Supporting information

Iridium(I)-Catalyzed Hydration/Esterification of 2-Alkynylphenols and Carboxylic Acids

Linwei Zeng,[a] Renjie Chen,[a] Chen Zhang,[a] Hujun Xie,*[,b] and Sunliang Cui*[,a]

[a]*Institute of Drug Discovery and Design, College of Pharmaceutical Sciences, Zhejiang University, Hangzhou 310058, China*
[b]*Department of Applied Chemistry, Zhejiang Gongshang University, Hangzhou 310018, China*

Email: slcui@zju.edu.cn

hujunxie@gmail.com

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1. General Information

The reaction temperatures are reported corresponding to the oil bath temperature. Reactions were monitored by thin layer chromatography (TLC) using silicycle pre-coated silica gel plates. Column chromatography was performed over silica gel (200–300mesh).

Melting points were measured with X–4 micro melting point apparatus.

HRMS were performed on Waters GCT premier time of flight mass spectrometer (EI) or Agilent Technologies 6224 TOF LC/MS apparatus (ESI).

^{1}H NMR spectra and ^{13}C NMR spectra were recorded on a *Bruker AV-600* spectrometer or a WNMR-I-400 spectrometer in chloroform-*d* (contain internal TMS). Chemical shifts of ^{1}H NMR spectra were reported in ppm with the internal TMS signal at 0 ppm as a standard, and chemical shifts of ^{13}C NMR spectra were reported in ppm with the chloroform signal at 77.16 ppm as a standard.[1] The data is being reported as (s = singlet, d = doublet, t = triplet, q = quartet, dd = double doublet, dt = double of triplet, m = multiplet or unresolved, br = broad singlet, coupling constant(s) in Hz, integration).

Chloro(1,5-cyclooctadiene)iridium(I) dimer ([Ir(cod)Cl]$_2$, CAS: 12112-67-3, 98% purity) was purchased from Sinocompound Technology Co., Ltd.

Solvents, such as Ethyl acetate (EA), petroleum ether (PE), dichloromethane (DCM), *N, N*-dimethylformamide (DMF), tetrahydrofuran (THF), acetic acid (AcOH) and methanol (MeOH) were obtained commercially and used without further purification unless otherwise noted.

Anhydrous solvents were purified according to standard methods.[2]

2. Starting Materials

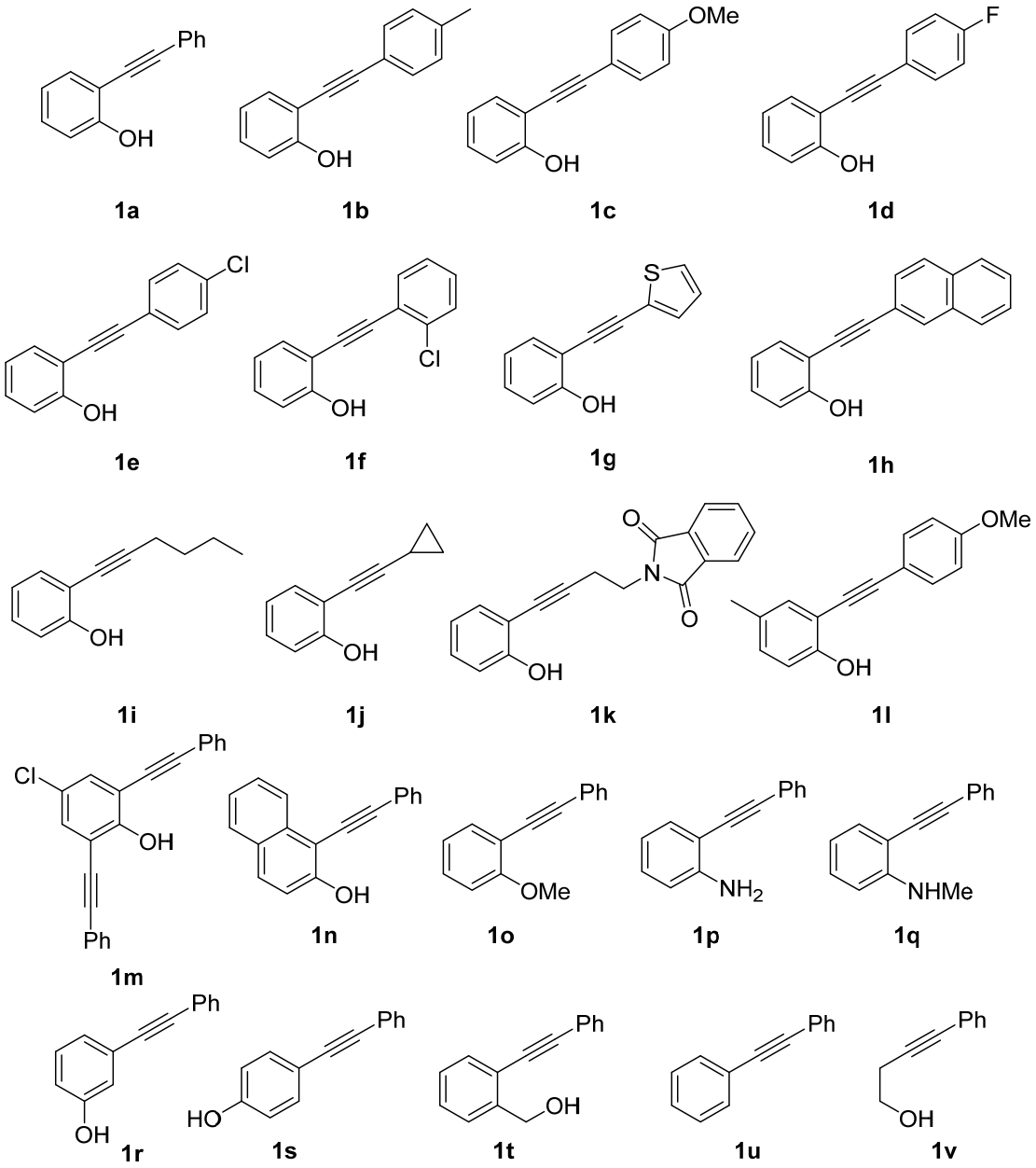
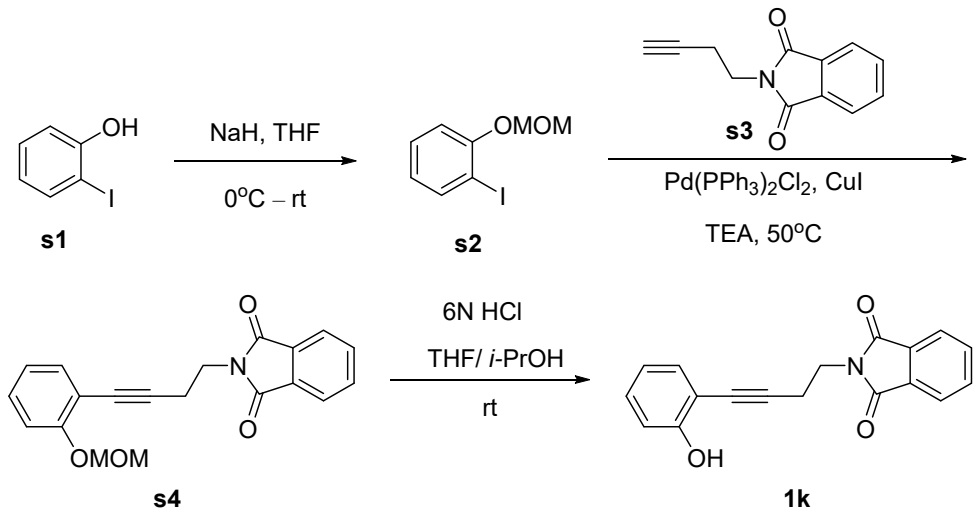


Figure S1. Alkynes

All starting alkynes were shown in **Figure S1**. Diphenyl acetylene **1u** was commercial available. Alkynes **1a**- **1j**, **1l**, **1n-1t** and **iv** were prepared according to the literature. [3-7]

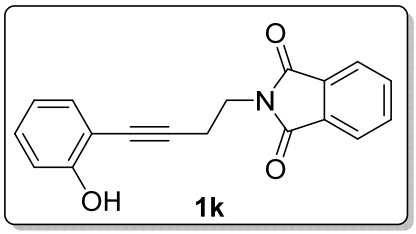
Alkyne **1k** was synthesized by the following procedure.



Scheme S1

Synthesis of s2 and s3: Compounds **s2**[4] and **s3**[8] were prepared according to the literature.

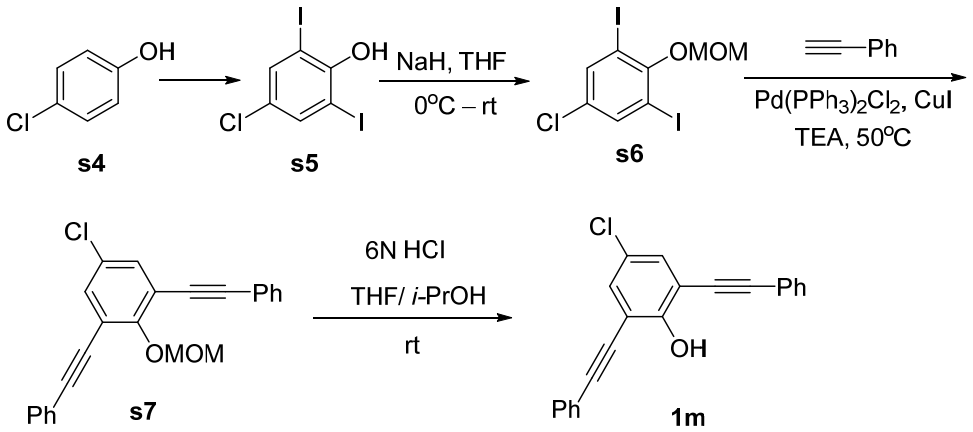
Synthesis of 1k: To a mixture of **s2** (264 mg, 1 mmol), **s3** (220 mg, 1.1 mmol), $Pd(PPh_3)_2Cl_2$ (14 mg, 2 mol %) and CuI (4 mg, 2 mol %) was added dry trimethylamine (5 mL). The reaction was stirred at 50 °C for 2 h under argon atmosphere. The reaction was cooled to room temperature, ethyl acetate was added and the mixture was filtrated through a pad of celite. The filtrate was concentrated and purified by silica gel chromatography using PE/EA (*V/V*, 50/1) as eluent to afford **s4**; **s4** was dissolved in THF (2 mL) and isopropanol (2 mL), then 6N HCl (1 mL) was added and the reaction was stirred at room temperature for 24h. The reaction was extracted with Et_2O for 3 times, and the combined organic phase was washed by brine, dried over anhydrous Na_2SO_4, concentrated and further purified by silica gel chromatography using PE: EA = 50:1 as eluent to obtain compound **1k** as a white solid.



2-(4-(2-hydroxyphenyl)but-3-yn-1-yl)isoindoline-1,3-dione

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.91 – 7.87 (m, 2H), 7.75 – 7.71 (m, 2H), 7.24 – 7.16 (m, 2H), 6.92 (dd, J_1 = 7.8 Hz, J_1 = 0.6 Hz, 1H), 6.82 – 6.76 (m, 1H), 6.36 (s, 1H), 4.03 (t, J = 6.0 Hz, 2H), 2.88 (t, J = 6.0 Hz, 2H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 168.87, 157.40, 134.42, 132.00, 131.88, 130.10, 123.73, 120.09, 115.28, 109.59, 93.17, 77.06, 37.03, 20.34. **MS (m/z)**: 292 $(M+H)^+$.

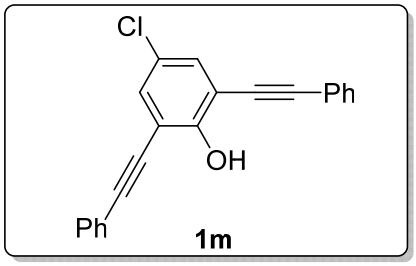
Alkyne **1m** was synthesized by the following procedure.



Scheme S2

Synthesis of s6: Compounds **s6** was prepared by a modified procedure according to the literature. [4,9]

Synthesis of 1m: To a mixture of **s6** (264 mg, 1 mmol), phenylacetylene (208 mg, 2.2 mmol), $Pd(PPh_3)_2Cl_2$ (14 mg, 2 mol %) and CuI (4 mg, 2 mol %) was added dry trimethylamine (5 mL). Then the reaction was stirred at 50 °C for 2h under argon atmosphere. The reaction was cooled to room temperature, ethyl acetate was added and the mixture was filtrated through a pad of celite. The filtrate was concentrated and purified by silica gel chromatography using PE/EA (*V/V*, 50/1) as eluent to afford **s7**; **s7** was dissolved in THF (2 mL) and isopropanol (2 mL), then 6N HCl (1 mL) was added and the reaction was stirred at room temperature for 24h. The reaction was extracted with Et_2O for 3 times, and the combined organic phase was washed by brine, dried over anhydrous Na_2SO_4, concentrated and further purified by silica gel chromatography using PE: EA = 50:1 as eluent to obtain compound **1m** as a white solid.



4-chloro-2,6-bis(phenylethynyl)phenol

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.64 – 7.50 (m, 4H), 7.44 – 7.31 (m, 8H), 6.22 (s, 1H). **^{13}C NMR (151 MHz, $CDCl_3$)** δ 155.84, 132.12, 131.87, 129.16, 128.63, 125.01, 122.32, 111.74, 96.64, 82.45. **MS (m/z)**: 329 $(M+H)^+$.

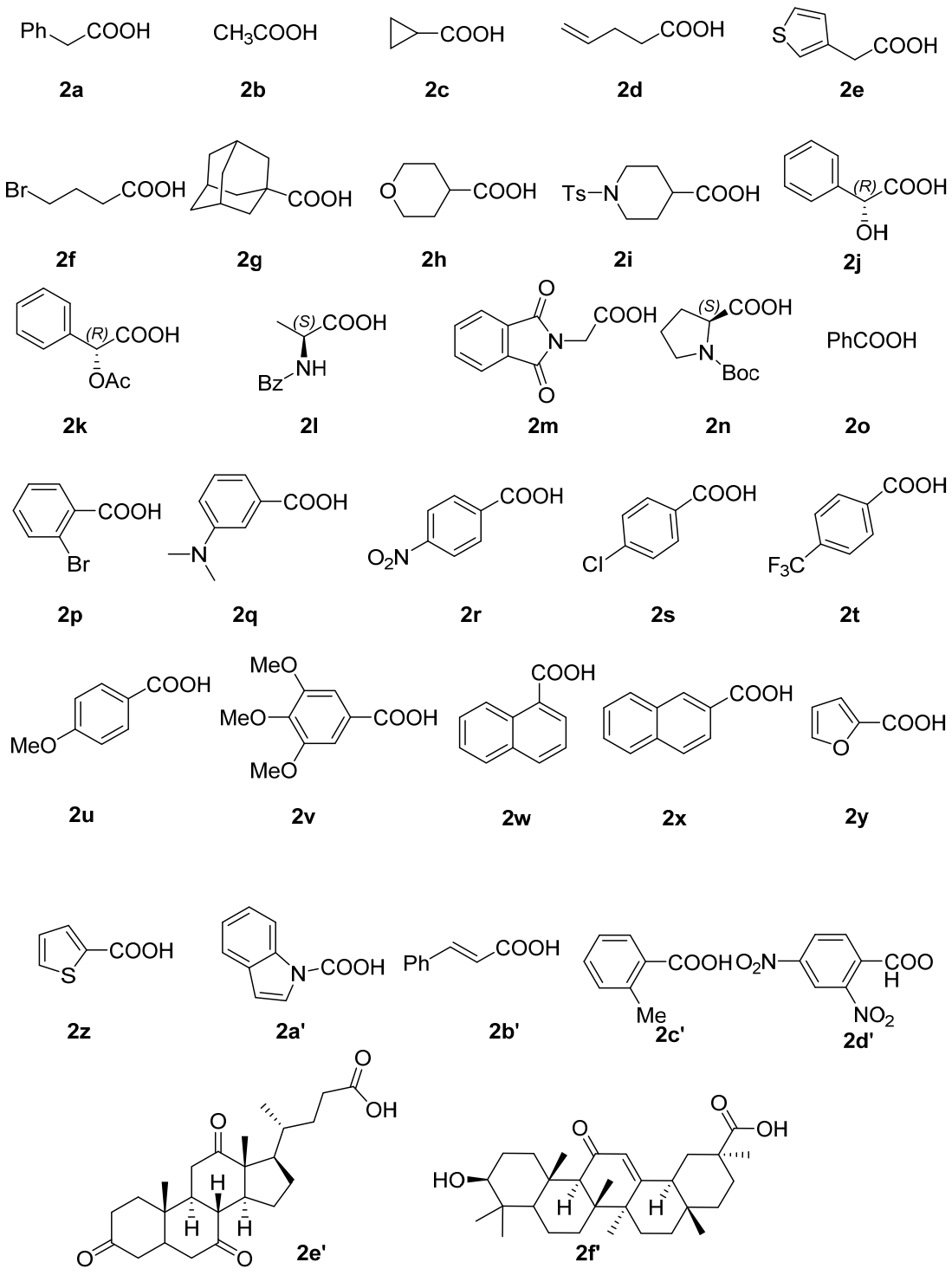
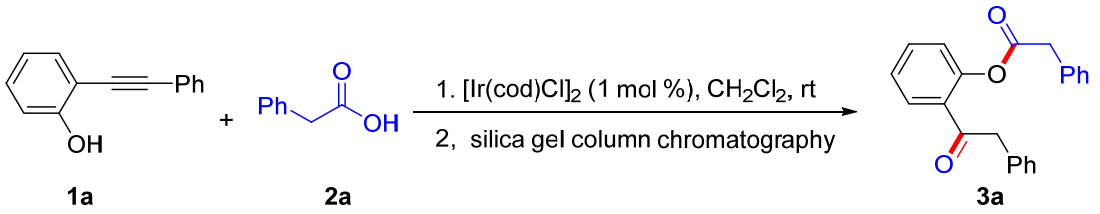


Figure S2. Carboxylic acids

Acids **2a-2h**, **2j**, **2o-2z**, **2b'-2f'** were commercial available. Acids **2i**, **2k-2n** and **2a'** were synthesized according to the literatures.[10-13]

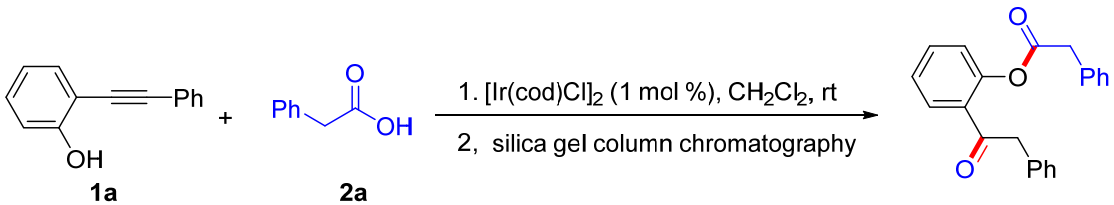
3. Typical Procedure for the Synthesis of 3a



1a **2a** **3a**

To a vial was added 2-(phenylethynyl)phenol **1a** (39 mg, 0.2 mmol), phenylacetic acid **2a** (30 mg, 0.22 mmol) and catalytic $[Ir(cod)Cl]_2$ (1.4 mg, 1 mol %). Dichloromethane (2 mL) was added as solvent and the mixture was stirred at room temperature for 12 h. Solvent was removed under vacuum and the residue was purified by silica gel column chromatography using PE/EA (*V*/*V*, 20/1) as eluent to give 2-(2-phenylacetyl)phenyl 2-phenylacetate **3a** (57 mg, 87% yield) as a white solid.

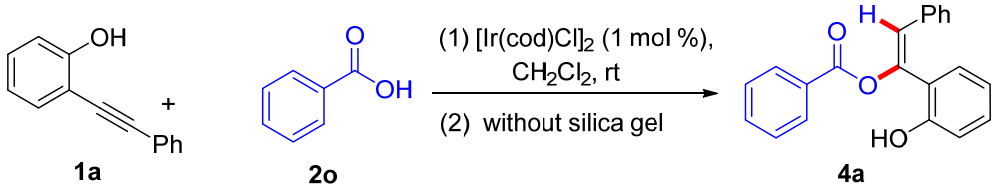
4. Gram-Scale Synthesis of 3a



1a (5 mmol) **2a** (5.5 mmol) **3a,** 1.4 g, 85%

To a flask was added 2-(phenylethynyl)phenol **1a** (970 mg, 5 mmol), phenylacetic acid **2a** (750 mg, 5.5 mmol), and catalytic $[Ir(cod)Cl]_2$ (33 mg, 1 mol %). Dichloromethane (50 mL) was added as solvent and the mixture was stirred at room temperature for 12 h. Solvent was removed under vacuum and the residue was purified by silica gel column chromatography using PE/EA (*V*/*V*, 20/1) as eluent to give 2-(2-phenylacetyl)phenyl 2-phenylacetate **3a** (1.4 g, 85% yield) as a white solid.

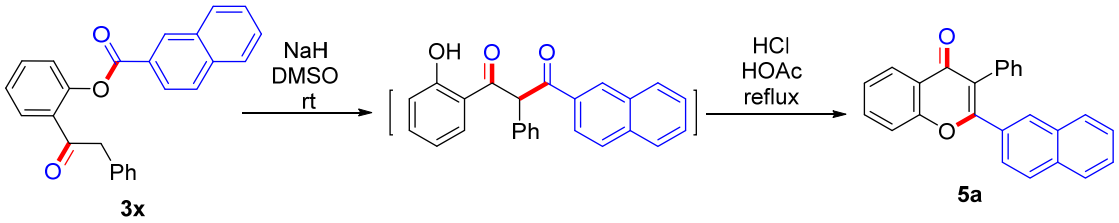
5. Typical Procedure for the Synthesis of 4a



1a **2o** **4a**

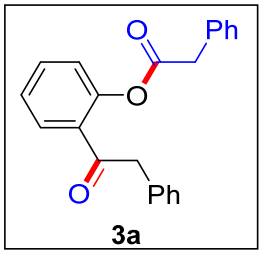
To a vial was added 2-(phenylethynyl)phenol **1a** (39 mg, 0.2 mmol), benzoic acid **2o** (24.5 mg, 0.2 mmol) and catalytic $[Ir(cod)Cl]_2$ (1.4 mg, 1 mol %). Dry dichloromethane (2 mL) was added as solvent and the mixture was stirred at room temperature for 12 h. Solvent was removed under vacuum and the crude product was purified by recrystallization from PE/EA (*V*/*V*, 10/1) to give (*E*)-1-(2-hydroxyphenyl)-2-phenylvinyl benzoate **4a** (58 mg, 91% yield) as a white solid.

6. Typical Procedure for the Synthesis of 5a



To a schlenk tube was added **3x** (55mg, 0.15 mmol) and DMSO (0.5 mL), then NaH (9 mg, 60%, 0.22 mmol.) was added and the reaction was stirred at room temperature for 1h. Water was added and the mixture was extracted with ethyl acetate (3×5 mL), the combined organic phase was washed by brine for several times, dried over anhydrous Na_2SO_4, filtered and concentrated in vacuum to afford the intermediate which was dissolved in acetic acid (2 mL), then concentrated HCl (0.2 mL) was added and the mixture was refluxed for 2h. The mixture was concentrated in vacuum to afford the residue which was purified by silica gel chromatography using PE/EA (*V*/*V*, 20/1) as eluent to give 2-(naphthalen-2-yl)-3-phenyl-4H-chromen-4-one **5a** (36 mg, 69 % yield) as a white solid.

7. Characterization of Compounds



2-(2-phenylacetyl)phenyl 2-phenylacetate

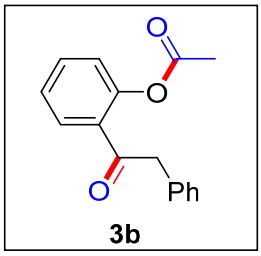
White solid, m. p. 98-100 ℃, (58 mg, 88% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 20/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.77 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.52 – 7.48 (m, 1H), 7.38 – 7.24 (m, 9H), 7.18 – 7.13 (m, 2H), 7.08 (d, J = 7.8 Hz, 1H), 4.11 (s, 2H), 3.90 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.94, 170.28, 148.98, 134.15, 133.27, 133.24, 131.02, 129.94, 129.74, 129.73, 128.81, 128.71, 127.49, 127.08, 126.20, 123.83, 48.23, 41.35.

HRMS (EI) Calcd for $C_{22}H_{18}O_3$ $(M)^+$: 330.1256; Found: 330.1254.



3b

2-(2-phenylacetyl)phenyl acetate

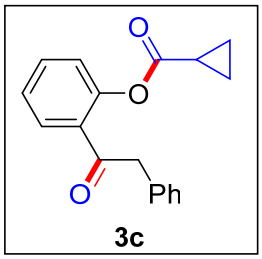
White solid, m. p. 106-108 ℃, (46 mg, 91% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 20/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.82 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.55 – 7.50 (m, 1H), 7.35 – 7.29 (m, 3H), 7.28 – 7.25 (m, 1H), 7.24 – 7.19 (m, 2H), 7.12 (dd, J_1 = 8.4 Hz, J_2 = 1.2 Hz, 1H), 4.21 (s, 2H), 2.30 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.64, 169.73, 149.11, 134.16, 133.44, 130.67, 130.12, 129.68, 128.75, 127.11, 126.16, 124.04, 48.09, 21.27.

HRMS (EI) Calcd for $C_{16}H_{14}O_3$ $(M)^+$: 254.0943; Found: 254.0945.



3c

2-(2-phenylacetyl)phenyl cyclopropanecarboxylate

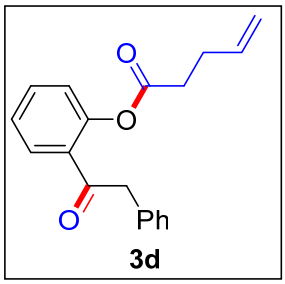
Colorless oil, (45 mg, 81% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.72 (dd, J_1 = 7.8 Hz, J_2 = 1.8 Hz, 1H), 7.50 – 7.45 (m, 1H), 7.38 – 7.18 (m, 6H), 7.12 (dd, J_1 = 8.4 Hz, J_2 = 1.2 Hz, 1H), 4.19 (s, 2H), 1.91 – 1.81 (m, 1H), 1.20 – 1.14 (m, 2H), 1.05 – 0.99 (m, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 198.01, 173.33, 148.89, 134.25, 133.00, 131.60, 129.74, 129.70, 128.64, 127.00, 125.95, 123.73, 48.48, 13.24, 9.42.

HRMS (EI) Calcd for $C_{18}H_{16}O_3$ $(M)^+$: 280.1099; Found: 280.1098.



3d

2-(2-phenylacetyl)phenyl pent-4-enoate

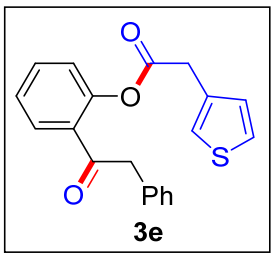
Colorless oil, (26 mg, 45% yield).

TLC: Rf = 0.15 (Petroleum ether/EtOAc = 20/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.78 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.52 – 7.50 (m, 1H), 7.34 – 7.24 (m, 4H), 7.23 – 7.19 (m, 2H), 7.11 (dd, J_1 = 7.8 Hz, J_2 = 0.6 Hz, 1H), 5.92 – 5.84 (m, 1H), 5.15 – 5.10 (m, 1H), 5.08 – 5.02 (m, 1H), 4.19 (s, 2H), 2.68 (t, J = 7.8 Hz, 2H), 2.51 – 2.46 (m, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.78, 171.66, 149.08, 136.52, 134.23, 133.27, 131.11, 129.96, 129.71, 128.75, 127.11, 126.09, 124.00, 115.96, 48.28, 33.62, 28.63.

HRMS (EI) Calcd for $C_{19}H_{18}O_3$ $(M)^+$: 294.1256; Found: 294.1255.



3e

2-(2-phenylacetyl)phenyl 2-(thiophen-3-yl)acetate

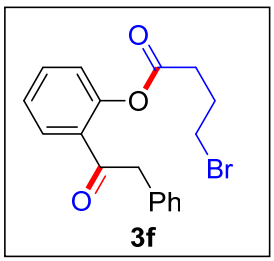
White solid, m. p. 94-96 ℃, (55 mg, 81% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 20/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.77 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.52 – 7.47 (m, 1H), 7.35 – 7.21 (m, 6H), 7.20 – 7.13 (m, 2H), 7.12 – 7.06 (m, 2H), 4.12 (s, 2H), 3.92 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.82, 169.77, 148.99, 134.16, 133.29, 132.79, 130.97, 129.97, 129.71, 128.79, 128.72, 127.09, 126.22, 125.99, 123.85, 123.60, 48.17, 35.81.

HRMS (EI) Calcd for $C_{20}H_{16}O_3S$ $(M)^+$: 336.0820; Found: 336.0820.



3f

2-(2-phenylacetyl)phenyl 4-bromobutanoate

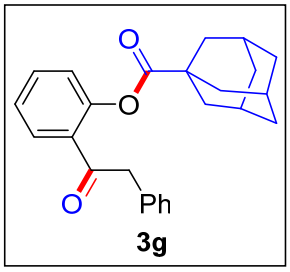
Colorless oil, (35 mg, 49% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 20/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.80 (dd, J_1 = 7.8 Hz, J_2 = 1.8 Hz, 1H), 7.55 – 7.49 (m, 1H), 7.36 – 7.17 (m, 6H), 7.11 (d, J = 7.8 Hz, 1H), 4.19 (s, 2H), 3.50 (t, J = 6.6 Hz, 2H), 2.77 (t, J = 7.2 Hz, 2H), 2.26 (p, J = 6.6 Hz, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.67, 171.29, 148.96, 134.17, 133.39, 130.80, 130.01, 129.66, 128.76, 127.12, 126.18, 123.97, 48.08, 32.69, 32.61, 27.57.

HRMS (EI) Calcd for $C_{18}H_{17}BrO_3$ $(M)^+$: 360.0361; Found: 360.0359.



3g

2-(2-phenylacetyl)phenyl (3r,5r,7r)-adamantane-1-carboxylate

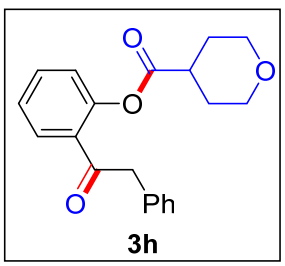
Colorless oil, (42 mg, 56% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 20/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.67 (dd, J_1 = 7.8 Hz, J_2 = 1.8 Hz, 1H), 7.50 – 7.44 (m, 1H), 7.37 – 7.17 (m, 6H), 7.04 (dd, J_1 = 7.8 Hz, J_2 = 0.6 Hz, 1H), 4.16 (s, 2H), 2.10 – 2.00 (m, 9H), 1.84 – 1.71 (m, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 198.27, 176.04, 149.07, 134.23, 132.75, 132.24, 129.77, 129.35, 128.70, 127.05, 125.78, 123.65, 48.68, 41.11, 38.72, 36.53, 27.99.

HRMS (EI) Calcd for $C_{25}H_{26}O_3$ $(M)^+$: 374.1882; Found: 374.1885.



3h

2-(2-phenylacetyl)phenyl tetrahydro-2H-pyran-4-carboxylate

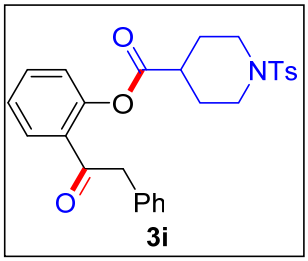
Colorless oil, (56 mg, 87% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 8/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.77 (dd, J_1 = 7.8 Hz, J_2 = 1.8 Hz, 1H), 7.54 – 7.46 (m, 1H), 7.34 – 7.23 (m, 4H), 7.22 – 7.18 (m, 2H), 7.08 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 4.17 (s, 2H), 3.99 (dt, J_1 = 11.4 Hz, J_2 = 3.6 Hz, 2H), 3.46 (td, J_1 = 11.4 Hz, J_2 = 2.4 Hz, 2H), 2.80 (tt, J_1 = 10.8 Hz, J_2 = 4.2 Hz, 1H), 2.01 – 1.94 (m, 2H), 1.93 – 1.85 (m, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.70, 172.99, 148.88, 134.12, 133.16, 131.15, 129.73, 129.63, 128.70, 127.06, 126.06, 123.81, 67.07, 48.09, 40.15, 28.45.

HRMS (EI) Calcd for $C_{20}H_{20}O_4$ $(M)^+$: 324.1362; Found: 324.1362.



3i

2-(2-phenylacetyl)phenyl 1-tosylpiperidine-4-carboxylate

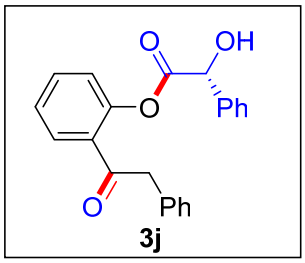
White solid, m. p. 122-124 ℃, (82 mg, 86% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 5/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.79 (dd, J_1 = 7.8 Hz, J_2 = 1.8 Hz, 1H), 7.64 (d, J = 8.4 Hz, 2H), 7.53 – 7.48 (m, 1H), 7.35 – 7.23 (m, 6H), 7.21 – 7.14 (m, 2H), 7.03 (dd, J_1 = 8.4 Hz, J_2 = 1.2 Hz, 1H), 4.15 (s, 2H), 3.69 (dt, J_1 = 11.4 Hz, J_2 = 3.6 Hz, 2H), 2.55 – 2.45 (m, 3H), 2.43 (s, 3H), 2.14 – 2.07 (m, 2H), 1.97 – 1.89 (m, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.55, 172.59, 148.78, 143.75, 134.03, 133.38, 132.94, 130.64, 129.90, 129.79, 129.60, 128.75, 127.79, 127.13, 126.23, 123.86, 47.92, 45.47, 40.06, 27.25, 21.65.

HRMS (EI) Calcd for $C_{27}H_{27}NO_5S$ $(M)^+$: 477.1610; Found: 477.1613.



3j

2-(2-phenylacetyl)phenyl (*R*)-2-hydroxy-2-phenylacetate

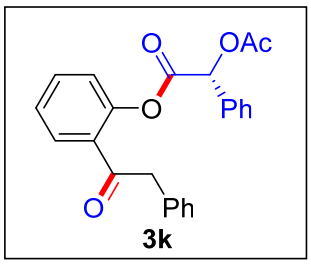
Colorless oil, (46 mg, 67% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 4/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.76 (d, *J* = 7.8 Hz, 1H), 7.52 (d, *J* = 7.2 Hz, 2H), 7.48 – 7.44 (m, 1H), 7.40 – 7.36 (m, 2H), 7.36 – 7.22 (m, 5H), 7.11 (d, *J* = 7.2 Hz, 2H), 6.97 (d, *J* = 7.8 Hz, 1H), 5.47 (s, 1H), 4.06 – 3.95 (m, 2H), 3.55 (br, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.69, 172.15, 148.63, 137.42, 133.94, 133.41, 130.56, 130.24, 129.65, 128.94, 128.90, 128.73, 127.16, 127.13, 126.61, 123.52, 73.58, 48.15.

HRMS (EI) Calcd for $C_{22}H_{18}O_4$ $(M)^+$: 346.1205; Found: 346.1208.



3k

2-(2-phenylacetyl)phenyl (*R*)-2-acetoxy-2-phenylacetate

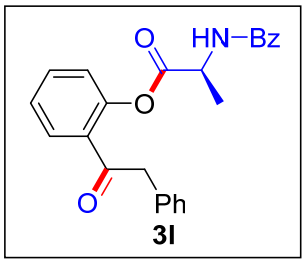
Colorless oil, (74 mg, 95% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 3/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.62 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.59 – 7.54 (m, 2H), 7.45 – 7.36 (m, 4H), 7.28 – 7.19 (m, 4H), 7.09 – 6.99 (m, 3H), 6.19 (s, 1H), 3.93 (d, *J* = 16.8 Hz, 1H), 3.87 (d, *J* = 16.8 Hz, 1H), 2.21 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.85, 170.45, 167.35, 148.11, 134.00, 132.86, 132.71, 131.78, 129.86, 129.82, 129.73, 129.13, 128.49, 128.12, 126.91, 126.51, 123.20, 74.74, 48.84, 20.74.

HRMS (EI) Calcd for $C_{24}H_{20}O_5$ $(M)^+$: 388.1311; Found: 388.1316.



3l

2-(2-phenylacetyl)phenyl benzoyl-*L*-alaninate

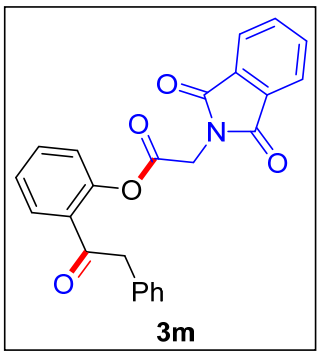
Colorless oil, (57 mg, 73% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 4/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.85 – 7.79 (m, 3H), 7.53 – 7.45 (m, 2H), 7.39 – 7.35 (m, 2H), 7.32 – 7.22 (m, 4H), 7.19 (d, *J* = 7.8 Hz, 2H), 7.15 (d, *J* = 7.8 Hz, 1H), 7.13 – 7.05 (m, 1H), 5.11 – 5.00 (m, 1H), 4.21 (s, 2H), 1.63 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.83, 171.42, 166.97, 148.91, 134.01, 133.85, 133.61, 131.76, 130.25, 130.12, 129.63, 128.71, 128.61, 127.21, 127.09, 126.42, 124.06, 48.89, 47.97, 17.80.

HRMS (EI) Calcd for $C_{24}H_{21}NO_4$ $(M)^+$: 387.1471; Found: 387.1469.



3m

2-(2-phenylacetyl)phenyl 2-(1,3-dioxoisoindolin-2-yl)acetate

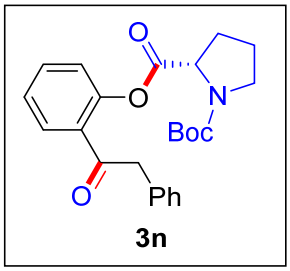
White solid, m. p. 116-118 ℃, (63 mg, 79% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 4/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.92 – 7.86 (m, 2H), 7.78 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.76 – 7.72 (m, 2H), 7.53 – 7.48 (m, 1H), 7.32 – 7.28 (m, 3H), 7.27 – 7.16 (m, 4H), 4.74 (s, 2H), 4.20 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.27, 167.34, 166.25, 148.64, 134.40, 134.10, 133.37, 132.11, 130.57, 130.24, 129.66, 128.75, 127.07, 126.58, 123.86, 123.81, 48.30, 39.31.

HRMS (EI) Calcd for $C_{24}H_{17}NO_5$ $(M)^+$: 399.1107; Found: 399.1104.



3n

1-(tert-butyl) 2-(2-(2-phenylacetyl)phenyl) (S)-pyrrolidine-1,2-dicarboxylate

Colorless oil, (70 mg, 86% yield).

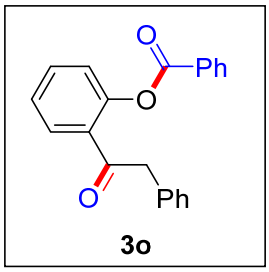
TLC: Rf = 0.15 (Petroleum ether/EtOAc = 3/1).

^{1}H NMR (600 MHz, $CDCl_3$, 2 rotamers seen, ratio = 46: 54) δ 7.76 – 7.67 (m, 1H), 7.54 – 7.44 (m, 1H), 7.36 – 7.08 (m, 7H), 4.53 (dd, J_1 = 8.4 Hz, J_2 = 3.6 Hz, 0.46H), 4.46 (dd, J_1 = 8.4 Hz, J_2 = 3.6 Hz, 0.54H), 4.26 – 4.16 (m, 2H), 3.61 – 3.37 (m, 2H), 2.42 – 2.17 (m, 2H), 2.05 – 1.81 (m, 2H), 1.47 (s, 4.14H), 1.45 (s, 4.86H).

^{13}C NMR (151 MHz, $CDCl_3$, 2 rotamers seen) δ 198.21, 198.04, 171.24, 171.03, 154.55, 153.85, 148.63, 148.33, 134.30, 134.07, 132.97, 132.92, 131.79, 131.76, 129.77, 129.70, 129.33, 129.30, 128.66, 128.57, 127.05, 126.94, 126.10, 126.01, 123.87, 123.27, 80.16, 79.97, 59.22, 59.18, 48.39, 48.17, 46.74, 46.51, 30.07,

29.24, 28.51, 24.51, 23.56.

HRMS (EI) Calcd for $C_{24}H_{27}NO_5$ $(M)^+$: 409.1889; Found: 409.1885.



3o

2-(2-phenylacetyl)phenyl benzoate

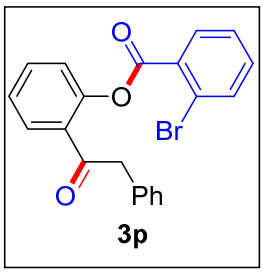
White solid, m. p. 78-80 ℃, (56 mg, 89% yield).

TLC: Rf = 0.25 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.19 (dd, J_1 = 8.4 Hz, J_2 = 1.2 Hz, 2H), 7.82 (dd, J_1 = 7.8 Hz, J_2 = 1.8 Hz, 1H), 7.66 – 7.61 (m, 1H), 7.58 – 7.54 (m, 1H), 7.53 – 7.48 (m, 2H), 7.36 – 7.32 (m, 1H), 7.29 – 7.20 (m, 4H), 7.20 – 7.13 (m, 2H), 4.20 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.91, 165.20, 149.21, 134.14, 133.94, 133.19, 131.69, 130.46, 130.03, 129.70, 129.32, 128.80, 128.68, 127.05, 126.24, 124.01, 48.64.

HRMS (EI) Calcd for $C_{21}H_{16}O_3$ $(M)^+$: 316.1099; Found: 316.1096.



3p

2-(2-phenylacetyl)phenyl 2-bromobenzoate

Colorless oil, (76 mg, 96% yield).

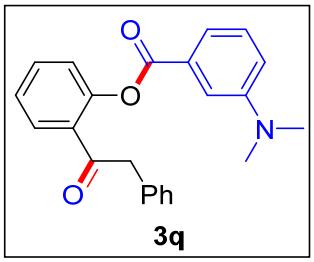
TLC: Rf = 0.25 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.07 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.82 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.69 (d, J = 7.8 Hz, 1H), 7.57 – 7.52 (m, 1H), 7.42 – 7.17

(m, 9H), 4.20 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.69, 164.30, 148.86, 134.56, 134.11, 133.36, 133.33, 132.23, 131.16, 131.01, 130.04, 129.65, 128.68, 127.52, 127.02, 126.40, 123.95, 122.38, 48.25.

HRMS (EI) Calcd for $C_{21}H_{15}BrO_3$ $(M)^+$: 394.0205; Found: 394.0201.



3q

2-(2-phenylacetyl)phenyl 3-(dimethylamino)benzoate

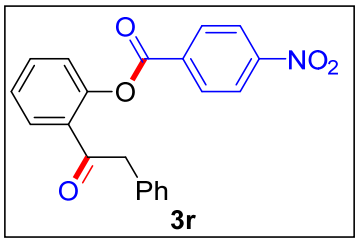
Yellow solid, m. p. 95-97 ℃, (66 mg, 92% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 8/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.83 – 7.78 (m, 1H), 7.60 – 7.51 (m, 3H), 7.42 – 7.16 (m, 8H), 7.02 – 6.97 (m, 1H), 4.22 (s, 2H), 3.02 (s, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 198.10, 165.80, 150.71, 149.34, 134.21, 133.07, 131.93, 129.99, 129.80, 129.76, 129.43, 128.61, 126.98, 126.10, 123.96, 118.27, 117.73, 113.79, 48.84, 40.60.

HRMS (EI) Calcd for $C_{23}H_{21}NO_3$ $(M)^+$: 359.1521; Found: 359.1525.



3r

2-(2-phenylacetyl)phenyl 4-nitrobenzoate

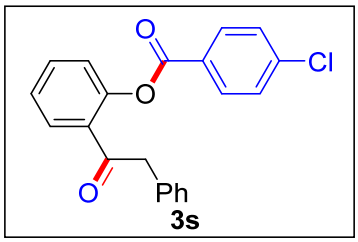
Yellow solid, m. p. 113-115 ℃, (66 mg, 71% yield).

TLC: Rf = 0.15 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.37 – 8.27 (m, 4H), 7.90 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.62 – 7.57 (m, 1H), 7.42 – 7.37 (m, 1H), 7.30 – 7.20 (m, 4H), 7.19 – 7.13 (m, 2H), 4.20 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.34, 163.57, 150.99, 148.94, 134.92, 133.96, 133.64, 131.56, 130.58, 130.32, 129.57, 128.81, 127.19, 126.71, 124.03, 123.82, 48.08.

HRMS (EI) Calcd for $C_{21}H_{15}NO_5$ $(M)^+$: 361.0950; Found: 361.0951.



3s

2-(2-phenylacetyl)phenyl 4-chlorobenzoate

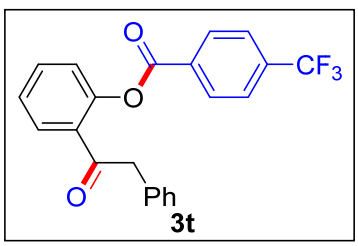
White solid, m. p. 87-89 ℃, (52 mg, 74% yield).

TLC: Rf = 0.25 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.10 (d, J = 8.4 Hz, 2H), 7.82 (dd, J_1 = 7.8 Hz, J_2 = 1.8 Hz, 1H), 7.59 – 7.54 (m, 1H), 7.47 (d, J = 8.4 Hz, 2H), 7.38 – 7.33 (m, 1H), 7.30 – 7.20 (m, 4H), 7.16 (d, J = 7.2 Hz, 2H), 4.18 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.69, 164.43, 149.07, 140.43, 134.06, 133.32, 131.82, 131.34, 130.08, 129.64, 129.15, 128.73, 127.85, 127.11, 126.37, 124.02, 48.43.

HRMS (EI) Calcd for $C_{21}H_{15}ClO_3$ $(M)^+$: 350.0710; Found: 350.0714.



3t

2-(2-phenylacetyl)phenyl 4-(trifluoromethyl)benzoate

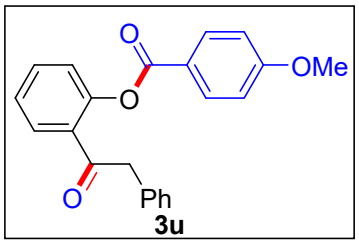
White solid, m. p. 75-77 ℃, (55 mg, 72% yield).

TLC: Rf = 0.25 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.27 (d, J = 8.4 Hz, 2H), 7.87 (dd, J_1 = 7.8 Hz, J_2 = 1.8 Hz, 1H), 7.76 (d, J = 8.4 Hz, 2H), 7.63 – 7.55 (m, 1H), 7.42 – 7.35 (m, 1H), 7.31 – 7.14 (m, 6H), 4.20 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.52, 164.17, 149.04, 135.20 (q, J = 32.5 Hz), 134.03, 133.48, 132.71, 131.01, 130.85, 130.21, 129.61, 128.78, 127.16, 126.54, 125.79 (q, J = 3.7 Hz), 124.05, 123.70 (q, J = 273.3 Hz), 48.28.

HRMS (EI) Calcd for $C_{22}H_{15}F_3O_3$ $(M)^+$: 384.0973; Found: 384.0971.



3u

2-(2-phenylacetyl)phenyl 4-methoxybenzoate

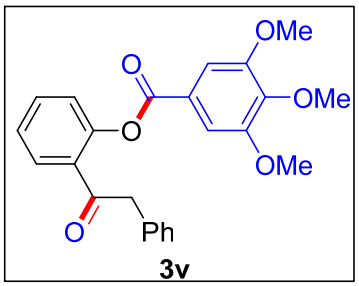
White solid, m. p. 89-91 ℃, (56 mg, 81% yield).

TLC: Rf = 0.15 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.14 (d, J = 7.8 Hz, 2H), 7.82 – 7.75 (m, 1H), 7.57 – 7.51 (m, 1H), 7.33 – 7.30 (m, 1H), 7.28 – 7.19 (m, 4H), 7.16 (d, J = 7.8 Hz, 2H), 6.97 (d, J = 9.0 Hz, 2H), 4.19 (s, 2H), 3.87 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 198.07, 164.83, 164.24, 149.29, 134.20, 133.09, 132.60, 131.89, 129.94, 129.73, 128.63, 127.00, 126.06, 124.03, 121.55, 114.11, 55.65, 48.73.

HRMS (EI) Calcd for $C_{22}H_{18}O_4$ $(M)^+$: 346.1205; Found: 346.1209.



3v

2-(2-phenylacetyl)phenyl 3,4,5-trimethoxybenzoate

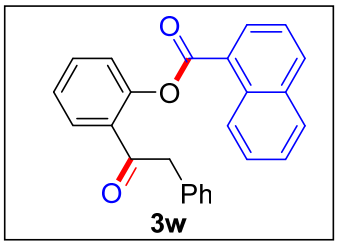
White solid, m. p. 102-104 ℃, (66 mg, 81% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 5/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.83 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.61 – 7.56 (m, 1H), 7.43 (s, 2H), 7.38 – 7.34 (m, 1H), 7.30 – 7.17 (m, 6H), 4.21 (s, 2H), 3.94 (s, 3H), 3.92 (s, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.93, 164.82, 153.23, 149.23, 143.12, 134.15, 133.24, 131.63, 130.00, 129.67, 128.69, 127.07, 126.24, 124.17, 124.00, 107.71, 61.08, 56.42, 48.53.

HRMS (EI) Calcd for $C_{24}H_{22}O_6$ $(M)^+$: 406.1416; Found: 406.1419.



3w

2-(2-phenylacetyl)phenyl 1-naphthoate

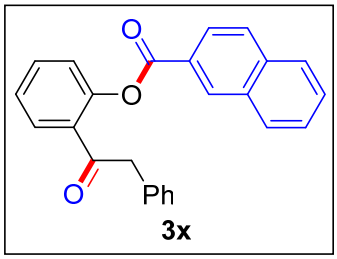
Colorless oil, (72 mg, 98% yield).

TLC: Rf = 0.25 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.97 (d, J = 8.4 Hz, 1H), 8.48 (dd, J_1 = 7.2 Hz, J_2 = 1.2 Hz, 1H), 8.06 (d, J = 7.8 Hz, 1H), 7.88 (d, J = 8.4 Hz, 1H), 7.82 (dd, J_1 = 7.8 Hz, J_2 = 1.8 Hz, 1H), 7.65 – 7.50 (m, 4H), 7.35 – 7.31 (m, 1H), 7.29 (dd, J_1 = 8.4 Hz, J_2 = 0.6 Hz, 1H), 7.26 – 7.11 (m, 5H), 4.21 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 198.01, 165.65, 149.19, 134.57, 134.14, 133.98, 133.23, 131.80, 131.78, 131.66, 129.99, 129.67, 128.77, 128.64, 128.30, 126.98, 126.50, 126.19, 125.77, 125.58, 124.72, 124.11, 48.46.

HRMS (EI) Calcd for $C_{25}H_{18}O_3$ $(M)^+$: 366.1256; Found: 366.1259.



3x

2-(2-phenylacetyl)phenyl 2-naphthoate

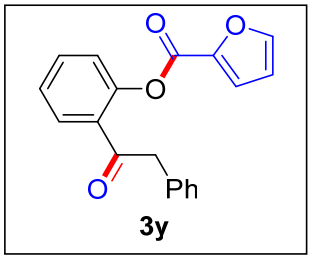
White solid, m. p. 109-111 ℃, (57 mg, 78% yield).

TLC: Rf = 0.25 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.77 (s, 1H), 8.17 (dd, J_1 = 8.4 Hz, J_2 = 1.2 Hz, 1H), 7.98 (d, J = 8.4 Hz, 1H), 7.94 (d, J = 9.0 Hz, 1H), 7.91 (d, J = 7.8 Hz, 1H), 7.83 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.65 – 7.55 (m, 3H), 7.38 – 7.34 (m, 1H), 7.32 – 7.15 (m, 6H), 4.22 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.99, 165.39, 149.32, 136.08, 134.14, 133.24, 132.65, 132.39, 131.76, 130.06, 129.70, 128.88, 128.69, 128.66, 127.97, 127.05, 126.99, 126.52, 126.27, 125.60, 124.06, 48.66.

HRMS (EI) Calcd for $C_{25}H_{18}O_3$ $(M)^+$: 366.1256; Found: 366.1255.



3y

2-(2-phenylacetyl)phenyl furan-2-carboxylate

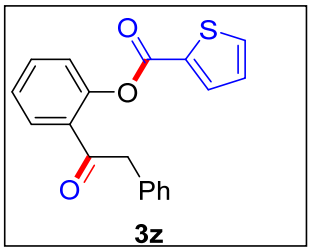
White solid, m. p. 91-93 ℃, (59 mg, 96% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.81 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.67 (d, J = 1.2 Hz, 1H), 7.58 – 7.53 (m, 1H), 7.39 (d, J = 3.6 Hz, 1H), 7.36 – 7.32 (m, 1H), 7.31 – 7.17 (m, 6H), 4.23 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.78, 156.68, 148.36, 147.54, 143.84, 134.14, 133.32, 131.39, 130.20, 129.73, 128.70, 127.08, 126.46, 123.90, 120.22, 112.49, 48.63.

HRMS (EI) Calcd for $C_{19}H_{14}O_4$ $(M)^+$: 306.0892; Found: 306.0897.



3z

2-(2-phenylacetyl)phenyl thiophene-2-carboxylate

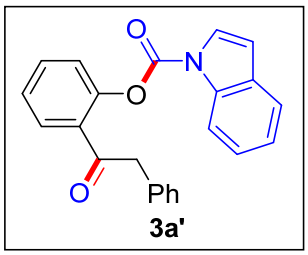
White solid, m. p. 99-101 ℃, (62 mg, 97% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.98 (d, J = 3.6 Hz, 1H), 7.79 (d, J = 7.8 Hz, 1H), 7.67 (dd, J_1 = 4.8 Hz, J_2 = 1.2 Hz, 1H), 7.58 – 7.52 (m, 1H), 7.36 – 7.31 (m, 1H), 7.30 – 7.15 (m, 7H), 4.22 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.90, 160.42, 148.68, 135.33, 134.12, 134.09, 133.20, 132.43, 131.60, 130.07, 129.74, 128.69, 128.32, 127.07, 126.38, 123.94, 48.77.

HRMS (EI) Calcd for $C_{19}H_{14}O_3S$ $(M)^+$: 322.0664; Found: 322.0667.



3a'

2-(2-phenylacetyl)phenyl 1H-indole-1-carboxylate

Brown oil, (62 mg, 88% yield).

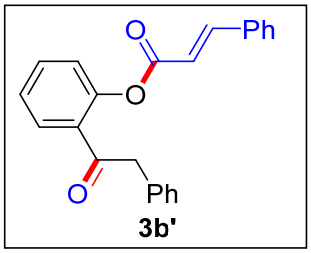
TLC: Rf = 0.15 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.17 (s, 1H), 7.86 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz,

1H), 7.70 (d, *J* = 3.6 Hz, 1H), 7.62 – 7.56 (m, 2H), 7.41 – 7.36 (m, 1H), 7.36 – 7.14 (m, 8H), 6.67 (d, *J* = 3.6 Hz, 1H), 4.21 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.49, 148.50, 133.87, 133.48, 131.18, 130.79, 130.16, 129.60, 128.76, 127.13, 126.76, 125.75, 124.91, 124.03, 123.60, 121.27, 115.44, 109.30, 48.30.

HRMS (EI) Calcd for $C_{23}H_{17}NO_3$ $(M)^+$: 355.1208; Found: 355.1210.



3b'

2-(2-phenylacetyl)phenyl cinnamate

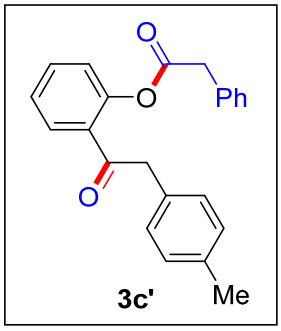
White solid, m. p. 100-101 ℃, (63 mg, 92% yield).

TLC: Rf = 0.3 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.87 (d, *J* = 15.6 Hz, 1H), 7.80 (dd, J_1 = 7.8 Hz, J_2 = 1.8 Hz, 1H), 7.60 – 7.52 (m, 3H), 7.44 – 7.39 (m, 3H), 7.35 – 7.28 (m, 3H), 7.26 – 7.18 (m, 4H), 6.64 (d, *J* = 15.6 Hz, 1H), 4.22 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 198.01, 165.30, 149.05, 147.47, 134.25, 134.15, 133.18, 131.62, 130.98, 129.99, 129.73, 129.09, 128.70, 128.57, 127.05, 126.14, 123.91, 116.91, 48.60.

HRMS (EI) Calcd for $C_{23}H_{18}O_3$ $(M)^+$: 342.1256; Found: 342.1259.



3c'

2-(2-(p-tolyl)acetyl)phenyl 2-phenylacetate

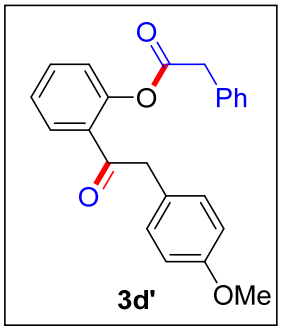
White solid, m. p. 121-123 ℃, (63 mg, 91% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.74 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.48 – 7.44 (m, 1H), 7.37 – 7.22 (m, 6H), 7.10 (d, J = 7.8 Hz, 2H), 7.08 – 7.00 (m, 3H), 4.05 (s, 2H), 3.89 (s, 2H), 2.31 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 198.08, 170.16, 148.99, 136.61, 133.29, 133.10, 131.13, 131.06, 129.92, 129.71, 129.55, 129.41, 128.77, 127.44, 126.12, 123.78, 47.87, 41.34, 21.20.

HRMS (EI) Calcd for $C_{23}H_{20}O_3$ $(M)^+$: 344.1412; Found: 344.1416.



2-(2-(4-methoxyphenyl)acetyl)phenyl 2-phenylacetate

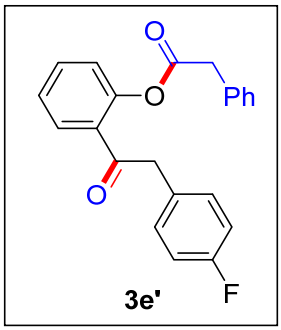
White solid, m. p. 123-125 ℃, (67 mg, 93% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.73 (dd, J_1 = 7.8 Hz, J_2 = 1.8 Hz, 1H), 7.49 – 7.45 (m, 1H), 7.38 – 7.24 (m, 6H), 7.09 – 7.04 (m, 3H), 6.87 – 6.81 (m, 2H), 4.03 (s, 2H), 3.89 (s, 2H), 3.78 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 198.26, 170.19, 158.67, 148.95, 133.27, 133.10, 131.16, 130.73, 129.87, 129.71, 128.79, 127.46, 126.14, 126.13, 123.77, 114.15, 55.33, 47.41, 41.36.

HRMS (EI) Calcd for $C_{23}H_{20}O_4$ $(M)^+$: 360.1362; Found: 360.1369.



2-(2-(4-fluorophenyl)acetyl)phenyl 2-phenylacetate

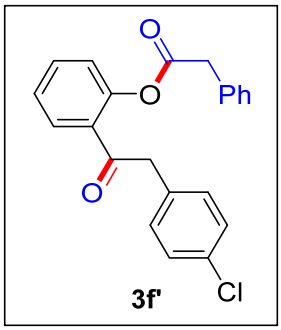
White solid, m. p. 71-73 ℃, (61 mg, 88% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.73 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.53 – 7.47 (m, 1H), 7.41 – 7.26 (m, 6H), 7.13 – 7.03 (m, 3H), 7.03 – 6.92 (m, 2H), 4.05 (s, 2H), 3.89 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.72, 170.19, 162.04 (d, J = 245.3 Hz), 148.96, 133.31, 133.19, 131.33 (d, J = 8.0 Hz), 131.07, 129.81 (d, J = 3.3 Hz), 129.73, 129.71, 128.83, 127.53, 126.21, 123.81, 115.52 (d, J = 21.4 Hz), 47.30, 41.40.

HRMS (EI) Calcd for $C_{22}H_{17}FO_3$ $(M)^+$: 348.1162; Found: 348.1164.



2-(2-(4-chlorophenyl)acetyl)phenyl 2-phenylacetate

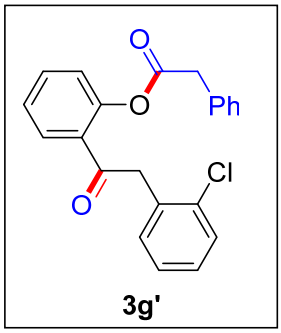
White solid, m. p. 103-105 ℃, (64 mg, 88% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.75 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.54 – 7.49 (m, 1H), 7.37 – 7.24 (m, 8H), 7.09 (d, J = 7.8 Hz, 1H), 7.05 (d, J = 7.8 Hz, 2H), 4.05 (s, 2H), 3.90 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.44, 170.26, 148.91, 133.44, 133.12, 132.98, 132.52, 131.18, 130.87, 129.74, 129.71, 128.82, 128.79, 127.54, 126.25, 123.82, 47.39, 41.36.

HRMS (EI) Calcd for $C_{22}H_{17}ClO_3$ $(M)^+$: 364.0866; Found: 364.0861.



3g'

2-(2-(2-chlorophenyl)acetyl)phenyl 2-phenylacetate

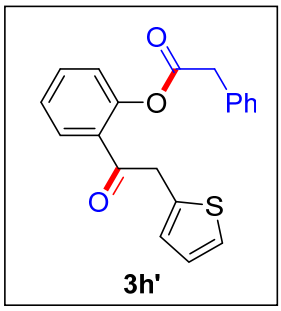
White solid, m. p. 113-115 ℃, (57 mg, 79% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.84 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.53 – 7.48 (m, 1H), 7.41 – 7.19 (m, 9H), 7.16 – 7.06 (m, 2H), 4.22 (s, 2H), 3.90 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 196.49, 170.16, 149.04, 134.60, 133.33, 133.23, 132.92, 132.01, 131.09, 129.87, 129.71, 129.53, 128.81, 128.74, 127.48, 126.98, 126.25, 123.81, 46.20, 41.42.

HRMS (EI) Calcd for $C_{22}H_{17}ClO_3$ $(M)^+$: 364.0866; Found: 364.0867.



3h'

2-(2-(thiophen-2-yl)acetyl)phenyl 2-phenylacetate

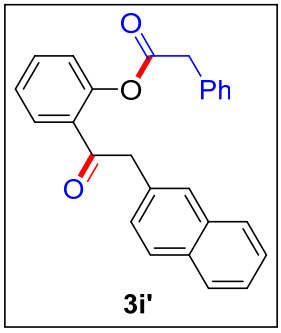
White solid, m. p. 63-65 ℃, (46 mg, 68% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 8/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.2 Hz, 1H), 7.53 – 7.47 (m, 1H), 7.39 – 7.32 (m, 4H), 7.32 – 7.27 (m, 2H), 7.22 (d, *J* = 4.8 Hz, 1H), 7.09 (d, *J* = 7.8 Hz, 1H), 6.98 – 6.93 (m, 1H), 6.83 (d, *J* = 3.0 Hz, 1H), 4.28 (s, 2H), 3.91 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 196.25, 170.10, 149.13, 135.17, 133.44, 133.19, 130.61, 129.97, 129.71, 128.85, 127.53, 127.10, 127.01, 126.22, 125.25, 123.86, 42.18, 41.41.

HRMS (EI) Calcd for $C_{20}H_{16}O_3S$ $(M)^+$: 336.0820; Found: 336.0825.



3i'

2-(2-(naphthalen-2-yl)acetyl)phenyl 2-phenylacetate

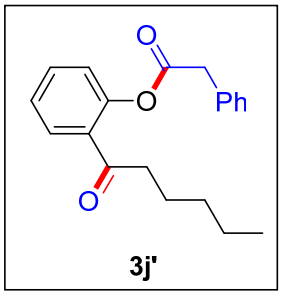
White solid, m. p. 139-141 °C, (54 mg, 71% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.88 – 7.69 (m, 4H), 7.61 (s, 1H), 7.52 – 7.41 (m, 3H), 7.36 – 7.25 (m, 7H), 7.09 (d, *J* = 8.4 Hz, 1H), 4.26 (s, 2H), 3.90 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 197.94, 170.24, 149.07, 133.65, 133.28, 133.26, 132.55, 131.79, 131.17, 129.98, 129.74, 128.83, 128.43, 128.32, 127.86, 127.82, 127.81, 127.50, 126.22, 125.90, 123.86, 48.46, 41.41.

HRMS (EI) Calcd for $C_{26}H_{20}O_3$ $(M)^+$: 380.1412; Found: 380.1419.



2-hexanoylphenyl 2-phenylacetate

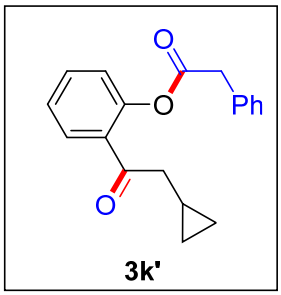
Colorless oil, (20 mg, 31% yield).

TLC: Rf = 0.25 (Petroleum ether/EtOAc = 8/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.72 (dd, J_1 = 7.8 Hz, J_2 = 1.8 Hz, 1H), 7.50 – 7.45 (m, 1H), 7.42 – 7.33 (m, 4H), 7.32 – 7.27 (m, 2H), 7.06 (dd, J_1 = 8.4 Hz, J_2 = 1.2 Hz, 1H), 3.92 (s, 2H), 2.82 – 2.74 (m, 2H), 1.66 – 1.60 (m, 2H), 1.35 – 1.25 (m, 4H), 0.89 (t, J = 7.2 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 200.80, 170.19, 148.87, 133.33, 132.93, 131.49, 129.71, 129.70, 128.79, 127.47, 126.17, 123.78, 41.64, 41.41, 31.51, 23.88, 22.64, 14.08.

HRMS (EI) Calcd for $C_{20}H_{22}O_3$ $(M)^+$: 310.1569; Found: 310.1571.



2-(2-cyclopropylacetyl)phenyl 2-phenylacetate

Colorless oil, (46 mg, 79% yield).

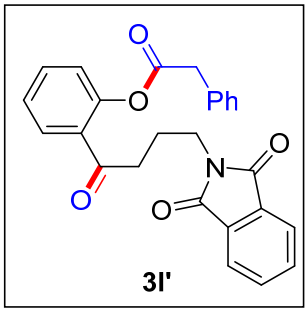
TLC: Rf = 0.2 (Petroleum ether/EtOAc = 8/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.70 (dd, J_1 = 7.8 Hz, J_2 = 1.8 Hz, 1H), 7.50 – 7.45 (m, 1H), 7.43 – 7.33 (m, 4H), 7.32 – 7.25 (m, 2H), 7.06 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz,

1H), 3.93 (s, 2H), 2.68 (d, J = 6.6 Hz, 2H), 1.11 – 0.96 (m, 1H), 0.58 – 0.48 (m, 2H), 0.12 – 0.03 (m, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 200.31, 170.11, 148.82, 133.27, 132.93, 131.34, 129.67, 128.77, 127.45, 126.12, 123.71, 46.79, 41.38, 6.39, 4.57.

HRMS (EI) Calcd for $C_{19}H_{18}O_3$ $(M)^+$: 294.1256; Found: 294.1259.



2-(4-(1,3-dioxoisoindolin-2-yl)butanoyl)phenyl 2-phenylacetate

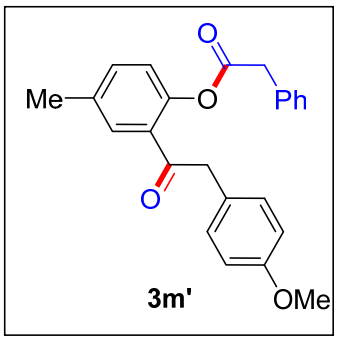
White soild, m. p. 96-98 ℃, (76 mg, 89% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 8/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.89 – 7.80 (m, 2H), 7.76 – 7.68 (m, 3H), 7.50 – 7.45 (m, 1H), 7.42 – 7.27 (m, 6H), 7.04 (d, J = 8.0 Hz, 1H), 3.90 (s, 2H), 3.74 (t, J = 6.6 Hz, 2H), 2.87 (t, J = 7.2 Hz, 2H), 2.07 – 1.99 (m, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 198.93, 170.28, 168.58, 148.90, 134.11, 133.29, 133.23, 132.16, 130.88, 129.82, 129.71, 128.81, 127.49, 126.24, 123.75, 123.40, 41.33, 38.86, 37.42, 23.14.

HRMS (EI) Calcd for $C_{26}H_{21}NO_5$ $(M)^+$: 427.1420; Found: 427.1419.



2-(2-(4-methoxyphenyl)acetyl)-4-methylphenyl 2-phenylacetate

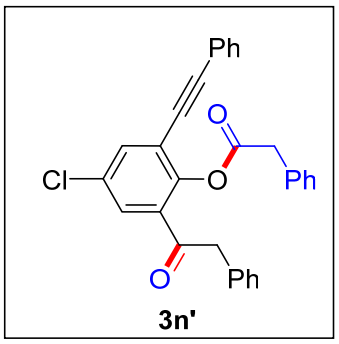
White soild, m. p. 95-97 ℃, (60 mg, 81% yield).

TLC: Rf = 0.15 (Petroleum ether/EtOAc = 8/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.54 (s, 1H), 7.41 – 7.26 (m, 6H), 7.05 (d, *J* = 8.4 Hz, 2H), 6.95 (d, *J* = 8.4 Hz, 1H), 6.85 (d, *J* = 9.0 Hz, 2H), 4.02 (s, 2H), 3.89 (s, 2H), 3.79 (s, 3H), 2.36 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 198.45, 170.35, 158.66, 146.75, 135.95, 133.69, 133.35, 130.93, 130.77, 130.26, 129.72, 128.81, 127.46, 126.27, 123.46, 114.14, 55.36, 47.40, 41.42, 21.00.

HRMS (EI) Calcd for $C_{24}H_{22}O_4$ $(M)^+$: 374.1518; Found: 374.1515.



3n'

4-chloro-2-(2-phenylacetyl)-6-(phenylethynyl)phenyl 2-phenylacetate

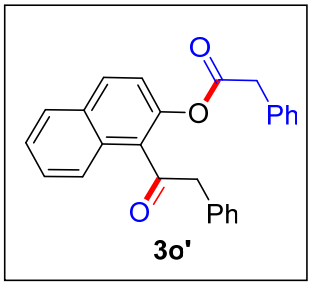
White soild, m. p. 98-100 ℃, (51 mg, 55% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.65 (d, *J* = 2.4 Hz, 1H), 7.63 (d, *J* = 2.4 Hz, 1H), 7.41 – 7.22 (m, 13H), 7.11 (d, *J* = 7.2 Hz, 2H), 4.02 (s, 2H), 3.93 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 196.27, 169.16, 148.27, 135.77, 133.41, 133.15, 132.75, 131.90, 131.59, 129.76, 129.73, 129.32, 128.83, 128.60, 127.56, 127.34, 122.11, 121.34, 96.41, 82.58, 48.36, 41.20.

HRMS (EI) Calcd for $C_{30}H_{21}ClO_3$ $(M)^+$: 464.1179; Found: 464.1170.



3o'

1-(2-phenylacetyl)naphthalen-2-yl 2-phenylacetate

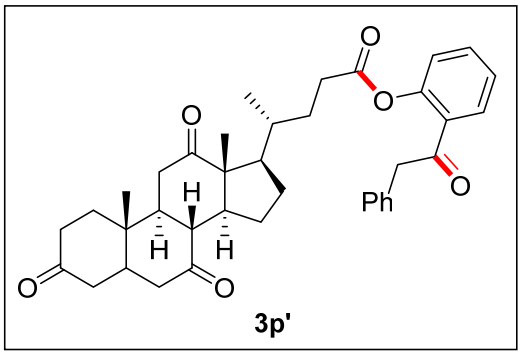
Brown oil, (57 mg, 75% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.84 (d, *J* = 9.0 Hz, 1H), 7.81 (d, *J* = 7.8 Hz, 1H), 7.51 (d, *J* = 8.4 Hz, 1H), 7.46 – 7.34 (m, 6H), 7.33 – 7.29 (m, 1H), 7.28 – 7.19 (m, 4H), 7.11 (d, *J* = 7.2 Hz, 2H), 3.94 (s, 2H), 3.82 (s, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 202.44, 169.67, 144.50, 133.12, 132.94, 131.53, 130.93, 130.13, 130.07, 129.90, 129.54, 129.03, 128.67, 128.37, 127.75, 127.67, 127.24, 126.26, 124.60, 121.21, 51.63, 41.47.

HRMS (EI) Calcd for $C_{26}H_{20}O_3$ $(M)^+$: 380.1412; Found: 380.1415.



3p'

2-(2-phenylacetyl)phenyl (4R)-4-((8R,9S,10S,13R,14S,17R)-10,13-dimethyl-3,7,12-triox-ohexadecahydro-1H-cyclopenta[a]phenanthren-17-yl)pentanoate

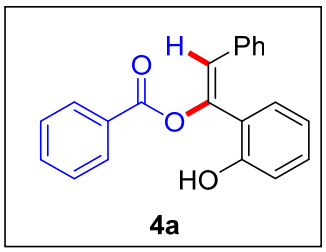
White soild, m. p. 138-140 °C, (99 mg, 83% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 4/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.77 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.55 – 7.48 (m, 1H), 7.35 – 7.27 (m, 3H), 7.27 – 7.19 (m, 3H), 7.11 (d, J = 7.8 Hz, 1H), 4.19 (s, 2H), 2.95 – 2.81 (m, 3H), 2.70 – 2.63 (m, 1H), 2.57 – 2.49 (m, 1H), 2.37 – 2.19 (m, 6H), 2.16 – 1.93 (m, 7H), 1.88 – 1.82 (m, 1H), 1.65 – 1.58 (m, 1H), 1.52 – 1.45 (m, 1H), 1.40 (s, 3H), 1.39 – 1.33 (m, 2H), 1.28 – 1.21 (m, 1H), 1.07 (s, 3H), 0.90 (d, J = 6.6 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 212.05, 209.16, 208.81, 197.79, 172.62, 149.04, 134.23, 133.17, 131.25, 129.84, 129.70, 128.70, 127.05, 126.00, 123.93, 57.03, 51.86, 49.10, 48.27, 46.94, 45.82, 45.64, 45.09, 42.90, 38.74, 36.59, 36.12, 35.53, 35.38, 31.64, 30.17, 27.69, 25.25, 22.00, 18.81, 11.96.

HRMS (EI) Calcd for $C_{38}H_{44}O_6$ $(M)^+$: 596.3138; Found: 596.3131.



4a

(E)-1-(2-hydroxyphenyl)-2-phenylvinyl benzoate

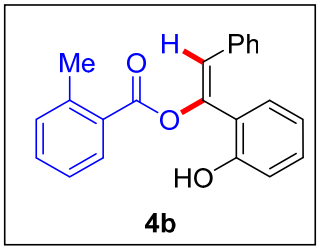
White soild, m. p. 95-97 ℃, (58mg, 91% yield).

TLC: Rf = 0.3 (Petroleum ether/EtOAc = 8/1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.13 (d, J = 7.6 Hz, 2H), 7.64 – 7.58 (m, 1H), 7.51 – 7.44 (m, 2H), 7.36 – 7.27 (m, 3H), 7.21 – 7.15 (m, 3H), 7.08 – 7.02 (m, 2H), 7.01 – 6.92 (m, 2H), 6.72 (s, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 167.80, 154.54, 143.28, 134.12, 132.75, 131.70, 130.46, 130.39, 128.88, 128.74, 128.61, 128.45, 128.27, 124.97, 121.67, 120.94, 117.59.

HRMS (EI) Calcd for $C_{21}H_{16}O_3$ $(M)^+$: 316.1099; Found: 316.1095.



4b

(E)-1-(2-hydroxyphenyl)-2-phenylvinyl 2-methylbenzoate

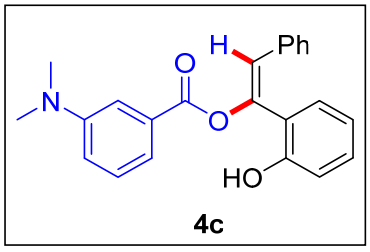
Grown gum, (61mg, 93% yield).

TLC: Rf = 0.3 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (dd, J_1 = 8.0 Hz, J_2 = 1.2 Hz, 1H), 7.45 – 7.40 (m, 1H), 7.35 – 7.27 (m, 3H), 7.27 – 7.22 (m, 2H), 7.19 – 7.14 (m, 3H), 7.07 – 7.02 (m, 2H), 7.00 – 6.93 (m, 2H), 6.69 (s, 1H), 2.61 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 168.36, 154.52, 143.25, 141.69, 133.26, 132.84, 132.11, 131.61, 131.57, 130.39, 128.57, 128.41, 128.19, 127.75, 126.04, 124.88, 121.86, 120.92, 117.55, 22.16.

HRMS (EI) Calcd for $C_{22}H_{18}O_3$ $(M)^+$: 330.1256; Found: 330.1255.



4c

(*E*)-1-(2-hydroxyphenyl)-2-phenylvinyl 3-(dimethylamino)benzoate

Yellow gum (quant.).

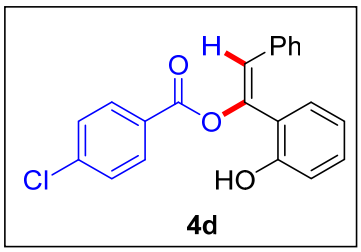
TLC: Rf = 0.2 (Petroleum ether/EtOAc = 8/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.48 – 7.45 (m, 1H), 7.42 (dd, J_1 = 2.4 Hz, J_2 = 1.8 Hz, 1H), 7.36 (br, 1H), 7.33 – 7.28 (m, 3H), 7.19 – 7.15 (m, 3H), 7.07 – 7.02 (m, 2H), 6.98 (dd, J_1 = 8.4 Hz, J_2 = 1.2 Hz, 1H), 6.96 – 6.92 (m, 2H), 6.71 (s, 1H), 2.98 (s, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 168.57, 154.59, 150.63, 143.51, 132.90, 131.60,

130.48, 129.43, 129.33, 128.57, 128.44, 128.16, 124.81, 121.82, 120.86, 118.17, 117.80, 117.55, 113.67, 40.59.

HRMS (EI) Calcd for $C_{23}H_{21}NO_3$ $(M)^+$: 359.1521; Found: 359.1527.



4d

(*E*)-1-(2-hydroxyphenyl)-2-phenylvinyl 4-chlorobenzoate

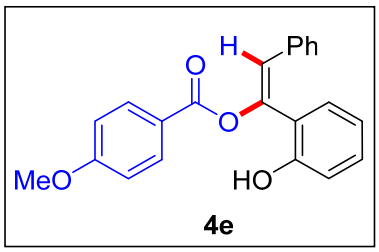
Yellow gum, (62mg, 89% yield).

TLC: Rf = 0.3 (Petroleum ether/EtOAc = 8/1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (d, *J* = 8.4 Hz, 2H), 7.45 (d, *J* = 8.8 Hz, 2H), 7.36 – 7.28 (m, 2H), 7.22 – 7.15 (m, 4H), 7.07 – 7.02 (m, 2H), 7.00 – 6.93 (m, 2H), 6.72 (s, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 166.91, 154.49, 143.09, 140.72, 132.60, 131.81, 131.74, 130.43, 129.14, 128.65, 128.46, 128.38, 127.35, 125.09, 121.47, 121.00, 117.60.

HRMS (EI) Calcd for $C_{21}H_{15}ClO_3$ $(M)^+$: 350.0710; Found: 350.0713.



4e

(*E*)-1-(2-hydroxyphenyl)-2-phenylvinyl 4-methoxybenzoate

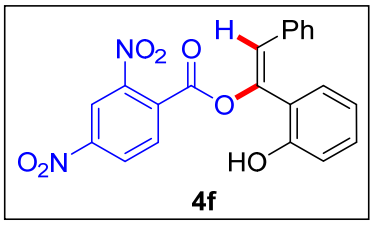
White soild, m. p. 106-108 ℃, (64 mg, 92% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (d, *J* = 8.8 Hz, 2H), 7.46 (s, 1H), 7.36 – 7.27 (m, 2H), 7.20 – 7.14 (m, 3H), 7.07 – 6.90 (m, 6H), 6.69 (s, 1H), 3.85 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 167.62, 164.34, 154.62, 143.41, 132.90, 132.57, 131.61, 130.48, 128.57, 128.42, 128.15, 124.93, 121.90, 121.08, 120.85, 117.61, 114.01, 55.65.

HRMS (EI) Calcd for $C_{22}H_{18}O_4$ $(M)^+$: 346.1205; Found: 346.1209.



4f

(*E*)-1-(2-hydroxyphenyl)-2-phenylvinyl 2,4-dinitrobenzoate

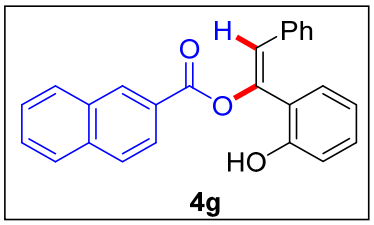
Yellow soild, m. p. 141-143 ℃, (74mg, 91% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 5/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.85 (d, *J* = 2.1 Hz, 1H), 8.54 (dd, *J* = 8.4, 2.1 Hz, 1H), 7.94 (d, *J* = 8.4 Hz, 1H), 7.40 – 7.36 (m, 1H), 7.29 (dd, *J* = 7.7, 1.2 Hz, 1H), 7.24 – 7.17 (m, 3H), 7.11 – 7.06 (m, 2H), 7.04 – 6.97 (m, 2H), 6.84 (s, 1H), 6.37 (s, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 164.40, 154.21, 149.43, 148.15, 142.33, 132.20, 132.01, 131.92, 131.70, 130.54, 128.84, 128.74, 128.64, 127.86, 125.42, 121.25, 120.16, 119.94, 117.44.

HRMS (EI) Calcd for $C_{21}H_{14}N_2O_7$ $(M)^+$: 406.0801; Found: 406.0803.



4g

(*E*)-1-(2-hydroxyphenyl)-2-phenylvinyl 2-naphthoate

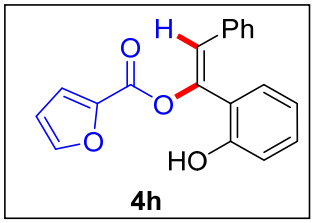
White soild, m. p. 153-155 ℃, (65 mg, 89% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.71 (s, 1H), 8.10 (dd, J_1 = 8.8 Hz, J_2 = 1.6 Hz, 1H), 7.97 (d, J = 8.0 Hz, 1H), 7.92 – 7.85 (m, 2H), 7.64 – 7.53 (m, 2H), 7.40 – 7.30 (m, 3H), 7.22 – 7.16 (m, 3H), 7.10 – 7.04 (m, 2H), 7.03 – 6.94 (m, 2H), 6.77 (s, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 168.02, 154.62, 143.41, 136.07, 132.80, 132.51, 132.38, 131.74, 130.52, 129.65, 129.00, 128.63, 128.60, 128.48, 128.29, 127.98, 127.08, 126.05, 125.42, 125.05, 121.73, 120.96, 117.64.

HRMS (EI) Calcd for $C_{25}H_{18}O_3$ $(M)^+$: 366.1256; Found: 366.1254.



4h

(*E*)-1-(2-hydroxyphenyl)-2-phenylvinyl furan-2-carboxylate

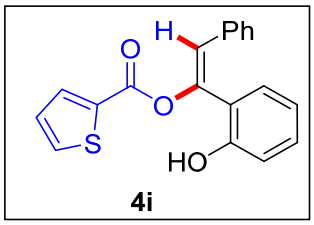
Grey gum, (53 mg, 87% yield).

TLC: Rf = 0.15 (Petroleum ether/EtOAc = 8/1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (dd, J_1 = 1.6 Hz, J_2 = 0.4 Hz, 1H), 7.35 – 7.29 (m, 3H), 7.20 – 7.15 (m, 3H), 7.08 (br, 1H), 7.06 – 7.02 (m, 2H), 7.00 – 6.93 (m, 2H), 6.73 (s, 1H), 6.55 (dd, J_1 = 3.6, J_2 = 2.0 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 159.28, 154.52, 147.64, 143.53, 142.47, 132.57, 131.80, 130.56, 128.61, 128.48, 128.36, 125.35, 121.31, 120.96, 120.44, 117.63, 112.49.

HRMS (EI) Calcd for $C_{19}H_{14}O_4$ $(M)^+$: 306.0892; Found: 306.0894.



4i

(*E*)-1-(2-hydroxyphenyl)-2-phenylvinyl thiophene-2-carboxylate

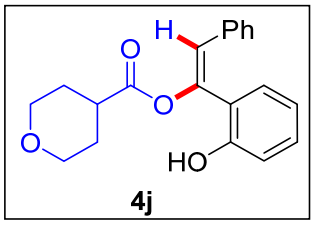
Brown gum, (58 mg, 90% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, *J* = 4.0 Hz, 1H), 7.66 (d, *J* = 4.8 Hz, 1H), 7.36 – 7.29 (m, 2H), 7.21 – 7.12 (m, 5H), 7.08 – 7.01 (m, 2H), 7.01 – 6.93 (m, 2H), 6.74 (s, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 163.22, 154.53, 142.92, 135.37, 134.34, 132.65, 132.13, 131.77, 130.52, 128.63, 128.49, 128.35, 128.29, 125.28, 121.49, 120.97, 117.62.

HRMS (EI) Calcd for $C_{19}H_{14}O_3S$ $(M)^+$: 322.0664; Found: 322.0667.



4j

(*E*)-1-(2-hydroxyphenyl)-2-phenylvinyl tetrahydro-2H-pyran-4-carboxylate

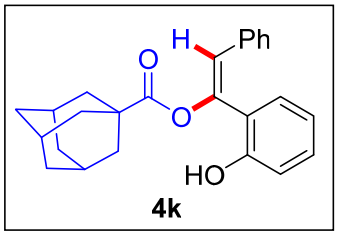
Brown oil, (55 mg, 85% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.34 – 7.30 (m, 1H), 7.23 – 7.13 (m, 4H), 7.01 – 6.90 (m, 5H), 6.55 (s, 1H), 3.95 (dt, J_1 = 12.0 Hz, J_2 = 3.6 Hz, 2H), 3.44 (td, J_1 = 11.4 Hz, J_2 = 1.8 Hz, 2H), 2.72 – 2.65 (m, 1H), 1.92 – 1.87 (m, 2H), 1.85 – 1.77 (m, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 175.64, 154.34, 143.01, 132.63, 131.66, 130.21, 128.58, 128.37, 128.26, 124.53, 121.47, 120.91, 117.49, 66.97, 39.90, 28.46.

HRMS (EI) Calcd for $C_{20}H_{20}O_4$ $(M)^+$: 324.1362; Found: 324.1366.



4k

(*E*)-1-(2-hydroxyphenyl)-2-phenylvinyl (3r,5r,7r)-adamantane-1-carboxylate

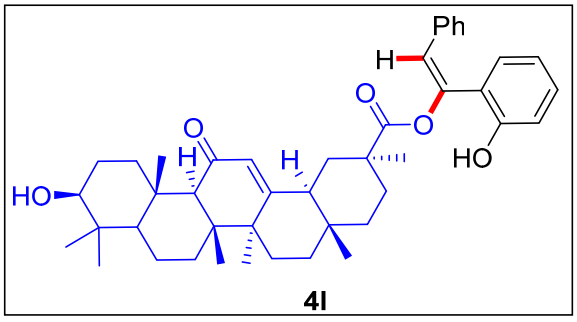
Brown oil, (62 mg, 83% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.34 – 7.29 (m, 1H), 7.21 (d, *J* = 7.2 Hz, 1H), 7.18 – 7.13 (m, 3H), 7.08 (s, 1H), 7.02 – 6.92 (m, 4H), 6.51 (s, 1H), 2.04 (s, 3H), 1.94 (s, 6H), 1.77 – 1.69 (m, 6H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 179.02, 154.43, 143.47, 132.92, 131.46, 130.17, 128.54, 128.34, 128.08, 124.16, 121.78, 120.80, 117.47, 40.88, 38.66, 36.47, 27.91.

HRMS (EI) Calcd for $C_{25}H_{26}O_3$ $(M)^+$: 374.1882; Found: 374.1880.



4l

(E)-1-(2-hydroxyphenyl)-2-phenylvinyl (2S,4aS,6aS,6bR,10S,12aS,12bR,14bS)-10-hydr--oxy-2,4a,6a,6b,9,9,12a-heptamethyl-13-oxo-

1,2,3,4,4a,5,6,6a,6b,7,8,8a,9,10,11,12,12a,12b,13,14b-icosahydropicene-2-carboxylate

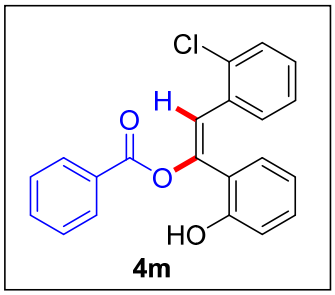
White soild, m. p. 172-174 ℃, (89 mg, 68% yield).

TLC: Rf = 0.15 (Petroleum ether/EtOAc = 5/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 7.35 – 7.28 (m, 1H), 7.24 (d, *J* = 7.2 Hz, 1H), 7.21 – 7.09 (m, 4H), 7.07 – 7.00 (m, 2H), 7.00 – 6.90 (m, 2H), 6.52 (s, 1H), 5.62 (s, 1H), 3.23 (dd, J_1 = 10.8 Hz, J_2 = 5.6 Hz, 1H), 2.79 (d, *J* = 13.2 Hz, 1H), 2.33 (s, 1H), 2.06 – 1.94 (m, 4H), 1.88 – 1.76 (m, 2H), 1.72 – 1.57 (m, 5H), 1.48 – 1.37 (m, 4H), 1.35 (s, 3H), 1.27 – 1.24 (m, 1H), 1.22 (s, 3H), 1.19 – 1.16 (m, 1H), 1.14 (s, 3H), 1.11 (s, 3H), 1.01 (s, 3H), 0.99 – 0.93 (m, 2H), 0.81 (s, 3H), 0.69 (d, *J* = 11.4 Hz, 1H), 0.66 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 200.48, 177.84, 169.02, 154.37, 143.36, 132.77, 131.55, 130.41, 128.70, 128.53, 128.41, 128.12, 124.22, 121.63, 120.85, 117.37, 78.91, 61.94, 55.08, 48.30, 45.51, 44.03, 43.33, 41.13, 39.27, 37.55, 37.23, 32.91, 31.83, 31.24, 28.45, 28.24, 28.06, 27.39, 26.54, 26.49, 23.48, 18.81, 17.62, 16.50, 15.74.

HRMS (EI) Calcd for $C_{44}H_{56}O_5$ $(M)^+$: 664.4128; Found: 664.4120.



4m

(*E*)-2-(2-chlorophenyl)-1-(2-hydroxyphenyl)vinyl benzoate

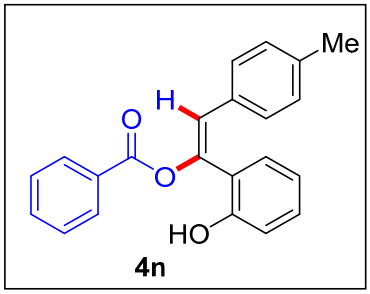
White soild, m. p. 113-115 ℃, (65 mg, 92% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.14 (d, *J* = 7.6 Hz, 2H), 7.65 – 7.59 (m, 1H), 7.52 – 7.45 (m, 2H), 7.35 (d, *J* = 8.0 Hz, 1H), 7.32 – 7.22 (m, 2H), 7.18 – 7.09 (m, 2H), 7.03 – 6.87 (m, 5H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 167.53, 154.47, 145.20, 134.21, 134.01, 131.62, 131.44, 130.46, 130.39, 129.51, 129.33, 128.77, 126.73, 121.87, 121.08, 120.72, 117.49.

HRMS (EI) Calcd for $C_{21}H_{15}ClO_3$ $(M)^+$: 350.0710; Found: 350.0714.



4n

(*E*)-1-(2-hydroxyphenyl)-2-(*p*-tolyl)vinyl benzoate

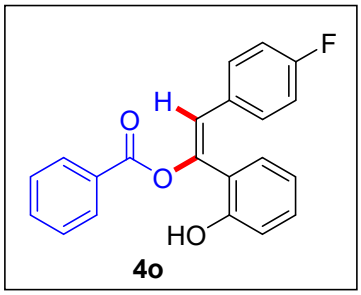
White soild, m. p. 81-82 ℃, (53 mg, 81% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.16 – 8.07 (m, 2H), 7.64 – 7.57 (m, 1H), 7.50 – 7.43 (m, 2H), 7.35 – 7.23 (m, 3H), 7.03 – 6.89 (m, 6H), 6.68 (s, 1H), 2.26 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 167.82, 154.54, 142.44, 138.24, 134.07, 131.61, 130.46, 130.37, 129.84, 129.37, 128.95, 128.71, 128.33, 124.83, 121.81, 120.90, 117.51, 21.35.

HRMS (EI) Calcd for $C_{22}H_{18}O_3$ $(M)^+$: 330.1256; Found: 330.1259.



4o

(*E*)-2-(4-fluorophenyl)-1-(2-hydroxyphenyl)vinyl benzoate

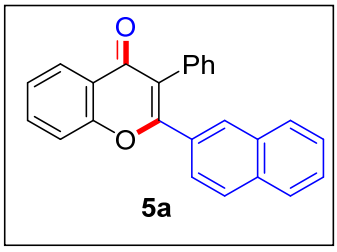
White soild, m. p. 116-118 ℃, (60 mg, 90% yield).

TLC: Rf = 0.2 (Petroleum ether/EtOAc = 10/1).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12 (dd, J_1= 8.4 Hz, J_2 = 1.2 Hz, 2H), 7.65 – 7.58 (m, 1H), 7.50 – 7.44 (m, 2H), 7.36 – 7.28 (m, 3H), 7.04 – 6.94 (m, 4H), 6.90 – 6.83 (m, 2H), 6.68 (s, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 167.85, 162.47 (d, J = 248.7 Hz), 154.53, 143.12, 143.10, 134.19, 131.84, 130.44, 130.40, 130.15 (d, J = 8.1 Hz), 128.92 (d, J = 3.3 Hz), 128.76, 123.87, 121.44, 121.07, 117.72, 115.66 (d, J = 21.6 Hz).

HRMS (EI) Calcd for $C_{21}H_{15}FO_3$ $(M)^+$: 334.1005; Found: 334.1004.



5a

2-(naphthalen-2-yl)-3-phenyl-4H-chromen-4-one

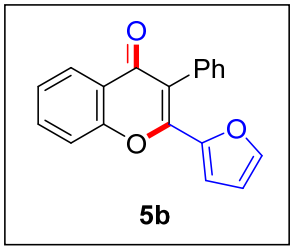
White soild, m. p. 177-179 ℃, (36mg, 69% yield).

TLC: Rf = 0.15 (Petroleum ether/EtOAc = 8/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.33 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 8.04 (s, 1H), 7.80 – 7.71 (m, 3H), 7.67 (d, J = 8.4 Hz, 1H), 7.60 (d, J = 8.4 Hz, 1H), 7.54 – 7.44 (m, 3H), 7.35 (dd, J_1 = 8.4 Hz, J_2 = 1.8 Hz, 1H), 7.32 – 7.25 (m, 5H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 177.53, 161.49, 156.31, 133.85, 133.78, 133.04, 132.67, 131.45, 130.80, 130.28, 128.89, 128.50, 127.83, 127.79, 127.77, 127.69, 126.74, 126.58, 126.21, 125.26, 123.73, 123.29, 118.15.

HRMS (EI) Calcd for $C_{25}H_{16}O_2$ $(M)^+$: 348.1150; Found: 348.1157.



5b

2-(furan-2-yl)-3-phenyl-4H-chromen-4-one

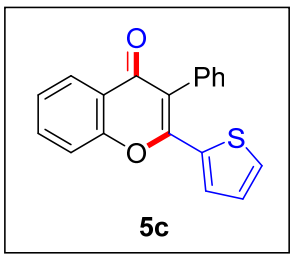
White soild, m. p. 139-141 ℃, (37mg, 86% yield).

TLC: Rf = 0.15 (Petroleum ether/EtOAc = 8/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.25 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.72 – 7.68 (m, 1H), 7.59 – 7.56 (m, 1H), 7.49 – 7.39 (m, 5H), 7.32 – 7.28 (m, 2H), 6.34 (dd, J_1 = 3.6 Hz, J_2 = 1.2 Hz, 1H), 6.04 (dd, J_1 = 3.6 Hz, J_2 = 0.6 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 177.24, 155.73, 151.87, 146.09, 145.09, 133.83, 132.94, 130.45, 128.99, 128.36, 126.32, 125.21, 123.66, 121.08, 118.03, 116.62, 112.22.

HRMS (EI) Calcd for $C_{19}H_{12}O_3$ $(M)^+$: 288.0786; Found: 288.0789.



5c

3-phenyl-2-(thiophen-2-yl)-4H-chromen-4-one

White soild, m. p. 150-152 ℃, (41mg, 91% yield).

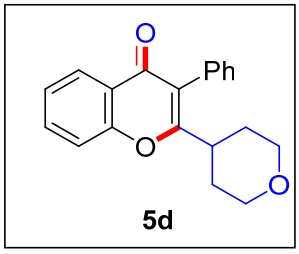
TLC: Rf = 0.15 (Petroleum ether/EtOAc = 8/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.25 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.73 – 7.68

(m, 1H), 7.56 (d, J = 7.8 Hz, 1H), 7.51 – 7.45 (m, 3H), 7.43 – 7.39 (m, 2H), 7.34 – 7.29 (m, 2H), 7.17 (dd, J_1 = 4.2 Hz, J_2 = 1.2 Hz, 1H), 6.95 (dd, J_1 = 4.8 Hz, J_2 = 3.6 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 177.51, 155.82, 155.71, 135.34, 133.85, 133.00, 131.43, 131.07, 131.02, 129.38, 128.78, 127.47, 126.38, 125.18, 123.45, 121.36, 117.88.

HRMS (EI) Calcd for $C_{19}H_{12}O_2S$ $(M)^+$: 304.0558; Found: 304.0560.



5d

3-phenyl-2-(tetrahydro-2H-pyran-4-yl)-4H-chromen-4-one

White soild, m. p. 179-180 ℃, (41mg, 90% yield).

TLC: Rf = 0.1 (Petroleum ether/EtOAc = 5/1).

^{1}H NMR (600 MHz, $CDCl_3$) δ 8.23 (dd, J_1 = 7.8 Hz, J_2 = 1.2 Hz, 1H), 7.71 – 7.66 (m, 1H), 7.50 – 7.44 (m, 3H), 7.42 – 7.38 (m, 2H), 7.26 – 7.24 (m, 2H), 4.01 (dd, J_1 = 11.4 Hz, J_2 = 4.2 Hz, 2H), 3.37 – 3.25 (m, 2H), 2.94 – 2.85 (m, 1H), 2.22 – 2.11 (m, 2H), 1.68 – 1.64 (m, 2H).

^{13}C NMR (151 MHz, $CDCl_3$) δ 177.34, 167.12, 156.08, 133.63, 132.89, 130.33, 128.75, 128.13, 126.41, 125.09, 123.59, 123.08, 117.82, 67.37, 38.47, 29.70.

HRMS (EI) Calcd for $C_{20}H_{18}O_3$ $(M)^+$: 306.1256; Found: 306.1258.

8. X-ray Crystallographic Analysis of 3r, 4c and 5f

Crystals suitable for X-ray diffraction experiments were obtained by following methods:

Compound **3r** was crystallized from mixed solvent of hexane/choroform; **4f** was crystallized from mixed solvent of PE/DCM; **5c** was crystallized from Hexane/EA. Intensity data for compound **3r**, **4f** and **5c** were collected on 'Bruke Apex2' diffractometer at 296(2) (MoK/α radiation, radiation wavelength = 0.7107).

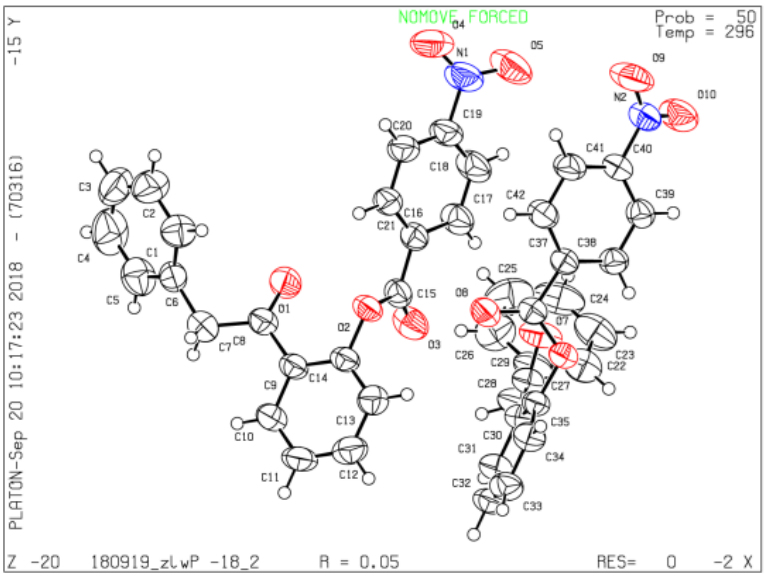


Figure S3. X-ray crystallographic structure **3r** (ORTEP view with 50% thermal ellipsoid contour probability, CCDC 1894582)

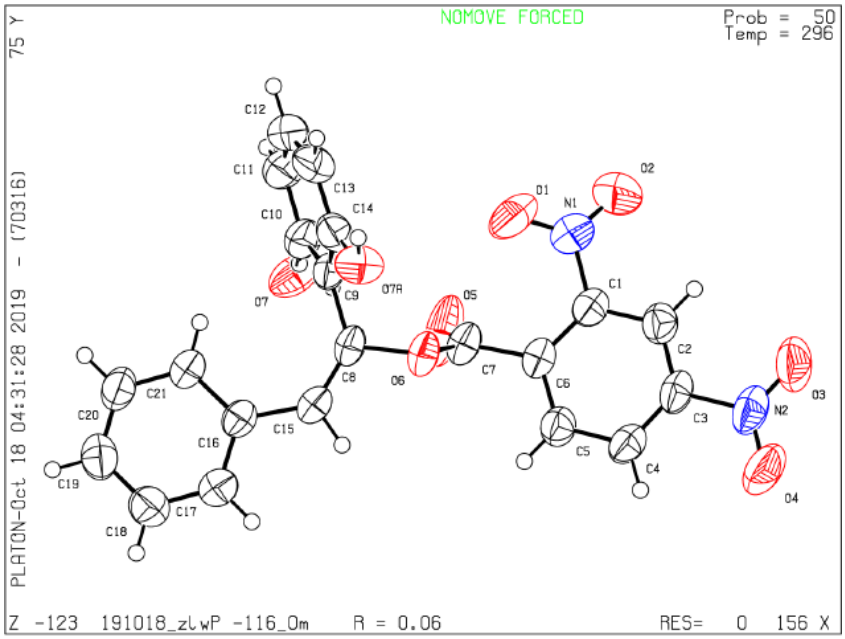


Figure S4. X-ray crystallographic structure **4f** (ORTEP view with 50% thermal ellipsoid contour probability, CCDC 1960048)

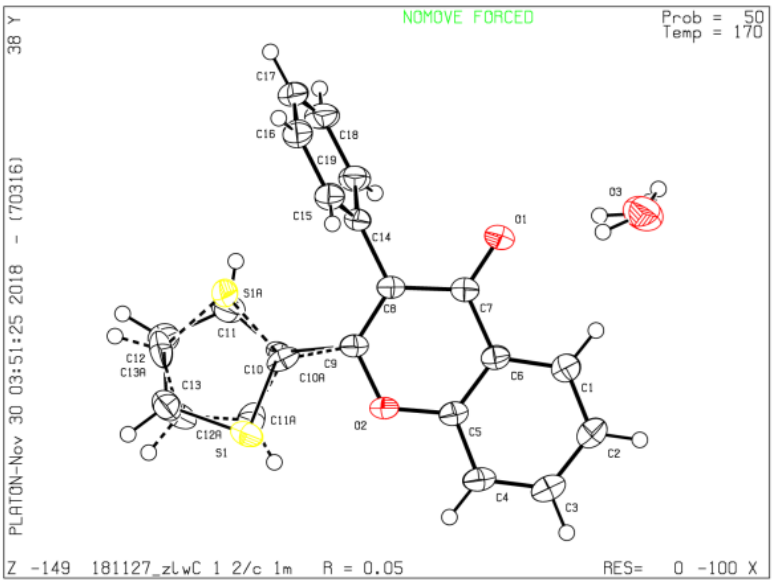


Figure S5. X-ray crystallographic structure **5c** (ORTEP view with 50% thermal ellipsoid contour probability, CCDC 1883891)

Table S1. Crystal data and structure refinements for **3r**, **4c** and **5f**

Compounds	**3r**	**4f**	**5c**
CCDC No.	1894582	1960048	1883891
Empirical formula	C21 H15 N O5	C21 H14 N2 O7	2(C19 H12 O2 S), H2 O
Formula weight	361.34	406.34	626.71
Crystal system	triclinic	triclinic	monoclinic
Space group	P-1	P-1	C 1 2/c 1
Hall group	-p 1	-p 1	-C 2yc
a/Å	11.020(2)	6.914(4)	18.6651(5)
b/Å	11.052(2)	10.600(8)	9.1102(3)
c/Å	16.364(3)	13.029(10)	18.3035(5)
α/°	106.830(16)	99.77(3)	90
β/°	104.080(16)	96.31(2)	108.2240(1)
γ/°	100.237(15)	92.38(4)	90
Volume	1782.9(6)	933.5(11)	2956.26(15)
Z	4	2	4
Temperature/K	296(2)	296(2)	170(2)
X-ray wavelength/Å	0.71073	0.71073	0.71073
2θ range for data collection/°	1.97 to 29.24	2.73 to 26.47	2.30 to 32.55
Crystal color	yellow	yellow	colourless
ρ_{Calcd} g/m^3	1.346	1.446	1.408
μ/mm^{-1}	0.097	0.111	0.227

Max. transmission	0.964	0.989	0.979
Min. transmission	0.954	0.968	0.911
F_000	752	420	1304
Crystal_size/mm^3	0.49×0.46×0.38	0.30×0.16×0.10	0.42×0.38×0.10
Radiation	MoK\α	MoK\α	MoK\α
Independent reflections I > 2σ (I)	4355	3064	4170
Independent reflections	6500	4125	5380
Index ranges	–13≦h≦11 –13≦k≦11 –15≦l≦19	–8≦h≦8 –13≦k≦13 –16≦l≦16	–22≦h≦28 –13≦k≦10 –27≦l≦27
Data/restraints/parameters	6500/0/487	4125/0/283	5380/13/253
Final R indexes R [I>2σ (I)]gt	R1 = 0.0526 wR2 = 0.1258	R1 = 0.0582 wR2 = 0.1572	R1 = 0.0471 wR2 = 0.1249
Final R indexes R [all data]	R1 = 0.0835 wR2 = 0.1532	R1 = 0.0761 wR2 = 0.1752	R1 = 0.0671 wR2 = 0.1394
Goodness-of-fit on F^2	1.036	1.106	1.034
Largest peak/deepest hole eÅ^{-3}	0.234/-0.234	0.265/-0.296	0.608/-0.313

9. References

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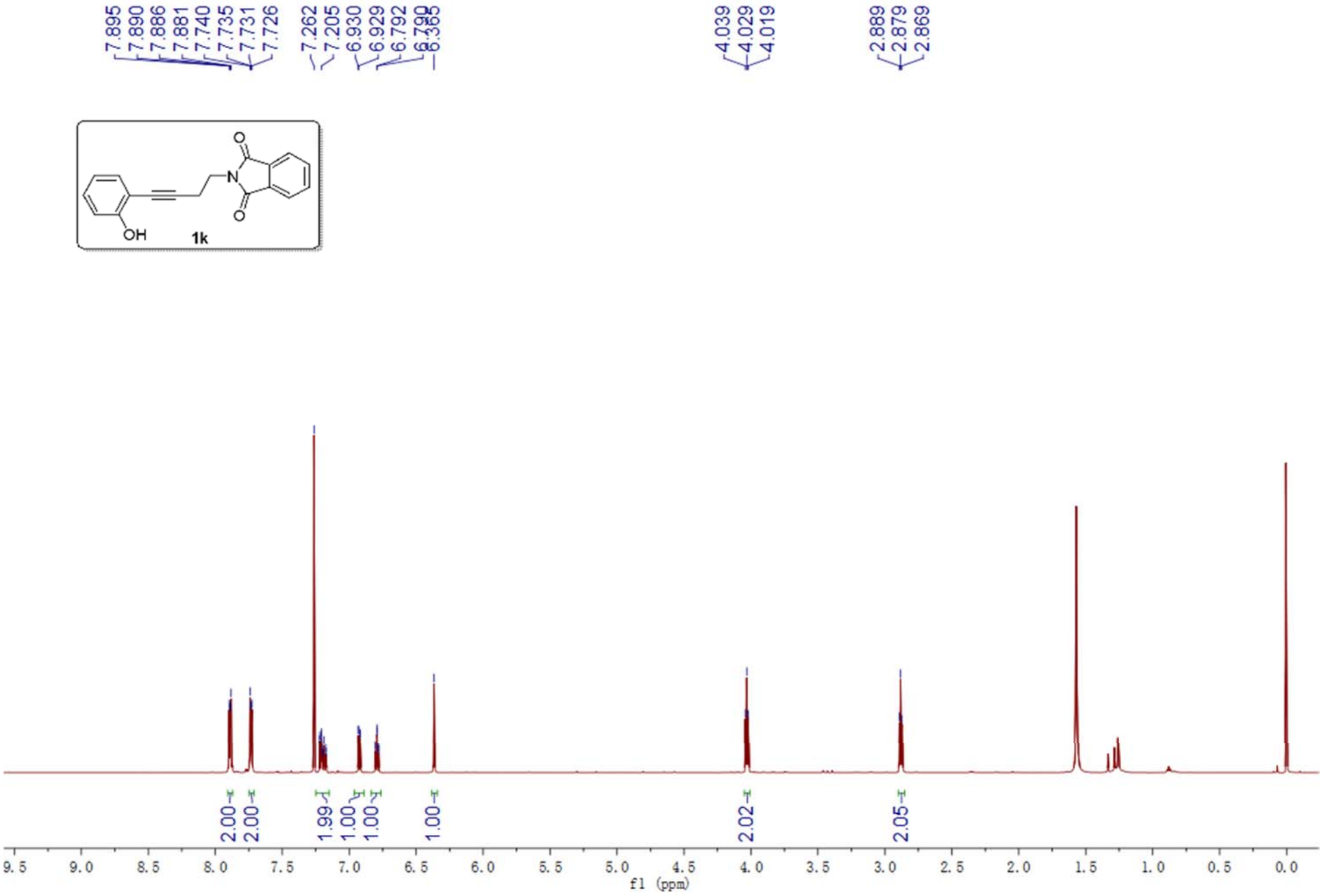

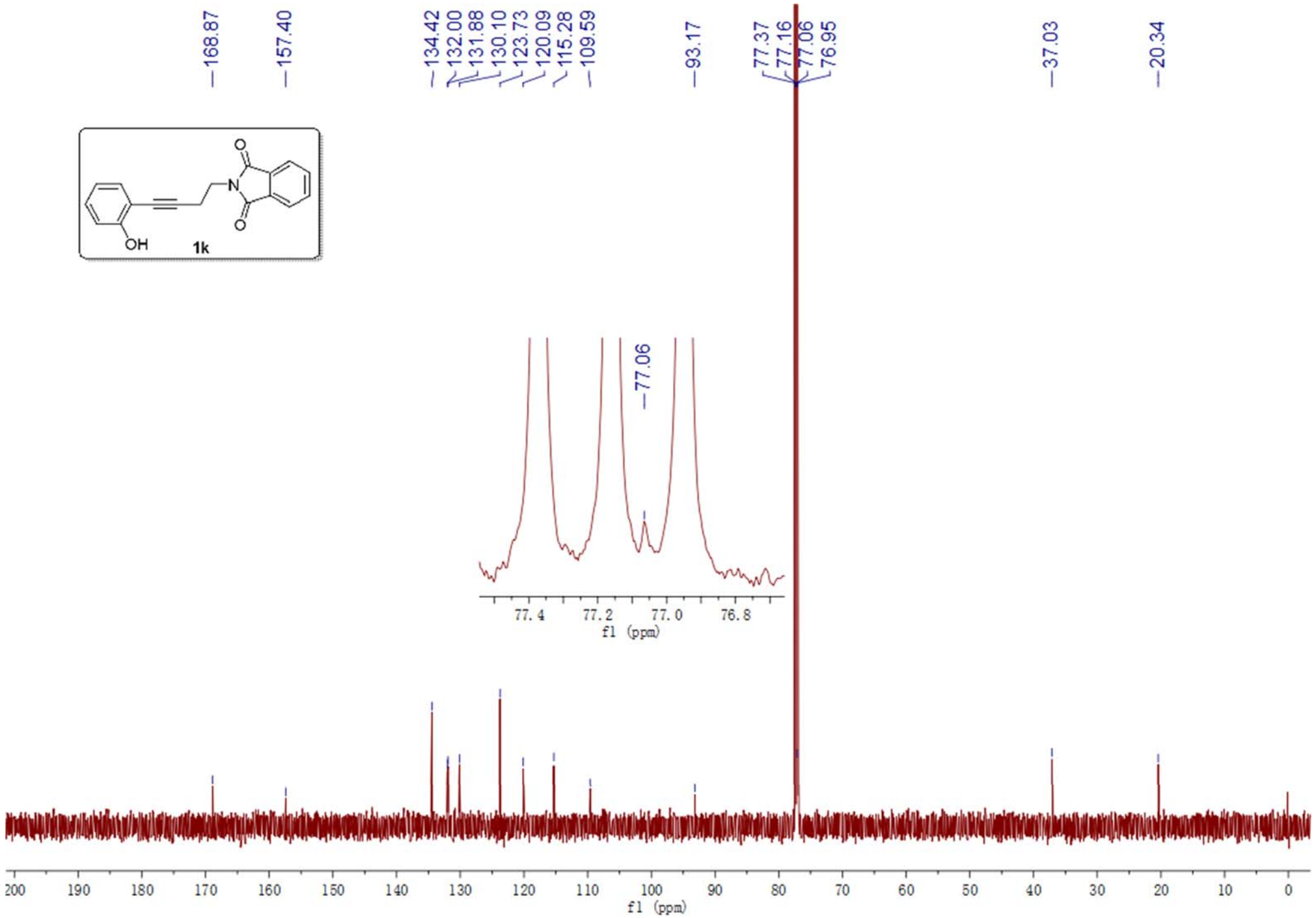
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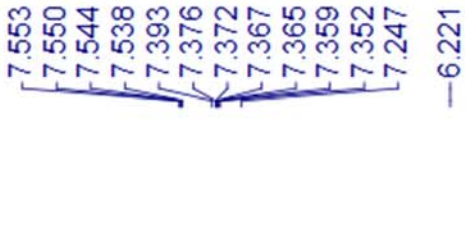
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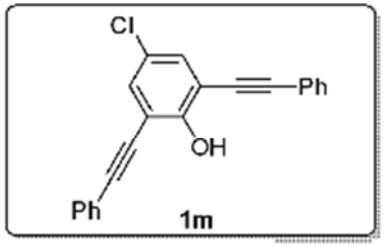
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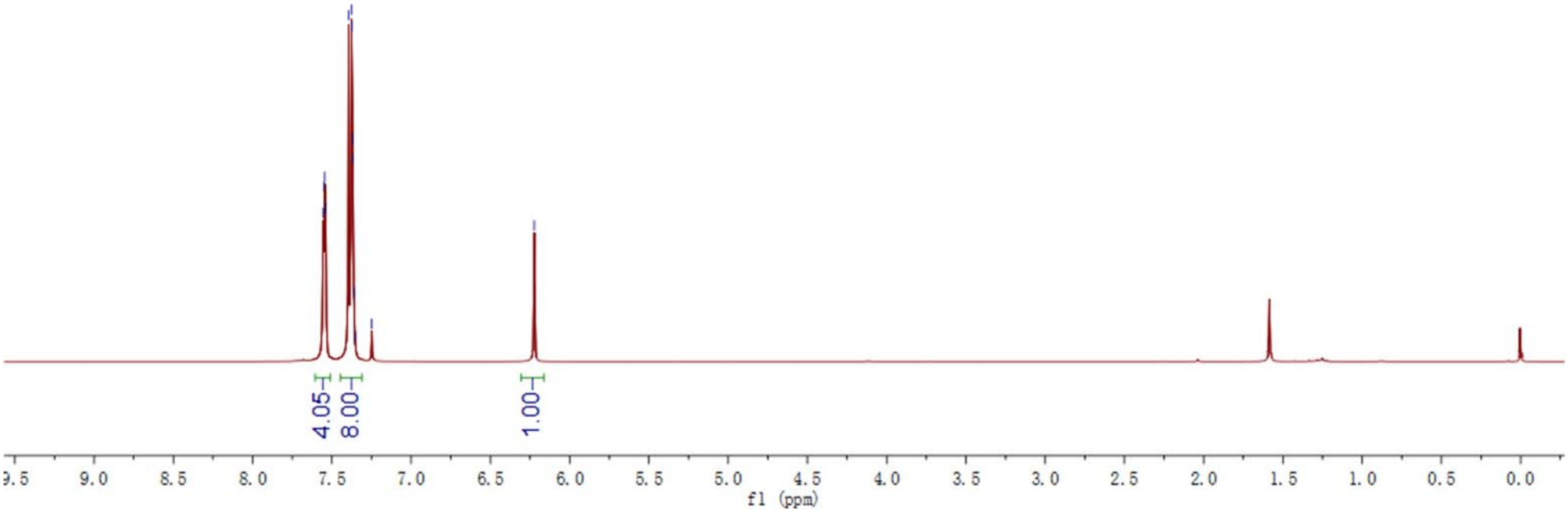
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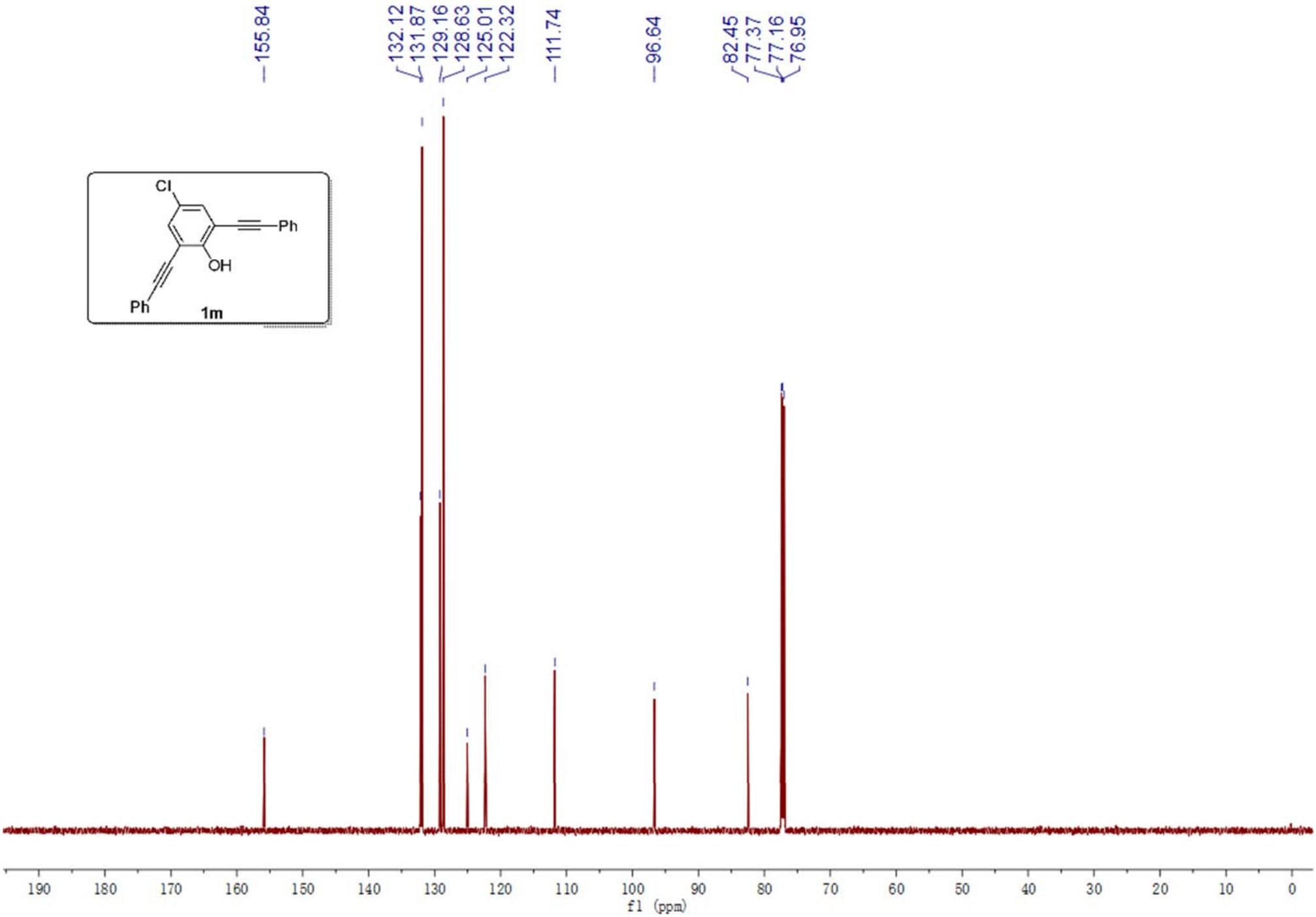
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Ph

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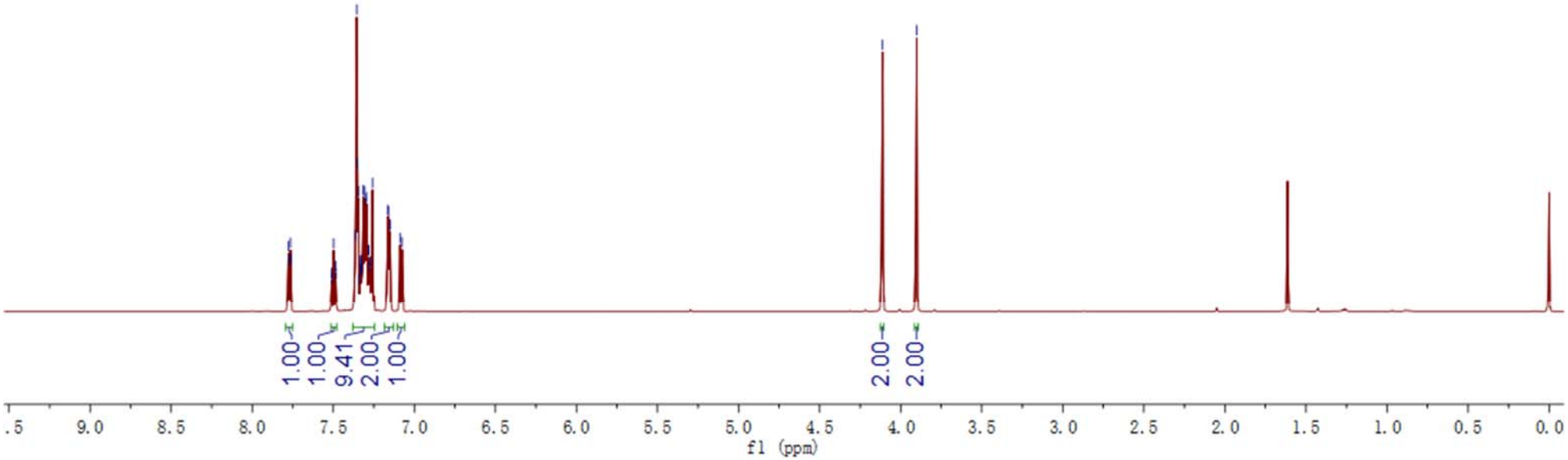
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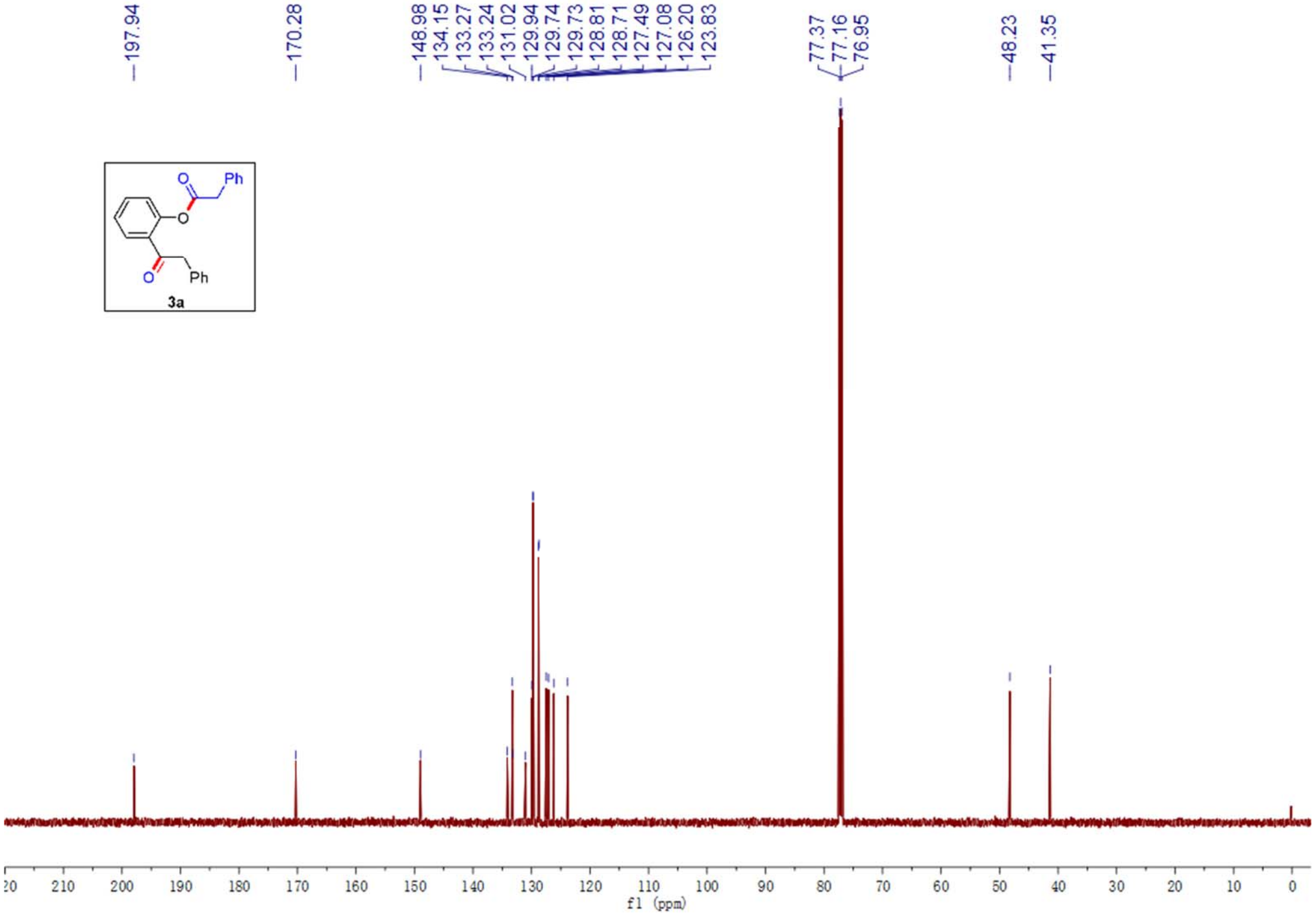
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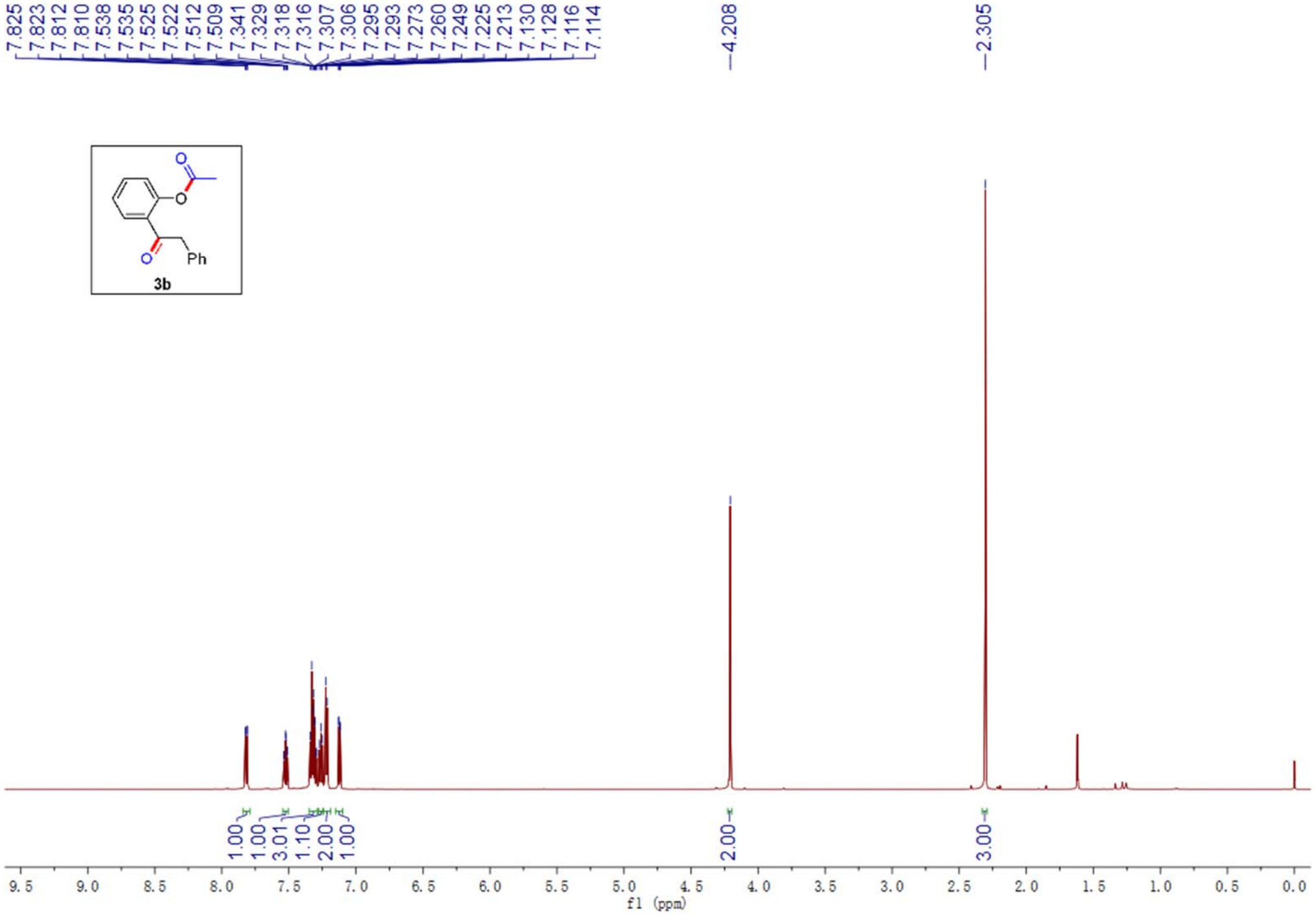
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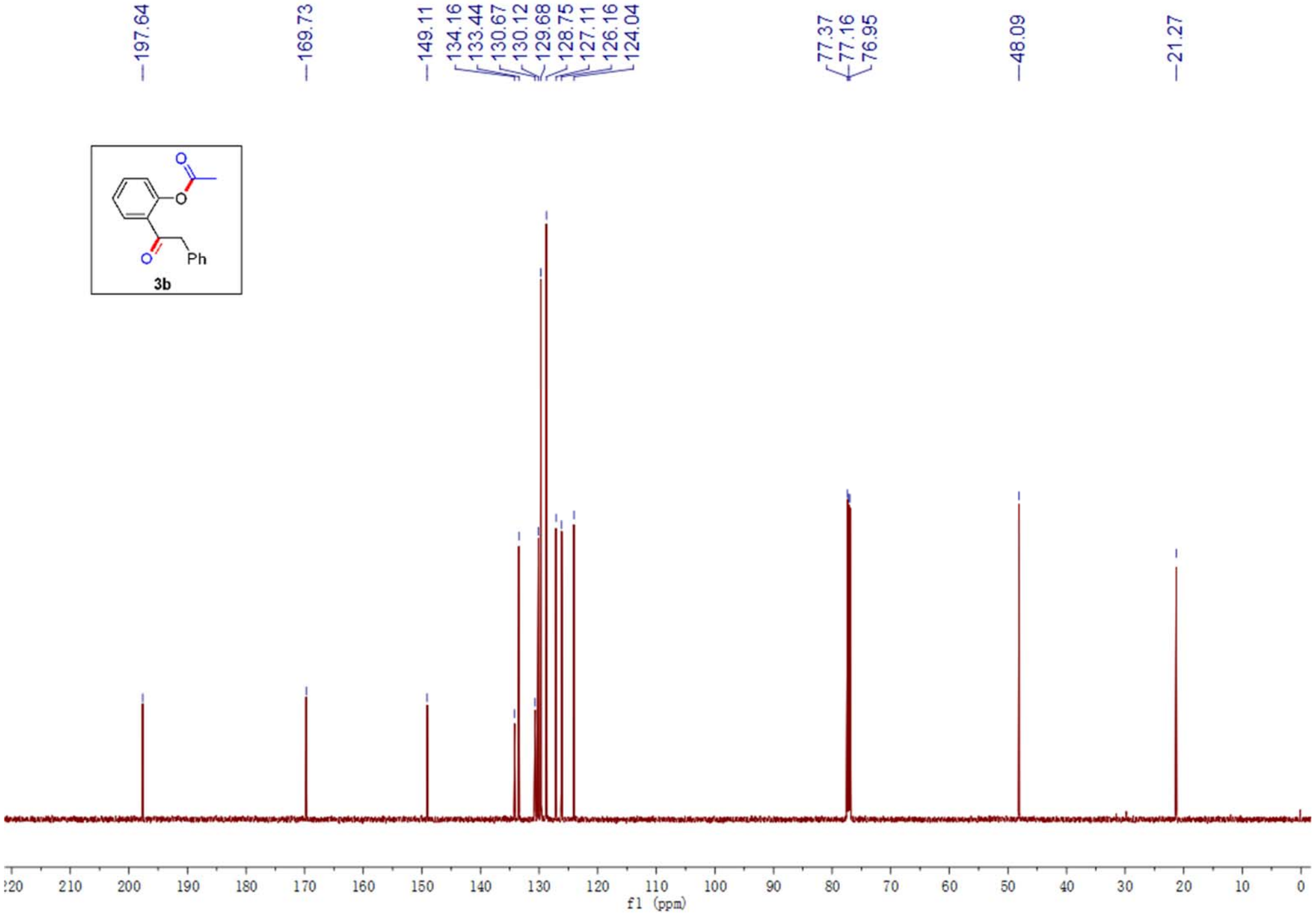
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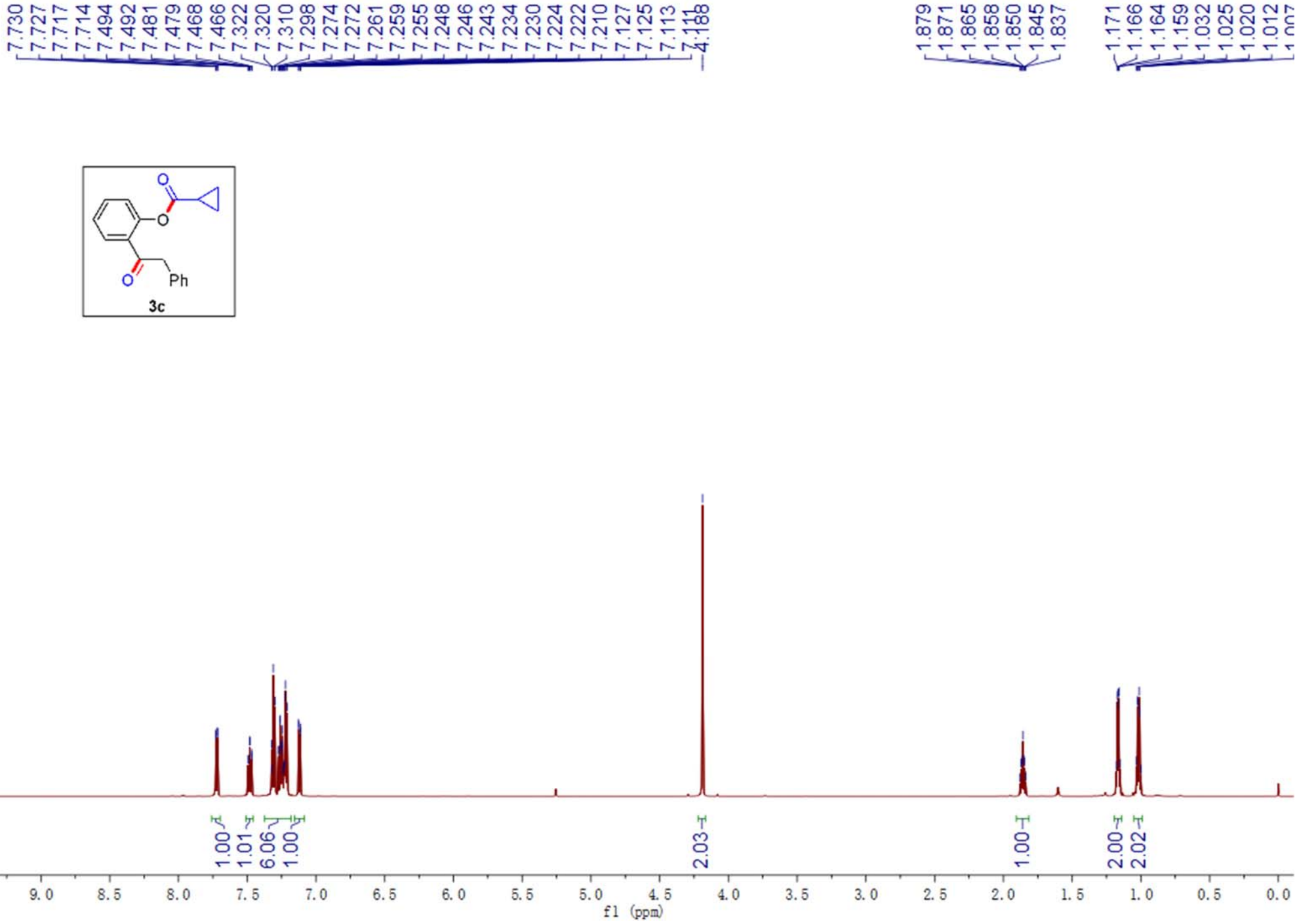
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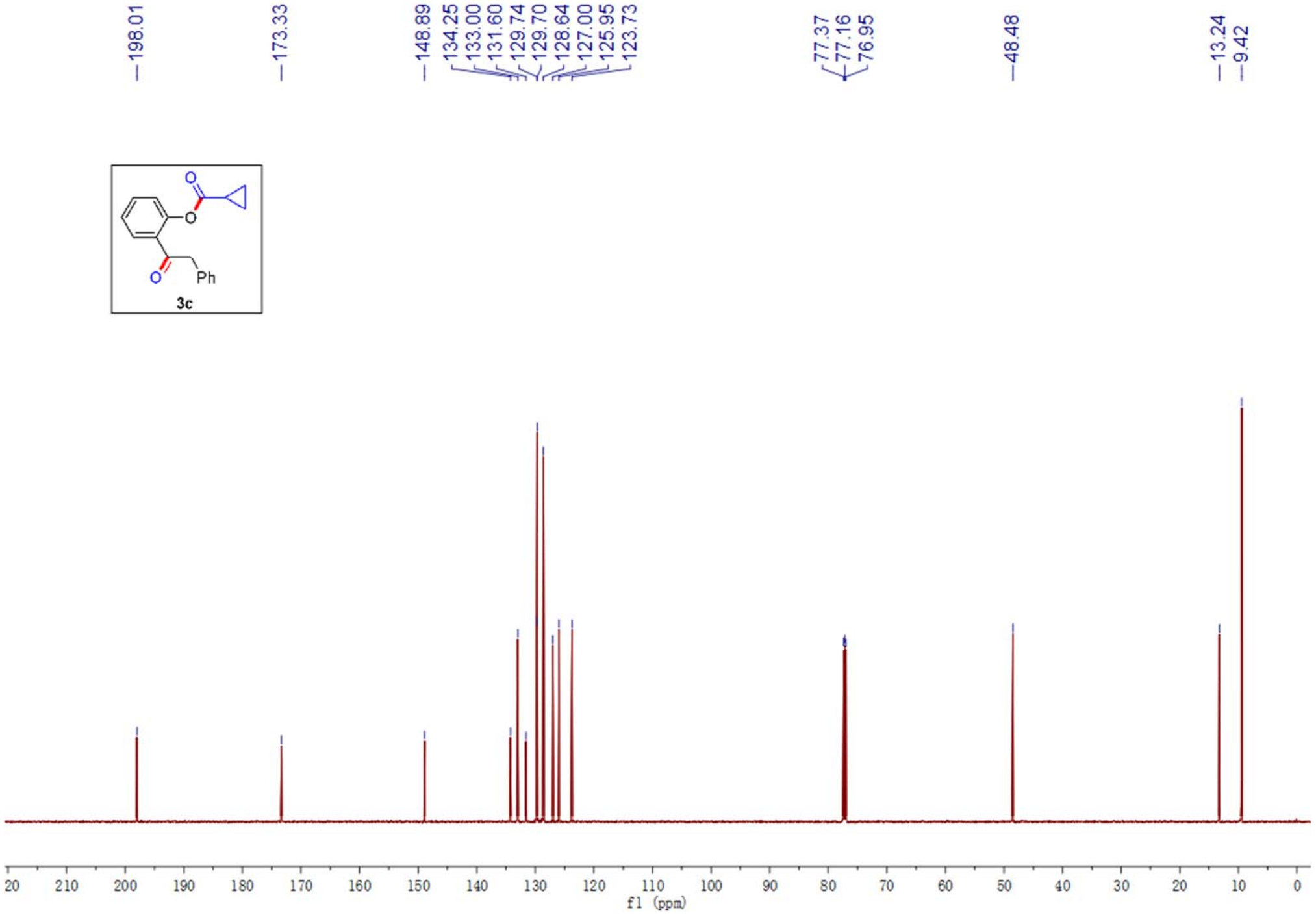
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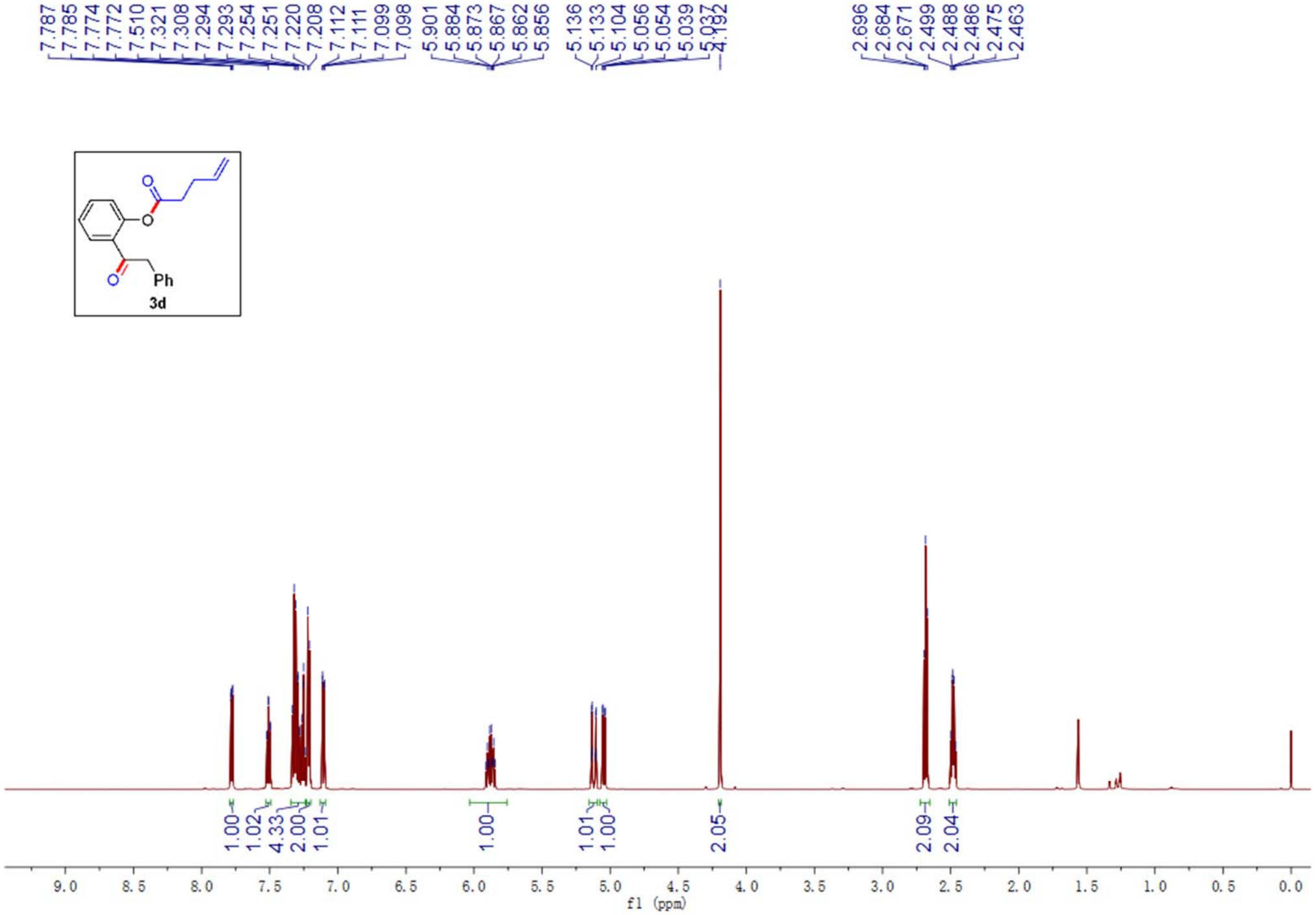
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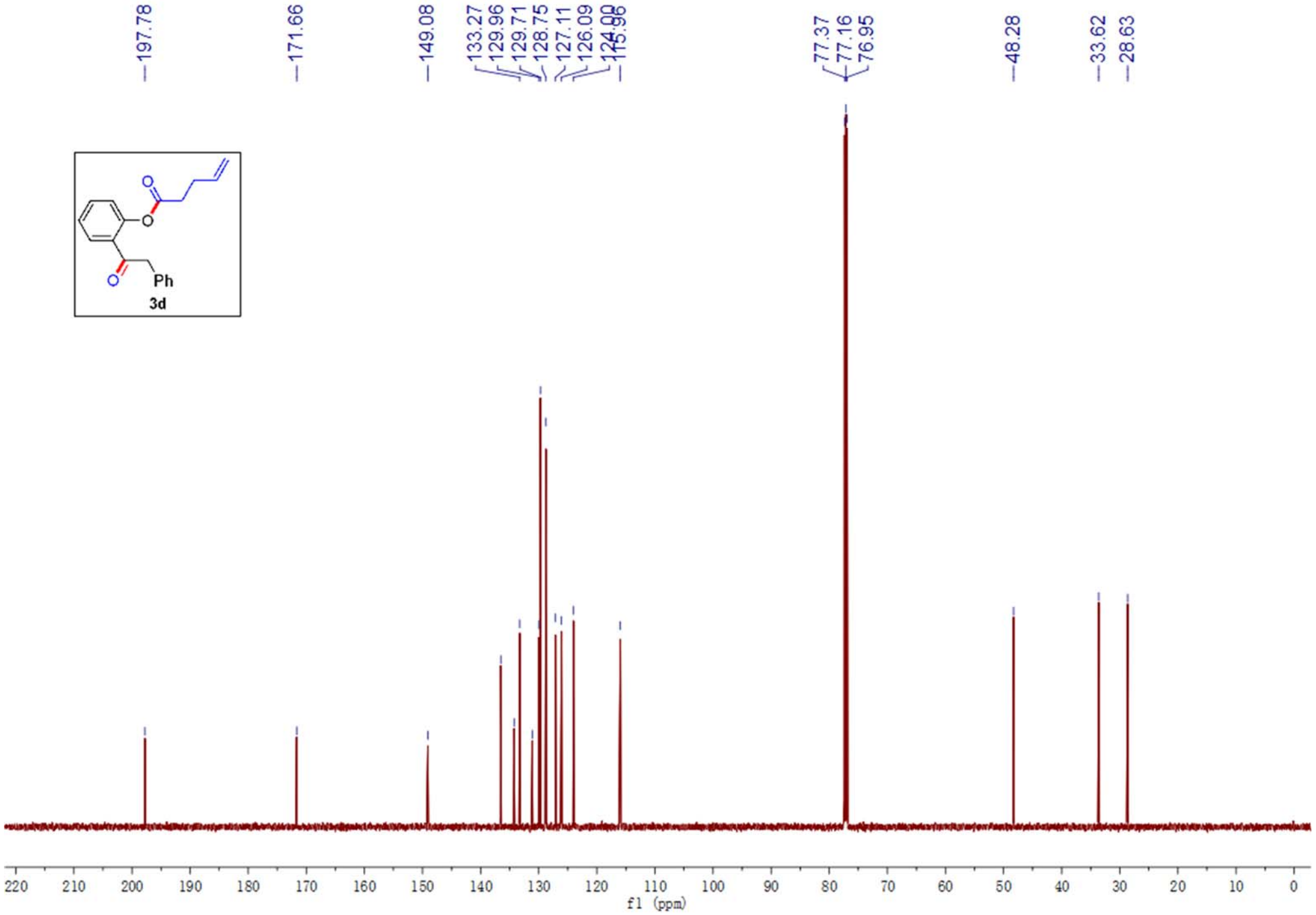
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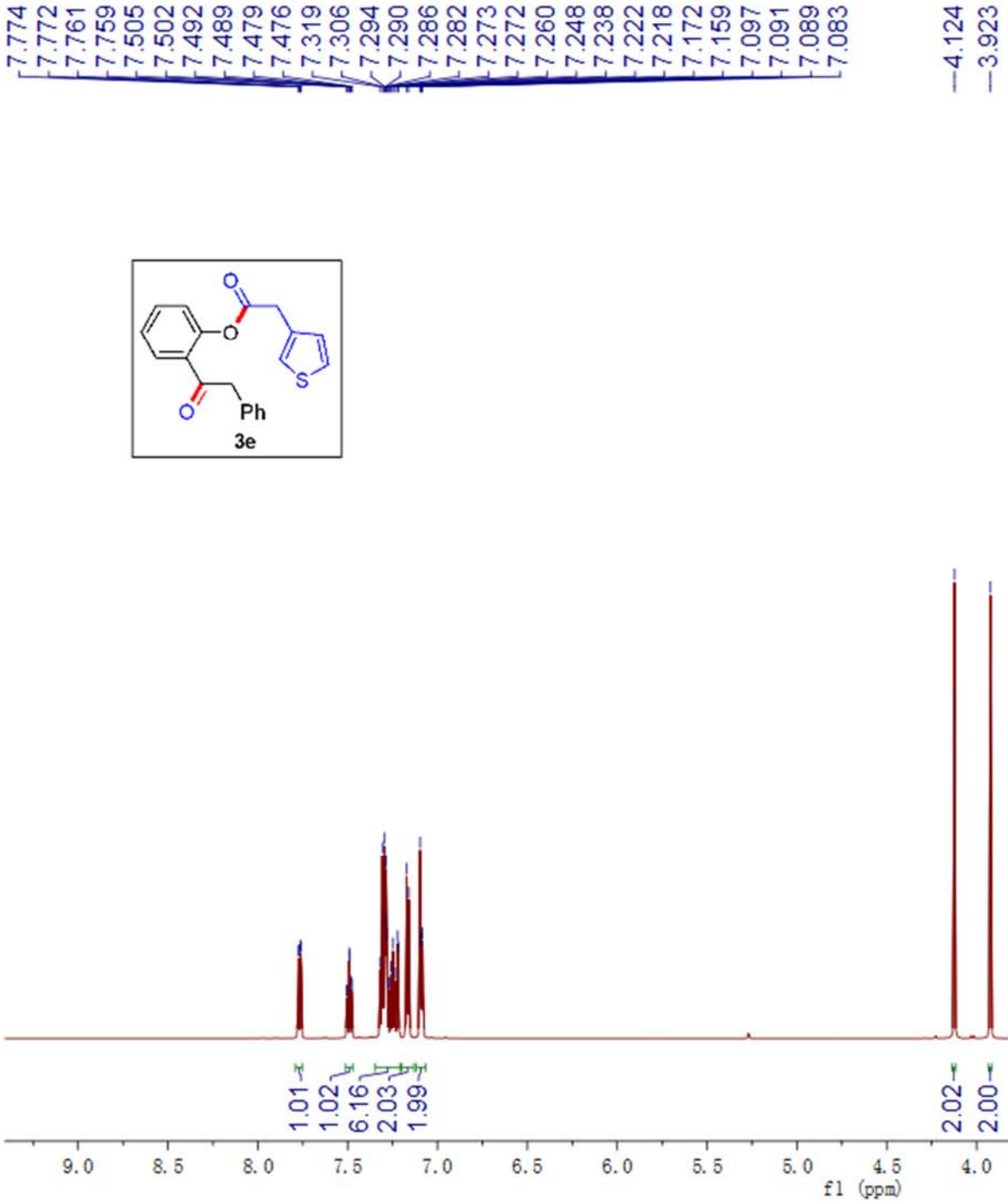
127.11
126.09
124.00
115.96
77.37
77.16
76.95
48.28
33.62
28.63
Ph
3d
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.761
7.759
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7.502
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7.489
7.479
7.476
7.319
7.306
7.294
7.290
7.286
7.282
7.273
7.272
7.260
7.248
7.238
7.222
7.218
7.172
7.159
7.097
7.091
7.089
7.083
4.124
3.923
O
O
S
O
Ph
3e
1.01
1.02
6.16
2.03
1.99
2.02
2.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
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3.5
3.0
2.5
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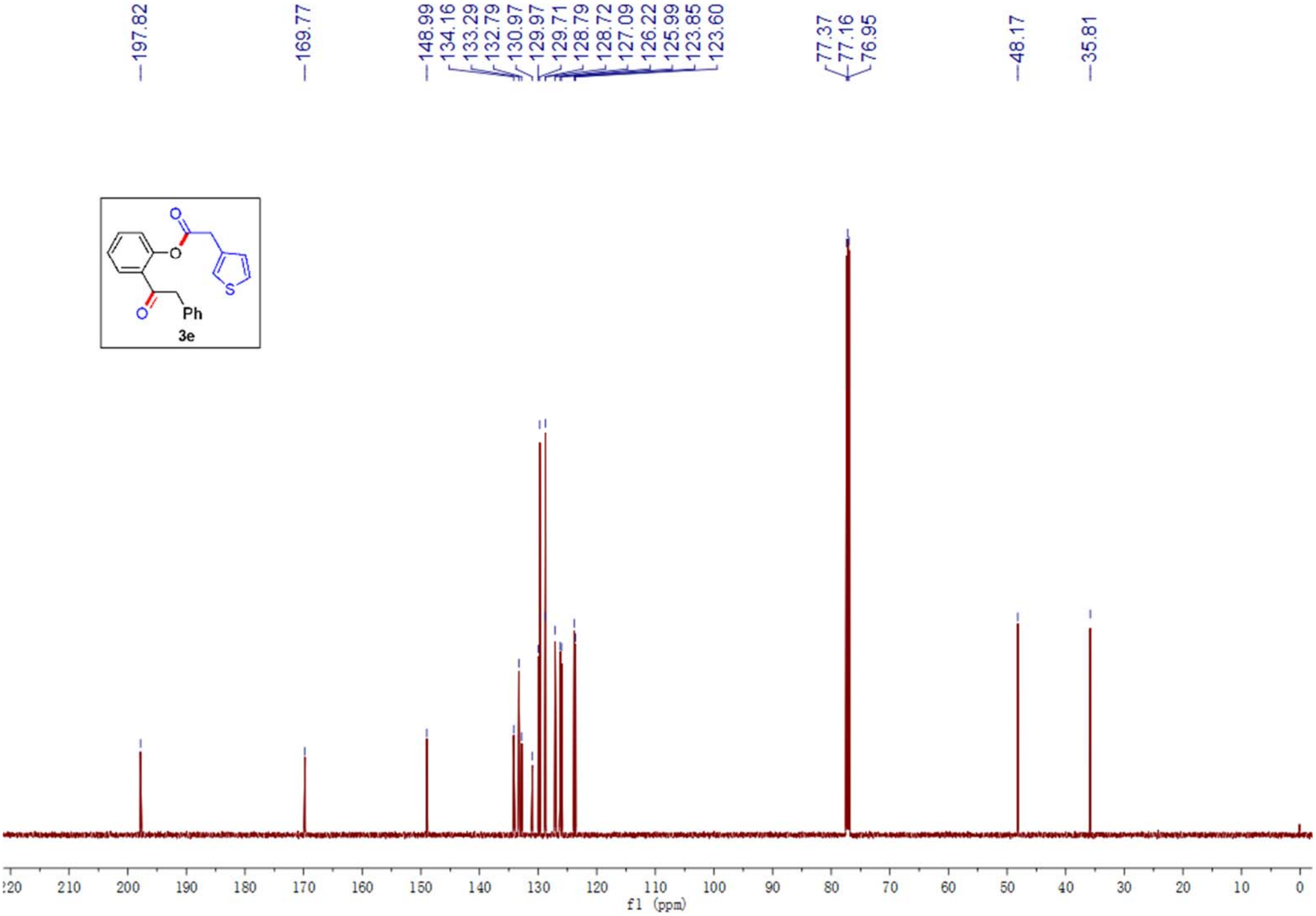
0.0
f1 (ppm)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134.16
133.29
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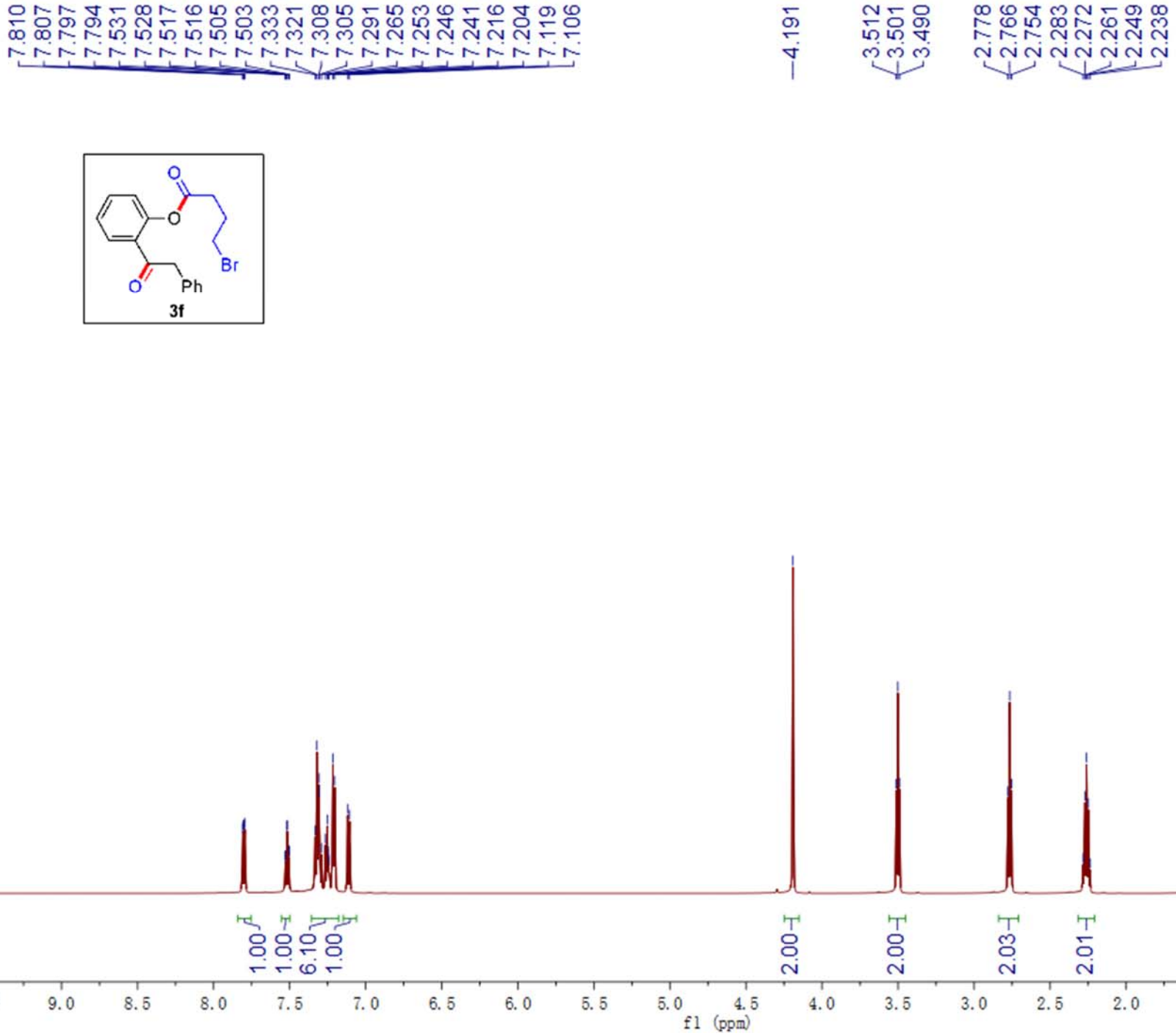
129.97
129.71
128.79
128.72
127.09
126.22
125.99
123.85
123.60
77.37
77.16
76.95
48.17
35.81
O
O
O
S
Ph
3e
f1 (ppm)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7.797
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7.516
7.505
7.503
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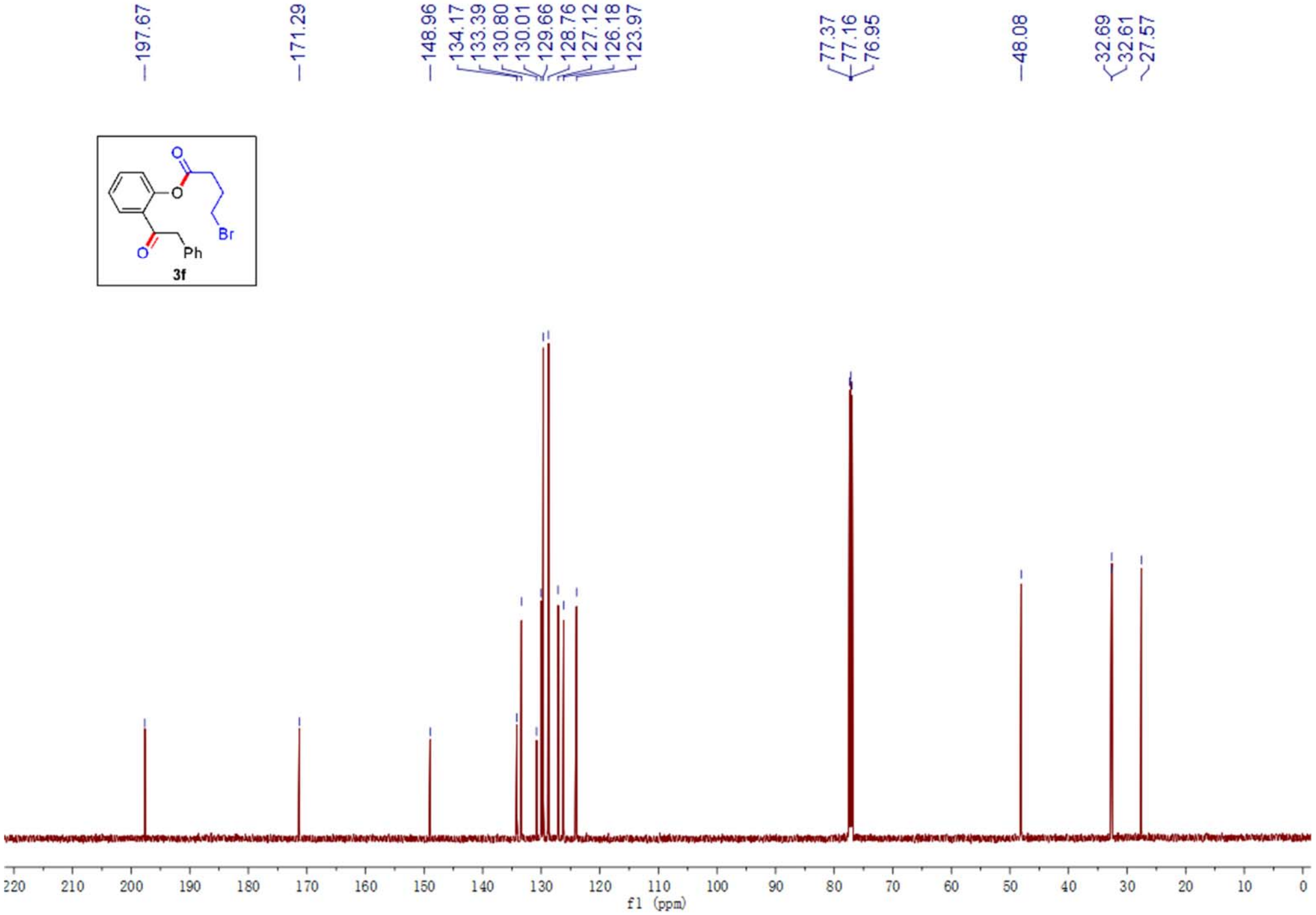
7.321
7.308
7.305
7.291
7.265
7.253
7.246
7.241
7.216
7.204
7.119
7.106
4.191
3.512
3.501
3.490
2.778
2.766
2.754
2.283
2.272
2.261
2.249
2.238
O
O
Br
O
Ph
3f
1.00
1.00
6.10
1.00
2.00
2.00
2.03
2.01
f1 (ppm)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129.66
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127.12
126.18
123.97
77.37
77.16
76.95
48.08
32.69
32.61
27.57
O
O
Br
O
Ph
3f
220
210
200
190
180
170
160
150
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130
120
110
100
90
80
70
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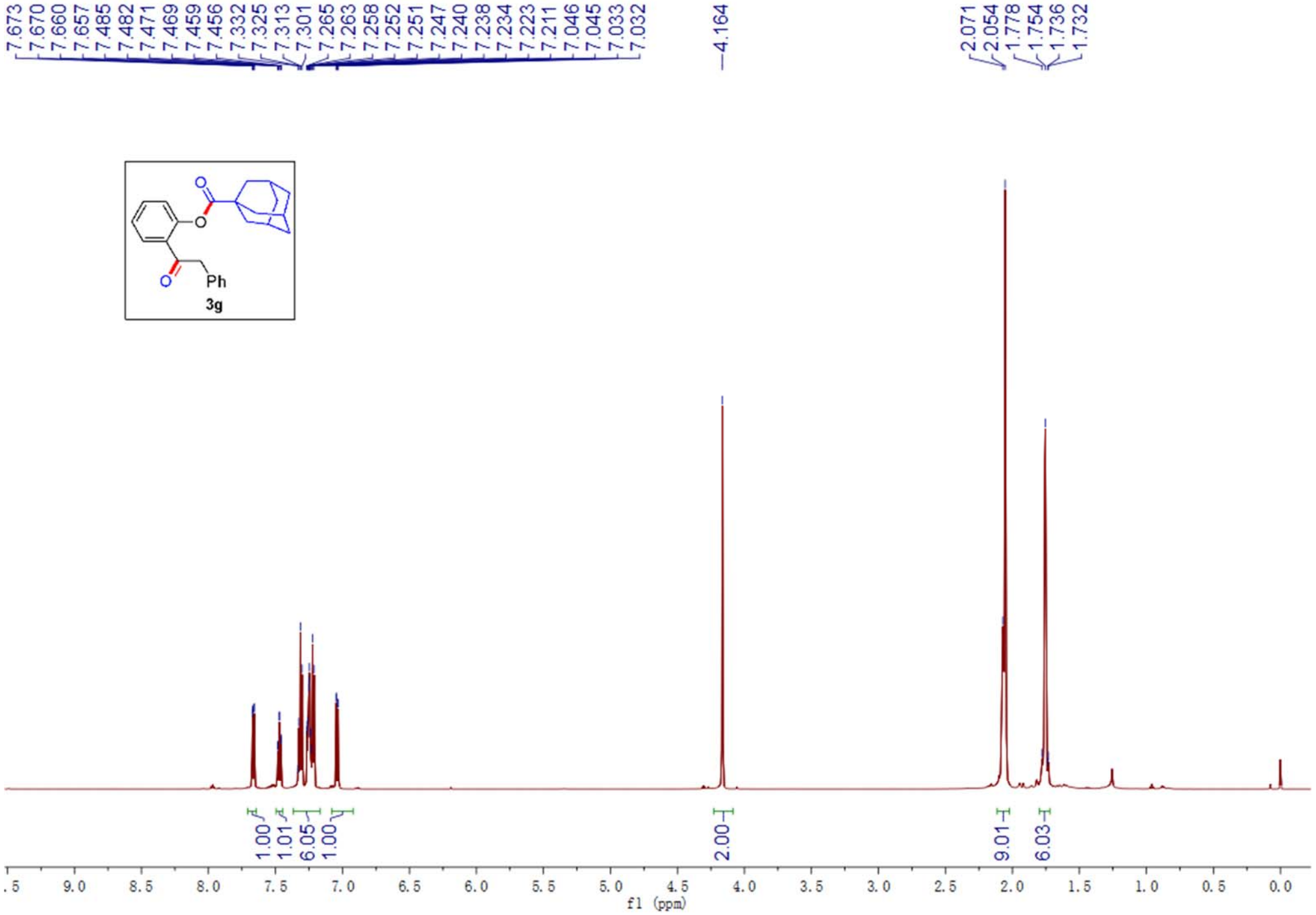
50
40
30
20
10
0
f1 (ppm)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7.660
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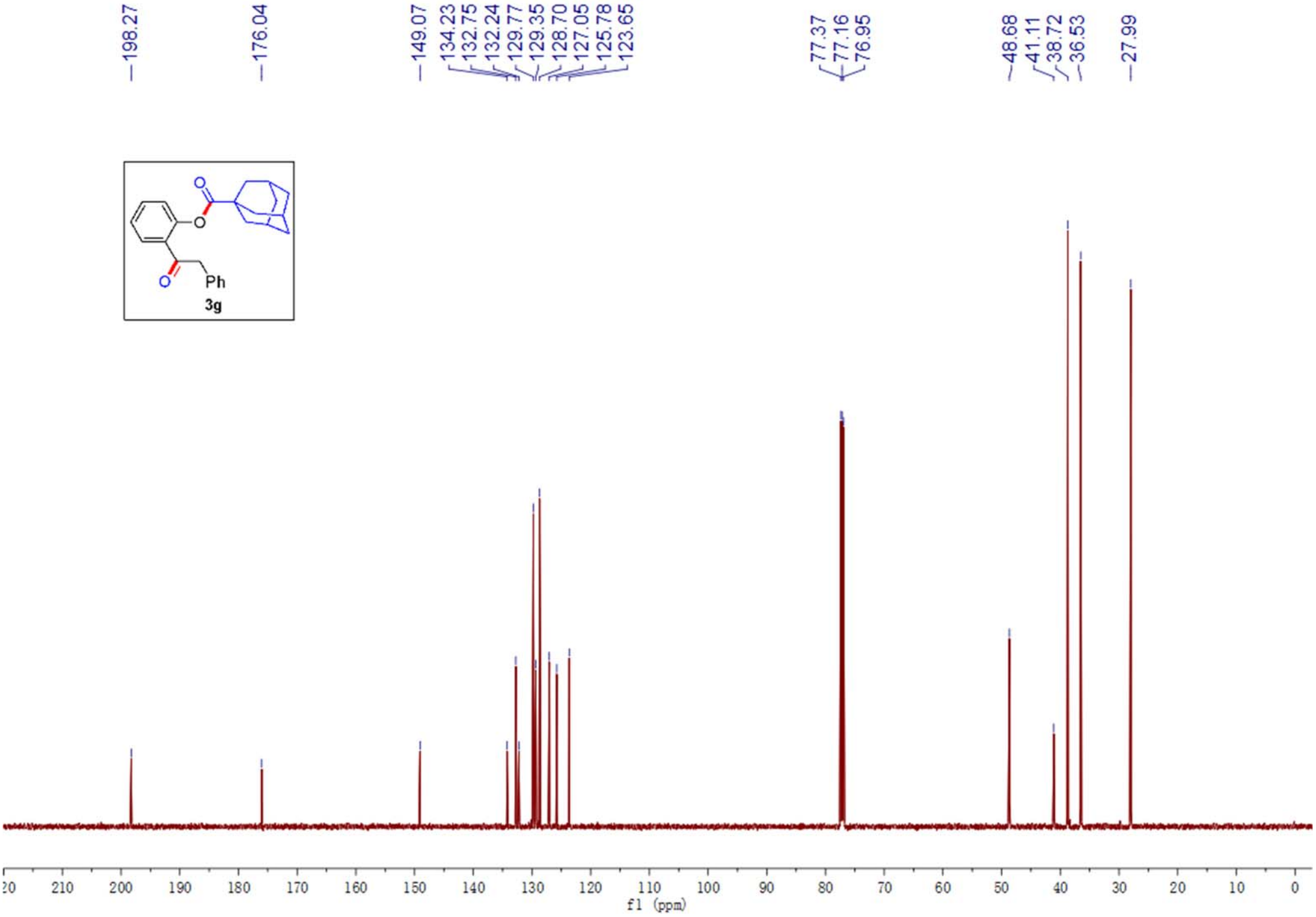
7.469
7.459
7.456
7.332
7.325
7.313
7.301
7.265
7.263
7.258
7.252
7.251
7.247
7.240
7.238
7.234
7.223
7.211
7.046
7.045
7.033
7.032
4.164
2.071
2.054
1.778
1.754
1.736
1.732
Ph
3g
1.00
1.01
6.05
1.00
2.00
9.01
6.03
f1 (ppm)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176.04
149.07
134.23
132.75
132.24
129.77
129.35
128.70
127.05
125.78
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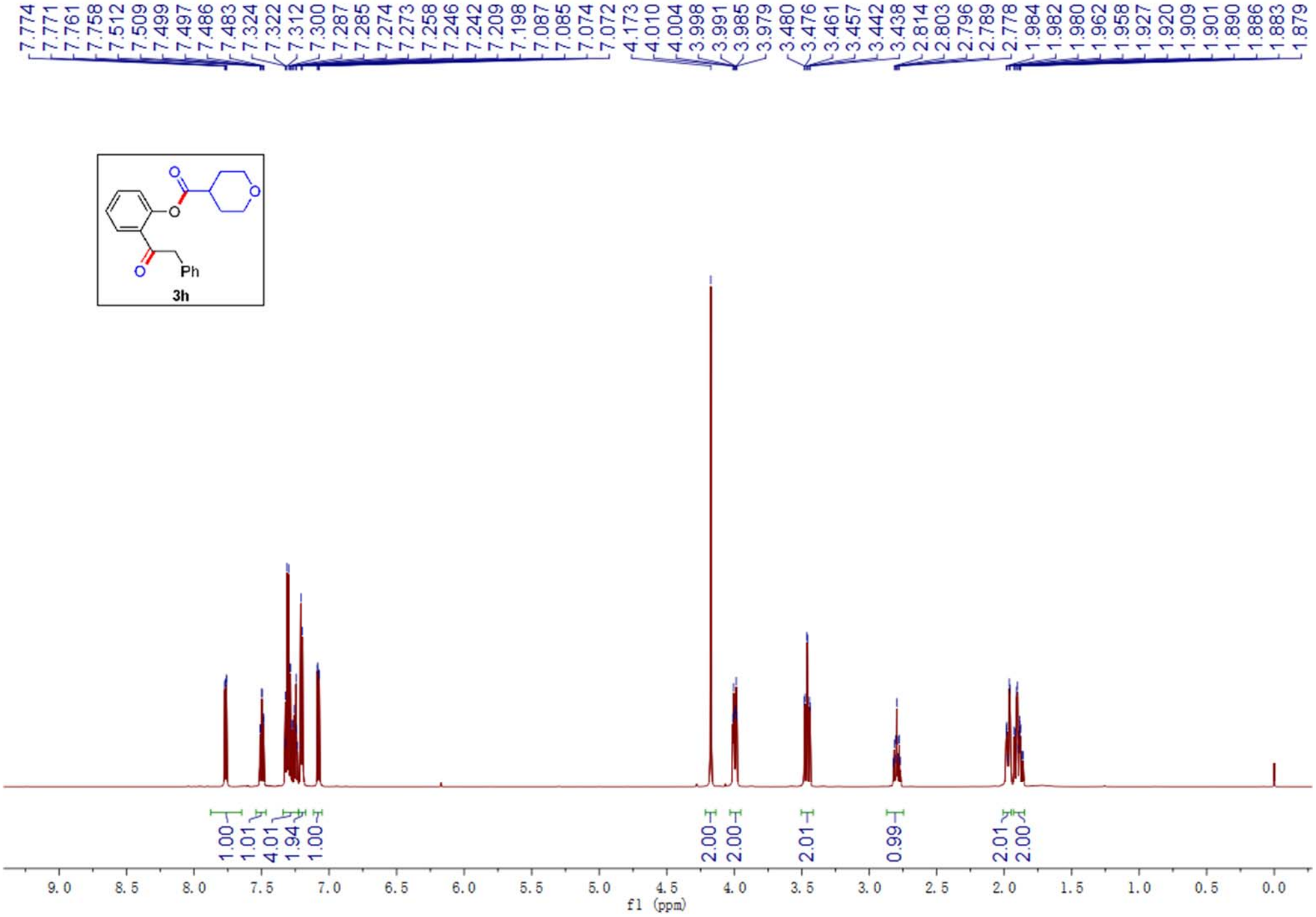
77.16
76.95
48.68
41.11
38.72
36.53
27.99
Ph
3g
f1 (ppm)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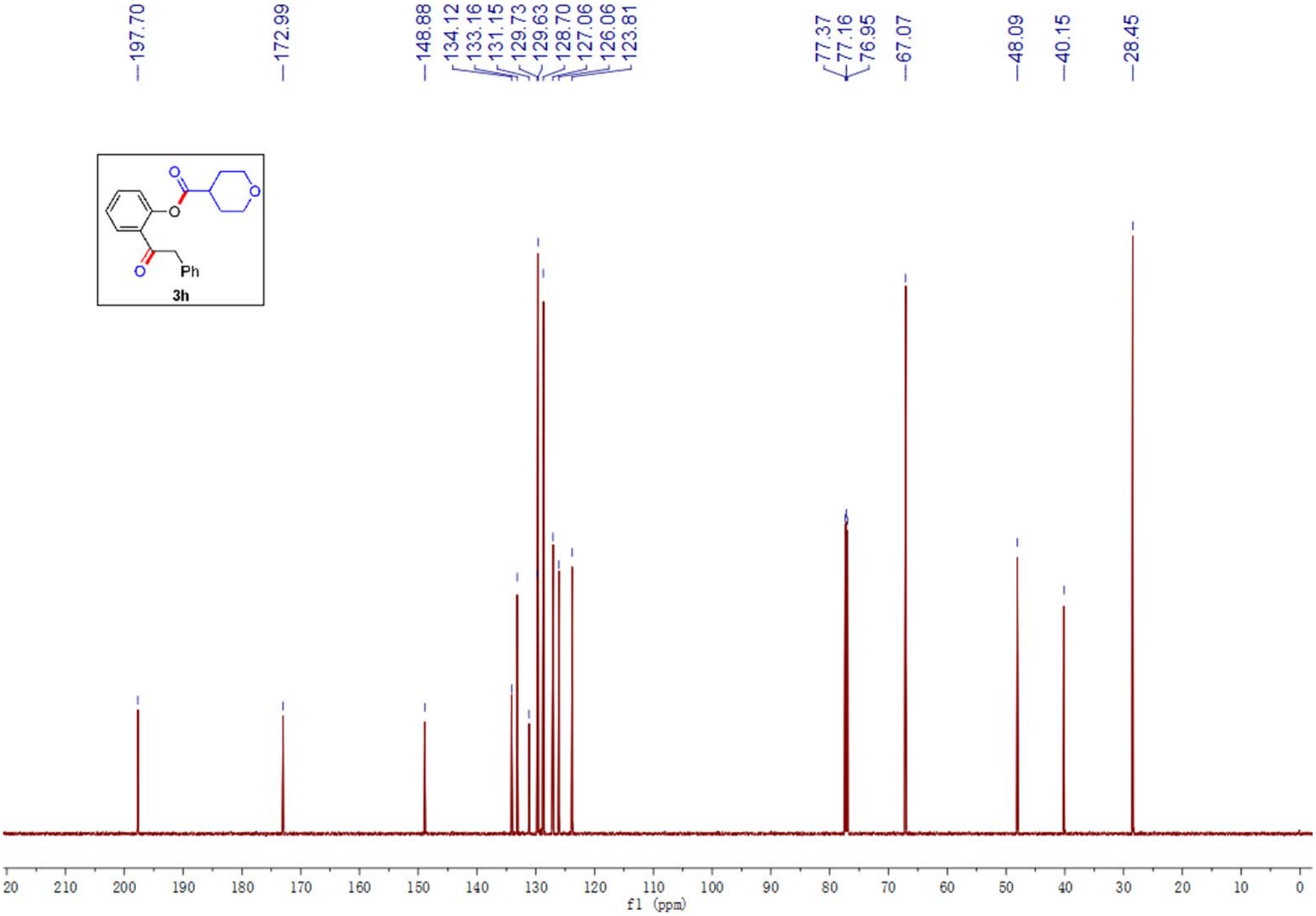
7.509
7.499
7.497
7.486
7.483
7.324
7.322
7.312
7.300
7.287
7.285
7.274
7.273
7.258
7.246
7.242
7.209
7.198
7.087
7.085
7.074
7.072
4.173
4.010
4.004
3.998
3.991
3.985
3.979
3.480
3.476
3.461
3.457
3.442
3.438
2.814
2.803
2.796
2.789
2.778
1.984
1.982
1.980
1.962
1.958
1.927
1.920
1.909
1.901
1.890
1.886
1.883
1.879
Ph
3h
1.00
1.01
4.01
1.94
1.00
2.00
2.00
2.01
0.99
2.01
2.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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131.15
129.73
129.63
128.70
127.06
126.06
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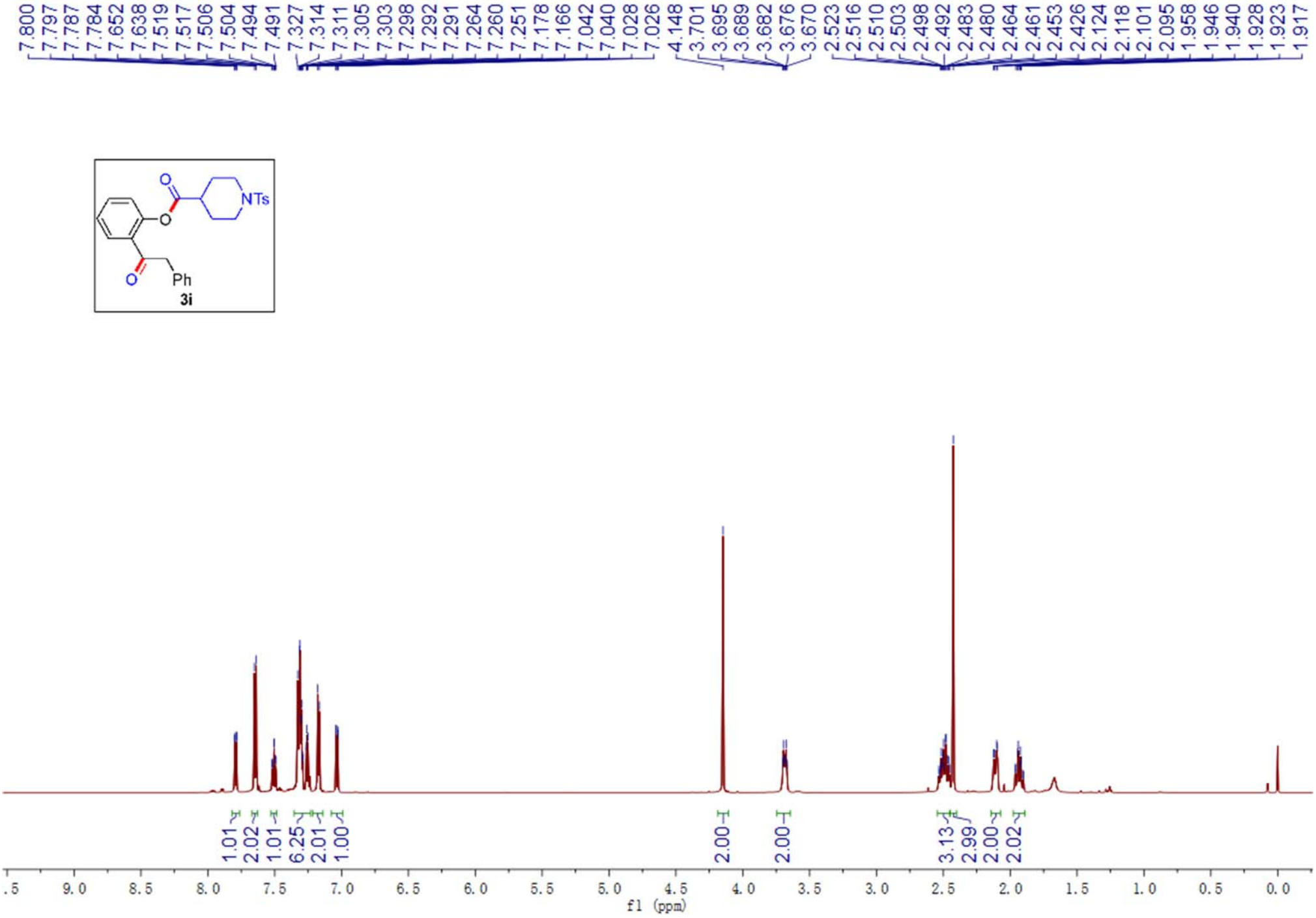
77.37
77.16
76.95
67.07
48.09
40.15
28.45
Ph
3h
f1 (ppm)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7.797
7.787
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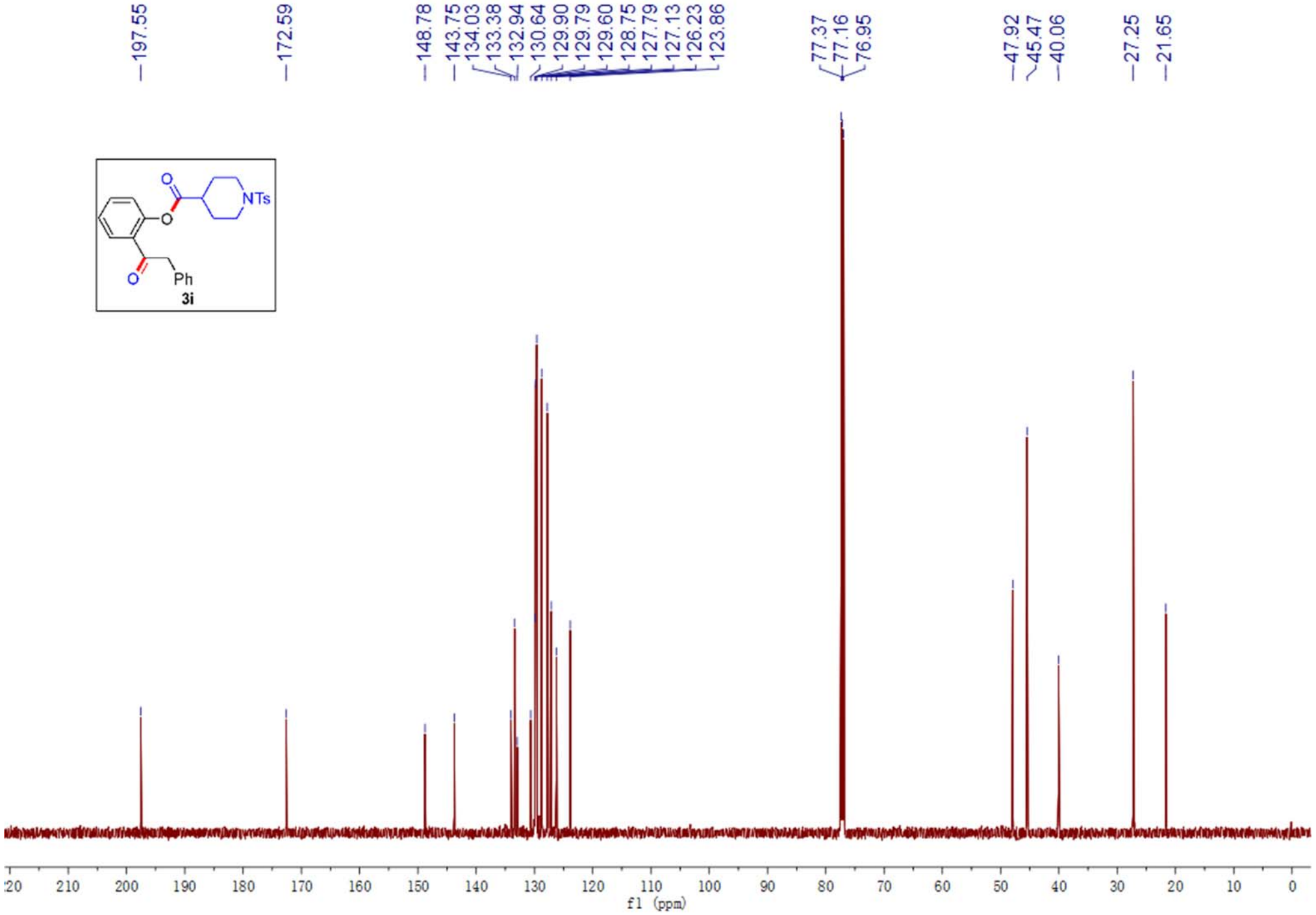
7.652
7.638
7.519
7.517
7.506
7.504
7.494
7.491
7.327
7.314
7.311
7.305
7.303
7.298
7.292
7.291
7.264
7.260
7.251
7.178
7.166
7.042
7.040
7.028
7.026
4.148
3.701
3.695
3.689
3.682
3.676
3.670
2.523
2.516
2.510
2.503
2.498
2.492
2.483
2.480
2.464
2.461
2.453
2.426
2.124
2.118
2.101
2.095
1.958
1.946
1.940
1.928
1.923
1.917
NTs
Ph
3i
1.01
2.02
1.01
6.25
2.01
1.00
2.00
2.00
3.13
2.99
2.00
2.02
f1 (ppm)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143.75
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130.64
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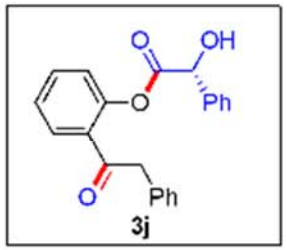
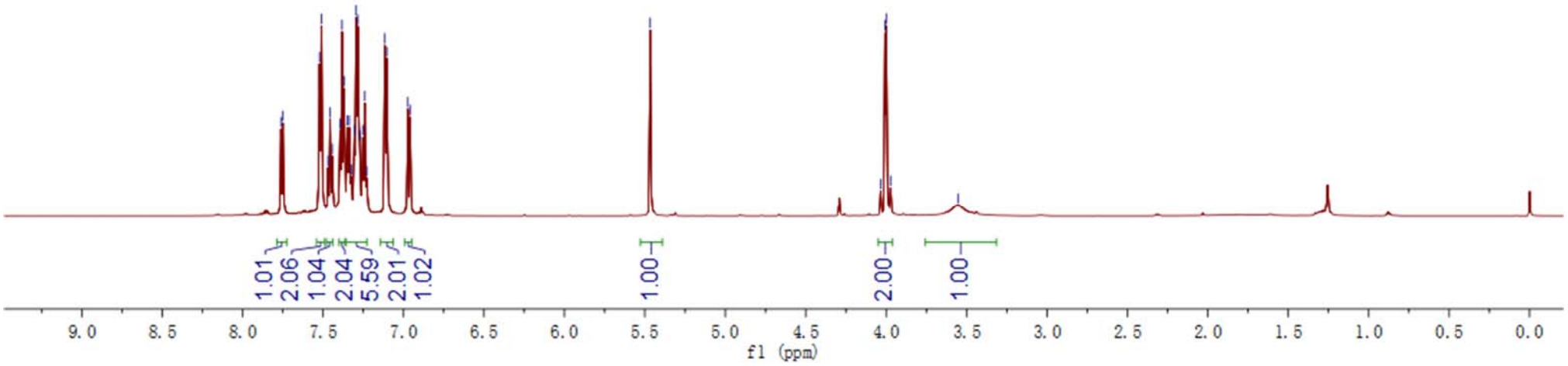
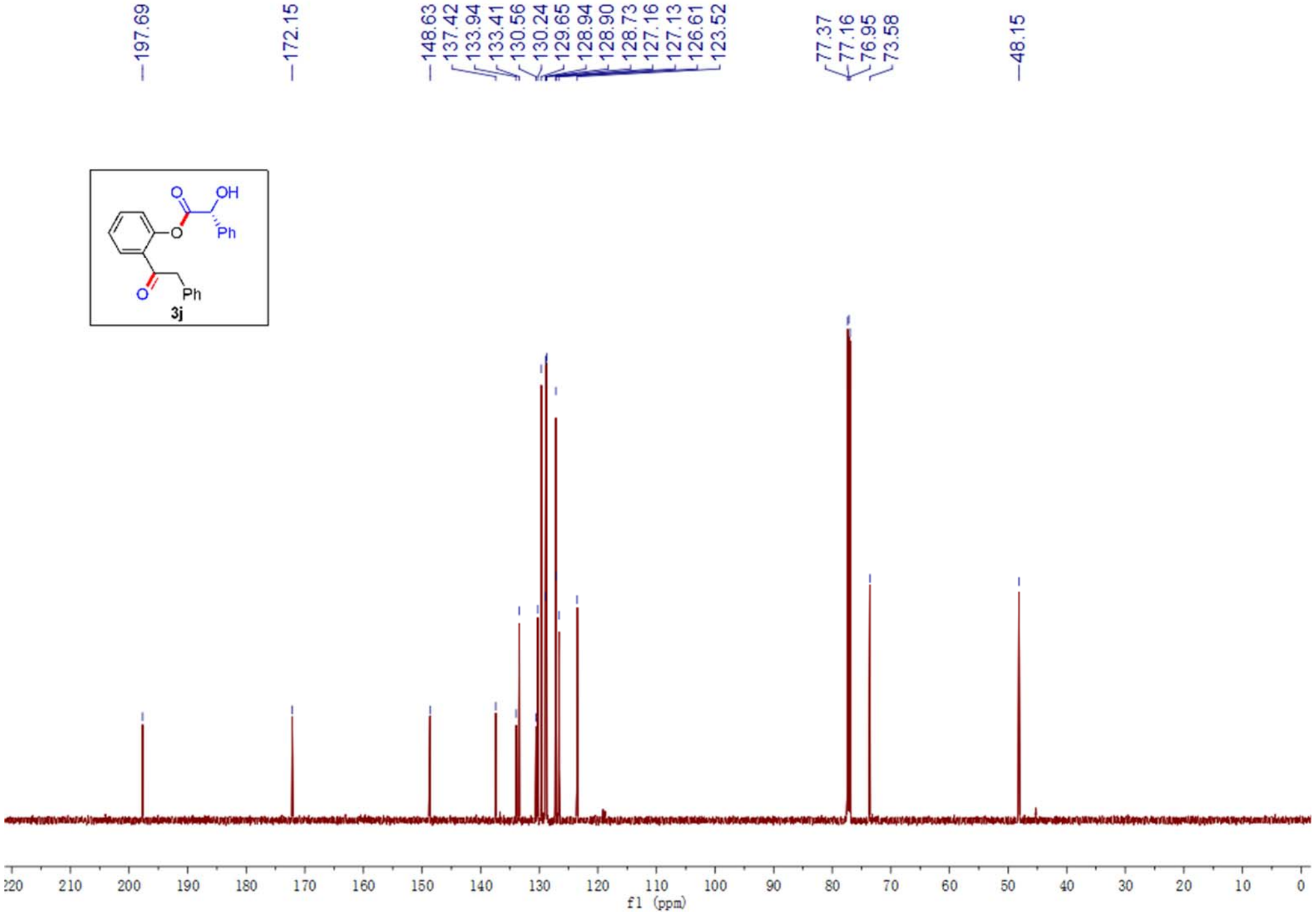
129.79
129.60
128.75
127.79
127.13
126.23
123.86
77.37
77.16
76.95
47.92
45.47
40.06
27.25
21.65
NTs
Ph
3i
f1 (ppm)


7.762
7.749
7.522
7.510
7.469
7.456
7.444
7.394
7.382
7.370
7.349
7.337
7.325
7.306
7.294
7.284
7.272
7.253
7.240
7.116
7.104
6.973
6.960
5.467
4.034
4.007
3.999
3.973
3.554


O
OH
Ph
O
O
Ph

3j


1.01
2.06
1.04
2.04
5.59
2.01
1.02
1.00
2.00
1.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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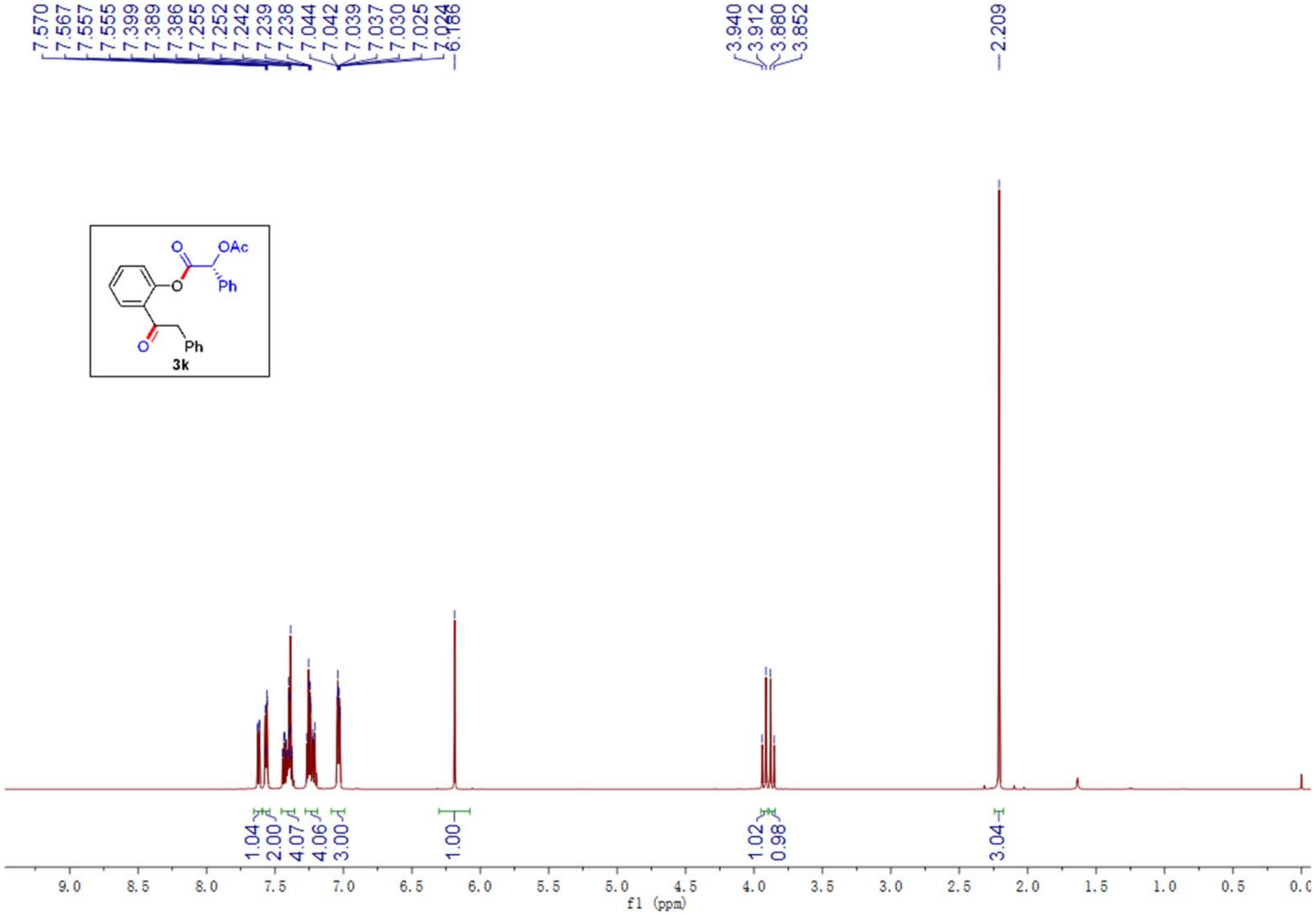
133.41
130.56
130.24
129.65
128.94
128.90
128.73
127.16
127.13
126.61
123.52
77.37
77.16
76.95
73.58
48.15
OH
O
Ph
O
Ph
3j
f1 (ppm)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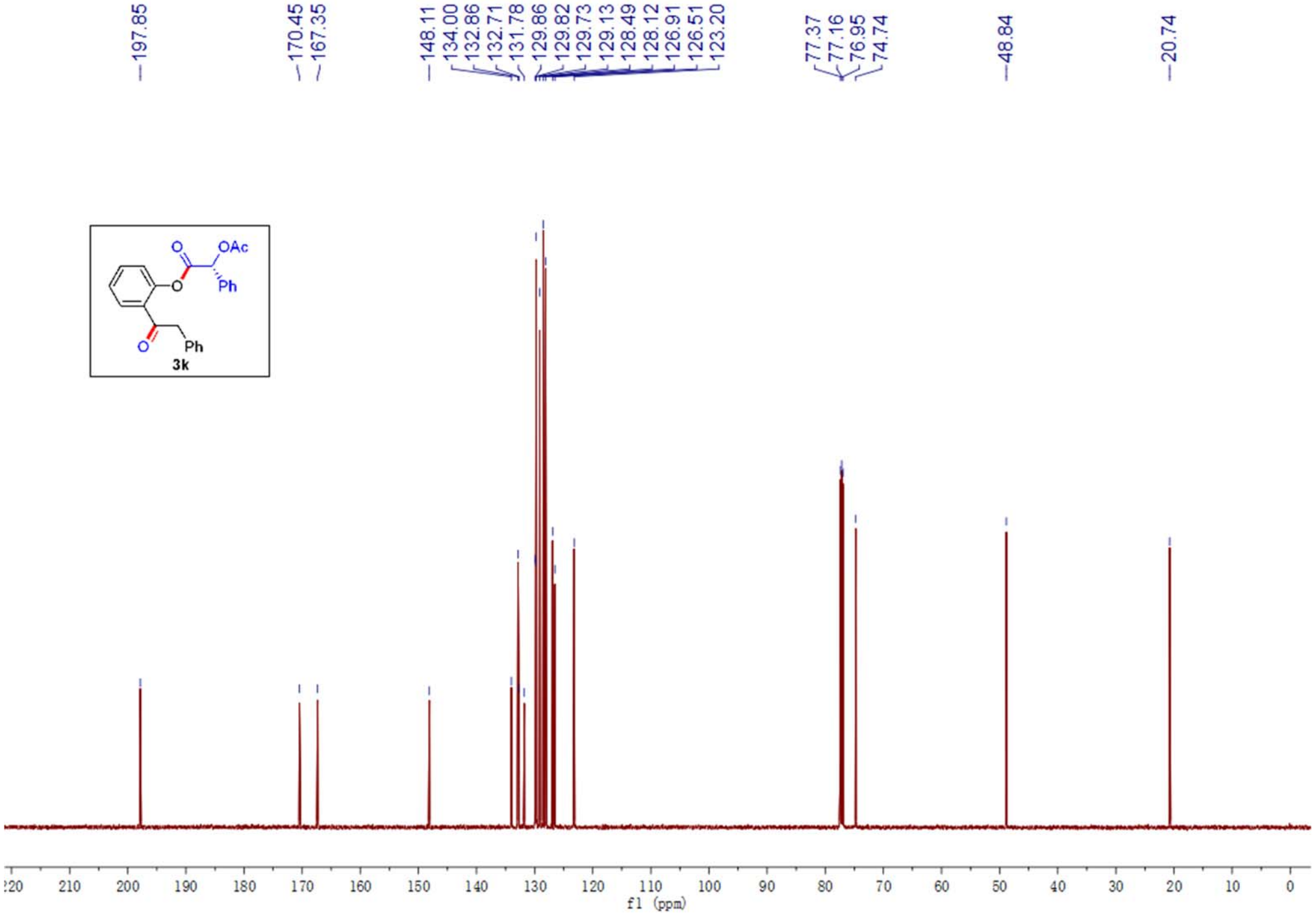
7.567
7.557
7.555
7.399
7.389
7.386
7.255
7.252
7.242
7.239
7.238
7.044
7.042
7.039
7.037
7.030
7.025
7.024
6.186
3.940
3.912
3.880
3.852
2.209
OAc
Ph
Ph
3k
1.04
2.00
4.07
4.06
3.00
1.00
1.02
0.98
3.04
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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170.45
167.35
148.11
134.00
132.86
132.71
131.78
129.86
129.82
129.73
129.13
128.49
128.12
126.91
126.51
123.20
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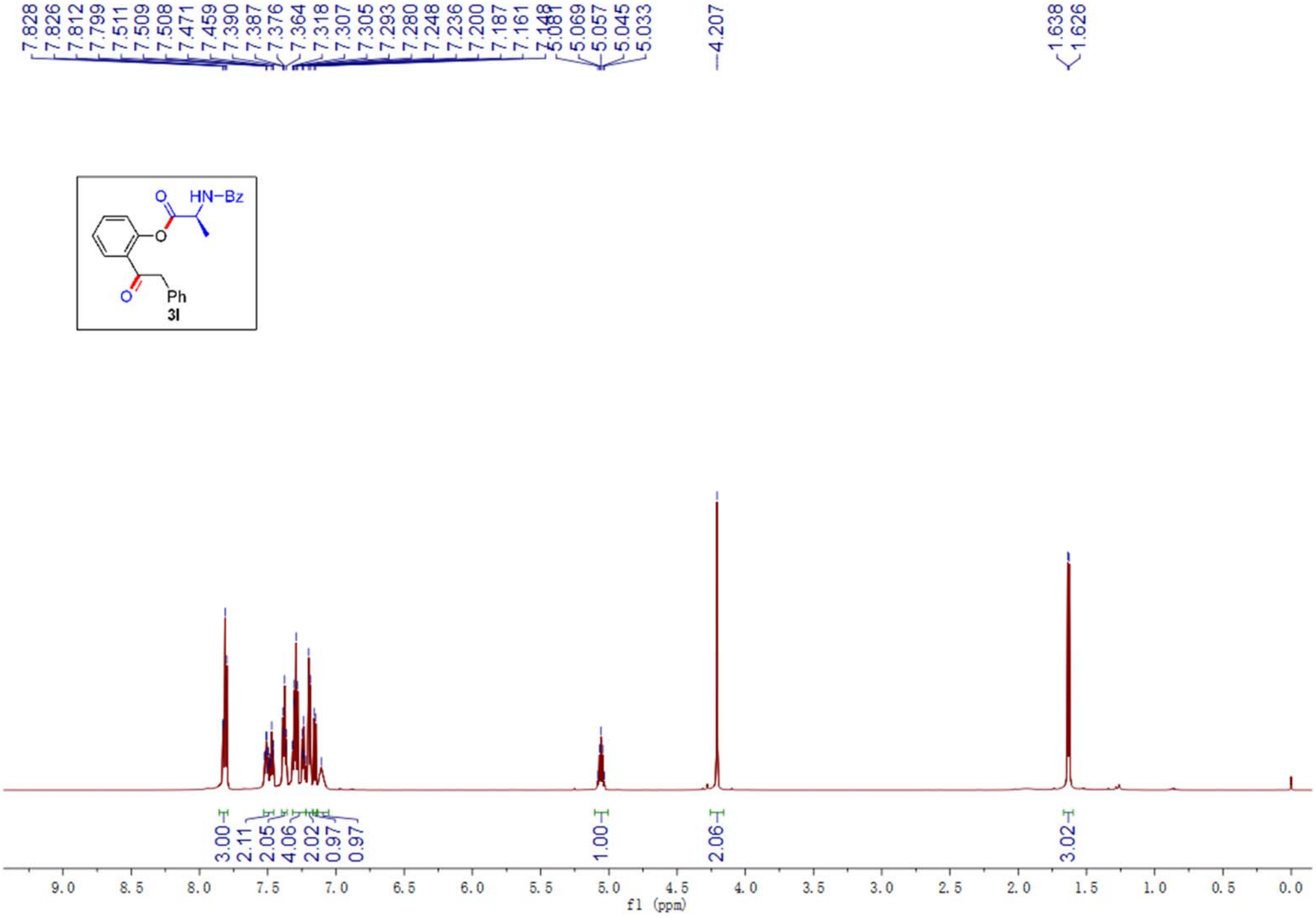
77.16
76.95
74.74
48.84
20.74
OAc
Ph
Ph
3k
f1 (ppm)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7.812
7.799
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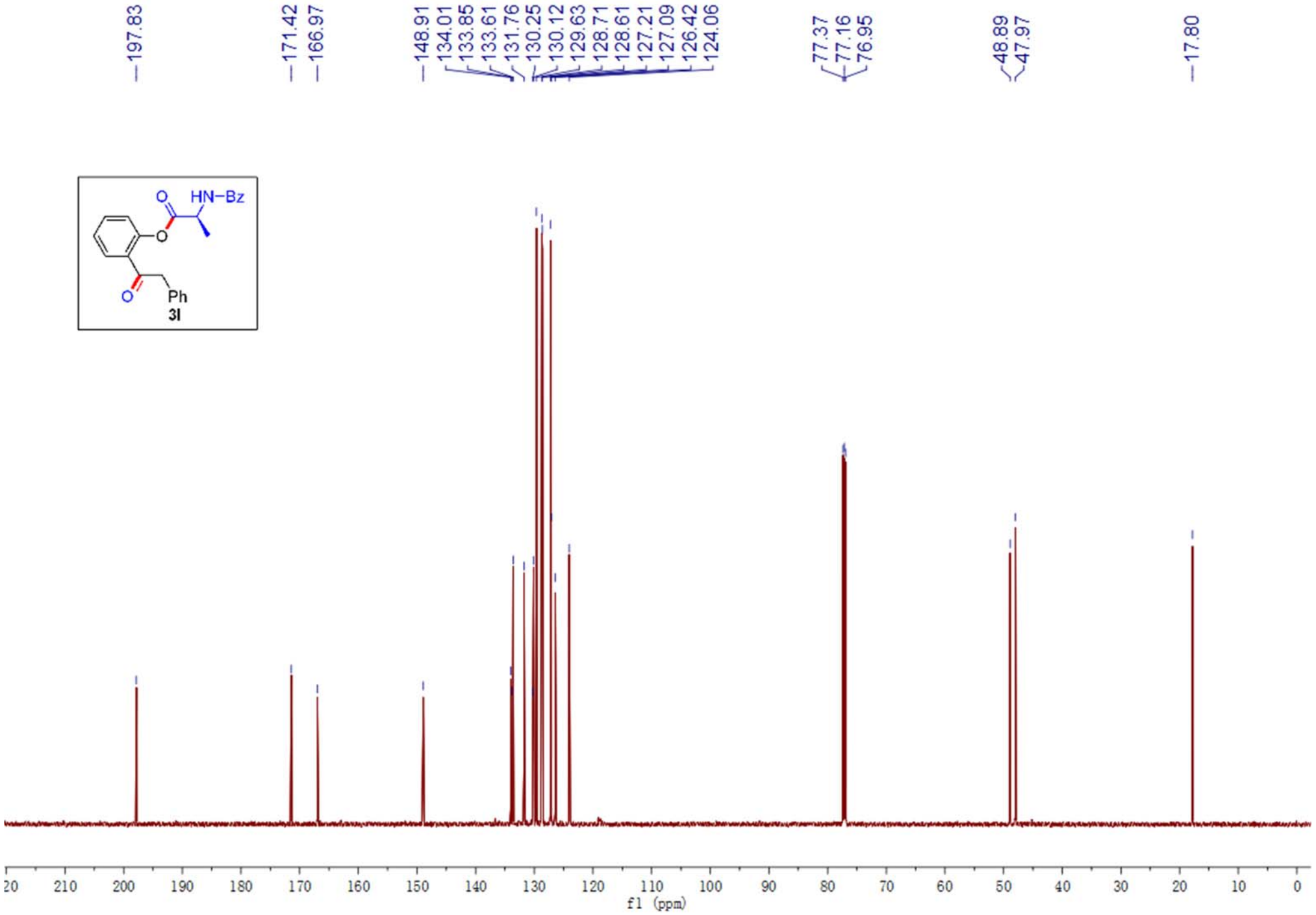
7.509
7.508
7.471
7.459
7.390
7.387
7.376
7.364
7.318
7.307
7.305
7.293
7.280
7.248
7.236
7.200
7.187
7.161
7.148
5.081
5.069
5.057
5.045
5.033
4.207
1.638
1.626
HN–Bz
O
O
O
Ph
3l
3.00
2.11
2.05
4.06
2.02
0.97
0.97
1.00
2.06
3.02
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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148.91
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133.61
131.76
130.25
130.12
129.63
128.71
128.61
127.21
127.09
126.42
124.06
77.37
77.16
76.95
48.89
47.97
17.80
HN–Bz
Ph
3l
f1 (ppm)


7.896
7.890
7.886
7.884
7.881
7.783
7.781
7.770
7.768
7.745
7.743
7.741
7.738
7.734
7.729
7.308
7.306
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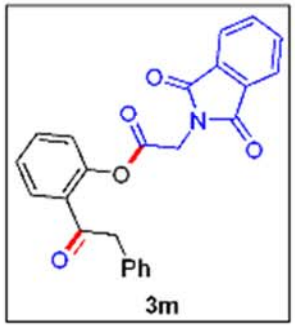
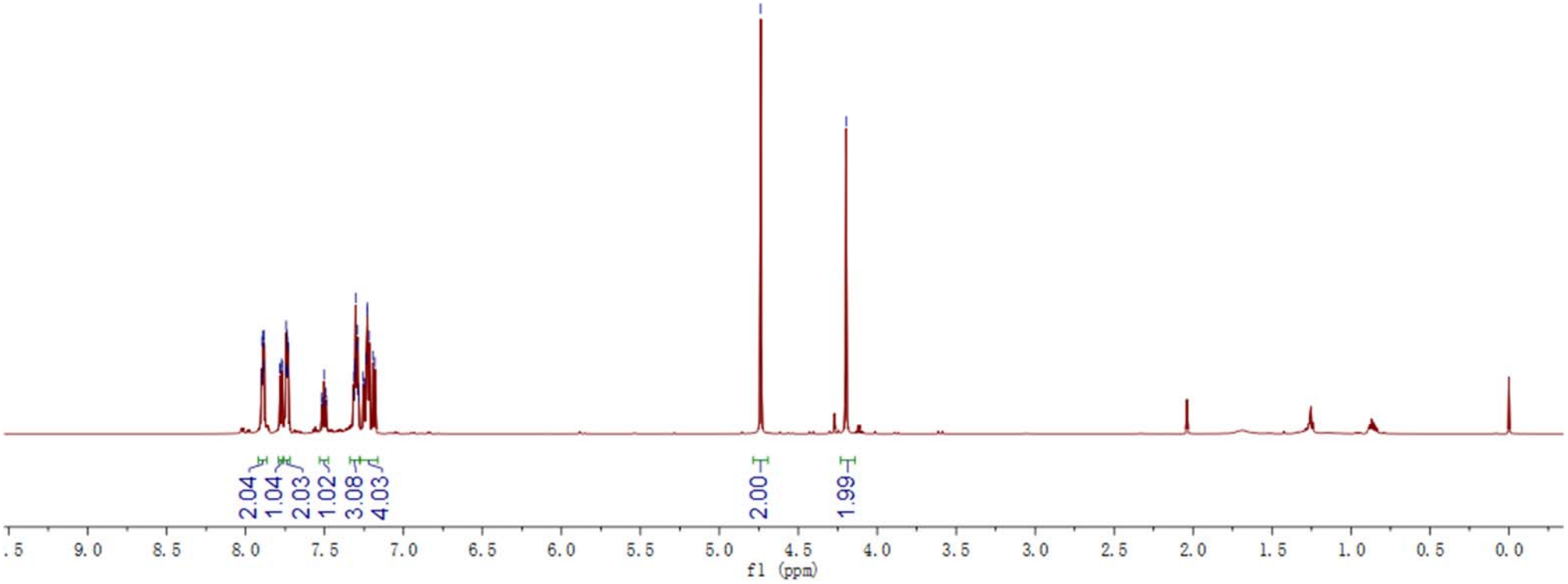
7.236
7.230
7.228
7.217
7.194
7.181
4.738
4.197


O
O
N
O
O
O
Ph

3m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1.04
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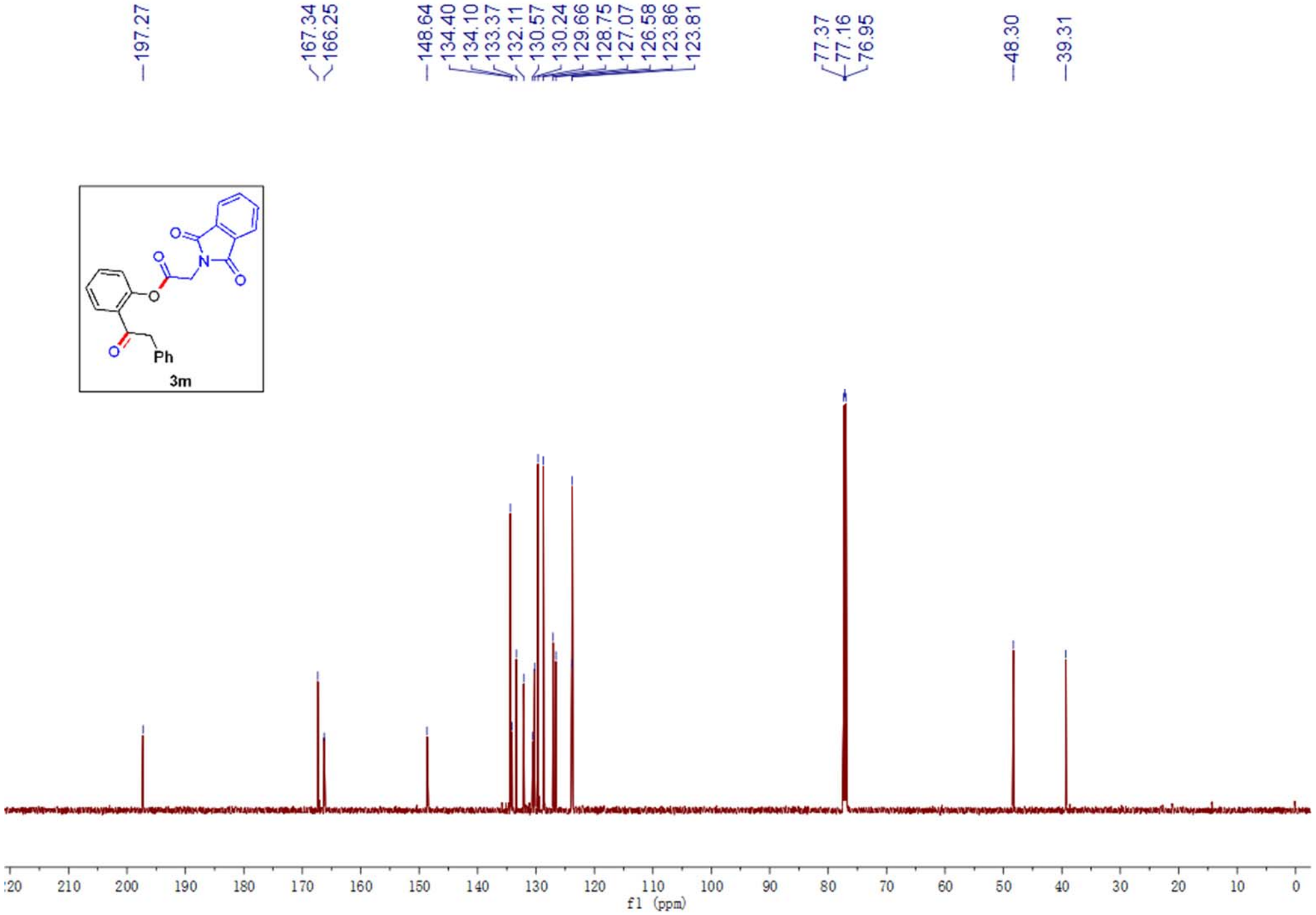
1.02
3.08
4.03
2.00
1.99
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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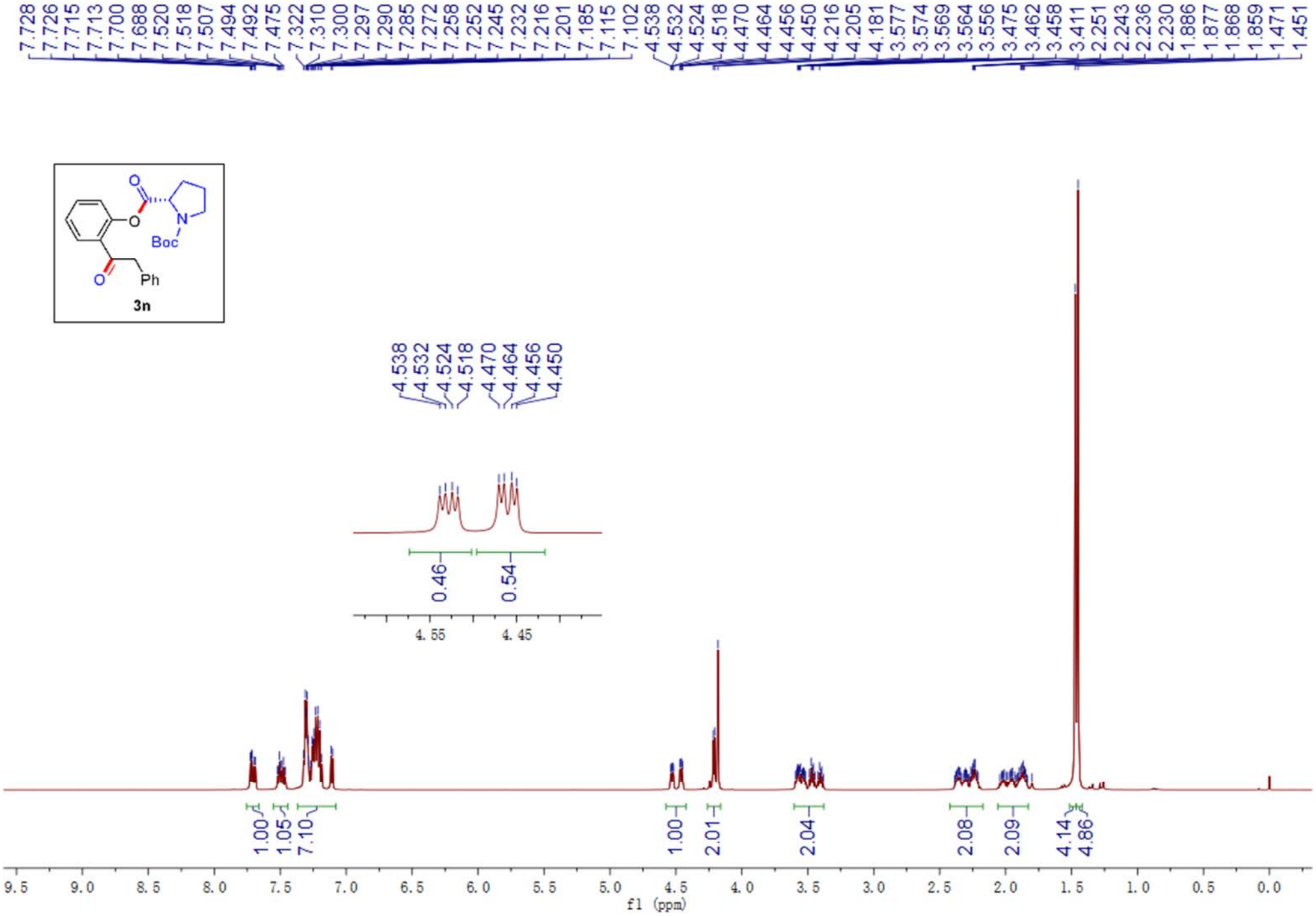
134.10
133.37
132.11
130.57
130.24
129.66
128.75
127.07
126.58
123.86
123.81
77.37
77.16
76.95
48.30
39.31
Ph
3m
f1 (ppm)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7.492
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7.322
7.310
7.300
7.297
7.290
7.285
7.272
7.258
7.252
7.245
7.232
7.216
7.201
7.185
7.115
7.102
4.538
4.532
4.524
4.518
4.470
4.464
4.456
4.450
4.216
4.205
4.181
3.577
3.574
3.569
3.564
3.556
3.475
3.462
3.458
3.411
2.251
2.243
2.236
2.230
1.886
1.877
1.868
1.859
1.471
1.451
Boc
Ph
3n
0.46
0.54
4.55
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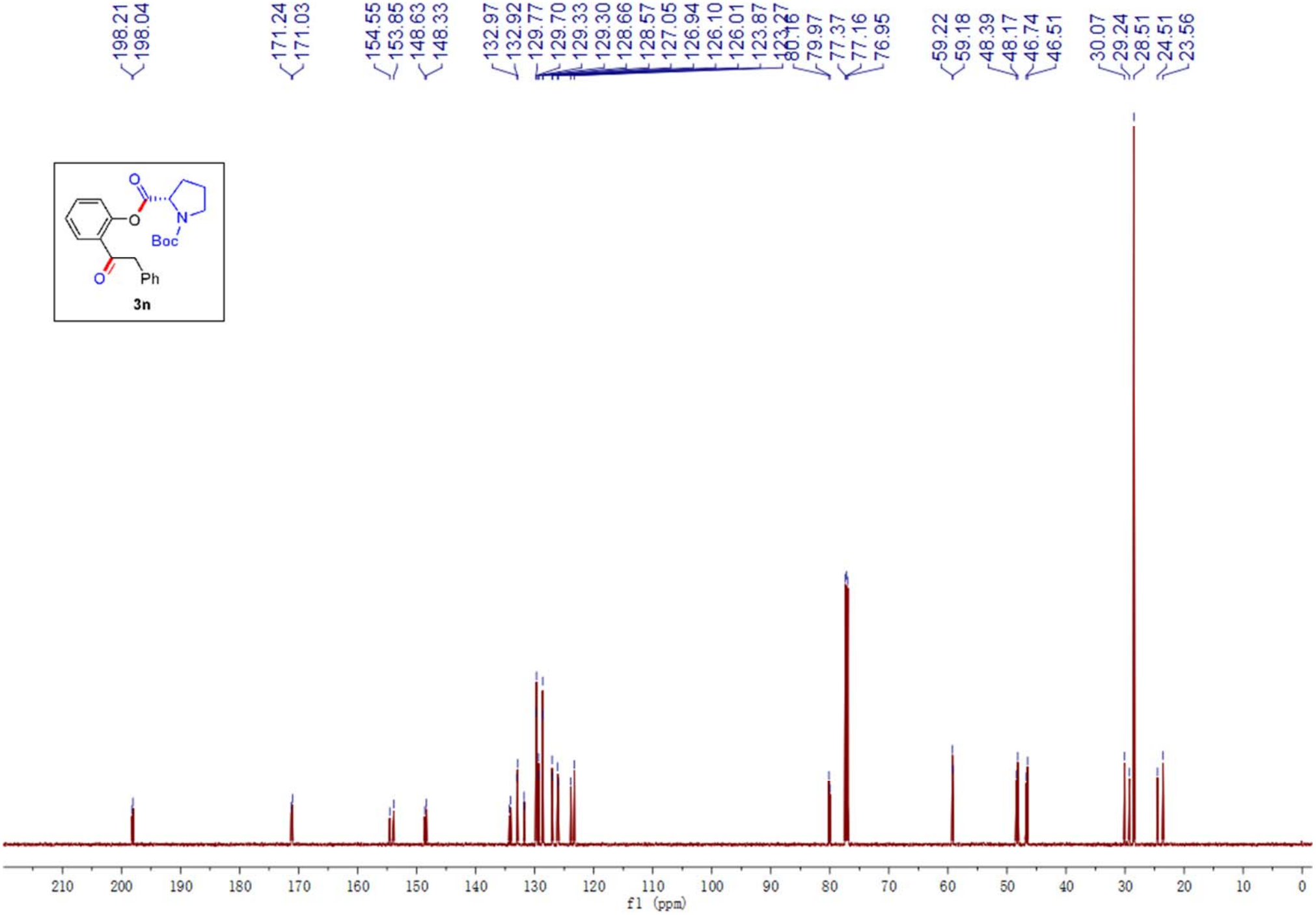
1.00
1.05
7.10
1.00
2.01
2.04
2.08
2.09
4.14
4.86
f1 (ppm)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153.85
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148.33
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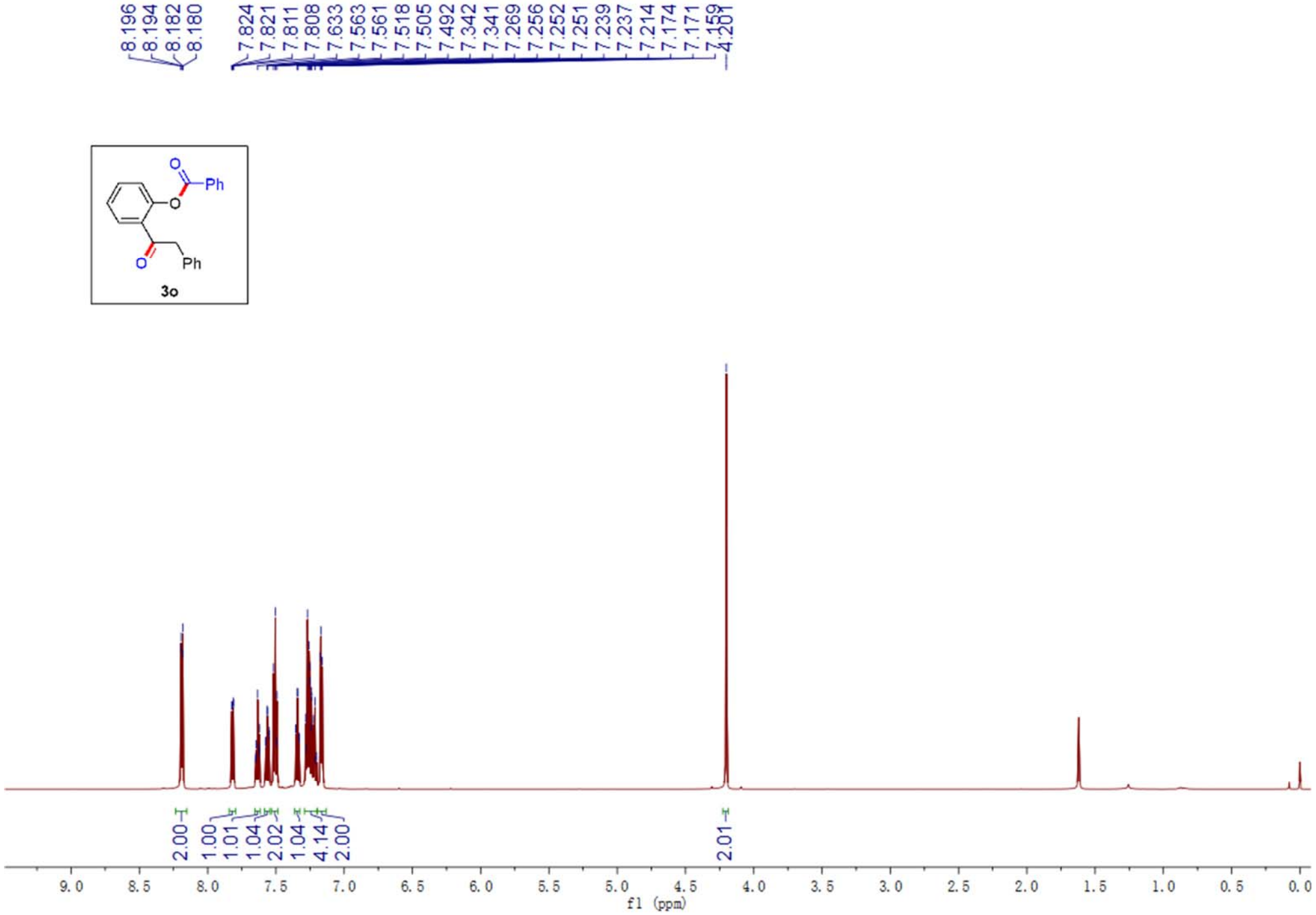
129.70
129.33
129.30
128.66
128.57
127.05
126.94
126.10
126.01
123.87
123.27
80.16
79.97
77.37
77.16
76.95
59.22
59.18
48.39
48.17
46.74
46.51
30.07
29.24
28.51
24.51
23.56
O
O
N
Boc
O
Ph
3n
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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8.180
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7.518
7.505
7.492
7.342
7.341
7.269
7.256
7.252
7.251
7.239
7.237
7.214
7.174
7.171
7.159
4.201
O
Ph
O
O
Ph
3o
2.00
1.00
1.01
1.04
2.02
1.04
4.14
2.00
2.01
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
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1.5
1.0
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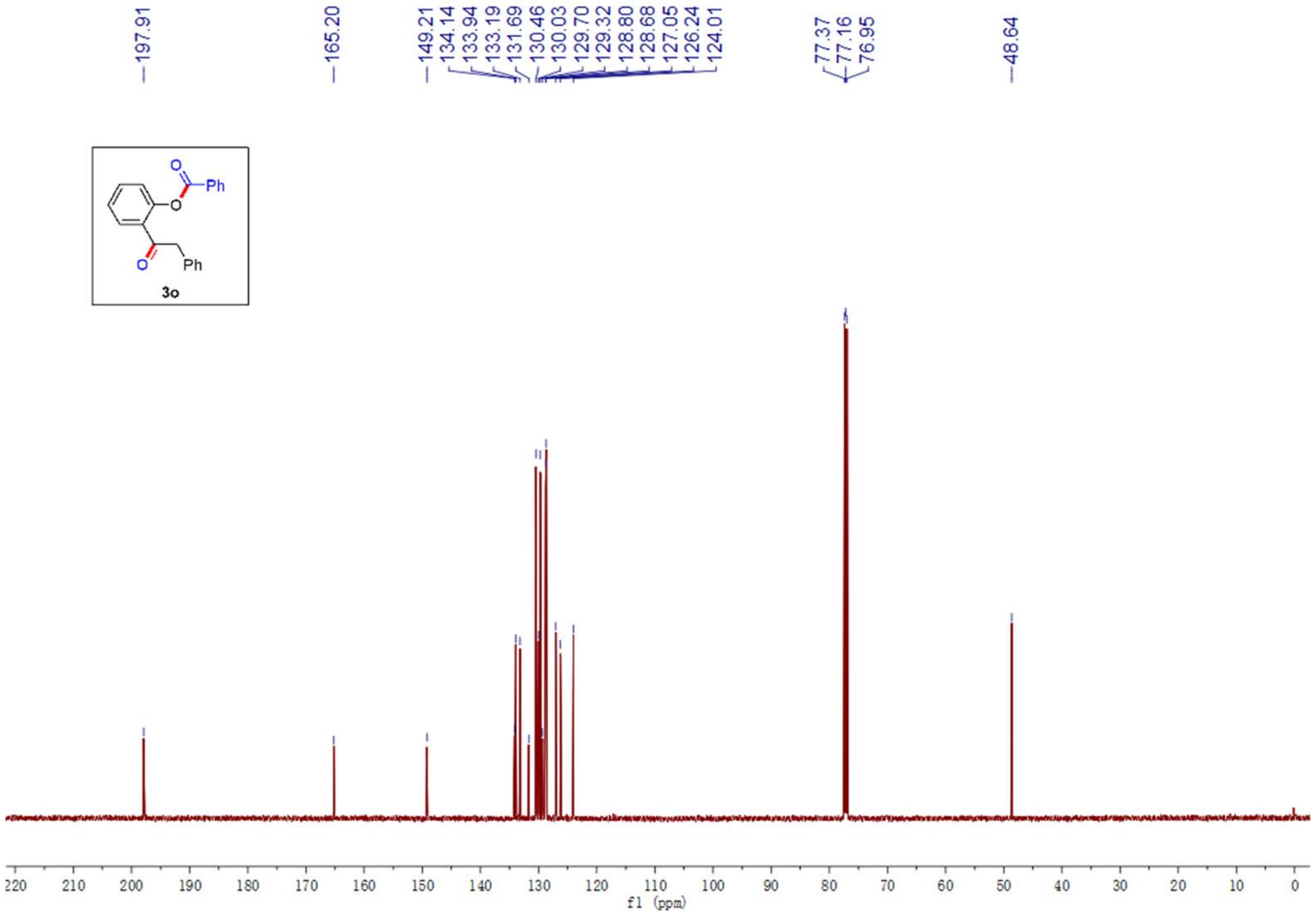
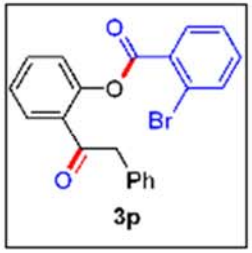
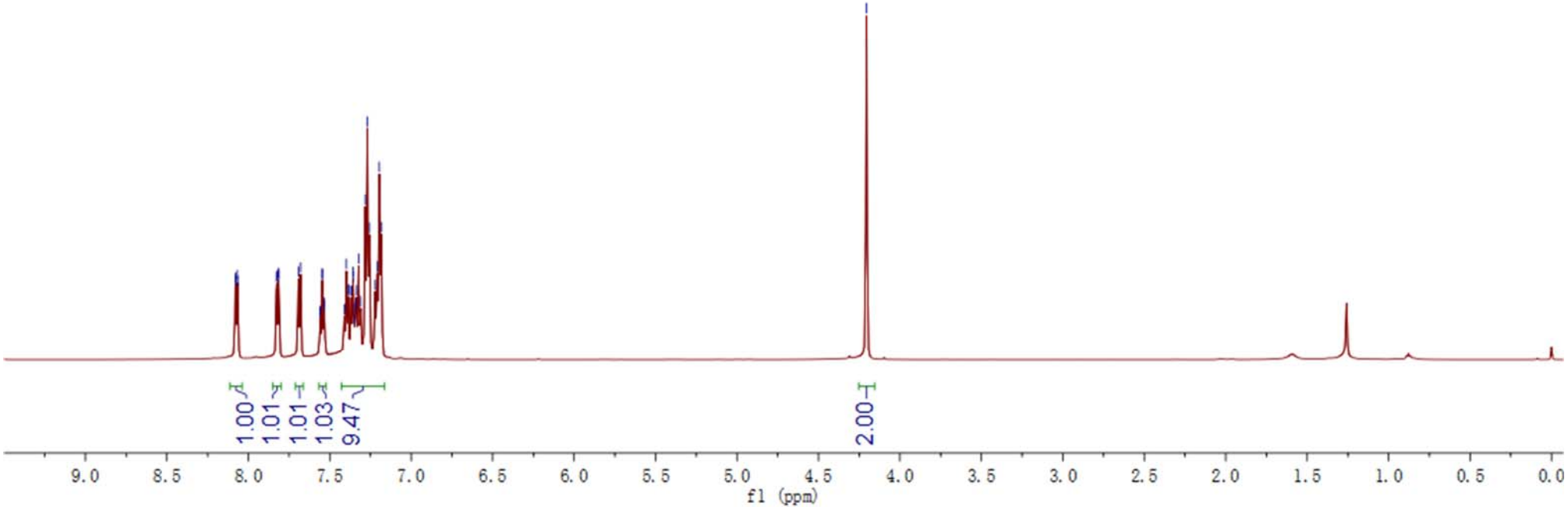
0.0
f1 (ppm)


197.91
165.20
149.21
134.14
133.94
133.19
131.69
130.46
130.03
129.70
129.32
128.80
128.68
127.05
126.24
124.01
77.37
77.16
76.95
48.64
O
Ph
O
O
Ph
3o
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.080
8.078
8.067
8.065
7.827
7.825
7.814
7.812
7.692
7.679
7.547
7.545
7.534
7.398
7.387
7.386
7.370
7.368
7.357
7.355
7.341
7.336
7.323
7.310
7.282
7.269
7.257
7.222
7.209
7.196
7.184
4.205


O
O
Br
O
Ph

3p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1.01
1.03
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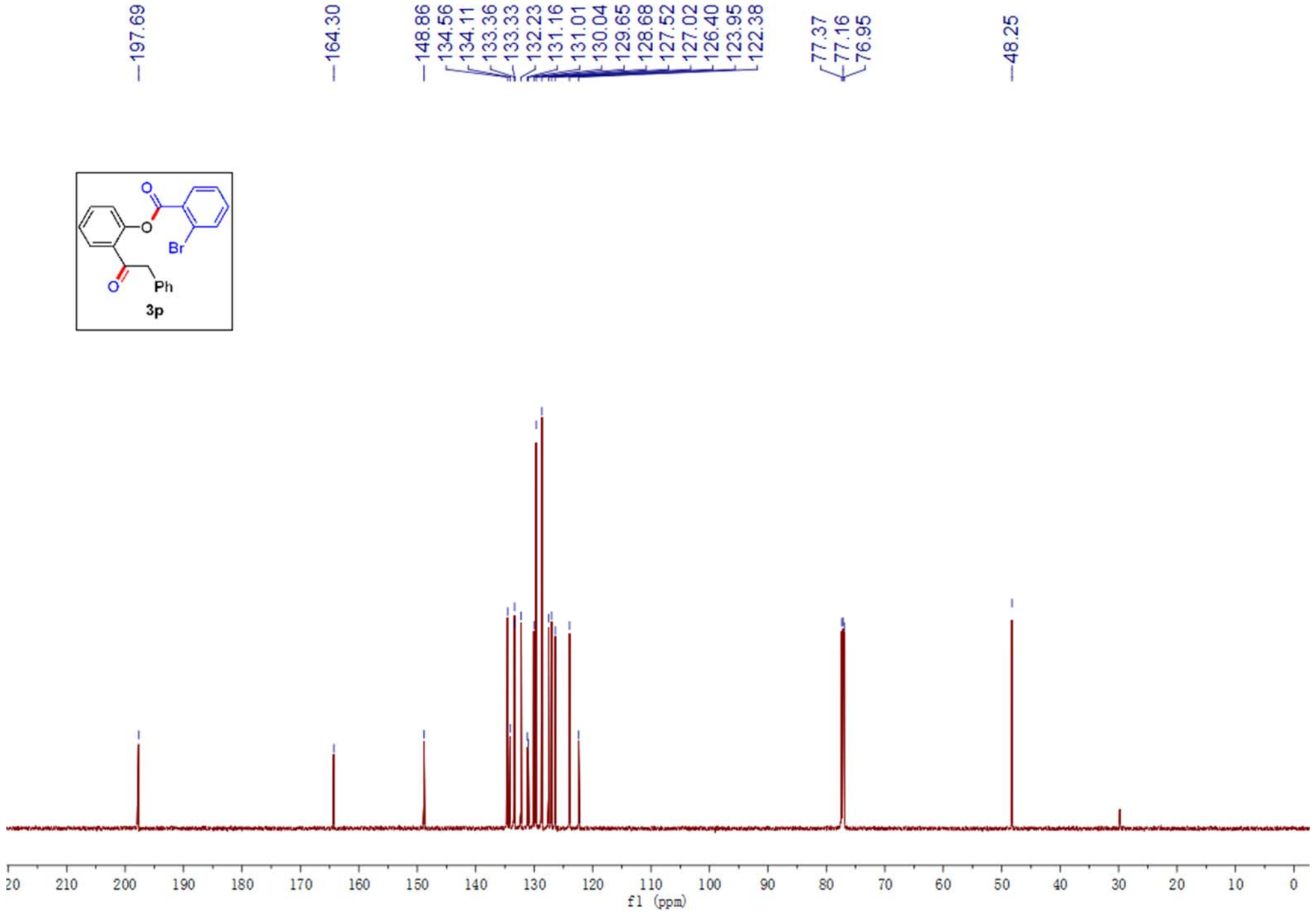
2.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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148.86
134.56
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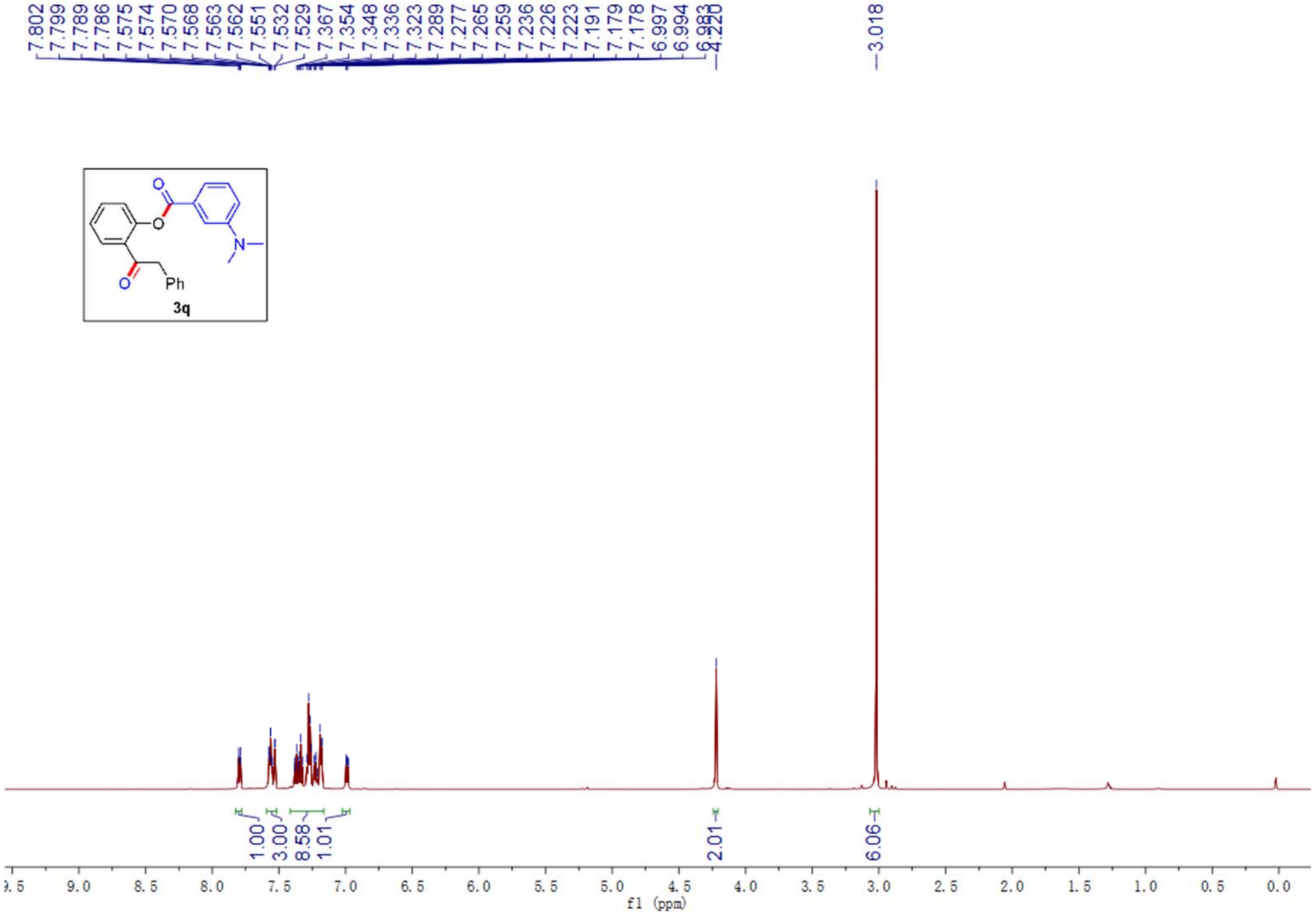
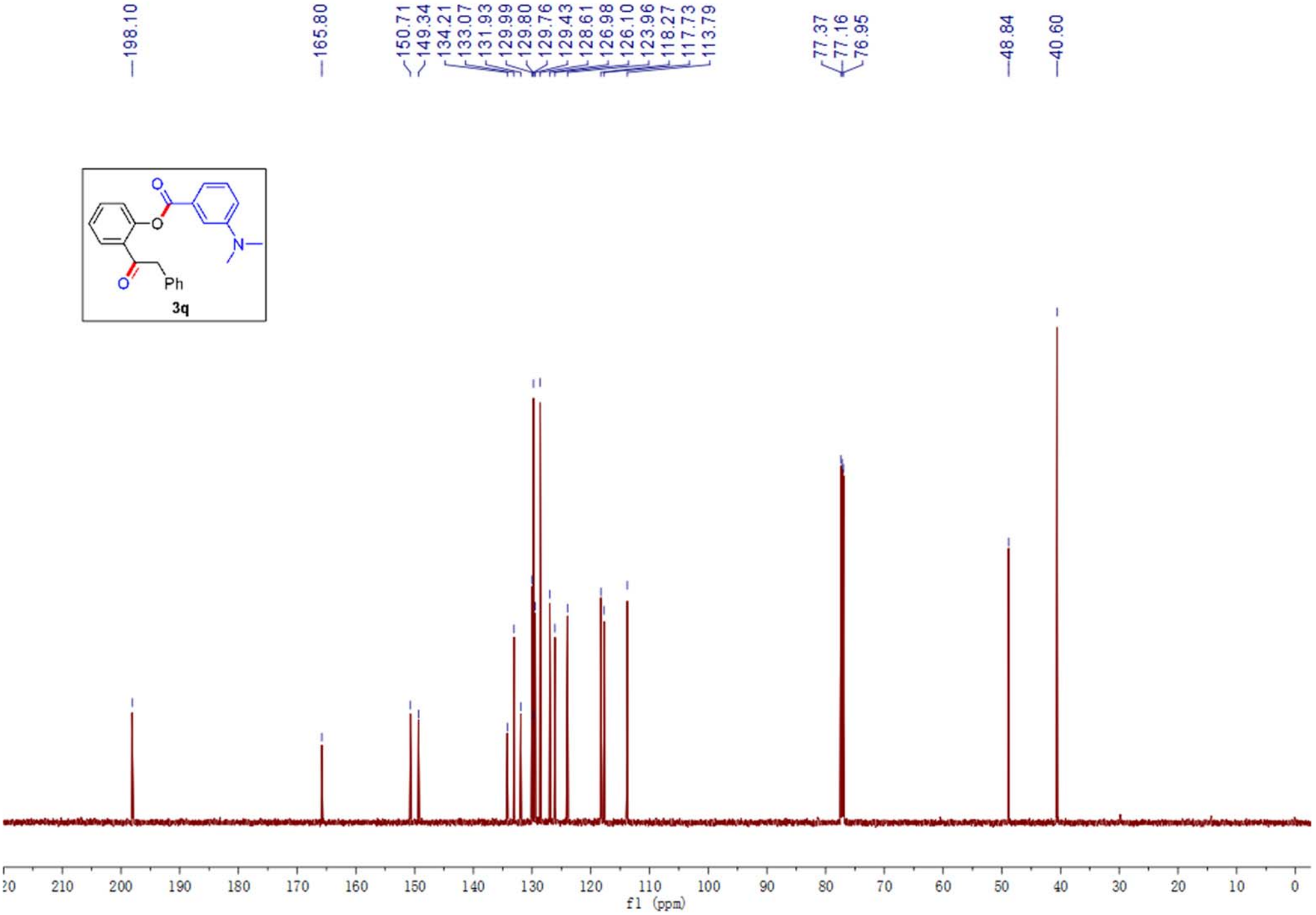
133.36
133.33
132.23
131.16
131.01
130.04
129.65
128.68
127.52
127.02
126.40
123.95
122.38
77.37
77.16
76.95
48.25
O
O
Br
O
Ph
3p
f1 (ppm)


7.802
7.799
7.789
7.786
7.575
7.574
7.570
7.568
7.563
7.562
7.551
7.532
7.529
7.367
7.354
7.348
7.336
7.323
7.289
7.277
7.265
7.259
7.236
7.226
7.223
7.191
7.179
7.178
6.997
6.994
4.220
3.018
O
O
N
O
Ph
3q
1.00
3.00
8.58
1.01
2.01
6.06
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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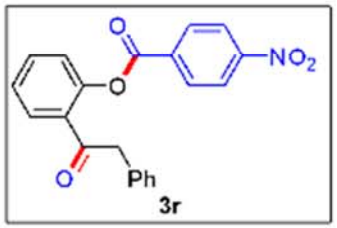
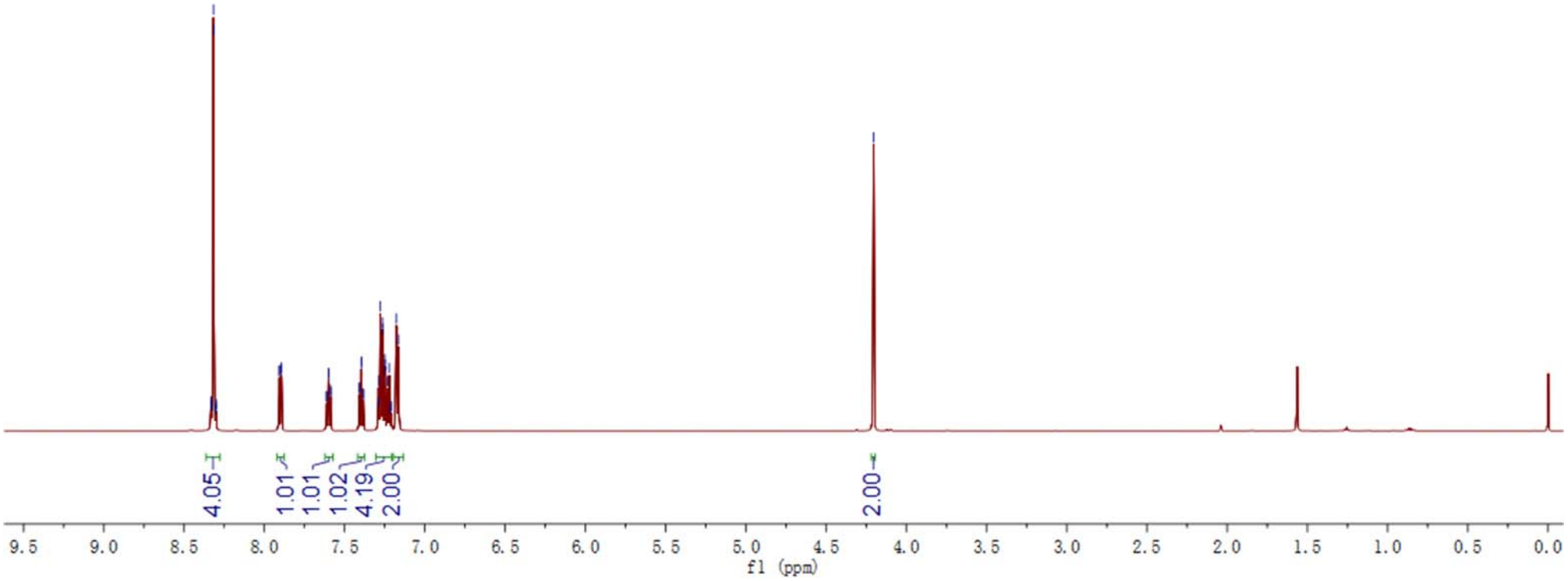
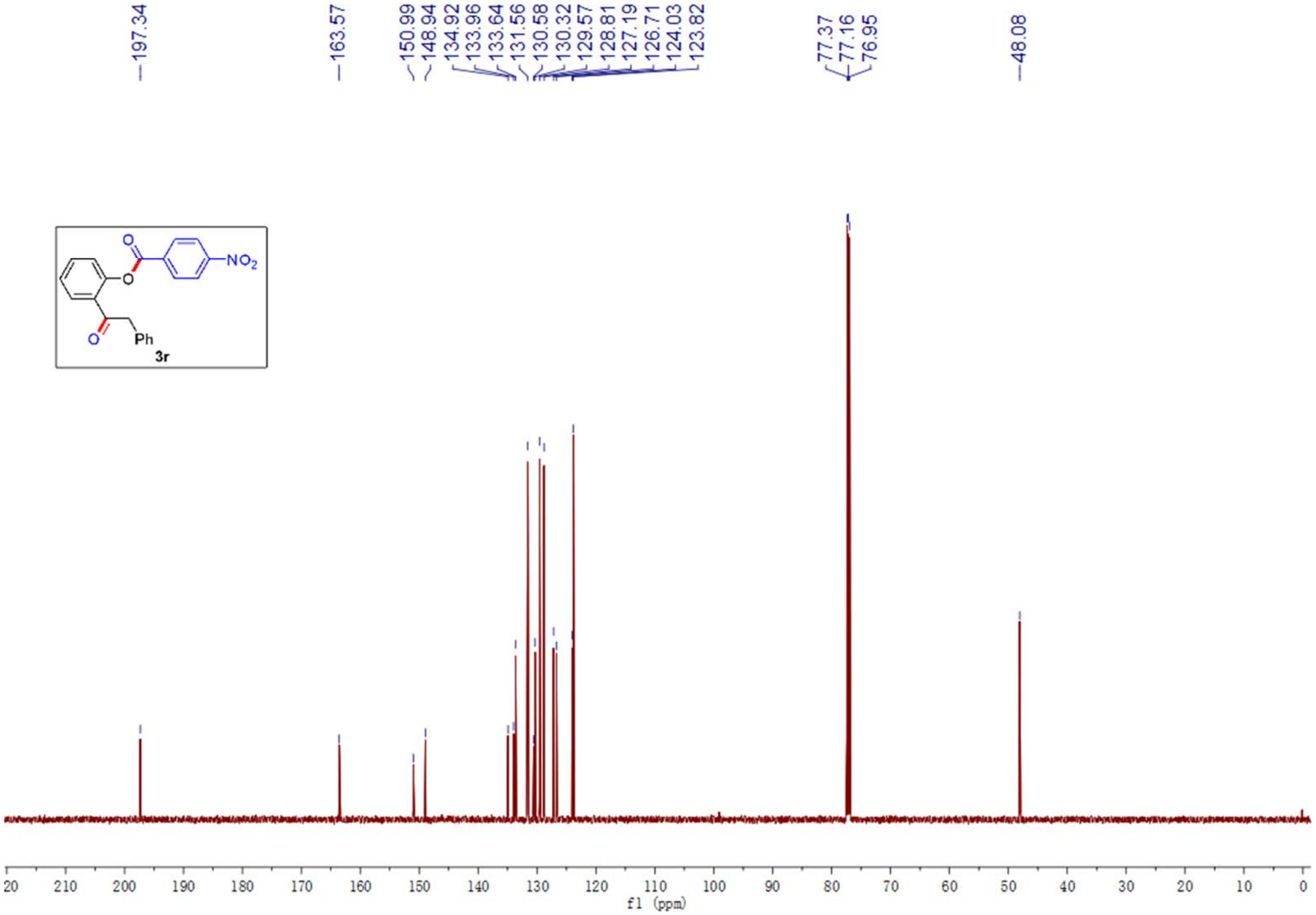
150.71
149.34
134.21
133.07
131.93
129.99
129.80
129.76
129.43
128.61
126.98
126.10
123.96
118.27
117.73
113.79
77.37
77.16
76.95
48.84
40.60
O
O
N
O
Ph
3q
f1 (ppm)


8.333
8.332
8.328
8.318
8.316
8.305
8.302
8.300
7.908
7.906
7.895
7.893
7.601
7.598
7.588
7.585
7.409
7.407
7.396
7.394
7.289
7.277
7.264
7.262
7.251
7.248
7.247
7.233
7.221
7.177
7.165
4.203


O
O
NO2
O
Ph
3r


4.05
1.01
1.01
1.02
4.19
2.00
2.00
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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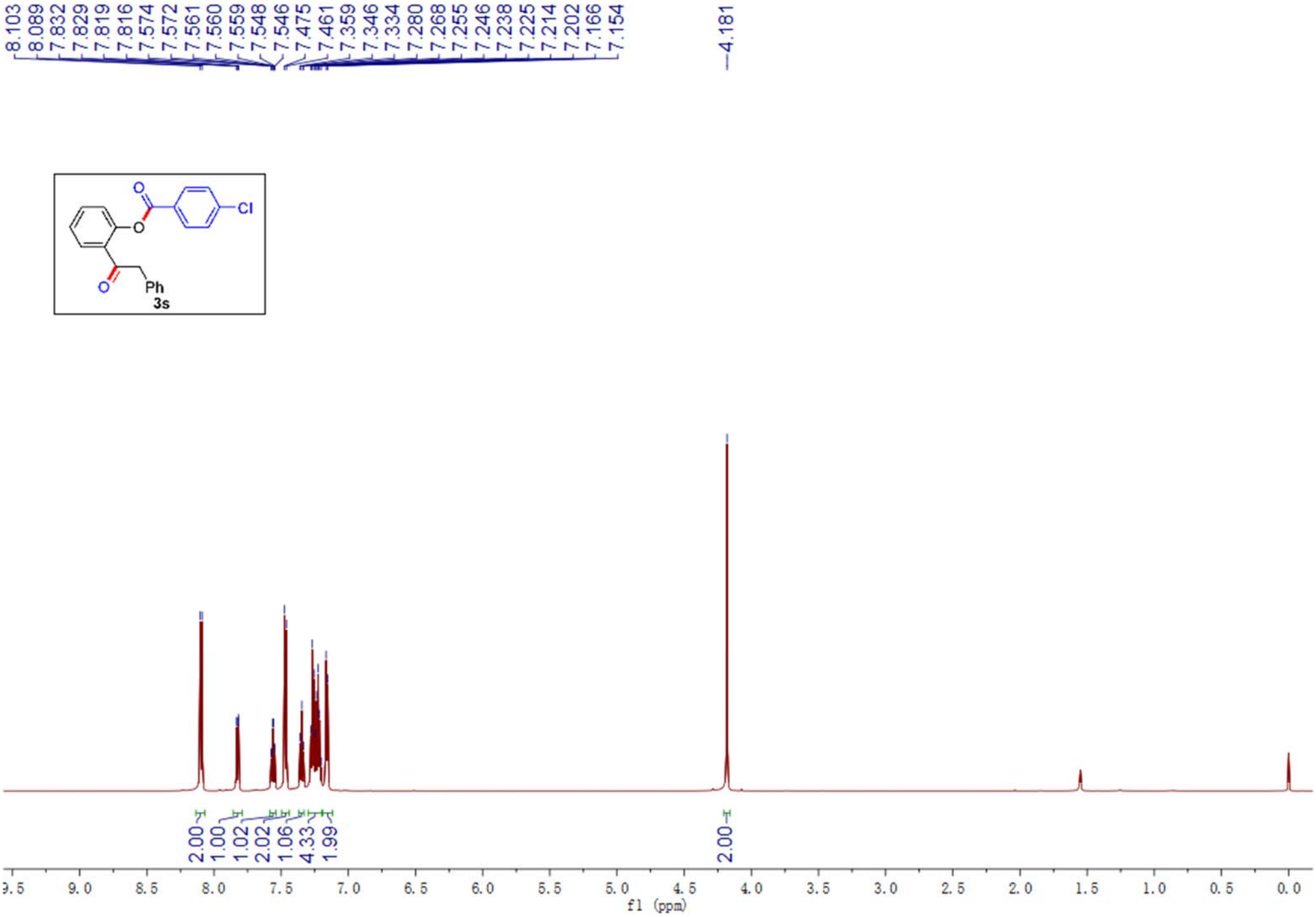
163.57
150.99
148.94
134.92
133.96
133.64
131.56
130.58
130.32
129.57
128.81
127.19
126.71
124.03
123.82
77.37
77.16
76.95
48.08
NO2
O
O
O
Ph
3r
20
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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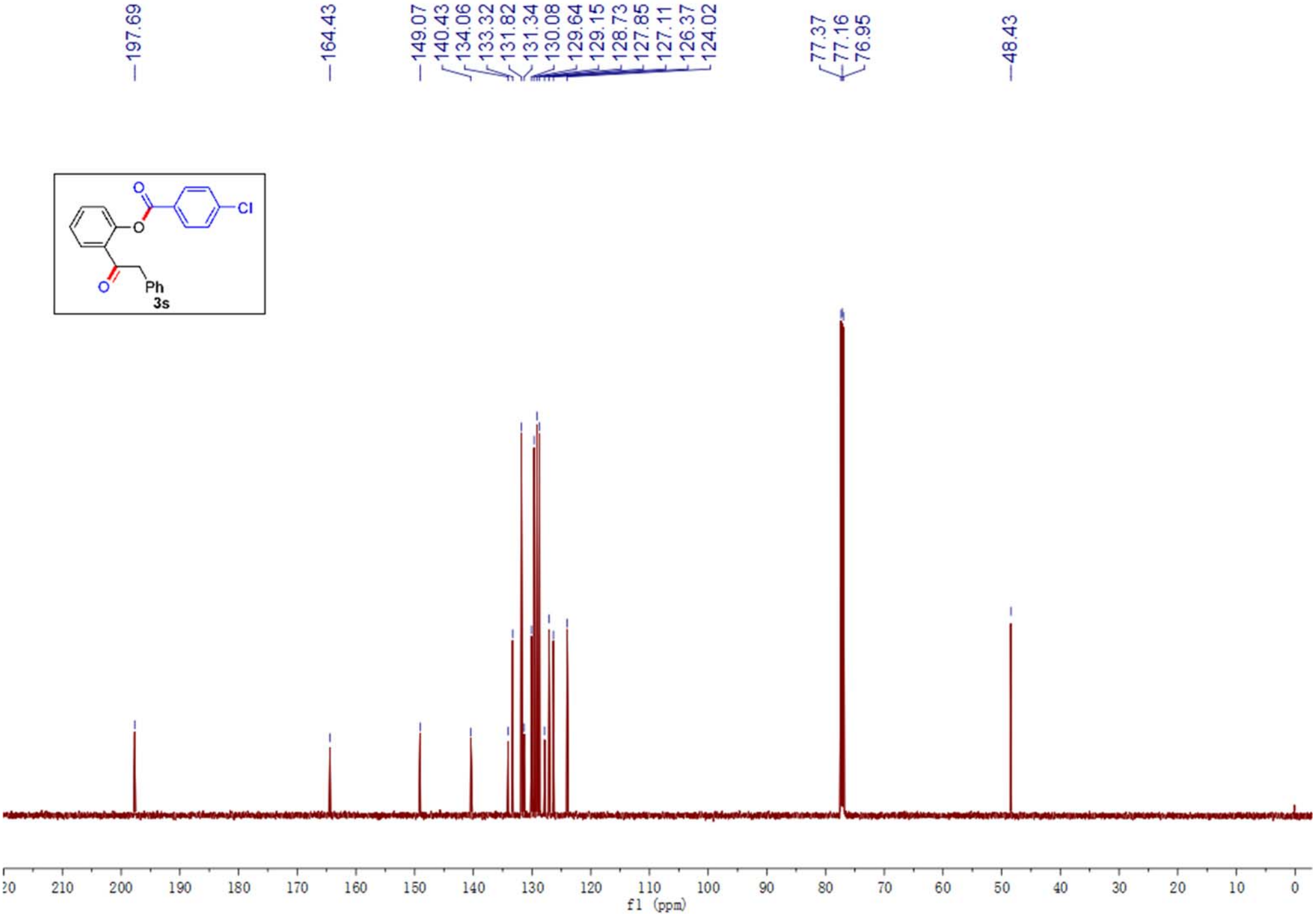
8.089
7.832
7.829
7.819
7.816
7.574
7.572
7.561
7.560
7.559
7.548
7.546
7.475
7.461
7.359
7.346
7.334
7.280
7.268
7.255
7.246
7.238
7.225
7.214
7.202
7.166
7.154
4.181
Cl
O
O
O
Ph
3s
2.00
1.00
1.02
2.02
1.06
4.33
1.99
2.00
f1 (ppm)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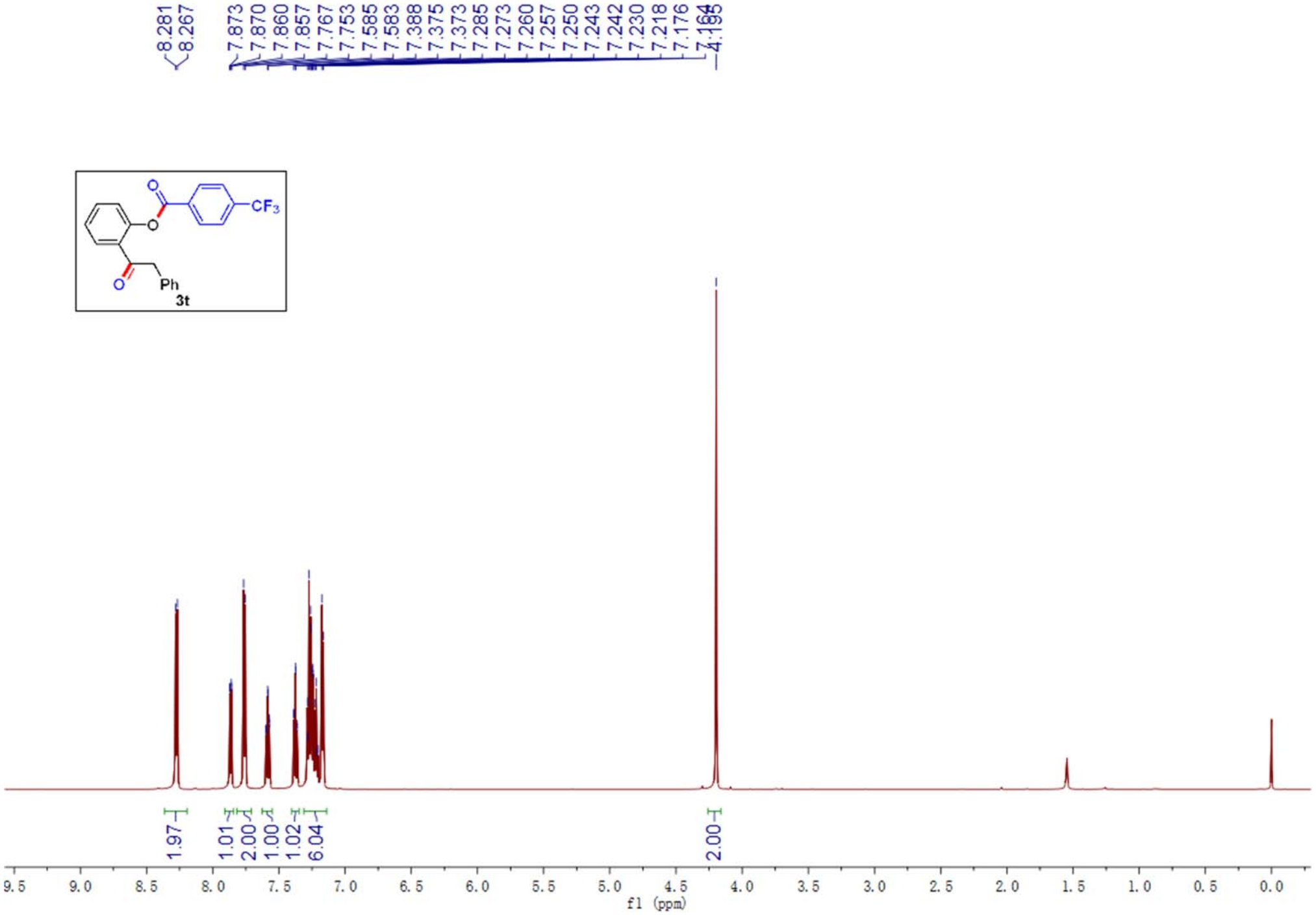
149.07
140.43
134.06
133.32
131.82
131.34
130.08
129.64
129.15
128.73
127.85
127.11
126.37
124.02
77.37
77.16
76.95
48.43
Cl
O
O
O
Ph
3s
f1 (ppm)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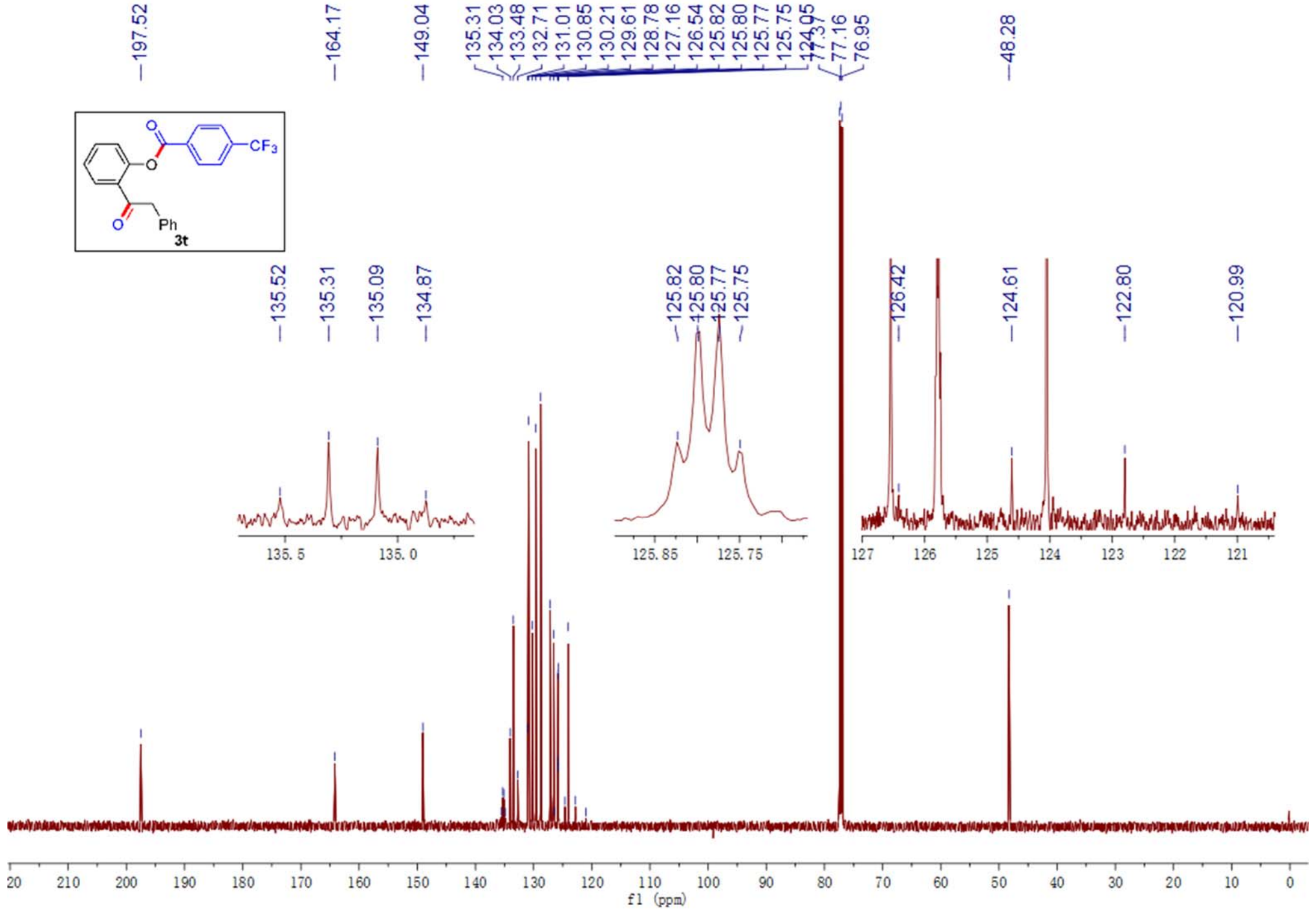
8.267
7.873
7.870
7.860
7.857
7.767
7.753
7.585
7.583
7.388
7.375
7.373
7.285
7.273
7.260
7.257
7.250
7.243
7.242
7.230
7.218
7.176
7.164
4.195
CF3
O
O
O
Ph
3t
1.97
1.01
2.00
1.00
1.02
6.04
2.00
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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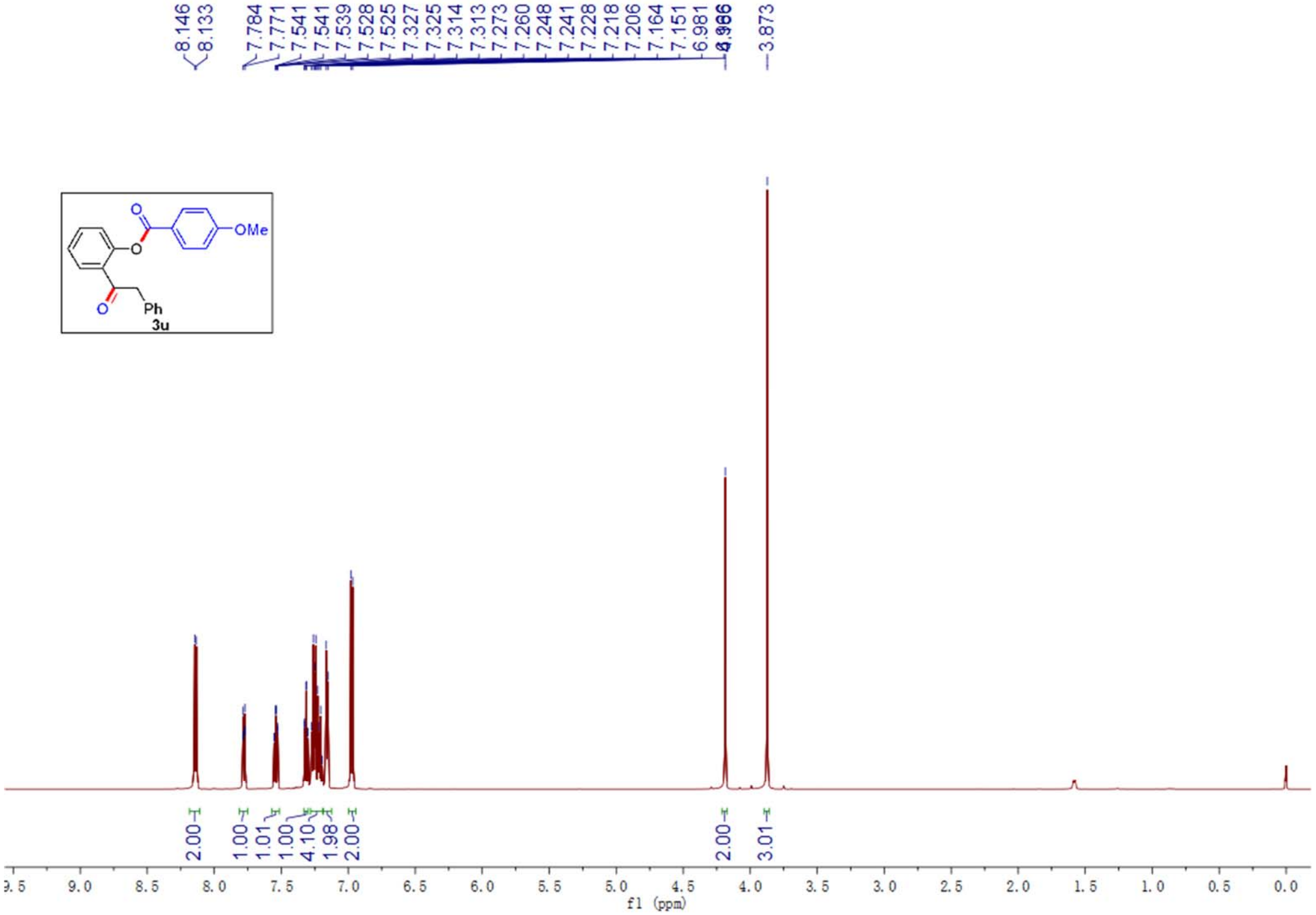
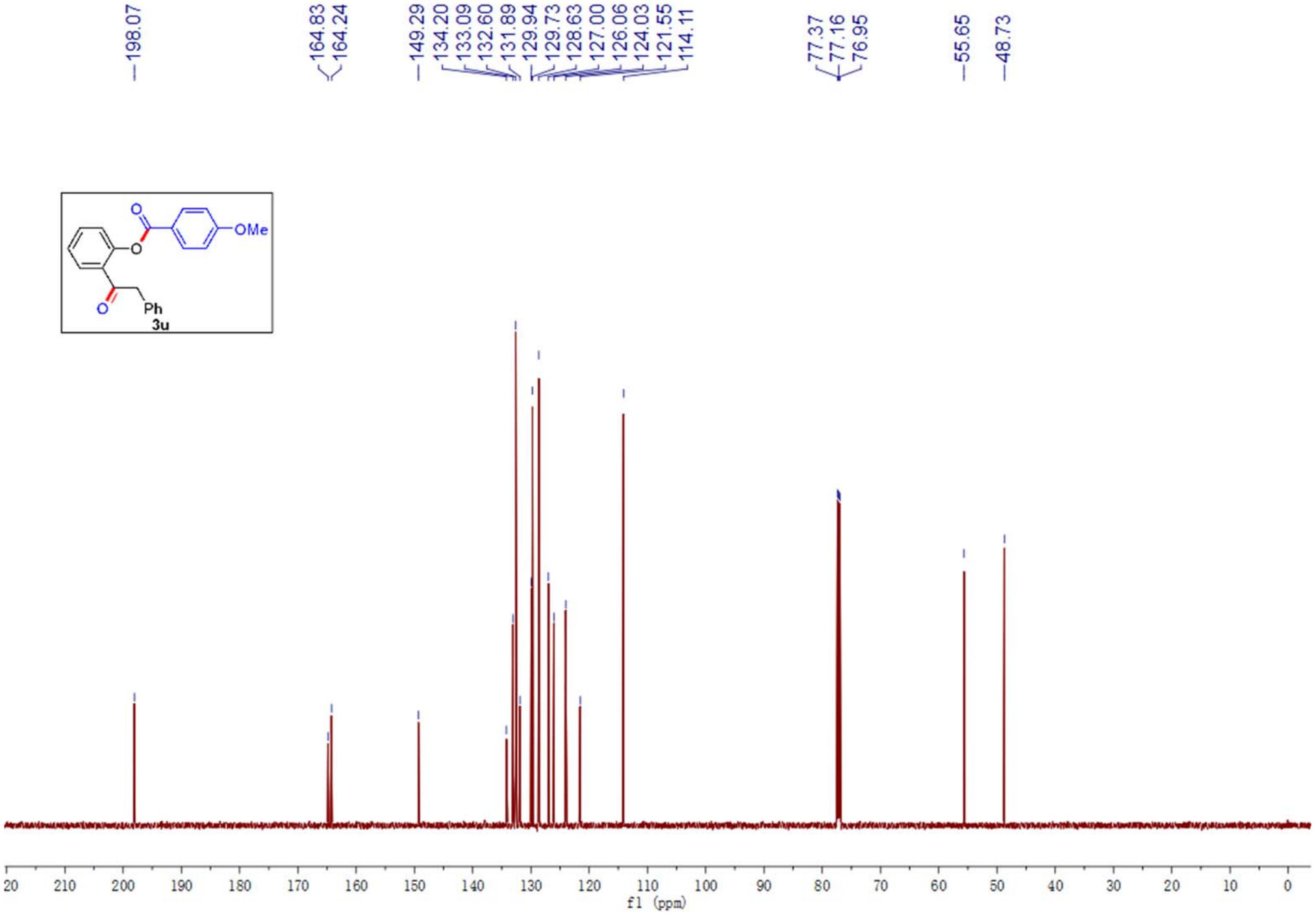
149.04
135.31
134.03
133.48
132.71
131.01
130.85
130.21
129.61
128.78
127.16
126.54
125.82
125.80
125.77
125.75
124.95
77.37
77.16
76.95
48.28
CF3
O
O
O
Ph
3t
135.52
135.31
135.09
134.87
125.82
125.80
125.77
125.75
126.42
124.61
122.80
120.99
135.5
135.0
125.85
125.75
127
126
125
124
123
122
121
20
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.146
8.133
7.784
7.771
7.541
7.541
7.539
7.528
7.525
7.327
7.325
7.314
7.313
7.273
7.260
7.248
7.241
7.228
7.218
7.206
7.164
7.151
6.981
3.873
OMe
Ph
3u
2.00
1.00
1.01
1.00
4.10
1.98
2.00
2.00
3.01
f1 (ppm)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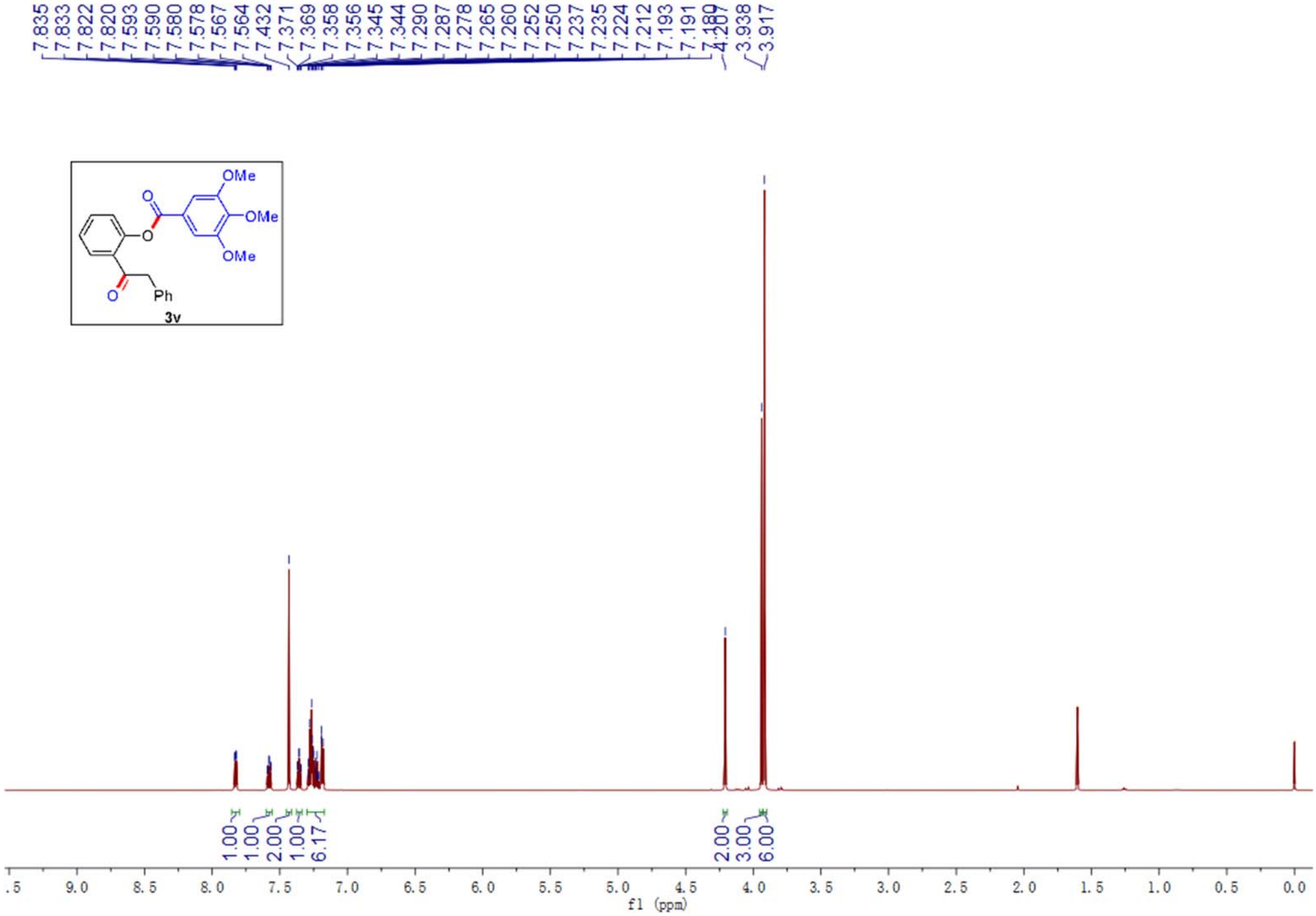
164.24
149.29
134.20
133.09
132.60
131.89
129.94
129.73
128.63
127.00
126.06
124.03
121.55
114.11
77.37
77.16
76.95
55.65
48.73
OMe
Ph
3u
f1 (ppm)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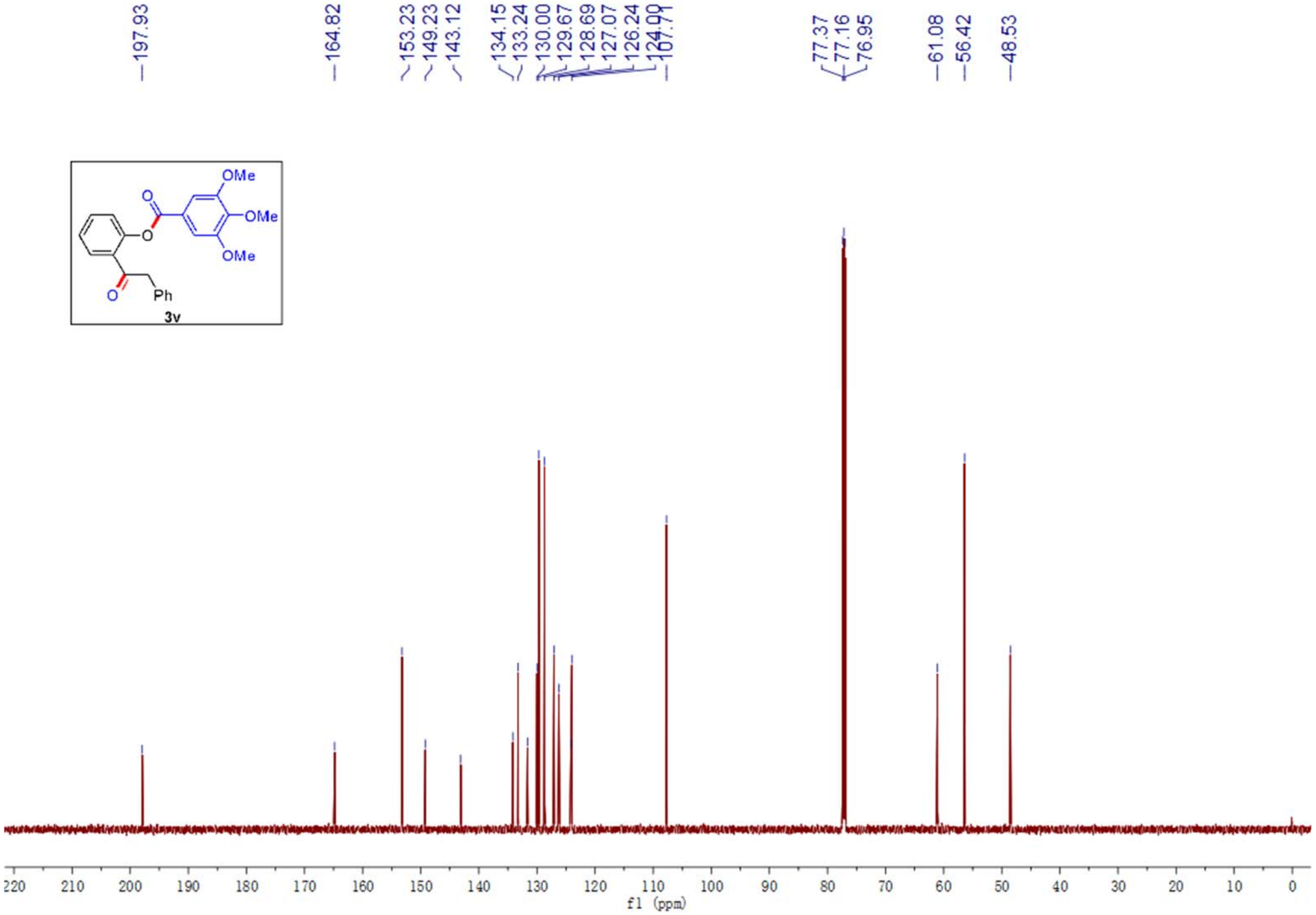
7.590
7.580
7.578
7.567
7.564
7.432
7.371
7.369
7.358
7.356
7.345
7.344
7.290
7.287
7.278
7.265
7.260
7.252
7.250
7.237
7.235
7.224
7.212
7.193
7.191
7.180
4.207
3.938
3.917
OMe
OMe
OMe
O
O
O
Ph
3v
1.00
1.00
2.00
1.00
6.17
2.00
3.00
6.00
f1 (ppm)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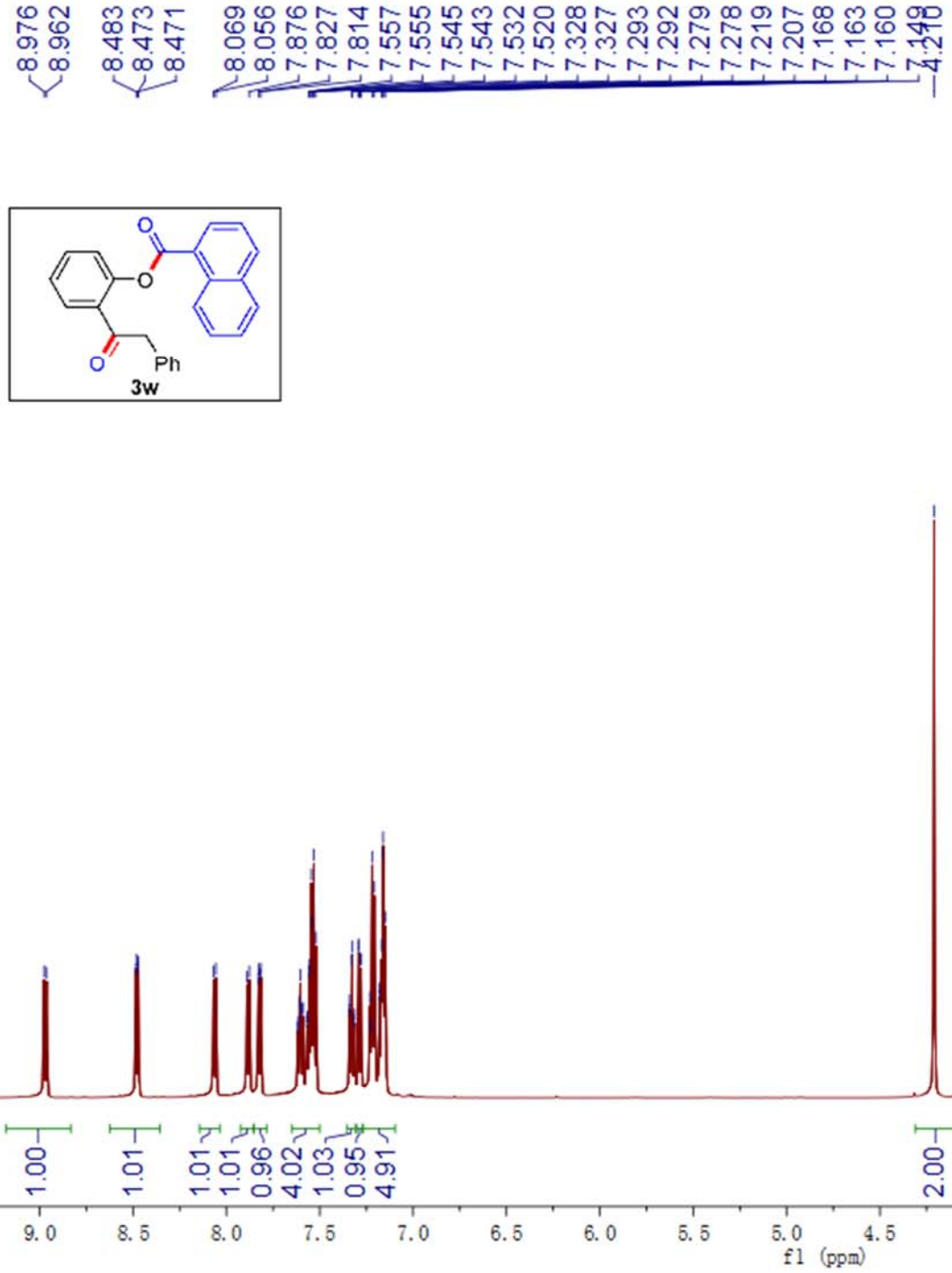
134.15
133.24
130.00
129.67
128.69
127.07
126.24
124.90
107.71
77.37
77.16
76.95
61.08
56.42
48.53
OMe
OMe
OMe
O
O
O
Ph
3v
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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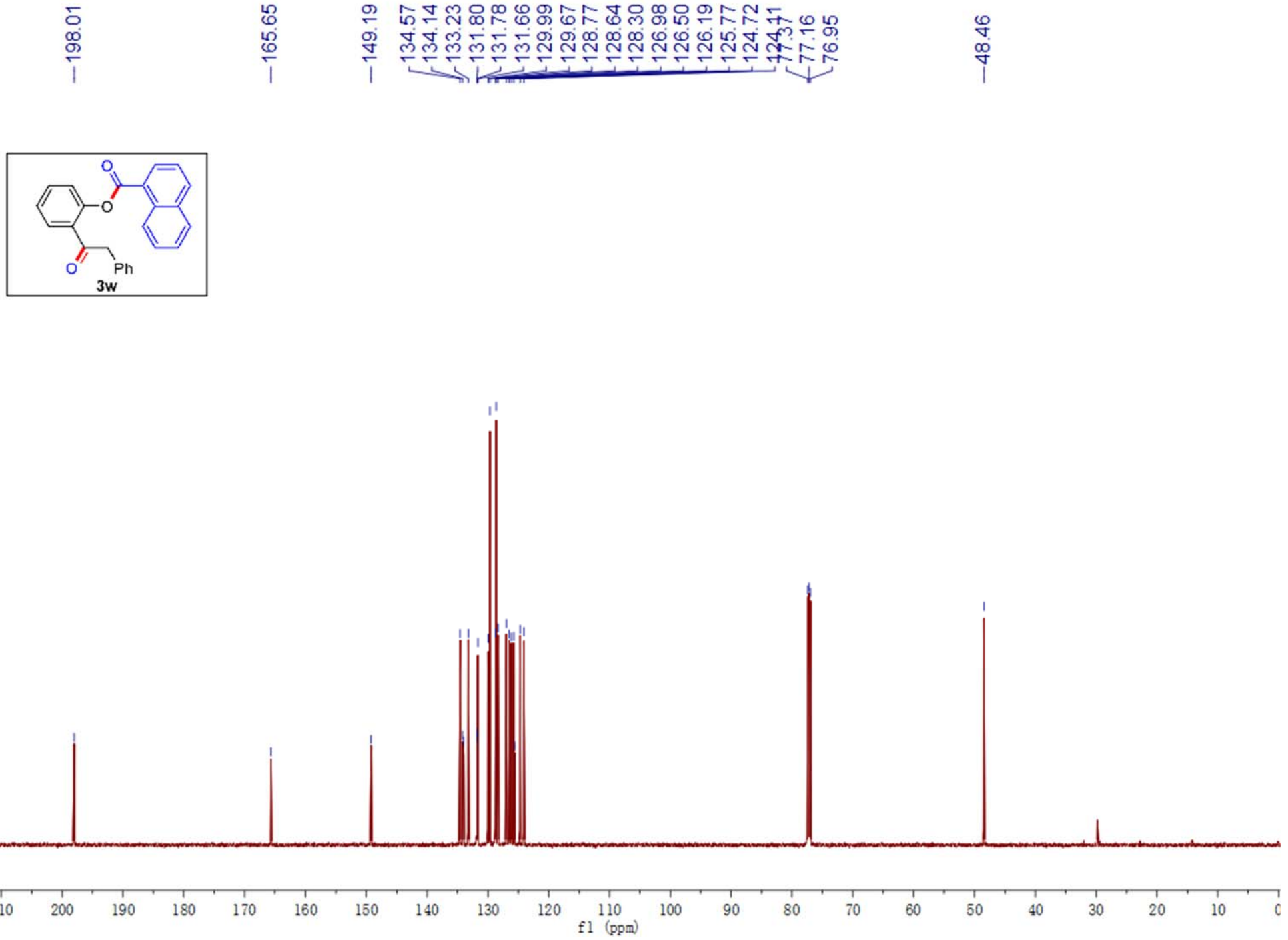
8.473
8.471
8.069
8.056
7.876
7.827
7.814
7.557
7.555
7.545
7.543
7.532
7.520
7.328
7.327
7.293
7.292
7.279
7.278
7.219
7.207
7.168
7.163
7.160
7.149
4.210
O
O
O
Ph
3w
1.00
1.01
1.01
1.01
0.96
4.02
1.03
0.95
4.91
2.00
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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133.23
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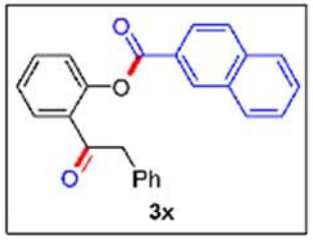
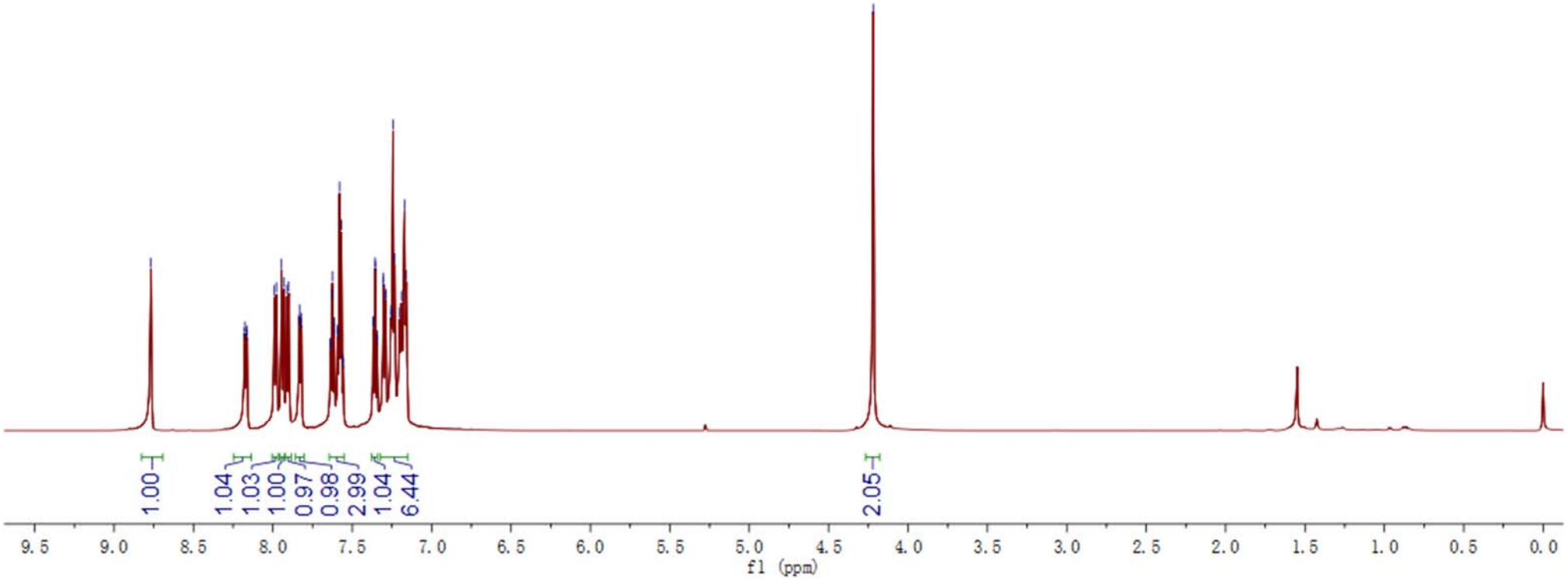
131.78
131.66
129.99
129.67
128.77
128.64
128.30
126.98
126.50
126.19
125.77
124.72
124.11
77.37
77.16
76.95
48.46
O
O
O
Ph
3w
f1 (ppm)


8.768
7.991
7.977
7.946
7.931
7.913
7.900
7.832
7.819
7.627
7.625
7.580
7.568
7.356
7.354
7.304
7.303
7.291
7.290
7.256
7.254
7.243
7.232
7.203
7.191
7.171
7.159
4.219


O
O
O
Ph

3x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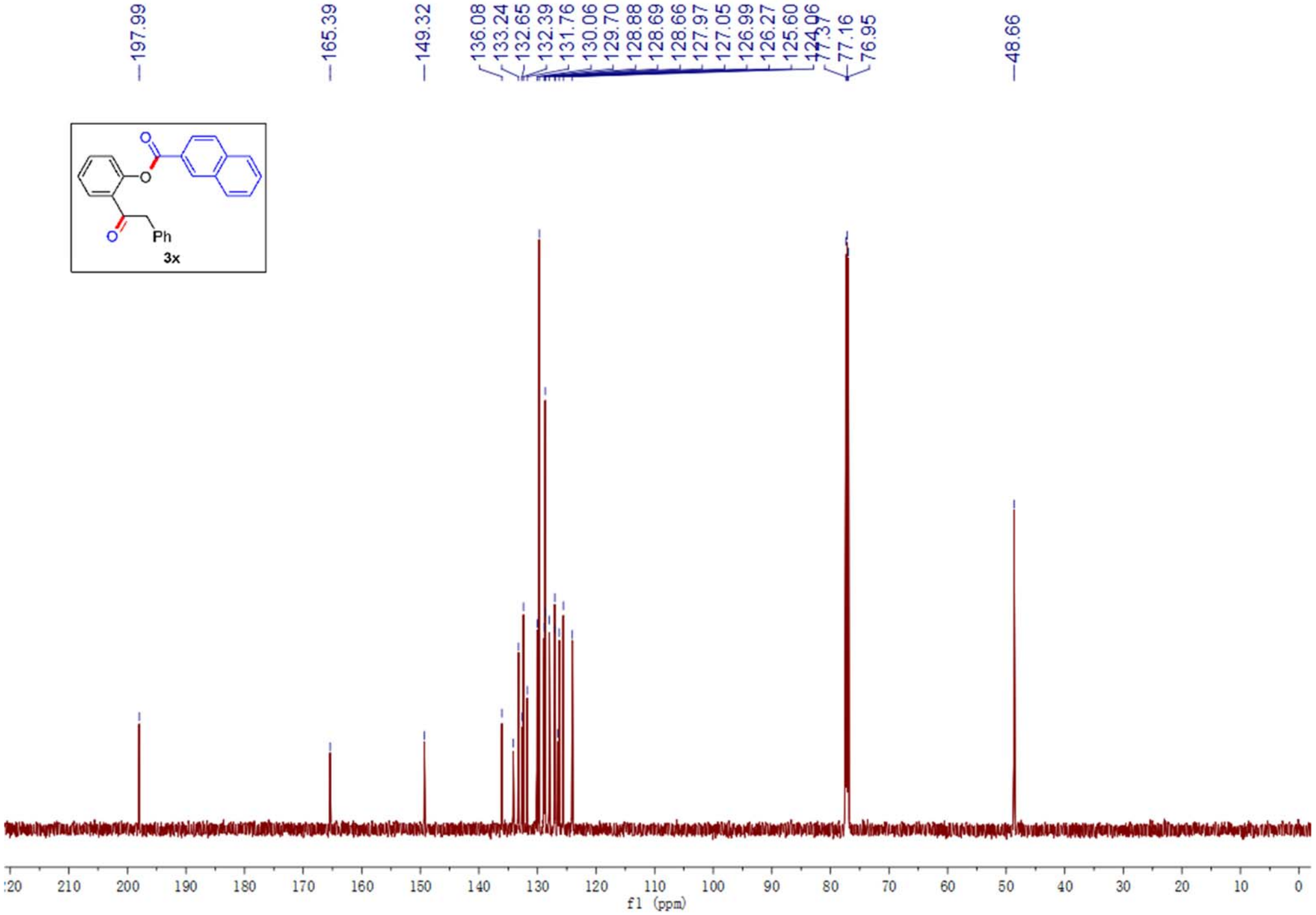
1.04
1.03
1.00
0.97
0.98
2.99
1.04
6.44
2.05
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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136.08
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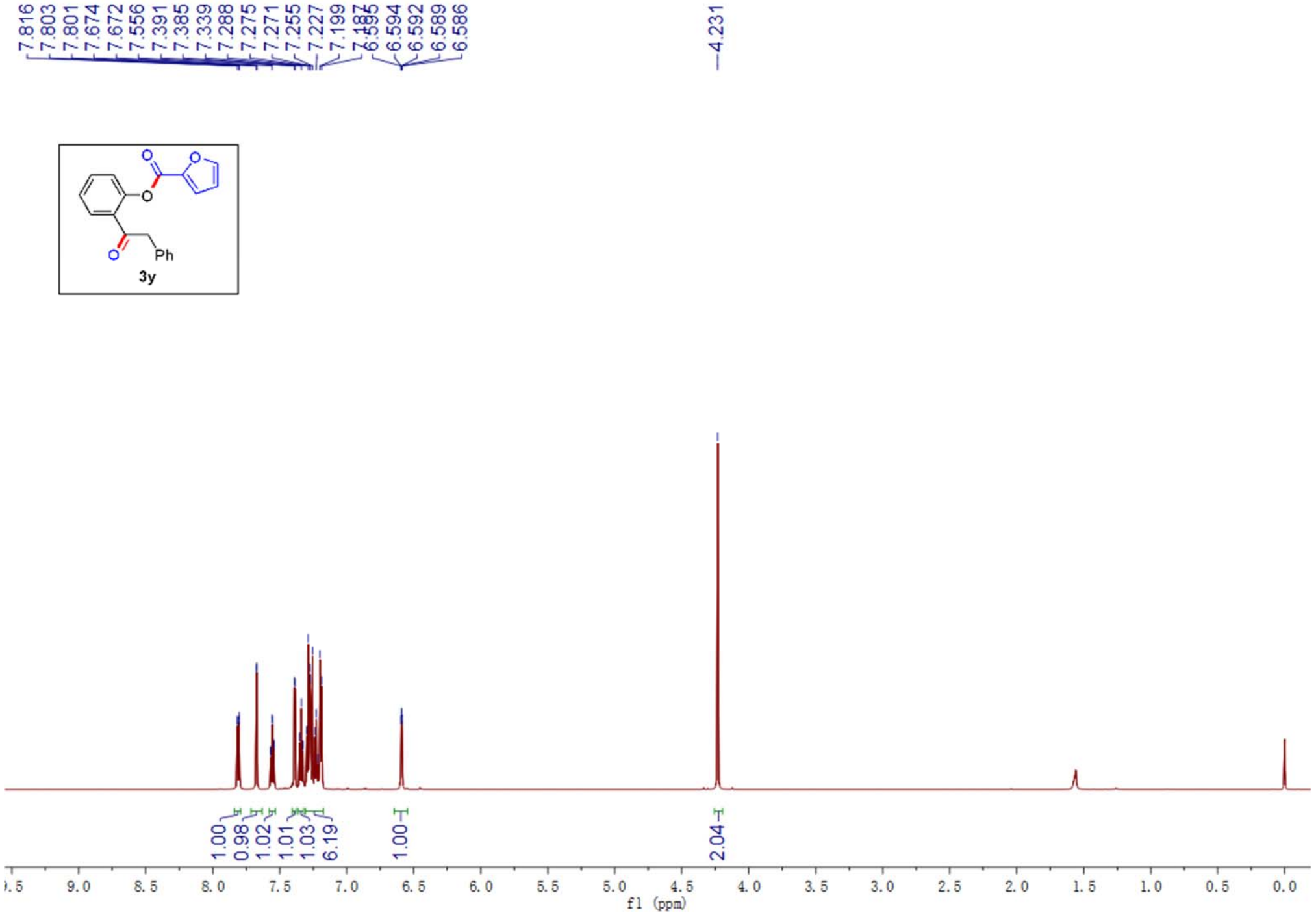
132.65
132.39
131.76
130.06
129.70
128.88
128.69
128.66
127.97
127.05
126.99
126.27
125.60
124.06
77.37
77.16
76.95
48.66
O
O
O
Ph
3x
f1 (ppm)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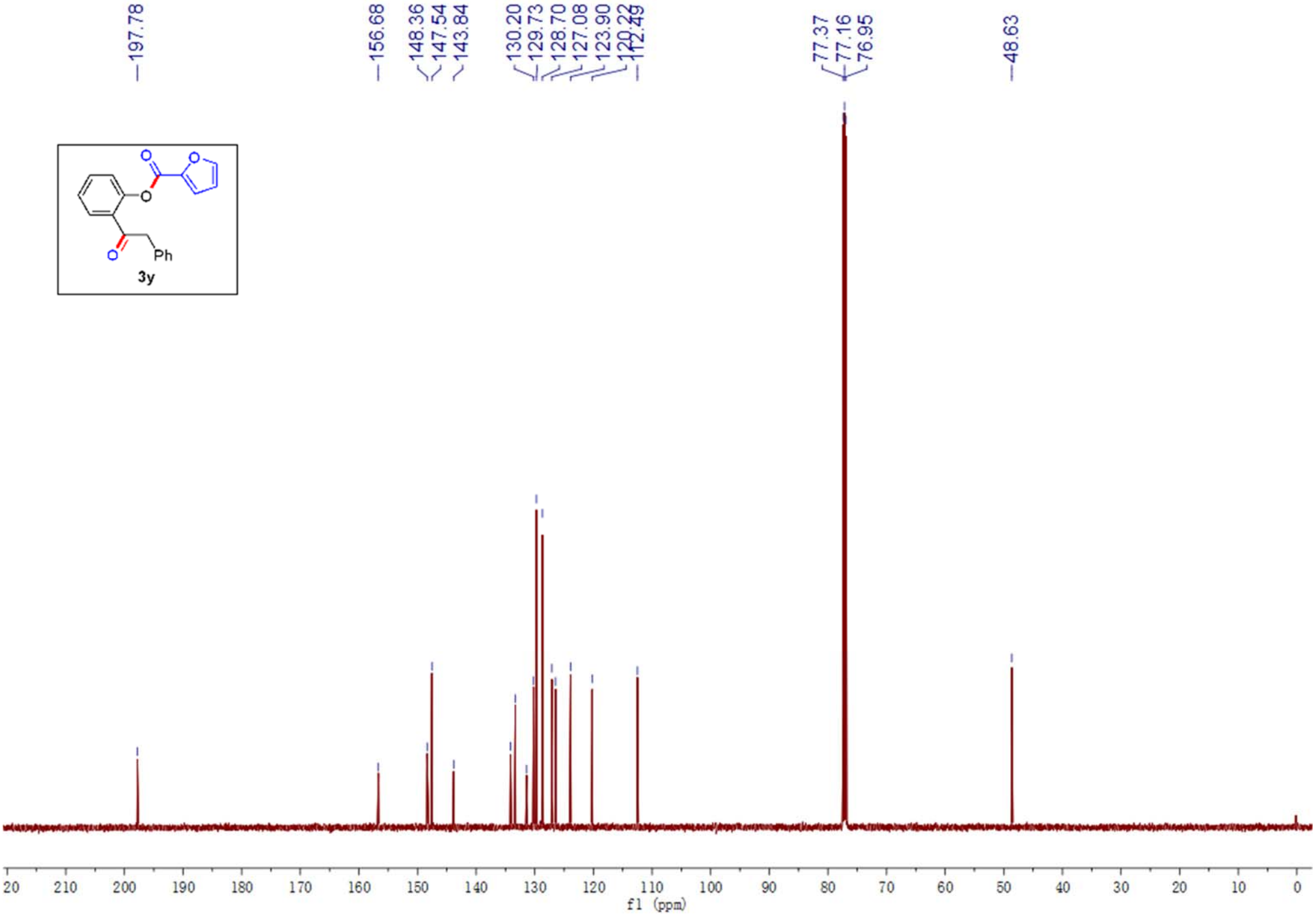
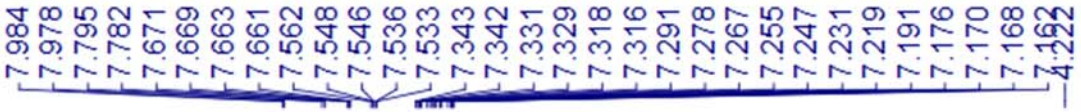
7.391
7.385
7.339
7.288
7.275
7.271
7.255
7.227
7.199
6.594
6.592
6.589
6.586
4.231
Ph
3y
1.00
0.98
1.02
1.01
1.03
6.19
1.00
2.04
f1 (ppm)


197.78
156.68
148.36
147.54
143.84
130.20
129.73
128.70
127.08
123.90
120.22
112.49
77.37
77.16
76.95
48.63
Ph
3y
20
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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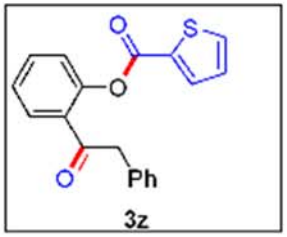
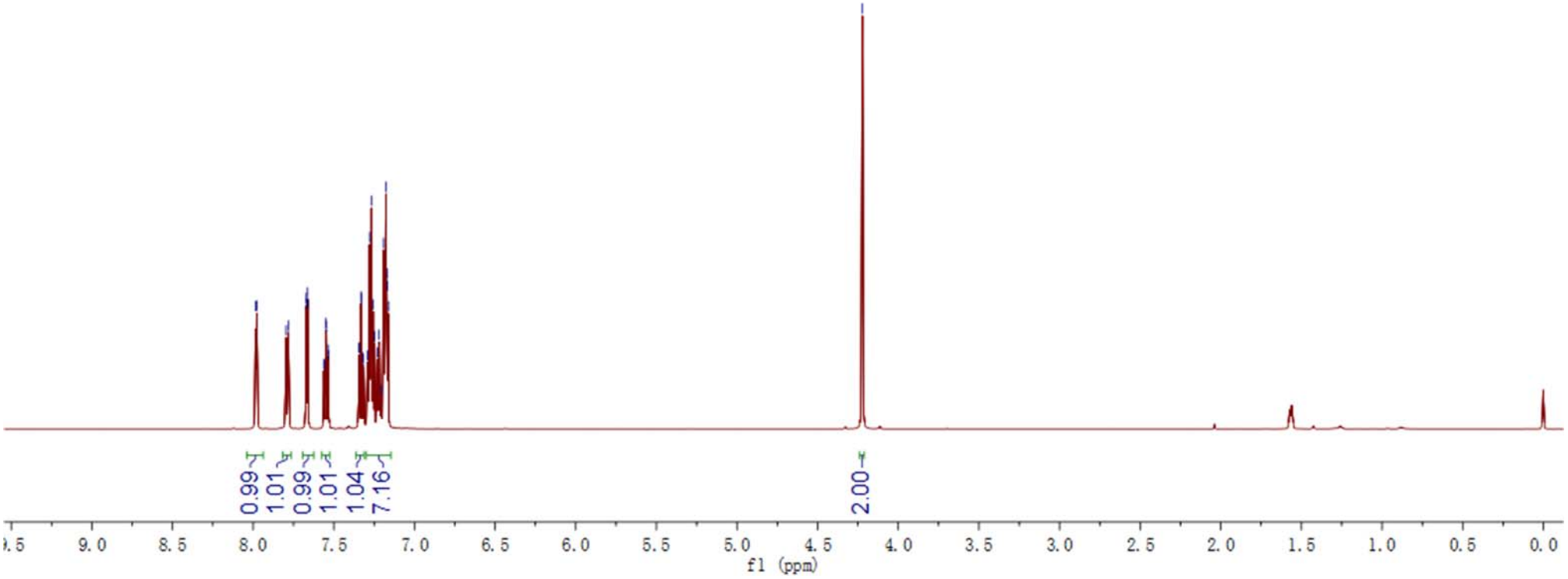
7.669
7.663
7.661
7.562
7.548
7.546
7.536
7.533
7.343
7.342
7.331
7.329
7.318
7.316
7.291
7.278
7.267
7.255
7.247
7.231
7.219
7.191
7.176
7.170
7.168
7.162
4.222


O
S
O
O
Ph

3z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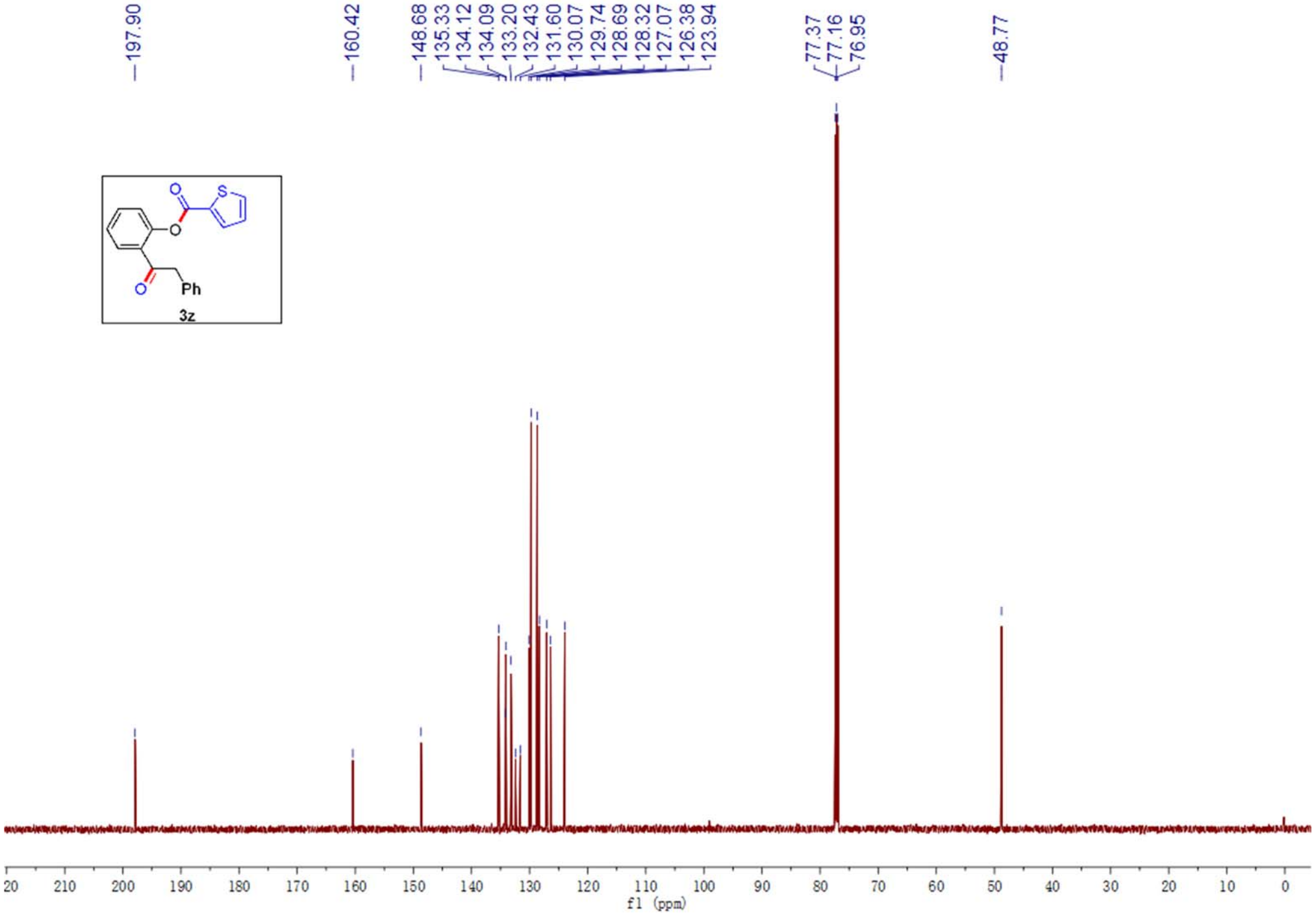
1.01
0.99
1.01
1.04
7.16
2.00
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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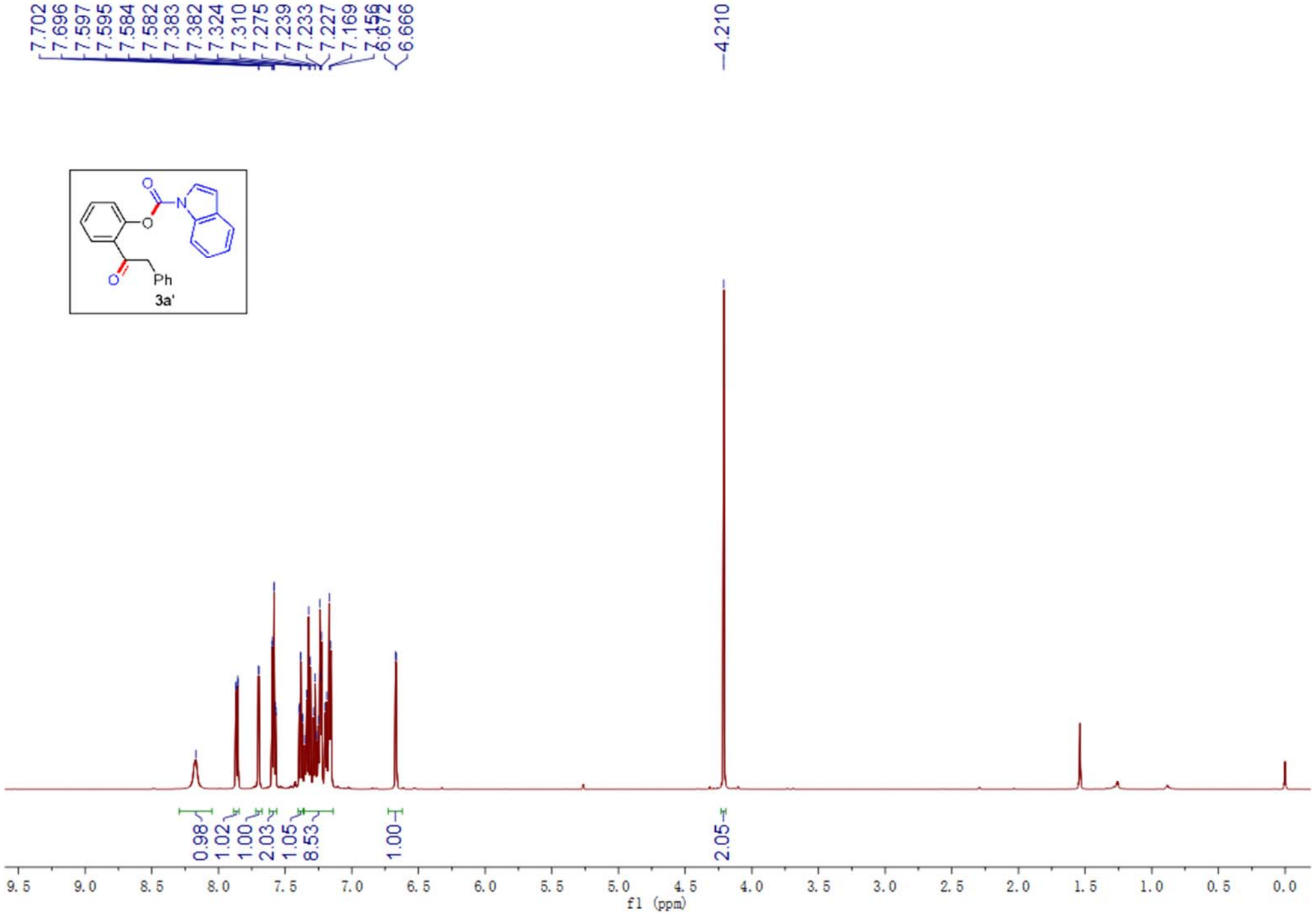
160.42
148.68
135.33
134.12
134.09
133.20
132.43
131.60
130.07
129.74
128.69
128.32
127.07
126.38
123.94
77.37
77.16
76.95
48.77
O
S
O
O
Ph
3z
20
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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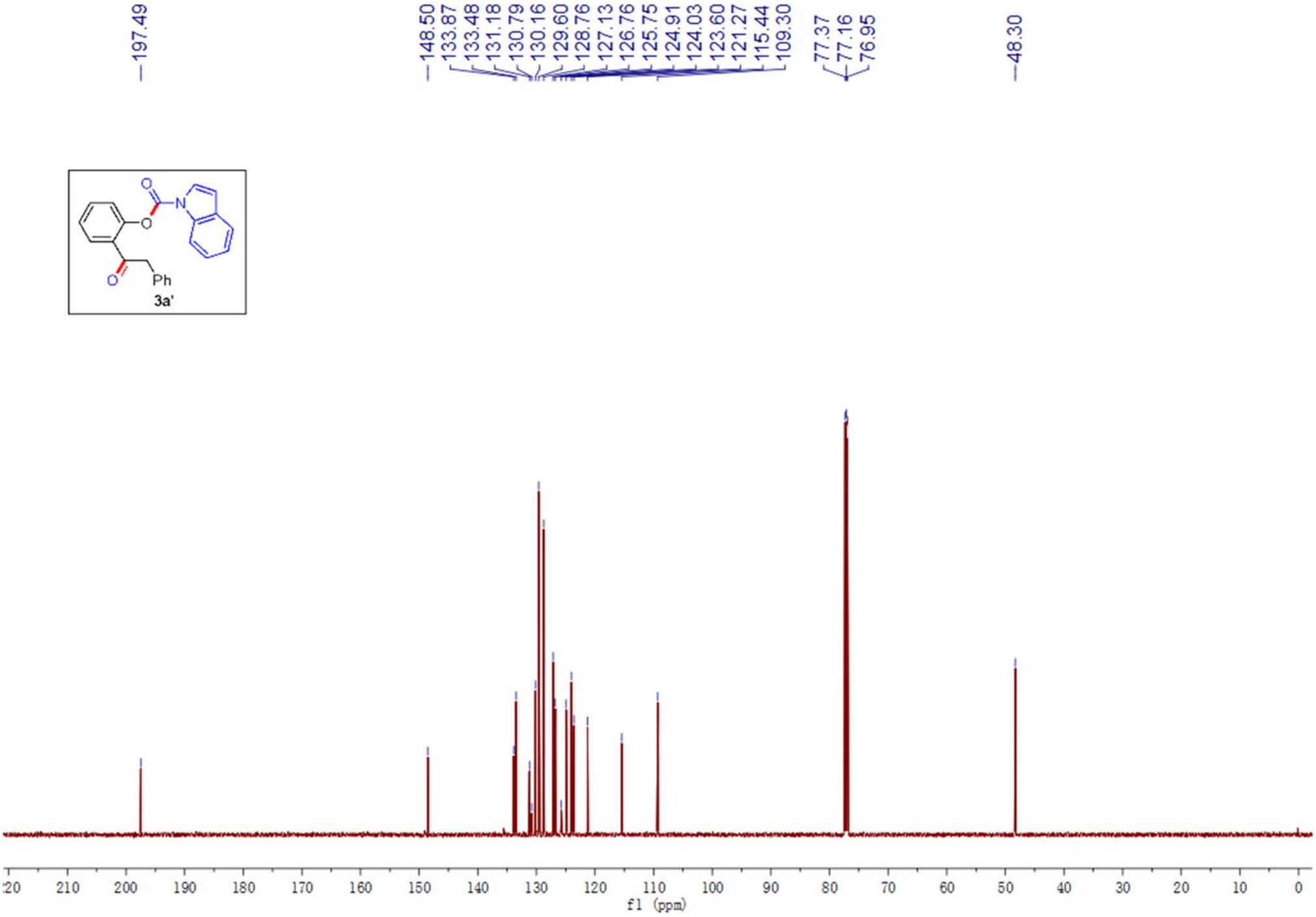
7.696
7.597
7.595
7.584
7.582
7.383
7.382
7.324
7.310
7.275
7.239
7.233
7.227
7.169
7.156
6.672
6.666
4.210
Ph
3a'
0.98
1.02
1.00
2.03
1.05
8.53
1.00
2.05
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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148.50
133.87
133.48
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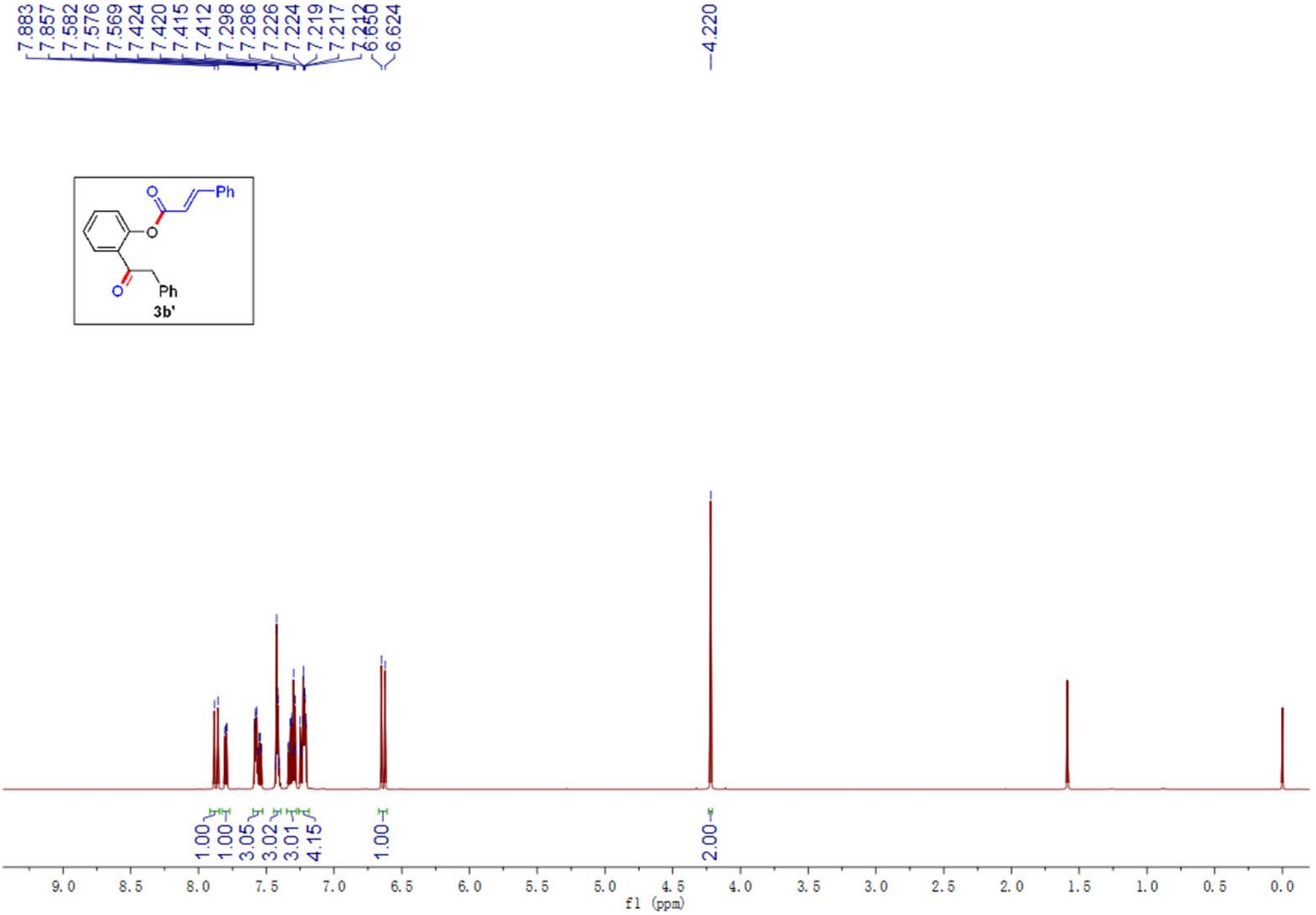
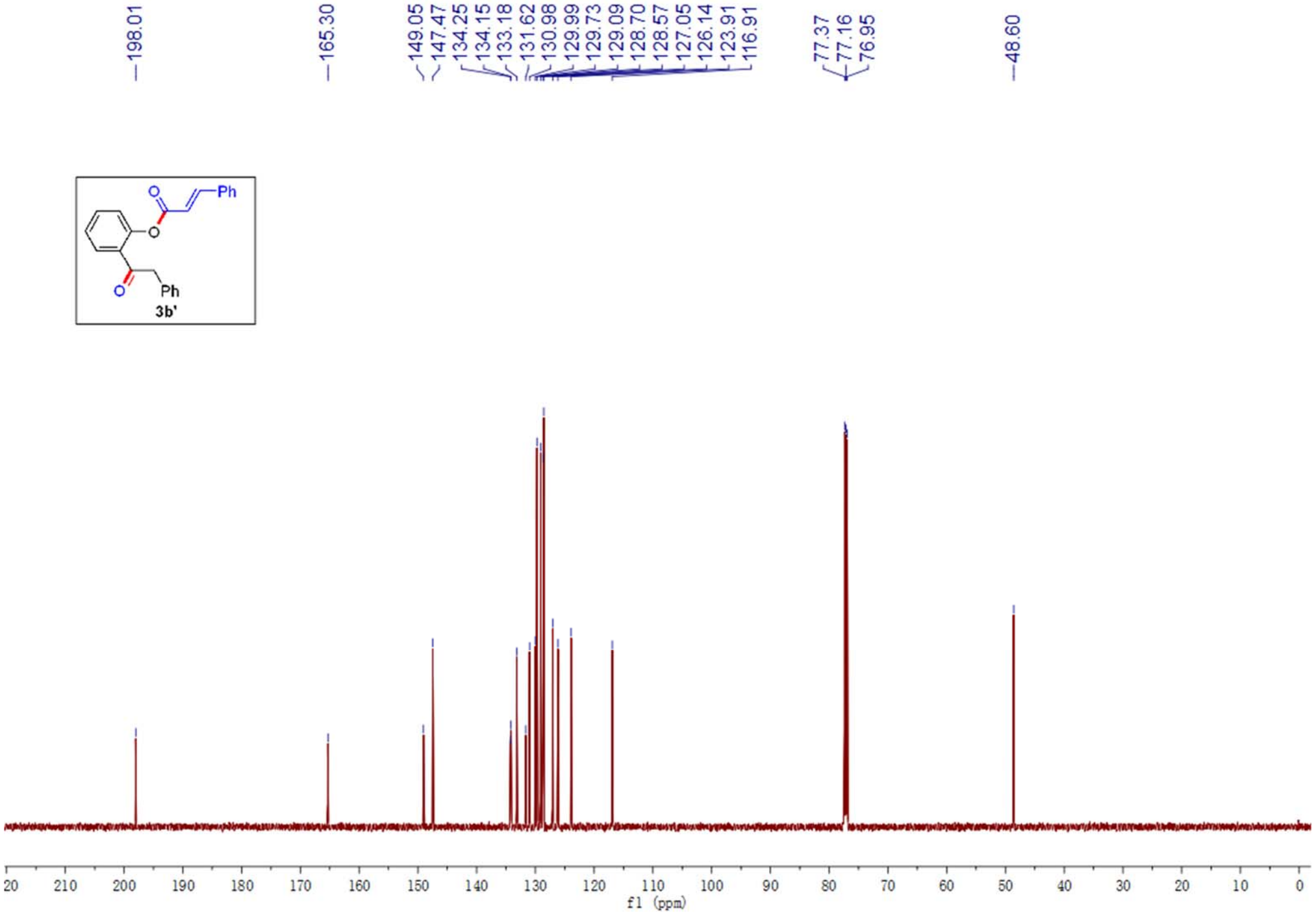
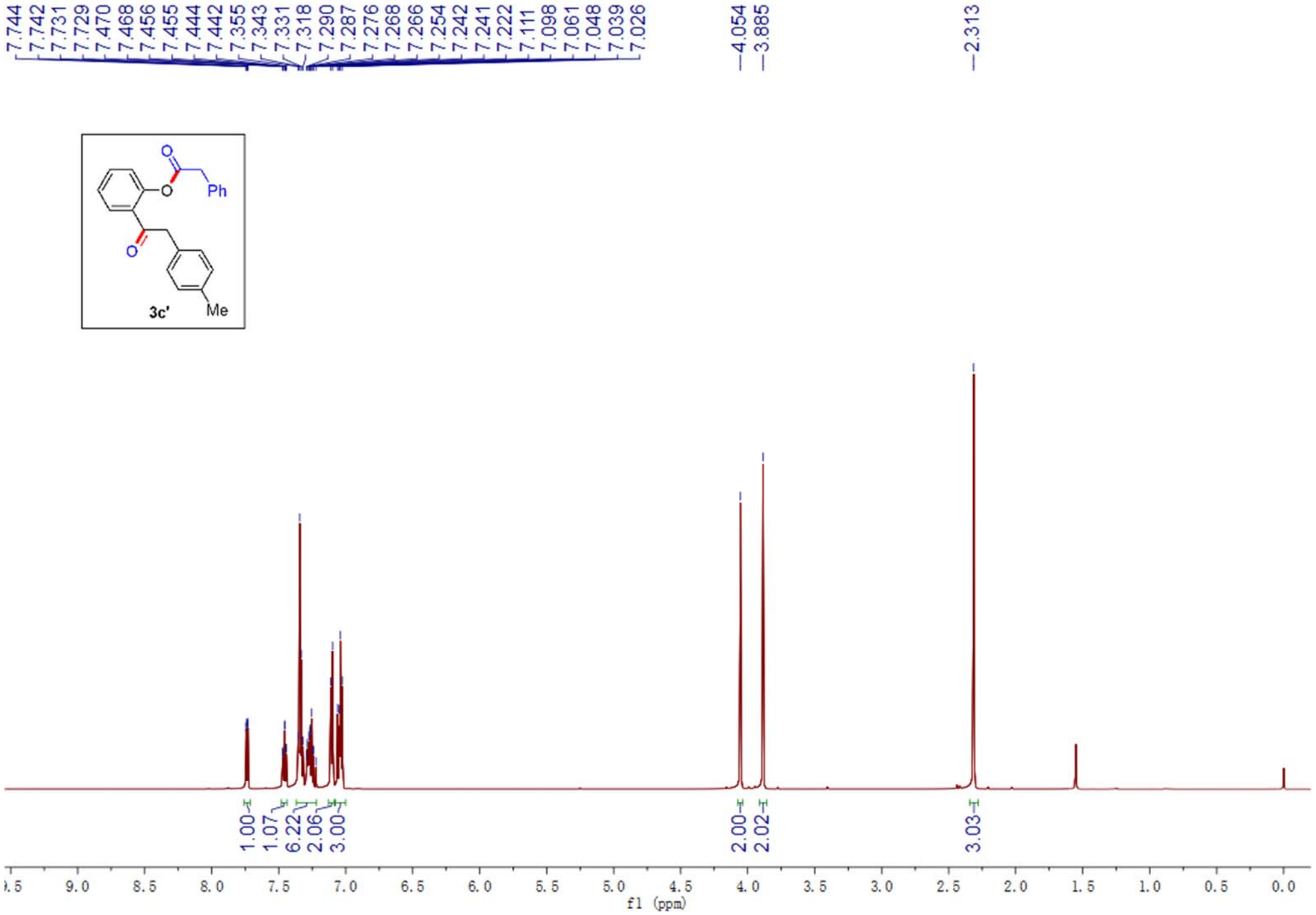
130.79
130.16
129.60
128.76
127.13
126.76
125.75
124.91
124.03
123.60
121.27
115.44
109.30
77.37
77.16
76.95
48.30
O
N
O
O
Ph
3a'
f1 (ppm)


7.883
7.857
7.582
7.576
7.569
7.424
7.420
7.415
7.412
7.298
7.286
7.226
7.224
7.219
7.217
7.212
6.650
6.624
4.220
Ph
Ph
3b'
1.00
1.00
3.05
3.02
3.01
4.15
1.00
2.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


198.01
165.30
149.05
147.47
134.25
134.15
133.18
131.62
130.98
129.99
129.73
129.09
128.70
128.57
127.05
126.14
123.91
116.91
77.37
77.16
76.95
48.60
Ph
O
O
O
Ph
3b'
f1 (ppm)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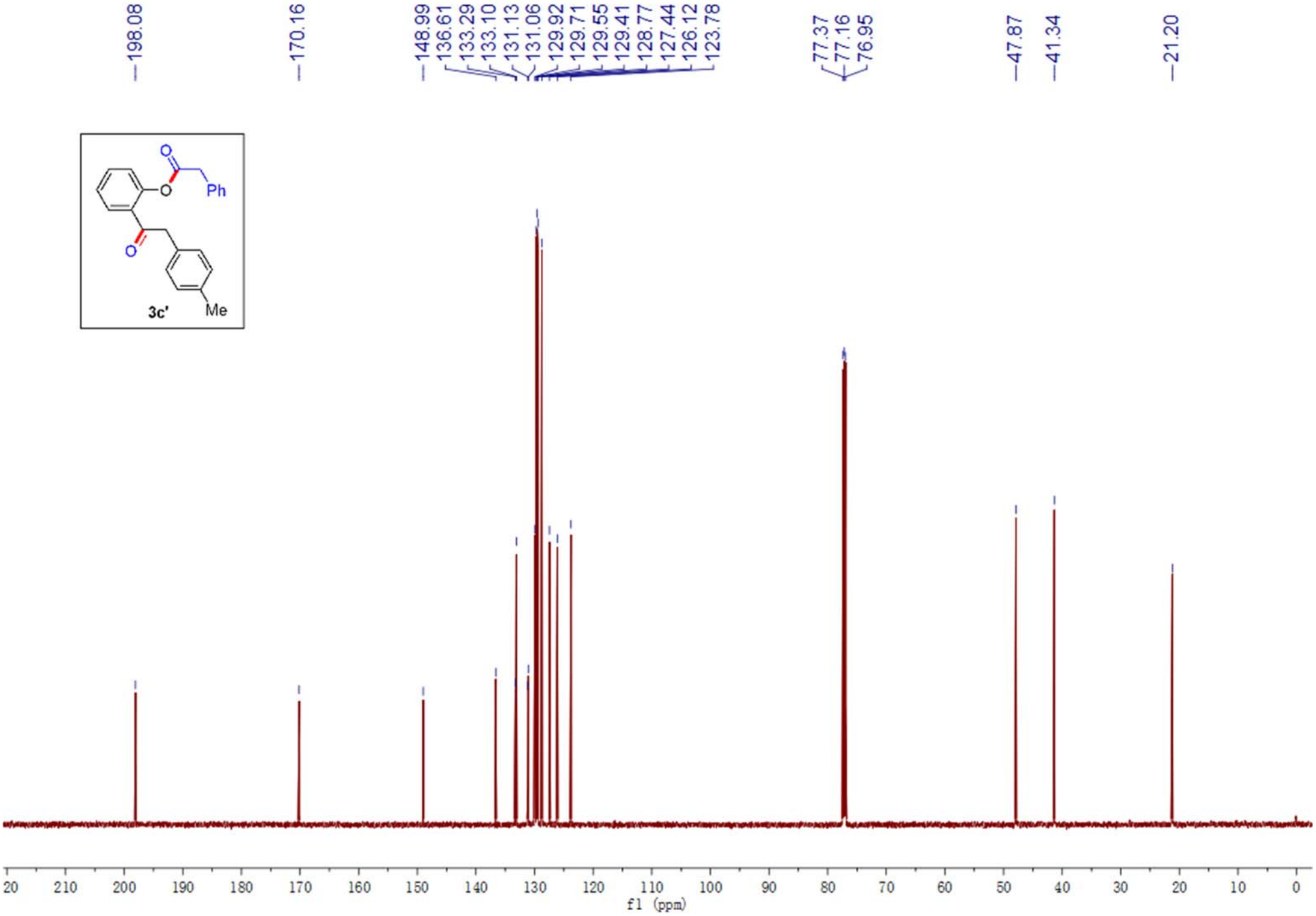
7.742
7.731
7.729
7.470
7.468
7.456
7.455
7.444
7.442
7.355
7.343
7.331
7.318
7.290
7.287
7.276
7.268
7.266
7.254
7.242
7.241
7.222
7.111
7.098
7.061
7.048
7.039
7.026
4.054
3.885
2.313
Ph
O
O
3c'
Me
1.00
1.07
6.22
2.06
3.00
2.00
2.02
3.03
f1 (ppm)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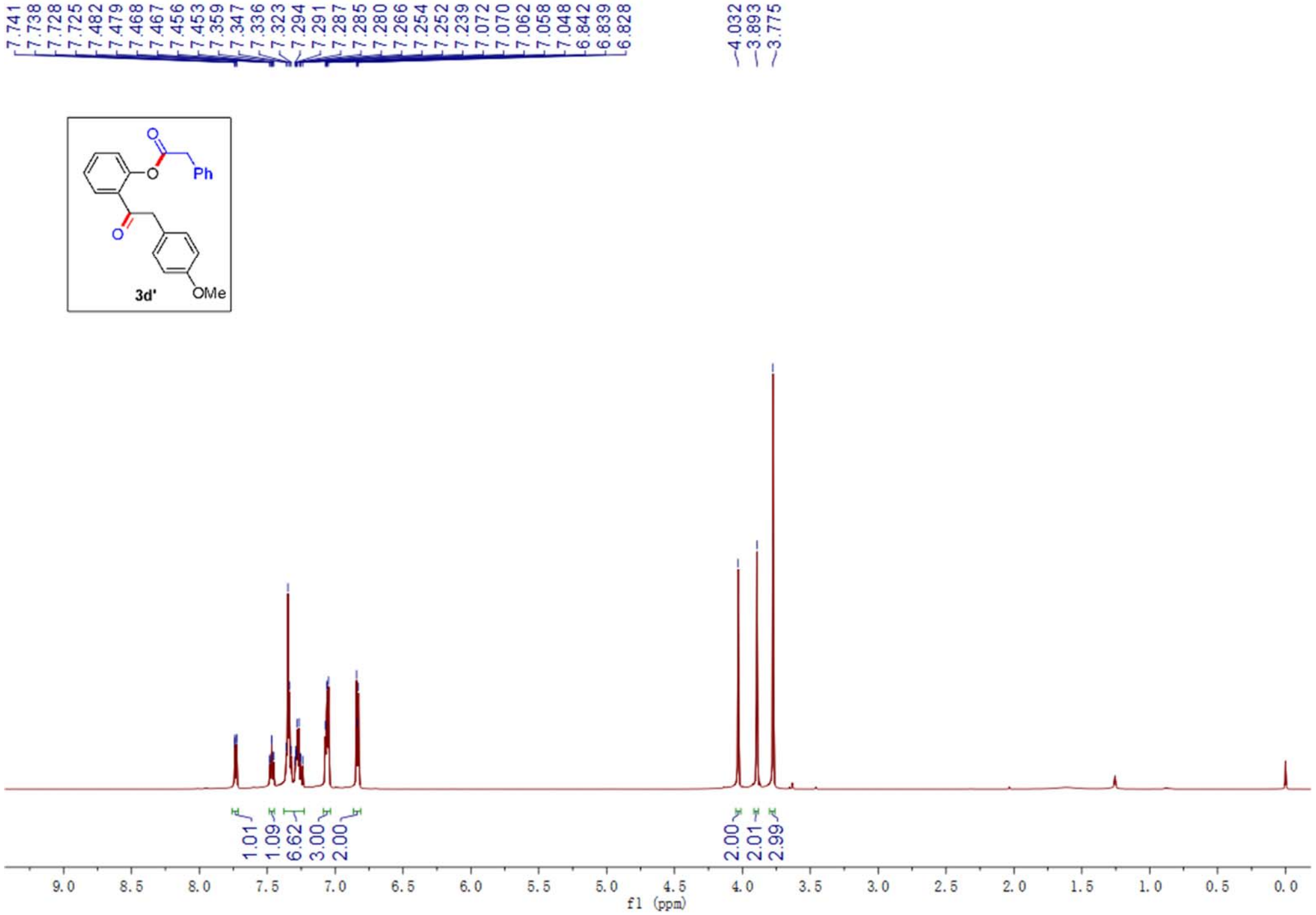
170.16
148.99
136.61
133.29
133.10
131.13
131.06
129.92
129.71
129.55
129.41
128.77
127.44
126.12
123.78
77.37
77.16
76.95
47.87
41.34
21.20
O
O
Ph
O
3c'
Me
20
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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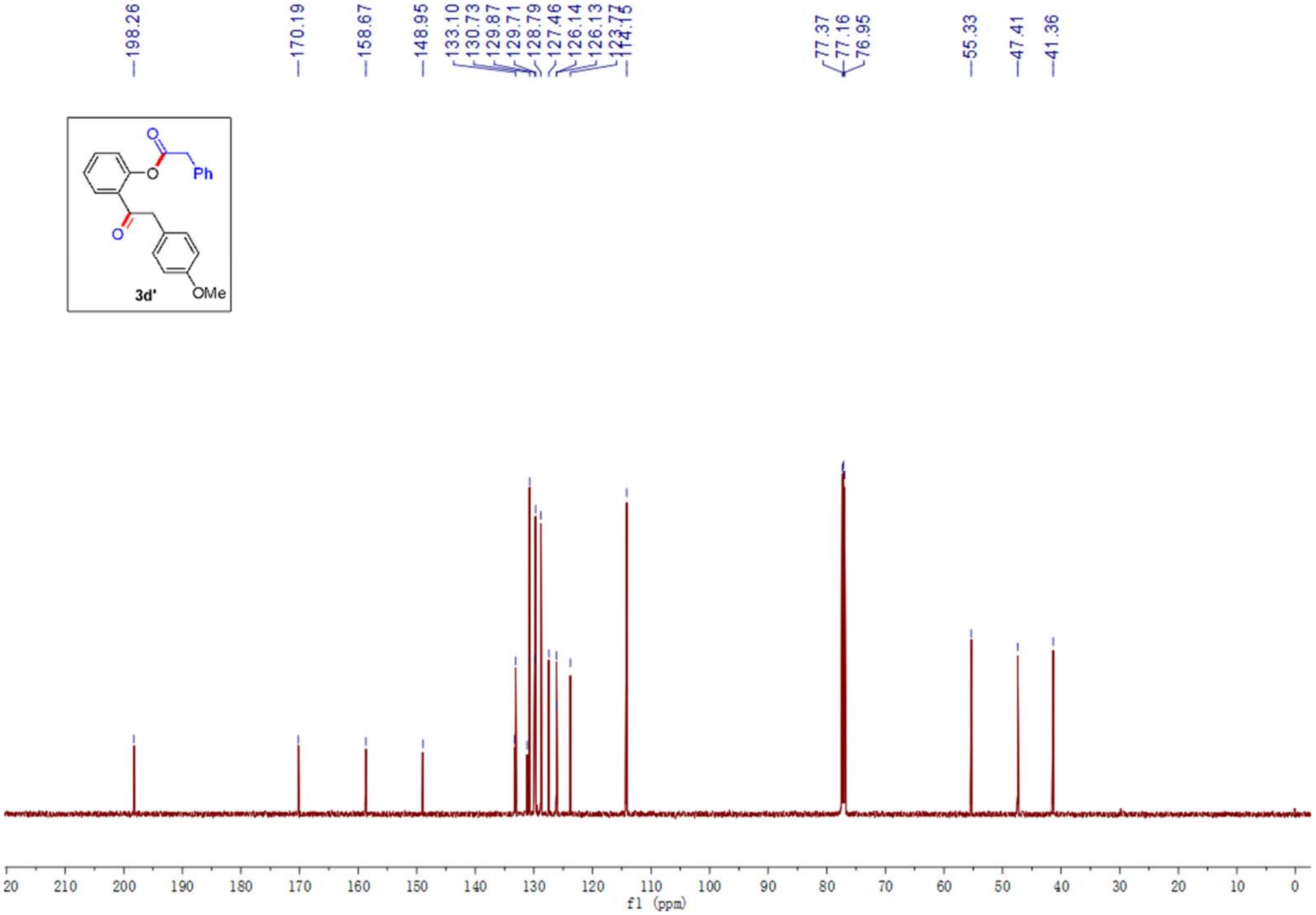
7.738
7.728
7.725
7.482
7.479
7.468
7.467
7.456
7.453
7.359
7.347
7.336
7.323
7.294
7.291
7.287
7.285
7.280
7.266
7.254
7.252
7.239
7.072
7.070
7.062
7.058
7.048
6.842
6.839
6.828
4.032
3.893
3.775
Ph
OMe
3d'
1.01
1.09
6.62
3.00
2.00
2.00
2.01
2.99
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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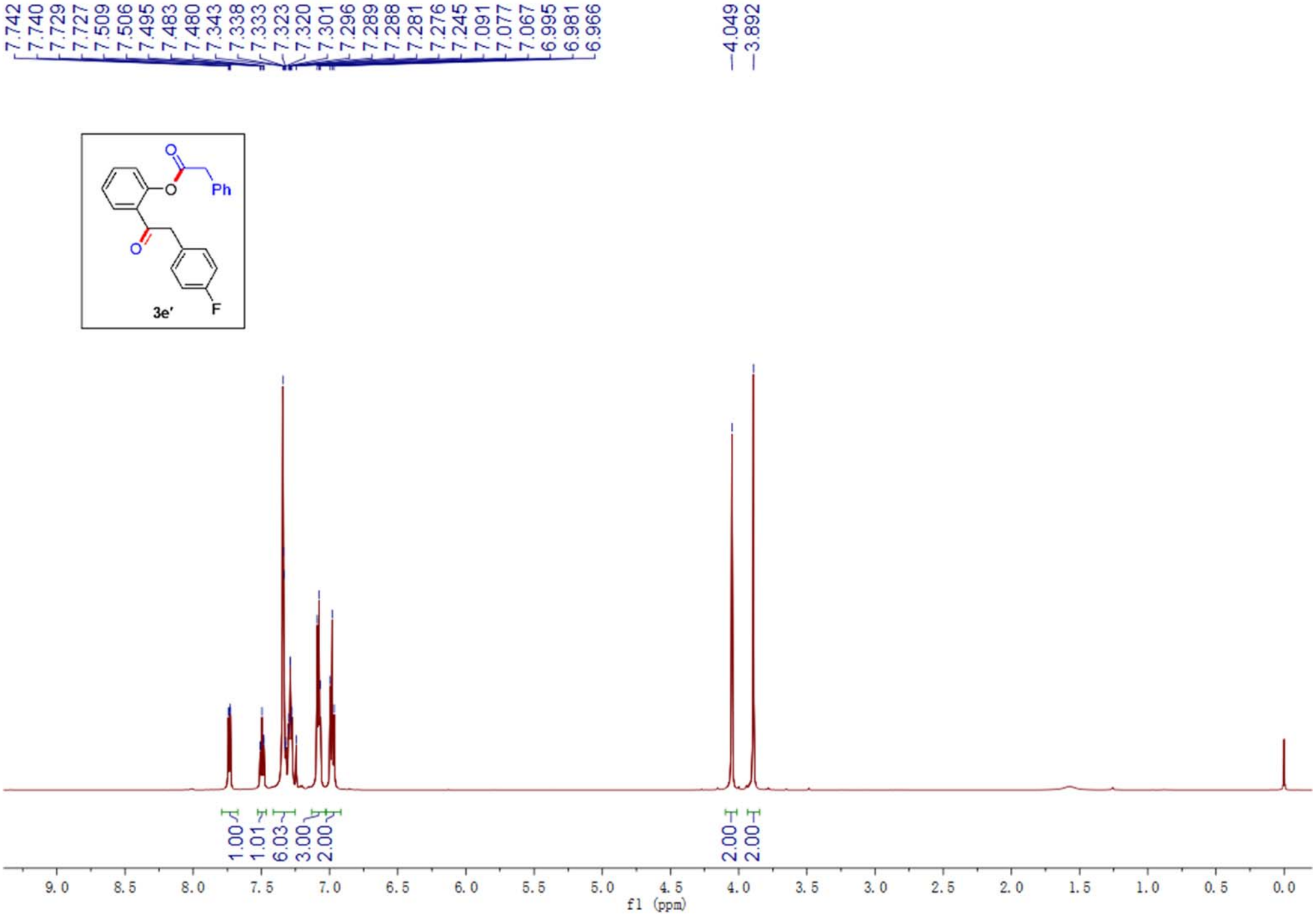
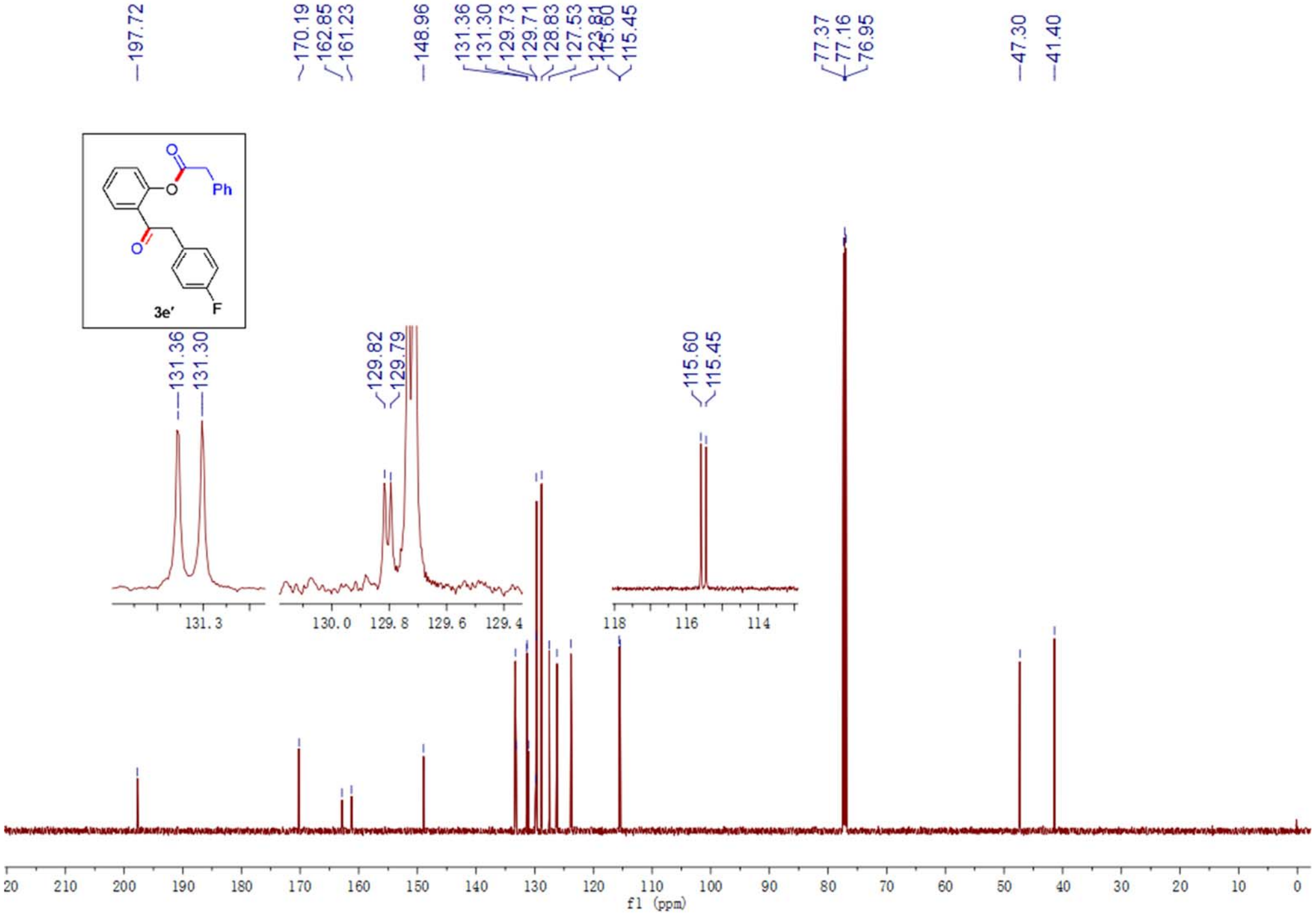
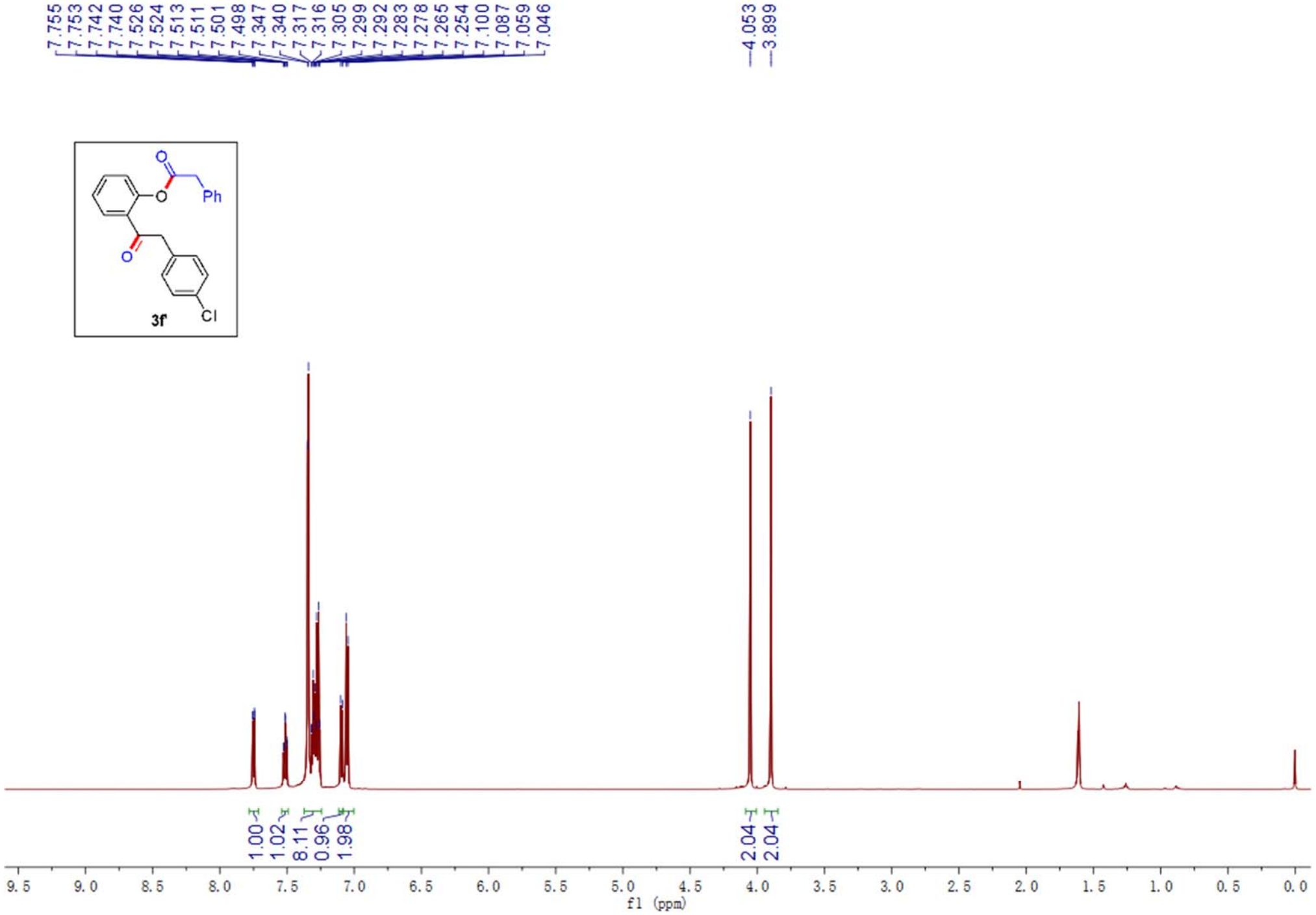
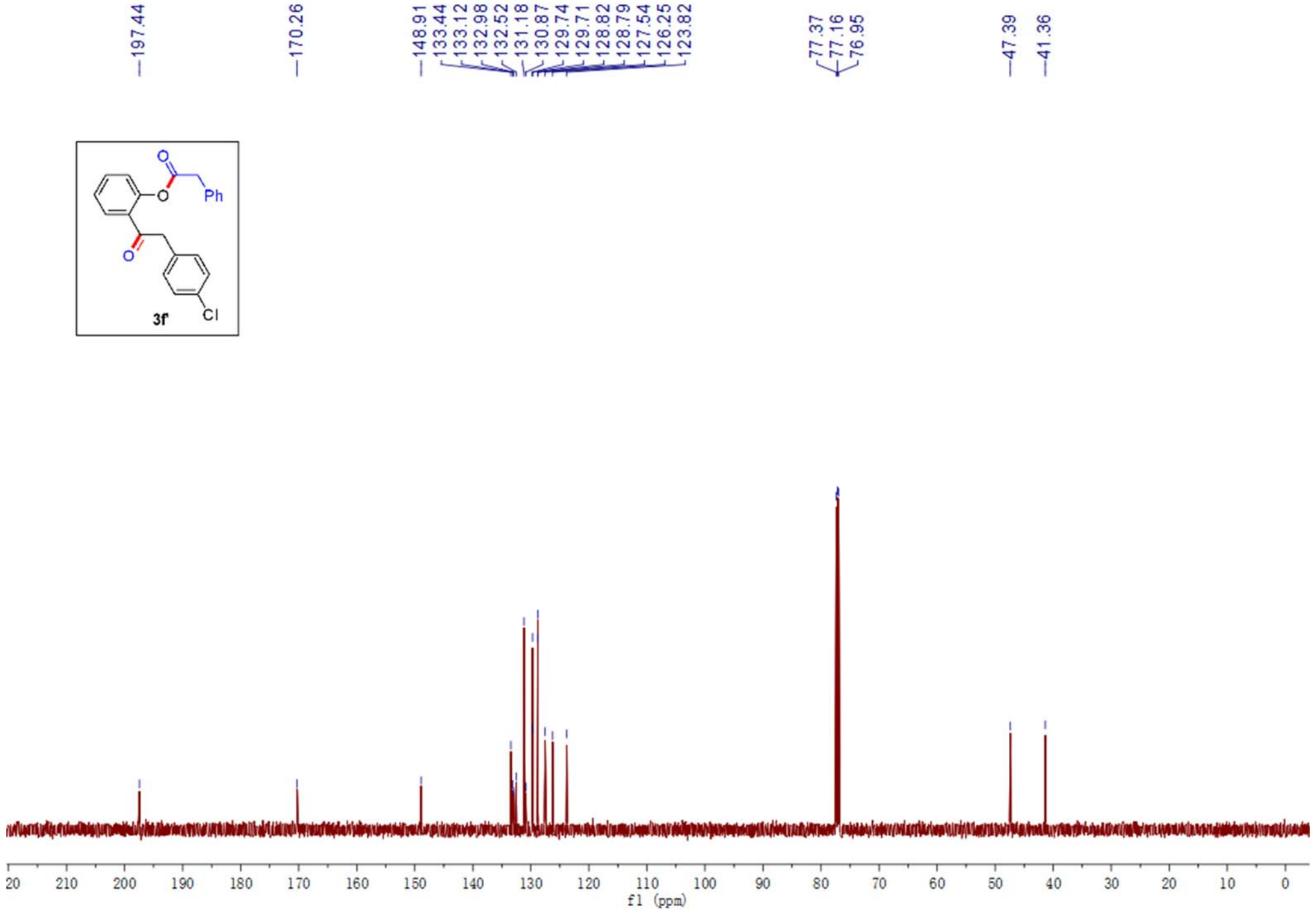
158.67
148.95
133.10
130.73
129.87
129.71
128.79
127.46
126.14
126.13
77.37
77.16
76.95
55.33
47.41
41.36
Ph
OMe
3d'
f1 (ppm)


7.742
7.740
7.729
7.727
7.509
7.506
7.495
7.483
7.480
7.343
7.338
7.333
7.323
7.320
7.301
7.296
7.289
7.288
7.281
7.276
7.245
7.091
7.077
7.067
6.995
6.981
6.966
4.049
3.892
Ph
O
O
3e'
F
1.00
1.01
6.03
3.00
2.00
2.00
2.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


197.72
170.19
162.85
161.23
148.96
131.36
131.30
129.73
129.71
128.83
127.53
123.81
115.60
115.45
77.37
77.16
76.95
47.30
41.40
Ph
O
O
3e'
F
131.36
131.30
129.82
129.79
115.60
115.45
131.3
130.0
129.8
129.6
129.4
118
116
114
f1 (ppm)


7.755
7.753
7.742
7.740
7.526
7.524
7.513
7.511
7.501
7.498
7.347
7.340
7.317
7.316
7.305
7.299
7.292
7.283
7.278
7.265
7.254
7.100
7.087
7.059
7.046
4.053
3.899
O
O
Ph
O
3f
Cl
1.00
1.02
8.11
0.96
1.98
2.04
2.04
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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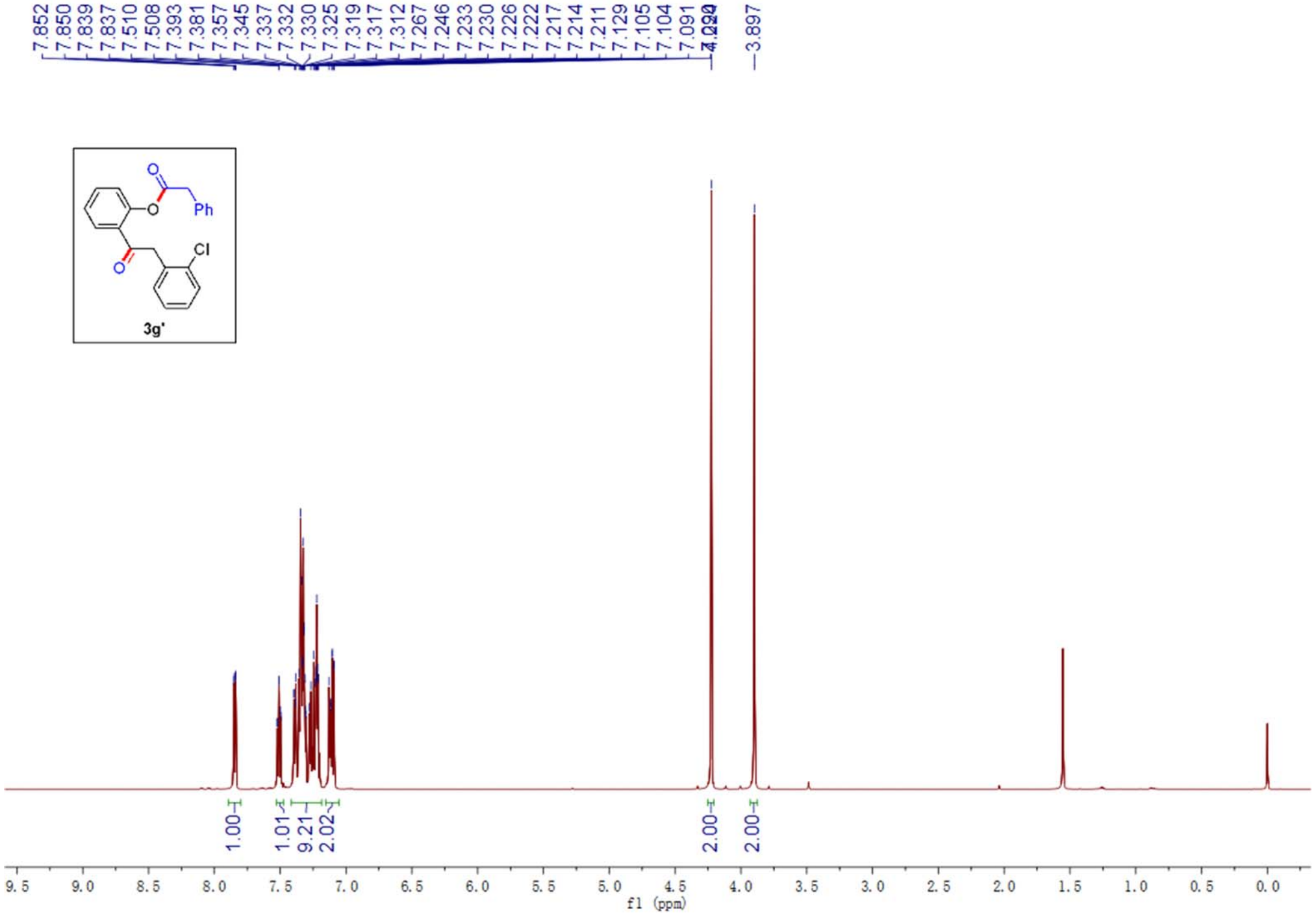
132.98
132.52
131.18
130.87
129.74
129.71
128.82
128.79
127.54
126.25
123.82
77.37
77.16
76.95
47.39
41.36
O
O
Ph
O
Cl
3f
20
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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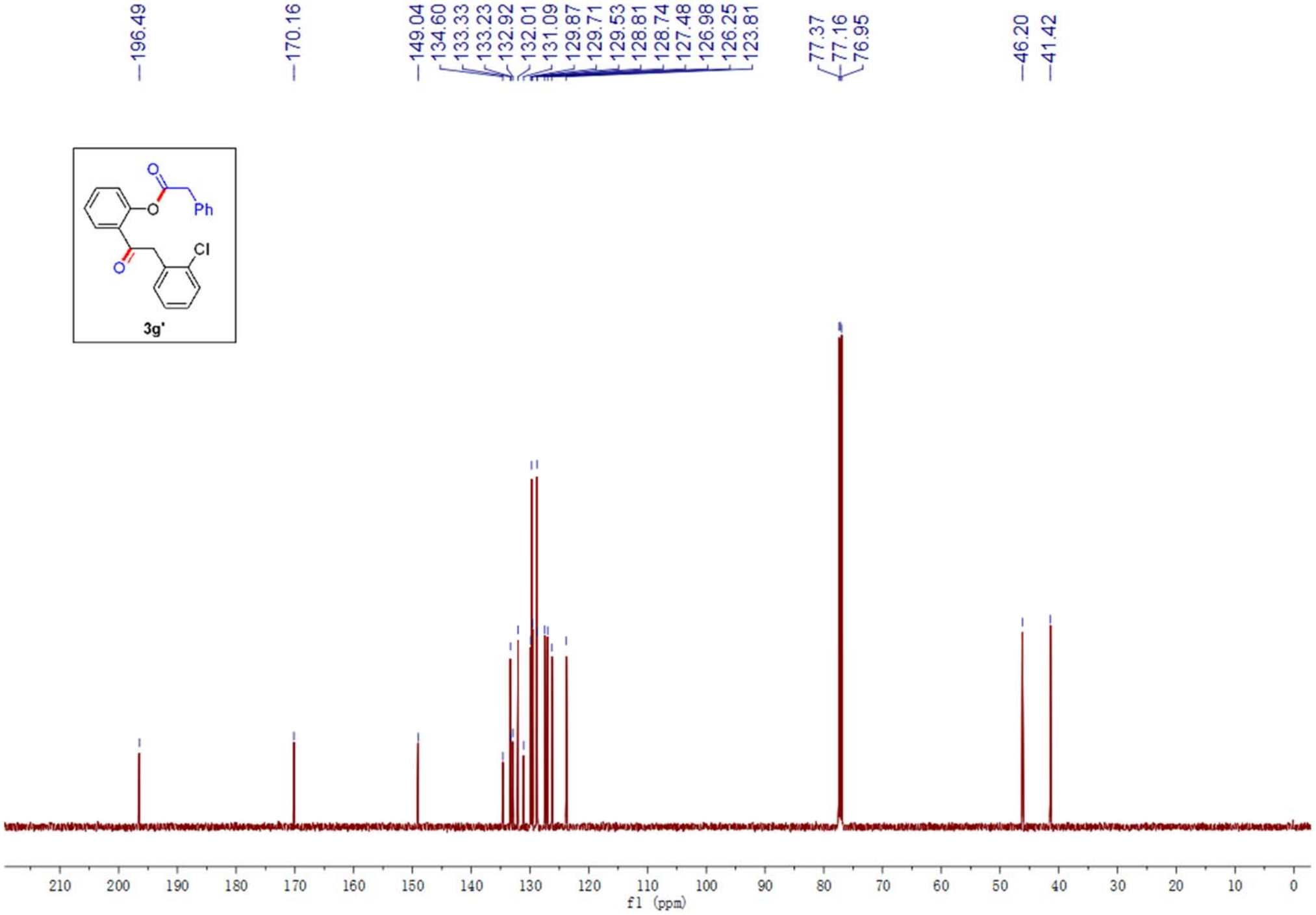
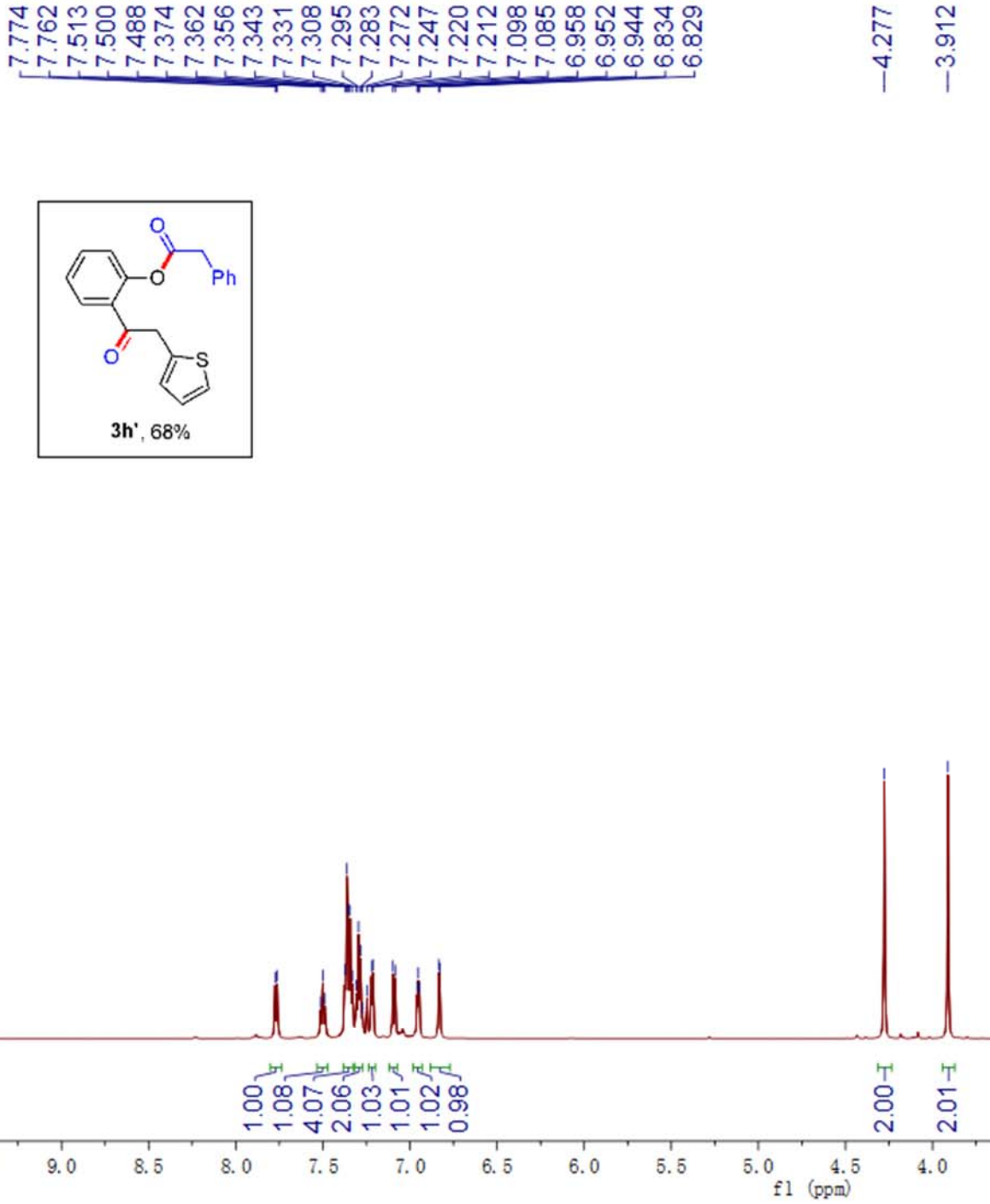
7.510
7.508
7.393
7.381
7.357
7.345
7.337
7.332
7.330
7.325
7.319
7.317
7.312
7.267
7.246
7.233
7.230
7.226
7.222
7.217
7.214
7.211
7.129
7.105
7.104
7.091
3.897
O
O
Ph
Cl
O
3g'
1.00
1.01
9.21
2.02
2.00
2.00
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


196.49
170.16
149.04
134.60
133.33
133.23
132.92
132.01
131.09
129.87
129.71
129.53
128.81
128.74
127.48
126.98
126.25
123.81
77.37
77.16
76.95
46.20
41.42
O
O
Ph
O
Cl
3g'
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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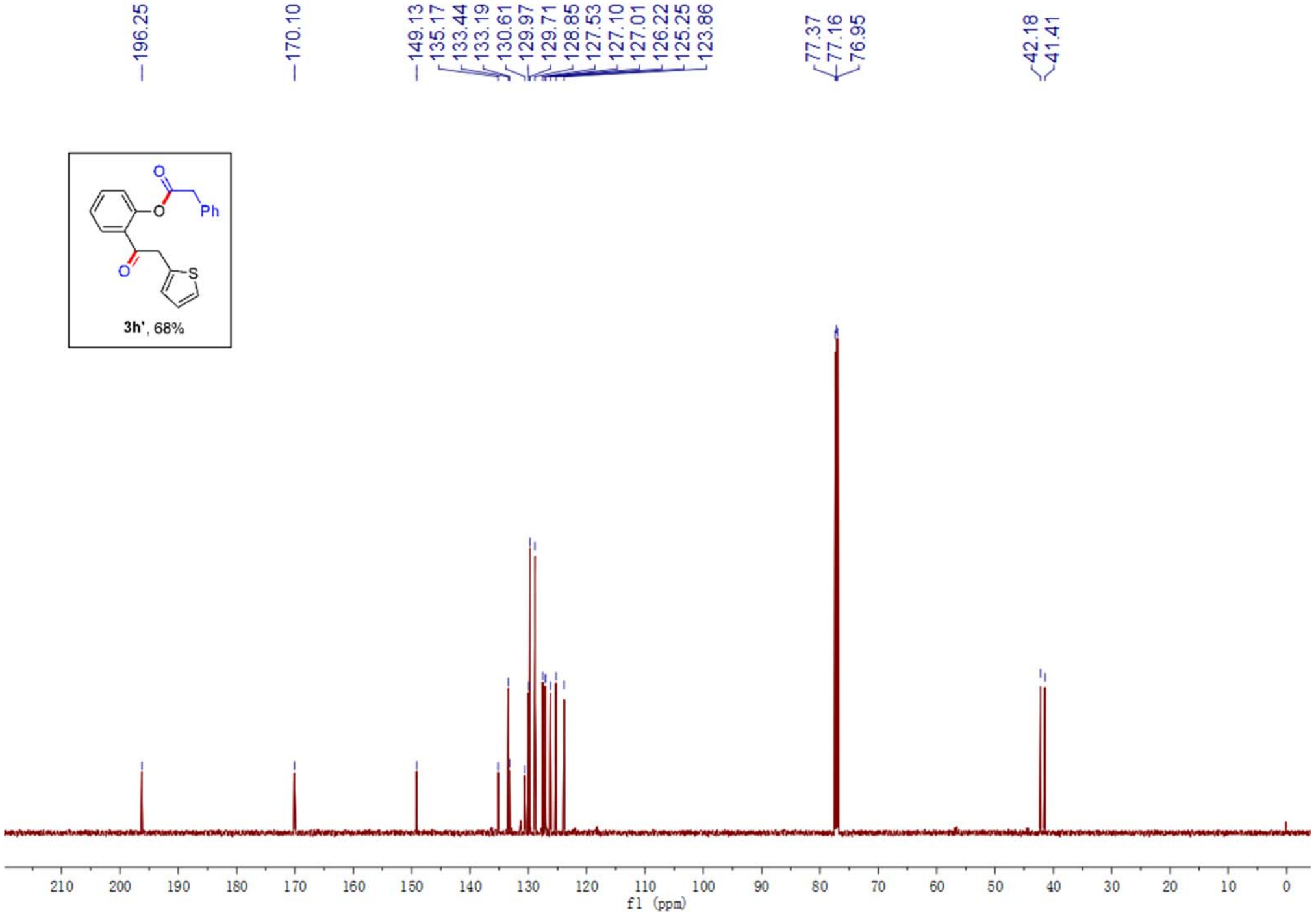
7.500
7.488
7.374
7.362
7.356
7.343
7.331
7.308
7.295
7.283
7.272
7.247
7.220
7.212
7.098
7.085
6.958
6.952
6.944
6.834
6.829
4.277
3.912
O
O
Ph
O
S
3h', 68%
1.00
1.08
4.07
2.06
1.03
1.01
1.02
0.98
2.00
2.01
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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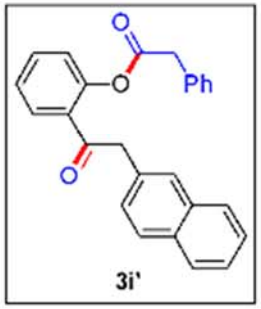
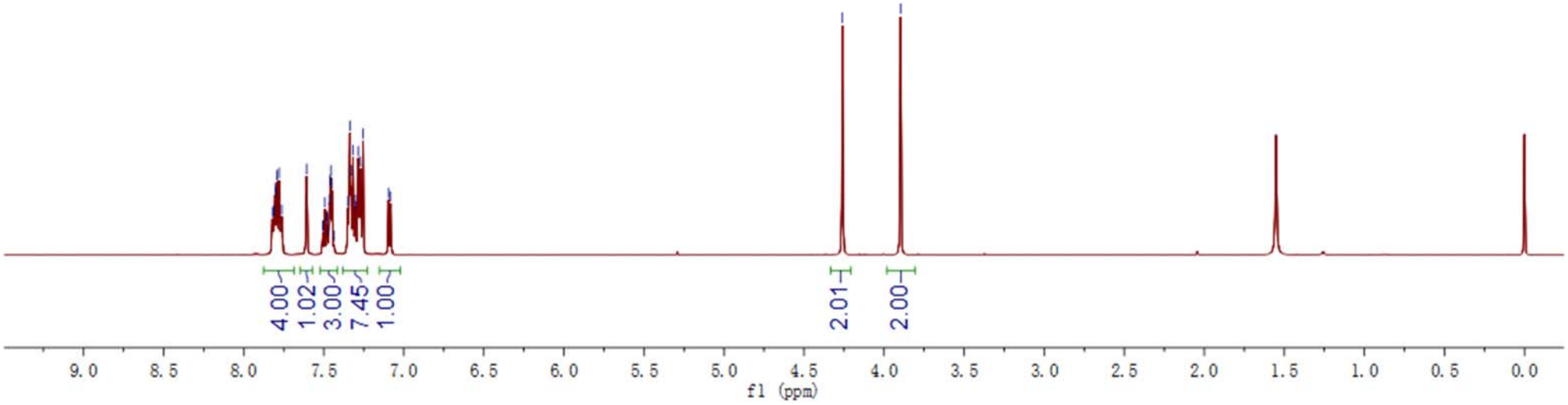
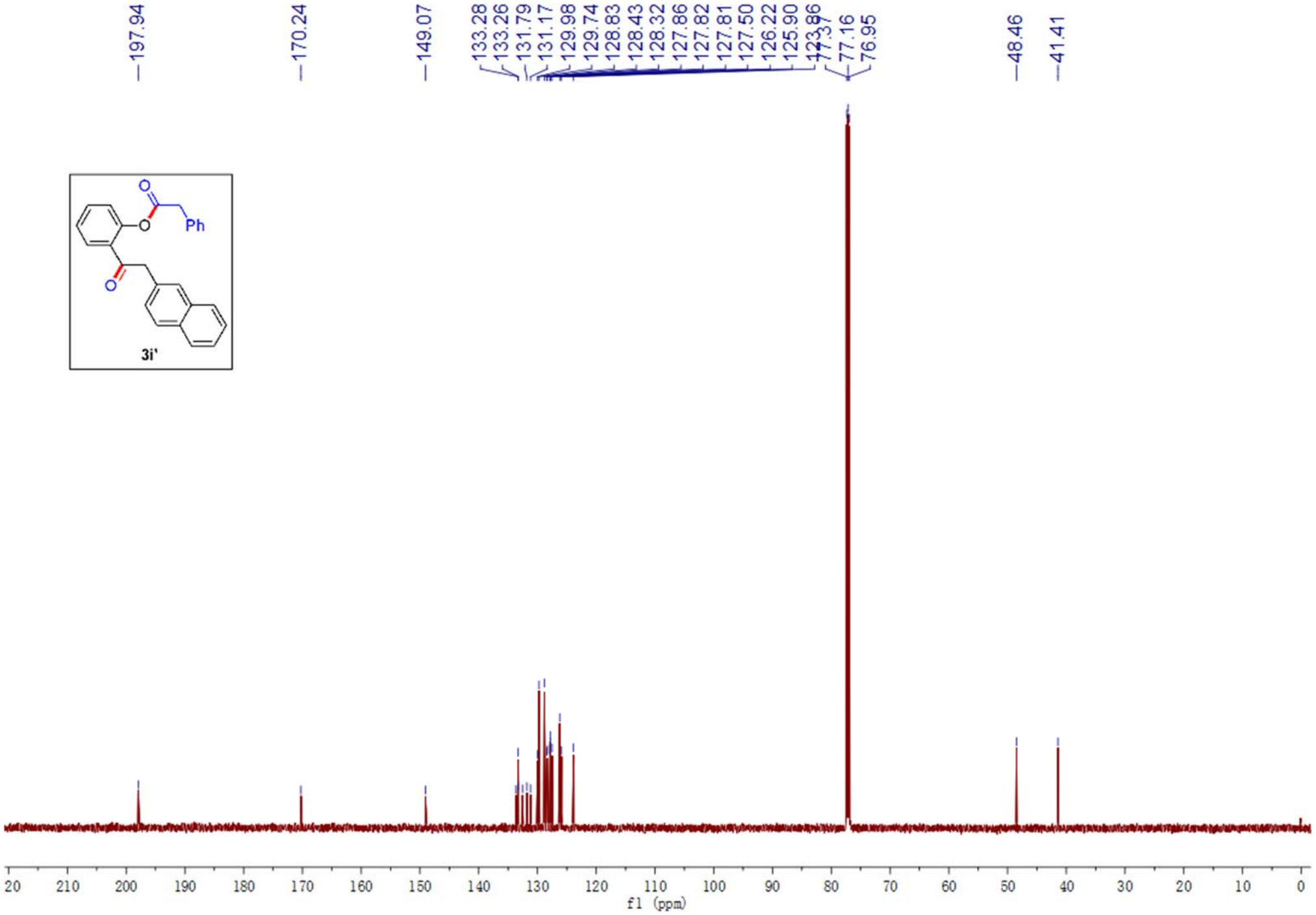
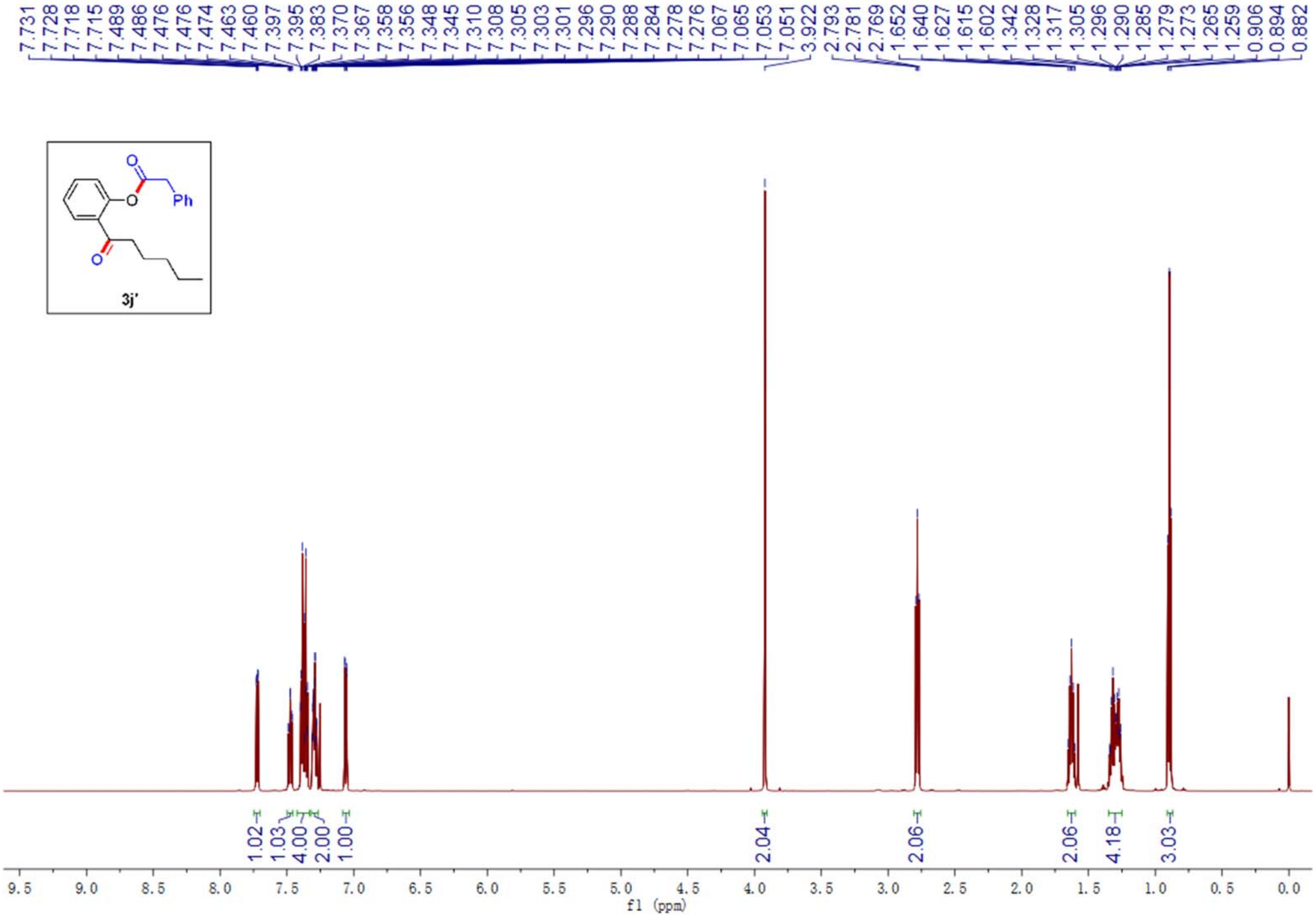
170.10
149.13
135.17
133.44
133.19
130.61
129.97
129.71
128.85
127.53
127.10
127.01
126.22
125.25
123.86
77.37
77.16
76.95
42.18
41.41
O
O
Ph
O
S
3h', 68%
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.821
7.810
7.803
7.801
7.793
7.779
7.761
7.607
7.506
7.504
7.493
7.480
7.478
7.473
7.464
7.461
7.455
7.449
7.437
7.348
7.337
7.329
7.317
7.304
7.300
7.285
7.270
7.254
7.096
7.082
4.260
3.897


O
O
Ph
O
3i'


4.00
1.02
3.00
7.45
1.00
2.01
2.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


197.94
170.24
149.07
133.28
133.26
131.79
131.17
129.98
129.74
128.83
128.43
128.32
127.86
127.82
127.81
127.50
126.22
125.90
123.86
77.37
77.16
76.95
48.46
41.41
Ph
3i'
20
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.718
7.715
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7.486
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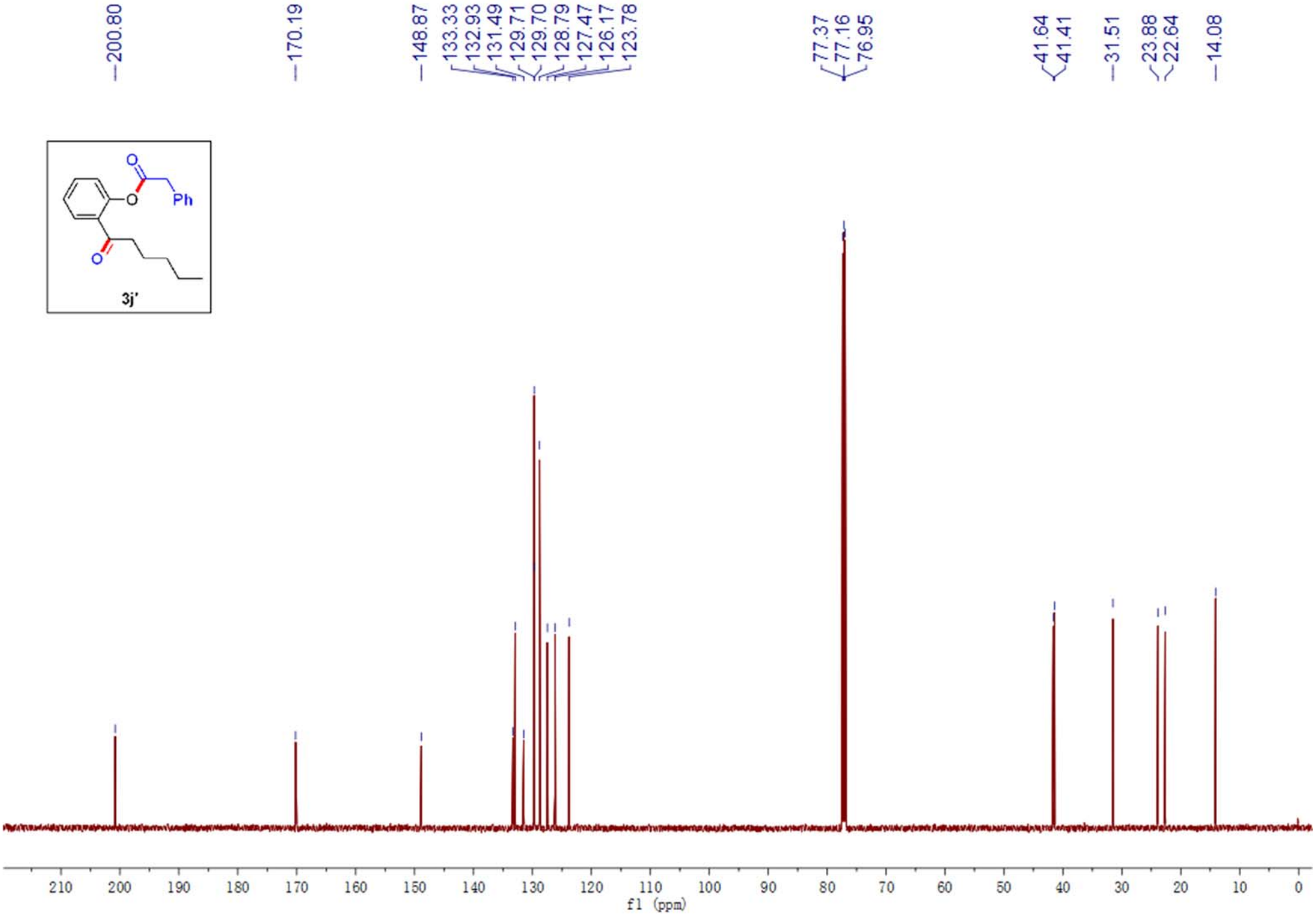
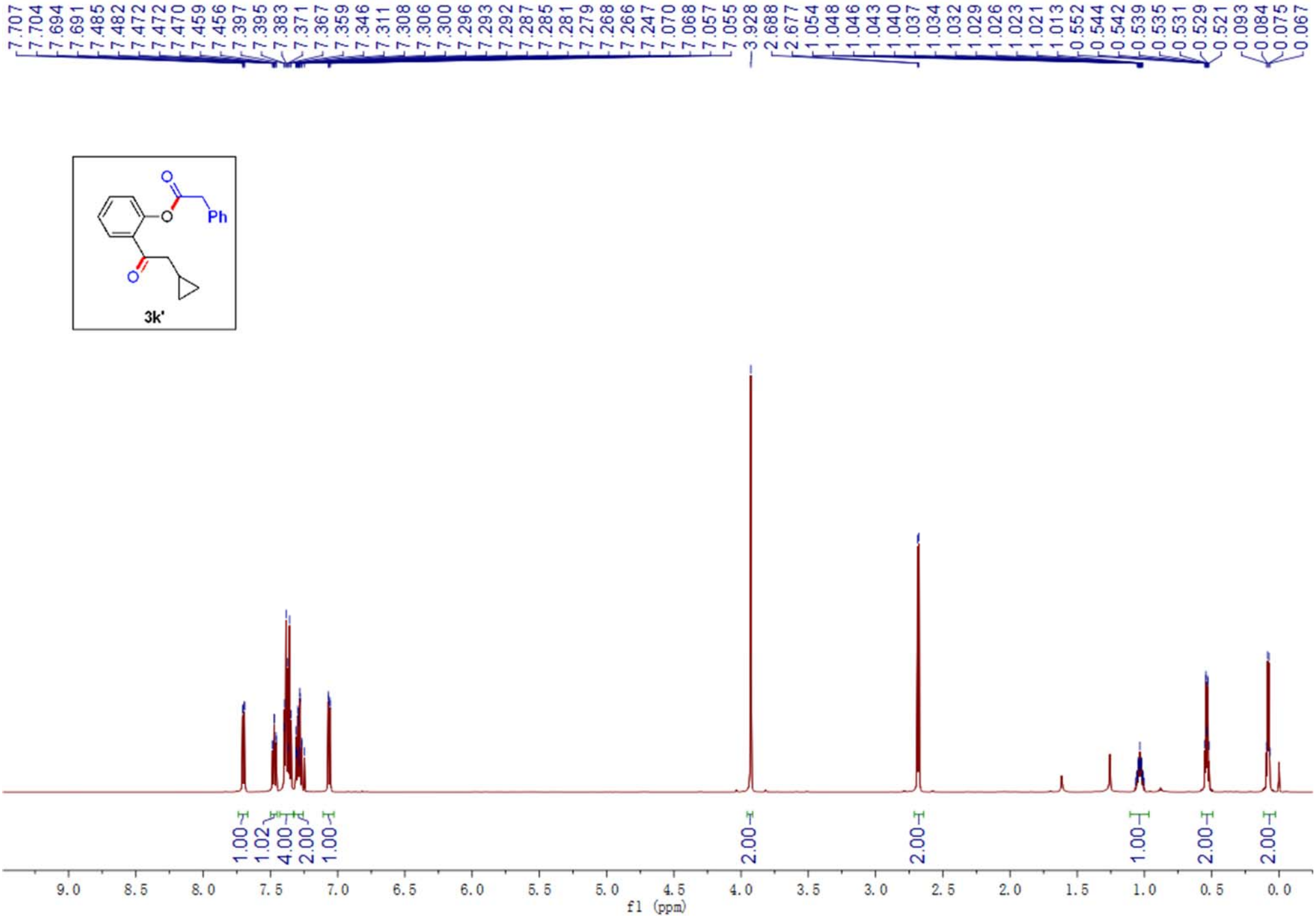
7.476
7.474
7.463
7.460
7.397
7.395
7.383
7.370
7.367
7.358
7.356
7.348
7.345
7.310
7.308
7.305
7.303
7.301
7.296
7.290
7.288
7.284
7.278
7.276
7.067
7.065
7.053
7.051
3.922
2.793
2.781
2.769
1.652
1.640
1.627
1.615
1.602
1.342
1.328
1.317
1.305
1.296
1.290
1.285
1.279
1.273
1.265
1.259
0.906
0.894
0.882
O
O
Ph
O
3j'
1.02
1.03
4.00
2.00
1.00
2.04
2.06
2.06
4.18
3.03
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


200.80
170.19
148.87
133.33
132.93
131.49
129.71
129.70
128.79
127.47
126.17
123.78
77.37
77.16
76.95
41.64
41.41
31.51
23.88
22.64
14.08
O
O
O
Ph
3j'
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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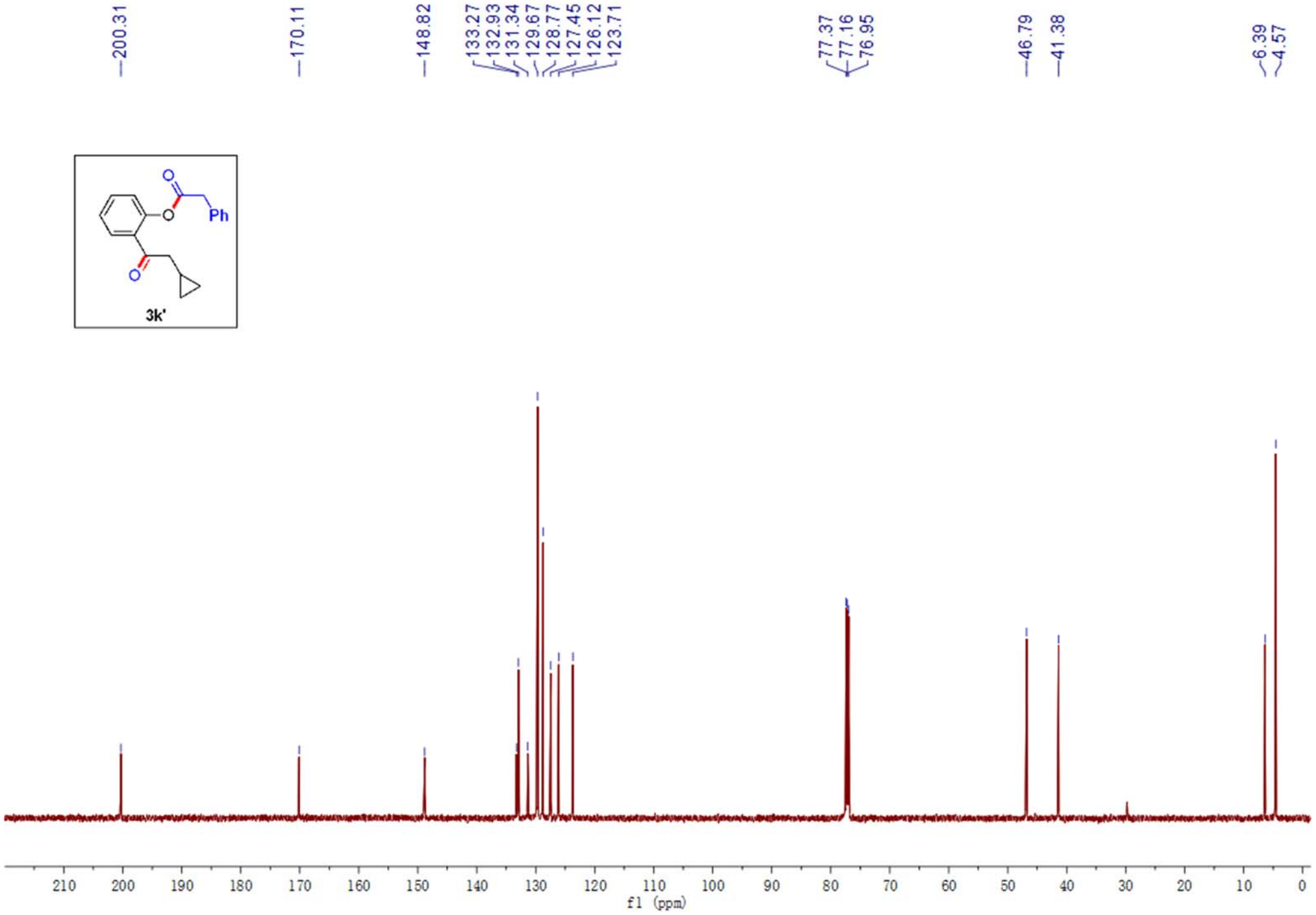
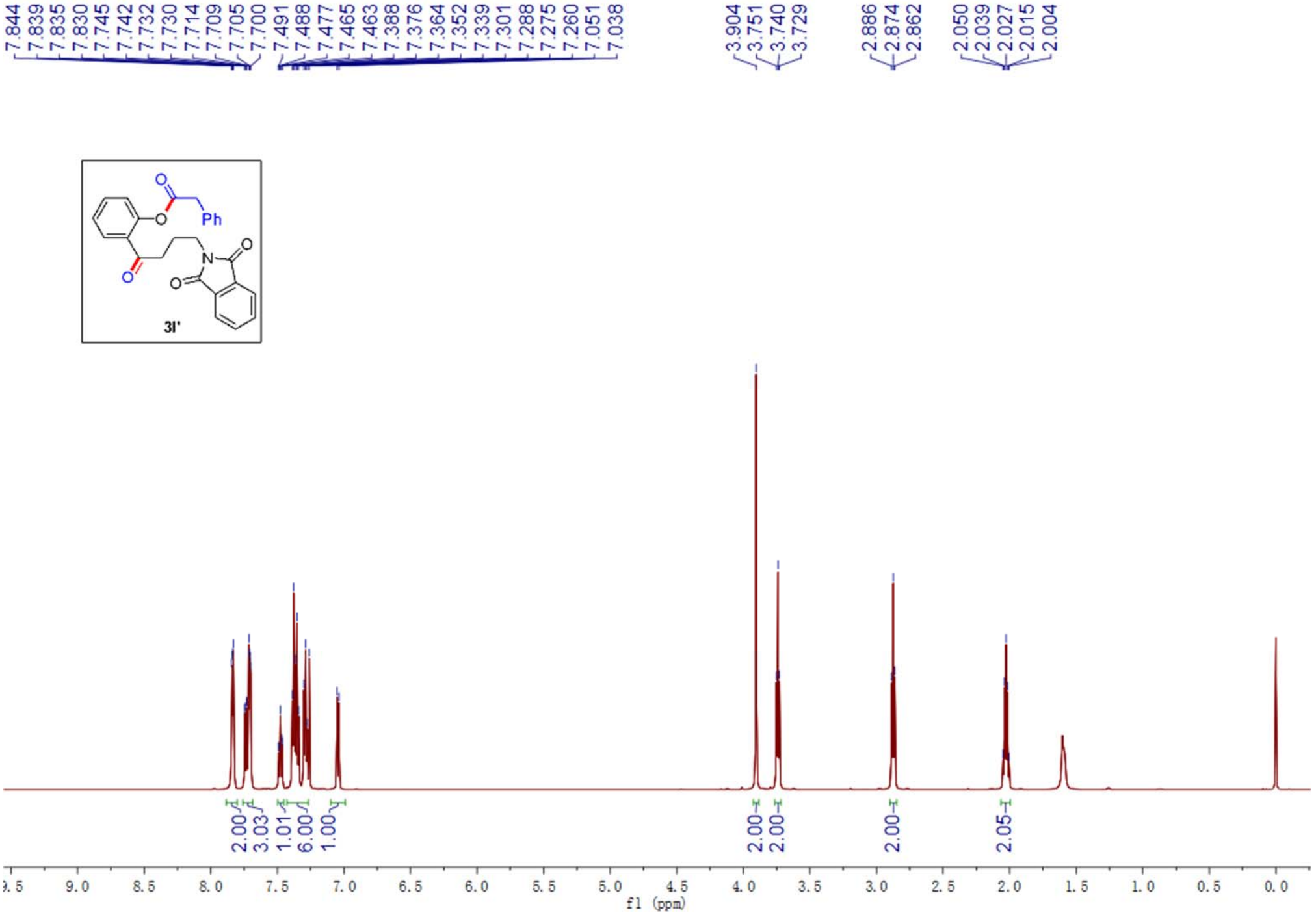
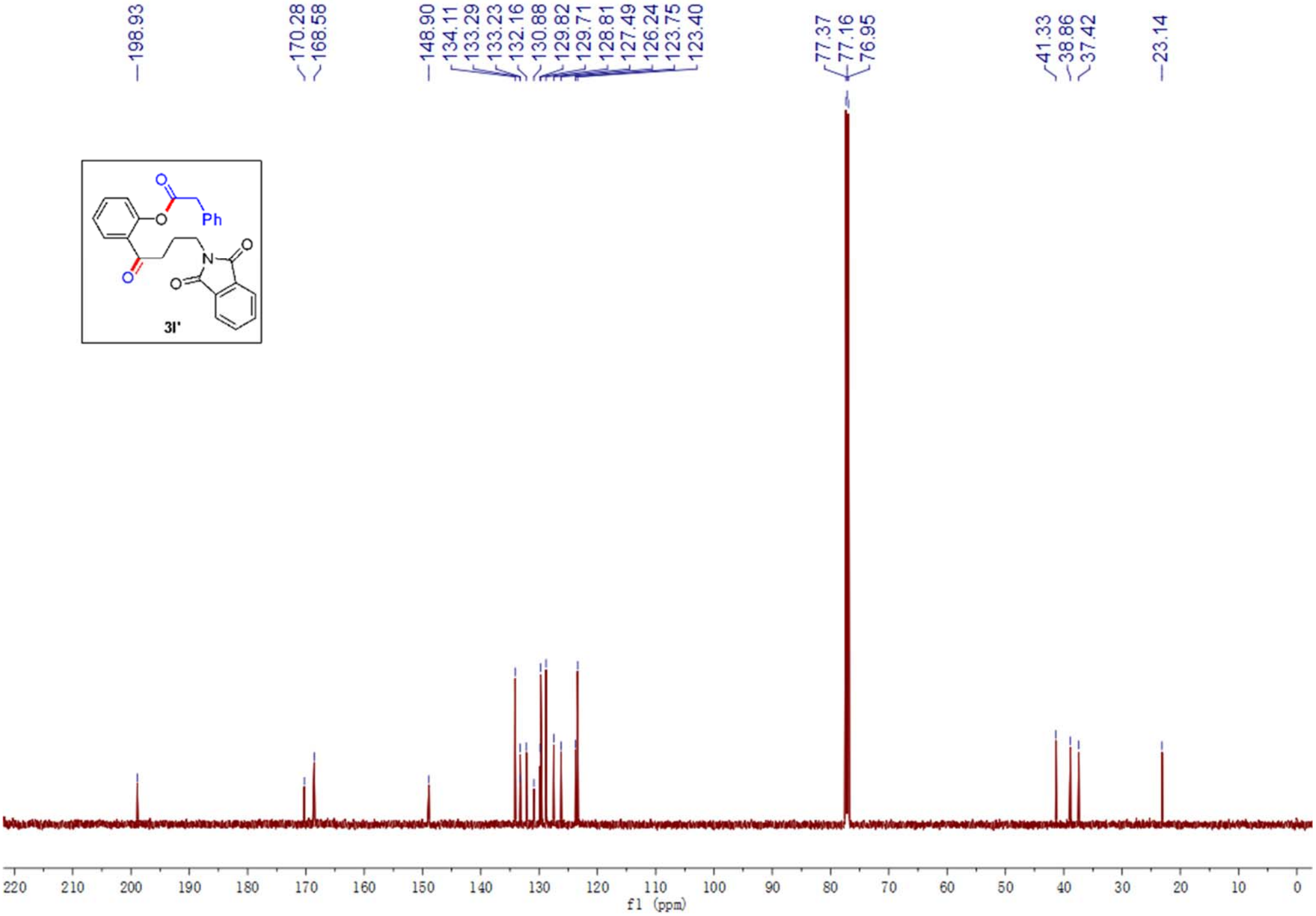
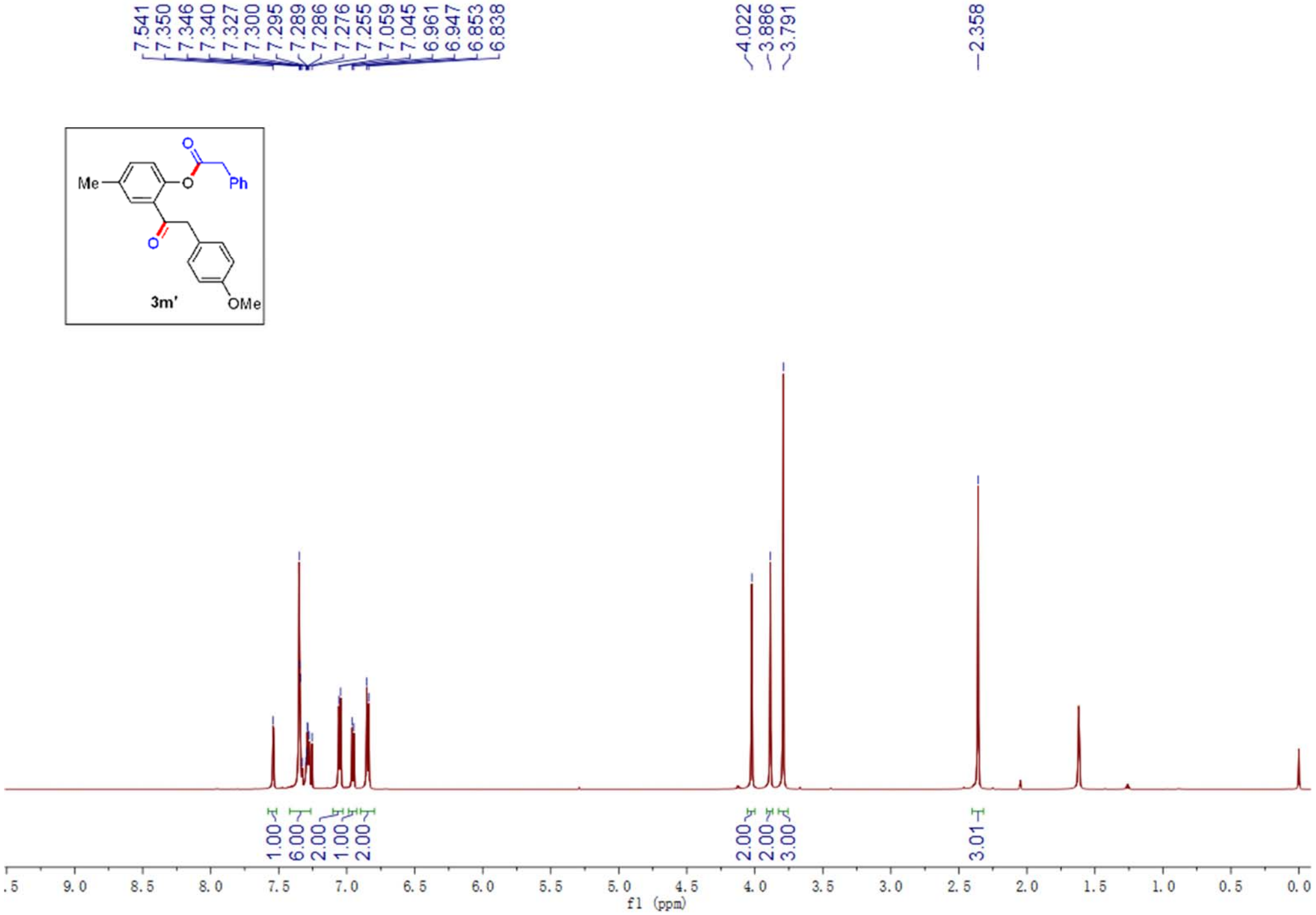
7.704
7.694
7.691
7.485
7.482
7.472
7.472
7.470
7.459
7.456
7.397
7.395
7.383
7.371
7.367
7.359
7.346
7.311
7.308
7.306
7.300
7.296
7.293
7.292
7.287
7.285
7.281
7.279
7.268
7.266
7.247
7.070
7.068
7.057
7.055
3.928
2.688
2.677
1.054
1.048
1.046
1.043
1.040
1.037
1.034
1.032
1.029
1.026
1.023
1.021
1.013
0.552
0.544
0.542
0.539
0.535
0.531
0.529
0.521
0.093
0.084
0.075
0.067
Ph
3k'
1.00
1.02
4.00
2.00
1.00
2.00
2.00
1.00
2.00
2.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


200.31
170.11
148.82
133.27
132.93
131.34
129.67
128.77
127.45
126.12
123.71
77.37
77.16
76.95
46.79
41.38
6.39
4.57
Ph
3k'
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.844
7.839
7.835
7.830
7.745
7.742
7.732
7.730
7.714
7.709
7.705
7.700
7.491
7.488
7.477
7.465
7.463
7.388
7.376
7.364
7.352
7.339
7.301
7.288
7.275
7.260
7.051
7.038
3.904
3.751
3.740
3.729
2.886
2.874
2.862
2.050
2.039
2.027
2.015
2.004
Ph
O
N
3l'
2.00
3.03
1.01
6.00
1.00
2.00
2.00
2.00
2.05
f1 (ppm)


198.93
170.28
168.58
148.90
134.11
133.29
133.23
132.16
130.88
129.82
129.71
128.81
127.49
126.24
123.75
123.40
77.37
77.16
76.95
41.33
38.86
37.42
23.14
Ph
O
N
3l'
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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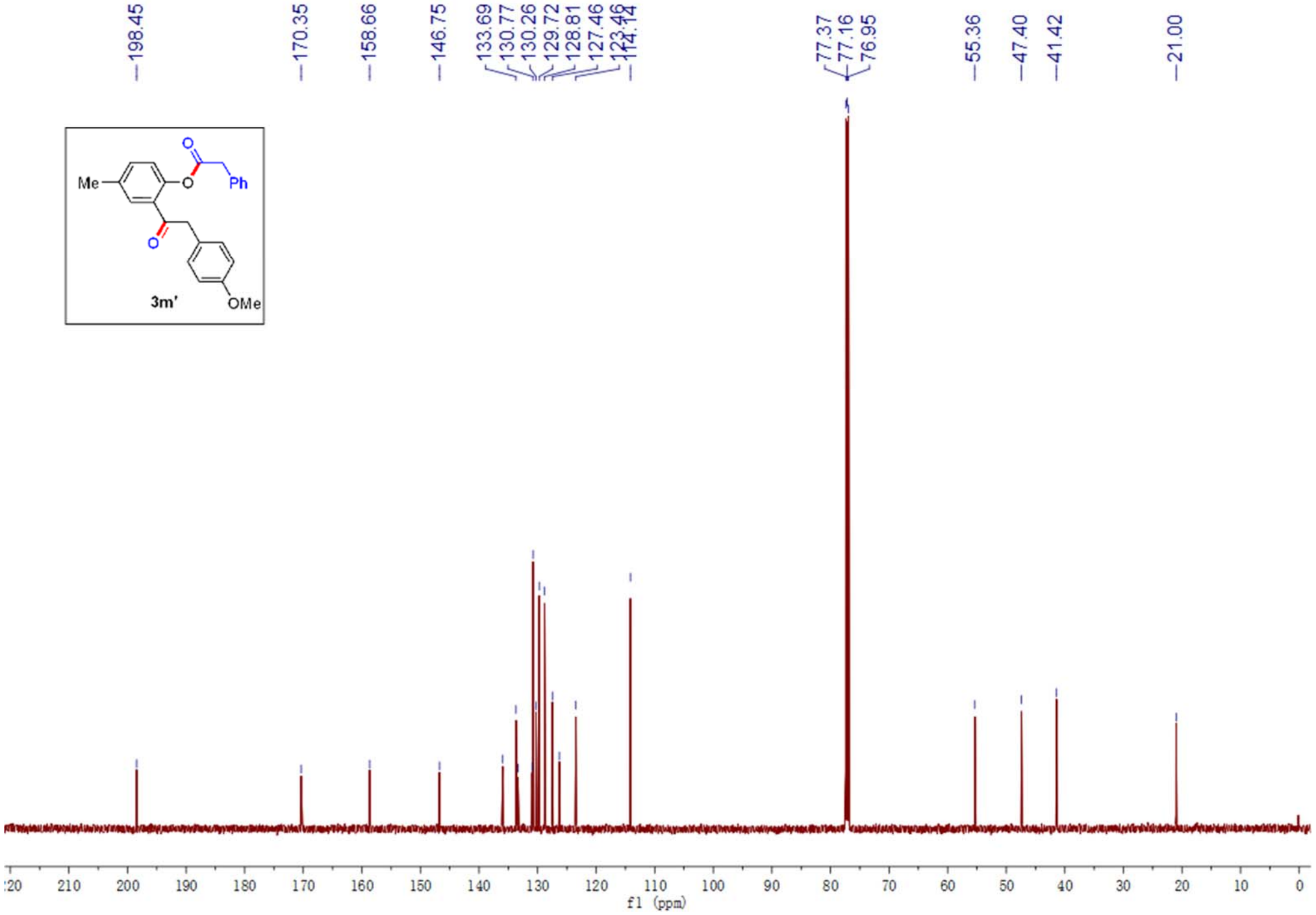
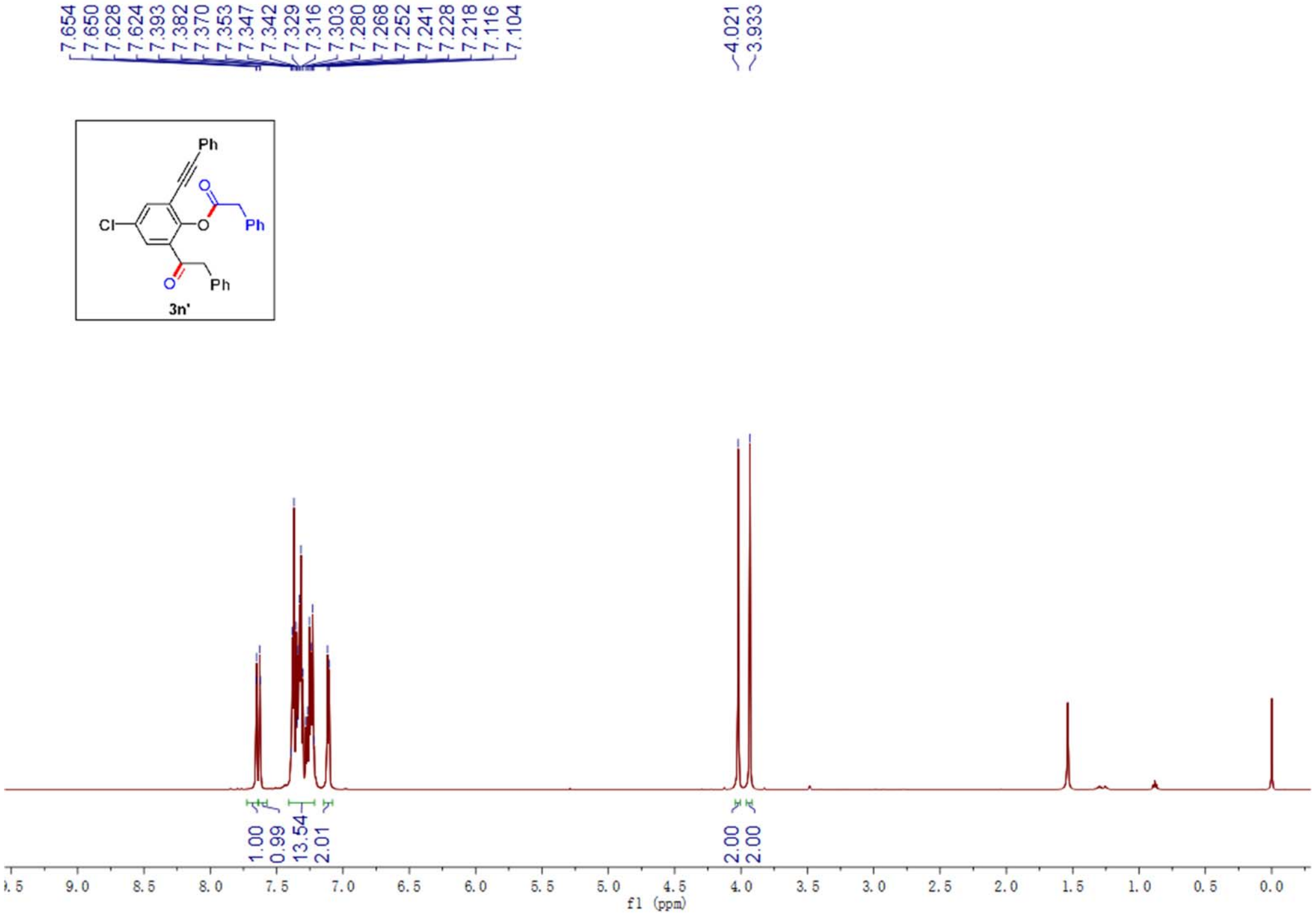
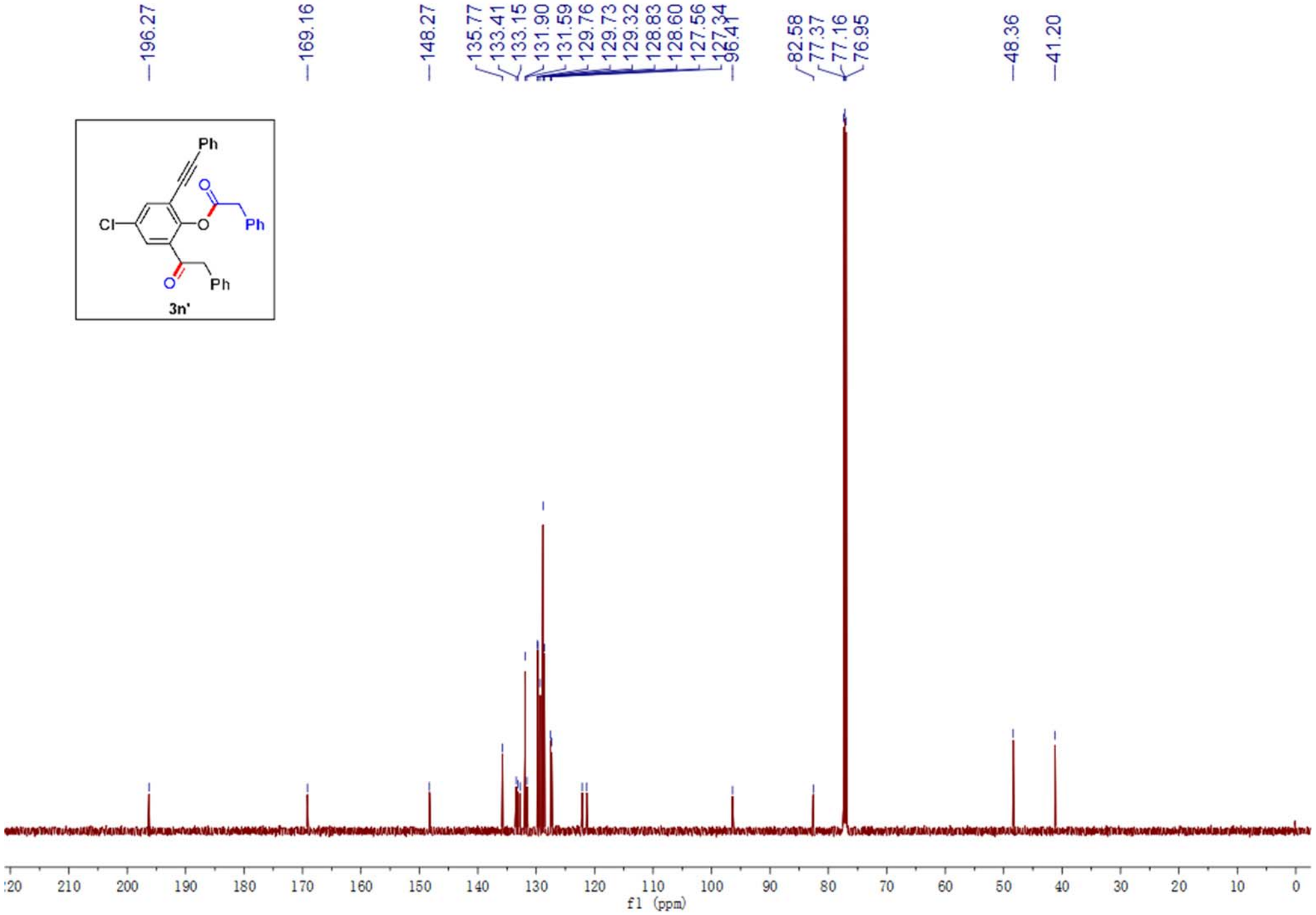
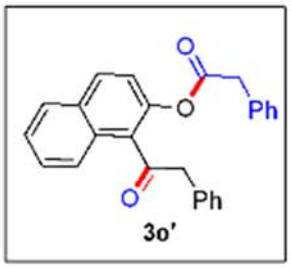
7.350
7.346
7.340
7.327
7.300
7.295
7.289
7.286
7.276
7.255
7.059
7.045
6.961
6.947
6.853
6.838
4.022
3.886
3.791
2.358
Me
O
Ph
O
O
3m'
OMe
1.00
6.00
2.00
1.00
2.00
2.00
2.00
3.00
3.01
f1 (ppm)


198.45
170.35
158.66
146.75
133.69
130.77
130.26
129.72
128.81
127.46
123.46
114.14
77.37
77.16
76.95
55.36
47.40
41.42
21.00
Me
O
Ph
O
3m'
OMe
f1 (ppm)

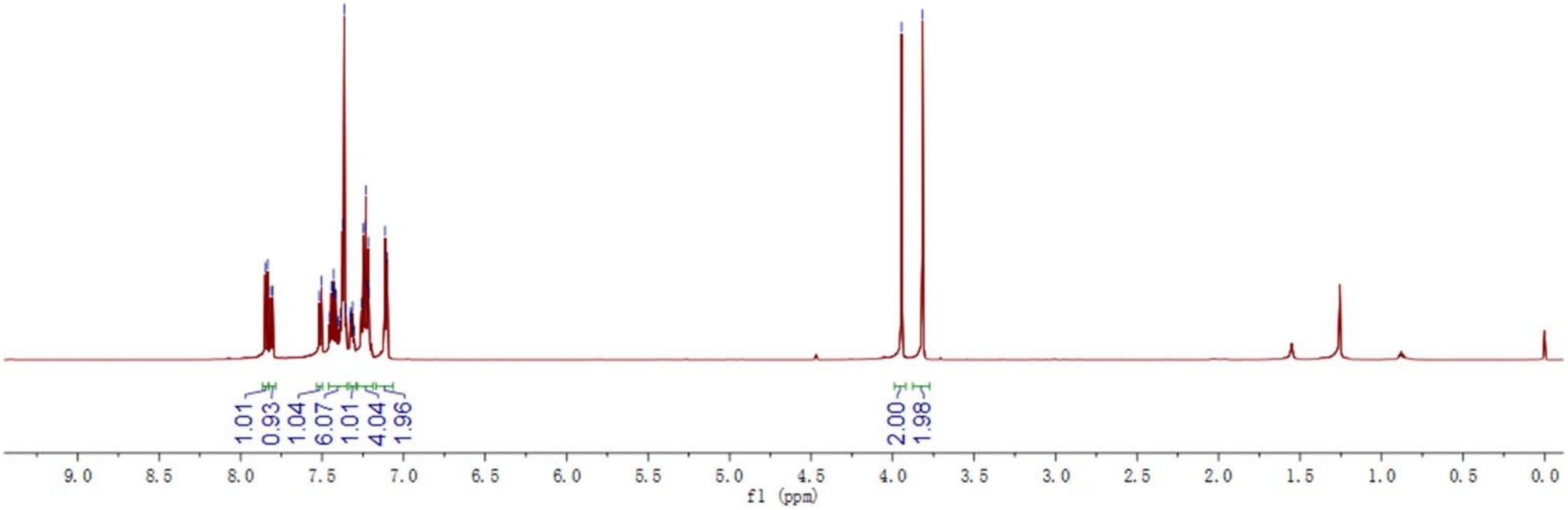

7.654
7.650
7.628
7.624
7.393
7.382
7.370
7.353
7.347
7.342
7.329
7.316
7.303
7.280
7.268
7.252
7.241
7.228
7.218
7.116
7.104
4.021
3.933
Ph
Cl
O
Ph
O
Ph
3n'
1.00
0.99
13.54
2.01
2.00
2.00
f1 (ppm)

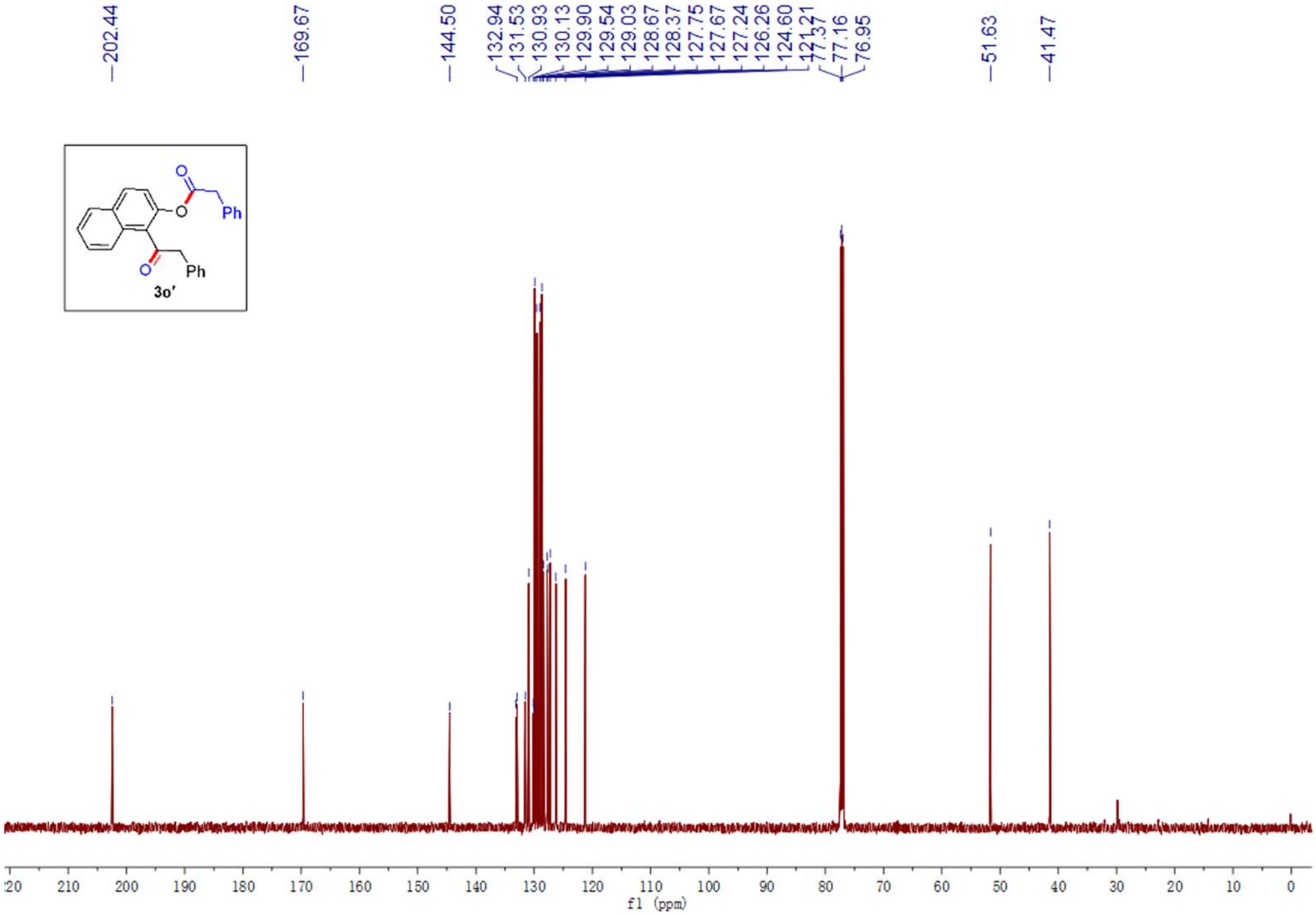

196.27
169.16
148.27
135.77
133.41
133.15
131.90
131.59
129.76
129.73
129.32
128.83
128.60
127.56
127.34
96.41
82.58
77.37
77.16
76.95
48.36
41.20
Ph
Cl
O
Ph
O
Ph
3n'
f1 (ppm)

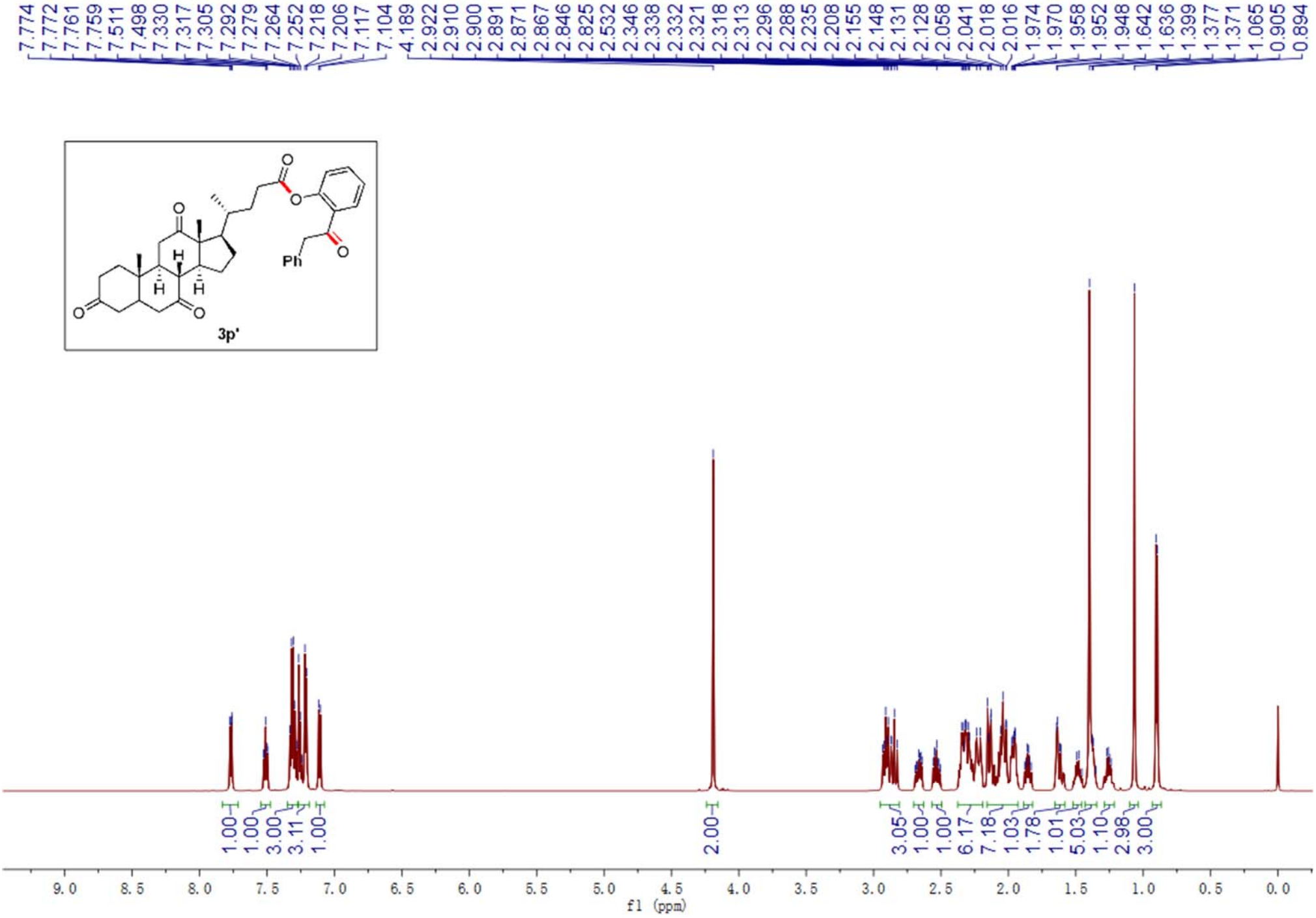

7.849
7.834
7.815
7.802
7.518
7.504
7.455
7.444
7.433
7.429
7.426
7.415
7.414
7.403
7.402
7.387
7.374
7.363
7.353
7.328
7.324
7.318
7.314
7.308
7.259
7.247
7.234
7.231
7.222
7.216
7.211
7.113
7.101
3.945
3.816

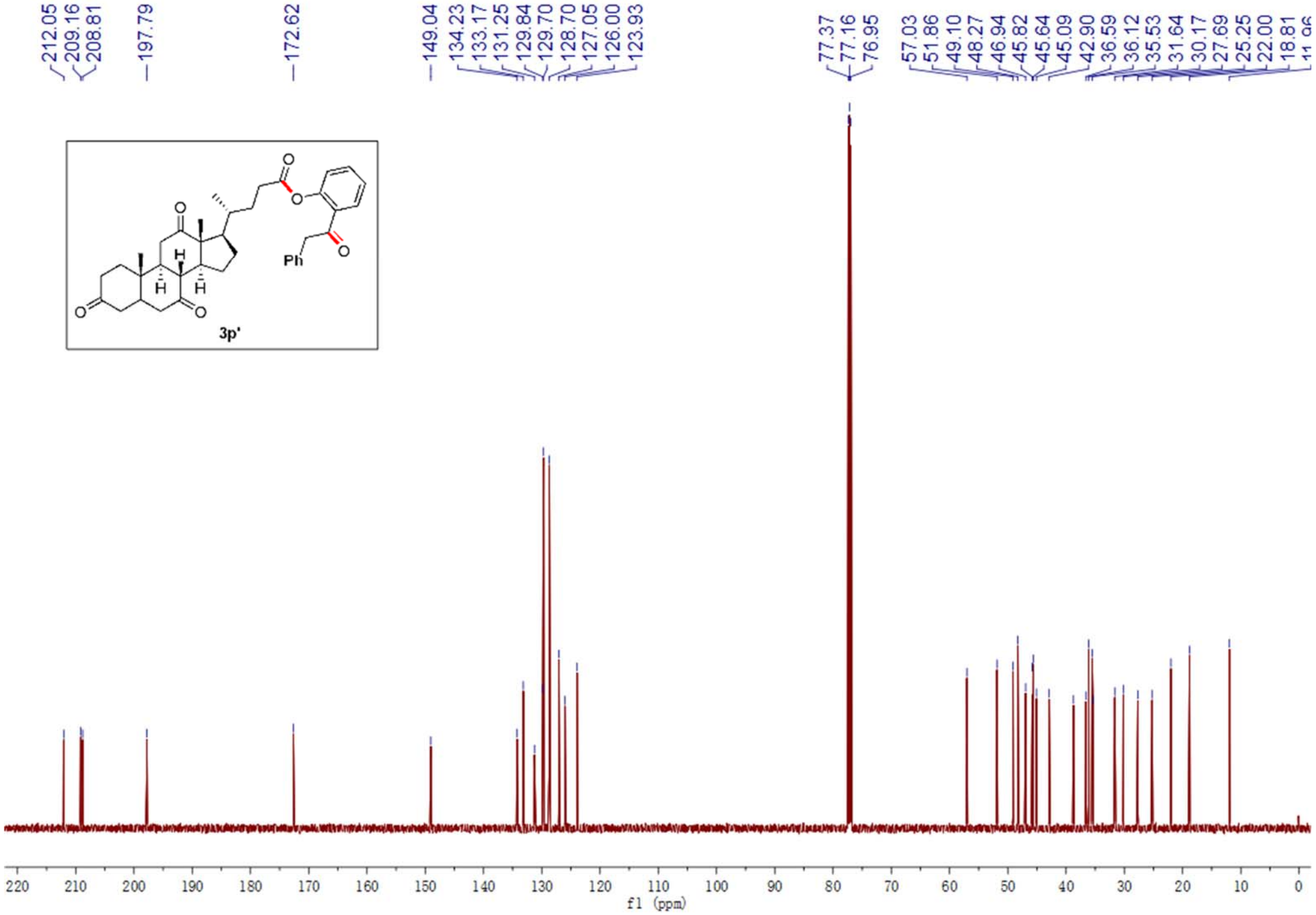

O
O
Ph
O
Ph

3o'

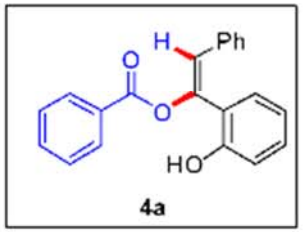

1.01
0.93
1.04
6.07
1.01
4.04
1.96
2.00
1.98
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


202.44
169.67
144.50
132.94
131.53
130.93
130.13
129.90
129.54
129.03
128.67
128.37
127.75
127.67
127.24
126.26
124.60
121.21
77.37
77.16
76.95
51.63
41.47
Ph
Ph
3o'
f1 (ppm)

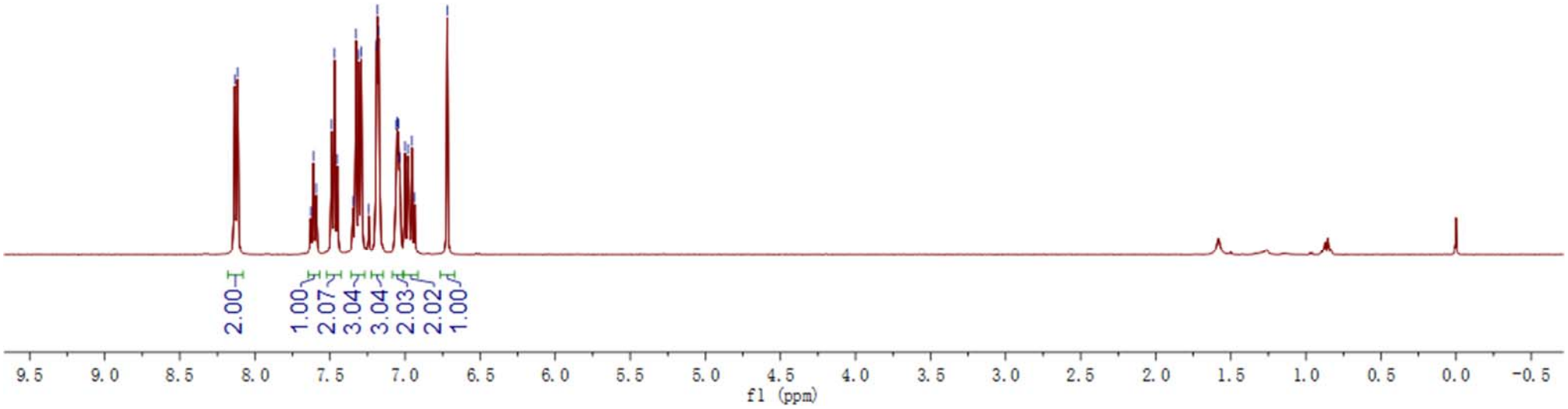

7.774
7.772
7.761
7.759
7.511
7.498
7.330
7.317
7.305
7.292
7.279
7.264
7.252
7.218
7.206
7.117
7.104
4.189
2.922
2.910
2.900
2.891
2.871
2.867
2.846
2.825
2.532
2.346
2.338
2.332
2.321
2.318
2.313
2.296
2.288
2.235
2.208
2.155
2.148
2.131
2.128
2.058
2.041
2.018
2.016
1.974
1.970
1.958
1.952
1.948
1.642
1.636
1.399
1.377
1.371
1.065
0.905
0.894
Ph
3p'
1.00
1.00
3.00
3.11
1.00
2.00
3.05
1.00
1.00
6.17
7.18
1.03
1.78
1.01
5.03
1.10
2.98
3.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

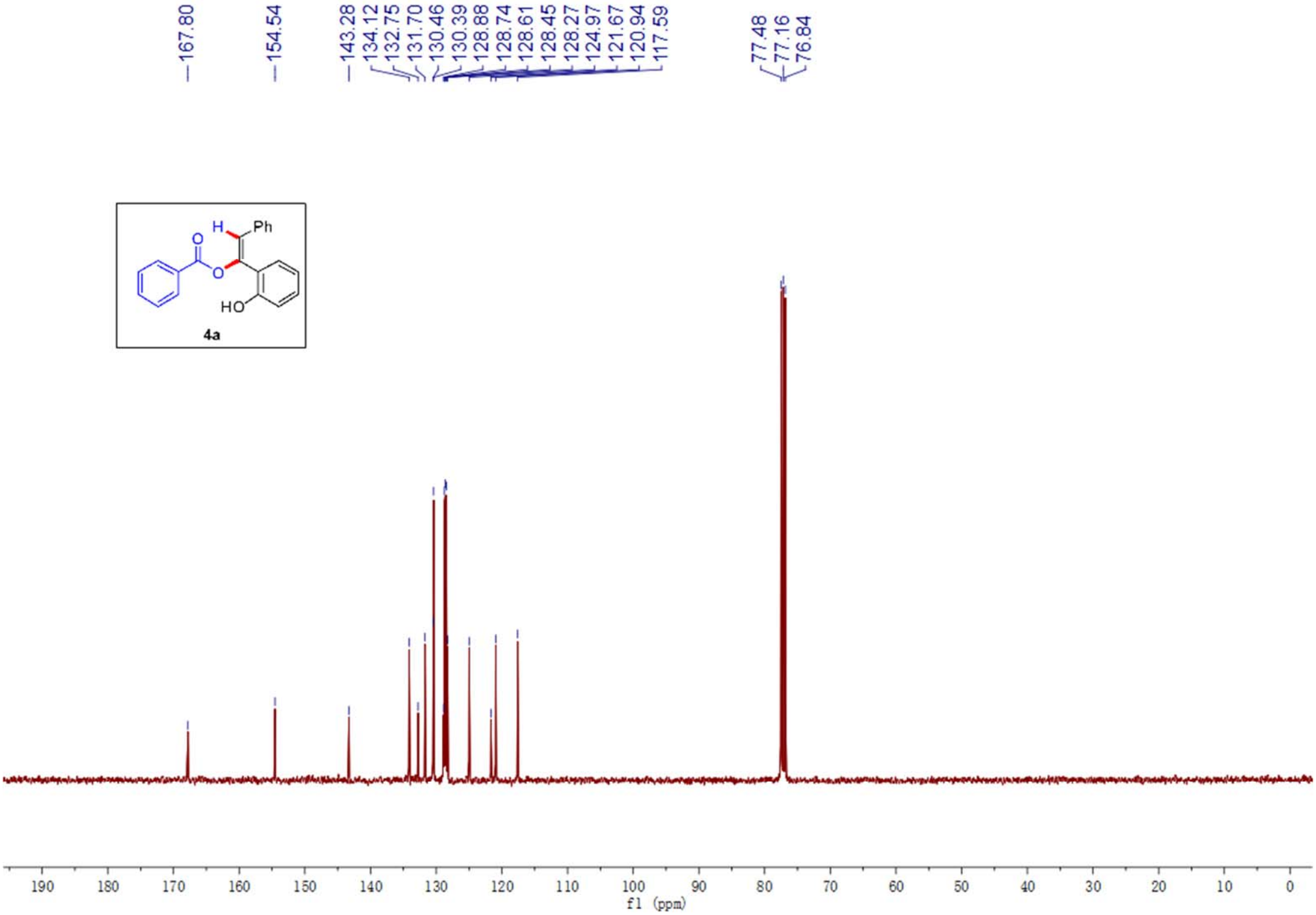

212.05
209.16
208.81
197.79
172.62
149.04
134.23
133.17
131.25
129.84
129.70
128.70
127.05
126.00
123.93
77.37
77.16
76.95
57.03
51.86
49.10
48.27
46.94
45.82
45.64
45.09
42.90
36.59
36.12
35.53
31.64
30.17
27.69
25.25
22.00
18.81
Ph
3p'
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.135
8.116
7.629
7.610
7.592
7.489
7.470
7.451
7.345
7.326
7.308
7.292
7.241
7.191
7.184
7.175
7.058
7.053
7.044
7.035
7.000
6.980
6.954
6.935
6.719

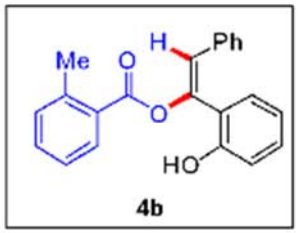

H
Ph
O
O
HO

4a

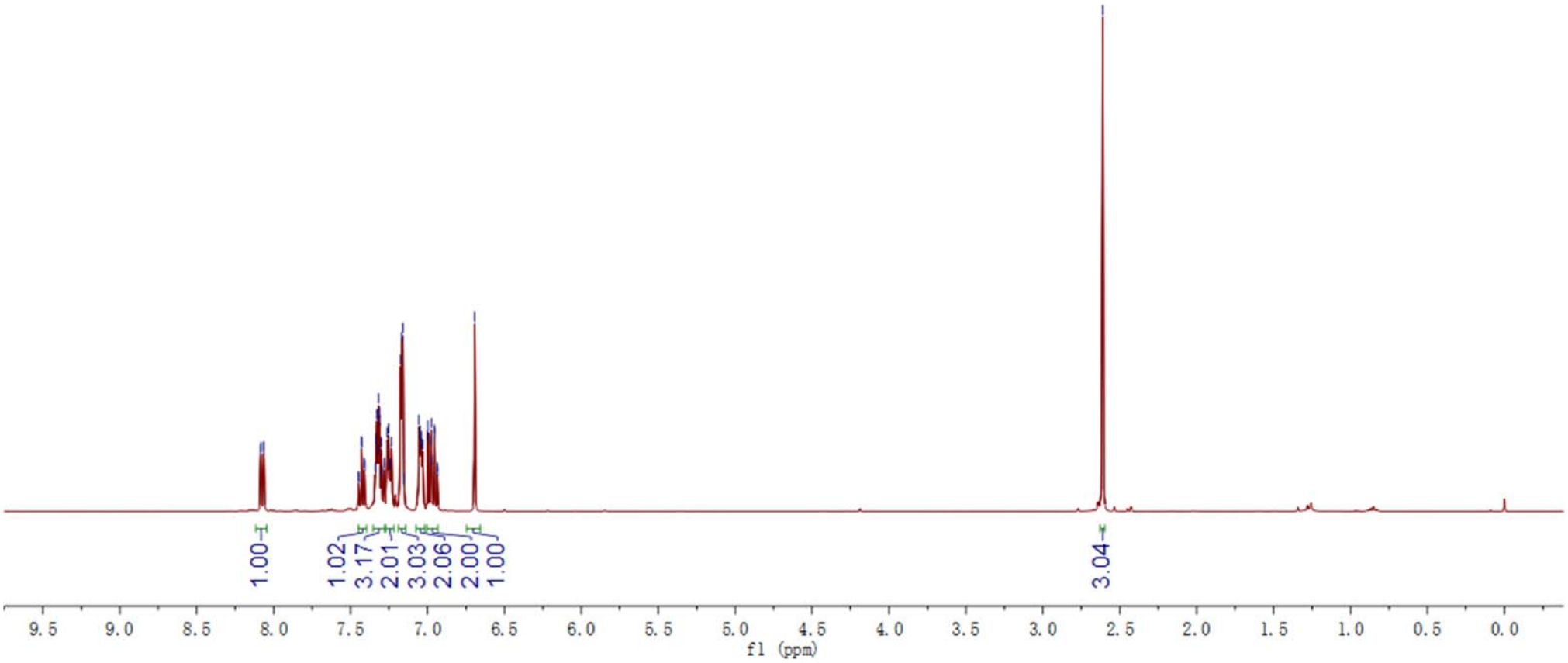

2.00
1.00
2.07
3.04
3.04
2.03
2.02
1.00
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

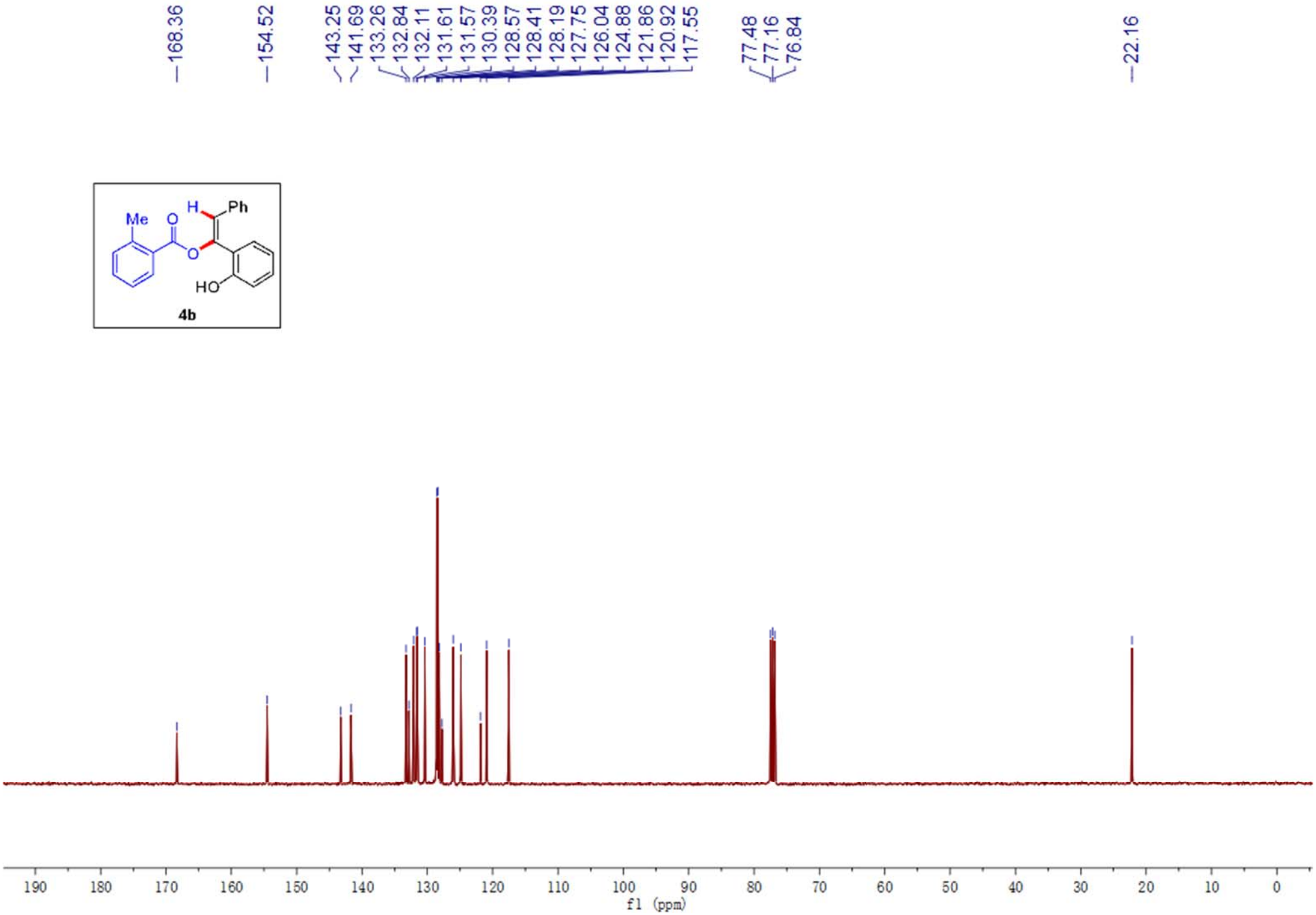

167.80
154.54
143.28
134.12
132.75
131.70
130.46
130.39
128.88
128.74
128.61
128.45
128.27
124.97
121.67
120.94
117.59
77.48
77.16
76.84
H
Ph
O
O
HO
4a
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

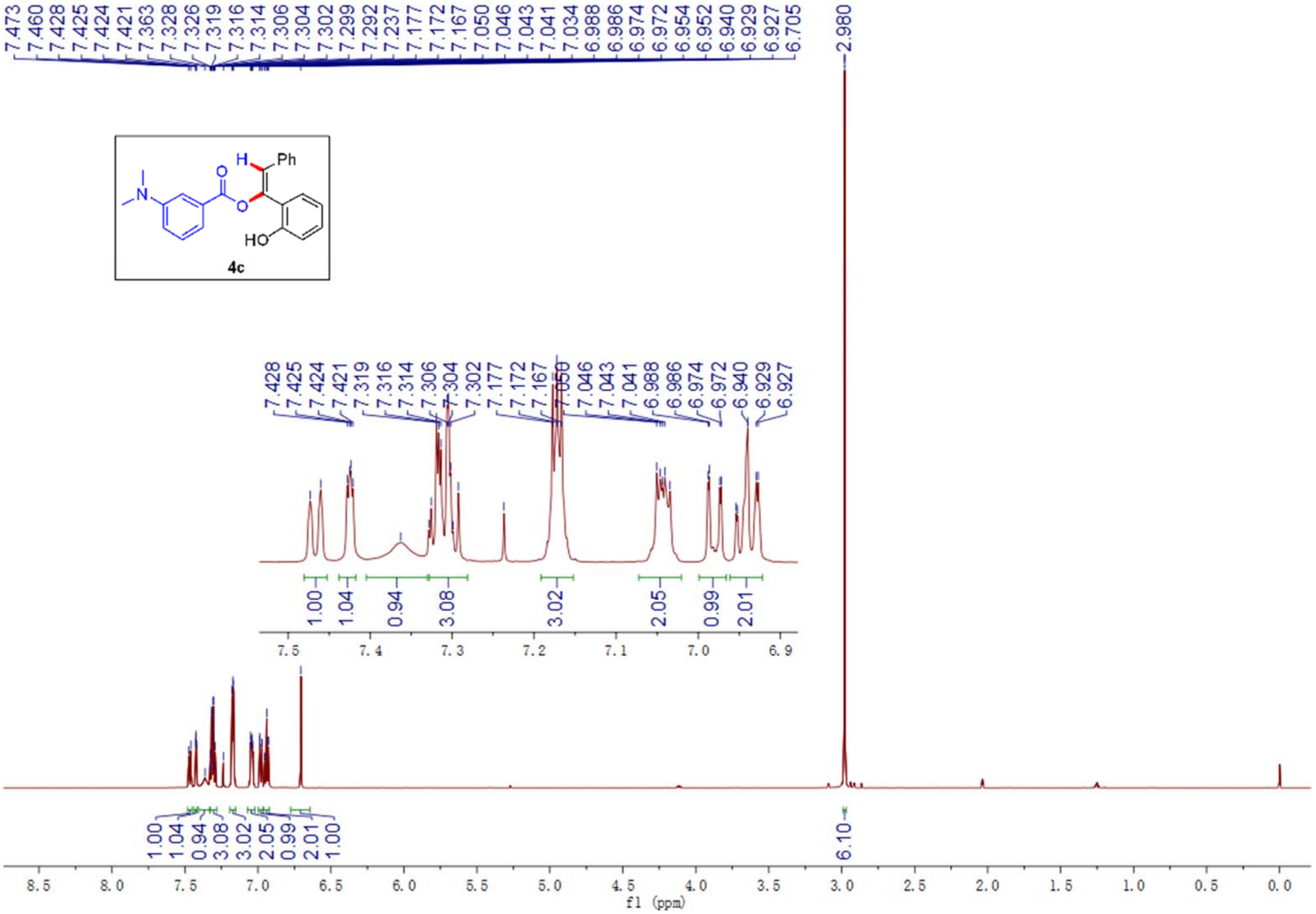

8.086
8.083
8.066
8.063
7.429
7.426
7.335
7.330
7.326
7.321
7.318
7.311
7.307
7.300
7.261
7.252
7.233
7.175
7.167
7.159
7.055
7.049
7.046
7.041
7.038
7.031
6.999
6.997
6.978
6.974
6.954
6.952
2.611

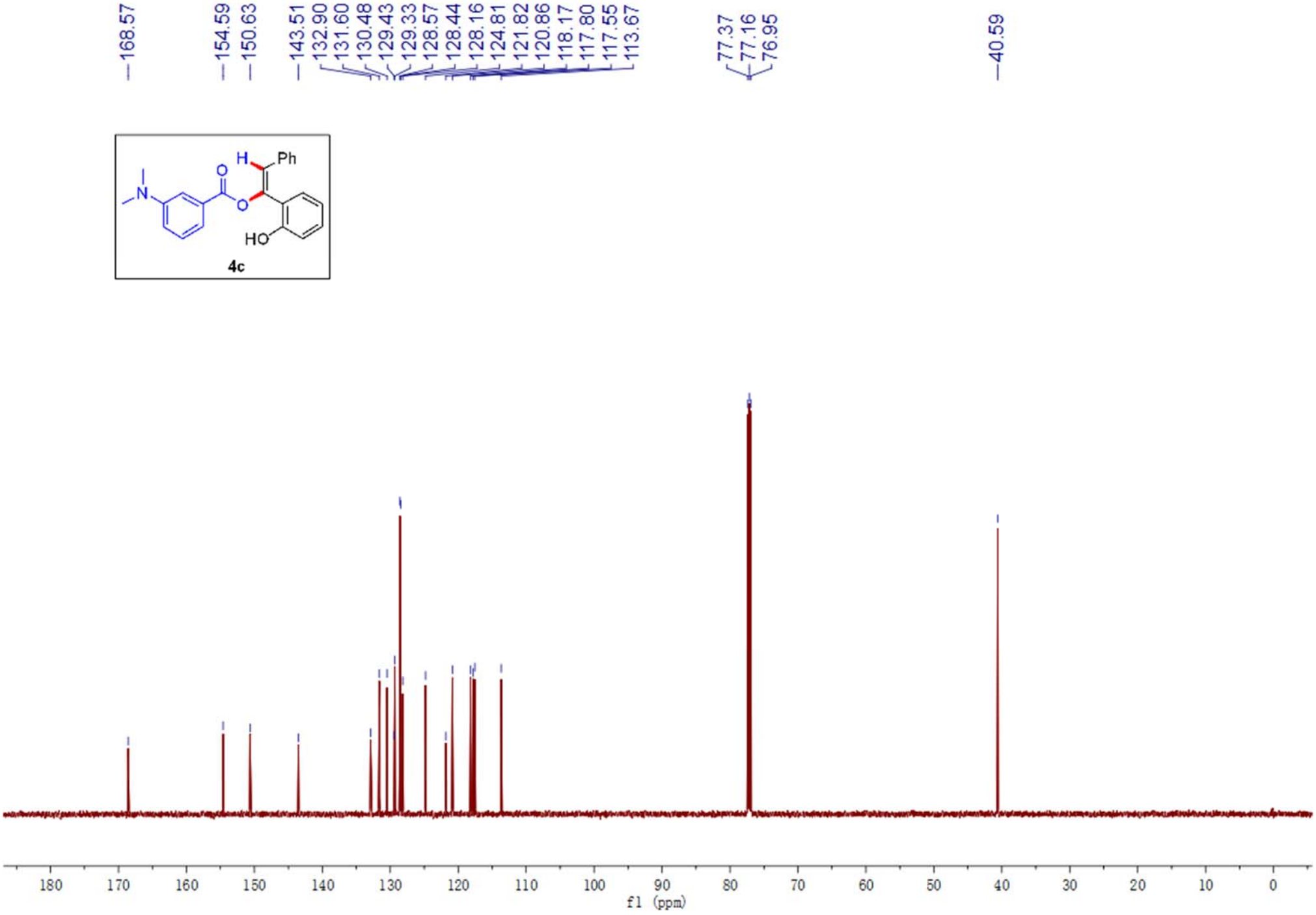

Me
O
H
Ph
O
HO

4b

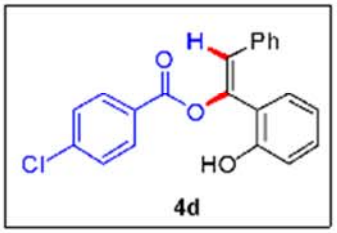

1.00
1.02
3.17
2.01
3.03
2.06
2.00
1.00
3.04
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


168.36
154.52
143.25
141.69
133.26
132.84
132.11
131.61
131.57
130.39
128.57
128.41
128.19
127.75
126.04
124.88
121.86
120.92
117.55
77.48
77.16
76.84
22.16
Me
O
H
Ph
O
HO
4b
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

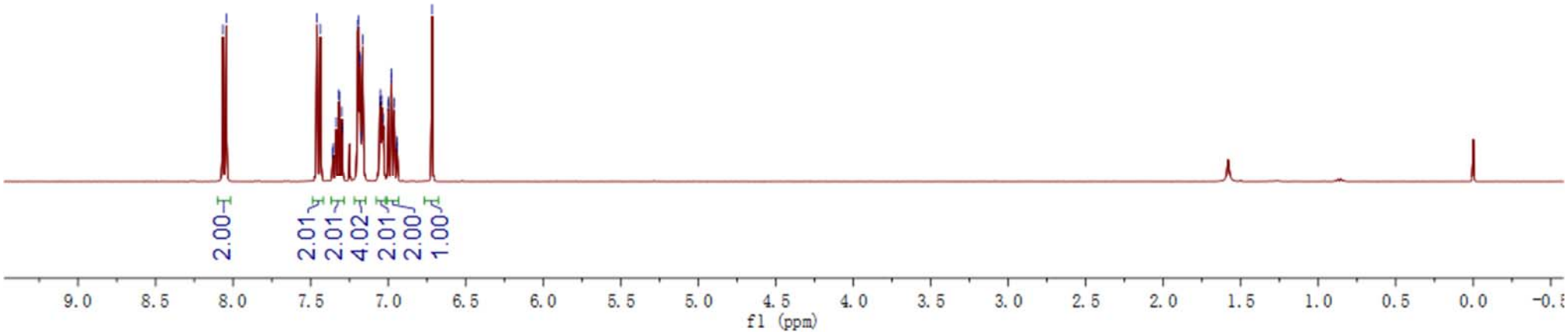

7.473
7.460
7.428
7.425
7.424
7.421
7.363
7.328
7.326
7.319
7.316
7.314
7.306
7.304
7.302
7.299
7.292
7.237
7.177
7.172
7.167
7.050
7.046
7.043
7.041
7.034
6.988
6.986
6.974
6.972
6.954
6.952
6.940
6.929
6.927
6.705
2.980
H
Ph
O
N
O
HO
4c
1.00
1.04
0.94
3.08
3.02
2.05
0.99
2.01
6.10
f1 (ppm)

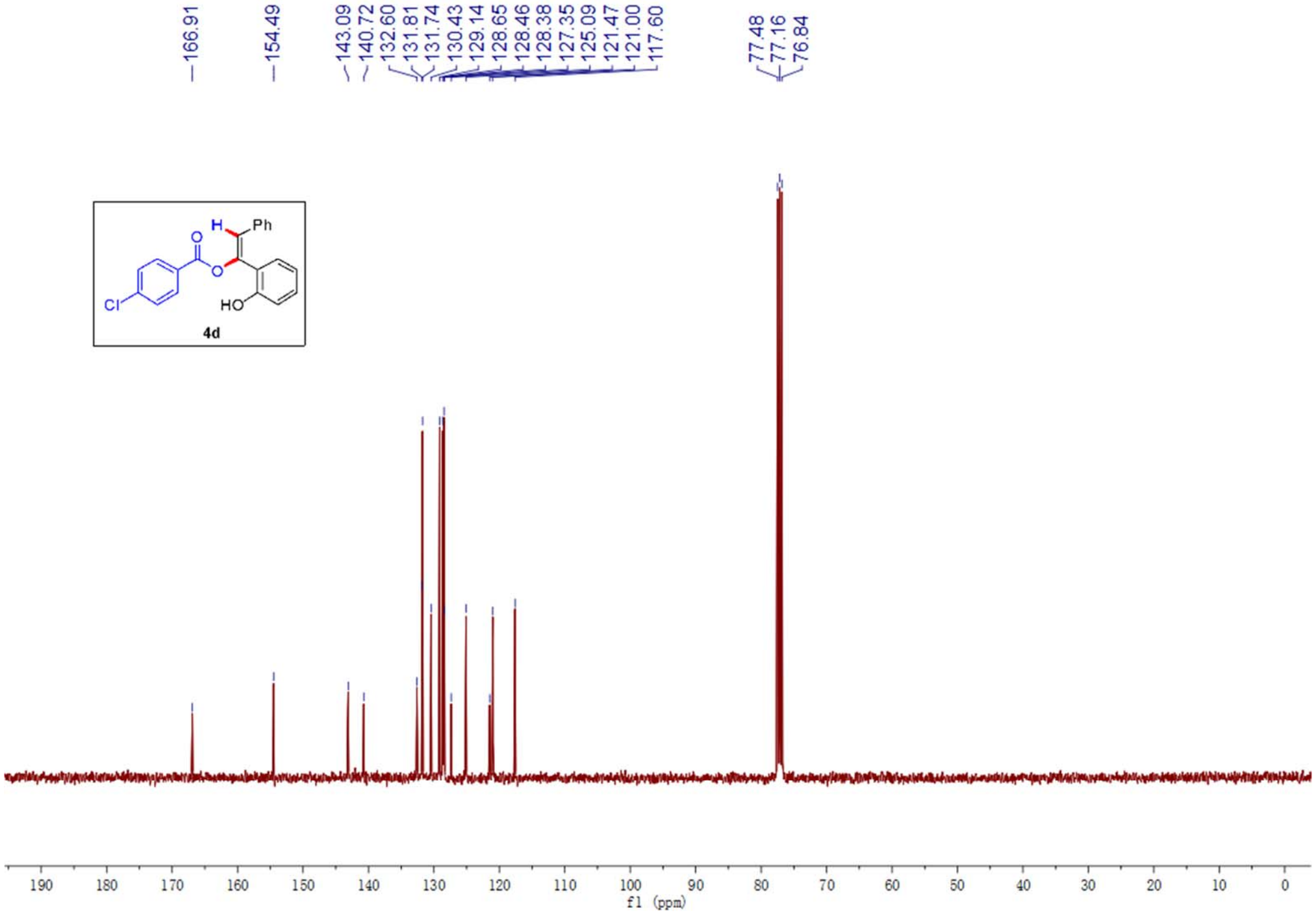

168.57
154.59
150.63
143.51
132.90
131.60
130.48
129.43
129.33
128.57
128.44
128.16
124.81
121.82
120.86
118.17
117.80
117.55
113.67
77.37
77.16
76.95
40.59
H
Ph
O
N
O
HO
4c
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.065
8.044
7.459
7.437
7.357
7.353
7.335
7.318
7.314
7.299
7.296
7.196
7.190
7.181
7.179
7.173
7.164
7.053
7.049
7.040
7.030
7.000
6.999
6.979
6.978
6.961
6.943
6.941
6.716

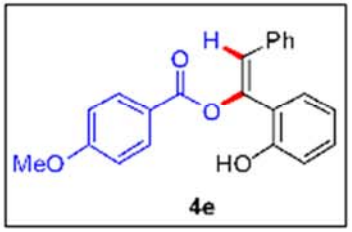

H
Ph
O
O
Cl
HO

4d

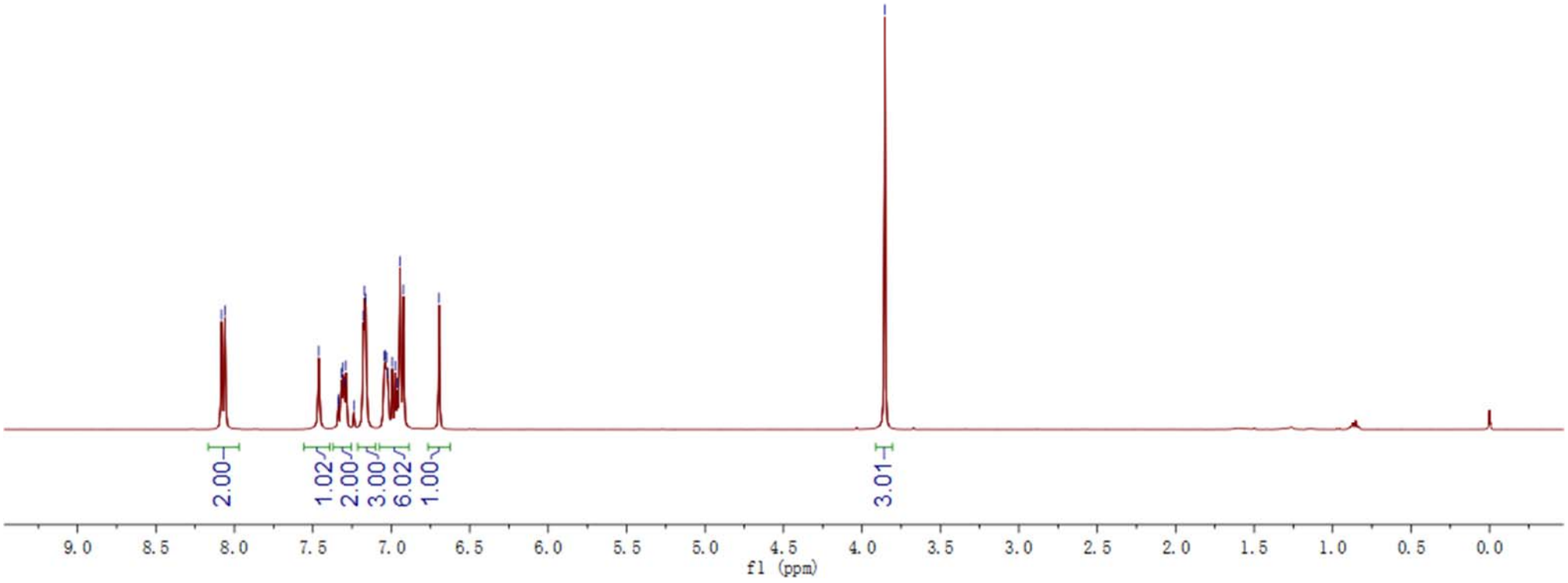

2.00
2.01
2.01
4.02
2.01
2.00
1.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


166.91
154.49
143.09
140.72
132.60
131.81
131.74
130.43
129.14
128.65
128.46
128.38
127.35
125.09
121.47
121.00
117.60
77.48
77.16
76.84
H
Ph
O
O
Cl
HO
4d
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.082
8.060
7.462
7.339
7.336
7.317
7.308
7.297
7.289
7.238
7.178
7.170
7.162
7.044
7.038
7.030
7.021
6.994
6.974
6.961
6.944
6.922
6.695
3.854


H
Ph
O
O
MeO
HO

4e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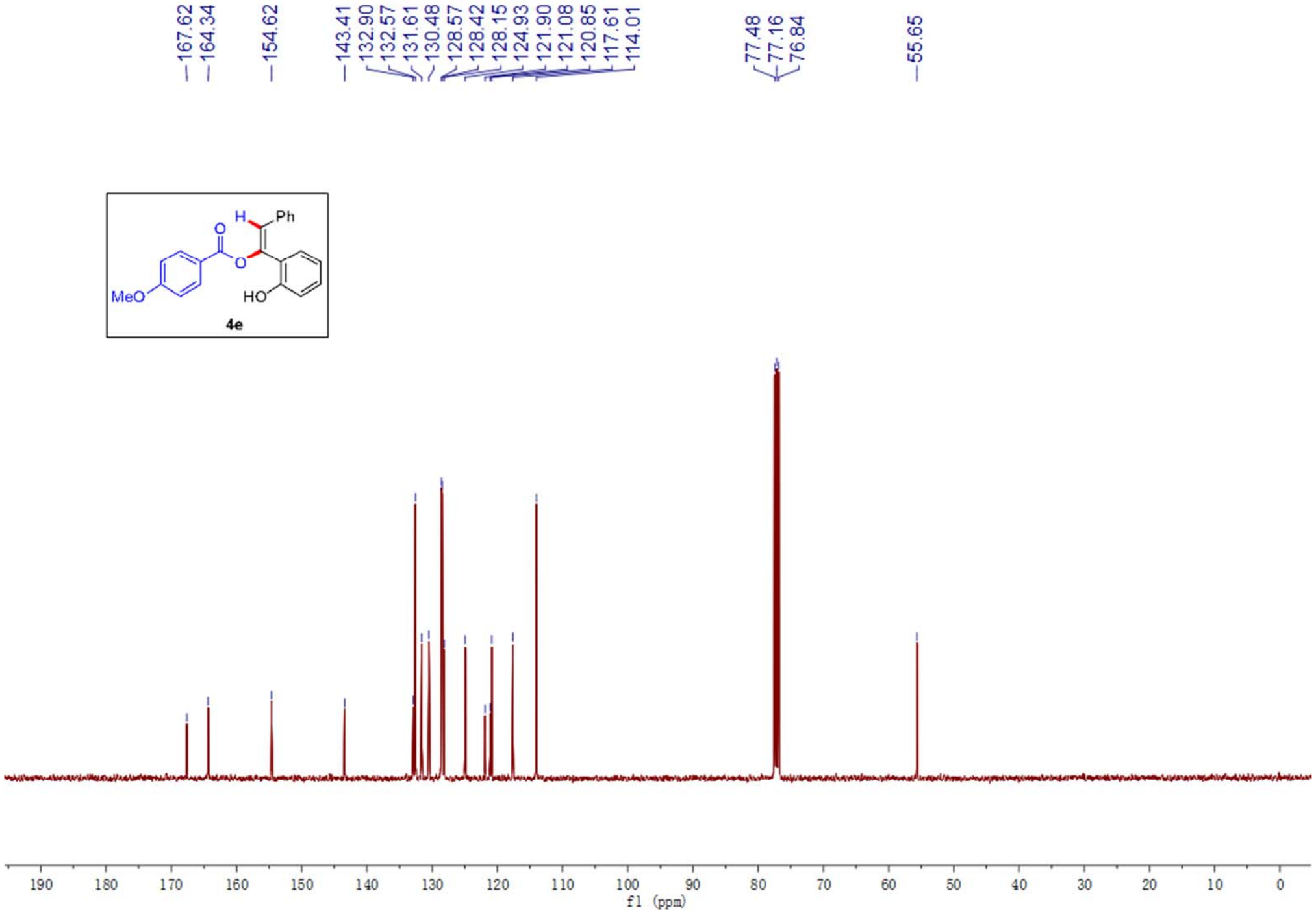
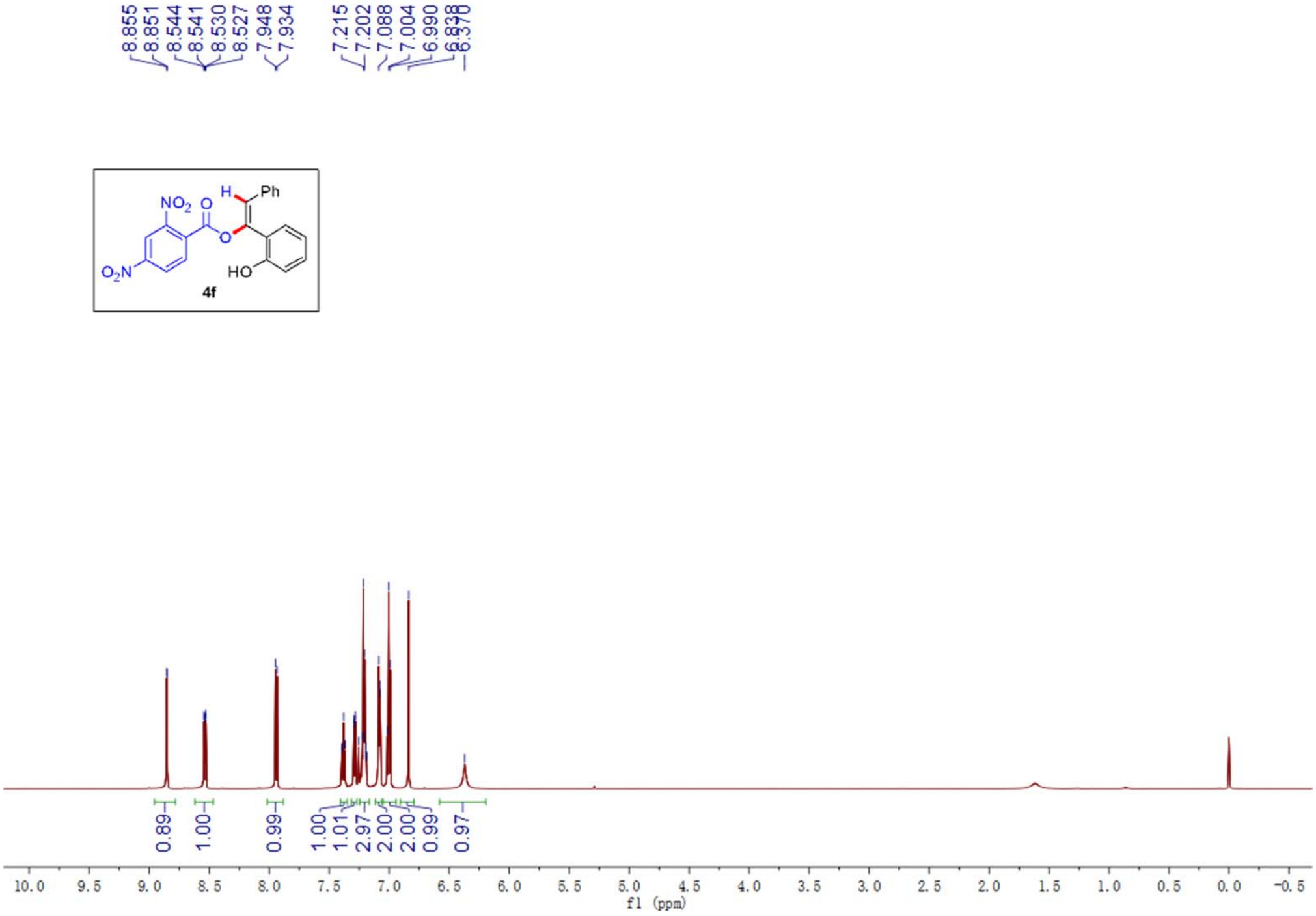
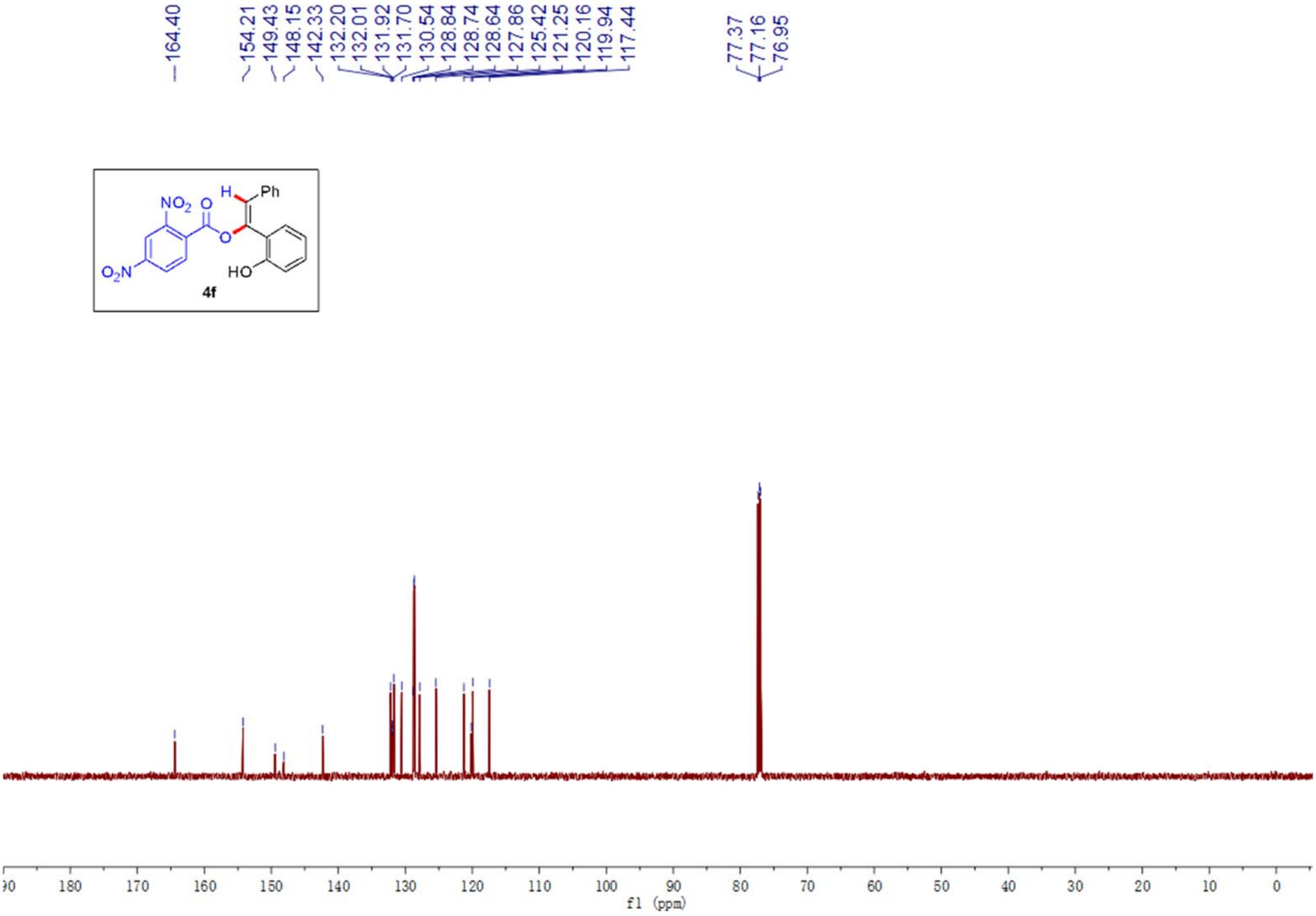
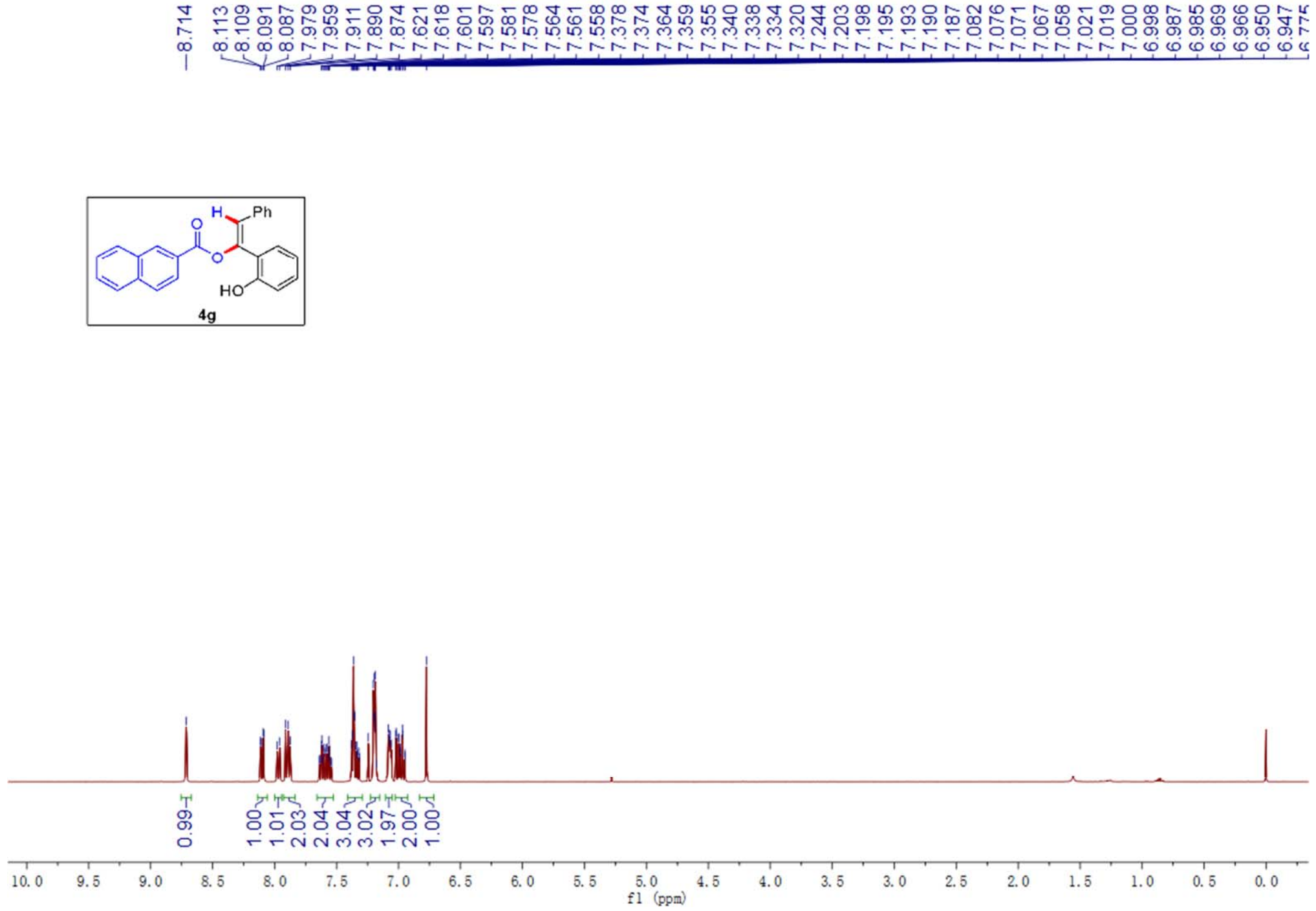
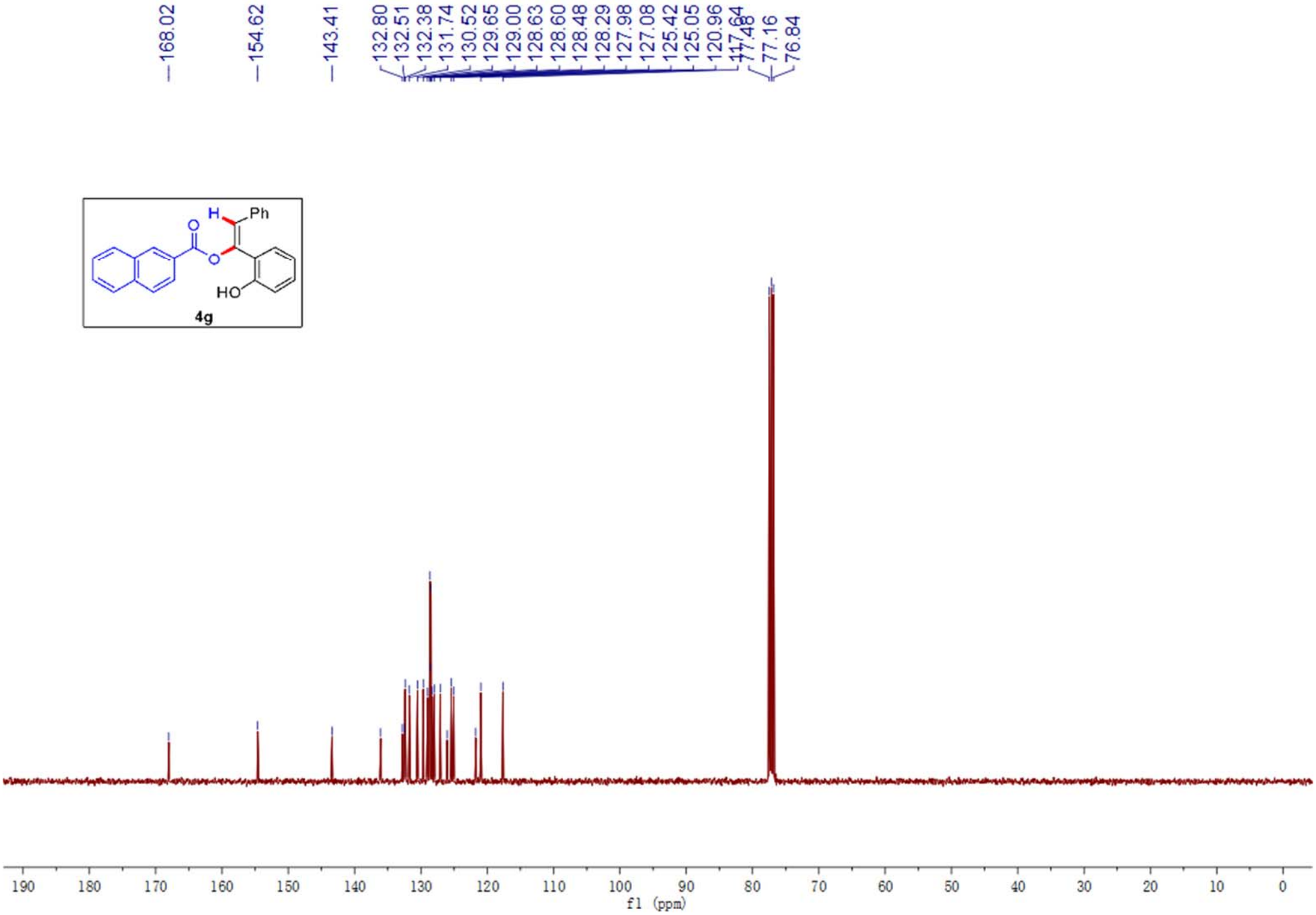
2.00
3.00
6.02
1.00
3.01
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


167.62
164.34
154.62
143.41
132.90
132.57
131.61
130.48
128.57
128.42
128.15
124.93
121.90
121.08
120.85
117.61
114.01
77.48
77.16
76.84
55.65
H
Ph
O
O
MeO
HO
4e
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.855
8.851
8.544
8.541
8.530
8.527
7.948
7.934
7.215
7.202
7.088
7.004
6.990
6.838
6.370
NO2
O
H
Ph
O
O2N
HO
4f
0.89
1.00
0.99
1.00
1.01
2.97
2.00
2.00
0.99
0.97
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


164.40
154.21
149.43
148.15
142.33
132.20
132.01
131.92
131.70
130.54
128.84
128.74
128.64
127.86
125.42
121.25
120.16
119.94
117.44
77.37
77.16
76.95
NO2
O
H
Ph
O
O2N
HO
4f
f1 (ppm)


8.714
8.113
8.109
8.091
8.087
7.979
7.959
7.911
7.890
7.874
7.621
7.618
7.601
7.597
7.581
7.578
7.564
7.561
7.558
7.378
7.374
7.364
7.359
7.355
7.340
7.338
7.334
7.320
7.244
7.203
7.198
7.195
7.193
7.190
7.187
7.082
7.076
7.071
7.067
7.058
7.021
7.019
7.000
6.998
6.987
6.985
6.969
6.966
6.950
6.947
H
Ph
O
O
HO
4g
0.99
1.00
1.01
2.03
2.04
3.04
3.02
1.97
2.00
1.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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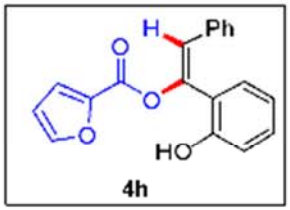
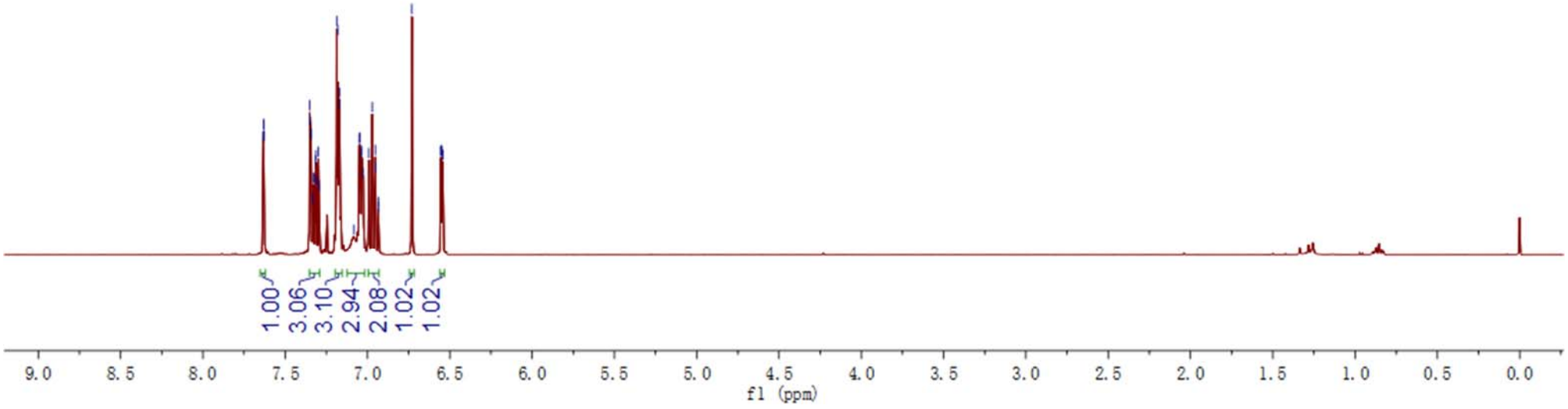
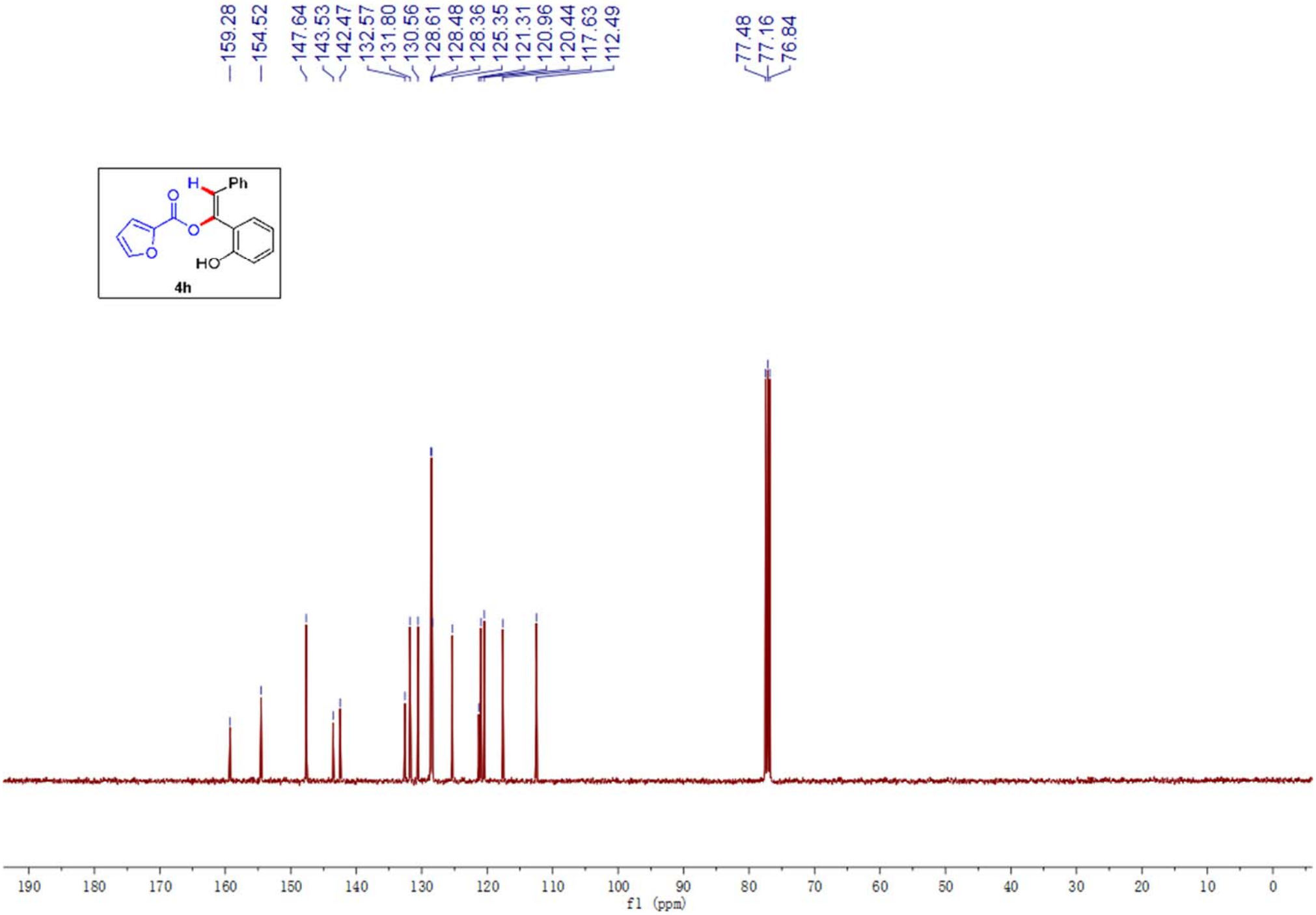
154.62
143.41
132.80
132.51
132.38
131.74
130.52
129.65
129.00
128.63
128.60
128.48
128.29
127.98
127.08
125.42
125.05
120.96
117.64
77.48
77.16
76.84
H
Ph
O
O
HO
4g
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.633
7.632
7.629
7.628
7.351
7.350
7.342
7.341
7.333
7.329
7.327
7.317
7.313
7.308
7.298
7.294
7.187
7.181
7.173
7.170
7.084
7.050
7.045
7.037
7.035
7.026
6.992
6.971
6.953
6.950
6.934
6.931
6.730
6.556
6.551
6.547
6.542

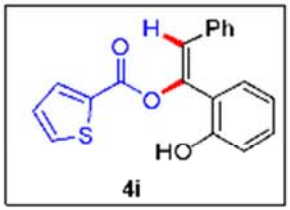

H
Ph
O
O
O
HO

4h

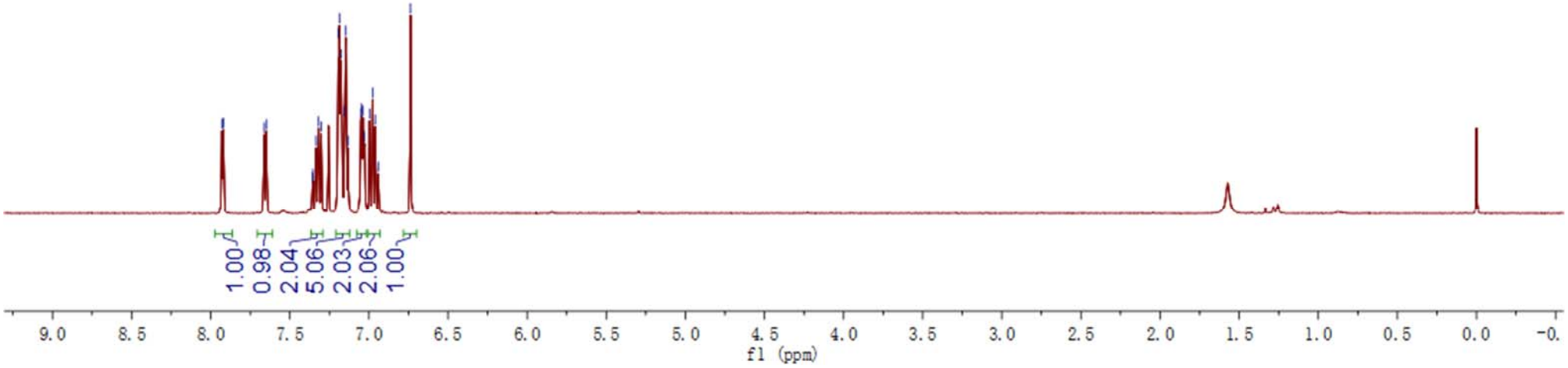

1.00
3.06
3.10
2.94
2.08
1.02
1.02
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

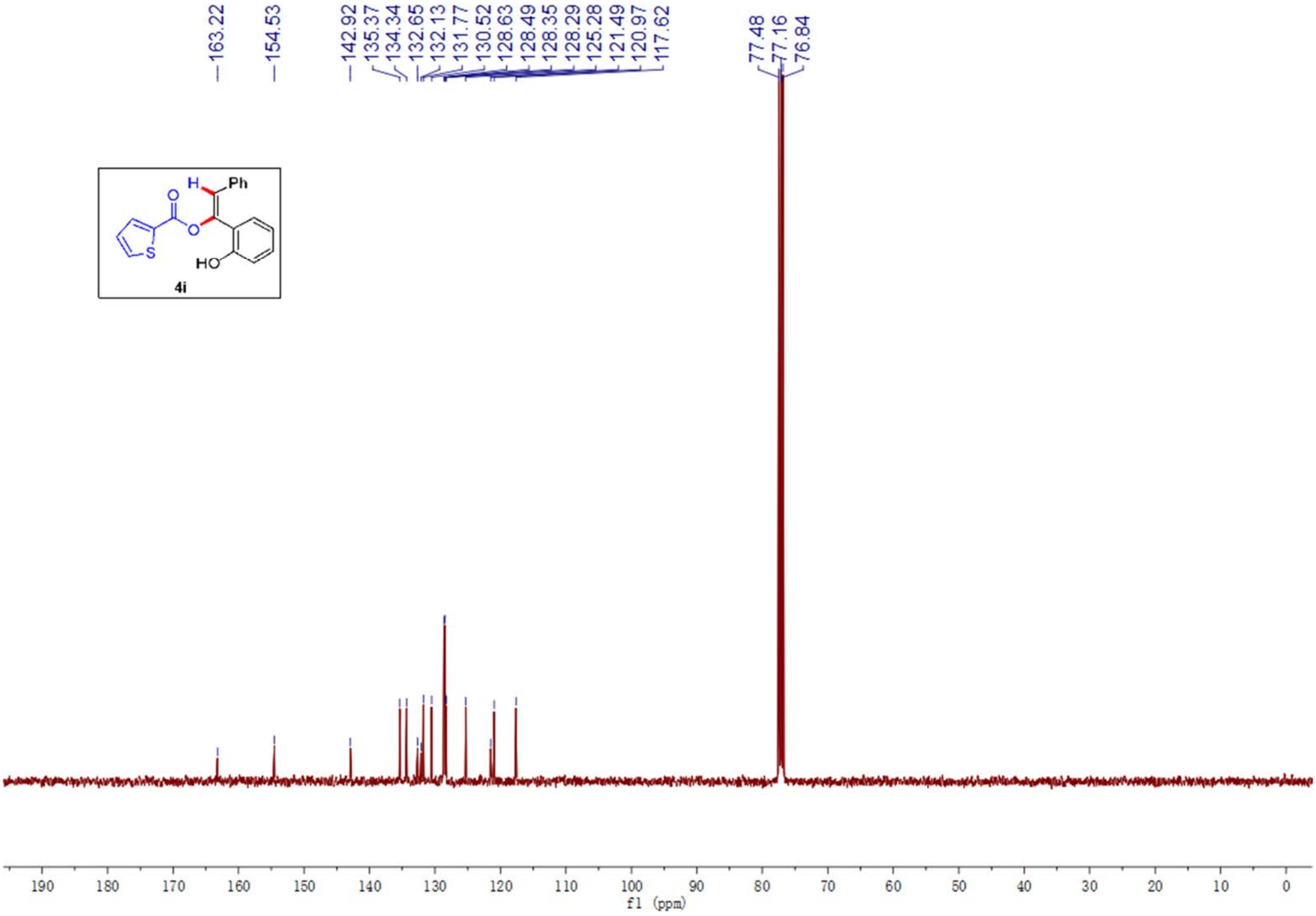

159.28
154.52
147.64
143.53
142.47
132.57
131.80
130.56
128.61
128.48
128.36
125.35
121.31
120.96
120.44
117.63
112.49
77.48
77.16
76.84
H
Ph
O
O
O
HO
4h
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

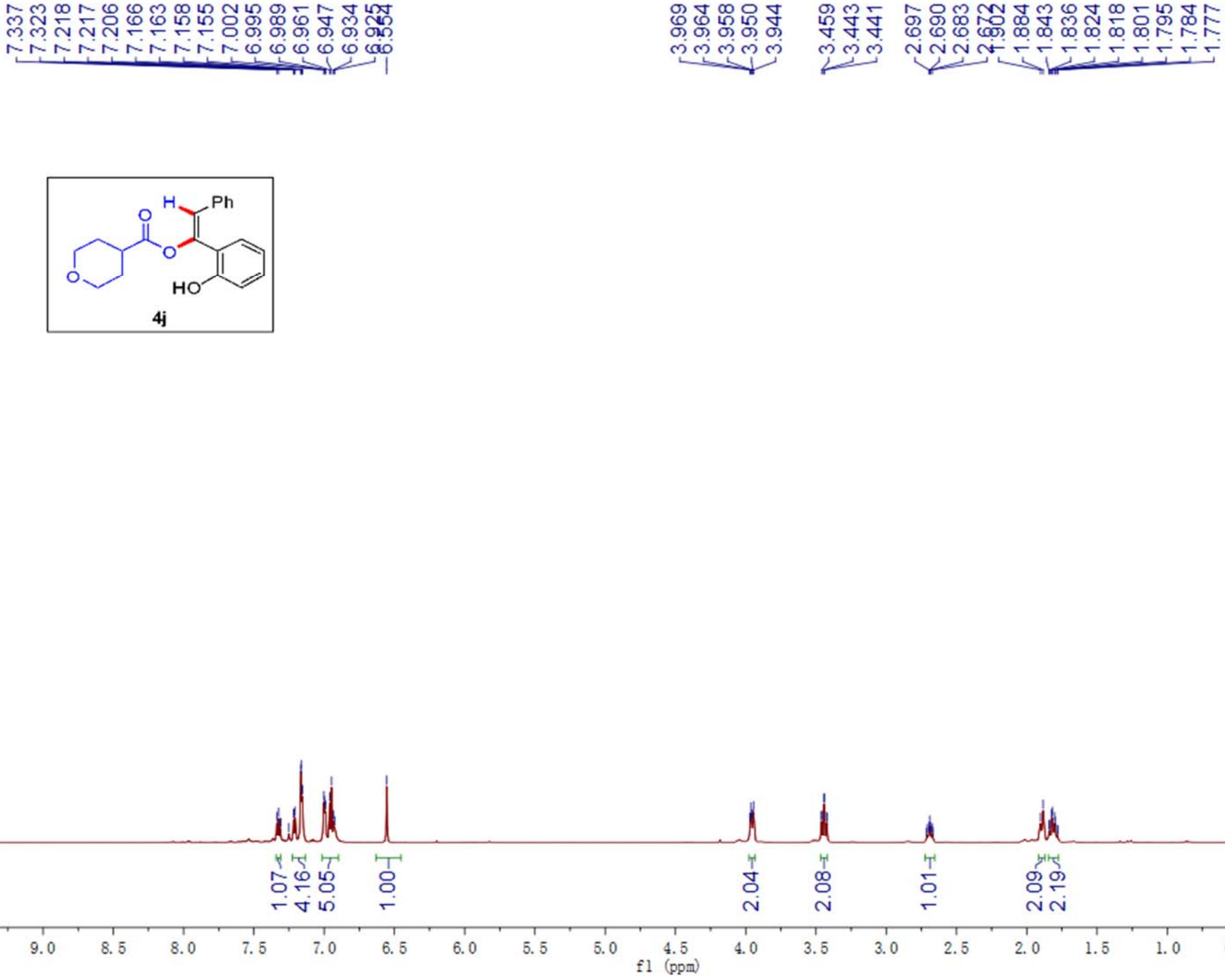

7.930
7.920
7.661
7.649
7.357
7.356
7.355
7.353
7.334
7.318
7.302
7.193
7.186
7.177
7.154
7.146
7.133
7.051
7.046
7.037
7.028
6.996
6.977
6.960
6.941
6.737

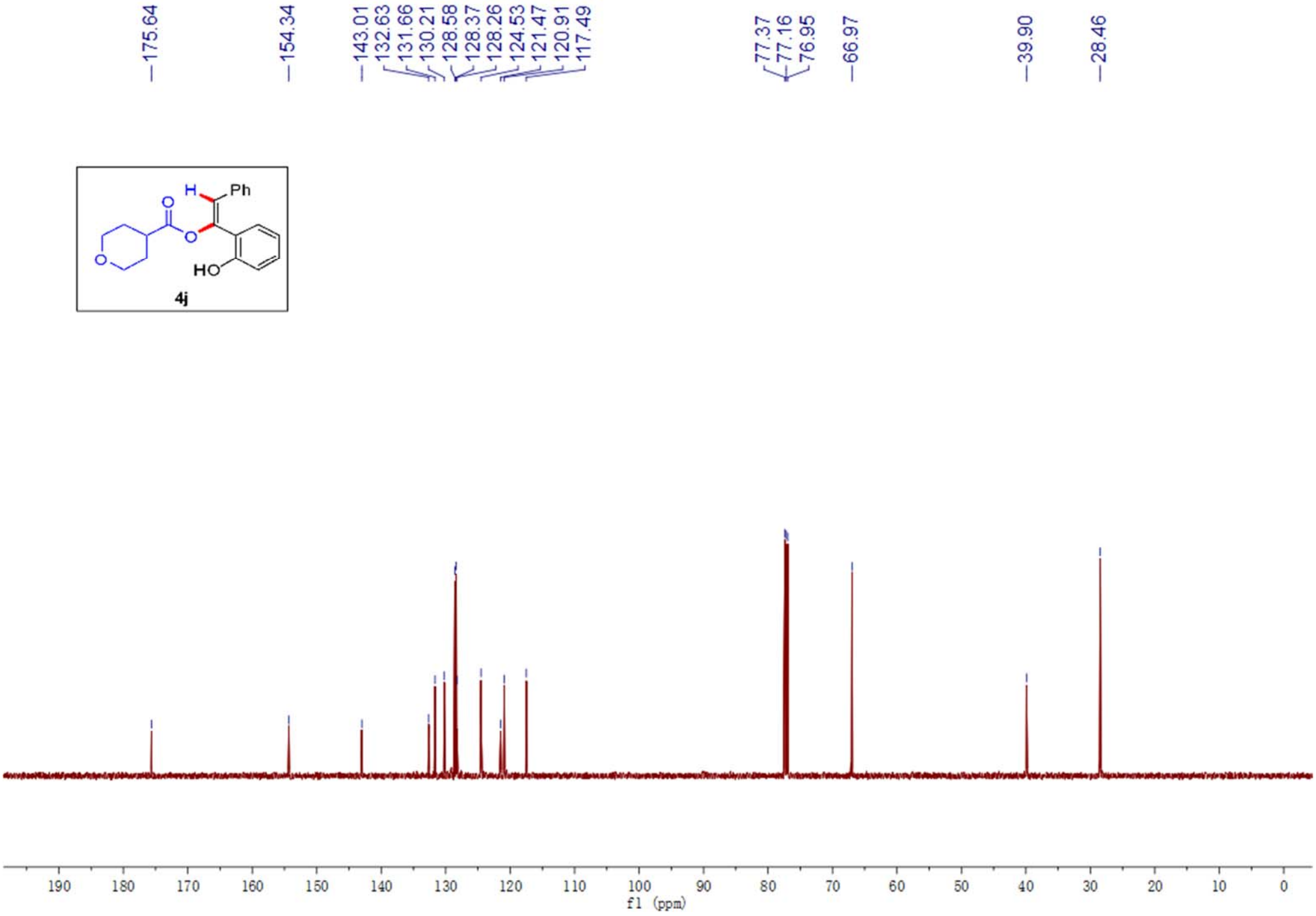

H
Ph
O
O
S
HO

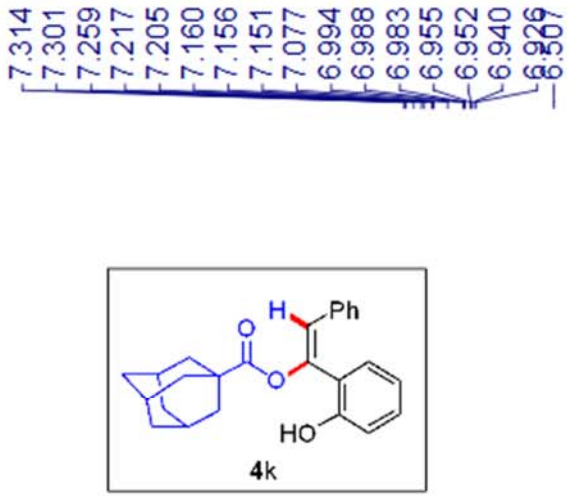
4i

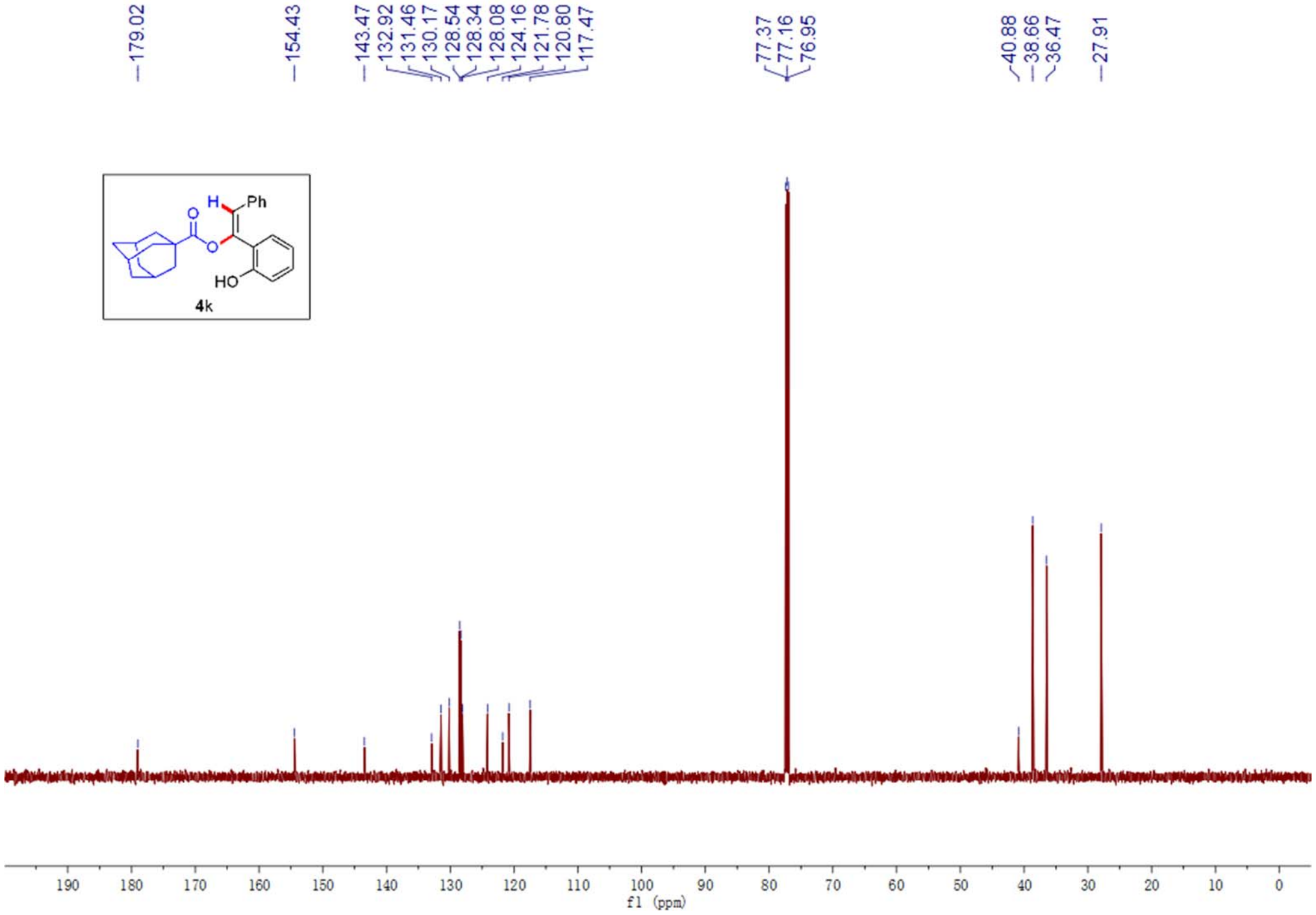

1.00
0.98
2.04
5.06
2.03
2.06
1.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.
f1 (ppm)

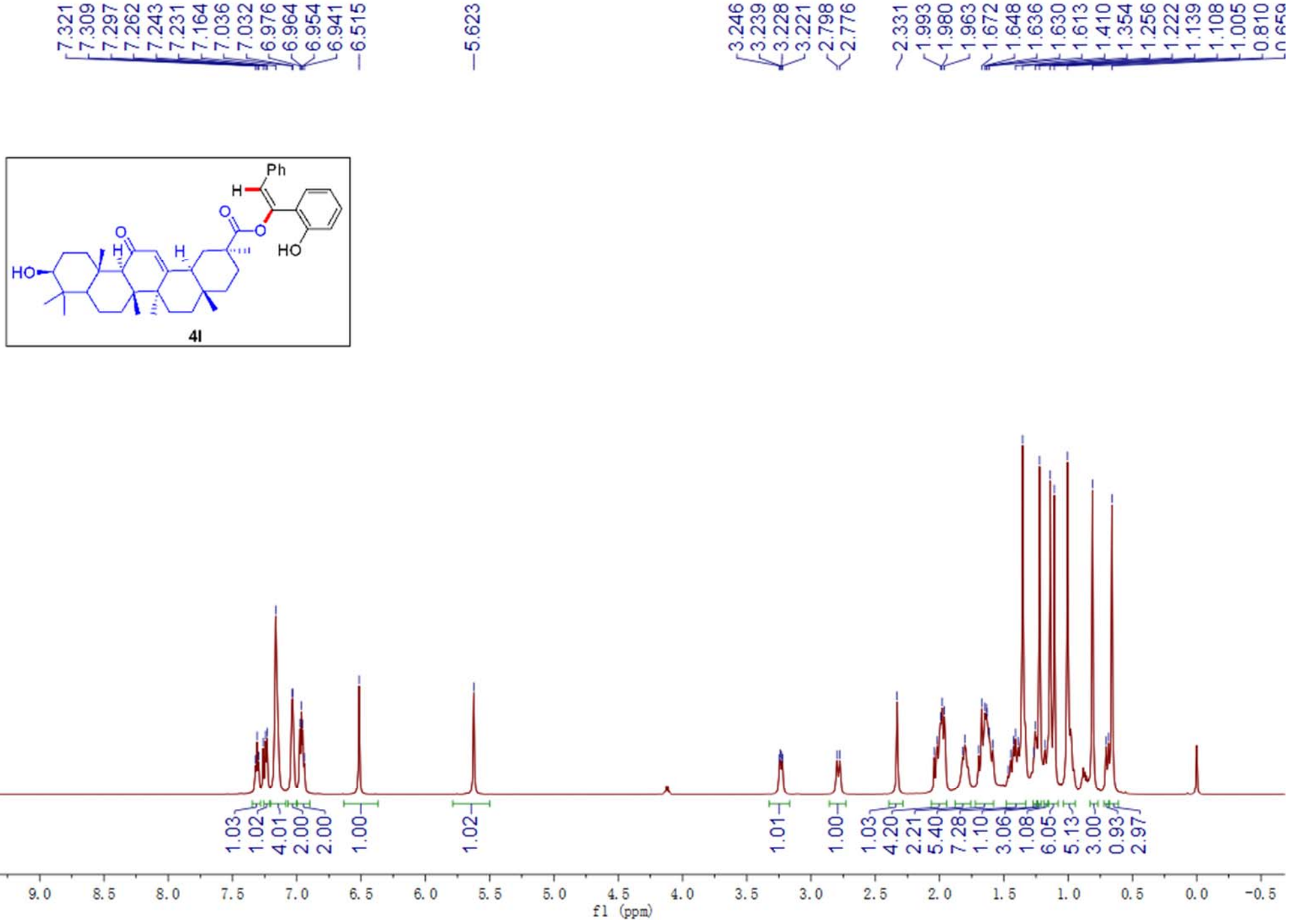

163.22
154.53
142.92
135.37
134.34
132.65
132.13
131.77
130.52
128.63
128.49
128.35
128.29
125.28
121.49
120.97
117.62
77.48
77.16
76.84
H
Ph
O
O
S
HO
4i
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.337
7.323
7.218
7.217
7.206
7.166
7.163
7.158
7.155
7.002
6.995
6.989
6.961
6.947
6.934
3.969
3.964
3.958
3.950
3.944
3.459
3.443
3.441
2.697
2.690
2.683
1.884
1.843
1.836
1.824
1.818
1.801
1.795
1.784
1.777
H
Ph
O
O
O
HO
4j
1.07
4.16
5.05
1.00
2.04
2.08
1.01
2.09
2.19
f1 (ppm)


175.64
154.34
143.01
132.63
131.66
130.21
128.58
128.37
128.26
124.53
121.47
120.91
117.49
77.37
77.16
76.95
66.97
39.90
28.46
H
Ph
O
O
O
HO
4j
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.314
7.301
7.259
7.217
7.205
7.160
7.156
7.151
7.077
6.994
6.988
6.983
6.955
6.952
6.940
6.926
6.507
2.045
1.941
1.759
1.739
1.716
1.696
H
Ph
O
O
HO
4k
1.05
1.10
3.00
1.00
4.11
1.00
3.04
6.10
6.45
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


179.02
154.43
143.47
132.92
131.46
130.17
128.54
128.34
128.08
124.16
121.78
120.80
117.47
77.37
77.16
76.95
40.88
38.66
36.47
27.91
H
Ph
O
O
HO
4k
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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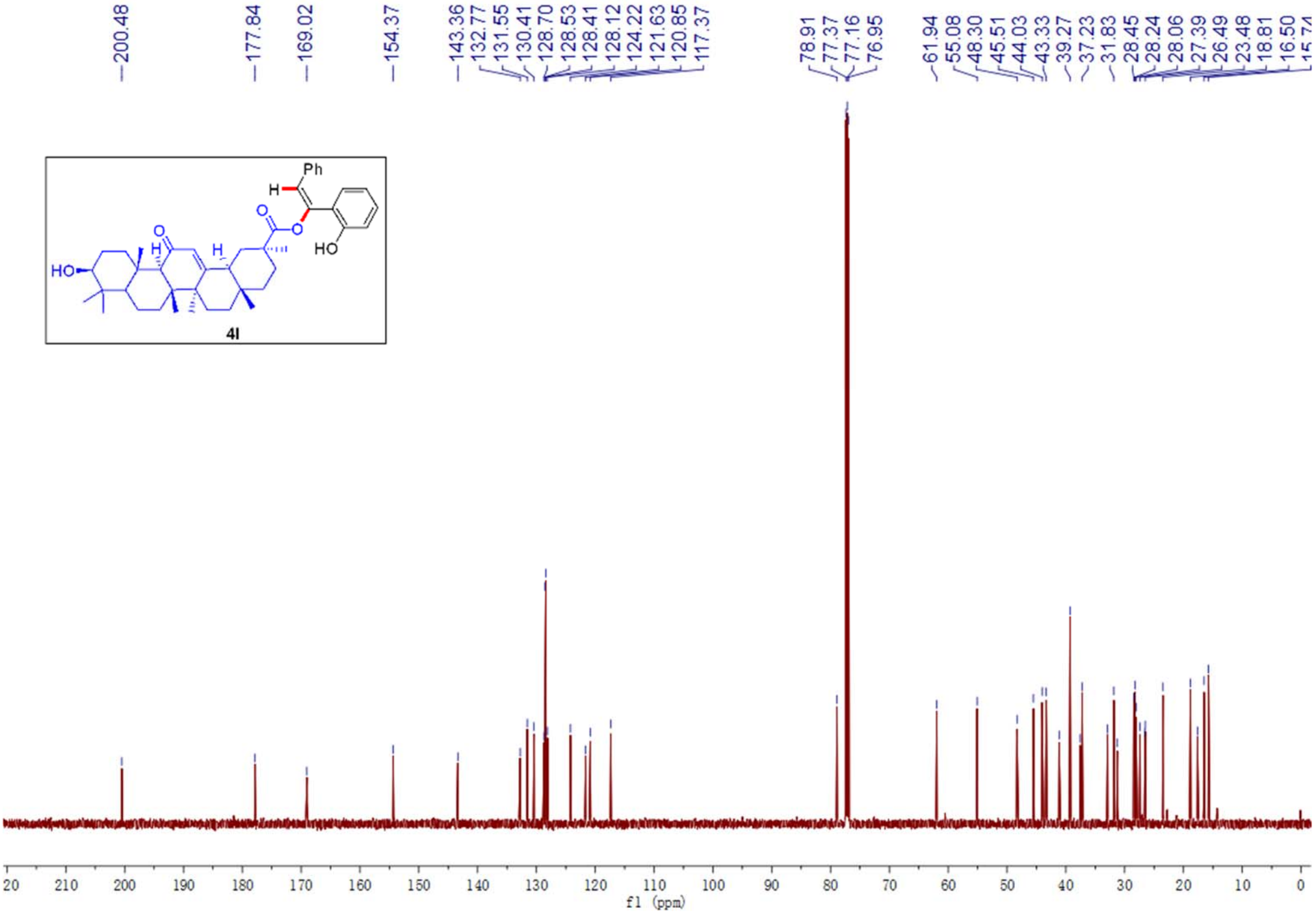
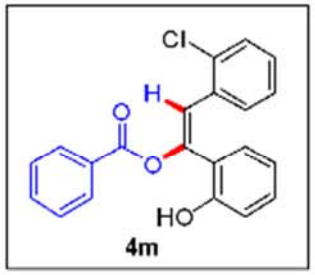
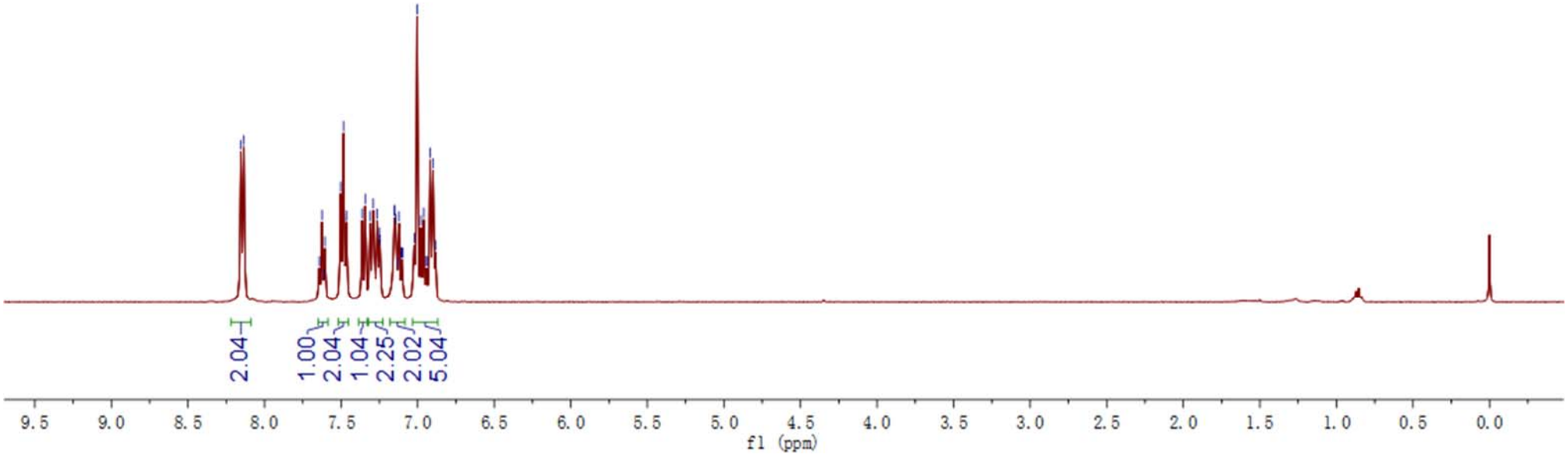
7.309
7.297
7.262
7.243
7.231
7.164
7.036
7.032
6.976
6.964
6.954
6.941
6.515
5.623
3.246
3.239
3.228
3.221
2.798
2.776
2.331
1.993
1.980
1.963
1.672
1.648
1.636
1.630
1.613
1.410
1.354
1.256
1.222
1.139
1.108
1.005
0.810
Ph
H
O
O
O
H
HO
HO
4l
1.03
1.02
4.01
2.00
2.00
1.00
1.02
1.01
1.00
1.03
4.20
2.21
5.40
7.28
1.10
3.06
1.08
6.05
5.13
3.00
0.93
2.97
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

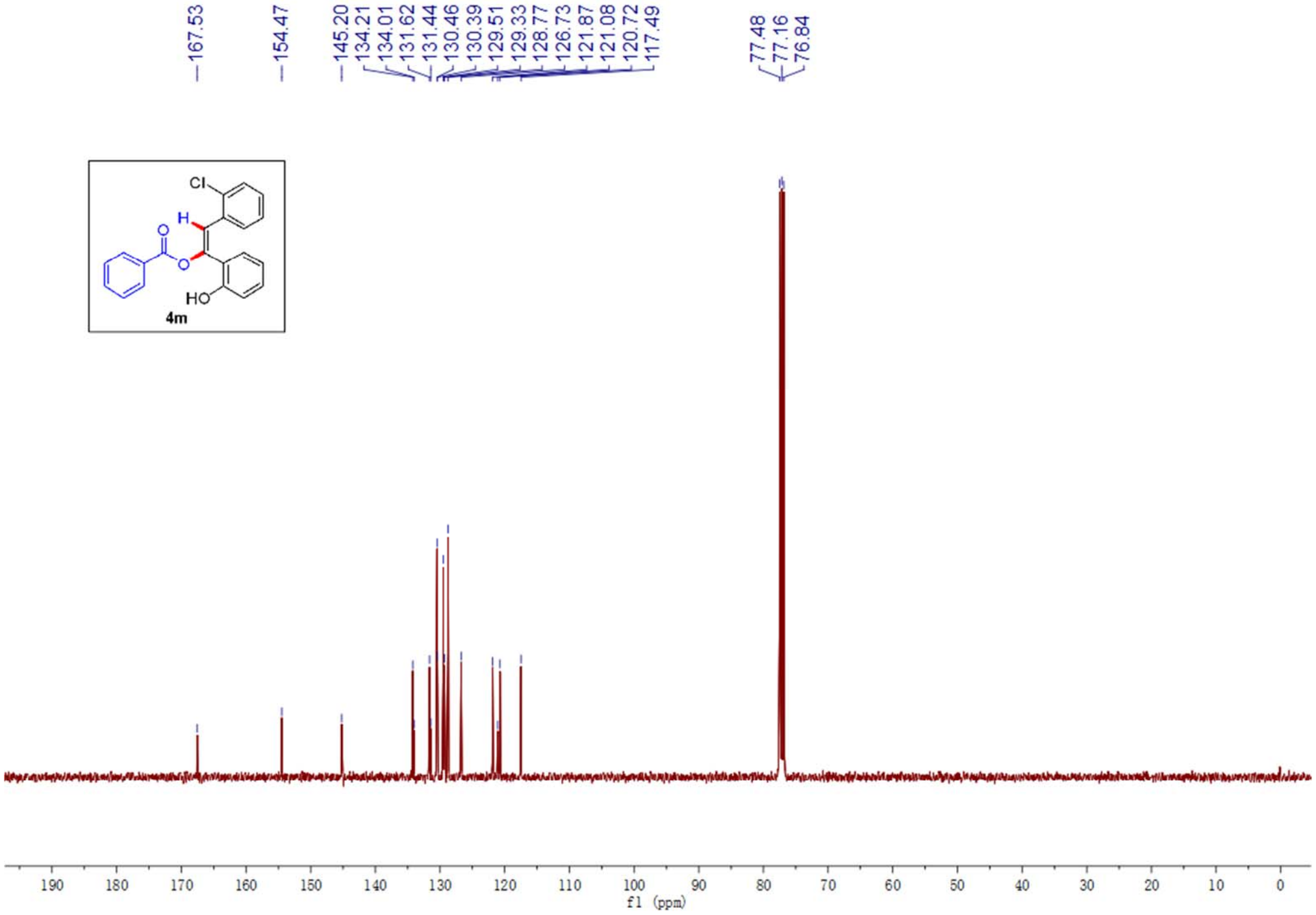

200.48
177.84
169.02
154.37
143.36
132.77
131.55
130.41
128.70
128.53
128.41
128.12
124.22
121.63
120.85
117.37
78.91
77.37
77.16
76.95
61.94
55.08
48.30
45.51
44.03
43.33
39.27
37.23
31.83
28.45
28.24
28.06
27.39
26.49
23.48
18.81
16.50
Ph
H
O
O
O
H
H
HO
HO
4l
f1 (ppm)

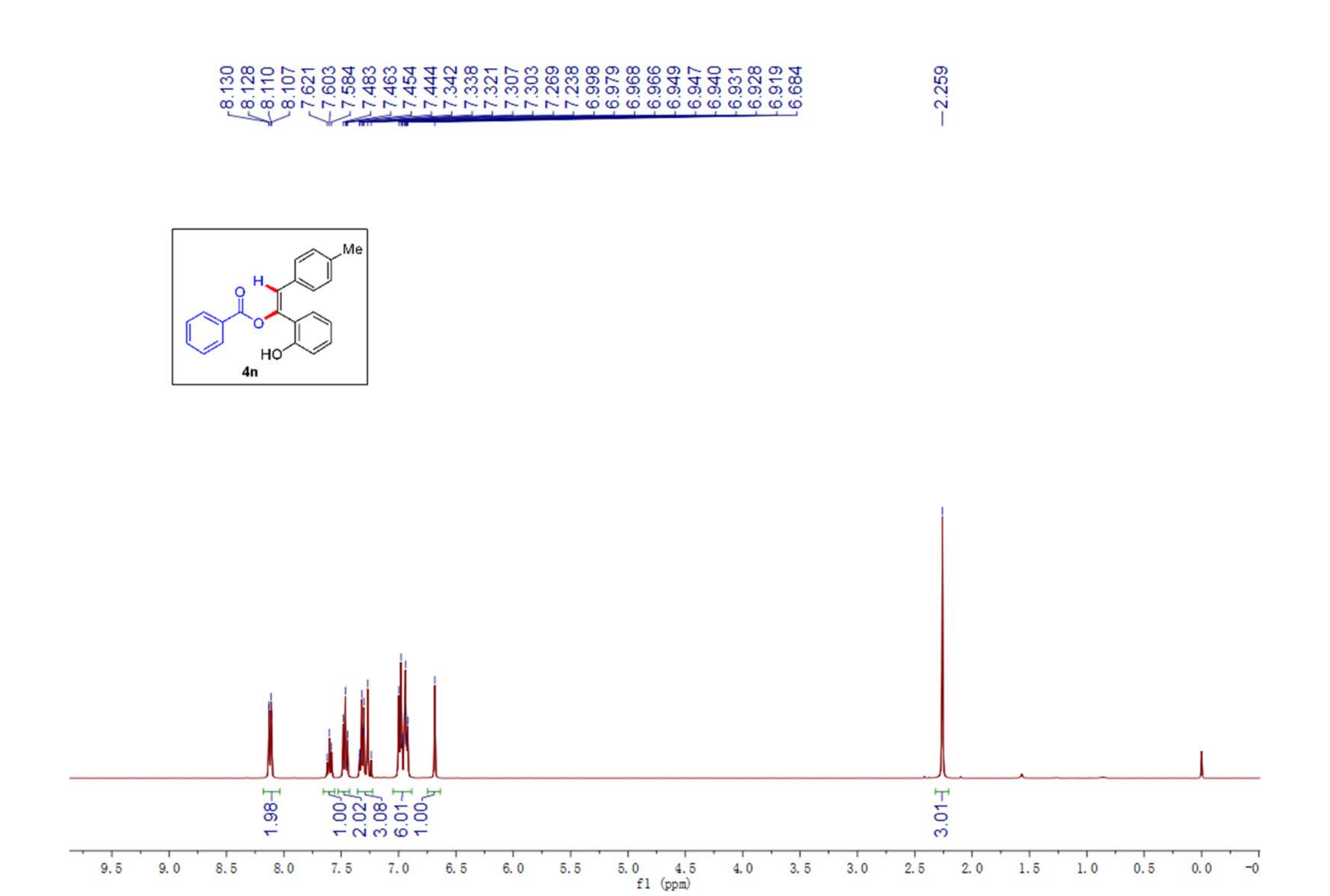

8.154
8.135
7.643
7.625
7.614
7.606
7.503
7.484
7.465
7.362
7.342
7.309
7.290
7.264
7.250
7.245
7.151
7.150
7.143
7.131
7.121
7.103
7.103
7.102
7.101
7.023
7.004
6.979
6.960
6.942
6.941
6.918
6.900
6.884

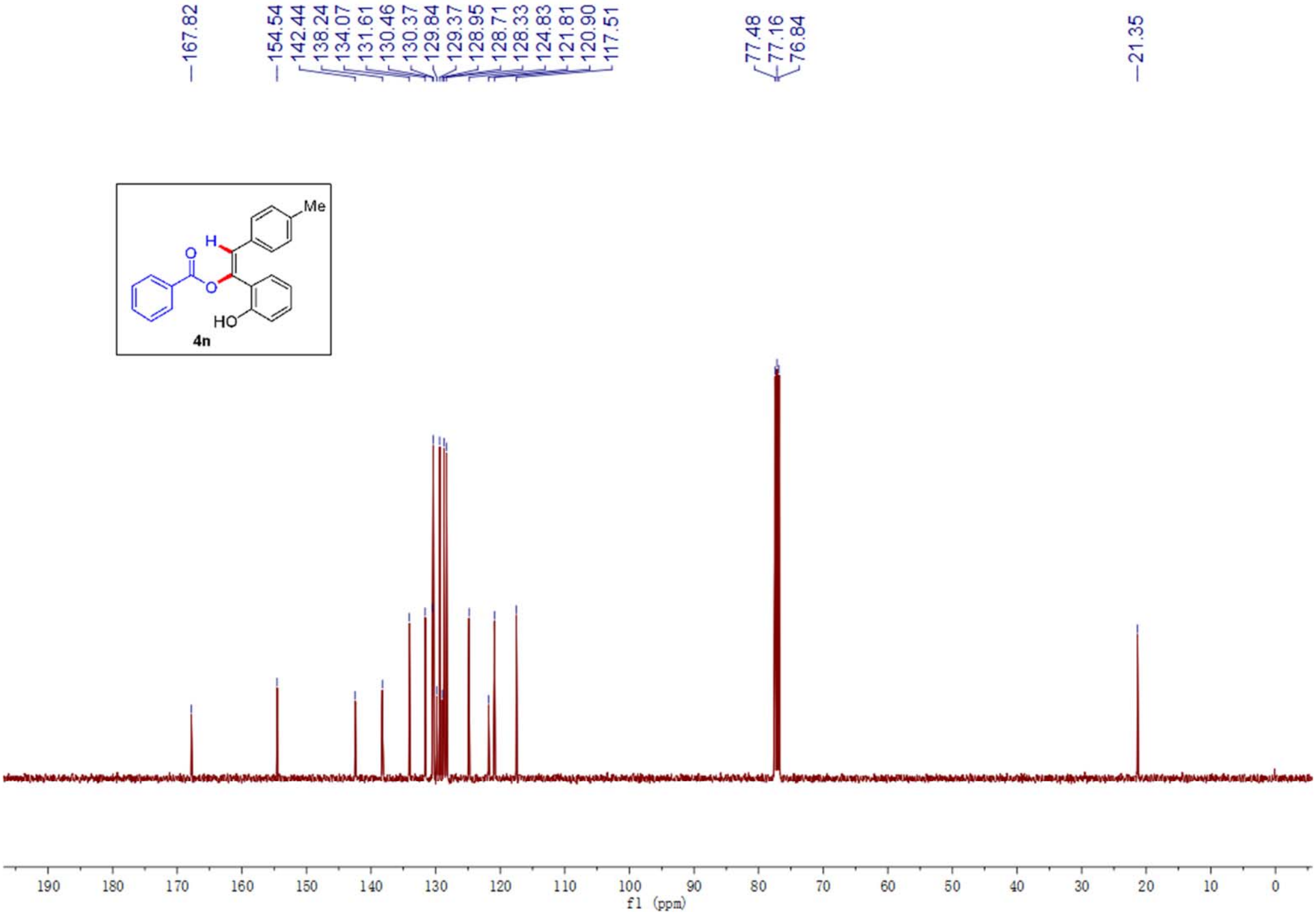

Cl
H
O
O
HO

4m

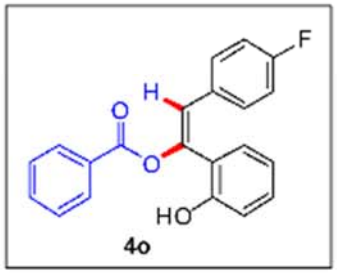

2.04
1.00
2.04
1.04
2.25
2.02
5.04
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


167.53
154.47
145.20
134.21
134.01
131.62
131.44
130.46
130.39
129.51
129.33
128.77
126.73
121.87
121.08
120.72
117.49
77.48
77.16
76.84
Cl
H
O
O
HO
4m
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

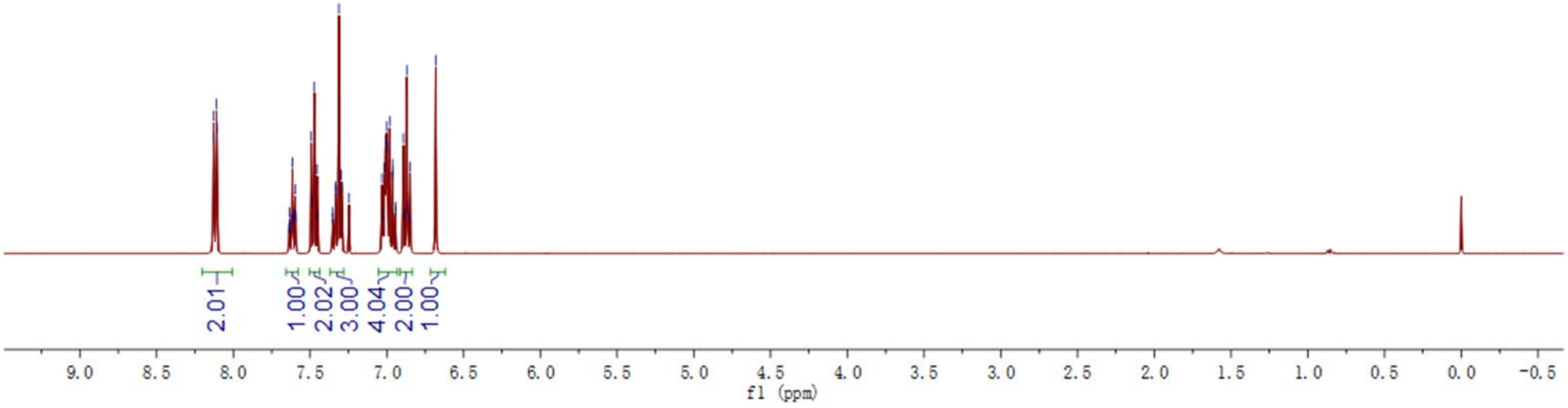

8.130
8.128
8.110
8.107
7.621
7.603
7.584
7.483
7.463
7.454
7.444
7.342
7.338
7.321
7.307
7.303
7.269
7.238
6.998
6.979
6.968
6.966
6.949
6.947
6.940
6.931
6.928
6.919
6.684
2.259
Me
H
O
O
HO
4n
1.98
1.00
2.02
3.08
6.01
1.00
3.01
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

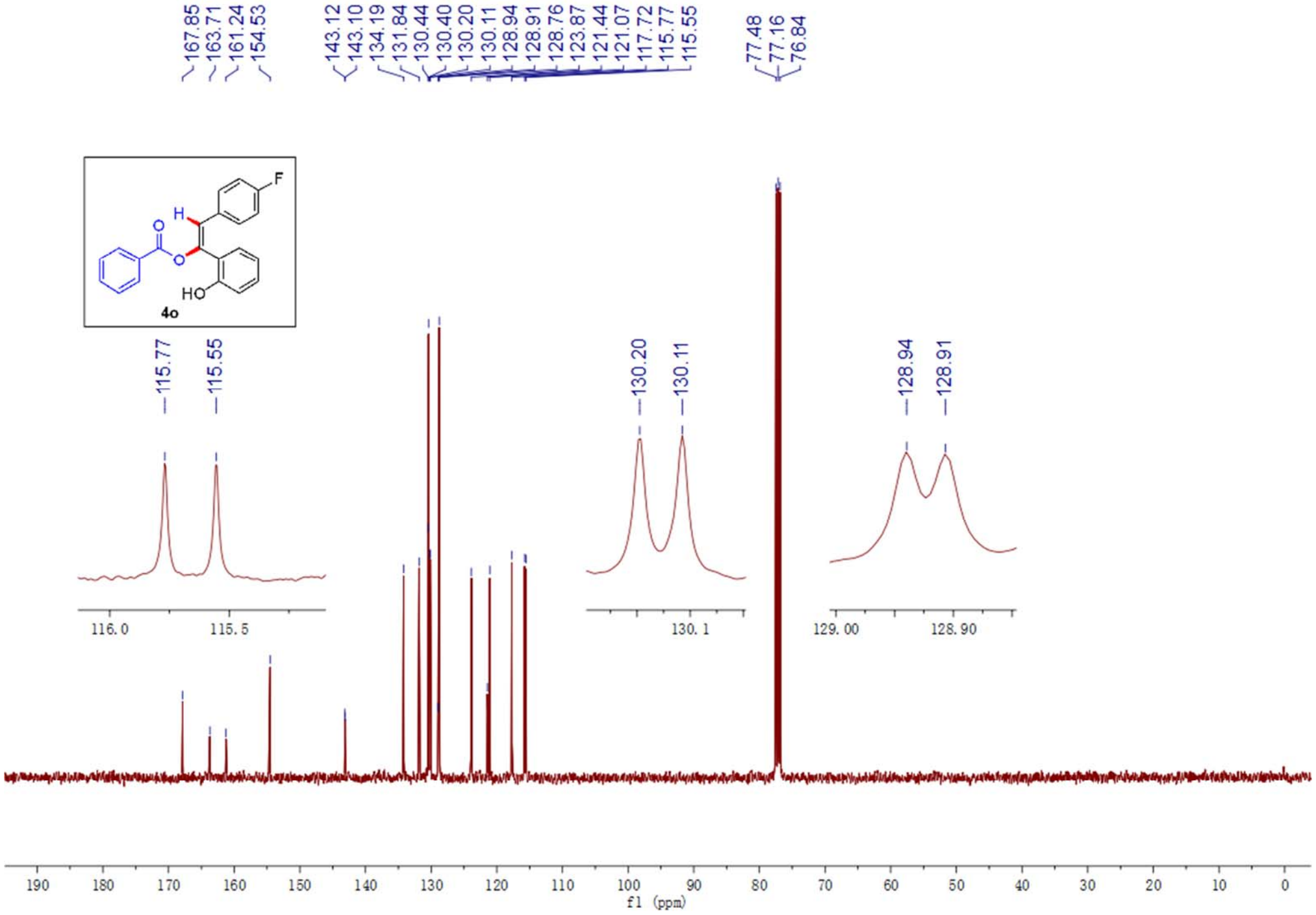

167.82
154.54
142.44
138.24
134.07
131.61
130.46
130.37
129.84
129.37
128.95
128.71
128.33
124.83
121.81
120.90
117.51
77.48
77.16
76.84
21.35
Me
H
O
O
HO
4n
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.131
8.128
8.110
8.107
7.637
7.634
7.631
7.620
7.615
7.611
7.600
7.597
7.593
7.492
7.488
7.472
7.458
7.453
7.356
7.352
7.333
7.331
7.312
7.296
7.293
7.247
7.031
7.026
7.017
7.009
7.002
6.996
6.982
6.963
6.961
6.944
6.942
6.892
6.886
6.870
6.865
6.853
6.848
6.682

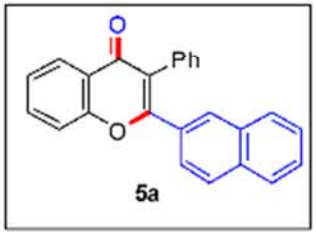

F
H
O
O
HO

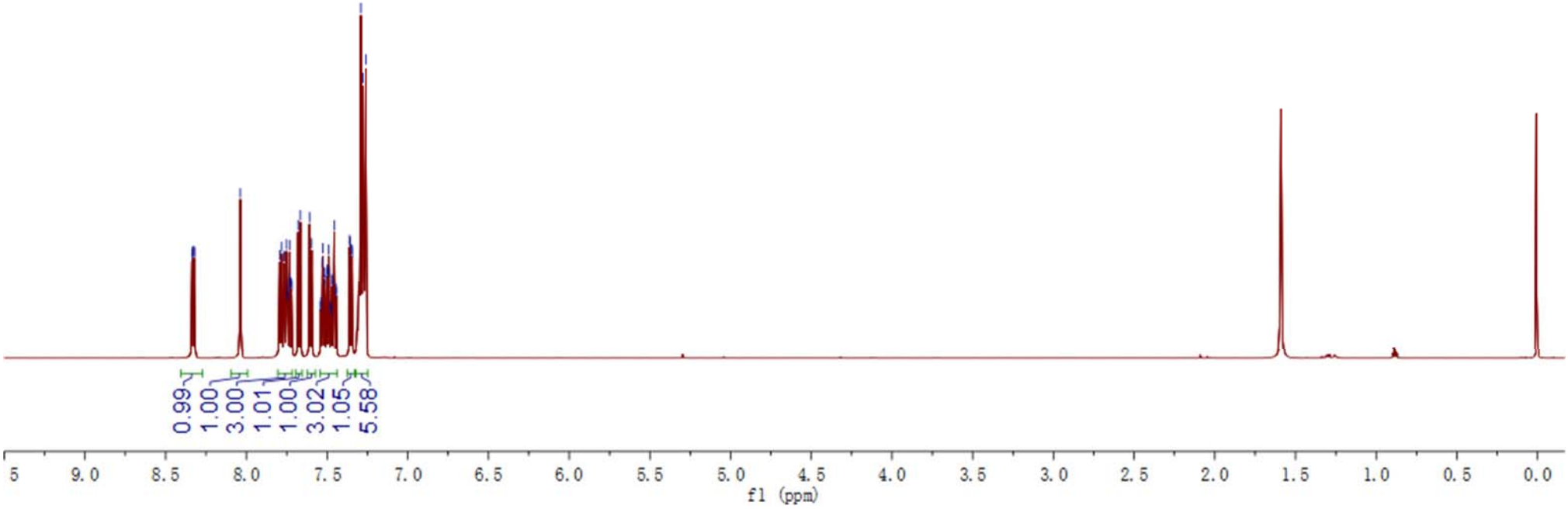
4o


2.01
1.00
2.02
3.00
4.04
2.00
1.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


167.85
163.71
161.24
154.53
143.12
143.10
134.19
131.84
130.44
130.40
130.20
130.11
128.94
128.91
128.76
123.87
121.44
121.07
117.72
115.77
115.55
77.48
77.16
76.84
F
H
O
O
HO
4o
115.77
115.55
130.20
130.11
128.94
128.91
116.0
115.5
130.1
129.00
128.90
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.336
8.334
8.323
8.321
8.037
7.794
7.780
7.765
7.751
7.746
7.743
7.734
7.731
7.729
7.720
7.717
7.679
7.665
7.608
7.594
7.540
7.538
7.528
7.526
7.515
7.513
7.502
7.500
7.488
7.487
7.477
7.475
7.468
7.466
7.455
7.443
7.441
7.360
7.357
7.346
7.343
7.290
7.277
7.259


O
Ph
O
5a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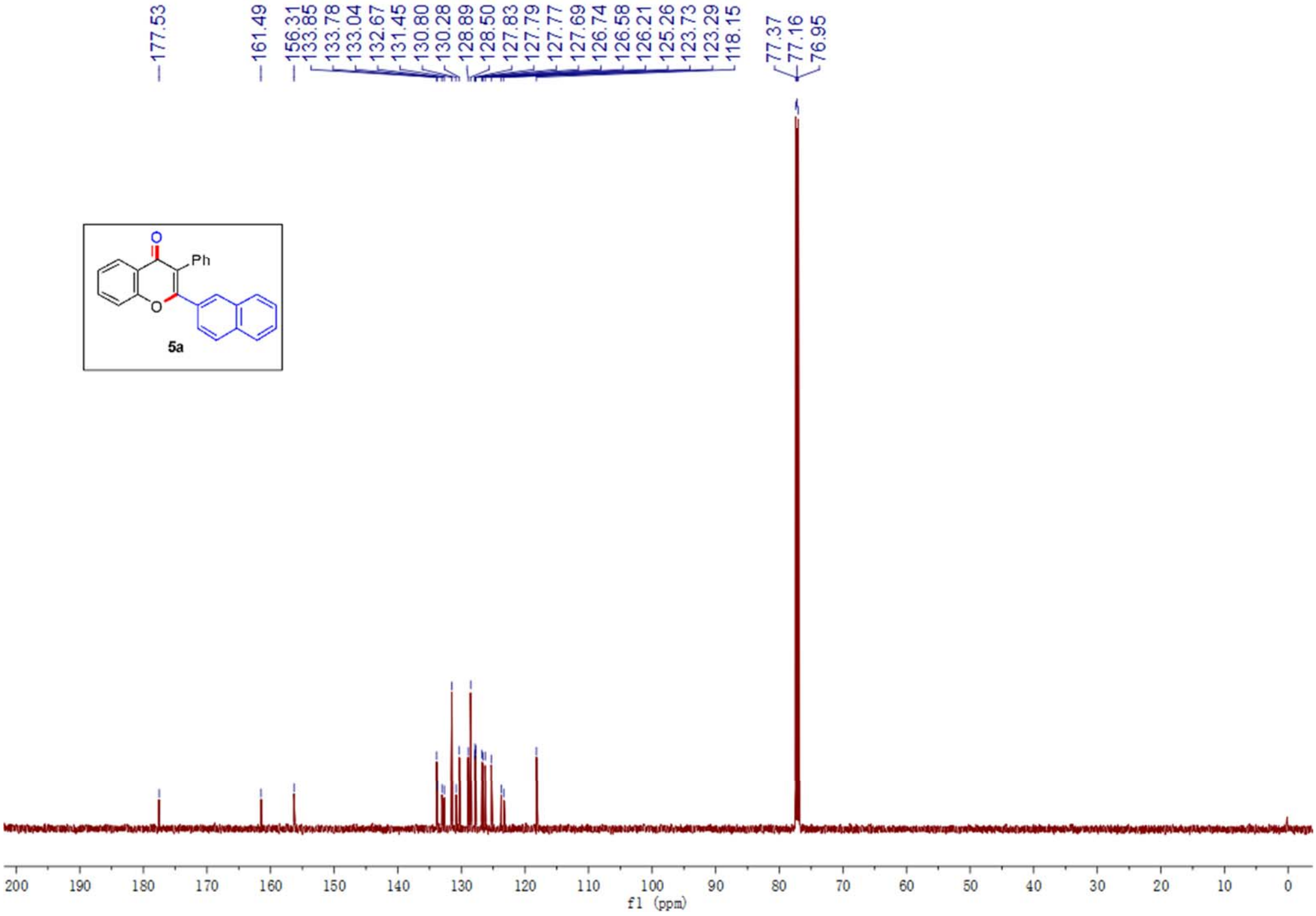
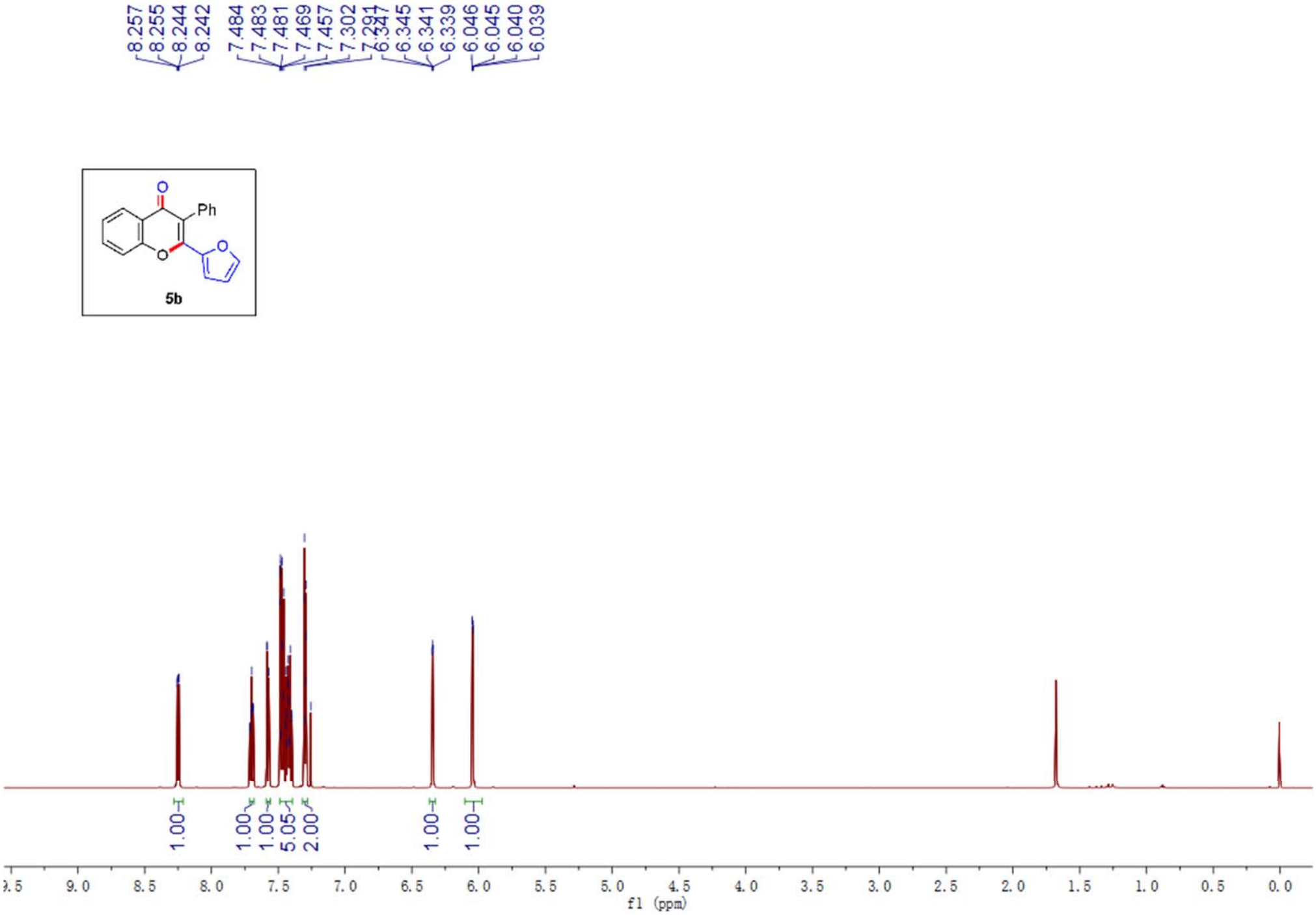
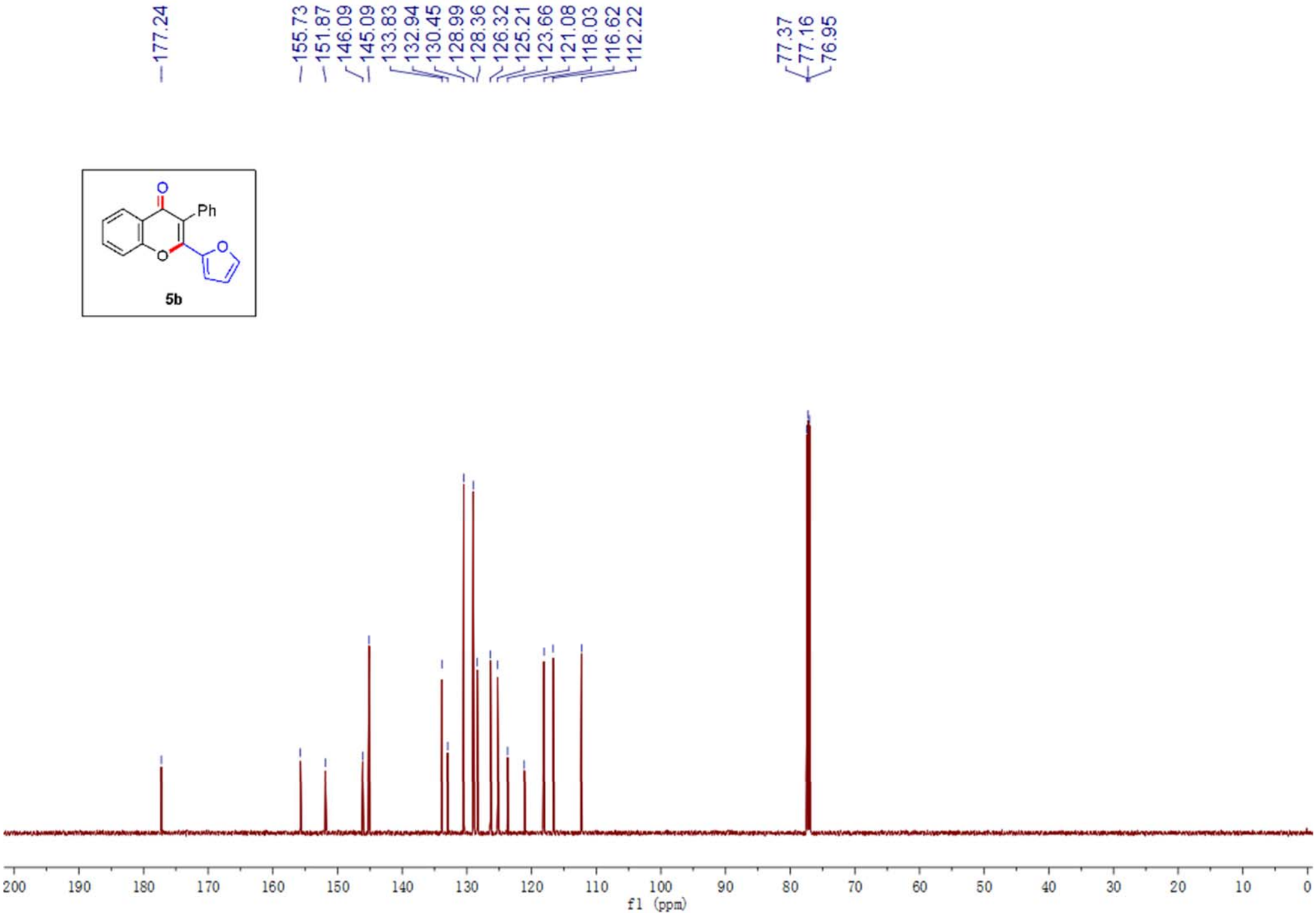
1.00
3.00
1.01
1.00
3.02
1.05
5.58
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


177.53
161.49
156.31
133.85
133.78
133.04
132.67
131.45
130.80
130.28
128.89
128.50
127.83
127.79
127.77
127.69
126.74
126.58
126.21
125.26
123.73
123.29
118.15
77.37
77.16
76.95
O
Ph
O
5a
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.257
8.255
8.244
8.242
7.484
7.483
7.481
7.469
7.457
7.302
7.291
6.347
6.345
6.341
6.339
6.046
6.045
6.040
6.039
O
Ph
O
O
5b
1.00
1.00
1.00
5.05
2.00
1.00
1.00
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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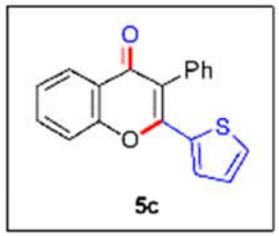
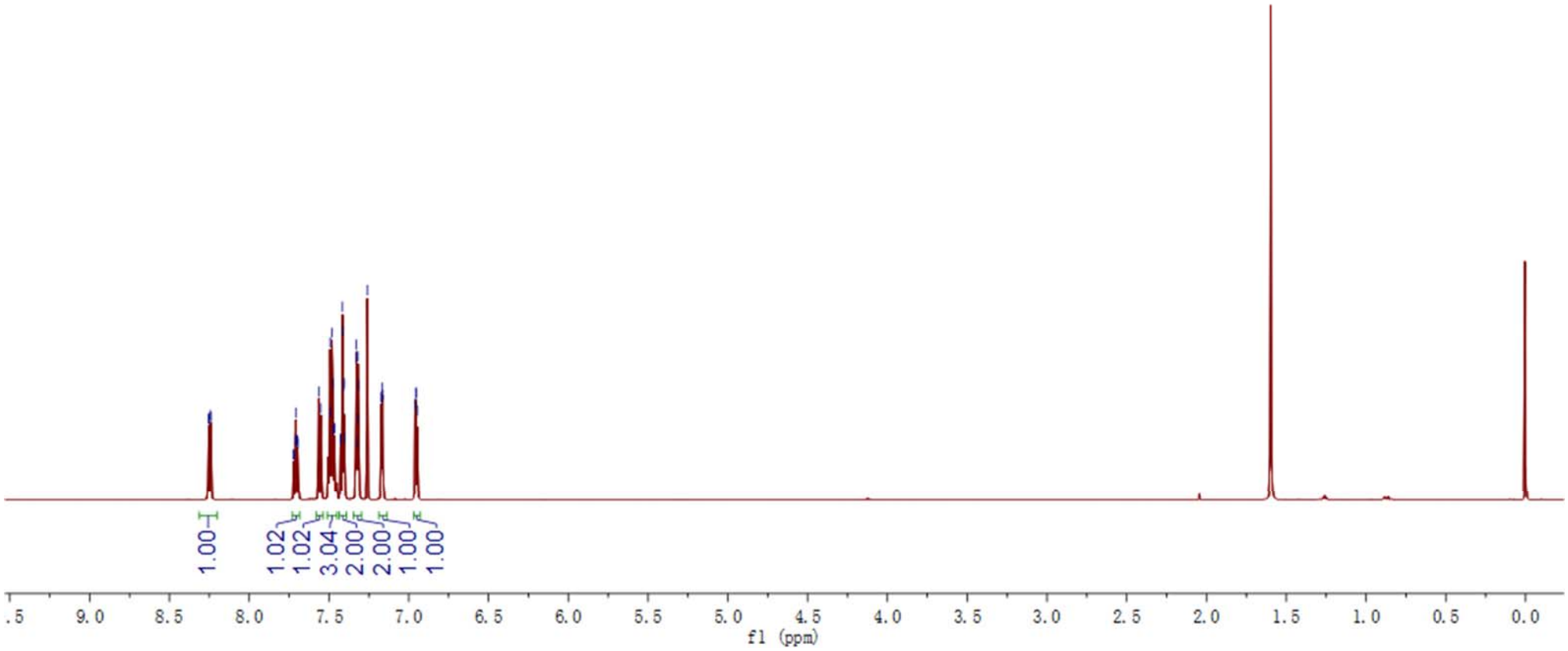
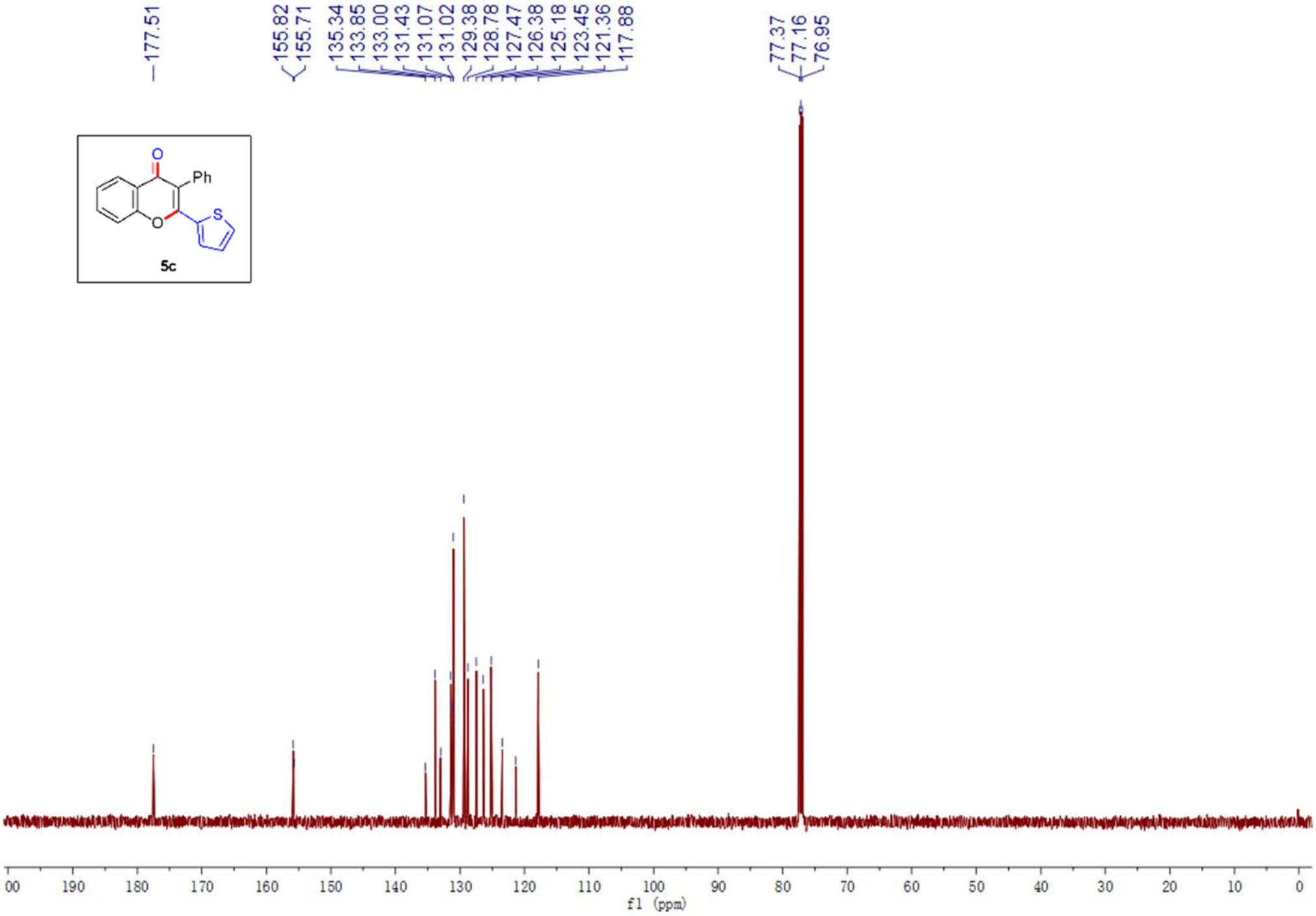
155.73
151.87
146.09
145.09
133.83
132.94
130.45
128.99
128.36
126.32
125.21
123.66
121.08
118.03
116.62
112.22
77.37
77.16
76.95
O
Ph
O
O
5b
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.255
8.253
8.242
8.240
7.721
7.719
7.709
7.707
7.705
7.695
7.693
7.563
7.550
7.492
7.490
7.480
7.475
7.472
7.464
7.428
7.426
7.415
7.413
7.406
7.404
7.401
7.330
7.327
7.324
7.319
7.316
7.314
7.259
7.171
7.169
7.164
7.162
6.960
6.954
6.952
6.946


O
Ph
O
S
5c


1.00
1.02
1.02
3.04
2.00
2.00
1.00
1.00
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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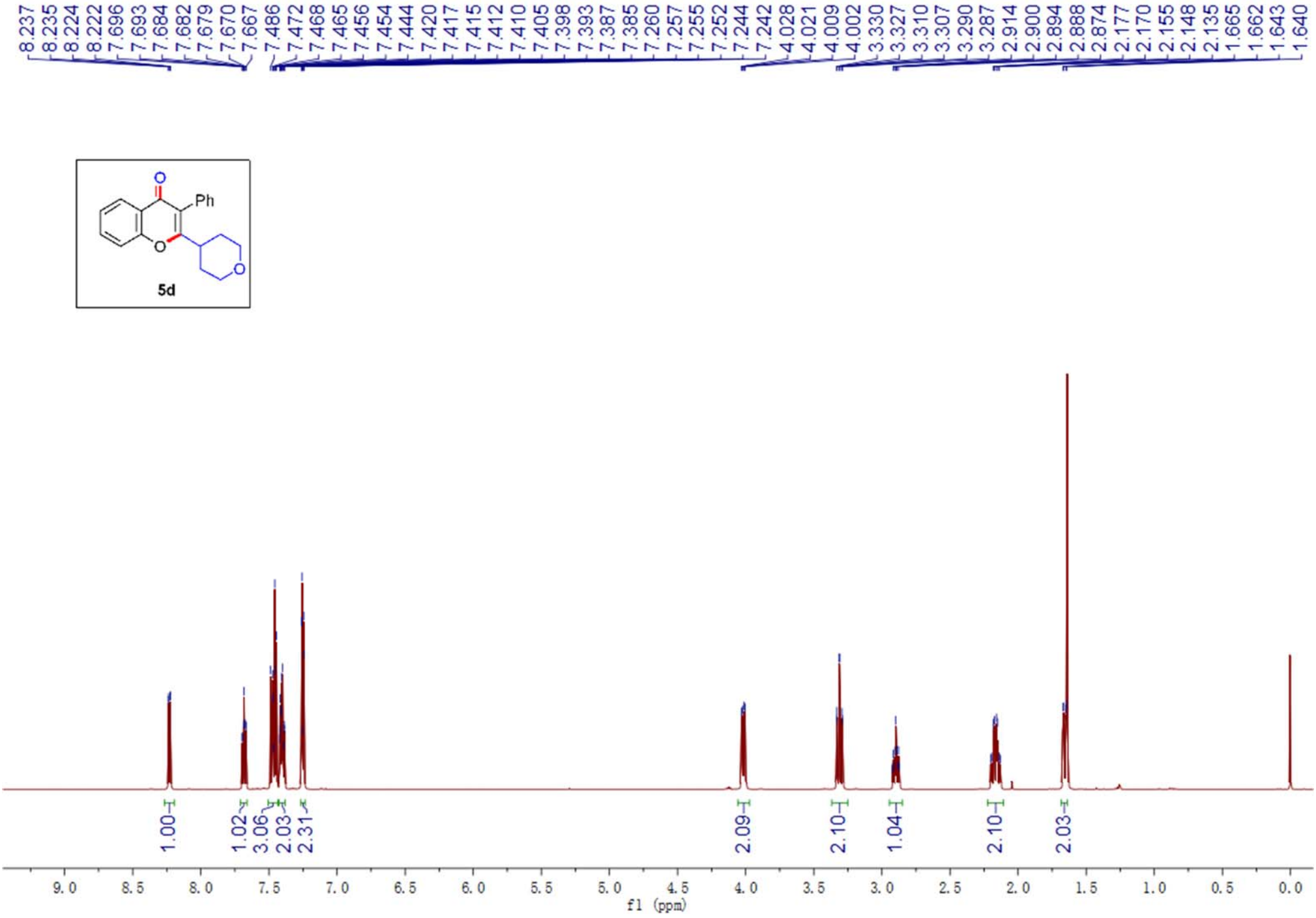
133.00
131.43
131.07
131.02
129.38
128.78
127.47
126.38
125.18
123.45
121.36
117.88
77.37
77.16
76.95
O
Ph
O
S
5c
f1 (ppm)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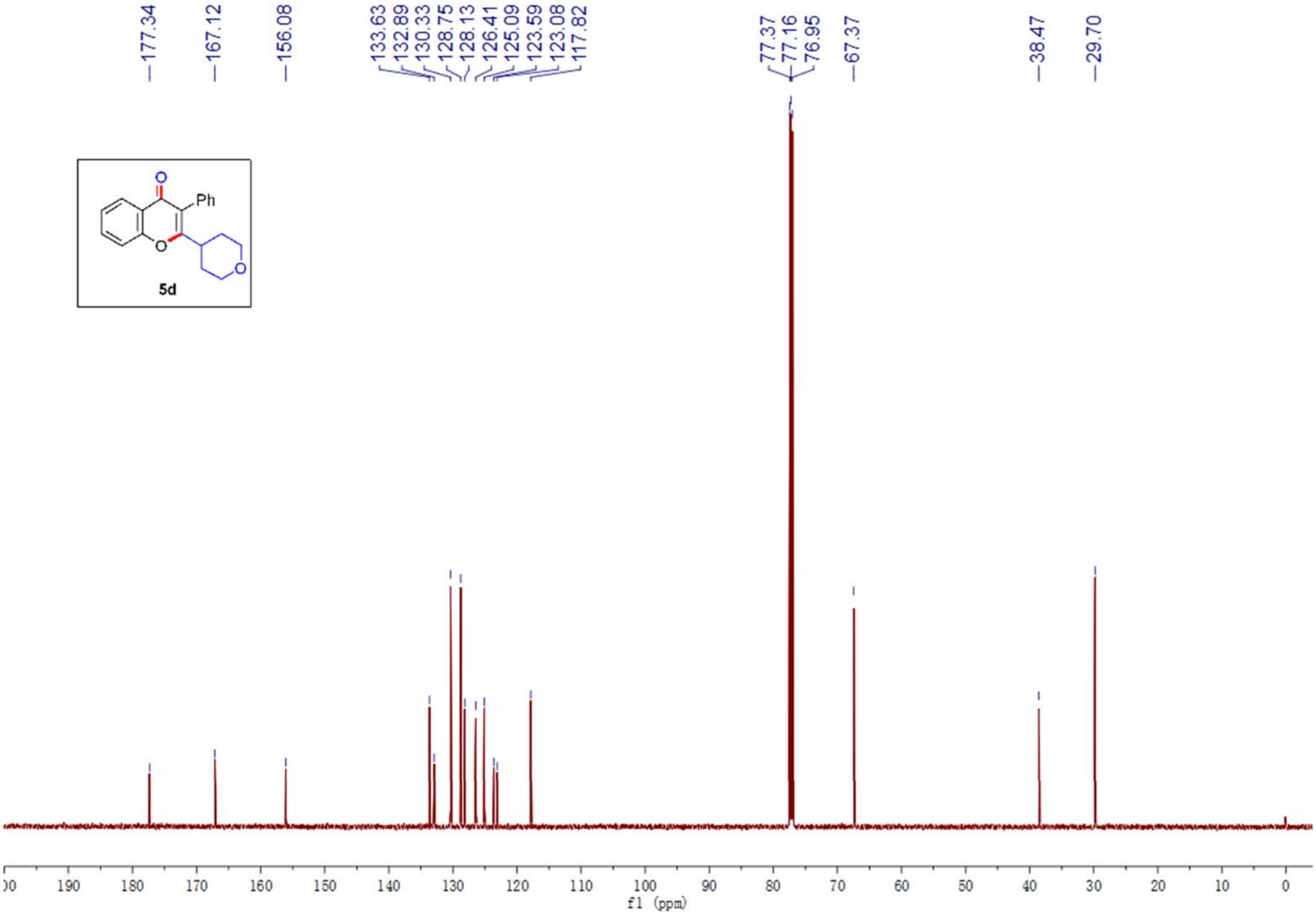
8.222
7.696
7.693
7.684
7.682
7.679
7.670
7.667
7.486
7.472
7.468
7.465
7.456
7.454
7.444
7.420
7.417
7.415
7.412
7.410
7.405
7.398
7.393
7.387
7.385
7.260
7.257
7.255
7.252
7.244
7.242
4.028
4.021
4.009
4.002
3.330
3.327
3.310
3.307
3.290
3.287
2.914
2.900
2.894
2.888
2.874
2.177
2.170
2.155
2.148
2.135
1.665
1.662
1.643
1.640
O
Ph
O
O
5d
1.00
1.02
3.06
2.03
2.31
2.09
2.10
1.04
2.10
2.03
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


177.34
167.12
156.08
133.63
132.89
130.33
128.75
128.13
126.41
125.09
123.59
123.08
117.82
77.37
77.16
76.95
67.37
38.47
29.70
O
Ph
O
O
5d
f1 (ppm)