Supporting Information

Visible light as a sole requirement for alkylation of α–C(sp^3)–H of *N*-aryltetrahydroisoquinolines with alkylboronic acids

Feihu Cong,[a] Wenjing Zhang,[a] Gan Zhang,[a] Jie Liu,*[a] Yicheng Zhang,[a]
Chao Zhou,*[a] and Lei Wang[a,b]

a. Key Laboratory of Green and Precise Synthetic Chemistry and Applications, Ministry of Education; Department of chemistry, Huaibei Normal University, Huaibei, Anhui 235000, P. R. China

b. College of Material Chemistry and Chemical Engineering, Key Laboratory of Organosilicon Chemistry and Material Technology, Ministry of Education, Hangzhou Normal University, Hangzhou 311121, Zhejiang, P. R. China

E-mail: jieliu_1024@163.com, zhouch110@163.com

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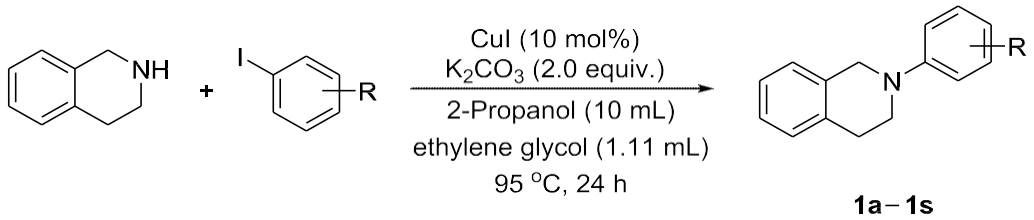
1. General Information

All materials were obtained from commercial suppliers or prepared according to standard procedure unless otherwise noted. Solvents were purified and dried according to standard methods prior to use. For product purification by flash column chromatography, silica gel (200~300 mesh) and light petroleum ether (bp. 60~90) are used. All ^{1}H NMR, ^{13}C NMR and ^{19}F NMR spectra were recorded on a 600 MHz Bruker FT-NMR spectrometer (600 MHz or 150 MHz or 565 MHz, respectively). All chemical shifts of ^{1}H NMR are given as δ value (ppm) with reference to tetramethylsilane (TMS) as an internal standard. The peak patterns are indicated as follows: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), dd (doublet of doublet) and td (triplet of doublet) The coupling constants, *J*, are reported in Hertz (Hz). High resolution mass spectroscopy data of the products were collected on a Thermo Scientific Q Exactive and Agilent Technologies 6540 UHD Accurate-Mass Q-TOF LC/MS (ESI).

2. Experimental Section

2.1 Typical procedure for the preparation of 1a–1s

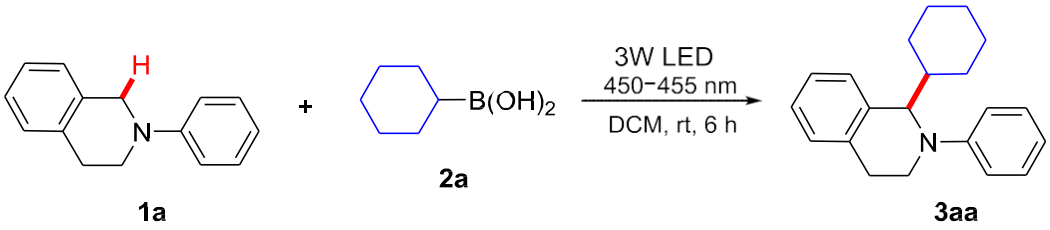


1a – 1s

The substrates **1a–1s** were synthesized according to literature procedure.[1] A typical procedure is described as following for the synthesis of **1a**: Copper(I) iodide (200 mg, 1.0 mmol) and potassium carbonate (2.76 g, 20.0 mmol) were added to a Schlenk tube. The tube was evacuated and back filled with nitrogen. 2-Propanol (10.0 mL), ethylene glycol (1.11 mL, 20.0 mmol), 1,2,3,4-tetrahydroisoquinoline (1.60 g,

12 mmol) and iodobenzene (1.11 mL, 10.0 mmol) were added successively via a micro-syringe at room temperature. The reaction mixture was heated at 95~100 °C and kept for 24 h and then allowed to cool to room temperature. Diethyl ether (20 mL) and water (20 mL) were then added. The aqueous layer was extracted by diethyl ether (2×20 mL). The combined organic phases were washed with brine, dried over anhydrous sodium sulfate and concentrated in vacuo. The residue was purified by flash column chromatography with mixed petroleum ether and ethyl acetate (petroleum ether/ethyl acetate = 98/2) to give the compound **1a** as a yellow solid (1.78 g, 85 % yield).

2.2 Representative procedure for the photoreaction of 1a and 2a to 3aa

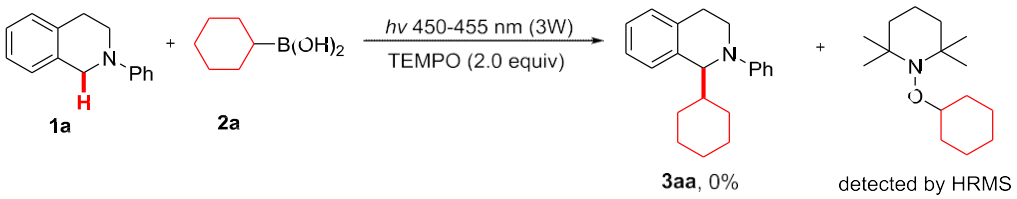


1a **2a** **3aa**

A 10 mL oven-dried reaction vessel equipped with a magnetic stirrer bar was charged with 2-phenyl-1,2,3,4-tetrahydroisoquinoline (**1a**, 0.20 mmol), cyclohexylboronic acid (**2a**, 0.40 mmol), and DCM (2.5 mL). The reaction mixture was exposed to blue LED (450–455 nm, 3 W) irradiation at room temperature with stirring for 6 h. The mixture was evaporated to dryness in vacuo and the residue was separated on a silica gel column with mixed petroleum ether and ethyl acetate (petroleum ether/ethyl acetate = 20: 1) as eluent to afford the desired products **3aa** as a yellow liquid (45.4 mg, 78% yield).

3. Preliminary Mechanistic Study

3.1 Free radical experiments



N-Phenyltetrahydroisoquinoline (**1a**, 0.2 mmol) with cyclohexylboronic acid (**2a**, 0.2 mmol), TEMPO (2,2,6,6-tetramethyl-1-piperidinyloxy, 0.40 mmol, 2.0 equiv.) were added to a Schlenk tube successively, which containing a magnetic stirring bar, then DCM (2.0 mL) was added via syringe. The reaction mixture was stirred for 6 hours under 3 W blue LED (450–455 nm) irradiation at room temperature. No corresponding product **3aa** was detected, the compound formed by **2a** and TEMPO was detected through HRMS (Figure S1), indicating that a radical pathway was involved in the reaction.

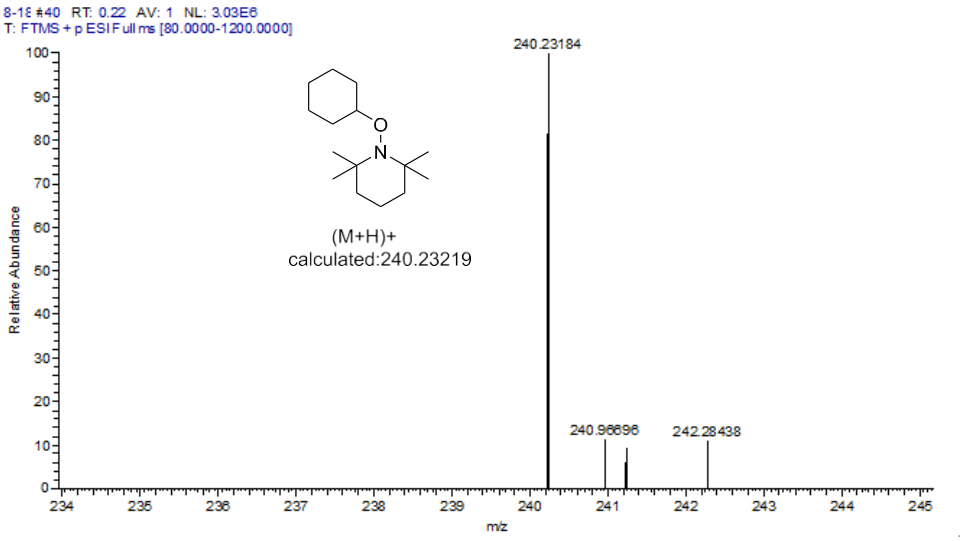


Figure S1. HRMS analysis of the compound formed by **2a** and TEMPO

3.2 UV/Vis absorption spectra

The UV/Vis absorption spectra of 2-phenyl-1,2,3,4-tetrahydroisoquinoline (**1a**, 0.03 mol/L), cyclohexylboronic acid (**2a**, 0.03 mol/L), and a mixture of **1a**/**2a** (1:1, 0.03 mol/L) in DCM were recorded in 1.0 cm path quartz cuvettes by using a SHIMADZU UV-2700i spectrometer, respectively. The obtained charge-transfer bands in UV/vis absorption spectra were shown in Figure S2.

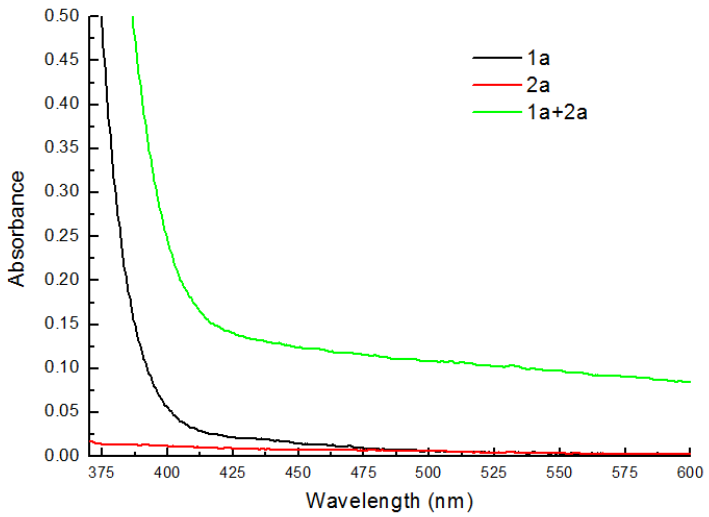


Figure S2. UV/Vis absorption spectra of **1a**, **2a** and a mixture of **1a**/**2a**

3.3 Determination of singlet oxygen species

For further exploration of the active species of singlet oxygen involved in the reaction, a general recommended reagent, 2,2,6,6-tetramethylpiperidine (TEMP) was used to trap $^1O_2$. When air-saturated DCM solution of *N*-phenyltetrahydroisoquinoline (**1a**) and cyclohexylboronic acid (**2a**), with TEMP under the irradiation of LED (450–455 nm, 3.0 W) resulted in the formation of a characteristic signal $^1O_2$ adduct with TEMP (Figure S3). The characteristic signal of $^1O_2$ was recorded by an EPR instrument (Figure S3), implying that $^1O_2$ was formed during the reaction.

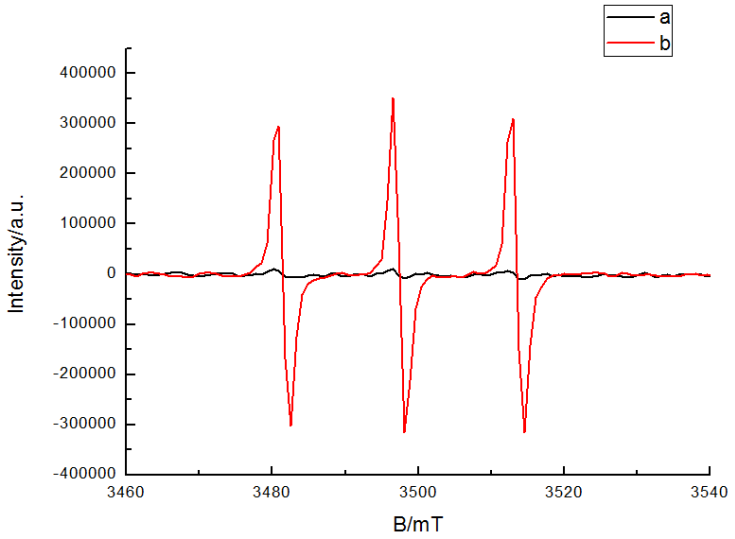
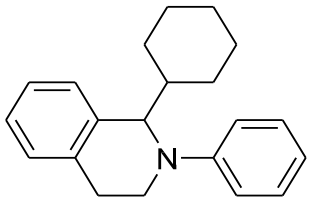


Figure S3. Electron spin resonance (ESR) spectra of characteristic signal of $^1O_2$ formed during the reaction

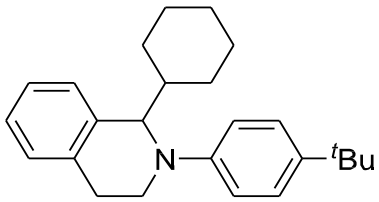
(a) A solution of TEMP (0.2 mol/L) with *N*-phenyltetrahydroisoquinoline (**1a**) and cyclohexylboronic acid (**2a**) in air-saturated DCM without light irradiation

(b) A solution of TEMP (0.2 mol/L) with *N*-phenyltetrahydroisoquinoline (**1a**) and cyclohexylboronic acid (**2a**) in air-saturated DME under LED (450–455 nm) irradiation for 10 s

4. Characterization Data for the Products

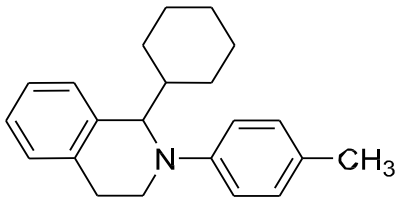


1-Cyclohexyl-2-phenyl-1,2,3,4-tetrahydroisoquinoline (3aa). Light yellow liquid, 45.4 mg, 78% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.22–7.19 (m, 2H), 7.15–7.10 (m, 3H), 7.06 (d, J = 7.8 Hz, 1H), 6.85 (d, J = 7.8 Hz, 2H), 6.66 (t, J = 7.2 Hz, 1H), 4.41 (d, J = 8.4 Hz, 1H), 3.73–3.69 (m, 1H), 3.47–3.43 (m, 1H), 3.03–2.94 (m, 2H), 1.97 (d, J = 13.8 Hz, 1H), 1.75–1.69 (m, 4H), 1.63–1.60 (m, 1H), 1.20–1.04 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 150.0, 137.9, 135.3, 129.2, 128.4, 128.2, 126.6, 125.2, 116.3, 113.0, 63.8, 44.1, 43.0, 31.0, 30.7, 27.4, 26.7, 26.5, 26.5. HRMS (ESI, *m/z*) [M + H]$^+$ Calcd. for $[C_{21}H_{26}N]^+$: 292.2060, found: 292.2055.

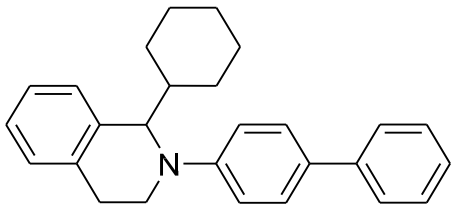


2-(4-(*tert*-Butyl)phenyl)-1-cyclohexyl-1,2,3,4-tetrahydroisoquinoline (3ba). Light yellow liquid, 48.6 mg, 70% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.25–7.22 (m, 2H), 7.14–7.07(m, 3H),7.05–7.02(m, 1H), 6.81–6.78 (m, 2H), 4.37 (d, J = 5.4 Hz, 1H), 3.73–3.68 (m, 1H), 3.46–3.40 (m, 1H), 2.98–2.94 (m, 2H), 2.00 (d, J = 11.4 Hz, 1H), 1.77–1.68 (m, 4H), 1.61 (d, J = 7.8 Hz, 1H), 1.27 (s, 9H), 1.20–1.03 (m, 5H). ^{13}C

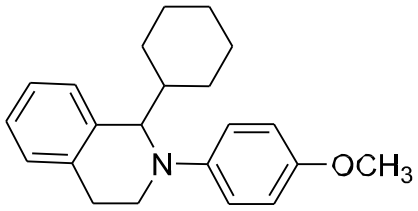
NMR (150 MHz, $CDCl_3$) δ: 147.8, 138.9, 137.9, 135.5, 128.4, 128.2, 126.5, 125.9, 125.1, 112.7, 64.1, 44.2, 43.1, 33.7, 31.6, 31.0, 30.6, 27.4, 26.8, 26.5, 26.5. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{25}H_{34}N]^+$: 348.2686, found: 348.2689.



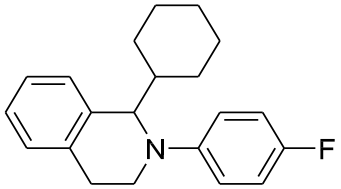
1-Cyclohexyl-2-(*p*-tolyl)-1,2,3,4-tetrahydroisoquinoline (3ca). Light yellow liquid, 50.7 mg, 83% yield. ^1H NMR (600 MHz, $CDCl_3$) δ: 7.14–7.08 (m, 3H), 7.06–7.04 (m, 1H), 7.01 (d, J = 8.4 Hz, 2H), 6.76 (d, J = 9.0 Hz, 2H), 4.34 (d, J = 7.8 Hz, 1H), 3.71–3.67 (m, 1H), 3.46–3.42 (m, 1H), 2.95 (t, J = 6.6 Hz, 2H), 2.22 (s, 3H), 1.99–1.96 (m, 1H), 1.75–1.68 (m, 4H), 1.62–1.60 (m, 1H), 1.18–1.01 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 148.1, 137.9, 135.4, 129.7 128.5, 128.3, 126.5, 125.6, 125.1, 113.4, 64.0, 44.2, 43.1, 31.0, 30.8, 27.3, 26.7, 26.5, 20.3. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{22}H_{28}N]^+$: 306.2216, found: 306.2211.



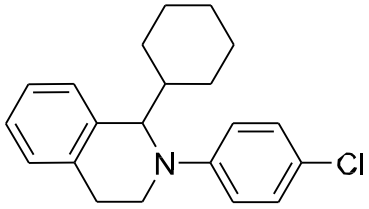
2-([1,1'-Biphenyl]-4-yl)-1-cyclohexyl-1,2,3,4-tetrahydroisoquinoline (3da). Light yellow liquid, 52.9 mg, 72% yield. ^1H NMR (600 MHz, $CDCl_3$) δ: 7.53 (dd, J = 8.4, 1.2 Hz, 2H), 7.48 (d, J = 9.0 Hz, 2H), 7.37 (t, J = 7.8 Hz, 2H), 7.24–7.23 (m, 1H), 7.18–7.12 (m, 3H), 7.08 (d, J = 8.4 Hz, 1H), 6.92 (d, J = 9.0 Hz, 2H), 4.47 (d, J = 8.4 Hz, 1H), 3.78–3.75 (m, 1H), 3.53–3.48 (m, 1H), 3.08–2.99 (m, 2H), 1.99–1.98 (m, 1H), 1.79–1.71 (m, 4H), 1.64–1.62 (m, 1H), 1.20–1.07 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 149.3, 141.2, 137.8, 135.2, 128.9, 128.6, 128.4, 128.2, 127.7, 126.7, 126.2, 125.9, 125.3, 113.0, 63.8, 44.2, 43.1, 31.0, 30.7, 27.5, 26.7, 26.4, 26.4. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{27}H_{30}N]^+$: 368.2373, found: 368.2378.



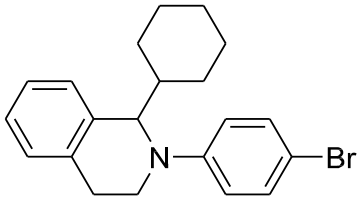
1-Cyclohexyl-2-(4-methoxyphenyl)-1,2,3,4-tetrahydroisoquinoline (3ea). Light yellow liquid, 53.3 mg, 83% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.18–7.12 (m, 3H), 7.10–7.08 (m, 1H), 6.84–6.80 (m, 4H), 4.26 (d, J = 7.8 Hz, 1H), 3.75 (s, 3H), 3.73–3.69 (m, 1H), 3.46 (dt, J = 12.6, 6.6 Hz, 1H), 2.99–2.91 (m, 2H), 2.04–2.01 (m, 1H), 1.78–1.72 (m, 4H), 1.66–1.63 (m, 1H), 1.21–1.06 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 151.6, 145.1, 137.8, 135.3, 128.5, 128.4, 126.4, 125.0, 115.4, 114.7, 64.6, 55.8, 44.0, 43.5, 31.0, 30.8, 26.9, 26.7, 26.5, 26.5. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{22}H_{28}NO]^+$: 322.2165, found: 322.2162.



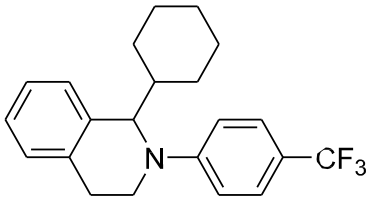
1-Cyclohexyl-2-(4-fluorophenyl)-1,2,3,4-tetrahydroisoquinoline (3fa). Light yellow liquid, 39.0 mg, 63% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.16–7.09 (m, 3H), 7.06–7.05 (m, 1H), 6.93–6.85 (m, 2H), 6.77–6.74 (m, 2H), 4.27 (d, J = 7.8 Hz, 1H), 3.69–3.64 (m, 1H), 3.43–3.38 (m, 1H), 2.94 (t, J = 7.2 Hz, 2H), 1.99–1.95 (m, 1H), 1.77–1.69 (m, 4H), 1.64–1.60 (m, 1H), 1.21–1.01 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 155.3 (d, J = 233.9 Hz), 146.9, 137.7, 135.2, 128.4 (d, J = 6.0 Hz), 126.7, 125.3, 115.4 (d, J = 21.6 Hz), 114.6 (d, J = 7.1 Hz), 64.5, 44.1, 43.5, 31.0, 30.8, 27.0, 26.7, 26.5, 26.5. ^{19}F NMR (564 MHz, $CDCl_3$) δ: –128.99. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{21}H_{25}FN]^+$: 310.1966, found: 310.1961.



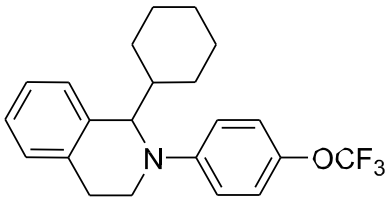
2-(4-Chlorophenyl)-1-cyclohexyl-1,2,3,4-tetrahydroisoquinoline (3ga). Light yellow liquid, 42.9 mg, 66% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.16–7.10 (m, 5H), 7.04 (d, J = 7.2 Hz, 1H), 6.73 (d, J = 8.4 Hz, 2H), 4.33 (d, J = 8.4 Hz, 1H), 3.68–3.64 (m, 1H), 3.39–3.35 (m, 1H), 3.03–2.91 (m, 2H), 1.91 (d, J = 12.6 Hz, 1H), 1.74–1.67 (m, 4H), 1.62–1.56 (m, 1H), 1.17–1.02 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 148.6, 137.6, 135.1, 128.9, 128.4, 128.3, 126.8, 125.4, 121.0, 114.1, 64.0, 44.2, 43.3, 31.0, 30.7, 27.3, 26.7, 26.5, 26.4. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{21}H_{25}ClN]^+$: 326.1670, found: 326.1666.



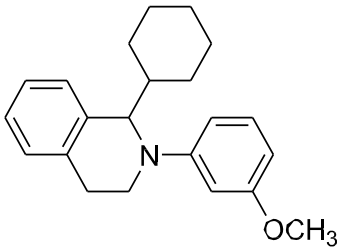
2-(4-Bromophenyl)-1-cyclohexyl-1,2,3,4-tetrahydroisoquinoline (3ha). Light yellow liquid, 48.0 mg, 65% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.27–7.24 (m, 2H), 7.17–7.14 (m, 1H), 7.13–7.10 (m, 2H), 7.06–7.04 (m, 1H), 6.71–6.68 (m, 2H), 4.34 (d, J = 8.4 Hz, 1H), 3.66 (dt, J = 12.0, 6.0 Hz, 1H), 3.40–3.35 (m, 1H), 3.05–3.00 (m, 1H), 2.97–2.92 (m, 1H), 1.92–1.89 (m, 1H), 1.75–1.67 (m, 4H), 1.63–1.60 (m, 1H), 1.19–0.97 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 149.0, 137.6, 135.0, 131.8, 128.3, 128.2, 126.8, 125.4, 114.5, 108.0, 63.9, 44.1, 43.2, 31.0, 30.7, 27.3, 26.7, 26.4, 26.4. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{21}H_{25}BrN]^+$: 370.1165, found: 370.1167.



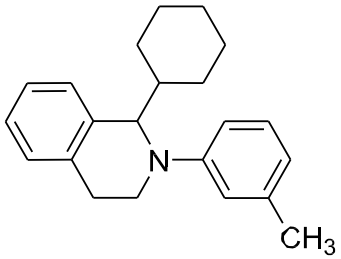
1-Cyclohexyl-2-(4-(trifluoromethyl)phenyl)-1,2,3,4-tetrahydroisoquinoline (3ia). Light yellow liquid, 41.7 mg, 58% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.48 (d, J = 9.0 Hz, 2H), 7.25–7.18 (m, 3H), 7.12–7.11 (m, 1H), 6.89 (d, J = 9.0 Hz, 2H), 4.53 (d, J = 8.4 Hz, 1H), 3.77 (dt, J = 11.4, 6.0 Hz, 1H), 3.51–3.46 (m, 1H), 3.19–3.13 (m, 1H), 3.05–3.01 (m, 1H), 1.95–1.92 (m, 1H), 1.81–1.73 (m, 4H), 1.68–1.66 (m, 1H), 1.22–1.09 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 151.9, 137.4, 134.9, 128.2, 128.2, 127.0, 126.4 (q, J = 3.8 Hz), 125.6, 125.2 (q, J = 268.5 Hz), 117.4 (q, J = 32.7 Hz), 111.6, 63.6, 44.2, 43.3, 31.0, 30.7, 27.5, 26.6, 26.4, 26.3. ^{19}F NMR (564 MHz, $CDCl_3$) δ: –61.24. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{22}H_{25}F_3N]^+$: 360.1934, found: 360.1939.



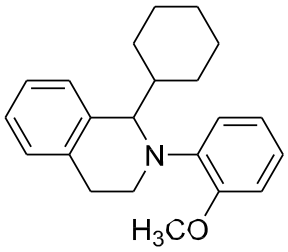
1-Cyclohexyl-2-(4-(trifluoromethoxy)phenyl)-1,2,3,4-tetrahydroisoquinoline (3ja). Light yellow liquid, 53.3 mg, 71% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.16–7.11 (m, 3H), 7.06–7.04 (m, 3H), 6.79–6.77 (m, 2H), 4.35 (d, J = 8.4 Hz, 1H), 3.71–3.67 (m,1H), 3.42–3.38 (m, 1H), 3.04–3.00 (m, 1H), 2.98–2.94 (m, 1H), 1.95–1.92 (m, 1H), 1.76–1.68 (m, 4H), 1.63–1.61 (m, 1H), 1.16–1.01 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 148.8, 139.7, 137.5, 135.0, 128.3, 128.3, 126.8, 125.4, 122.1, 120.8 (q, J = 253.5 Hz), 113.3, 64.1, 44.1, 43.4, 31.0, 30.7, 27.3, 26.7, 26.4, 26.4. ^{19}F NMR (564 MHz, $CDCl_3$) δ: –58.36. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{22}H_{25}F_3NO]^+$: 376.1883, found: 376.1884.



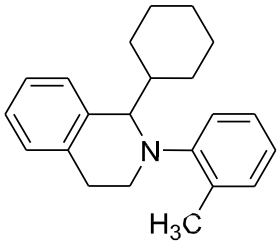
1-Cyclohexyl-2-(3-methoxyphenyl)-1,2,3,4-tetrahydroisoquinoline (3ka). Light yellow liquid, 45.0 mg, 70% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.16–7.10 (m, 4H), 7.06–7.05 (m, 1H), 6.48 (dd, J = 8.4, 2.4 Hz, 1H), 6.39 (t, J = 2.4 Hz, 1H), 6.25 (dd, J = 7.8, 2.4 Hz, 1H), 4.40 (d, J = 8.4 Hz, 1H), 3.77 (s, 3H), 3.72–3.68 (m, 1H), 3.46–3.42 (m, 1H), 3.04–2.95 (m, 2H), 1.97–1.94 (m, 1H), 1.75–1.68 (m, 4H), 1.63–1.60 (m, 1H), 1.17–1.02 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 160.7, 151.4, 137.9, 135.3, 129.7, 128.3, 128.2, 126.6, 125.2, 106.2, 100.7, 99.7, 63.9, 55.2, 44.1, 43.1, 30.9, 30.7, 27.5, 26.7, 26.5, 26.4. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{22}H_{28}NO]^+$: 322.2165, found: 322.2163.



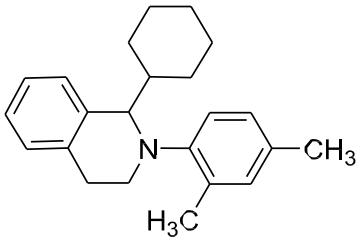
1-Cyclohexyl-2-(*m*-tolyl)-1,2,3,4-tetrahydroisoquinoline (3la). Light yellow liquid, 43.3 mg, 71% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.06–7.00 (m, 4H), 6.98–6.97 (m, 1H), 6.58 (d, J = 6.6 Hz, 2H), 6.42 (d, J = 7.2 Hz, 1H), 4.32 (d, J = 8.4 Hz, 1H), 3.62 (dt, J = 12.0, 6.0 Hz, 1H), 3.40–3.36 (m, 1H), 2.91–2.87 (m, 2H), 2.22 (s, 3H), 1.90–1.88 (m, 1H), 1.67–1.61 (m, 4H), 1.55–1.53 (m, 1H), 1.10–0.99 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 150.2, 138.8, 138.0, 135.4, 129.0, 128.4, 128.3, 126.6, 125.2, 117.4, 113.8, 110.3, 63.8, 44.2, 43.0, 31.0, 30.8, 27.4, 26.8, 26.5, 26.5, 22.2. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{22}H_{28}N]^+$: 306.2216, found: 306.2211.



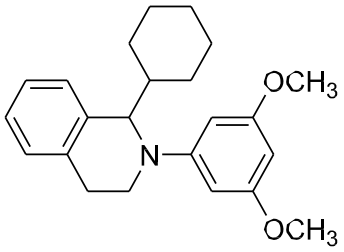
1-Cyclohexyl-2-(2-methoxyphenyl)-1,2,3,4-tetrahydroisoquinoline (3ma). Light yellow liquid, 40.5 mg, 63% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.14–7.10 (m, 3H), 7.07–7.05 (m, 1H), 6.87–6.85 (m, 1H), 6.83 (dd, J = 7.8, 1.2 Hz, 1H), 6.76 (dd, J = 7.8, 1.8 Hz, 1H), 6.74–6.71 (m, 1H), 4.08 (d, J = 7.8 Hz, 1H), 3.84 (s, 3H), 3.64–3.61 (m, 2H), 2.85–2.79 (m, 1H), 2.71–2.66 (m, 1H), 2.12–2.08 (m, 1H), 1.74–1.62 (m, 5H), 1.19–1.03 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 152.8, 141.9, 138.4, 135.3, 129.0, 128.5, 126.0, 124.8, 121.7, 121.3, 121.0, 112.3, 65.0, 55.8, 43.3, 42.9, 31.3, 31.1, 26.7, 26.6, 26.5. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{22}H_{28}NO]^+$: 322.2165, found: 322.2169.



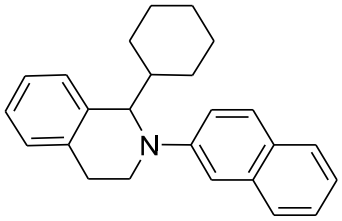
1-Cyclohexyl-2-(*o*-tolyl)-1,2,3,4-tetrahydroisoquinoline (3na). Light yellow liquid, 35.4 mg, 58% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.18–7.14 (m, 4H), 7.10–7.08 (m, 1H), 6.98–6.95 (m, 1H), 6.92–6.89 (m, 1H), 6.81–6.79 (m, 1H), 4.02 (d, J = 6.6 Hz 1H), 3.51–3.47 (m, 1H), 3.16–3.12 (m, 1H), 2.75–2.69 (m, 1H), 2.65–2.60 (m, 1H), 2.39 (s, 3H), 1.98–1.94 (m, 1H), 1.73–1.61 (m, 5H), 1.17–1.07 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 152.1, 138.5, 136.2, 133.4, 131.0, 128.8, 128.1, 126.3, 125.9, 125.2, 123.0, 122.8, 66.0, 45.5, 44.9, 31.1, 30.4, 26.9, 26.7, 26.7, 26.3, 18.6. HRMS (ESI, *m/z*) $[M + H]^+$: Calcd. for $[C_{22}H_{28}N]^+$: 306.2216, found: 306.2212.



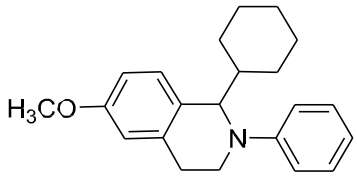
1-Cyclohexyl-2-(2,4-dimethylphenyl)-1,2,3,4-tetrahydroisoquinoline (3oa). Light yellow liquid, 44.1 mg, 69% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.16–7.14 (m, 3H), 7.08 (d, J = 5.4, 1.2 Hz, 1H), 6.98 (d, J = 2.4 Hz, 1H), 6.76 (dd, J = 8.4, 2.4 Hz, 1H), 6.71 (d, J = 8.4 Hz, 1H), 4.00 (d, J = 6.6 Hz, 1H), 3.43–3.42 (m, 1H), 3.09–3.05 (m, 1H), 2.74–2.68 (m,1H), 2.64–2.59 (m, 1H), 2.35 (s, 3H), 2.22 (s, 3H), 1.95–1.90 (m, 1H), 1.72–1.60 (m, 5H), 1.17–1.06 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 149.7, 138.6, 136.4, 133.5, 132.2, 131.8, 128.8, 128.2, 127.0, 125.9, 125.2, 123.1, 66.2, 46.0, 45.2, 31.1, 30.3, 27.0, 26.8, 26.7, 26.5, 20.8, 18.4. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{23}H_{30}N]^+$: 320.2373, found: 320.2372.



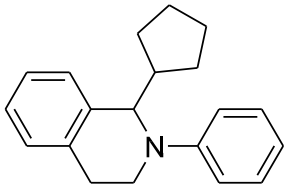
1-Cyclohexyl-2-(3,5-dimethoxyphenyl)-1,2,3,4-tetrahydroisoquinoline (3pa). Light yellow liquid, 51.3 mg, 73% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.16–7.09 (m, 3H), 7.06–7.04 (m, 1H), 6.04 (d, J = 2.4 Hz, 2H), 5.88 (t, J = 2.4 Hz, 1H), 4.37 (d, J = 7.8 Hz, 1H), 3.77 (s, 6H), 3.71–3.67 (m, 1H), 3.46–3.41 (m, 1H), 3.04–2.94 (m, 2H), 1.96–1.93 (m, 1H), 1.75–1.68 (m, 4H), 1.63–1.60 (m, 1H), 1.16–1.07 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 161.6, 151.8, 137.8, 135.2, 128.3, 128.2, 126.7, 125.3, 92.5, 88.1, 64.0, 55.2, 44.1, 43.2, 31.0, 30.8, 27.5, 26.7, 26.4, 26.4. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{23}H_{30}NO_2]^+$: 352.2271, found: 352.2271.



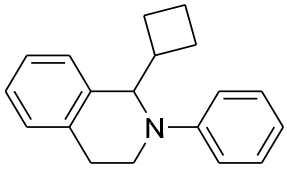
1-Cyclohexyl-2-(naphthalen-2-yl)-1,2,3,4-tetrahydroisoquinoline (3qa). Light yellow liquid, 38.8 mg, 57% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.66 (d, J = 9.0 Hz, 1H), 7.63 (d, J = 7.8 Hz, 1H), 7.59 (d, J = 7.8 Hz, 1H), 7.33–7.30 (m, 1H), 7.26 (dd, J = 6.6, 2.4 Hz, 1H), 7.17–7.10 (m, 5H), 6.99 (d, J = 2.4 Hz, 1H), 4.55 (d, J = 8.4 Hz, 1H), 3.81–3.76 (m, 1H), 3.63–3.59 (m, 1H), 3.01 (t, J = 6.6 Hz, 2H), 1.99–1.96 (m, 1H), 1.78–1.70 (m, 4H), 1.63–1.60 (m, 1H), 1.16–1.07 (m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 147.9, 137.9, 135.2, 135.2, 128.7, 128.5, 128.4, 127.4, 126.8, 126.7, 126.3, 126.2, 125.3, 122.0, 117.0, 106.9, 63.9, 44.1, 43.1, 31.1, 31.0, 27.3, 26.7, 26.5, 26.5. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{25}H_{28}N]^+$: 342.2216, found: 342.2217.



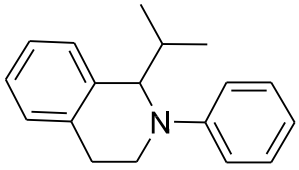
1-cyclohexyl-6-methoxy-2-phenyl-1,2,3,4-tetrahydroisoquinoline (3ra). Light yellow liquid, 54.6 mg, 85% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.22–7.18 (m, 2H), 6.99–6.96 (m, 1H), 6.84 (d, J = 8.4 Hz, 2H), 6.68–6.65 (m, 3H), 4.36–4.34 (m, 1H), 3.76 (s, 3H), 3.71–3.67 (m, 1H), 3.46–3.41 (m, 1H), 3.00–2.91 (m, 2H), 1.96 (d, J = 12.6 Hz, 1H), 1.75–1.69 (m, 4H), 1.63–1.61 (m, 1H), 1.17–1.02(m, 5H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 158.2, 150.0, 136.5, 130.0, 129.3, 129.1, 116.3, 113.4, 113.1, 110.9, 63.3, 55.2, 44.2, 42.7, 30.9, 30.6, 27.7, 26.7, 26.5, 26.4. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{22}H_{28}NO]^+$: 322.2165, found: 322.2168.



1-Cyclopentyl-2-phenyl-1,2,3,4-tetrahydroisoquinoline (3ab).[2] Light yellow liquid, 41.6 mg, 75% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.13–7.10 (m, 2H), 7.07–7.00 (m, 4H), 6.81–6.79 (m, 2H), 6.61–6.58 (m, 1H), 4.45–4.43 (m, 1H), 3.66–3.61 (m, 1H), 3.56–3.52 (m, 1H), 2.96–2.90 (m, 1H), 2.81–2.76 (m, 1H), 2.27–2.19 (m, 1H), 1.78–1.73 (m, 1H), 1.64–1.53 (m, 3H), 1.45–1.30 (m, 4H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 150.1, 138.9, 134.9, 129.2, 128.7, 127.7, 126.5, 125.4, 116.9, 113.9, 62.8, 47.2, 42.0, 31.1, 30.7, 26.8, 25.2, 24.5.

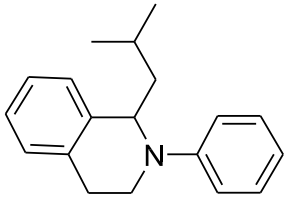


(**1-Cyclobutyl-2-phenyl-1,2,3,4-tetrahydroisoquinoline (3ac).**[2] Light yellow liquid, 38.4 mg, 73% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.22–7.19 (m, 2H), 7.14–7.08 (m, 4H), 6.92–6.90 (m, 2H), 6.72–6.69 (m, 1H), 4.59 (d, J = 7.8 Hz, 1H), 3.59–3.57 (m, 2H), 3.01–2.96 (m, 1H), 2.86–2.79 (m, 1H), 2.76–2.71 (m, 1H), 1.95–1.84 (m, 4H), 1.78–1.65 (m, 2H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 150.3, 137.6, 134.8, 129.1, 128.7, 127.2, 126.5, 125.5, 117.3, 114.4, 63.3, 41.9, 41.7, 27.4, 27.0, 26.7, 18.0.

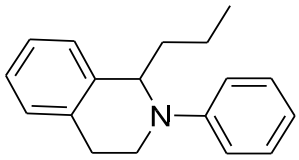


1-(*iso*-Propyl)-2-phenyl-1,2,3,4-tetrahydroisoquinoline (3ad).[3] Light yellow liquid, 34.7 mg, 69% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.22–7.19 (m, 2H), 7.14–7.07 (m, 4H), 6.85 (d, J = 8.4 Hz, 2H), 6.67 (t, J = 7.2 Hz, 1H), 4.37 (d, J = 8.4 Hz,

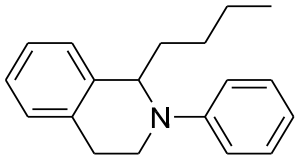
1H), 3.71 (dt, *J* = 12.6, 6.0 Hz, 1H), 3.46–3.42 (m, 1H), 2.98–2.95 (m, 2H), 2.15–2.07 (m, 1H), 1.05 (d, *J* = 7.2 Hz, 3H), 0.93 (d, *J* = 6.6 Hz, 3H). ^{13}C NMR (150 MHz, $CDCl_3$) *δ*: 150.1, 137.9, 135.4, 129.2, 128.4, 128.3, 126.7, 125.4, 116.6, 113.3, 64.7, 43.1, 34.5, 27.5, 20.7, 20.2.



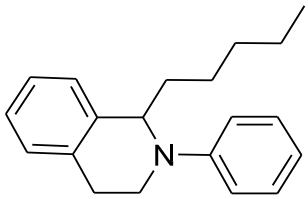
1-(*iso*-Butyl)-2-phenyl-1,2,3,4-tetrahydroisoquinoline (3ae). Light yellow liquid, 37.1 mg, 70% yield. ^{1}H NMR (600 MHz, $CDCl_3$) *δ*: 7.23–7.20 (m, 2H), 7.15–7.07 (m, 4H), 6.89–6.88 (m, 2H), 6.71 (t, *J* = 7.2 Hz, 1H), 4.75 (t, *J* = 7.2 Hz, 1H), 3.64–3.58 (m, 2H), 3.01–2.97 (m, 1H), 2.79–2.75 (m, 1H), 1.91–1.87 (m, 1H), 1.75–1.71 (m, 1H), 1.54–1.49 (m, 1H), 1.04 (d, *J* = 6.6 Hz, 3H), 0.95 (d, *J* = 6.6 Hz, 3H). ^{13}C NMR (150 MHz, $CDCl_3$) *δ*: 149.8, 139.4, 134.9, 129.3, 128.7, 127.2, 126.3, 125.7, 117.2, 114.2, 56.8, 45.9, 41.6, 26.5, 25.1, 22.9, 22.8. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{19}H_{24}N]^+$: 266.1903, found: 266.1901.



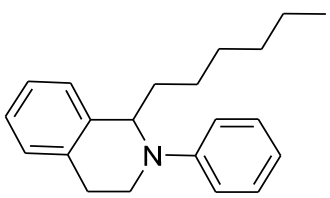
2-Phenyl-1-(*n*-propyl)-1,2,3,4-tetrahydroisoquinoline (3af).[4] Light yellow liquid, 36.7 mg, 73% yield. ^{1}H NMR (600 MHz, $CDCl_3$) *δ*: 7.24–7.21 (m, 2H), 7.14–7.08 (m, 4H), 6.86 (d, *J* = 8.4 Hz, 2H), 6.70 (t, *J* = 6.6 Hz, 1H), 4.66–4.63 (m, 1H), 3.62–3.55 (m, 2H), 3.02–2.98 (m, 1H), 2.86–2.82 (m, 1H), 1.95–1.91 (m, 1H), 1.70–1.66 (m, 1H), 1.50–1.40 (m, 2H), 0.93 (td, *J* = 7.2, 1.8 Hz, 3H). ^{13}C NMR (150 MHz, $CDCl_3$) *δ*: 149.8, 139.2, 135.1, 129.3, 128.6, 127.4, 126.4, 125.8, 117.0, 113.7, 59.0, 41.9, 39.1, 27.2, 20.2, 14.2.



1-(*n*-Butyl)-2-phenyl-1,2,3,4-tetrahydroisoquinoline (3ag).[3] Light yellow liquid, 38.2 mg, 72% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.23–7.19 (m, 2H), 7.12–7.06 (m, 4H), 6.84 (d, J = 7.8 Hz, 2H), 6.69 (t, J = 7.2 Hz, 1H), 4.62 (t, J = 7.2 Hz, 1H), 3.59–3.51 (m, 2H), 2.99–2.94 (m, 1H), 2.79 (dt, J = 16.2, 5.2 Hz, 1H), 1.96–1.91 (m, 1H), 1.71–1.66 (m, 1H), 1.45–1.30 (m, 4H), 0.87 (t, 7.2 Hz, 3H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 149.9, 139.4, 135.1, 129.4, 128.7, 127.5, 126.5, 125.9, 117.1, 113.9, 59.4, 42.0, 36.8, 29.3, 27.3, 23.0, 14.3.

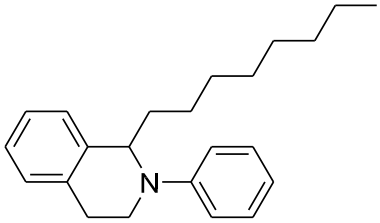


1-(*n*-Pentyl)-2-phenyl-1,2,3,4-tetrahydroisoquinoline (3ah).[2] Light yellow liquid, 37.4 mg, 67% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.18–7.14 (m, 2H), 7.10–7.02 (m, 4H), 6.79 (d, J = 8.4 Hz, 2H), 6.63 (t, J = 7.2 Hz, 1H), 4.56 (t, J = 7.2 Hz, 1H), 3.56–3.50 (m, 2H), 2.97–2.92 (m, 1H), 2.77 (dt, J = 16.2, 5.4 Hz, 1H), 1.90–1.85 (m, 1H), 1.64–1.60 (m, 1H), 1.42–1.38 (m, 1H), 1.35–1.31 (m, 1H), 1.24–1.21 (m, 4H), 0.82–0.78 (m, 3H). ^{13}C NMR (150 MHz, $CDCl_3$) δ: 149.7, 139.2, 135.0, 129.2, 128.5, 127.3, 126.4, 125.7, 116.9, 113.7, 59.2, 41.8, 36.8, 31.9, 27.1, 26.6, 22.7, 14.1.



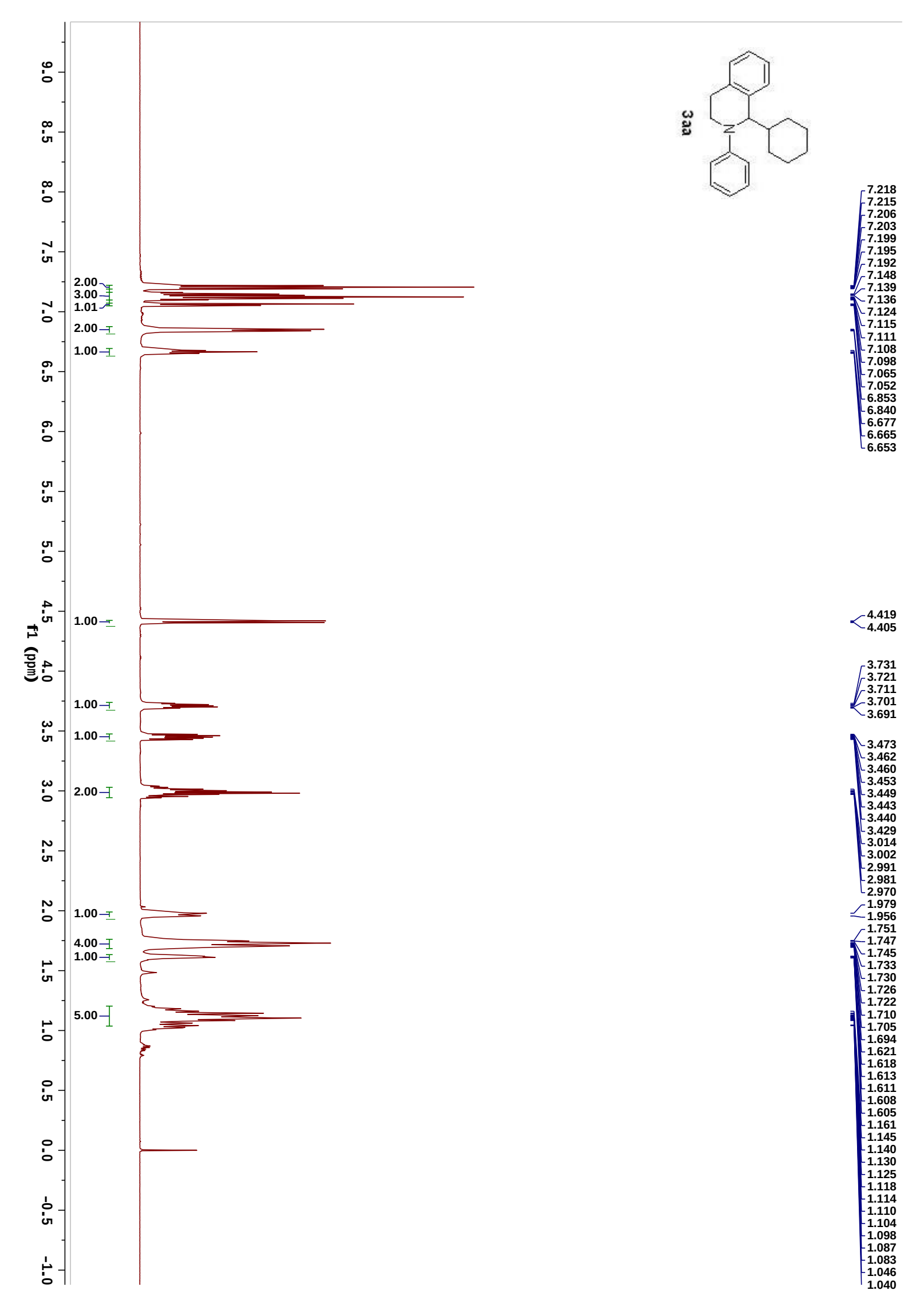
1-(*n*-Hexyl)-2-phenyl-1,2,3,4-tetrahydroisoquinoline (3ai). Light yellow liquid, 40.5 mg, 69% yield. ^{1}H NMR (600 MHz, $CDCl_3$) δ: 7.24–7.21 (m, 2H), 7.16–7.09 (m,

4H), 6.86 (d, *J* = 7.8 Hz, 2H), 6.70 (t, *J* = 7.2 Hz, 1H), 4.63 (t, *J* = 7.2 Hz, 1H), 3.64–3.55 (m, 2H), 3.03–2.98 (m, 1H), 2.86–2.82 (m, 1H), 1.98–1.91 (m, 1H), 1.72–1.66(m, 1H), 1.49–1.45 (m, 1H), 1.40–1.36 (m, 1H), 1.32–1.25 (m, 6H), 0.86 (t, *J* = 6.6 Hz, 3H). ^{13}C NMR (150 MHz, $CDCl_3$) *δ*: 149.7, 139.3, 135.0, 129.3, 128.5, 127.4, 126.4, 125.7, 116.9, 113.7, 59.3, 41.8, 36.9, 31.9, 29.4, 27.1, 26.9, 22.7, 14.1. HRMS (ESI, *m/z*) $[M + H]^+$ Calcd. for $[C_{21}H_{28}N]^+$: 294.2216, found: 294.2211.



1-(*n*-Octyl)-2-phenyl-1,2,3,4-tetrahydroisoquinoline (3aj).[5] Light yellow liquid, 41.8 mg, 65% yield. ^{1}H NMR (600 MHz, $CDCl_3$) *δ*: 7.25–7.21 (m, 2H), 7.16–7.09 (m, 4H), 6.86 (d, *J* = 8.4 Hz, 2H), 6.70 (t, *J* = 7.2 Hz, 1H), 4.63 (t, *J* = 7.2 Hz, 1H), 3.64–3.56 (m, 2H), 3.04–2.99 (m, 1H), 2.84 (dt, *J* = 15.6, 5.4 Hz, 1H), 1.98–1.92 (m, 1H), 1.72–1.66 (m, 1H), 1.49–1.43 (m, 1H), 1.41–1.36 (m, 1H), 1.31–1.23 (m, 10H), 0.87 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (150 MHz, $CDCl_3$) *δ*: 149.7, 139.3, 135.0, 129.2, 128.5, 127.3, 126.4, 125.7, 116.9, 113.7, 59.2, 41.8, 36.8, 31.9, 29.7, 29.6, 29.3, 27.1, 26.9, 22.7, 14.1.

5. Copies of ^{1}H and ^{13}C NMR NMR Spectra of the Products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7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
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0.0
-0.5
-1.0
2.00
3.00
1.01
2.00
1.00
1.00
1.00
1.00
2.00
1.00
4.00
1.00
5.00
7.218
7.215
7.206
7.203
7.199
7.195
7.192
7.148
7.139
7.136
7.124
7.115
7.111
7.108
7.098
7.065
7.052
6.853
6.840
6.677
6.665
6.653
4.419
4.405
3.731
3.721
3.711
3.701
3.691
3.473
3.462
3.460
3.453
3.449
3.443
3.440
3.429
3.014
3.002
2.991
2.981
2.970
1.979
1.956
1.751
1.747
1.745
1.733
1.730
1.726
1.722
1.710
1.705
1.694
1.621
1.618
1.613
1.611
1.608
1.605
1.161
1.145
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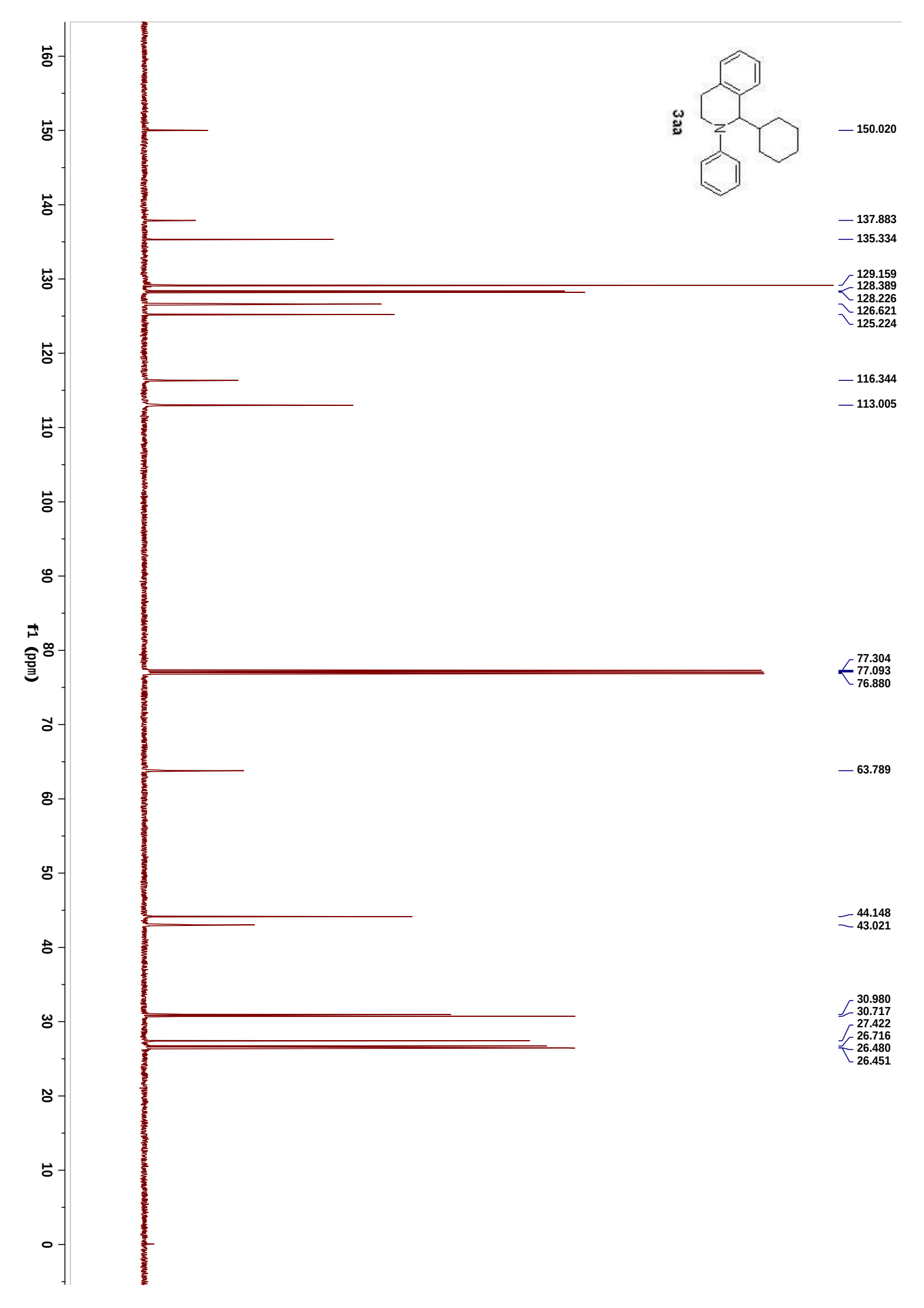
1.104
1.098
1.087
1.083
1.046
1.040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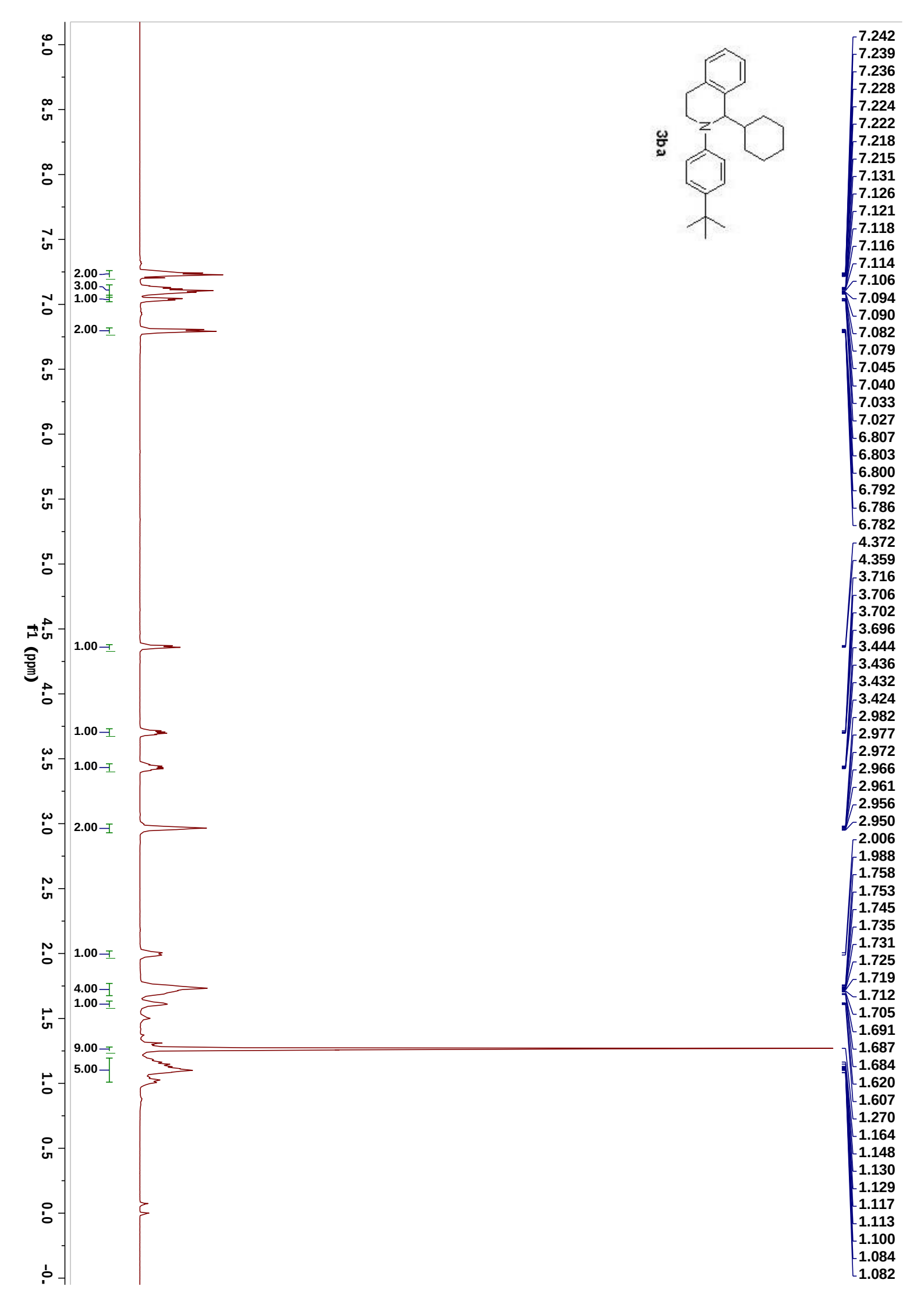
129.159
128.389
128.226
126.621
125.224
116.344
113.005
77.304
77.093
76.880
63.789
44.148
43.021
30.980
30.717
27.422
26.716
26.480
26.451
f1 (ppm)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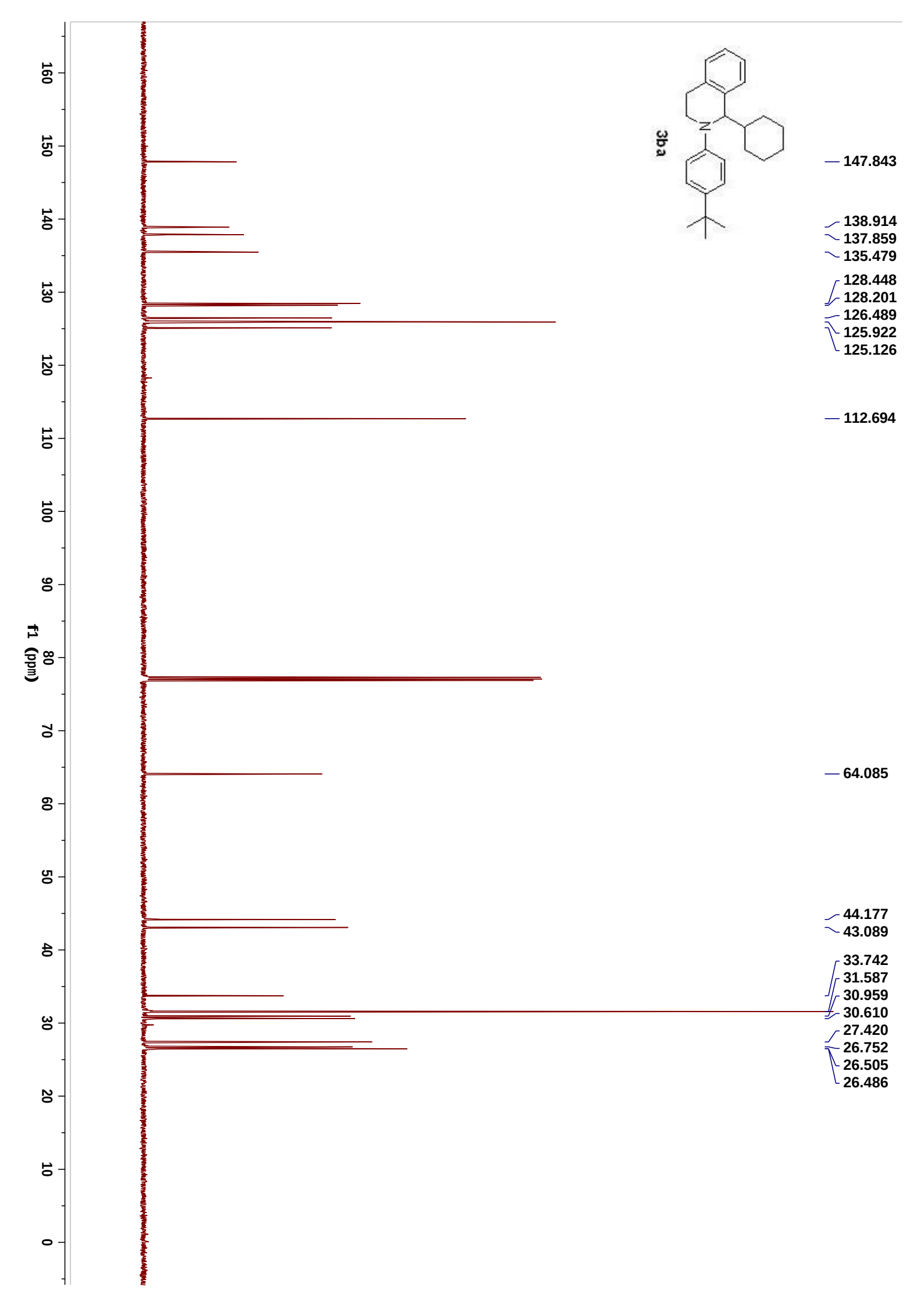
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.
2.00
3.00
1.00
2.00
1.00
1.00
1.00
2.00
1.00
4.00
1.00
9.00
5.00
7.242
7.239
7.236
7.228
7.224
7.222
7.218
7.215
7.131
7.126
7.121
7.118
7.116
7.114
7.106
7.094
7.090
7.082
7.079
7.045
7.040
7.033
7.027
6.807
6.803
6.800
6.792
6.786
6.782
4.372
4.359
3.716
3.706
3.702
3.696
3.444
3.436
3.432
3.424
2.982
2.977
2.972
2.966
2.961
2.956
2.950
2.006
1.988
1.758
1.753
1.745
1.735
1.731
1.725
1.719
1.712
1.705
1.691
1.687
1.684
1.620
1.607
1.270
1.164
1.148
1.130
1.129
1.117
1.113
1.100
1.084
1.082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137.859
135.479
128.448
128.201
126.489
125.922
125.126
112.694
64.085
44.177
43.089
33.742
31.587
30.959
30.610
27.420
26.752
26.505
26.486
f1 (ppm)
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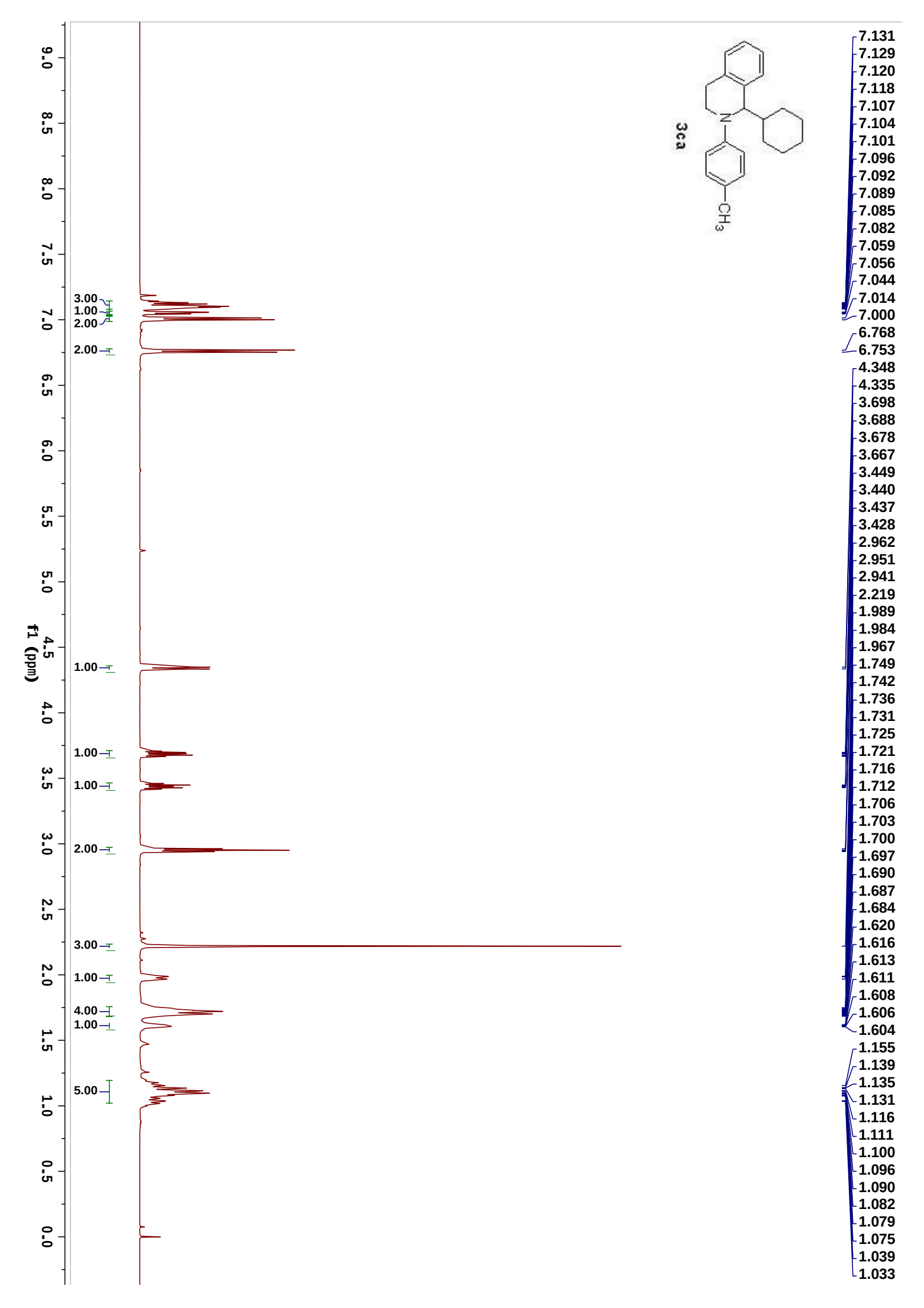
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0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5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3.00
1.00
2.00
2.00
1.00
1.00
1.00
2.00
3.00
1.00
4.00
1.00
5.00
7.131
7.129
7.120
7.118
7.107
7.104
7.101
7.096
7.092
7.089
7.085
7.082
7.059
7.056
7.044
7.014
7.000
6.768
6.753
4.348
4.335
3.698
3.688
3.678
3.667
3.449
3.440
3.437
3.428
2.962
2.951
2.941
2.219
1.989
1.984
1.967
1.749
1.742
1.736
1.731
1.725
1.721
1.716
1.712
1.706
1.703
1.700
1.697
1.690
1.687
1.684
1.620
1.616
1.613
1.611
1.608
1.606
1.604
1.155
1.139
1.135
1.131
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1.090
1.082
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1.075
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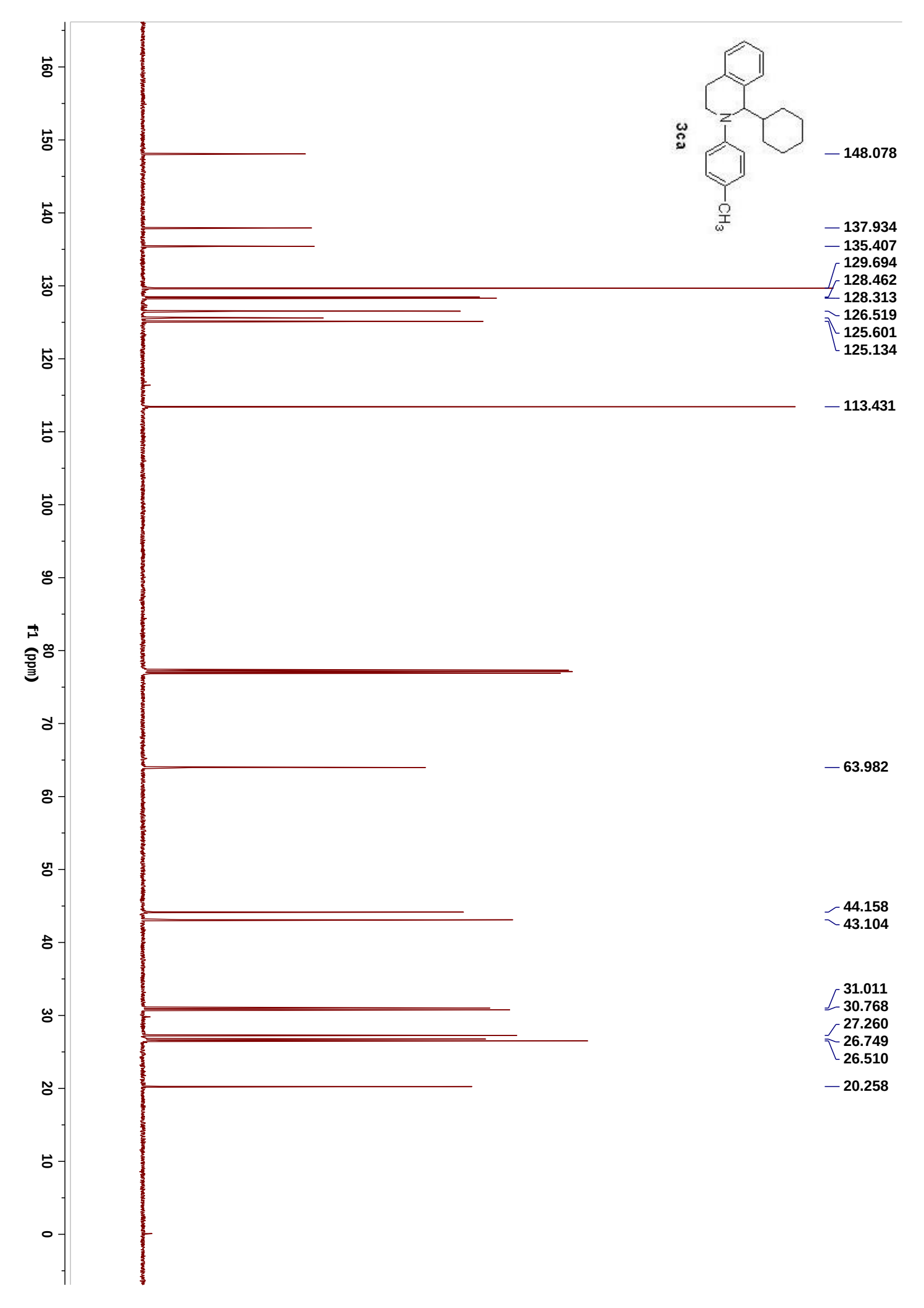
1.033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CH3
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128.313
126.519
125.601
125.134
113.431
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43.104
31.011
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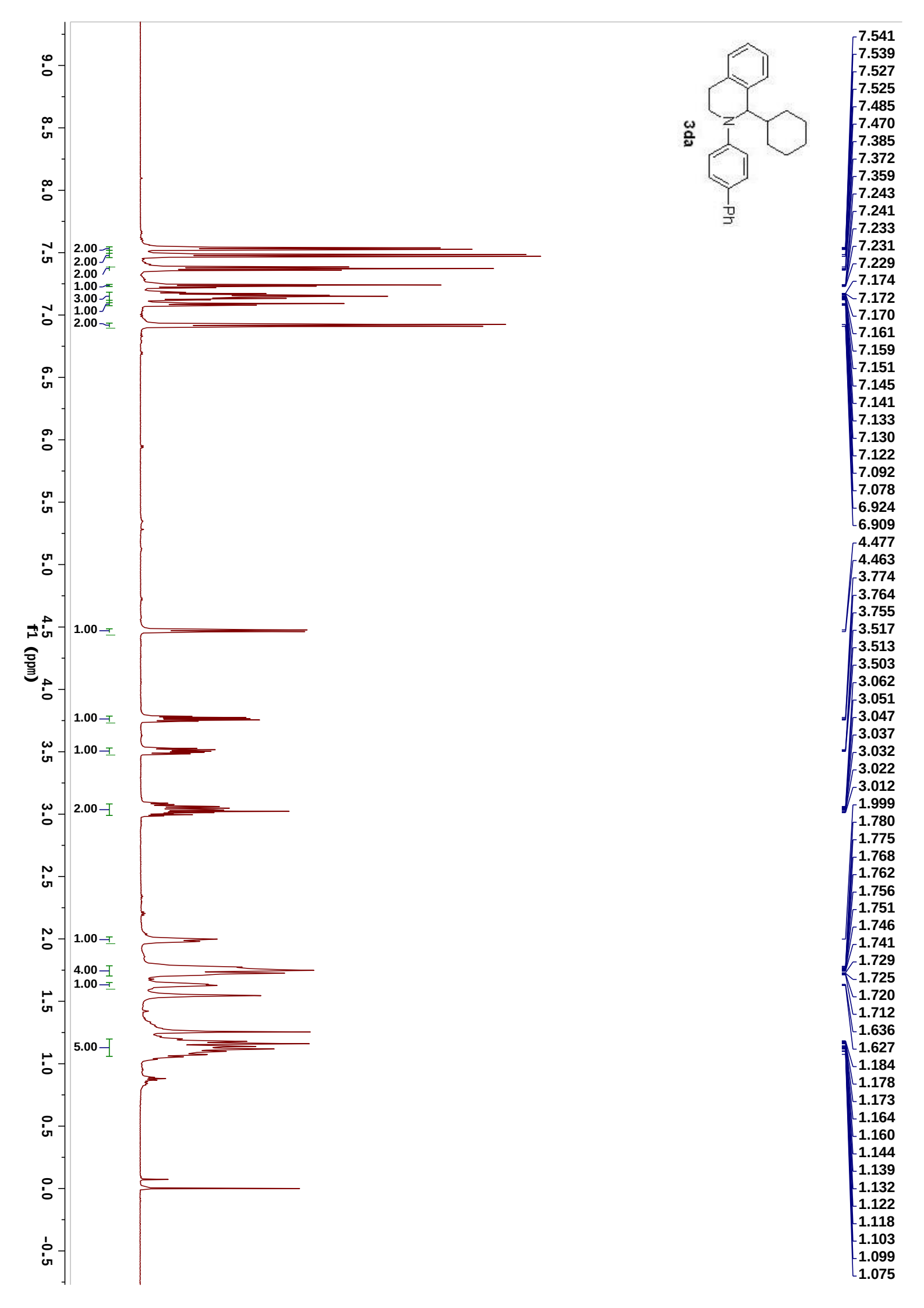
27.260
26.749
26.510
20.258
f1 (ppm)


3da
N
Ph
f1 (ppm)
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8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
2.00
2.00
2.00
1.00
3.00
1.00
2.00
1.00
1.00
1.00
2.00
1.00
4.00
1.00
5.00
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7.539
7.527
7.525
7.485
7.470
7.385
7.372
7.359
7.243
7.241
7.233
7.231
7.229
7.174
7.172
7.170
7.161
7.159
7.151
7.145
7.141
7.133
7.130
7.122
7.092
7.078
6.924
6.909
4.477
4.463
3.774
3.764
3.755
3.517
3.513
3.503
3.062
3.051
3.047
3.037
3.032
3.022
3.012
1.999
1.780
1.775
1.768
1.762
1.756
1.751
1.746
1.741
1.729
1.725
1.720
1.712
1.636
1.627
1.184
1.178
1.173
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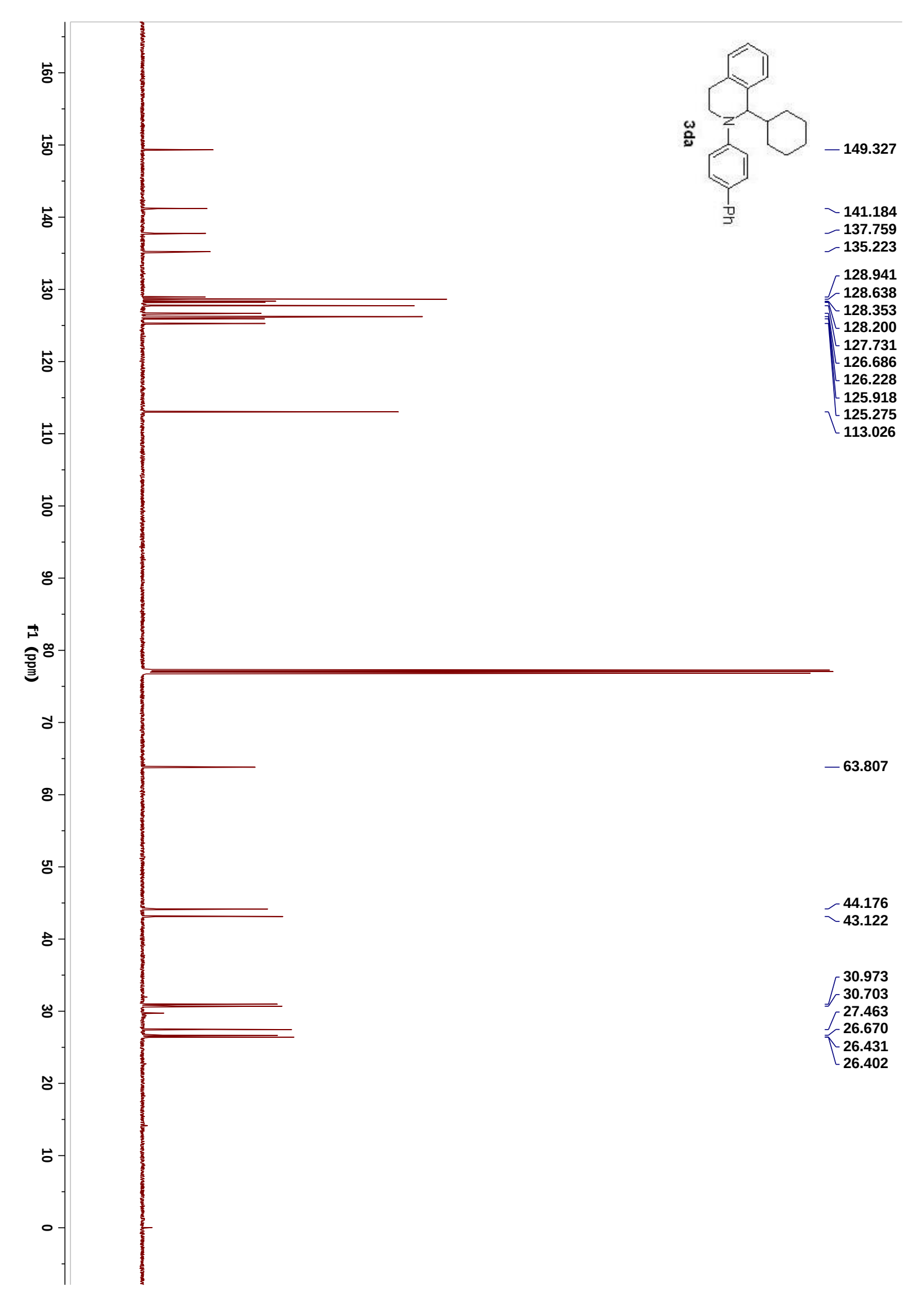
1.160
1.144
1.139
1.132
1.122
1.118
1.103
1.099
1.075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Ph
N
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128.200
127.731
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126.228
125.918
125.275
113.026
63.807
44.176
43.122
30.973
30.703
27.463
26.670
26.431
26.402
f1 (ppm)
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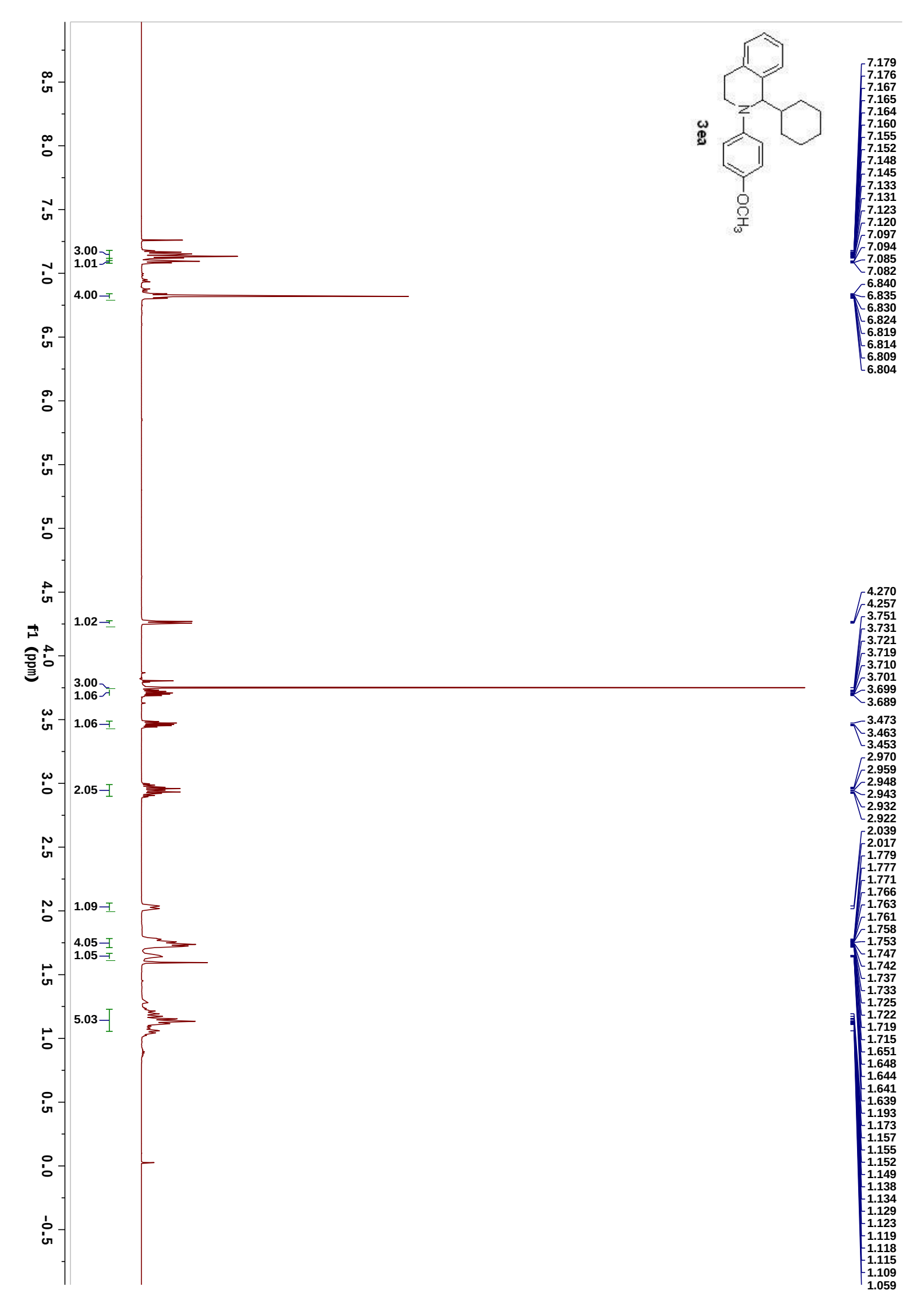
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


3ea
OCH3
f1 (ppm)
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7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
3.00
1.01
4.00
1.02
3.00
1.06
1.06
2.05
1.09
4.05
1.05
5.03
7.179
7.176
7.167
7.165
7.164
7.160
7.155
7.152
7.148
7.145
7.133
7.131
7.123
7.120
7.097
7.094
7.085
7.082
6.840
6.835
6.830
6.824
6.819
6.814
6.809
6.804
4.270
4.257
3.751
3.731
3.721
3.719
3.710
3.701
3.699
3.689
3.473
3.463
3.453
2.970
2.959
2.948
2.943
2.932
2.922
2.039
2.017
1.779
1.777
1.771
1.766
1.763
1.761
1.758
1.753
1.747
1.742
1.737
1.733
1.725
1.722
1.719
1.715
1.651
1.648
1.644
1.641
1.639
1.193
1.173
1.157
1.155
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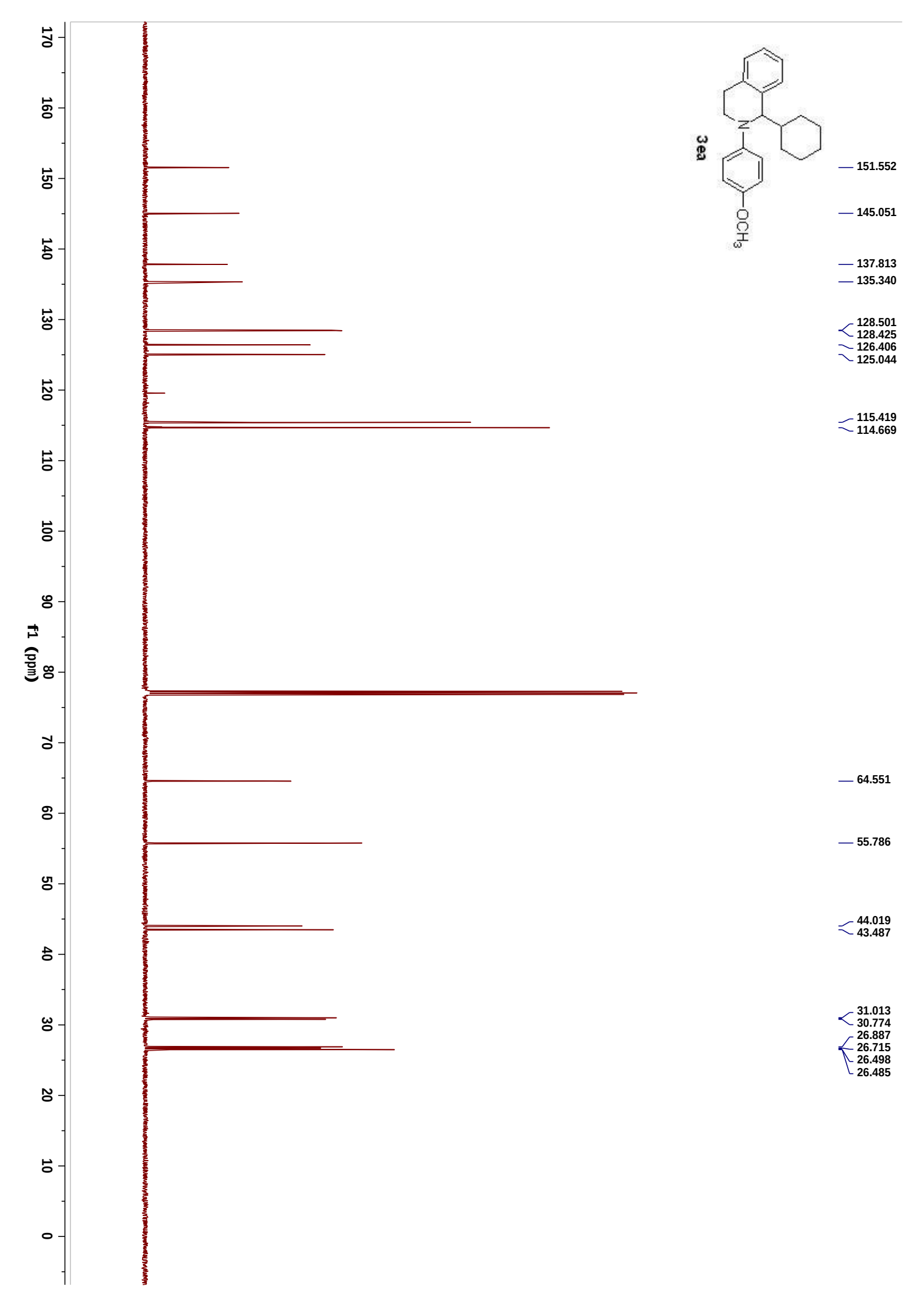
1.138
1.134
1.129
1.123
1.119
1.118
1.115
1.109
1.059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OCH3
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115.419
114.669
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44.019
43.487
31.013
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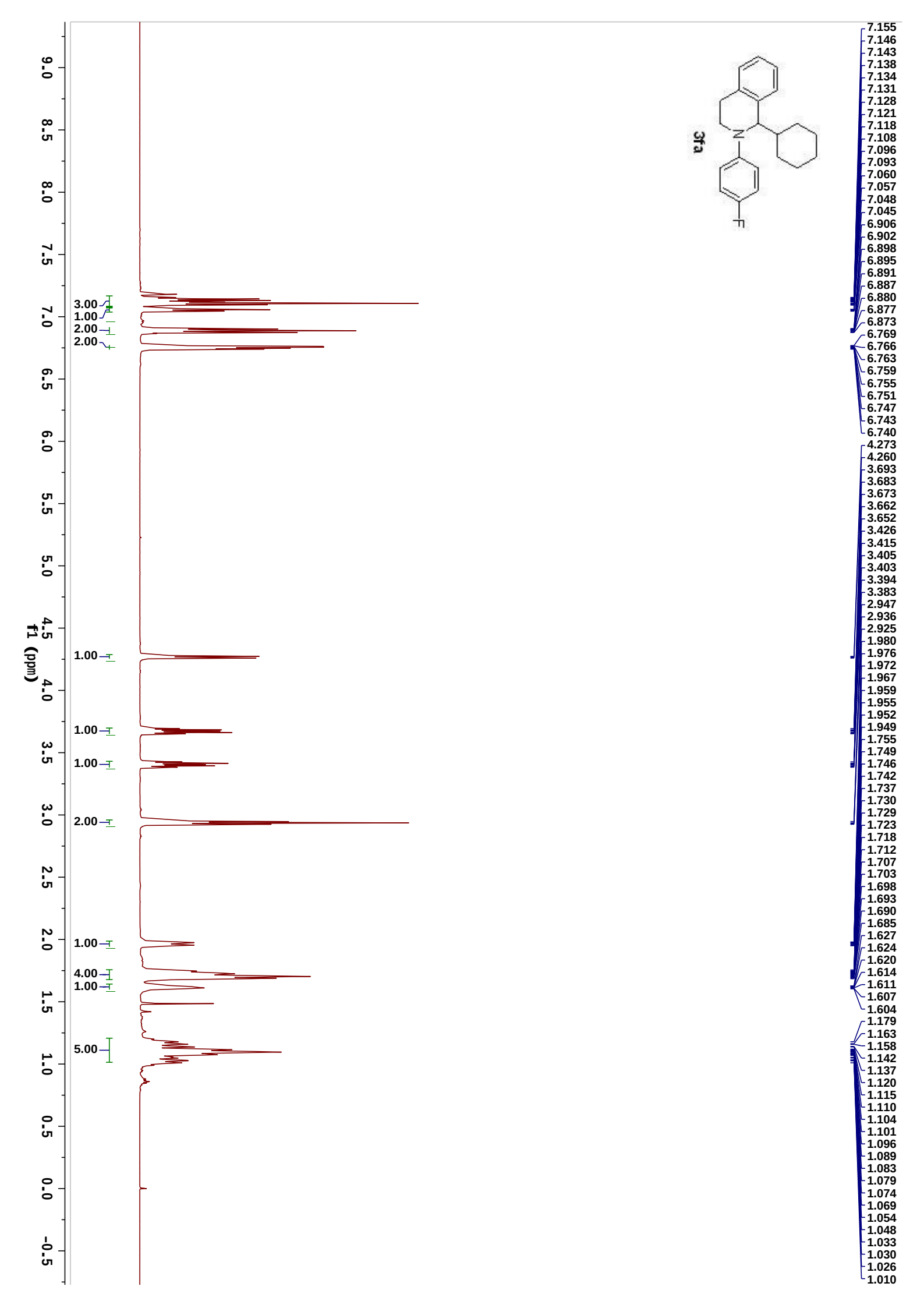
26.715
26.498
26.485
f1 (ppm)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F
f1 (ppm)
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8.0
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5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
3.00
1.00
2.00
2.00
1.00
1.00
1.00
2.00
1.00
4.00
1.00
5.00
7.155
7.146
7.143
7.138
7.134
7.131
7.128
7.121
7.118
7.108
7.096
7.093
7.060
7.057
7.048
7.045
6.906
6.902
6.898
6.895
6.891
6.887
6.880
6.877
6.873
6.769
6.766
6.763
6.759
6.755
6.751
6.747
6.743
6.740
4.273
4.260
3.693
3.683
3.673
3.662
3.652
3.426
3.415
3.405
3.403
3.394
3.383
2.947
2.936
2.925
1.980
1.976
1.972
1.967
1.959
1.955
1.952
1.949
1.755
1.749
1.746
1.742
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1.712
1.707
1.703
1.698
1.693
1.690
1.685
1.627
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1.620
1.614
1.611
1.607
1.604
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1.163
1.158
1.142
1.137
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1.115
1.110
1.104
1.101
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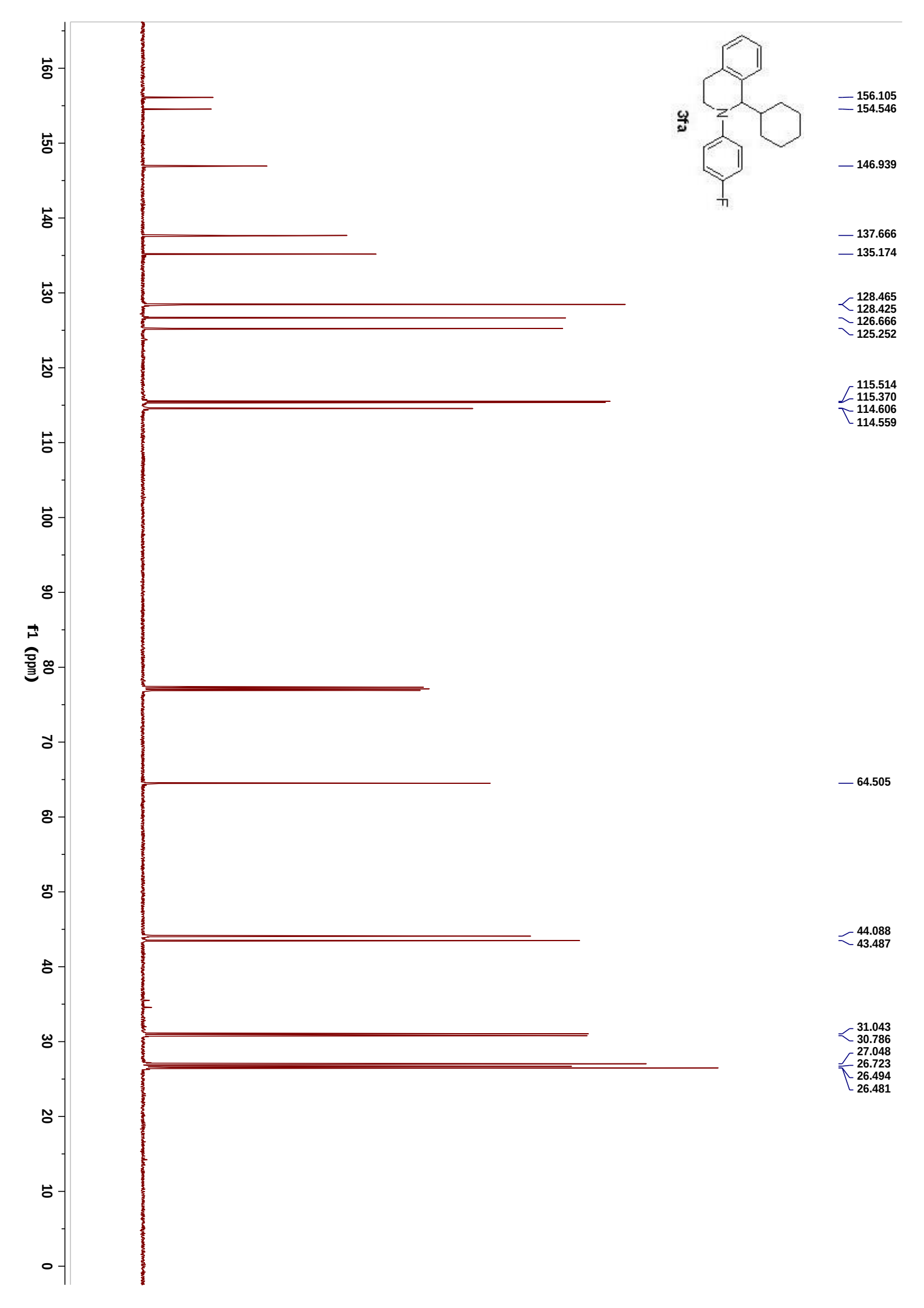
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126.666
125.252
115.514
115.370
114.606
114.559
64.505
44.088
43.487
31.043
30.786
27.048
26.723
26.494
26.481
f1 (ppm)
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150
140
130
120
110
100
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70
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40
30
20
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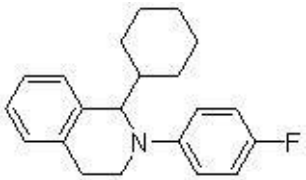
0



3fa

-128.989

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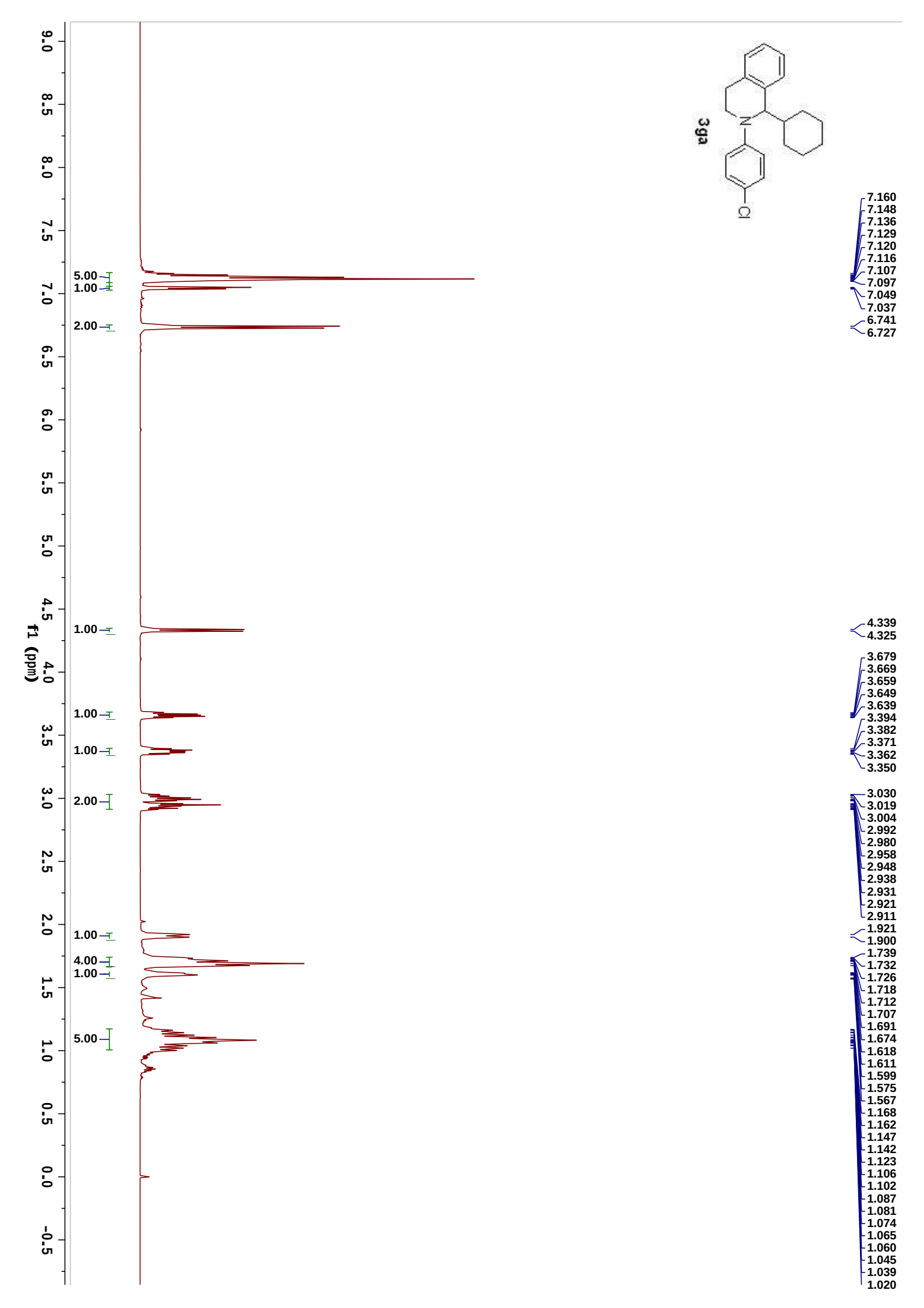
f1 (ppm)


3ga
N
Cl
f1 (ppm)
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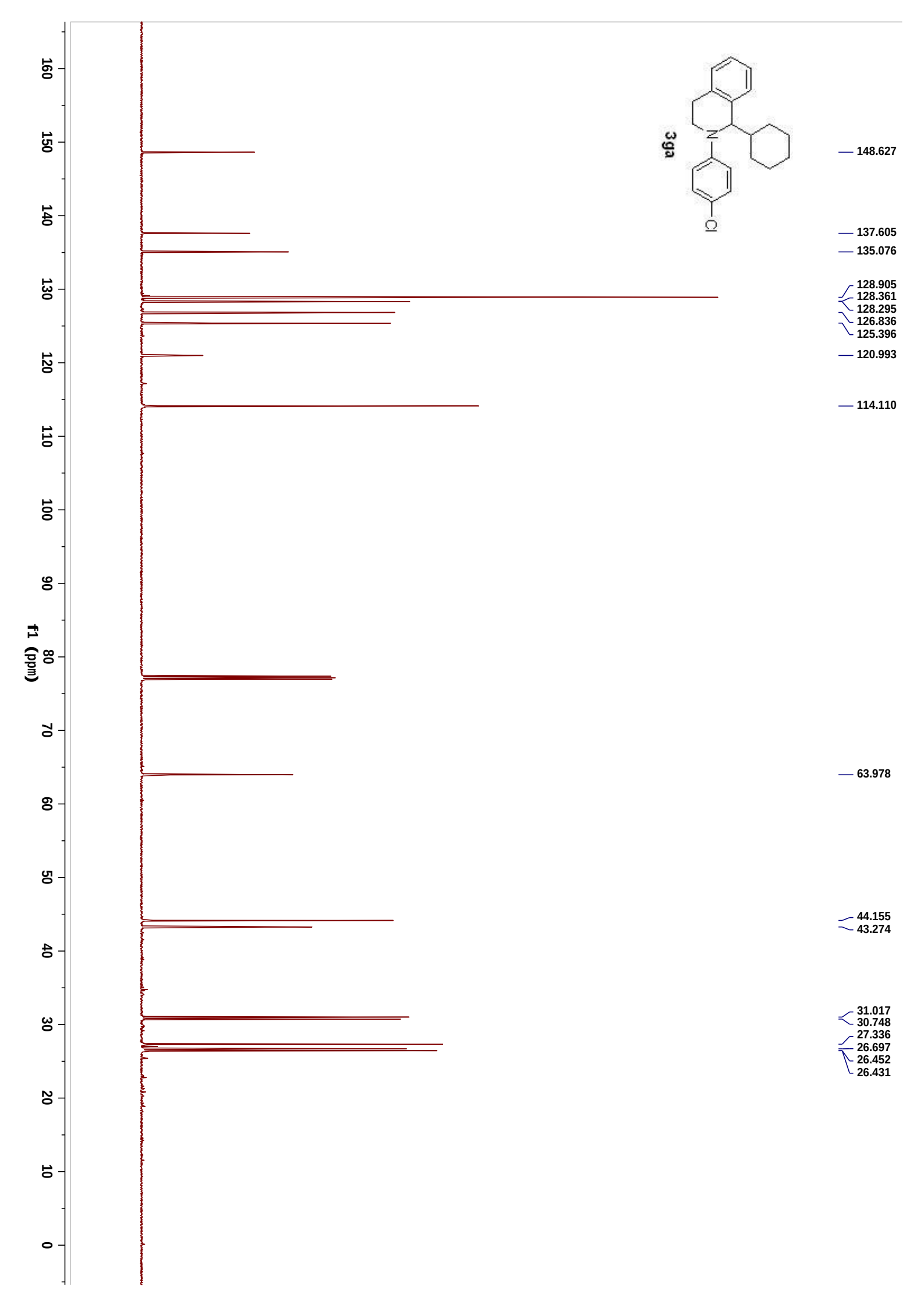
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
5.00
1.00
2.00
1.00
1.00
1.00
2.00
1.00
4.00
1.00
5.00
7.160
7.148
7.136
7.129
7.120
7.116
7.107
7.097
7.049
7.037
6.741
6.727
4.339
4.325
3.679
3.669
3.659
3.649
3.639
3.394
3.382
3.371
3.362
3.350
3.030
3.019
3.004
2.992
2.980
2.958
2.948
2.938
2.931
2.921
2.911
1.921
1.900
1.739
1.732
1.726
1.718
1.712
1.707
1.691
1.674
1.618
1.611
1.599
1.575
1.567
1.168
1.162
1.147
1.142
1.123
1.106
1.102
1.087
1.081
1.074
1.065
1.060
1.045
1.039
1.020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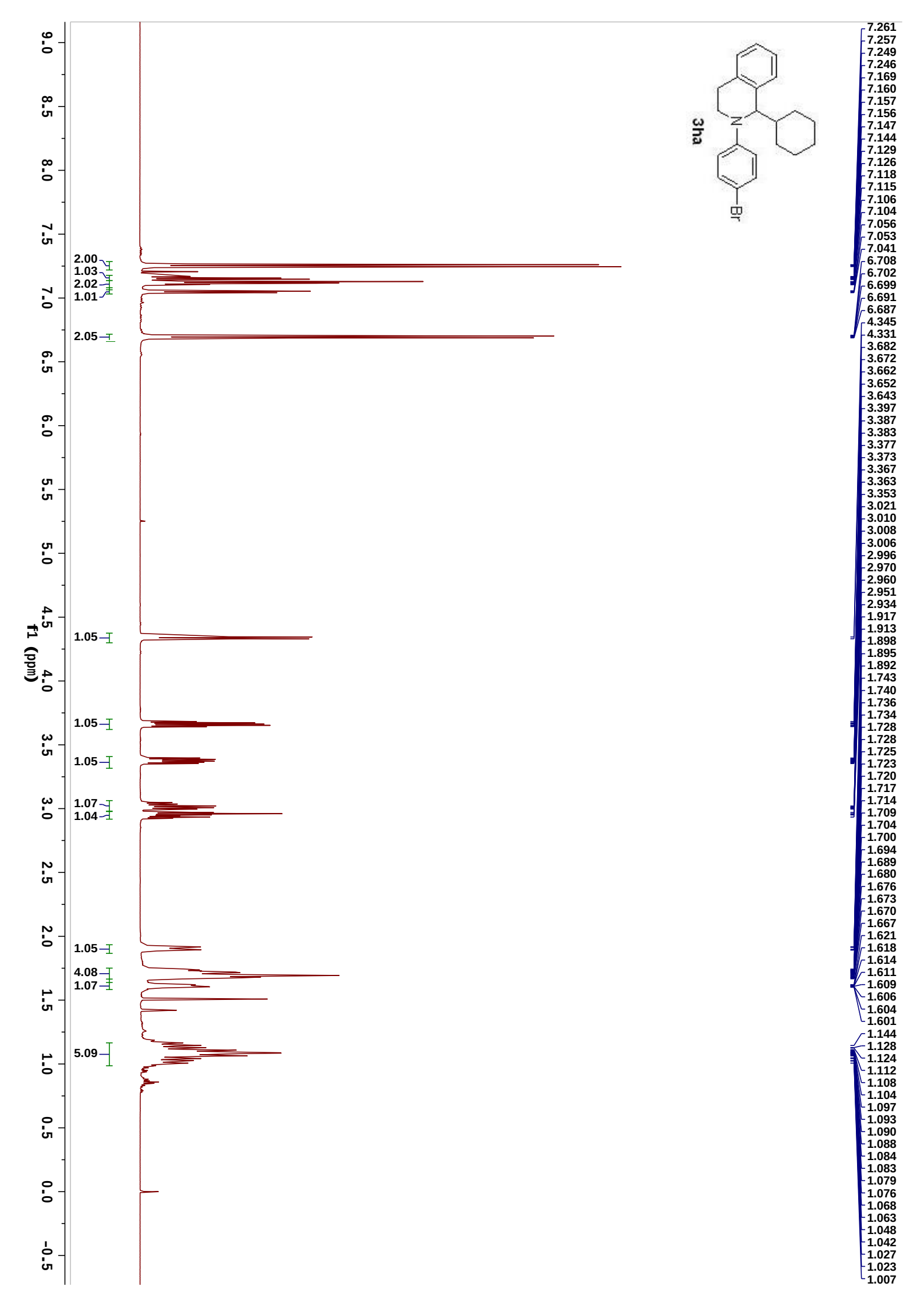
126.836
125.396
120.993
114.110
63.978
44.155
43.274
31.017
30.748
27.336
26.697
26.452
26.431
f1 (ppm)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0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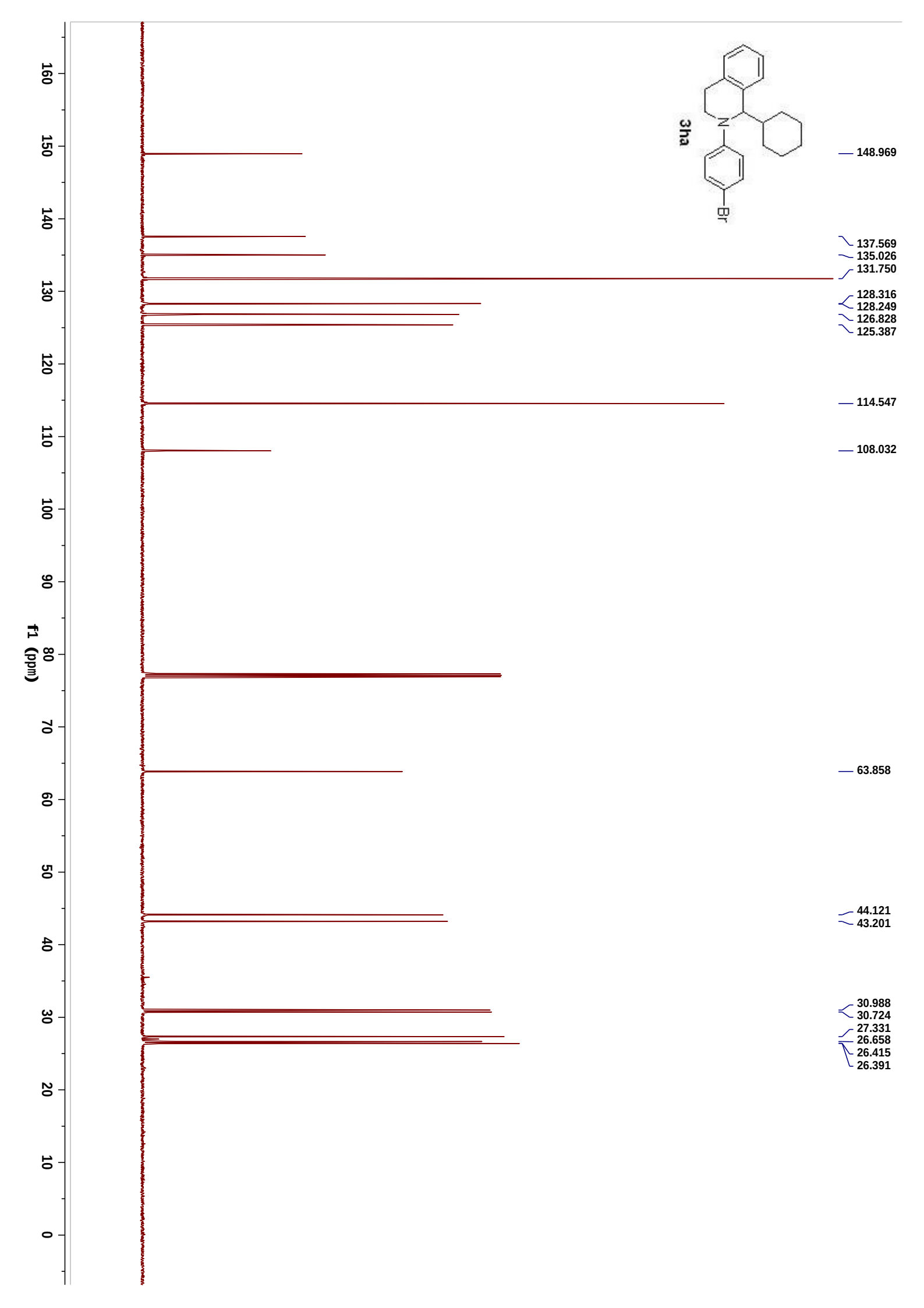
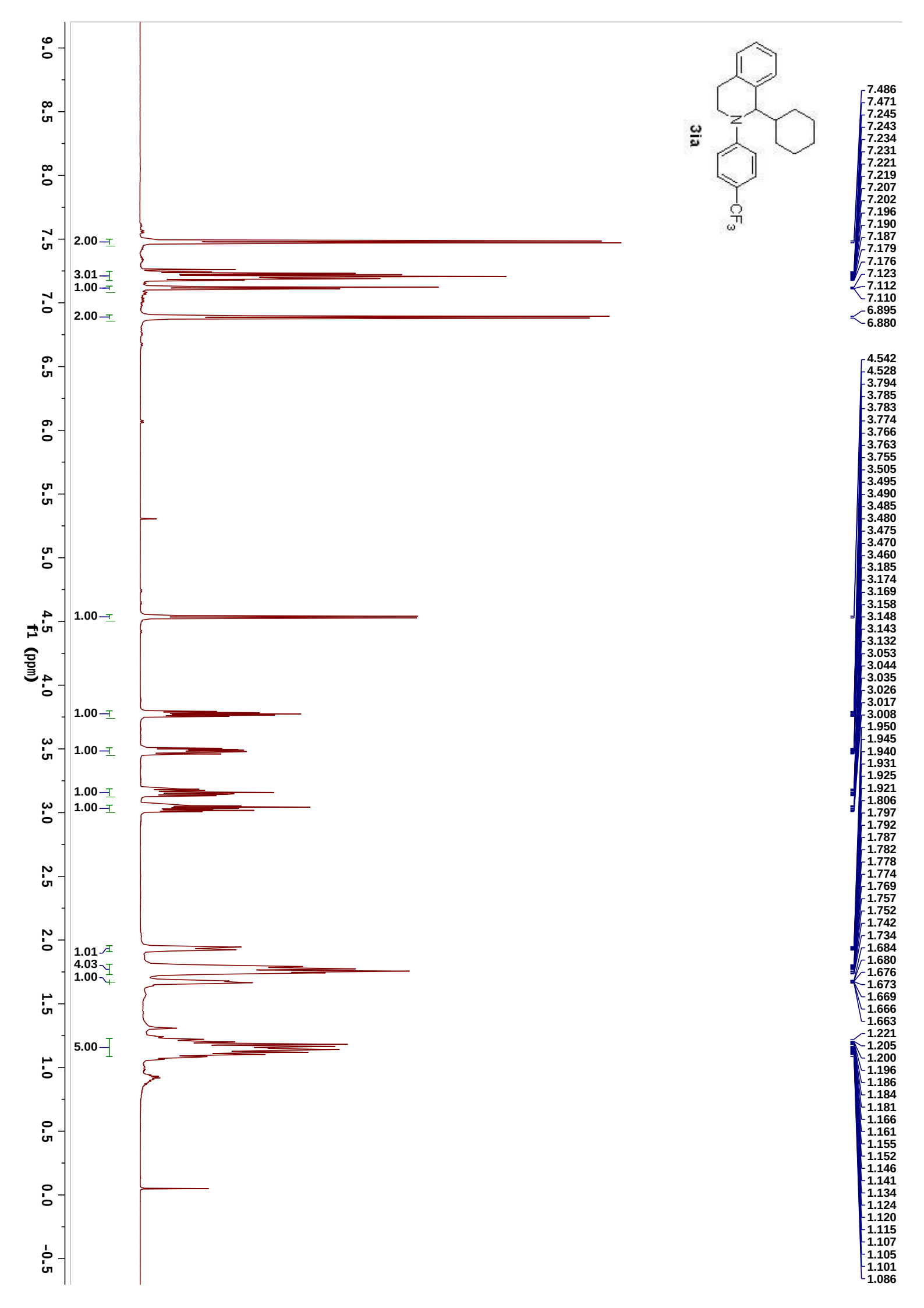
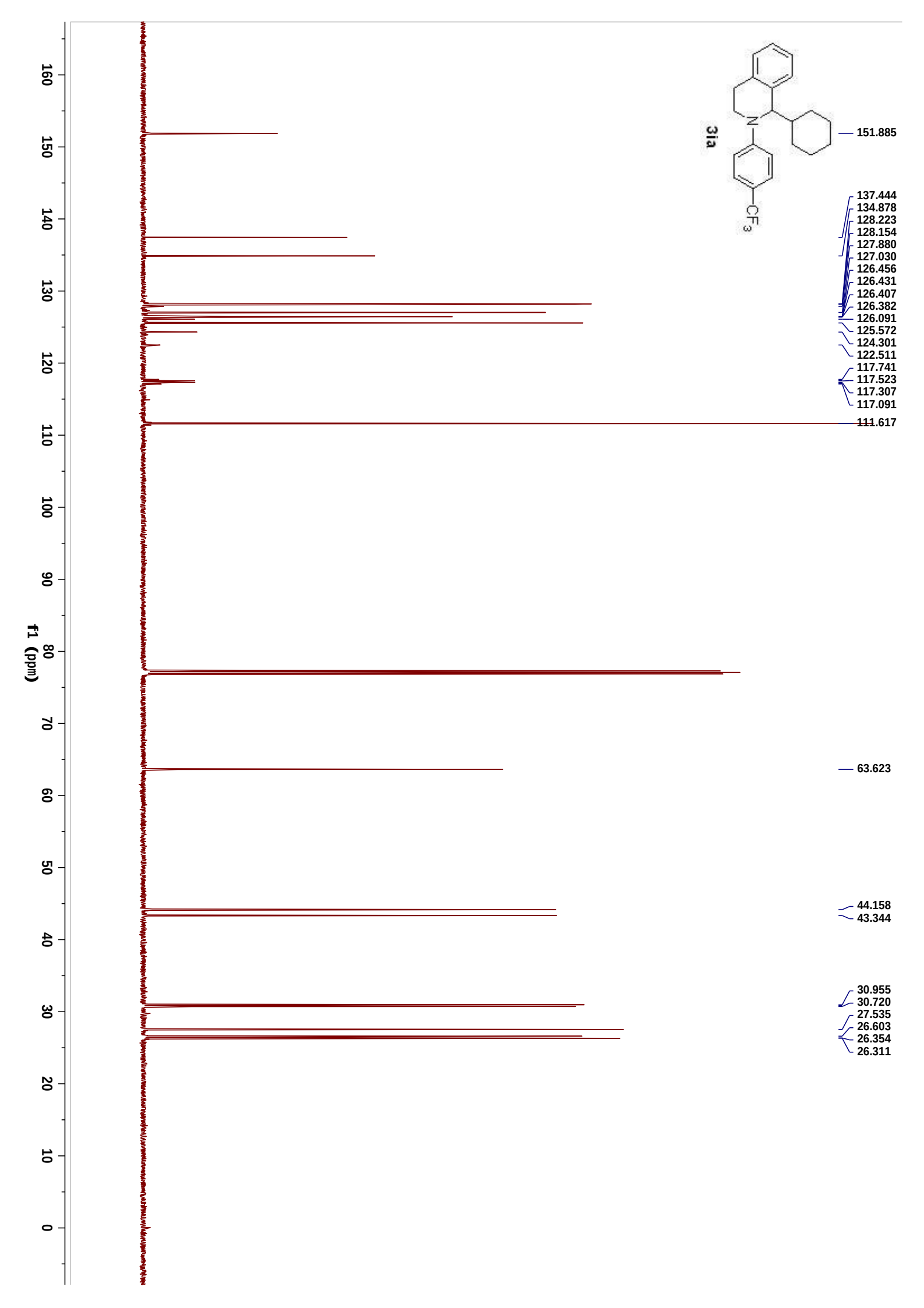
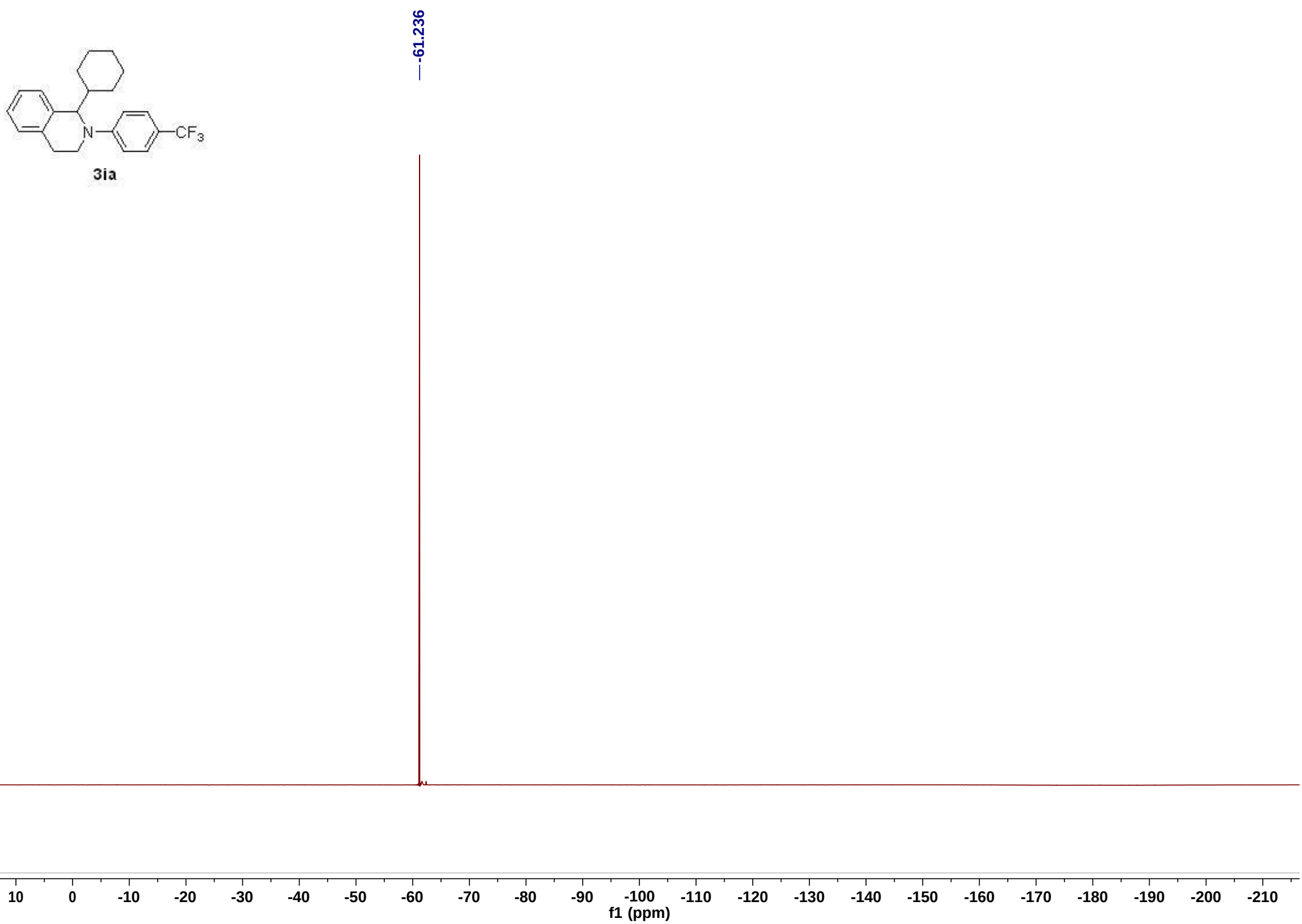
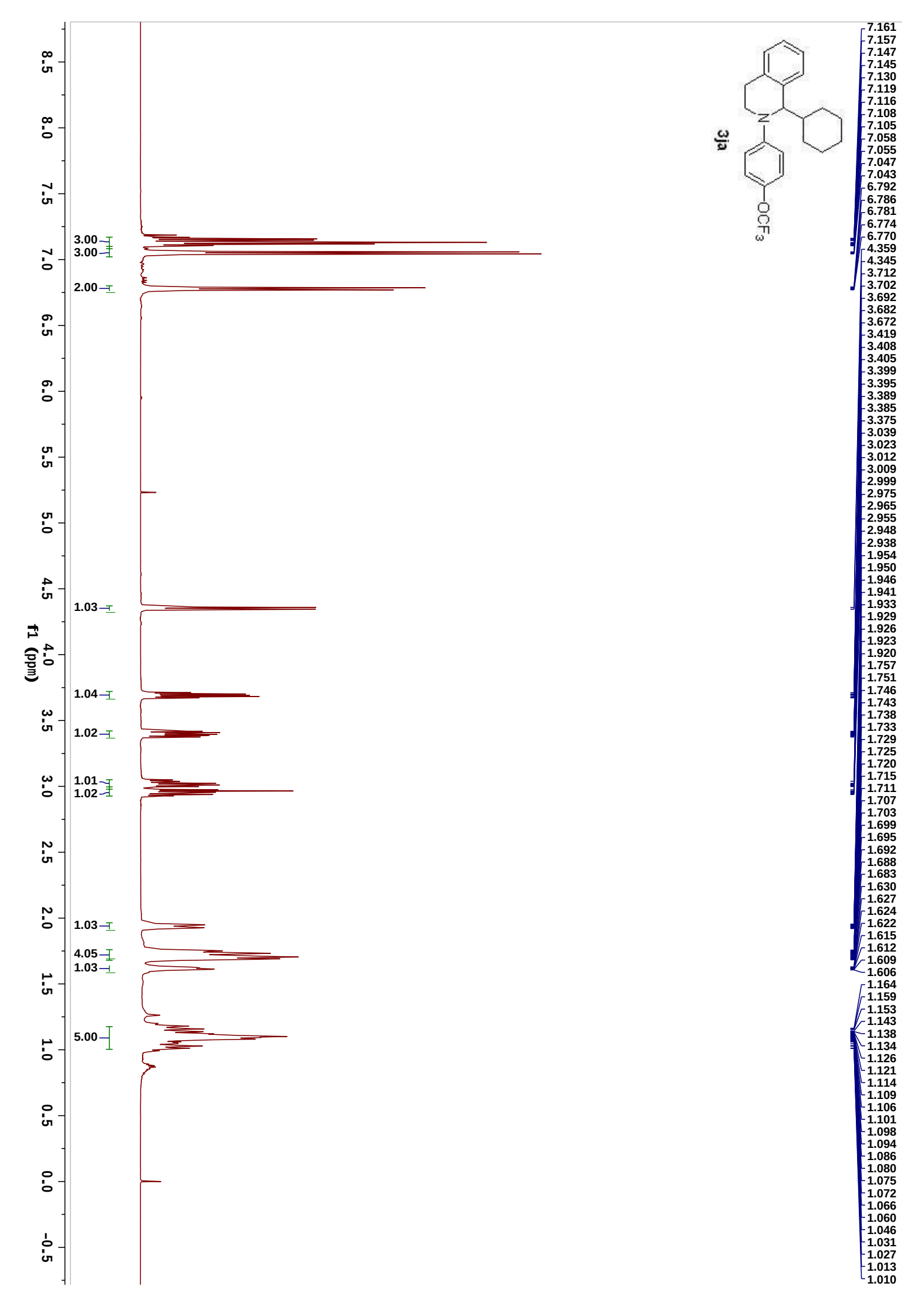
N
Br
f1 (ppm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
2.00
1.03
2.02
1.01
2.05
1.05
1.05
1.05
1.07
1.04
1.05
4.08
1.07
5.09
7.261
7.257
7.249
7.246
7.169
7.160
7.157
7.156
7.147
7.144
7.129
7.126
7.118
7.115
7.106
7.104
7.056
7.053
7.041
6.708
6.702
6.699
6.691
6.687
4.345
4.331
3.682
3.672
3.662
3.652
3.643
3.397
3.387
3.383
3.377
3.373
3.367
3.363
3.353
3.021
3.010
3.008
3.006
2.996
2.970
2.960
2.951
2.934
1.917
1.913
1.898
1.895
1.892
1.743
1.740
1.736
1.734
1.728
1.728
1.725
1.723
1.720
1.717
1.714
1.709
1.704
1.700
1.694
1.689
1.680
1.676
1.673
1.670
1.667
1.621
1.618
1.614
1.611
1.609
1.606
1.604
1.601
1.144
1.128
1.124
1.112
1.108
1.104
1.097
1.093
1.090
1.088
1.084
1.083
1.079
1.076
1.068
1.063
1.048
1.042
1.027
1.023
1.007

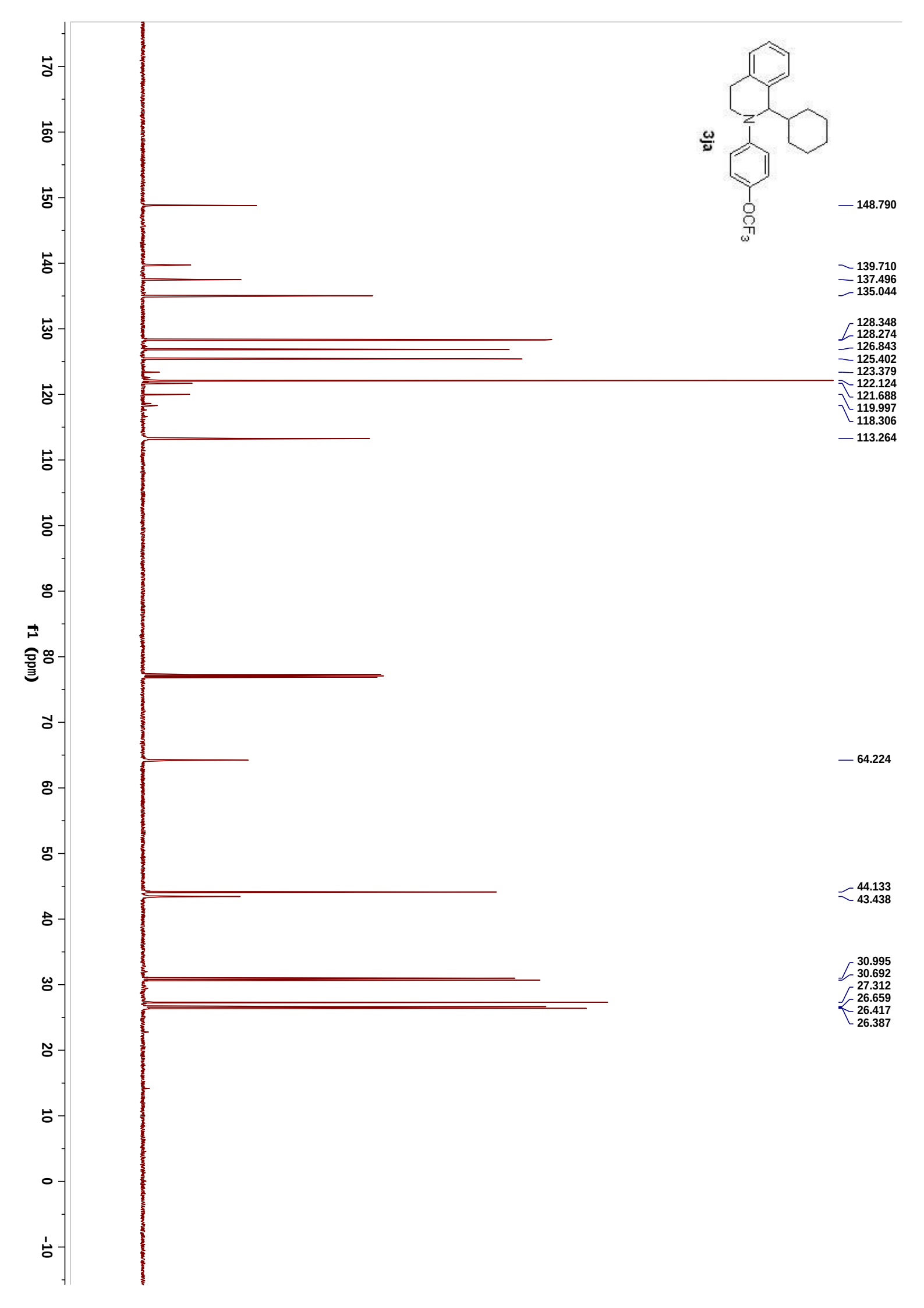

3ha
N
Br
148.969
137.569
135.026
131.750
128.316
128.249
126.828
125.387
114.547
108.032
63.858
44.121
43.201
30.988
30.724
27.331
26.658
26.415
26.391
f1 (ppm)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

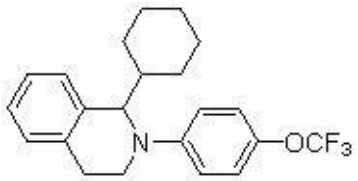

3ia
CF3
N
f1 (ppm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
2.00
3.01
1.00
2.00
1.00
1.00
1.00
1.00
1.00
1.01
4.03
1.00
5.00
7.486
7.471
7.245
7.243
7.234
7.231
7.221
7.219
7.207
7.202
7.196
7.190
7.187
7.179
7.176
7.123
7.112
7.110
6.895
6.880
4.542
4.528
3.794
3.785
3.783
3.774
3.766
3.763
3.755
3.505
3.495
3.490
3.485
3.480
3.475
3.470
3.460
3.185
3.174
3.169
3.158
3.148
3.143
3.132
3.053
3.044
3.035
3.026
3.017
3.008
1.950
1.945
1.940
1.931
1.925
1.921
1.806
1.797
1.792
1.787
1.782
1.778
1.774
1.769
1.757
1.752
1.742
1.734
1.684
1.680
1.676
1.673
1.669
1.666
1.663
1.221
1.205
1.200
1.196
1.186
1.184
1.181
1.166
1.161
1.155
1.152
1.146
1.141
1.134
1.124
1.120
1.115
1.107
1.105
1.101
1.086


3ia
N
CF3
151.885
137.444
134.878
128.223
128.154
127.880
127.030
126.456
126.431
126.407
126.382
126.091
125.572
124.301
122.511
117.741
117.523
117.307
117.091
111.617
63.623
44.158
43.344
30.955
30.720
27.535
26.603
26.354
26.311
f1 (ppm)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


-61.236
N
CF3
3ia
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)


3ja
OCF3
f1 (ppm)
3.00
3.00
2.00
1.03
1.04
1.02
1.01
1.02
1.03
4.05
1.03
5.00


3ja
OCF3
N
148.790
139.710
137.496
135.044
128.348
128.274
126.843
125.402
123.379
122.124
121.688
119.997
118.306
113.264
64.224
44.133
43.438
30.995
30.692
27.312
26.659
26.417
26.387
f1 (ppm)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10

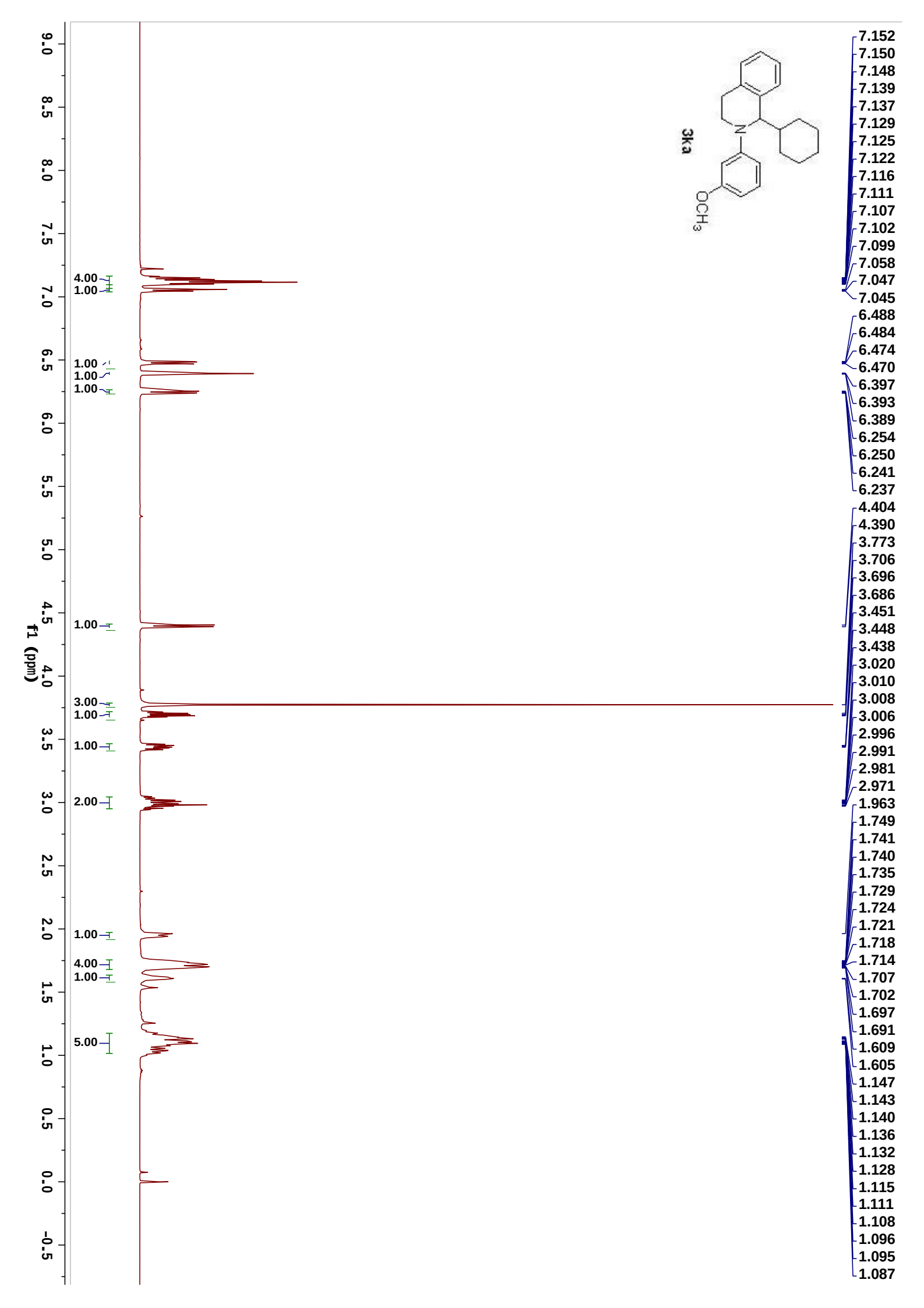


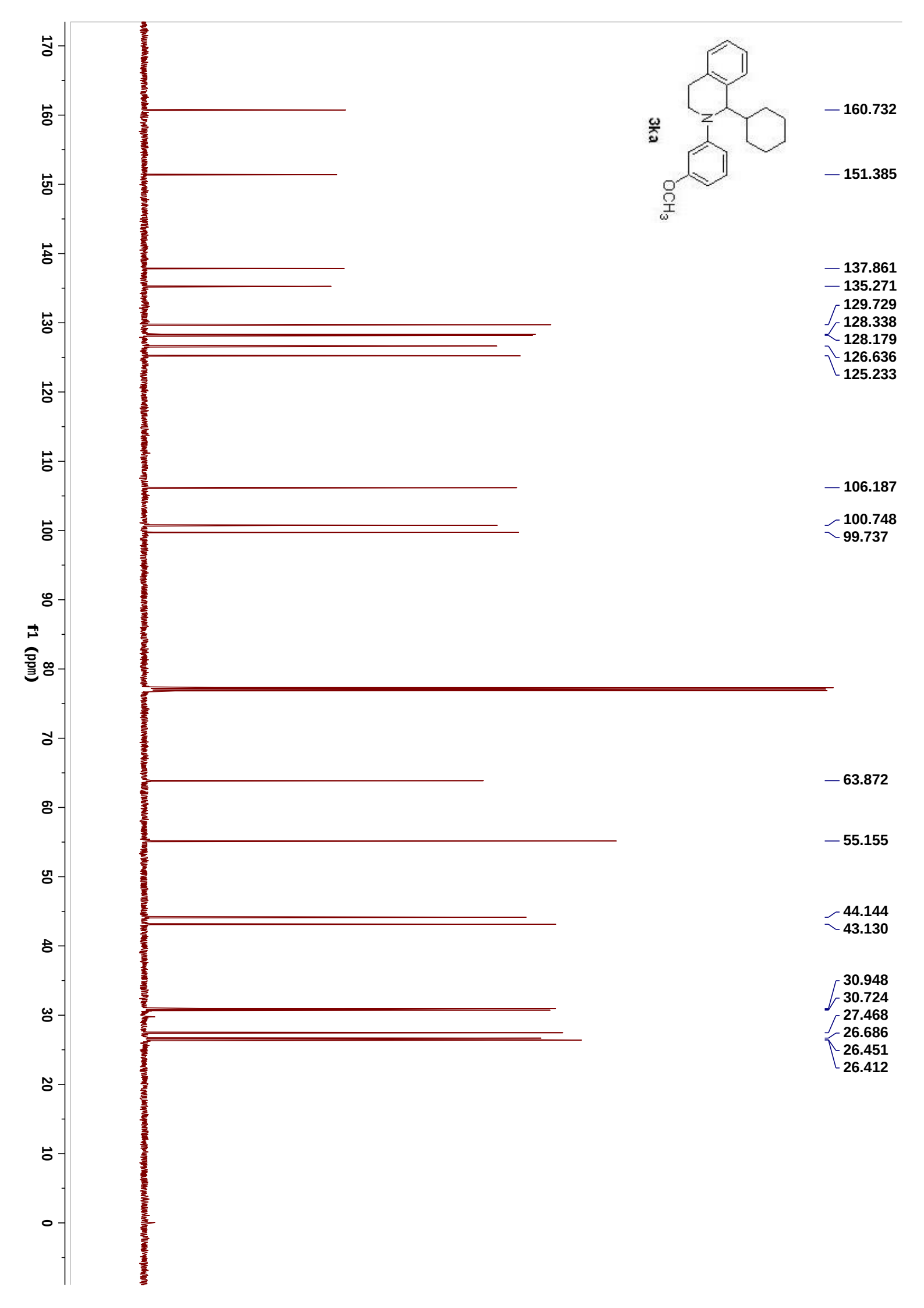
3ja

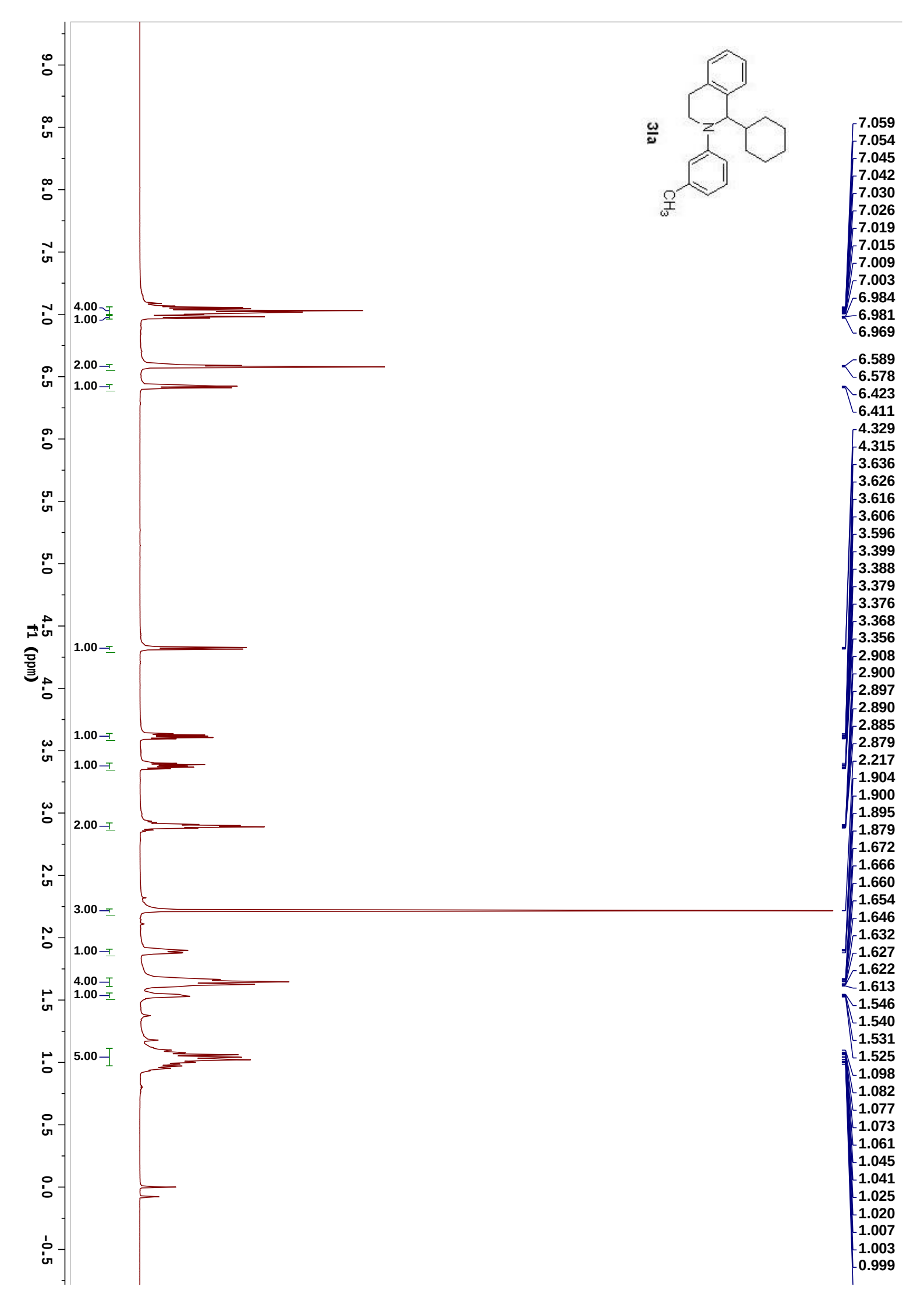
-58.359

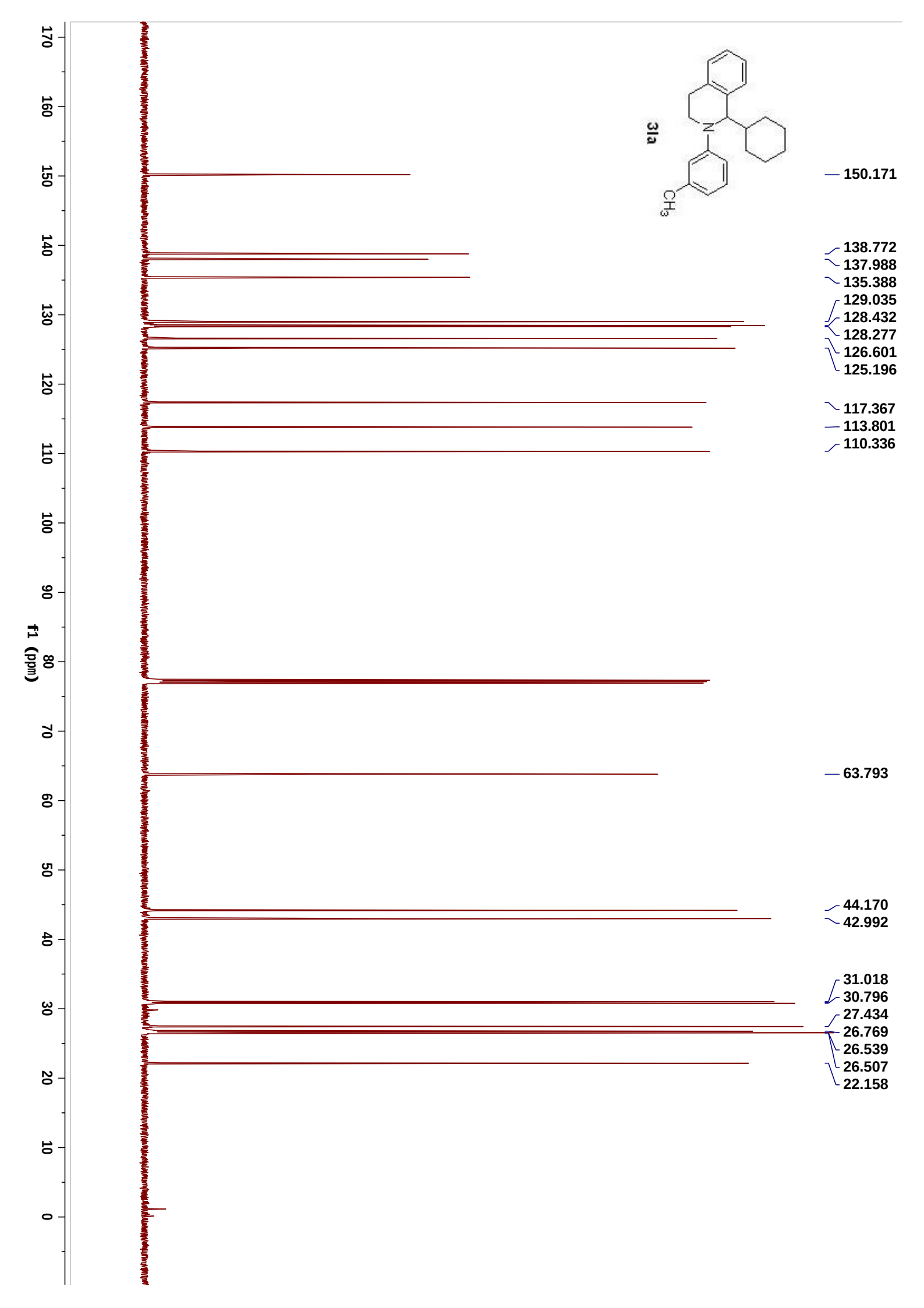
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210

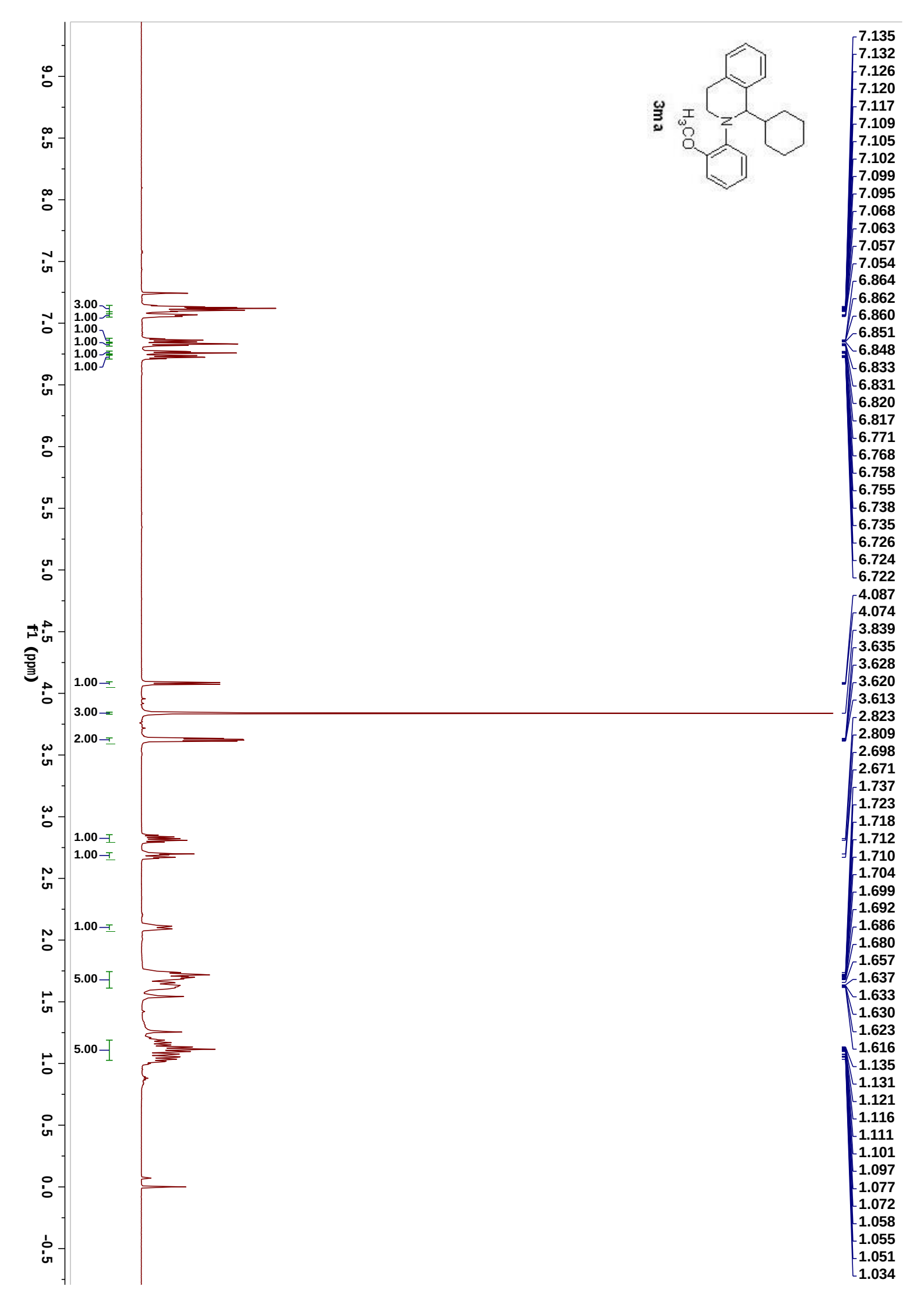
f1 (ppm)

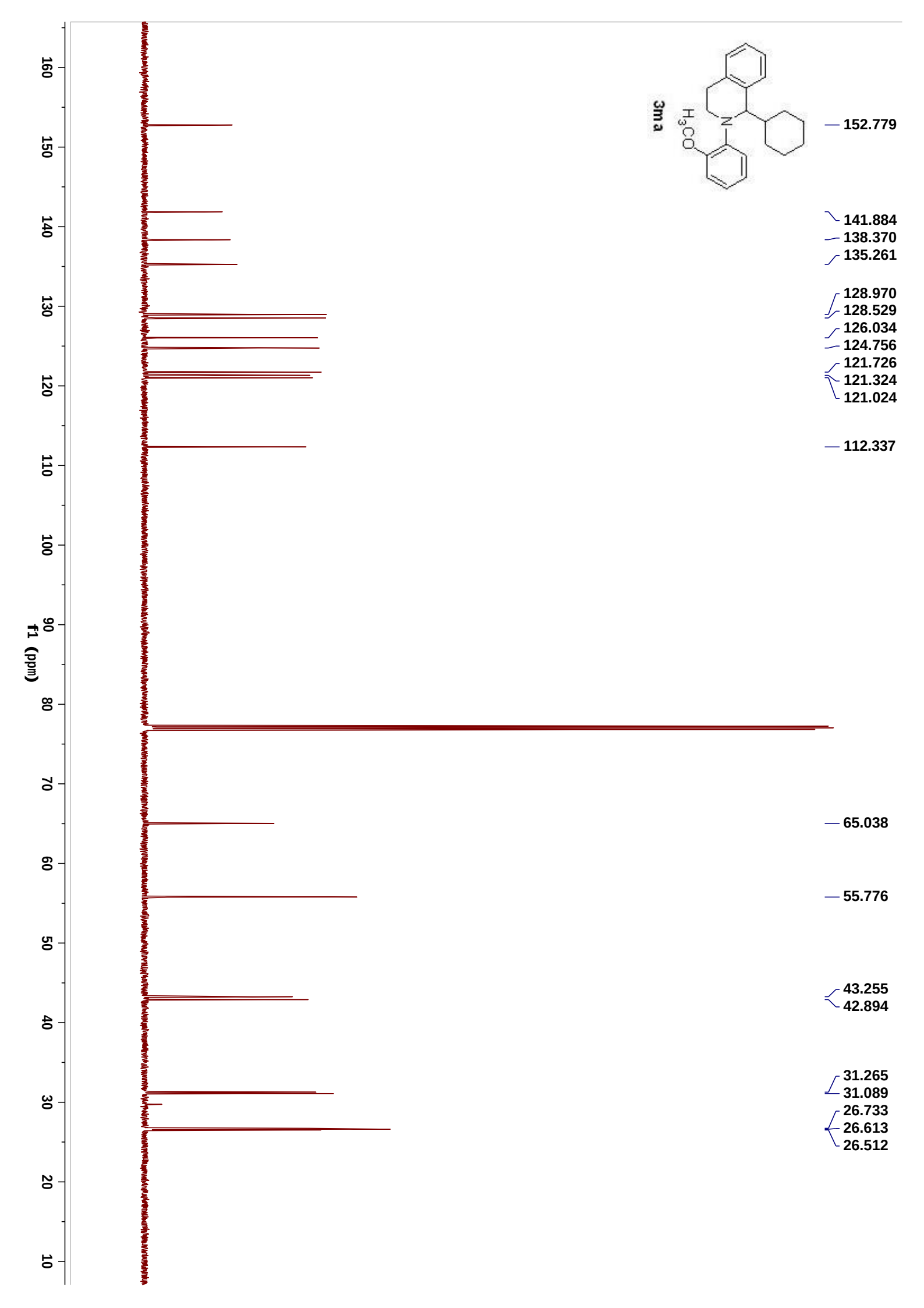

3ka
OCH3
N
f1 (ppm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
4.00
1.00
1.00
1.00
1.00
1.00
3.00
1.00
1.00
2.00
1.00
4.00
1.00
5.00
7.152
7.150
7.148
7.139
7.137
7.129
7.125
7.122
7.116
7.111
7.107
7.102
7.099
7.058
7.047
7.045
6.488
6.484
6.474
6.470
6.397
6.393
6.389
6.254
6.250
6.241
6.237
4.404
4.390
3.773
3.706
3.696
3.686
3.451
3.448
3.438
3.020
3.010
3.008
3.006
2.996
2.991
2.981
2.971
1.963
1.749
1.741
1.740
1.735
1.729
1.724
1.721
1.718
1.714
1.707
1.702
1.697
1.691
1.609
1.605
1.147
1.143
1.140
1.136
1.132
1.128
1.115
1.111
1.108
1.096
1.095
1.087

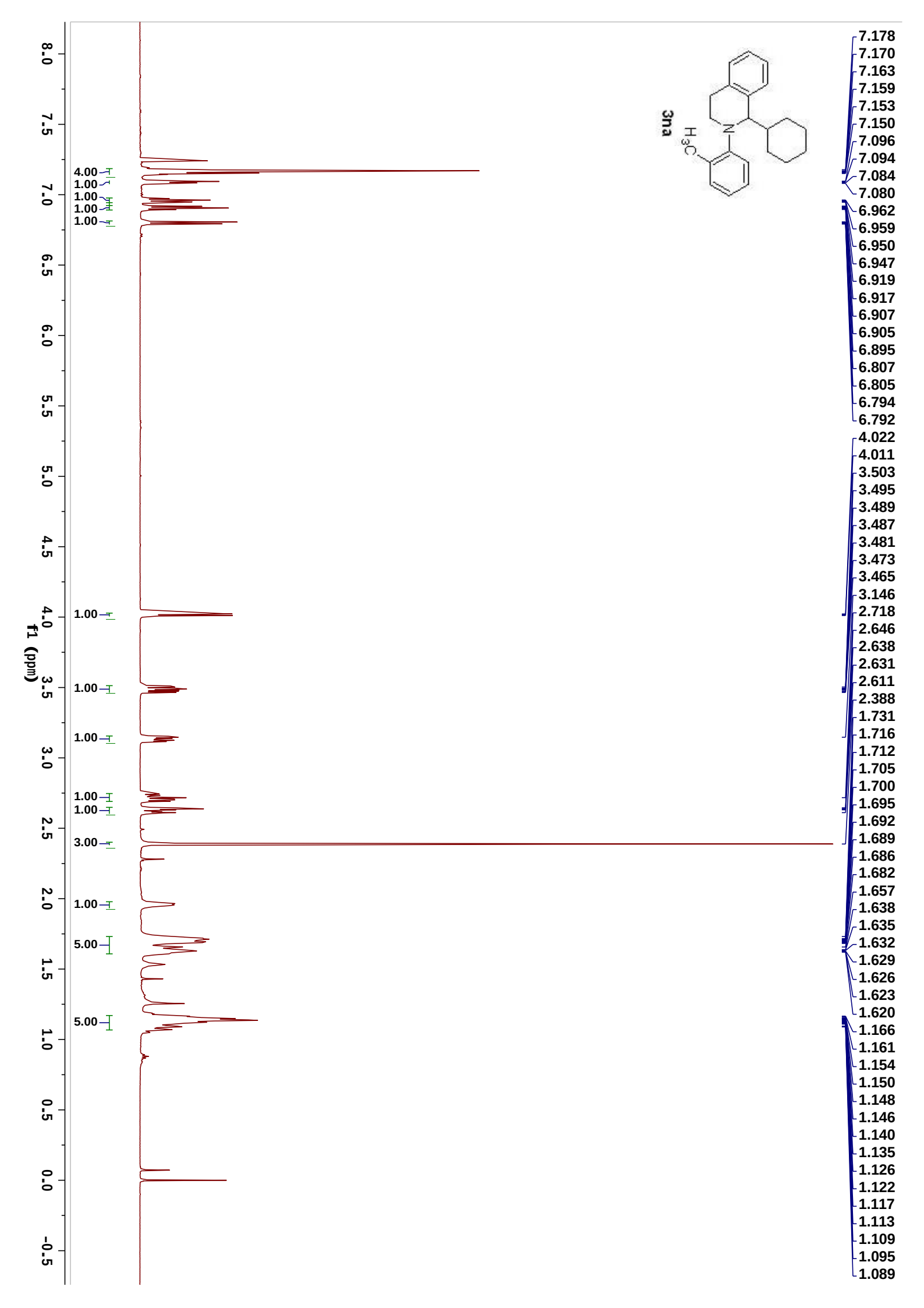

3ka
OCH3
160.732
151.385
137.861
135.271
129.729
128.338
128.179
126.636
125.233
106.187
100.748
99.737
63.872
55.155
44.144
43.130
30.948
30.724
27.468
26.686
26.451
26.412
f1 (ppm)

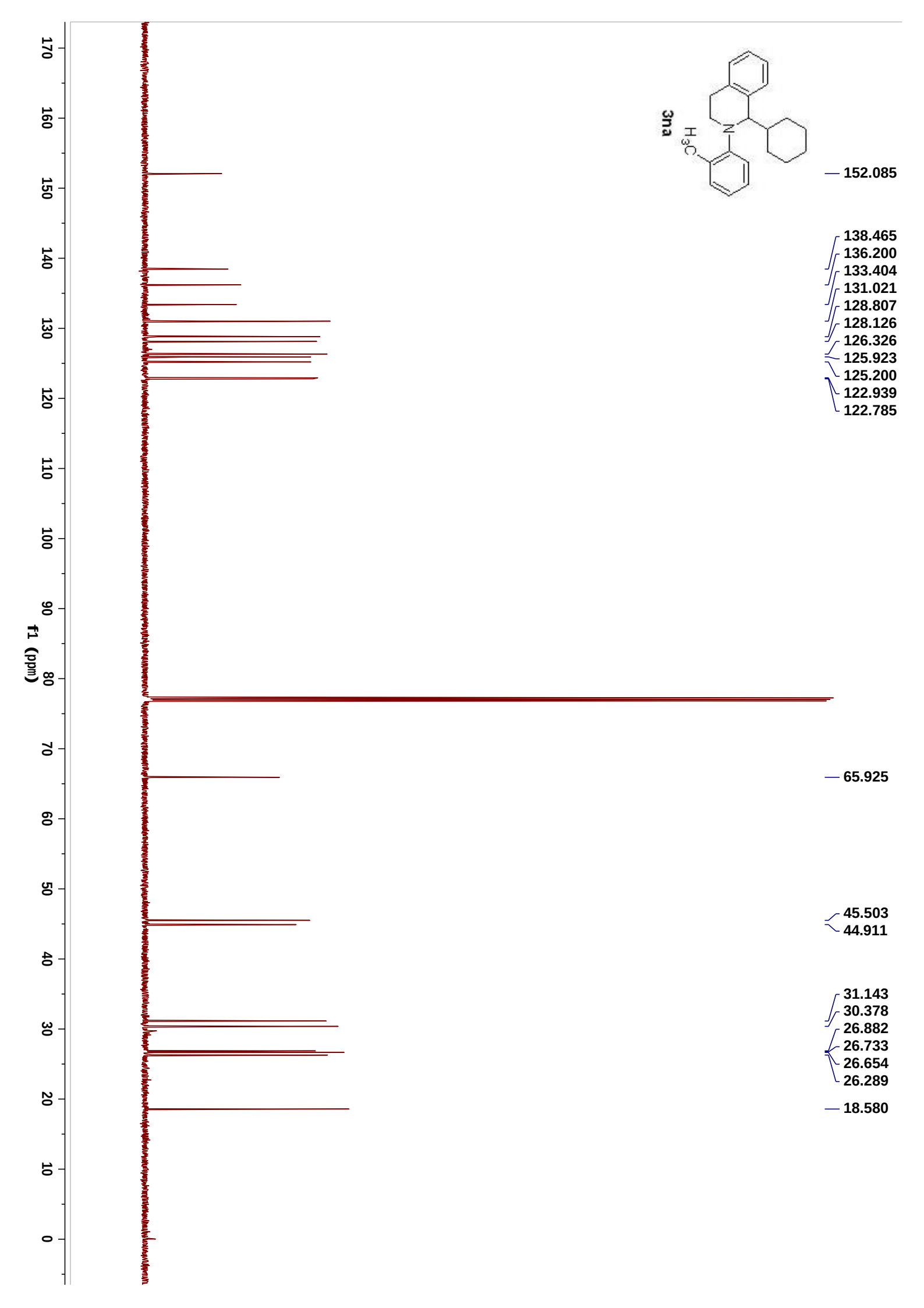

3la
CH3
f1 (ppm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
4.00
1.00
2.00
1.00
1.00
1.00
1.00
2.00
3.00
1.00
4.00
1.00
5.00
7.059
7.054
7.045
7.042
7.030
7.026
7.019
7.015
7.009
7.003
6.984
6.981
6.969
6.589
6.578
6.423
6.411
4.329
4.315
3.636
3.626
3.616
3.606
3.596
3.399
3.388
3.379
3.376
3.368
3.356
2.908
2.900
2.897
2.890
2.885
2.879
2.217
1.904
1.900
1.895
1.879
1.672
1.666
1.660
1.654
1.646
1.632
1.627
1.622
1.613
1.546
1.540
1.531
1.525
1.098
1.082
1.077
1.073
1.061
1.045
1.041
1.025
1.020
1.007
1.003
0.999

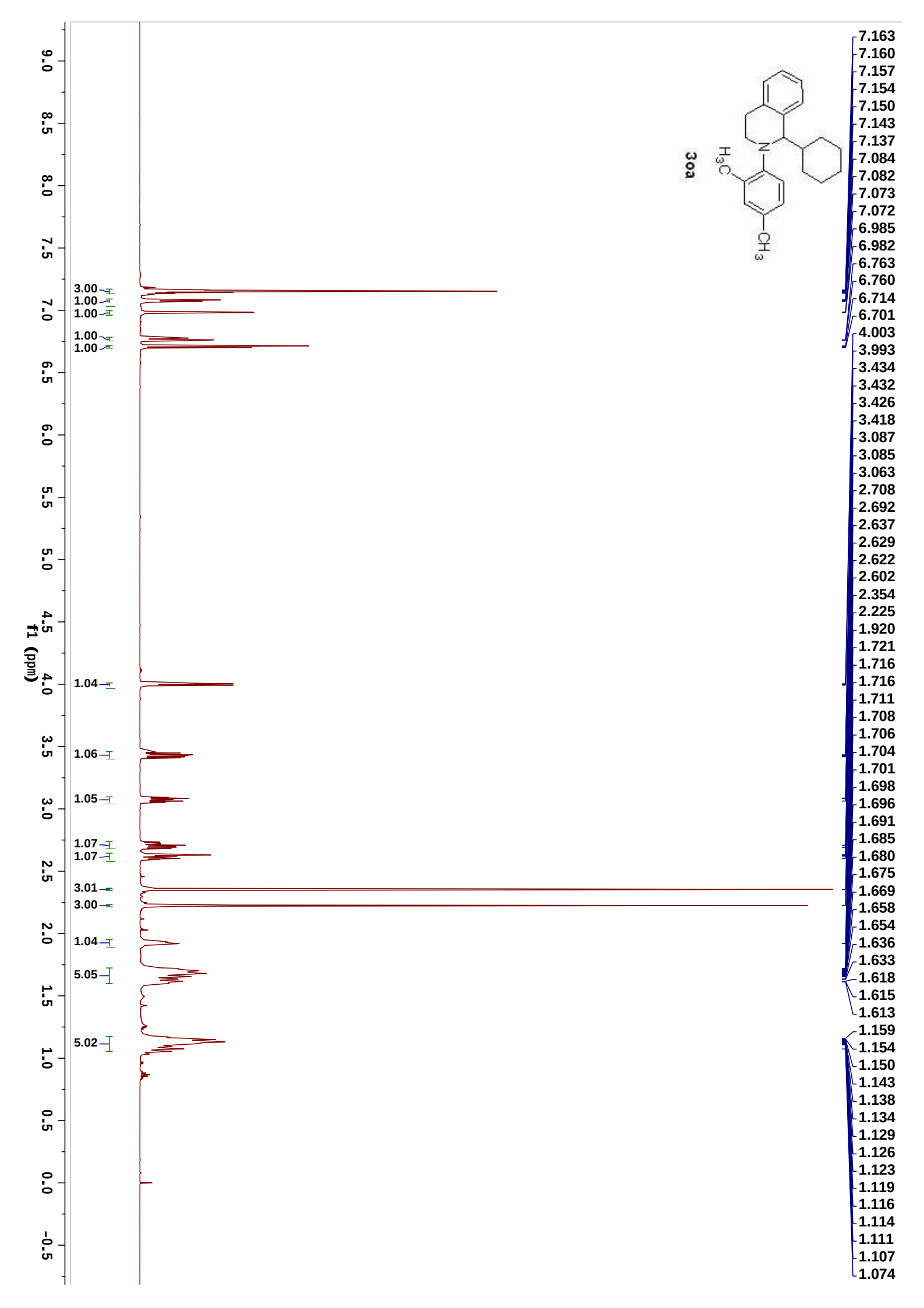

3la
CH3
150.171
138.772
137.988
135.388
129.035
128.432
128.277
126.601
125.196
117.367
113.801
110.336
63.793
44.170
42.992
31.018
30.796
27.434
26.769
26.539
26.507
22.158
f1 (ppm)

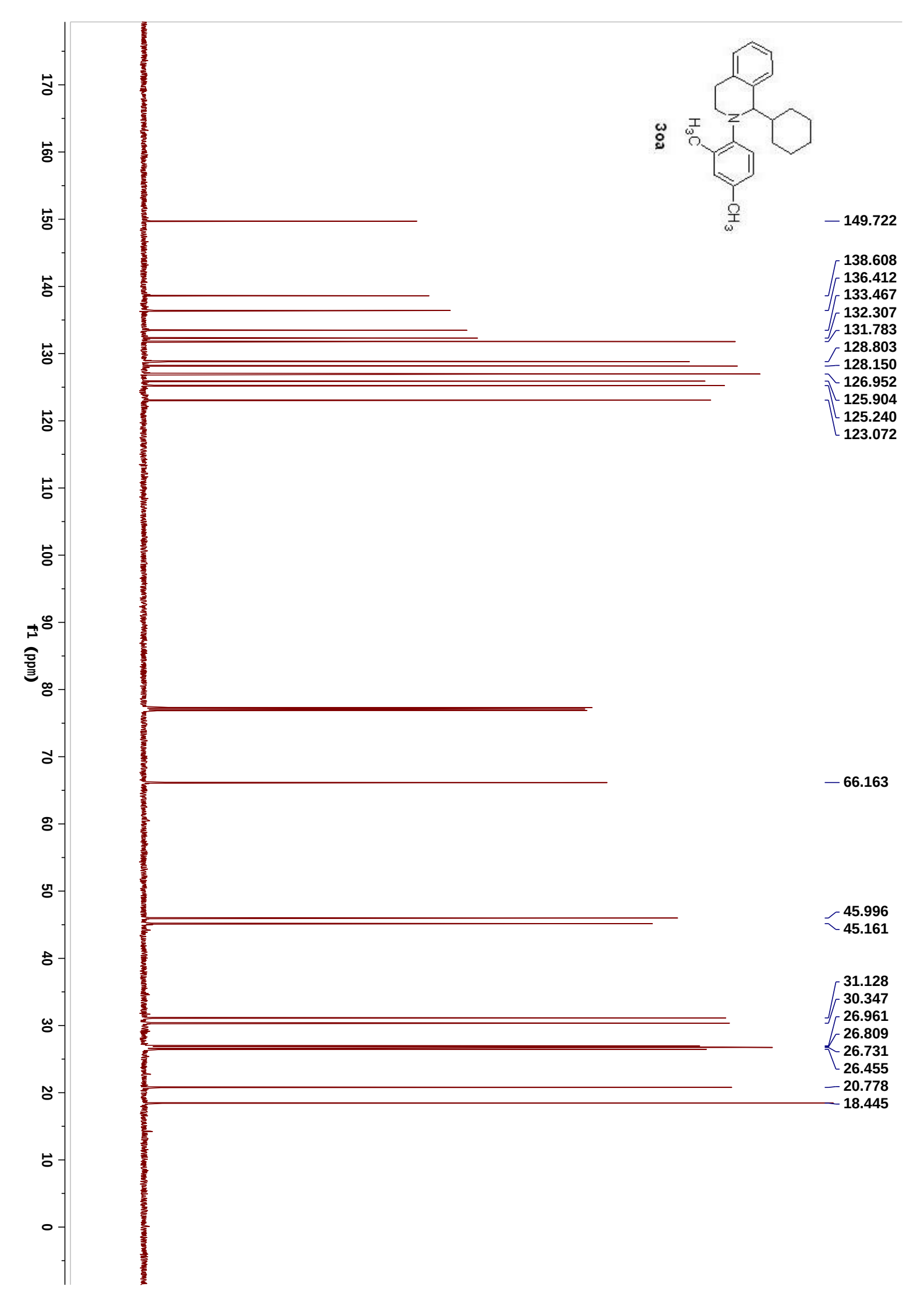

3ma
H3CO
N
f1 (ppm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
3.00
1.00
1.00
1.00
1.00
1.00
1.00
3.00
2.00
1.00
1.00
1.00
5.00
5.00
7.135
7.132
7.126
7.120
7.117
7.109
7.105
7.102
7.099
7.095
7.068
7.063
7.057
7.054
6.864
6.862
6.860
6.851
6.848
6.833
6.831
6.820
6.817
6.771
6.768
6.758
6.755
6.738
6.735
6.726
6.724
6.722
4.087
4.074
3.839
3.635
3.628
3.620
3.613
2.823
2.809
2.698
2.671
1.737
1.723
1.718
1.712
1.710
1.704
1.699
1.692
1.686
1.680
1.657
1.637
1.633
1.630
1.623
1.616
1.135
1.131
1.121
1.116
1.111
1.101
1.097
1.077
1.072
1.058
1.055
1.051
1.034

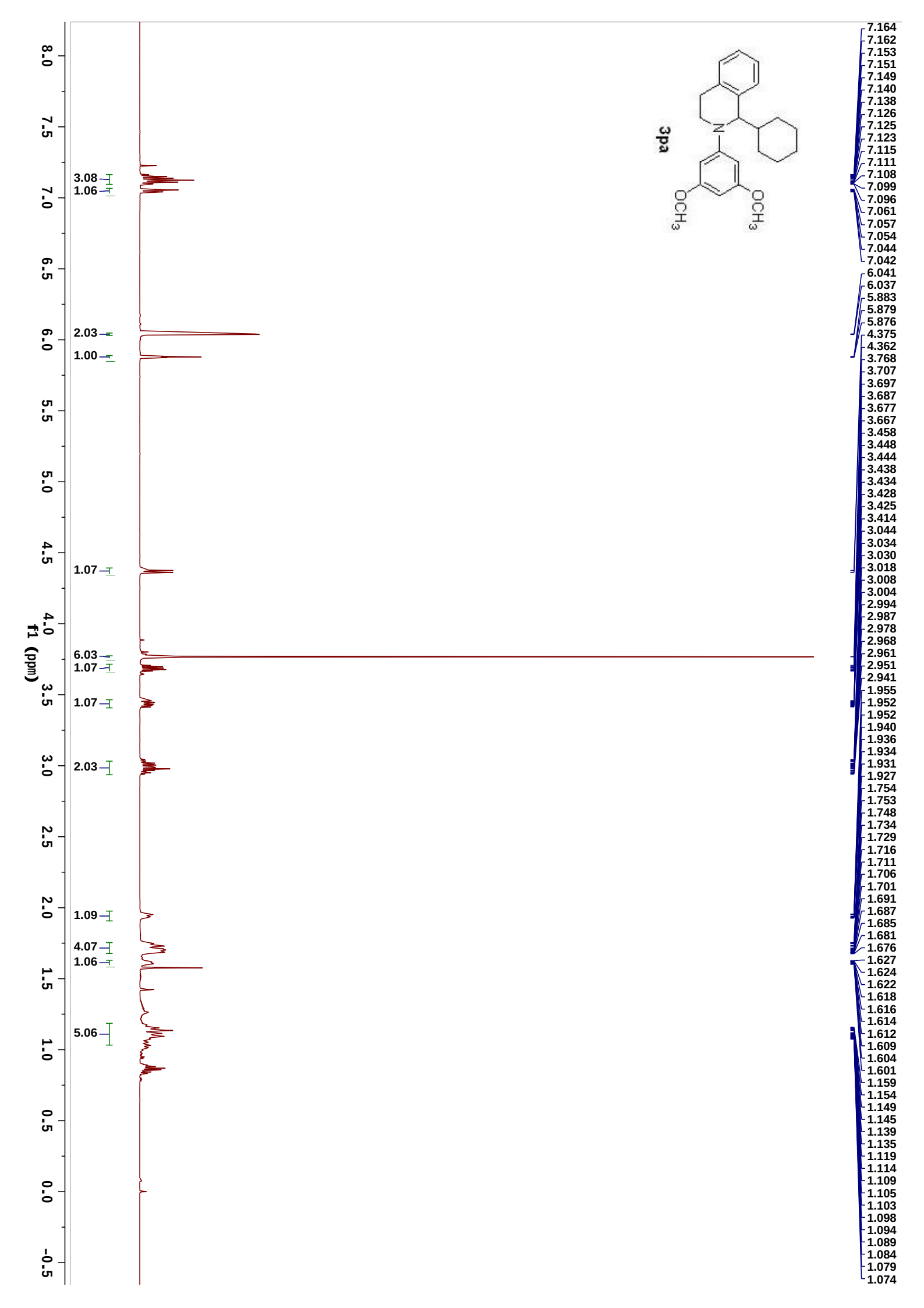

3ma
H3CO
N
152.779
141.884
138.370
135.261
128.970
128.529
126.034
124.756
121.726
121.324
121.024
112.337
65.038
55.776
43.255
42.894
31.265
31.089
26.733
26.613
26.512
f1 (ppm)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

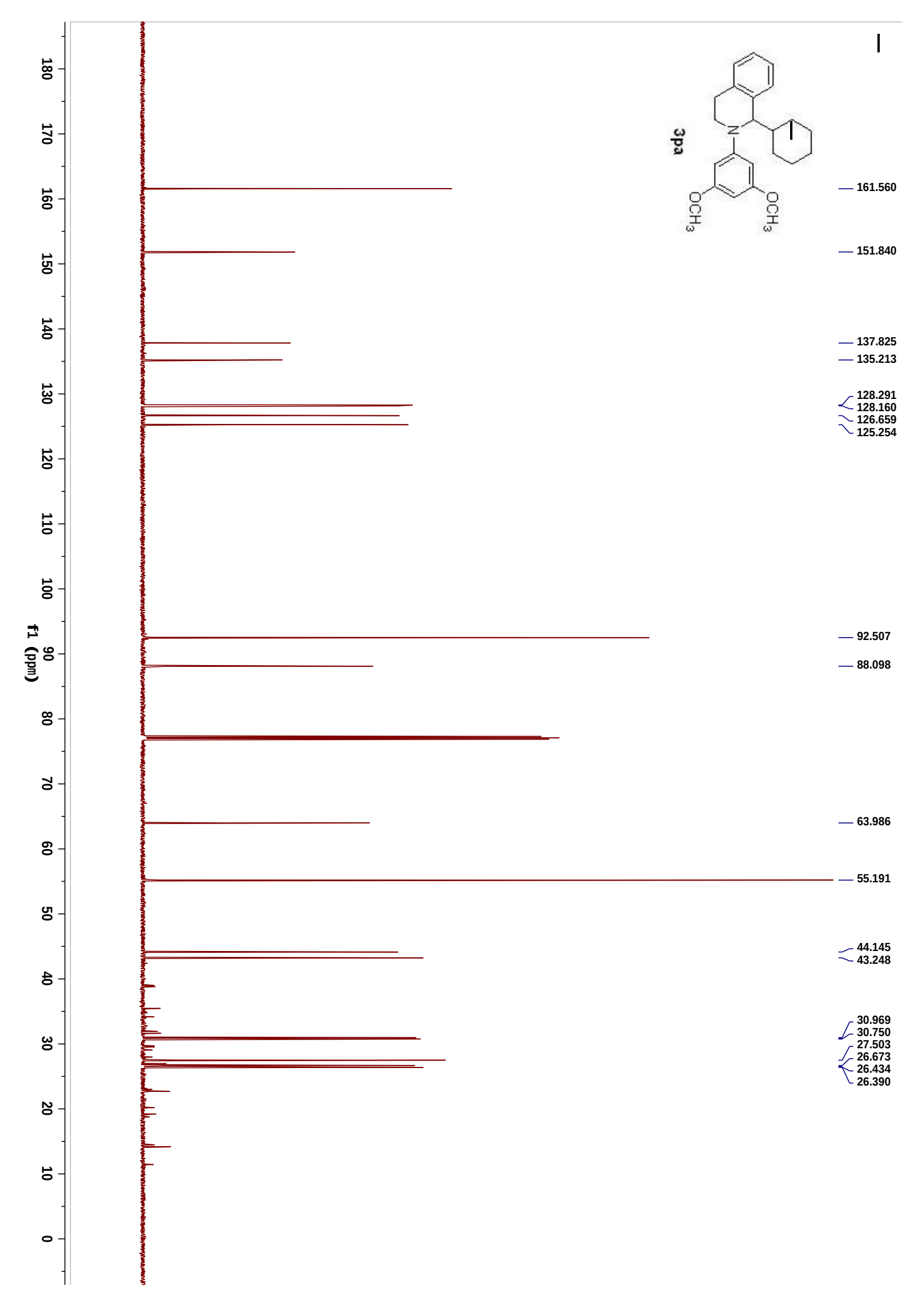

3na
H3C
N
f1 (ppm)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
4.00
1.00
1.00
1.00
1.00
1.00
1.00
1.00
1.00
1.00
3.00
1.00
5.00
5.00
7.178
7.170
7.163
7.159
7.153
7.150
7.096
7.094
7.084
7.080
6.962
6.959
6.950
6.947
6.919
6.917
6.907
6.905
6.895
6.807
6.805
6.794
6.792
4.022
4.011
3.503
3.495
3.489
3.487
3.481
3.473
3.465
3.146
2.718
2.646
2.638
2.631
2.611
2.388
1.731
1.716
1.712
1.705
1.700
1.695
1.692
1.689
1.686
1.682
1.657
1.638
1.635
1.632
1.629
1.626
1.623
1.620
1.166
1.161
1.154
1.150
1.148
1.146
1.140
1.135
1.126
1.122
1.117
1.113
1.109
1.095
1.089

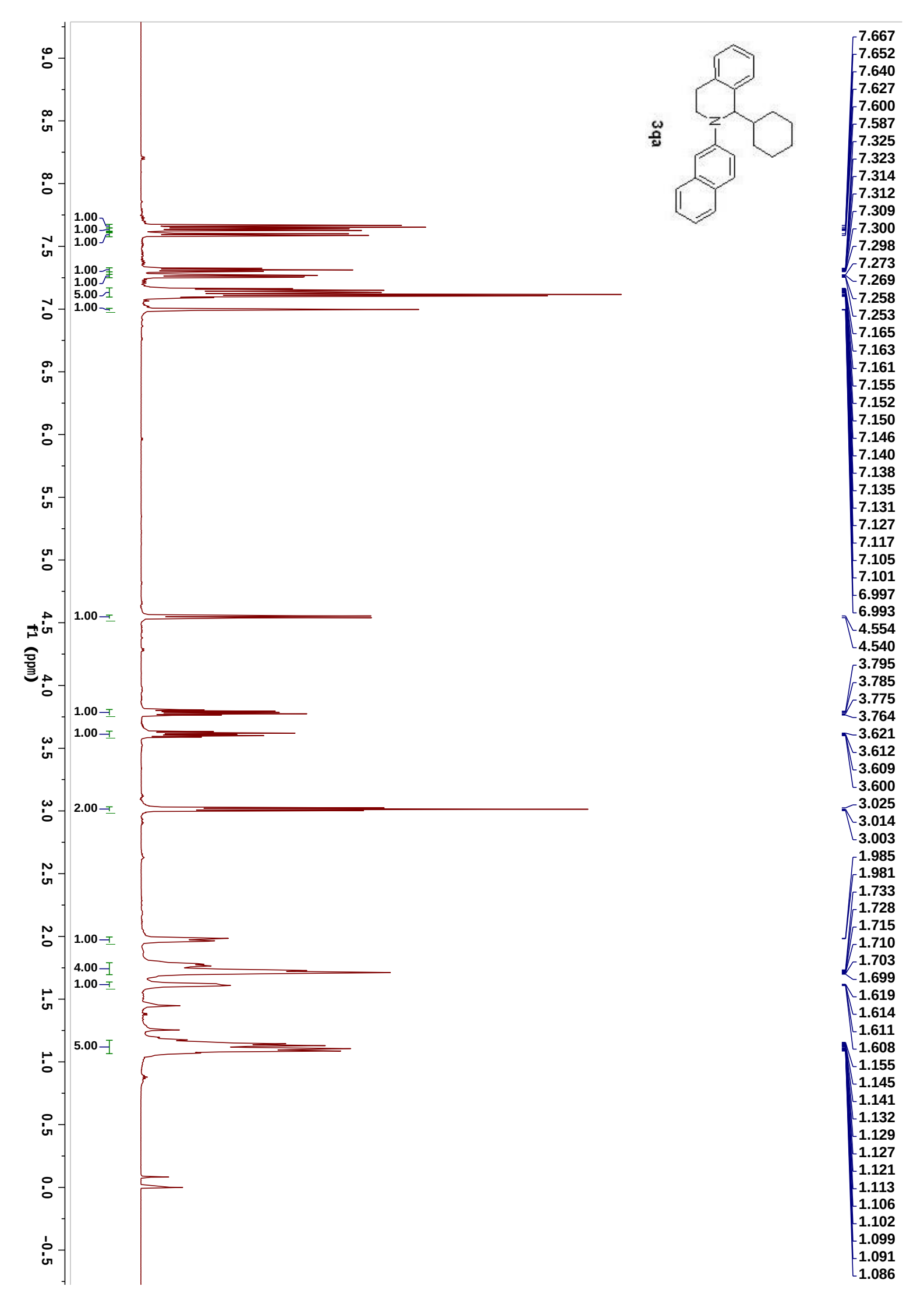

3na
H3C
N
152.085
138.465
136.200
133.404
131.021
128.807
128.126
126.326
125.923
125.200
122.939
122.785
65.925
45.503
44.911
31.143
30.378
26.882
26.733
26.654
26.289
18.580
f1 (ppm)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


3oa
H3C
N
CH3
f1 (ppm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
3.00
1.00
1.00
1.00
1.00
1.04
1.06
1.05
1.07
1.07
3.01
3.00
1.04
5.05
5.02
7.163
7.160
7.157
7.154
7.150
7.143
7.137
7.084
7.082
7.073
7.072
6.985
6.982
6.763
6.760
6.714
6.701
4.003
3.993
3.434
3.432
3.426
3.418
3.087
3.085
3.063
2.708
2.692
2.637
2.629
2.622
2.602
2.354
2.225
1.920
1.721
1.716
1.716
1.711
1.708
1.706
1.704
1.701
1.698
1.696
1.691
1.685
1.680
1.675
1.669
1.658
1.654
1.636
1.633
1.618
1.615
1.613
1.159
1.154
1.150
1.143
1.138
1.134
1.129
1.126
1.123
1.119
1.116
1.114
1.111
1.107
1.074


3oa
H3C
CH3
N
149.722
138.608
136.412
133.467
132.307
131.783
128.803
128.150
126.952
125.904
125.240
123.072
66.163
45.996
45.161
31.128
30.347
26.961
26.809
26.731
26.455
20.778
18.445
f1 (ppm)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


3pa
OCH3
OCH3
N
f1 (ppm)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
3.08
1.06
2.03
1.00
1.07
6.03
1.07
1.07
2.03
1.09
4.07
1.06
5.06
7.164
7.162
7.153
7.151
7.149
7.140
7.138
7.126
7.125
7.123
7.115
7.111
7.108
7.099
7.096
7.061
7.057
7.054
7.044
7.042
6.041
6.037
5.883
5.879
5.876
4.375
4.362
3.768
3.707
3.697
3.687
3.677
3.667
3.458
3.448
3.444
3.438
3.434
3.428
3.425
3.414
3.044
3.034
3.030
3.018
3.008
3.004
2.994
2.987
2.978
2.968
2.961
2.951
2.941
1.955
1.952
1.952
1.940
1.936
1.934
1.931
1.927
1.754
1.753
1.748
1.734
1.729
1.716
1.711
1.706
1.701
1.691
1.687
1.685
1.681
1.676
1.627
1.624
1.622
1.618
1.616
1.614
1.612
1.609
1.604
1.601
1.159
1.154
1.149
1.145
1.139
1.135
1.119
1.114
1.109
1.105
1.103
1.098
1.094
1.089
1.084
1.079
1.074


3pa
OCH3
OCH3
N
161.560
151.840
137.825
135.213
128.291
128.160
126.659
125.254
92.507
88.098
63.986
55.191
44.145
43.248
30.969
30.750
27.503
26.673
26.434
26.390
f1 (ppm)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0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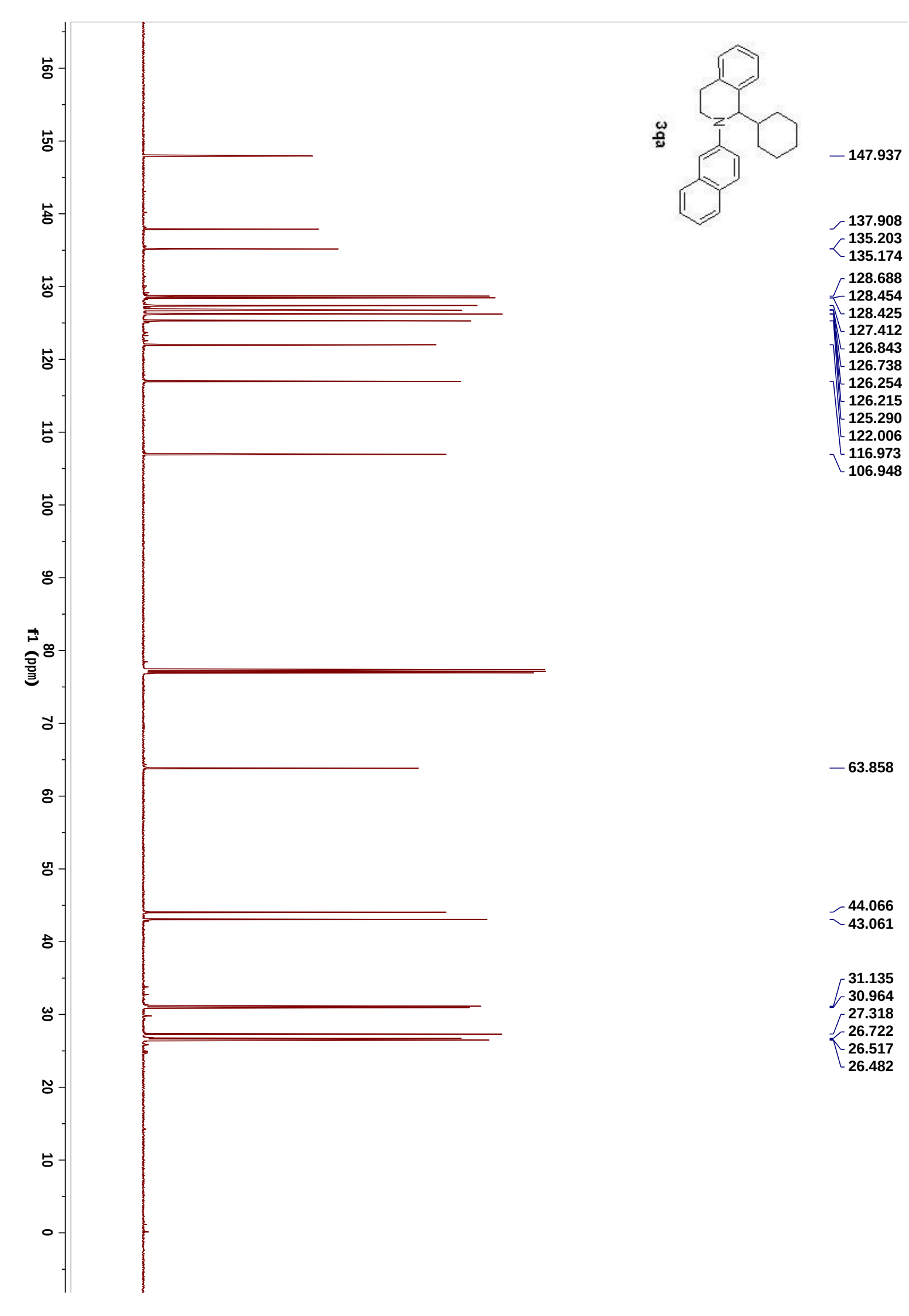
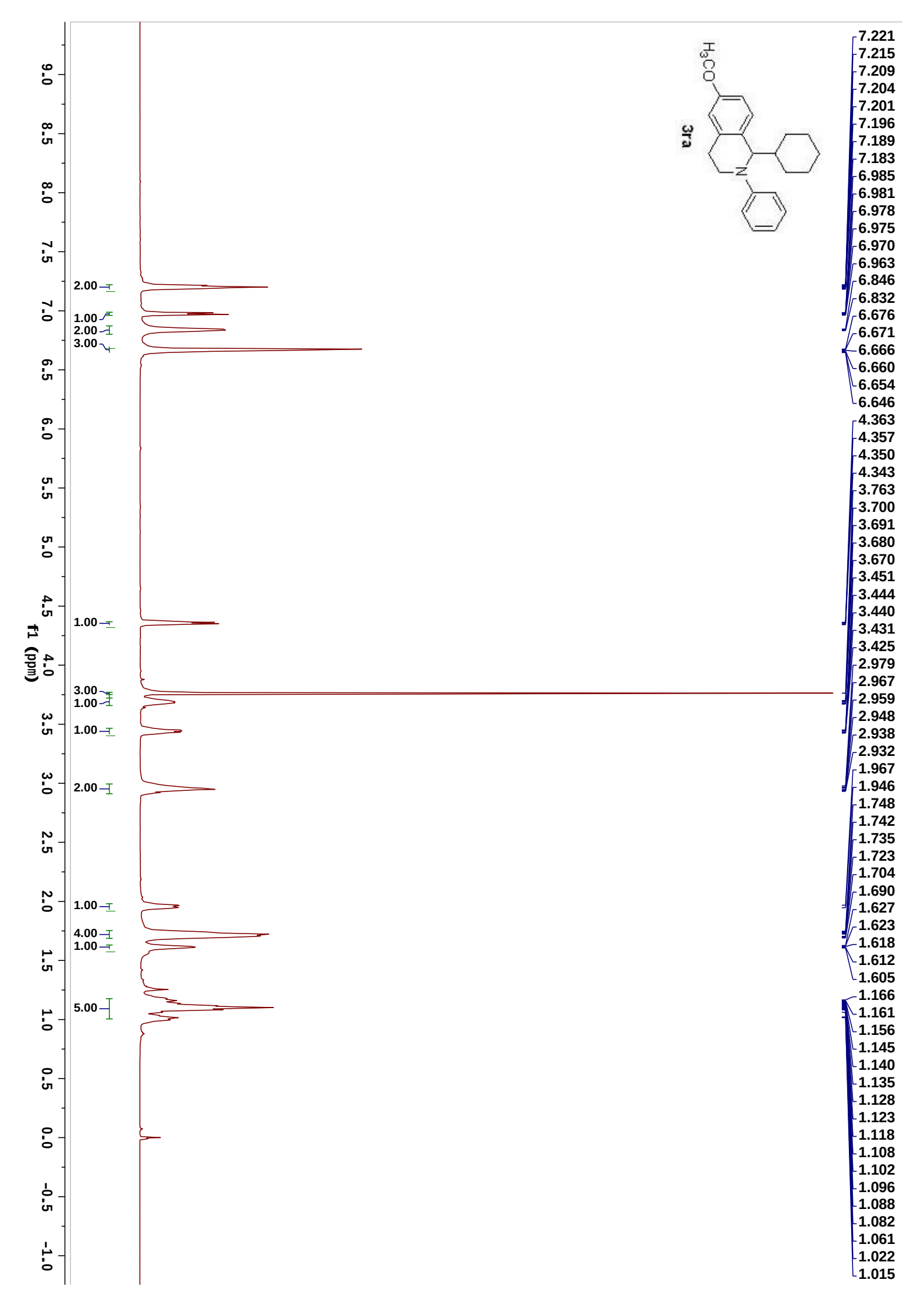
f1 (ppm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
1.00
1.00
1.00
1.00
1.00
5.00
1.00
1.00
1.00
1.00
2.00
1.00
4.00
1.00
5.00
7.667
7.652
7.640
7.627
7.600
7.587
7.325
7.323
7.314
7.312
7.309
7.300
7.298
7.273
7.269
7.258
7.253
7.165
7.163
7.161
7.155
7.152
7.150
7.146
7.140
7.138
7.135
7.131
7.127
7.117
7.105
7.101
6.997
6.993
4.554
4.540
3.795
3.785
3.775
3.764
3.621
3.612
3.609
3.600
3.025
3.014
3.003
1.985
1.981
1.733
1.728
1.715
1.710
1.703
1.699
1.619
1.614
1.611
1.608
1.155
1.145
1.141
1.132
1.129
1.127
1.121
1.113
1.106
1.102
1.099
1.091
1.086


3qa
147.937
137.908
135.203
135.174
128.688
128.454
128.425
127.412
126.843
126.738
126.254
126.215
125.290
122.006
116.973
106.948
63.858
44.066
43.061
31.135
30.964
27.318
26.722
26.517
26.482
f1 (ppm)


3ra
H3CO
N
f1 (ppm)
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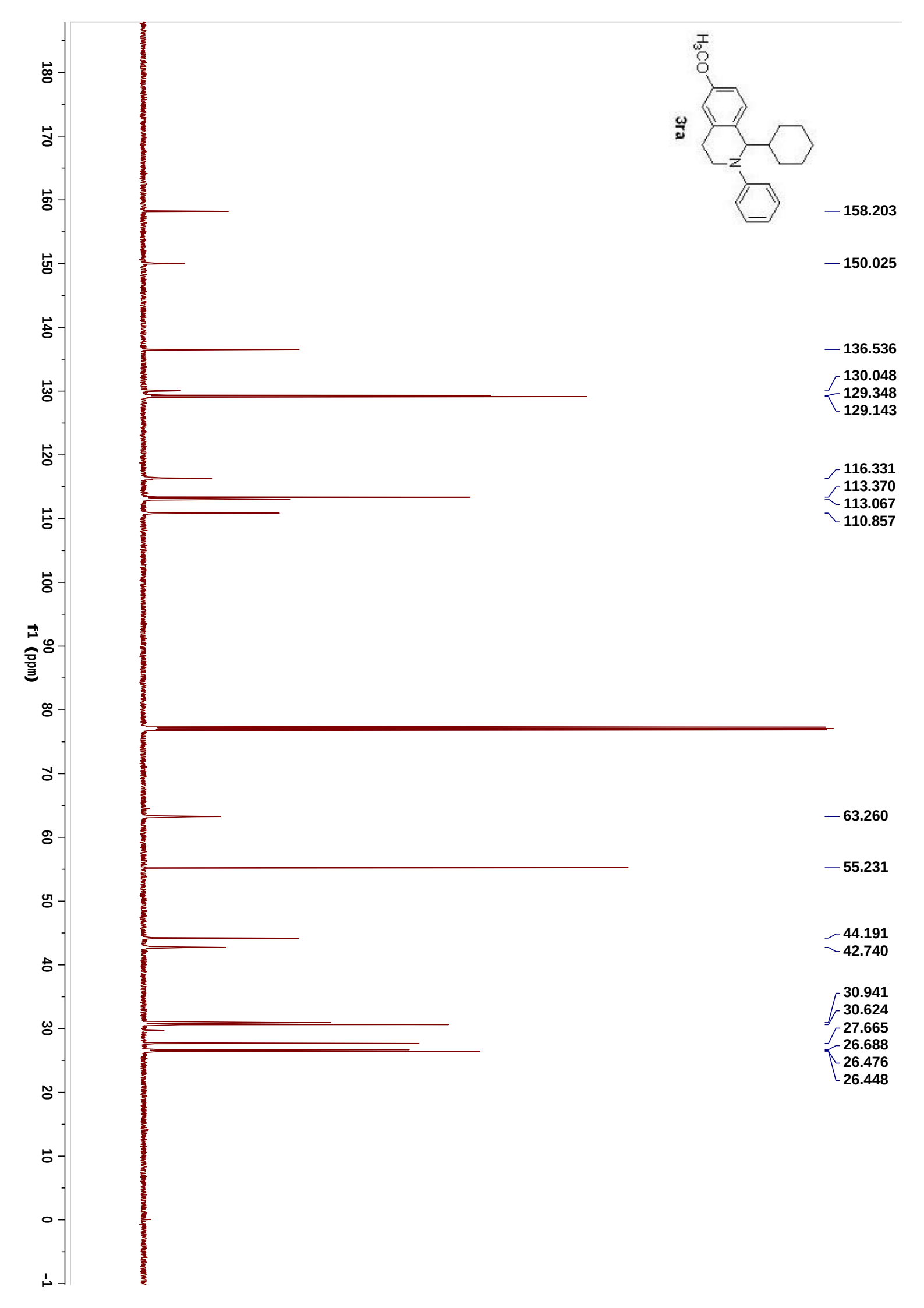
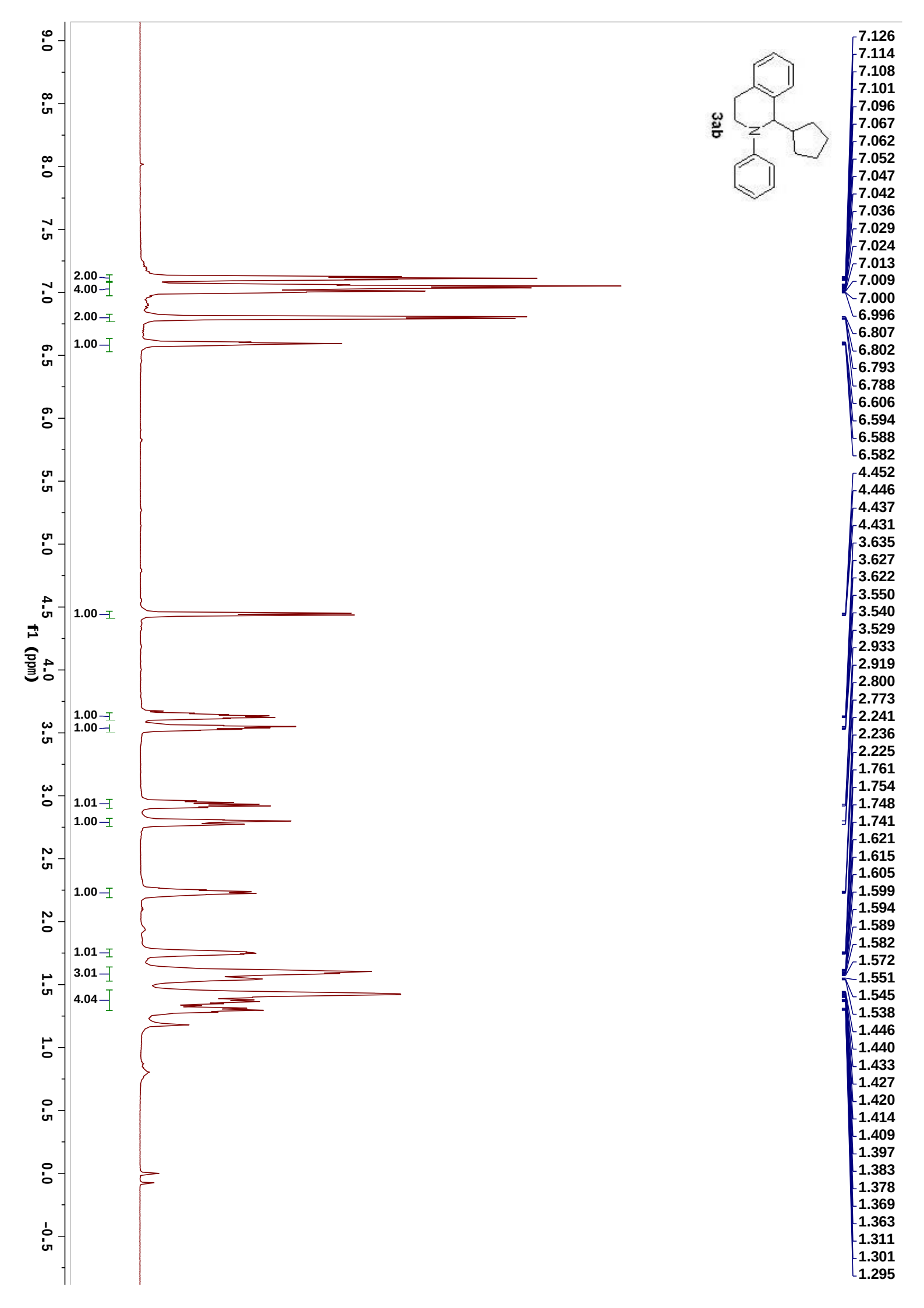
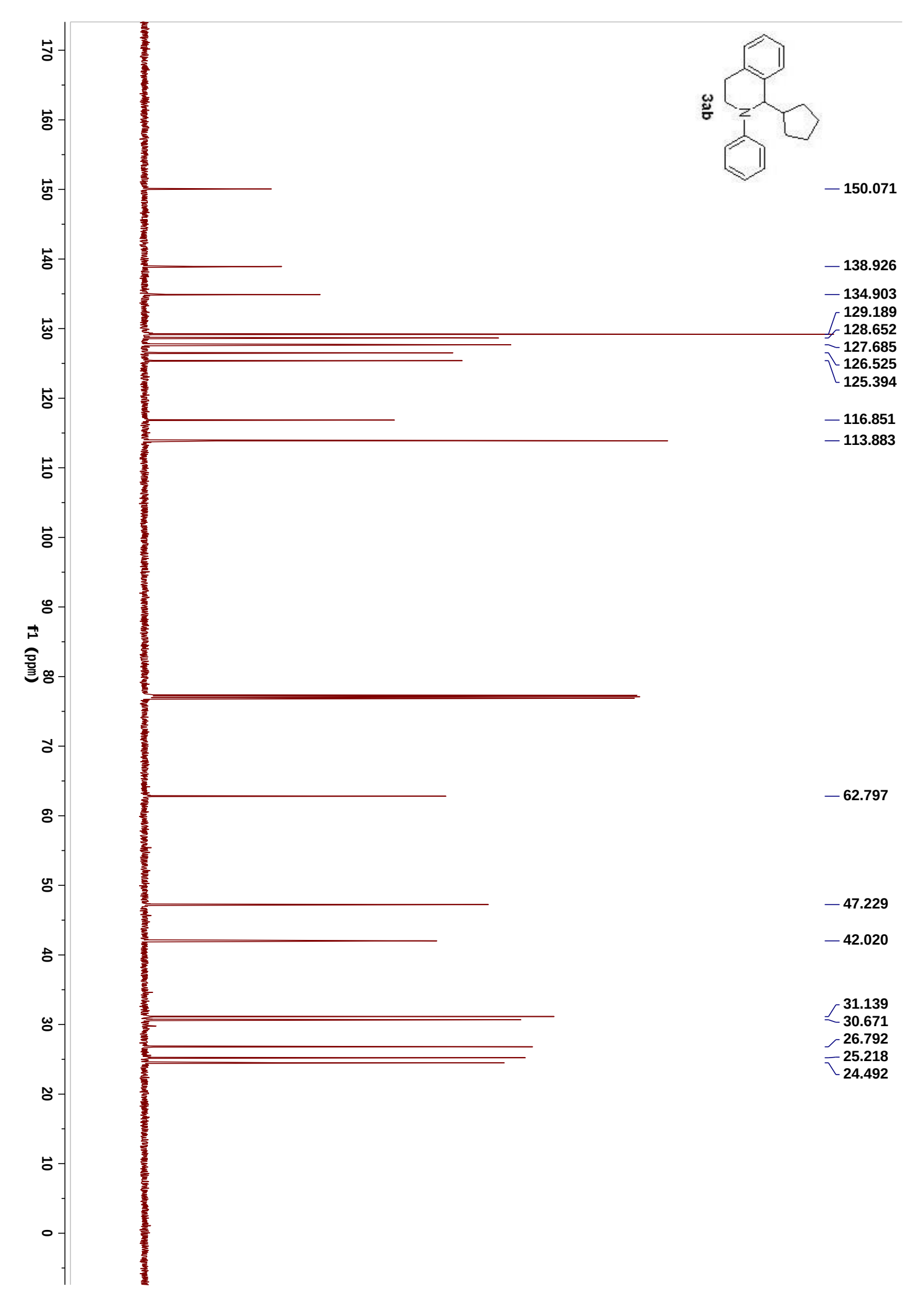
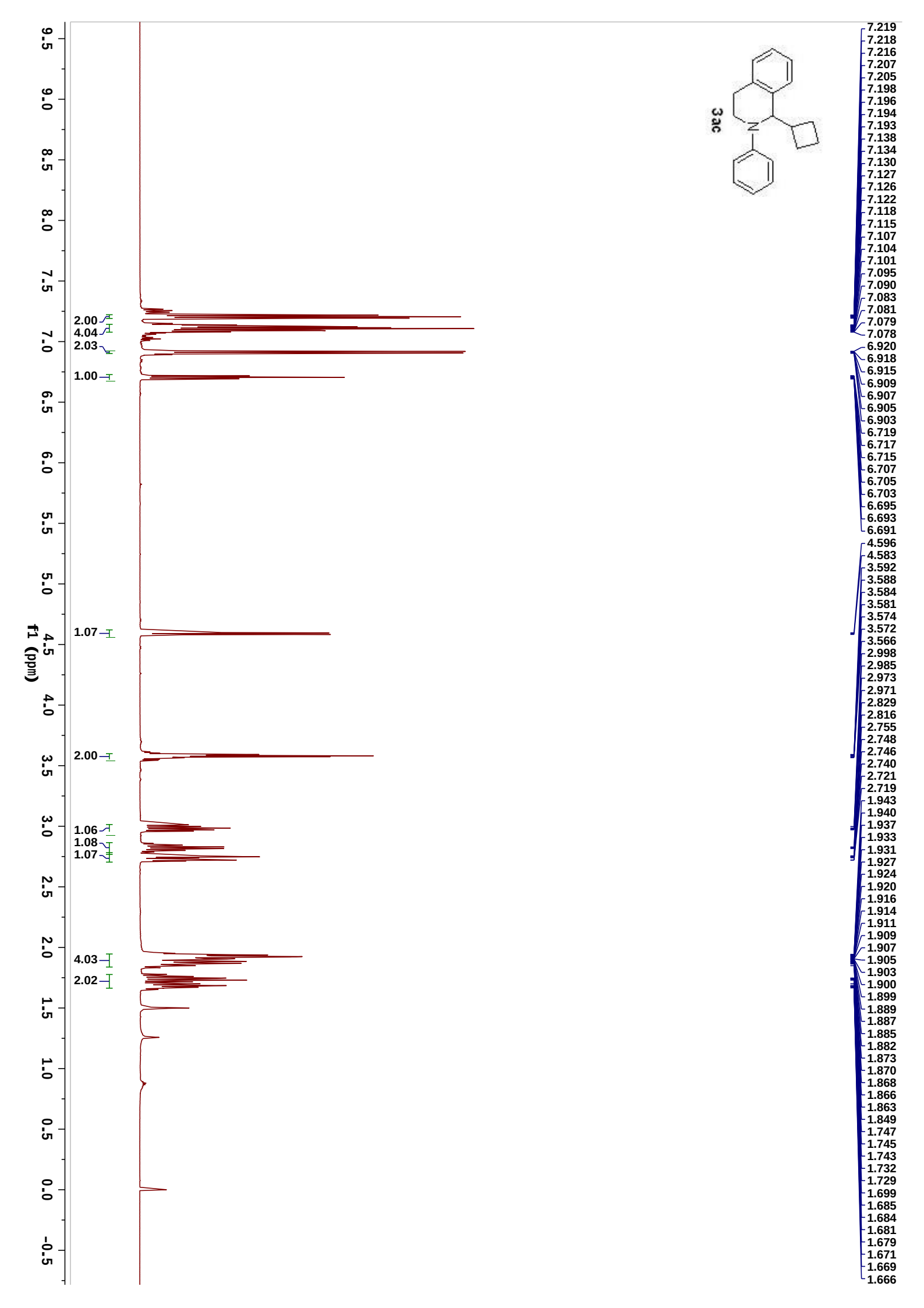
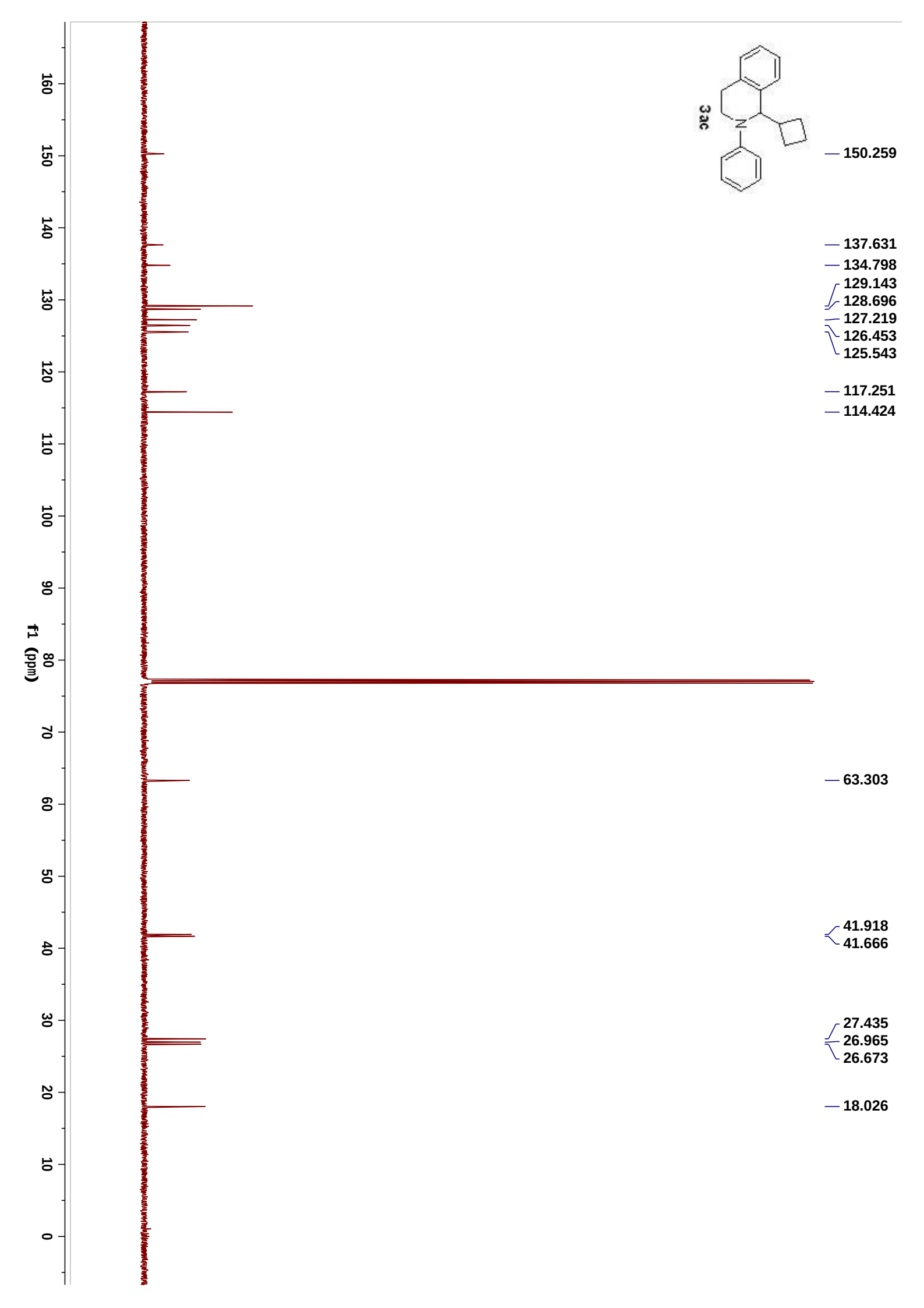
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
2.00
1.00
2.00
3.00
1.00
3.00
1.00
1.00
2.00
1.00
4.00
1.00
5.00
7.221
7.215
7.209
7.204
7.201
7.196
7.189
7.183
6.985
6.981
6.978
6.975
6.970
6.963
6.846
6.832
6.676
6.671
6.666
6.660
6.654
6.646
4.363
4.357
4.350
4.343
3.763
3.700
3.691
3.680
3.670
3.451
3.444
3.440
3.431
3.425
2.979
2.967
2.959
2.948
2.938
2.932
1.967
1.946
1.748
1.742
1.735
1.723
1.704
1.690
1.627
1.623
1.618
1.612
1.605
1.166
1.161
1.156
1.145
1.140
1.135
1.128
1.123
1.118
1.108
1.102
1.096
1.088
1.082
1.061
1.022
1.015

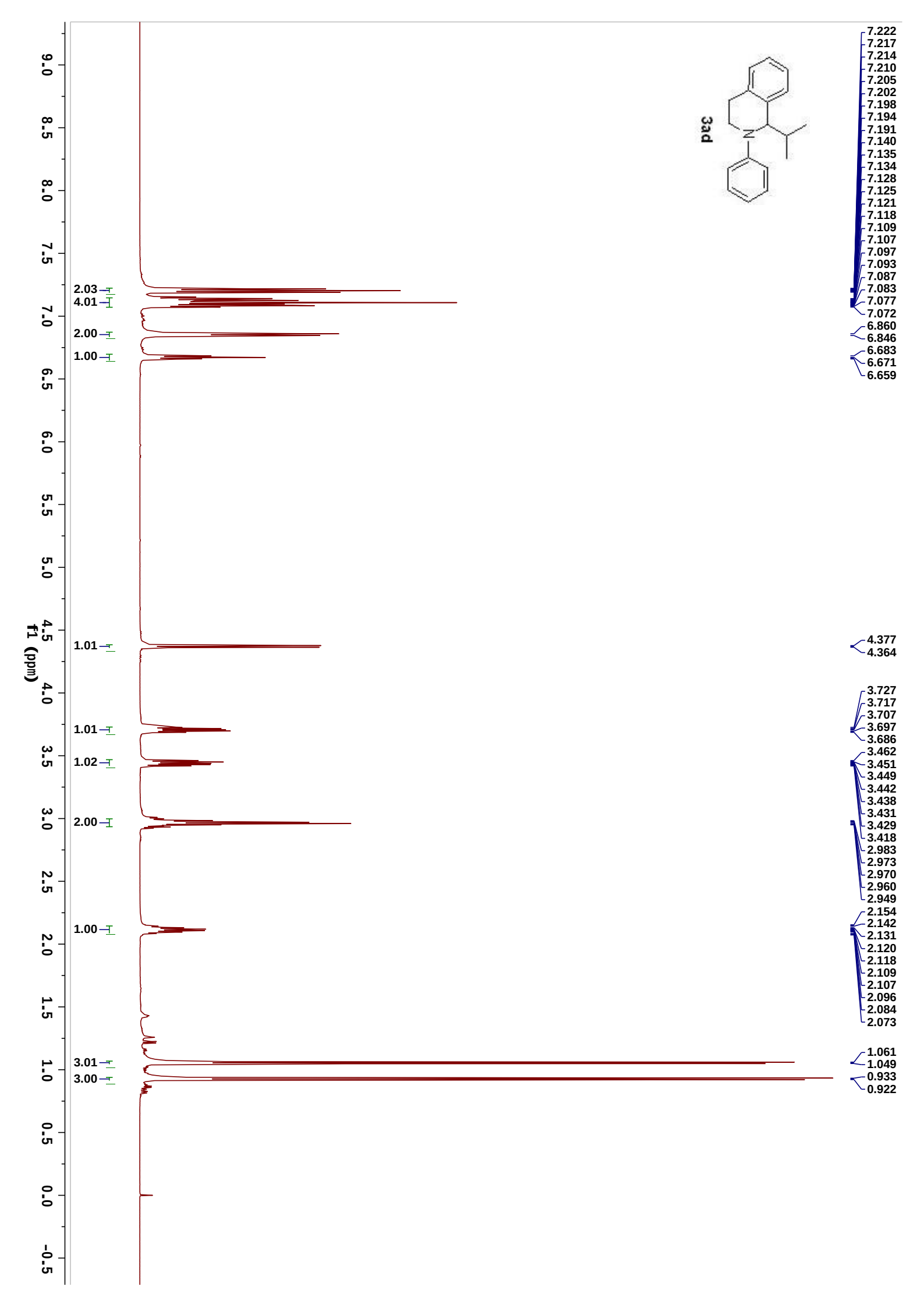

H3CO
N
3ra
158.203
150.025
136.536
130.048
129.348
129.143
116.331
113.370
113.067
110.857
63.260
55.231
44.191
42.740
30.941
30.624
27.665
26.688
26.476
26.448
f1 (ppm)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-1

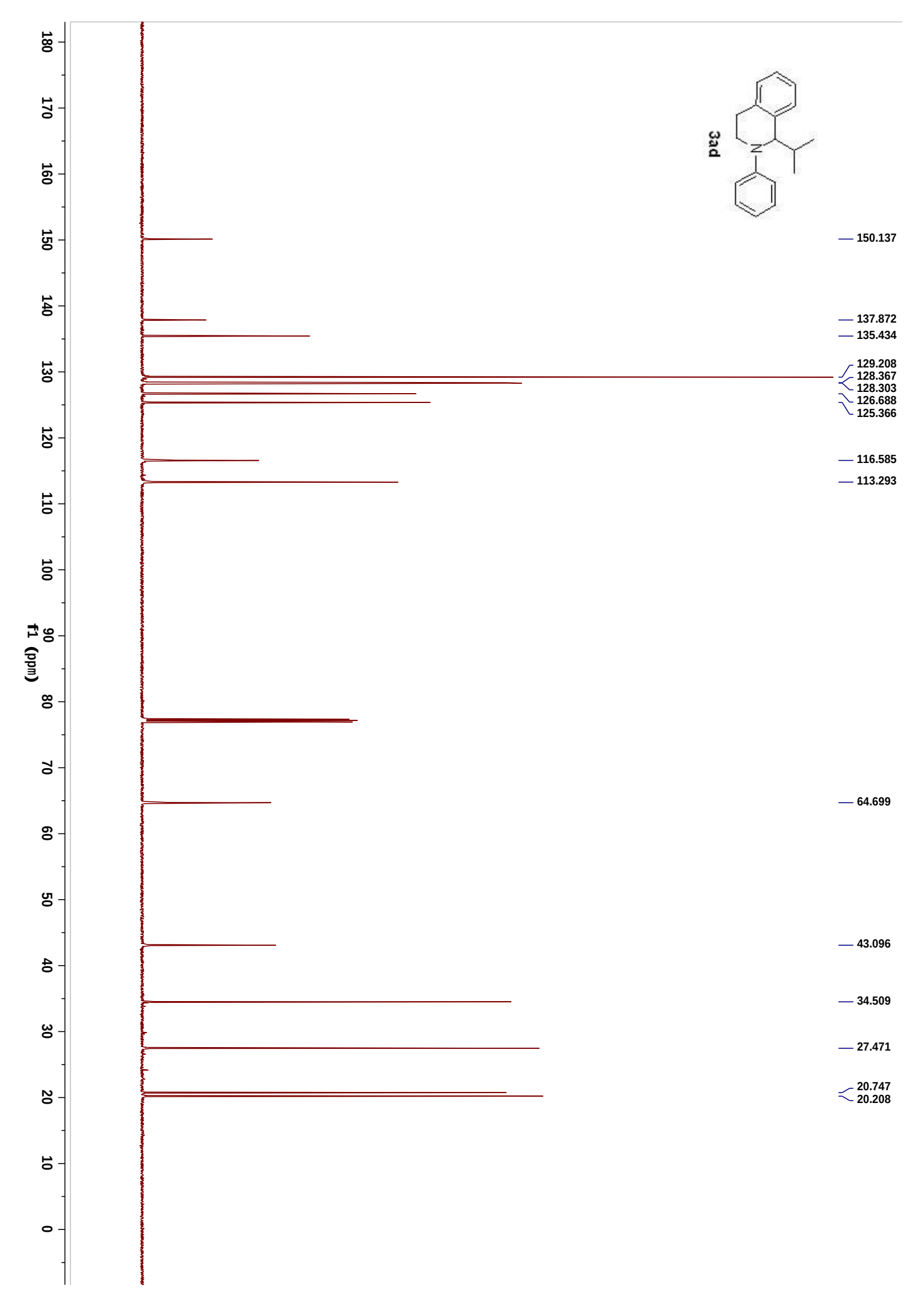

3ab
f1 (ppm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
2.00
4.00
2.00
1.00
1.00
1.00
1.00
1.01
1.00
1.00
1.01
3.01
4.04
7.126
7.114
7.108
7.101
7.096
7.067
7.062
7.052
7.047
7.042
7.036
7.029
7.024
7.013
7.009
7.000
6.996
6.807
6.802
6.793
6.788
6.606
6.594
6.588
6.582
4.452
4.446
4.437
4.431
3.635
3.627
3.622
3.550
3.540
3.529
2.933
2.919
2.800
2.773
2.241
2.236
2.225
1.761
1.754
1.748
1.741
1.621
1.615
1.605
1.599
1.594
1.589
1.582
1.572
1.551
1.545
1.538
1.446
1.440
1.433
1.427
1.420
1.414
1.409
1.397
1.383
1.378
1.369
1.363
1.311
1.301
1.295

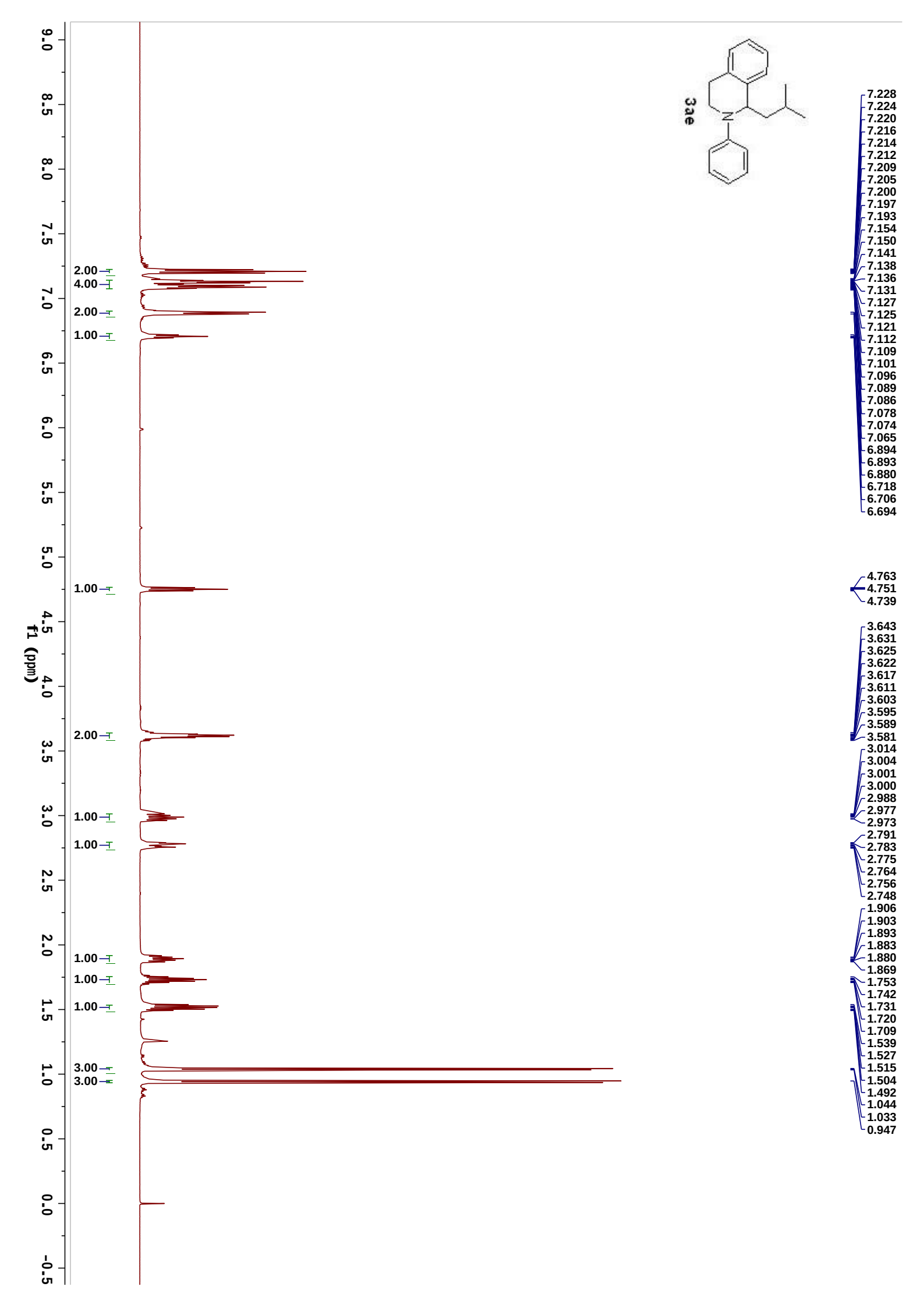

3ab
150.071
138.926
134.903
129.189
128.652
127.685
126.525
125.394
116.851
113.883
62.797
47.229
42.020
31.139
30.671
26.792
25.218
24.492
f1 (ppm)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


3ac
f1 (ppm)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
2.00
4.04
2.03
1.00
1.07
2.00
1.06
1.08
1.07
4.03
2.02
7.219
7.218
7.216
7.207
7.205
7.198
7.196
7.194
7.193
7.138
7.134
7.130
7.127
7.126
7.122
7.118
7.115
7.107
7.104
7.101
7.095
7.090
7.083
7.081
7.079
7.078
6.920
6.918
6.915
6.909
6.907
6.905
6.903
6.719
6.717
6.715
6.707
6.705
6.703
6.695
6.693
6.691
4.596
4.583
3.592
3.588
3.584
3.581
3.574
3.572
3.566
2.998
2.985
2.973
2.971
2.829
2.816
2.755
2.748
2.746
2.740
2.721
2.719
1.943
1.940
1.937
1.933
1.931
1.927
1.924
1.920
1.916
1.914
1.911
1.909
1.907
1.905
1.903
1.900
1.899
1.889
1.887
1.885
1.882
1.873
1.870
1.868
1.866
1.863
1.849
1.747
1.745
1.743
1.732
1.729
1.699
1.685
1.684
1.681
1.679
1.671
1.669
1.666


3ac
150.259
137.631
134.798
129.143
128.696
127.219
126.453
125.543
117.251
114.424
63.303
41.918
41.666
27.435
26.965
26.673
18.026
f1 (ppm)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


3ad
f1 (ppm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
2.03
4.01
2.00
1.00
1.01
1.01
1.02
2.00
1.00
3.01
3.00
7.222
7.217
7.214
7.210
7.205
7.202
7.198
7.194
7.191
7.140
7.135
7.134
7.128
7.125
7.121
7.118
7.109
7.107
7.097
7.093
7.087
7.083
7.077
7.072
6.860
6.846
6.683
6.671
6.659
4.377
4.364
3.727
3.717
3.707
3.697
3.686
3.462
3.451
3.449
3.442
3.438
3.431
3.429
3.418
2.983
2.973
2.970
2.960
2.949
2.154
2.142
2.131
2.120
2.118
2.109
2.107
2.096
2.084
2.073
1.061
1.049
0.933
0.922


3ad
150.137
137.872
135.434
129.208
128.367
128.303
126.688
125.366
116.585
113.293
64.699
43.096
34.509
27.471
20.747
20.208
f1 (ppm)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


3ae
f1 (ppm)
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8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
2.00
4.00
2.00
1.00
1.00
2.00
1.00
1.00
1.00
1.00
1.00
3.00
3.00
7.228
7.224
7.220
7.216
7.214
7.212
7.209
7.205
7.200
7.197
7.193
7.154
7.150
7.141
7.138
7.136
7.131
7.127
7.125
7.121
7.112
7.109
7.101
7.096
7.089
7.086
7.078
7.074
7.065
6.894
6.893
6.880
6.718
6.706
6.694
4.763
4.751
4.739
3.643
3.631
3.625
3.622
3.617
3.611
3.603
3.595
3.589
3.581
3.014
3.004
3.001
3.000
2.988
2.977
2.973
2.791
2.783
2.775
2.764
2.756
2.748
1.906
1.903
1.893
1.883
1.880
1.869
1.753
1.742
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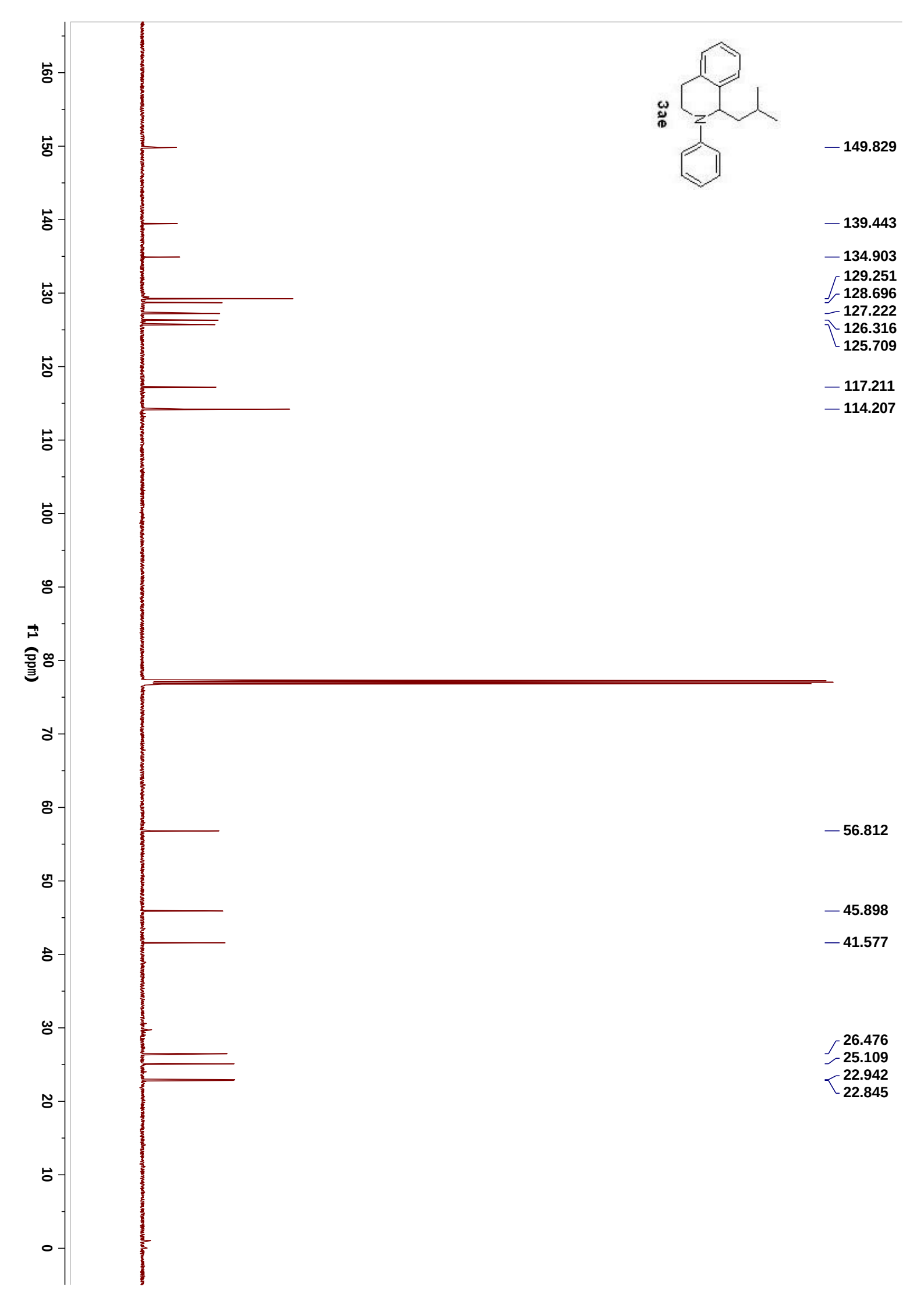
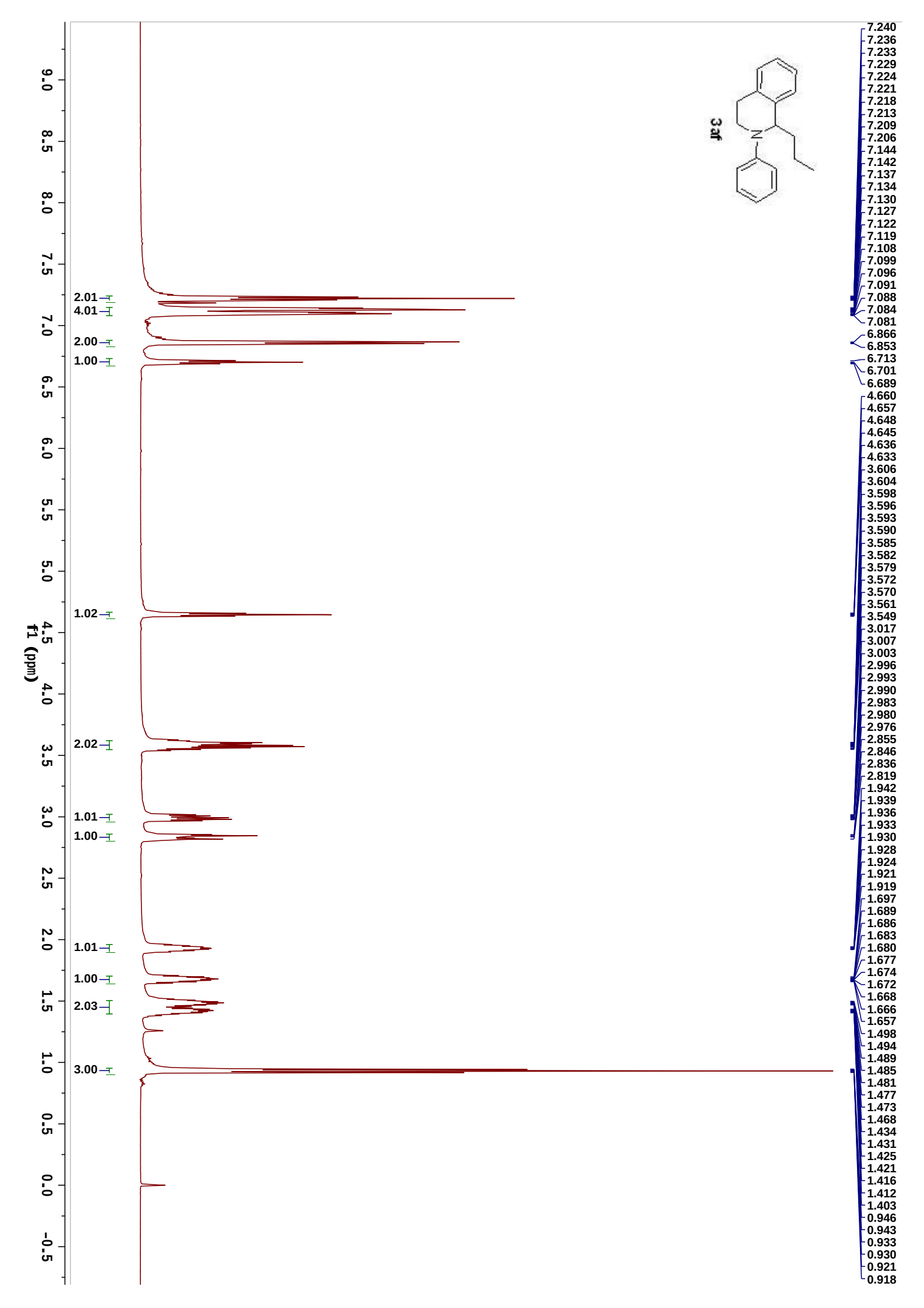
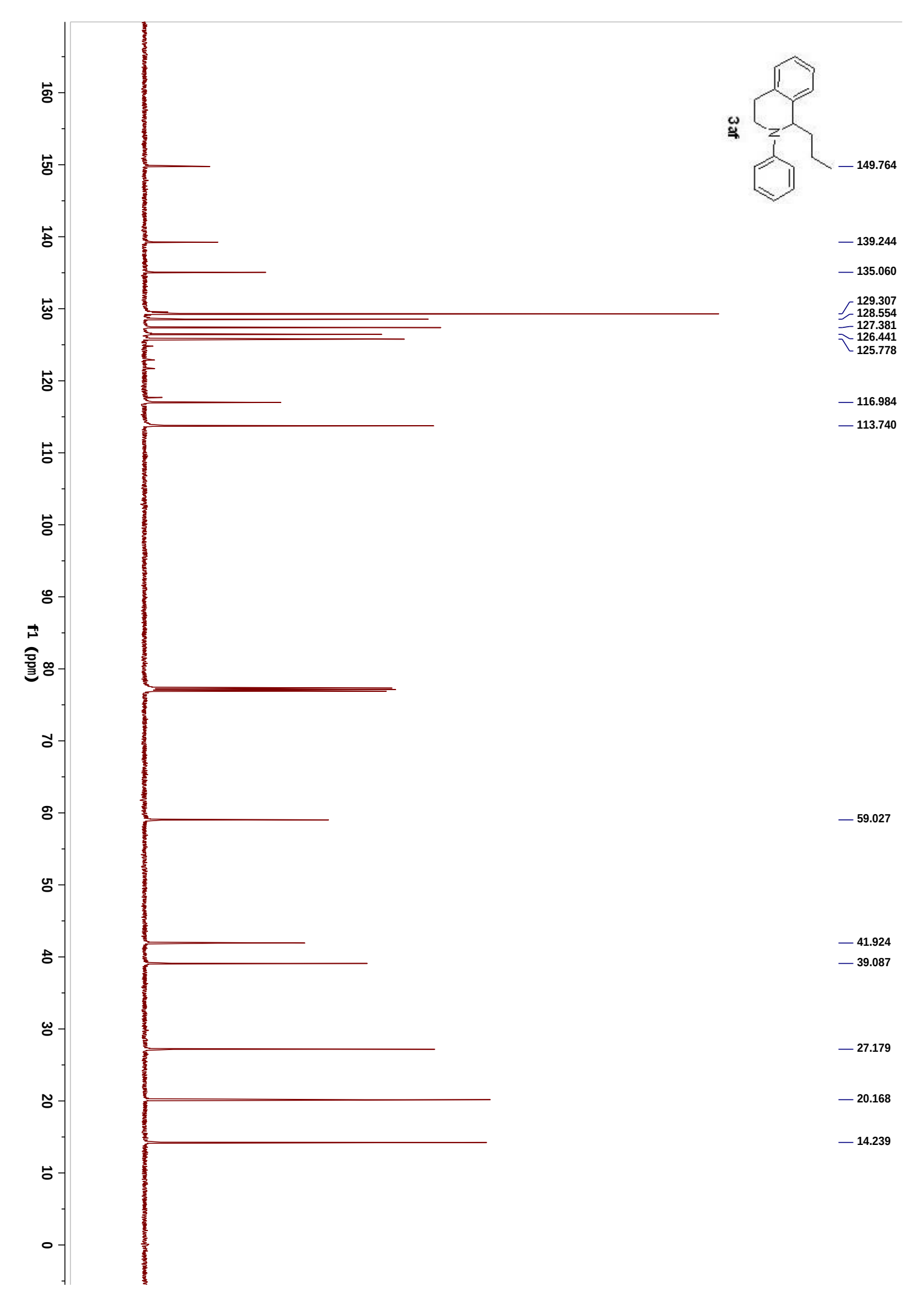
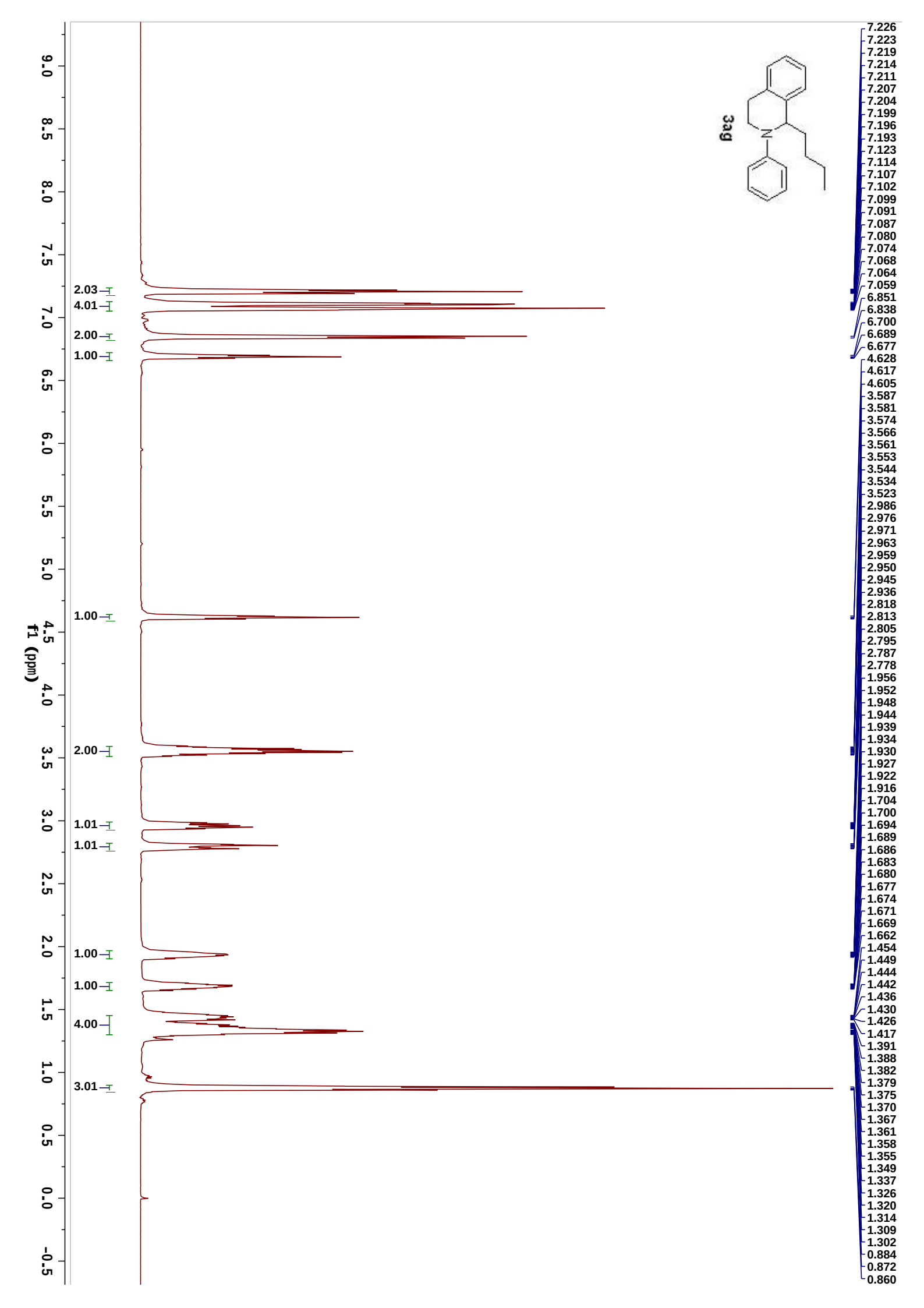
1.709
1.539
1.527
1.515
1.504
1.492
1.044
1.033
0.947


3ae
149.829
139.443
134.903
129.251
128.696
127.222
126.316
125.709
117.211
114.207
56.812
45.898
41.577
26.476
25.109
22.942
22.845
f1 (ppm)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


3af
f1 (ppm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
2.01
4.01
2.00
1.00
1.02
2.02
1.01
1.00
1.01
1.00
2.03
3.00
7.240
7.236
7.233
7.229
7.224
7.221
7.218
7.213
7.209
7.206
7.144
7.142
7.137
7.134
7.130
7.127
7.122
7.119
7.108
7.099
7.096
7.091
7.088
7.084
7.081
6.866
6.853
6.713
6.701
6.689
4.660
4.657
4.648
4.645
4.636
4.633
3.606
3.604
3.598
3.596
3.593
3.590
3.585
3.582
3.579
3.572
3.570
3.561
3.549
3.017
3.007
3.003
2.996
2.993
2.990
2.983
2.980
2.976
2.855
2.846
2.836
2.819
1.942
1.939
1.936
1.933
1.930
1.928
1.924
1.921
1.919
1.697
1.689
1.686
1.683
1.680
1.677
1.674
1.672
1.668
1.666
1.657
1.498
1.494
1.489
1.485
1.481
1.477
1.473
1.468
1.434
1.431
1.425
1.421
1.416
1.412
1.403
0.946
0.943
0.933
0.930
0.921
0.918


3af
149.764
139.244
135.060
129.307
128.554
127.381
126.441
125.778
116.984
113.740
59.027
41.924
39.087
27.179
20.168
14.239
f1 (ppm)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


3ag
f1 (ppm)
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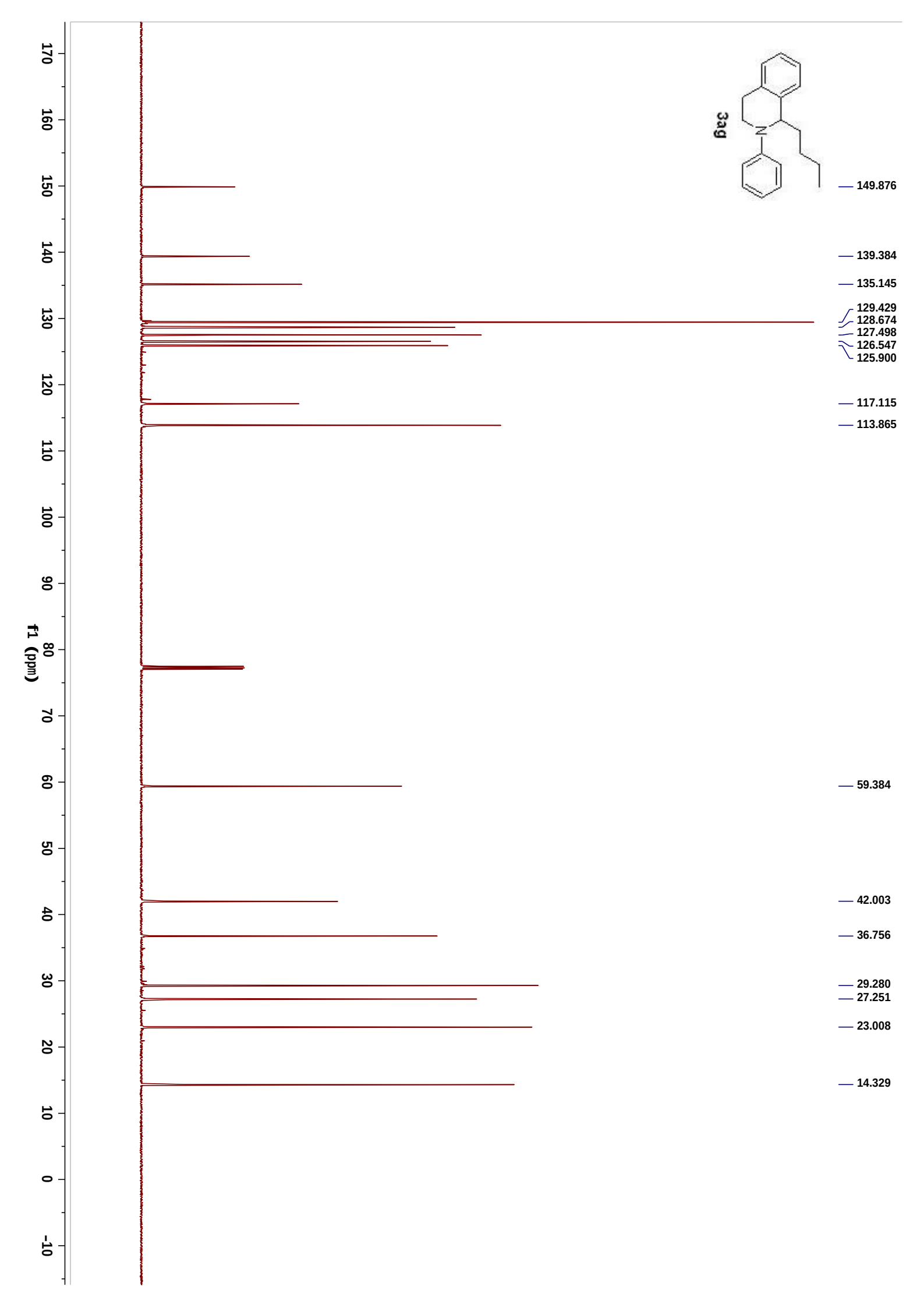
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
2.03
4.01
2.00
1.00
1.00
2.00
1.01
1.01
1.00
1.00
4.00
3.01
7.226
7.223
7.219
7.214
7.211
7.207
7.204
7.199
7.196
7.193
7.123
7.114
7.107
7.102
7.099
7.091
7.087
7.080
7.074
7.068
7.064
7.059
6.851
6.838
6.700
6.689
6.677
4.628
4.617
4.605
3.587
3.581
3.574
3.566
3.561
3.553
3.544
3.534
3.523
2.986
2.976
2.971
2.963
2.959
2.950
2.945
2.936
2.818
2.813
2.805
2.795
2.787
2.778
1.956
1.952
1.948
1.944
1.939
1.934
1.930
1.927
1.922
1.916
1.704
1.700
1.694
1.689
1.686
1.683
1.680
1.677
1.674
1.671
1.669
1.662
1.454
1.449
1.444
1.442
1.436
1.430
1.426
1.417
1.391
1.388
1.382
1.379
1.375
1.370
1.367
1.361
1.358
1.355
1.349
1.337
1.326
1.320
1.314
1.309
1.302
0.884
0.872
0.860


3ag
N
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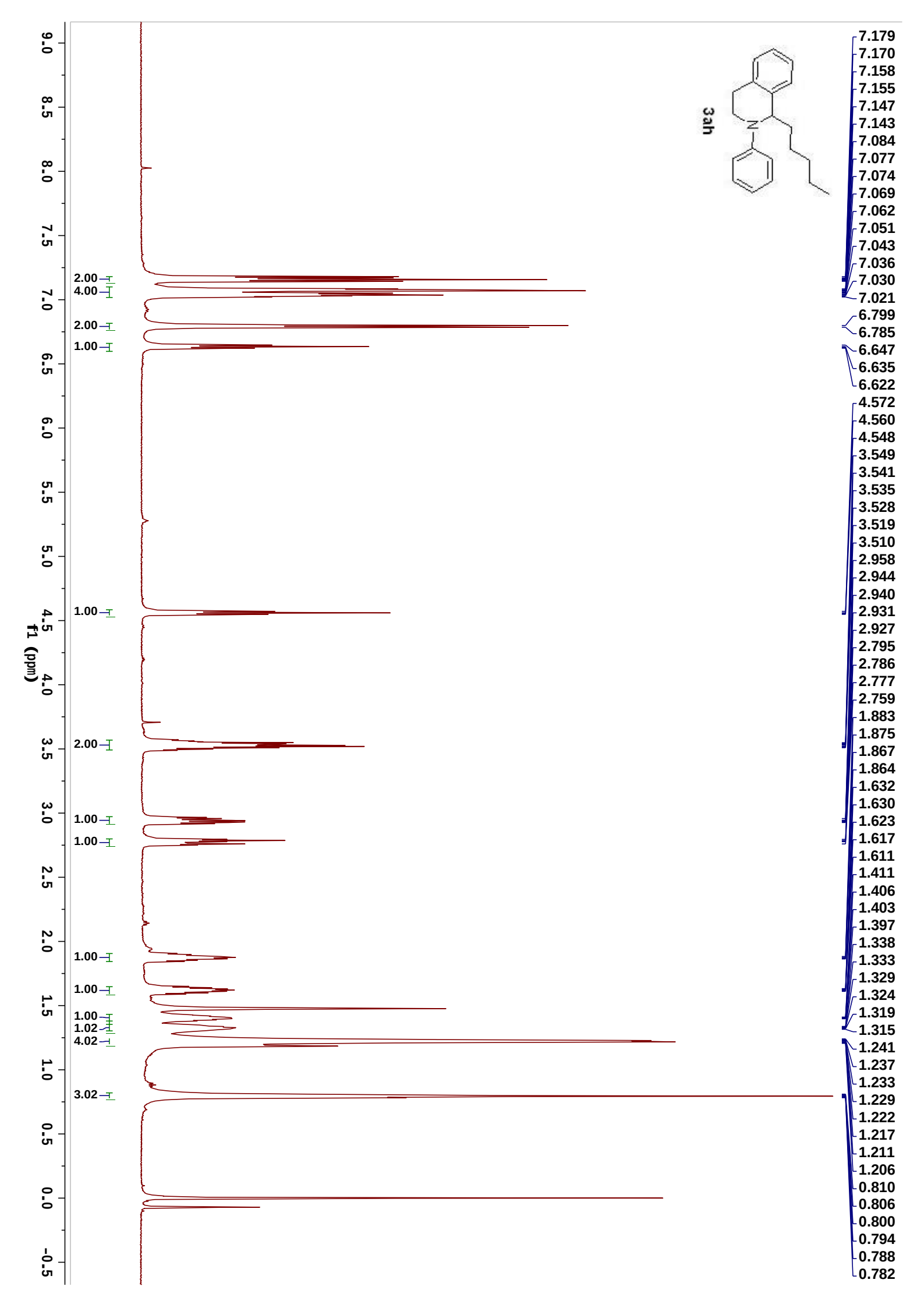
135.145
129.429
128.674
127.498
126.547
125.900
117.115
113.865
59.384
42.003
36.756
29.280
27.251
23.008
14.329
f1 (ppm)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10


3ah
f1 (ppm)
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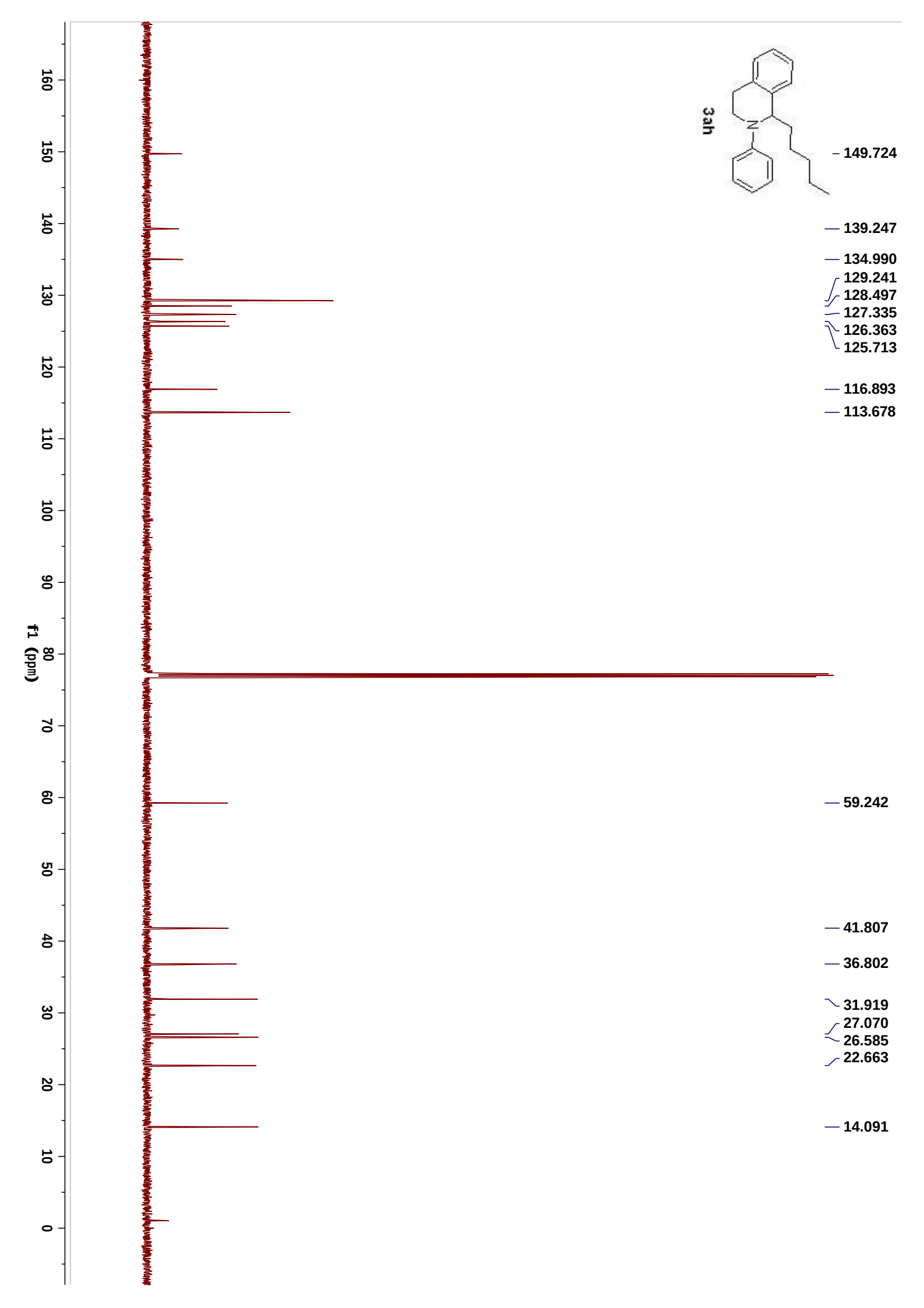
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
2.00
4.00
2.00
1.00
1.00
2.00
1.00
1.00
1.00
1.00
1.00
1.02
4.02
3.02
7.179
7.170
7.158
7.155
7.147
7.143
7.084
7.077
7.074
7.069
7.062
7.051
7.043
7.036
7.030
7.021
6.799
6.785
6.647
6.635
6.622
4.572
4.560
4.548
3.549
3.541
3.535
3.528
3.519
3.510
2.958
2.944
2.940
2.931
2.927
2.795
2.786
2.777
2.759
1.883
1.875
1.867
1.864
1.632
1.630
1.623
1.617
1.611
1.411
1.406
1.403
1.397
1.338
1.333
1.329
1.324
1.319
1.315
1.241
1.237
1.233
1.229
1.222
1.217
1.211
1.206
0.810
0.806
0.800
0.794
0.788
0.782


3ah
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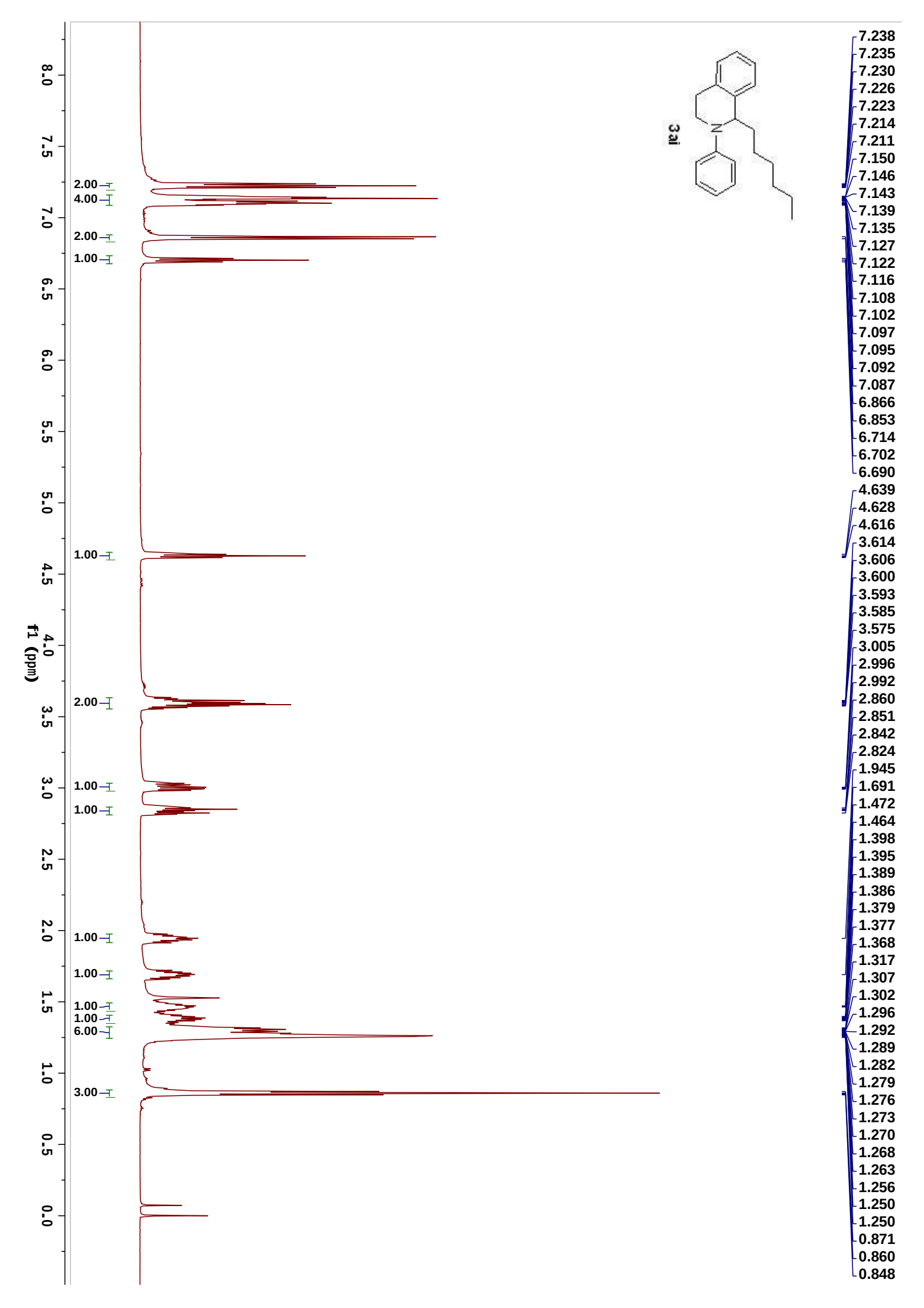
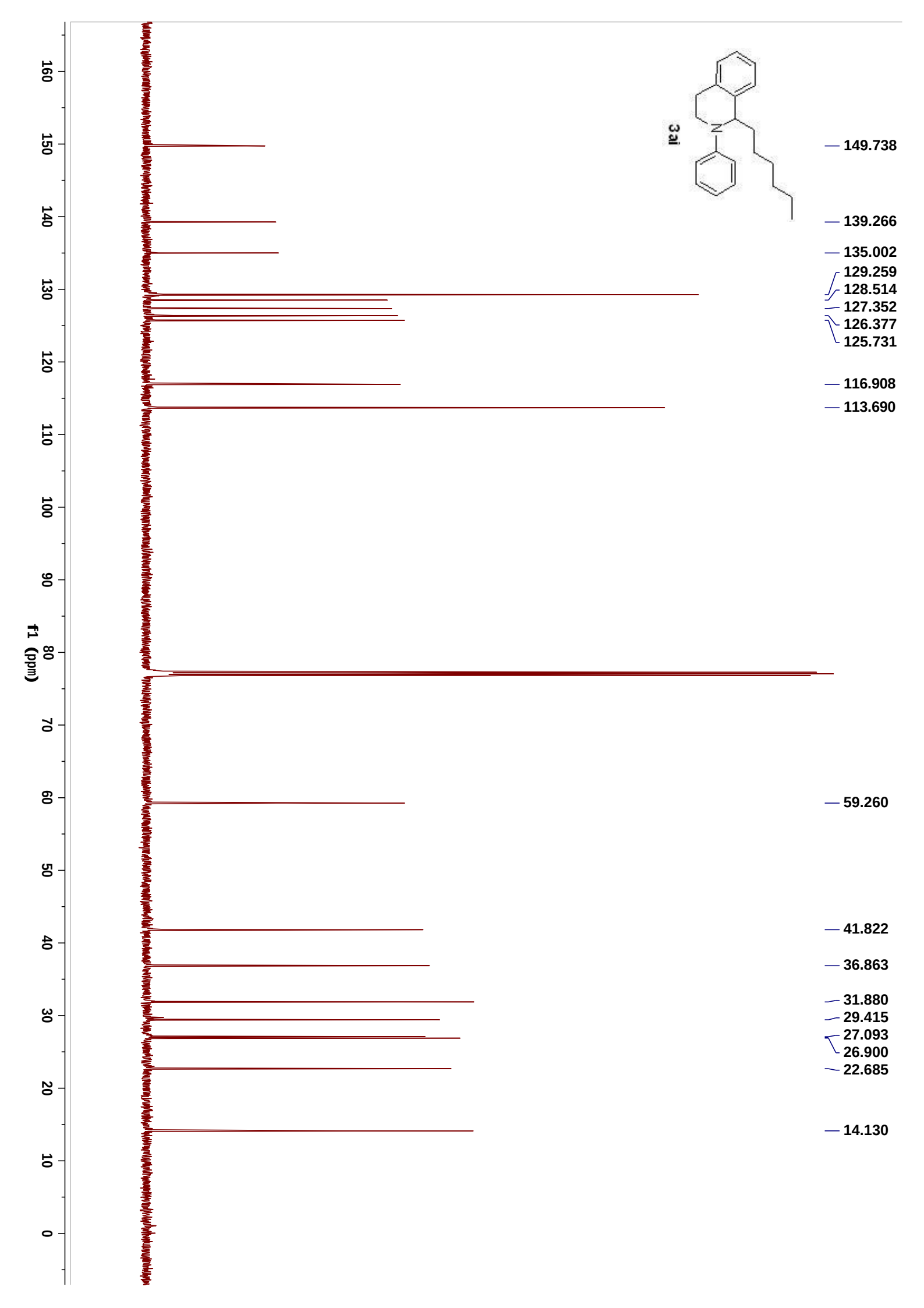
134.990
129.241
128.497
127.335
126.363
125.713
116.893
113.678
59.242
41.807
36.802
31.919
27.070
26.585
22.663
14.091
f1 (ppm)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


3ai
f1 (ppm)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2.00
4.00
2.00
1.00
1.00
2.00
1.00
1.00
1.00
1.00
1.00
6.00
3.00
7.238
7.235
7.230
7.226
7.223
7.214
7.211
7.150
7.146
7.143
7.139
7.135
7.127
7.122
7.116
7.108
7.102
7.097
7.095
7.092
7.087
6.866
6.853
6.714
6.702
6.690
4.639
4.628
4.616
3.614
3.606
3.600
3.593
3.585
3.575
3.005
2.996
2.992
2.860
2.851
2.842
2.824
1.945
1.691
1.472
1.464
1.398
1.395
1.389
1.386
1.379
1.377
1.368
1.317
1.307
1.302
1.296
1.292
1.289
1.282
1.279
1.276
1.273
1.270
1.268
1.263
1.256
1.250
1.250
0.871
0.860
0.848


3ai
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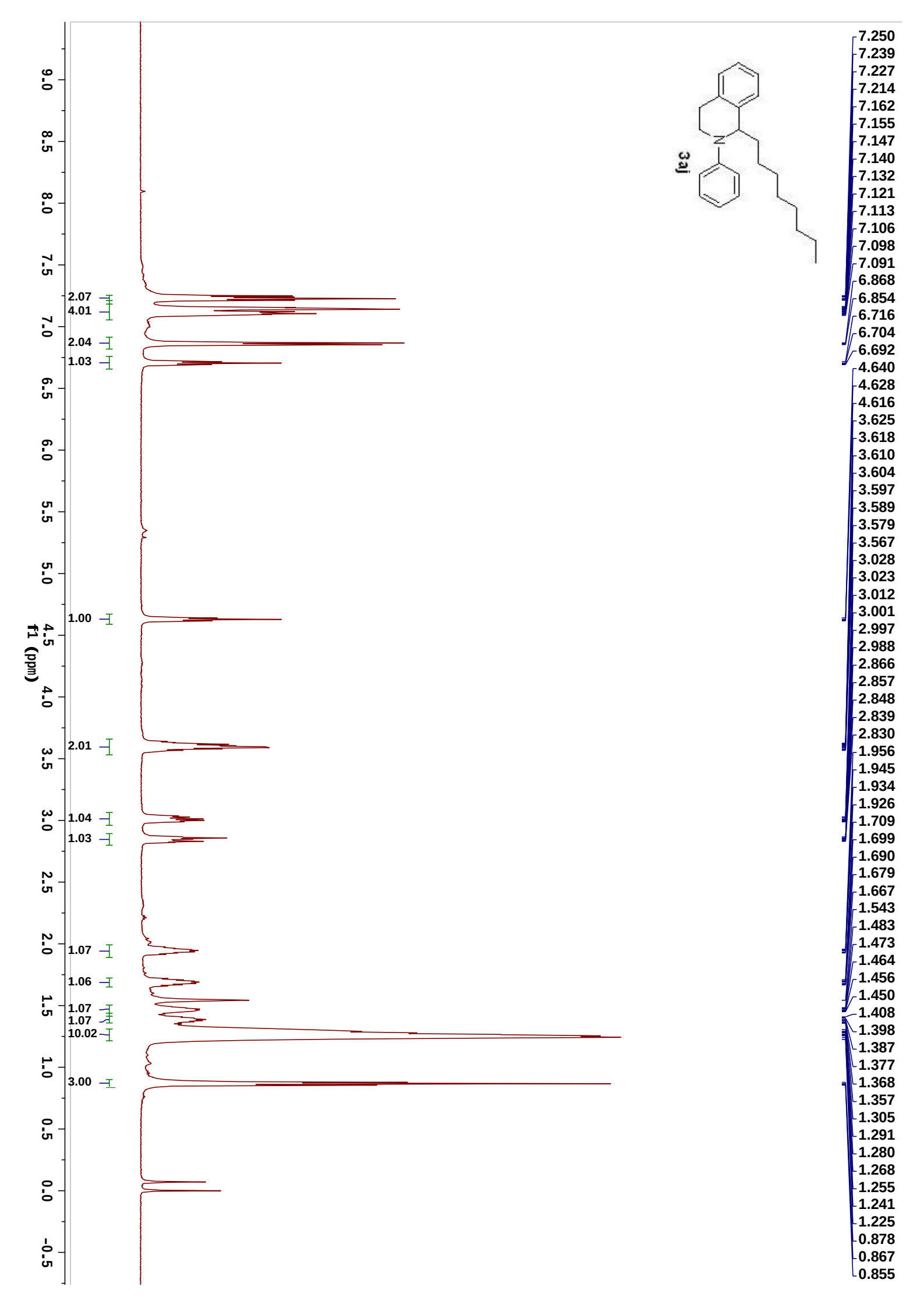
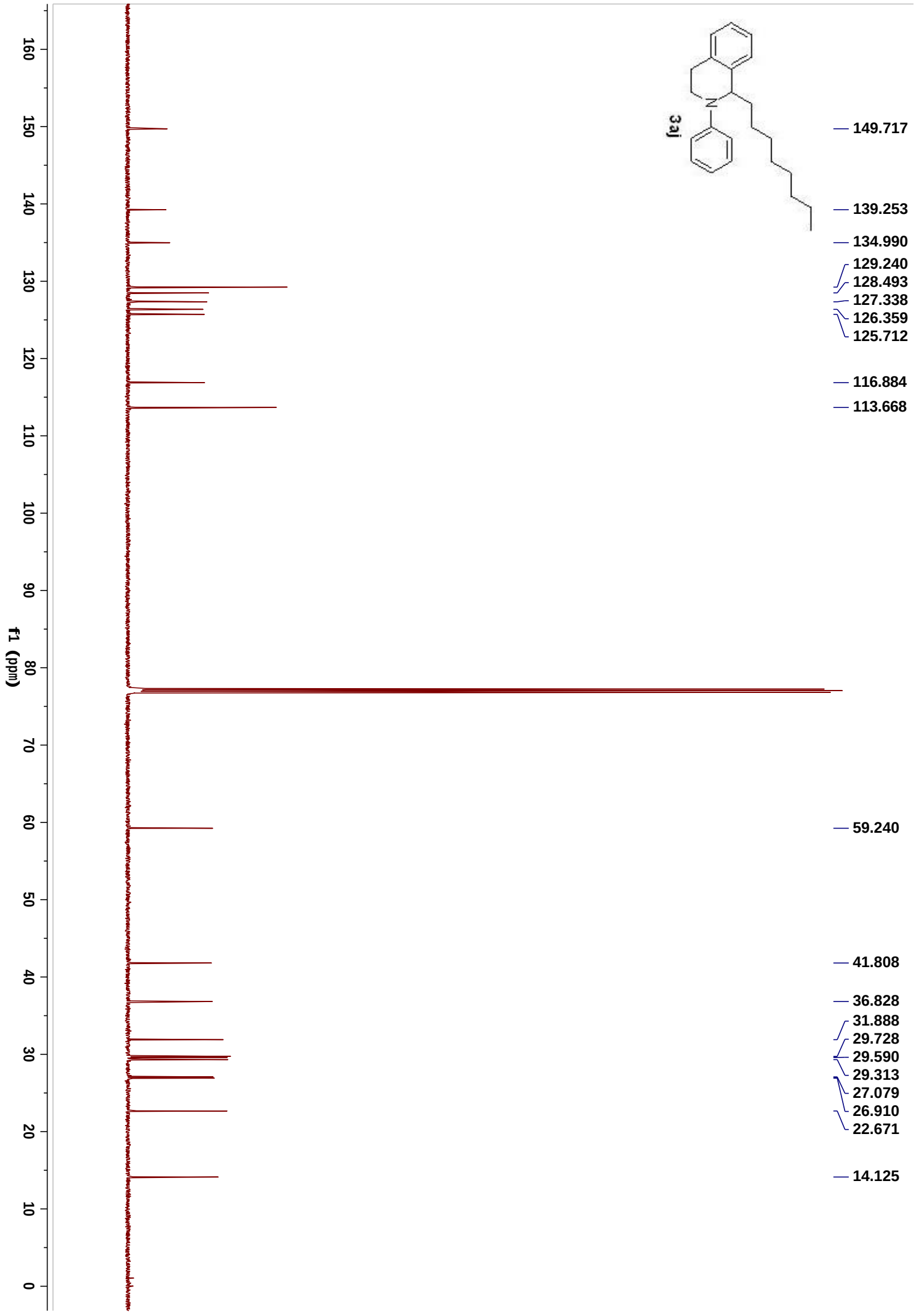
135.002
129.259
128.514
127.352
126.377
125.731
116.908
113.690
59.260
41.822
36.863
31.880
29.415
27.093
26.900
22.685
14.130
f1 (ppm)


3aj
f1 (ppm)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
2.07
4.01
2.04
1.03
1.00
2.01
1.04
1.03
1.07
1.06
1.07
1.07
10.02
3.00
7.250
7.239
7.227
7.214
7.162
7.155
7.147
7.140
7.132
7.121
7.113
7.106
7.098
7.091
6.868
6.854
6.716
6.704
6.692
4.640
4.628
4.616
3.625
3.618
3.610
3.604
3.597
3.589
3.579
3.567
3.028
3.023
3.012
3.001
2.997
2.988
2.866
2.857
2.848
2.839
2.830
1.956
1.945
1.934
1.926
1.709
1.699
1.690
1.679
1.667
1.543
1.483
1.473
1.464
1.456
1.450
1.408
1.398
1.387
1.377
1.368
1.357
1.305
1.291
1.280
1.268
1.255
1.241
1.225
0.878
0.867
0.855


3aj
149.717
139.253
134.990
129.240
128.493
127.338
126.359
125.712
116.884
113.668
59.240
41.808
36.828
31.888
29.728
29.590
29.313
27.079
26.910
22.671
14.125
f1 (ppm)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

6. References

[1] Zhang, T.; Liang, W.; Huang, Y.; Li, X.; Liu, Y.; Yang, B.; He, C.; Zhou, X.; Zhang, J. Bifunctional Organic Sponge Photocatalyst for Efficient Cross-Dehydrogenative Coupling of Tertiary Amines to Ketones. *Chem. Commun.* **2017**, *53*, 12536–12539.

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[3] Zhou, W.-J.; Cao, G.-M.; Shen, G.; Zhu, X.-Y.; Gui, Y.-Y.; Ye, J. H.; Sun, L.; Liao, L.-L.; Li, J.; Yu, D.-G. Visible-Light-Driven Palladium-Catalyzed Radical Alkylation of C−H Bonds with Unactivated Alkyl Bromides. *Angew. Chem. Int. Ed.*, **2017**, *56*, 15683–15687.

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