Supporting Information

Copper-Catalyzed Ullmann-Type Coupling and Decarboxylation Cascade of Arylhalides with Malonates to Access *α*-Aryl Esters

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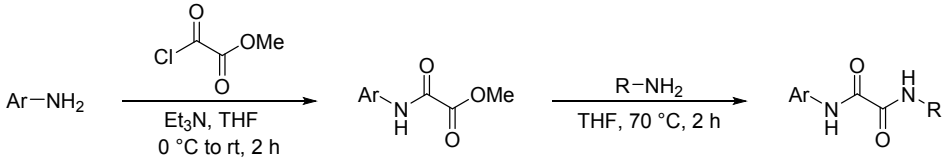
I. General information and materials

Reagent: All the reactions were carried out under inert atmosphere. All the solvents used for the reactions were dried according to standard procedures. All glassware was oven dried before use. All commercial materials were used as received unless otherwise noted. CuCl (99%, bidepharm), CuBr (99.5%, bidepharm), CuI (99%, bidepharm), Cu_2O (98%, bidepharm), CuOAc (95%, bidepharm), *t*-BuONa (98%, TCI), *t*-BuOK (97%, TCI) were used in Cu-catalyzed reactions. Anhydrous THF, *t*-BuOH, *i*-PrOH, EtOH, CH_3OH and 1,4-dioxane were purchased from Energy-Chemical. All the reactions were monitored by thin layer chromatography (TLC, Silica gel). The spots were visualized by UV light. Purification of products was conducted by flash chromatography on silica gel.

Instruments: All experiments were conducted under inert atmosphere unless otherwise noted. ^1H and ^{13}C NMR spectra were recorded on a Bruker Ascend^{TM} 400 (400 MHz) spectrometer. Chemical shifts were reported in parts per million (ppm), and the residual solvent peak was used as an internal reference: ^1H (chloroform δ 7.26; DMSO δ 2.50), ^{13}C (chloroform δ 77.16; DMSO δ 39.5). Data were reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad), coupling constants (Hz) and integration. Melting point (MP) was obtained on Hanon MP-430. For thin layer chromatography (TLC), Merck pre-coated TLC plates (Merck 60 F254) were used, and compounds were visualized with a UV light at 254nm. All GC-MS analyses were performed on an Agilent Technologies 8860 GC system equipped with a 5977B MS detector. High resolution mass spectra (HRMS) were obtained on an Agilent 1290II-6545 spectrometer (Q-TOF). Column chromatography was performed with silica gel (200-300 mesh ASTM).

II. General procedure for the preparation of ligands

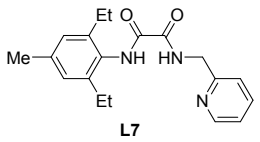
Preparation of *N*-alkyl-*N*'-aryloxalamide



To a solution of the corresponding aniline in THF (0.2 M) was added Et_3N (1.2 equiv.). Mono-methyl oxalyl chloride (1.1 equiv.) was then added to the solution slowly in an ice-water bath. After the resulting mixture was stirred at room temperature for 2 h, the mixture was washed with the same volume of water and DCM. The organic phase was dried over Na_2SO_4 and evaporated. The crude product was purified with silica gel chromatography to afford the corresponding methyl *N*-aryloxamate.

To a magnetically stirred solution of the above mono-amide in THF (1.0 M) was added corresponding amine (1.2 equiv.) at room temperature. The resulting mixture was stirred under 70 °C (oil bath) until the conversion was completed as detected by TLC. It was cooled to room temperature in the air and then to -18 °C in refrigerator. In most cases, the products would precipitate out as crystals. If no precipitate appeared, hexane was added to the mixture until the products

precipitated out. The mixture was filtered, and the solids were collected and washed with cold diethyl ether or methanol to afford the corresponding unsymmetrical *N*-alkyl-*N*'-aryloxalamides. They were pure enough to be used without further purification. [1,2]

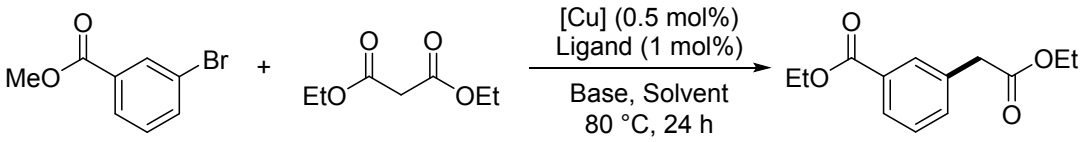


L7

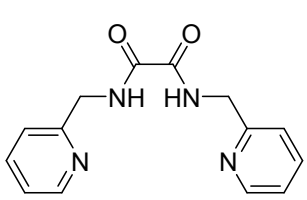
L7: white solid; MP (125.2-126.3 °C); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.74 (s, 1H), 8.59 (dd, J = 4.8, 0.6 Hz, 1H), 8.49 (s, 1H), 7.72 – 7.67 (m, 1H), 7.30 (d, J = 7.8 Hz, 1H), 7.23 (dd, J = 7.2, 5.0 Hz, 1H), 6.95 (s, 2H), 4.68 (d, J = 5.6 Hz, 2H), 2.54 (q, J = 7.6 Hz, 4H), 2.32 (s, 3H), 1.17 (t, J = 7.6 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.2, 158.8, 155.4, 149.6, 141.0, 138.2, 137.1, 128.6, 127.4, 122.8, 122.1, 45.1, 24.9, 21.4, 14.6. **HRMS** (ESI) Calcd for $C_{19}H_{23}N_3O_2$ 325.1790 $[M+H]^+$, Found 325.1793.

III. Optimization of reaction conditions.

Optimization of ligands



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



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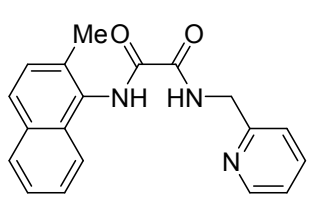

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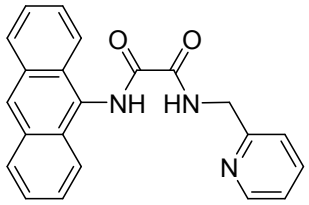

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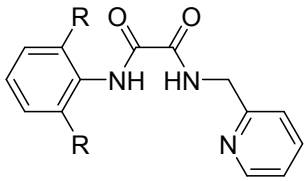
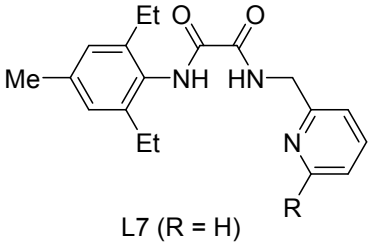
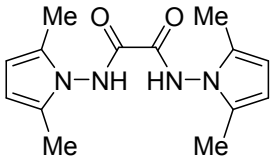


L4 (R = Ph)
L5 (R = OMe)
L6 (R = iPr)



L7 (R = H)
L8 (R = Me)



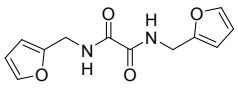
L9

Entry	[Cu]	Ligand	Base (equiv.)	Solvent	Yield (%)[a]
1	CuCl	L1	t-BuONa (3)	EtOH	0
2	CuCl	L2	t-BuONa (3)	EtOH	0
3	CuCl	L3	t-BuONa (3)	EtOH	28
4	CuCl	L4	t-BuONa (3)	EtOH	6
5	CuCl	L5	t-BuONa (3)	EtOH	20
6	CuCl	L6	t-BuONa (3)	EtOH	27
7	***CuCl***	***L7***	***t-BuONa (3)***	***EtOH***	***30***
8	CuCl	L8	t-BuONa (3)	EtOH	23
9	CuCl	L9	t-BuONa (3)	EtOH	0

[a]NMR yield

To a Schlenk tube were added (aryl)hetero bromides (8.0 mmol), diethyl malonate (16 mmol, 2 equiv.), *t*-BuONa (24 mmol, 3 equiv.), Ligand (0.08 mmol, 1 mol%), CuCl (0.02 mmol, 0.5 mol%) and redistilled EtOH (8 mL), the mixture was stirred at 80°C (oil bath) under N_2 atmosphere before it was concentrated under vacuum. The yield of the desired product was detected by ^{1}H-NMR.

Other selected ligands failed for realizing this reaction[3-8]



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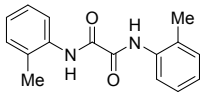

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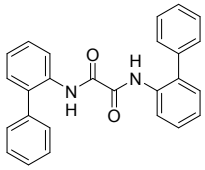

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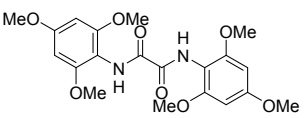

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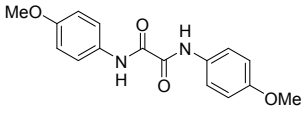

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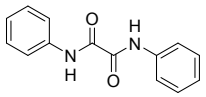

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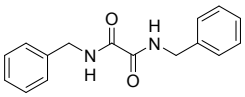

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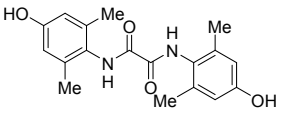

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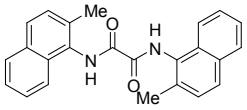

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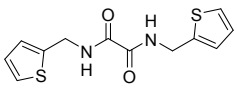

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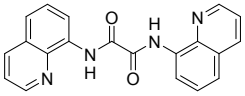

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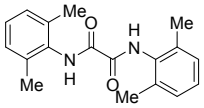

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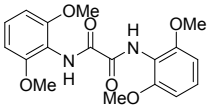
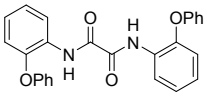


L22



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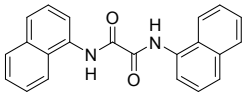

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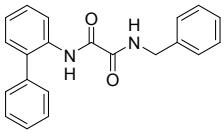
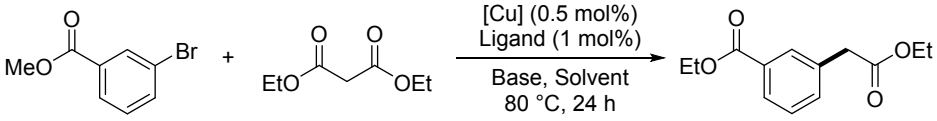


L25

Optimization of copper-catalyzed Ullmann-type coupling



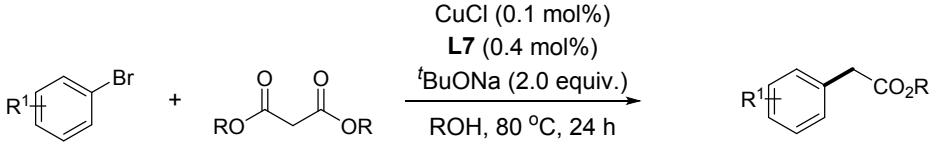
1a **2a** **3a**

Entry	[Cu]	Ligand	Base (equiv.)	Solvent	Temperature °C	Yield (%)
1	CuCl	L7	t-BuONa (3)	EtOH	50	0
2	CuCl	L7	t-BuONa (3)	EtOH	60	24
3	CuCl	L7	t-BuONa (3)	EtOH	100	15
4[a]	CuCl	L7	t-BuONa (3)	EtOH	80	28
5	CuBr	L7	t-BuONa (3)	EtOH	80	27
6	CuI	L7	t-BuONa (3)	EtOH	80	12
7	Cu_2O	L7	t-BuONa (3)	EtOH	80	20
8	CuOAc	L7	t-BuONa (3)	EtOH	80	28
9	CuCl	L7	t-BuONa (3)	t-BuOH	80	N.D.
10	CuCl	L7	t-BuONa (3)	i-PrOH	80	N.D
11	CuCl	L7	t-BuONa (3)	CH_3OH	80	29
12	CuCl	L7	t-BuONa (3)	1,4-dioxane	80	N.D.
13[b]	CuCl	L7	t-BuONa (3)	1,4-dioxane	80	N.D.
14[c]	CuCl	L7	t-BuONa (3)	1,4-dioxane	80	19
13	CuCl	L7	t-BuOK (3)	EtOH	80	18
14[d]	CuCl	L7	t-BuONa (1.5)	EtOH	80	53
15[e]	CuCl	L7	t-BuONa	EtOH	80	62
16[f]	CuCl	L7	t-BuONa	EtOH	80	57
17[g]	CuCl	L7	t-BuONa	EtOH	80	4
18[h]	CuCl	L7	t-BuONa	EtOH	80	29
19[i]	CuCl	L7	t-BuONa	EtOH	80	53
20[e,j]	CuCl	L7	t-BuONa	EtOH	80	85
21[e,k]	CuCl	L7	t-BuONa	EtOH	80	89
22[e,l]	CuCl	L7	t-BuONa	EtOH	80	43
23	CuCl	-	t-BuONa	EtOH	80	0
24	-	L7	t-BuONa	EtOH	80	0

[a]CuCl (1 mol %) and L7 (2 mol %). [b]EtOH (4 equiv.). [c]CuCl (5 mol %) , L7 (10 mol %) and EtOH (4 equiv.) [d]Base (12 mmol). [e]Base (16 mmol). [f]Base (20 mmol). [g]Base (32 mmol). [h]2a (24 mmol). [i]Solvent (6 ml). [j][Cu] (0.25 mol %). [k][Cu] (0.1 mol %), Ligand (0.4 mol %). [l][Cu] (0.1 mol %), Ligand (0.2 mol %).

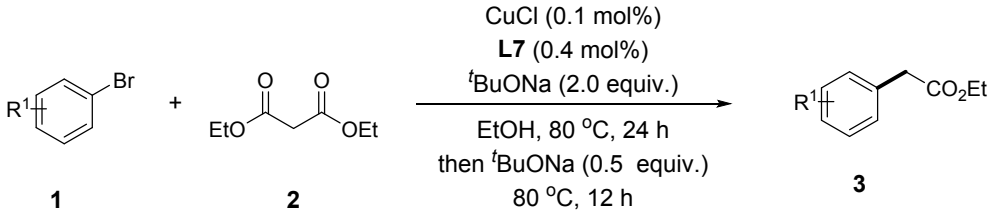
To a Schlenk tube were added (hetero)aryl bromides (8 mmol, 1 equiv.), diethyl malonate, *t*-BuONa, Ligand and [Cu] and redistilled solvent, the mixture was stirred at 80°C (oil bath) under N_2 atmosphere before it was concentrated under vacuum. The yield of the desired product was detected by ^{1}H-NMR.

IV. General procedures for the Cu-catalyzed *α*-arylesters formation

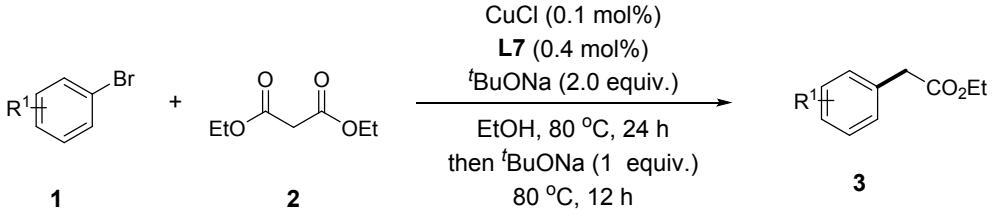


1 **2** **3**

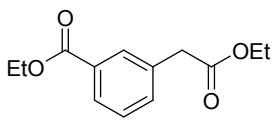
General procedure A: The (hetero)aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) were placed into a Schlenk tube (35 mL). The reaction vessel was evacuated and backfilled with nitrogen for three times, then malonic acid diester (16.0 mmol) and ROH (8.0 mL) were added under a positive nitrogen pressure (Note: for liquid substrates, they were added after the tube was backfilled with nitrogen). The reaction mixture was heated at 80 °C (oil bath) for 24 h under vigorous stirring. 2N HCl was then added to adjust pH to ≤ 1. The cooled mixture was subsequently diluted with ethyl acetate and washed with brine. The organic phase was dried over Na_2SO_4 and concentrated in vacuo. The residue was purified by silica gel flash chromatography to afford the corresponding *α*-aryl ester.



General procedure B: The (hetero)aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.08 mmol, 0.01 equiv.) and CuCl (0.02 mmol, 0.0025 equiv.) were placed into a Schlenk tube (35 mL). The reaction vessel was evacuated and backfilled with nitrogen for three times, then malonic acid diester (16.0 mmol) and EtOH (8.0 mL) were added under a positive nitrogen pressure (Note: for liquid substrates, they were added after the tube was backfilled with nitrogen). The reaction mixture was heated at 80 °C (oil bath) for 24 h under vigorous stirring. The cooled solution was added *t*-BuONa (4 mmol) and was heated at 80 °C (oil bath) for 12 h. 2N HCl was then added to adjust pH to ≤ 1. The cooled mixture was subsequently diluted with ethyl acetate and washed with brine. The organic phase was dried over Na_2SO_4 and concentrated in vacuo. The residue was purified by silica gel flash chromatography to afford the corresponding *α*-aryl ester.



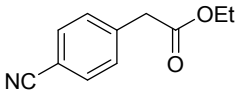
General procedure C: The (hetero)aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.08 mmol, 0.01 equiv.) and CuCl (0.02 mmol, 0.0025 equiv.) were placed into a Schlenk tube (35 mL). The reaction vessel was evacuated and backfilled with nitrogen for three times, then malonic acid diester (16.0 mmol) and EtOH (8.0 mL) were added under a positive nitrogen pressure (Note: for liquid substrates, they were added after the tube was backfilled with nitrogen). The reaction mixture was heated at 80 °C (oil bath) for 24 h under vigorous stirring. The cooled solution was added *t*-BuONa (8 mmol) and was heated at 80 °C (oil bath) for 12 h. 2N HCl was then added to adjust pH to ≤ 1. The cooled mixture was subsequently diluted with ethyl acetate and washed with brine. The organic phase was dried over Na_2SO_4 and concentrated in vacuo. The residue was purified by silica gel flash chromatography to afford the corresponding *α*-aryl ester.



3a

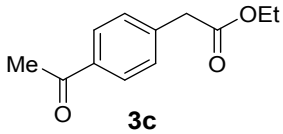
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2

equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80° C for 24 h afforded compound **3a** in 74 % yield (1.39 g) as a colorless oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96–7.92 (m, 2H), 7.48–7.45 (m, 1H), 7.41–7.36 (m, 1H), 4.36 (q, J = 7.1 Hz, 2H), 4.14 (q, J = 7.1 Hz, 2H), 1.38 (t, J = 7.1 Hz, 3H), 1.24 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 166.5, 134.5, 133.8, 130.9, 130.5, 128.6, 128.4, 61.1, 41.2, 14.1. **MS** (EI) m/z 236.09 $[M]^{+}$.[9]



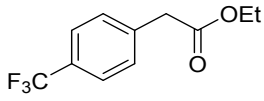
3b

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3b** in 68 % yield (1.03 g) as a white solid according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/70 to 1/30). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 (d, J = 8.1 Hz, 2H), 7.40 (d, J = 8.1 Hz, 2H), 4.16 (q, J = 7.1 Hz, 2H), 3.67 (s, 2H), 1.25 (t, J = 7.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.4, 139.6, 132.4, 130.3, 118.8, 111.3, 61.4, 41.5, 14.2. **MS** (EI) m/z 189.07 $[M]^{+}$. MP (89.1–90.3°C). [10]



3c

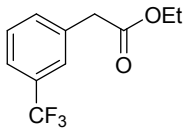
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80°C for 24 h afforded compound **3c** in 65 % yield (1.07 g) as a white solid according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/70 to 1/30). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 (d, J = 8.2 Hz, 2H), 7.35 (d, J = 8.2 Hz, 2H), 4.14 (q, J = 7.1 Hz, 2H), 3.64 (s, 2H), 2.55 (s, 3H), 1.23 (t, J = 7.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 197.8, 170.9, 139.6, 136.1, 129.6, 128.7, 61.2, 41.4, 26.7, 14.2. MS (EI) m/z 206.09 $[M]^{+}$. MP (49.0–50.0°C).[10]



3d

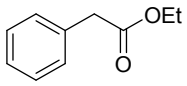
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80°C for 24 h afforded compound **3d** in 81 % yield (1.50 g) as a colorless solid according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 (d, J = 8.1 Hz, 2H), 7.41 (d, J = 8.1 Hz, 2H), 4.17 (q, J = 7.1 Hz, 2H), 3.67 (s, 1H), 1.26 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.9, 138.3, 129.8, 129.6 (q, $^{2}J_{C\text{-}F}$ = 32.6 Hz), 125.6 (q, $^{3}J_{C\text{-}F}$ = 3.8 Hz), 124.2 (q, $^{1}J_{C\text{-}F}$ = 277.3 Hz), 61.3, 41.3, 14.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.6. **MS** (EI) m/z 232.06 $[M]^{+}$.

MP (36.0–37.0°C). [10]



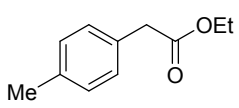
3e

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80°C for 24 h afforded compound **3e** in 63 % yield (1.17 g) as a colorless oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57–7.39 (m, 4H), 4.16 (q, J = 7.1 Hz, 2H), 3.66 (s, 2H), 1.24 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.8, 135.2, 132.8, 129.9 (q, $^{2}J_{C\text{-}F}$ = 32.2 Hz), 129.0, 126.1 (q, $^{3}J_{C\text{-}F}$ = 3.8 Hz), 124.2 (q, $^{1}J_{C\text{-}F}$ = 272.6 Hz), 124.0 (q, $^{3}J_{C\text{-}F}$ = 3.8 Hz), 61.1, 41.0, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.6. **MS** (EI) m/z 232.05 $[M]^{+}$.[9]



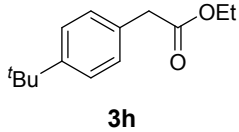
3f

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80°C for 24 h afforded compound **3f** in 74 % yield (1.17 g) as a pale yellow oil according to the **general procedure C**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, CDCl3) δ 7.38–7.22 (m, 5H), 4.14 (q, J = 7.1 Hz, 2H), 3.60 (s, 2H), 1.24 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, CDC l_3) δ 171.7, 134.2, 129.3, 128.6, 127.1, 60.8, 41.5, 14.2. MS (EI) m/z 164.06 $[M]^{+}$.[11]



3g

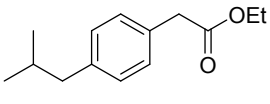
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3g** in 80 % yield (1.14 g) as a colorless oil according to the **general procedure C**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.16 (dd, J = 18.2, 8.0 Hz, 4H), 4.15 (q, J = 7.1 Hz, 2H), 3.57 (s, 1H), 2.33 (s, 3H), 1.25 (t, J = 7.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.7, 136.8, 131.2, 129.4, 129.2, 60.9, 41.2, 21.2, 14.3. MS (EI) m/z 178.08 $[M]^{+}$.[10]



3h

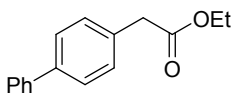
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3h** in 83 % yield (1.46 g) as a colorless oil according to the **general procedure C**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 (d, J = 8.2 Hz, 2H), 7.23 (d, J = 8.2 Hz, 2H), 4.16 (q, J = 7.1 Hz, 2H), 3.59 (s, 2H), 1.32 (s, 9H), 1.27 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100

MHz, $CDCl_3$) δ 171.9, 150.0, 131.2, 129.0, 125.6, 60.9, 41.0, 34.6, 31.5, 14.3. MS (EI) m/z 220.13 $[M]^+$.[12]



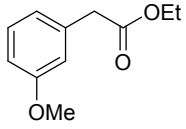
3i

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.08 mmol, 0.01 equiv.) and CuCl (0.02 mmol, 0.0025 equiv.) in EtOH (8 ml) at 80°C for 24 h afforded compound **3i** in 71 % yield (1.14 g) as a pale yellow oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (d, J = 8.0 Hz, 2H), 7.10 (d, J = 8.0 Hz, 2H), 4.16 (q, J = 7.1 Hz, 2H), 3.59 (s, 2H), 2.46 (d, J = 7.2 Hz, 2H), 1.92 - 1.80 (m, 1H), 1.26 (t, J = 7.1 Hz, 3H), 0.91 (d, J = 6.6 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.0, 140.6, 131.5, 129.4, 129.0, 60.9, 45.2, 41.2,30.3, 22.5, 14.3. MS (EI) m/z 220.12 $[M]^+$.[13]



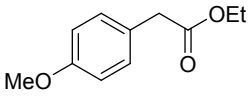
3j

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3j** in 80 % yield (1.54 g) as a colorless oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63–7.56 (m, 4H), 7.45 (t, J = 7.6 Hz, 2H), 7.38 (d, J = 7.9 Hz, 2H), 7.35 (d, J = 7.3 Hz, 1H), 4.20 (q, J = 7.1 Hz, 2H), 3.68 (s, 1H), 1.30 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.7, 140.9, 140.1, 133.3, 129.8, 128.9, 127.4, 127.3, 127.2, 61.0, 41.2, 14.3. MS (EI) m/z 240.10 $[M]^+$. [14]



3k

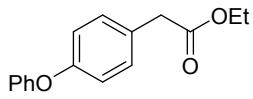
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80°C for 24 h afforded compound **3k** in 70 % yield (1.09 g) as a pale yellow liquid according to the **general procedure B**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24 (t, J = 7.9 Hz, 1H), 6.89– 6.80 (m, 3H), 4.16 (q, J = 7.1 Hz, 2H), 3.81 (s, 3H), 3.59 (s, 2H), 1.26 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.5, 159.8, 135.7, 129.6, 121.7, 115.0, 112.7, 60.9, 55.3, 41.6, 14.4; MS (EI) m/z 194.08 $[M]^+$.[10]



3l

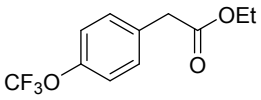
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80°C for 24 h afforded compound **3l** in 75 % yield (1.17 g) as a pale yellow liquid according to the **general procedure C**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 (d, J = 8.7 Hz, 2H), 6.86 (d, J = 8.7 Hz, 2H), 4.14 (q, J = 7.1 Hz, 2H), 3.78 (s, 3H), 3.55 (s, 2H), 1.25 (t, J = 7.1 Hz, 3H); ^{13}C NMR

(100 MHz, $CDCl_3$) δ 171.9, 158.7, 130.3, 126.3, 114.0, 60.7, 55.2, 40.5, 14.2. MS (EI) m/z 194.07 $[M]^+$.[10]



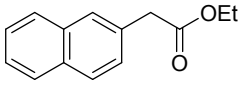
3m

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3m** in 70 % yield (1.44 g) as a colorless oil according to the **general procedure C**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, CDCl3) δ 7.23–7.18 (m, 2H), 7.13 (d, J = 8.6 Hz, 2H), 7.00 - 6.94 (m, 1H), 6.91–6.83 (m, 4H), 4.05 (q, J = 7.1 Hz, 2H), 3.47 (s, 2H), 1.15 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, CDCl3) δ 171.7, 157.3, 156.4, 130.6, 129.8, 129.0, 123.3, 119.0, 118.9, 60.9, 40.7, 14.2. MS (EI) m/z 256.10 $[M]^+$.[15]



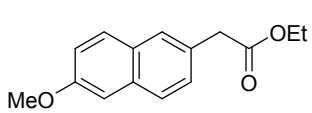
3n

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80°C for 24 h afforded compound **3n** in 50 % yield (0.99 g) as a colorless oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 (d, J = 8.0 Hz, 2H), 7.17 (d, J = 8.0 Hz, 2H), 4.16 (q, J = 7.1 Hz, 2H), 3.61 (s, 2H), 1.25 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 148.5, 133.0, 130.8, 121.1, 120.6 (q, $^1J_{C\text{-}F}$ = 257.2 Hz), 61.1, 40.7, 14.3. MS (EI) m/z 248.04 $[M]^+$.[16]



3o

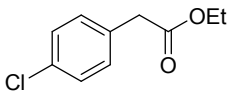
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3o** in 90 % yield (1.54 g) as a pale yellow oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87–7.81 (m, 3H), 7.77 (s, 1H), 7.54–7.44 (m, 3H), 4.21 (q, J = 7.1 Hz, 2H), 3.81 (s, 2H), 1.29 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.6, 133.6, 132.6, 131.7, 128.2, 128.0, 127.7, 127.6, 127.4, 126.2, 125.8, 61.0, 41.7, 14.3. MS (EI) m/z 214.10 $[M]^+$.[10]



3p

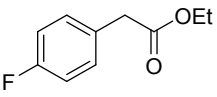
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80°C for 24 h afforded compound **3p** in 85

% yield (1.22 g) as a white solid according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 (m, 2H), 7.67 (s, 1H), 7.40 (dd, J = 8.4, 1.8 Hz, 1H), 7.16 (m, 2H), 4.15 (q, J = 7.1 Hz, 2H), 3.88 (s, 3H), 3.72 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.9, 157.7, 133.7, 129.4, 129.2, 129.0, 128.0, 127.8, 127.1, 119.0, 105.7, 60.9, 55.4, 41.5, 14.3. MS (EI) m/z 244.09 $[M]^+$. MP (52.3 - 53.5°C). [14]



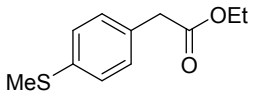
3q

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3q** in 77 % yield (1.22 g) as a pale yellow oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 (d, J = 8.5 Hz, 2H), 7.21 (d, J = 8.5 Hz, 2H), 4.15 (q, J = 7.1 Hz, 2H), 3.57 (s, 2H), 1.25 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 133.1, 132.7, 132.0, 128.7, 61.0, 40,8, 14.2. MS (EI) m/z 198.03 $[M]^+$.[16]



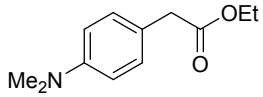
3r

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3r** in 61 % yield (0.88 g) as a colorless yellow oil according to the **general procedure C**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27–7.22 (m, 2H), 7.03–6.98 (m, 2H), 4.15 (q, J = 7.1 Hz, 2H), 1.25 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.4, 162.1(d, $^{1}J_{C\text{-}F}$ = 245.36 Hz), 160.8, 130.8 (d, $^{3}J_{C\text{-}F}$ = 8.0 Hz), 130.0 (d, $^{4}J_{C\text{-}F}$ = 2.9 Hz), 115.3 (d, $^{2}J_{C\text{-}F}$ = 21.3 Hz), 60.7, 40.5, 14.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ -115.9. MS (EI) m/z 182.05 $[M]^+$.[10]



3s

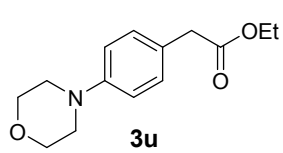
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3s** in 71 % yield (1.18 g) as a white solid according to the **general procedure B**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24–7.17 (m, 4H), 4.14 (q, J = 7.1 Hz, 2H), 3.56 (s, 2H), 2.46 (s, 3H), 1.24 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.6, 137.2, 131.1, 129.8, 127.0, 61.0, 40.9, 16.0, 14.3. MS (EI) m/z 210.06 $[M]^+$. MP (49.5–50.5°C). [10]



3t

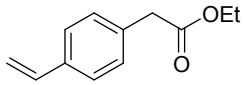
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001

equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3t** in 44 % yield (0.73 g) as a pale yellow oil according to the **general procedure B**. (Ethyl Acetate/Hexane: 1/50 to 1/10). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.16 (d, J = 8.7 Hz, 2H), 6.70 (d, J = 8.7 Hz, 2H), 4.14 (q, J = 7.1 Hz, 2H), 3.51 (s, 2H), 2.93 (s, 6H), 1.25 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.5, 149.9, 130.0, 122.1, 112.9, 60.8, 40.8, 40.6, 14.3. MS (EI) m/z 207.09 $[M]^+$.[10]



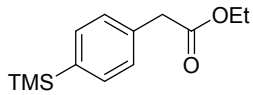
3u

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3u** in 39 % yield (0.78 g) as a pale yellow oil according to the **general procedure C**. (Ethyl Acetate/Hexane: 1/50 to 1/10). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.19 (d, J = 8.7 Hz, 2H), 6.87 (d, J = 8.7 Hz, 2H), 4.14 (q, J = 7.1 Hz, 2H), 3.85 (t, J = 4.8 Hz, 4H), 3.53 (s, 2H), 3.13 (t, J = 4.9 Hz, 4H), 1.24 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.1, 150.4, 130.1, 125.7, 115.9, 67.0, 60.8, 49.5, 40.6, 14.3. MS (EI) m/z 249.10 $[M]^+$.[17]



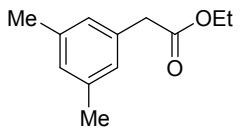
3v

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3v** in 54 % yield (0.82 g) as a colorless oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34 (d, J = 8.2 Hz, 2H), 7.22 (d, J = 8.2 Hz, 2H), 6.67 (dd, J = 17.6, 10.9 Hz, 1H), 5.70 (dd, J = 17.6, 0.7 Hz, 1H), 5.20 (dd, J = 10.9, 0.7 Hz, 1H), 4.12 (q, J = 7.1 Hz, 2H), 3.57 (s, 2H), 1.22 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.4, 136.5, 136.4, 133.7, 129.5, 126.4, 113.7, 60.8, 41.1, 14.2. MS (EI) m/z 190.05 $[M]^+$.[11]



3w

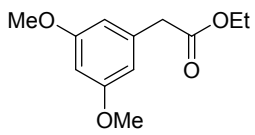
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.08 mmol, 0.01 equiv.) and CuCl (0.02 mmol, 0.0025 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3w** in 78 % yield (1.47 g) as a colorless oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 (d, J = 8.0 Hz, 2H), 7.33 (d, J = 8.0 Hz, 2H), 4.19 (q, J = 7.1 Hz, 2H), 3.65 (s, 2H), 1.30 (t, J = 7.1 Hz, 3H), 0.31 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.6, 139.0, 134.8, 133.7, 128.7, 60.9, 41.4, 14.3, 1.1. MS (EI) m/z 236.09 $[M]^+$.[18]



3x

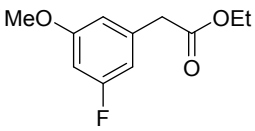
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in

EtOH (8 ml) at 80 °C for 24 h afforded compound **3x** in 76 % yield (1.17 g) as a pale yellow oil according to the **general procedure C**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.94 (s, 3H), 4.17 (q, J = 7.1 Hz, 2H), 3.56 (s, 2H), 2.37 (s, 6H), 1.29 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.9, 138.1, 134.0, 128.8, 127.1, 60.9, 41.4, 21.3, 14.3. MS (EI) m/z 192.10 $[M]^{+}$.[19]



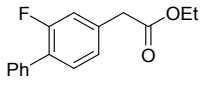
3y

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3y** in 76 % yield (1.36 g) as a colorless oil according to the **general procedure C**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.44 (d, J = 2.3 Hz, 2H), 6.37 (t, J = 2.3 Hz, 1H), 4.15 (q, J = 7.1 Hz, 2H), 3.78 (s, 6H), 3.54 (s, 2H), 1.26 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.5, 161.0, 136.3, 107.4, 99.3, 61.0, 55.4, 41.8, 14.3. MS (EI) m/z 224.10 $[M]^{+}$.[11]



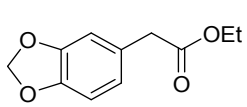
3z

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3z** in 74 % yield (1.26 g) as a colorless oil according to the **general procedure B**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.63–6.58 (m, 2H), 6.55–6.49 (m, 1H), 4.16 (q, J = 7.1 Hz, 2H), 3.78 (s, 3H), 3.55 (s, 2H), 1.26 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.0, 163.7 (d, $^{1}J_{C\text{-}F}$ = 244.9 Hz), 161.0 (d, $^{3}J_{C\text{-}F}$ = 11.5 Hz), 136.9 (d, $^{3}J_{C\text{-}F}$ = 10.1 Hz), 111.0, 108.7 (d, $^{2}J_{C\text{-}F}$ = 22.1 Hz), 100.5 (d, $^{2}J_{C\text{-}F}$ = 25.1 Hz), 61.2, 55.6, 41.4, 14.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ -111.9. **HRMS** (EI) Calcd for $C_{11}H_{13}FO_3$ 212.0849 $[M]^{+}$, Found 212.0851.



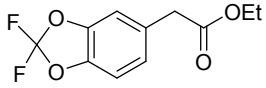
3aa

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3aa** in 78 % yield (1.61 g) as a colorless oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62–7.58 (m, 2H), 7.50–7.39 (m, 4H), 7.19 (s, 1H), 7.16 (d, J = 2.3 Hz, 1H), 4.23 (q, J = 7.1 Hz, 2H), 3.68 (s, 2H), 1.32 (t, J = 7.2 Hz, 3H) ; ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.1, 159.7 (d, $^{1}J_{C\text{-}F}$ = 248.3 Hz), 135.6, 135.5 (d, $^{4}J_{C\text{-}F}$ = 8.1 Hz), 130.8, 129.1, 128.5, 127.9 (d, $^{3}J_{C\text{-}F}$ = 13.7 Hz), 127.8, 125.4, 117.1 (d, $^{2}J_{C\text{-}F}$ = 23.7 Hz), 61.2, 40.9, 14.3; ^{19}F NMR (376 MHz, CDCl3) δ -117.9. MS (EI) m/z 258.11 $[M]^{+}$.[20]



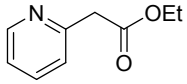
3ab

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3ab** in 75 % yield (1.25 g) as a colorless oil according to the **general procedure C**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.79 – 6.70 (m, 3H), 5.93 (s, 2H), 4.14 (q, J = 7.1 Hz, 2H), 3.51 (s, 1H), 1.25 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.8, 147.9, 146.8, 127.9, 122.5, 109.8, 108.4, 101.1, 61.0, 41.7, 41.1, 14.3. MS (EI) m/z 208.06 $[M]^{+}$.[18]



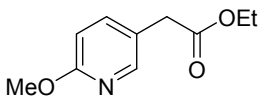
3ac

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3ac** in 68 % yield (1.33 g) as a pale yellow oil according to the **general procedure B**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.04–6.96 (m, 3H), 4.16 (q, J = 7.1 Hz, 2H), 3.59 (s, 1H), 1.26 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 144.0, 143.0, 131.7(t, $^{1}J_{C\text{-}F}$ = 252.8 Hz), 130.2, 129.2, 124.6, 110.7, 109.4, 61.2, 41.0, 14.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ -50.04. MS (EI) m/z 244.04 $[M]^{+}$.[16]



3ad

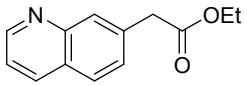
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.08 mmol, 0.01 equiv.) and CuCl (0.02 mmol, 0.0025 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3ad** in 65 % yield (0.86 g) as a pale yellow oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/50 to 1/10). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.48 (d, J = 4.2 Hz, 1H), 7.65–7.61 (m, 1H), 7.27 (d, J = 7.8 Hz, 1H), 7.18–7.15 (m, 1H), 4.16 (q, J = 7.1 Hz, 2H), 3.82 (s, 2H), 1.23 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.7, 154.6, 149.5, 136.7, 123.9, 122.2, 61.1, 44.0, 14.2. MS (EI) m/z 165.06 (M^{+}).[18]



3ae

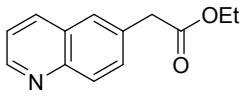
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3ae** in 62 % yield (0.97 g) as a pale yellow oil according to the **general procedure C**. (Ethyl Acetate/Hexane: 1/50 to 1/10). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, J = 2.0 Hz, 1H), 7.48 (dd, J = 8.5, 2.0 Hz, 1H), 6.67 (d, J = 8.5 Hz, 1H), 4.10 (q, J = 7.1 Hz, 2H), 3.87 (s, 3H), 3.47 (s, 2H), 1.20 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.3, 163.4, 146.9, 139.7, 122.6,

110.8, 61.0, 53.4, 37.6, 14.2. **HRMS** (ESI) Calcd for $C_{10}H_{13}NO_3$ 196.0968 $[M+H]^+$, Found 196.0977.



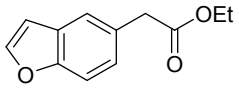
3af

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3af** in 71 % yield (1.22 g) as a pale yellow oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/50 to 1/10). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.87 (dd, J = 4.2, 1.6 Hz, 1H), 8.11 (d, J = 8.9 Hz, 1H), 7.98 (s, 1H), 7.77 (d, J = 8.4 Hz, 1H), 7.49 (dd, J = 8.4, 1.6 Hz, 1H), 7.35 (dd, J = 8.3, 4.2 Hz, 1H), 4.16 (q, J = 7.1 Hz, 2H), 3.80 (s, 2H), 1.24 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 150.7, 148.3, 135.9, 135.8, 129.6, 128.3, 128.0, 127.3, 121.1, 61.1, 41.7, 14.2. **HRMS** (ESI) Calcd for $C_{13}H_{13}NO_2$ 216.1019 $[M+H]^+$, Found 216.1026.



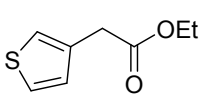
3ag

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3ag** in 70 % yield (1.21 g) as a pale yellow oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/50 to 1/10). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.87 (dd, J = 4.2, 1.5 Hz, 1H), 8.10 (d, J = 8.3 Hz, 1H), 8.06 (d, J = 8.6 Hz, 1H), 7.64 (dd, J = 8.6, 1.5 Hz, 1H), 7.37 (dd, J = 8.3, 4.2 Hz, 1H), 4.16 (q, J = 7.1 Hz, 2H), 3.79 (s, 2H), 1.25 (t, J = 7.1 Hz, 3H); 13C NMR (100 MHz, $CDCl_3$) δ 171.3, 150.4, 147.5, 136.0, 132.7, 131.2, 129.7, 128.3, 127.9, 121.4, 61.2, 41.4, 14.3. MS (EI) m/z 215.09 $[M]^+$.[11]



3ah

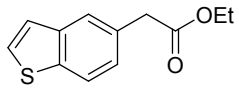
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3ah** in 62 % yield (1.01 g) as a pale yellow oil according to the **general procedure C**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, J = 2.2 Hz, 1H), 7.53 (d, J = 1.2 Hz, 1H), 7.46 (d, J = 8.5 Hz, 1H), 7.23 (d, J = 8.5, 1H), 6.73 (dd, J = 2.2, 1.2 Hz, 1H), 4.16 (q, J = 5.2 Hz, 2H), 3.71 (s, 2H), 1.26 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.0, 154.2, 145.4, 128.7, 127.8, 125.6, 121.8, 111.4, 106.6, 60.9, 41.3, 14.2. **HRMS** (EI) Calcd for $C_{12}H_{12}O_3$ 204.0786 $[M]^+$, Found 204.0793.



3ai

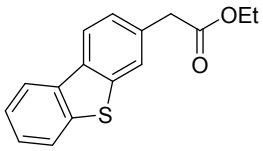
The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3ai** in 41 % yield (0.56 g) as a

colorless oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27–7.23 (m, 1H), 7.14–7.12 (m, 1H), 7.03 (dd, J = 5.0, 1.2 Hz, 1H), 4.15 (q, J = 7.1 Hz, 2H), 3.63 (s, 2H), 1.25 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.1, 133.8, 128.5, 125.7, 122.8, 60.9, 35.9, 14.2. MS (EI) m/z 169.99 $[M]^+$.[10]



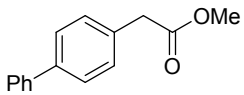
3aj

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80 °C for 24 h afforded compound **3aj** in 63 % yield (1.11 g) as a colorless oil according to the **general procedure C**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, J = 8.3 Hz, 1H), 7.74 (d, J = 0.9 Hz, 1H), 7.44 (d, J = 5.4 Hz, 1H), 7.31–7.27 (m, 2H), 4.17 (q, J = 7.1 Hz, 2H), 3.73 (s, 2H), 1.26 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171,9, 140.1, 138.7, 130.4 ,127.0, 125.8, 124.3, 123.8, 122.7, 61.0, 41.5, 14.3. MS (EI) m/z 220.05 $[M]^+$.[21]



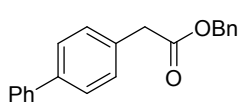
3ak

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in EtOH (8 ml) at 80°C for 24 h afforded compound **3ak** in 73 % yield (1.58 g) as a colorless oil according to the **general procedure B**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.19–8.13 (m, 1H), 8.08 (s, 1H), 7.89–7.84 (m, 1H), 7.81 (d, J = 8.2 Hz, 1H), 7.47 (m, Hz, 2H), 7.40 (dd, J = 8.2, 1.6 Hz, 1H), 4.20 (q, J = 7.1 Hz, 2H), 3.83 (s, 2H), 1.30 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.8, 139.9, 138.3, 136.0, 135.4, 130.6, 126.9, 124.4, 122.9, 122.4, 121.7, 61.0, 41.5, 14.3. **HRMS** (EI) Calcd for $C_{16}H_{14}O_2S$ 270.0715 $[M]^+$, Found 270.0720.



3al

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in MeOH (8 ml) at 80 °C for 24 h afforded compound **3al** in 56 % yield (1.01 g) as a colorless oil according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, CDCl3) δ 7.65–7.60 (m, 4H), 7.51–7.45 (m, 2H), 7.43–7.35 (m, 3H), 3.76 (s, 3H), 3.72 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 172.1, 140.9, 140.2, 133.1, 129.8, 128.9, 127.4, 127.2, 52.2, 40.9. MS (EI) m/z 226.08 $[M]^+$.[22]

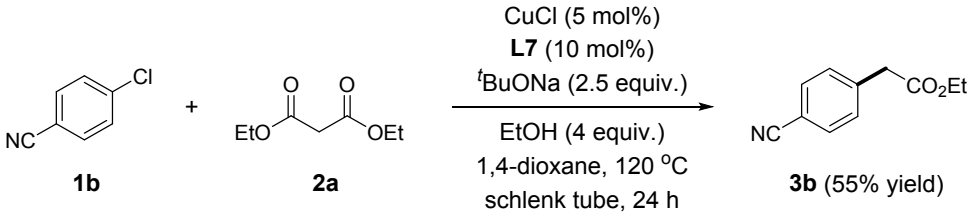


3am

The reaction of the aryl bromide (8.0 mmol), *t*-BuONa (16 mmol, 2 equiv.),

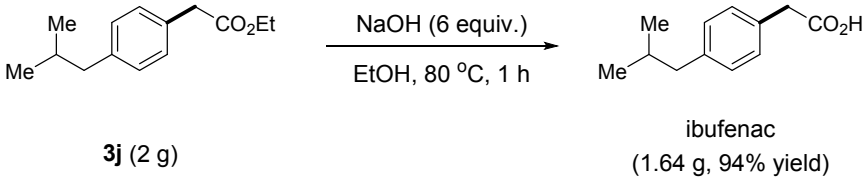
L7 (0.032 mmol, 0.004 equiv.) and CuCl (0.008 mmol, 0.001 equiv.) in BnOH (8 ml) at 80 °C for 24 h afforded compound **3am** in 49 % yield (1.18 g) as a white solid according to the **general procedure A**. (Ethyl Acetate/Hexane: 1/100 to 1/50). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62–7.55 (m, 4H), 7.45 (m 2H), 7.40–7.33 (m, 8H), 5.18 (s, 2H), 3.73 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.5, 140.9, 140.2, 136.0, 133.0, 129.9, 128.9, 128.7, 128.4, 128.3, 127.5, 127.4, 127.2, 66.8, 41.1. MS (EI) m/z 302.01 $[M]^+$. MP (66.5–67.5°C). [22]

V. Reaction of the arylchloride with diethyl malonate to form the *α*-arylester 3b.



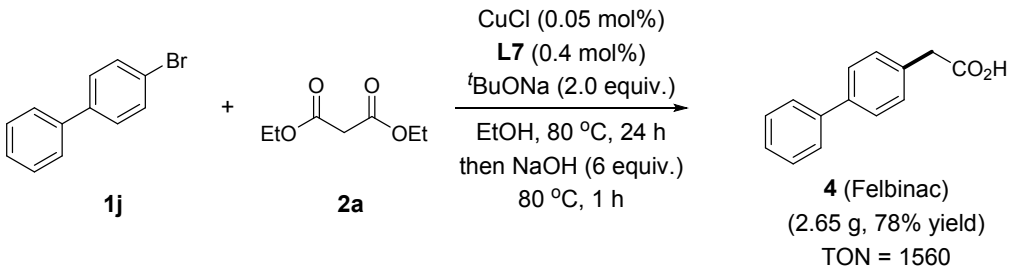
The aryl chloride **1b** (1mmol), *t*-BuONa (2.5 mmol, 2.5 equiv.), **L7** (0.1 mmol, 0.1 equiv.) and CuCl (0.05 mmol, 0.05 equiv.) were placed into a Schlenk tube (15 mL). The reaction vessel was evacuated and backfilled with nitrogen for three times, then malonic acid diester **2a** (1.5 mmol, 1.5 equiv.), EtOH (233 μL, 4 equiv.) and 1,4-dioxane (1 mL) were added under a positive nitrogen pressure (Note: for liquid substrates, they were added after the tube was backfilled with nitrogen). The reaction mixture was heated at 120 °C for 24 h under vigorous stirring. 2N HCl was then added to adjust pH to ≤ 1. The cooled mixture was subsequently diluted with ethyl acetate and washed with brine. The organic phase was dried over Na_2SO_4 and concentrated in vacuo. The residue was purified by silica gel flash chromatography to afford the corresponding *α*-aryl ester **3b** in 55% yield.

VI. The application of synthesizing ibufenac and felbinac.



The *α*-arylester **3j** (2 g) were placed into a Schlenk tube (120 mL). Then NaOH (6 equiv.) was added to the Schlenk tube, the reaction mixture was heated at 80 °C (oil bath) for 1 h. Wash the aqueous phase with ethyl acetate, and 2N HCl was added to adjust pH to ≤ 1. Then the aqueous phase was diluted with ethyl acetate and washed with brine. The organic phase was dried over Na_2SO_4 and concentrated in vacuo. ibufenac (crude product) can be obtained by drying the organic phase on Na_2SO_4 and concentrating it in vacuo. Then, pure ibufenac can be obtained by recrystallization with ethyl acetate in 94% yield (1.64 g) as a white solid. ^{1}H NMR (400 MHz, DMSO) δ 12.24 (s, 1H), 7.16 (d, J = 8.1 Hz, 2H), 7.08 (d, J = 8.1 Hz, 2H), 3.51 (s, 2H), 2.41 (d, J =

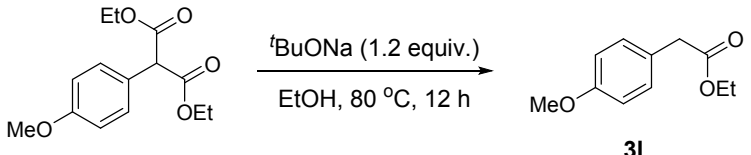
7.2 Hz, 2H), 1.87–1.75 (m, 1H), 0.86 (d, J = 6.6 Hz, 6H). ^{13}C NMR (100 MHz, DMSO) δ 173.2, 139.8, 132.7, 129.5, 129.3, 44.1, 40.8, 30.1, 22.6. MP (81.5-83.0°C). [23]



1j **2a** **4** (Felbinac) (2.65 g, 78% yield) TON = 1560

The aryl bromide **1j** (16 mmol, 3.73 g), *t*-BuONa (16 mmol, 2 equiv.), **L7** (0.032 mmol, 0.04 equiv.) and CuCl (0.008 mmol, 0.0005 equiv.) were placed into a Schlenk tube (120 mL). The reaction vessel was evacuated and backfilled with nitrogen for three times, then malonic acid diester (32.0 mmol, 2 equiv.) and EtOH (16 mL) were added under a positive nitrogen pressure. The reaction mixture was heated at 80 °C (oil bath) for 24 h under vigorous stirring. Then NaOH (6 equiv.) was added to the Schlenk tube, the reaction mixture was heated at 80 °C (oil bath) for 1 h. Wash the aqueous phase with ethyl acetate, and 2N HCl was added to adjust pH to $\leq$ 1. Then the aqueous phase was diluted with ethyl acetate and washed with brine. The organic phase was dried over Na_2SO_4 and concentrated in vacuo. Felbinac (**4**, crude product) can be obtained by drying the organic phase on Na_2SO_4 and concentrating it in vacuo. Then, pure felbinac **4** can be obtained by recrystallization with ethyl acetate in 78% yield (2.65 g) as a white solid. ^{1}H NMR (400 MHz, DMSO) δ 12.39 (s, 1H), 7.68–7.60 (m, 4H), 7.49–7.44 (m, 2H), 7.39–7.34 (m, 3H), 3.63 (s, 2H). ^{13}C NMR (100 MHz, DMSO) δ 173.1, 140.4, 139.0, 134.8,130.4, 129.4, 127.8, 127.0. MP (157.2-159.0°C). [22]

VII. Reaction of the α-aryl malonate 5l to form α-arylester 3l



5l **3l** yield:67%

α-Aryl malonate (2 mmol), *t*-BuONa (2.2 mmol, 1.2 equiv.) and EtOH (2ml) were placed into a Schlenk tube (15 mL). The reaction mixture was heated at 80 °C (oil bath) for 12 h under vigorous stirring. Wash the aqueous phase with ethyl acetate, and 2N HCl was added to adjust pH to $\leq$ 1. Then the aqueous phase was diluted with ethyl acetate and washed with brine. The organic phase was dried over Na_2SO_4 and concentrated in vacuo. The residue was purified by silica gel flash

chromatography to afford the corresponding α-aryl ester **3l** in 67% yield.

VIII. References

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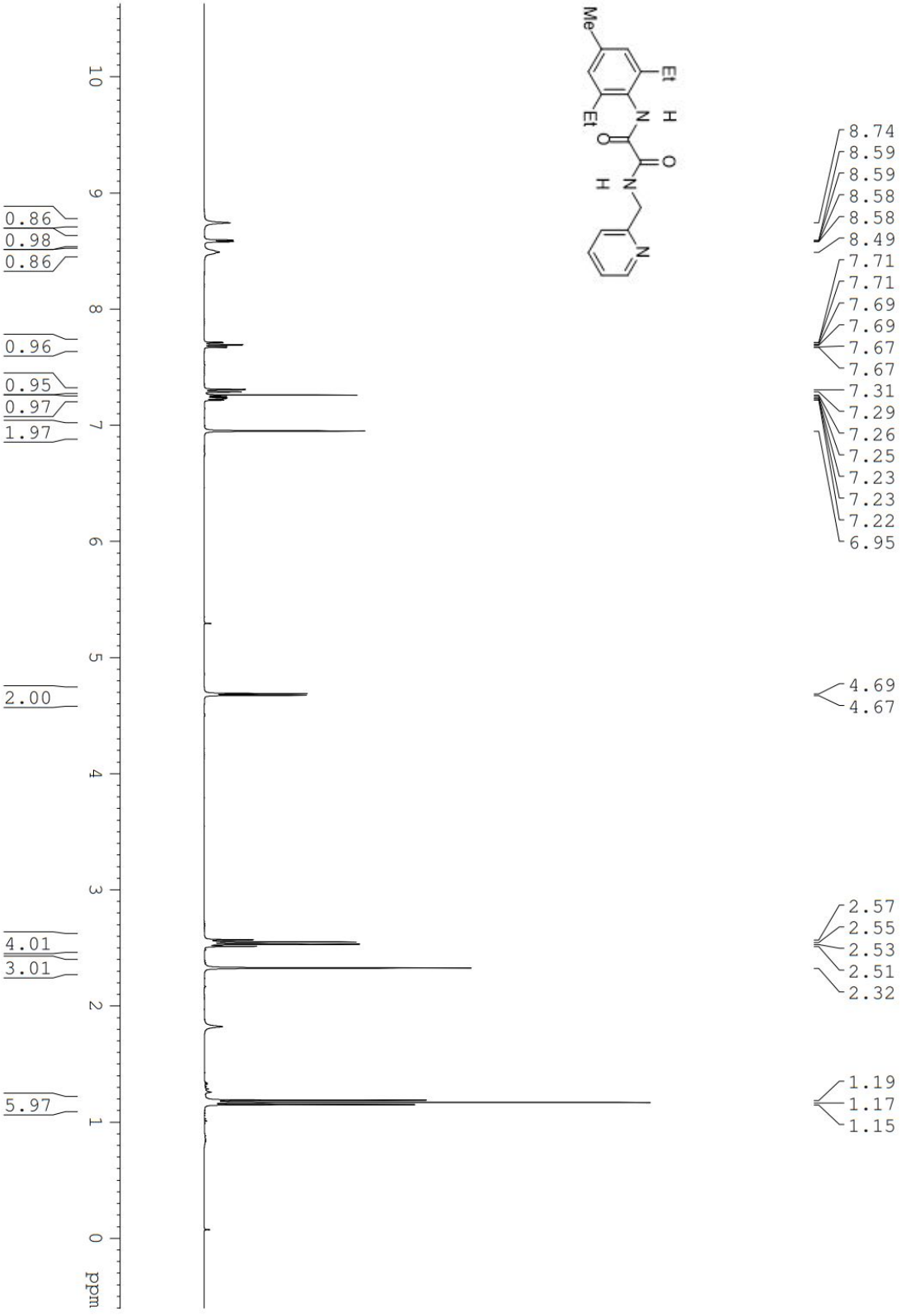
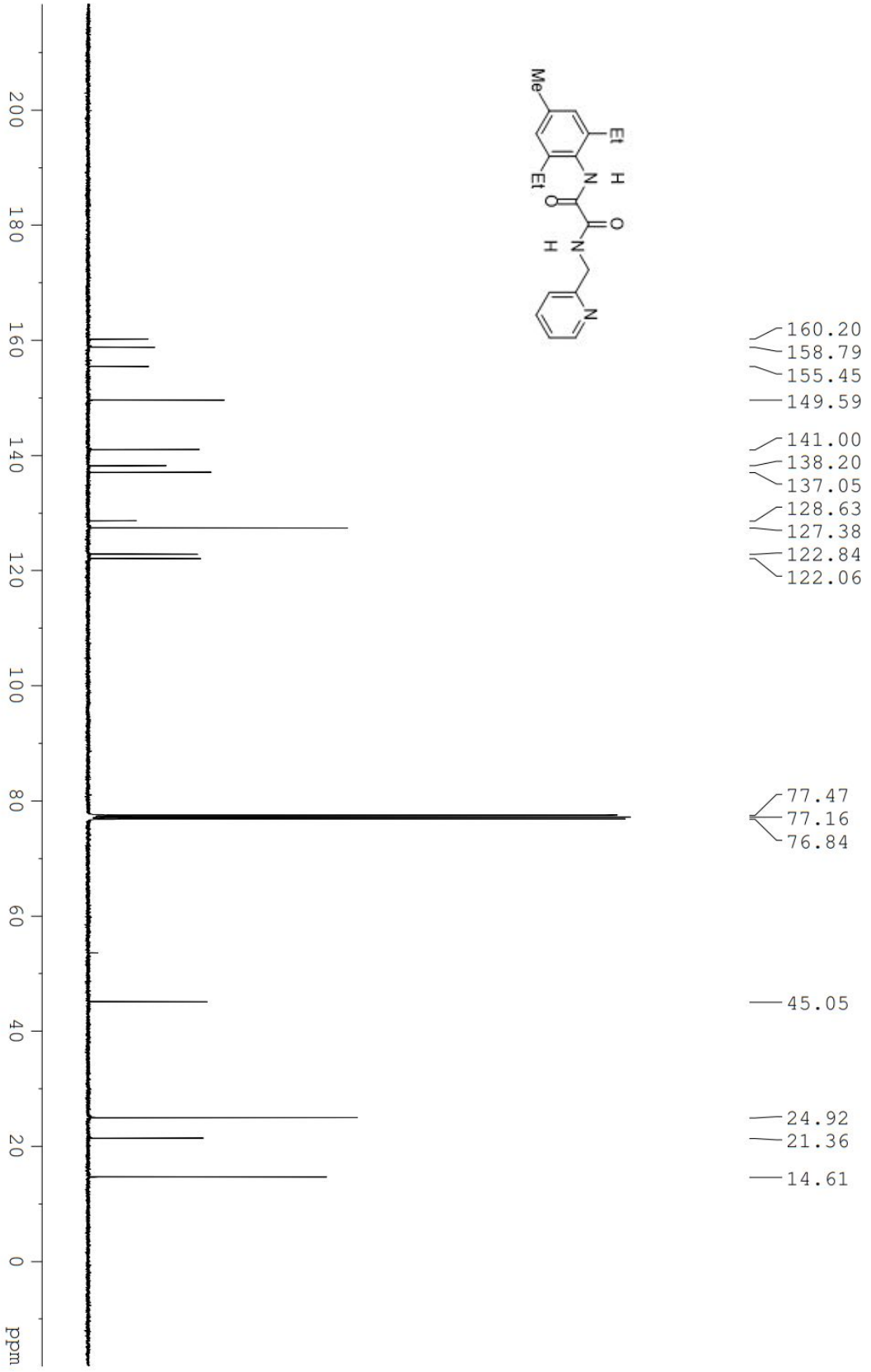
IX. Copies of ^{1}H and ^{13}C spectrum of ligand, *α*-aryl esters, and acids

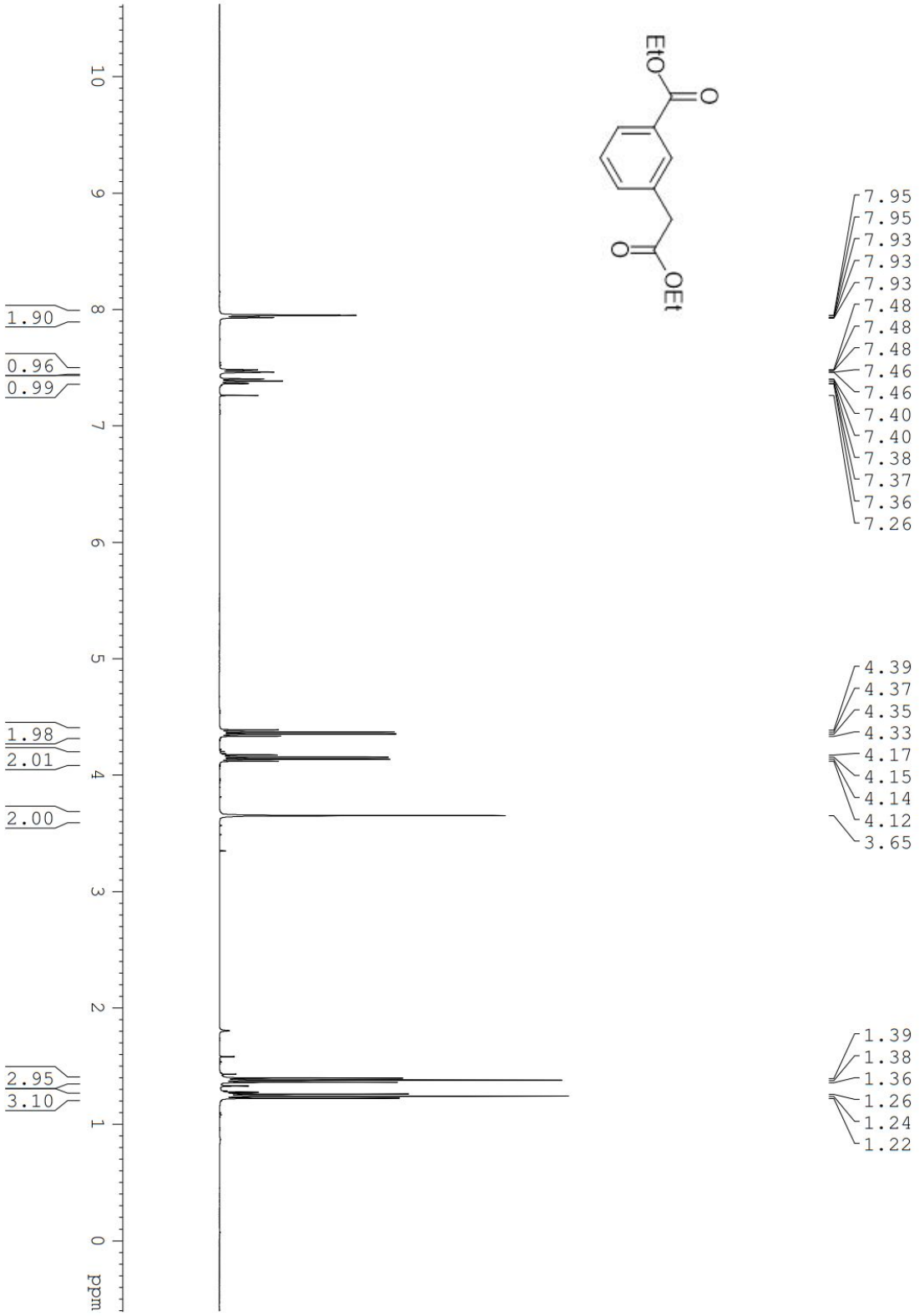
^{1}H NMR Spectrum of **L7 (400** MHz, $CDCl_3$)



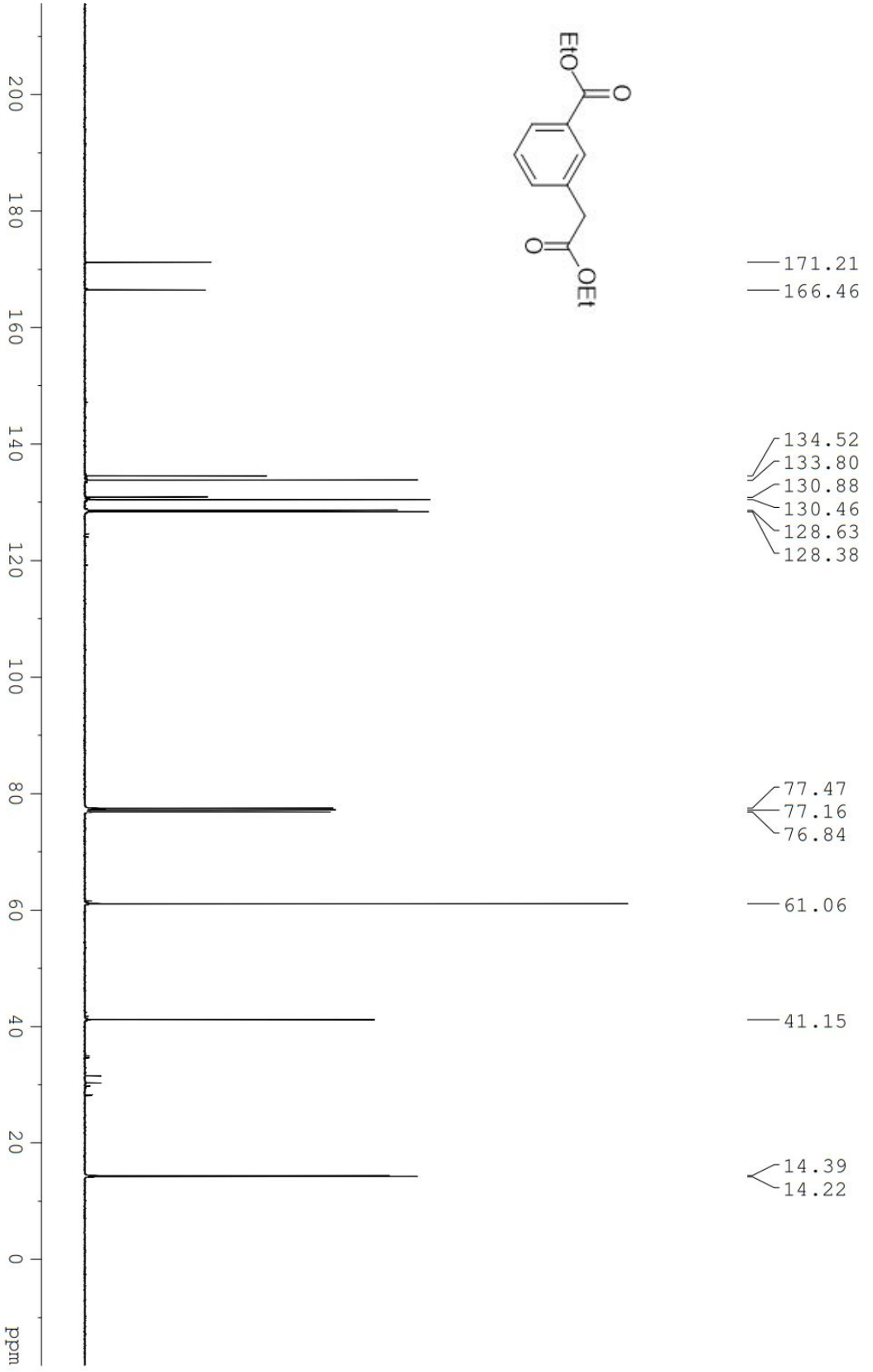
^{13}C NMR Spectrum of **L7 (100** MHz, $CDCl_3$)



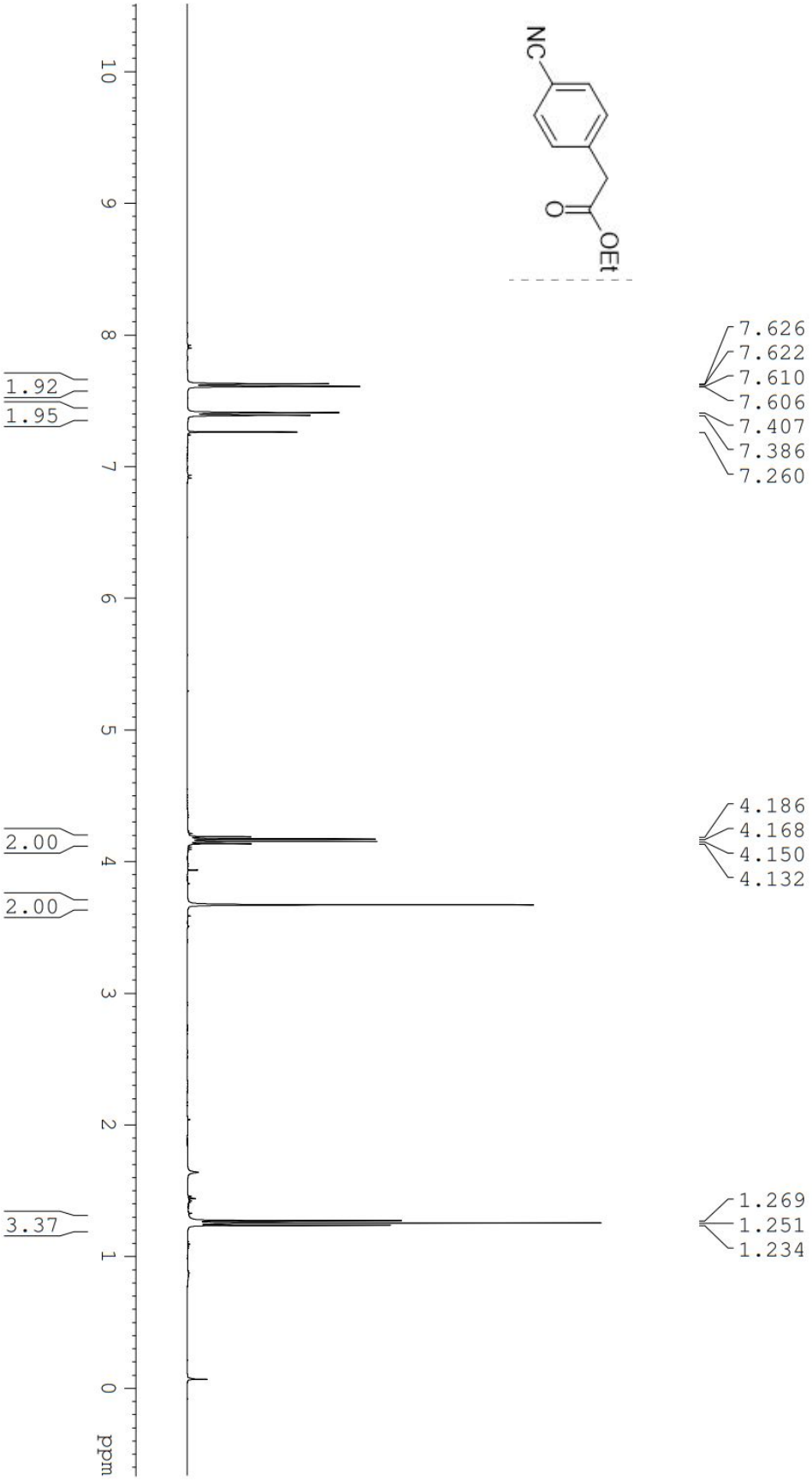
^{1}H NMR Spectrum of **3a (400** MHz, $CDCl_3$)



^{13}C NMR Spectrum of **3a** (**100** MHz, $CDCl_3$)



^{1}H NMR Spectrum of **3b (400** MHz, $CDCl_3$)



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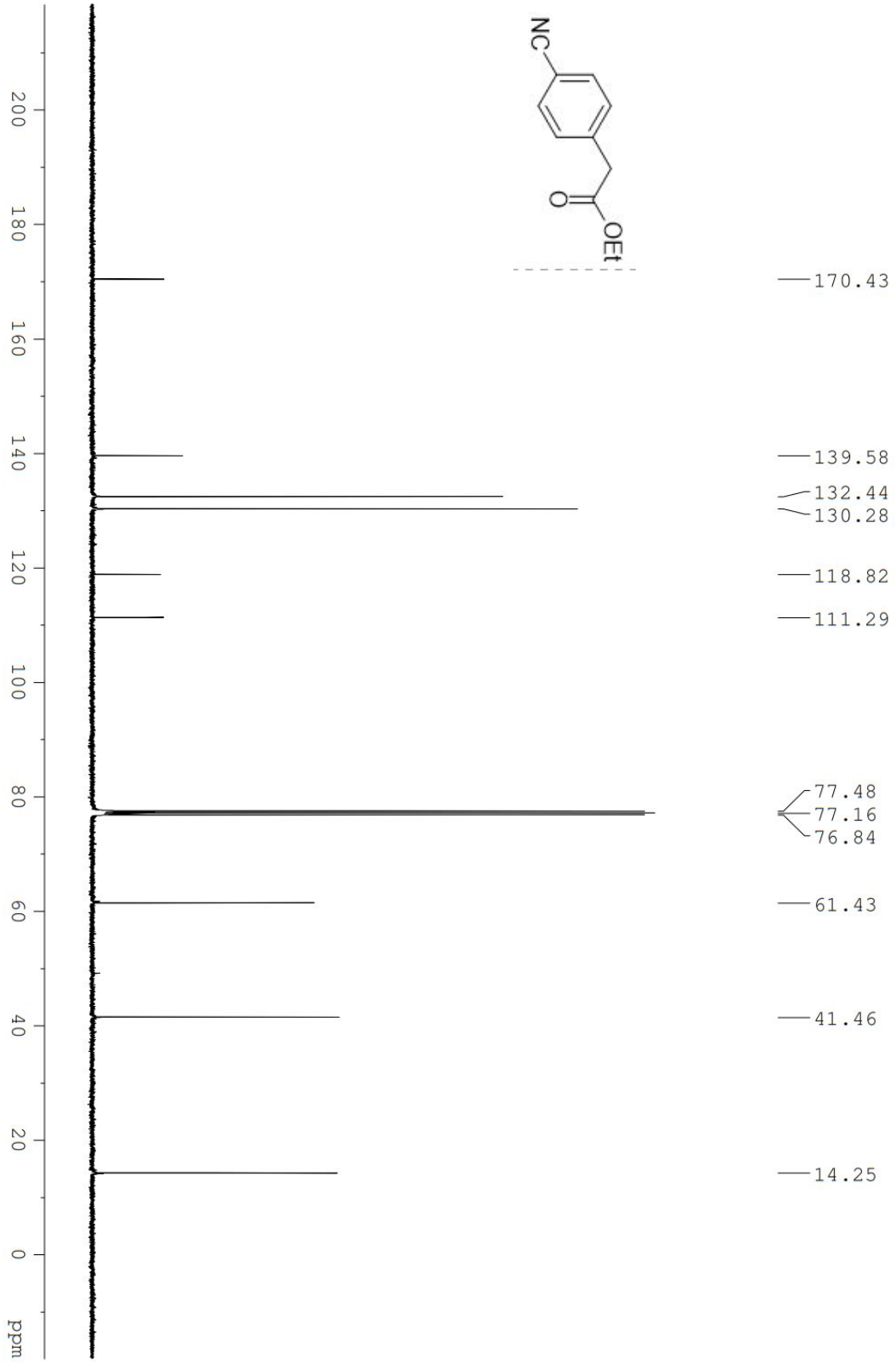
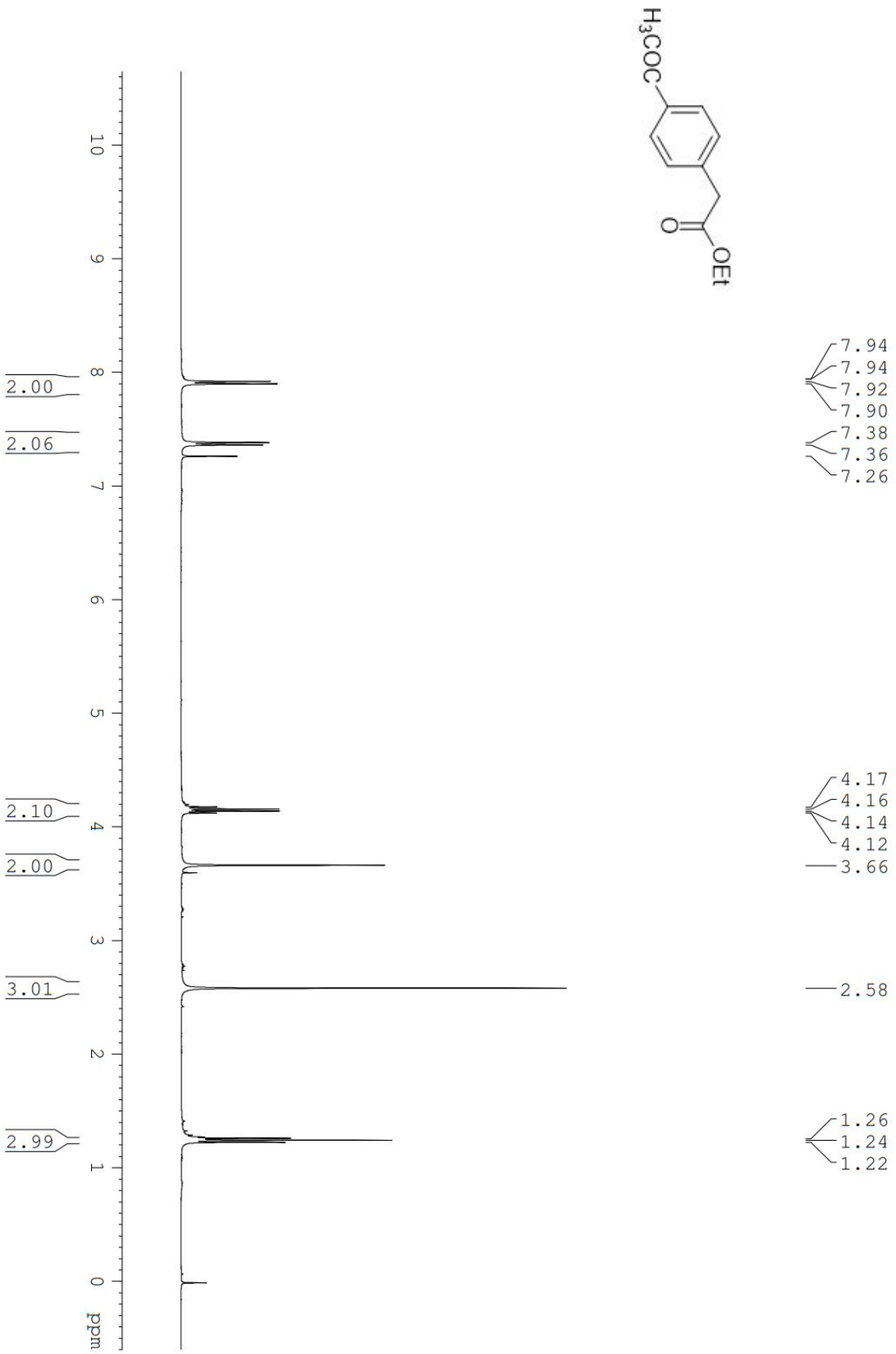
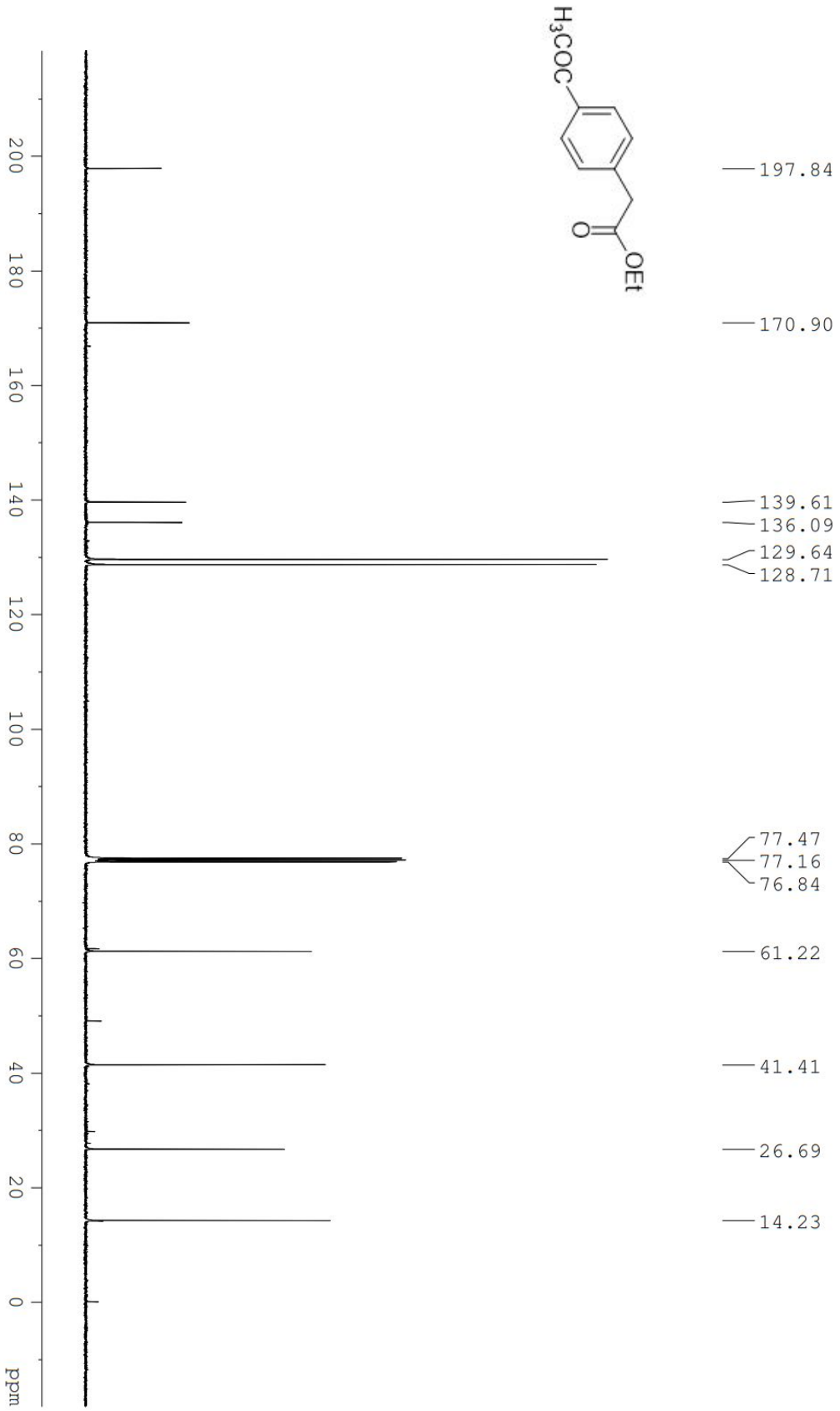


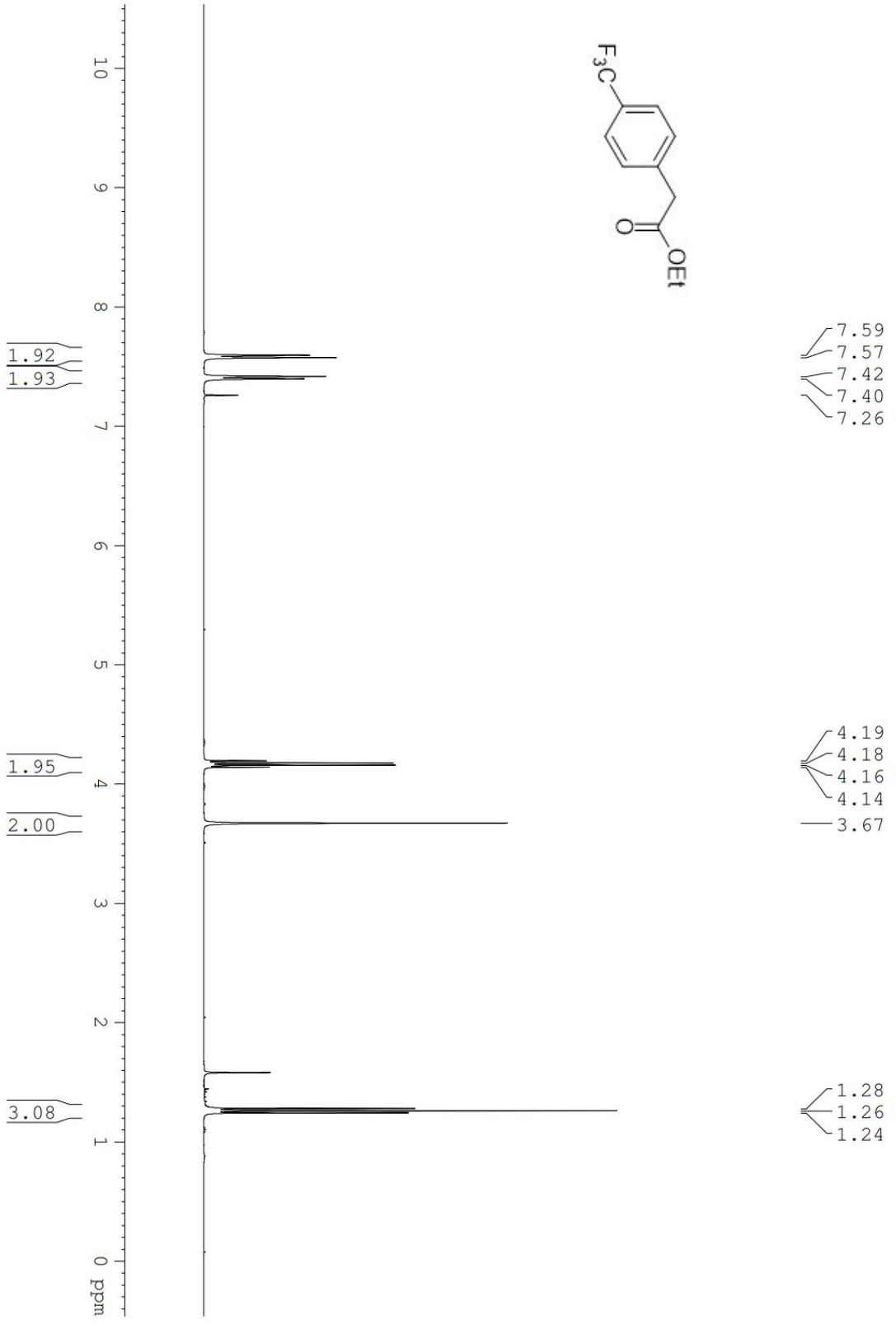
^{1}H NMR Spectrum of **3c (400** MHz, $CDCl_3$)



^{13}C NMR Spectrum of **3c (100** MHz, $CDCl_3$)



^{1}H NMR Spectrum of **3d (400** MHz, $CDCl_3$)



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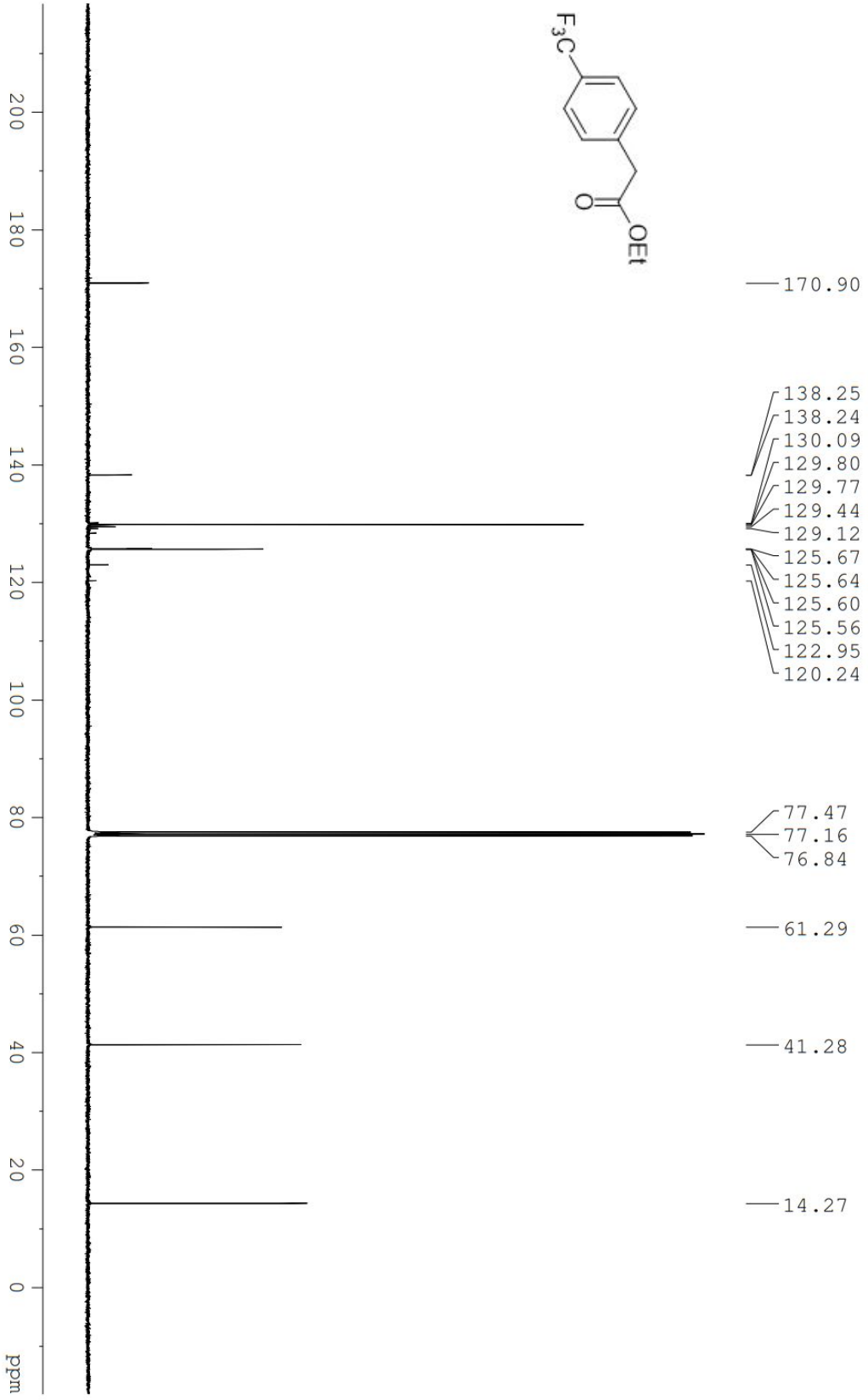
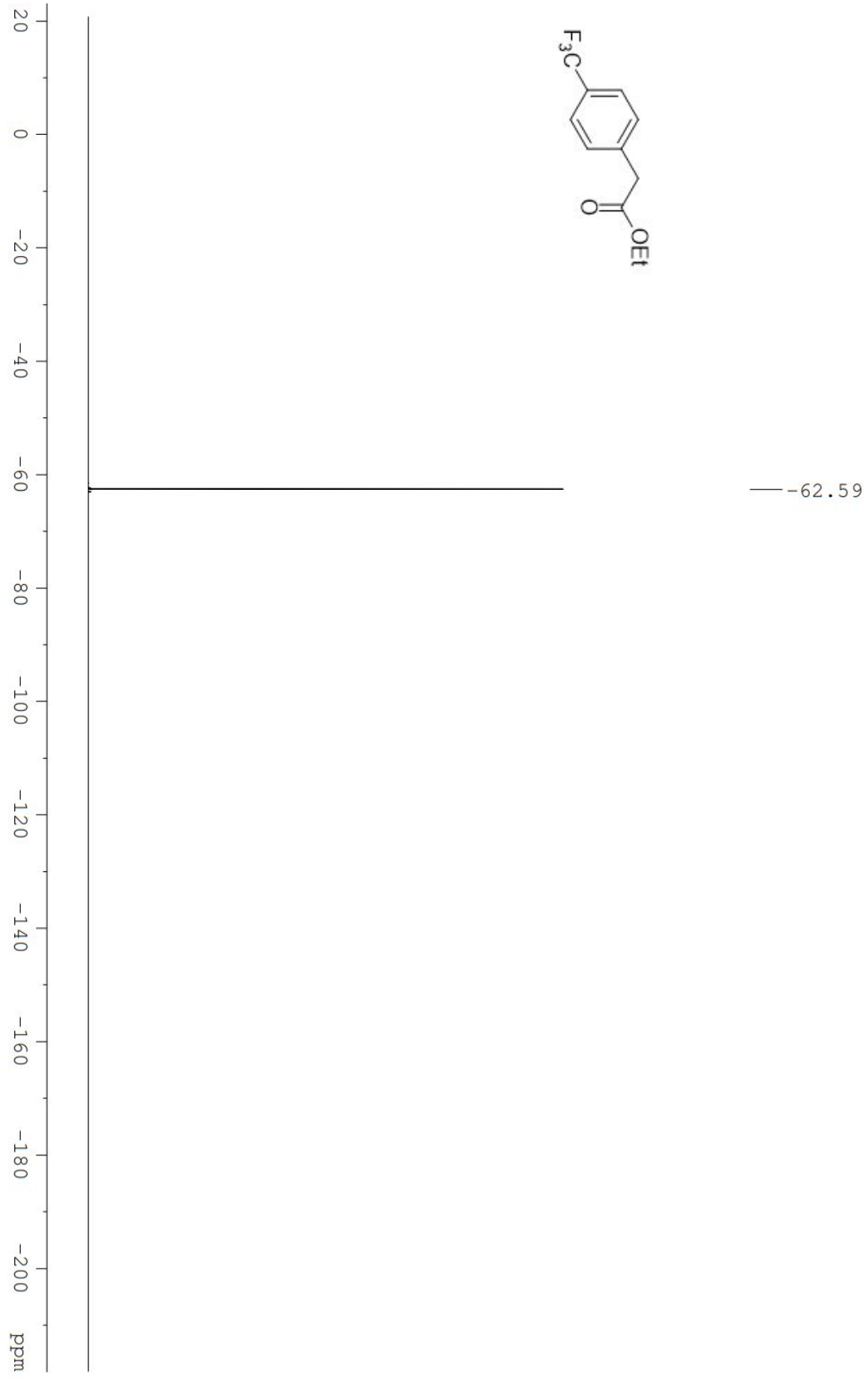
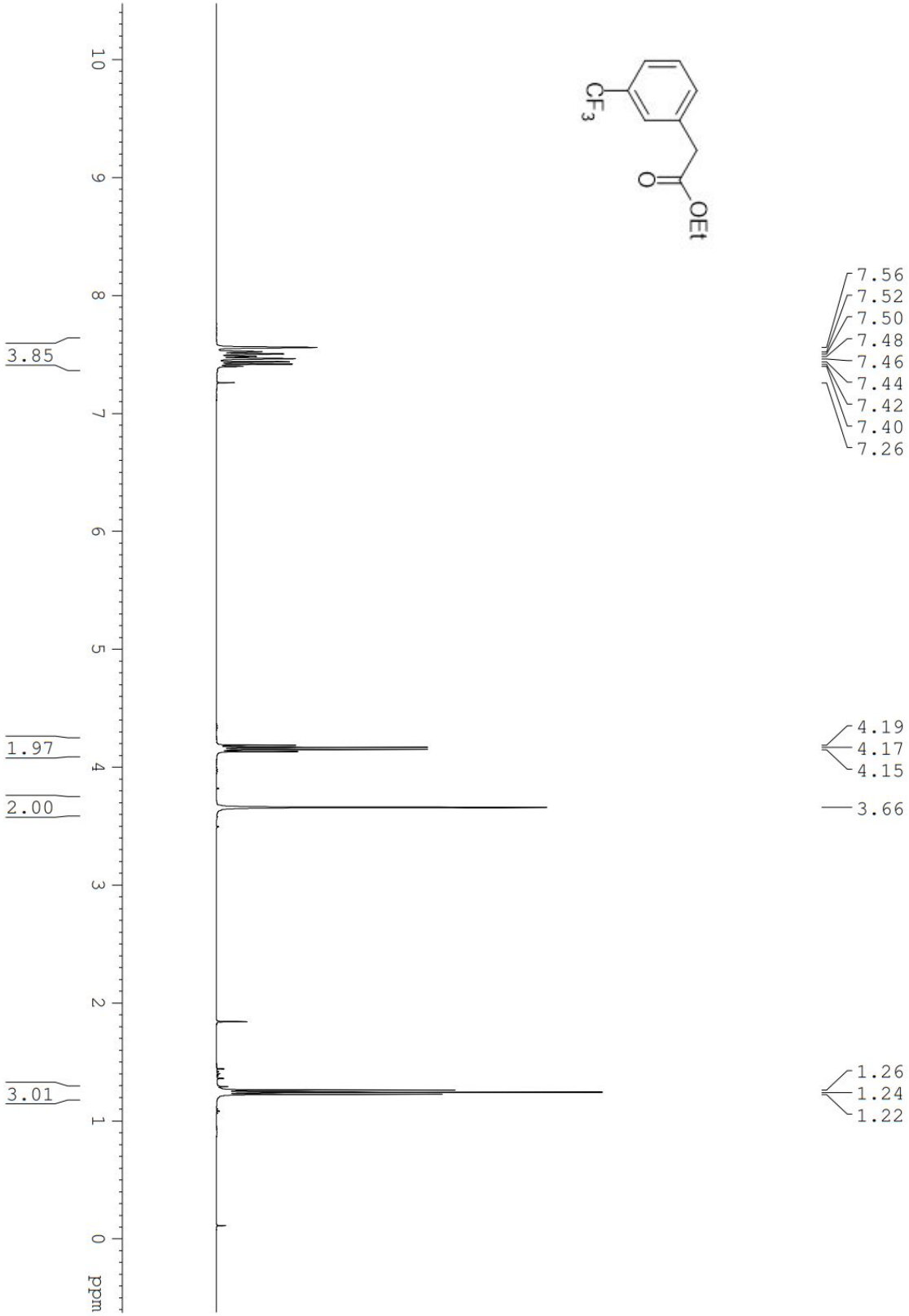


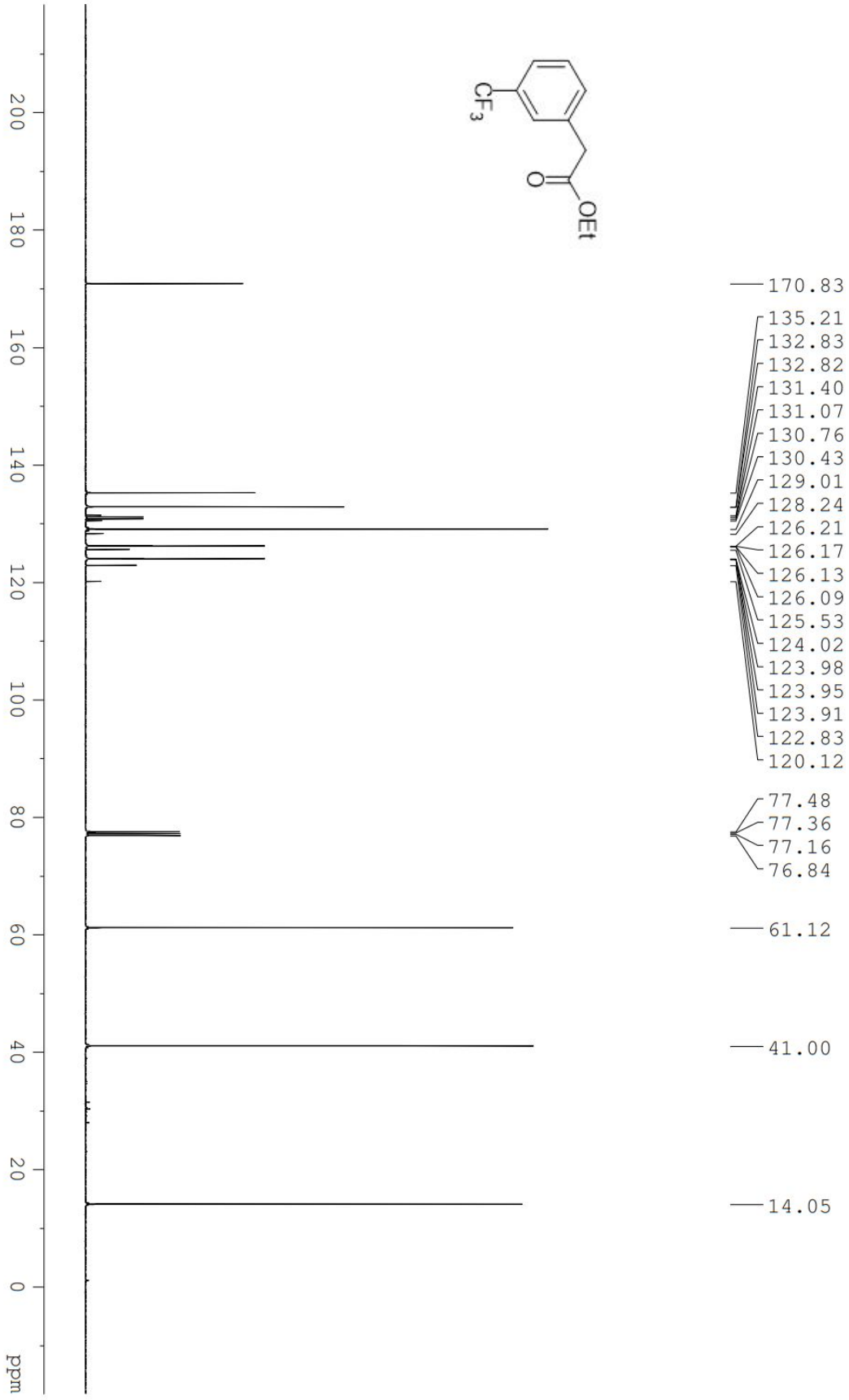
^{19}F NMR Spectrum of **3d (376** MHz, $CDCl_3$)



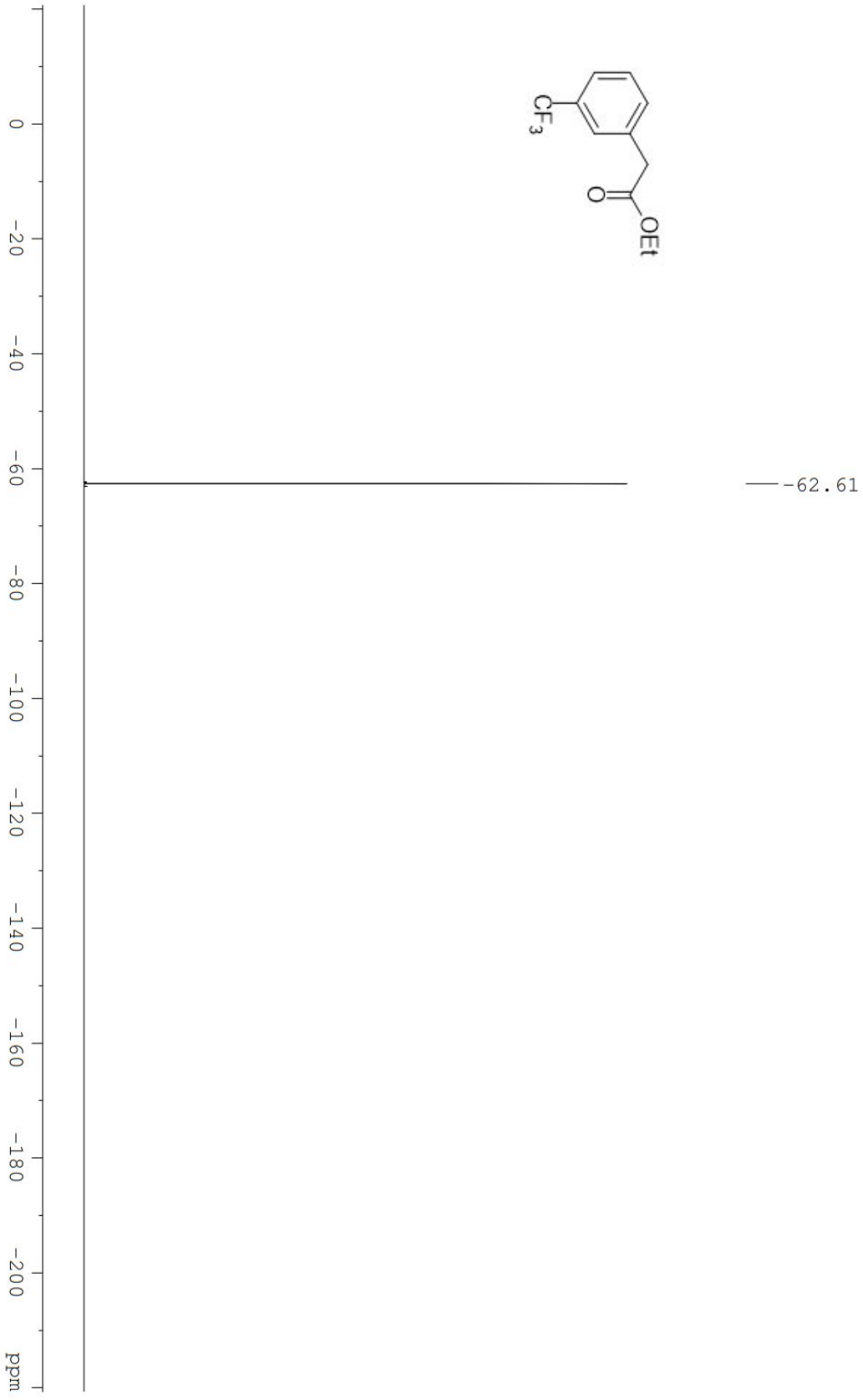
^{1}H NMR Spectrum of **3e (400** MHz, $CDCl_3$)



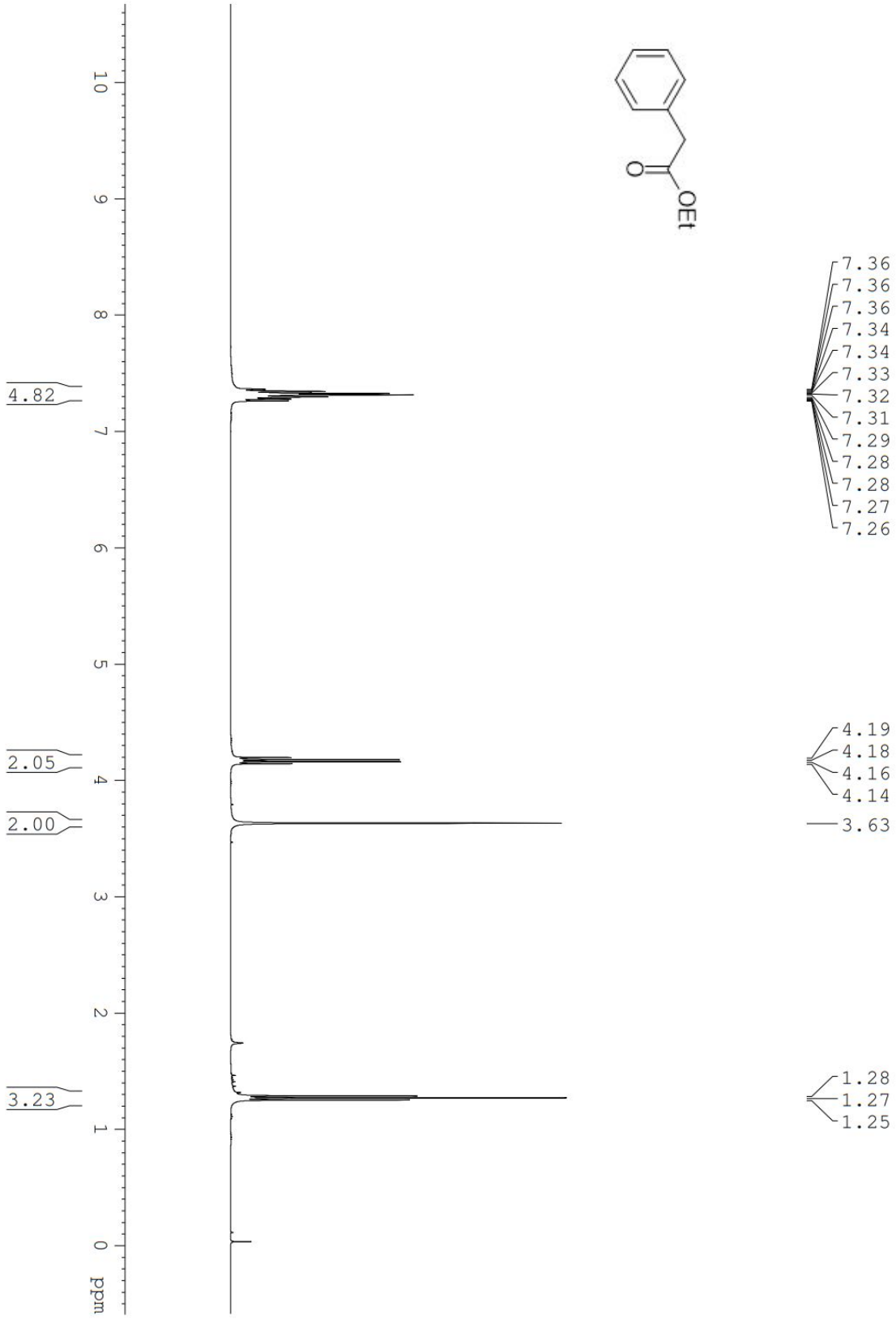
^{13}C NMR Spectrum of **3e (100** MHz, $CDCl_3$)



^{19}F NMR Spectrum of **3e (376** MHz, $CDCl_3$)



^{1}H NMR Spectrum of **3f (400** MHz, $CDCl_3$)



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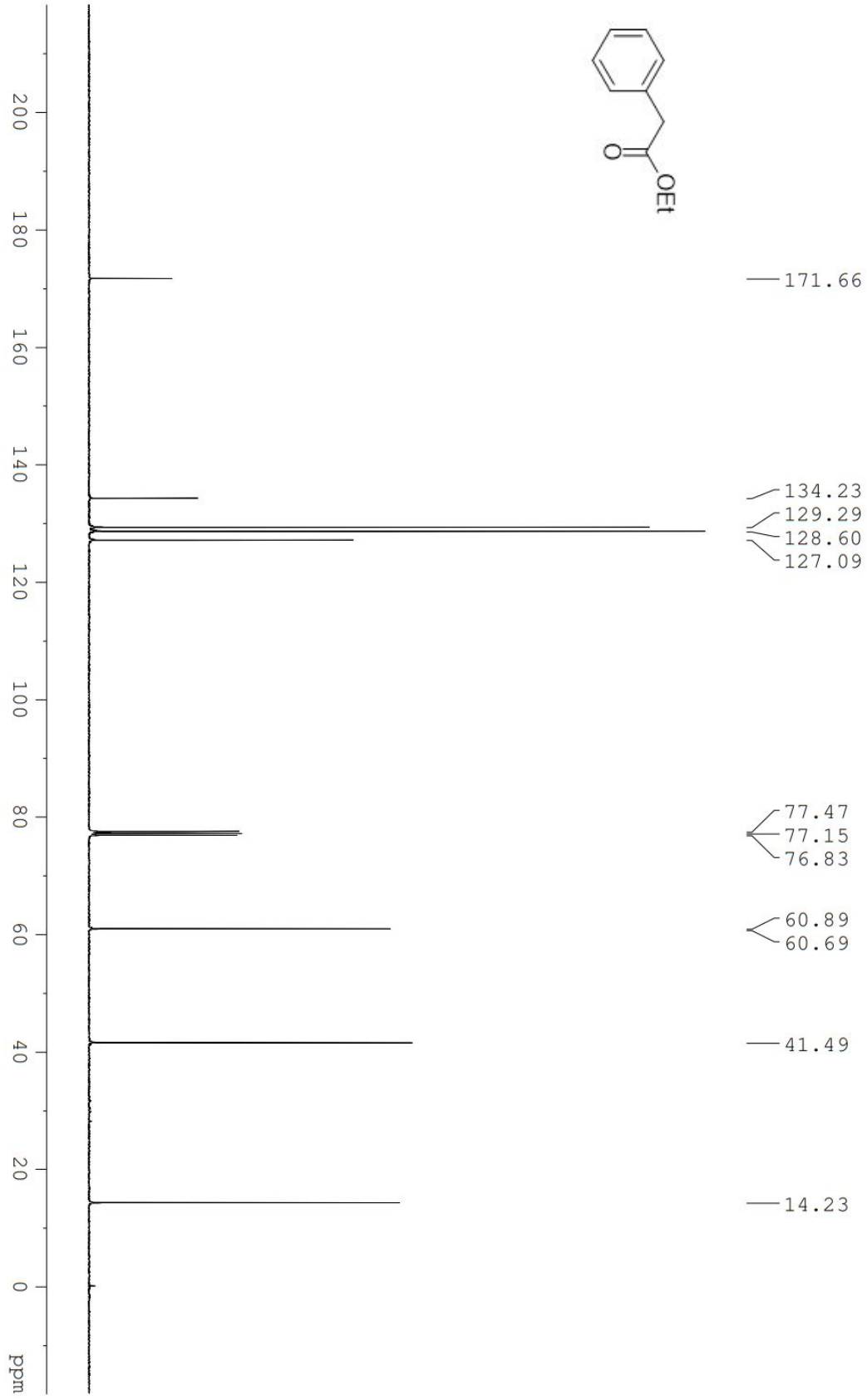
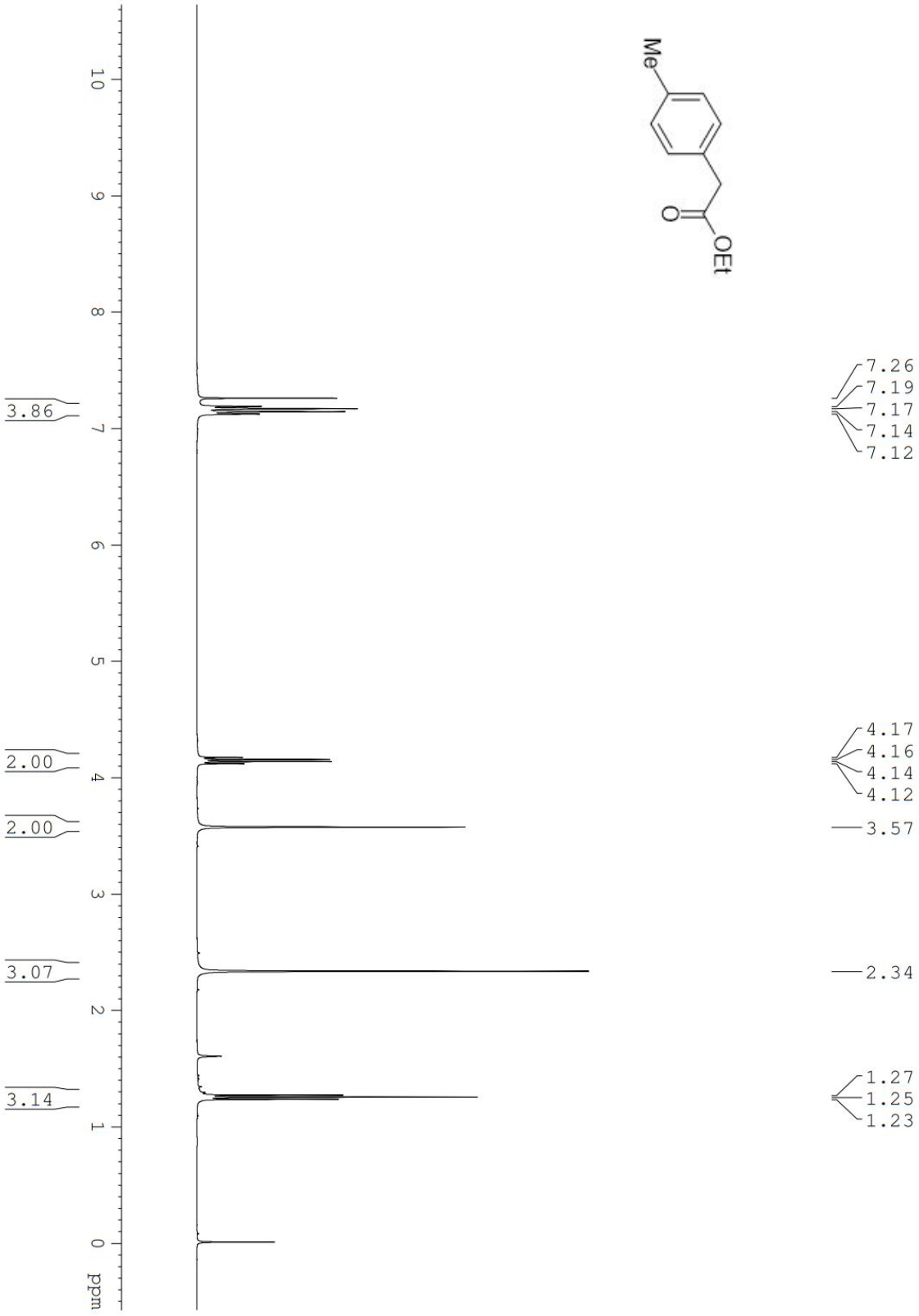
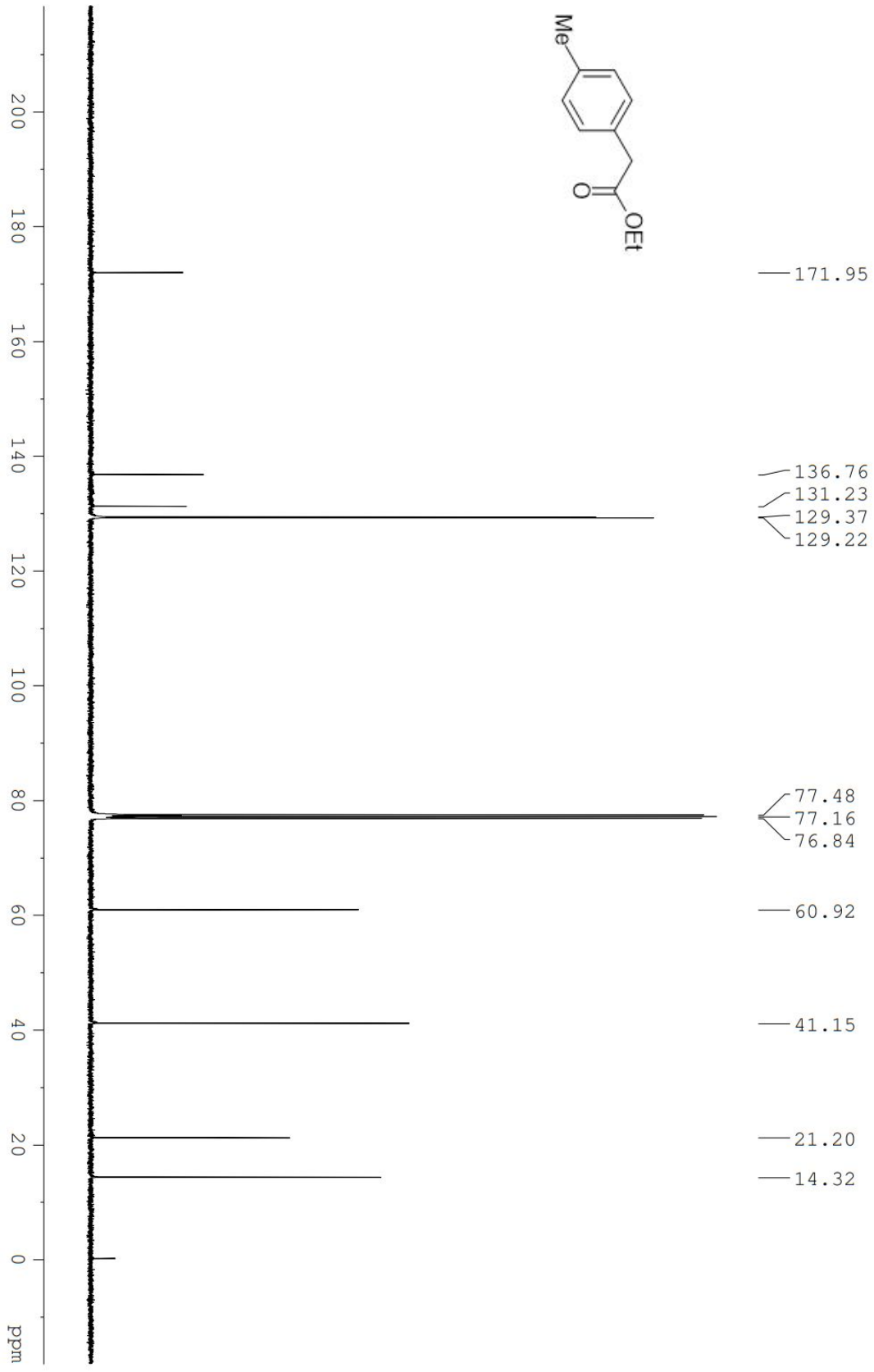


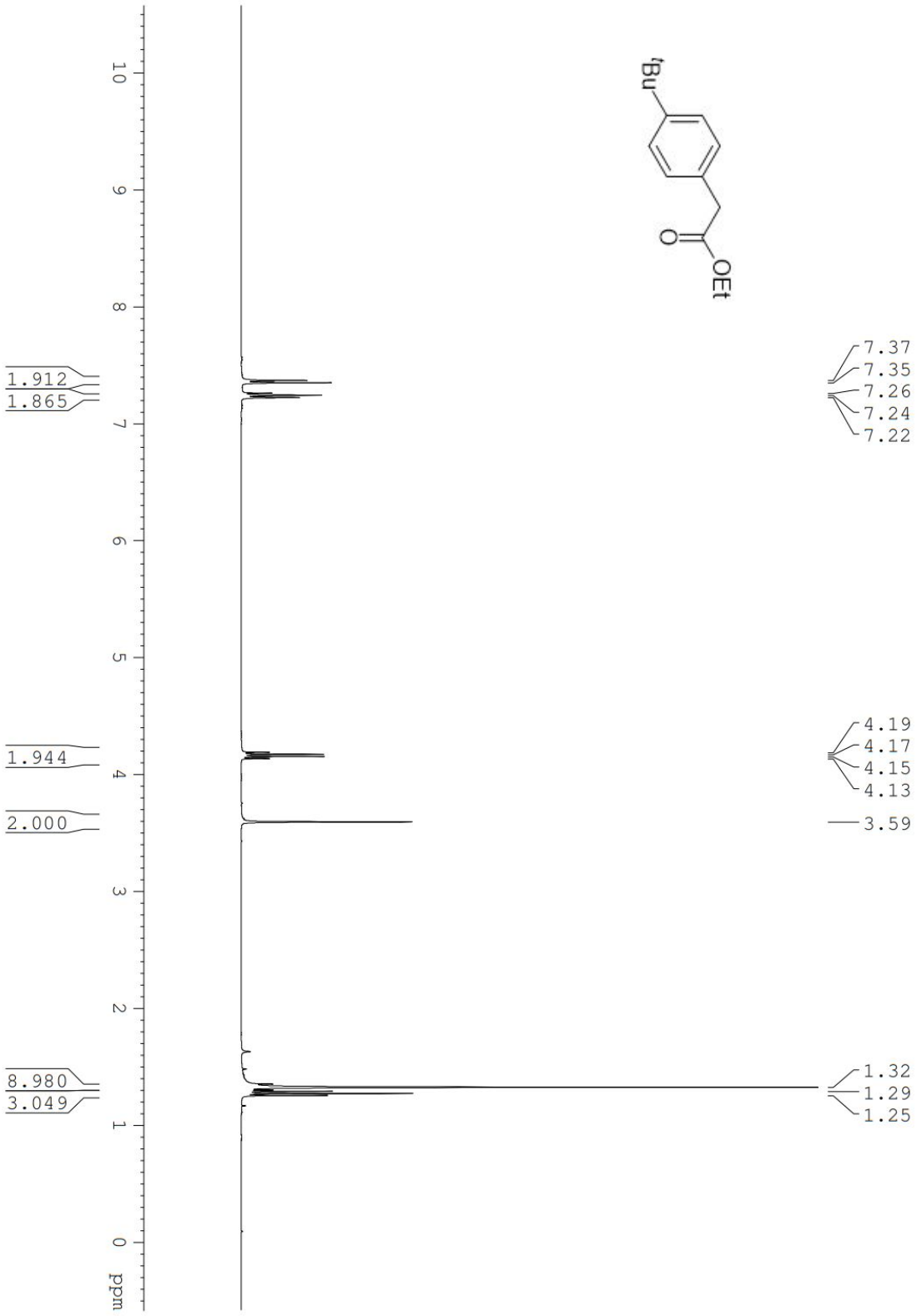
^{1}H NMR Spectrum of **3g (400** MHz, $CDCl_3$)



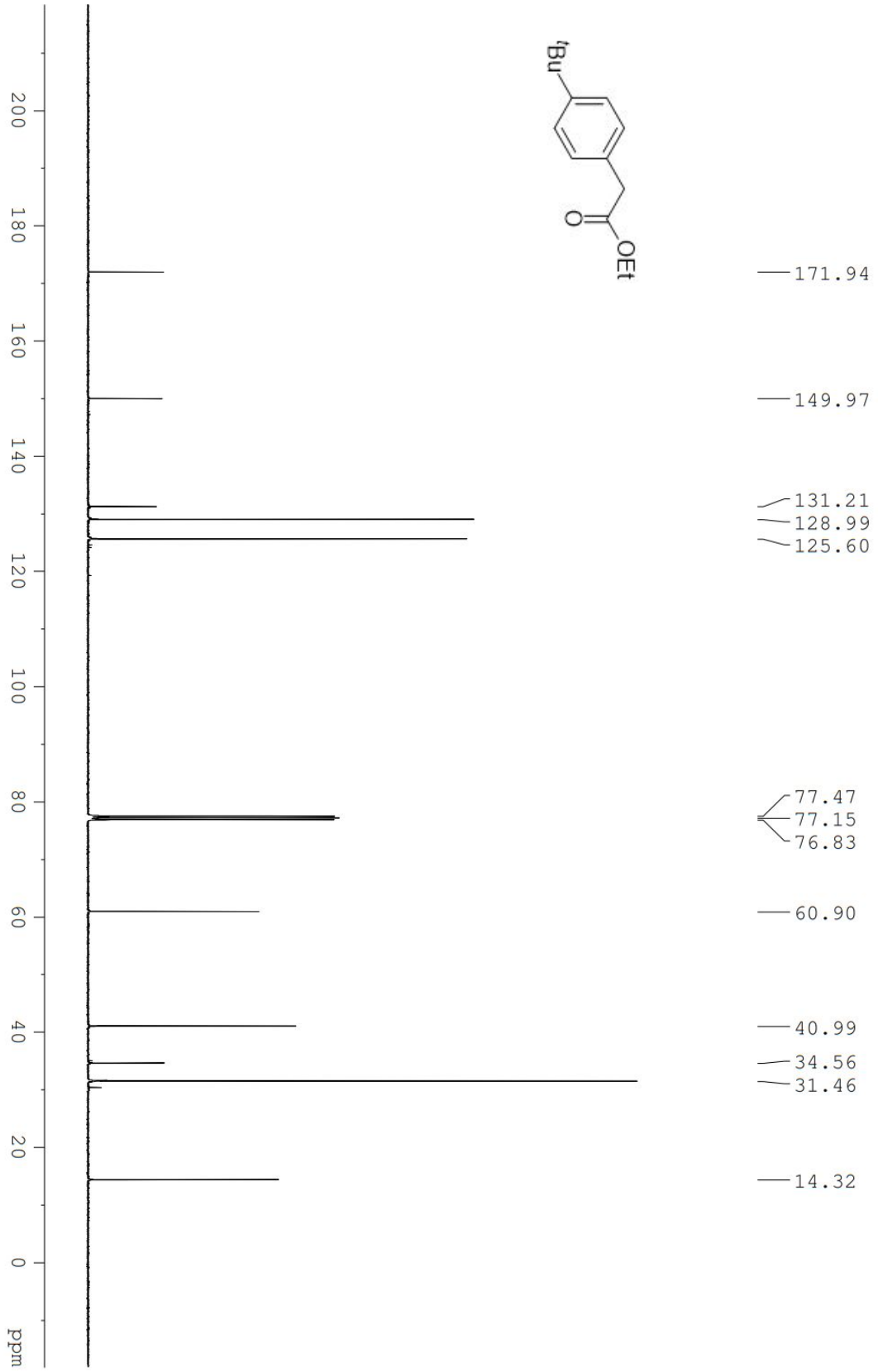
^{13}C NMR Spectrum of **3g (100** MHz, $CDCl_3$)



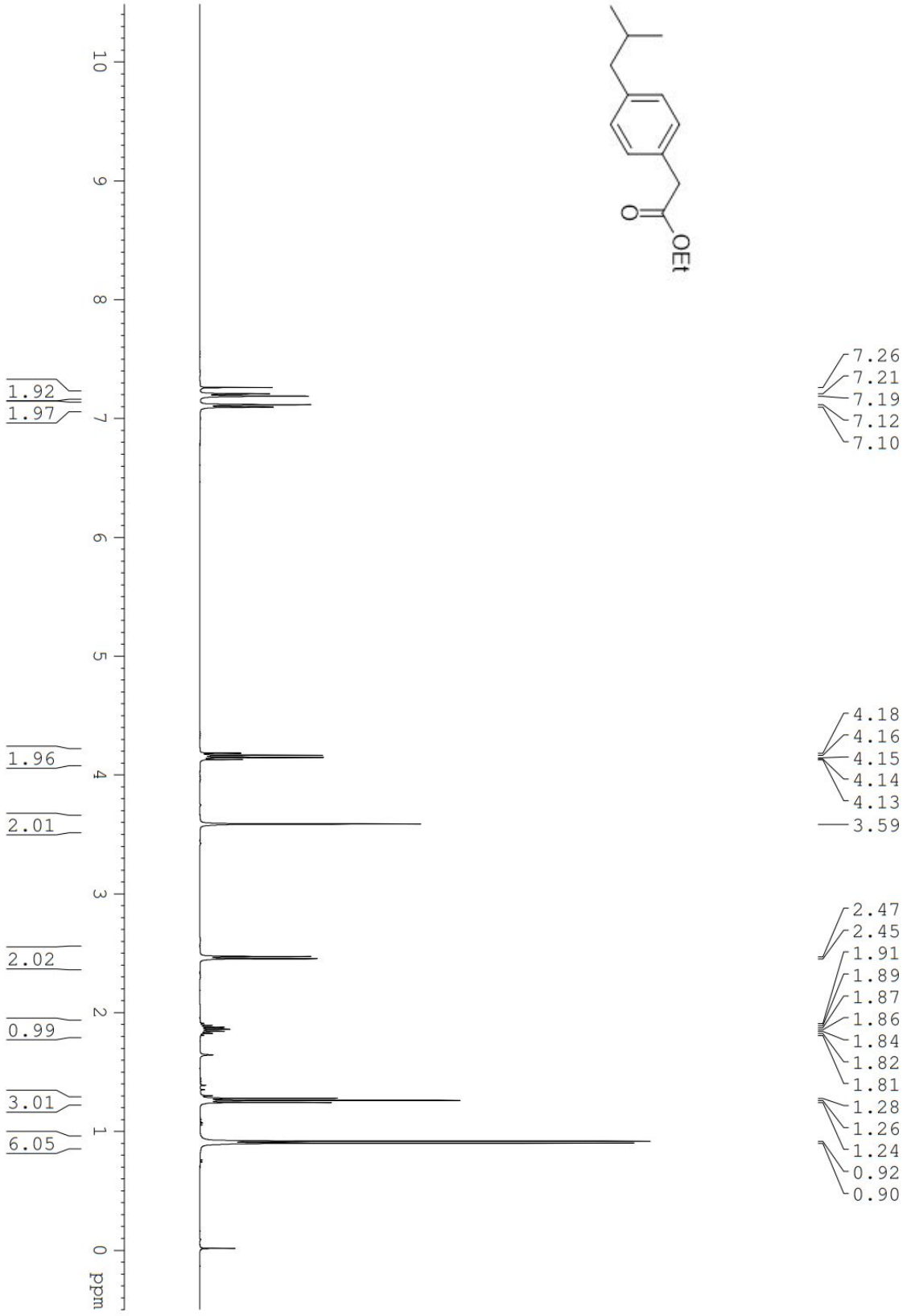
^{1}H NMR Spectrum of **3h (400** MHz, $CDCl_3$)



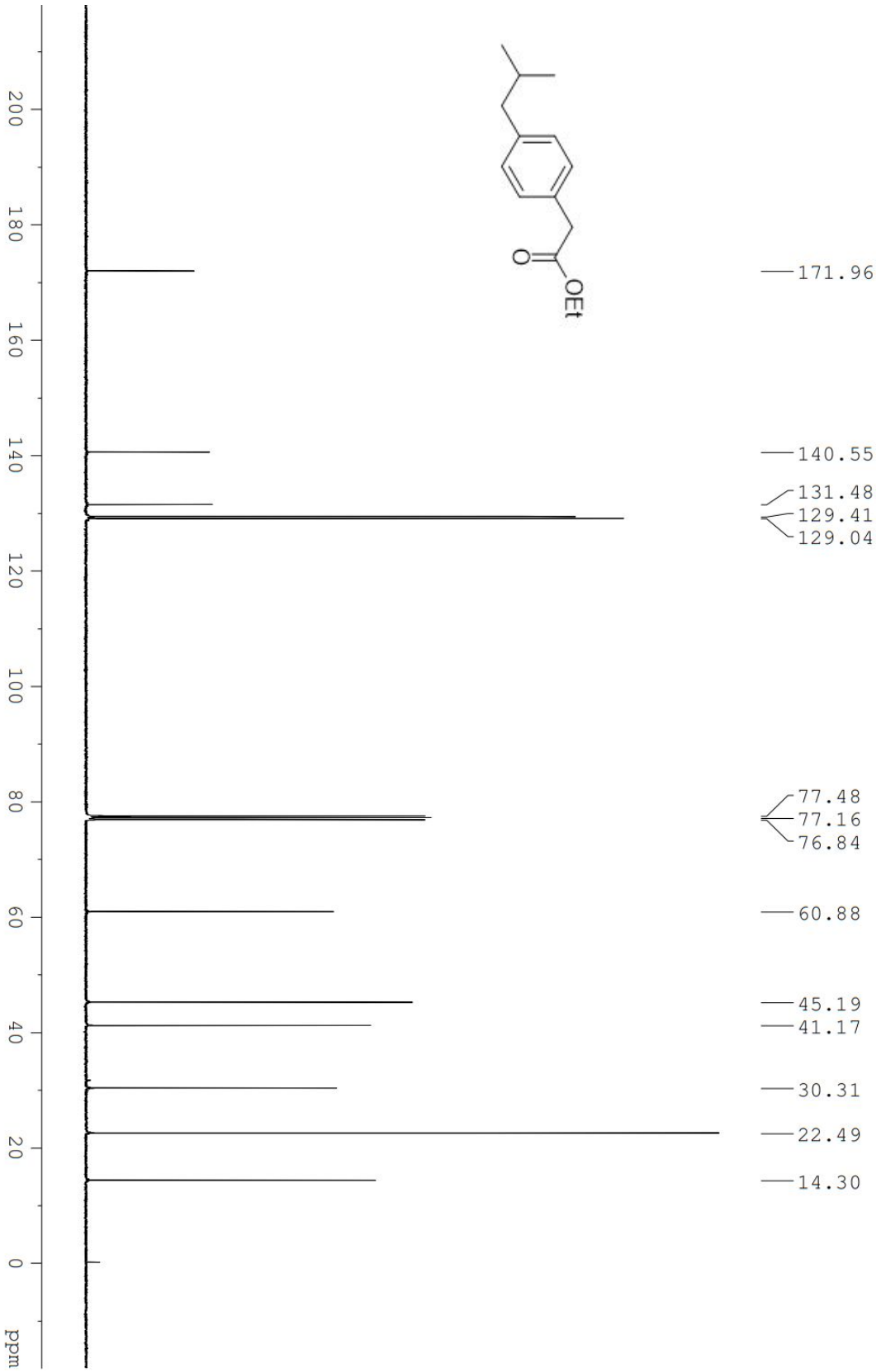
^{13}C NMR Spectrum of **3h (100** MHz, $CDCl_3$)



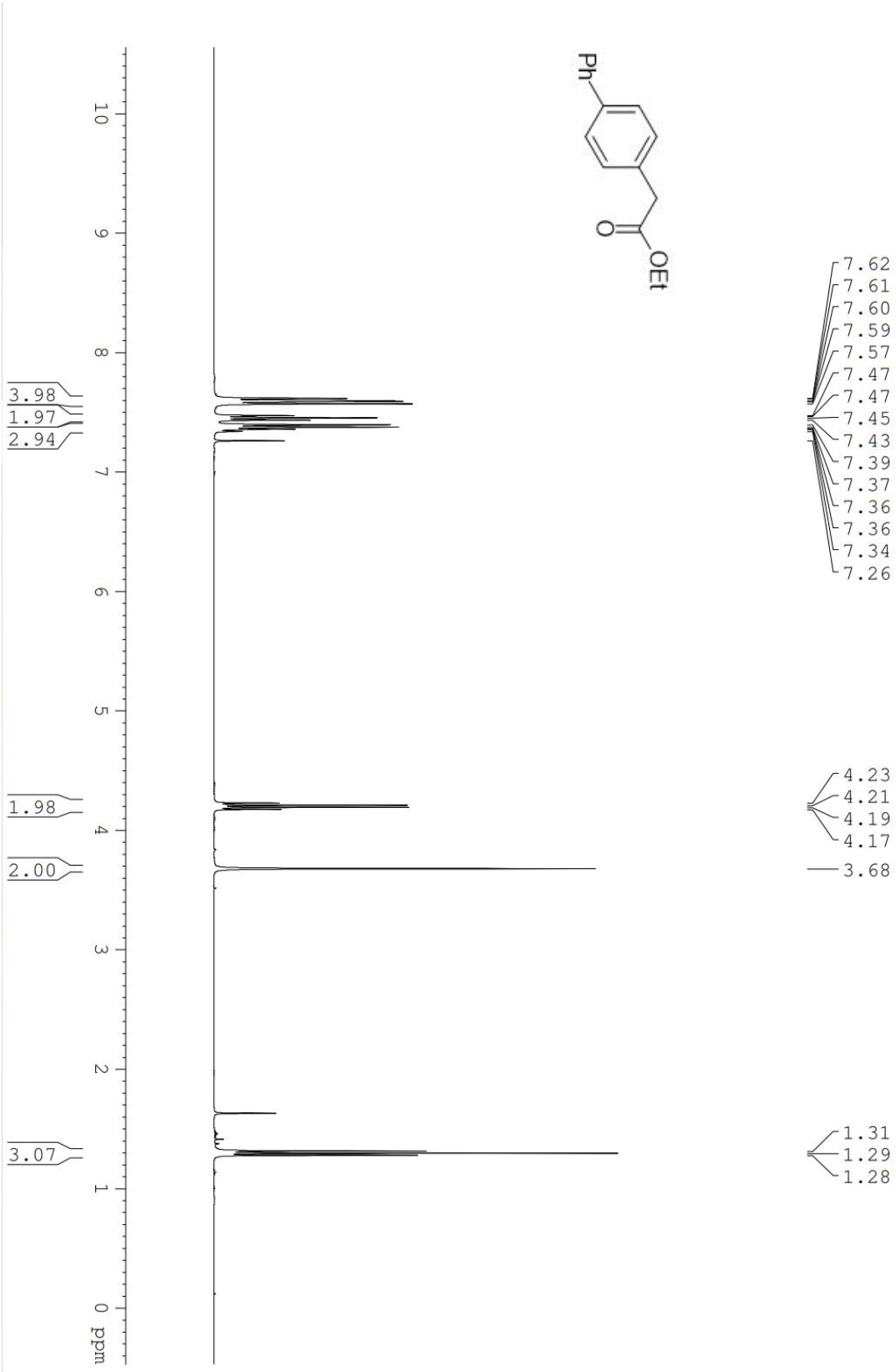
^{1}H NMR Spectrum of **3i (400** MHz, $CDCl_3$)



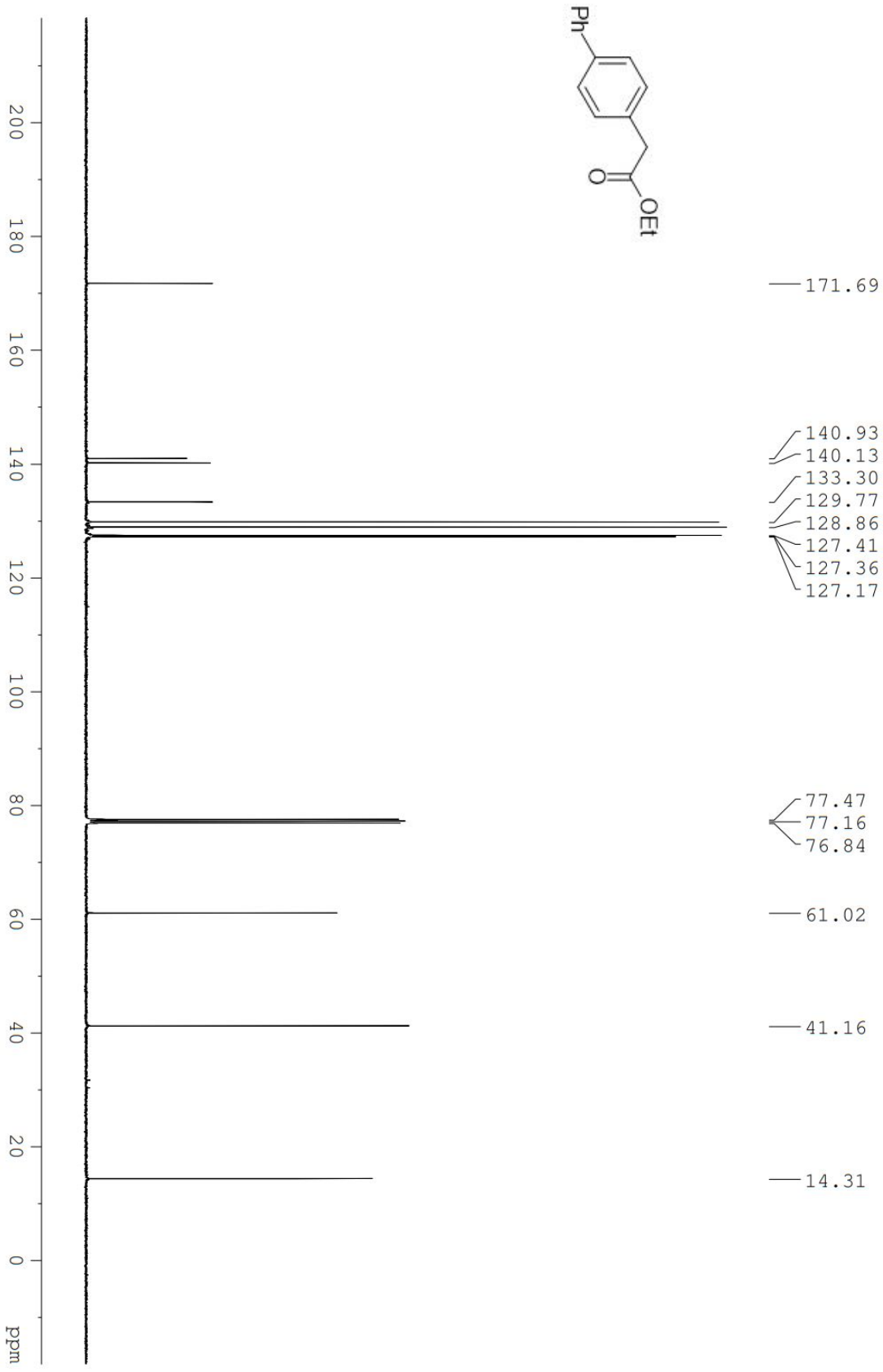
^{13}C NMR Spectrum of **3i (100** MHz, $CDCl_3$)



^{1}H NMR Spectrum of **3j (400** MHz, $CDCl_3$)



^{13}C NMR Spectrum of **3j (100** MHz, $CDCl_3$)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OEt
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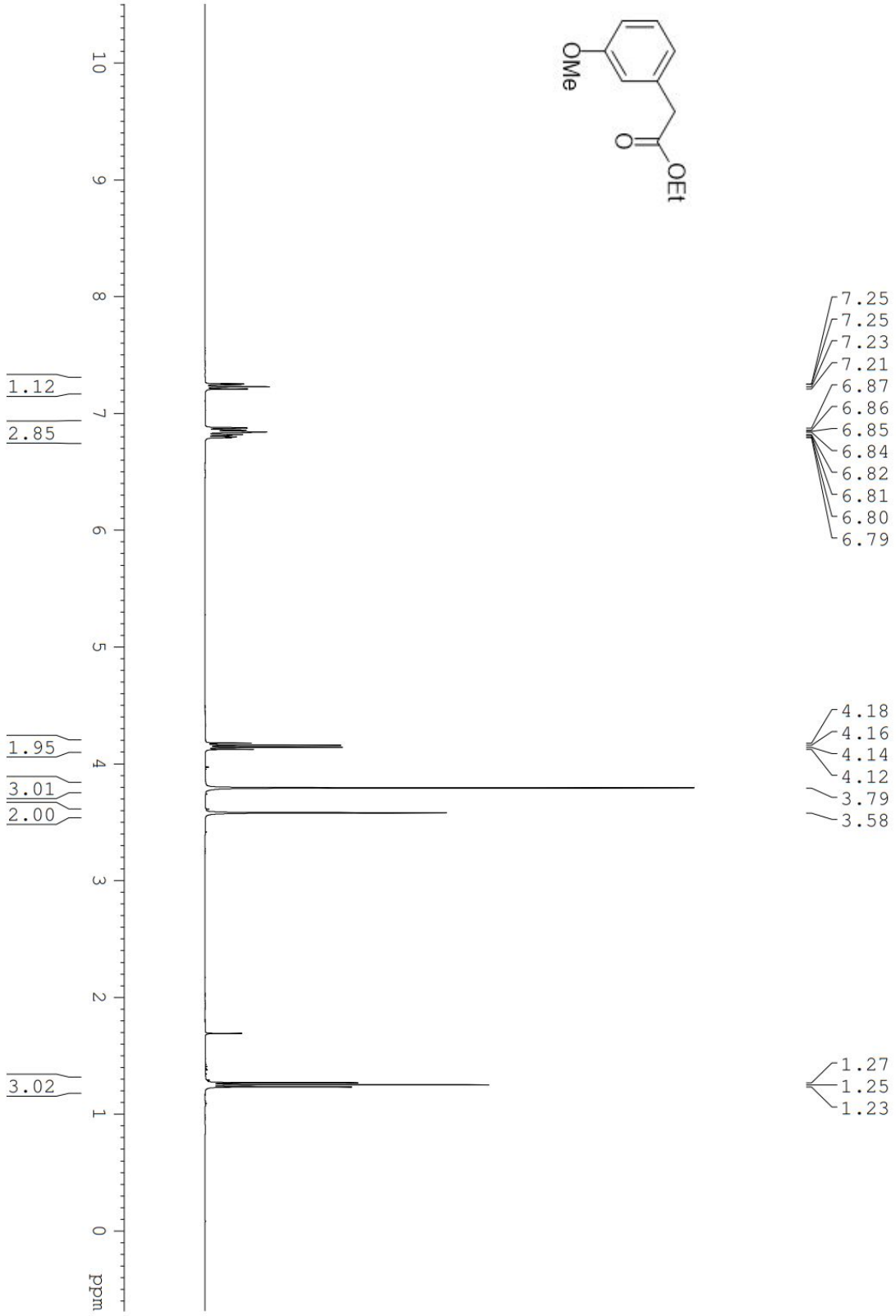
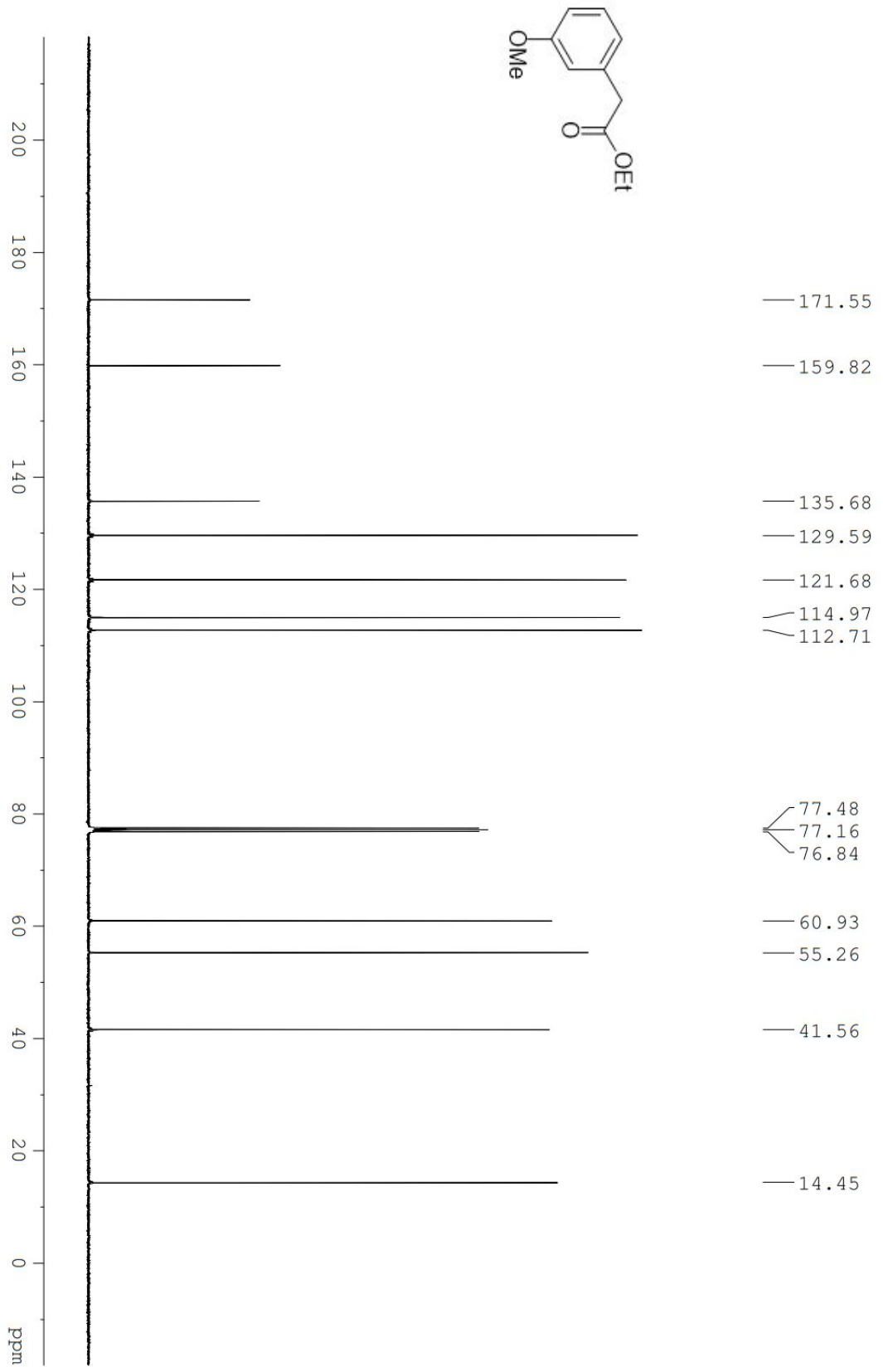
140.93
140.13
133.30
129.77
128.86
127.41
127.36
127.17
77.47
77.16
76.84
61.02
41.16
14.31
200
180
160
140
120
100
80
60
40
20
0
ppm

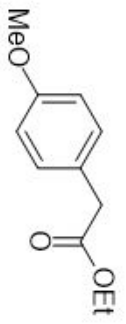
^{1}H NMR Spectrum of **3k (400** MHz, $CDCl_3$)

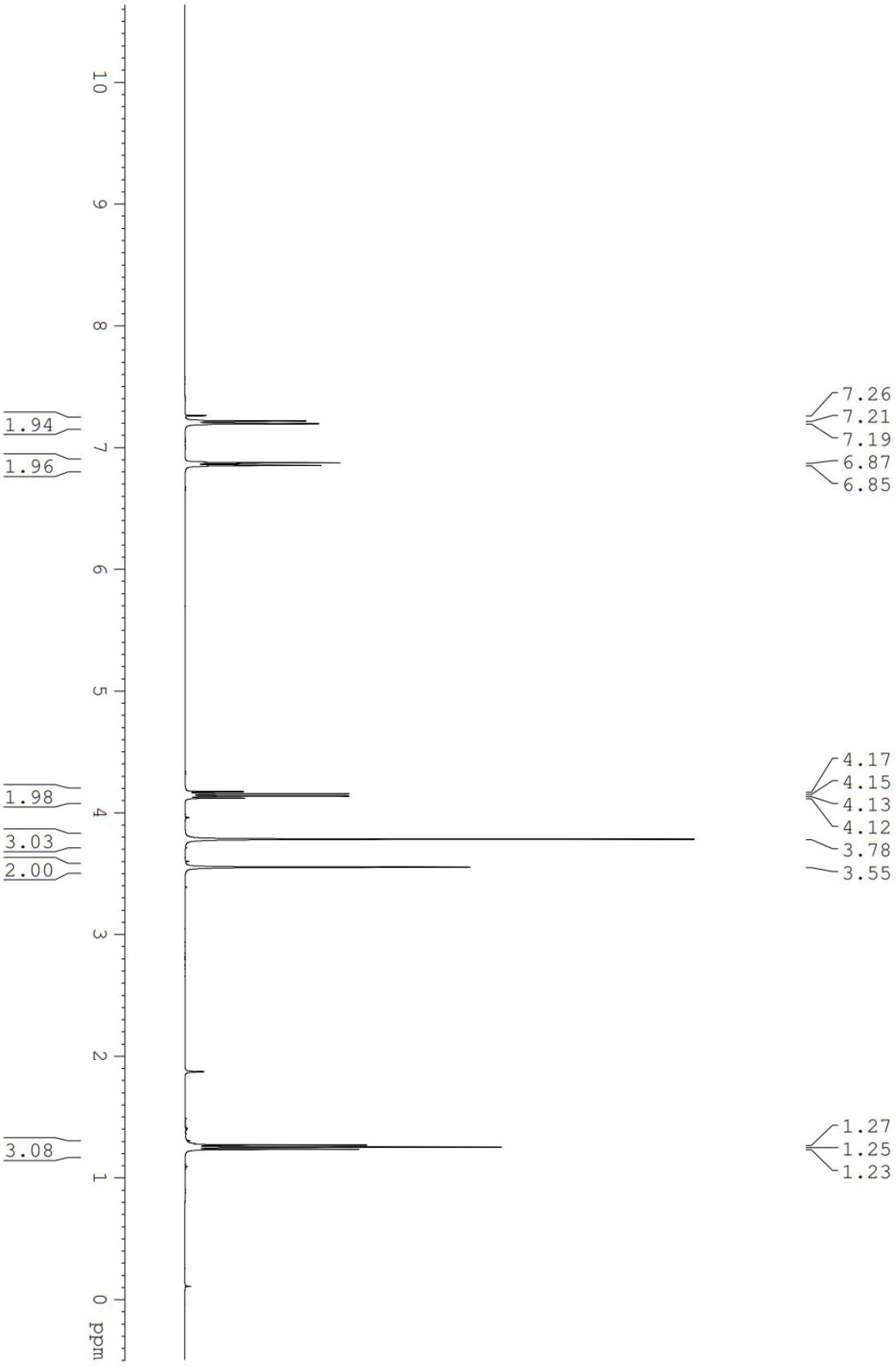


^{13}C NMR Spectrum of **3k (100** MHz, $CDCl_3$)

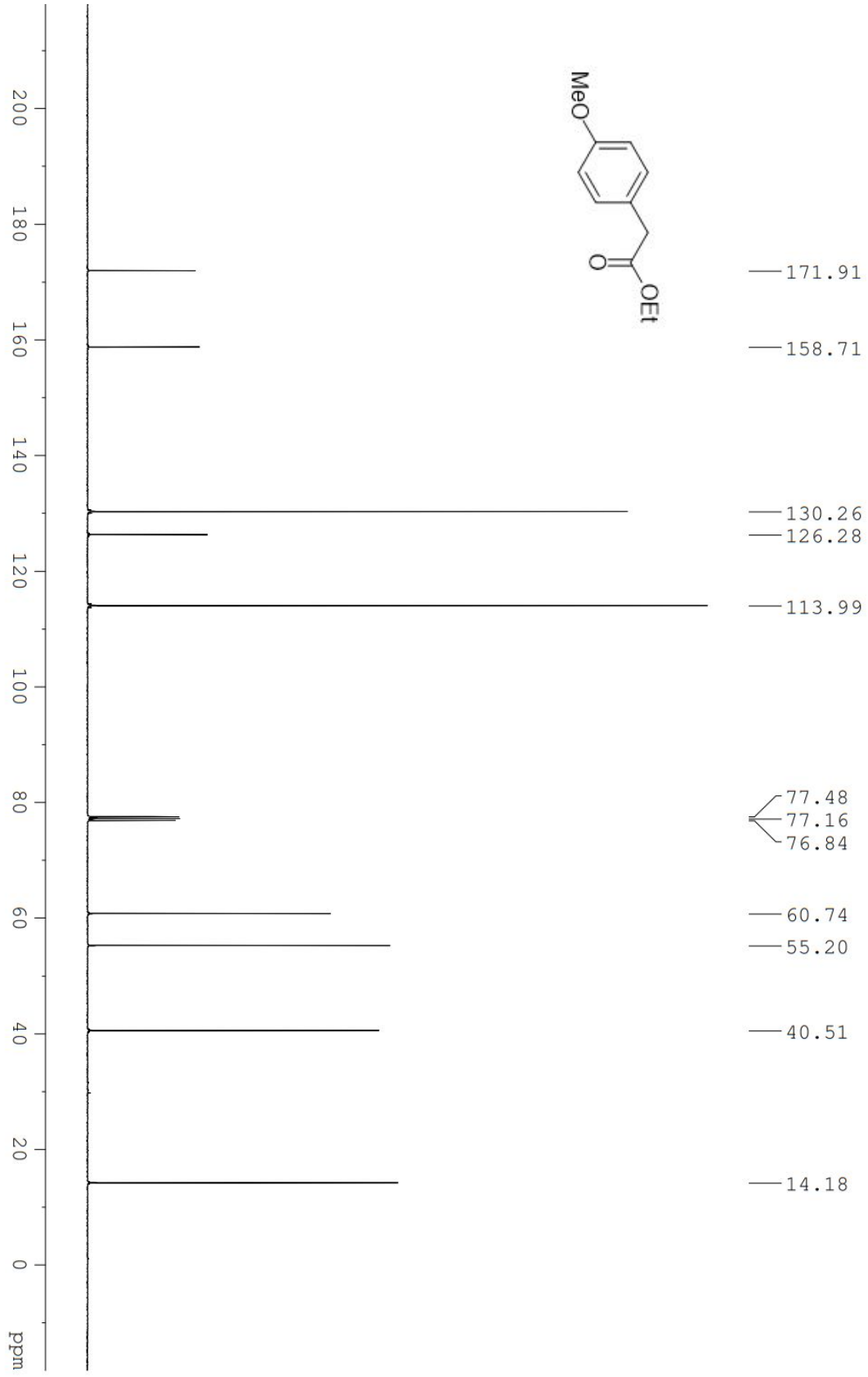


^{1}H NMR Spectrum of **3l (400** MHz, $CDCl_3$)

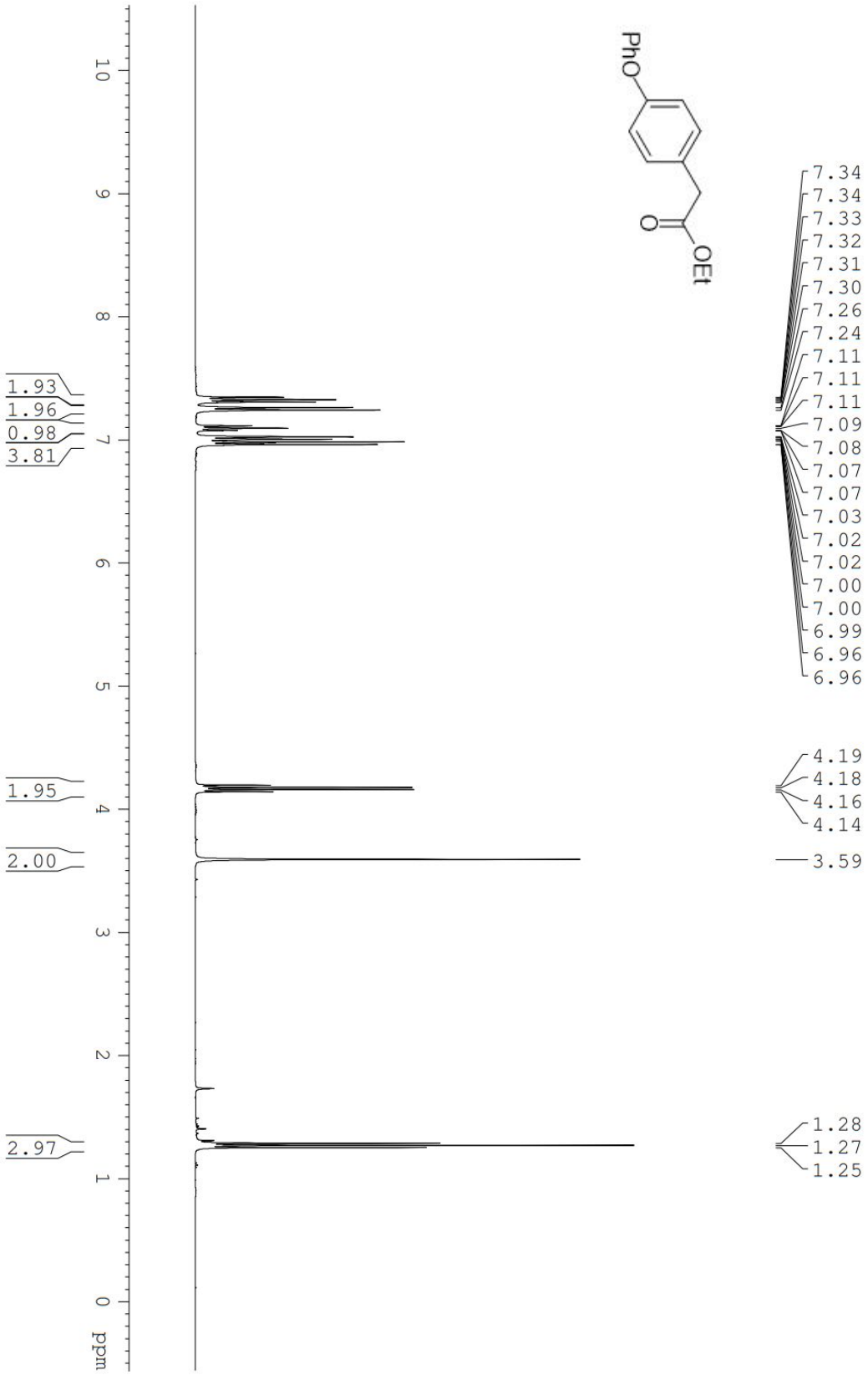




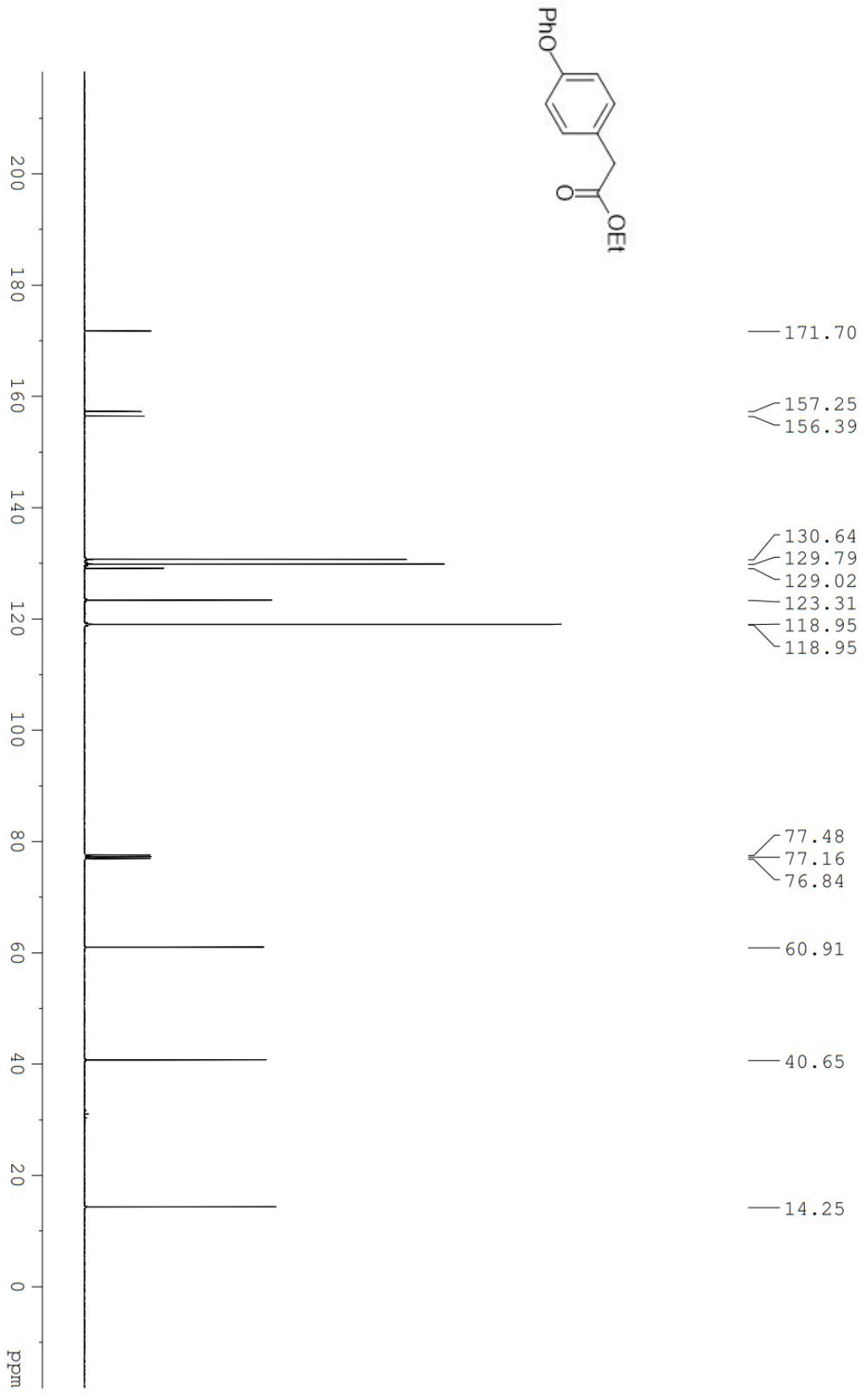
^{13}C NMR Spectrum of **3l (100** MHz, $CDCl_3$)



^{1}H NMR Spectrum of **3m (400** MHz, $CDCl_3$)



^{13}C NMR Spectrum of **3m (100** MHz, $CDCl_3$)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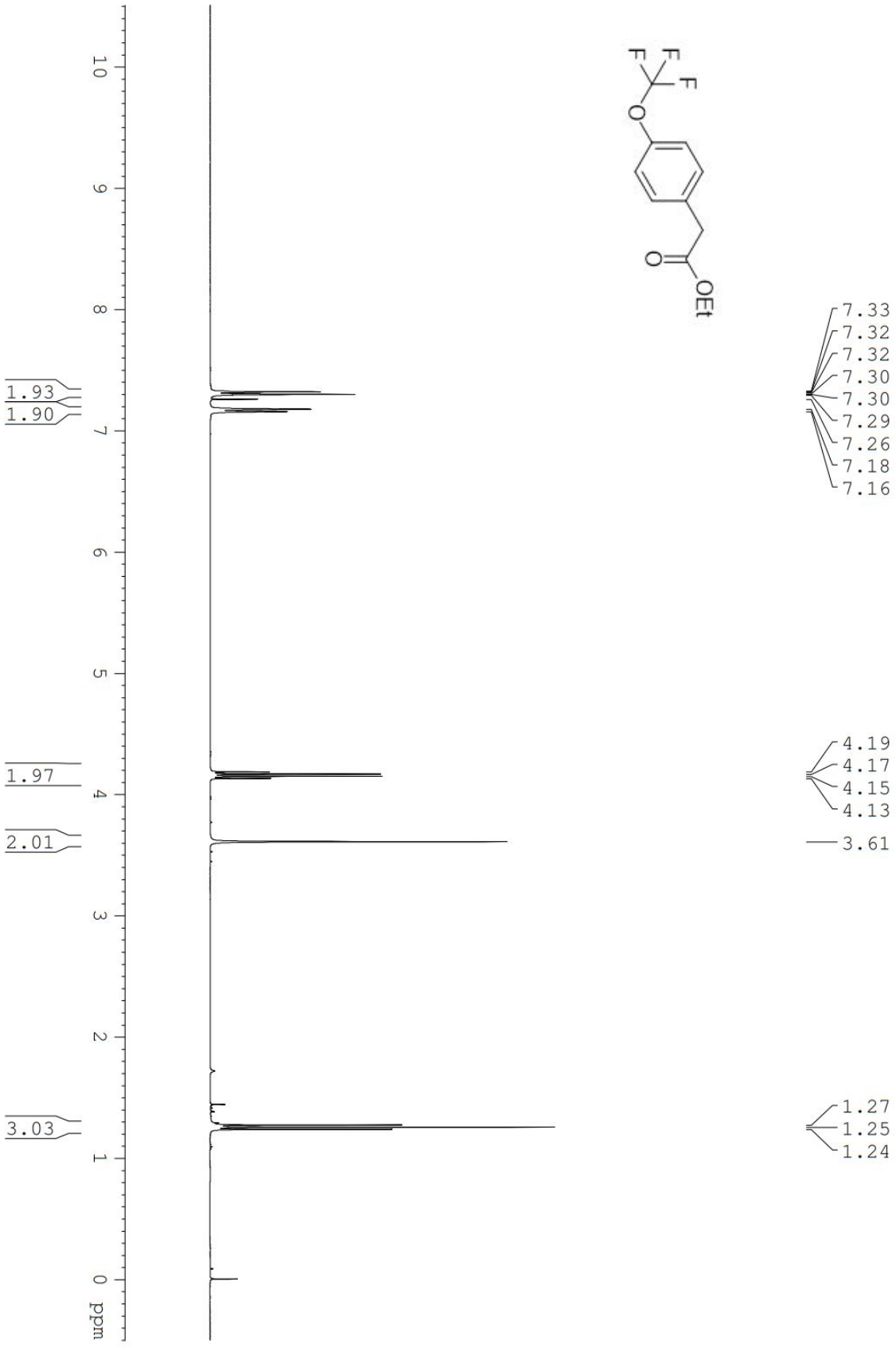
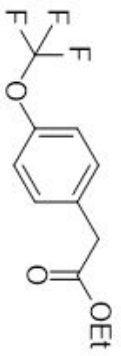
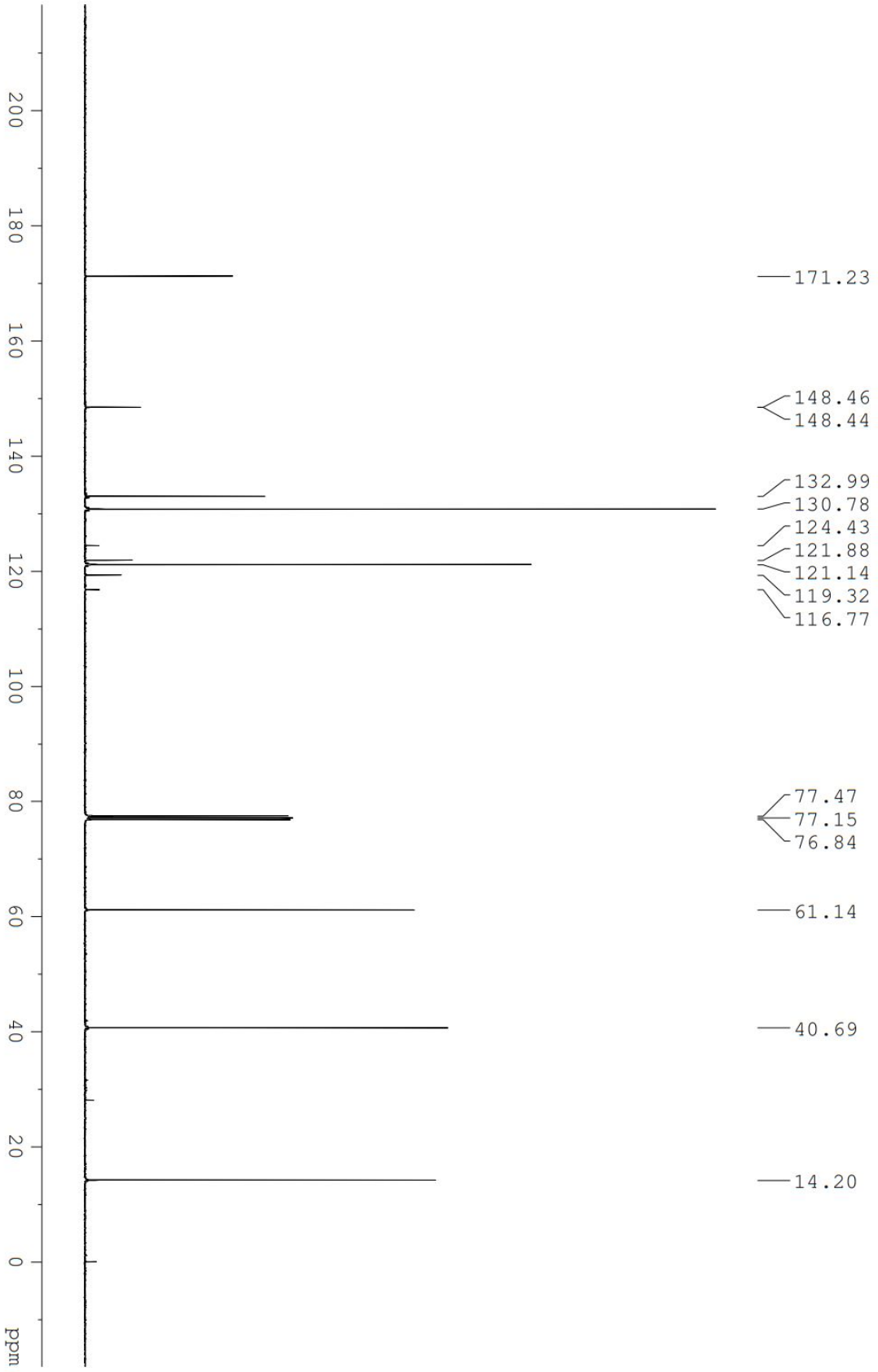
O
OEt
200
180
160
140
120
100
80
60
40
20
0
ppm
171.70
157.25
156.39
130.64
129.79
129.02
123.31
118.95
118.95
77.48
77.16
76.84
60.91
40.65
14.25

^{1}H NMR Spectrum of **3n (400** MHz, $CDCl_3$)

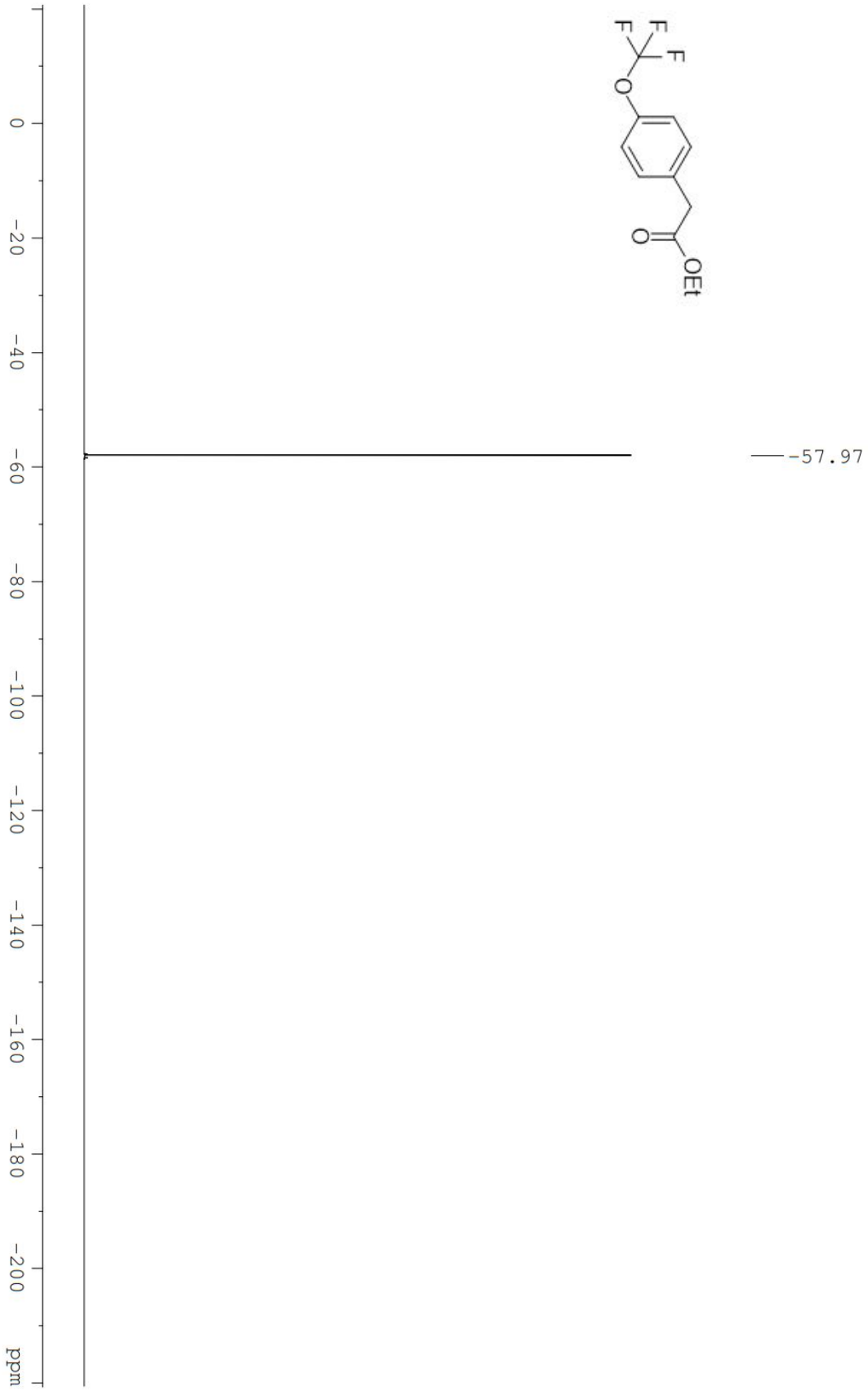


^{13}C NMR Spectrum of **3n (100** MHz, $CDCl_3$)

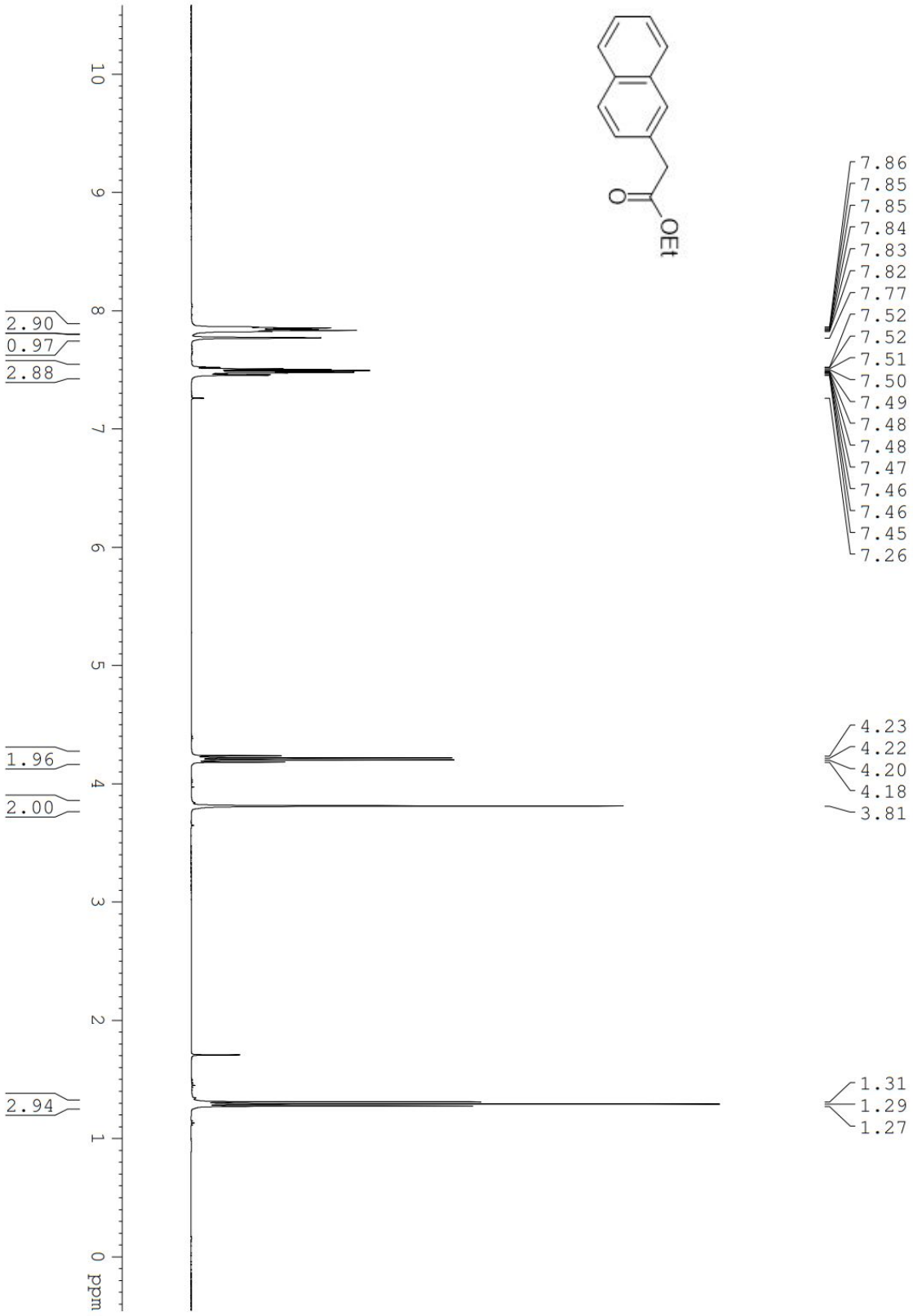




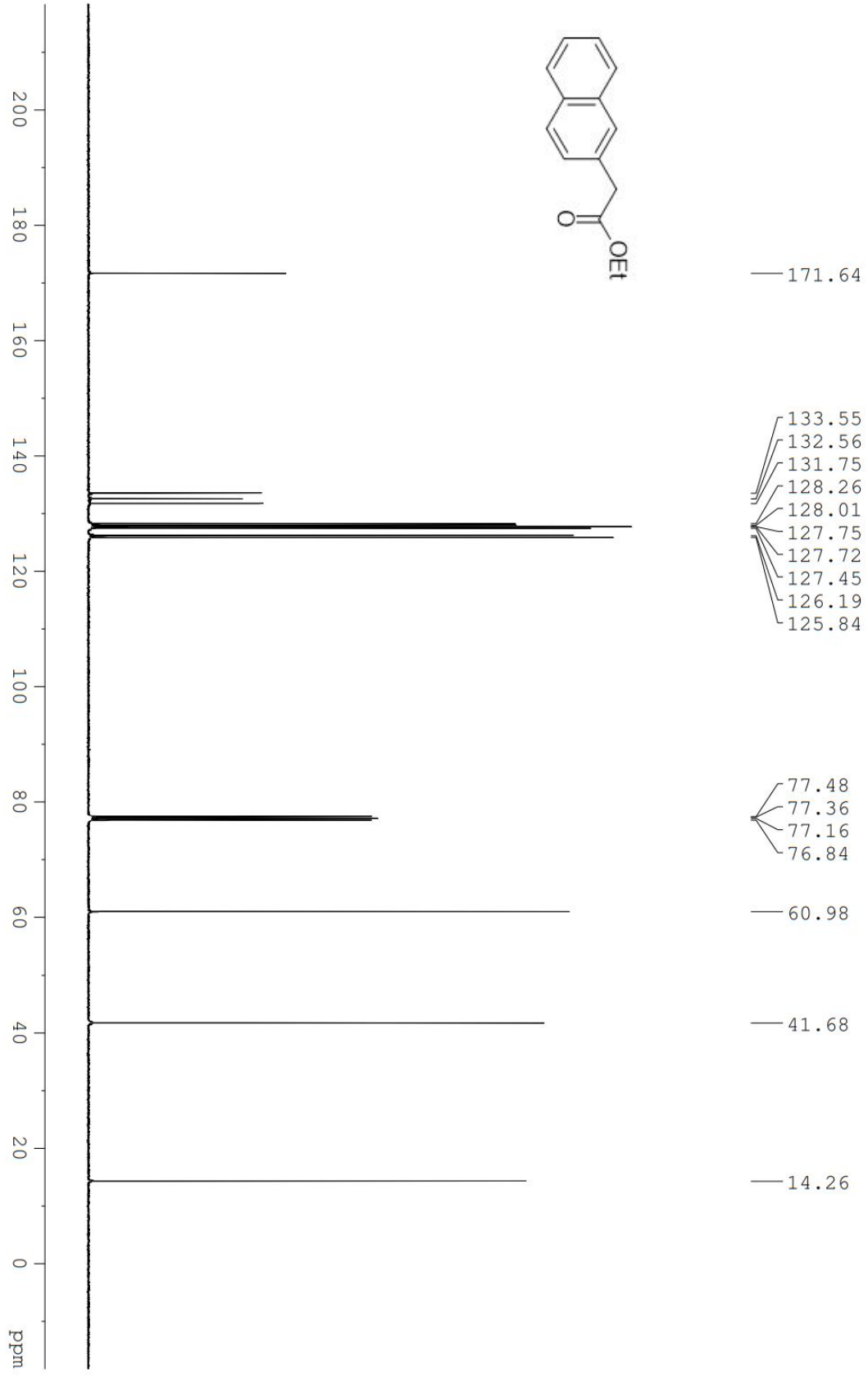
^{19}F NMR Spectrum of **3n (376** MHz, $CDCl_3$)



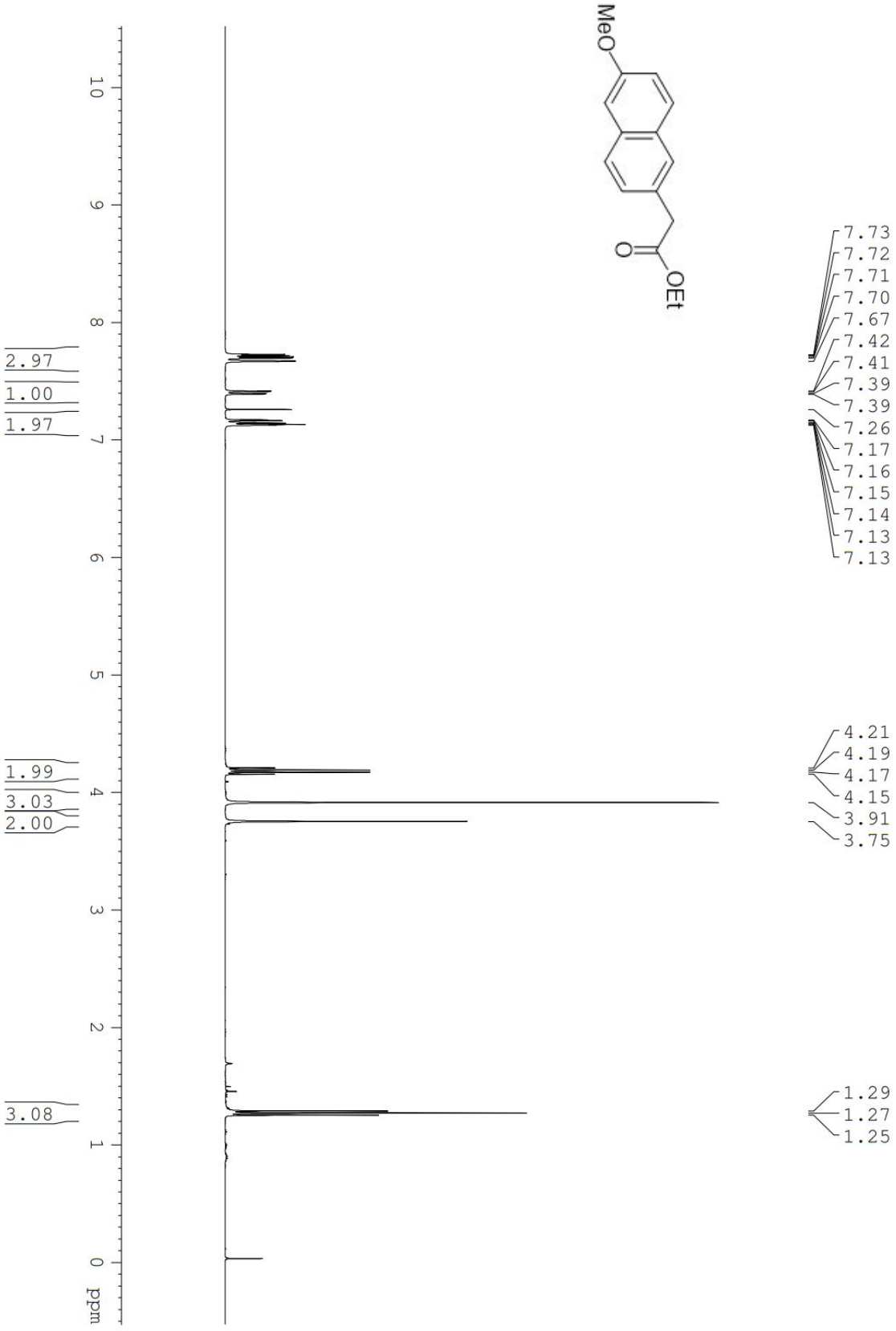
^{1}H NMR Spectrum of **3o (400** MHz, $CDCl_3$)



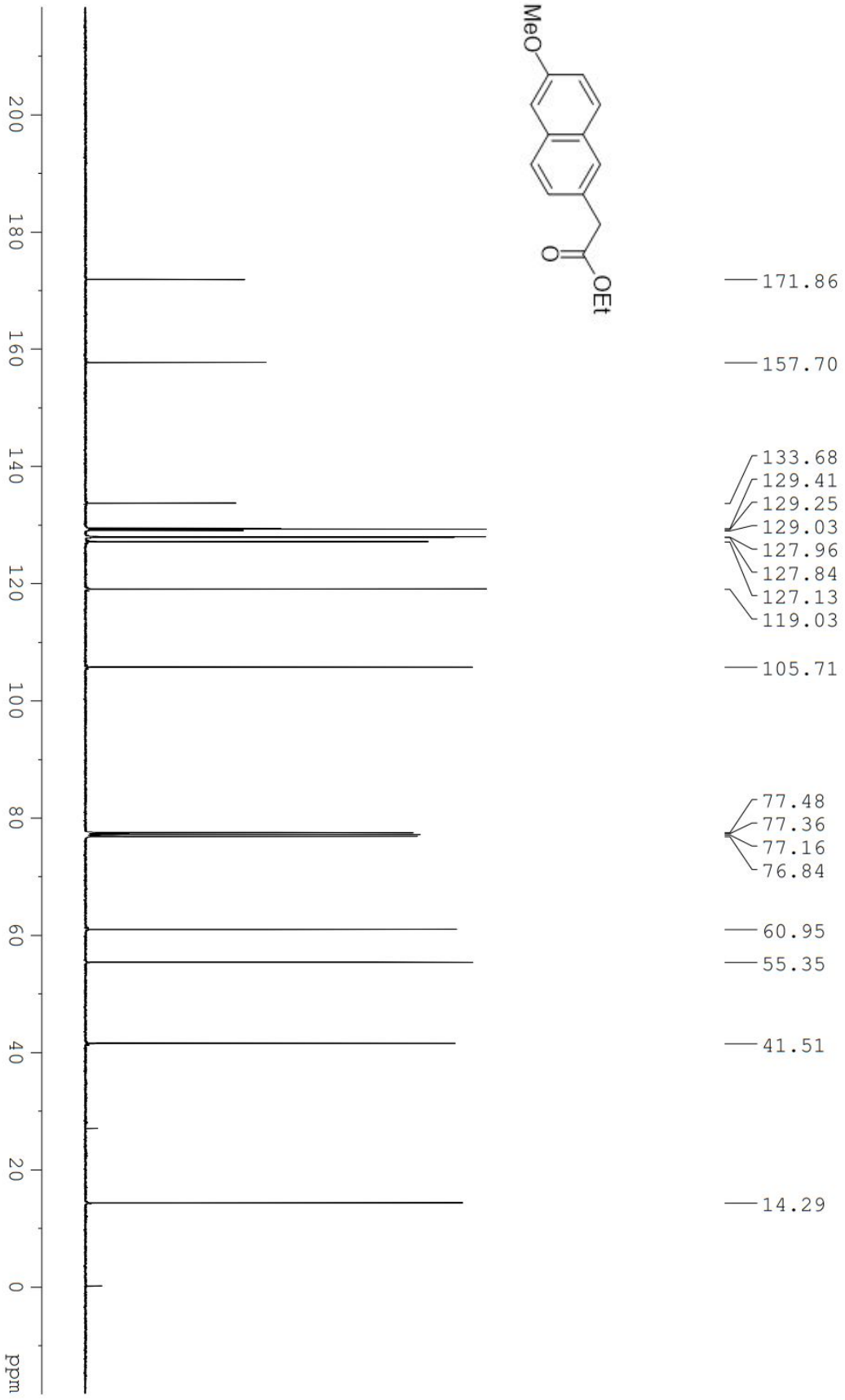
^{13}C NMR Spectrum of **3o (100** MHz, $CDCl_3$)



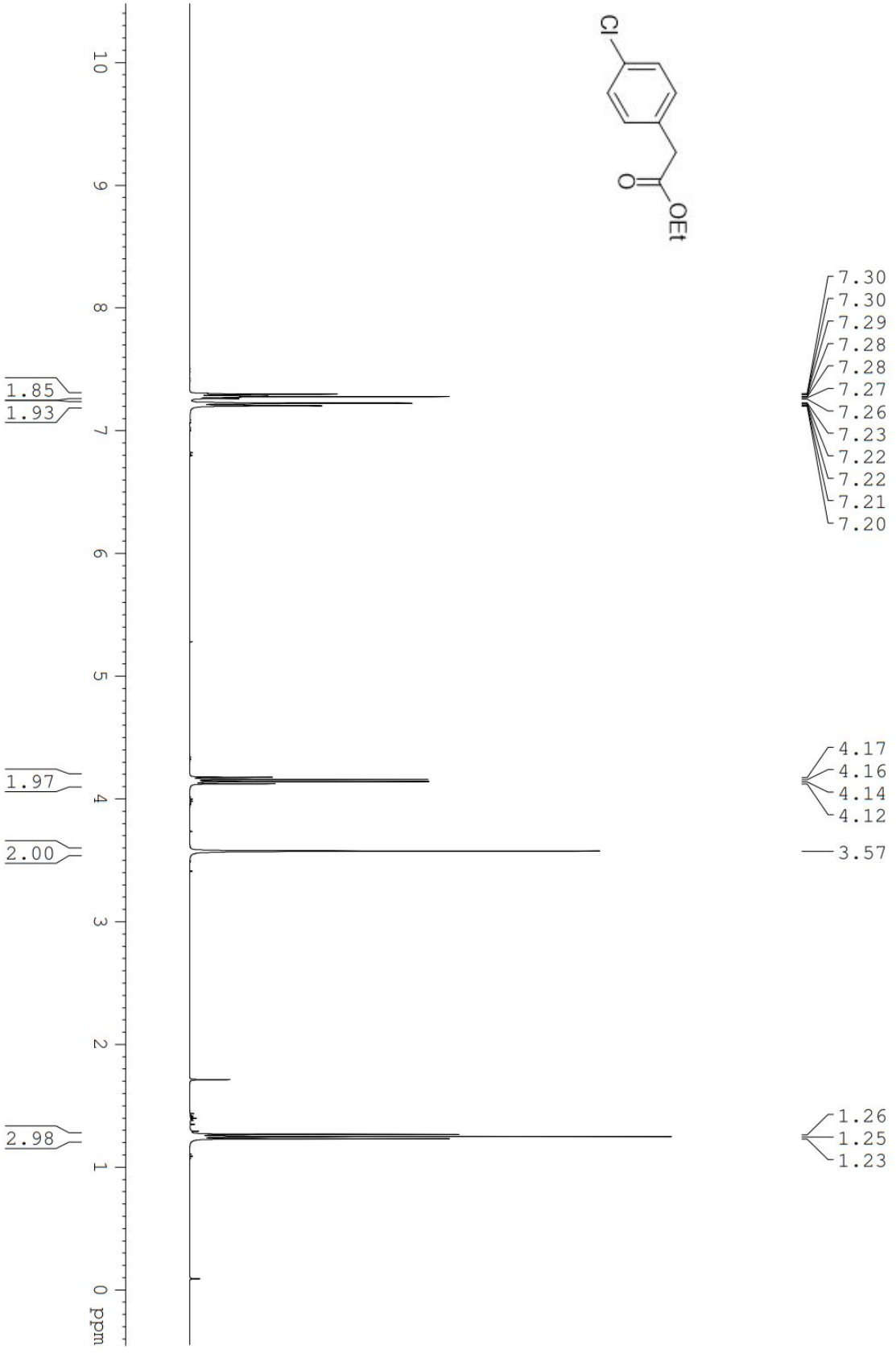
^{1}H NMR Spectrum of **3p (400** MHz, $CDCl_3$)



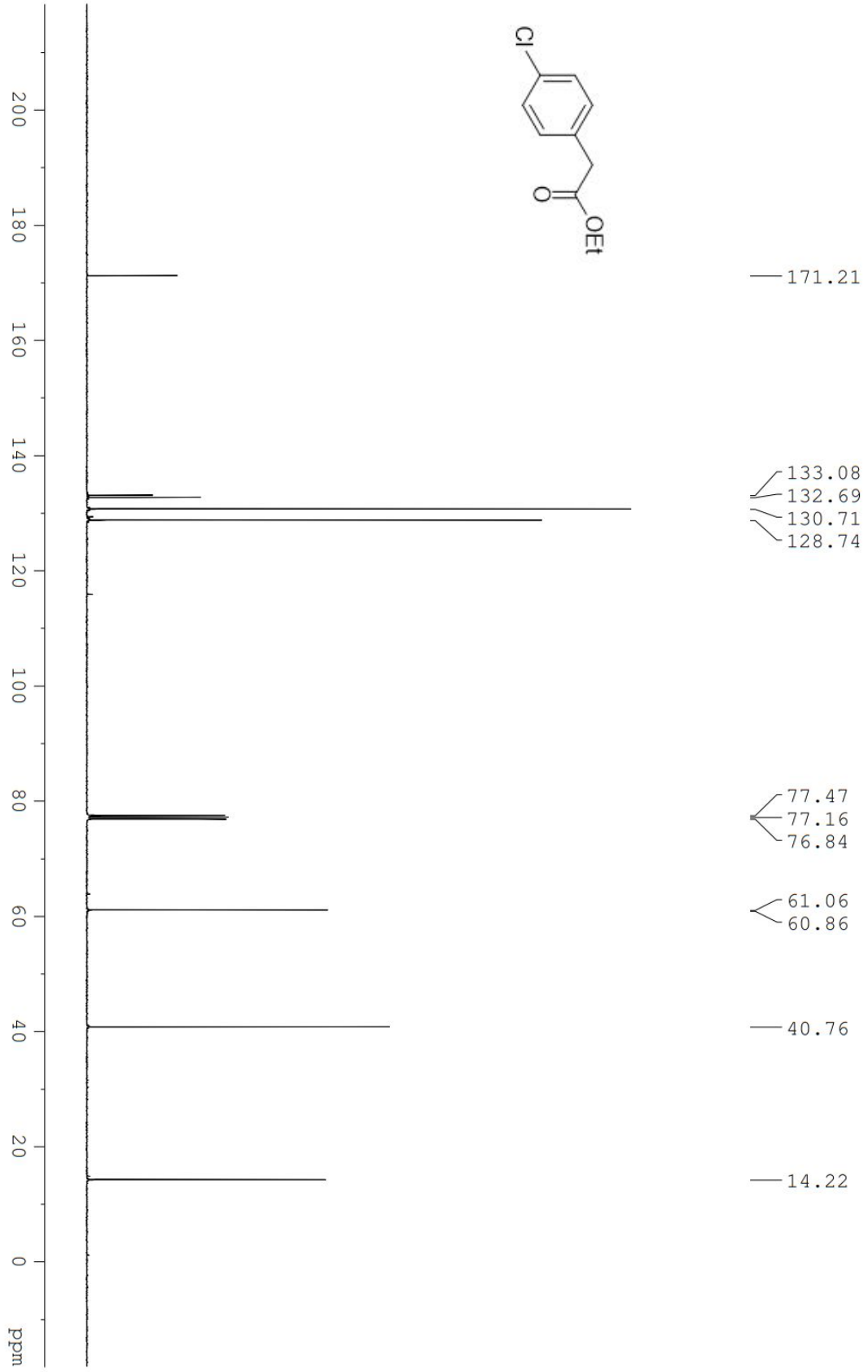
^{13}C NMR Spectrum of **3p (100** MHz, $CDCl_3$)



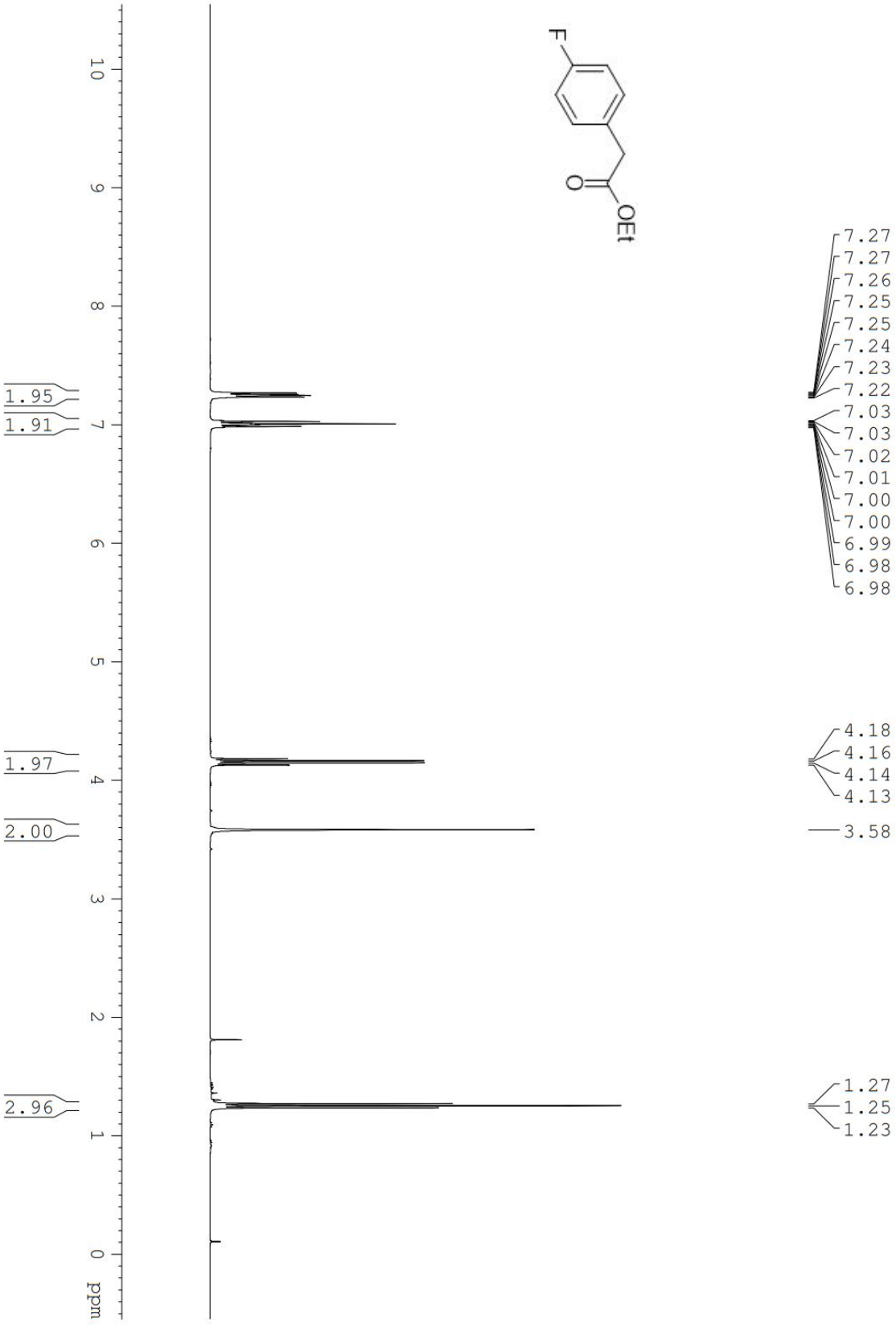
^{1}H NMR Spectrum of **3q** (**400** MHz, $CDCl_3$)



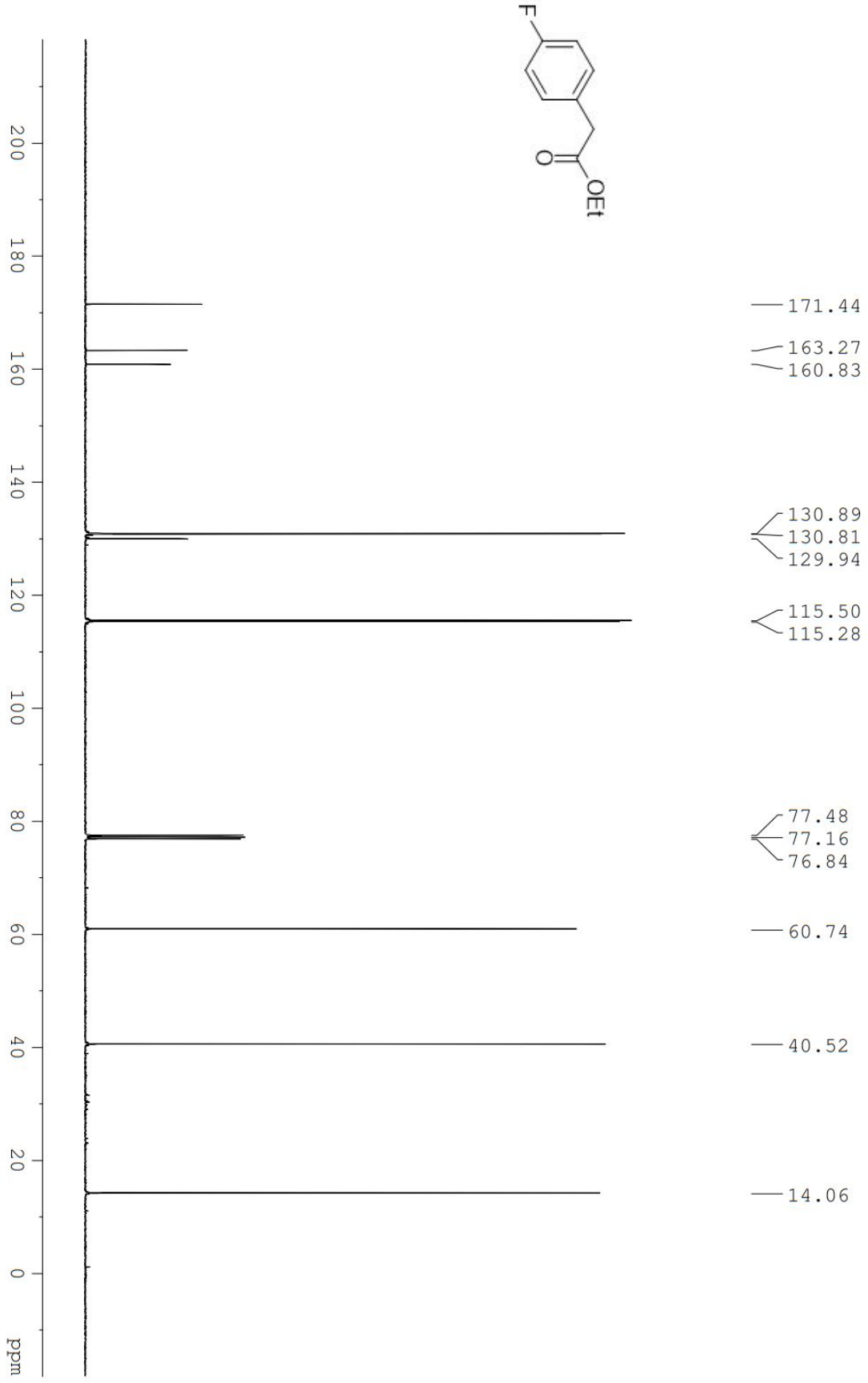
^{13}C NMR Spectrum of **3q (100** MHz, $CDCl_3$)



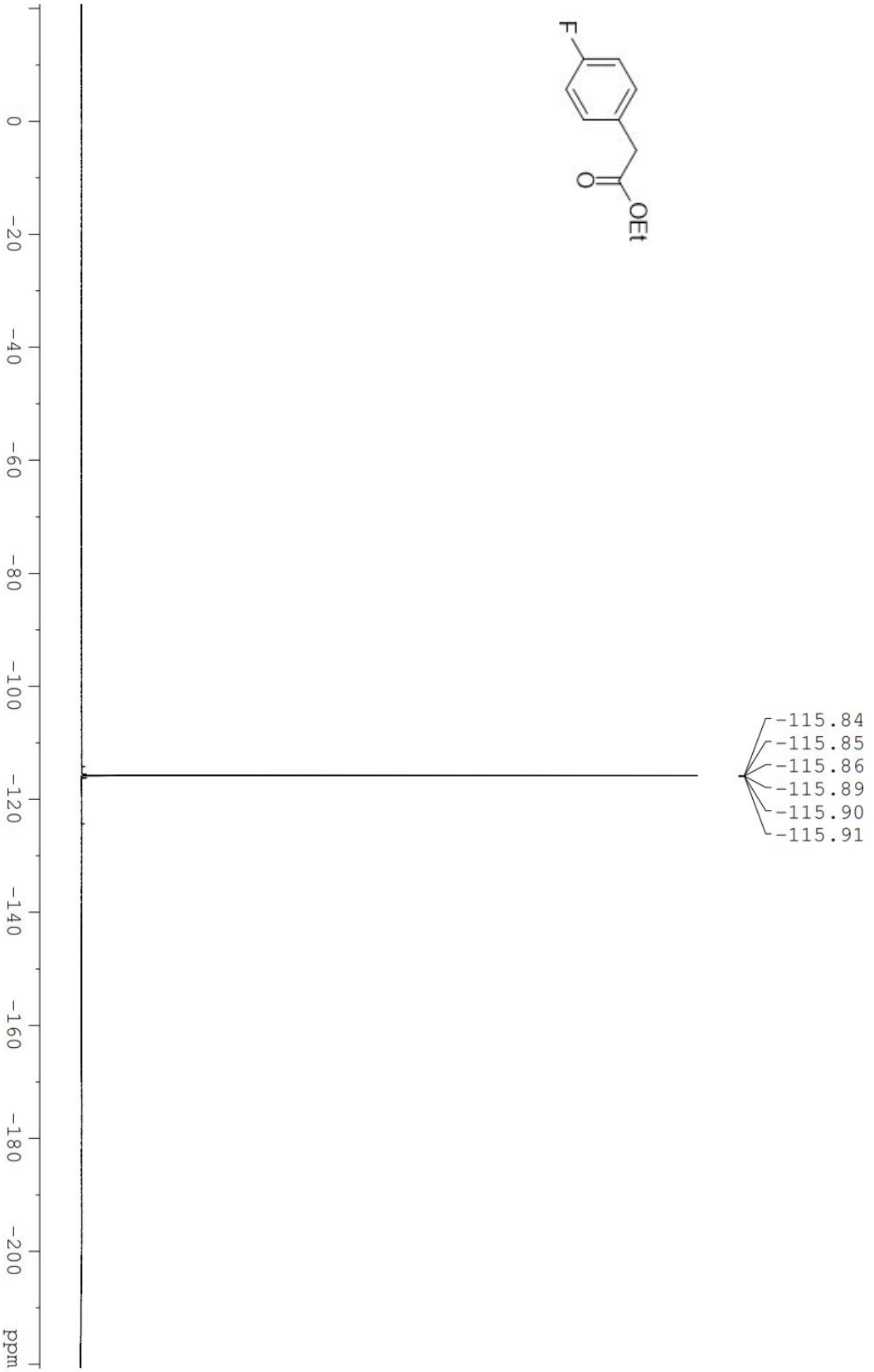
^{1}H NMR Spectrum of **3r (400** MHz, $CDCl_3$)



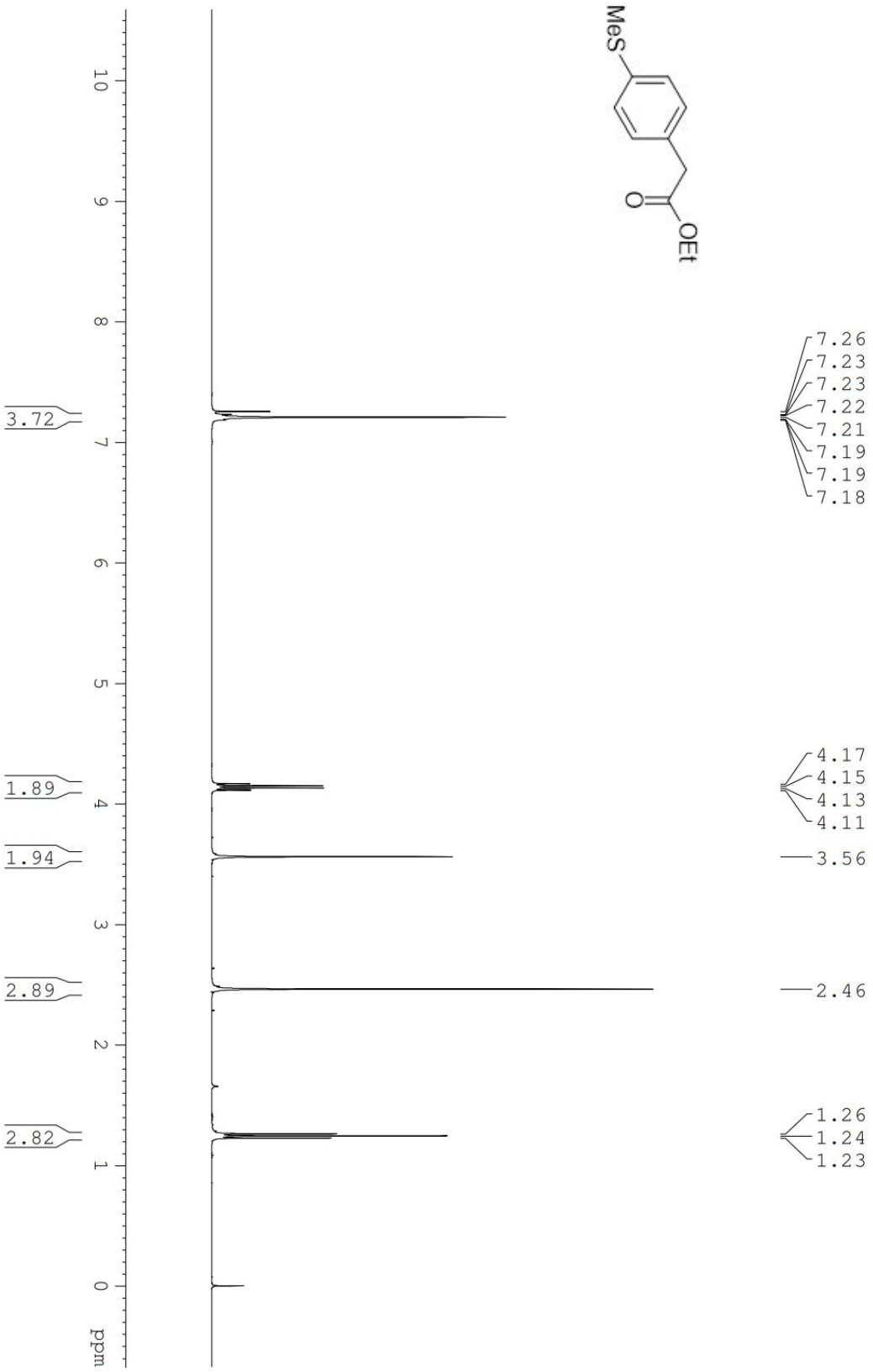
^{13}C NMR Spectrum of **3r (100** MHz, $CDCl_3$)


F
O
OEt
200
180
160
140
120
100
80
60
40
20
0
ppm
171.44
163.27
160.83
130.89
130.81
129.94
115.50
115.28
77.48
77.16
76.84
60.74
40.52
14.06

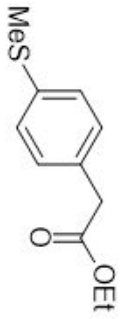
^{19}F NMR Spectrum of **3r (376** MHz, $CDCl_3$)

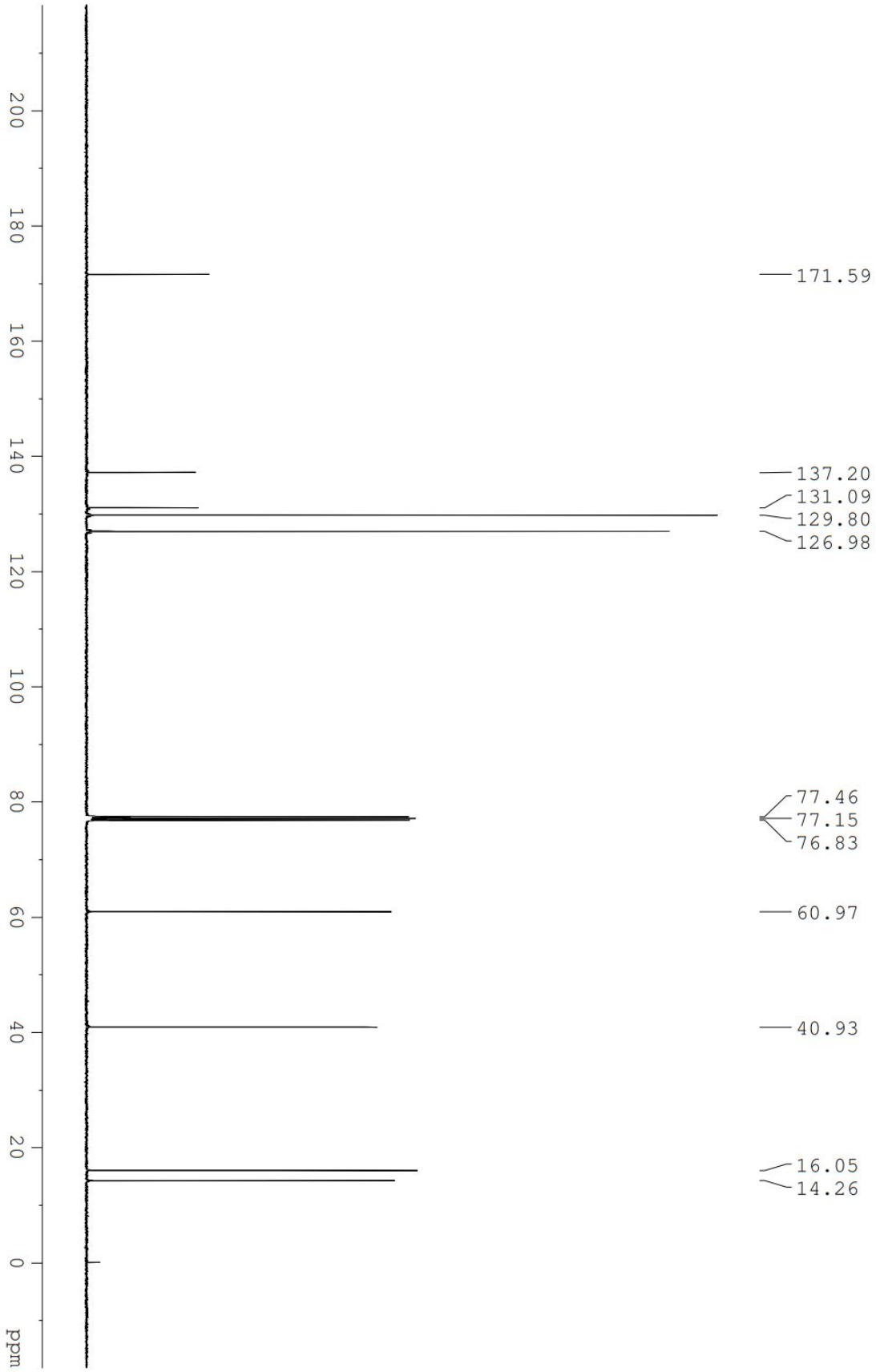


^{1}H NMR Spectrum of **3s (400** MHz, $CDCl_3$)

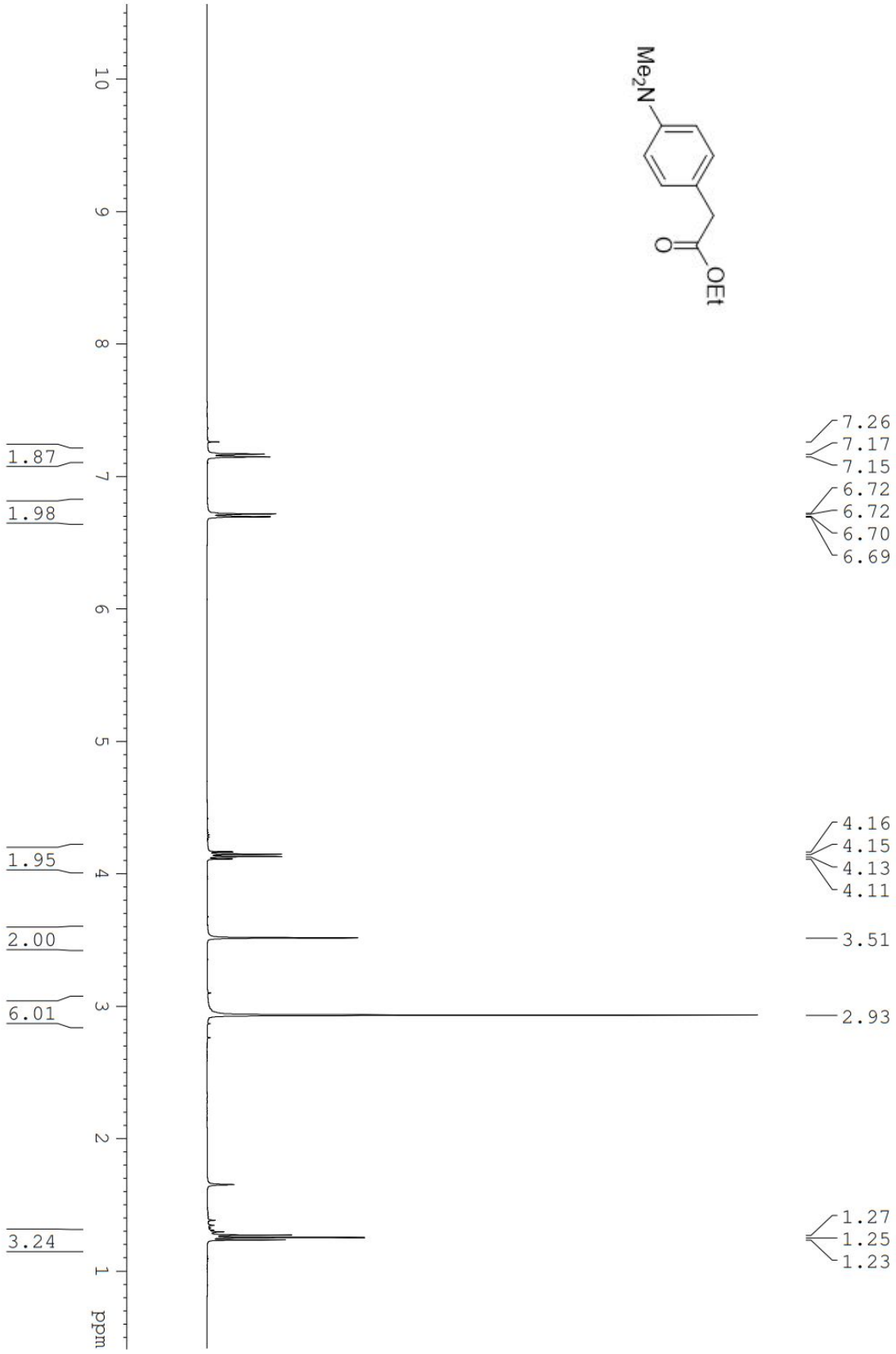


^{13}C NMR Spectrum of **3s (100** MHz, $CDCl_3$)

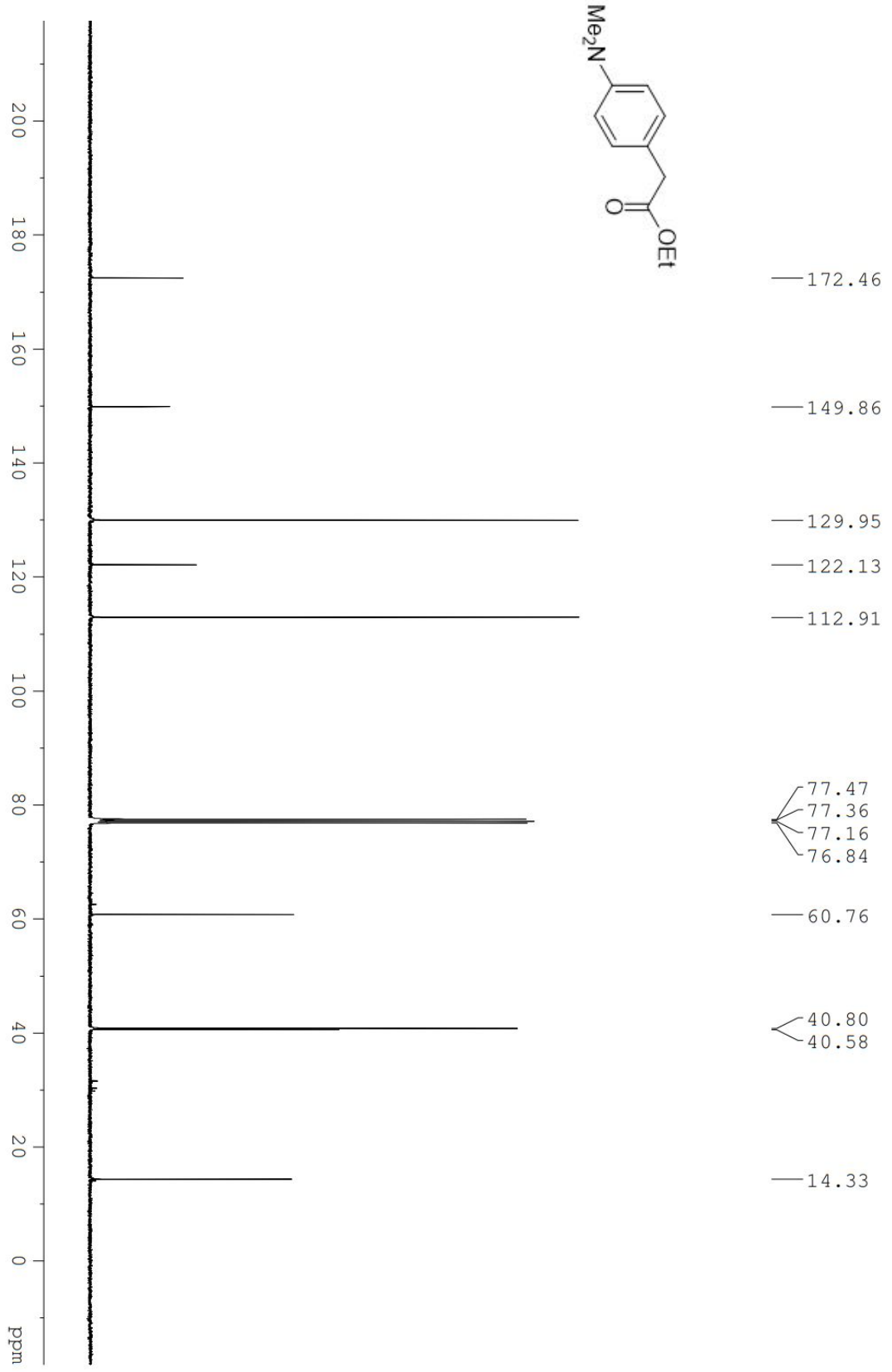




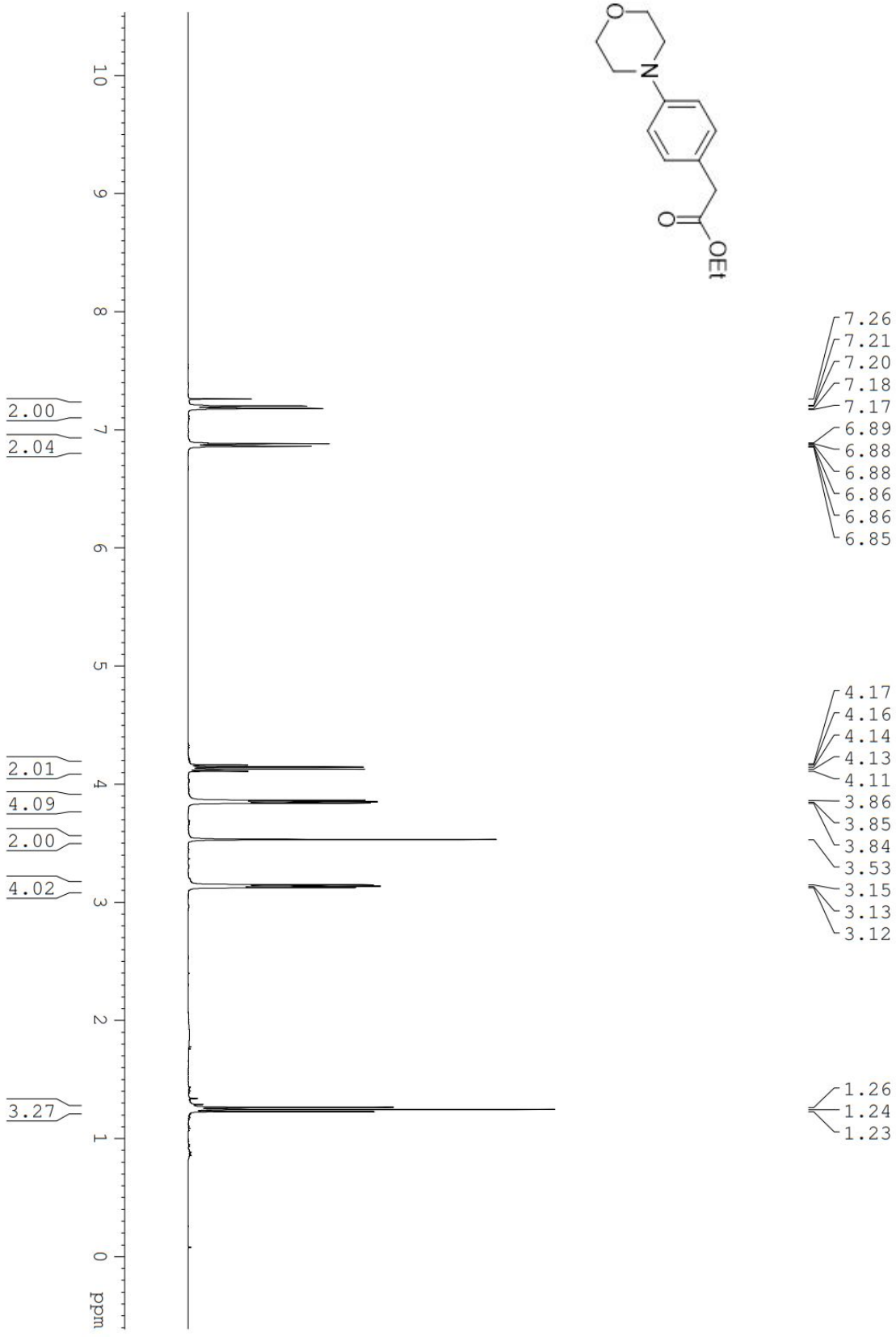
^{1}H NMR Spectrum of **3t (400** MHz, $CDCl_3$)



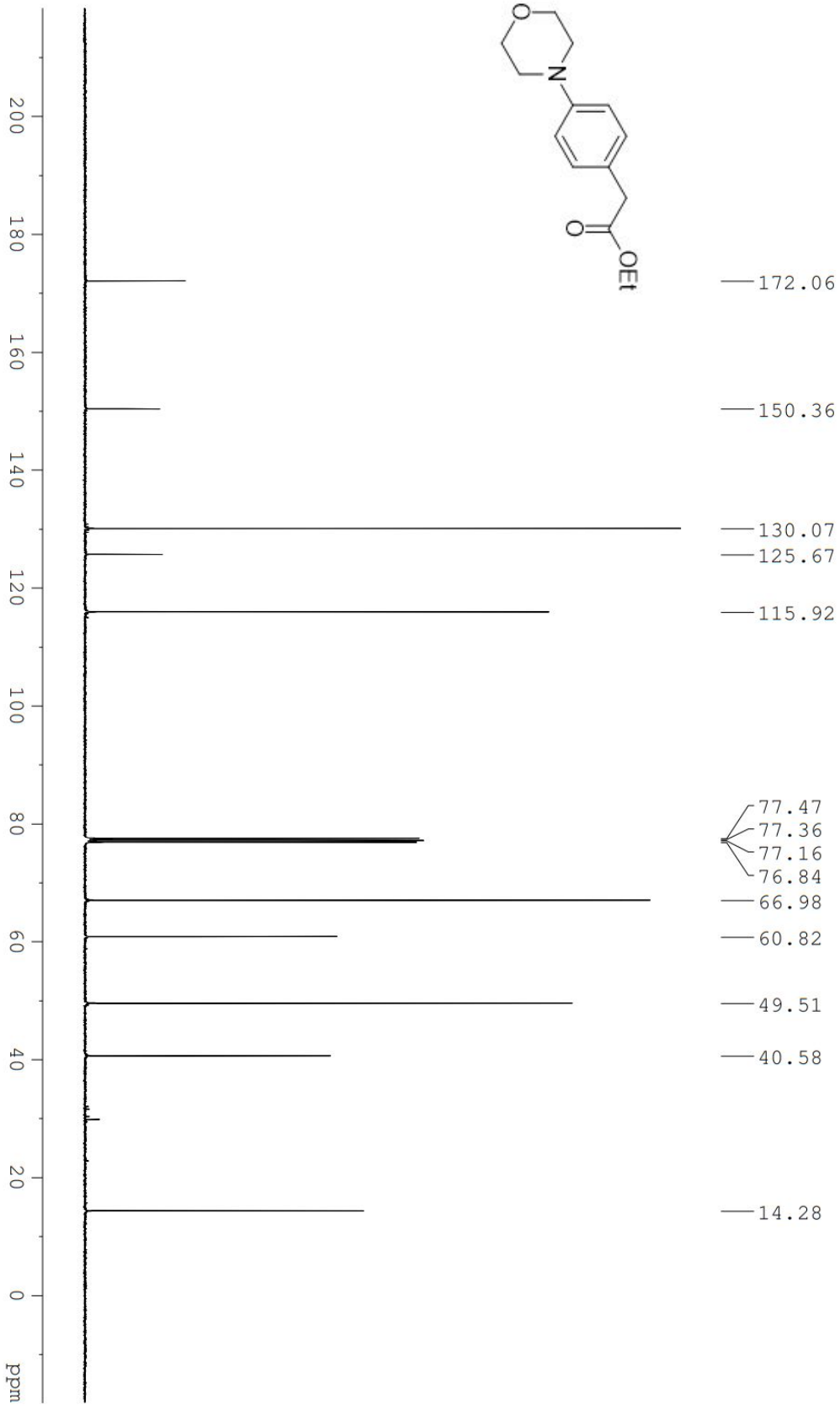
^{13}C NMR Spectrum of **3t (100** MHz, $CDCl_3$)


Me2N
O
OEt
200
180
160
140
120
100
80
60
40
20
0
ppm
172.46
149.86
129.95
122.13
112.91
77.47
77.36
77.16
76.84
60.76
40.80
40.58
14.33

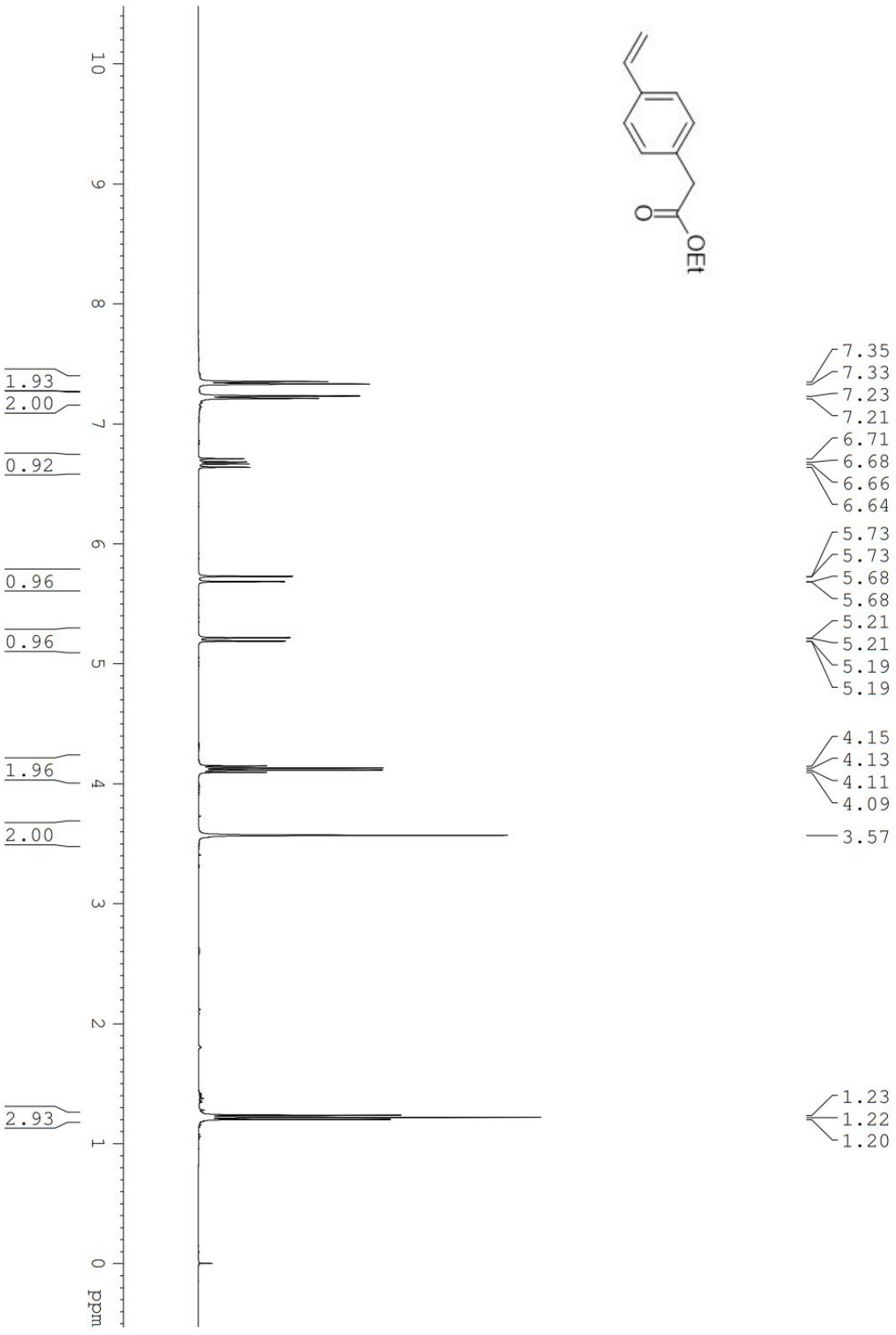
^{1}H NMR Spectrum of **3u (400** MHz, $CDCl_3$)



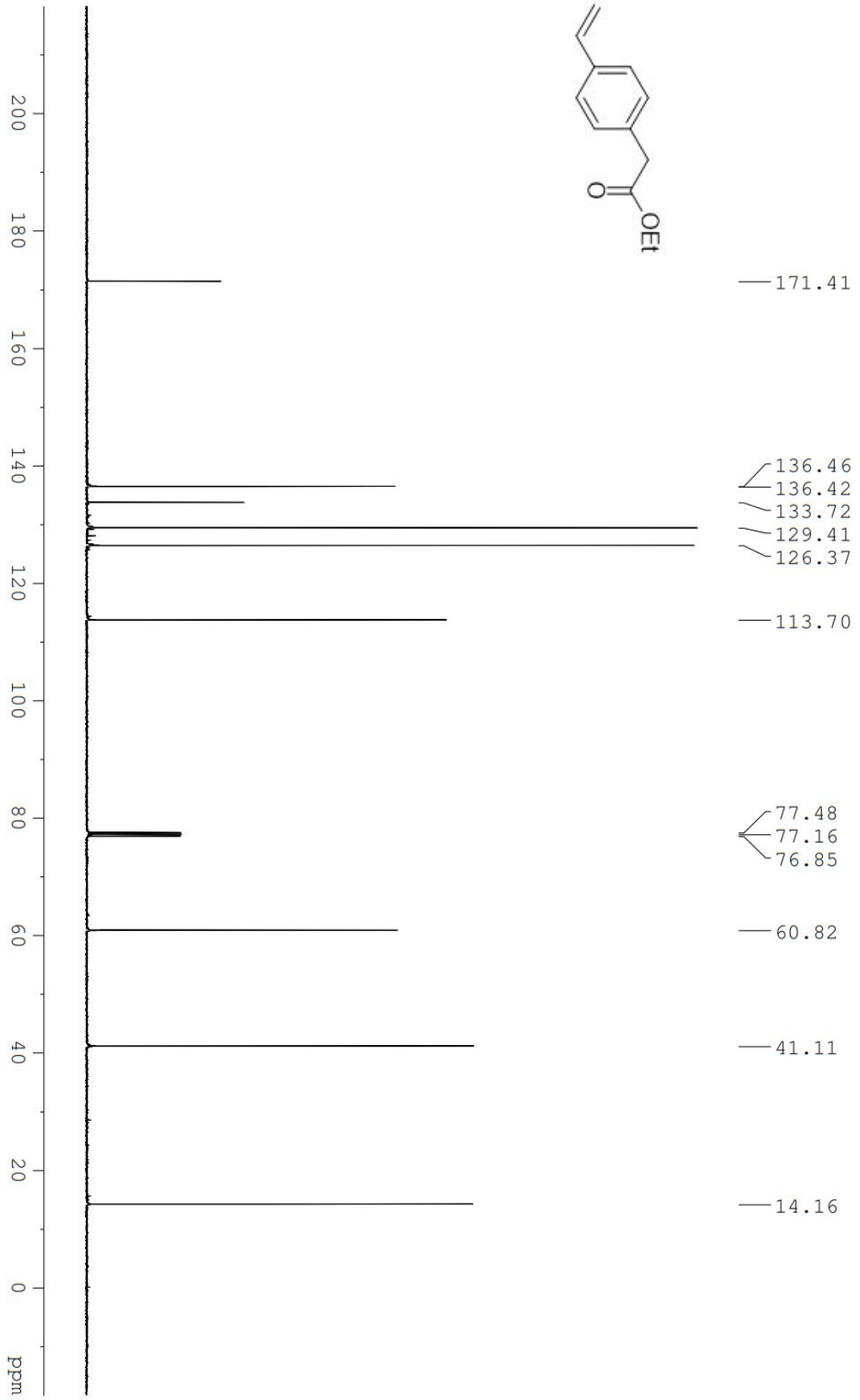
^{13}C NMR Spectrum of **3u (100** MHz, $CDCl_3$)



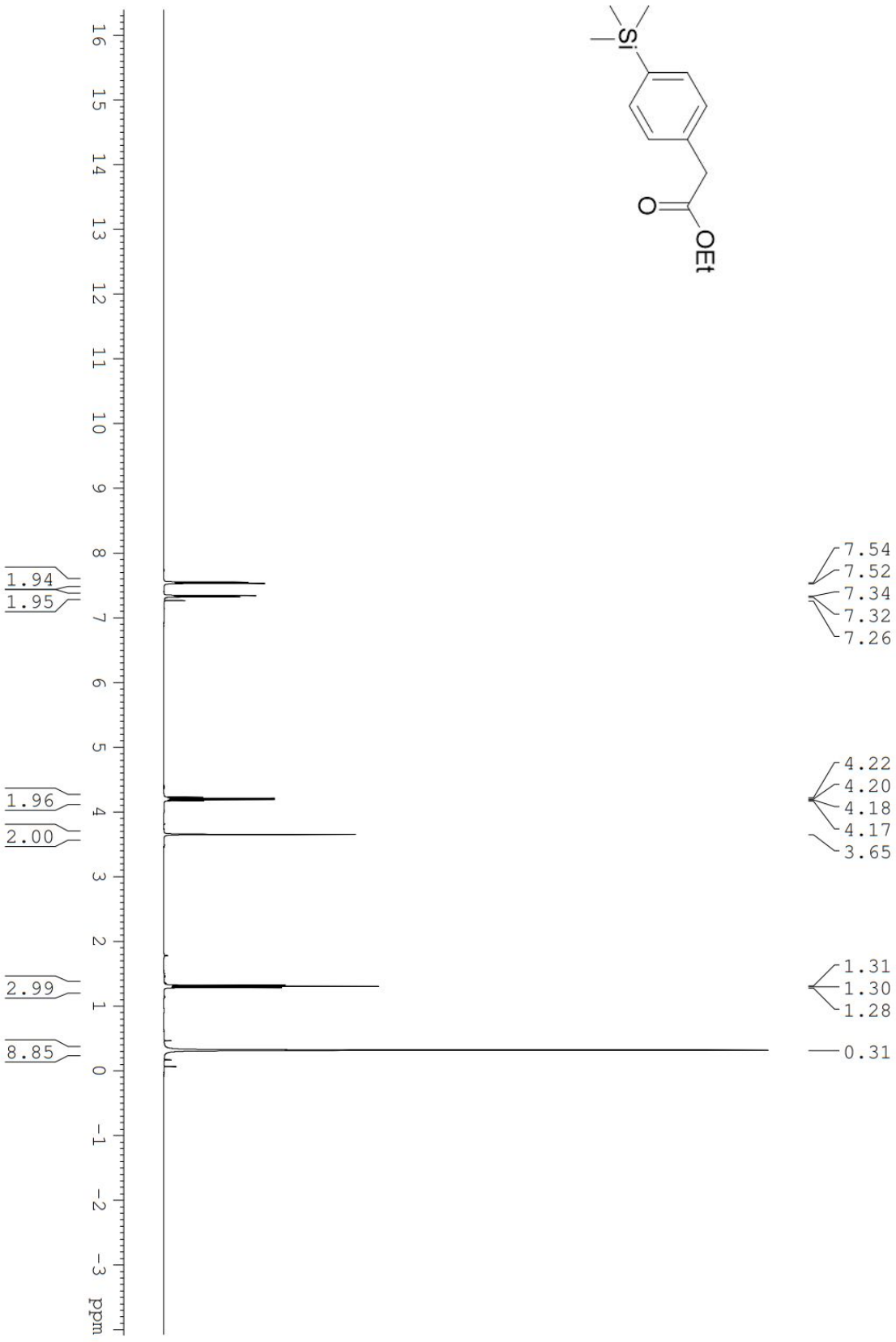
^{1}H NMR Spectrum of **3v (400** MHz, $CDCl_3$)



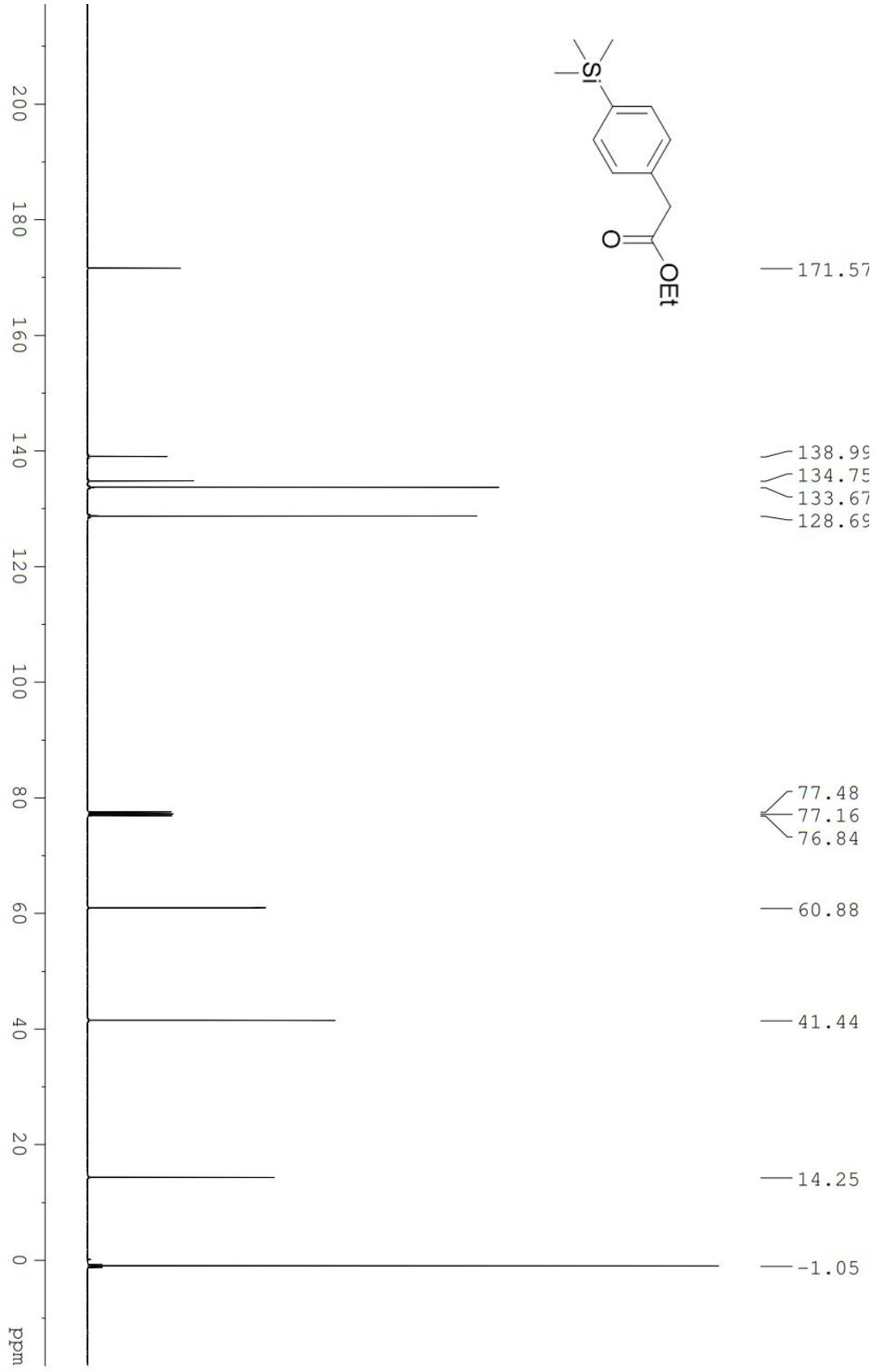
^{13}C NMR Spectrum of **3v (100** MHz, $CDCl_3$)



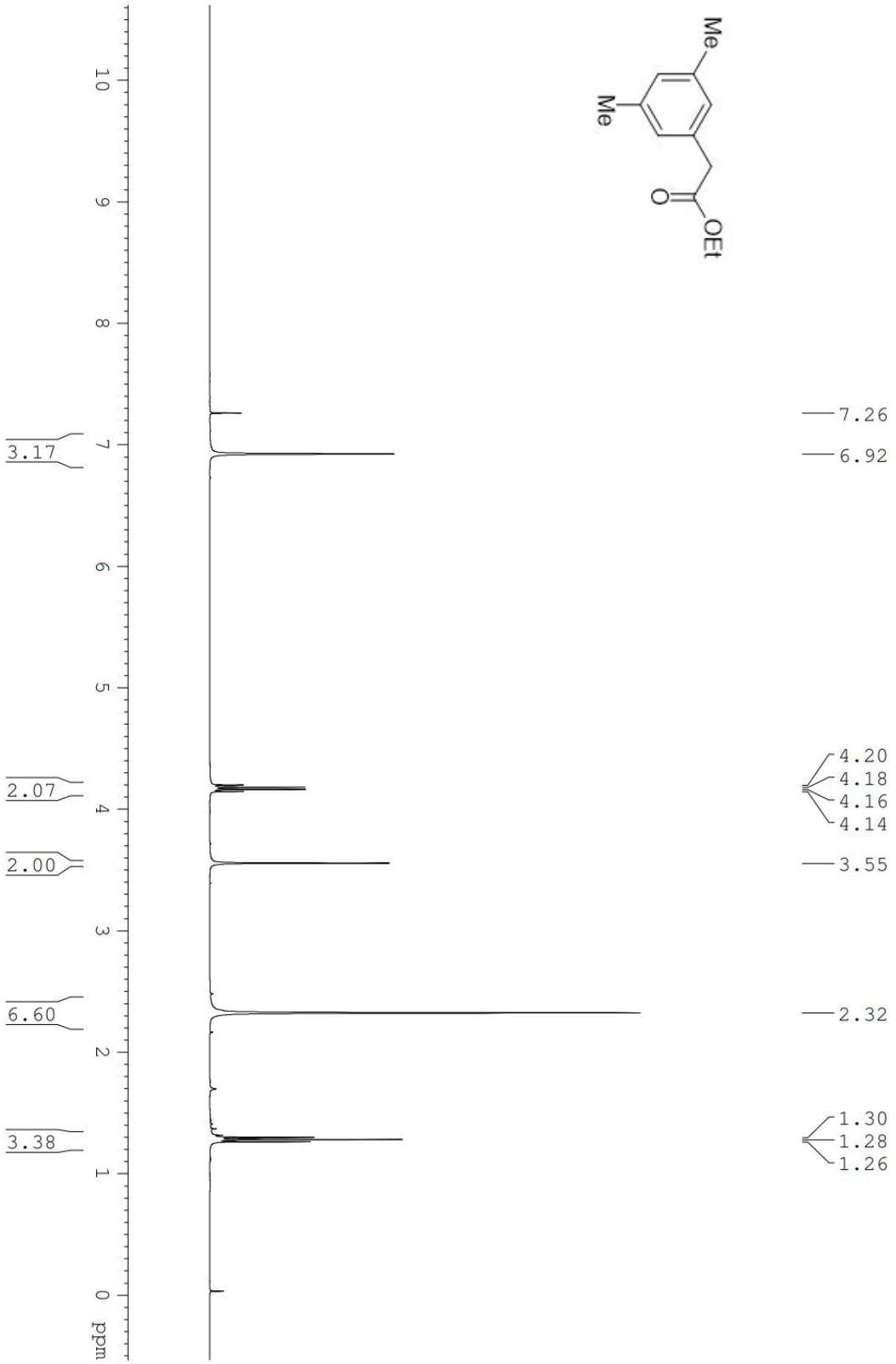
^{1}H NMR Spectrum of **3w (400** MHz, $CDCl_3$)



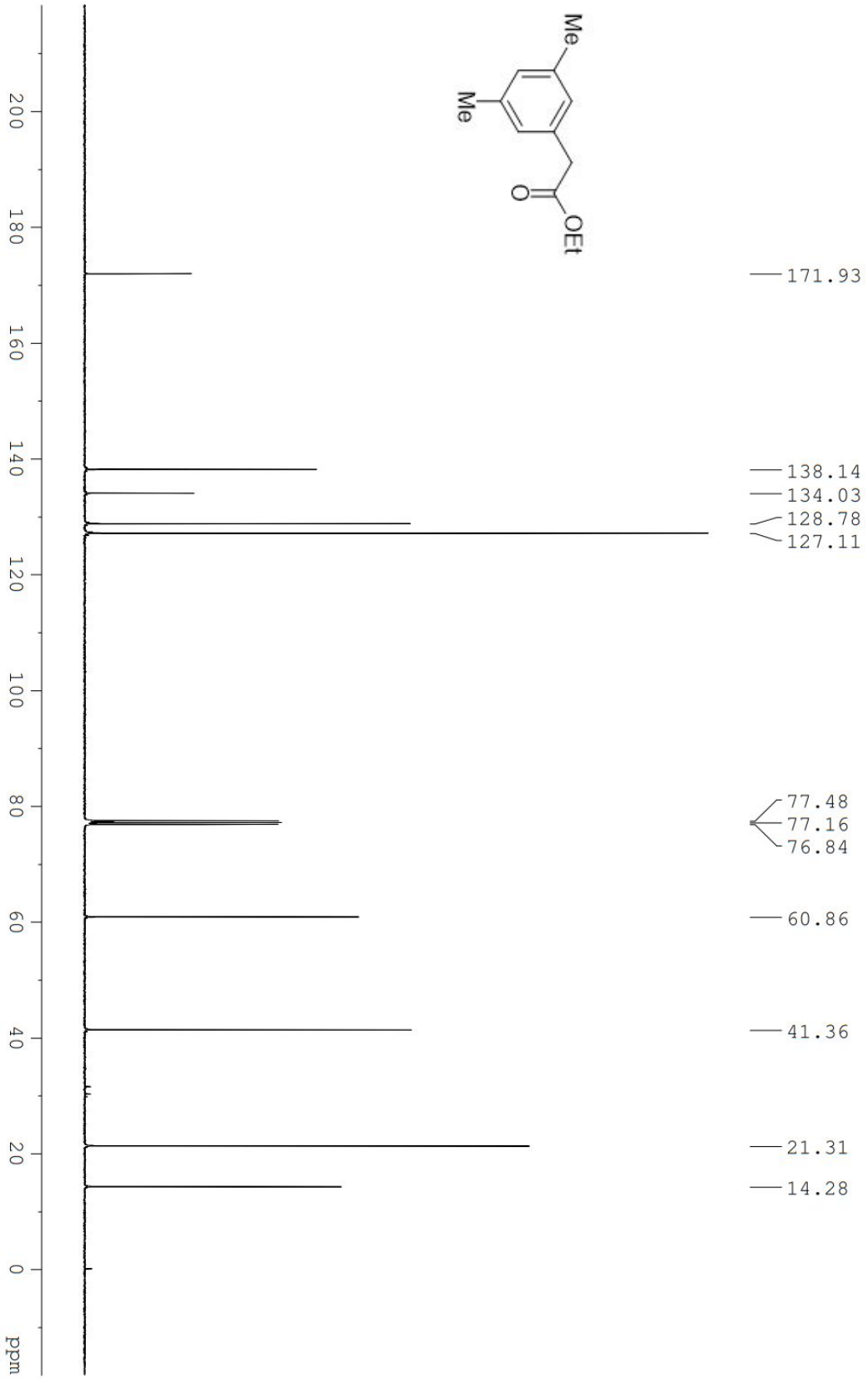
^{13}C NMR Spectrum of **3w (100** MHz, $CDCl_3$)



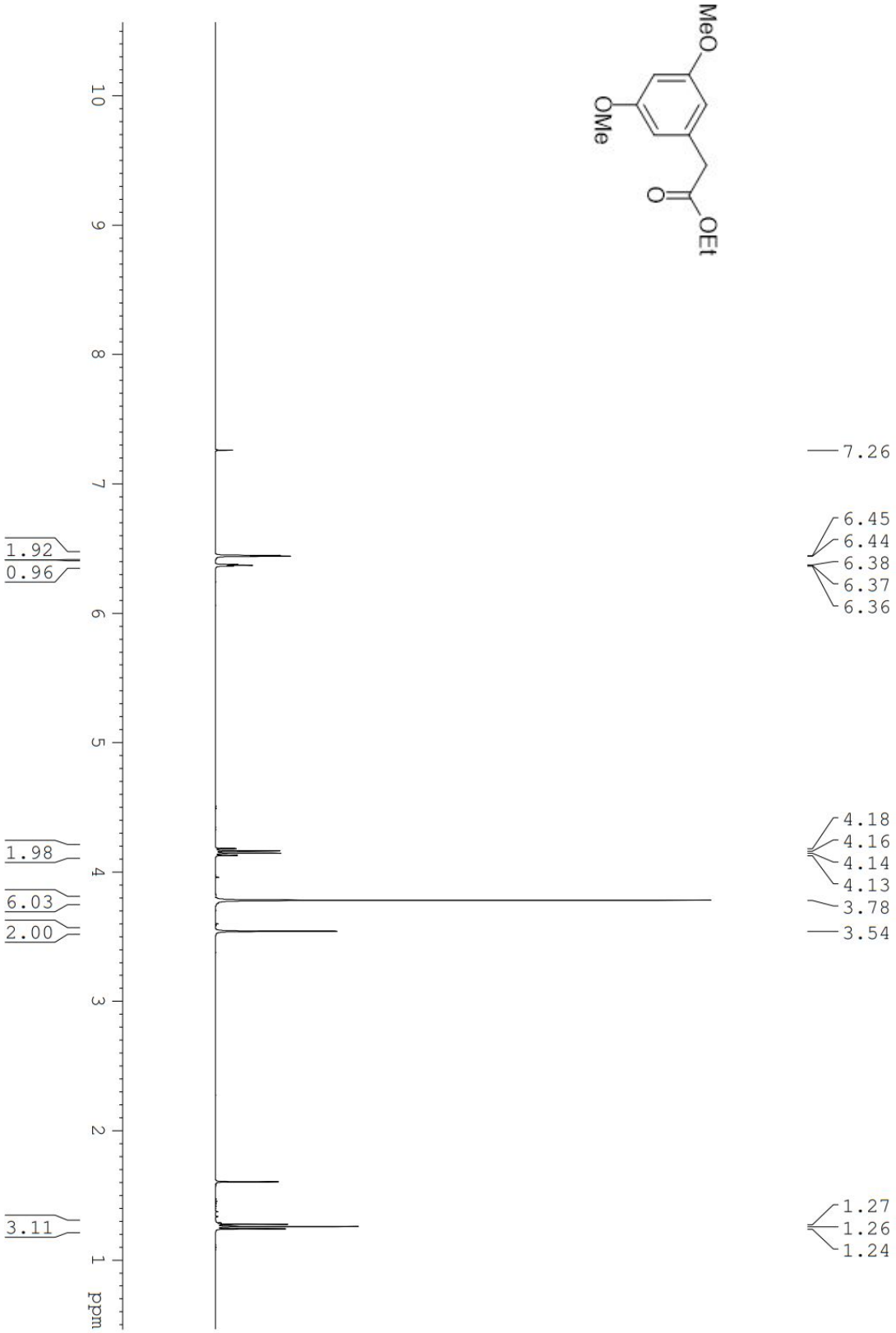
^{1}H NMR Spectrum of **3x (400** MHz, $CDCl_3$)



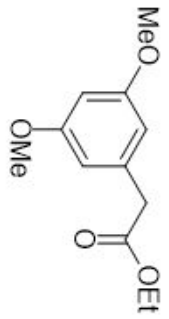
^{13}C NMR Spectrum of **3x (100** MHz, $CDCl_3$)

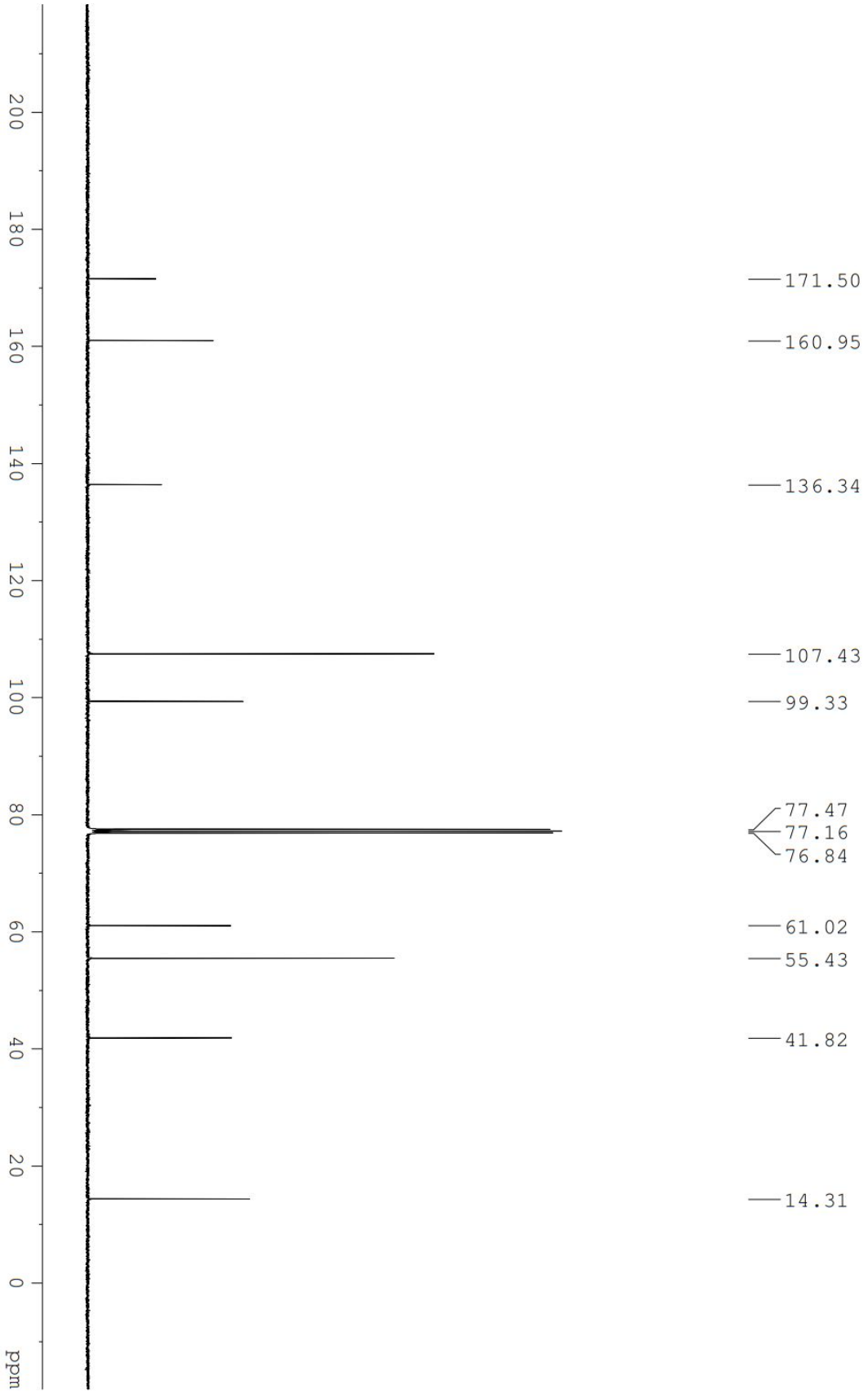


^{1}H NMR Spectrum of **3y (400** MHz, $CDCl_3$)

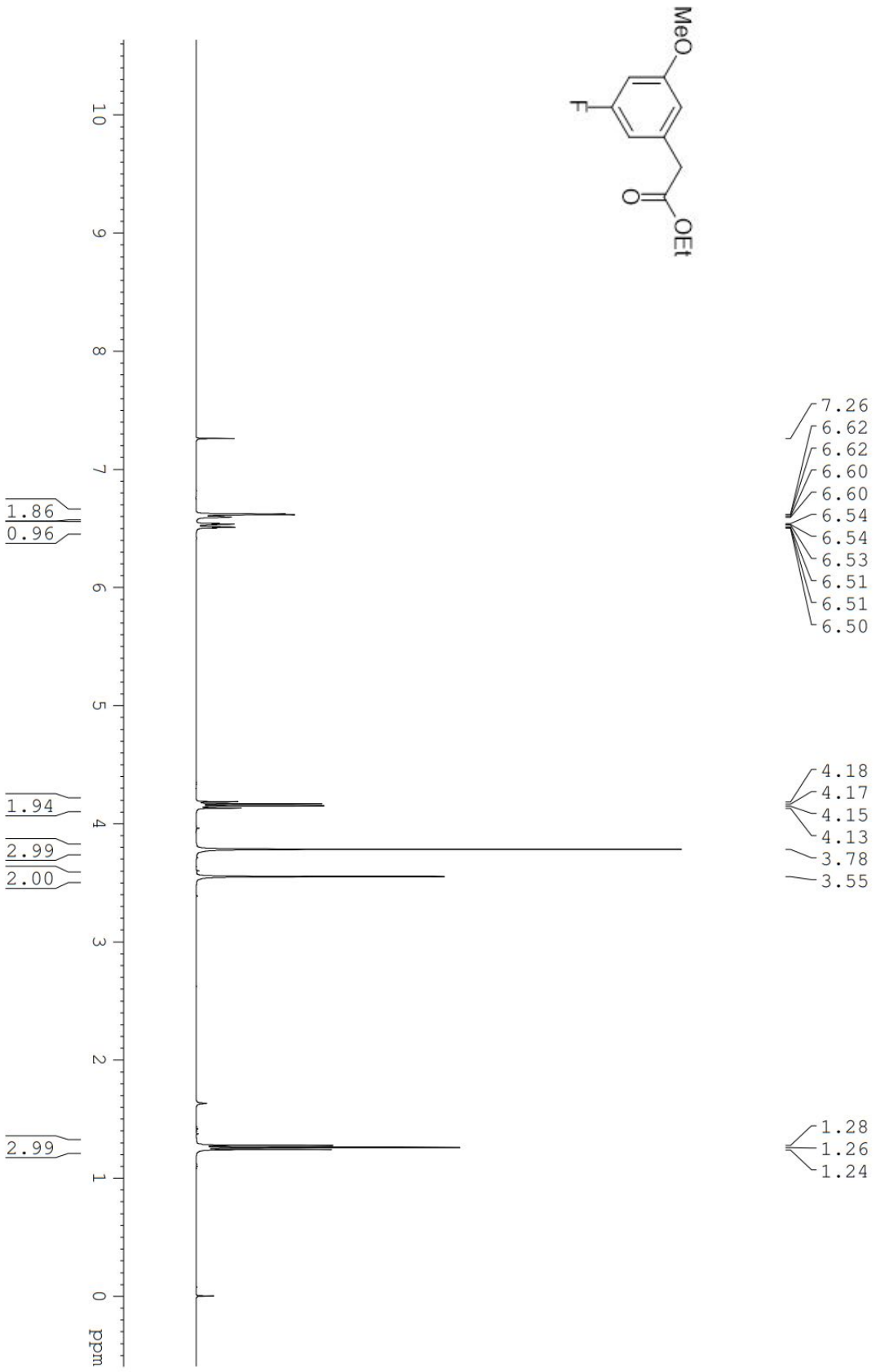


^{13}C NMR Spectrum of **3y (100** MHz, $CDCl_3$)

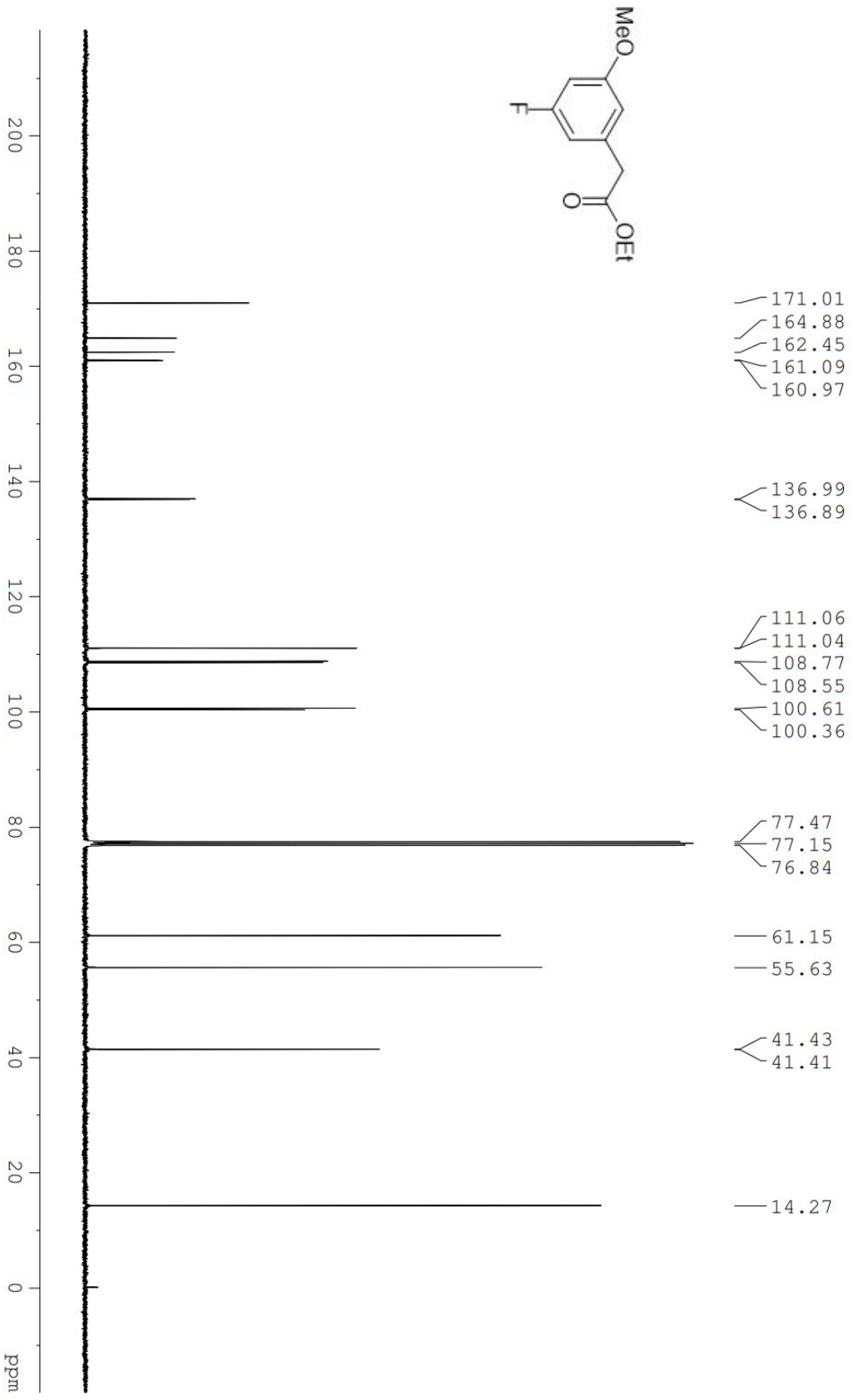




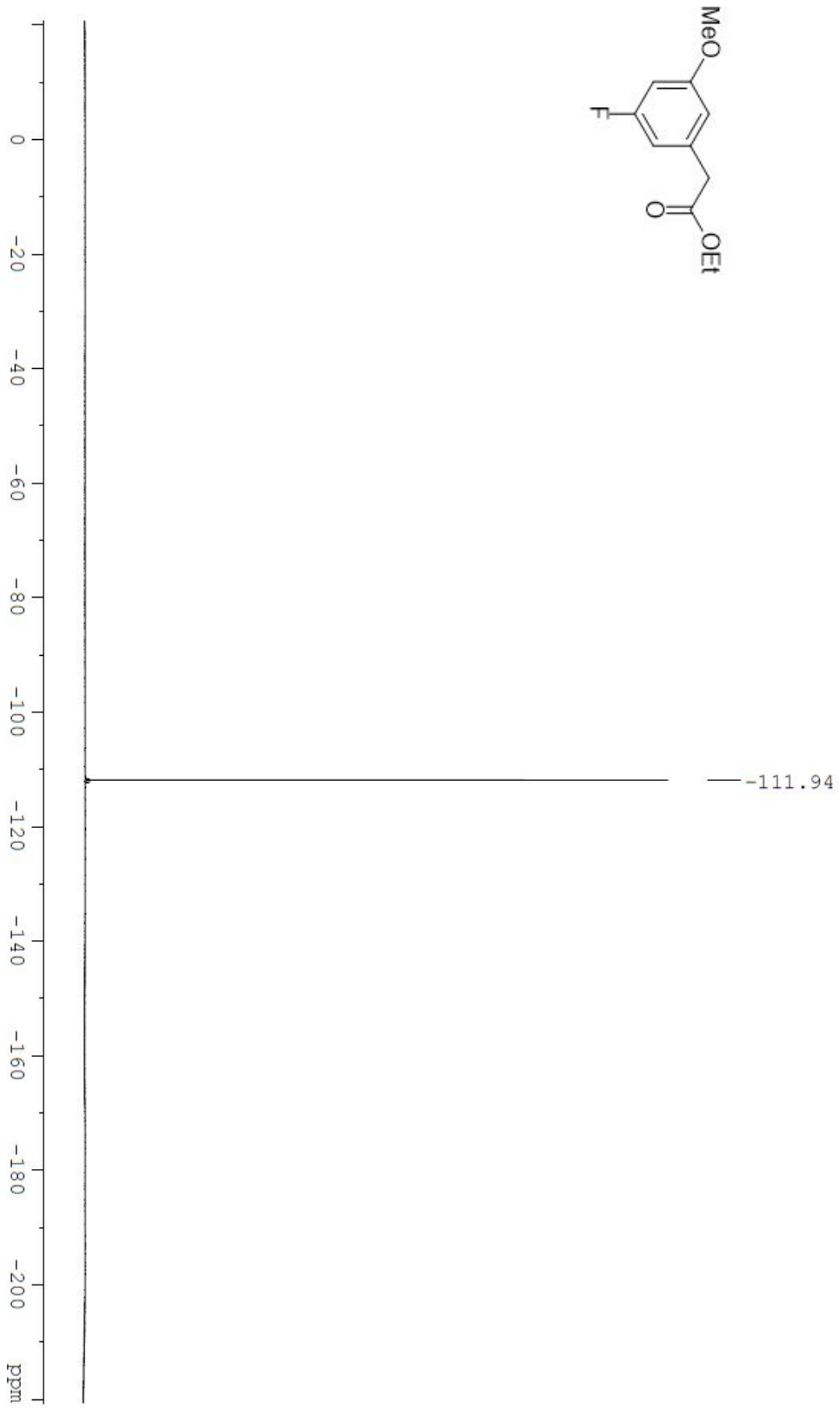
^{1}H NMR Spectrum of **3z (400** MHz, $CDCl_3$)



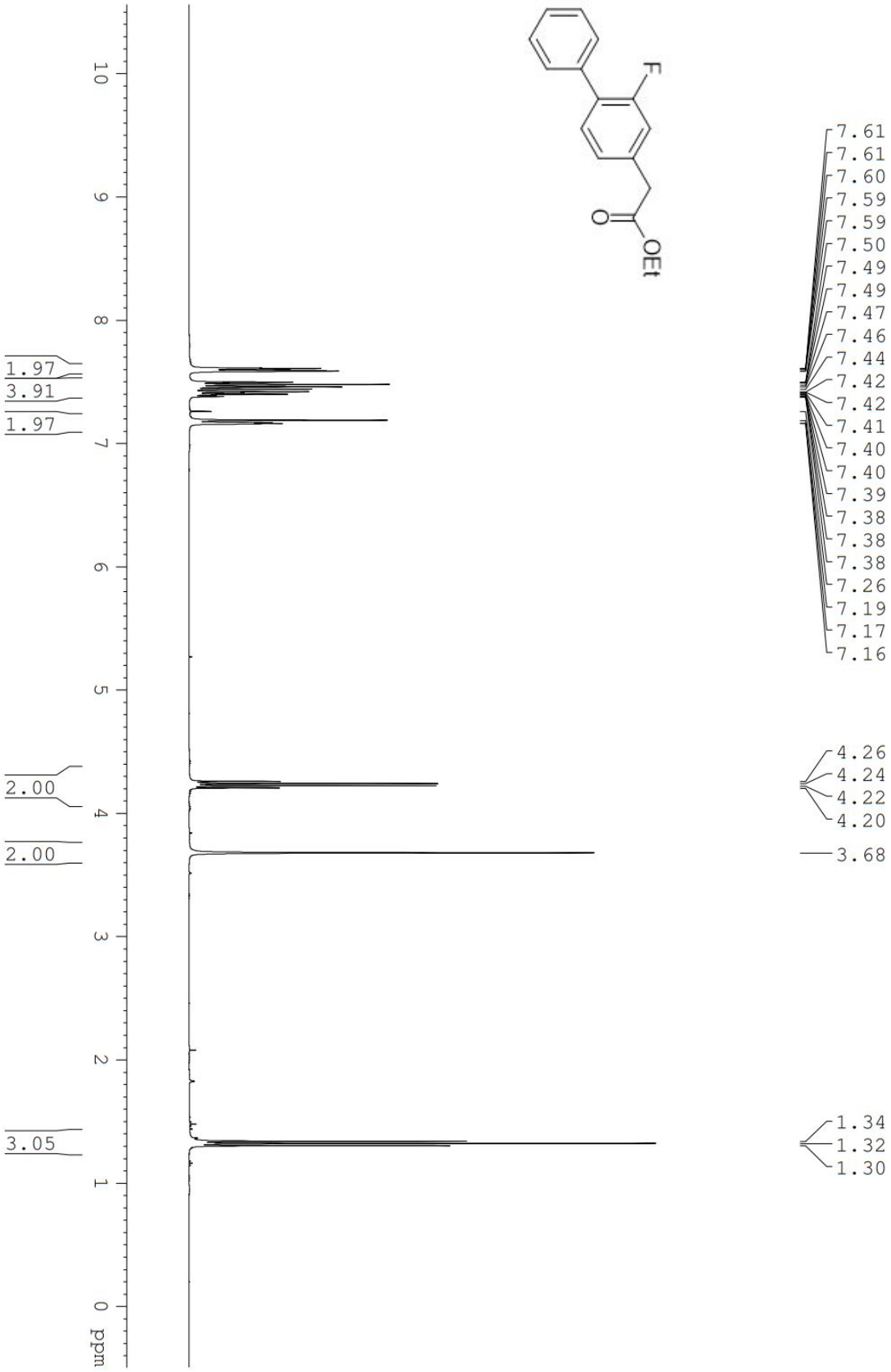
^{13}C NMR Spectrum of **3z (100** MHz, $CDCl_3$)



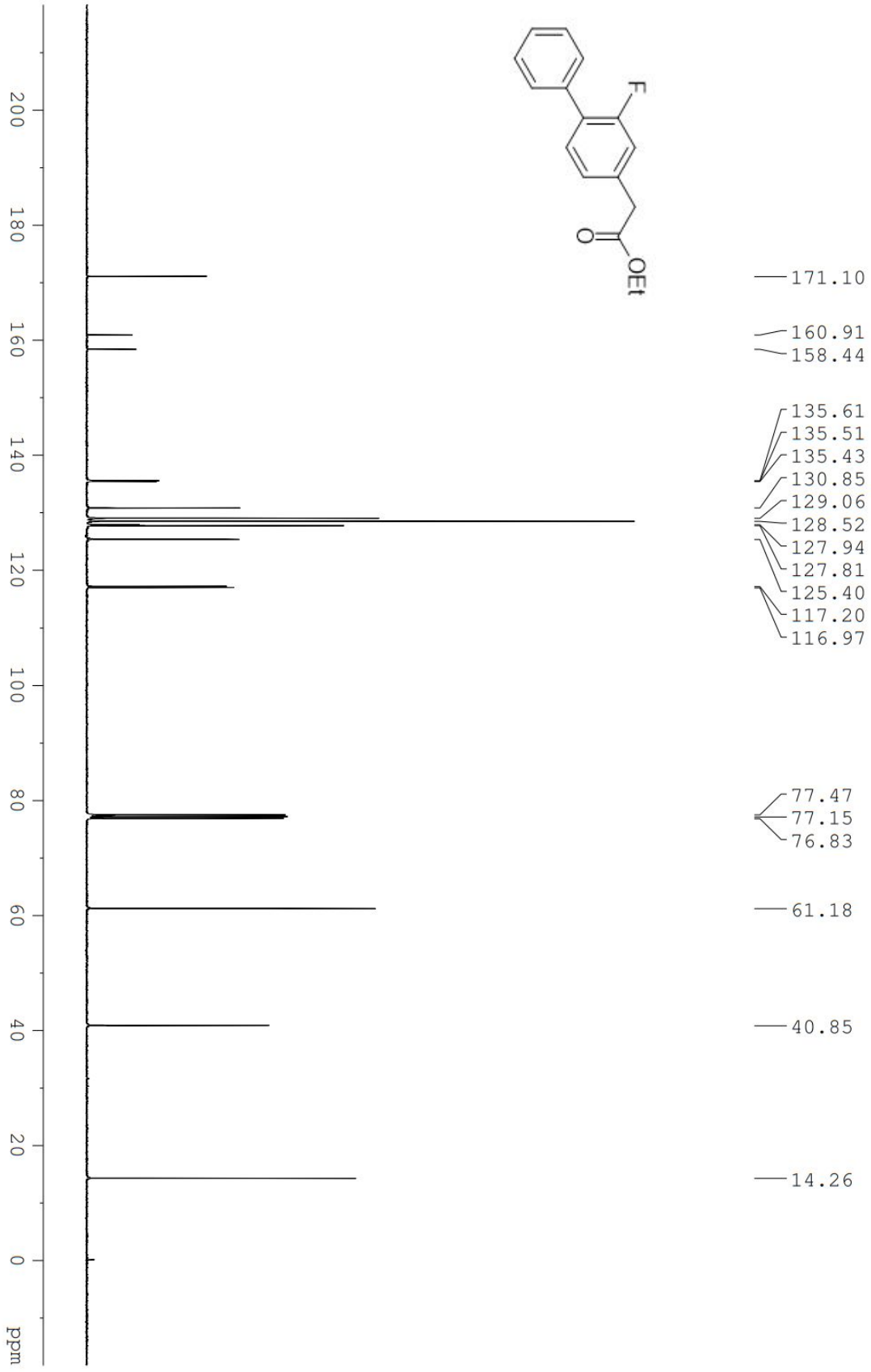
^{19}F NMR Spectrum of **3z (376** MHz, $CDCl_3$)



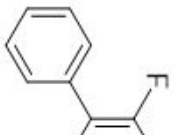
^{1}H NMR Spectrum of **3aa (400** MHz, $CDCl_3$)

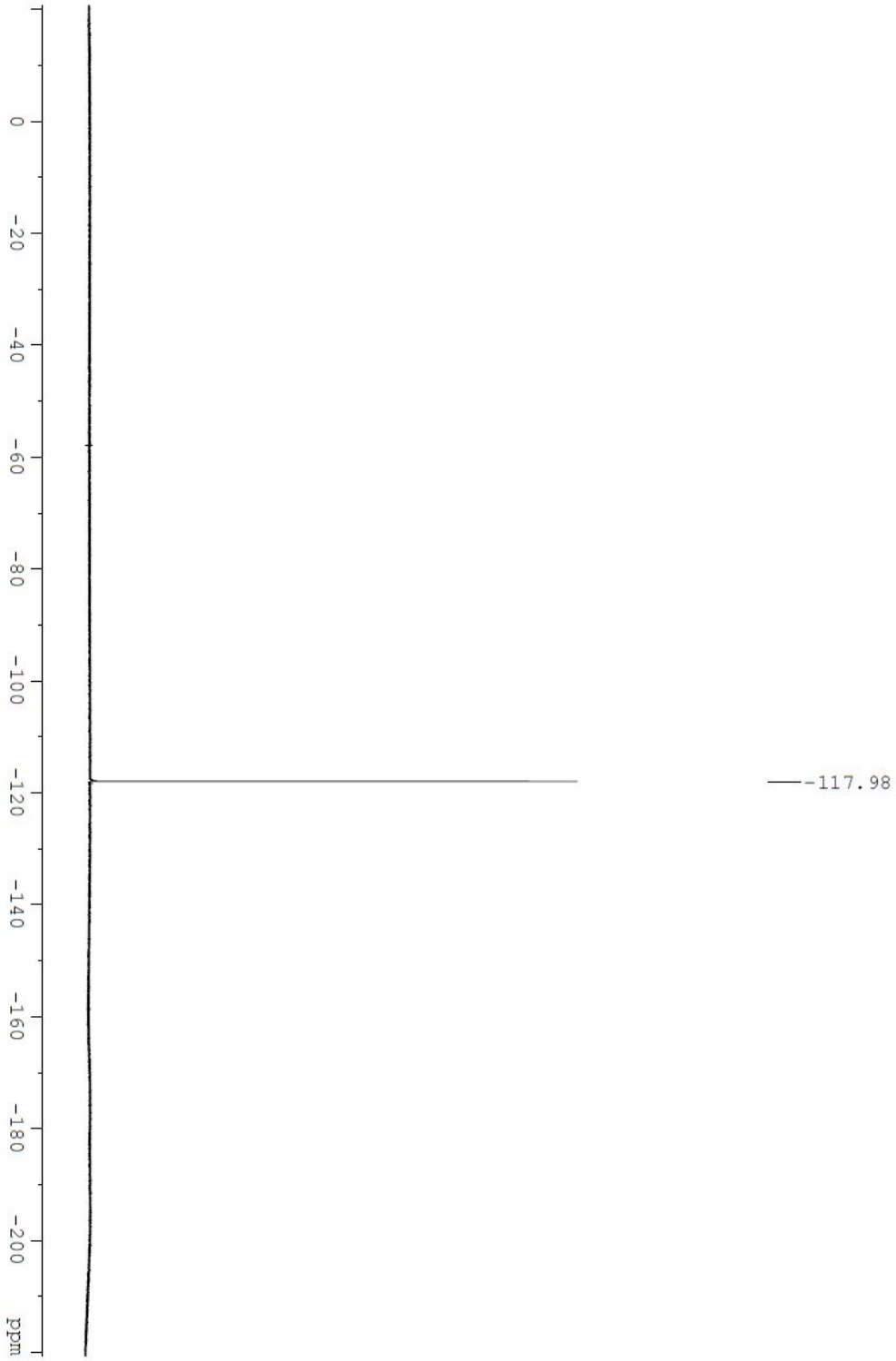


^{13}C NMR Spectrum of **3aa (100** MHz, $CDCl_3$)

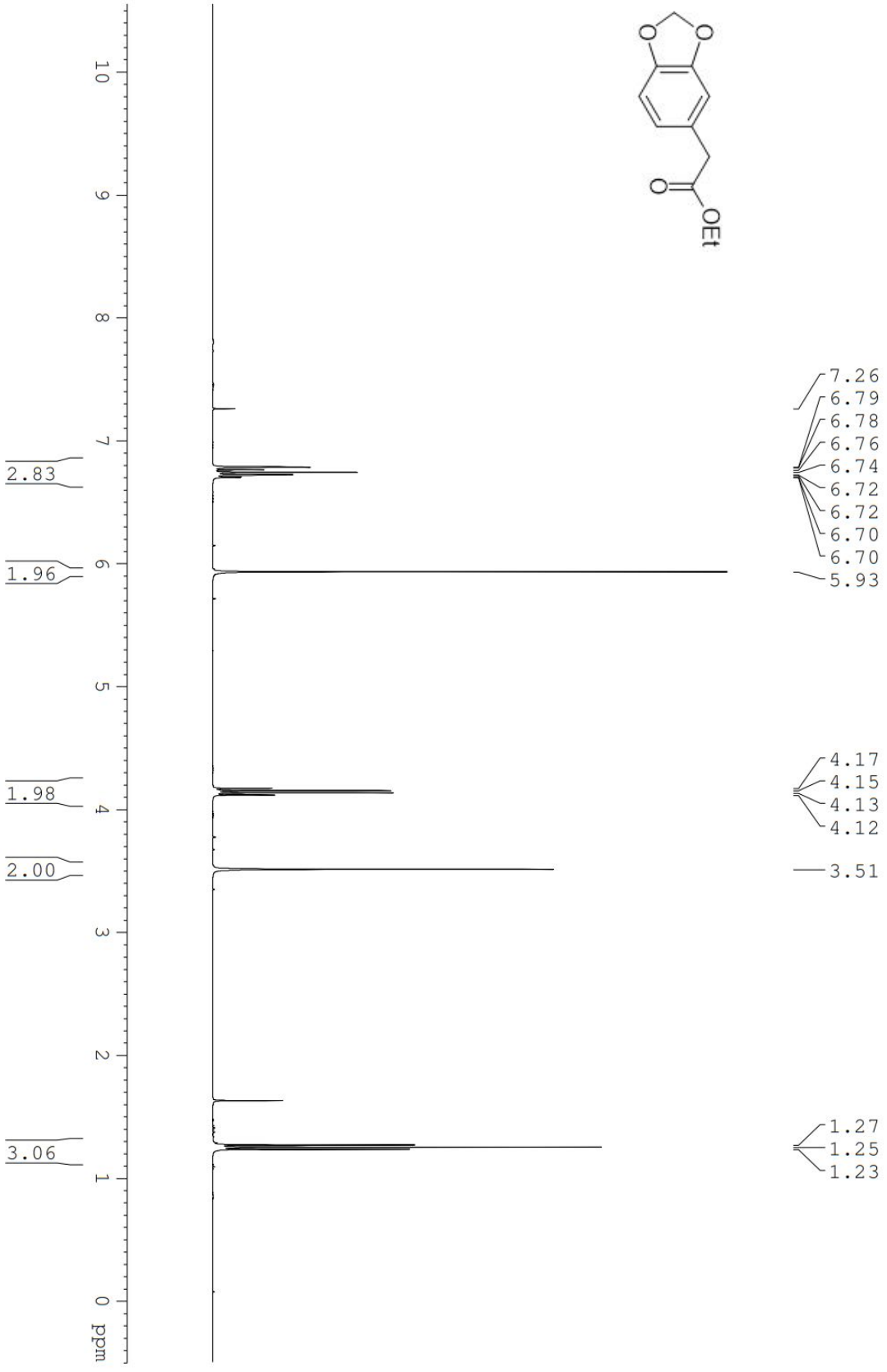


^{19}F NMR Spectrum of **3aa (376** MHz, $CDCl_3$)

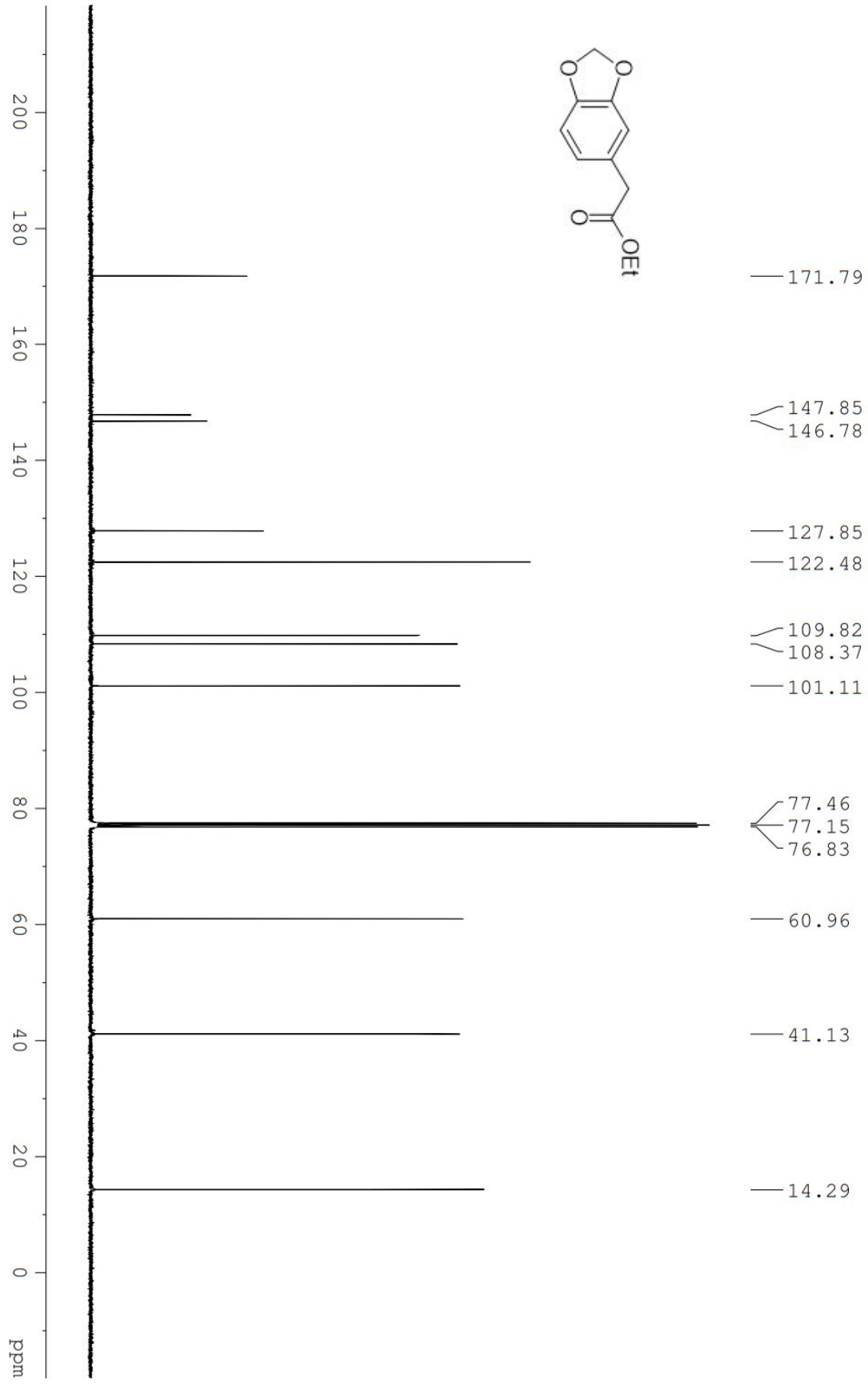




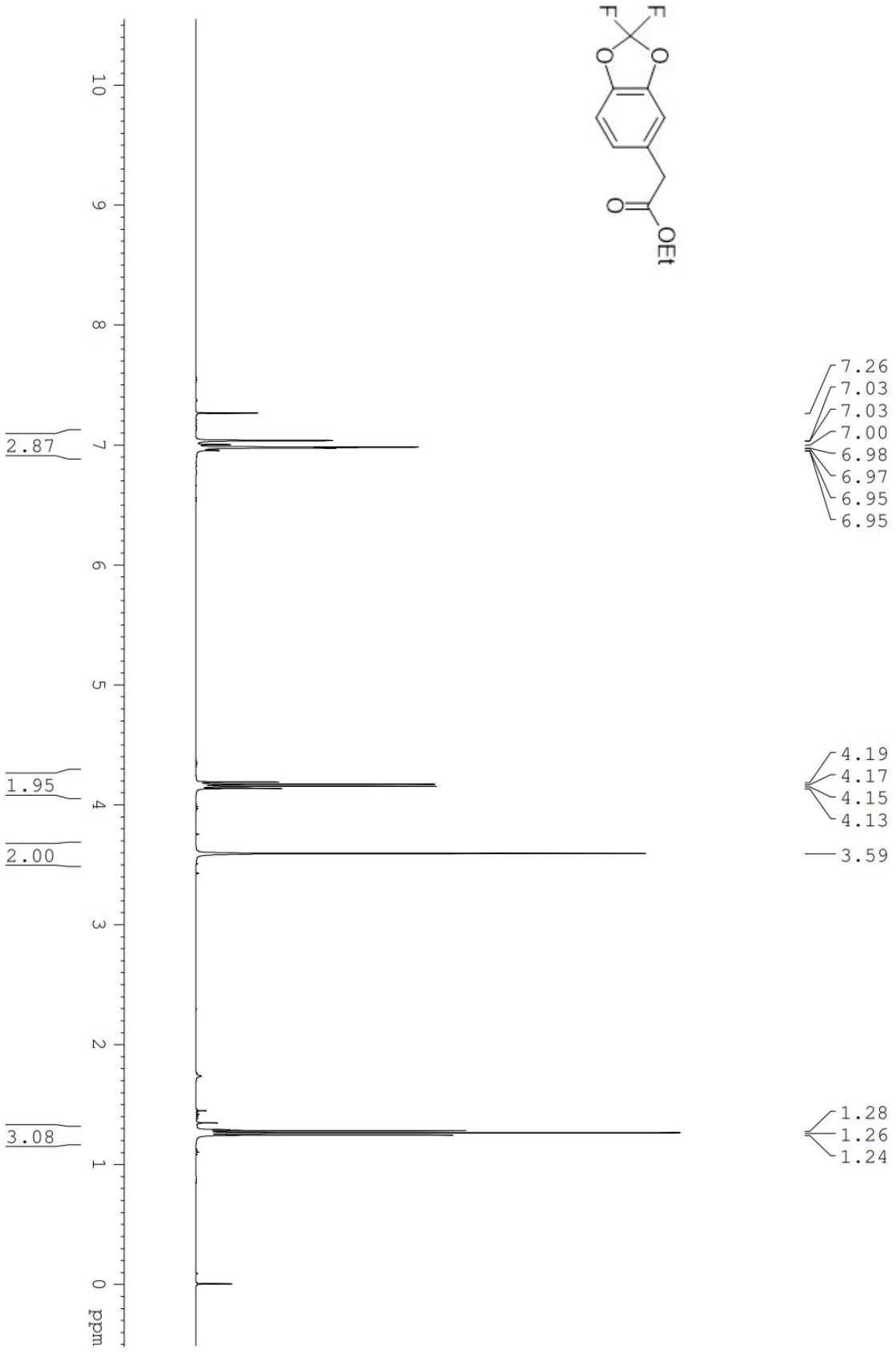
^{1}H NMR Spectrum of **3ab (400** MHz, $CDCl_3$)



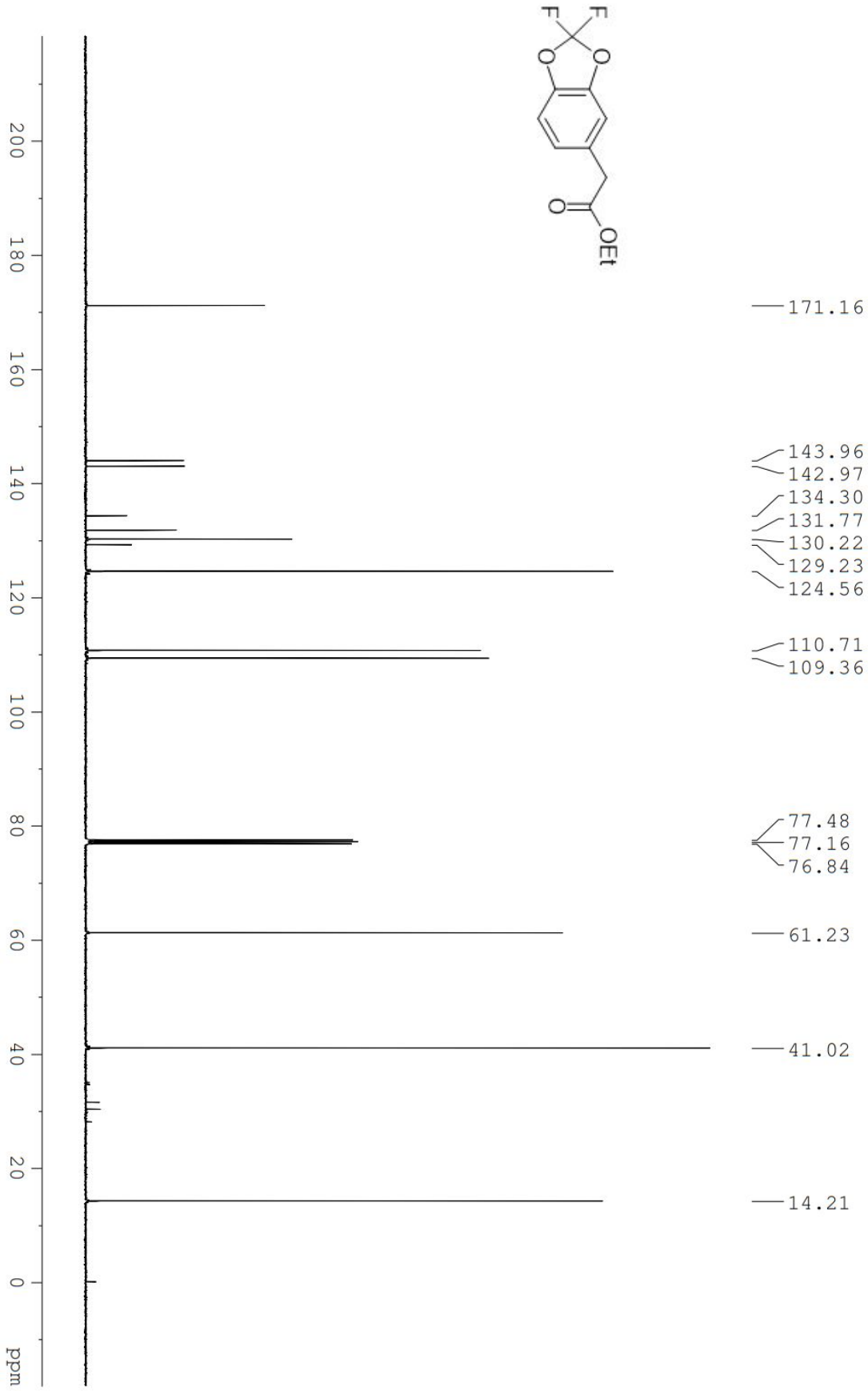
^{13}C NMR Spectrum of **3ab (100** MHz, $CDCl_3$)



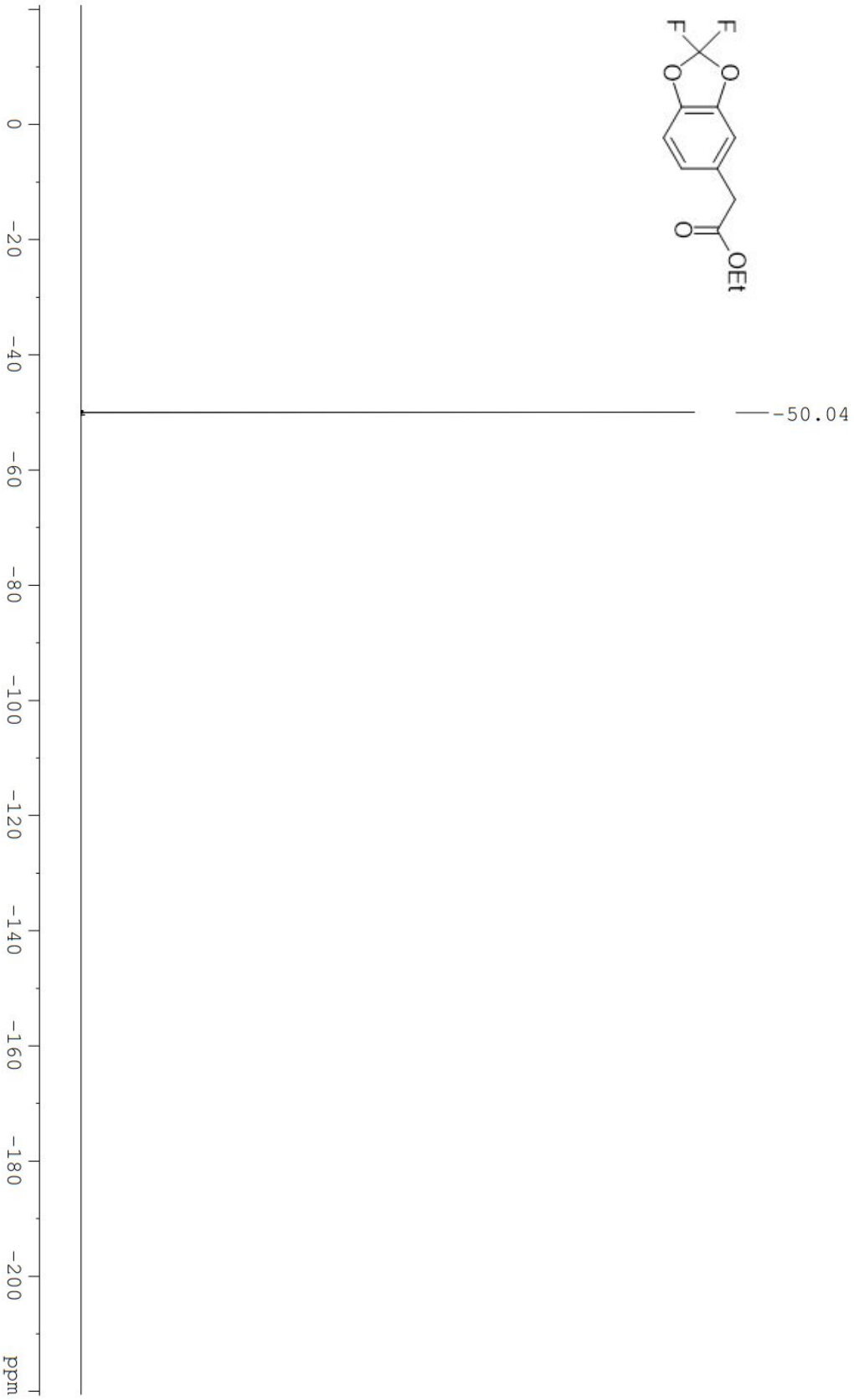
^{1}H NMR Spectrum of **3ac (400** MHz, $CDCl_3$)



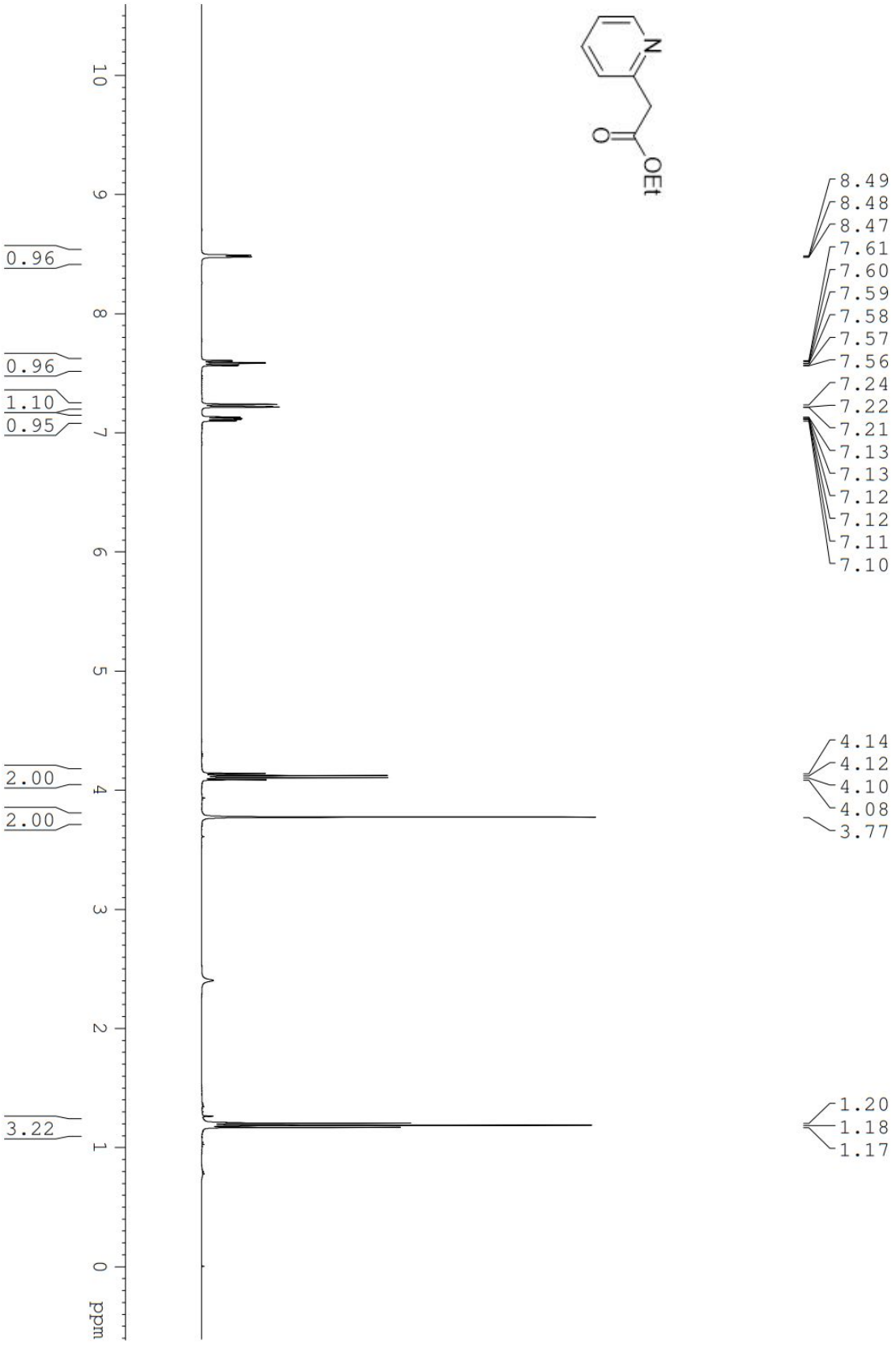
^{13}C NMR Spectrum of **3ac (100** MHz, $CDCl_3$)


F
F
O
O
O
OEt
200
180
160
140
120
100
80
60
40
20
0
ppm
171.16
143.96
142.97
134.30
131.77
130.22
129.23
124.56
110.71
109.36
77.48
77.16
76.84
61.23
41.02
14.21

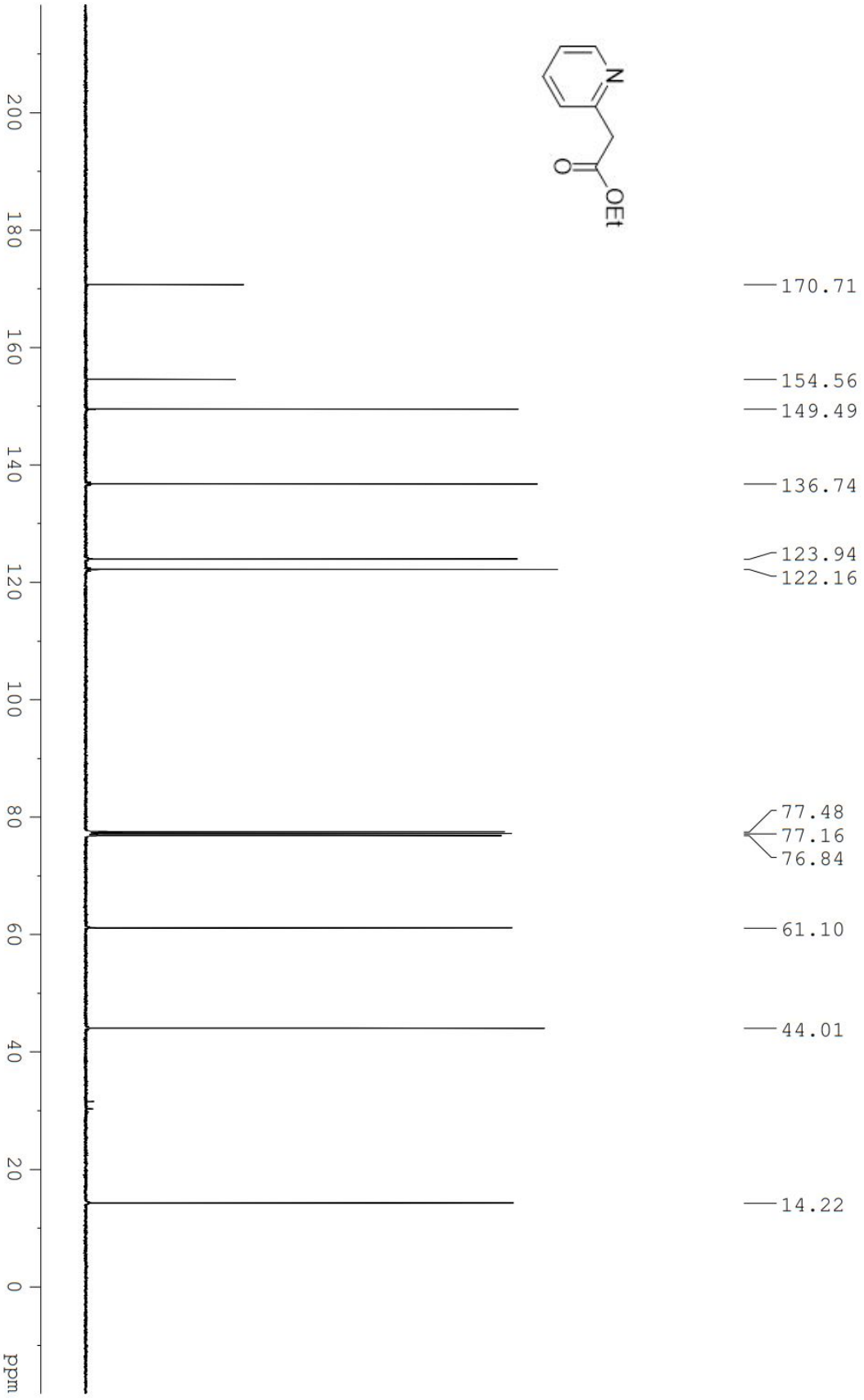
^{19}F NMR Spectrum of **3ac (376** MHz, $CDCl_3$)



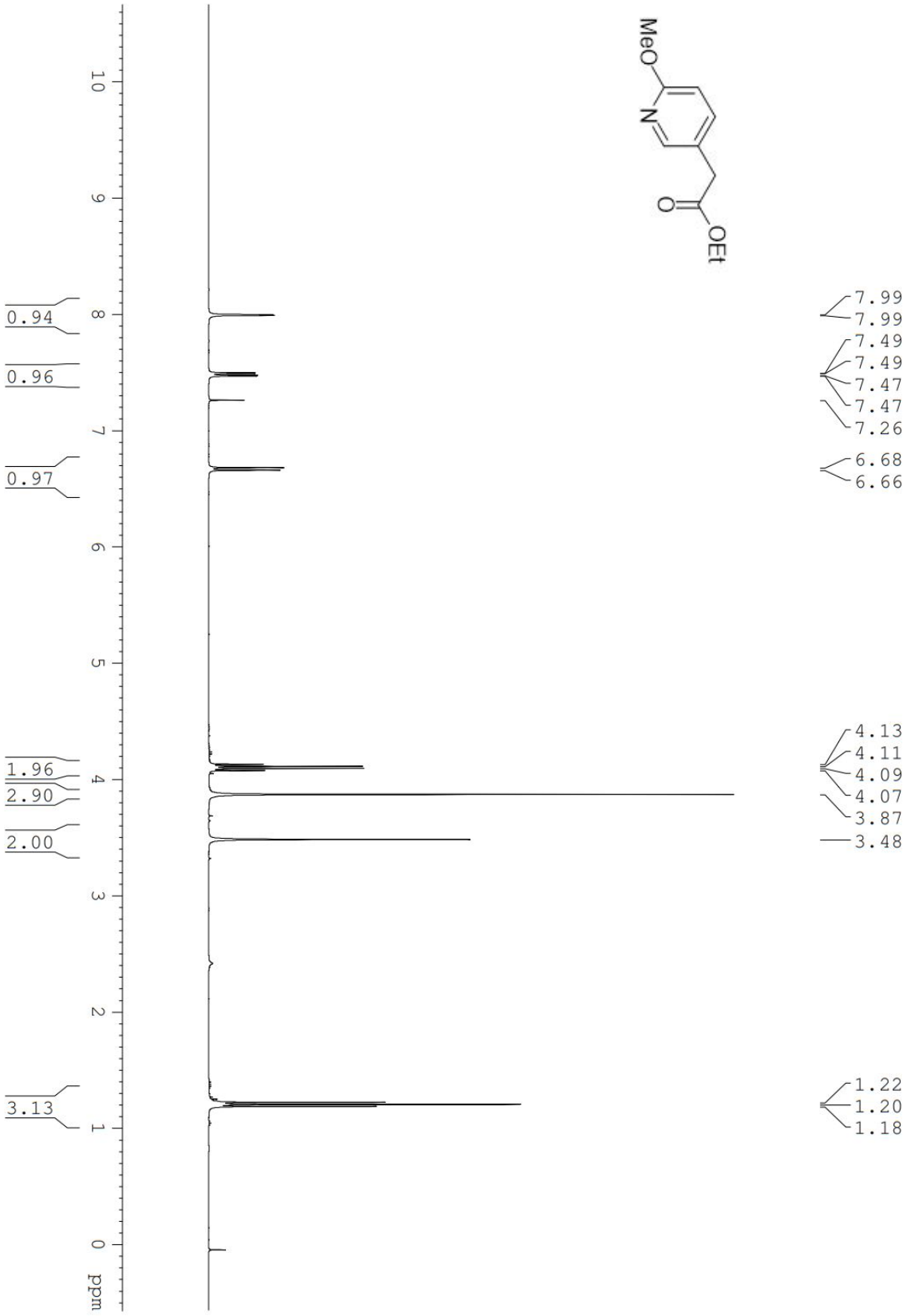
^{1}H NMR Spectrum of **3ad (400** MHz, $CDCl_3$)



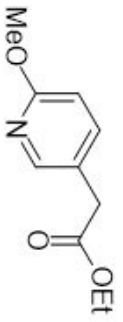
^{13}C NMR Spectrum of **3ad (100** MHz, $CDCl_3$)

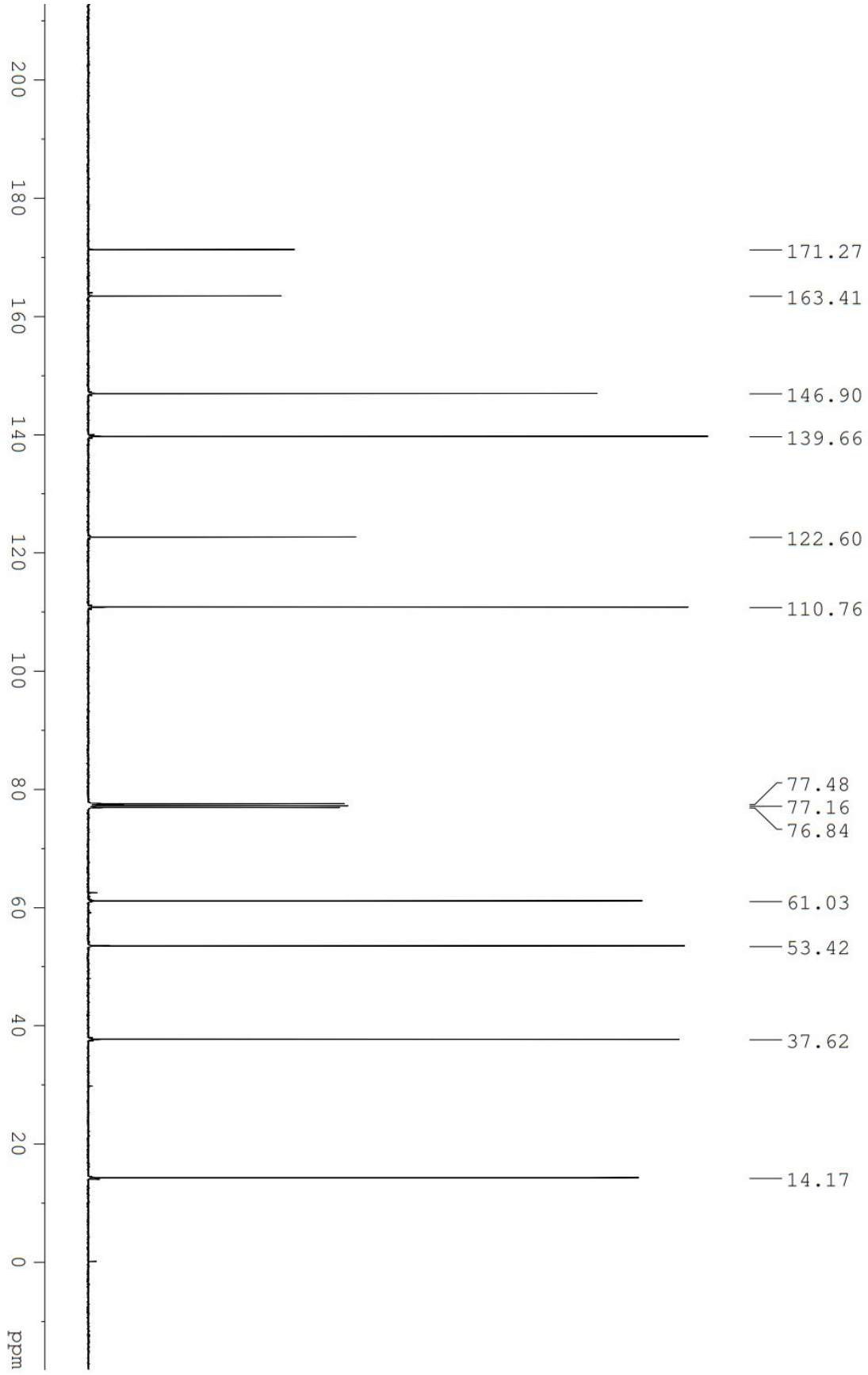


^{1}H NMR Spectrum of **3ae (400** MHz, $CDCl_3$)

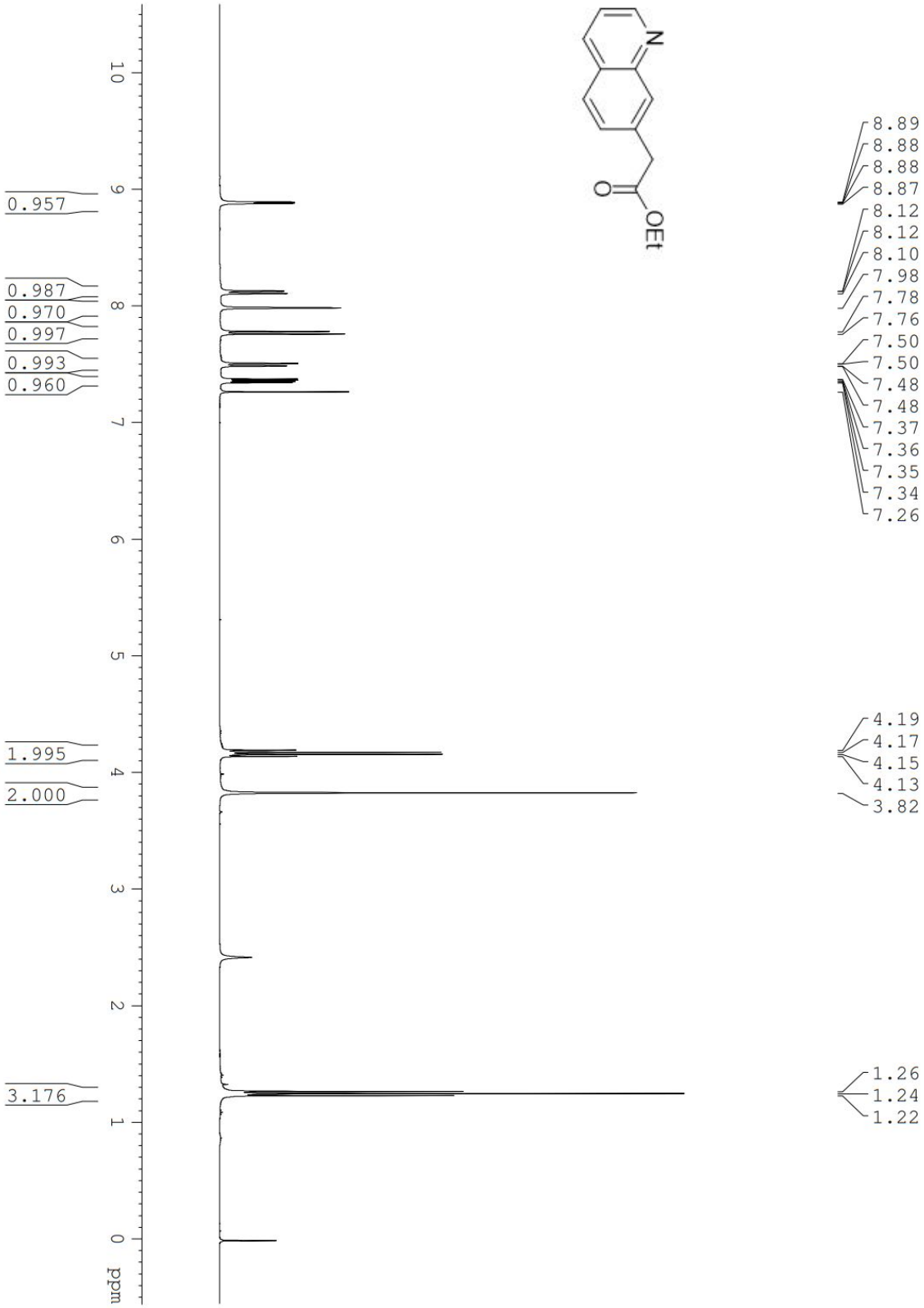


^{13}C NMR Spectrum of **3ae (100** MHz, $CDCl_3$)

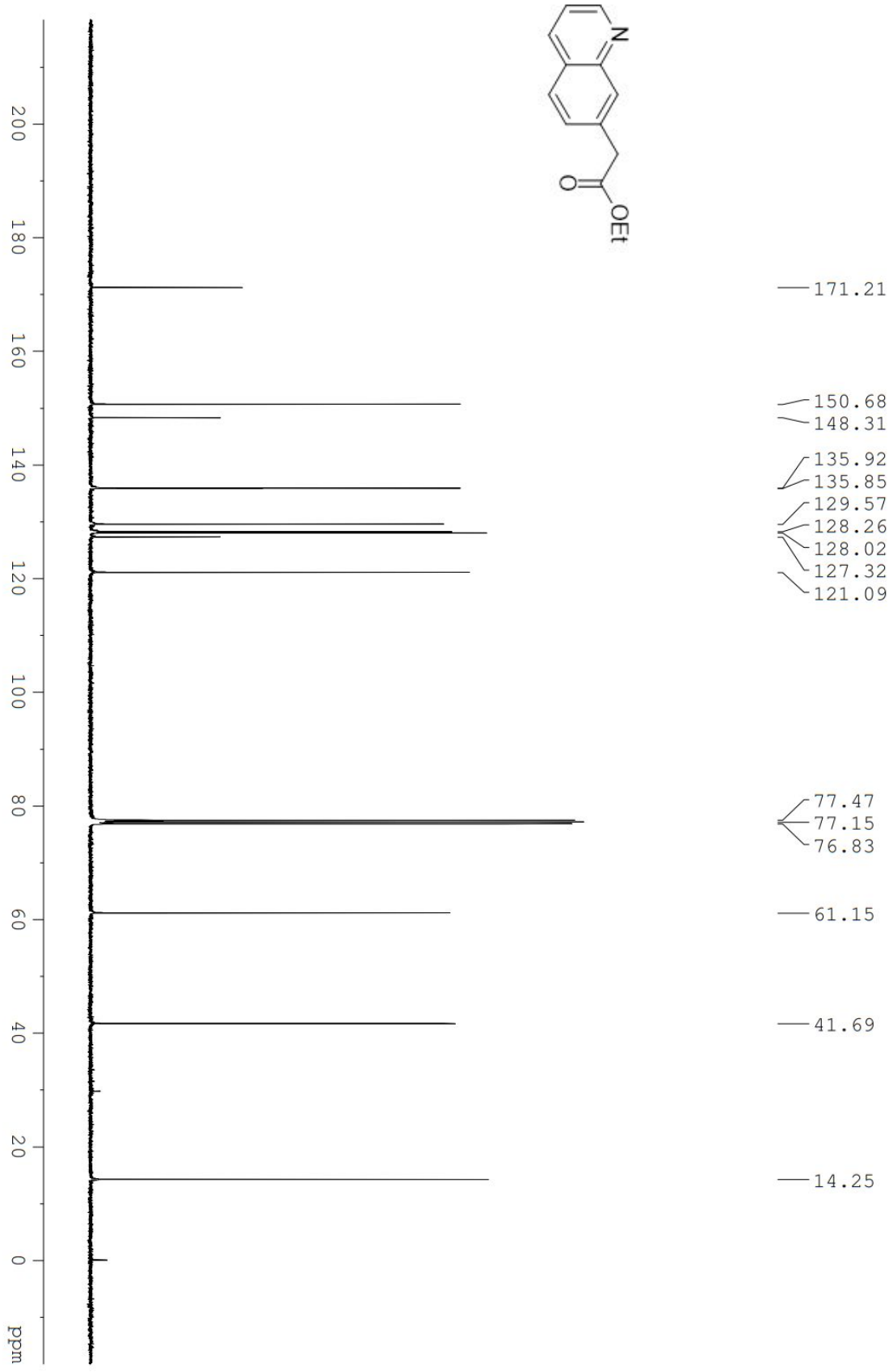




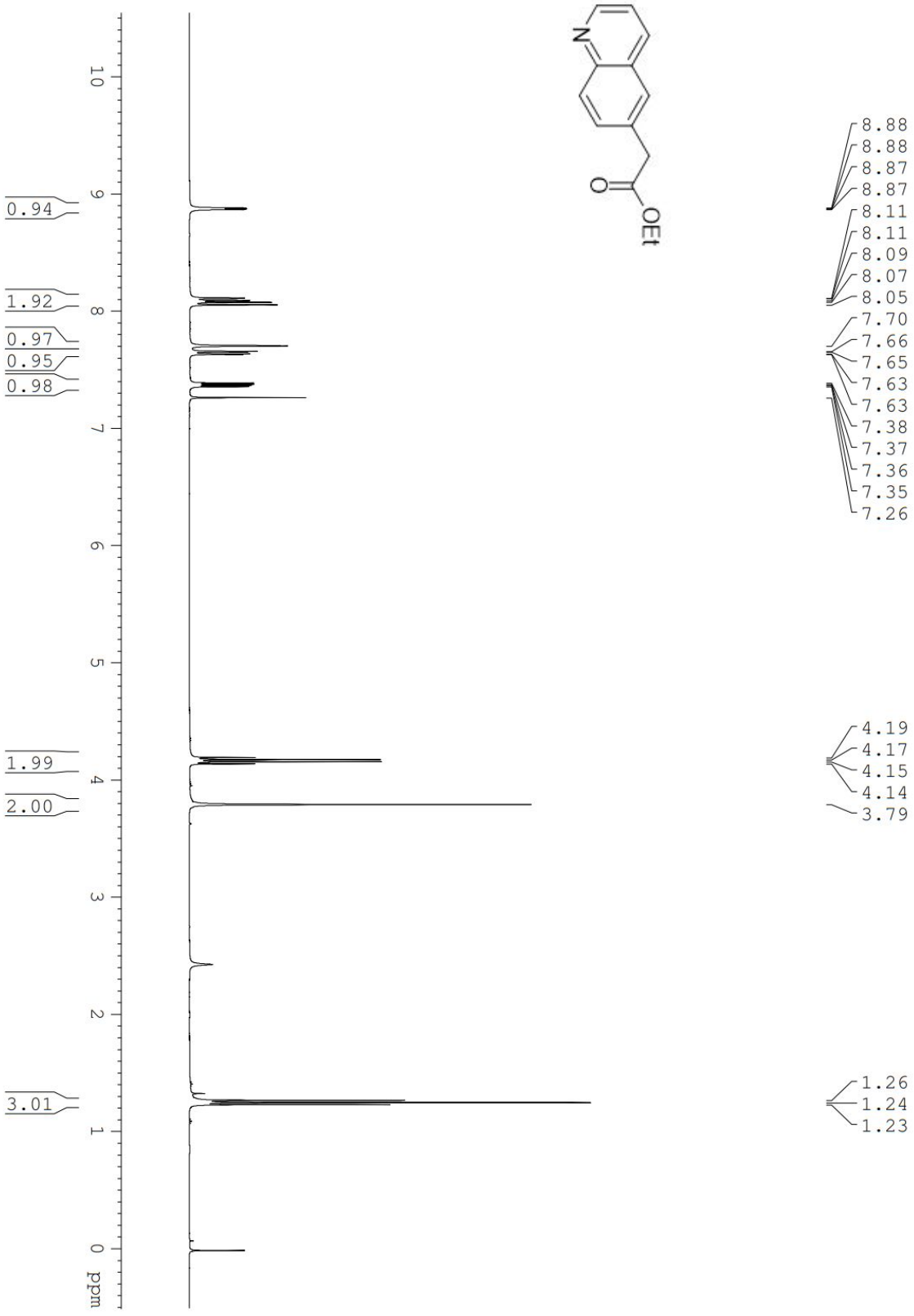
^{1}H NMR Spectrum of **3af (400** MHz, $CDCl_3$)



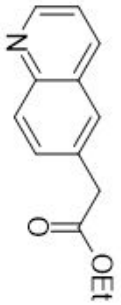
^{13}C NMR Spectrum of **3af (100** MHz, $CDCl_3$)

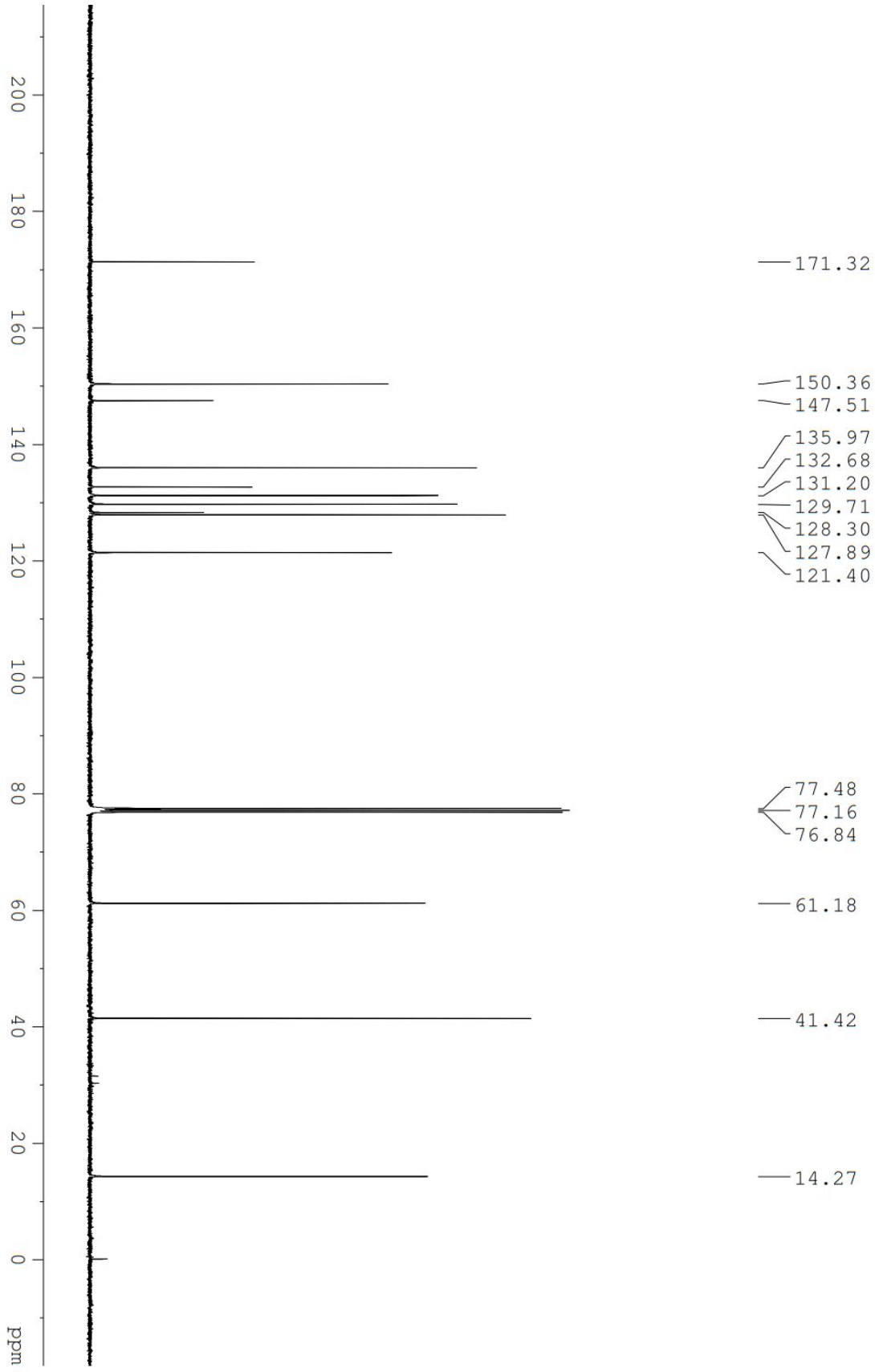

N
O
OEt
171.21
150.68
148.31
135.92
135.85
129.57
128.26
128.02
127.32
121.09
77.47
77.15
76.83
61.15
41.69
14.25
200
180
160
140
120
100
80
60
40
20
0
ppm

^{1}H NMR Spectrum of **3ag (400** MHz, $CDCl_3$)

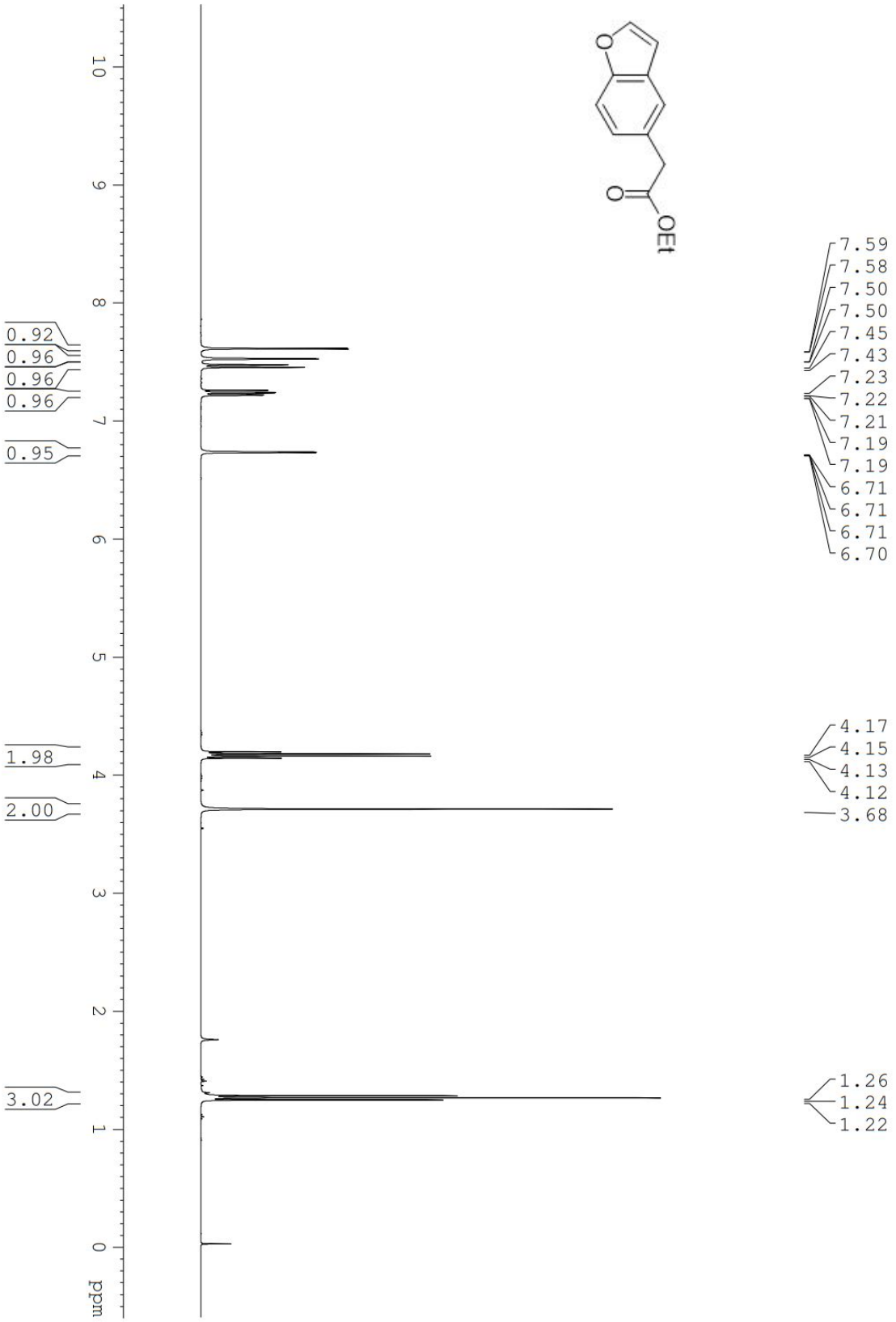


^{13}C NMR Spectrum of **3ag (100** MHz, $CDCl_3$)

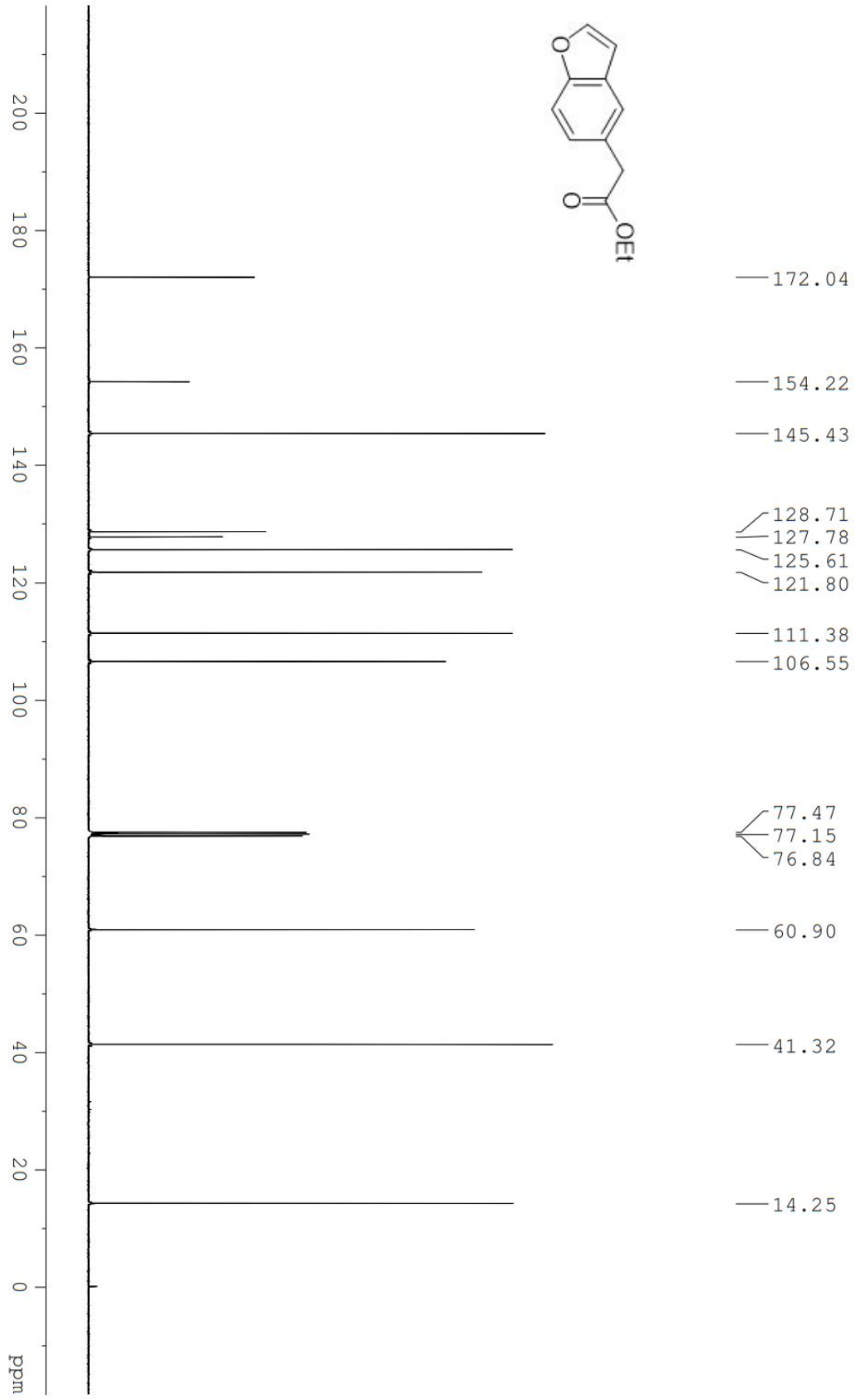




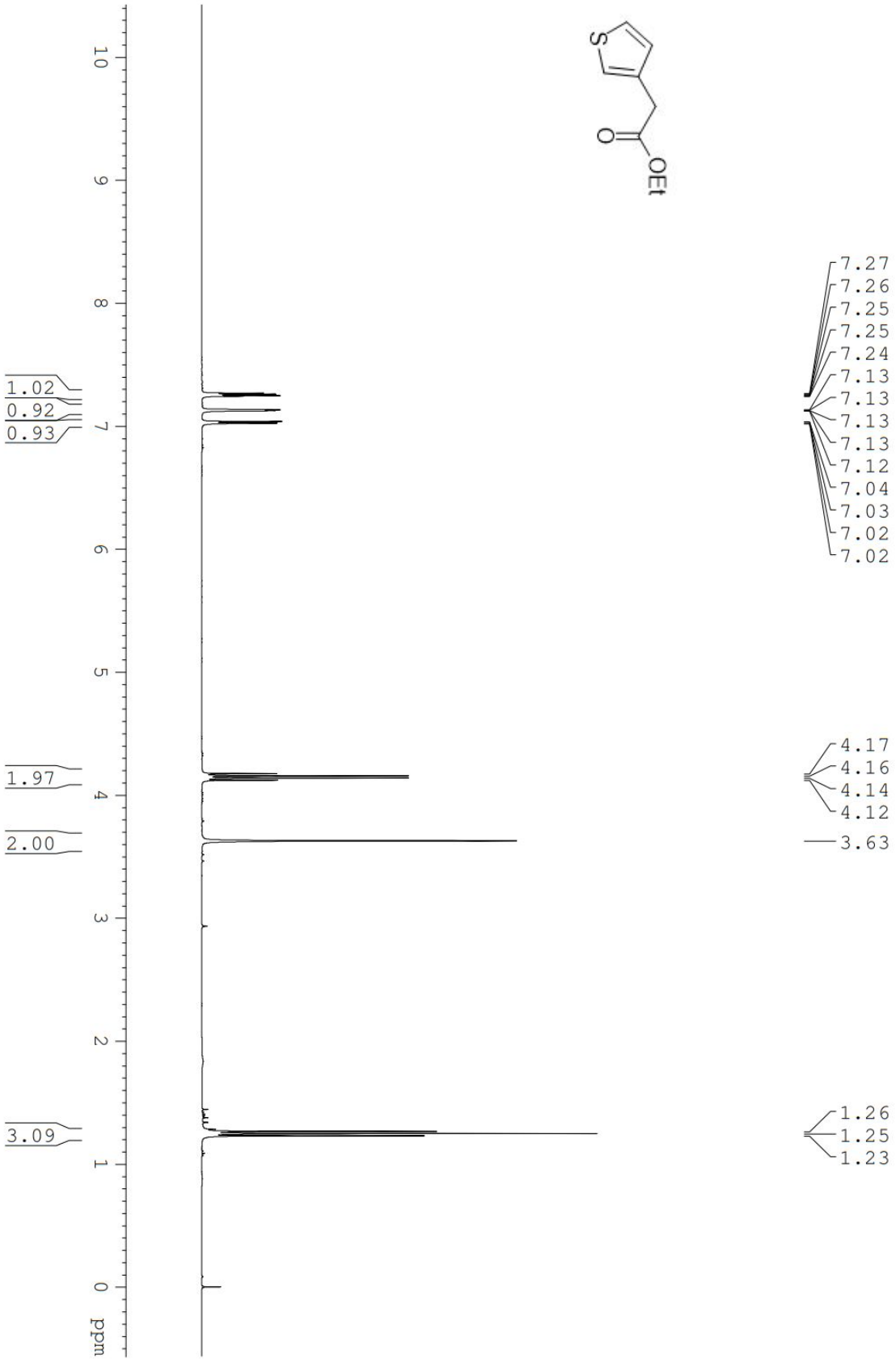
^{1}H NMR Spectrum of **3ah (400** MHz, $CDCl_3$)



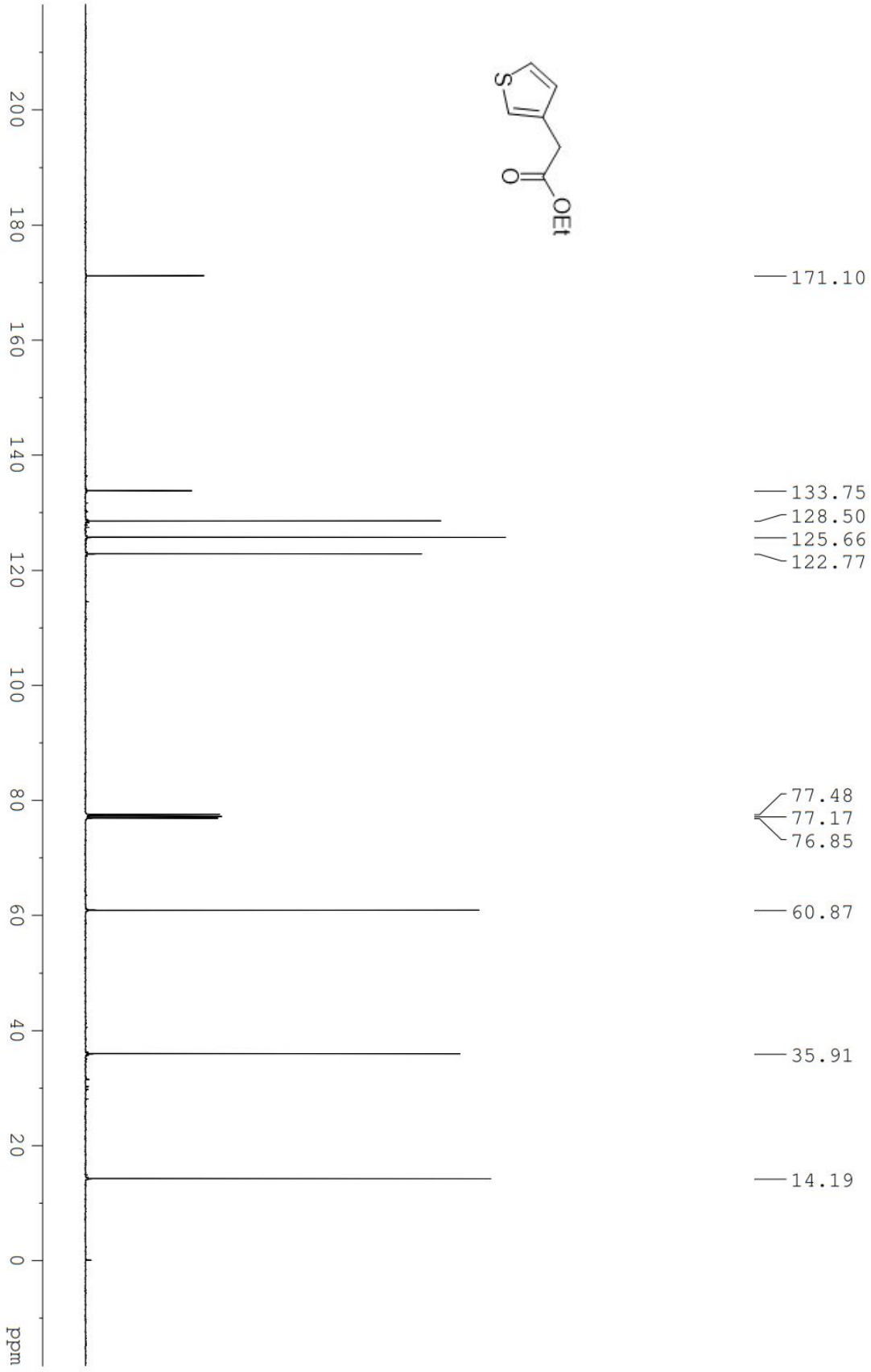
^{13}C NMR Spectrum of **3ah (100** MHz, $CDCl_3$)



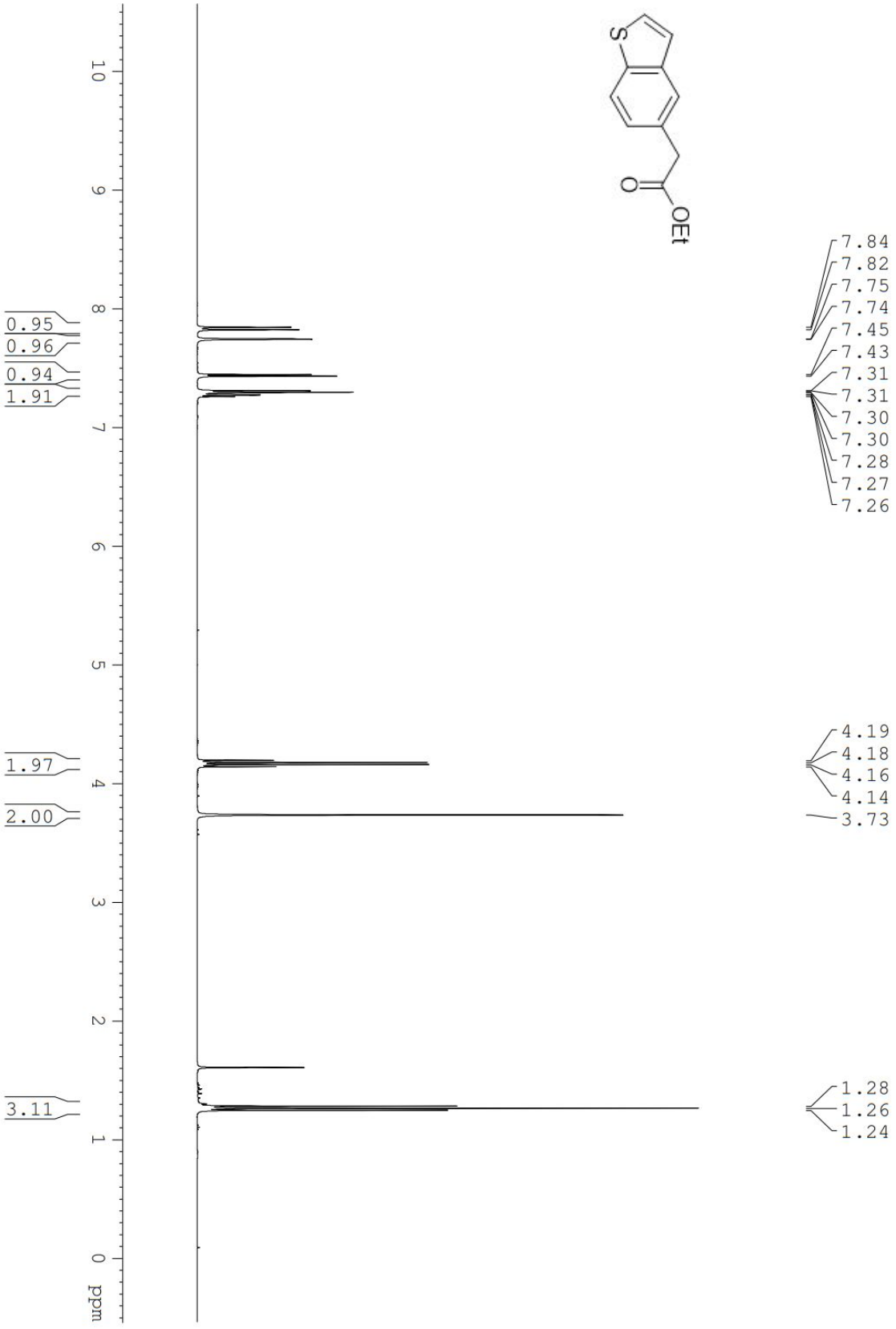
^{1}H NMR Spectrum of **3ai (400** MHz, $CDCl_3$)



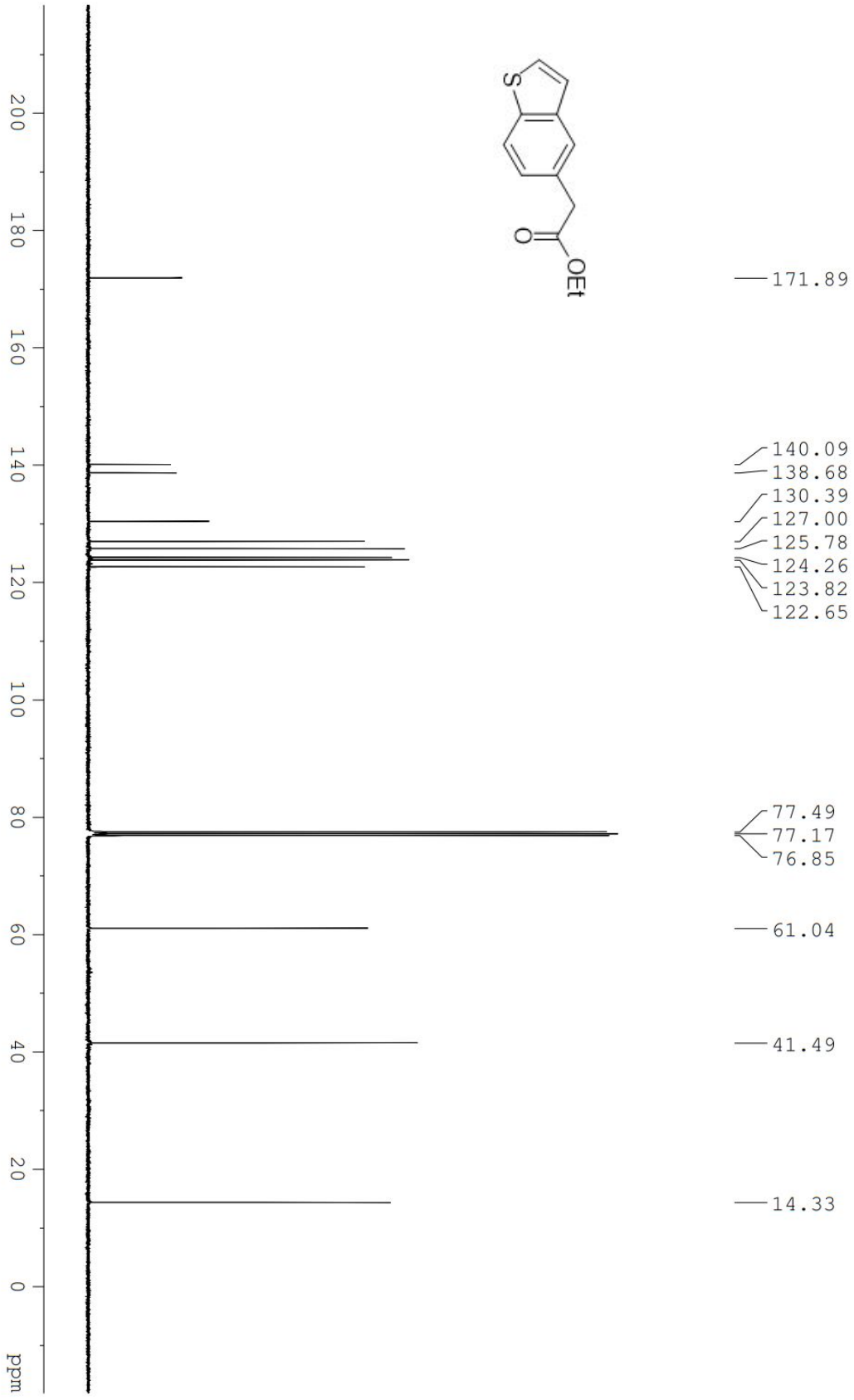
^{13}C NMR Spectrum of **3ai (100** MHz, $CDCl_3$)



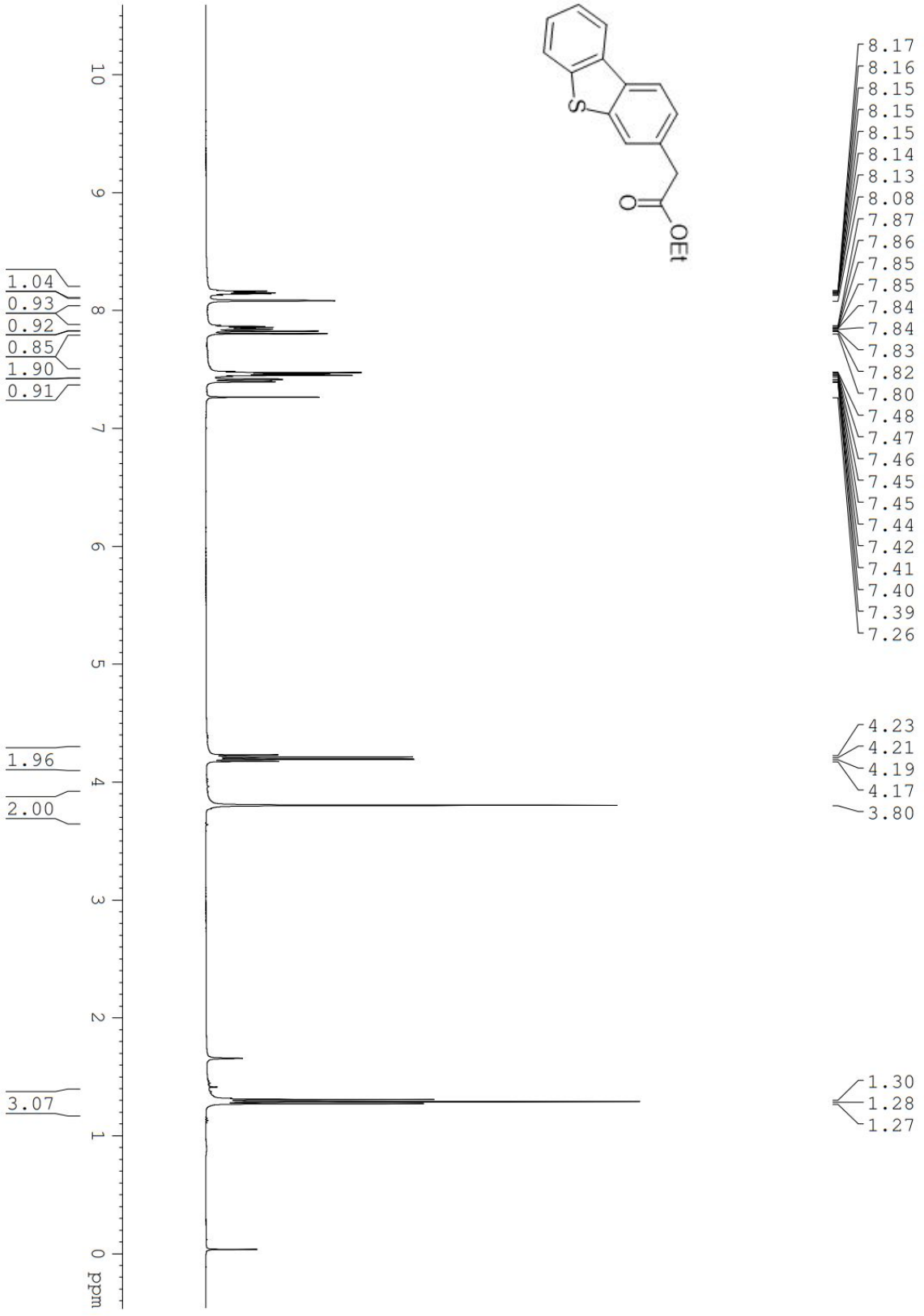
^{1}H NMR Spectrum of **3aj (400** MHz, $CDCl_3$)



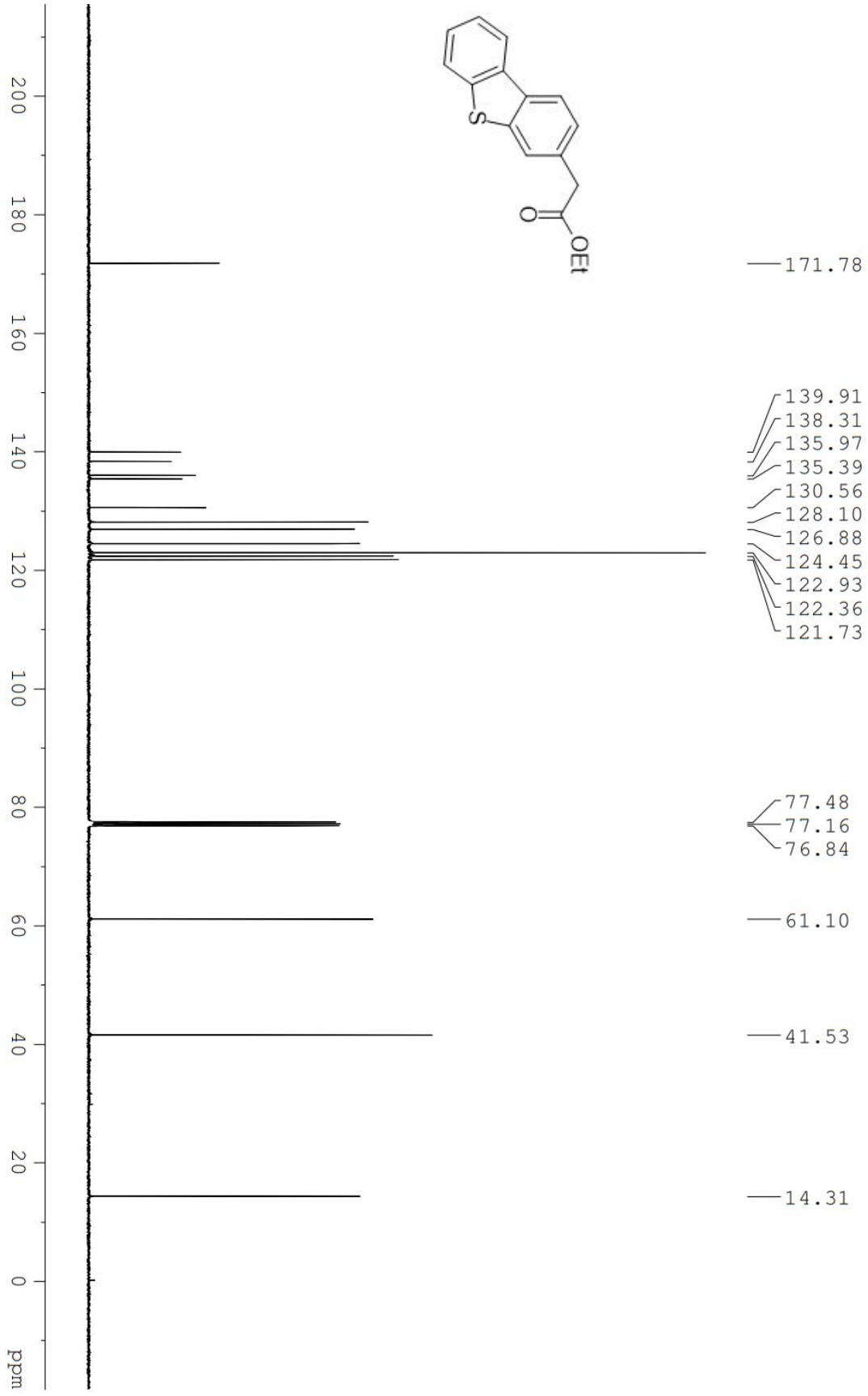
^{13}C NMR Spectrum of **3aj (100** MHz, $CDCl_3$)



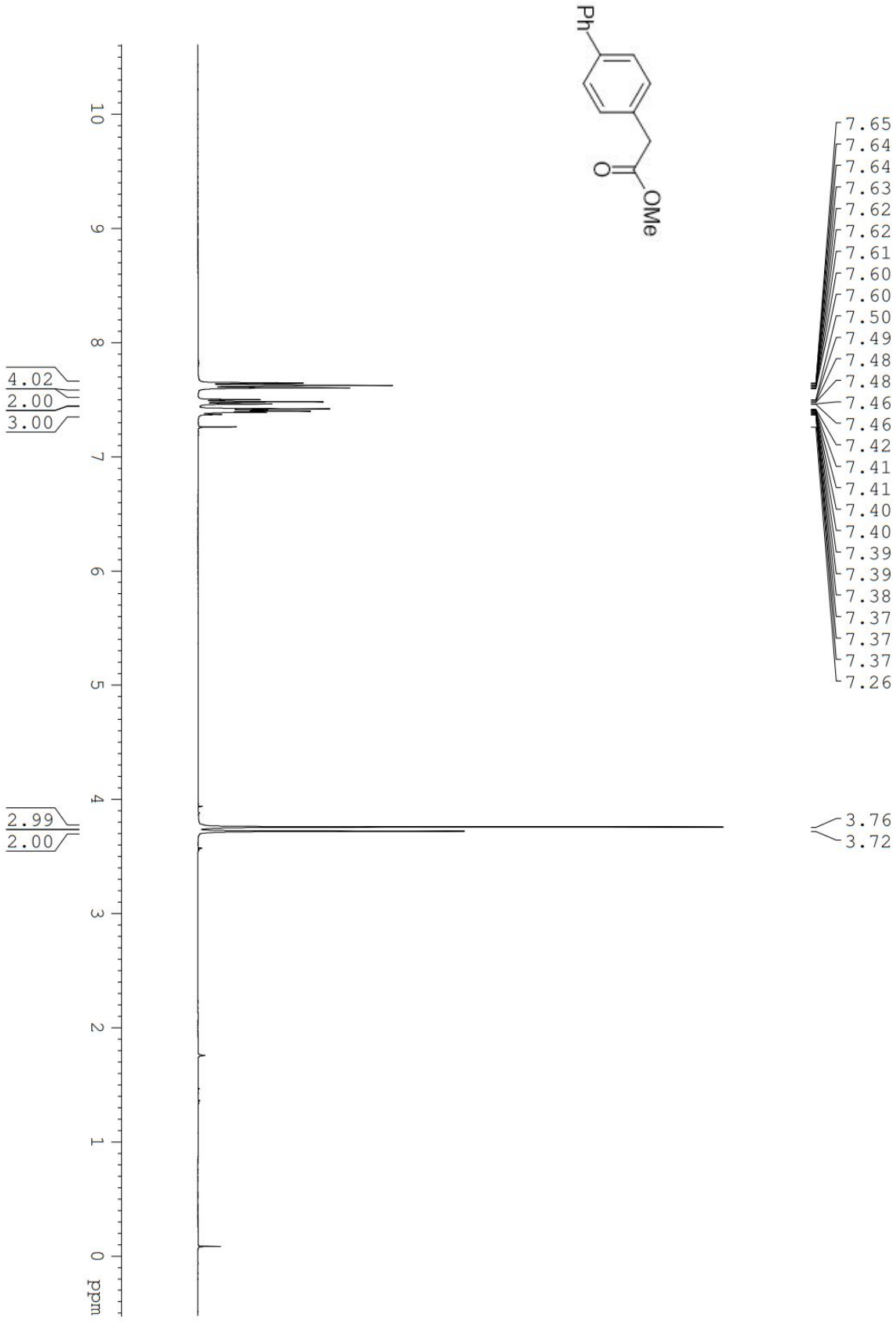
^{1}H NMR Spectrum of **3ak (400** MHz, $CDCl_3$)



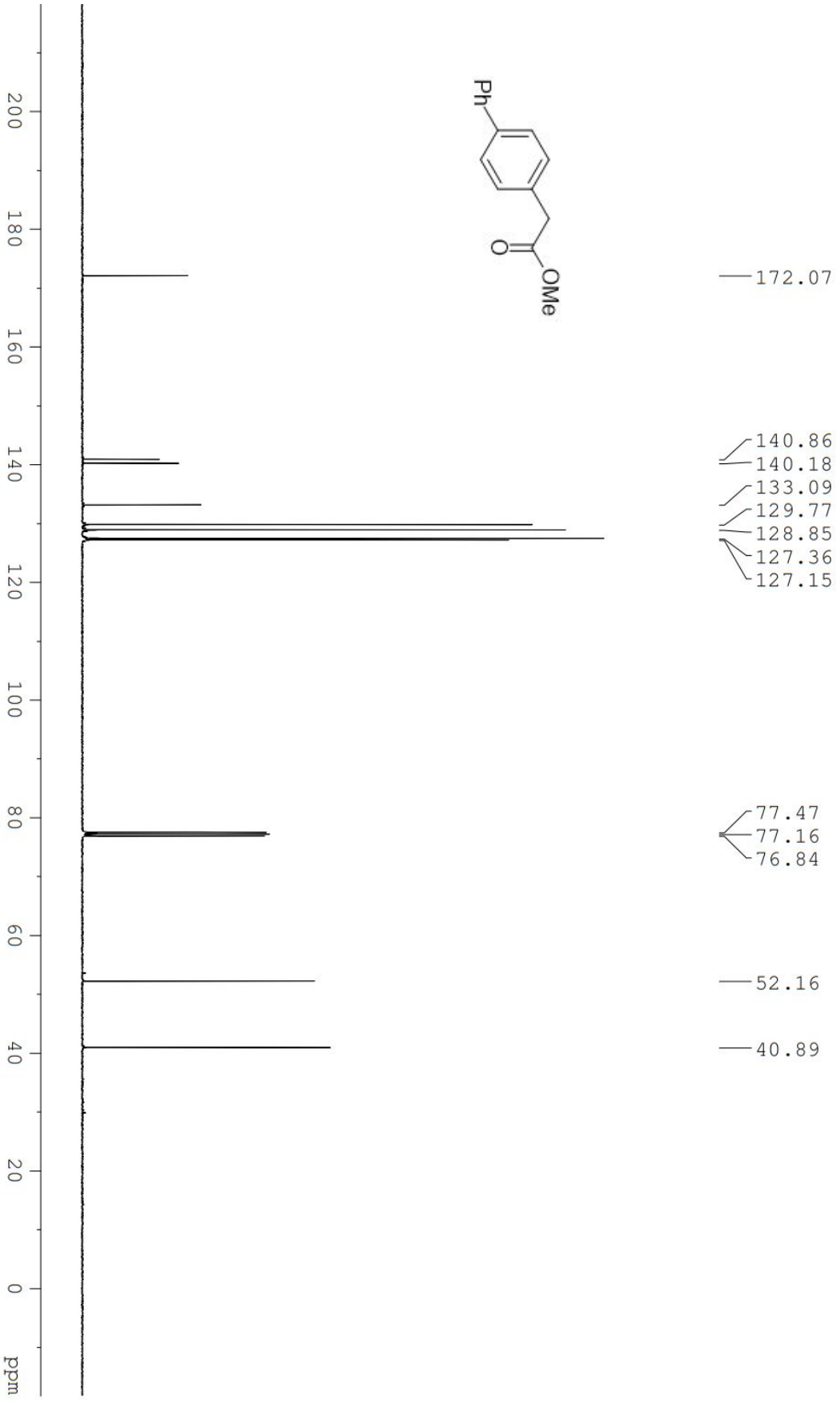
^{13}C NMR Spectrum of **3ak (100** MHz, $CDCl_3$)


200
180
160
140
120
100
80
60
40
20
0
ppm
S
O
OEt
171.78
139.91
138.31
135.97
135.39
130.56
128.10
126.88
124.45
122.93
122.36
121.73
77.48
77.16
76.84
61.10
41.53
14.31

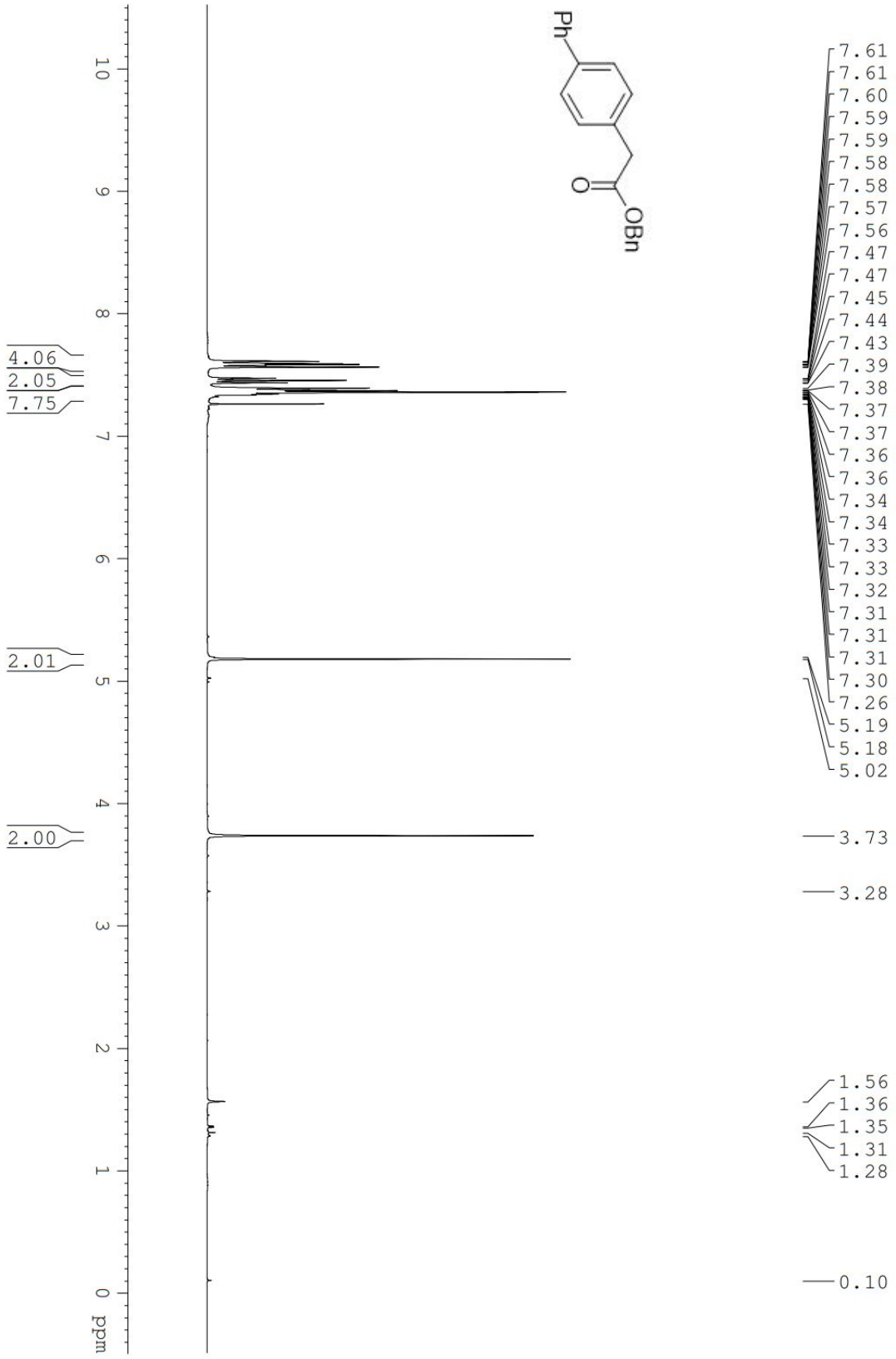
^{1}H NMR Spectrum of **3al (400** MHz, $CDCl_3$)



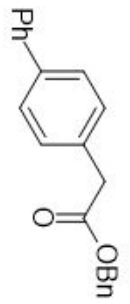
^{13}C NMR Spectrum of **3al (100** MHz, $CDCl_3$)

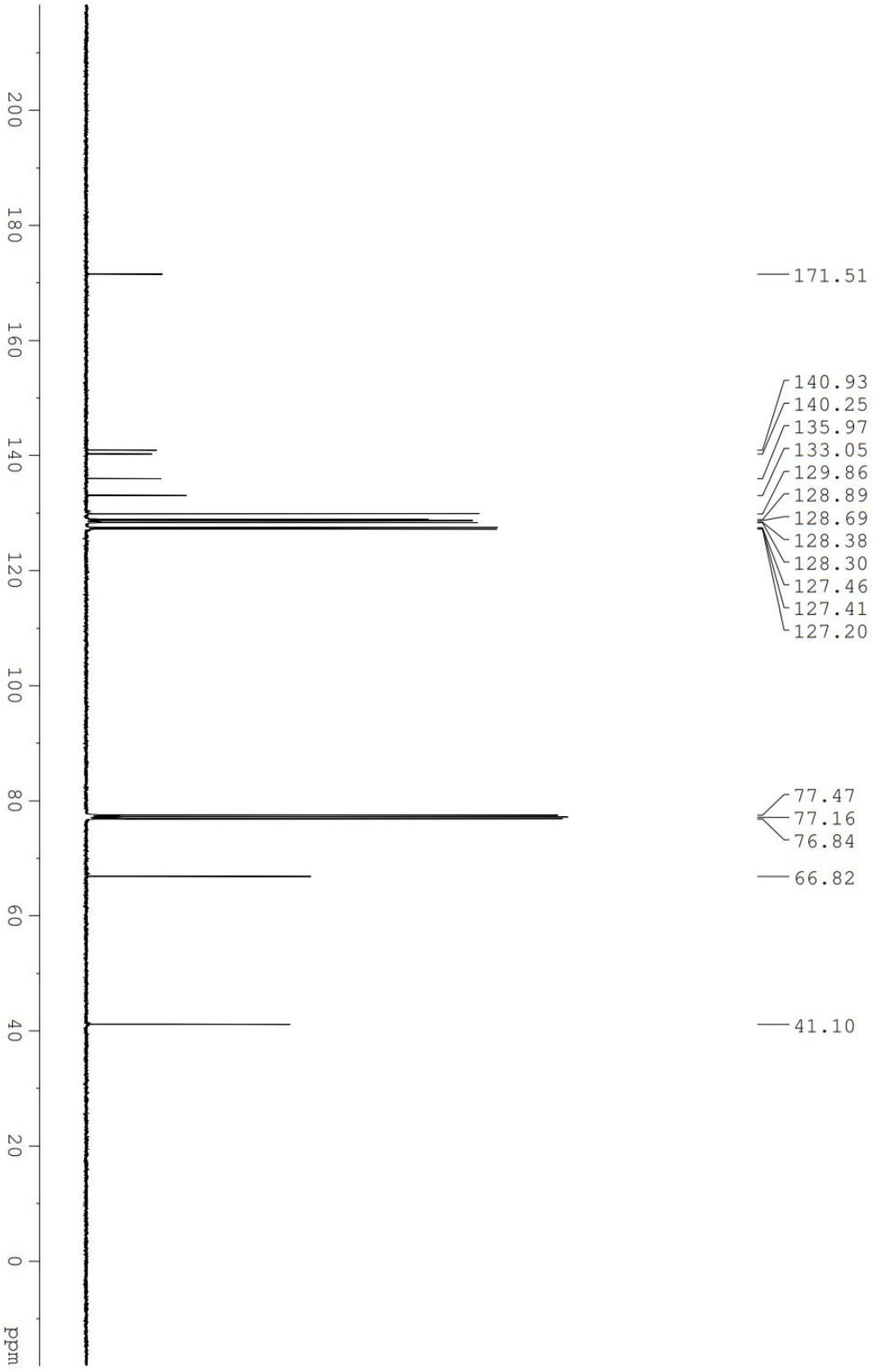


^{1}H NMR Spectrum of **3am (400** MHz, $CDCl_3$)

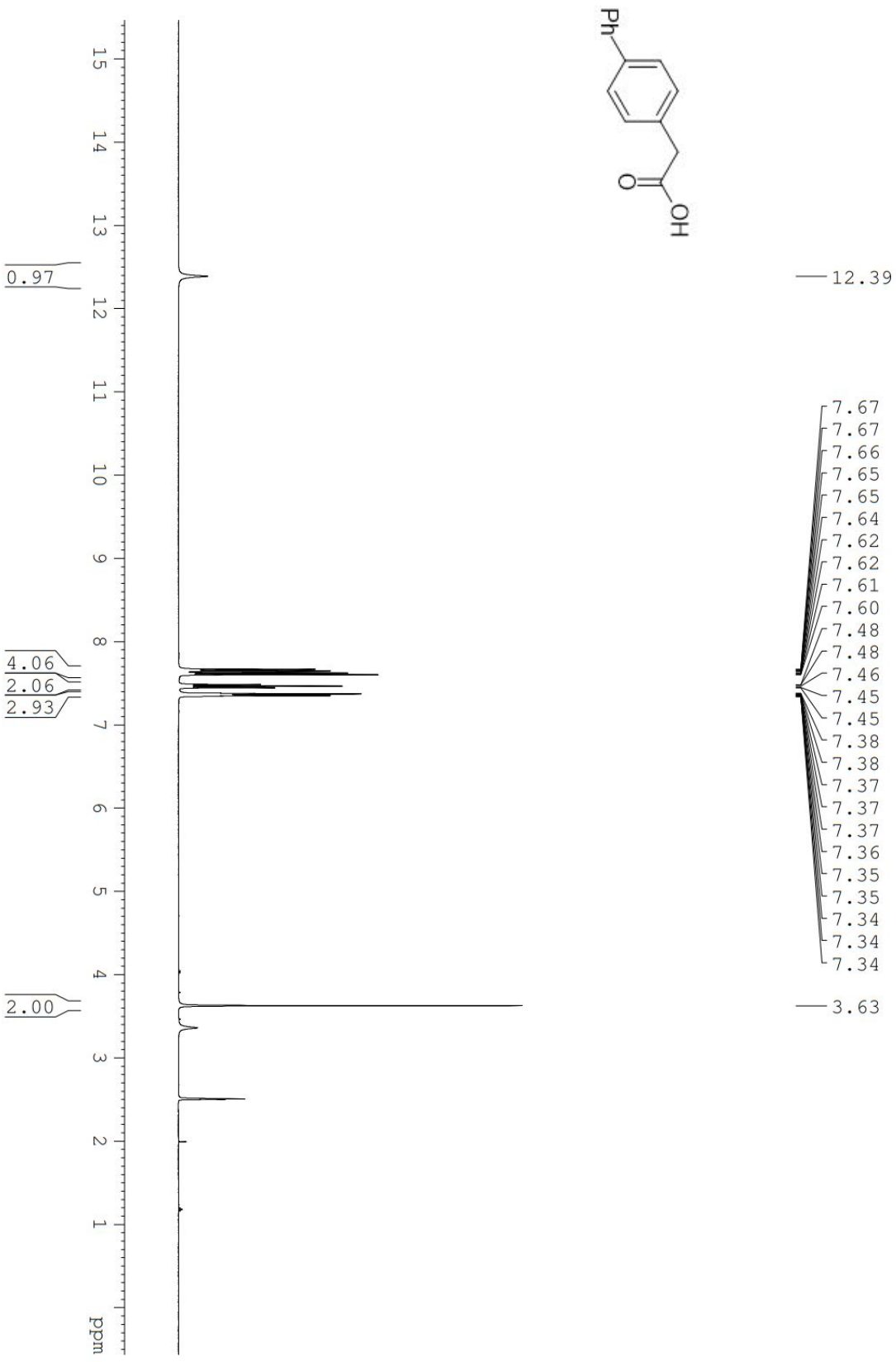


^{13}C NMR Spectrum of **3am (100** MHz, $CDCl_3$)

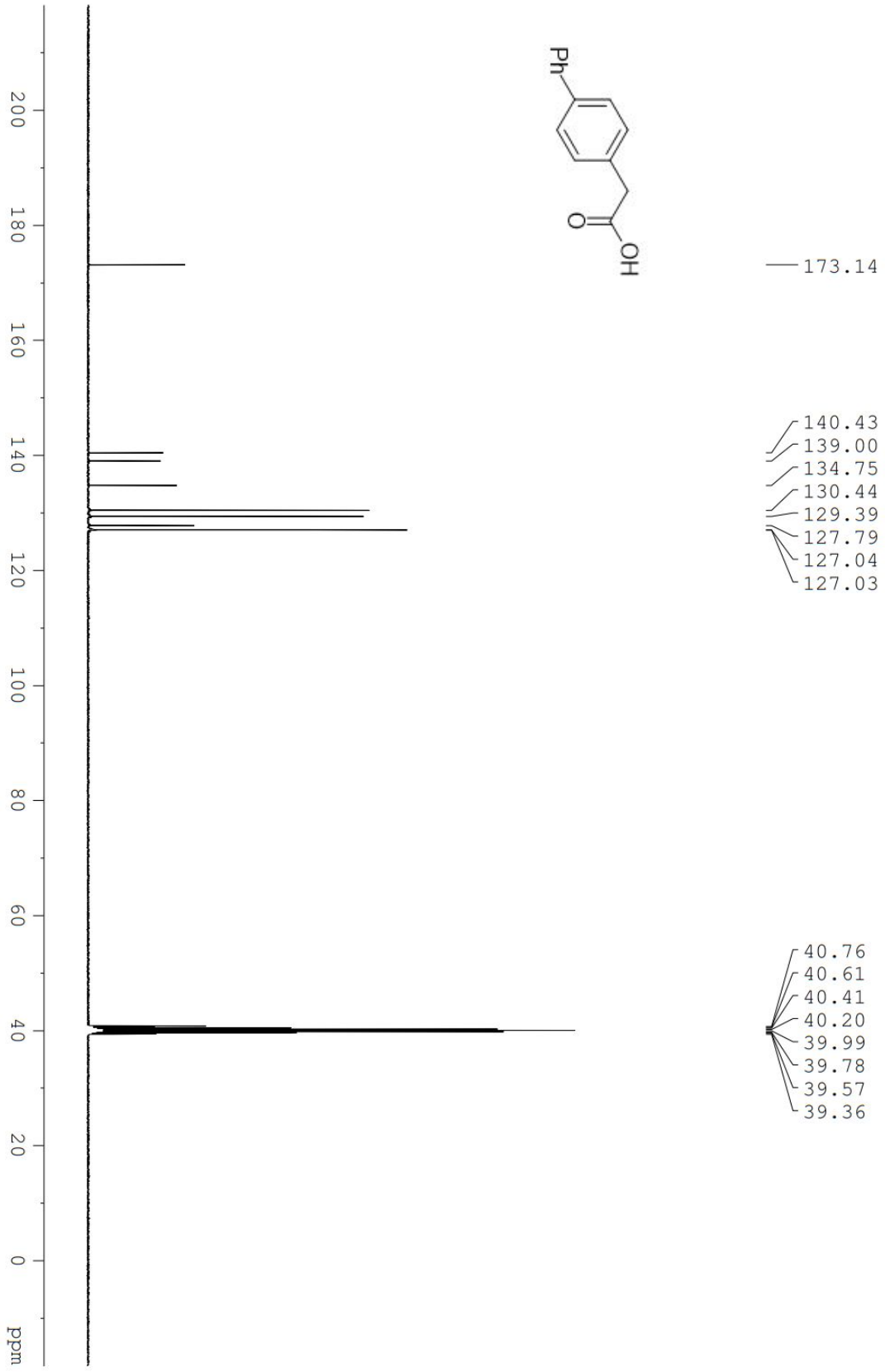




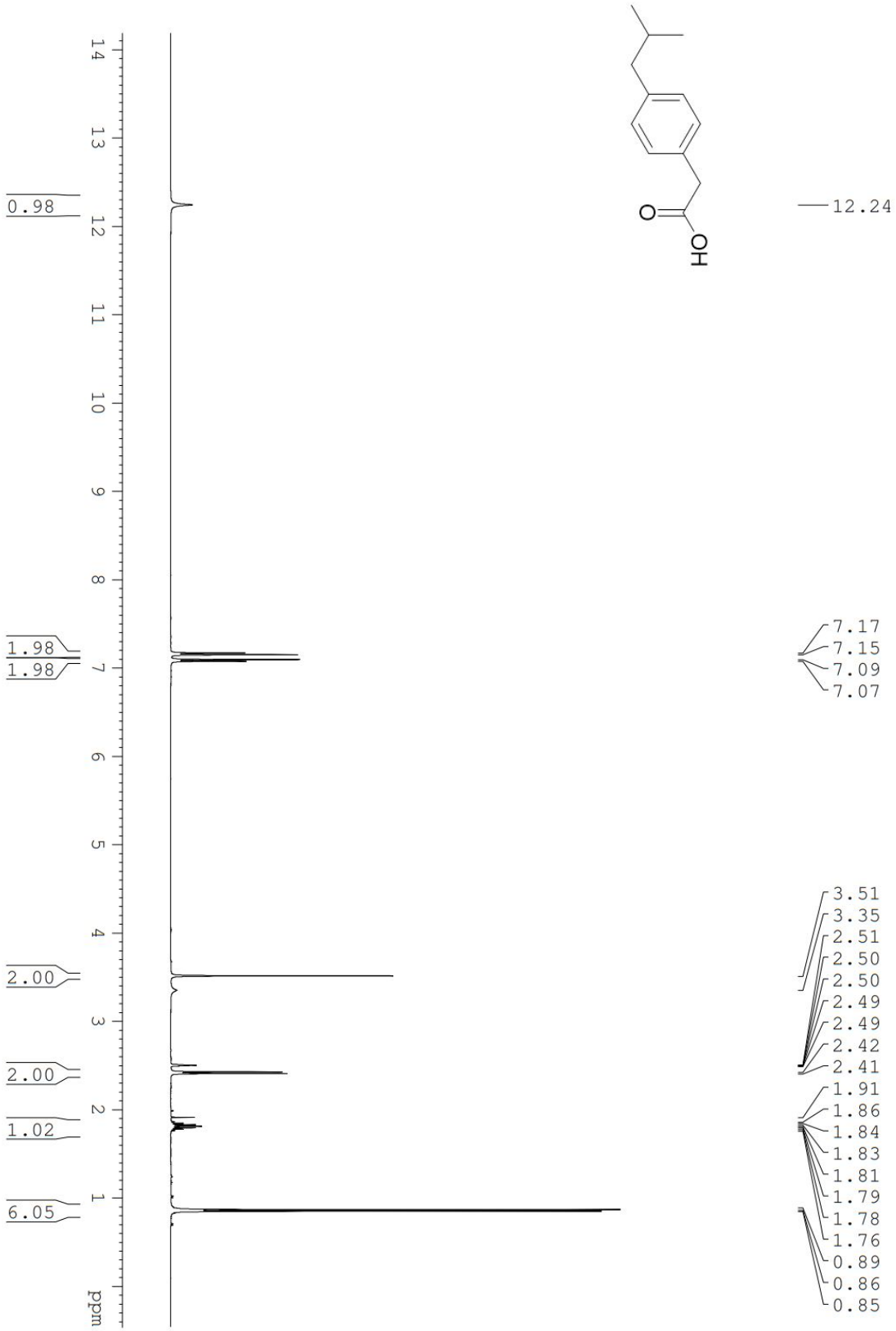
^{1}H NMR Spectrum of **4 (400** MHz, DMSO)



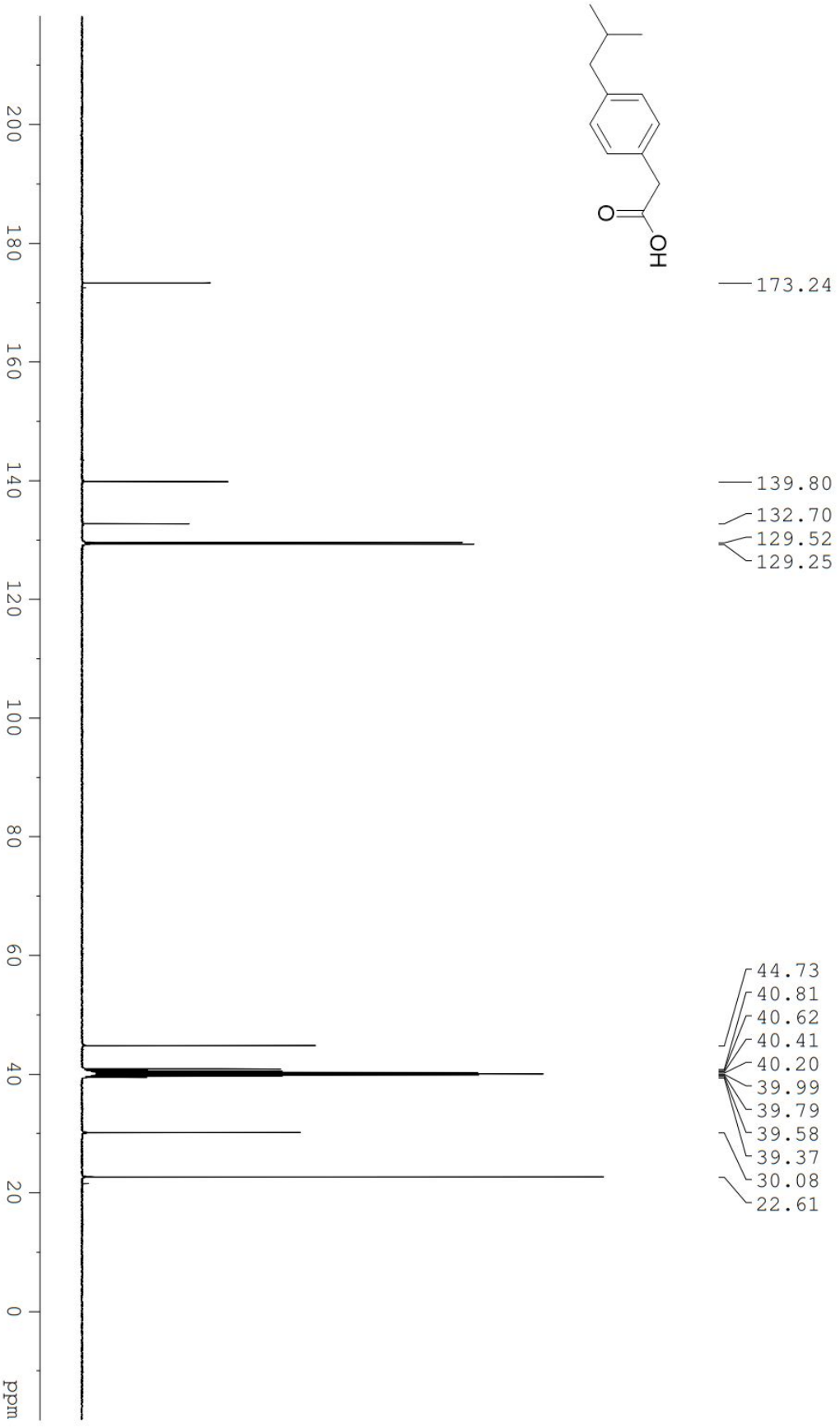
^{13}C NMR Spectrum of **4 (100** MHz, DMSO)



^{1}H NMR Spectrum of **ibufenac (400** MHz, DMSO)



^{13}C NMR Spectrum of **ibufenac (100** MHz, DMSO)


200
180
160
140
120
100
80
60
40
20
0
ppm
O
HO
173.24
139.80
132.70
129.52
129.25
44.73
40.81
40.62
40.41
40.20
39.99
39.79
39.58
39.37
30.08
22.61