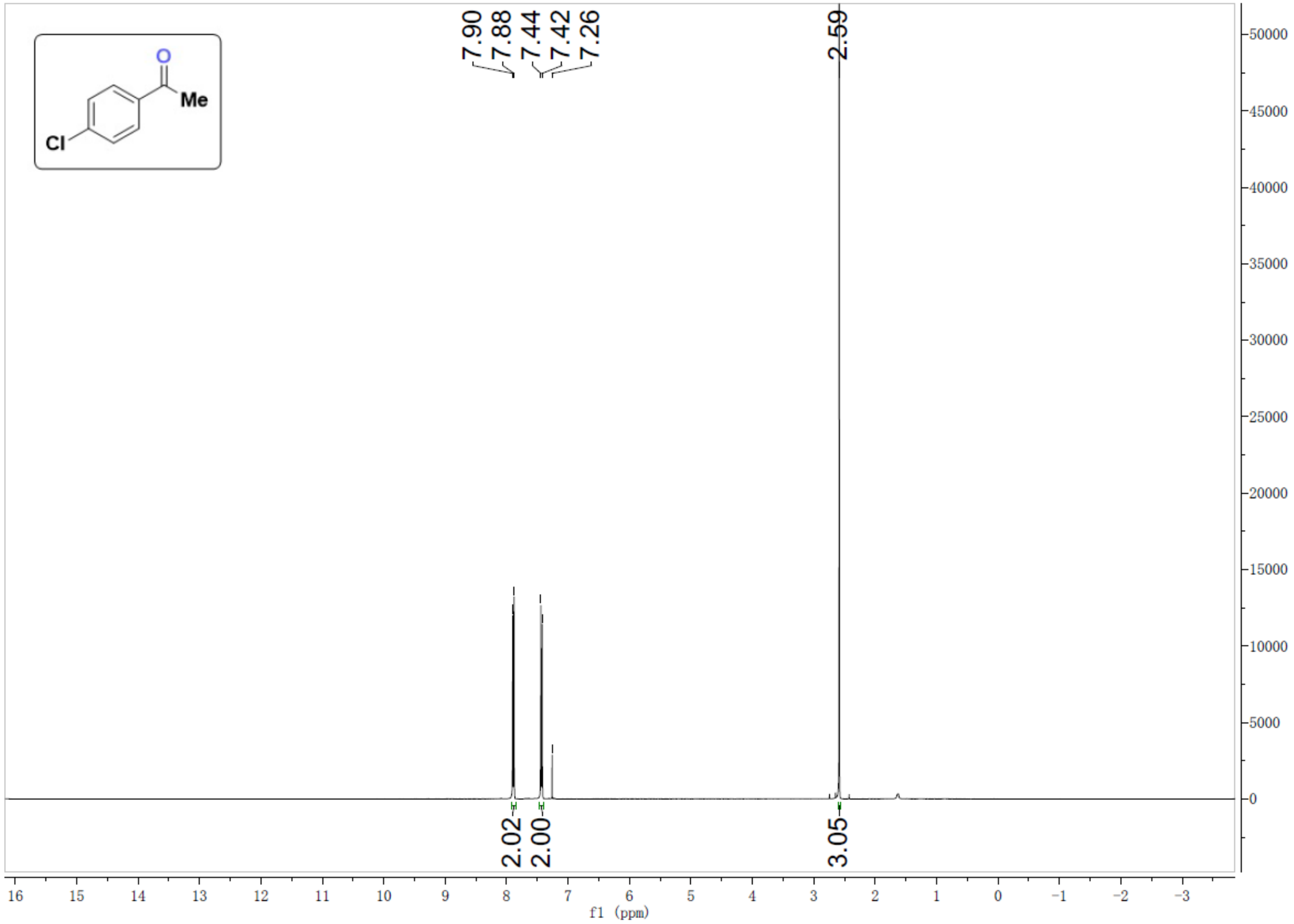


O
Me
N
8.65
8.64
8.01
7.99
7.81
7.81
7.79
7.79
7.77
7.77
7.45
7.44
7.44
7.43
7.43
7.43
7.42
7.41
7.26
2.69
0.98
0.99
1.00
0.99
3.00
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1 -2 -3
f1 (ppm)
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000

^{13}C NMR of 5u

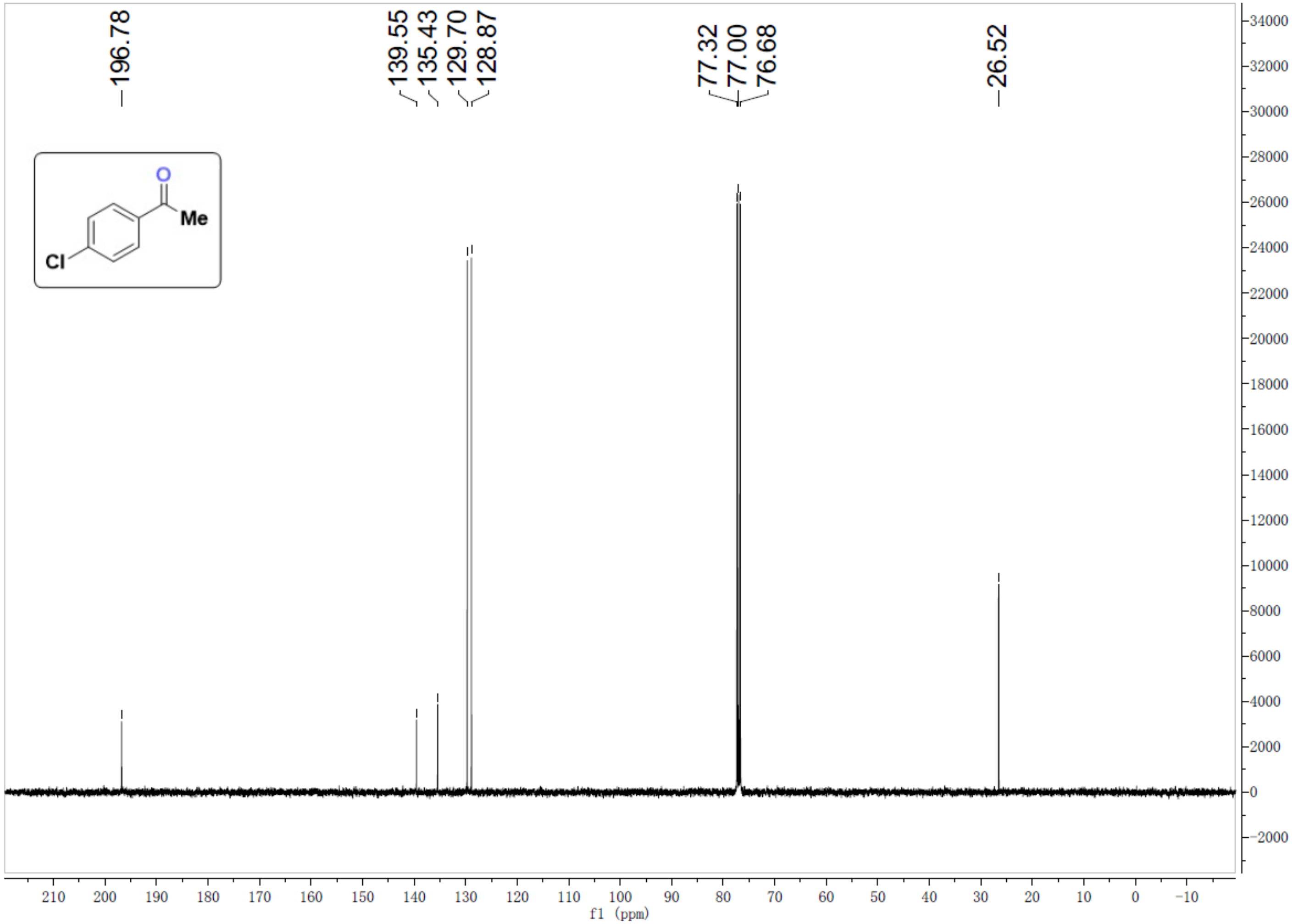

199.98
153.52
148.90
136.74
126.99
121.54
77.32
77.00
76.68
25.68
O
Me
N
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 5v

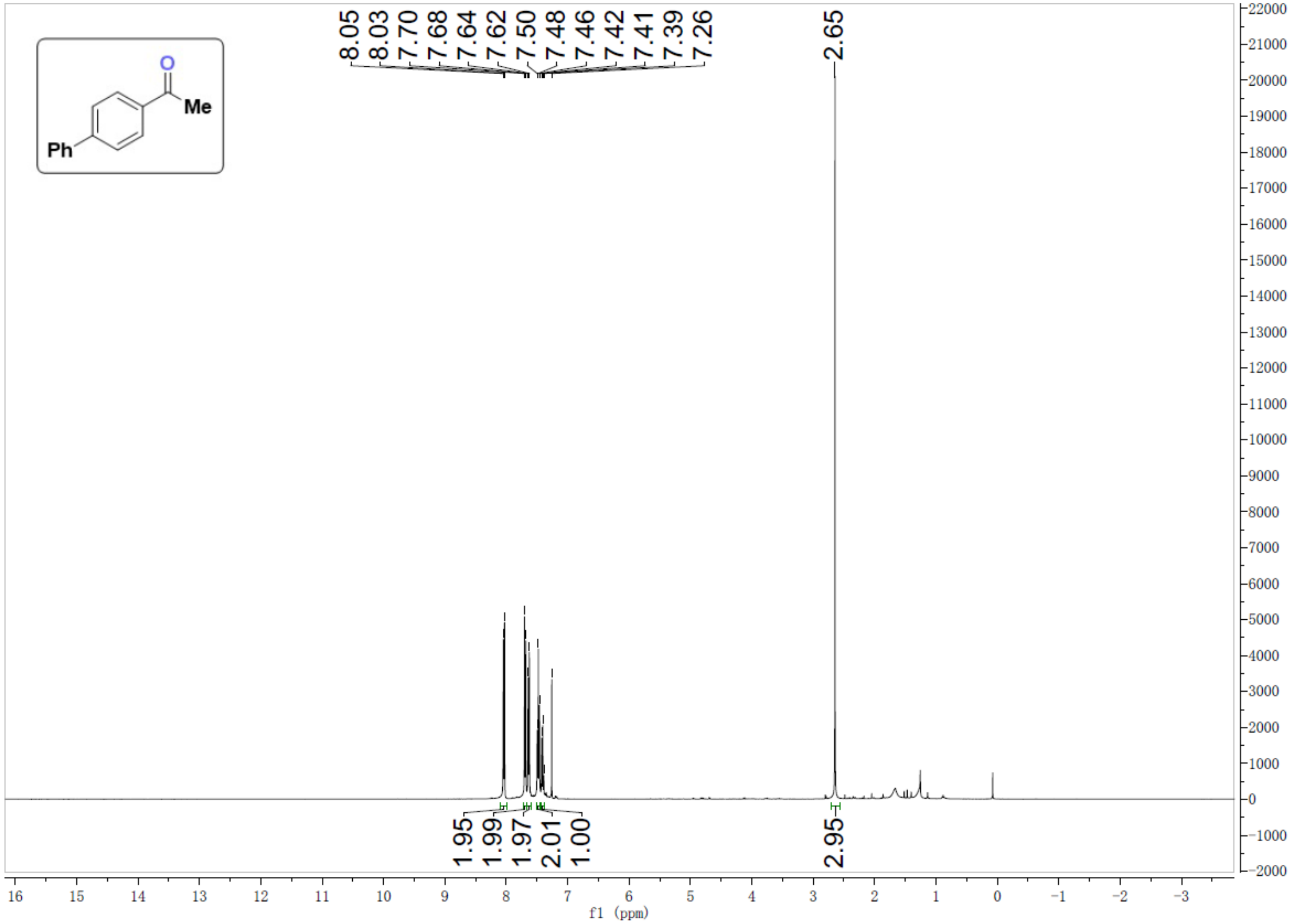


O
Me
Cl
7.90
7.88
7.44
7.42
7.26
2.59
2.02
2.00
3.05
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

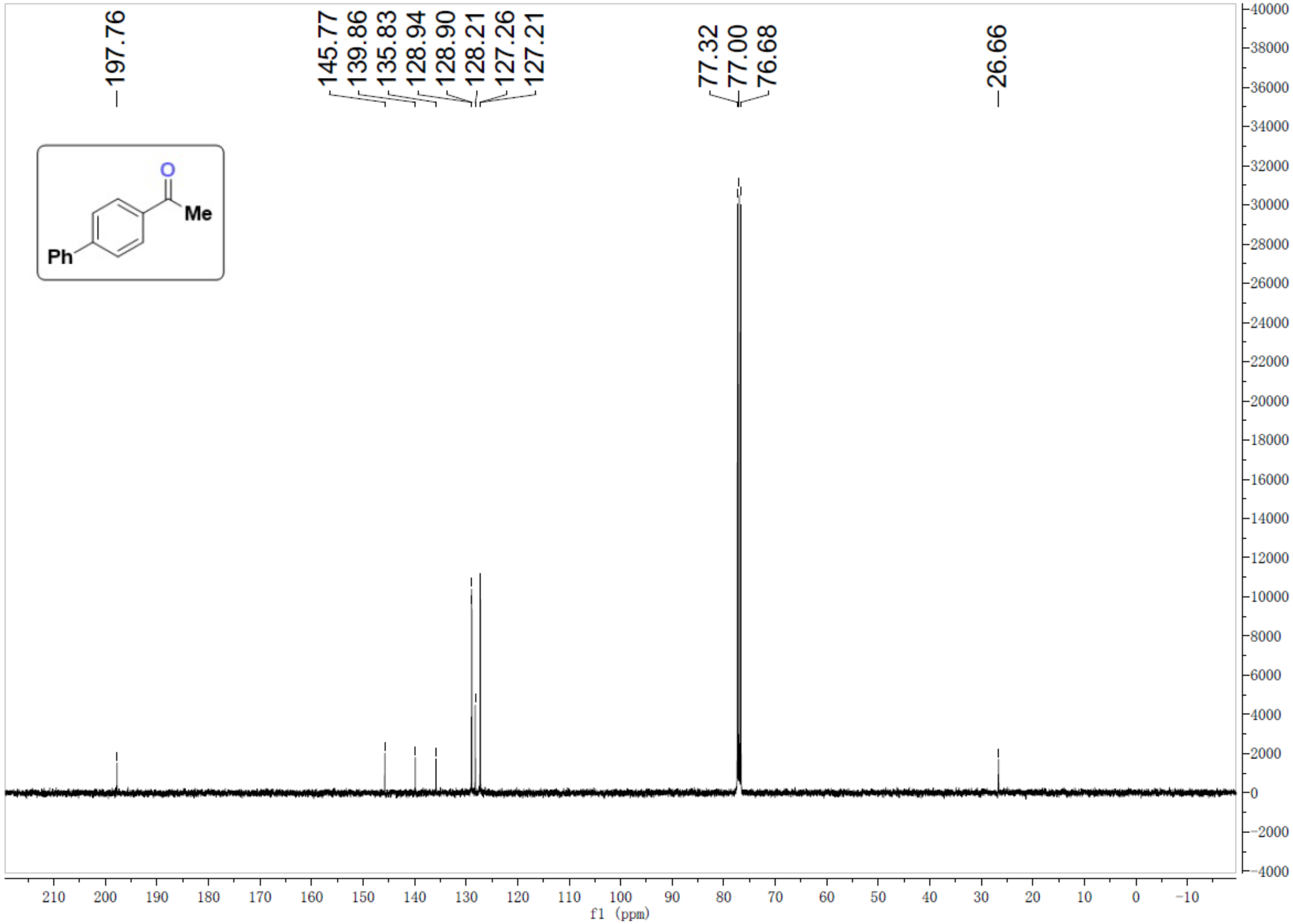
^{13}C NMR of 5v


196.78
139.55
135.43
129.70
128.87
77.32
77.00
76.68
26.52
Cl
Me
O
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)
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000

^{1}H NMR of 5w

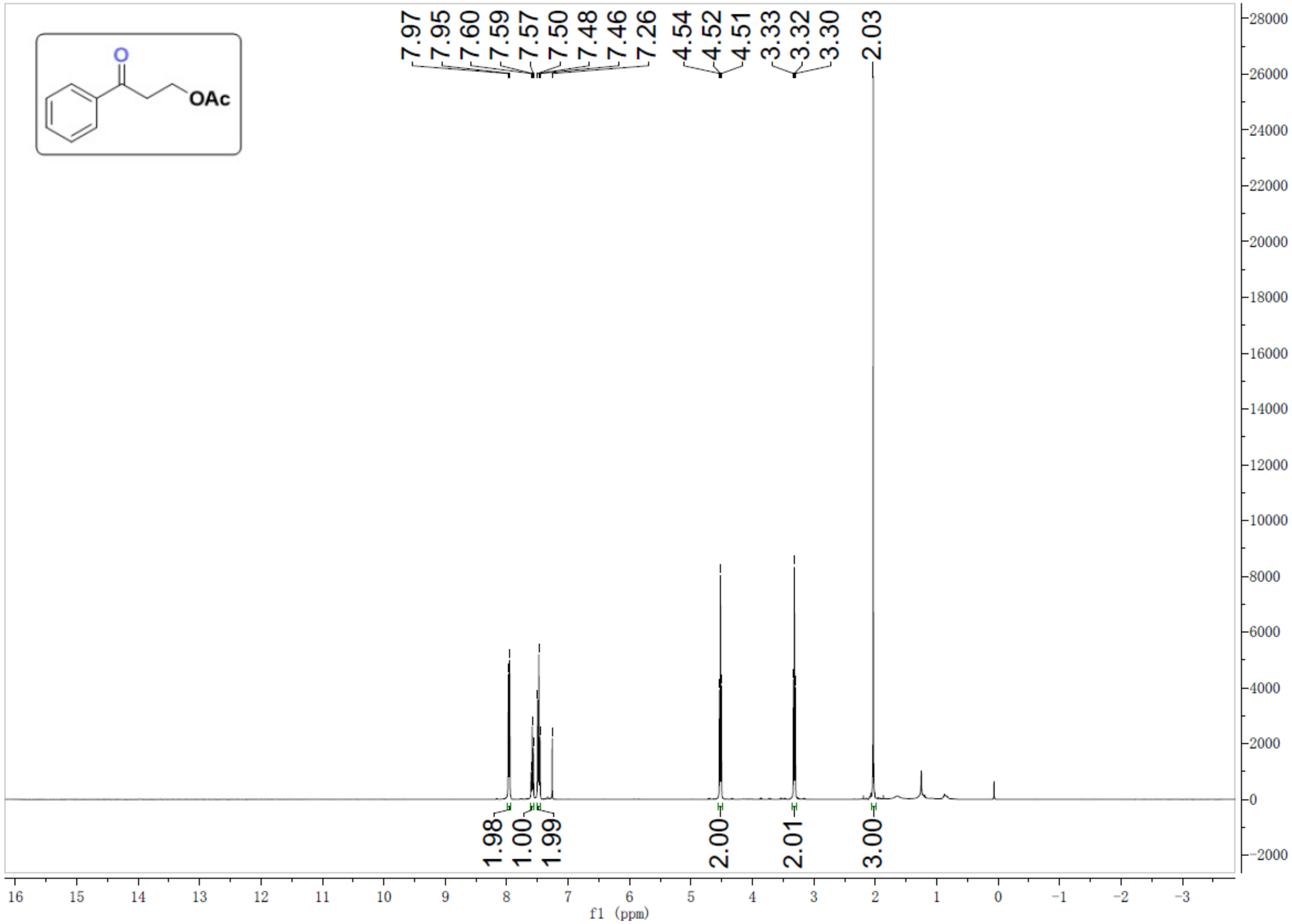

8.05
8.03
7.70
7.68
7.64
7.62
7.50
7.48
7.46
7.42
7.41
7.39
7.26
2.65
1.95
1.99
1.97
2.01
1.00
2.95
O
Me
Ph
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 5w

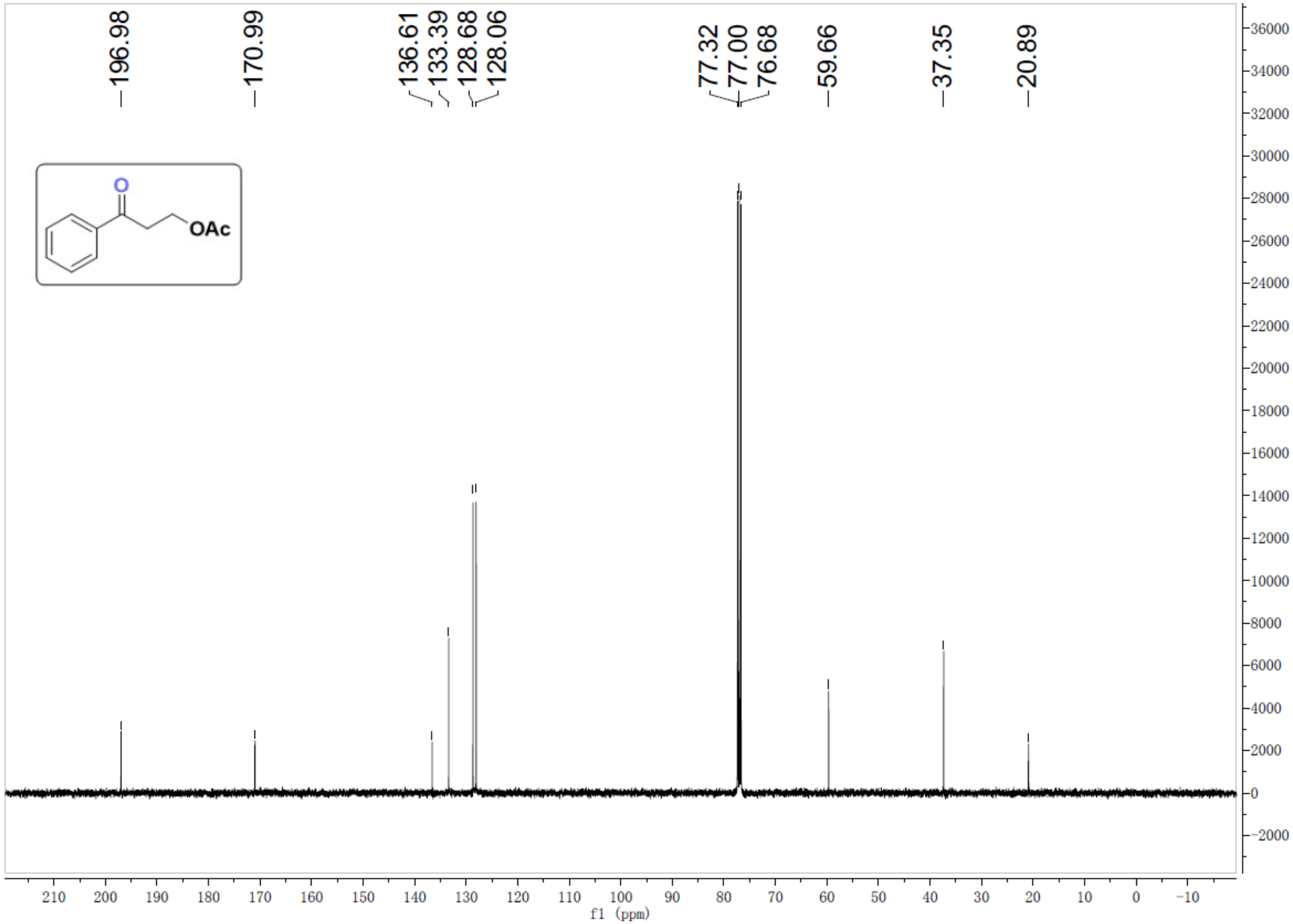


197.76
145.77
139.86
135.83
128.94
128.90
128.21
127.26
127.21
77.32
77.00
76.68
26.66
O
Me
Ph
40000
38000
36000
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
-4000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

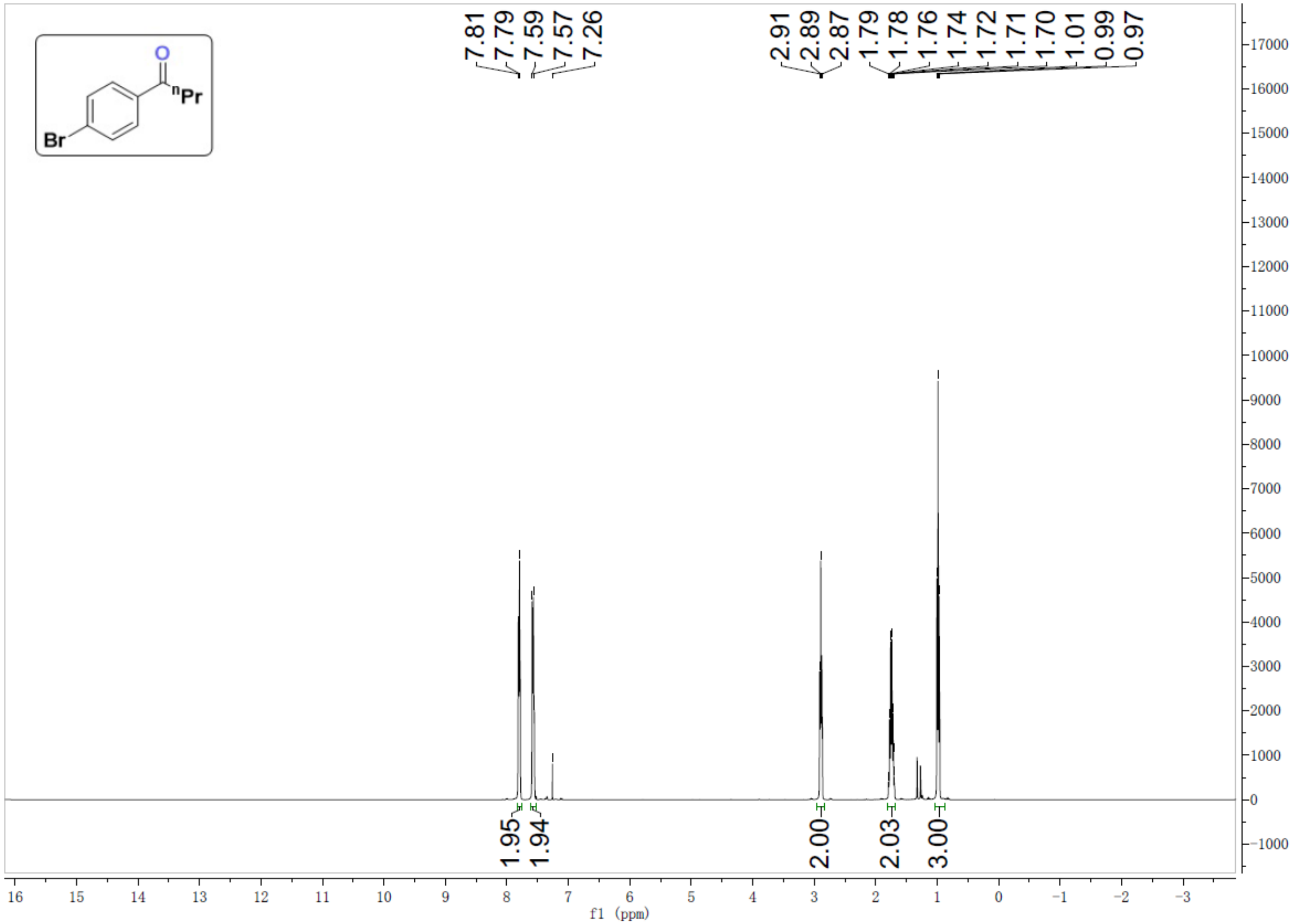
^{1}H NMR of 5x


OAc
7.97
7.95
7.60
7.59
7.57
7.50
7.48
7.46
7.26
4.54
4.52
4.51
3.33
3.32
3.30
2.03
1.98
1.00
1.99
2.00
2.01
3.00
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

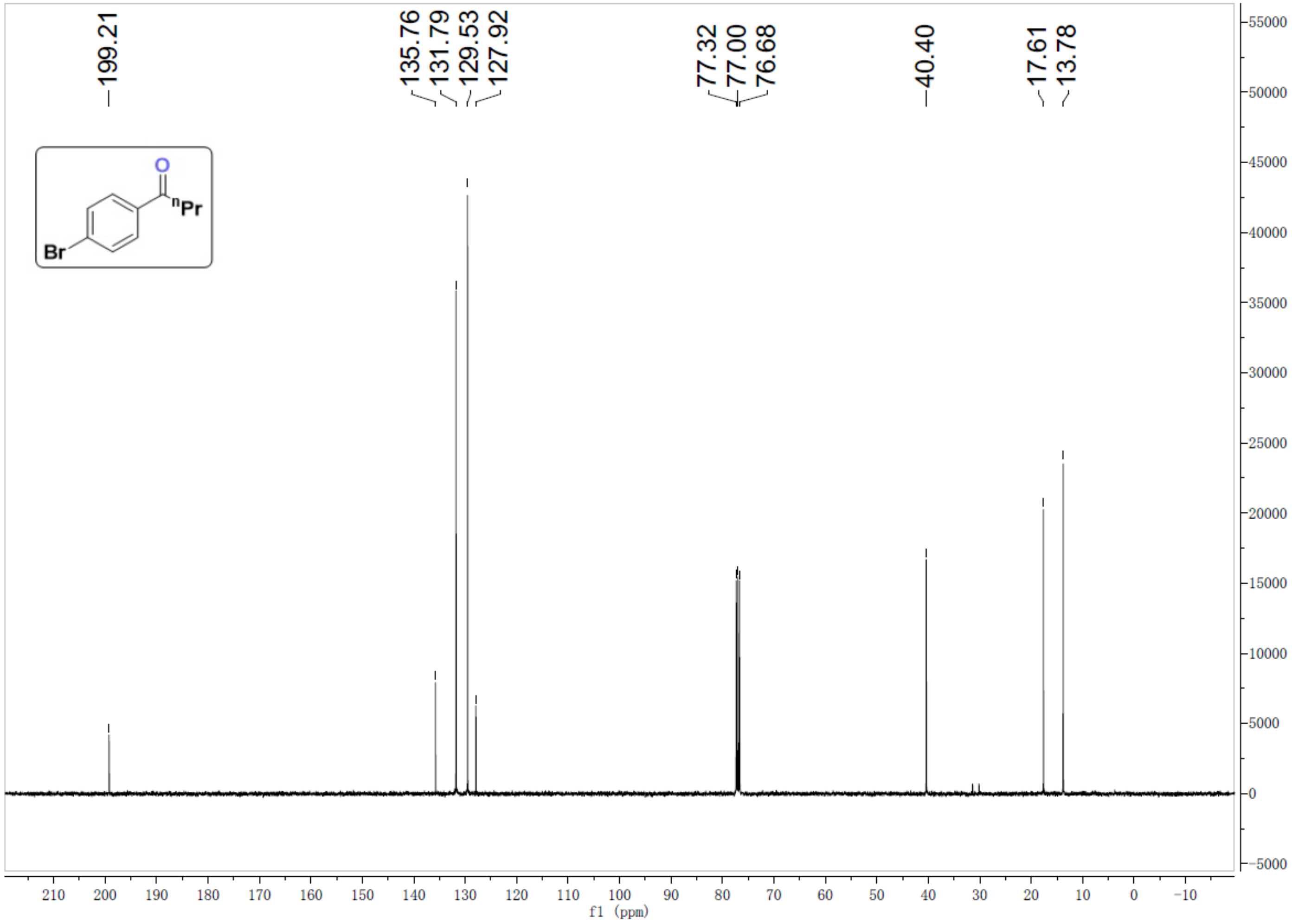
^{13}C NMR of 5x


196.98
170.99
136.61
133.39
128.68
128.06
77.32
77.00
76.68
59.66
37.35
20.89
O
OAc
36000
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
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)

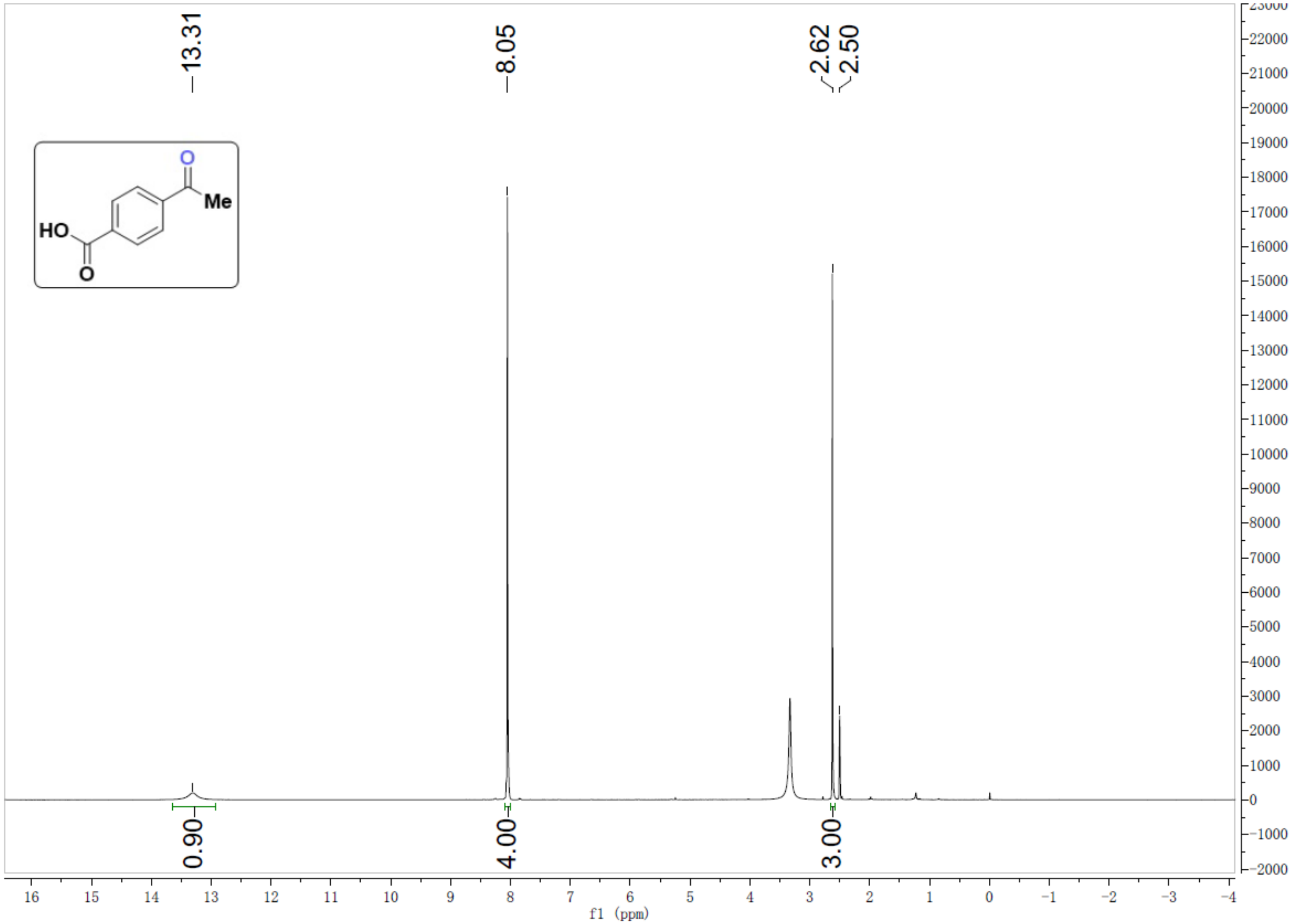
^{1}H NMR of 5y


O
nPr
Br
7.81
7.79
7.59
7.57
7.26
2.91
2.89
2.87
1.79
1.78
1.76
1.74
1.72
1.71
1.70
1.01
0.99
0.97
1.95
1.94
2.00
2.03
3.00
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 5y

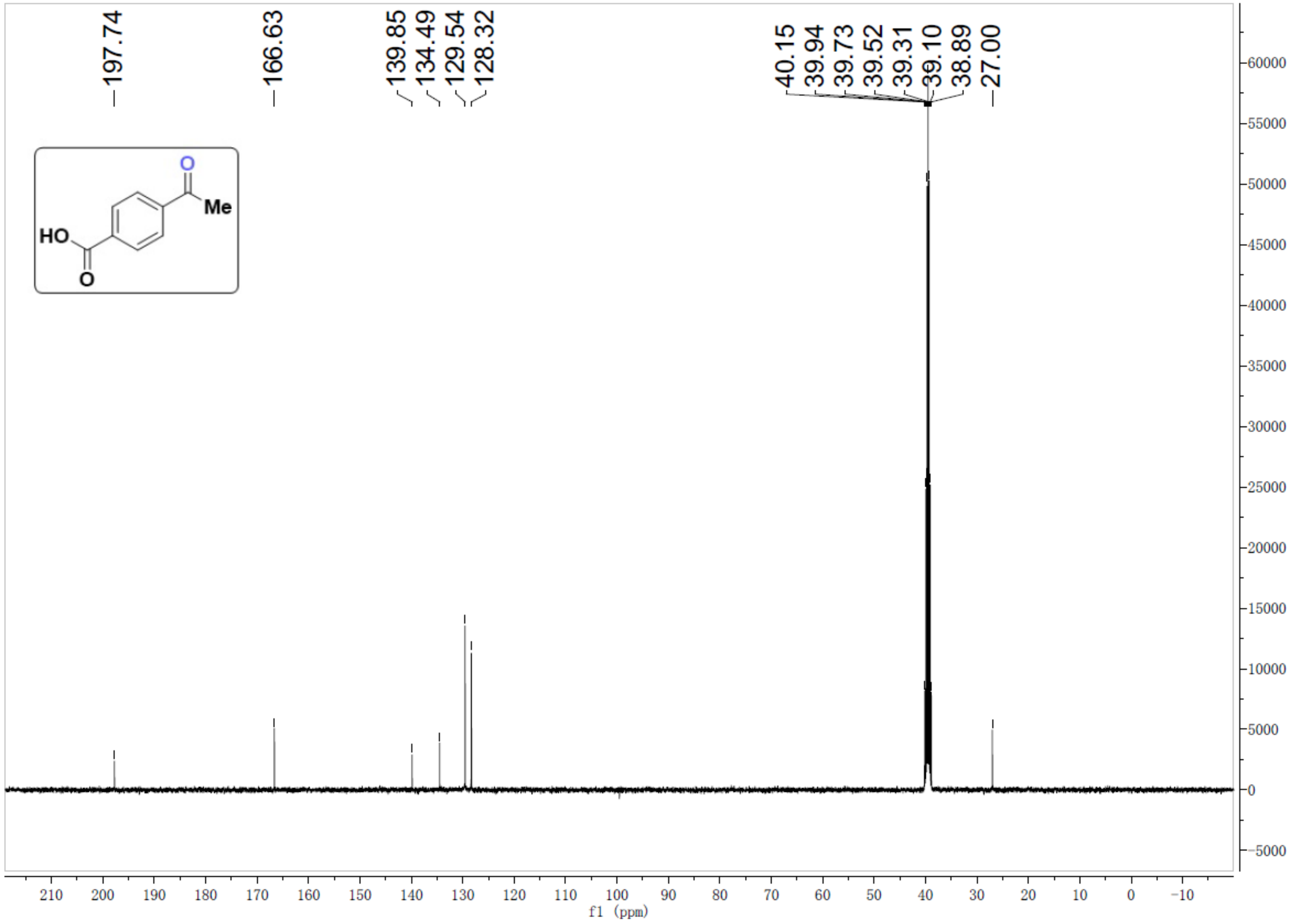

199.21
135.76
131.79
129.53
127.92
77.32
77.00
76.68
40.40
17.61
13.78
Br
O
nPr
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000

^{1}H NMR of 5z

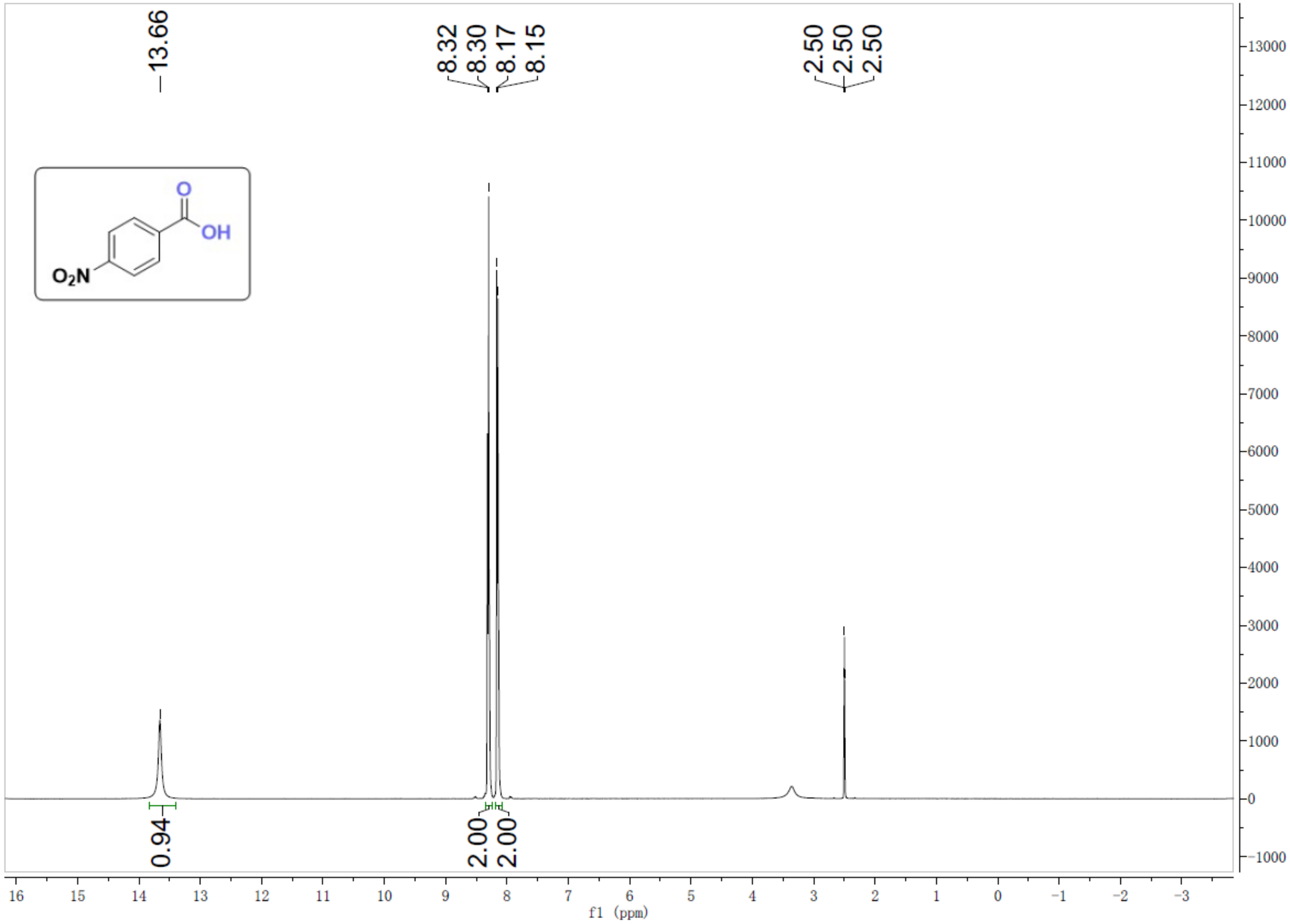


13.31
8.05
2.62
2.50
HO
O
O
Me
0.90
4.00
3.00
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
f1 (ppm)
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000

^{13}C NMR of 5z

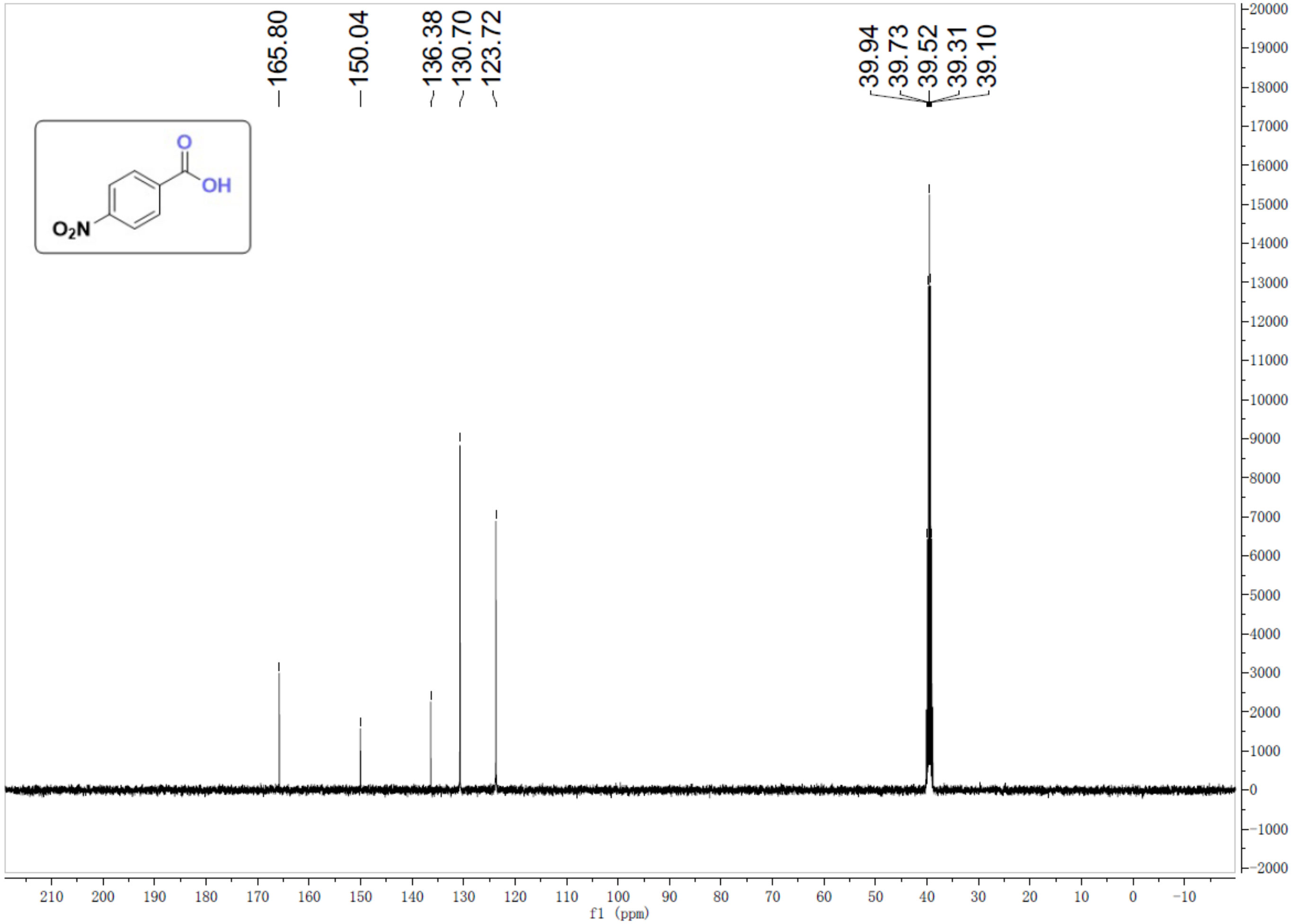

197.74
166.63
139.85
134.49
129.54
128.32
40.15
39.94
39.73
39.52
39.31
39.10
38.89
27.00
O
Me
HO
O
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 6a

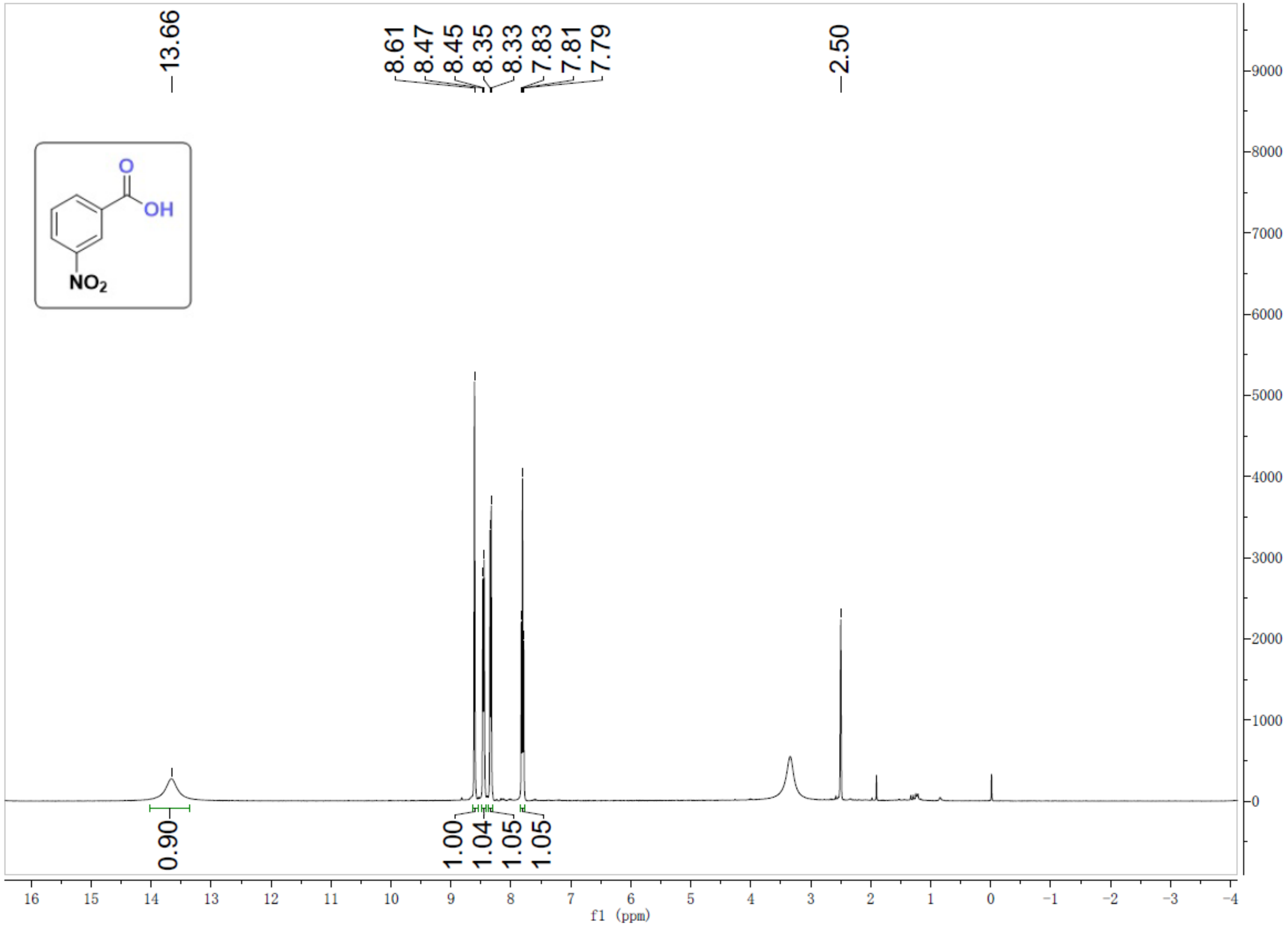


13.66
8.32
8.30
8.17
8.15
2.50
2.50
2.50
O
OH
O₂N
0.94
2.00
2.00
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−2
−3
f1 (ppm)

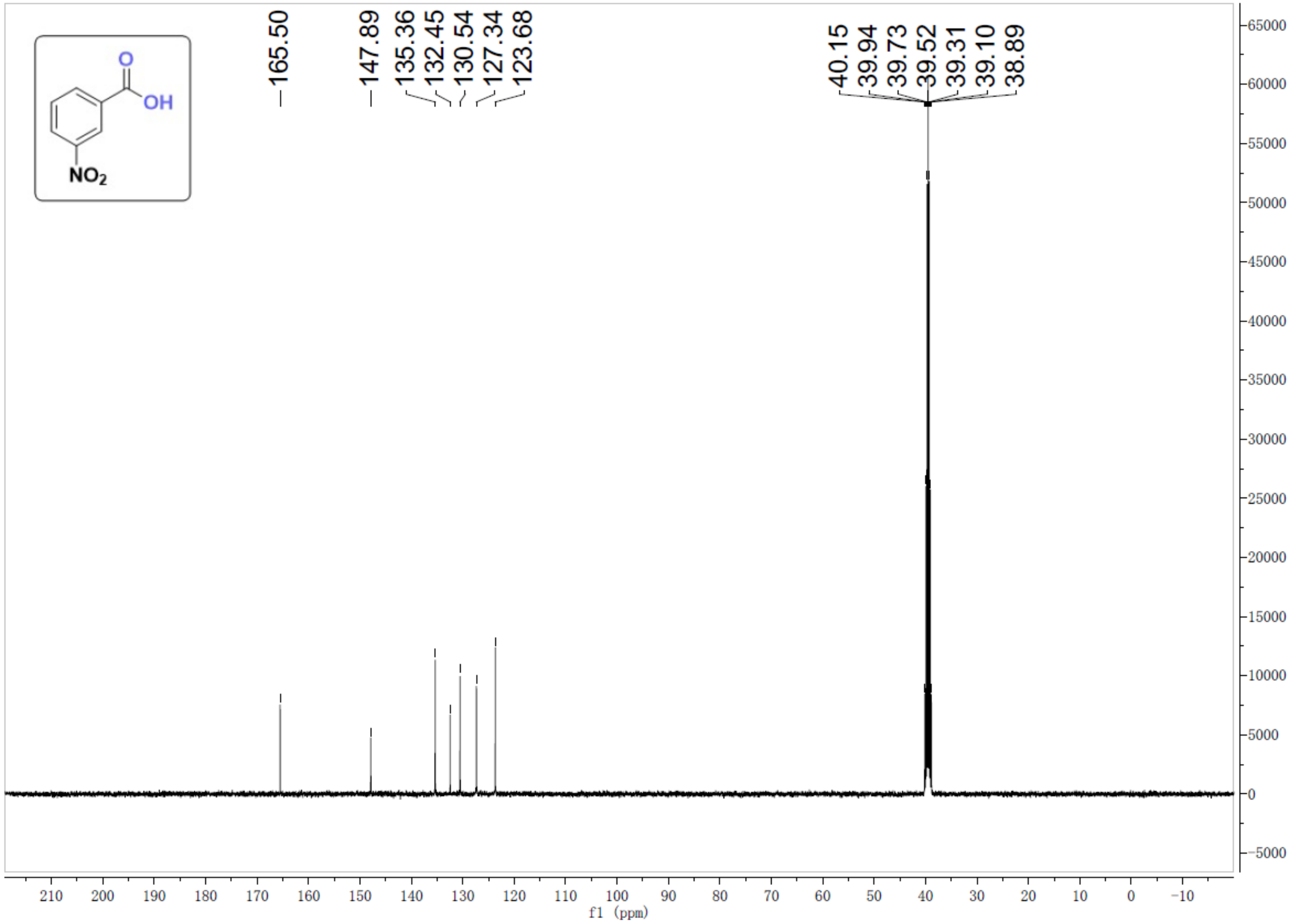
^{13}C NMR of 6a


165.80
150.04
136.38
130.70
123.72
39.94
39.73
39.52
39.31
39.10
O
OH
O2N
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
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)

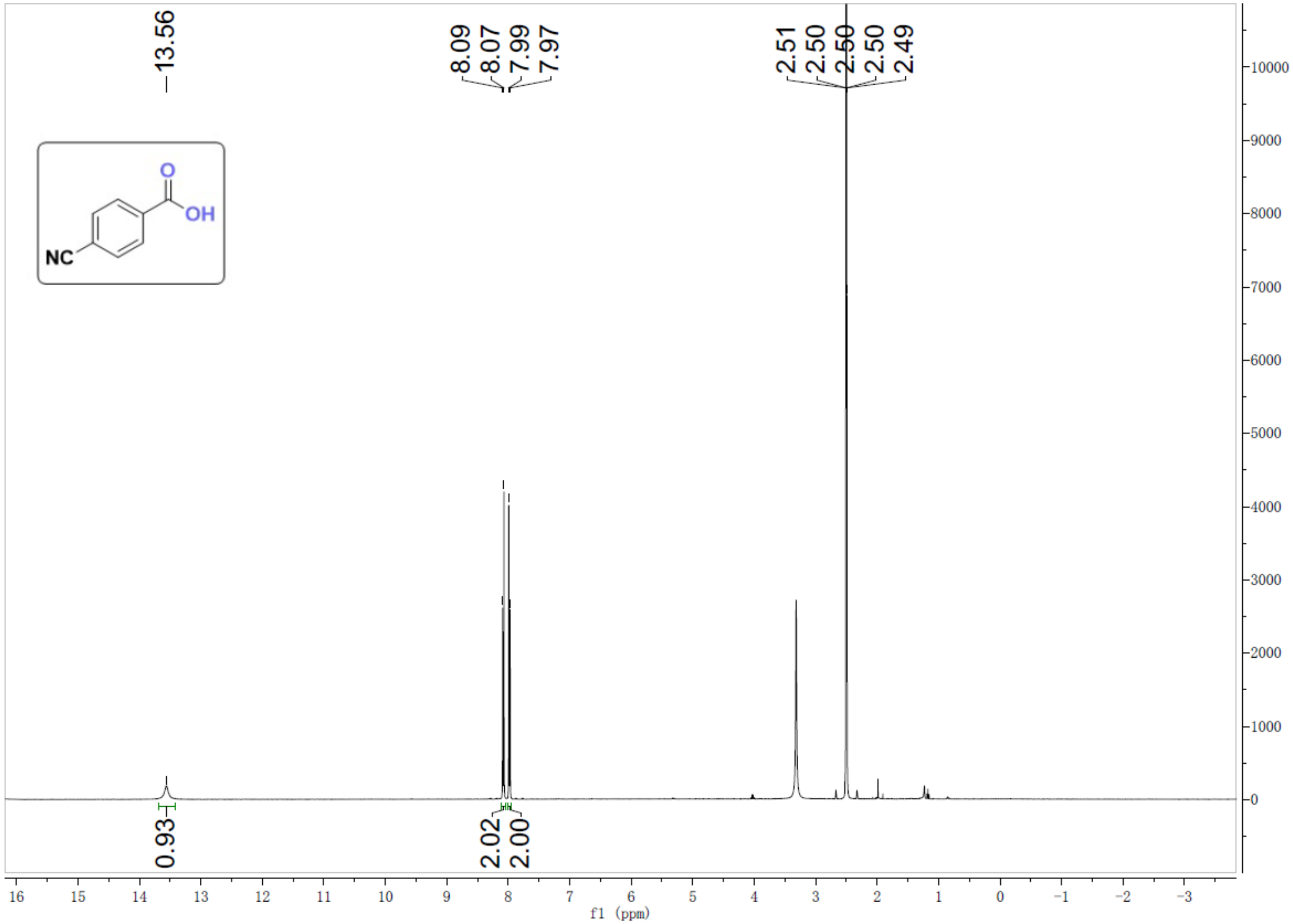
^{1}H NMR of 6b


13.66
8.61
8.47
8.45
8.35
8.33
7.83
7.81
7.79
2.50
O
OH
NO2
0.90
1.00
1.04
1.05
1.05
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
f1 (ppm)

^{13}C NMR of 6b

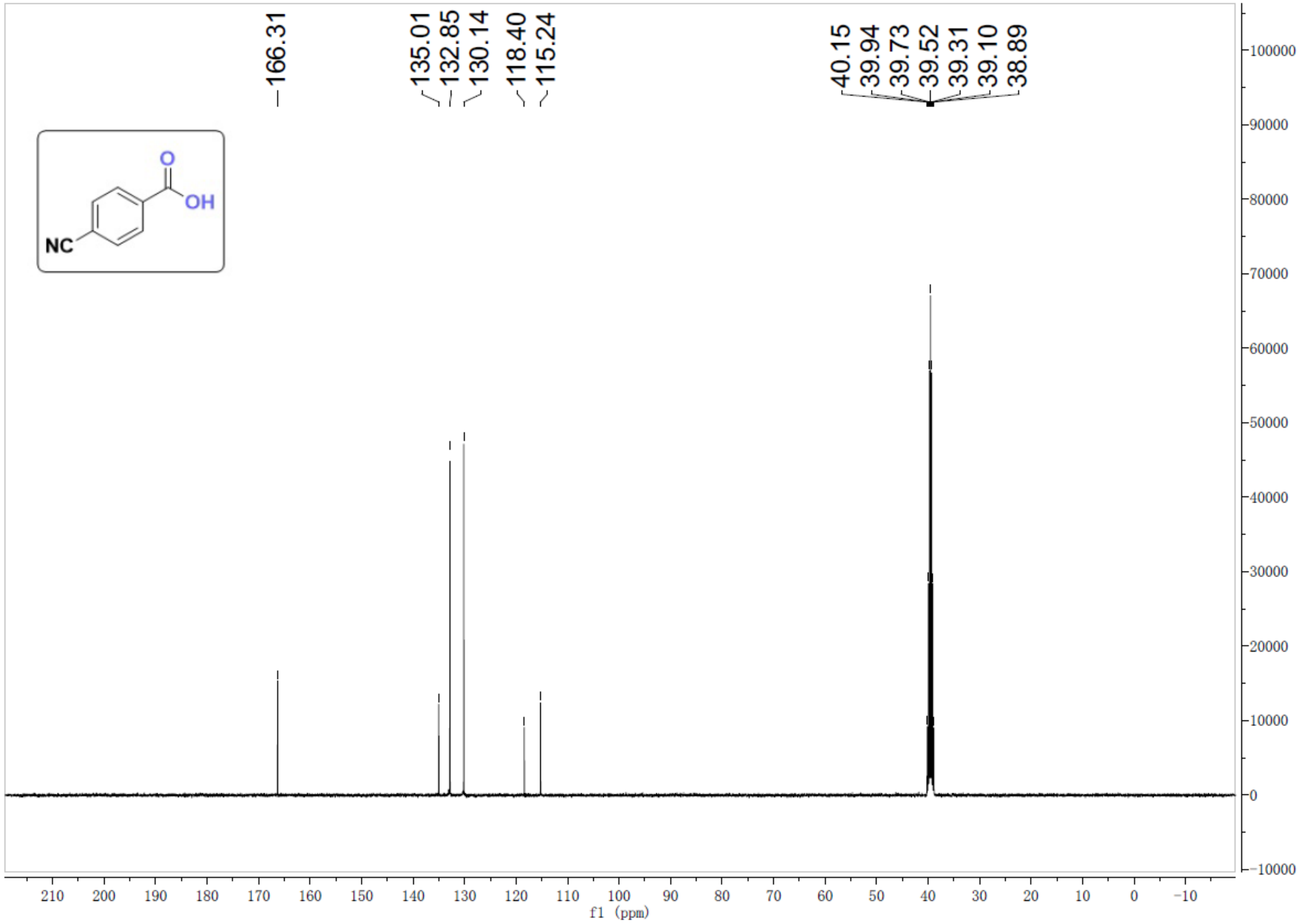

O
OH
NO2
165.50
147.89
135.36
132.45
130.54
127.34
123.68
40.15
39.94
39.73
39.52
39.31
39.10
38.89
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 6c

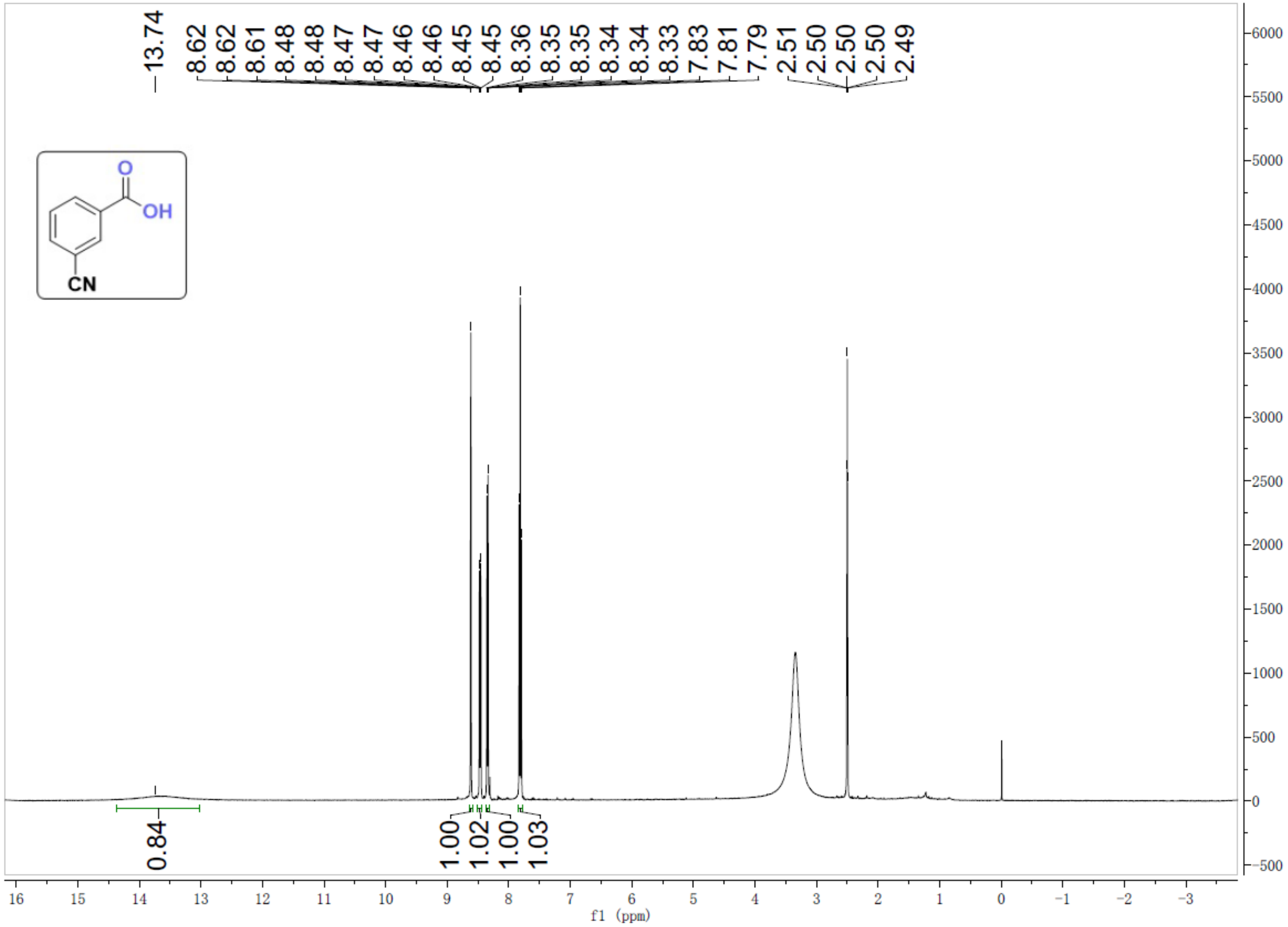


13.56
8.09
8.07
7.99
7.97
2.51
2.50
2.50
2.50
2.49
NC
O
OH
0.93
2.02
2.00
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

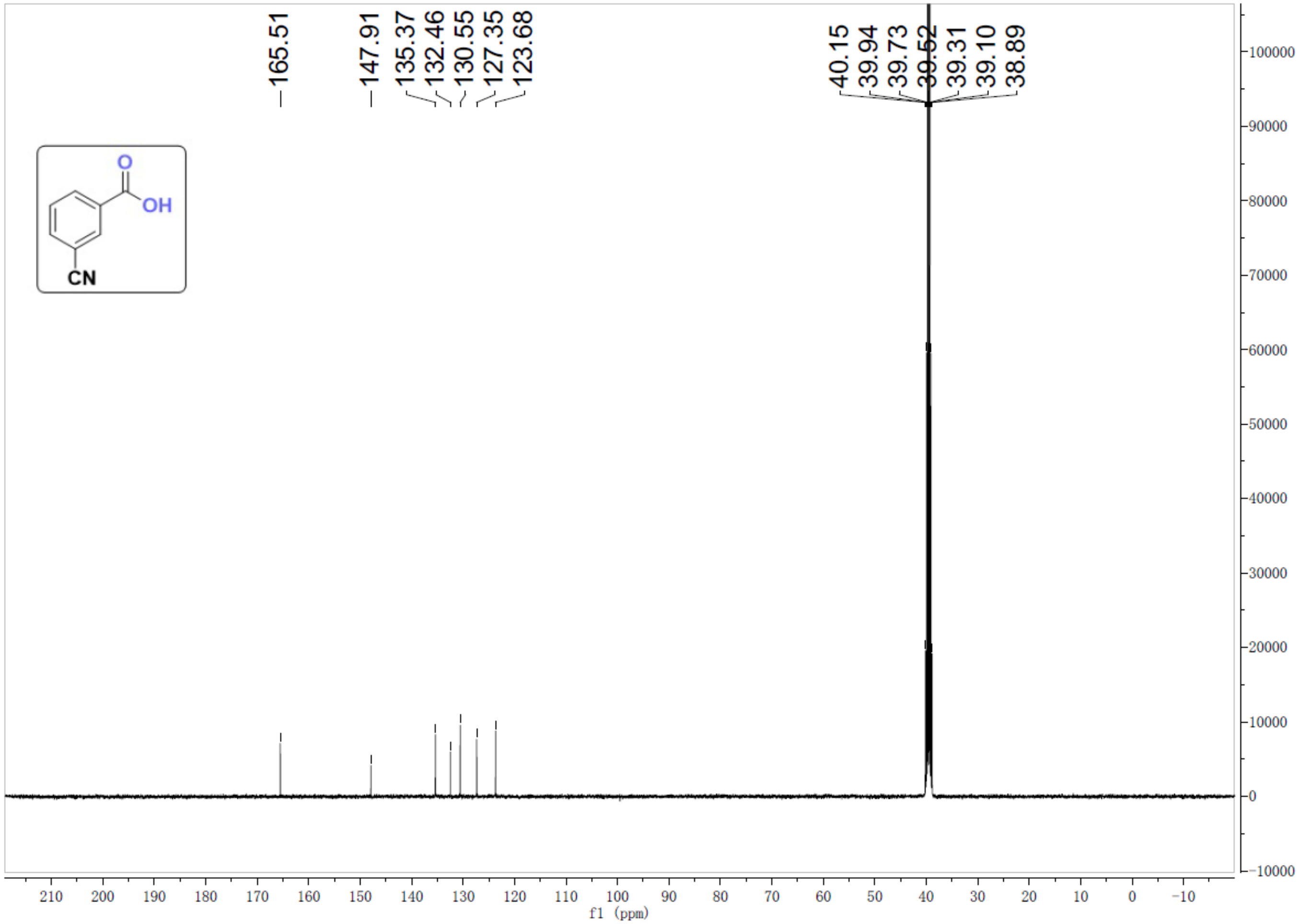
^{13}C NMR of 6c


166.31
135.01
132.85
130.14
118.40
115.24
40.15
39.94
39.73
39.52
39.31
39.10
38.89
NC
O
OH
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
−10000
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)

^{1}H NMR of 6d

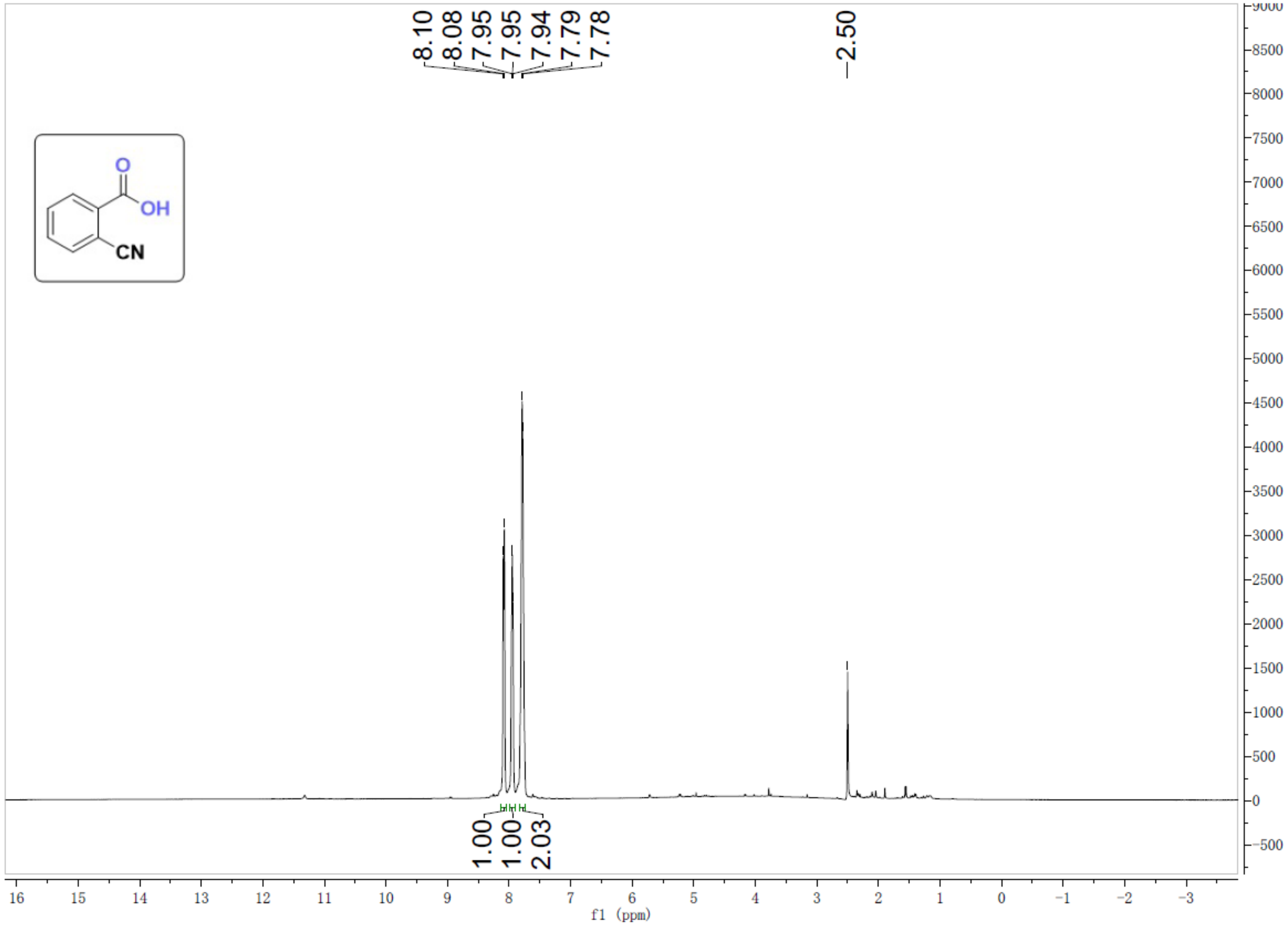

13.74
8.62
8.62
8.61
8.48
8.48
8.47
8.47
8.46
8.45
8.45
8.36
8.35
8.35
8.34
8.34
8.33
7.83
7.81
7.79
2.51
2.50
2.50
2.50
2.49
O
OH
CN
0.84
1.00
1.02
1.00
1.03
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 6d



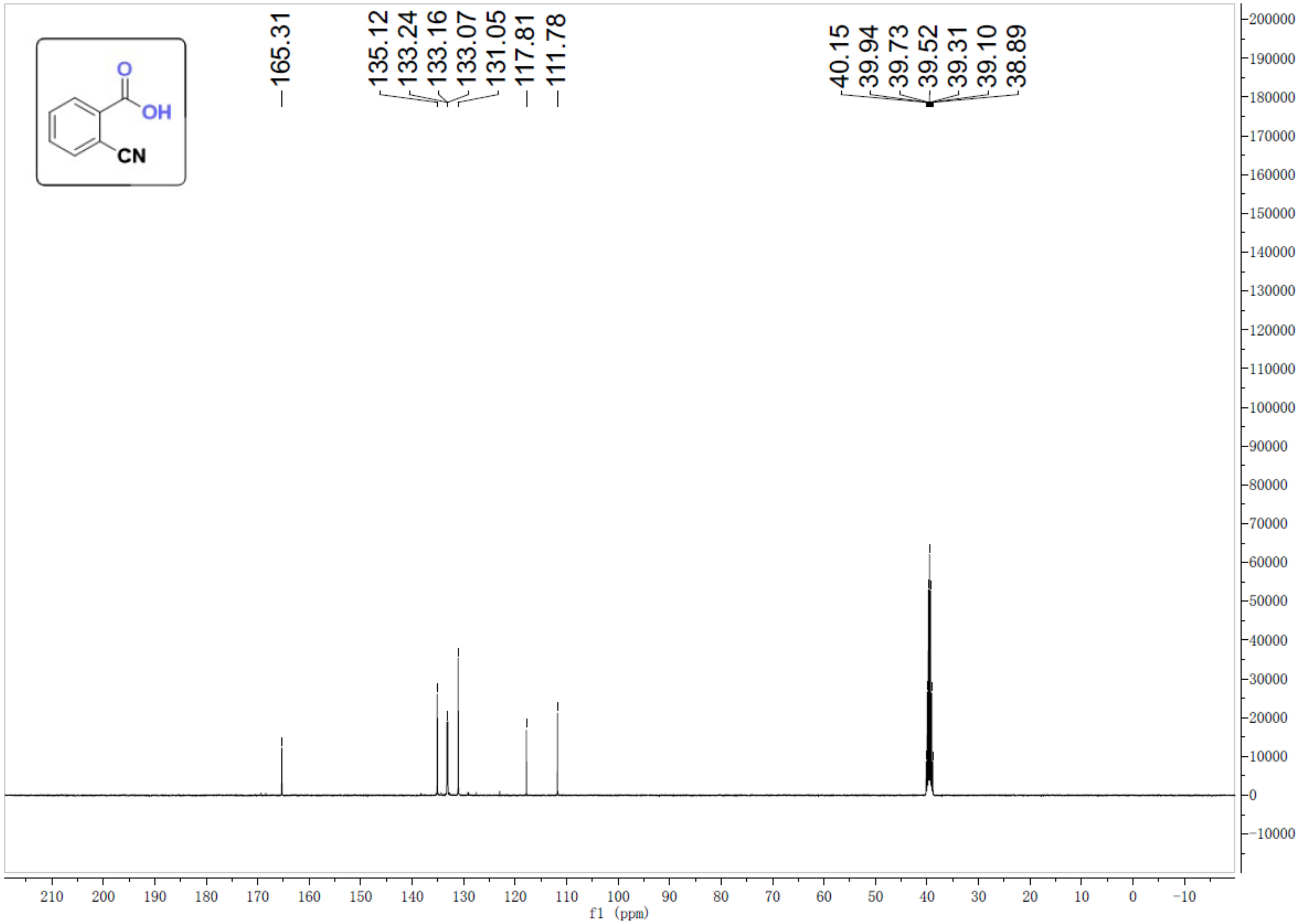
165.51
147.91
135.37
132.46
130.55
127.35
123.68
40.15
39.94
39.73
39.52
39.31
39.10
38.89
O
OH
CN
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 6e

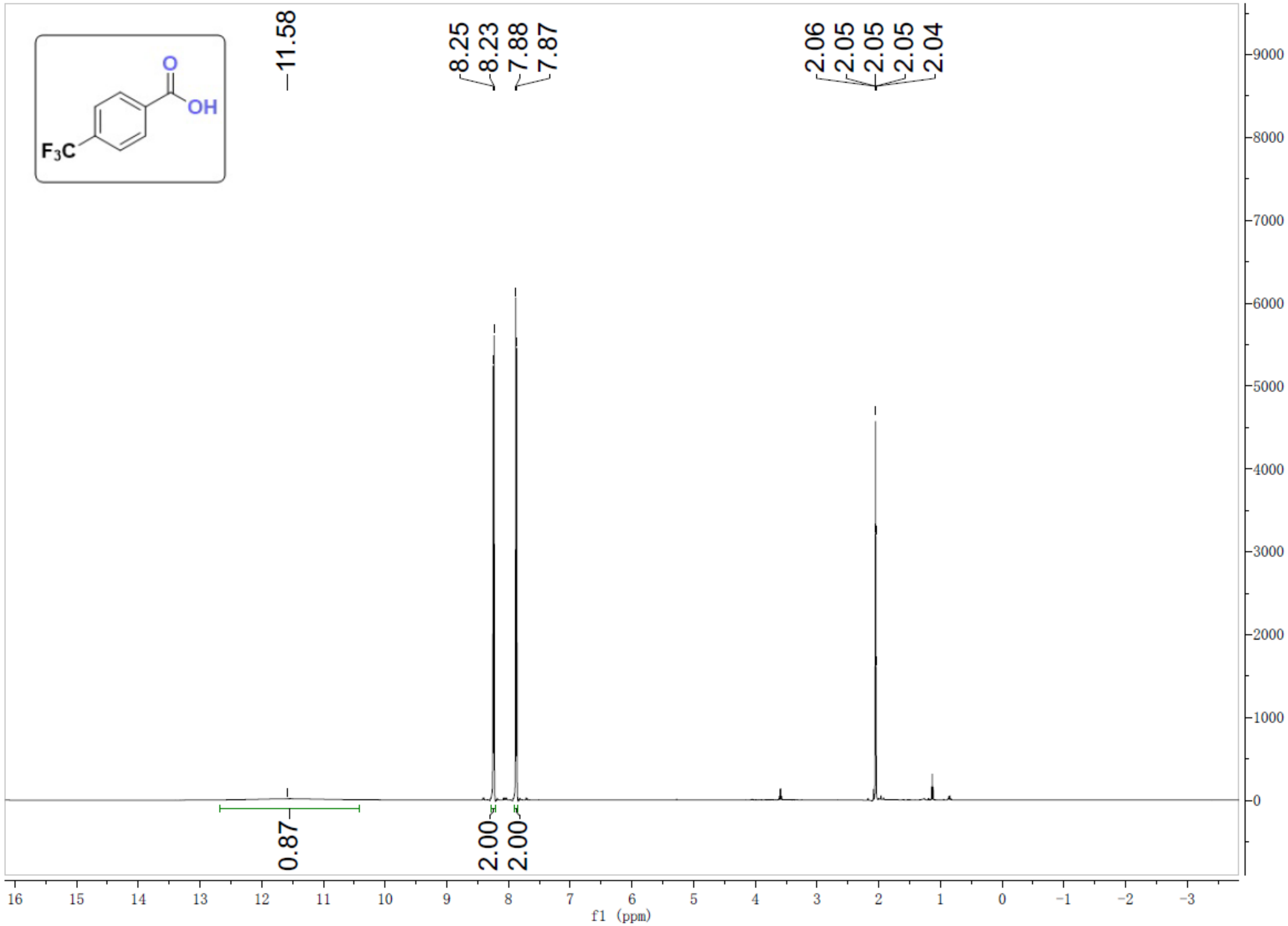


8.10
8.08
7.95
7.95
7.94
7.79
7.78
2.50
O
OH
CN
1.00
1.00
2.03
f1 (ppm)
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1 -2 -3
9000 8500 8000 7500 7000 6500 6000 5500 5000 4500 4000 3500 3000 2500 2000 1500 1000 500 0 -500

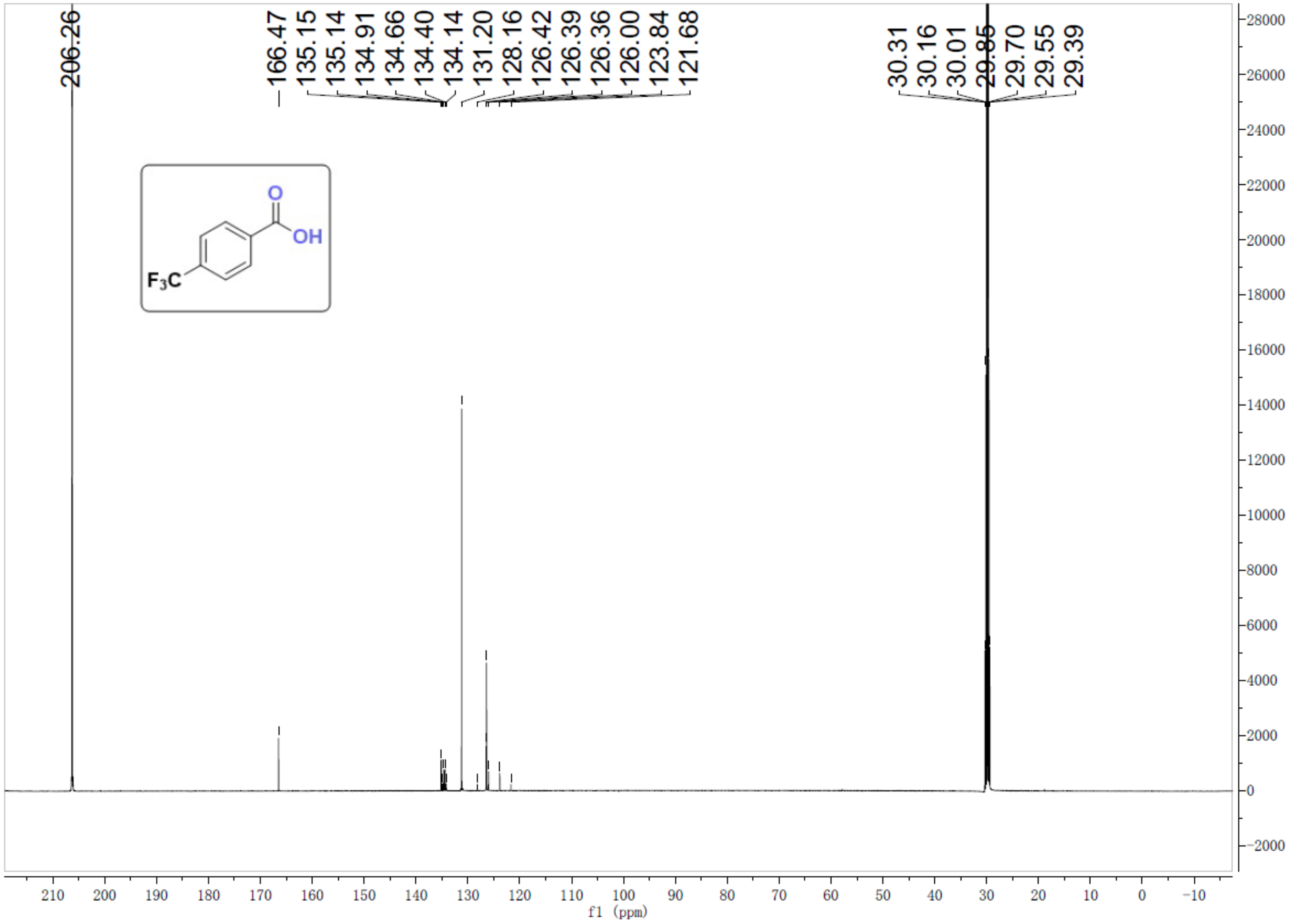
^{13}C NMR of 6e


O
OH
CN
165.31
135.12
133.24
133.16
133.07
131.05
117.81
111.78
40.15
39.94
39.73
39.52
39.31
39.10
38.89
200000
190000
180000
170000
160000
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
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)

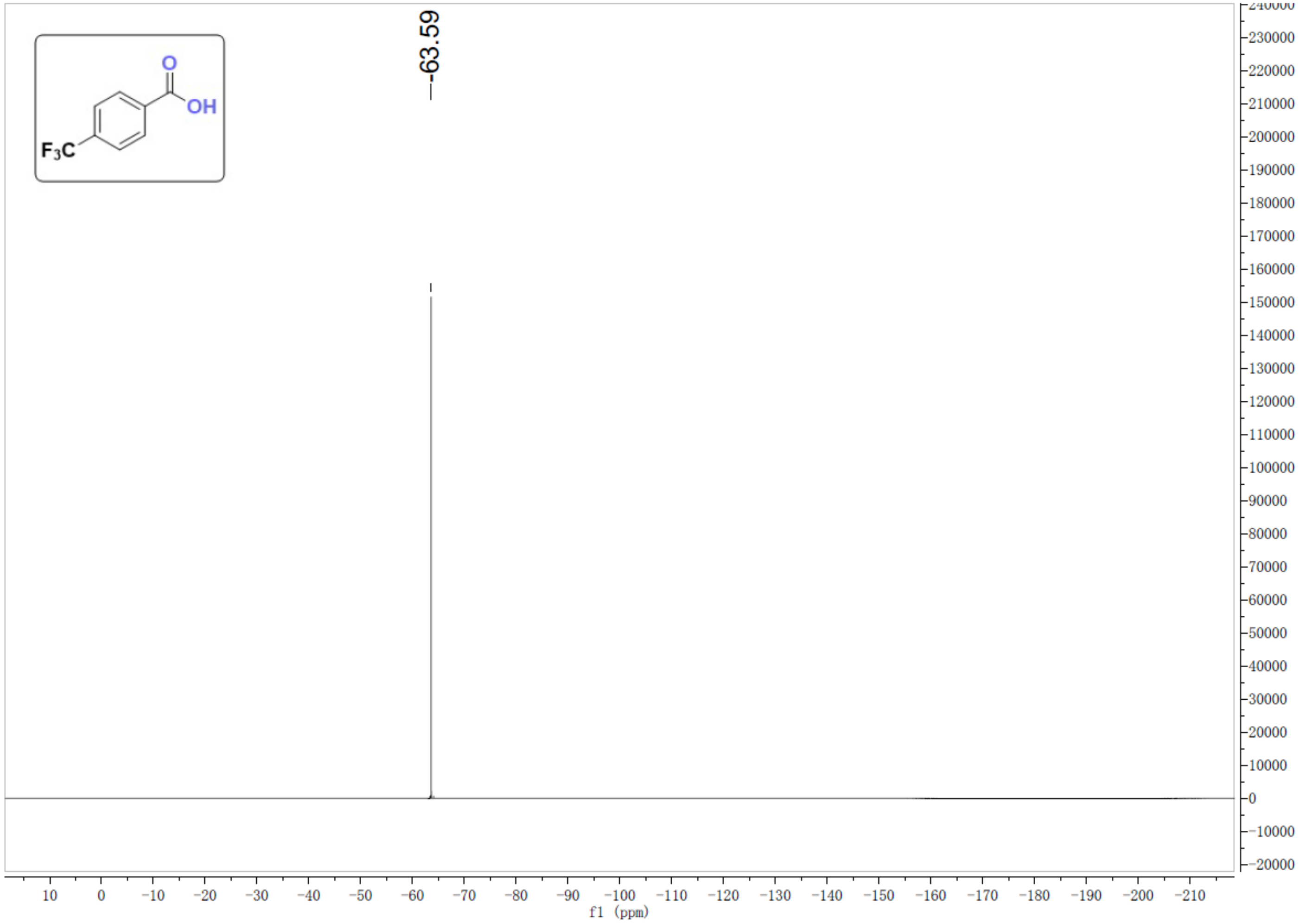
^{1}H NMR of 6f


O
OH
F₃C
11.58
8.25
8.23
7.88
7.87
2.06
2.05
2.05
2.05
2.04
0.87
2.00
2.00
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 6f

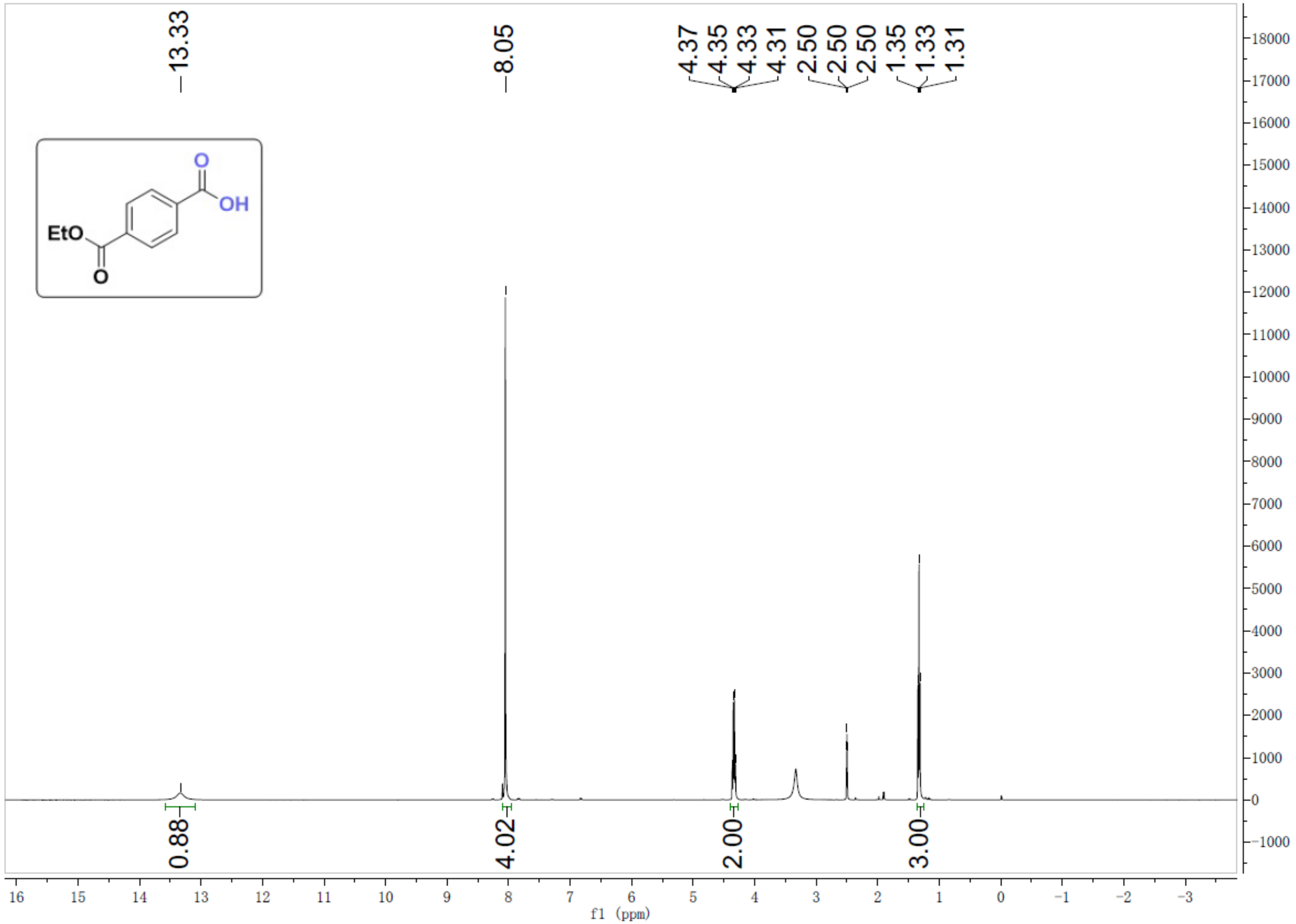

206.26
166.47
135.15
135.14
134.91
134.66
134.40
134.14
131.20
128.16
126.42
126.39
126.36
126.00
123.84
121.68
30.31
30.16
30.01
29.85
29.70
29.55
29.39
O
OH
F3C
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{19}F NMR of 6f

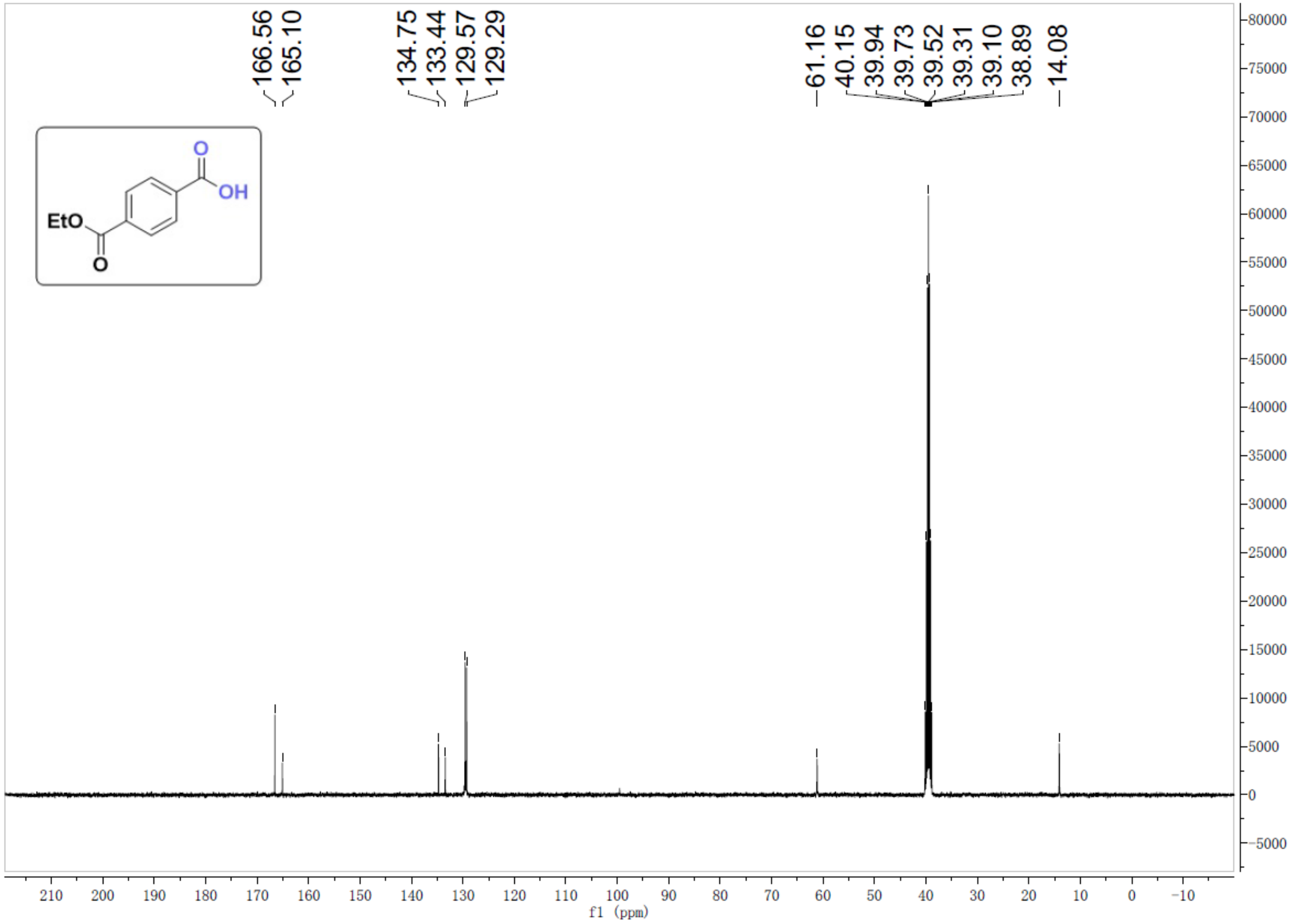


O
OH
F₃C
-63.59
240000
230000
220000
210000
200000
190000
180000
170000
160000
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
-20000
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

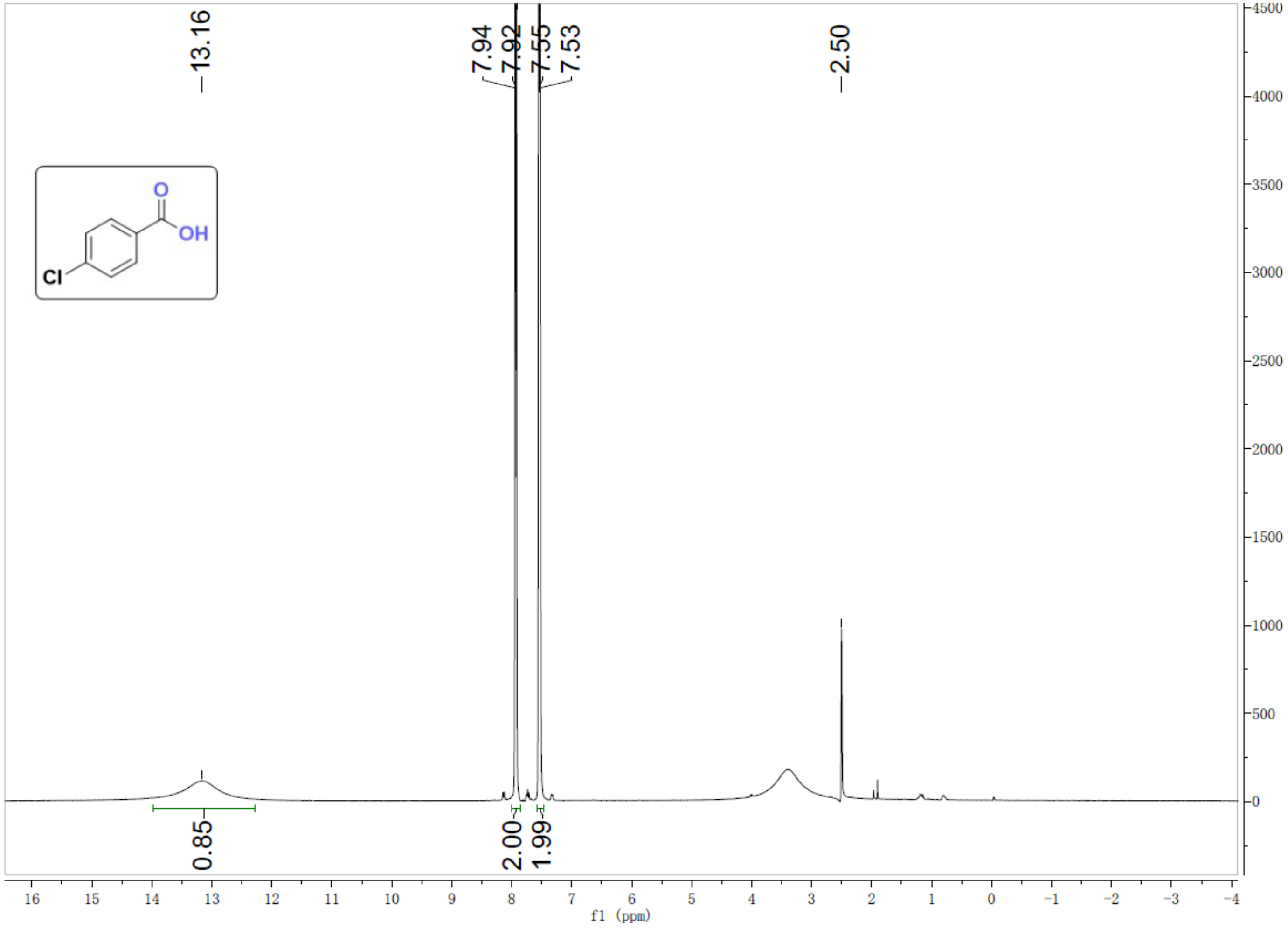
^{1}H NMR of 6g


13.33
8.05
4.37
4.35
4.33
4.31
2.50
2.50
2.50
1.35
1.33
1.31
EtO
O
O
OH
0.88
4.02
2.00
3.00
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 6g

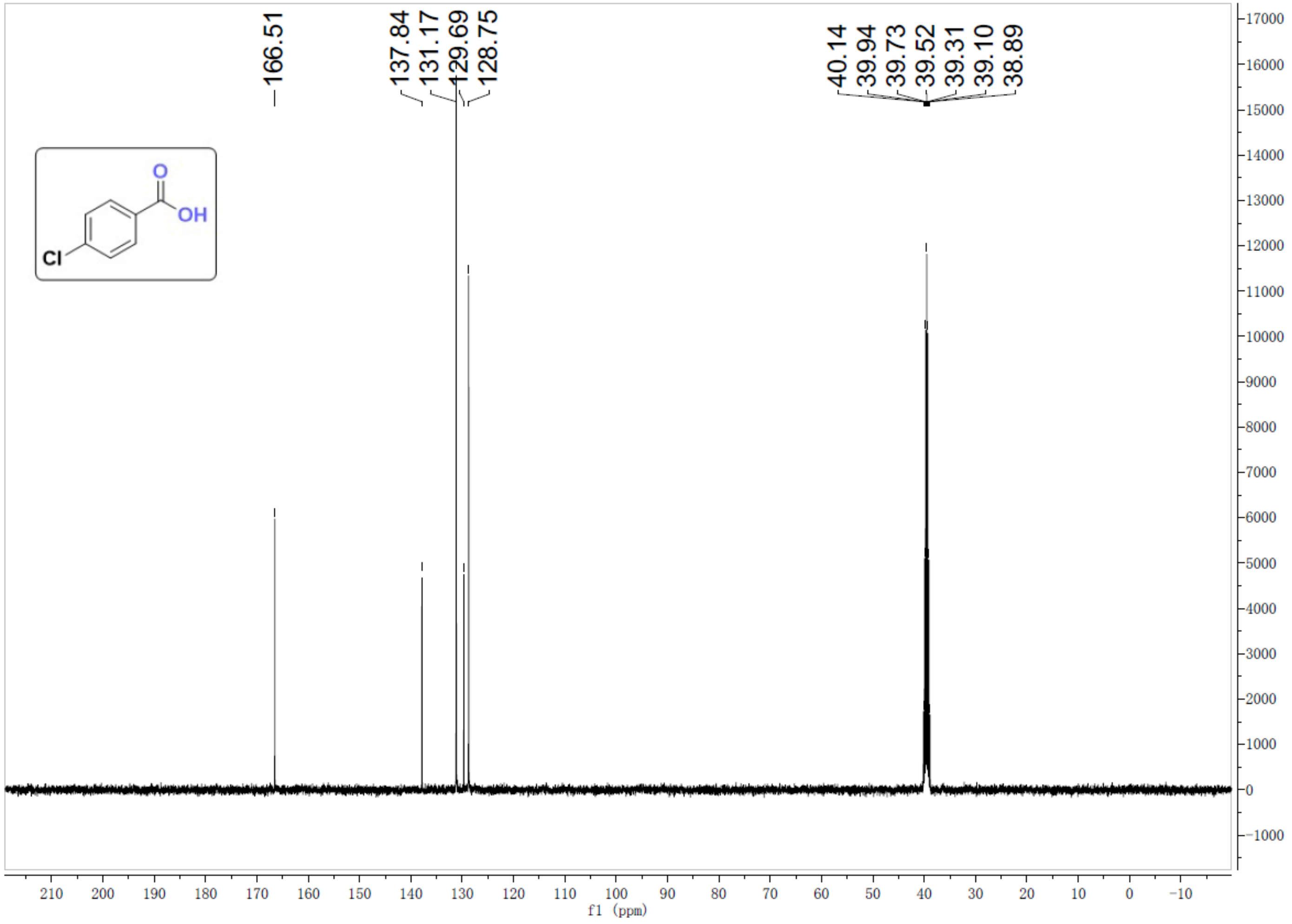

166.56
165.10
134.75
133.44
129.57
129.29
61.16
40.15
39.94
39.73
39.52
39.31
39.10
38.89
14.08
O
OH
EtO
O
80000
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
−5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

^{1}H NMR of 6h

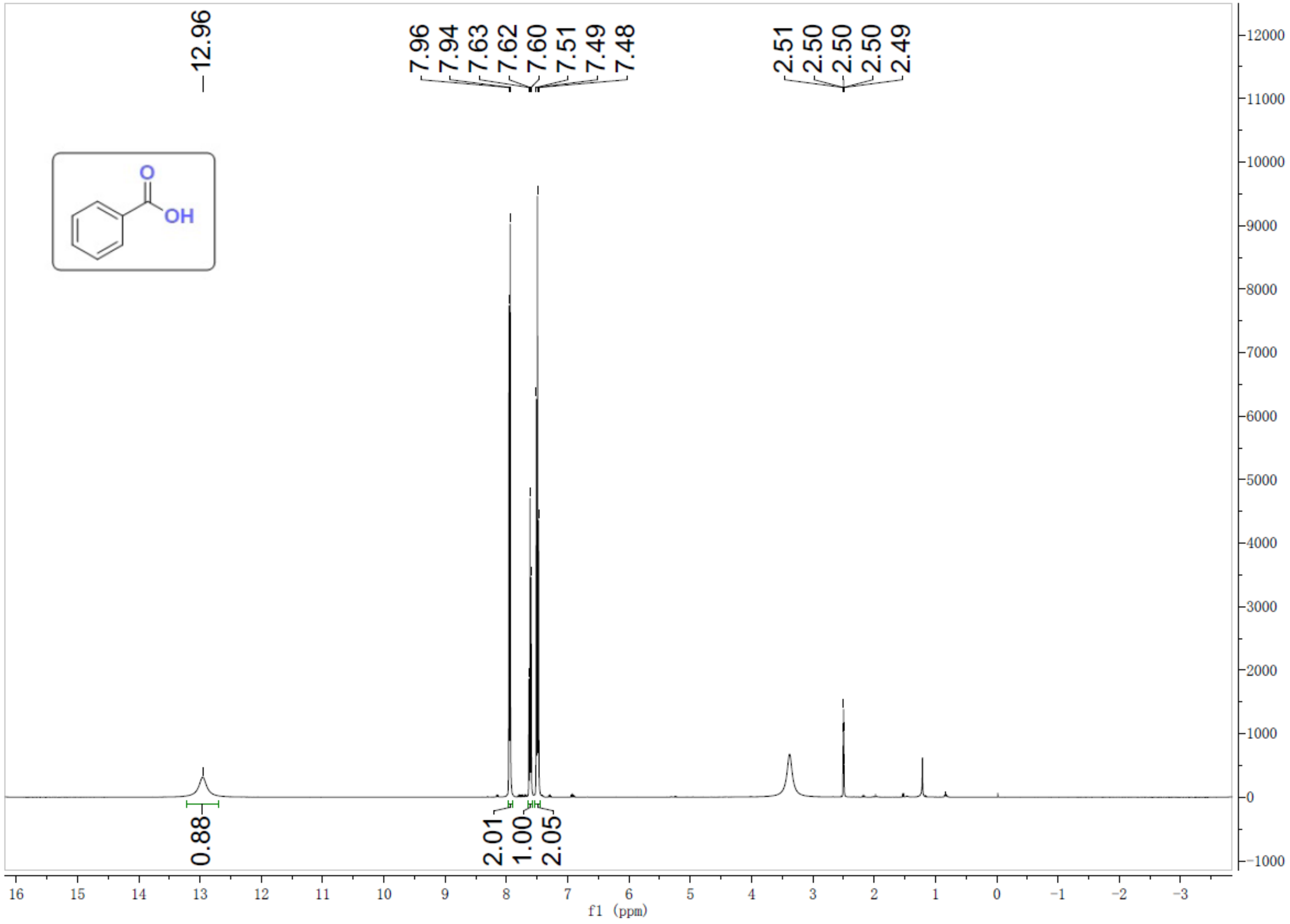


13.16
7.94
7.92
7.55
7.53
2.50
O
OH
Cl
0.85
2.00
1.99
4500
4000
3500
3000
2500
2000
1500
1000
500
0
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−2
−3
−4
f1 (ppm)

^{13}C NMR of 6h

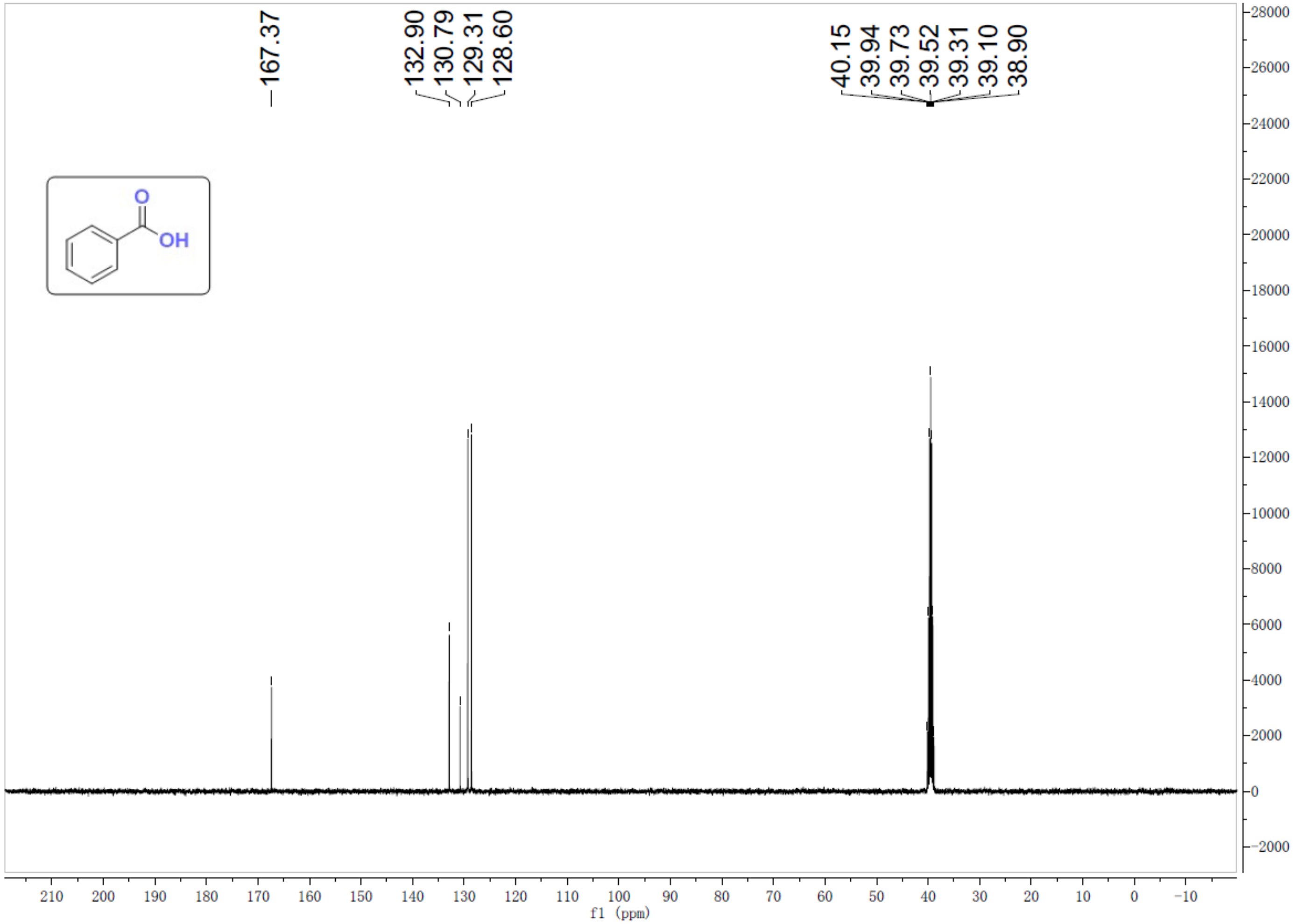

166.51
137.84
131.17
129.69
128.75
40.14
39.94
39.73
39.52
39.31
39.10
38.89
O
OH
Cl
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

^{1}H NMR of 6i

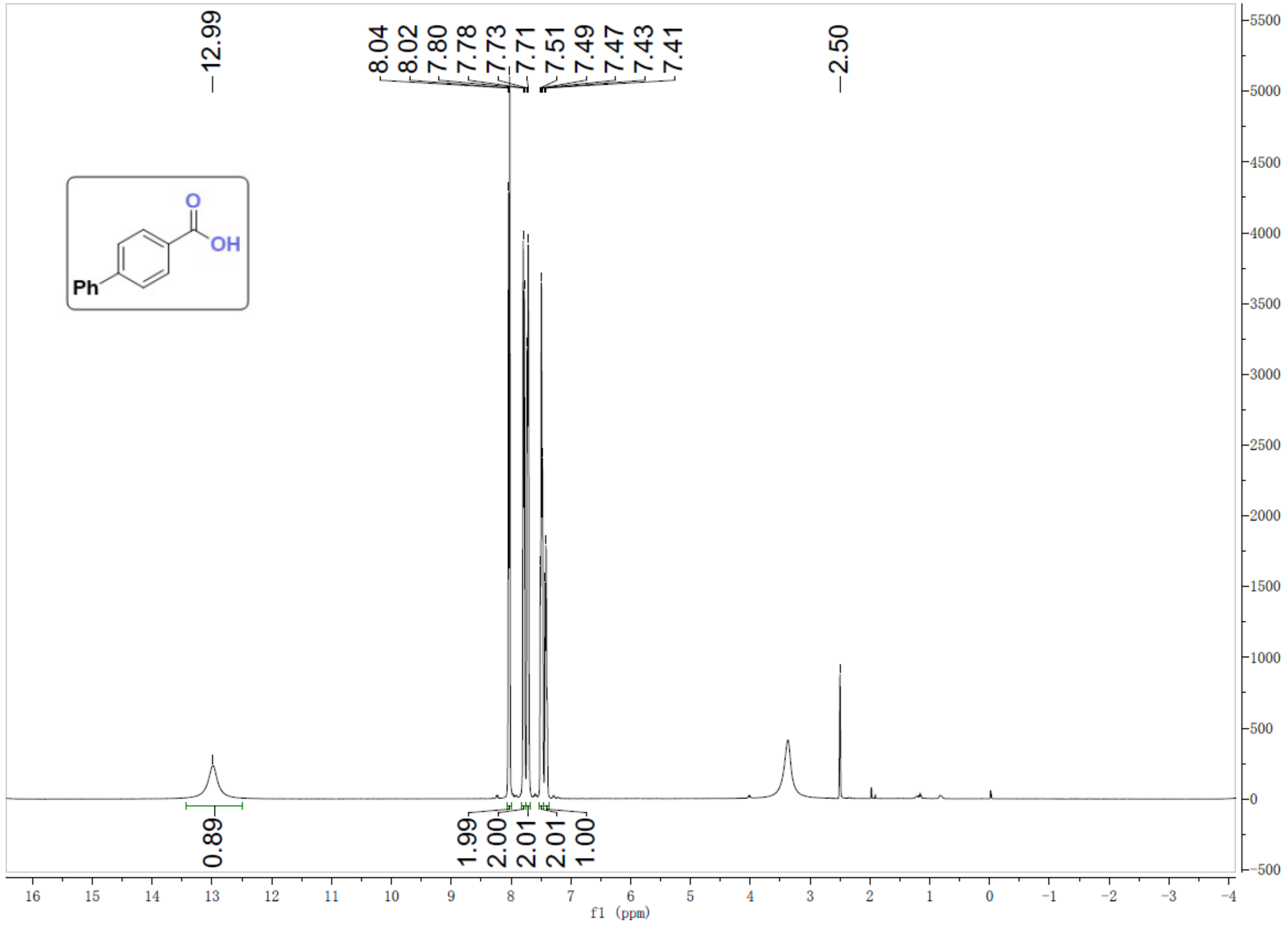


12.96
7.96
7.94
7.63
7.62
7.60
7.51
7.49
7.48
2.51
2.50
2.50
2.50
2.49
OH
O
0.88
2.01
1.00
2.05
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 6i

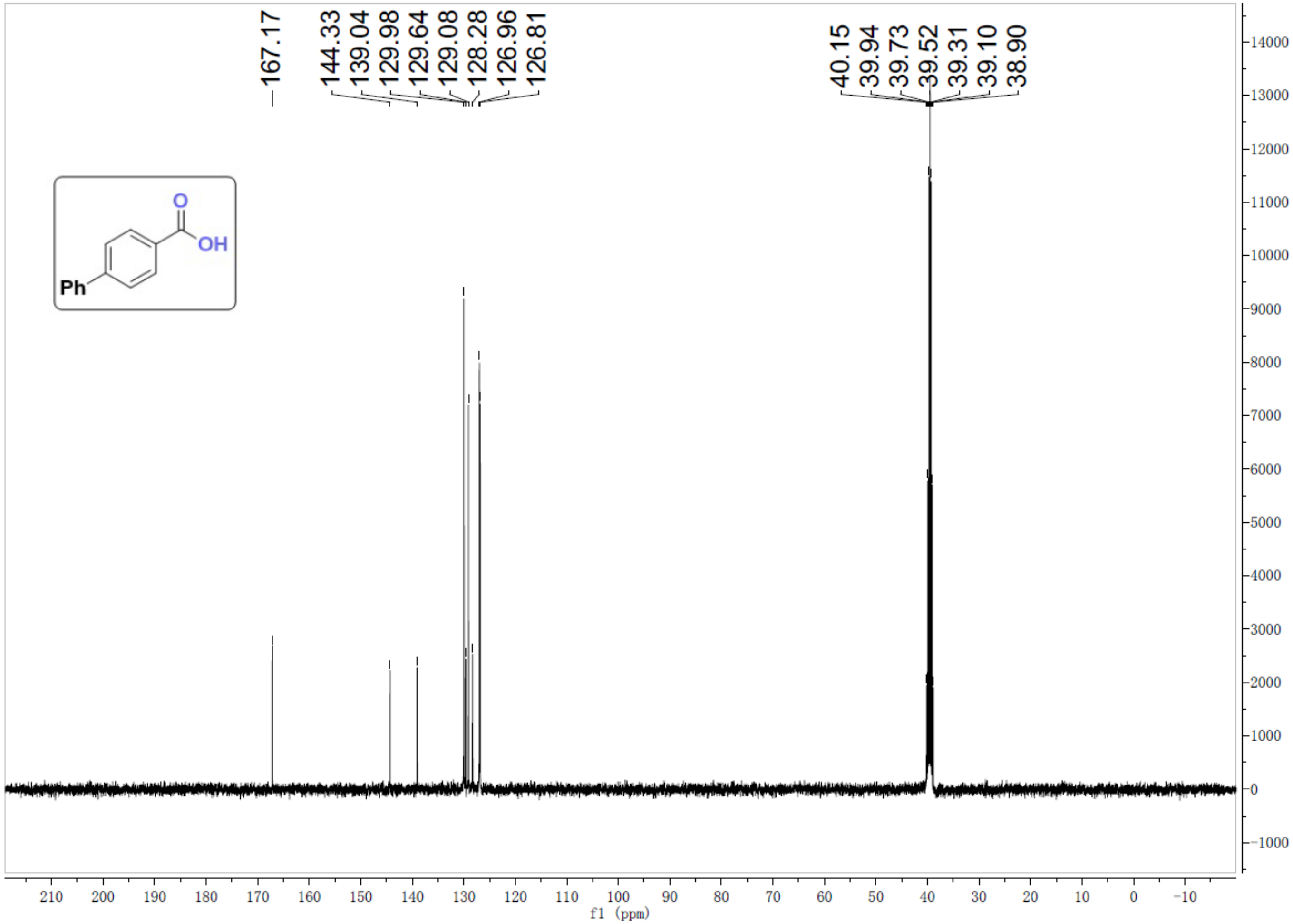

167.37
132.90
130.79
129.31
128.60
40.15
39.94
39.73
39.52
39.31
39.10
38.90
O
OH
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 6j

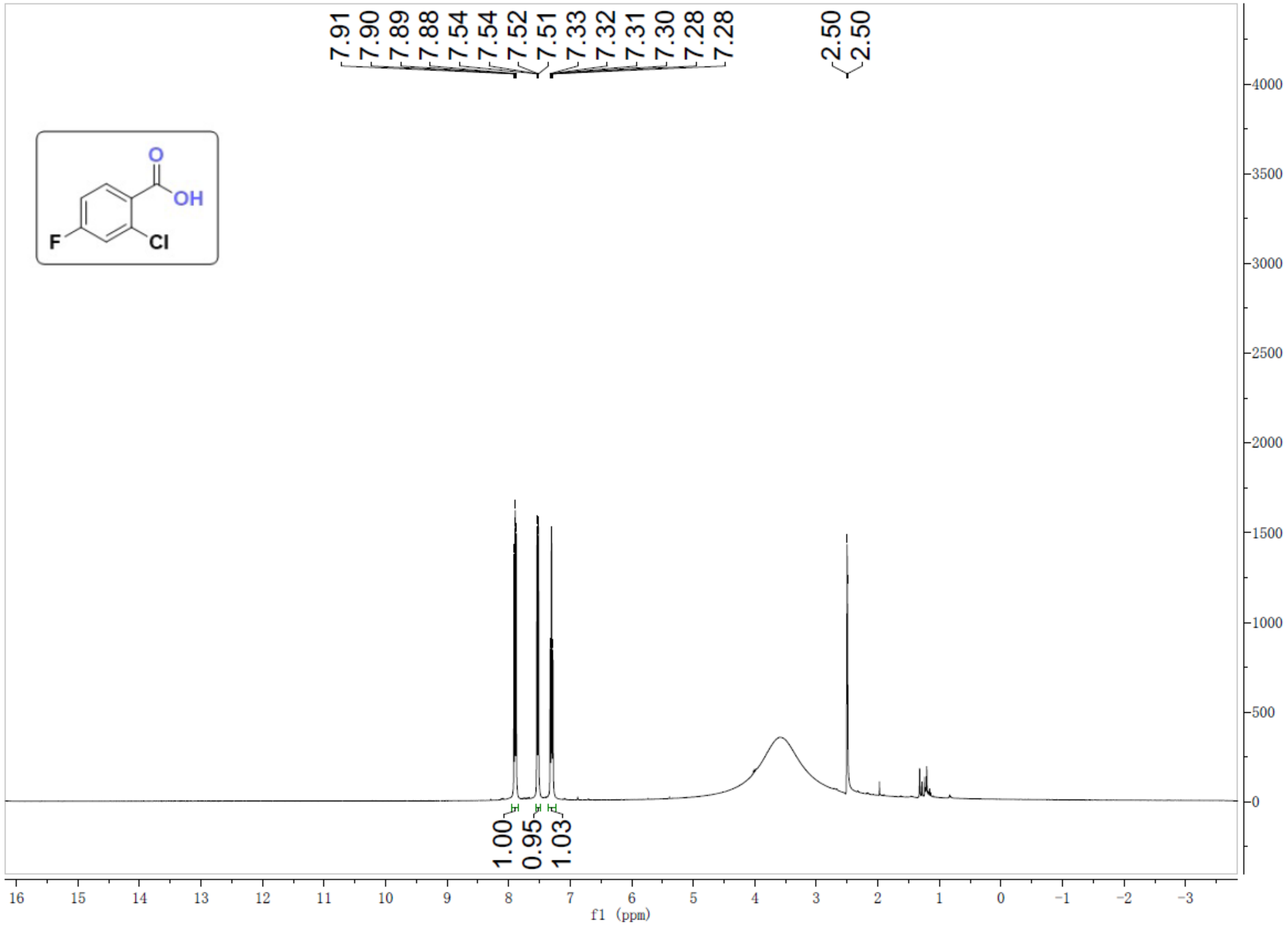


12.99
8.04
8.02
7.80
7.78
7.73
7.71
7.51
7.49
7.47
7.43
7.41
2.50
O
OH
Ph
0.89
1.99
2.00
2.01
2.01
1.00
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−2
−3
−4
f1 (ppm)
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
−500

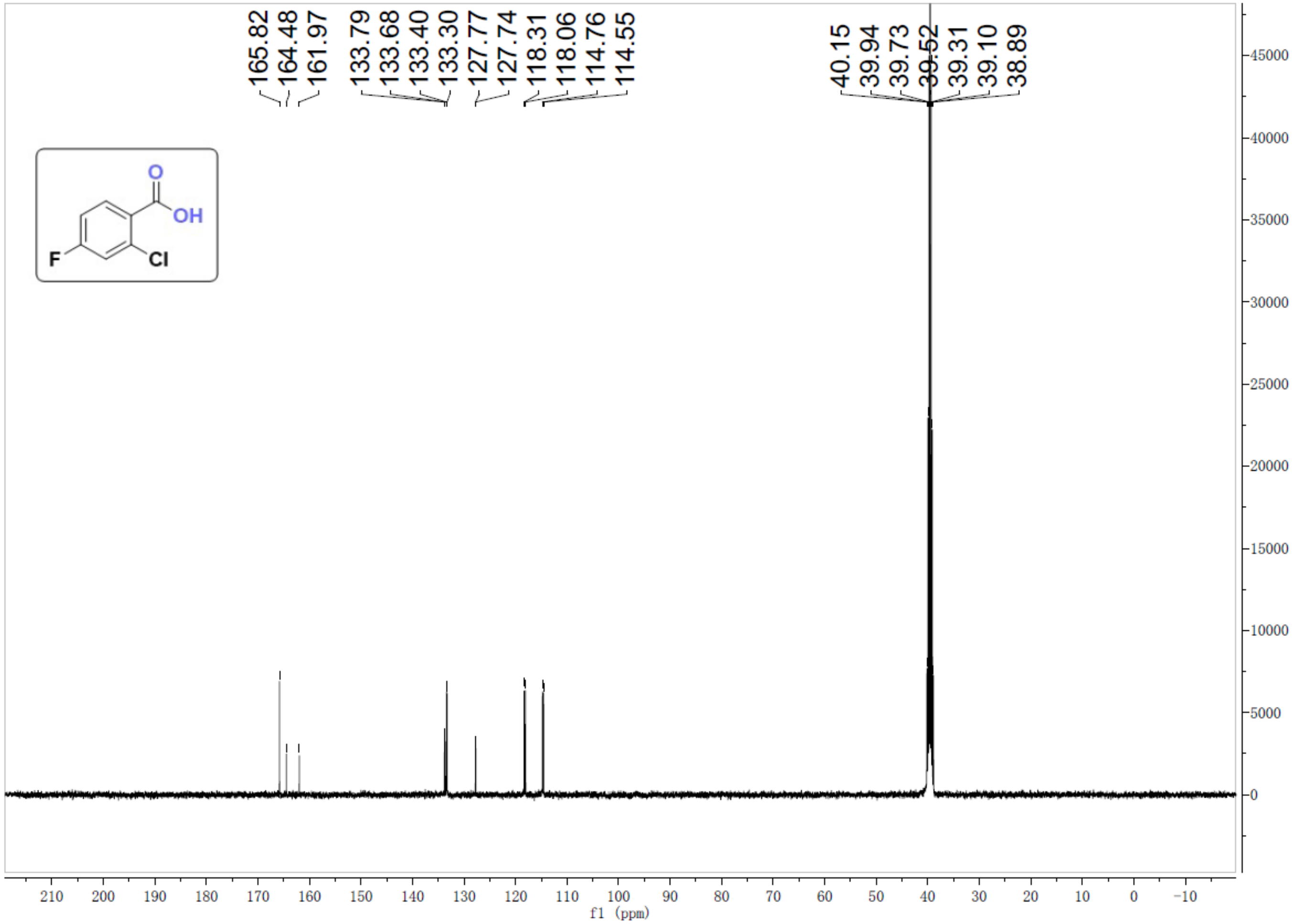
^{13}C NMR of 6j


167.17
144.33
139.04
129.98
129.64
129.08
128.28
126.96
126.81
40.15
39.94
39.73
39.52
39.31
39.10
38.90
O
OH
Ph
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)

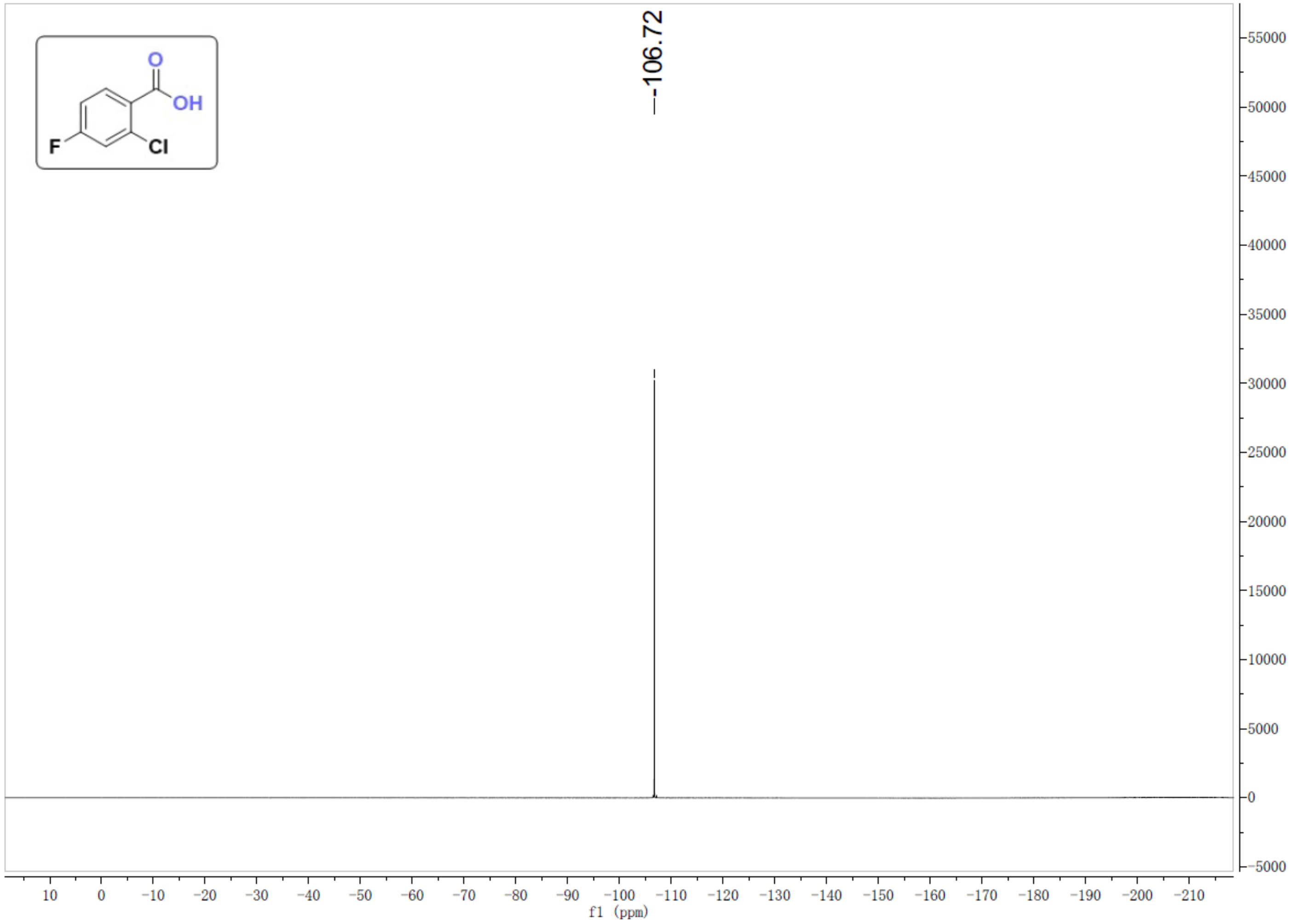
^{1}H NMR of 6k


7.91
7.90
7.89
7.88
7.54
7.54
7.52
7.51
7.33
7.32
7.31
7.30
7.28
7.28
2.50
2.50
O
OH
F
Cl
1.00
0.95
1.03
4000
3500
3000
2500
2000
1500
1000
500
0
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 6k


165.82
164.48
161.97
133.79
133.68
133.40
133.30
127.77
127.74
118.31
118.06
114.76
114.55
40.15
39.94
39.73
39.52
39.31
39.10
38.89
O
OH
F
Cl
45000
40000
35000
30000
25000
20000
15000
10000
5000
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)

^{19}F NMR of 6k



O
OH
F
Cl
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50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
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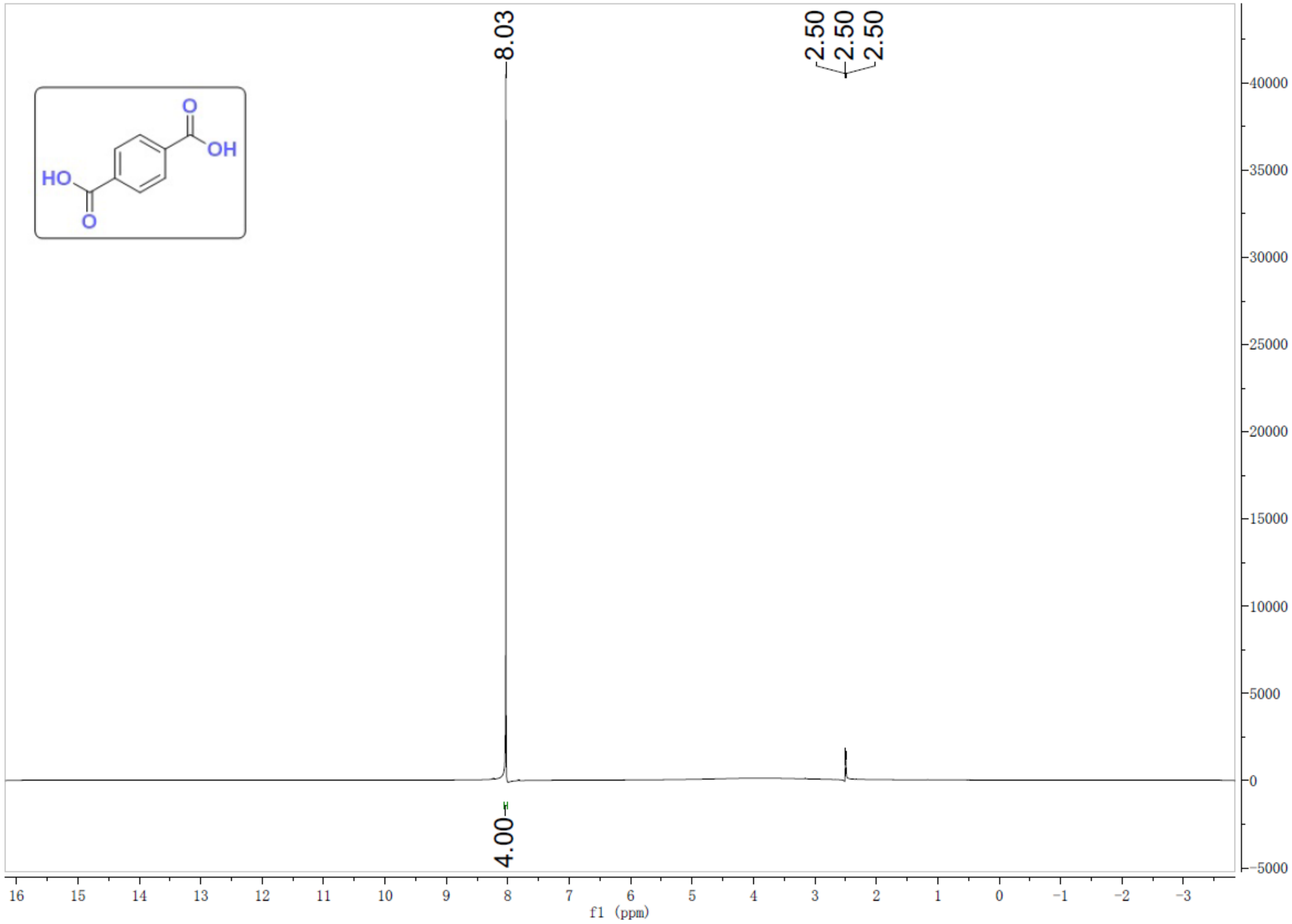
-190
-200
-210
f1 (ppm)

^{1}H NMR of 6l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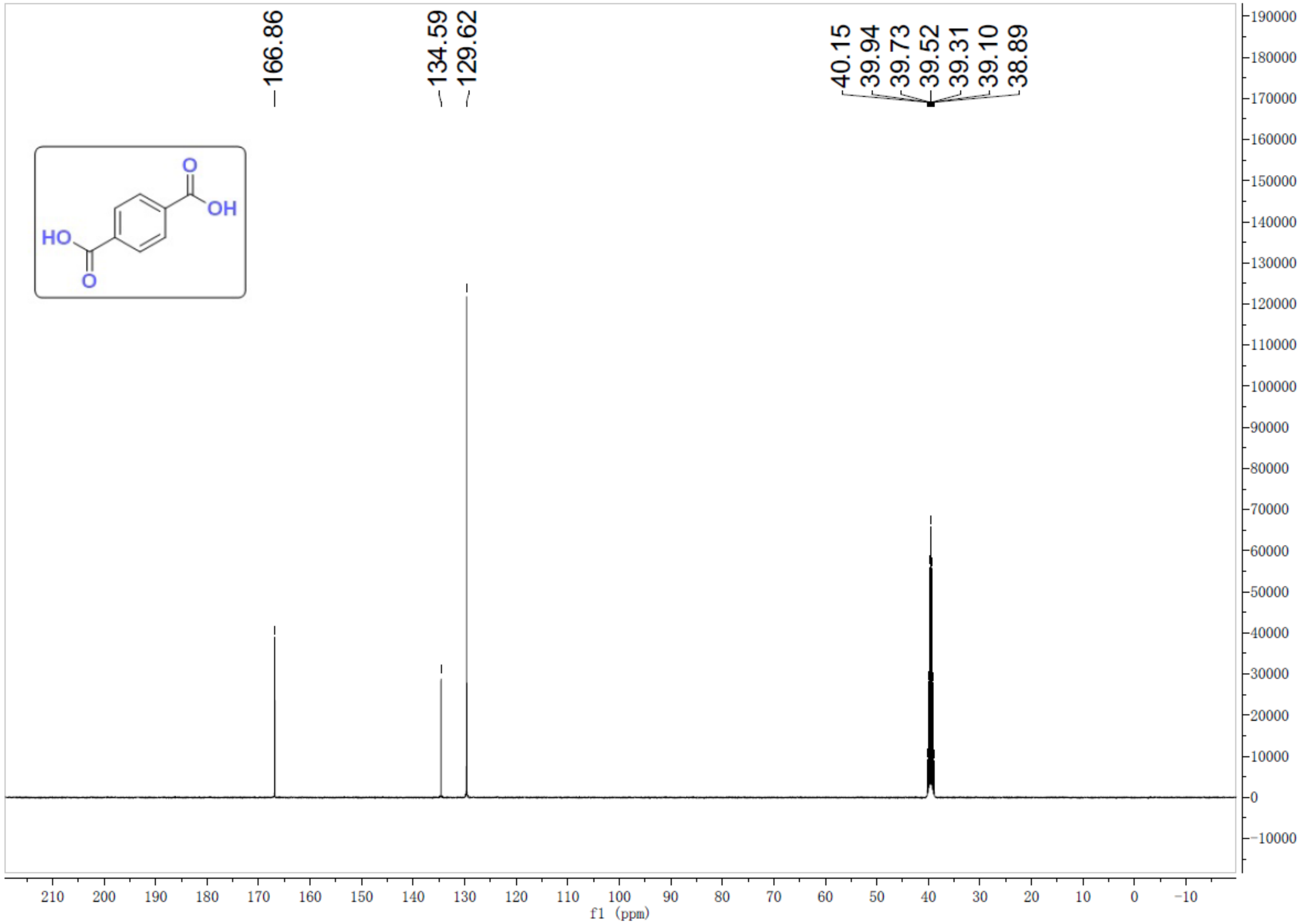
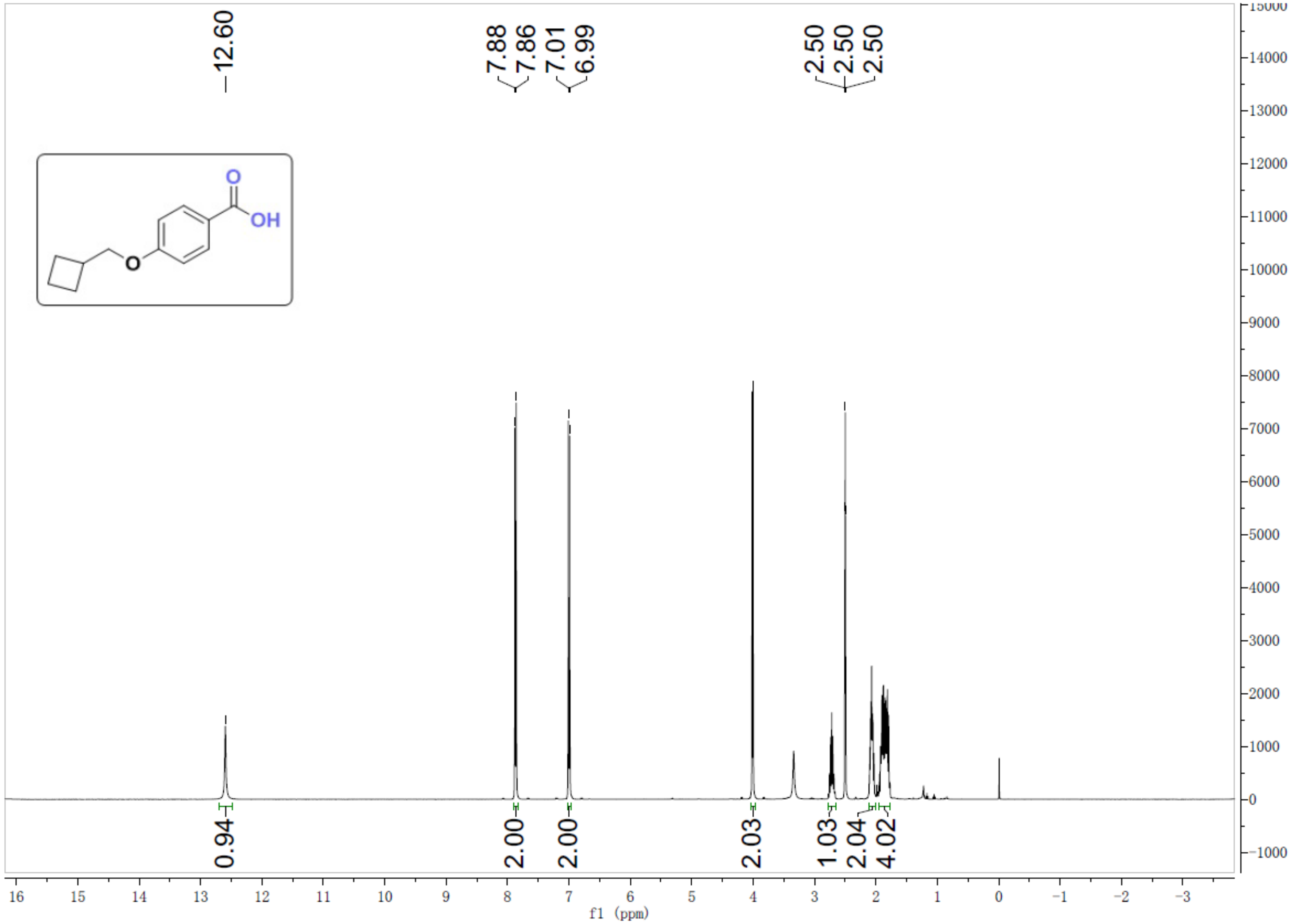
2.50
2.50
2.50
4.00
HO
OH
O
O
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 6l



166.86
134.59
129.62
40.15
39.94
39.73
39.52
39.31
39.10
38.89
O
OH
HO
O
190000
180000
170000
160000
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
−10000
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)

^{1}H NMR of 6m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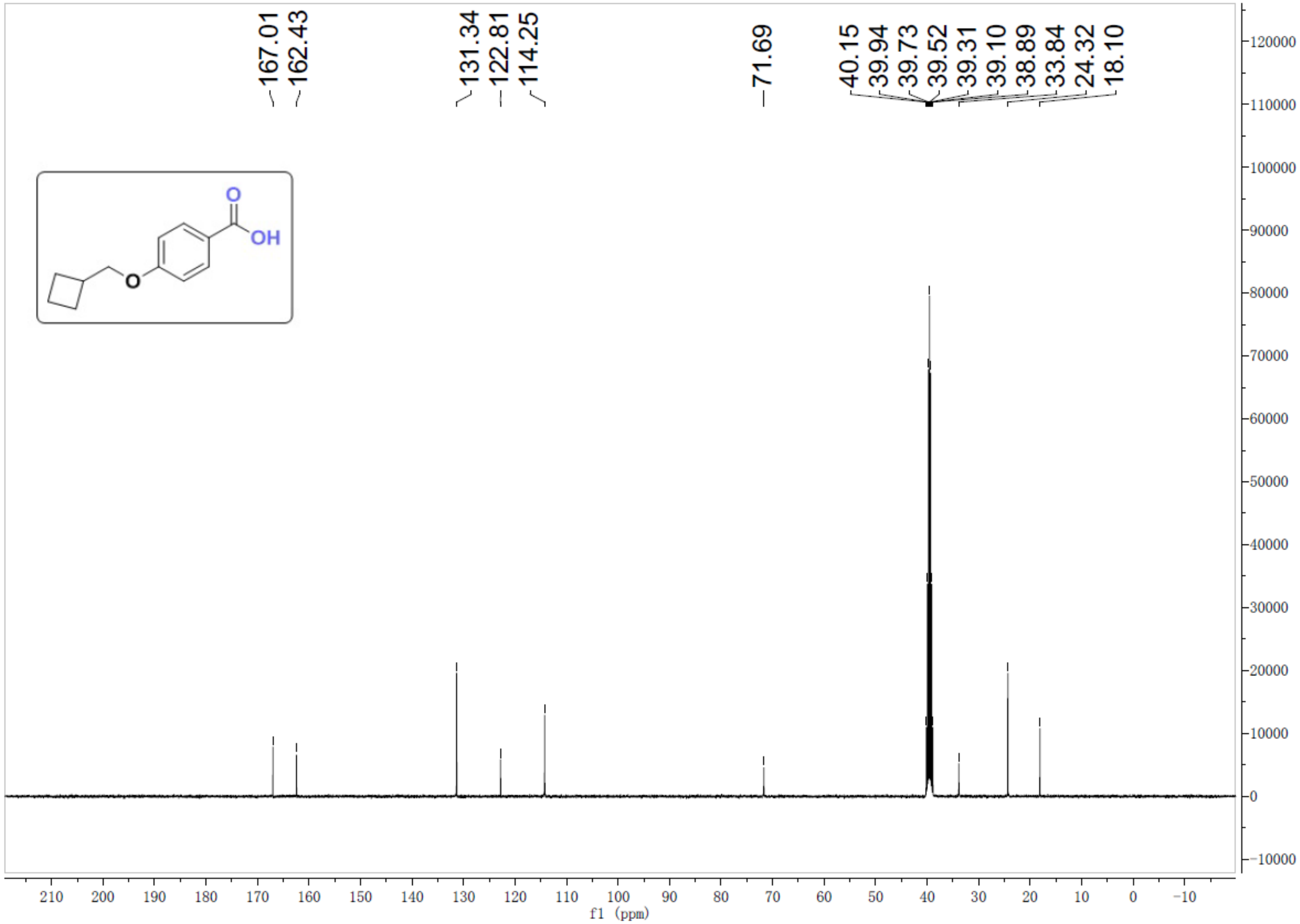
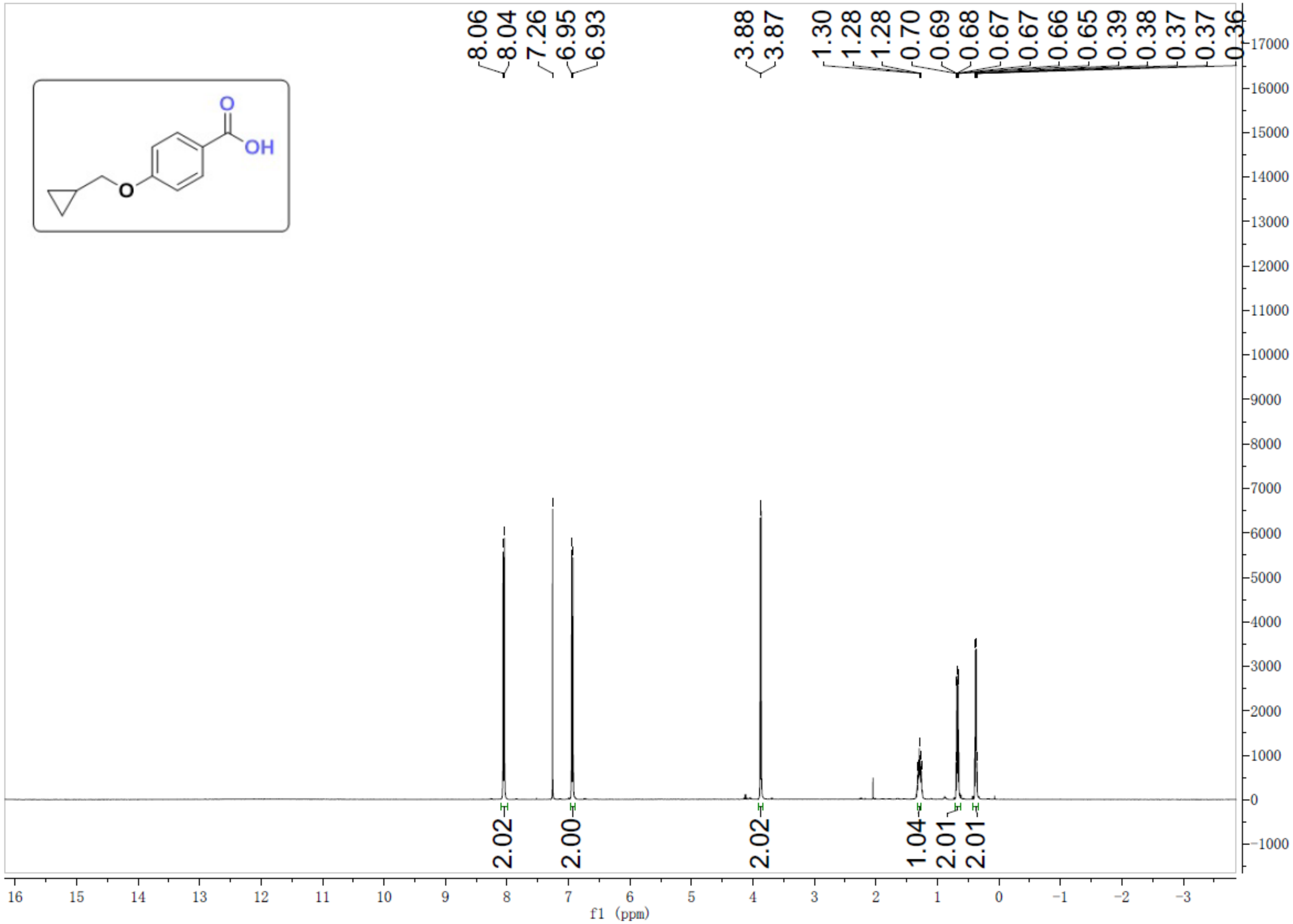
7.88
7.86
7.01
6.99
2.50
2.50
2.50
O
OH
O
0.94
2.00
2.00
2.03
1.03
2.04
4.02
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000

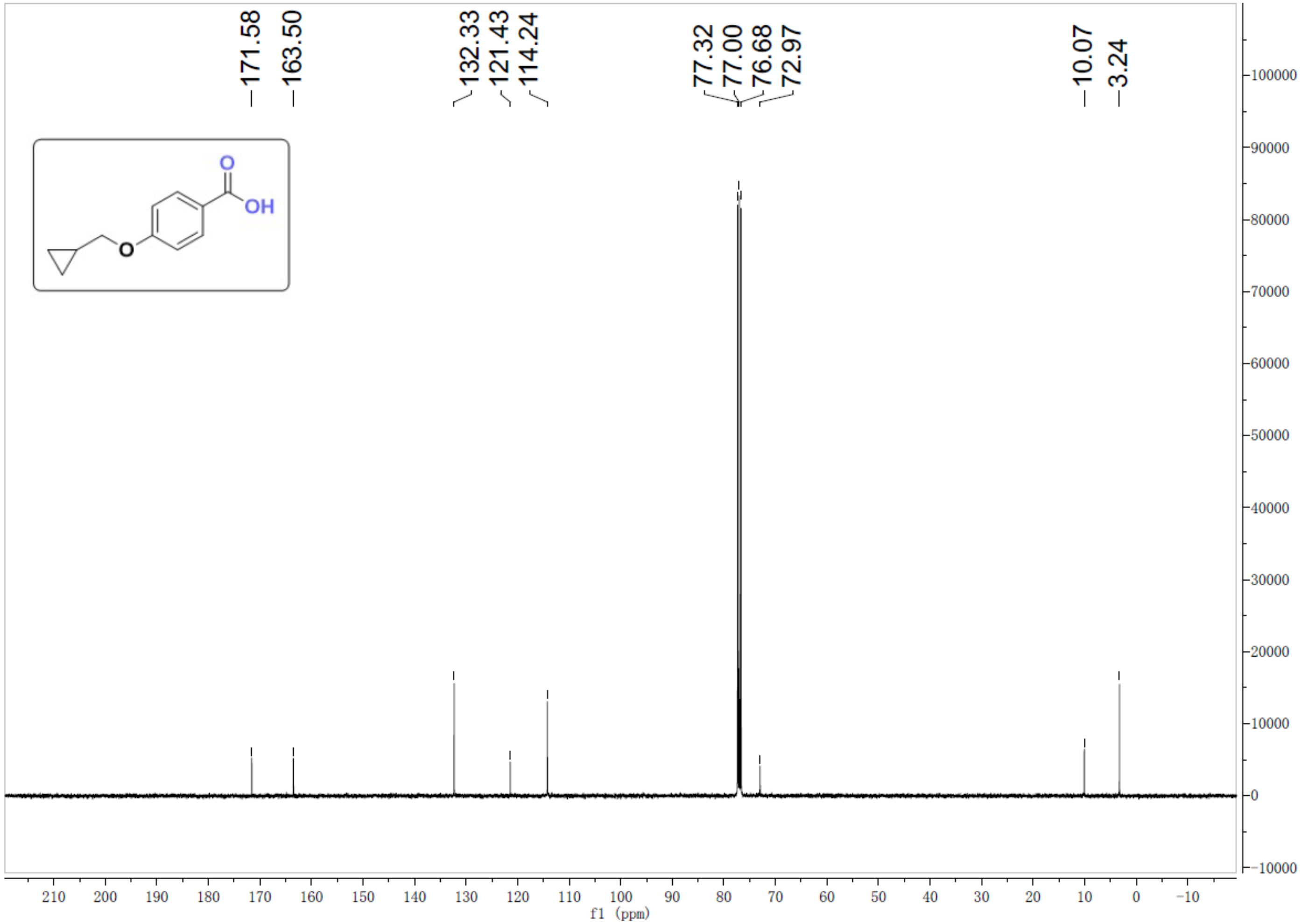
^{13}C NMR of 6m


167.01
162.43
131.34
122.81
114.25
71.69
40.15
39.94
39.73
39.52
39.31
39.10
38.89
33.84
24.32
18.10
O
OH
O
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
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)

^{1}H NMR of 6n

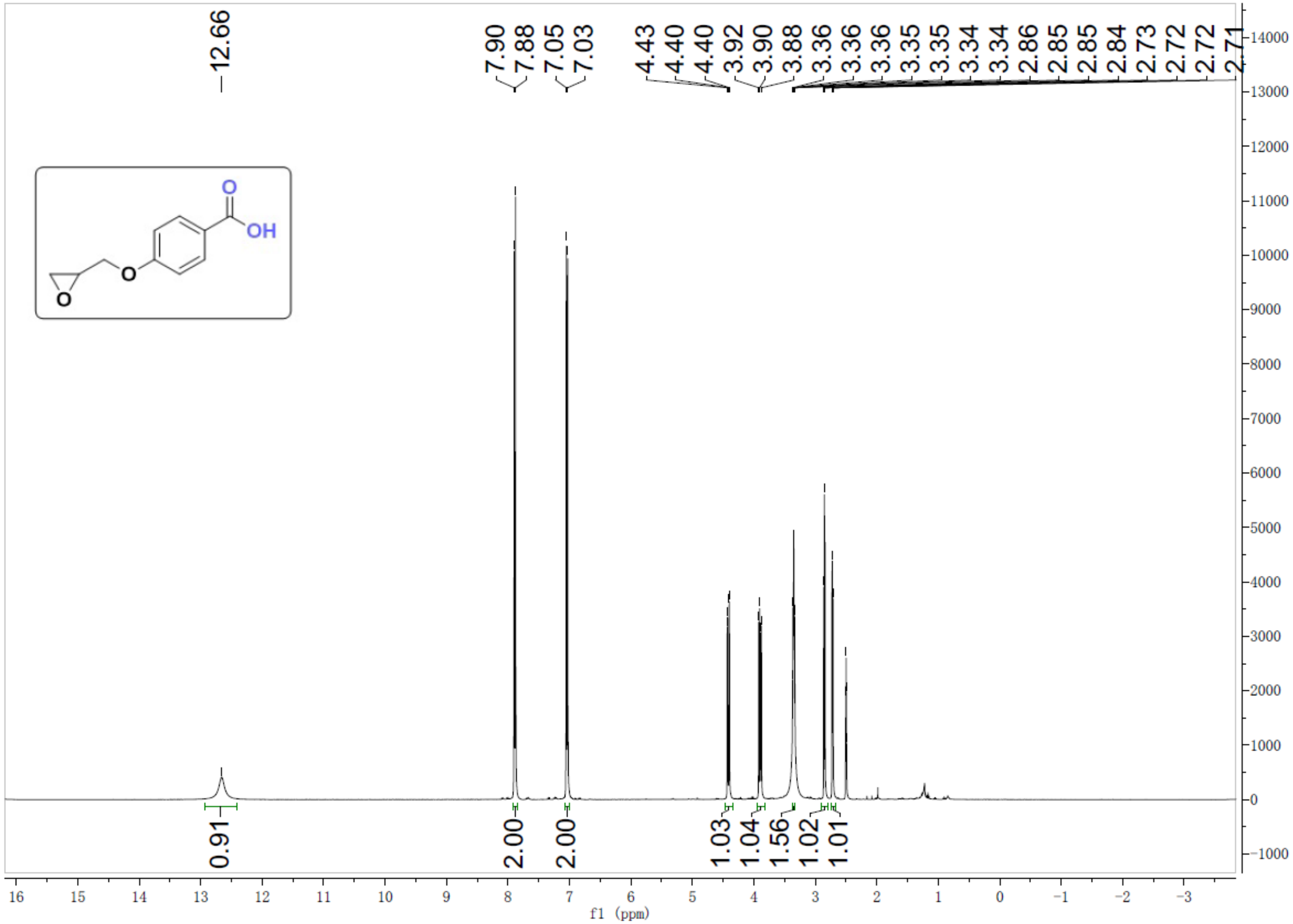

O
OH
O
8.06
8.04
7.26
6.95
6.93
3.88
3.87
1.30
1.28
1.28
0.70
0.69
0.68
0.67
0.67
0.66
0.65
0.39
0.38
0.37
0.37
0.36
2.02
2.00
2.02
1.04
2.01
2.01
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 6n

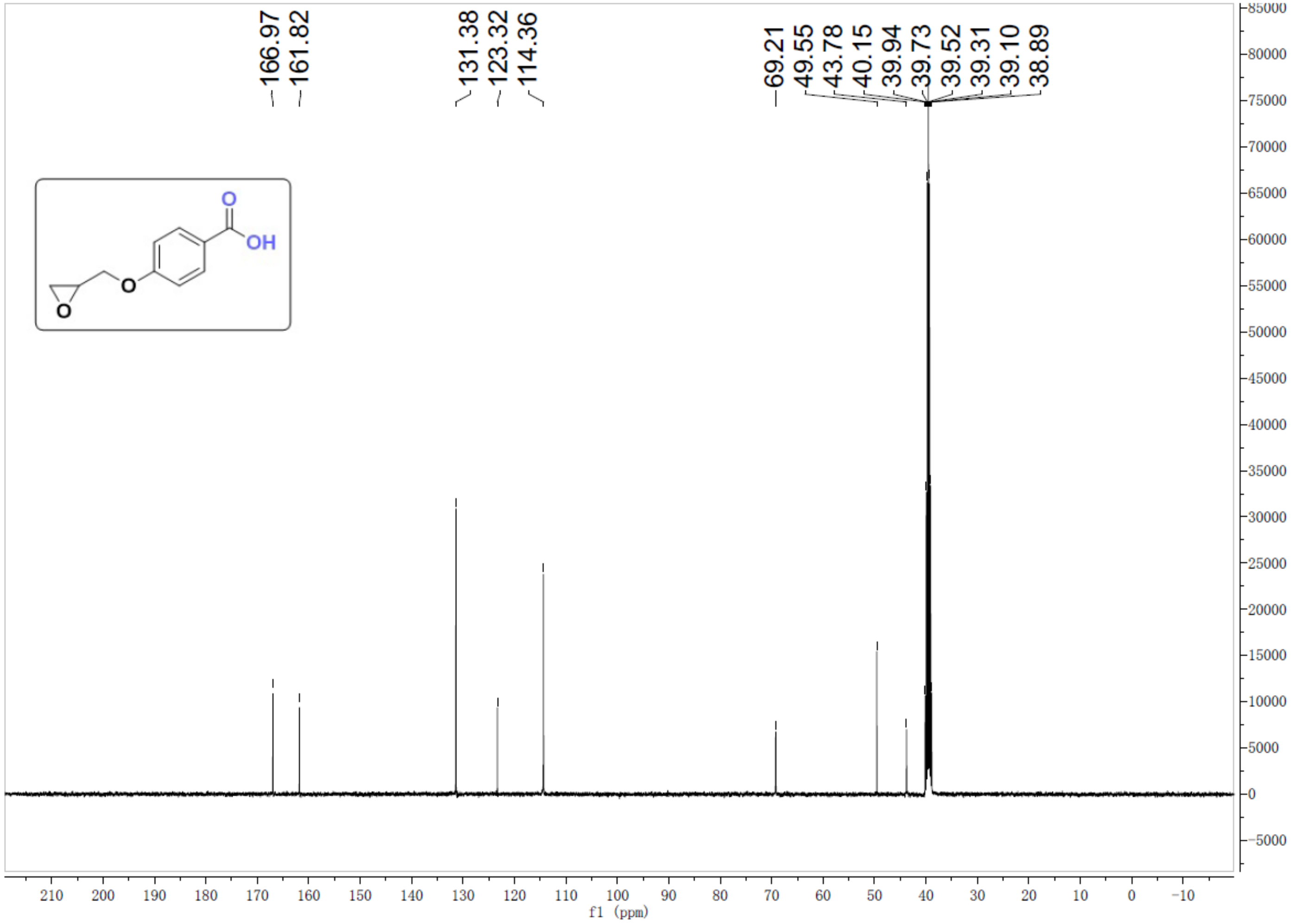


171.58
163.50
132.33
121.43
114.24
77.32
77.00
76.68
72.97
10.07
3.24
O
OH
O
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 6o

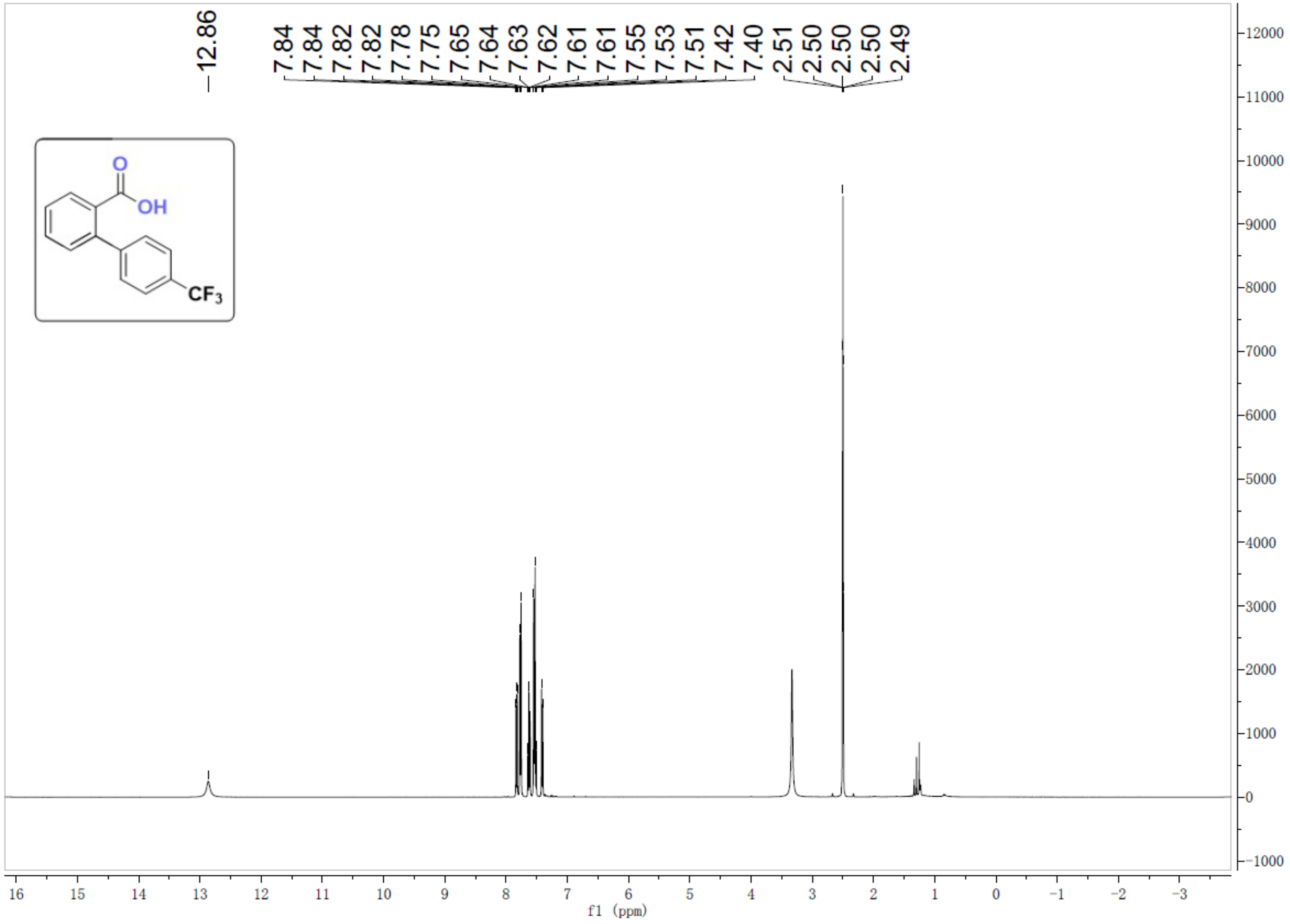

12.66
7.90
7.88
7.05
7.03
4.43
4.40
4.40
3.92
3.90
3.88
3.36
3.36
3.36
3.35
3.35
3.34
3.34
2.86
2.85
2.85
2.84
2.73
2.72
2.72
2.71
0.91
2.00
2.00
1.03
1.04
1.56
1.02
1.01
O
OH
O
O
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−2
−3
f1 (ppm)

^{13}C NMR of 6o



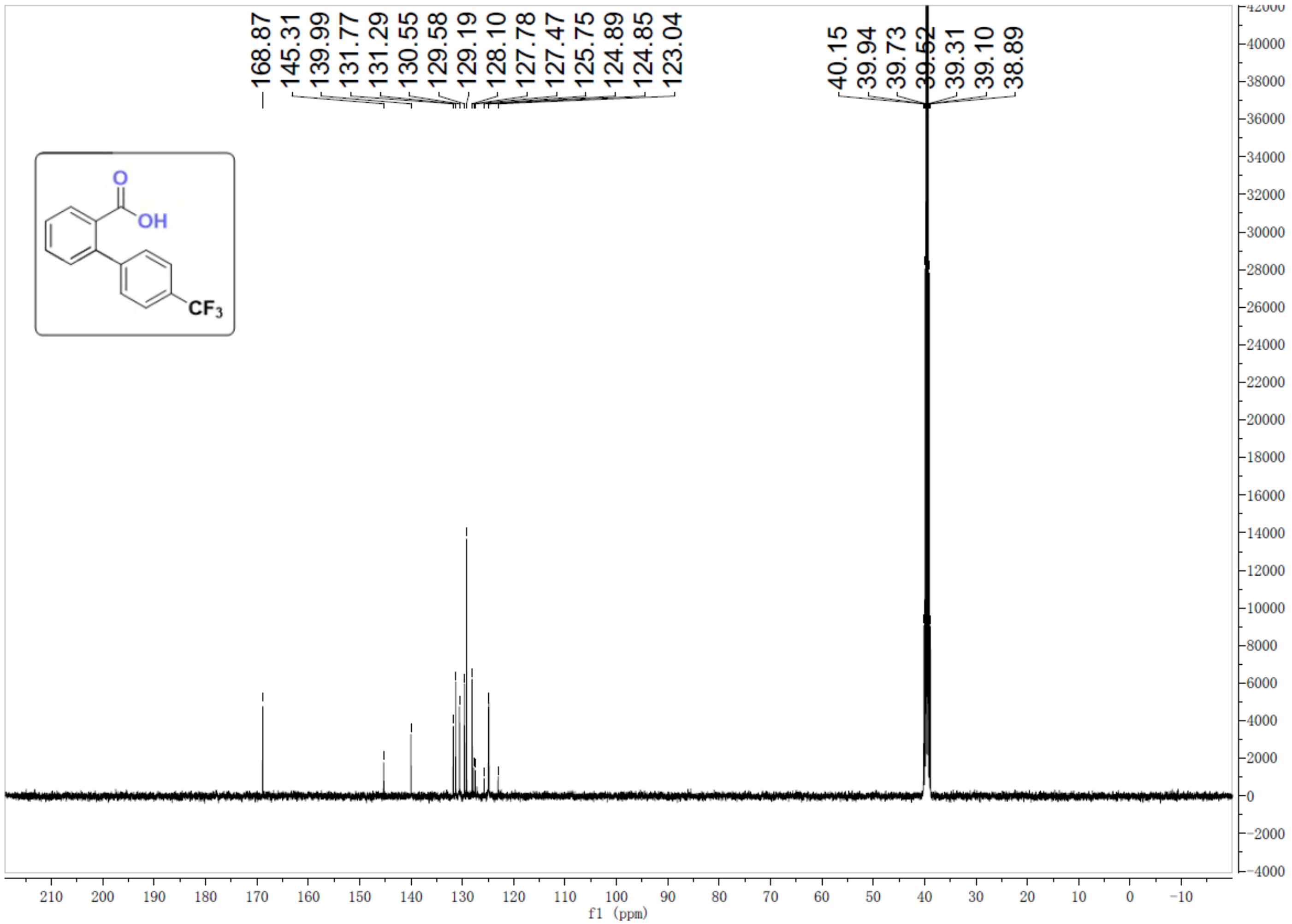
166.97
161.82
131.38
123.32
114.36
69.21
49.55
43.78
40.15
39.94
39.73
39.52
39.31
39.10
38.89
O
OH
O
O
85000
80000
75000
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 6p

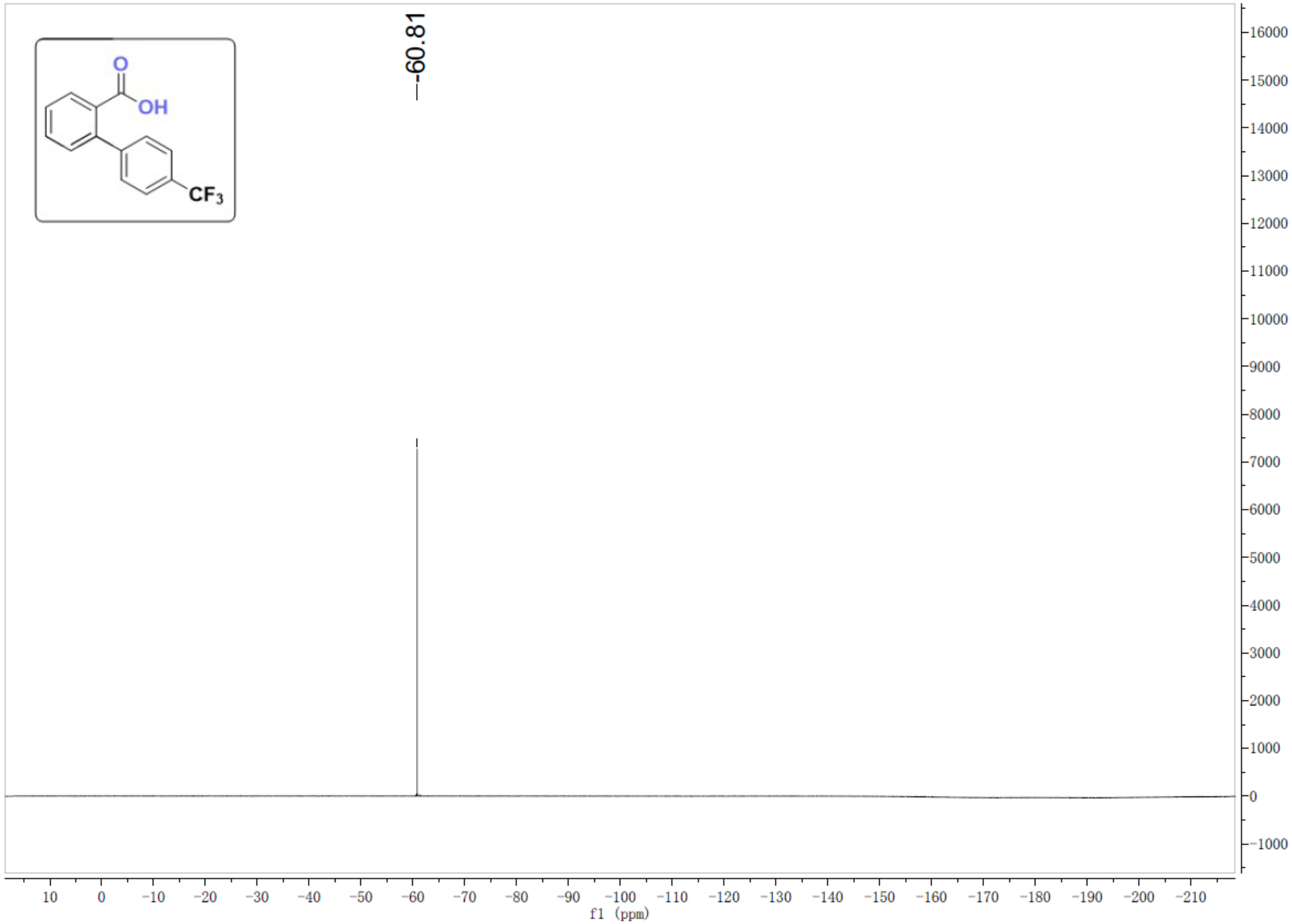


12.86
7.84
7.84
7.82
7.82
7.78
7.75
7.65
7.64
7.63
7.62
7.61
7.61
7.55
7.53
7.51
7.42
7.40
2.51
2.50
2.50
2.50
2.49
O
OH
CF3
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 6p

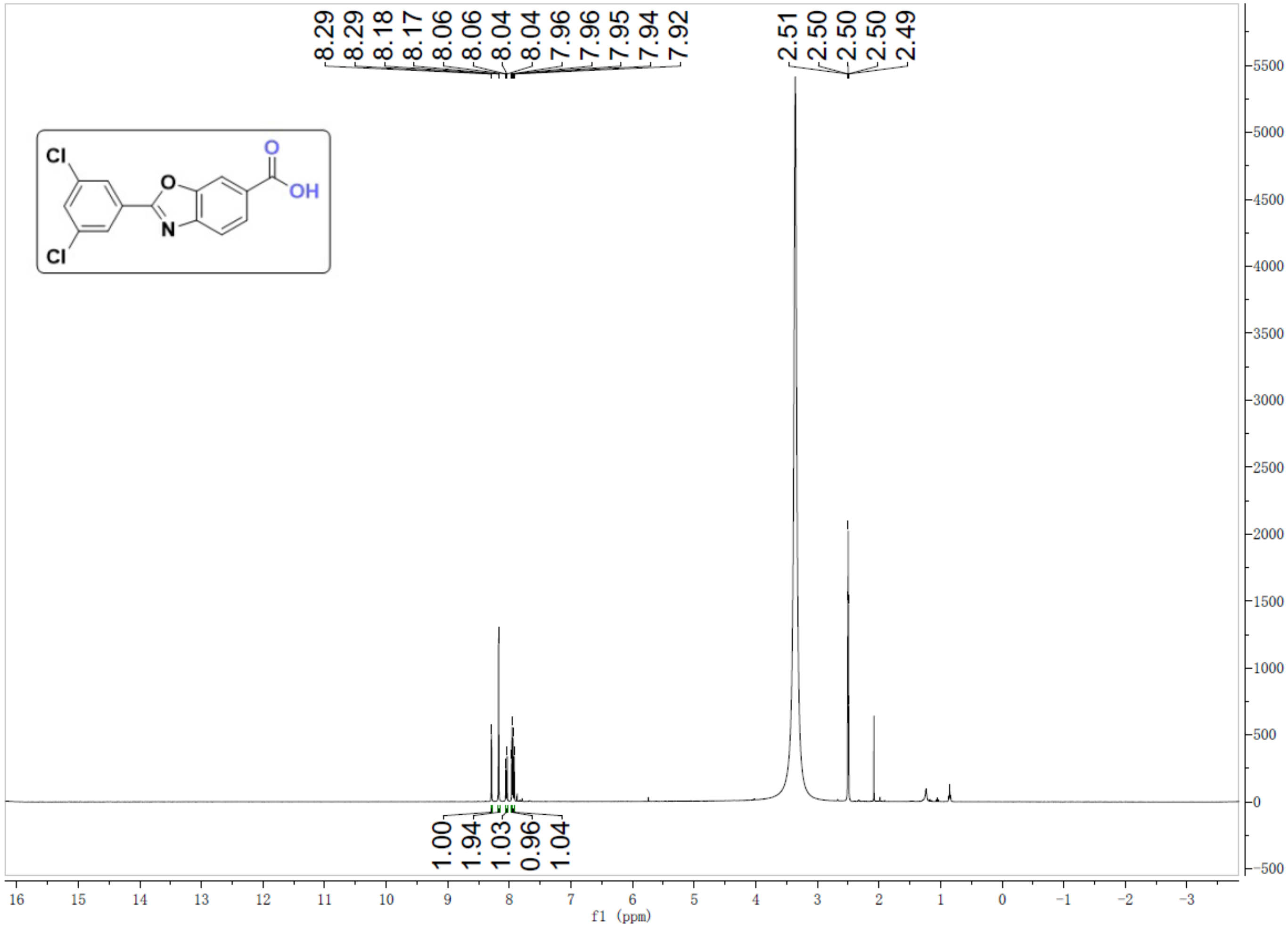

168.87
145.31
139.99
131.77
131.29
130.55
129.58
129.19
128.10
127.78
127.47
125.75
124.89
124.85
123.04
40.15
39.94
39.73
39.52
39.31
39.10
38.89
O
OH
CF3
f1 (ppm)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
42000
40000
38000
36000
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
-4000

^{19}F NMR of 6p



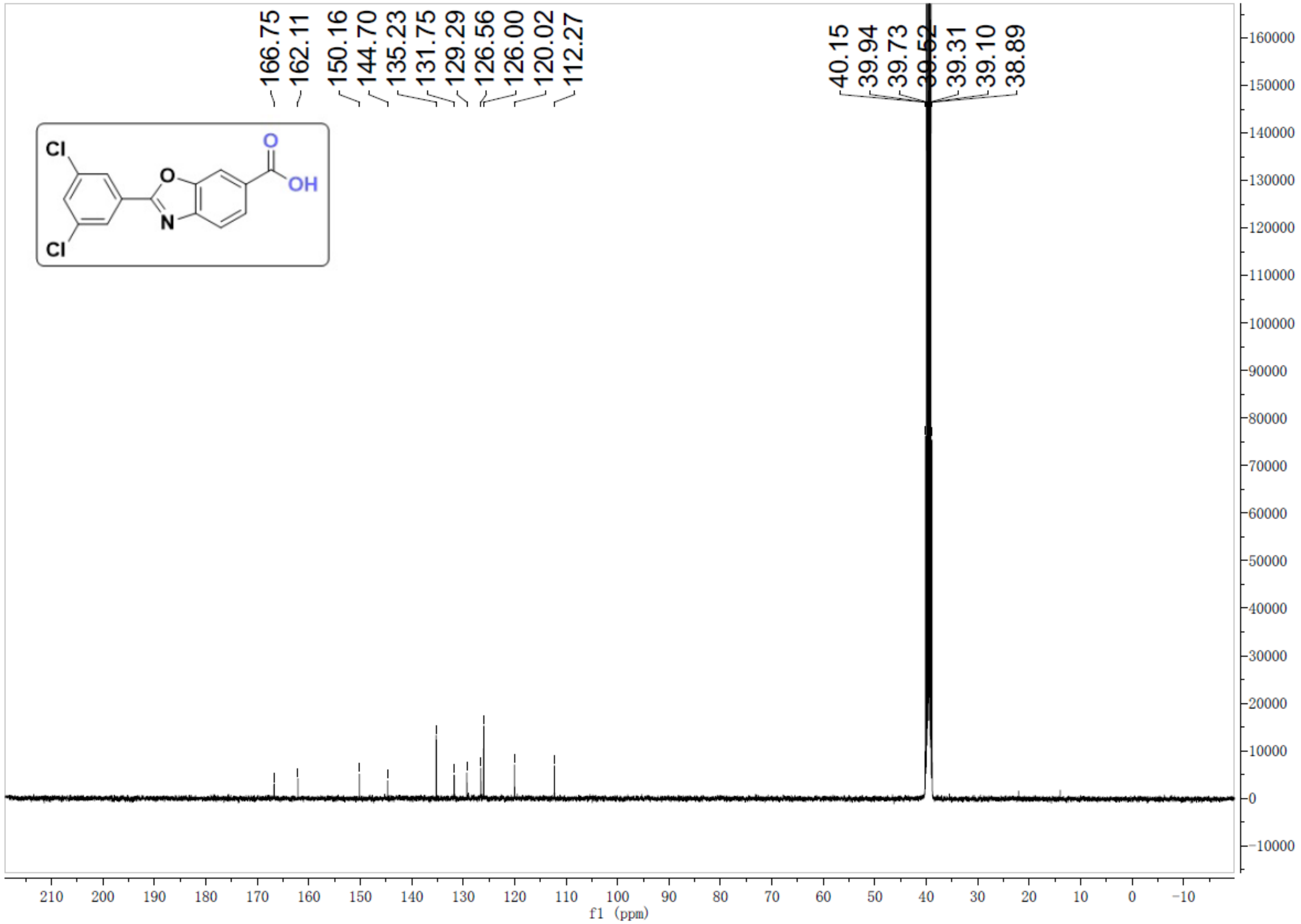
O
OH
CF3
-60.81
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

^{1}H NMR of 6q

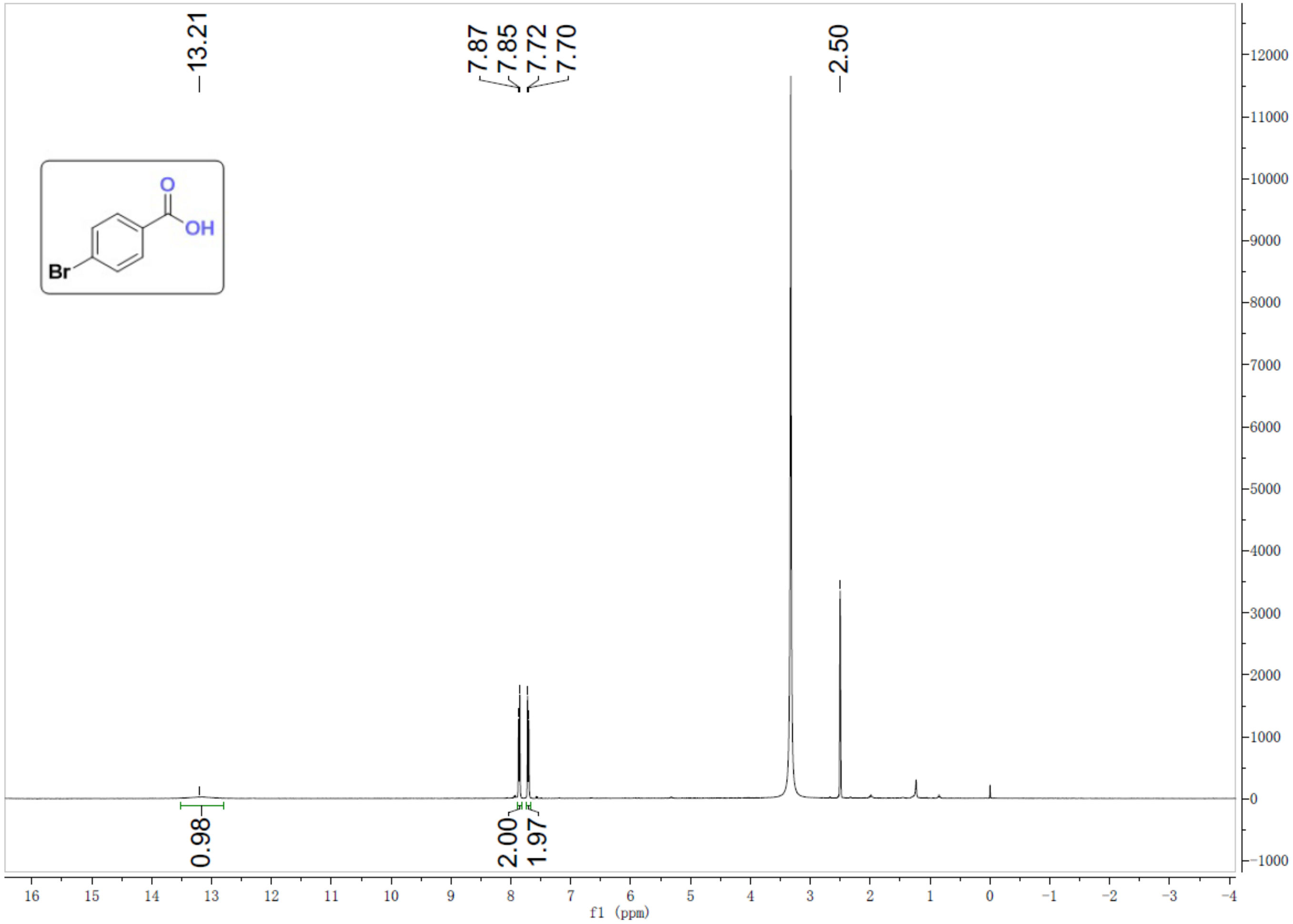


8.29
8.29
8.18
8.17
8.06
8.06
8.04
8.04
7.96
7.96
7.95
7.94
7.92
2.51
2.50
2.50
2.50
2.49
Cl
Cl
O
N
O
OH
1.00
1.94
1.03
0.96
1.04
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)

^{13}C NMR of 6q

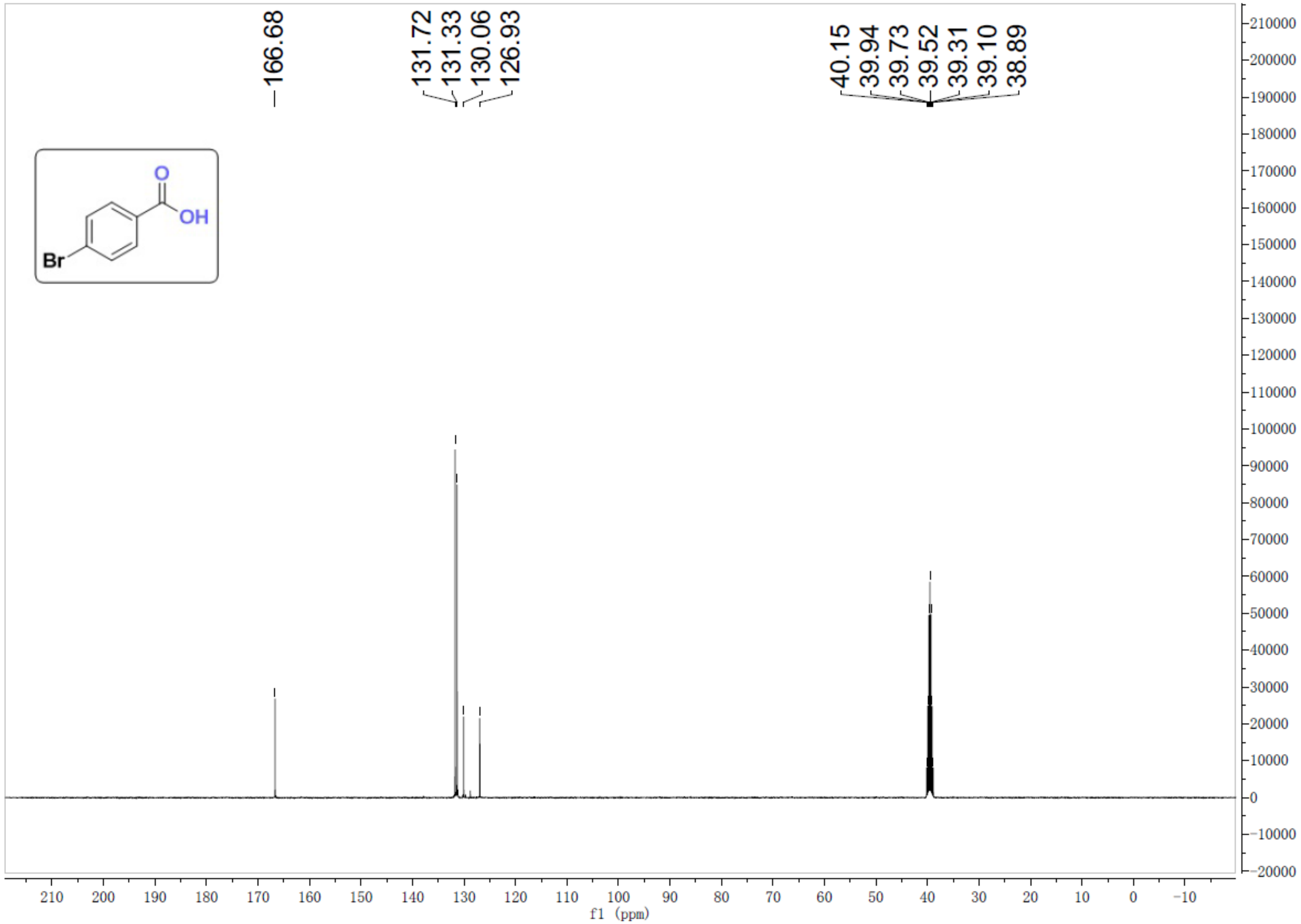

166.75
162.11
150.16
144.70
135.23
131.75
129.29
126.56
126.00
120.02
112.27
40.15
39.94
39.73
39.52
39.31
39.10
38.89
Cl
Cl
O
N
O
OH
160000
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

^{1}H NMR of 6r

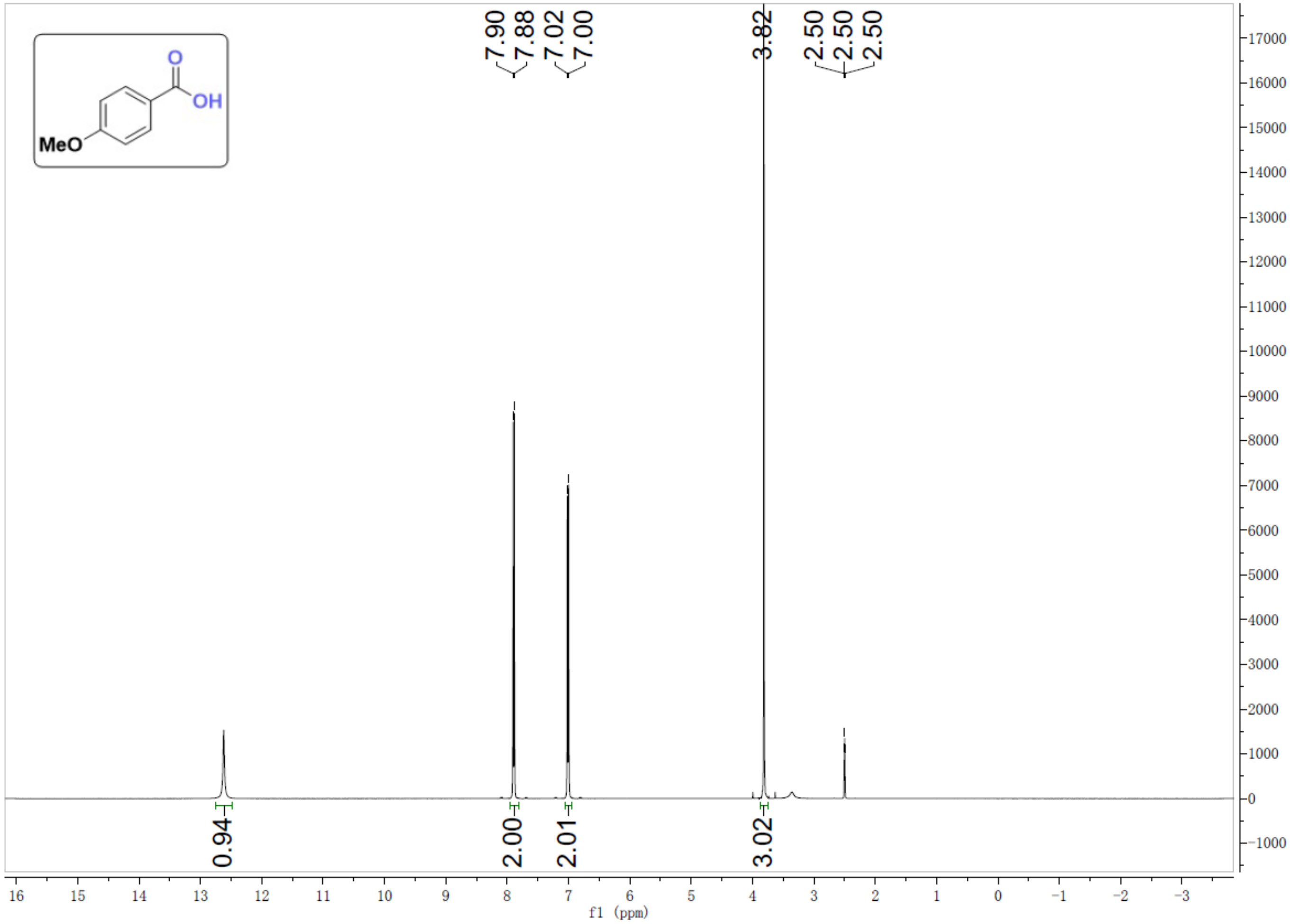


13.21
7.87
7.85
7.72
7.70
2.50
O
OH
Br
0.98
2.00
1.97
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
f1 (ppm)

^{13}C NMR of 6r

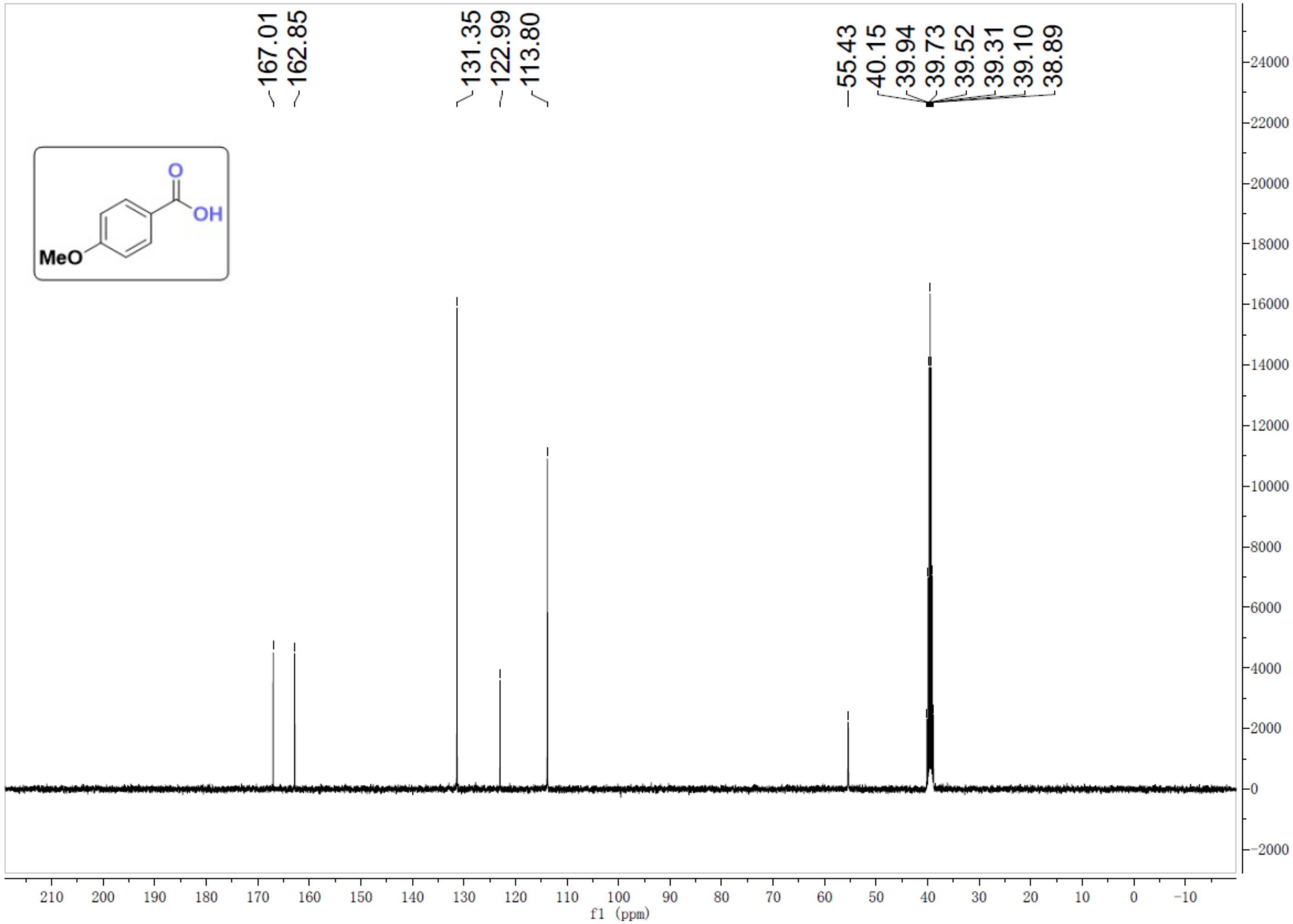

166.68
131.72
131.33
130.06
126.93
40.15
39.94
39.73
39.52
39.31
39.10
38.89
Br
O
OH
210000
200000
190000
180000
170000
160000
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
−10000
−20000
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

^{1}H NMR of 6s

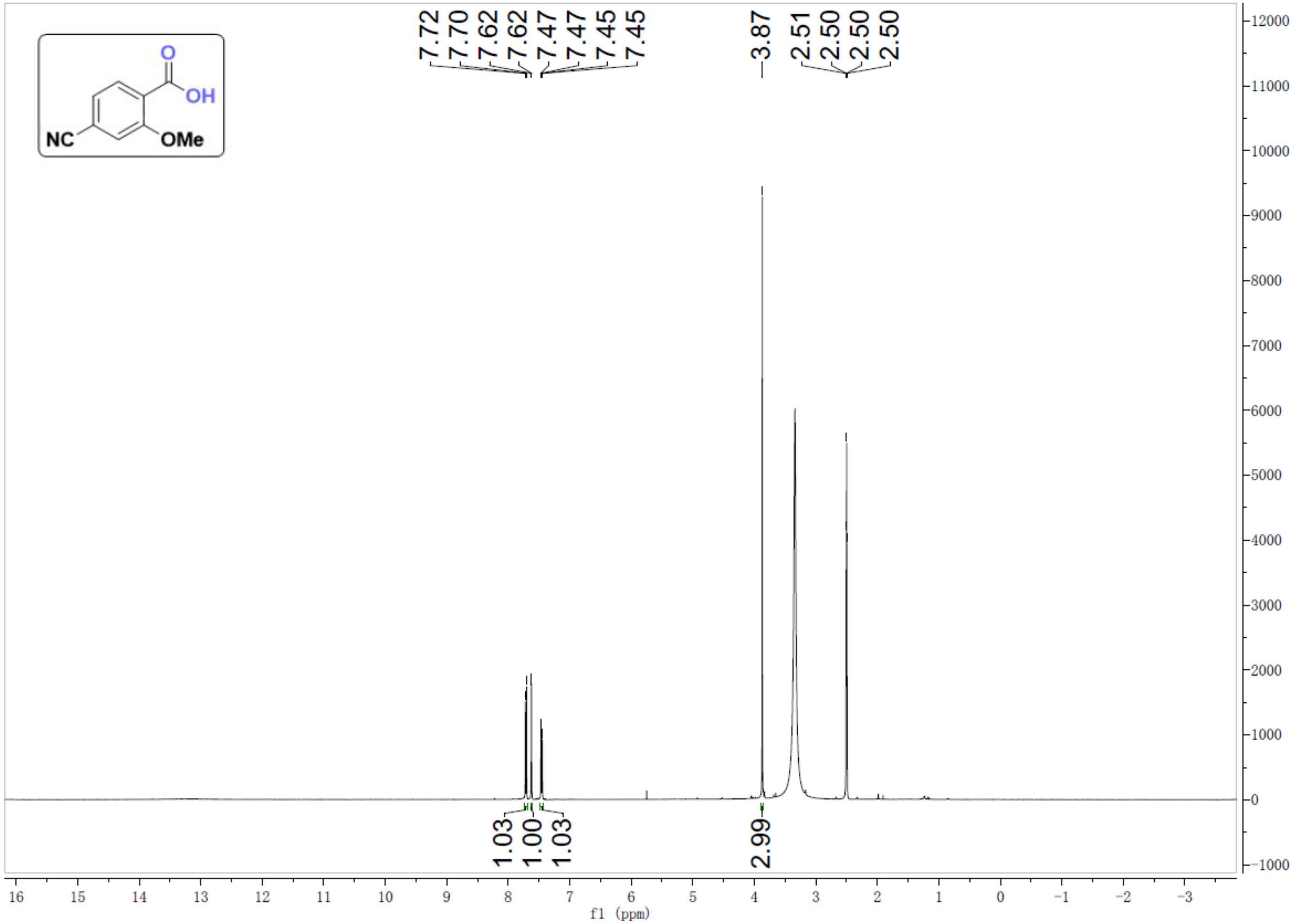


MeO
O
OH
7.90
7.88
7.02
7.00
3.82
2.50
2.50
2.50
0.94
2.00
2.01
3.02
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
−2
−3
f1 (ppm)

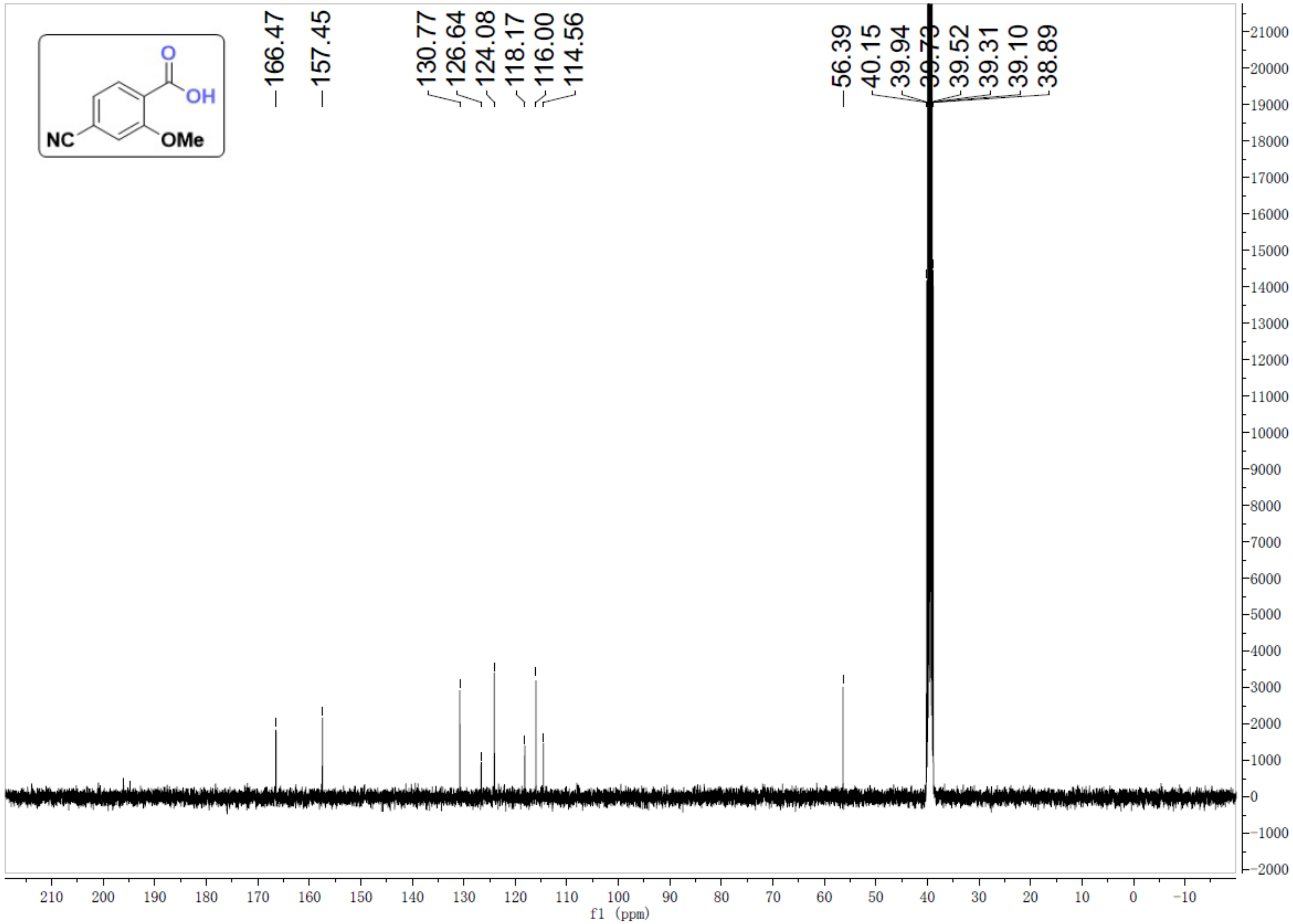
^{13}C NMR of 6s


167.01
162.85
131.35
122.99
113.80
55.43
40.15
39.94
39.73
39.52
39.31
39.10
38.89
MeO
O
OH
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
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)

^{1}H NMR of 6t


O
OH
NC
OMe
7.72
7.70
7.62
7.62
7.47
7.47
7.45
7.45
3.87
2.51
2.50
2.50
2.50
1.03
1.00
1.03
2.99
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f1 (ppm)
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000

^{13}C NMR of 6u


O
OH
NC
OMe
166.47
157.45
130.77
126.64
124.08
118.17
116.00
114.56
56.39
40.15
39.94
39.73
39.52
39.31
39.10
38.89
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
−2000
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)

IX. References:

1. Luo, Y.-R. Comprehensive Handbook of Chemical Bond Energies. CRC press. **2007**.
2. a) Pistritto, V. A., Schutzbach-Horton, M. E., Nicewicz, D. A. *J. Am. Chem. Soc.* **2020**, *142*, 17187-17194. b) Zelenka, J., Svobodová, E., Tarábek, J., Hoskovcová, I., Boguschová, V., Bailly, S., Sikorski, M., Roithová, J., Cibulka, R. *Org. Lett.* **2019**, *21*, 114-119. c) Qrareya, H., Ravelli, D., Fagnoni, M., Albini, A. *Adv. Synth. Catal.* **2013**, *355*, 2891-2899. d) Fukuzumi, S., Ohkubo, K., Suenobu, T., Kato, K., Fujitsuka, M., Ito, O. *J. Am. Chem. Soc.* **2001**, *123*, 8459-8467. E) Handoo, K. L., Cheng, J. P., Parker, V. D. *J. Am. Chem. Soc.* **1993**, *115*, 5067-5072.
3. Mayer, J. M., *Acc. Chem. Res.* **2010**, *44*, 36-46.
4. Mack, J. B., Gipson, J. D., Du Bois, J., Sigman, M. S. *J. Am. Chem. Soc.* **2017**, *139*, 9503-0506.
5. Aoki, K., Yonekura, K., Ikeda, Y., Ueno, R., Shirakawa, E. *Adv. Synth. Catal.* **2020**, *362*, 2200-2204.
6. Balahura, R. J., Sorokin, A., Bernadou, J., Meunier, B. *Inorg. Chem.* **1997**, *36*, 3488-3492.
7. Xu, F., Qian, X., Li, Y., Xu, H. *Org. Lett.* **2017**, *19*, 6332-6335.
8. Zhang, L., Hu, X. *Chem. Sci.* **2017**, *8*, 7009-7013.
9. Merlino, F., Yousif, A. M., Billard, É., Dufour-Gallant, J., Turcotte, S., Grieco, P., Chatenet, D., Lubell, W. D. *J. Med. Chem.* **2016**, *59*, 4740-4752.
10. Lambertucci, C., Sundukova, M., Kachare, D. D., Panmand, D. S., Ben, D. D., Buccioni, M., Marucci, G., Marchenkova, A., Thomas, A., Nistri, A., Cristalli, G., Volpini, R. *Eur. J. Med. Chem.* **2013**, *65*, 41-50.
11. Zhao, B., Brittain, W. J. *Macromolecules* **2000**, *33*, 342-348.
12. Manolikakes, G., Hernandez, C. M., Schade, M. A., Metzger, A., Knochel, P. *J. Org. Chem.* **2008**, *73*, 8422-8436.
13. Tachinami, T., Nishimura, T., Ushimaru, R., Noyori, R., Naka, H. *J. Am. Chem. Soc.* **2013**, *135*, 50-53.
14. Qian, W., Zhang, L., Sun, H., Jiang, H., Liu, H. *Adv. Synth. Catal.* **2012**, *354*, 3231-3236.
15. Chen, Z., Wen, Y., Fu, Y., Chen, H., Ye, M., Luo, G. *Synlett* **2017**, *28*, 981-985.
16. Sultane, P. R., Bielawski, C. W. *J. Org. Chem.* **2017**, *82*, 1046-1052.
17. Meng, M., Yang, L., Cheng, K., Qi, C. *J. Org. Chem.* **2018**, *83*, 3275-3284.
18. Marui, K., Higashiura, Y., Kodama, S., Hashidate, S., Nomoto, A., Yano, S., Ueshima, M., Ogawa, A. *Tetrahedron* **2014**, *70*, 2431-2438.
19. Donald, J. R., Berrell, S. L. *Chem. Sci.* **2019**, *10*, 5832-5836.
20. Ang, W. J., Chng, Y. S., Lam, Y. *RSC Adv.* **2015**, *5*, 81415-81428.
21. Hong, B., Aganda, K. C. C., Lee, A. *Org. Lett.* **2020**, *22*, 4395-4399.
22. Katsina, T., Clavier, L., Giffard, J.-F., Silva, N., Fournier, J., Tamion, R., Copin, C., Arseniyadis, S., Jean, A. *Org. Process Res. Dev.* **2020**, *24*, 856-860.
23. Dubrovskiy, A. V., Larock, R. C. *Org. Lett.* **2010**, *12*, 3117-3119.
24. Hrder, Z., Ruan, J., Xiao, J. *Chem. Eur. J.* **2008**, *14*, 5555-5566.
25. Hayashi, M., Shibuya, M., Iwabuchi, Y. *J. Org. Chem.* **2012**, *77*, 3005-3009.
26. Fortun, S., Beauclair, P., Schmitzer, A. R. *RSC Adv.* **2017**, *7*, 21036-21044.
27. Ruan, J., Li, X., Saidi, O., Xiao, J. *J. Am. Chem. Soc.* **2008**, *130*, 2424-2425.
28. Yoshida, M., Katagiri, Y., Zhu, W.-B., Shishido, K. *Org. Biomol. Chem.* **2009**, *7*, 4062-4066.

29. Gross, U., Koos, P., O'Brien, M., Polyzos, A., Ley, S. V. *Eur. J. Org. Chem.* **2014**, *29*, 6418-6430.
30. Kalmode, H. P., Vadagaonkar, K. S., Shinde, S. L., Chaskar, A. C. *J. Org. Chem.* **2017**, *82*, 3781-3786.
31. Friis, S. D., Andersen, T. L., Skrydstrup, T. *Org. Lett.* **2013**, *15*, 1378-1381.
32. Mao, Y., Liu, Y., Hu, Y., Wang, L., Zhang, S., Wang, W. *ACS Catal.* **2018**, *8*, 3016-3020.
33. Zhang, X., Zhang, W., Shi, L., Guo, C., Zhang, L., Lu, X. *Chem. Commun.* **2012**, *48*, 6292-6294.
34. Mallia, C. J., Walter, G. C., Baxendale, I. R. *Beilstein J. Org. Chem.* **2016**, *12*, 1503-1511.
35. Yu, H., Ru, S., Zhai, Y., Dai, G., Han, S., Wei, Y. *ChemCatChem* **2018**, *10*, 1253-1257.