Electronic Supplementary Information

Copper-Catalyzed *C*-Alkylation of Secondary Alcohols and Methyl Ketones with Alcohols Employing the Aerobic Relay Race Methodology

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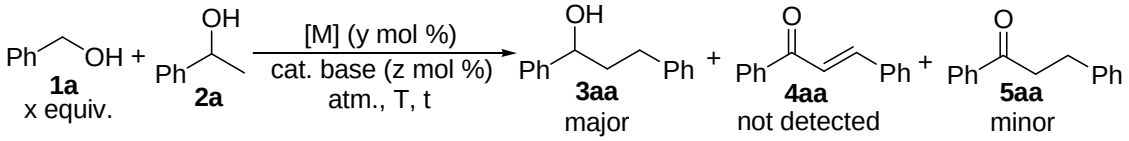
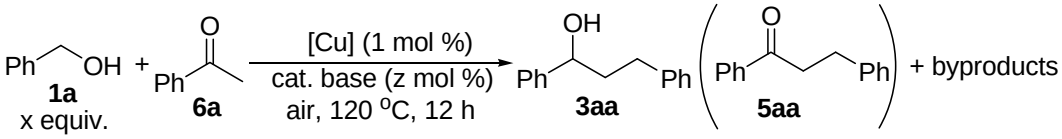
Table S1. Condition Screening of Cu-Catalyzed Aerobic *β*-Alkylation of Secondary Alcohols.[a]



Run	Cat. M[b]	x, y, z	atm., T, t	**3**+**5**%[c]	**3**/**5**[c]
1	-	1.3, 0, 30	N_2, 110 °C, 36 h	trace	-
2	$RhCl_3$	1.3, 1, 30	N_2, 110 °C, 36 h	39	>99/1
3	$RhCl_3$	1.3, 1, 30	air, 110 °C, 36 h	46	>99/1
4	$RuCl_3$	1.3, 1, 30	N_2, 110 °C, 36 h	38	>99/1
5	$RuCl_3$	1.3, 1, 30	air, 110 °C, 36 h	36	>99/1
6	$IrCl_3$	1.3, 1, 30	N_2, 110 °C, 36 h	68	>99/1
7	$IrCl_3$	1.3, 1, 30	air, 110 °C, 36 h	66	>99/1
8	$Pd(OAc)_2$	1.3, 1, 30	N_2, 110 °C, 36 h	53	98/2
9	$Pd(OAc)_2$	1.3, 1, 30	air, 110 °C, 36 h	82	97/3
10	$Cu(OAc)_2$	1.3, 1, 30	N_2, 110 °C, 36 h	54	95/5
11	$Cu(OAc)_2$	1.3, 1, 30	air, 110 °C, 24 h	98	97/3
12[d]	$Cu(OAc)_2$	1.3, 1, 30	air, 110 °C, 24 h	78	>99/1
13	***$Cu(OAc)_2$***	***1.3, 1, 30***	***air, 120 °C, 24 h***	***99 (87)***	***>99/1***
14	CuI	1.3, 1, 30	air, 120 °C, 24 h	96	98/2
15	CuBr	1.3, 1, 30	air, 120 °C, 24 h	93	>99/1
16	$CuBr_2$	1.3, 1, 30	air, 120 °C, 24 h	93	>99/1
17	$CuCl_2$	1.3, 1, 30	air, 120 °C, 24 h	89	>99/1
18	CuO	1.3, 1, 30	air, 120 °C, 24 h	66	>99/1
19	Cu_2SO_4	1.3, 1, 30	air, 120 °C, 24 h	98	>99/1
20	$Cu(OTf)_2$	1.3, 1, 30	air, 120 °C, 24 h	94	>99/1
21	$Cu(OAc)_2$	1.0, 1, 30	air, 120 °C, 24 h	83	>99/1
22	$Cu(OAc)_2$	1.3, 1, 15	air, 120 °C, 24 h	92	95/5
23	$Cu(OAc)_2$	1.3, 2, 30	air, 120 °C, 24 h	95	98/2

[a] The mixture of **1a**, **2a** (3 mmol), Cu catalyst, and KOH was heated in a sealed 20 mL Schlenk tube and monitored by GC-MS and/or ^{1}H NMR. Alsolute alcohols were used in reactions under nitrogen. Commercial alcohols without any pretreatment were directly used in aerobic reactions. [b] Catalysts were abbreviated: $RhCl_3{\cdot}3H_2O$ to $RhCl_3$, $RuCl_3{\cdot}nH_2O$ to $RuCl_3$, $Cu(OAc)_2{\cdot}H_2O$ to $Cu(OAc)_2$, and $CuCl_2.2H_2O$ to $CuCl_2$. [c] NMR yields (isolated yields in parenthesis) based on **2a**. **3aa**/**5aa** ratios measured by ^{1}H NMR spectroscopic analysis. [d] 1 mol % Of 2,2'-bipyridine added.

Table S2. Condition Screening of Cu-Catalyzed Aerobic α-Alkylation of Methyl Ketones.[a]



Run	Cat. Cu	base	x, z	**3**+**5**%[b]	**3**/**5**[c]
1	$Cu(OAc)_2 \cdot H_2O$	KOH	3, 30	63	66/34
2	$Cu(OAc)_2 \cdot H_2O$	CsOH	3, 30	50	78/22
3	$Cu(OAc)_2 \cdot H_2O$	NaOH	3, 30	85	78/22
4	CuI	NaOH	3, 30	84	80/20
5	CuO	NaOH	3, 30	86	77/23
6	CuBr	NaOH	3, 30	87	77/23
7	$CuBr_2$	NaOH	3, 30	85	81/19
8	$CuCl_2 \cdot 2H_2O$	NaOH	3, 30	78	79/21
9	Cu_2SO_4	NaOH	3, 30	80	79/21
10	$Cu(OAc)_2 \cdot H_2O$	NaOH	3, 60	96	89/11
11	$Cu(OAc)_2 \cdot H_2O$	NaOH	2, 60	92	77/23
12	***$Cu(OAc)_2 \cdot H_2O$***	***NaOH***	***3, 90***	***99 (85)***	***95/5***

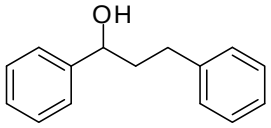
[a] Reactions were monitored by GC-MS and/or ^{1}H NMR. Usually full conversion of **6a** were observed. [b] ^{1}H NMR yields (isolated yields in parenthesis) based on **6a**. [c] **3aa**/**5aa** ratios measured by ^{1}H NMR spectroscopic analysis.

General. Substrates, bases and catalysts were all purchased. Bases (KOH, NaOH, etc.) of AR grade (>99% purity) were used. All reactions were carried out in sealed Schlenk tubes and monitored by TLC, GC-MS and/or ^{1}H NMR. Unless otherwise noted, substrates and catalysts were used as purchased without further purification and degassing in reactions carried out under air. As analyzed, samples of commercial alcohols are usually contaminated by trace amount of corresponding aldehydes or ketones. Thus, in control reactions and mechanistic studies where needed, absolute alcohols (freshly distilled from CaH_2, degassed and stored under N_2 in a Schlenk flask, 100% purity without any contaminants as confirmed by GC analysis) were used as noted. Products were purified by column chromatography on silica gel using petroleum ether and ethyl acetate as eluent. ^{1}H and ^{13}C NMR spectra were recorded on a Bruker Avance-III 500 instrument (500 MHz for ^{1}H and 125.4 MHz for ^{13}C NMR spectroscopy). Unless otherwise noted, $CDCl_3$ was used as the solvent. Chemical shift values for ^{1}H and ^{13}C NMR were referred to internal Me_4Si (0 ppm). Mass spectra were measured on a Shimadzu GCMS-QP2010 Plus spectrometer (EI). HRMS (EI) analysis was performed by the Analytical Center at the Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences.

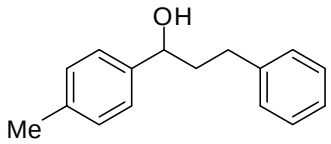
Typical Procedure for Copper-Catalyzed Aerobic *β*-Alkylation of Secondary Alcohols with Alcohols. The mixture of commercial benzyl alcohol **1a** (0.41 mL, 3.9 mmol), 1-phenylethanol **2a** (366.5 mg, 3 mmol), $Cu(OAc)_2.H_2O$ (6 mg, 0.03 mmol, 1 mol%) and KOH (50.5 mg, 0.9 mmol, 30 mol%) was sealed in a 20 mL Schlenk tube under air and then heated at 120 °C, monitored by GC-MS and/or ^{1}H NMR. After completion of the reaction (99% by GC), the mixture was quenched with ethyl acetate, washed successively with diluted hydrochloric acid, brine and water, extracted with ethyl acetate. The combined organic layer was then dried over $CaCl_2$ and concentrated *in vacuo*. Column chromatography of the crude product using ethyl acetate and petroleum ether (60-90 ^{o}C) (v/v 1/30) gave **3aa** in 87 % isolated yield (0.55 g).

Typical Procedure for Copper-Catalyzed Aerobic *α*-Alkylation of Methyl Ketones with Alcohols. The mixture of commercial benzyl alcohol **1a** (0.93 mL, 9 mmol), phenylacetone **6a** (360.5 mg, 3 mmol), $Cu(OAc)_2.H_2O$ (6 mg, 0.03 mmol, 1 mol%) and NaOH (151.5 mg, 2.7 mmol, 90 mol%) was sealed in a 20 mL Schlenk tube under air and then heated at 120 °C, monitored by GC-MS and/or ^{1}H NMR. After completion of the reaction (99% by GC), the mixture was quenched with ethyl acetate, washed successively with diluted hydrochloric acid, brine and water, extracted with ethyl acetate. The combined organic layer was then dried over $CaCl_2$ and concentrated *in vacuo*. Column chromatography of the crude product using ethyl acetate and petroleum ether (60-90 ^{o}C) (v/v 1/30) gave **3aa** in 85 % isolated yield (0.54 g).

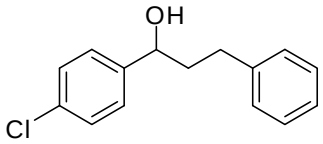
Characterization of Products.



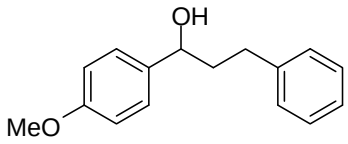
1,3-Diphenylpropan-1-ol (3aa). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.24-7.07 (m, 10H), 4.50-4.47 (m, 1H), 3.00 (b, 1H), 2.61-2.52 (m, 2H), 2.01-1.87 (m, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 144.4, 141.6, 128.23, 128.18, 128.1, 127.2, 125.8, 125.6, 73.4, 40.2, 31.8. MS (EI): *m/z* (%) 212 (9), 194 (20), 107 (100), 92 (20), 91 (22), 79 (57), 78 (10), 77 (28), 51 (7). This compound was known.[1]



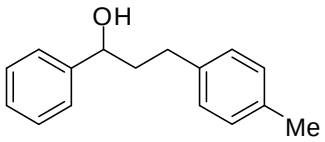
3-Phenyl-1-*p*-tolylpropan-1-ol (3ab). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.34-7.13 (m, 9H), 4.61-4.58 (m, 1H), 2.73-2.59 (m, 2H), 2.33 (s, 3H), 2.31 (b, 1H), 2.13-1.95 (m, 2H). MS (EI): *m/z* (%) 226 (10), 209 (3), 208 (15), 121 (100), 93 (36), 92 (10), 91 (35), 77 (22), 65 (9), 51 (4).This compound was known.[2]



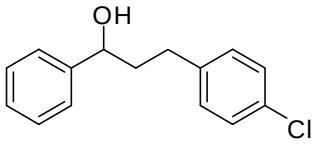
1–(4–Chlorophenyl)–3–phenylpropan–1–ol (3ac). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.20-7.04 (m, 9H), 4.41 (t, J = 6.5 Hz, 1H), 3.59 (b, 1H), 2.58-2.45 (m, 2H), 1.95-1.78 (m, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 158.5, 141.6, 136.5, 128.1, 128.0, 126.9, 125.4, 113.4, 72.8, 54.7, 40.0, 31.7. MS (EI): *m/z* (%) 246 (1), 228 (30), 193 (13), 143 (31), 131 (100), 115 (13), 113 (22), 92 (31), 91 (26), 78 (11), 77 (52), 51 (7). This compound was known.[3]



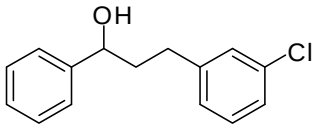
1–(4–Methoxyphenyl)–3–phenylpropan–1–ol (3ad). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.22-7.07 (m, 7H), 6.75 (d, J = 8.5 Hz, 2H), 4.45 (t, J = 8.0 Hz, 1H), 4.43 (b, 1H), 3.59 (s, 3H), 2.62-2.47 (m, 2H), 2.04-1.84 (m, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 142.7, 141.6, 132.7, 128.22, 128.16, 128.1, 127.1, 125.7, 72.6, 40.1, 31.5. MS (EI): *m/z* (%) 242 (7), 224 (4), 137 (100), 135 (6), 109 (20), 94 (9), 91 (9), 79 (3), 77 (10), 51 (2). This compound was known.[2]



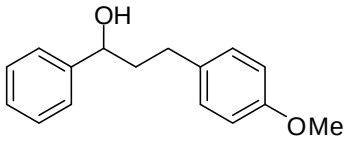
1-Phenyl-3-*p*-tolylpropan-1-ol (3ba). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.28-7.18 (m, 5H), 7.04-7.00 (m, 4H), 4.54-4.52 (m, 1H), 2.64-2.50 (m, 3H), 2.63 (b, 1H), 2.26 (s, 3H), 2.03-1.89 (m, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 144.5, 138.6, 135.0, 128.9, 128.3, 128.2, 127.3, 125.8, 73.6, 40.4, 31.4, 20.8. MS (EI): *m/z* (%) 226 (5), 208 (77), 193 (37), 107 (100), 105(50), 92 (14), 92 (41), 79 (92), 77 (60), 65 (10), 51 (12). This compound was known.[4]



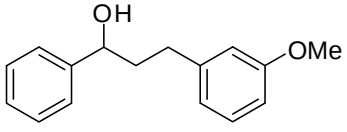
3-(4-Chlorophenyl)-1-phenylpropan-1-ol (3ca). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.27-7.15 (m, 7H), 6.98 (d, J = 8.5 Hz, 2H), 4.49 (t, J = 6.0 Hz, 1H), 2.98 (b, 1H), 2.57-2.49 (m, 2H), 2.00-1.82 (m, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 144.2, 140.1, 131.3, 129.6, 128.3, 128.2, 125.7, 73.3, 40.0, 31.1. MS (EI): *m/z* (%) 244 (14), 228 (25), 193 (15), 125 (20), 115 (12), 107 (91), 105 (84), 103 (30), 91 (17), 79 (82), 78 (15), 77 (100), 51 (21). This compound was known.[3]



3-(3-Chlorophenyl)-1-phenylpropan-1-ol (3da). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.37-7.05 (m, 9H), 4.66-4.65 (m, 1H), 4.64 (b, 1H), 2.75-2.62 (m, 2H), 2.13-1.95 (m, 3H). MS (EI): *m/z* (%) 246 (10), 193 (6), 107 (100), 105 (24), 91 (14), 79 (57), 77 (42), 65 (2), 51 (9). This compound was known.[5]

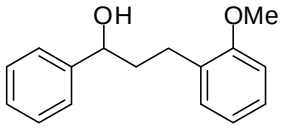


3-(4-Methoxyphenyl)-1-phenylpropan-1-ol (3ea). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.23-7.16 (m, 5H), 6.99 (d, J = 8.5 Hz, 2H), 6.73 (d, J = 8.5 Hz, 2H), 4.50 (d, J = 6.5 Hz, 1H), 3.60 (s, 3H), 3.26 (b, 1H), 2.58-2.47 (m, 2H), 2.02-1.84 (m, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 157.4, 144.5, 133.7, 129.0, 128.1, 127.1, 125.7, 113.5, 73.2, 54.8, 40.4, 30.8. MS (EI): *m/z* (%) 242 (1), 240 (28), 224 (23), 135 (16), 121 (100), 107 (18), 105 (45), 91 (22), 79 (27), 78 (17), 77 (56), 65 (8), 51 (11). This compound was known.[4]

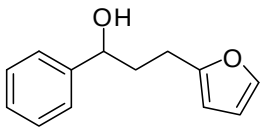


3-(3-Methoxyphenyl)-1-phenylpropan-1-ol (3fa). ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.32-7.15 (m, 7H), 6.77-6.70 (m, 2H), 4.65-4.62(m, 1H), 3.75 (s, 3H), 2.72-2.58 (m, 2H), 2.18 (b, 1H), 2.13-1.97 (m, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ159.6, 144.5, 143.4, 129.3, 128.4, 127.5, 125.9, 120.8, 114.1,

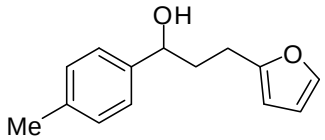
111.1, 73.7, 55.1, 40.3, 32.0. MS (EI): *m/z* (%) 242 (7), 224 (2), 193 (1), 165 (1), 122 (100), 107 (16), 92 (4), 91 (9), 79 (19), 77 (13), 65 (3), 51(2). HRMS Calcd for $C_{16}H_{18}O_2$ (M+): 242.1307; found: 242.1306.



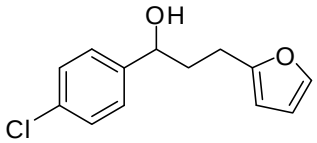
3-(2-Methoxyphenyl)-1-phenylpropan-1-ol (3ga). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.26-7.05 (m, 7H), 6.84-6.73 (m, 2H), 4.53-4.50 (m, 1H), 3.66 (s, 3H), 3.05 (b, 1H), 2.69-2.63 (m, 2H), 2.03-1.88 (m, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 157.1, 144.5, 129.9, 129.7, 128.0, 127.0, 126.9, 125.7, 120.4, 73.3, 54.9, 38.9, 26.3. MS (EI): *m/z* (%) 242 (27), 224 (75), 209 (12), 193 (25), 135 (28), 122 (49), 107 (100), 105 (38), 91 (71), 79 (89), 78 (18), 77 (64), 65 (18), 51 (14). This compound was known.[6]



3-(Furan-2-yl)-1-phenylpropan-1-ol (3ha). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.30-7.20 (m, 6H), 6.24-6.23 (m, 1H), 5.95-5.94 (m, 1H), 4.60-4.57 (m, 1H), 2.69-2.57 (m, 3H), 2.52 (b, 1H), 2.06-1.95 (m, 2H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 155.5, 144.2, 140.8, 128.3, 127.4, 125.8, 110.0, 104.9, 73.4, 37.0, 24.2. MS (EI): *m/z* (%) 202 (6), 184 (100), 155 (32), 141 (16), 107 (40), 105 (26), 91 (20), 79 (66), 77 (43), 65 (8), 53 (15), 51 (11). This compound was known.[7]

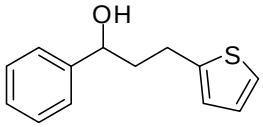


3-(Furan-2-yl)-1-*p*-tolylpropan-1-ol (3hb). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.22-7.06 (m, 5H), 6.21 (t, J = 2.25 Hz, 1H), 5.92 (d, J = 3.0 Hz, 1H), 4.53-4.50 (m, 1H), 2.79 (b, 1H), 2.66-2.55 (m, 2H), 2.28 (s, 3H), 2.05-1.90 (m, 2H). ^{13}C NMR (125 MHz, $CDCl_3$) δ155.8, 141.6, 141.0, 136.9, 128.9, 125.7, 109.9, 104.7, 73.1, 36.8, 24.2, 20.9. MS (EI): *m/z* (%) 216 (19), 199 (17), 198 (100), 183 (26), 169 (21), 155 (17), 134 (47), 121 (92), 119 (43), 118 (41), 105 (14), 93 (67), 91 (43), 81 (37), 77 (30), 65 (12), 53 (12). HRMS Calcd for $C_{14}H_{16}O_2$ (M+): 216.1155; found: 216.1154.

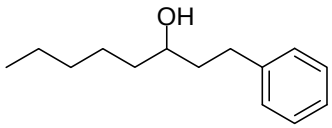


1-(4-Chlorophenyl)-3-(furan-2-yl)propan-1-ol (3hc). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.23-7.09 (m, 5H), 6.17-6.16 (m, 1H), 5.88-5.87 (m, 1H), 4.53-4.50 (m, 1H), 2.57 (t, J = 15.0 Hz, 2H), 1.98-1.84

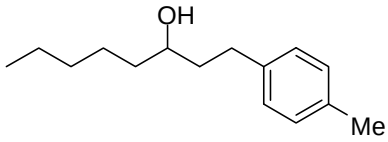
(m, 1H) , 1.91 (b, 1H). ^{13}C NMR (125 MHz, $CDCl_3$) δ155.2, 142.7, 140.9, 133.1, 128.5, 127.2, 110.1, 105.1, 72.8, 37.1, 24.1. MS (EI): *m/z* (%) 236 (11), 219 (15), 218 (100)., 189 (12), 183 (46), 165 (12), 154 (39), 143 (20), 141(72), 138 (25), 113 (34), 95 (12), 81 (61), 77 (84), 65 (7), 55 (9), 53 (18). HRMS Calcd for $C_{13}H_{13}ClO_2$ (M+): 236.0602; found: 236.0602.



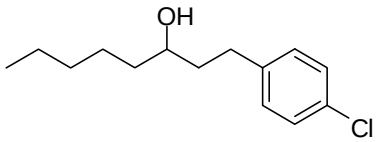
1–Phenyl–3–(thiophen–2–yl)propan–1–ol (3ia). ^{1}H NMR (500 MHz, $CDCl_3$): *δ* 7.27-7.21 (m, 5H), 7.05-7.04 (m, 1H), 6.87-6.85 (m, 1H), 6.73-6.72 (m, 1H), 4.59-4.57 (m, 1H), 2.88-2.77 (m, 2H), 2.53 (b, 1H), 2.11-1.94 (m, 2H). MS (EI): *m/z* (%) 218 (8), 200 (72), 285 (11), 167 (15), 133 (9), 121 (15), 107 (49), 105 (23), 98 (100), 91 (9), 79 (86), 77 (77), 65 (9), 51 (21). This compound was known.[6]



1-Phenyloctan-3-ol (3ae). ^{1}H NMR (500 MHz, $CDCl_3$): *δ* 7.24-7.11 (m, 4H), 3.59-3.54 (m, 1H), 2.78-2.60 (m, 2H), 2.45 (b, 1H), 1.75-1.70 (m, 2H), 1.43-1.26 (m, 8H), 0.88 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$): *δ* 142.5, 128.53, 128.46, 125.8, 71.3, 39.2, 37.7, 32.2, 32.1, 25.5, 22.8, 14.2. MS (EI): *m/z* (%) 206 (1.16), 117 (44.46), 104 (100), 92 (43.7), 91 (88.44), 79 (5.17), 78 (10.13), 77 (5.98), 65 (7.51), 55 (18.89). This compound was known.[8]

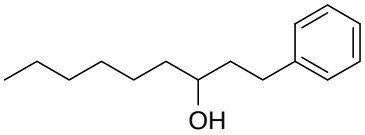


1-*p*-Tolyloctan-3-ol (3be). ^{1}H NMR (500 MHz, $CDCl_3$): *δ* 7.08-6.91 (m, 4H), 3.52-3.47 (m, 1H), 2.66-2.50 (m, 2H), 2.21 (s, 3H), 1.75 (b, 1H), 1.67-1.59 (m, 2H), 1.35-1.18 (m, 8H), 0.79 (t, *J* = 6.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ139.0, 135.0, 128.9, 128.2, 71.2, 39.1, 37.4, 31.8, 31.5, 25.2, 22.5, 20.8, 13.9. MS (EI): *m/z* (%) 220 (16), 202 (35), 131 (99), 119 (16), 118 (100), 106 (48), 105 (88), 92 (12), 91 (21), 79 (9), 78 (3), 77 (9), 55 (13). HRMS Calcd for $C_{15}H_{24}O$ (M+): 220.1825; found: 220.1824.

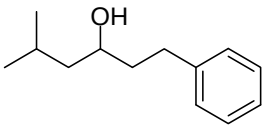


1-(4-Chlorophenyl)octan-3-ol (3ce). ^{1}H NMR (500 MHz, $CDCl_3$): *δ* 7.15-6.91 (m, 4H), 3.48-3.43 (m, 1H), 2.64-2.47 (m, 2H), 2.32 (br, s, 1H), 1.62-1.56 (m, 2H), 1.35-1.15 (m, 8H), 0.78 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ140.6, 131.2, 129.6, 128.2, 70.9, 38.7, 37.4, 31.7, 31.2, 25.1,

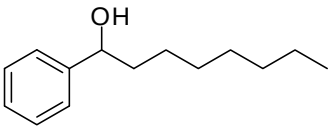
22.5, 13.9. MS (EI): *m/z* (%) . 240 (4), 222 (27), 151 (38), 138 (100), 125 (65), 117 (7), 103 (8), 91 (15), 83 (12), 77 (6), 55 (26), 51 (1). HRMS Calcd for $C_{14}H_{21}ClO$ (M+): 240.1279; found: 240.1279.



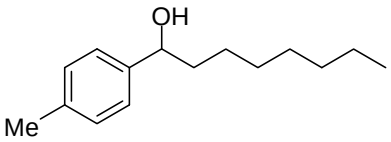
1-Phenylnonan-3-ol (3af). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.26-7.13 (m, 5H), 3.61-3.56 (m, 1H), 2.80-2.61 (m, 2H), 2.07 (b, 1H), 1.76-1.72 (m, 2H), 1.46-1.26 (m, 10H), 0.88 (t, J = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 142.2, 128.3, 128.2, 125.6, 71.1, 38.9, 37.5, 32.0, 31.7, 29.3, 25.5, 22.5, 13.9. MS (EI): *m/z* (%) 220 (0.5), 202 (16), 117 (36), 104 (100), 92 (46), 91 (97), 79 (6), 79 (11), 77 (8), 69 (10), 65 (11), 51 (3). This compound was known.[9]



5-Methyl-1-phenylhexan-3-ol (3ag). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.23-7.12 (m, 5H), 3.71-3.66 (m, 1H), 2.81-2.62 (m, 1H), 1.77-1.67 (m, 3H), 1.67 (b, 1H), 1.40-1.26 (m, 2H), 0.90 (t, J = 7.0 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 142.2, 128.32, 128.31, 125.7, 69.4, 46.7, 39.6, 32.0, 24.6, 23.4, 22.1. MS (EI): *m/z* (%) 192 (1.76), 174 (34.12), 131 (10.66), 118 (22.10), 117 (35.28), 104 (87.17), 92 (50.46), 91 (100), 79 (5.97), 78 (12.67), 77 (7.72), 65 (9.69), 55 (3.92). This compound was known.[10]

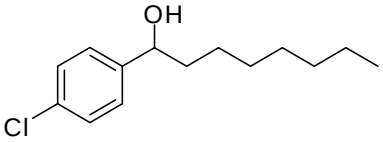


1–Phenyloctan–1–ol (3ja). ^{1}H NMR (500 MHz, CDCl3): δ 7.29-7.19 (m, 5H), 4.54 (t, J = 6.75 Hz, 1H), 2.74 (b, 1H), 1.73-1.63 (m, 2H), 1.36-1.20 (m, 10H), 0.87 (t, J = 7.25 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 144.9, 128.2, 127.2, 125.8, 74.5, 39.0, 31.7, 29.4, 29.1, 25.7, 22.5, 14.0. MS (EI): *m/z* (%) 206 (2), 188 (1), 120 (4), 107 (100), 105 (8), 98 (100), 92 (1), 91 (4), 79 (35), 77 (15), 65 (1), 55 (2), 51 (3). This compound was known.[11]

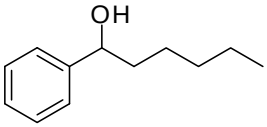


1-*p*-Tolyloctan-1-ol (3jb). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.18-7.10 (m, 4H), 4.54 (t, J = 6.75 Hz, 1H), 2.31 (s, 4H), 1.75-1.62 (m, 2H), 1.36-1.25 (m, 10H), 0.86 (t, J = 3.5 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 142.0, 136.9, 128.9, 125.8, 74.3, 38.9, 31.8, 29.5, 29.2, 25.8, 22.6, 21.0, 14.0. MS (EI): *m/z* (%) 220 (5), 122 (12), 119 (4), 93 (26), 92 (2), 91 (11), 77 (7), 65 (2), 55 (1), 51 (1). This

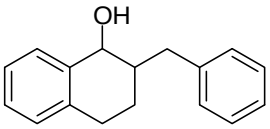
compound was known.[12]



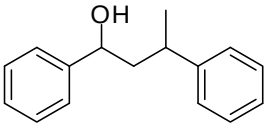
1-(4-Chlorophenyl)octan-1-ol (3jc). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.31-7.20 (m, 4H), 4.56 (t, J = 6.75, 1H), 2.60 (b, 4H), 1.75-1.61 (m, 2H), 1.33-1.92 (m, 10H), 0.87 (t, J = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 143.5, 133.0, 128.5, 127.3, 74.9, 39.1, 31.8, 29.5, 29.2, 25.7, 22.7,14.1. MS (EI): *m/z* (%) 240 (8), 143 (33), 141 (100), 125 (2), 113 (13), 91 (1), 77 (20), 78 (2), 57 (2), 55(2). This compound was known.[13]



1-Phenylhexan-1-ol (3ka). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.31-7.21 (m, 5H), 4.56 (t, J = 6.75 Hz, 1H), 2.44 (b, 1H), 1.74-1.64 (m, 2H), 1.40-1.21 (m, 6H), 0.86 (t, J = 7.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$): δ 144.9, 128.3, 127.3, 125.9, 74.6, 39.0, 31.7, 25.4, 22.5, 14.0. MS (EI): *m/z* (%) 178 (5.02), 107 (100), 91 (2.47), 79 (35.78), 77 (13.72), 65 (0.6), 55 (1.02). This compound was known.[14]



2–Benzyl–1,2,3,4–tetrahydronaphthalen–1–ol (3ah). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.46-7.44 (m, 1H), 7.28-7.35 (m, 2H), 7.20-7.13 (m, 5H), 7.06-7.03 (m, 1H), 4.42-4.40 (d, J = 7.5 Hz, 1H), 3.05-3.01 (m, 1H), 2.71-2.68 (m, 2H), 2.45-2.40 (m, 1H), 2.13 (b, 1H), 1.99-1.90 (m, 2H), 1.47-1.39 (m, 1H). MS (EI): *m/z* (%) 238 (17), 220 (20), 160 (15), 146 (84), 129 (66), 92 (38), 91 (100), 79 (5), 77 (15), 65 (25), 51 (9). This compound was known.[6]



1,3–Diphenylbutan–1–ol (3aa'). ^{1}H NMR ($CDCl_3$, 500 MHz): δ 7.33-7.16 (m, 10H), 4.52 (t, J = 7.0 Hz, 1H), 2.73-2.57 (m, 1H), 2.17-2.14 (m, 1H), 1.94-1.88 (m, 2H), 1.24 (d, J = 7.0 Hz, 3H). MS (EI): *m/z* (%) 226 (6), 208 (16), 193 (7), 121 (24), 107 (100), 106 (59), 103 (14), 91 (46), 79 (82), 78 (19), 77 (54), 65 (6), 51 (13). This compound was known.[15]

Reference

1. Qin, C.; Wu, H.; Cheng, J.; Chen, X. A.; Liu, M.; Zhang, W.; Su, W.; Ding, J. *J. Org. Chem*. **2007**, *72*, 4102-4107.

2. Kim, B. T.; Kim, H.-S.; Kim, T.-J.; Shim, S. C.; Cho, C. S. *Organometallics,* **2003,** *22,* 3608–3610.

3. Fujita, K.; Asai, C.; Yamaguchi, T.; Hanasaka, F.; Yamaguchi, R. *Org. Lett.* **2005**, *7*, 4017-4019.

4. Nishide, K.; Shigeta, Y.; Obata, K.; Node, M. *J. Am. Chem. Soc.* **1996**, *118*, 13103.

5. Martínez, R.; Ramon, D. J.; Yus, M. *Tetrahedron*, **2006**, *62*, 8982–8987.

7. Kose, O.; Saito, S. *Org. Biomol. Chem.* **2010**, *8*, 896-900.

6. Cheung, H. W.; Lee, T. Y.; Lui, H. Y.; Yeung, C. H.; Laua, C. P. *Adv. Synth. Catal*. **2008**, 350, 2975-2983.

8. Goto, M.; Akimoto, K.; Aoki, K.; Shindo, M.; Koga, K. *Chem. Pharm. Bull.* **2000**, *48*, 1529-1531.

9. Suzuki, K.; Hasegawa, T.; Imai, T.; Maeta, H.; Ohba, S. *Tetrahedron*, **1995**, *51*, 4483.

10. Pratt, E. F.; Kubler, D. G. *J. Am. Chem. Soc*. **1954**, *76*, 52.

11. Trindade, A. F.; Gois, P. M. P.; Veiros, L. F.; Andre, V.; Duarte, M. T.; Afonso, C. A. M.; Caddick, S.; Cloke, F. G. N. *J. Org. Chem.* **2008**, *73*, 4076-4086.

12. Buu-Hoi, N. P.; Xuong, N. D.; Diep, B. K. *J. Org. Chem*.**1961**, *26* 1673-1674.

13. Muzart, J.; Ajjou, A. N. *Synthesis*. **1993**, *8*, 785-787.

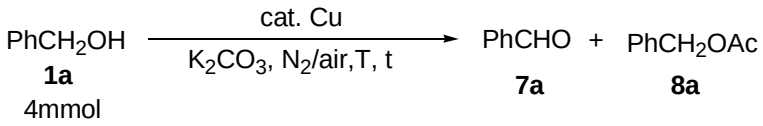
14. Adam, W.; Lukacs, Z.; Viebach, K.; Humpf, H.-U.; Saha-Moller, C. R.; Schreier, P. *J. Org. Chem.* **2000**, *65*, 186-190.

15. Liao, Y.-X.; Xing, C.-H; He, P.; Hu, Q.-S. *Org. Lett.* **2008***, 10*, 2509.

Elementary Reactions and Mechanistic Studies

Cu-Mediated Alcohol Oxidation.

Table S3. Cu-mediated Oxidation of Primary Alcohol.



Run	Cu (mol%)	K_2CO_3 (mol%)	condition	**7a**%[a]	**8a**%[a]
1	$Cu(OAC)_2{\cdot}H_2O$ (5)	-	N_2, 120 °C, 6 h	NR	
2	$Cu(OAC)_2{\cdot}H_2O$ (5)	50	N_2, 120 °C, 12 h	NR	
3	$Cu(OAC)_2{\cdot}H_2O$ (5)	-	air, 120 °C, 6 h	2.8	
4	$Cu(OAC)_2{\cdot}H_2O$ (5)	50	air, 120 °C, 6 h 12 h	4.4 5.8	
5	$Cu(OAC)_2{\cdot}H_2O$ (5)	-	N_2, 150 °C, 6 h 12 h	2.3 2.4	 13
6	$Cu(OAC)_2{\cdot}H_2O$ (5)	-	N_2, 180 °C, 6 h 12 h	2.8 2.7	 10
7	$Cu(OAC)_2{\cdot}H_2O$ (10)	-	N_2, 150 °C, 6 h 12 h	5 4 (4)	17% 18% (13%)
8	$Cu(OAC)_2{\cdot}H_2O$ (20)	-	N_2, 150 °C, 6 h 12 h	5.4 5.5 (8)	33% 39% (33%)
9	CuI (10)	-	N_2, 150 °C, 6 h	NR	
10	CuI (20)	-	N_2, 150 °C, 6 h	NR	
11	CuI (50)	-	N_2, 150 °C, 6 h	NR	

[a] Absolute **1a** was used. GC yield (NMR yield in parenthesis).

Discussion on Table S3 (See also: Q. Li, S. Fan, Q. Sun, H. Tian, X. Yu, Q. Xu, *Org. Biomol. Chem.* accepted):

As shown in the table, no reaction was observed when absolute **1a** and Cu(II) were heated at 120 °C under nitrogen (runs 1-2), but 2-6% yield of **7a** could be detected if the same reactions were performed under air (runs 3-4). When the same reactions (run 1) were heated at higher temperatures under nitrogen (runs 5-6, 150-180 °C), yields of **7a** were surprisingly found to be irrelevant to reaction temperature and time, but to the amounts of Cu(II) added, i.e., nearly half amounts of **7a** (in mol/mol ratio to Cu(II) added) were always generated under these conditions. This was further confirmed by adding more amounts of Cu(II) and by both GC and NMR spectroscopic analysis (runs 7-8). In the latter cases, ca. 1-2 folds of benzyl acetate **8a** (in mol/mol ratio to Cu(II) added) were also detected and confirmed (runs 7-8). Since 10-50 mol% of a Cu(I) species (CuI), although an active alcohol oxidation and *N*-alkylation catalyst, were found inactive under nitrogen even at 150 °C (runs 9-11), we deduce, Cu(I) species may be generated in the anaerobic reactions of Cu(II) and **1a** (runs 3-6) via eqs. S1-S3, giving constant yields of **7a** and **8a**. Thus, when heated under nitrogen, $Cu(OAc)_2$ firstly reacts with **1a**, resulting in the reduction of Cu(II) to a Cu(I) species like CuOAc

and concurrent oxidation of **1a** to **7a**, giving also the acetic acid (HOAc) as a byproduct (eq. S1). Due to the presence of large excess **1a**, the generated HOAc may quickly undergo dehydrative esterification with **1a** at the high temperatures to give benzyl acetate **8a** (eq. S2). As a result, half amounts of **7a** was generated during the process, with detection of **8a** as a byproduct (eq. S3). In these cases, Cu(II) may essentially be the direct oxidant for the alcohols under anaerobic conditions, with itself reduced to Cu(I) by the alcohol.

$$2\,Cu(OAc)_2 + \underset{\mathbf{1a}}{PhCH_2OH} \longrightarrow 2\,CuOAc + \underset{\mathbf{7a}}{PhCHO} + 2\,HOAc \quad (S1)$$

$$HOAc + \underset{\mathbf{1a}}{PhCH_2OH} \longrightarrow \underset{\mathbf{8a}}{PhCH_2OAc} + H_2O \quad (S2)$$

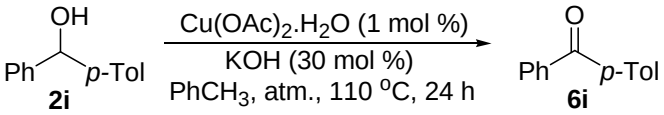
Overall Reaction (eq. S1 + eq. S2):

$$2\,Cu(OAc)_2 + 3\,\underset{\mathbf{1a}}{PhCH_2OH} \longrightarrow 2\,CuOAc + \underset{\mathbf{7a}}{PhCHO} + 2\,\underset{\mathbf{8a}}{PhCH_2OAc} + H_2O \quad (S3)$$

On the other hand, since 1-2 equiv. of benzyl acetate **8a** (in mol/mol ratio to Cu(II) added) was produced, one of the potential reactions as shown below may also be possible to give benzyl acetate **8a** (eq. S4).

$$CuOAc + 2\,\underset{\mathbf{1a}}{PhCH_2OH} \longrightarrow PhCH_2OCu + \underset{\mathbf{8a}}{PhCH_2OAc} + H_2O \quad (S4)$$

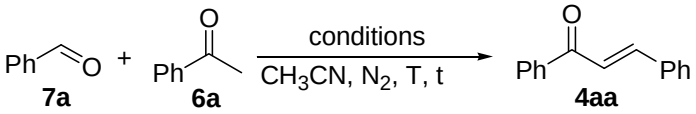
Cu-Mediated Oxidation of Secondary Alcohol:



run	[Cu] (mol%)	atm.	**6i**% (NMR yield based on **2i**)
1	5	air	77%
2	5	N_2	NR

Note: 0.5 mmol absolute **2i** (100% purity as confirmed by NMR) in 0.5 mL toluene was stirred in a sealed Schlenk tube (20 mL) and monitored by NMR.

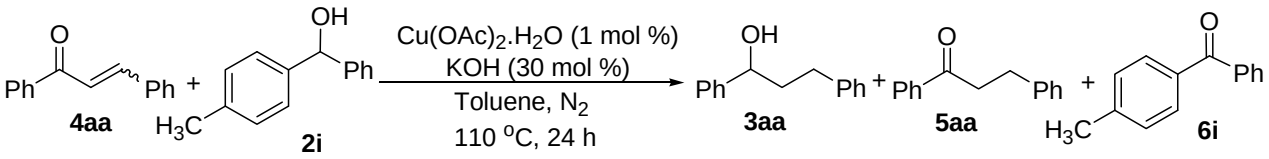
Cu-Promoted Condensation of Benzaldehyde and Acetophenone:



run	cat. [Cu] (mol%)	**4aa**% (GC yield based on **6a**)
1	none	100 °C, 6 h: 0.9%; 12 h: 1.4%
2	$Cu(OAc)_2$ (5)	100 °C, 6 h: 75%; 12 h: 87%
3	none	r.t., 12 h: 0%
4	$Cu(TFA)_2$ (5)	r.t., 12 h: 2%
5	$Cu(OTf)_2$ (5)	r.t., 12 h: 54%

Note: 5 mmol **7a** and 5 mmol **6a** in acetonitrile (0.5 mL) were stirred in a sealed Schlenk tube under nitrogen and monitored by GC-MS.

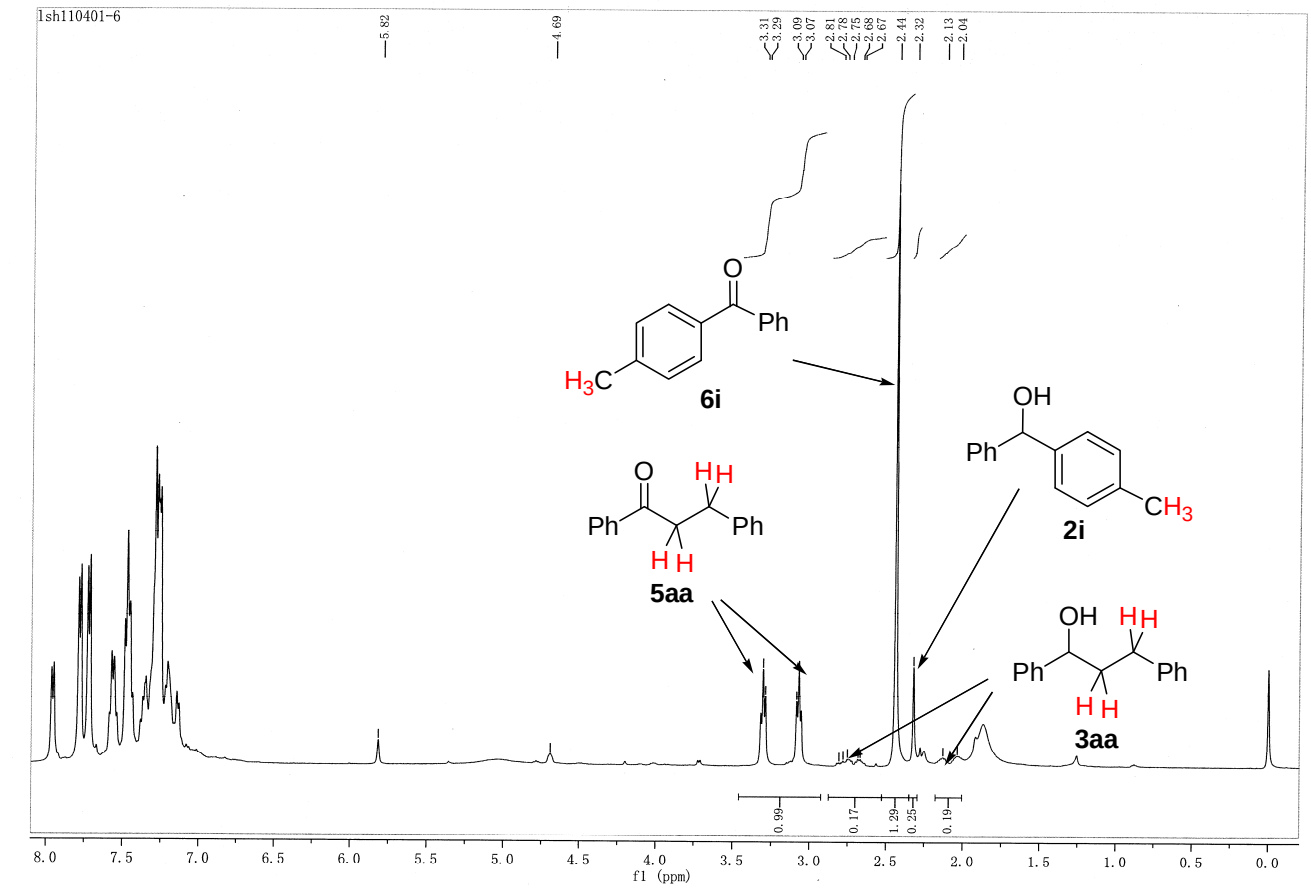
Table S4. Cu-Catalyzed Transfer Hydrogenation of Chalcone **4aa** by Phenyl(*p*-tolyl)methanol **2i**.[a]



run	**2i** (equiv.)	**3aa/5aa**[b]	**6i**%[c]	(4***3aa**+2***5aa**)/(2***6i**)[d]
1	1.0	26/74	84	0.97/1.00
2	3.0	61/39	54	0.75/1.00

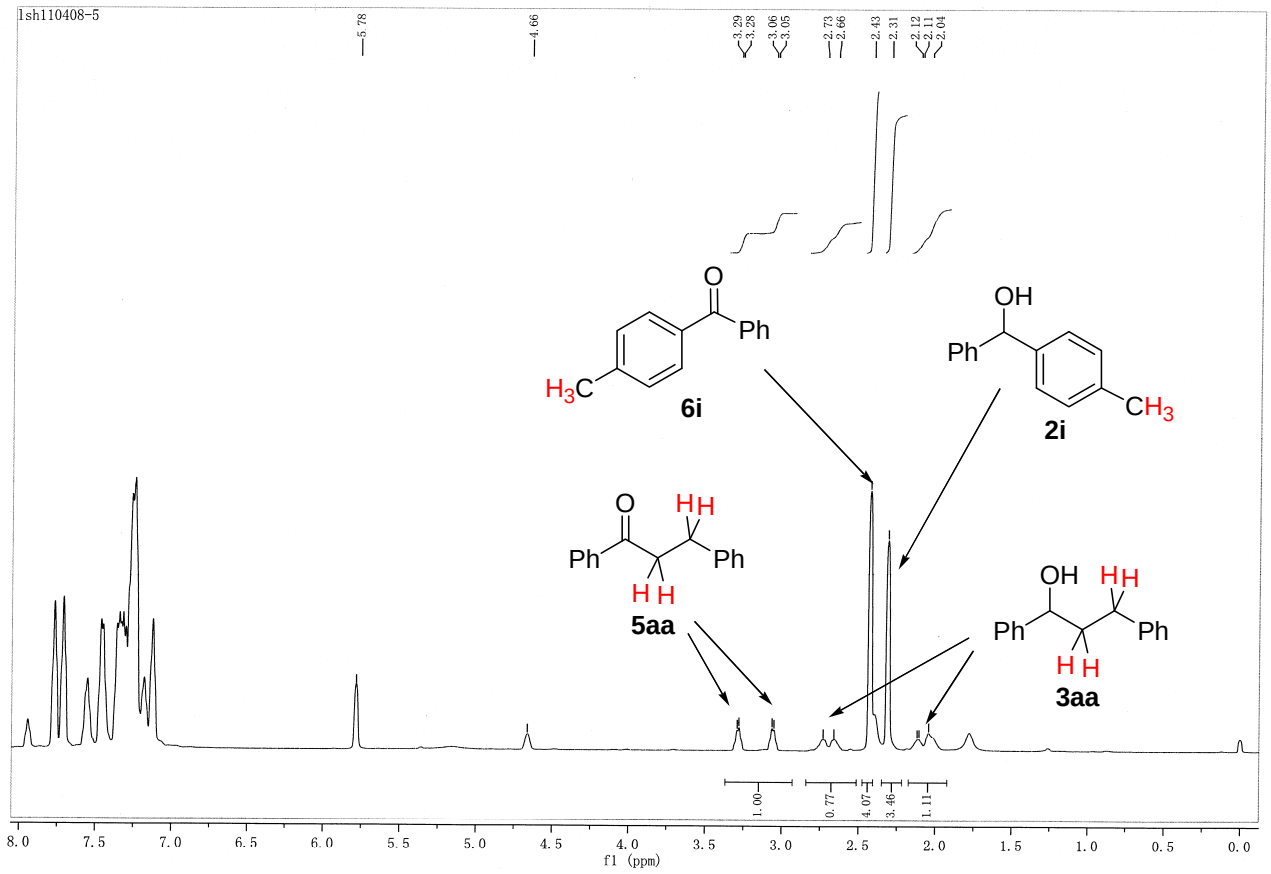
[a] The mixture of **4aa** (0.5 mmol), **2i**, KOH (30 mol%), and $Cu(OAc)_2 \cdot H_2O$ (1 mol%) in toluene (0.5 mL) in a sealed Schlenk tube was heated under N_2. [b] The ratios were determined by ^{1}H NMR analysis. [c] ^{1}H NMR yields based on **2i**. [d] Mol. ratios of the hydrogens accepted (4***3aa** + 2***5aa**) vs. the hydrogens donated (2***6i**) were determined by ^{1}H NMR analysis.

^{1}H NMR spectra of run 1.



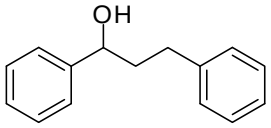
3aa/5aa = 0.17*2/0.99 = 26/74
6i% = 0.25/(0.25 + 1.29) = 84%
$Mol._{hydrogens\ accepted}$ = 4***3aa** + 2***5aa** = 4*(0.17/2) + 2*(0.99/4) = 0.835
$Mol._{hydrogens\ donated}$ = 2***6i** = 2*(1.29/3) = 0.86
$Mol._{hydrogens\ accepted}/Mol._{hydrogens\ donated}$ = 0.835/0.86 = 0.97/1.00

^{1}H NMR spectra of run 2.



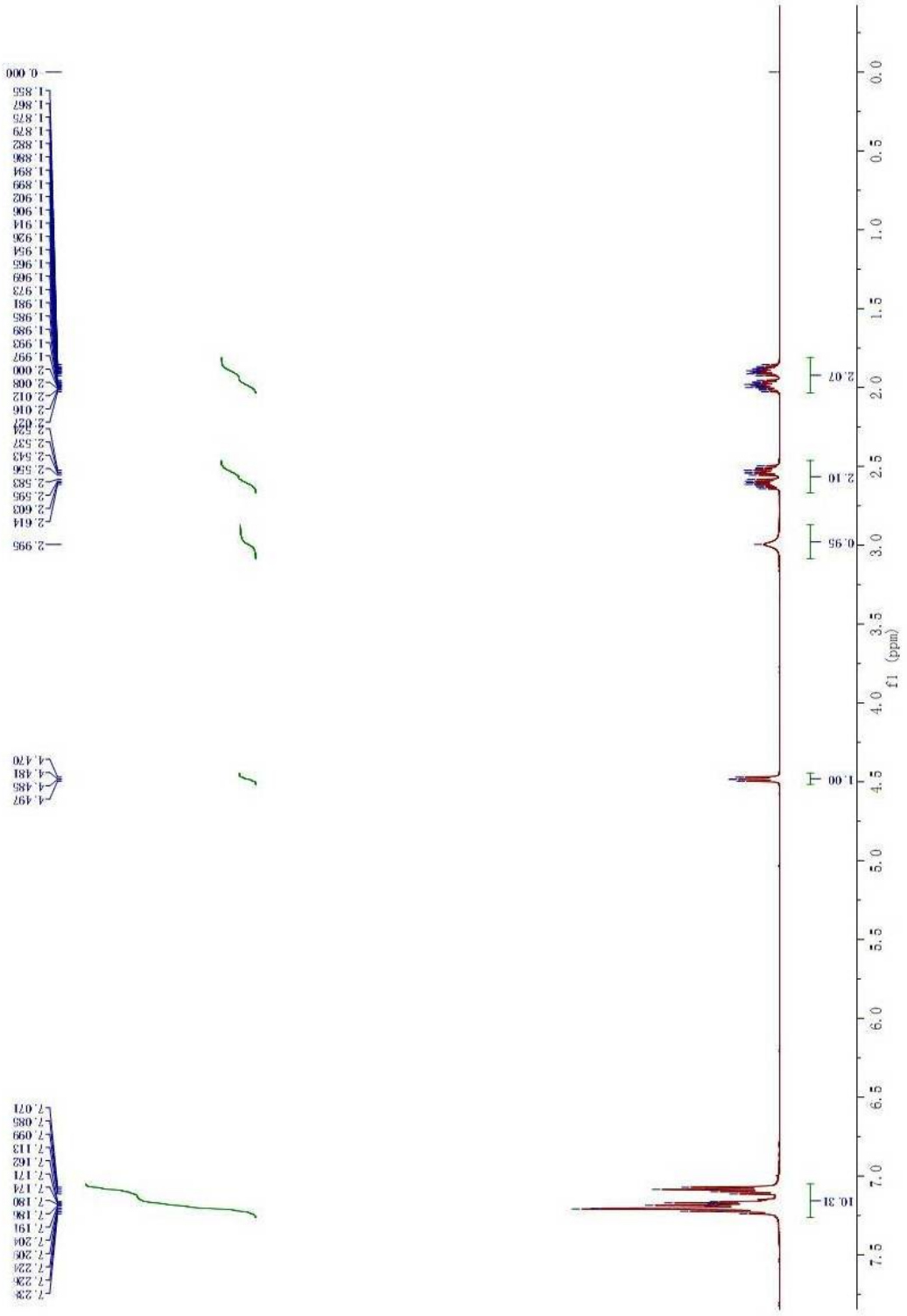
3aa/5aa = 0.77*2/1.00 = 61/39
6i% = 4.07/(4.07 + 3.46) = 54%
Mol.$_{\text{hydrogens accepted}}$ = 4***3aa** + 2***5aa** = 4*(0.77/2) + 2*(1.00/4) = 2.04
Mol.$_{\text{hydrogens donated}}$ = 2***6i** = 2*(4.07/3) = 2.71
Mol.$_{\text{hydrogens accepted}}$/Mol.$_{\text{hydrogens donated}}$ = 2.04/2.71 = 0.75/1.00

^{1}H and ^{13}C NMR Spectra of the Products

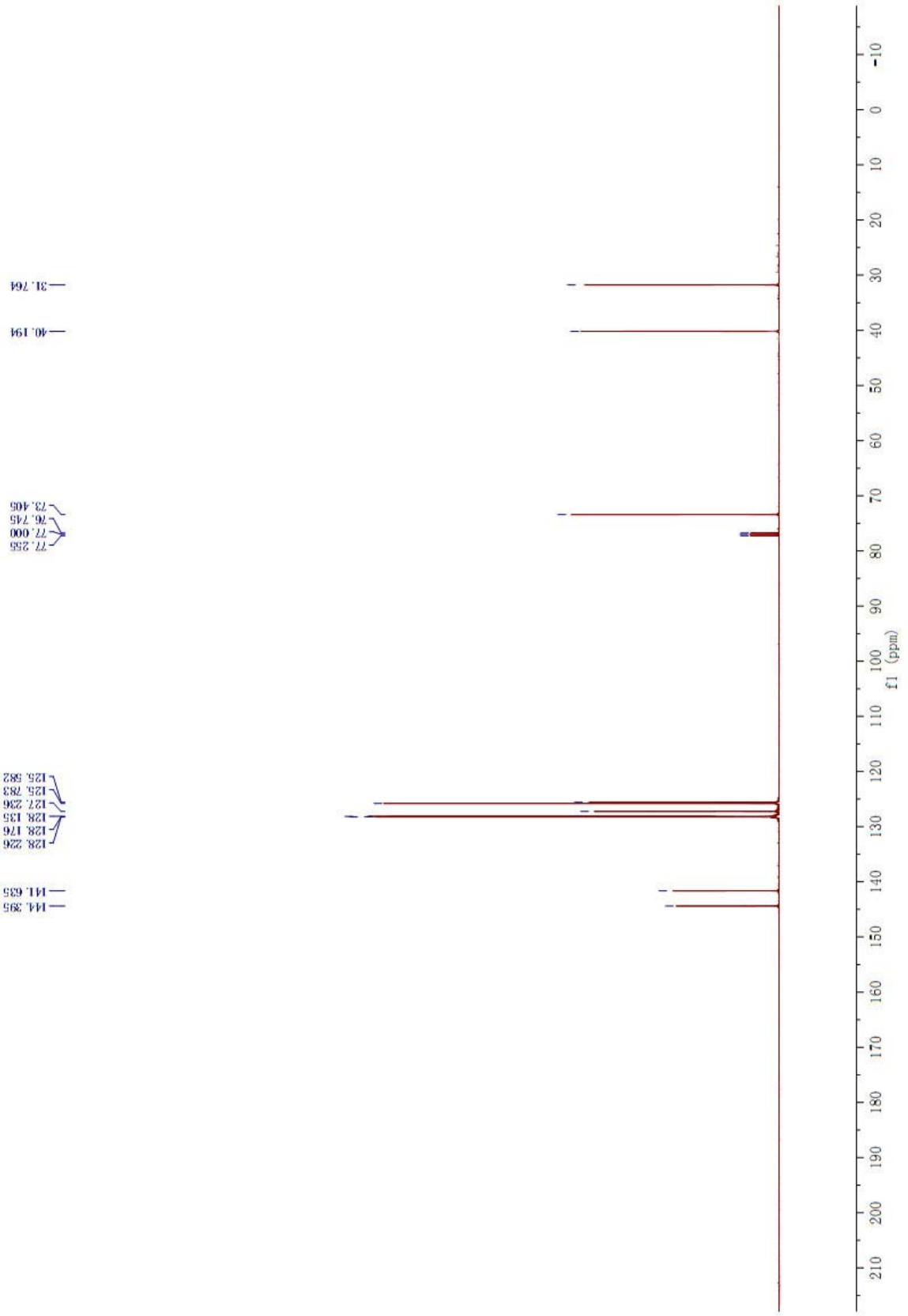


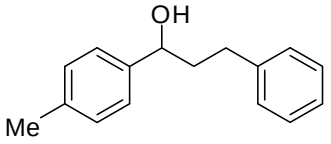
3aa

^{1}H NMR



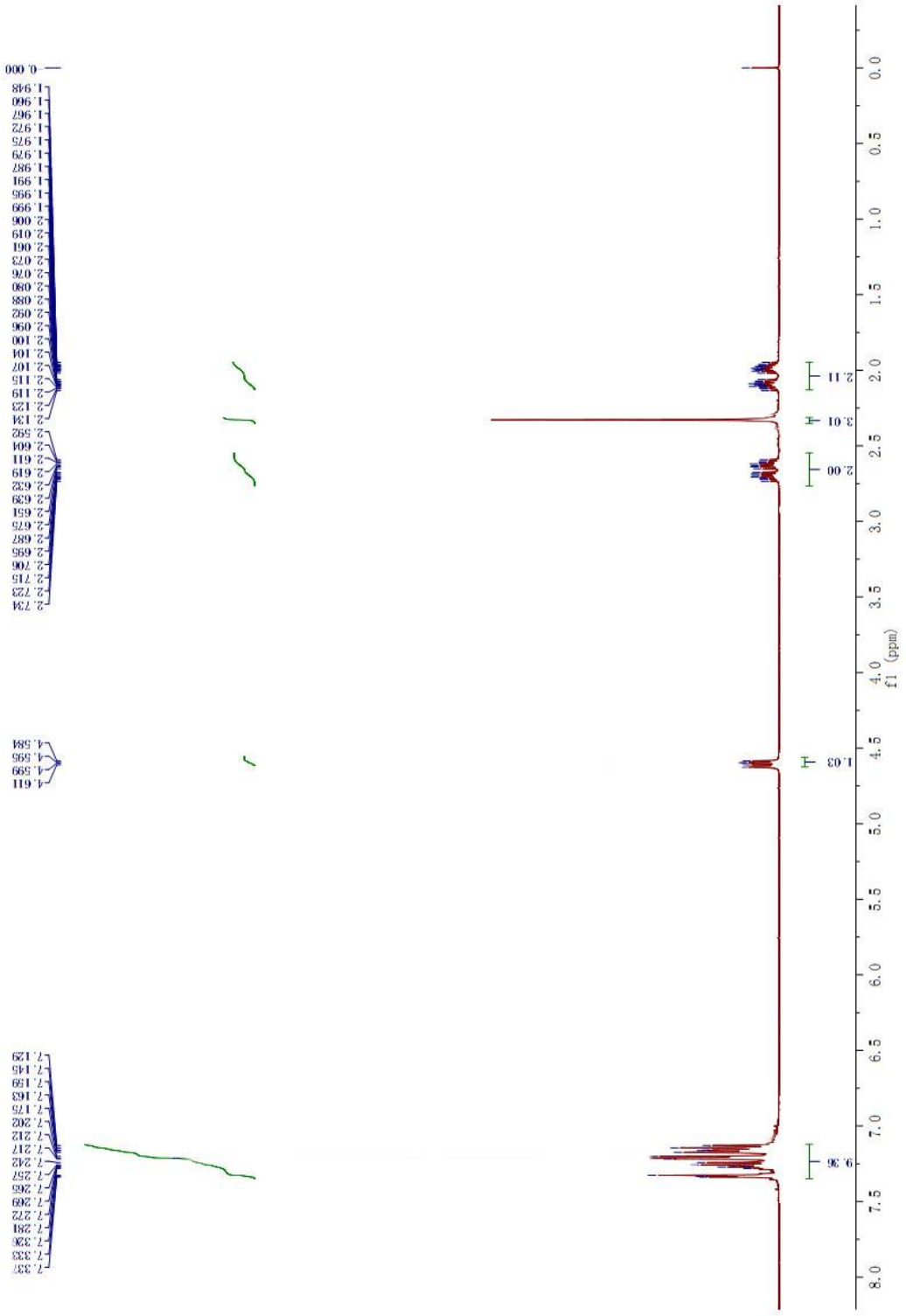
^{13}C NMR

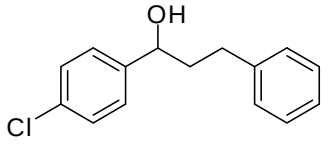




3ab

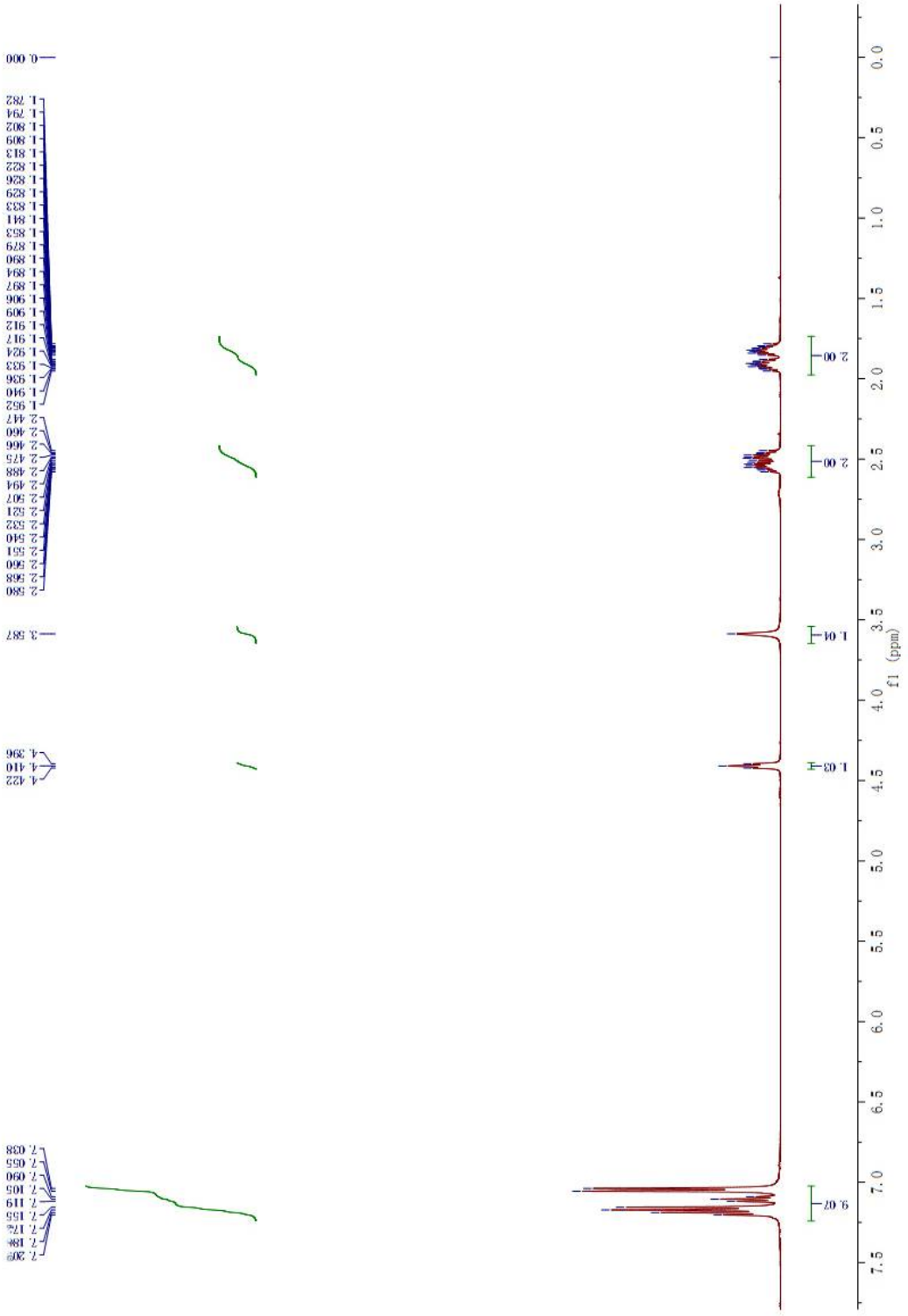
^{1}H NMR



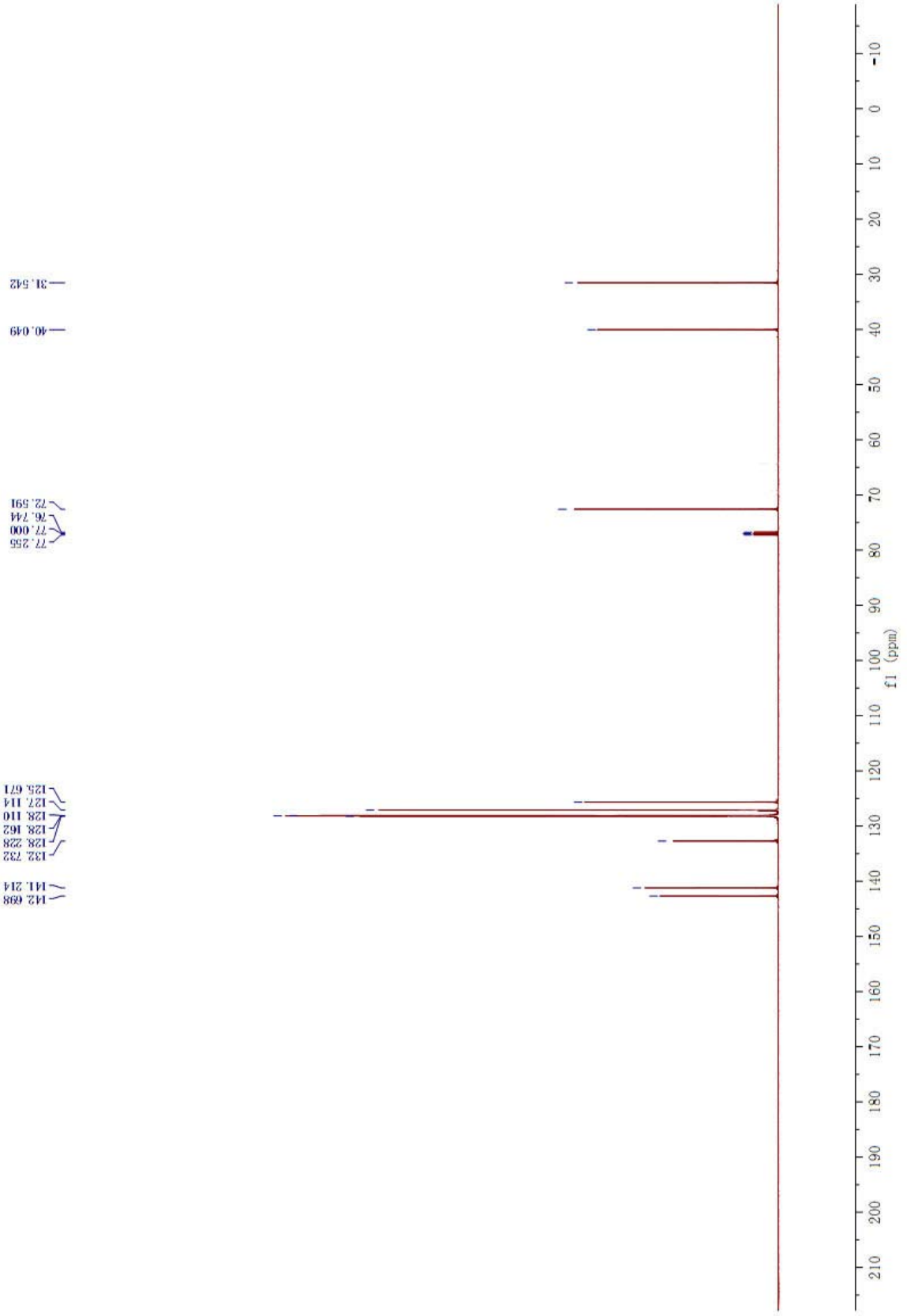


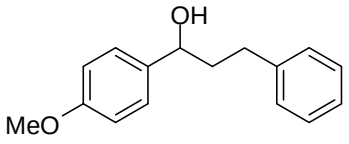
3ac

^{1}H NMR



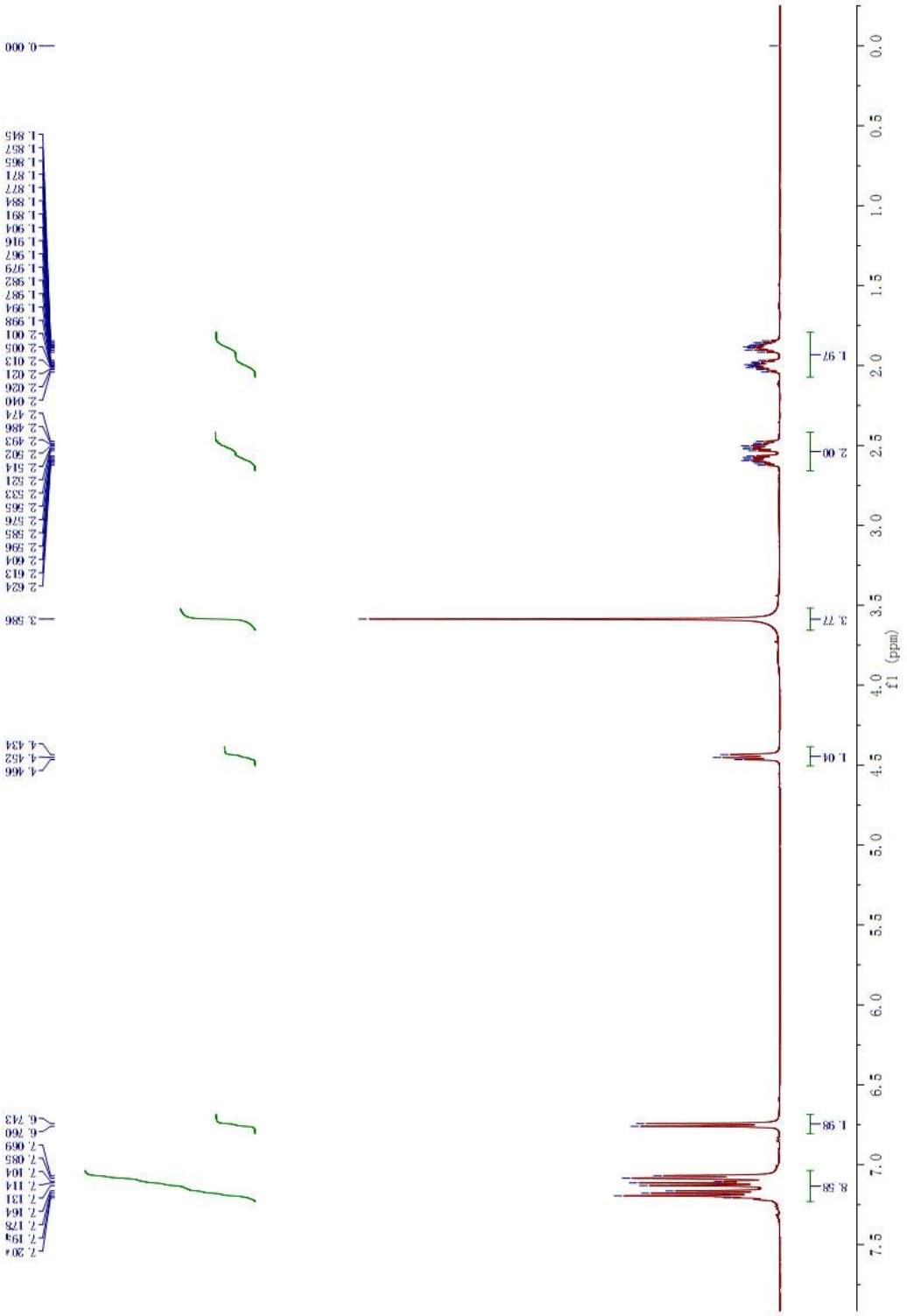
^{13}C NMR



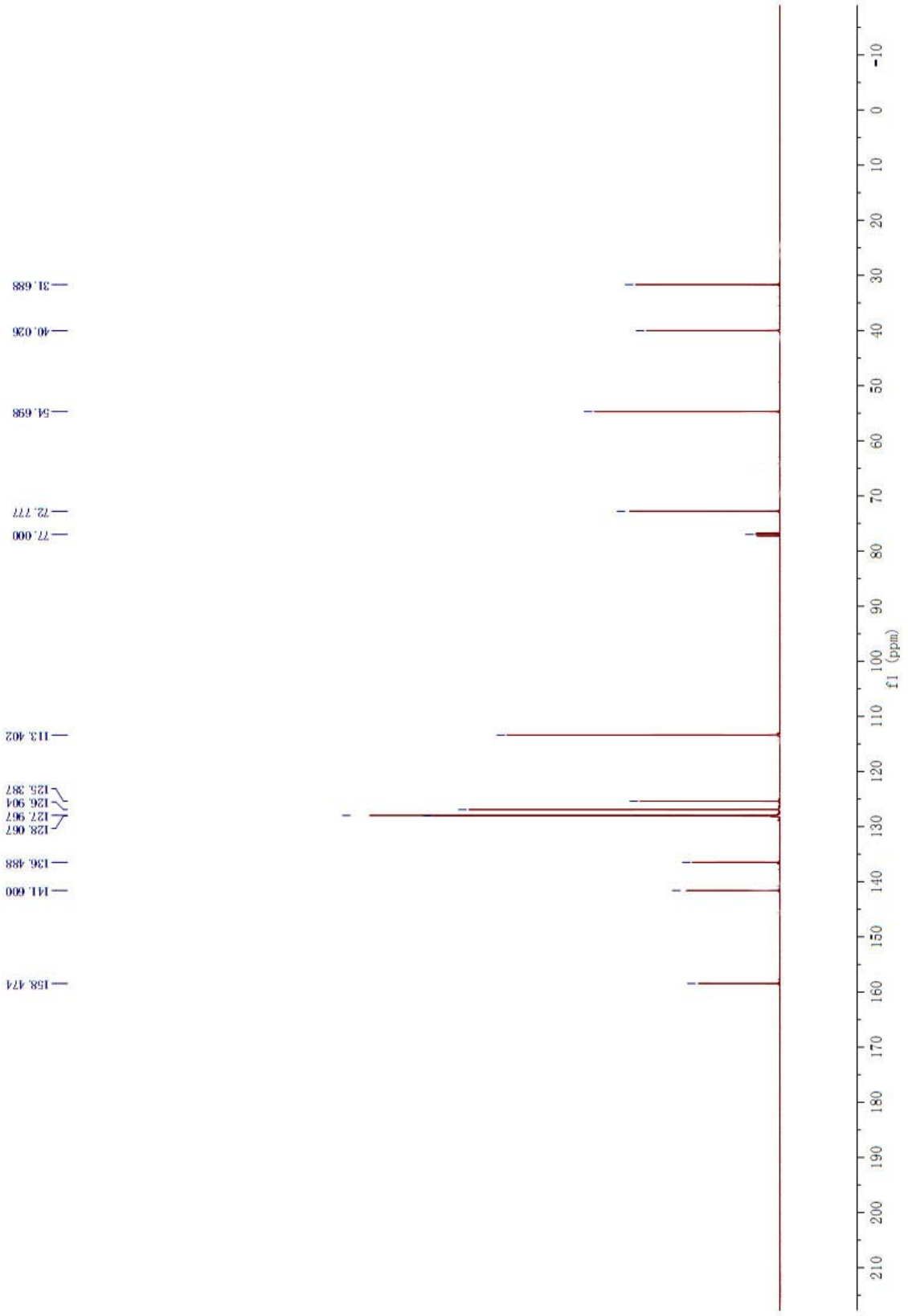


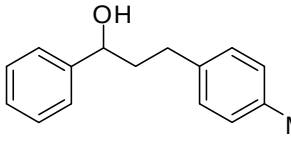
3ad

^{1}H NMR



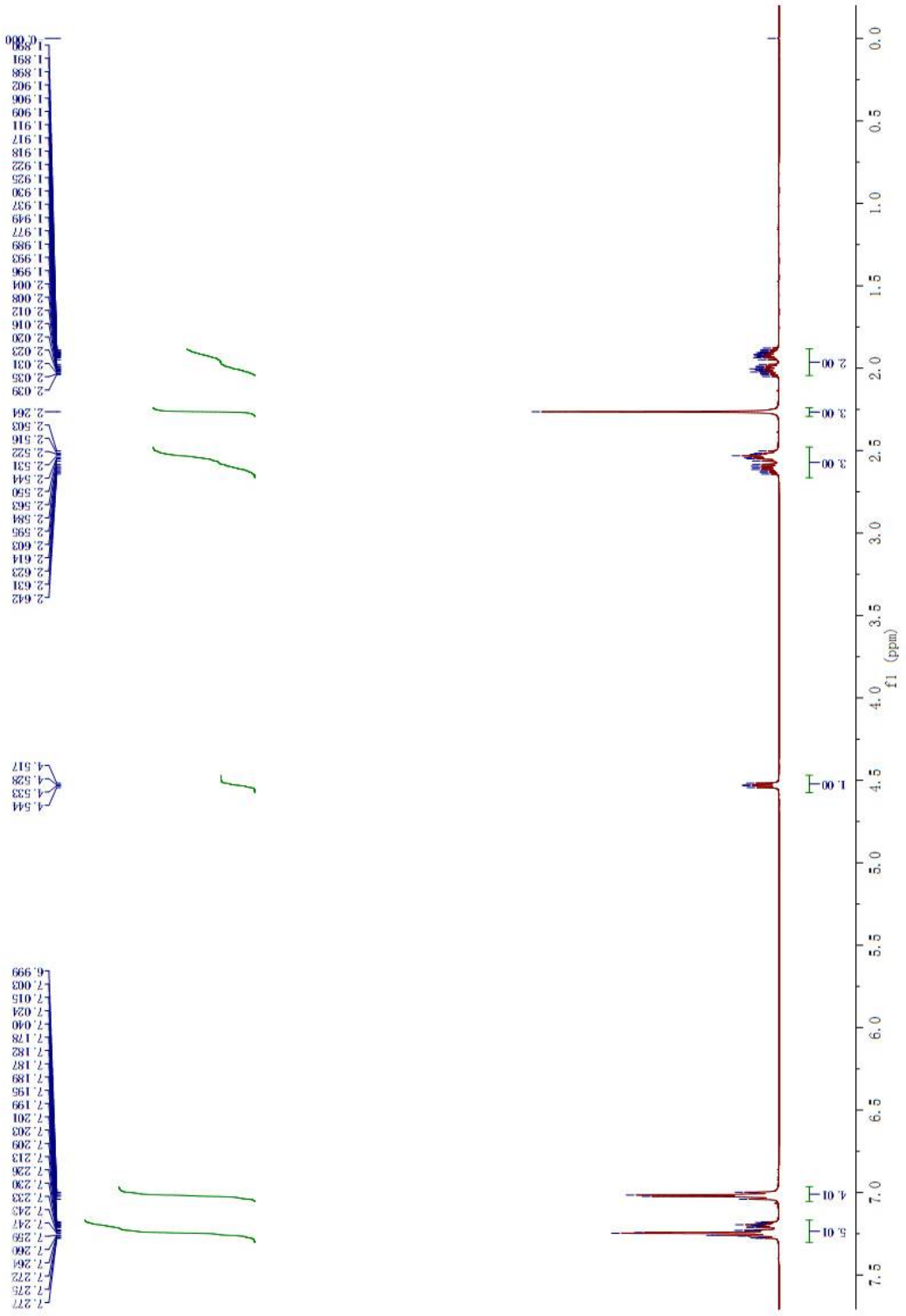
^{13}C NMR



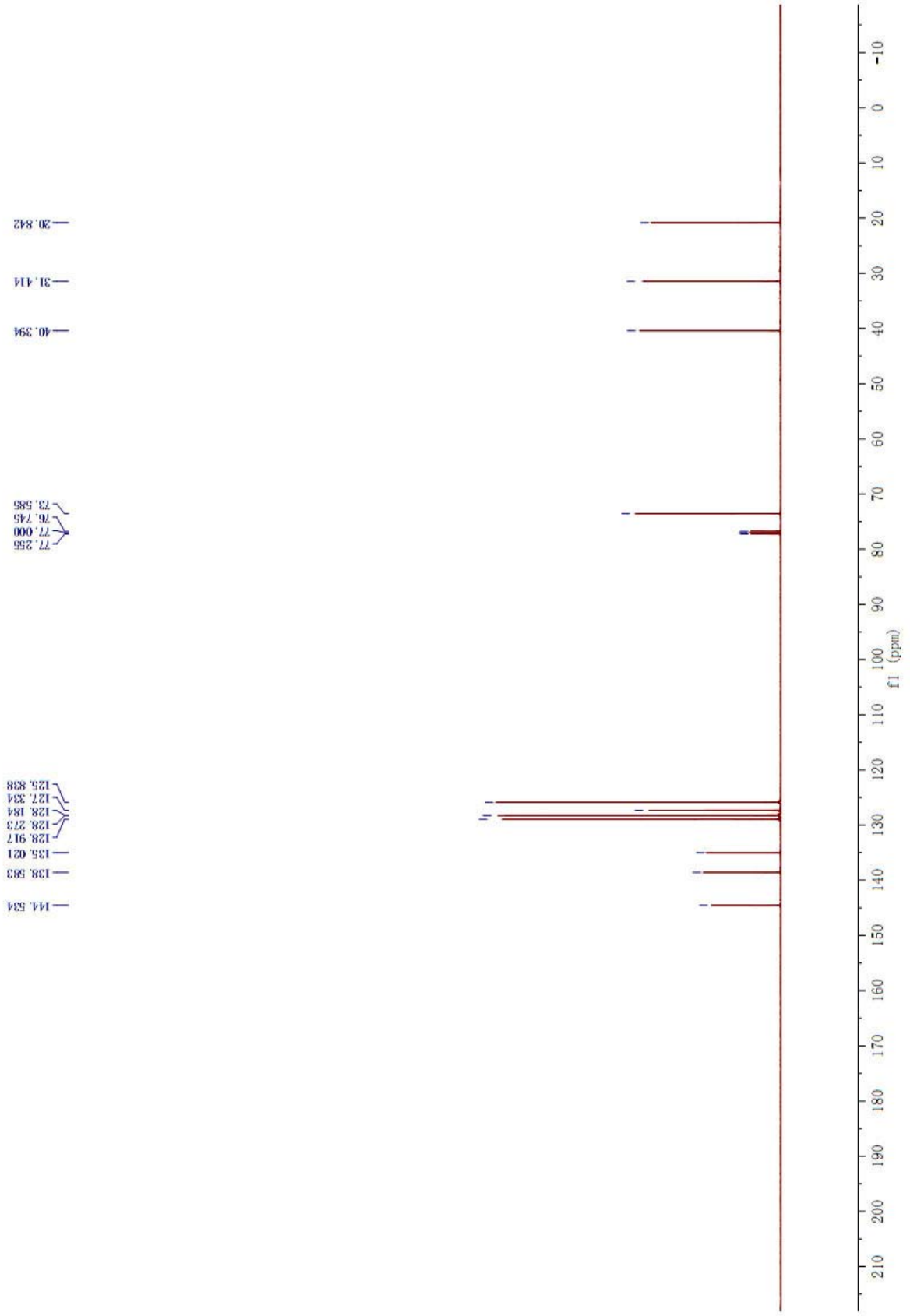


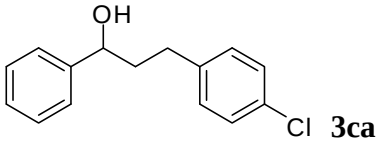
3ba

^{1}H NMR



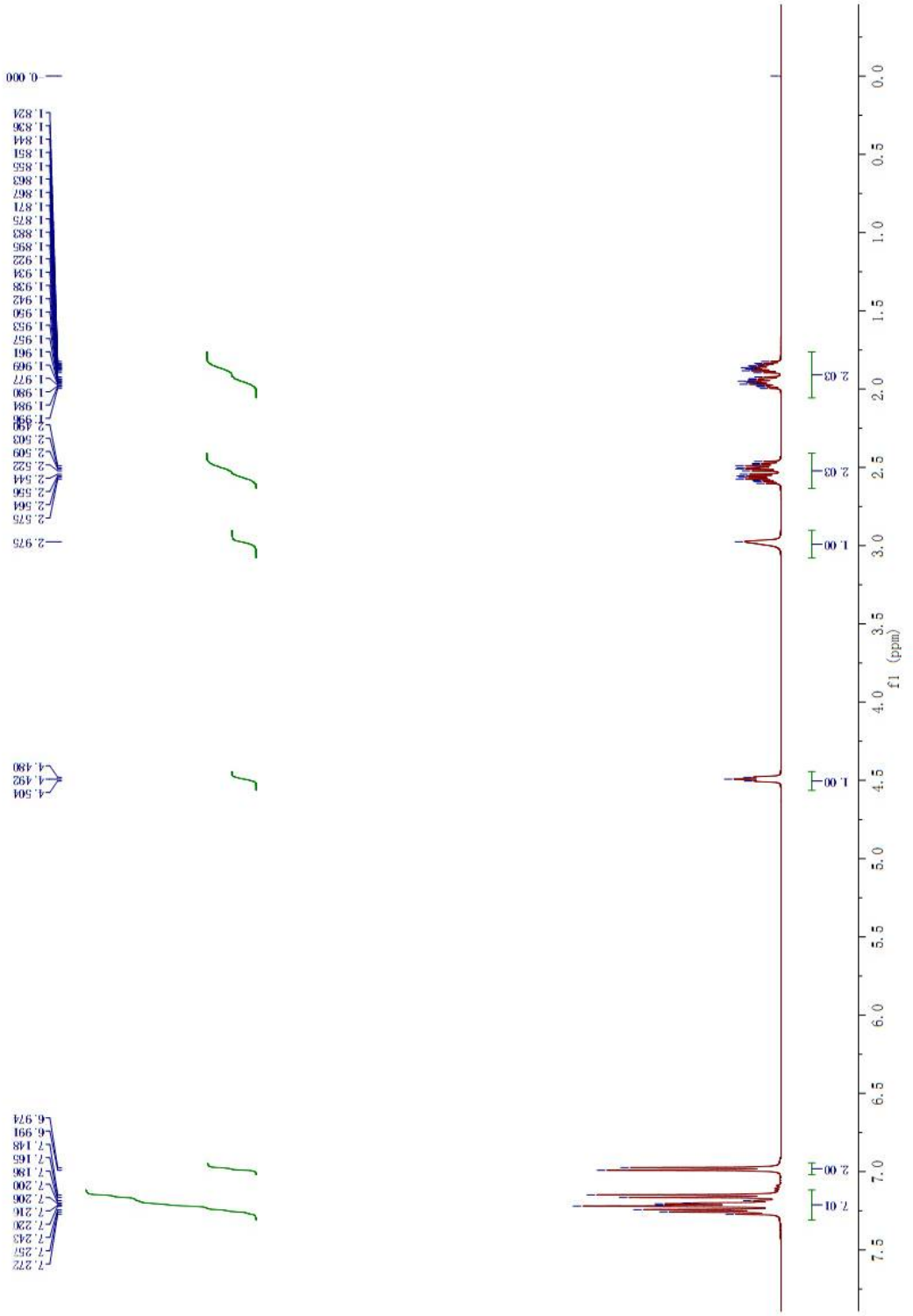
^{13}C NMR



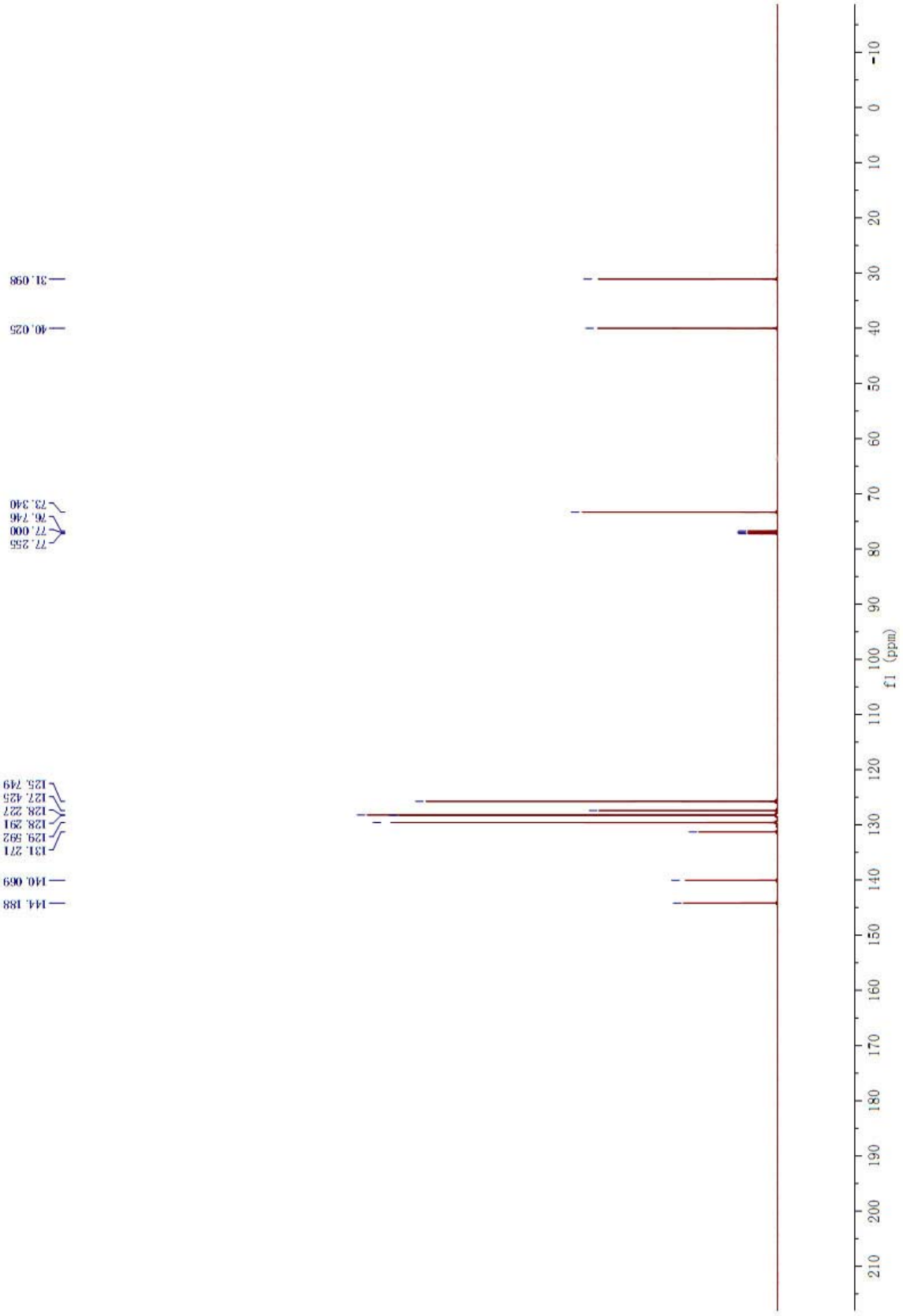


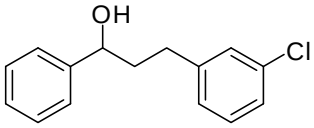
3ca

^{1}H NMR



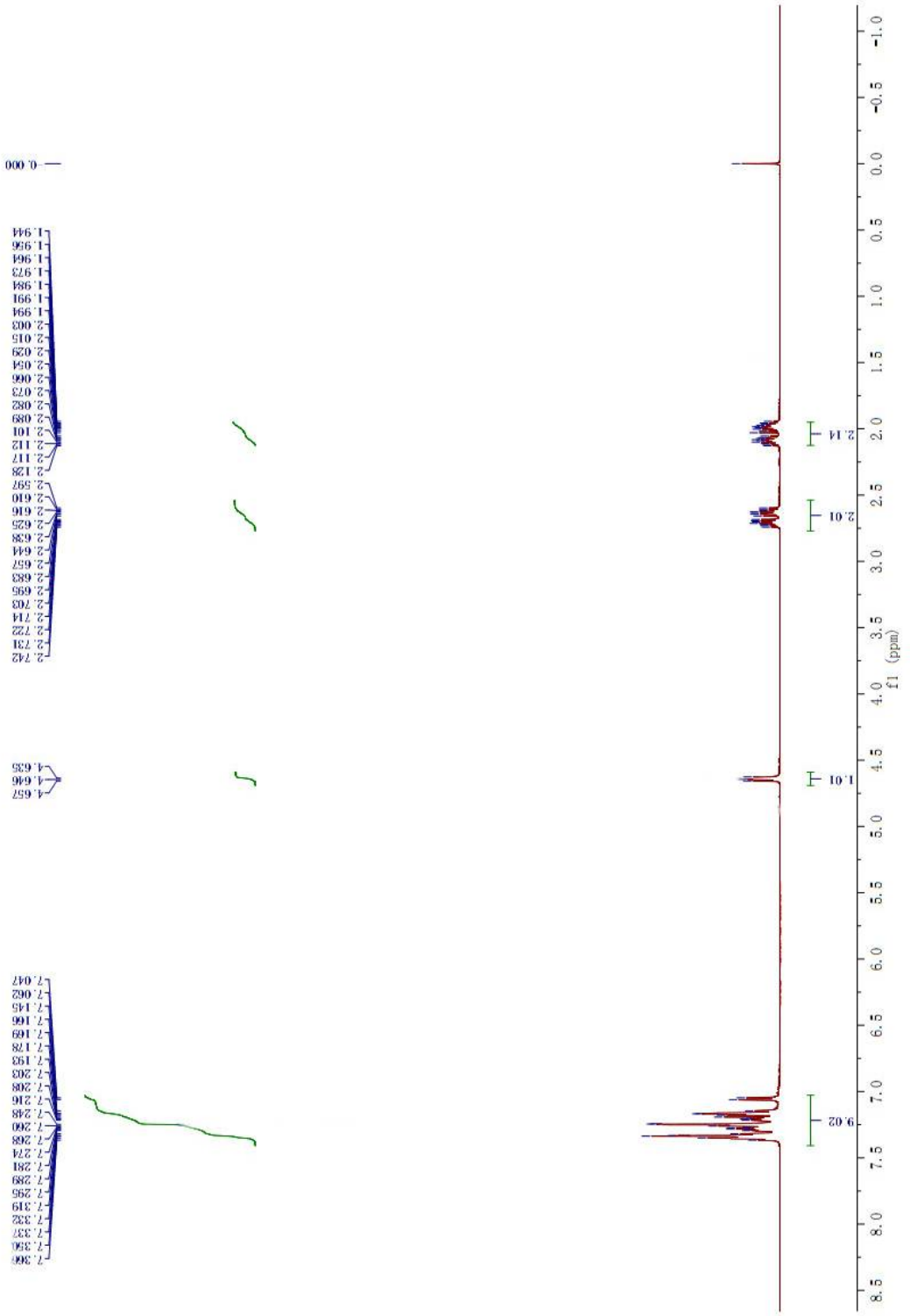
^{13}C NMR

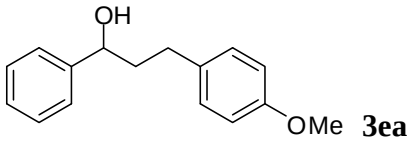




3da

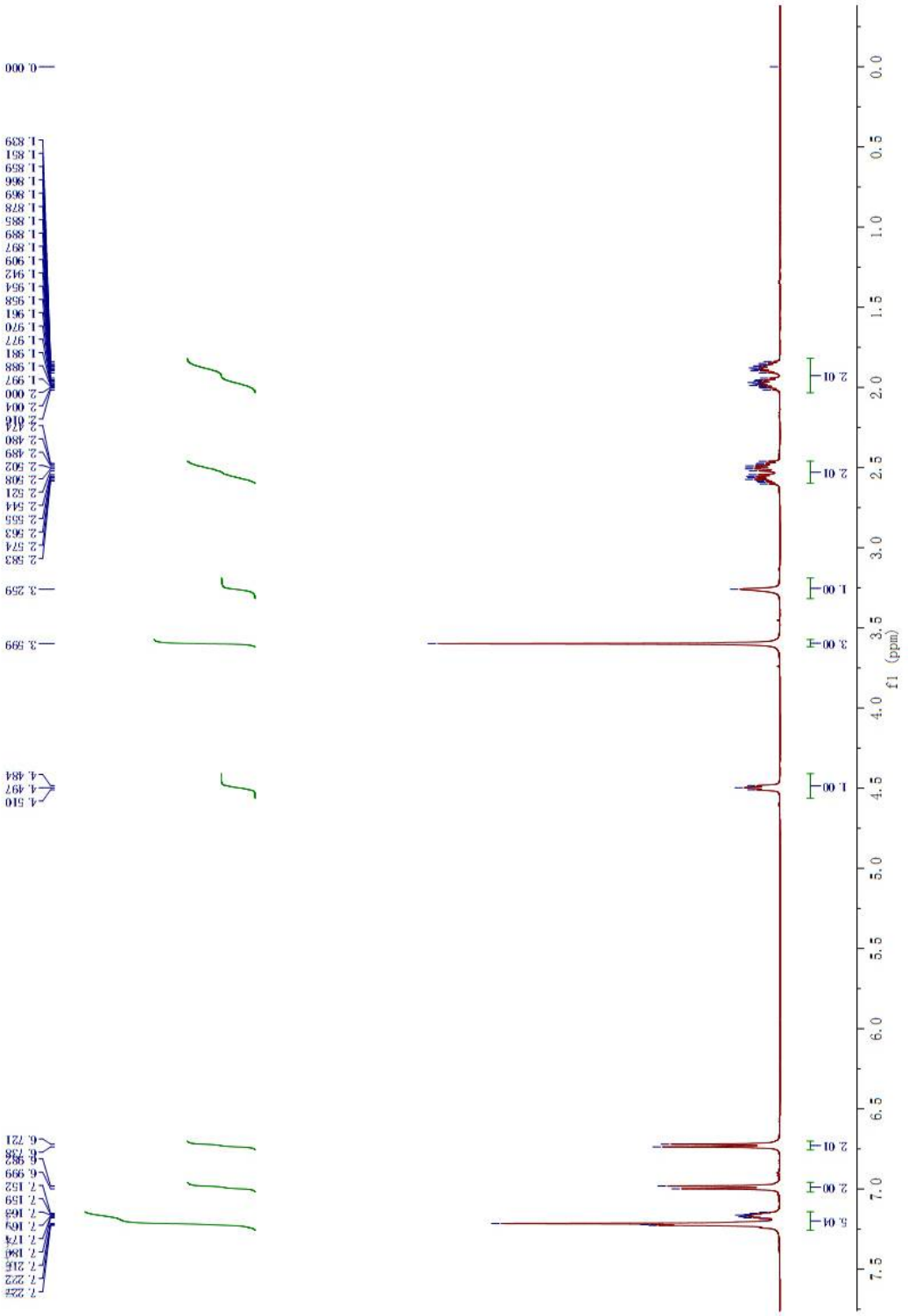
^{1}H NMR



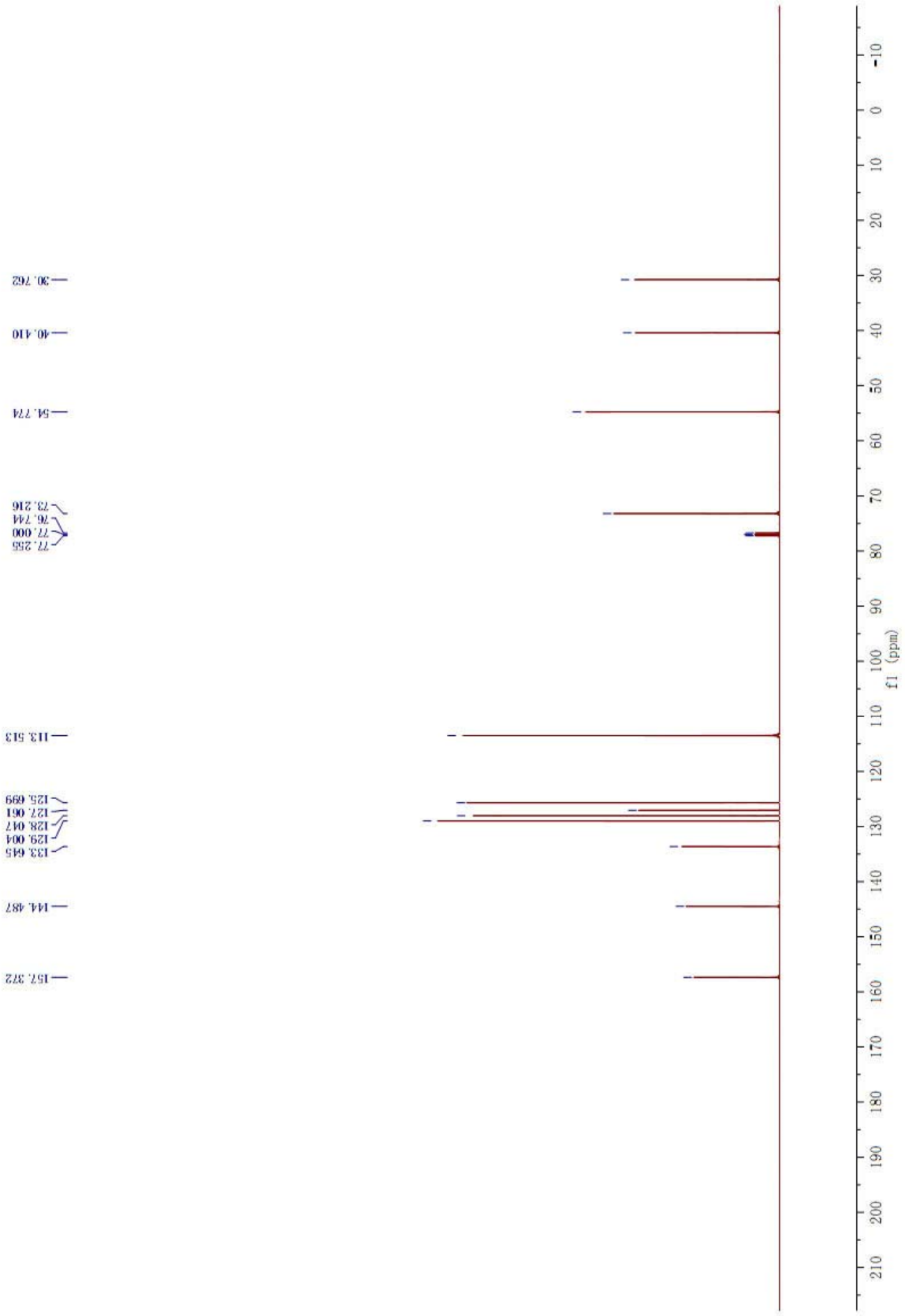


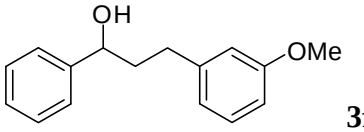
3ea

^{1}H NMR



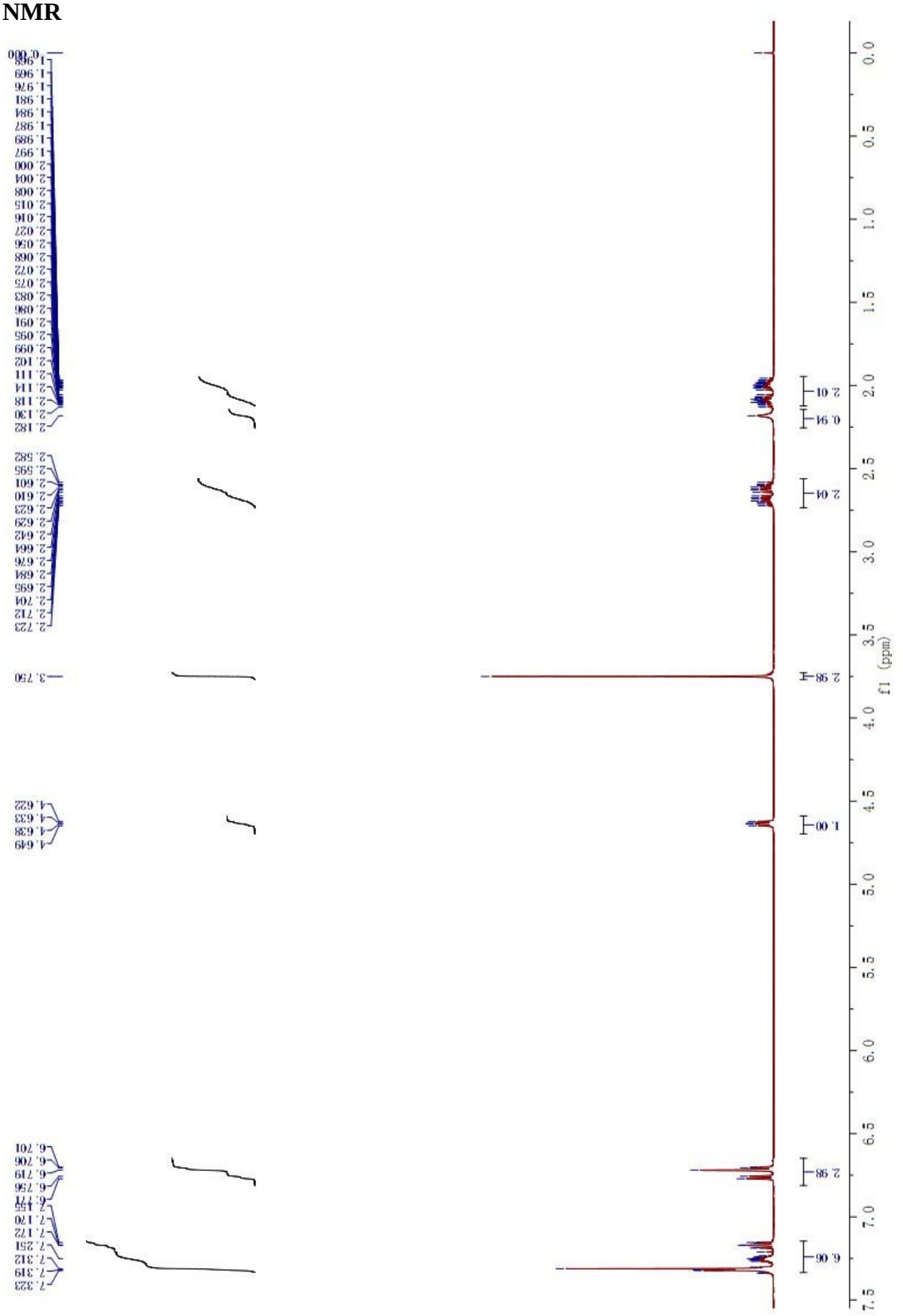
^{13}C NMR



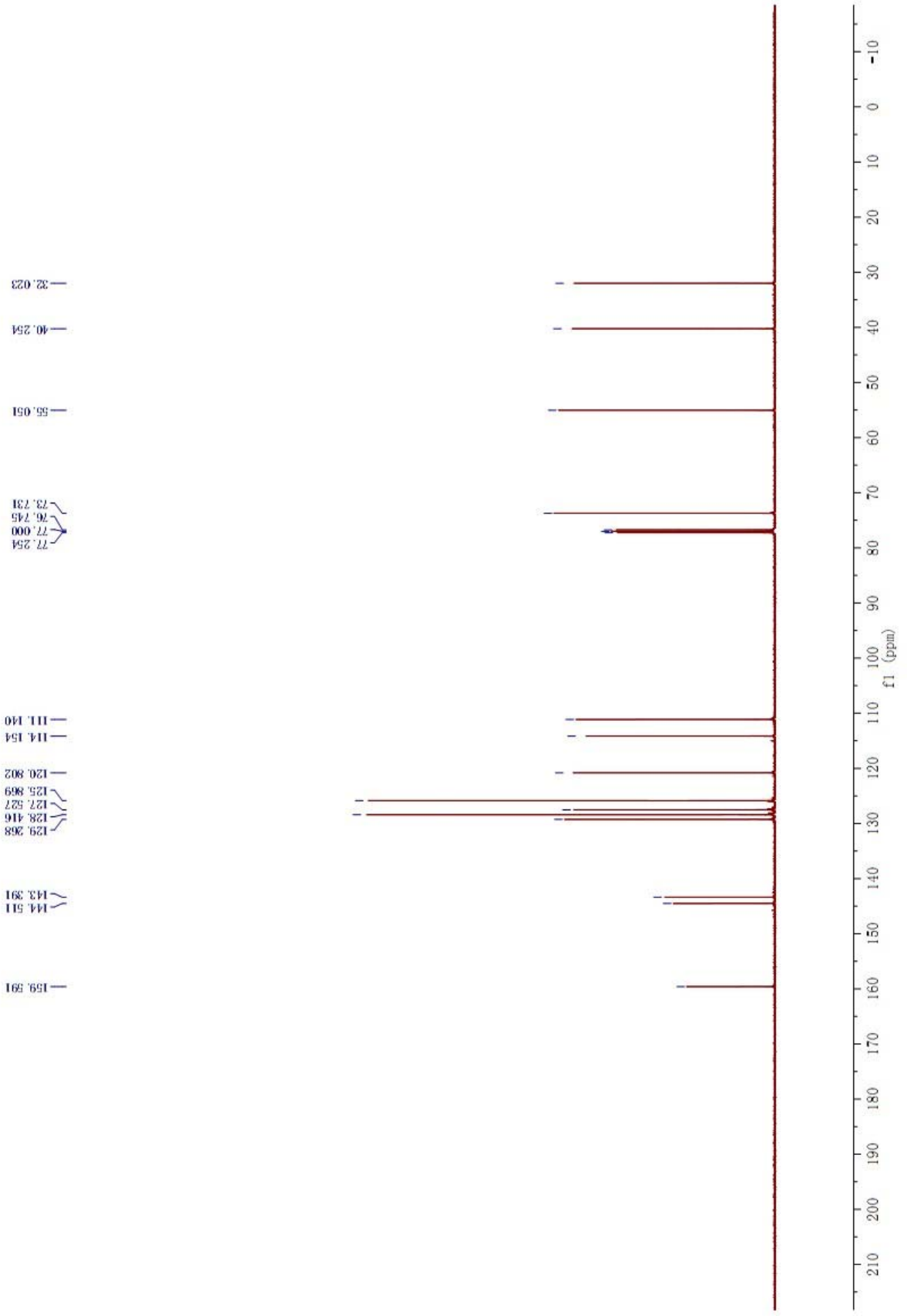


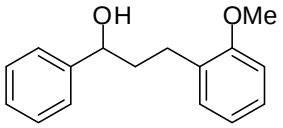
3fa

^{1}H NMR



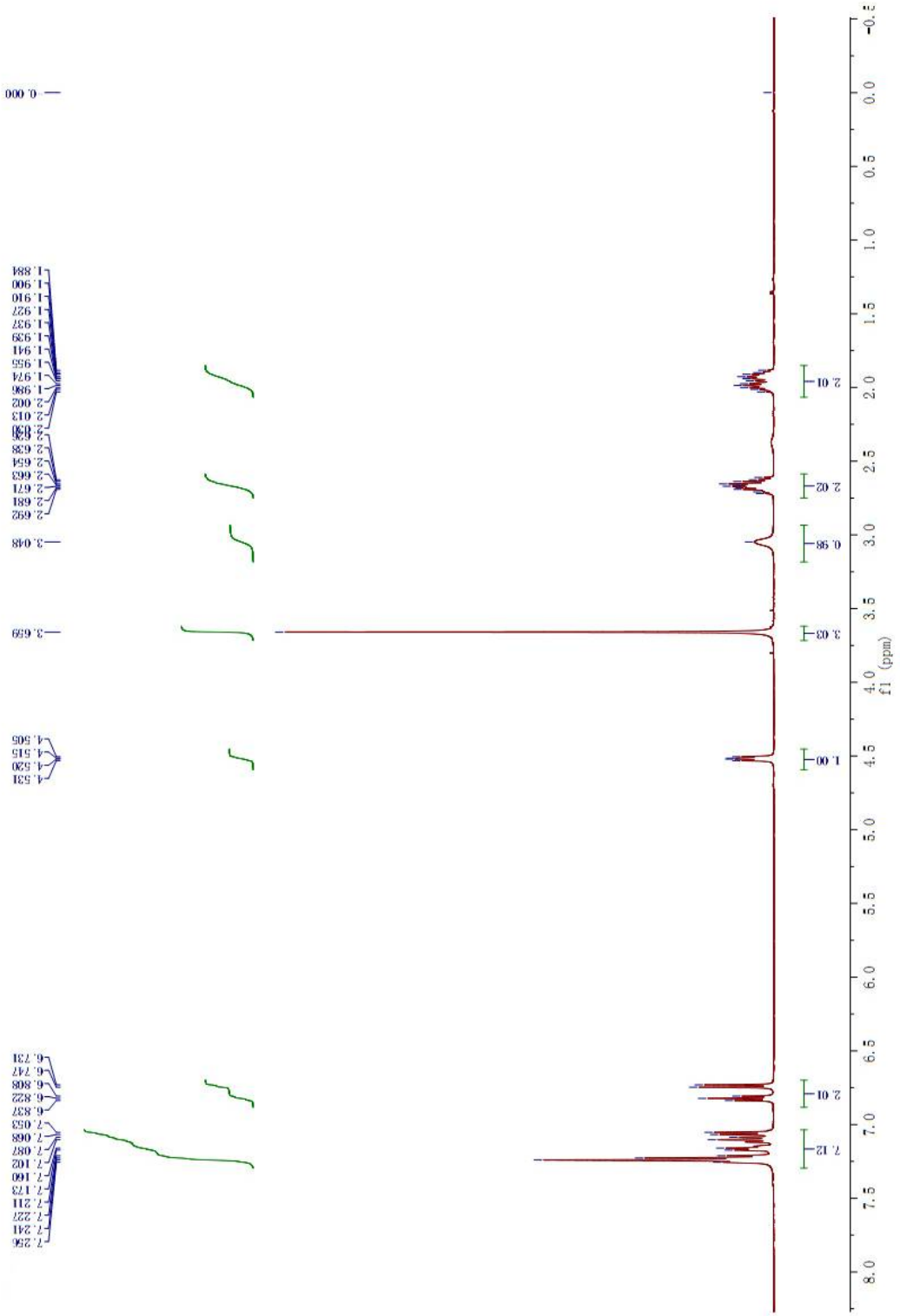
^{13}C NMR



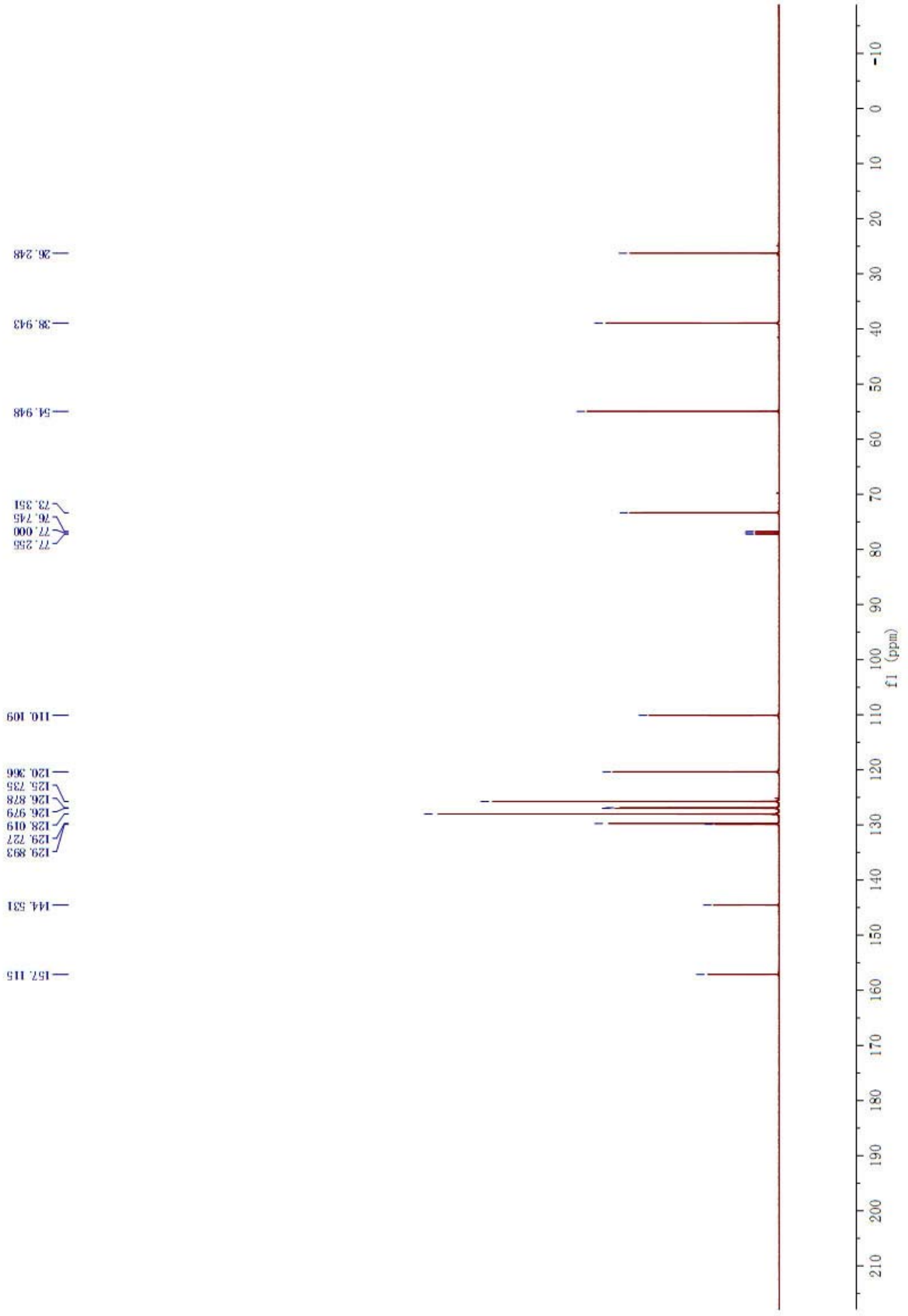


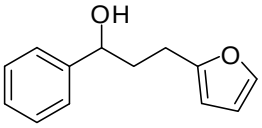
3ga

^{1}H NMR



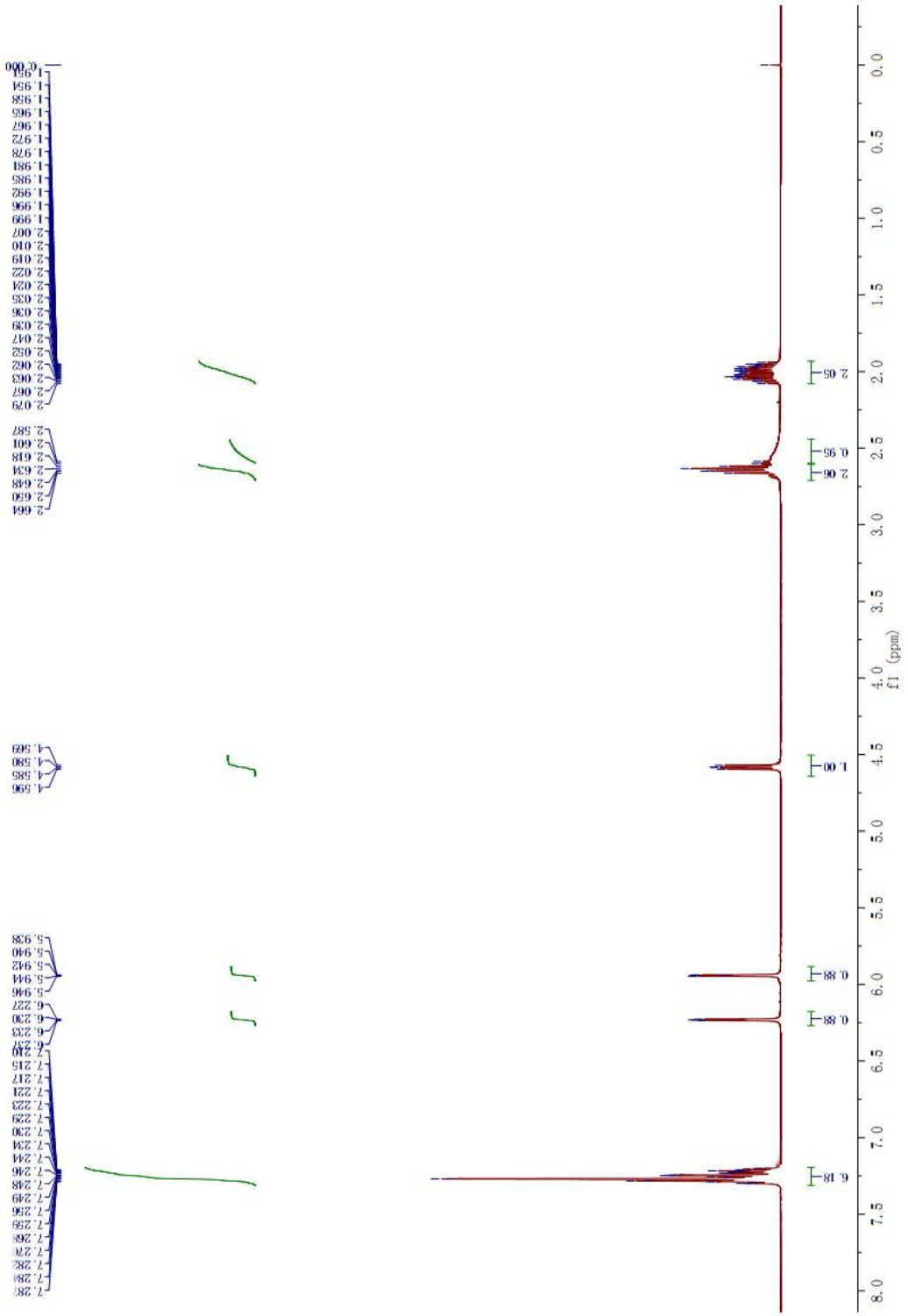
^{13}C NMR



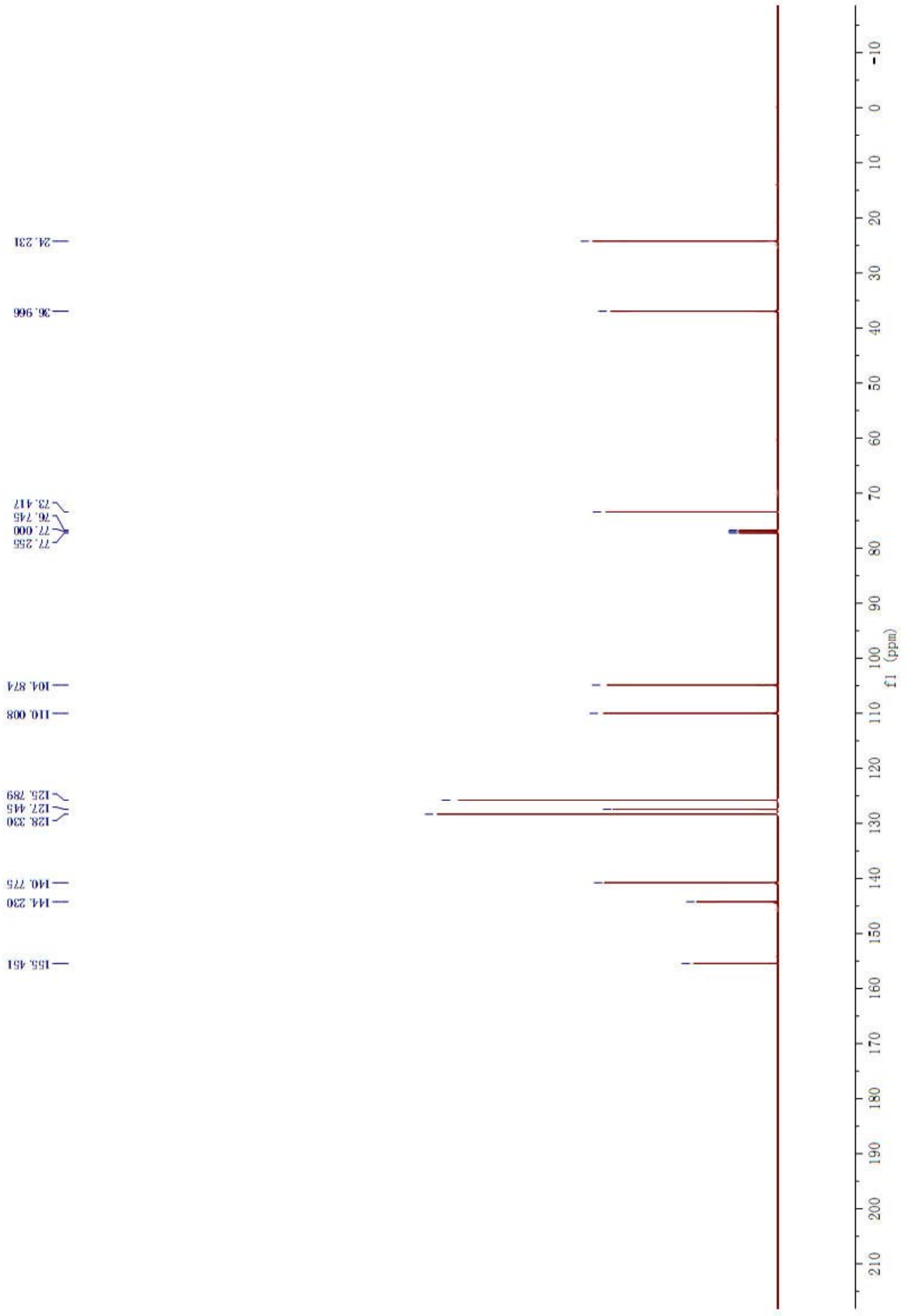


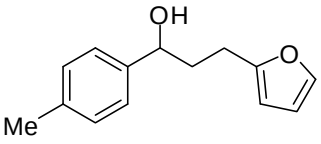
3ha

^{1}H NMR



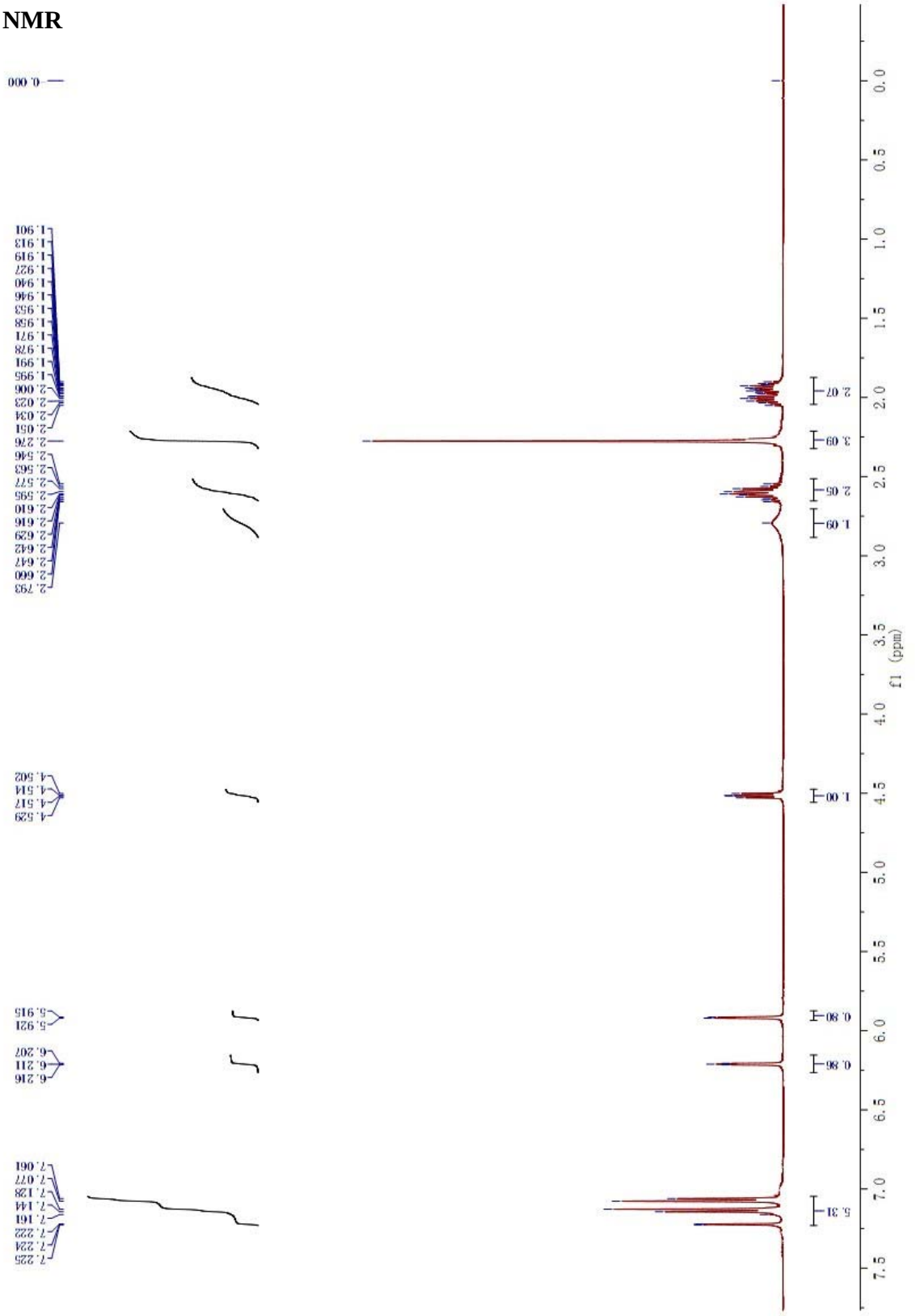
^{13}C NMR



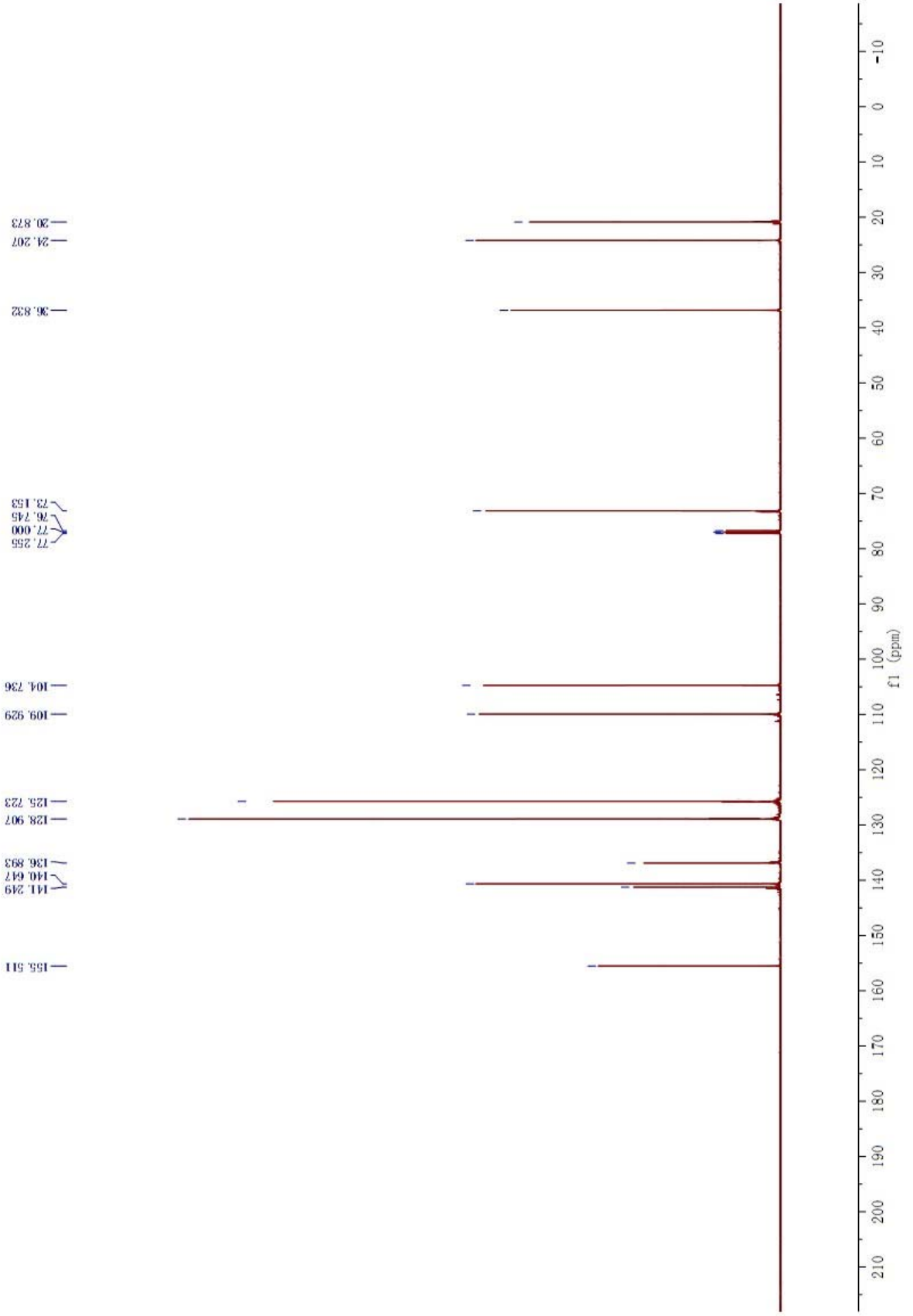


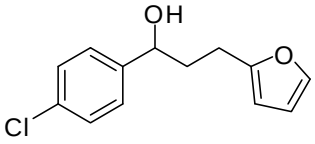
3hb

^{1}H NMR



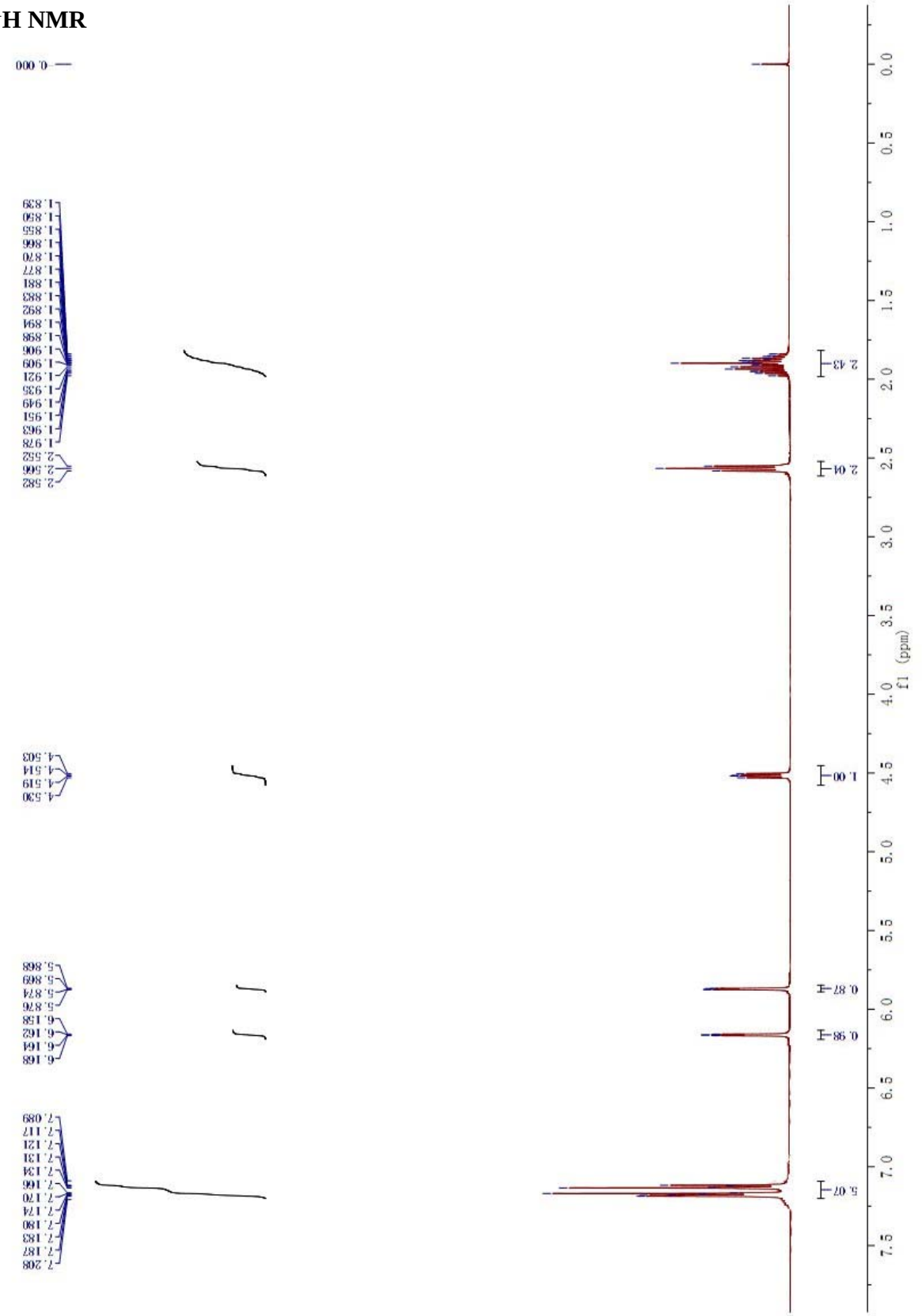
^{13}C NMR



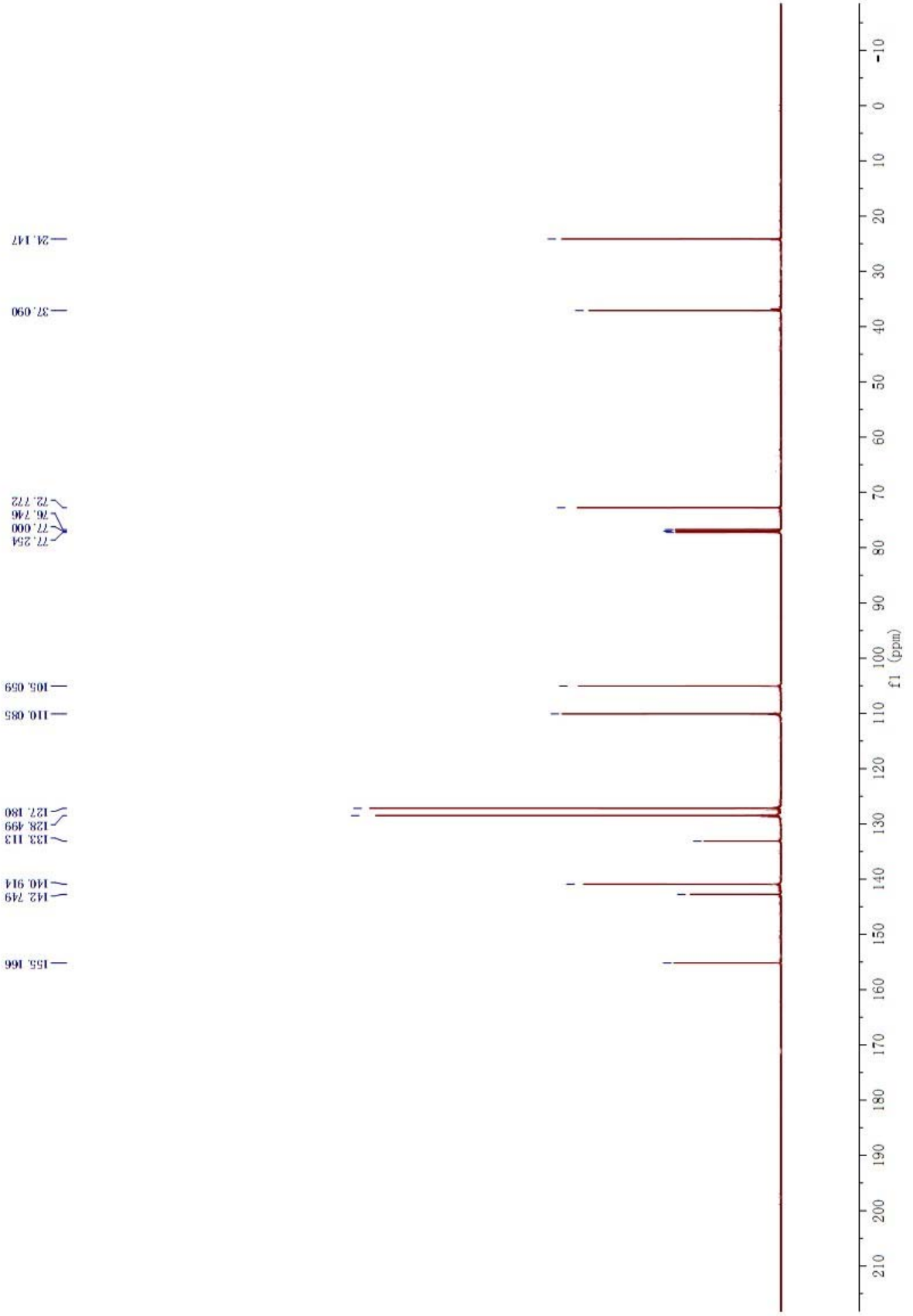


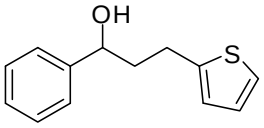
3hc

^{1}H NMR



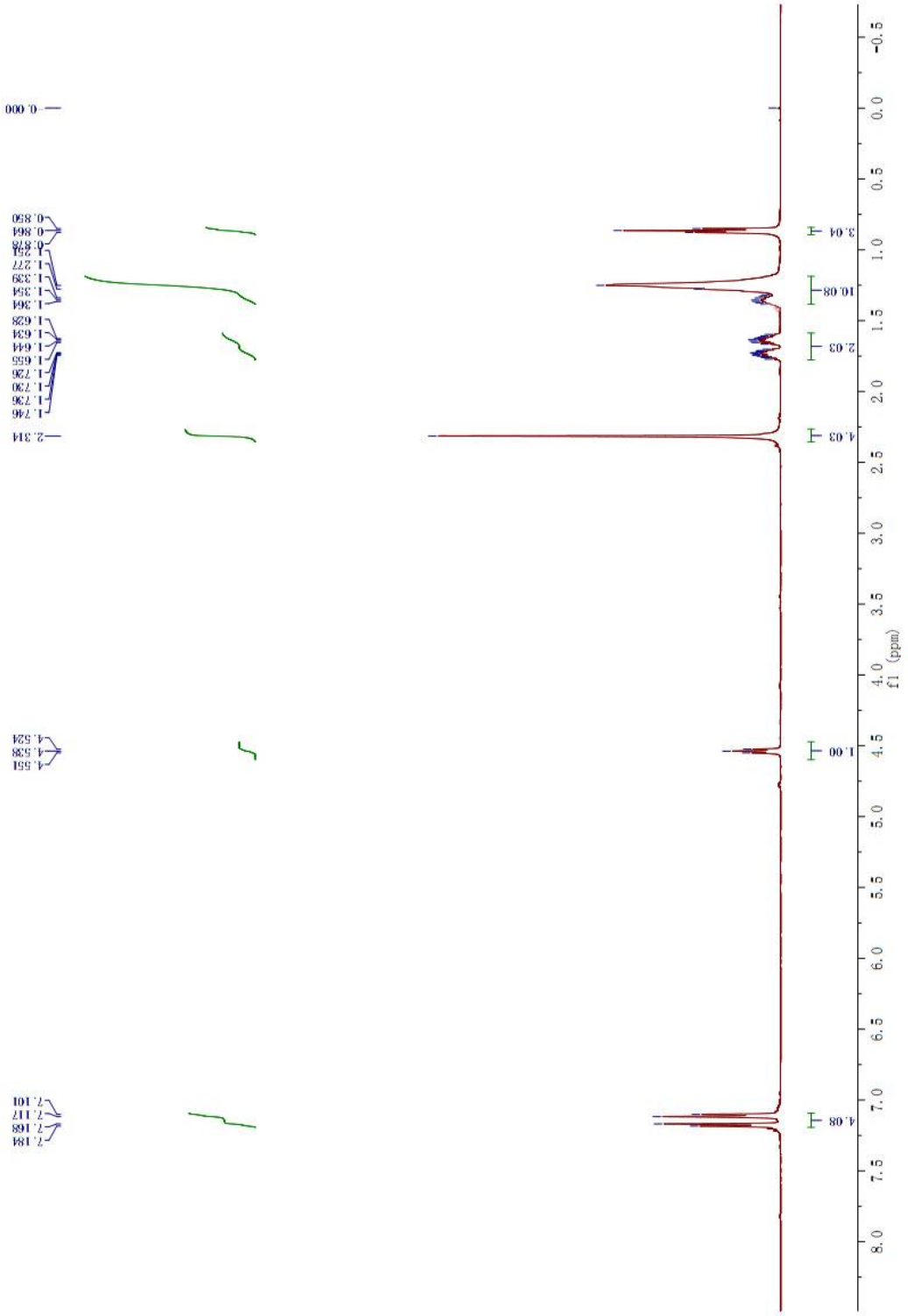
^{13}C NMR

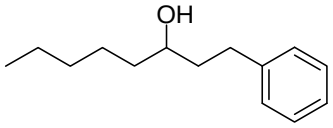



OH
S

3ia

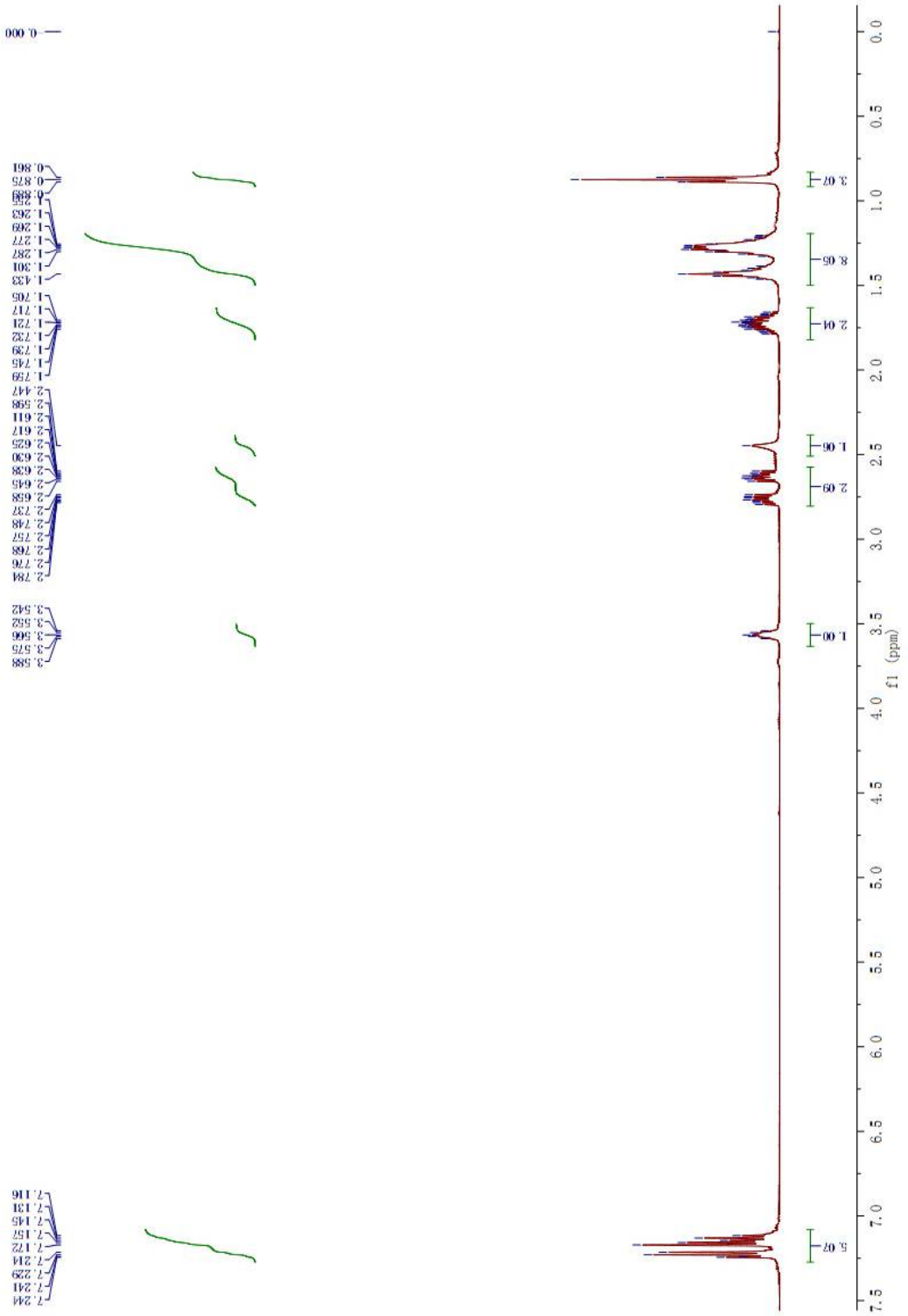
^{1}H NMR


0.000
0.830
0.864
0.876
1.277
1.339
1.354
1.364
1.628
1.634
1.644
1.655
1.726
1.730
1.736
1.746
2.314
4.524
4.538
4.551
7.101
7.117
7.168
7.184
3.04
10.08
2.03
4.03
1.00
4.08
f1 (ppm)

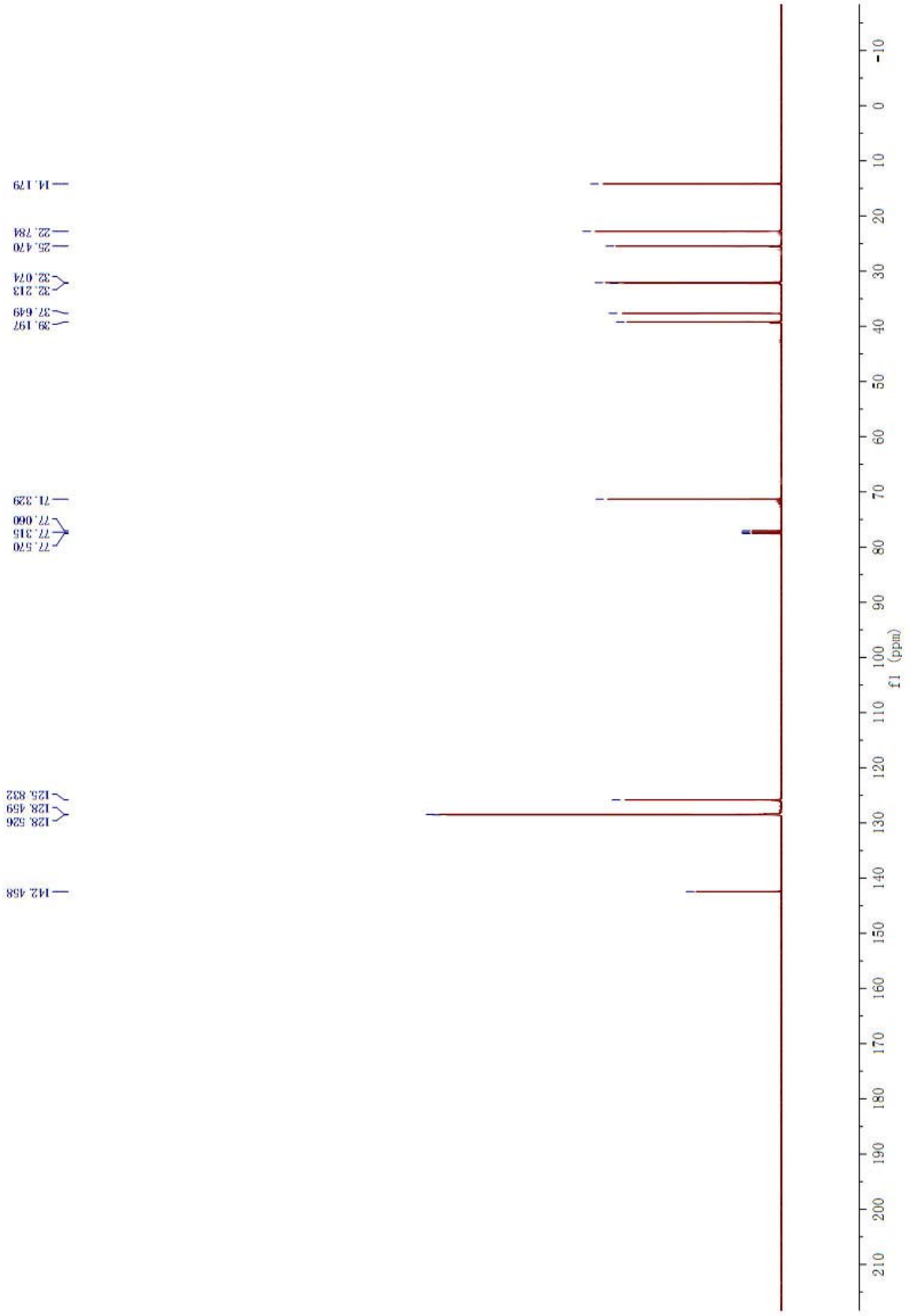


3ae

^{1}H NMR



^{13}C NMR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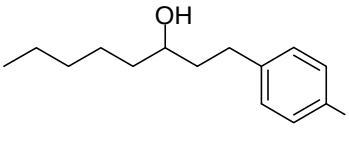
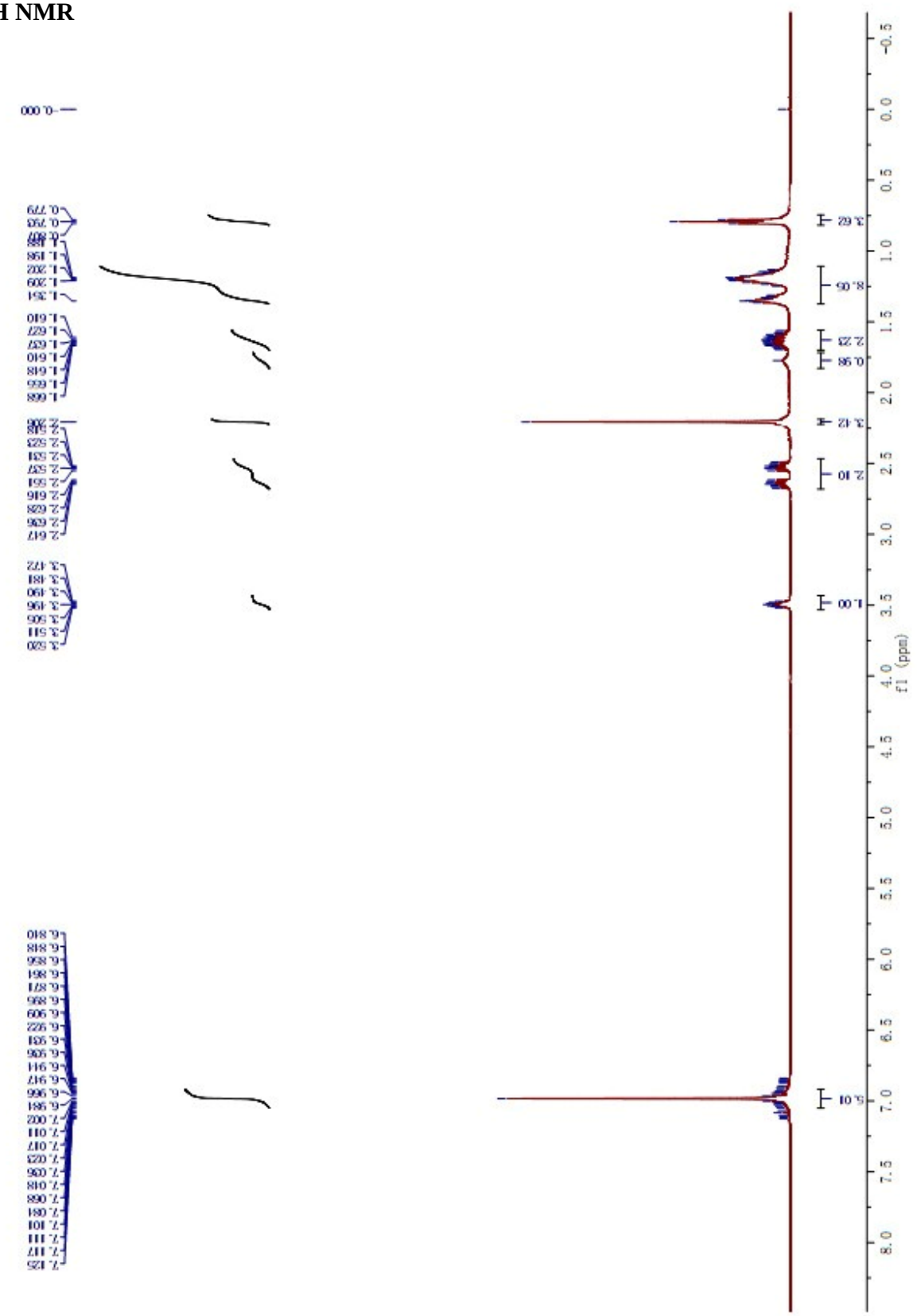
25.470
32.074
32.213
37.649
39.197
71.329
77.060
77.315
77.570
125.832
128.459
128.626
142.458
f1 (ppm)

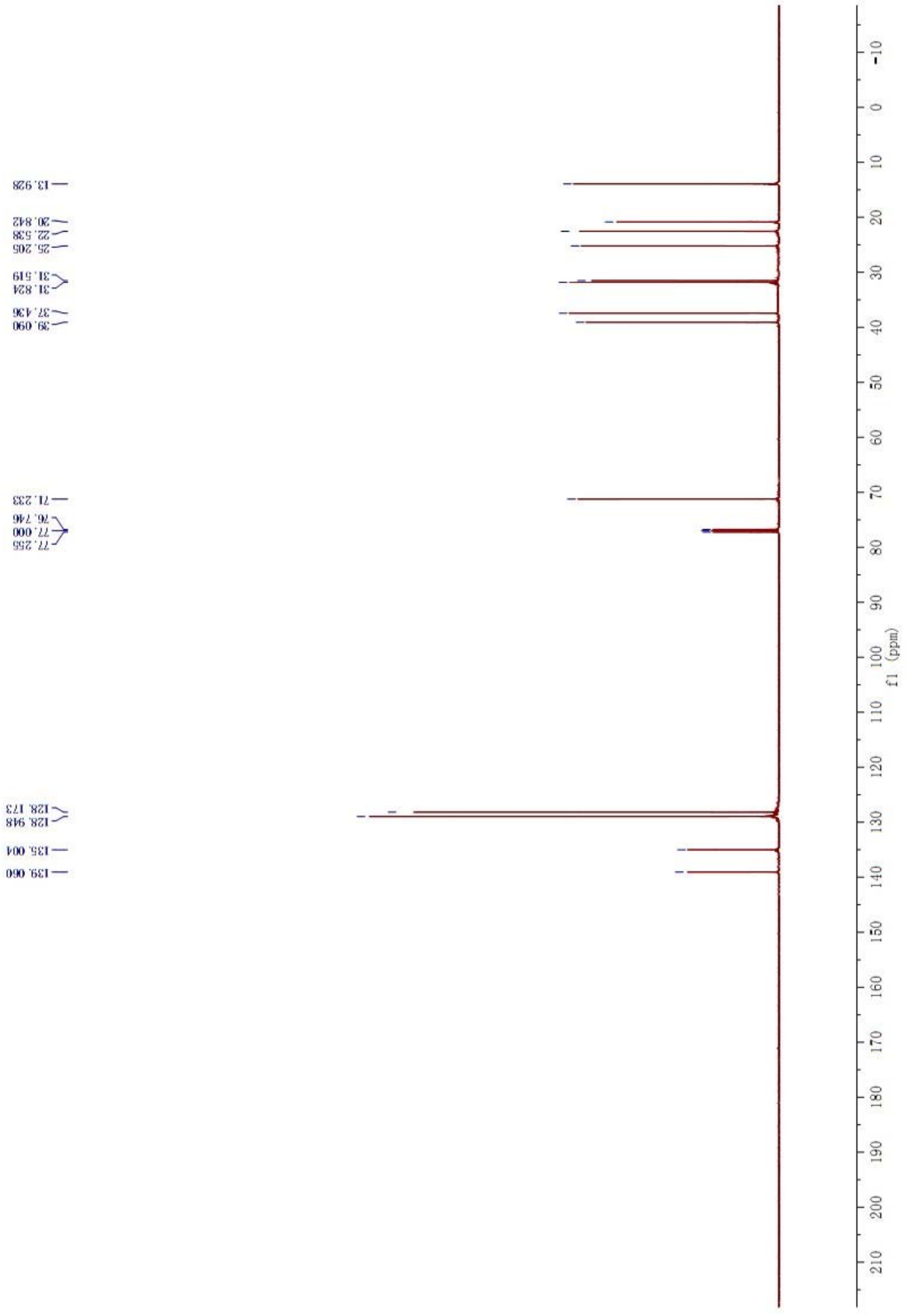


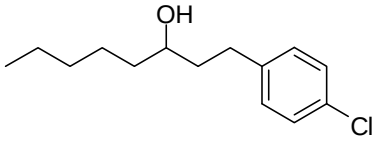
3be

^{1}H NMR



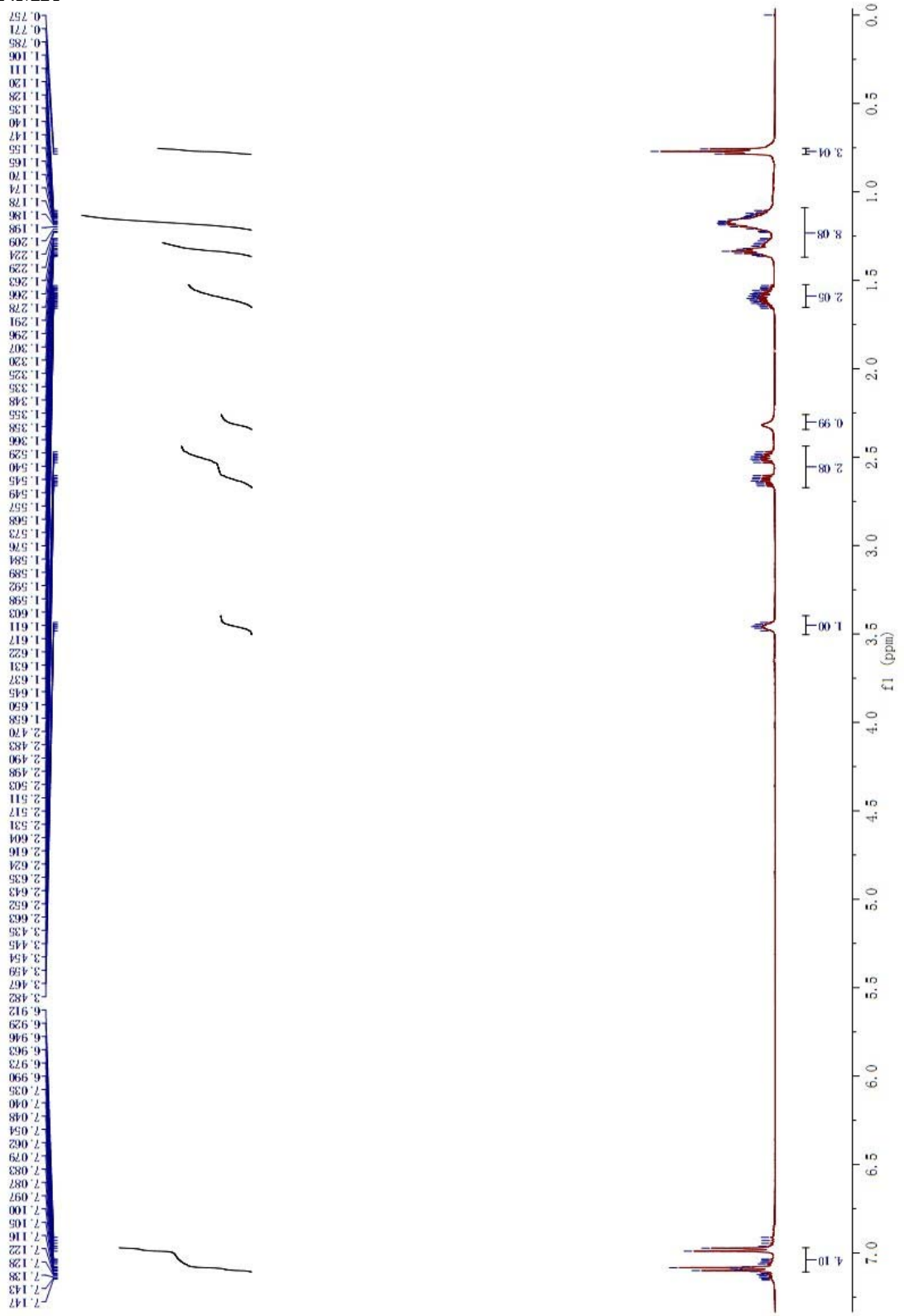
^{13}C NMR



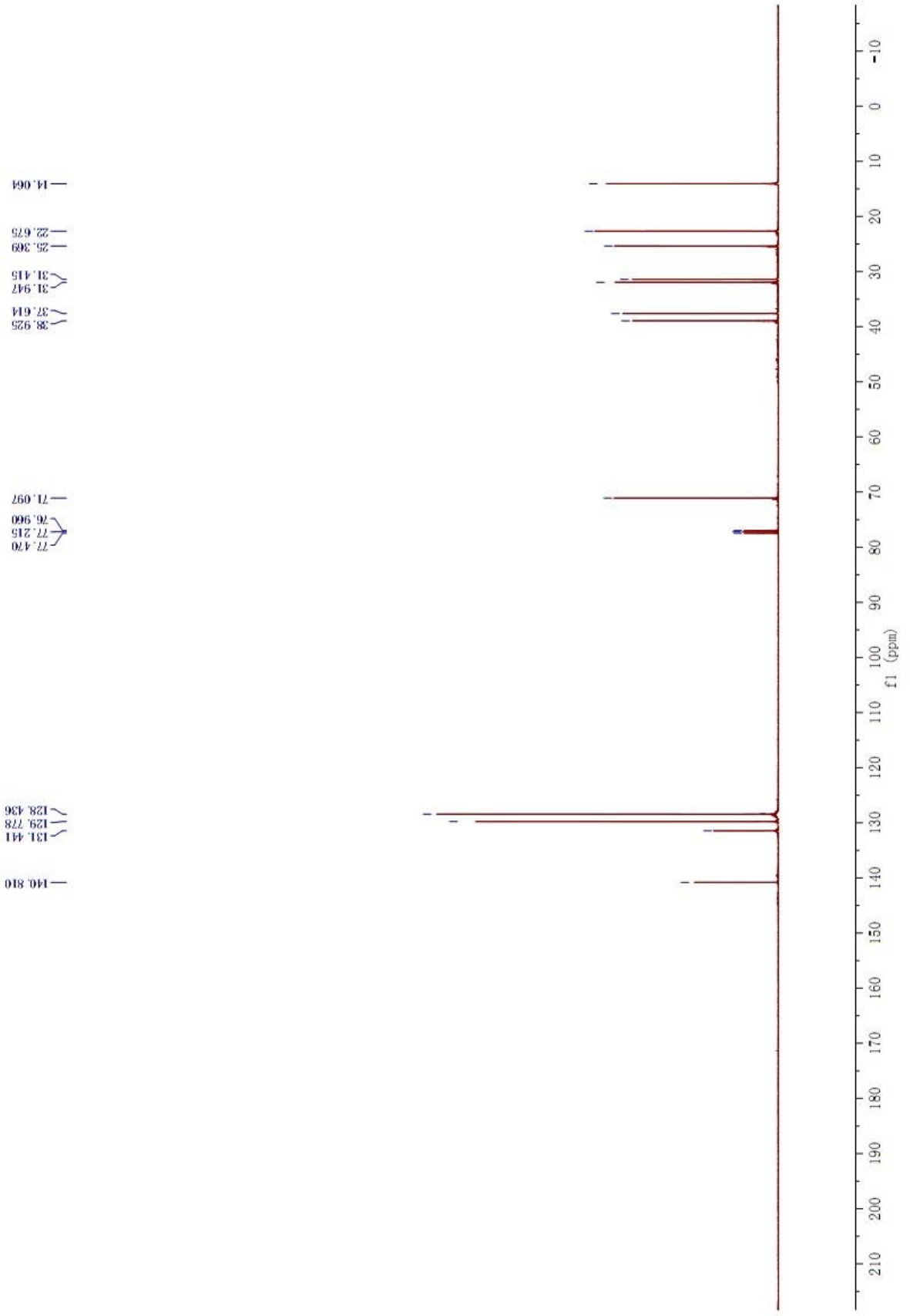


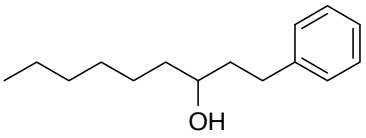
3ce

^{1}H NMR



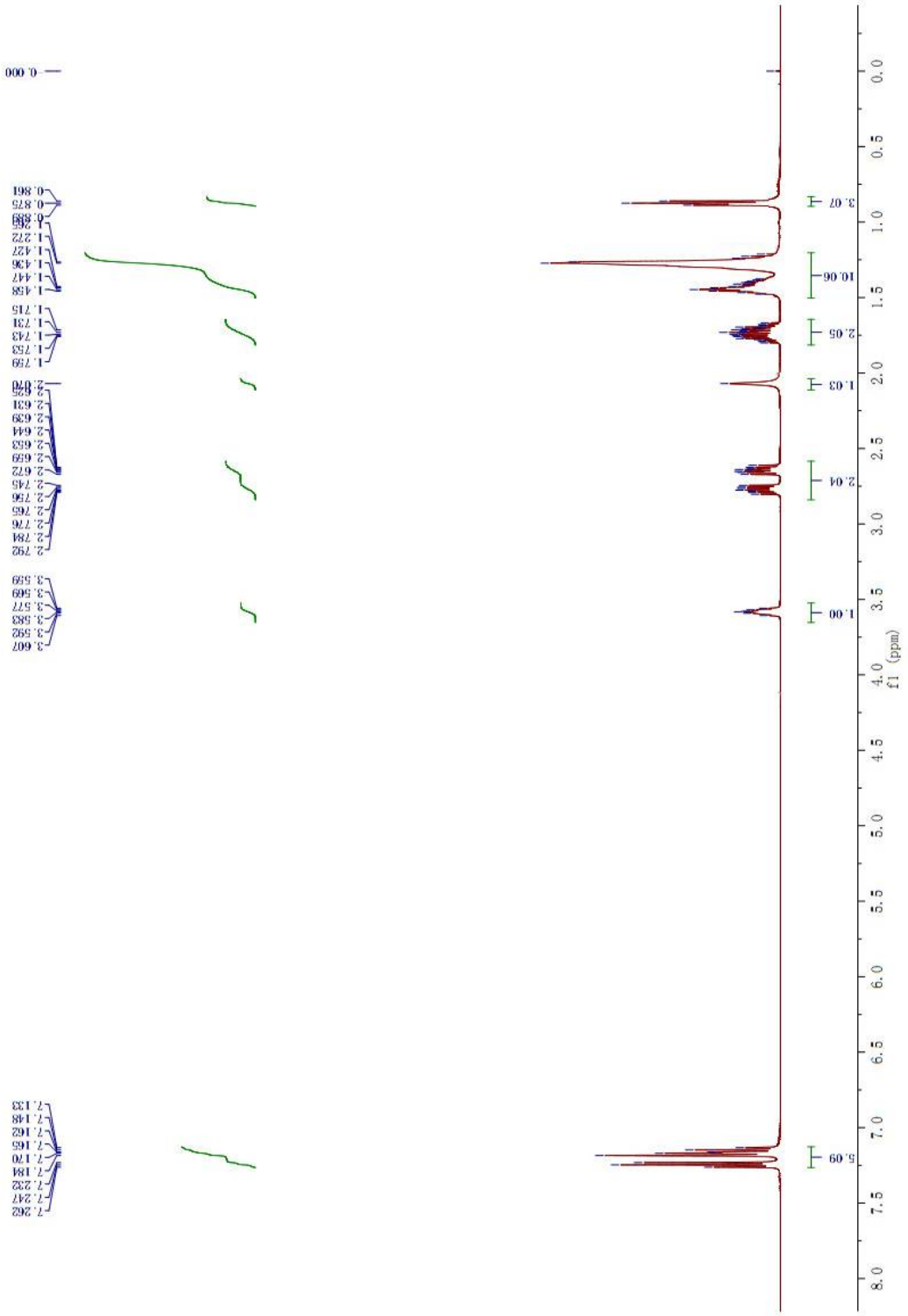
^{13}C NMR



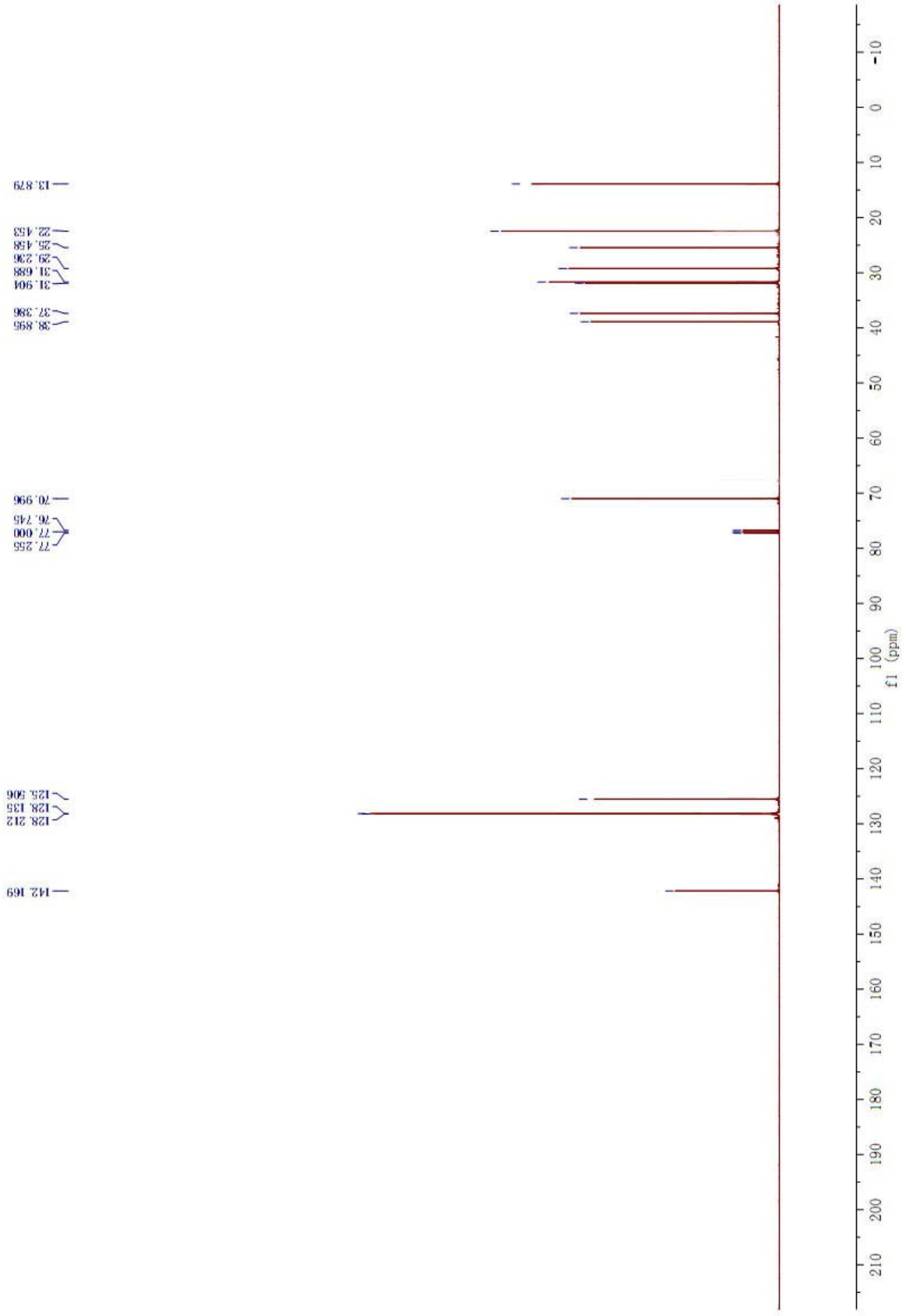


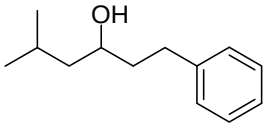
3af

^{1}H NMR



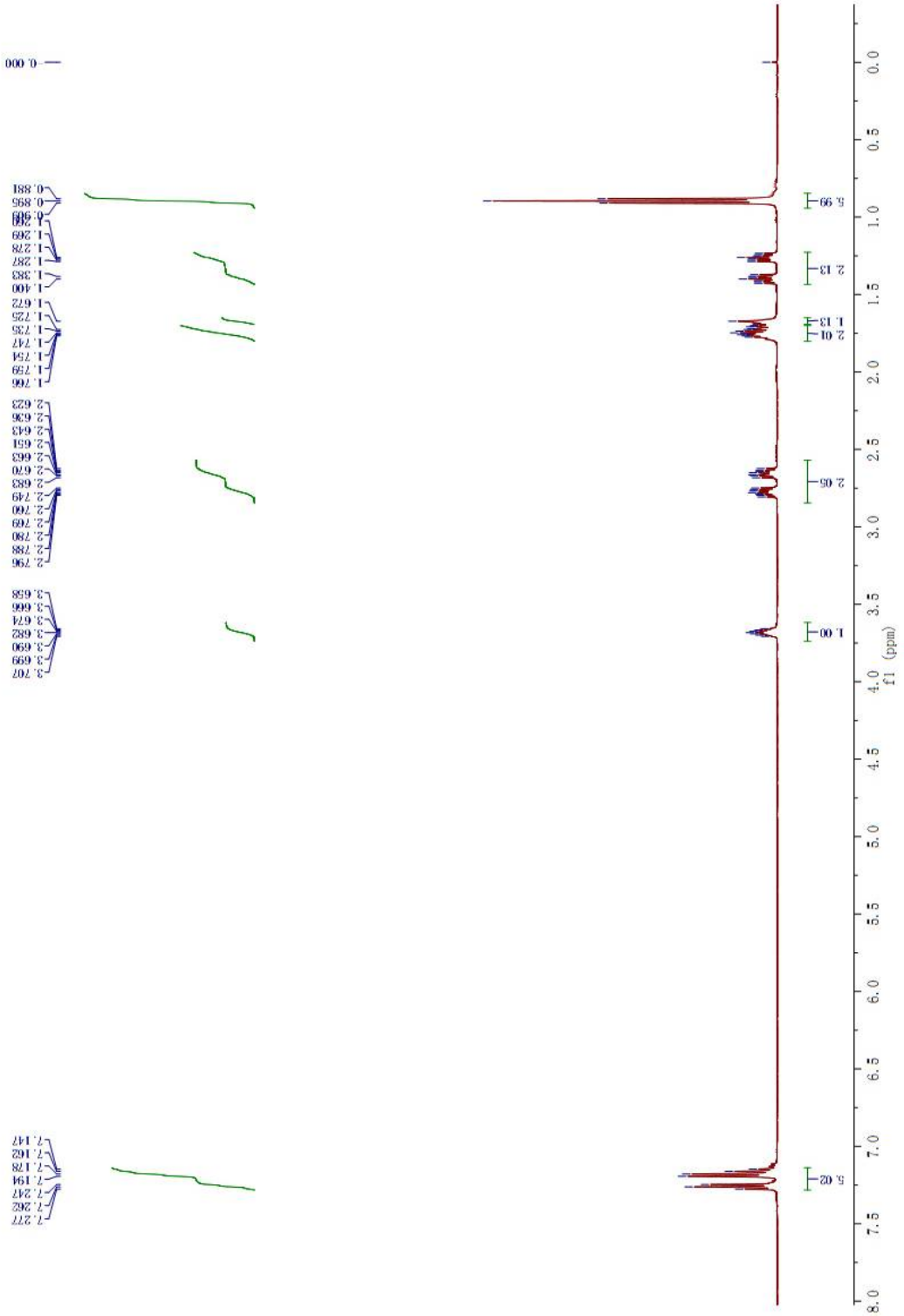
^{13}C NMR



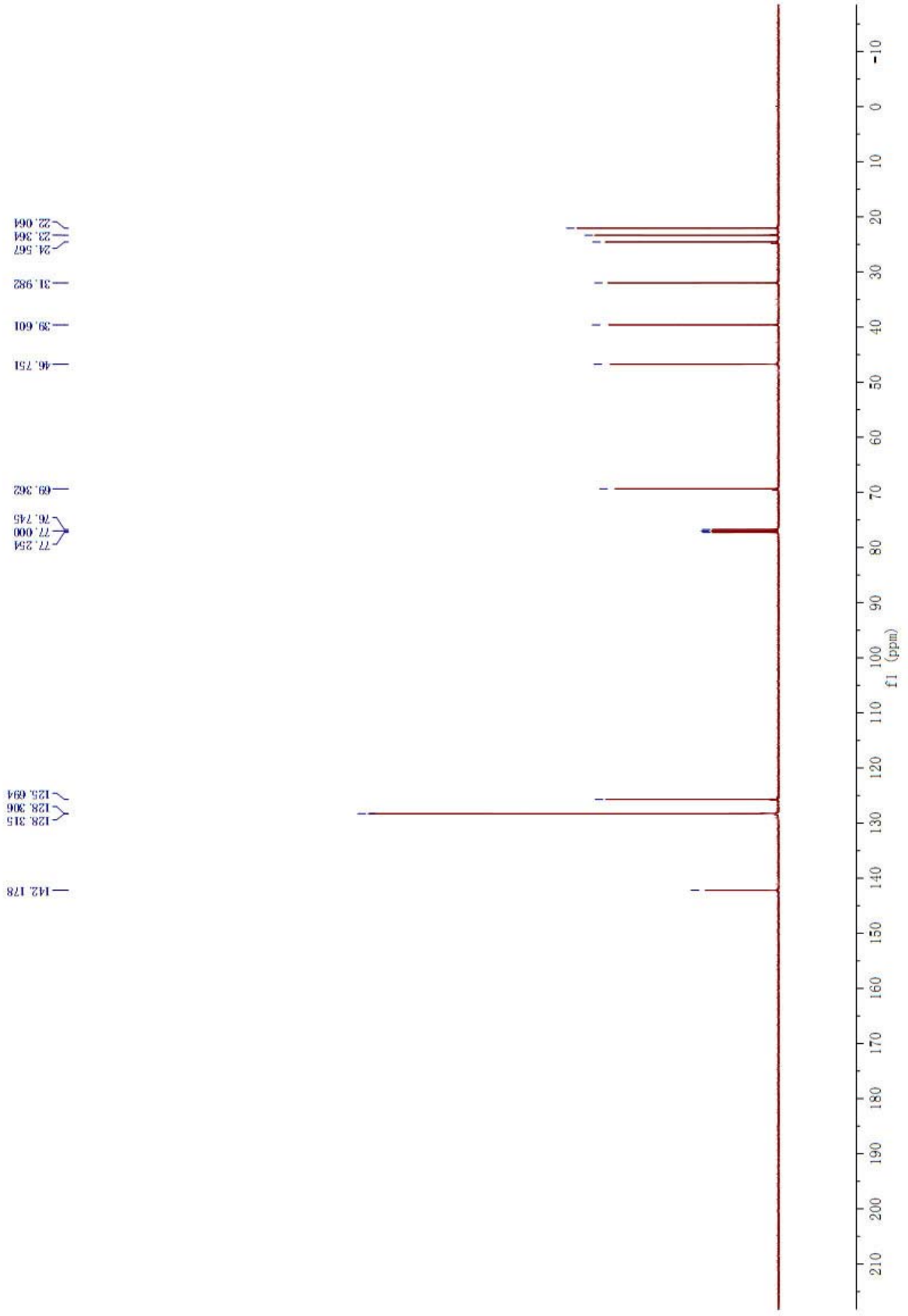


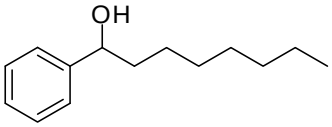
3ag

^{1}H NMR



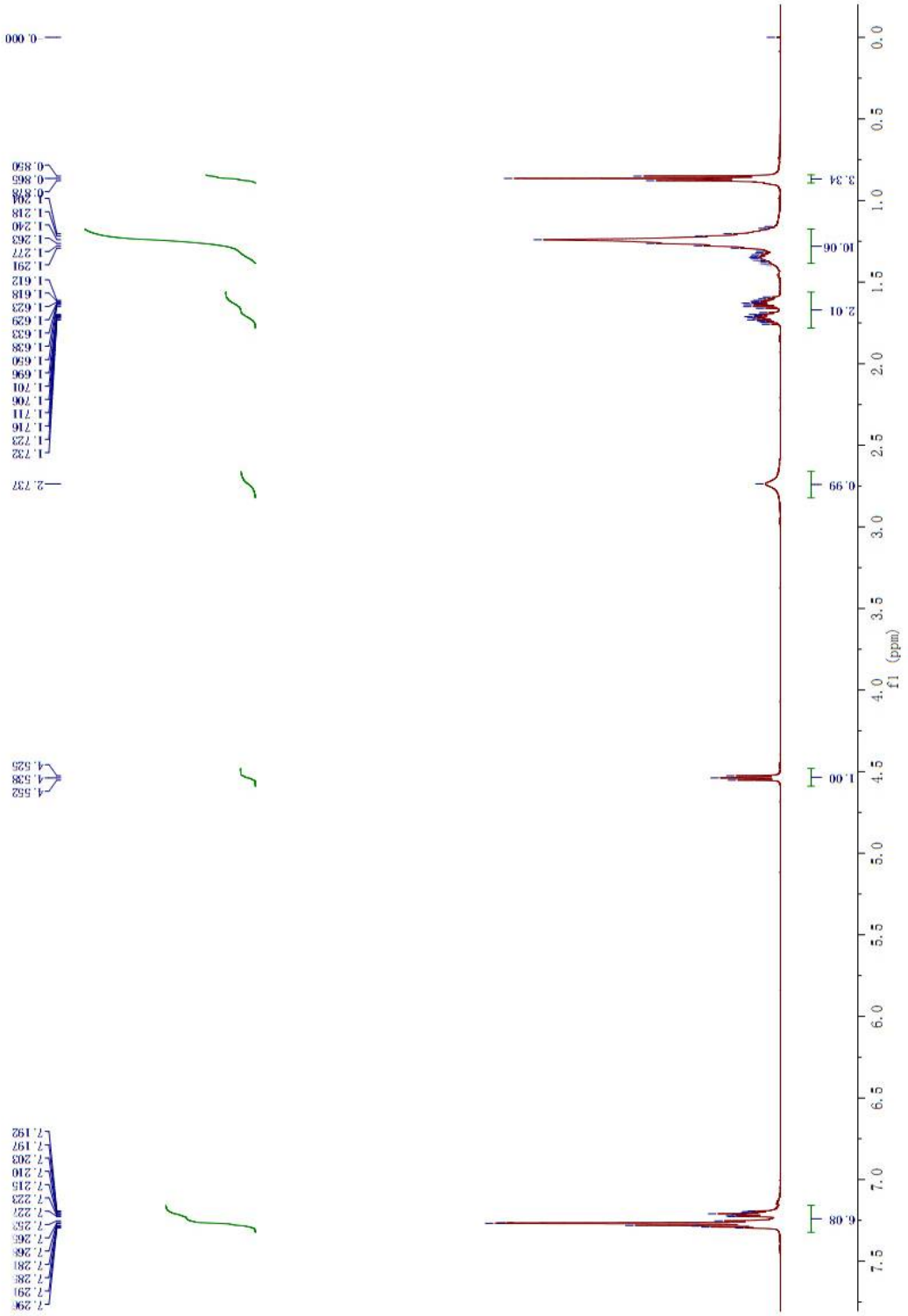
^{13}C NMR



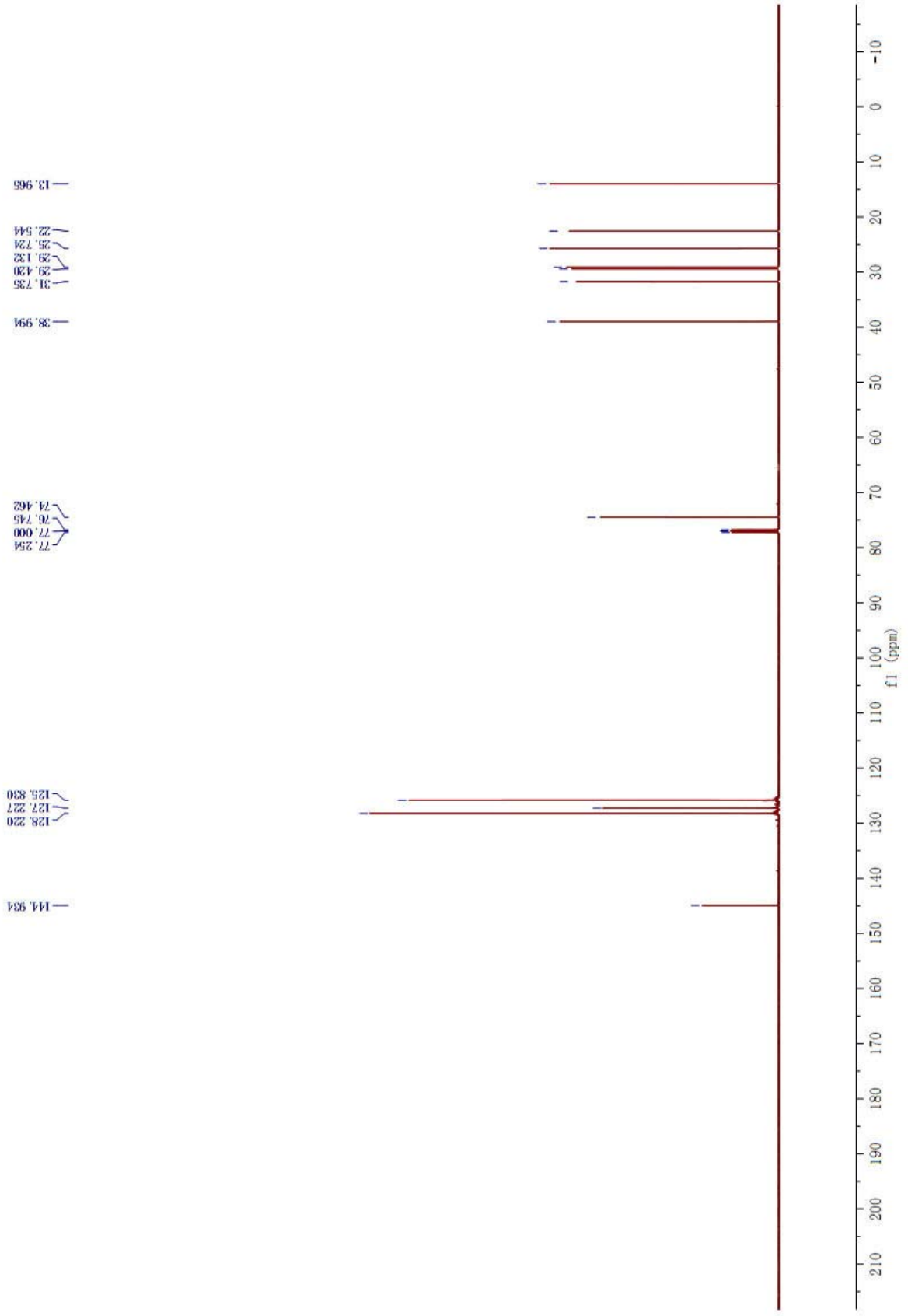


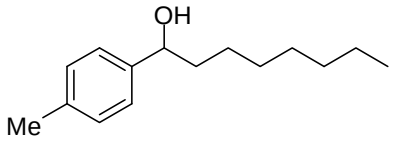
3ja

^{1}H NMR



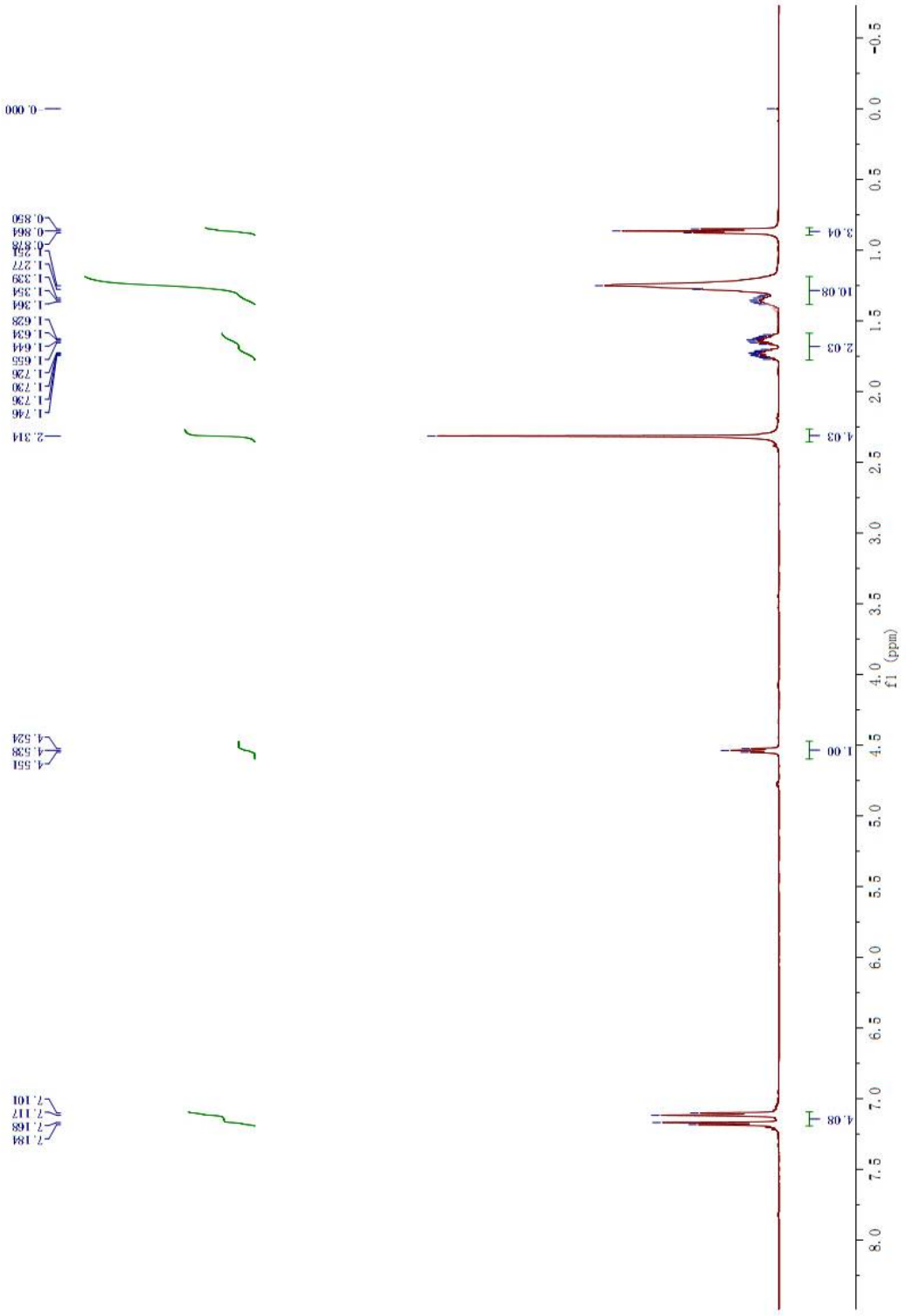
^{13}C NMR



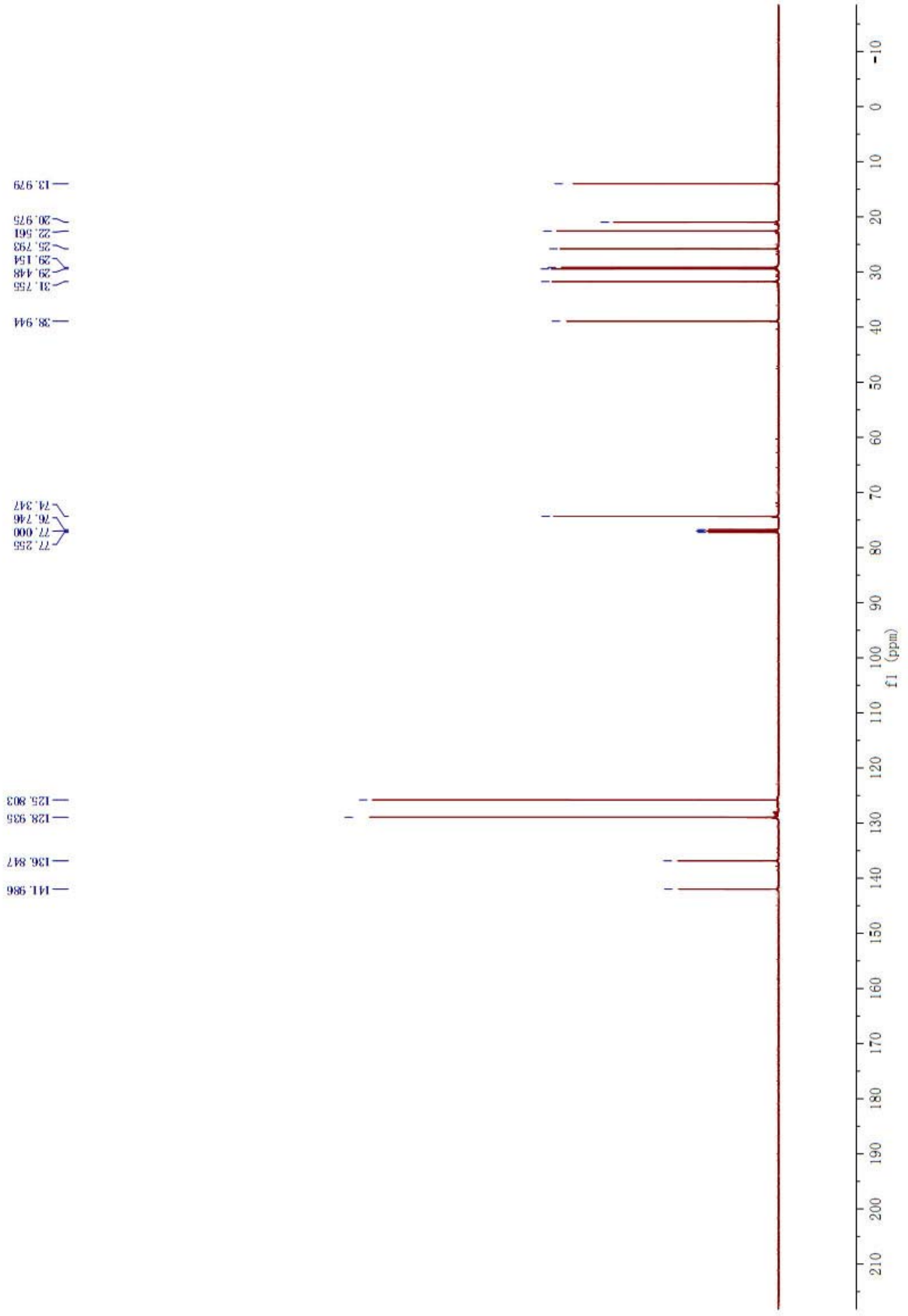


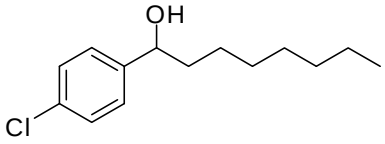
3jb

^{1}H NMR



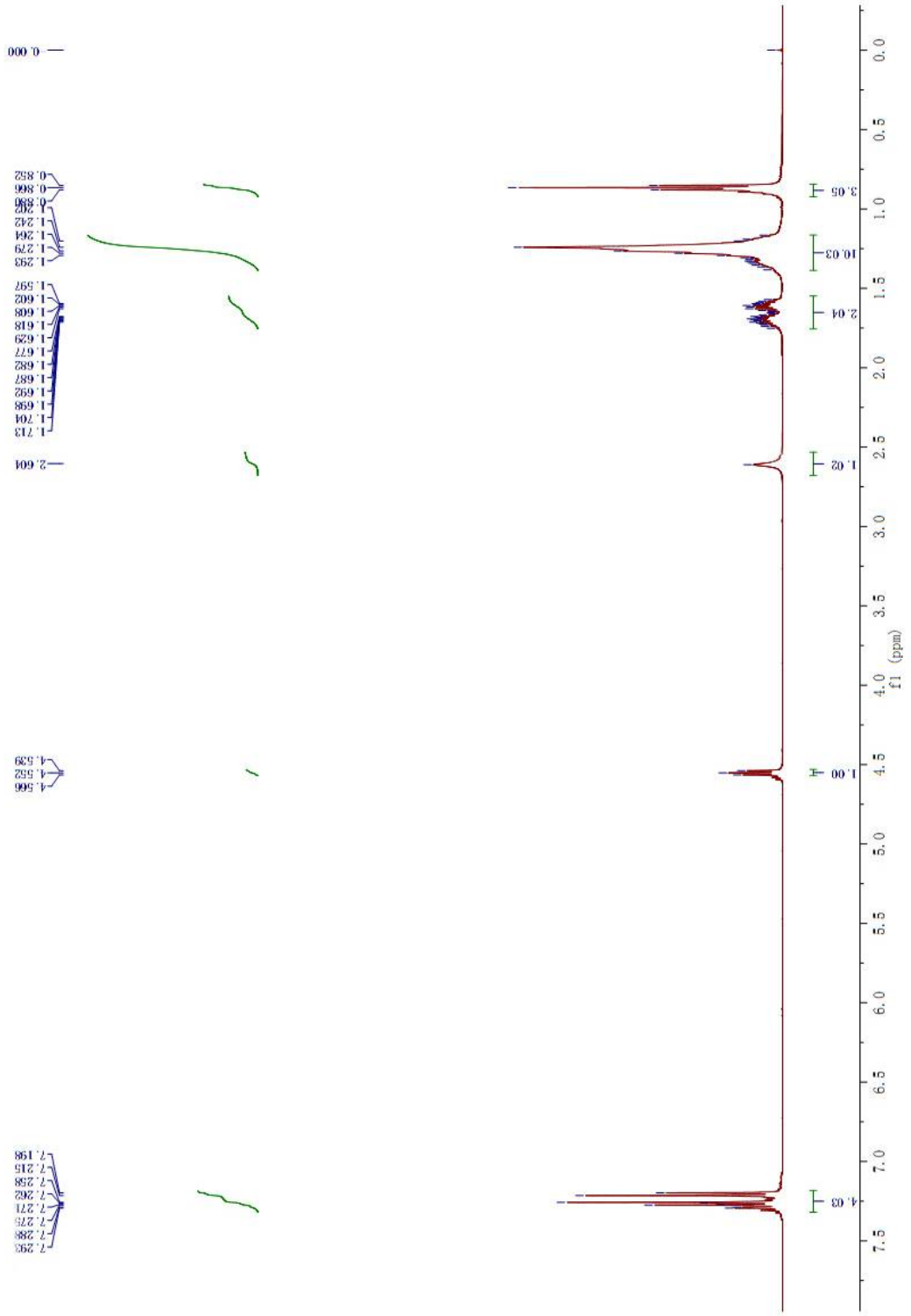
^{13}C NMR



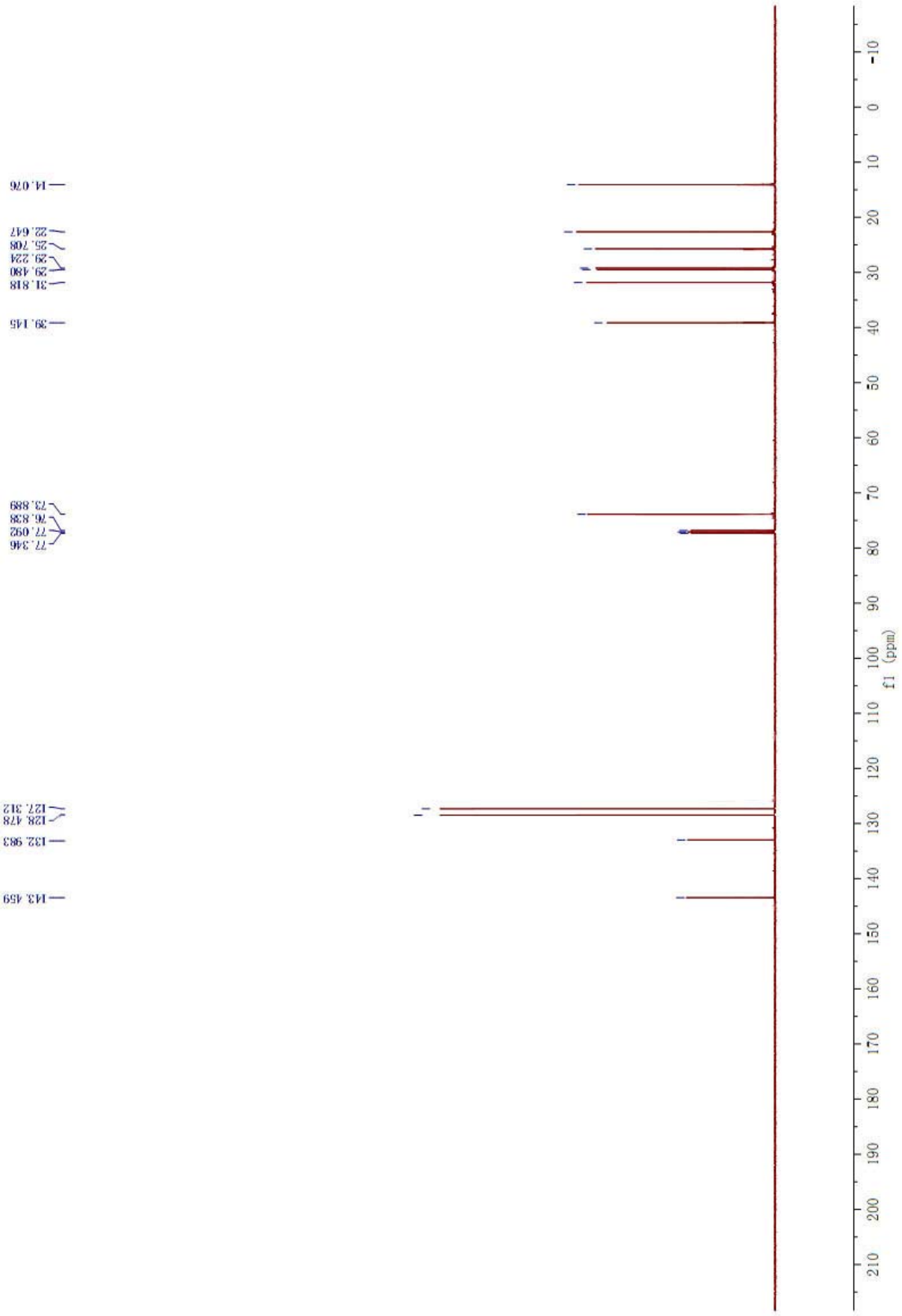


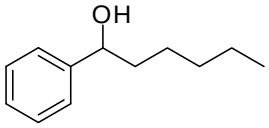
3jc

^{1}H NMR



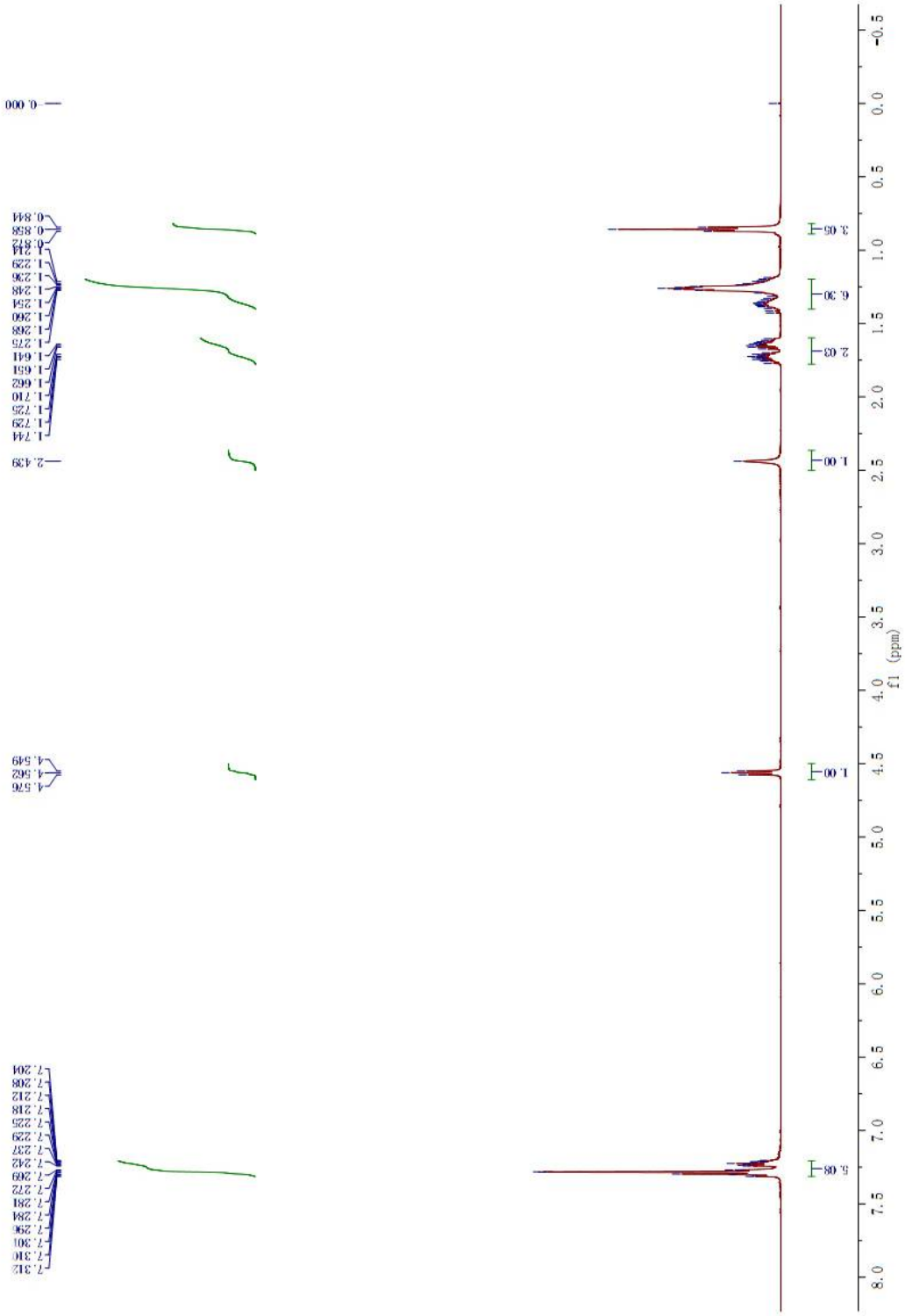
^{13}C NMR



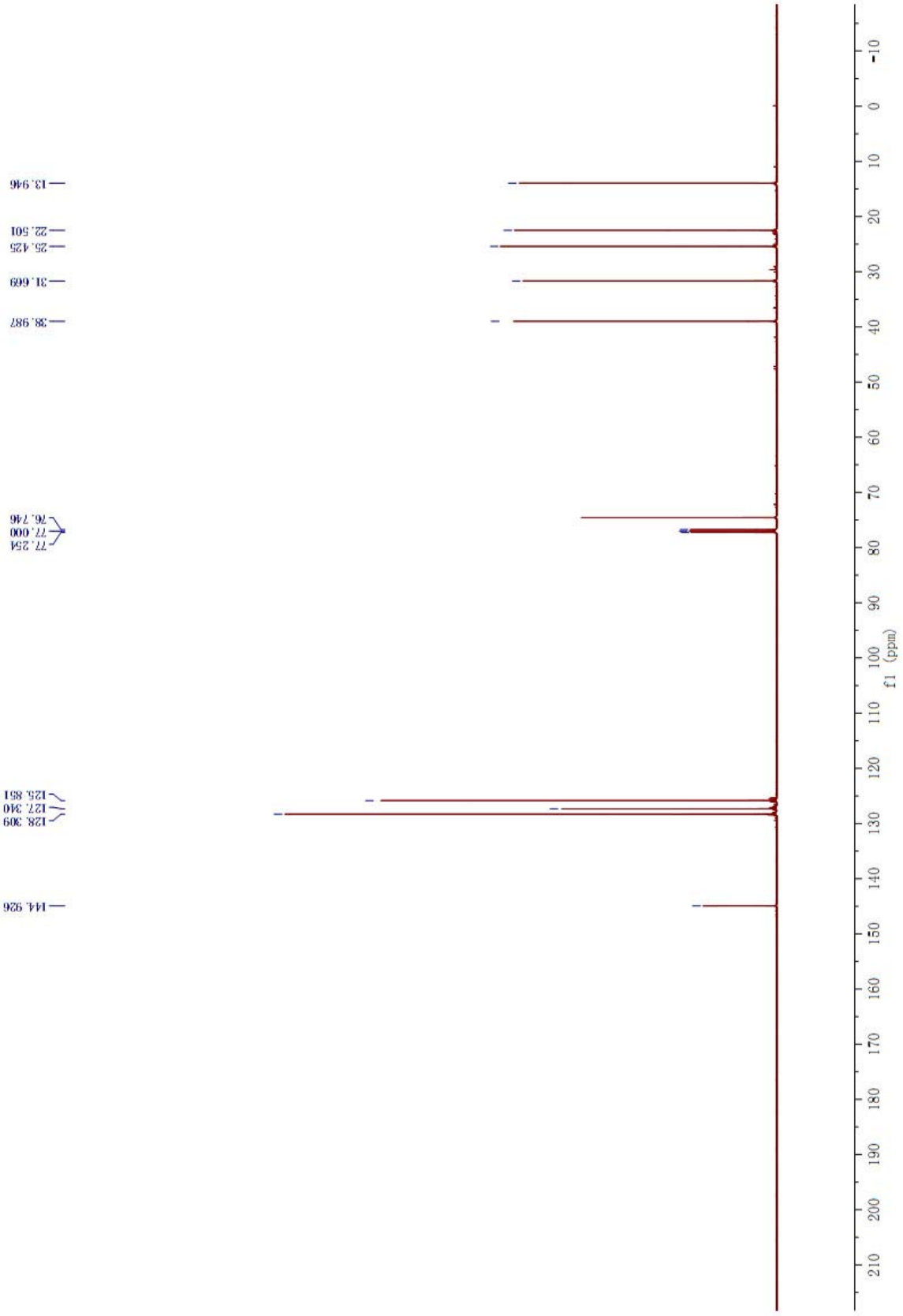


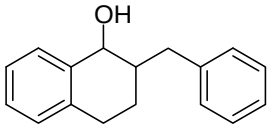
3ka

^{1}H NMR



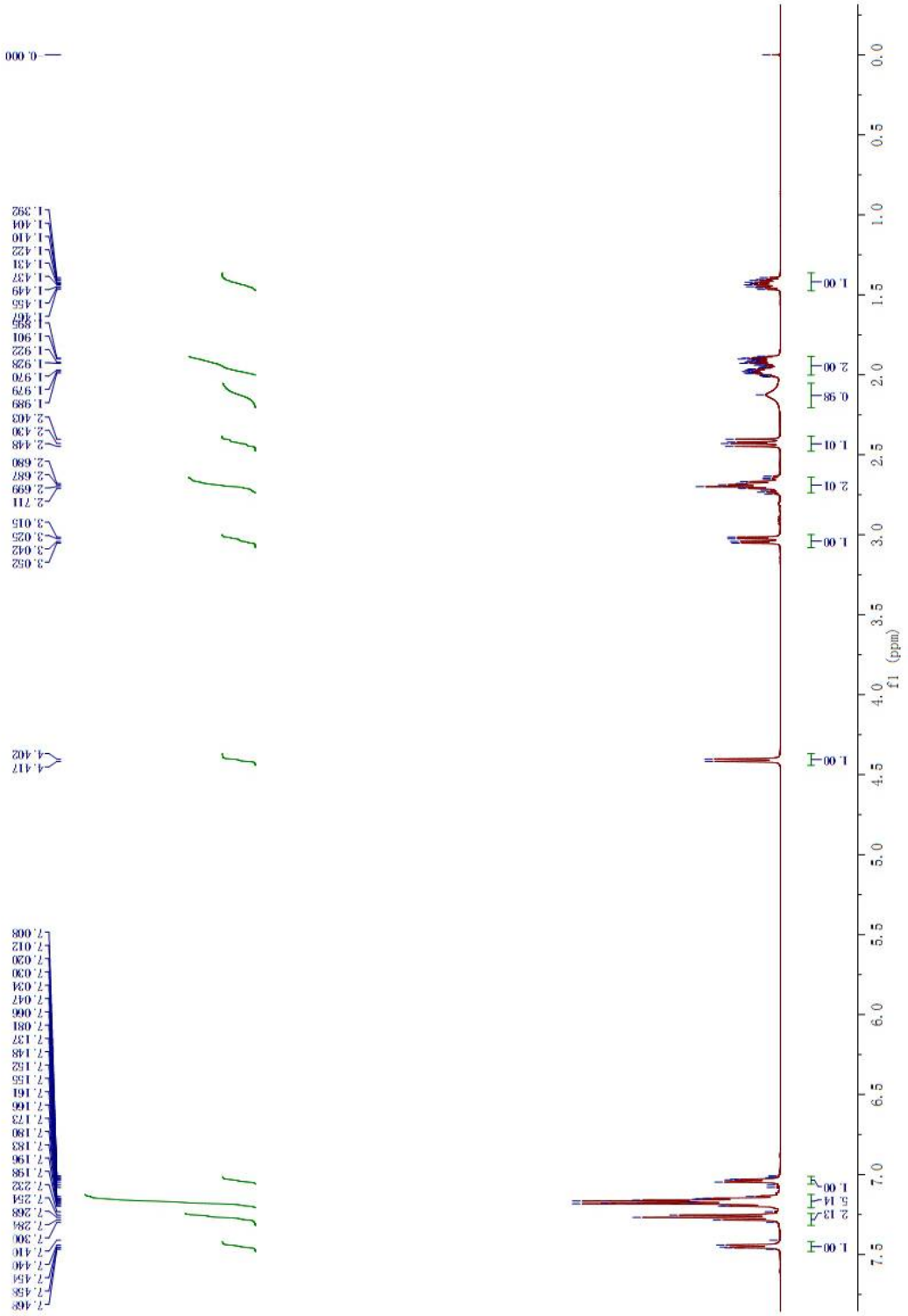
^{13}C NMR

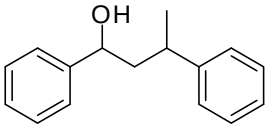




3ah

^{1}H NMR





3aa'

^{1}H NMR