Supporting Information

Metal-free Desulfurizing Radical Reductive C-C Coupling of Thiols and Alkenes

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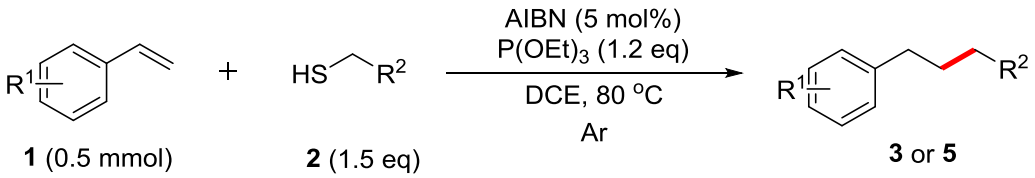
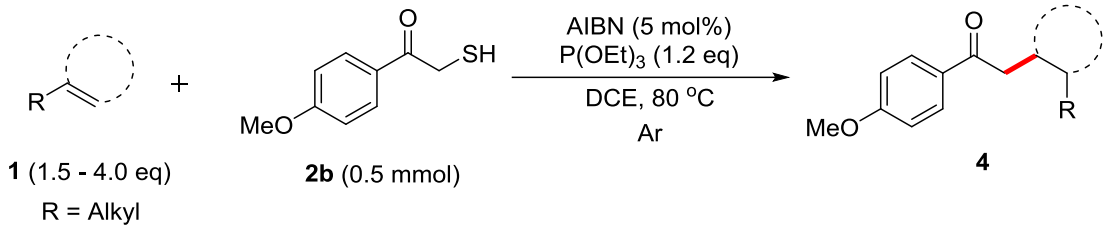
1. General information

All manipulations were conducted with a standard Schlenk technique under argon atmosphere (1 atm). ^{1}H-NMR spectra were recorded with a Bruker AVIII-400 spectrometer. Chemical shifts (in ppm) were referenced to $CDCl_3$ (δ = 7.26 ppm) or TMS (δ = 0.00 ppm) as an internal standard. ^{13}C-NMR spectra were obtained by the same NMR spectrometer and were calibrated with $CDCl_3$ (δ = 77.00 ppm). Mass spectra were recorded by PE SCLEX QSTAR spectrometer. Unless otherwise noted, materials obtained from commercial suppliers were used without further purification.

2. General procedure of reductive C-C coupling of styrenes and thiols



General procedure A (for styrenes substrates): a 25 mL Schlenk tube was equipped with a rubber septum and magnetic stir bar and was charged with AIBN (4.5 mg, 5.0 mol %). The tube was evacuated and backfilled with Ar for 3 times. Styrene **1** (0.5 mmol, 1.0 equiv), thiol **2** (0.75 mmol, 1.5 equiv), DCE (4.0 mL), $P(OEt)_3$ (105 uL, 1.2 equiv) were added respectively with syringe under Ar. The mixture was stirred at 80 ℃ under Ar for 12 h. The mixture was diluted with water (10 mL) and extracted with DCM (3 × 10 mL). The combined organic extracts were washed with a saturated solution of NaCl (15 mL), dried over $MgSO_4$, and evaporated in vacuo. The residue was purified by chromatography on silica gel (PE/EA = 50:1) to afford product **3** or **5**.



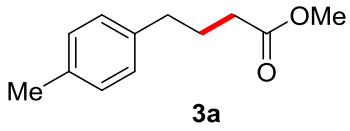
1 (1.5 - 4.0 eq)
R = Alkyl

2b (0.5 mmol)

4

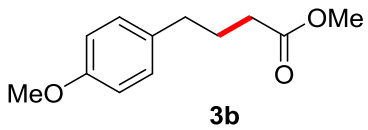
General procedure B (for aliphatic olefins): a 25 mL Schlenk tube was equipped with a rubber septum and magnetic stir bar and was charged with AIBN (4.5 mg, 5.0 mol %) and Thiol **2b** (0.5 mmol, 1.0 equiv). The tube was evacuated and backfilled with Ar for 3 times. Then aliphatic olefins **1** (0.75 mmol, 1.5 equiv), DCE (4.0 mL), $P(OEt)_3$ (105 uL, 1.2 equiv) were added respectively with syringe under Ar. The mixture was stirred at 80 ℃ under Ar for 12 h. The mixture was diluted with water (10 mL) and extracted with DCM (3 × 10 mL). The combined organic extracts were washed with a saturated solution of NaCl (15 mL), dried over $MgSO_4$, and evaporated in vacuo. The residue was purified by chromatography on silica gel (PE/EA = 50:1) to afford product **4.**

3. Analytical Data for All Products



3a

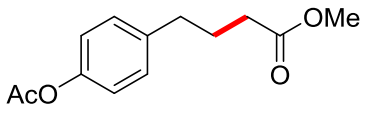
methyl 4-(p-tolyl)butanoate (3a)[1]: According to general procedure A , a solution of **1a** (0.5 mmol, 59.1 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3a** (79.7 mg, 83%) as colorless oil after purification on silica gel (PE:EA=50:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.17-7.06 (m, 4H), 3.70 (s, 3H), 2.65 (t, *J* = 7.6 Hz, 2H), 2.37 (t, *J* = 7.2 Hz, 2H), 2.36 (s, 3H), 2.05-1.92 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.0, 138.3, 135.4, 129.1, 128.4, 51.5, 34.7, 33.4, 26.6, 21.0. MS (70 ev): m/z (%): 58.8 (85), 104.9 (100), 117.8 (55), 191.9 (M+, 15).



3b

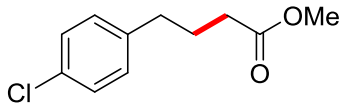
methyl 4-(4-methoxyphenyl)butanoate (3b): According to general procedure A, a solution of **1b** (0.5 mmol, 67.1 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN

(0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3b** (95.7 mg, 92%) as colorless oil after purification on silica gel (PE:EA=50:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.12 (d, *J* = 8.6 Hz, 2H), 6.85 (d, *J* = 8.6 Hz, 2H), 3.81 (s, 3H), 3.69 (s, 3H), 2.62 (t, *J* = 7.6 Hz, 2H), 2.34 (t, *J* = 7.5 Hz, 2H), 1.98-1.91 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.0, 157.9, 133.5, 129.4, 113.8, 55.3, 51.5, 34.2, 33.4, 26.7. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{12}H_{17}O_3$: 209.1178; found: 209.1178.



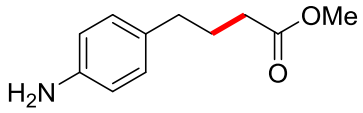
3c

methyl 4-(4-acetoxyphenyl)butanoate (3c): According to general procedure A , a solution of **1c** (0.5 mmol, 81.1 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3c** (89.7 mg, 76%) as colorless oil after purification on silica gel (PE:EA=15:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (d, *J* = 8.5 Hz, 2H), 7.02 (d, *J* = 8.5 Hz, 2H), 3.69 (s, 3H), 2.69-2.63 (m, 2H), 2.36 (t, *J* = 7.4 Hz, 2H), 2.31 (s, 3H), 2.05-1.92 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.9, 169.7, 148.9, 138.9, 129.4, 121.4, 51.6, 34.5, 33.3, 26.4, 21.2. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{13}H_{17}O_4$: 237.1127; found: 237.1131.



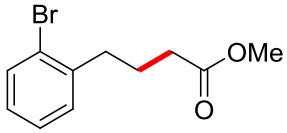
3d

methyl 4-(4-chlorophenyl)butanoate (3d)[1]: According to general procedure A , a solution of **1d** (0.5 mmol, 69.2 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3d** (71.1 mg, 67%) as colorless oil after purification on silica gel (PE:EA=30:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27 (d, *J* = 8.4 Hz, 2H), 7.13 (d, *J* = 8.4 Hz, 2H), 3.69 (s, 3H), 2.72-2.57 (m, 2H), 2.34 (t, *J* = 7.4 Hz, 2H), 1.99-1.91 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.8, 139.8, 131.7, 129.8, 128.5, 51.6, 34.4, 33.2, 26.4. MS (70 ev): m/z (%): 58.8 (95), 88.7 (50), 124.8 (100), 211.7 (M+, 10).



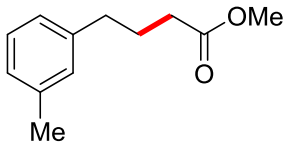
3e

methyl 4-(4-aminophenyl)butanoate (3e): According to general procedure A , a solution of **1e** (0.5 mmol, 59.6 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3e** (72.4 mg, 75%) as colorless oil after purification on silica gel (PE:EA=3:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.99 (d, *J* = 8.3 Hz, 2H), 6.64 (d, *J* = 8.4 Hz, 2H), 3.68 (s, 3H), 3.54 (s, 2H), 2.56 (t, *J* = 7.5 Hz, 2H), 2.34 (t, *J* = 7.5 Hz, 2H), 1.96-1.88 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.1, 144.5, 131.4, 129.3, 115.3, 51.5, 34.3, 33.4, 26.8. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{11}H_{16}NO_2$: 194.1181; found: 194.1182.



3f

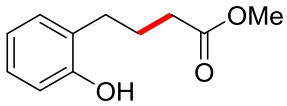
methyl 4-(2-bromophenyl)butanoate (3f)[1]: According to general procedure A , a solution of **1f** (0.5 mmol, 91.5 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3f** (91.0 mg, 71%) as colorless oil after purification on silica gel (PE:EA=50:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 (d, *J* = 8.1 Hz, 1H), 7.32-7.21 (m, 2H), 7.10-7.05 (m, 1H), 3.70 (s, 3H), 2.80 (t, *J* = 7.6 Hz, 2H), 2.47-2.37 (m, 2H), 2.09-1.91 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.8, 140.7, 132.9, 130.5, 127.8, 127.5, 124.5, 51.6, 35.3, 33.4, 25.0. GC-MS (EI) ([M]) Calcd. for $C_{11}H_{13}ClO_2$: 212.1; found: 211.7. MS (70 ev): m/z (%): 58.9 (100), 88.8 (85), 168.8 (60), 255.8 (M+, 5).



3g

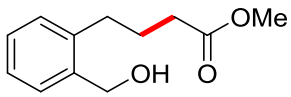
methyl 4-(m-tolyl)butanoate (3g)[2]: According to general procedure A , a solution of **1g** (0.5 mmol, 59.1 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3g** (86.4 mg, 90%) as colorless oil after purification on

silica gel (PE:EA=50:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21 (t, *J* = 7.9 Hz, 1H), 7.08-6.99 (m, 3H), 3.70 (s, 3H), 2.65 (t, *J* = 7.2 Hz, 2H), 2.37 (s, 3H), 2.36 (t, *J* = 7.4 Hz, 2H) 2.02-1.95 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.9, 141.3, 137.9, 129.3, 128.3, 126.7, 125.5, 51.5, 35.1, 33.5, 26.5, 21.4. MS (70 ev): m/z (%): 58.8 (100), 104.9 (85), 117.8 (55), 191.9 (M+, 10).



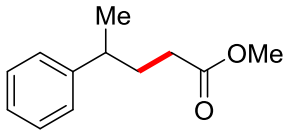
3h

methyl 4-(2-hydroxyphenyl)butanoate (3h): According to general procedure A , a solution of **1a** (0.5 mmol, 60.0 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3h** (62.1 mg, 64%) as colorless oil after purification on silica gel (PE:EA=15:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.17 – 7.09 (m, 2H), 6.91 – 6.83 (m, 2H), 6.49 (s, 1H), 3.74 (s, 3H), 2.69 (t, *J* = 7.6 Hz, 2H), 2.43 (t, *J* = 6.9 Hz, 2H), 1.99-1.91 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.4, 154.3, 130.2, 127.6, 127.2, 120.4, 115.8, 51.9, 32.9, 29.4, 24.9. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{11}H_{15}O_3$: 195.1021; found: 195.1024.



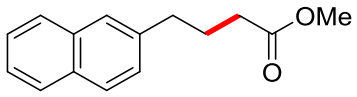
3i

methyl 4-(2-(hydroxymethyl)phenyl)butanoate (3i): According to general procedure A , a solution of **1i** (0.5 mmol, 67.1 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3i** (55.1 mg, 53%) as colorless oil after purification on silica gel (PE:EA=5:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 (m, 1H), 7.31-7.17 (m, 3H), 4.72 (s, 2H), 3.68 (s, 3H), 2.74 (t, *J* = 8.0 Hz, 2H), 2.41 (t, *J* = 7.1 Hz, 2H), 2.23 (s, 1H), 2.08-1.86 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.2, 139.7, 138.5, 129.5, 128.7, 127.9, 126.5, 63.1, 51.6, 33.5, 31.6, 26.2. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{12}H_{17}O_3$: 209.1178; found: 209.1176.



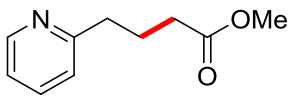
3j

methyl 4-phenylpentanoate (3j)[1]: According to general procedure A , a solution of **1j** (0.5 mmol, 59.1 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3j** (83.5 mg, 87%) as colorless oil after purification on silica gel (PE:EA=50:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36-7.30 (m, 2H), 7.25-7.18 (m, 3H), 3.65 (s, 3H), 2.87-2.67 (m, 1H), 2.37-2.12 (m, 2H), 2.07-1.84 (m, 2H), 1.31 (d, *J* = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.1, 146.2, 128.4, 127.0, 126.2, 51.5, 39.4, 33.2, 32.3, 22.2. MS (70 ev): m/z (%): 58.8 (65), 76.8 (55), 104.9 (100), 191.9 (M+, 10).



3k

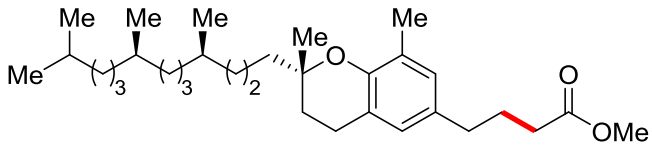
methyl 4-(naphthalen-2-yl)butanoate (3k)[1]: According to general procedure A, a solution of **1k** (0.5 mmol, 77.1 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3k** (87.8 mg, 77%) as colorless oil after purification on silica gel (PE:EA=50:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90-7.77 (m, 3H), 7.66 (s, 1H), 7.56-7.42 (m, 2H), 7.37 (dd, *J* = 8.4, 1.8 Hz, 1H), 3.71 (s, 3H), 2.86 (t, *J* = 7.5 Hz, 2H), 2.41 (t, *J* = 7.5 Hz, 2H), 2.18-2.04 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 174.0, 138.9, 133.6, 132.1, 128.0, 127.6, 127.5, 127.3, 126.6, 126.0, 125.3, 51.5, 35.3, 33.4, 26.4. MS (70 ev): m/z (%): 62.9 (100), 115.9 (100), 197.0 (100), 228.1 (M+, 100).



3l

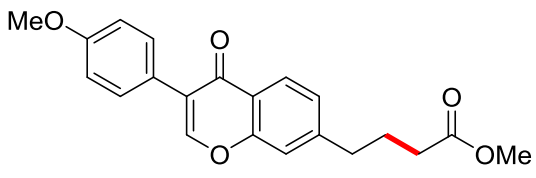
methyl 4-(pyridin-2-yl)butanoate (3l): According to general procedure A, a solution of **1l** (0.5 mmol, 53.1 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025

mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3l** (50.1 mg, 56%) as colorless oil after purification on silica gel (PE:EA=20:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.54-8.51 (m, 1H), 7.59 (td, *J* = 7.7, 1.9 Hz, 1H), 7.19-7.06 (m, 2H), 3.67 (s, 3H), 2.83 (t, *J* = 7.2 Hz, 2H), 2.38 (t, *J* = 7.5 Hz, 2H), 2.12-2.04 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.8, 161.1, 149.3, 136.3, 122.9, 121.2, 51.5, 37.4, 33.4, 24.8. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{10}H_{14}NO_2$: 180.1025; found: 180.1024.



3m

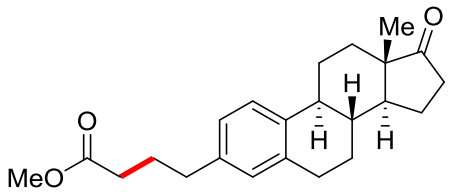
methyl 4-((S)-2,8-dimethyl-2-((4S,8S)-4,8,12-trimethyltridecyl)chroman-6-yl)butanoate (3m): According to general procedure A, a solution of **1m** (0.5 mmol, 206.3 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3m** (141.0 mg, 58%) as colorless oil after purification on silica gel (PE:EA=50:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.79 (s, 1H), 6.73 (s, 1H), 3.69 (s, 3H), 2.76-2.71 (m, 2H), 2.54 (t, *J* = 7.6 Hz, 2H), 2.36 (t, *J* = 7.5 Hz, 2H), 2.16 (s, 3H), 1.97-1.89 (m, 2H), 1.86-1.72 (m, 2H), 1.67-1.02 (m, 21H), 1.28 (s, 3H), 0.90-0.86 (m, 12H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.2, 150.3, 131.4, 128.5, 126.6, 126.0, 120.2, 75.8, 51.5, 40.2, 39.4, 37.5, 37.4, 37.3, 34.4, 33.6, 32.8, 32.7, 31.3, 28.0, 26.8, 24.8, 24.5, 24.3, 22.74, 22.65, 22.4, 21.0, 19.8, 19.7, 16.1. HRMS (ESI) ($[M+NH_4]^+$) Calcd. for $C_{32}H_{58}NO_3$: 504.4417; found: 504.4425.



3n

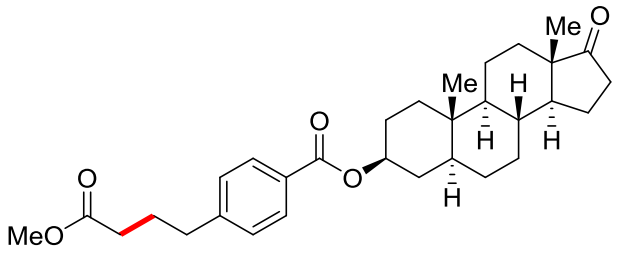
methyl 4-(3-(4-methoxyphenyl)-4-oxo-4H-chromen-7-yl)butanoate (3n): According to general procedure A, a solution of **1n** (0.5 mmol, 139.2 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol,

105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3n** (87.3 mg, 50%) as white solid after purification on silica gel (PE:EA=4:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.23 (d, *J* = 8.1 Hz, 1H), 7.98 (s, 1H), 7.52 (d, *J* = 8.8 Hz, 2H), 7.33-7.24 (m, 2H), 6.99 (d, *J* = 8.7 Hz, 2H), 3.86 (s, 3H), 3.70 (s, 3H), 2.81 (t, *J* = 7.2 Hz, 2H), 2.39 (t, *J* = 7.3 Hz, 2H), 2.17-1.97 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.3, 173.6, 159.6, 156.3, 152.4, 148.2, 130.1, 126.4, 125.9, 124.9, 124.2, 122.8, 117.3, 113.9, 55.4, 51.7, 35.1, 33.2, 25.9. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{21}H_{21}O_5$: 353.1389; found: 353.1388.



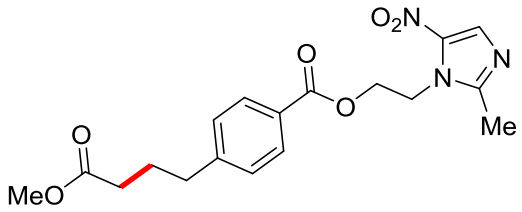
3o

methyl 4-((8R,9S,13S,14S)-13-methyl-17-oxo-7,8,9,11,12,13,14,15,16,17-decahydro-6H-cyclopenta[a]phenanthren-3-yl)butanoate (3o): According to general procedure A , a solution of **1o** (0.5 mmol, 140.0 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3o** (128.2 mg, 72%) as white solid after purification on silica gel (PE:EA=10:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.23 (d, *J* = 1.0 Hz, 1H), 7.02-6.98 (m, 1H), 6.95 (s, 1H), 3.69 (s, 3H), 2.94-2.90 (m, 2H), 2.61 (t, *J* = 7.6 Hz, 2H), 2.53 (dd, *J* = 18.7, 8.6 Hz, 1H), 2.47-2.41 (m, 1H), 2.37 (t, *J* = 7.5 Hz, 2H), 2.33-2.26 (m, 1H), 2.21-2.11 (m, 1H), 2.12-2.01 (m, 2H), 2.01-1.91 (m, 3H), 1.76-1.38 (m, 6H), 0.93 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 220.9, 174.0, 138.9, 137.4, 136.4, 129.1, 125.9, 125.4, 51.5, 50.5, 48.0, 44.3, 38.2, 35.9, 34.6, 33.5, 31.6, 29.4, 26.6, 26.5, 25.8, 21.6, 13.9. HRMS (ESI) ($[M+Na]^+$) Calcd. for $C_{23}H_{30}NaO_3$: 377.2093; found: 377.2094.



3p

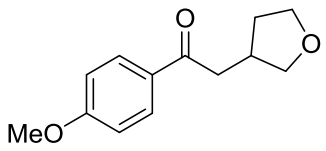
(3S,5S,8R,9S,10S,13S,14S)-10,13-dimethyl-17-oxohexadecahydro-1H-cyclopenta[a]phenanthren-3-yl 4-(4-methoxy-4-oxobutyl)benzoate (3p): According to general procedure A , a solution of **1p** (0.5 mmol, 210.0 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3p** (137.1 mg, 55%) as white solid after purification on silica gel (PE:EA=5:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, *J* = 8.3 Hz, 2H), 7.24 (d, *J* = 8.3 Hz, 2H), 4.98-4.89 (m, 1H), 3.67 (s, 3H), 2.70 (t, *J* = 7.6 Hz, 2H), 2.54 – 2.40 (m, 1H), 2.33 (t, *J* = 7.4 Hz, 2H), 2.13-2.03 (m, 1H), 2.02-1.89 (m, 4H), 1.86-1.21 (m, 16H), 1.18-0.95 (m, 2H), 0.91 (s, 3H), 0.87 (s, 3H), 0.82-0.70 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 221.2, 173.7, 166.1, 146.7, 129.7, 128.8, 128.4, 73.9, 54.3, 51.6, 51.4, 47.8, 44.7, 36.8, 35.9, 35.7, 35.2, 35.1, 34.1, 33.2, 31.5, 30.8, 28.3, 27.5, 26.2, 21.8, 20.5, 13.8, 12.3. HRMS (ESI) ([M+Na]$^+$) Calcd. for $C_{31}H_{43}O_5$: 495.3110; found: 495.3121.



3q

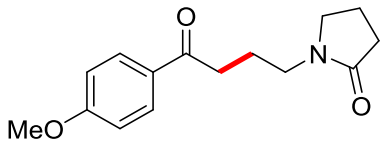
2-(2-methyl-5-nitro-1H-imidazol-1-yl)ethyl 4-(4-methoxy-4-oxobutyl)benzoate (3q): According to general procedure A , a solution of **1q** (0.5 mmol, 150.0 mg), Methyl thioglycolate (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **3q** (92.1 mg, 50%) as white solid after purification on silica gel (PE:EA=1:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (s, 1H), 7.86 (d, *J* = 8.1 Hz, 2H), 7.27 (d, *J* = 9.7 Hz, 2H), 4.73-4.69 (m, 2H), 4.68-4.65 (m, 2H), 3.69 (s, 3H), 2.73 (t, *J* = 7.6 Hz, 2H), 2.50 (s, 3H), 2.35 (t, *J* = 7.4 Hz, 2H), 1.99 (p, *J* = 7.5 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ

173.6, 166.0, 150.9, 147.8, 133.3, 129.8, 128.8, 126.9, 62.7, 51.6, 45.3, 35.1, 33.2, 26.0, 14.4. HRMS (ESI) ([M+H]$^+$) Calcd. for $C_{18}H_{22}N_3O_6$: 376.1509; found: 376.1506.



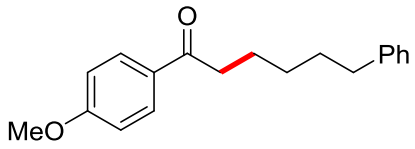
4a

1-(4-methoxyphenyl)-2-(tetrahydrofuran-3-yl)ethan-1-one (4a): According to general procedure B, a solution of **1r** (1.5 mmol, 105.1 mg), **2b** (0.5 mmol, 92.1 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **4a** (69.3 mg, 63%) as colorless oil after purification on silica gel (PE:EA=5:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, *J* = 8.9 Hz, 2H), 6.94 (d, *J* = 8.9 Hz, 2H), 4.03 (dd, *J* = 8.6, 7.1 Hz, 1H), 3.91-3.86 (m, 1H), 3.88 (s, 3H), 3.83-3.72 (m, 1H), 3.45 (dd, *J* = 8.6, 6.3 Hz, 1H), 3.14-2.98 (m, 2H), 2.86-2.76 (m, 1H), 2.23-2.15 (m, 1H), 1.64-1.56 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.6, 163.5, 130.3, 130.0, 113.8, 73.3, 67.7, 55.5, 42.1, 34.8, 32.3. HRMS (ESI) ([M+H]$^+$) Calcd. for $C_{13}H_{17}O_3$: 221.1178; found: 221.1178.



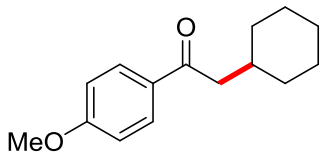
4b

1-(4-(4-methoxyphenyl)-4-oxobutyl)pyrrolidin-2-one (4b): According to general procedure B, a solution of **1s** (0.75 mmol, 83.5 mg), **2b** (0.5 mmol, 92.1 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **4b** (106.3 mg, 82%) as colorless oil after purification on silica gel (PE:EA=50:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 8.9 Hz, 2H), 6.90 (d, *J* = 8.9 Hz, 2H), 3.84 (s, 3H), 3.40-3.33 (m, 4H), 2.91 (t, *J* = 7.2 Hz, 2H), 2.30 (t, *J* = 8.1 Hz, 2H), 2.09-1.87 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.9, 175.1, 163.5, 130.3, 129.8, 113.7, 55.4, 47.0, 42.0, 35.2, 31.0, 21.9, 17.9. HRMS (ESI) ([M+H]$^+$) Calcd. for $C_{15}H_{20}NO_3$: 262.1443; found: 262.1441.



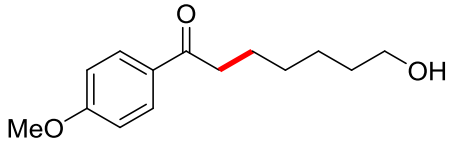
4c

1-(4-methoxyphenyl)-6-phenylhexan-1-one (4c): According to general procedure B, a solution of **1t** (1.5 mmol, 198.1 mg), **2b** (0.5 mmol, 92.1 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **4c** (70.4 mg, 50%) as colorless oil after purification on silica gel (PE:EA=10:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.9 Hz, 2H), 7.38 – 7.26 (m, 2H), 7.22-7.18 (m, 3H), 6.96 (d, *J* = 8.9 Hz, 2H), 3.89 (s, 3H), 2.94 (t, *J* = 7.2 Hz, 2H), 2.66 (t, *J* = 7.6 Hz, 2H), 1.79 (p, *J* = 7.5 Hz, 2H), 1.75-1.65 (m, 2H), 1.53-1.40 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.1, 163.3, 142.6, 130.3, 130.2, 128.4, 128.3, 125.7, 113.7, 55.5, 38.2, 35.8, 31.4, 29.1, 24.4. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{19}H_{23}O_2$: 283.1698; found: 283.1696.



4d

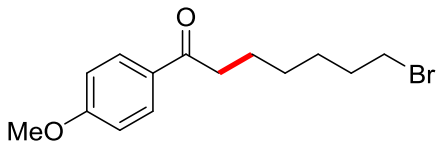
2-cyclohexyl-1-(4-methoxyphenyl)ethan-1-one (4d): According to general procedure B , a solution of **1u** (3.0 mmol, 246.4 mg), **2b** (0.5 mmol, 92.1 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **4d** (30.1 mg, 25%) as colorless oil after purification on silica gel (PE:EA=20:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 (d, *J* = 9.1 Hz, 2H), 6.95 (d, *J* = 9.1 Hz, 2H), 3.89 (s, 3H), 2.78 (d, *J* = 6.9 Hz, 2H), 2.02-1.94 (m, 1H), 1.84-1.61 (m, 5H), 1.39-1.11 (m, 3H), 1.08-0.94 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 198.9, 163.3, 130.6, 130.4, 113.6, 55.5, 45.9, 34.8, 33.5, 26.3, 26.2. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{15}H_{21}O_2$: 233.1542; found: 233.1543.



4e

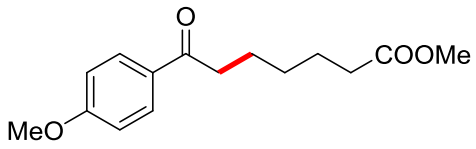
7-hydroxy-1-(4-methoxyphenyl)heptan-1-one (4e): According to general procedure

B , a solution of **1v** (0.75 mmol, 64.6 mg), **2b** (0.5 mmol, 92.1 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **4e** (33.3 mg, 28%) as white solid after purification on silica gel (PE:EA=5:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 (d, *J* = 8.9 Hz, 2H), 6.94 (d, *J* = 8.9 Hz, 2H), 3.87 (s, 3H), 3.65 (t, *J* = 6.5 Hz, 2H), 2.93 (t, *J* = 7.4 Hz, 2H), 1.78-1.70 (m, 2H), 1.64-1.56 (m, 3H), 1.46-1.40 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.1, 163.3, 130.3, 130.1, 113.7, 62.9, 55.5, 38.1, 32.6, 29.1, 25.6, 24.5. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{14}H_{21}O_3$: 237.1491; found: 237.1484.



4f

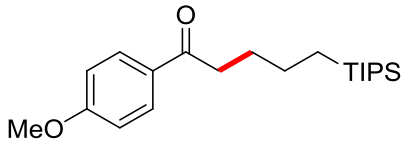
7-bromo-1-(4-methoxyphenyl)heptan-1-one (4f): According to general procedure B , a solution of **1w** (0.75 mmol, 111.8 mg), **2b** (0.5 mmol, 92.1 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **4f** (77.5 mg, 52%) as white solid after purification on silica gel (PE:EA=10:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, *J* = 8.9 Hz, 2H), 6.95 (d, *J* = 8.9 Hz, 2H), 3.89 (s, 3H), 3.43 (t, *J* = 6.8 Hz, 2H), 2.94 (t, *J* = 7.3 Hz, 2H), 1.93-1.86 (m, 2H), 1.76 (p, *J* = 7.4 Hz, 2H), 1.59-1.37 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 198.9, 163.4, 130.3, 130.1, 113.7, 55.5, 38.0, 33.9, 32.6, 28.5, 28.0, 24.3. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{14}H_{20}BrO_2$: 299.0647; found: 299.0637.



4g

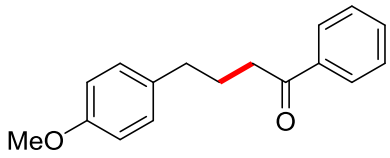
methyl 7-(4-methoxyphenyl)-7-oxoheptanoate (4g): According to general procedure B, a solution of **1x** (2.0 mmol, 228.2 mg), **2b** (0.5 mmol, 92.1 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **4g** (59.7 mg, 45%) as white solid after purification on silica gel (PE:EA=10:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 (d, *J* = 8.9 Hz, 2H), 6.94 (d, *J* = 8.9 Hz, 2H), 3.88 (s, 3H), 3.68 (s, 3H), 2.93 (t, *J* = 7.4 Hz, 2H), 2.34 (t, *J* = 7.5

Hz, 2H), 1.80-1.66 (m, 4H), 1.49-1.35 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 198.8, 174.1, 163.4, 130.3, 130.1, 113.7, 55.5, 51.5, 37.9, 33.9, 28.9, 24.8, 24.1. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{15}H_{21}O_4$: 265.1440; found: 265.1434.



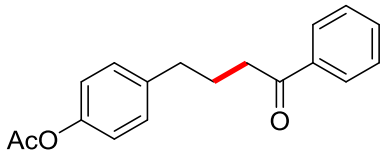
4h

1-(4-methoxyphenyl)-5-(triisopropylsilyl)pentan-1-one (4h): According to general procedure B , a solution of **1y** (1.0 mmol, 198.0 mg), **2b** (0.5 mmol, 92.1 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **4h** (103.1 mg, 59%) as colorless oil after purification on silica gel (PE:EA=50:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.8 Hz, 2H), 6.95 (d, *J* = 8.7 Hz, 2H), 3.89 (s, 3H), 2.94 (t, *J* = 7.5 Hz, 2H), 1.77 (p, *J* = 7.5 Hz, 2H), 1.50-1.42 (m, 2H), 1.05 (s, 21H), 0.78-0.55 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.3, 163.3, 130.3, 130.2, 113.7, 55.4, 38.0, 29.3, 24.3, 18.9, 10.9, 9.4. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{21}H_{37}O_2Si$: 349.2563; found: 349.2557.



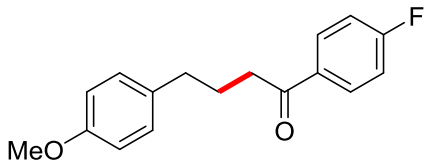
5a

4-(4-methoxyphenyl)-1-phenylbutan-1-one (5a): According to general procedure A, a solution of **1b** (0.5 mmol, 67.1 mg), **2c** (0.75 mmol, 112.5 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **5a** (112.1 mg, 88%) as white solid after purification on silica gel (PE:EA=40:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03-7.89 (m, 2H), 7.64-7.53 (m, 1H), 7.49-7.45 (m, 2H), 7.16 (d, *J* = 8.6 Hz, 2H), 6.87 (d, *J* = 8.6 Hz, 2H), 3.82 (s, 3H), 3.00 (t, *J* = 7.3 Hz, 2H), 2.70 (t, *J* = 7.5 Hz, 2H), 2.12-2.04(m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.2, 157.9, 137.1, 133.8, 132.9, 129.4, 128.6, 128.0, 113.9, 55.3, 37.7, 34.3, 25.9. MS (70 ev): m/z (%): 76.8 (100), 120.9 (50), 253.9 (M+, 3).



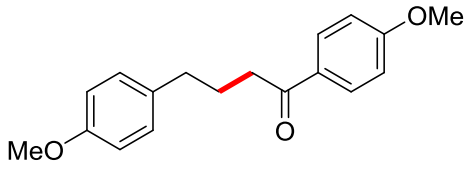
5b

4-(4-oxo-4-phenylbutyl)phenyl acetate (5b): According to general procedure A , a solution of **1c** (0.5 mmol, 81.1 mg), **2c** (0.75 mmol, 112.5 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **5b** (117.0 mg, 83%) as white solid after purification on silica gel (PE:EA=15:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01-7.90 (m, 2H), 7.63-7.53 (m, 1H), 7.51-7.42 (m, 2H), 7.23 (d, *J* = 8.5 Hz, 2H), 7.03 (d, *J* = 8.5 Hz, 2H), 3.00 (t, *J* = 7.2 Hz, 2H), 2.73 (t, *J* = 7.6 Hz, 2H), 2.30 (s, 3H), 2.18-2.02 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 199.9, 169.6, 148.9, 139.3, 136.9, 133.0, 129.4, 128.6, 128.0, 121.4, 37.6, 34.6, 25.6, 21.1. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{18}H_{19}O_3$: 283.1334; found: 283.1334.



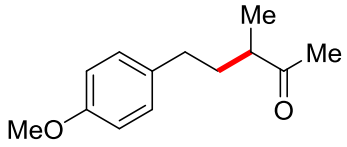
5c

1-(4-fluorophenyl)-4-(4-methoxyphenyl)butan-1-one (5c)[3]: According to general procedure A , a solution of **1b** (0.5 mmol, 67.1 mg), **2d** (0.6 mmol, 102.6 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **5c** (113.2 mg, 83%) as white solid after purification on silica gel (PE:EA=30:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01-7.92 (m, 2H), 7.20-7.06 (m, 4H), 6.86 (d, *J* = 8.6 Hz, 2H), 3.81 (s, 3H), 2.96 (t, *J* = 7.3 Hz, 2H), 2.69 (t, *J* = 7.5 Hz, 2H), 2.18-1.97 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 198.6, 165.7 (d, J_{C-F} = 255.2 Hz), 157.9, 133.7, 133.4 (d, J_{C-F} = 3.0 Hz), 130.6 (d, J_{C-F} = 9.2 Hz), 129.3, 115.7 (d, J_{C-F} = 21.8 Hz), 113.9, 55.3, 37.6, 34.3, 26.0**.** ^{19}F NMR (376 MHz, $CDCl_3$) δ -105.6. MS (70 ev): m/z (%): 94.8 (88), 122.8 (100), 271.9 (M+, 1).



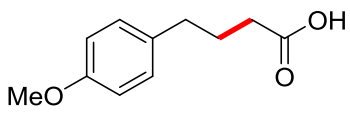
5d

1,4-bis(4-methoxyphenyl)butan-1-one (5d)[3]: According to general procedure A, a solution of **1b** (0.5 mmol, 67.1 mg), **2b** (0.6 mmol, 109.8 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **5d** (121.3 mg, 85%) as white solid after purification on silica gel (PE:EA=20:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (d, *J* = 8.9 Hz, 2H), 7.15 (d, *J* = 8.6 Hz, 2H), 6.94 (d, *J* = 8.9 Hz, 2H), 6.86 (d, *J* = 8.6 Hz, 2H), 3.87 (s, 3H), 3.80 (s, 3H), 2.93 (t, *J* = 7.3 Hz, 2H), 2.68 (t, *J* = 7.5 Hz, 2H), 2.13-2.01 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 198.8, 163.4, 157.9, 133.9, 130.3, 130.1, 129.4, 113.8, 113.7, 55.5, 55.3, 37.3, 34.4, 26.2. MS (70 ev): m/z (%): 76.8 (60), 134.8 (100), 284.1 (M+, 3).



5e

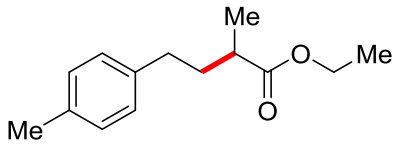
5-(4-methoxyphenyl)-3-methylpentan-2-one (5e)[4]: According to general procedure A, a solution of **1b** (0.5 mmol, 67.1 mg), **2e** (0.75 mmol, 78.1 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **5e** (63.9 mg, 62%) as colorless oil after purification on silica gel (PE:EA=20:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.10 (d, *J* = 8.6 Hz, 2H), 6.85 (d, *J* = 8.6 Hz, 2H), 3.81 (s, 3H), 2.67-2.45 (m, 3H), 2.14 (s, 3H), 2.04-1.95 (m, 1H), 1.67-1.58 (m, 1H), 1.15 (d, *J* = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 212.5, 157.9, 133.7, 129.3, 113.9, 55.3, 46.4, 34.6, 32.5, 28.1, 16.3. MS (70 ev): m/z (%): 77.8 (60), 120.8 (90), 133.8 (100), 206.0 (M+, 5).



5f

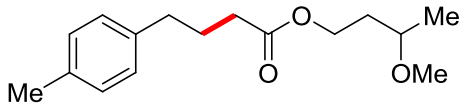
4-(4-methoxyphenyl)butanoic acid (5f)[5]: According to general procedure A, a

solution of **1a** (0.5 mmol, 59.1 mg), **2f** (0.75 mmol, 69.1 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **5f** (55.7 mg, 57%) as white solid after purification on silica gel (PE:EA=4:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.12 (s, 1H), 7.13 (d, *J* = 8.6 Hz, 2H), 6.86 (d, *J* = 8.6 Hz, 2H), 3.82 (s, 3H), 2.65 (t, *J* = 7.5 Hz, 2H), 2.39 (t, *J* = 7.5 Hz, 2H), 1.96 (p, *J* = 7.5 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 180.0, 157.9, 133.3, 129.4, 113.9, 55.3, 34.1, 33.3, 26.5. MS (70 ev): m/z (%): 77.9 (82), 120.8 (100), 194.0 (M+, 15).



5g

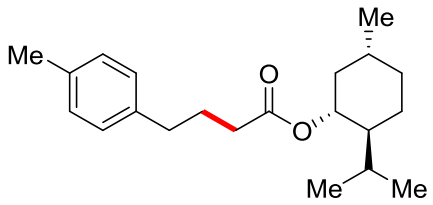
ethyl 2-methyl-4-(p-tolyl)butanoate (5g): According to general procedure A, a solution of **1a** (0.5 mmol, 59.1 mg), **2g** (0.75 mmol, 101.2 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **5g** (69.3 mg, 63%) as colorless oil after purification on silica gel (PE:EA=100:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.12-7.08 (m, 4H), 4.17 (q, *J* = 7.2 Hz, 2H), 2.60 (t, *J* = 8.0 Hz, 2H), 2.52-2.43 (m, 1H), 2.34 (s, 3H), 2.06-1.96 (m,1H), 1.80-1.64 (m, 1H), 1.29 (t, *J* = 7.1 Hz, 3H), 1.21 (d, *J* = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 138.7, 135.3, 129.1, 128.3, 60.2, 39.1, 35.6, 33.0, 20.9, 17.1, 14.3. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{14}H_{21}O_2$: 221.1542; found: 221.1543.



5h

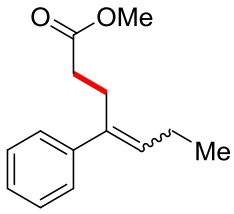
3-methoxybutyl 4-(p-tolyl)butanoate (5h): According to general procedure A, a solution of **1a** (0.5 mmol, 59.1 mg), **2h** (0.75 mmol, 133.7 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **5h** (110.9 mg, 84%) as colorless oil after purification on silica gel (PE:EA=20:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.13 (d, *J* = 8.2 Hz, 2H), 7.09 (d, *J* = 8.3 Hz, 2H), 4.19 (t, *J* = 6.8 Hz, 2H), 3.47-3.39 (m, 1H), 3.34 (s, 3H), 2.64 (t, *J* = 7.6 Hz, 2H), 2.35 (s, 3H), 2.34 (t, *J* = 7.4 Hz, 2H), 1.96 (p, *J* = 7.6 Hz, 2H), 1.90-1.69 (m,

2H), 1.19 (d, *J* = 6.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.6, 138.3, 135.4, 129.1, 128.4, 73.7, 61.4, 56.1, 35.6, 34.7, 33.7, 26.7, 21.0, 19.1. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{16}H_{25}O_3$: 265.1804; found: 265.1796.



5i

(1R,2S,5R)-2-isopropyl-5-methylcyclohexyl 4-(p-tolyl)butanoate (5i): According to general procedure A, a solution of **1a** (0.5 mmol, 59.1 mg), **2i** (0.75 mmol, 172.5 mg), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **5i** (120.1 mg, 76%) as colorless oil after purification on silica gel (PE:EA=100:1). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.13 (d, *J* = 8.3 Hz, 2H), 7.10 (d, *J* = 8.3 Hz, 2H), 4.73 (td, *J* = 10.9, 4.4 Hz, 1H), 2.64 (t, *J* = 7.6 Hz, 2H), 2.35 (s, 3H), 2.34 (t, *J* = 7.6 Hz, 2H), 2.12-1.84 (m, 4H), 1.74-1.67 (m, 2H), 1.57-1.47 (m, 1H), 1.45-1.33 (m, 1H), 1.18-1.02 (m, 1H), 0.94 (d, *J* = 2.8 Hz, 3H), 0.92 (d, *J* = 3.3 Hz, 3H), 1.02-0.84 (m, 2H), 0.80 (d, *J* = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.1, 138.5, 135.4, 129.1, 128.4, 74.0, 47.1, 41.0, 34.8, 34.3, 34.1, 31.4, 26.9, 26.3, 23.4, 22.1, 21.0, 20.8, 16.3. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{21}H_{33}O_2$: 317.2481; found: 317.2476.



6

E/Z = 3:1

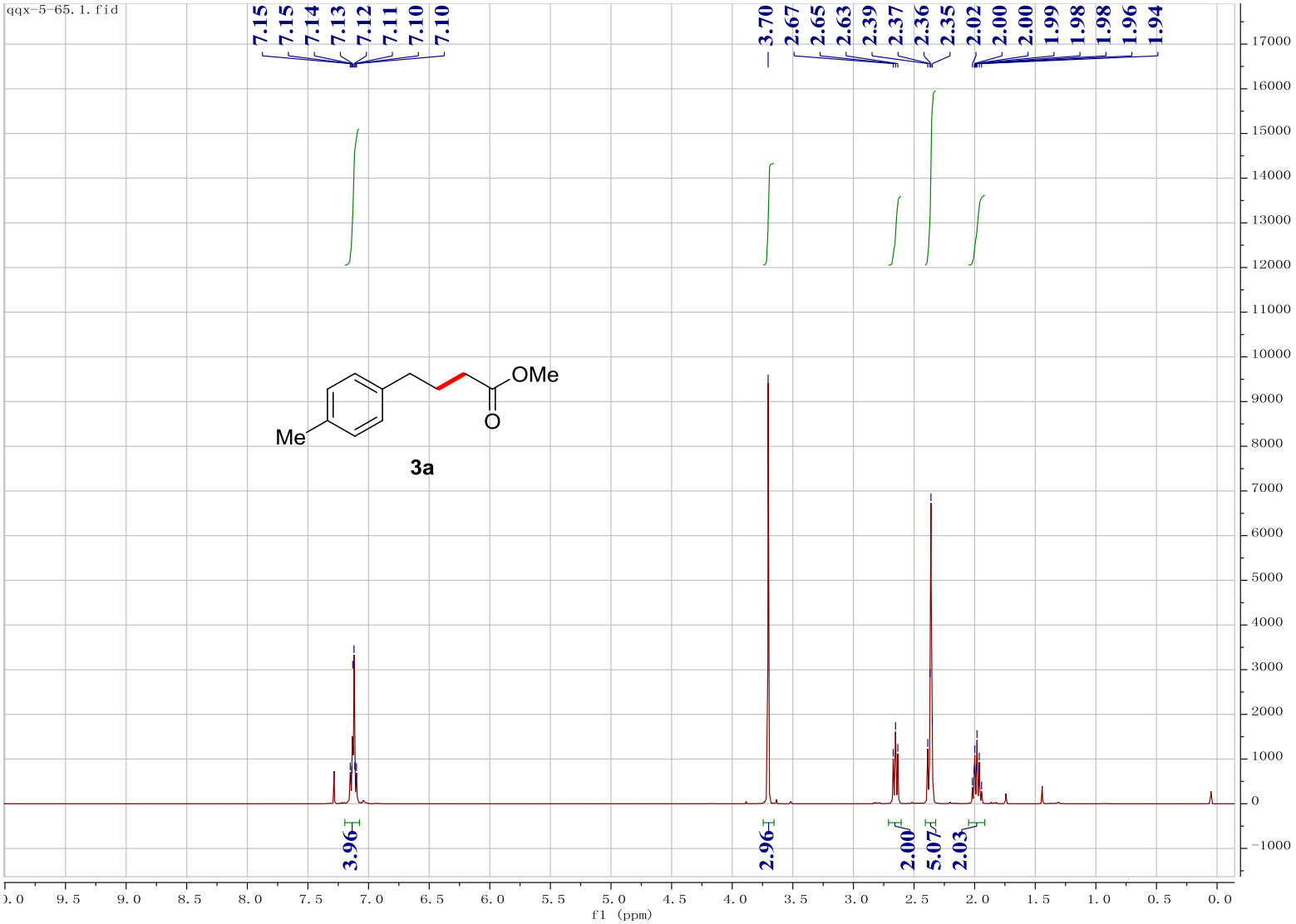
methyl 4-phenylhept-4-enoate (6): According to general procedure A, a solution of **1z** (0.5 mmol, 72.0 mg), **1b** (0.75 mmol, 65 uL), AIBN (0.025 mmol, 4.5 mg), $P(OEt)_3$ (0.6 mmol, 105 uL) in DCE (4.0 mL) were stirred at 80 ℃ under Ar for 12 h to afford **6** (68.4 mg, 63%, a mixture of *E*/*Z*) as colorless oil after purification on silica gel (PE:EA=150:1). *E*: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.21 (m, 5H), 5.72

(t, *J* = 7.3 Hz, 1H), 3.65 (s, 3H), 2.87 (t, *J* = 8.0 Hz, 2H), 2.35 (t, *J* = 8.4 Hz, 2H), 2.26 (p, *J* = 7.4 Hz, 2H), 1.09 (t, *J* = 7.5 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.6, 142.2, 137.6, 132.0, 128.3, 128.1, 126.8, 126.4, 51.5, 33.3, 25.1, 21.8, 14.4. HRMS (ESI) ($[M+H]^+$) Calcd. for $C_{14}H_{19}O_2$: 219.1385; found: 219.1385.

References:

1. K. Zhang, L.; Si, X.; Yang, Y.; Witzel, S.; Sekine, K.; Rudolph, M.; Rominger, F.; Hashmi, A. S. K. *ACS Catal*. **2019**, *9*, 6118.
2. Amriev, R.A.; Velichko, F.K. *Russ. Chem. Bull.* **1977**, *26*, 2194.
3. Liu, X.-Q.; Hsiao, C.-C.; Guo, L.; Rueping, M. *Org. Lett*. **2018**, *20*, 2976.
4. Lu, X.-Y.; Liu, J.-H.; Lu, X.; Zhang, Z.-Q.; Gong, T.-J.; Xiao, B.; Fu, Y. *Chem. Commun*. **2016**, *52*, 5324.
5. Mahmoodi, N. O.; Jazayri, M. *Synth. Commun*. **2001**, *31*, 1467.

4. NMR Spectra for All Compound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2.37
2.36
2.35
2.02
2.00
2.00
1.99
1.98
1.98
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Me
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2.00
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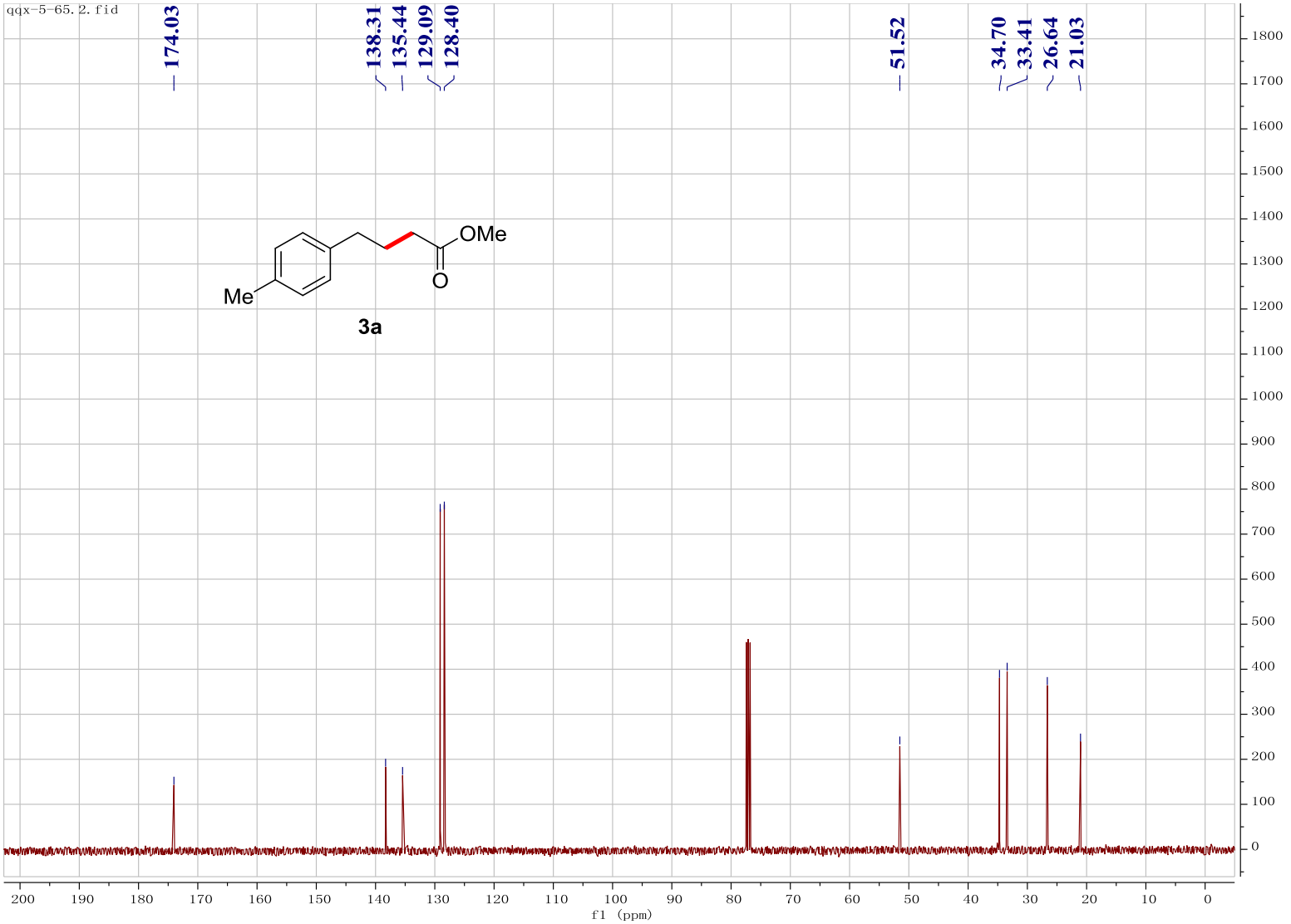
f1 (ppm)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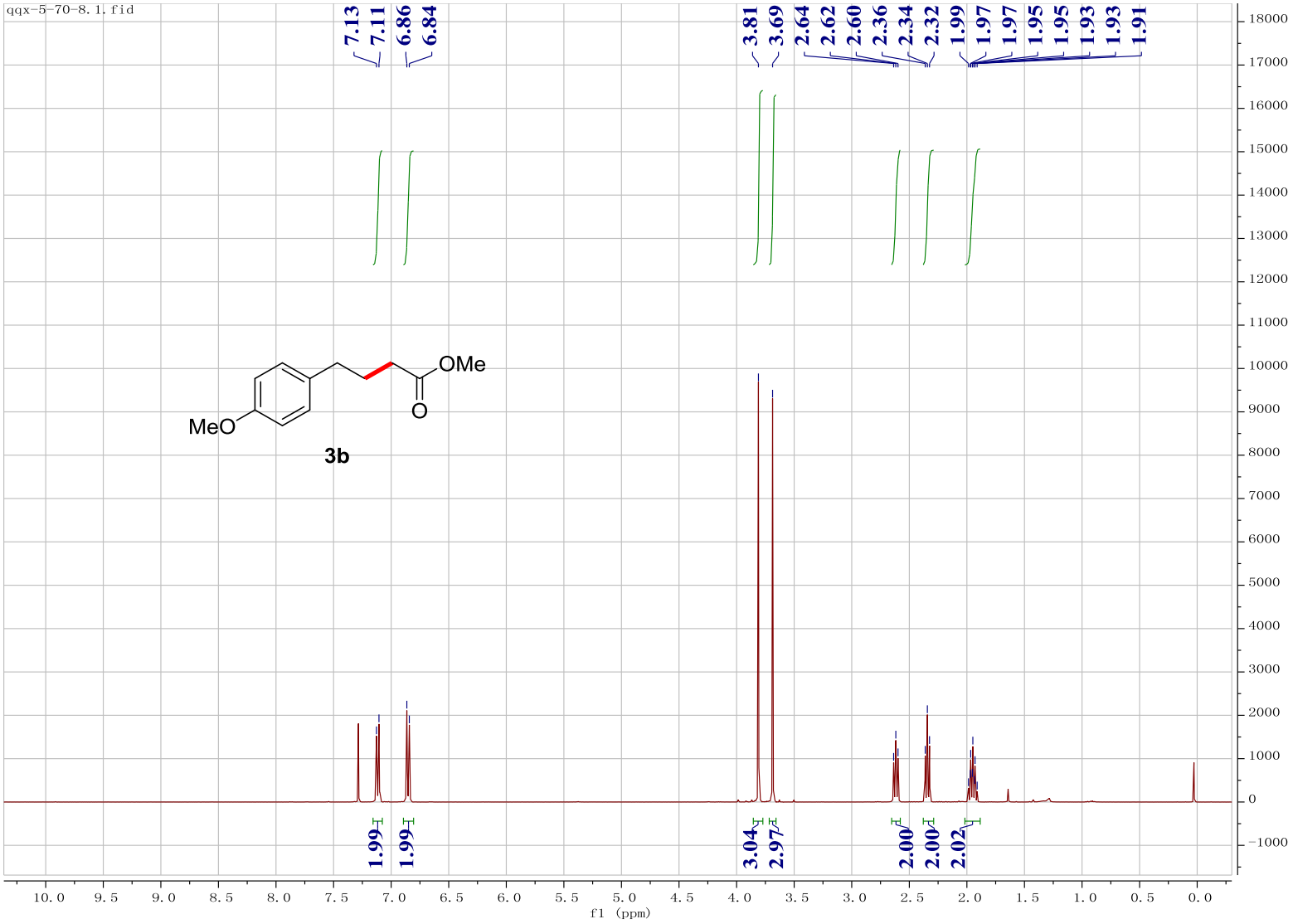
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1.97
1.97
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1.93
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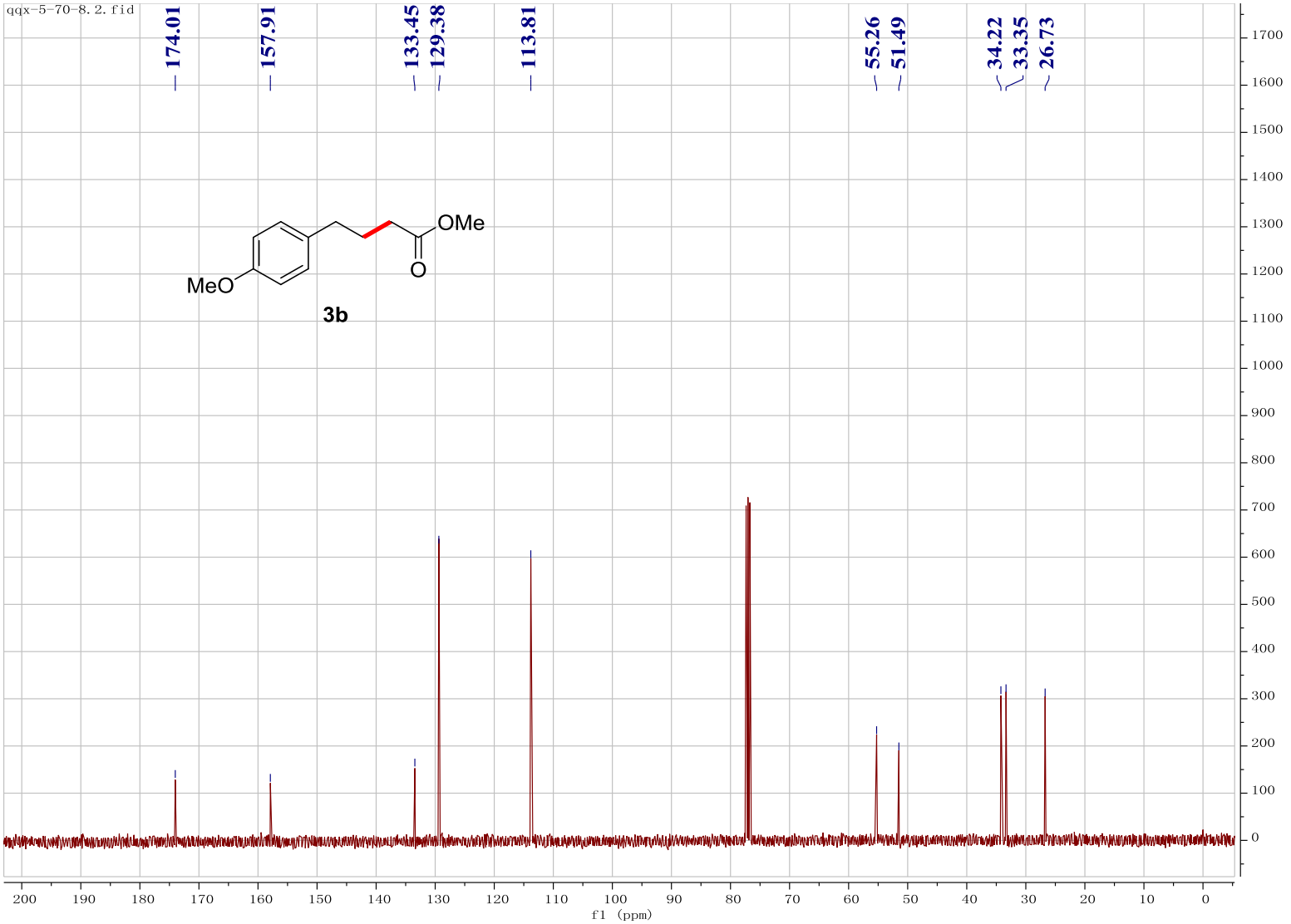
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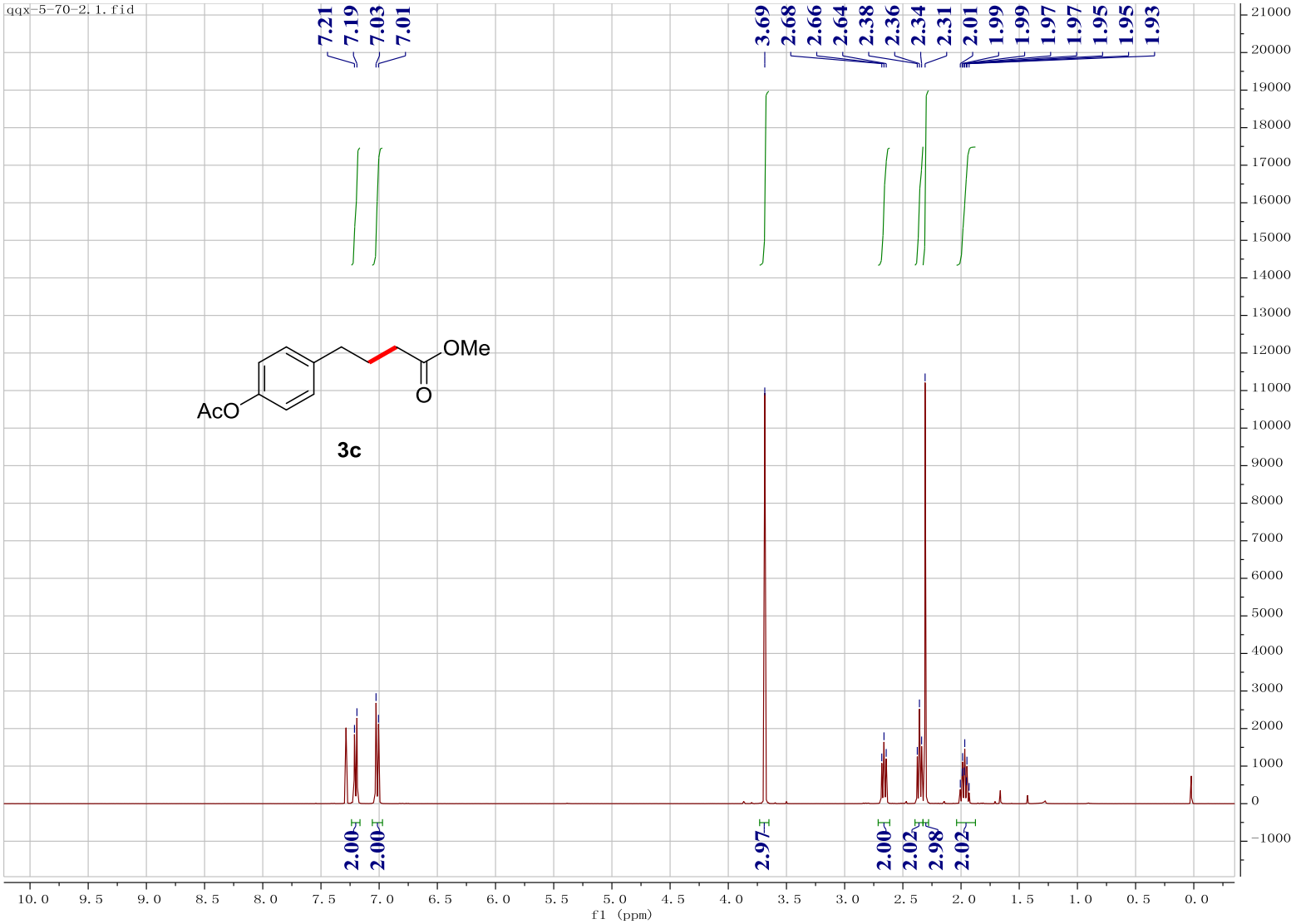
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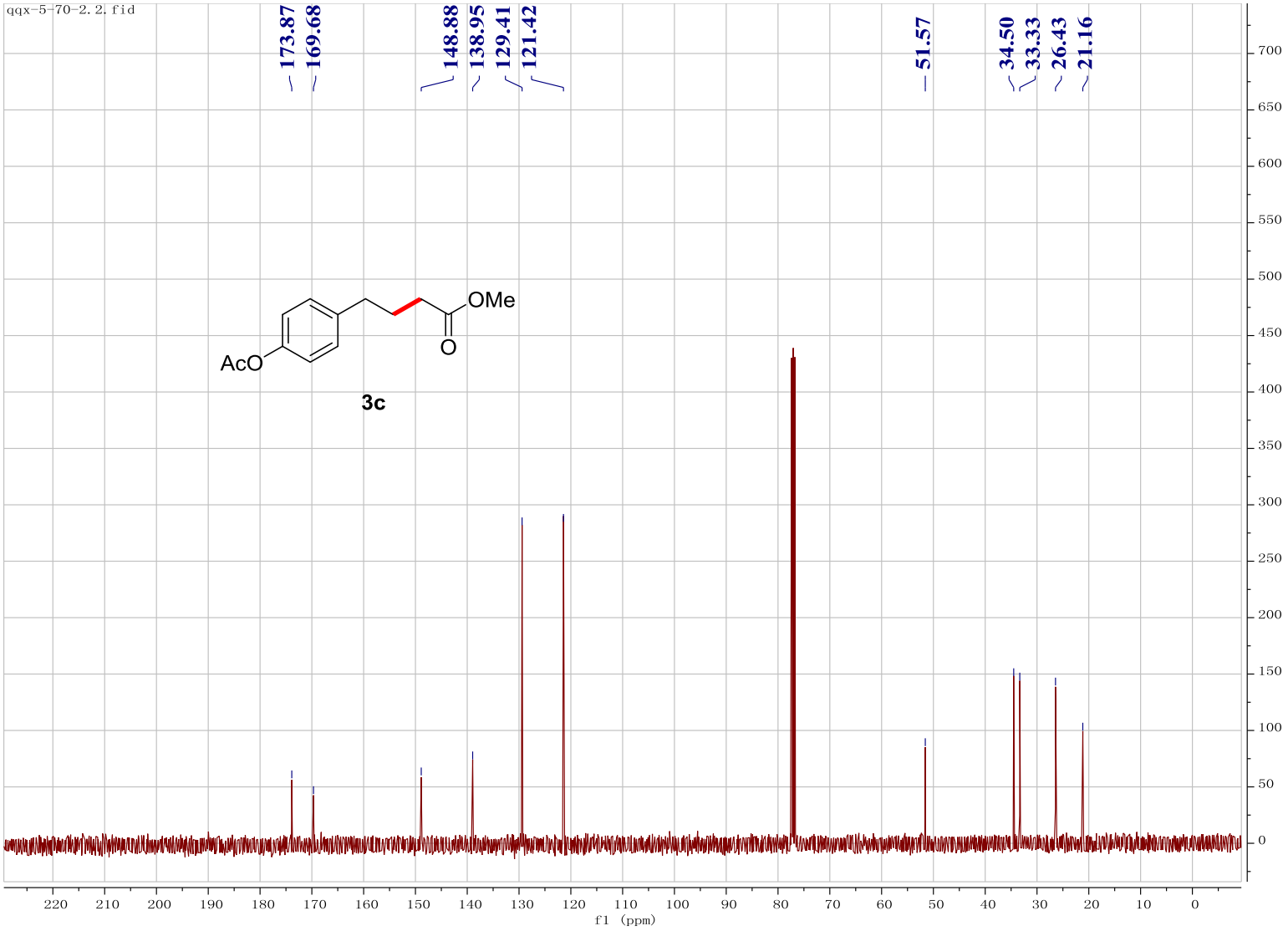
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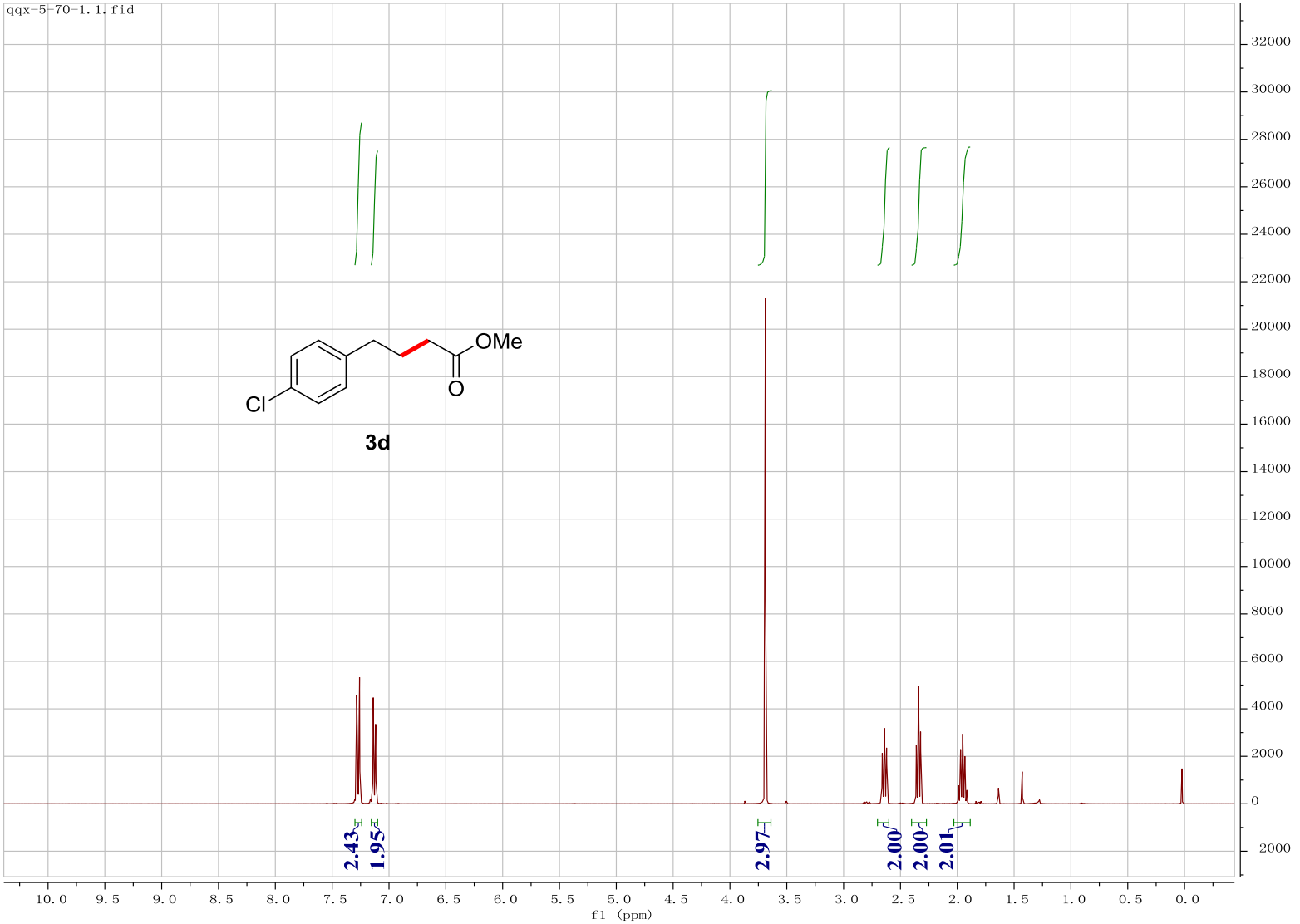
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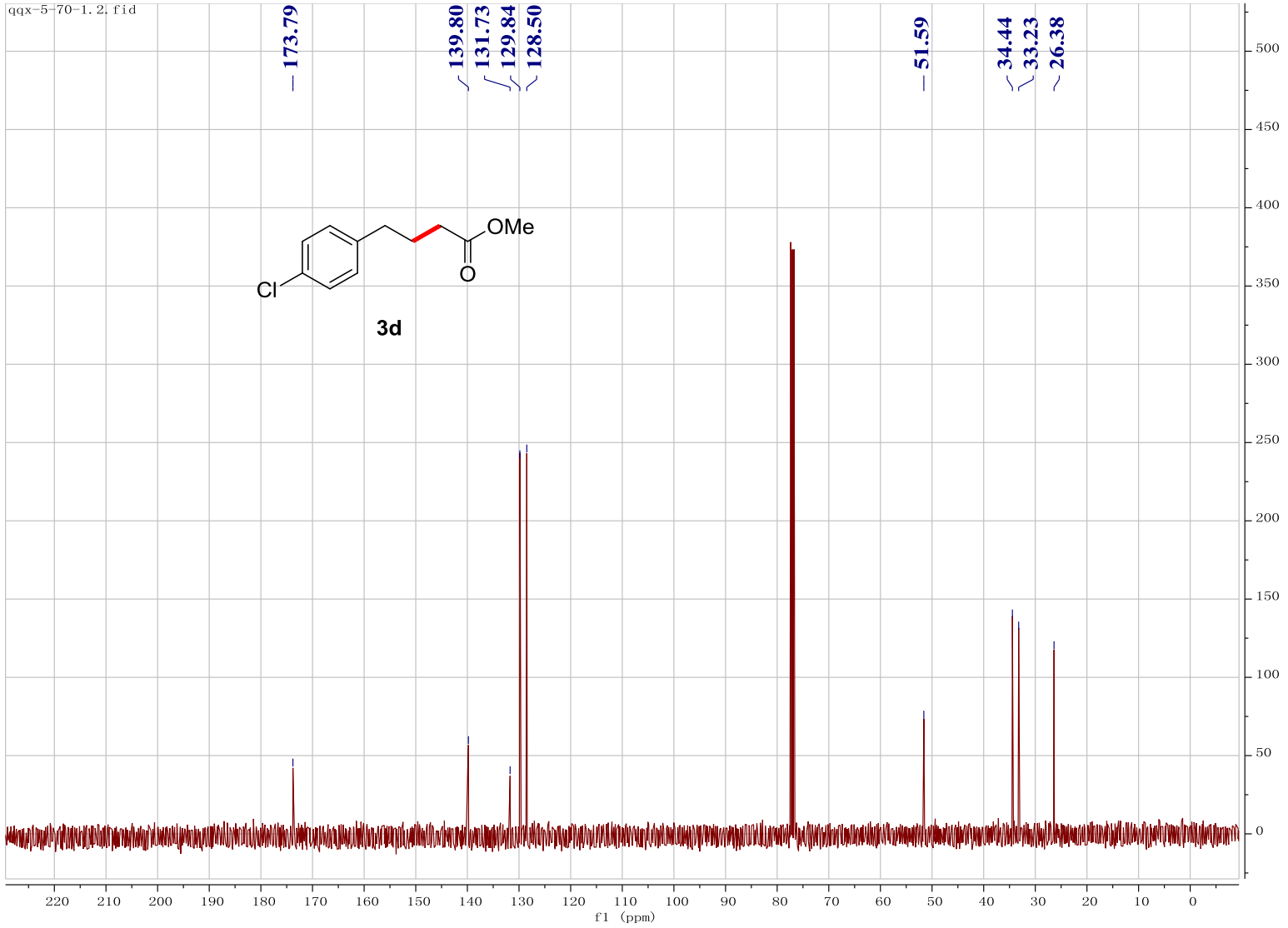
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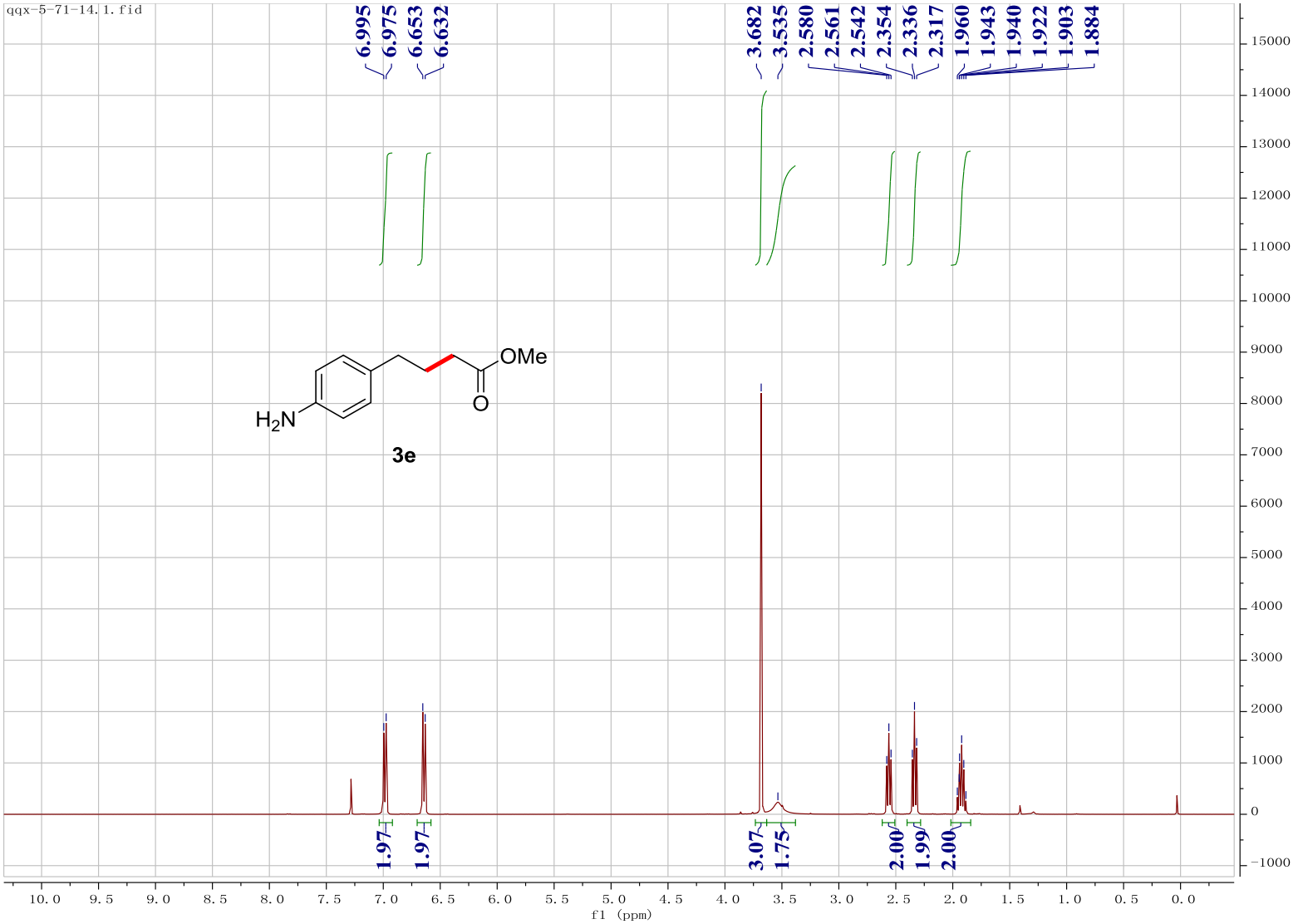
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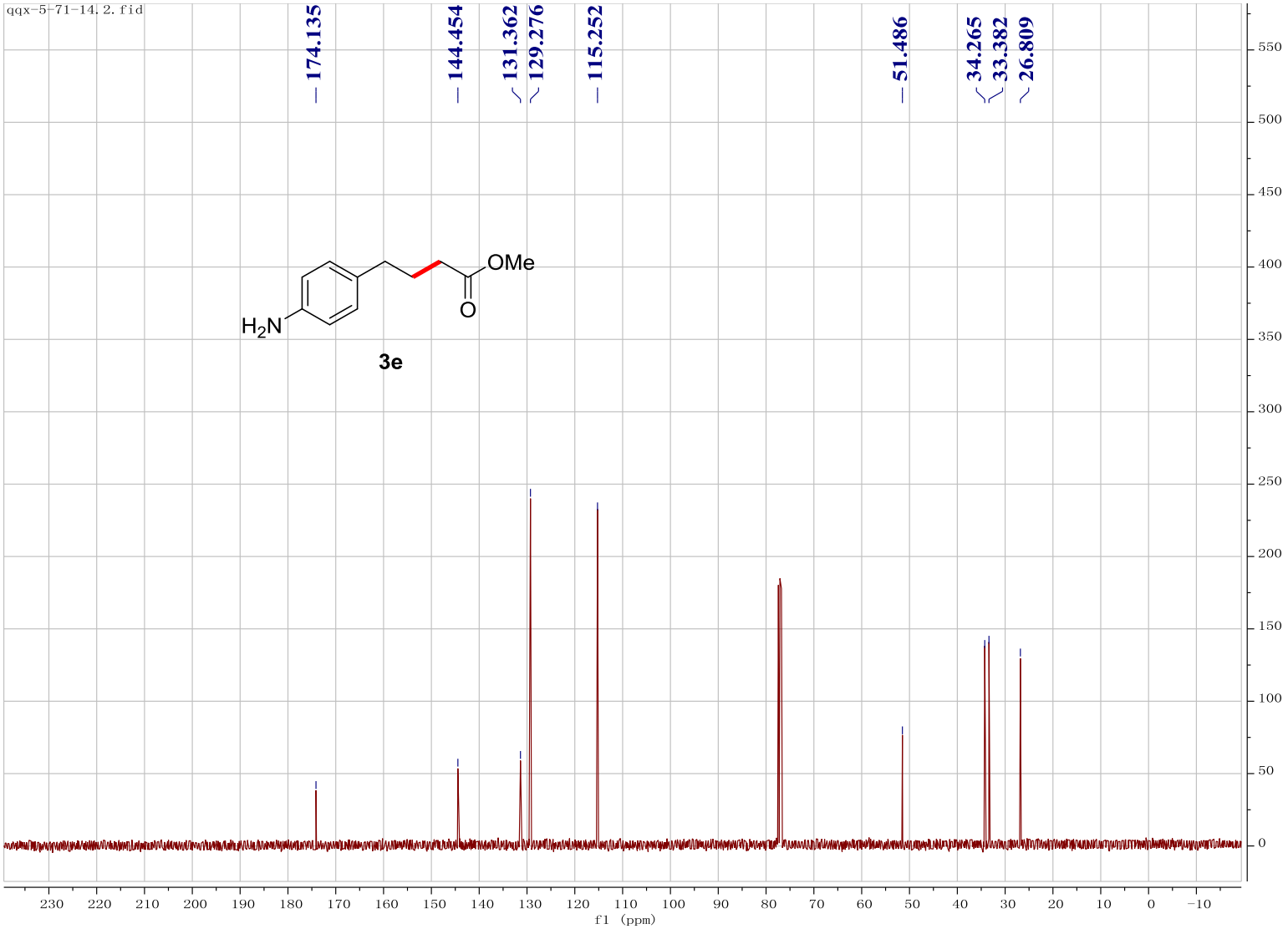
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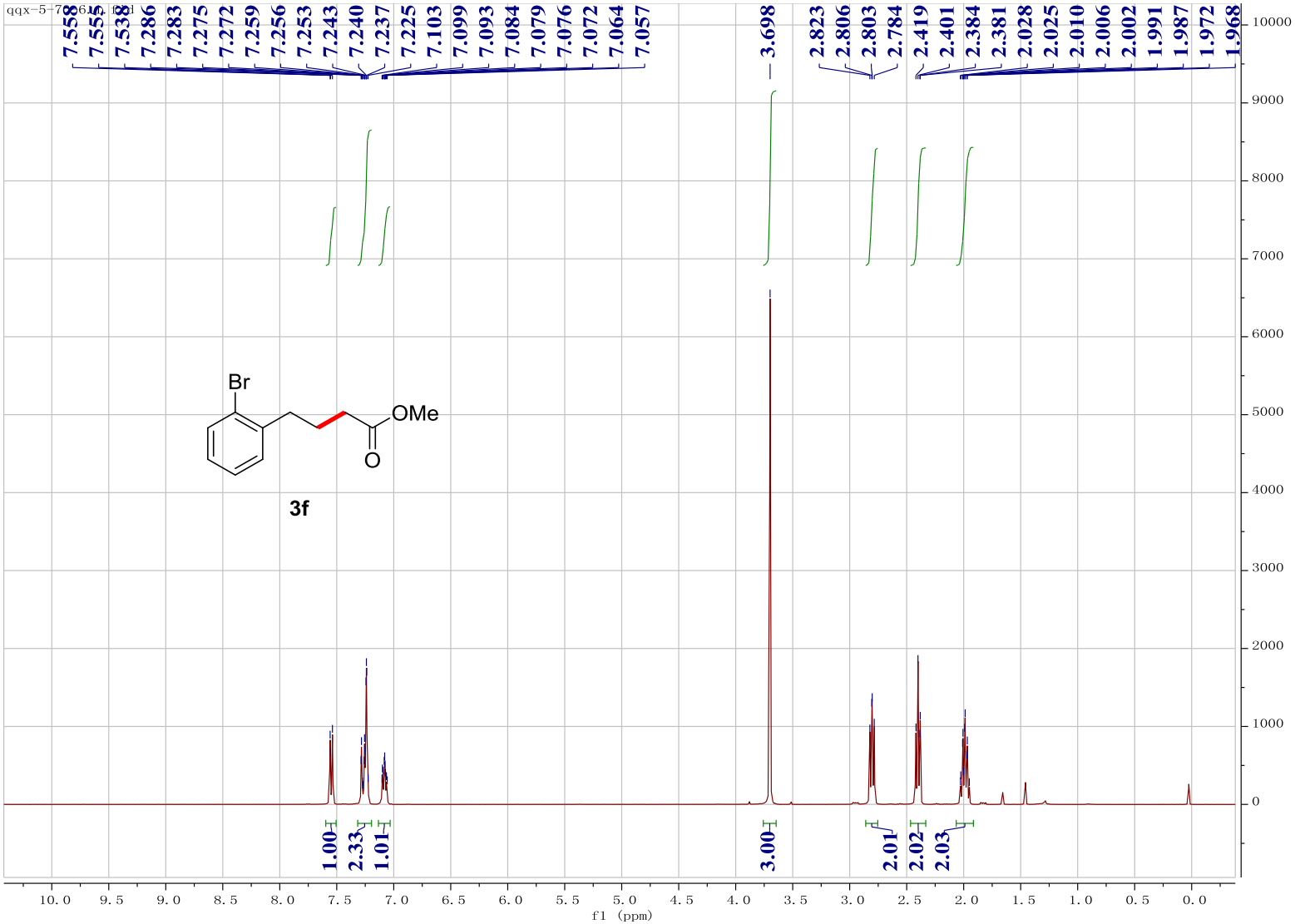
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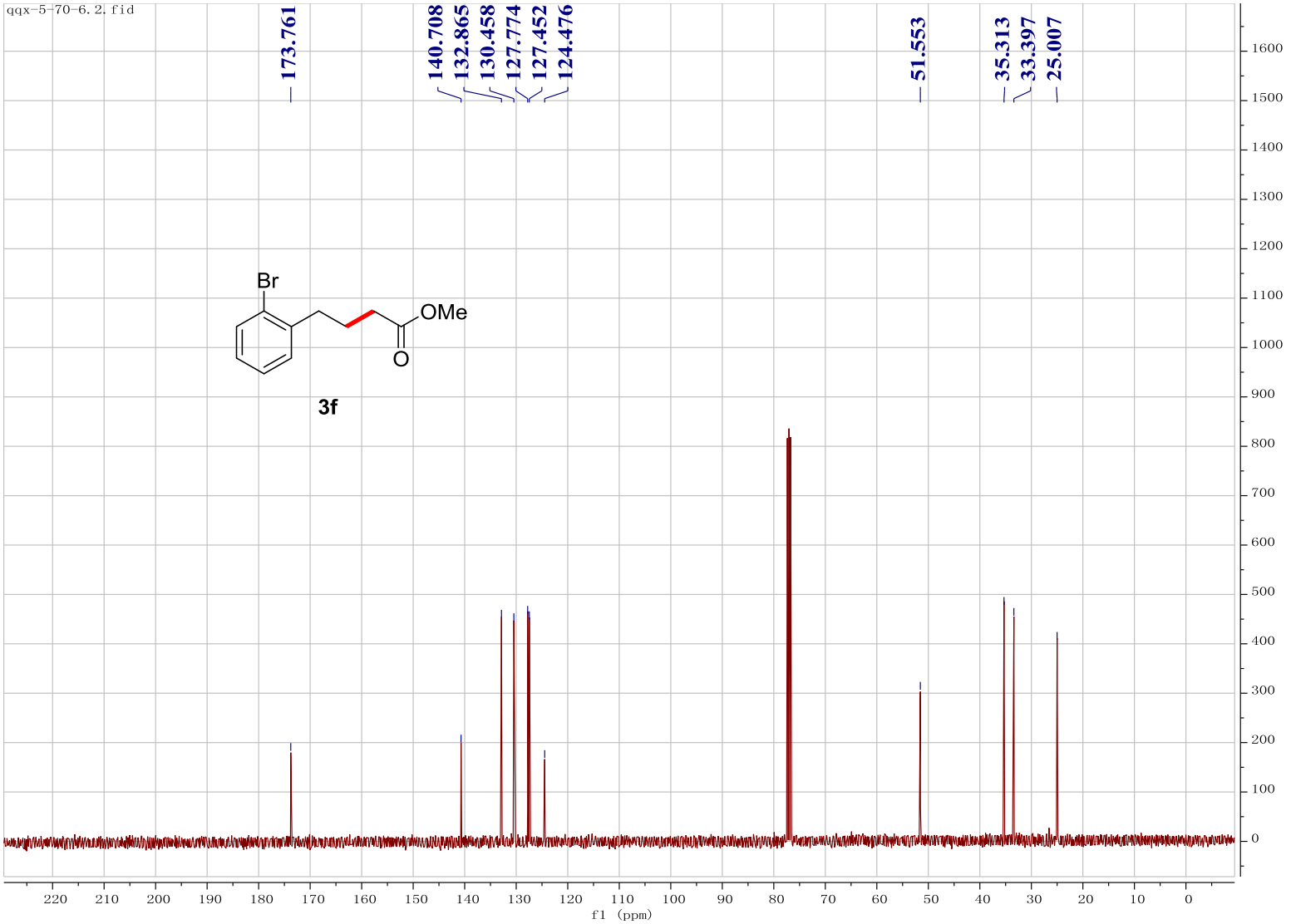
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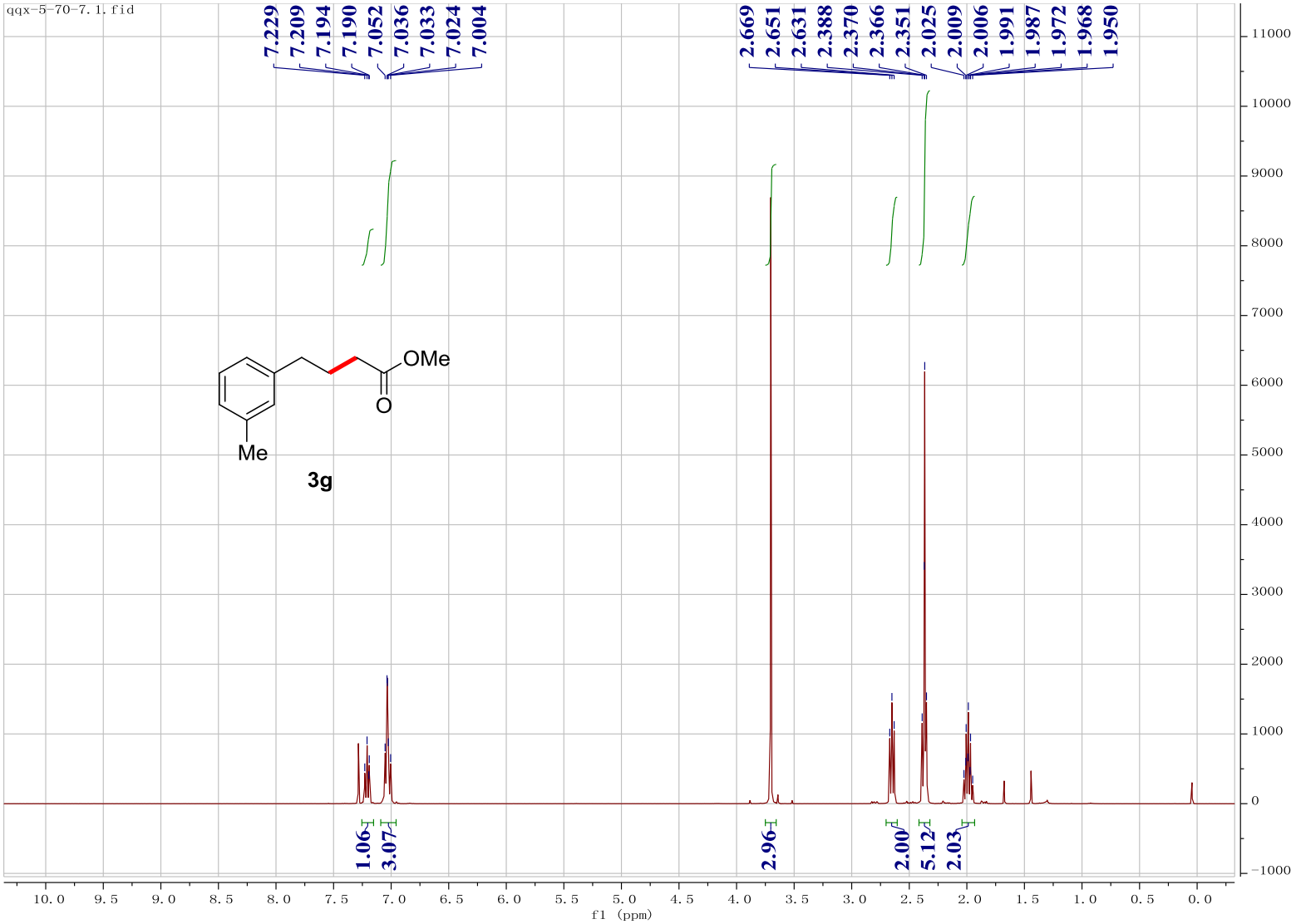
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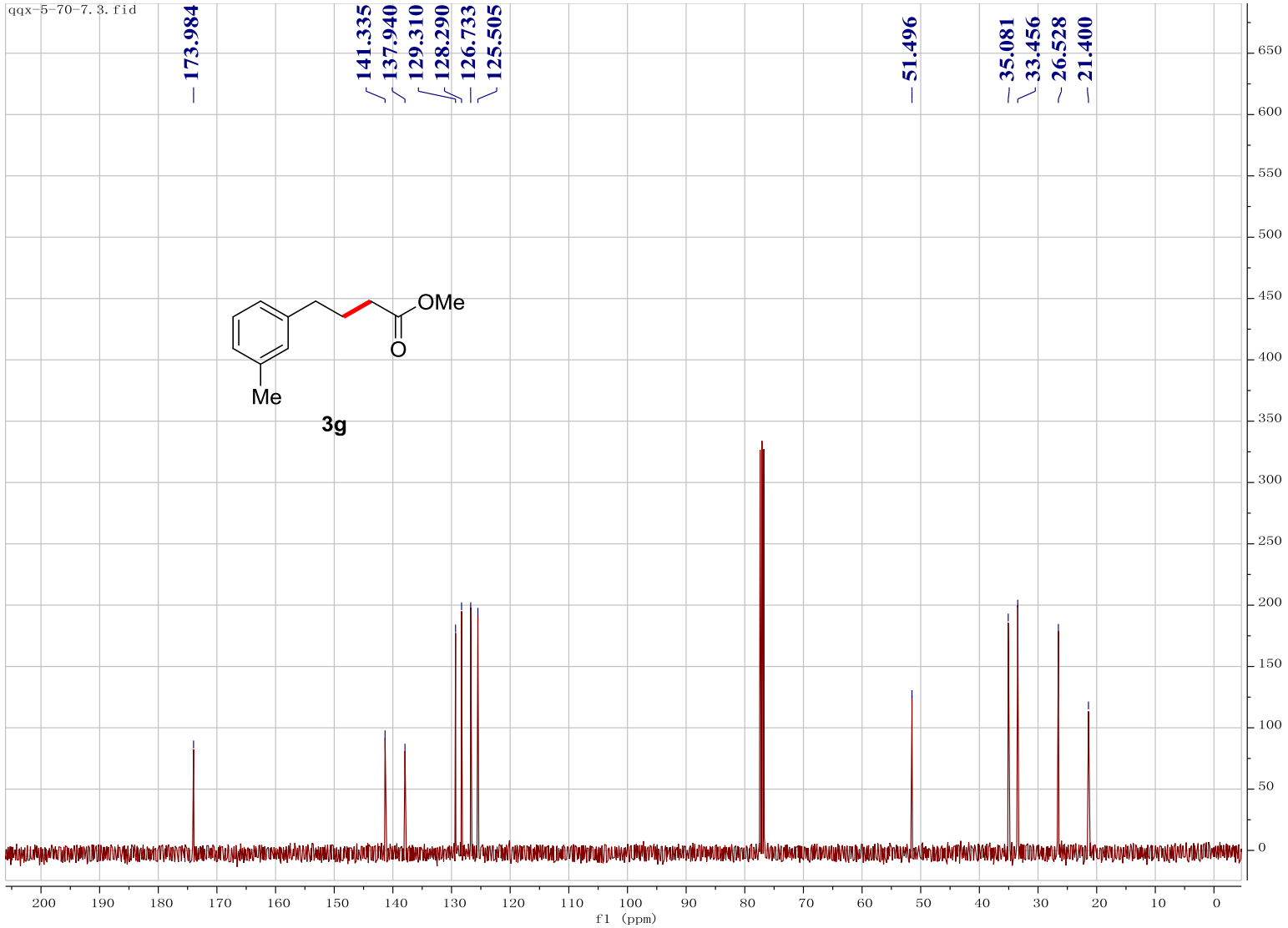
2.03
f1 (ppm)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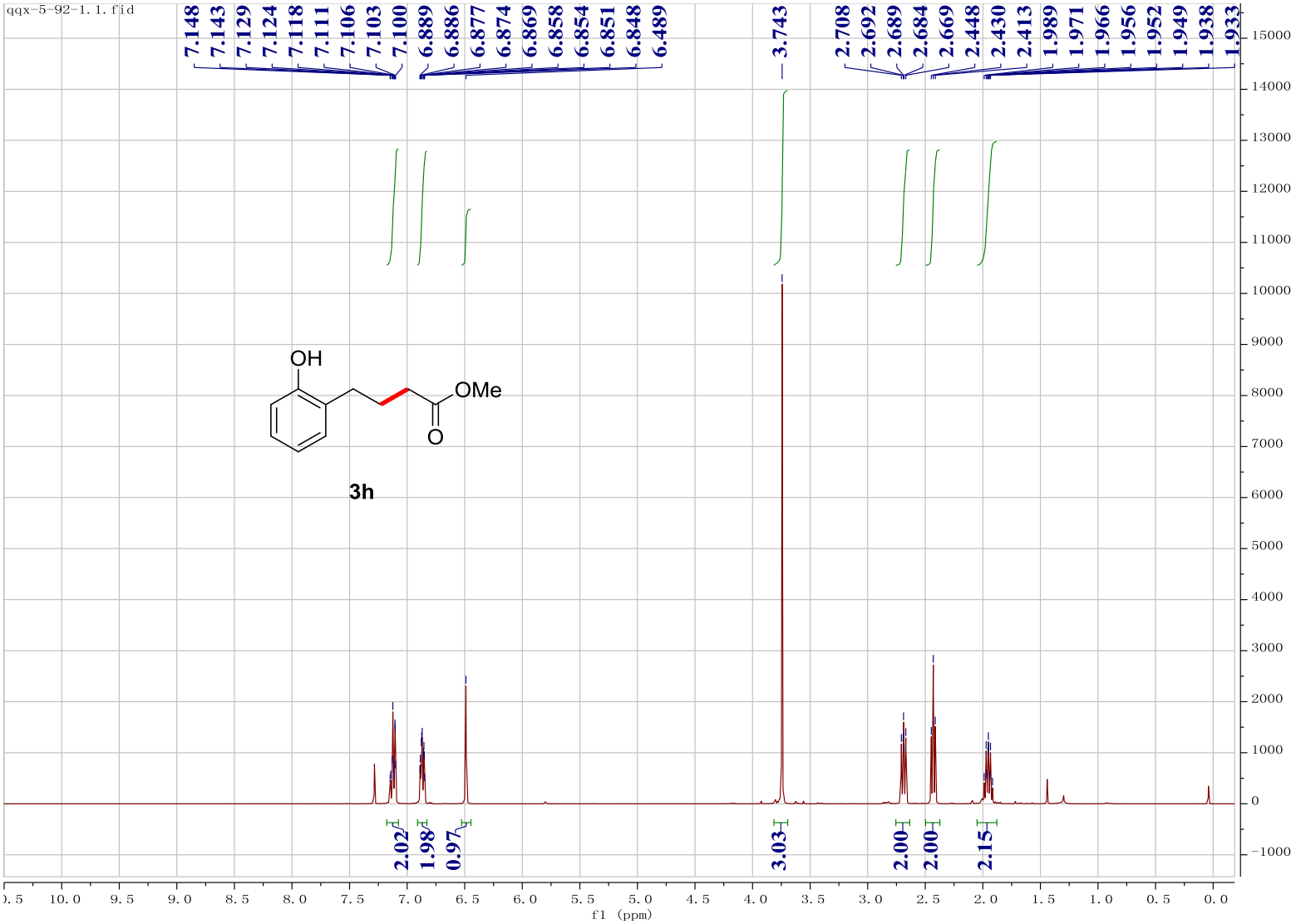
141.335
137.940
129.310
128.290
126.733
125.505
51.496
35.081
33.456
26.528
21.400
OMe
O
Me
3g
f1 (ppm)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7.143
7.129
7.124
7.118
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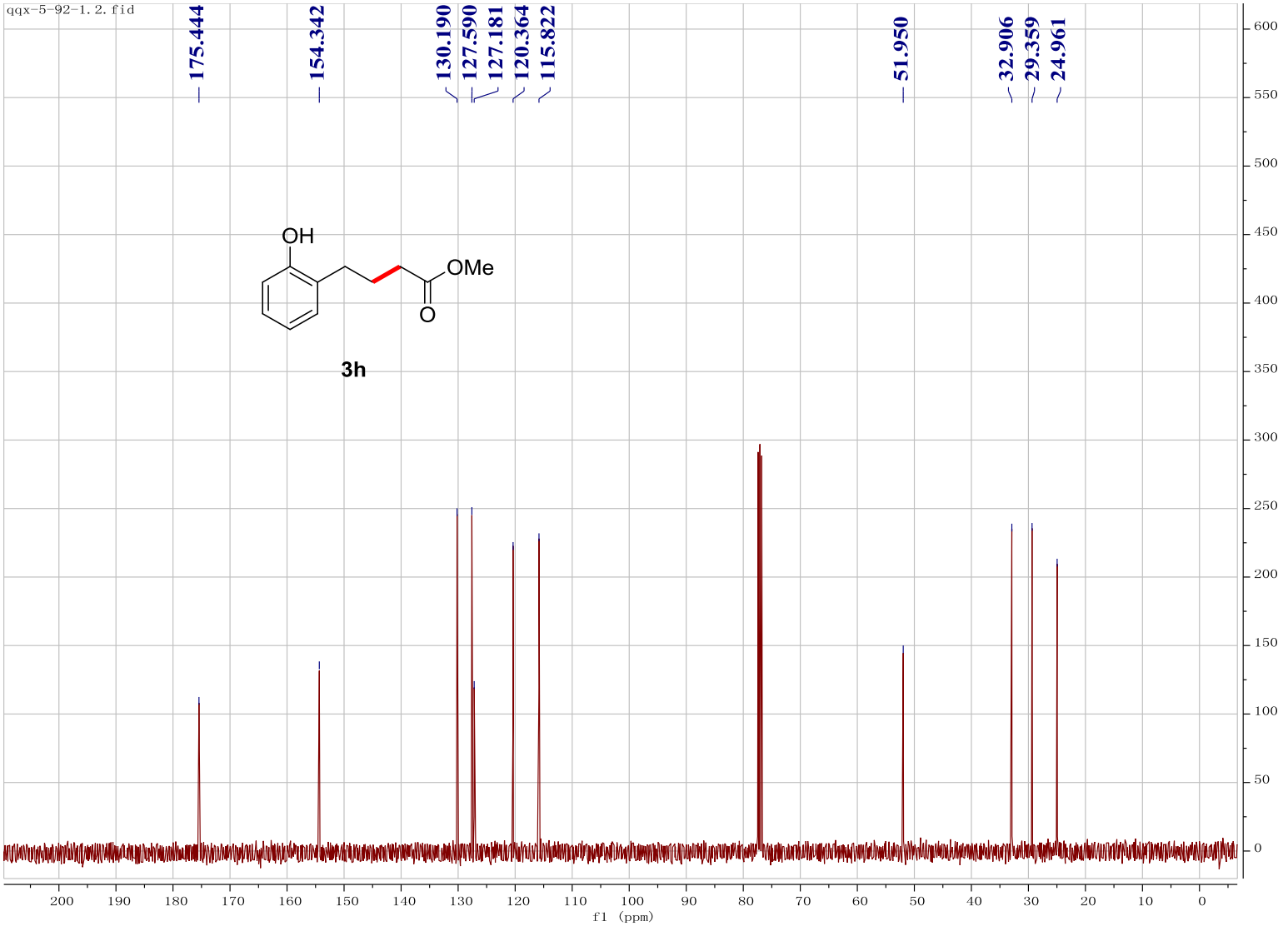
7.106
7.103
7.100
6.889
6.886
6.877
6.874
6.869
6.858
6.854
6.851
6.848
6.489
3.743
2.708
2.692
2.689
2.684
2.669
2.448
2.430
2.413
1.989
1.971
1.966
1.956
1.952
1.949
1.938
1.933
OH
OMe
O
3h
2.02
1.98
0.97
3.03
2.00
2.00
2.15
f1 (ppm)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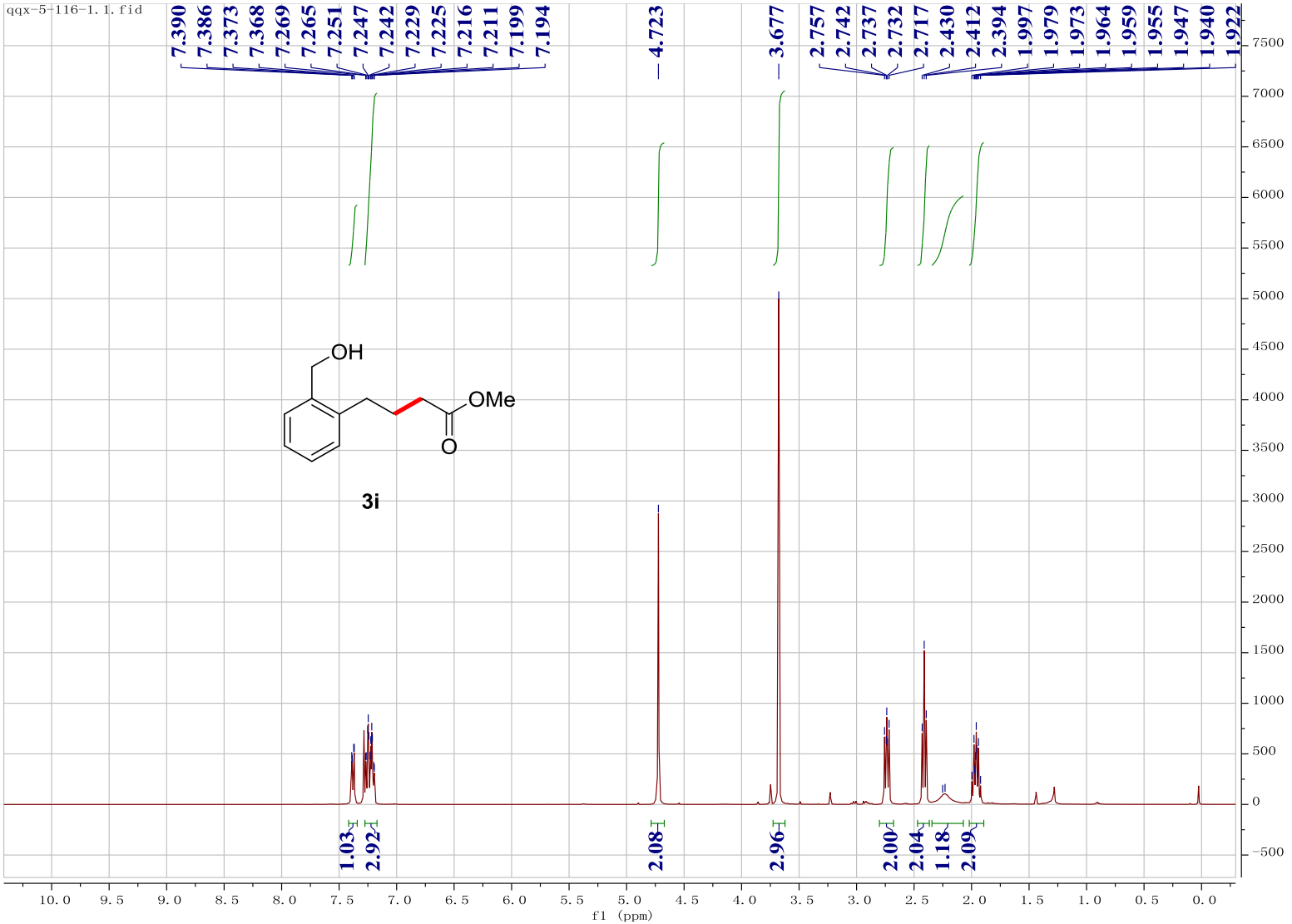
130.190
127.590
127.181
120.364
115.822
51.950
32.906
29.359
24.961
OH
OMe
O
3h
f1 (ppm)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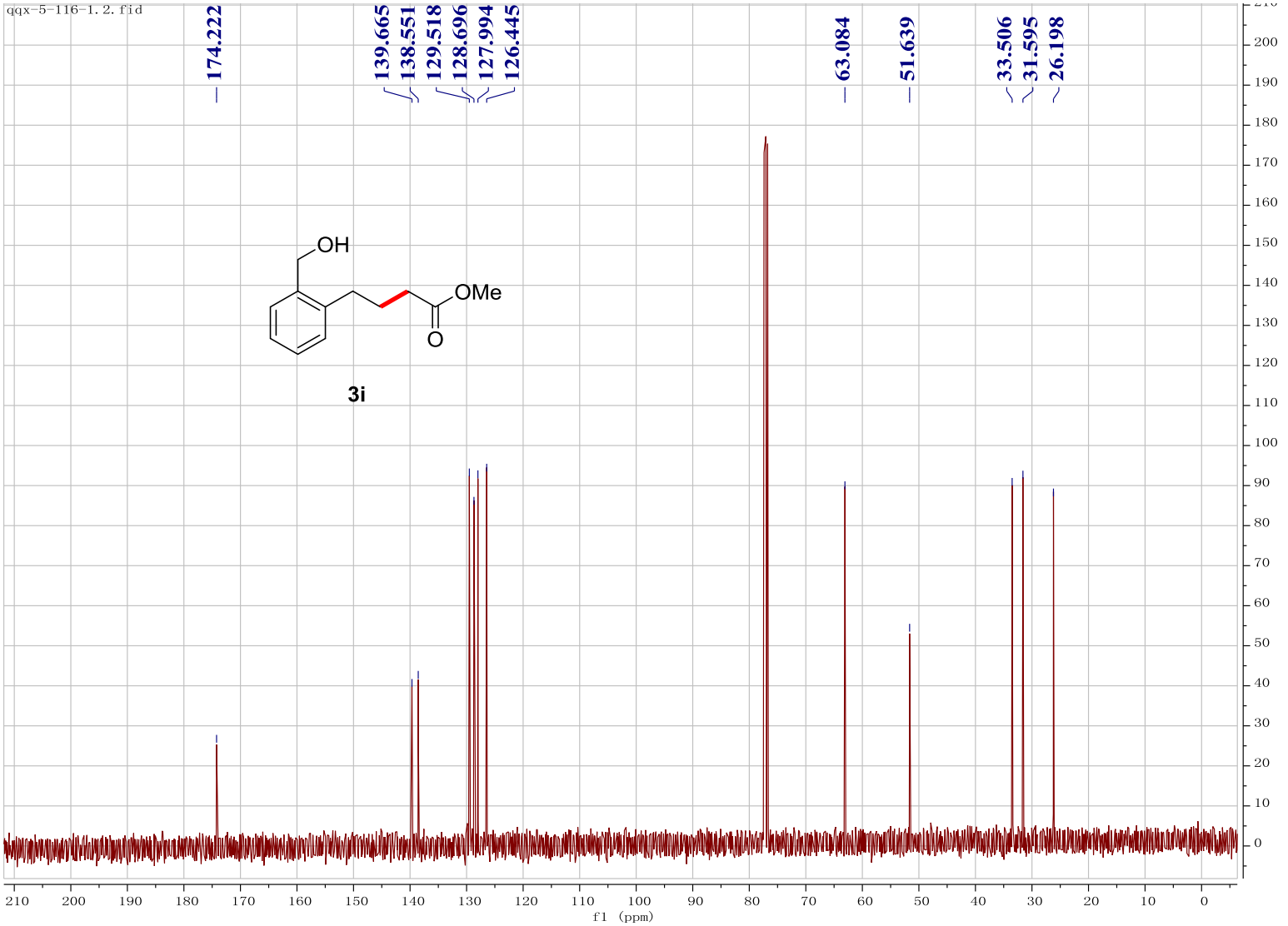
7.386
7.373
7.368
7.269
7.265
7.251
7.247
7.242
7.229
7.225
7.216
7.211
7.199
7.194
4.723
3.677
2.757
2.742
2.737
2.732
2.717
2.430
2.412
2.394
1.997
1.979
1.973
1.964
1.959
1.955
1.947
1.940
1.922
OH
OMe
O
3i
1.03
2.92
2.08
2.96
2.00
2.04
1.18
2.09
f1 (ppm)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138.551
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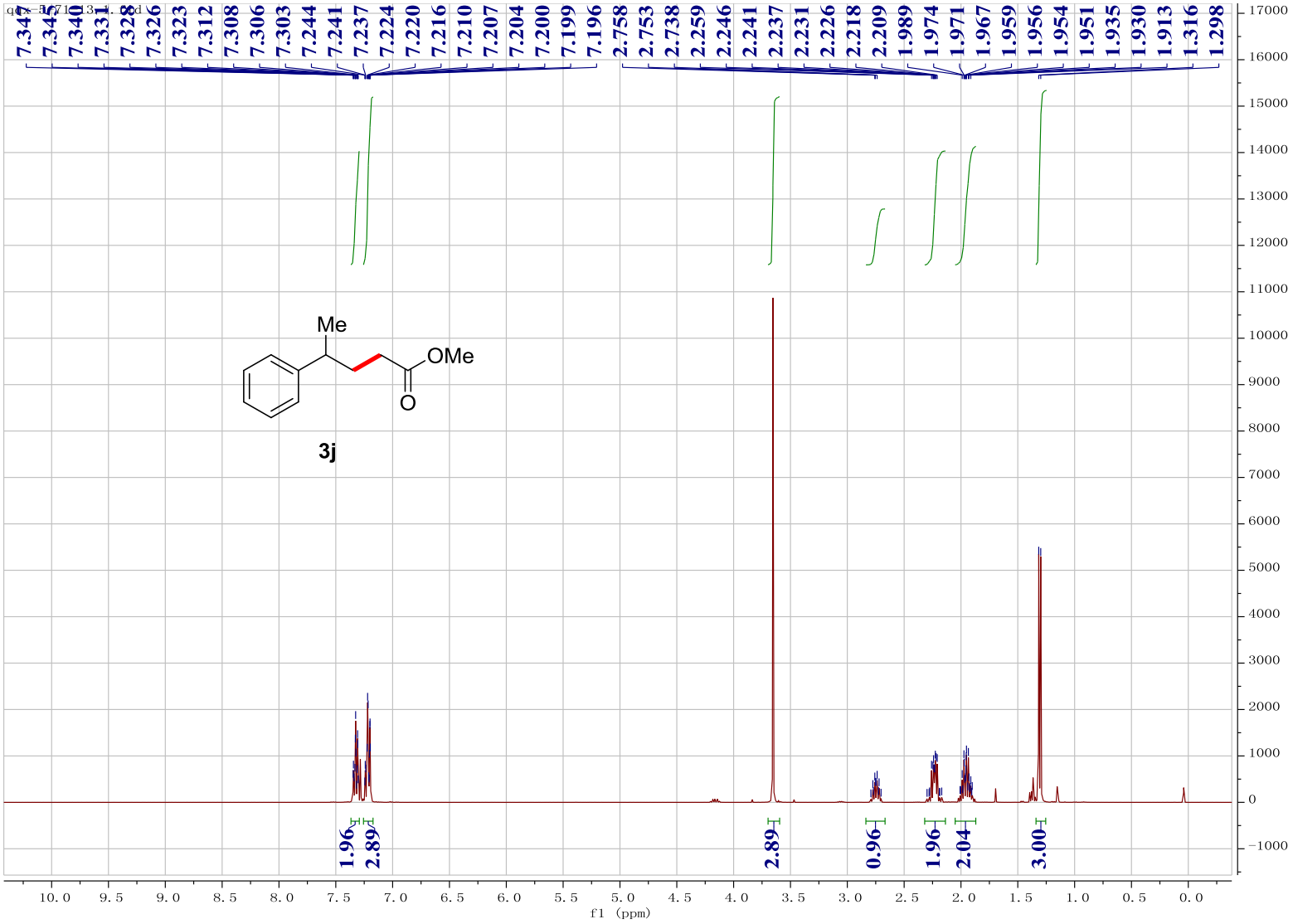
127.994
126.445
63.084
51.639
33.506
31.595
26.198
OH
OMe
O
3i
f1 (ppm)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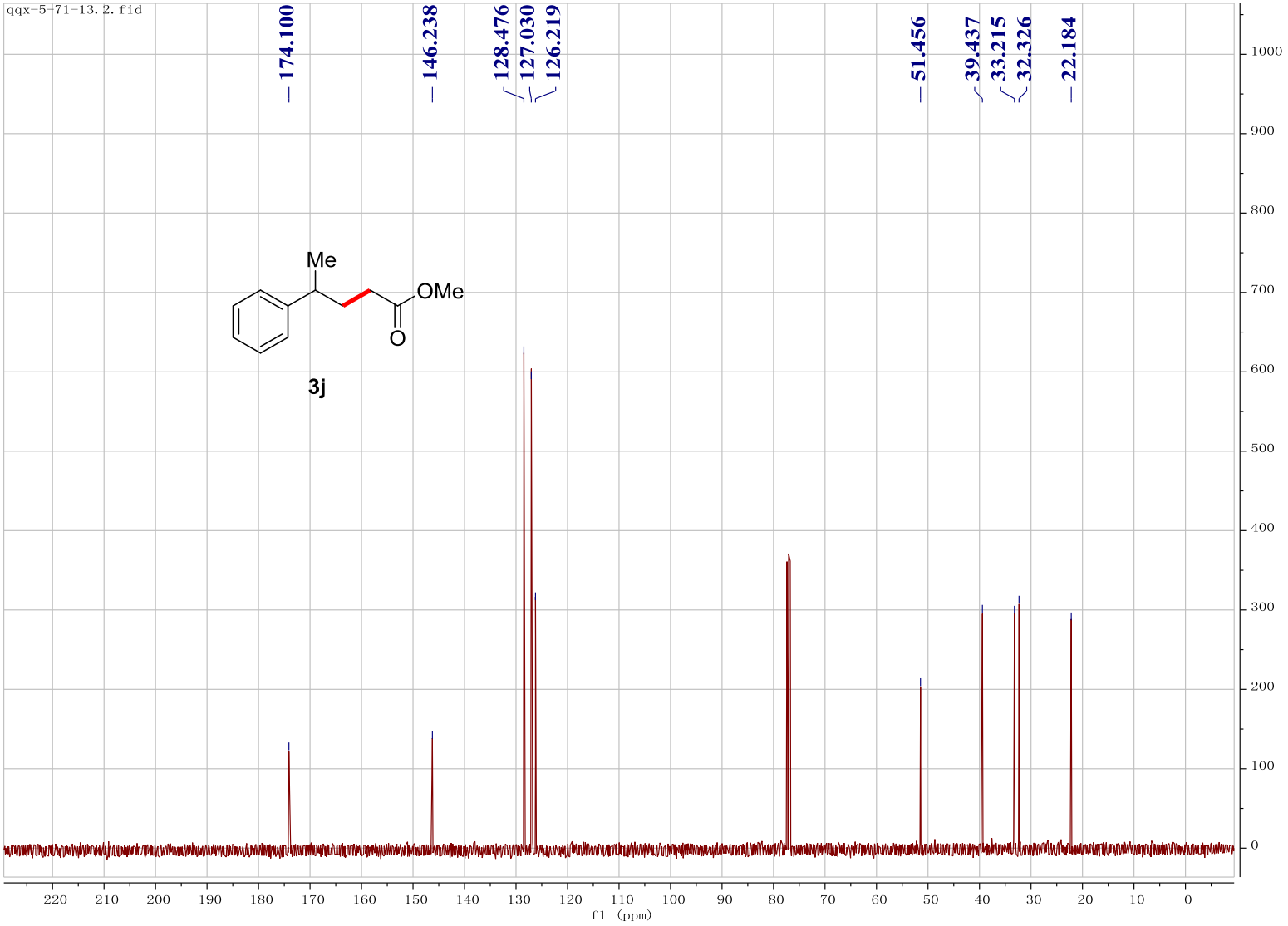
7.345
7.340
7.331
7.328
7.326
7.323
7.312
7.308
7.306
7.303
7.244
7.241
7.237
7.224
7.220
7.216
7.210
7.207
7.204
7.200
7.199
7.196
2.758
2.753
2.738
2.259
2.246
2.241
2.237
2.231
2.226
2.218
2.209
1.989
1.974
1.971
1.967
1.959
1.956
1.954
1.951
1.935
1.930
1.913
1.316
1.298
Me
OMe
O
3j
1.96
2.89
2.89
0.96
1.96
2.04
3.00
f1 (ppm)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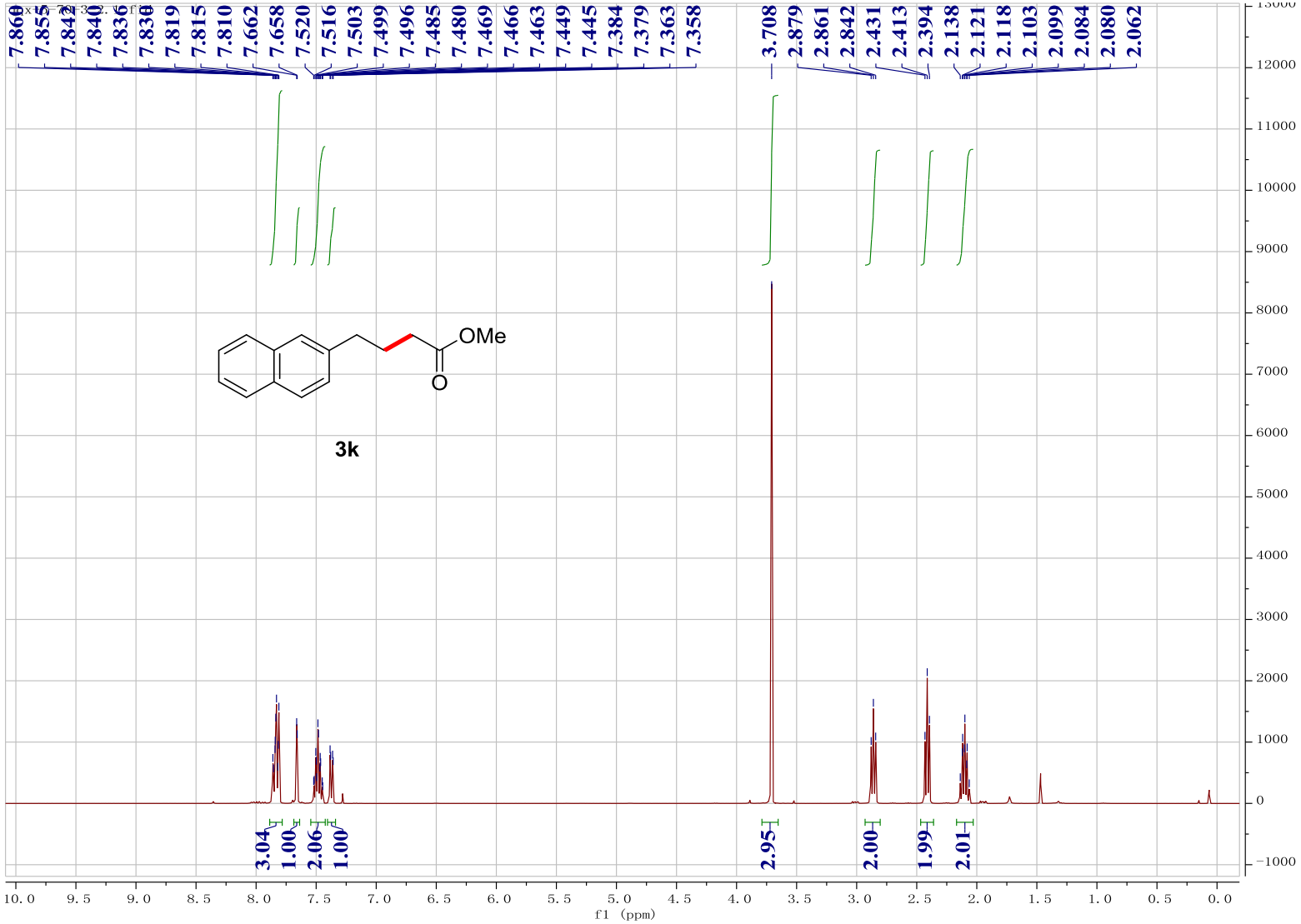
146.238
128.476
127.030
126.219
51.456
39.437
33.215
32.326
22.184
Me
OMe
O
3j
f1 (ppm)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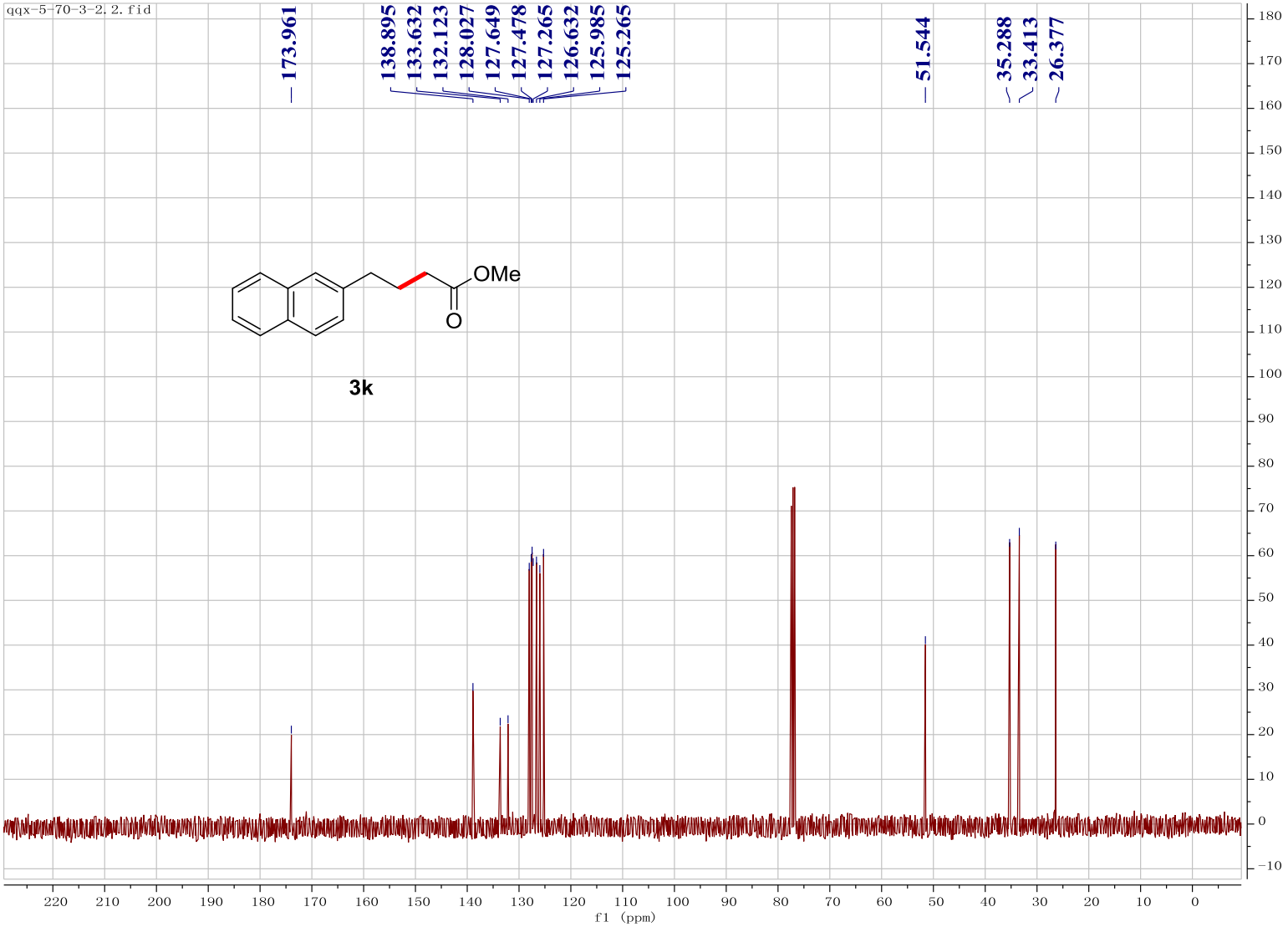
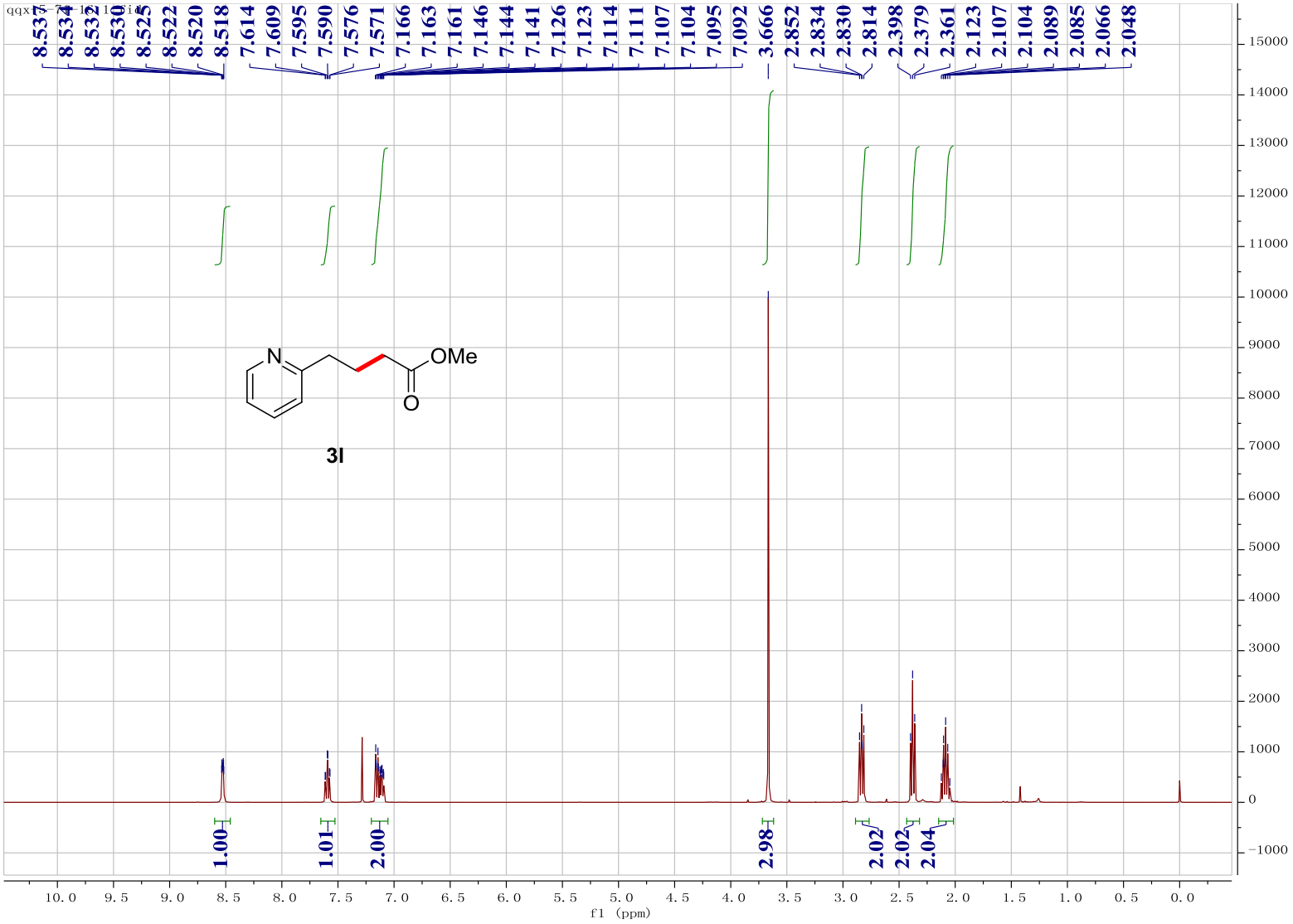
7.855
7.842
7.840
7.836
7.830
7.819
7.815
7.810
7.662
7.658
7.520
7.516
7.503
7.499
7.496
7.485
7.480
7.469
7.466
7.463
7.449
7.445
7.384
7.379
7.363
7.358
3.708
2.879
2.861
2.842
2.431
2.413
2.394
2.138
2.121
2.118
2.103
2.099
2.084
2.080
2.062
OMe
O
3k
3.04
1.00
2.06
1.00
2.95
2.00
1.99
2.01
f1 (ppm)


qqx-5-70-3-2.2.fid
173.961
138.895
133.632
132.123
128.027
127.649
127.478
127.265
126.632
125.985
125.265
51.544
35.288
33.413
26.377
OMe
O
3k
f1 (ppm)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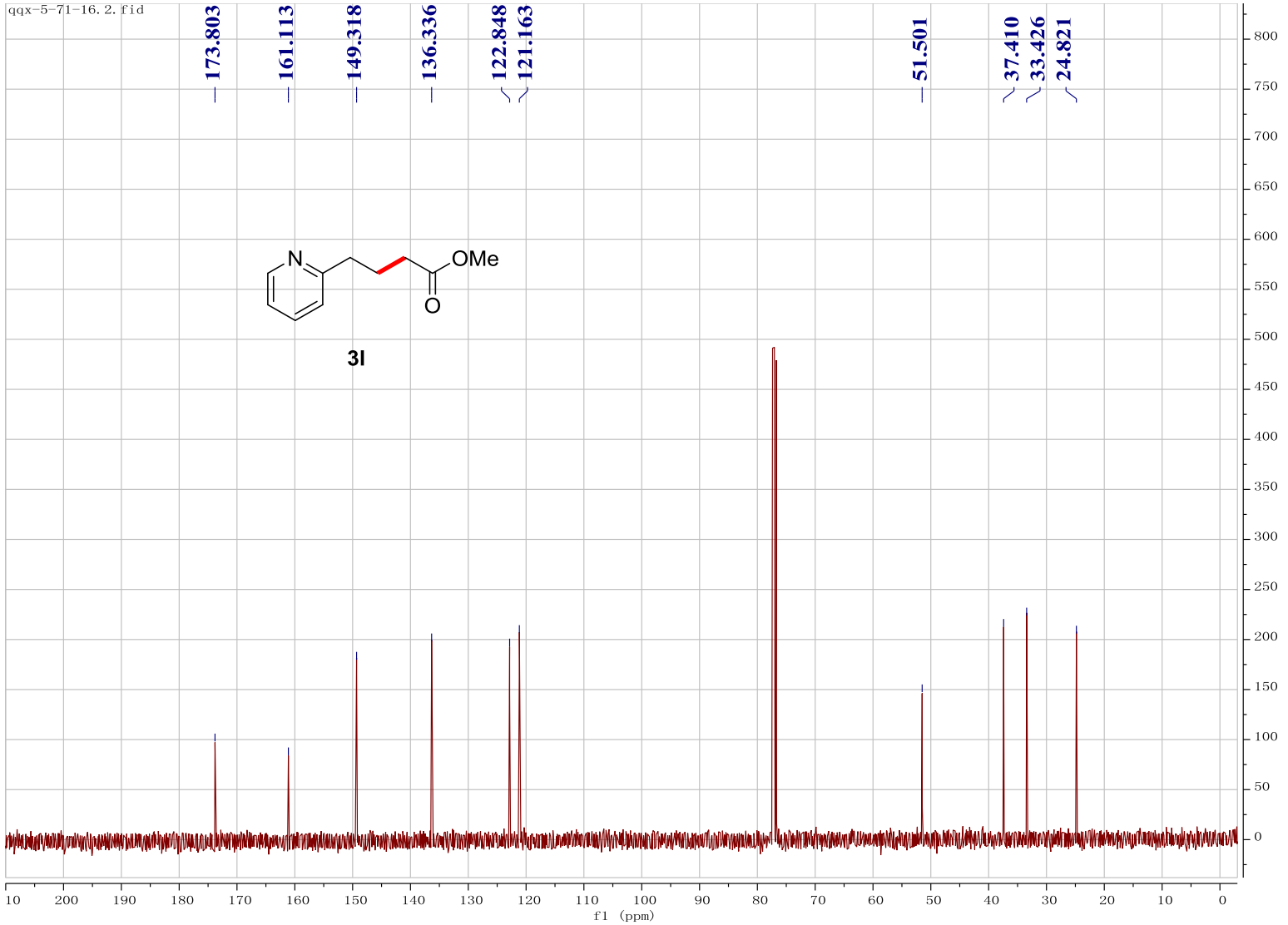
8.534
8.532
8.530
8.525
8.522
8.520
8.518
7.614
7.609
7.595
7.590
7.576
7.571
7.166
7.163
7.161
7.146
7.144
7.141
7.126
7.123
7.114
7.111
7.107
7.104
7.095
7.092
3.666
2.852
2.834
2.830
2.814
2.398
2.379
2.361
2.123
2.107
2.104
2.089
2.085
2.066
2.048
N
OMe
O
3l
1.00
1.01
2.00
2.98
2.02
2.02
2.04
f1 (ppm)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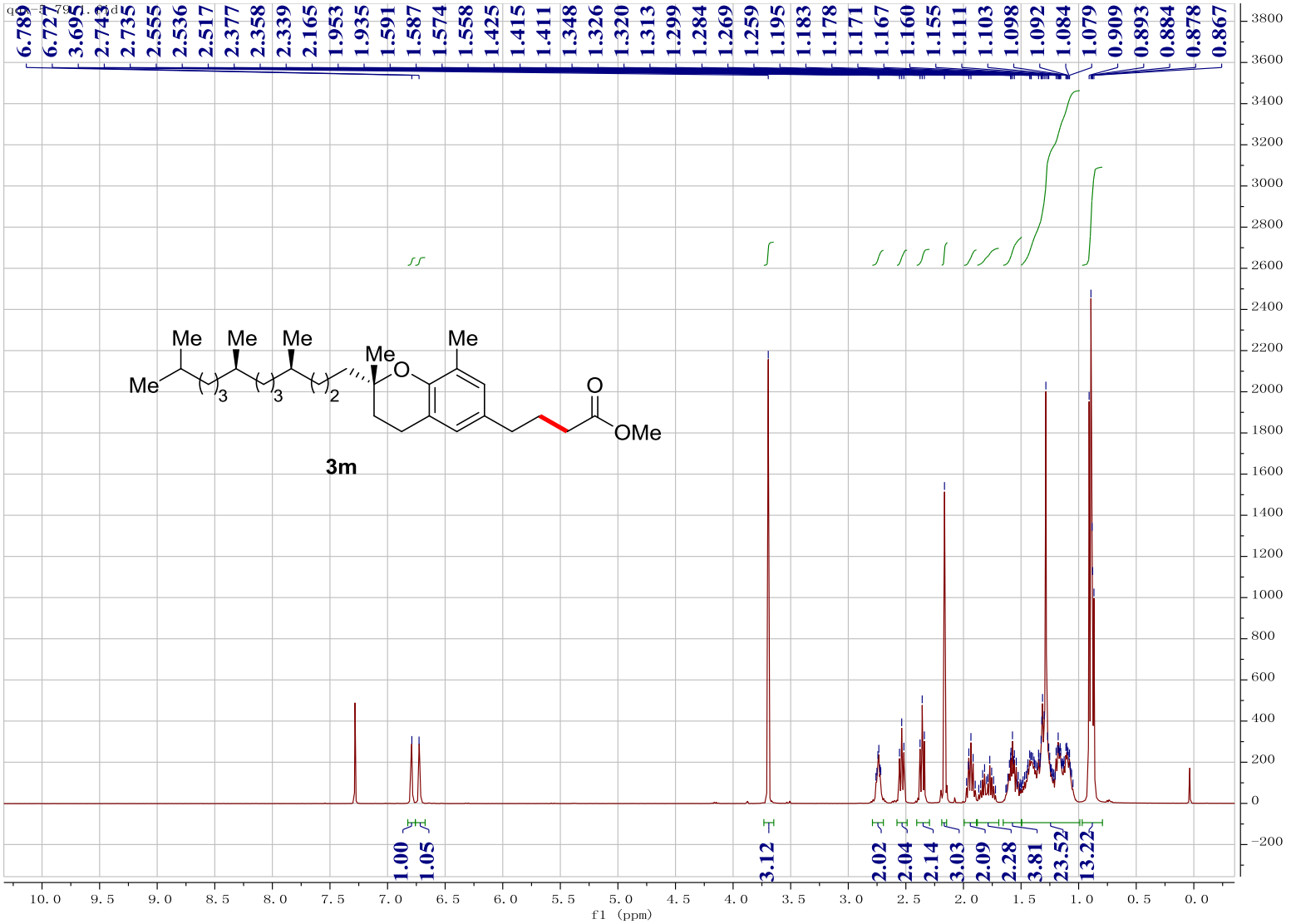
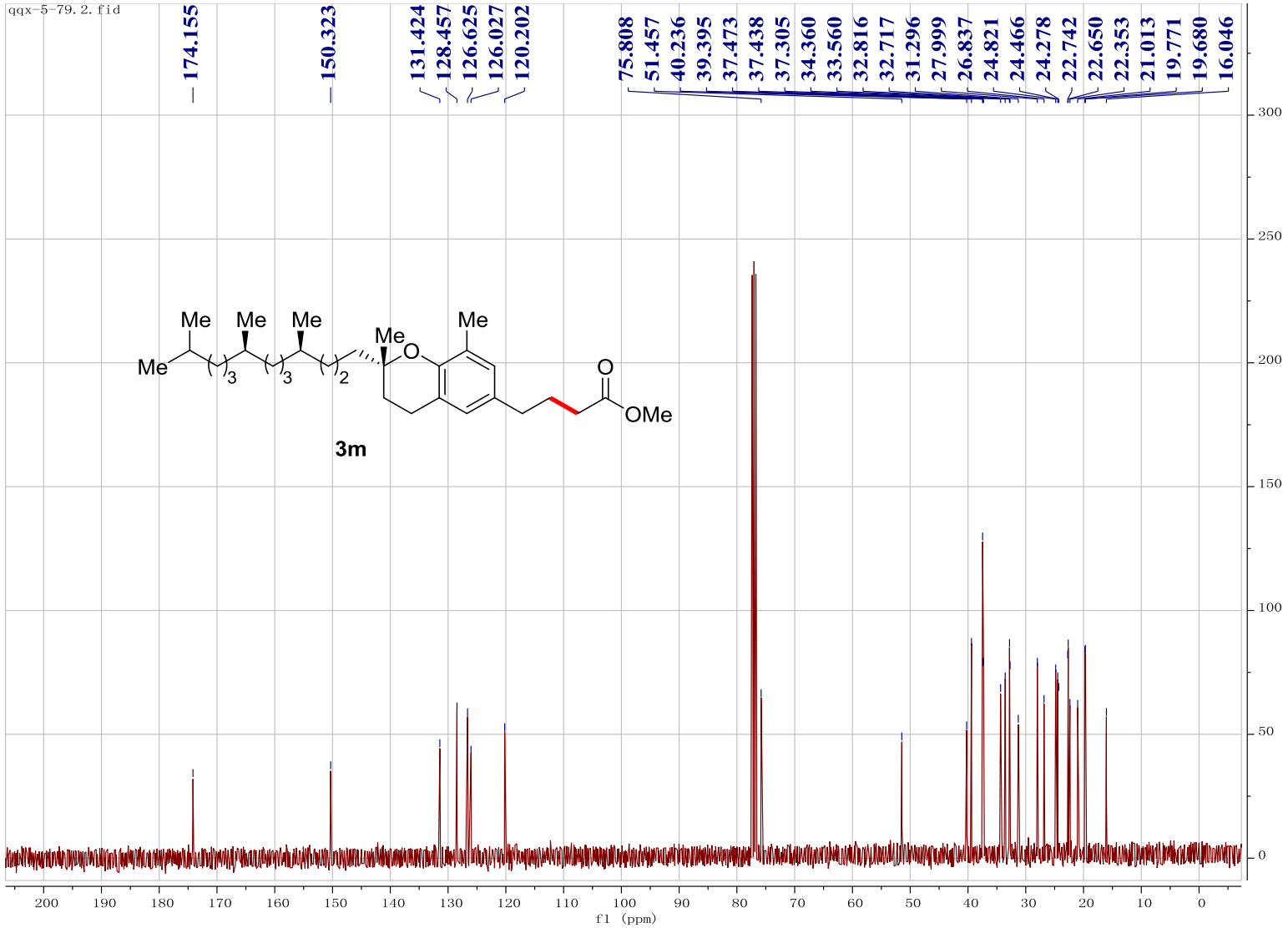
161.113
149.318
136.336
122.848
121.163
51.501
37.410
33.426
24.821
N
OMe
O
3l
f1 (ppm)


6.789
6.727
3.695
2.743
2.735
2.555
2.536
2.517
2.377
2.358
2.339
2.165
1.953
1.935
1.591
1.587
1.574
1.558
1.425
1.415
1.411
1.348
1.326
1.320
1.313
1.299
1.284
1.269
1.259
1.195
1.183
1.178
1.171
1.167
1.160
1.155
1.111
1.103
1.098
1.092
1.084
1.079
0.909
0.893
0.884
0.878
0.867
Me
Me
Me
Me
Me
Me
O
O
OMe
3m
1.00
1.05
3.12
2.02
2.04
2.14
3.03
2.09
2.28
3.81
23.52
13.22
f1 (ppm)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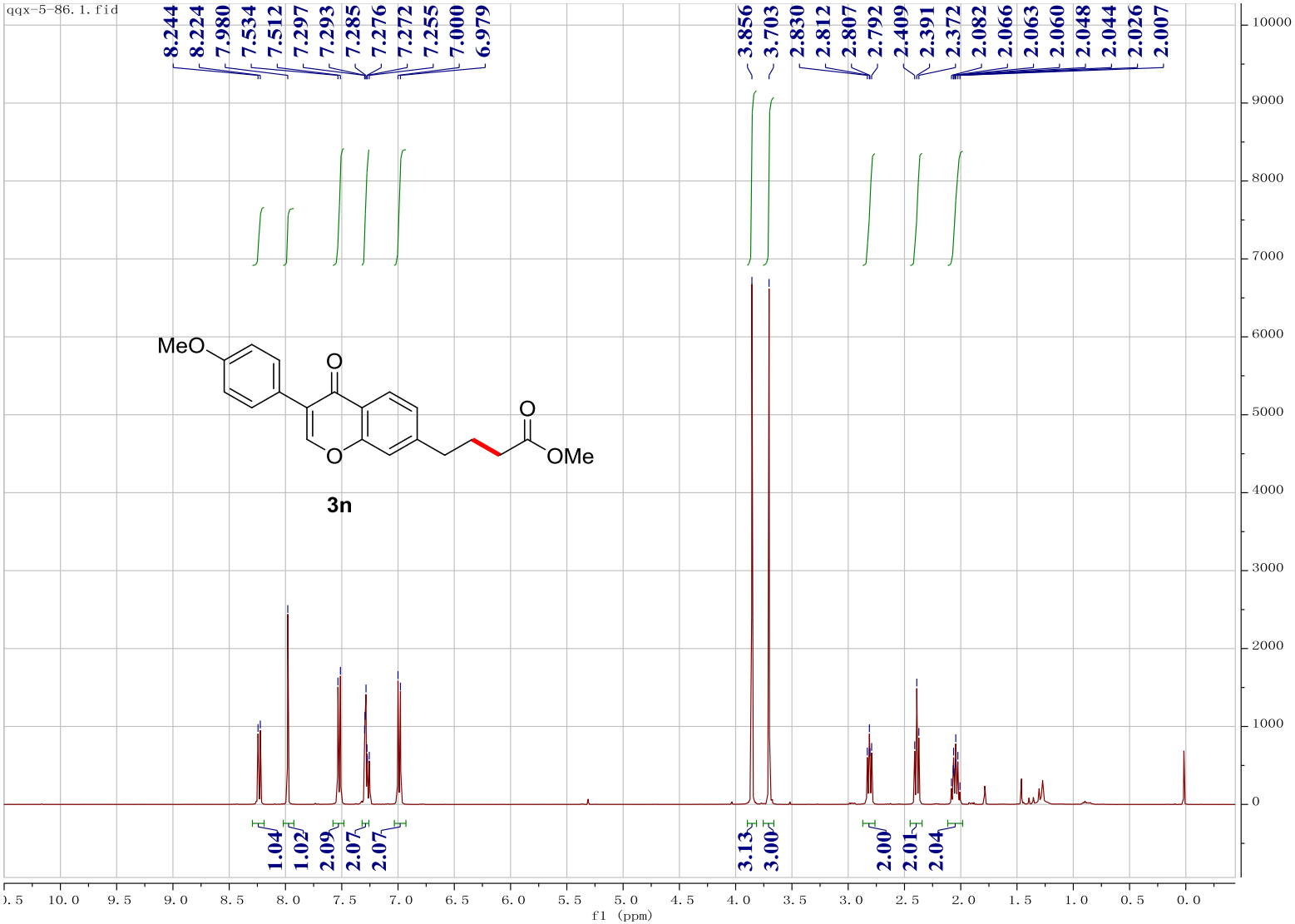
150.323
131.424
128.457
126.625
126.027
120.202
75.808
51.457
40.236
39.395
37.473
37.438
37.305
34.360
33.560
32.816
32.717
31.296
27.999
26.837
24.821
24.466
24.278
22.742
22.650
22.353
21.013
19.771
19.680
16.046
Me
Me
Me
Me
Me
Me
O
O
OMe
3m
f1 (ppm)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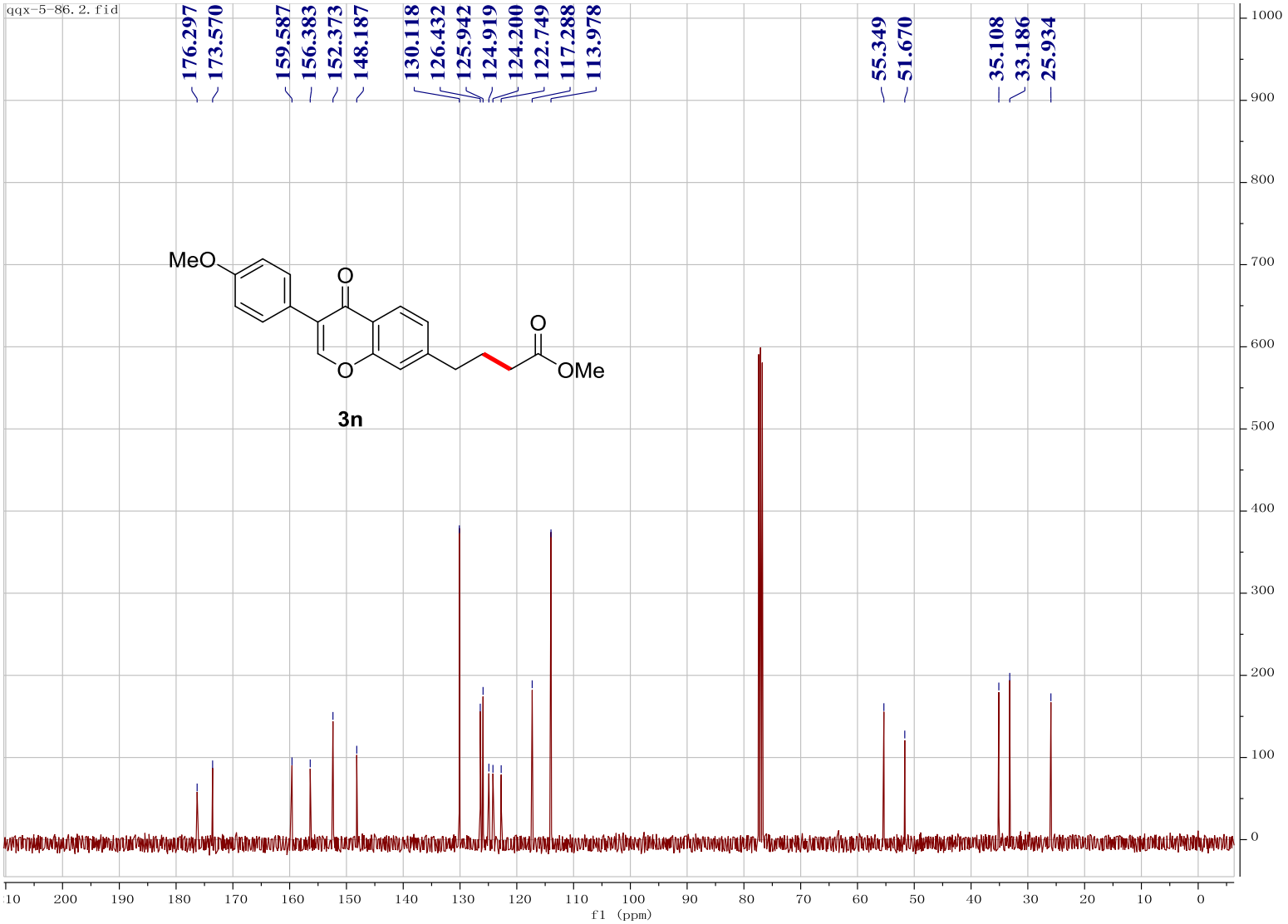
8.244
8.224
7.980
7.534
7.512
7.297
7.293
7.285
7.276
7.272
7.255
7.000
6.979
3.856
3.703
2.830
2.812
2.807
2.792
2.409
2.391
2.372
2.082
2.066
2.063
2.060
2.048
2.044
2.026
2.007
MeO
O
O
O
OMe
3n
1.04
1.02
2.09
2.07
2.07
3.13
3.00
2.00
2.01
2.04
f1 (ppm)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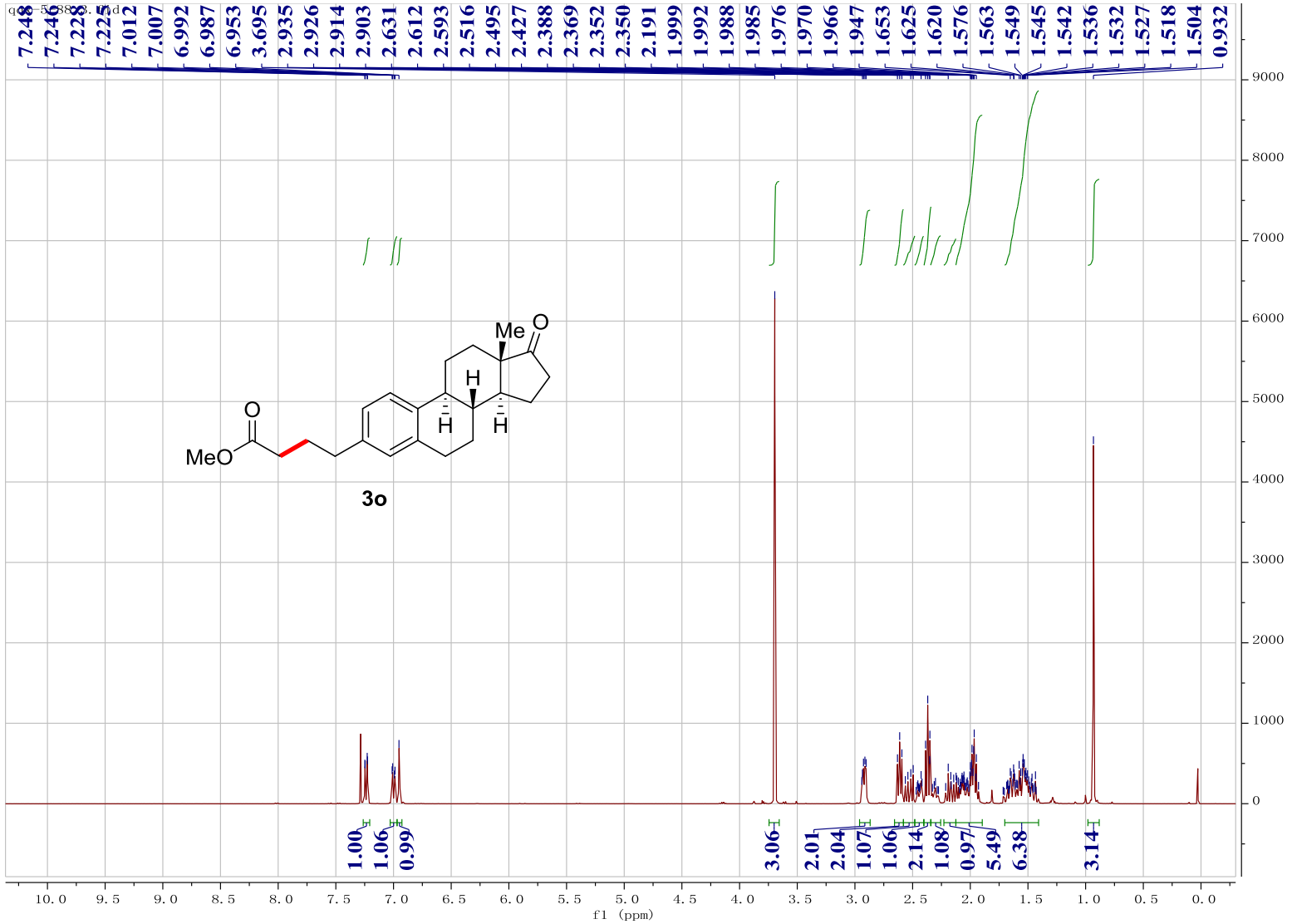
173.570
159.587
156.383
152.373
148.187
130.118
126.432
125.942
124.919
124.200
122.749
117.288
113.978
55.349
51.670
35.108
33.186
25.934
MeO
O
O
O
OMe
3n
f1 (ppm)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7.225
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7.007
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6.987
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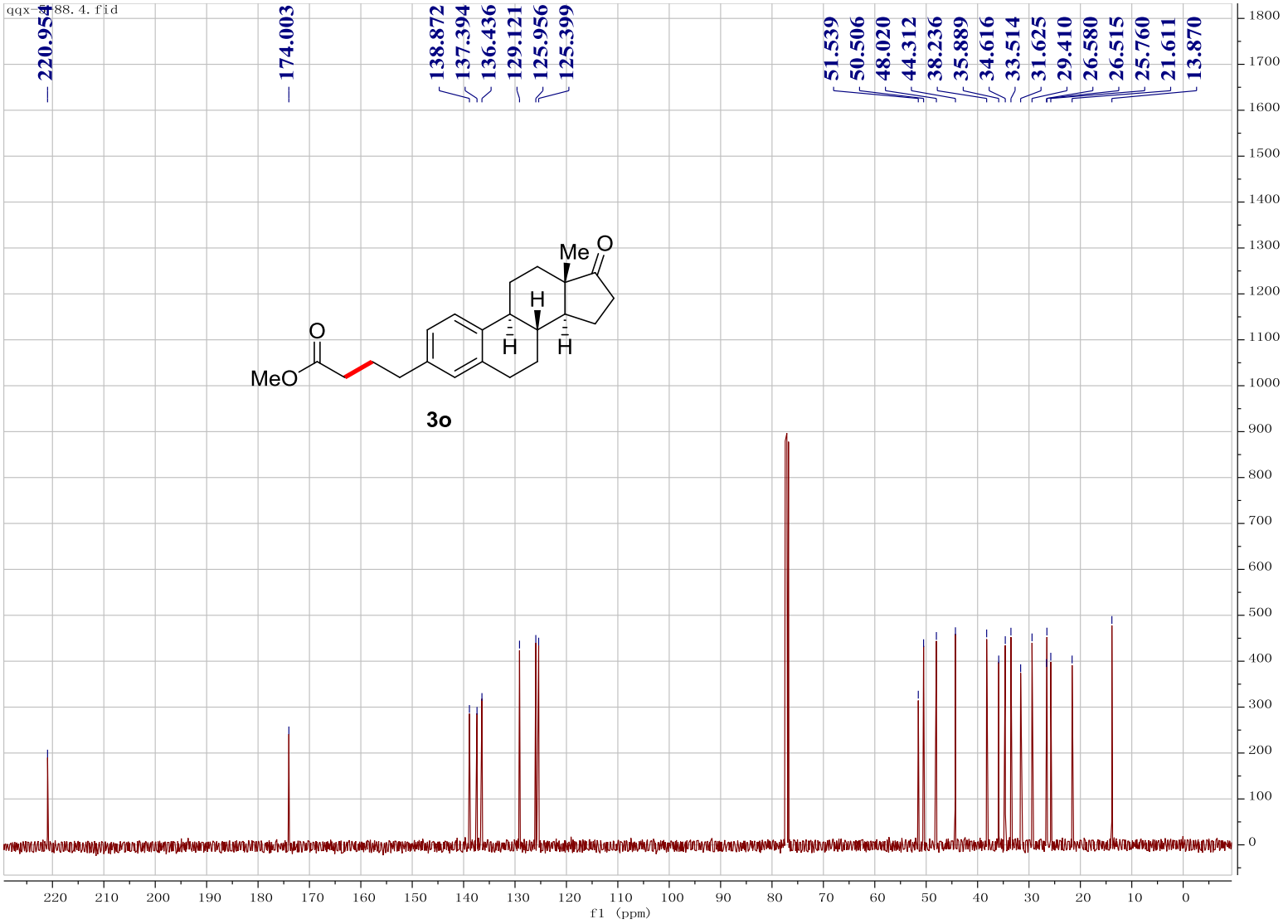
3.695
2.935
2.926
2.914
2.903
2.631
2.612
2.593
2.516
2.495
2.427
2.388
2.369
2.352
2.350
2.191
1.999
1.992
1.988
1.985
1.976
1.970
1.966
1.947
1.653
1.625
1.620
1.576
1.563
1.549
1.545
1.542
1.536
1.532
1.527
1.518
1.504
0.932
Me
O
H
H
H
O
MeO
3o
1.00
1.06
0.99
3.06
2.01
2.04
1.07
1.06
2.14
1.08
0.97
5.49
6.38
3.14
f1 (ppm)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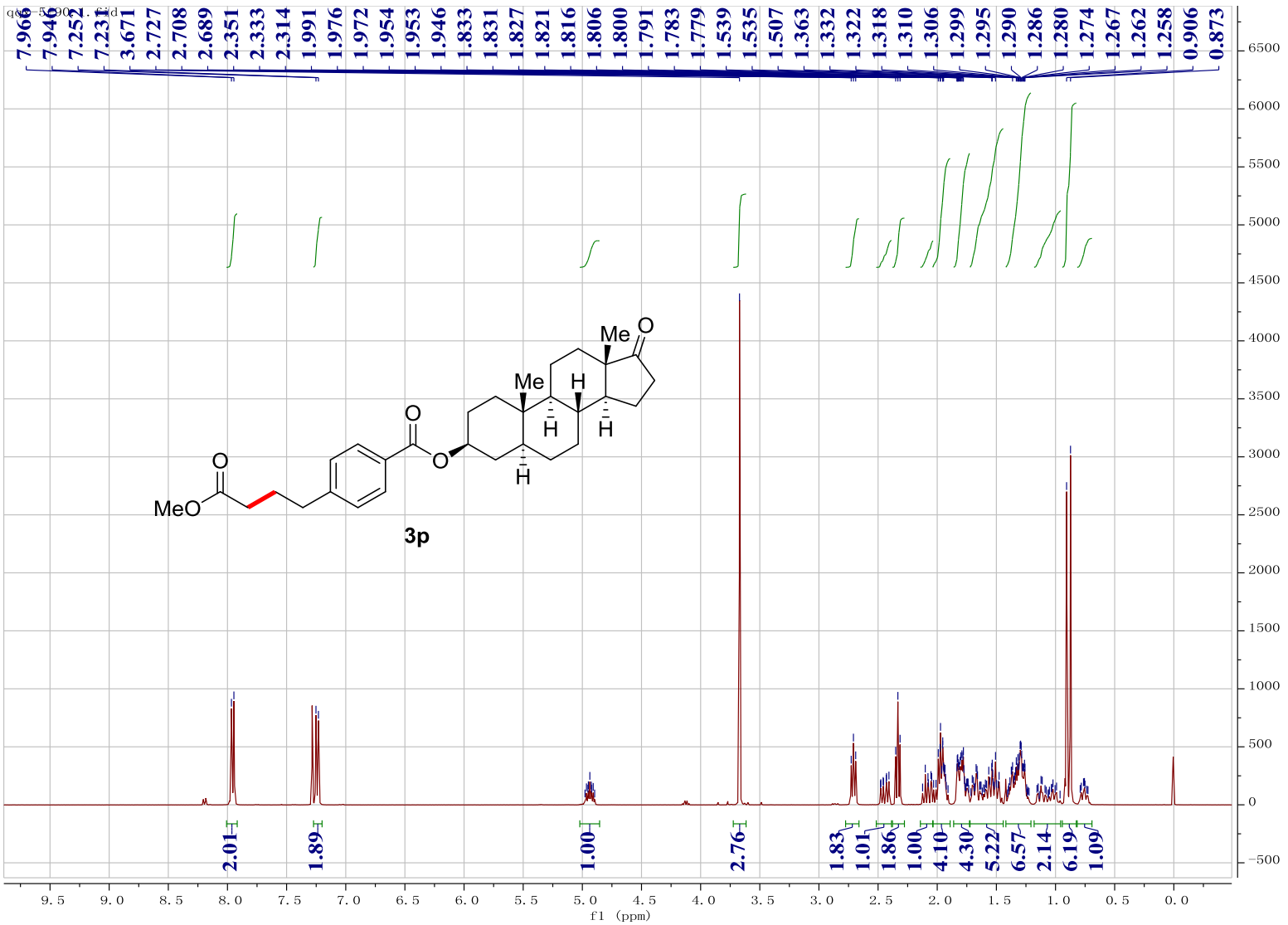
125.399
51.539
50.506
48.020
44.312
38.236
35.889
34.616
33.514
31.625
29.410
26.580
26.515
25.760
21.611
13.870
Me
O
H
H
H
O
MeO
3o
f1 (ppm)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2.333
2.314
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1.976
1.972
1.954
1.953
1.946
1.833
1.831
1.827
1.821
1.816
1.806
1.800
1.791
1.783
1.779
1.539
1.535
1.507
1.363
1.332
1.322
1.318
1.310
1.306
1.299
1.295
1.290
1.286
1.280
1.274
1.267
1.262
1.258
0.906
0.873
Me
O
Me
H
O
O
O
MeO
H
H
H
3p
2.01
1.89
1.00
2.76
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1.01
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1.00
4.10
4.30
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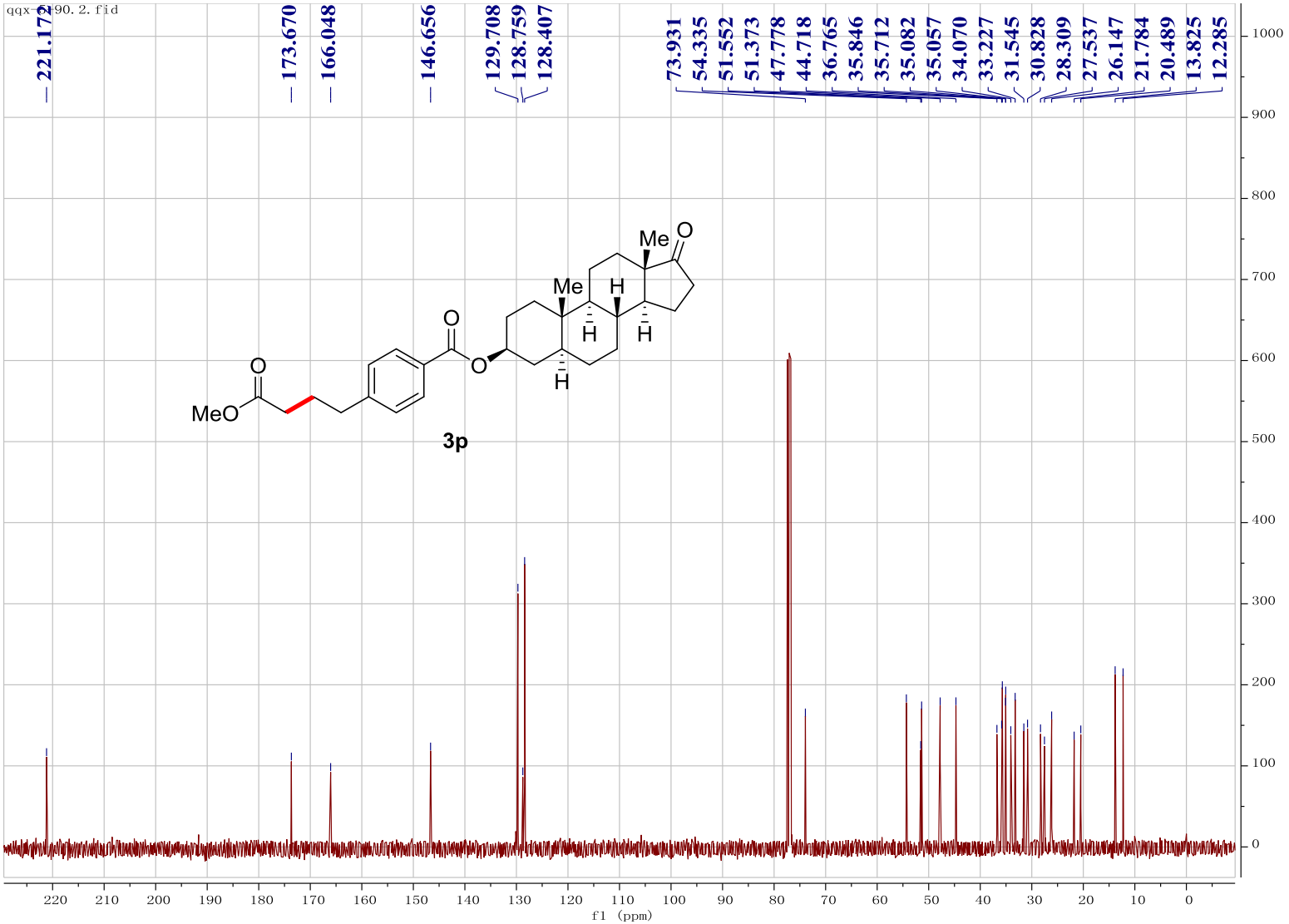
6.57
2.14
6.19
1.09
f1 (ppm)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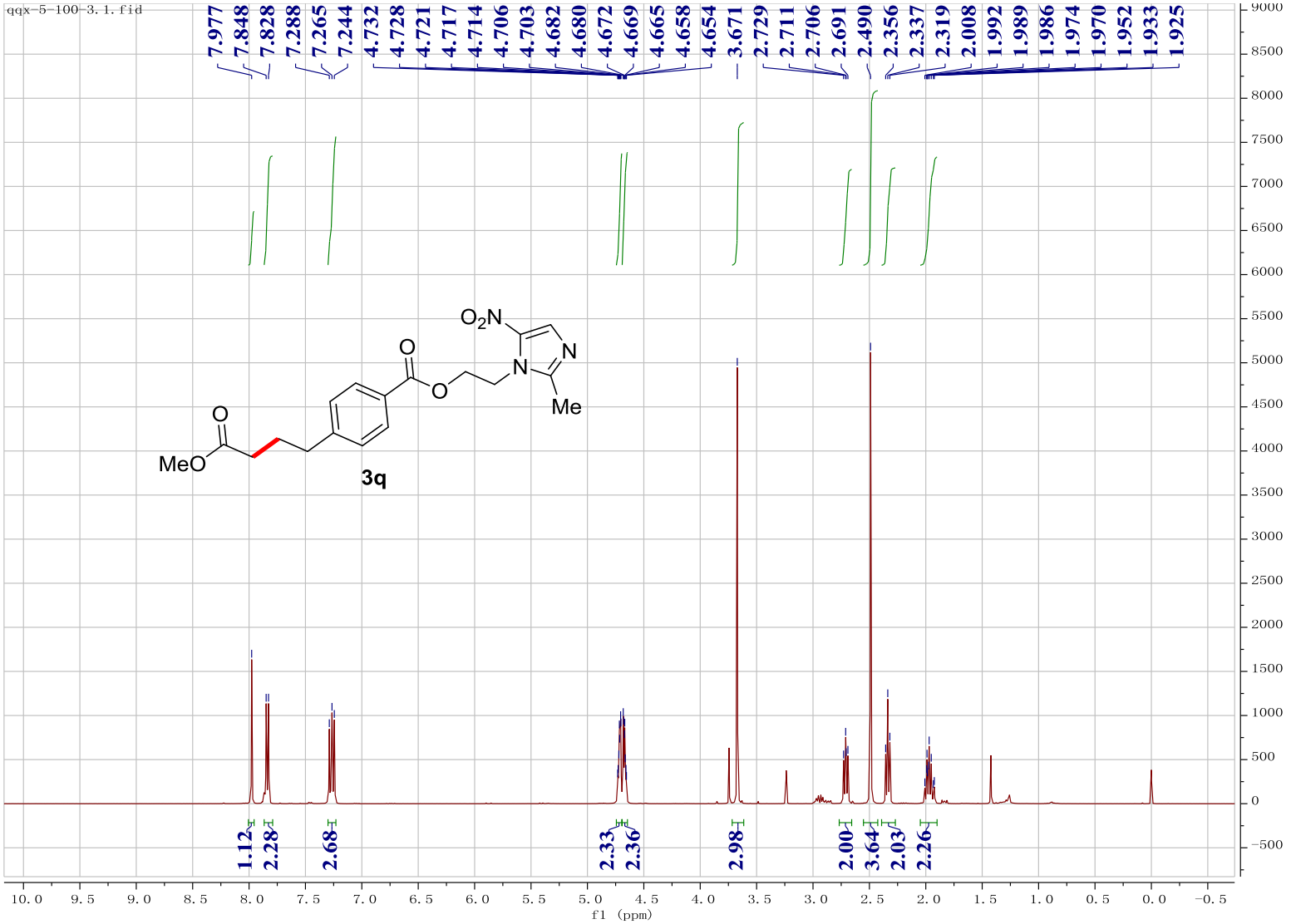
128.759
128.407
73.931
54.335
51.552
51.373
47.778
44.718
36.765
35.846
35.712
35.082
35.057
34.070
33.227
31.545
30.828
28.309
27.537
26.147
21.784
20.489
13.825
12.285
Me
O
Me
H
O
O
H
H
H
O
MeO
3p
f1 (ppm)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7.288
7.265
7.244
4.732
4.728
4.721
4.717
4.714
4.706
4.703
4.682
4.680
4.672
4.669
4.665
4.658
4.654
3.671
2.729
2.711
2.706
2.691
2.490
2.356
2.337
2.319
2.008
1.992
1.989
1.986
1.974
1.970
1.952
1.933
1.925
O2N
N
N
Me
O
O
O
MeO
3q
1.12
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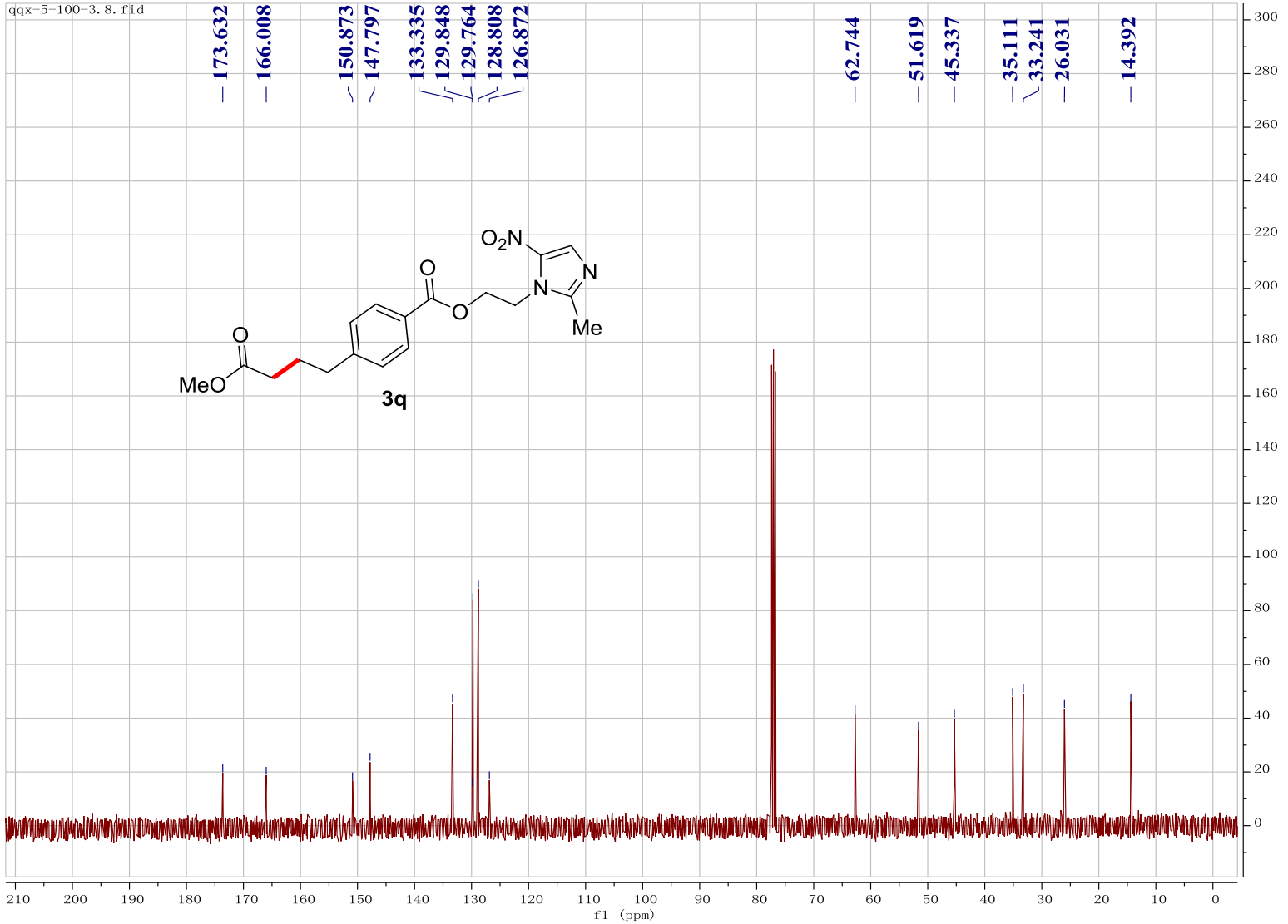
2.68
2.33
2.36
2.98
2.00
3.64
2.03
2.26
f1 (ppm)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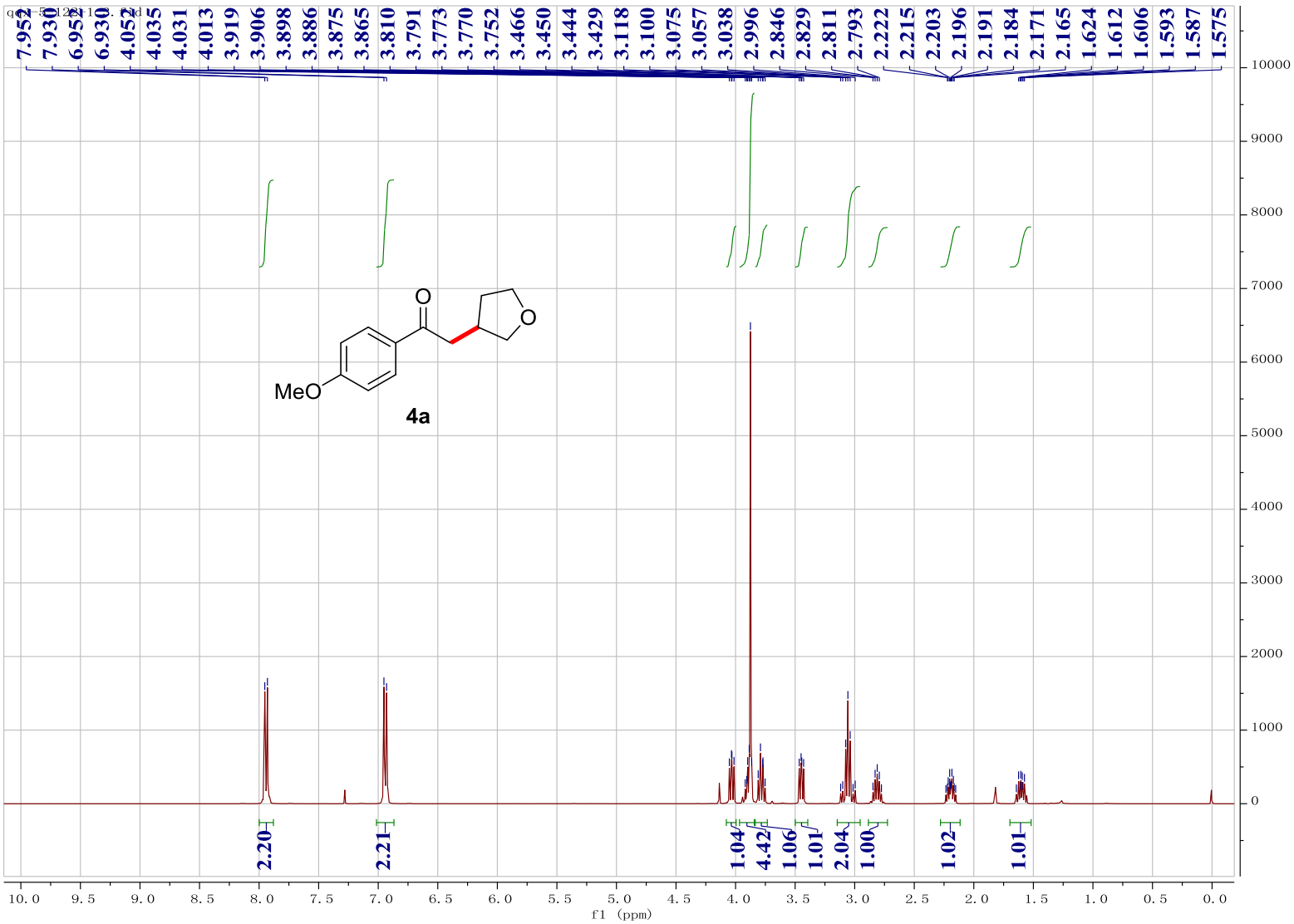
129.848
129.764
128.808
126.872
62.744
51.619
45.337
35.111
33.241
26.031
14.392
O2N
N
N
Me
O
O
O
MeO
3q
f1 (ppm)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6.930
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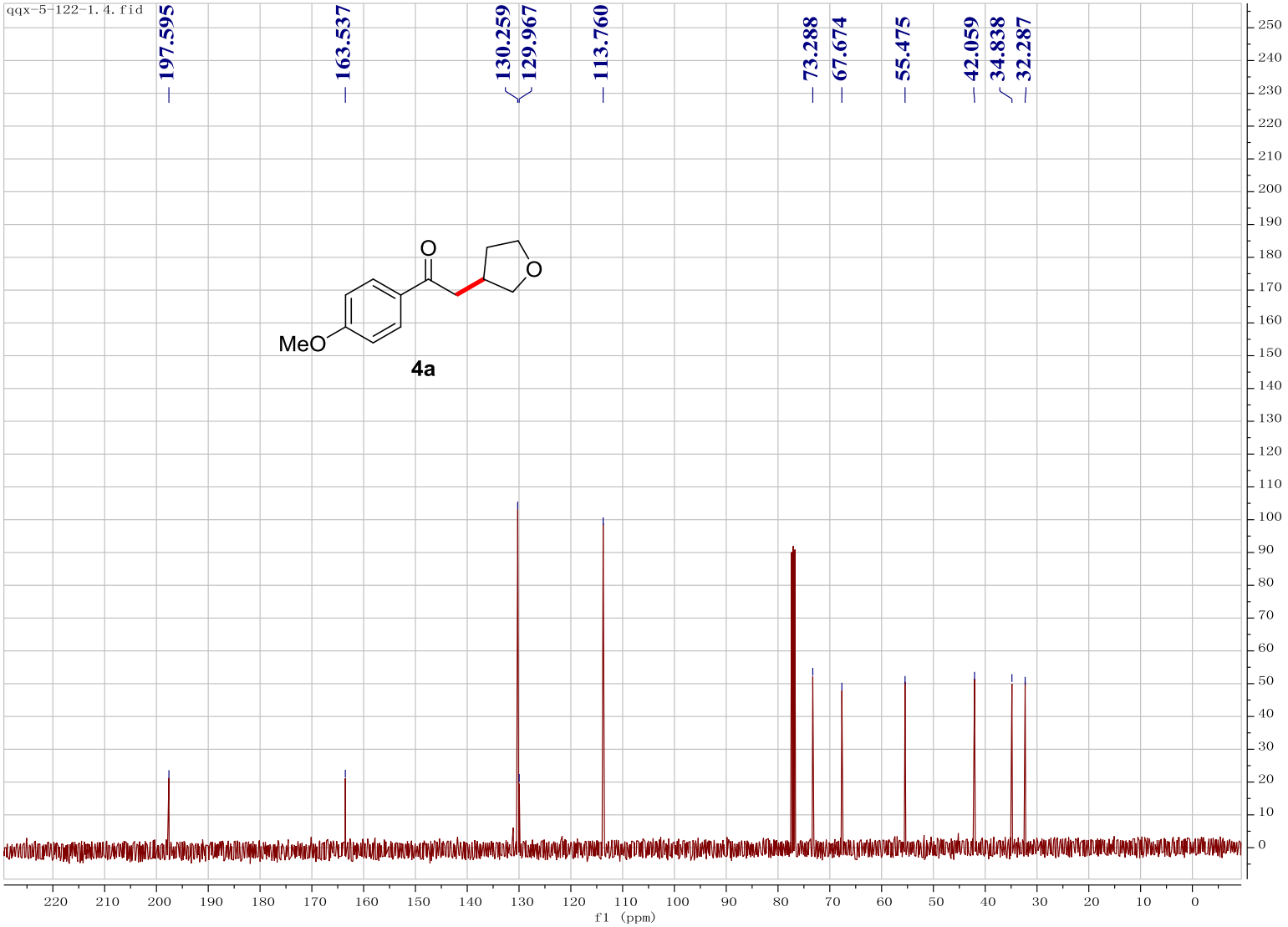
4.035
4.031
4.013
3.919
3.906
3.898
3.886
3.875
3.865
3.810
3.791
3.773
3.770
3.752
3.466
3.450
3.444
3.429
3.118
3.100
3.075
3.057
3.038
2.996
2.846
2.829
2.811
2.793
2.222
2.215
2.203
2.196
2.191
2.184
2.171
2.165
1.624
1.612
1.606
1.593
1.587
1.575
MeO
O
O
4a
2.20
2.21
1.04
4.42
1.06
1.01
2.04
1.00
1.02
1.01
f1 (ppm)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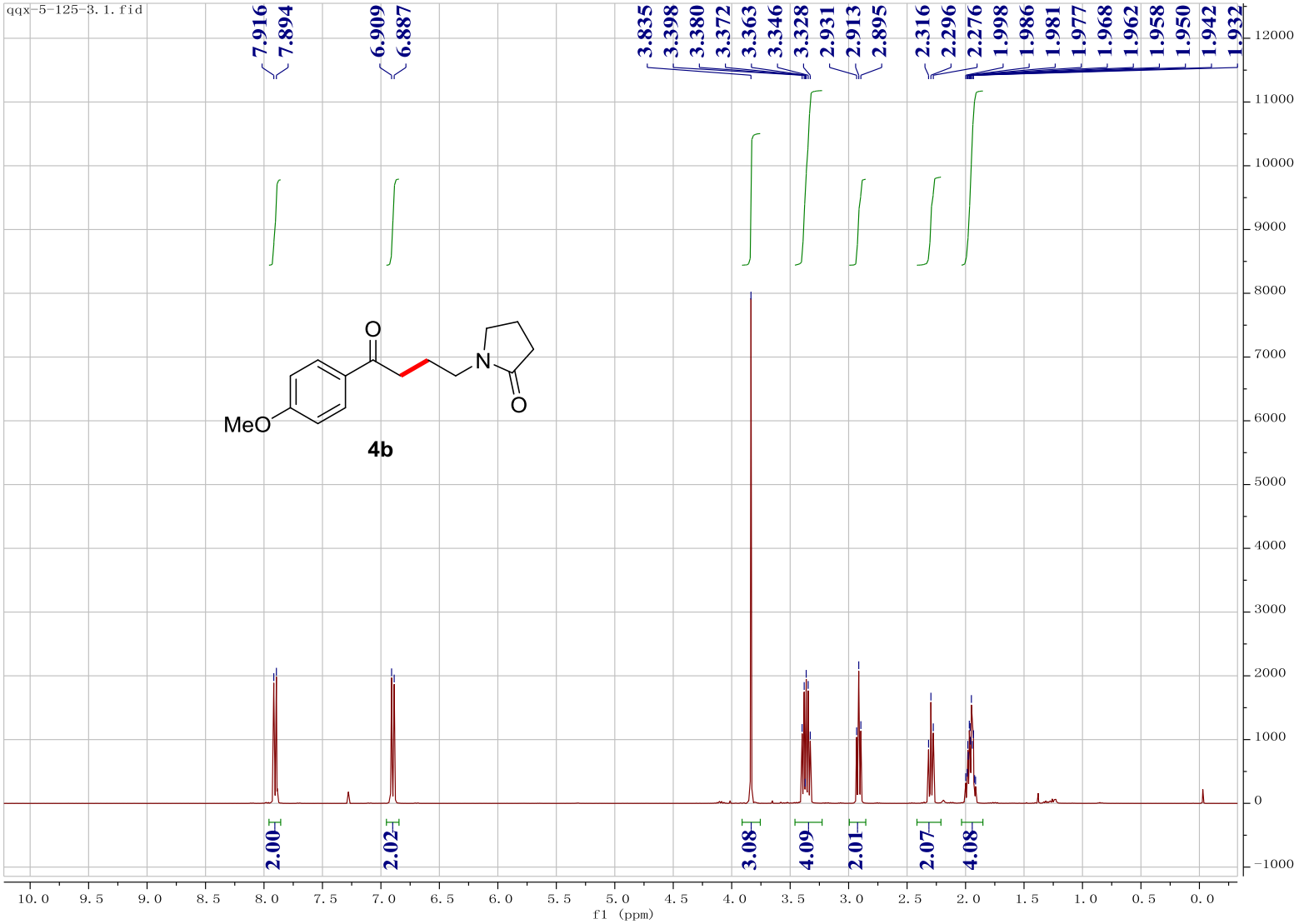
197.595
163.537
130.259
129.967
113.760
73.288
67.674
55.475
42.059
34.838
32.287
O
O
MeO
4a
f1 (ppm)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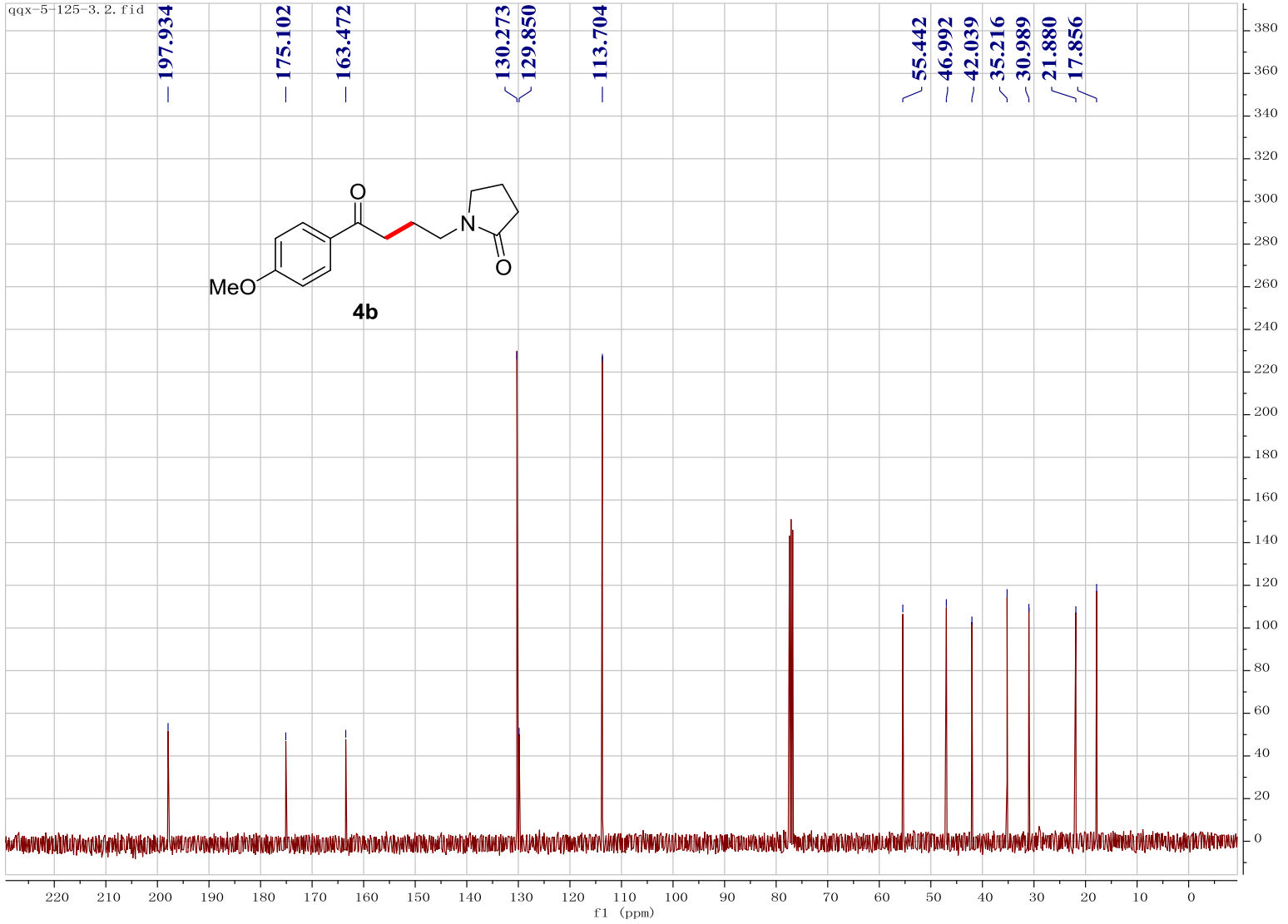
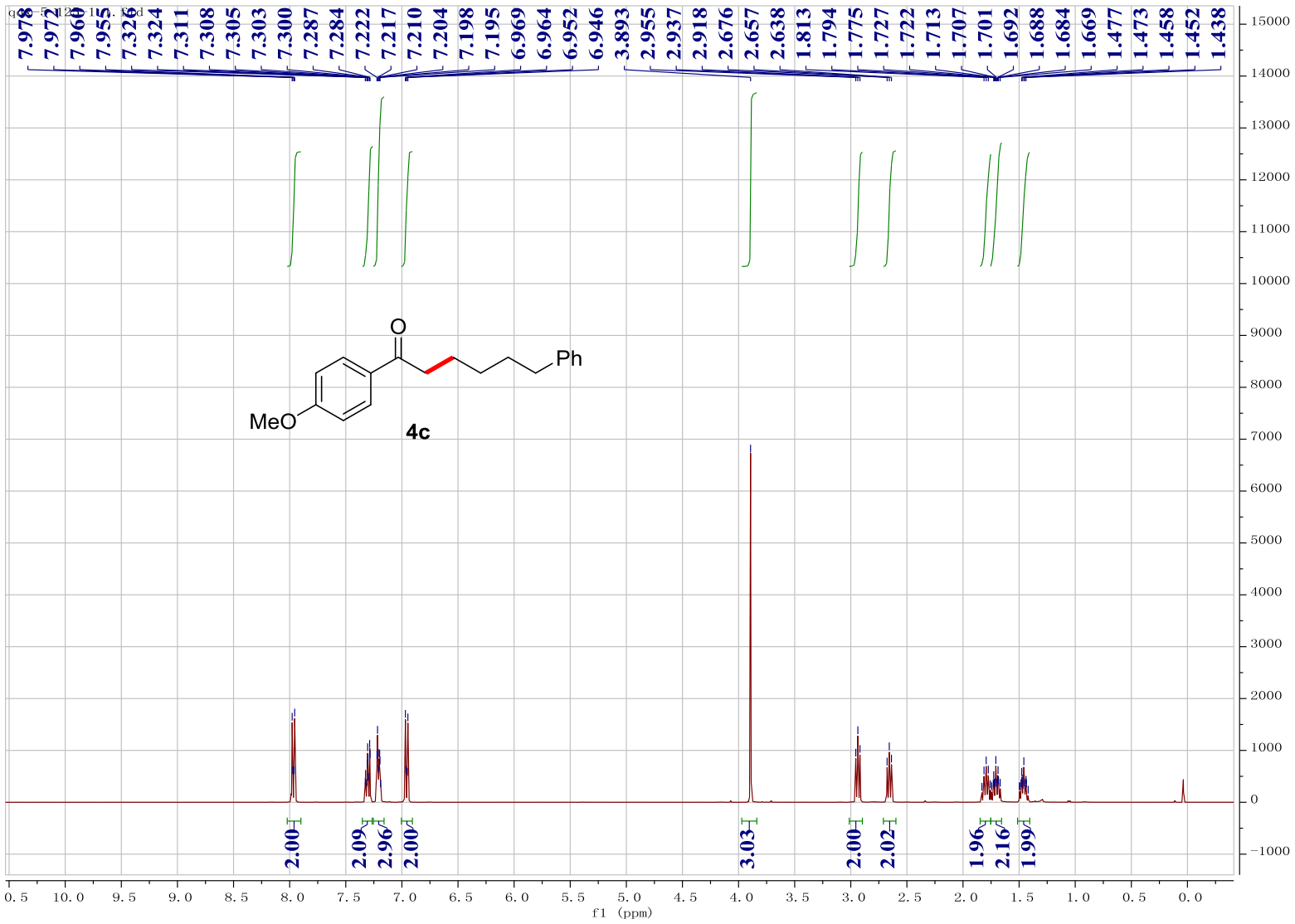
6.909
6.887
3.835
3.398
3.380
3.372
3.363
3.346
3.328
2.931
2.913
2.895
2.316
2.296
2.276
1.998
1.986
1.981
1.977
1.968
1.962
1.958
1.950
1.942
1.932
O
N
O
MeO
4b
2.00
2.02
3.08
4.09
2.01
2.07
4.08
f1 (ppm)


qqx-5-125-3.2.fid
197.934
175.102
163.472
130.273
129.850
113.704
55.442
46.992
42.039
35.216
30.989
21.880
17.856
O
N
O
MeO
4b
f1 (ppm)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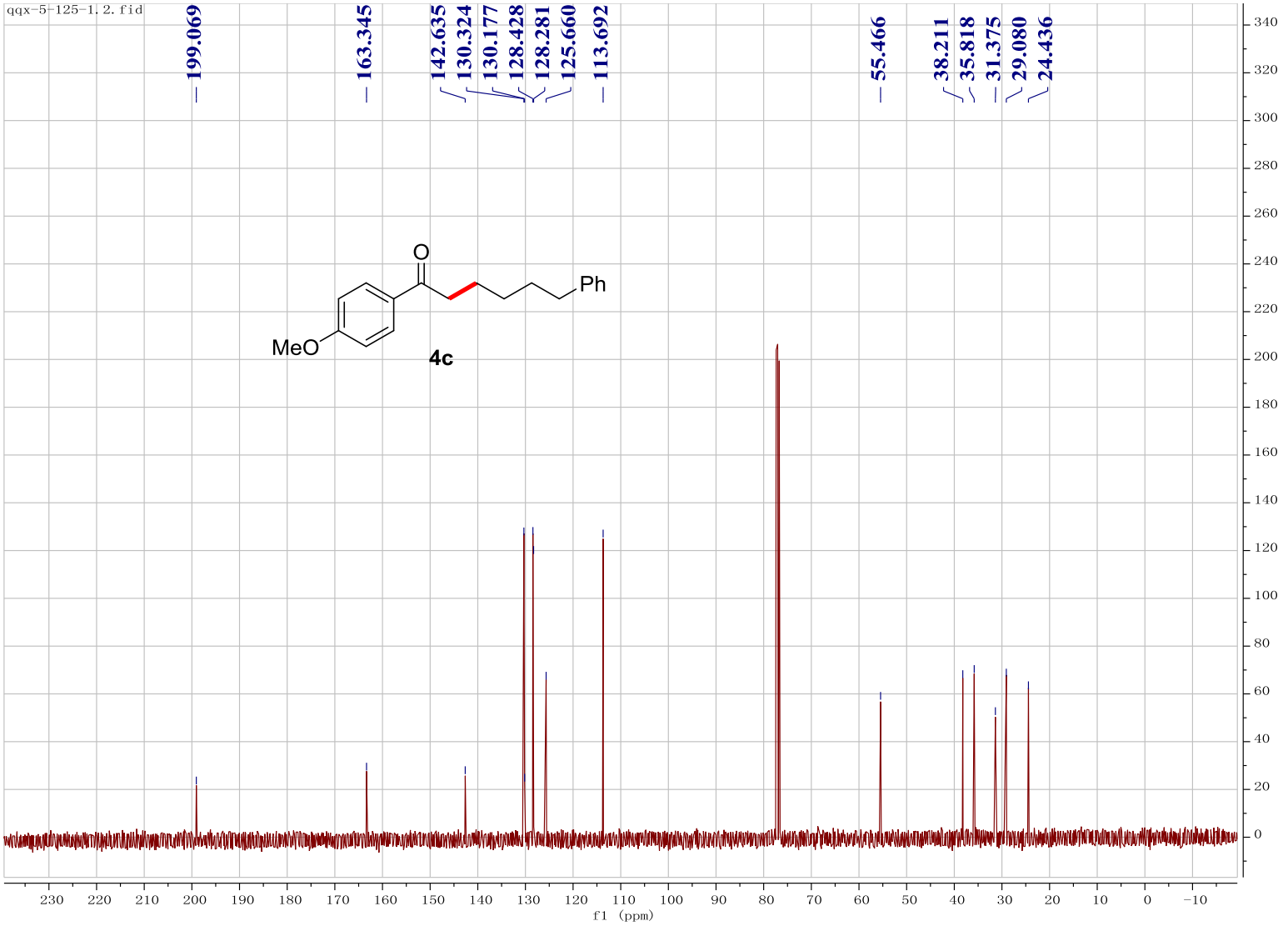
7.972
7.960
7.955
7.326
7.324
7.311
7.308
7.305
7.303
7.300
7.287
7.284
7.222
7.217
7.210
7.204
7.198
7.195
6.969
6.964
6.952
6.946
3.893
2.955
2.937
2.918
2.676
2.657
2.638
1.813
1.794
1.775
1.727
1.722
1.713
1.707
1.701
1.692
1.688
1.684
1.669
1.477
1.473
1.458
1.452
1.438
O
Ph
MeO
4c
2.00
2.09
2.96
2.00
3.03
2.00
2.02
1.96
2.16
1.99
f1 (ppm)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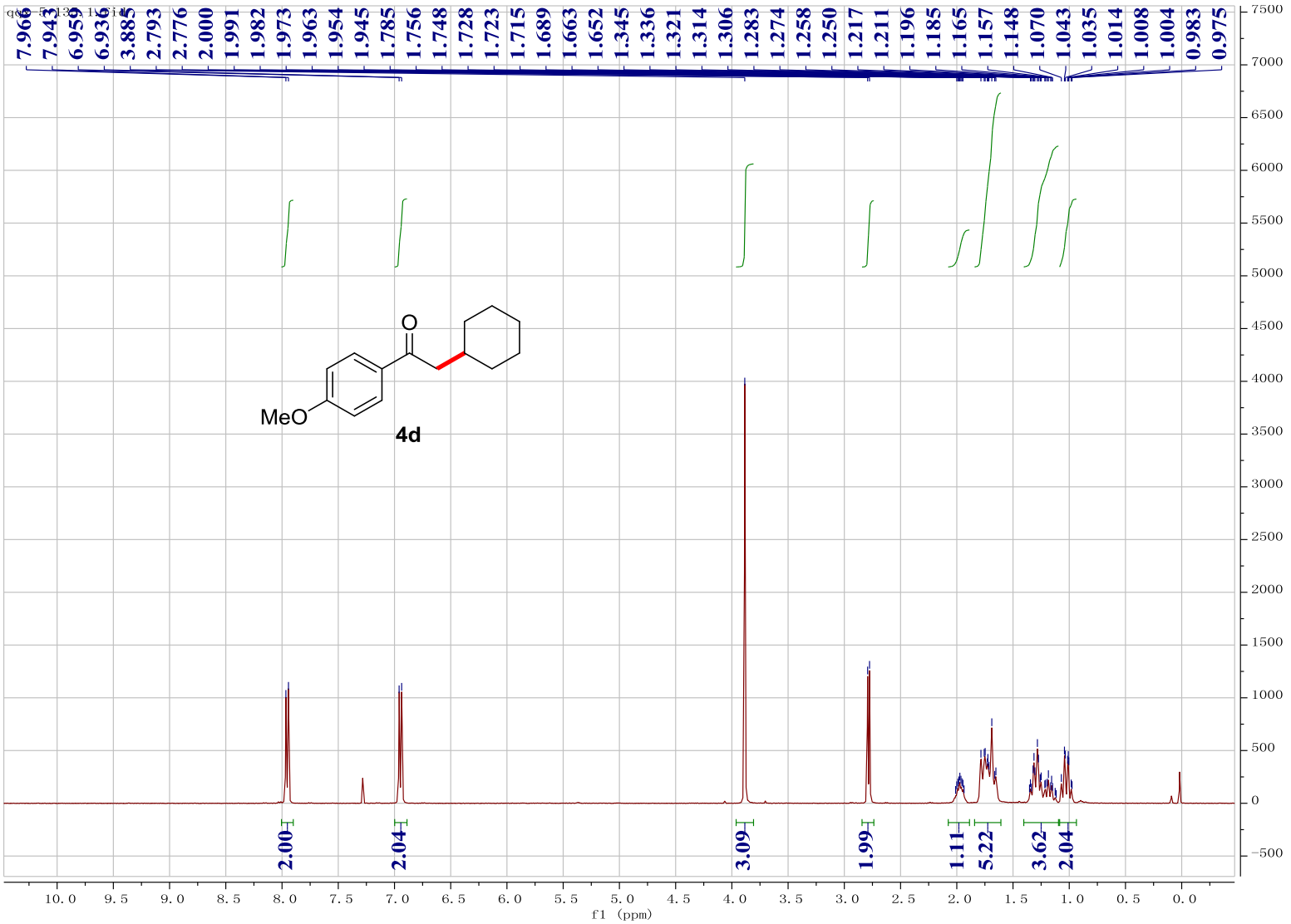
142.635
130.324
130.177
128.428
128.281
125.660
113.692
55.466
38.211
35.818
31.375
29.080
24.436
O
Ph
MeO
4c
f1 (ppm)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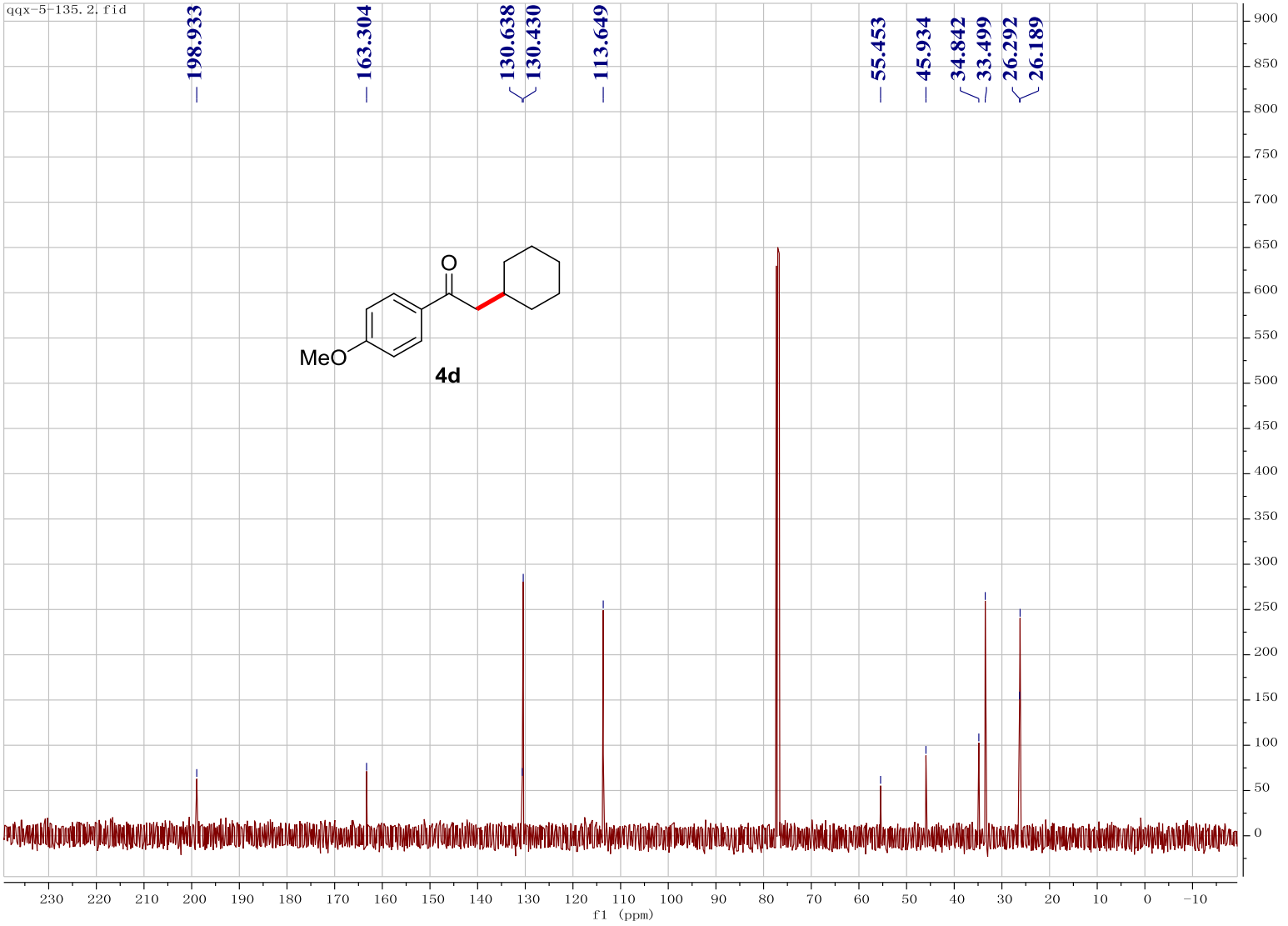
6.959
6.936
3.885
2.793
2.776
2.000
1.991
1.982
1.973
1.963
1.954
1.945
1.785
1.756
1.748
1.728
1.723
1.715
1.689
1.663
1.652
1.345
1.336
1.321
1.314
1.306
1.283
1.274
1.258
1.250
1.217
1.211
1.196
1.185
1.165
1.157
1.148
1.070
1.043
1.035
1.014
1.008
1.004
0.983
0.975
O
MeO
4d
2.00
2.04
3.09
1.99
1.11
5.22
3.62
2.04
f1 (ppm)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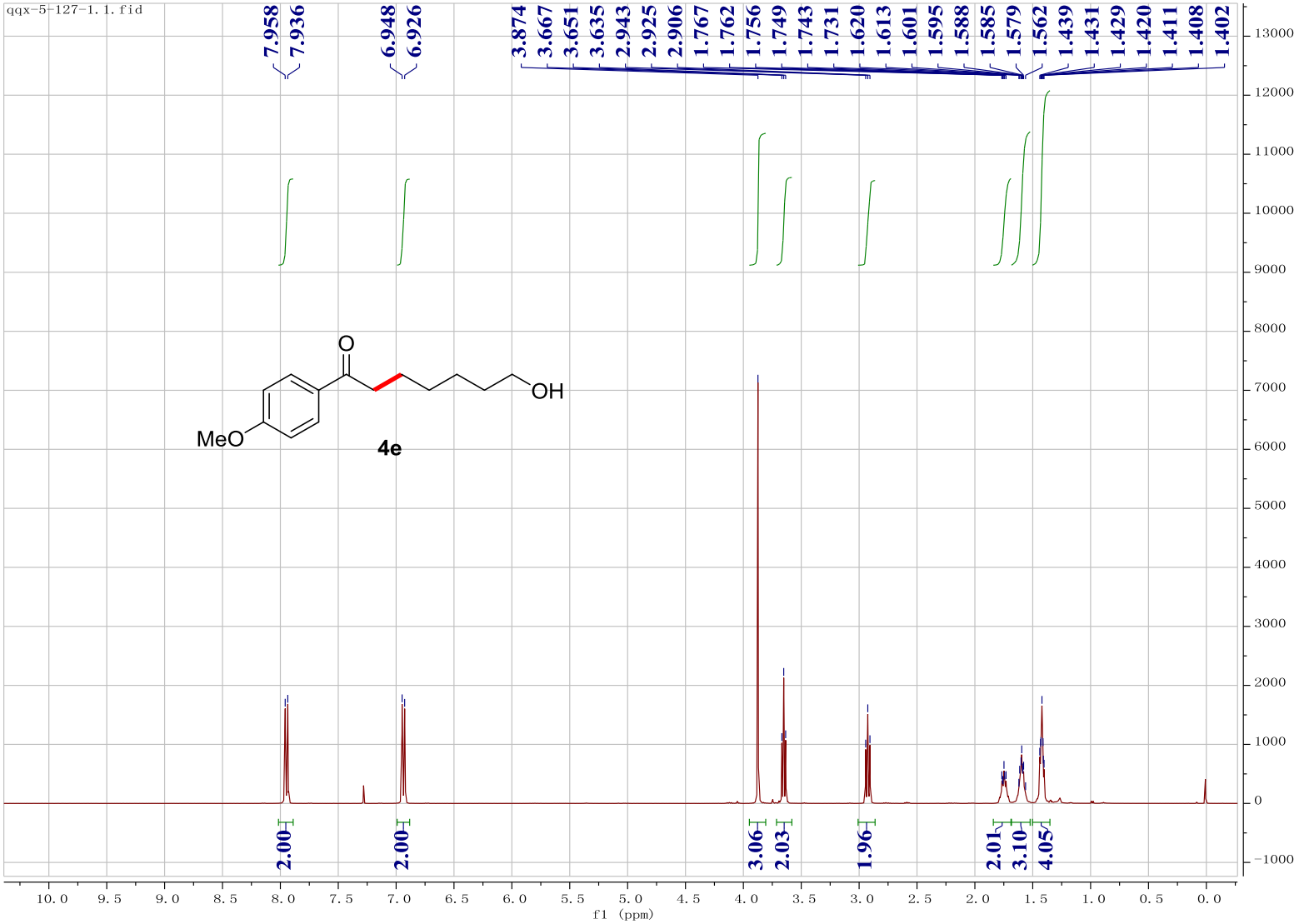
198.933
163.304
130.638
130.430
113.649
55.453
45.934
34.842
33.499
26.292
26.189
O
MeO
4d
f1 (ppm)


qqx-5-127-1.1.fid
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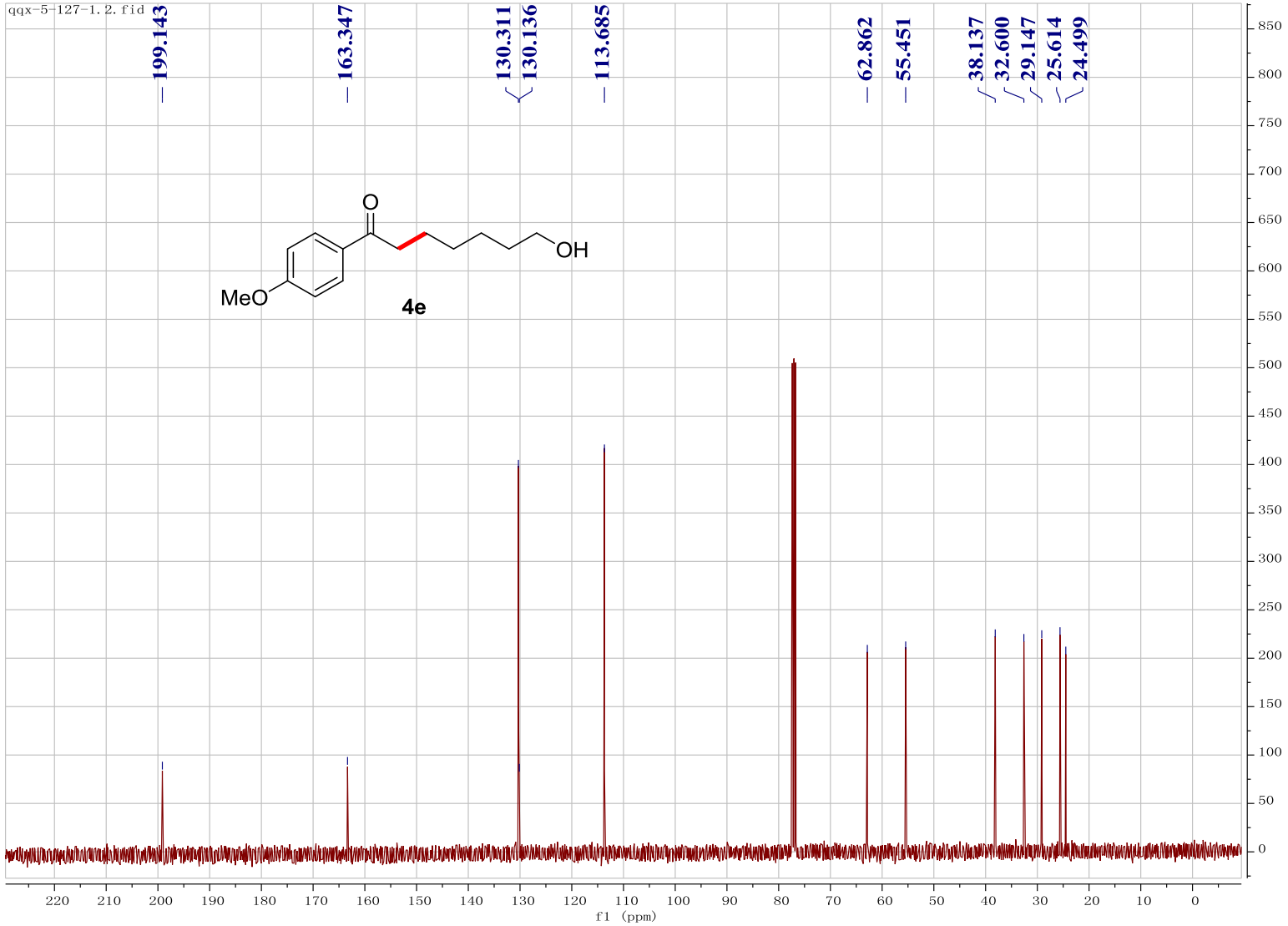
7.936
6.948
6.926
3.874
3.667
3.651
3.635
2.943
2.925
2.906
1.767
1.762
1.756
1.749
1.743
1.731
1.620
1.613
1.601
1.595
1.588
1.585
1.579
1.562
1.439
1.431
1.429
1.420
1.411
1.408
1.402
O
OH
MeO
4e
2.00
2.00
3.06
2.03
1.96
2.01
3.10
4.05
f1 (ppm)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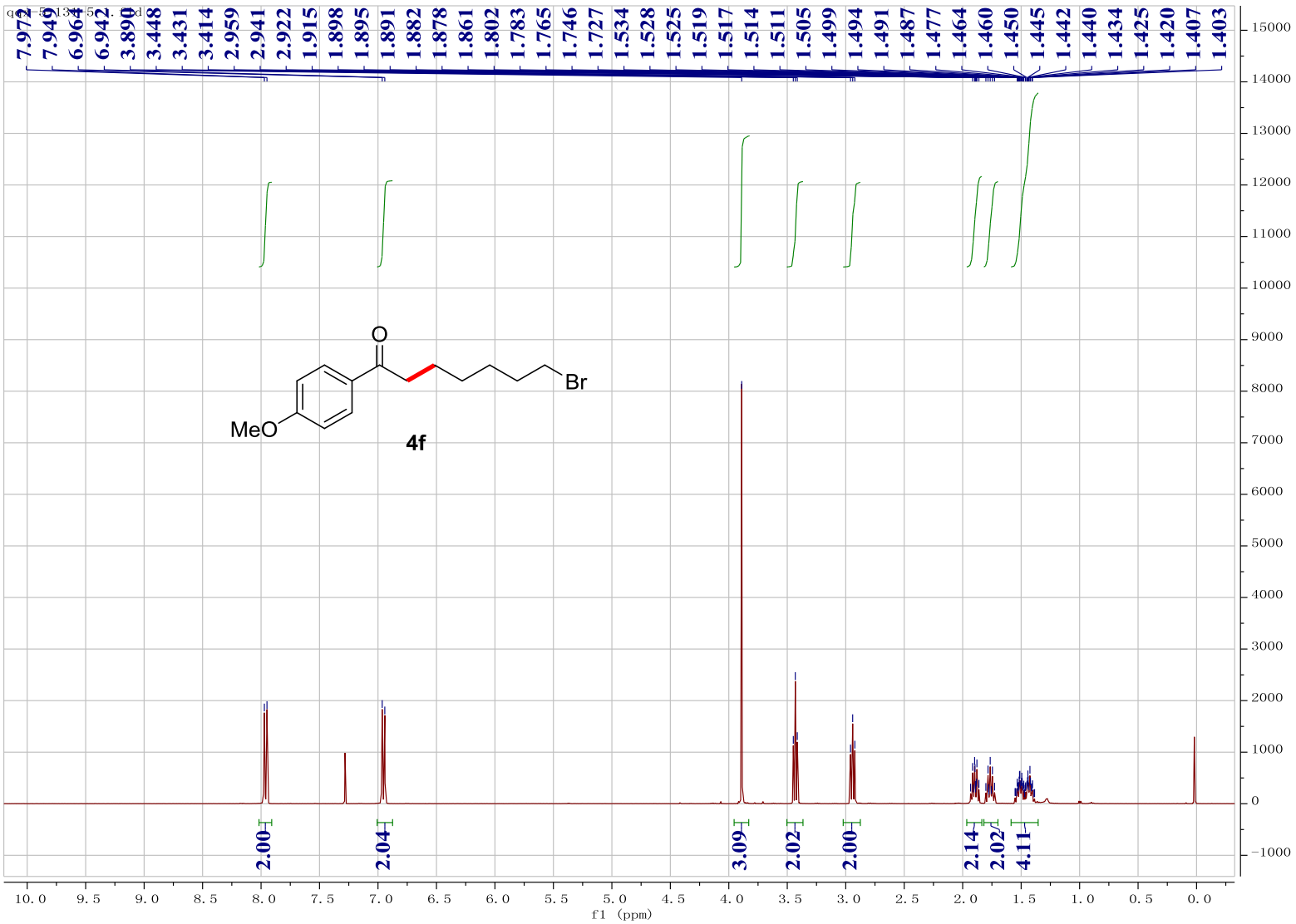
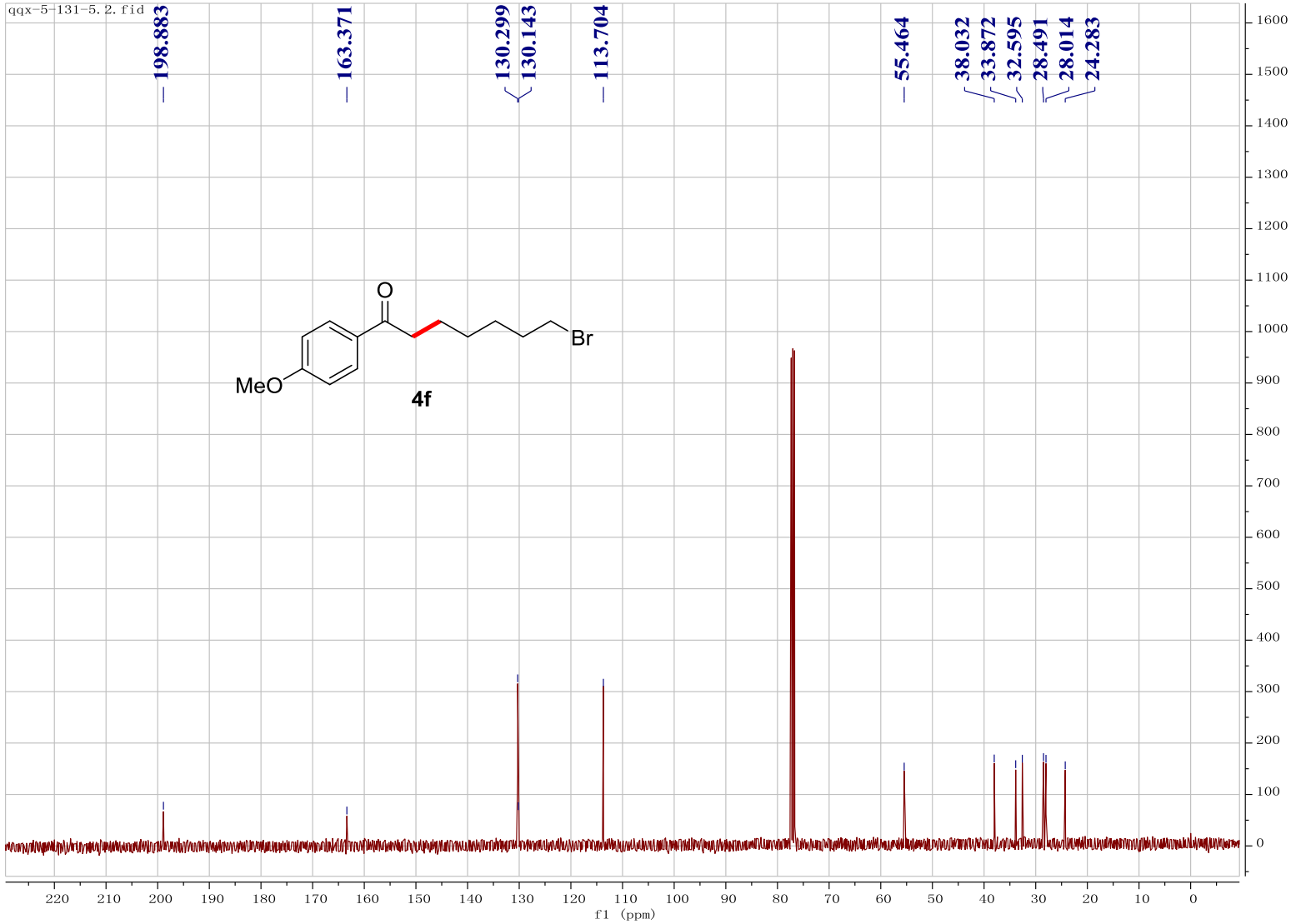
130.311
130.136
113.685
62.862
55.451
38.137
32.600
29.147
25.614
24.499
O
OH
MeO
4e
f1 (ppm)


7.972
7.949
6.964
6.942
3.890
3.448
3.431
3.414
2.959
2.941
2.922
1.915
1.898
1.895
1.891
1.882
1.878
1.861
1.802
1.783
1.765
1.746
1.727
1.534
1.528
1.525
1.519
1.517
1.514
1.511
1.505
1.499
1.494
1.491
1.487
1.477
1.464
1.460
1.450
1.445
1.442
1.440
1.434
1.425
1.420
1.407
1.403
O
Br
MeO
4f
2.00
2.04
3.09
2.02
2.00
2.14
2.02
4.11
f1 (ppm)


qqx-5-131-5.2.fid
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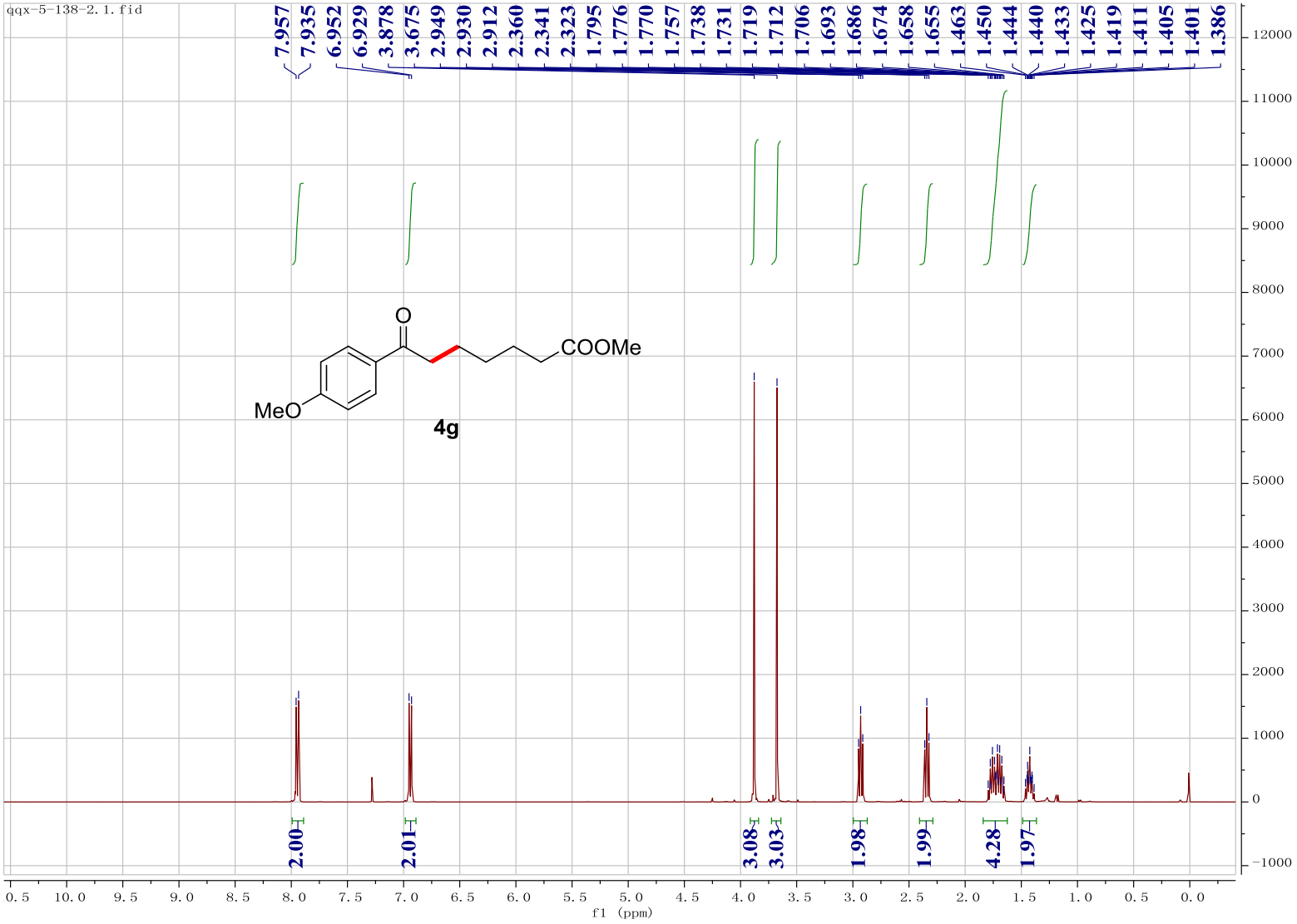
163.371
130.299
130.143
113.704
55.464
38.032
33.872
32.595
28.491
28.014
24.283
O
Br
MeO
4f
f1 (ppm)


qqx-5-138-2.1.fid
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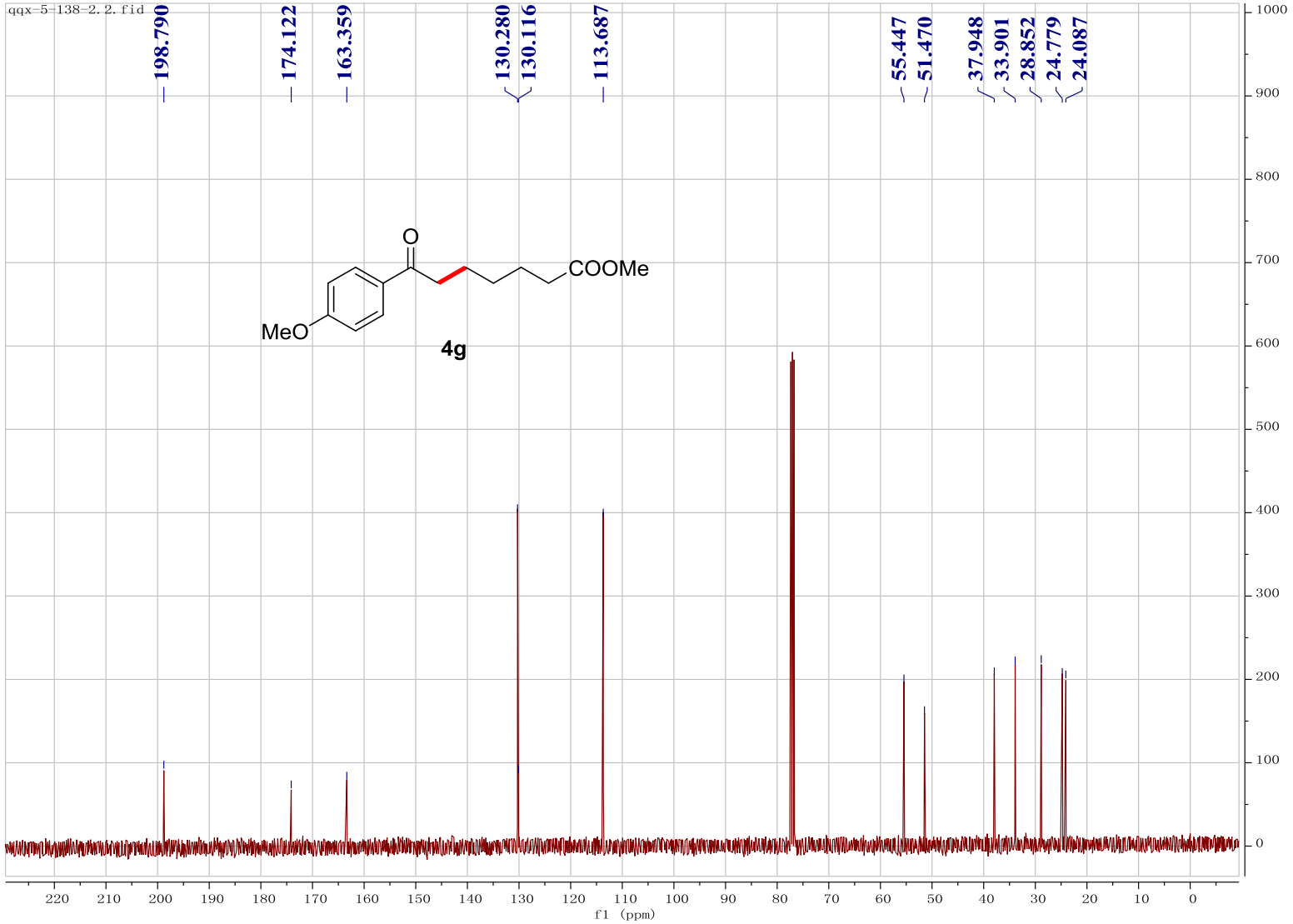
7.935
6.952
6.929
3.878
3.675
2.949
2.930
2.912
2.360
2.341
2.323
1.795
1.776
1.770
1.757
1.738
1.731
1.719
1.712
1.706
1.693
1.686
1.674
1.658
1.655
1.463
1.450
1.444
1.440
1.433
1.425
1.419
1.411
1.405
1.401
1.386
O
COOMe
MeO
4g
2.00
2.01
3.08
3.03
1.98
1.99
4.28
1.97
f1 (ppm)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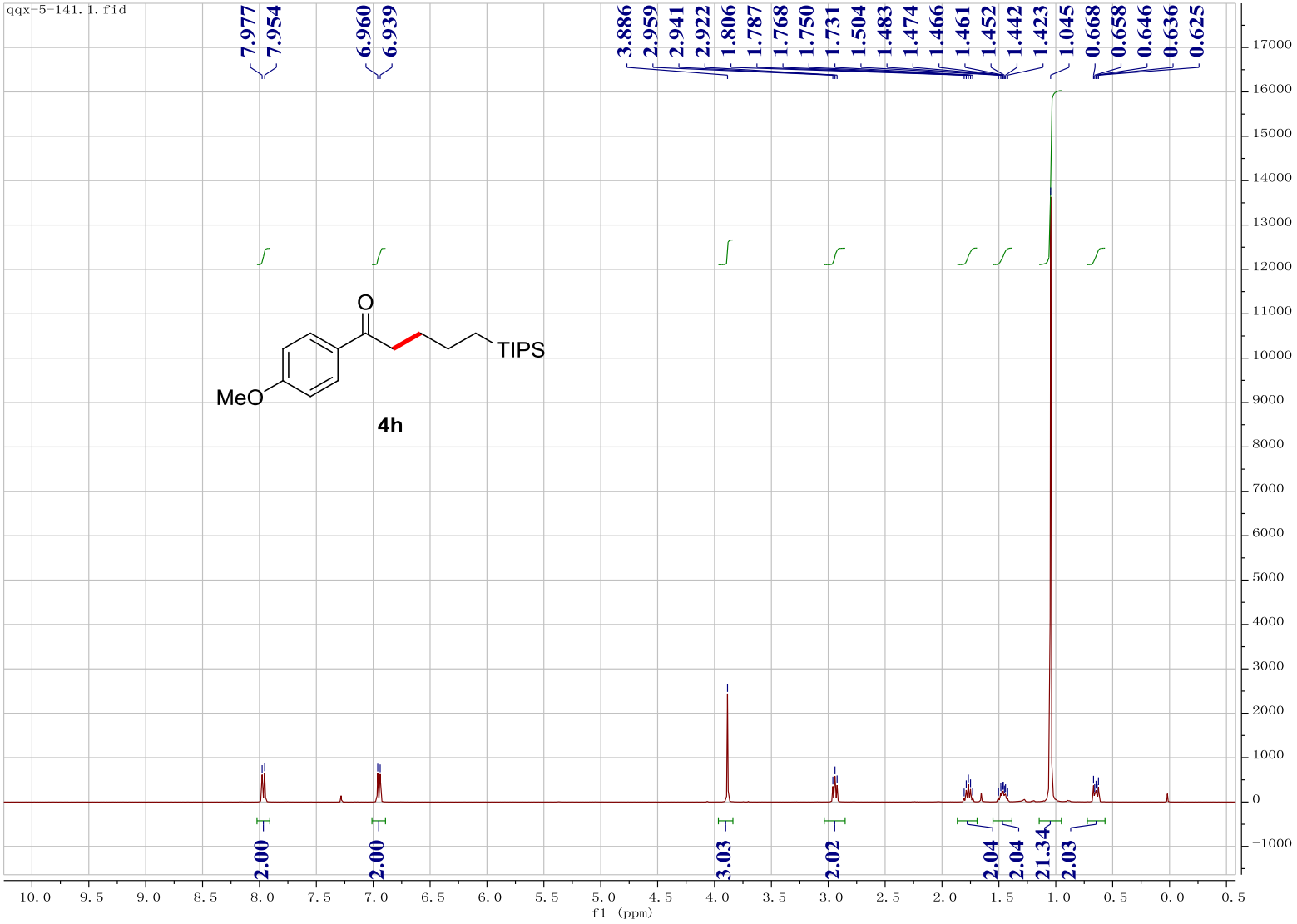
174.122
163.359
130.280
130.116
113.687
55.447
51.470
37.948
33.901
28.852
24.779
24.087
O
COOMe
MeO
4g
f1 (ppm)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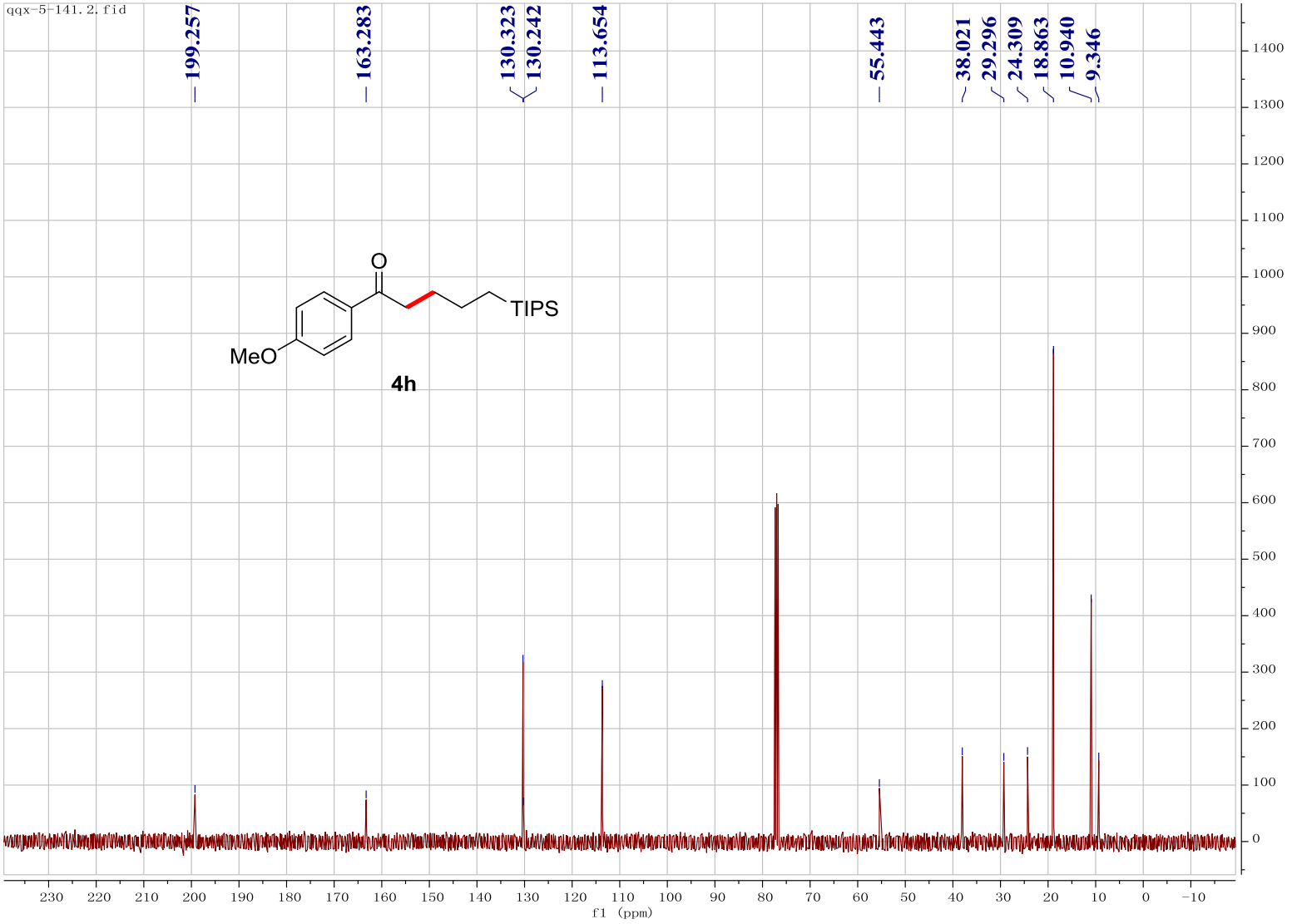
7.954
6.960
6.939
3.886
2.959
2.941
2.922
1.806
1.787
1.768
1.750
1.731
1.504
1.483
1.474
1.466
1.461
1.452
1.442
1.423
1.045
0.668
0.658
0.646
0.636
0.625
O
TIPS
MeO
4h
2.00
2.00
3.03
2.02
2.04
2.04
21.34
2.03
f1 (ppm)


qqx-5-141.2.fid
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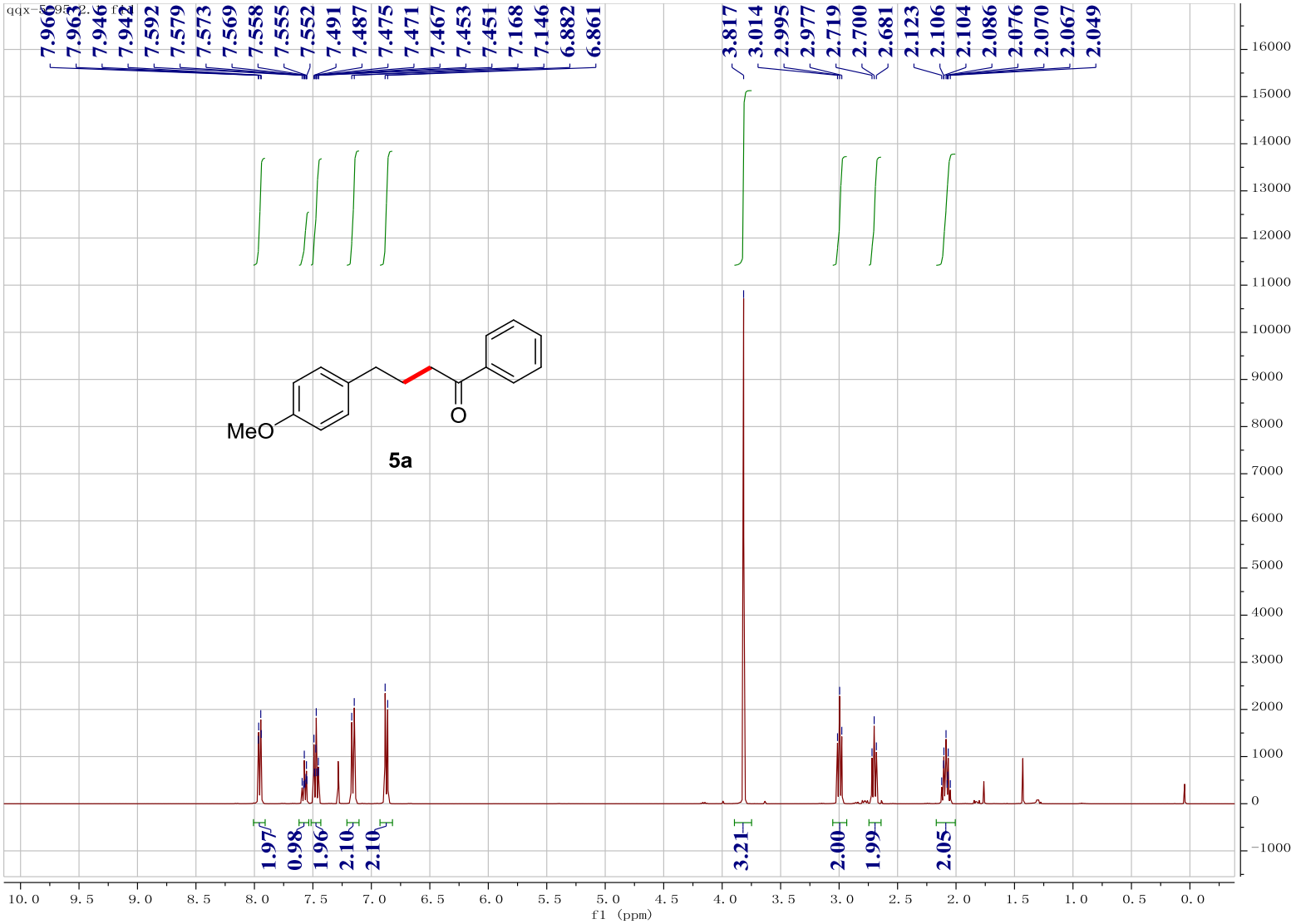
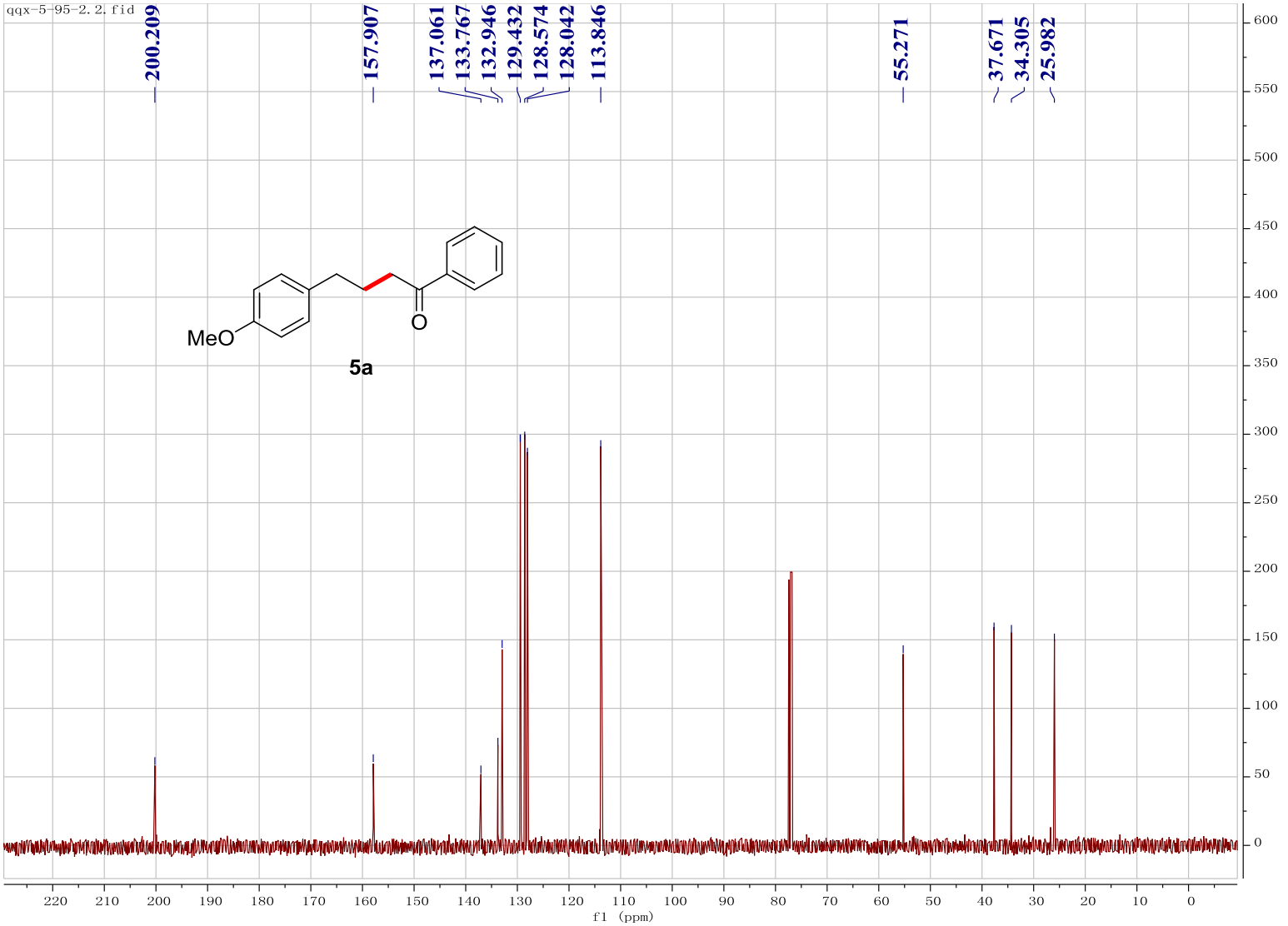
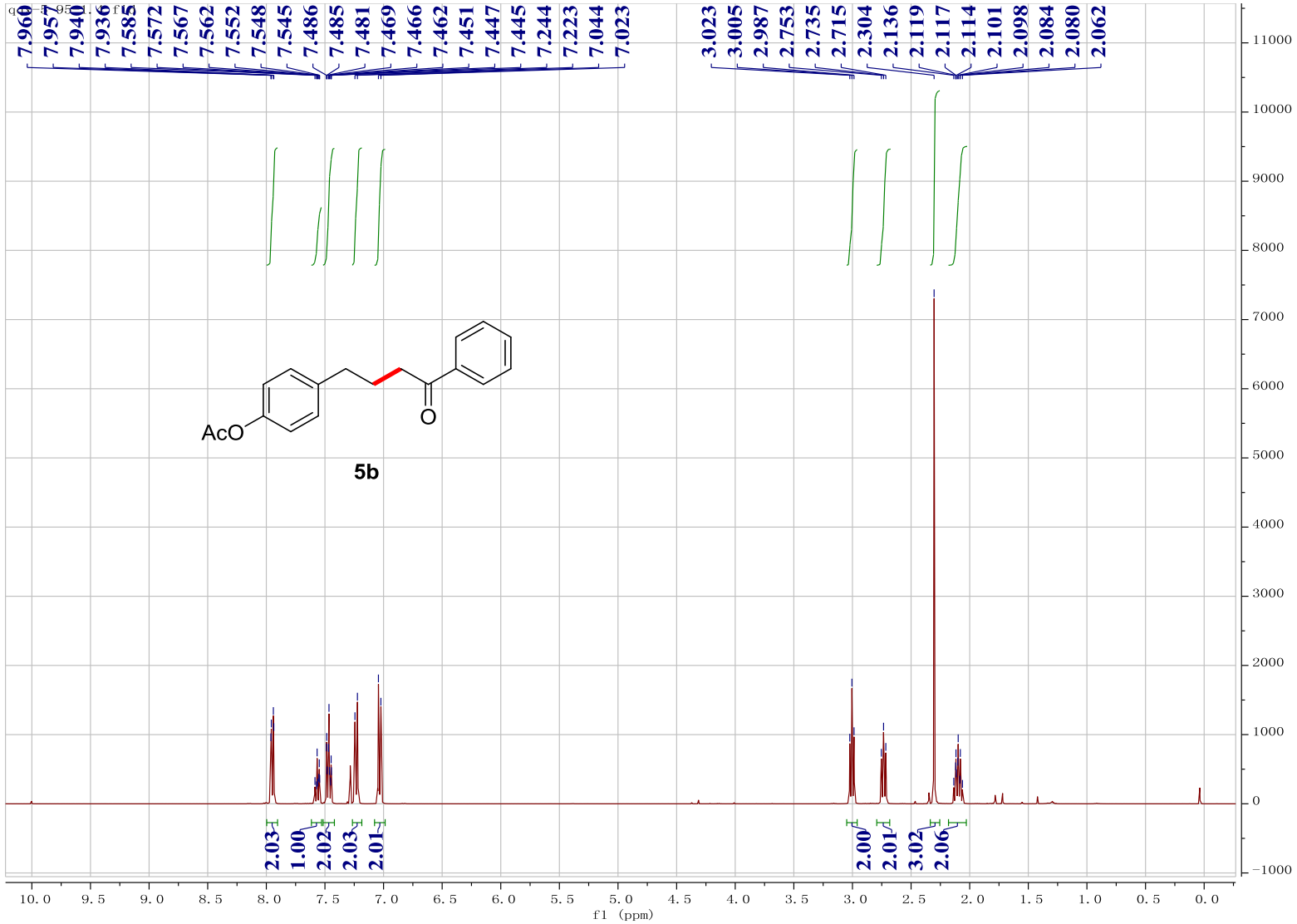
163.283
130.323
130.242
113.654
55.443
38.021
29.296
24.309
18.863
10.940
9.346
O
TIPS
MeO
4h
f1 (ppm)


7.966
7.963
7.946
7.942
7.592
7.579
7.573
7.569
7.558
7.555
7.552
7.491
7.487
7.475
7.471
7.467
7.453
7.451
7.168
7.146
6.882
6.861
3.817
3.014
2.995
2.977
2.719
2.700
2.681
2.123
2.106
2.104
2.086
2.076
2.070
2.067
2.049
MeO
O
5a
1.97
0.98
1.96
2.10
2.10
3.21
2.00
1.99
2.05
f1 (ppm)


qqx-5-95-2.2.fid
200.209
157.907
137.061
133.767
132.946
129.432
128.574
128.042
113.846
55.271
37.671
34.305
25.982
MeO
O
5a
f1 (ppm)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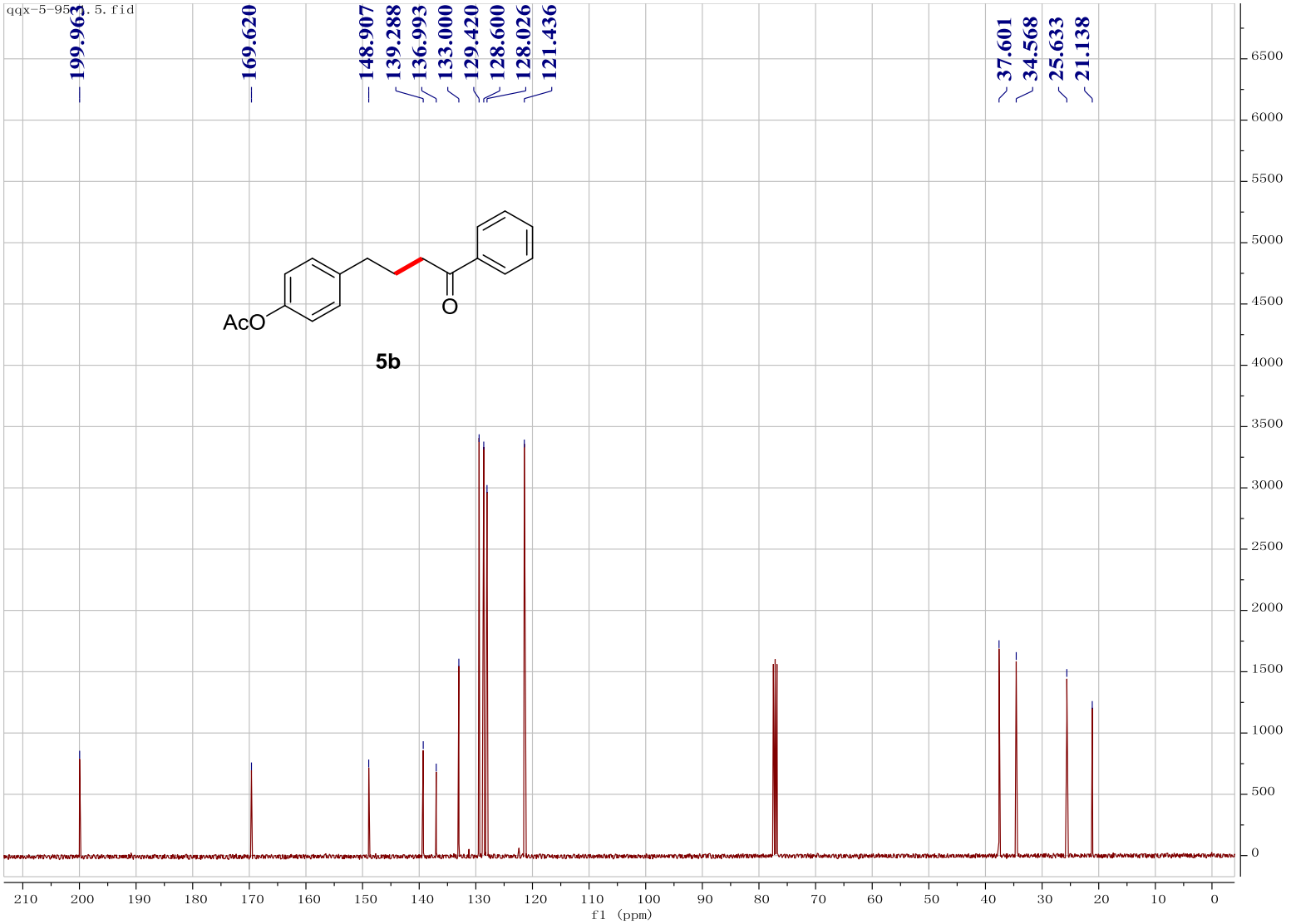
7.957
7.940
7.936
7.585
7.572
7.567
7.562
7.552
7.548
7.545
7.486
7.485
7.481
7.469
7.466
7.462
7.451
7.447
7.445
7.244
7.223
7.044
7.023
3.023
3.005
2.987
2.753
2.735
2.715
2.304
2.136
2.119
2.117
2.114
2.101
2.098
2.084
2.080
2.062
AcO
O
5b
2.03
1.00
2.02
2.03
2.01
2.00
2.01
3.02
2.06
f1 (ppm)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169.620
148.907
139.288
136.993
133.000
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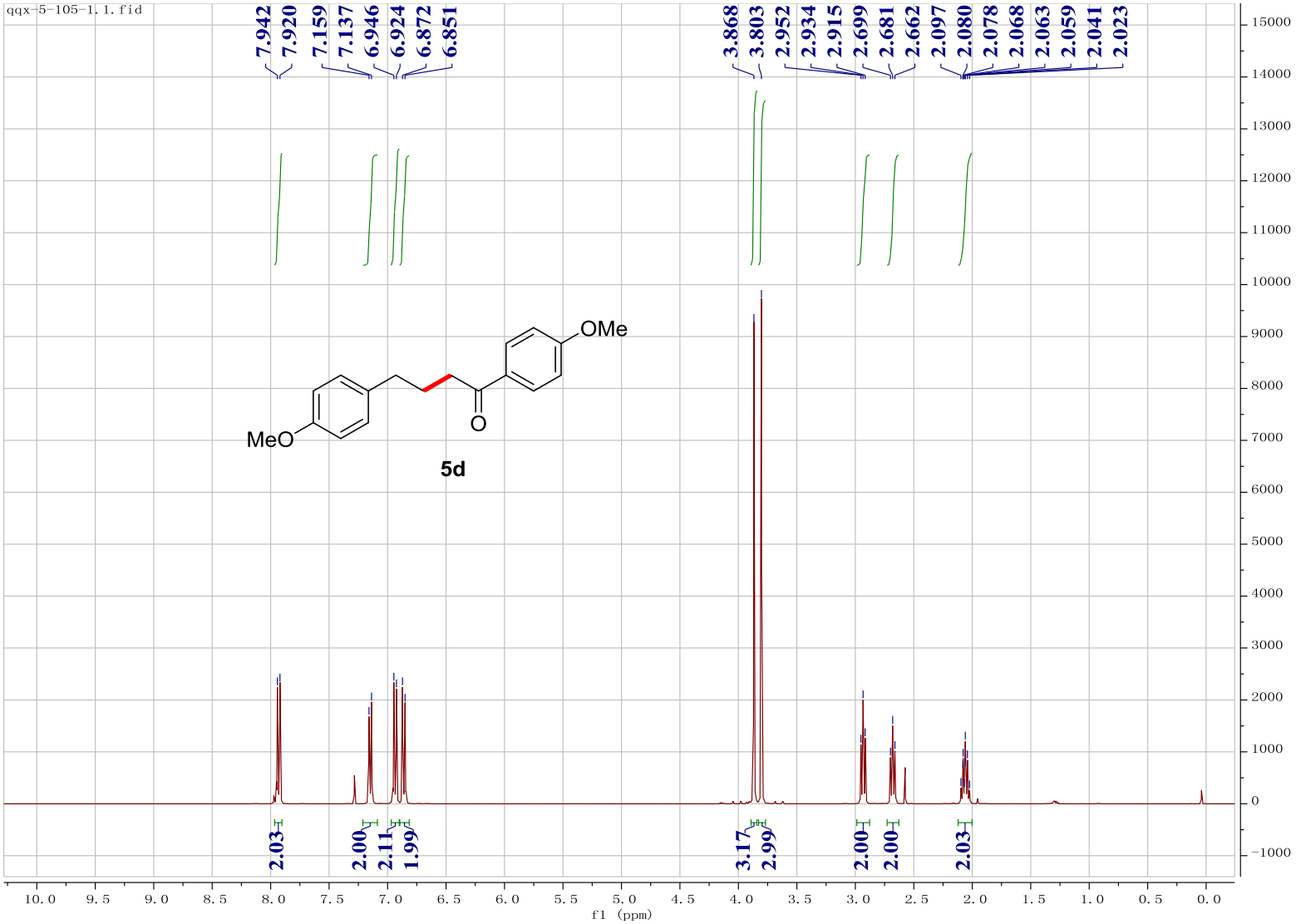
128.600
128.026
121.436
37.601
34.568
25.633
21.138
AcO
O
5b
f1 (ppm)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7.137
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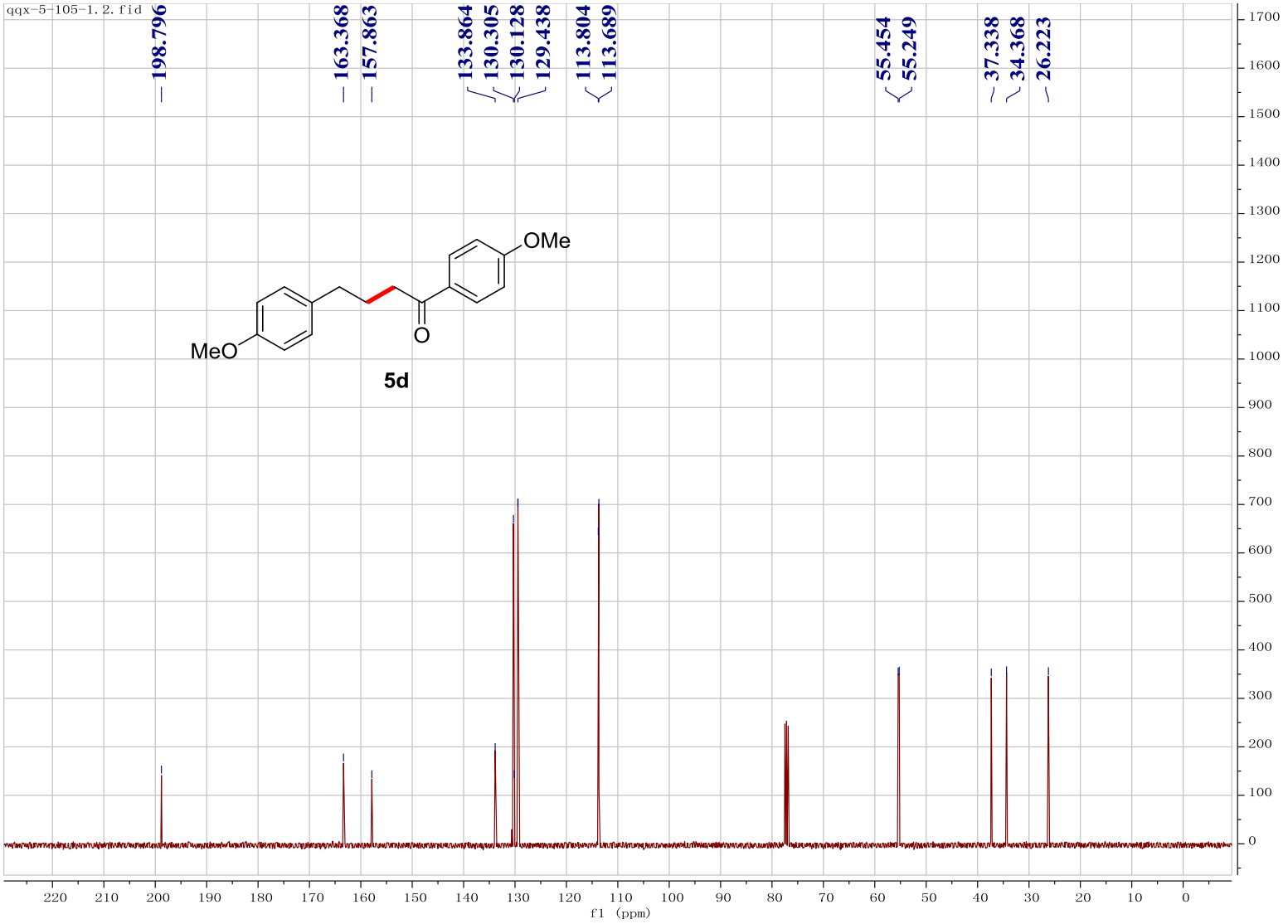
6.924
6.872
6.851
3.868
3.803
2.952
2.934
2.915
2.699
2.681
2.662
2.097
2.080
2.078
2.068
2.063
2.059
2.041
2.023
OMe
MeO
O
5d
2.03
2.00
2.11
1.99
3.17
2.99
2.00
2.00
2.03
f1 (ppm)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157.863
133.864
130.305
130.128
129.438
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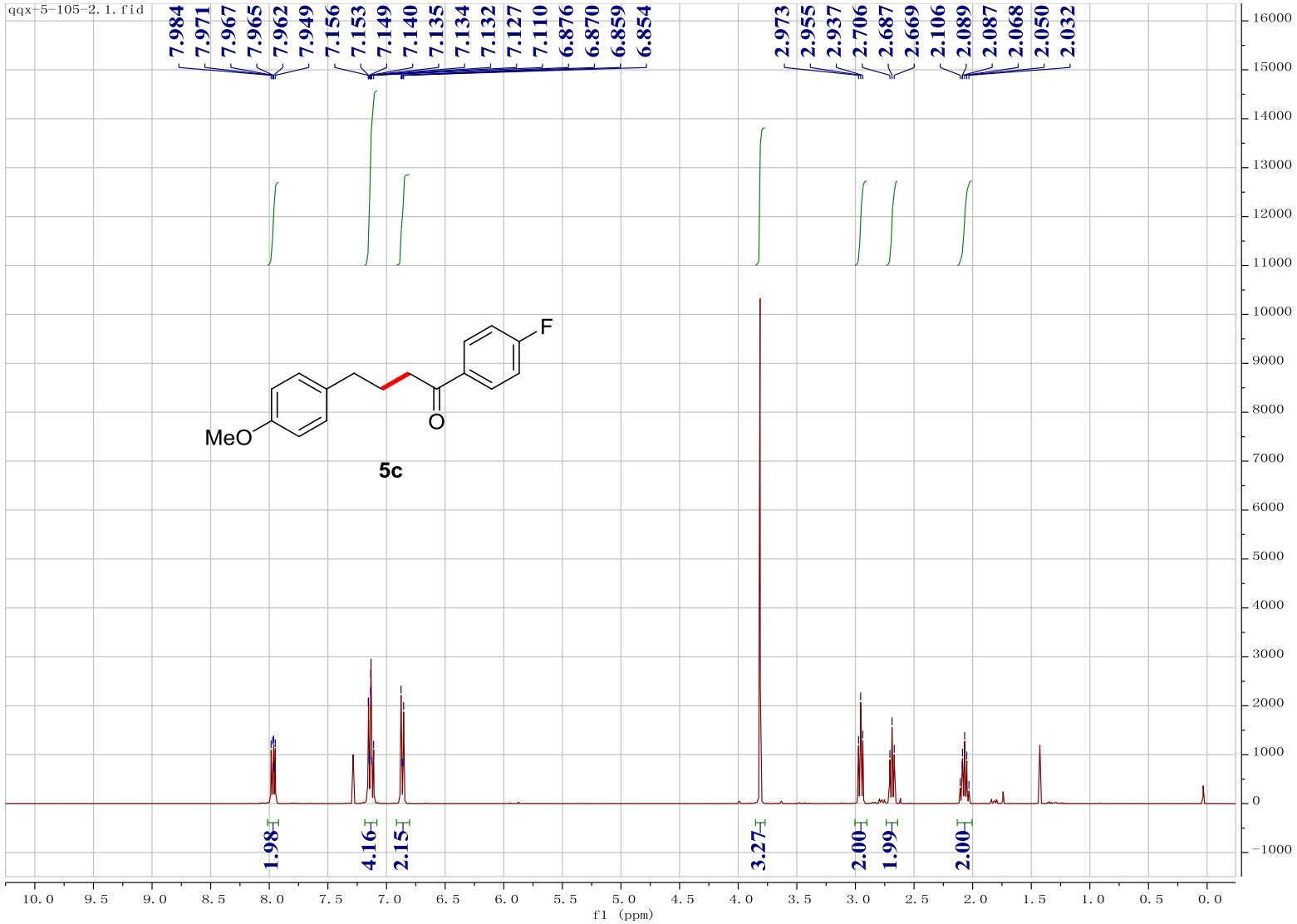
113.689
55.454
55.249
37.338
34.368
26.223
OMe
MeO
O
5d
f1 (ppm)


qqx-5-105-2.1.fid
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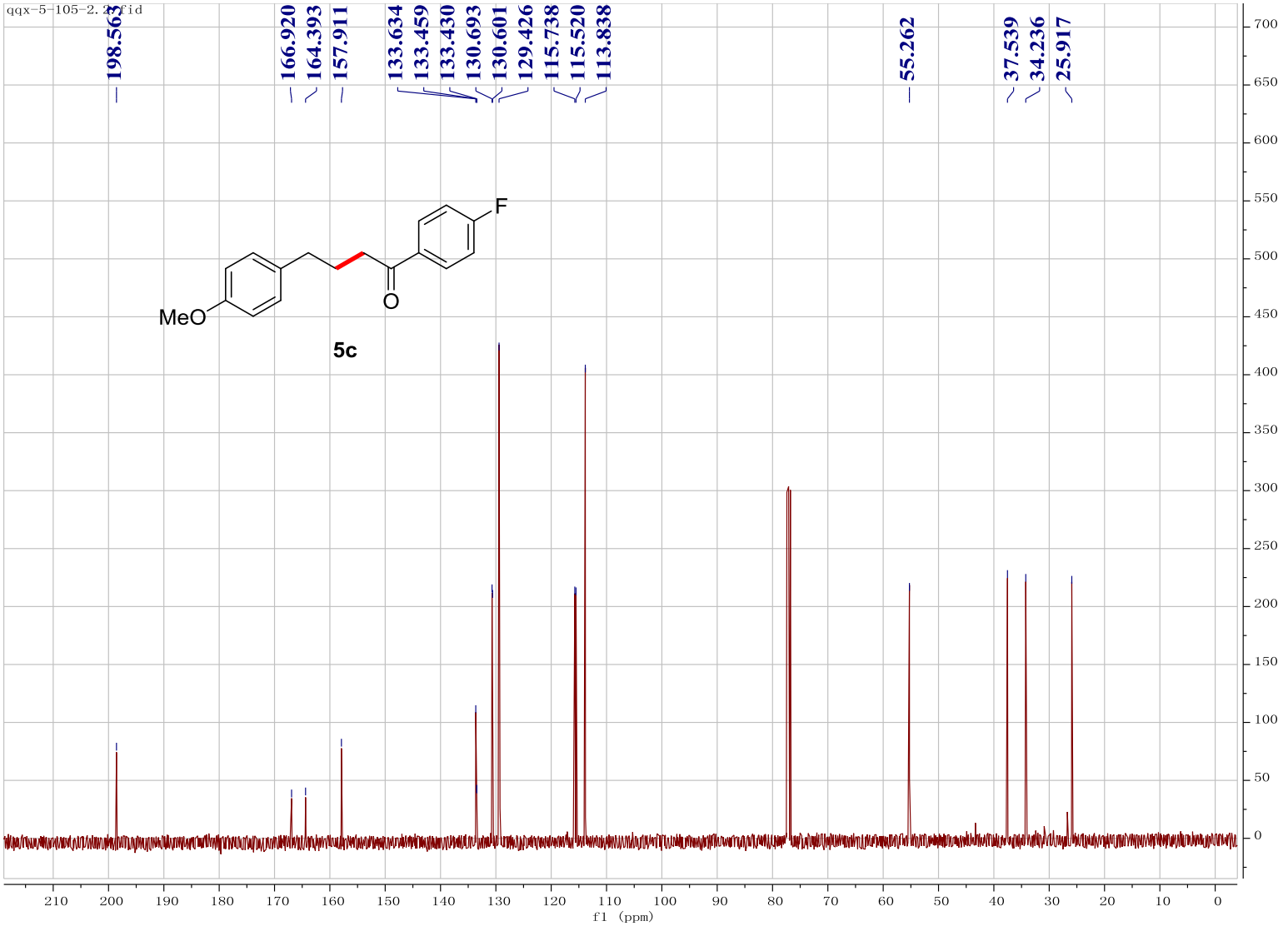
7.971
7.967
7.965
7.962
7.949
7.156
7.153
7.149
7.140
7.135
7.134
7.132
7.127
7.110
6.876
6.870
6.859
6.854
2.973
2.955
2.937
2.706
2.687
2.669
2.106
2.089
2.087
2.068
2.050
2.032
F
O
MeO
5c
1.98
4.16
2.15
3.27
2.00
1.99
2.00
f1 (ppm)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133.459
133.430
130.693
130.601
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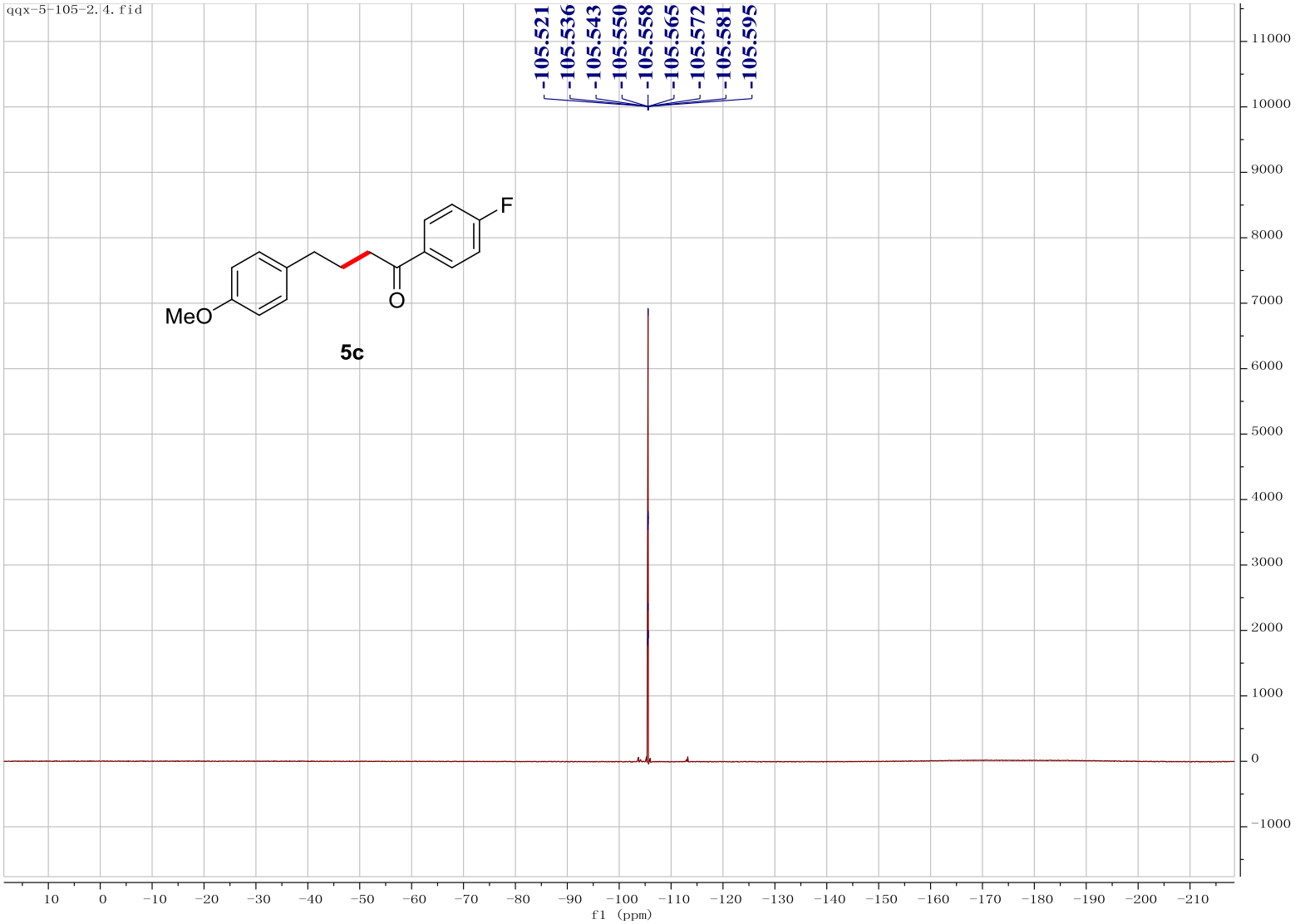
115.520
113.838
55.262
37.539
34.236
25.917
F
MeO
O
5c
f1 (ppm)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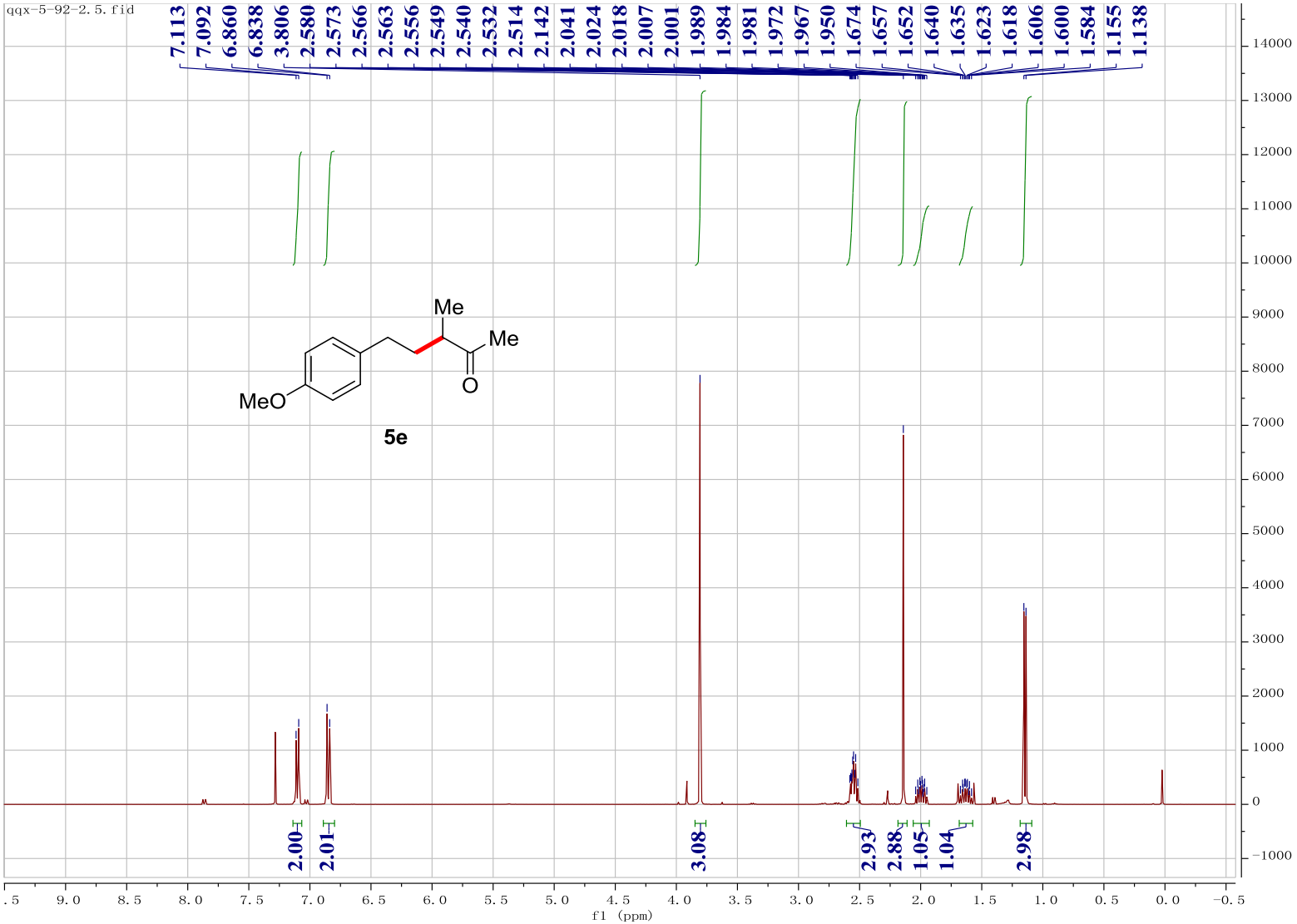
-105.536
-105.543
-105.550
-105.558
-105.565
-105.572
-105.581
-105.595
F
MeO
O
5c
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
10
0
−10
−20
−30
−40
−50
−60
−70
−80
−90
−100
−110
−120
−130
−140
−150
−160
−170
−180
−190
−200
−210
f1 (ppm)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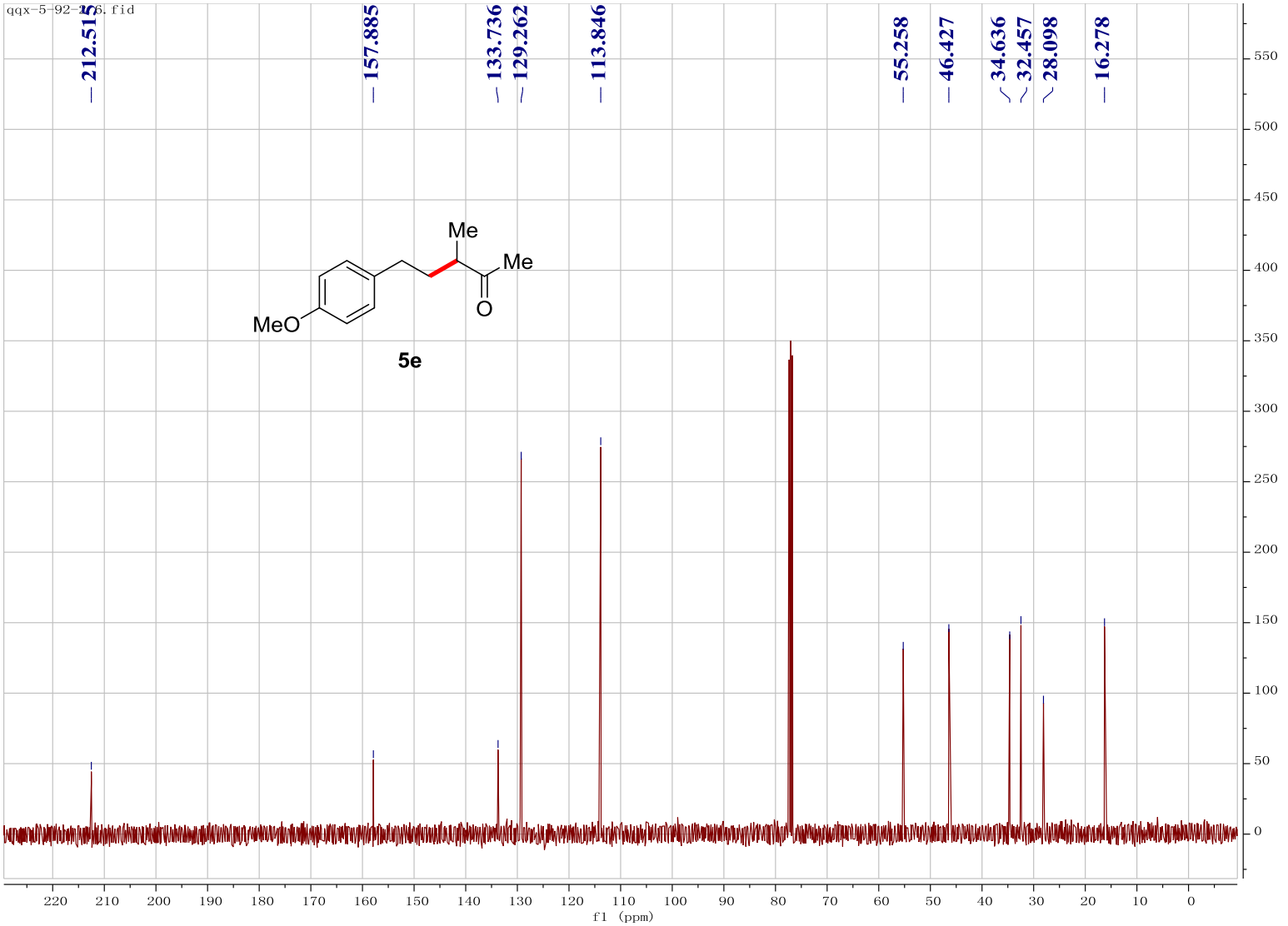
7.092
6.860
6.838
3.806
2.580
2.573
2.566
2.563
2.556
2.549
2.540
2.532
2.514
2.142
2.041
2.024
2.018
2.007
2.001
1.989
1.984
1.981
1.972
1.967
1.950
1.674
1.657
1.652
1.640
1.635
1.623
1.618
1.606
1.600
1.584
1.155
1.138
Me
Me
O
MeO
5e
2.00
2.01
3.08
2.93
2.88
1.05
1.04
2.98
f1 (ppm)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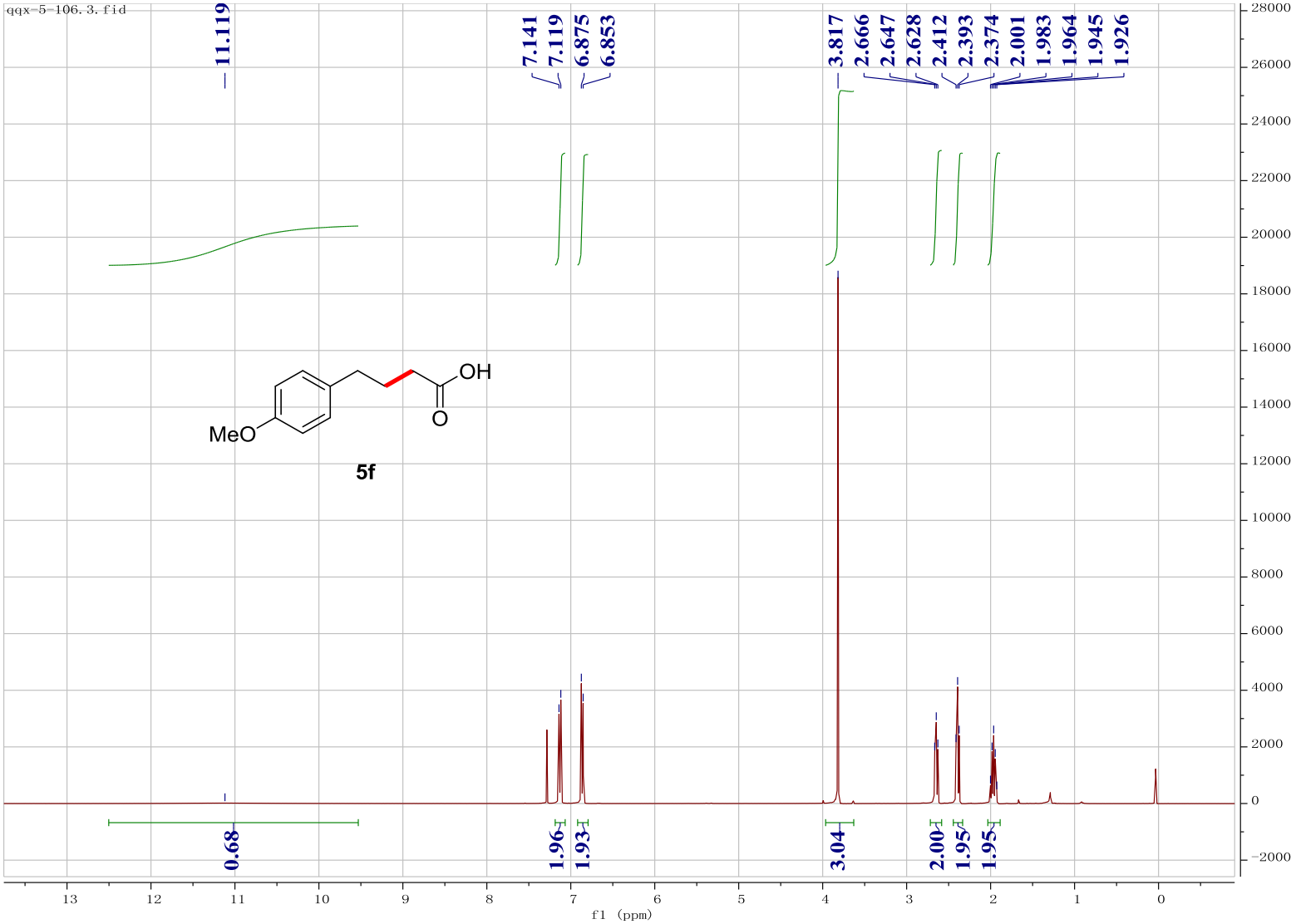
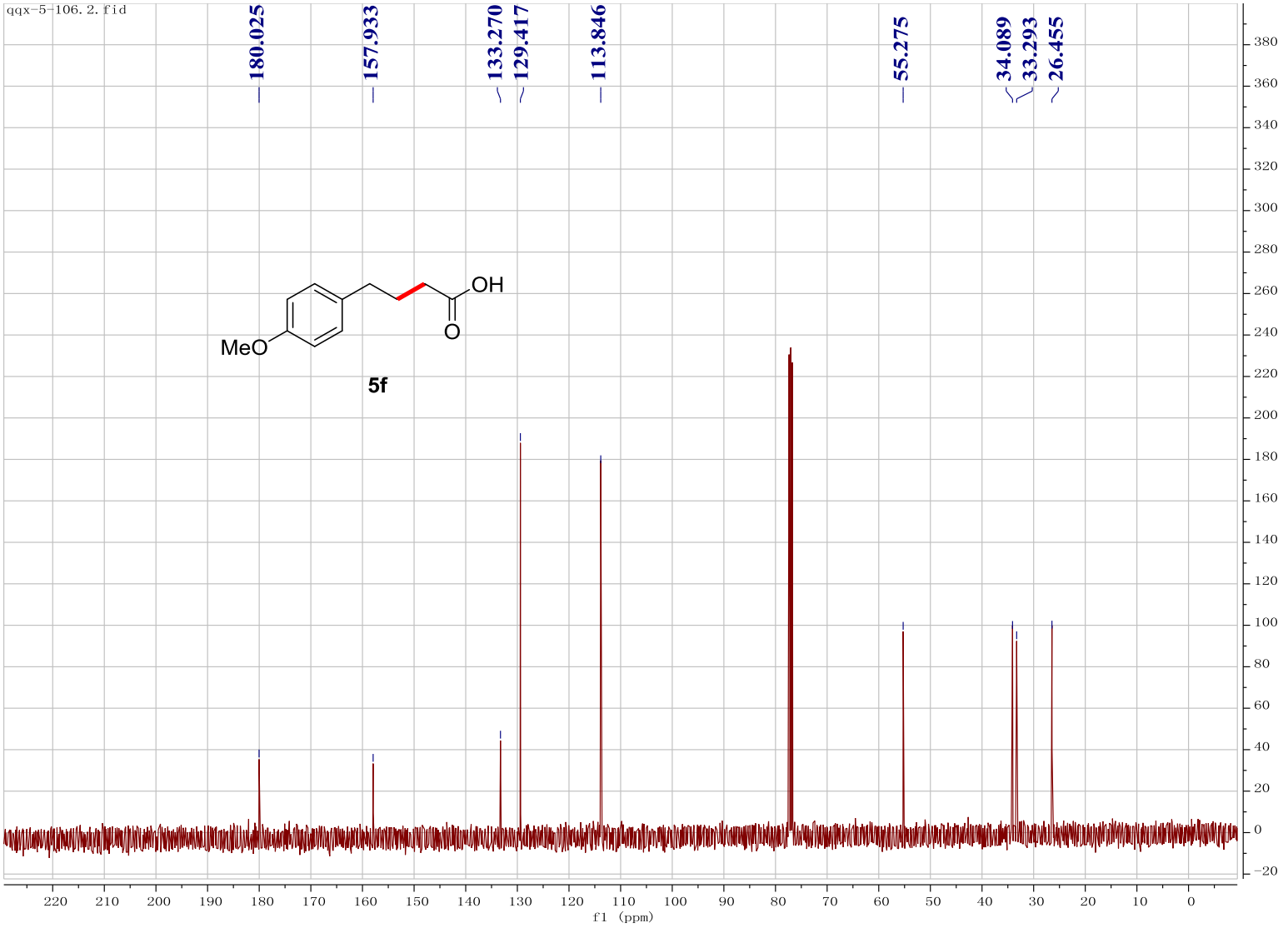
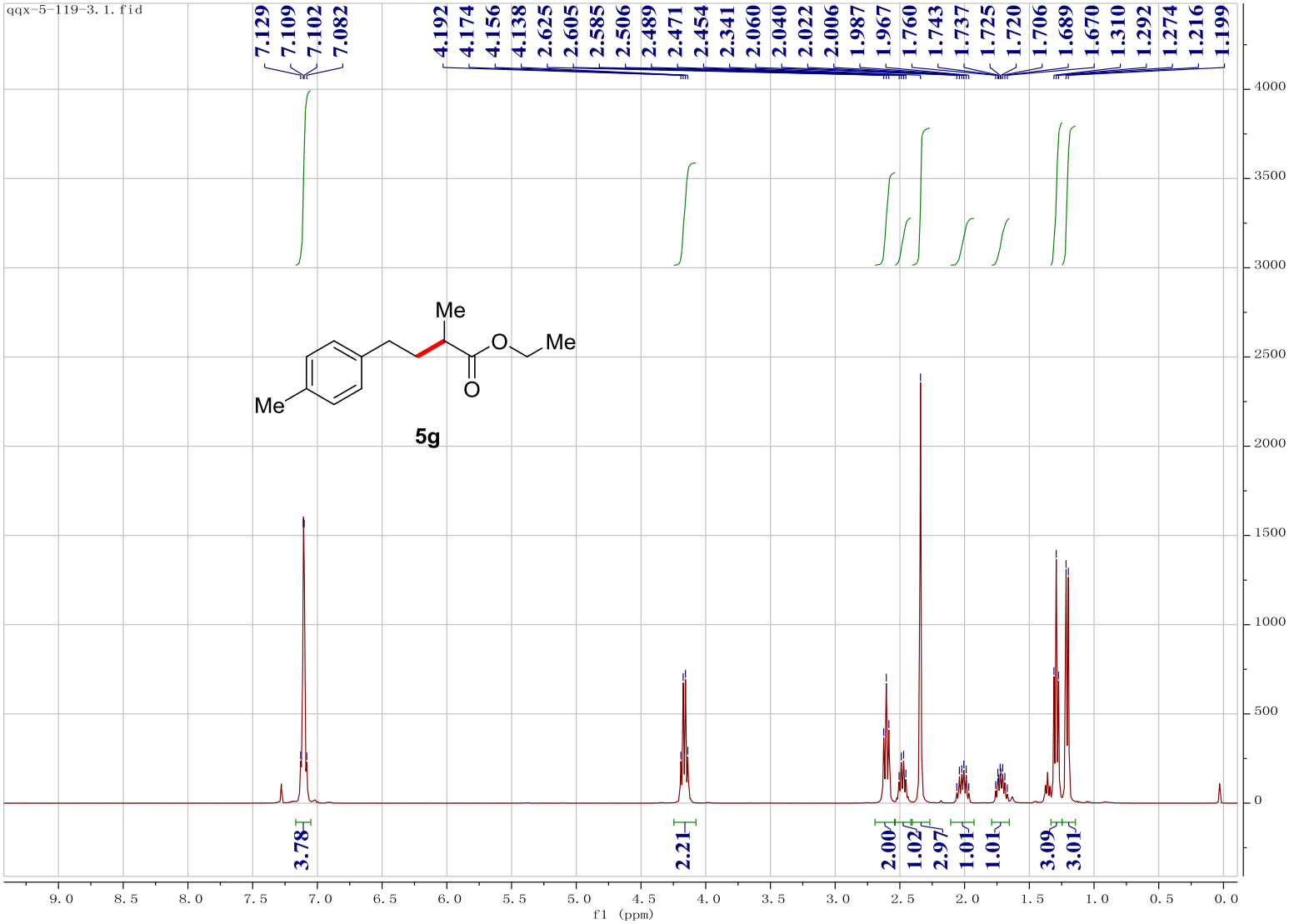
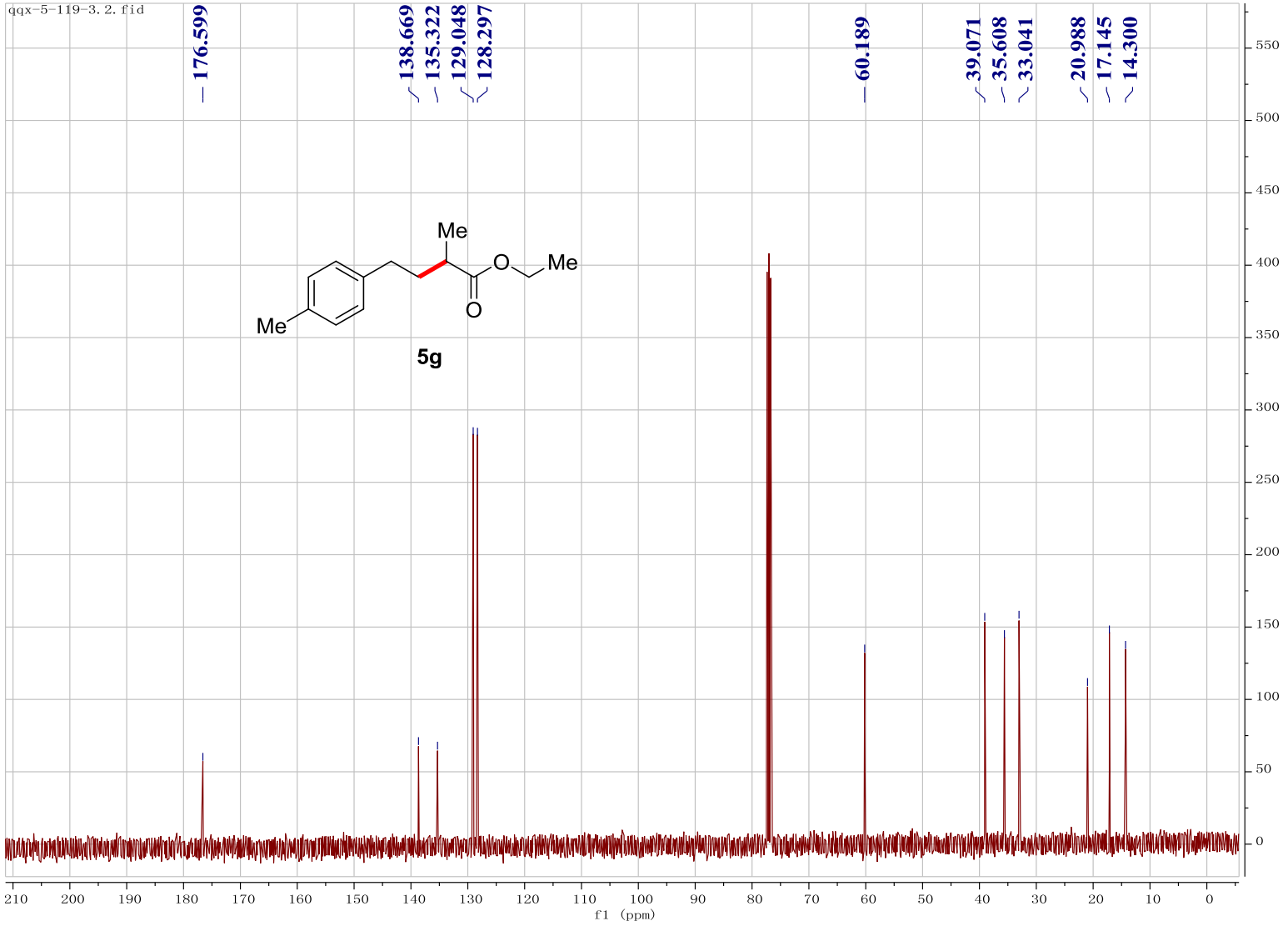
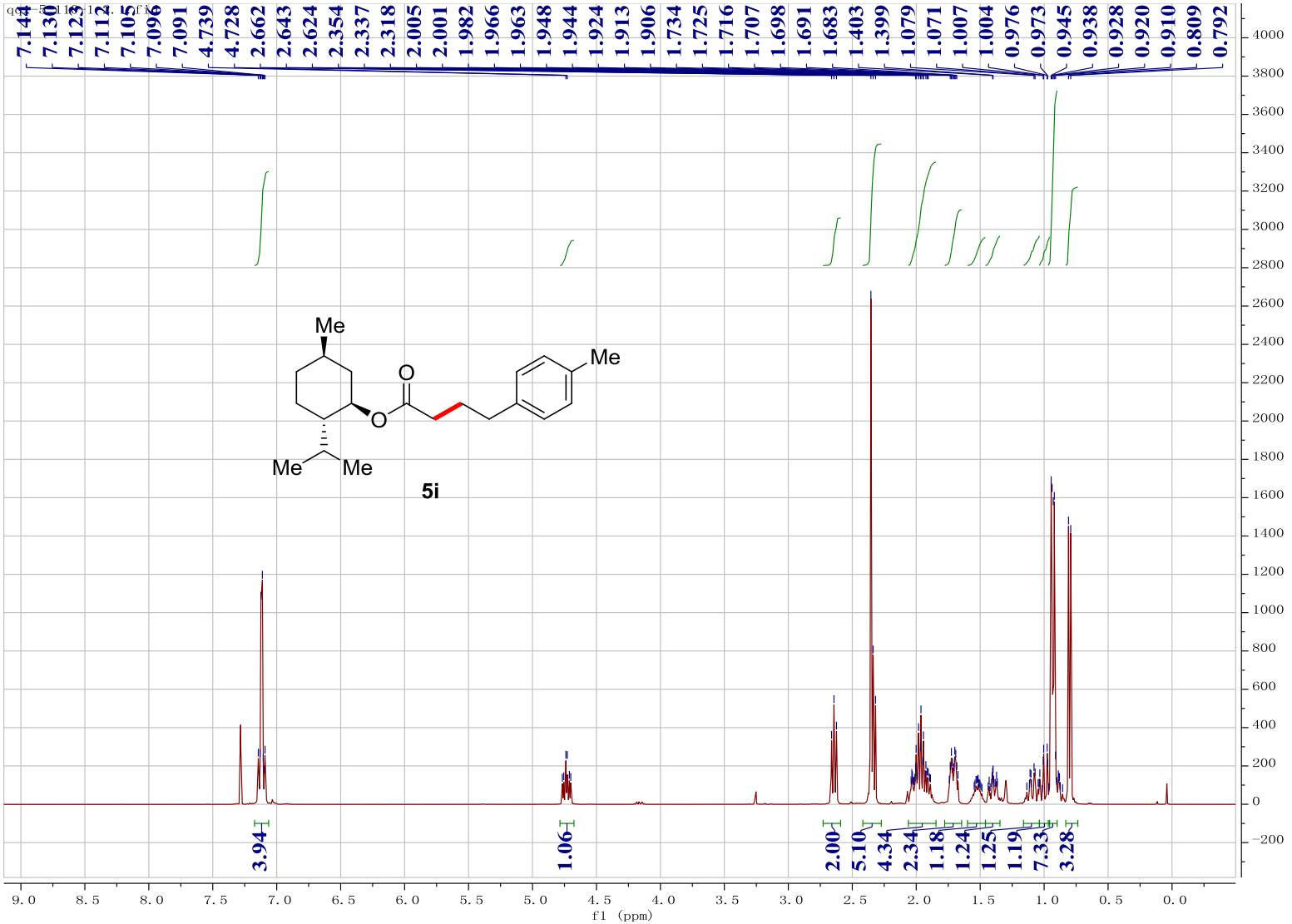
157.885
133.736
129.262
113.846
55.258
46.427
34.636
32.457
28.098
16.278
Me
Me
O
MeO
5e
f1 (ppm)

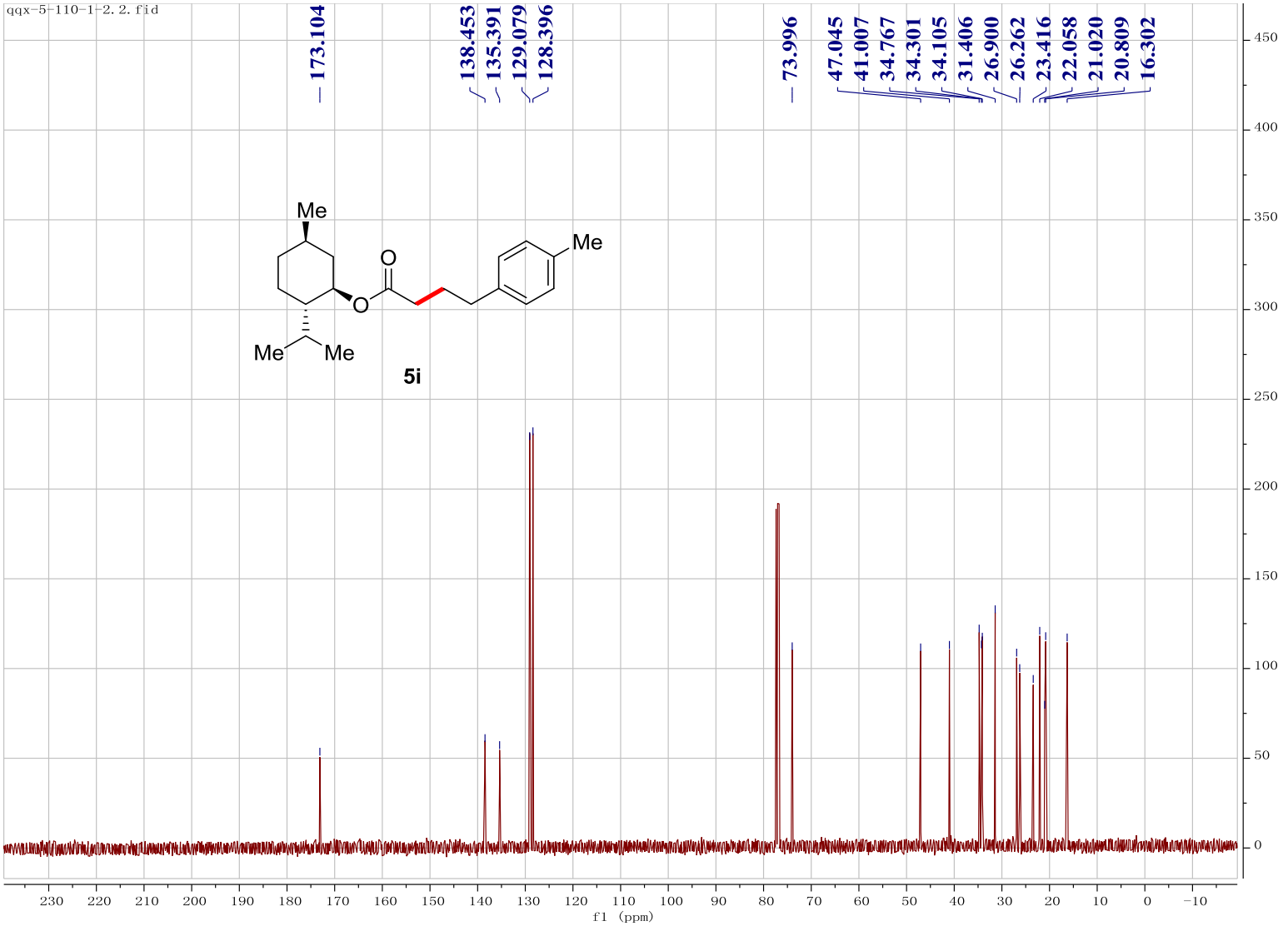

qqx-5-106.3.fid
11.119
7.141
7.119
6.875
6.853
3.817
2.666
2.647
2.628
2.412
2.393
2.374
2.001
1.983
1.964
1.945
1.926
OH
O
MeO
5f
0.68
1.96
1.93
3.04
2.00
1.95
1.95
f1 (ppm)


qqx-5-106.2.fid
180.025
157.933
133.270
129.417
113.846
55.275
34.089
33.293
26.455
OH
O
MeO
5f
f1 (ppm)


qqx-5-119-3.1.fid
7.129
7.109
7.102
7.082
4.192
4.174
4.156
4.138
2.625
2.605
2.585
2.506
2.489
2.471
2.454
2.341
2.060
2.040
2.022
2.006
1.987
1.967
1.760
1.743
1.737
1.725
1.720
1.706
1.689
1.670
1.310
1.292
1.274
1.216
1.199
Me
O
Me
Me
O
5g
3.78
2.21
2.00
1.02
2.97
1.01
1.01
3.09
3.01
f1 (ppm)


qqx-5-119-3.2.fid
176.599
138.669
135.322
129.048
128.297
60.189
39.071
35.608
33.041
20.988
17.145
14.300
Me
O
Me
O
Me
5g
f1 (ppm)


7.144
7.130
7.123
7.112
7.105
7.096
7.091
4.739
4.728
2.662
2.643
2.624
2.354
2.337
2.318
2.005
2.001
1.982
1.966
1.963
1.948
1.944
1.924
1.913
1.906
1.734
1.725
1.716
1.707
1.698
1.691
1.683
1.403
1.399
1.079
1.071
1.007
1.004
0.976
0.973
0.945
0.938
0.928
0.920
0.910
0.809
0.792
Me
O
O
Me
Me
Me
5i
3.94
1.06
2.00
5.10
4.34
2.34
1.18
1.24
1.25
1.19
7.33
3.28
f1 (ppm)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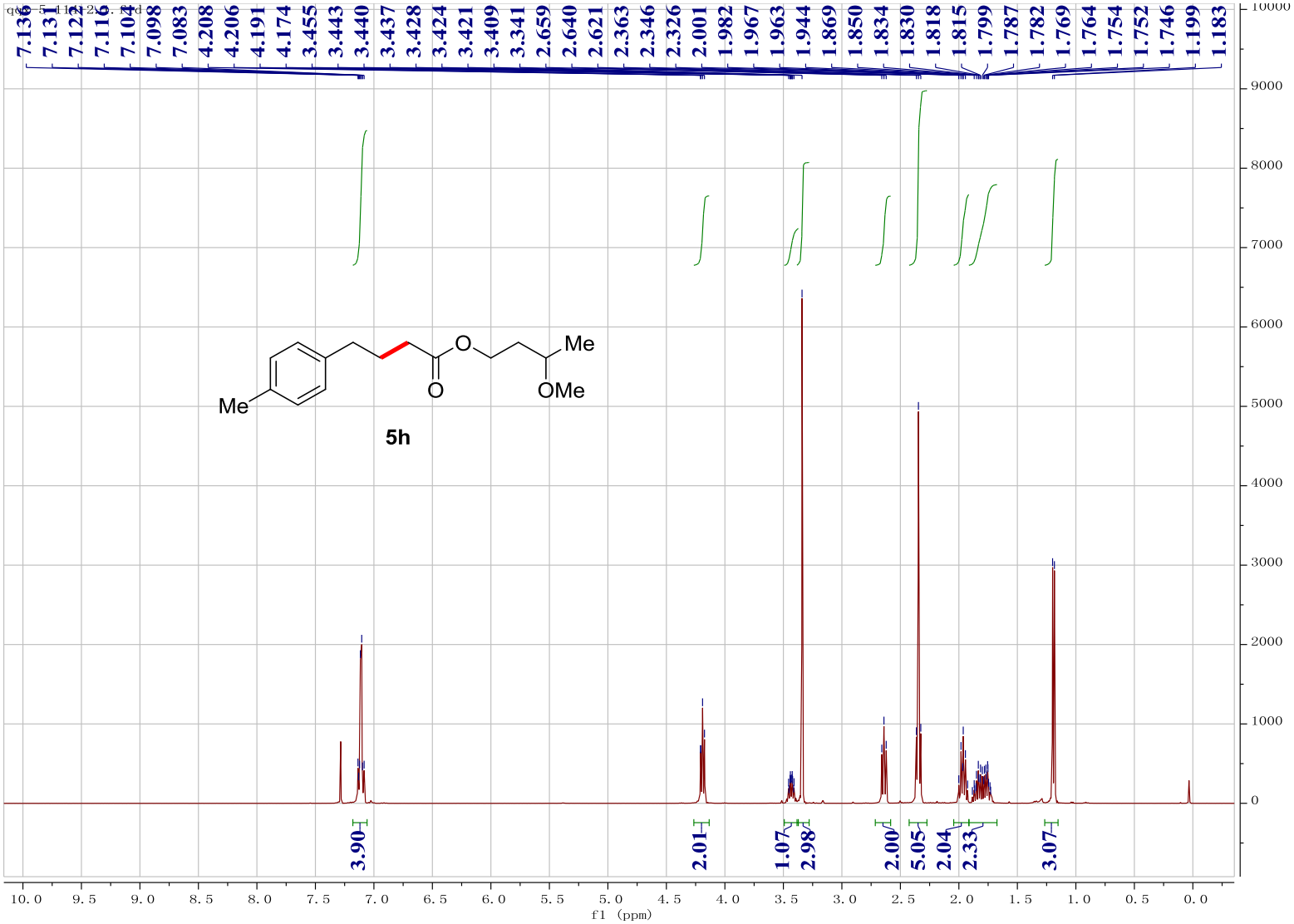
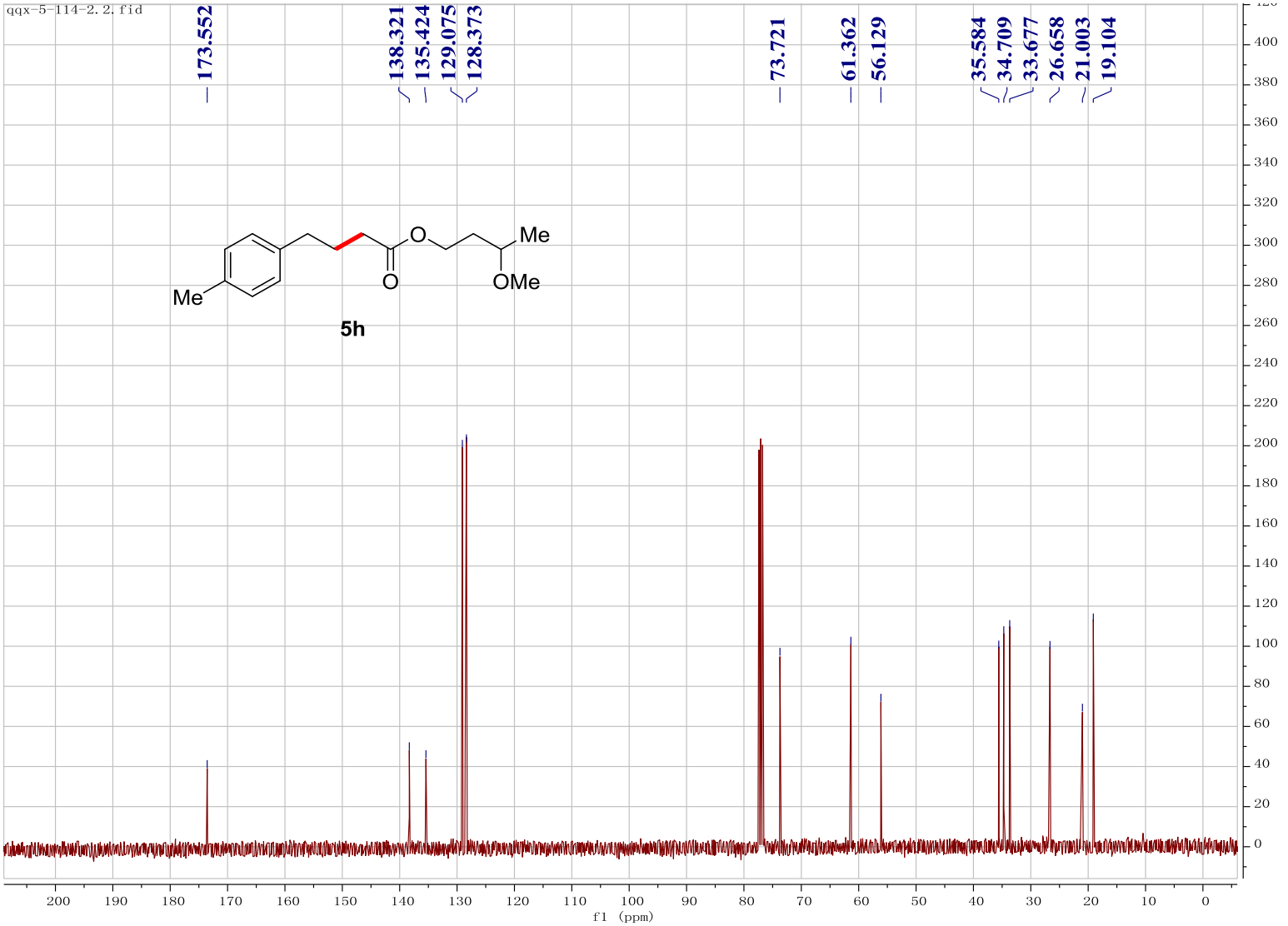
173.104
138.453
135.391
129.079
128.396
73.996
47.045
41.007
34.767
34.301
34.105
31.406
26.900
26.262
23.416
22.058
21.020
20.809
16.302
Me
Me
Me
Me
O
O
5i
f1 (ppm)


7.136
7.131
7.122
7.116
7.104
7.098
7.083
4.208
4.206
4.191
4.174
3.455
3.443
3.440
3.437
3.428
3.424
3.421
3.409
3.341
2.659
2.640
2.621
2.363
2.346
2.326
2.001
1.982
1.967
1.963
1.944
1.869
1.850
1.834
1.830
1.818
1.815
1.799
1.787
1.782
1.769
1.764
1.754
1.752
1.746
1.199
1.183
Me
O
O
Me
OMe
Me
5h
3.90
2.01
1.07
2.98
2.00
5.05
2.04
2.33
3.07
f1 (ppm)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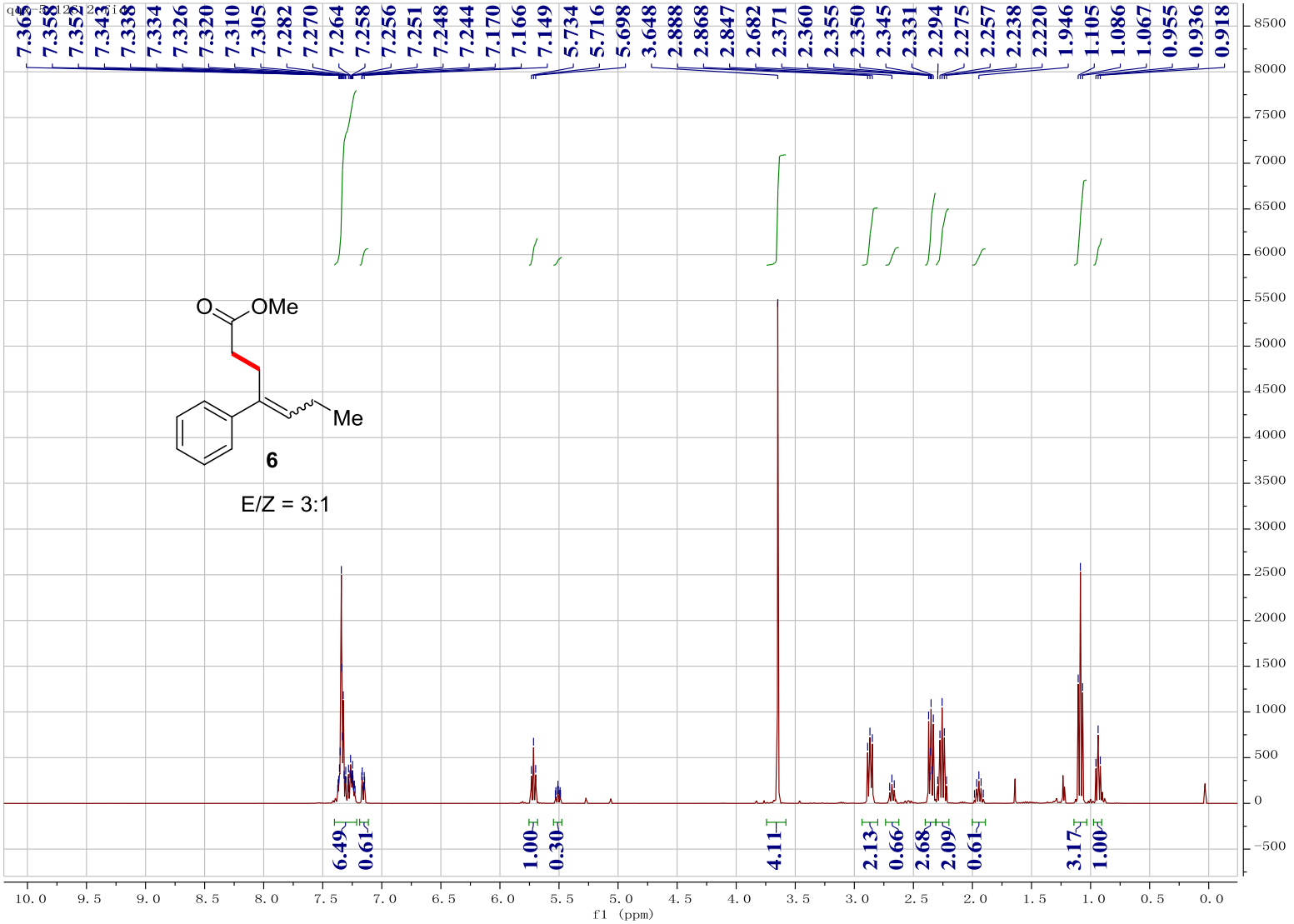
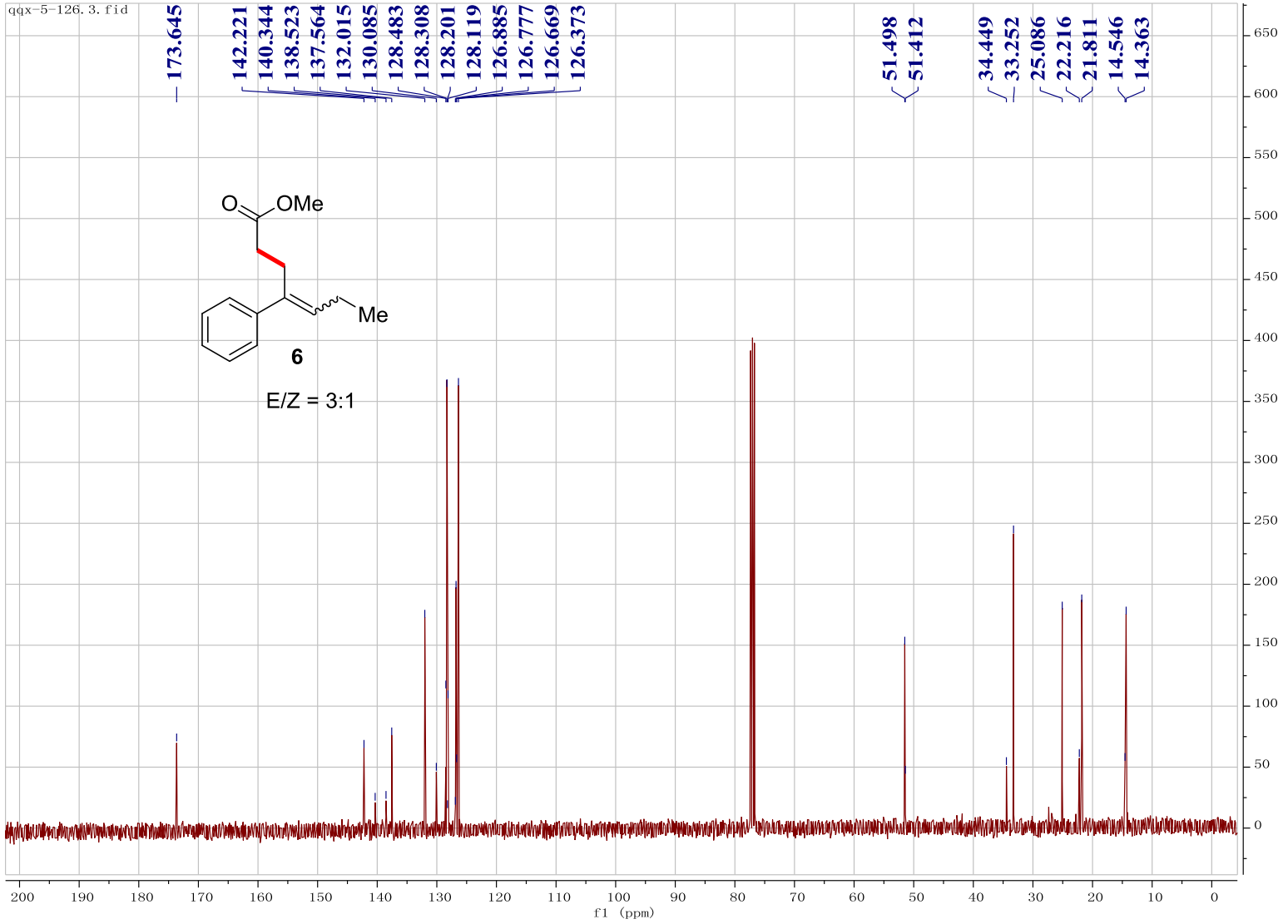
173.552
138.321
135.424
129.075
128.373
73.721
61.362
56.129
35.584
34.709
33.677
26.658
21.003
19.104
Me
O
O
Me
OMe
Me
5h
f1 (ppm)


7.365
7.358
7.351
7.343
7.338
7.334
7.326
7.320
7.310
7.305
7.282
7.270
7.264
7.258
7.256
7.251
7.248
7.244
7.170
7.166
7.149
5.734
5.716
5.698
3.648
2.888
2.868
2.847
2.682
2.371
2.360
2.355
2.350
2.345
2.331
2.294
2.275
2.257
2.238
2.220
1.946
1.105
1.086
1.067
0.955
0.936
0.918
O
OMe
Me
6
E/Z = 3:1
6.49
0.61
1.00
0.30
4.11
2.13
0.66
2.68
2.09
0.61
3.17
1.00
f1 (ppm)


qqx-5-126.3.fid
173.645
142.221
140.344
138.523
137.564
132.015
130.085
128.483
128.308
128.201
128.119
126.885
126.777
126.669
126.373
51.498
51.412
34.449
33.252
25.086
22.216
21.811
14.546
14.363
O
OMe
Me
6
E/Z = 3:1
f1 (ppm)